CORDEX:
The COordinated Regional Downscaling Experiment

background, status and perspectives

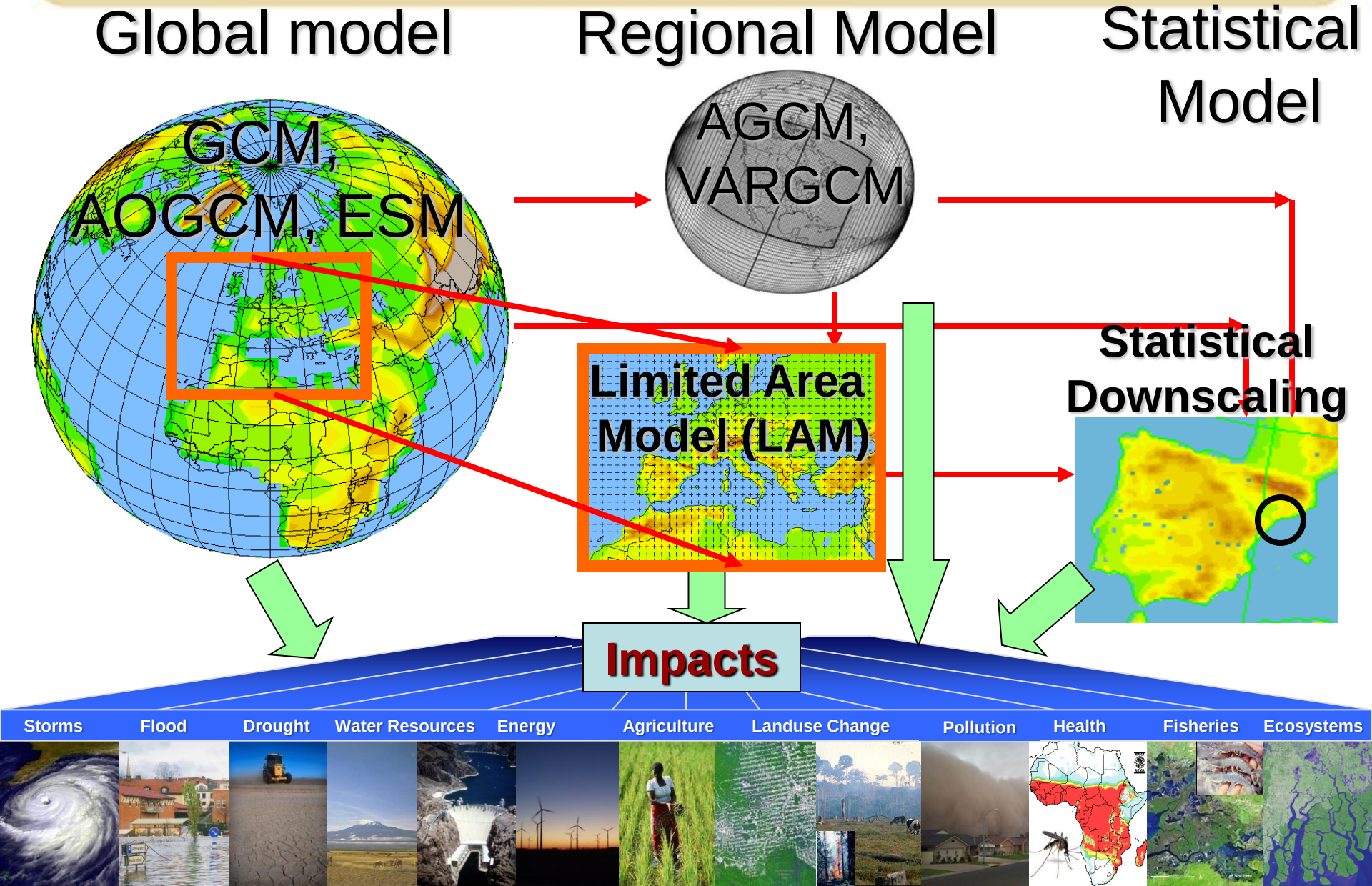
S. Somot (Météo-France / CNRM-GAME)

with materials from F. Giorgi (ICTP) and C. Jones (SMHI), CORDEX-PIs

WCRP CORDEX

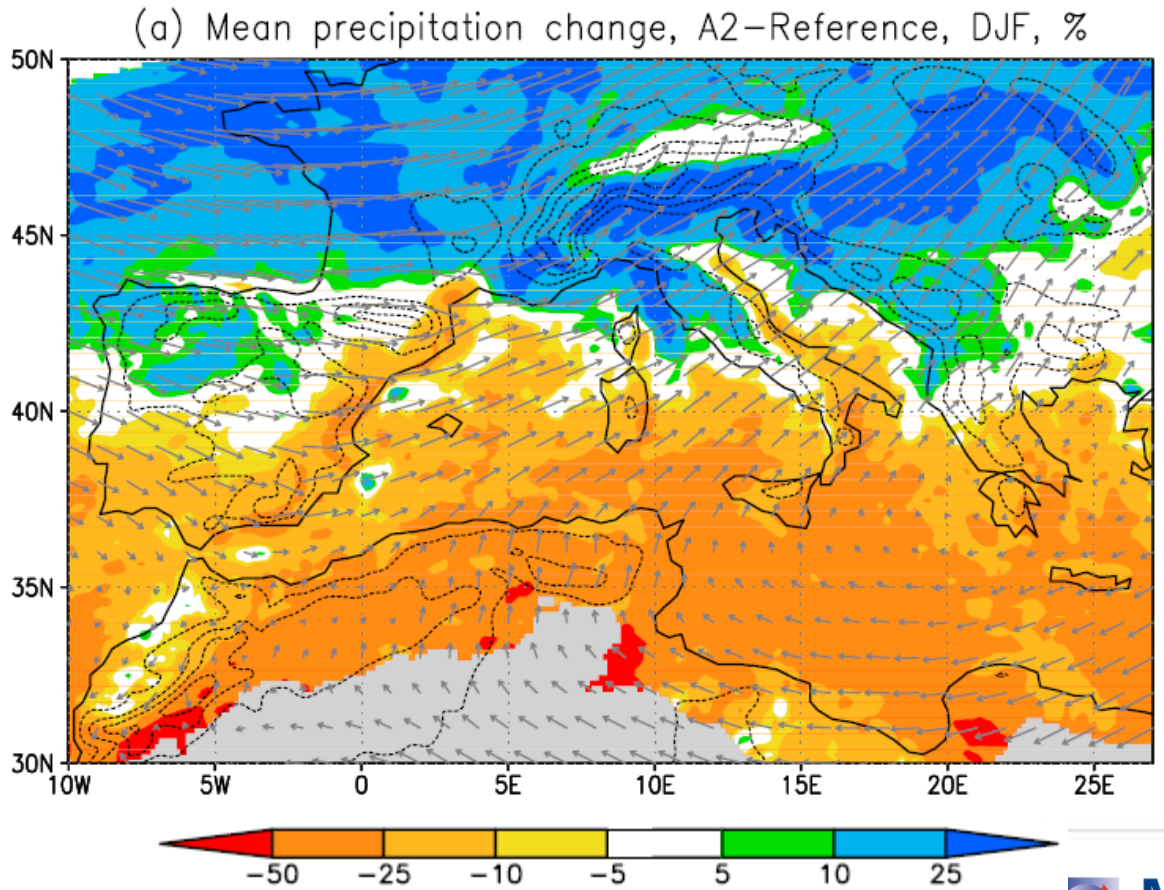
METEO FRANCE
Toujours un temps d'avance

Regional Climate Downscaling: background



Regional Climate Downscaling: background

Effect of the topography
on the mean precipitation change signal



Gao et al. 2006

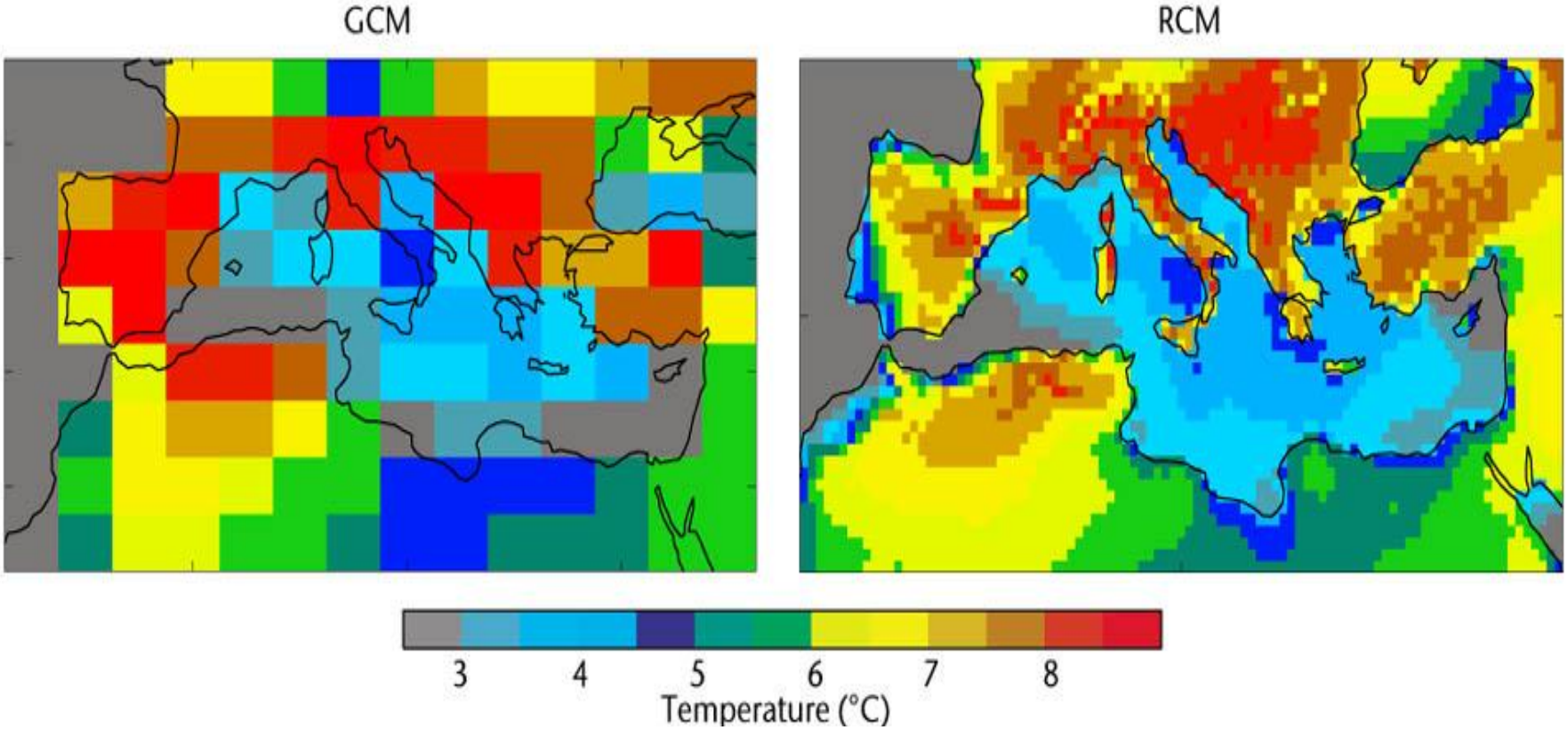
2071-2100 vs 1961-1990, RCM 20 km

METEO FRANCE
Toujours un temps d'avance

Regional Climate Downscaling: background

Effect of the resolution on the climat change pattern

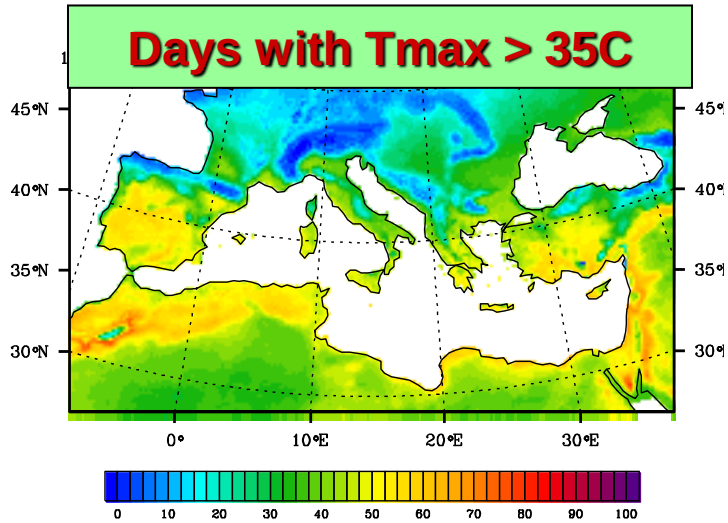
Temperature change in the 2080s (JJA), Scenario A2

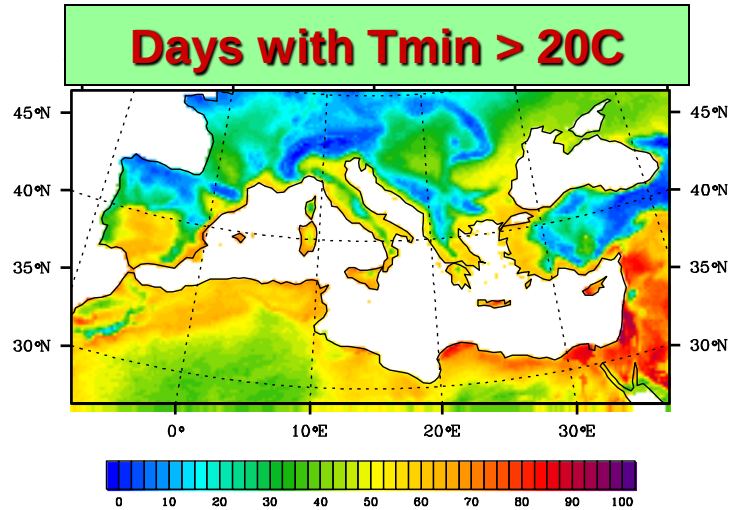


Climate on islands changes very differently to the surrounding Mediterranean Sea, and can only be predicted using an RCM

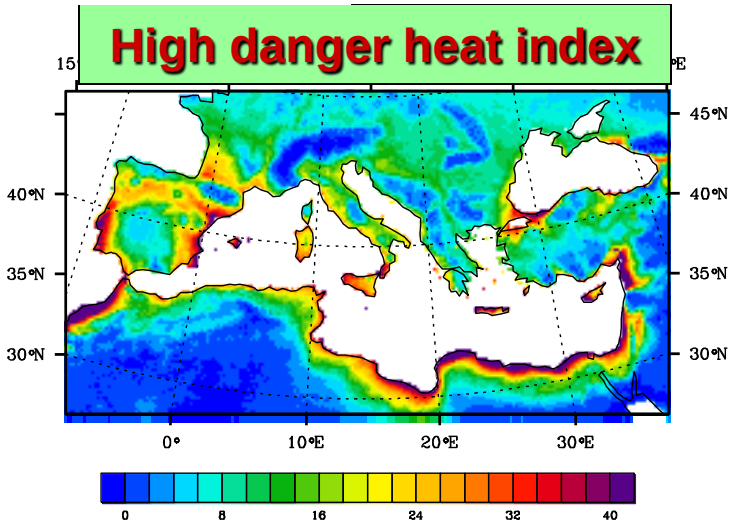
Regional Climate Downscaling: background

Coastlines effect in regional climate models





Change in heat related indices (A2 vs REF)

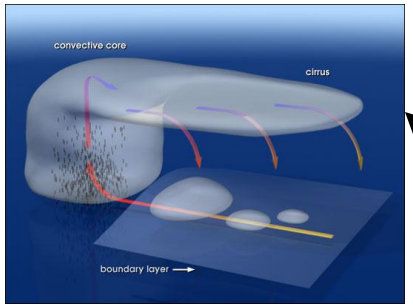


Diffenbaugh et al. 2008

METEO FRANCE
Toujours un temps d'avance

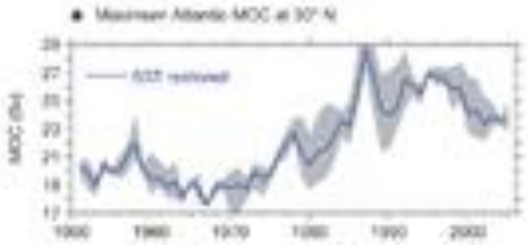
Regional Climate Downscaling: background

Characterizing uncertainties in regional projections

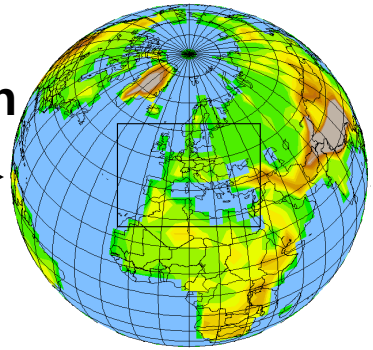


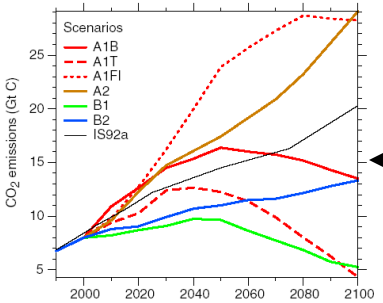
RCD Configuration

Internal Variability



GCM Configuration

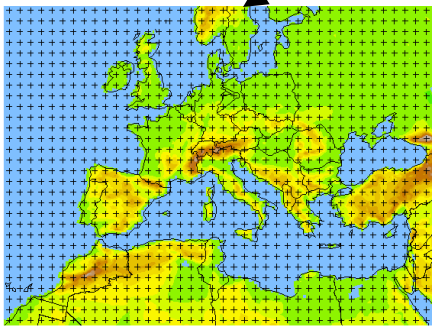




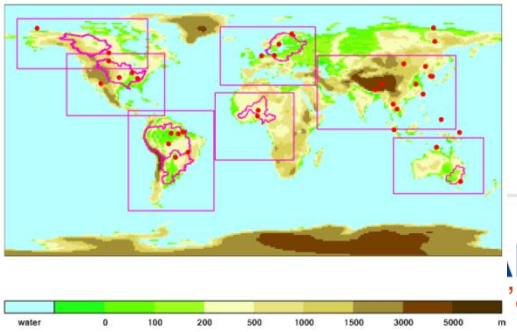
Forcing Scenario

Experiment (i,j,k …)

RCD Approach



Geographic Region

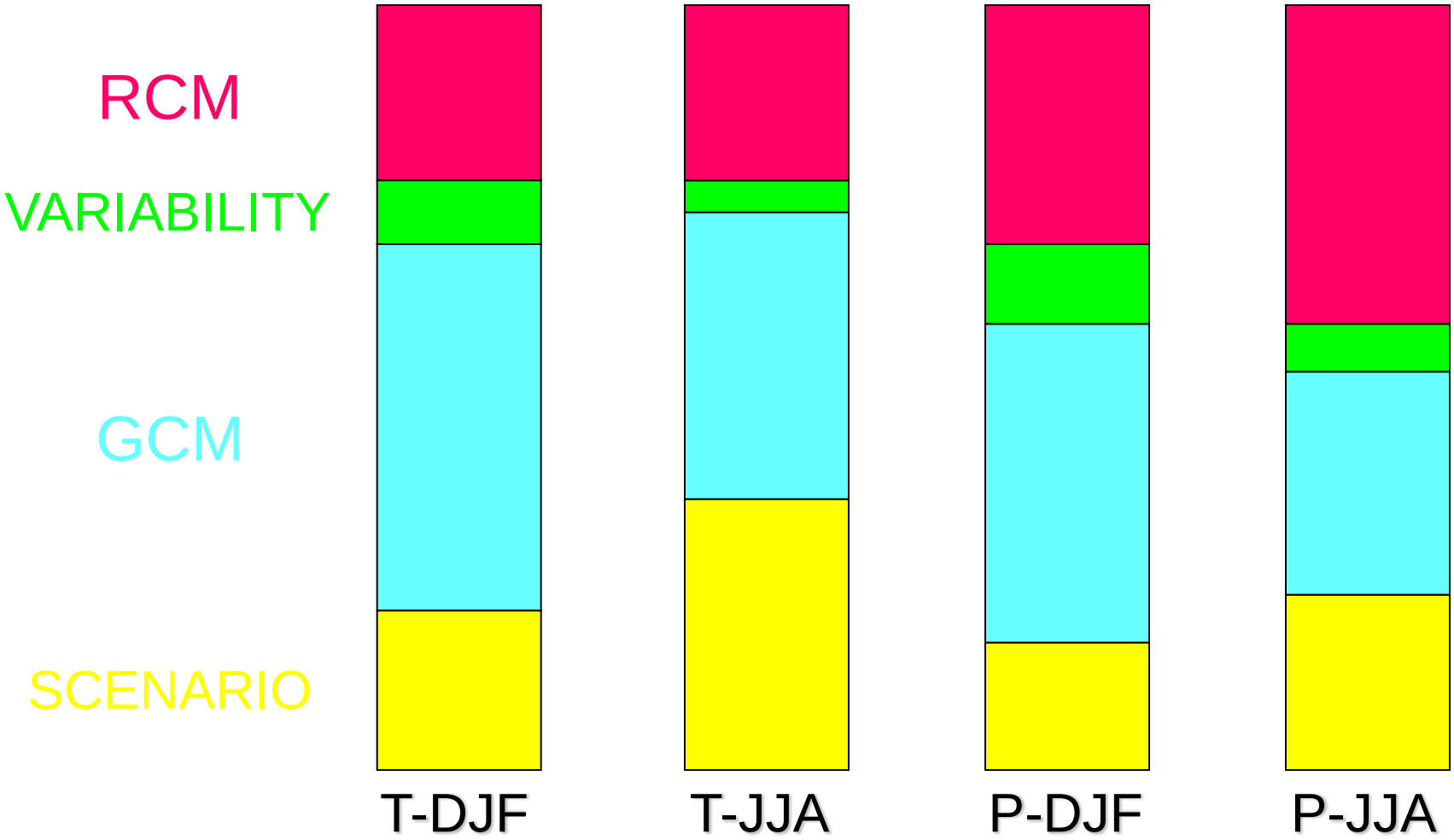


Giorgi et al. EOS 2008

Regional Climate Downscaling: background

Sources of uncertainty in RCM multi-model ensemble
(Note: scenario and GCM uncertainties are probably underestimated wrt CMIP)

PRUDENCE project, Europe, 2071-2100 vs 1961-1990



adapted from Déqué et al. 2006

CORDEX: definition and main goals

CORDEX: Coordinated Regional Downscaling Experiment

CORDEX: a coordinated international activity, under the WCRP umbrella that would develop a framework to:

1. **Evaluate, inter-compare** and **improve** **regional climate downscaling** (RCD) models and techniques
2. Define **standards** for the preparation and dissemination of RCD data
3. Provide a **coordinated set** of RCD-based **projections** over **regions worldwide** for use in impact / adaptation / vulnerability (IAV) studies
4. Facilitate communication with the **impact/end user** community and involve the research community from **developing countries**

CORDEX: history and organisation

- CORDEX is a WCRP initiative
- Leaded by F. Giorgi (ICTP) and C. Jones (SMHI)
- Endorsed by WCRP in Dec 2008 with the creation of the TFRCD (Task Force on Regional Climate Downscaling)
- A suite of CORDEX workshops: Toulouse (Feb. 2009), Lund (May 2009), Lille (June 2010), Trieste (Mar. 2011)

- Definition of several domains to be covered at 50 km
- Participation from modelling groups all over the world
- A general set of instructions for running the CORDEX simulations

- Central database archives at DMI + ESG nodes + regional databases
- Specifications for standardized output format following (as closely as possible) the CMIP5 protocol:

  tas_MED-44_CNRM-CM5_rcp85_r8i1p1_CNRM-ALADIN52_v1_mon_207101-208012.nc

CORDEX: Other activities

- Formation of regional diagnostics/evaluation teams
- Compile suitable metrics for model evaluation
- Gather relevant observational datasets
- Regional CORDEX workshops
- Creation of CORDEX databanks (DMI, KMA): http://cordex.dmi.dk/joomla/
- Email server (IA State): http://mesonet.agron.iastate.edu/mailman/listinfo/cordex
- Emailing list: cordex@mesonet.agron.iastate.edu
- CORDEX web portal: http://wcrp.ipsl.jussieu.fr/cordex/about.html
- A dedicated and very successfull EGU session every year (CL5.3: Regional climate modeling, including CORDEX)
- Definition of reference periods for analysis: 1976-2005 (?), 2011-2040, 2041-2070, 2071-2100

CORDEX simulations

- CORE
  - Resolution: 50 km, 12 official domains (+ 2 new proposed domains)
  - Africa domain is the priority (but as many domains as possible)
  - ERA-Interim lateral forcing for evaluation (1989-2007)
  - Simulation: historical (1951-2005)
  - Simulation: scenario RCP4.5 (2005-2100)
  - Simulation: scenario RCP8.5 (2005-2100)
  - One driving GCM required (but as many GCM as possible)
  - Transient simulations (1951-2100) are advised but time slices are possible (1981-2010 ?, 2011-2040, 2041-2070)

- TIER1
  - Resolution: 12 km for Euro-CORDEX and Med-CORDEX
  - Fully coupled Regional Climate System Model (RCSM) for Med-CORDEX
  - Full ERA-Interim period (1979-now)
  - Scenario RCP2.6, RCP6.0

CORDEX Phase I experiment design

Model Evaluation Framework

Climate Projection Framework

Multiple regions (Initial focus on Africa)
50 km grid spacing

ERA-Interim LBC
1989-2007

RCP4.5, RCP8.5
1951-2100 / 1980-2070

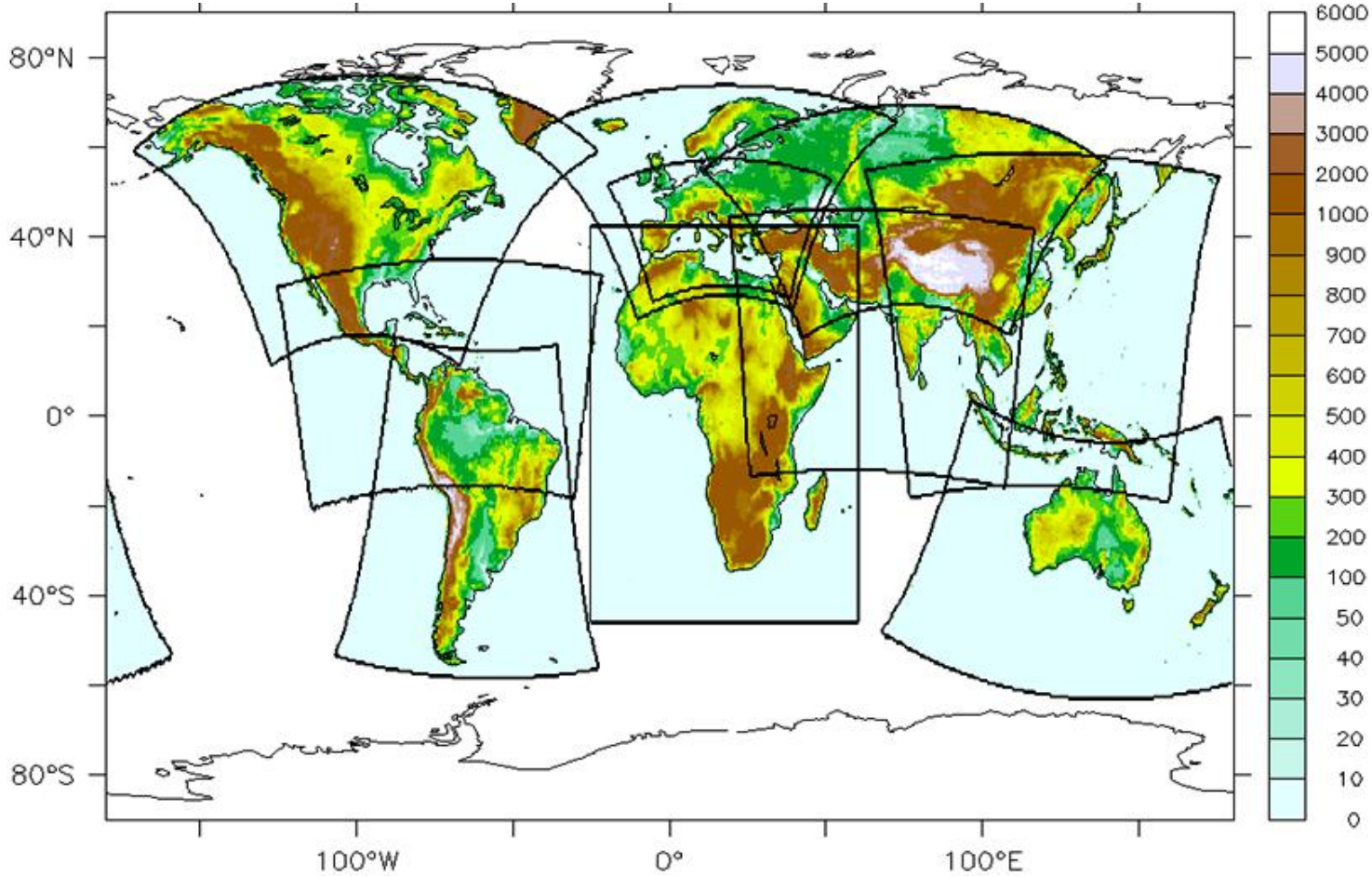
Decadal predictions
1980-2010, 1990-2000, 2005-2035

Regional Analysis
Regional Databanks

Giorgi et al.
WMO Bulletin 2009

Multiple AOGCMs

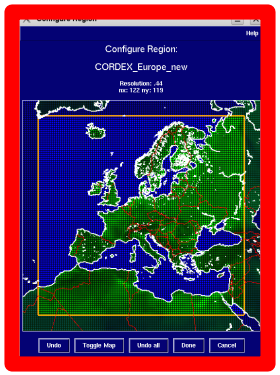
CORDEX: 12 domains at 0.44° or 50 km



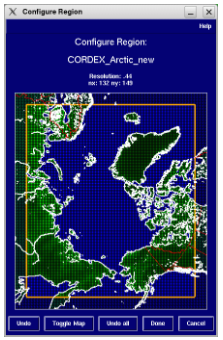
CORDEX DOMAINS (plus Arctic & Antarctica)

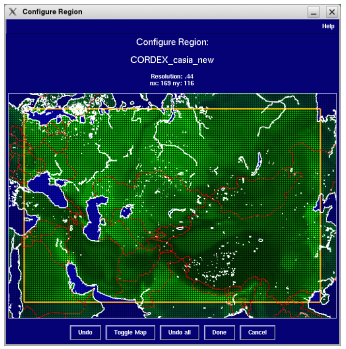
CORDEX: 12 domains at 0.44° or 50 km

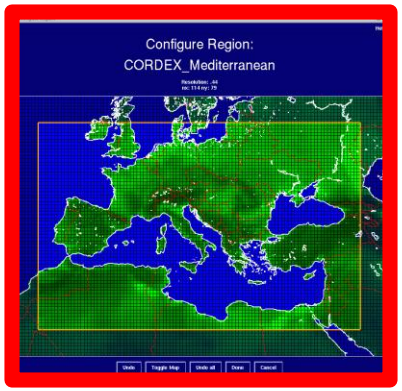
NARCCAP



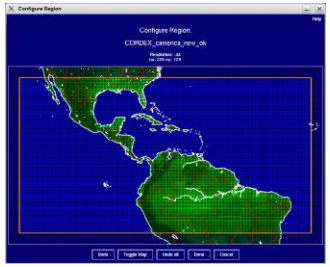
PRUDENCE
ENSEMBLES
IMPACT2C

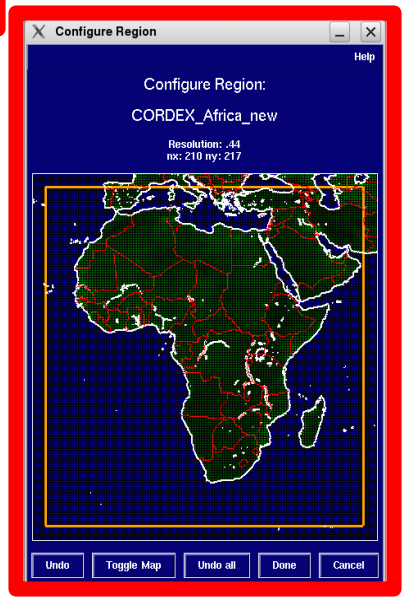


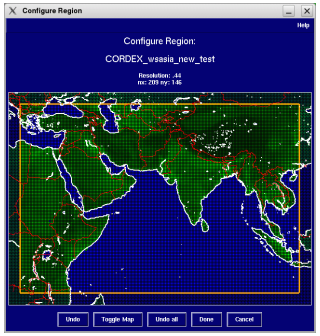


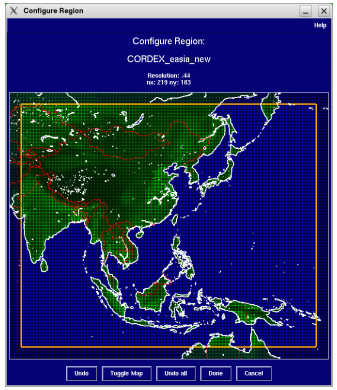


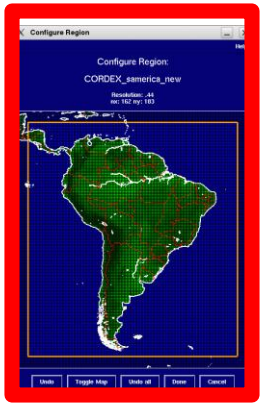
HyMeX
MedCLIVAR
CIRCE
CLIMRUN





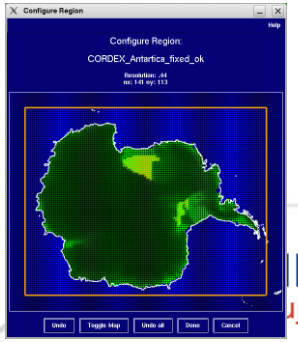


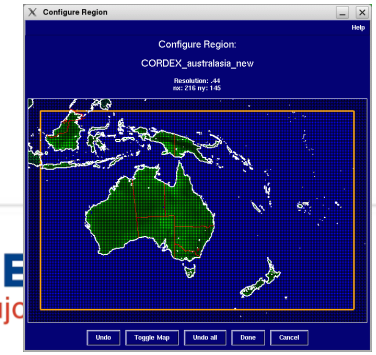




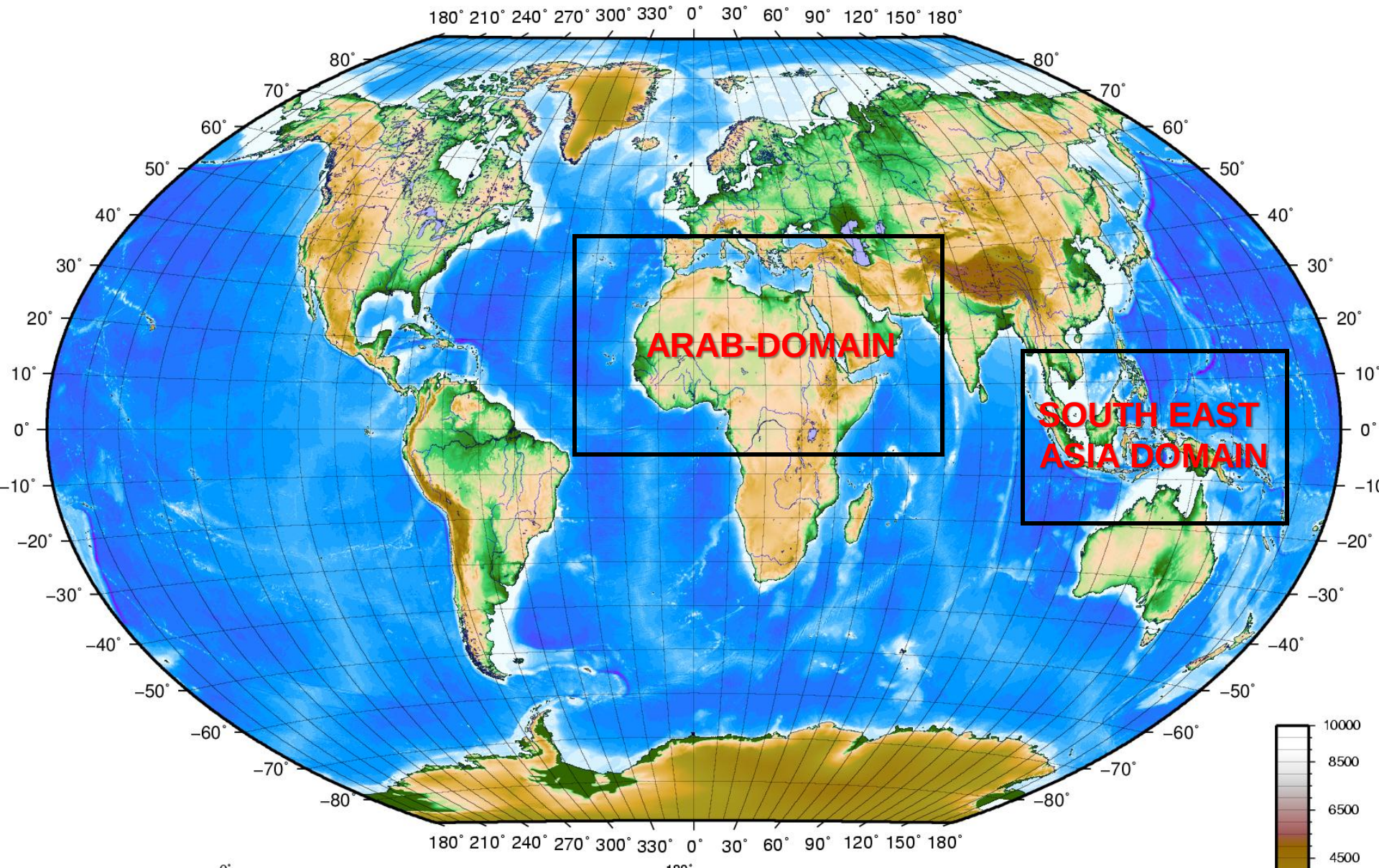
CLARIS
CLARIS-LPB

AMMA
ENSEMBLES





CORDEX: 2 new proposed domains



First multi-model CORDEX study: Africa domain

Nikulin G. et al. 2012: *Precipitation Climatology in an Ensemble of CORDEX-Africa Regional Climate Simulations. J. Climate, 25, 6057–6078. doi: http://dx.doi.org/10.1175/JCLI-D-11-00375.1*

HIRHAM5	**(DMI, Denmark)**
CCLM48	**(CCLMcom consortium)**
REMO	**(MPI, Germany)**
RACMO22	**(KNMI, Netherlands)**
ARPEGE51	**(CNRM, France)**
RegCM3	**(ICTP, Italy)**
PRECIS	**(University of Cape Town, South Africa)**
WRF311	**(University of Cantabria, Spain)**
MM5	**(University of Murcia, Spain)**
CRCM5	**(Université du Québec à Montréal, Canada)**

First multi-model CORDEX study: Africa domain

Simulations and observations

Driven by ERA-Interim, Africa domain, 50 km, 1989-2008

RCM data: 3-hourly precipitation:

- ✓ seasonal mean
- ✓ annual cycle
- ✓ diurnal cycle

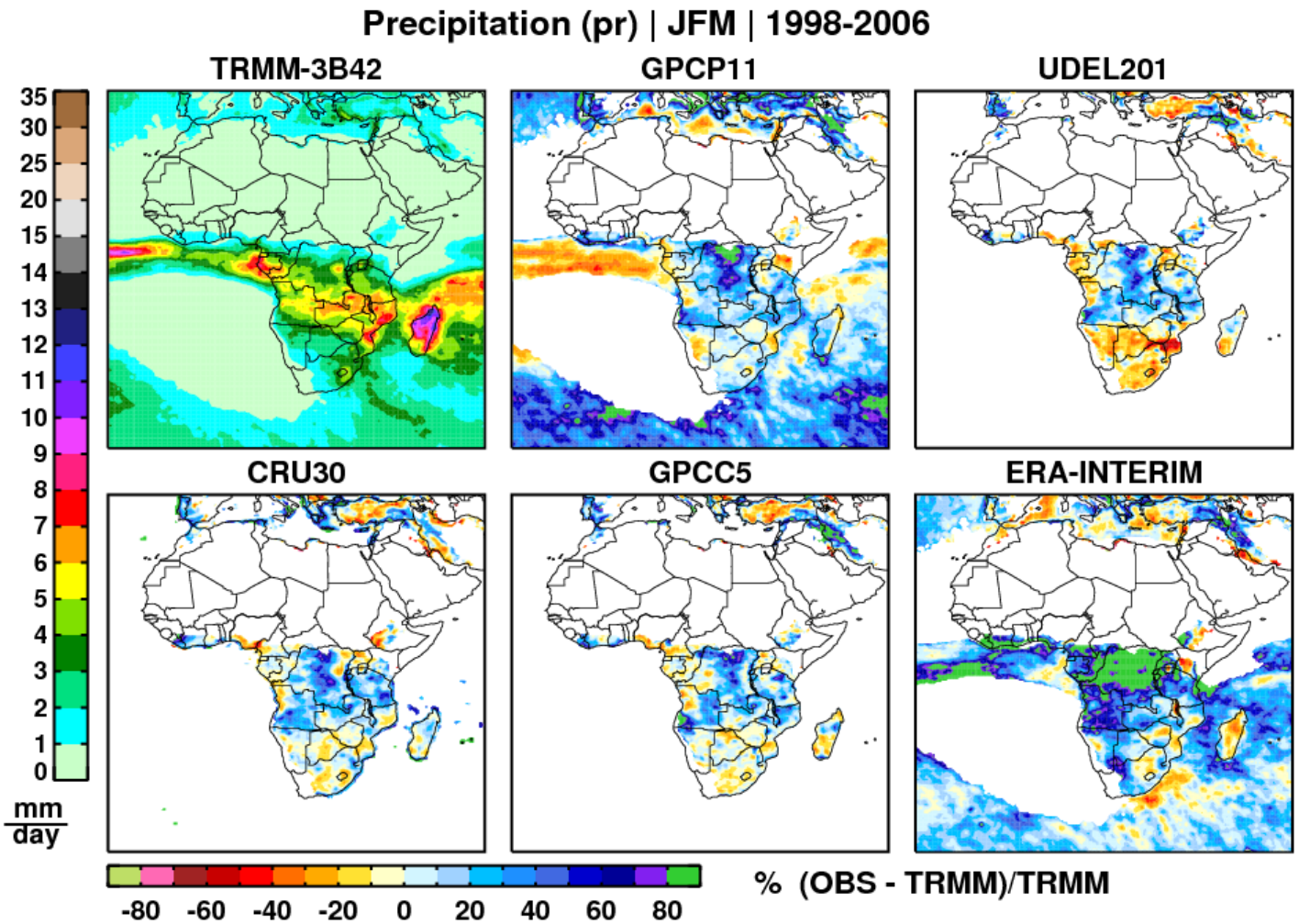
Gridded precipitation products:

- ✓ TRMM-3B42 (3-hourly, 0.25°, 1998-2008)
- ✓ CMORPH (3-hourly,0.25°, 2003-2008)
- ✓ GPCP11 (daily, 1°, 1998-2008)
- ✓ GPCC5 (monthly, 0.5°, 1989-2008)
- ✓ CRU30 (monthly, 0.5°, 1989-2006)
- ✓ Univ. Delaware, v. 2.01 (monthly, 0.5°, 1989-2008)

all different grids remapped onto the same 0.44 rotated grid

First multi-model CORDEX study: Africa domain

Gridded precipitation products



Relative difference can locally reach 50% and more

First multi-model CORDEX study: Africa domain

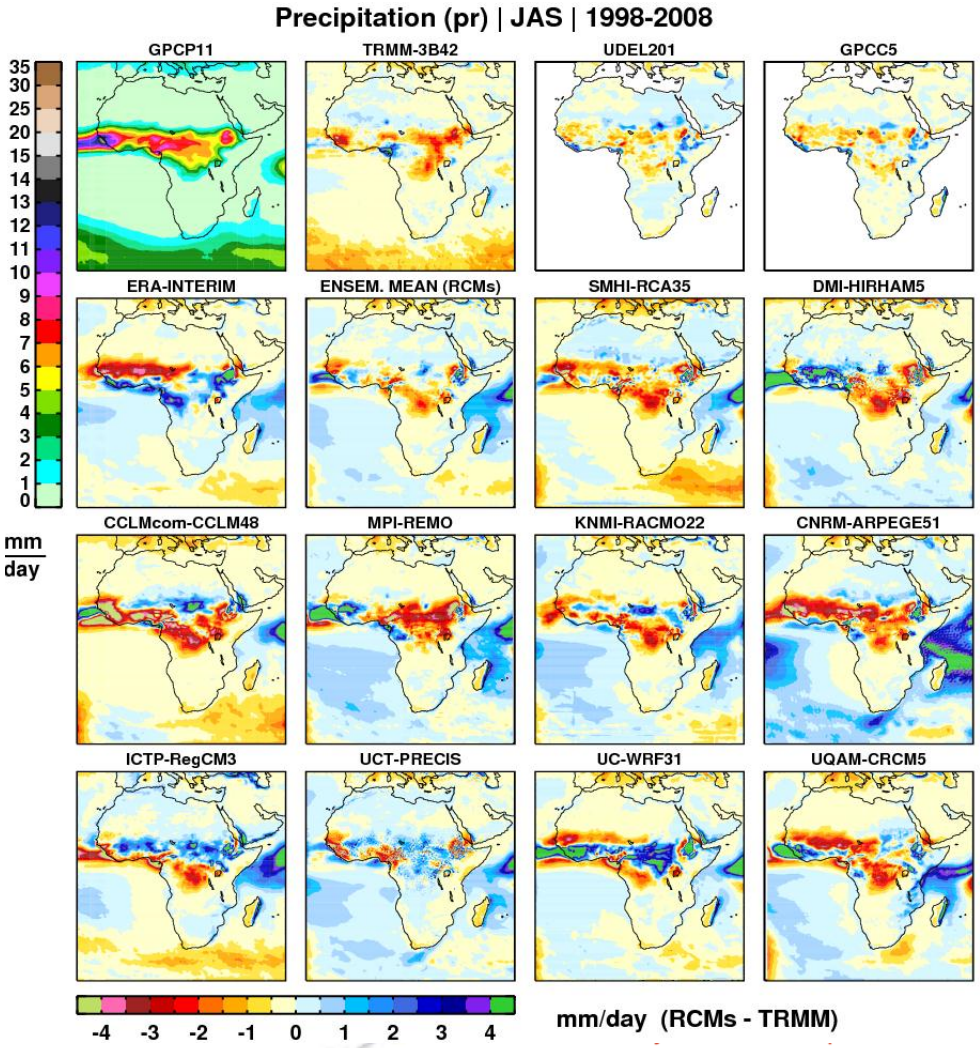
Seasonal means (JAS)

spatial patterns of biases are different

many RCMs show smaller biases than ERA-Interim

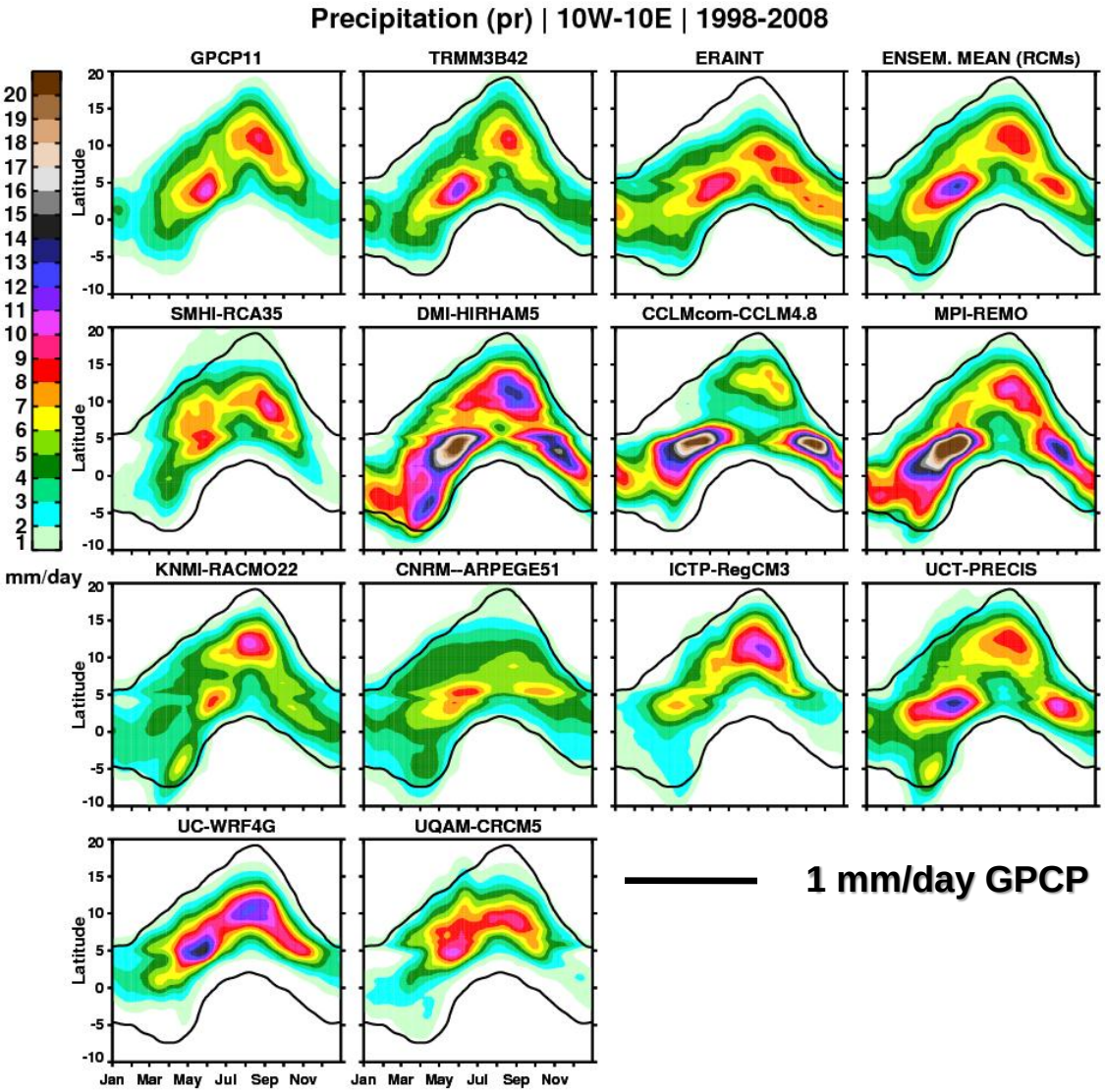
common feature is overestimation in eastern part of domain (quality of satellite products ?)

ensemble mean outperforms RCMs (cancelation of biases of opposite sign)



First multi-model CORDEX study: Africa domain

Annual cycle (10W-10E)

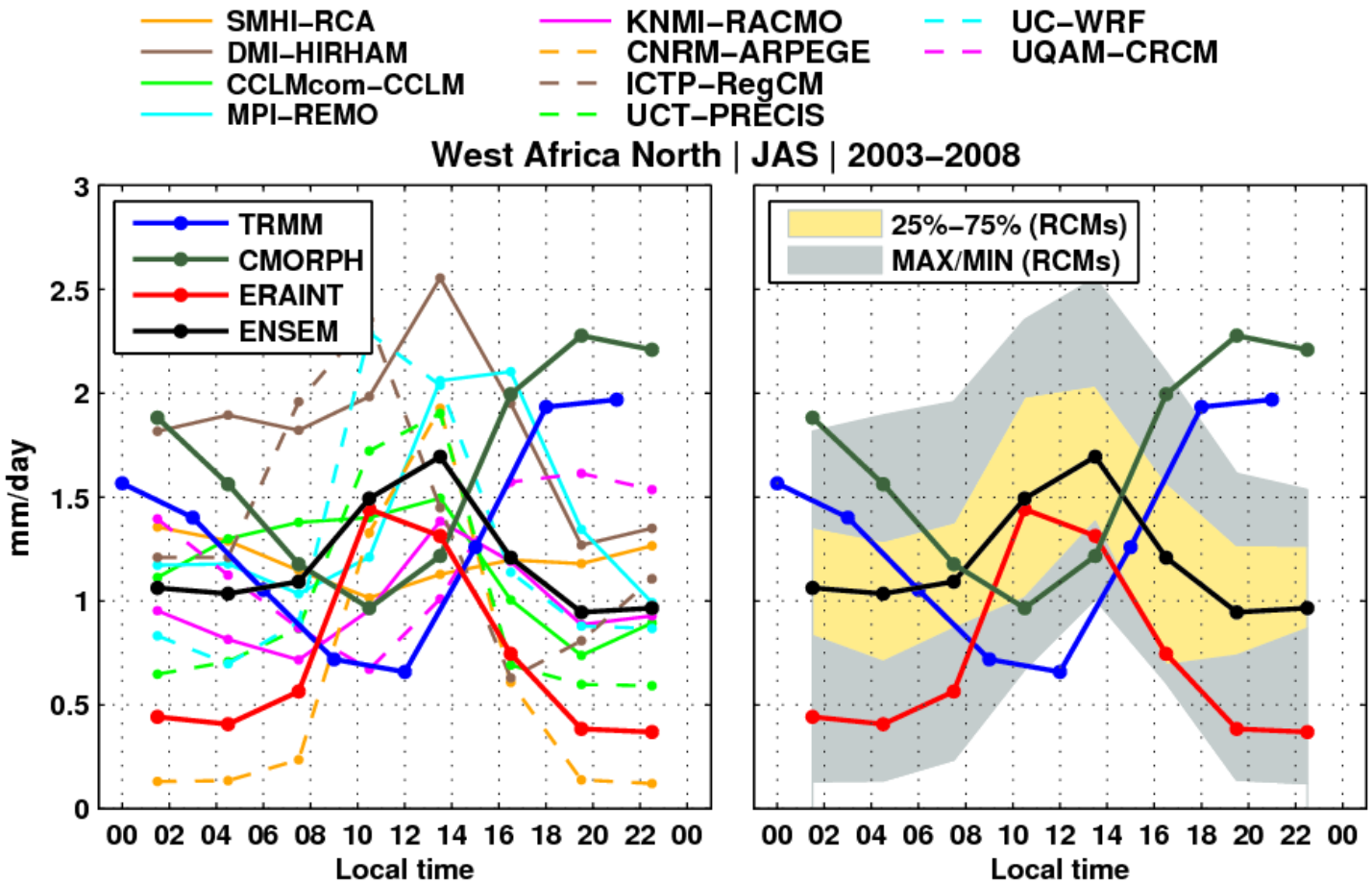


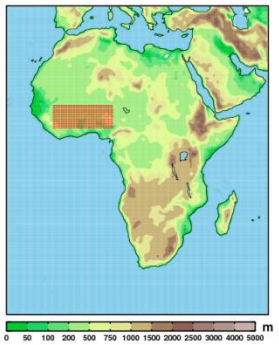
All RCMs produce a version of the WAM onset with different degree of distortion

Ensemble mean corrects individual biases

First multi-model CORDEX study: Africa domain

Diurnal cycle





only CRCM5 can reproduce diurnal cycle here
ensemble mean cannot correct the phase of diurnal cycle

Conclusion

- Evaluation and scenario simulations are ready for many CORDEX regions
- Some RCMs ran over many different regions
- Some RCMs used multi-GCM forcings
- Some 12km RCM runs are ready
- Some preliminary papers were ready for IPCC-AR5

- Need for data upload in the databases
- Need for more multi-model regional analysis
- Need for more multi-region analysis
- Need for a better coordination of the analyses (period, observations, …)
- Need for metadata about the models
- Need for better communication of the regional good practices (web portal)

- In 2012, dismantling of the TFRCD and creation of the WGRC (Working Group on Regional Climate science and information) with a Scientific Advisory Committee (CORDEX will be a project of the WGRC)
- Next international CORDEX meeting: Brussels (Nov 2013)

Pourquoi je vois rose quand j'entends CORDEX ?

Une vision plus personnelle

Pourquoi CORDEX est une chance pour notre communauté ?

- La régionalisation: une communauté encore jeune, en pleine croissance, et en manque de repère

CORDEX permet de:
- Donner un cadre de travail, partager de bonnes pratiques entre groupes de modélisation et entre régions.
- Transmettre les bonnes pratiques de la communauté GCM (évaluation, mise à disposition des données, analyse multi-modèle, prise en compte de l'incertitude)
- S'organiser pour être prêt à répondre à la demande de la communauté des impacts et des décideurs

Positionnement de la régionalisation dans MISSTERRE

Une vision plus personnelle

- A attaquer des questions (phénomènes, zones géographiques) inaccessibles aux GCMs de part leur manque de résolution (extrêmes de pluie, vents locaux, cyclones tropicaux, îles, effet orographique, land-use, chimie régionale): Notion de valeur ajoutée des RCMs (downscaling)
- A mieux cerner/comprendre/résoudre les biais des GCMs. RCM vu comme des outils pour aider à améliorer les GCMs (même physique, même résolution mais moins cher à faire tourner). Séparer l'origine des biais (grande échelle vs physique locale). Simu pilotée ERA-Int, Zoomé/guidé, Nudging. Tests de sensibilité à la physique, à la résolution, aux composantes du système climatique
- A préparer l'avenir: la résolution des RCMs maintenant est la résolution des GCMs de demain
- A comprendre dans quelles situations une meilleure représentation d'une zone particulière (résolution, physique, couplage) peut améliorer la grande échelle: Notion d'upscaling (stretched grid, two-way nesting)

Sans oublier les problèmes des RCMs

Une vision plus personnelle

- Forçage aux bords: problème mal posé, on dégrade la transmission de l'information. Solution: tester son modèle en Big-Brother/Little-Brother Experiment, two-way nesting
- Variabilité interne: oui ça existe aussi avec les RCMs. Solution: simu d'ensemble, spectral nudging
- Inconsistence des physiques: incohérence entre le modèle forceur et le modèle forcé. Solution: utiliser la même physique
- Source d'incertitude supplémentaire dans la cascade d'incertitude liée au changement climatique. Solution: ne pas faire de régional quand inutile, projets coordonnés à la CORDEX
- Sensibilité des résultats à la taille, position, résolution du domaine. Solution: cadre commun (CORDEX), spectral nudging