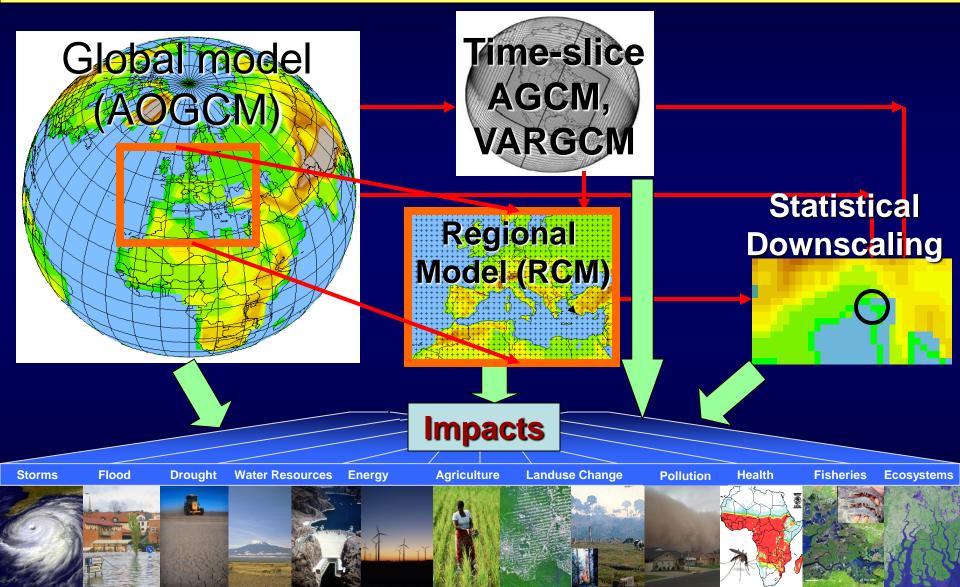
# Regional Climate Modeling: Status and Perspectives

## Abdus Salam ICTP, Trieste, Italy

Filippo Giorgi

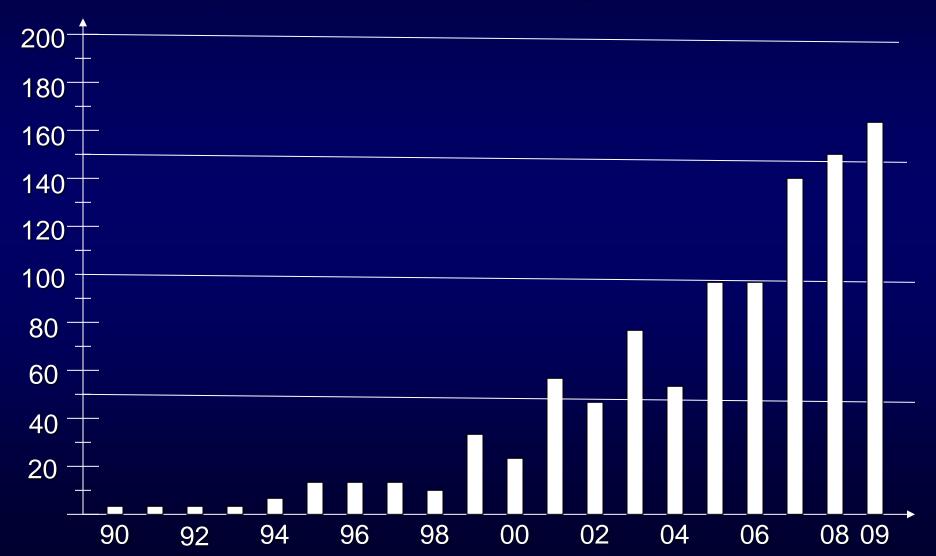
TCCI Workshop, Taipei, 1-3 November 2010

# Various tools are available to "downscale" regional and local climate change information



## The use of RCMs has been steadily growing

Number of papers in the ISI under "regional climate model"



## Some key projects and literature

- Review papers: Giorgi and Mearns (1991), McGregor (1997), Giorgi and Mearns (1999), Giorgi et al. (IPCC 2001), Leung et al. (2003), Mearns et al. (2003), Wang et al. (2004), Giorgi (2006), Laprise (2007), Rummukainen (2010)
- European projects: PRUDENCE, AMMA, ENSEMBLES, CECILIA, CLARIS, ACQWA
- Intercomparison projects: PIRCS, RMIP, NARCCAP, NEWBALTIC, ARCMIP, PLATIN, ARC, NAMAP, QUIRCS, Transferability
- Special issues: JGR 1999; JMSJ 2004; TAC 2006; CC 2007; MAP 2004, 2008; CCH 2006; MET.-ZEIT. 2008

# Regional Climate Modeling Advantages

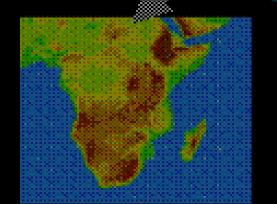
- Physically based downscaling
  - Capability of developing comprehensive regional climate modeling systems
- Wide variety of applications
  - Process studies
  - Paleoclimate
  - Climate change
  - Seasonal prediction
- High resolution through multiple nesting (currently <10 to 50 km grid interval)</li>

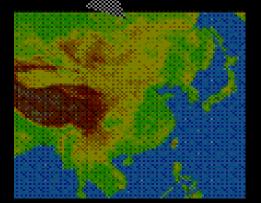
# Regional Climate Modeling Limitations

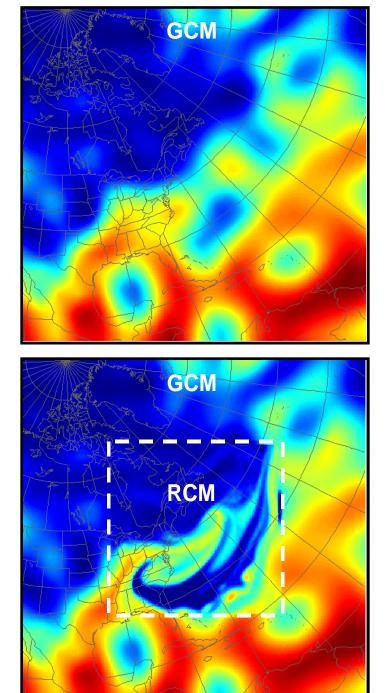
- One-way nesting

   No regional-to-global feedbacks
- Technical issues in the nesting technique
   Domain, LBC procedure, physics, etc.
- Not intended to correct systematic errors in the large scale forcing fields
   Always analyse first the forcing fields
- Computationally demanding

# Regional Climate Modeling The "Added Value" issue

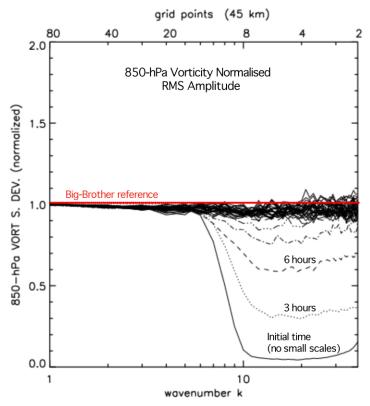






### **Dynamical Downscaling**

Generation of small scales by a high-resolution RCM driven by low-resolution GCM data (900 hPa specific humidity)

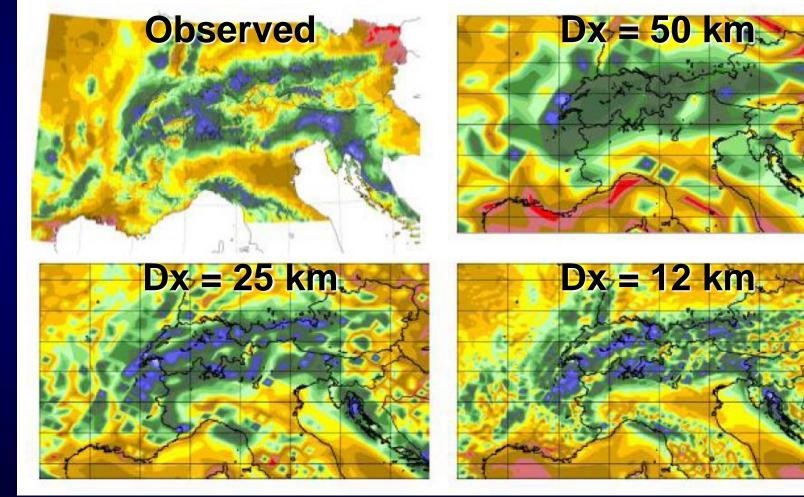


### Large scales Short scales

From Laprise et al. (2007)

The value of resolution: RCM simulation of precipitation at different resolutions over the Alps (1960-1990)

Mean annual precipitation (mm/day)



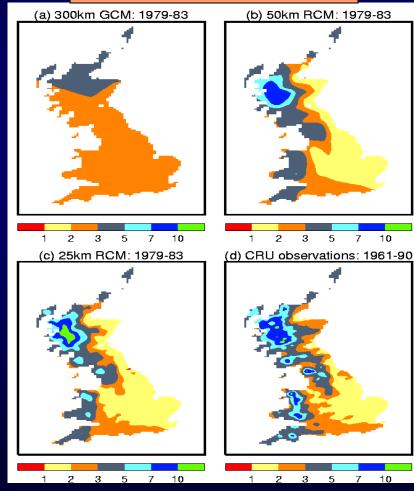
#### From Christensen et al. 2005

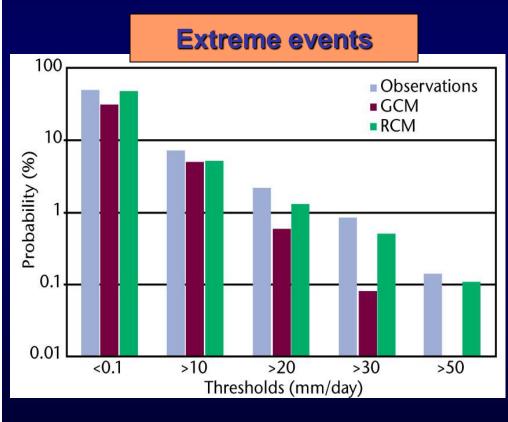
# The added value of RCMs

10

10

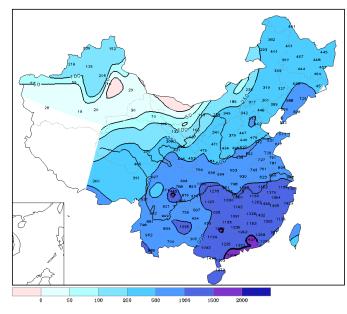
### **Topographic forcing**





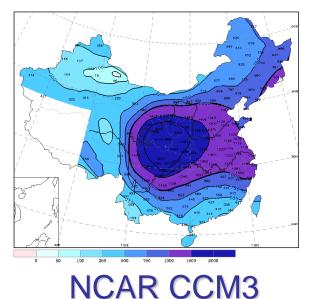
Courtesy of R. Jones

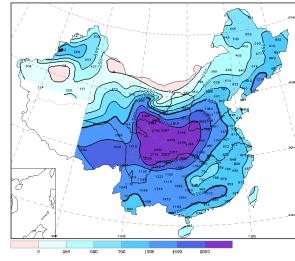
### **OBSERVATIONS**



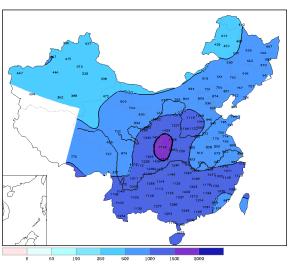
Simulation of east Asia monsoon precipitation by GCMs has been traditionally very difficult

(Mean annual precipitation is shown; Gao et al. 2006)



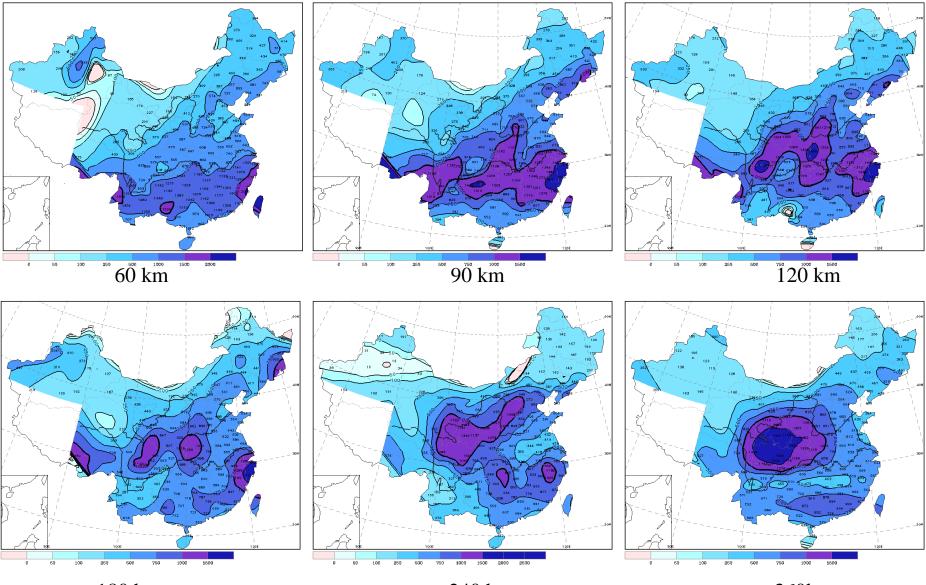


T63 NCC GCM



CSIRO GCM

### Mean annual precipitation (mm/day)

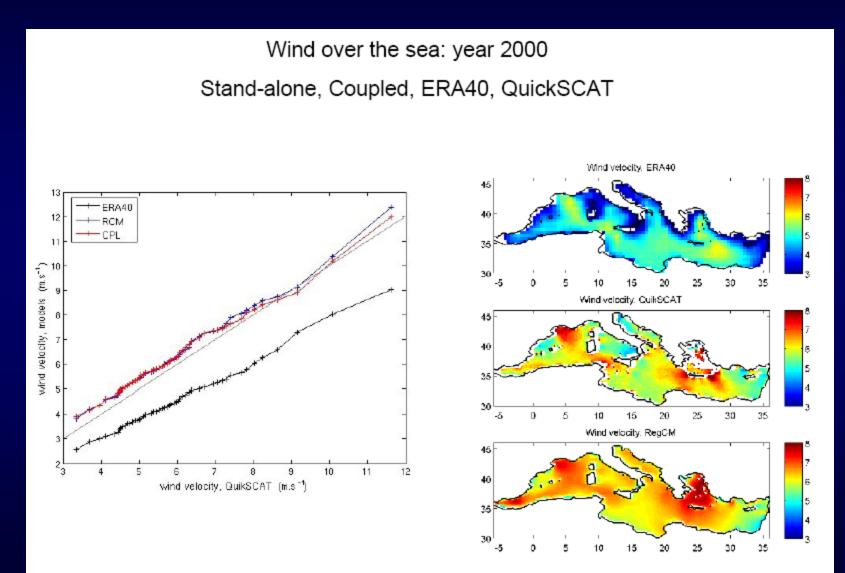


180 km

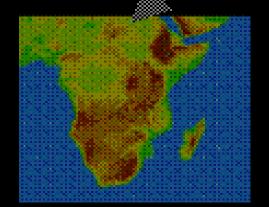
240 km

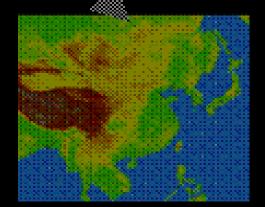
360km

# Surface winds in a coupled regional RCM for the Mediterranean 30 km resolution, 1960-1990, ERA40 LBC (Artale et al. 2010)

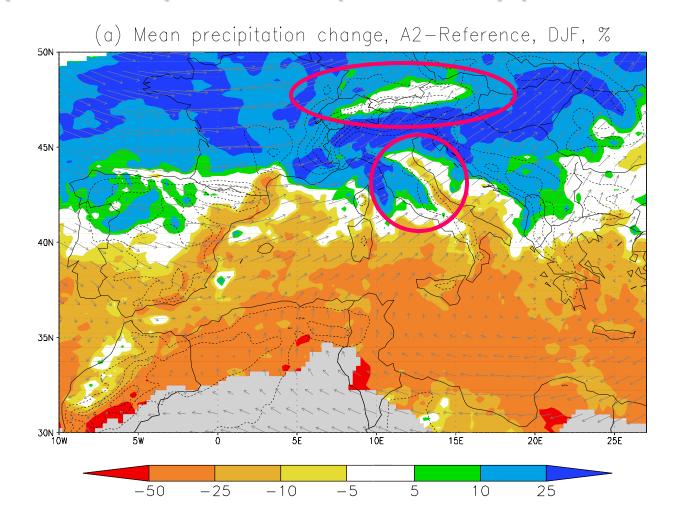


# Regional climate modeling: Does high resolution affect the climate change signal?





### Do high resolution forcings affect the climate change signal? Topography DJF Precipitation change (%)- dx=20 km A2 (2071-2100) – Control (1961-1990) (Gao et al. 2006)

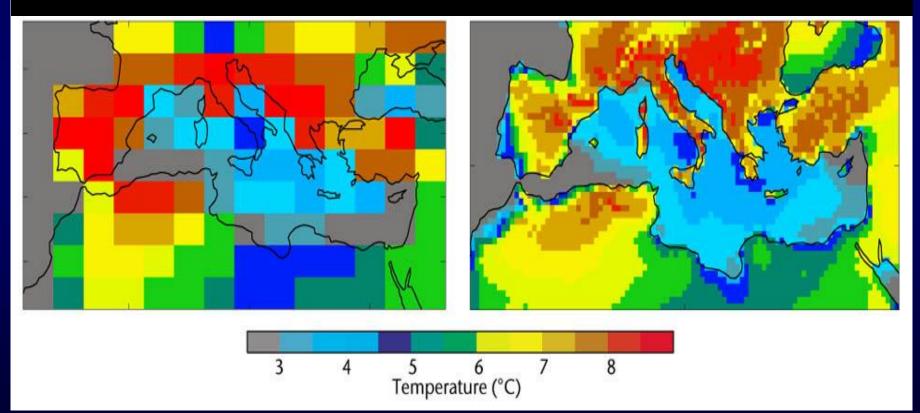


## Do high resolution forcings affect the climate change signal? Coastlines

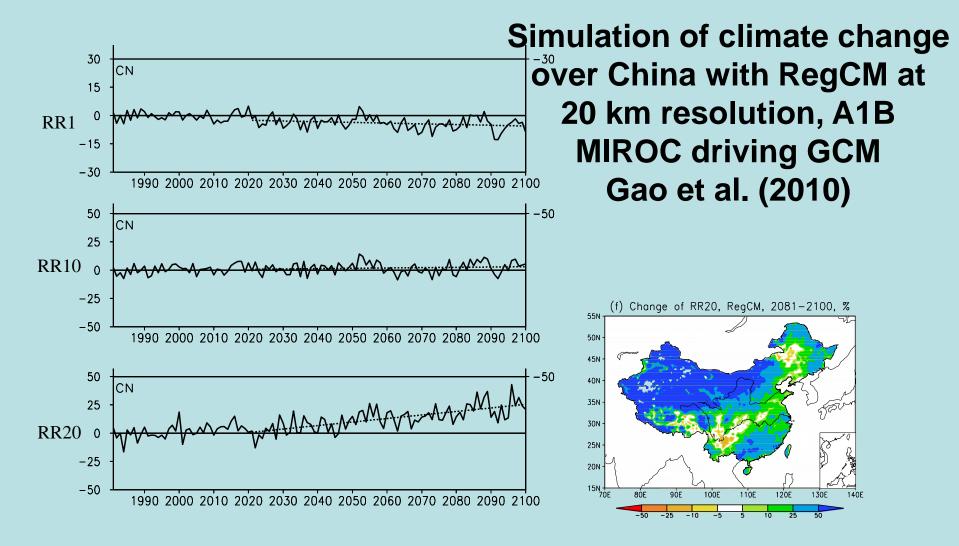
## Summer temperature change, 2080s, A2

#### Global climate model

Regional climate model



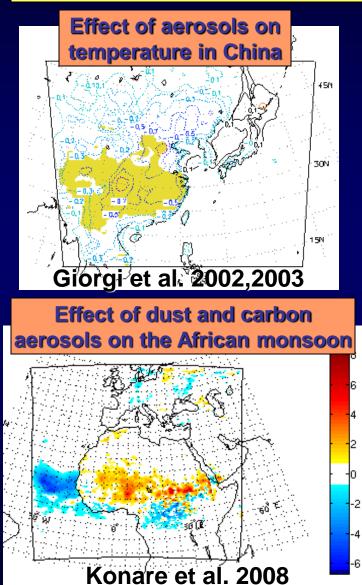
### (Courtesy of R. Jones)



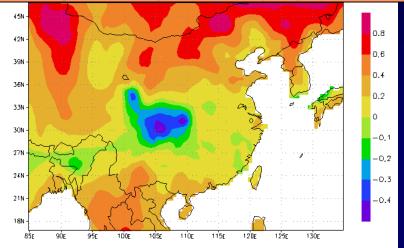
### Changes in the intensity of precipitation (%)

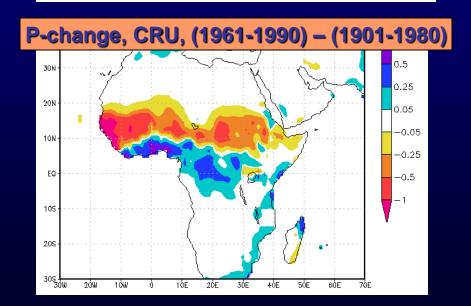
RR1: days with precipitation between 1~10mm/day RR10: days with precipitation between 10~20mm/day RR20: days with precipitation >20mm/day

# Do high resolution forcings affect the climate change signal? Aerosols



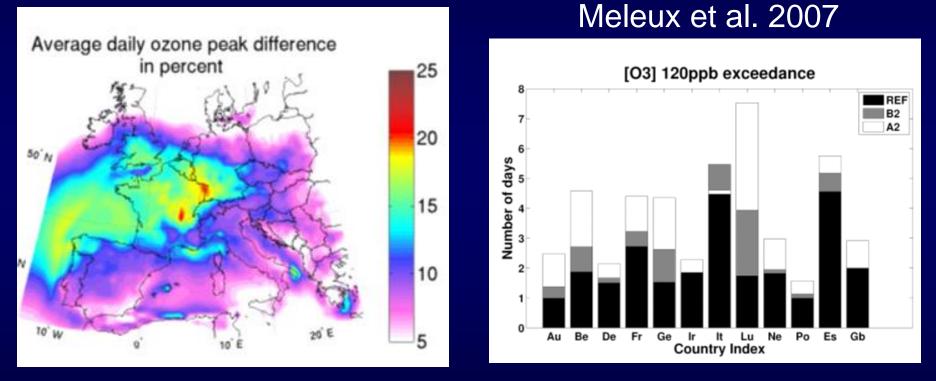
#### T-change, CRU, (1981-1998) - (1951-1980)





## Use of RCMs for impact studies: Air quality

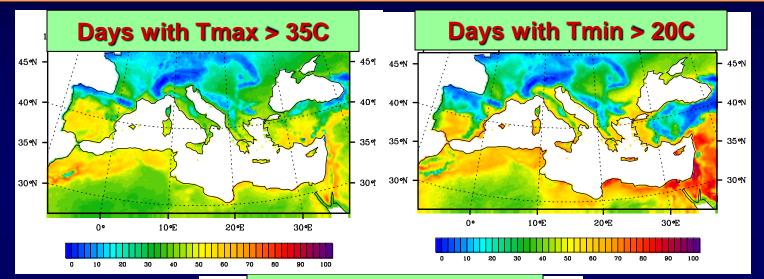
Change in summer ozone concentration statistics A2 scenario (2071-2100) minus (1961-1990)

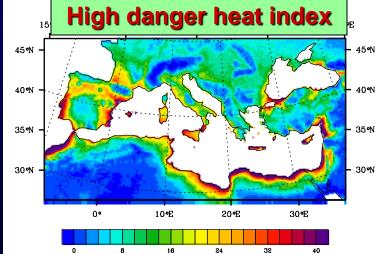


Climate change will increase ozone concentrations over Europe because of higher temperatures, reduced precipitation and more stagnant conditions

### Application of RCMs to impacts studies Health impacts

### Increase of heat-related stress over the Mediterranean





### Diffenbaugh et al. (2007)

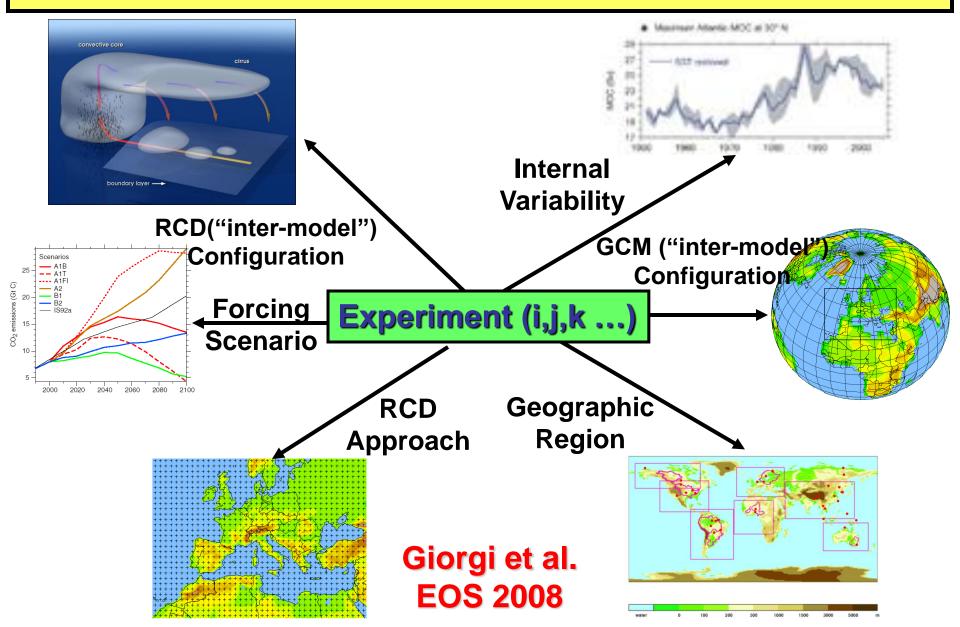
## Regional Climate Models: "State of the art"

- Many RCMs today available, some of them "portable" and used by wide communities (e.g. RegCM, PRECIS, RSM, WRF)
- Grid spacing of 10-30 km (sub-10 km for some models);
- Upgrade to non-hydrostatic, cloud-resolving frameworks in order to go to sub-10 km resolutions
- Decadal to centennial simulations the "accepted standard"
- Virtually all regions of the World have been simulated
- Encouraging results from some two-way nested experiments
- Several RCM coupling efforts under way, including atmosphere, ocean, aerosol, and biosphere components
- Wide range of applications
  - Process studies, paleoclimate, climate change, seasonal prediction, impacts, climate-aerosol interactions, air-sea interactions, landatmosphere feedbacks

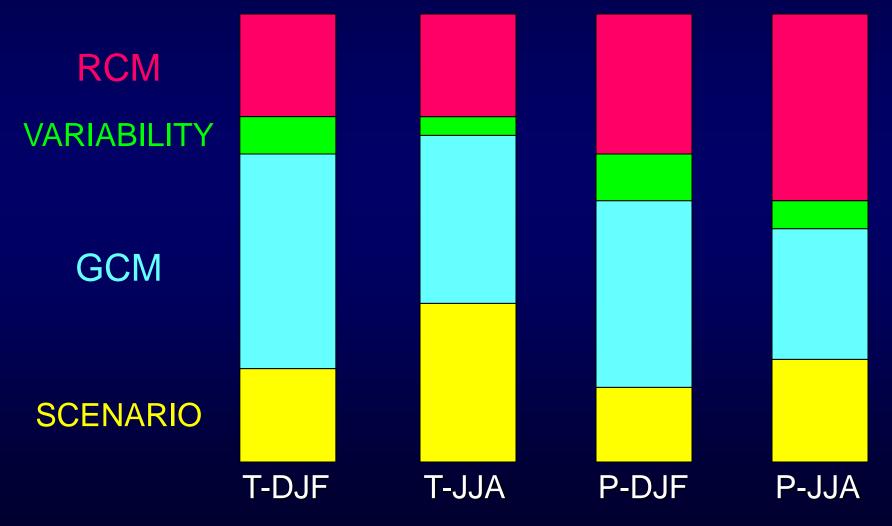
# The WCRP COordinated Regional climate Downscaling Experiment



### Uncertainties in regional climate projections, Regional Climate Change "Hyper-Matrix Framework"



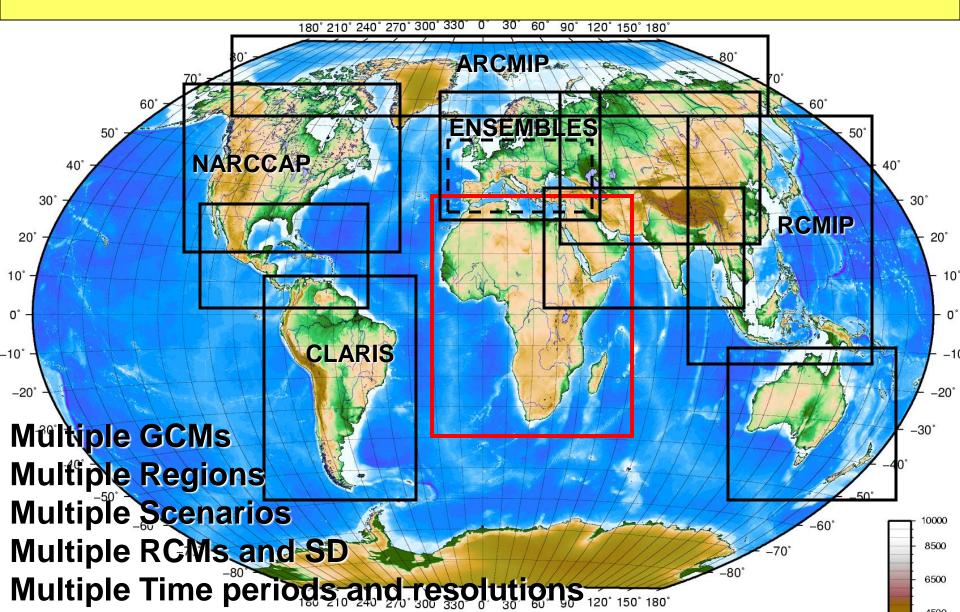
Sources of uncertainty in the simulation of temperature and precipitation change (2071-2100 minus 1961-1990) by the ensemble of PRUDENCE simulations (whole Europe) (Note: the scenario range is about half of the full IPCC range, the GCM range does not cover the full IPCC range) (Adapted from Deque et al. 2006)

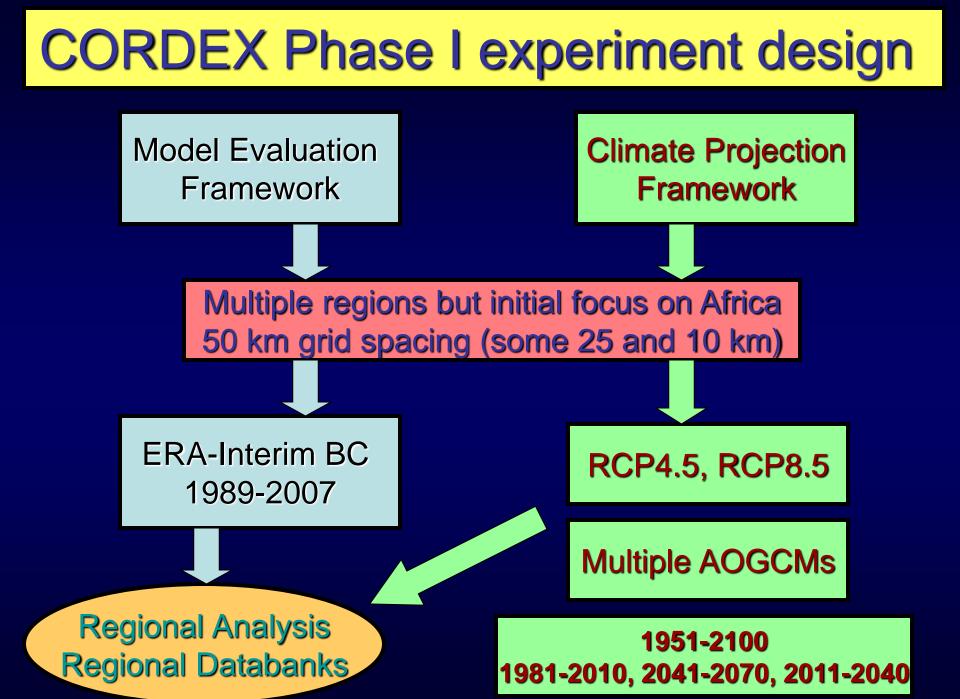


# CORDEX: COordinated Regional climate Downscaling EXperiment

- Task Force on Regional Climate Downscaling (TFRCD)
  - Evaluate and possibly improve different regional downscaling techniques (Model Evaluation Framework, AMIP-like)
  - Design a common framework for the next generation RCD-based climate change projections for input to impact/adaptation work (Model Projection Framework, CMIP-like)
  - Facilitate the engagement of the end-user community and the scientific community from developing countries

# The CORDEX Framework





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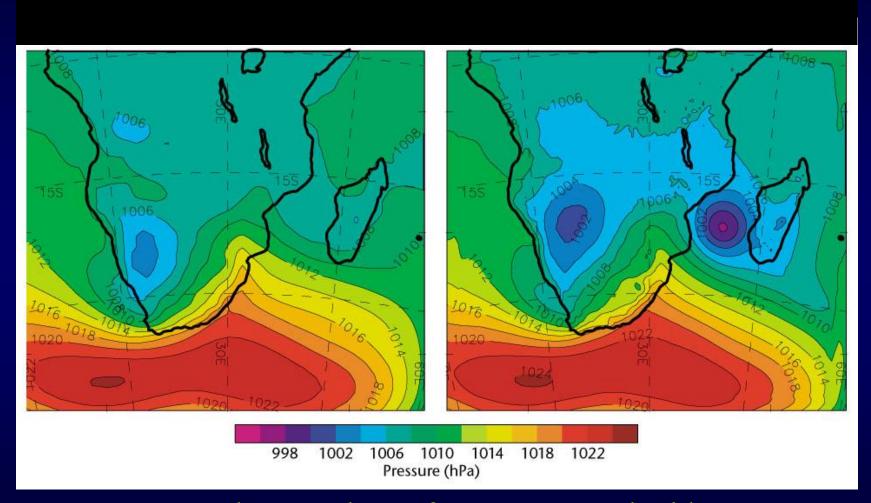
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- RCMs can enlarge the modeling community and as such have an important "educational" role
- CORDEX will provide an important benchmark framework for the downscaling community.



## SIMULATION OF A TROPICAL CYCLONE



RCMs can simulate circulation features not resolved by GCMs

### Intraseasonal variability: Precipitation over East Asia Sept 1994 thru August 1995

RegCM

### CRU Obs

