

Centro Euro-Mediterraneo
per i Cambiamenti Climatici

Scenari futuri di cambiamento climatico nel Mediterraneo e in Italia

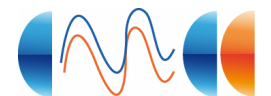
Silvio Gualdi, Centro Euro-Mediterraneo per i Cambiamenti Climatici
Istituto Nazionale di Geofisica e Vulcanologia

Climatica...mente Cambiando, TRENINO CLIMA 2011

“Impatti, mitigazione e adattamento: una scommessa globale sul clima che verrà, 9 Settembre, Trento

Piano della Presentazione:

- **Cambiamento Climatico: osservazioni dirette**
- **Modelli Numerici e Simulazioni del Clima**
- **Proiezioni di Cambiamento Climatico: scala regionale (Mediterraneo)**
- **Proiezioni di Cambiamento Climatico: zoom sull'Italia**



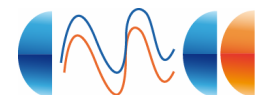
Bibliografia e Sorgenti:

IPCC, 2007: *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*.

Editors: Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

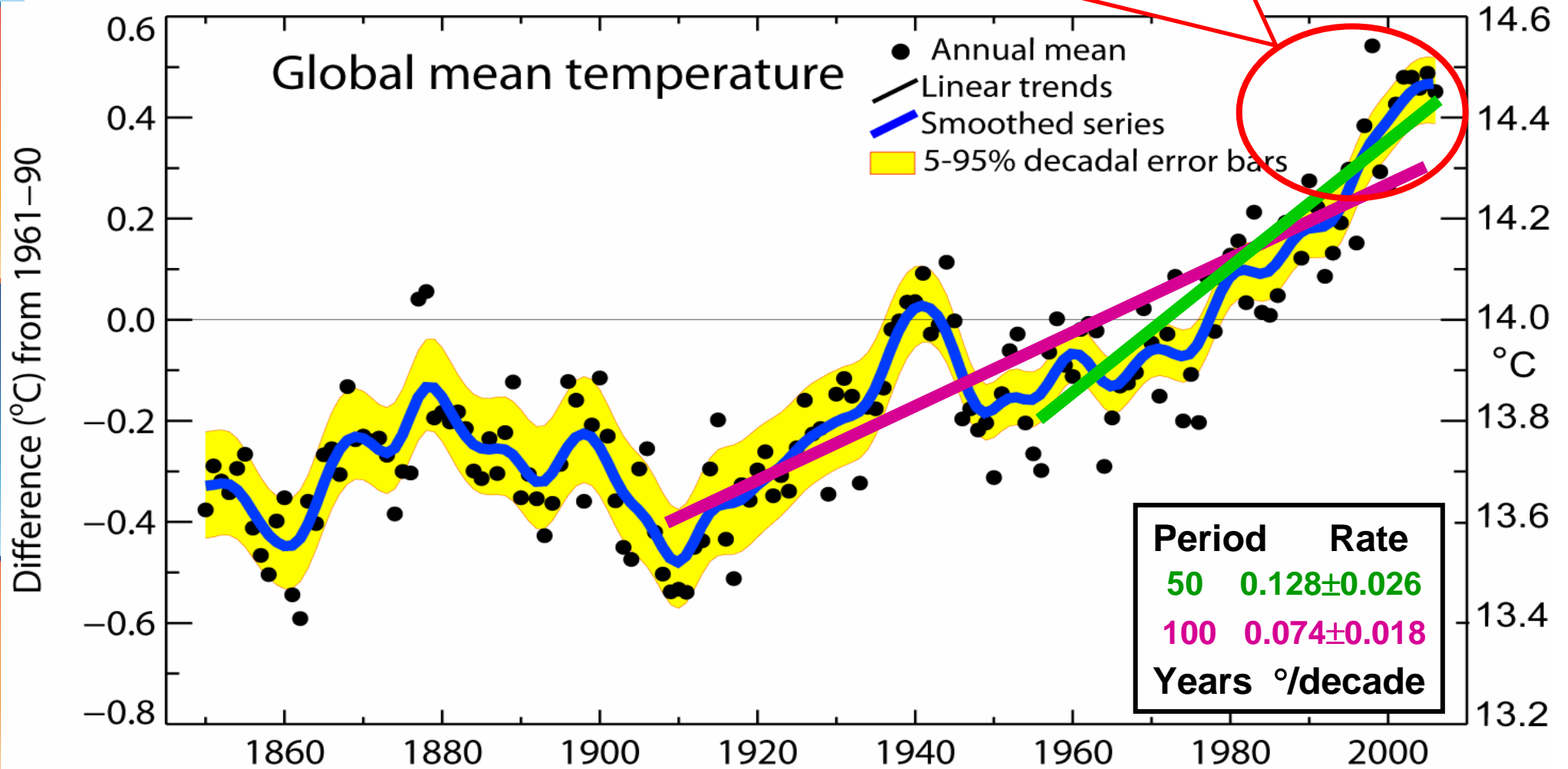
Gualdi S., F. Giorgi, and A. Navarra, 2009. *Le proiezioni del clima futuro nell'area dell'Euro-Mediterraneo negli scenari globali e regionali*, in "*I cambiamenti climatici in Italia. Vulnerabilità e Impatti*" eds S. Castellari e V. Artale, Bologna, Edizioni Bionomia University Press, pp 47-80.

Gualdi S., S. Somot, W. May, S. Castellari, M. Déqué and coauthors, 2011. *Future Climate Projections*, in *Regional Assessment of Climate Change in the Mediterranean*. A. Navarra, L. Tubiana (eds.), Springer, Dordrecht, The Netherlands. In press.



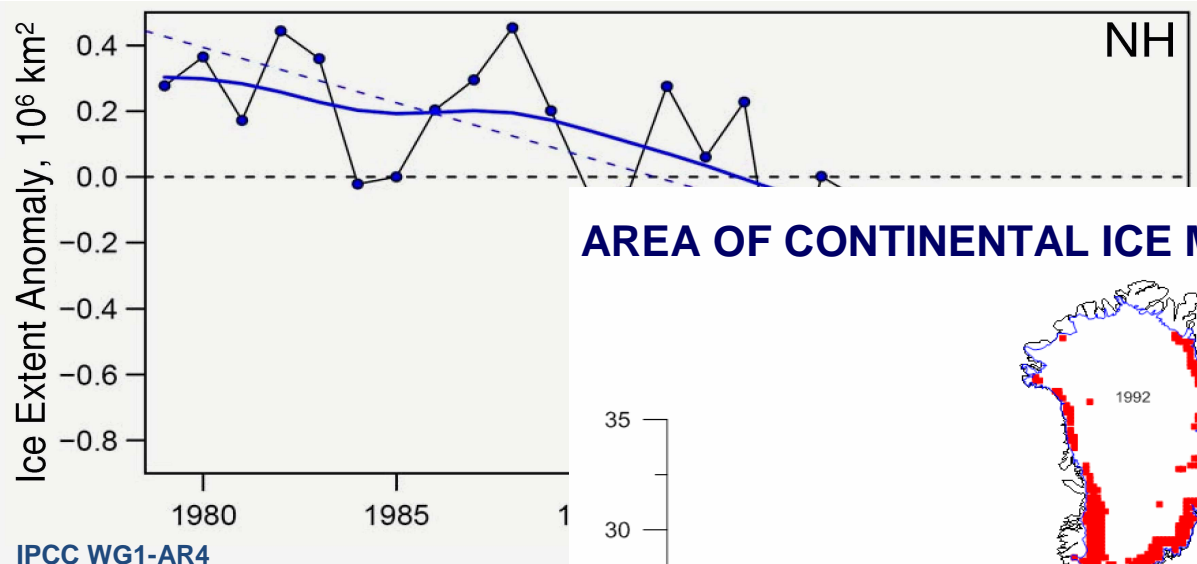
Cambiamento Climatico: osservazioni dirette

Warmest 12 years:
1998, 2005, 2003, 2002, 2004, 2006, 2001,
1997, 1995, 1999, 1990, 2000

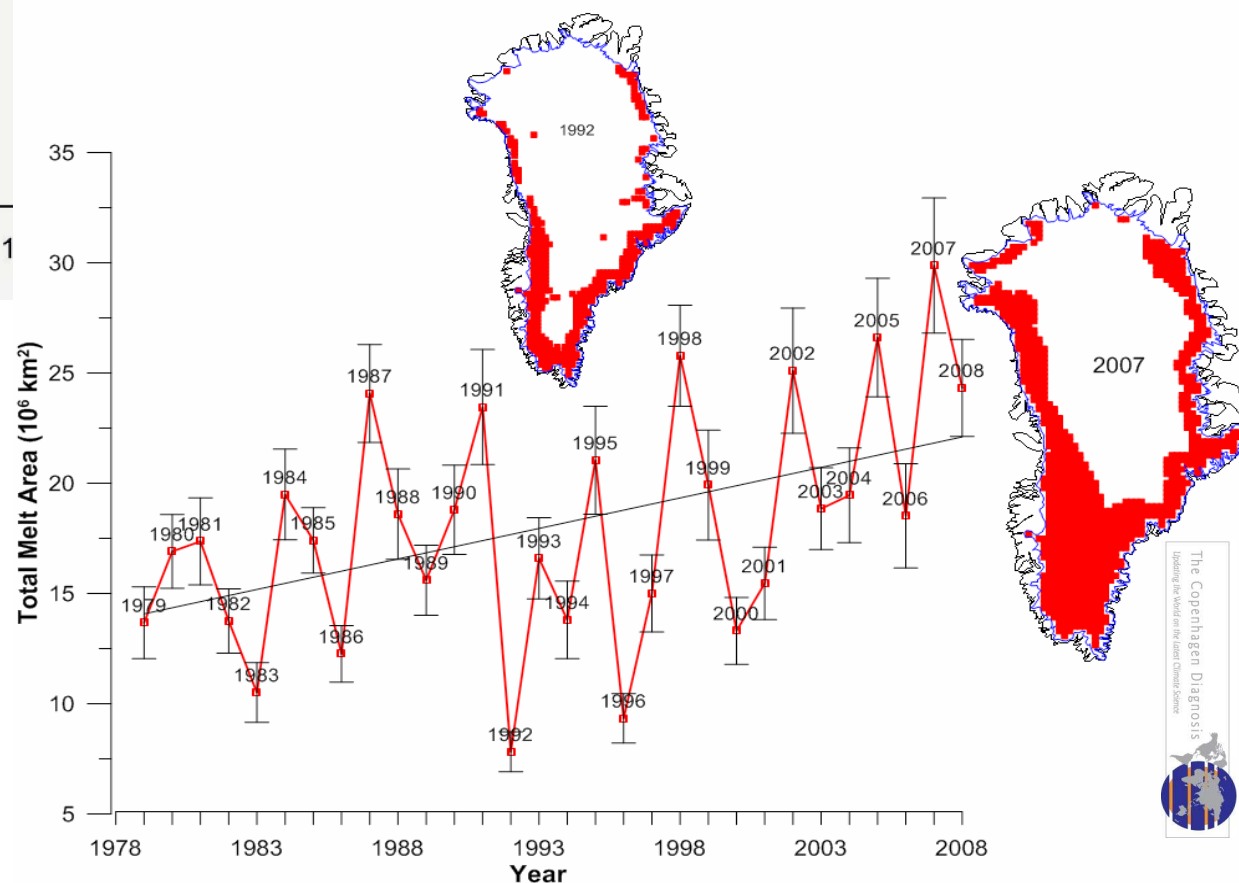


Cambiamento Climatico: osservazioni dirette

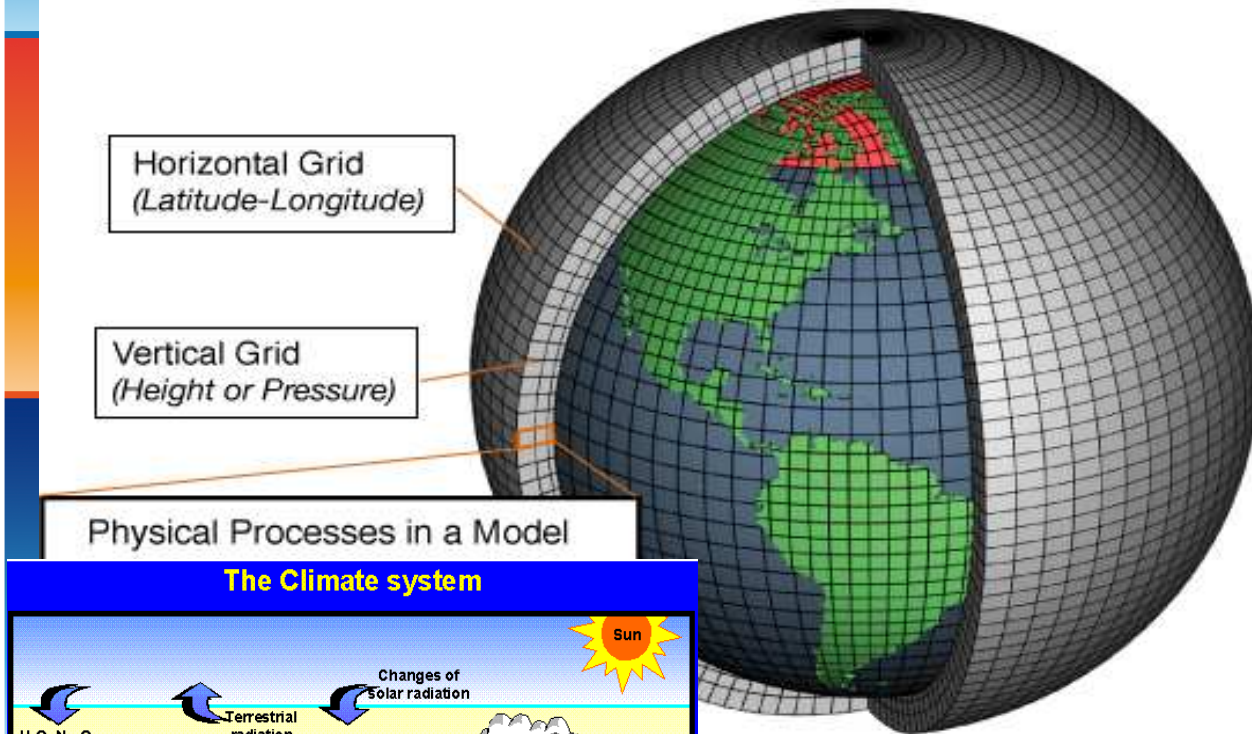
Arctic sea ice area decreased by 2.7% per decade
(Summer: -7.4% per decade)



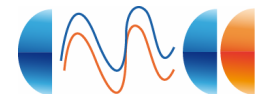
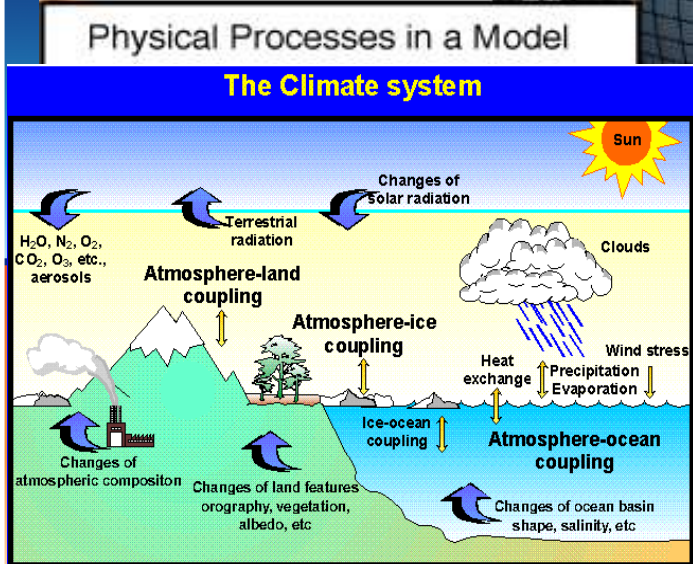
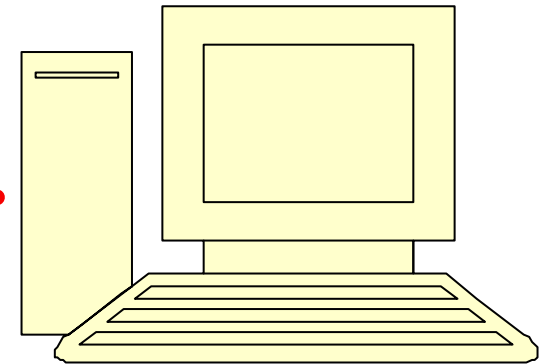
AREA OF CONTINENTAL ICE MELTING IN GREENLAND SINCE 1979



Modelli Numerici e Simulazioni del Clima



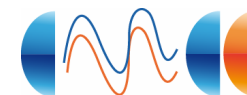
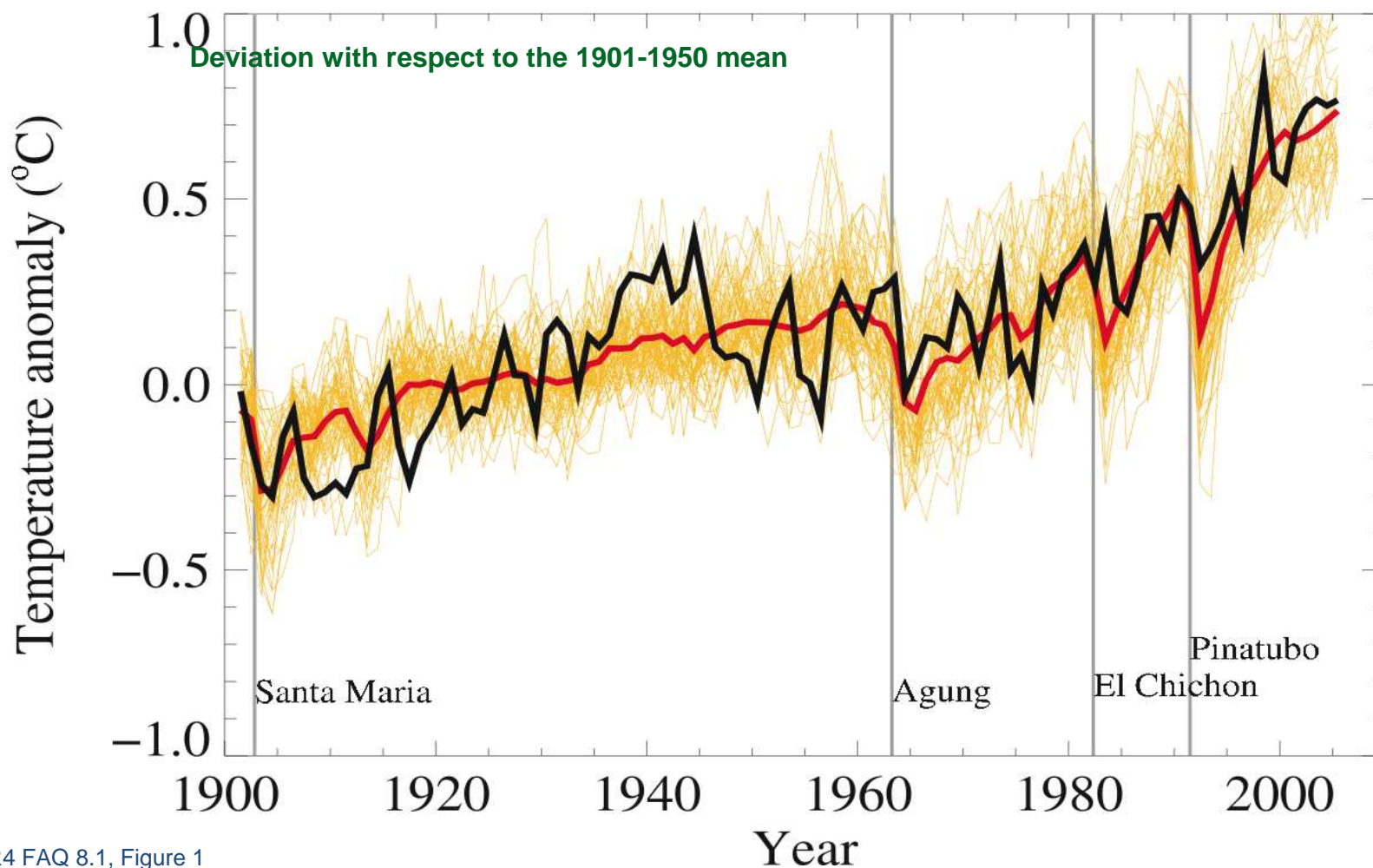
powerful
super-computer



Modelli Numerici e Simulazioni del Clima

HOW GOOD ARE CLIMATE MODELS TO REPRODUCE THE OBSERVED MEAN CLIMATE?

Evolution of the mean surface temperature observed and simulated



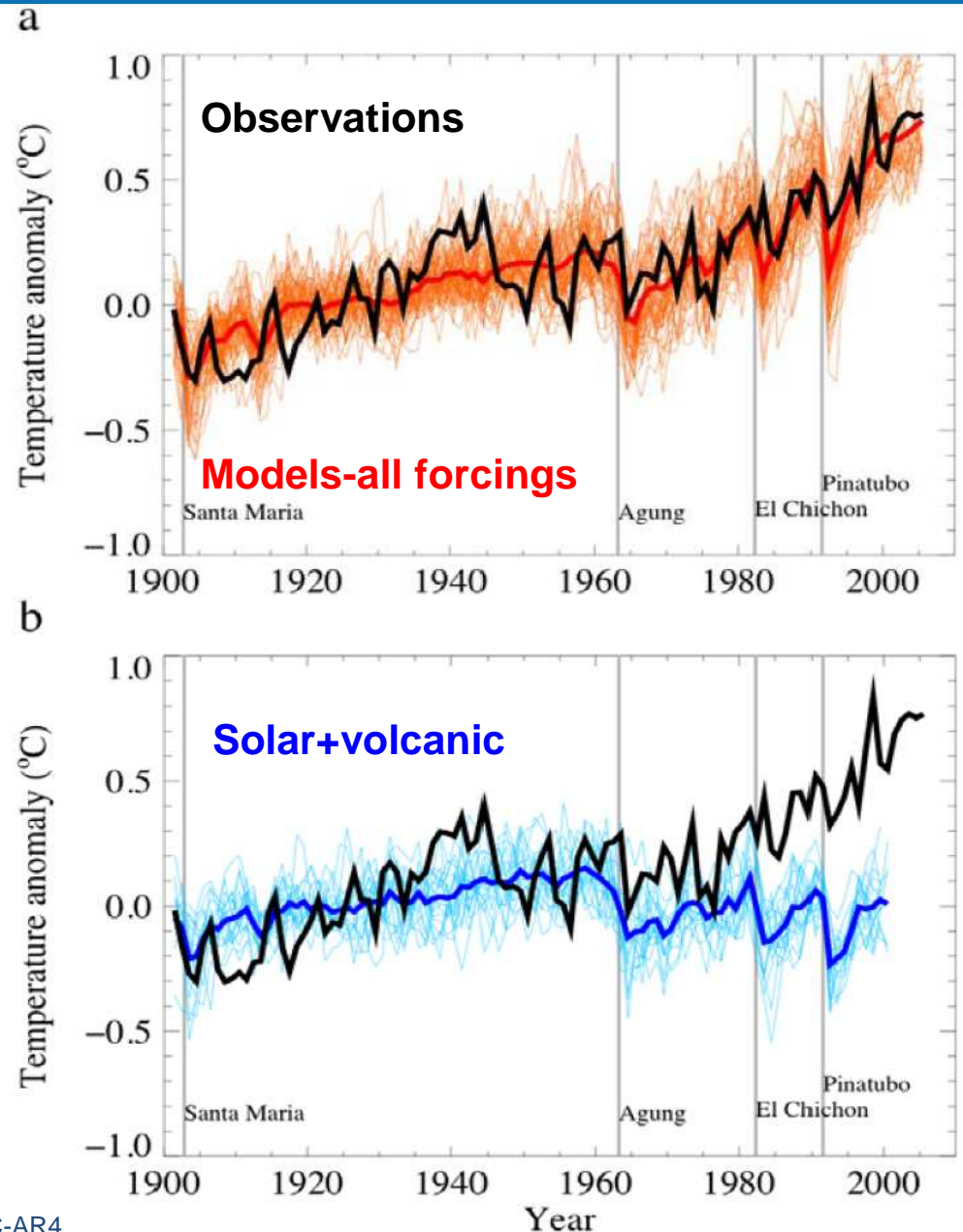
Modelli Numerici e Simulazioni del Clima

Simulation of the 20th century with the Climate models forced with:

- **all forcings (natural+anthropogenic)**
- **only natural (solar+volcanic) forcings**

Observed changes are:

- ✓ consistent with expected responses to all forcings
- ✓ inconsistent with alternative explanations

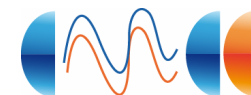


Modelli Numerici e Simulazioni del Clima

I modelli riproducono ragionevolmente bene le principali caratteristiche del clima osservato e i meccanismi fondamentali che sono alla base dei cambiamenti osservati nel recente passato ...

... quindi possiamo utilizzarli per cercare di ottenere informazioni su possibili futuri cambiamenti del clima dovuti alle attività umane (gas serra, aerosol, uso del suolo ...)

PROIEZIONI DI CAMBIAMENTO CLIMATICO



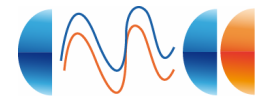
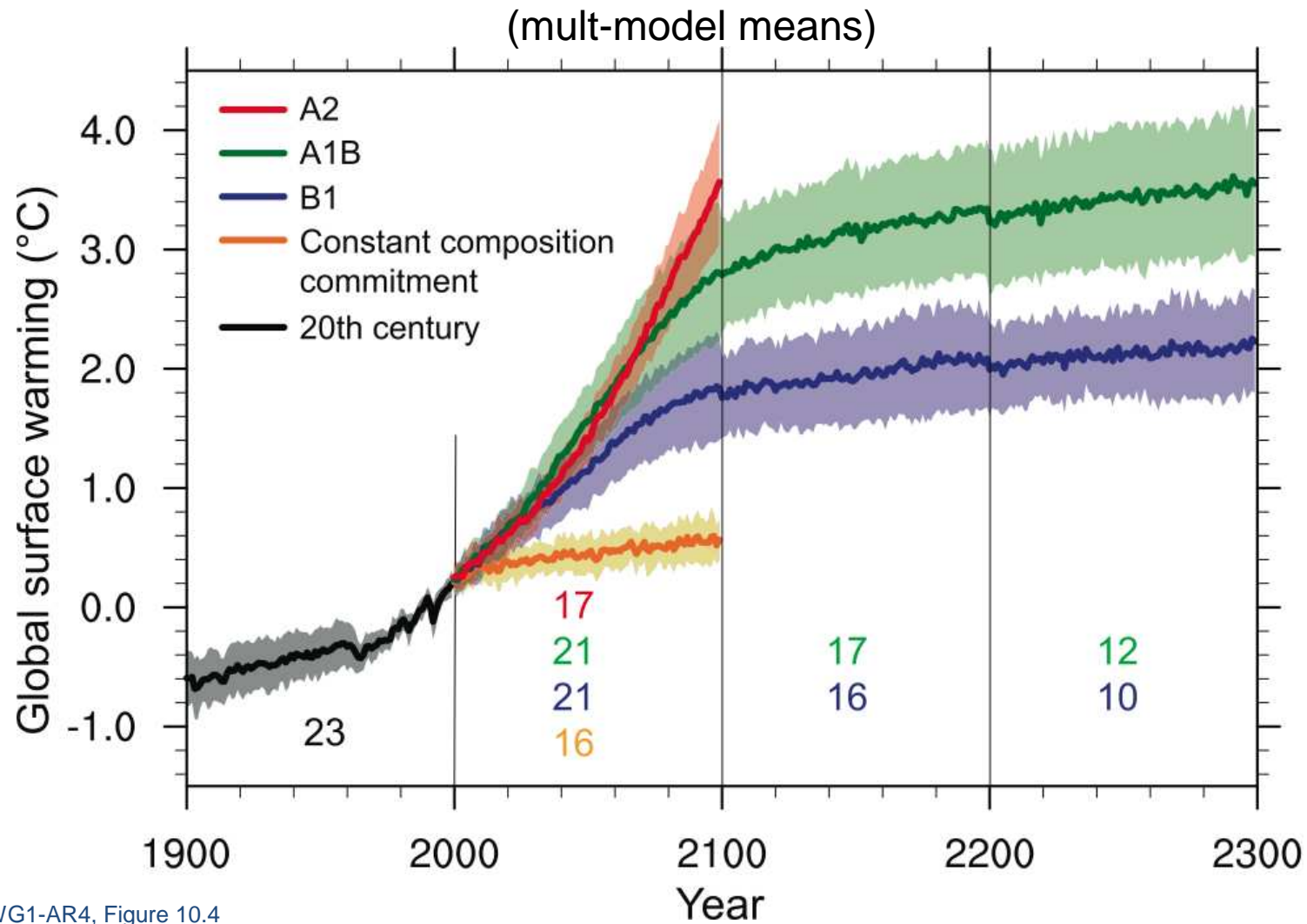
Proiezioni di Cambiamento Climatico

Le proiezioni di cambiamento climatico sono eseguite per mezzo di **SCENARI** (descrizione di un ipotetico **sviluppo socio-economico** del pianeta nel futuro).

Uno scenario provvede informazioni sulle **emissioni** (**concentrations** atmosferiche) di gas serra, aerosol, cambiamento di uso del suolo, etc ... che vengono fornite ai modelli per produrre **proiezioni climatiche**

Proiezioni di Cambiamento Climatico

GLOBAL MEAN SURFACE TEMPERATURE FOR THE DIFFERENT SCENARIOS



Proiezioni di Cambiamento Climatico

SCENARIO A1B

Difference between the 2080-2099 mean and the 1980-1999 mean

SURFACE TEMPERATURE

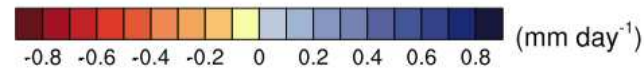
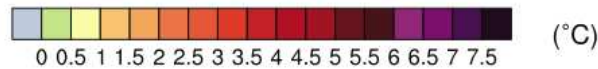
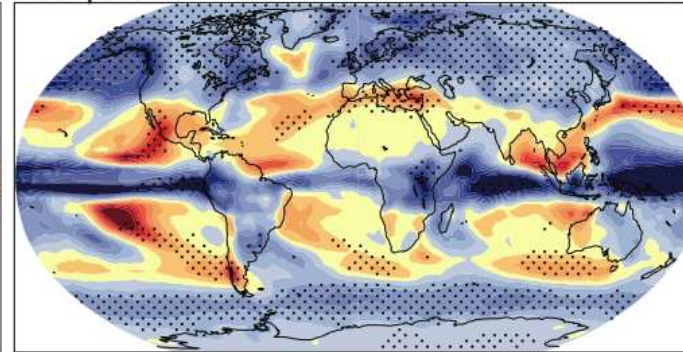
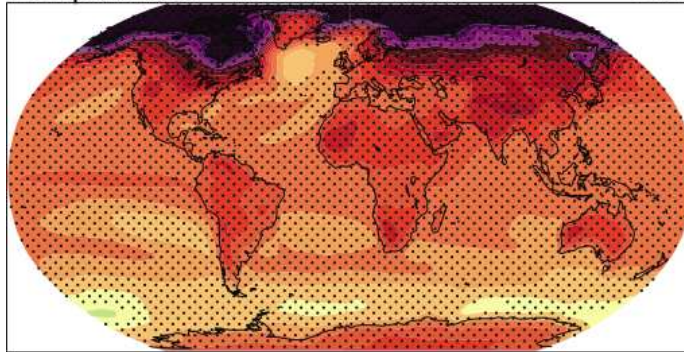
PRECIPITATION

BOREAL
WINTER

Temperature A1B: 2080-2099

DJF Precipitation A1B: 2080-2099

DJF

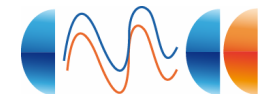
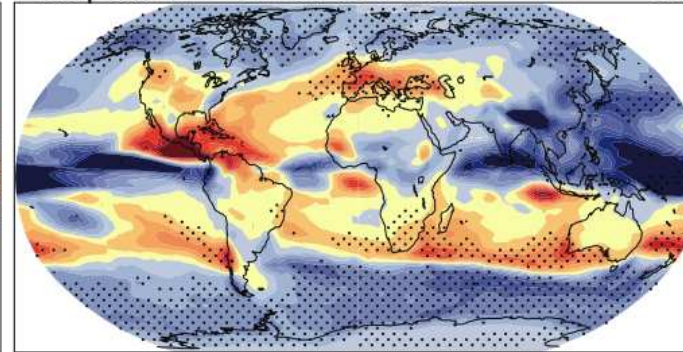
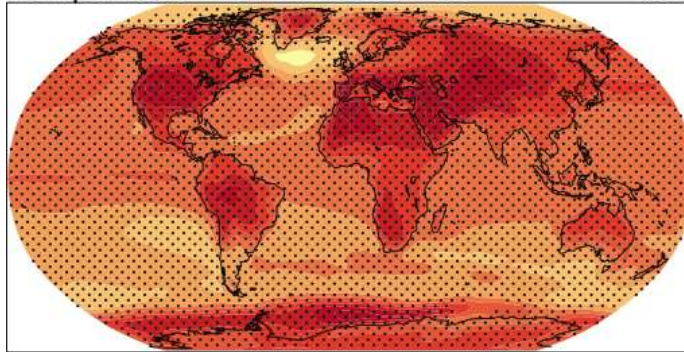


BOREAL
SUMMER

Temperature A1B: 2080-2099

JJA Precipitation A1B: 2080-2099

JJA

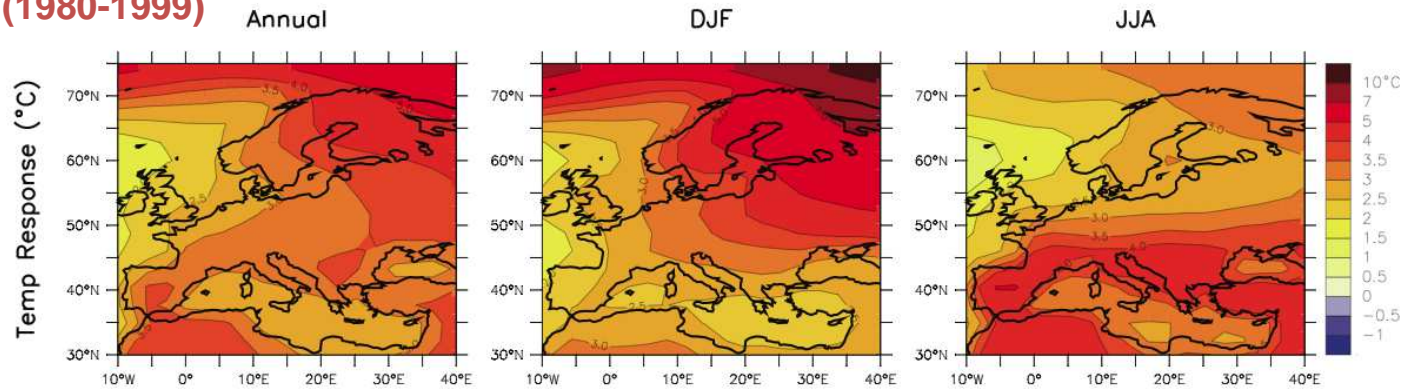


Proiezioni di Cambiamento Climatico

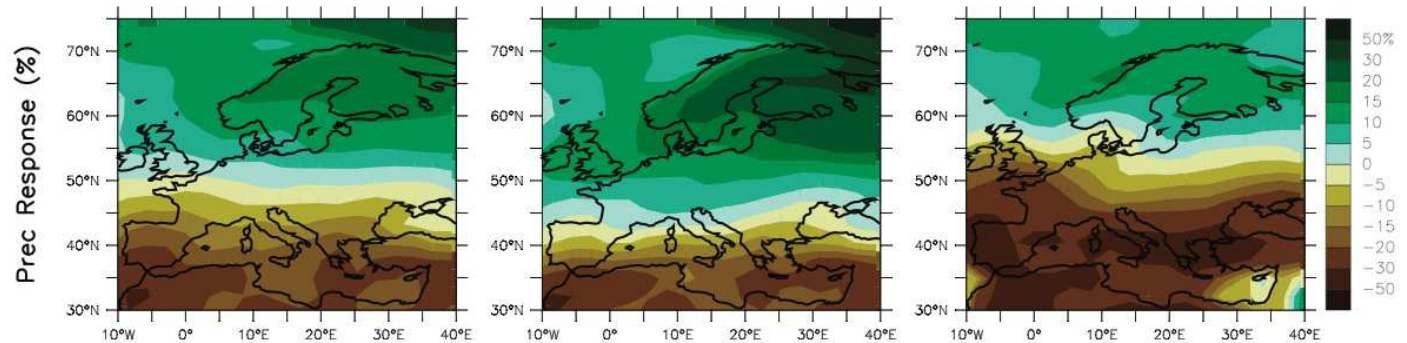
Change in the European region in the A1B scenario

A1B (2080-2099) – (1980-1999)

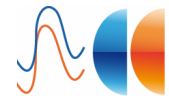
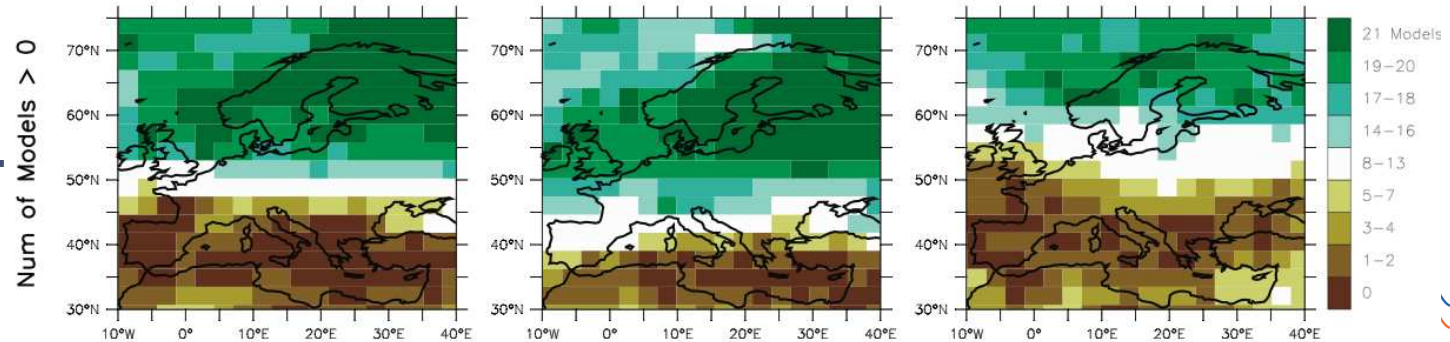
SURF. TEMP.



PRECIP.



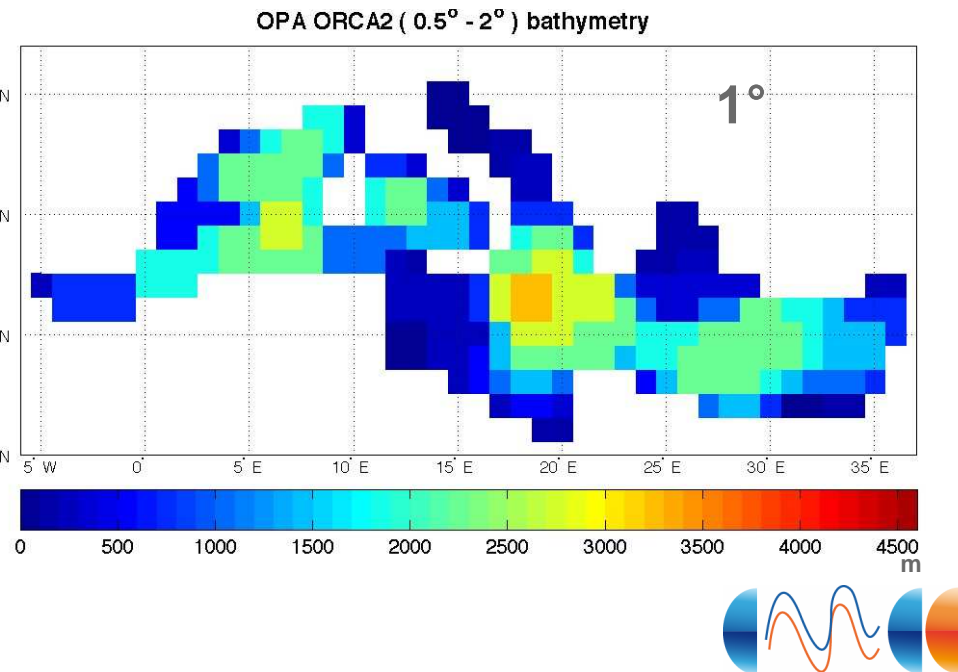
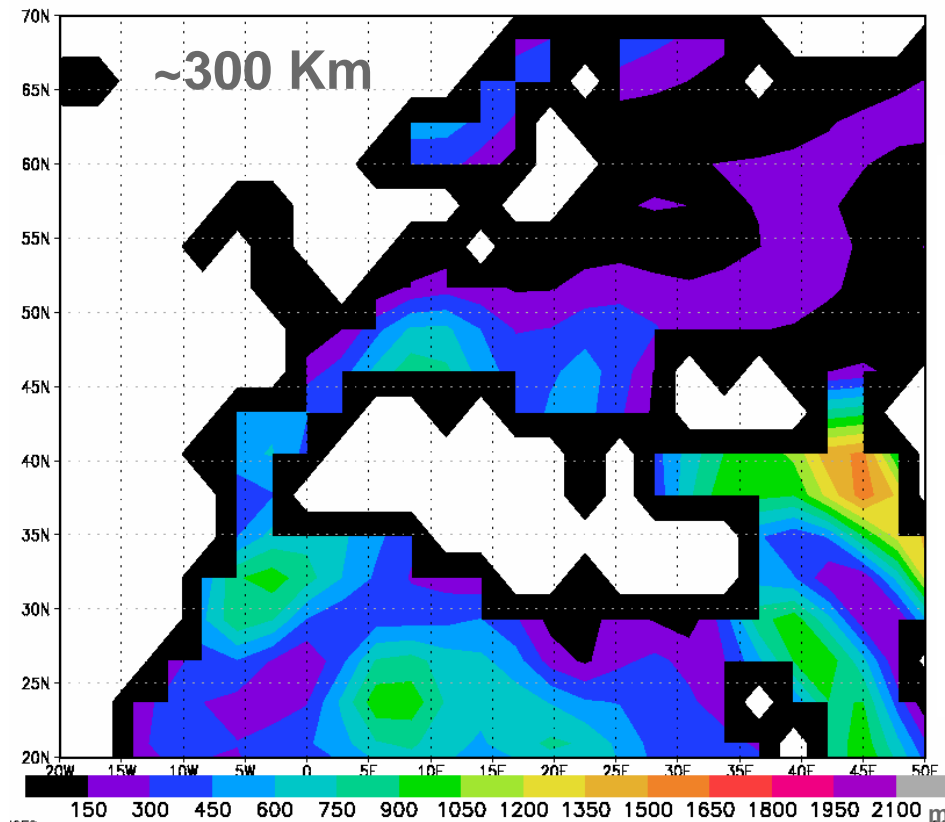
NUM. MODEL.



Proiezioni di Cambiamento Climatico: scala regionale

State of the art (CMIP3-AR4) coupled models are inadequate to resolve the dynamical features of the Euro-Mediterranean region

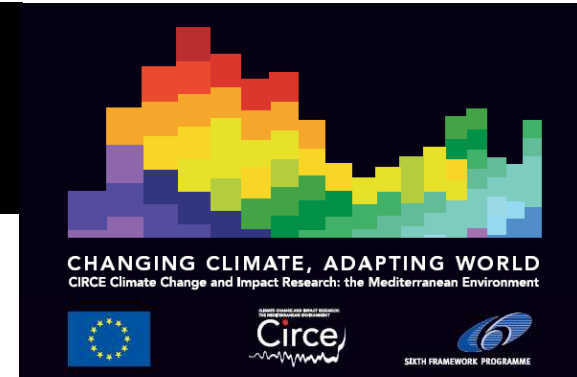
Orography, Land-Sea mask and Mediterranean Sea bathymetry as represented in a “standard” CMIP3 (IPCC-AR4) model with horizontal resolution of ~300 Km



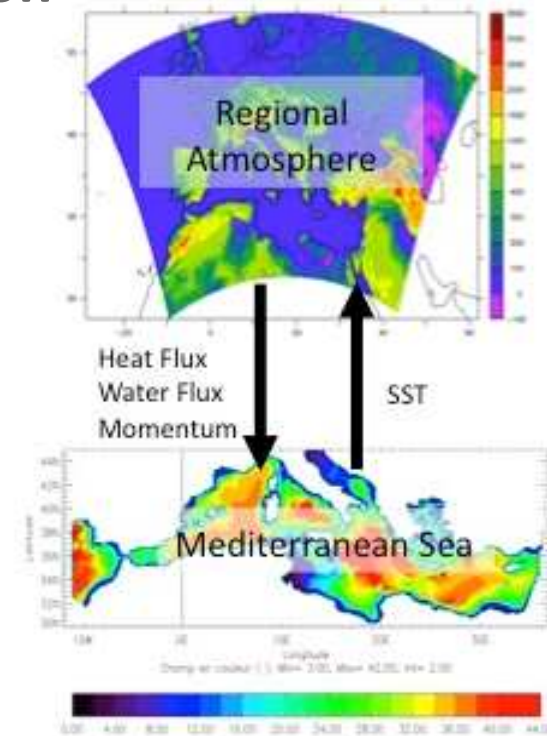
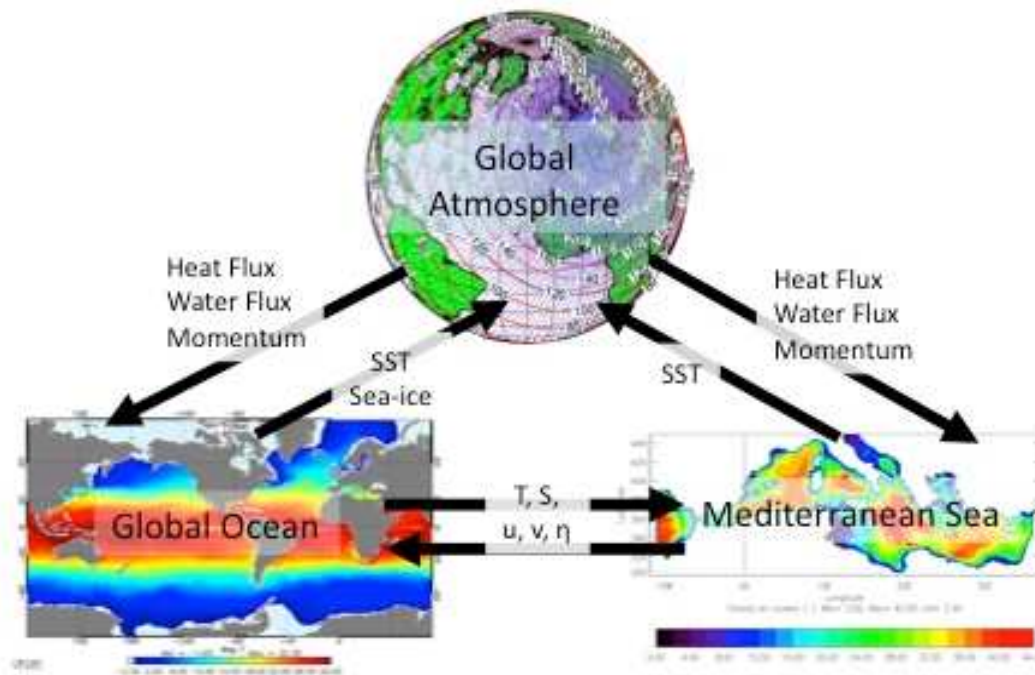
Proiezioni di Cambiamento Climatico: scala regionale

A European project to improve the projections in the Euro-Mediterranean region

CIRCE
Climate Change and Impact Research:
The Mediterranean Environment

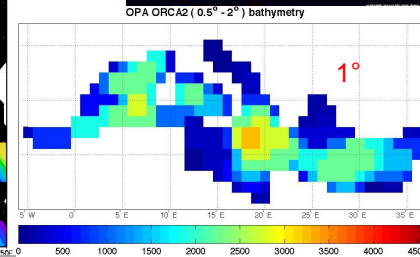
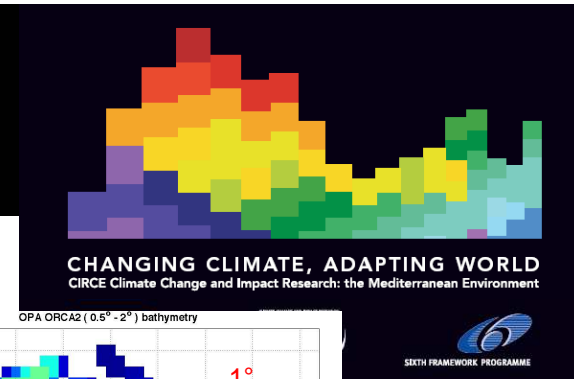
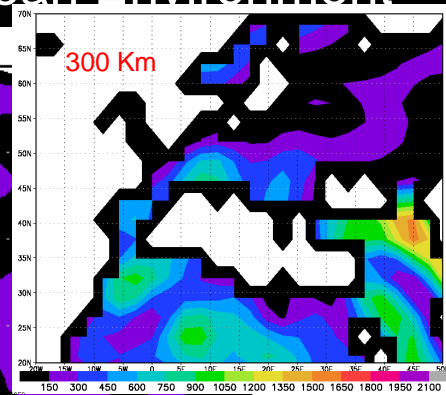
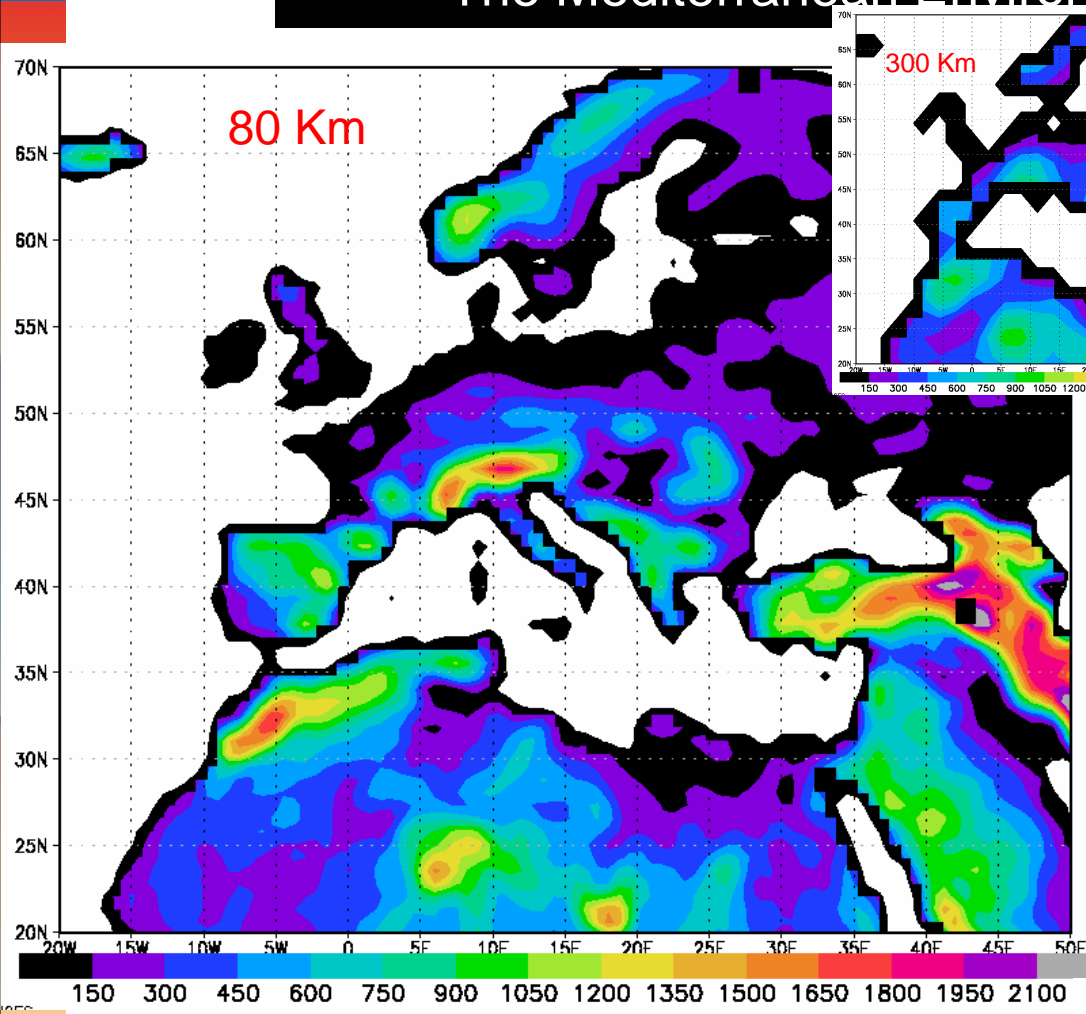


CIRCE MODELS: High-resolution and coupled atmosphere-ocean in the Mediterranean region

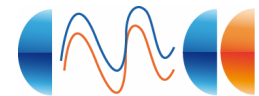
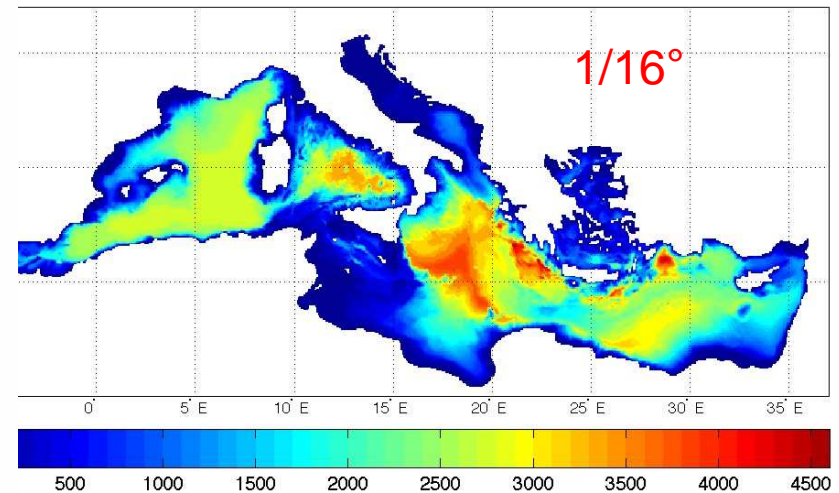


Proiezioni di Cambiamento Climatico: scala regionale

CIRCE Climate Change and Impact Research: The Mediterranean Environment



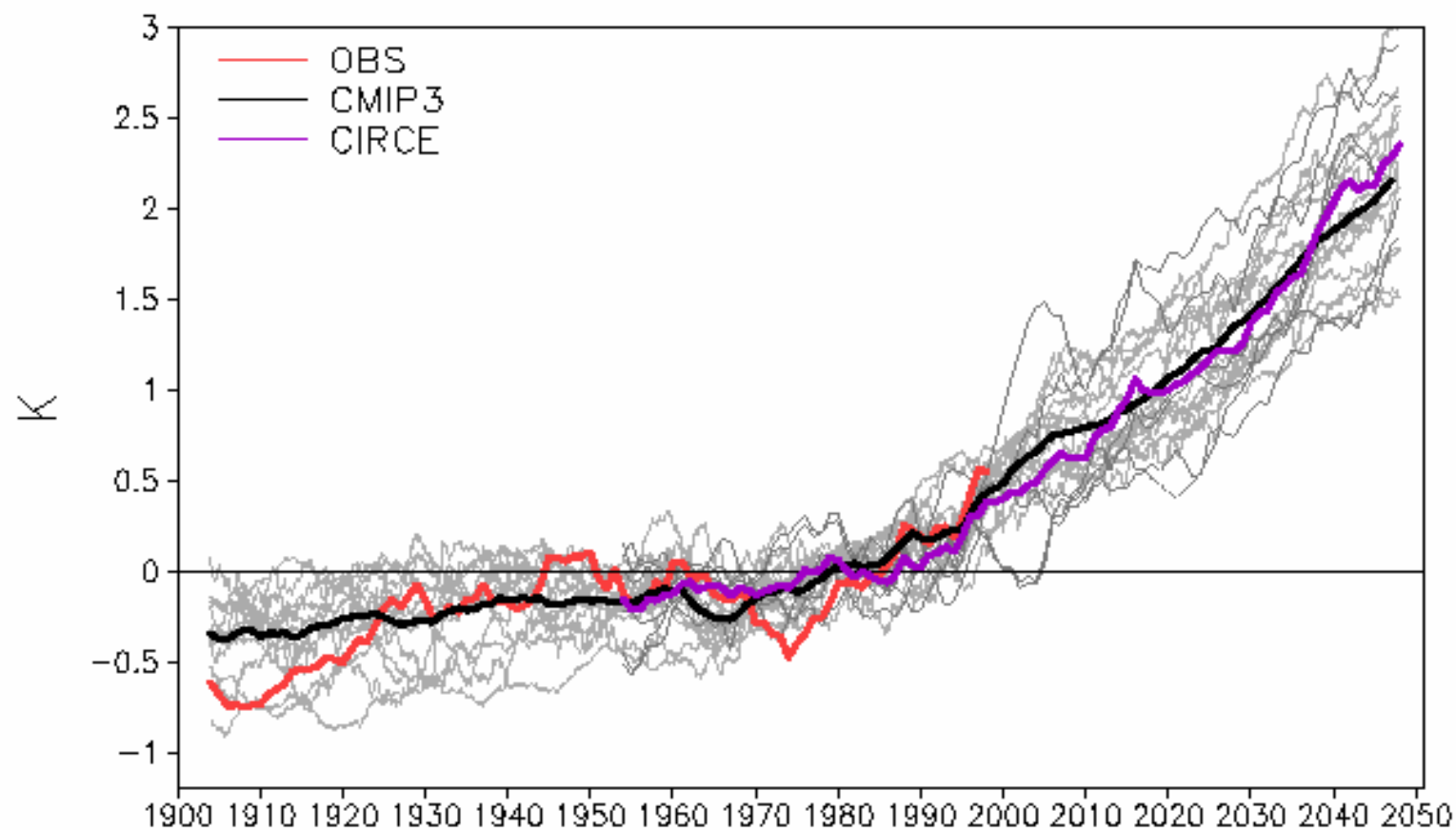
NEMO MED 1/16° bathymetry



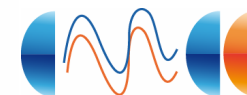
Proiezioni di Cambiamento Climatico: scala regionale

Proiezioni di Cambiamento Climatico nel Mediterraneo

Evolution of the T2m over the Mediterranean region



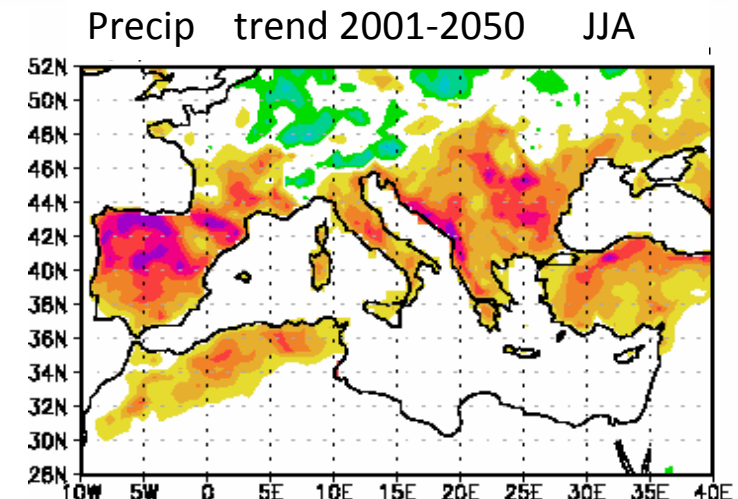
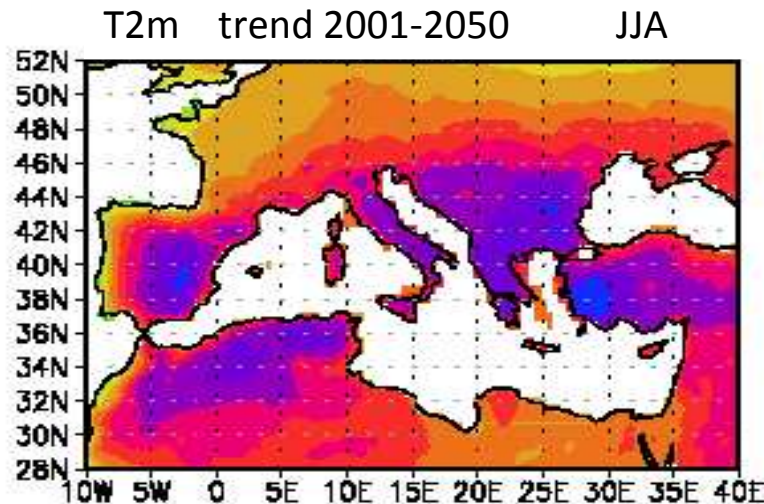
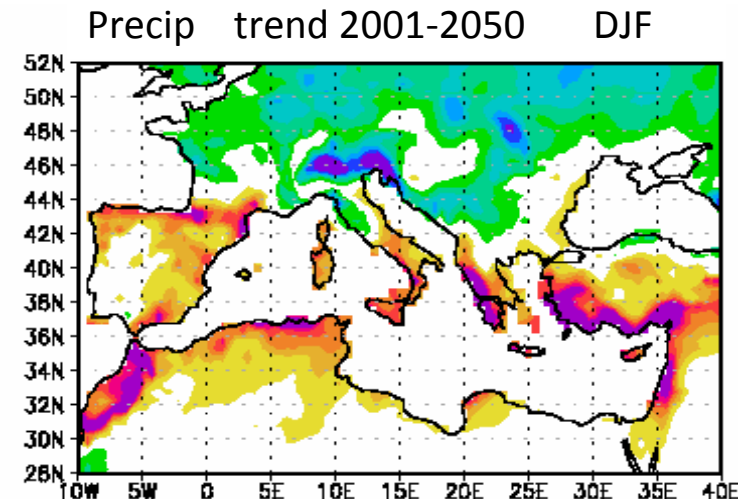
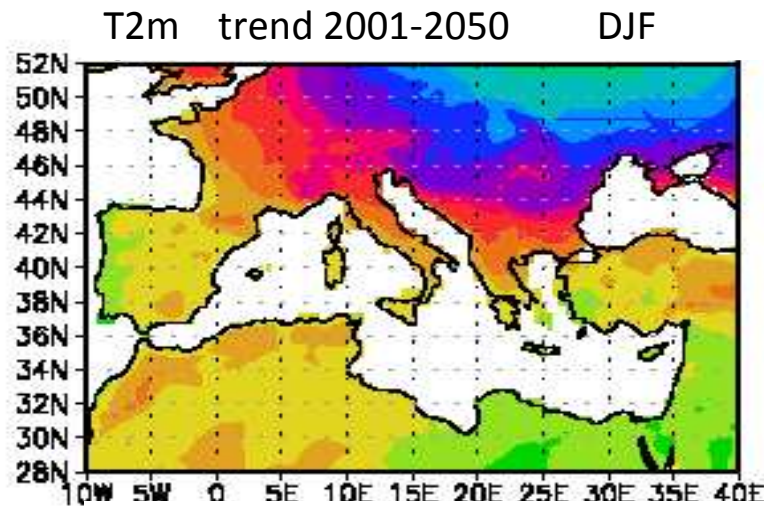
(Gualdi et al., 2011)



Proiezioni di Cambiamento Climatico: scala regionale

Proiezioni di Cambiamento Climatico nel Mediterraneo

T2m and Precipitation projected trends



(Gualdi et al., 2011)

10*(°C/decade)

(mm/day)/decade

Proiezioni di Cambiamento Climatico: scala regionale

FMED = Full Mediterranean (28-48 N, 9.5 W-38.5 E);

NMED = Northern Mediterranean (41-48 N, 9.5 W-38.5 E)

SMED = Southern Mediterranean (28-41 N, 9.5 W-38.5 E)

WMED = Western Mediterranean (28-44 N, 9.5 W-10.5 E)

CMED = Central Mediterranean (28-46 N, 10.5-20.5 E)

EMED = Eastern Mediterranean (28-44 N, 20.5-38.5 E)

ALPS = Alpine region (44-48 N, 5.5-15.5 E)

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

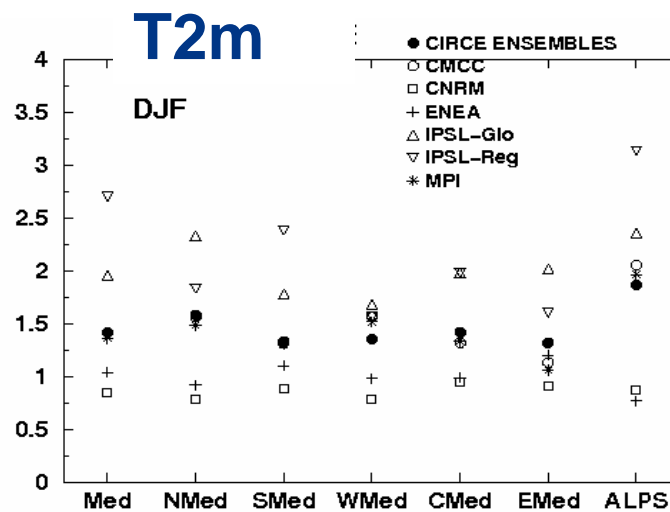


Proiezioni di Cambiamento Climatico: scala regionale

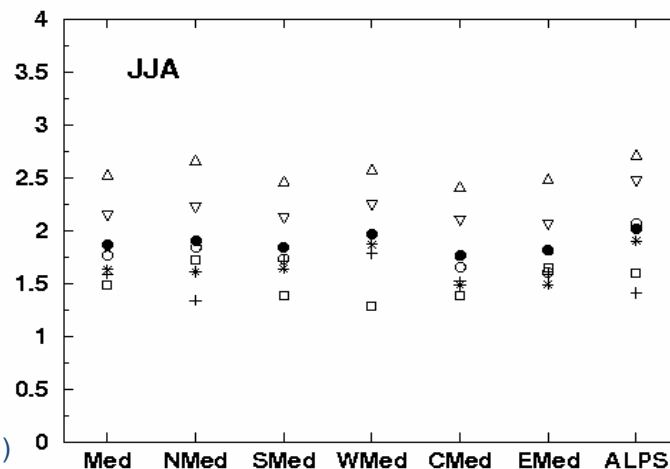
Proiezioni di Cambiamento Climatico nel Mediterraneo

Change in **T2m** and **Precipitation** for specific sub-regions (2021-2050) - (1961-1990)

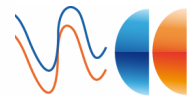
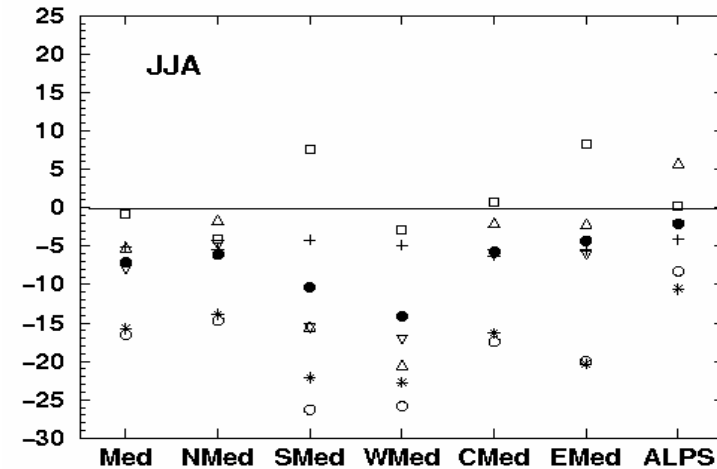
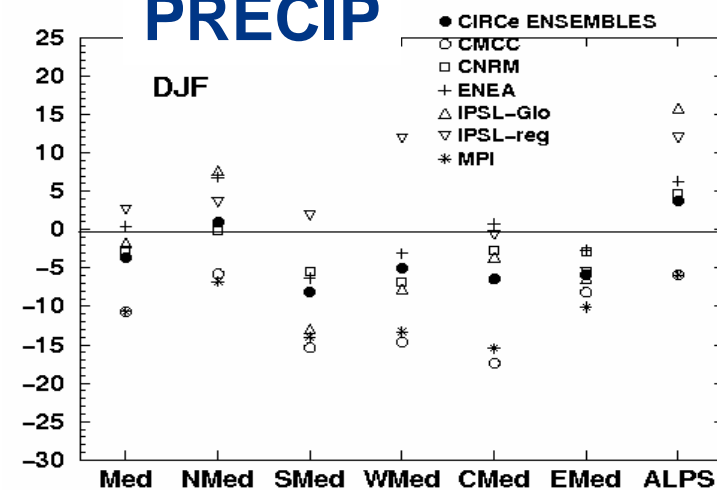
DJF



JJA



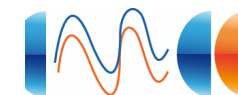
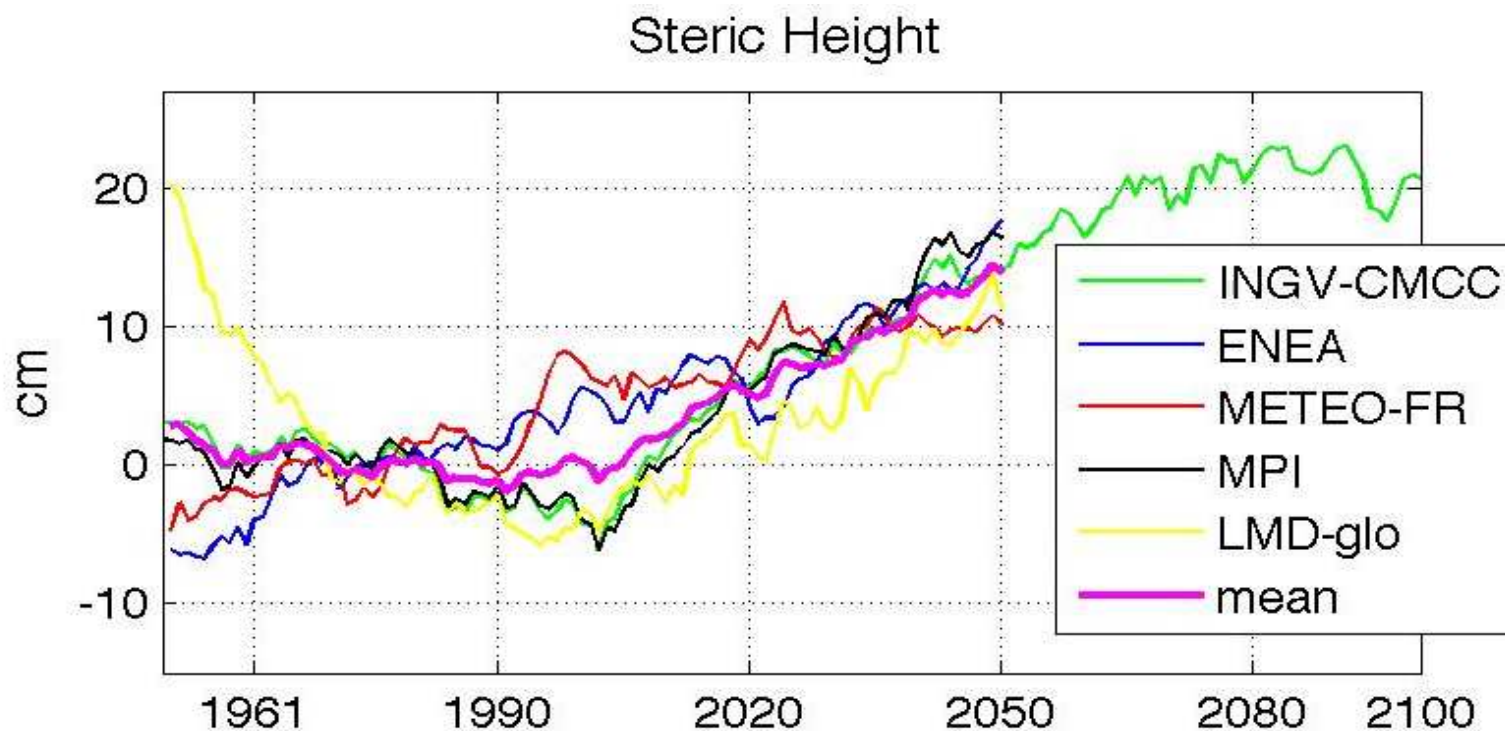
PRECIP DJF



Proiezioni di Cambiamento Climatico: scala regionale

Proiezioni di Cambiamento Climatico nel Mediterraneo

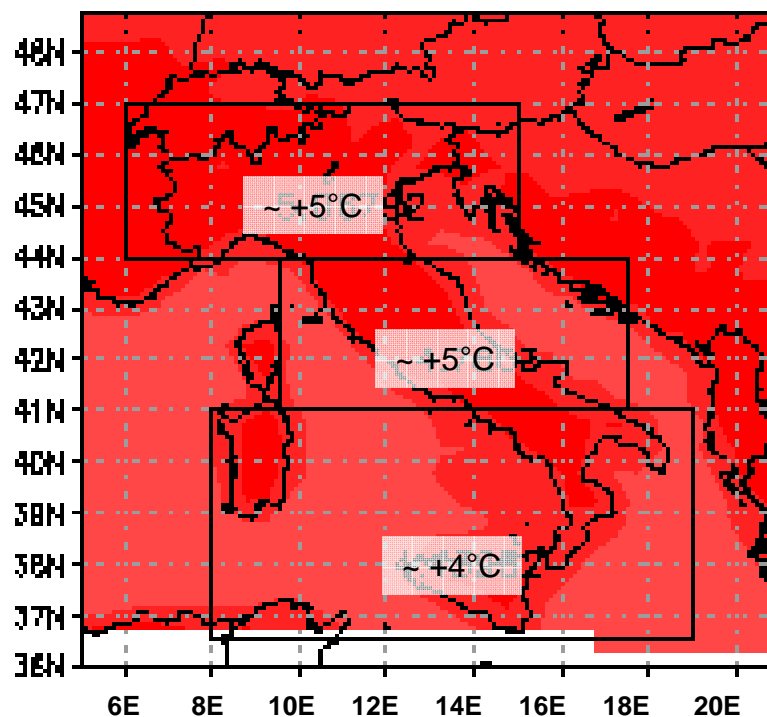
Mediterranean SEA LEVEL CHANGE due to the STERIC EFFECT in the CIRCE projections



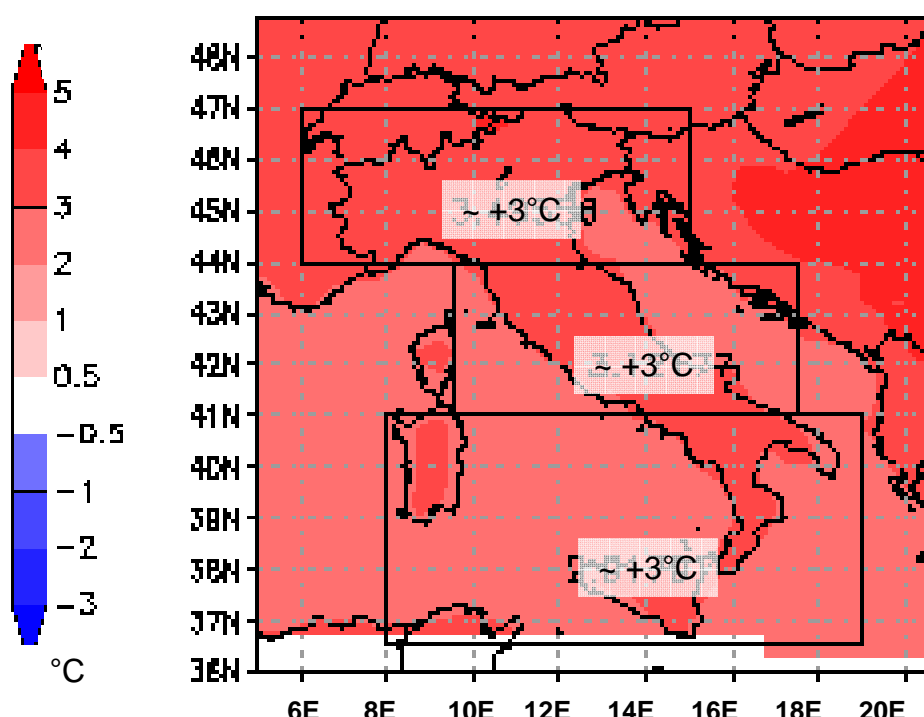
Proiezioni di Cambiamento Climatico: zoom sull'Italia

Cambiamento medio della Temperatura alla superficie simulato dai modelli PRUDENCE per l'inverno e l'estate, 2071-2100 rispetto a 1961-1990, scenario A2

T2m change A2 JJA Italy: ~ +5°C



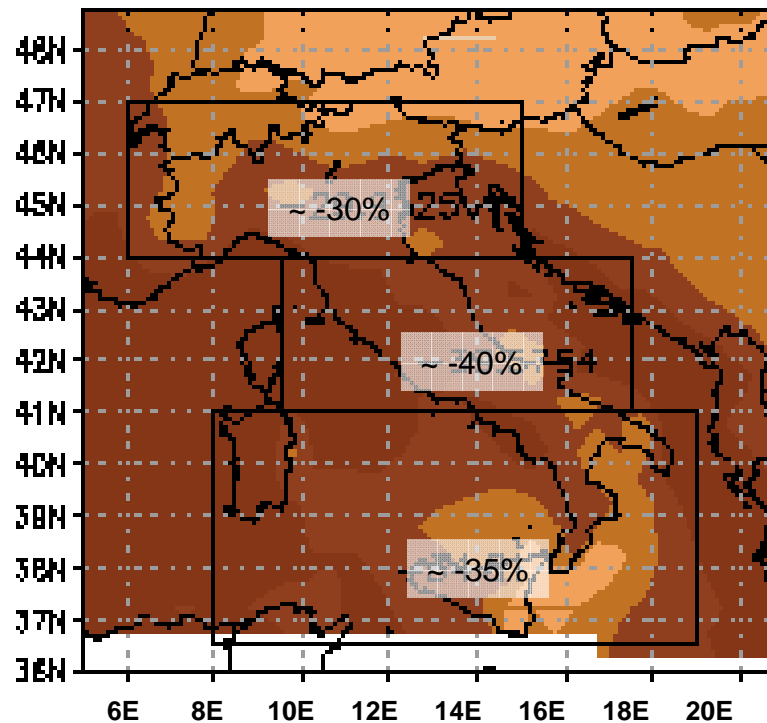
T2m change A2 DJF Italy: ~ +3°C



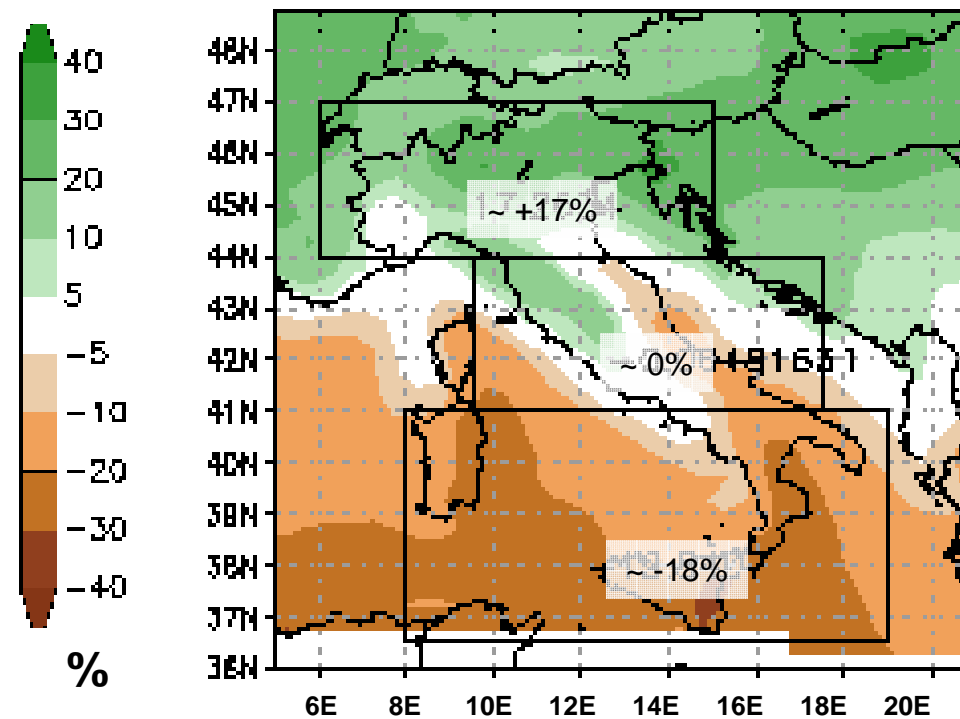
Proiezioni di Cambiamento Climatico: zoom sull'Italia

Cambiamento medio di Precipitazione simulato dai modelli PRUDENCE per l'inverno e l'estate, 2071-2100 rispetto a 1961-1990, scenario A2

Precip change A2 JJA Italy: ~ -35%



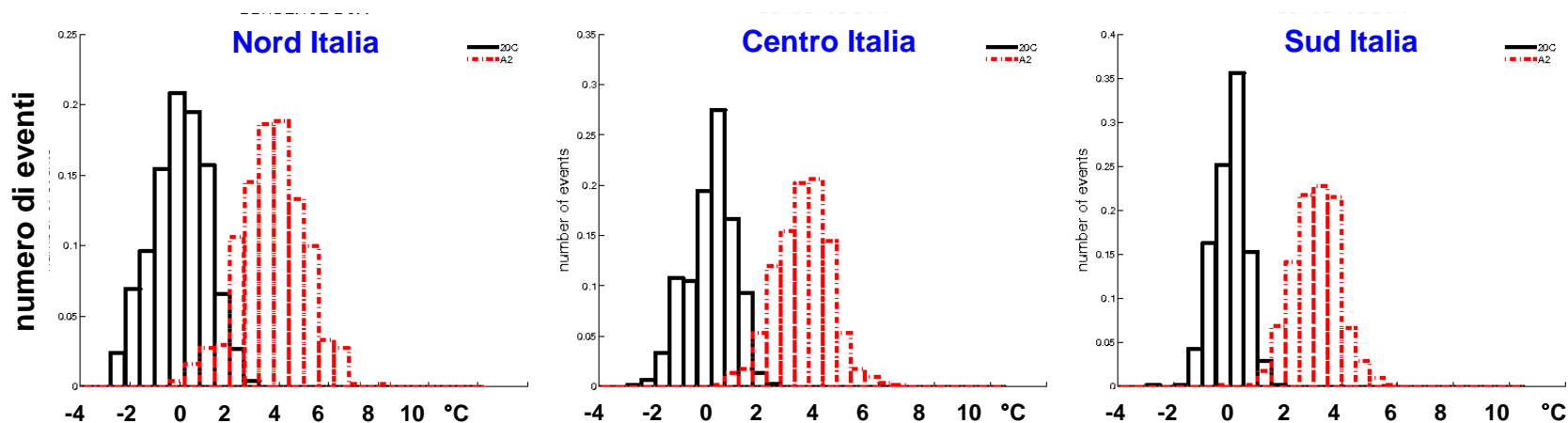
Precip change A2 DJF Italy: ~ -1%



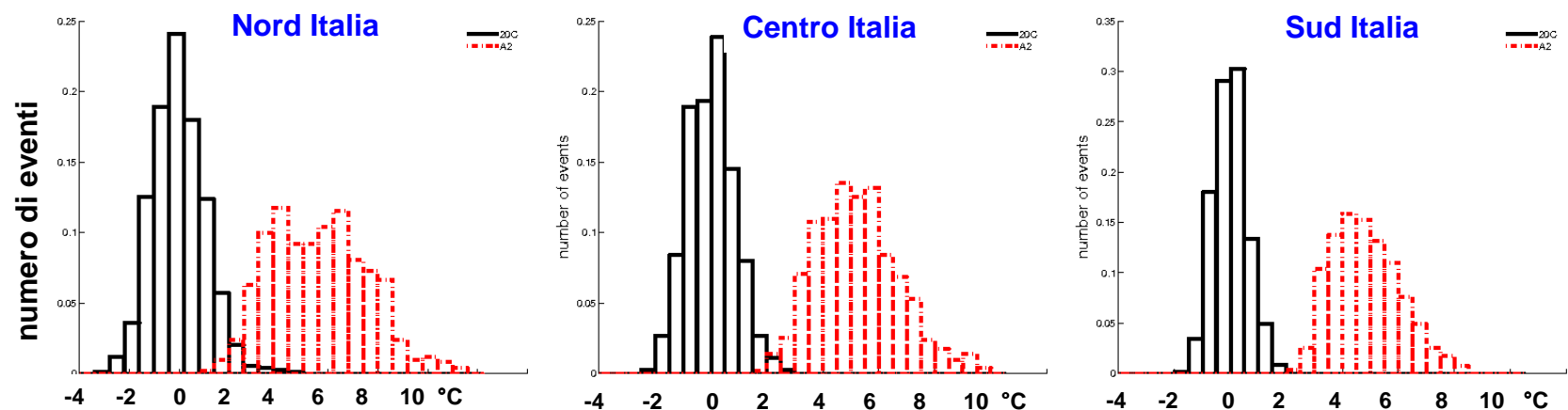
Proiezioni di Cambiamento Climatico: zoom sull'Italia

Distribuzione delle anomalie stagionali di Temperatura (rispetto alla media 1961-1990) calcolate dalle simulazioni di PRUDENCE per il 1961-1990 (istogrammi neri) e il 2071-2100, scenario A2 (istogrammi rossi)

DJF



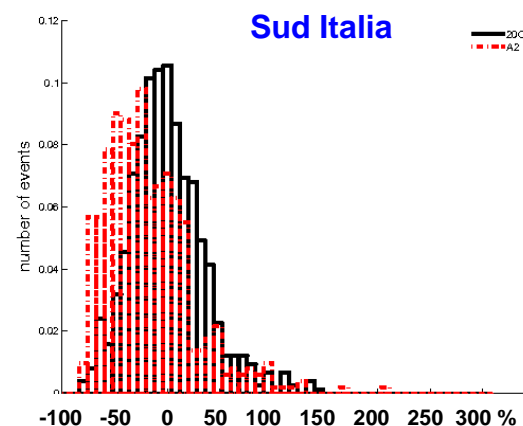
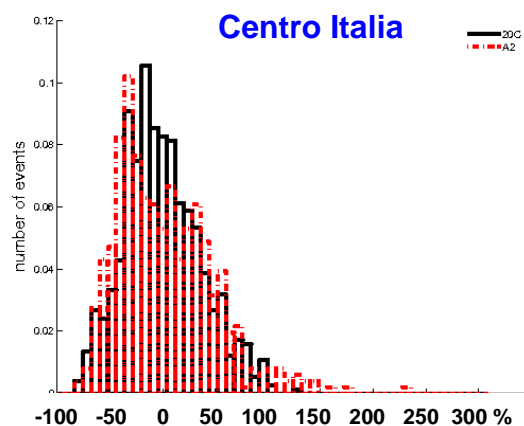
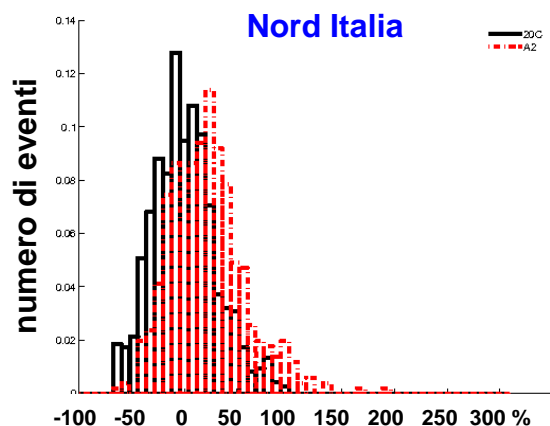
JJA



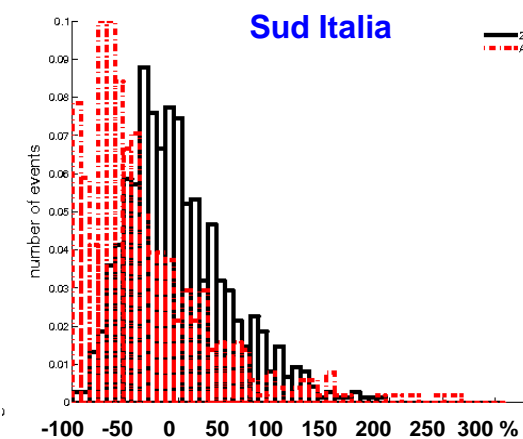
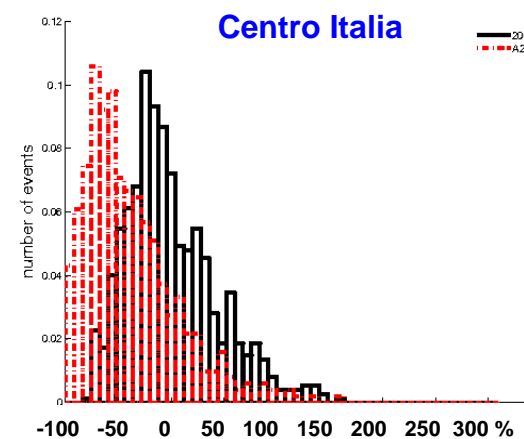
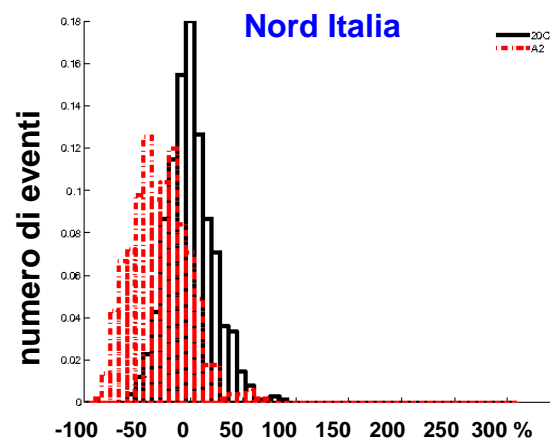
Proiezioni di Cambiamento Climatico: zoom sull'Italia

Distribuzione delle anomalie stagionali di Precipitazione (rispetto alla media 1961-1990) calcolate dalle simulazioni di PRUDENCE per il 1961-1990 (istogrammi neri) e il 2071-2100, scenario A2 (istogrammi rossi)

DJF

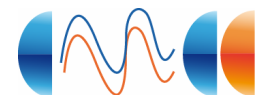


JJA



Sommario e Conclusioni

- ✓ Per poter approntare opportune politiche di adattamento ai cambiamenti climatici, le proiezioni devono fornire informazioni a scala regionale (locale).
- ✓ Proiezioni di cambiamento climatico per il Mediterraneo e la penisola Italiana sono state eseguite in numerosi programmi e progetti internazionali (CIRCE, PRUDENCE, ecc.).
- ✓ Per la regione del Mediterraneo e la penisola italiana le proiezioni indicano un marcato riscaldamento sia in inverno che in estate (fino a + 5°C alla fine del 21° Secolo).
- ✓ Per la precipitazione I risultati delle proiezioni sono meno omogenei: calo generalizzato in estate, mentre in inverno più precipitazioni al nord (Alpi) e diminuzione nel Mediterraneo centro orientale e nel sud Italia.
- ✓ La comunità scientifica è fortemente impegnata nello sviluppo di nuovi modelli ad alta risoluzione e che permettano di includere nel sistema processi a piccola scala per produrre proiezioni sempre più accurate alle scale locali (CMIP5)





Thanks

Cambiamento Climatico: osservazioni dirette

Sea-Level rise: partly due to continental ice melting and partly to ocean warming

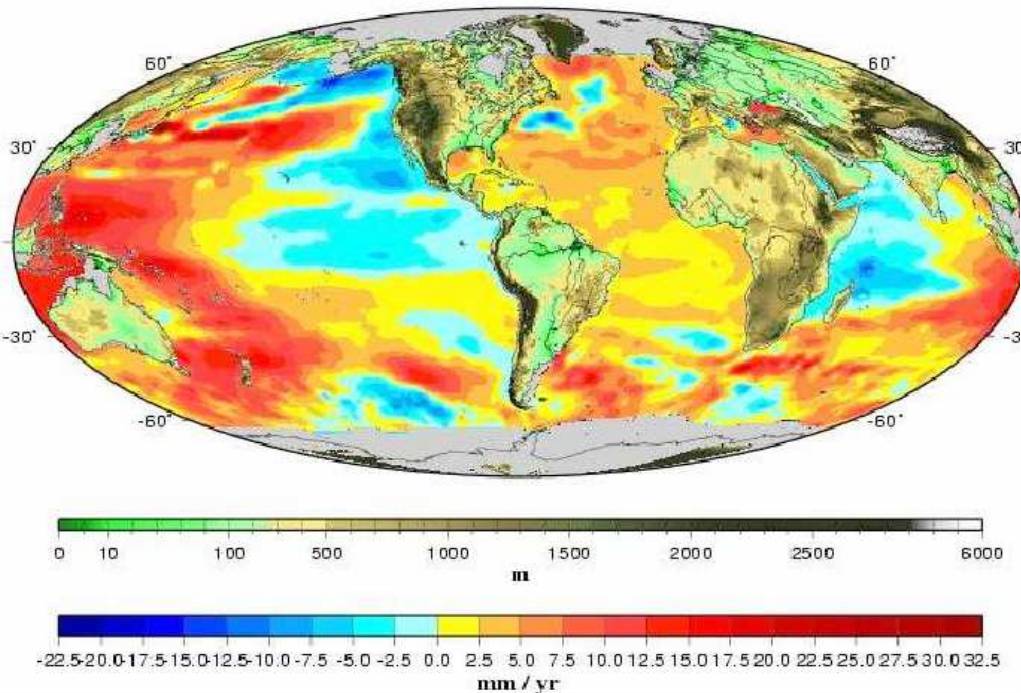
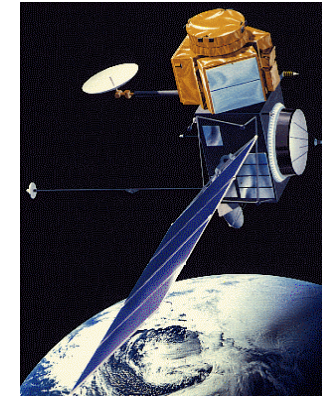


Figure 7. Sea level trends over 1993-2003 from the T/P mission.

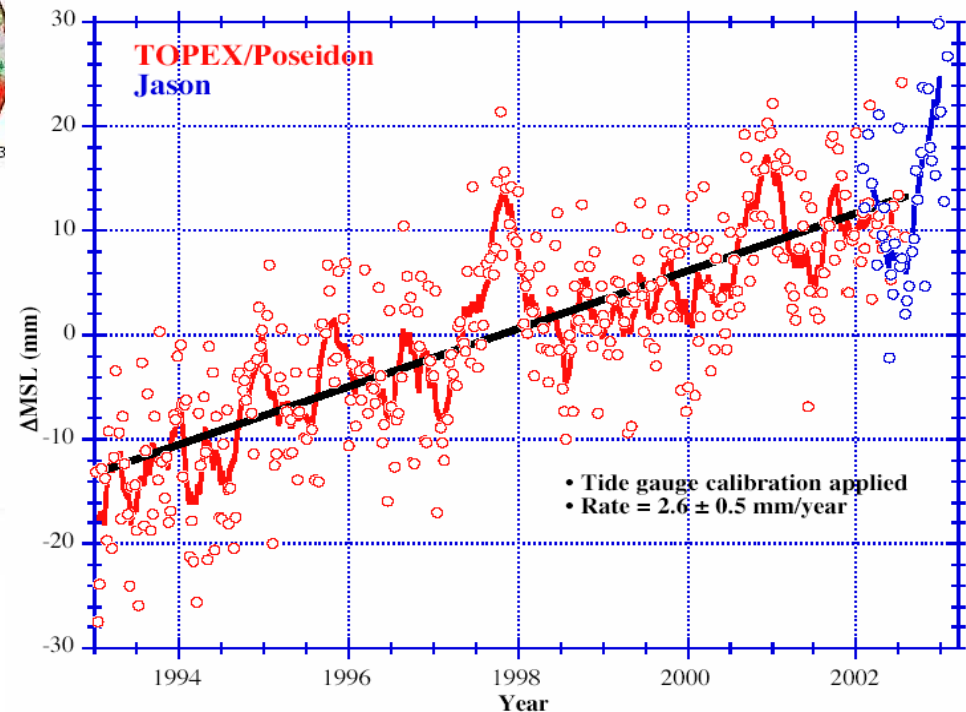
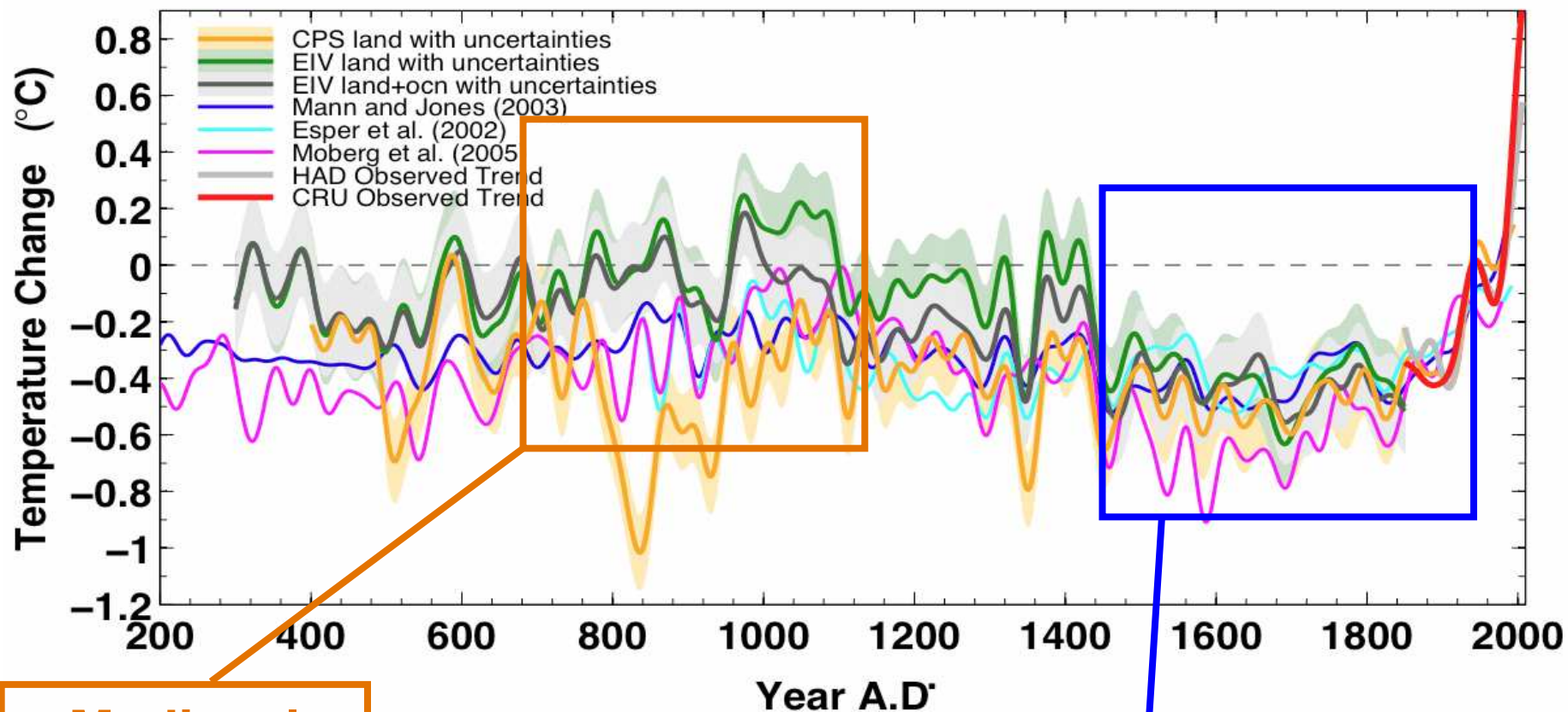


Figure 5. Global mean sea level variations from T/P and Jason.

[Figures from Cazenave and Nerem, 2004]

Cambiamento Climatico: osservazioni dirette

Northern Hemisphere reconstructed temperature change since 200AD



Medieval warm period

Little Ice Age