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AEMet Agencia Estatal de Meteorología

Downscaled Climate Change Projections over Spain: preliminary development

Project: Estimación de Incertidumbres en Proyecciones de Cambio Climático

Delegación Territorial de Andalucia, Ceuta y Melilla (Sevilla)
Unidad de Estudios y Desarrollo

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1. Preliminary phase's objetives

- Analyze available information from Global Climate Models (GCM) in the Ensembles Project.
- Adapt this information for obtain downscaled climate change projections over Spain.

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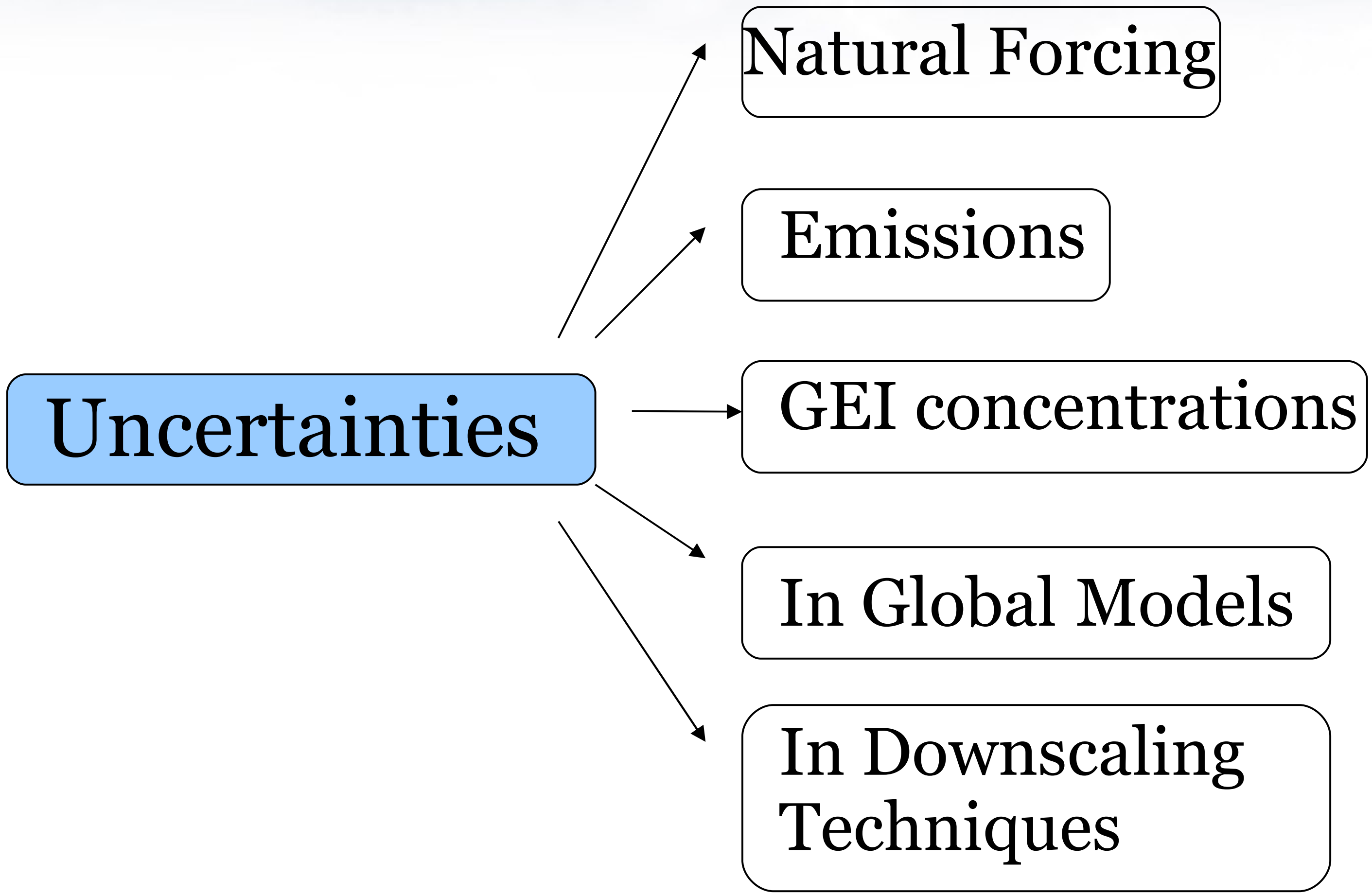
2. Introduction

- The climate change projections have uncertainties. These uncertainties can be described as cascade (MITCHELL y HULME, 1999) because these can be related themselves.
- Therefore we will use different Global Climate Models and scenarios.
- So that, the downscaled projections because inherit all the uncertainties affect them.
- The most important uncertainties are:

2. Introduction



We use scenarios (with different features) and Global Climate Models for analyse some of these uncertainties.

3. Method

Downscaling techniques

- Statistical
  - Spatial downscaling of daily predictor–predictand relations.
  - Low computational need.

- Dynamical
  - Numerical model.
  - High computational need.

Statistical DownScaling Model: SDSM

It is based on the lineal hypothesis, it means, the relation between predictor and predictand is lineal.

-The predictor variables provide information concerning the large scale state of the atmosphere.

- The predictand variables describe conditions at the local scale and depend on predictor variables.

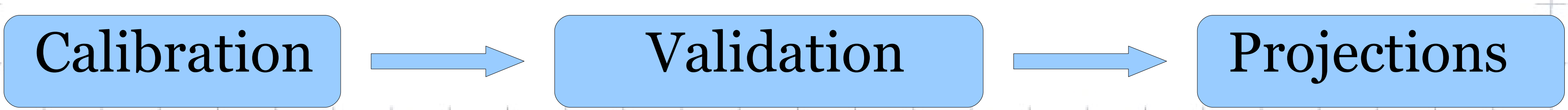
In our case:

-Predictor variables: the variables that we had downloaded from Global Climate Models.

-Predictand variables: extreme temperatures and precipitations.

Acquired skills

- Wide knowledge about downscaling methods, climate models and scenarios.
- Learn bash commands for create script and two tools: *cdo* and *nco*.
- Automatize some procedures with previous tools.
- Learn to work in remote computer.
- Finally, will execute the next process



4. Procedure

- Analyze available information from the GCM: data and features' models.
- Select the predictor variables.
- Download the data files corresponding to each predictor variable.
- Design a strategy for work with the files and create some scripts for automatize some procedures.
- Automatize procedures for obtain standardized data and then the series for Spain.

Select data

We are interested in:

- Daily data.
- Reference period: 1961-1990.
- Projection period: 2010-2100 (general).
- Variables in several levels (1000hPa, 850hPa,700hPa and 500hPa): temperature, specific humidity, meridional and zonal component of velocity of wind and geopotential height (?).
- Surface Variables: pressure in sea level, maximum and minimum temperature (2m).

Remap data

- As the several Global Climate Models use different grids (between them).

-We use the Reanalysis NCEP/NCAR for calibration our projections and their files have gaussian grid (with the cdo tools).

- So we need remap our data files (different models), according to one gaussian grid. For this, use a text file with the coordinates X and Y for each point from the gaussian grid.

Calculations to standardize

- To standardize data file, need to calculate(with cdo tools):

  - The average: $\bar{x}$
  - The standard deviation.

  (for each variable and each year)

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}$$

  - The anomaly: $\Delta = (x - \bar{x})/\sigma$

- We have created a script with the corresponding commands to standardize.

5. Data

Ensembles Project

ENSEMBLES

It has two lines of work: *stream 1* and *stream 2*:

Ensembles stream1		Resolución	
Institución	Modelo	lat	long
Beijing Climate Center, China Meteorological Administration	BCM2	64	128
CNRM-CERFACS	CNRM-CM3	64	128
Institute for Meteorology, Freie Universitaet Berlin	EGMAM	48	96
Met. Office Hadley Center	HADGEM1	145	192
Istituto Nazionale di Geofisica e Vulcanologia	INGVSX	160	320
Inst. Piere Simon Laplace	IPSLCM4	72	96
Max-Planck-Institut fuer Meteorologie (MD)	MPEH5	96	192
Danish Meteorological Institute & Max Planck	DMIEH5	48	96

Ensembles stream2		Resolución	
Institución	Modelo	lat	long
Danish Meteorological Institute & Max Planck	DMIEH5C	48	96
CNRM-CERFACS	CNRM-CM33	64	128
Institute for Meteorology, Freie Universitaet Berlin	EGMAM2	48	96
Met. Office Hadley Center	HADGEM2AO	144	192
Met. Office Hadley Center	HADCM3C	73	96
Inst. Piere Simon Laplace	IPSLCM4v2	143	144
Max-Planck-Institut fuer Meteorologie (MD)	MPEH5C	48	96

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Scenarios

Scenario	Features
20C3M	It considers a increase of GEI in the same way than the emissions during s.XX. (Current climate).
SRES A1B	Quick economical growth and implementation of new and efficient technology. Low population growth. The environmental quality is not the most important.
SRES A2	Heterogeneous world,high population growth and low economical development.
SRES B1	Quick economical changes to a global society. Introduction of new and efficient technology.
E1	Mitigation scenario, which is based on a increment of radiative forcing 2,9 W/m^2 .

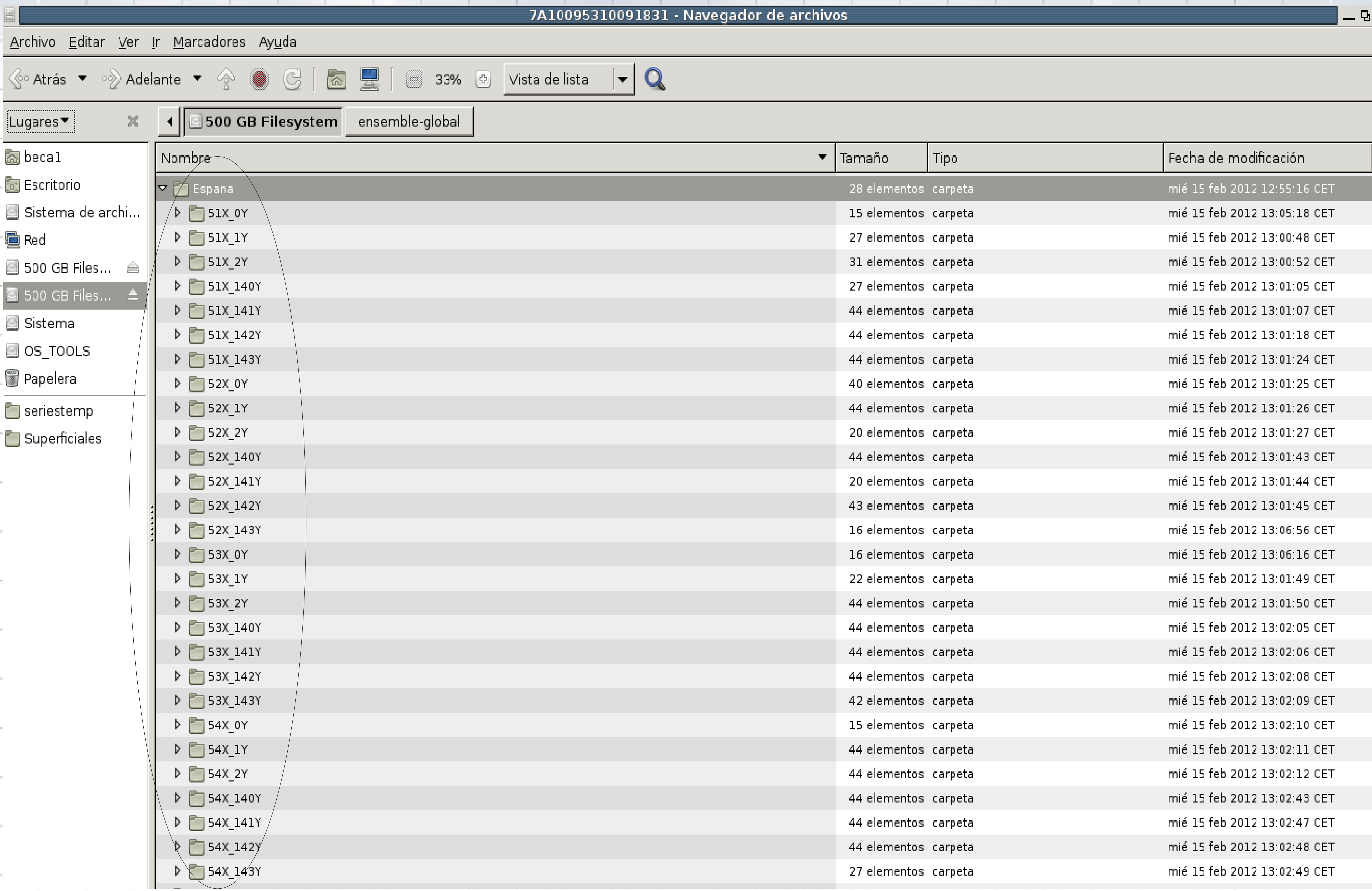
Data for calibration: NCEP/NCAR Reanalysis 1 project

* The necp's grid is 2.5 degree x 2.5 degree global grids (144 x 73), it means, gaussian. Therefore, it does not need to remap (again).

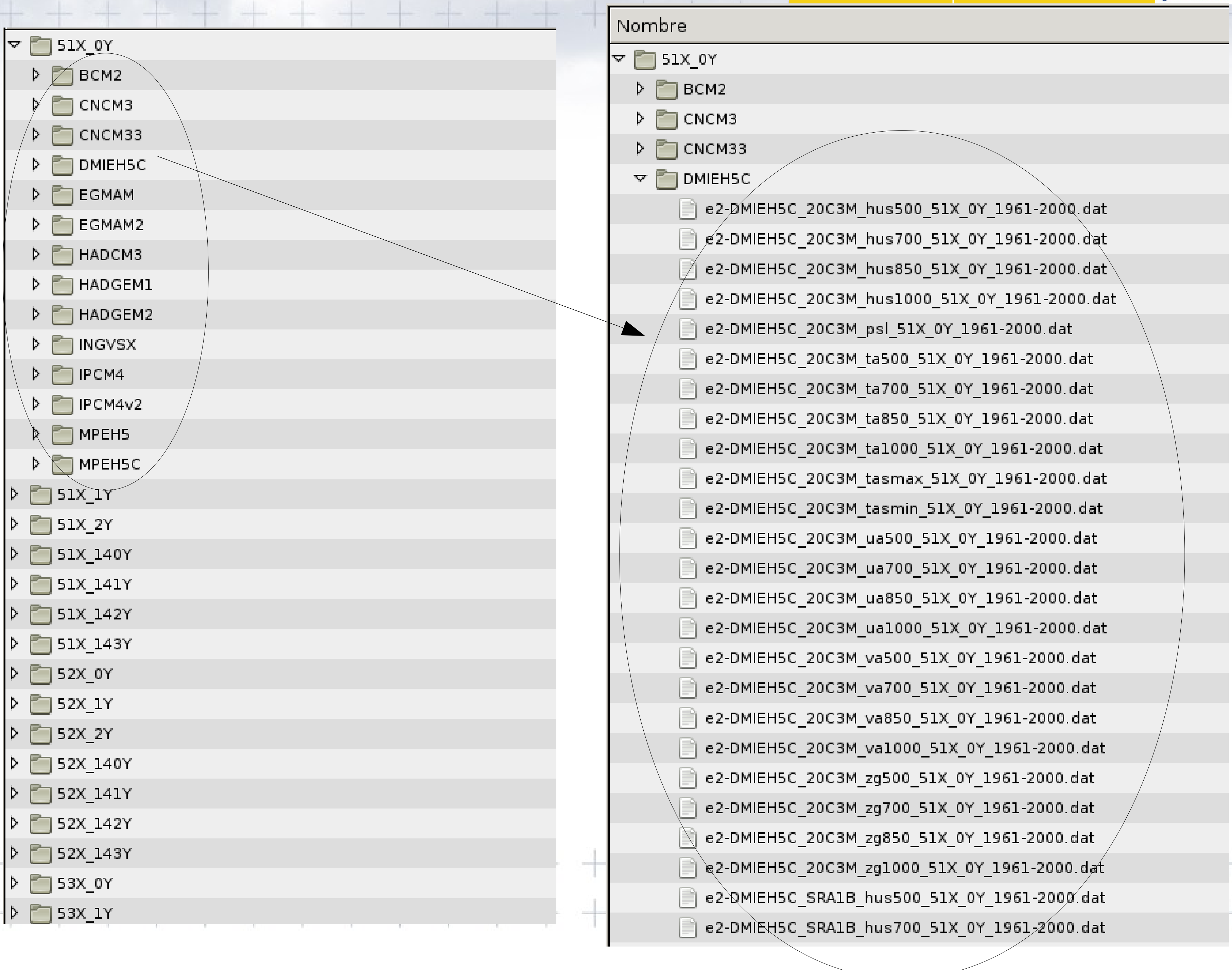
Data's volume

Model	Data	Standardized files	Spain Points (28)
Ensembles, stream 1	507 files 696,5GB	507 files (in course)	(in course)
Ensembles, stream 2	377 files 411,1GB	377 files (in course)	(in course)
NCEP surface	150 files 2,15 GB	3 files 2,1 GB	23 files/point 112,2 MB
NCEP pressure levels	250 files 27,3GB	20 files 14,3 GB	

We have:



Nombre	Tamaño	Tipo	Fecha de modificación
Espana	28 elementos	carpeta	mié 15 feb 2012 12:55:16 CET
51X_0Y	15 elementos	carpeta	mié 15 feb 2012 13:05:18 CET
51X_1Y	27 elementos	carpeta	mié 15 feb 2012 13:00:48 CET
51X_2Y	31 elementos	carpeta	mié 15 feb 2012 13:00:52 CET
51X_140Y	27 elementos	carpeta	mié 15 feb 2012 13:01:05 CET
51X_141Y	44 elementos	carpeta	mié 15 feb 2012 13:01:07 CET
51X_142Y	44 elementos	carpeta	mié 15 feb 2012 13:01:18 CET
51X_143Y	44 elementos	carpeta	mié 15 feb 2012 13:01:24 CET
52X_0Y	40 elementos	carpeta	mié 15 feb 2012 13:01:25 CET
52X_1Y	44 elementos	carpeta	mié 15 feb 2012 13:01:26 CET
52X_2Y	20 elementos	carpeta	mié 15 feb 2012 13:01:27 CET
52X_140Y	44 elementos	carpeta	mié 15 feb 2012 13:01:43 CET
52X_141Y	20 elementos	carpeta	mié 15 feb 2012 13:01:44 CET
52X_142Y	43 elementos	carpeta	mié 15 feb 2012 13:01:45 CET
52X_143Y	16 elementos	carpeta	mié 15 feb 2012 13:06:56 CET
53X_0Y	16 elementos	carpeta	mié 15 feb 2012 13:06:16 CET
53X_1Y	22 elementos	carpeta	mié 15 feb 2012 13:01:49 CET
53X_2Y	44 elementos	carpeta	mié 15 feb 2012 13:01:50 CET
53X_140Y	44 elementos	carpeta	mié 15 feb 2012 13:02:05 CET
53X_141Y	44 elementos	carpeta	mié 15 feb 2012 13:02:06 CET
53X_142Y	44 elementos	carpeta	mié 15 feb 2012 13:02:08 CET
53X_143Y	42 elementos	carpeta	mié 15 feb 2012 13:02:09 CET
54X_0Y	15 elementos	carpeta	mié 15 feb 2012 13:02:10 CET
54X_1Y	44 elementos	carpeta	mié 15 feb 2012 13:02:11 CET
54X_2Y	44 elementos	carpeta	mié 15 feb 2012 13:02:12 CET
54X_140Y	44 elementos	carpeta	mié 15 feb 2012 13:02:43 CET
54X_141Y	44 elementos	carpeta	mié 15 feb 2012 13:02:47 CET
54X_142Y	44 elementos	carpeta	mié 15 feb 2012 13:02:48 CET
54X_143Y	27 elementos	carpeta	mié 15 feb 2012 13:02:49 CET


51X_0Y
BCM2
CNCM3
CNCM33
DMIEH5C
EGMAM
EGMAM2
HADCM3
HADGEM1
HADGEM2
INGVSX
IPCM4
IPCM4v2
MPEH5
MPEH5C
51X_1Y
51X_2Y
51X_140Y
51X_141Y
51X_142Y
51X_143Y
52X_0Y
52X_1Y
52X_2Y
52X_140Y
52X_141Y
52X_142Y
52X_143Y
53X_0Y
53X_1Y
Nombre
51X_0Y
BCM2
CNCM3
CNCM33
DMIEH5C
e2-DMIEH5C_20C3M_hus500_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_hus700_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_hus850_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_hus1000_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_psl_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_ta500_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_ta700_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_ta850_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_ta1000_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_tasmax_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_tasmin_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_ua500_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_ua700_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_ua850_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_ua1000_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_va500_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_va700_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_va850_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_va1000_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_zg500_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_zg700_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_zg850_51X_0Y_1961-2000.dat
e2-DMIEH5C_20C3M_zg1000_51X_0Y_1961-2000.dat
e2-DMIEH5C_SRA1B_hus500_51X_0Y_1961-2000.dat
e2-DMIEH5C_SRA1B_hus700_51X_0Y_1961-2000.dat

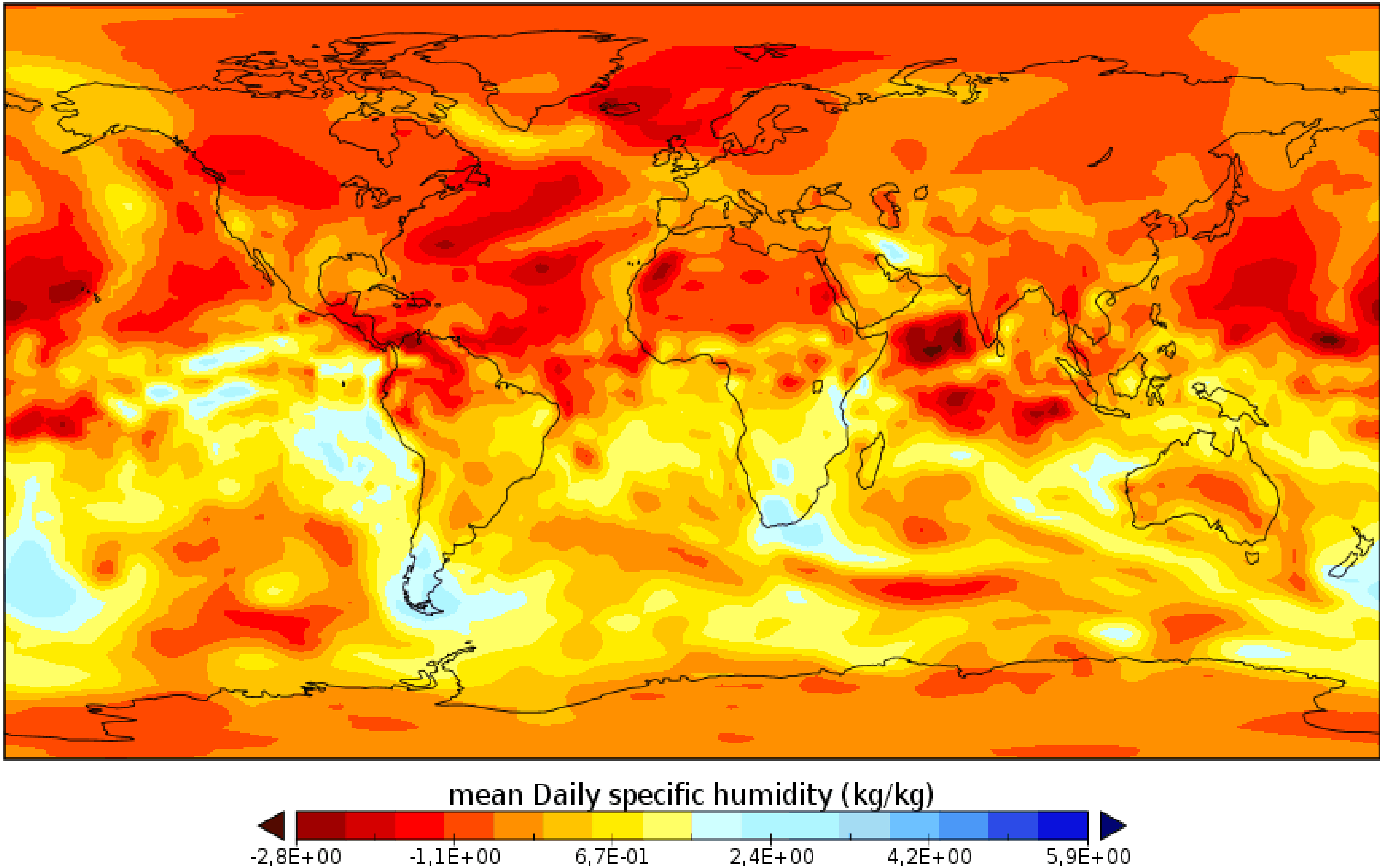
- Finally the data file for each predictor variable has the next form:

e2-DMIEH5C_20C3M_hu...51X_0Y_1961-2000.dat

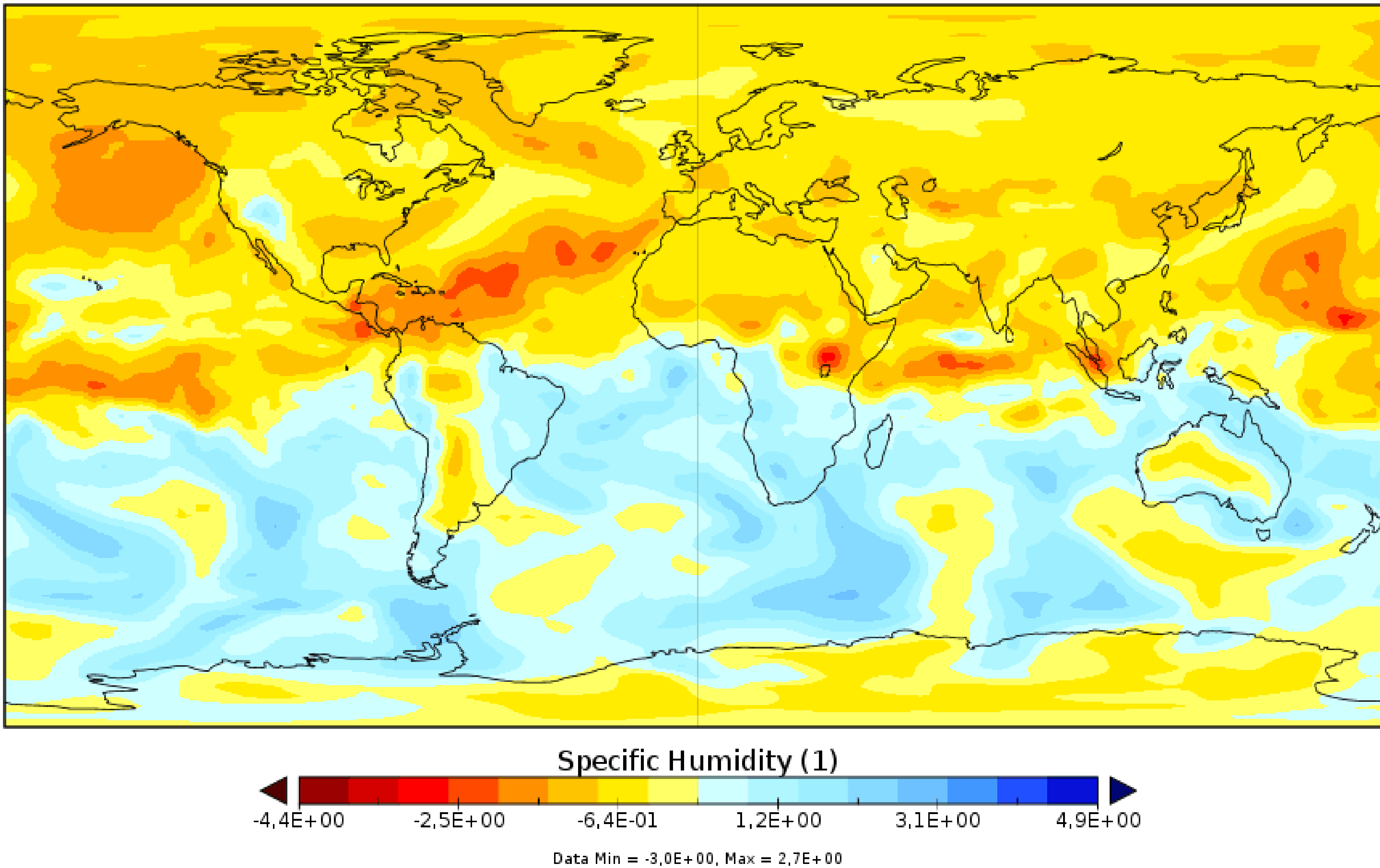
```
-0.59013
-1.30631
-1.34741
-0.69874
 0.52297
-0.63742
-1.41637
-1.18580
 0.35242
-0.66807
-1.20171
-0.92643
-1.28703
-1.17620
-0.53449
-0.32150
-0.67554
-0.63707
-0.94324
-0.88300
-1.33365
-1.53361
-0.83591
-1.16015
-1.51699
-1.33378
 0.40364
-1.01061
-0.26172
-0.67887
 0.70057
-0.69168
-1.65638
-0.79313
-0.38395
```

6. Example: Standardized data of variable specific humidity in level 1000 hPa with different models (23/3/1965)

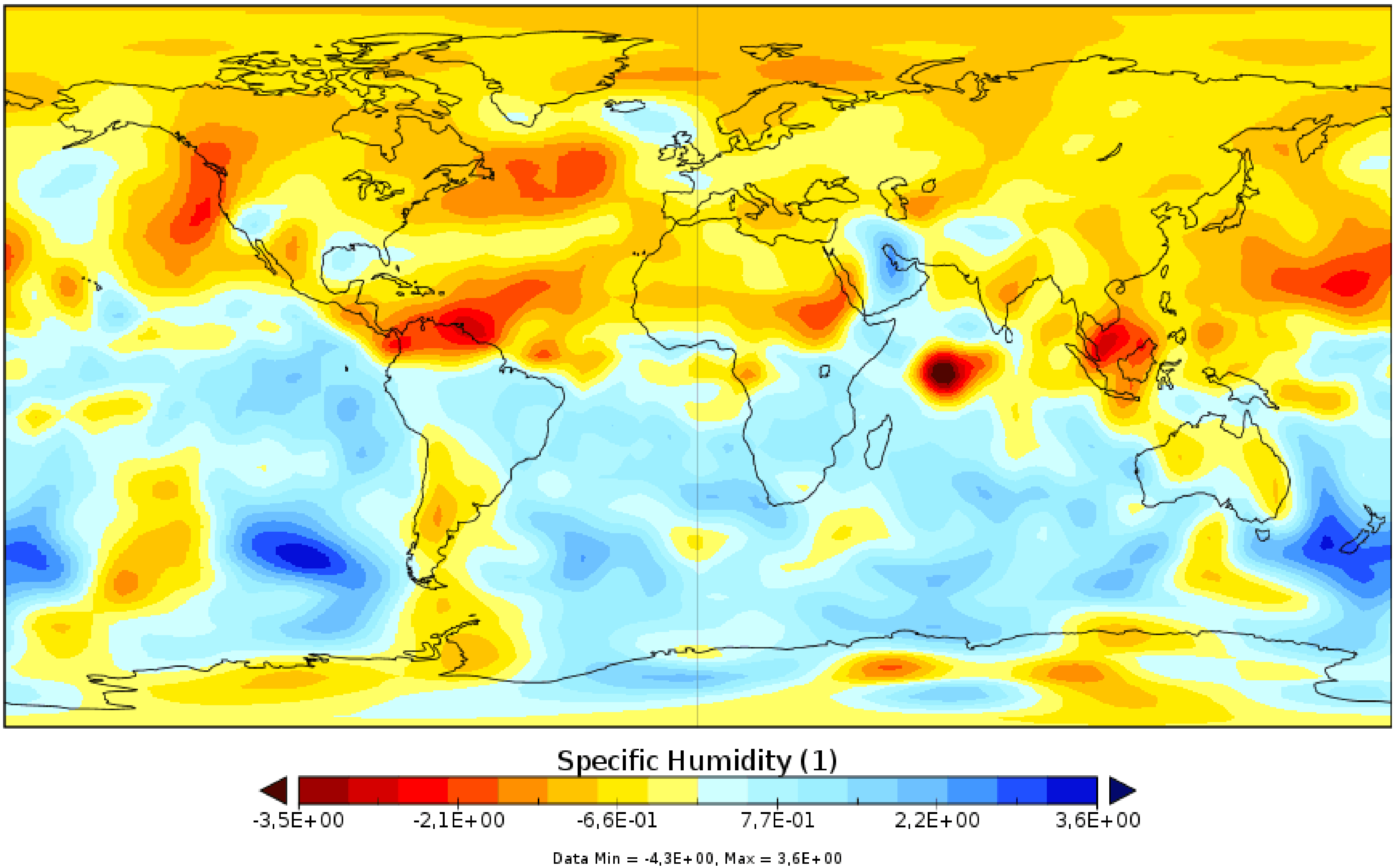
Reanalysis NCEP/NCAR



ENSEMBLES, stream1, model:CNCM3 and scenario: 20C3M

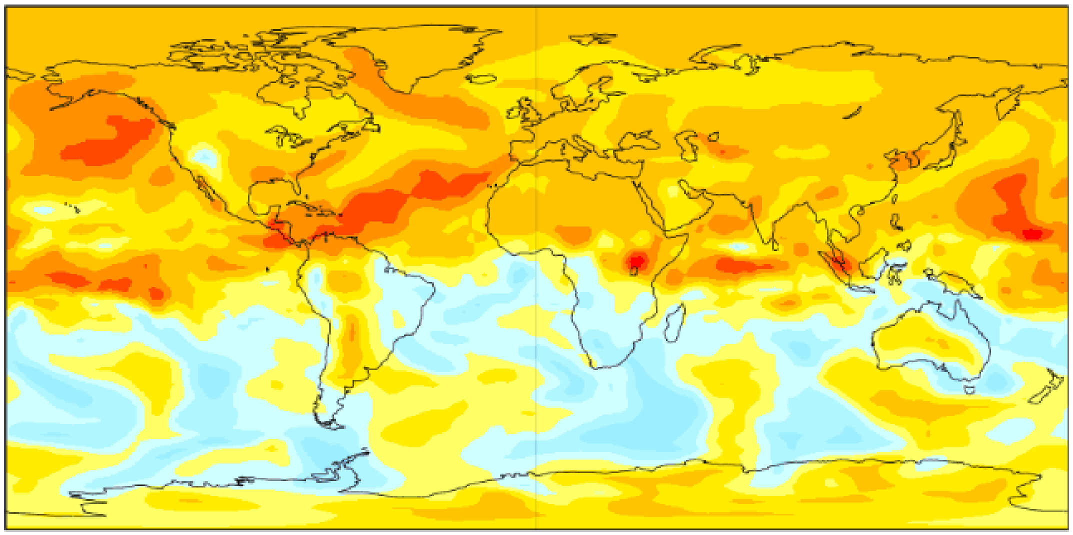


ENSEMBLES, stream2, model:EGMAM2 and scenario: 20C3M

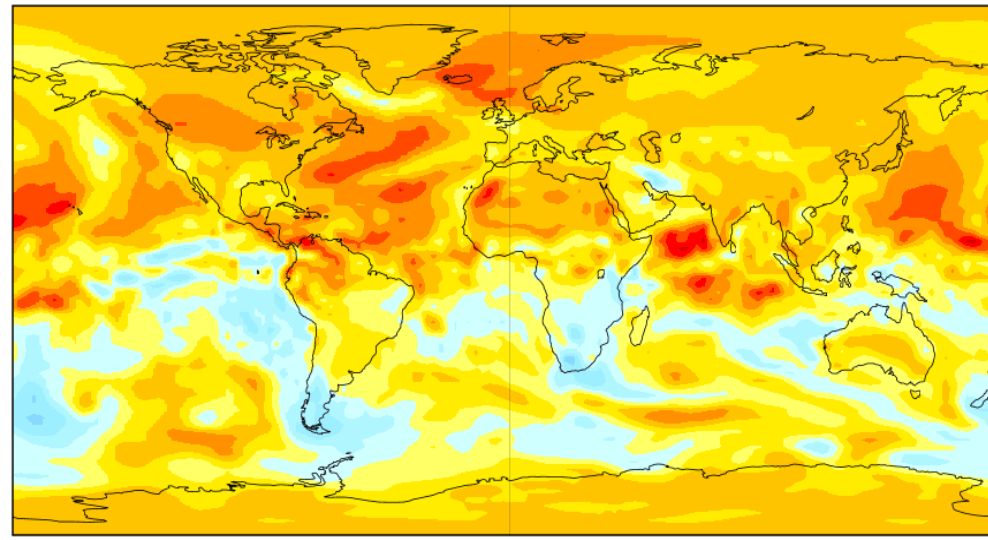


If we change the scale

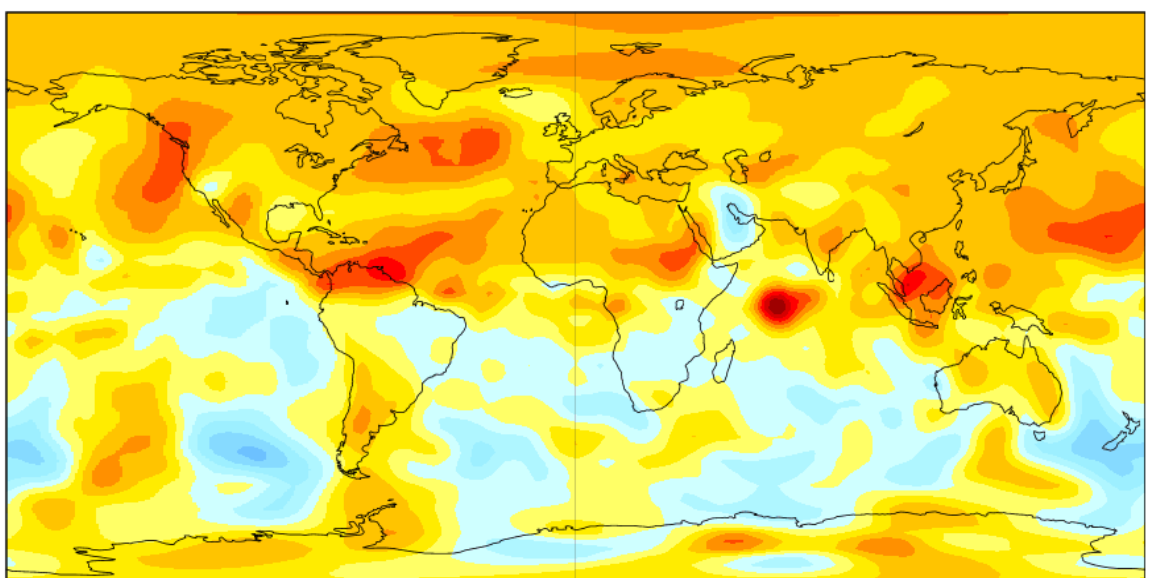
CNCM3



Ncep



EGMAM2



7. Comments

- There are more of thousand files with data, this suppose a big volume of data to work which needs space for save it and for analysis it.

- It is important to select the correct period of time for reduce size of file and for work comfortably, but you must be very careful with select this period because each GCM use one calendar.

8. Future Plans

- Finish standardize and obtain Spain series.
- Identify cells with each meteorological station.
- Calibrate the models with Reanalysis NCEP/NCAR for each variable and for each climatological station.
- Obtain the climate change projections for extreme temperature and precipitation for each climatological station.
- Evaluate the projections' uncertainties.

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