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Downscaled climate projections in the Pyrenees during the 21st century

A. Barrera-Escoda & J. Cunillera

Equip de Canvi Climàtic. Àrea de Climatologia. Servei Meteorològic de Catalunya.
Departament de Territori i Sostenibilitat. Generalitat de Catalunya.
Barcelona.

tbarrera@meteo.cat

http://www.meteo.cat/

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- Downscaling current climate of Catalonia (T, P)
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General framework

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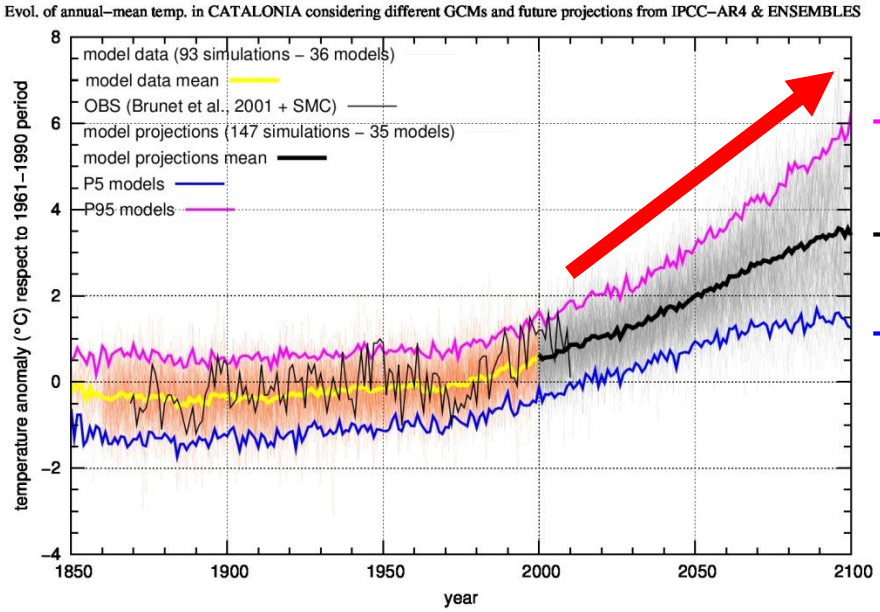
General Framework: GCM simulations



+6ºC

+3,5ºC

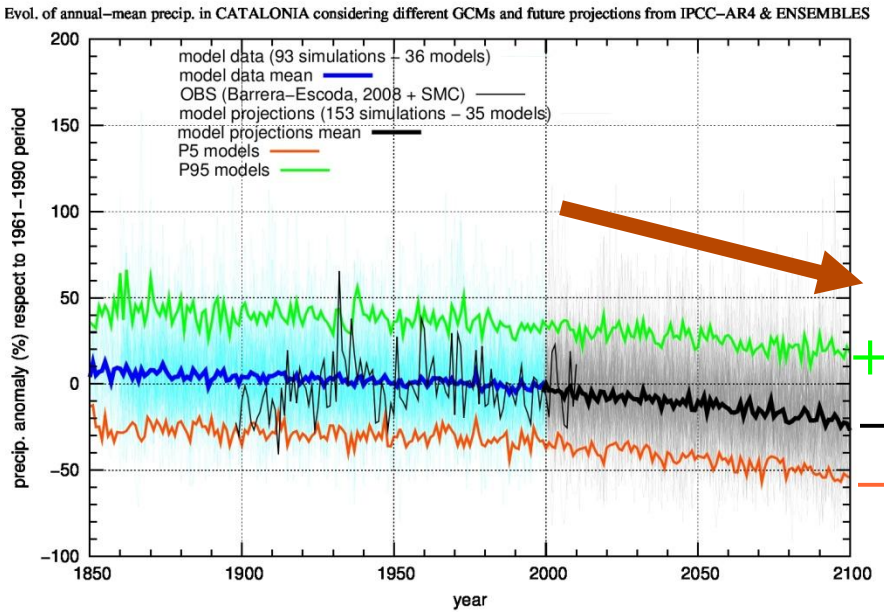
+1,5ºC

IPCC-AR4 & ENSEMBLES global simulations considering only Catalonia.

Reference period: **1961-1990**

TEMPERATURE

PRECIPITATION



+20%

–25%

–55%

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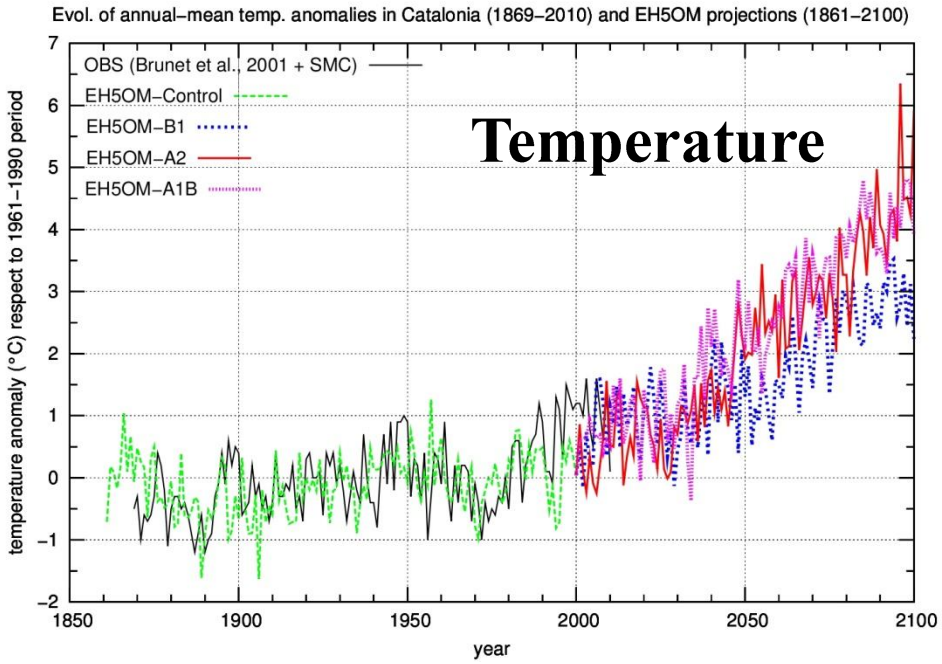
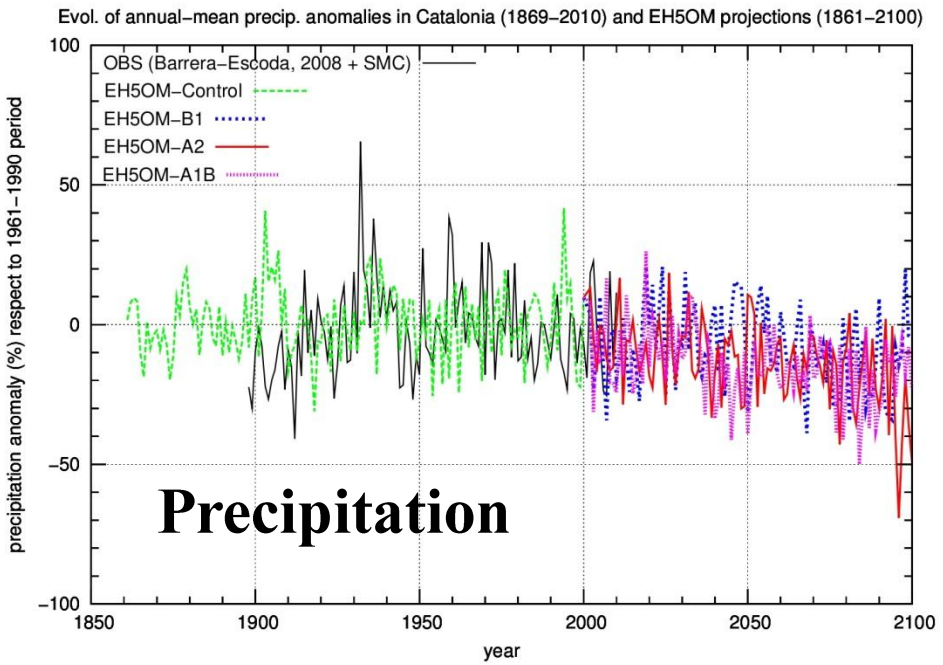
General Framework: ECHAM5/MPI-OM

ECHAM5/MPI-OM AOGCM has shown to be one of the best **GCMs** in reproducing **current climate** in **North Atlantic** area and **Europe** under known radiative forcings (Van Ulden & Van Oldenborgh, 2006) and, especially, in the **Western Mediterranean** zone (Altava-Ortiz, Ph.D., 2010). Therefore, it seems to be one of the **best models** in order to develop future climate projections for **Western Mediterranean** area.





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Simulation setup

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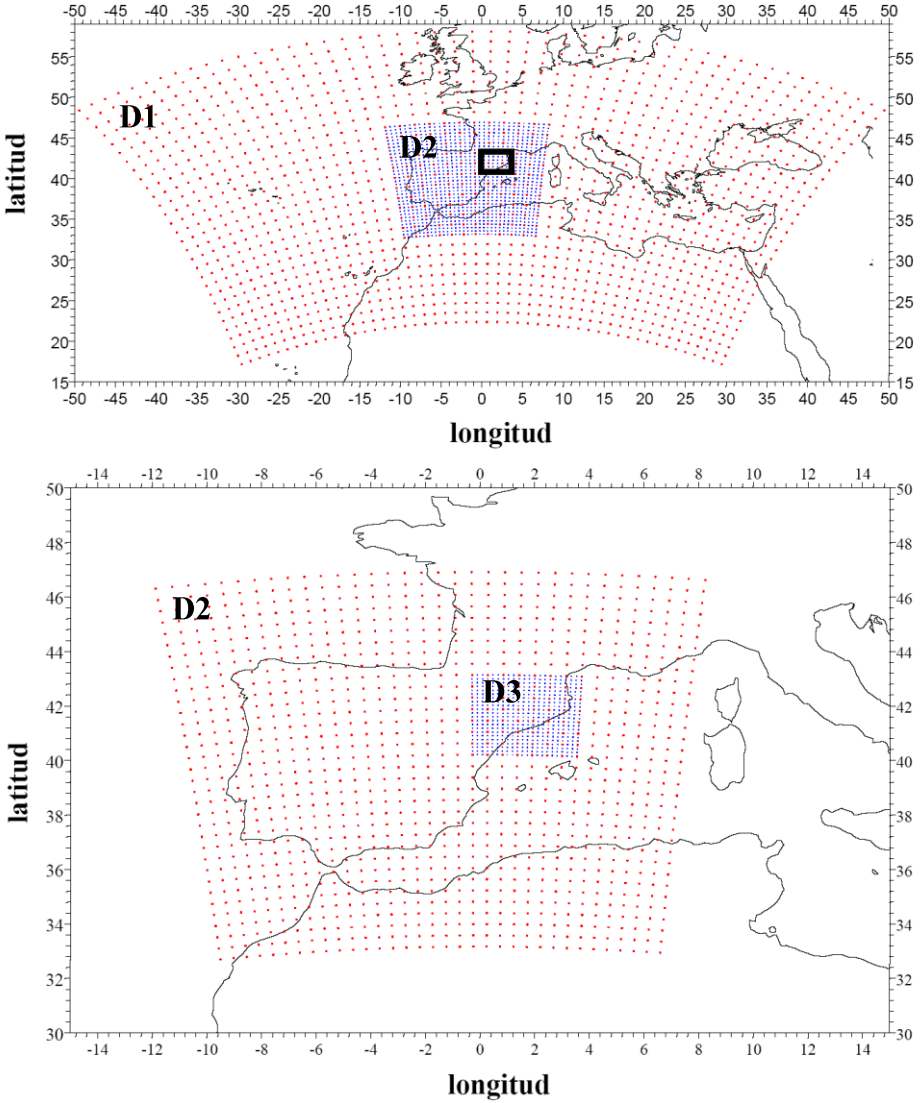
Simulation setup



- **Dynamical downscaling** technique with the **MM5** mesoscale model.
- Three **1-way nested** domains with **135**, **45** and **15** ***km*** horizontal resolution and **23** vertical levels.
- Dimensions **fitted** to **minimise computing time** and **disc space** for the output. **Simple** set of **parameterisations** to **minimise computing time** considering Fernández *et al.* (2007).
- **Dynamical nudging** applied to **mother domain** to guarantee mass continuity during the simulation and to follow the large-scale patterns. (Salathé *et al.*, 2008, *J. Climate*).
- 5-year simulations **reinitialised every 5 year** for the period **1971-2100**.

(0ºE, 40ºN)	D01	D02	D03
Resolution	135 km	45 km	15 km
N. pts.	30*50	34*37	22*22
(nesti,nestj)	(1,1)	(10,19)	(18,20)

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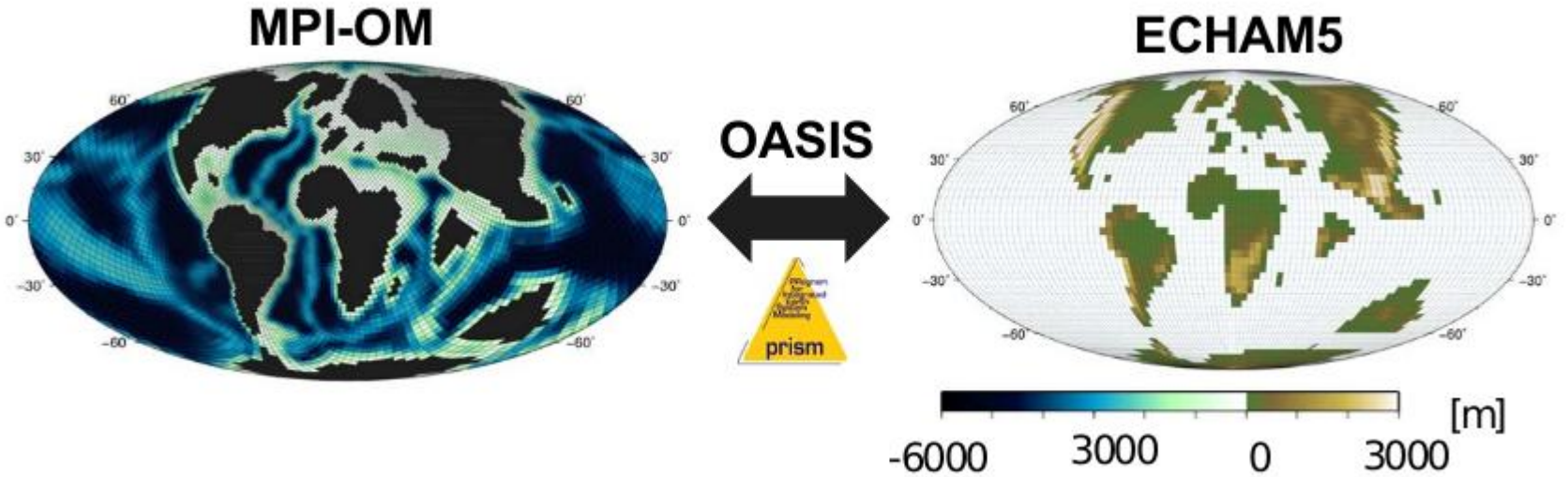
Simulation setup

4 experiments nesting MM5 into a GCM:

1) **2,5º ERA40** Reanalyses for the 1971-2000 period **(MM5+ERA40)=>** To verify MM5 skill
2) **1,875º** ECHAM5/MPI-OM (**EH5OM**) AOGCM 20C3M run 1 **IPCC-AR4** simulation for the 1971-2000 period (**MM5+ECHAM5**)=> Construction of the reference climate.
3) **1,875º EH5OM SRES_A2** (**severe** emission scenario) run 1 **IPCC-AR4** simulation for the 2001-2100 period (**MM5+EH5A2**).
4) **1,875º EH5OM SRES_B1** (**moderate** emission scenario) run 1 **IPCC-AR4** simulation for the 2001-2100 period (**MM5+EH5B1**).

EH5OM data are **free** and on-line available for **scientific comunity** at **CERA** portal from **WDCC:**

http://cera-www.dkrz.de/CERA/index.html



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Downscaling current climate

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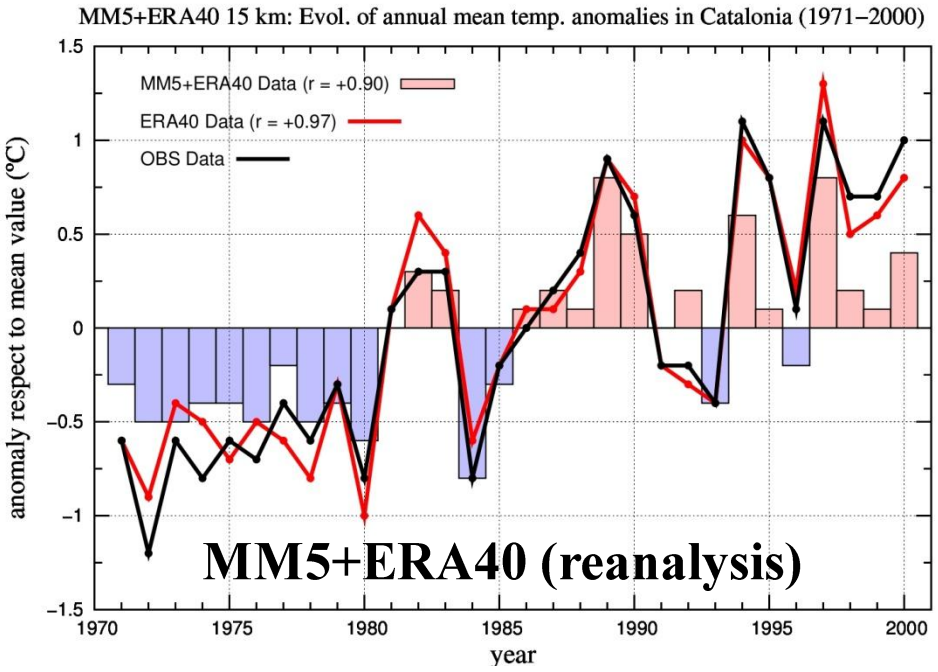
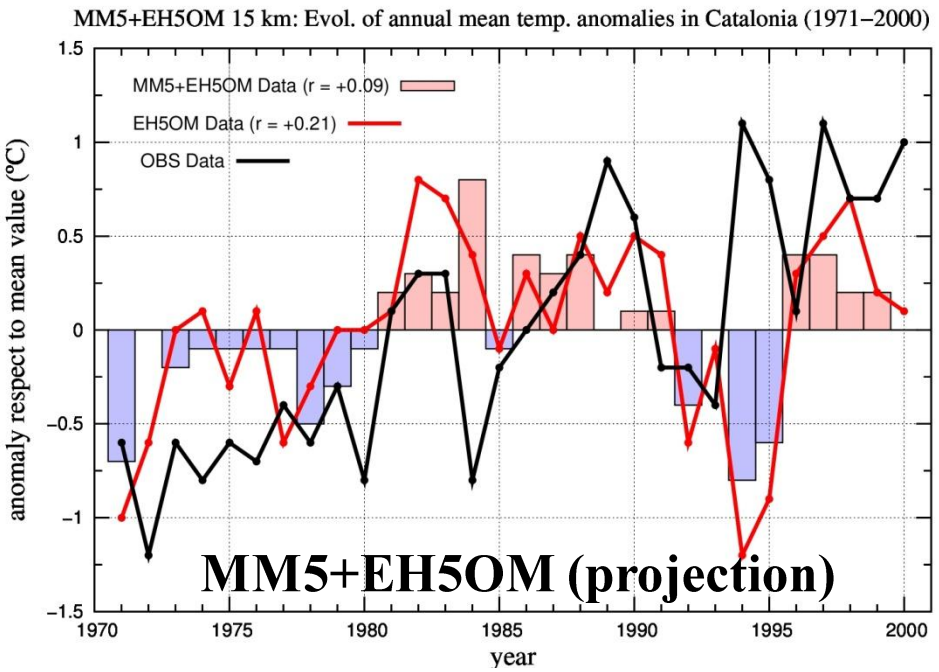
Downscaling current climate



Interannual variability (evolution of anomalies 1971-2000)

15 KM

ANNUAL-MEAN TEMP. ANOMALIES (ºC)



- MM5 variability range is **similar** to observational one.

- MM5 temporal trend has the **same sign** as observations.

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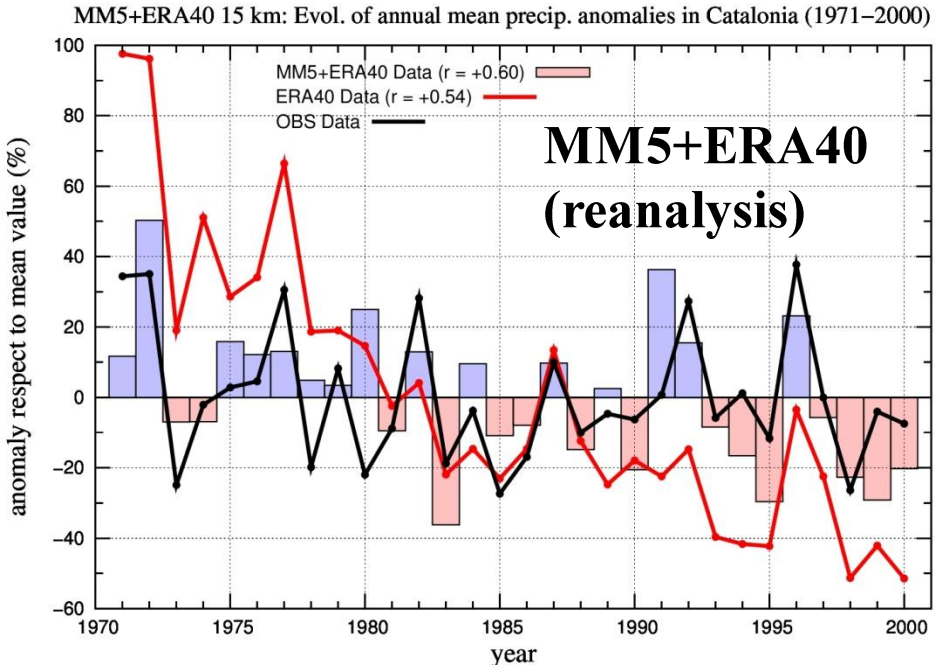
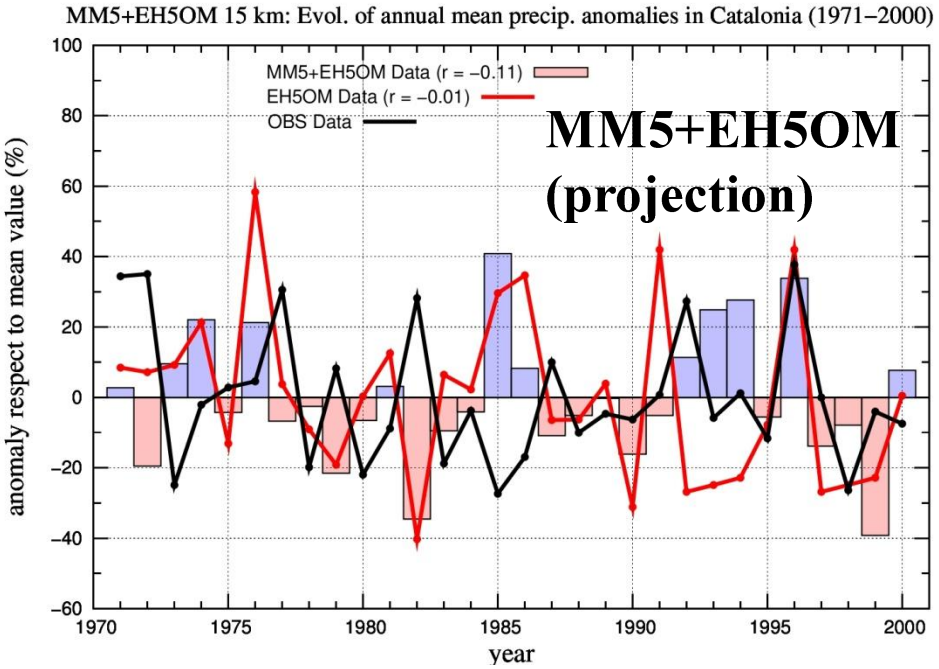
Downscaling current climate



Interannual variability (evolution of anomalies 1971-2000)

15 KM

ANNUAL-MEAN PRECIP. ANOMALIES (ºC)

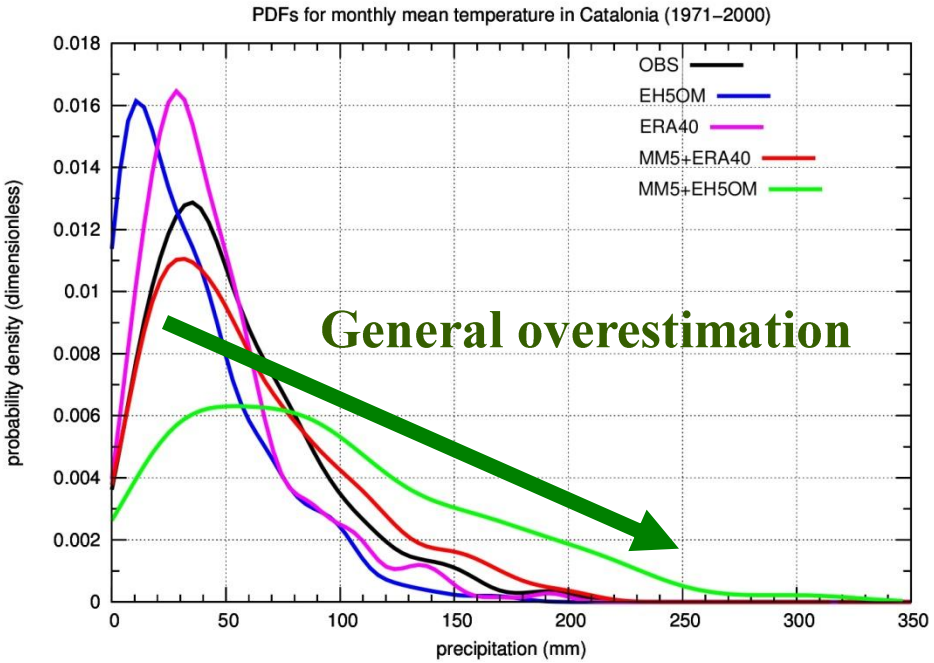


- MM5 variability range is **similar** to observational one.

- MM5 temporal trend has the **same sign** as observations.

- Downscaling technique **improves** results from ERA-40.

Downscaling current climate



MONTHLY PRECIPITATION (mm)

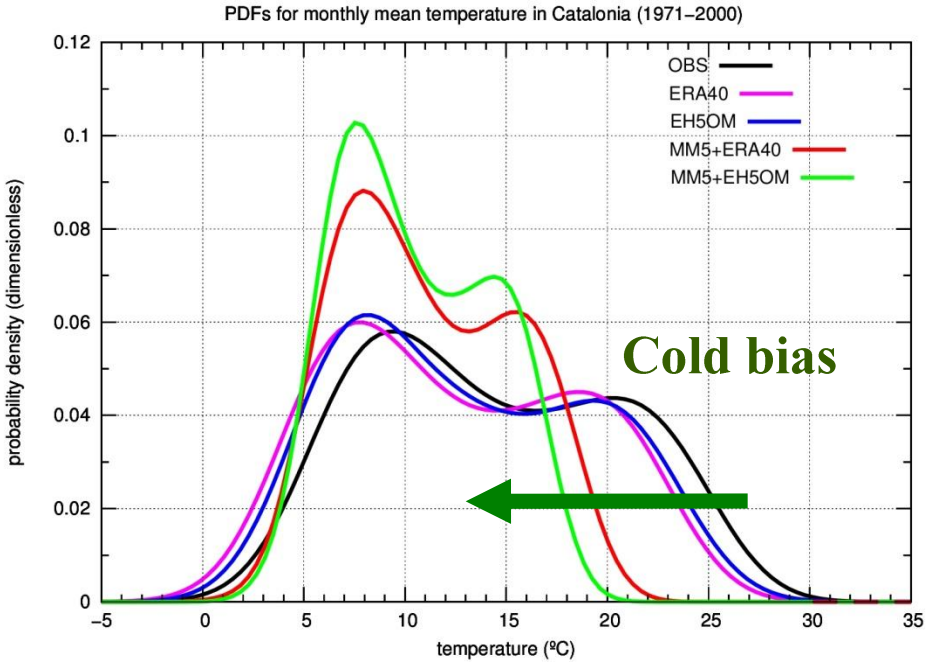
- Temperature cycle is **well captured** by MM5, but with values lower than obs. (not shown)

- Precipitation cycle is **not well reproduced** by MM5, with a significant overestimation in winter and spring respect to obs. (not shown)

Frequency distributions (PDFs 1971-2000)

15 KM

MONTHLY TEMPERATURE (ºC)



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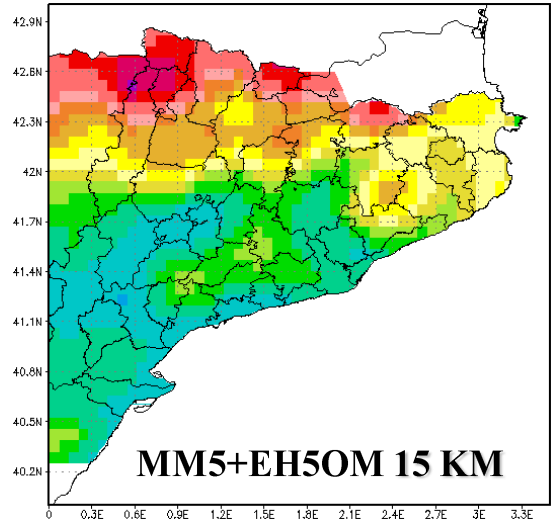
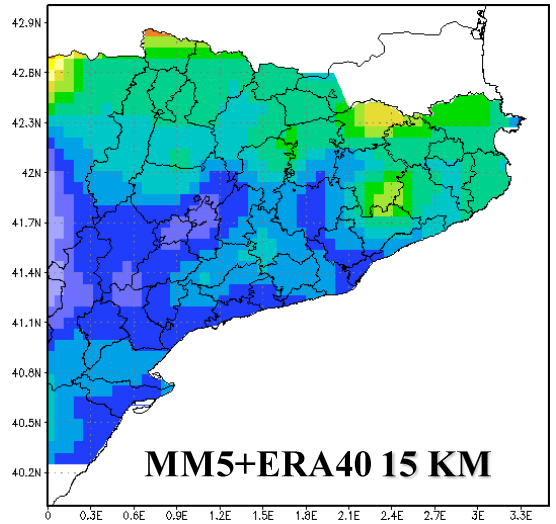
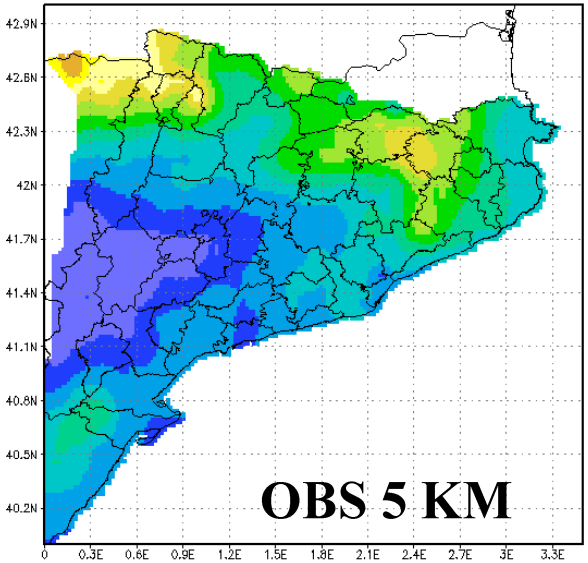
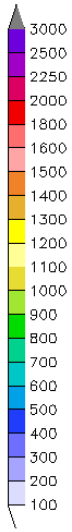
Downscaling current climate

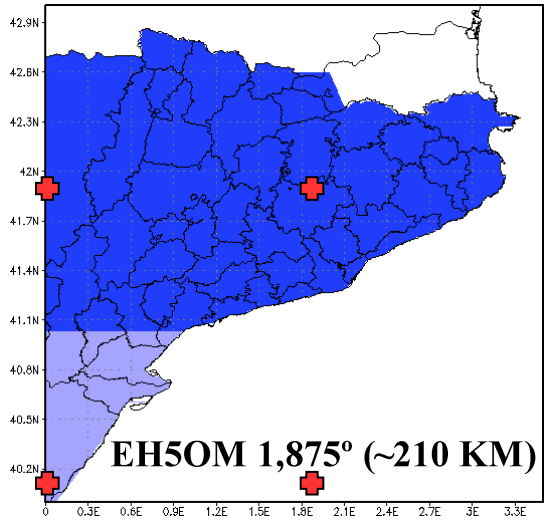
Spatial variability (1971-2000 annual-mean precipitation field)

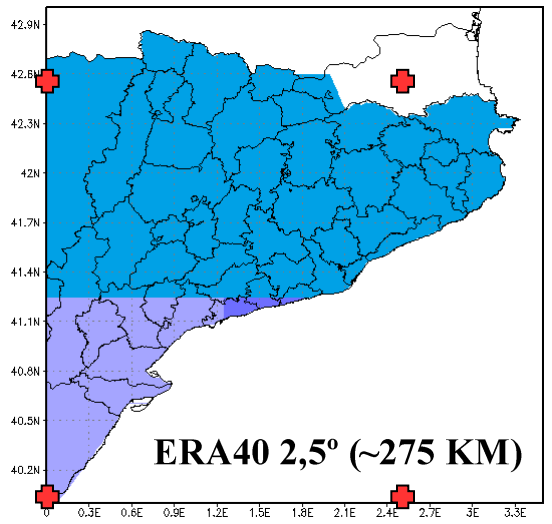












- **Spatial pattern** produced by MM5 is **similar to** observational one (correct location of precipitation maxima and minima), although it is **overestimated**.

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Downscaled projections

Downscaled projections

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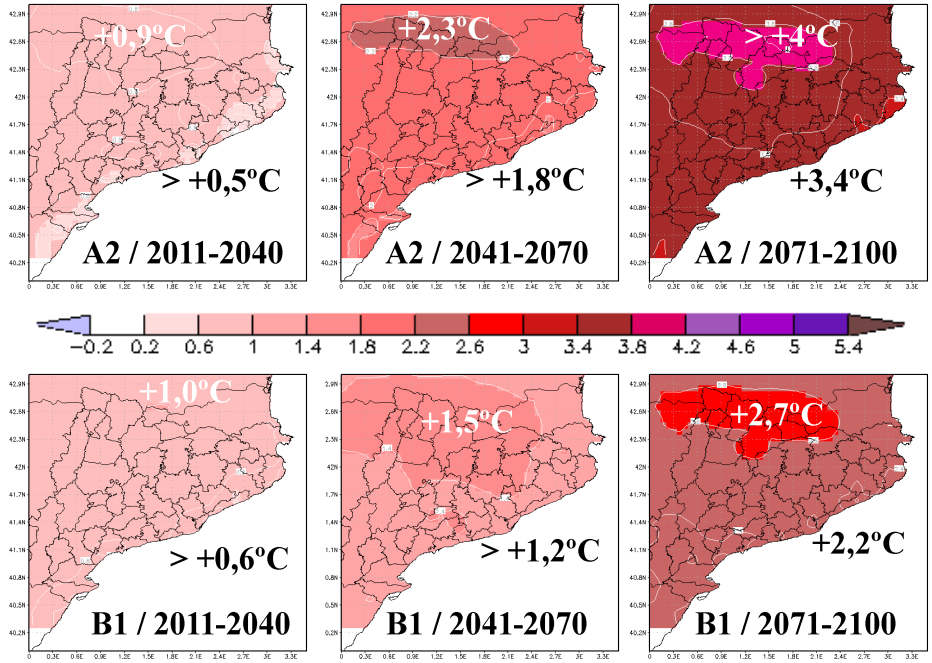
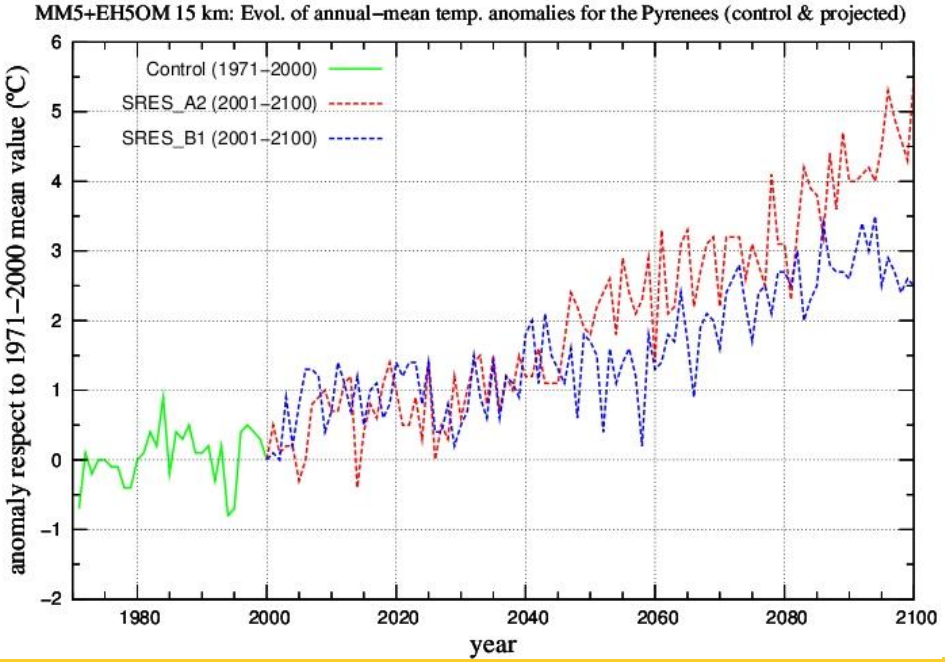


Projected annual variations respect to 1971-2000 period

TEMPERATURE (ºC)

15 KM



- Linear trends for the PYRENEES:

SRES-A2 +4,5ºC in 100 *yr.* ⇒ Sig. CL=95%

SRES-B1 +2,4ºC in 100 *yr.* ⇒ Sig. CL=95%

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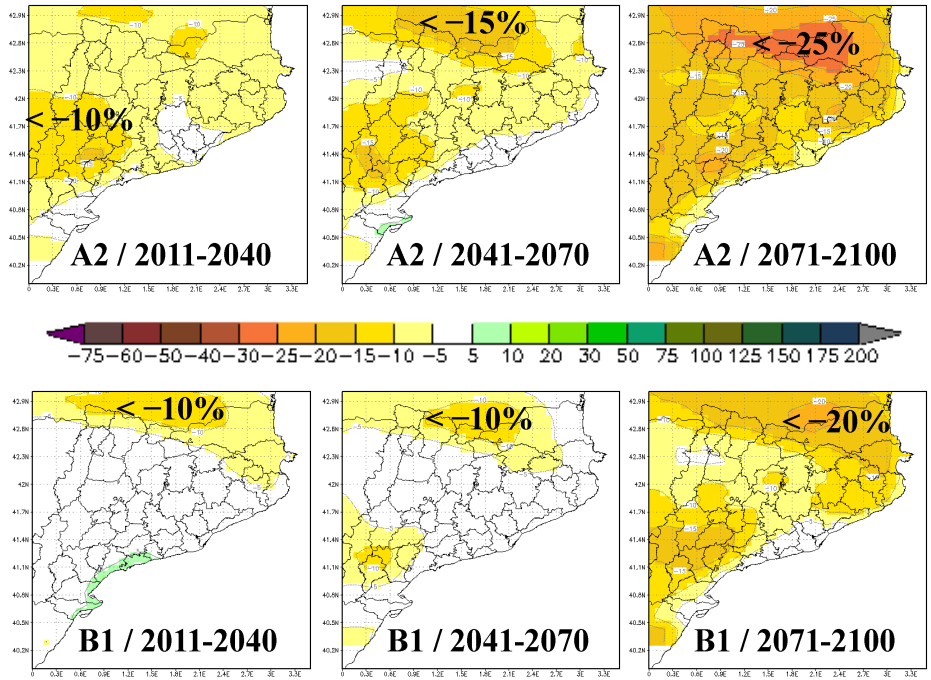
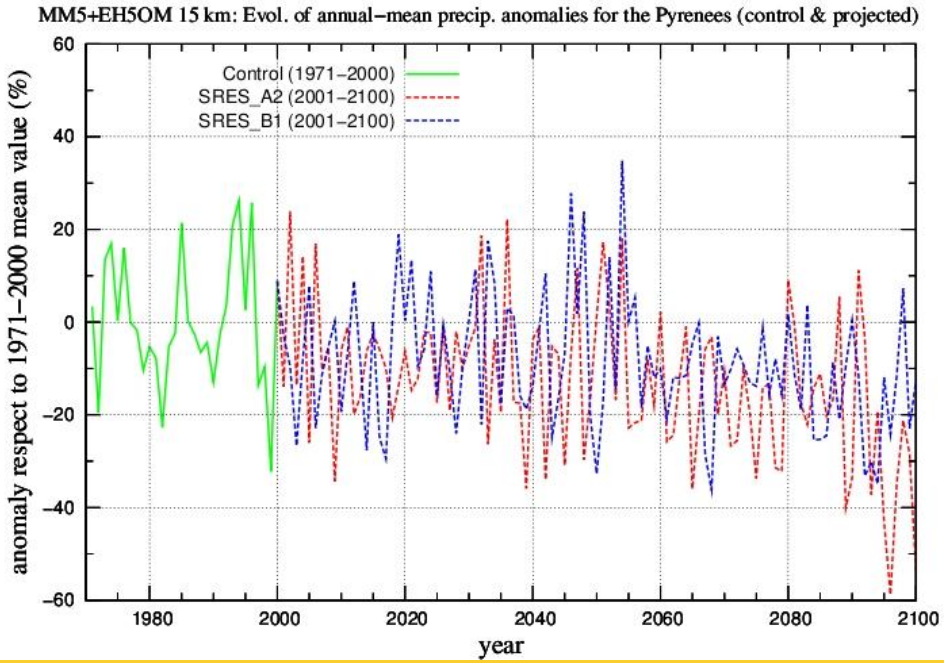
Downscaled projections



Projected annual variations respect to 1971-2000 period

PRECIPITATION (%)

15 KM



- Linear trends for the PYRENEES:

SRES-A2 −17,0% in 100 *yr.* ⇒ Sig. CL=95%

SRES-B1 −8,7% in 100 *yr.* ⇒ No Sig.

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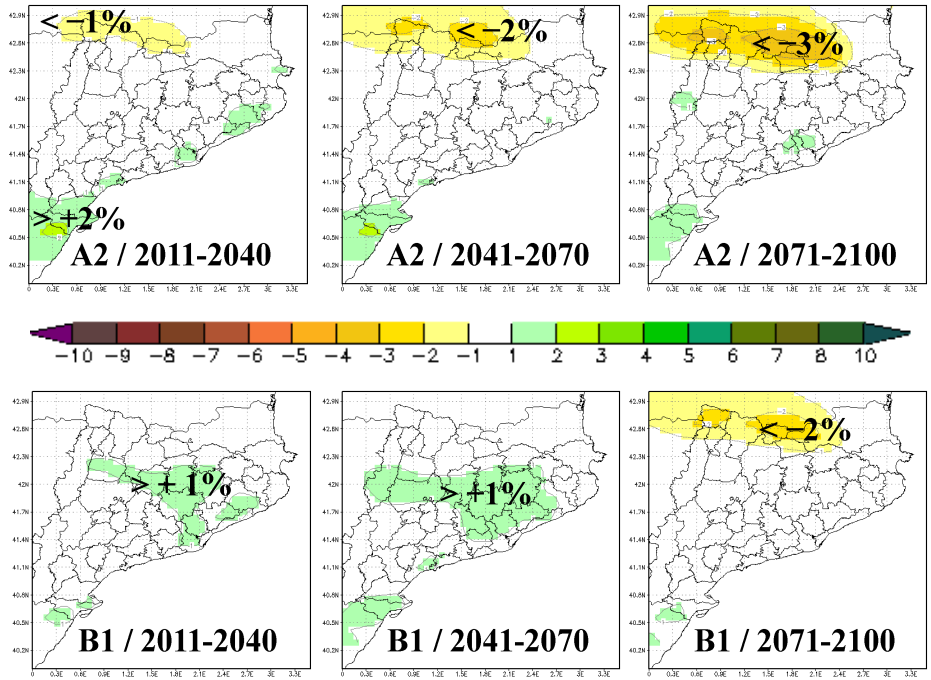
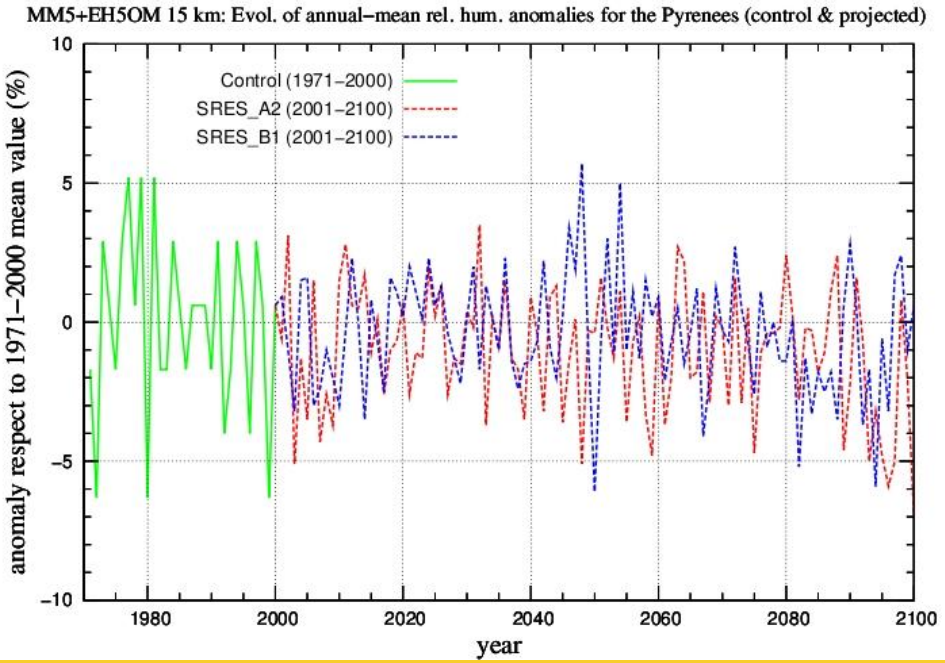
Downscaled projections



Projected annual variations respect to 1971-2000 period

RELATIVE HUMIDITY (%)

15 KM



- Linear trends for the PYRENEES:

SRES-A2 −1,5% in 100 *yr.* ⇒ Sig. NC=90%

SRES-B1 −0,9% in 100 *yr.* ⇒ No Sig.

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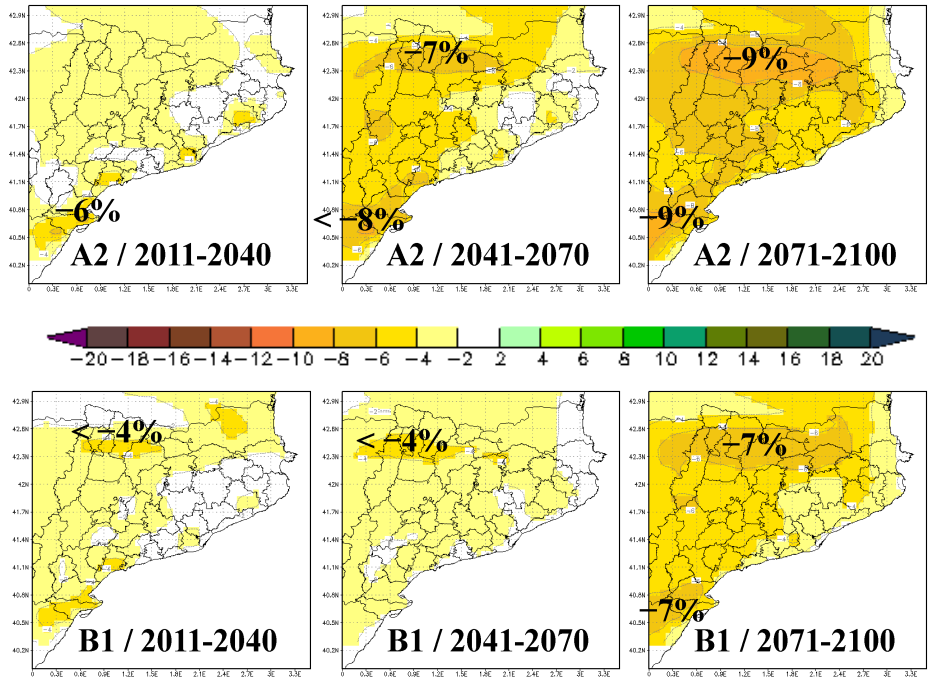
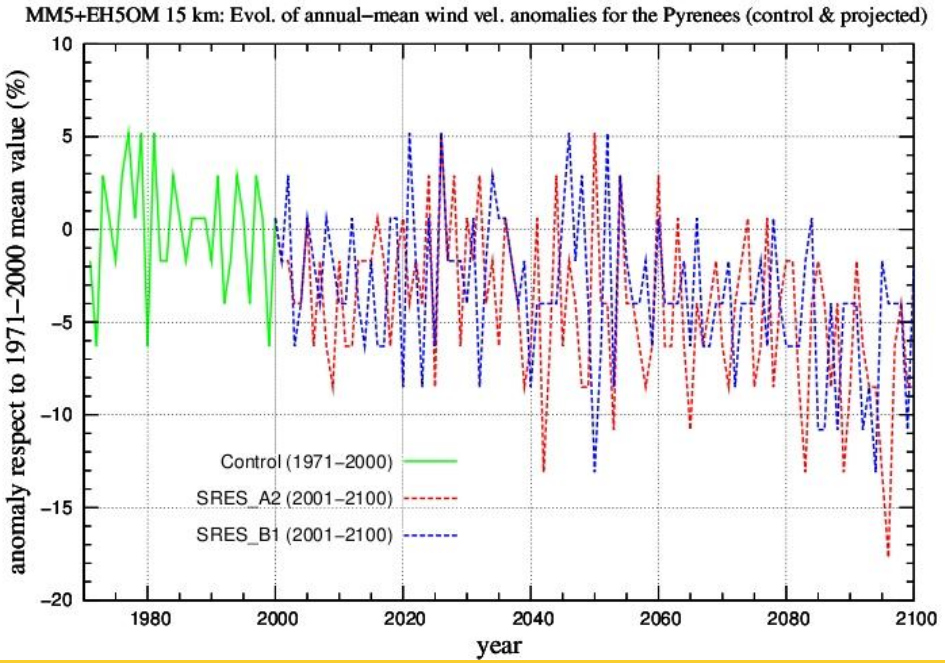
Downscaled projections



Projected annual variations respect to 1971-2000 period

10-METER WIND VELOCITY (%)

15 KM



- Linear trends for the PYRENEES:

SRES-A2 −5,6% en 100 *yr.* ⇒ Sig. CL=95%

SRES-B1 −4,5% en 100 *yr.* ⇒Sig. CL=95%

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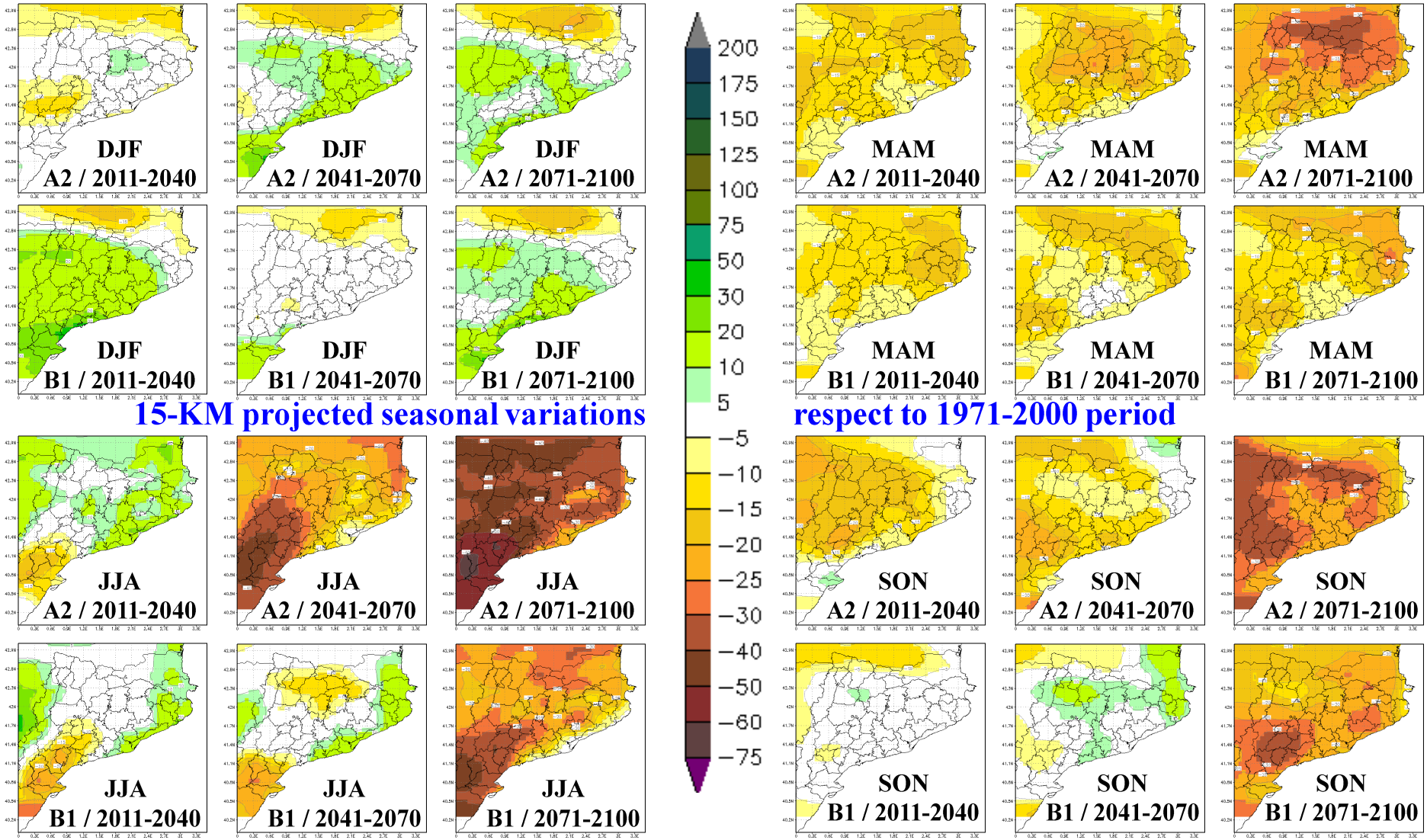
Downscaled projections



15-KM projected seasonal variations respect to 1971-2000 period

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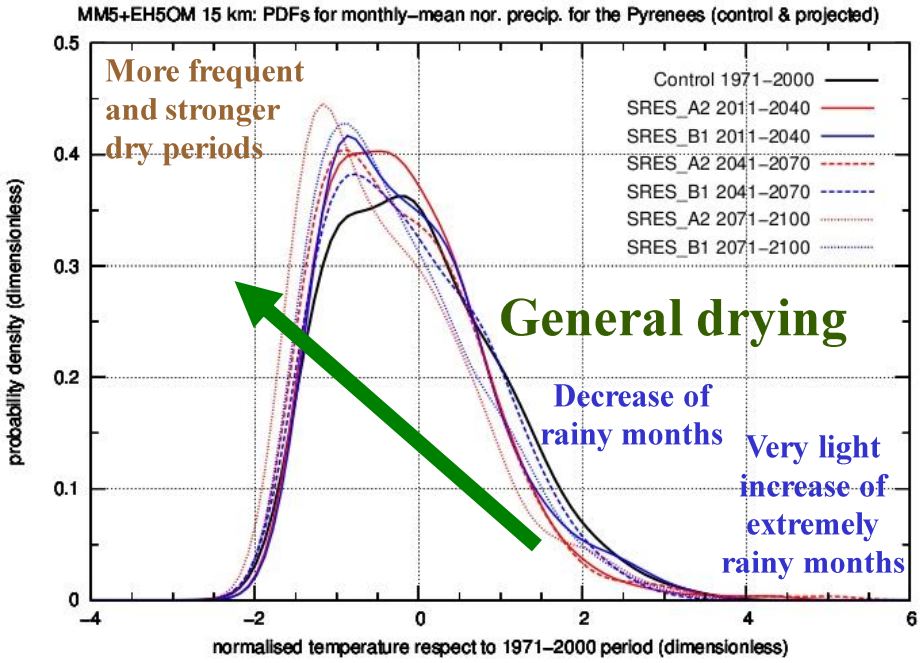
Downscaled projections

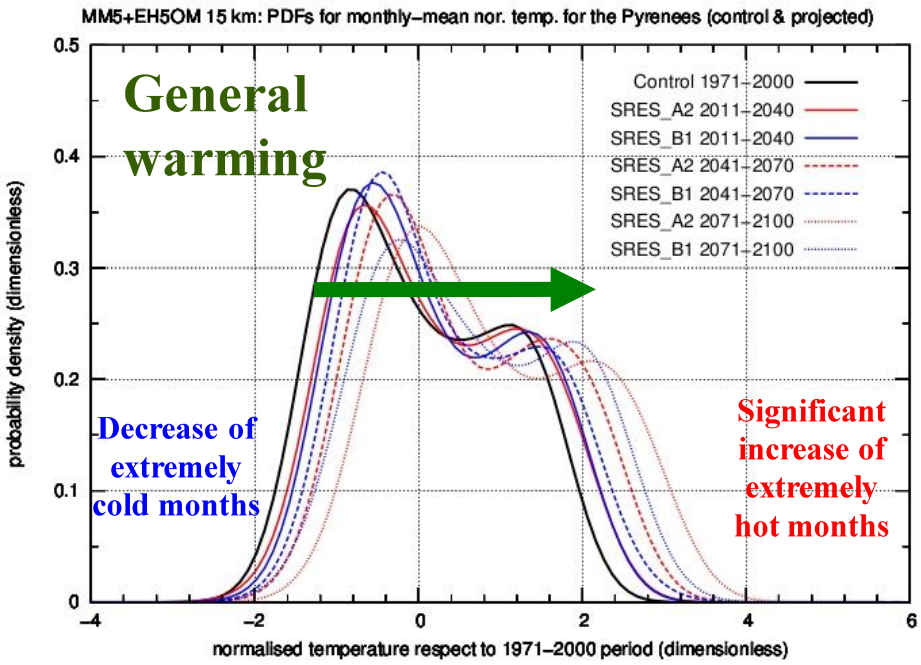


MONTHLY PRECIPITATION

15 KM

Projected frequency distributions (Normalised PDFs respect to 1971-2000 period)

MONTHLY TEMPERATURE



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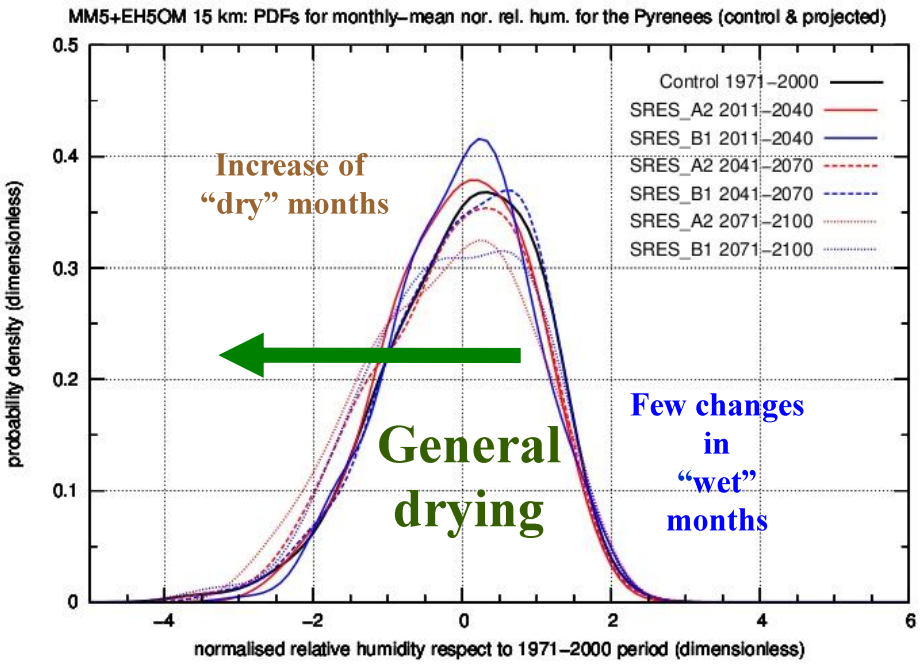
Downscaled projections

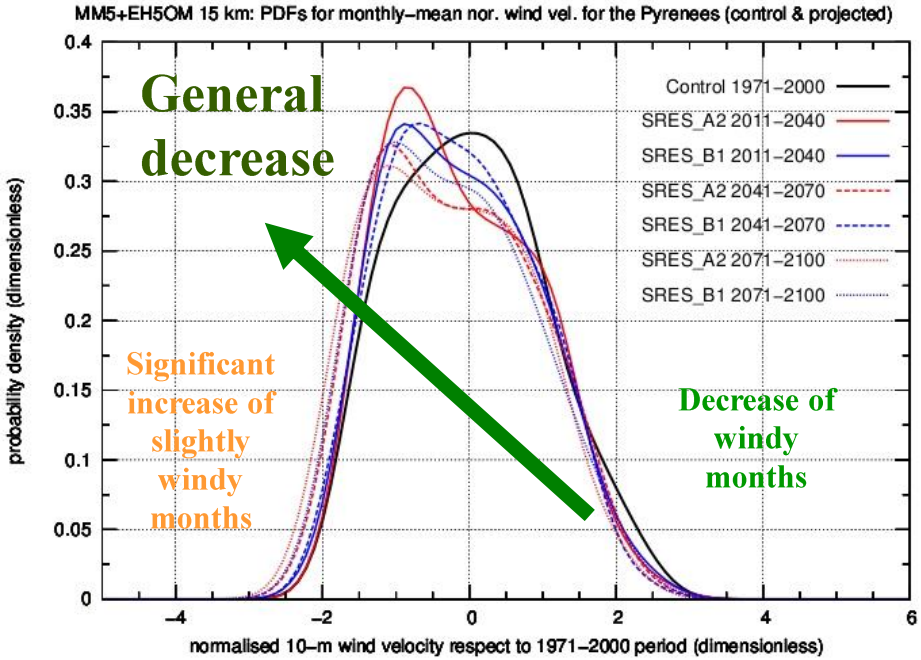


MONTHLY RELATIVE HUMIDITY

15 KM

Projected frequency distributions (Normalised PDFs respect to 1971-2000 period)

MONTHLY 10-METER WIND VELOCITY



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Conclusions & future work

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Conclusions & future work

CONCLUSIONS:

- The **simulations correctly** reproduce the range of inter-annual **variability** as well as the sign of trends presented in obs., but not the seasonal cycle of precip. (yes, for temp.).
- General **overestimation** and **cold bias** for **precip.** and **temp.** **fields**, respectively.
- **Significant** and **robust increase** in **temp.**, up to **+4.5ºC** by the **end** of this **century** respect to 1971-2000 period. Significant **increase** in **hot** months and **decrease** in **cold** months ⇒ **Less available snow**.
- **Decrease** in **precip.**, up to **25%** by the **end** of this **century**. Great **differences** at **sesonal** scale, depending on the scenario. **More variability** with a significant increase in **dry** and **extremely dry** months ⇒ **Less water resources**.
- **Increase** of months with **RH below** 1971-2000 mean value.
- **Decrease** in **WV** with a **greater** range of **variability**, although with a significant **increase** in **slightly windy** months and a **decrease** in **windy** months.
- It is projected **changes more significant** and **stronger** for the **A2** scenario (**severe**) than for the **B1** scenario (**moderate**).

Conclusions & future work

FUTURE WORK (Under development within the **ESCAT Project,** SMC and Barcelona Supercomputing Center, Final results in **July 2012**)

- *Improving results*:

- **Redefinition** of integration **domains**, covering a larger area (especially **D3**) and **increase** in scale (**5-10 km**).

- Use of more **complex parameterisations** (**Kain-Fritsch Convection Scheme, NOAH Land Soil Model and RRTM Radiation Scheme**) in order to **improve** the simulated **seasonal cycle** of precipitation and reduce the **cold bias** in temperature.

- *New simulations*:

- Other emission scenarios: **A1B**, RCPs

- Other **GCMs** and/or simulations from **IPCC-AR5**. (**IPCC-AR4 ECHAM5/MPI-OM Run1 & Run3**)

- Other mesoscale models: **WRF**.

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THANK YOU VERY MUCH FOR YOUR ATTENTION !!!

Moltes gràcies per la vostra atenció !!!

Gràcies
Mersi
Eskerrik
Mercés
Gracias
Merci

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