



# The CORDEX initiative

## Emerging issues and future plans

*Filippo Giorgi, ICTP, Trieste, Italy*

# COordinated Regional Downscaling EXperiment (CORDEX) – Some history

- Initial discussions across the downscaling community (mostly RCM)
  - Toulouse 2009
- Establishment by the WCRP of the Task Force on Regional Climate Downscaling, TFRCD (2010)
- Design of Phase I CORDEX framework (Giorgi et al. 2009; Jones et al. 2011) and first CORDEX Conference (Trieste 2011)
- Establishment by the WCRP of the Science Advisory Team, SAT (2012)
- Second PAN-CORDEX conference ICRC-CORDEX 2013, Brussels, 2013.
  - More than 400 abstracts presented, > 500 participants.
- Establishment by WCRP of the Working Group on Regional Climate, WGRC (2013).

# CORDEX Vision and Goals

The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships

- To better understand relevant regional/local climate phenomena, their variability and changes through downscaling
- To evaluate and improve regional climate downscaling models and techniques (RCM, ESD, VAR-AGCM, HIR-AGCM)
- To produce large coordinated sets of regional downscaled projections worldwide
- To foster communication and knowledge exchange with users of regional climate information

# CORDEX Management

- CORDEX Science advisory team (SAT), 12 members



SAT-2 meeting  
SMHI (Sweden)  
25-27 Feb., 2015

- International Project Office for CORDEX (IPOC) hosted at SMHI since January 2015 (E. O'Rourke Head).
- CORDEX archiving coordinated by IS-ENES
- Regional points of contact (POCs), 2-3 per region

# CORDEX Phase I experiment design

Model Evaluation  
Framework

Climate Projection  
Framework

AMIP  
like

Multiple regions at 50 km grid spacing  
Higher for some regions (Europe – 12 km)

CMIP  
like

ERA-Interim LBC  
1989-2007

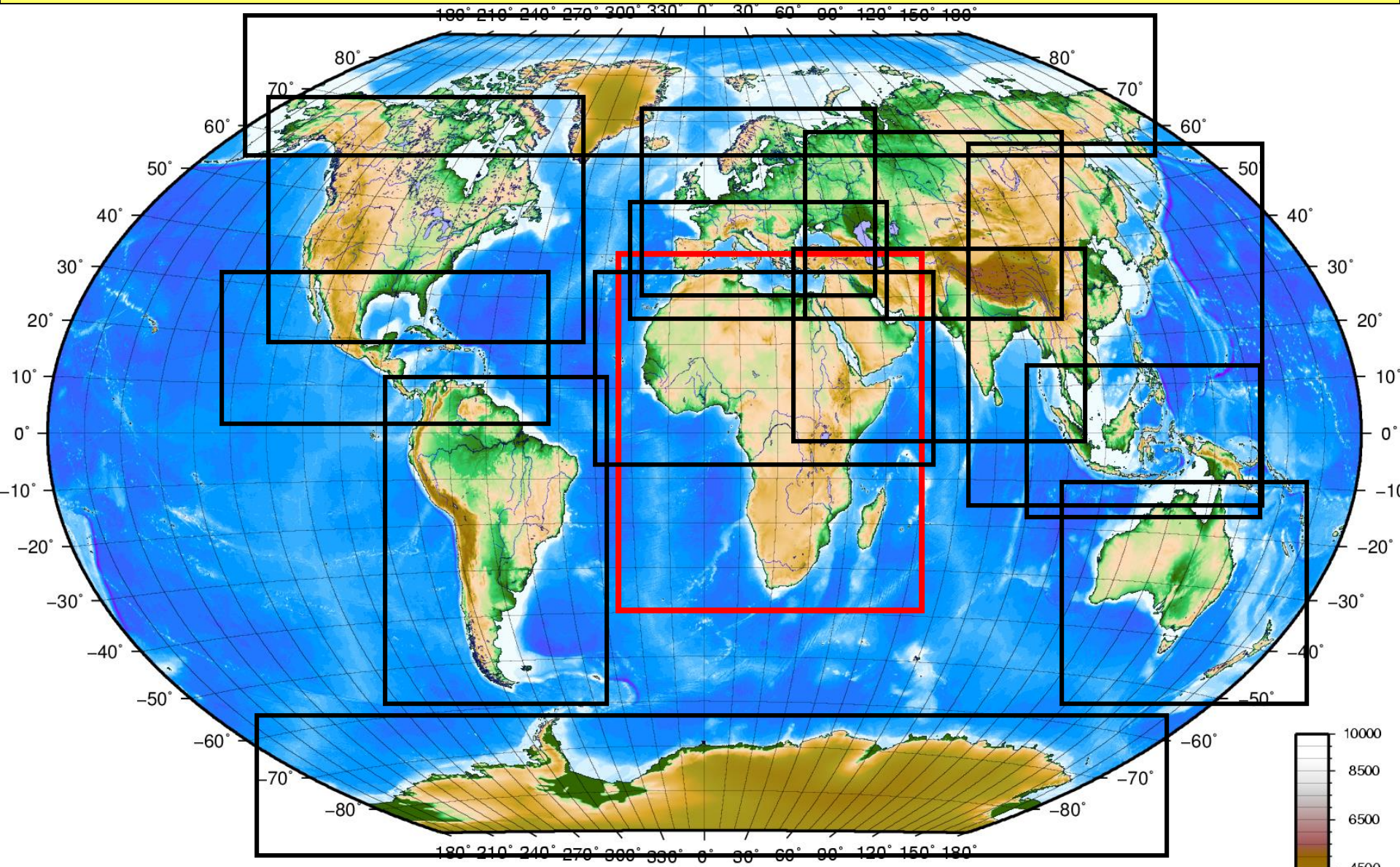
Evaluation of present day  
GCM-driven climate runs

Scenarios (1951-2100)  
RCP4.5, RCP8.5

Regional Analysis  
Regional Databanks

Multiple driving AOGCMs

# CORDEX domains



# Ensembles of projections are available for most domains

## CORDEX-S. ASIA

### CORDEX-South Asia Multi Models Output

Historical (1950 - 2005) | Evaluation Run (1989 - 2009) | RCP 4.5

Variable name (Monthly and Daily)	SMHI-RCA4	IITM-RegCM4-GFDL	IITM-RegCM4-LMDZ	COSMO-CLM	IITM-LMDZ
Institute's / Data Providers	Rosby Centre, SMHI	CCCR-IITM, Pune	CCCR-IITM, Pune	Goethe Inst - Univ. of Frankfurt	CCCR-IITM, Pune
Rainfall (pr)	✓	✓	✓	✓	✓
Surface Air Temperature (tas)	✓	✓	✓	✓	✓
Surface Air Temp. Maximum (tasmax)	✓	✓	✓	--	✓
Surface Air Temp. Minimum (tasmin)	✓	✓	✓	--	✓
Sea-level Pressure (psl)	✓	✓	✓	--	✓
Surface Specific Humidity (huss)	✓	✓	✓	--	✓
Surface Zonal Wind (uas)	✓	✓	✓	--	✓
Surface Meridional Wind (vas)	✓	✓	✓	--	✓
Downward Shortwave Radiation (zswd)	--	✓	✓	--	--

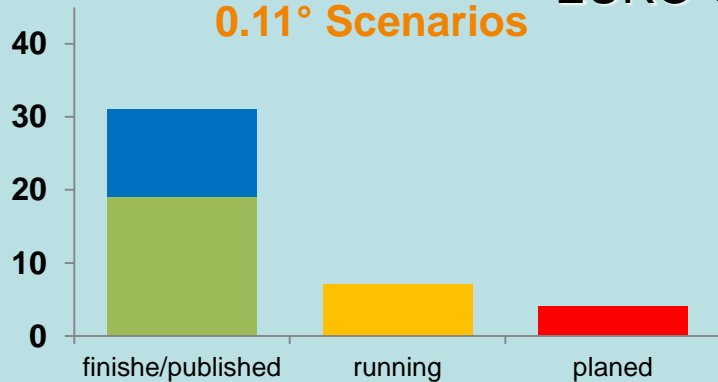
To download the data please [click here](#)  
 Regridding script example, click here to [download](#) | [script](#)

## CORDEX-AFRICA

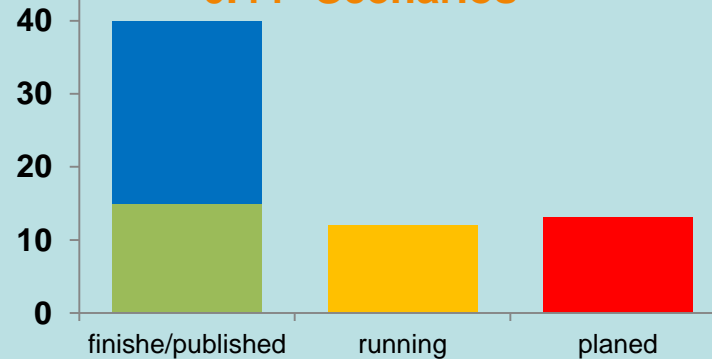
RCP4.5	RCP4.5 Models								Sum	RCP8.5	RCP8.5 Models								Sum								
	BCCR-greenWRF	CCMa-CamRCM4	CLMcom-CCLM4-8	CNRM-ALADIN	CSC-REMO	DMI-HIRHAM5	ICTP-RegCM4	KNMI-RACMO2.2			MOHC-GA3RCM	SMHI-RCA4	UCLM-PROMES	ULL-WRF311	UCAN-WRF34	UQAM-CRCM	BCCR-greenWRF	CCMa-CamRCM4		CLMcom-CCLM4-8	CNRM-ALADIN	CSC-REMO	DMI-HIRHAM5	ICTP-RegCM4	KNMI-RACMO2.2	MOHC-GA3RCM	SMHI-RCA4
CanESM2	✓	✓	✓	✓	✓	✓	✓	✓	3	CanESM2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	2						
CNRM-CM5	✓	✓	✓	✓	✓	✓	✓	✓	3	CNRM-CM5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	3						
NorESM1-M	✓	✓	✓	✓	✓	✓	✓	✓	1	NorESM1-M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	1						
EC-EARTH (r1)	✓	✓	✓	✓	✓	✓	✓	✓	1	EC-EARTH (r1)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	1						
EC-EARTH (r3)	✓	✓	✓	✓	✓	✓	✓	✓	1	EC-EARTH (r3)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	1						
EC-EARTH (r12)	✓	✓	✓	✓	✓	✓	✓	✓	3	EC-EARTH (r12)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	3						
HadGEM2-ES	✓	✓	✓	✓	✓	✓	✓	✓	3	HadGEM2-ES	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	3						
MIROC5	✓	✓	✓	✓	✓	✓	✓	✓	1	MIROC5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	1						
MPI-ESM-LR	✓	✓	✓	✓	✓	✓	✓	✓	4	MPI-ESM-LR	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	4						
GFDL-ESM2M	✓	✓	✓	✓	✓	✓	✓	✓	1	GFDL-ESM2M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	1						
HADCM3	✓	✓	✓	✓	✓	✓	✓	✓	1	HADCM3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	1						
sum	1	4	1	2	1	1	1	1	8	sum	1	4	1	2	1	2	1	1	1	8							

## EURO-CORDEX

0.11° Scenarios



0.44° Scenarios

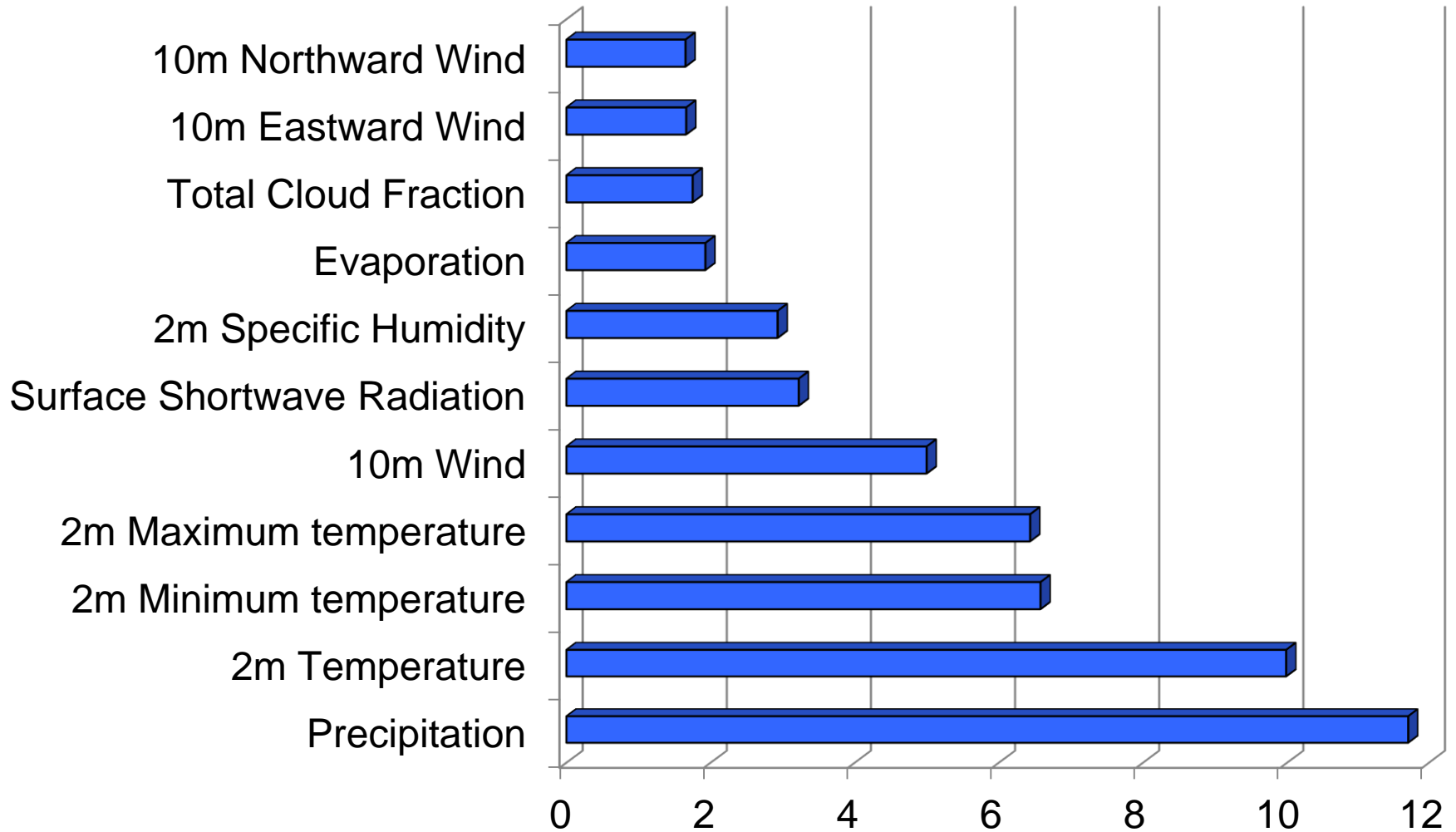


# CORDEX Archiving

- A common CORDEX standard for archiving RCM output has been established
- Main focus on Earth System Grid Federation (ESGF), 3 Regional Data Portal still exist but moving to ESGF
- **CORDEX-ESGF** is in operation since mid-Sep 2013 (1436 users as of 12Apr 2015)
- Complexity of post-processing of RCM output to the CORDEX format was strongly underestimated, still a bottleneck for many CORDEX RCM groups
- A common tool for post-processing, such as Climate Output Model Rewriter (CMOR) in CMIP5, is not available but work on it is ongoing



# Most downloaded variables



Percentage of total CORDEX downloads

# Emerging scientific challenges

## ✧ **Added value**

Internal variability & added value as functions of scale; Very high resolution modeling; Bias correction uncertainties and consistency

## ✧ **Human element**

Coupling of regional climate and urban development (e.g. coastal megacities); Land use change; Aerosol effects.

## ✧ **Coordination of regional coupled modelling**

Ocean-ice-atmosphere; Lakes; Dynamic land surface; Natural fires; Atmospheric chemistry; Carbon cycle; Aerosols; Marine biogeochemistry

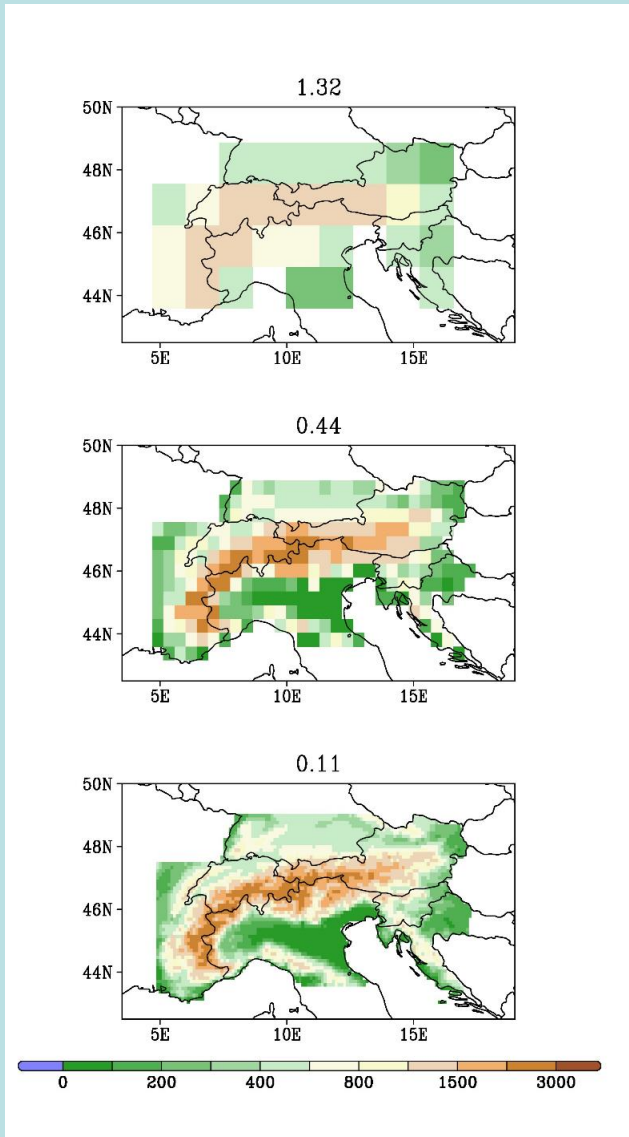
## ✧ **Precipitation**

Extremes; Convective systems; Coastal storm systems; MJO/Monsoon

## ✧ **Local wind systems**

Wind storms; Strong regional winds; Wind energy

# A study of added value using Euro-CORDEX and Med-CORDEX data



Horizontal resolutions: 1.32°, 0.44° and 0.11°

## GCMs :

MPI-ES-MR

EC-EARTH

CNRM-CM5

HadGEM-ES

## RCMs:

CCLM

RACMO

ALADIN

RegCM4.3

RCA4

Reference period: 1975-2004

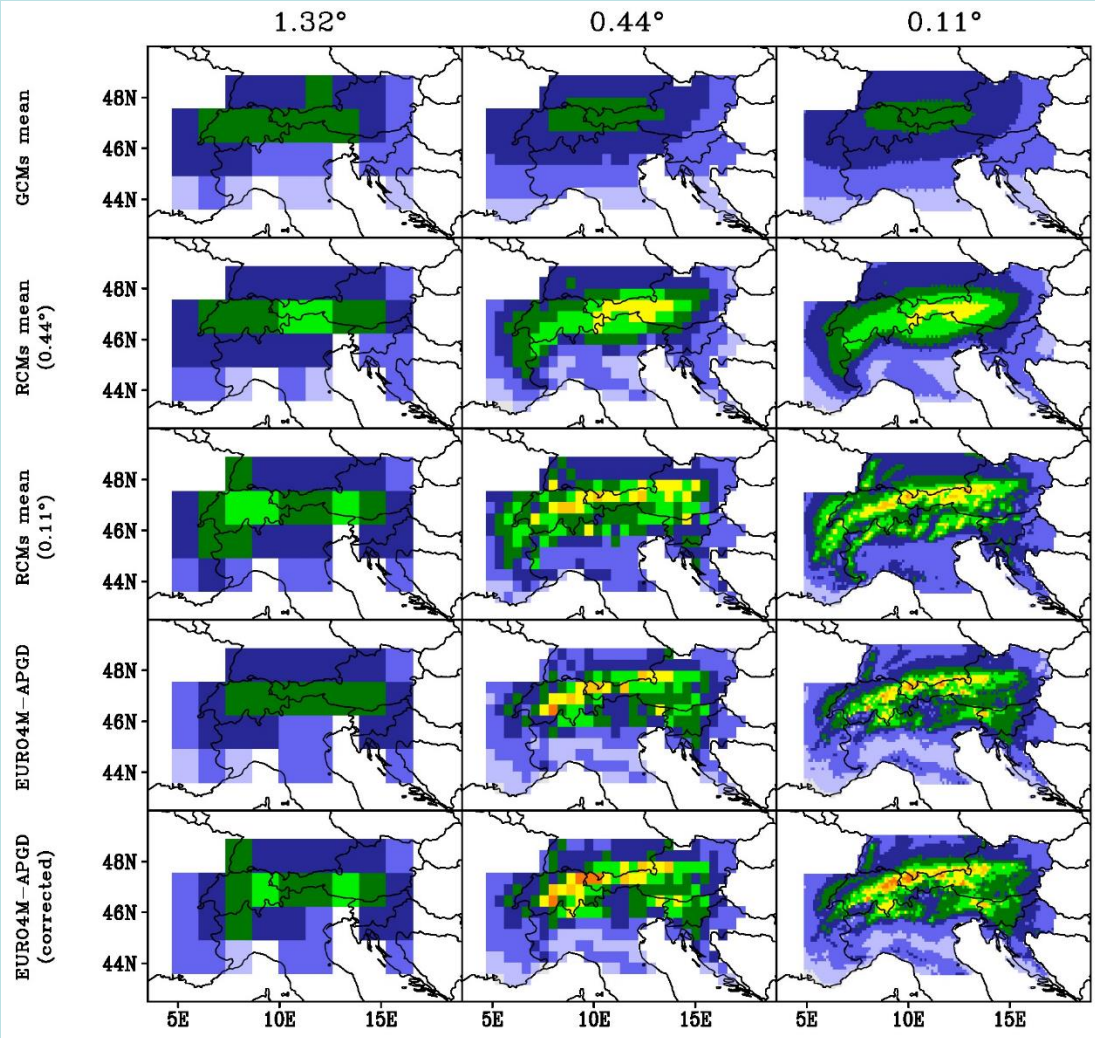
Future period: 2070-2099

Observational data: EURO4M-APGD  
(Isotta et al., 2014)

Torma et al. (2015) JGR

# Added value: Simulation of spatial precipitation patterns

JJA



Higher resolution



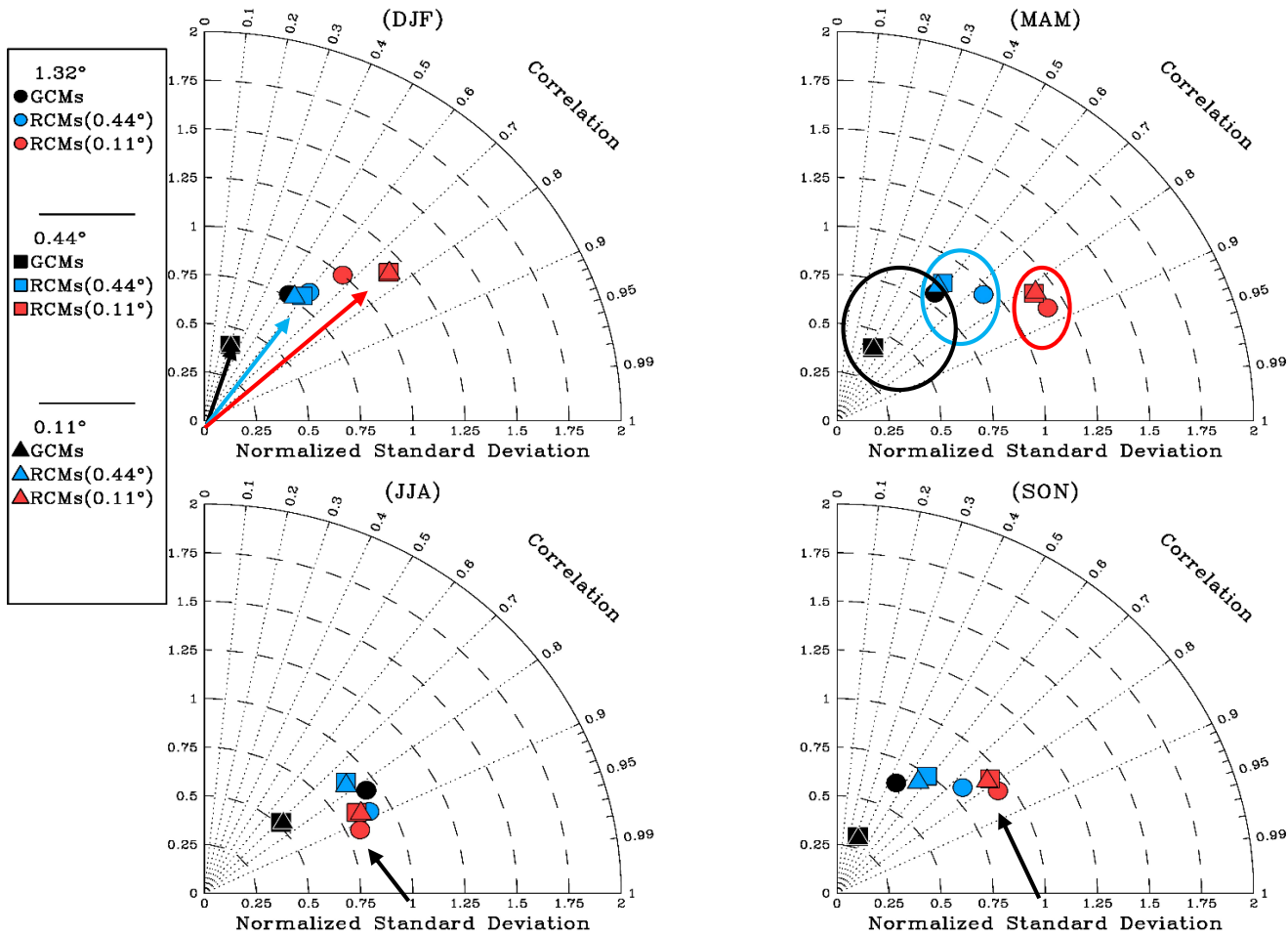
Increasing details  
in precipitation  
spatial distribution



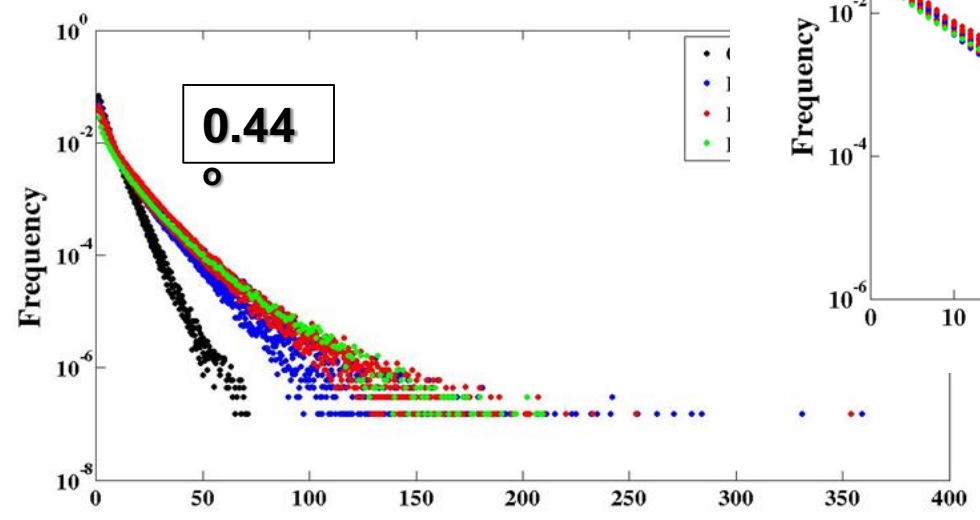
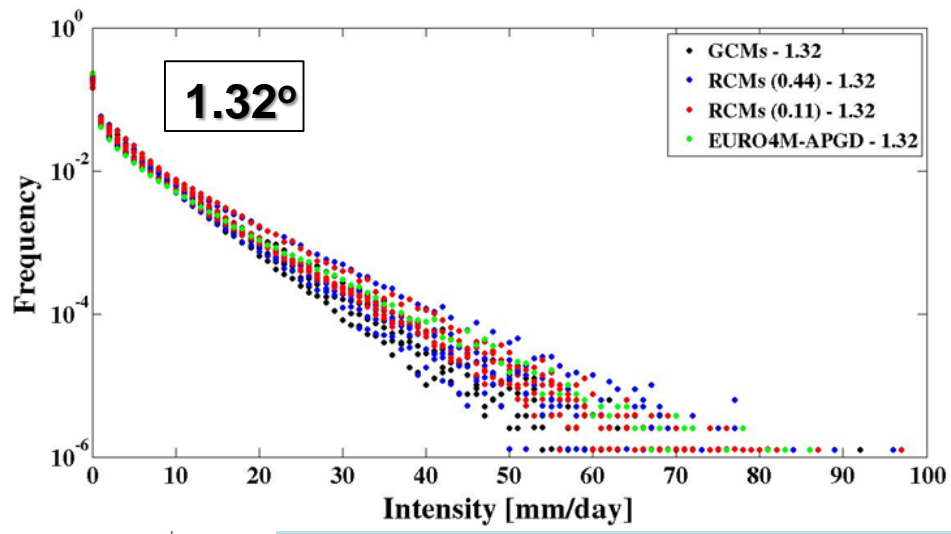
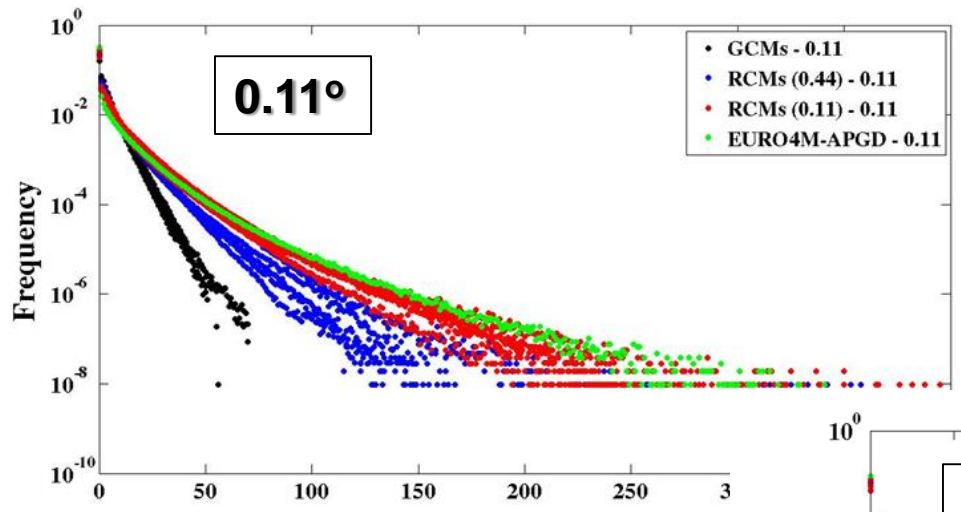
Fine scale AV

# Metric of added value: Taylor diagram

1976-2005



# Added value: Simulation of daily precipitation intensity PDF

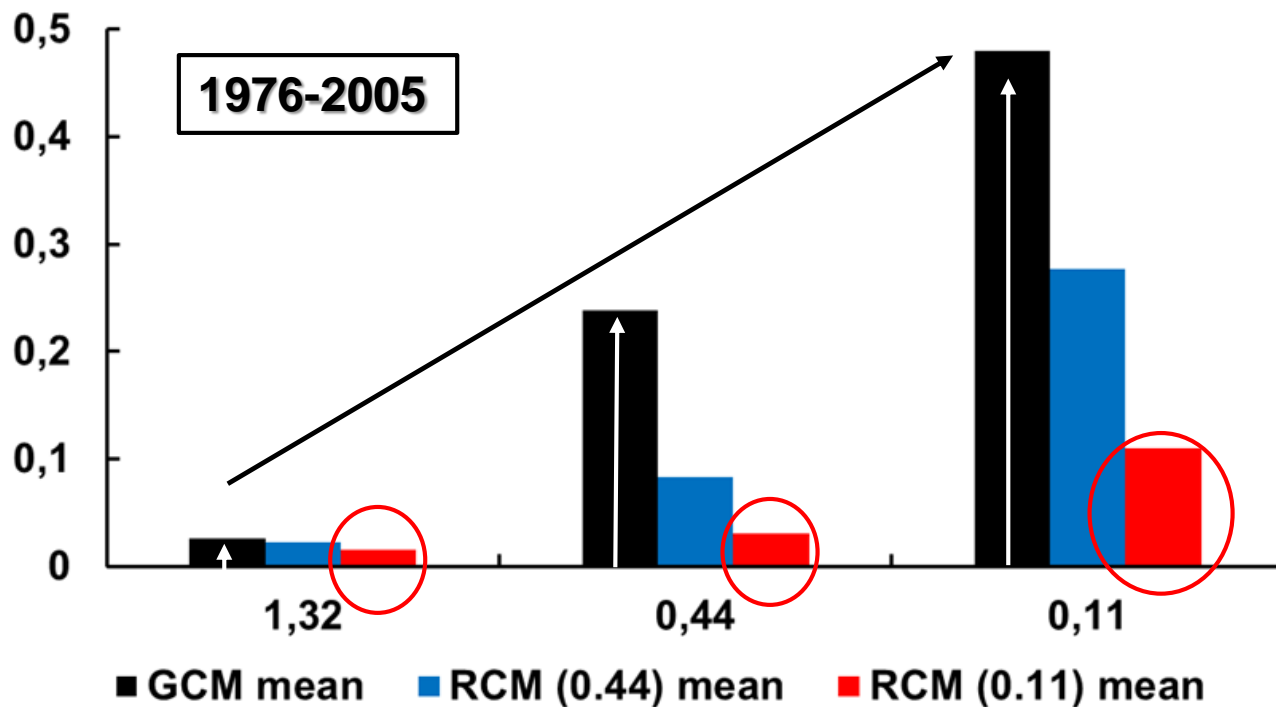
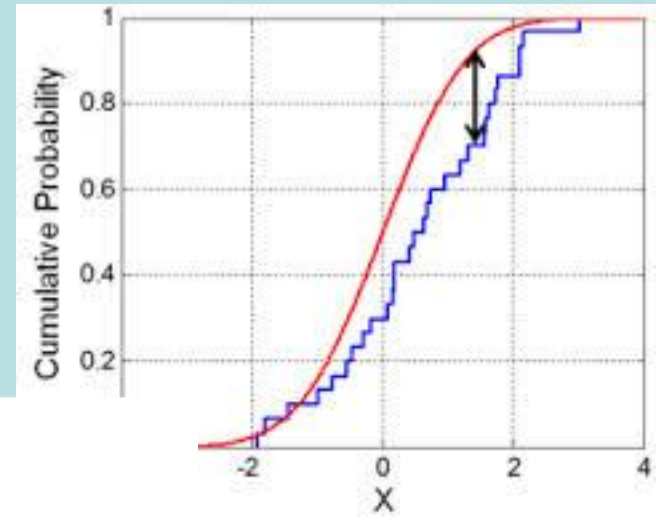


RCMs are always closer to OBS

# Metric of added value: Kolmogorov-Smirnov (KS) distance

Kolmogorov-Smirnov distance

$$d_{KS}(F, G) = \sup_{t \in \mathbb{R}} |F(t) - G(t)|$$



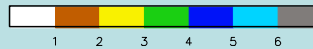
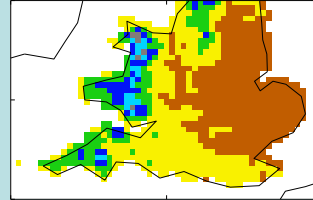
# Cloud resolving modeling

Daily precipitation  
(1990-2003)

Mean precip

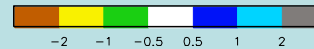
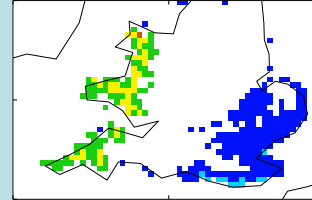
Obs

Rain gauge



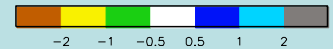
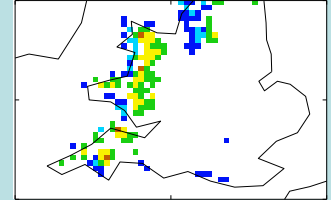
Bias

1.5km-gauge



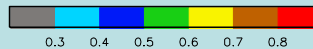
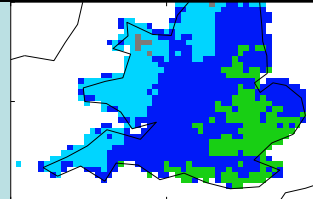
Bias

12km-gauge

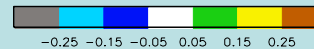
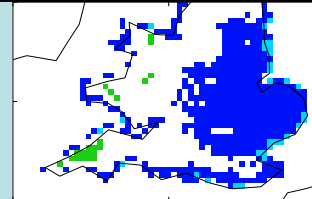


Dry day  
occurrence

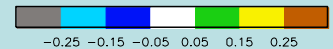
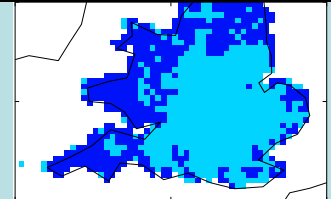
Rain gauge



1.5km-gauge



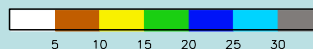
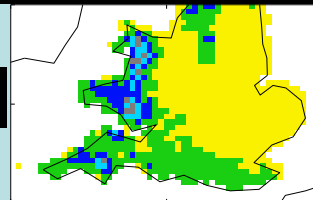
12km-gauge



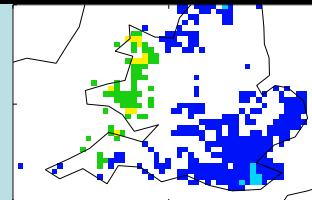
Courtesy of E. Kendon  
UKMO

Heavy precip

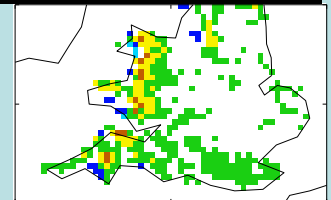
Rain gauge



1.5km-gauge

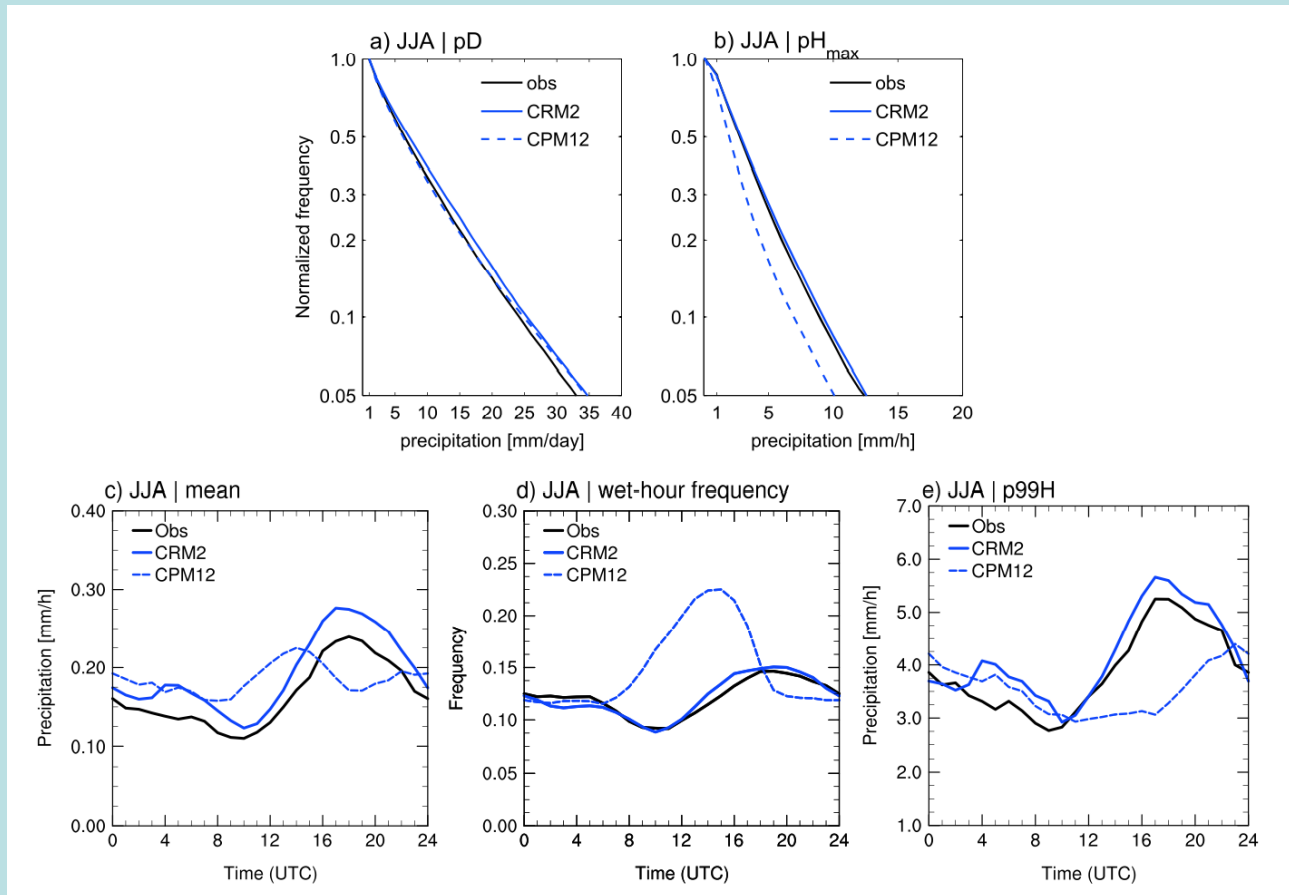


12km-gauge





# Cloud resolving modeling



Improvement of the diurnal cycle of precipitation  
**From Ban et al. GRL (2015)**

# Development of coupled regional models (Med-CORDEX)

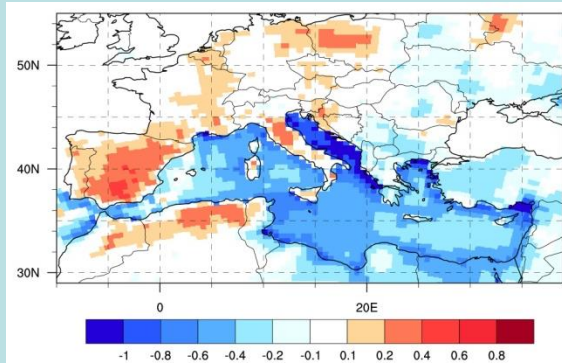
Climate change evolution (1950-2100) for the Mediterranean comparing ARCM and fully coupled RCSM

Scenario: CNRM-CM5, RCP8.5

Model: ALADIN52, CNRM-RCSM4, 50km

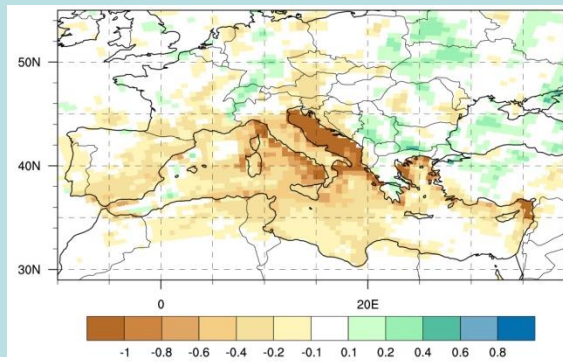
Period: 2071-2100 versus 1976-2005

$\Delta T_{2m}(RCSM) - \Delta T_{2m}(RCM)$

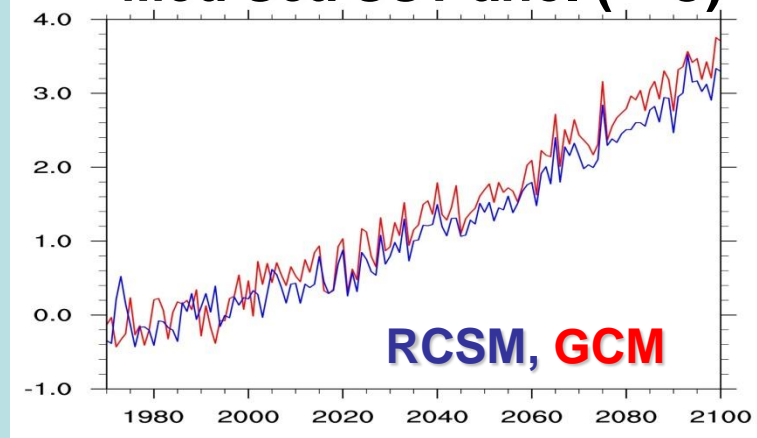


$\Delta Prec(RCSM) - \Delta Prec(RCM)$

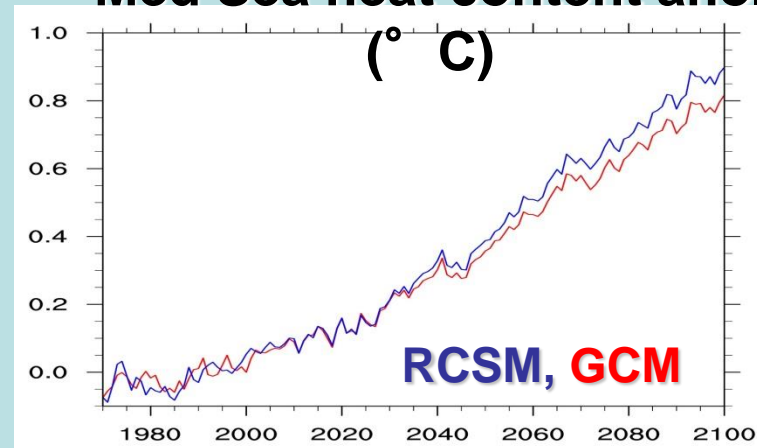
JJA



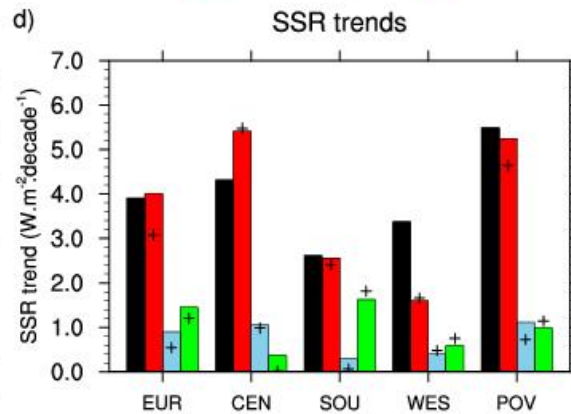
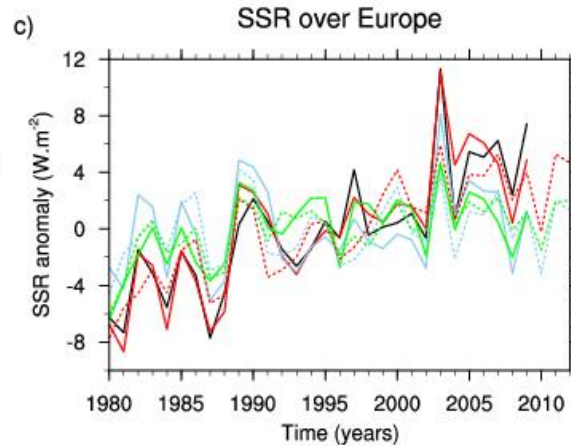
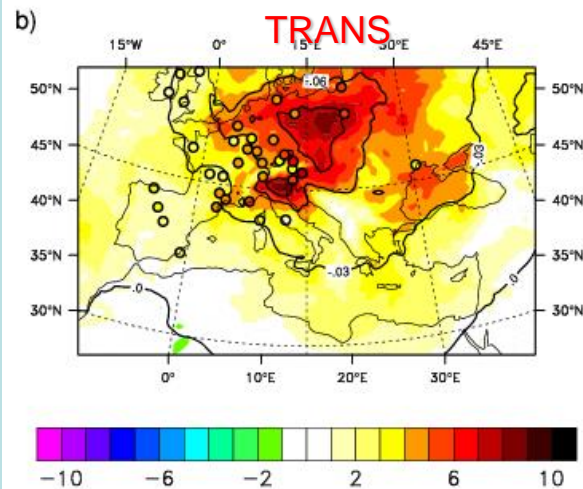
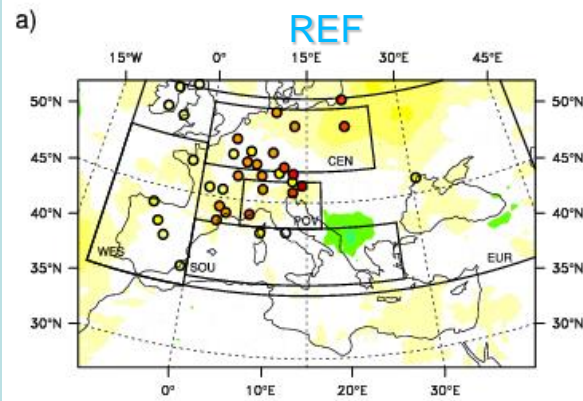
Med Sea SST ano. ( $^{\circ}$  C)



Med Sea heat content ano.



# Effects of aerosols on European brightening (Med-CORDEX)



=> Stronger brightening in **TRANS** than in **REF**, both in clear-sky and all-sky conditions

=> Comparison with ground-based homogenized measurements : (GEBA, *Sanchez-Lorenzo et al., 2013*)

- Best agreement found with **TRANS**, **REF** underestimate the brightening

- Spatial correlation increased from 0.10 (**REF**) to 0.42 (**TRANS**)

- 81 % of the brightening due to aerosol

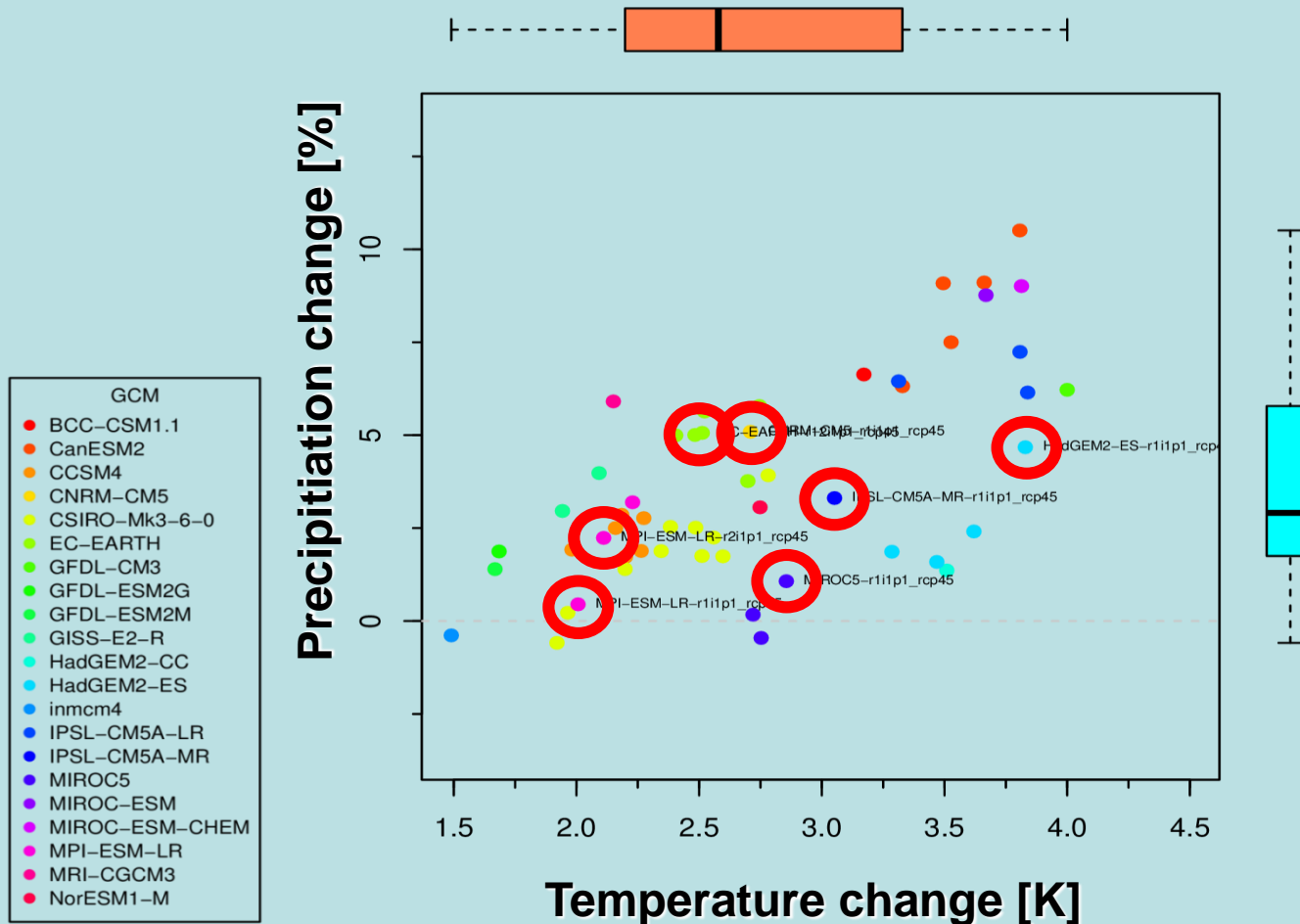
- **ERA-Interim** also underestimates the brightening

*Downward surface solar radiation (SSR) trend (all-sky, W/m²/decade)*

Courtesy of P. Nabat, MétéoFrance

# There are still large uncertainties in regional projections (-> Copernicus)

EUR-11 RCP4.5 GCMs  
2071-2100 against 1961-1990  
region: CORDEX.Europe, season: annual



# The “Distillation” Paradigm

Regional climate information is available from multiple sources (GCMs, RCDs, “post-processing”) and needs to be “distilled” to assess its value

## Sparsely populated matrix

Choice of GCM-RCD-Scenario  
Matrix filling (Pattern Scaling)

## VIA relevance

Higher order statistics  
Fine spatial/temporal scales  
Non-conventional variables



## Credibility

Multiple lines of evidence  
Process understanding  
Seamless skill  
Inter-model/method agreement  
Observed trends

## Systematic model errors

Suitable metrics  
Effect on change signal  
Bias correction  
Model weighting/exclusion

## Uncertainty characterization

Intermodel range/standard deviation  
PDFs

# CORDEX Flagship Pilot Studies



Focus on smaller regions  
to address specific  
science  
and VIA issues

Effects of regional forcings  
Land-use change  
Urbanization  
Aerosols

Intercomparison of different downscaling techniques  
(e.g. RCM, ESD)

Modeling (Added Value) at multiple scales, down to cloud resolving.  
Model development

Availability/production of high quality, high resolution, multiple variable **observations**

Interactions with other WCRP projects  
(e.g. GEWEX)

Development of coupled Regional Earth System Models (RESMs)

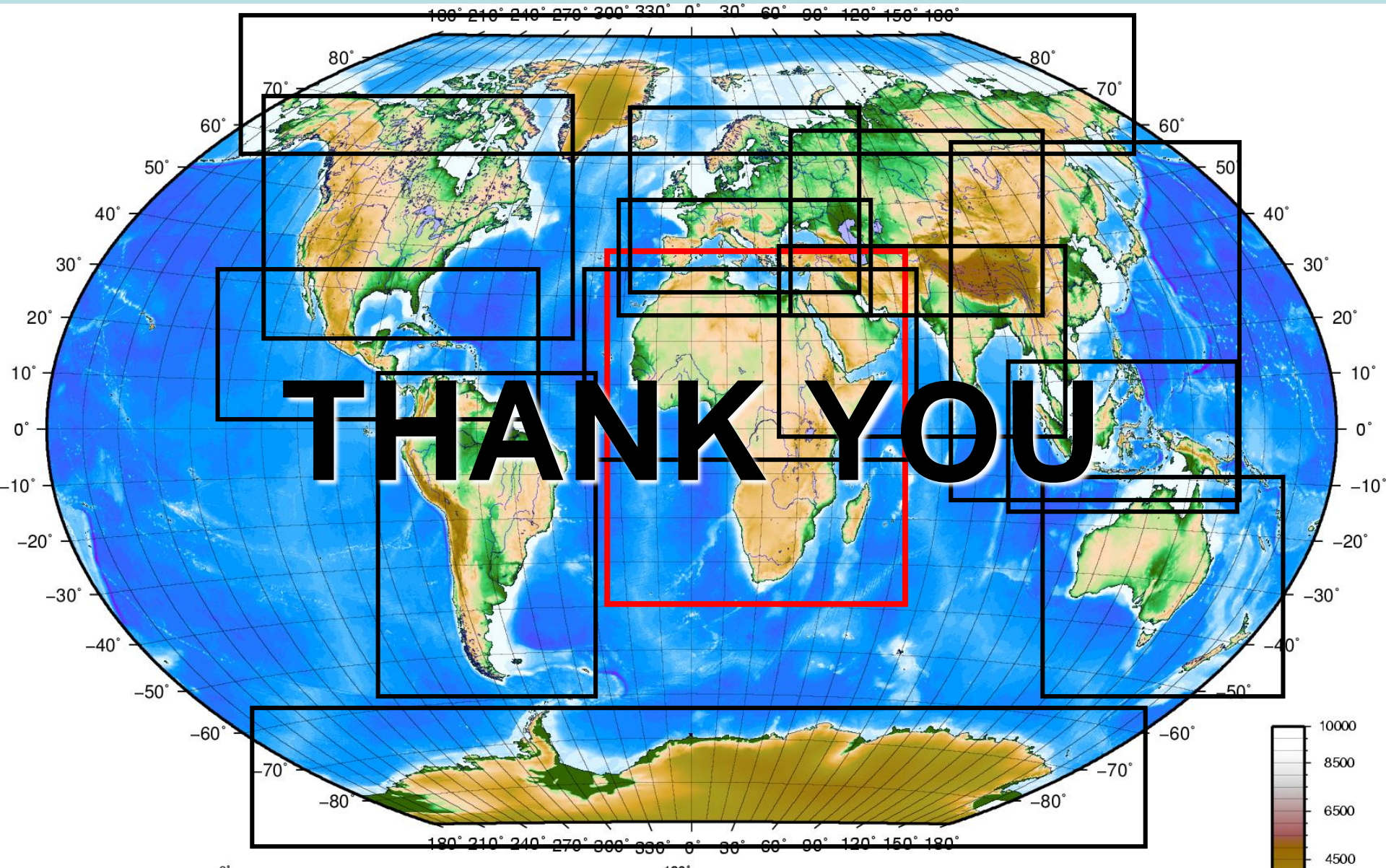
Production of large ensembles for **uncertainty** characterization

Relevance for **VIA** and **adaptation/policy** applications  
Distillation of actionable information

Study of phenomena relevant for regional climate and impacts through targeted experiments (e.g. **MCS, TC, extremes, monsoon**)

# Summary plans for CORDEX Phase II

- Flexible resolution for standard domains
  - dx = 12.5 km, 25 km, 50 km (higher for some regions?)
- CMIP6 (+ CMIP5?) driving GCMs
  - RCP8.5, RCP4.5, RCP2.6
- Flagship Pilot Studies
  - Proposals to be elicited from the regional communities
  - Procedure/criteria for endorsement of FPS to be designed
  - Consistent framework across FPSs
- Better integration of statistical downscaling
- ESGF framework for data storage and provision
- More emphasis on process-based model assessment and development
- **Third CORDEX Conference, Stockholm, 17-20 May 2016**



**THANK YOU**