

# Multidimensional Analysis of Snow Cover Data in South Dakota Diversity of Landscapes

Nature Precedings: doi:10.1038/npre.2008.24445.1. Posted 27 Oct 2008

Photo picture taken:  
Thursday, March 27, 2008,  
1:45 am

Shmagin, B.A. & C.A. Johnston  
Water Research Institute      Department of Biology & Microbiology

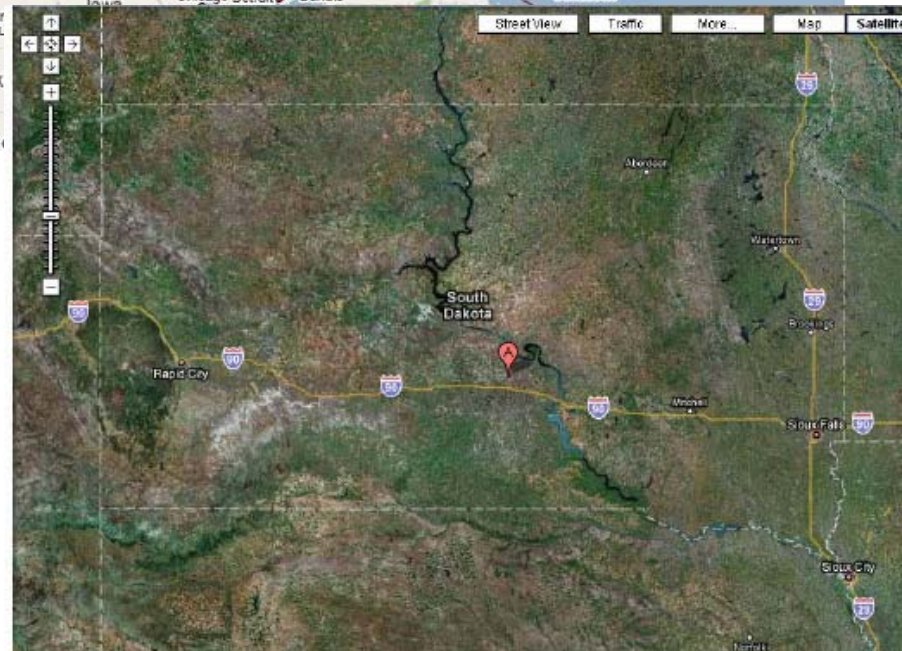
South Dakota State University,  
Brookings, SD



# Topics

- Introduction: maps & snow fall as the most reliable characteristic
- Data & philosophy of analysis
- Analysis of snow fall for period 1955-79
- Regime of snow fall in SD
- Improving the knowledge & creating maps of natural resources of SD
- Questions

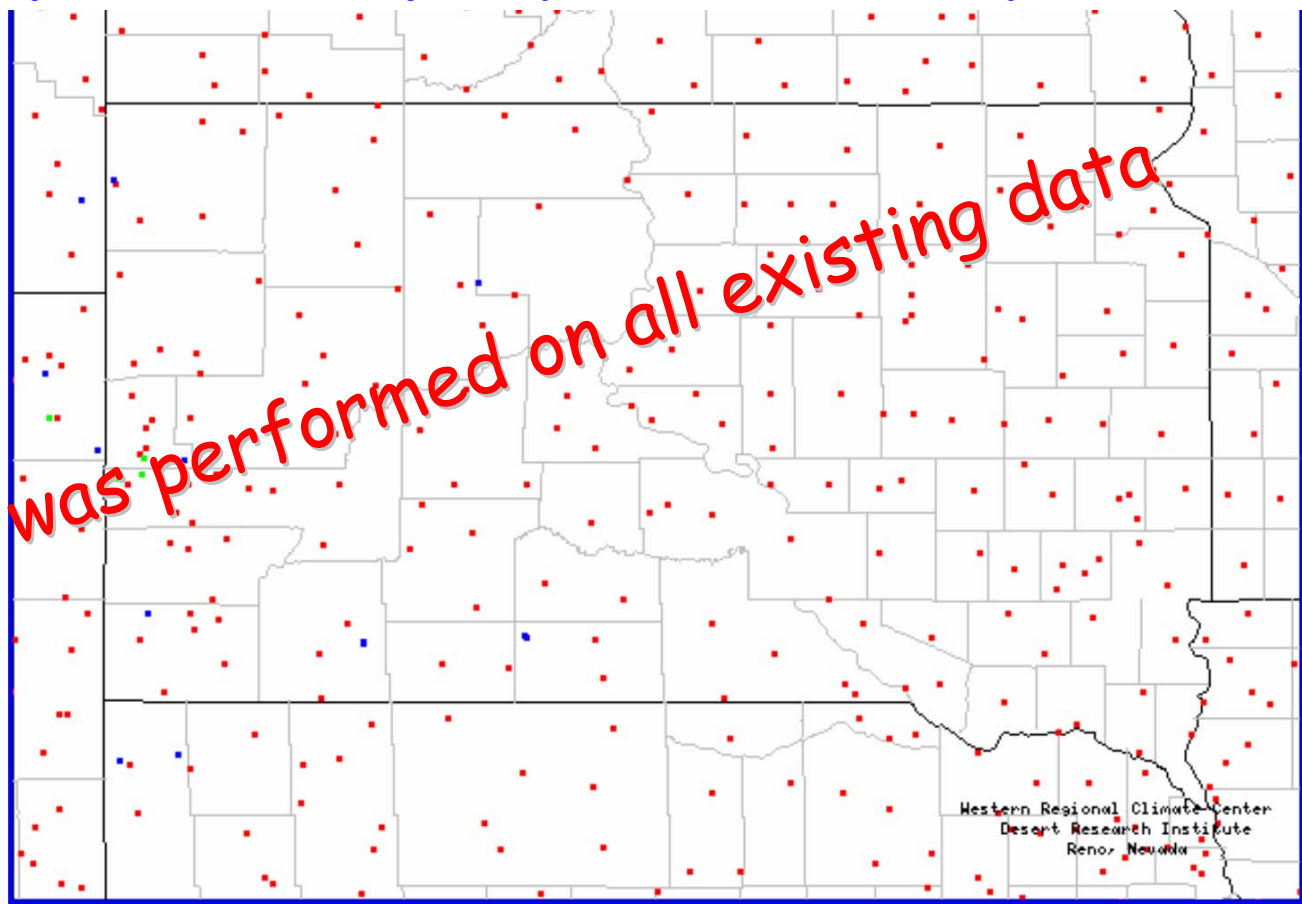
# Maps as a universal tool



[http://hprcc.unl.edu/cgi-bin/cli\\_perl\\_lib/cliMAIN.pl?sd1076](http://hprcc.unl.edu/cgi-bin/cli_perl_lib/cliMAIN.pl?sd1076)

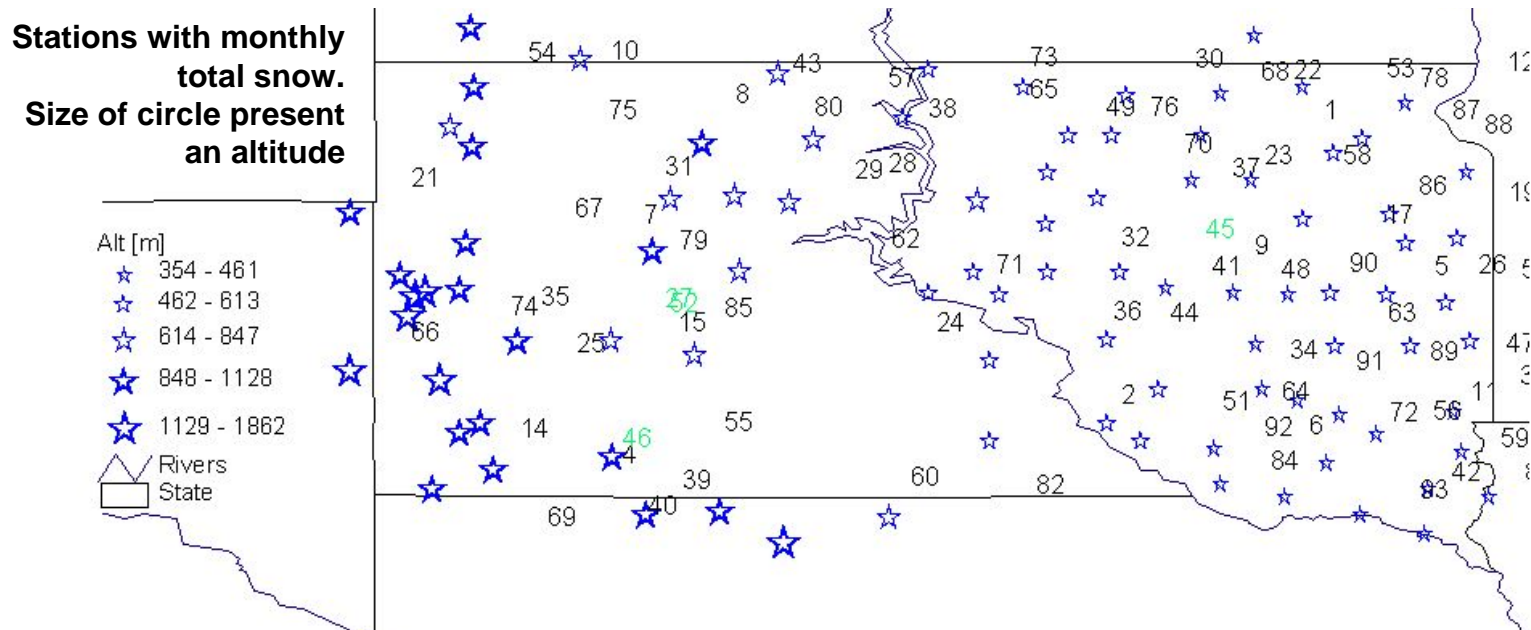
# Data & philosophy of analysis

*The analysis was performed on all existing data*



Western Regional Climate Center  
Desert Research Institute  
Reno, Nevada

# Data on monthly snow fall in SD



Initial matrix:  $X_{(n \times p)}$  or  $X_{(93 \times 11)}$  there are:

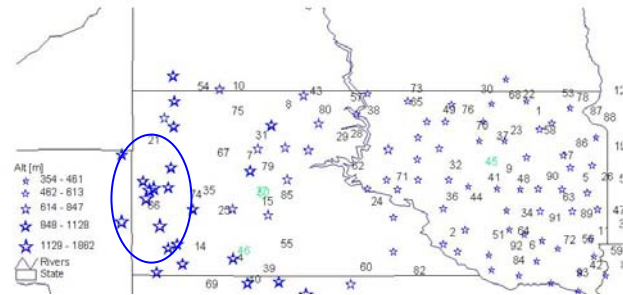
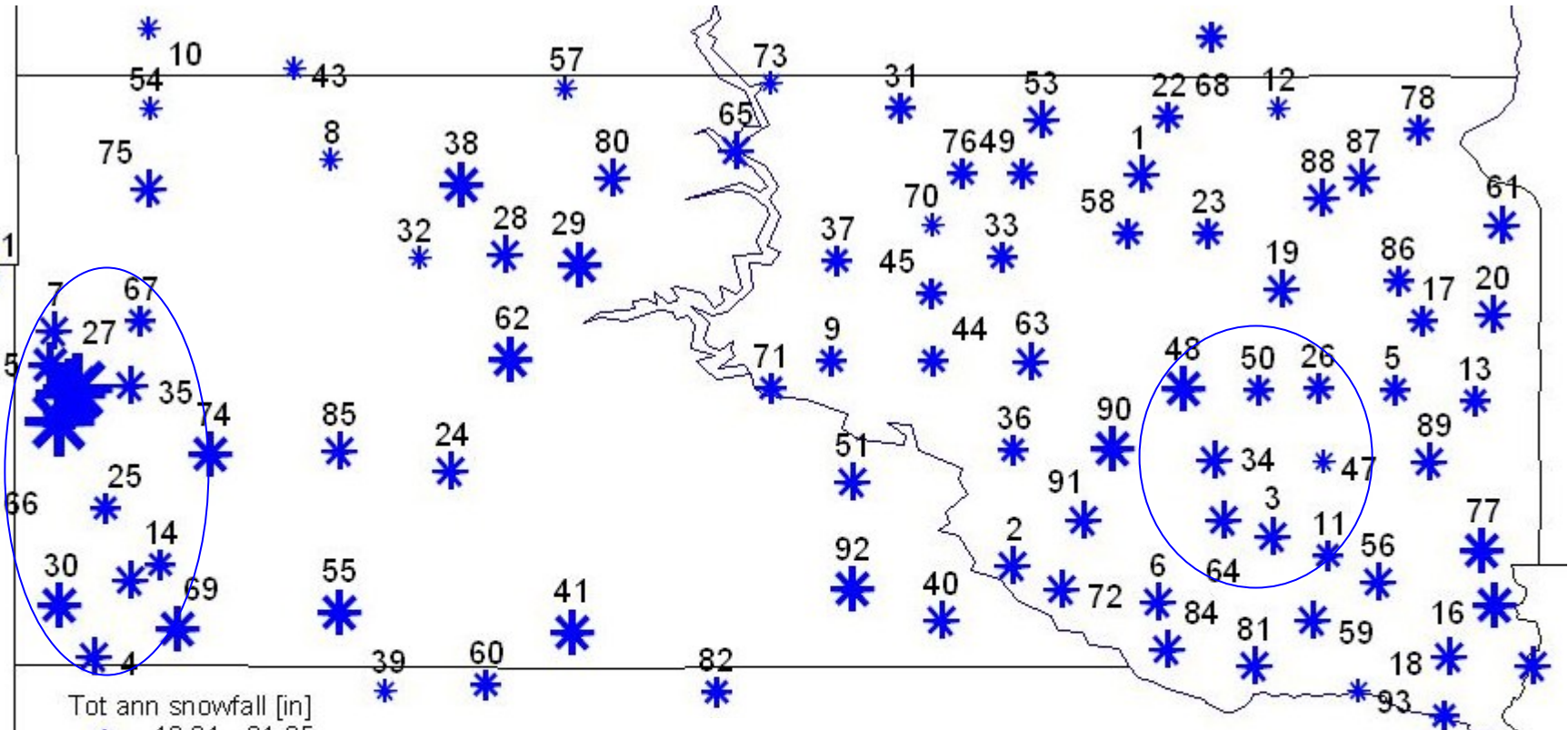
$n=93$  – number of rows or stations, those stations have mutual time interval of 18 winters of observations (1952-53 – 1969-70),

$p=11$  – number of variables or 10 monthly proportions & annual total snowfall for the winter season



# Average annual snow fall in SD

Nature Precedings : doi:10.1038/npre.2008.24445.1 : Posted 27 Oct 2008

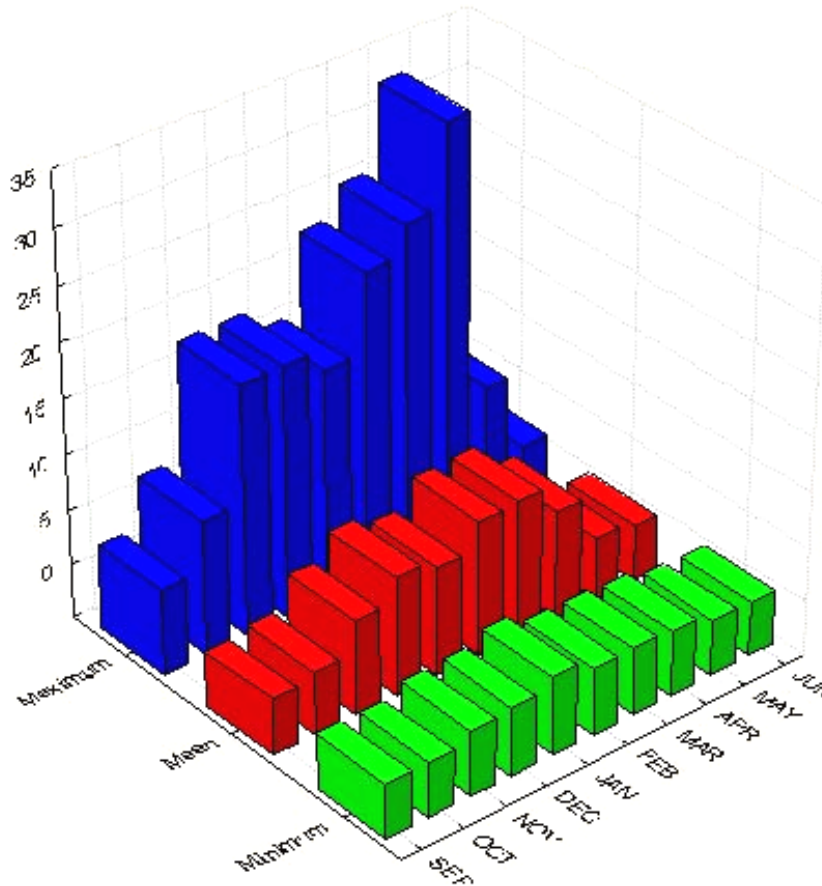


The average annual sum of total monthly snowfall (September-June) for SD **34.6 [in]** obtained on 93 stations for 1952-1970, ranged from **10.21 to 152.3 [in]**

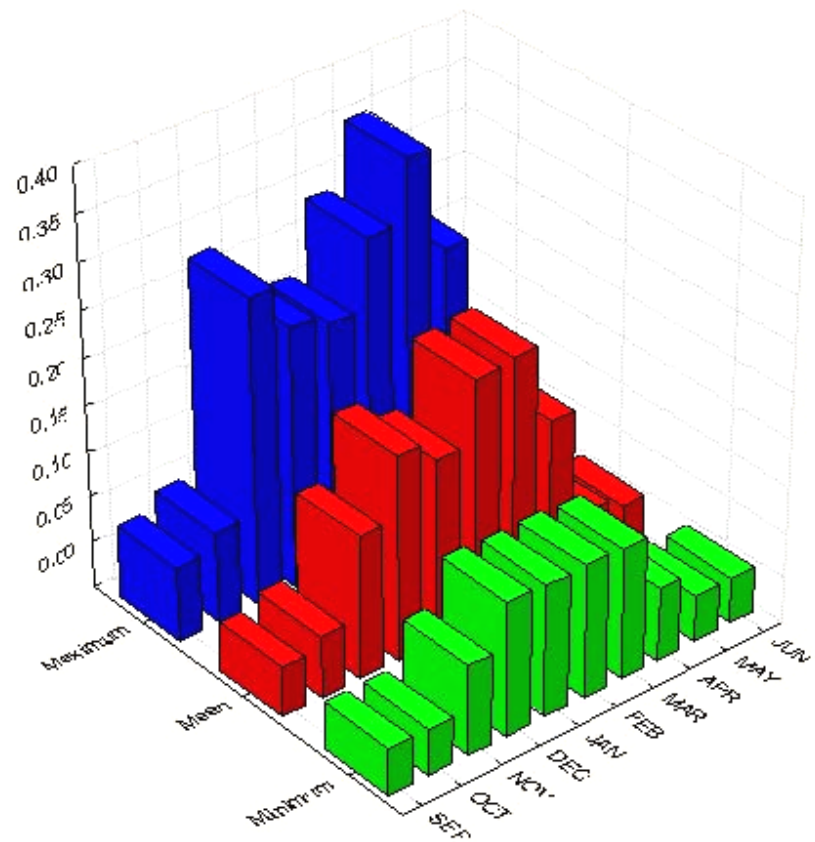
**Stations with monthly total snow. Size of circle present an altitude**

# Average annual snow fall in SD

3D Sequential Graph



3D Sequential Graph



The average total monthly snowfall [in] obtained on 93 stations for 1952-1970 (left) & monthly proportion of total annual

# Data & philosophy of analysis

**Multivariate analysis** is the simultaneous statistical consideration of relationships among many measured properties of a given system (Gould 1996, p. 42;).

A **factor** is a portion of a quantity, usually an integer or polynomial that, when multiplied by other factors, gives the entire quantity.

The determination of factors is called factorization (or sometimes "factoring"). It is usually desired to break factors down into the smallest possible pieces so that no factor is itself factorable.

**Factor analysis** allows the determination of common axes influencing sets of independent measured sets.

The main applications of factor analytic techniques are:

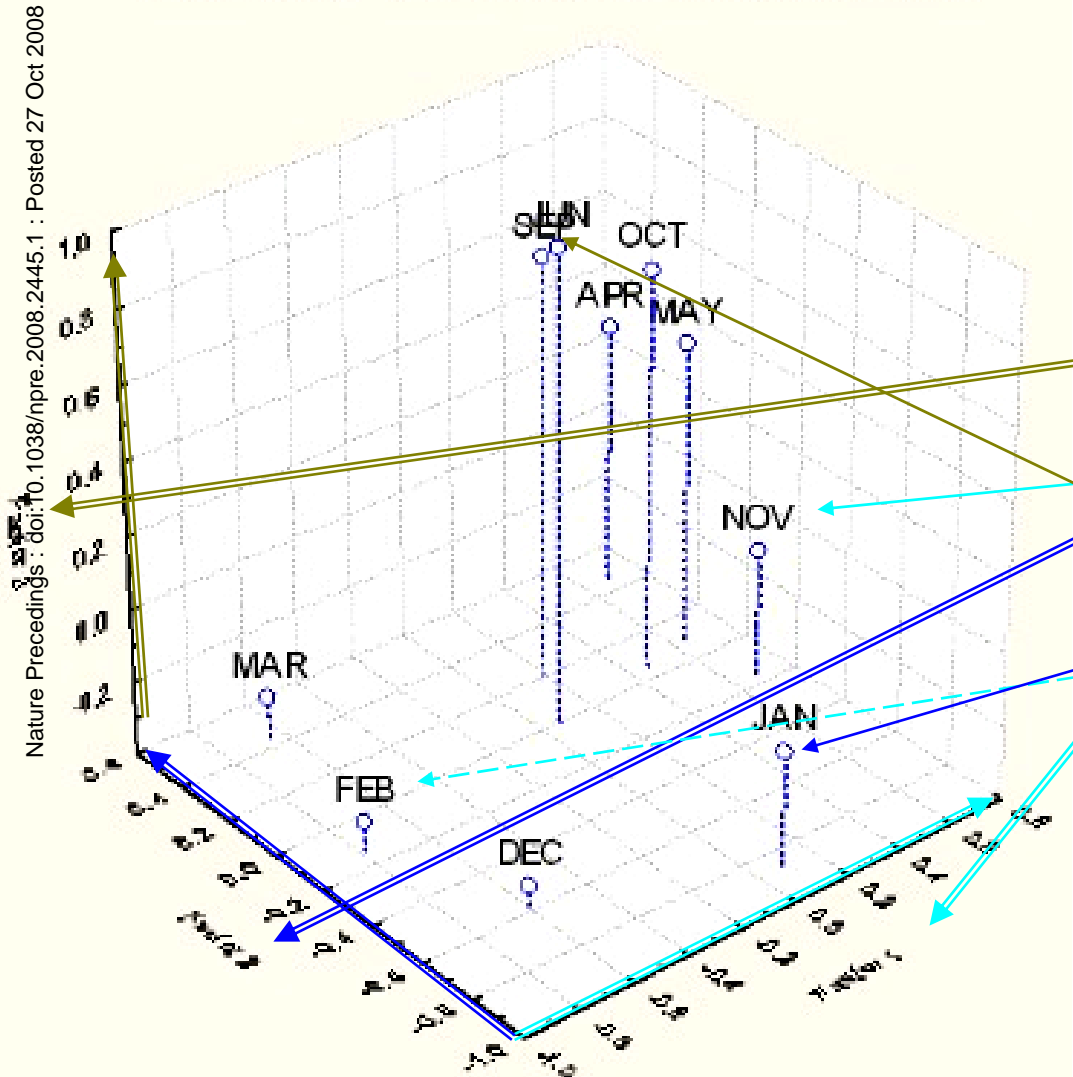
- (1) to *reduce* the number of variables &
- (2) **to detect structure in the relationships between variables.**

(From: Wolfram *MathWorld*)



# Structure of monthly snow fall

3D Scatterplot Factor Loadings (Varimax normalized)



Factor Loading

	Factor 1	Factor 2	Factor 3
SEP			<b>0.74</b>
OCT	0.46		<b>0.69</b>
NOV	<b>0.69</b>		
DEC	<b>-0.59</b>	<b>-0.58</b>	-0.35
JAN		<b>-0.86</b>	
FEB	<b>-0.79</b>		-0.33
MAR	<b>-0.65</b>	0.43	-0.29
APR	<b>0.69</b>	0.46	0.31
MAY	<b>0.65</b>		0.42
JUN			<b>0.88</b>
Expl.Var	<b>3.03</b>	<b>1.58</b>	<b>2.40</b>
Prp.Totl	0.30	0.16	0.24

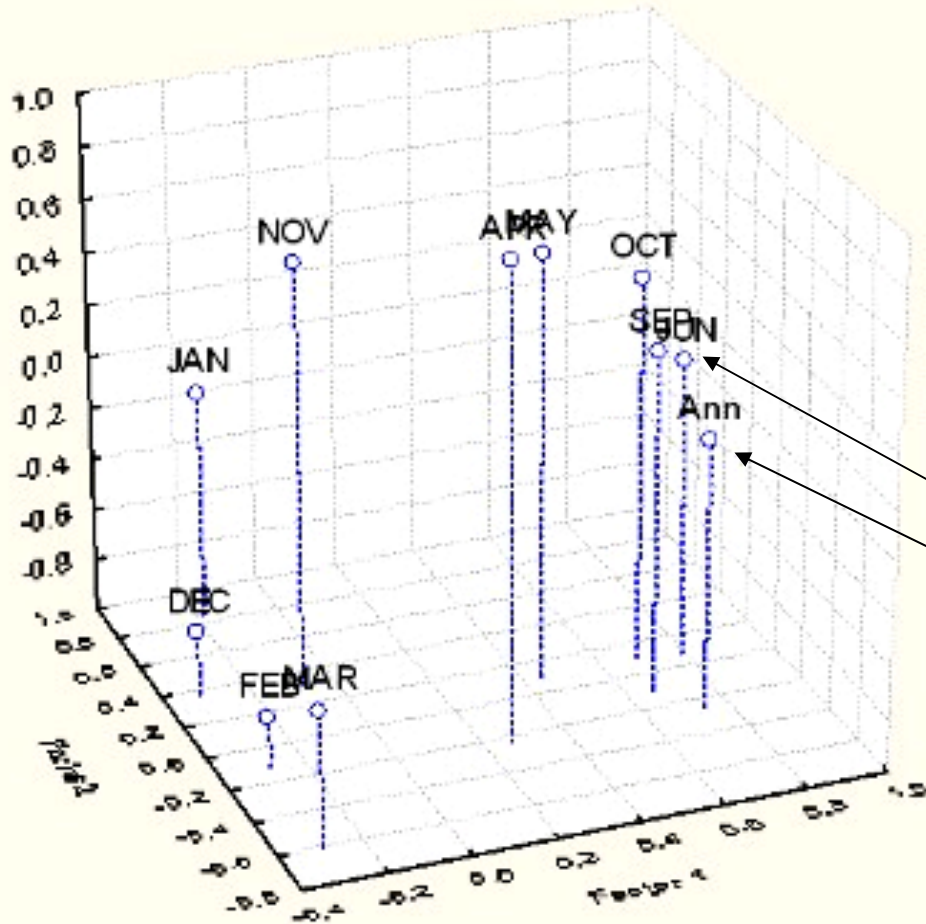
# Annual & monthly snow fall in SD

Factor Loadings, Factor 1 vs. Factor 2 vs. Factor 3

Rotation: Varimax normalized

Extraction: Principal components

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## Factor Loading

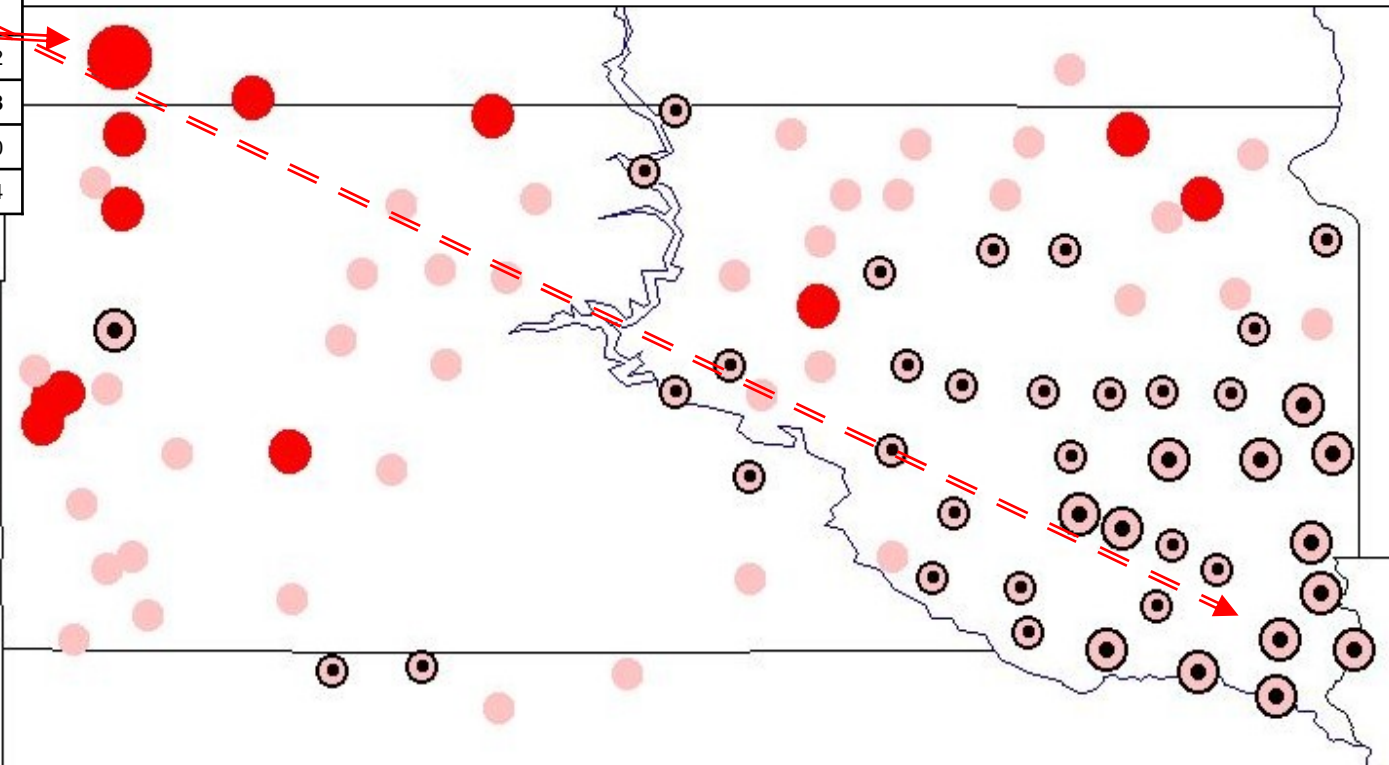
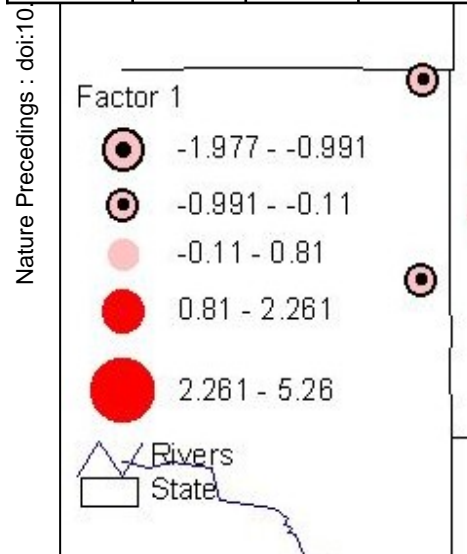
	Factor 1	Factor 2	Factor 3
SEP	<b>0.66</b>		0.31
OCT	<b>0.69</b>		0.47
NOV		0.32	<b>0.62</b>
DEC	-0.31	0.37	<b>-0.76</b>
JAN		<b>0.85</b>	
FEB	-0.28		<b>-0.81</b>
MAR	-0.30	<b>-0.60</b>	-0.48
APR	0.27		<b>0.82</b>
MAY	0.45		<b>0.63</b>
JUN	<b>0.79</b>		
Ann	<b>0.74</b>	-0.25	
Expl.Var	<b>2.66</b>	1.49	<b>3.26</b>
Prp.Totl	0.24	0.14	0.30

# Distribution of monthly snow fall

## Factor 1 Scores distribution

Size of circle present Factor Scores

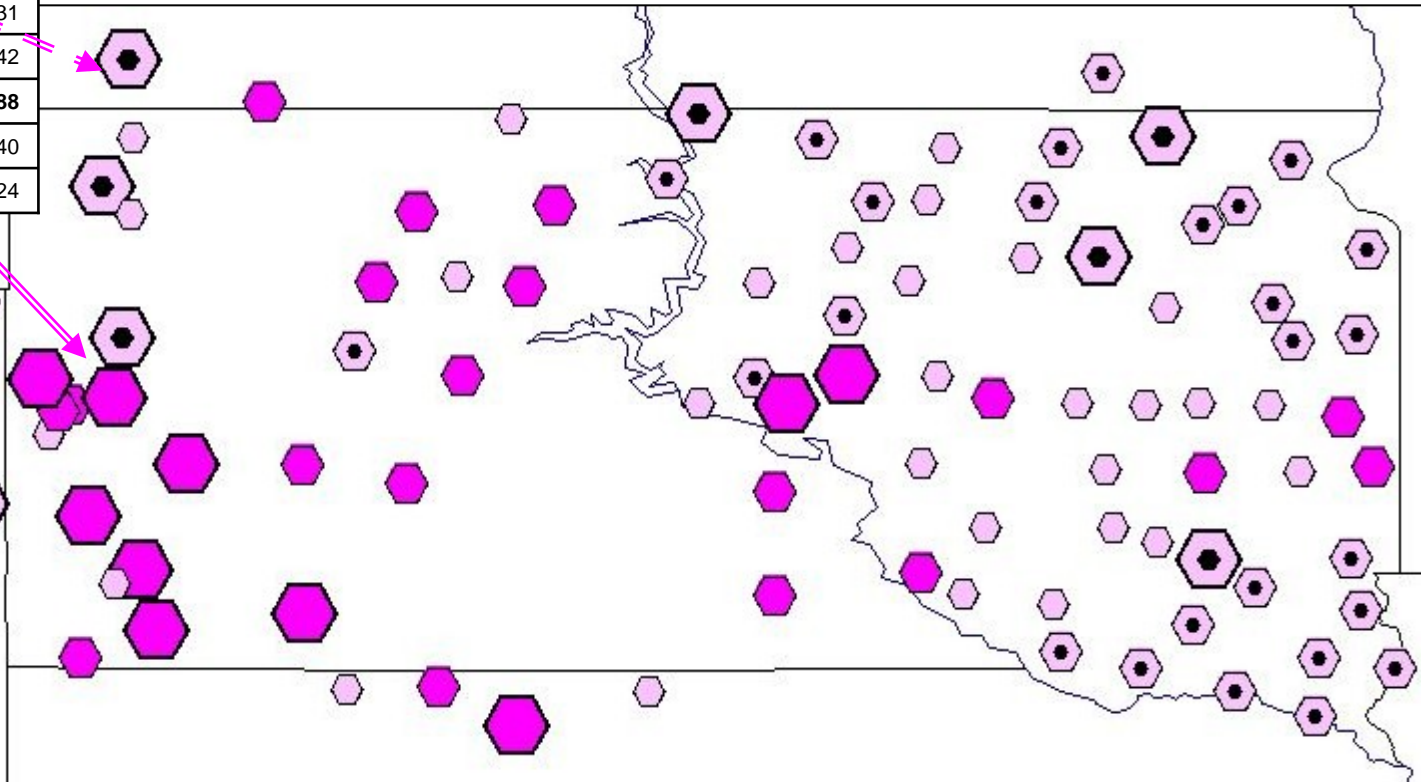
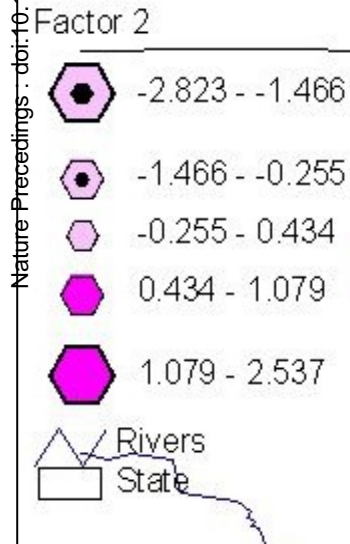
	Factor 1	Factor 2	Factor 3
SEP			<b>0.74</b>
OCT	0.46		<b>0.69</b>
NOV	<b>0.69</b>		
DEC	<b>-0.59</b>	<b>-0.58</b>	-0.35
JAN		<b>-0.86</b>	
FEB	<b>-0.79</b>		-0.33
MAR	<b>-0.65</b>	0.43	-0.29
APR	<b>0.69</b>	0.46	-0.31
MAY	<b>0.65</b>		0.42
JUN			<b>0.88</b>
expl.Var	3.03	1.58	2.40
prop.Totl	0.30	0.16	0.24



# Distribution of monthly snow fall

Factor 2 Scores distribution  
Size of circle present Factor Scores

	Factor 1	Factor 2	Factor 3
SEP			<b>0.74</b>
OCT	0.46		<b>0.69</b>
NOV	<b>0.69</b>		
DEC	<b>-0.59</b>	<b>-0.58</b>	-0.35
JAN		<b>-0.86</b>	
FEB	<b>-0.79</b>		-0.33
MAR	<b>-0.65</b>	0.43	-0.29
APR	<b>0.69</b>	0.46	-0.31
MAY	<b>0.65</b>		0.42
JUN			<b>0.88</b>
Expl.Var	3.03	1.58	2.40
Com.Totl	0.30	0.16	0.24



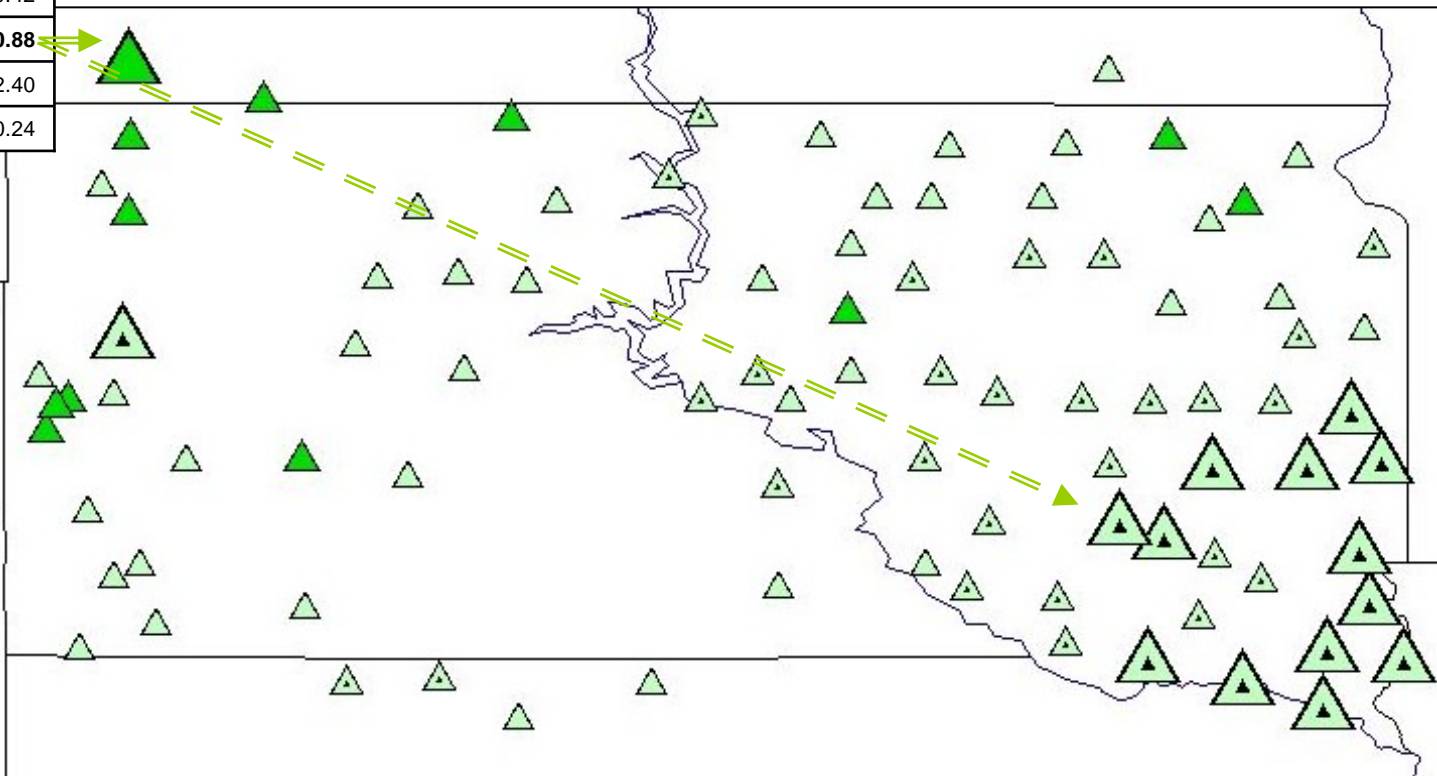
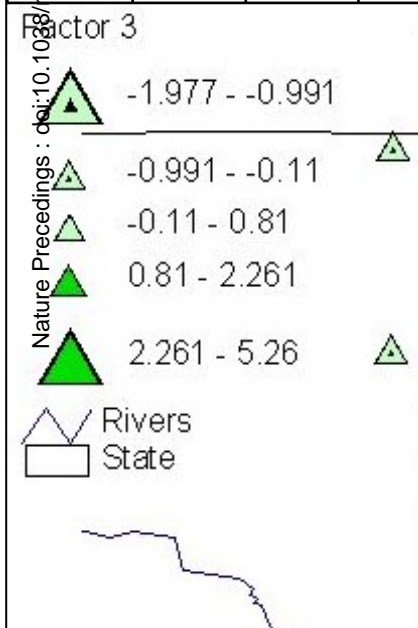


# Distribution of monthly snow fall

## Factor 3 Scores distribution

Size of circle present Factor Scores

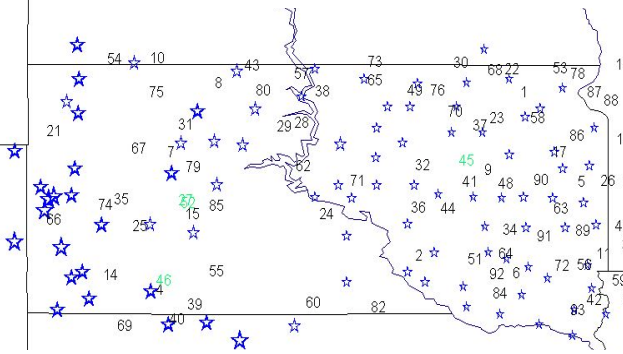
	Factor 1	Factor 2	Factor 3
SEP			<b>0.74</b>
OCT	0.46		<b>0.69</b>
NOV	<b>0.69</b>		
DEC	<b>-0.59</b>	<b>-0.58</b>	-0.35
JAN		<b>-0.86</b>	
FEB	<b>-0.79</b>		-0.33
MAR	<b>-0.65</b>	0.43	-0.29
APR	<b>0.69</b>	0.46	0.31
MAY	<b>0.65</b>		0.42
JUN			<b>0.88</b>
Pl.Var	3.03	1.58	2.40
Per.Totl	0.30	0.16	0.24



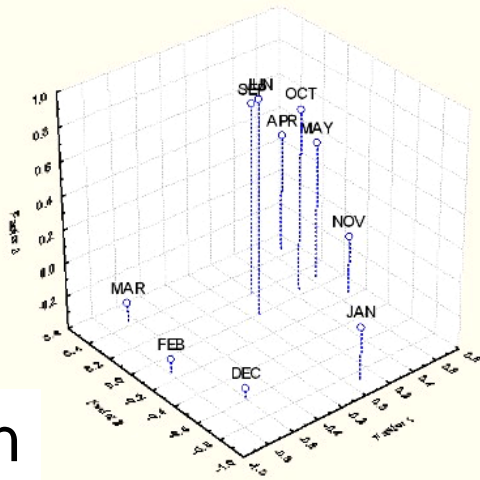
# Structure of monthly snow fall

Size of circle present an altitude

Stations with monthly data



3D Scatterplot Factor Loadings (Varimax normalized)



	[in]	Factor 1	Factor 2	Factor 3
SEP	<b>.15</b>			<b>0.74</b>
OCT	<b>.66</b>	0.46		<b>0.69</b>
NOV	<b>3.6</b>	<b>0.69</b>		
DEC	<b>5.7</b>	<b>-0.59</b>	<b>-0.58</b>	-0.35
JAN	<b>4.9</b>		<b>-0.86</b>	
FEB	<b>7.2</b>	<b>-0.79</b>		-0.33
MAR	<b>7.6</b>	<b>-0.65</b>	0.43	-0.29
APR	<b>4.9</b>	<b>0.69</b>	0.46	0.31
MAY	<b>.57</b>	<b>0.65</b>		0.42
JUN	<b>.04</b>			<b>0.88</b>
Expl.Var		3.03	1.58	2.40
Prp.Totl		0.30	0.16	0.24

## Factor Scores distribution

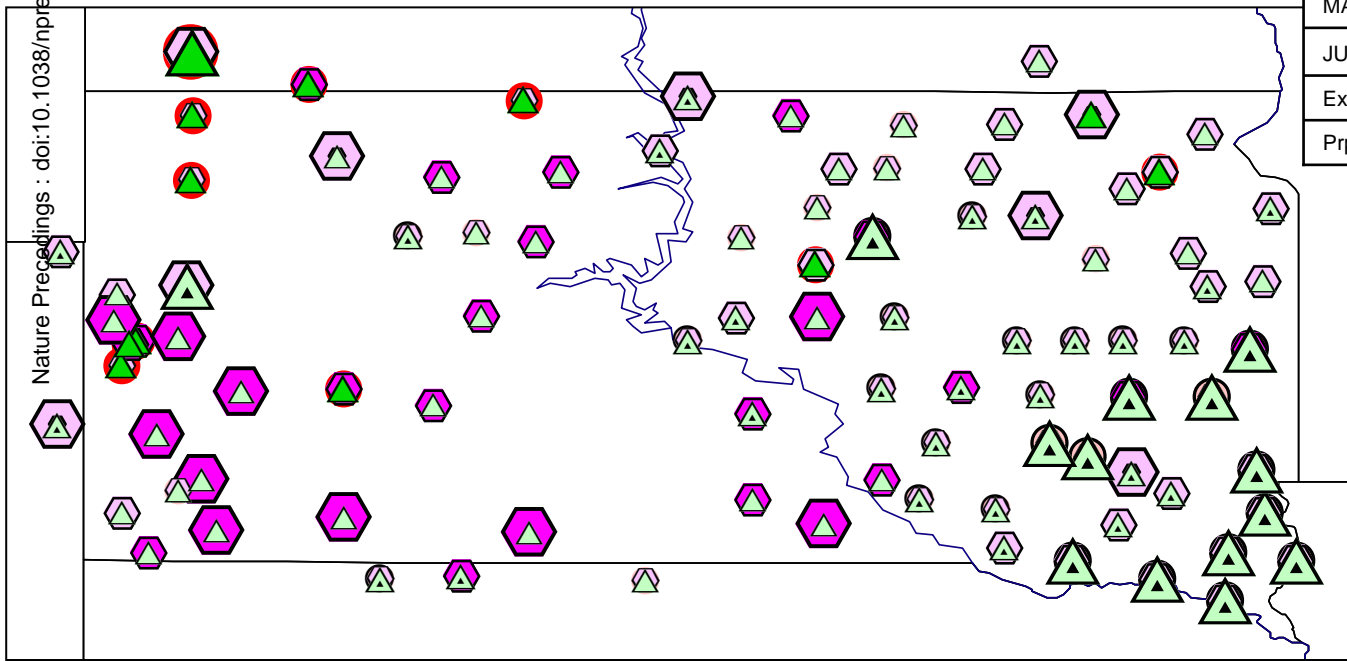
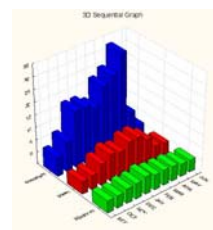


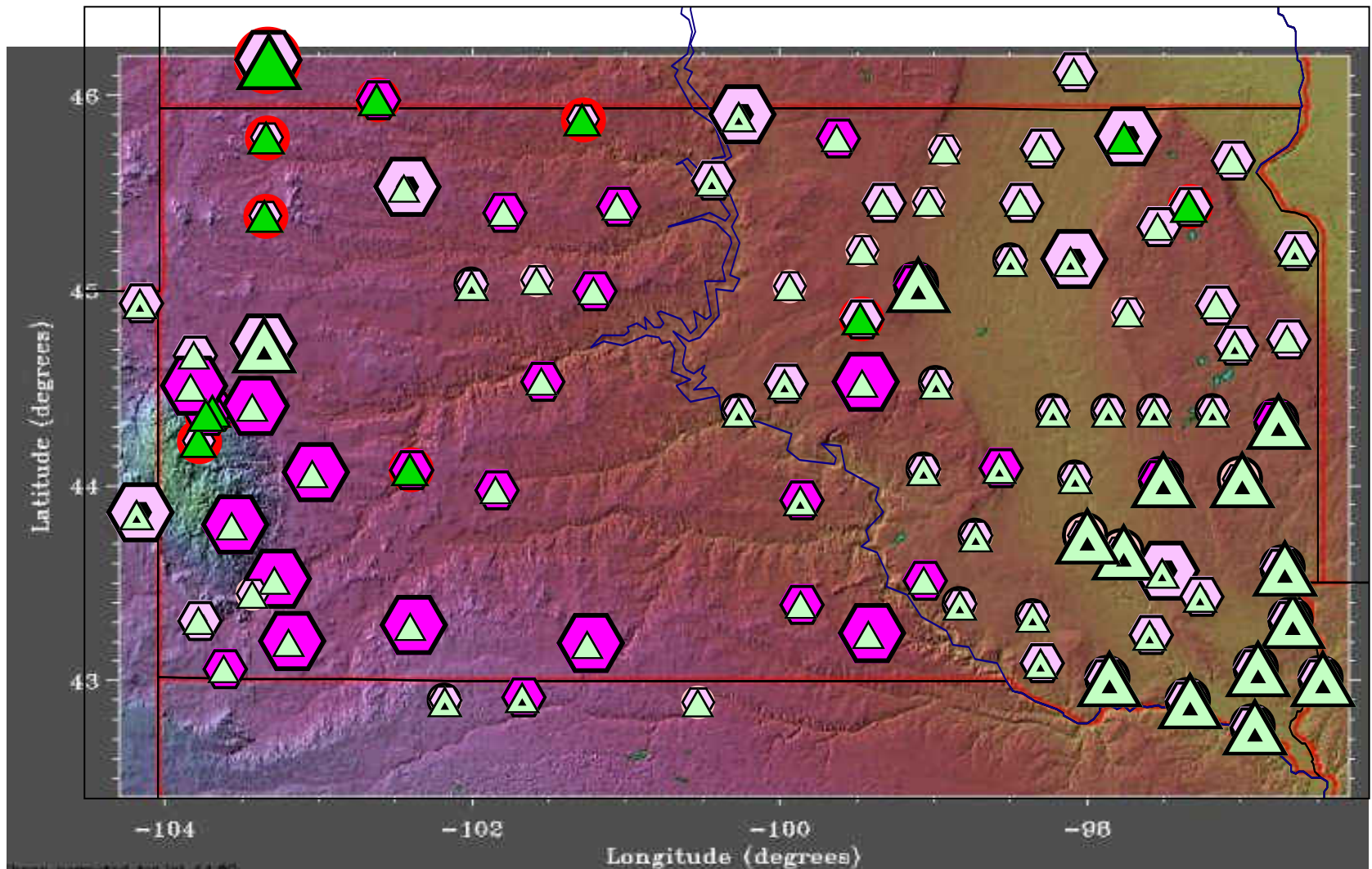
Table of average total annual snow fall & Factor Loading



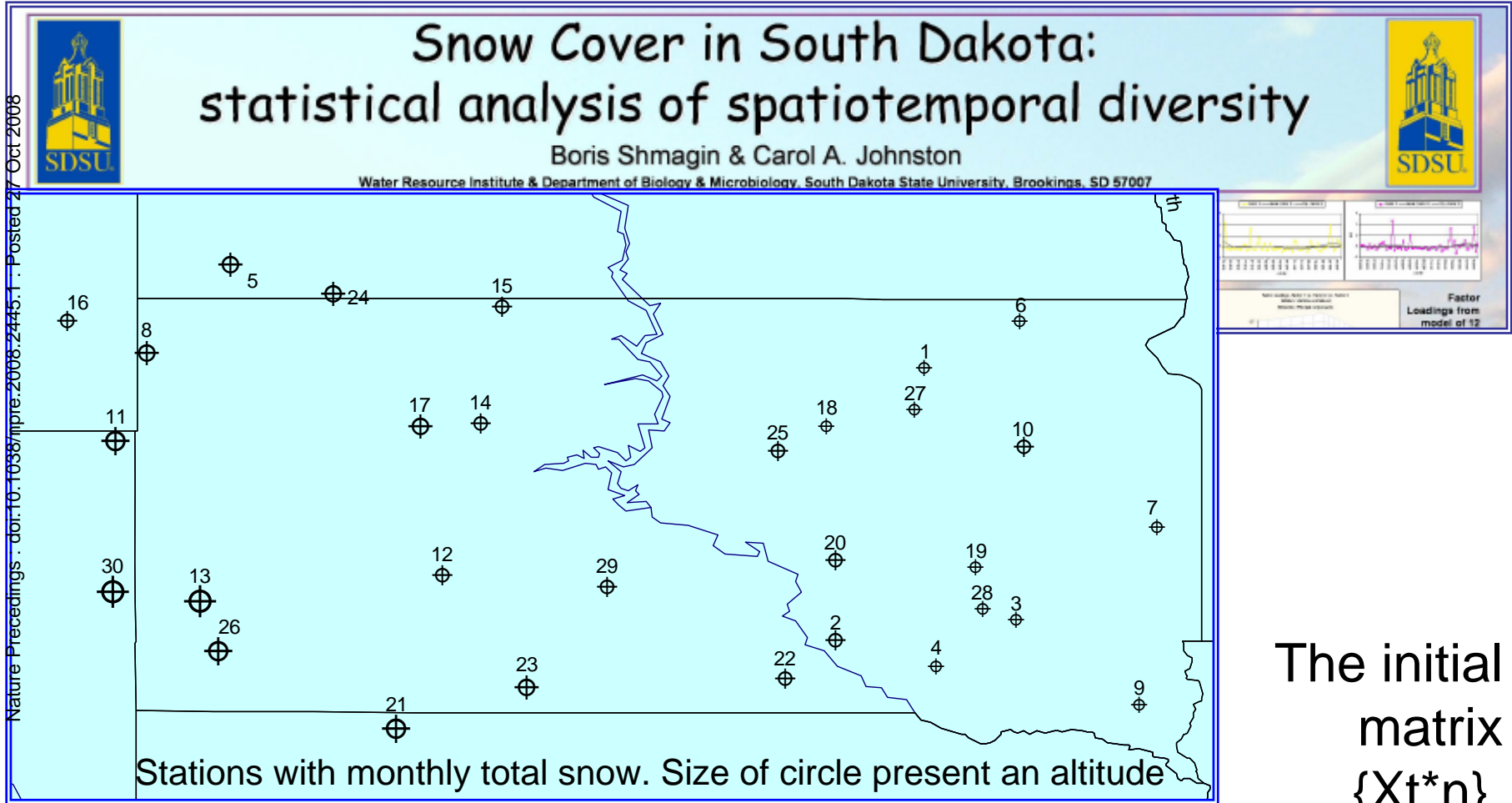
Nature Precedings : doi:10.1038/npre.2008.24445.1 : Posted 27 Oct 2008

# Snow fall & landscapes of SD

Nature Precedings : doi:10.1038/npre.2008.24445.1 : Posted 27 Oct 2008



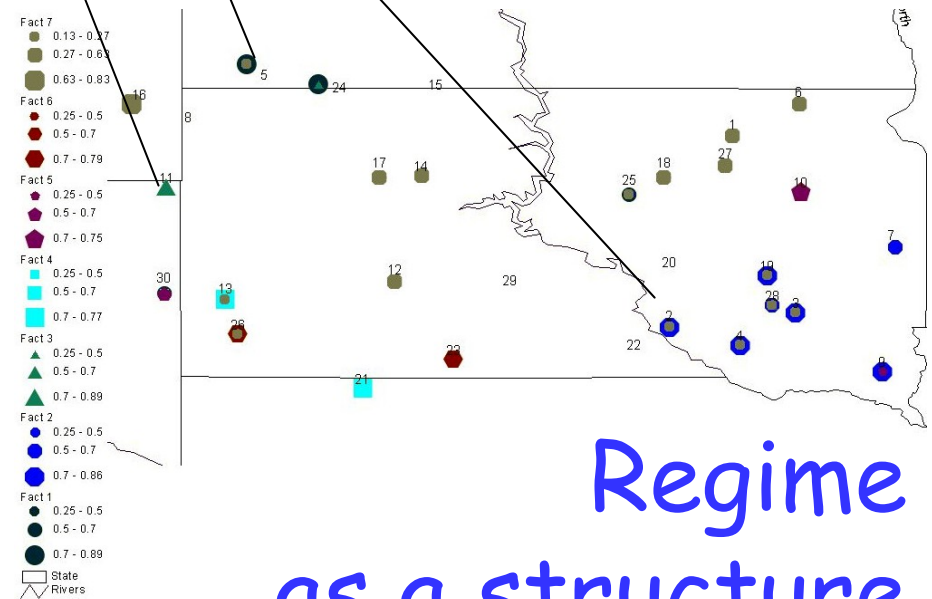
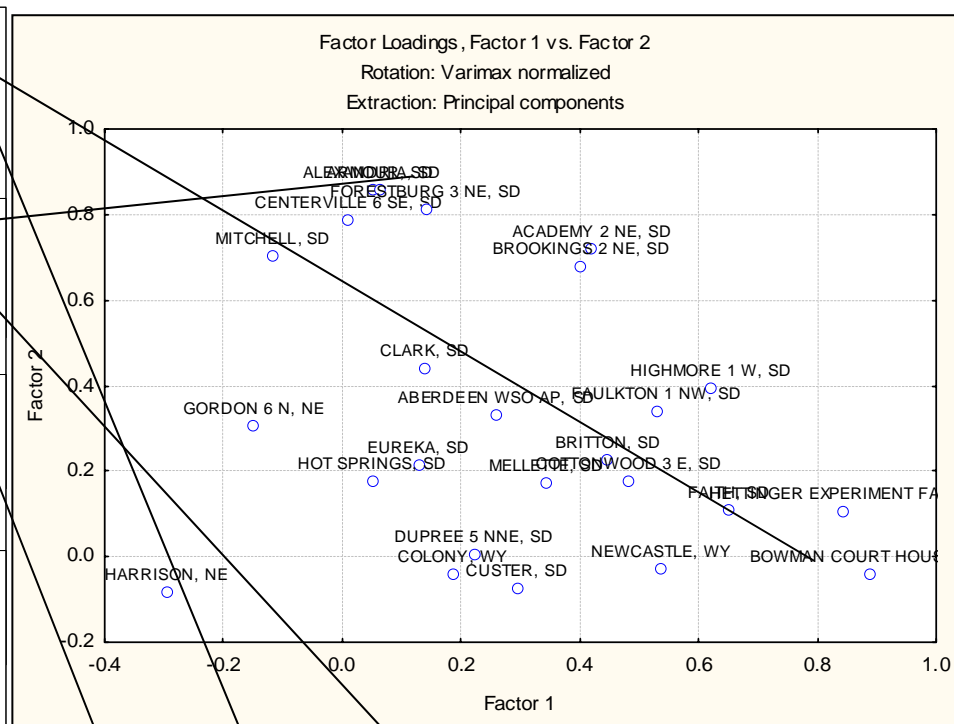
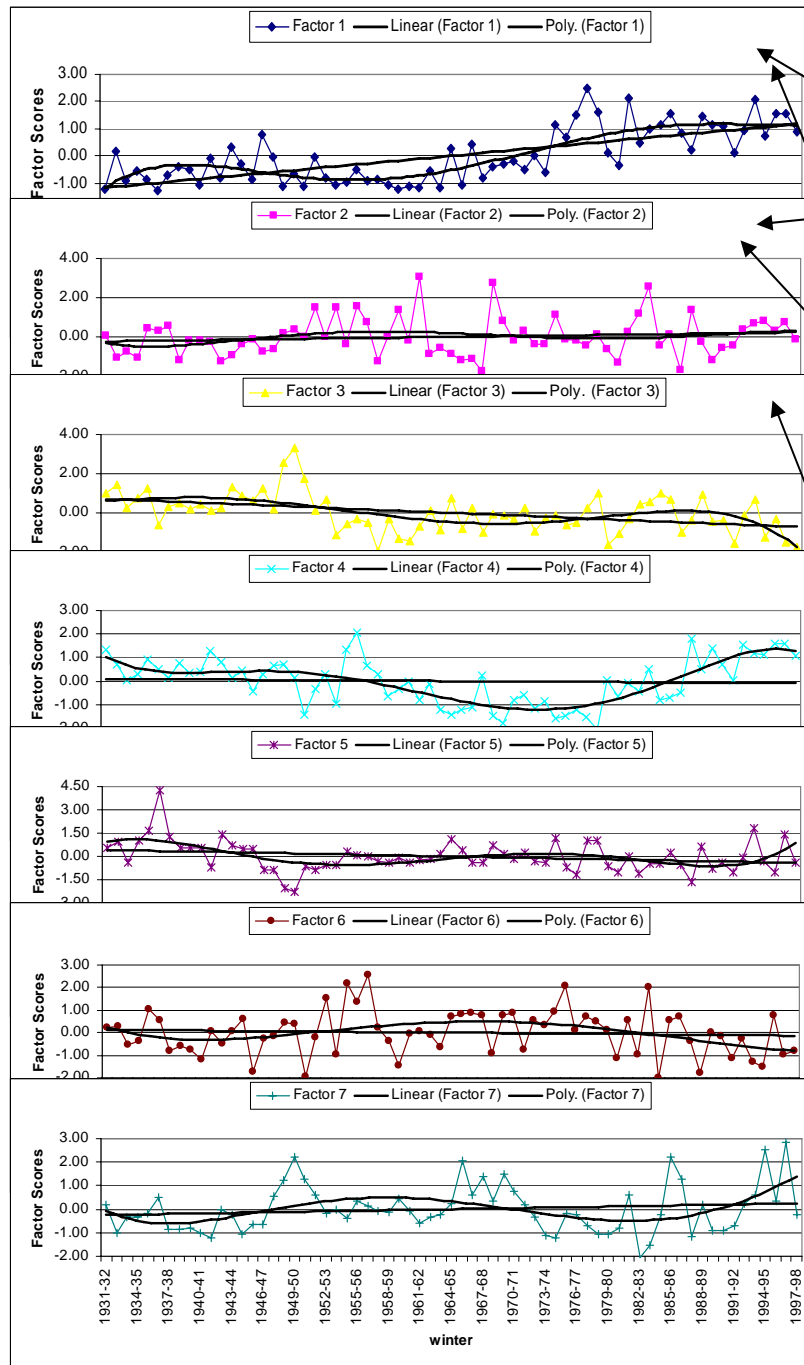
# Regime of snow fall in SD



The initial matrix  $\{X_t \times n\}$ ,

where are:  $t$  = number of years (67- 1931-1998) &  $n$  = number of meteorological stations (25),

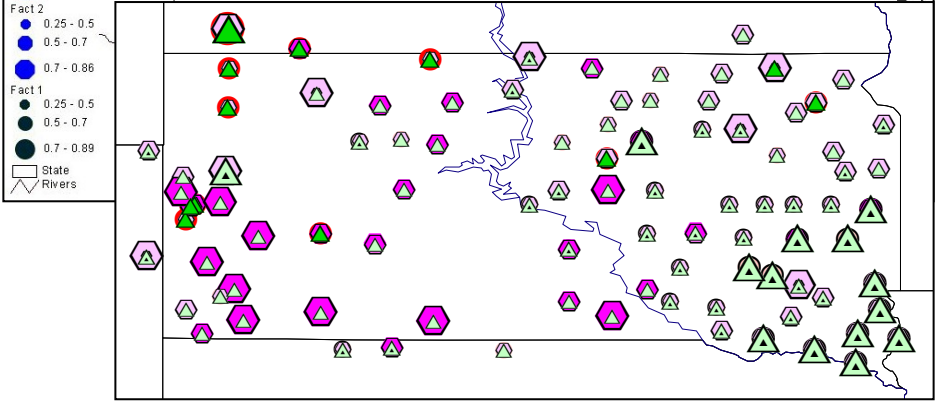
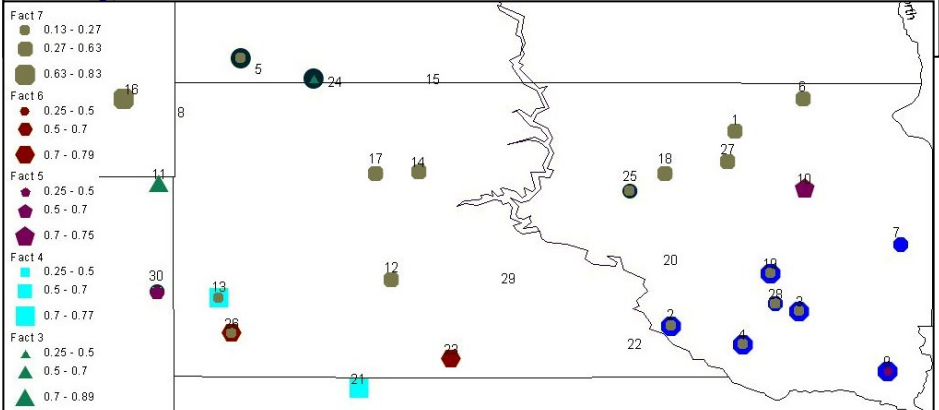
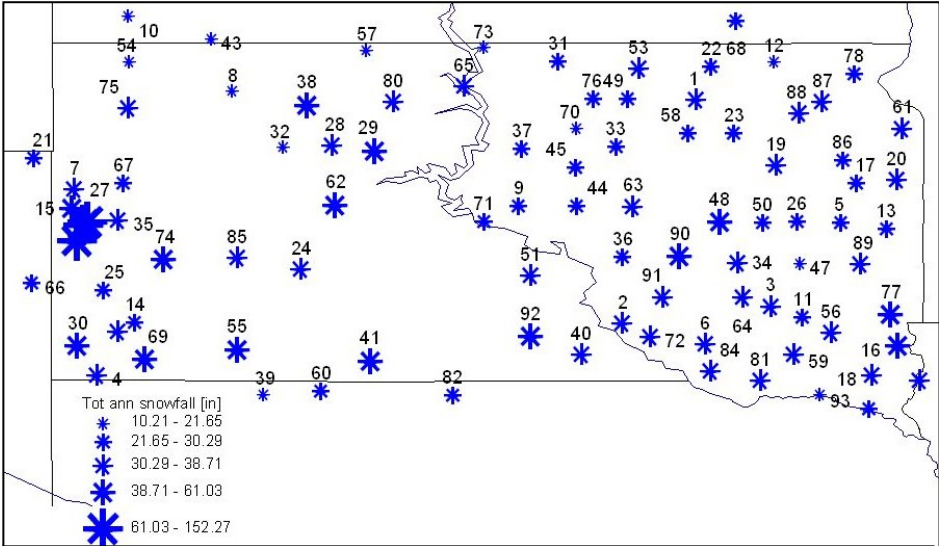
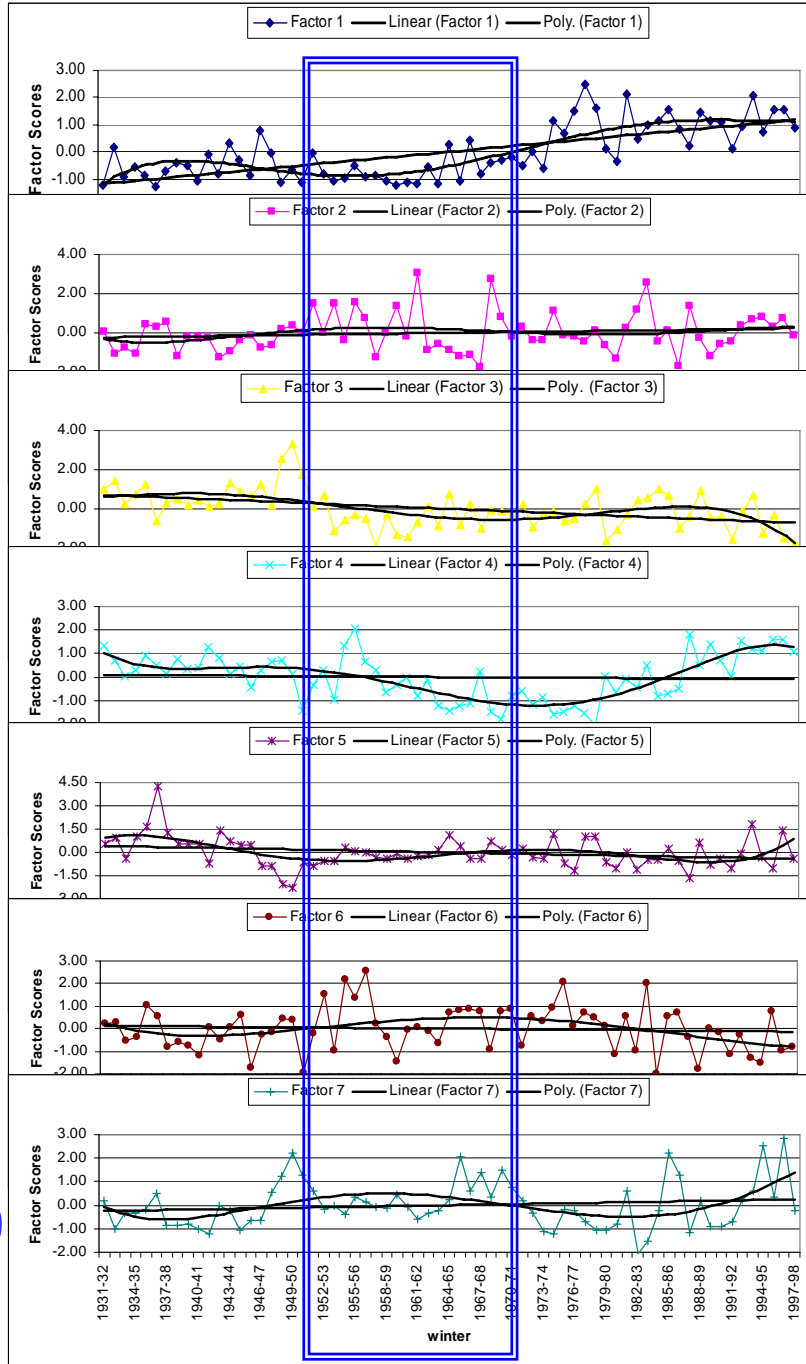




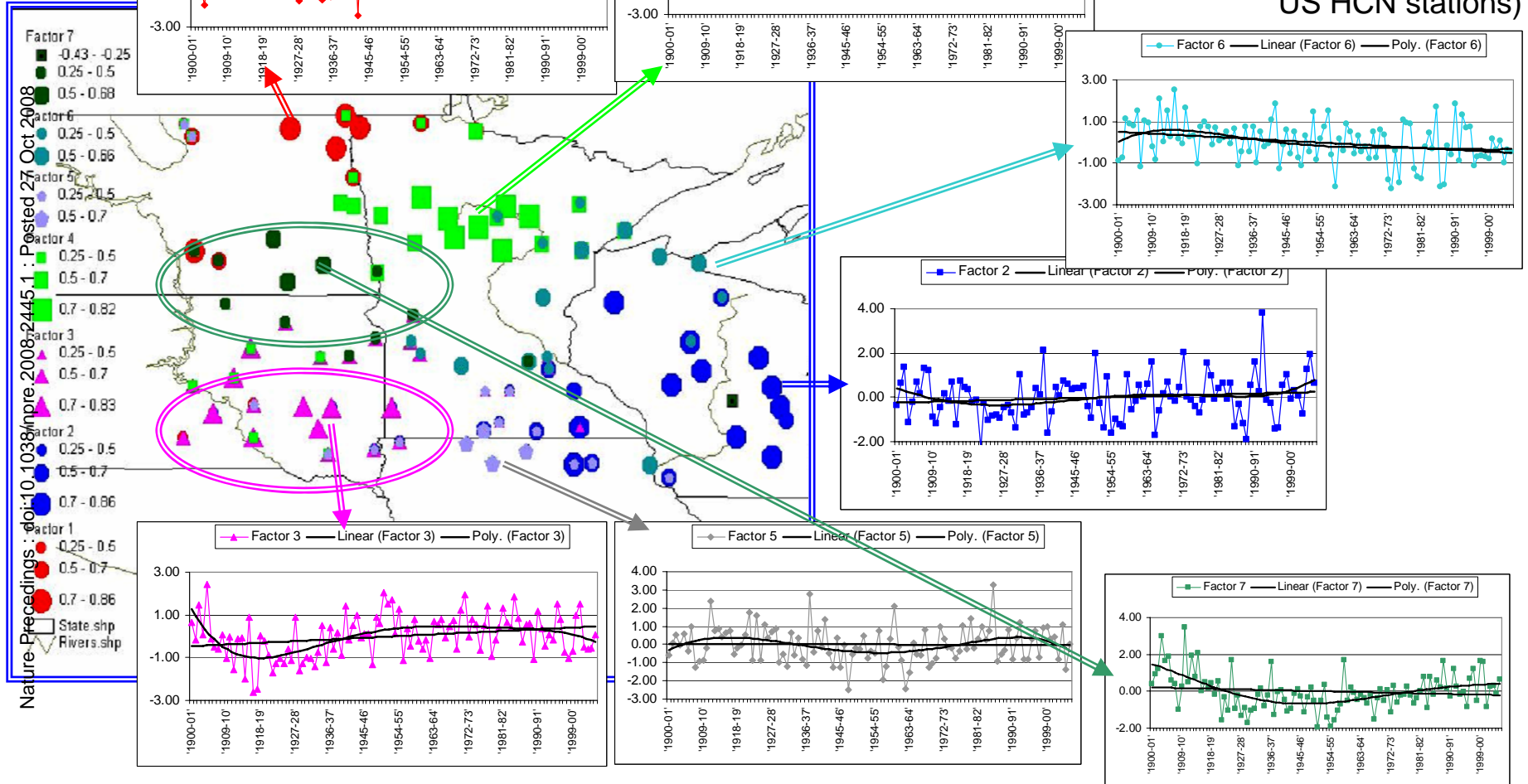
Regime  
 as a structure

# Regime & snowfall distribution

Nature Precedings : doi:10.1038/npre.2006.2445.1 : Posted 27 Oct 2006



# Spatial temporal structure of annual precipitations regime in MN & around for 1930-31 – 1984-85 hydrologic years (87 US HCN stations)



# Precipitation regime around SD

# Improving the knowledge & creating maps of natural resources of SD

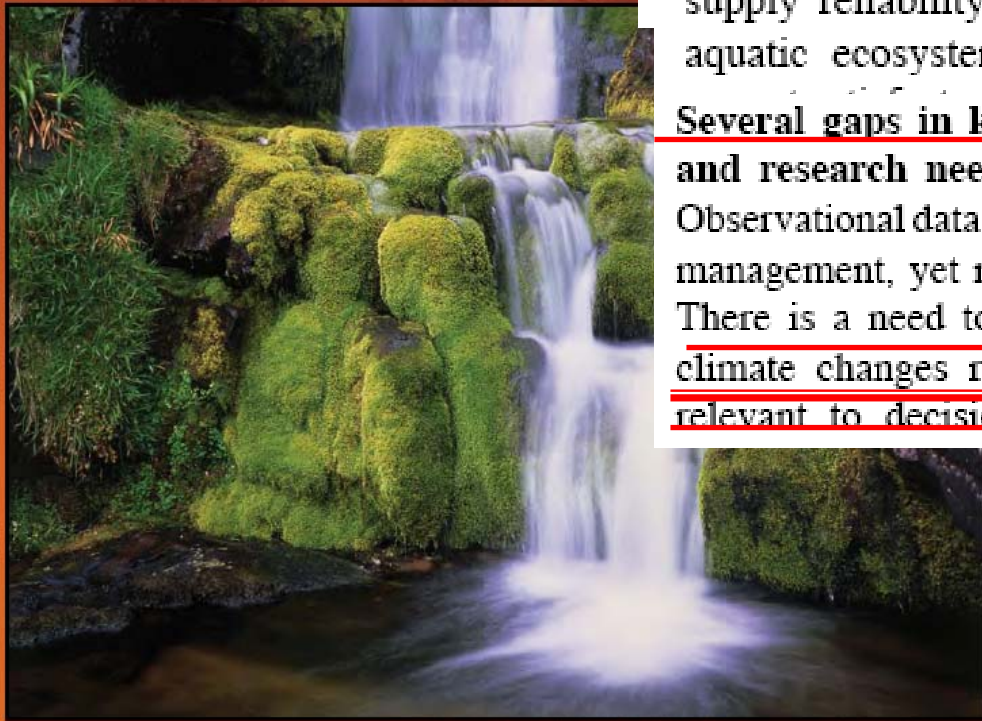


# CLIMATE CHANGE AND WATER

IPCC Technical Pa

Observed warming over several decades has been linked to changes in the large-scale hydrological cycle such as: increasing atmospheric water vapour content; changing Current water management practices may not be robust enough to cope with the impacts of climate change on water supply reliability, flood risk, health, agriculture, energy and aquatic ecosystems. In many locations, water management

Several gaps in knowledge exist in terms of observations and research needs related to climate change and water. Observational data and data access are prerequisites for adaptive management, yet many observational networks are shrinking. There is a need to improve understanding and modelling of climate changes related to the hydrological cycle at scales relevant to decision making. Information about the water-



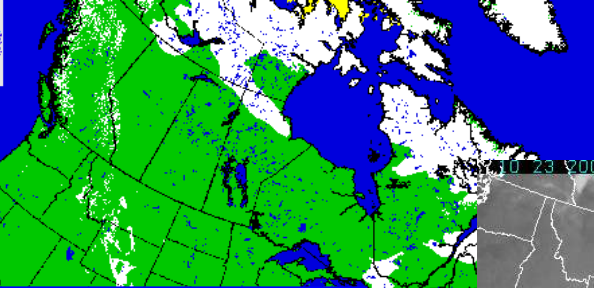
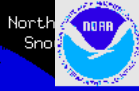
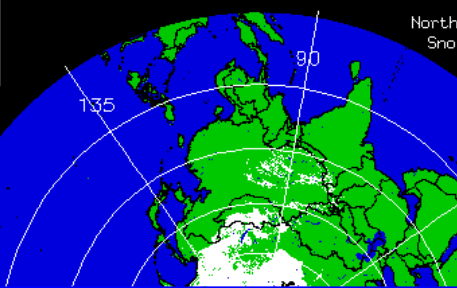
From  
Reports'  
conclusions

# "... gaps in knowledge ..." - from Reports' conclusions



NOAA Satellites and Information

National Environmental Satellite, Data, and Information Service



10 23 2008 102452



[HTTP://WWW.GOES.NOAA.GOV](http://www.goes.noaa.gov)

10/23/2008

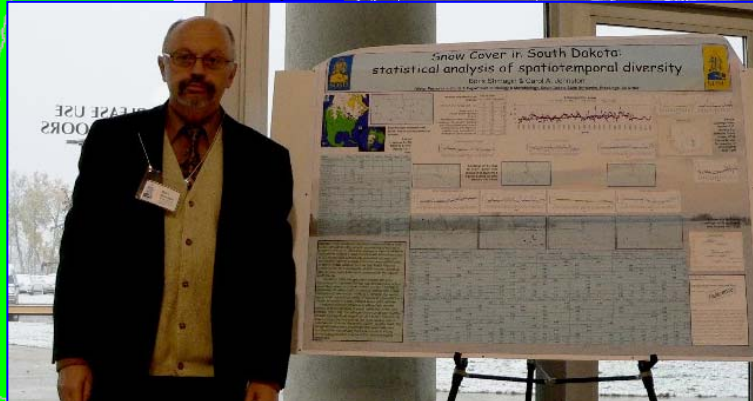
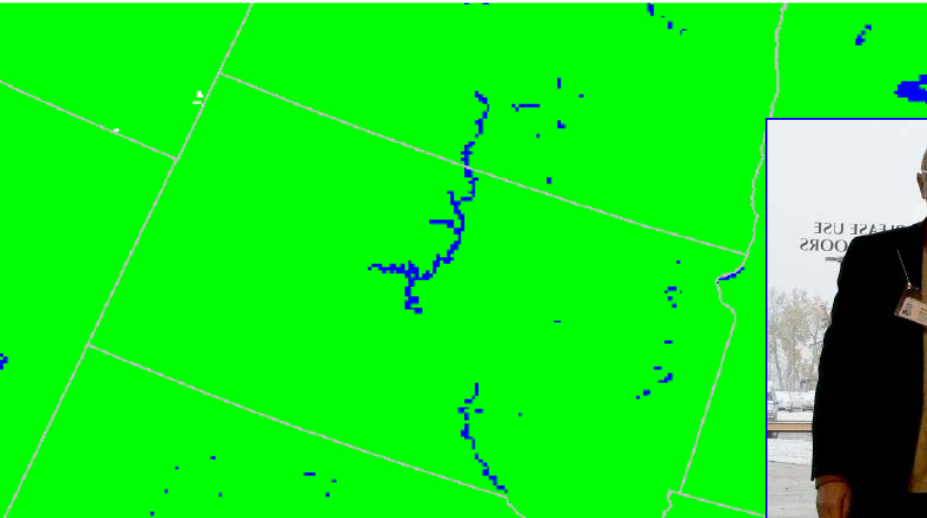
NOAA Satellites and Information  
National Environmental Satellite, Data, and Information Service

SSD Snow and Ice Detection

Satellite Services Division  
Snow and Ice Products

NOAA / NESDIS / OSDPD / SSD /

Privacy Policy Mission Statement



It was 1.5 inches of snowfall in Brookings, SD, on the day of poster presentation, Oct 22, 2008.

Nature Precedings: doi:10.1038/npre.2008.24445.1 : Posted 27 Oct 2008

"... at scales relevant to decision making.." -  
from Reports' conclusions

Nature Precedings : doi:10.1038/npre.2008.24445.1 : Posted 27 Oct 2008

The screenshot shows a web browser window with the title "South Dakota Diversity of Temperature: Pictures from Statistical Analysis : Nature Precedings - Windows Internet Explorer". The address bar shows the URL "http://precedings.nature.com/documents/1082/version/1". The browser has several tabs open, including "sd air temperature pictures - G...", "South Dakota Diversity of ...", and "South Dakota Diversity of Te...". The page content includes a navigation bar with "Home", "Browse by subject", and "Advanced search". The main content area is titled "Document information" and displays the document title "South Dakota Diversity of Temperature: Pictures from Statistical Analysis" by Boris Shmagin<sup>1</sup> & Dennis Todev<sup>1</sup>. It shows a "1 vote" button, correspondence information, and a list of subjects: "Earth and Environment". The abstract begins with "The regional diversity of monthly temperature was analyzed based on long-term data obtained for South Dakota (SD) from the High Plains Regional Climate Center. Multidimensional statistical methods were used and the principal results presented as a". On the right side, there is a "Participate" section with links for "Submit a document", "My recent activity", "Invite a colleague", and "Feedback". Below that is a "Frequently Asked Questions:" section with links for "What is Nature Precedings?" and "What is voting and who can vote?".

South Dakota Diversity of Temperature: Pictures from Statistical Analysis : Nature Precedings - Windows Internet Explorer

http://precedings.nature.com/documents/1082/version/1

sd air temperature pictures - G... South Dakota Diversity of ... South Dakota Diversity of Te...

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**Document information**

hdl:10101/npre.2007.1082.1

**South Dakota Diversity of Temperature: Pictures from Statistical Analysis** 1 vote  
Boris Shmagin<sup>1</sup> & Dennis Todev<sup>1</sup>  
Correspondence: (Login to view email address)  
1. South Dakota State University  
PDF (4.3 MB)

Document Type: Manuscript

Date: Received 22 September 2007 15:18 UTC; Posted 24 September 2007

Subjects: Earth and Environment

Tags: multidimensional statistics regional temperature temperature seasonality

Abstract: The regional diversity of monthly temperature was analyzed based on long-term data obtained for South Dakota (SD) from the High Plains Regional Climate Center. Multidimensional statistical methods were used and the principal results presented as a

**Participate**

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Invite a colleague  
Feedback

**Frequently Asked Questions:**

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Voting is intended to be an informal way of showing support for a researcher's work.



# Not from the Reports' conclusions

Nature Precedings : doi:10.1038/npre.2008.2445.1 : Posted 27 Oct 2008



## Academic Course as Research Seminar in Data Analysis on South Dakota Climate & Water Resources (for undergrad & graduate students)



**Boris Shmagin & Din Chen**

Department of Agricultural & Biosystems Engineering & Department of Mathematics and Statistics, South Dakota State University, Brookings, SD 57007

**Abstract:**  
Data analysis allows quantitative description of the behavior of natural and human dynamic systems & opens a way to understand their structure. Seminar style academic courses are fundamental blocks for creating the craft atmosphere & research culture in the university. The originality of a realized approach is based on the use of special prepared reasonable small initial matrix  $(K_{n \times n})$  with special constricted properties. This matrix is used to introduce all main statistical conceptions & techniques for students (mean, variability, correlation – as descriptive statistics, & also clustering and factorization – as multidimensional and multivariable exploratory techniques).

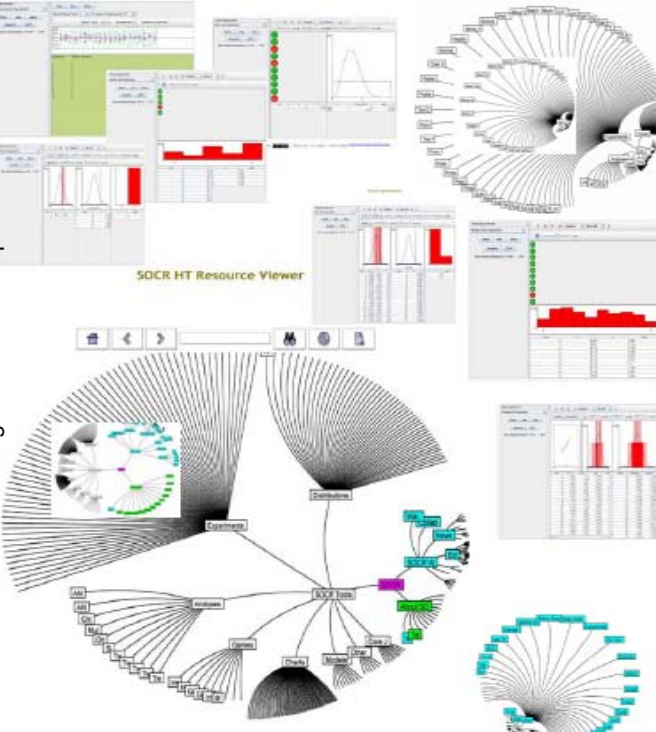
The second novelty are the illustrations based on the webpage (<http://www.socr.ucla.edu/>) to visualize the associated statistical principles of probability & distribution along with examples of real data that is a more appropriate way for students with non-mathematical majors grasp the concept presented. The designed course introduces models & tools for analysis of empirical climatic, hydrologic or environmental (economic, medical & others) data for students & then provides the hands on experience involving techniques of data analysis for research.

The goal for students will be to produce a publication, oral or poster conference presentation or other presentation in accordance with the level of completed research (undergraduate, master or PhD). The student's reports will be the basis for evaluating success in learning. Analysis completed by students may be used in civil and ag engineering projects in SD for improving the normative base in the state, & also in research that require descriptions of SD's natural conditions like agriculture & wildlife.

### SD Climate & Water Resources: Analysis of Existing Empirical Data

- I. PREFACE – Course as a seminar for undergraduate & graduate students
- II. INTRODUCTION – Empirical Data & Statistical analysis
- III. PRIMARY STATISTIC ANALYSIS
  1. Table of data (matrix) of the initial model
  2. Parameters of sampling from five definitions.
  3. Table of the parameters of variables.
  4. Variable histogram.
  5. Histograms of standardized data.
  6. The graphs of variables constructed from the number.
  7. Sampling nonconditionally definition according to Student's & Fisher's tests.
- IV. PAIRED REGRESSION AND THE CORRELATION MATRIX
  1. Simple linear model.
  2. Variance of the dependent variable and the coefficient of paired correlation.
  3. A model of the dependent/dependent variable ratio.
  4. Regression & correlation for four pairs of variables.
  5. Regression & correlation for the entire set of variables.
  6. Correlation matrix.
  7. Correlation matrix for samples from 15 definition.
- V. MULTIPLE REGRESSION & CORRELATION
  1. Multiple regression model.
  2. A step-by-step regression for X4SR from 7 remaining variables.
  3. The results of the step-by-step regression for the variables X4SR & X1CR from the rest.
- VI. CLUSTER ANALYSIS
  1. The models & procedures of cluster analysis.
  2. A hierarchical tree diagram of variables.
  3. A hierarchical tree diagram of observation points.
- VII. FACTOR ANALYSIS
  1. A model of factor analysis.
  - 1.1. The method of component analysis.
  - 1.2. The method of factor analysis.
  - 1.3. Factor model parameters.
  2. The factor structure of the interrelationships between variables.
  3. Distribution of sampling points by factor values.
  - 3.1. Graphs of factors and variables from the respective groups.
  - 3.2. Graphs of variable regression from factors.
  - 3.3. Diagrams of point distribution in factor planes.
- VIII. CONCLUSION AND PRESENTATION OF EVERY STUDENT RESULTS ON SEMINAR

**Professors:**  
Dr. Boris Shmagin rededicated course for SD on base of similar course: "System analysis of hydrological data" he was teaching for graduate students in hydrology for eleven years (1985-1996) Department of Hydrology Faculty of Geology Moscow State University, Russia. For course were developed & published textbooks, & for one time (Geol 5261) Winter Quarter 1998 with Dr. Howard Moores) in UMN-Duluth.  
Dr. Din Chen is the state climatologist and regularly deals with practical issues of climatic data, including quality control & analysis of trends in such data. He teaches a 300-level class in climate & sea-levels as a graduate level class in meteorology.  
Dr. Din Chen is Professor in Geostatistics in Department of Mathematics & Statistics, South Dakota State University.






# For discussion

Regional analysis of empirical hydro & climate data has to be the direction of SDSU research.

The goal is Atlas of climate & natural resources of South Dakota.

# Questions

A sunset scene with a bright sun low on the horizon over a body of water. In the foreground, a pine branch with needles hangs down from the top right, partially obscuring the sun. The sky is a mix of orange, yellow, and pink.

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