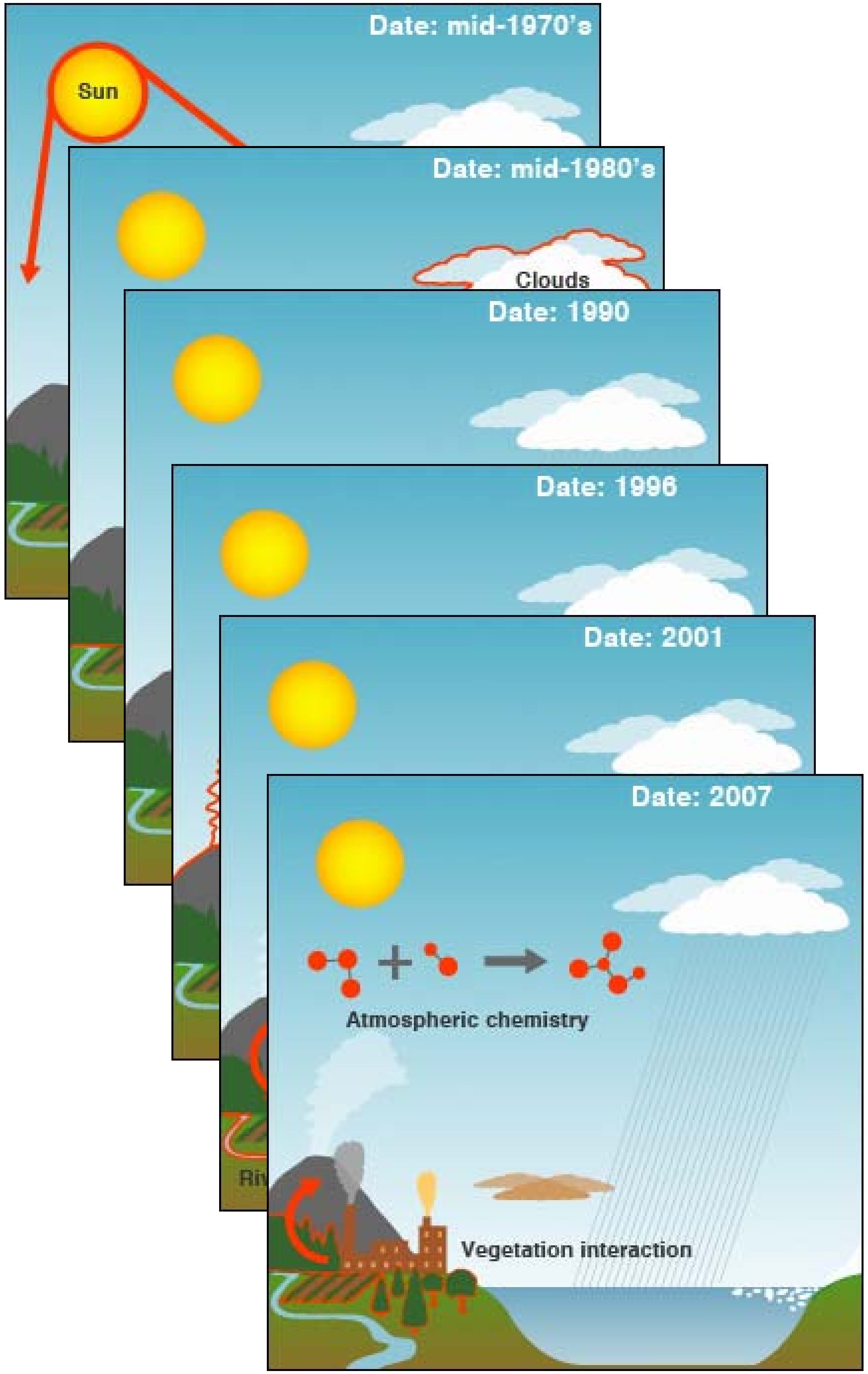
LOCAL SCALE CLIMATE CHANGE SCENARIOS

Pedro Garrett

2009



Mid 1970s
Early climate models were limited. They only included carbon dioxide, heat from the sun (radiation) and rain, but not clouds.

Mid 1980s
Clouds, land surface and ice were added into the mix in the 1980s. Different types of land behave differently; deserts and ice are more likely to reflect radiation, and forests are more likely to absorb it.

1990 - IPCC's first report
A simple model of the oceans now joins the picture, as the first IPCC report comes out. To begin with, only the top layer of the sea was modeled.

1996 Second Assessment Report
More sophisticated models of the ocean are added. Volcanoes are also shown. Their eruptions throw particles into the atmosphere, which can block sunlight and temporarily reduce global temperatures.

2001 Third Assessment Report
By bringing the carbon cycle into the picture, the different ways C02 is stored and released into the atmosphere gives greater realism to climate models. Understanding of the oceans is deepened

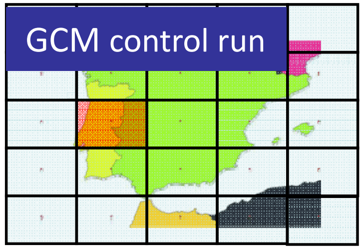
2007 Fourth Assessment Report
Chemical reactions in the atmosphere join the climate models; they are now produced using computing power 256 times more powerful than that available in the 1970s.

SIM-CCIAM

THE DELTA CHANGE METHOD

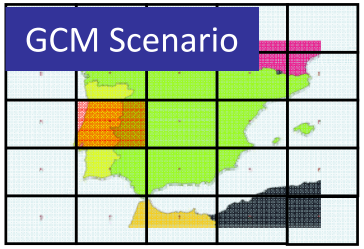
LOCAL CLIMATE CHANGE SCENARIOS

THE DELTA CHANGE METHOD
LOCAL CLIMATE CHANGE SCENARIOS



TEMPERATURE	
	JANEIRO
1961	10
1962	13
1963	12
1964	13
1965	12
...	
1990	11

Average = 12ºC



TEMPERATURE	
	JANEIRO
2041	12
2042	15
2043	10
2044	14
2045	16
...	
2060	13

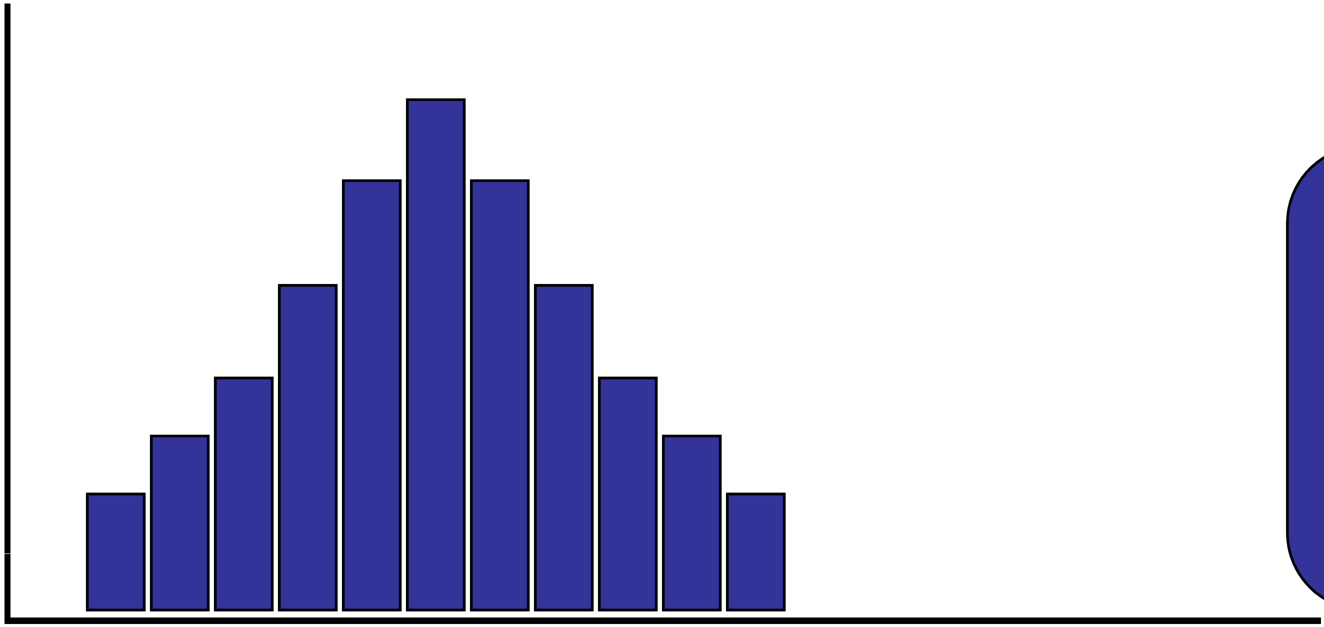
Average = 14ºC

$$\Delta T = T_{2041-2060} - T_{1961-1090}$$

The anomaly is then added to the observed dataset from the meteorological station

THE DELTA CHANGE METHOD
LOCAL CLIMATE CHANGE SCENARIOS

What will happen to the daily distribution of temperature in January???

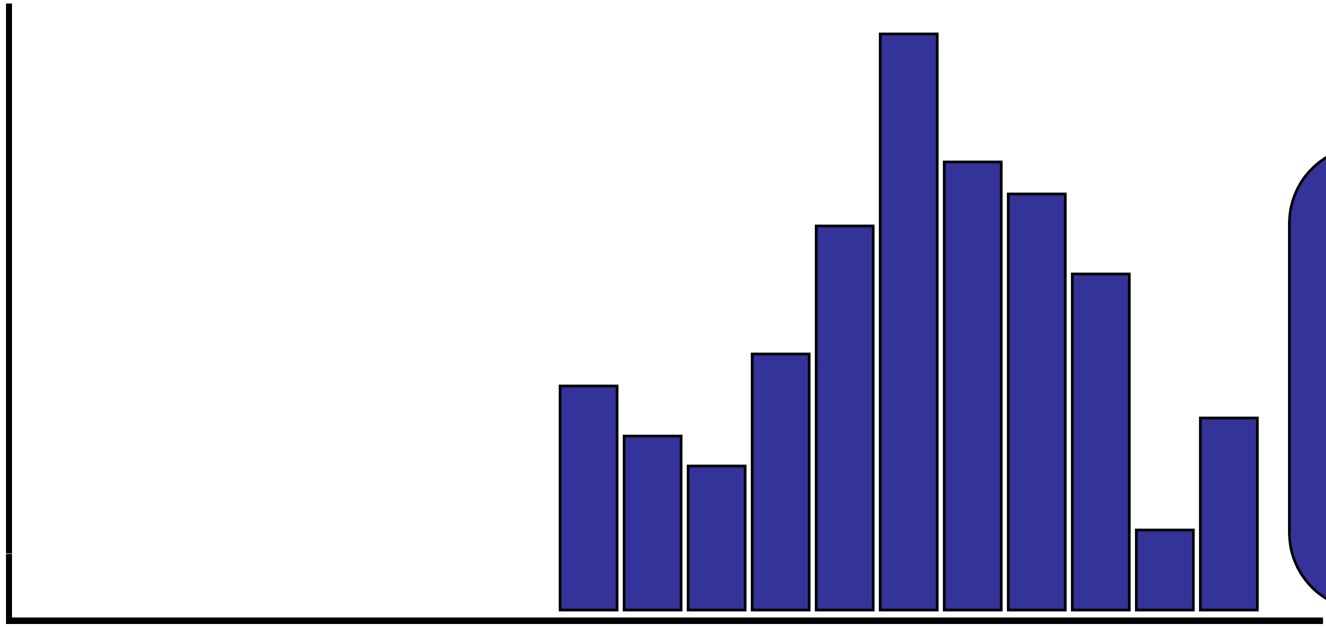


Ignoring possible changes in the data variability could led to misinterpretation of the results specially when dealing with extreme Weather events

Is it prudent to assume that the daily distribution of the data is going to maintain???

THE DELTA CHANGE METHOD
LOCAL CLIMATE CHANGE SCENARIOS

What will happen to the daily distribution of temperature in January???



Ignoring possible changes in the data variability could led to misinterpretation of the results specially when dealing with extreme Weather events

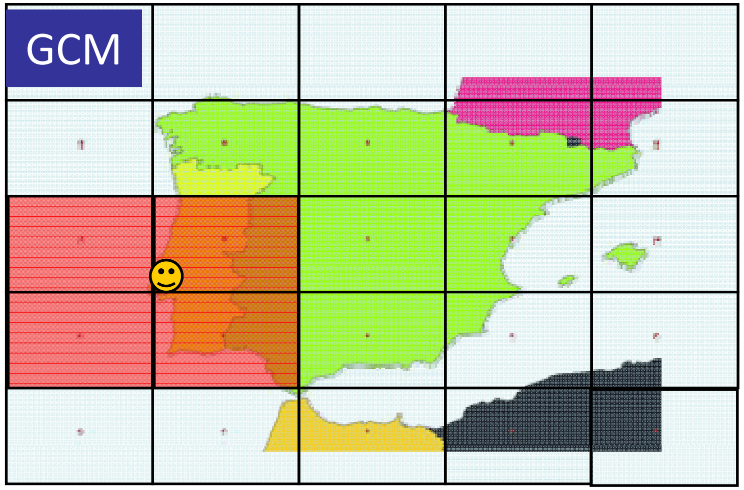
Is it prudent to assume that the daily distribution of the data is going to maintain???

THE DELTA CHANGE METHOD

LOCAL CLIMATE CHANGE SCENARIOS

IMPORTANT CONSIDERATIONS WHEN DEALING WITH THE DELTA CHANGE METHOD...

1 - Witch grid box to choose from the Global Circulation Model?



Is common to use one or even several grid boxes to find the optimal relationship
Between large scale parameters and local climate variables

THE DELTA CHANGE METHOD

LOCAL CLIMATE CHANGE SCENARIOS

IMPORTANT CONSIDERATIONS WHEN DEALING WITH THE DELTA CHANGE METHOD...

1 - Witch grid box to choose from the Global Circulation Model?

2 – How do we validate these results?

3 – should we use this data to calculate extreme weather events?

this method assumes that the variability of the data is going to maintain

4 – Be aware when using this method to calculate:

heat waves
cold waves
precipitation regimes

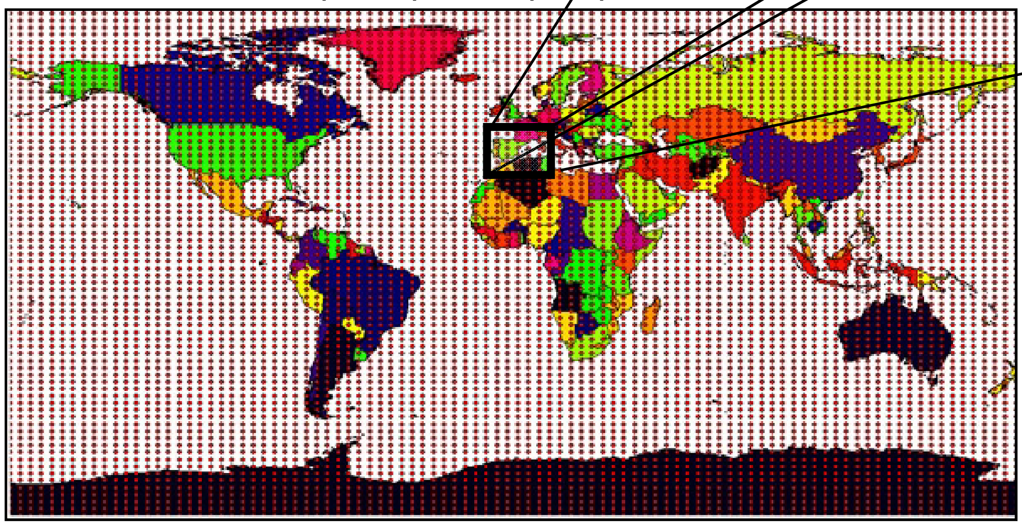
DYNAMICAL AND STATISTICAL DOWNSCALING

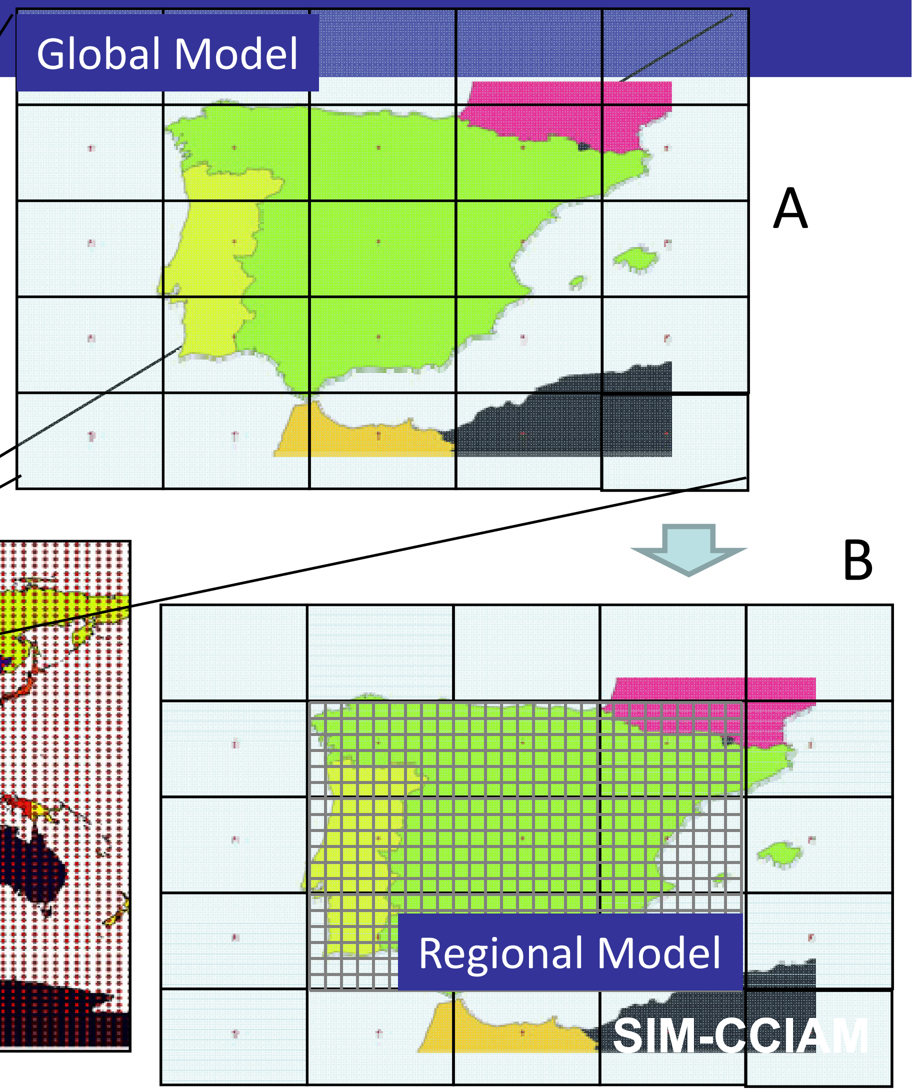
LOCAL CLIMATE CHANGE SCENARIOS

DYNAMICAL DOWNSCALING

RCM have the same characteristics
as the GCM but runs with higher spatial
resolution in a process called nesting

HadCM3 GRID 96 (3,75º) X 73 (2,5º)





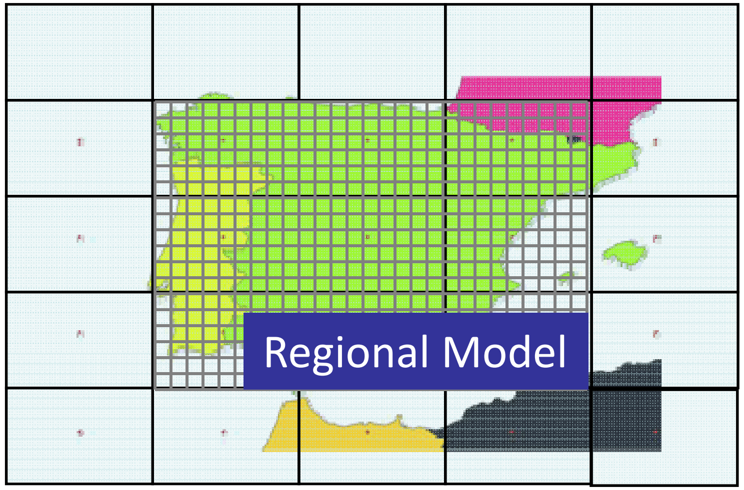
DYNAMICAL DOWNSCALING

PRECIS regional climate model

(Providing REgional Climates for Impacts Studies)

100-by-100 gridbox domain
2.8 GHz machine
30 year simulation

4.5 months



OUTPUT FROM GCM:

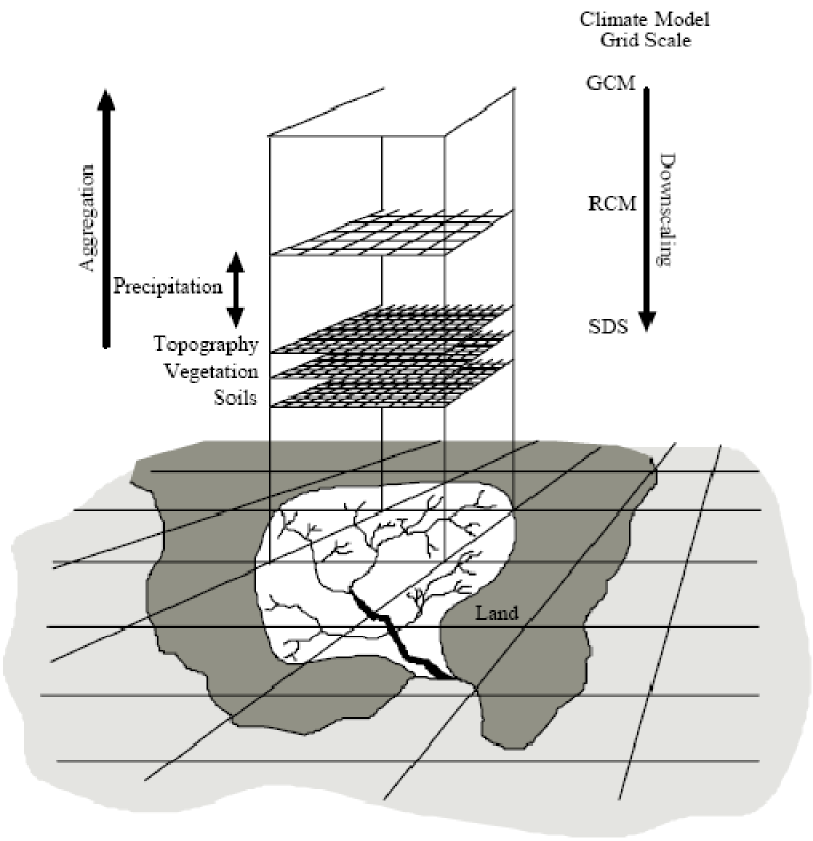
SNOW AMOUNT AFTER TIMESTEP
NET DOWN SURFACE SW FLUX BELOW
TOTAL DOWNWARD SURFACE SW FLUX
HICE INC. DUE TO DIFFUSION
SURFACE & B.LAYER HEAT FLUXES
SURF & BL TOTL MOISTURE FLUX
TEMPERATURE AT 1.5M
SPECIFIC HUMIDITY AT 1.5M
RELATIVE HUMIDITY AT 1.5M
10 METRE WIND SPEED
LARGE SCALE RAINFALL RATE
LARGE SCALE SNOWFALL RATE
CONVECTIVE RAINFALL RATE
CONVECTIVE SNOWFALL RATE
TOTAL PRECIPITATION RATE
SOIL MOISTURE CONTENT
LARGE SCALE RAINFALL RATE
LARGE SCALE SNOWFALL RATE

SIM-CCIA

DYNAMICAL DOWNSCALING

STRENGTHS	WEAKNESS
•Spatial resolutions between 10-50 km •Responds in physically consistent ways to different external forcing •Resolve atmospheric processes such as orographic precipitation •Consistency with the GCM	•Dependent on the realism of GCM boundary forcing •Choice of domain size and location affects the results •Requires significant computing power •Initial boundary conditions affects the results •Choice of cloud/convection scheme affects results •Not readily transferred to new regions or domains

STATISTICAL DOWNSCALING



There are deterministic methods (eg multiple linear regressions and neural networks) which assumes a relationship between large scale variables and the local climate, such as precipitation and temperature.

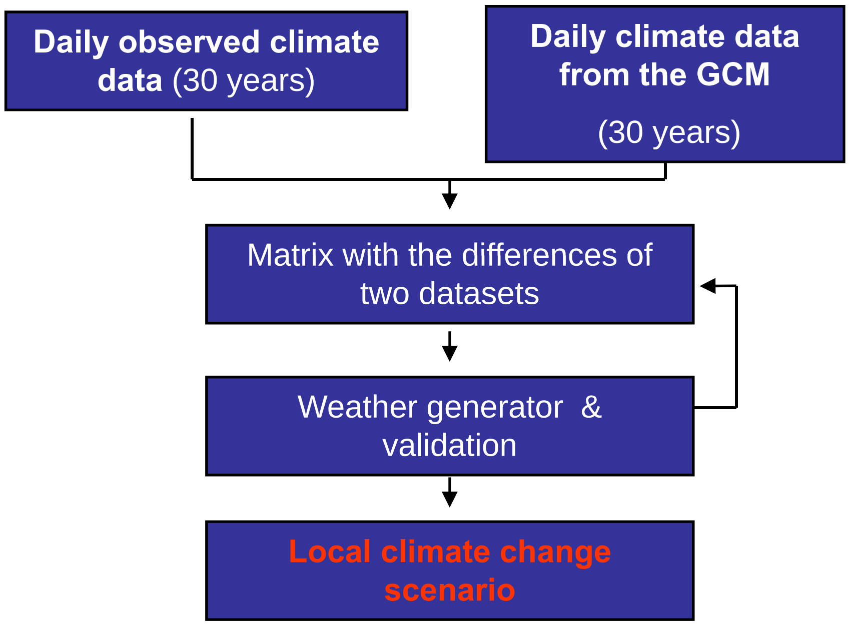
Stochastic methods can reproduced climatic time series statistically identical to those observed.

There are also hybrid methods that are the combination of the two earlier. In this case transfer equations are used to determine the relationship between large scale variables with local weather and then stochastic methods are used to determine its intensity.

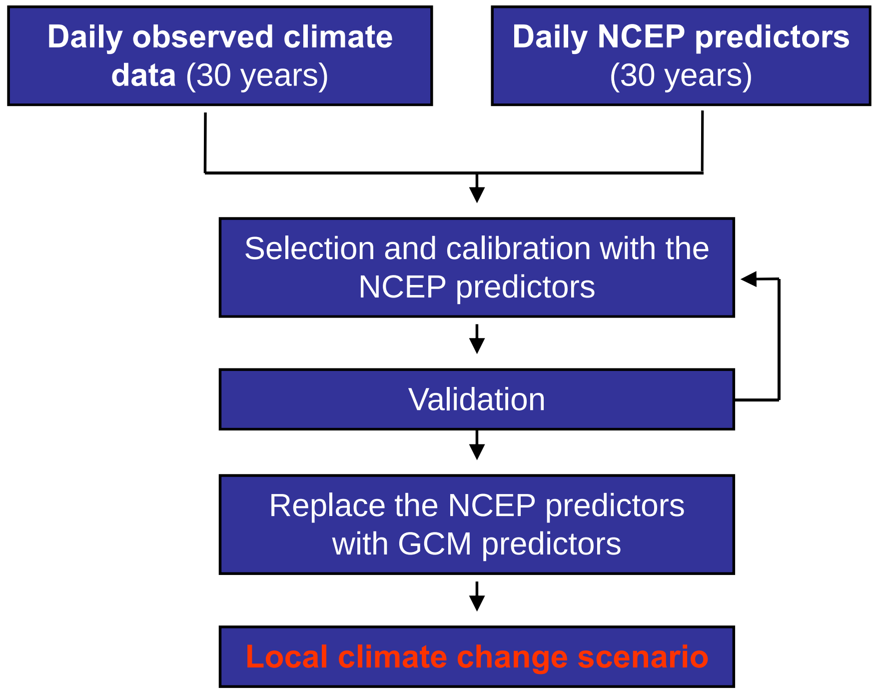
STATISTICAL DOWNSCALING

COMPARISON BETWEEN A STOCHASTIC AND HYBRID METHOD

STOCHASTIC METHOD



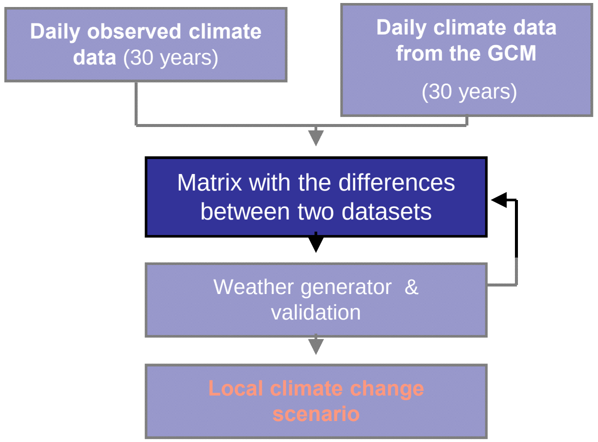
HYBRID METHOD (DETERMINISTIC & STOCHASTIC)



STATISTICAL DOWNSCALING

COMPARISON BETWEEN A STOCHASTIC AND HYBRID METHOD

STOCHASTIC METHOD



Matrix with the difference between the control run and future scenario

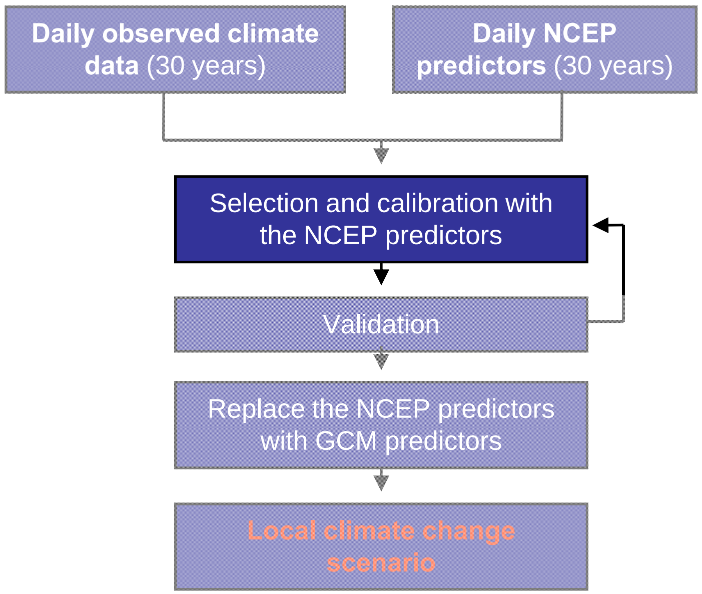
	Monthly rain	Wet spell	Dry spell	Max temperature	Min temperature	Temp. Standard Deviation
Jan	0.92	0.82	1.13	1.15	1.14	1.00
Feb	1.28	1.28	0.82	1.17	1.16	1.18
Mar	1.14	1.08	1.05	1.17	1.15	1.11
Apr	0.95	0.67	0.96	1.15	1.14	1.20
May	0.65	0.79	1.13	1.13	1.13	1.46
Jun	0.72	0.84	1.42	1.12	1.13	1.13
Jul	1.14	1.26	0.98	1.11	1.11	1.20
Aug	0.83	1.06	1.15	1.11	1.11	1.16
Sep	0.56	0.75	1.26	1.12	1.11	1.15
Oct	0.77	0.85	1.09	1.13	1.13	1.13
Nov	0.95	0.87	0.86	1.13	1.13	1.12
Dec	1.19	0.99	1.00	1.14	1.14	1.10

Results for Lisbon

STATISTICAL DOWNSCALING

COMPARISON BETWEEN A STOCHASTIC AND HYBRID METHOD

HYBRID METHOD (DETERMINISTIC & STOCHASTIC)



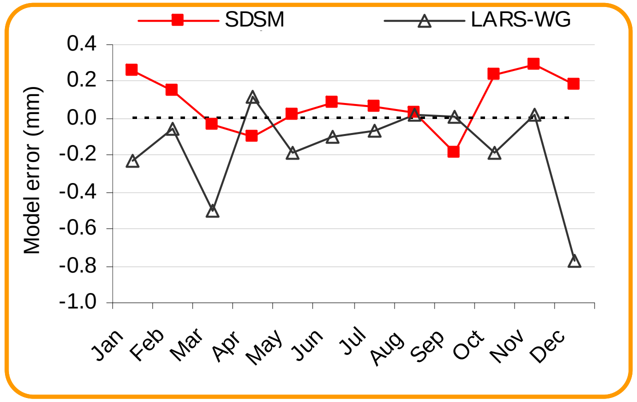
Precipitation (pp)	Maximum temperature (Tmax)	Minimum temperature (Tmin)
Surface zonal velocity	Surface zonal velocity	Surface airflow strength
850 hPa zonal velocity	500 hPa geopotential height	Surface vorticity
850 hPa air flow strength	850 hPa zonal velocity	Surface specific humidity
850 hPa geopotential height	Mean temperature at 2m	Mean temperature at 2m
Near surface relative humidity		

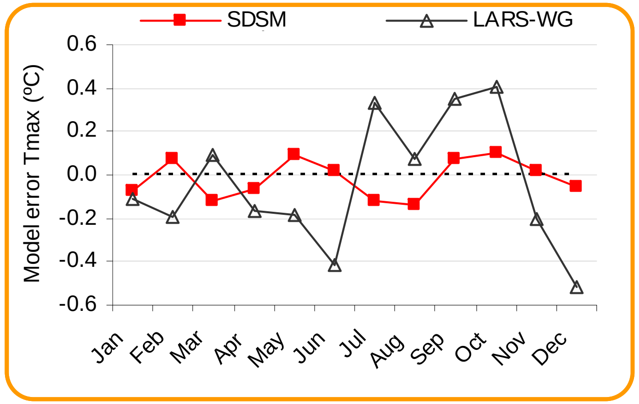
Results for Lisbon

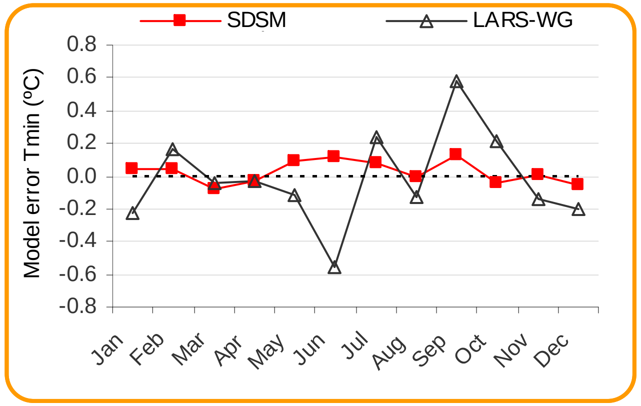
STATISTICAL DOWNSCALING

COMPARISON BETWEEN A STOCHASTIC AND HYBRID METHOD

VALIDATION FOR THE MEAN:







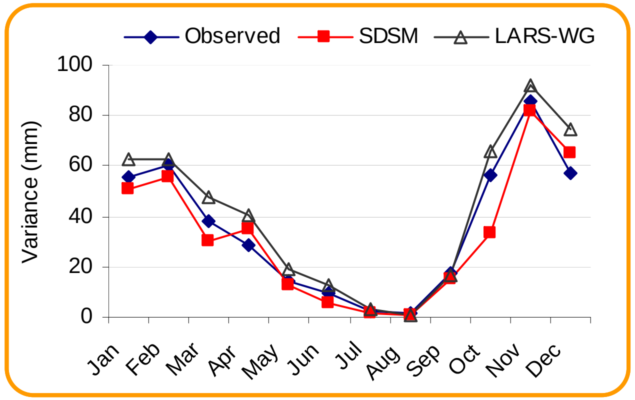
	Tmin		Tmax		Precipitation	
	SDSM	LARS-WG	SDSM	LARS-WG	SDSM	LARS-WG
Jan	0.828	0.039	0.828	0.796	0.014	0.076
Feb	0.689	0.078	0.593	0.215	0.020	0.995
Mar	0.433	0.682	0.047	0.947	0.112	0.007
Apr	0.575	0.500	0.101	0.206	0.138	0.002
May	0.596	0.176	0.303	0.065	0.327	0.813
Jun	0.825	0.000	0.382	0.002	0.151	0.862
Jul	0.098	0.995	0.034	0.341	0.323	0.525
Aug	0.069	0.011	0.033	0.418	0.623	0.656
Sep	0.561	0.000	0.663	0.153	0.826	0.460
Oct	0.502	0.032	0.341	0.024	0.215	0.360
Nov	0.715	0.216	0.691	0.035	0.012	0.372
Dec	0.426	0.103	0.771	0.000	0.025	0.053

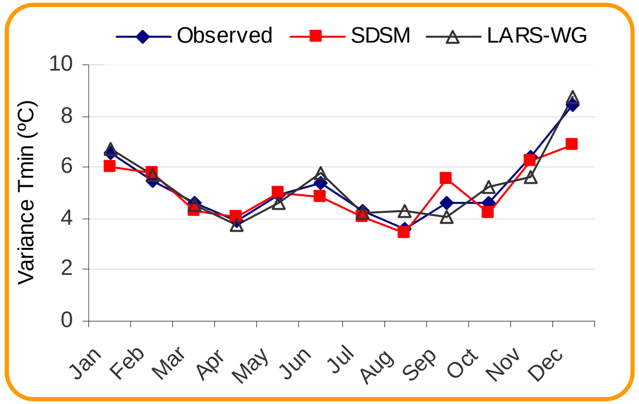
Test results (p values) of the Mann-Whitney U test for the difference of means of the observed (1981-1990) and downscaled daily Tmin, Tmax and precipitation at the 95% confidence level

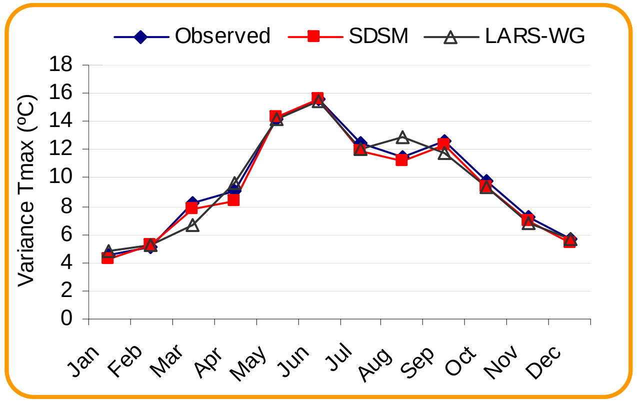
STATISTICAL DOWNSCALING

COMPARISON BETWEEN A STOCHASTIC AND HYBRID METHOD

VALIDATION FOR THE VARIANCE:







	Tmin		Tmax		Precipitation	
	SDSM	LARS-WG	SDSM	LARS-WG	SDSM	LARS-WG
Jan	0.167	0.591	0.771	0.003	0.441	0.523
Feb	0.261	0.482	0.033	0.158	0.705	0.893
Mar	0.224	0.418	0.735	0.045	0.905	0.099
Apr	0.326	0.771	0.509	0.240	0.696	0.685
May	0.265	0.792	0.695	0.363	0.917	0.318
Jun	0.844	0.065	0.674	0.764	0.523	0.513
Jul	0.164	0.125	0.530	0.505	0.310	0.383
Aug	0.244	0.000	0.687	0.114	0.563	0.771
Sep	0.003	0.110	0.853	0.397	0.336	0.967
Oct	0.133	0.147	0.495	0.728	0.449	0.614
Nov	0.701	0.028	0.470	0.832	0.500	0.965
Dec	0.002	0.979	0.483	0.565	0.613	0.042

Test results (p values) of the Brown-Forsythe test for the difference of variances of the observed and downscaled daily Tmin, Tmax and precipitation at the 95% confidence level

STATISTICAL DOWNSCALING

COMPARISON BETWEEN A STOCHASTIC AND HYBRID METHOD

IMPORTANT CONSIDERATIONS WHEN VALIDATING THE RESULTS...

Many statistical methods depend on the assumptions that the data have a nearly normal distribution and are uncorrelated when collected over regular time periods. If these assumptions are not verified the classical statistical methods may be misleading and a non-parametric approach produces more robust results.

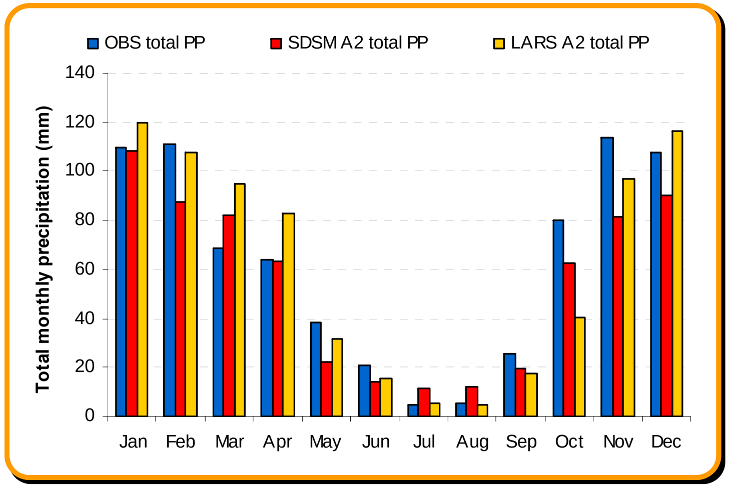
To assess the uncertainty of the results at the 95% confidence intervals you can use a bootstrapping non-parametric approach. Bootstrapping is a method of estimating the properties of an estimator, such as the mean and variance, by measuring its properties when sampling from an approximating distribution.

IF THE MODEL CAN REPRESENT THE OBSERVED CLIMATE THEN WE ARE READY TO BUILD CLIMATE CHANGE SCENARIOS

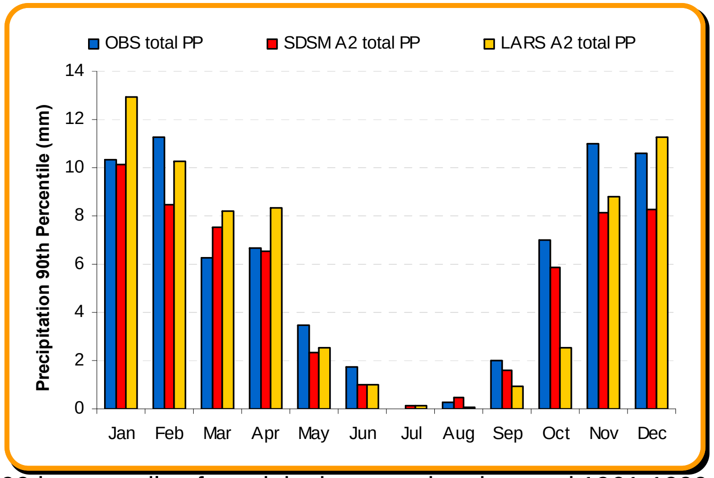
STATISTICAL DOWNSCALING

COMPARISON BETWEEN A STOCHASTIC AND HYBRID METHOD

A2a SRES SCENARIO FOR LISBON BETWEEN 2041 and 2070 (LISBOA GEOFISICA)



Total monthly precipitation over the observed 1961-1990 and the 2041-2070 period



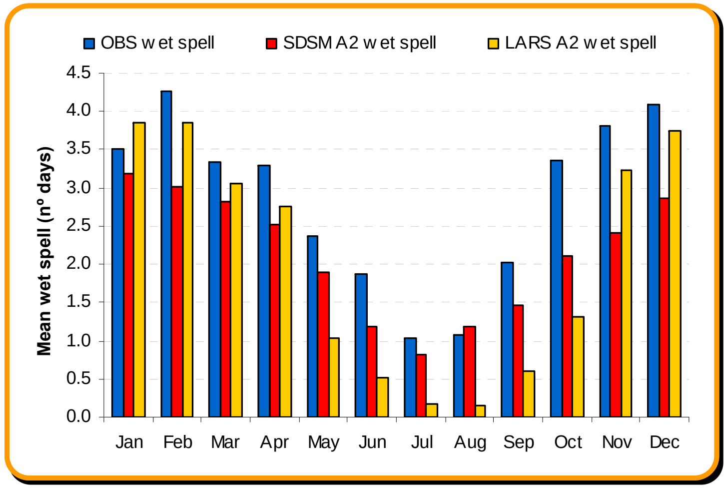
90th percentile of precipitation over the observed 1961-1990 and the 2041-2070 period

Spite off both models having similar trends it is important to notice that between July and October the accumulated monthly precipitation and the peaks over the 90 percentile are always smaller in the stochastic method and higher in the remaining months then the hybrid method.

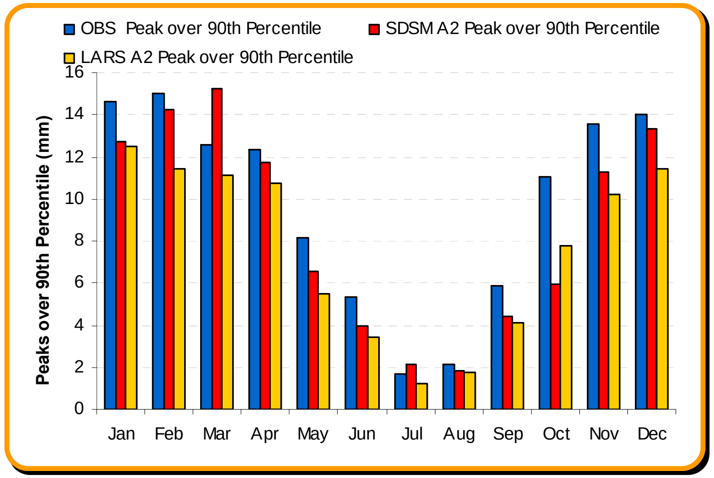
STATISTICAL DOWNSCALING

COMPARISON BETWEEN A STOCHASTIC AND HYBRID METHOD

A2a SRES SCENARIO FOR LISBON BETWEEN 2041 and 2070 (LISBOA GEOFISICA)



Mean wet spell length over the observed 1961-1990 and the 2041-2070 period



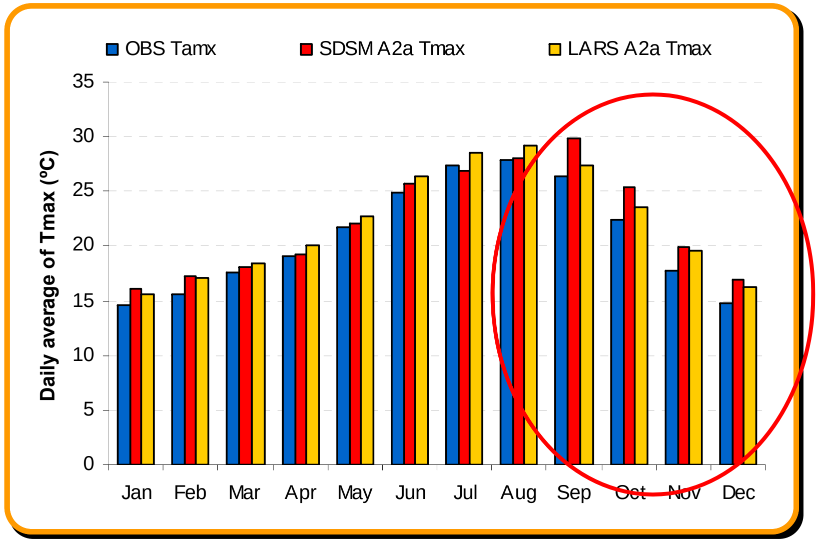
Peaks over the 90th percentile over the observed 1961-1990 and the 2041-2070 period

The same observations is possible to find between May and October for the monthly number of wet days and the number of peaks over the 90 percentile. In the remaining months the stochastic method presents higher values then the hybrid method.

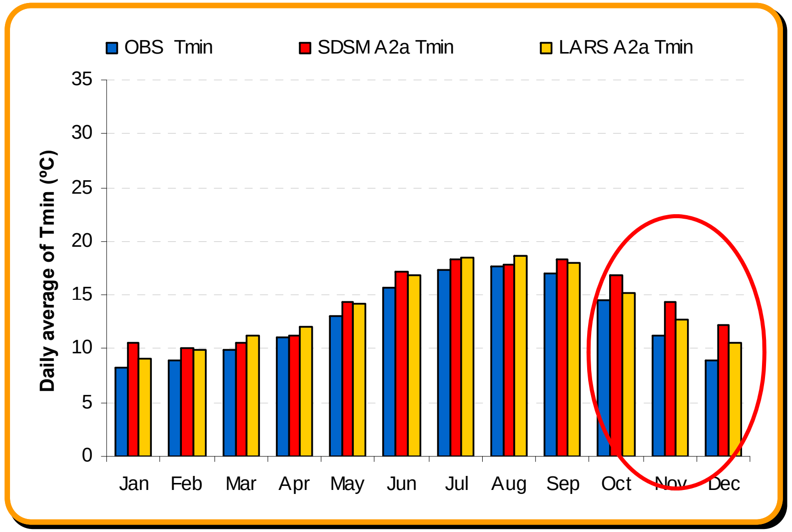
STATISTICAL DOWNSCALING

COMPARISON BETWEEN A STOCHASTIC AND HYBRID METHOD

A2a SRES SCENARIO FOR LISBON BETWEEN 2041 and 2070 (LISBOA GEOFISICA)



Maximum temperature over the observed 1961-1990 and the 2041-2070 period



Minimum temperature over the observed 1961-1990 and the 2041-2070 period

STATISTICAL DOWNSCALING

COMPARISON BETWEEN A STOCHASTIC AND HYBRID METHOD

STRENGTHS	WEAKNESS
•Station–scale climate information from GCM–scale output •Cheap, computationally undemanding and readily transferable •Ensembles of climate scenarios permit risk and uncertainty analyses	•Dependent on the realism of GCM • Requires high quality data for model Calibration • Predictor–predictand relationships are often non–stationary • Choice of predictor variables affects Results • Low–frequency climate variability problematic

PROJECT MAIN GOAL:

Construction of **long – term** environmental and socio-economic scenarios

Toxicity assessment for **mixtures** of Substances

Health risk assessment for **selected groups** of population

Defining **uncertainty** bounds and sensitivity analyses

MAIN GOALS FOR THE PORTUGUESE CASE STUDY:

Evolution of **air pollution**,

Consequences of **climate change** and emissions of air pollutants in **HUMAN HEALTH.**

THE END

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