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Rainfall variability in the upper Napo River Basin, Ecuadorian Amazon

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FLORIDA INTERNATIONAL UNIVERSITY

Miami, Florida

RAINFALL VARIABILITY IN THE UPPER NAPO RIVER BASIN, ECUADORIAN AMAZON

A thesis submitted in partial fulfillment of the
requirements for the degree of
MASTER OF SCIENCE
in
ENVIRONMENTAL STUDIES
by
Marcelo Vicente Ayabaca

2004

To: Dean R. Bruce Dunlap
College of Arts and Sciences

This thesis, written by Marcelo Vicente Ayabaca, and entitled Rainfall Variability in the Upper Napo River Basin, Ecuadorian Amazon, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this thesis and recommend that it be approved.

Dean Whitman

Robert Black

Michael McClain, Major Professor

Date of Defense: April 2, 2004

The thesis of Marcelo Vicente Ayabaca is approved.

Dean R. Bruce Dunlap
College of Arts and Sciences

Dean Douglas Wartzok
University Graduate School

Florida International University, 2004

DEDICATION

To God and my parents.

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ABSTRACT OF THESIS

RAINFALL VARIABILITY IN THE UPPER NAPO RIVER BASIN, ECUADORIAN AMAZON

by

Marcelo Vicente Ayabaca

Florida International University, 2004

Miami, Florida

Professor Michael McClain, Major Professor

The purpose of this research was to investigate the influence of elevation and other terrain characteristics over the spatial and temporal distribution of rainfall. A comparative analysis was conducted between several methods of spatial interpolations using mean monthly precipitation values in order to select the best. Following those previous results it was possible to fit an Artificial Neural Network model for interpolation of monthly precipitation values for a period of 20 years, with input values such as longitude, latitude, elevation, four geomorphologic characteristics and anchored by seven weather stations, it reached a high correlation coefficient ($r=0.85$). This research demonstrated a strong influence of elevation and other geomorphologic variables over the spatial distribution of precipitation and the agreement that there are nonlinear relationships. This model will be used to fill gaps in time-series of monthly precipitation, and to generate maps of spatial distribution of monthly precipitation at a resolution of 1km^2.

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INTRODUCTION

In the Earth Sciences, it is known that available water in its different physical states is the principal factor to support any kind of life known until now, and its distribution along with environmental temperature define diversity and concentration of life in every zone in the Earth. In continental zones, the principal source of water is rainfall. For that reason this climatic parameter is defined as a fundamental input data set to drive surface water runoff and environmental models (along with soil parameters, topography, network configuration, etc.). Furthermore, water is the principal medium to dissolve and transport chemical components such as nutrients. The quality and quantity of water define the dynamic level of nutrient interchange processes at multiple spatial and temporal scales.

In the Napo River Basin (the study area) abundant precipitation among other climatic factors define its special character as an outstanding forest tropical zone, recognized as one of the eleven highest biodiversity hotspots on the world. The Napo River is also important in the larger Amazon Basin because, like other Amazon tributary rivers that start in the Easter Cordillera of the Andes, it is an important supplier of water and nutrients to the lowland basin. Walker et al. (1995) explain that Andean Rivers contribute both 13% of total water volume and 90-95% of suspended sediments to the Amazon River; this is the principal reason why it is necessary to understand the dynamic water processes in these headwater catchments. The Andean Amazon Rivers Analysis and Management Project (AARAM), which was created in order to deal with this important environmental issue, has one of its several objectives to develop comprehensive hydrologic and environmental models of four Amazon pilot catchments.

From a climatologic viewpoint, precipitation exhibits the most random spatial and temporal behavior. For that reason, it is desirable that there be as many observation points (rain-gauge stations) as possible. This is not the case for the Napo River Basin and other Amazon Andean catchments due to the scarcity of climatologic and hydrologic networks that guarantee enough data in quality and quantity. The World Meteorological Organization, in its Guide to Hydrological Practices (WMO No. 168, 1974), recommends minimum densities for rainfall networks for several regions. The topographic complexity of the Eastern slope of the Andes requires that a high density of stations be installed. At the same time, the lack of logistic services for this zone raise the installation and maintenance costs of climatic stations above what institutions responsible of these activities can afford. Alternative solutions have been taken, such as placing climatic stations near towns and settlements. But the density of these stations is not enough to meet the climatic requirements of the WMO norms. For example, The National Institute of Meteorology and Hydrology -INAMHI- in Ecuador, which is responsible for the National Hydro-Meteorological Network, has been suffering constant governmental budget reductions during the last decade. This situation has resulted in a reduction of active meteorological and hydrologic stations, affecting the quality and quantity of available climatologic information.

This research focuses on a hydrological approach that takes into account topographic features in order to improve the spatial modeling of precipitation and to overcome the scarcity of observations points. This research examines several interpolation methods such as regression analysis, geostatistic, inverse weighted distance, and artificial neural networks in order to evaluate their accuracy and consistence, with the goal to select the best methodology for using to generate a model which is able to fill gaps in time-series of monthly rainfall, maps of spatial distribution and synthetic series for a regular rain- gauge network at monthly level.

LITERATURE REVIEW

Recent hydrologic models have been using several methods for spatial analysis of climatologic parameters by incorporating values of topographic features, vegetation cover and runoff with good results depending on available information and research objectives (Olsson et al. 2002, Shang et al. 2001). As this research focuses on the influence of elevation on the spatial distribution of precipitation, the literature reviews have been directed in that way. There are three principal approaches using different spatial interpolation methods and tools with successful results. They are regression analysis, kriging, and artificial neural networks .

Regression Analysis

Multivariate regression is one of the deterministic interpolation methods that have been used in Geostatistics as an alternative to the traditional inverse weighted distance method. Although there have been other modern interpolation methods, multivariate regression is the most versatile in that it includes several predictor variables, and it also as been used to recognize the principal predictor variables which have been further applied in other more sophisticated models. There are several references in climatic applications that have used regression analysis, but recent researches guiding this proposal are Marquinez et al. (2003), Hay et al. (1998) and Wotling G et al. (2000).

Marquinez et al. (2003) estimated multi-annual seasonal and annual precipitation using a linear regression analysis in a 10590km^2 study area in the northern zone of the Cantabrian Coast, Spain. The Cantabrian area is a mountainous zone with elevations ranging from 0 m to 2640 m. This study works with 117-rainfall recording stations, 84 of them used to generate the regression analysis and the remaining 33 as set of test validation for the model. They used a multivariable polynomial function of third degree, with 5 predictor variables such as, elevation, sub-basin mean elevation, slope, a west distance and a Euclidian distance from coastline. Values were generated form a Digital Terrain model (DTM) with a cell size of 200m. Marquinez et al. (2003) conclude that models that use additional topographical features give better correlation than models that only include elevation factors. In this analysis, they tested the regression results against real values from test stations not used to generate the polynomial function.

Other research in this topic is done by Hay et al. (1998), who use a multiple linear regression for daily precipitation for a zone of 1820 Km^2 Animas River basin of Southwestern Colorado, US. Elevation range from 2000 to 4000m and precipitation records are available from 22 stations. This linear regression model is part of precipitation-runoff model that uses a DTM with a resolution of 5 km to generate the predictor variables such as location coordinates, elevation, range, slope, aspect, exposure, barrier, orientation, using circles of influence with radius of 20 km and 40 km.

Wotling et al. (2000) used principal components before generating a linear regression for storm rainfall in Tahiti and conducted a comparative analysis against the ordinary Kriging (OK) method. In this case the polynomial function that includes elevation factor gave better accuracy than OK, which only uses map coordinates.

The reviewed papers explain that elevation as predictor factor among other topographic features has strong influence in a Regression analysis of spatial distribution in precipitation, and that it is possible to account with this method as a effective solution.

Furthermore the Regression analysis could be merged with inverse weighted distance (IWD) and kriging methods using their interpolation equation as drift function.

Kriging methods

Kriging is a geostastistial method with a collection of versions depending on the type of application. This method calculates a best linear unbiased estimate for an interpolated point using the surrounding observation points. Surrounding points are assumed to have some definable covariance function, and the interpolation weights to calculate the estimate value are obtained by resolving an equation system containing lagrange multipliers generated by the surrounding points. (Kitanadis, 1997) and (ESRI-a, 2001).

Depending upon the interpretation or assumptions about the predictable data, it is possible to use different versions of the Kriging method to solve for an isotropic or nonisotropic, stationary or nonstationary random data field. In addition, there are simplified versions that use predefined or intrinsic variogram functions, thereby reducing costs and providing practical solutions.

Goovaerts (2000) studied the influence of on the spatial interpolation of rainfall in Algarve, Portugal, a southern and mountainous zone covering 5000 Km^2. His analysis used multi-annual monthly rainfall from 36 rain gauge stations. He performed a detailed comparative analysis among several interpolation methods including thiessen polygon, inverse weighted distance (IWD), ordinary kriging, linear regression, kriging with drift and ordinary cokriging.

He concluded that kriging methods that included an elevation factor gave better interpolation results that others, and it is easy to understand that the thiessen polygon method gave the worst results. It is necessary to comment about the procedure to rate the results of interpolation methods, because Goovaerts (2000) used a relative coefficient between mean square error (MSE) divide by the MSE of the linear regression model.

Kastelec et al. (2002) used a universal kriging interpolation with an intrinsic spherical variogram to generate a Mean yearly precipitation for all Slovenia's area (20253 Km^2). The ancillary parameter was elevation taken from a NTM with 1km. resolution. The model is applied for a mountainous zone with elevation range from 0 m to 2864 m, and includes and 362 observation points. In this case, precipitation is defined as stationary and nonisotropic random field variable. An additional contribution of this study is the iterative procedure to analyze maximum and minimum axes of the ellipsoid area of interpolation influence.

Brass and Rodriguez (1993) explain didactically several solutions developed by U.S Bureau of Reclamation for polynomial variogram models that have been used to estimate the mean area of storm precipitation in mountainous regions, specifically of the Colorado River Basin.

Neural networks

Artificial neural networks (ANNs) with genetic algorithms and expert systems are the principal developments in artificial intelligence. ANNs have given useful results in real and complex applications where it is difficult and sometimes impossible to find analytical solutions. This tool can be used for recognition of images; voices and other kind of signals, and for this reason ANNs are used in innumerable applications and sciences. For example, this tool has been used in robot training, remote sensing, marketing, mining exploration, space exploration, missile navigation, medicine and weather prediction.

In general ANNs are simplified version of neurobiological networks that try to simulate the intricate connections among axons and dendrites (Hugh 2001),such an ANN, nodes and their interconnected lines have values or coefficients, which are fitted by using an iterative correction procedures in order to approach a specific goal (Gurmey, 2003)

The fundaments of ANNs sound very simple, but it involves strong mathematical support. There are several typologies of ANNs depending on their application. The first one developed known as the binary one layer perceptron model. The descendants of this model include the multi-layer (MLP), the radial Basis and the Competitive Learning models. Of course there are a large number of other models (Hen Hu et al.2002), but this research was dealing with MLP models.

In Meteorological applications there are good approaches for weather forecasting (Hall et al, 1997) and for improving the results of Meteorological Radars (Osrodka et. 2003). The University of Arizona has a project for precipitation estimation using GOES images (PERSIANN, 2002) that have developed a method that could be used to generate better accuracy for daily precipitation, Maeda et al. (2001) used neural networks to predict storm influences in reducing snow hazards.

Research with similar objectives to this proposal, has been developed by Antonic et al. (2001). They used an ANN approach to calculate several monthly climatic variables for the mountainous zone of Croatia, (56538 km^2) using 127 weather stations. Their models relied on two principal stations, which had long records. These stations were used to train the ANN, which was able to generate interpolated values for seven climatic parameters across the remaining stations. They were able to incorporate elevation effects and temporal interpolation into only one model.

Their research used an ANN architecture known as MLP with 17 neurons in the input layer for predictor (input) variables, where 12 neurons work as dummy variables that define a select month and the remaining 5 neurons are used for other variables as elevation, longitude, latitude, and the value of one of the seven monthly climatic parameters (mean, daily minimum and maximum temperature, mean relative humidity, precipitation, mean global solar radiation and potential evapotranspiration). The ANN works with two hidden layers with 6 neurons each, and only one neuron for the output layer.

The value of this study is its ability to figure out that an ANN model based on only three weather stations could reflect the behavior across the country and over a long time period. Typically, successful results of a ANN depend on the quality and quantity of data and the researcher's ability to figure out the right network architecture.

STUDY AREA

Ecuador is located in the northwestern zone of South America, with longitudes between 81°W and 75°W, and Latitudes between 2°N and 6°S. It covers 276000 km^2 of continental land and it has a western coast bounded by the Pacific Ocean. This country, due to its geographic position, is unique because it does not only belongs to the Tropical zone, but the El Niño- Southern Oscillation –ENSO also directly affects it. Moreover, Ecuador is geomorphologically complex due to the Cordillera of the Andes that crosses it in a north-south direction and divides the Ecuadorian territory in to three main geographic zones, with diverse local microclimates. The Ecuadorian Napo River Basin, the study area, is located in the Eastern zone of this country, and is defined by the shaded area in Figure 2.

The study area is located on the eastern slope of the Cordillera of the Andes and belongs to the northwest zone of the Amazon basin. The Napo River Basin is shared politically between Ecuador and Peru, but this research focus only on the Ecuadorian zone, the nearest sector to the Andean Cordillera.

The Ecuadorian Napo River Basin is located in longitudes between 78°25'W and 76°25'W, and latitudes between 0°10' N and 1°30' S. It is approximately 330 km from East to West and 118 km from North to South, and it has an area of 33000 km^2. Elevation varies from 200 m. in low zones to a maximum elevation of 5897 m (Cotopaxi volcano). It includes the most active volcanoes in the Andean Cordillera such as Reventador, Zumaco, Cotopaxi and Antizana.

INAMHI (2001) using Keoppen's System (Figure 1) has classified 23 climatic zones in Ecuador; 9 are in the study area, but in general there are a mixture of moorland (Paramo) in highland zones, temperate dry in Eastern zones of the Andean Cordillera and Tropical Forest in the low lands. This zone has an average annual rainfall that varies from 2700 to 4100 mm and with mean air temperature from 20°C to 30°C.

From a biological viewpoint, The Ecuadorian Napo River Basin contains one of the twenty five highest world hotspots of biodiversity; Myers et al. (2000) reported more than 307 tree species with diameter at breast height > 10 cm. per hectare. At the same time this zone has the highest rate of deforestation; Mena (2001) calculated an annual rate above 1.24% with a total current deforestation of 33% of the natural rainforest due to colonization, timber and oil exploitations. The population is estimated to be about 165,600 inhabitants with a demographic index between 3.1% and 5.6% y^{-1} in Napo and Orellana provinces, respectively (INEC, 2001).

Principal climatic facts

The northwestern zone of South America is affected by the high atmospheric dynamics of the Intertropical Convergence Zone (ITCZ), which is influenced by the Semi-permanent Anticyclone of South Pacific, the Caribbean Anticyclone, the Atmospheric Amazon Disturbance and the Low Pressure Peruvian Zone. These features are responsible for a regional rain type, and its seasonal movements are predominantly controlled by the seasonal solar, for that reason the wet and dry times are near the equinox and the solstice respectively (McGregor, 1998).

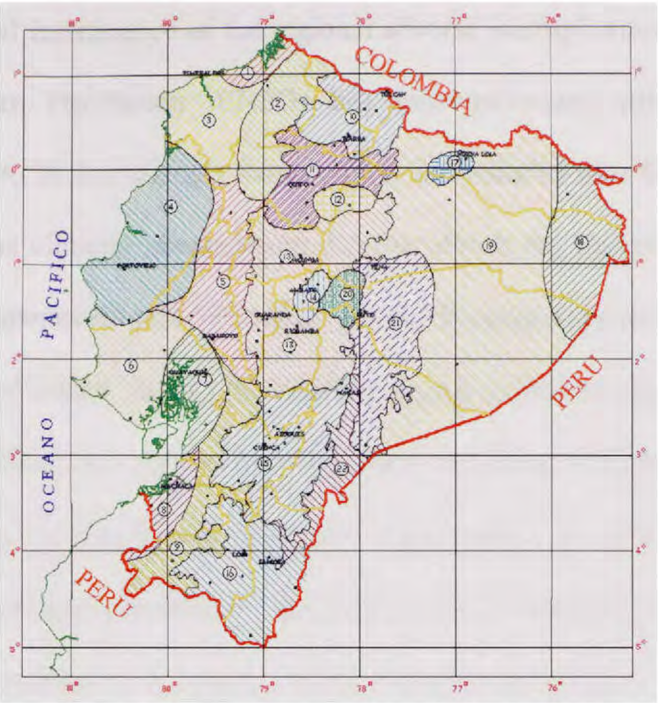


Figure 1: Climatic Zones of Ecuador (INAMHI-2001)

Figure 2: Study Area. Upper Napo River Basin

The cyclical interference of the regional adverse atmospheric-ocean phenomenon, El Niño- Southern Oscillation -ENSO- has intercontinental influence with global ramifications due to its increasingly harsh effects and reduced time between consecutive ENSO events. This climatic phenomenon directly affects the Pacific Ocean Coast with increasing sea temperatures and West-East winds, bringing high moist air masses over western continental zones leading to high precipitation and consequent hydrological, ecological and economical effects over Ecuador, Peru and Colombia. In addition, it reduces the air mass movement from the Atmospheric Amazon Disturbance and consequently it decreases precipitation amounts in the northwestern Amazon Zone. The ENSO effects are visible but its triggers are still under study (McGregor, 1998), but it is clear that ENSO dislocates the normal climatic patterns over the entire Ecuadorian territory.

Another aspect that is necessary to take into account for this research is that the Amazonian region has high levels of evaporation, due to the high levels of solar radiation and its vegetation cover type (a natural tropical rain forest). Models of energy balance have confirmed the influence of vegetation as regulating moisture and air temperature in this basin (Lean et al. 1996). Walker et al. (2002) explain that of total annual precipitation in the Amazon Basin, which has been calculated between 2000 mm and 3664 mm, the evapotranspiration by the forest contributes between 48.2 and 80.7%, and only the remaining 19.3 to 51.8% is the product of oceanic water-vapor. This implies that convective clouds are the principal source of precipitation with their moisture derived from evaporation in the adjacent forest.

Finally, the topographic complexity due to the double mountain range of the Cordillera of the Andes that cross Ecuador in a north-south direction is not only responsible for three principal geographical and climatic zones, but also contributes to the formation many microclimate areas due to convectional and topographic rainfalls, which are typical in mountainous tropical latitudes. The average elevation for the eastern mountain chain of the Andean Cordillera in Ecuador is approximately 4000 meters; it represents a real barrier to the normal air movement and effectively generates orographic rainfall due to condensation when water-vapor rises above 2000m (Lutgens et al. 2003).

Data Available for study

The climatic data used in this study belong to INAMHI, an active member of AARAM project. For the zone there have been cataloged 18 Climatic and 19 rain gauge stations with a period from 1959 to 2002.

It was necessary to include additional 37 stations that surround the study area in order to provide better spatial coverage and to overcome the scarcity of information in the study area. Appendix C contains a graphical inventory of monthly precipitation records. From 74 stations it is easy to verify that during the decade of 80's there were more concentrated records, but during the 90's there has been a reduction in the number of stations. For 2000 there were 24 active stations but only 7 weather and 5 rain gauge stations into the study area. This is a clear reflection of the deterioration of the climatic network. Figure 3 and Appendix B show geographical locations of climatic and rain-gauge station.

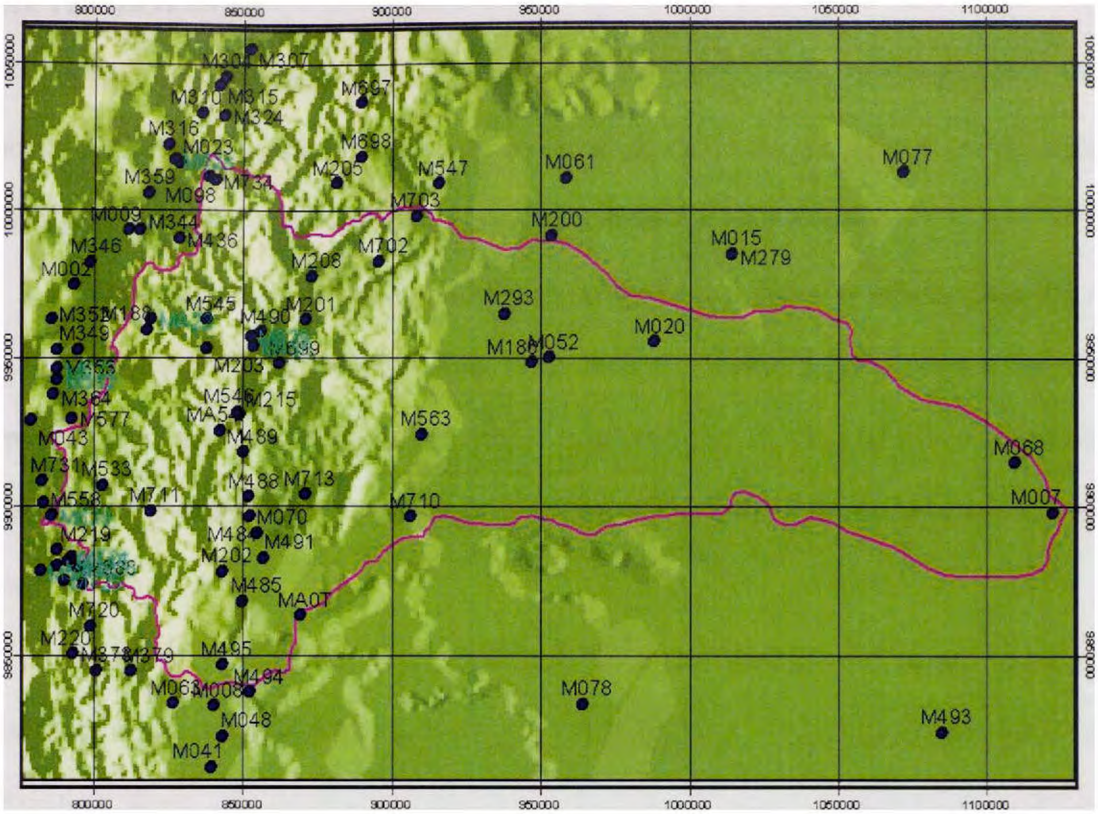


Figure 3. Geographical locations of climatic and rain-gauge station

Another information source is topographic maps at a scale 1:250.000 from the Military Geographic Institute of Ecuador (IGM). These maps have been digitized in ARCINFO format used to generate a Digital Terrain model (DTM) These graphical data were managed in a Geographic Information System (GIS) platform and turned the framework for spatial interpolation methods.

METHODOLOGY

This study focuses on monthly and multi-monthly values of Precipitation for all observation points located in the study area and selected surrounding stations in order to get a good coverage and to guarantee enough accuracy in this analysis.

This study starts with an exploratory analysis in order to verify the quantity and quality of available climatologic data in the area by finding dependencies in time and space and testing the interpolation methods using didactic versions of their algorithms in commercial software packages that usually have more sophisticate versions but with more concise results.

Second, the GIS platform ARCVIEW was used to process topographic maps of the study area zone in order to generate a NTM and related physical characteristics like as elevation, slope, aspect hill-shade that were incorporated into the interpolation models.

Analysis of quality of information

This analysis focuses on quantity and quality of available climatologic data at monthly time steps. The correlation method will be used in order to verify relationships between stations. This analysis helps to determine if it is possible to fill in missing values using neighboring stations and correlation weights.

This Analysis helps to recognize if there is a linear relationship between two neighboring stations using monthly and annual values (Levine et al. 1998). The Pearson product moment coefficient of correlation (r_{ab}) is given by

$$r_{ab} = \frac{SSx_a x_b}{\sqrt{Sx_a x_a Sx_b x_b}} = \frac{\sum (x_{ai} - \bar{x}_a)(x_{bi} - \bar{x}_b)}{\sqrt{\sum (x_{ai} - \bar{x}_a)^2 \sum (x_{bi} - \bar{x}_b)^2}}, \qquad (1)$$

where x_{ia} and x_{ib} are the monthly precipitation values at stations

$\bar{x}_a$ and $\bar{x}_b$ are the mean monthly precipitation values at stations

a, b are different weather or rain-gauge stations

The hypothesis to test for the population correlation coefficient ρ

Ho: ρ_{ab} is equal 0 (there is no correlation)

H1: ρ_{ab} is not equal 0 (there is correlation).

The test statistic for determining the existence of a significant correlation is given by

$$t = \frac{r - \rho}{\sqrt{\frac{1 - r^2}{n - 2}}}; df = (n - 2) \qquad (2)$$

where the statistic t follows a t distribution with n-2 degrees of freedom.

Cluster Analysis.

This analysis was used to generate groups of stations that have a similar climatic pattern of monthly precipitation during the year. The Euclidian distance was selected as the dissimilarity coefficient between stations. It was necessary to use standardized variables due to the significant differences in magnitude between the 12 monthly precipitation and geographic coordinates.

The dissimilarly coefficient between stations i and j, d(i,j) is given by,

$$d(i,j) = \sqrt{(x_{ik} - x_{jk})^2 + \ldots\ldots + (x_{in} - x_{jn})^2}\ ; \text{k= 1 ..n variables} \qquad (3)$$

Where d(i,j) = Euclidian distance between stations i and j

x_{ik}, x_{jk} are standardized variables such as monthly precipitation, longitude, latitude and elevation values

The classification used the Agglomerative Nesting method(Kaufman et all, 1990). This hierarchical technique starts with subgroups that hold only one station per group; the next steps are successive fusions of nearest subgroups using the average distance among sub-groups.

The average distance between groups is given by

$$d(R,Q) = \frac{1}{n_R * n_Q} \sum_{\substack{i \in R \\ j \in Q}} d(i,j) \qquad (4)$$

Where d(R,Q)=Dissimilarly coefficient between Groups R and Q

n_R = number of element in group R

n_Q=number of elements in group Q

d(i,j) is dissimilarly coefficient between stations i and j and defined by (3)

The procedure stops when all stations are grouped into a single big group. This method produces a clustering tree or dendrogram, with scaled height (0 to 10) of dissimilarly distance among groups. A clustering state at a level of 25% of the maximum dissimilarity is recommended .(S-PLUS, 1999).

Generation of Numerical Terrain model.

In order to incorporate physical characteristics in spatial interpolation models, and to produce a framework for visual verification of the quality of model results, it is necessary to work with topographic maps to generate Digital terrain models (DTM) at several resolutions. This procedure had the following sequential steps

- The source data are from digitalized topographic maps at a 1:250,000 scale that cover the Napo River Basin. Using available procedures in Geographic Information System (GIS) software it is possible to transform from contour curves to sample points, then to a DTM, which can be a Triangulated Irregular Network (TIN), and raster cells or grid types.
- Usually, GIS tools use the spatial interpolation method inverse weighted distance (IWD) with a Natural Neighbor points criteria a TIN is generated, and with a posterior processing it is possible to generate the raster grids. In addition to elevation and coordinate values that are inherent values for DTM and grids, it is necessary generate additional terrain features such as slope and aspect (horizontal direction) and hill-shade for several Sun elevation and horizontal azimuth.
- For every observation point, values for average elevation, slope, aspect hill—shade are extracted and incorporated as additional variables for interpolation methods.

Because of the large volume of data used in this research, it was necessary to develop an application in GIS software (ARCVIEW) specially for processes to export data from GIS to external applications and posterior results importation. The GIS used in this research should have the following principal modules:

- Importation of digital topographic maps
- Transformation to NTM, generation of additional terrain characteristics
- Importation of climatic stations as sample points
- Interface module with statistic data base of climatic stations

- Interfaces to export data from NTM
- Interfaces to export data from sample points
- Interfaces to import GRID data from other applications
- Modules of interpolation methods

Interpolation methods.

Selection of observation points and validation for interpolation methods.

Previous exploratory analysis of precipitation helped to generate a collection of selected observation points that could be the most significant for the zone. These stations have been in operation during the last 10 years and could include 70% of the available climatologic stations. The remaining stations are used as an observation point set to test the goodness of fit for each interpolation method.

According to hydrologic practices there are two methods commonly used to estimate missing data and they can be interpreted as weight interpolation by neighboring stations. The principal condition for using these methods is that the stations should have similar precipitation regimes; in other words, good spatial autocorrelation and close distances between the target observation point and its neighbors.

These methods can be used when missed data account for less than of 10% of the full record (WMO 1974). In addition, It is necessary to note that in zones where there are large topographic influences on precipitation, it is not recommended to use these methods. In this case it is preferable to use an isohyetal map. (Gray 1973).

Inverse Weighted distance(IWD)

The Inverse distance weighted interpolation is a deterministic method and it is commonly used when spaces between sample points are relatively close and have a linear relation. This method assumes that a predicted value is a function of the inverse distance from nearest observation points. The general formula is defined by

$$z(\mathbf{u}_k) = \frac{\sum_{i=1}^{i=n} w(h_{ik}) * z(\mathbf{u}_i)}{\sum_{i=1}^{i=n} w(h_{ik})} \tag{5}$$

$$w_{ij} = \frac{1}{h_{ij}^{a}}; \tag{6}$$

$$h_{ij} = \left\|\mathbf{u}_i - \mathbf{u}_j\right\| = \sqrt{(u_{1,i} - u_{1,j})^2 + (u_{2,i} - u_{2,j})^2} \tag{7}$$

Where, z($\mathbf{u}_k$) is interpolated point

w(h_{ik}) influence weight for an observation point.

H_{ij} is a Euclidian distance between $\mathbf{u}_i$ and $\mathbf{u}_j$ points.

Other more sophisticated versions of the weight function have been developed. One of them uses triangular sub-areas among interpolated points and their nearest neighbors and no-collinear observation points and the interpolated points that should be contained in the triangle generated from the three observation points.

Thiessen Polygon method

This interpolation method should be used when only specific conditions exist such as if there is a sufficient density of observation points and there are significant correlation between near stations, but generally these criteria are sub-estimated and this method is used without pervious analysis of spatial distribution specially in areas where topographic factors have important influence.

This method is defined as the inverse weighted distance with only one nearest observation point .

$$y(\mathbf{x}_i) = y(\mathbf{x}_j)) \text{ for } j = k(\min(h_{ik})) \tag{8}$$

$$h_{ik} = \|\mathbf{x}_i - \mathbf{x}_k\| = \sqrt{(x_{1,i} - x_{1,k})^2 + (x_{2,i} - x_{2,k})^2} \tag{9}$$

Where, y($\mathbf{x}_i$) is interpolated point

h_{ik} is a Euclidian distance between $\mathbf{x}_i$ and $\mathbf{x}_k$ points.

Inverse weighted distance and trend function

It is an modified IDW method in which the influence of elevation or other factors can be considered in this kind of interpolation.

The general formula is defined by

$$z_k = \frac{\sum_{i=1}^{i=n} g_{ki} * w(h_{ik}) * z(\mathbf{u}_i)}{\sum_{i=1}^{i=n} w(h_{ik})} \tag{10}$$

$$g_{ki} = \frac{f(\mathbf{u}_k)}{f(\mathbf{u}_i)} \tag{11}$$

Where g_{ki} is the ratio between trend function values at observation points and the interpolated point.

$f(\mathbf{u}_i)$ is a trend or drift function value for point *i*, that can be found using a regression analysis.

Linear Regression Analysis

In order to understand the influence of topographic features such as elevation, longitude, latitude, slope and aspect on the spatial distribution of monthly precipitation, regression analysis and variogram analysis methods will be used.

Fitting a lineal regression model and verifying multicollinearity helps to determine if there is dependence between precipitation and the other predictor variables by using a correlation matrix and scatter plot matrix.

Correlation values are defined by

$$r_{ij} = \frac{SSx_i x_j}{\sqrt{Sx_i x_i Sx_j x_j}}, \text{ where i, j are model variables,} \tag{12}$$

The hypothesis to test for the population correlation coefficient ρ is previously defined in equation (1), with a rejection region defined for $\alpha = 0.05$.

The other way to test for multi-collinearity between predictor variables is by using a variance inflation factor (VIF), which uses the correlation matrix of transformed predictor variables in a standardized form defined by Neker et al. (1996)

$$x_{ij} = \frac{z_{ij} - u_j}{Sx_j};\ I = 1,2,3....n\ (sample),\ j = 1,2,3\ (predictor\ variables). \tag{13}$$

The variance inflation Factor is defined by

$$VIF_{ii} = (1 - R_{ii}^2)^{-1}; \tag{14}$$

Where R^2 is the coefficient of multiple determination for each predictor variable expressed by other remaining predictor variables.

The hypothesis to test for the variance inflation factor

Ho: VIFii is 1 (there is no correlation)

H1: VIFii is not 1 (there is correlation).

The test statistic for determining the existence of a significant correlation is given by

The mean of VIF is defined by

$$\left(\overline{VIF}\right)=\frac{\sum_{i=1}^{n} VIF_{ii}}{n} \tag{15}$$

With a rejection region defined by (VIF) > 10.

The general regression model is given by

$$y_i=\beta_0+\sum_{k=1}^{v}\beta_k x_{ki}+\sum_{k=1}^{v}\sum_{l=1}^{v}\beta_{kl}x_{ki}x_{li}+\sum_{k=1}^{v}\sum_{l=1}^{v}\sum_{m=1}^{v}\beta_k x_{ki}x_{li}x_{mi}+\xi\,, \tag{16}$$

where k,l,m = 1,2,3..v variables.or

$$y_i=\sum_{k=0}^{v}\sum_{l=0}^{v}\sum_{m=0}^{v}\beta_{klm}x_{ki}x_{li}x_{mi}+\xi \text{ where k,l,m = 0,1,2,3..v variables} \tag{16.a}$$

The Overall regression F-test is used to verify the significance of the regression model.

Hypothesis Ho: Every β_{klm} are 0

H1: at least one of β_{klm} is not zero.

The test statistic is $F^*=\frac{MSR}{MSE};fd=p-1,n-p;\alpha=0.05$ (17)

Where p= number of β_{klm}; n=number of observation points

The ANOVA table for regression Analysis is used to verify the lack of fit for models

Hypothesis Ho: $E[y]=\sum_{k=1}^{q}\sum_{l=1}^{q}\sum_{m=1}^{q}\beta_{klm}x_i x_l x_m$,

H1: $E[y]\neq\sum_{k=1}^{q}\sum_{l=1}^{q}\sum_{m=1}^{q}\beta_{klm}x_i x_l x_m$

The test statistic is $$F^* = \frac{SSLF\big/(c-p)}{SSPE\big/(n-c)};\ fd = c-p, n-c; \alpha = 0.05 \qquad (18)$$

Where c= number of subgroups of repeated data

And the influence for every factor is verify using the Partial F-test

Hypothesis Ho: β_k is 0

H1: β_k is not 0.

The test statistic is $$F^* = \frac{[SSR(F)-SSR(R)]\big/(p-1)}{SSE\big/(n-p)};\ fd = p-1, n-p; \alpha = 0.05 \qquad (19)$$

The best model was selected using minimum SSE criteria

Variogram Analysis

Variograms is used to analyze the spatial autocorrelation values between observation points and their relative spatial distribution. This analysis helps to find if it is first necessary to apply some coordinate rotation in the event of anisotropic behavior and second to recognize if the data are stationary or have some tendency. This initial analysis indicates if more or less model complexity is needed (Kinanidis, 1997).

This analysis starts with the construction of an empirical semivariogram of monthly multi-annual precipitation values using the following formulas

$$\gamma(h) = \gamma(\mathbf{u}_{i+1}, \mathbf{u}_i) = \left(Z(\mathbf{u}_{i+1}) - Z(\mathbf{u}_i)\right)^2 \tag{20}$$

$$\gamma^*(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} \left(Z(\mathbf{u}_{i+1}) - Z(\mathbf{u}_i)\right)^2 \tag{21}$$

$$h = \left\|\mathbf{u}_{i+1} - \mathbf{u}_i\right\| = \sqrt{\left(u_{1,i+1} - u_{1,i}\right)^2 + \left(u_{2,i+1} - u_{2,i}\right)^{2}{}^{2}} \tag{22}$$

where $Z(\mathbf{u}_\mathrm{i})$= monthly multi annual precipitation from station i

$\mathbf{u}_\mathrm{i}$ = coordinate vector (longitude, latitude, elevation) for an observation point or station i

The covariance function is defined by

$$R(\mathbf{u}_{i+1}, \mathbf{u}_i) = E[Z(\mathbf{u}_{i+1}) - m(\mathbf{u}_{i+1}))(Z(\mathbf{u}_i) - m(\mathbf{u}_i)], \tag{23}$$

$$\text{where } m(\mathbf{u}) = E[Z(\mathbf{u})] \tag{24}$$

Kriging Models

The objective of Kriging methods is to find the best linear unbiased estimate of a linear function of field Z(u) using several interpolation models that have a solution of a matrix equation system using Lagrange values. The estimator is formed by linear combinations of the observed values (Brass et al. 1993)

$$\hat{Z}_0 = \hat{Z}(\mathbf{u}_0) = \sum_{i=1}^{n} \lambda_i Z(\mathbf{u}_i) \tag{25}$$

With the condition of unbiased of estimate error defined by

$$E[(\hat{Z}_0 - Z_0)] = E[(\sum_{i=1}^{n} \lambda_i Z(\mathbf{u}_i) - Z(\mathbf{u}_0))] = 0 \tag{26}$$

And the best estimators will be those that give the smallest estimation variance.

$$\sigma^2 = E[(Z_0 - \hat{Z}_0)^2] = \mathrm{var}[Z_0 - \hat{Z}_0] \tag{27}$$

The principal definitions used in this methodology are:

The mean of random Z(u) is defined as: $m(\mathbf{u}) = E[Z(\mathbf{u})]$ (28)

The residual from the mean is defined as $Y(\mathbf{u}) = Z(\mathbf{u}) - m(\mathbf{u})$ (29)

The spatial dependence of random process Z(u) at any two points u_i and $_{ui+1}$ can be modeled by using covariance or semivariogram defined by

$$\begin{aligned} \mathrm{cov}(\mathbf{u}_{i+1}, \mathbf{u}_i) &= E[Z(\mathbf{u}_{i+1}) - m(\mathbf{u}_{i+1}))(Z(\mathbf{u}_i) - m(\mathbf{u}_i)] \\ &= E[Z(\mathbf{u}_{i+1})Z(\mathbf{u}_i)] + m(\mathbf{u}_{i+1})m(\mathbf{u}_i) \\ &= E[Y(\mathbf{u}_{i+1})Y(\mathbf{u}_i)] \end{aligned} \tag{30}$$

$$\begin{aligned} \gamma(\mathbf{u}_{i+1}, \mathbf{u}_i) &= \frac{1}{2}\mathrm{var}[Z(\mathbf{u}_{i+1}) - Z(\mathbf{u}_i)] \\ &= \frac{1}{2}E[(Z(\mathbf{u}_{i+1}) - Z(\mathbf{u}_i))^2] - \frac{1}{2}[(m(\mathbf{u}_{i+1}) - m(\mathbf{u}_i))^2] \\ &= \frac{1}{2}E[(Y(\mathbf{u}_{i+1})Y(\mathbf{u}_i))^2] \end{aligned} \tag{31}$$

Kriging has different approaches and depending if the random field Z(u) has a spatial tendency in a specific direction (anisotropy) or not (isotropy) and if the mean of Z(u) is constant (stationary) or not (non-stationary).

Isotropic and Stationary Kriging models

The most common and simplest kriging models are for isotropic and stationary random variables, in which they assume that the mean is constant (*m*(u)=m) and covariance and variogram are function only of the Euclidian distance.

$$\mathrm{cov}(\mathbf{u}_{i+1},\mathbf{u}_i)=\mathrm{cov}(h) \tag{32}$$

$$\gamma(\mathbf{u}_{i+1},\mathbf{u}_i)=\gamma(h) \tag{33}$$

The following models were tested in this study.

1. Gaussian model: $\gamma(h)=\sigma^2\left(1-e^{\left(-h^a/l^a\right)}\right)$; where a =2, (34)
2. Exponential model is the Gaussian model with a =1
3. Spherical model. $\gamma(h)=\begin{cases}\sigma^2\left(1-\dfrac{2h}{2\alpha}+\dfrac{h^3}{2\alpha^3}\right); & for\, 0\le h\le\alpha\\ \sigma^2, & ;for\quad h>\alpha\end{cases}$ (35)

Solution Procedure

The construction of matrix equation systems is a simplification of the general procedure that follows the two principal conditions, unbiased solution and minimum variance.

The first condition needed to enforce the unbiased solution is

$$E[z_o-Z(\mathbf{u}_0)]=\left(\sum_{i=1}^{n}\lambda_{i-2}-1\right)m=0\,; \tag{36}$$

With a solution of $\sum\lambda_i=1$, (37) Second is that the mean square estimations error MSE must to be minimum or minimum variance.

$$E\left[(Z_o - Z(\mathbf{u}_0))^2\right] = -\sum_{i=1}^{n}\sum_{i=1}^{n}\lambda_i\lambda_j\gamma\left(\left\|\mathbf{u}_i - \mathbf{u}_j\right\|\right) - 2\sum_{i=1}^{n}\lambda_i\gamma\left(\left\|\mathbf{u}_i - \mathbf{u}_j\right\|\right) \tag{38}$$

Then the system of equations to solve is:

$$-\sum_{j=1}^{n}\lambda_j\gamma\left(\left\|\mathbf{u}_i - \mathbf{u}_j\right\|\right) + v = -\gamma\left(\left\|\mathbf{u}_i - \mathbf{u}_j\right\|\right) \text{ ; } i=1,2,3\ldots\text{n} \tag{39}$$

where v is a Lagrange multiplier, and n is observation points

The developed matrix representation of the system of equations in (39) is

$$\begin{bmatrix} 0 & -\gamma\left(\left\|\mathbf{u}_1 - \mathbf{u}_2\right\|\right) & \cdots & -\gamma\left(\left\|\mathbf{u}_1 - \mathbf{u}_n\right\|\right) & 1 \\ -\gamma\left(\left\|\mathbf{u}_2 - \mathbf{u}_1\right\|\right) & 0 & \cdots & -\gamma\left(\left\|\mathbf{u}_1 - \mathbf{u}_2\right\|\right) & 1 \\ \vdots & \vdots & & \vdots & \vdots \\ -\gamma\left(\left\|\mathbf{u}_n - \mathbf{u}_1\right\|\right) & -\gamma\left(\left\|u_n - \mathbf{u}_2\right\|\right) & \cdots & 0 & 1 \\ 1 & 1 & \cdots & 1 & 0 \end{bmatrix} \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \vdots \\ \lambda_n \\ v \end{bmatrix} = \begin{bmatrix} -\gamma\left(\left\|\mathbf{u}_1 - \mathbf{u}_0\right\|\right) \\ -\gamma\left(\left\|\mathbf{u}_2 - \mathbf{u}_0\right\|\right) \\ \vdots \\ -\gamma\left(\left\|\mathbf{u}_n - \mathbf{u}_0\right\|\right) \\ 1 \end{bmatrix} \tag{40}$$

The variance is defined by

$$\sigma^2 = E[(Z_0 - Z(\mathbf{u}_0))^2] = -v + \sum_{j=1}^{n}\lambda_j\gamma\left(\left\|\mathbf{u}_i - \mathbf{u}_0\right\|\right) \tag{41}$$

The decision rule to accept or reject the quality of Kriging method, it uses the principal criteria that residuals follow a normal distribution, then it is possible to use the following test.

$$Q_1 = \frac{1}{n-1}\sum_{k=2}^{n}\varepsilon_k \text{ ; } E[Q_1] = 0\text{; with a rejection region } Q1 > \frac{2}{\sqrt{n-1}} \text{ and} \tag{42}$$

$$Q_2 = \frac{1}{n-1}\sum_{k=2}^{n}\varepsilon_k^2 \text{ ; } E[Q_2] = 1\text{;with a rejection region } \left|Q_2 - 1\right| > \frac{2.8}{\sqrt{n-1}} \tag{43}$$

Artificial Neural Networks.

Artificial Neural Networks belong to a group of Artificial Intelligence computer tools, developed to deal with complicated models in which the canonical approach can be very simple, due to a complex relation among predictor and predicted variables. This method has been used in a large number of successful applications. Antonic et al. (2001) demonstrated an excellent approach for interpolation of climatic variables using neural networks.

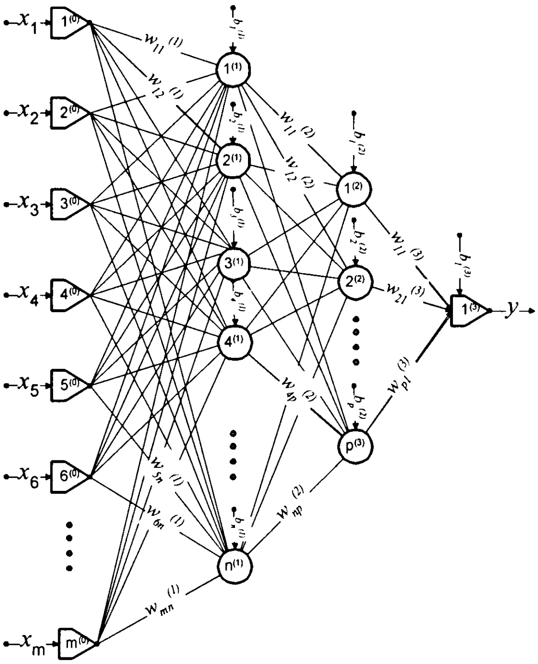


Figure 4.:Diagram of a artificial neural network(ANN) with a multi layer perceptron (MLP) typology

Neural networks are a loose simplistic abstraction of a biological neural network (Hugh, 2001). This structure is defined by several layers of cells (neuron or perceptrons) in which are stored a value (weight). Cells are interrelated with other cells by weight and are modulated by a special function (activation function). There is a large number of neural network typologies, but this study used a nonlinear multi-layer with hyperbolic tangent function ANN type. Figure 4 is a representation for a ANN with a input layer of m predictor variables, two hidden layers, and an output layer with one predicted variable.

The general function for the multi layer perceptron (MLP) typology in Figure 5 is defined by

$$y = f\left(\sum_{k=1}^{k=p} w_{k1}^{(3)} * f\left(\sum_{j=1}^{j=n} w_{jk}^{(2)} * f\left(\sum_{i=1}^{i=m} w_{ij}^{(1)} x_i + b_j^{(1)} \right) + b_k^{(2)} \right) + b_1^{(3)} \right) \tag{44}$$

Where

$$a_j^{(p)} = \sum_{i=1} w_{ij} o_i^{(p)} + b_j^{(p)} \tag{45}$$

$$o_j^{p+1} = f(a_j^{(p)}) \tag{46}$$

The activation function is

$$f(x) = \tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}} \tag{47}$$

and its derivative function is

$$f'(x) = \left(1 - (f(x))^2\right) \tag{48}$$

The selected learning procedure was the back-propagation training method where the estimated errors are used to calculate weight changes using the least mean squares method. The back-propagation method is essentially a gradient descent approach that minimizes errors in order to adjust the connection weights.

$$Q = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 = 0; \tag{49}$$

Where n is number of training samples

y_i= real value from the training sample, and

$\hat{y}_i$=calculated output value

This procedure try to rectify weight (w) values in inverse way, and it starts sharing the output errors for the last perceptron with a modified error δ_{pj}

The last perceptron layer is defined by

$$\delta_j^{(3)} = \left(y_j - \hat{y}_j\right) f'(a_j^{(3)}) \qquad (50)$$

Where y_j= real value from the training sample, and

$\hat{y}_i$=calculate output value

Other inner layers are defined by

$$\delta_j^{(p)} = f'(a_j^{(p)}) \sum_{k=1}^{v} \delta_k^{(p+1)} w_{jk}^{(p+1)} \qquad (51)$$

Where k = a index for every interconnection weight from the p+1 layer,

The correction value over each interconnection between neurons i and j is defined by

$$\Delta w_{ij}^{(p)}(t+1) = \eta \delta_j^{(p)} o_i^{(p)} + \alpha \Delta w_{ij}^{(p)}(t); \qquad (52)$$

where η is the learning rate with a range between 0.1 and 0.9.

α is the smoothing term with a range between 0.2 and 0.8.

$\delta^p{}_j$ is the delta of neuron u_j,

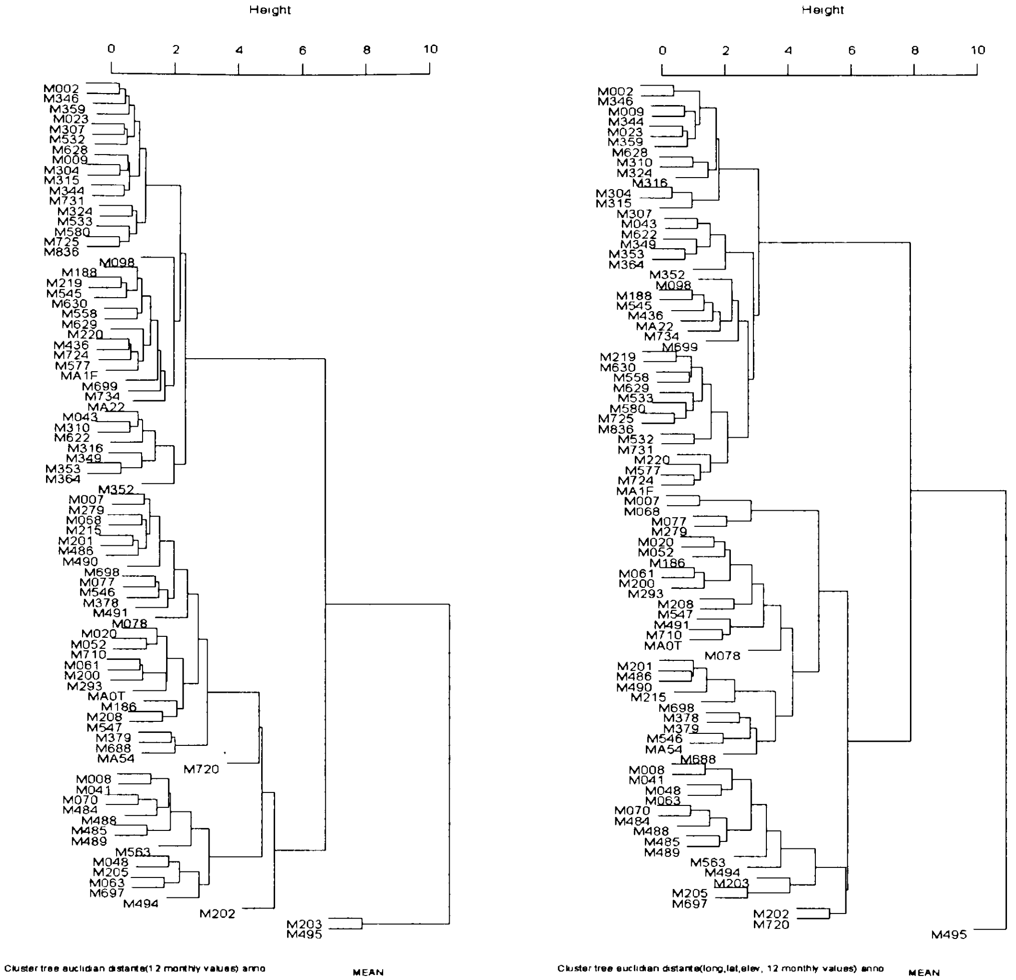
$o^p{}_i$ is the output of the preceding neuron u_i,

RESULTS

The exploratory analysis of monthly precipitation starts with the generation of box-plot graphs (Appendix C), histograms of monthly precipitation (Appendix D) and a check for normal distribution (Appendix E) for each station from a total of 86 stations. This preliminary analysis helped to correct some errors in the series, and eliminated stations with non-remedied errors. After checking and correcting all data set with the help of INAMHI's staff, it was assumed that cleaned data are real. Observing all box-plots it is easy to recognize that there are different cyclical patterns throughout of the year among stations.

Fourteen summary tables of the correlation of monthly precipitation between all stations pear month, global group for all months were generated and compiled in Appendix F. The correlation coefficient that has some significance level has been color coded. The darkest color corresponds to a 99%(α=0.01) confidence level, the dark-gray tone for 95%(α=0.05), gray for 90%(α=0.10) and light gray for 75%(α=0.25). Using these tables it is possible to recognize that there is enough evidence that a lot of stations have significant correlation, but it does not help so much to select stations, which could be used for fitting the models.

Cluster analysis was the best way to select stations because it helped to identify several subgroups of stations that have similar rainfall patterns. The analysis was done year by year in two versions for all stations that have 12 monthly observations, one using only precipitation values and the other including latitude, longitude and elevation. These results are compiled in Appendix G.



a. Euclidian distance(12 monthly values) b: Euclidian distance (12 monthly values, latitude, longitude and elevation)

Figure 5: Cluster Classification for mean-monthly precipitation

The principal limitation was that only into the decade of 80's were the sufficient stations that it was possible to get representative classifications, but since 1992, there has been a permanent decrease in the number of stations and consequently the cluster analysis lost significance.

This decrease in number of stations made impossible to make a comparative analysis for all interpolation methods due to the non-uniform distribution of data in space and time. For this reason, in this analysis it was chosen to work only using mean monthly values of precipitation. Of course the mean monthly precipitation is not a correct definition from a climatologic point of view. It should be called an average of monthly values of precipitation or multi –annual monthly values of precipitation.

Working with mean-monthly values, it was possible to generate a consistent clustering of stations that have similar climatic patterns. It is possible to recognize in Figure 5a six principal subgroups for a cluster analysis using only 12 mean-monthly values, while in Figure 5b it is possible to recognize until ten subgroups due to the influence of longitude, latitude and elevation.

Maps were generated in order to verify the spatial distribution of these clustering classifications. The Figure 6 shows four good continuous areas or zones that hold clustered stations for 12 mean-monthly values, one over the mountains chains, two in the piedmont and one big zone over the lower jungle. When latitude, longitude and elevation are included into the clustering classification it is possible to recognize more consistent zones. Figure 7 shows results very similar to the zones generated by INAMHI (2001) and showed in Figure 1, in which were used several additional climatic parameters using Kepper's climatic classification. It is comprehensive because air temperature has a very high correlation with elevation in Ecuador (Ayabaca, 2001), as are other climatic parameters such as potential evaporation and radiation.

Finally, using the cluster classification results and selecting stations which have longer continuous data during 1980 – 2002 period, it was possible to prepare the set of 45 stations to fit the models (SET 1) and another with 18 stations as a test set to evaluate the models (SET 2).

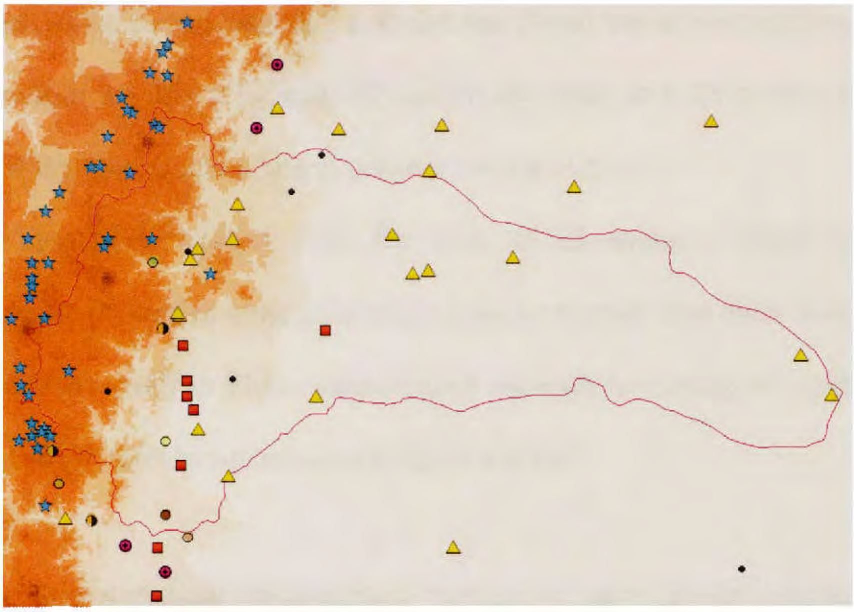


Figure 6: Cluster Classification with 12 mean monthly values

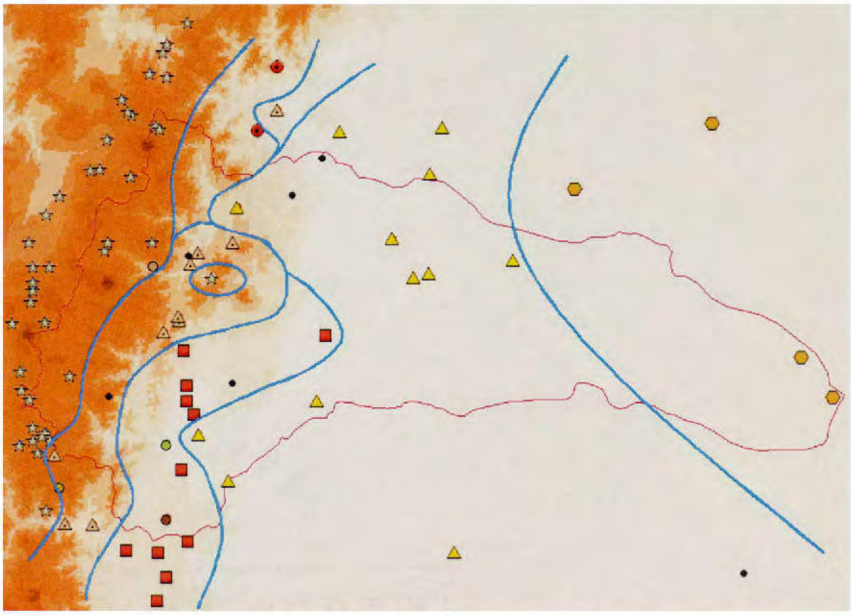


Figure 7: Cluster Classification with 12 mean monthly values plus longitude, latitude and elevation

The Figure 8 shows the stations of SET 1 group with a square symbol and the stations of SET 2 group with a circle symbol. This map reflects an additional criteria of selection such as the stations for SET 1, which are placed into or surrounding at the study area, and Stations for SET 2 located only within the study area. Of course this criteria is biased, but is the normal procedure to achieve more accuracy.

The remaining stations from the total of 86 stations, which do not have trustworthy data, or located outside of study area, or contain data older than the 1980's, were grouped into a SET 0. These stations were not used for testing the models, with the exception of ANN, which requires an additional test set.

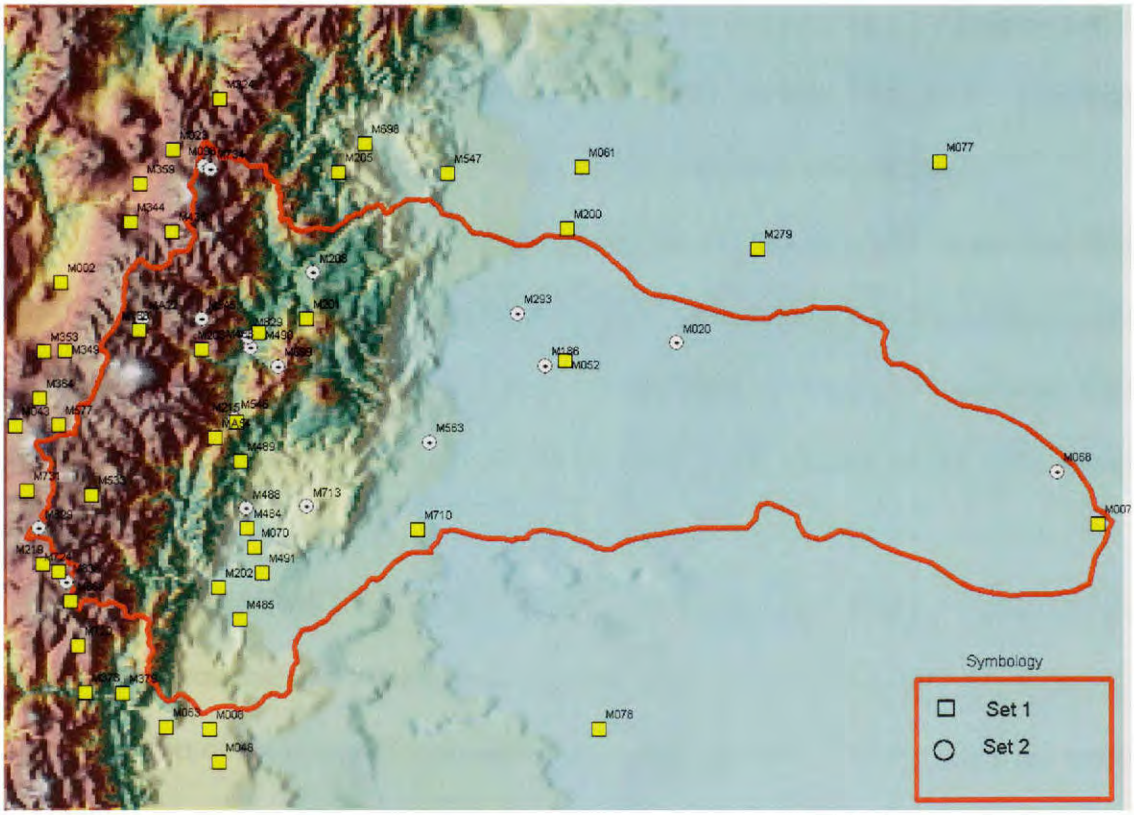


Figure 8: Location of fit set(SET 1) and test set (SET 2) station groups

Analysis of mean monthly values of precipitation.

In order to incorporate into the Linear Regression model characteristic geomorphologic data for the study area, it was necessary to generate raster maps of elevation, slope and aspect was generated for a $1km^2$ resolution (Appendix H) and extract from them the cell values in which the station is located. In this case it is necessary to note that there were representative differences if they were extracted using point position of the station.

Additional geomorphologic characteristic were generated to use later in more complex Linear Regression models and ANN. These variables are two orthogonal components (90° and 180° of Azimuth) of hill-shade for 45° of sun elevation for a $1km^2$ resolution. average of elevation, slope, aspect and two components of hill-shade per 10 km (radius=5km), 20km (radius=10km) and 30km (radius= 30km) of smoothing resolution. Tables with variables used by models are compiled in Appendix I.

Because the variable slope exhibits high values in cells where the terrain has large elevation differences, and it is difficult to define aspect correctly for flat-lying terrain zones, the hill-shade maps not only proved more useful in order to overcome these inconsistencies and also are able to simulate the relative obstruction of cloud movement by high elevations.

Using parameters such as sun elevation and horizontal azimuths, several hill-shade maps were analyzed visually and checked there should be some congruence with the distribution of mean monthly precipitation values, and after verified with the results of linear regression models in which those variables were included.

In this analysis, sun elevation ranged between 30° and 50° and azimuths ranged between 90° and 130°; they give a representative significance into the linear regression models. Of course these parameters vary month by month but usually the maximum differences were found between January and July. A deeper analysis on this topic would be very interesting but it was outside the scope of this research. In order to cover this horizontal variability, the decision was to use the orthogonal components, reflected in two hill-shade maps for 90° and 180° of azimuth and an average of 45° for sun-elevation.

Linear regression Analysis.

The Linear regression analysis started using independent or descriptive variables to longitude and latitude of the station, cell values of elevation, slope and aspect for 1km^2 resolution, and log of Mean-monthly rainfall for 12 months as the dependent or target variable. There were two principal transformations; one was using the *log* of rainfall not only to avoid negative calculated values if models are made using the un-transformed target variable and also to improve the fitting of models. The other transformation was standardization of longitude (Lon1) and latitude (Lat1) in order to reduce their huge difference in magnitude with other variables. After those transformations, there was no problem to justify their significance as valid models because all fulfill the F-test for the global significance at a confidence level of 95% (α=0.05). The partial F-test was used in order to create a model with the most significant variables.

There are two representative Linear Regression models (Appendix J and Table 3). The R1 model, which uses all variables (latitude, longitude, elevation, slope and aspect) in which elevation is justified at 3rd power, slope at 2nd power and aspect, longitude and latitude are justified at 1st power. The other model R2 uses only geomorphologic characteristics, in which elevation and aspect have similar significance to that found in R1 model, but aspect was eliminated.

An additional use of the linear regression analysis is to help to identify the influence of the descriptive variables. In this case, the preliminary conclusion is the proven influence of geomorphologic characteristics on the spatial distribution of rainfall, of these characteristics; the elevation is the most significant variable in relation to other variables such as slope and aspect.

Using these two models, the Root Mean Squared Error (RMSE) for SET 2 was generated in order to check their goodness against other models (Table 3). A first concern was the higher values in June to September for the model R1, inclusively higher than the RMSE values of the Thiessen model in those months, while for model R2, it has only one higher value in June, which is lower that the RMSE value of Thiessen model. Similar abnormality was showed for several models in June and July, but their values are always lower that Thieesen Values. For that reason, before making any conclusion in order to ascribe this abnormality to the rainfall randomness for these four months, it was necessary to analyze other geomorphologic characteristics and several smoothing resolutions.

The additional variables used in models were two hill-shade components for 90° and 180 of azimuth for 1km^2 of resolution, elevation, slope, aspect and two components of Hill-shade smoothing resolution for surrounding circles with radii of 5km, 10km and 15km. Since the elevation variable for all resolutions has high correlation, only elevation for 1km^2 was chosen (Correlation tables, Appendix I).

The new linear regression analysis was to use 19 descriptive variables (longitude, latitude, elevation, slope1k, aspect1k, hill-shade-45-90-1k, hill-shade-45-180-1k, slope5k, aspect5k, hill-shade-45-90-5k, hill-shade-45-180-5k, slope10k, aspect10k, hill-shade-45-90-10k, hill-shade-45-180-10k, slope15k, aspect15k, hill-shade-45-90-15k, hill-shade-45-180-15k) and mean-monthly values of rainfall as target variable.

Before using these variables to fit the models it was necessary to test the collinearity between explanatory variables. Appendix I compiles several summary tables such as Pearson correlation coefficients (R) and the variance inflationary factor (VIF) analysis for all 19 explanatory variables. The Pearson correlation tables did not help so much in this analysis because all variables showed significant correlation values between them, but the VIF did. Table 1 compiles selected cases of VIF analysis, in which cells that contains high VIF values had been shadowed (FIV> 10 =dark, 10>VIF >5= shadow, FIV < 5= white) to emphasize the collinearity significance of one variable in relation with others into the combination of variables showed in the first column at the same row. In this case, when the 4 variables for 10km of smoothing resolution (radius=5km) are included into the analysis group, the variable Slope5k shows a VIF value greater than 10. As soon as 4 variables for 20km of smoothing resolution (radius=10km) are included, the variable Slope10k shows also high collinearity. Finally, when the last 4 additional variables for 30 km^2 of smoothing resolution (radius=15km) are included, 8 variables show high values for their VIF factor,. It is easy to infer that the last set of 4 variables will not give any new information. Using the results of this analysis all variables that had VIF values higher than 10 were dismissed from the analysis of variance for testing the significance of explanatory variables (ANOVA) .

Using ANOVA, the remaining 11 variables were checked for their influence on the mean precipitation. This analysis was performed over the 45 stations that belong to SET 1 and using their log mean monthly precipitation values for 12 months (536 samples). Table 2 shows the summary of the ANOVA table in which there are only variables that have significant influence for the dependent variable with p-value < 0.05.

Table 1: Summary for Variance Inflationary Factor (VIF) for explanatory variables

Variables includes in FIV Analysis	LONMETER	LATMETER	EleMeter1k	Slope1k	Aspect1k	Hill90451k	Hill180451k	Slope5k	Aspect5k	Hill90455k	Hill180455k	Slope10k	Aspect10k	Hill904510k	Hill1804510k	Slope15k	Aspect15k	Hill904515k	Hill1804515k
LONMETER,LATMETER	1.05	1.05																	
LONMETER,LATMETER,EleMeter1k	2.60	1.21	2.48																
LONMETER,LATMETER,EleMeter1k,Slope1k,Aspect1k	2.77	1.25	2.75	1.74	1.75														
LATMETER,LATMETER,EleMeter1k,Slope1k,Aspect1k,Slope1k,Aspect1k,Hill90451k,Hill180451k	3.08	1.43	3.08	2.09	2.53	1.64	1.32												
LONMETER,LATMETER,EleMeter1k,Slope1k,Aspect1k,Slope1k,Aspect1k,Hill90451k,Hill180451k,Slope5k,Aspect5k,Hill90455k,Hill180455k	3.38	1.75	3.80	4.17	2.66	2.45	2.76	3.69	3.52	2.94	3.57								
LONMETER,LATMETER,EleMeter1k,Slope1k,Aspect1k,Slope1k,Aspect1k,Hill90451k,Hill180451k,Slope5k,Aspect5k,Hill90455k,Hill180455k,Slope10k,Aspect10k,Hill904510k,Hill1804510k	4.13	2.10	4.17	4.89	2.95	2.71	3.81	12.35	5.04	6.69	9.97	8.05	5.85	8.60	5.17				
LONMETER,LATMETER,EleMeter1k,Slope1k,Aspect1k,Slope1k,Aspect1k,Hill90451k,Hill180451k,Slope5k,Aspect5k,Hill90455k,Hill180455k,Slope10k,Aspect10k,Hill904510k,Hill1804510k,Slope15k,Aspect15k,Hill904515k,Hill1804515k	4.56	2.78	6.35	8.86	3.22	3.71	3.99	16.31	5.52	7.67	15.00	24.03	8.40	33.33	16.02	13.56	8.28	25.74	10.10

The ANOVA support the conclusion that there is sufficient evidence that the spatial distribution of precipitation is ruled by longitude, latitude, elevation and a combination at several scales of aspect, slope and hill-shade in the Napo River Basin.

It is necessary to note that VIF results do not imply that those variables that showed high colliniearty should not be used to perform the linear regression models. It only suggests that it is not advisable to use all variables at the same time. Furthermore, it implies that it is possible to create at least three valid combinations of variables by interchanging sets of variables for geomorphologic characteristics of those three resolution levels (5k,10k,15) into of the base set conformed with latitude, longitude, elevation and 4 geomorphologic characteristics for the 1km^2 solution. For this reason, the linear regression was challenging due to the several alternatives of variables combination that gave similar results. Appendix J compiles summary tables for several linear regression models (LRM) and Table 3 is the summary of root mean square error (RMSE) for SET 2 of representative LGM for several combinations of variables. Figure 9 contains the graphical representation of those models that have lower values of RMSE values than those from the Thiessen model such as R2, R9 to R12 and R19. R1 is also included.

Table 2: ANOVA summary for 13 explanatory variables.

Variable	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
LONMETER	1	27.3	27.3	148.6	0.000
LATMETER	1	47.7	47.7	260.1	0.000
EleMeter1k	1	39.3	39.3	214.4	0.000
Slope1k	1	13.0	13.0	71.1	0.000
Aspect1k	1	5.3	5.3	29.1	0.000
Hill180451k	1	4.4	4.4	24.1	0.000
Aspect5k	1	2.5	2.5	13.5	0.000
Hill90455k	1	3.0	3.0	16.3	0.000
Hill180455k	1	3.1	3.1	16.8	0.000
Aspect10k	1	8.4	8.4	45.9	0.000
Hill904510k	1	12.7	12.7	69.3	0.000
Hill1804510k	1	1.6	1.6	8.5	0.004
sinmonth	1	4.1	4.1	22.4	0.000
Residuals	526	96.5	0.183		
Residual standard error: 0.4282978 on 526 degrees of freedom					
Multiple R-Squared: 0.6411754					
F-statistic: 72.2998 on 13 and 526 degrees of freedom, the p-value is 0					

One of the most important problems was over-fitting the models, with high correlation values for fitting set(SET 1) but at the same time with the worst results for RMSE for test set (SET 2). The model R3 in Table 3 is a typical example.

Using the SET 1 dataset, all models, except the model R19, were fitted per month in order to get the lowest RMSE in each month, but these results are not reflected when these models are tested with SET 2, especially in the months June, July and August.

The models R2, R11 and R12 are special cases for the LRM because they were fitted without geographical variables (latitude, and longitude). In spite of lower correlation coefficients in relation to those from other model for SET 1, these regressions showed better results for SET-2. The principal restriction is that these models are not a real alternative solution if they are not used in combination with the inverse weighted distance method with influence of LR model (IWD + influence(R2)).

Table 3. Summary for RMSE of SET 2 for several Linear Regression models

Code	Model	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T1	Thissen Polygon	117.3	106.1	131.5	130.4	135.6	134.9	131.6	101.1	109.2	105.8	122.7	115.3
R1	Regr1(long,lat,elev,slope,aspect)	62.4	62.9	73.6	74.8	76.7	117.7	134.0	105.1	129.7	59.2	71.1	43.2
R2	Regr2(elev,slope,aspect)(ln)	54.3	52.6	55.7	65.7	53.7	89.6	105.0	66.8	68.4	49.5	71.4	40.0
R3	Reg(Long,Lati,Elev1,slope1k,Aspect5k,Hill180,Hill90)(3)(ln)	2005.4	7685.8	7158.2	1728.1	2874.7	2659.0	248.6	376.0	1020.5	5470.7	1167.0	12132.4
R4	Reg(Long,Lati,Elev1,slope1k,Aspect5k,Hill180,Hill90)(2)(ln)	90.2	83.1	265.2	147.6	130.1	204.4	179.7	127.7	132.9	105.8	180.1	184.5
R5	Reg(Long,Lati,Elev1,slope1k,Aspect5k,Hill180,Hill90)(3)(ln)(not	149.5	105.0	122.1	102.8	106.6	194.4	181.9	143.0	105.7	103.3	129.4	142.4
R6	Reg(Long,lati,Elev1,Slope,Aspect)(3)(ln)	62.4	62.9	73.6	74.8	76.7	117.7	134.0	105.1	129.7	62.6	74.0	43.2
R7	Reg(Long,lati,Elev1,Slope,Aspect5k)(3)(ln)	63.6	62.9	65.3	97.3	76.7	212.3	175.6	139.4	87.5	64.2	67.4	48.4
R8	Reg(Long,Lati,Elev1,slope,Hill120)(3)(ln)	61.9	68.2	65.9	71.3	61.2	105.3	153.3	105.1	112.2	55.0	67.7	58.3
R9	Reg(Long,Lati,Elev1,slope,Hill180,Hill90)(3)(ln)	91.9	94.5	69.4	83.2	70.1	90.3	117.7	73.6	83.2	77.8	94.8	55.1
R10	Reg(Long,Lati,Elev1,Hill180,Hill90)(3)(ln)	74.7	79.1	82.1	72.2	62.1	126.9	111.7	98.5	89.1	64.1	56.9	52.1
R11	Reg(Elev1,Hill180,Hill90)(3)(ln)	65.9	65.5	65.3	73.0	68.4	112.4	120.5	80.6	79.1	61.4	71.4	68.4
R12	Reg(Elev1,Hill180,Hill90)(4)(ln)	77.3	65.5	65.3	73.0	86.9	101.4	109.8	77.3	82.8	61.4	71.4	68.4
R13	Reg(Long,lati,Elev1,Slope,Aspect)(4)(ln)	61.3	62.9	66.0	82.5	74.1	460.1	285.3	189.1	158.7	64.2	74.0	45.5
R14	Reg(Elev1,Slope1k,Aspect5k,Hill180,Hill90)(3)(ln)	79.4	70.5	172.0	88.0	93.2	164.5	155.8	105.5	85.6	101.4	102.7	87.0
R15	Reg(Elev1,Slope,Aspect)(3)(ln)	51.8	61.1	54.7	74.5	95.8	247.3	250.0	146.9	92.3	46.7	69.9	39.9
R16	Reg(Long,Lati,Elev1,slope1k,Aspect5k,Hill180,Hill90)(1)(ln)	66.4	70.5	58.8	70.7	68.7	124.4	144.4	83.8	88.8	58.2	69.3	53.4
R17	Reg(Long,Lati,Elev1,slope5k,Aspect5k,Hill180,Hill90)(1)(ln)	66.4	70.5	58.8	70.7	68.7	102.7	124.4	83.8	88.8	58.2	69.3	58.8
R18	Reg(Long,Lati,Elev1,slope5k,Hill180,Hill90)(3)	72.6	219.3	126.6	90.1	126.8	278.4	706.3	178.9	136.7	94.1	103.0	75.6
R19	Reg(Long,Lati,Elev,slope,Hill180,Hill90,sinmonth)(1)	69.4	71.4	72.1	94.2	94.5	107.4	101.4	76.0	98.8	76.2	96.1	59.6

Finally, with the inclusion of the monthly cyclical pattern on the year by using the trigonometric function *sin*(x) for the variable month, it was possible to get a single function (R19) for all months, but with low correlation coefficient (r=.78) for SET 1, and better results in RMSE for SET 2. but the model which can be considered to be the best model, with RMSE= 101.4 and r=.358 in July, it fails the t-test for significance in coefficient correlation. The models R10 and R19 were selected as representative of this analysis and joined with models generated with other methods into the Table 5.

This analysis did not produce enough improvement for June and July (Figure 9) and conclude that only using geomorphologic characteristics cannot reduce randomness in these months, of course using LR models.

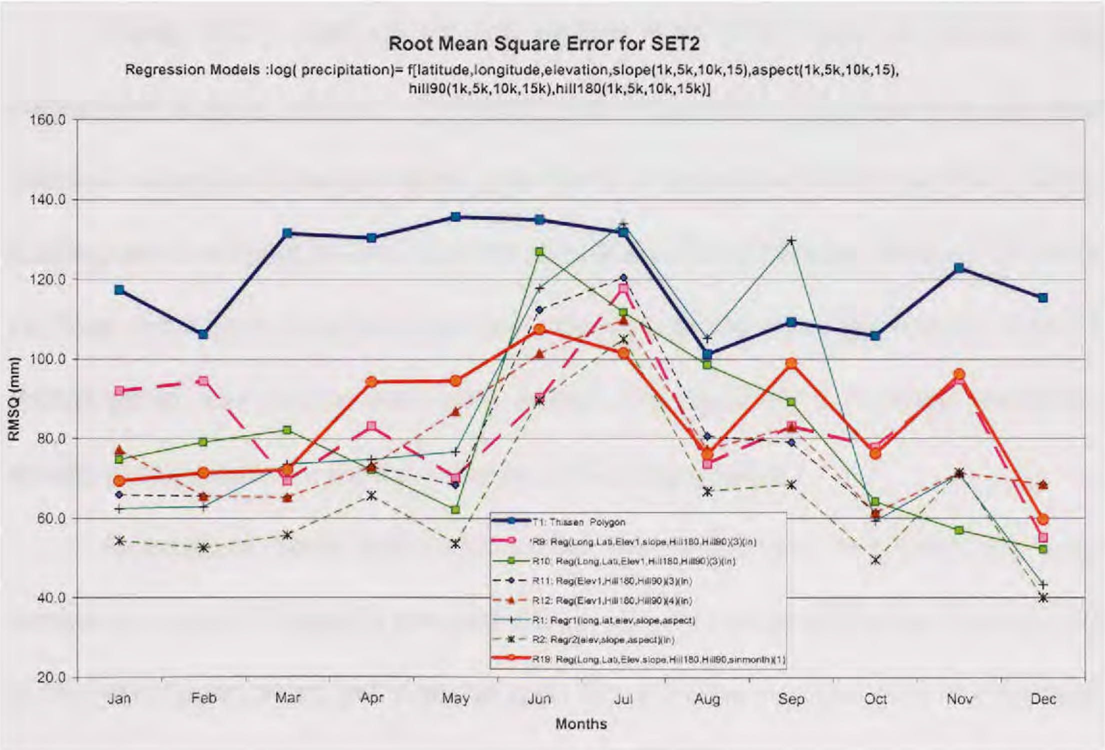


Figure 9: Chart for RMSE of SET 2 for several linear regression models

Figure 9: Chart for RMSE of SET 2 for several linear regression models

Geostatistic Analysis

This analysis started with an additional exploratory spatial analysis in order to check the normal range for the spatial distribution of sample points and their mean-monthly precipitation, and other variables in order to do some transformation if necessary, before fitting Kriging models. Appendix K has several charts per month such as spatial trend, histograms for original and transformed variables, semi-variogram clouds and covariance clouds. The Box-Cox transformation (Neker et al., 1996) of mean-monthly precipitation works for months between November and March. For other months, or for elevation, slope and aspect, it does not help as much. This analysis used the Geostatistic tools of a trial version of ArcGis v 8.10 (ESRI, 2001).

Using SET 1 stations, several models were fitted such as ordinary Kriging, Disjunctive Kriging, ordinary co-Kriging and Disjunctive cokriging with the spherical intrinsic variogram function which gave the best results to fit the models. Disjunctive Kriging and Cokriging models used the elevation as an additional variable. The inclusion of slope and aspect variables does not help to improve cokriging models. The SET 2 station group was used to test every model. The Appendix L contains the table with statistical summaries for the most successful Kriging models.

Geostatistic Tools help much to test the models, but it suffers from a special weakness, because Cokringin methods use the elevation as an additional variable inherent to the observation point, but it not as used like a locator variable such as longitude and latitude. For that reason it was not possible to include elevation when the interpolation program generated a regular grid. In other words this package treats precipitation and elevation as variables to interpolate, but the elevation is an independent variable that defines precipitation distribution. This software works in a bi-dimensional distribution of the dependents variables, but in precipitation it needs at least a tri-dimensional treatment.

Using the Spatial Analysis tool of ArcGis, it was possible to also generate other deterministic interpolation models such as inverse weighted distance (IDW), global polynomial (GP), local polynomial (LP) and radial basic function (RBF). All these methods use only latitude and longitude as descriptive variable for spatial distribution of precipitation. The statistic results were summarized in an additional table in Appendix L. Map samples for several interpolation method were compiled in Appendix M. The values of RMSE for SET 2 for three Kriging models and the deterministic models named above were integrated to the Table 5 and the Figure 11.

Artificial Neural Networks

Using the Multi Layer Perceptron (MLP) topology of the Artificial Neural Network (ANN) method. Several models were tested with three approaches. The first used the same 19 variables used to fit the linear regression models with month as categorical variable, The second used sinusoidal transformations of the variable month, and the last approach included mean-monthly values of precipitation of selected stations which work like anchor stations.

In this modeling the SET 1 was used as the Training set (TRN), SET 2 as the Verification set (VLD), and the SET 0 as the complementary Test set (TST). Of course, results from SET 0 were not taken into consideration in order to maintain the same criteria with other methods.

In order to avoid over fitting the models due to an excessive number of descriptive variables and perceptrons, step-forward and step-backward procedures were used in order to eliminate the non representative variables and reduce the number of percentrons. This procedure used two principal control criteria. The first is to optimize with a reduction in the minimum values for the Mean Square Error (MSE) or the standard sample deviation (σ) and Mean Absolute Error (MAE), while maximizing the correlation coefficient (r). The second is that three coefficients should be similar for both SET 1 and SET 2. Several models were tested and the statistic results were compiled in appendix N, and the root mean square errors (RMSE) of SET 2 (VLD) are summarized in the Table 4 and graphically represented in Figure 10.

Table 4: Root mean square error in SET 2 for several ANN models

Root Mean Square Error of SET 2 for several ANN models

Code	Model	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Year
T1	Thissen Polygon	117.3	106.1	131.5	130.4	135.6	134.9	131.6	101.1	109.2	105.8	122.7	115.3	120.1
N1	22-35-1(full),random	43.7	56.7	40.6	39.6	50.0	43.4	55.1	57.0	61.9	32.3	50.7	52.3	49.4
N2	22-35-1(full)	44.4	49.0	61.8	78.1	77.2	83.2	85.4	73.4	93.8	65.3	76.1	53.9	71.6
N3	15-7-1	40.9	43.9	75.5	67.6	68.6	84.0	73.7	41.4	81.3	74.9	83.3	53.2	67.5
N4	15-28-1	61.5	66.5	80.7	77.6	76.1	82.1	87.2	83.9	89.7	74.1	75.0	59.7	76.7
N5	14-17-1	87.7	80.6	71.8	73.0	58.7	74.7	80.9	61.4	91.6	81.8	88.3	62.7	76.9
N6	31-38-1,(full,month=ctg)	63.9	61.4	61.7	76.9	68.0	87.6	93.7	67.8	83.7	58.5	83.9	55.2	73.0
N7	31-43-1,(fullmonth=ctg)	62.6	58.5	56.2	75.5	50.3	77.7	88.6	63.3	94.1	69.4	88.3	65.7	72.1
N8	23-38-1,(month=ctg)	60.6	59.0	60.0	58.2	72.4	85.0	92.1	91.3	100.1	59.0	71.0	62.8	74.2
N9	8-5-1(3 stations)	54.9	52.3	56.4	66.8	49.4	83.1	90.0	52.4	76.7	46.5	60.1	38.2	62.6
N10	8-5-1(3 stations),random	39.5	34.0	45.7	37.7	42.1	51.3	70.2	40.9	64.3	35.5	54.7	39.0	47.7

The model named as ANN 22-35-1, with 22 input variables, 35 perceptrons in a hidden layer and only one output, gives significant differences in correlation coefficients for TRN and VLD sets ($r_{(TRN)}=0.969$, $r_{(VLD)}=0.762$), the same for MAE ($e_{(TRN)}= 24.0$, $e_{(VLD)}=58.2$) and also for standard deviation ($\sigma_{(TRN)}=22.88$, $\sigma_{(VLD)}=48.60$).

For the model ANN 8-5-1, with 8 input variables (latitude, longitude, elevation, two components for hill-shade for smoothing radius =5km, and three pivotal stations (M008, M007 and M378) gives the best results because there is an improvement in error coefficients for SET 2, such as in correlation coefficients for the VLD set ($r_{(TRN)}=0.926$, $r_{(VLD)}=0.822$), for MAE ($e_{(TRN)}= 36.9$, $e_{(VLD)}=47.3$) and also for standard deviation ($\sigma_{(TRN)}=24.84$, $\sigma_{(VLD)}=40.91$).

One of the outstanding characteristics of the ANN:8-5-1 model is the elimination of the month as a variable, and representative reduction of the number of variables when included the anchor Stations,

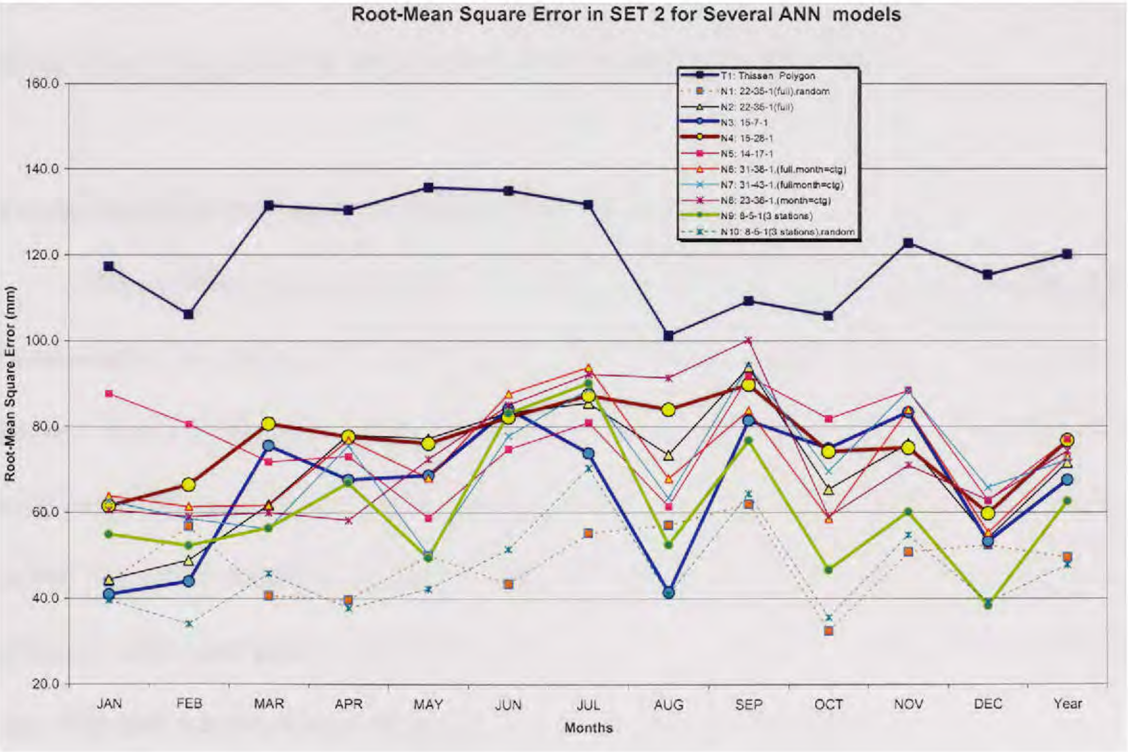


Figure 10: Chart of Root Mean Square error (RMSE) in Test set (SET 2) for several Artificial Neural Network (ANN) models

Because tested models had persistent differences between error indicators between SET 1 and SET 2, and in order to understand this special behavior, the full sample data (SET 1, 2 and 0) were randomly regrouped and fitted new models. The results were better and an improvement in error indicators, for example the ANN 8-5-1 V2 models gave the correlation coefficients for TRN and VLD sets ($r_{(TRN)}$=0.918, $r_{(VLD)}$ =0.910,$r_{(TST)}$=0.825), for MAE($e_{(TRN)}$= 39.9, $e_{(VLD)}$=39.0, $e_{(TST)}$=49.8) and also for standard deviation ($\sigma_{(TRN)}$=40.7, $\sigma_{(VLD)}$=43.8,$\sigma_{(TST)}$=59.9) achieved very similar values. In Figure 10 two models fitted with this new reordered dataset are drawn with dotted lines. These results showed that a better model is fitted when a random selection is used to generate the training, validation and testing sets. Finally three of the most successful models fitted using with pre-selected sets were incorporated into Table 5.

Inverse weighted Distance plus Lineal regression influence.

This method takes advantage of LRM in order to include the geomorphologic characteristics as factors that modify the weight over rainfall values of the nearest stations. There were tested using the influence the LGM named REG1 that was fitted using longitude and latitude, elevation slope and aspect; in this case it produces worst results. The other model was using a LRM named REG2, which was fitted using only elevation, slope and aspect. This last model gives excellent results except for the months June, July and August, shown in figure 11 as line labeled (IDW+$\text{inf}_{(REG2)}$).

Model Selection

With the summary of RMSE on test set SET-2 for all representative models selected from different methods and put together in Table 5 and presented in Figure 11, it is possible to decide what method could be selected to develop as the model for monthly values for a time period of at least 10 years.

Table 5. Summary for RMSE of SET 2 for several interpolation methods

Code	METHOD	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T1	Thissen Polygon	117.3	106.1	131.5	130.4	135.6	134.9	131.6	101.1	109.2	105.8	122.7	115.3
R1	Regr1(long,lat,elev,slope,aspect)	62.4	62.9	73.6	74.8	76.7	117.7	134.0	105.1	129.7	59.2	71.1	43.2
R2	Regr2(elev,slope,aspect)(ln)	54.3	52.6	55.7	65.7	53.7	89.6	105.0	66.8	68.4	49.5	71.4	40.0
WI	IWD(4points)	93.6	84.7	97.6	105.5	100.8	116.3	116.1	86.1	93.8	78.3	92.8	76.2
W2	IWD+inf(Regr2)(1/cuad)	60.6	53.1	64.5	69.4	68.6	111.3	113.3	77.9	64.6	50.6	54.7	31.4
W3	IDW(15points)	80.1	77.1	85.5	94.0	93.7	102.3	103.5	76.2	86.9	72.5	88.1	66.6
B1	Rob ustMM(lat,long)	59.4	81.4	89.6	122.7	111.1	105.7	108.6	76.5	89.7	67.0	83.6	79.2
L1	Local Poly Int	67.5	66.8	69.5	82.9	76.0	91.8	98.5	63.2	79.1	61.2	80.2	57.5
K1	Ordinary Kriging	76.1	77.2	78.2	97.8	95.8	100.6	104.7	83.5	91.9	74.8	73.5	49.7
K2	Disyuntive Kriging	78.5	80.1	87.1	107.2	109.9	110.3	103.5	88.9	104.7	92.3	92.8	71.6
K3	Ordinary Cokriging	64.2	66.5	67.0	90.9	85.3	96.9	104.4	79.9	87.3	57.9	65.6	48.3
R9	Reg(Long,Lati,Elev1,slope,Hill180, Hill90)(3)(ln)	91.9	94.5	69.4	83.2	70.1	90.3	117.7	73.6	83.2	77.8	94.8	55.1
R10	Reg(Long,Lati,Elev1,Hill180,Hill90) (3)(ln)	74.7	79.1	82.1	72.2	62.1	126.9	111.7	98.5	89.1	64.1	56.9	52.1
R19	Reg(Long,Lati,Elev,slope,Hill180, Hill90,sinmonth)(1)	69.4	71.4	72.1	94.2	94.5	107.4	101.4	76.0	98.8	76.2	96.1	59.6
N3	A.Neural Net:15-7-1	40.9	43.9	75.5	67.6	68.6	84.0	73.7	41.4	81.3	74.9	83.3	53.2
N2	A.Neural Net:22-35-1(full)	44.4	49.0	61.8	78.1	77.2	83.2	85.4	73.4	93.8	65.3	76.1	53.9
N5	A.Neural Net:14-17-1	87.7	80.6	71.8	73.0	58.7	74.7	80.9	61.4	91.6	81.8	88.3	62.7
N9	A.Neural Net: 8-5-1(3 stations)	54.9	52.3	56.4	66.8	49.4	83.1	90.0	52.4	76.7	46.5	60.1	38.2

The lower value of RMSE and the t-test for significance of coefficient correlation in SET 2 were the principal selection criteria to choose the best method, but there are additional facts such as generalization of the model to incorporate the time variability, guarantee that there will be better results that those obtained using the most simplistic methods like Thiessen polygon

In this case there are only two options, which are able to incorporate the monthly variability over the year and throughout the years. They are LGM and ANN models.

The inverse weighted distance (IDW), kriging and radial basic function are methods that fit models for a single month. These models cannot incorporate the temporal variability. In this case the selection is only the methodology, because the model should be fitted month by month.

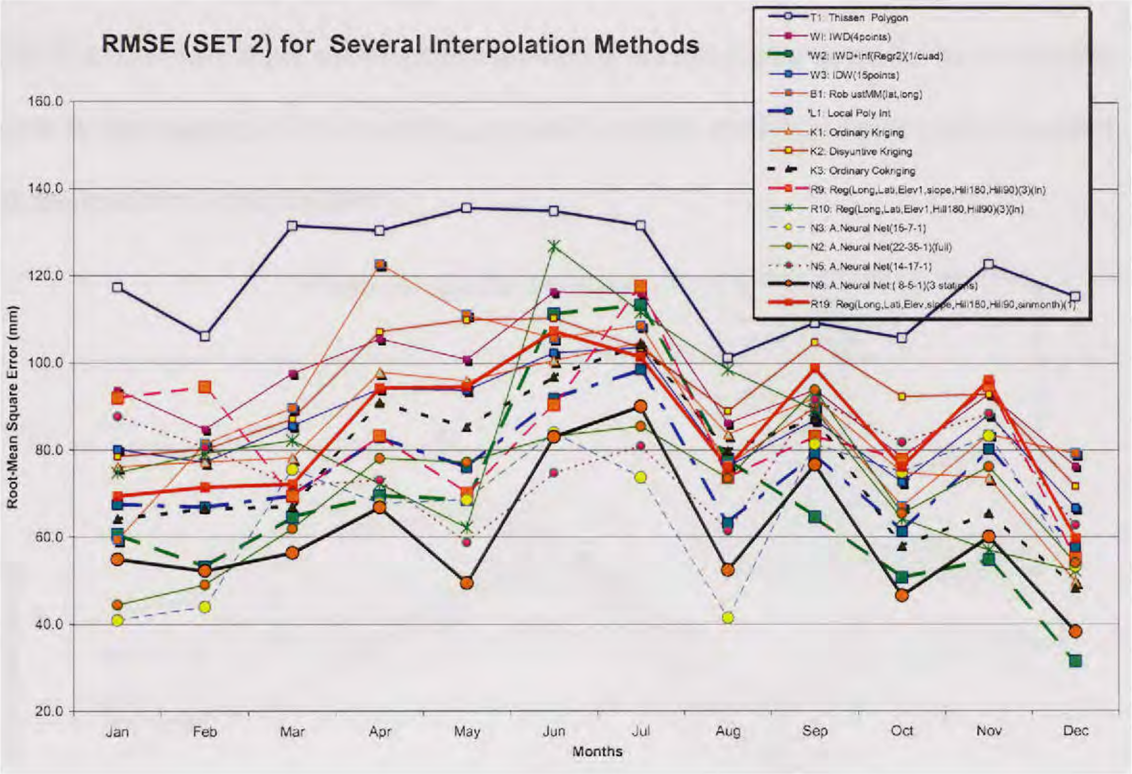


Figure 11: Chart for RMSE of SET 2 for representative models from several interpolation methods.

All models which have RMSE > 101.0 in July should be eliminated because they fail the t-test for significance of correlation (T-test R), for example the model R19 has a low correlation coefficient in July (0.358) with RMSE 101.4. It has a p-value(T-test R) of 0.072. In this case the majority of methods are eliminated. Only local interpolation and all ANN models remain as selective options.

Eventually the decision was between ANN models which give lower values for RMSE in general, and more specifically for the model N9 that includes anchor stations, as it has the lowest RMSE value for all months (47.7) high coefficient correlation (0.90) for SET 2. There are other reasons that supports its selection such as model have a similar pattern to the majority of the models generated for other methods, and a total agreement with the results of Antonic(2001).

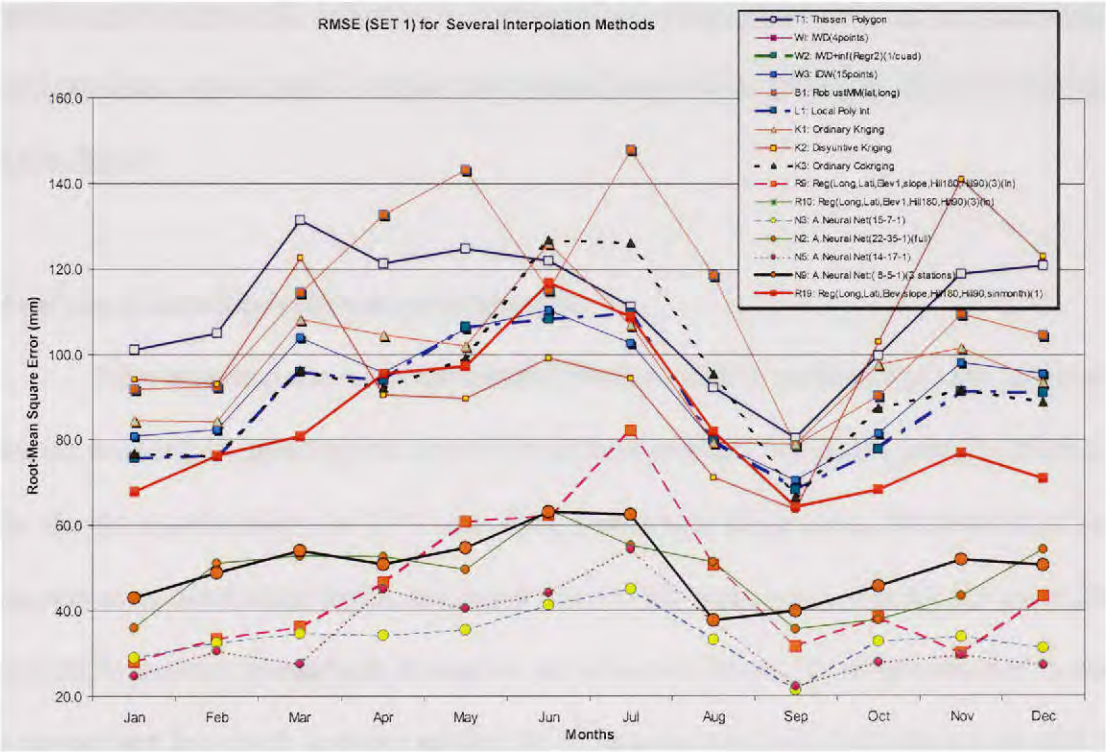


Figure 12: Chart for RMSE of fitting set (SET 1) for representative models from several interpolation methods.

During all analyses, the fit of SET 1 was checked using the correlation coefficient (R) and RMSE as control parameters, but they never weighed on the decision to select the best method. Figure 12 shows RMSE values for selected models for SET 1 and it is possible to observe that the ANN models had better results in fit set in comparison to LGM, but it is not possible to make a fair comparison with kriging and similar models because they generated a RMSE from cross validation for SET 1.

This analysis not only helped to select the method to fit an interpolation model for monthly precipitation for 10 years but also the most important conclusion: LGM, ANN models justify the high influence of elevation and other geomorphologic characteristics such as slope, aspect and hill-shade over spatial distribution of precipitation for the Napo River Basin.

Analysis of monthly values of precipitation.

After selecting the Artificial Neural Network (ANN) method from the analysis of the mean-monthly precipitation, several models were fitted and tested initially using data for the time period between 1981 and 2002. But during the process, the number of valid records or non-null-data-tuples decreased due to data gaps, especially for the years 2001 and 2002. In order to establish a common and random dataset for all process and to make a correct and fair check between models, 6712 records were selected from a total of 8067. In spite of eliminating of 16%of the data from the full dataset, the remaining n-tuples (84%) were enough to fit the models without affecting the results. This new dataset was split randomly in three subsets; 4813 (%68) records for the training set (TRN), 977(16%) for the validation set (VLD) and 977(16%) for the testing set (TST).

Thirty descriptor or explanatory variables were used in this analysis; 2 geographical descriptors (longitude and latitude), 12 geomorphologic descriptors such as elevation, aspect, slope and hill-shade for 1km, 10km 20 km and 30k m of Smooth resolution (eleva1k, slope1k, aspect1k, hill-shade-45-90-1k, hill-shade-45-180-1k, slope5k, aspect5k,hill-shade-45-90-5k,hill-shade-45-180-5k, slope10k, aspect10k, hill-shade-45-90-10k, hill-shade-45-180-10k, slope15k, aspect15k, hill-shade-45-90-15k, hill-shade-45-180-15k), 4 descriptors to define time such year and month with its trigonometric transformations for month (year, month, *sin*(π/6*month), *cos*(π/6*month)), and the monthly precipitation from 8 elective anchor stations (M002, M007, M008, M052, M061, M063, M315, M378).; The monthly precipitation for all observation points is the target or dependent variable.

Statistical summary tables (Appendix O) were generated for all fitted models. They contain significant coefficients, indexes and several statistical tests for each subset divided per month, total of months and for the total sample. There are mean and sample standard deviation for actual, calculated and residuals values; root mean square error (RMSE), correlation coefficient (r), mean absolute error (MAE), F-test for the equality of two variances, t-test for the mean difference, t-test for existence of correlations and t-test for the mean difference of paired samples.

Thiessen Polygon model.

In order to have some references with which the ANN models can be checked, a Thiessen Polygon model was performed for the 3 sub-datasets. The Training Set (TRN) and Validation set (VDL) were interpolated using Test set (TST). The TRN was interpolated using cross validation with itself. The results from this method were compiled in a statistical summary table (Appendix O) and values of RMSE, R and MAE were compiled in Tables 4,5 and 6 and displayed in Figures 14, 15 and 16 respectively. All valid ANN models should have a significant improvement in RMSE, R and MAE in relation to values from this model.

Artificial Neural Network (ANN) models

The process to fit ANN models was performed using a mixture of step forward and step backward for selecting variable, increasing, decreasing and reordering of layers and perceptrons. More than 100 models were tested and run several times in order to confirm and to get consistent results. The principal criteria were to maximize R, to minimize RMSE and MSE, and all of them should be very similar for TRN, VLD and TST sets. There are additional behavioral parameters of the ANNs to take into count such as the optimal distribution of weight values into the neural structure, inalterable residuals after a large number of iterations, several shakes and noise inclusion in order to avoid local minimums.

One of the most critical aspects of this kind of model is the inclusion of time parameters due to monthly periodicity into the year. It is easy to recognize there are several modal and bimodal patterns from the box-plot charts per station (Appendix C), and the known annual recurrence of ENSO phenomenon over all of Ecuador that is reflected in consecutive dry and rainy years. Two approaches were used. One was by including month as a categorical and year as a numeric variable. This generates an additional 12 dummy variables; another was by using trigonometric transformations for month variables such as *sin* and *cos* functions. Eventually, the inclusion of anchor stations was the best solution because it showed both year and month to be useless as explanatory variables (Antoníc et al. 2001).

Of course the inclusion of non-transformed variables of month and year into the model was also useful because it shows is its graphical outputs the seasonal periodicity; also, a model was able to generate a recognizable pattern for variable year, in which it showed temporal notable decrease of precipitation during NINO-event years amount, and a general negative tendency through years. These patterns disappear as soon as anchor stations are included into the model.

For the most representative fitted ANN models reports and the summary table were produced, and all of them are compiled in Appendix O. Finally, RMSE, MAE and R values from the three most successful models were included in Tables 6, 7 and 8, and presented in Figures 13, 14 and 15.

These three selected ANN models have high correlation coefficient (.84 to .87), low values for MAE (53 to 59) and RMSE (80 to 90) among TRN, VLD and TST sets for the accumulated months (Total). They contrast significantly with results from the Thiessen model with values of R(.60-.54), MAE(97-107) and RMSE(143-160). Although these ANN models show very similar values in their indexes, there are important differences between them such as the number of variables. The model 30-15-1 (ANN1) has all 30 input variables used in this analysis; the model 10-8-4-1 (ANN3) with only input variables such as latitude, longitude, elevation, and 7 anchor stations (M002, M007, M008, M052, M061, M063, M378). While the model 14-8-4-1 (ANN2) differs from

ANN3, in its 4 additional variables as slope, aspect and two hill-shade components for 1km^2- resolution.

Finally, the model ANN2 was chosen as the best model because t has better indexes and good weigh distribution in its neural structure . Of course, the model ANN3 could be selected a well, because the difference in relation with ANN2 is only 3% of degradation in its indexes. In other words, the inclusion of the four geomorphologic variables only improves 3% in the accuracy of ANN3 model, while an ANN 5-5 1 (latitude, longitude, M008,M378) model, which for results got R= 0.74 and MAE = 77, shows a degradation in its indecies such as %16 in R and %32 in MAE in relation with the values of model ANN3.

A common characteristic of ANN2 and ANN3 is the same neural structure of 12 perceptrons, which are distributed 8 in the 1st hidden layer and 4 in the 2nd hidden layer. Other numbers of perceptrons or combinations did not give similar indexes between models, or between subsets in each model.

It is necessary to note that it was possible to make optimal models using only two anchor stations (M378 and M008), with little degradation of their control indexes and they could be a good alternative for the best model because with them the goal of "a model with lowest number of explanatory variables" was achieved, but there were other factors such has the geographical place and influence area of the anchor stations. For that reason, in order to guarantee the representation of the local behavior of precipitation especially on the lower zones of the study area, the models with more anchor stations were preferred.

After selecting the ANN2 as the best model, a comparative analysis was made between Summary Tables (Appendix O) between of ANN2 and Thiessen models. In this case, ANN2 shows high correlation coefficients for all 12 months for all sub-dataset, these values are significantly better in all 52 columns in comparison with the values of Thiessen. Both methods pass the F-test for the equality of two variances, t-test for the mean difference and t-test for existence of correlations, but for t-test for the mean difference of paired samples, the Thiessen model fails only in 3 of total of 52 columns, while the ANN2 model fails in 17 columns. These questionable results obligated me to perform more additional analysis in order to resolve these inconsistencies.

First, results were checked visually using scatter diagrams for calculated values and the residuals for both models. (Figures 16 to 19 for TRN, VLD and TST sets.). From these figures is easy to recognize that ANN2 has less scatter in all sets, while the Thiessen model has the most. Including the chart of residuals makes it easier to recognize the improvement in error reduction for the ANN2 model.

Second, the same statistical tests as before were performed, but now per station, they were done of all 74 stations and their summary tables were compiled in Appendix P.

Due to the real dataset and the results of ANN2 model failed Levene's test (McBeam et al.,1998) for checking the homogeneity variance between stations. It implies that the power of F-test is reduced, specifically for test differences among the group means. For that reason, the inconsistent results for the t-test for paired samples found in Summary tables (Appendix O) for the ANN2 model can be dismissed because the severe differences in variance values between stations. In other words, only the t-test for coefficient correlation is valid.

Table 6: Summary of root mean square error (RMSE) for Thiessen and three ANN models.

Model	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	total
Thiessen-type-TST (0)	122.54	154.67	110.41	168.21	186.97	162.90	171.97	142.12	127.26	130.96	226.21	174.59	160.54
Thiessen-type-TRN (1)	151.01	142.73	152.43	196.26	157.06	177.95	162.65	114.16	155.63	150.22	192.02	145.12	158.72
Thiessen-type-VLD (2)	136.22	114.38	151.60	144.03	151.91	145.97	133.86	135.88	131.44	178.54	167.65	124.13	143.49
30-15-1-type-TST (0)	76.02	77.64	82.51	94.51	81.18	84.14	98.89	66.06	58.76	64.54	112.40	86.51	84.65
30-15-1-type-TRN (1)	68.49	80.95	79.65	90.87	78.08	84.67	77.28	61.33	80.54	89.24	91.29	74.76	79.77
30-15-1-type-VLD (2)	78.20	68.96	82.58	93.94	106.07	96.57	72.27	89.97	76.64	81.57	75.86	74.87	83.57
14-8-4-1-v8-type-TST (0)	76.97	71.36	87.10	90.61	73.94	93.26	90.98	60.94	64.54	62.18	106.39	94.88	84.12
14-8-4-1-v8-type-TRN (1)	73.69	86.26	85.66	91.67	81.91	83.61	77.45	62.37	83.40	95.64	95.62	83.45	83.31
14-8-4-1-v8-type-VLD (2)	79.69	71.80	87.04	86.41	94.65	93.74	71.55	90.41	84.61	78.24	73.81	79.05	83.29
10-8-4-1-v3-type-TST (0)	74.57	91.34	86.30	92.13	72.91	89.84	100.51	60.75	68.38	68.62	101.70	93.18	86.01
10-8-4-1-v3-type-TRN (1)	76.06	88.81	88.66	98.07	85.26	103.49	86.67	68.92	86.52	98.87	108.92	90.74	89.96
10-8-4-1-v3-type-VLD (2)	81.73	73.30	87.76	94.89	111.73	95.50	75.23	93.03	78.07	68.31	84.39	77.70	85.58

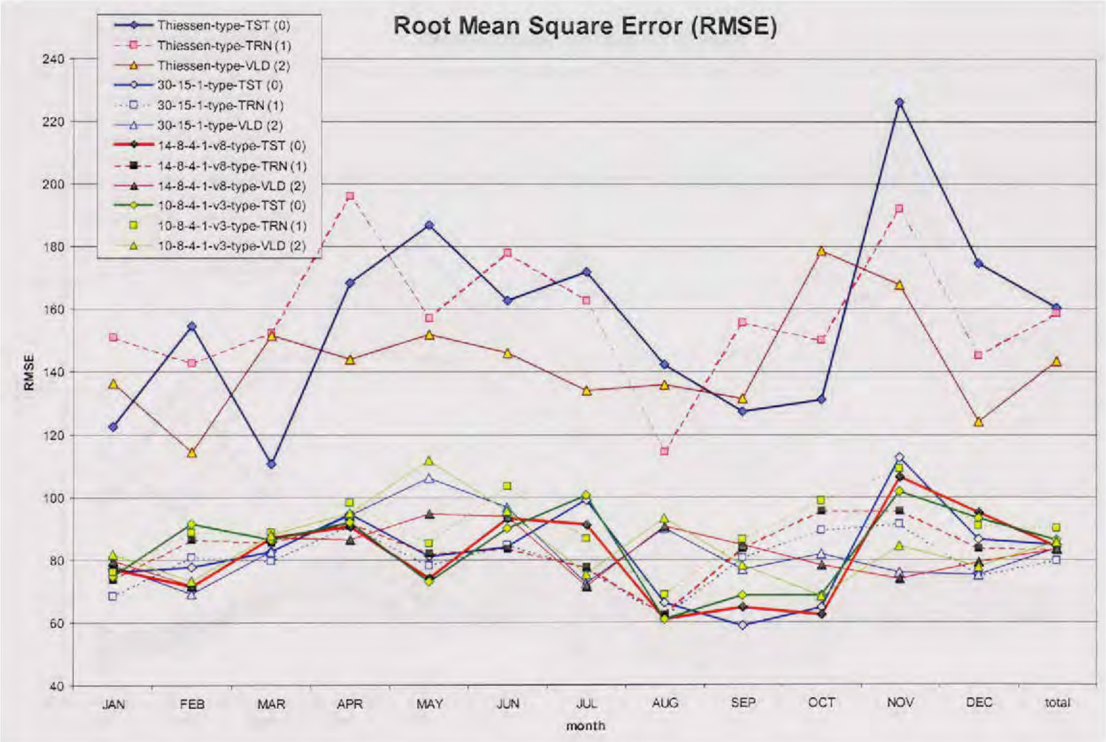


Figure 13: Chart for RMSE for Thiessen and three ANN models

Table 7: Summary of Mean Absolute Error (MAE) for Thiessen and three ANN models.

Model	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	total
Thiessen-type-TST (0)	78.11	100.66	78.95	117.28	127.23	109.15	125.26	103.40	81.66	91.65	151.38	110.43	107.18
Thiessen-type-TRN (1)	98.05	93.91	106.09	131.96	111.05	114.51	104.51	81.97	106.30	99.35	120.04	97.64	105.23
Thiessen-type-VLD (2)	87.85	75.60	104.65	106.02	106.26	99.88	90.28	92.59	91.97	121.90	113.25	81.18	97.24
30-15-1-type-TST (0)	53.18	53.74	57.74	69.03	60.05	56.72	71.85	49.20	44.92	50.21	63.40	58.00	58.43
30-15-1-type-TRN (1)	49.65	52.05	57.48	62.69	53.16	55.88	50.82	44.21	51.99	58.21	52.24	52.96	53.42
30-15-1-type-VLD (2)	49.74	52.16	59.28	66.10	67.90	66.25	54.82	58.42	52.35	61.99	55.45	51.53	57.87
14-8-4-1-v8-type-TST (0)	52.34	49.08	59.96	62.03	54.83	54.46	64.83	49.73	47.27	47.24	65.11	63.02	56.62
14-8-4-1-v8-type-TRN (1)	53.71	52.67	58.91	61.99	56.64	55.63	48.52	45.07	53.61	60.97	53.25	58.86	54.90
14-8-4-1-v8-type-VLD (2)	46.83	51.77	58.65	60.44	64.13	64.91	50.38	56.39	54.86	58.54	56.08	52.88	56.30
10-8-4-1-v3-type-TST (0)	47.18	55.49	59.68	64.36	56.45	58.66	73.41	48.42	51.99	52.90	62.92	62.22	58.84
10-8-4-1-v3-type-TRN (1)	52.65	55.28	60.35	66.29	58.45	66.18	57.16	49.92	55.71	63.72	63.01	61.60	58.99
10-8-4-1-v3-type-VLD (2)	47.76	53.35	64.20	66.13	70.37	67.67	55.07	63.53	51.10	49.89	60.44	51.64	58.44

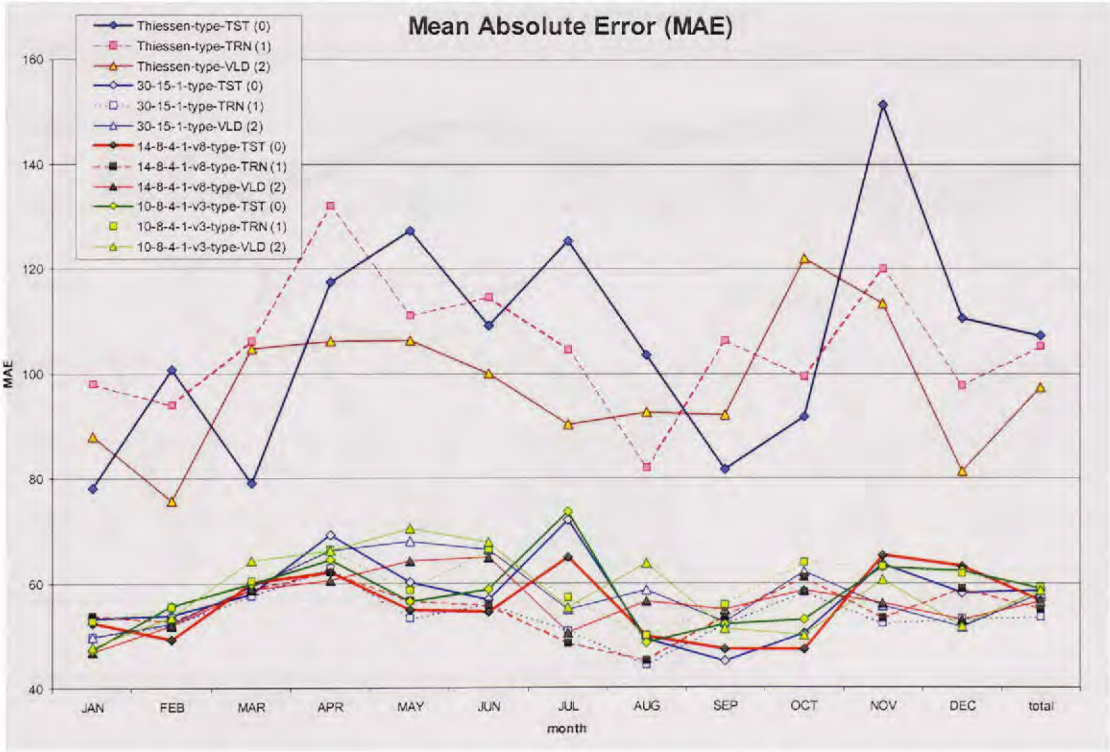


Figure 14: Chart for MAE for Thiessen and three ANN models.

Table 8: Summary of correlation coefficient (R) for Thiessen and three ANN models.

Model	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	total
Thiessen-type-TST (0)	0.617	0.353	0.718	0.554	0.395	0.677	0.555	0.552	0.692	0.679	0.333	0.271	0.545
Thiessen-type-TRN (1)	0.379	0.557	0.469	0.451	0.626	0.652	0.576	0.672	0.486	0.467	0.447	0.428	0.555
Thiessen-type-VLD (2)	0.537	0.673	0.599	0.652	0.616	0.699	0.735	0.535	0.589	0.340	0.484	0.566	0.601
30-15-1-type-TST (0)	0.824	0.802	0.822	0.849	0.882	0.915	0.836	0.872	0.910	0.919	0.769	0.836	0.860
30-15-1-type-TRN (1)	0.865	0.845	0.850	0.870	0.901	0.917	0.901	0.905	0.846	0.799	0.873	0.831	0.880
30-15-1-type-VLD (2)	0.834	0.868	0.858	0.845	0.813	0.872	0.879	0.801	0.850	0.840	0.844	0.838	0.854
14-8-4-1-v8-type-TST (0)	0.817	0.834	0.800	0.860	0.906	0.899	0.857	0.888	0.900	0.926	0.793	0.813	0.862
14-8-4-1-v8-type-TRN (1)	0.841	0.822	0.824	0.868	0.892	0.919	0.901	0.899	0.833	0.782	0.861	0.794	0.868
14-8-4-1-v8-type-VLD (2)	0.830	0.858	0.839	0.865	0.854	0.883	0.880	0.798	0.823	0.870	0.858	0.816	0.854
10-8-4-1-v3-type-TST (0)	0.832	0.712	0.805	0.848	0.909	0.896	0.822	0.895	0.881	0.905	0.815	0.810	0.852
10-8-4-1-v3-type-TRN (1)	0.829	0.810	0.811	0.847	0.881	0.873	0.873	0.877	0.819	0.759	0.820	0.748	0.844
10-8-4-1-v3-type-VLD (2)	0.817	0.856	0.836	0.838	0.787	0.874	0.863	0.780	0.846	0.886	0.805	0.827	0.845

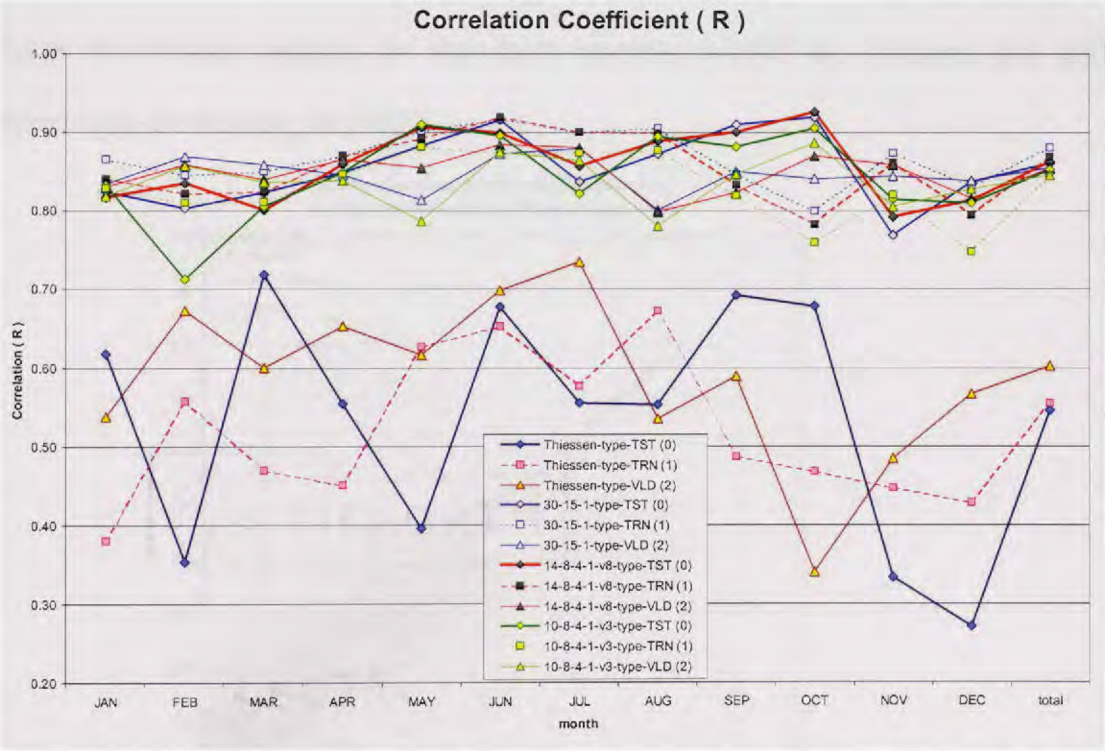


Figure 15: Chart for correlation coefficient for Thiessen and three ANN models.

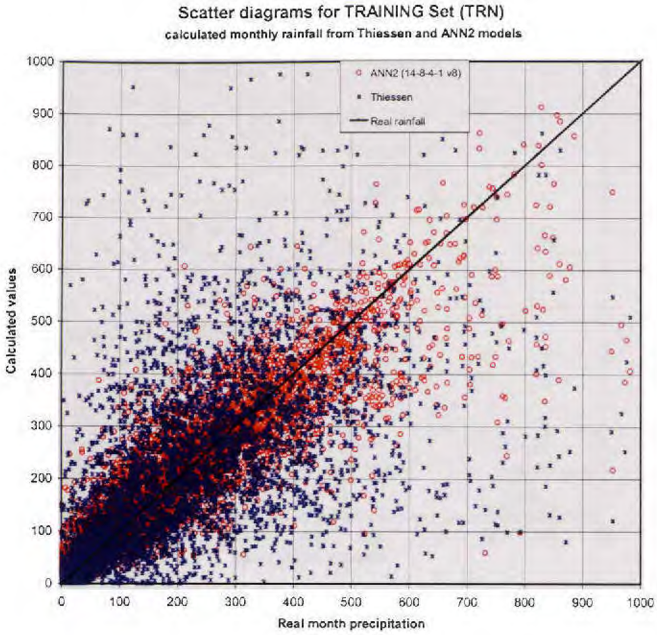


Figure 16: Scatter diagram for calculated monthly rainfall for Thiessen and ANN2 models into the training set (TRN).

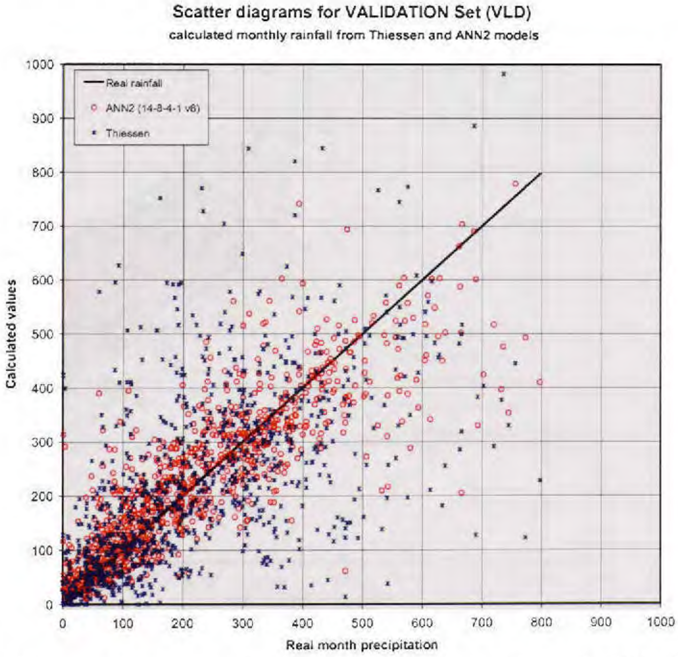


Figure 17: Scatter diagram for calculated Monthly rainfall for Thiessen and ANN2 models into the validation set (VLD).

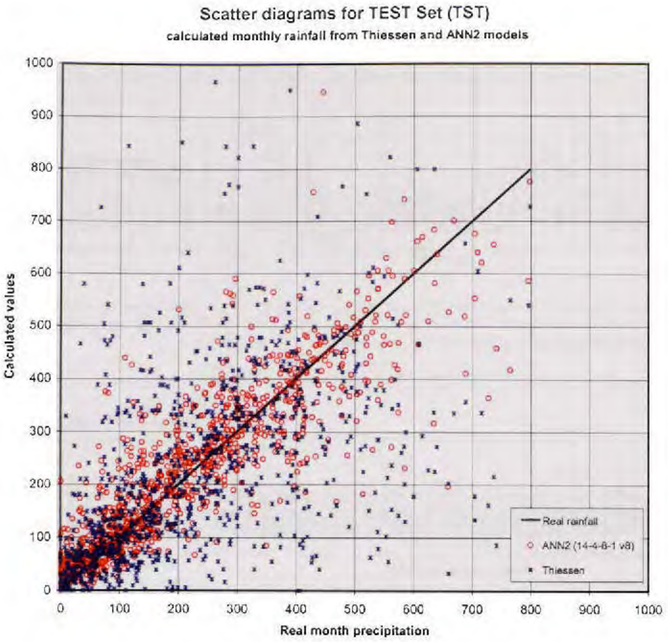


Figure 18: Scatter diagram for calculated monthly rainfall for Thiessen and ANN2 models into the Test set (TST)

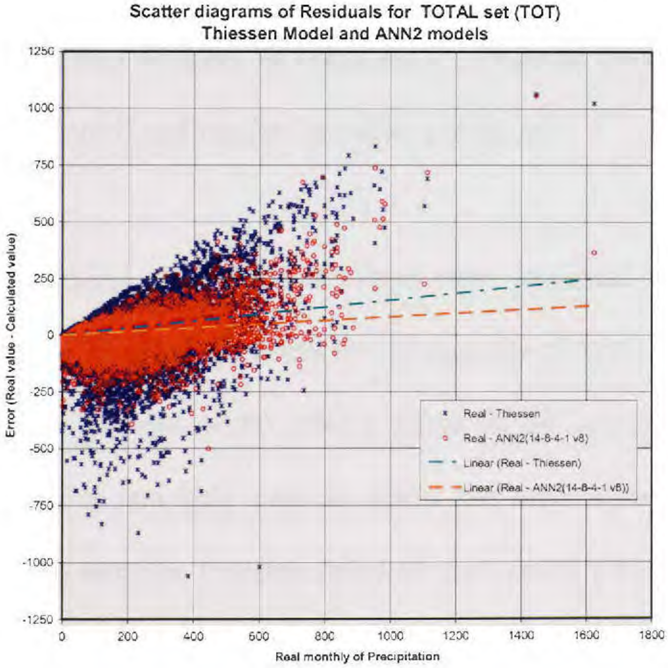


Figure 19: Scatter diagram for of monthly rainfall for Thiessen and ANN2 models for the total dataset

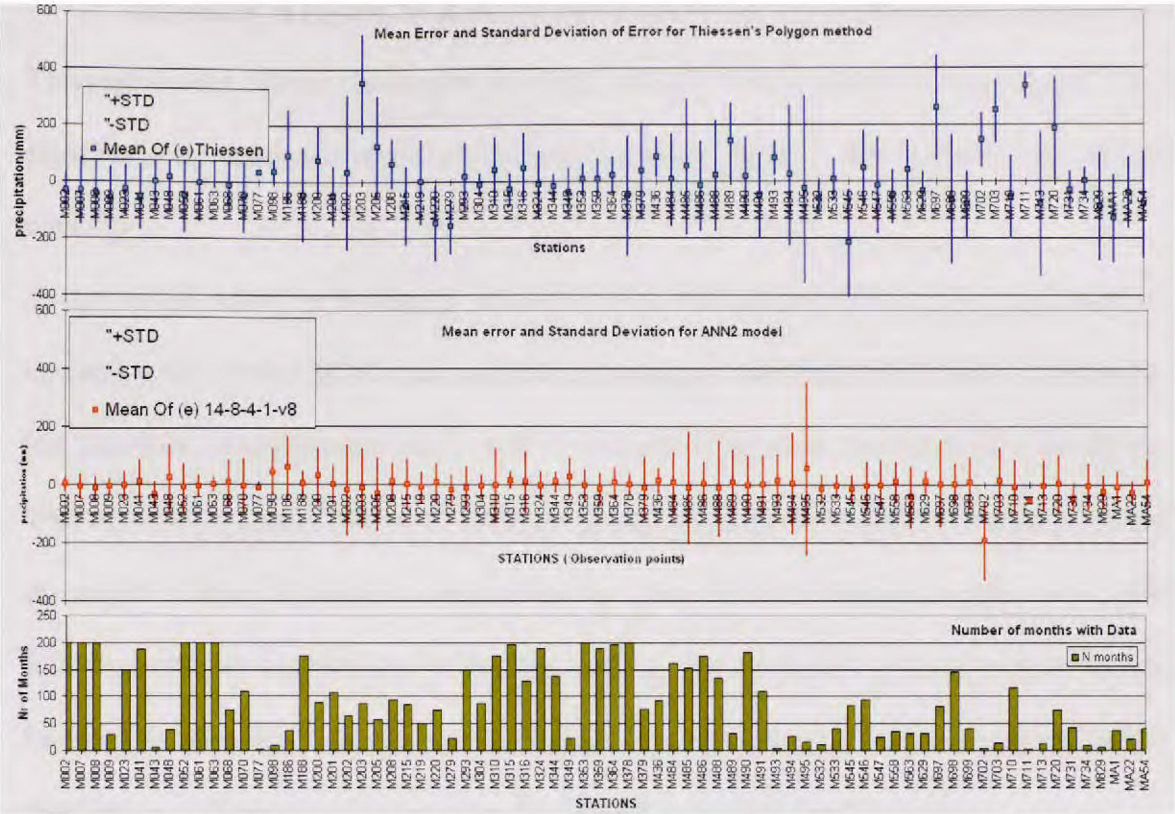


Figure 20: Chart of mean of residuals and standard deviation of residuals for Thiessen and ANN2 model and number of values per station.

Checking the results of these new statistical summary tables(Appendix P), Thiessen model failed the F-test for the equality of two variances in 41 stations from the total of 74 stations, while ANN2 failed in 54 stations. In this case, they are not inconsistencies and help only to select the method to generate the pooled variance between two samples Thiessen failed for the t-test for the mean difference in 36 stations, while ANN2 did in only 11 stations. The similar situation is for t-test for mean in paired samples. Finally, for the t-test for existence of correlation, which has real importance in this analysis, Thiessen failed in 15 stations ANN2 did in only 10 stations.

The charts in Figure 20 show the better quality of the ANN2 model in relation to Thieseen model. These charts help to check visually which station in each model has a significant by displaced mean of residuals and how large is the range of its standard deviation.

In the model ANN2 it is easy to recognize that the station M495 has a large standard deviation, the station M702 has a significant negative position of its mean of residuals, but also these stations have only 4 and 16 records of monthly precipitation respectively. This means that these stations do not have enough significance to justify a redefinition of the model. These stations are included into the group of the 10 stations in which the ANN fails the t-test for existence of correlation. In this case the series of these stations should be checked from their original records, especially for the stations M699, M494 and M495 that belong to the study area and have 40, 26 and 16 records respectively.

Generation of interpolation maps.

Because the principal goal of this research is to generate practical results, the ANN2 model was tested generating 12 maps for spatial distribution of monthly precipitation for the year 1995. The model calculated 33600 points per month, which represent all cells of 1km^2 resolution that cover the study area.

Appendix Q compiles 12 interpolated maps with the same and regular range of color scales, while Figures 21 and 22 display the months of July, 1995, and November, 1995, respectively, but using modified color scales in order to reveal some artifacts of the model

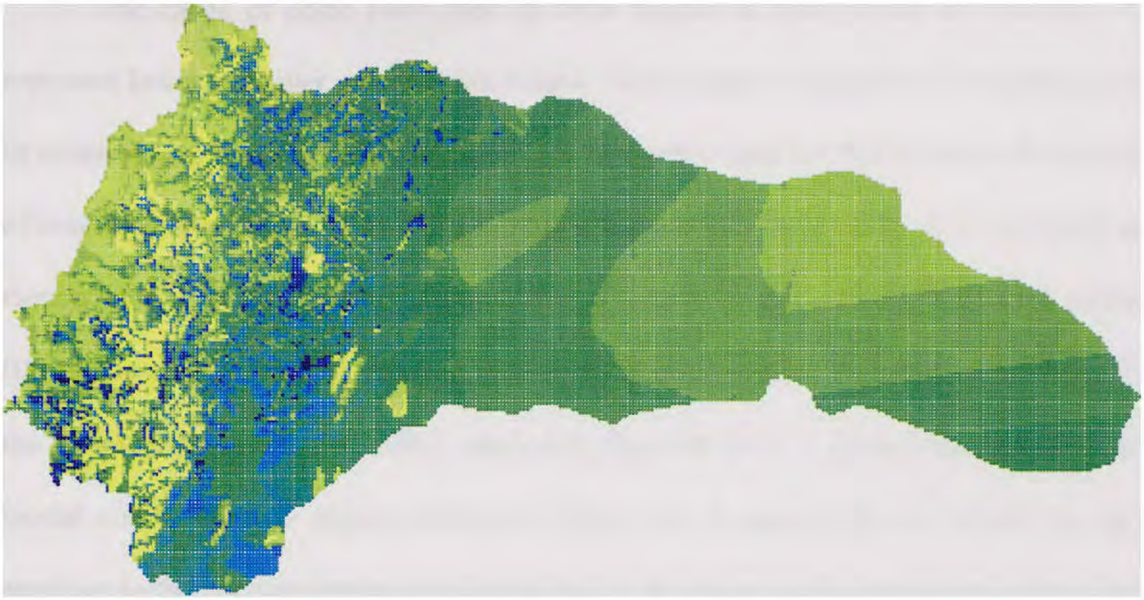


Figure 21. Spatial distribution of monthly rainfall for July, 1995.

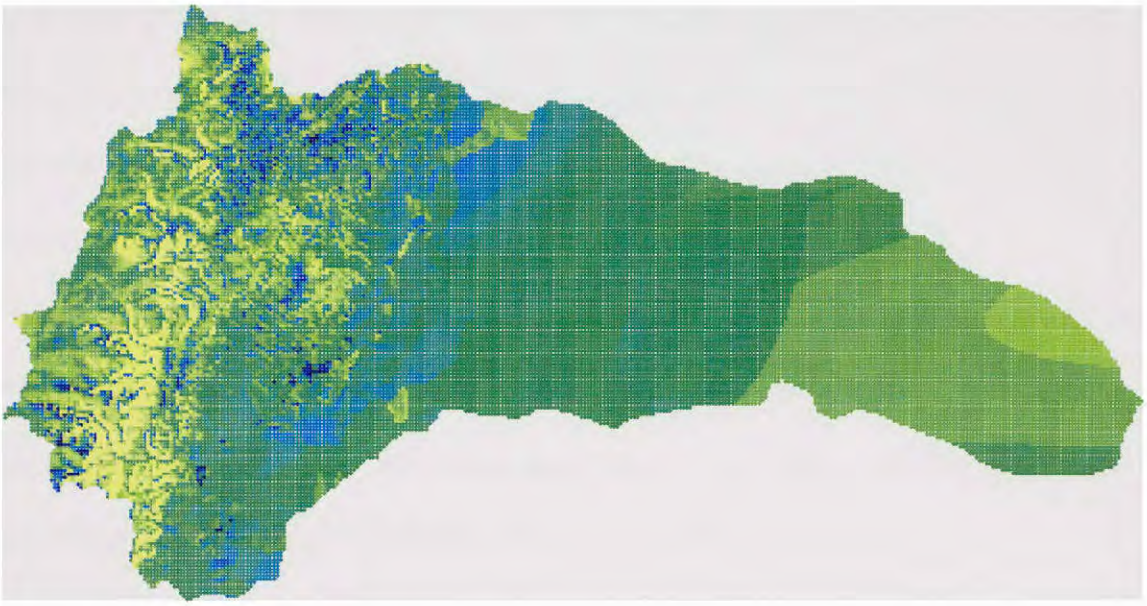


Figure 22. Spatial distribution of monthly rainfall for November, 1995.

The range of color scale used in these figures is from yellow to dark blue to represent lower to higher precipitation values. In this case it is possible to recognize that in zones of low elevations the model generates poorer results but this is due to the quality of map resolution from which the geomorphologic values were taken. It is necessary to remember that the topographic maps used as source to generate the digital terrain model (DTM) have 100m vertical resolution. Due to the high variability in elevation ranges in the mountainous zone, the 100m resolution does not have a detrimental influence in model results. This is clearly shown in Figure 22. It means that the model is very sensitive to the geomorphologic characteristics in the large lowland zone where elevation ranges only between 200m to 400m. This problem could be overcome by using a better DTM.

DISCUSION AND CONCLUSIONS

Mean monthly precipitation models.

During the process of choosing which method to fit models using monthly precipitation values, there were fundamental decisions to be made such as whether or not to split the dataset into sub-sets, what criteria would be used to select or exclude stations, and whether or not to use only the results of the test set in the selection decision. I also had to decide whether to include elevation and other geomorphologic characteristics into the models to improve their accuracy.

Several previous studies have used cross validation to generate mean square error (MSE) indexes, but all of them worked with complete datasets of mean-monthly precipitation without missing values and they represent an uniform serial data for the same period (Goovaerts, 2000), (Kastelec et al, 2002), Marquinez et al,(203). The dataset for this research, however, was incomplete and mean-monthly precipitation has different ranges of years for different stations.

In regression analysis cross validation is basically used to test the influence of one specific point over the term coefficients into the model and it helps to recognize if a particular point is an outlier. When the dataset has a large number of samples, however, the influence of one point usually does not have any affect on the model.

On other hand, for geostatistic methods such as Kriging and other spatial interpolations methods such as IDW and local polynomials, the cross validation made sense because according to the theory of these methods, the calculated value in a point that belongs to the fit set should be the same actual value as the point. In addition these methods did not use the full dataset to generate a single equation but used only a small number of points nearest to the point to interpolate because if they used the full dataset the results would produce a smoothed surface very similar to the results of global polynomial interpolation method and a individual point would loose its significance.

In artificial neural networks (ANN) it is not advisable and sometimes not applicable to use cross validation due to the large number of samples that commonly required for using this method. For example, the number of samples in the dataset for mean-monthly precipitation was 747 (100%) samples, and the omission of a single point does not have any influence on the model but the omission of 207 (28%) samples has a strong influence. Another inconvenience in ANN methods is due to its own solution algorithms, which are iterative processes of approximation by which the minimum RME is reached. These methods do not guarantee that an ANN will achieve the same minimum value in each run. They only promise to locate solutions close to the hypothetical minimum.

The different concepts and constraints between methods led me to split the full dataset into two subsets; one to fit the model (fit set or SET 1) and other to test the model (test set or SET 2). A correct comparison of MSE between models of different methods is only possible using test set, while the comparative analysis between models should use the fit set. MSEs could only be compared between Geostatic and similar methods (inverse weighted distance, radial basic functions, local polynomial, etc.), and separated from LGM and ANN methods that constitute another group of methods with compatible MSEs.

Another aspect of the strategy is to split the database using two different approaches; the models should be tested for their ability to fill missing values or to overcome the scarcity of stations. The first approach, which was used in the second part of this research, would generate a lot of insolvable, non-compatible and exhausted procedures, especially for methods that are not able to incorporate the temporal variability using monthly values. This includes using mean-monthly values, in which the one-parameter time (years) was eliminated. There were still problems, such as the irregular number of samples in each month, that cause a loss of significance of a global RMSE and other indexes. Using the second approach it was possible to overcome a lot of inconsistencies because the selection was by station and used only those stations that have values for all 12 months.

In all, 23 stations were eliminated from the total of 86 stations because they did not have enough values to generate at least 10 years of complete mean monthly values. The remaining 63 stations were split in two groups; one for fitting the models and another to test them. At this level the selection was made using hydrologic criteria rather than a choosing randomly. All stations that had data in a sufficiently long series and were representative for each climatic zone, were selected to compose the fit set and a enough number of stations were picked to guarantee adequate accuracy for models. In this case 45 stations fulfilled that criteria and the remaining stations composed the test set.

Furthermore, because the objective in this analysis was to check if the methods are able to deal with the scarcity of stations, its focus was to find models that better predict values for stations that were never used to fit the model. For this reason the criterion to select the best method was to check which model shows better accuracy with the values in stations of test set, in spite of the model had gotten high level of matching with stations of fit test. Because it was feasible to over fit models using different subterfuges (increasing the number of explanatory variables or their power in LG, number of perceptrons in ANN, increasing or decreasing area of influence or points in Kriging, IDW, etc.

After this crucial decision, it was possible to continue the process and generate RMSE of residuals with the same meaning but it was only for stations of the test set, while for the fit set there was a mixture of RMSE from cross validation for spatial interpolation methods and RMSE of residuals for LG and ANN models

Previous studies found that the inclusion of elevation and other geomorphologic characteristics improved the model accuracy. Marquinez et al. (2003) fit a LGM including elevation and other geomorphologic characteristics for mean monthly precipitation. They got R^2 values for the fit set between 0.65 and 0.72 for dry and wet seasons, respectively. In the current research, I got R^2 values for the fit set between 0.71 and 0.83 depending on the months. Marquinez et al. (2003), also used mean error in his analysis of the test set, but this analysis is useless.

A similar situation occurred with the results of Govaerts (2000), who included elevation in cokriging and LR models, and used cross validation to calculate the MSE for a full dataset of mean-month precipitation. He made a graphical comparative analysis between methods such as kriging, crokiging, IWD, LR, local polynomial and Thiessen polygons. He presented values of linear correlation coefficients (R) for the LR model between 0.39 to 0.83 depending on months. For the current research the LG model R19 achieved R between 0.62 and 0.81, depending on months for the entire dataset, while the model ANN3 present an marginally better R between 0.63 and 0.92. The most important contribution of Govaerts (2000) is his comparative plot-chart of relative MSE between several methods. It shows a pattern very similar to the plot-chart for RMSE generated in my research for the test set, and it arrived at similar conclusions, such as Thiessen models give the worst result, and the inclusion of elevation into de models improves their accuracy.

My research clearly demonstrated that ANN is the best choice of interpolation method, with its approaches of using only geomorphologic characteristics or including anchor stations, because they not only have lower RMSE for the test set (Figure 13) but also have consistent RMSE in the fit set in comparison with LG models (Figure 14).

Furthermore, ANN with Multi layer Perceptrons topology is easy to implement using any common computational language with non-complicated algorithms and with low computational resources. Of course, as Everit et al. (2001) commented, for some statisticians it is hard to accept that this kind method is a good alternative to generate models. But, like a didactic example linear regression and robust regression models are particular cases of ANN when it has a single perceptron in a hidden layer and the activation function is linear (slope=1) . Of course this process does not fulfill all the rigid rules that statistics impose, but an ANN generates the same results.

Finally, my results supported similar results from Wotling (2000), Govaerts (2000), and Antonic el al. (2001) that found elevation to be an important factor in the spatial distribution of mean–monthly precipitation. Furthermore, and in concordance with Prudhomme (1999), Marquinez et al. (2003) and Hay et al. (1998), I found that not only elevation but also other geomorphologic characteristic have a high influence on the spatial distribution of this meteorological parameter.

My analysis supports the two hypothesis proposed for this research; there is sufficient evidence that elevation has a strong influence on the distribution of precipitation on the eastern side of the cordillera of the Andes at least into the upper Napo River Basin, and the topography features have important additional influence on the distribution of precipitation over the same study area.

Monthly precipitation Models

Based on the results of the analysis of first part of this research, it was feasible to generate models for monthly precipitation values for the period 1980 to 2002. The ANN models overcome by themselves the regional inter-annual variability and they achieved high correlation coefficient very similar to the research of Antonic et al. (2001).

Using the ANN method, two models were generated. The model 14-8-4-1 (ANN2) with 14 explanatory variables including 2 for geographic position (latitude, longitude), elevation, 4 for geomorphologic characteristics (slope, aspect, hill-shade901k, hill-shade1801k) and 7 anchor stations (M002, M007, M008, M052, M061, M063, M378). The model 10-8-4-1 (ANN3) had 10 explanatory variables. ANN3 is similar to ANN2 but without 4 geomorphologic variables. ANN2 had correlation coefficients (R) of 0.862, 0.868, 0.854 for training (TRN), validation (VLD) and testing (TST) sets, respectively, while ANN3 had $R_{(TRN)}$= 0.852, $R_{(VLD)}$= 0.844 and $R_{(TST)}$= 0.845. Values, that are higher than those from Antonic et al. (2001) who had $R_{(TRN)}$=0.815 and $R_{(TST)}$=

0.800. But his ANN model used only 2 anchor stations in addition to longitude, latitude, elevation and month (categorical) as descriptive variables.

It is necessary to note that with M007, M008 and M378 as anchor stations it was possible to generate ANN models with high correlation coefficients and they could also be good alternatives, but in order to take advantage of the available stations and incorporate more local variability and give more influence to the lower elevation zone in the study area, I incorporated 4 additional anchor stations into the model.

Antonic et al. (2001) and Hay et al. (1998) are the only references to deal with monthly precipitation values. Antonic et al. uses the ANN method for a mountainous zone of Croatia (56538 Km^2) using 127 climatic stations. Hay et al. used the MLG method for Animas River Basin of southwestern Colorado U.S (2000 Km^2) using 22 stations. Of course, the outstanding characteristic of Antonic et al.'s model is that a single ANN model can interpolate monthly precipitation and six additional climatic parameters at a monthly level (mean, maximum and minimum of temperature, relative humidity, global solar radiation and potential evapotranspiration).

In other references, the ANN method was used to fit more complex models for weather broadcasting using meteorological radars (Osrodka et al. 2003, Maeda et al. 2003), and precipitable water at monthly levels using GOES images (PERSIAN 2003). ANN is a good alternative in these analyses because traditional methods generate complex algorithms with low levels of accuracy and are overloaded with a massive amount of information (Hall et al. 1997). As these and other authors note, however, for climatological analyses this method is not yet totally accepted due to the supposed difficulty in analyzing the relation between variables. But it is possible to overcome that limitation if the ANN is used correctly (Cannon et al. 2002).

During the process of building the model, one of the most important issues was to include the inter-annual variability of rainfall and the influence of ENSO (McGregor et al. 1998). This was a challenge, however, because the ANN models for variable years gave curves that clearly reflected the period of lower annual precipitation in NINO years in relation to other non-NINO years. Furthermore, it showed that there is a real and general decreasing trend in precipitation from 1982 to 2000. The same situation happened with the variable month in that trigonometric transformations were not necessary because the ANN models also showed the cyclic behavior for this variable. These collateral and interesting results disappeared as soon as the anchor stations were included; the variables of year and month became useless because the anchor stations gave intrinsically the answer for the temporal variability not only monthly but also annual levels.

ANNs used correctly could be a good tool to analyze the properties in time-series data; similar results are only feasible using more complex methods like spectral analysis, Furier series and statistical time-series analysis. In this case using the technique referred to as Reversing Engineering, the ANNs help to determine relationships between factors and effects, and then other mathematical tools can be used to justify them.

In my opinion and based on my results, the principal goal of this thesis research was achieved because through the ANN model it was possible to synthesize the variability of precipitation over spatial and temporal scales with a high level of confidence. This model can be used to fill gaps in time-series of monthly precipitation for a period 1981 to 2000, and to generate interpolated maps of spatial distribution of monthly precipitation at a resolution of 1km^2.

Answering the research questions.

Question # 1: Is the density of climatologic stations sufficient to define good homogeneous climatic zones in Napo River Basin?

The cluster analysis proved to be a useful tool to generate climatic zones, especially when elevation and geographic coordinates were included into the Euclidian distance for 12 mean monthly precipitation values. These results were very similar to the climatic zones defined by INAMHI using Kepper's classification, in which values of other climatic parameters are included such as air temperature, relative humidity, potential evaporation, and global radiation.

Question # 2: What is the level of influence of terrain elevation in the spatial distribution of precipitation for the study area?

From results of ANN models for monthly precipitation, it is easy to infer that if the difference between the ANN2(14-8-4-1) and ANN3(10-8-4-1) models is 4 geomorphologic characteristic at 1km^2 of resolution and with these additional variables the correlation coefficient increases by only 3%., For model ANN(5-5-1), from which elevation was also eliminated the degradation in its correlation coefficient was 32%.

In addition, during the analysis to select the best method using mean-monthly values of precipitation, in linear regression analysis, without exception the variable elevation was selected for all models. This is verified in ANOVA (Table 2).

Question # 3: Are higher complexity models a guarantee for a better accurateness for precipitation ?

The answer depends on the point of view because one of the better LR models used 6 principal variables plus 15 additional terms among interactions and powers from those principal variables, while the ANN model AN9 (8-5-1) used only 8 variables, but with 2 matrixes of weights (8 x 5 and 5 x 1) in which the interactions between those variables are included intrinsically.

If the question is considered using only ANN models, it is easy to infer that the inclusion of 23 variables into the model ANN1(30-15-1) did not generate better results in relation for those generated from the model ANN2(14-8-4-1). Furthermore it generated over-fitted models. A similar situation happened with LG model R3 for mean values of precipitation. It had an excellent match with the fit set but at the same time the worst match with the test test.

Question # 4: What model of spatial analysis can be used to generate the best regular network of virtual observation points?

This question was debated throughout this research, during the analysis for selecting the best method and after using the ANN method to fit a model for mean month values.

The model selected by the author is a artificial neural network (ANN) model of Multi layer perceptron topology (MLP), with 14 input variables, 8 perceptron in the 1st layer and 4 in the 2nd layer, and a single output and the activation function was the tangent hyperbolic function

Question # 5: Is it possible to create a unique model that can synthesize variability of precipitation in spatial and temporal scales?

The final results of this research support an affirmative answer because the model is able to generate at any point into the study area an interpolated monthly precipitation value only with actual monthly precipitation values of only 7 anchor stations for a specific month into a time period between 1982 and 2000. The other variables such as longitude, latitude, elevation, slope, aspect and two components of hill-shade are constant for each interpolated point.

Finally, this research has reached its main goal, which was to develop a model that is able to generate a map of monthly precipitation, to fill gaps in time-series for actual stations and to create virtual stations with time-series data. Of course there are alternatives ANN models generated in this research that need to be checked and analyzed with a better climatologic criteria, because by reducing the number of input variables it is possible to generate simpler models to produce more understandable isohyets maps.

Future research and applications.

The results of this research are the beginning for a more detailed and comparative analyses with other researches undertaken for hydrologic characterization throughout the Amazon Ecuadorian zone by INAMHI with collaboration other international institutions.

Before the model can be generalized for all territory of Ecuador, it will be necessary to check inconsistencies in those stations where the model failed to determine if the problem is data trustworthiness or problems with the functioning of the model.

In the immediate future, I will begin with the analysis of the influence of vegetation cover as an additional factor to improve the spatial distribution of precipitation using the digital maps of vegetation indexed generated by NOAA for 1km^2 of resolution. This activity that will take place as part of a process of data exploration for building a hydrologic and environmental model that will be applied in a pilot sub-basin into the study area.

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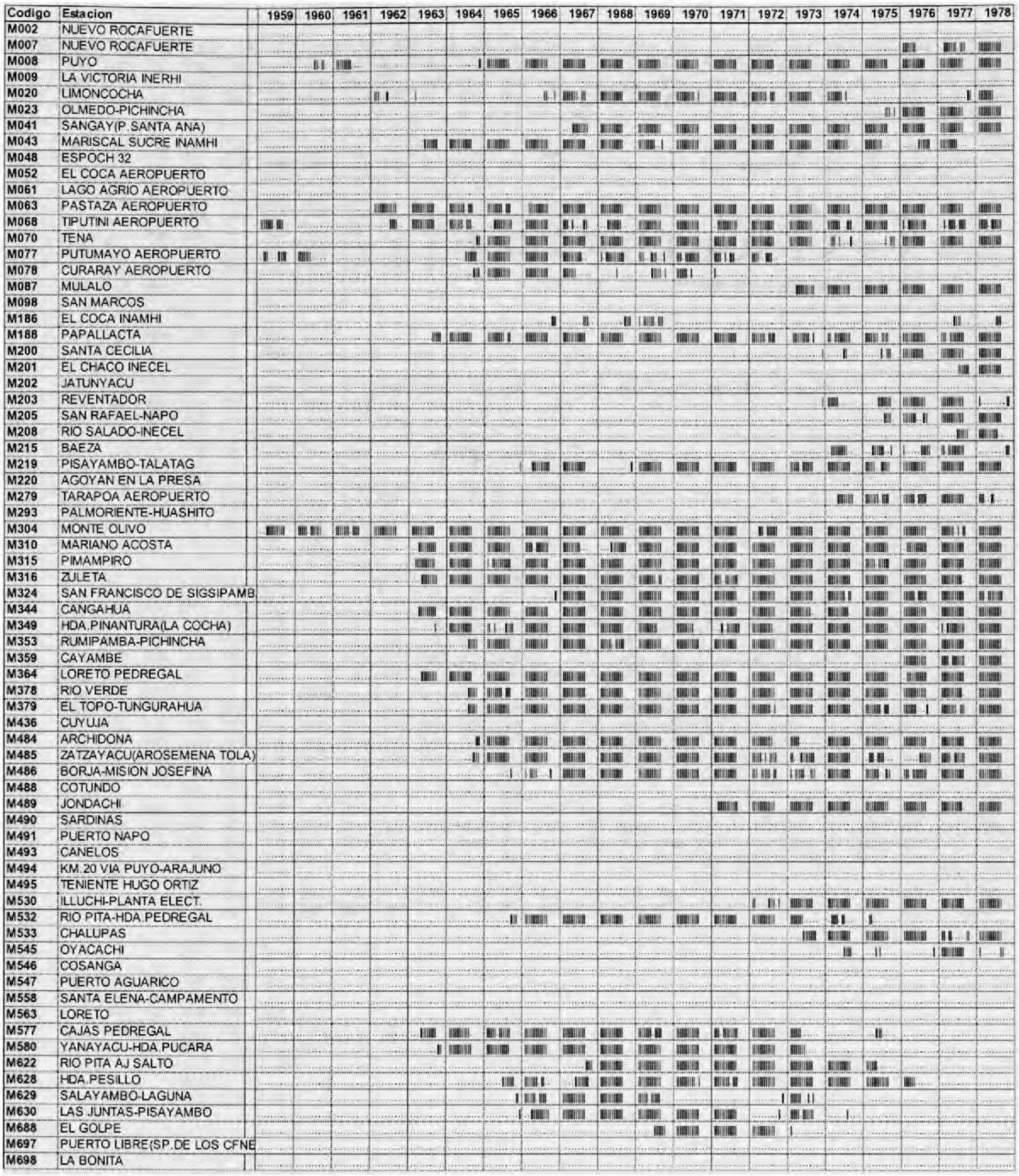
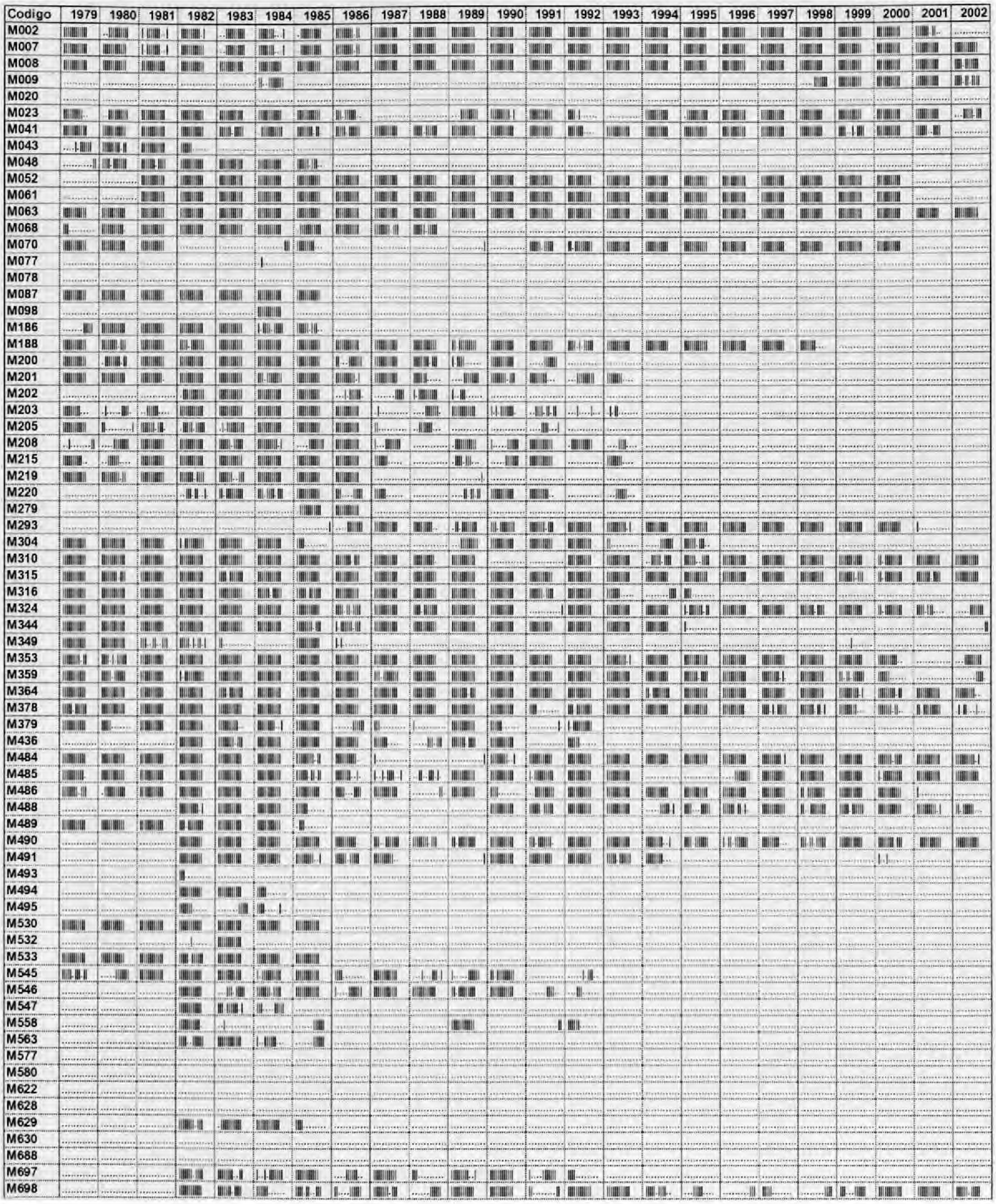
APPENDIX A

Table A.1 : Inventory of monthly precipitation values for weather and rain-gauge Stations



Codigo	Estacion
M002	NUEVO ROCAFUERTE
M007	NUEVO ROCAFUERTE
M008	PUYO
M009	LA VICTORIA INERHI
M020	LIMONCOCHA
M023	OLMEDO-PICHINCHA
M041	SANGAY(P.SANTA ANA)
M043	MARISCAL SUCRE INAMHI
M048	ESPOCH 32
M052	EL COCA AEROPUERTO
M061	LAGO AGRIO AEROPUERTO
M063	PASTAZA AEROPUERTO
M068	TIPUTINI AEROPUERTO
M070	TENA
M077	PUTUMAYO AEROPUERTO
M078	CURARAY AEROPUERTO
M087	MULALO
M098	SAN MARCOS
M186	EL COCA INAMHI
M188	PAPALLACTA
M200	SANTA CECILIA
M201	EL CHACO INECEL
M202	JATUNYACU
M203	REVENTADOR
M205	SAN RAFAEL-NAPO
M208	RIO SALADO-INECEL
M215	BAEZA
M219	PISAYAMBO-TALATAG
M220	AGOYAN EN LA PRESA
M279	TARAPOA AEROPUERTO
M293	PALMORIENTE-HUASHITO
M304	MONTE OLIVO
M310	MARIANO ACOSTA
M315	PIMAMPIRO
M316	ZULETA
M324	SAN FRANCISCO DE SIGSIPAMB
M344	CANGAHUA
M349	HDA.PINANTURA(LA COCHA)
M353	RUMIPAMBA-PICHINCHA
M359	CAYAMBE
M364	LORETO PEDREGAL
M378	RIO VERDE
M379	EL TOPO-TUNGURAHUA
M436	CUYUJA
M484	ARCHIDONA
M485	ZATZAYACU(AROSEMENA TOLA)
M486	BORJA-MISION JOSEFINA
M488	COTUNDO
M489	JONDACHI
M490	SARDINAS
M491	PUERTO NAPO
M493	CANELOS
M494	KM.20 VIA PUYO-ARAJUNO
M495	TENIENTE HUGO ORTIZ
M530	ILLUCHI-PLANTA ELECT.
M532	RIO PITA-HDA.PEDREGAL
M533	CHALUPAS
M545	OYACACHI
M546	COSANGA
M547	PUERTO AGUARICO
M558	SANTA ELENA-CAMPAMENTO
M563	LORETO
M577	CAJAS PEDREGAL
M580	YANAYACU-HDA.PUCARA
M622	RIO PITA AJ SALTO
M628	HDA.PESILLO
M629	SALAYAMBO-LAGUNA
M630	LAS JUNTAS-PISAYAMBO
M688	EL GOLPE
M697	PUERTO LIBRE(SP.DE LOS CFNE
M698	LA BONITA

Table A.1: Inventory of monthly precipitation values for weather and rain-gauge Stations (....continuation)



APPENDIX B

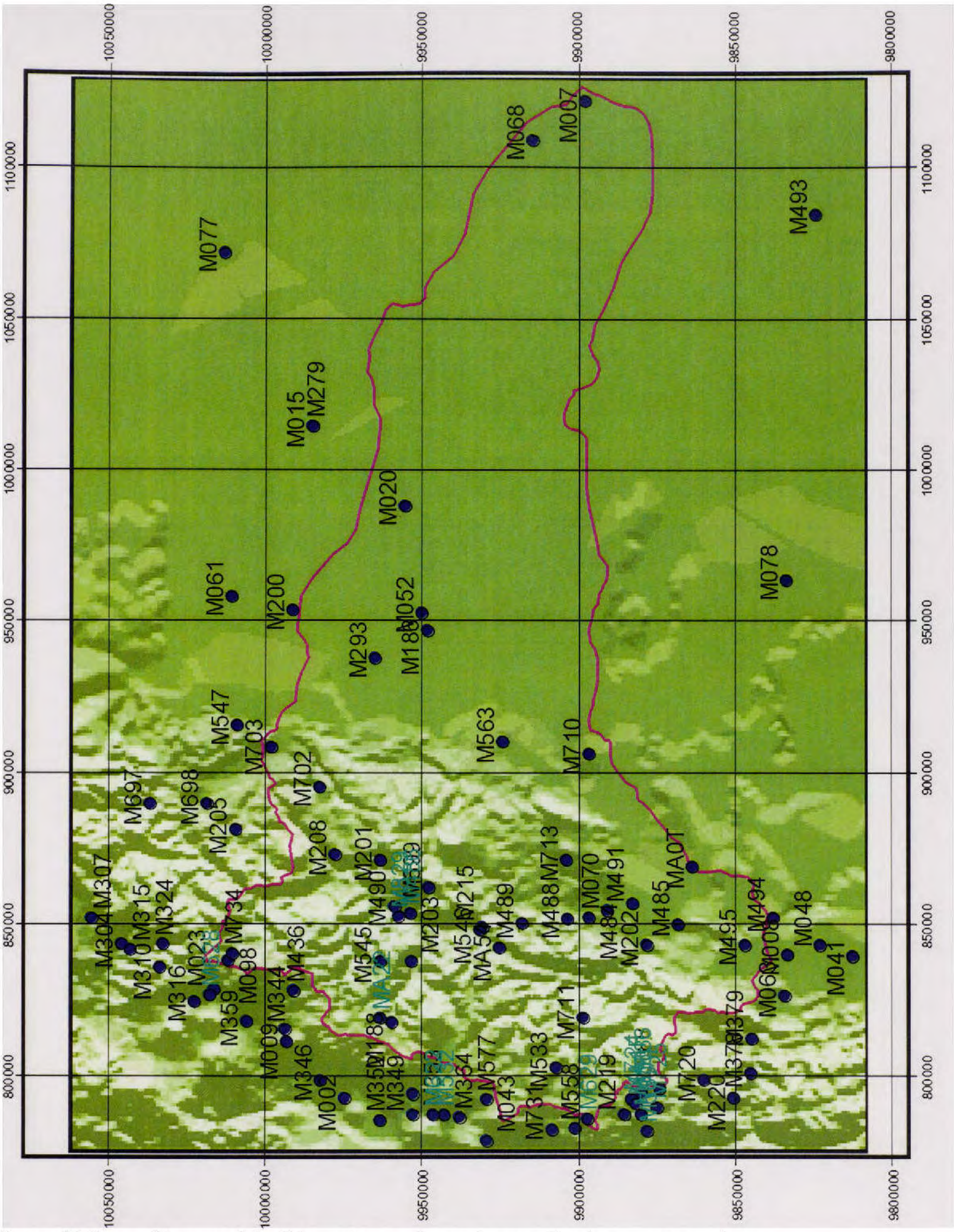


Figure B.1: Geographical locations of weather and rain-gauge stations

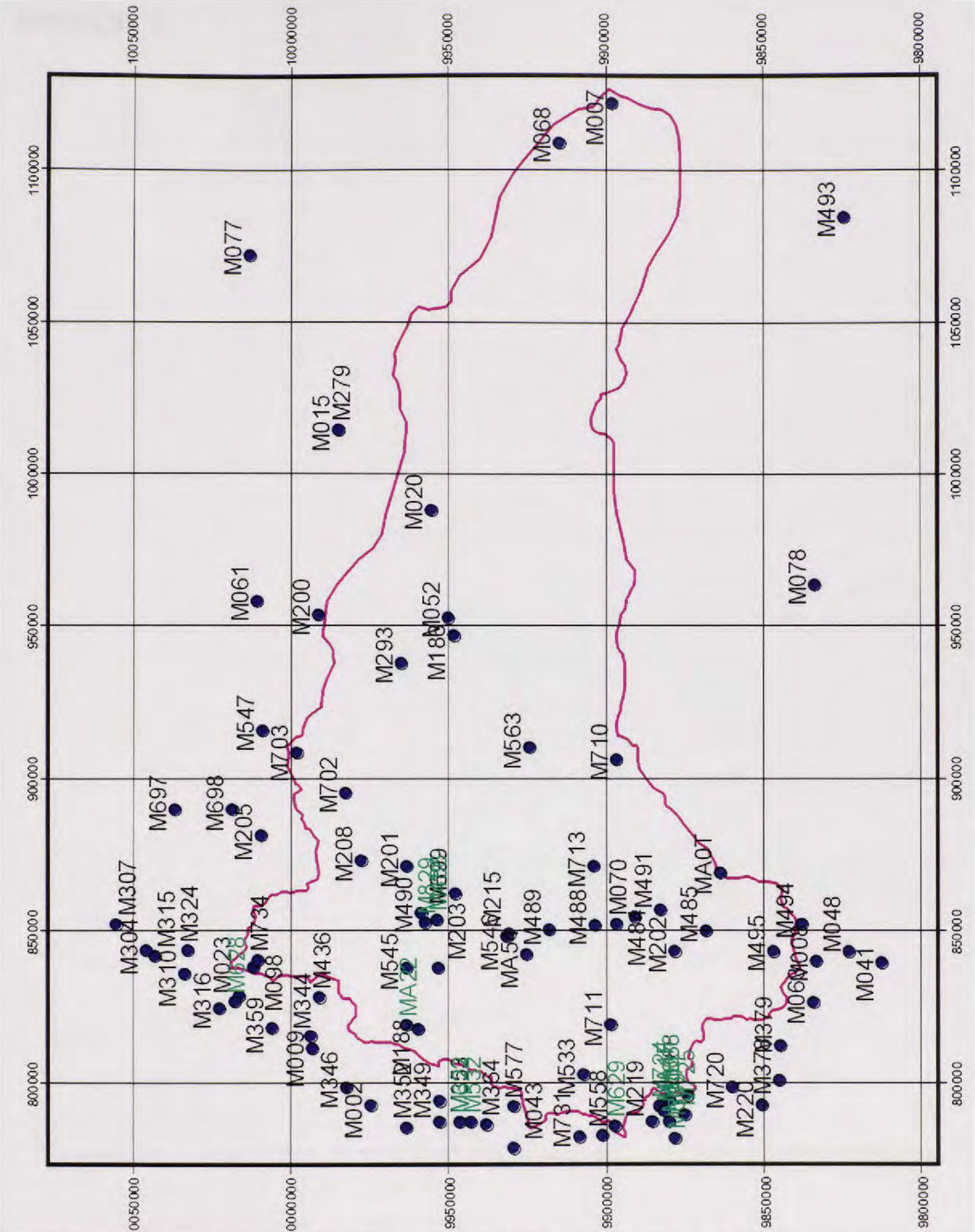
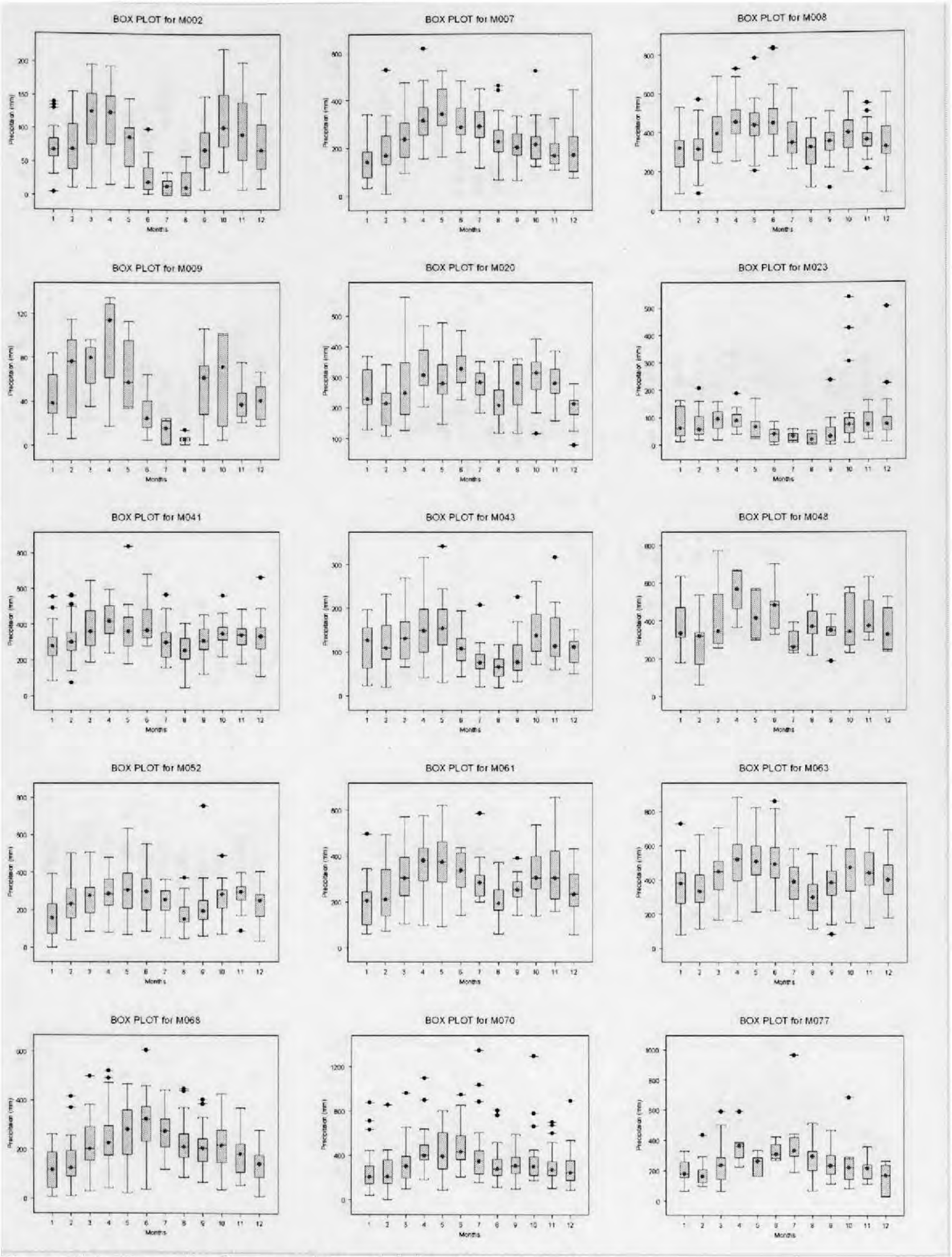


Figure B.2: Geographical locations of weather and rain-gauge stations

APPENDIX C



BOX PLOT for M002

BOX PLOT for M007

BOX PLOT for M008

BOX PLOT for M009

BOX PLOT for M020

BOX PLOT for M023

BOX PLOT for M041

BOX PLOT for M043

BOX PLOT for M048

BOX PLOT for M052

BOX PLOT for M061

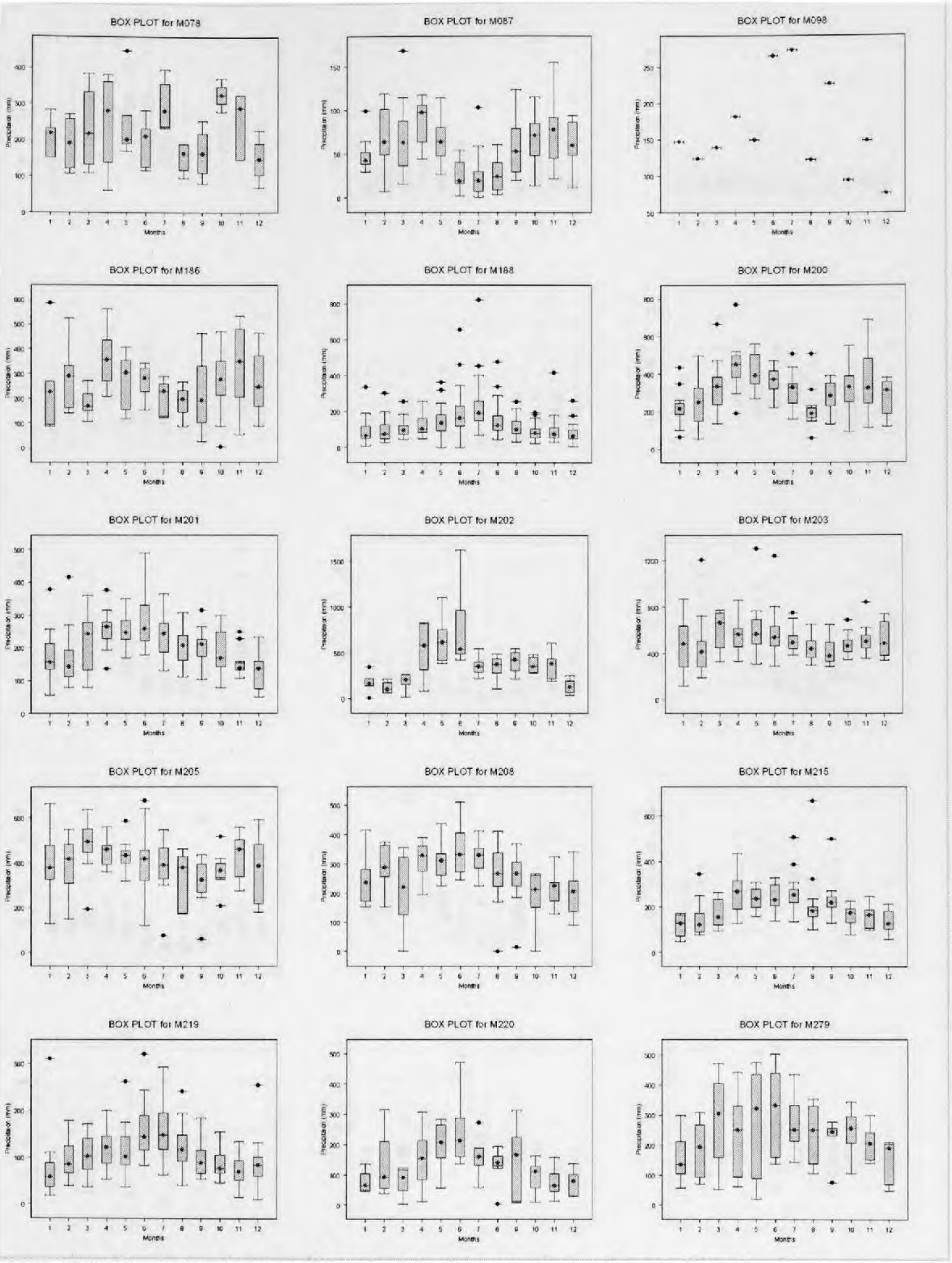
BOX PLOT for M063

BOX PLOT for M068

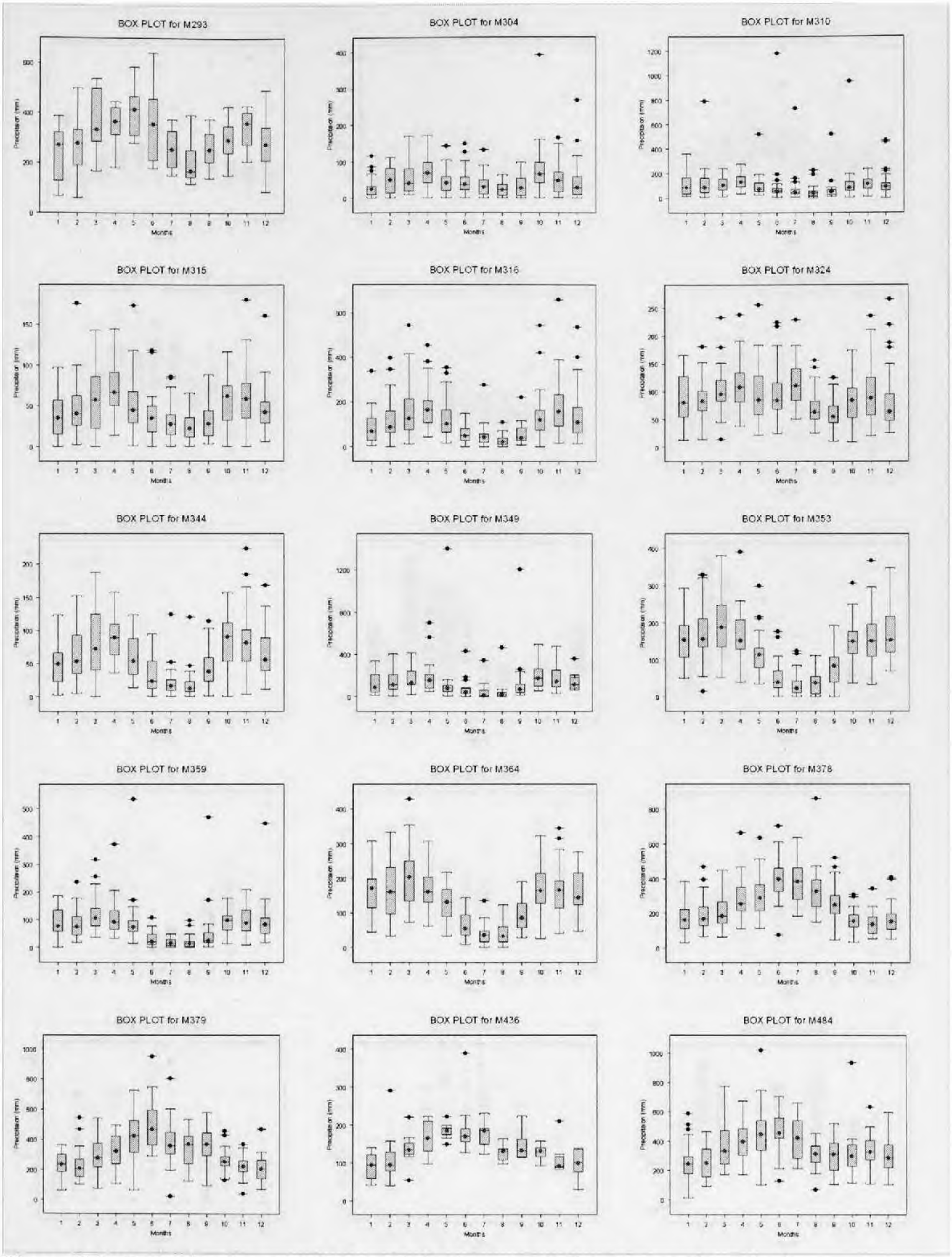
BOX PLOT for M070

BOX PLOT for M077

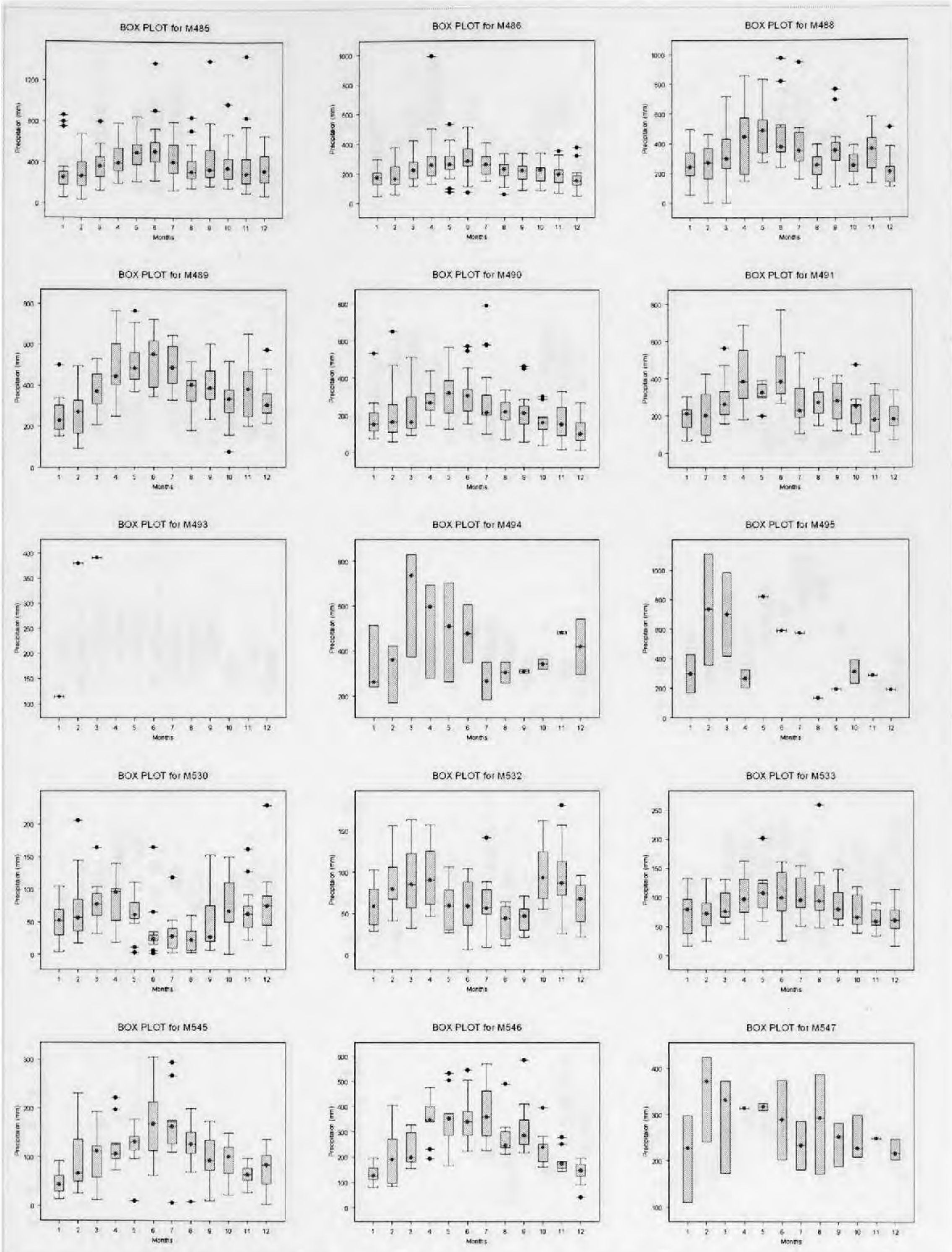
FigureC.1: Box-plot for monthly precipitation per station



FigureC.1: Box-plot for monthly precipitation per station (…continuation).



FigureC.1: Box-plot for monthly precipitation per station (…continuation).



BOX PLOT for M485

BOX PLOT for M486

BOX PLOT for M488

BOX PLOT for M489

BOX PLOT for M490

BOX PLOT for M491

BOX PLOT for M493

BOX PLOT for M494

BOX PLOT for M495

BOX PLOT for M530

BOX PLOT for M532

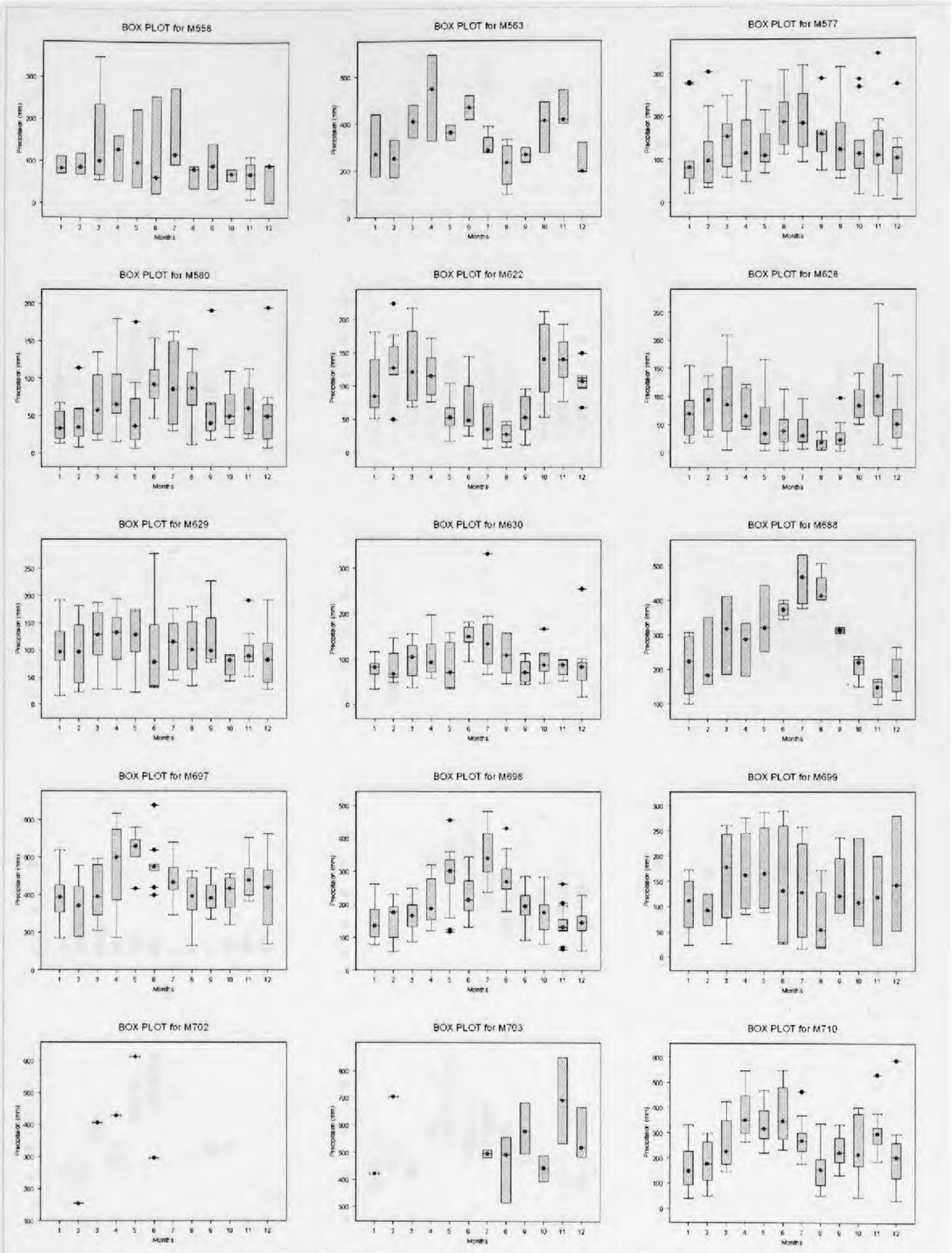
BOX PLOT for M533

BOX PLOT for M545

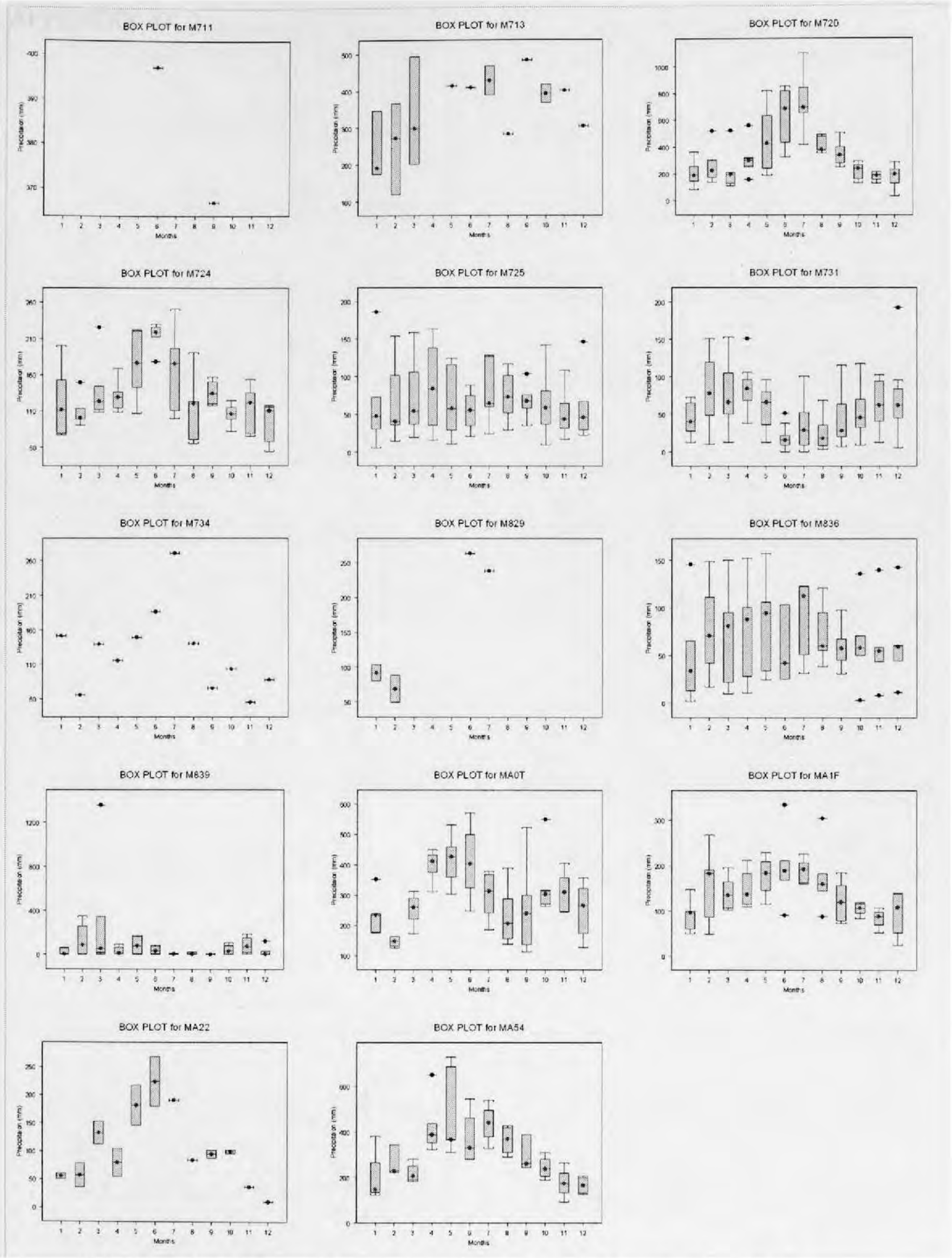
BOX PLOT for M546

BOX PLOT for M547

FigureC.1: Box-plot for monthly precipitation per station (…continuation).



FigureC.1: Box-plot for monthly precipitation per station (…continuation).



BOX PLOT for M711

BOX PLOT for M713

BOX PLOT for M720

BOX PLOT for M724

BOX PLOT for M725

BOX PLOT for M731

BOX PLOT for M734

BOX PLOT for M829

BOX PLOT for M836

BOX PLOT for M839

BOX PLOT for MA0T

BOX PLOT for MA1F

BOX PLOT for MA22

BOX PLOT for MA54

FigureC.1: Box-plot for monthly precipitation per station (…continuation).

APPENDIX D

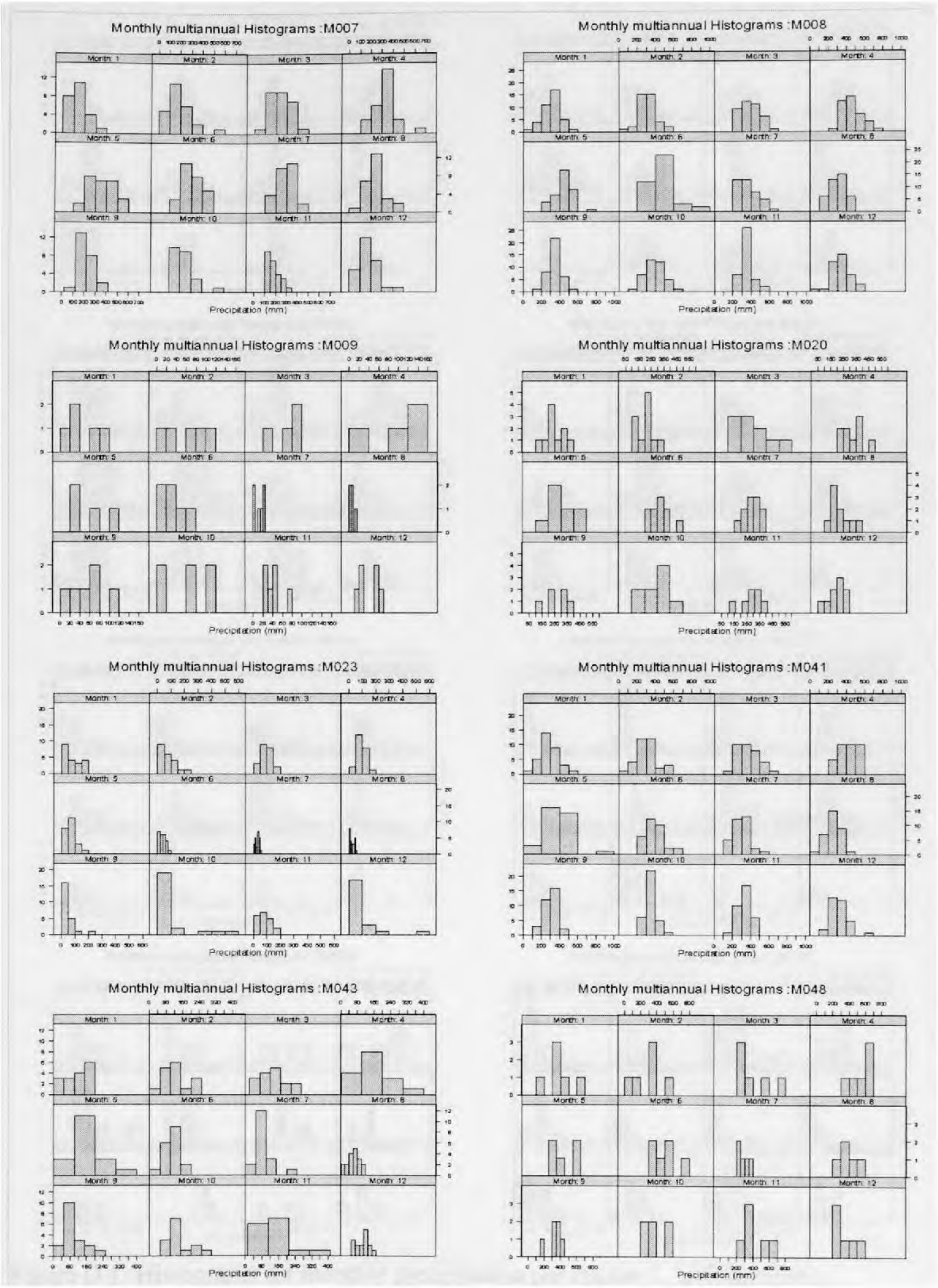


Figure D.1: Histograms for monthly precipitation per station.

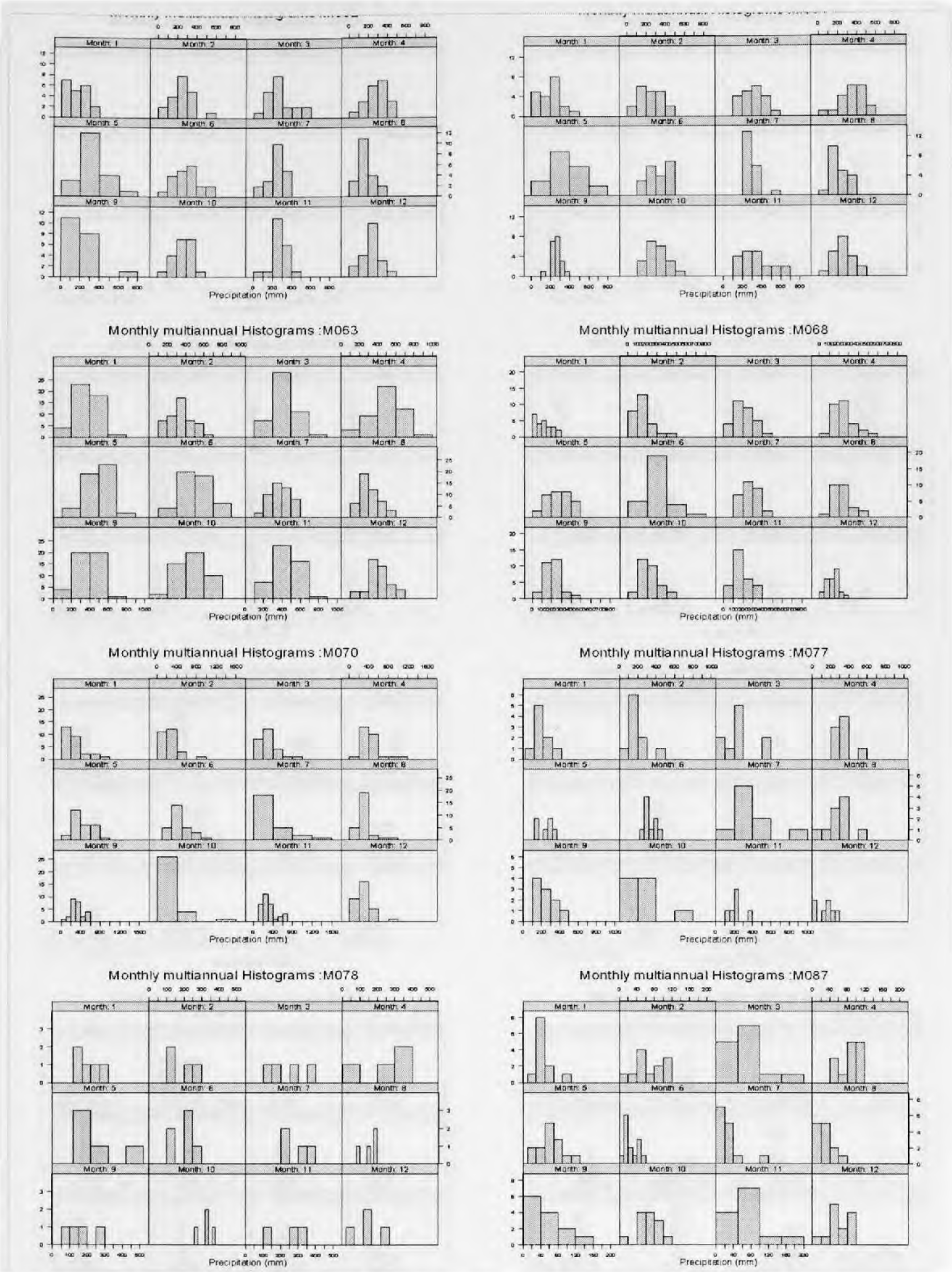


Figure D.1: Histograms for monthly precipitation per station (…continuation)

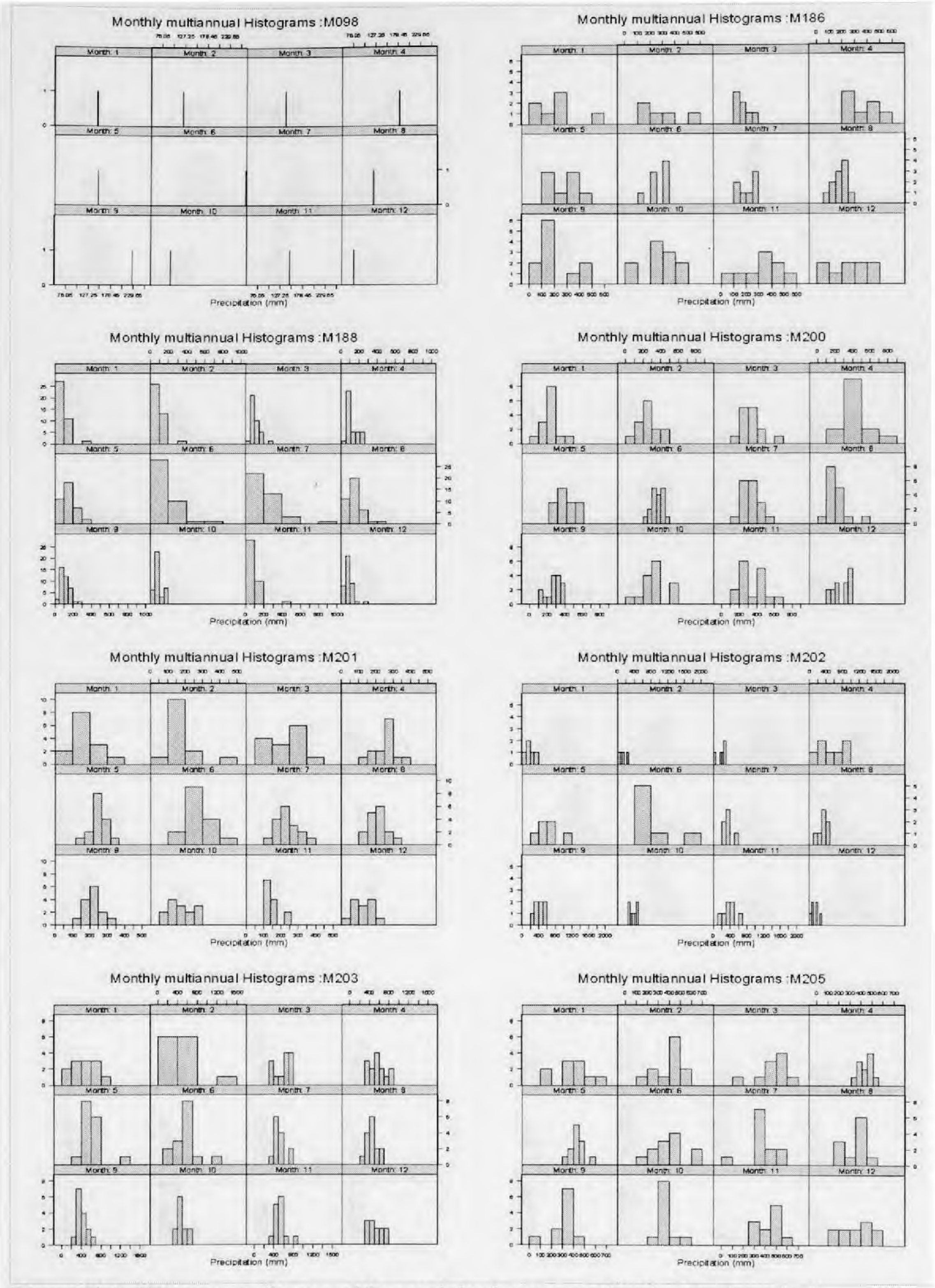


Figure D.1: Histograms for monthly precipitation per station (…continuation)

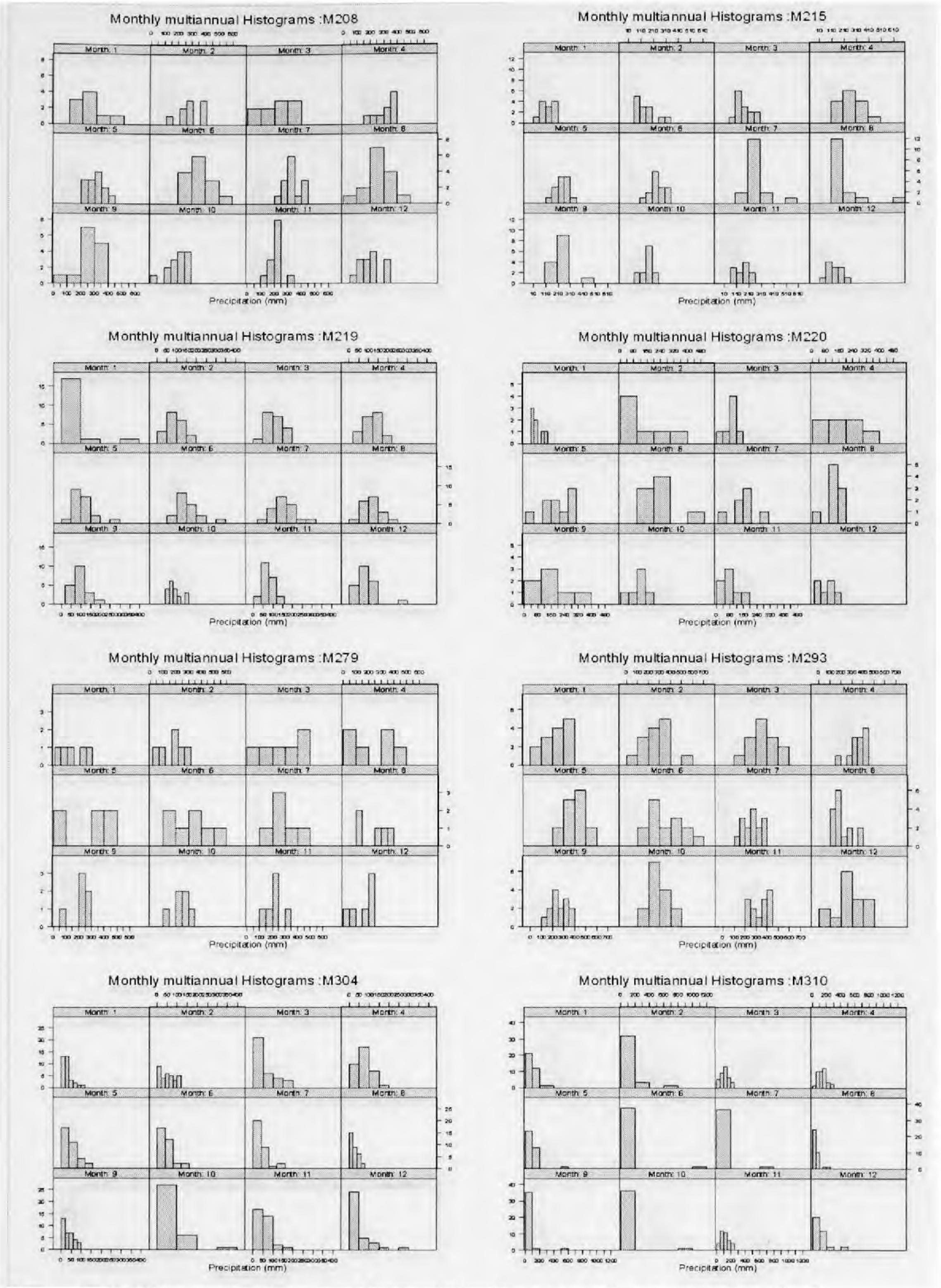


Figure D.1: Histograms for monthly precipitation per station (…continuation)

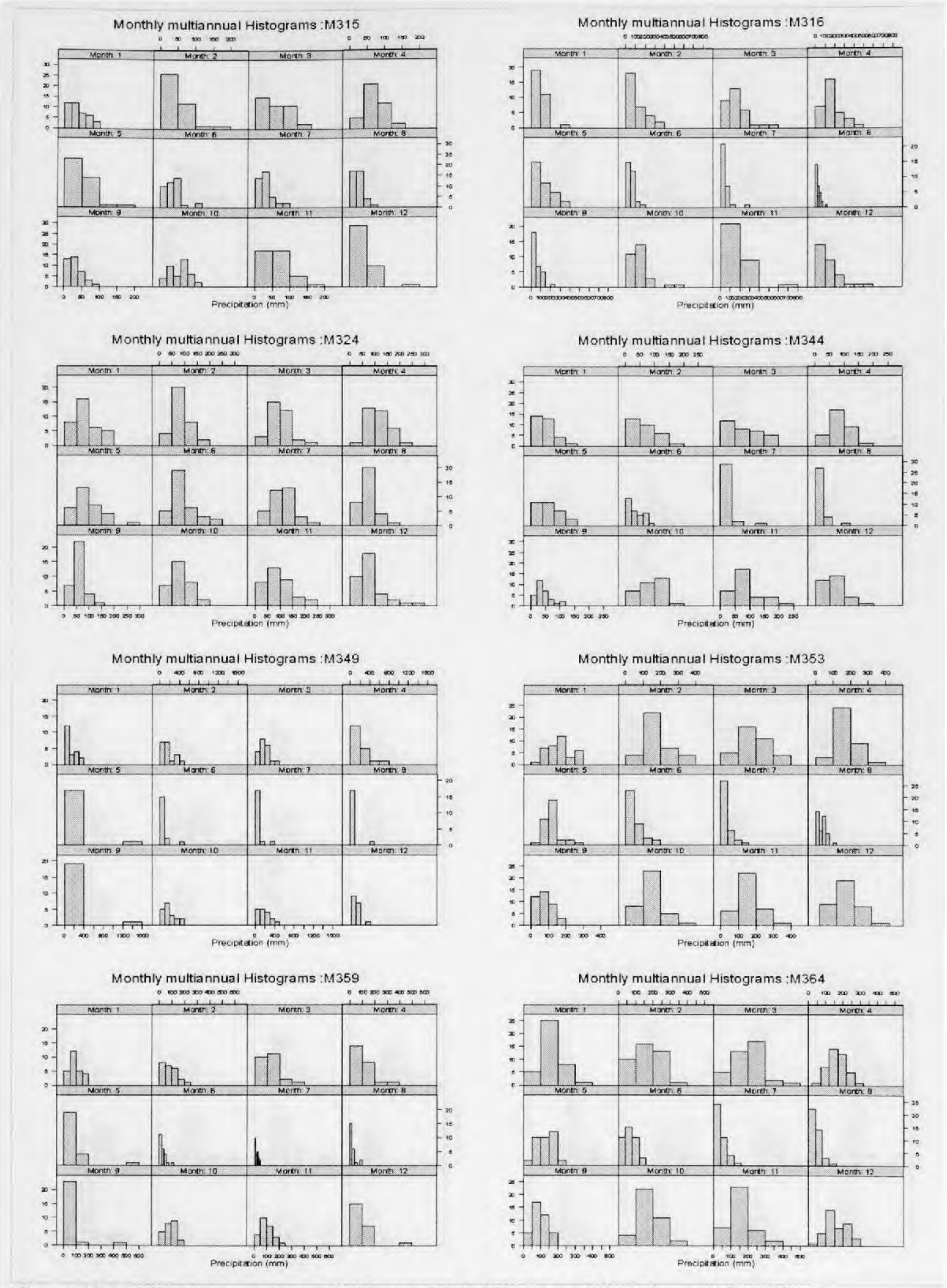


Figure D.1: Histograms for monthly precipitation per station (…continuation)

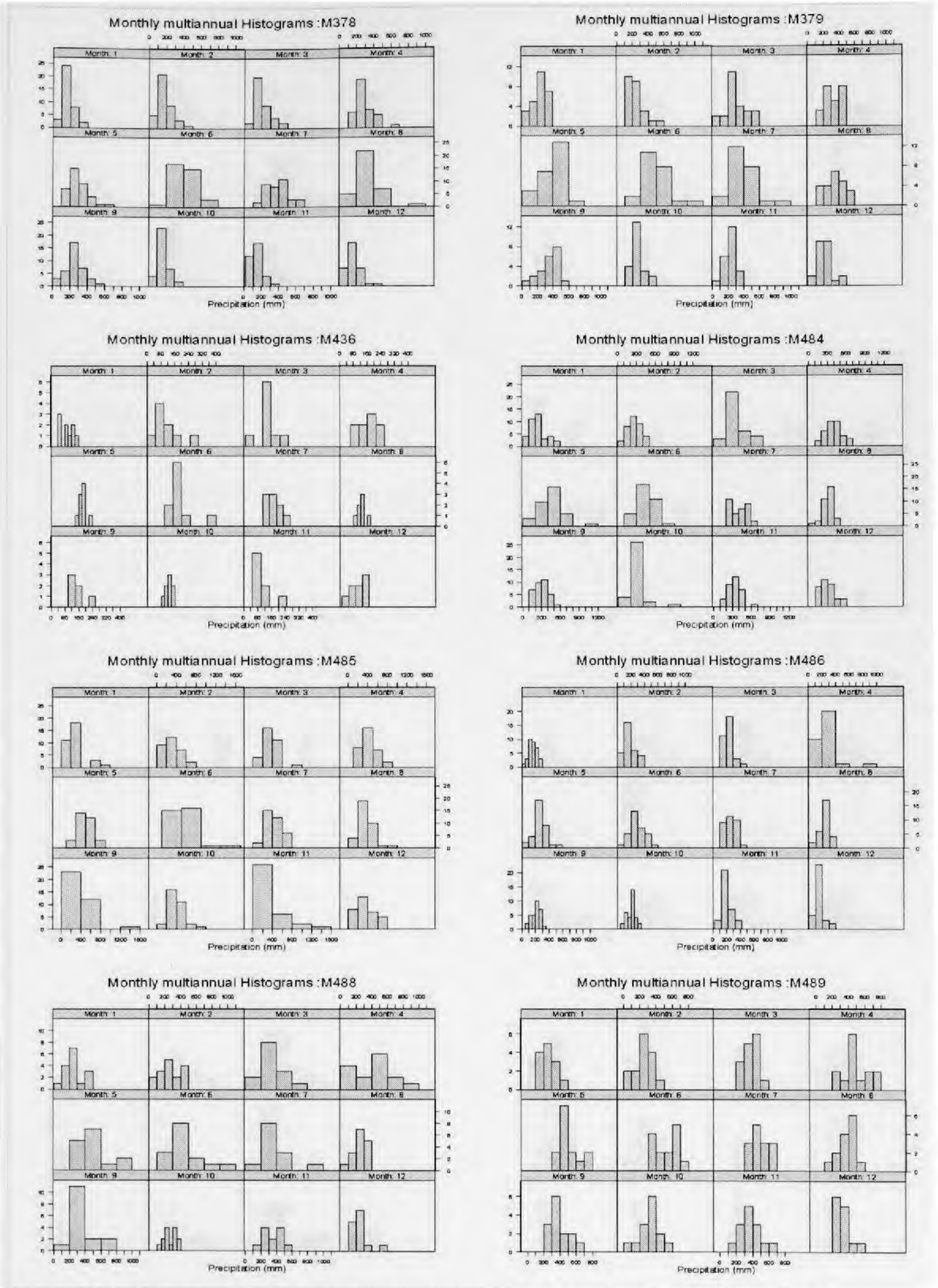
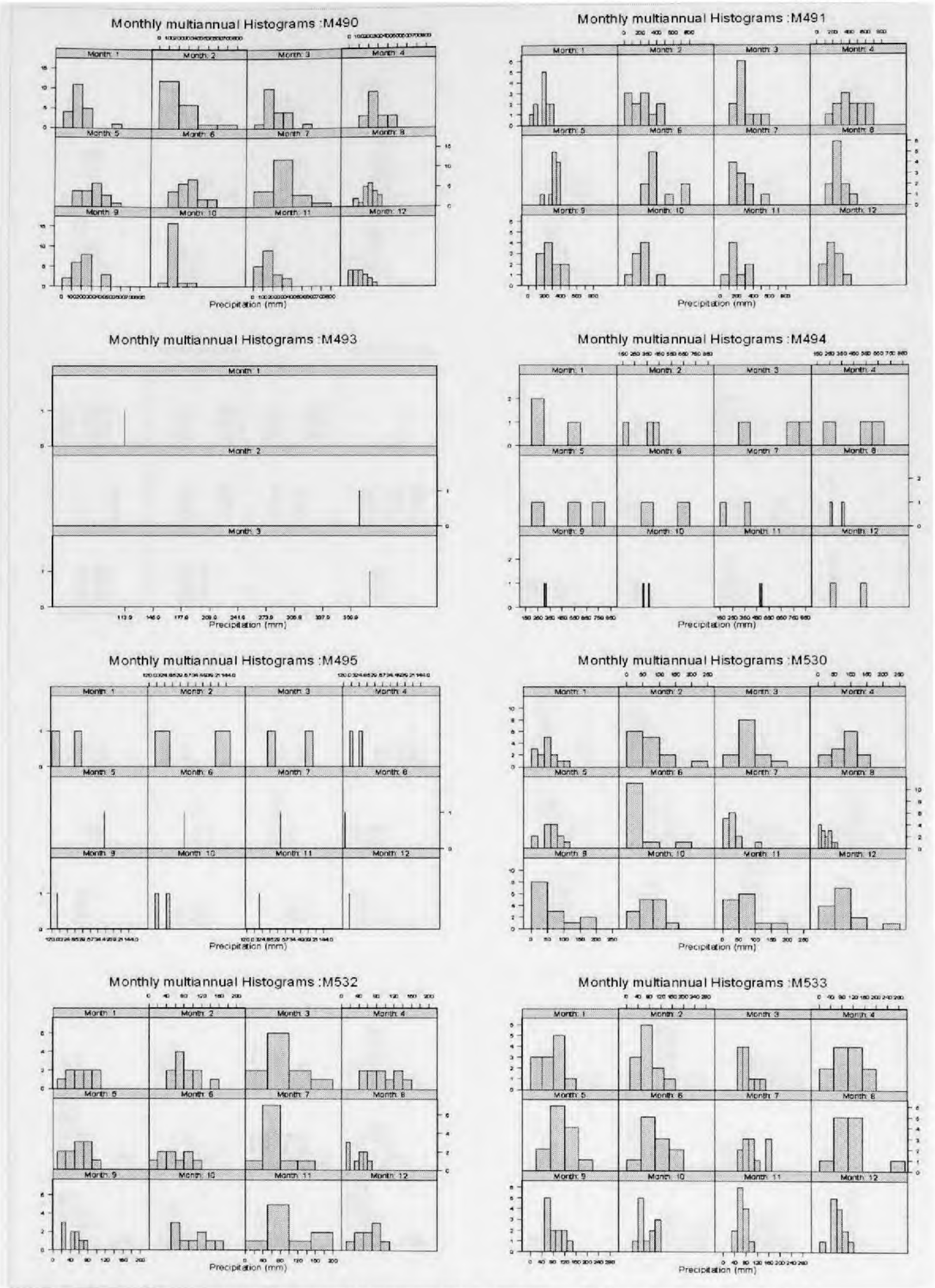


Figure D.1: Histograms for monthly precipitation per station (…continuation)



Monthly multiannual Histograms :M490

Monthly multiannual Histograms :M491

Monthly multiannual Histograms :M493

Monthly multiannual Histograms :M494

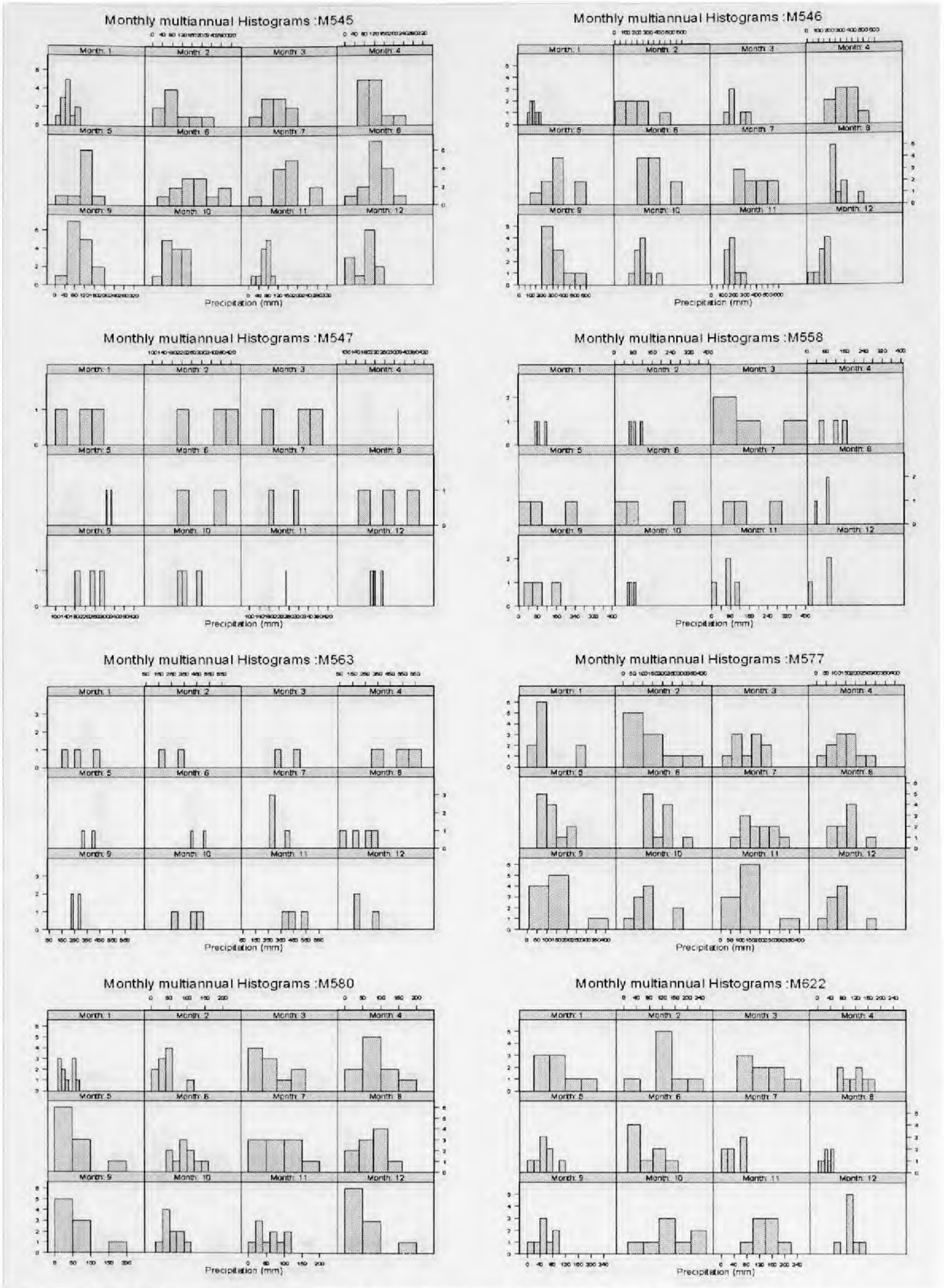
Monthly multiannual Histograms :M495

Monthly multiannual Histograms :M530

Monthly multiannual Histograms :M532

Monthly multiannual Histograms :M533

Figure D.1: Histograms for monthly precipitation per station (…continuation)



Monthly multiannual Histograms :M545

Monthly multiannual Histograms :M546

Monthly multiannual Histograms :M547

Monthly multiannual Histograms :M558

Monthly multiannual Histograms :M563

Monthly multiannual Histograms :M577

Monthly multiannual Histograms :M580

Monthly multiannual Histograms :M622

Figure D.1: Histograms for monthly precipitation per station (…continuation)

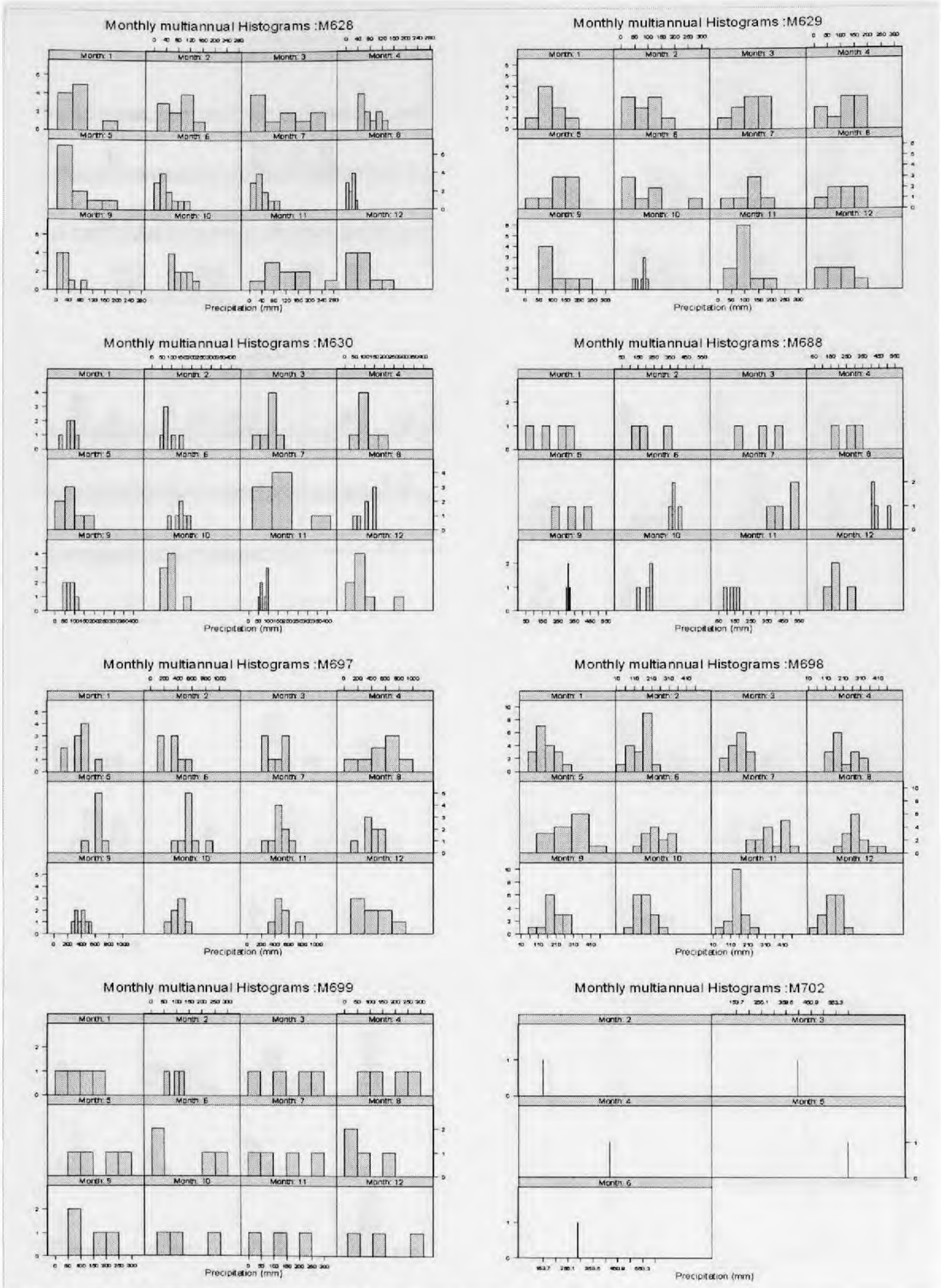


Figure D.1: Histograms for monthly precipitation per station (...continuation)

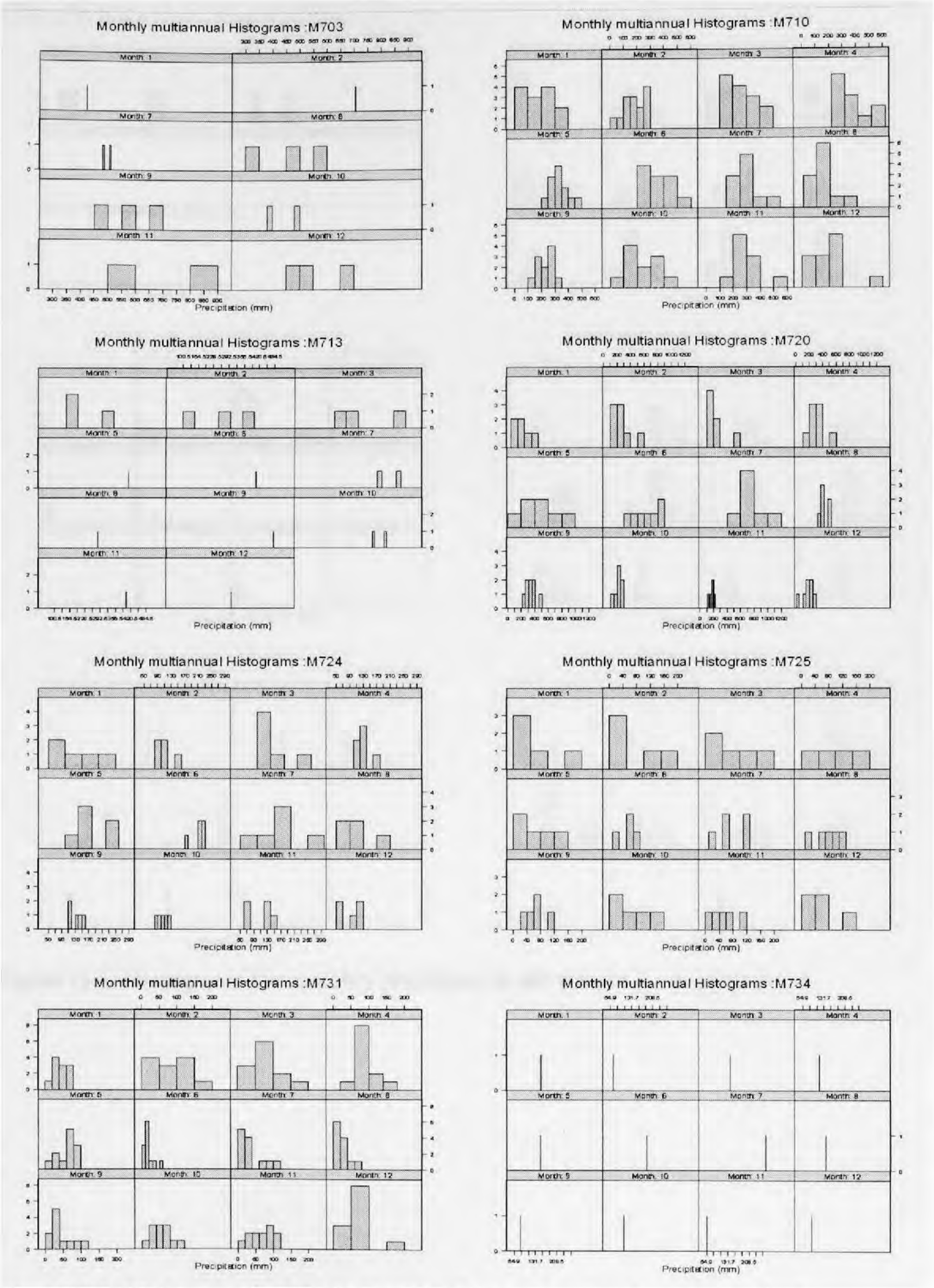


Figure D.1: Histograms for monthly precipitation per station (...continuation)

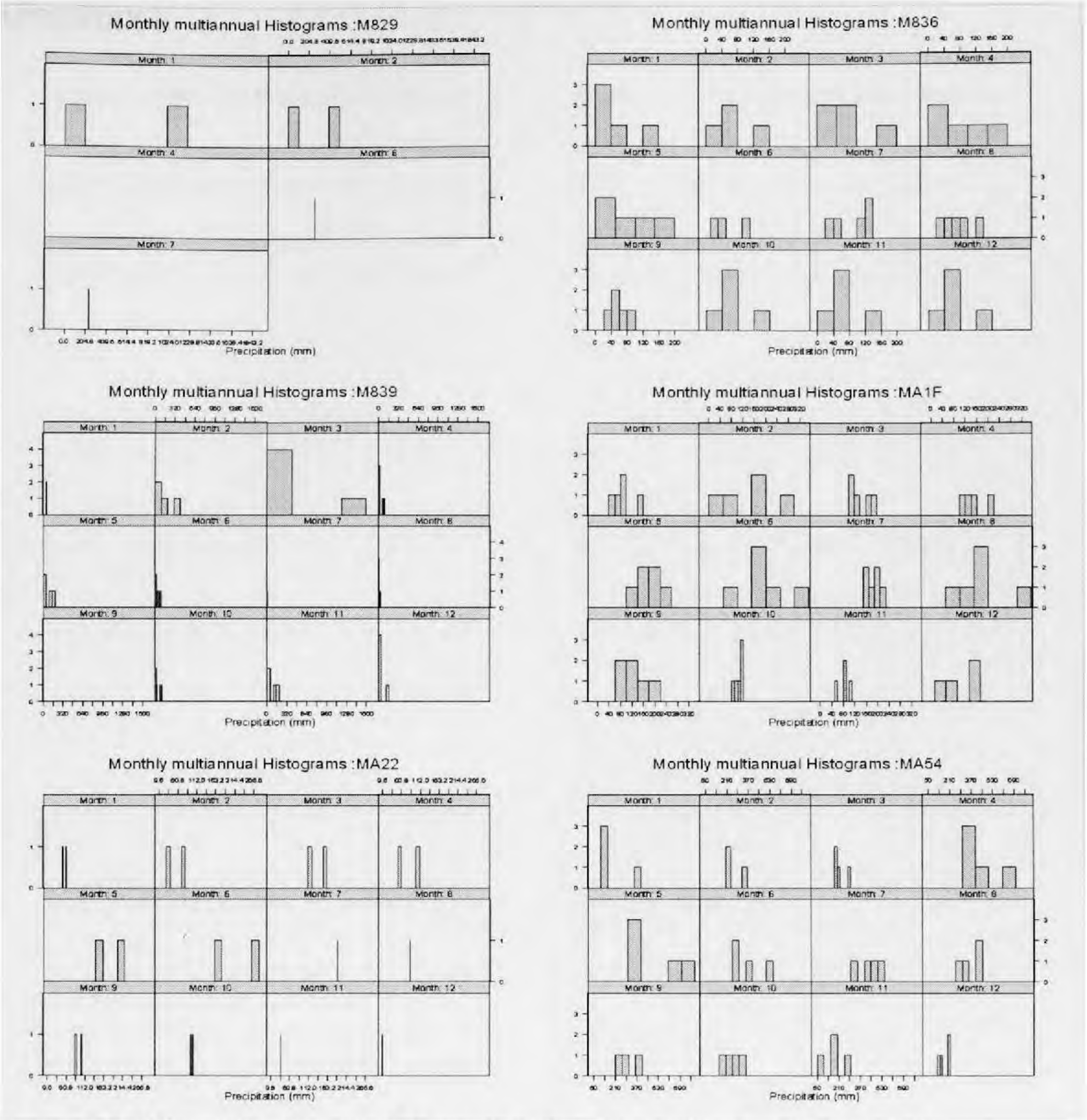


Figure D.1: Histograms for monthly precipitation per station (…continuation)

APPENDIX E

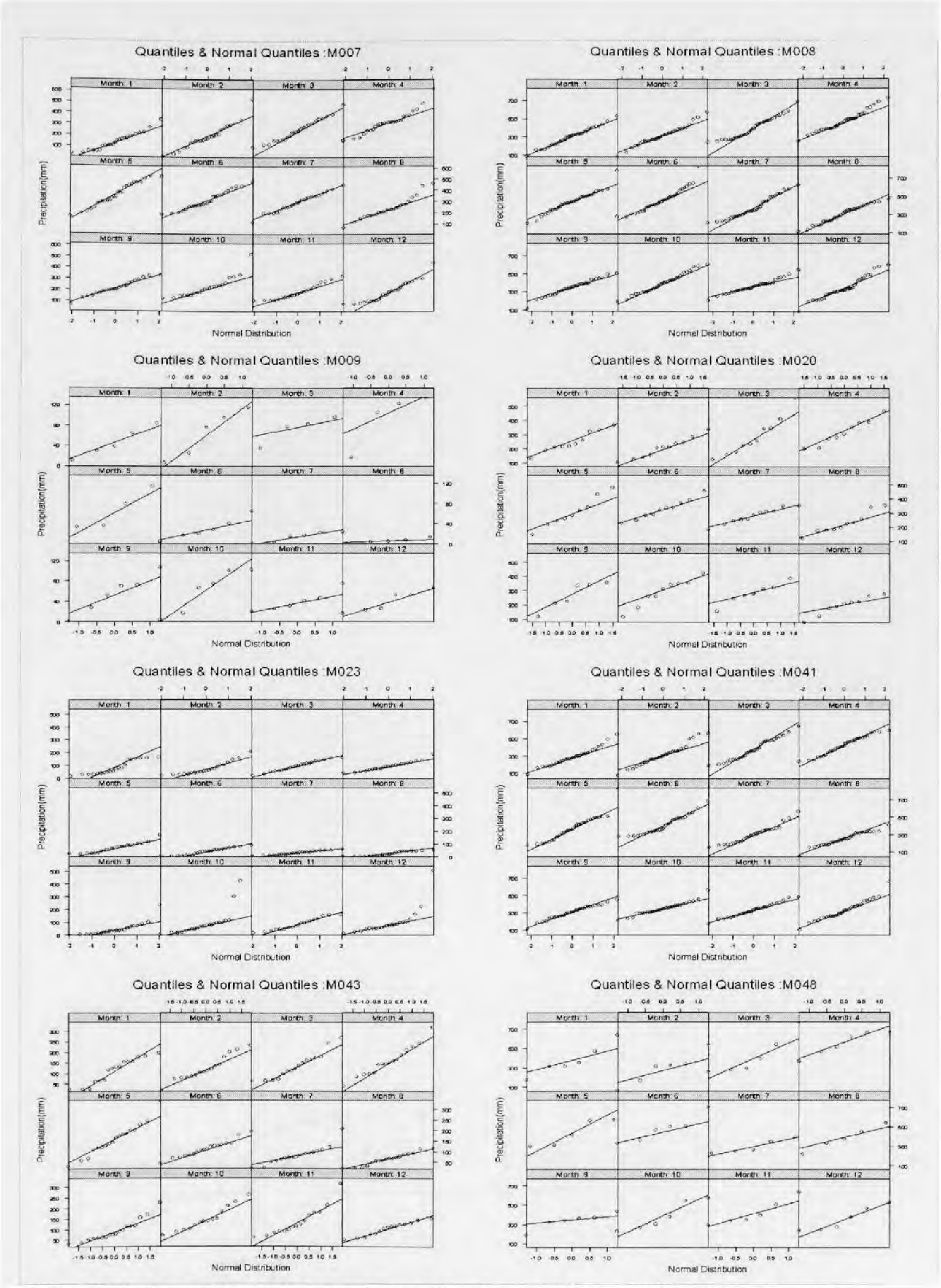


Figure E.1: Quantiles and normal quantiles for monthly precipitation per station.

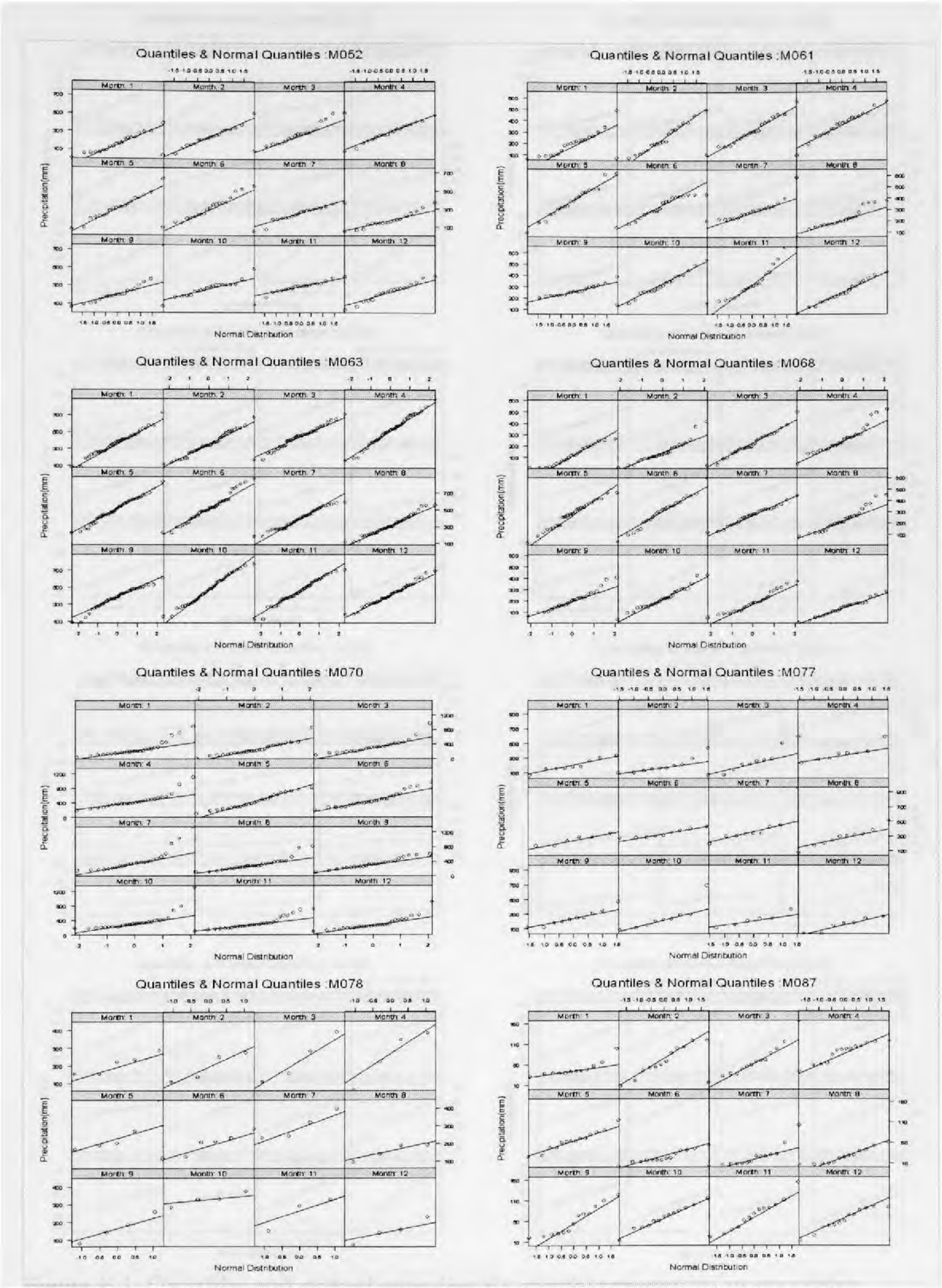


Figure E.1: Quantiles and normal quantiles for monthly precipitation per station (…continuation)

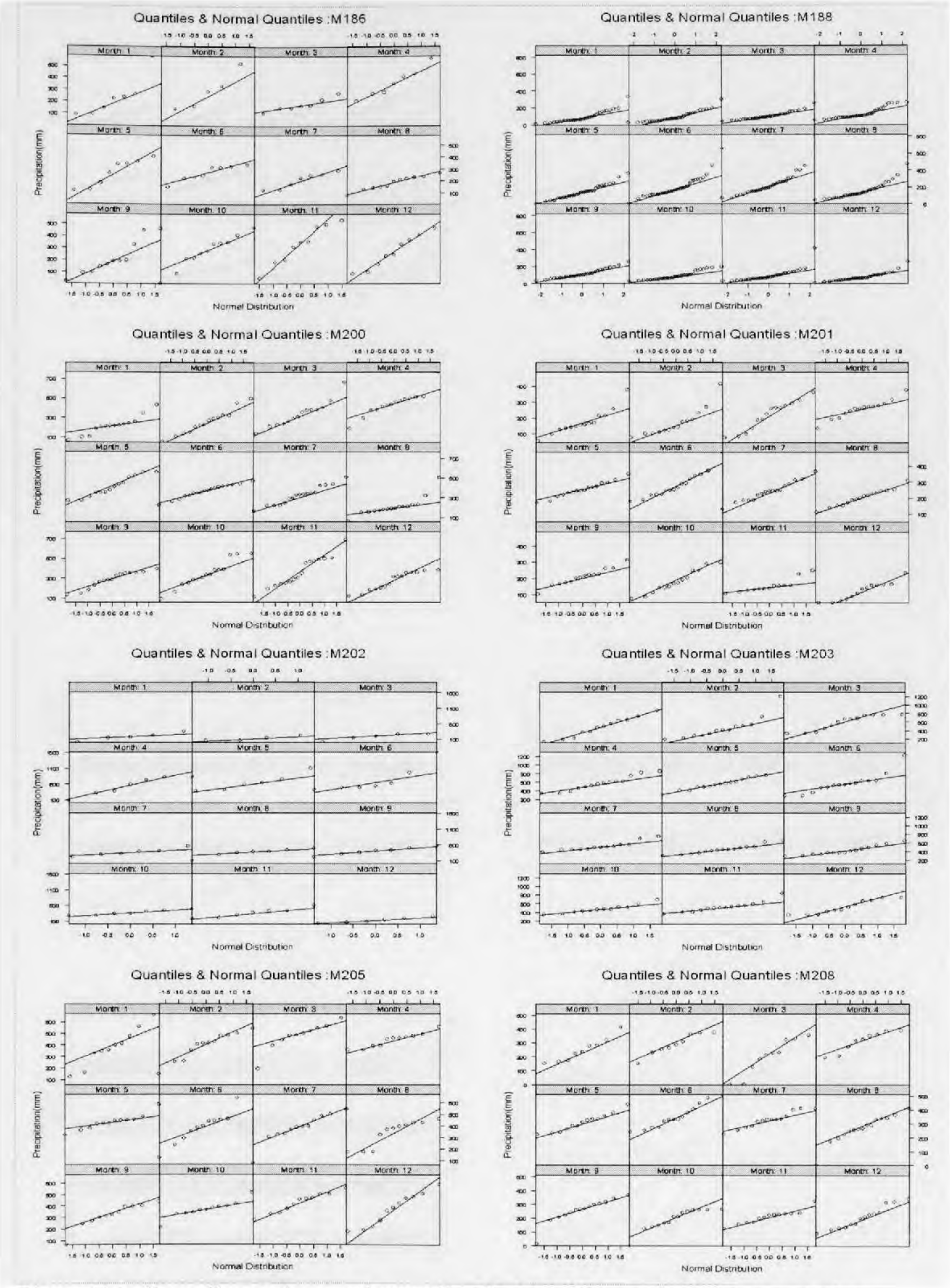
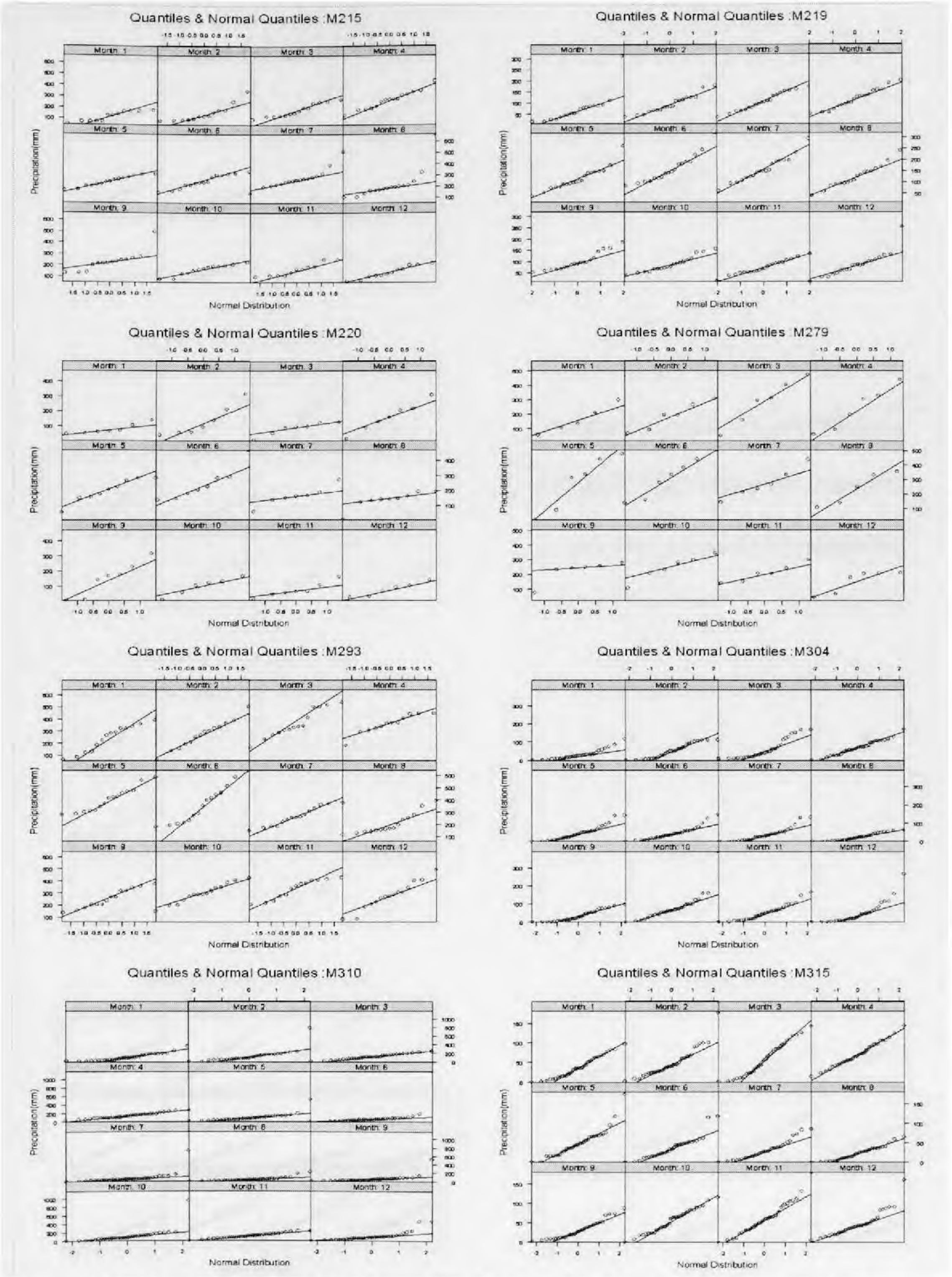


Figure E.1: Quantiles and normal quantiles for monthly precipitation per station (...continuation)



Quantiles & Normal Quantiles :M215

Quantiles & Normal Quantiles :M219

Quantiles & Normal Quantiles :M220

Quantiles & Normal Quantiles :M279

Quantiles & Normal Quantiles :M293

Quantiles & Normal Quantiles :M304

Quantiles & Normal Quantiles :M310

Quantiles & Normal Quantiles :M315

Figure E.1: Quantiles and normal quantiles for monthly precipitation per station (...continuation)

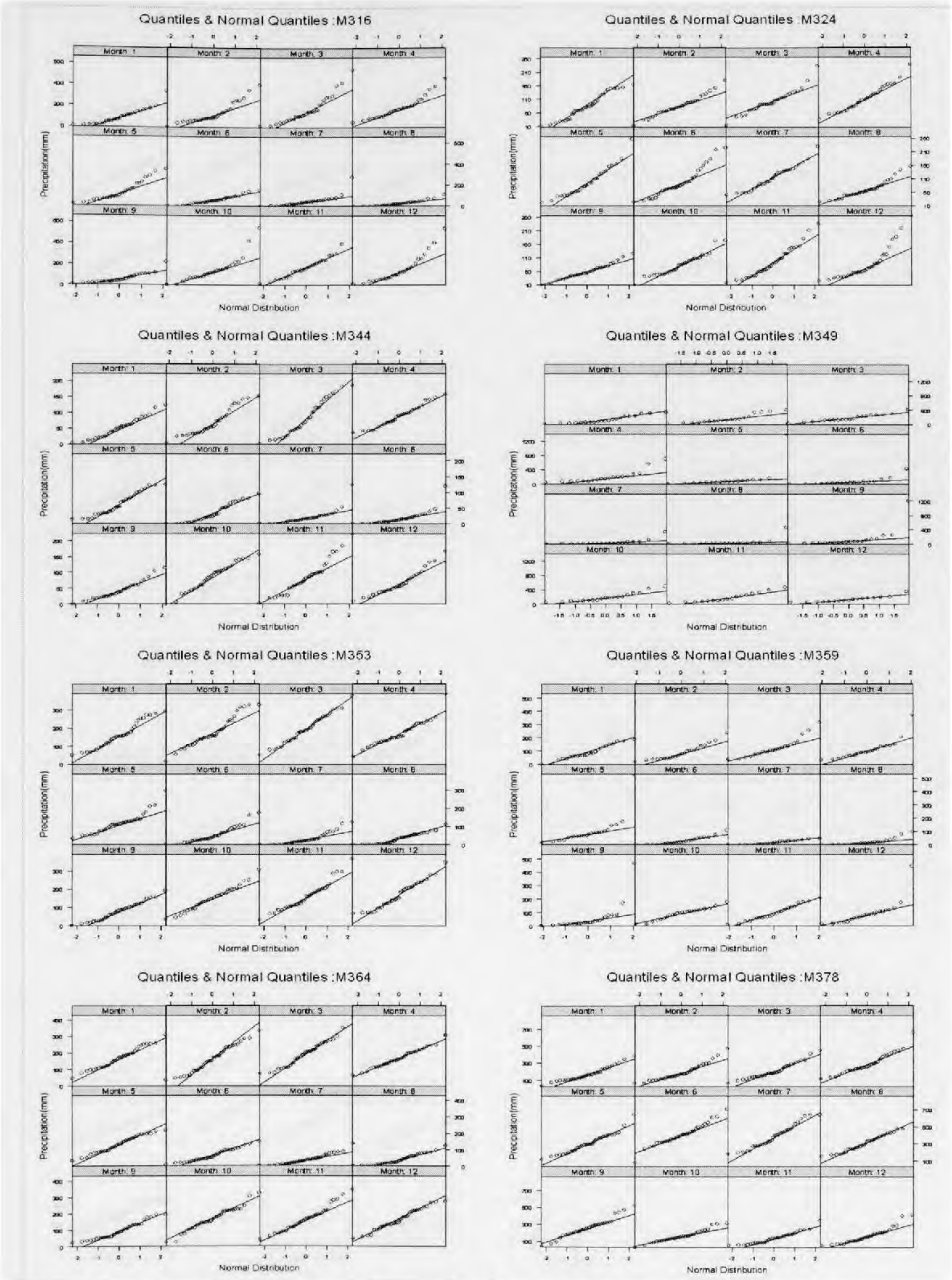


Figure E.1: Quantiles and normal quantiles for monthly precipitation per station (...continuation)

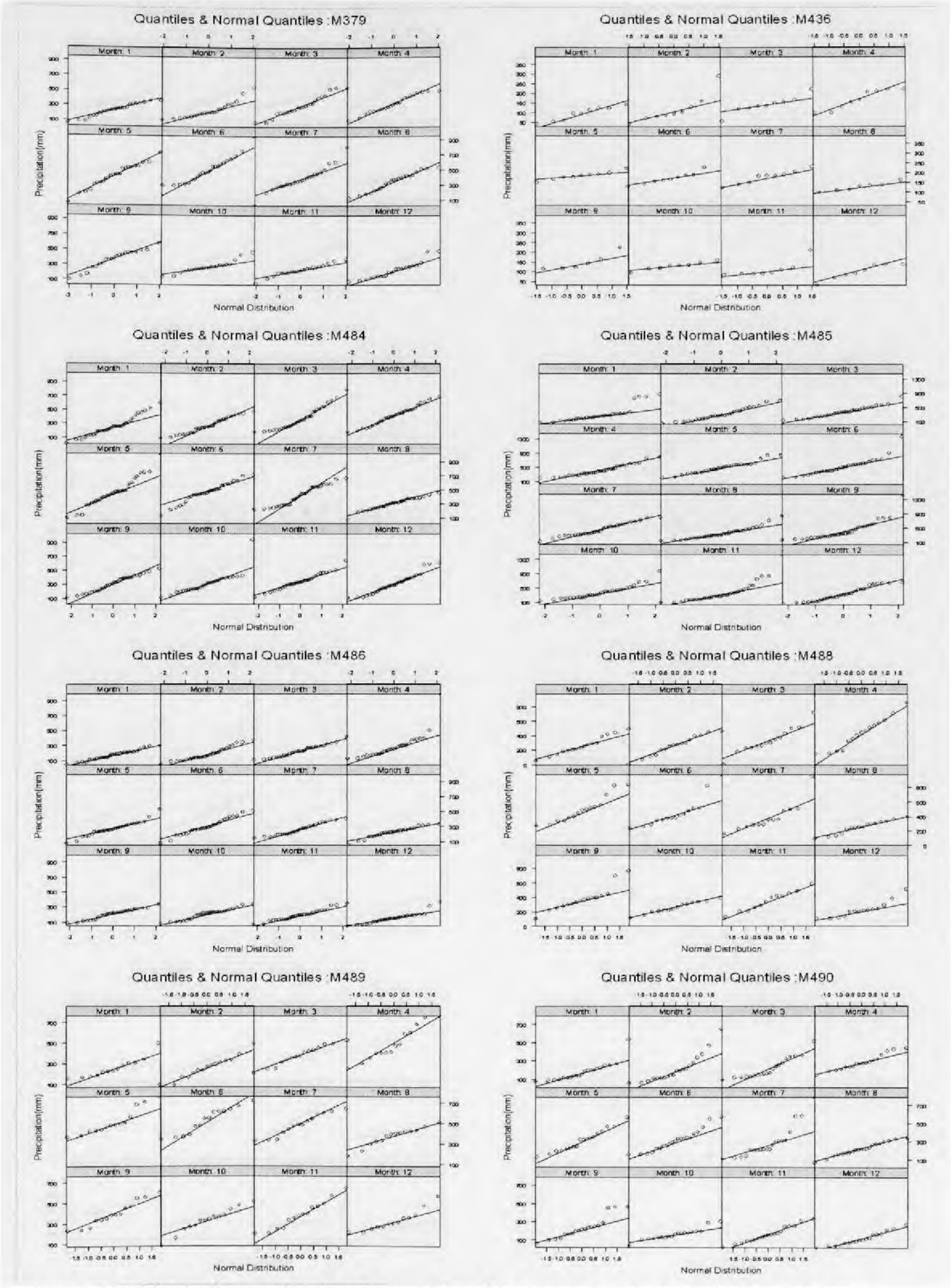
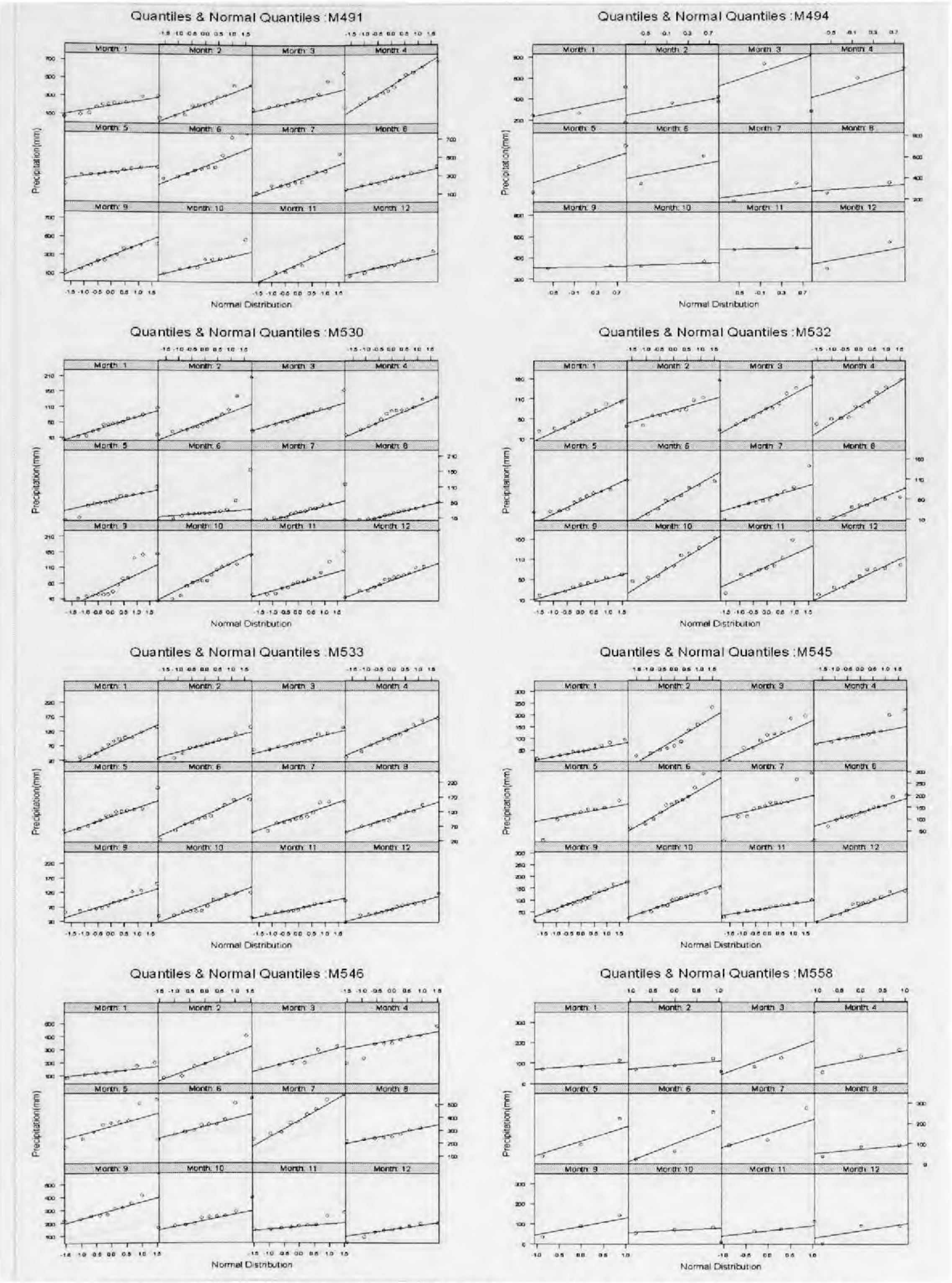


Figure E.1: Quantiles and normal quantiles for monthly precipitation per station (...continuation)



Quantiles & Normal Quantiles :M491

Quantiles & Normal Quantiles :M494

Quantiles & Normal Quantiles :M530

Quantiles & Normal Quantiles :M532

Quantiles & Normal Quantiles :M533

Quantiles & Normal Quantiles :M545

Quantiles & Normal Quantiles :M546

Quantiles & Normal Quantiles :M558

Figure E.1: Quantiles and normal quantiles for monthly precipitation per station (...continuation)

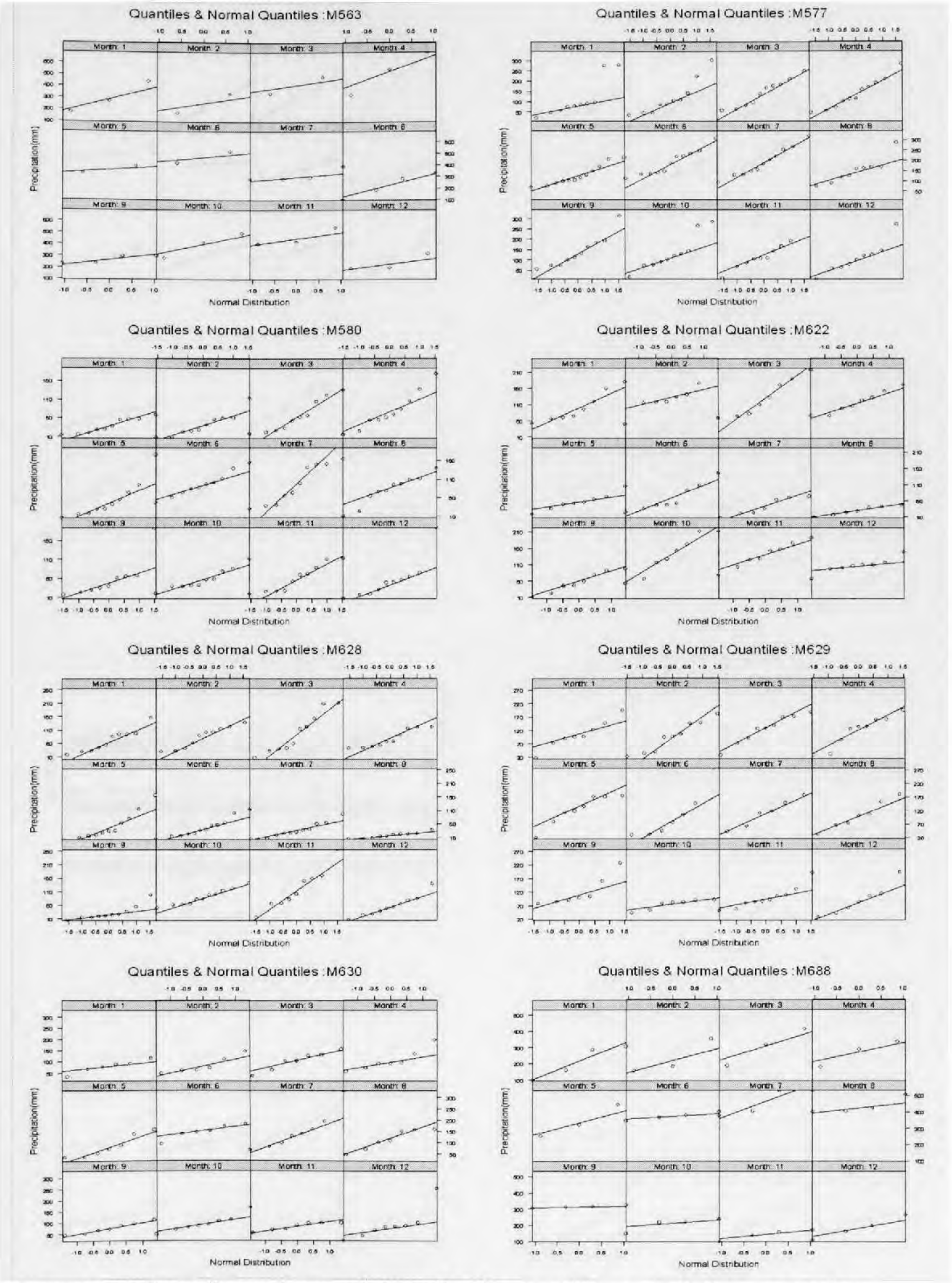


Figure E.1: Quantiles and normal quantiles for monthly precipitation per station (...continuation)

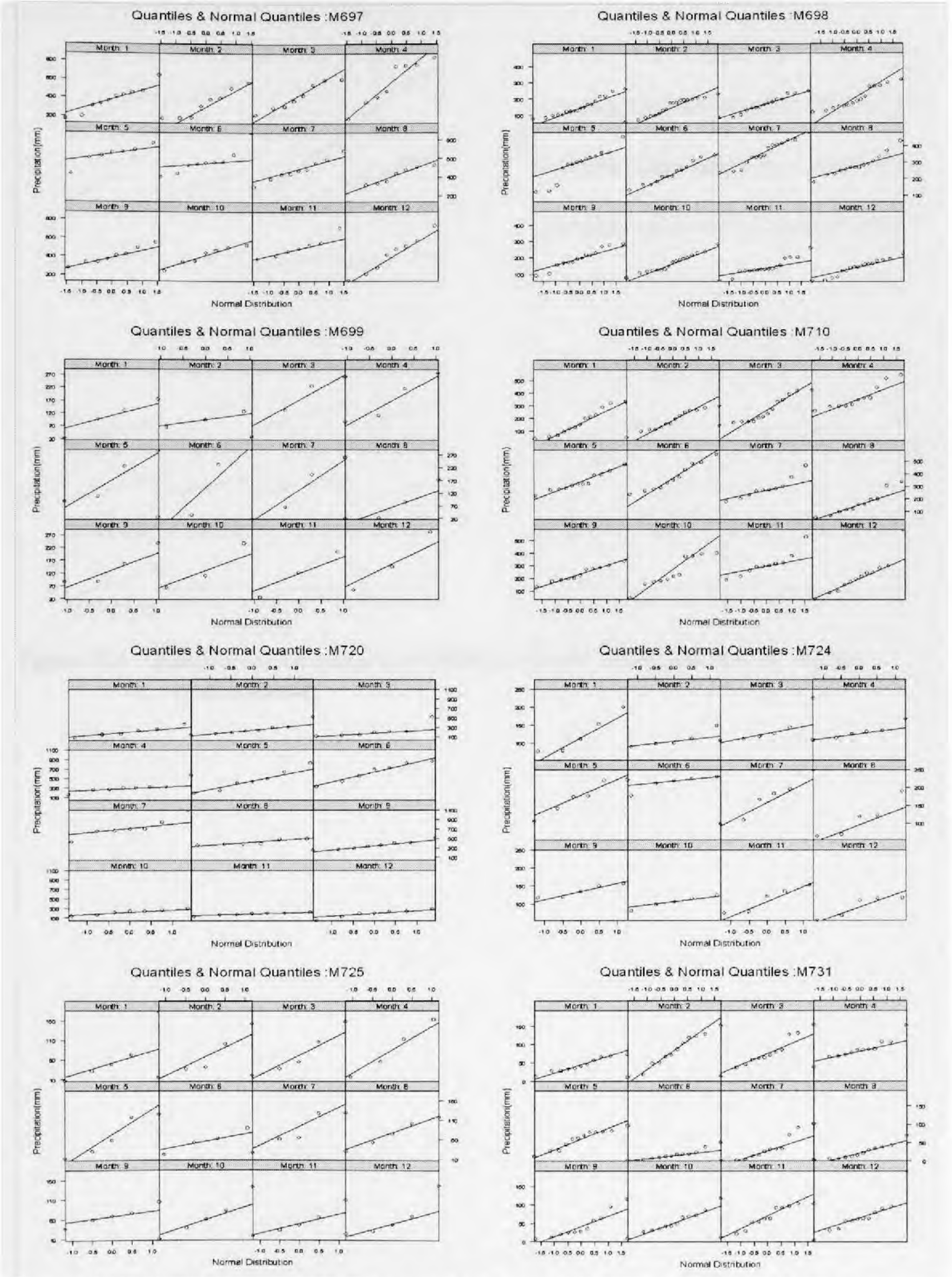
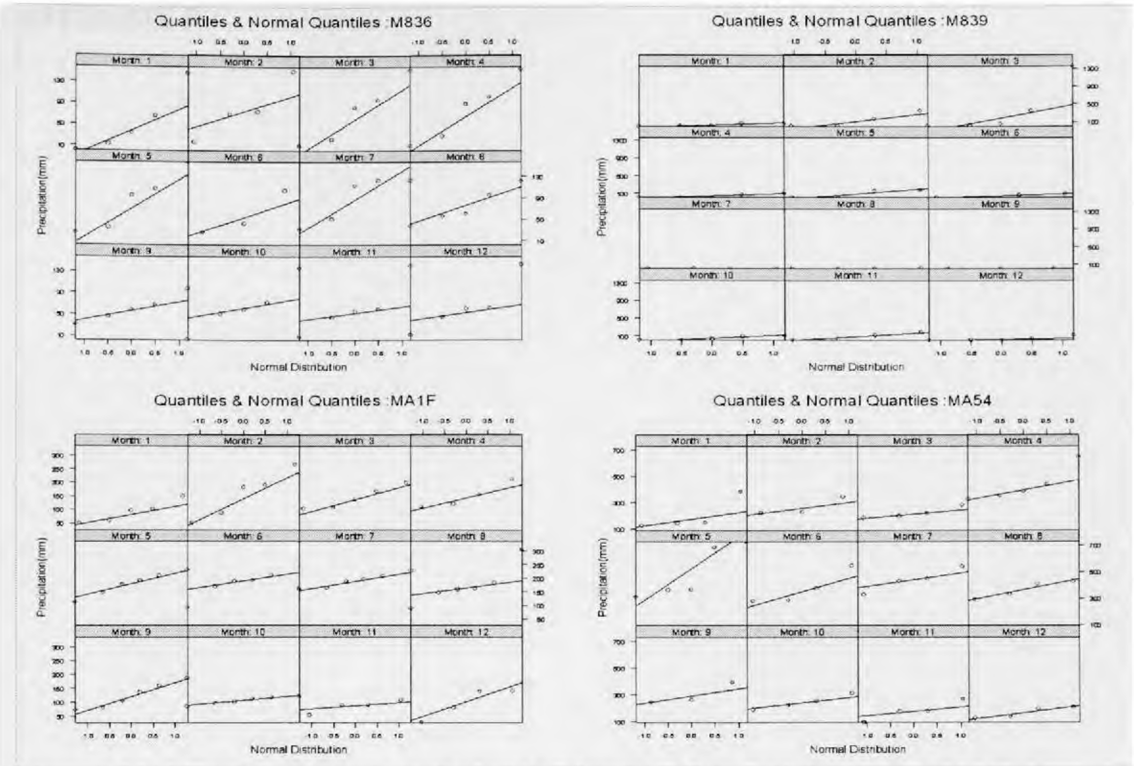


Figure E.1: Quantiles and normal quantiles for monthly precipitation per station (...continuation)



Quantiles & Normal Quantiles :M836

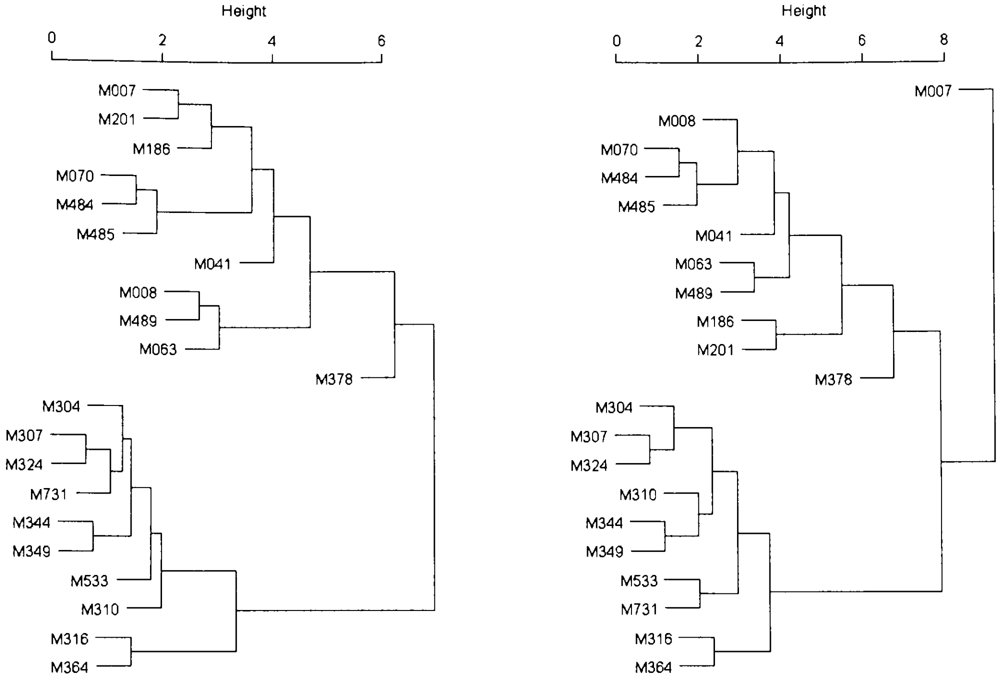
Quantiles & Normal Quantiles :M839

Quantiles & Normal Quantiles :MA1F

Quantiles & Normal Quantiles :MA54

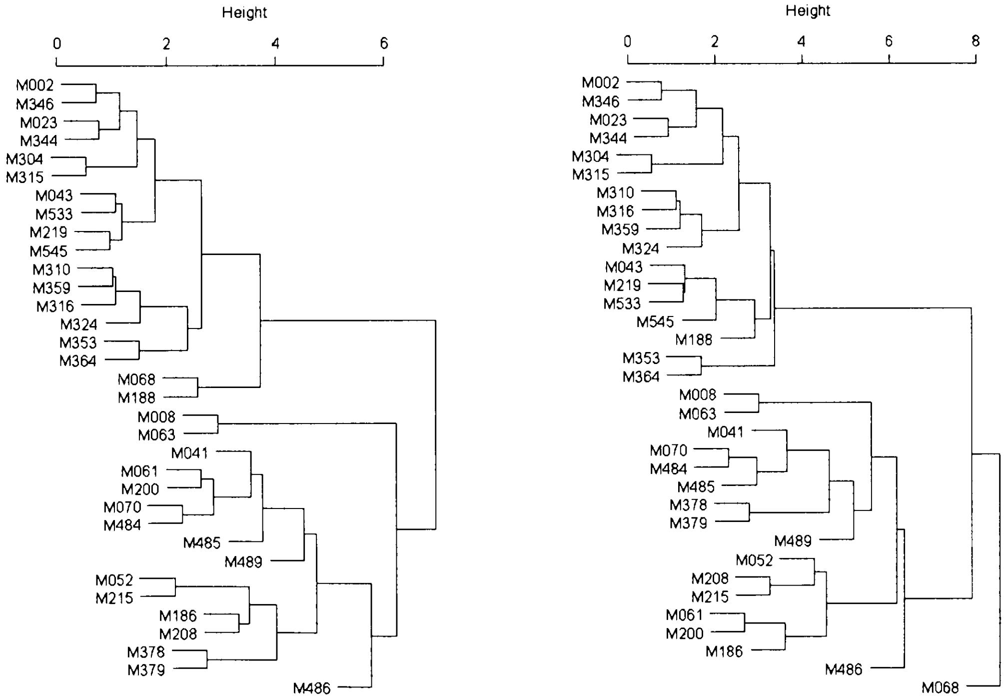
Figure E.1: Quantiles and normal quantiles for monthly precipitation per station (...continuation)

APPENDIX F



Cluster tree euclidian distante(12 monthly values) anno : 1980

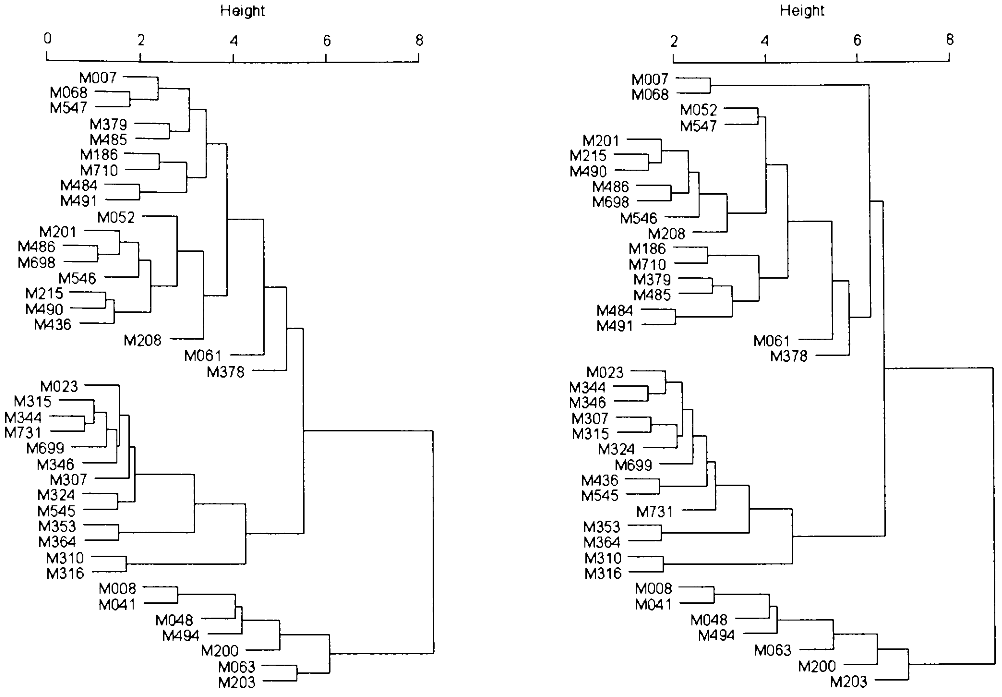
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno . 1980



Cluster tree euclidian distante(12 monthly values) anno . 1981

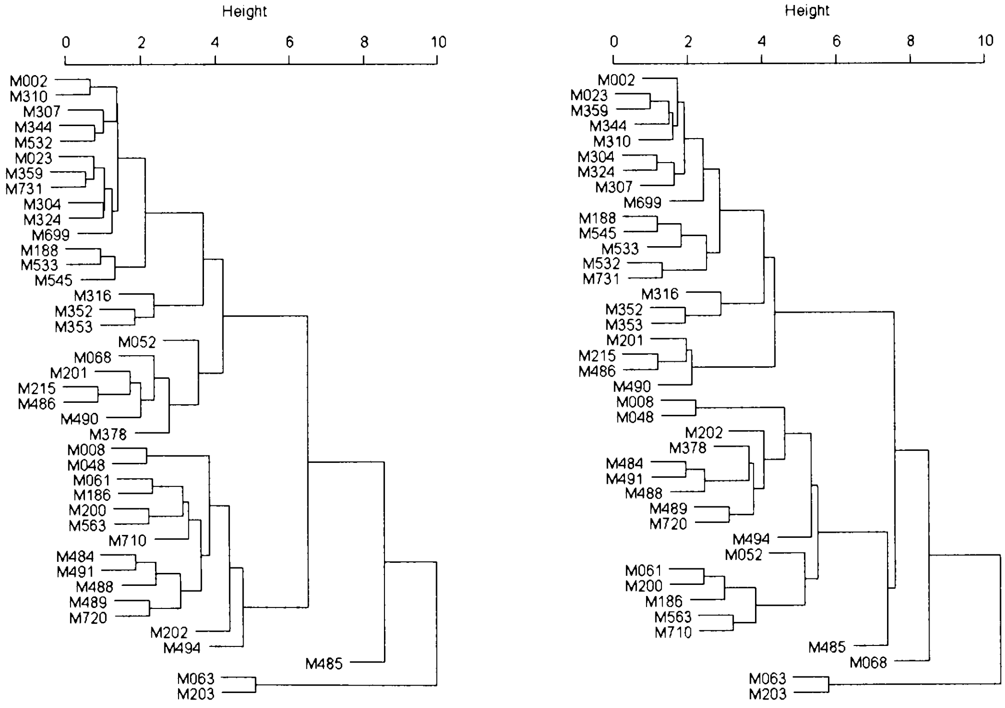
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno 1981

Figure F.1: Cluster Classification for monthly precipitation per year.



Cluster tree euclidian distante(12 monthly values) anno : 1982

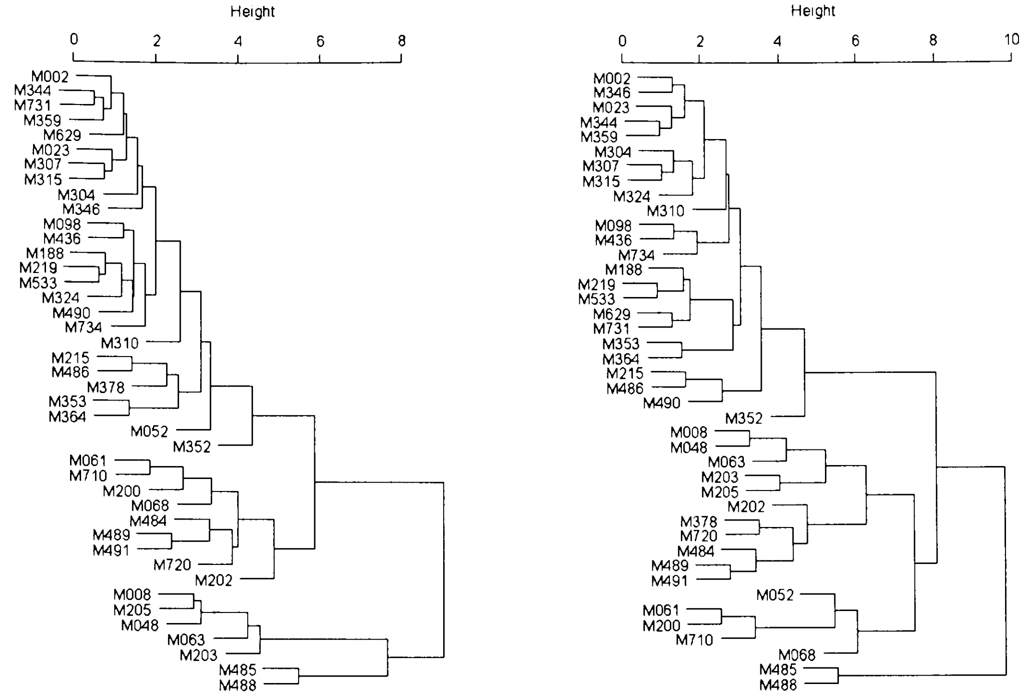
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno : 1982



Cluster tree euclidian distante(12 monthly values) anno 1983

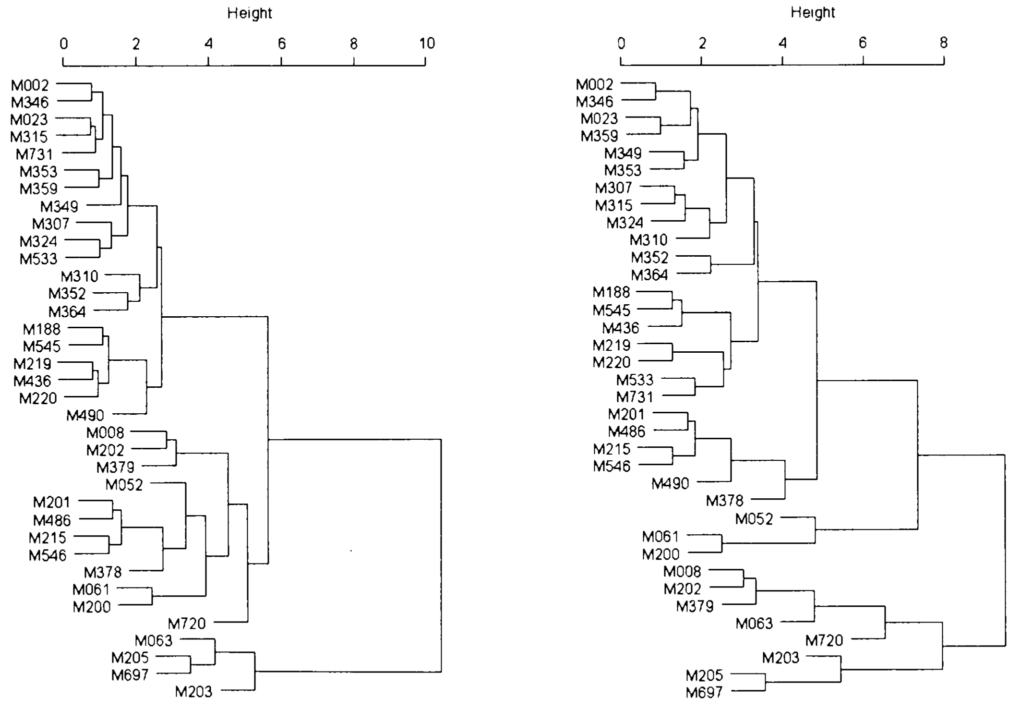
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno : 1983

Figure F.1: Cluster Classification for monthly precipitation per year (...continuation).



Cluster tree euclidian distante(12 monthly values) anno 1984

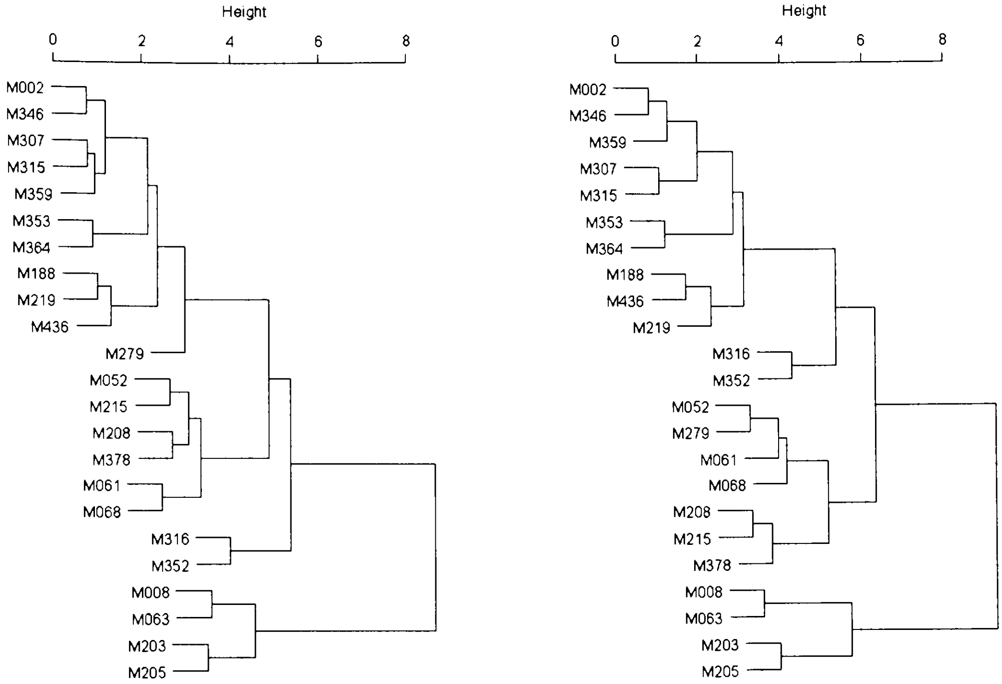
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno : 1984



Cluster tree euclidian distante(12 monthly values) anno 1985

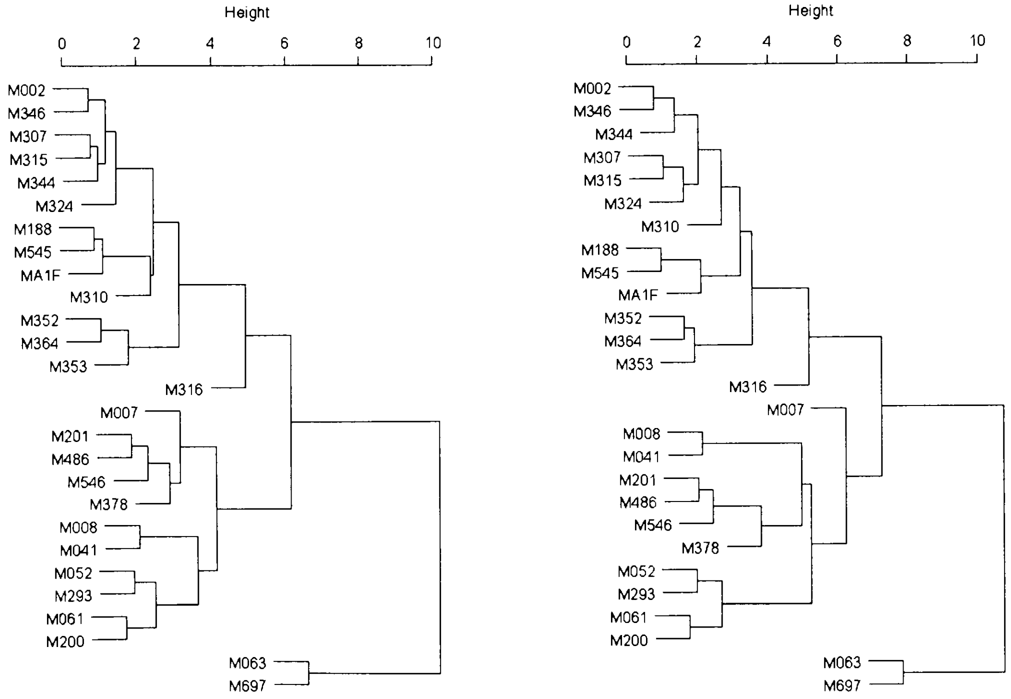
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno 1985

Figure F.1: Cluster Classification for monthly precipitation per year (...continuation).



Cluster tree euclidian distante(12 monthly values) anno : 1986

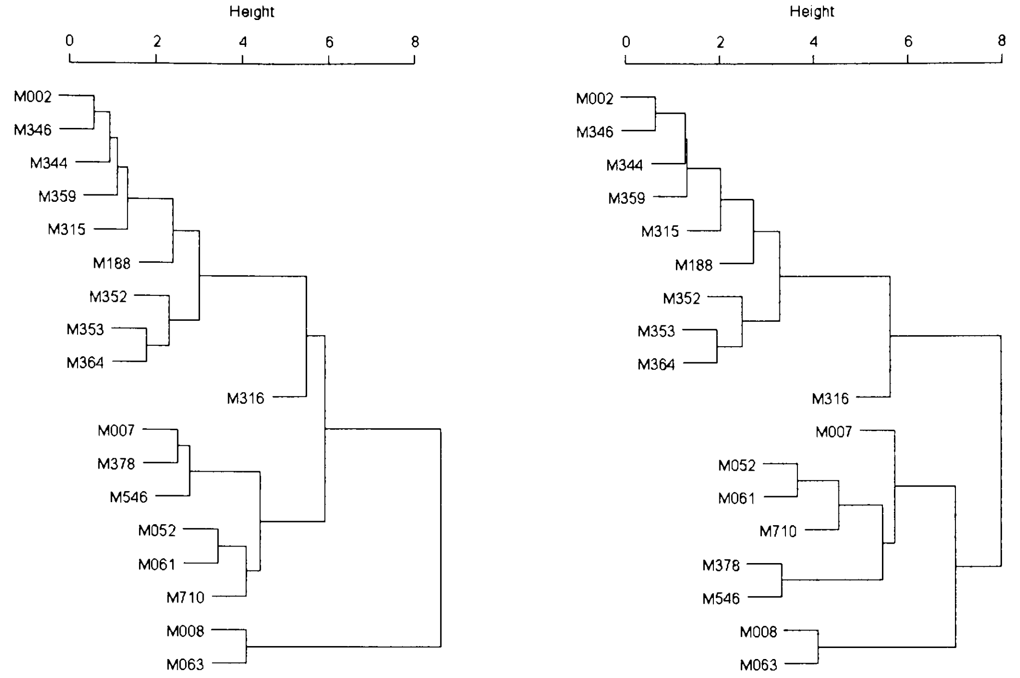
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno : 1986



Cluster tree euclidian distante(12 monthly values) anno : 1987

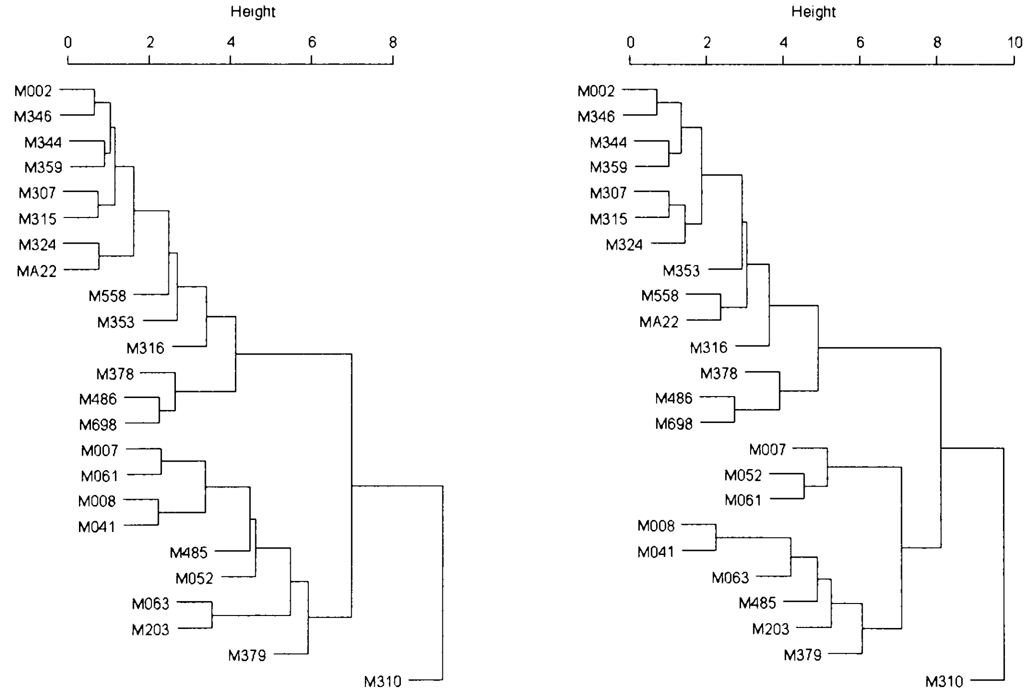
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno : 1987

Figure F.1: Cluster Classification for monthly precipitation per year (…continuation).



Cluster tree euclidian distante(12 monthly values) anno . 1988

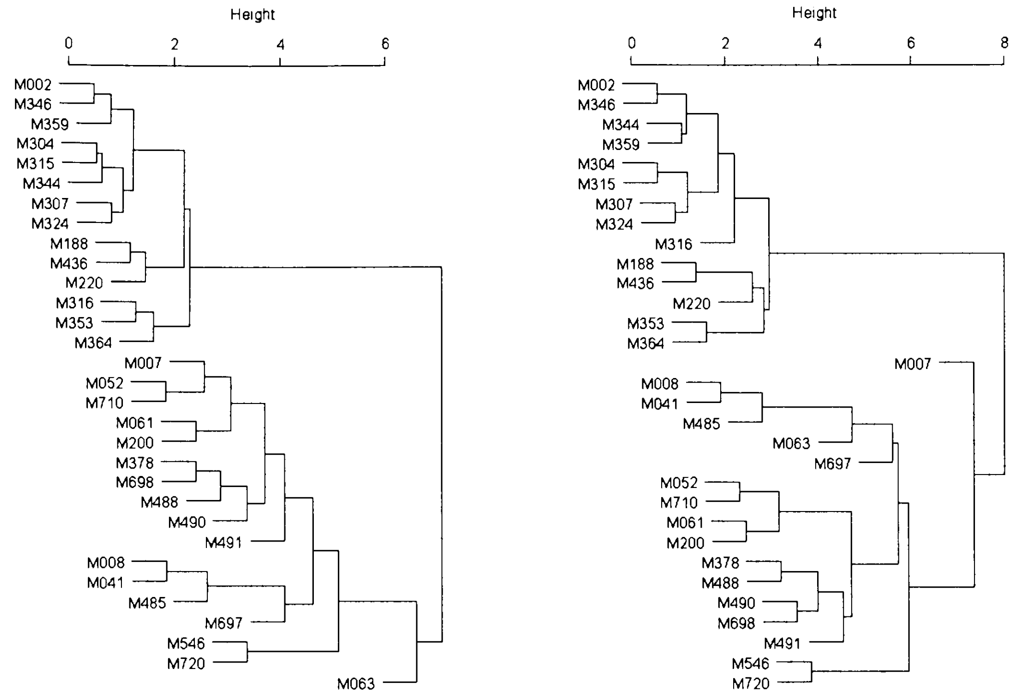
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno : 1988



Cluster tree euclidian distante(12 monthly values) anno 1989

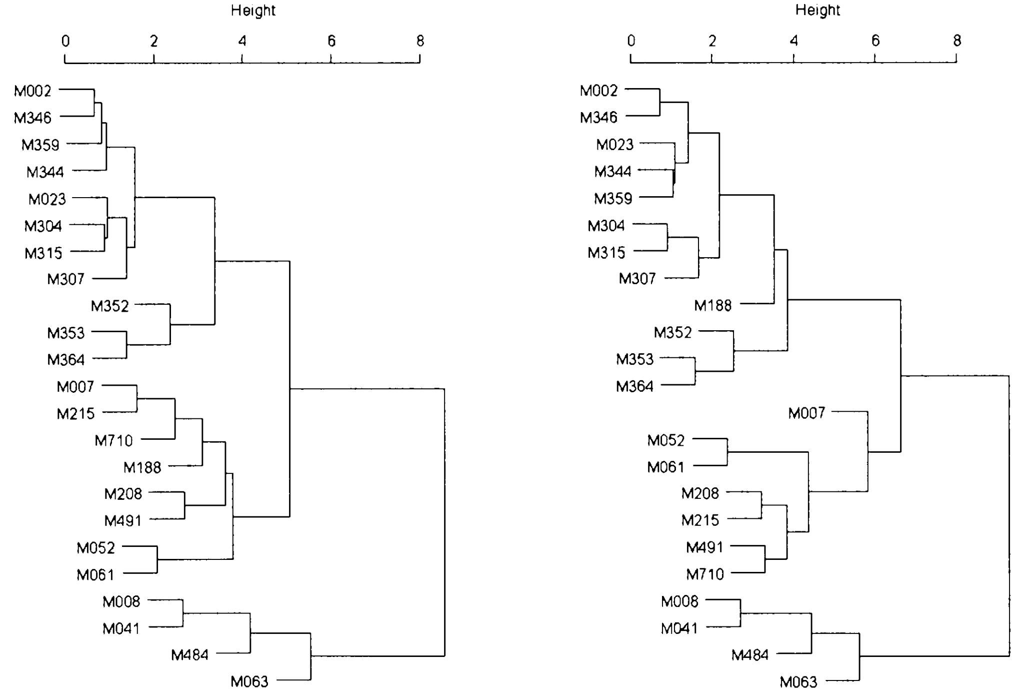
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno 1989

Figure F.1: Cluster Classification for monthly precipitation per year (...continuation).



Cluster tree euclidian distante(12 monthly values) anno 1990

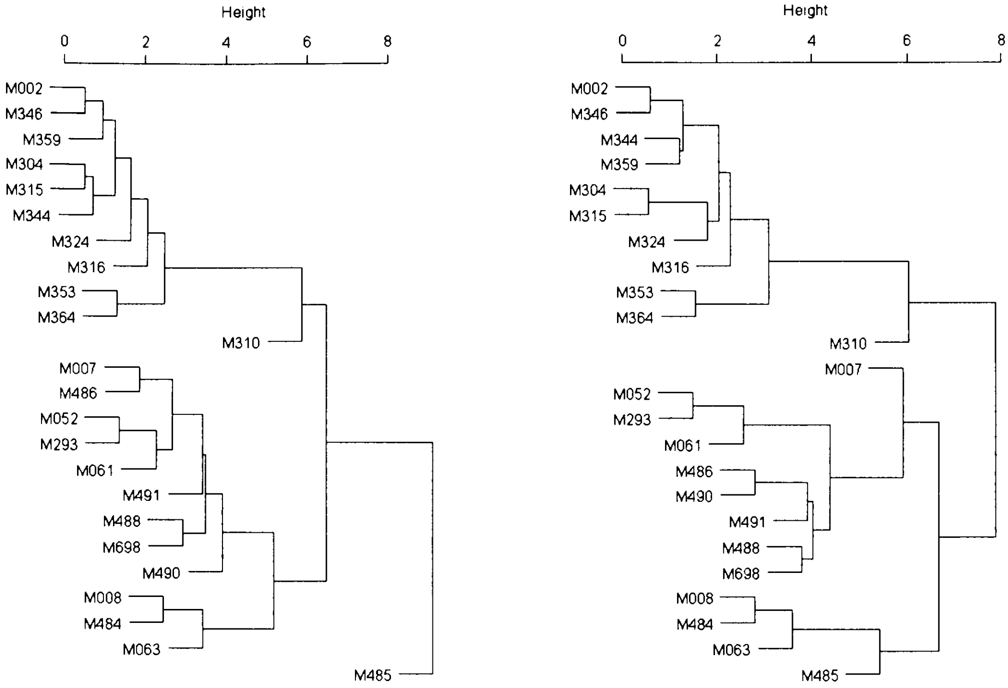
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno : 1990



Cluster tree euclidian distante(12 monthly values) anno 1991

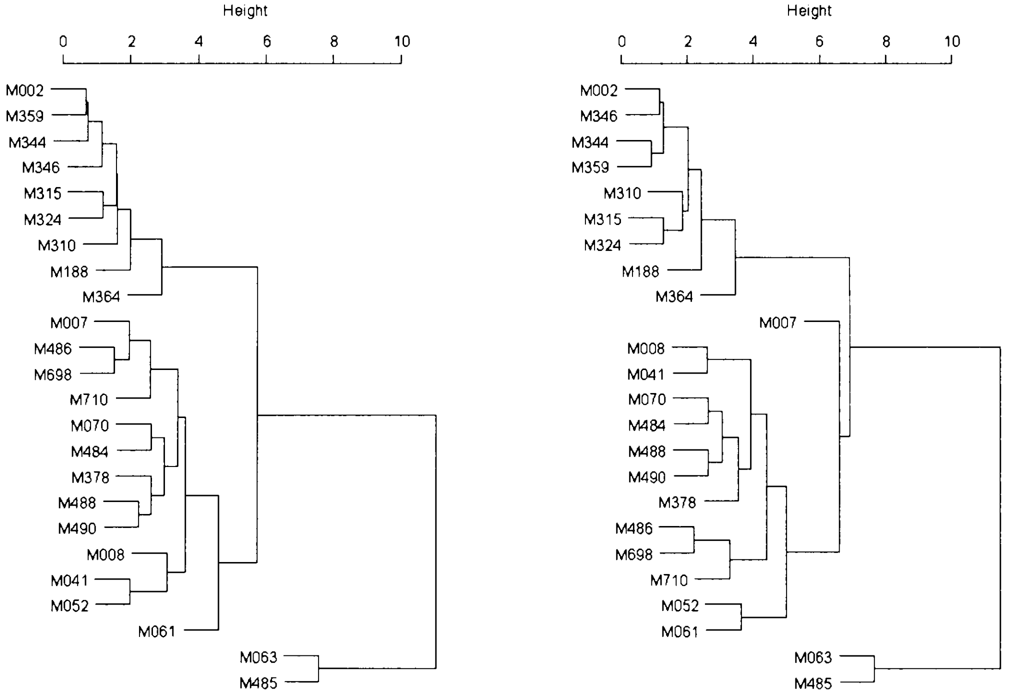
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno 1991

Figure F.1: Cluster Classification for monthly precipitation per year (...continuation).



Cluster tree euclidian distante(12 monthly values) anno : 1992

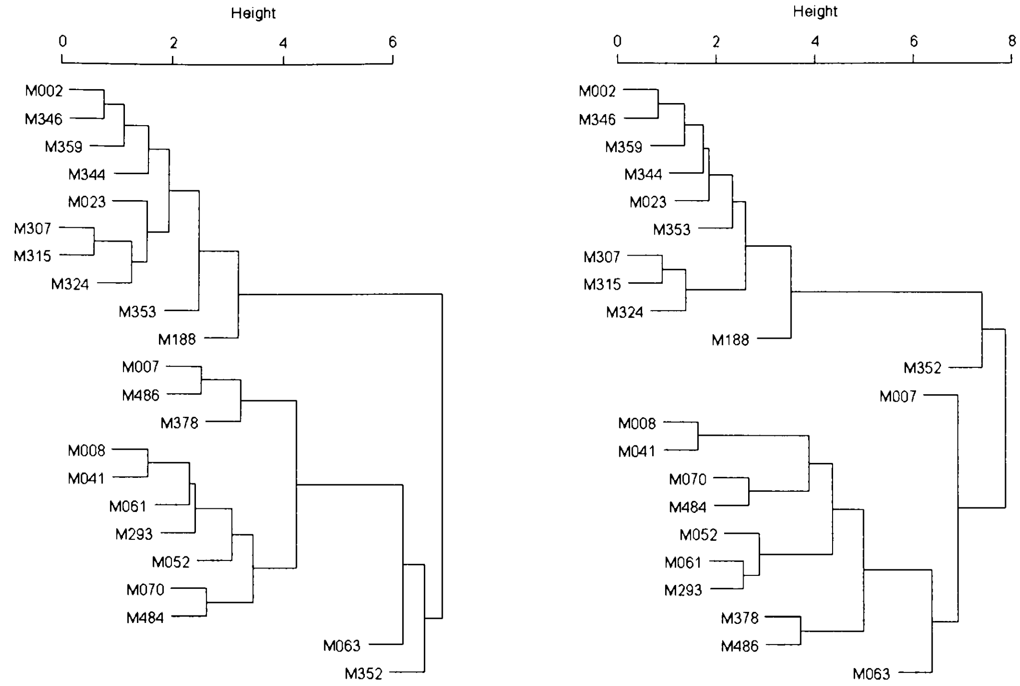
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno : 1992



Cluster tree euclidian distante(12 monthly values) anno 1993

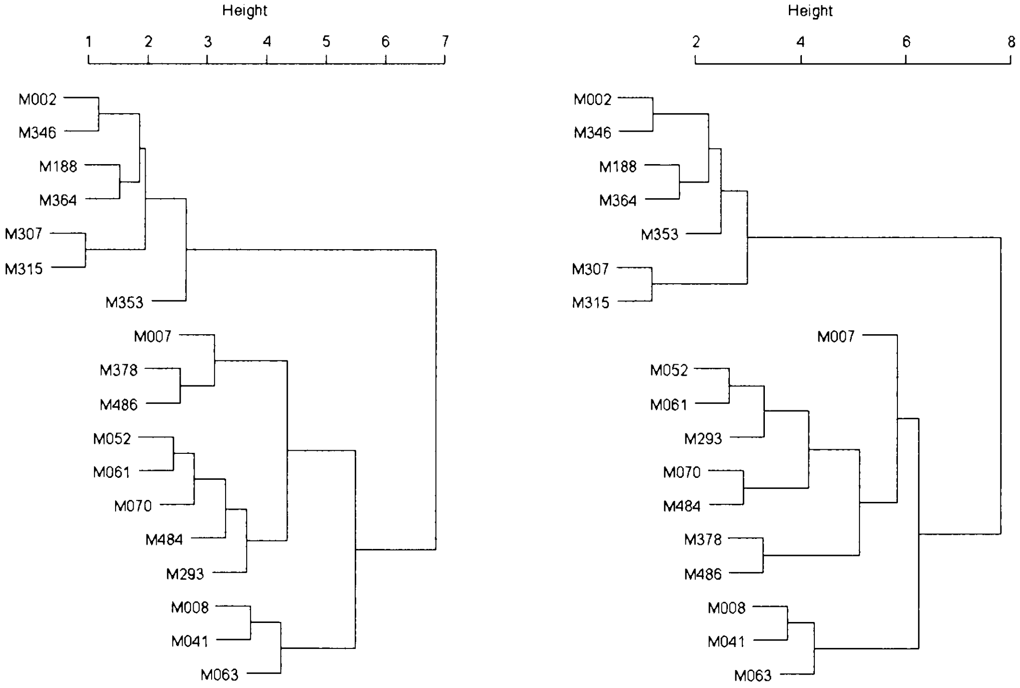
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno 1993

Figure F.1: Cluster Classification for monthly precipitation per year (...continuation).



Cluster tree euclidian distante(12 monthly values) anno : 1994

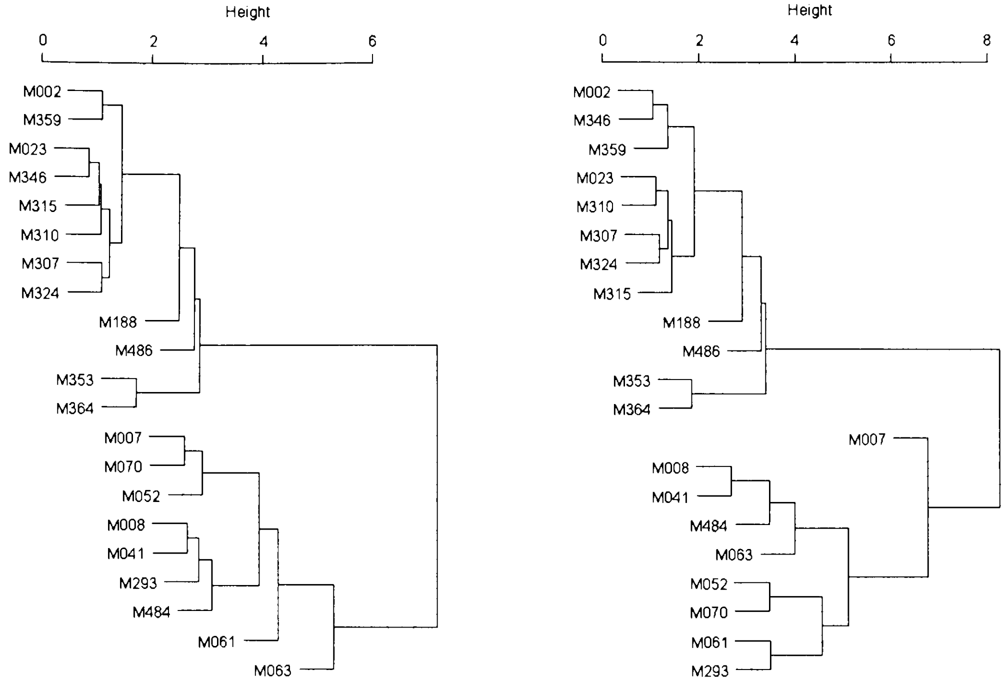
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno : 1994



Cluster tree euclidian distante(12 monthly values) anno : 1995

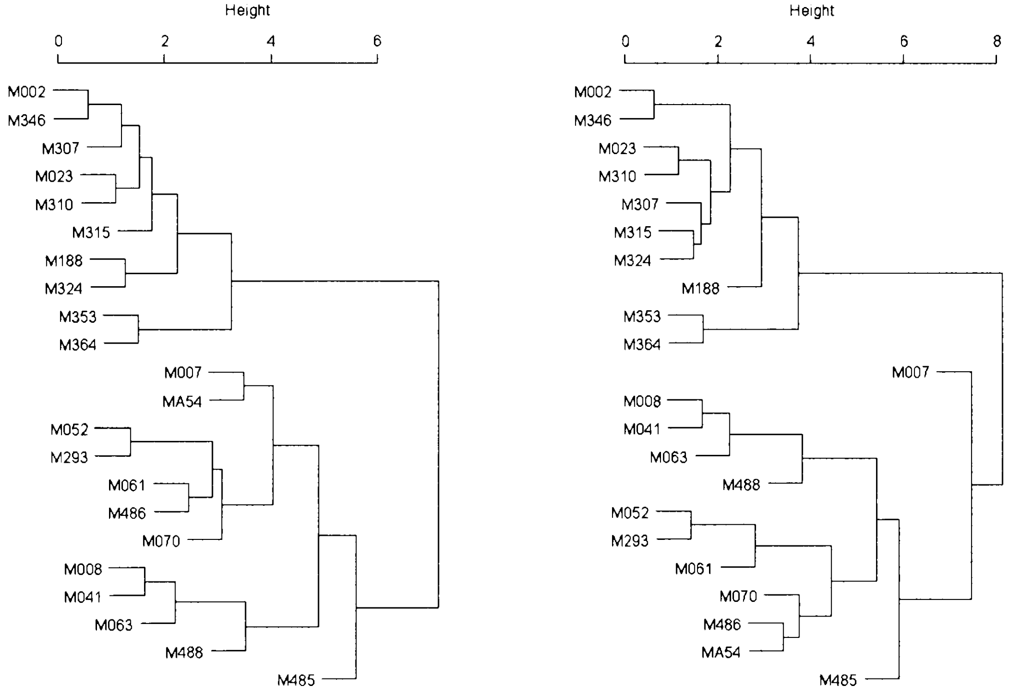
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno : 1995

Figure F.1: Cluster Classification for monthly precipitation per year (...continuation).



Cluster tree euclidian distante(12 monthly values) anno 1996

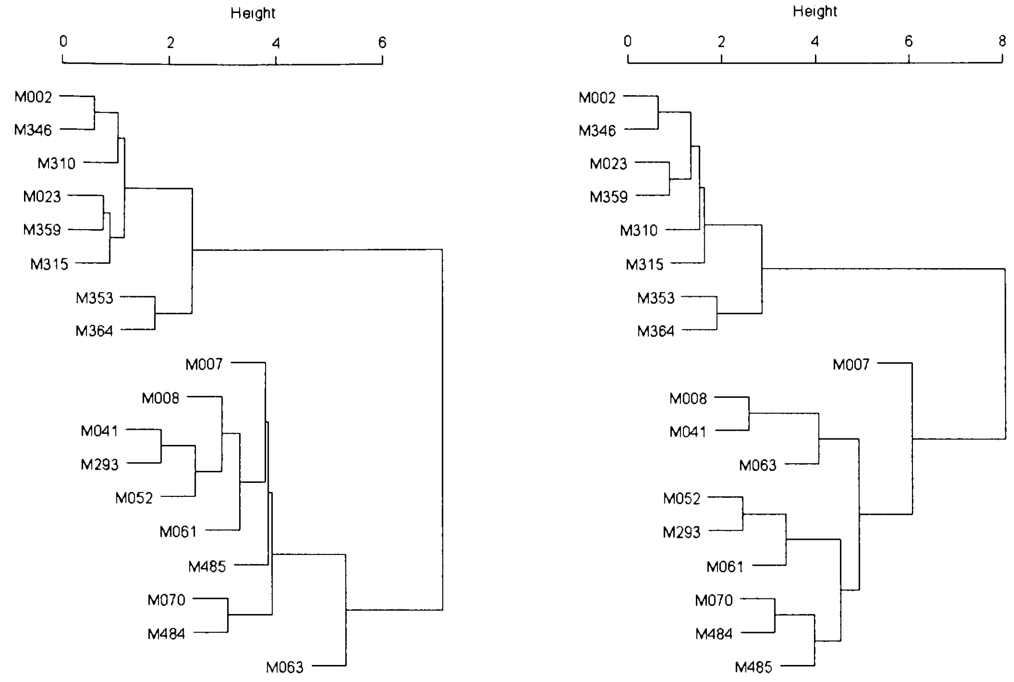
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno . 1996



Cluster tree euclidian distante(12 monthly values) anno 1997

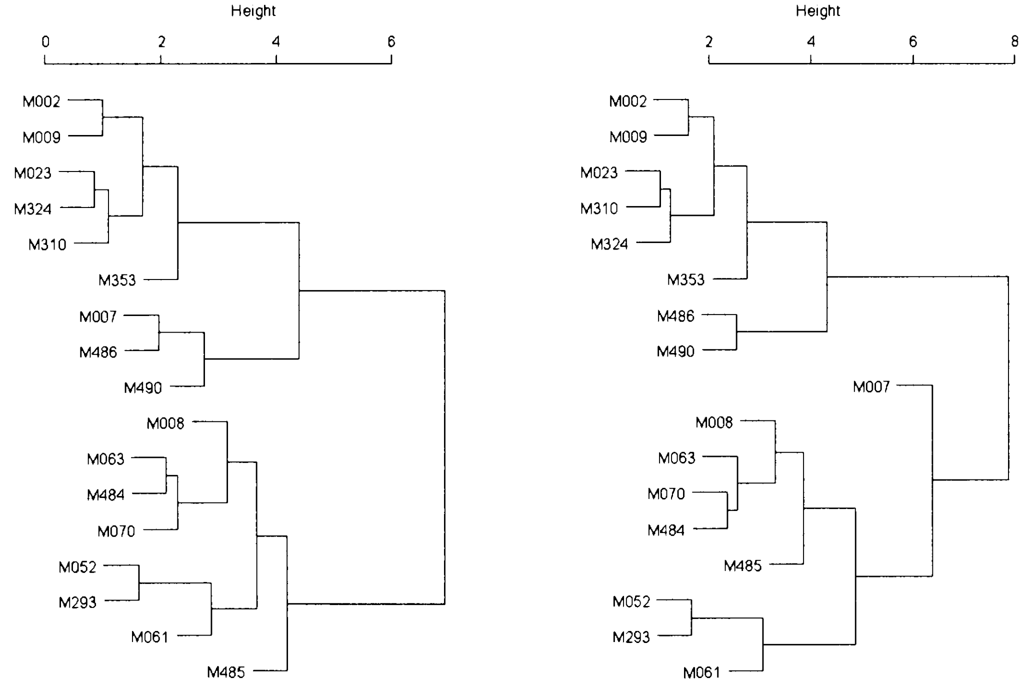
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno 1997

Figure F.1: Cluster Classification for monthly precipitation per year (...continuation).



Cluster tree euclidian distante(12 monthly values) anno : 1998

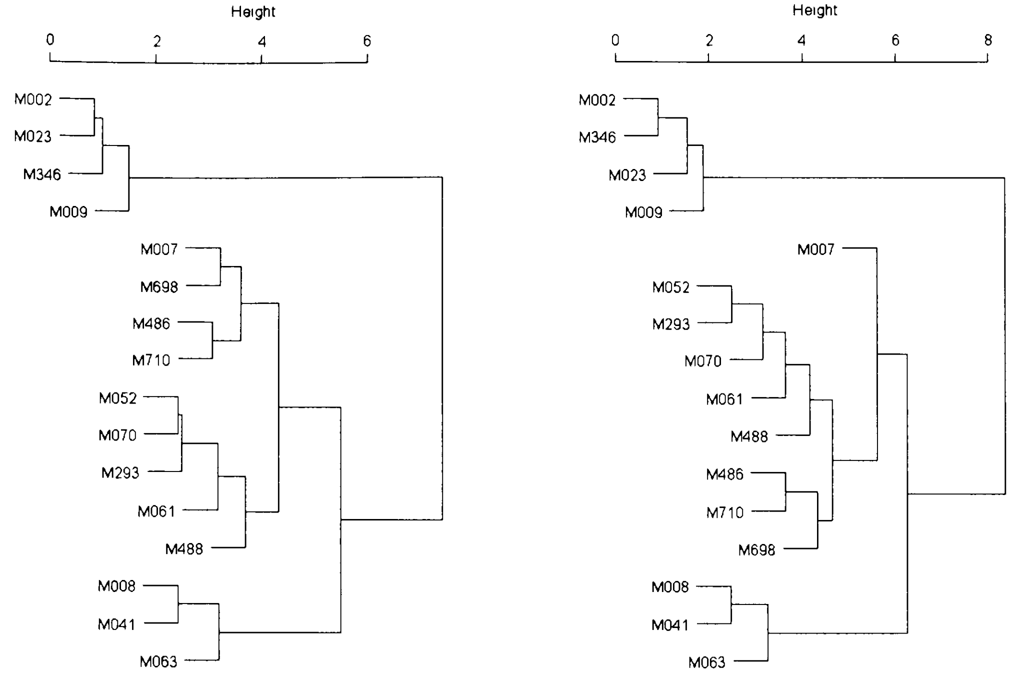
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno : 1998



Cluster tree euclidian distante(12 monthly values) anno : 1999

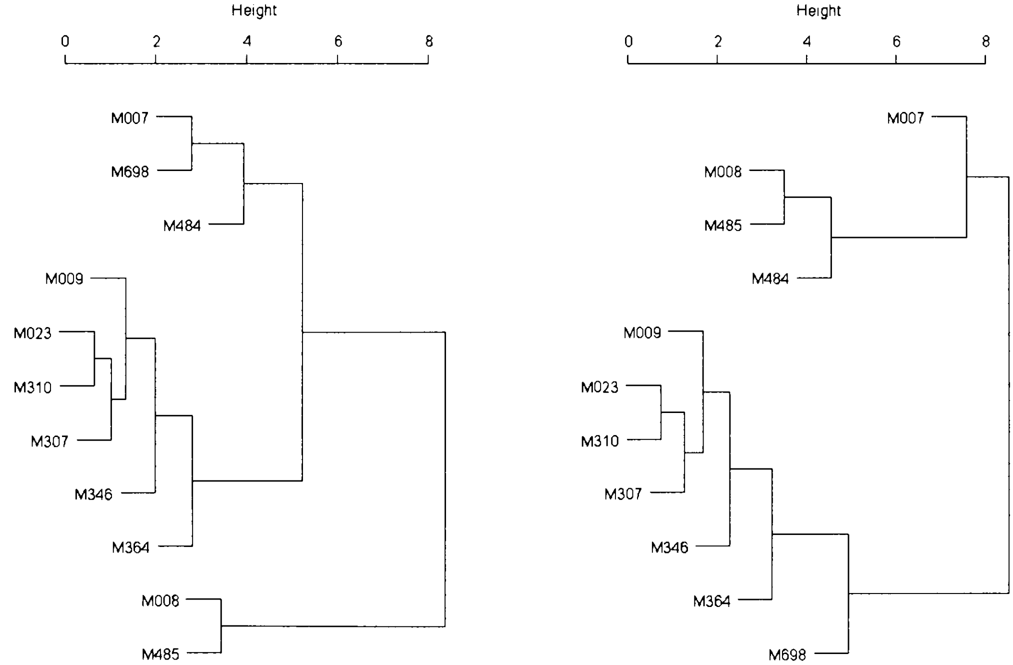
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno 1999

Figure F.1: Cluster Classification for monthly precipitation per year (...continuation).



Cluster tree euclidian distante(12 monthly values) anno : 2000

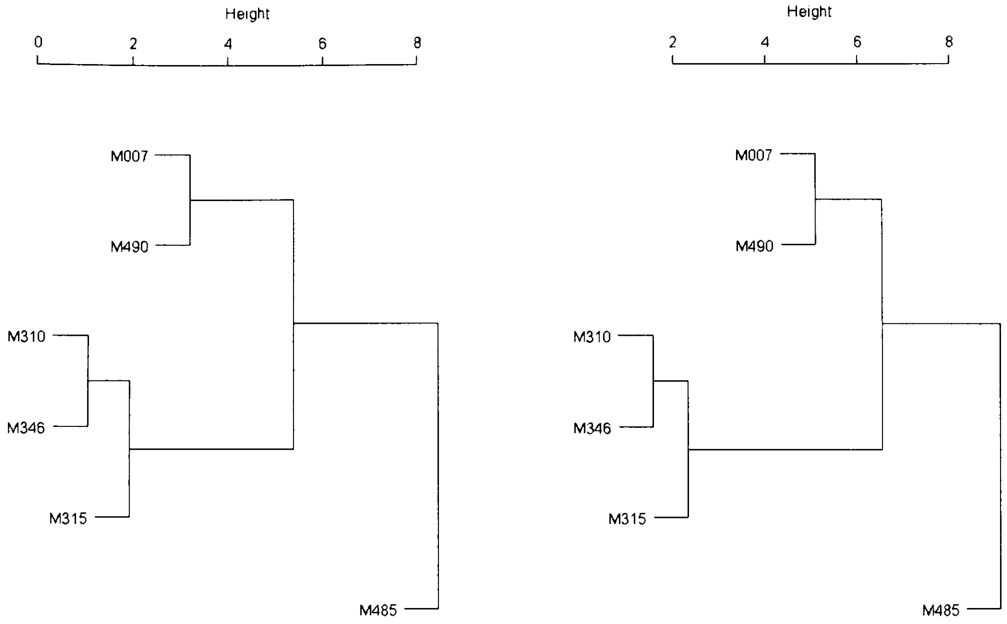
Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno 2000



Cluster tree euclidian distante(12 monthly values) anno : 2001

Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno 2001

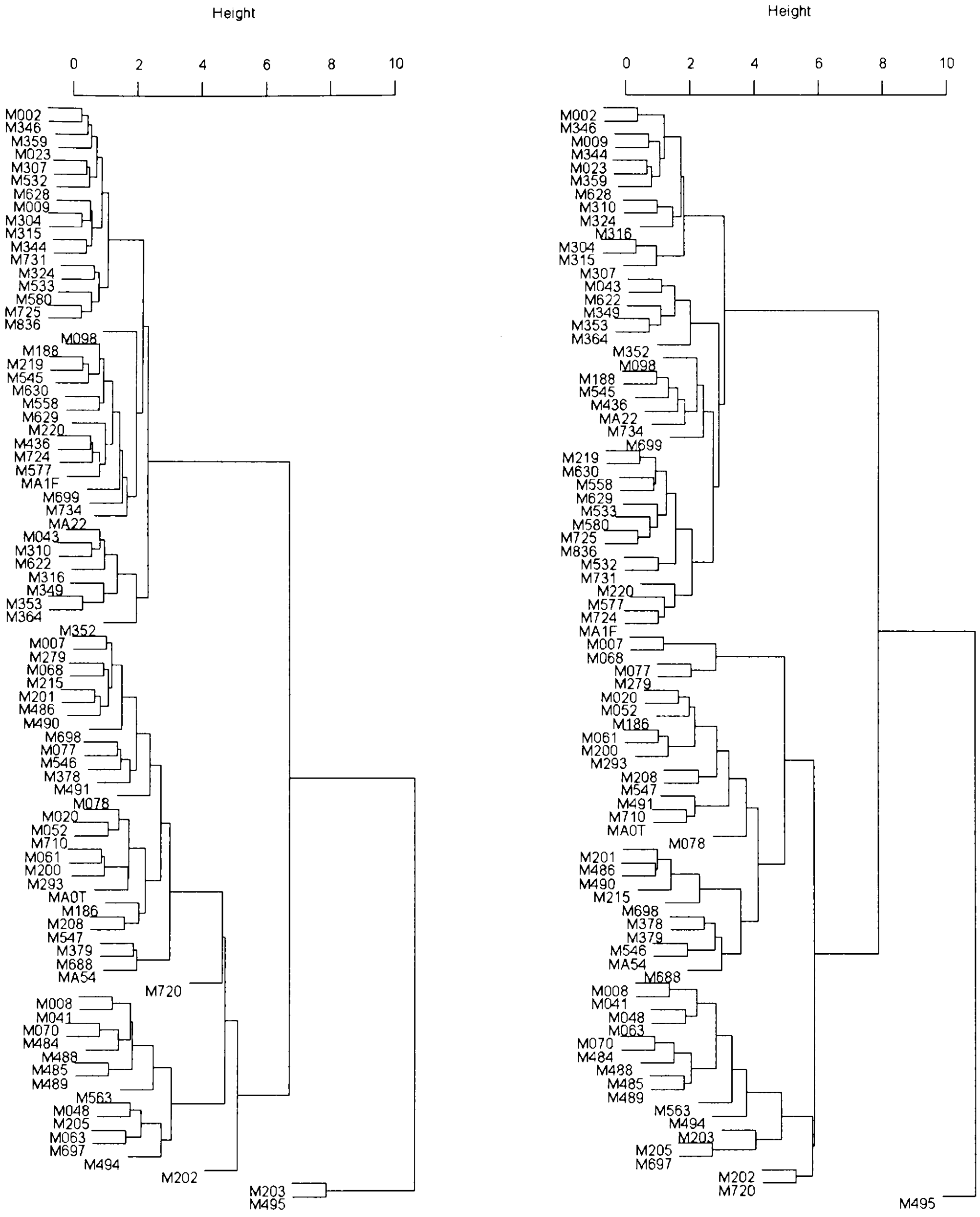
Figure F.1: Cluster Classification for monthly precipitation per year (...continuation).



Cluster tree euclidian distante(12 monthly values) anno : 2002

Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno : 2002

Figure F.1: Cluster Classification for monthly precipitation per year (...continuation).



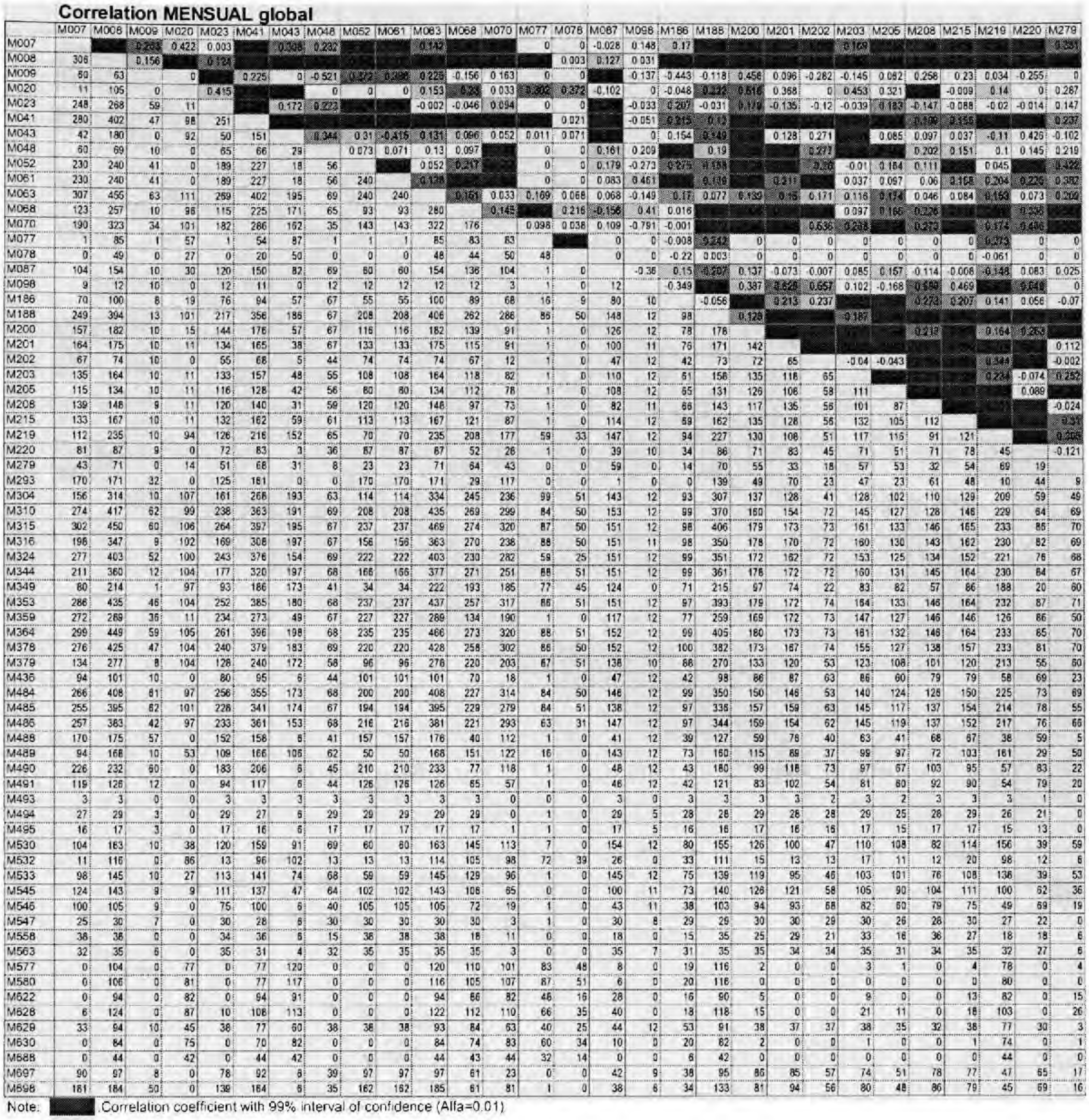
Cluster tree euclidian distante(12 monthly values) anno MEAN

Cluster tree euclidian distante(long,lat,elev, 12 monthly values) anno MEAN

Figure F.2: Cluster Classification for mean monthly precipitation per year.

APPENDIX G

Table G.1: Pearson Correlation coefficients in monthly precipitation between stations



Correlation MENSUAL global

	M007	M008	M009	M020	M023	M041	M043	M048	M052	M061	M063	M068	M070	M077	M078	M087	M098	M186	M188	M200	M201	M202	M203	M205	M208	M215	M219	M220	M279
M007		■	0.203	0.422	0.003	■	0.308	0.232	■	■	0.142	■	■	0	0	-0.028	0.148	0.17	■	■	■	■	0.169	■	■	■	■	■	0.351
M008	306		0.156	■	0.124	■	■	■	■	■	■	■	■	■	0.003	0.127	0.031	■	■	■	■	■	■	■	■	■	■	■	■
M009	60	63		0	■	0.225	0	-0.521	0.372	0.398	0.225	-0.156	0.163	0	0	■	-0.137	-0.443	-0.118	0.456	0.096	-0.282	-0.145	0.082	0.258	0.23	0.034	-0.255	0
M020	11	105	0		0.415	■	■	0	0	0	0.153	0.23	0.033	0.302	0.372	-0.102	0	-0.048	0.222	0.616	0.368	0	0.453	0.321	■	-0.009	0.14	0	0.287
M023	248	268	59	11		■	0.172	0.223	■	■	-0.002	-0.046	0.094	0	0	■	-0.033	0.207	-0.031	0.179	-0.135	-0.12	-0.039	0.183	-0.147	-0.088	-0.02	-0.014	0.147
M041	280	402	47	98	251		■	■	■	■	■	■	■	■	0.021	■	-0.051	0.215	0.13	■	■	■	■	■	0.109	0.156	■	■	0.237
M043	42	180	0	92	50	151		0.344	0.31	-0.415	0.131	0.096	0.052	0.011	0.071	■	0	0.154	0.149	■	0.128	0.271	■	0.085	0.097	0.037	-0.11	0.426	-0.102
M048	60	69	10	0	65	66	29		0.073	0.071	0.13	0.097	■	0	0	0.161	0.209	■	0.19	■	■	0.273	■	■	0.202	0.151	0.1	0.145	0.219
M052	230	240	41	0	189	227	18	56		■	0.052	0.217	■	0	0	0.179	-0.273	0.275	0.158	■	■	0.26	-0.01	0.164	0.111	■	0.045	■	0.422
M061	230	240	41	0	189	227	18	56	240		0.138	■	■	0	0	0.083	0.461	■	0.139	■	0.211	■	0.037	0.097	0.06	0.158	0.204	0.226	0.382
M063	307	455	63	111	269	402	195	69	240	240		0.161	0.033	0.169	0.068	0.068	-0.149	0.17	0.077	0.139	0.15	0.171	0.116	0.174	0.046	0.084	0.153	0.073	0.209
M068	123	257	10	96	115	225	171	65	93	93	280		0.145	■	0.216	-0.156	0.41	0.016	■	■	■	■	0.097	0.166	0.226	■	■	0.235	■
M070	190	323	34	101	182	286	162	35	143	143	322	176		0.098	0.038	0.109	-0.791	-0.001	■	■	■	0.636	0.288	■	0.273	■	0.174	0.406	■
M077	1	85	1	57	1	54	87	1	1	1	85	83	83		■	0	0	-0.008	0.242	0	0	0	0	0	0	0	0.273	0	0
M078	0	49	0	27	0	20	50	0	0	0	48	44	50	48		0	0	-0.22	0.003	0	0	0	0	0	0	0	-0.061	0	0
M087	104	154	10	30	120	150	82	69	60	60	154	136	104	1	0		-0.36	0.15	0.207	0.137	-0.073	-0.007	0.085	0.157	-0.114	-0.008	-0.148	0.083	0.025
M098	9	12	10	0	12	11	0	12	12	12	12	12	3	1	0	12		-0.349	■	0.387	0.628	0.657	0.102	-0.168	0.599	0.469	■	0.048	0
M186	70	100	8	19	76	94	57	67	55	55	100	89	68	16	9	80	10		-0.056	■	0.213	0.237	■	■	0.273	0.207	0.141	0.056	-0.07
M188	249	394	13	101	217	356	186	67	208	208	406	262	286	86	50	148	12	98		0.128	■	■	0.187	■	■	■	■	■	■
M200	157	182	10	15	144	176	57	67	116	116	182	139	91	1	0	126	12	78	178		■	■	■	■	0.212	■	0.164	0.263	■
M201	164	175	10	11	134	165	38	67	133	133	175	115	91	1	0	100	11	76	171	142		■	■	■	■	■	■	■	0.112
M202	67	74	10	0	55	68	5	44	74	74	74	67	12	1	0	47	12	42	73	72	65		-0.04	-0.043	■	■	0.344	■	-0.002
M203	135	164	10	11	133	157	48	55	108	108	164	118	82	1	0	110	12	61	158	135	118	65		■	■	■	0.234	-0.074	0.252
M205	115	134	10	11	116	128	42	56	80	80	134	112	78	1	0	108	12	65	131	126	106	58	111		■	■	■	0.089	■
M208	139	148	9	11	120	140	31	59	120	120	148	97	73	1	0	82	11	66	143	117	135	56	101	87		■	■	■	-0.024
M215	133	167	10	11	132	162	59	61	113	113	167	121	87	1	0	114	12	69	162	135	128	56	132	105	112		■	■	0.31
M219	112	235	10	94	126	216	152	65	70	70	235	208	177	59	33	147	12	94	227	130	108	51	117	116	91	121		■	0.205
M220	81	87	9	0	72	83	3	36	87	87	67	52	26	1	0	39	10	34	86	71	83	45	71	51	71	78	45		-0.121
M279	43	71	0	14	51	68	31	8	23	23	71	64	43	0	0	59	0	14	70	55	33	18	57	53	32	54	69	19	
M293	170	171	32	0	125	161	0	0	170	170	171	29	117	0	0	1	0	0	139	49	70	23	47	23	61	48	10	44	9
M304	156	314	10	107	161	268	193	63	114	114	334	245	236	99	51	143	12	93	307	137	128	41	128	102	110	129	209	59	49
M310	274	417	62	99	238	363	191	69	208	208	435	269	299	84	50	153	12	99	370	160	154	72	145	127	128	146	229	64	69
M315	302	450	60	106	264	397	195	67	237	237	469	274	320	87	50	151	12	98	406	179	173	73	161	133	146	165	233	86	70
M316	198	347	9	102	169	308	197	67	156	156	363	270	238	88	50	151	11	98	350	178	170	72	160	130	143	162	230	82	69
M324	277	403	52	100	243	376	154	69	222	222	403	230	282	59	25	151	12	99	351	172	162	72	153	125	134	152	221	76	68
M344	211	360	12	104	177	320	197	68	166	166	377	271	251	88	51	151	12	99	361	178	172	72	160	131	145	164	230	64	67
M349	80	214	1	97	93	186	173	41	34	34	222	193	185	77	45	124	0	71	215	97	74	22	83	82	57	86	188	20	60
M353	286	435	46	104	252	385	180	68	237	237	437	257	317	86	51	151	12	97	393	179	172	74	164	133	146	164	232	87	71
M359	272	289	36	11	234	273	49	67	227	227	289	134	190	1	0	117	12	77	259	169	172	73	147	127	146	146	126	86	50
M364	299	449	59	105	261	396	198	68	235	235	466	273	320	88	51	152	12	99	405	180	173	73	161	132	146	164	233	65	70
M378	276	425	47	104	240	379	183	69	220	220	428	258	302	86	50	152	12	100	382	173	167	74	155	127	138	157	233	81	70
M379	134	277	8	104	128	240	172	58	96	96	276	220	203	67	51	138	10	88	270	133	120	53	123	108	101	120	213	55	60
M436	94	101	10	0	80	95	6	44	101	101	101	70	18	1	0	47	12	42	98	86	87	63	86	60	79	79	58	69	23
M484	266	408	61	97	256	355	173	68	200	200	408	227	314	84	50	146	12	99	350	150	146	53	140	124	128	150	225	73	69
M485	255	395	62	101	228	341	174	67	194	194	395	229	279	84	51	138	12	97	336	157	159	63	145	117	137	154	214	78	55
M486	257	383	42	97	233	361	153	68	216	216	381	221	293	63	31	147	12	97	344	159	154	62	145	119	137	152	217	76	66
M488	170	175	57	0	152	158	6	41	157	157	176	40	112	1	0	41	12	39	127	59	76	40	63	41	68	67	38	59	5
M489	94	168	10	53	109	166	106	62	50	50	168	151	122	16	0	143	12	73	160	115	89	37	99	97	72	103	161	29	50
M490	226	232	60	0	183	206	6	45	210	210	233	77	118	1	0	48	12	43	180	99	118	73	97	67	103	95	57	83	22
M491	119	126	12	0	94	117	6	44	126	126	126	65	57	1	0	46	12	42	121	83	102	54	81	60	92	90	54	79	20
M493	3	3	0	0	3	3	3	3	3	3	3	3	0	0	0	3	0	3	3	3	3	2	3	2	3	3	3	1	0
M494	27	29	3	0	29	27	6	29	29	29	29	29	0	1	0	29	5	28	28	29	28	28	29	25	28	29	26	21	0
M495	16	17	3	0	17	16	6	17	17	17	17	17	1	1	0	17	5	16	16	17	16	16	17	15	17	17	15	13	0
M530	104	163	10	38	120	159	91	69	60	60	163	145	113	7	0	154	12	80	155	126	100	47	110	108	82	114	156	39	59
M532	11	116	0	86	13	96	102	13	13	13	114	105	98	72	39	26	0	33	111	15	13	13	17	11	12	20	98	12	6
M533	98	145	10	27	113	141	74	68	59	59	145	129	96	1	0	145	12	75	139	119	95	46	103	101	76	108	136	39	53
M545	124	143	9	9	111	137	47	64	102	102	143	106	65	0	0	100	11	73	140	126	121	58	105	90	104	111	100	62	36
M546	100	105	9	0	75	100	6	40	105	105	105	72	19	1	0	43	11	38	103	94	93	68	82	60	79	75	49	69	19
M547	25	30	7	0	30	28	6	30	30	30	30	30	3	1	0	30	8	29	29	30	30	29	30	26	28	30	27	22	0
M558	38	38	0	0	34	36	6	15	38	38	38	18	11	0	0	18	0	15	35	25	29	21	33	16	36	27	18	18	6
M563	32	35	6	0	35	31	4	32	35	35	35	35	3	0	0	35	7	31	35	35	34	34	35	31	34	35	32	27	6
M577	0	104	0	77	0	77	120	0	0	0	120	110	101	83	48	8	0	19	116	2	0	0	3	1	0	4	78	0	4
M580	0	106	0	81	0	77	117	0	0	0	116	105	107	87	51	6	0	20	116	0	0	0	0	0	0	0	80	0	0
M622	0	94	0	82	0	94	91	0	0	0	94	86	82	46	16	28	0	16	90	5	0	0	9	0	0	13	82	0	15
M628	6	124	0	87	10	108	113	0	0	0	122	112	110	66	35	40	0	18	118	15	0	0	21	11	0	18	103	0	26
M629	33	94	10	45	38	77	60	38	38	38	93	84	63	40	25	44	12	53	91	38	37	37	38	35	32	38	77	30	3
M630	0	84	0	75	0	70	82	0	0	0	84	74	83	60	34	10	0	20	82	2	0	0	1	0	0	1	74	0	1
M688	0	44	0	42	0	44	42	0	0	0	44	43	44	32	14	0	0	6	42	0	0	0	0	0	0	0	44	0	0
M697	90	97	8	0	78	92	6	39	97	97	97	61	23	0	0	42	9	38	95	86	85	57	74	51	78	77	47	65	17
M698	181	184	50	0	139	164	6	35	162	162	185	61	81	1	0	38	6	34	133	81	94	56	80	48	86	79	45	69	16

Note: ■ :Correlation coefficient with 99% interval of confidence (Alfa=0.01)

▩ :Correlation coefficient with 95% interval of confidence (Alfa=0.05)

▨ :Correlation coefficient with 90% interval of confidence (Alfa=0.10)

░ :Correlation coefficient with 75% interval of confidence (Alfa=0.25)

Table G.1: Pearson Correlation coefficients in monthly precipitation between stations (….continuation).

	M293	M304	M310	M315	M316	M324	M344	M349	M353	M359	M364	M378	M379	M436	M484	M485	M486	M488	M489	M490	M491	M493	M494	M495	M530	M532	M533	M545	M546
M007	[illegible]	[illegible]	0.036	0.109	0.03	[illegible]	0.039	-0.192	[illegible]	-0.009	-0.102	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.981	0.027	0.241	0.111	0.328	[illegible]	[illegible]	[illegible]
M008	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.038	0.09	[illegible]	0.116	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.26	0.304	0.038	0.107	0.237	[illegible]	[illegible]	[illegible]
M009	[illegible]	0.042	[illegible]	[illegible]	0.399	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	0.096	0.338	0.377	0.06	-0.088	[illegible]	0.035	-0.27	0.12	0.205	0	-0.7	0.941	[illegible]	0	-0.006	0.219	0.28
M020	0	0.091	0.17	0.142	0.25	0.226	0.121	0.142	0.046	-0.03	0.154	0.184	0.186	0	0.158	[illegible]	0.259	0	0.273	0	0	0	0	0	0.009	0.156	0.234	0.484	0
M023	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.118	[illegible]	-0.049	0.084	-0.073	0.099	0.042	-0.009	-0.086	-0.169	0.477	0.027	-0.232	[illegible]	[illegible]	0.013	-0.03	-0.29
M041	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.076	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.122	[illegible]	0.588	0.378	0.101	[illegible]	[illegible]	[illegible]	0.194	0.194
M043	0	[illegible]	[illegible]	[illegible]	[illegible]	0.143	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.074	0.069	0.507	-0.069	0.15	0.039	0.263	0.137	0.486	0.166	0.288	0.038	0.366	[illegible]	[illegible]	-0.195	0.047	0.518
M048	0	0.092	0.102	0.132	0.013	0.18	-0.026	0.01	0.113	0.004	0.056	0.136	0.268	-0.012	[illegible]	[illegible]	0.268	0.352	0.269	0.175	[illegible]	0.693	[illegible]	-0.072	0.078	0.5	0.278	0.027	0.107
M052	[illegible]	0.068	0.18	[illegible]	0.174	[illegible]	0.169	-0.076	[illegible]	[illegible]	0.16	[illegible]	0.269	[illegible]	[illegible]	0.102	[illegible]	0.132	-0.018	[illegible]	[illegible]	0.981	0.171	0.62	0.1	0.211	-0.017	[illegible]	[illegible]
M061	[illegible]	-0.006	0.022	[illegible]	[illegible]	[illegible]	[illegible]	0.009	[illegible]	[illegible]	[illegible]	[illegible]	0.215	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.185	[illegible]	[illegible]	-0.868	-0.135	-0.059	0.002	0.42	0.072	0.222	[illegible]
M063	0.101	0.125	[illegible]	[illegible]	[illegible]	0.08	[illegible]	0.013	0.087	0.086	[illegible]	-0.011	0.096	-0.051	0.09	[illegible]	0.103	0.137	0.156	0.014	0.053	-0.897	0.2	0.139	0.018	0.217	0.078	0.108	0.003
M068	0.348	-0.031	-0.039	0.02	-0.014	0.09	-0.076	-0.03	[illegible]	-0.072	-0.139	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.24	[illegible]	0.284	0.174	0.895	0.003	0.275	-0.062	-0.089	[illegible]	[illegible]	[illegible]
M070	[illegible]	0.18	0.03	[illegible]	-0.034	[illegible]	0.099	[illegible]	0.002	0.07	-0.062	[illegible]	[illegible]	0.481	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0.078	0.09	[illegible]	[illegible]	[illegible]
M077	0	-0.089	-0.018	0.014	-0.004	0.063	-0.086	-0.093	-0.082	0	-0.046	[illegible]	0.109	0	0.104	0.178	0.3	0	0.096	0	0	0	0	0	-0.077	0.073	0	0	0
M078	0	-0.114	-0.078	-0.104	0.02	-0.295	-0.12	0.103	-0.049	0	-0.069	0.017	0.188	0	0.149	0.053	-0.109	0	0	0	0	0	0	0	0	0.07	0	0	0
M087	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.144	0.077	-0.028	-0.058	0.003	0.17	0.023	0.033	0.085	-0.703	0.297	0.567	[illegible]	[illegible]	-0.115	-0.085	-6E-05
M098	0	-0.368	-0.109	0.249	0.054	0.251	-0.155	0	-0.386	-0.009	-0.408	0.664	0.569	0.546	0.132	0.695	0.416	0.663	0.56	0.635	0.107	0	0.55	-0.336	-0.008	0	[illegible]	[illegible]	0.643
M186	0	0.116	0.157	0.106	0.205	0.139	0.078	0.038	0.129	0.045	0.206	0.024	0.116	0.084	0.073	0.075	0.145	0.226	-0.058	0.133	0.364	0.575	0.241	-0.422	0.162	0.242	0.117	-0.044	0.163
M188	0.207	[illegible]	0.184	0.034	7E-04	[illegible]	-0.069	-0.086	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.122	[illegible]	0.202	[illegible]	[illegible]	[illegible]	-0.908	-0.165	0.046	-0.101	0.191	[illegible]	[illegible]	[illegible]
M200	[illegible]	[illegible]	0.105	[illegible]	[illegible]	[illegible]	[illegible]	0.093	0.101	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.223	[illegible]	0.057	[illegible]	0.976	0.267	0.123	[illegible]	0.491	[illegible]	0.193	0.233
M201	[illegible]	0.008	0.184	0.104	-0.024	[illegible]	-0.031	-0.215	[illegible]	-0.112	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.232	0.113	0.238	-0.066	0.026	[illegible]	[illegible]	[illegible]
M202	[illegible]	0.016	[illegible]	0.223	0.006	0.247	0.153	-0.076	-0.047	0.087	-0.026	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.411	[illegible]	[illegible]	1	0.082	-0.16	-0.02	0.018	[illegible]	0.3	[illegible]
M203	0.179	0.092	-0.077	0.116	0.087	0.207	-0.011	0.232	0.094	0.021	0.036	0.107	0.026	0.101	[illegible]	0.166	0.211	0.254	0.207	0.002	0.264	-0.045	0.227	-0.243	0.082	0.049	0.084	[illegible]	-0.055
M205	0.375	0.129	0.214	0.143	[illegible]	[illegible]	0.079	0.084	0.145	0.15	0.151	0.206	0.195	0.082	[illegible]	[illegible]	[illegible]	0.282	[illegible]	0.047	[illegible]	1	[illegible]	-0.028	0.158	0.333	[illegible]	0.224	-0.011
M208	0.157	-0.017	0.14	-0.024	-0.106	[illegible]	-0.2	-0.247	[illegible]	-0.192	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.189	0.189	0.308	[illegible]	[illegible]	[illegible]	-0.324	0.133	0.116	-0.12	-0.19	[illegible]	[illegible]	[illegible]
M215	0.099	0.009	[illegible]	0.011	-0.14	0.195	-0.061	-0.154	[illegible]	-0.14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.176	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.255	0.073	-0.054	0.038	0.178	[illegible]	[illegible]	[illegible]
M219	-0.565	[illegible]	0.116	0.134	0.051	[illegible]	-0.046	-0.044	[illegible]	-0.181	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.311	-0.661	-0.227	0.225	0.024	[illegible]	[illegible]	[illegible]	[illegible]
M220	0.297	[illegible]	[illegible]	0.174	-0.013	[illegible]	0.085	-0.341	-0.202	-0.028	-0.218	[illegible]	[illegible]	[illegible]	[illegible]	0.283	[illegible]	0.324	[illegible]	[illegible]	[illegible]	0	-0.393	0.227	0.04	0.291	[illegible]	[illegible]	[illegible]
M279	[illegible]	0.244	0.115	0.05	0.029	0.277	0.149	-0.138	0.042	0.138	-0.13	[illegible]	0.25	-0.174	0.256	[illegible]	[illegible]	0.193	[illegible]	-0.13	0.155	0	0	0	-0.052	0.455	0.285	[illegible]	0.331
M293		0.147	0.113	[illegible]	0.233	[illegible]	0.256	-1	[illegible]	[illegible]	[illegible]	0.164	[illegible]	[illegible]	[illegible]	0.463	[illegible]	[illegible]	0	[illegible]	[illegible]	0	0	0	0	0	0	0.207	0.328
M304	60		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2E-04	-0.061	0.13	0.073	-0.011	0.137	0.019	0.149	-0.07	0.103	-1	-0.022	0.451	[illegible]	[illegible]	0.063	0.185	0.008
M310	142	289		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.002	[illegible]	0.178	0.106	0.014	0.066	-0.03	0.058	0.149	-0.086	-0.672	0.167	-0.238	[illegible]	[illegible]	0.11	0.111	[illegible]
M315	169	320	432		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.091	-0.061	0.295	0.126	0.072	[illegible]	0.198	0.051	0.02	0.039	-0.987	0.019	-0.028	[illegible]	[illegible]	0.025	0.14	-0.011
M316	89	309	333	362		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.135	0.008	0.024	-0.048	0.023	0.125	-0.003	-0.091	0.063	-0.806	0.088	-0.162	[illegible]	[illegible]	0.011	0.023	-0.132
M324	154	263	376	398	306		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.153	[illegible]	[illegible]	0.095	[illegible]	[illegible]	[illegible]	[illegible]	0.053	-0.234	0.273	0.009	[illegible]	[illegible]	0.156	[illegible]	0.201
M344	98	313	344	376	358	319		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.143	0.176	0.04	-0.019	0.064	0.011	0.021	-0.023	0.059	0.177	0.102	0.389	[illegible]	[illegible]	0.018	-0.005	-0.014
M349	2	208	217	222	221	191	221		[illegible]	[illegible]	[illegible]	-0.145	0.09	-0.294	0.156	0.103	0.034	-0.223	-0.02	-0.372	-0.011	-0.242	0.08	-0.12	[illegible]	[illegible]	[illegible]	-0.126	-0.415
M353	166	303	400	434	347	389	359	214		[illegible]	[illegible]	[illegible]	[illegible]	-0.139	-0.074	-0.061	-0.076	-0.043	-0.141	-0.164	-0.059	-0.691	0.259	0.086	[illegible]	[illegible]	-0.151	[illegible]	-0.237
M359	158	169	257	285	211	269	223	90	285		[illegible]	[illegible]	-0.234	0.015	0.029	0.047	0.121	0.051	-0.082	-0.049	-0.011	-1	0.168	0.285	[illegible]	[illegible]	0.061	-0.058	-0.161
M364	167	319	430	463	363	395	373	224	432	283		[illegible]	[illegible]	-0.16	-0.077	-0.101	-0.113	-0.018	-0.115	-0.15	-0.129	-0.944	0.26	0.375	[illegible]	[illegible]	-0.179	[illegible]	[illegible]
M378	152	295	398	423	341	382	350	215	413	267	425		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.291	-0.051	0.377	-0.142	-0.155	[illegible]	[illegible]	[illegible]
M379	38	254	265	278	276	248	277	202	278	143	278	276		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.019	0.173	0.259	-0.052	2E-04	[illegible]	[illegible]	[illegible]
M436	46	64	87	100	99	99	98	25	101	99	99	100	74		[illegible]	0.21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.072	-0.071	0.356	0.026	0.193	[illegible]	[illegible]	[illegible]
M484	136	266	373	403	302	355	315	207	388	250	404	380	254	75		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.216	0.234	-0.098	-0.005	0.087	[illegible]	[illegible]	[illegible]
M485	128	273	367	391	308	345	317	198	376	237	392	366	255	90	361		[illegible]	[illegible]	[illegible]	[illegible]	0.215	-0.006	0.222	-0.051	-0.126	-0.052	[illegible]	[illegible]	0.226
M486	148	265	354	378	298	360	307	190	375	258	377	360	245	86	349	328		[illegible]	[illegible]	[illegible]	[illegible]	-0.674	0.04	0.321	-5E-04	0.147	[illegible]	[illegible]	[illegible]
M488	114	88	150	172	87	154	95	18	160	148	173	153	55	58	172	155	148		0.343	[illegible]	[illegible]	0.425	[illegible]	0.155	-0.117	-0.049	[illegible]	[illegible]	0.196
M489	0	162	167	165	166	165	166	135	165	106	166	167	151	37	160	152	158	37		[illegible]	[illegible]	0.342	0.057	0.267	0.05	0.065	[illegible]	[illegible]	[illegible]
M490	152	97	203	229	135	206	147	26	216	205	226	205	82	97	198	193	187	165	38		[illegible]	-0.716	0.191	-0.027	-0.127	0.068	[illegible]	[illegible]	[illegible]
M491	74	82	98	125	108	113	121	23	125	124	124	117	69	82	114	108	114	93	38	121		-0.172	0.213	0.061	-0.047	-0.333	[illegible]	[illegible]	[illegible]
M493	0	2	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3		0.683	-0.571	0.713	0	-0.599	-0.98	0.342
M494	0	28	29	28	29	29	29	11	29	28	28	29	27	28	29	29	29	28	28	29	29	3		0.183	0.043	0.183	-0.002	-0.27	-0.036
M495	0	16	17	17	17	17	17	6	17	16	17	17	14	16	17	17	17	17	16	17	17	3	16		0.042	0.292	0.039	0.11	0.126
M530	1	150	162	160	160	160	160	132	160	117	161	161	147	47	154	146	154	41	152	48	46	3	29	17		[illegible]	-0.03	-0.004	-0.079
M532	0	113	109	115	114	102	116	97	115	13	115	115	113	12	113	112	105	13	51	13	13	0	13	6	35		-0.09	0.28	0.278
M533	1	136	144	142	142	142	142	116	142	110	143	143	130	46	137	132	138	40	134	47	45	3	28	16	145	24		[illegible]	[illegible]
M545	37	110	131	140	140	142	141	73	142	132	141	142	107	78	118	132	130	55	89	87	75	3	28	16	100	15	93		[illegible]
M546	56	62	87	104	102	99	103	22	105	103	103	100	69	88	68	89	84	54	33	101	78	3	25	17	43	9	42	79	
M547	0	29	30	29	30	30	30	11	30	29	29	30	27	29	30	30	30	29	29	30	30	3	25	15	30	11	29	29	25
M558	19	28	36	38	38	37	37	14	38	37	37	35	36	35	26	36	38	19	11	36	25	3	12	7	18	2	17	26	31
M563	1	28	35	34	34	35	34	16	35	34	34	35	33	34	34	33	35	28	28	35	33	3	25	12	35	12	35	35	30
M577	0	120	116	121	121	82	123	103	107	0	123	107	107	0	103	101	85	0	32	0	0	0	0	0	17	92	6	2	0
M580	0	116	112	118	117	82	119	103	109	0	119	109	109	0	103	104	84	0	31	0	0	0	0	0	15	95	4	0	0
M622	0	91	88	93	92	93	92	85	93	0	94	94	93	0	86	88	89	0	53	0	0	0	0	0	37	79	26	7	0
M628	0	121	116	123	122	107	122	114	123	6	123	123	122	0	116	110	106	0	64	0	0	0	0	0	49	94	38	7	0
M629	0	93	87	93	92	83	94	67	93	37	93	94	89	37	90	92	86	37	46	38	38	3	27	17	47	66	41	37	34
M630	0	84	77	84	82	75	83	76	83	0	84	84	84	0	76	82	75	0	24	0	0	0	0	0	13	79	8	1	0
M688	0	41	44	44	42	44	44	35	44	0	44	44	43	0	43	42	42	0	24	0	0	0	0	0	8	44	0	0	0
M697	52	64	76	96	94	88	95	23	97	95	95	89	66	80	71	86	82	58	32	93	80	3	23	13	42	11	41	70	83
M698	118	79	161	181	112	170	124	21	167	156	178	165	75	86	152	157	147	128	31	175	102	3	26	15	38	12	37	76	84

Note: ■ :Correlation coefficient with 99% interval of confidence (Alfa=0.01)

▩ :Correlation coefficient with 95% interval of confidence (Alfa=0.05)

▨ :Correlation coefficient with 90% interval of confidence (Alfa=0.10)

░ :Correlation coefficient with 75% interval of confidence (Alfa=0.25)

Table G.1:. Pearson Correlation coefficients in monthly precipitation between stations (….continuation).

	M547	M558	M563	M577	M580	M622	M628	M629	M630	M688	M697	M698	M699	M702	M703	M710	M713	M720	M724	M725	M731	M734	M829	M836	M839	MA1F	MA22	MA54
M007	0.204	[illegible]	0.15	0	0	0	-0.487	0.27	0	0	[illegible]	[illegible]	0.196	0.821	-0.094	[illegible]	0.18	[illegible]	0	0	0.091	-0.019	0.203	0	0	[illegible]	[illegible]	[illegible]
M008	-0.111	[illegible]	[illegible]	0.108	[illegible]	0.174	0.115	0.056	[illegible]	0.147	[illegible]	0.183	0.003	0.43	0.065	[illegible]	[illegible]	[illegible]	[illegible]	0.216	0.106	0.31	0.868	0.187	0.115	[illegible]	[illegible]	[illegible]
M009	0.628	0	-0.227	0	0	0	0	0.66	0	0	0.422	-0.002	0	0	0.891	0.229	0.095	-0.183	0	0	[illegible]	-0.894	0	0	0	0	0	0.19
M020	0	0	0	0.026	0.126	0.135	0.131	0.156	0.054	0.076	0	0	0	0	0	0	0	0	0.268	0.09	0.009	0	0	0.078	0.095	0.119	0	0
M023	-0.065	0.157	0.103	0	0	0	0.291	0.271	0	0	0.067	-0.162	-0.016	-0.199	0.478	[illegible]	0.058	-0.254	0	0	[illegible]	-0.341	0.224	0	0	0.442	-0.048	-0.001
M041	-0.032	0.317	[illegible]	0.114	[illegible]	[illegible]	0.234	0.005	0.271	0.1	[illegible]	0.017	-0.13	0.884	0.169	[illegible]	0.436	0.131	0.286	0.229	[illegible]	0.156	0.721	0.143	0.333	[illegible]	0.408	0.342
M043	-0.196	0.465	0.435	0.087	0.101	[illegible]	[illegible]	0.2	0.012	[illegible]	0.585	0.558	0.513	0	0	-0.126	0	0	0.154	-0.054	[illegible]	0	0.965	-0.084	0.208	-0.202	0	0
M048	-0.008	0.263	[illegible]	0	0	0	0	-0.013	0	0	[illegible]	-0.031	-0.174	0.12	0.018	[illegible]	0.456	0.136	0	0	0.038	0.335	0.688	0	0	0	0	0
M052	0.383	0.412	0.175	0	0	0	0	0.381	0	0	[illegible]	0.198	0.099	-0.393	0.27	[illegible]	0.391	0.201	0	0	0.237	-0.415	0.093	0	0	0.188	0.433	[illegible]
M061	0.058	0.382	0.221	0	0	0	0	-0.027	0	0	0.206	0.372	0.22	0.73	0.529	[illegible]	0.401	0.233	0	0	0.08	0.112	-0.249	0	0	0.22	[illegible]	[illegible]
M063	0.064	-0.184	0.398	0.135	0.066	0.173	0.139	-0.136	0.007	[illegible]	[illegible]	0.011	0.312	-0.217	-0.38	0.132	0.053	-0.09	0.119	-0.152	0.148	-0.14	-0.031	-0.065	-0.051	-0.121	0.112	0.125
M068	0.236	0.09	-0.043	0.166	0.208	-0.169	[illegible]	-0.182	0.151	0.333	0.197	[illegible]	0.188	0.333	-0.081	0.265	0.255	[illegible]	[illegible]	0.119	-0.055	0.253	0.082	0.232	0.032	0.254	0	0
M070	-0.725	0.582	1	0.223	0.206	-0.142	-1E-03	0.119	[illegible]	0.376	0.482	[illegible]	0.136	0	-0.87	[illegible]	0.41	0.482	[illegible]	0.184	0.007	0.996	0	0.095	[illegible]	[illegible]	0	[illegible]
M077	0	0	0	0.204	0.228	0.093	-0.048	-0.034	0.152	0.187	0	0	0	0	0	0	0	0	0.314	[illegible]	0	0	0	0.236	0.035	0.121	0	0
M078	0	0	0	-0.019	-0.223	0.183	0.169	-0.474	-0.032	0.051	0	0	0	0	0	0	0	0	0.351	0.011	0	0	0	-0.008	0.464	-0.204	0	0
M087	0.237	0.409	0.227	0.374	0.102	[illegible]	0.217	[illegible]	0.116	0	0.309	-0.174	0.085	0.297	0.897	0.074	0.309	-0.273	-0.094	-0.028	[illegible]	-0.582	0.782	0.084	-0.142	0	0	0
M098	0.122	0	-0.182	0	0	0	0	0.119	0	0	0.135	0.57	0	0	0.681	0.856	0.393	[illegible]	0	0	-0.129	0.615	0	0	0	0	0	0
M186	0.053	0.437	[illegible]	[illegible]	0.318	0.242	0.208	-0.083	0.41	-0.85	0.3	0.177	-0.177	0.414	-0.327	[illegible]	0.302	-0.095	-0.378	0.184	0.107	0.01	0.907	-0.258	-0.719	-0.329	0	0
M188	0.127	[illegible]	-0.093	[illegible]	[illegible]	-0.166	0.018	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.059	0.216	0.4	[illegible]	0.524	[illegible]	[illegible]	[illegible]	-0.083	0.256	0.424	0.159	-0.062	[illegible]	[illegible]	[illegible]
M200	0.186	0.241	[illegible]	-1	0	0.436	0.028	0.346	1	0	[illegible]	0.204	0.004	0.603	0.609	[illegible]	0.602	0.216	0.993	0	0.209	-0.136	0.83	0.182	1	0.056	0.396	0
M201	0.192	0.436	0.157	0	0	0	0	0.188	0	0	[illegible]	[illegible]	0.191	0.546	[illegible]	[illegible]	0.474	[illegible]	0	0	-0.108	0.132	0.589	0	0	[illegible]	[illegible]	0
M202	-0.131	[illegible]	0.385	0	0	0	0	0.251	0	0	[illegible]	0.228	0.227	0.509	0.448	[illegible]	0.459	[illegible]	0	0	-0.077	0.393	0.625	0	0	[illegible]	0.947	0
M203	-0.015	-0.229	0.306	-0.426	0	-0.033	0.207	-0.052	0	0	0.248	0.063	-0.087	0.783	[illegible]	[illegible]	0.402	0.091	0.799	0	0.077	0.159	0.609	0.141	-0.405	-0.289	0.036	0
M205	0.232	0.376	0.393	0	0	0	0.407	-0.043	0	0	[illegible]	-0.195	-0.138	0.652	0.331	0.249	0.322	0.179	0	0	0.187	-0.218	0.074	0	0	0.102	0	0
M208	0.14	0.139	0.039	0	0	0	0	0.1	0	0	[illegible]	[illegible]	-0.01	0.683	0.793	0.288	0.448	[illegible]	0	0	-0.133	0.054	0.301	0	0	[illegible]	0.454	0
M215	6E-04	0.157	0.268	0.78	0	-0.331	-0.247	0.217	0	0	0.216	[illegible]	0.113	0.693	0.225	[illegible]	[illegible]	[illegible]	0.643	0	-0.007	-0.113	0.455	-0.109	-1	0.085	0.101	0
M219	0.359	0.567	-0.165	0.282	[illegible]	0.043	[illegible]	0.136	[illegible]	[illegible]	0.346	[illegible]	0.157	-0.029	0.756	0.247	0.56	[illegible]	[illegible]	[illegible]	0.003	0.499	0.052	[illegible]	-0.044	[illegible]	0	0
M220	0.239	[illegible]	-0.046	0	0	0	0	0.417	0	0	[illegible]	[illegible]	-0.085	0.612	0.404	[illegible]	0.405	[illegible]	0	0	0.085	0.489	1	0	0	[illegible]	[illegible]	0
M279	0	0.355	0.338	0.481	0	-0.404	-0.083	0.096	0	0	-0.024	0.358	-0.168	0	0	0.082	-1	0.546	0.324	0	0.036	0	-0.116	0.495	0	0	0	0
M293	0	0.438	0	0	0	0	0	0	0	0	0.276	0.107	0.172	0	0.592	[illegible]	0	0.336	0	0	0	0	-1	0	0	[illegible]	[illegible]	0.185
M304	0.171	0.244	-0.148	[illegible]	[illegible]	[illegible]	[illegible]	0.246	[illegible]	-0.33	[illegible]	0.032	0.193	0.351	0.136	0.014	0.2	-0.07	-0.169	0.019	[illegible]	-0.271	1	0.051	-0.002	0.069	0.277	0
M310	-0.076	0.415	0.238	[illegible]	[illegible]	[illegible]	[illegible]	0.165	[illegible]	-0.278	-0.059	-0.066	0.137	0.293	0.036	-0.067	-0.002	0.2	-0.145	0.195	[illegible]	-0.042	0.601	-0.069	0.213	0.309	0.661	-0.011
M315	0.093	0.381	0.01	[illegible]	[illegible]	[illegible]	[illegible]	0.159	[illegible]	-0.264	0.212	-0.011	0.145	0.678	0.453	[illegible]	0.074	-0.121	0.015	0.055	[illegible]	-0.248	0.812	0.026	0.065	0.032	0.343	0.178
M316	-0.003	[illegible]	0.016	0.219	0.201	[illegible]	[illegible]	0.056	0.105	[illegible]	0.167	-0.242	0.14	0.081	0.486	0.24	0.033	-0.237	-0.239	-0.015	[illegible]	-0.163	0.093	-0.095	0.24	-0.183	0.136	0
M324	-0.041	[illegible]	0.137	0.222	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.088	[illegible]	[illegible]	0.057	0.267	0.486	[illegible]	0.518	[illegible]	0.214	[illegible]	[illegible]	-0.044	0.42	0.199	0.319	[illegible]	[illegible]	[illegible]
M344	0.124	0.337	0.052	0.181	0.134	[illegible]	[illegible]	0.2	-0.01	[illegible]	0.14	-0.166	0.083	0.626	[illegible]	0.122	-0.042	-0.268	-0.184	-0.051	[illegible]	0.567	0.455	-0.048	0.223	-0.114	0.034	0
M349	-0.475	-0.253	-0.204	[illegible]	0.186	0.277	[illegible]	-0.045	0.102	0.018	0.199	-0.439	0.241	0	0	0.137	0.204	-0.485	0.026	-0.019	[illegible]	0	-0.685	0.04	0.063	0.095	0	0
M353	-0.117	0.095	0.124	0.027	4E-04	[illegible]	[illegible]	0.102	-0.125	[illegible]	-0.027	[illegible]	-0.159	0.335	0.499	0.135	-0.031	[illegible]	-0.283	-0.195	[illegible]	-0.65	0.354	-0.248	[illegible]	-0.29	-0.313	-0.252
M359	-0.015	[illegible]	0.173	0	0	0	-0.052	[illegible]	0	0	0.148	-0.144	0.032	0.339	[illegible]	[illegible]	0.069	[illegible]	0	0	[illegible]	0.593	0.446	0	0	-0.124	-0.009	0.046
M364	0.054	0.278	0.157	0.009	0.045	[illegible]	[illegible]	-0.029	-0.183	[illegible]	-0.069	[illegible]	0.025	0.503	0.324	0.086	-0.02	[illegible]	-0.393	-0.25	[illegible]	-0.526	0.425	-0.135	0.272	[illegible]	-0.173	-0.253
M378	0.331	0.235	-0.076	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.058	0.544	0.179	[illegible]	0.460	[illegible]	[illegible]	[illegible]	-0.127	0.331	0.348	[illegible]	-0.148	[illegible]	[illegible]	[illegible]
M379	0.126	0.349	0.111	[illegible]	[illegible]	[illegible]	-0.224	0.21	0.242	[illegible]	[illegible]	[illegible]	0.132	0.721	0.017	[illegible]	[illegible]	[illegible]	[illegible]	0.207	-0.129	0.1	0.098	0.202	0.013	[illegible]	[illegible]	0
M436	0.244	[illegible]	0.032	0	0	0	0	0.406	0	0	[illegible]	[illegible]	0.11	0.594	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0.076	-0.164	0.266	0	0	[illegible]	[illegible]	0
M484	0.044	0.318	[illegible]	0.171	[illegible]	-0.081	0.05	0.355	0.246	[illegible]	[illegible]	[illegible]	0.072	0.186	0.745	[illegible]	[illegible]	[illegible]	0.306	0.253	0.009	0.17	0.426	0.182	0.125	[illegible]	[illegible]	[illegible]
M485	0.343	0.197	0.241	[illegible]	0.216	-0.155	-0.012	0.01	[illegible]	0.25	0.136	0.184	-0.111	0.768	0.048	0.092	0.464	0.177	[illegible]	[illegible]	-0.069	0.506	0.56	[illegible]	-0.201	0.266	0.414	0.37
M486	0.205	0.285	0.245	0.173	[illegible]	-0.188	-0.031	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.166	0.627	[illegible]	[illegible]	0.831	[illegible]	[illegible]	[illegible]	-0.014	-0.334	[illegible]	0.187	-0.083	[illegible]	[illegible]	[illegible]
M488	0.331	0.182	0.356	0	0	0	0	-0.029	0	0	0.273	[illegible]	0.015	0.031	0.161	[illegible]	0.521	[illegible]	0	0	-0.01	0.563	0.946	0	0	0.616	0.563	[illegible]
M489	0.306	-0.306	-0.133	0.22	0.121	-0.074	-0.029	0.273	[illegible]	0.427	0.26	0.454	-0.034	0.935	0.07	0.1	[illegible]	[illegible]	[illegible]	0.241	-0.025	0.393	1	-0.021	-0.018	[illegible]	0	0
M490	0.185	0.419	0.254	0	0	0	0	0.175	0	0	0.085	[illegible]	0.203	0.812	0.678	0.151	0.411	[illegible]	0	0	-0.087	0.239	0.547	0	0	[illegible]	0.558	[illegible]
M491	0.094	0.223	[illegible]	0	0	0	0	0.226	0	0	[illegible]	[illegible]	-0.097	0.408	0.472	[illegible]	0.57	[illegible]	0	0	-0.047	-0.012	0.581	0	0	[illegible]	0.694	1
M493	0.834	0.404	0.75	0	0	0	0	-0.81	0	0	0.117	0.228	0.536	0	0	-0.456	0	0	0	0	0.416	0	-1	0	0	0	0	0
M494	0.163	0.046	[illegible]	0	0	0	0	-0.246	0	0	0.116	-0.047	-0.198	0.333	0	0.338	0.408	-0.475	0	0	0.026	0.606	0.764	0	0	0	0	0
M495	-0.69	-0.44	-0.008	0	0	0	0	0.459	0	0	0.366	0.068	0.218	0	0	-0.056	0.185	-0.107	0	0	0.336	-0.496	-0.426	0	0	0	0	0
M530	-0.028	0.582	0.118	0.392	-0.091	0.398	0.15	[illegible]	0.026	-0.22	0.253	-0.254	0.128	0.456	0.799	0.018	0.103	-0.3	-0.079	0.302	[illegible]	-0.696	-0.02	0.026	0.193	0	0	0
M532	0.386	1	0.106	[illegible]	[illegible]	[illegible]	[illegible]	0.202	[illegible]	0.266	0.354	-0.273	0.375	0.456	0	-0.052	-0.543	-0.372	-0.098	0.196	[illegible]	0	0	-0.079	[illegible]	-0.198	0	0
M533	0.213	0.494	0.105	0.408	0.424	0.104	-0.108	0.243	-0.183	0	0.252	[illegible]	-0.109	0.729	0.68	[illegible]	0.425	[illegible]	0.265	-0.556	-0.026	0.497	0.994	-0.133	0.363	0	0	0
M545	0.163	[illegible]	-0.103	1	0	0.144	0.243	[illegible]	0	0	[illegible]	[illegible]	0.191	0.016	0.816	0.229	[illegible]	[illegible]	-1	0	-0.005	0.401	[illegible]	1	0	[illegible]	[illegible]	0
M546	0.166	[illegible]	0.123	0	0	0	0	0.429	0	0	[illegible]	[illegible]	0.108	0.811	0.311	0.27	[illegible]	[illegible]	0	0	-0.019	0.155	0.035	0	0	[illegible]	[illegible]	0
M547		-0.053	-0.184	0	0	0	0	0.221	0	0	0.08	0.128	0.174	-0.122	0.925	-0.122	0.099	-0.232	0	0	0.131	-0.094	0.496	0	0	0	0	0
M558	12		0.389	0	0	0	0	0.552	0	0	0.212	0.231	0.069	0	0.68	0.198	-0.813	[illegible]	0	0	0.647	0	0.668	0	0	0.806	[illegible]	0
M563	23	16		0	0	0	0	-0.276	0	0	0.297	-0.003	-0.103	0.239	1	[illegible]	0.213	-0.175	0	0	0.045	-0.258	0.877	0	0	0	0	0
M577	0	0	0		[illegible]	0.124	0.081	0.103	[illegible]	0.227	0	0	0	0	0	0	0	0	0.042	[illegible]	0.314	0	0	0.134	0.092	[illegible]	0	0
M580	0	0	0	113		0.057	0.186	0.256	[illegible]	[illegible]	0	0	0	0	0	0	0	0	[illegible]	[illegible]	0	0	0	[illegible]	0.188	0.372	0	0
M622	0	0	0	71	72		[illegible]	-0.109	-0.063	[illegible]	0	0	0	0	0	0	0	0	-0.397	-0.054	[illegible]	0	0	-0.213	[illegible]	[illegible]	0	0
M628	0	0	0	89	90	92		-0.094	0.249	[illegible]	0	0	0	0	0	0	0	0	-0.152	0.028	0.459	0	0	-0.123	0.216	-0.197	0	0
M629	26	11	27	53	54	36	50		0.089	0.308	[illegible]	0.235	-0.067	0.095	0.669	-0.025	0.374	0.063	0.474	0.326	[illegible]	-0.371	0.964	-0.043	-0.399	0.142	0	0
M630	0	0	0	75	79	65	75	50		[illegible]	0	0	0	0	0	0	0	0	[illegible]	[illegible]	0	0	0	0.198	0.157	[illegible]	0	0
M688	0	0	0	42	44	44	42	8	33		0	0	0	0	0	0	0	0	[illegible]	[illegible]	0	0	0	[illegible]	-0.104	[illegible]	0	0
M697	25	33	31	0	0	0	0	32	0	0		[illegible]	-0.002	0.71	0.54	[illegible]	0.634	[illegible]	0	0	0.2	-0.2	0.567	0	0	0.361	0.294	0
M698	24	36	29	0	0	0	0	31	0	0	76		0.084	0.891	-0.032	0.206	0.468	[illegible]	0	0	-0.206	0.072	0.327	0	0	0.423	0.413	[illegible]

Note: ■ :Correlation coefficient with 99% interval of confidence (Alfa=0.01)

▩ :Correlation coefficient with 95% interval of confidence (Alfa=0.05)

▨ :Correlation coefficient with 90% interval of confidence (Alfa=0.10)

░ :Correlation coefficient with 75% interval of confidence (Alfa=0.25)

Table G.2: Confidence Interval for Pearson Correlation coefficients in monthly precipitation between stations

Coenfidence Interval for Correlation coefficient Monthly global

	M007	M008	M009	M020	M023	M041	M043	M048	M052	M061	M063	M068	M070	M077	M078	M087	M098	M186	M188	M200	M201	M202	M203	M205	M208	M215	M219	M220	M279
M007	1	1	0.958	0.804	0.038	1	0.953	0.926	1	1	0.987	1	1	0	0	0.222	0.296	0.841	1	1	1	1	0.951	0.994	1	1	1	1	0.97
M008	1	1	0.778	1	0.957	1	1	1	1	1	1	1	1	0.993	0.014	0.884	0.076	0.996	1	1	1	1	1	1	0.997	1	1	1	1
M009	0.958	0.778	1	0	1	0.872	0	0.877	0.983	0.988	0.923	0.332	0.642	0	0	0.995	0.293	0.729	0.299	0.814	0.209	0.571	0.312	0.135	0.498	0.477	0.075	0.492	0
M020	0.804	1	0	1	0.795	1	0.99	0	0	0	0.891	0.976	0.259	0.978	0.944	0.409	0	0.154	0.974	0.951	0.735	0	0.839	0.665	0.999	0.022	0.821	0	0.679
M023	0.038	0.957	1	0.795	1	1	0.767	0.926	0.998	0.999	0.027	0.378	0.793	0	0	1	0.081	0.927	0.352	0.968	0.879	0.617	0.343	0.92	0.892	0.683	0.179	0.095	0.697
M041	1	1	0.872	1	1	1	0.997	1	1	1	0.999	0.995	1	0.997	0.07	0.991	0.119	0.963	0.976	1	1	1	1	1	0.975	0.95	1	0.999	0.948
M043	0.953	1	0	0.99	0.767	0.997	1	0.932	0.79	0.913	0.932	0.789	0.489	0.082	0.375	1	0	0.748	0.958	1	0.556	0.341	1	0.407	0.396	0.222	0.821	0.28	0.413
M048	0.926	1	0.877	0	0.926	1	0.932	1	0.408	0.398	0.714	0.556	1	0	0	0.814	0.485	0.99	0.877	0.995	0.992	0.932	0.999	1	0.875	0.756	0.574	0.603	0.397
M052	1	1	0.983	0	0.998	1	0.79	0.408	1	1	0.581	0.963	1	0	0	0.829	0.609	0.958	0.984	1	0.999	0.984	0.08	0.855	0.772	0.999	0.291	0.998	0.955
M061	1	1	0.988	0	0.999	1	0.913	0.398	1	1	0.967	0.999	1	0	0	0.471	0.869	0.991	0.985	1	0.985	0.999	0.297	0.61	0.482	0.905	0.909	0.964	0.928
M063	0.987	1	0.923	0.891	0.027	0.999	0.932	0.714	0.581	0.967	1	0.988	0.45	0.878	0.352	0.595	0.356	0.908	0.879	0.938	0.953	0.854	0.861	0.956	0.425	0.72	0.981	0.497	0.92
M068	1	1	0.332	0.976	0.378	0.995	0.789	0.556	0.963	0.999	0.988	1	0.946	1	0.841	0.931	0.814	0.115	1	1	1	1	0.705	0.951	0.974	1	1	0.985	1
M070	1	1	0.642	0.259	0.793	1	0.489	1	1	1	0.45	0.946	1	0.62	0.207	0.73	0.58	0.009	0.997	1	1	0.927	0.985	0.999	0.981	1	0.979	0.988	0.999
M077	0	0.993	0	0.978	0	0.997	0.082	0	0	0	0.878	1	0.62	1	0.999	0	0	0.023	0.975	0	0	0	0	0	0	0	0.963	0	0
M078	0	0.014	0	0.944	0	0.07	0.375	0	0	0	0.352	0.841	0.207	0.999	1	0	0	0.431	0.014	0	0	0	0	0	0	0	0.264	0	0
M087	0.222	0.884	0.995	0.409	1	0.991	1	0.814	0.829	0.471	0.595	0.931	0.73	0	0	1	0.749	0.816	0.988	0.874	0.527	0.038	0.625	0.894	0.69	0.067	0.926	0.384	0.151
M098	0.296	0.076	0.293	0	0.081	0.119	0	0.485	0.609	0.869	0.356	0.814	0.58	0	0	0.749	1	0.678	0.999	0.786	0.962	0.94	0.247	0.399	0.98	0.876	1	0.958	0
M186	0.841	0.996	0.729	0.154	0.927	0.963	0.748	0.99	0.958	0.991	0.908	0.115	0.009	0.023	0.431	0.816	0.678	1	0.415	1	0.936	0.869	0.995	0.998	0.973	0.912	0.826	0.249	0.188
M188	1	1	0.299	0.974	0.352	0.976	0.958	0.877	0.984	0.985	0.879	1	0.997	0.975	0.014	0.988	0.999	0.415	1	0.912	1	0.998	0.981	0.998	1	1	1	1	1
M200	1	1	0.814	0.951	0.968	1	1	0.995	1	1	0.938	1	1	0	0	0.874	0.786	1	0.912	1	0.992	0.998	1	0.999	0.982	1	0.938	0.967	0.995
M201	1	1	0.209	0.735	0.879	1	0.556	0.992	0.999	0.985	0.953	1	1	0	0	0.527	0.962	0.936	1	0.992	1	1	1	1	1	1	1	1	0.465
M202	1	1	0.571	0	0.617	1	0.341	0.932	0.984	0.999	0.854	1	0.927	0	0	0.038	0.94	0.869	0.998	0.998	1	1	0.246	0.252	1	1	0.986	1	0.006
M203	0.951	1	0.312	0.839	0.343	1	1	0.999	0.08	0.297	0.861	0.705	0.985	0	0	0.625	0.247	0.995	0.981	1	1	0.246	1	1	0.995	0.993	0.989	0.462	0.942
M205	0.994	1	0.135	0.665	0.92	1	0.407	1	0.855	0.61	0.956	0.951	0.999	0	0	0.894	0.399	0.998	0.998	0.999	1	0.252	1	1	1	1	1	0.466	0.991
M208	1	0.997	0.498	0.999	0.892	0.975	0.395	0.875	0.772	0.482	0.425	0.974	0.981	0	0	0.69	0.98	0.973	1	0.982	1	1	0.995	1	1	1	1	1	0.104
M215	1	1	0.477	0.022	0.683	0.95	0.222	0.756	0.999	0.905	0.72	1	1	0	0	0.067	0.876	0.912	1	1	1	1	0.993	1	1	1	1	1	0.977
M219	1	1	0.075	0.821	0.179	1	0.821	0.574	0.291	0.909	0.981	1	0.979	0.963	0.264	0.926	1	0.826	1	0.938	1	0.986	0.989	1	1	1	1	1	0.989
M220	1	1	0.492	0	0.095	0.999	0.28	0.603	0.998	0.964	0.497	0.985	0.988	0	0	0.384	0.958	0.249	1	0.967	1	1	0.462	0.466	1	1	1	1	0.379
M279	0.97	1	0	0.679	0.697	0.948	0.413	0.397	0.955	0.928	0.92	1	0.999	0	0	0.151	0	0.188	1	0.995	0.465	0.006	0.942	0.991	0.104	0.977	0.989	0.379	1
M293	1	1	0.992	0	0.999	1	0	0	1	1	0.811	0.936	1	0	0	0	0	0	0.986	1	0.998	0.998	0.772	0.923	0.774	0.498	0.912	0.95	0.993
M304	0.996	1	0.955	0.647	1	1	1	0.526	0.527	0.046	0.978	0.368	0.986	0.621	0.575	1	0.761	0.731	0.997	0.998	0.069	0.081	0.696	0.803	0.14	0.078	0.999	0.994	0.909
M310	0.452	0.999	1	0.908	1	0.993	1	0.594	0.979	0.242	0.997	0.48	0.396	0.128	0.412	1	0.264	0.878	0.954	0.816	0.978	1	0.642	0.984	0.884	1	0.919	0.999	0.653
M315	0.941	1	1	0.855	1	1	1	0.712	0.999	1	1	0.259	0.995	0.104	0.528	1	0.564	0.702	0.508	1	0.827	0.942	0.858	0.899	0.223	0.115	0.959	0.891	0.319
M316	0.327	0.995	0.713	0.989	1	1	1	0.086	0.97	0.998	0.999	0.178	0.403	0.028	0.108	1	0.125	0.953	0.011	1	0.243	0.041	0.724	0.996	0.786	0.924	0.562	0.091	0.185
M324	0.998	1	0.991	0.977	1	1	0.977	0.861	0.998	0.999	0.893	0.827	1	0.367	0.848	0.998	0.568	0.829	1	0.996	1	0.977	0.99	1	0.994	0.984	1	0.998	0.978
M344	0.431	0.999	0.999	0.78	1	1	1	0.164	0.985	0.998	0.995	0.79	0.88	0.573	0.599	1	0.37	0.555	0.91	0.999	0.311	0.801	0.106	0.632	0.984	0.562	0.515	0.56	0.773
M349	0.913	0.417	0	0.834	0.999	0.695	1	0.05	0.33	0.041	0.15	0.322	1	0.58	0.501	1	0	0.246	0.791	0.634	0.935	0.263	0.965	0.546	0.936	0.843	0.456	0.859	0.708
M353	0.991	0.939	1	0.358	1	1	1	0.641	0.999	0.998	0.931	0.998	0.034	0.549	0.266	1	0.784	0.793	1	0.968	0.999	0.309	0.769	0.904	1	0.999	1	0.939	0.275
M359	0.123	1	1	0.069	1	1	0.999	0.027	1	0.996	0.737	0.594	0.666	0	0	1	0.022	0.301	0.998	0.999	0.858	0.537	0.203	0.907	0.98	0.908	0.929	0.204	0.659
M364	0.921	0.986	1	0.883	1	1	1	0.349	0.978	0.996	0.993	0.978	0.73	0.327	0.367	1	0.811	0.959	1	0.992	0.997	0.172	0.346	0.917	0.997	0.999	1	0.955	0.716
M378	1	1	0.481	0.938	0.931	1	0.683	0.735	0.997	0.992	0.183	1	1	0.999	0.091	0.992	0.981	0.187	1	0.992	1	1	0.986	0.981	1	1	1	1	0.998
M379	1	1	0.587	0.94	0.994	1	0.632	0.954	0.959	0.964	0.89	1	1	0.685	0.815	0.908	0.914	0.718	1	1	1	1	0.221	0.96	1	1	1	1	0.946
M436	1	1	0.919	0	0.333	0.999	0.695	0.064	1	1	0.387	0.999	0.946	0	0	0.395	0.934	0.312	1	0.995	1	1	0.644	0.465	1	1	1	1	0.573
M484	1	1	0.356	0.877	0.818	1	0.632	1	1	1	0.93	0.998	1	0.652	0.699	0.267	0.318	0.525	1	1	1	1	0.999	1	0.999	1	1	0.995	0.987
M485	0.999	1	0.501	0.993	0.727	1	0.952	1	0.843	1	0.996	1	1	0.896	0.288	0.503	0.988	0.534	0.984	0.991	1	0.998	0.952	1	0.951	0.971	0.998	0.988	1
M486	1	1	0.995	0.989	0.869	1	0.368	0.967	1	1	0.956	1	1	0.983	0.439	0.033	0.821	0.842	1	1	1	1	0.989	0.995	0.98	1	1	1	1
M488	0.995	1	0.206	0	0.396	1	0.385	0.976	0.9	0.996	0.929	0.865	1	0	0	0.713	0.979	0.834	0.979	0.91	1	0.996	0.955	0.926	0.989	0.999	0.995	0.988	0.244
M489	1	1	0.549	0.952	0.074	1	0.838	0.977	0.099	0.801	0.956	1	1	0.277	0	0.214	0.942	0.376	1	1	1	0.989	0.96	0.999	0.994	1	1	1	1
M490	1	1	0.638	0	0.752	0.918	0.672	0.749	1	1	0.17	0.988	1	0	0	0.178	0.967	0.606	1	0.427	1	1	0.013	0.296	1	1	0.994	1	0.437
M491	1	1	0.477	0	0.897	1	0.247	0.996	1	0.999	0.443	0.834	1	0	0	0.424	0.259	0.982	1	1	1	1	0.983	0.997	1	1	0.978	1	0.487
M493	0.875	0.167	0	0	0.316	0.401	0.186	0.487	0.877	0.669	0.709	0.705	0	0	0	0.497	0	0.39	0.725	0.86	0.149	0	0.029	0	0.21	0.164	0.46	0	0
M494	0.105	0.891	0.494	0	0.109	0.948	0.056	0.999	0.626	0.516	0.701	0.011	0	0	0	0.882	0.663	0.784	0.6	0.838	0.433	0.323	0.763	0.993	0.499	0.292	0.735	0.922	0
M495	0.632	0.114	0.78	0	0.629	0.29	0.525	0.217	0.983	0.176	0.405	0.715	0	0	0	0.98	0.42	0.897	0.135	0.361	0.626	0.445	0.652	0.08	0.343	0.162	0.58	0.545	0
M530	0.739	0.827	0.997	0.041	1	0.997	1	0.475	0.552	0.014	0.183	0.538	0.587	0.131	0	1	0.019	0.85	0.787	0.999	0.487	0.109	0.603	0.897	0.717	0.308	0.232	0.189	0.306
M532	0.676	0.99	0	0.848	0.999	0.999	1	0.918	0.511	0.847	0.98	0.635	0.619	0.457	0.327	1	0	0.824	0.956	0.937	0.072	0.047	0.149	0.682	0.445	0.547	0.991	0.641	0.636
M533	1	1	0.017	0.759	0.105	0.992	0.905	0.978	0.104	0.41	0.651	0.998	0.993	0	0	0.833	1	0.683	1	0.999	1	0.999	0.602	0.991	0.998	1	1	1	0.944
M545	1	1	0.428	0.813	0.244	0.944	0.249	0.168	0.996	0.975	0.801	1	0.995	0	0	0.598	1	0.291	1	0.96	1	0.978	0.998	0.966	1	1	1	1	1
M546	1	1	0.534	0	0.988	0.947	0.708	0.489	0.999	1	0.023	1	0.998	0	0	3E-04	0.967	0.672	1	0.976	1	1	0.373	0.064	1	1	1	1	0.833
M547	0.671	0.44	0.869	0	0.269	0.129	0.291	0.035	0.951	0.238	0.261	0.79	0.516	0	0	0.793	0.227	0.216	0.488	0.674	0.69	0.503	0.062	0.746	0.521	0.003	0.934	0.716	0
M558	0.996	0.999	0	0	0.624	0.94	0.647	0.656	0.99	0.982	0.73	0.276	0.94	0	0	0.908	0	0.897	1	0.753	0.982	1	0.8	0.848	0.58	0.566	0.984	1	0.51
M563	0.588	0.999	0.334	0	0.443	0.996	0.435	0.995	0.684	0.798	0.979	0.195	0.987	0	0	0.811	0.304	0.999	0.404	1	0.623	0.975	0.926	0.971	0.174	0.88	0.632	0.18	0.487
M577	0	0.724	0	0.176	0	0.675	0.654	0	0	0	0.859	0.921	0.975	0.936	0.102	0.639	0	0.994	1	0	0	0	0.28	0	0	0.78	0.988	0	0.481
M580	0	0.999	0	0.736	0	0.999	0.719	0	0	0	0.518	0.965	0.968	0.967	0.884	0.153	0	0.828	1	0	0	0	0	0	0	0	1	0	0
M622	0	0.906	0	0.835	0	0.999	1	0	0	0	0.904	0.881	0.796	0.47	0.503	0.999	0	0.634	0.883	0.537	0	0	0.066	0	0	0.73	0.301	0	0.865
M628	0.672	0.798	0	0.774	0.586	0.974	0.999	0	0	0	0.873	0.994	0.008	0.3	0.668	0.822	0	0.592	0.151	0.079	0	0	0.633	0.785	0	0.676	0.996	0	0.313
M629	0.871	0.407	0.97	0.695	0.978	0.036	0.875	0.061	0.982	0.129	0.807	0.902	0.649	0.164	0.983	0.992	0.288	0.447	0.999	0.967	0.734	0.866	0.242	0.192	0.415	0.809	0.763	0.978	0.061
M630	0	1	0	0.357	0	0.977	0.083	0	0	0	0.052	0.8	0.992	0.752	0.141	0.251	0	0.927	1	0	0	0	0	0	0	0	1	0	0
M688	0	0.66	0	0.368	0	0.482	0.993	0	0	0	0.998	0.971	0.988	0.695	0.137	0	0	0.968	1	0	0	0	0	0	0	0	0.999	0	0
M697	1	1	0.702	0	0.44	1	0.757	0.992	0.992	0.956	0.991	0.873	0.98	0	0	0.954	0.271	0.933	1	0.999	0.999	0.998	0.967	0.999	1	0.941	0.983	1	0.072
M698	1	0.987	0.012	0	0.943	0.176	0.751	0.14	0.967	0.977	0.122	1	1	0	0	0.704	0.762	0.683	1	0.933	1	0.909	0.422	0.817	1	1	1	1	0.826

Table G.2: Confidence Interval for Pearson Correlation coefficients in monthly precipitation between stations (…. continuation).

	M293	M304	M310	M315	M316	M324	M344	M349	M353	M359	M364	M378	M379	M436	M484	M485	M486	M488	M489	M490	M491	M493	M494	M495	M530	M532	M533	M545	M546
M007	1	0.996	0.452	0.941	0.327	0.998	0.431	0.913	0.991	0.123	0.921	1	1	1	1	0.999	1	0.995	1	1	1	0.875	0.105	0.632	0.739	0.676	1	1	1
M008	1	1	0.999	1	0.995	1	0.999	0.417	0.939	1	0.986	1	1	1	1	1	1	1	1	1	1	0.167	0.891	0.114	0.827	0.99	1	1	1
M009	0.992	0.955	1	1	0.713	0.991	0.999	0	1	1	1	0.481	0.587	0.919	0.356	0.501	0.995	0.206	0.549	0.638	0.477	0	0.494	0.78	0.997	0	0.017	0.428	0.534
M020	0	0.647	0.908	0.855	0.989	0.977	0.78	0.834	0.358	0.069	0.883	0.938	0.94	0	0.877	0.993	0.989	0	0.952	0	0	0	0	0	0.041	0.848	0.759	0.813	0
M023	0.999	1	1	1	1	1	1	0.999	1	1	1	0.931	0.994	0.333	0.818	0.727	0.869	0.396	0.074	0.752	0.897	0.316	0.109	0.629	1	0.999	0.105	0.244	0.988
M041	1	1	0.993	1	1	1	1	0.695	1	1	1	1	1	0.999	1	1	1	1	1	0.918	1	0.401	0.948	0.29	0.997	0.999	0.992	0.944	0.947
M043	0	1	1	1	1	0.977	1	1	1	0.999	1	0.683	0.632	0.695	0.632	0.952	0.368	0.385	0.838	0.672	0.247	0.186	0.056	0.525	1	1	0.905	0.249	0.708
M048	0	0.526	0.594	0.712	0.086	0.861	0.164	0.05	0.641	0.027	0.349	0.735	0.954	0.064	1	1	0.967	0.976	0.977	0.749	0.996	0.487	0.999	0.217	0.475	0.918	0.978	0.168	0.489
M052	1	0.527	0.979	0.999	0.97	0.998	0.985	0.33	0.999	1	0.978	0.997	0.959	1	1	0.843	1	0.9	0.099	1	1	0.877	0.626	0.983	0.552	0.511	0.104	0.996	0.999
M061	1	0.046	0.242	1	0.998	0.999	0.998	0.041	0.998	0.996	0.996	0.992	0.964	1	1	1	1	0.996	0.801	1	0.999	0.669	0.516	0.176	0.014	0.847	0.41	0.975	1
M063	0.811	0.978	0.997	1	0.999	0.893	0.995	0.15	0.931	0.737	0.993	0.183	0.89	0.387	0.93	0.996	0.956	0.929	0.956	0.17	0.443	0.709	0.701	0.405	0.183	0.98	0.651	0.801	0.023
M068	0.936	0.368	0.48	0.259	0.178	0.827	0.79	0.322	0.998	0.594	0.978	1	1	0.999	0.998	1	1	0.865	1	0.988	0.834	0.705	0.011	0.715	0.538	0.635	0.998	1	1
M070	1	0.986	0.396	0.995	0.403	1	0.88	1	0.034	0.666	0.73	1	1	0.946	1	1	1	1	1	1	1	0	0	0	0.587	0.619	0.993	0.995	0.998
M077	0	0.621	0.128	0.104	0.028	0.367	0.573	0.58	0.549	0	0.327	0.999	0.685	0	0.652	0.896	0.983	0	0.277	0	0	0	0	0	0.131	0.457	0	0	0
M078	0	0.575	0.412	0.528	0.108	0.848	0.599	0.501	0.266	0	0.367	0.091	0.815	0	0.699	0.288	0.439	0	0	0	0	0	0	0	0	0.327	0	0	0
M087	0	1	1	1	1	0.998	1	1	1	1	1	0.992	0.908	0.395	0.267	0.503	0.033	0.713	0.214	0.178	0.424	0.497	0.882	0.98	1	1	0.833	0.598	3E-04
M098	0	0.761	0.264	0.564	0.125	0.568	0.37	0	0.784	0.022	0.811	0.981	0.914	0.934	0.318	0.988	0.821	0.979	0.942	0.967	0.259	0	0.663	0.42	0.019	0	1	1	0.967
M186	0	0.731	0.878	0.702	0.953	0.829	0.555	0.246	0.793	0.301	0.959	0.187	0.718	0.312	0.525	0.534	0.842	0.834	0.376	0.606	0.982	0.39	0.784	0.897	0.85	0.824	0.683	0.291	0.672
M188	0.986	0.997	0.954	0.508	0.011	1	0.91	0.791	1	0.998	1	1	1	1	1	0.984	1	0.979	1	1	1	0.725	0.6	0.135	0.787	0.956	1	1	1
M200	1	0.998	0.816	1	1	0.996	0.999	0.634	0.968	0.999	0.992	0.992	1	0.995	1	0.991	1	0.91	1	0.427	1	0.86	0.838	0.361	0.999	0.937	0.999	0.96	0.976
M201	0.998	0.069	0.978	0.827	0.243	1	0.311	0.935	0.999	0.858	0.997	1	1	1	1	1	1	1	1	1	1	0.149	0.433	0.626	0.487	0.072	1	1	1
M202	0.998	0.081	1	0.942	0.041	0.977	0.801	0.263	0.309	0.537	0.172	1	1	1	1	0.998	1	0.996	0.989	1	1	0	0.323	0.445	0.109	0.047	0.999	0.978	1
M203	0.772	0.696	0.642	0.858	0.724	0.99	0.106	0.965	0.769	0.203	0.346	0.986	0.221	0.644	0.999	0.952	0.989	0.955	0.96	0.013	0.983	0.029	0.763	0.652	0.603	0.149	0.602	0.998	0.373
M205	0.923	0.803	0.984	0.899	0.996	1	0.632	0.546	0.904	0.907	0.917	0.981	0.96	0.465	1	1	0.995	0.926	0.999	0.296	0.997	0	0.993	0.08	0.897	0.682	0.991	0.966	0.064
M208	0.774	0.14	0.884	0.223	0.786	0.994	0.984	0.936	1	0.98	0.997	1	1	1	0.999	0.951	0.98	0.989	0.994	1	1	0.21	0.499	0.343	0.717	0.445	0.998	1	1
M215	0.498	0.078	1	0.115	0.924	0.984	0.562	0.843	0.999	0.908	0.999	1	1	1	1	0.971	1	0.999	1	1	1	0.164	0.292	0.162	0.308	0.547	1	1	1
M219	0.912	0.999	0.919	0.959	0.562	1	0.515	0.456	1	0.929	1	1	1	1	1	0.998	1	0.995	1	0.994	0.978	0.46	0.735	0.58	0.232	0.991	1	1	1
M220	0.95	0.994	0.999	0.891	0.091	0.998	0.56	0.859	0.939	0.204	0.955	1	1	1	0.995	0.988	1	0.988	1	1	1	0	0.922	0.545	0.189	0.641	1	1	1
M279	0.993	0.909	0.653	0.319	0.185	0.978	0.773	0.708	0.275	0.659	0.716	0.998	0.946	0.573	0.987	1	1	0.244	1	0.437	0.487	0	0	0	0.306	0.636	0.944	1	0.833
M293	1	0.737	0.821	1	0.972	1	0.989	0	1	0.999	0.998	0.977	0.991	1	1	0.959	1	0.999	0	0.995	1	0	0	0	0	0	0	0.782	0.986
M304	0.737	1	1	1	1	1	1	0.999	1	1	1	0.002	0.664	0.694	0.779	0.146	0.974	0.136	0.942	0.501	0.641	0	0.089	0.921	1	1	0.531	0.947	0.052
M310	0.821	1	1	1	1	1	1	1	1	0.999	1	0.027	0.998	0.901	0.959	0.209	0.781	0.28	0.545	0.966	0.603	0.469	0.613	0.643	1	1	0.811	0.792	0.998
M315	1	1	1	1	1	1	1	1	1	1	1	0.938	0.688	0.99	0.989	0.842	1	0.961	0.486	0.233	0.336	0.899	0.075	0.085	1	1	0.234	0.901	0.088
M316	0.972	1	1	1	1	1	1	1	1	1	1	1	0.975	0.059	0.32	0.6	0.307	0.752	0.035	0.707	0.484	0.597	0.351	0.465	1	1	0.102	0.212	0.814
M324	1	1	1	1	1	1	1	0.999	1	1	1	1	0.984	1	1	0.935	1	0.994	0.999	0.994	0.422	0.151	0.847	0.028	1	1	0.936	1	0.954
M344	0.989	1	1	1	1	1	1	1	1	1	1	1	0.983	0.917	0.522	0.262	0.733	0.081	0.214	0.219	0.48	0.113	0.401	0.877	1	1	0.168	0.048	0.11
M349	0	0.999	1	1	1	0.999	1	1	1	1	1	0.966	0.796	0.846	0.983	0.851	0.363	0.627	0.179	0.939	0.039	0.156	0.186	0.18	1	1	0.993	0.712	0.946
M353	1	1	1	1	1	1	1	1	1	1	1	1	1	0.833	0.857	0.882	0.857	0.409	0.929	0.976	0.484	0.485	0.825	0.258	1	1	0.928	0.999	0.985
M359	0.999	1	0.999	1	1	1	1	1	1	1	1	1	0.99	0.118	0.355	0.525	0.949	0.464	0.599	0.513	0.096	0	0.607	0.715	1	0.999	0.47	0.494	0.895
M364	0.998	1	1	1	1	1	1	1	1	1	1	1	1	0.886	0.88	0.954	0.972	0.19	0.861	0.976	0.846	0.787	0.819	0.862	1	1	0.968	0.996	0.997
M378	0.977	0.002	0.027	0.938	1	1	1	0.966	1	1	1	1	1	1	1	1	1	0.998	1	1	1	0.188	0.208	0.865	0.928	0.902	1	1	1
M379	0.991	0.664	0.998	0.688	0.975	0.984	0.983	0.796	1	0.99	1	1	1	1	1	1	1	0.998	1	1	1	0.012	0.611	0.63	0.467	0.002	1	1	1
M436	1	0.694	0.901	0.99	0.059	1	0.917	0.846	0.833	0.118	0.886	1	1	1	1	0.953	1	0.991	1	1	1	0.046	0.282	0.824	0.136	0.452	1	1	1
M484	1	0.779	0.959	0.989	0.32	1	0.522	0.983	0.857	0.355	0.88	1	1	1	1	1	1	1	1	1	1	0.139	0.779	0.293	0.047	0.64	1	0.996	1
M485	0.959	0.146	0.209	0.842	0.6	0.935	0.262	0.851	0.882	0.525	0.954	1	1	0.953	1	1	1	1	1	1	0.971	0.94	0.753	0.154	0.871	0.415	0.999	0.999	0.966
M486	1	0.974	0.781	1	0.307	1	0.733	0.363	0.857	0.949	0.972	1	1	1	1	1	1	0.994	1	1	1	0.47	0.162	0.791	0.004	0.865	1	1	1
M488	0.999	0.136	0.28	0.961	0.752	0.994	0.081	0.627	0.409	0.464	0.19	0.998	0.998	0.991	1	1	0.994	1	0.962	0.995	0.997	0.279	0.998	0.448	0.534	0.126	0.999	0.998	0.844
M489	0	0.942	0.545	0.486	0.035	0.999	0.214	0.179	0.929	0.599	0.861	1	1	1	1	1	1	0.962	1	0.996	0.996	0.222	0.228	0.683	0.462	0.351	0.995	1	1
M490	0.995	0.501	0.966	0.233	0.707	0.994	0.219	0.939	0.976	0.513	0.976	1	1	1	1	1	1	0.995	0.996	1	1	0.508	0.679	0.081	0.61	0.175	0.999	1	1
M491	1	0.641	0.603	0.336	0.484	0.422	0.48	0.039	0.484	0.096	0.846	1	1	1	1	0.971	1	0.997	0.996	1	1	0.11	0.734	0.182	0.243	0.733	0.999	1	1
M493	0	0	0.469	0.899	0.597	0.151	0.113	0.156	0.485	0	0.787	0.188	0.012	0.046	0.139	0.94	0.47	0.279	0.222	0.508	0.11	1	0.479	0.387	0.505	0	0.409	0.871	0.222
M494	0	0.089	0.613	0.075	0.351	0.847	0.401	0.186	0.825	0.607	0.819	0.208	0.611	0.282	0.779	0.753	0.162	0.998	0.228	0.679	0.734	0.479	1	0.501	0.174	0.45	0.01	0.835	0.135
M495	0	0.921	0.643	0.085	0.465	0.028	0.877	0.18	0.258	0.715	0.862	0.865	0.63	0.824	0.293	0.154	0.791	0.448	0.683	0.081	0.182	0.387	0.501	1	0.128	0.426	0.115	0.315	0.37
M530	0	1	1	1	1	1	1	1	1	1	1	0.928	0.467	0.136	0.047	0.871	0.004	0.534	0.462	0.61	0.243	0.505	0.174	0.128	1	1	0.276	0.034	0.386
M532	0	1	1	1	1	1	1	1	1	0.999	1	0.902	0.002	0.452	0.64	0.415	0.865	0.126	0.351	0.175	0.733	0	0.45	0.426	1	1	0.324	0.688	0.53
M533	0	0.531	0.811	0.234	0.102	0.936	0.168	0.993	0.928	0.47	0.968	1	1	1	1	0.999	1	0.999	0.995	0.999	0.999	0.409	0.01	0.115	0.276	0.324	1	1	1
M545	0.782	0.947	0.792	0.901	0.212	1	0.048	0.712	0.999	0.494	0.996	1	1	1	0.996	0.999	1	0.998	1	1	1	0.871	0.835	0.315	0.034	0.688	1	1	1
M546	0.986	0.052	0.998	0.088	0.814	0.954	0.11	0.946	0.985	0.895	0.997	1	1	1	1	0.966	1	0.844	1	1	1	0.222	0.135	0.37	0.386	0.53	1	1	1
M547	0	0.625	0.311	0.37	0.014	0.171	0.484	0.861	0.461	0.06	0.219	0.926	0.469	0.797	0.182	0.936	0.723	0.921	0.894	0.673	0.379	0.628	0.563	0.988	0.118	0.759	0.732	0.602	0.574
M558	0.939	0.79	0.988	0.985	0.999	1	0.959	0.617	0.429	0.997	0.904	0.825	0.963	0.993	0.886	0.751	0.917	0.543	0.64	0.988	0.715	0.264	0.112	0.677	0.985	0	0.956	0.992	1
M563	0	0.548	0.831	0.046	0.072	0.568	0.232	0.553	0.522	0.673	0.625	0.337	0.462	0.142	1	0.823	0.844	0.937	0.5	0.86	0.99	0.54	0.999	0.02	0.501	0.256	0.451	0.444	0.481
M577	0	0.995	0.995	0.993	0.984	0.955	0.955	0.997	0.215	0	0.076	0.998	0.999	0	0.915	0.995	0.886	0	0.773	0	0	0	0	0	0.88	0.995	0.578	0	0
M580	0	1	1	1	0.97	1	0.854	0.939	0.003	0	0.374	1	0.994	0	0.998	0.973	1	0	0.483	0	0	0	0	0	0.253	1	0.424	0	0
M622	0	1	1	1	1	0.999	1	0.99	1	0	1	1	0.996	0	0.541	0.851	0.922	0	0.401	0	0	0	0	0	0.985	1	0.385	0.242	0
M628	0	1	1	1	1	1	1	0.995	1	0.078	1	0.999	0.987	0	0.406	0.096	0.246	0	0.179	0	0	0	0	0	0.697	1	0.48	0.4	0
M629	0	0.983	0.872	0.872	0.404	0.991	0.946	0.281	0.671	0.999	0.221	0.996	0.952	0.987	0.985	0.078	1	0.136	0.934	0.706	0.93	0.601	0.783	0.954	1	0.897	0.875	0.993	0.989
M630	0	0.999	0.997	0.998	0.652	1	0.075	0.62	0.739	0	0.904	1	0.973	0	0.97	1	1	0	0.993	0	0	0	0	0	0.066	1	0.336	0	0
M688	0	0.965	0.932	0.917	0.999	0.431	1	0.081	1	0	1	1	1	0	0.999	0.89	0.993	0	0.962	0	0	0	0	0	0.399	0.951	0	0	0
M697	0.951	0.994	0.387	0.962	0.893	0.993	0.825	0.638	0.208	0.847	0.493	1	0.996	1	0.998	0.787	1	0.962	0.849	0.58	1	0.075	0.401	0.781	0.894	0.714	0.888	0.999	0.997
M698	0.751	0.222	0.596	0.119	0.99	0.995	0.961	0.953	1	0.927	1	1	1	1	1	0.979	1	0.996	0.99	1	0.999	0.147	0.187	0.192	0.876	0.609	0.992	1	1

Table G.2: Confidence Interval for Pearson Correlation coefficients in monthly precipitation between stations (…. continuation).

	M547	M558	M563	M577	M580	M622	M628	M629	M630	M688	M697	M698	M699	M702	M703	M710	M713	M720	M724	M725	M731	M734	M829	M836	M839	MA1F	MA22	MA54
M007	0.671	0.996	0.588	0	0	0	0.672	0.871	0	0	1	1	0.781	0.821	0.251	1	0.443	1	0	0	0.641	0.038	0.338	0	0	0.999	1	1
M008	0.44	0.999	0.999	0.724	0.999	0.906	0.798	0.407	1	0.66	1	0.987	0.013	0.53	0.197	1	0.997	0.998	0.997	0.941	0.79	0.674	0.988	0.92	0.582	1	0.997	0.999
M009	0.869	0	0.334	0	0	0	0	0.97	0	0	0.702	0.012	0	0	0.958	0.828	0.191	0.387	0	0	1	0.974	0	0	0	0	0	0.602
M020	0	0	0	0.176	0.736	0.835	0.774	0.695	0.357	0.368	0	0	0	0	0	0	0	0	0.955	0.548	0.029	0	0	0.517	0.486	0.428	0	0
M023	0.269	0.624	0.443	0	0	0	0.586	0.978	0	0	0.44	0.943	0.072	0.252	0.769	0.995	0.186	0.964	0	0	1	0.722	0.371	0	0	0.62	0.146	0.007
M041	0.129	0.94	0.996	0.675	0.999	0.999	0.974	0.036	0.977	0.482	1	0.176	0.582	0.797	0.483	1	0.93	0.742	0.982	0.949	0.999	0.353	0.894	0.806	0.984	0.995	0.926	0.98
M043	0.291	0.647	0.435	0.654	0.719	1	0.999	0.875	0.083	0.993	0.757	0.751	0.702	0	0	0.187	0	0	0.769	0.354	1	0	0.832	0.556	0.853	0.668	0	0
M048	0.035	0.656	0.995	0	0	0	0	0.061	0	0	0.992	0.14	0.651	0.153	0.023	0.999	0.95	0.578	0	0	0.24	0.713	0.483	0	0	0	0	0
M052	0.951	0.99	0.684	0	0	0	0	0.982	0	0	0.992	0.967	0.479	0.487	0.705	1	0.902	0.935	0	0	0.93	0.82	0.158	0	0	0.734	0.946	0.992
M061	0.238	0.982	0.798	0	0	0	0	0.129	0	0	0.956	0.977	0.848	0.839	0.971	1	0.911	0.966	0	0	0.454	0.271	0.41	0	0	0.809	0.993	0.998
M063	0.261	0.73	0.979	0.859	0.518	0.904	0.873	0.807	0.052	0.998	0.991	0.122	0.961	0.275	0.868	0.88	0.17	0.585	0.651	0.814	0.922	0.337	0.052	0.45	0.279	0.656	0.363	0.601
M068	0.79	0.276	0.195	0.921	0.965	0.881	0.994	0.902	0.8	0.971	0.873	1	0.767	0.416	0.207	0.981	0.693	1	0.995	0.664	0.454	0.572	0.138	0.96	0.175	0.924	0	0
M070	0.516	0.94	0.987	0.975	0.968	0.796	0.008	0.649	0.992	0.988	0.98	1	0.229	0	0.671	1	0.507	0.988	0.997	0.89	0.053	0.94	0	0.614	0.994	0.999	0	1
M077	0	0	0	0.936	0.967	0.47	0.3	0.164	0.752	0.695	0	0	0	0	0	0	0	0	0.929	0.999	0	0	0	0.918	0.137	0.407	0	0
M078	0	0	0	0.102	0.884	0.503	0.668	0.983	0.141	0.137	0	0	0	0	0	0	0	0	0.801	0.039	0	0	0	0.03	0.824	0.534	0	0
M087	0.793	0.908	0.811	0.639	0.153	0.999	0.822	0.992	0.251	0	0.954	0.704	0.367	0.372	0.961	0.357	0.803	0.911	0.272	0.057	1	0.943	0.572	0.243	0.339	0	0	0
M098	0.227	0	0.304	0	0	0	0	0.288	0	0	0.271	0.762	0	0	0.794	0.979	0.739	0.997	0	0	0.31	0.965	0	0	0	0	0	0
M186	0.216	0.897	0.999	0.994	0.828	0.634	0.592	0.447	0.927	0.968	0.933	0.683	0.661	0.512	0.409	0.999	0.762	0.411	0.684	0.47	0.65	0.023	0.724	0.699	0.719	0.573	0	0
M188	0.488	1	0.404	1	1	0.883	0.151	0.999	1	1	1	1	0.291	0.273	0.888	0.999	0.979	1	1	1	0.664	0.578	0.657	0.851	0.329	1	1	1
M200	0.674	0.753	1	0	0	0.537	0.079	0.967	0	0	0.999	0.933	0.021	0.718	0.973	1	0.972	0.919	0.925	0	0.979	0.326	0.987	0.117	0	0.204	0.82	0
M201	0.69	0.982	0.623	0	0	0	0	0.734	0	0	0.999	1	0.774	0.659	0.999	1	0.96	1	0	0	0.711	0.302	0.836	0	0	0.998	0.999	0
M202	0.503	1	0.975	0	0	0	0	0.866	0	0	0.998	0.909	0.856	0.618	0.833	0.999	0.952	1	0	0	0.393	0.794	0.625	0	0	0.998	0.947	0
M203	0.062	0.8	0.926	0.28	0	0.066	0.633	0.242	0	0	0.967	0.422	0.412	0.883	0.999	0.999	0.912	0.534	0.969	0	0.573	0.379	0.853	0.238	0.405	0.704	0.113	0
M205	0.746	0.848	0.971	0	0	0	0.785	0.192	0	0	0.999	0.817	0.597	0.652	0.68	0.934	0.776	0.744	0	0	0.946	0.504	0.111	0	0	0.206	0	0
M208	0.521	0.58	0.174	0	0	0	0	0.415	0	0	1	1	0.042	0.797	0.989	0.989	0.906	1	0	0	0.765	0.126	0.488	0	0	1	0.897	0
M215	0.003	0.566	0.88	0.78	0	0.73	0.676	0.809	0	0	0.941	1	0.488	0.805	0.494	1	0.991	1	0.832	0	0.057	0.274	0.695	0.163	0	0.245	0.218	0
M219	0.934	0.984	0.632	0.988	1	0.301	0.996	0.763	1	0.999	0.983	1	0.618	0.037	0.918	0.894	0.985	1	1	1	0.028	0.902	0.088	0.994	0.24	0.998	0	0
M220	0.716	1	0.18	0	0	0	0	0.978	0	0	1	1	0.338	0.612	0.72	0.995	0.88	1	0	0	0.394	0.848	0.984	0	0	1	1	0
M279	0	0.51	0.487	0.481	0	0.865	0.313	0.061	0	0	0.072	0.826	0.378	0	0	0.179	0	0.933	0.324	0	0.215	0	0.116	0.495	0	0	0	0
M293	0	0.939	0	0	0	0	0	0	0	0	0.951	0.751	0.387	0	0.928	1	0	0.972	0	0	0	0	0	0	0	0.999	0.998	0.792
M304	0.625	0.79	0.548	0.995	1	1	1	0.983	0.999	0.965	0.994	0.222	0.666	0.438	0.252	0.097	0.588	0.43	0.807	0.131	1	0.605	0	0.357	0.013	0.299	0.718	0
M310	0.311	0.988	0.831	0.995	1	1	1	0.872	0.997	0.932	0.387	0.596	0.62	0.368	0.104	0.518	0.007	0.897	0.748	0.897	1	0.102	0.969	0.459	0.871	0.986	0.981	0.059
M315	0.37	0.985	0.046	0.993	1	1	1	0.872	0.998	0.917	0.962	0.119	0.645	0.678	0.932	1	0.238	0.728	0.091	0.368	1	0.562	0.974	0.194	0.355	0.198	0.862	0.762
M316	0.014	0.999	0.072	0.984	0.97	1	1	0.404	0.652	0.999	0.893	0.99	0.628	0.103	0.958	0.985	0.103	0.969	0.913	0.104	1	0.369	0.158	0.613	0.907	0.831	0.432	0
M324	0.171	1	0.568	0.955	1	0.999	1	0.991	1	0.431	0.993	0.995	0.278	0.336	0.952	1	0.977	0.993	0.91	0.999	1	0.108	0.652	0.933	0.979	0.998	1	1
M344	0.484	0.959	0.232	0.955	0.854	1	1	0.946	0.075	1	0.825	0.961	0.404	0.741	0.994	0.797	0.135	0.986	0.851	0.34	1	0.982	0.636	0.341	0.884	0.627	0.114	0
M349	0.861	0.617	0.553	0.997	0.939	0.99	0.995	0.281	0.62	0.081	0.638	0.953	0.706	0	0	0.435	0.339	0.952	0.149	0.119	1	0	0.685	0.273	0.312	0.31	0	0
M353	0.461	0.429	0.522	0.215	0.003	1	1	0.671	0.739	1	0.208	1	0.697	0.418	0.959	0.881	0.099	1	0.977	0.908	1	0.978	0.564	0.979	0.99	0.978	0.821	0.916
M359	0.06	0.997	0.673	0	0	0	0.078	0.999	0	0	0.847	0.927	0.164	0.423	0.995	0.999	0.22	1	0	0	1	0.988	0.625	0	0	0.53	0.031	0.237
M364	0.219	0.904	0.625	0.076	0.374	1	1	0.221	0.904	1	0.493	1	0.127	0.503	0.78	0.682	0.065	1	0.985	0.972	1	0.921	0.658	0.79	0.949	0.998	0.522	0.985
M378	0.926	0.825	0.337	0.998	1	1	0.999	0.996	1	1	1	1	0.294	0.657	0.507	0.993	0.956	1	1	1	0.865	0.707	0.555	0.998	0.705	1	1	1
M379	0.469	0.963	0.462	0.999	0.994	0.996	0.987	0.952	0.973	1	0.996	1	0.55	0.83	0.035	1	0.997	1	1	0.98	0.849	0.216	0.098	0.939	0.072	1	1	0
M436	0.797	0.993	0.142	0	0	0	0	0.987	0	0	1	1	0.489	0.709	0.993	1	0.999	1	0	0	0.387	0.389	0.436	0	0	1	1	0
M484	0.182	0.886	1	0.915	0.998	0.541	0.406	0.985	0.97	0.999	0.998	1	0.317	0.236	0.911	1	0.998	0.999	0.979	0.966	0.08	0.403	0.66	0.897	0.586	0.993	0.991	1
M485	0.936	0.751	0.823	0.995	0.973	0.851	0.096	0.078	1	0.89	0.787	0.979	0.494	0.871	0.125	0.704	0.955	0.882	0.997	0.992	0.562	0.907	0.809	0.99	0.829	0.947	0.93	0.989
M486	0.723	0.917	0.844	0.886	1	0.922	0.246	1	1	0.993	1	1	0.659	0.742	0.993	1	0.981	1	1	0.993	0.133	0.712	0.996	0.906	0.422	1	0.999	1
M488	0.921	0.543	0.937	0	0	0	0	0.136	0	0	0.962	0.998	0.061	0.04	0.204	1	0.978	0.992	0	0	0.049	0.981	0.79	0	0	0.987	0.854	1
M489	0.894	0.64	0.5	0.773	0.483	0.401	0.179	0.934	0.993	0.962	0.849	0.99	0.131	0.98	0.089	0.45	0.993	0.997	0.998	0.815	0.219	0.794	0	0.101	0.086	0.99	0	0
M490	0.673	0.988	0.86	0	0	0	0	0.706	0	0	0.58	1	0.808	0.905	0.975	0.92	0.919	1	0	0	0.444	0.545	0.796	0	0	1	0.987	1
M491	0.379	0.715	0.99	0	0	0	0	0.93	0	0	1	0.999	0.414	0.504	0.762	1	0.989	1	0	0	0.242	0.029	0.774	0	0	1	0.962	0
M493	0.628	0.264	0.54	0	0	0	0	0.601	0	0	0.075	0.147	0.36	0	0	0.302	0	0	0	0	0.273	0	0	0	0	0	0	0
M494	0.563	0.112	0.999	0	0	0	0	0.783	0	0	0.401	0.187	0.648	0.416	0	0.927	0.759	0.97	0	0	0.106	0.722	0.553	0	0	0	0	0
M495	0.988	0.677	0.02	0	0	0	0	0.954	0	0	0.781	0.192	0.504	0	0	0.17	0.275	0.232	0	0	0.812	0.604	0.28	0	0	0	0	0
M530	0.118	0.985	0.501	0.88	0.253	0.985	0.697	1	0.066	0.399	0.894	0.876	0.531	0.56	0.895	0.091	0.325	0.94	0.287	0.776	1	0.988	0.012	0.096	0.597	0	0	0
M532	0.759	0	0.256	0.995	1	1	1	0.897	1	0.951	0.714	0.609	0.989	0.56	0	0.135	0.543	0.766	0.533	0.902	1	0	0	0.514	0.999	0.667	0	0
M533	0.732	0.956	0.451	0.578	0.424	0.385	0.48	0.875	0.336	0	0.888	0.992	0.452	0.837	0.794	0.998	0.93	1	0.64	0.805	0.24	0.9	0.933	0.349	0.698	0	0	0
M545	0.602	0.992	0.444	0	0	0.242	0.4	0.993	0	0	0.999	1	0.742	0.02	0.981	0.941	0.994	1	0	0	0.039	0.779	0.994	0	0	1	1	0
M546	0.574	1	0.481	0	0	0	0	0.989	0	0	0.997	1	0.491	0.602	0.759	0.978	0.996	1	0	0	0.095	0.35	0.053	0	0	1	1	0
M547	1	0.13	0.6	0	0	0	0	0.741	0	0	0.295	0.448	0.561	0.122	0.976	0.479	0.252	0.701	0	0	0.511	0.176	0.33	0	0	0	0	0
M558	0.13	1	0.863	0	0	0	0	0.922	0	0	0.764	0.824	0.2	0	0.476	0.598	0.604	0.993	0	0	0.981	0	0.466	0	0	0.987	0.996	0
M563	0.6	0.863	1	0	0	0	0	0.837	0	0	0.896	0.011	0.382	0.301	0	1	0.494	0.636	0	0	0.202	0.423	0.681	0	0	0	0	0
M577	0	0	0	1	1	0.699	0.548	0.538	0.994	0.851	0	0	0	0	0	0	0	0	0.226	1	0.314	0	0	0.741	0.442	0.998	0	0
M580	0	0	0	1	1	0.367	0.92	0.938	1	0.997	0	0	0	0	0	0	0	0	0.996	1	0	0	0	0.996	0.789	0.939	0	0
M622	0	0	0	0.699	0.367	1	1	0.475	0.38	1	0	0	0	0	0	0	0	0	0.983	0.336	0.998	0	0	0.94	0.993	0.991	0	0
M628	0	0	0	0.548	0.92	1	1	0.485	0.969	1	0	0	0	0	0	0	0	0	0.762	0.183	0.988	0	0	0.733	0.864	0.655	0	0
M629	0.741	0.922	0.837	0.538	0.938	0.475	0.485	1	0.462	0.542	0.995	0.798	0.256	0.121	0.783	0.12	0.873	0.258	0.945	0.963	1	0.765	0.829	0.217	0.801	0.263	0	0
M630	0	0	0	0.994	1	0.38	0.969	0.462	1	0.999	0	0	0	0	0	0	0	0	1	1	0	0	0	0.904	0.648	0.995	0	0
M688	0	0	0	0.851	0.997	1	1	0.542	0.999	1	0	0	0	0	0	0	0	0	1	0.999	0	0	0	1	0.472	1	0	0
M697	0.295	0.764	0.896	0	0	0	0	0.995	0	0	1	1	0.008	0.821	0.893	1	0.967	0.999	0	0	0.797	0.394	0.681	0	0	0.892	0.763	0
M698	0.448	0.824	0.011	0	0	0	0	0.798	0	0	1	1	0.377	0.803	0.079	0.967	0.909	1	0	0	0.786	0.107	0.473	0	0	0.98	0.955	1

APPENDIX H

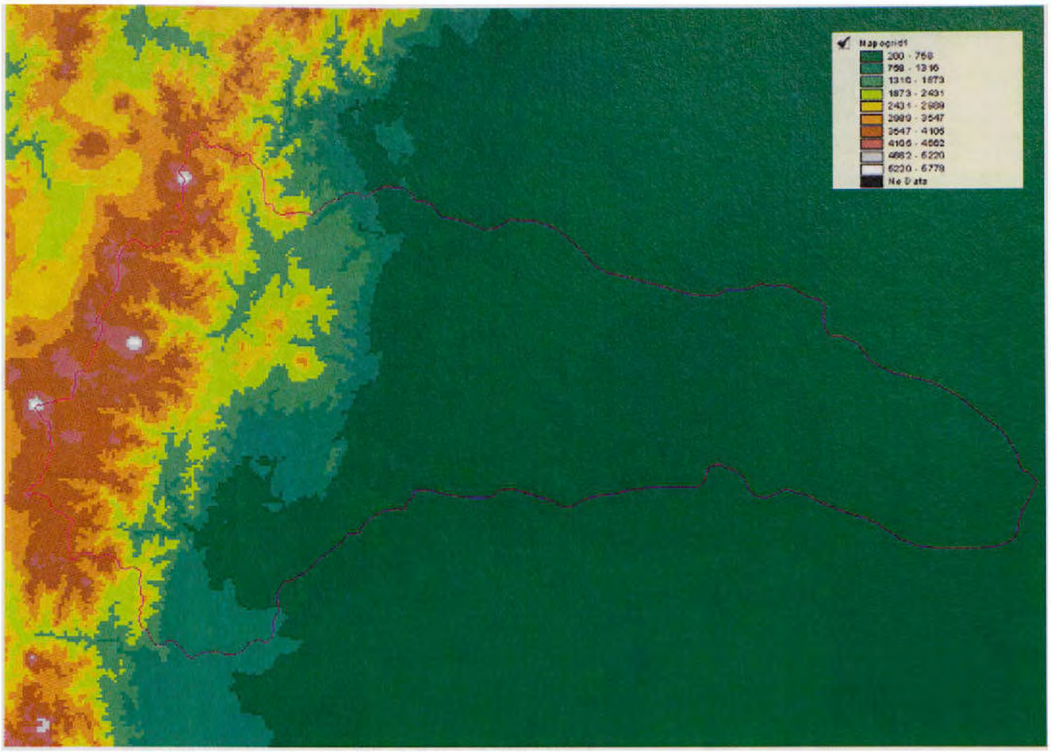


Figure H.1: Elevation map for 1km resolution.

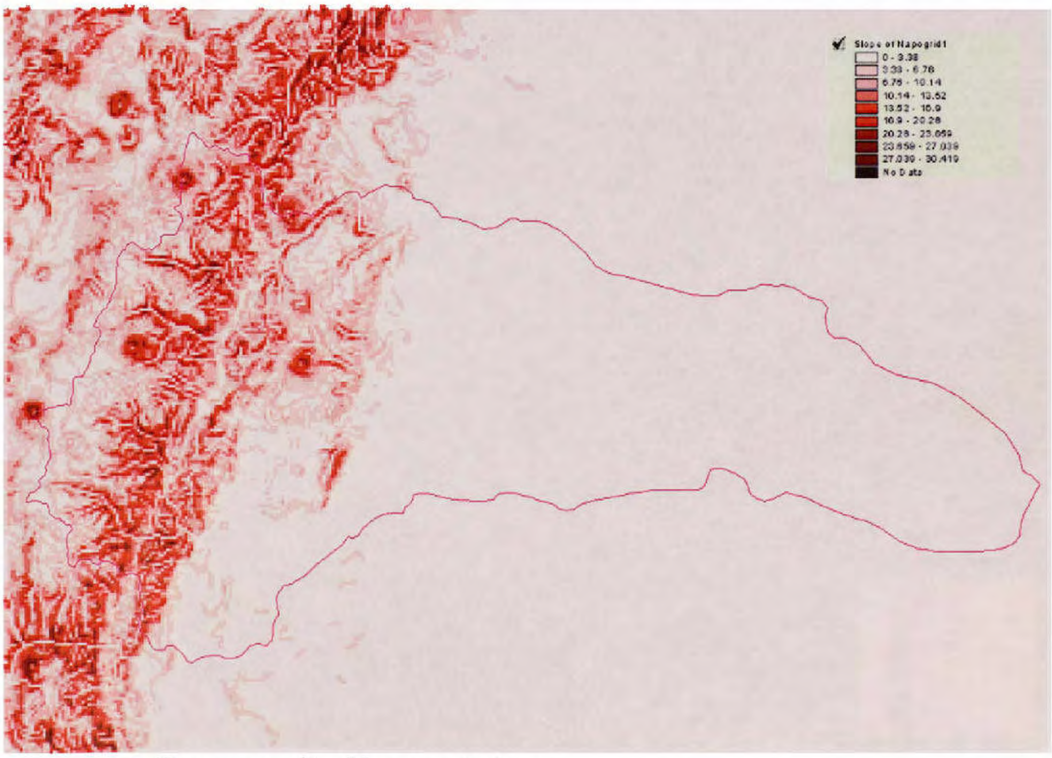


Figure H.2: Slope map for 1km resolution.

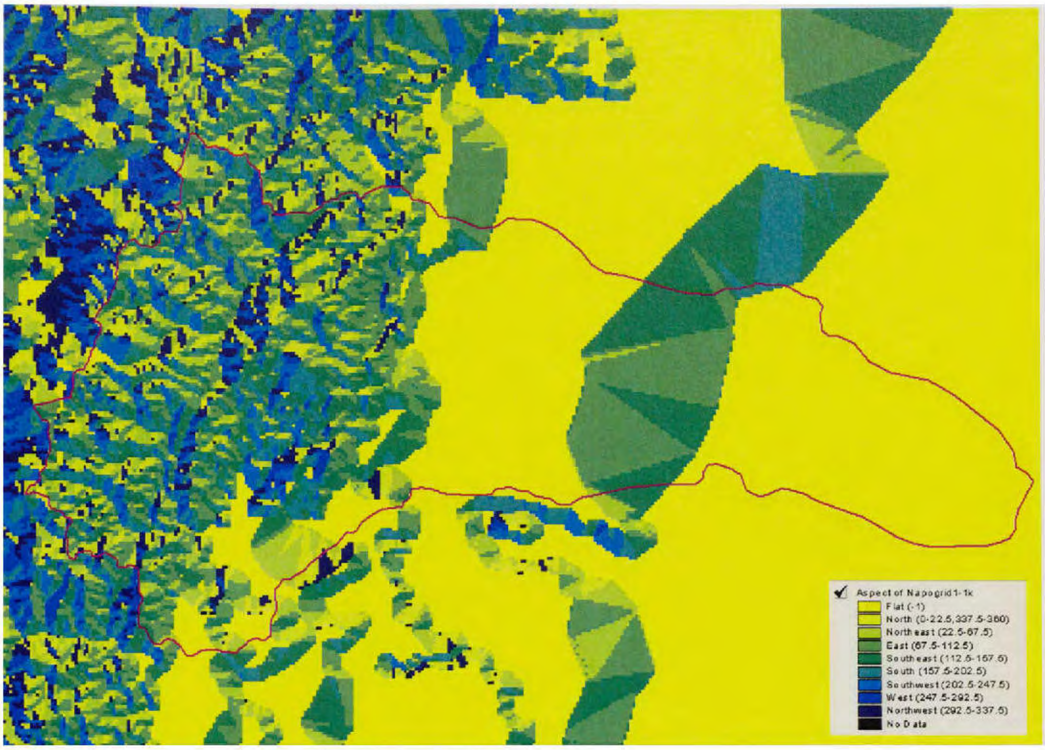


Figure H.3: Aspect map for 1km resolution.

Figure H.4: Hill-shade map at 90° azimuth and 45° sun elevation for 1km resolution.

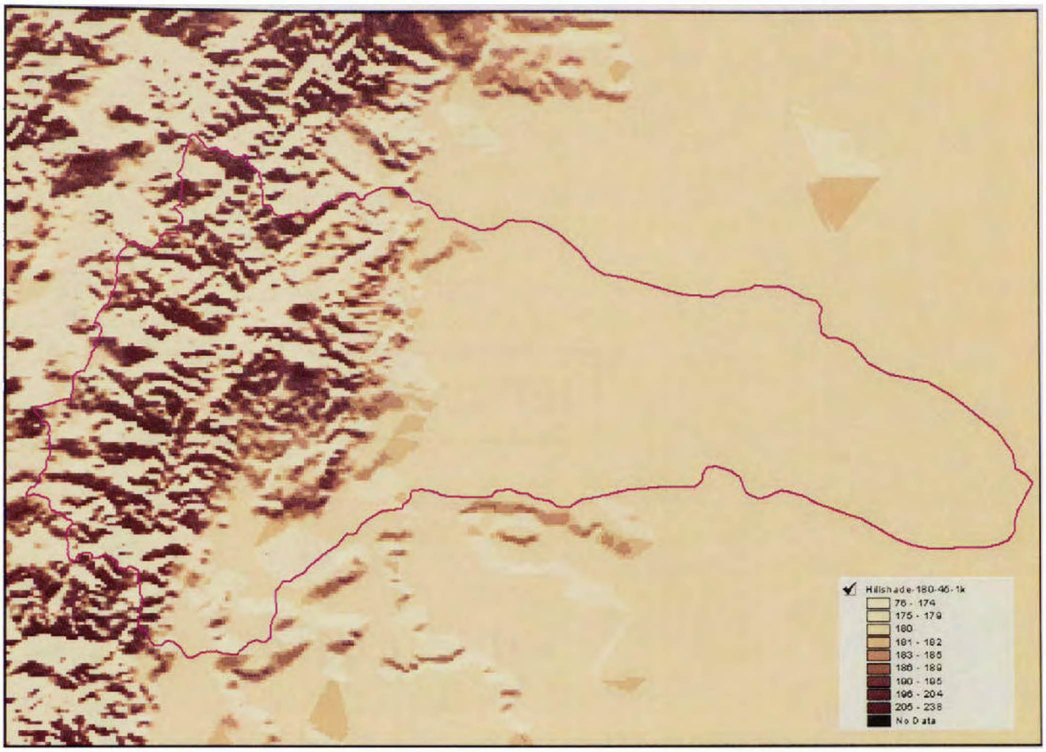


Figure H.5: Hill-shade map at 180° azimuth and 45° sun elevation for 1km resolution.

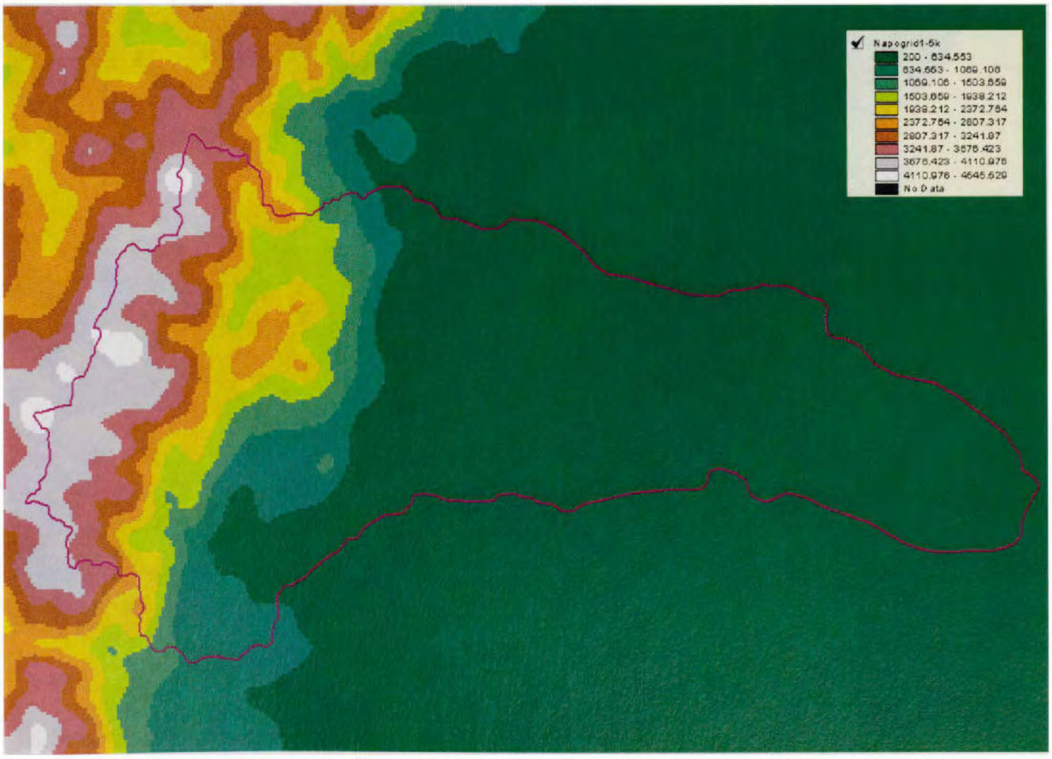


Figure H.6: Elevation map for 10km smutting resolution. (radius=5km)

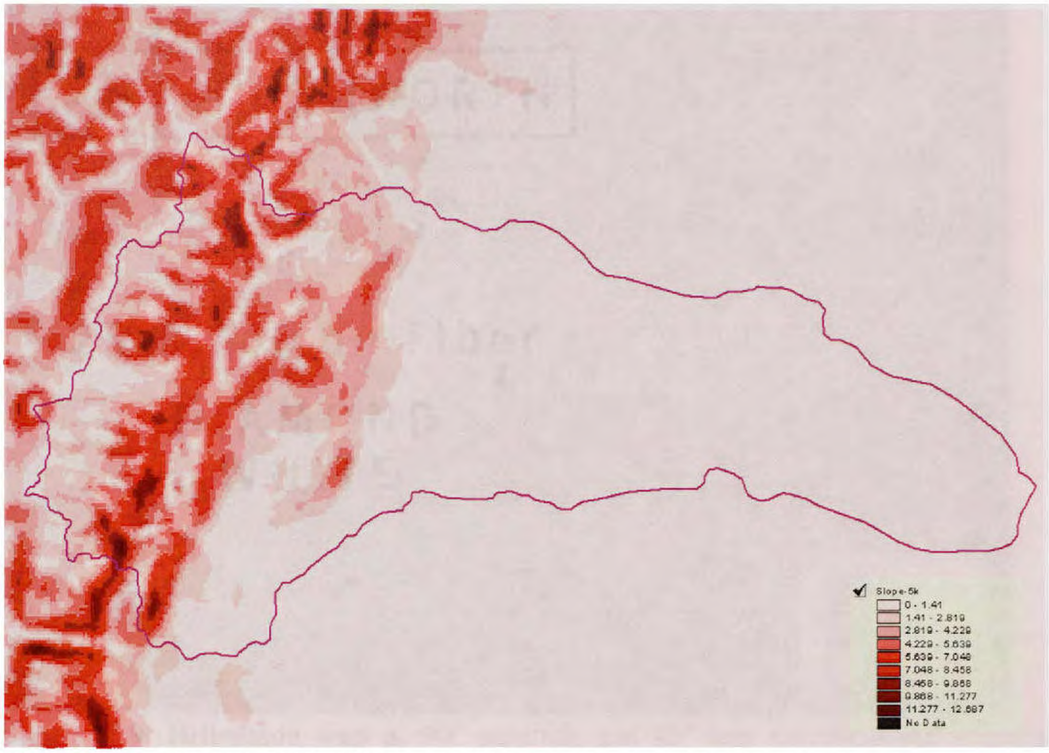


Figure H.7: Slope map for 10km smutting resolution. (radius=5km)

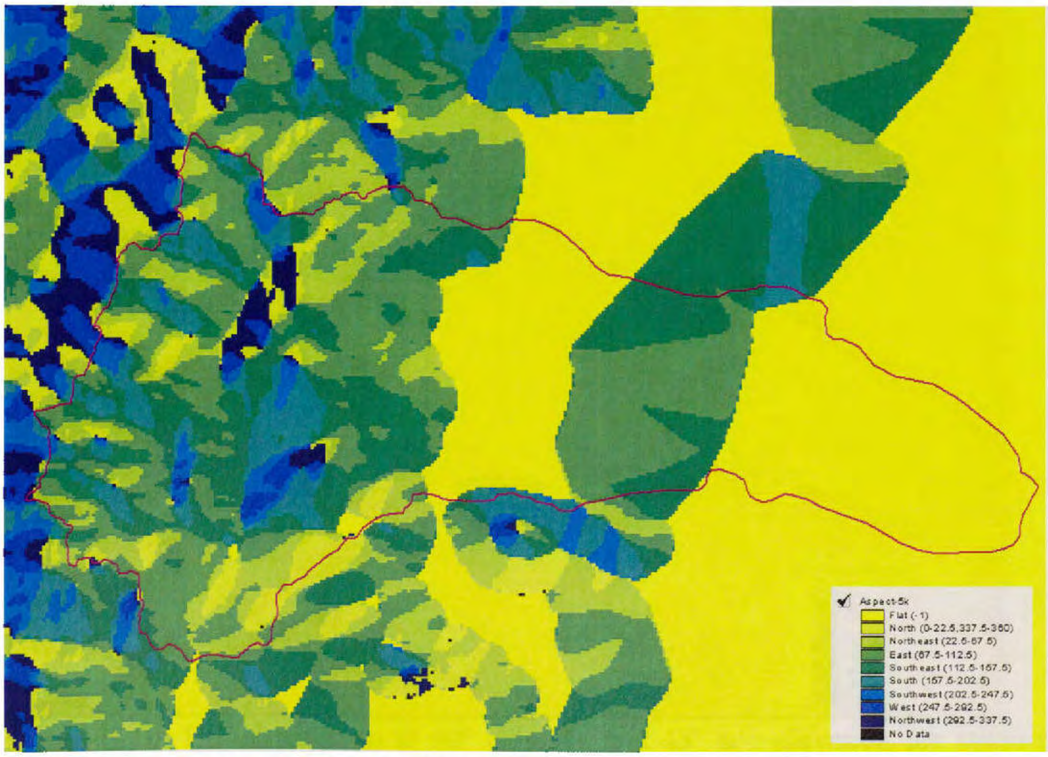


Figure H.8: Aspect map for 10km smutting resolution. (radius=5km)

Figure H.9: Hill-shade map at 90° azimuth and 45° sun elevation for 10km smutting resolution. (radius=5km)

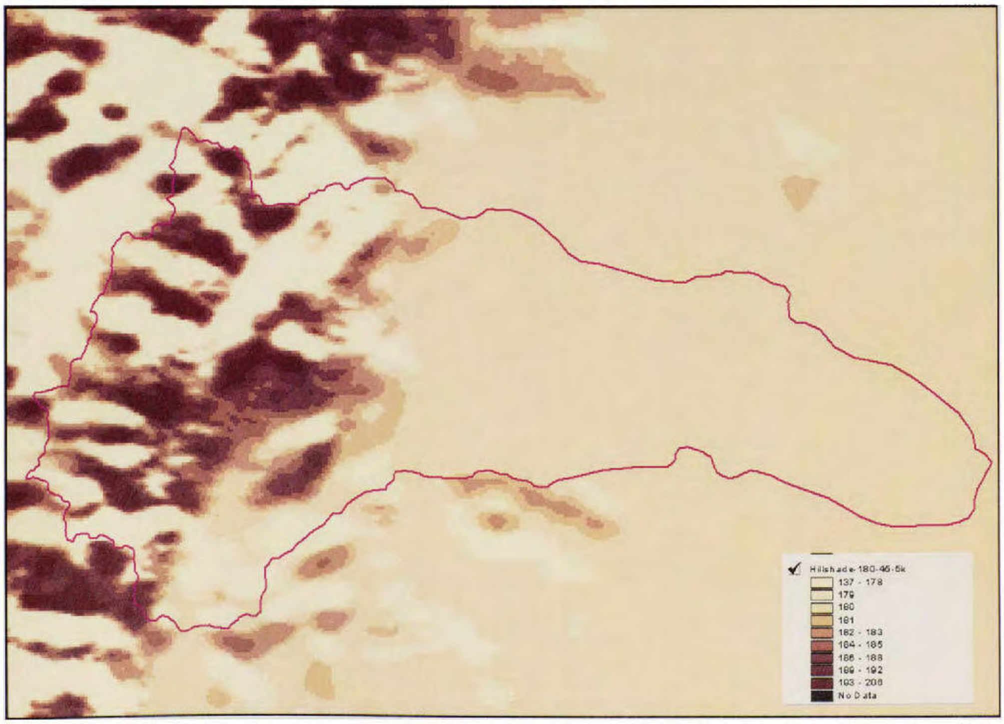


Figure H.10: Hill-shade map at 90° azimuth and 45° sun elevation for 10km smutting resolution. (radius=5km)

APPENDIX I

Table I.1: Dataset for analysis and modeling using mean monthly precipitation.

CODE	Type	Longitude	Latitude	Elevar	Slope	Aspect	# Years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
M009	0	811633	9993360	3600	9.71	35.50	6	44.98	63.50	72.55	94.98	64.93	28.62	12.92	5.74	54.73	60.93	40.28	39.93
M041	0	839403	9812599	1000	0.00	0.00	35	287.48	309.32	377.22	422.63	370.37	402.51	298.85	250.87	307.44	348.78	333.29	329.77
M220	0	793047	9850625	3372	12.36	150.67	10	75.56	129.83	80.67	157.46	200.48	241.78	160.91	136.64	148.81	97.27	72.57	76.82
M304	0	843844	10045845	1954	8.00	246.58	37	29.29	50.39	57.25	67.67	46.16	44.27	37.44	24.63	35.10	77.16	52.51	47.33
M310	0	836017	10033390	3000	6.35	61.90	39	102.49	122.96	112.68	140.29	98.31	92.16	75.75	48.12	62.96	118.30	117.51	112.28
M315	0	841771	10042923	2048	7.78	72.76	41	37.42	48.17	58.33	69.43	49.29	36.88	30.47	23.32	30.97	54.49	60.49	46.34
M316	0	824691	10022719	3000	2.10	316.95	33	89.04	127.35	160.65	178.33	130.82	56.55	47.77	29.04	57.68	141.65	180.46	145.39
M493	0	1084795	9824252	200	0.00	0.00	1	114.20	379.80	391.30									
M494	0	852437	9837639	891	3.06	163.55	3	339.50	318.17	647.07	523.40	492.87	477.40	266.80	305.10	310.40	342.20	482.60	419.55
M495	0	843165	9846877	1000	0.00	0.00	3	297.45	733.35	699.15	263.50	820.40	590.20	573.90	132.50	193.70	312.10	288.50	192.20
M532	0	787547	9942834	3736	9.78	280.95	13	62.58	83.05	88.02	93.54	58.25	59.43	64.42	39.58	45.18	101.43	98.41	63.97
M558	0	782759	9901162	3979	4.38	196.20	6	88.00	90.53	151.45	113.87	119.03	113.20	160.70	68.60	88.27	68.00	64.55	59.70
M580	0	781937	9878297	3283	12.10	295.46	11	37.58	41.78	63.60	77.87	53.69	94.92	94.21	80.14	58.70	56.31	59.49	55.78
M622	0	787548	9946522	3400	6.00	338.48	9	101.71	134.56	130.58	116.79	55.44	68.21	41.03	29.06	56.31	138.76	138.15	106.15
M628	0	826858	10017554	3200	2.94	247.34	12	69.67	82.10	97.23	75.98	51.97	45.48	37.45	17.49	30.83	88.77	118.23	55.60
M630	0	787507	9880136	3751	6.79	53.19	10	78.78	83.97	103.03	105.37	82.39	147.25	149.61	113.03	74.93	93.88	81.50	91.46
M697	0	889700	10036913	1000	2.75	266.48	11	377.90	334.01	412.21	557.05	635.34	566.46	476.59	383.84	394.71	403.57	493.93	412.16
M702	0	895496	9982835	1357	4.58	37.82	2		154.20	405.90	428.50	612.90	296.20						
M703	0	908289	9998154	500	1.01	224.43	5	421.70	704.10					495.30	454.20	584.67	441.40	691.75	555.67
M711	0	819082	9898553	3163	13.16	164.00	1						397.10			366.70			
M725	0	789854	9875032	3800	3.21	343.24	5	68.64	69.56	75.30	86.93	67.88	55.45	81.08	74.94	68.40	66.20	53.50	62.70
MA0T	0	869185	9863449	600	0.00	0.00	8	227.87	145.79	253.90	400.71	416.21	409.66	302.20	229.66	249.49	324.88	310.21	252.01
MA1F	0	791221	9881977	3722	8.35	242.39	8	90.64	155.30	140.98	148.88	177.80	197.22	190.25	173.57	122.35	104.95	84.40	95.63
M002	1	793126	9974613	2402	4.58	10.95	22	72.98	77.66	113.97	114.52	78.95	26.80	13.90	19.25	66.46	110.10	96.06	73.72
M007	1	1122198	9898194	200	0.00	0.00	28	138.97	187.00	245.80	317.47	355.61	309.10	291.17	235.44	212.06	222.10	180.50	181.02
M008	1	840114	9833137	1000	0.00	0.00	41	303.30	316.07	398.17	468.97	438.40	465.18	372.62	305.54	347.44	391.73	360.49	342.35
M023	1	828654	10016387	3200	9.14	209.15	27	79.44	73.25	93.18	91.49	66.40	38.42	29.06	22.28	44.60	108.54	83.18	98.60
M043	1	778723	9929162	3608	5.04	241.59	19	112.19	123.96	137.76	157.28	156.66	110.74	81.84	64.01	92.95	147.99	135.67	102.59
M048	1	843131	9822893	1000	0.00	0.00	7	378.08	290.83	423.40	549.32	430.94	477.03	295.14	381.30	336.27	385.65	420.60	356.22
M052	1	952887	9950135	300	0.00	0.00	20	166.18	235.13	279.96	287.56	306.46	302.36	242.59	173.67	223.75	266.04	283.49	233.72
M061	1	958479	10011082	300	0.00	0.00	20	201.62	244.02	311.70	368.48	369.29	324.99	292.78	217.86	256.74	319.77	339.29	247.57
M063	1	826439	9833986	1190	2.81	147.59	48	365.48	350.08	435.07	509.41	501.52	507.49	386.43	311.13	374.83	466.92	448.04	409.95
M070	1	854666	9890989	600	0.00	0.00	33	263.14	254.09	323.90	448.87	428.57	478.54	413.09	312.50	326.22	348.97	308.48	278.37
M077	1	1071981	10012947	200	0.00	0.00	12	197.69	193.33	260.99	359.54	245.83	332.32	400.63	281.79	245.24	250.47	217.72	151.47
M078	1	963899	9833762	300	0.00	0.00	8	207.92	190.60	232.75	251.35	256.34	196.52	298.38	153.68	164.88	326.63	254.10	148.00
M188	1	817847	9959606	3400	8.17	177.34	41	87.95	92.89	103.28	124.95	141.19	191.73	224.98	150.65	113.60	89.42	91.83	77.47
M200	1	953737	9991566	300	0.00	0.00	19	217.03	255.31	336.86	445.83	408.36	362.71	319.62	208.21	282.97	336.13	360.27	269.57
M201	1	871121	9963094	2200	6.23	282.15	17	172.58	171.19	217.09	257.23	252.59	280.94	240.61	203.64	207.99	181.27	153.68	122.57
M202	1	843140	9878178	628	2.71	351.23	8	177.52	119.60	181.72	532.64	650.43	736.60	361.98	347.57	399.64	373.69	367.96	135.23
M203	1	837684	9953327	2354	12.94	199.48	21	469.67	460.95	590.73	565.51	604.33	573.81	518.76	445.89	421.49	476.34	521.78	522.83
M205	1	881221	10009627	1174	9.97	17.47	15	384.29	392.81	478.15	444.07	431.78	407.35	379.42	338.45	316.04	368.25	425.73	371.81
M215	1	848909	9930692	2232	6.56	318.59	19	117.11	146.67	173.72	264.43	239.98	241.99	264.41	211.08	230.25	162.05	159.93	136.15
M219	1	787512	9885423	3815	9.38	244.63	23	73.12	94.47	105.59	117.43	114.64	158.10	155.72	123.27	98.74	87.39	73.58	85.01
M279	1	1014279	9985214	290	0.19	138.59	7	161.40	187.52	282.98	238.30	277.67	319.07	271.23	236.34	222.13	244.58	208.02	152.55
M324	1	843601	10032593	2473	6.41	345.72	38	85.24	86.64	102.84	112.64	96.26	95.80	113.33	69.54	59.22	83.03	95.03	84.35
M344	1	815346	9993667	3203	5.20	40.85	34	49.17	68.93	82.43	87.29	62.26	33.72	19.69	18.02	43.31	85.15	84.08	65.69
M349	1	794358	9952974	3135	7.27	295.63	24	125.43	153.25	170.60	200.92	147.48	75.34	42.00	47.87	139.06	192.21	186.17	139.08
M353	1	787643	9952700	3000	0.37	2.26	39	157.31	175.01	193.76	167.80	116.06	52.05	32.00	34.33	79.38	150.18	159.54	170.07
M359	1	818441	10005964	2802	1.89	286.14	27	88.05	87.55	121.59	107.20	97.14	28.71	17.61	20.76	55.46	91.07	97.37	94.21
M364	1	786462	9937887	3679	5.23	288.99	41	166.09	162.68	197.14	167.45	130.78	63.76	38.30	39.37	94.31	165.28	164.58	162.48
M378	1	800991	9844961	1599	5.17	180.25	40	171.12	188.21	208.74	287.33	301.11	402.07	384.04	325.56	259.52	163.74	142.46	167.78
M379	1	812592	9844671	1200	3.22	318.95	29	229.03	231.96	296.91	326.43	411.31	499.17	383.18	345.78	357.01	265.77	226.79	218.76
M436	1	828469	9990777	3874	7.42	247.06	10	93.48	116.40	138.96	166.93	183.78	191.73	176.77	125.59	147.07	128.11	111.03	99.45
M484	1	852103	9896895	700	2.80	85.55	39	249.16	261.92	366.96	405.27	459.12	459.05	413.88	301.49	304.84	309.09	336.85	302.09
M485	1	849845	9868116	606	1.33	349.42	38	292.36	302.23	368.65	417.02	491.94	525.32	447.68	348.87	412.94	377.53	367.77	339.85
M489	1	850386	9918176	1800	7.98	113.51	15	254.98	258.68	377.43	490.76	512.26	526.09	485.26	370.58	394.61	323.61	381.36	326.70
M490	1	856073	9958917	1713	6.15	305.07	22	178.99	209.63	219.02	281.51	308.02	310.63	289.39	218.55	228.13	161.11	161.45	116.02
M491	1	856825	9882807	600	0.00	0.00	13	194.79	230.45	288.94	416.18	325.68	439.98	268.31	265.83	278.30	232.31	197.41	193.06
M533	1	802874	9907295	3609	3.12	165.78	13	72.57	72.39	83.02	99.67	107.92	103.38	102.55	108.78	87.08	76.16	64.63	63.48
M547	1	915691	10009261	454	3.16	100.54	4	211.60	345.67	292.13	313.50	316.85	288.60	233.60	284.00	240.93	245.27	248.90	222.83
M577	1	792553	9929524	4000	0.00	0.00	12	109.80	117.73	142.23	138.06	125.93	188.55	190.45	149.19	140.03	130.66	133.23	109.09
M688	1	796164	9873982	4000	1.75	311.22	5	212.25	230.13	305.03	266.60	338.47	372.68	460.80	433.53	312.70	206.48	141.25	183.15
M698	1	889705	10018456	791	4.90	36.22	22	151.11	152.26	165.87	205.94	285.41	233.25	355.05	282.17	195.76	168.24	143.68	140.74
M710	1	906377	9896628	378	0.70	16.64	17	171.39	184.84	263.15	369.56	330.38	367.11	281.86	161.60	233.43	247.53	308.88	216.10
M720	1	798625	9859840	3000	5.39	175.67	11	204.58	256.24	217.30	308.18	456.80	625.67	725.07	410.33	350.21	220.33	178.90	185.41
M724	1	792398	9883113	3994	6.27	251.53	6	124.06	110.24	139.03	130.67	173.60	212.50	167.48	113.50	135.26	104.82	112.38	92.58
M731	1	782424	9908600	3800	4.10	310.33	12	43.48	80.50	76.18	85.08	60.28	18.16	35.38	23.98	44.19	53.78	65.18	69.03
MA54	1	842127	9925407	2400	0.00	0.00	5	199.70	265.10	220.15	429.86	491.38	371.60	437.18	364.25	298.10	243.30	176.63	165.88
M020	2	988223	9955657	290	0.18	131.21	13	249.56	208.61	285.83	319.53	302.03	325.37	279.09	226.24	265.63	290.93	283.94	197.78
M068	2	1109180	9914870	200	0.00	0.00	32	118.19	148.45	221.07	253.27	278.65	303.00	270.71	230.65	205.59	220.31	184.77	135.03
M098	2	838404	10011622	3577	5.80	65.20	1	147.50	124.00	139.40	181.90	149.80	265.50	273.70	122.30	227.00	94.50	149.10	76.50

Table I.2: Geomorphologic characteristics for surrounding area of stations.

Code	Type	EleMeter 1k	Slope 1k	Aspect 1k	Hill9045 1k	Hill18045 1k	Slope 5k	Aspect 5k	Hill9045 5k	Hill18045 5k	Slope 10k	Aspect 10k	Hill9045 10k	Hill18045 10k	Slope 15k	Aspect 15k	Hill9045 15k	Hill18045 15k
M009	0	3620.0	8.8	23.5	188.4	153.4	4.6	338.7	177.6	165.2	3.8	321.2	172.2	170.2	2.8	306.1	173.0	174.2
M041	0	1000.0	0.0	-1.0	180.0	180.0	0.0	124.2	180.0	180.0	0.1	103.8	180.0	180.0	0.2	97.8	181.0	180.0
M220	0	3310.6	14.6	166.1	195.5	199.6	7.6	194.2	172.2	201.3	2.5	173.3	180.5	187.8	1.3	145.3	181.0	183.0
M304	0	1993.2	11.7	245.1	147.7	194.6	4.7	279.9	164.8	176.9	3.6	285.7	168.6	176.7	2.2	295.1	173.0	176.7
M310	0	3021.9	9.2	200.2	194.5	167.1	6.6	47.4	193.7	164.9	3.7	16.5	183.0	168.4	3.3	340.8	176.0	169.8
M315	0	2034.4	7.5	123.3	196.7	173.0	3.3	328.0	174.2	170.9	3.2	311.9	171.9	172.8	2.7	320.2	174.0	173.0
M316	0	3000.0	1.1	167.8	177.6	178.6	2.3	304.4	173.7	175.8	1.4	291.0	176.0	178.3	1.9	308.0	175.0	176.0
M493	0	200.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0
M494	0	901.9	2.9	166.7	181.5	188.5	1.3	131.4	183.0	182.5	0.9	106.4	182.0	180.5	0.7	101.1	182.0	180.0
M495	0	1000.0	0.3	23.7	180.5	179.5	0.7	84.3	181.7	179.7	0.5	64.0	181.0	179.0	0.8	75.3	182.0	179.0
M532	0	3632.9	8.1	291.1	154.8	168.5	4.0	310.2	169.6	171.8	2.5	338.4	177.0	172.3	2.5	342.0	177.0	172.0
M558	0	3937.8	5.2	193.6	175.0	194.9	1.1	271.4	176.7	180.0	1.0	331.2	178.0	177.0	0.4	216.0	179.0	181.0
M580	0	3294.6	11.3	296.8	144.6	160.3	5.4	288.2	163.1	173.7	1.6	275.7	174.6	179.2	1.5	218.2	177.0	183.0
M622	0	3358.9	5.7	344.3	174.3	161.7	3.7	351.0	177.5	168.3	3.3	336.3	175.1	170.0	2.7	337.2	176.0	172.0
M628	0	3200.0	3.2	269.9	170.1	183.7	2.7	270.8	171.0	179.8	1.7	294.1	174.8	177.6	1.7	297.4	175.0	177.2
M630	0	3785.0	6.6	59.5	196.3	168.0	2.0	302.6	174.2	176.1	1.9	279.8	174.1	179.0	0.7	189.2	179.0	182.0
M697	0	1056.7	7.7	104.0	197.3	179.5	5.2	119.1	193.0	186.7	4.9	148.5	187.6	192.2	3.2	148.2	185.0	188.0
M702	0	1343.1	4.7	34.5	187.2	166.9	2.7	69.2	187.6	177.0	2.6	73.7	187.1	177.3	2.2	73.3	186.0	178.0
M703	0	500.6	1.4	204.2	177.9	183.6	0.6	164.5	180.0	182.0	1.1	75.5	183.0	179.0	1.0	81.1	183.0	179.0
M711	0	3193.7	11.6	154.5	190.5	208.6	6.2	89.2	197.8	178.8	5.0	102.9	194.7	182.5	4.9	119.9	192.0	186.6
M725	0	3820.2	4.1	343.9	175.5	166.7	2.4	30.3	183.6	173.1	1.0	295.1	176.8	178.1	1.2	232.7	176.0	182.0
MA0T	0	600.0	0.0	9.6	180.0	180.0	0.2	26.1	180.0	179.0	0.5	19.7	180.0	178.0	0.5	48.4	181.0	179.0
MA1F	0	3736.5	7.2	231.6	160.7	192.3	0.6	169.0	180.1	181.5	0.4	343.3	179.6	179.0	0.3	180.6	179.0	181.0
M002	1	2425.2	3.7	118.6	179.8	168.2	2.0	284.7	178.1	173.9	2.3	299.6	173.1	176.1	2.2	300.1	173.0	176.1
M007	1	200.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0
M008	1	1000.0	0.0	-1.0	180.0	180.0	0.0	49.8	180.0	180.0	0.3	99.7	181.0	180.0	0.7	98.2	182.0	180.0
M023	1	3248.9	6.1	207.2	169.5	195.0	3.1	266.4	169.8	180.2	1.9	302.1	174.8	176.8	2.0	304.9	174.0	176.0
M043	1	3628.8	4.5	238.0	167.9	185.9	2.7	244.3	172.2	183.2	1.1	326.9	178.3	177.0	0.5	333.7	179.0	178.3
M048	1	1000.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.4	75.1	181.0	179.5	0.6	85.5	182.0	180.0
M052	1	300.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0
M061	1	300.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.0	87.8	180.0	180.0
M063	1	1133.5	4.0	147.8	186.3	189.9	1.5	145.6	182.2	183.8	1.5	113.6	184.0	182.0	1.5	117.7	184.0	182.0
M070	1	600.0	0.0	-1.0	180.0	180.0	0.1	137.7	179.8	180.0	0.4	143.5	180.8	181.0	1.5	126.0	183.0	182.8
M077	1	200.0	0.0	-1.0	180.0	180.0	0.1	32.0	180.0	179.9	0.1	57.3	180.0	180.0	0.1	77.5	180.0	180.0
M078	1	300.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.0	66.3	180.0	180.0	0.1	79.4	180.0	180.0
M188	1	3428.2	8.9	158.5	185.8	199.7	2.3	112.2	186.2	182.4	1.8	82.2	185.1	178.9	1.5	80.0	184.0	178.9
M200	1	300.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.0	93.5	180.0	180.0	0.0	102.7	180.0	180.0
M201	1	2219.4	6.3	285.2	160.0	173.6	4.0	324.8	172.0	169.0	2.4	114.4	179.7	172.0	1.0	12.0	180.0	177.0
M202	1	647.0	2.9	106.9	179.8	170.9	1.4	77.6	183.9	179.0	2.2	98.4	186.3	181.0	2.2	101.0	186.0	181.0
M203	1	2256.6	11.3	190.7	168.2	209.5	5.4	200.6	173.1	194.9	3.2	113.6	188.9	183.4	3.2	94.8	189.0	180.0
M205	1	1123.2	6.2	14.1	184.0	159.9	2.2	75.3	186.1	177.9	3.0	85.1	189.2	178.6	2.8	62.2	187.0	175.4
M215	1	2242.2	5.5	329.1	170.4	164.5	2.8	106.5	188.0	181.8	3.7	127.0	188.5	186.3	3.8	123.5	189.0	186.0
M219	1	3628.6	8.9	247.5	151.9	188.3	2.7	231.4	173.4	184.5	1.4	225.3	176.4	182.9	0.1	99.1	180.0	180.0
M279	1	289.2	0.2	138.6	180.0	180.0	0.2	138.2	180.0	180.0	0.1	135.4	180.0	180.0	0.1	134.8	180.0	180.0
M324	1	2437.2	7.8	103.6	190.5	166.4	5.2	331.6	171.2	164.9	2.9	349.4	177.9	170.6	1.7	16.3	181.0	175.1
M344	1	3206.2	5.0	184.6	182.5	164.5	5.1	14.0	182.9	164.0	3.5	331.2	174.0	170.0	2.8	305.1	172.0	174.5
M349	1	3195.6	7.9	290.8	155.2	169.6	5.4	297.8	164.3	170.8	4.2	312.3	169.2	170.0	3.0	319.7	173.0	172.2
M353	1	3000.0	1.6	93.8	181.5	175.3	3.9	16.9	183.0	167.8	3.7	338.3	175.0	168.4	2.7	325.6	174.0	172.7
M359	1	2840.8	3.0	283.9	170.6	177.2	1.9	272.7	173.8	179.8	2.2	246.8	173.8	182.6	1.6	289.1	174.0	178.0
M364	1	3632.2	4.0	299.4	168.3	173.3	2.5	301.9	173.2	175.3	2.0	335.3	177.0	174.0	2.1	347.9	178.0	173.3
M378	1	1563.5	4.8	84.0	181.6	167.1	2.2	140.5	182.9	184.7	4.0	95.9	191.7	180.8	2.6	105.0	187.0	182.0
M379	1	1270.0	5.7	256.2	179.0	187.6	2.1	225.6	175.2	184.7	2.7	131.3	186.0	185.5	3.0	123.1	187.0	184.9
M436	1	3814.3	6.1	253.6	161.5	185.1	2.7	296.7	172.0	176.0	1.2	274.4	176.4	179.7	1.0	237.3	177.0	181.4
M484	1	665.8	2.3	114.3	186.4	181.9	1.4	131.6	183.1	183.0	2.2	129.0	185.2	184.0	2.7	119.6	187.0	184.0
M485	1	606.8	1.8	344.8	178.8	174.1	1.0	5.6	180.0	177.0	0.9	57.5	182.0	178.0	0.9	60.5	182.0	178.0
M489	1	1637.1	8.4	125.0	199.3	192.5	4.7	112.9	193.1	185.1	4.6	119.1	192.0	186.0	3.7	128.0	188.0	187.0
M490	1	1739.4	6.5	301.2	161.2	168.1	1.1	242.8	177.0	178.3	0.9	226.3	179.6	177.3	1.5	62.6	184.0	177.4
M491	1	600.0	0.0	-1.0	180.0	180.0	0.0	145.4	180.0	180.0	0.2	154.4	180.0	180.0	0.5	116.6	181.0	180.4
M533	1	3613.0	3.2	161.1	183.0	189.2	1.5	91.2	184.4	179.8	1.9	158.0	182.0	184.8	1.5	114.0	184.0	181.8
M547	1	468.1	2.4	96.4	187.3	180.7	2.1	122.4	185.1	183.1	1.2	113.4	183.0	181.0	0.6	115.3	181.0	181.0
M577	1	4000.0	0.0	-1.0	180.0	180.0	0.9	166.3	180.0	177.6	0.8	63.7	182.1	178.7	0.3	320.6	179.0	179.0
M688	1	3960.8	4.2	142.8	186.6	179.3	2.9	55.4	187.0	174.3	1.6	76.5	185.0	178.9	0.6	152.0	180.0	181.2
M698	1	762.0	4.1	38.6	187.7	169.4	2.6	73.8	187.5	177.4	2.0	85.9	186.0	179.1	1.5	99.7	184.0	180.3
M710	1	373.8	0.7	22.9	180.9	178.0	0.5	40.0	180.9	179.0	0.3	50.1	180.5	179.0	0.2	83.7	181.0	180.0
M720	1	3287.1	11.0	146.3	195.7	195.8	4.5	206.1	173.1	191.9	3.5	146.3	185.5	188.3	4.7	153.2	186.0	192.3
M724	1	3989.2	5.3	238.1	164.5	188.2	1.3	186.3	179.0	183.9	0.4	98.4	181.0	180.0	0.4	88.6	180.0	180.0
M731	1	3772.6	3.5	317.5	171.7	171.7	3.4	315.2	172.0	172.0	1.1	258.5	176.0	180.5	0.8	208.9	178.0	182.0
MA54	1	2400.0	0.5	25.1	181.5	179.8	4.5	95.4	193.5	180.6	5.1	120.6	193.0	187.0	4.4	126.5	190.0	187.7
M020	2	290.7	0.2	131.2	180.0	180.0	0.2	131.2	180.0	180.0	0.1	131.0	180.0	180.0	0.1	125.2	180.0	180.0
M068	2	200.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0	0.0	-1.0	180.0	180.0

Table I.3: Pearson correlation coefficient between explanatory variables and dependent variable (mean monthly precipitation grouped by months).

45	LONMETER	LATMETER	Elevar	Slope	Aspect	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LONMETER	1.000	0.226	-0.733	-0.423	-0.456	0.155	0.234	0.283	0.300	0.246	0.197	0.249	0.207	0.208	0.323	0.276	0.165
LATMETER	0.226	1.000	0.073	0.267	-0.041	-0.327	-0.227	-0.259	-0.369	-0.402	-0.486	-0.394	-0.408	-0.447	-0.351	-0.258	-0.282
Elevar	-0.733	0.073	1.000	0.502	0.468	-0.490	-0.520	-0.568	-0.665	-0.599	-0.555	-0.458	-0.472	-0.571	-0.670	-0.632	-0.498
Slope	-0.423	0.267	0.502	1.000	0.497	-0.044	-0.076	-0.103	-0.229	-0.160	-0.154	-0.099	-0.110	-0.160	-0.231	-0.134	-0.042
Aspect	-0.456	-0.041	0.468	0.497	1.000	-0.234	-0.286	-0.293	-0.290	-0.148	-0.091	-0.146	-0.121	-0.109	-0.296	-0.288	-0.273
JAN	0.155	-0.327	-0.490	-0.044	-0.234	1.000	0.938	0.964	0.871	0.814	0.747	0.688	0.772	0.833	0.913	0.904	0.950
FEB	0.234	-0.227	-0.520	-0.076	-0.286	0.938	1.000	0.949	0.831	0.795	0.709	0.704	0.768	0.815	0.858	0.845	0.924
MAR	0.283	-0.259	-0.568	-0.103	-0.293	0.964	0.949	1.000	0.872	0.805	0.731	0.671	0.750	0.831	0.912	0.917	0.967
APR	0.300	-0.369	-0.665	-0.229	-0.290	0.871	0.831	0.872	1.000	0.941	0.887	0.749	0.822	0.927	0.931	0.910	0.849
MAY	0.246	-0.402	-0.599	-0.160	-0.148	0.814	0.795	0.805	0.941	1.000	0.951	0.854	0.891	0.965	0.883	0.841	0.784
JUN	0.197	-0.486	-0.555	-0.154	-0.091	0.747	0.709	0.731	0.887	0.951	1.000	0.893	0.914	0.964	0.801	0.752	0.697
JUL	0.249	-0.394	-0.458	-0.099	-0.146	0.688	0.704	0.671	0.749	0.854	0.893	1.000	0.935	0.889	0.679	0.601	0.624
AUG	0.207	-0.408	-0.472	-0.110	-0.121	0.772	0.768	0.750	0.822	0.891	0.914	0.935	1.000	0.935	0.729	0.656	0.689
SEP	0.208	-0.447	-0.571	-0.160	-0.109	0.833	0.815	0.831	0.927	0.965	0.964	0.889	0.935	1.000	0.867	0.817	0.796
OCT	0.323	-0.351	-0.670	-0.231	-0.296	0.913	0.858	0.912	0.931	0.883	0.801	0.679	0.729	0.867	1.000	0.966	0.903
NOV	0.276	-0.258	-0.632	-0.134	-0.288	0.904	0.845	0.917	0.910	0.841	0.752	0.601	0.656	0.817	0.966	1.000	0.930
DEC	0.165	-0.282	-0.498	-0.042	-0.273	0.950	0.924	0.967	0.849	0.784	0.697	0.624	0.689	0.796	0.903	0.930	1.000

Table I.4: Pearson correlation coefficient between explanatory variables and dependent variable (mean monthly precipitation).

540	LONMETER	LATMETER	Elevar	Slope	Aspect	mean Valor
LONMETER	1.000	0.226	-0.733	-0.423	-0.456	0.223
LATMETER	0.226	1.000	0.073	0.267	-0.041	-0.339
Elevar	-0.733	0.073	1.000	0.502	0.468	-0.524
Slope	-0.423	0.267	0.502	1.000	0.497	-0.125
Aspect	-0.456	-0.041	0.468	0.497	1.000	-0.191
meanValor	0.223	-0.339	-0.524	-0.125	-0.191	1.000

Table I.5: Pearson correlation coefficient between explanatory variables and dependent variable (log of mean monthly precipitation grouped by months).

45	LONMETER	LATMETER	Elevar	Slope	Aspect	logJAN	logFEB	logMAR	logAPR	logMAY	logJUN	logJUL	logAUG	logSEP	logOCT	logNOV	logDEC
LONMETER	1.000	0.226	-0.733	-0.423	-0.456	0.257	0.311	0.369	0.377	0.347	0.332	0.363	0.333	0.310	0.397	0.365	0.269
LATMETER	0.226	1.000	0.073	0.267	-0.041	-0.340	-0.284	-0.290	-0.361	-0.396	-0.415	-0.384	-0.394	-0.425	-0.322	-0.265	-0.307
Elevar	-0.733	0.073	1.000	0.502	0.468	-0.590	-0.593	-0.655	-0.713	-0.654	-0.572	-0.519	-0.532	-0.608	-0.720	-0.715	-0.608
Slope	-0.423	0.267	0.502	1.000	0.497	-0.187	-0.209	-0.243	-0.282	-0.231	-0.180	-0.153	-0.168	-0.219	-0.298	-0.254	-0.190
Aspect	-0.456	-0.041	0.468	0.497	1.000	-0.257	-0.304	-0.318	-0.293	-0.193	-0.164	-0.149	-0.155	-0.177	-0.337	-0.326	-0.317
logJAN	0.257	-0.340	-0.590	-0.187	-0.257	1.000	0.945	0.963	0.915	0.890	0.803	0.725	0.777	0.878	0.934	0.913	0.935
logFEB	0.311	-0.284	-0.593	-0.209	-0.304	0.945	1.000	0.963	0.898	0.870	0.768	0.722	0.766	0.863	0.892	0.875	0.938
logMAR	0.369	-0.290	-0.655	-0.243	-0.318	0.963	0.963	1.000	0.923	0.877	0.777	0.698	0.749	0.872	0.939	0.931	0.962
logAPR	0.377	-0.361	-0.713	-0.282	-0.293	0.915	0.898	0.923	1.000	0.958	0.869	0.786	0.831	0.942	0.946	0.925	0.889
logMAY	0.347	-0.396	-0.654	-0.231	-0.193	0.890	0.870	0.877	0.958	1.000	0.938	0.880	0.912	0.977	0.900	0.861	0.832
logJUN	0.332	-0.415	-0.572	-0.180	-0.164	0.803	0.768	0.777	0.869	0.938	1.000	0.960	0.971	0.955	0.789	0.740	0.714
logJUL	0.363	-0.384	-0.519	-0.153	-0.149	0.725	0.722	0.698	0.786	0.880	0.960	1.000	0.979	0.900	0.689	0.636	0.636
logAUG	0.333	-0.394	-0.532	-0.168	-0.155	0.777	0.766	0.749	0.831	0.912	0.971	0.979	1.000	0.939	0.731	0.670	0.679
logSEP	0.310	-0.425	-0.608	-0.219	-0.177	0.878	0.863	0.872	0.942	0.977	0.955	0.900	0.939	1.000	0.876	0.830	0.813
logOCT	0.397	-0.322	-0.720	-0.298	-0.337	0.934	0.892	0.939	0.946	0.900	0.789	0.689	0.731	0.876	1.000	0.970	0.918
logNOV	0.365	-0.265	-0.715	-0.254	-0.326	0.913	0.875	0.931	0.925	0.861	0.740	0.636	0.670	0.830	0.970	1.000	0.932
logDEC	0.269	-0.307	-0.608	-0.190	-0.317	0.935	0.938	0.962	0.889	0.832	0.714	0.636	0.679	0.813	0.918	0.932	1.000

Table I.6: Pearson correlation coefficient between explanatory variables and dependent variable (log of mean monthly precipitation).

540	LONMETER	LATMETER	Elevar	Slope	Aspect	log mean Valor
LONMETER	1.000	0.226	-0.733	-0.423	-0.456	0.318
LATMETER	0.226	1.000	0.073	0.267	-0.041	-0.338
Elevar	-0.733	0.073	1.000	0.502	0.468	-0.576
Slope	-0.423	0.267	0.502	1.000	0.497	-0.198
Aspect	-0.456	-0.041	0.468	0.497	1.000	-0.219
logmeanValor	0.318	-0.338	-0.576	-0.198	-0.219	1.000

Table I.7: Pearson correlation coefficient.

45	LON METE R	LATM ETER	Ele Meter 1k	Slope 1k	Aspe ct 1k	Hill 9045 1k	Hill 18045 1k	Ele Meter 5k	Slope 5k	Aspe ct 5k	Hill 9045 5k	Hill 18045 5k	Ele Meter 10k	Slope 10k	Aspe ct 10k	Hill 9045 10k	Hill 18045 10k	Ele Meter 15k	Slope 15k	Aspe ct 15k	Hill 9045 15k	Hill 18045 15k
LONMETER	1.00	0.23	-0.73	-0.49	-0.50	0.19	-0.05	-0.74	-0.52	-0.51	0.18	0.08	-0.75	-0.49	-0.55	0.05	0.09	-0.76	-0.44	-0.53	0.05	0.05
LATMETER	0.23	1.00	0.07	0.12	0.04	-0.09	-0.20	0.08	0.25	0.20	-0.11	-0.35	0.08	0.09	0.31	-0.29	-0.38	0.09	-0.01	0.19	-0.35	-0.43
EleMeter1k	-0.73	0.07	1.00	0.54	0.56	-0.36	0.16	0.99	0.60	0.57	-0.31	-0.18	0.99	0.38	0.60	-0.26	-0.18	0.98	0.25	0.60	-0.31	-0.15
Slope1k	-0.49	0.12	0.54	1.00	0.58	-0.20	0.27	0.57	0.75	0.56	-0.29	0.18	0.59	0.59	0.37	0.12	0.02	0.59	0.54	0.08	0.18	0.04
Aspect1k	-0.50	0.04	0.56	0.58	1.00	-0.57	0.00	0.56	0.47	0.63	-0.44	-0.09	0.57	0.30	0.52	-0.25	-0.10	0.58	0.26	0.32	-0.15	-0.13
Hill90451k	0.19	-0.09	-0.36	-0.20	-0.57	1.00	0.04	-0.35	-0.08	-0.49	0.62	0.10	-0.36	0.10	-0.35	0.49	0.26	-0.36	0.20	-0.23	0.35	0.39
Hill180451k	-0.05	-0.20	0.16	0.27	0.00	0.04	1.00	0.17	0.04	0.04	-0.09	0.68	0.16	-0.11	-0.18	0.18	0.45	0.15	-0.01	-0.05	0.20	0.38
EleMeter5k	-0.74	0.08	0.99	0.57	0.56	-0.35	0.17	1.00	0.62	0.59	-0.34	-0.16	1.00	0.42	0.62	-0.24	-0.19	0.99	0.28	0.59	-0.28	-0.16
Slope5k	-0.52	0.25	0.60	0.75	0.47	-0.08	0.04	0.62	1.00	0.49	-0.17	-0.19	0.63	0.84	0.56	0.04	-0.20	0.63	0.69	0.34	0.00	-0.05
Aspect5k	-0.51	0.20	0.57	0.56	0.63	-0.49	0.04	0.59	0.49	1.00	-0.67	-0.10	0.61	0.28	0.65	-0.32	-0.15	0.62	0.22	0.39	-0.20	-0.15
Hill90455k	0.18	-0.11	-0.31	-0.29	-0.44	0.62	-0.09	-0.34	-0.17	-0.67	1.00	0.14	-0.35	0.15	-0.50	0.68	0.37	-0.34	0.16	-0.31	0.51	0.39
Hill180455k	0.08	-0.35	-0.18	0.18	-0.09	0.10	0.68	-0.16	-0.19	-0.10	0.14	1.00	-0.16	-0.07	-0.46	0.56	0.81	-0.17	0.12	-0.27	0.61	0.64
EleMeter10k	-0.75	0.08	0.99	0.59	0.57	-0.36	0.16	1.00	0.63	0.61	-0.35	-0.16	1.00	0.43	0.63	-0.24	-0.20	1.00	0.29	0.60	-0.27	-0.18
Slope10k	-0.49	0.09	0.38	0.59	0.30	0.10	-0.11	0.42	0.84	0.28	0.15	-0.07	0.43	1.00	0.38	0.32	0.01	0.44	0.90	0.28	0.25	0.11
Aspect10k	-0.55	0.31	0.60	0.37	0.52	-0.35	-0.18	0.62	0.56	0.65	-0.50	-0.46	0.63	0.38	1.00	-0.59	-0.50	0.64	0.29	0.71	-0.53	-0.45
Hill904510k	0.05	-0.29	-0.26	0.12	-0.25	0.49	0.18	-0.24	0.04	-0.32	0.68	0.56	-0.24	0.32	-0.59	1.00	0.64	-0.24	0.39	-0.49	0.92	0.66
Hill1804510k	0.09	-0.38	-0.18	0.02	-0.10	0.26	0.45	-0.19	-0.20	-0.15	0.37	0.81	-0.20	0.01	-0.50	0.64	1.00	-0.20	0.20	-0.34	0.69	0.89
EleMeter15k	-0.76	0.09	0.98	0.59	0.58	-0.36	0.15	0.99	0.63	0.62	-0.34	-0.17	1.00	0.44	0.64	-0.24	-0.20	1.00	0.31	0.60	-0.27	-0.19
Slope15k	-0.44	-0.01	0.25	0.54	0.26	0.20	-0.01	0.28	0.69	0.22	0.16	0.12	0.29	0.90	0.29	0.39	0.20	0.31	1.00	0.23	0.39	0.29
Aspect15k	-0.53	0.19	0.60	0.08	0.32	-0.23	-0.05	0.59	0.34	0.39	-0.31	-0.27	0.60	0.28	0.71	-0.49	-0.34	0.60	0.23	1.00	-0.59	-0.34
Hill904515k	0.05	-0.35	-0.31	0.18	-0.15	0.35	0.20	-0.28	0.00	-0.20	0.51	0.61	-0.27	0.25	-0.53	0.92	0.69	-0.27	0.39	-0.59	1.00	0.68
Hill1804515k	0.05	-0.43	-0.15	0.04	-0.13	0.39	0.38	-0.16	-0.05	-0.15	0.39	0.64	-0.18	0.11	-0.45	0.66	0.89	-0.19	0.29	-0.34	0.68	1.00

Note: :Correlation coefficient with 95% interval of confidence (Alfa=0.05)

Table I.8: t (Student test) value for Pearson correlation coefficient

45	LON METE R	LATM ETER	Ele Meter 1k	Slope 1k	Aspe ct 1k	Hill 9045 1k	Hill 18045 1k	Ele Meter 5k	Slope 5k	Aspe ct 5k	Hill 9045 5k	Hill 18045 5k	Ele Meter 10k	Slope 10k	Aspe ct 10k	Hill 9045 10k	Hill 18045 10k	Ele Meter 15k	Slope 15k	Aspe ct 15k	Hill 9045 15k	Hill 18045 15k
LONMETER	9999	1.52	-7.07	-3.68	-3.81	1.30	-0.35	-7.31	-4.01	-3.88	1.20	0.51	-7.52	-3.70	-4.33	0.33	0.57	-7.75	-3.19	-4.05	0.32	0.33
LATMETER	1.52	9999	0.47	0.82	0.28	-0.57	-1.36	0.50	1.68	1.33	-0.75	-2.48	0.56	0.60	2.12	-2.00	-2.66	0.60	-0.09	1.29	-2.45	-3.11
EleMeter1k	-7.07	0.47	9999	4.21	4.47	-2.55	1.08	64.67	4.86	4.57	-2.16	-1.23	43.81	2.72	4.89	-1.75	-1.23	35.97	1.69	4.88	-2.10	-0.99
Slope1k	-3.68	0.82	4.21	9999	4.62	-1.34	1.86	4.60	7.44	4.48	-1.99	1.21	4.74	4.79	2.64	0.79	0.11	4.82	4.21	0.54	1.19	0.29
Aspect1k	-3.81	0.28	4.47	4.62	9999	-4.58	0.03	4.45	3.50	5.35	-3.21	-0.62	4.56	2.08	3.97	-1.67	-0.68	4.73	1.74	2.25	-0.97	-0.89
Hill90451k	1.30	-0.57	-2.55	-1.34	-4.58	9999	0.29	-2.49	-0.50	-3.73	5.24	0.66	-2.51	0.68	-2.44	3.68	1.74	-2.55	1.30	-1.55	2.42	2.80
Hill180451k	-0.35	-1.36	1.08	1.86	0.03	0.29	9999	1.14	0.28	0.28	-0.62	6.06	1.08	-0.69	-1.17	1.21	3.32	0.99	-0.06	-0.33	1.37	2.71
EleMeter5k	-7.31	0.50	64.67	4.60	4.45	-2.49	1.14	9999	5.23	4.81	-2.36	-1.07	101.6	3.01	5.13	-1.62	-1.25	57.53	1.94	4.84	-1.92	-1.04
Slope5k	-4.01	1.68	4.86	7.44	3.50	-0.50	0.28	5.23	9999	3.66	-1.13	-1.29	5.33	10.17	4.44	0.24	-1.34	5.33	6.23	2.38	-0.01	-0.31
Aspect5k	-3.88	1.33	4.57	4.48	5.35	-3.73	0.28	4.81	3.66	9999	-5.85	-0.64	5.02	1.91	5.68	-2.21	-1.00	5.16	1.46	2.75	-1.35	-0.98
Hill90455k	1.20	-0.75	-2.16	-1.99	-3.21	5.24	-0.62	-2.36	-1.13	-5.85	9999	0.90	-2.42	0.99	-3.83	6.07	2.62	-2.41	1.07	-2.12	3.86	2.77
Hill180455k	0.51	-2.48	-1.23	1.21	-0.62	0.66	6.06	-1.07	-1.29	-0.64	0.90	9999	-1.07	-0.44	-3.40	4.44	8.91	-1.10	0.82	-1.82	5.04	5.53
EleMeter10k	-7.52	0.56	43.81	4.74	4.56	-2.51	1.08	101.6	5.33	5.02	-2.42	-1.07	9999	3.15	5.33	-1.59	-1.33	112.3	2.02	4.87	-1.86	-1.17
Slope10k	-3.70	0.60	2.72	4.79	2.08	0.68	-0.69	3.01	10.17	1.91	0.99	-0.44	3.15	9999	2.69	2.19	0.05	3.25	13.91	1.89	1.70	0.73
Aspect10k	-4.33	2.12	4.89	2.64	3.97	-2.44	-1.17	5.13	4.44	5.68	-3.83	-3.40	5.33	2.69	9999	-4.78	-3.80	5.51	2.02	6.60	-4.07	-3.33
Hill904510k	0.33	-2.00	-1.75	0.79	-1.67	3.68	1.21	-1.62	0.24	-2.21	6.07	4.44	-1.59	2.19	-4.78	9999	5.53	-1.61	2.79	-3.67	15.84	5.74
Hill1804510k	0.57	-2.66	-1.23	0.11	-0.68	1.74	3.32	-1.25	-1.34	-1.00	2.62	8.91	-1.33	0.05	-3.80	5.53	9999	-1.35	1.33	-2.33	6.30	12.88
EleMeter15k	-7.75	0.60	35.97	4.82	4.73	-2.55	0.99	57.53	5.33	5.16	-2.41	-1.10	112.3	3.25	5.51	-1.61	-1.35	9999	2.11	4.97	-1.86	-1.26
Slope15k	-3.19	-0.09	1.69	4.21	1.74	1.30	-0.06	1.94	6.23	1.46	1.07	0.82	2.02	13.91	2.02	2.79	1.33	2.11	9999	1.58	2.75	2.01
Aspect15k	-4.05	1.29	4.88	0.54	2.25	-1.55	-0.33	4.84	2.38	2.75	-2.12	-1.82	4.87	1.89	6.60	-3.67	-2.33	4.97	1.58	9999	-4.82	-2.37
Hill904515k	0.32	-2.45	-2.10	1.19	-0.97	2.42	1.37	-1.92	-0.01	-1.35	3.86	5.04	-1.86	1.70	-4.07	15.84	6.30	-1.86	2.75	-4.82	9999	6.12
Hill1804515k	0.33	-3.11	-0.99	0.29	-0.89	2.80	2.71	-1.04	-0.31	-0.98	2.77	5.53	-1.17	0.73	-3.33	5.74	12.88	-1.26	2.01	-2.37	6.12	9999

Table I.9: p-value (t) for Pearson correlation coefficient

45	LON METE R	LATM ETER	Ele Meter 1k	Slope 1k	Aspe ct 1k	Hill 9045 1k	Hill 18045 1k	Ele Meter 5k	Slope 5k	Aspe ct 5k	Hill 9045 5k	Hill 18045 5k	Ele Meter 10k	Slope 10k	Aspe ct 10k	Hill 9045 10k	Hill 18045 10k	Ele Meter 15k	Slope 15k	Aspe ct 15k	Hill 9045 15k	Hill 18045 15k
LONMETER	0.00	0.14	0.00	0.00	0.00	0.20	0.73	0.00	0.00	0.00	0.24	0.61	0.00	0.00	0.00	0.74	0.57	0.00	0.00	0.00	0.75	0.74
LATMETER	0.14	0.00	0.64	0.42	0.78	0.57	0.18	0.62	0.10	0.19	0.46	0.02	0.58	0.55	0.04	0.05	0.01	0.55	0.93	0.20	0.02	0.00
EleMeter1k	0.00	0.64	0.00	0.00	0.00	0.01	0.29	0.00	0.00	0.00	0.04	0.23	0.00	0.01	0.00	0.09	0.23	0.00	0.10	0.00	0.04	0.33
Slope1k	0.00	0.42	0.00	0.00	0.00	0.19	0.07	0.00	0.00	0.00	0.05	0.23	0.00	0.00	0.01	0.43	0.91	0.00	0.00	0.59	0.24	0.77
Aspect1k	0.00	0.78	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.00	0.00	0.54	0.00	0.04	0.00	0.10	0.50	0.00	0.09	0.03	0.34	0.38
Hill90451k	0.20	0.57	0.01	0.19	0.00	0.00	0.77	0.02	0.62	0.00	0.00	0.51	0.02	0.50	0.02	0.00	0.09	0.01	0.20	0.13	0.02	0.01
Hill180451k	0.73	0.18	0.29	0.07	0.97	0.77	0.00	0.26	0.78	0.78	0.54	0.00	0.29	0.49	0.25	0.23	0.00	0.33	0.95	0.74	0.18	0.01
EleMeter5k	0.00	0.62	0.00	0.00	0.00	0.02	0.26	0.00	0.00	0.00	0.02	0.29	0.00	0.00	0.00	0.11	0.22	0.00	0.06	0.00	0.06	0.30
Slope5k	0.00	0.10	0.00	0.00	0.00	0.62	0.78	0.00	0.00	0.00	0.26	0.20	0.00	0.00	0.00	0.81	0.19	0.00	0.00	0.02	0.99	0.76
Aspect5k	0.00	0.19	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.52	0.00	0.06	0.00	0.03	0.32	0.00	0.15	0.01	0.18	0.33
Hill90455k	0.24	0.46	0.04	0.05	0.00	0.00	0.54	0.02	0.26	0.00	0.00	0.37	0.02	0.33	0.00	0.00	0.01	0.02	0.29	0.04	0.00	0.01
Hill180455k	0.61	0.02	0.23	0.23	0.54	0.51	0.00	0.29	0.20	0.52	0.37	0.00	0.29	0.66	0.00	0.00	0.00	0.28	0.42	0.08	0.00	0.00
EleMeter10k	0.00	0.58	0.00	0.00	0.00	0.02	0.29	0.00	0.00	0.00	0.02	0.29	0.00	0.00	0.00	0.12	0.19	0.00	0.05	0.00	0.07	0.25
Slope10k	0.00	0.55	0.01	0.00	0.04	0.50	0.49	0.00	0.00	0.06	0.33	0.66	0.00	0.00	0.01	0.03	0.96	0.00	0.00	0.07	0.10	0.47
Aspect10k	0.00	0.04	0.00	0.01	0.00	0.02	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00
Hill904510k	0.74	0.05	0.09	0.43	0.10	0.00	0.23	0.11	0.81	0.03	0.00	0.00	0.12	0.03	0.00	0.00	0.00	0.11	0.01	0.00	0.00	0.00
Hill1804510k	0.57	0.01	0.23	0.91	0.50	0.09	0.00	0.22	0.19	0.32	0.01	0.00	0.19	0.96	0.00	0.00	0.00	0.18	0.19	0.02	0.00	0.00
EleMeter15k	0.00	0.55	0.00	0.00	0.00	0.01	0.33	0.00	0.00	0.00	0.02	0.28	0.00	0.00	0.00	0.11	0.18	0.00	0.04	0.00	0.07	0.21
Slope15k	0.00	0.93	0.10	0.00	0.09	0.20	0.95	0.06	0.00	0.15	0.29	0.42	0.05	0.00	0.05	0.01	0.19	0.04	0.00	0.12	0.01	0.05
Aspect15k	0.00	0.20	0.00	0.59	0.03	0.13	0.74	0.00	0.02	0.01	0.04	0.08	0.00	0.07	0.00	0.00	0.02	0.00	0.12	0.00	0.00	0.02
Hill904515k	0.75	0.02	0.04	0.24	0.34	0.02	0.18	0.06	0.99	0.18	0.00	0.00	0.07	0.10	0.00	0.00	0.00	0.07	0.01	0.00	0.00	0.00
Hill1804515k	0.74	0.00	0.33	0.77	0.38	0.01	0.01	0.30	0.76	0.33	0.01	0.00	0.25	0.47	0.00	0.00	0.00	0.21	0.05	0.02	0.00	0.00

Table I.10: Coefficient of multiple determination(R^2) between explanatory variables

	LONMETER	LATMETER	Ele Meter 1k	Slope 1k	Aspect 1k	Hill 9045 1k	Hill 18045 1k	Slope 5k	Aspect 5k	Hill 9045 5k	Hill 18045 5k	Slope 10k	Aspect 10k	Hill 9045 10k	Hill 18045 10k	Slope 15k	Aspect 15k	Hill 9045 15k	Hill 18045 15k
LATMETER	0.05	0.05																	
EleMeter1k	0.62	0.17	0.60																
Slope1k	0.64	0.20	0.62	0.34															
Aspect1k	0.64	0.20	0.64	0.43	0.43														
Hill90451k	0.65	0.20	0.65	0.45	0.59	0.39													
Hill180451k	0.68	0.30	0.68	0.52	0.60	0.39	0.24												
Slope5k	0.68	0.34	0.70	0.69	0.60	0.43	0.28	0.69											
Aspect5k	0.70	0.38	0.70	0.70	0.62	0.48	0.28	0.69	0.57										
Hill90455k	0.70	0.39	0.70	0.70	0.62	0.58	0.29	0.69	0.70	0.60									
Hill180455k	0.70	0.43	0.74	0.76	0.62	0.59	0.64	0.73	0.72	0.66	0.72								
Slope10k	0.72	0.43	0.74	0.76	0.63	0.59	0.71	0.91	0.72	0.71	0.76	0.87							
Aspect10k	0.75	0.49	0.74	0.77	0.63	0.60	0.71	0.91	0.73	0.74	0.78	0.87	0.73						
Hill904510k	0.75	0.51	0.75	0.77	0.63	0.60	0.73	0.92	0.77	0.84	0.83	0.88	0.82	0.88					
Hill1804510k	0.76	0.52	0.76	0.80	0.66	0.63	0.74	0.92	0.80	0.85	0.90	0.88	0.83	0.88	0.81				
Slope15k	0.76	0.52	0.77	0.80	0.67	0.66	0.74	0.92	0.81	0.86	0.90	0.95	0.84	0.89	0.82	0.90			
Aspect15k	0.77	0.56	0.84	0.89	0.68	0.69	0.75	0.92	0.81	0.86	0.93	0.95	0.85	0.90	0.85	0.90	0.83		
Hill904515k	0.78	0.56	0.84	0.89	0.69	0.72	0.75	0.93	0.81	0.87	0.93	0.95	0.88	0.97	0.86	0.92	0.88	0.96	
Hill1804515k	0.78	0.64	0.84	0.89	0.69	0.73	0.75	0.94	0.82	0.87	0.93	0.96	0.88	0.97	0.94	0.93	0.88	0.96	0.90

Table I.11: Variance Inflationary Factor(VIF)

	LONMETER	LATMETER	Ele Meter 1k	Slope 1k	Aspect 1k	Hill 9045 1k	Hill 18045 1k	Slope 5k	Aspect 5k	Hill 9045 5k	Hill 18045 5k	Slope 10k	Aspect 10k	Hill 9045 10k	Hill 18045 10k	Slope 15k	Aspect 15k	Hill 9045 15k	Hill 18045 15k
LATMETER	1.05	1.05																	
EleMeter1k	2.60	1.21	2.48																
Slope1k	2.74	1.25	2.62	1.50															
Aspect1k	2.77	1.25	2.75	1.74	1.75														
Hill90451k	2.85	1.25	2.88	1.82	2.45	1.64													
Hill180451k	3.08	1.43	3.08	2.09	2.53	1.64	1.32												
Slope5k	3.12	1.52	3.30	3.24	2.53	1.77	1.38	3.26											
Aspect5k	3.30	1.62	3.30	3.36	2.62	1.92	1.38	3.26	2.34										
Hill90455k	3.37	1.63	3.30	3.37	2.63	2.35	1.40	3.26	3.37	2.52									
Hill180455k	3.38	1.75	3.80	4.17	2.66	2.45	2.76	3.69	3.52	2.94	3.57								
Slope10k	3.56	1.76	3.90	4.22	2.67	2.45	3.47	11.47	3.54	3.41	4.22	7.78							
Aspect10k	3.94	1.95	3.91	4.39	2.72	2.47	3.48	11.48	3.64	3.83	4.45	7.96	3.66						
Hill904510k	3.98	2.03	4.01	4.41	2.74	2.53	3.75	12.32	4.39	6.14	5.94	8.01	5.62	8.56					
Hill1804510k	4.13	2.10	4.17	4.89	2.95	2.71	3.81	12.35	5.04	6.69	9.97	8.05	5.85	8.60	5.17				
Slope15k	4.16	2.10	4.27	4.95	3.01	2.91	3.82	13.25	5.32	7.29	9.97	19.00	6.32	8.73	5.55	9.87			
Aspect15k	4.30	2.26	6.11	8.79	3.17	3.19	3.96	13.30	5.34	7.33	14.54	19.19	6.54	10.36	6.72	10.26	5.94		
Hill904515k	4.45	2.27	6.35	8.79	3.17	3.62	3.98	13.39	5.36	7.66	14.69	20.62	8.38	32.98	7.31	12.33	8.25	25.47	
Hill1804515k	4.56	2.78	6.35	8.86	3.22	3.71	3.99	16.31	5.52	7.67	15.00	24.03	8.40	33.33	16.02	13.56	8.28	25.74	10.10

Note: ▨ :VIF > 10 ░ : VIF> 5

APPENDIX J

Table J.1: Summary of Regression Analysis for Linear Regression Model (LGM) R1

Variables	logJAN	logFEB	logMAR	logAPR	logMAY	logJUN	logJUL	logAUG	logSEP	logOCT	logNOV	logDEC
(Intercept)	5.065087	5.177034	5.443473	5.848083	5.752931	5.761224	5.543186	5.458304	5.503911	5.22997	5.078494	5.079986
LONG1	-0.304964	-0.30293	-0.236702	0.122209	0.318692	1.098113	1.35075	1.023199	0.387462	-0.193248	-0.414264	-0.418051
LATI1	-0.101911	-0.076469	0.00329	-0.216537	-0.38966	-0.837816	-1.151872	-0.904168	-0.367274	-0.019209	0.063566	-0.091696
Elev1	-0.315674	-0.267013	-0.507798	-0.286249	-0.212122	0.113103	0.463366	0.108259	-0.227503	-0.302448	-0.480144	-0.446455
Slope	-0.0994	-0.070586	-0.111139	-0.084723	-0.042441	-0.006491	0.036172	-0.003375	-0.033774	-0.089949	-0.086073	-0.120496
Aspect	0.000447	0.000197	0.000429	0.000183	0.000377	-0.000256	-0.000506	-0.000195	0.00028	0.000388	0.00049	0.000184
I(LATI1^2)	-0.005234	-0.057553	-0.062778	-0.120465	-0.141522	-0.167936	-0.111391	-0.133964	-0.174722	-0.042621	-0.065394	-0.016509
I(Elev1^2)	-0.071504	-0.062106	-0.121949	-0.088381	0.001639	0.243709	0.303645	0.073878	-0.000501	0.094791	0.111027	-0.04752
I(Slope^2)	0.016215	0.013258	0.015807	0.011719	0.009432	0.009386	0.008174	0.010029	0.008833	0.013885	0.014998	0.018241
I(LATI1^3)	-0.083078	-0.084068	-0.100135	-0.029281	0.005399	0.096137	0.19331	0.11674	-0.028156	-0.110578	-0.129127	-0.054682
I(Elev1^3)	0.004284	-0.024602	0.119719	0.044461	0.050056	0.087362	0.035262	0.183448	0.114668	-0.085516	-0.080395	0.0028
LONG1:LATI1	0.144479	0.154783	0.120092	0.170393	0.204761	0.423735	0.492735	0.466903	0.285506	0.094734	0.082835	0.10158
LONG1:Slope	0.131591	0.128269	0.096242	0.063049	0.08666	0.085416	0.145255	0.148456	0.086673	0.085045	0.104385	0.103019
LONG1:Elev1	-0.17208	-0.202257	-0.177911	0.13579	0.269321	0.855001	0.910856	0.66269	0.310312	-0.039604	-0.150709	-0.210655
Residual standard error:	0.312859	0.320995	0.29116	0.288285	0.366364	0.484789	0.516333	0.47066	0.337401	0.311195	0.317579	0.333813
Multiple R - Squared:	0.764128	0.71351	0.77947	0.824537	0.785433	0.817515	0.821206	0.829147	0.823989	0.776009	0.782929	0.733269
F -statistic:	7.725154	5.938938	8.428514	11.2058	8.728981	10.68282	10.95259	11.57248	11.16345	8.261415	8.600807	6.555527
degrees of freedom	31	31	31	31	31	31	31	31	31	31	31	31
p -Value	1.64E-06	2.36E-05	6.38E-07	2.45E-08	4.33E-07	4.31E-08	3.21E-08	1.67E-08	2.56E-08	7.94E-07	5.10E-07	8.94E-06
Min	-0.831512	-0.649362	-0.5578	-0.490467	-0.769154	-1.612363	-0.920105	-1.116012	-0.862992	-0.713478	-0.487807	-0.537865
1 Q	-0.139534	-0.193583	-0.155517	-0.163754	-0.165358	-0.223453	-0.305019	-0.231974	-0.153323	-0.149395	-0.184059	-0.231801
Median	-0.017238	-0.001202	-0.022923	-0.053692	-0.050259	-0.006109	0.001332	0.003711	-0.01074	-0.021852	0.025127	0.006694
3 Q	0.187736	0.187511	0.139188	0.202196	0.226895	0.313534	0.327245	0.278327	0.176766	0.174329	0.191545	0.266254
Max	0.688641	0.490344	0.540088	0.415877	0.726371	0.935378	0.987667	0.789983	0.703023	0.468689	0.538885	0.61928

Table J.2: Statistical Summary of LGM R1

REG1log	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-1 (TRN)													
MSE	1356.6	2317.8	2571.3	3711.4	6755.3	8326.3	12475.1	5801.4	2670.6	2489.8	2977.1	2599.0	4504.3
RMSE	36.8	48.1	50.7	60.9	82.2	91.2	111.7	76.2	51.7	49.9	54.6	51.0	67.1
Corr	0.920	0.854	0.903	0.906	0.854	0.871	0.757	0.823	0.893	0.894	0.891	0.876	0.871
t	15.35	10.76	13.74	14.07	10.76	11.65	7.61	9.50	13.03	13.08	12.85	11.90	41.18
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2 (VLD)													
MSE	4319.7	4701.7	4079.7	6130.4	8043.5	17327.5	20278.9	11913.6	7072.0	3780.9	5236.1	2233.1	8007.2
RMSE	65.7	68.6	63.9	78.3	89.7	131.6	142.4	109.1	84.1	61.5	72.4	47.3	89.5
Corr	0.583	0.586	0.752	0.808	0.753	0.500	0.242	0.320	0.668	0.805	0.829	0.831	0.668
t	2.87	2.89	4.42	5.14	4.44	2.31	1.00	1.31	3.47	5.26	5.74	5.79	12.87
pvalue	0.0055	0.0053	0.0002	0.0001	0.0002	0.0174	0.1666	0.1056	0.0017	0.0000	0.0000	0.0000	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207

Table J.3: Summary of Regression Analysis for Linear Regression Model (LGM) R2

MONTH	logJAN	logFEB	logMAR	logAPR	logMAY	logJUN	logJUL	logAUG	logSEP	logOCT	logNOV	logDEC
(Intercept)	5.543065	5.543886	5.737784	5.939248	5.811348	5.576689	5.300084	5.309139	5.533106	5.620835	5.54524	5.522636
Elev1	-0.868991	-0.717904	-0.813047	-0.89205	-1.127337	-1.757515	-1.833256	-1.812115	-1.240246	-0.766751	-0.818193	-0.802238
Slope	-0.170466	-0.152178	-0.166514	-0.143021	-0.110506	-0.126366	-0.118913	-0.141602	-0.11622	-0.150892	-0.144526	-0.182319
I(Elev1^2)	-0.348043	-0.263503	-0.257535	-0.316147	-0.301164	-0.275277	-0.180901	-0.316038	-0.309488	-0.218297	-0.226109	-0.297456
I(Slope^2)	0.017142	0.015328	0.016931	0.013961	0.012039	0.016349	0.016986	0.017352	0.01254	0.01517	0.015487	0.018819
I(Elev1^3)	0.459926	0.35673	0.394442	0.404717	0.527415	0.859841	0.896747	0.9353	0.624088	0.317477	0.335337	0.400665
Residual standard erro	0.339522	0.344442	0.308787	0.334492	0.436854	0.674632	0.773484	0.68646	0.452019	0.328451	0.339935	0.339225
Multiple R - Squared:	0.650522	0.585001	0.68795	0.702821	0.616193	0.55541	0.495223	0.542762	0.602567	0.686088	0.687109	0.653467
F -statistic:	14.51898	10.9952	17.19597	18.44681	12.52271	9.744259	7.652368	9.258948	11.82596	17.04768	17.12881	14.70868
degrees of freedom	39	39	39	39	39	39	39	39	39	39	39	39
p -Value	4.85E-08	1.19E-06	5.75E-09	2.29E-09	2.79E-07	4.26E-06	4.33E-05	7.13E-06	5.35E-07	6.44E-09	6.05E-09	4.13E-08
Min	-0.699695	-0.580687	-0.478793	-0.526074	-0.793762	-1.723702	-1.874444	-1.454337	-0.805341	-0.628841	-0.577216	-0.492333
1 Q	-0.169121	-0.2071	-0.189007	-0.20448	-0.243365	-0.209328	-0.26605	-0.297318	-0.218971	-0.192605	-0.229817	-0.231464
Median	-0.039044	-0.035917	-0.002845	-0.009728	-0.022754	0.046789	0.028235	-0.027185	0.020541	-0.012554	-0.008042	-0.027363
3 Q	0.187329	0.176524	0.192313	0.199646	0.202405	0.263613	0.204192	0.269896	0.221887	0.144186	0.223142	0.240401
Max	0.870091	0.92821	0.668913	0.852828	1.371117	2.198759	2.548336	2.129014	1.447163	0.727145	0.604353	0.752603

Table J.4: Statistical Summary of LGM R2

REG2	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-1 (TRN)													
MSE	2253.7	3190.3	3617.4	5928.7	11371.0	20318.8	23291.0	11113.3	5962.7	3539.2	4346.1	3325.3	8188.1
RMSE	47.5	56.5	60.1	77.0	106.6	142.5	152.6	105.4	77.2	59.5	65.9	57.7	90.5
Corr	0.865	0.794	0.861	0.847	0.745	0.686	0.539	0.663	0.754	0.847	0.840	0.843	0.759
t	11.31	8.57	11.12	10.45	7.33	6.18	4.20	5.80	7.52	10.44	10.13	10.26	27.00
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2 (VLD)													
MSE	2948.6	2763.2	3106.1	4321.7	2880.2	8033.3	11032.1	4460.8	4677.2	2451.0	5103.4	1601.8	4482.6
RMSE	54.3	52.6	55.7	65.7	53.7	89.6	105.0	66.8	68.4	49.5	71.4	40.0	67.0
Corr	0.724	0.793	0.811	0.870	0.890	0.784	0.601	0.721	0.816	0.888	0.875	0.904	0.798
t	4.20	5.21	5.37	6.59	7.57	5.04	3.01	4.03	5.46	7.46	6.99	8.18	18.99
pvalue	0.0003	0.0000	0.0000	0.0000	0.0000	0.0001	0.0042	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207

Table J.5: Summary of Regression Analysis for Linear Regression Model (LGM) R10

Fitx-11log	logJAN	logFEB	logMAR	logAPR	logMAY	logJUN	logJUL	logAUG	logSEP	logOCT	logNOV	logDEC
(Intercept)	110.9901	-1.249072	151.4276	115.7994	2.220371	3620.762	3755.037	4231.243	-1866.815	2116.168	2.557262	-3.150966
LATI1	-11.23193	-3.807661	-17.7171	-9.618489	-0.278057	-0.409096	-19.77814	-15.67623	-11.48681		-6.62673	-0.218932
Elev1	-0.22941	-0.218487	8.301966	-0.270582	-0.102579	0.260707	-0.730219	-0.629279	-0.520761	-0.354045	13.07261	-0.135006
Hill1804510k	-0.949971		-1.186332	-0.95553				-0.942533	89.72618		0.016793	0.047012
Hill904510k	0.051105	0.035478	-0.029726	0.028173		-60.37768	-59.80342	-67.19976	-55.88526	-34.83351		
I(LATI1^2)	0.134743					-0.128928						
I(Hill1804510k^3)	9.5E-06		1.25E-05	9.7E-06			2.67E-05	9.9E-06	0.000969			
LATI1:Hill1804510k	0.061757		0.0594	0.052371					0.062605		0.035462	
I(LATI1^3)		-0.136491								-0.07116		
LATI1:Hill904510k		0.021961	0.038799				0.108532	0.085601				
LONG1			15.80738	0.115903	0.414274	1.064827	49.25851	35.69712	0.505776		0.027047	-19.84456
I(Elev1^2)			-0.305563			0.278134					-0.405155	
I(Elev1^3)			0.369591				0.52039	0.466698	0.331115			
LONG1:Hill904510k			-0.087461				-0.269604	-0.194377				
Elev1:Hill1804510k			-0.050541								-0.074615	
I(LONG1^2)				-0.340917							-0.927847	-0.469426
I(LONG1^3)				0.087887							0.169538	0.105447
LONG1:LATI1				0.168368		0.268543	0.153111	0.194338	0.15984		0.179305	0.187298
I(Hill904510k^2)					0.000107	0.335472	0.324331	0.365634	0.308181	0.191322		
LONG1:Elev1					0.353446	0.826905	0.444527	0.455252	0.339253		-0.889854	
LATI1:Elev1					-0.174442							
I(Hill904510k^3)						-0.00062	-0.000586	-0.000663	-0.000566	-0.00035		
I(Hill1804510k^2)							-0.007107		-0.511028			
LONG1:Hill1804510k												0.111841

Residual standard err	0.35213	0.338445	0.331673	0.280672	0.328839	0.420567	0.363186	0.332318	0.274984	0.323671	0.347651	0.376902
degrees of freedom	37	39	32	34	38	34	31	31	31	39	33	36
Multiple R - Squared:	0.643363	0.599327	0.704598	0.817586	0.788102	0.84937	0.911539	0.914824	0.883087	0.695157	0.72309	0.60512
F -statistic:	9.53529	11.66726	6.360579	15.2389	23.55526	19.17186	24.57201	25.61179	18.01186	17.78697	7.833861	6.895852
p -Value	1.03E-06	6.22E-07	1.35E-05	7.71E-10	2.11E-11	3.43E-11	1E-12	5.69E-13	6.43E-11	3.7E-09	1.84E-06	1.78E-05

Reciduals:

Min	-0.722173	-0.662384	-0.549255	-0.537482	-0.612169	-1.305802	-0.731759	-0.702116	-0.505179	-0.695847	-0.450838	-0.712147
1 Q	-0.175293	-0.164737	-0.176978	-0.148038	-0.203648	-0.227131	-0.177043	-0.170067	-0.129046	-0.200344	-0.199696	-0.231094
Median	0.036002	0.003209	-0.014738	-0.020951	0.008508	0.052679	0.000557	0.015146	0.001607	0.043112	-0.030261	0.003274
3 Q	0.183723	0.224337	0.147437	0.129682	0.164181	0.230674	0.186254	0.202165	0.122859	0.227957	0.18527	0.175301
Max	0.869527	0.625133	0.73765	0.615118	0.673817	0.615332	0.646482	0.532401	0.67131	0.73042	0.908349	1.132714

Table J.6: Statistical Summary of LGM R10

Setx3-11log	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR

type-1 (TRN)

MSE	4751.9	4008.2	5776.9	5054.5	7091.4	7713.6	7281.3	3443.4	2836.6	4578.4	5561.1	5996.8	5341.2
MRSE	68.9	63.3	76.0	71.1	84.2	87.8	85.3	58.7	53.3	67.7	74.6	77.4	73.1
Corr	0.682	0.731	0.765	0.870	0.845	0.879	0.850	0.890	0.886	0.795	0.783	0.678	0.843
t	6.12	7.02	7.78	11.57	10.38	12.11	10.60	12.82	12.54	8.59	8.25	6.06	36.42
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540

type-2 (VLD)

MSE	5586.9	6263.9	6748.0	5209.2	3859.5	16094.1	12468.8	9694.8	7945.3	4106.4	3234.4	2714.3	7062.5
MRSE	74.7	79.1	82.1	72.2	62.1	126.9	111.7	98.5	89.1	64.1	56.9	52.1	84.0
Corr	0.336	0.469	0.712	0.852	0.856	0.521	0.604	0.411	0.607	0.798	0.903	0.815	0.707
t	1.43	2.12	3.92	6.08	6.40	2.44	3.03	1.74	2.96	5.14	8.14	5.44	14.33
pvalue	0.0865	0.0248	0.0007	0.0000	0.0000	0.0133	0.0040	0.0507	0.0049	0.0001	0.0000	0.0000	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207

Table J.7: Summary of Regression Analysis for Linear Regression Model (LGM) R11

Fitx-10log	logJAN	logFEB	logMAR	logAPR	logMAY	logJUN	logJUL	logAUG	logSEP	logOCT	logNOV	logDEC
(Intercept)	-12480.39	-11835.72	-10074.57	-7692.645	-5032.612	-6761.854	-1333.334	-1213.69	-7526.776	-6851.164	-8096.635	-7566.43
LONG1	-42.63196	-14.8191	-34.21088	-20.42131	-0.102241	-3.222884	54.05885	0.815871	2.780028	-33.27723	-76.87221	-20.14552
LATI1	-0.066614	0.037241	7.582539	-0.213998	-0.011959	0.208245	-18.30564	0.04365	0.115216	14.51942	22.97623	9.128307
Elev1	-0.253154	-2.346498	-1.710247	-0.170312	-0.93261	-17.01629	-1.904921	-8.879434	-1.481903	-0.821338	-11.12155	-2.017657
Slope	3.061304	3.155488	2.15381	-0.034365	-0.050255	2.441276	0.021736	1.02053	-0.016412	-0.142998	1.810062	1.74035
Hill1804510k	207.374	201.2562	200.2357	129.487	135.5844	185.8124	83.72319	99.86066	205.7064	157.2451	132.1503	128.0186
Hill904510k	1.669686	-0.592887	-30.30748		-49.03686	-69.30674	-57.0291	-77.65285	-76.18299	-41.59339	2.461505	0.00351
I(LATI1^2)	0.206029											
I(Hill1804510k^2)	-1.157566	-1.129792	-1.120517	-0.725693	-0.763008	-1.051658	-0.481475	-0.565922	-1.156266	-0.884171	-0.746524	-0.721601
I(Slope^3)	0.001701	0.003491	0.00171	0.000861	0.000856			0.001187	0.001012	0.001525		0.001604
I(Hill1804510k^3)	0.002172	0.002133	0.002111	0.001355	0.00143	0.001983	0.000922	0.001068	0.002165	0.001656	0.001406	0.001356
LONG1:Slope	0.323854	0.577008	0.394257	0.076208	0.167062	0.33117			0.347537	0.099232		0.483432
LONG1:Hill1804510k	0.236078	0.200226	0.186103	0.114675		0.173479			0.054445		0.156689	0.103565
LATI1:Slope	-0.142548	-0.085388	-0.091577	-0.044624	-0.063826	-0.128038		-0.076045	-0.104599	-0.04048	-0.064166	-0.058923
Elev1:Slope	0.059162	0.246182	0.163624		0.085329	0.171009	0.059463		0.15472	0.074161		0.200959
Slope:Hill1804510k	-0.01703	-0.016382	-0.012196			-0.014074					-0.02345	-0.009706
Hill1804510k:Hill9045	-0.009304	-0.009728	-0.011081									
I(Elev1^2)		-0.568433	-0.466829									-0.441049
I(Slope^2)		-0.038536				0.023881					0.033971	
I(Hill904510k^2)		0.006281	0.176561		0.267935	0.383418	0.308857	0.431491	0.414849	0.233766		
I(Elev1^3)		0.635897	0.604353		0.285106	0.804015	0.825004	0.669149	0.480316	0.300866	0.446356	0.474205
LONG1:Elev1		-1.174565	-0.615536					0.491033				-1.100966
LONG1:Hill904510k		-0.12625				-0.158366	-0.29981		-0.07271	0.184844	0.27227	
I(Hill904510k^3)			-0.000322		-0.000487	-0.000706	-0.000557	-0.000797	-0.000752	-0.000436	-2.39E-05	
LATI1:Hill904510k			-0.041803				0.101595			-0.079559	-0.126773	-0.050606
I(LONG1^2)				-0.479658					0.118048		-0.110252	
I(LONG1^3)				0.119265		0.036142						
LONG1:LATI1				0.208486								
Elev1:Hill1804510k						0.082323		0.044642			0.057295	
Slope:Hill904510k								-0.006142			0.011769	
I(LATI1^3)										-0.104287	-0.076958	

Residual standard err	0.217177	0.231355	0.209933	0.209991	0.285011	0.307165	0.345934	0.325452	0.208801	0.217255	0.211276	0.267371
degrees of freedom	28	23	23	30	29	24	30	28	26	26	24	26
Multiple R - Squared:	0.897339	0.889583	0.914939	0.909904	0.878522	0.943283	0.922332	0.926213	0.943464	0.908438	0.925621	0.856482
F -statistic:	15.2964	8.823844	11.78062	21.64137	13.98178	19.95752	25.44715	21.9669	24.10481	14.33118	14.93357	8.620121
p -Value	8.31E-10	1.18E-06	7.49E-08	6.69E-12	1.98E-09	2.01E-10	7.79E-13	1E-11	7.97E-12	3.18E-09	4.45E-09	7.13E-07

Reciduals:

Min	-0.420508	-0.371168	-0.404767	-0.309823	-0.457971	-0.550731	-0.627625	-0.468799	-0.329947	-0.293398	-0.355593	-0.462867
1 Q	-0.085221	-0.142943	-0.066764	-0.091254	-0.151262	-0.101444	-0.19403	-0.174654	-0.068922	-0.10143	-0.091445	-0.166719
Median	0.024	0.006367	0.003665	-0.025052	-0.00684	0.007855	0.015468	-0.047343	0.005196	-0.005357	0.00322	0.004234
3 Q	0.133967	0.127143	0.076754	0.09066	0.133455	0.084342	0.198195	0.212736	0.099544	0.150811	0.112832	0.150992
Max	0.386411	0.437488	0.320766	0.466054	0.536337	0.74405	0.578757	0.576905	0.344274	0.452817	0.299658	0.537631

Table J.8: Statistical Summary for LGM R11

REGSetx3-10l	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-1 (TRN)													
MSE	785.9	1119.3	1311.9	2168.9	3687.0	3862.5	6743.1	2548.2	993.4	1472.3	900.8	1864.4	2288.1
MRSE	28.0	33.5	36.2	46.6	60.7	62.1	82.1	50.5	31.5	38.4	30.0	43.2	47.8
Corr	0.954	0.932	0.952	0.946	0.923	0.940	0.865	0.920	0.961	0.938	0.968	0.912	0.935
t	20.83	16.82	20.51	19.16	15.71	18.00	11.33	15.41	22.71	17.82	25.37	14.63	61.39
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2 (VLD)													
MSE	8447.8	8921.1	4814.0	6929.0	4913.1	8160.6	13844.2	5414.3	6916.6	6054.2	8978.0	3032.3	7254.5
MRSE	91.9	94.5	69.4	83.2	70.1	90.3	117.7	73.6	83.2	77.8	94.8	55.1	85.2
Corr	0.377	0.465	0.740	0.792	0.799	0.658	0.571	0.619	0.656	0.702	0.766	0.777	0.706
t	1.63	2.10	4.26	4.85	5.15	3.50	2.78	3.05	3.37	3.82	4.62	4.78	14.27
pvalue	0.0614	0.0260	0.0003	0.0001	0.0001	0.0015	0.0067	0.0040	0.0021	0.0008	0.0002	0.0001	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207

Table J.9: Summary of Regression Analysis for Linear Regression Model (LGM) R19

FitM-23log	logmeanValor
(Intercept)	-0.1974877
LONG1	-0.0908425
LATI1	-0.0745922
EleMeter1k	-0.0002828
Slope1k	0.0081229
Aspect1k	-0.0002576
Hill90451k	-0.0085162
Hill180451k	0.0110938
Aspect5k	-0.0008954
Hill90455k	-0.027281
Hill180455k	-0.0039082
Slope10k	-0.0075576
Aspect10k	-0.0006828
Hill904510k	0.0808477
Hill1804510k	-0.019328
sinmonth	0.2764621

Residual standard error:	0.4259868
degrees of freedom	524
Multiple R - Squared:	0.6463869
F -statistic:	63.85637
p -Value	0

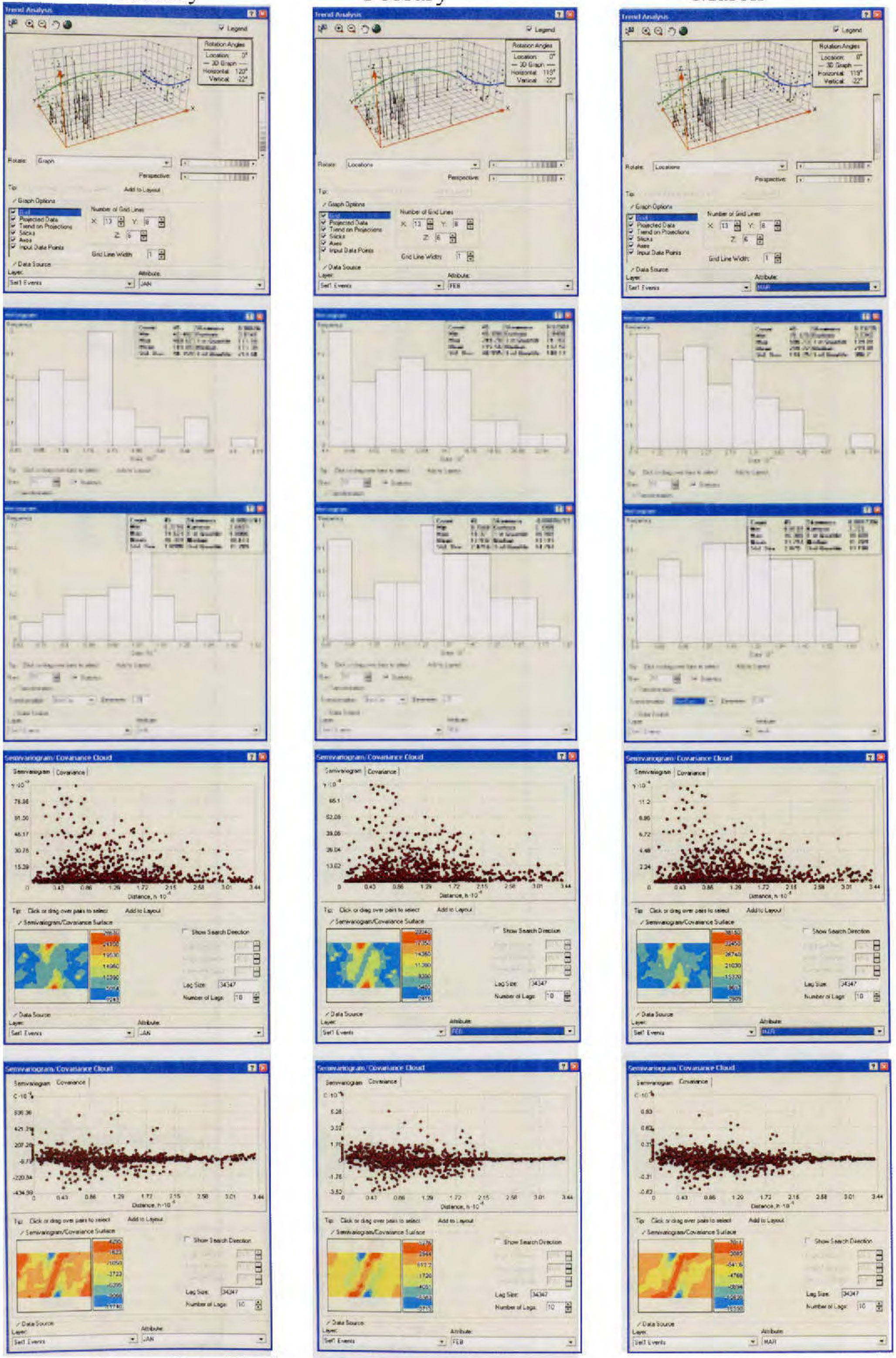
Reciduals:

Min	-1.679972
1 Q	-0.1900108
Median	0.05521656
3 Q	0.2525312
Max	1.156951

Table J.10: Statistical Summary for LGM R19

SetM3-23log	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-0 (TST)													
MSE	6647.3	22365.4	20238.0	13280.2	32403.9	14298.9	11736.8	7879.9	8601.9	6130.3	19767.0	11887.8	14631.1
MRSE	81.5	149.6	142.3	115.2	180.0	119.6	108.3	88.8	92.7	78.3	140.6	109.0	121.0
Corr	0.741	0.701	0.800	0.789	0.809	0.830	0.788	0.744	0.793	0.845	0.765	0.762	0.759
t	4.81	4.40	5.81	5.44	5.84	6.49	5.42	4.72	5.68	6.70	5.03	5.00	18.23
pvalue	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
n	21	22	21	20	20	21	20	20	21	20	20	20	246
type-1 (TRN)													
MSE	4586.7	5812.4	6534.4	9107.4	9447.4	13601.3	11831.7	6693.3	4117.3	4643.7	5912.5	5019.5	7275.6
MRSE	67.7	76.2	80.8	95.4	97.2	116.6	108.8	81.8	64.2	68.1	76.9	70.8	85.3
Corr	0.766	0.722	0.757	0.828	0.848	0.833	0.748	0.792	0.838	0.807	0.779	0.746	0.782
t	7.81	6.83	7.60	9.69	10.50	9.87	7.39	8.52	10.07	8.96	8.15	7.34	29.12
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2 (VLD)													
MSE	4810.8	5099.8	5202.4	8877.7	8935.6	11529.0	10284.3	5776.0	9759.2	5799.9	9230.6	3557.4	7408.3
MRSE	69.4	71.4	72.1	94.2	94.5	107.4	101.4	76.0	98.8	76.2	96.1	59.6	86.1
Corr	0.554	0.610	0.667	0.788	0.693	0.585	0.358	0.525	0.470	0.686	0.727	0.697	0.624
t	2.66	3.08	3.47	4.80	3.72	2.89	1.53	2.39	2.06	3.65	4.10	3.76	11.43
pvalue	0.0085	0.0036	0.0017	0.0001	0.0010	0.0054	0.0726	0.0152	0.0284	0.0012	0.0005	0.0009	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207
ALL													
MSE	5149.9	9945.8	9728.7	10092.4	14940.4	13331.6	11473.2	6792.6	6407.5	5246.0	9979.5	6391.6	9125.5
MRSE	71.8	99.7	98.6	100.5	122.2	115.5	107.1	82.4	80.0	72.4	99.9	79.9	95.5
Corr	0.727	0.620	0.716	0.813	0.788	0.815	0.735	0.774	0.772	0.795	0.725	0.716	0.749
t	9.58	7.20	9.24	12.42	11.43	12.75	9.77	10.92	10.93	11.71	9.42	9.17	35.57
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	84	85	83	81	82	84	83	82	83	82	82	82	993

APPENDIX K

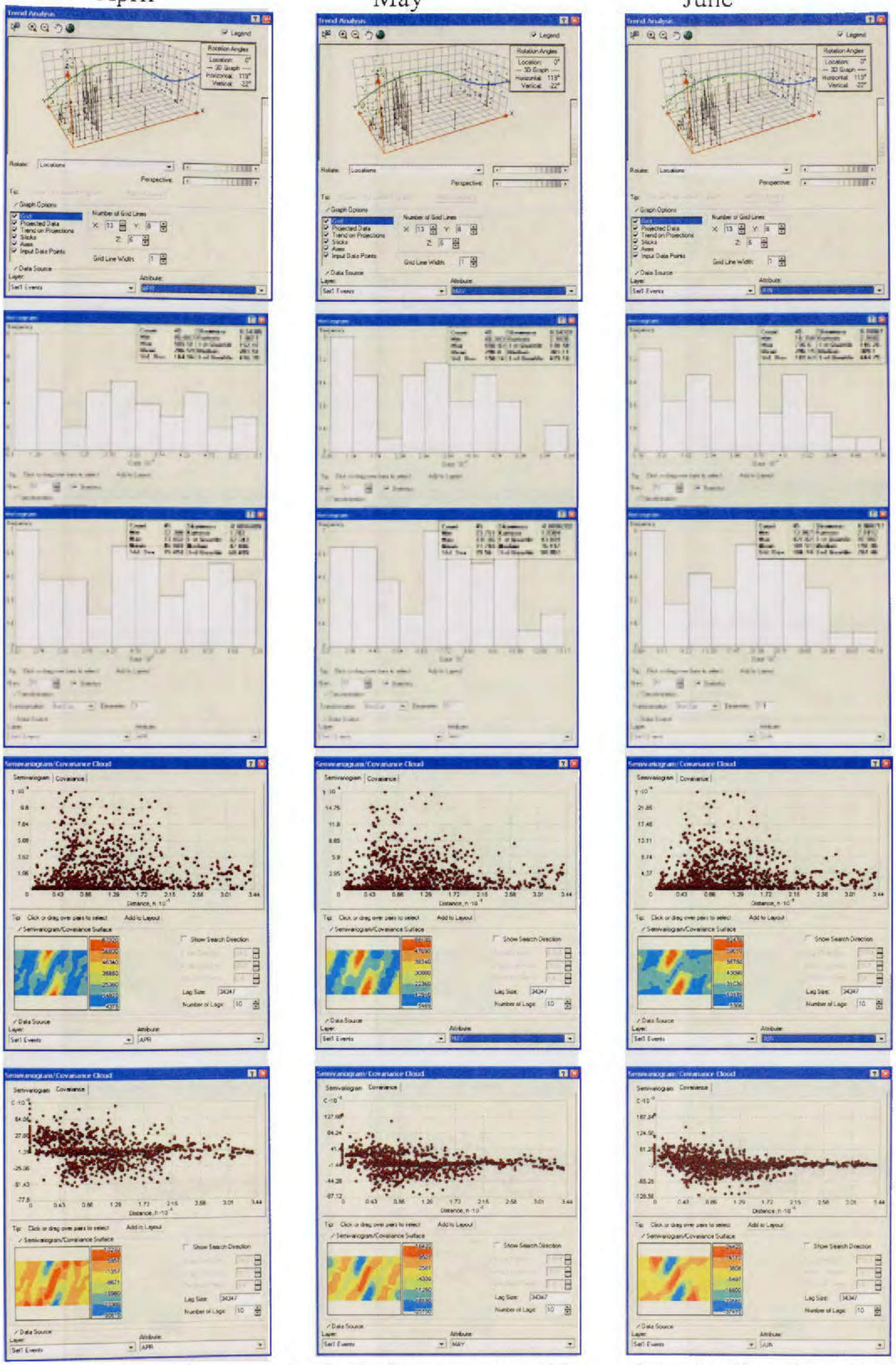


January

Febrary

March

Figure K.1: Exploratory Analysis for mean monthly precipitation



April

May

June

Figure K.1: Exploratory Analysis for mean monthly precipitation (continuation)

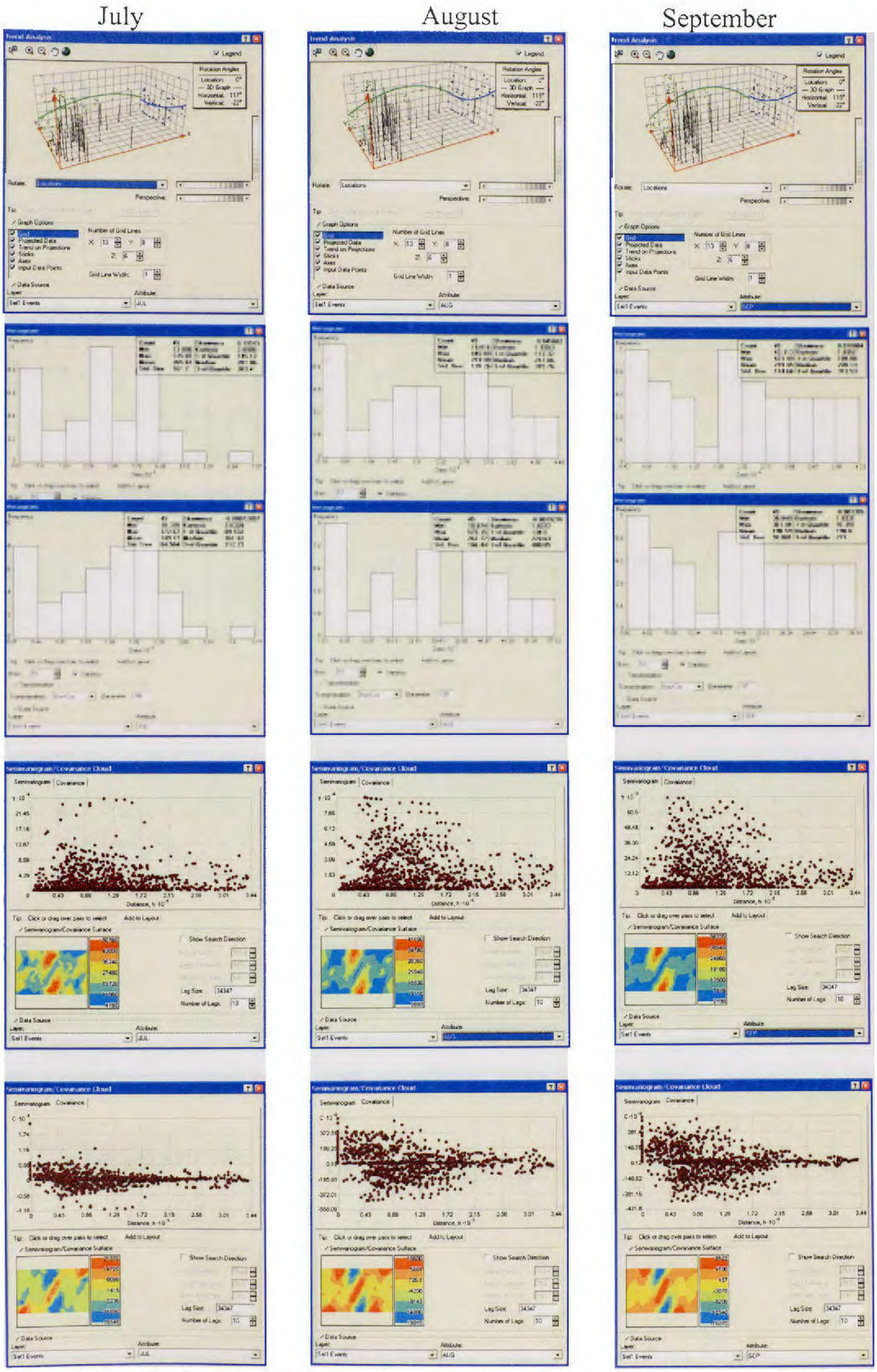


Figure K.1: Exploratory Analysis for mean monthly precipitation (continuation)

Figure K.1: Exploratory Analysis for mean monthly precipitation (continuation)

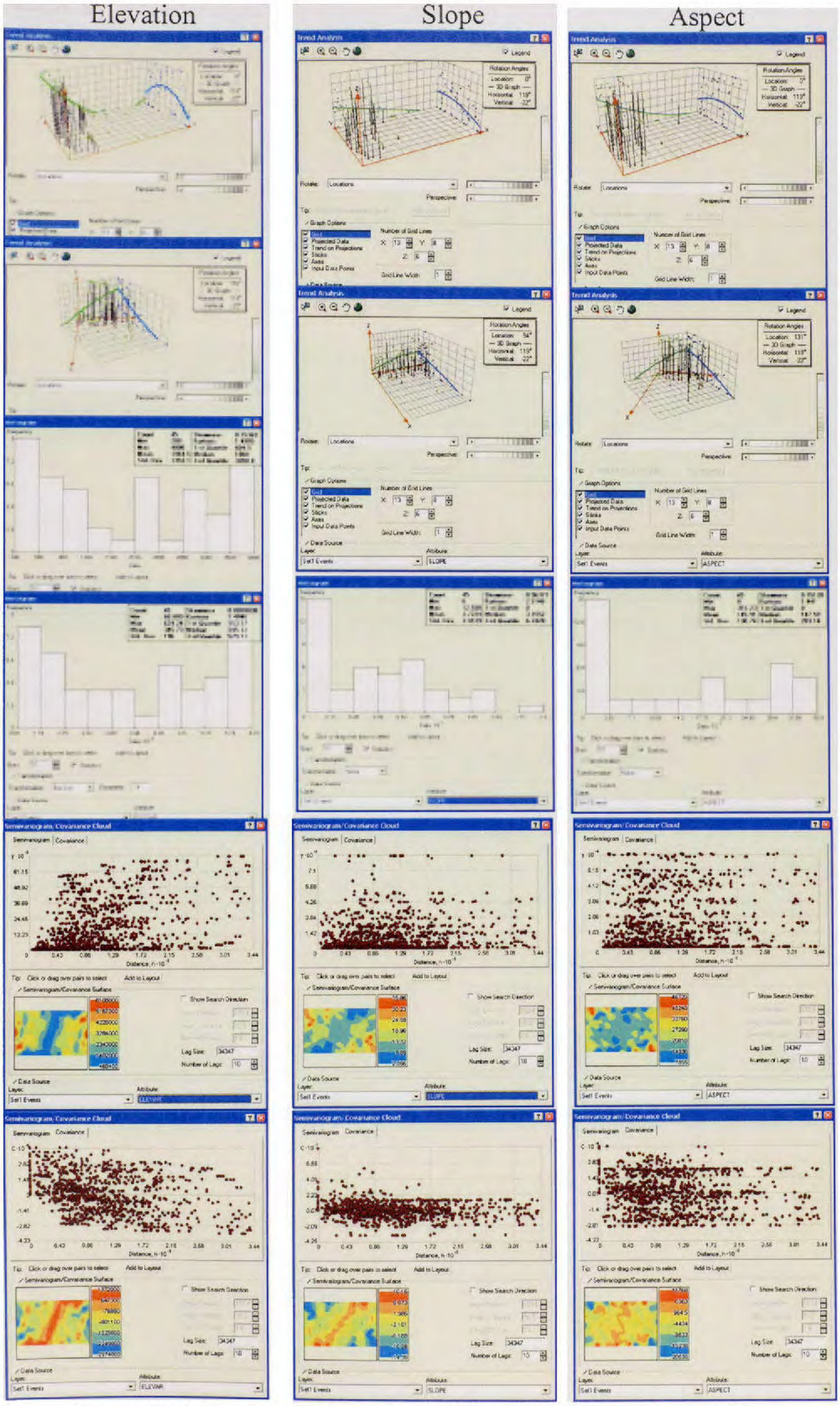


Figure K.2: Exploratory Analysis for geomorphologic variables

APPENDIX L

Table L.1: Statistical summary of Geostatistic models interpolation of mean monthly precipitation

MONTH	Jan	feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
OrdinaryK riging												
SET1												
trend removal	1	0	0	0	0	0	0	0	0	0	1	1
Mean:	4.343	3.077	5.636	9.142	8.89	10.38	4.281	0.2992	6.196	6.038	8.993	1.71
Root-Mean-Square:	84.39	84.09	108	104.4	101.8	126	106.9	79.28	78.74	97.6	101.4	93.51
Average Standard Error:	72.58	76.89	97.85	91	106	114.7	110	80.75	70.43	92.08	102.7	81.28
Mean Standardized:	0.0009	-0.02	-0.027	0.0255	0.0459	0.0451	0.0222	-8E-04	0.0399	0.0263	-0.003	-0.079
Root-Mean-Square Standar	1.295	1.214	1.317	1.183	0.9965	1.019	0.9796	1.021	1.077	1.015	1.243	1.531
SET2												
Mean:	17.31	36.32	34.37	36.23	41.2	35.42	33.33	36.66	10.54	31.61	19.46	27.65
Root-Mean-Square:	76.06	77.24	78.16	97.84	95.84	100.6	104.7	83.53	91.92	74.77	73.54	49.68
Average Standard Error:	68.97	71.64	91.37	76.69	97.45	104.3	101.6	72.01	62.96	92.57	90.49	80.46
Mean Standardized:	0.3944	0.6415	0.4607	0.5877	0.4897	0.3701	0.3703	0.6106	0.2279	0.3761	0.3977	0.5442
Root-Mean-Square Standar	1.311	1.29	0.9555	1.449	1.128	1.039	1.144	1.329	1.532	0.8063	0.9848	0.973
Disjuntive Kriging												
SET1												
Trend removal	1	1	1	0	0	0	0	0	0	1	1	1
Mean:	7.058	5.544	9.318	0.4576	0.3437	-1.587	0.9054	-4.438	0.0889	10.58	16.27	10.57
Root-Mean-Square:	94.14	93.01	122.6	90.52	89.58	99.1	94.41	71.09	63.53	102.9	141	123
Average Standard Error:	72.06	75.09	92.62	103.6	114.9	135	116.2	89.29	83.42	78.03	95.64	87.5
Mean Standardized:	-4E-05	-0.001	0.0036	0.0152	0.0099	0.0007	0.0082	-0.032	0.0078	0.0425	-8E-04	-0.06
Root-Mean-Square Standar	1.305	1.228	1.304	0.9669	0.9199	0.8442	0.9122	0.9253	0.869	1.215	1.404	1.539
SET2												
Mean:	21.2	36.4	36.51	30.46	30.13	25.13	31.16	28.42	2.834	9.149	17.06	30.57
Root-Mean-Square:	78.45	80.11	87.09	107.2	109.9	110.3	103.5	88.85	104.7	92.27	92.76	71.63
Average Standard Error:	68.55	73.38	91.1	88.65	99.92	115.5	102.9	77.63	72.53	76.18	87.88	78.4
Mean Standardized:	0.3449	0.5301	0.4175	0.4572	0.3635	0.2933	0.3588	0.5485	0.1377	0.099	0.2988	0.4474
Root-Mean-Square Standar	1.199	1.134	0.9149	1.468	1.4	1.252	1.148	1.549	1.749	1.245	1.164	0.9228
Ordinary Cokrigin (including Elevation)												
SET1												
Trend Removal	0	0	0	0	1	0	2	2	0	1	0	0
Mean:	4.604	3.476	4.946	3.215	3.192	11.12	7.524	8.468	1.208	7.218	6.929	4.244
Root-Mean-Square:	76.84	76.16	96.25	92.06	99.09	126.8	126.2	95.42	66.61	87.39	91.71	88.9
Average Standard Error:	83.08	84.17	102.8	90.57	109.3	114.2	118.5	94.63	72.89	89.54	97.12	84.06
Mean Standardized:	0.0156	0.0174	0.0183	0.0292	0.0285	0.0462	0.0636	0.0864	0.0082	0.0263	0.0347	0.0074
Root-Mean-Square Standar	1.027	0.9791	1.041	1.133	0.9627	1.019	1.061	1.016	1.007	1.001	1.145	1.238
SET2												
Mean:	22.19	37.23	34.74	32.77	42.3	32.91	21.69	31.44	7.727	29.38	20.06	32.62
Root-Mean-Square:	64.2	66.48	67	90.93	85.33	96.91	104.4	79.85	87.34	57.91	65.55	48.34
Average Standard Error:	82	85.31	103.1	86.17	107.1	107.5	119	94.19	69.13	89.36	96.41	84.84
Mean Standardized:	0.3389	0.498	0.3819	0.5123	0.4461	0.325	0.1652	0.343	0.1615	0.3885	0.3693	0.4839
Root-Mean-Square Standar	0.8732	0.8754	0.6855	1.265	0.9245	0.9599	0.8825	0.8454	1.355	0.6885	0.8862	0.7392

Table L.2: Statistical summary of deterministic models for interpolation of mean monthly precipitation

MONTH	Jan	feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Inverse Weting Distance (2/10)												
SET1												
mean	3.467	3.419	3.126	5.466	5.896	4.159	-0.001	2.1121	4.539	1..859	3.164	4.264
Root-meanSquare	80.79	82.24	103.8	95.69	105.9	110.2	102.5	79.38	70.48	81.29	97.92	95.48
SET2												
mean	8.78	26.01	23.18	17.95	29.15	14.65	14.05	26.09	0,07064	9.005	3.997	22.72
Root-meanSquare	80.1	77.12	85.48	94.03	93.73	102.3	103.5	76.16	86.85	72.54	88.08	66.61
Robust MM Regression												
SET1												
Function power	2	1	1	1	1	3	1	1	3	2	2	1
mean	-3.51	1.676	2.101	3.009	3.238	4.915	2.741	2.112	-0.89	-2.163	-3.207	1.657
Root-meanSquare	91.73	92.27	114.3	132.6	143.2	114.9	148	118.5	78.54	90.32	109.4	104.4
SET2												
mean	15.54	28.44	29.13	33.9	29.75	45.95	9.04	29.65	20.88	32.62	27.29	27.36
Root-meanSquare	59.38	81.36	89.61	122.7	111.1	105.7	108.6	76.53	89.73	66.95	83.55	79.19
Local Regression												
SET1												
Function power	1	1	1	1	1	1	2	1	1	1	1	1
mean	-0.697	4.271	-2.642	-9.814	-14.15	-10.35	0.4757	-6.88	-7.029	-0.893	-3.844	-3.319
Root-meanSquare	75.79	76.26	95.79	93.87	106.3	108.2	109.5	79.86	68.2	77.68	91.35	91.08
SET2												
mean	12.76	28.98	27.91	26.93	33.44	15.17	34.7	25.99	1.341	21	13.49	27.11
Root-meanSquare	67.47	66.83	69.48	82.91	75.99	91.8	98.5	63.18	79.12	61.19	80.16	57.47

Table L.3: Statistical summary of Thiessen models for mean monthly precipitation

Thiessen	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-0 (TST)													
MSE	7799.0	22904.0	16964.8	12879.7	21156.8	18613.6	19271.6	13858.0	17596.4	7022.7	19220.2	13361.5	15933.9
RMSE	88.3	151.3	130.2	113.5	145.5	136.4	138.8	117.7	132.7	83.8	138.6	115.6	126.2
Corr	0.693	0.625	0.732	0.744	0.797	0.711	0.625	0.658	0.539	0.770	0.646	0.626	0.679
t	4.19	3.58	4.68	4.72	5.59	4.40	3.40	3.71	2.79	5.13	3.59	3.41	14.47
pvalue	0.0002	0.0009	0.0001	0.0001	0.0000	0.0002	0.0016	0.0008	0.0059	0.0000	0.0010	0.0016	0.0000
n	21	22	21	20	20	21	20	20	21	20	20	20	246
type-1 (TRN)													
MSE	10205.2	11002.4	17269.2	14701.6	15519.9	14876.4	12325.4	8487.1	6449.0	9955.1	14142.4	14582.3	12459.7
RMSE	101.0	104.9	131.4	121.3	124.6	122.0	111.0	92.1	80.3	99.8	118.9	120.8	111.6
Corr	0.390	0.317	0.357	0.651	0.682	0.769	0.751	0.739	0.743	0.587	0.488	0.306	0.652
t	2.78	2.19	2.50	5.63	6.12	7.88	7.46	7.20	7.28	4.75	3.67	2.11	19.94
pvalue	0.0040	0.0169	0.0081	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0206	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2 (VLD)													
MSE	13760.1	11260.8	17287.6	17003.6	18393.2	18198.3	17328.2	10228.3	11914.7	11183.9	15059.3	13288.2	14574.6
RMSE	117.3	106.1	131.5	130.4	135.6	134.9	131.6	101.1	109.2	105.8	122.7	115.3	120.7
Corr	0.020	0.288	0.317	0.475	0.465	0.392	0.227	0.332	0.429	0.463	0.503	0.361	0.443
t	0.08	1.20	1.29	2.02	2.03	1.70	0.93	1.36	1.84	2.02	2.25	1.50	7.07
pvalue	**0.4684**	**0.1235**	**0.1076**	0.0315	0.0301	**0.0539**	**0.1827**	**0.0963**	0.0427	0.0308	0.0199	**0.0770**	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207
ALL													
MSE	10365.4	14137.5	17196.0	14706.5	17490.4	16522.6	15084.1	10158.0	10388.9	9494.6	15571.0	14016.3	13761.2
RMSE	101.8	118.9	131.1	121.3	132.3	128.5	122.8	100.8	101.9	97.4	124.8	118.4	117.3
Corr	0.433	0.430	0.485	0.665	0.682	0.719	0.668	0.675	0.639	0.631	0.533	0.408	0.633
t	4.35	4.34	4.99	7.92	8.34	9.38	8.08	8.19	7.47	7.27	5.64	4.00	25.71
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000
n	84	85	83	81	82	84	83	82	83	82	82	82	993

APPENDIX M

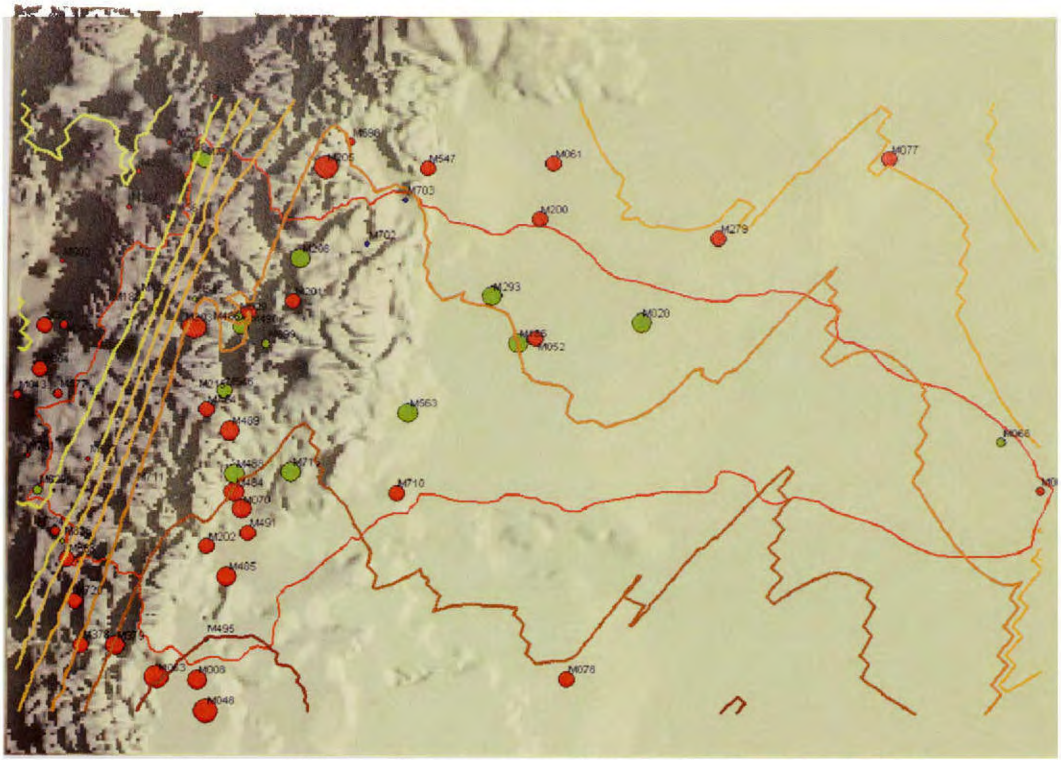


Figure M.1: Ordinary Kriging for mean monthly precipitation in January

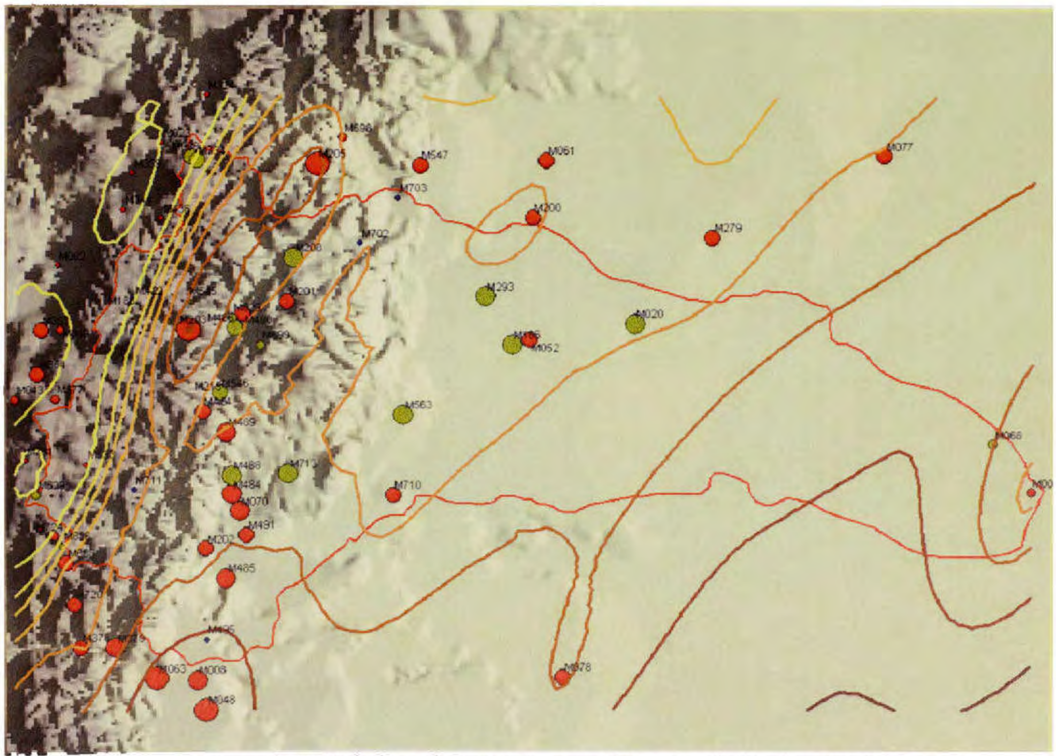


Figure M.2: Disjunctive Kriging for mean monthly precipitation in January

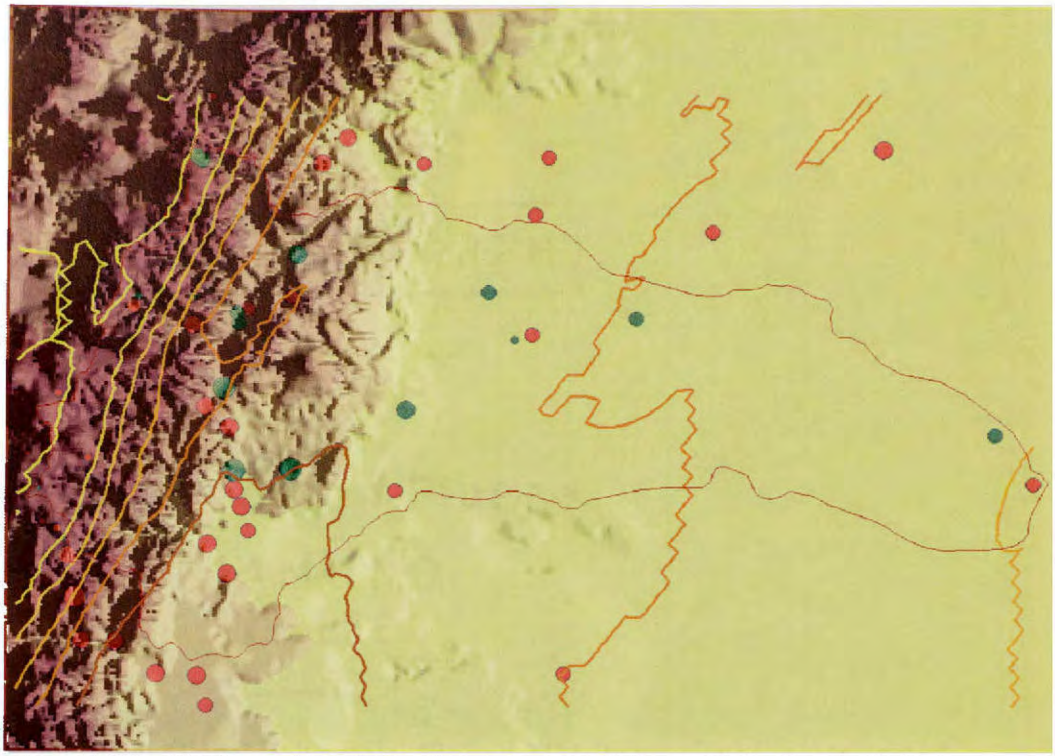


Figure M.3: Ordinary Cokriging for mean monthly precipitation in July

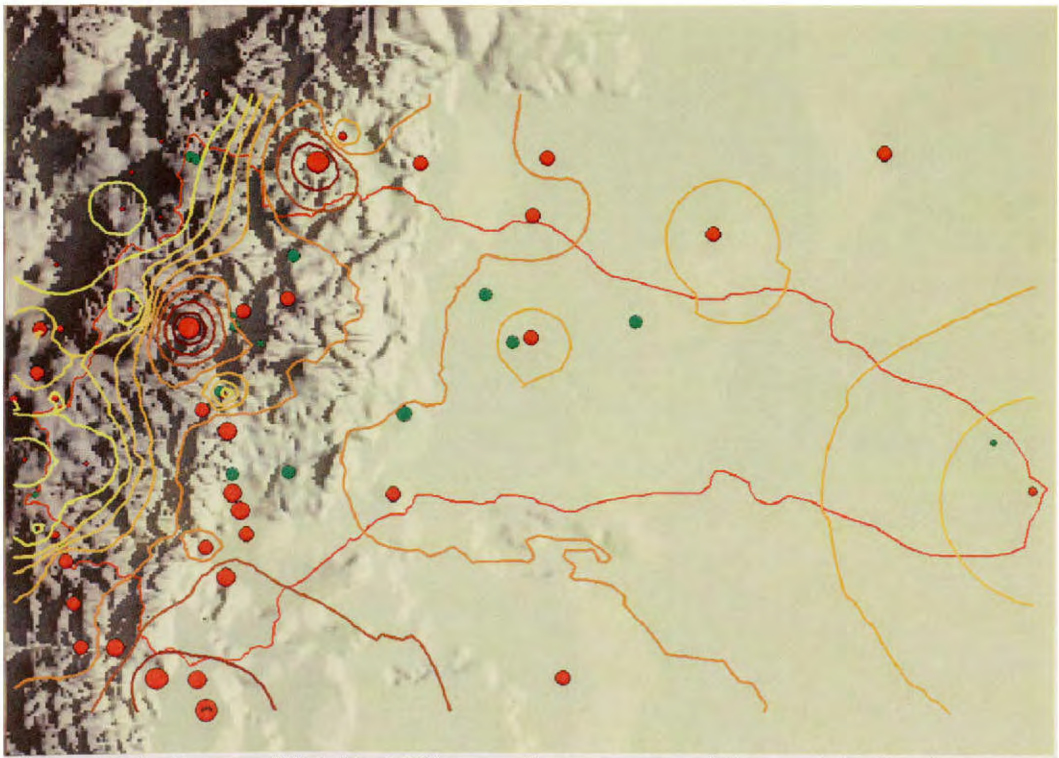


Figure M.4: Inverse Weighted Distance for mean monthly precipitation in January

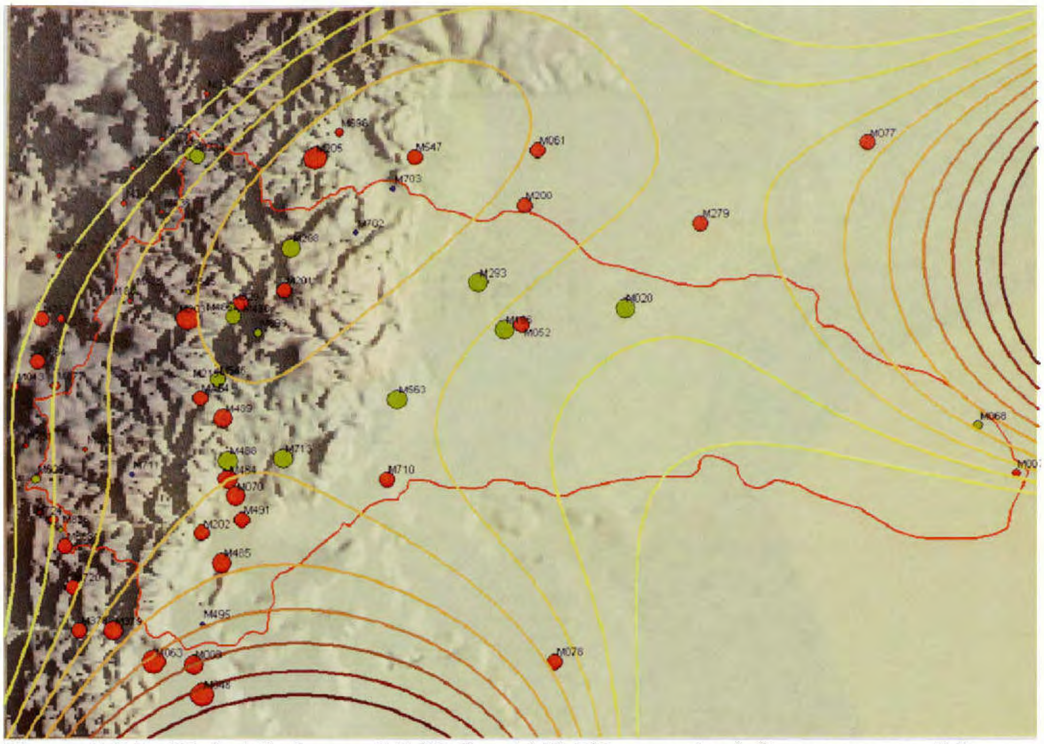


Figure M.5: Global Polynomial (Robust MM Regression) for mean monthly precipitation in January

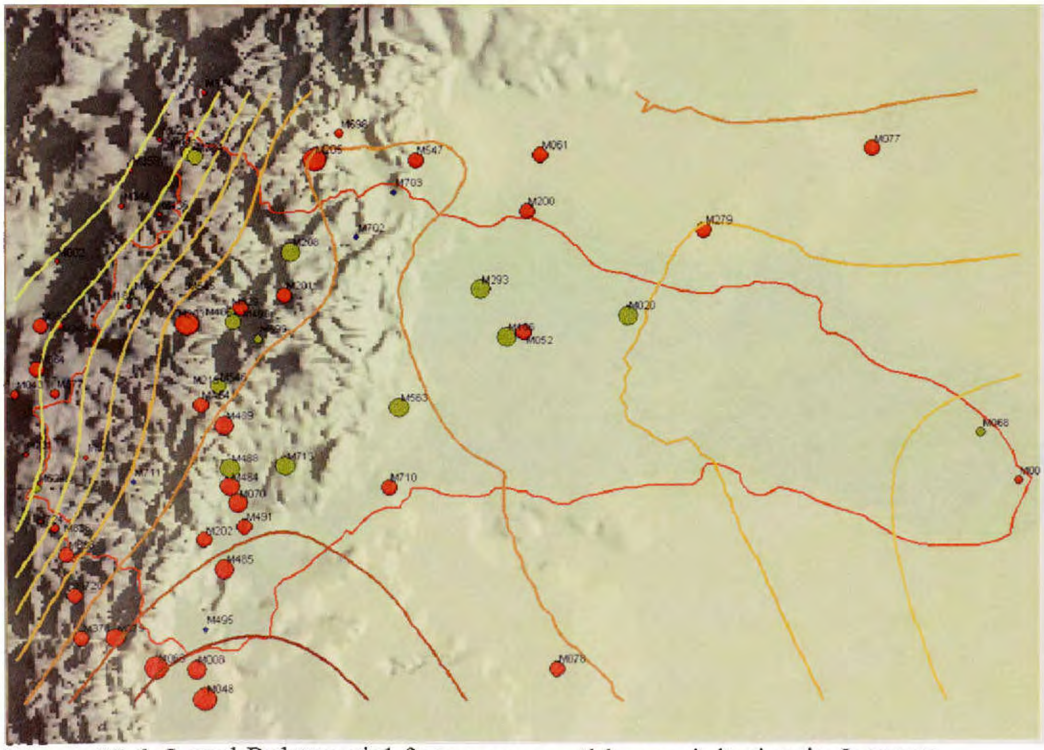


Figure M.6: Local Polynomial for mean monthly precipitation in January

Figure M.7: Thiessen polygons for mean monthly precipitation in January

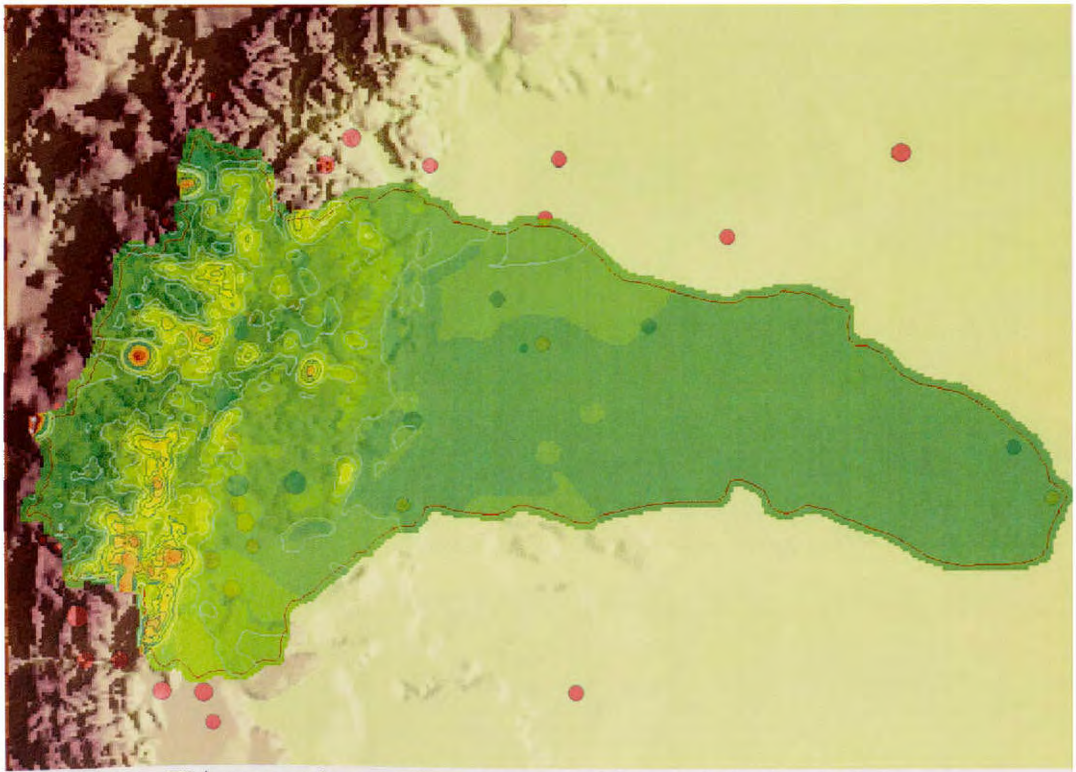


Figure M.8: Thiessen polygons for mean monthly precipitation in July.

APPENDIX N

Table N.1: Summary of Fitted model ANN 22-35-1, pre-selected sets

Mean monthly values

Artificial Neural Network : 22-35-1 full model pre-selected sets

Input column n	Importance, %
LONMETER	1.141802
LATMETER	2.107998
EleMeter1k	9.65867
Slope1k	0.653594
Aspect1k	0.856658
Hill90451k	2.817111
Hill180451k	4.383456
Slope5k	0.90981
Aspect5k	2.805979
Hill90455k	0.82926
Hill180455k	0.757346
Slope10k	5.658961
Aspect10k	0.694495
Hill904510k	5.542648
Hill1804510k	0.590088
Slope15k	12.435626
Aspect15k	1.206395
Hill904515k	3.897564
Hill1804515k	0.894261
Month	15.930092
CosMonth	20.297591
SinMonth	5.930596

TRN	Target	Output	AE	ARE	Corr	r^2
Mean:	234.793	234.3958	24.00801	0.14683	0.9696	0.9363
Std Dev:	134.895	130.7621	22.63817	0.221787		
Min:	13.89	28.08323	0.103186	0.000972		
Max:	736.6	595.9953	167.7992	2.866847		

VLD	Target	Output	AE	ARE		
Mean:	212.8193	206.8633	58.22903	0.338457	0.762	0.53
Std Dev:	108.6613	110.6459	48.6043	0.331144		
Min:	9.9	32.82173	0.272074	0.002034		
Max:	519.76	522.5099	248.3908	2.315326		

TST	Target	Output	AE	ARE		
Mean:	183.6385	201.0259	90.77324	0.777538	0.698	0.241
Std Dev:	170.3974	144.5927	87.33058	0.923056		
Min:	5.74	10.10857	0.155702	0.001639		
Max:	820.4	665.4288	459.2621	5.177144		

ALL	Target	Output	AE	ARE		
Mean:	217.5397	220.3896	47.68173	0.343024	0.849	0.668
Std Dev:	141.4251	131.4061	58.72398	0.573058		
Min:	5.74	10.10857	0.103186	0.000972		
Max:	820.4	665.4288	459.2621	5.177144		

Table N.2: Statistical Summary for ANN:22-35-1 (month= not categorical, pre-selected Sets)

22-35-1-noc	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-0													
MSE	11494.9	23275.4	19571.1	16640.1	27973.4	17944.1	14244.5	12541.9	14040.7	9534.0	20635.0	15664.6	16995.1
RMSE	107.2	152.6	139.9	129.0	167.3	134.0	119.4	112.0	118.5	97.6	143.6	125.2	130.4
Corr	0.502	0.638	0.718	0.632	0.705	0.721	0.708	0.684	0.715	0.699	0.614	0.573	0.654
t	2.53	3.71	4.50	3.46	4.21	4.54	4.25	3.98	4.46	4.15	3.30	2.96	13.51
pvalue	0.0102	0.0007	0.0001	0.0014	0.0003	0.0001	0.0002	0.0004	0.0001	0.0003	0.0020	0.0042	0.0000
n	21	22	21	20	20	21	20	20	21	20	20	20	246
type-1													
MSE	738.1	1117.5	1018.1	1344.3	1176.6	1664.1	2287.6	1601.4	813.9	968.7	1181.9	1173.2	1257.1
RMSE	27.2	33.4	31.9	36.7	34.3	40.8	47.8	40.0	28.5	31.1	34.4	34.3	35.5
Corr	0.959	0.941	0.962	0.971	0.977	0.975	0.955	0.961	0.968	0.965	0.969	0.958	0.965
t	22.24	18.29	23.24	26.49	30.24	28.85	21.17	22.86	25.41	23.97	25.71	22.03	85.30
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2													
MSE	1970.0	2397.0	3824.1	6095.6	5956.5	6921.9	7297.8	5384.2	8800.5	4269.8	5790.2	2910.3	5120.7
RMSE	44.4	49.0	61.8	78.1	77.2	83.2	85.4	73.4	93.8	65.3	76.1	53.9	71.6
Corr	0.826	0.821	0.766	0.806	0.772	0.722	0.551	0.586	0.543	0.780	0.840	0.821	0.757
t	5.86	5.75	4.62	5.10	4.71	4.18	2.64	2.80	2.50	4.83	6.01	5.57	16.59
pvalue	0.0000	0.0000	0.0002	0.0001	0.0001	0.0004	0.0089	0.0067	0.0122	0.0001	0.0000	0.0000	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207
ALL													
MSE	3691.3	7123.4	6287.0	6059.5	8703.4	6860.8	6255.3	5054.0	5796.2	3742.1	6881.9	5067.8	5961.4
RMSE	60.8	84.4	79.3	77.8	93.3	82.8	79.1	71.1	76.1	61.2	83.0	71.2	77.2
Corr	0.791	0.735	0.817	0.856	0.844	0.879	0.859	0.855	0.808	0.855	0.810	0.797	0.839
t	11.72	9.88	12.76	14.74	14.06	16.72	15.11	14.74	12.32	14.73	12.35	11.80	48.50
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	84	85	83	81	82	84	83	82	83	82	82	82	993

Table N.3: Summary of Fitted model ANN 8-5-1, pre-selected sets

Mean monthly values

Artificial Neural Network :8-5-1-V1 preset nocategorical

Input column n	Importance, %
LONMETER	8.929375
LATMETER	6.344521
EleMeter1k	53.710599
Hill90455k	8.698775
Hill180455k	16.10549
M007	1.465547
M008	1.544461
M378	3.201231

TRN	Target	Output	AE	ARE	Corr	r^2
Mean:	234.793	233.6667	36.95225	0.248092	0.926	0.836
Std Dev:	134.895	125.6759	34.84446	0.43532		
Min:	13.89	32.72009	0.181181	0.000724		
Max:	736.6	600.1708	240.7257	7.019765		

VLD	Target	Output	AE	ARE		
Mean:	212.8193	207.0077	47.32471	0.330147	0.822	0.579
Std Dev:	108.6613	96.44289	40.91677	0.647842		
Min:	9.9	50.3898	0.684381	0.003873		
Max:	519.76	492.8495	211.1085	8.063089		

TST	Target	Output	AE	ARE		
Mean:	183.6385	214.5198	92.08609	0.816188	0.587	0.101
Std Dev:	170.3974	163.1426	124.241	1.297674		
Min:	5.74	32.369	0.491979	0.0027		
Max:	820.4	715.5471	585.357	7.769331		

ALL	Target	Output	AE	ARE		
Mean:	217.5397	223.366	52.77302	0.405934	0.784	0.528
Std Dev:	141.4251	131.3563	73.2012	0.81496		
Min:	5.74	32.369	0.181181	0.000724		
Max:	820.4	715.5471	585.357	8.063089		

Table N.4: Statistical Summary for ANN:8-5-1 (pre-selected Sets)

8-5-1 v1 p	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
type-0													
MSE	18913.3	31858.6	26696.7	22959.3	31663.6	18191.2	23402.0	21611.5	20890.3	19335.1	27608.0	23609.0	23915.4
RMSE	137.5	178.5	163.4	151.5	177.9	134.9	153.0	147.0	144.5	139.1	166.2	153.7	154.6
Corr	0.466	0.456	0.570	0.642	0.662	0.780	0.628	0.548	0.581	0.608	0.511	0.484	0.588
t	2.30	2.29	3.03	3.55	3.74	5.44	3.42	2.78	3.11	3.25	2.52	2.35	11.35
pvalue	0.0166	0.0164	0.0035	0.0011	0.0007	0.0000	0.0015	0.0062	0.0029	0.0022	0.0106	0.0153	0.0000
n	21	22	21	20	20	21	20	20	21	20	20	20	246
type-1													
MSE	1859.5	2384.2	2928.2	2586.4	2987.6	3973.3	3896.2	1424.3	1579.2	2084.8	2682.9	2569.2	2579.6
RMSE	43.1	48.8	54.1	50.9	54.7	63.0	62.4	37.7	39.7	45.7	51.8	50.7	50.8
Corr	0.892	0.867	0.890	0.935	0.939	0.942	0.921	0.955	0.944	0.918	0.901	0.884	0.926
t	12.91	11.42	12.82	17.35	17.88	18.35	15.50	21.08	18.75	15.19	13.66	12.37	57.09
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2													
MSE	3015.5	2731.9	3181.0	4465.5	2442.1	6898.6	8106.3	2746.1	5876.8	2165.5	3611.2	1457.8	3913.8
RMSE	54.9	52.3	56.4	66.8	49.4	83.1	90.0	52.4	76.7	46.5	60.1	38.2	62.6
Corr	0.735	0.781	0.823	0.874	0.907	0.717	0.549	0.740	0.797	0.897	0.907	0.907	0.822
t	4.33	5.00	5.61	6.74	8.33	4.12	2.63	4.26	5.12	7.86	8.36	8.36	20.67
pvalue	0.0003	0.0001	0.0000	0.0000	0.0000	0.0004	0.0091	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207
ALL													
MSE	6370.6	10086.5	8993.7	7987.9	9868.6	8154.6	9509.4	6622.0	7345.4	6308.9	8954.6	7470.4	8143.3
RMSE	79.8	100.4	94.8	89.4	99.3	90.3	97.5	81.4	85.7	79.4	94.6	86.4	90.2
Corr	0.677	0.631	0.736	0.811	0.820	0.860	0.792	0.789	0.750	0.792	0.735	0.714	0.784
t	8.33	7.40	9.78	12.32	12.83	15.25	11.68	11.49	10.22	11.59	9.71	9.11	39.82
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	84	85	83	81	82	84	83	82	83	82	82	82	993

Table N.5: Summary of Fitted model ANN 8-5-1,random sets

Mean monthly values

Artificial Neural Network :8-5-1-V2

random notcategor

Input column n	Importance, %
LONMETER	38.984879
LATMETER	20.720652
EleMeter1k	31.538441
Hill90455k	2.416446
Hill180455k	4.527311
M007	0.472428
M008	0.55867
M378	0.781173

TRN	Target	Output	AE	ARE	Corr	r^2
Mean:	220.2222	218.3884	39.90619	0.319534	0.918	0.814
Std Dev:	143.8777	132.1813	40.74893	0.736099		
Min:	5.74	23.98172	0.065726	0.000225		
Max:	820.4	602.2495	370.773	12.96137		

VLD	Target	Output	AE	ARE	Corr	r^2
Mean:	209.8177	202.4966	39.05023	0.281386	0.91	0.805
Std Dev:	139.9739	133.2527	43.81595	0.378899		
Min:	17.49	32.49638	0.376278	0.002217		
Max:	604.33	620.961	324.9902	3.488147		

TST	Target	Output	AE	ARE	Corr	r^2
Mean:	213.7676	201.0661	49.87123	0.301993		
Std Dev:	131.5545	128.8802	59.96956	0.44138	0.825	0.633
Min:	19.25	32.10697	0.019898	0.000038		
Max:	691.75	566.1494	326.3804	4.686751		

ALL	Target	Output	AE	ARE	Corr	r^2
Mean:	217.5397	213.1036	41.35557	0.310673	0.903	0.789
Std Dev:	141.4251	132.0607	44.98426	0.650735		
Min:	5.74	23.98172	0.019898	0.000038		
Max:	820.4	620.961	370.773	12.96137		

Table N.6: Statistical Summary for ANN:8-5-1 R (Random sets)

8-5-1 v1 r	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-0													
MSE	1043.8	13739.5	10494.5	3649.3	6928.4	3369.3	5045.1	4410.9	2622.3	3081.8	4475.4	2805.9	5196.5
RMSE	32.3	117.2	102.4	60.4	83.2	58.0	71.0	66.4	51.2	55.5	66.9	53.0	72.1
Corr	0.967	0.823	0.885	0.944	0.954	0.954	0.914	0.918	0.947	0.962	0.944	0.935	0.906
t	16.54	6.47	8.30	12.11	13.55	13.81	9.54	9.79	12.83	15.04	12.17	11.20	33.51
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	21	22	21	20	20	21	20	20	21	20	20	20	246
type-1													
MSE	3931.6	4044.4	5508.7	3585.9	2846.9	4606.2	3851.8	2099.3	1329.0	2995.8	4421.3	4315.6	3628.1
RMSE	62.7	63.6	74.2	59.9	53.4	67.9	62.1	45.8	36.5	54.7	66.5	65.7	60.2
Corr	0.756	0.760	0.806	0.918	0.941	0.929	0.925	0.936	0.951	0.885	0.853	0.788	0.897
t	7.58	7.66	8.92	15.16	18.20	16.48	15.97	17.48	20.07	12.49	10.74	8.38	47.01
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2													
MSE	1561.5	1155.7	2088.4	1422.9	1775.7	2635.9	4931.5	1671.9	4130.8	1258.8	2987.3	1522.5	2271.9
RMSE	39.5	34.0	45.7	37.7	42.1	51.3	70.2	40.9	64.3	35.5	54.7	39.0	47.7
Corr	0.878	0.913	0.892	0.960	0.942	0.897	0.753	0.841	0.848	0.940	0.964	0.912	0.900
t	7.34	8.98	7.63	12.87	10.86	8.12	4.57	6.03	6.20	10.68	13.96	8.61	29.63
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207
ALL													
MSE	2701.8	5942.0	6069.6	3174.3	3620.3	3874.8	4373.5	2574.5	2230.1	2656.7	4137.2	3368.3	3733.9
RMSE	52.0	77.1	77.9	56.3	60.2	62.2	66.1	50.7	47.2	51.5	64.3	58.0	61.1
Corr	0.860	0.795	0.833	0.932	0.939	0.934	0.903	0.914	0.928	0.914	0.906	0.865	0.903
t	15.28	11.94	13.55	22.93	24.32	23.66	18.93	20.15	22.34	20.18	19.17	15.45	66.13
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	84	85	83	81	82	84	83	82	83	82	82	82	993

Table N.7: Statistical Summary for ANN:15-7-1 (month= not categorical, pre-selected Sets)

15-7-1 noca	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-0													
MSE	11611.4	32018.4	26022.3	15211.0	32142.6	16035.0	20076.7	11943.2	15420.4	10034.3	25685.4	16371.8	19449.5
RMSE	107.8	178.9	161.3	123.3	179.3	126.6	141.7	109.3	124.2	100.2	160.3	128.0	139.5
Corr	0.476	0.441	0.683	0.700	0.743	0.795	0.616	0.527	0.599	0.709	0.570	0.541	0.636
t	2.36	2.20	4.07	4.16	4.72	5.71	3.31	2.63	3.26	4.26	2.94	2.73	12.86
pvalue	0.0146	0.0199	0.0003	0.0003	0.0001	0.0000	0.0019	0.0085	0.0021	0.0002	0.0044	0.0068	0.0000
n	21	22	21	20	20	21	20	20	21	20	20	20	246
type-1													
MSE	847.0	1049.7	1196.5	1163.5	1256.7	1703.5	2015.3	1101.3	451.8	1072.9	1138.5	973.7	1164.2
RMSE	29.1	32.4	34.6	34.1	35.4	41.3	44.9	33.2	21.3	32.8	33.7	31.2	34.1
Corr	0.950	0.940	0.957	0.972	0.977	0.978	0.961	0.970	0.984	0.960	0.967	0.962	0.967
t	19.93	18.05	21.56	27.24	29.87	30.74	22.65	26.33	35.87	22.63	24.74	22.99	88.74
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2													
MSE	1671.5	1929.8	5703.3	4573.8	4700.3	7061.3	5434.7	1711.4	6615.0	5602.6	6933.5	2830.1	4553.5
RMSE	40.9	43.9	75.5	67.6	68.6	84.0	73.7	41.4	81.3	74.9	83.3	53.2	67.5
Corr	0.875	0.856	0.707	0.870	0.838	0.748	0.739	0.907	0.706	0.727	0.814	0.797	0.804
t	7.23	6.62	3.87	6.61	5.96	4.51	4.39	8.34	3.86	4.10	5.42	5.11	19.34
pvalue	0.0000	0.0000	0.0008	0.0000	0.0000	0.0002	0.0002	0.0000	0.0008	0.0005	0.0000	0.0001	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207
ALL													
MSE	3714.8	9251.5	8400.8	5305.7	9503.7	6434.5	7109.0	3872.2	5501.3	4197.7	8327.0	5114.2	6400.6
RMSE	60.9	96.2	91.7	72.8	97.5	80.2	84.3	62.2	74.2	64.8	91.3	71.5	80.0
Corr	0.791	0.647	0.760	0.882	0.830	0.892	0.848	0.867	0.813	0.849	0.779	0.782	0.831
t	11.73	7.74	10.52	16.65	13.33	17.90	14.40	15.53	12.57	14.39	11.12	11.22	46.94
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	84	85	83	81	82	84	83	82	83	82	82	82	993

Table N.8: Statistical Summary for ANN:15-28-1 (month= not categorical, pre-selected Sets)

15-28-1 noc	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-0													
MSE	6722.7	25344.3	18095.5	6927.5	17493.7	9183.2	5673.1	9118.0	8564.6	5124.9	14997.3	12922.7	11774.8
RMSE	82.0	159.2	134.5	83.2	132.3	95.8	75.3	95.5	92.5	71.6	122.5	113.7	108.5
Corr	0.761	0.570	0.761	0.855	0.863	0.857	0.914	0.720	0.793	0.833	0.754	0.662	0.779
t	5.11	3.10	5.12	6.99	7.23	7.25	9.59	4.40	5.67	6.39	4.87	3.75	19.43
pvalue	0.0000	0.0028	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0007	0.0000
n	21	22	21	20	20	21	20	20	21	20	20	20	246
type-1													
MSE	1155.2	2380.9	2333.2	3861.4	2725.9	3047.6	4574.2	3035.5	1409.9	1688.8	2213.5	2273.9	2558.3
RMSE	34.0	48.8	48.3	62.1	52.2	55.2	67.6	55.1	37.5	41.1	47.0	47.7	50.6
Corr	0.932	0.869	0.914	0.907	0.943	0.957	0.908	0.934	0.947	0.944	0.925	0.930	0.927
t	16.91	11.51	14.76	14.12	18.56	21.63	14.24	17.18	19.24	18.72	15.91	16.55	57.45
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2													
MSE	3788.1	4418.5	6507.6	6028.1	5785.2	6742.8	7601.3	7038.1	8045.6	5498.0	5626.1	3564.5	5881.5
RMSE	61.5	66.5	80.7	77.6	76.1	82.1	87.2	83.9	89.7	74.1	75.0	59.7	76.7
Corr	0.639	0.652	0.587	0.810	0.761	0.694	0.527	0.593	0.597	0.702	0.833	0.760	0.715
t	3.33	3.44	2.81	5.17	4.54	3.85	2.48	2.85	2.88	3.82	5.84	4.53	14.66
pvalue	0.0021	0.0017	0.0066	0.0001	0.0002	0.0007	0.0123	0.0060	0.0057	0.0008	0.0000	0.0002	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207
ALL													
MSE	3111.2	8755.8	7176.2	5046.5	6962.1	5373.4	5495.5	5348.9	4579.2	3316.6	6039.0	5138.7	5534.3
RMSE	55.8	93.6	84.7	71.0	83.4	73.3	74.1	73.1	67.7	57.6	77.7	71.7	74.4
Corr	0.829	0.661	0.783	0.881	0.879	0.908	0.877	0.855	0.843	0.873	0.839	0.811	0.851
t	13.41	8.03	11.34	16.56	16.52	19.62	16.45	14.76	14.10	16.02	13.79	12.42	51.05
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	84	85	83	81	82	84	83	82	83	82	82	82	993

Table N.9: Statistical Summary for ANN:14-17-1 (month= not categorical, pre-selected Sets)

14-17-1 noc	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-0													
MSE	19761.5	29430.8	26723.8	14639.5	23610.2	9957.9	10928.2	9944.4	14698.3	12225.0	21177.0	14613.6	17415.5
RMSE	140.6	171.6	163.5	121.0	153.7	99.8	104.5	99.7	121.2	110.6	145.5	120.9	132.0
Corr	0.389	0.470	0.530	0.665	0.799	0.846	0.791	0.646	0.628	0.627	0.590	0.600	0.637
t	1.84	2.38	2.73	3.77	5.65	6.91	5.48	3.59	3.52	3.41	3.10	3.18	12.92
pvalue	0.0408	0.0136	0.0067	0.0007	0.0000	0.0000	0.0000	0.0010	0.0011	0.0015	0.0031	0.0026	0.0000
n	21	22	21	20	20	21	20	20	21	20	20	20	246
type-1													
MSE	616.1	940.0	753.7	2018.0	1632.6	1943.1	2934.3	1391.3	489.8	770.2	868.8	740.3	1258.2
RMSE	24.8	30.7	27.5	44.9	40.4	44.1	54.2	37.3	22.1	27.8	29.5	27.2	35.5
Corr	0.965	0.949	0.974	0.952	0.969	0.975	0.942	0.961	0.981	0.968	0.975	0.967	0.965
t	24.00	19.83	28.11	20.37	25.73	28.50	18.44	22.64	33.01	25.48	28.80	24.73	85.17
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2													
MSE	7685.6	6492.0	5154.6	5332.3	3447.8	5582.4	6538.5	3765.3	8397.7	6685.7	7799.9	3926.9	5916.5
RMSE	87.7	80.6	71.8	73.0	58.7	74.7	80.9	61.4	91.6	81.8	88.3	62.7	76.9
Corr	0.451	0.584	0.732	0.829	0.885	0.750	0.573	0.683	0.548	0.652	0.739	0.732	0.728
t	2.02	2.88	4.16	5.55	7.36	4.54	2.80	3.62	2.54	3.33	4.25	4.16	15.19
pvalue	0.0301	0.0054	0.0004	0.0000	0.0000	0.0002	0.0064	0.0013	0.0113	0.0023	0.0003	0.0004	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207
ALL													
MSE	6917.4	9489.8	8225.8	5789.1	7369.3	4726.6	5642.2	3969.6	5704.4	4790.4	7258.9	4784.6	6232.0
RMSE	83.2	97.4	90.7	76.1	85.8	68.8	75.1	63.0	75.5	69.2	85.2	69.2	78.9
Corr	0.648	0.647	0.753	0.861	0.869	0.920	0.874	0.870	0.800	0.816	0.791	0.802	0.831
t	7.70	7.73	10.30	15.05	15.74	21.24	16.16	15.76	12.01	12.61	11.58	12.03	46.98
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	84	85	83	81	82	84	83	82	83	82	82	82	993

Table N.10: Statistical Summary for ANN:31-38-1 (month= categorical, pre-selected Sets)

31-38-1 cate	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-0													
MSE	10090.9	26749.1	18867.5	14581.6	24815.9	12350.8	17864.5	12246.1	11772.9	7626.2	21946.1	15800.3	16263.5
RMSE	100.5	163.6	137.4	120.8	157.5	111.1	133.7	110.7	108.5	87.3	148.1	125.7	127.5
Corr	0.557	0.604	0.759	0.696	0.751	0.833	0.625	0.564	0.695	0.740	0.611	0.551	0.664
t	2.92	3.39	5.08	4.11	4.82	6.55	3.40	2.90	4.22	4.66	3.27	2.80	13.89
pvalue	0.0044	0.0015	0.0000	0.0003	0.0001	0.0000	0.0016	0.0048	0.0002	0.0001	0.0021	0.0059	0.0000
n	21	22	21	20	20	21	20	20	21	20	20	20	246
type-1													
MSE	2489.9	3539.8	4697.8	4517.5	3509.5	5762.4	4744.1	4469.5	2242.9	2369.6	3697.0	3904.3	3828.7
RMSE	49.9	59.5	68.5	67.2	59.2	75.9	68.9	66.9	47.4	48.7	60.8	62.5	61.9
Corr	0.856	0.801	0.818	0.898	0.927	0.914	0.906	0.852	0.914	0.907	0.868	0.813	0.890
t	10.87	8.76	9.32	13.37	16.19	14.80	14.04	10.67	14.74	14.14	11.49	9.14	45.28
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2													
MSE	4078.1	3767.2	3802.4	5908.1	4629.0	7667.9	8786.4	4603.3	7009.3	3421.2	7034.9	3051.2	5325.1
RMSE	63.9	61.4	61.7	76.9	68.0	87.6	93.7	67.8	83.7	58.5	83.9	55.2	73.0
Corr	0.596	0.686	0.769	0.827	0.836	0.713	0.467	0.559	0.664	0.833	0.780	0.746	0.753
t	2.97	3.77	4.65	5.51	5.90	4.06	2.11	2.61	3.44	5.84	4.82	4.34	16.37
pvalue	0.0045	0.0008	0.0002	0.0000	0.0000	0.0005	0.0254	0.0098	0.0018	0.0000	0.0001	0.0003	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207
ALL													
MSE	4730.5	9595.1	8099.5	7277.1	8938.3	7817.8	8782.3	6394.0	5630.3	3869.7	8840.0	6628.9	7221.1
RMSE	68.8	98.0	90.0	85.3	94.5	88.4	93.7	80.0	75.0	62.2	94.0	81.4	85.0
Corr	0.726	0.637	0.759	0.836	0.841	0.873	0.796	0.759	0.802	0.850	0.749	0.709	0.801
t	9.56	7.52	10.50	13.54	13.89	16.22	11.84	10.44	12.10	14.42	10.10	9.00	42.09
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	84	85	83	81	82	84	83	82	83	82	82	82	993

Table N.11: Statistical Summary for ANN:31-43-1 (month= categorical, pre-selected Sets)

31-43-1-cate	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-0													
MSE	14701.4	31345.7	23107.5	16934.0	27549.6	22226.6	26378.7	16393.0	20549.0	14869.5	28415.8	21529.6	22045.9
RMSE	121.2	177.0	152.0	130.1	166.0	149.1	162.4	128.0	143.3	121.9	168.6	146.7	148.5
Corr	0.417	0.439	0.623	0.651	0.705	0.723	0.532	0.532	0.584	0.533	0.413	0.390	0.563
t	2.00	2.18	3.47	3.63	4.22	4.56	2.66	2.67	3.14	2.67	1.92	1.80	10.65
pvalue	0.0299	0.0205	0.0013	0.0009	0.0003	0.0001	0.0079	0.0078	0.0027	0.0078	0.0351	0.0447	0.0000
n	21	22	21	20	20	21	20	20	21	20	20	20	246
type-1													
MSE	1074.8	1868.4	2138.6	1904.3	2133.3	3312.2	1900.5	1385.2	990.3	1337.2	2091.5	1787.7	1827.0
RMSE	32.8	43.2	46.2	43.6	46.2	57.6	43.6	37.2	31.5	36.6	45.7	42.3	42.7
Corr	0.940	0.888	0.923	0.953	0.956	0.948	0.963	0.956	0.966	0.944	0.924	0.915	0.949
t	17.99	12.66	15.73	20.58	21.37	19.57	23.30	21.42	24.39	18.75	15.81	14.82	69.91
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2													
MSE	3922.3	3419.9	3155.1	5700.0	2525.5	6036.0	7852.5	4004.7	8848.9	4821.6	7791.4	4317.2	5199.3
RMSE	62.6	58.5	56.2	75.5	50.3	77.7	88.6	63.3	94.1	69.4	88.3	65.7	72.1
Corr	0.670	0.732	0.813	0.822	0.901	0.734	0.473	0.593	0.572	0.750	0.764	0.637	0.755
t	3.61	4.30	5.40	5.41	8.04	4.32	2.15	2.85	2.70	4.39	4.59	3.20	16.49
pvalue	0.0012	0.0003	0.0000	0.0000	0.0000	0.0003	0.0237	0.0061	0.0082	0.0003	0.0002	0.0030	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207
ALL													
MSE	5091.6	9826.4	7652.1	6365.1	8413.7	8624.5	9089.7	5588.7	7548.5	5360.1	9693.8	7127.2	7538.9
RMSE	71.4	99.1	87.5	79.8	91.7	92.9	95.3	74.8	86.9	73.2	98.5	84.4	86.8
Corr	0.721	0.617	0.774	0.847	0.850	0.854	0.802	0.810	0.759	0.788	0.709	0.690	0.797
t	9.42	7.13	10.99	14.17	14.41	14.85	12.09	12.37	10.49	11.46	8.99	8.53	41.58
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	84	85	83	81	82	84	83	82	83	82	82	82	993

Table N.12: Statistical Summary for ANN:23-38-1 (month= categorical, pre-selected Sets)

23-38-1 cate	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-0													
MSE	20092.8	29458.4	33588.9	25654.6	30720.4	30338.6	26317.3	26919.9	22889.9	16587.2	23810.6	20374.1	25613.3
RMSE	141.7	171.6	183.3	160.2	175.3	174.2	162.2	164.1	151.3	128.8	154.3	142.7	160.0
Corr	0.477	0.473	0.458	0.582	0.667	0.676	0.557	0.483	0.656	0.603	0.578	0.521	0.566
t	2.36	2.40	2.25	3.03	3.79	4.00	2.84	2.34	3.79	3.21	3.01	2.59	10.71
pvalue	0.0145	0.0131	0.0184	0.0036	0.0007	0.0004	0.0054	0.0154	0.0006	0.0024	0.0038	0.0092	0.0000
n	21	22	21	20	20	21	20	20	21	20	20	20	246
type-1													
MSE	594.8	943.7	1064.9	1448.3	1572.1	2070.0	1716.1	1325.9	950.7	921.6	1093.6	1024.5	1227.2
RMSE	24.4	30.7	32.6	38.1	39.6	45.5	41.4	36.4	30.8	30.4	33.1	32.0	35.0
Corr	0.966	0.944	0.961	0.965	0.968	0.968	0.966	0.961	0.963	0.962	0.961	0.956	0.966
t	24.38	18.74	22.92	24.17	25.38	25.20	24.58	22.67	23.45	23.09	22.64	21.40	86.78
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2													
MSE	3667.8	3480.3	3599.3	3390.1	5237.4	7224.5	8483.9	8330.5	10017.5	3482.7	5035.1	3939.4	5505.2
RMSE	60.6	59.0	60.0	58.2	72.4	85.0	92.1	91.3	100.1	59.0	71.0	62.8	74.2
Corr	0.653	0.747	0.783	0.895	0.790	0.714	0.416	0.277	0.483	0.828	0.834	0.689	0.746
t	3.45	4.49	4.87	7.53	4.99	4.08	1.83	1.12	2.14	5.72	5.86	3.68	16.02
pvalue	0.0017	0.0002	0.0001	0.0000	0.0001	0.0004	0.0431	0.1408	0.0247	0.0000	0.0000	0.0011	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207
ALL													
MSE	6127.8	8861.1	9813.0	7808.7	9441.3	10241.7	9111.8	9020.5	8358.7	5273.5	7451.5	6348.2	8160.3
RMSE	78.3	94.1	99.1	88.4	97.2	101.2	95.5	95.0	91.4	72.6	86.3	79.7	90.3
Corr	0.694	0.660	0.706	0.819	0.829	0.837	0.805	0.714	0.744	0.804	0.786	0.734	0.787
t	8.74	8.01	8.96	12.67	13.28	13.84	12.20	9.13	10.02	12.10	11.36	9.66	40.13
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	84	85	83	81	82	84	83	82	83	82	82	82	993

Table N.13: Statistical Summary for ANN:22-35-1 (month= not categorical, random selected Sets)

22-35-1-noc	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
type-0													
MSE	1316.6	11650.6	8155.2	3020.6	11053.4	3996.2	4468.2	2469.7	2291.6	1514.9	4743.0	2618.3	4817.2
RMSE	36.3	107.9	90.3	55.0	105.1	63.2	66.8	49.7	47.9	38.9	68.9	51.2	69.4
Corr	0.966	0.840	0.917	0.939	0.917	0.946	0.917	0.955	0.955	0.961	0.953	0.940	0.915
t	16.39	6.93	9.99	11.63	9.73	12.78	9.75	13.60	14.10	14.79	13.41	11.72	35.47
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	21	22	21	20	20	21	20	20	21	20	20	20	246
type-1													
MSE	1293.7	2604.5	2792.1	2767.7	2461.3	4045.1	3034.7	2628.2	1263.3	1424.7	1863.1	2947.5	2427.1
RMSE	36.0	51.0	52.8	52.6	49.6	63.6	55.1	51.3	35.5	37.7	43.2	54.3	49.3
Corr	0.925	0.880	0.902	0.932	0.954	0.940	0.940	0.918	0.952	0.947	0.936	0.890	0.932
t	15.98	12.13	13.70	16.85	20.96	18.13	18.14	15.17	20.32	19.30	17.38	12.79	59.66
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	45	45	45	45	45	45	45	45	45	45	45	45	540
type-2													
MSE	1913.2	3219.5	1650.1	1570.3	2496.8	1880.4	3039.4	3246.7	3832.0	1045.8	2574.1	2736.4	2439.4
RMSE	43.7	56.7	40.6	39.6	50.0	43.4	55.1	57.0	61.9	32.3	50.7	52.3	49.4
Corr	0.848	0.798	0.920	0.960	0.934	0.928	0.807	0.800	0.826	0.953	0.962	0.865	0.894
t	6.39	5.30	9.11	12.76	10.13	9.97	5.46	5.17	5.68	12.25	13.71	6.67	28.54
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
n	18	18	17	16	17	18	18	17	17	17	17	17	207
ALL													
MSE	1432.2	5076.1	3915.1	2593.6	4564.3	3569.0	3381.1	2717.7	2049.6	1368.2	2712.9	2823.4	3021.8
RMSE	37.8	71.2	62.6	50.9	67.6	59.7	58.1	52.1	45.3	37.0	52.1	53.1	55.0
Corr	0.928	0.824	0.889	0.940	0.924	0.942	0.926	0.918	0.933	0.952	0.940	0.904	0.922
t	22.54	13.23	17.44	24.52	21.66	25.30	22.06	20.72	23.29	27.82	24.53	18.89	74.83
pvalue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n	84	85	83	81	82	84	83	82	83	82	82	82	993

APPENDIX O

Table O.1: Summary of Fitted model ANN 30-8-4-1 for monthly precipitation values.

30-8-4-1

Input column name	Importance, %
LONMETER	2.119749
LATMETER	4.442434
EleMeter1k	6.000781
Slope1k	2.028617
Aspect1k	5.586047
Hill90451k	2.091436
Hill180451k	3.101492
Slope5k	1.931786
Aspect5k	7.727721
Hill90455k	2.906411
Hill180455k	2.734637
Slope10k	4.444591
Aspect10k	2.164093
Hill904510k	0.507711
Hill1804510k	4.116325
Slope15k	6.702489
Aspect15k	3.432374
Hill904515k	7.748228
Hill1804515k	24.095682
Year	0.113078
Month	1.851932
CosMonth	2.141375
SinMonth	0.141838
M002	0.169432
M007	0.176374
M008	0.375297
M052	0.216925
M061	0.160141
M063	0.330491
M378	0.440514

Statistic Summary

TRN	Target	Output	AE	ARE	Correlatio	R-squared
Mean:	226.2273	226.1269	52.74989	81030543	0.881	0.7105
Std Dev:	167.8727	147.5044	59.29746	8.97E+08		
Min:	0	10.57704	0.005641	0.000024		
Max:	1622.4	1196.124	787.3569	1E+10		

VLD	Target	Output	AE	ARE		
Mean:	217.7735	225.2935	56.65473	51177073	0.859	0.674
Std Dev:	159.3253	144.0733	59.71071	7.14E+08		
Min:	0	12.66547	0.005752	0.000041		
Max:	797.6	844.122	457.8803	1E+10		

TST	Target	Output	AE	ARE		
Mean:	223.0182	229.6942	58.98626	81883317	0.854	0.684
Std Dev:	163.5999	153.7766	63.24508	9.01E+08		
Min:	0	13.23639	0.004726	0.000048		
Max:	797.8	870.9584	489.1318	1E+10		

ALL	Target	Output	AE	ARE		
Mean:	224.5434	226.5216	54.21405	76843506	0.874	0.701
Std Dev:	166.0781	147.945	59.99003	8.73E+08		
Min:	0	10.57704	0.004726	0.000024		
Max:	1622.4	1196.124	787.3569	1E+10		

Table O.2: Summary of Fitted model ANN 30-15-1 for monthly precipitation values.

30-15-1

Input column name	Importance (%)
LONMETER	4.564728
LATMETER	7.785914
EleMeter1k	9.814269
Slope1k	4.553371
Aspect1k	3.996983
Hill90451k	0.866006
Hill180451k	1.66227
Slope5k	1.801869
Aspect5k	1.77668
Hill90455k	4.233871
Hill180455k	0.735321
Slope10k	8.447202
Aspect10k	2.324274
Hill904510k	16.383211
Hill1804510k	1.908268
Slope15k	11.426796
Aspect15k	2.185139
Hill904515k	1.909058
Hill1804515k	3.434762
Year	0.431987
Month	0.933971
CosMonth	1.388589
SinMonth	0.532462
M002	0.880643
M007	0.839919
M008	1.275607
M052	0.545848
M061	0.782039
M063	0.953262
M378	1.625681

Statistic Summary

TST	Target	Output	AE	ARE	Correlation	R-squared
Mean:	226.2273	225.8058	53.41888	81030543	0.879	0.707
Std Dev:	167.8727	147.4607	59.24704	8.97E+08		
Min:	0	9.978454	0.02005	0.000196		
Max:	1622.4	1039.343	1026.038	1E+10		

VLD	Target	Output	AE	ARE	**0.854**	**0.663**
Mean:	217.7735	225.502	57.87237	51177073	0.854	0.663
Std Dev:	159.3253	144.049	60.28499	7.14E+08		
Min:	0	12.87851	0.017449	0.000058		
Max:	797.6	715.5247	463.9138	1E+10		

TST	Target	Output	AE	ARE	**0.86**	**0.697**
Mean:	223.0182	230.5266	58.43452	81883317	0.86	0.697
Std Dev:	163.5999	153.2721	61.24141	9.01E+08		
Min:	0	16.44296	0.320892	0.001055		
Max:	797.8	849.4968	470.5705	1E+10		

Table O.3: Summary of Fitted model ANN 14-8-4-1 for monthly precipitation values.

14-8-4-1-v8

Input column name	Importance, %
LONMETER	20.540562
LATMETER	7.880114
EleMeter1k	11.131686
Slope1k	38.7973
Aspect1k	4.698443
Hill90451k	10.725356
Hill180451k	5.013013
M002	0.124871
M007	0.124234
M008	0.268686
M052	0.046884
M061	0.091689
M063	0.211321
M378	0.345841

Statistic Summary

TRN	Target	Output	AE	ARE	Corr =r	r^2
Mean:	226.2273	226.0284	54.89845	81030543	0.8681	0.6732
Std Dev:	167.8727	145.7336	62.65769	8.97E+08		
Min:	0	9.953243	0.009074	0.000083		
Max:	1622.4	1260.277	1056.124	1E+10		

VLD	Target	Output	AE	ARE		
Mean:	217.7735	223.046	56.30408	51177073	0.8536	0.6498
Std Dev:	159.3253	140.7445	61.37003	7.14E+08		
Min:	0	11.11843	0.002546	0.00003		
Max:	797.6	778.1497	461.0953	1E+10		

TST	Target	Output	AE	ARE		
Mean:	223.0182	230.2724	56.62069	81883317	0.8619	0.698
Std Dev:	163.5999	153.0694	62.20786	9.01E+08		
Min:	0	10.92637	0.062673	0.000159		
Max:	797.8	946.1728	501.0728	1E+10		

ALL	Target	Output	AE	ARE		
Mean:	224.5434	226.2106	55.35004	76843506	0.8648	0.674
Std Dev:	166.0781	146.1241	62.41257	8.73E+08		
Min:	0	9.953243	0.002546	0.00003		
Max:	1622.4	1260.277	1056.124	1E+10		

Table O.4: Summary of Fitted model ANN 10-8-4-1 for monthly precipitation values.

10-8-4-1 v3

Input column nam	Importance, %
LONMETER	47.741474
LATMETER	30.238394
EleMeter1k	19.284261
M002	0.295166
M007	0.370042
M008	0.523076
M052	0.154075
M061	0.267945
M062	0.197493
M378	0.928075

Statistic Summary

TRN	Target	Output	AE	ARE	Corr=r	R^2
Mean:	226.2273	226.1001	58.98789	81030543	0.8442	0.5978
Std Dev:	167.8727	141.8638	67.9193	8.97E+08		
Min:	0	0.010269	0.004921	0.000029		
Max:	1622.4	887.7595	1086.056	1E+10		

VLD	Target	Output	AE	ARE		
Mean:	217.7735	222.0893	58.43784	51177073	0.8446	0.6256
Std Dev:	159.3253	139.8708	62.51524	7.14E+08		
Min:	0	0.002215	0.078553	0.000204		
Max:	797.6	800.0728	460.2871	1E+10		

TST	Target	Output	AE	ARE		
Mean:	223.0182	227.7261	58.84404	81883317	0.8522	0.6548
Std Dev:	163.5999	146.3975	62.73114	9.01E+08		
Min:	0	0.007579	0.042108	0.000645		
Max:	797.8	730.8505	482.4988	1E+10		

ALL	Target	Output	AE	ARE		
Mean:	224.5434	225.7558	58.88771	76843506	0.8452	0.6105
Std Dev:	166.0781	142.2517	66.43369	8.73E+08		
Min:	0	0.002215	0.004921	0.000029		
Max:	1622.4	887.7595	1086.056	1E+10		

Table O.5: Statistical Summary of Thiessen model for monthly precipitation values.

Thiessen-r	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	total
type-TST (0)													
n	67	73	93	117	76	111	93	53	69	68	72	85	977
Mean Observations(x)	184.133	171.204	226.561	251.722	269.430	244.500	237.580	231.487	188.148	224.097	243.063	174.484	223.018
Sample.Dev.Std x	124.812	126.154	143.809	173.181	169.844	200.402	177.098	132.591	136.395	160.727	174.689	158.257	163.684
Mean calculate(y)	204.279	196.733	213.714	258.413	227.489	212.303	238.941	262.374	211.422	211.678	253.226	173.649	222.226
Sample.Dev.Std y	149.093	142.811	149.575	183.730	163.538	198.492	188.806	159.171	173.062	166.655	215.214	130.202	172.658
Fvalue (x/y)	1.427	1.282	1.082	1.126	1.079	1.019	1.137	1.441	1.610	1.075	1.518	1.477	1.113
p(F(x/y))	0.076	0.147	0.353	0.263	0.372	0.460	0.270	0.095	0.026	0.384	0.040	0.038	0.048
t Student (x/y)	-0.848	-1.145	0.597	-0.287	1.551	1.203	-0.051	-1.085	-0.877	0.442	-0.311	0.038	0.104
p(t(x/y))	0.399	0.256	0.552	0.775	0.125	0.232	0.960	0.283	0.382	0.660	0.756	0.970	0.917
Mean Square Error(MSE)	15017.035	23922.668	12191.315	28294.407	34959.217	26536.859	29573.591	20197.222	16194.999	17150.626	51171.255	30481.542	25771.731
Root MSE (MRSE)	122.544	154.670	110.414	168.209	186.974	162.901	171.970	142.117	127.260	130.960	226.211	174.590	160.536
Mean Abs.Error (MAE)	78.107	100.660	78.955	117.275	127.230	109.152	125.262	103.404	81.662	91.654	151.381	110.432	107.179
Correlation (r)	0.617	0.353	0.718	0.554	0.395	0.677	0.555	0.552	0.692	0.679	0.333	0.271	0.545
t Student (r)	6.326	3.178	9.846	7.136	3.700	9.593	6.365	4.728	7.847	7.507	2.956	2.561	20.298
p(t(r))	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.006	0.000
Mean(e)	-20.146	-25.529	12.847	-6.691	41.941	32.197	-1.361	-30.887	-23.274	12.419	-10.164	0.834	0.792
Std.Dev.(e)	121.789	153.604	110.259	168.799	183.420	160.412	172.896	140.047	126.030	131.340	227.568	175.624	160.616
t Student (e)	-1.354	-1.420	1.124	-0.429	1.993	2.115	-0.076	-1.606	-1.534	0.780	-0.379	0.044	0.154
p(t(e))	0.180	0.160	0.264	0.669	0.050	0.037	0.940	0.114	0.130	0.438	0.706	0.965	0.877
type-TRN (1)													
n	398	431	436	416	463	416	439	419	409	341	277	368	4813
Mean Observations(x)	183.331	203.975	233.979	281.953	280.889	268.566	235.415	183.497	213.362	212.288	212.870	184.830	226.227
Sample.Dev.Std x	136.146	151.339	151.094	183.673	179.451	211.616	177.069	142.403	150.942	147.954	184.794	134.655	167.890
Mean calculate(y)	183.975	208.337	232.240	285.015	279.421	267.046	230.903	183.090	210.549	213.826	214.009	187.629	226.208
Sample.Dev.Std y	135.242	152.188	144.771	191.002	184.144	215.601	176.599	139.726	156.293	143.457	180.949	136.951	168.717
Fvalue (x/y)	1.013	1.011	1.089	1.081	1.053	1.038	1.005	1.039	1.072	1.064	1.043	1.034	1.010
p(F(x/y))	0.447	0.454	0.186	0.213	0.290	0.352	0.478	0.349	0.241	0.285	0.364	0.373	0.367
t Student (x/y)	-0.067	-0.422	0.174	-0.236	0.123	0.103	0.378	0.042	0.262	-0.138	-0.073	-0.279	0.006
p(t(x/y))	0.947	0.673	0.862	0.814	0.902	0.918	0.706	0.967	0.794	0.890	0.942	0.780	0.996
Mean Square Error(MSE)	22803.601	20372.730	23236.008	38517.550	24668.230	31666.069	26454.885	13033.633	24220.378	22565.586	36872.822	21058.816	25191.016
Root MSE (MRSE)	151.009	142.733	152.434	196.259	157.061	177.950	162.650	114.165	155.629	150.218	192.023	145.117	158.717
Mean Abs.Error (MAE)	98.047	93.910	106.092	131.956	111.045	114.512	104.505	81.974	106.304	99.350	120.035	97.641	105.228
Correlation (r)	0.379	0.557	0.469	0.451	0.626	0.652	0.576	0.672	0.486	0.467	0.447	0.428	0.555
t Student (r)	8.156	13.896	11.052	10.270	17.249	17.512	14.744	18.524	11.224	9.734	8.284	9.055	46.308
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	-0.643	-4.361	1.739	-3.063	1.468	1.520	4.512	0.407	2.813	-1.538	-1.139	-2.798	0.019
Std.Dev.(e)	151.197	142.832	152.599	196.471	157.224	178.157	162.772	114.301	155.794	150.431	192.367	145.287	158.733
t Student (e)	-0.085	-0.634	0.238	-0.318	0.201	0.174	0.581	0.073	0.365	-0.189	-0.099	-0.369	0.008
p(t(e))	0.932	0.526	0.812	0.751	0.841	0.862	0.562	0.942	0.715	0.850	0.922	0.712	0.993
type-VLD (2)													
n	91	89	115	80	53	93	58	97	79	79	66	77	977
Mean Observations(x)	171.980	178.955	222.762	306.514	281.542	265.161	217.519	199.224	191.019	228.567	193.400	176.813	217.773
Sample.Dev.Std x	141.033	138.218	160.316	169.668	181.722	197.538	149.910	147.351	133.112	147.575	141.426	136.800	159.407
Mean calculate(y)	190.130	196.306	247.467	278.423	272.889	243.758	235.950	167.647	218.119	213.439	225.147	158.609	218.783
Sample.Dev.Std y	141.059	142.676	174.032	171.280	166.297	171.183	197.013	125.328	150.459	163.191	178.859	128.093	162.090
Fvalue (x/y)	1.000	1.066	1.178	1.019	1.194	1.332	1.727	1.382	1.278	1.223	1.599	1.141	1.034
p(F(x/y))	0.499	0.383	0.191	0.467	0.262	0.086	0.021	0.057	0.141	0.188	0.030	0.284	0.301
t Student (x/y)	-0.868	-0.824	-1.120	1.042	0.256	0.790	-0.567	1.608	-1.199	0.611	-1.131	0.852	-0.139
p(t(x/y))	0.388	0.412	0.265	0.301	0.799	0.432	0.572	0.111	0.234	0.543	0.260	0.397	0.890
Mean Square Error(MSE)	18554.888	13081.924	22982.460	20744.238	23077.550	21307.503	17917.559	18463.867	17277.240	31876.800	28105.149	15407.080	20588.212
Root MSE (MRSE)	136.216	114.376	151.600	144.029	151.913	145.971	133.856	135.882	131.443	178.541	167.646	124.125	143.486
Mean Abs.Error (MAE)	87.853	75.598	104.655	106.024	106.264	99.883	90.283	92.589	91.973	121.897	113.253	81.181	97.236
Correlation (r)	0.537	0.673	0.599	0.652	0.616	0.699	0.735	0.535	0.589	0.340	0.484	0.566	0.601
t Student (r)	6.003	8.482	7.950	7.602	5.585	9.315	8.106	6.177	6.399	3.168	4.423	5.951	23.501
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Mean(e)	-18.149	-17.351	-24.705	28.091	8.653	21.403	-18.431	31.576	-27.100	15.128	-31.747	18.204	-1.009
Std.Dev.(e)	135.750	113.693	150.228	142.154	153.118	145.176	133.739	132.849	129.441	179.035	165.874	123.588	143.556
t Student (e)	-1.275	-1.440	-1.764	1.767	0.411	1.422	-1.050	2.341	-1.861	0.751	-1.555	1.293	-0.220
p(t(e))	0.205	0.153	0.080	0.081	0.682	0.158	0.298	0.021	0.067	0.455	0.125	0.200	0.826
ALL													
n	556	593	644	613	592	620	590	569	557	488	415	530	6767
Mean Observations(x)	181.570	196.186	230.905	279.388	279.476	263.747	233.997	190.648	207.069	216.569	215.012	182.006	224.543
Sample.Dev.Std x	135.481	146.891	151.596	180.344	178.199	207.465	174.412	142.858	146.935	149.563	177.070	138.793	166.090
Mean calculate(y)	187.429	205.103	232.284	279.077	272.170	253.752	232.666	187.843	211.731	213.464	222.585	181.171	224.561
Sample.Dev.Std y	137.831	149.524	151.132	187.161	180.645	207.275	180.349	141.231	157.387	149.850	187.104	134.809	168.352
Fvalue (x/y)	1.035	1.036	1.006	1.077	1.028	1.002	1.069	1.023	1.147	1.004	1.117	1.060	1.027
p(F(x/y))	0.343	0.333	0.469	0.179	0.370	0.491	0.208	0.393	0.053	0.483	0.131	0.252	0.133
t Student (x/y)	-0.715	-1.036	-0.163	0.030	0.701	0.849	0.129	0.333	-0.511	0.324	-0.599	0.099	-0.006
p(t(x/y))	0.475	0.301	0.870	0.976	0.484	0.396	0.898	0.739	0.610	0.746	0.550	0.921	0.995
Mean Square Error(MSE)	21169.909	19715.502	21595.768	34246.796	25846.961	29193.990	26107.215	14626.608	22241.457	23318.391	37959.137	21748.907	24610.318
Root MSE (MRSE)	145.499	140.412	146.955	185.059	160.770	170.862	161.577	120.941	149.136	152.704	194.831	147.475	156.877
Mean Abs.Error (MAE)	93.976	91.992	101.917	125.770	112.695	111.358	106.379	85.780	101.219	101.928	124.395	97.301	104.356
Correlation (r)	0.433	0.552	0.528	0.493	0.599	0.661	0.585	0.637	0.521	0.479	0.428	0.418	0.560
t Student (r)	11.313	16.110	15.754	13.990	18.160	21.908	17.486	19.684	14.383	12.027	9.628	10.577	55.588
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	-5.859	-8.917	-1.379	0.311	7.307	9.995	1.331	2.806	-4.661	3.105	-7.573	0.836	-0.018
Std.Dev.(e)	145.512	140.247	147.063	185.210	160.740	170.708	161.709	121.014	149.197	152.829	194.919	147.612	156.888
t Student (e)	-0.949	-1.548	-0.238	0.042	1.106	1.458	0.200	0.553	-0.737	0.449	-0.791	0.130	-0.009
p(t(e))	0.343	0.122	0.812	0.967	0.269	0.145	0.842	0.580	0.461	0.654	0.429	0.896	0.993

Note: : p-values that fails the test at 95% intervale of confidence (alfa=0.05)

Table O.6: Statistical Summary of ANN(30-15-1) model for monthly precipitation values.

30-15-1 r	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	total
type-TST (0)													
n	67	73	93	117	76	111	93	53	69	68	72	85	977
Mean Observations(x)	184.133	171.204	226.561	251.722	269.430	244.500	237.580	231.487	188.148	224.097	243.063	174.484	223.018
Sample.Dev.Std x	124.812	126.154	143.809	173.181	169.844	200.402	177.098	132.591	136.395	160.727	174.689	158.257	163.684
Mean calculate(y)	186.672	186.368	226.852	267.233	262.928	265.566	252.127	244.673	200.381	217.088	235.806	180.082	230.527
Sample.Dev.Std y	132.012	115.520	132.115	166.882	165.798	195.528	163.988	122.417	136.200	134.638	151.285	128.628	153.351
Fvalue (x/y)	1.119	1.193	1.185	1.077	1.049	1.050	1.166	1.173	1.003	1.425	1.333	1.514	1.139
p(F(x/y))	0.325	0.228	0.209	0.345	0.418	0.398	0.231	0.283	0.495	0.075	0.114	0.030	0.021
t Student (x/y)	-0.114	-0.757	-0.014	-0.698	0.239	-0.793	-0.581	-0.532	-0.527	0.276	0.266	-0.253	-1.046
p(t(x/y))	0.909	0.451	0.989	0.487	0.812	0.430	0.563	0.597	0.600	0.784	0.791	0.801	0.296
Mean Square Error(MSE)	5779.551	6028.680	6808.707	8932.892	6590.246	7078.759	9779.180	4363.367	3452.388	4165.516	12633.954	7484.557	7165.104
Root MSE (MRSE)	76.023	77.645	82.515	94.514	81.180	84.135	98.890	66.056	58.757	64.541	112.401	86.513	84.647
Mean Abs.Error (MAE)	53.183	53.739	57.740	69.032	60.055	56.718	71.848	49.199	44.917	50.205	63.400	58.005	58.435
Correlation (r)	0.824	0.802	0.822	0.849	0.882	0.915	0.836	0.872	0.910	0.919	0.769	0.836	0.860
t Student (r)	11.713	11.320	13.794	17.231	16.140	23.657	14.559	12.700	17.943	18.963	10.064	13.897	52.713
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	-2.539	-15.164	-0.291	-15.511	6.502	-21.066	-14.547	-13.186	-12.233	7.009	7.257	-5.598	-7.508
Std.Dev.(e)	76.554	76.676	82.962	93.634	81.457	81.825	98.344	65.346	57.890	64.636	112.954	86.844	84.356
t Student (e)	-0.271	-1.690	-0.034	-1.792	0.696	-2.712	-1.426	-1.469	-1.755	0.894	0.545	-0.594	-2.782
p(t(e))	0.787	0.095	0.973	0.076	0.489	0.008	0.157	0.148	0.084	0.374	0.587	0.554	0.006
type-TRN (1)													
n	398	431	436	416	463	416	439	419	409	341	277	368	4813
Mean Observations(x)	183.331	203.975	233.979	281.953	280.889	268.566	235.415	183.497	213.362	212.288	212.870	184.830	226.227
Sample.Dev.Std x	136.146	151.339	151.094	183.673	179.451	211.616	177.069	142.403	150.942	147.954	184.794	134.655	167.890
Mean calculate(y)	180.039	207.323	235.274	279.886	274.167	274.507	230.192	192.145	209.596	214.392	206.313	185.058	225.806
Sample.Dev.Std y	113.012	131.745	130.035	168.243	162.254	188.595	153.799	132.672	126.369	127.208	147.840	112.830	147.476
Fvalue (x/y)	1.451	1.320	1.350	1.192	1.223	1.259	1.325	1.152	1.427	1.353	1.562	1.424	1.296
p(F(x/y))	0.000	0.002	0.001	0.037	0.015	0.010	0.002	0.074	0.000	0.003	0.000	0.000	0.000
t Student (x/y)	0.371	-0.346	-0.136	0.169	0.598	-0.427	0.467	-0.909	0.387	-0.199	0.461	-0.025	0.131
p(t(x/y))	0.711	0.729	0.892	0.866	0.550	0.669	0.641	0.364	0.699	0.842	0.645	0.980	0.896
Mean Square Error(MSE)	4691.083	6552.342	6343.760	8257.489	6097.063	7168.283	5972.898	3761.044	6486.151	7964.110	8334.047	5588.999	6363.788
Root MSE (MRSE)	68.491	80.947	79.648	90.871	78.084	84.666	77.285	61.327	80.537	89.242	91.291	74.760	79.773
Mean Abs.Error (MAE)	49.655	52.052	57.483	62.694	53.162	55.878	50.817	44.213	51.986	58.210	52.235	52.964	53.419
Correlation (r)	0.865	0.845	0.850	0.870	0.901	0.917	0.901	0.905	0.846	0.799	0.873	0.831	0.880
t Student (r)	34.292	32.757	33.547	35.901	44.574	46.795	43.297	43.366	31.979	24.494	29.641	28.607	128.432
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	3.292	-3.348	-1.295	2.067	6.722	-5.940	5.223	-8.647	3.765	-2.104	6.558	-0.228	0.421
Std.Dev.(e)	68.498	80.971	79.729	90.957	77.878	84.559	77.196	60.787	80.547	89.348	91.220	74.861	79.781
t Student (e)	0.959	-0.858	-0.339	0.463	1.857	-1.433	1.418	-2.912	0.945	-0.435	1.196	-0.058	0.366
p(t(e))	0.338	0.391	0.735	0.643	0.064	0.153	0.157	0.004	0.345	0.664	0.233	0.953	0.714
type-VLD (2)													
n	91	89	115	80	53	93	58	97	79	79	66	77	977
Mean Observations(x)	171.980	178.955	222.762	306.514	281.542	265.161	217.519	199.224	191.019	228.567	193.400	176.813	217.773
Sample.Dev.Std x	141.033	138.218	160.316	169.668	181.722	197.538	149.910	147.351	133.112	147.575	141.426	136.800	159.407
Mean calculate(y)	182.837	189.128	233.315	303.852	288.752	271.617	227.520	212.881	213.337	239.323	191.394	167.579	225.502
Sample.Dev.Std y	116.736	121.575	138.806	169.803	163.177	170.605	142.018	132.174	136.250	138.701	110.798	118.483	144.123
Fvalue (x/y)	1.460	1.293	1.334	1.002	1.240	1.341	1.114	1.243	1.048	1.132	1.629	1.333	1.223
p(F(x/y))	0.037	0.115	0.063	0.497	0.220	0.081	0.342	0.144	0.419	0.293	0.026	0.106	0.001
t Student (x/y)	-0.566	-0.521	-0.534	0.099	-0.215	-0.239	-0.369	-0.680	-1.041	-0.472	0.091	0.448	-1.124
p(t(x/y))	0.572	0.603	0.595	0.921	0.831	0.812	0.714	0.498	0.301	0.638	0.928	0.656	0.261
Mean Square Error(MSE)	6115.919	4756.001	6819.527	8823.994	11251.522	9326.375	5222.757	8094.735	5873.046	6653.662	5754.936	5605.764	6983.490
Root MSE (MRSE)	78.204	68.964	82.580	93.936	106.073	96.573	72.269	89.971	76.636	81.570	75.861	74.872	83.567
Mean Abs.Error (MAE)	49.742	52.161	59.285	66.097	67.903	66.250	54.821	58.422	52.352	61.987	55.448	51.531	57.872
Correlation (r)	0.834	0.868	0.858	0.845	0.813	0.872	0.879	0.801	0.850	0.840	0.844	0.838	0.854
t Student (r)	14.245	16.322	17.784	13.958	9.983	16.954	13.798	13.031	14.170	13.594	12.568	13.290	51.308
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	-10.857	-10.173	-10.554	2.662	-7.211	-6.455	-10.001	-13.657	-22.318	-10.755	2.006	9.234	-7.729
Std.Dev.(e)	77.876	68.596	82.262	94.491	106.841	96.879	72.198	89.390	73.782	81.374	76.416	74.787	83.252
t Student (e)	-1.330	-1.399	-1.376	0.252	-0.491	-0.643	-1.055	-1.505	-2.689	-1.175	0.213	1.083	-2.902
p(t(e))	0.187	0.165	0.172	0.802	0.625	0.522	0.296	0.136	0.009	0.244	0.832	0.282	0.004
ALL													
n	556	593	644	613	592	620	590	569	557	488	415	530	6767
Mean Observations(x)	181.570	196.186	230.905	279.388	279.476	263.747	233.997	190.648	207.069	216.569	215.012	182.006	224.543
Sample.Dev.Std x	135.481	146.891	151.596	180.344	178.199	207.465	174.412	142.858	146.935	149.563	177.070	138.793	166.090
Mean calculate(y)	181.297	202.013	233.708	280.599	274.030	272.472	233.387	200.572	208.985	218.803	209.057	181.721	226.444
Sample.Dev.Std y	115.858	128.464	131.762	168.226	162.624	187.022	154.301	132.431	128.855	130.211	143.537	116.247	147.849
Fvalue (x/y)	1.367	1.307	1.324	1.149	1.201	1.231	1.278	1.164	1.300	1.319	1.522	1.425	1.262
p(F(x/y))	0.000	0.001	0.000	0.043	0.013	0.005	0.001	0.036	0.001	0.001	0.000	0.000	0.000
t Student (x/y)	0.036	-0.727	-0.354	-0.122	0.549	-0.778	0.064	-1.215	-0.231	-0.249	0.532	0.036	-0.703
p(t(x/y))	0.971	0.467	0.723	0.903	0.583	0.437	0.949	0.225	0.817	0.803	0.595	0.971	0.482
Mean Square Error(MSE)	5055.449	6218.275	6495.861	8460.332	6621.841	7475.969	6499.129	4555.932	6023.378	7222.656	8669.883	5895.439	6568.951
Root MSE (MRSE)	71.102	78.856	80.597	91.980	81.375	86.464	80.617	67.498	77.610	84.986	93.112	76.782	81.049
Mean Abs.Error (MAE)	50.094	52.276	57.842	64.348	55.366	57.584	54.526	47.100	51.163	57.706	54.683	53.564	54.786
Correlation (r)	0.851	0.845	0.847	0.863	0.890	0.910	0.887	0.885	0.849	0.824	0.852	0.833	0.873
t Student (r)	38.131	38.391	40.403	42.183	47.477	54.519	46.472	45.229	37.913	32.052	33.051	34.556	147.278
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	0.274	-5.827	-2.803	-1.210	5.446	-8.726	0.610	-9.924	-1.916	-2.234	5.955	0.286	-1.900
Std.Dev.(e)	71.165	78.707	80.611	92.047	81.261	86.092	80.683	66.823	77.657	85.044	93.034	76.854	81.033
t Student (e)	0.091	-1.803	-0.883	-0.326	1.631	-2.524	0.184	-3.543	-0.582	-0.580	1.304	0.086	-1.929
p(t(e))	0.928	0.072	0.378	0.745	0.103	0.012	0.854	0.000	0.561	0.562	0.193	0.932	0.054

Note: : p-values that fails the test at 95% intervale of confidence (alfa=0.05)

Table O.7: Statistical Summary of ANN(14-8-4-1) model for monthly precipitation values.

14-8-4-1-v8	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	total
type-TST (0)													
n	67	73	93	117	76	111	93	53	69	68	72	85	977
Mean Observations(x)	184.133	171.204	226.561	251.722	269.430	244.500	237.580	231.487	188.148	224.097	243.063	174.484	223.018
Sample.Dev.Std x	124.812	126.154	143.809	173.181	169.844	200.402	177.098	132.591	136.395	160.727	174.689	158.257	163.684
Mean calculate(y)	196.775	184.422	220.808	261.043	258.222	263.754	240.954	240.375	209.899	218.186	235.894	198.800	230.272
Sample.Dev.Std y	127.744	117.302	129.088	167.849	169.043	207.076	155.167	118.895	137.694	134.728	147.458	133.204	153.148
Fvalue (x/y)	1.048	1.157	1.241	1.065	1.009	1.068	1.303	1.244	1.019	1.423	1.403	1.412	1.142
p(F(x/y))	0.425	0.269	0.151	0.368	0.484	0.366	0.103	0.217	0.469	0.076	0.078	0.058	0.019
t Student (x/y)	-0.579	-0.656	0.287	-0.418	0.408	-0.704	-0.138	-0.363	-0.932	0.232	0.266	-1.084	-1.012
p(t(x/y))	0.564	0.514	0.775	0.677	0.685	0.483	0.890	0.718	0.355	0.817	0.791	0.282	0.312
Mean Square Error(MSE)	5924.710	5092.727	7586.417	8211.014	5466.859	8698.110	8278.208	3713.443	4165.806	3866.768	11317.789	9001.293	7075.721
Root MSE (MRSE)	76.972	71.363	87.100	90.615	73.938	93.264	90.985	60.938	64.543	62.183	106.385	94.875	84.117
Mean Abs.Error (MAE)	52.336	49.076	59.960	62.030	54.831	54.461	64.833	49.729	47.268	47.239	65.113	63.015	56.621
Correlation (r)	0.817	0.834	0.800	0.860	0.906	0.899	0.857	0.888	0.900	0.926	0.793	0.813	0.862
t Student (r)	11.412	12.745	12.727	18.036	18.385	21.468	15.844	13.825	16.929	19.898	10.877	12.722	53.095
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	-12.642	-13.217	5.754	-9.320	11.208	-19.254	-3.375	-8.888	-21.752	5.911	7.169	-24.317	-7.254
Std.Dev.(e)	76.500	70.614	87.381	90.522	73.569	91.668	91.415	60.863	61.213	62.362	106.888	92.250	83.847
t Student (e)	-1.353	-1.599	0.635	-1.114	1.328	-2.213	-0.356	-1.063	-2.952	0.782	0.569	-2.430	-2.704
p(t(e))	0.181	0.114	0.527	0.268	0.188	0.029	0.723	0.293	0.004	0.437	0.571	0.017	0.007
type-TRN (1)													
n	398	431	436	416	463	416	439	419	409	341	277	368	4813
Mean Observations(x)	183.331	203.975	233.979	281.953	280.889	268.566	235.415	183.497	213.362	212.288	212.870	184.830	226.227
Sample.Dev.Std x	136.146	151.339	151.094	183.673	179.451	211.616	177.069	142.403	150.942	147.954	184.794	134.655	167.890
Mean calculate(y)	185.573	206.931	230.083	271.518	271.221	269.135	227.423	188.336	213.933	225.845	209.735	197.463	226.028
Sample.Dev.Std y	111.794	126.027	125.177	164.130	165.961	188.014	154.979	129.000	122.104	137.967	140.961	117.860	145.749
Fvalue (x/y)	1.483	1.442	1.457	1.252	1.169	1.267	1.305	1.219	1.528	1.150	1.719	1.305	1.327
p(F(x/y))	0.000	0.000	0.000	0.011	0.047	0.008	0.003	0.022	0.000	0.099	0.000	0.005	0.000
t Student (x/y)	-0.254	-0.312	0.415	0.864	0.851	-0.041	0.712	-0.516	-0.060	-1.238	0.224	-1.354	0.062
p(t(x/y))	0.800	0.755	0.678	0.388	0.395	0.967	0.477	0.606	0.953	0.217	0.822	0.176	0.951
Mean Square Error(MSE)	5430.848	7440.517	7338.289	8403.612	6709.297	6990.836	5998.562	3890.424	6955.460	9146.613	9144.071	6964.436	6939.826
Root MSE (MRSE)	73.694	86.258	85.664	91.671	81.910	83.611	77.450	62.373	83.399	95.638	95.625	83.453	83.306
Mean Abs.Error (MAE)	53.707	52.673	58.912	61.986	56.640	55.626	48.521	45.071	53.612	60.968	53.246	58.862	54.898
Correlation (r)	0.841	0.822	0.824	0.868	0.892	0.919	0.901	0.899	0.833	0.782	0.861	0.794	0.868
t Student (r)	30.906	29.842	30.265	35.638	42.309	47.408	43.292	42.012	30.423	23.120	28.062	24.980	121.349
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	-2.241	-2.956	3.896	10.435	9.668	-0.568	7.991	-4.839	-0.571	-13.557	3.135	-12.633	0.199
Std.Dev.(e)	73.753	86.308	85.673	91.185	81.426	83.710	77.125	62.260	83.500	94.811	95.746	82.604	83.314
t Student (e)	-0.606	-0.711	0.950	2.334	2.555	-0.139	2.171	-1.591	-0.138	-2.641	0.545	-2.934	0.166
p(t(e))	0.545	0.477	0.343	0.020	0.011	0.890	0.030	0.112	0.890	0.009	0.586	0.004	0.868
type-VLD (2)													
n	91	89	115	80	53	93	58	97	79	79	66	77	977
Mean Observations(x)	171.980	178.955	222.762	306.514	281.542	265.161	217.519	199.224	191.019	228.567	193.400	176.813	217.773
Sample.Dev.Std x	141.033	138.218	160.316	169.668	181.722	197.538	149.910	147.351	133.112	147.575	141.426	136.800	159.407
Mean calculate(y)	185.840	190.709	220.961	290.350	275.951	255.782	218.486	209.489	215.068	251.147	202.047	179.496	223.046
Sample.Dev.Std y	121.881	124.022	129.279	153.342	168.171	159.515	143.830	134.505	140.181	148.048	107.516	119.605	140.817
Fvalue (x/y)	1.339	1.242	1.538	1.224	1.168	1.534	1.086	1.200	1.109	1.006	1.730	1.308	1.281
p(F(x/y))	0.084	0.156	0.011	0.185	0.289	0.021	0.378	0.187	0.324	0.489	0.014	0.122	0.000
t Student (x/y)	-0.709	-0.597	0.094	0.632	0.164	0.356	-0.035	-0.507	-1.106	-0.960	-0.395	-0.130	-0.775
p(t(x/y))	0.480	0.552	0.925	0.529	0.870	0.722	0.972	0.614	0.272	0.340	0.693	0.897	0.439
Mean Square Error(MSE)	6350.880	5154.530	7575.667	7466.930	8957.806	8787.663	5118.750	8174.402	7158.179	6121.316	5448.387	6248.807	6936.430
Root MSE (MRSE)	79.692	71.795	87.038	86.411	94.646	93.743	71.545	90.412	84.606	78.239	73.813	79.049	83.285
Mean Abs.Error (MAE)	46.828	51.775	58.654	60.443	64.127	64.914	50.380	56.393	54.857	58.542	56.077	52.877	56.304
Correlation (r)	0.830	0.858	0.839	0.865	0.854	0.883	0.880	0.798	0.823	0.870	0.858	0.816	0.854
t Student (r)	14.013	15.573	16.388	15.217	11.730	17.982	13.871	12.927	12.702	15.479	13.386	12.216	51.177
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	-13.860	-11.754	1.801	16.164	5.590	9.379	-0.967	-10.265	-24.049	-22.580	-8.647	-2.683	-5.273
Std.Dev.(e)	78.913	71.228	87.401	85.422	95.385	93.778	72.164	90.294	81.634	75.388	73.867	79.522	83.161
t Student (e)	-1.675	-1.557	0.221	1.692	0.427	0.965	-0.102	-1.120	-2.618	-2.662	-0.951	-0.296	-1.982
p(t(e))	0.097	0.123	0.825	0.094	0.671	0.337	0.919	0.266	0.011	0.009	0.345	0.768	0.048
ALL													
n	556	593	644	613	592	620	590	569	557	488	415	530	6767
Mean Observations(x)	181.570	196.186	230.905	279.388	279.476	263.747	233.997	190.648	207.069	216.569	215.012	182.006	224.543
Sample.Dev.Std x	135.481	146.891	151.596	180.344	178.199	207.465	174.412	142.858	146.935	149.563	177.070	138.793	166.090
Mean calculate(y)	186.966	201.726	227.114	271.976	269.975	266.168	228.678	196.790	213.594	228.874	213.051	195.067	226.211
Sample.Dev.Std y	115.337	124.785	126.358	163.431	166.337	187.415	153.815	129.830	126.564	139.283	137.506	120.628	146.135
Fvalue (x/y)	1.380	1.386	1.439	1.218	1.148	1.225	1.286	1.211	1.348	1.153	1.658	1.324	1.292
p(F(x/y))	0.000	0.000	0.000	0.007	0.047	0.006	0.001	0.011	0.000	0.058	0.000	0.001	0.000
t Student (x/y)	-0.715	-0.700	0.487	0.754	0.948	-0.216	0.556	-0.759	-0.794	-1.330	0.178	-1.635	-0.620
p(t(x/y))	0.475	0.484	0.626	0.451	0.343	0.829	0.579	0.448	0.427	0.184	0.859	0.102	0.535
Mean Square Error(MSE)	5640.941	6808.406	7416.510	8244.609	6751.097	7566.017	6271.406	4604.248	6638.635	7921.146	8933.451	7187.133	6958.956
Root MSE (MRSE)	75.106	82.513	86.119	90.800	82.165	86.983	79.192	67.855	81.478	89.001	94.517	84.777	83.420
Mean Abs.Error (MAE)	52.416	52.095	59.017	61.793	57.078	56.810	51.275	47.435	53.003	58.662	55.755	58.659	55.350
Correlation (r)	0.833	0.828	0.823	0.866	0.890	0.908	0.891	0.881	0.833	0.816	0.848	0.800	0.865
t Student (r)	35.450	35.917	36.726	42.748	47.367	53.807	47.680	44.397	35.538	31.082	32.561	30.628	141.714
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	-5.396	-5.540	3.791	7.412	9.501	-2.422	5.319	-6.141	-6.525	-12.305	1.961	-13.061	-1.667
Std.Dev.(e)	74.980	82.396	86.103	90.571	81.683	87.019	79.080	67.636	81.289	88.237	94.611	83.844	83.410
t Student (e)	-1.697	-1.637	1.117	2.026	2.830	-0.693	1.634	-2.166	-1.894	-3.081	0.422	-3.586	-1.644
p(t(e))	0.090	0.102	0.264	0.043	0.005	0.489	0.103	0.031	0.059	0.002	0.673	0.000	0.100

Note: : p-values that fails the test at 95% intervale of confidence (alfa=0.05)

Table O.8: Statistical Summary of ANN(10-8-4-1) model for monthly precipitation values.

10-8-4-1-v3	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	total
type-TST (0)													
n	67	73	93	117	76	111	93	53	69	68	72	85	977
Mean Observations(x)	184.133	171.204	226.561	251.722	269.430	244.500	237.580	231.487	188.148	224.097	243.063	174.484	223.018
Sample.Dev.Std x	124.812	126.154	143.809	173.181	169.844	200.402	177.098	132.591	136.395	160.727	174.689	158.257	163.684
Mean calculate(y)	196.284	176.812	215.230	255.153	261.363	257.627	238.774	244.027	205.156	233.718	236.661	186.742	227.726
Sample.Dev.Std y	130.305	113.936	127.007	158.083	172.548	184.400	149.271	108.981	136.926	141.258	128.684	125.257	146.472
Fvalue (x/y)	1.090	1.226	1.282	1.200	1.032	1.181	1.408	1.480	1.008	1.295	1.843	1.596	1.249
p(F(x/y))	0.364	0.195	0.118	0.164	0.446	0.192	0.051	0.080	0.487	0.147	0.005	0.017	0.000
t Student (x/y)	-0.551	-0.282	0.570	-0.158	0.290	-0.508	-0.050	-0.532	-0.731	-0.371	0.250	-0.560	-0.670
p(t(x/y))	0.583	0.779	0.570	0.875	0.772	0.613	0.960	0.597	0.467	0.712	0.803	0.576	0.503
Mean Square Error(MSE)	5561.069	8343.462	7446.939	8487.058	5316.131	8070.361	10102.306	3689.995	4676.109	4708.257	10342.587	8682.969	7397.817
Root MSE (MRSE)	74.573	91.343	86.296	92.125	72.912	89.835	100.510	60.745	68.382	68.617	101.699	93.182	86.011
Mean Abs.Error (MAE)	47.180	55.486	59.676	64.360	56.450	58.664	73.412	48.423	51.990	52.903	62.918	62.219	58.844
Correlation (r)	0.832	0.712	0.805	0.848	0.909	0.896	0.822	0.895	0.881	0.905	0.815	0.810	0.852
t Student (r)	12.090	8.545	12.953	17.161	18.802	21.022	13.745	14.304	15.229	17.302	11.755	12.569	50.859
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	-12.151	-5.608	11.331	-3.431	8.068	-13.127	-1.194	-12.540	-17.008	-9.621	6.402	-12.258	-4.708
Std.Dev.(e)	74.131	91.801	86.012	92.457	72.946	89.274	101.048	60.006	66.718	68.444	102.209	92.921	85.926
t Student (e)	-1.342	-0.522	1.270	-0.401	0.964	-1.549	-0.114	-1.521	-2.118	-1.159	0.531	-1.216	-1.713
p(t(e))	0.184	0.603	0.207	0.689	0.338	0.124	0.910	0.134	0.038	0.251	0.597	0.227	0.087
type-TRN (1)													
n	398	431	436	416	463	416	439	419	409	341	277	368	4813
Mean Observations(x)	183.331	203.975	233.979	281.953	280.889	268.566	235.415	183.497	213.362	212.288	212.870	184.830	226.227
Sample.Dev.Std x	136.146	151.339	151.094	183.673	179.451	211.616	177.069	142.403	150.942	147.954	184.794	134.655	167.890
Mean calculate(y)	183.640	206.964	227.580	274.479	273.217	268.737	227.941	191.322	213.932	226.622	208.904	193.897	226.100
Sample.Dev.Std y	111.016	128.071	127.145	160.667	161.661	177.156	148.887	127.652	121.828	129.720	125.065	114.281	141.879
Fvalue (x/y)	1.504	1.396	1.412	1.307	1.232	1.427	1.414	1.244	1.535	1.301	2.183	1.388	1.400
p(F(x/y))	0.000	0.000	0.000	0.003	0.013	0.000	0.000	0.013	0.000	0.008	0.000	0.001	0.000
t Student (x/y)	-0.035	-0.313	0.677	0.625	0.683	-0.013	0.677	-0.837	-0.059	-1.345	0.296	-0.985	0.040
p(t(x/y))	0.972	0.754	0.499	0.532	0.494	0.990	0.499	0.403	0.953	0.179	0.767	0.325	0.968
Mean Square Error(MSE)	5784.907	7886.826	7860.739	9616.977	7268.995	10709.646	7511.521	4750.399	7485.219	9776.264	11864.566	8233.033	8092.602
Root MSE (MRSE)	76.059	88.808	88.661	98.066	85.258	103.487	86.669	68.923	86.517	98.875	108.925	90.736	89.959
Mean Abs.Error (MAE)	52.649	55.277	60.352	66.295	58.451	66.183	57.158	49.917	55.710	63.720	63.010	61.598	58.988
Correlation (r)	0.829	0.810	0.811	0.847	0.881	0.873	0.873	0.877	0.819	0.759	0.820	0.748	0.844
t Student (r)	29.503	28.636	28.872	32.363	39.965	36.360	37.479	37.216	28.799	21.436	23.750	21.557	109.282
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	-0.309	-2.989	6.399	7.473	7.672	-0.171	7.474	-7.824	-0.570	-14.334	3.967	-9.067	0.127
Std.Dev.(e)	76.154	88.861	88.531	97.899	85.004	103.612	86.445	68.559	86.621	97.974	109.049	90.405	89.968
t Student (e)	-0.081	-0.698	1.509	1.557	1.942	-0.034	1.812	-2.336	-0.133	-2.702	0.605	-1.924	0.098
p(t(e))	0.936	0.485	0.132	0.120	0.053	0.973	0.071	0.020	0.894	0.007	0.545	0.055	0.922
type-VLD (2)													
n	91	89	115	80	53	93	58	97	79	79	66	77	977
Mean Observations(x)	171.980	178.955	222.762	306.514	281.542	265.161	217.519	199.224	191.019	228.567	193.400	176.813	217.773
Sample.Dev.Std x	141.033	138.218	160.316	169.668	181.722	197.538	149.910	147.351	133.112	147.575	141.426	136.800	159.407
Mean calculate(y)	181.936	193.819	218.838	294.305	272.684	265.971	215.122	200.972	215.973	234.382	206.362	183.216	222.089
Sample.Dev.Std y	122.550	128.939	130.856	162.184	150.644	166.854	135.397	130.685	135.440	128.914	109.288	125.402	139.942
Fvalue (x/y)	1.324	1.149	1.501	1.094	1.455	1.402	1.226	1.271	1.035	1.310	1.675	1.190	1.298
p(F(x/y))	0.092	0.258	0.016	0.345	0.090	0.054	0.222	0.121	0.439	0.117	0.020	0.225	0.000
t Student (x/y)	-0.508	-0.742	0.203	0.465	0.273	-0.030	0.090	-0.087	-1.168	-0.264	-0.589	-0.303	-0.636
p(t(x/y))	0.612	0.460	0.839	0.643	0.786	0.976	0.928	0.931	0.246	0.793	0.557	0.763	0.525
Mean Square Error(MSE)	6680.040	5372.931	7701.202	9004.898	12483.120	9120.107	5659.433	8654.906	6095.419	4666.924	7120.914	6036.955	7323.136
Root MSE (MRSE)	81.732	73.300	87.756	94.894	111.728	95.499	75.229	93.032	78.073	68.315	84.386	77.698	85.575
Mean Abs.Error (MAE)	47.764	53.353	64.203	66.133	70.366	67.675	55.074	63.533	51.103	49.893	60.445	51.644	58.438
Correlation (r)	0.817	0.856	0.836	0.838	0.787	0.874	0.863	0.780	0.846	0.886	0.805	0.827	0.845
t Student (r)	13.386	15.460	16.188	13.567	9.101	17.194	12.811	12.158	13.948	16.751	10.856	12.726	49.259
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	-9.956	-14.864	3.924	12.209	8.858	-0.809	2.397	-1.748	-24.954	-5.815	-12.962	-6.403	-4.316
Std.Dev.(e)	81.572	72.184	88.052	94.699	112.442	96.013	75.848	93.499	74.450	68.502	84.023	77.941	85.510
t Student (e)	-1.164	-1.943	0.478	1.153	0.573	-0.081	0.241	-0.184	-2.979	-0.755	-1.253	-0.721	-1.578
p(t(e))	0.247	0.055	0.634	0.252	0.569	0.935	0.811	0.854	0.004	0.453	0.215	0.473	0.115
ALL													
n	556	593	644	613	592	620	590	569	557	488	415	530	6767
Mean Observations(x)	181.570	196.186	230.905	279.388	279.476	263.747	233.997	190.648	207.069	216.569	215.012	182.006	224.543
Sample.Dev.Std x	135.481	146.891	151.596	180.344	178.199	207.465	174.412	142.858	146.935	149.563	177.070	138.793	166.090
Mean calculate(y)	184.885	201.279	224.236	273.378	271.647	266.333	228.388	197.876	213.134	228.867	213.315	191.198	225.756
Sample.Dev.Std y	115.277	126.766	127.690	160.493	161.928	176.746	147.558	127.270	125.567	131.022	123.524	117.596	142.262
Fvalue (x/y)	1.381	1.343	1.409	1.263	1.211	1.378	1.397	1.260	1.369	1.303	2.055	1.393	1.363
p(F(x/y))	0.000	0.000	0.000	0.002	0.010	0.000	0.000	0.003	0.000	0.002	0.000	0.000	0.000
t Student (x/y)	-0.439	-0.639	0.854	0.616	0.791	-0.236	0.596	-0.901	-0.741	-1.366	0.160	-1.163	-0.456
p(t(x/y))	0.660	0.523	0.393	0.538	0.429	0.813	0.551	0.368	0.459	0.172	0.873	0.245	0.648
Mean Square Error(MSE)	5904.439	7565.743	7772.493	9321.436	7485.095	9998.698	7737.829	5317.246	6940.116	8242.939	10846.100	7986.140	7881.198
Root MSE (MRSE)	76.840	86.981	88.162	96.548	86.516	99.993	87.965	72.919	83.307	90.791	104.145	89.365	88.776
Mean Abs.Error (MAE)	51.190	55.014	60.942	65.905	59.261	65.060	59.515	52.099	54.596	59.975	62.586	60.251	58.888
Correlation (r)	0.824	0.808	0.815	0.846	0.876	0.876	0.864	0.862	0.825	0.802	0.817	0.771	0.845
t Student (r)	34.237	33.348	35.616	39.244	44.059	45.240	41.618	40.426	34.386	29.587	28.801	27.841	130.098
p(t(r))	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean(e)	-3.315	-5.094	6.669	6.010	7.829	-2.586	5.608	-7.228	-6.065	-12.298	1.697	-9.192	-1.212
Std.Dev.(e)	76.838	86.905	87.977	96.439	86.234	100.041	87.860	72.624	83.161	90.046	104.256	88.975	88.774
t Student (e)	-1.017	-1.427	1.924	1.543	2.209	-0.644	1.551	-2.374	-1.721	-3.017	0.332	-2.378	-1.123
p(t(e))	0.309	0.154	0.055	0.123	0.028	0.520	0.122	0.018	0.086	0.003	0.740	0.018	0.261

Note: : p-values that fails the test at 95% intervale of confidence (alfa=0.05)

APPENDIX P

Table P.1: Statistical Summary by Station for Equal Variances a means

F-Test for Equal Variances(x) and t-Test for Equal mean(x) for Thiessen and ANN(14-8-4-1) models

		Original Data		Thiessen Polygon						ANN: 14-8-4-1 v8					
CODE	N months	StDev of Precipitation	Mean of Precipitation	StDev Of Thiessen	Mean Of Thiessen	F , Ho: s^2=s^2	pvalue(F)	t , Ho: u=u	pvalue(t)	StDev Of 14-8-1-v8	Mean Of 14-8-1-v8	F , Ho: s^2=s^2	pvalue(F)	t , Ho: u=u	pvalue(t)
M002	200	52.65	72.54	74.92	106.87	2.03	0.01	-2.62	0.01	50.20	70.58	1.10	0.37	0.19	0.85
M007	200	108.80	242.71	118.94	275.58	1.19	0.27	-1.43	0.16	92.78	248.62	1.38	0.14	-0.29	0.77
M008	200	119.63	375.73	155.82	415.43	1.70	0.04	-1.41	0.16	101.63	388.75	1.39	0.13	-0.58	0.56
M009	30	37.19	52.77	126.38	113.14	11.55	0.00	-3.21	0.00	14.94	60.29	6.20	0.00	-1.31	0.19
M023	149	61.10	70.93	93.39	97.18	2.34	0.00	-1.65	0.10	28.35	74.66	4.64	0.00	-0.39	0.70
M041	187	114.49	337.91	152.12	390.58	1.77	0.03	-1.94	0.06	89.25	327.24	1.65	0.04	0.51	0.61
M043	6	59.23	137.82	79.07	138.08	1.78	0.02	-0.02	0.98	61.08	173.19	1.06	0.42	-2.91	0.01
M048	38	149.31	409.11	123.77	393.74	1.46	0.10	0.55	0.58	85.08	388.09	3.08	0.00	0.86	0.39
M052	200	115.64	254.97	118.50	303.09	1.05	0.43	-2.03	0.05	66.40	266.11	3.03	0.00	-0.58	0.56
M061	200	120.11	292.10	136.84	294.05	1.30	0.18	-0.08	0.94	109.62	297.08	1.20	0.26	-0.21	0.83
M063	200	143.58	457.68	126.65	356.57	1.29	0.19	3.70	0.00	139.25	456.42	1.06	0.42	0.04	0.97
M068	74	100.61	229.33	105.67	241.27	1.10	0.37	-0.57	0.57	75.06	224.29	1.80	0.02	0.28	0.78
M070	109	129.92	288.01	128.39	342.09	1.02	0.47	-2.07	0.04	86.70	293.27	2.25	0.00	-0.24	0.81
M077	1	0.00	292.20	0.00	257.90					0.00	304.63				
M098	9	65.89	164.51	75.74	126.89	1.32	0.17	2.62	0.01	29.17	121.37	5.10	0.00	4.19	0.00
M186	36	115.42	297.43	112.42	206.02	1.05	0.43	3.97	0.00	50.26	237.98	5.27	0.00	3.31	0.00
M188	175	58.81	100.85	159.25	146.12	7.33	0.00	-1.87	0.07	48.87	98.56	1.45	0.10	0.21	0.84
M200	89	127.95	338.56	109.17	263.97	1.37	0.14	3.10	0.00	92.42	309.69	1.92	0.01	1.28	0.20
M201	108	79.35	212.10	113.26	262.02	2.04	0.01	-2.53	0.01	70.18	212.15	1.28	0.20	0.00	1.00
M202	65	260.59	379.16	209.72	346.02	1.54	0.07	0.69	0.49	196.68	398.23	1.76	0.03	-0.41	0.68
M203	87	146.91	499.20	83.98	149.86	3.06	0.00	14.45	0.00	84.32	511.48	3.04	0.00	-0.51	0.61
M205	58	118.50	400.50	141.11	277.32	1.42	0.11	4.68	0.00	84.06	433.13	1.99	0.01	-1.57	0.12
M208	93	76.89	278.13	97.84	214.73	1.62	0.05	3.57	0.00	50.27	269.40	2.34	0.00	0.67	0.51
M215	85	100.44	201.81	126.59	287.14	1.59	0.06	-3.70	0.00	54.88	201.52	3.35	0.00	0.02	0.99
M219	50	52.88	115.01	160.99	116.06	9.27	0.00	-0.04	0.97	47.96	124.15	1.22	0.25	-0.90	0.37
M220	74	88.95	144.34	165.54	291.81	3.46	0.00	-5.49	0.00	73.63	139.03	1.46	0.10	0.32	0.75
M279	22	59.98	125.26	102.49	283.48	2.92	0.00	-9.33	0.00	18.87	146.17	10.10	0.00	-2.33	0.02
M293	150	108.90	297.86	120.38	280.37	1.22	0.24	0.75	0.45	77.78	309.62	1.96	0.01	-0.62	0.54
M304	86	42.52	42.84	42.73	54.40	1.01	0.49	-1.34	0.19	19.50	49.02	4.75	0.00	-0.92	0.36
M310	175	128.59	113.41	45.03	75.66	8.15	0.00	1.94	0.06	59.98	116.17	4.60	0.00	-0.14	0.89
M315	197	33.15	47.74	65.21	77.59	3.87	0.00	-2.86	0.01	21.23	33.38	2.44	0.00	2.55	0.01
M316	128	130.70	129.38	93.36	82.12	1.96	0.01	2.06	0.04	60.15	120.17	4.72	0.00	0.45	0.66
M324	190	43.66	87.20	127.21	100.80	8.49	0.00	-0.71	0.48	27.38	88.96	2.54	0.00	-0.24	0.81
M344	137	45.51	54.22	57.09	73.82	1.57	0.06	-1.88	0.07	22.27	45.10	4.18	0.00	1.26	0.21
M349	23	66.42	85.38	95.81	123.40	2.08	0.01	-2.28	0.02	9.67	61.05	47.22	0.00	2.54	0.01
M353	199	78.17	118.50	79.32	112.88	1.03	0.46	0.35	0.73	55.18	120.57	2.01	0.01	-0.15	0.88
M359	190	75.62	76.57	57.20	68.46	1.75	0.03	0.60	0.55	52.77	91.64	2.05	0.01	-1.14	0.26
M364	196	81.69	132.92	76.40	111.66	1.14	0.32	1.33	0.19	64.58	125.92	1.60	0.05	0.47	0.64
M378	200	130.93	249.81	193.13	303.35	2.18	0.00	-1.61	0.11	126.02	250.47	1.08	0.40	-0.03	0.98
M379	76	158.01	344.36	163.55	309.24	1.07	0.41	1.08	0.28	104.61	357.90	2.28	0.00	-0.50	0.62
M436	92	54.93	142.15	49.02	56.98	1.26	0.22	8.10	0.00	35.34	129.99	2.42	0.00	1.30	0.20
M484	161	121.58	340.20	166.62	334.70	1.88	0.02	0.19	0.85	53.27	334.44	5.21	0.00	0.30	0.76
M485	153	204.46	381.26	184.45	330.32	1.23	0.24	1.29	0.20	75.11	393.55	7.41	0.00	-0.39	0.69
M486	176	89.77	213.20	154.70	229.16	2.97	0.00	-0.62	0.53	51.38	210.32	3.05	0.00	0.19	0.85
M488	133	181.60	345.55	118.54	326.00	2.35	0.00	0.63	0.53	76.74	359.70	5.60	0.00	-0.50	0.62
M489	32	118.59	346.33	133.12	204.73	1.26	0.21	5.56	0.00	40.05	339.57	8.77	0.00	0.38	0.71
M490	183	118.72	225.22	113.75	207.54	1.09	0.38	0.75	0.46	69.82	227.03	2.89	0.00	-0.09	0.93
M491	109	130.96	283.97	147.50	334.03	1.27	0.21	-1.78	0.08	69.03	284.60	3.60	0.00	-0.03	0.98
M493	3	156.77	295.10	103.61	213.03	2.29	0.00	3.06	0.00	75.64	281.25	4.30	0.00	0.56	0.58
M494	26	173.58	432.63	234.26	410.17	1.82	0.02	0.54	0.59	107.23	429.26	2.62	0.00	0.12	0.91
M495	16	301.62	438.26	163.54	465.83	3.40	0.00	-0.56	0.58	92.81	383.17	10.56	0.00	1.22	0.23
M532	11	56.62	67.53	92.84	129.50	2.69	0.00	-3.99	0.00	13.04	83.31	18.84	0.00	-1.90	0.06
M533	40	32.97	92.22	64.87	86.78	3.87	0.00	0.52	0.60	33.31	98.60	1.02	0.47	-0.95	0.35
M545	83	48.56	109.10	195.65	326.41	16.23	0.00	-7.55	0.00	32.69	125.63	2.21	0.00	-1.98	0.05
M546	94	120.90	271.64	124.86	226.63	1.07	0.41	1.81	0.08	85.36	278.33	2.01	0.01	-0.32	0.75
M547	24	80.19	268.32	125.23	283.64	2.44	0.00	-0.72	0.47	50.15	270.62	2.56	0.00	-0.17	0.86
M558	34	75.78	99.14	108.21	151.92	2.04	0.01	-2.80	0.01	24.15	90.49	9.85	0.00	0.76	0.45
M563	31	122.32	342.81	109.93	303.67	1.24	0.23	1.67	0.10	46.59	386.23	6.89	0.00	-2.32	0.02
M629	32	48.28	78.02	54.91	114.39	1.29	0.19	-3.48	0.00	20.05	69.04	5.80	0.00	1.20	0.23
M697	81	167.40	463.47	125.57	204.85	1.78	0.02	8.65	0.00	99.73	462.07	2.82	0.00	0.05	0.96
M698	145	89.73	211.13	212.32	275.62	5.60	0.00	-1.96	0.05	54.33	209.59	2.73	0.00	0.10	0.92
M699	40	90.27	135.52	87.57	217.50	1.06	0.42	-4.56	0.00	25.65	130.40	12.39	0.00	0.38	0.70
M702	4	131.40	435.88	91.97	291.20	2.04	0.01	6.31	0.00	131.64	630.23	1.00	0.50	-7.31	0.00
M703	14	135.41	533.01	158.97	285.31	1.38	0.13	8.30	0.00	83.20	519.49	2.65	0.00	0.60	0.55
M710	116	113.07	263.17	147.02	318.40	1.69	0.04	-2.08	0.04	63.93	273.24	3.13	0.00	-0.54	0.59
M711	2	21.50	381.90	22.84	47.15	1.13	0.34	74.71	0.00	20.28	438.64	1.12	0.34	-13.44	0.00
M713	13	106.64	339.19	297.46	422.11	7.78	0.00	-1.84	0.07	48.06	344.12	4.92	0.00	-0.30	0.77
M720	74	216.05	353.59	119.92	169.23	3.25	0.00	5.22	0.00	203.73	351.88	1.12	0.34	0.04	0.97
M731	41	45.92	58.44	54.93	92.18	1.43	0.11	-3.30	0.00	51.01	106.41	1.23	0.23	-4.89	0.00
M734	9	59.06	145.19	57.41	144.78	1.06	0.42	0.03	0.97	31.27	150.39	3.57	0.00	-0.54	0.59
M829	6	90.24	137.17	241.27	225.90	7.15	0.00	-2.41	0.02	53.29	161.54	2.87	0.00	-1.63	0.11
MA1F	37	66.28	139.43	171.84	271.30	6.72	0.00	-5.01	0.00	58.07	149.97	1.30	0.18	-0.84	0.41
MA22	20	66.23	108.78	151.45	150.11	5.23	0.00	-1.75	0.08	41.03	137.36	2.61	0.00	-2.57	0.01
MA54	40	135.57	315.23	183.89	397.68	1.84	0.02	-2.53	0.01	88.24	308.35	2.36	0.00	0.30	0.77

Levene 's Test for Homogenity of Variance Real Precipitation

Source	SSE	df	MSE	f	Pvalue(f)
Between S	1123712.8	73	15393.33	2.378983	0.000
Error	43307389	6693	6470.55		
Total	44431102	6767			

Levene 's Test for Homogenity of Variance for ANN(14-8-1) Error

Source	SEE	df	MSE	f	Pvalue(f)
Between S	1E+08	73	1386643	108.646	0.000
Sserror	8.5E+07	6693	12762.9		
SSt=(n-1)*S	1.9E+08	6767			

Note: : p-values that fails the test at 95% intervale of confidence (alfa=0.05)

Table P.2: Statistical Summary by Station for Paired t-test.

Paried t-Test for Error of Thiessen and ANN(14-8-4-1) models

		Error of Thiessen Polygon				Error of ANN: 14-8-4-1 v8			
CODE	N months	StDev of (e) Thiessen	Mean Of (e)Thiessen	Paried t-Test	pvalue(t)	StDev Of (e) 14-8-4-1-v8	Mean Of (e) 14-8-4-1-v8	Paried t-Test	Pvalue(t)
M002	200	62.30	-34.32	-7.79	0.000	21.79	1.96	1.27	0.204
M007	200	119.37	-32.87	-3.89	0.000	41.09	-5.91	-2.04	0.043
M008	200	119.77	-39.70	-4.69	0.000	40.01	-13.02	-4.60	0.000
M009	30	111.42	-60.37	-2.97	0.006	27.34	-7.52	-1.51	0.143
M023	149	83.75	-26.25	-3.83	0.000	49.63	-3.73	-0.92	0.360
M041	187	114.40	-52.67	-6.30	0.000	72.32	10.66	2.02	0.045
M043	6	95.85	-0.27	-0.01	0.995	45.97	-35.38	-1.89	0.118
M048	38	122.20	15.37	0.78	0.443	115.17	21.02	1.13	0.268
M052	200	128.85	-48.13	-5.28	0.000	81.57	-11.14	-1.93	0.055
M061	200	136.45	-1.95	-0.20	0.840	37.27	-4.98	-1.89	0.060
M063	200	119.75	101.10	11.94	0.000	23.68	1.26	0.75	0.454
M068	74	90.76	-11.94	-1.13	0.261	77.78	5.04	0.56	0.579
M070	109	124.47	-54.08	-4.54	0.000	92.93	-5.26	-0.59	0.556
M077	1	0.00	34.30			0.00	-12.43		
M098	9	42.28	37.62	2.67	0.028	79.92	43.14	1.62	0.144
M186	36	165.14	91.42	3.32	0.002	104.31	59.45	3.42	0.002
M188	175	165.72	-45.27	-3.61	0.000	43.63	2.28	0.69	0.489
M200	89	124.14	74.59	5.67	0.000	96.30	28.87	2.83	0.006
M201	108	105.70	-49.92	-4.91	0.000	64.67	-0.04	-0.01	0.994
M202	65	273.98	33.13	0.97	0.333	154.26	-19.07	-1.00	0.323
M203	87	175.75	349.34	18.54	0.000	134.83	-12.27	-0.85	0.398
M205	58	180.74	123.18	5.19	0.000	123.90	-32.63	-2.01	0.050
M208	93	87.58	63.40	6.98	0.000	65.89	8.73	1.28	0.205
M215	85	136.65	-85.33	-5.76	0.000	87.23	0.29	0.03	0.975
M219	50	148.79	-1.05	-0.05	0.960	50.94	-9.14	-1.27	0.211
M220	74	132.85	-147.46	-9.55	0.000	66.03	5.31	0.69	0.491
M279	22	96.59	-158.22	-7.68	0.000	54.67	-20.91	-1.79	0.087
M293	150	121.21	17.49	1.77	0.079	74.02	-11.76	-1.95	0.054
M304	86	37.86	-11.56	-2.83	0.006	37.30	-6.18	-1.54	0.128
M310	175	117.72	37.75	4.24	0.000	125.11	-2.76	-0.29	0.771
M315	197	57.16	-29.85	-7.33	0.000	28.27	14.36	7.13	0.000
M316	128	123.76	47.26	4.32	0.000	104.61	9.21	1.00	0.321
M324	190	118.42	-13.60	-1.58	0.115	42.38	-1.76	-0.57	0.567
M344	137	43.75	-19.60	-5.24	0.000	33.59	9.12	3.18	0.002
M349	23	85.51	-38.02	-2.13	0.044	65.38	24.33	1.78	0.088
M353	199	57.77	5.62	1.37	0.172	53.42	-2.07	-0.55	0.585
M359	190	70.17	8.11	1.59	0.113	55.18	-15.08	-3.77	0.000
M364	196	64.48	21.26	4.62	0.000	51.48	7.00	1.90	0.058
M378	200	209.85	-53.54	-3.61	0.000	35.50	-0.66	-0.26	0.792
M379	76	167.54	35.13	1.83	0.072	105.63	-13.54	-1.12	0.267
M436	92	68.92	85.17	11.85	0.000	41.56	12.15	2.80	0.006
M484	161	163.28	5.49	0.43	0.670	104.33	5.76	0.70	0.485
M485	153	238.98	50.94	2.64	0.009	192.49	-12.29	-0.79	0.431
M486	176	157.18	-15.95	-1.35	0.180	74.47	2.88	0.51	0.608
M488	133	193.79	19.56	1.16	0.247	162.77	-14.15	-1.00	0.318
M489	32	134.67	141.60	5.95	0.000	111.70	6.76	0.34	0.734
M490	183	136.49	17.68	1.75	0.081	98.65	-1.81	-0.25	0.804
M491	109	147.32	-50.07	-3.55	0.001	100.26	-0.64	-0.07	0.947
M493	3	58.70	82.07	2.42	0.136	89.52	13.85	0.27	0.814
M494	26	247.17	22.46	0.46	0.647	172.63	3.37	0.10	0.922
M495	16	330.35	-27.57	-0.33	0.743	296.56	55.09	0.74	0.469
M532	11	53.01	-61.97	-3.88	0.003	45.15	-15.78	-1.16	0.273
M533	40	71.96	5.44	0.48	0.635	37.80	-6.38	-1.07	0.292
M545	83	189.30	-217.31	-10.46	0.000	44.02	-16.53	-3.42	0.001
M546	94	132.41	45.01	3.30	0.001	84.00	-6.70	-0.77	0.441
M547	24	168.63	-15.33	-0.45	0.660	82.77	-2.31	-0.14	0.893
M558	34	93.75	-52.78	-3.28	0.002	68.81	8.64	0.73	0.469
M563	31	104.41	39.14	2.09	0.045	104.82	-43.42	-2.31	0.028
M629	32	68.29	-36.37	-3.01	0.005	36.76	8.99	1.38	0.177
M697	81	183.88	258.62	12.66	0.000	146.67	1.40	0.09	0.932
M698	145	223.91	-64.49	-3.47	0.001	70.13	1.54	0.26	0.792
M699	40	115.47	-81.98	-4.49	0.000	89.46	5.12	0.36	0.720
M702	4	94.25	144.68	3.07	0.055	135.37	-194.35	-2.87	0.064
M703	14	108.39	247.70	8.55	0.000	110.84	13.52	0.46	0.656
M710	116	143.21	-55.23	-4.15	0.000	94.35	-10.07	-1.15	0.253
M711	2	44.34	334.75	10.68	0.059	1.22	-56.74	-65.90	0.010
M713	13	252.87	-82.92	-1.18	0.260	85.71	-4.93	-0.21	0.839
M720	74	178.17	184.36	8.90	0.000	99.26	1.71	0.15	0.883
M731	41	65.88	-33.74	-3.28	0.002	38.32	-47.97	-8.01	0.000
M734	9	46.16	0.41	0.03	0.979	77.39	-5.20	-0.20	0.845
M829	6	188.38	-88.73	-1.15	0.301	54.36	-24.38	-1.10	0.322
MA1F	37	151.75	-131.87	-5.29	0.000	53.88	-10.53	-1.19	0.242
MA22	20	123.70	-41.33	-1.49	0.152	39.19	-28.58	-3.26	0.004
MA54	40	185.42	-82.45	-2.81	0.008	77.66	6.88	0.56	0.578

Note: : p-values that fails the test at 95% intervale of confidence (alfa=0.05)

Table P.3: Statistical Summary by Station, t –test for Correlation

t-Test for Correlation for Thiessen model

		Original Data			Thiessen Polygon							
CODE	N Months	S(X)	S(X^2)	Sxx	Sum(Y)	Sum(Y^2)	Syy	Sum(XY)	Sxy	Corre-lation	t(Corr)	pvalue (t)
M002	200	14508.7	1604109.9	551598.0	21373.4	3401226.6	1117115.4	1998639.1	448137.9	0.571	9.784	0.000
M007	200	48541.3	14137111.8	2355822.8	55115.5	18003674.2	2815082.4	14544459.3	1167569.2	0.453	7.158	0.000
M008	200	75146.8	31083052.8	2847845.1	83086.2	39348502.3	4831919.2	33630781.5	2412471.2	0.650	12.047	0.000
M009	30	1583.1	123640.8	40100.6	3394.3	847202.1	463159.7	250738.9	71621.7	0.526	3.269	0.001
M023	149	10568.3	1302065.5	552475.1	14480.0	2698009.2	1290825.3	1429616.2	402576.1	0.477	6.575	0.000
M041	187	63188.3	23789559.5	2437895.0	73037.6	32830722.0	4304032.1	26833585.4	2153789.8	0.665	12.108	0.000
M043	6	826.9	131500.6	17540.0	828.5	145660.0	31257.9	115611.4	1430.3	0.061	0.122	0.454
M048	38	15546.3	7185014.5	824818.6	14962.2	6458087.1	566839.0	6540803.7	419570.8	0.614	4.663	0.000
M052	200	50993.1	15662506.5	2661025.3	60618.6	21167249.2	2794175.9	16531292.2	1075640.5	0.394	6.041	0.000
M061	200	58419.7	19935110.7	2870803.9	58810.1	21019275.8	3726136.5	18624154.9	1445812.9	0.442	6.935	0.000
M063	200	91535.1	45995790.9	4102418.2	71314.5	28620988.1	3192198.5	34859396.3	2220496.8	0.614	10.935	0.000
M068	74	16970.1	4630618.6	738938.9	17854.0	5122842.7	815203.3	4570761.3	476380.7	0.614	6.597	0.000
M070	109	31393.1	10864582.6	1823053.0	37288.2	14536198.9	1780145.2	11704329.7	964951.8	0.536	6.561	0.000
M077	1	292.2	85380.8	0.0	257.9	66512.4	0.0	75358.4	0.0			
M098	9	1480.6	278303.7	34728.6	1142.0	190796.4	45889.3	221031.3	33159.6	0.831	3.947	0.003
M186	36	10707.6	3651091.1	466294.0	7416.6	1970248.6	442305.4	2182990.0	-22954.1	-0.051	-0.295	0.385
M188	175	17648.6	2381718.1	601871.9	25571.4	8149172.0	4412620.6	2696939.2	118085.5	0.072	0.956	0.170
M200	89	30132.2	11642304.9	1440625.3	23493.5	7250394.8	1048770.7	8520665.0	566610.6	0.461	4.845	0.000
M201	108	22907.0	5532289.8	673672.7	28298.5	8787326.0	1372464.0	6427497.1	425332.9	0.442	5.078	0.000
M202	65	24645.1	13690353.8	4346031.4	22491.5	10597463.1	2814885.1	9706146.5	1178373.1	0.337	2.840	0.003
M203	87	43430.6	23536673.1	1856017.8	13037.6	2560308.0	606526.3	6411446.4	-96953.5	-0.091	-0.846	0.200
M205	58	23228.9	10103478.3	800343.8	16084.4	5595392.9	1134911.5	6478372.9	36598.4	0.038	0.288	0.387
M208	93	25866.4	7738196.1	543888.0	19970.3	5169019.3	880708.7	5913902.5	359496.3	0.519	5.799	0.000
M215	85	17153.8	4309160.8	847362.5	24406.5	8354041.3	1346073.7	5237936.2	312474.7	0.293	2.788	0.003
M219	50	5750.5	798368.9	137003.9	5803.1	1943516.4	1269997.0	828500.5	161085.9	0.386	2.901	0.003
M220	74	10681.5	2119439.0	577622.2	21593.9	8301799.2	2000494.9	3761799.9	644837.1	0.600	6.362	0.000
M279	22	2755.7	420713.5	75537.0	6236.5	1988496.3	220590.2	831277.1	50098.8	0.388	1.883	0.037
M293	150	44679.5	15075400.5	1767015.7	42056.0	13950713.2	2159332.3	13395588.8	868648.5	0.445	6.040	0.000
M304	86	3684.2	311509.4	153680.0	4678.2	409667.5	155184.3	293929.6	93517.7	0.606	6.974	0.000
M310	175	19846.3	5128082.9	2877365.1	13240.5	1354646.6	352870.4	1911047.6	409476.5	0.406	5.850	0.000
M315	197	9405.6	664482.5	215420.0	15285.1	2019378.6	833417.8	934019.1	204244.8	0.482	7.683	0.000
M316	128	16560.5	4311956.7	2169377.3	10511.3	1970038.5	1106855.4	2025416.7	665476.2	0.429	5.338	0.000
M324	190	16568.2	1805115.1	360350.6	19152.8	4989182.1	3058499.3	2054266.0	384121.7	0.366	5.391	0.000
M344	137	7427.9	684462.9	281735.2	10113.2	1189742.7	443196.7	780653.7	232333.7	0.657	10.139	0.000
M349	23	1963.7	264713.6	97056.3	2838.2	552182.9	201949.0	311396.0	69075.4	0.493	2.599	0.008
M353	199	23581.3	4004156.8	1209796.5	22463.1	3781248.1	1245615.6	3559207.1	897352.4	0.731	15.036	0.000
M359	190	14547.4	2194544.9	1080719.4	13006.9	1508744.1	618326.0	1380155.5	384278.8	0.470	7.303	0.000
M364	196	26052.4	4764040.6	1301145.0	21885.6	3581891.0	1138118.1	3723290.4	814247.5	0.669	12.541	0.000
M378	200	49962.1	15892609.1	3411551.9	60670.3	25826833.3	7422406.8	16191524.9	1035446.9	0.206	2.959	0.002
M379	76	26171.7	10885233.2	1872629.5	23502.0	9273860.3	2006176.0	8980031.4	886777.6	0.458	4.426	0.000
M436	92	13077.5	2133456.2	274532.2	5241.7	517311.4	218665.6	775552.3	30461.7	0.124	1.189	0.119
M484	161	54771.7	20998163.4	2365001.2	53887.4	22478240.0	4441892.9	19602835.5	1270509.3	0.392	5.373	0.000
M485	153	58333.0	28594538.3	6354414.8	50539.6	21865764.5	5171312.4	20691020.5	1422219.9	0.248	3.147	0.001
M486	176	37524.0	9410619.3	1410331.9	40332.0	13430358.3	4187913.9	9236469.7	637503.9	0.262	3.586	0.000
M488	133	45958.6	20234253.9	4353104.1	43357.5	15989139.3	1854757.3	15607716.7	625385.9	0.220	2.582	0.005
M489	32	11082.5	4274132.6	435951.2	6551.4	1890663.9	549387.6	2480497.3	211563.2	0.432	2.626	0.007
M490	183	41215.4	11847821.2	2565257.3	37979.8	10237054.7	2354731.2	9318458.8	764619.2	0.311	4.404	0.000
M491	109	30952.5	10641829.4	1852313.3	36409.6	14511533.9	2349525.0	11268069.6	928912.3	0.445	5.144	0.000
M493	3	885.3	310405.4	49153.3	639.1	157620.8	21471.1	220465.3	31866.9	0.981	5.046	0.062
M494	26	11248.4	5619639.4	753235.5	10664.4	5746166.8	1371958.1	4912712.2	298964.6	0.294	1.507	0.072
M495	16	7012.1	4437731.1	1364634.4	7453.2	3873078.9	401192.0	3330834.3	64422.8	0.087	0.327	0.374
M532	11	742.8	82214.3	32055.0	1424.5	270668.4	86195.6	141267.2	45074.6	0.858	5.000	0.000
M533	40	3688.8	382587.8	42406.6	3471.1	465331.7	164118.3	322396.9	2292.0	0.027	0.169	0.433
M545	83	9055.0	1181219.2	193351.4	27091.7	11981624.5	3138730.4	3152409.8	196803.3	0.253	2.350	0.011
M546	94	25533.7	8295224.9	1359375.6	21302.8	6277642.7	1449884.3	6375996.5	589408.1	0.420	4.437	0.000
M547	24	6439.6	1875767.6	147915.6	6807.4	2291544.3	360682.0	1753823.0	-72715.9	-0.315	-1.556	0.067
M558	34	3370.6	523642.9	189497.5	5165.2	1171076.6	386391.6	654967.2	142913.5	0.528	3.518	0.001
M563	31	10627.2	4091971.1	448829.8	9413.8	3221256.5	362558.7	3469335.8	242163.7	0.600	4.042	0.000
M629	32	2496.7	267045.0	72247.8	3660.6	512204.5	93454.7	296167.9	10561.0	0.129	0.710	0.242
M697	81	37541.4	19641366.2	2241900.6	16593.1	4660587.3	1261439.6	8089660.8	399189.1	0.237	2.172	0.016
M698	145	30613.8	7622894.3	1159413.2	39965.5	17507143.9	6491687.4	8653642.6	215740.3	0.079	0.943	0.174
M699	40	5420.8	1052430.4	317803.6	8700.0	2191291.1	299041.1	1227466.5	48442.4	0.157	0.981	0.166
M702	4	1743.5	811747.9	51799.8	1164.8	364562.9	25373.1	532969.6	25262.4	0.697	1.374	0.152
M703	14	7462.1	4215711.6	238359.0	3994.3	1468145.3	328542.9	2336076.4	207085.9	0.740	3.811	0.001
M710	116	30527.6	9504183.1	1470266.1	36934.6	14245638.0	2485597.7	10518779.9	798739.4	0.418	4.910	0.000
M711	2	763.8	292157.3	462.1	94.3	4967.9	521.6	35522.2	-491.0	-1.000		
M713	13	4409.5	1632146.3	136477.8	5487.4	3378038.0	1061764.2	2076743.3	215459.4	0.566	2.277	0.022
M720	74	26165.7	12659525.9	3407581.9	12523.1	3169097.0	1049799.3	5498036.5	1069986.8	0.566	5.821	0.000
M731	41	2396.2	224379.3	84336.0	3779.5	469094.0	120688.6	236590.7	15702.0	0.156	0.984	0.166
M734	9	1306.7	217625.1	27906.8	1303.0	215013.8	26368.4	207794.9	18613.8	0.686	2.496	0.021
M829	6	823.0	153606.0	40717.8	1355.4	597252.7	291067.8	263088.5	77172.8	0.709	2.010	0.057
MA1F	37	5159.0	877466.6	158134.7	10038.2	3786405.2	1063014.4	1595744.5	196093.8	0.478	3.222	0.001
MA22	20	2175.5	319987.3	83347.3	3002.1	886426.1	435795.8	440766.9	114213.4	0.599	3.176	0.003
MA54	40	12609.1	4691545.8	716810.8	15907.2	7644814.7	1318839.4	5361796.8	347409.9	0.357	2.358	0.012

Note: : p-values that fails the test at 95% intervale of confidence (alfa=0.05)

Table P.4: Statistical Summary by Station, t-test for Correlation

t-Test for Correlation ANN(14-8-4-1) model

		Original Data			ANN: 14-8-4-1 v8							
CODE	N Months	S(X)	S(X^2)	Sxx	Sum(Y)	Sum(Y^2)	Syy	Sum(XY)	Sxy	Correlation	t(Corr)	pvalue (t)
M002	200	14508.7	1604109.9	551598.0	14116.0	1497714.8	501406.8	1503268.2	479243.8	0.911	31.139	0.000
M007	200	48541.3	14137111.8	2355822.8	49724.0	14075256.6	1712869.9	13934724.0	1866383.1	0.929	35.353	0.000
M008	200	75146.8	31083052.8	2847845.1	77750.0	32280754.6	2055469.3	31505684.8	2292379.5	0.947	41.690	0.000
M009	30	1583.1	123640.8	40100.6	1808.7	115522.8	6471.2	107896.0	12448.7	0.773	6.443	0.000
M023	149	10568.3	1302065.5	552475.1	11124.3	949519.2	118977.7	942457.8	153429.3	0.598	9.056	0.000
M041	187	63188.3	23789559.5	2437895.0	61194.5	21507169.4	1481665.7	22151391.2	1473435.9	0.775	16.694	0.000
M043	6	826.9	131500.6	17540.0	1039.2	198633.9	18655.8	156028.9	12814.3	0.708	2.007	0.058
M048	38	15546.3	7185014.5	824818.6	14747.4	5991167.0	267857.1	6334321.2	300966.3	0.640	5.002	0.000
M052	200	50993.1	15662506.5	2661025.3	53221.6	15040126.9	877417.4	14676836.2	1107156.7	0.725	14.793	0.000
M061	200	58419.7	19935110.7	2870803.9	59416.0	20042718.2	2391392.4	19848188.2	2492853.6	0.951	43.478	0.000
M063	200	91535.1	45995790.9	4102418.2	91283.6	45522306.4	3858829.4	45703103.7	3924837.0	0.986	84.597	0.000
M068	74	16970.1	4630618.6	738938.9	16597.3	4133820.4	411254.1	4160440.6	354256.7	0.643	7.117	0.000
M070	109	31393.1	10864582.6	1823053.0	31966.3	10186540.6	811846.8	10057758.4	851153.6	0.700	10.129	0.000
M077	1	292.2	85380.8	0.0	304.6	92799.7	0.0	89013.0	0.0			
M098	9	1480.6	278303.7	34728.6	1092.4	139393.4	6806.5	174927.7	-4780.0	-0.311	-0.865	0.208
M186	36	10707.6	3651091.1	466294.0	8567.3	2127260.5	88420.7	2635128.4	86934.7	0.428	2.762	0.005
M188	175	17648.6	2381718.1	601871.9	17248.8	2115762.4	415633.2	2082667.0	343135.9	0.686	12.403	0.000
M200	89	30132.2	11642304.9	1440625.3	27562.6	9287539.4	751633.3	10019749.1	688051.6	0.661	8.221	0.000
M201	108	22907.0	5532289.8	673672.7	22911.9	5387644.8	526969.5	5236218.0	376571.9	0.632	8.397	0.000
M202	65	24645.1	13690353.8	4346031.4	25884.9	12783692.8	2475606.9	12463759.9	2649378.7	0.808	10.874	0.000
M203	87	43430.6	23536673.1	1856017.8	44498.4	23371285.2	611391.1	22665778.4	452057.0	0.424	4.321	0.000
M205	58	23228.9	10103478.3	800343.8	25121.7	11283789.0	402782.8	10225221.3	164035.3	0.289	2.258	0.014
M208	93	25866.4	7738196.1	543888.0	25054.4	6982189.9	232479.2	7156915.5	188451.0	0.530	5.962	0.000
M215	85	17153.8	4309160.8	847362.5	17128.9	3704751.5	252980.4	3687346.3	230565.2	0.498	5.232	0.000
M219	50	5750.5	798368.9	137003.9	6207.3	883351.5	112729.3	775195.2	61288.6	0.493	3.928	0.000
M220	74	10681.5	2119439.0	577622.2	10288.5	1826238.2	395779.9	1812669.4	327575.2	0.685	7.981	0.000
M279	22	2755.7	420713.5	75537.0	3215.7	477521.5	7478.4	412928.1	10128.1	0.426	2.107	0.024
M293	150	44679.5	15075400.5	1767015.7	46443.6	15281574.5	901513.4	14759981.4	926132.1	0.734	13.140	0.000
M304	86	3684.2	311509.4	153680.0	4215.3	238945.6	32332.7	214456.8	33874.5	0.481	5.022	0.000
M310	175	19846.3	5128082.9	2877365.1	20329.7	2987728.7	626039.3	2695523.1	389987.0	0.291	3.994	0.000
M315	197	9405.6	664482.5	215420.0	6575.7	307798.5	88305.9	387501.7	73549.6	0.533	8.803	0.000
M316	128	16560.5	4311956.7	2169377.3	15381.6	2307937.3	459539.4	2609561.7	619501.6	0.620	8.881	0.000
M324	190	16568.2	1805115.1	360350.6	16903.0	1645455.2	141715.9	1555241.5	81284.5	0.360	5.286	0.000
M344	137	7427.9	684462.9	281735.2	6178.1	346082.7	67477.6	432848.0	97882.4	0.710	11.712	0.000
M349	23	1963.7	264713.6	97056.3	1404.1	87767.2	2055.3	122408.1	2532.2	0.179	0.835	0.207
M353	199	23581.3	4004156.8	1209796.5	23993.8	3495860.0	602890.3	3467056.1	623818.5	0.730	15.011	0.000
M359	190	14547.4	2194544.9	1080719.4	17411.8	2121859.9	526221.1	1848907.0	515766.7	0.684	12.854	0.000
M364	196	26052.4	4764040.6	1301145.0	24679.9	3920913.2	813276.0	4079272.0	798811.1	0.777	17.166	0.000
M378	200	49962.1	15892609.1	3411551.9	50094.7	15707759.3	3160349.7	15674766.8	3160577.3	0.963	49.959	0.000
M379	76	26171.7	10885233.2	1872629.5	27200.5	10555897.1	820790.2	10295194.2	928302.5	0.749	9.718	0.000
M436	92	13077.5	2133456.2	274532.2	11959.4	1668296.1	113644.6	1815481.9	115488.1	0.654	8.198	0.000
M484	161	54771.7	20998163.4	2365001.2	53844.6	18461675.8	453975.8	18856463.7	538701.9	0.520	7.674	0.000
M485	153	58333.0	28594538.3	6354414.8	60213.4	24554594.8	857504.8	23747148.5	790097.1	0.338	4.420	0.000
M486	176	37524.0	9410619.3	1410331.9	37016.9	8247523.4	461989.6	8343063.4	450883.3	0.559	8.883	0.000
M488	133	45958.6	20234253.9	4353104.1	47840.7	17985830.5	777306.2	17348205.0	816685.1	0.444	5.671	0.000
M489	32	11082.5	4274132.6	435951.2	10866.2	3739567.1	49721.0	3812710.5	49427.5	0.336	1.952	0.030
M490	183	41215.4	11847821.2	2565257.3	41546.4	10319506.5	887245.3	10197698.9	840585.7	0.557	9.027	0.000
M491	109	30952.5	10641829.4	1852313.3	31021.7	9343539.2	514655.5	9449892.6	640714.7	0.656	8.996	0.000
M493	3	885.3	310405.4	49153.3	843.8	248750.5	11442.3	271277.0	22284.5	0.940	2.747	0.111
M494	26	11248.4	5619639.4	753235.5	11160.9	5078436.7	287474.6	4976372.7	147837.1	0.318	1.641	0.057
M495	16	7012.1	4437731.1	1364634.4	6130.6	2478260.9	129213.9	2774121.3	87329.9	0.208	0.796	0.220
M532	11	742.8	82214.3	32055.0	916.4	78050.5	1701.4	68567.3	6683.4	0.905	6.382	0.000
M533	40	3688.8	382587.8	42406.6	3944.0	432167.5	43281.5	378694.3	14975.1	0.350	2.300	0.014
M545	83	9055.0	1181219.2	193351.4	10426.9	1397515.4	87634.8	1198586.4	61050.1	0.469	4.779	0.000
M546	94	25533.7	8295224.9	1359375.6	26163.4	7959761.3	677602.0	7797274.6	690379.4	0.719	9.932	0.000
M547	24	6439.6	1875767.6	147915.6	6494.9	1815517.8	57840.9	1766798.6	24098.0	0.261	1.266	0.109
M558	34	3370.6	523642.9	189497.5	3076.7	297655.2	19240.6	331250.4	26240.7	0.435	2.730	0.005
M563	31	10627.2	4091971.1	448829.8	11973.2	4689548.3	65115.2	4196739.5	92173.4	0.539	3.448	0.001
M629	32	2496.7	267045.0	72247.8	2209.1	164973.9	12466.1	193774.8	21414.4	0.714	5.579	0.000
M697	81	37541.4	19641366.2	2241900.6	37427.7	18089944.0	795671.8	18005036.2	658247.0	0.493	5.034	0.000
M698	145	30613.8	7622894.3	1159413.2	30390.4	6794562.1	425066.6	6854394.5	438078.4	0.624	9.550	0.000
M699	40	5420.8	1052430.4	317803.6	5216.1	705853.3	25652.1	722544.7	15654.3	0.173	1.085	0.142
M702	4	1743.5	811747.9	51799.8	2520.9	1640734.3	51985.6	1123207.5	24405.2	0.470	0.754	0.265
M703	14	7462.1	4215711.6	238359.0	7272.9	3868163.8	89981.4	3960804.3	84315.7	0.576	2.439	0.016
M710	116	30527.6	9504183.1	1470266.1	31695.4	9130426.6	470073.2	8799518.0	458261.5	0.551	7.054	0.000
M711	2	763.8	292157.3	462.1	877.3	385228.8	411.2	335472.4	435.9	1.000		
M713	13	4409.5	1632146.3	136477.8	4473.6	1567198.0	27714.7	1555434.1	38016.3	0.618	2.608	0.012
M720	74	26165.7	12659525.9	3407581.9	26039.5	12192925.5	3030046.0	12066482.3	2859178.3	0.890	16.545	0.000
M731	41	2396.2	224379.3	84336.0	4363.0	568378.9	104093.2	319831.2	64840.8	0.692	5.987	0.000
M734	9	1306.7	217625.1	27906.8	1353.5	211371.5	7822.0	190418.9	-6093.4	-0.412	-1.198	0.135
M829	6	823.0	153606.0	40717.8	969.3	170777.4	14197.1	153021.8	20070.4	0.835	3.032	0.019
MA1F	37	5159.0	877466.6	158134.7	5548.7	953498.7	121382.0	861172.0	87500.1	0.632	4.819	0.000
MA22	20	2175.5	319987.3	83347.3	2747.1	409328.7	31992.2	341897.9	43078.7	0.834	6.419	0.000
MA54	40	12609.1	4691545.8	716810.8	12333.8	4106729.9	303654.7	4280593.4	392635.6	0.842	9.605	0.000

Note: : p-values that fails the test at 95% intervale of confidence (alfa=0.05)

APPENDIX Q

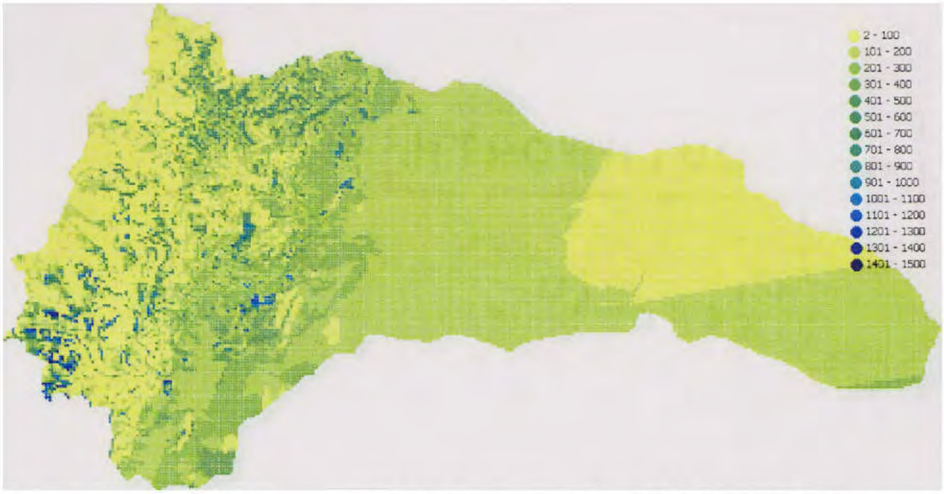


Figure Q.1: Interpolation map 1995-January of monthly precipitation.

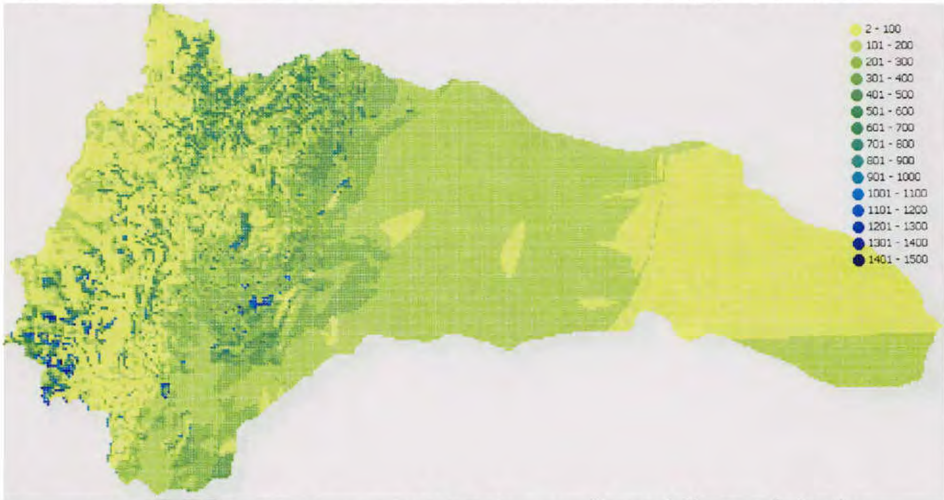


Figure Q.2: Interpolation map 1995-Febrary of monthly precipitation.

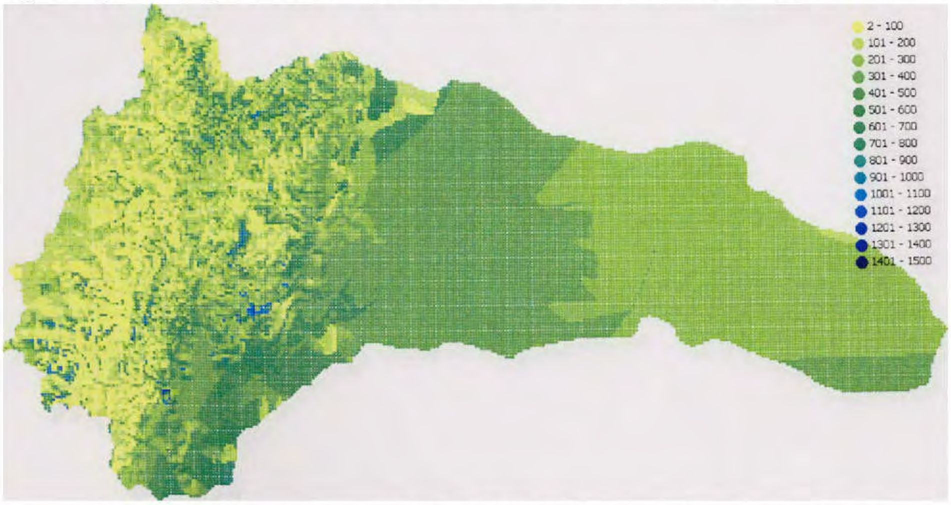


Figure Q.3: Interpolation map 1995-March of monthly precipitation.

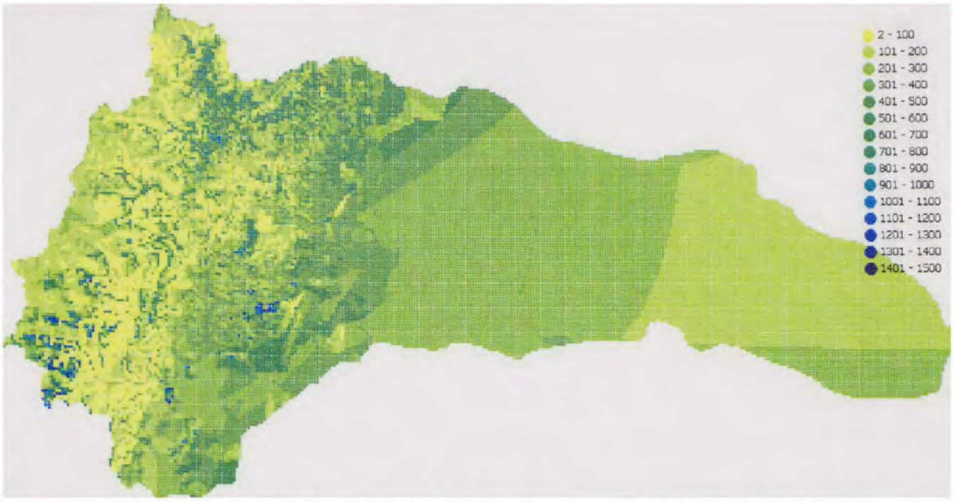


Figure Q.3: Interpolation map 1995-April of monthly precipitation.

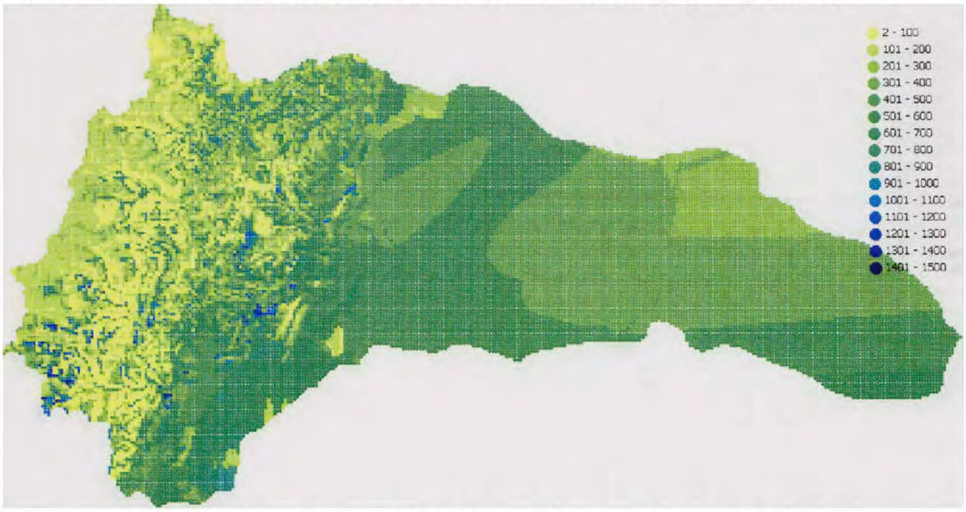


Figure Q.4: Interpolation map 1995-May of monthly precipitation.

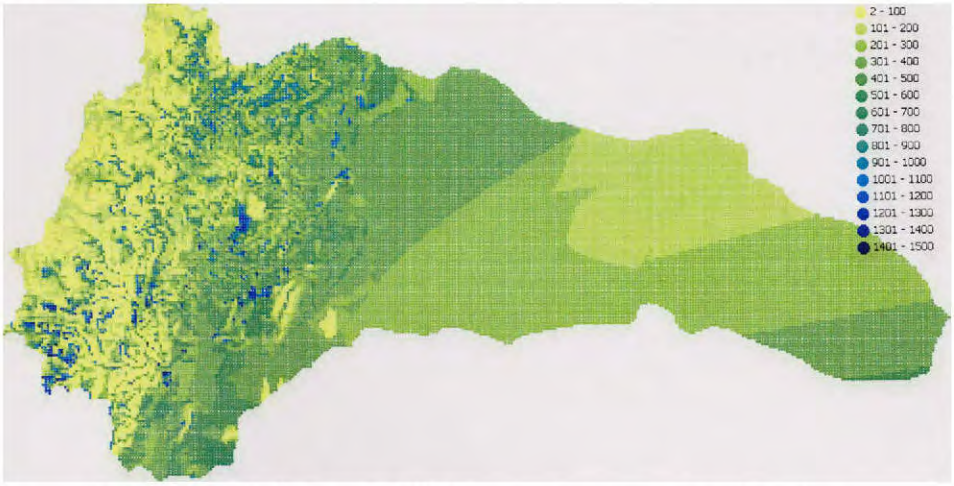


Figure Q.5: Interpolation map 1995-June of monthly precipitation.

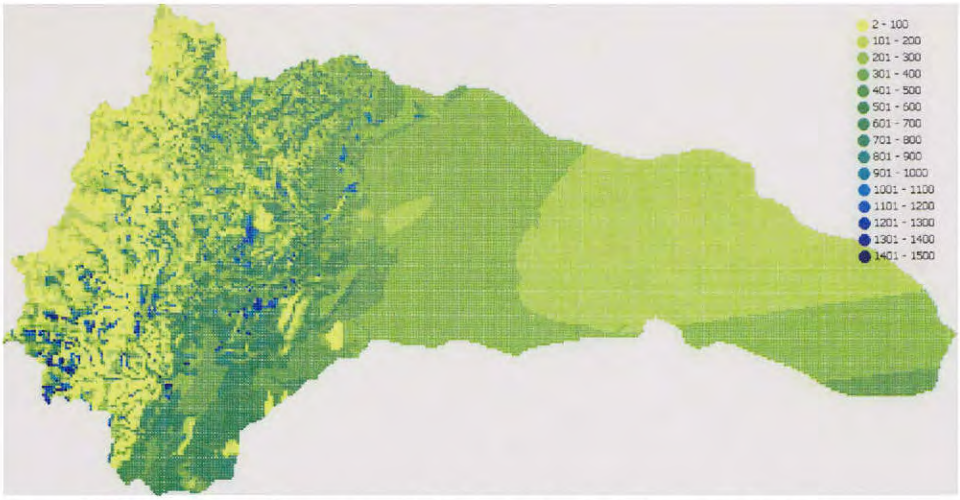


Figure Q.7: Interpolation map 1995-July of monthly precipitation.

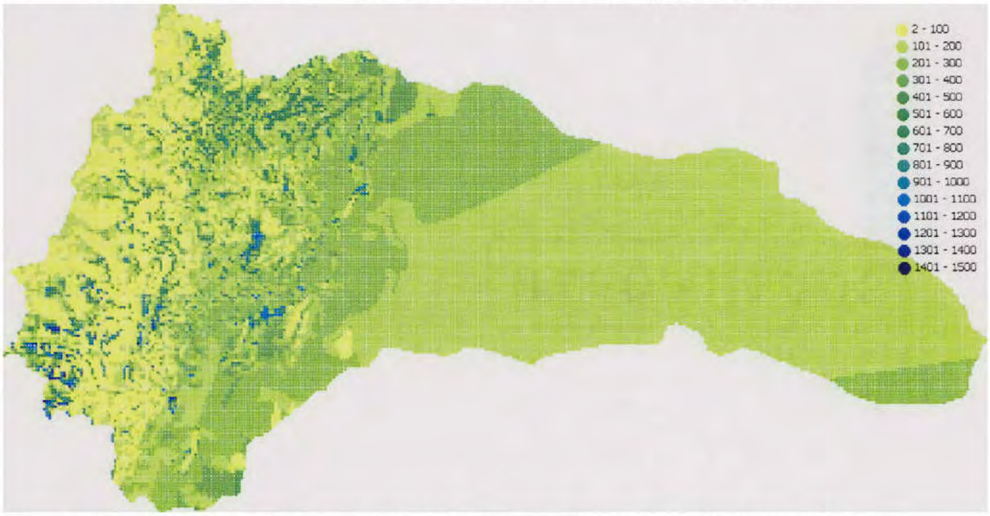


Figure Q.8: Interpolation map 1995-Augoust of monthly precipitation.

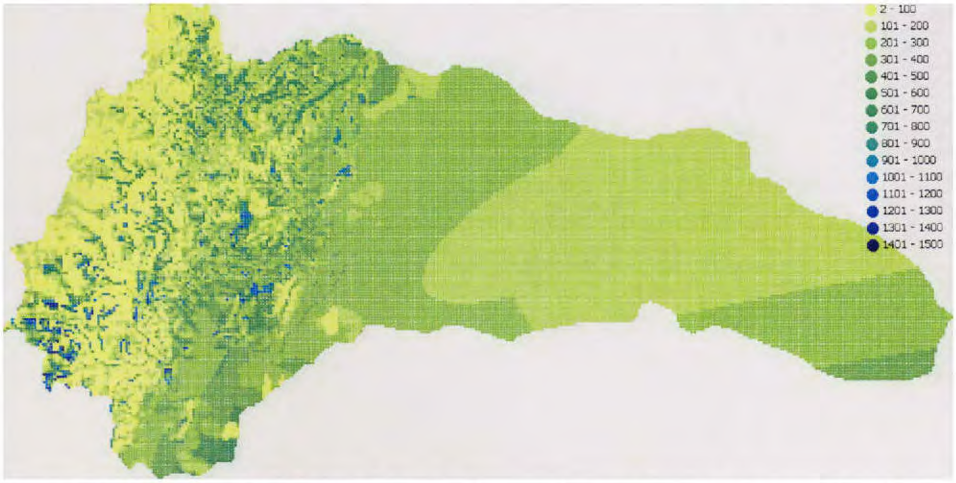


Figure Q.9: Interpolation map 1995-September of monthly precipitation.

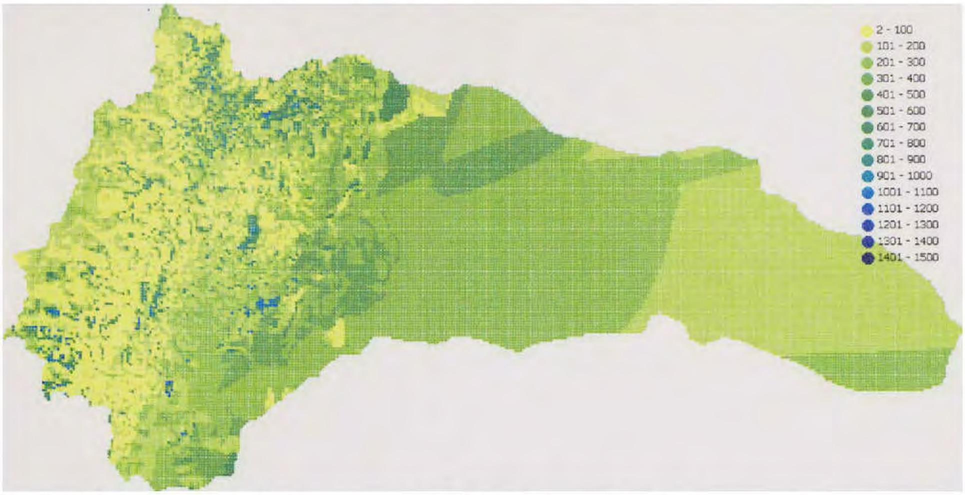


Figure Q.10: Interpolation map 1995-October of monthly precipitation.

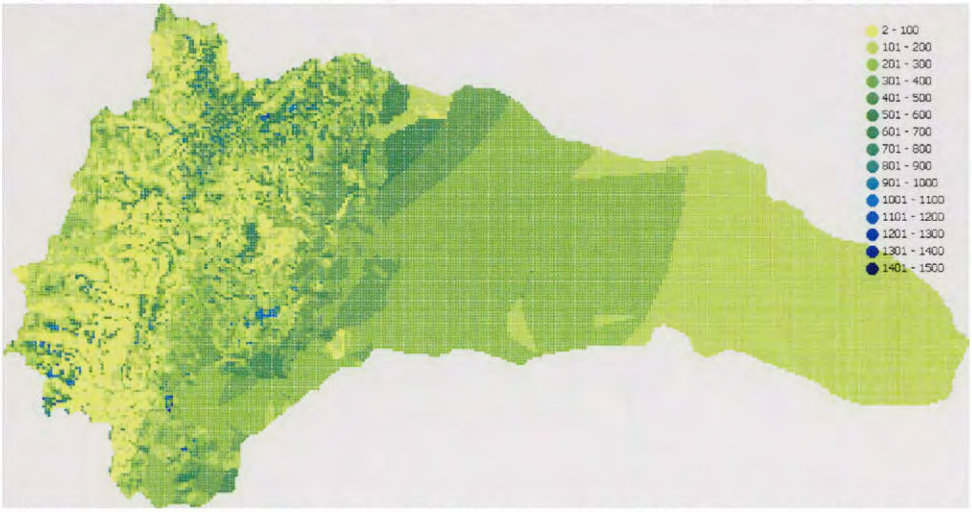


Figure Q.11: Interpolation map 1995-November of monthly precipitation.

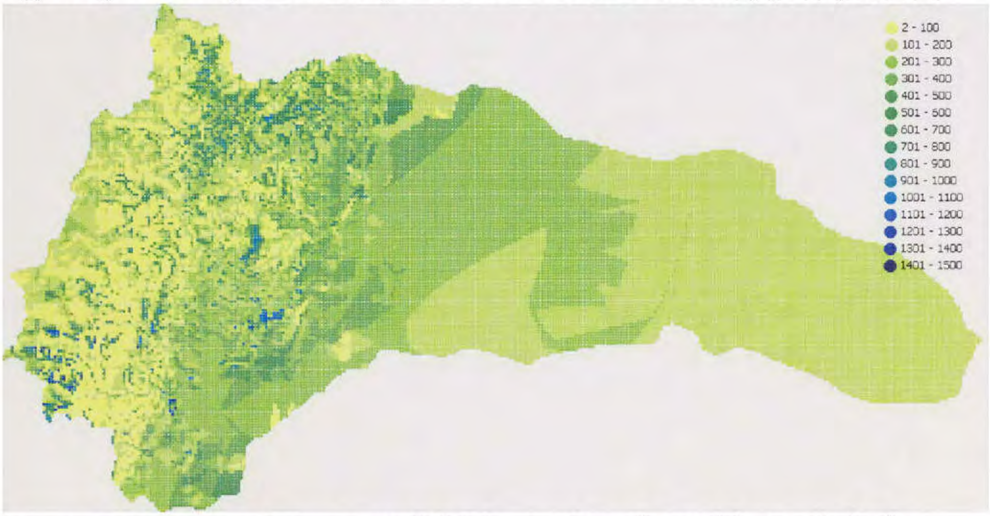


Figure Q.12: Interpolation map 1995-December of monthly precipitation.