Med-CORDEX:

a first coordinated inter-comparison of high-resolution and fully coupled regional climate models for the Mediterranean

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and the Med-CORDEX team

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WCRP CORDEX

HyMeX
HYdrological cycle in Mediterranean EXperiment

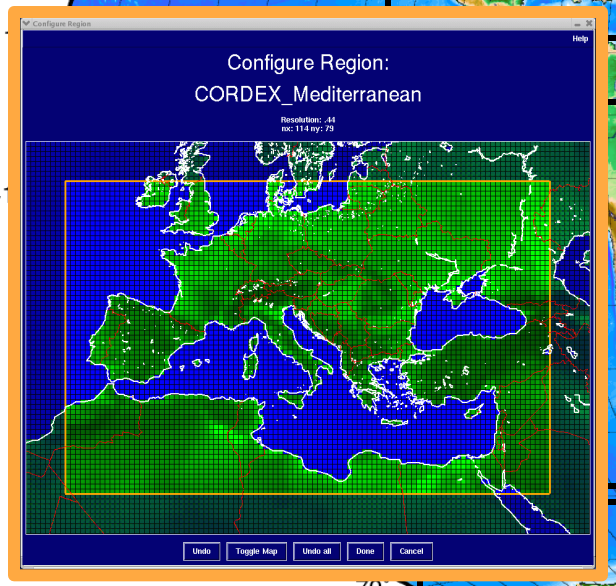
MedCLIVAR

ICTP The Abdus Salam International Centre for Theoretical Physics

IAEA

Med-CORDEX: one of the 12 CORDEX initial domains at 0.44° (50 km)

HyMeX
MedCLIVAR
FP6-CIRCE
FP7-CLIMRUN



Med-CORDEX:
motivations, scientific goals, modelling framework

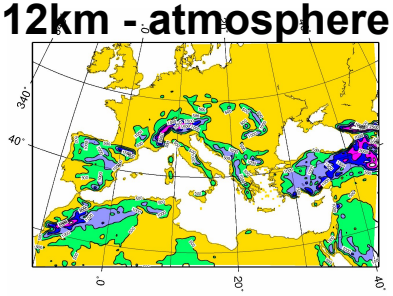
- Mediterranean: **perfect test case for regional climate modelling** and a well-established **climate change hot-spot** with GCM climate change agreement
- Need for **very high-resolution RCM** and for **air-sea-land high-frequency coupling**
- Need for a **reference modelling framework** for programs dedicated to the study of the Mediterranean climate (incl. **Med-CLIVAR** and **HyMeX)**

- Better **description and understanding** of the **full Mediterranean water cycle**, its feedbacks, its variability and trend for **each component of the climate system**
- Study the **variability (all scales) of the high-impact Mediterranean phenomena**: *cyclones, strong winds, intense air-sea exchanges, heavy precipitation events, flash floods, droughts, dense water formation, thermal heat content and sea level, …*
- Study the **future evolution** of the Mediterranean climate during the 21st century

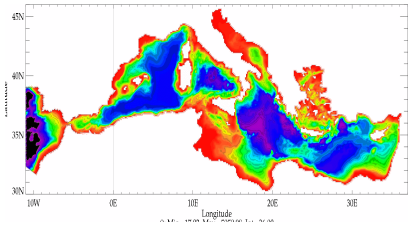
- Med-CORDEX is **one of the official CORDEX domains**
- Develop **very-high resolution RCMs** (up to 10km) and test their **added-value**
- Design, develop and evaluate a new generation of climate models: the **fully-coupled Regional Climate System Models**
- Develop a **coordinated set of regional climate simulations (past and future)** for all the physical components of the Mediterranean climate system

Med-CORDEX regional climate modelling exercise

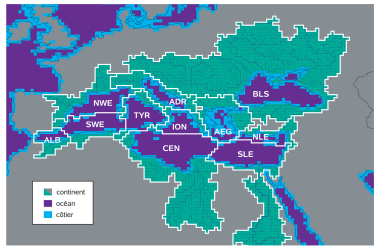
12km - atmosphere



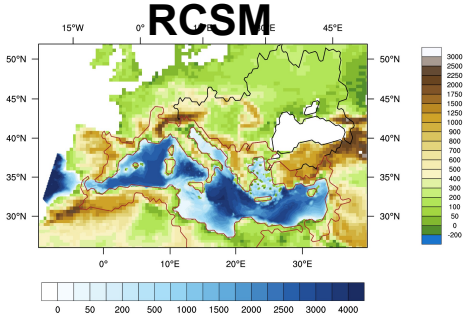
10km - ocean

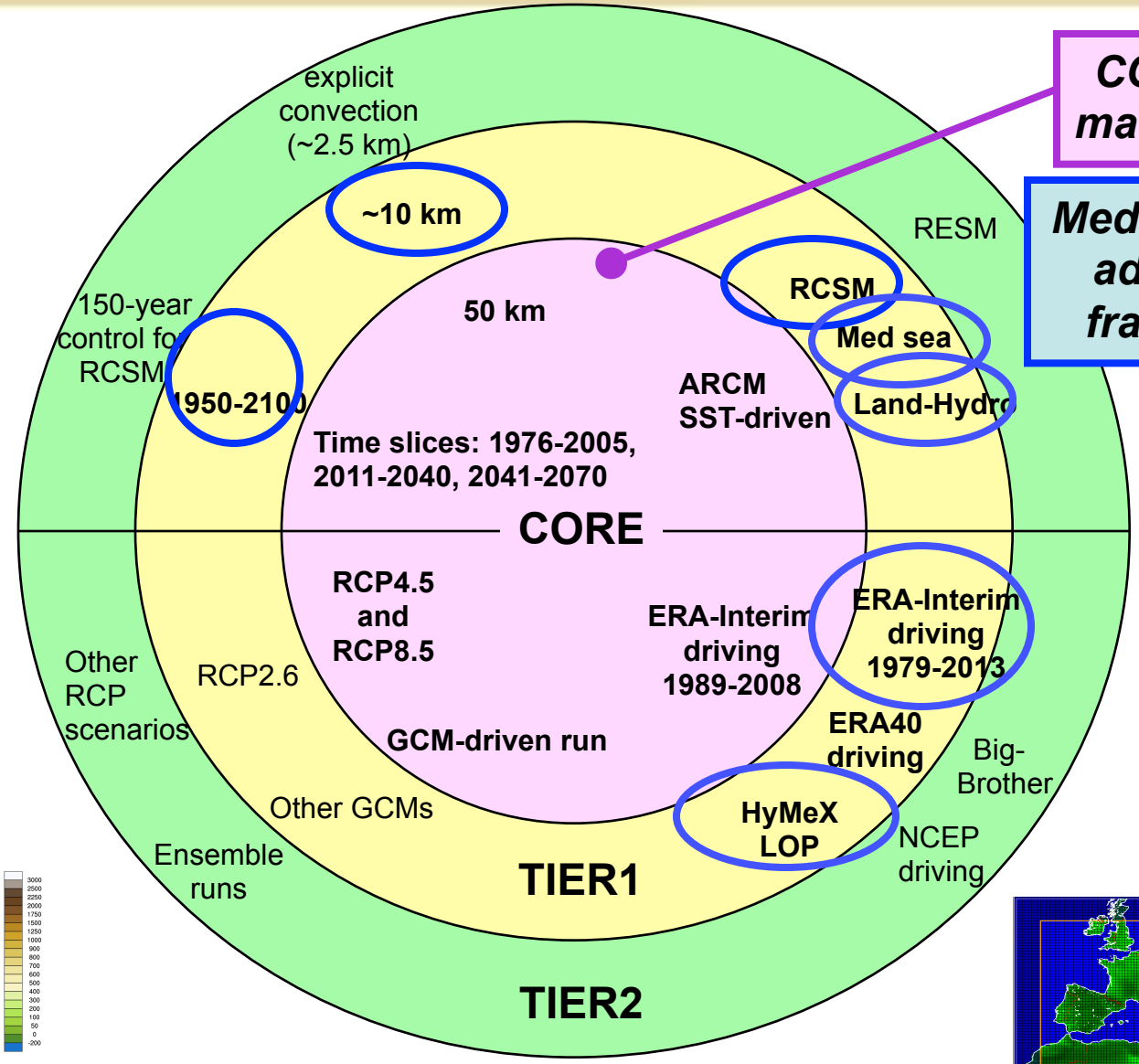


50km – river



RCSM





CORDEX mandatory

Med-CORDEX additional framework

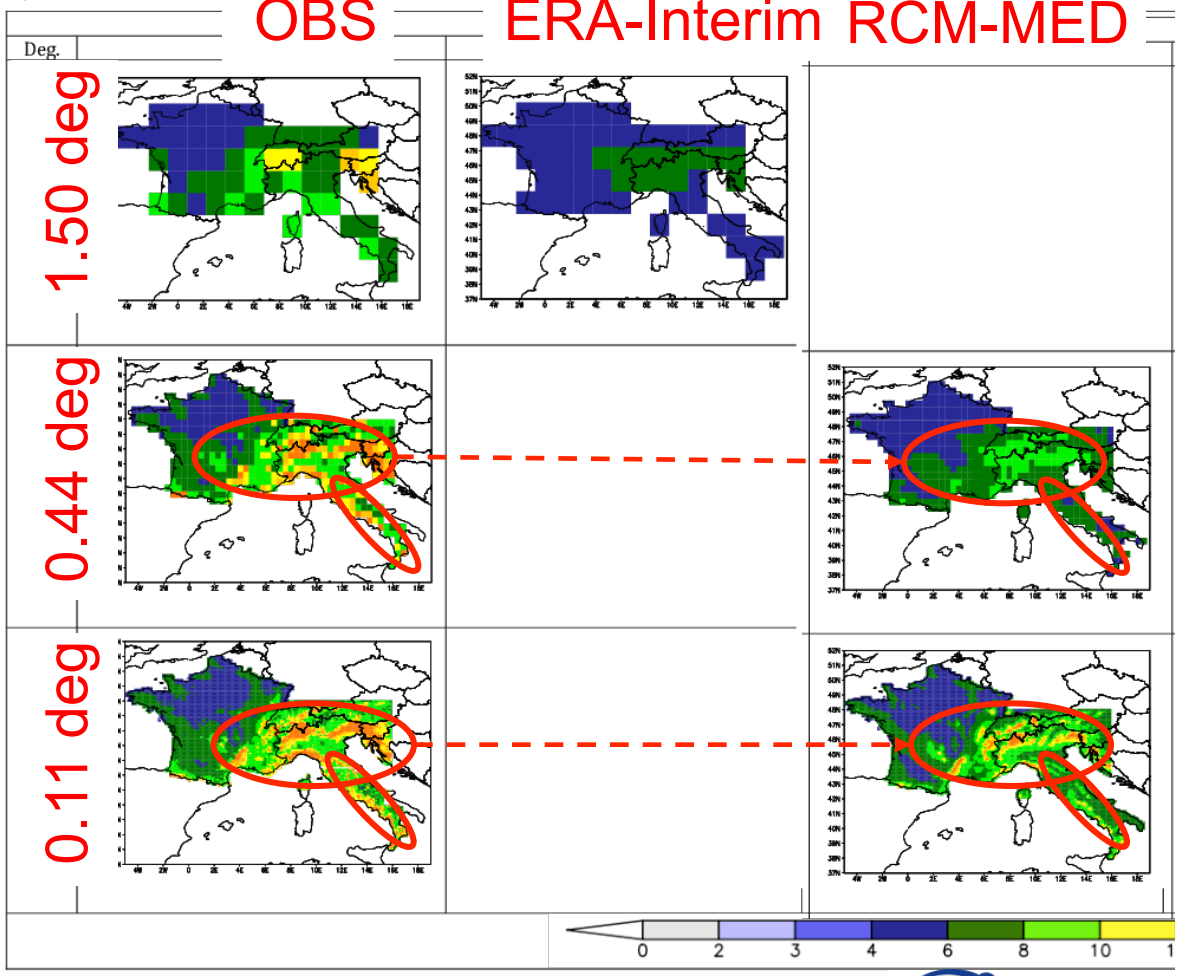
Med-CORDEX community and achievments

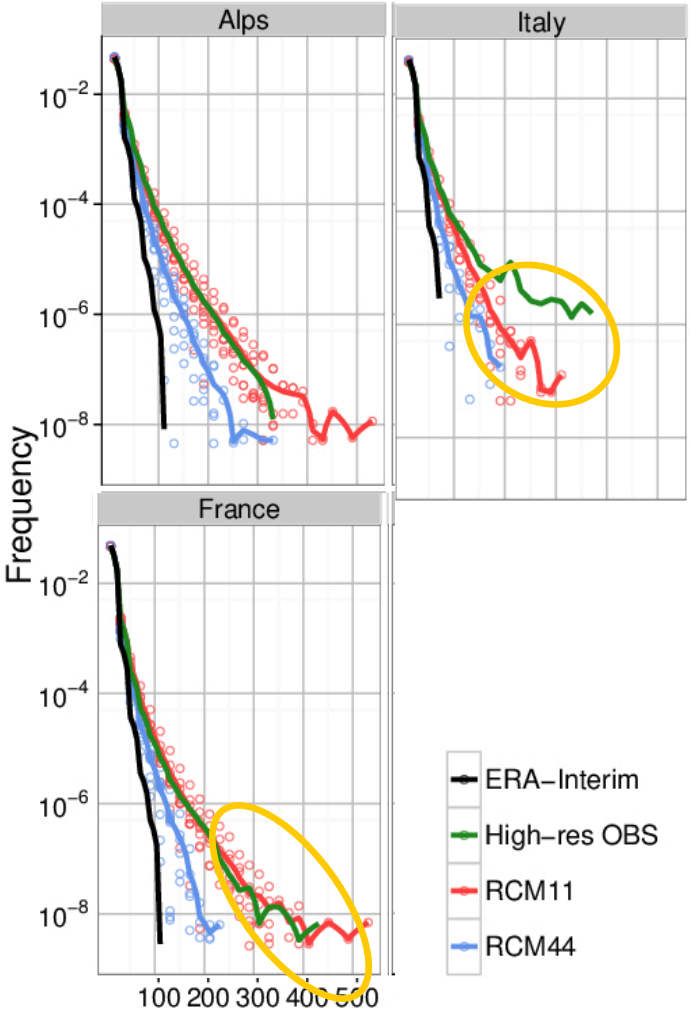
- People and models:
  - Active since 2009, today 70 members in the Med-CORDEX team
  - **23 different modelling groups** (ENEA, CNRM, LMD, MPI, IPSL, UCLM, ENSTA, MERCATOR, INSTM, GUF, ICTP, CMCC, Puertos de l'Estado, Univ. of Athens, Univ. Belgrade, UPM, KIT, ITU, UAH, Eotvos Lorand U, IC3, BSC, JRC) from 9 countries (France, Italy, Spain, Serbia, Greece, Turkey, Tunisia, Germany, Hungary) in Europe, Middle-East and North-Africa
  - 12 atmosphere RCMs, 10 ocean models, 4 surface models and **12 coupled RCSMs**
  - Historical and scenario runs use 6 different GCMs from CMIP5
- Archive strategy:
  - **An open and centralized database** hosted at ENEA : **www.medcordex.eu**
  - Storage, format, variable specifications: CORDEX + extension for ocean/river variables
  - 90 data users, 115.000 files, 3.1 To (upload) and **120.000 files and 5.9 To (download)**
- Reference, Communication and Publications:
  - Web site: www.medcordex.eu / emailing list: medcordex@hymex.org
  - **Steering committee:** B. Ahrens (GUF), E. Coppola (ICTP), G. Jordà (IMEDEA), G. Sannino (ENEA), S. Somot (CNRM)
  - A reference paper: Ruti et al. (BAMS,2016) and 42 published articles since 2011
  - Med-CORDEX meetings: Toulouse 2009, 2012, Palaiseau 2014 + HyMeX workshops
  - **A special issue in Climate Dynamics**.

Results for mean daily precipitation intensity and PDF

Models: ALADIN5.2, RegCM4.4 CCLM4-8-18, PROMES
OBS: SAFRAN, EURO4M-APGD , CETEMPS gridded dataset

Analysis period: 1989-2008; (Italy)





Fantini A., et al., 2016. Climate Dynamics

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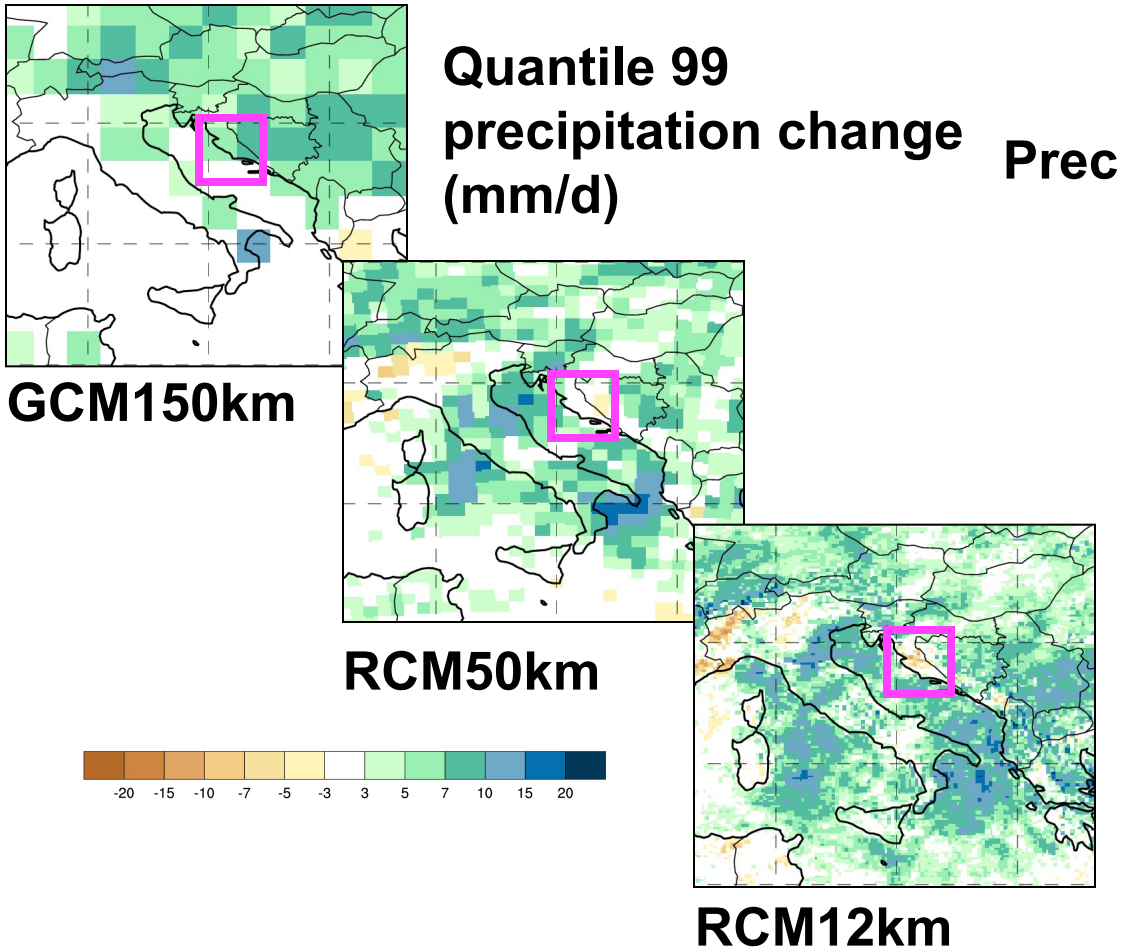
Heavy Precipitation Events:
climate change scenarios and 12-km RCM added-value

Climate change evolution (1950-2100, SON, mm/d) for mountain areas

Scenario: GCM CNRM-CM5 (150km), RCP8.5 *(2071-2100 vs 1976-2005)*

Model: RCM ALADIN, 50km and 12km

Quantile 99 precipitation change (mm/d)



Precip. quantile-quantile plot (mm/d), Croatian Mountain

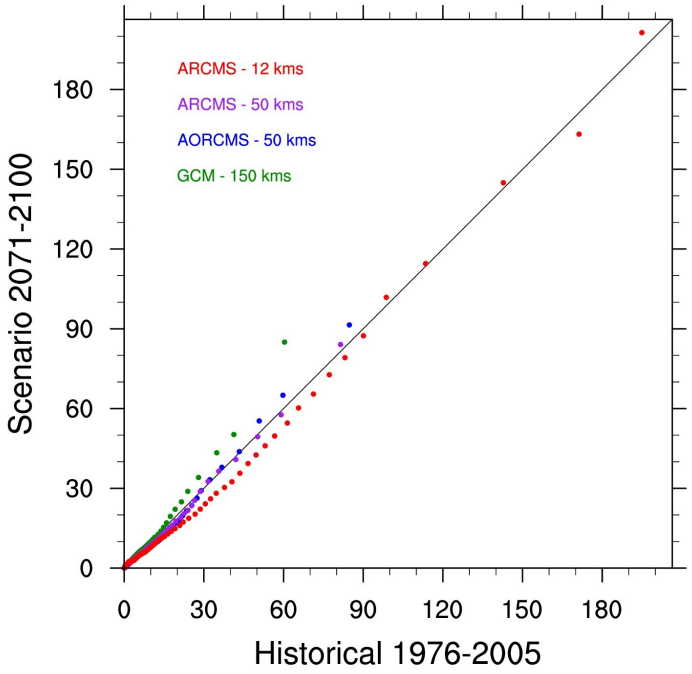


Fig: C. Dubois, CNRM

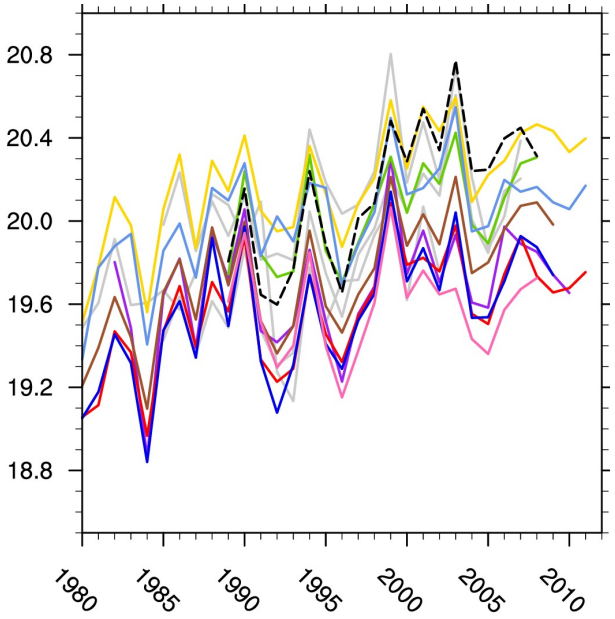
Mediterranean SST:
RCSM evaluation at various scales

Interannual variability hindcast (1980-2010) as simulated by an ensemble of fully-coupled Regional Climate System Model (RCSM) in Med-CORDEX

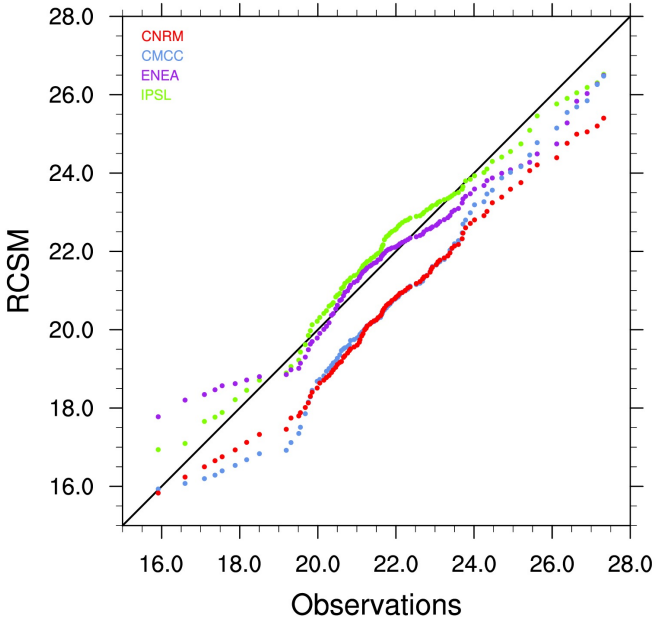
Models: RCSM from CNRM, LMD, INSTM, GUF, ENEA, UniBel, CMCC, IPSL

Obs: EN4, Marullo OISST, Rixen/MedAtlas-II, ERAInt SST analysis and the LION buoy

Interannual time series (°C, Med Sea average)



Daily quantile-quantile plot (JJA, °C, 2002-2008)



Sub-daily time series (July 2002, °C)

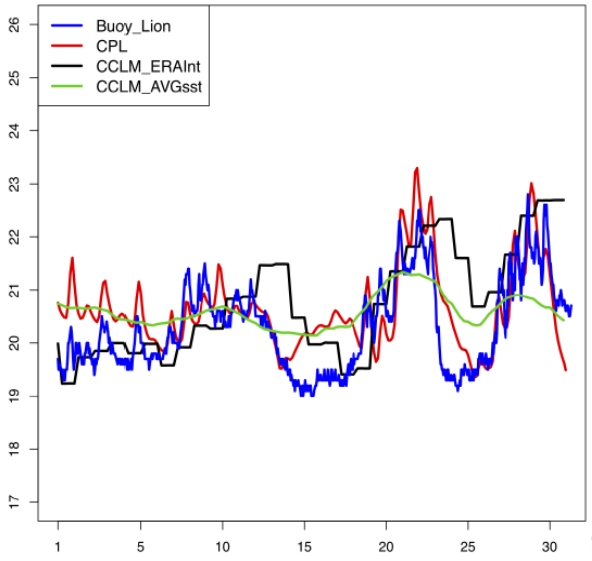


Fig: Ruti et al. BAMS, C. Dubois, CNRM ; B. Ahrens GUF

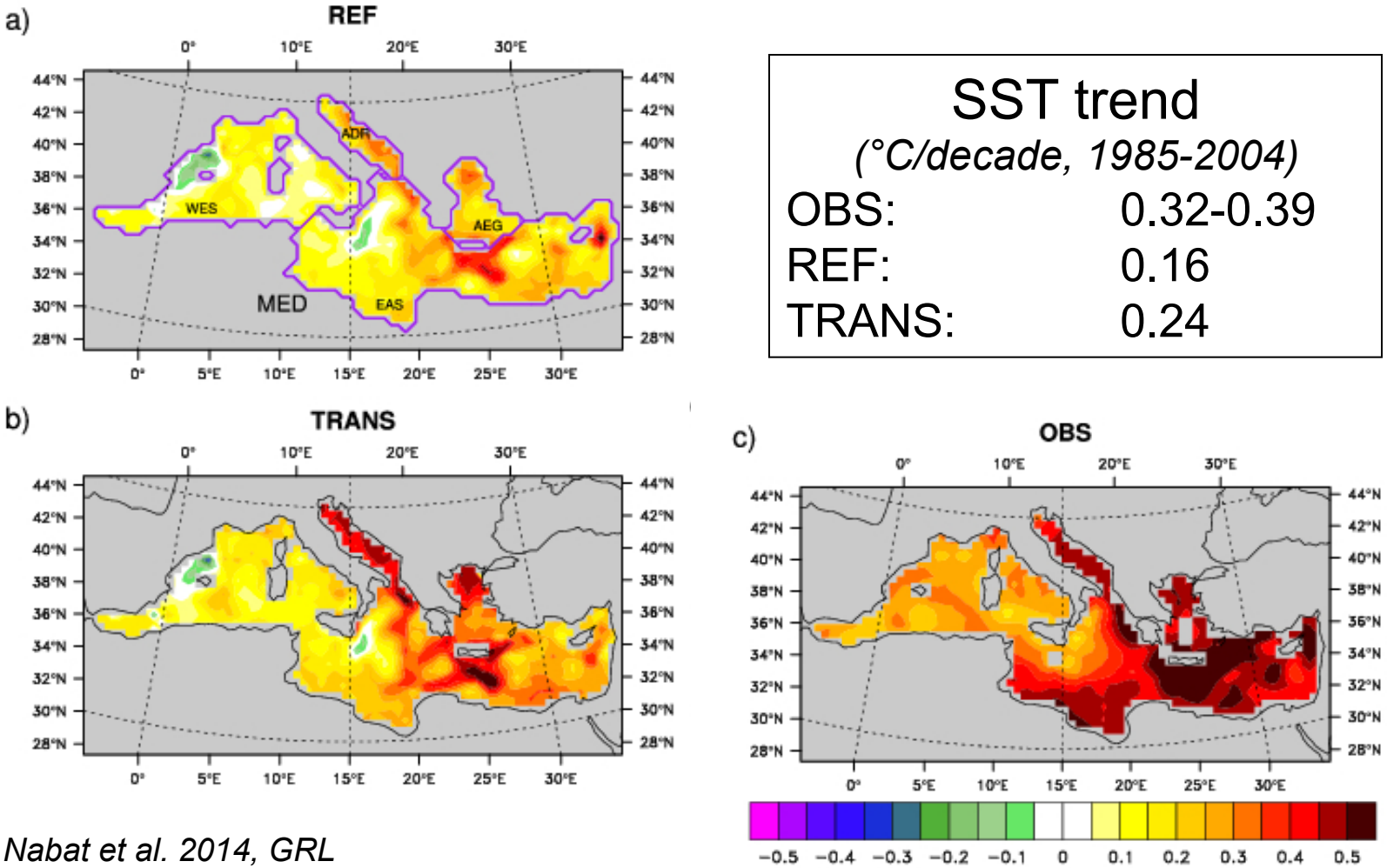
METEO FRANCE
Toujours un temps d'avance

Mediterranean SST:
Reproducing the trends in RCSM

Interannual variability hindcast using RCSM with/without sulphate aerosol trend

Models: ERA-Int driven run, CNRM-REF and CNRM-TRANS

Obs: Marullo (SST, 1985-2007), HadSST, ECMWF analysis



SST trend (°C/decade, 1985-2004)	
OBS:	0.32-0.39
REF:	0.16
TRANS:	0.24

Fig: P. Nabat et al. 2014, GRL

Mediterranean SST:
climate change signal as seen by GCM and RCSM

Regional climate change scenarios using Regional Climate System Models (RCSM)

GCM: IPSL-CM5-MR, CNRM-CM5

RCSM: CNRM, ENEA, LMD

Run: HIST + RCP4.5 (Ref period: 1976-2005), 20-year filter

Mediterranean SST anomaly (°C)

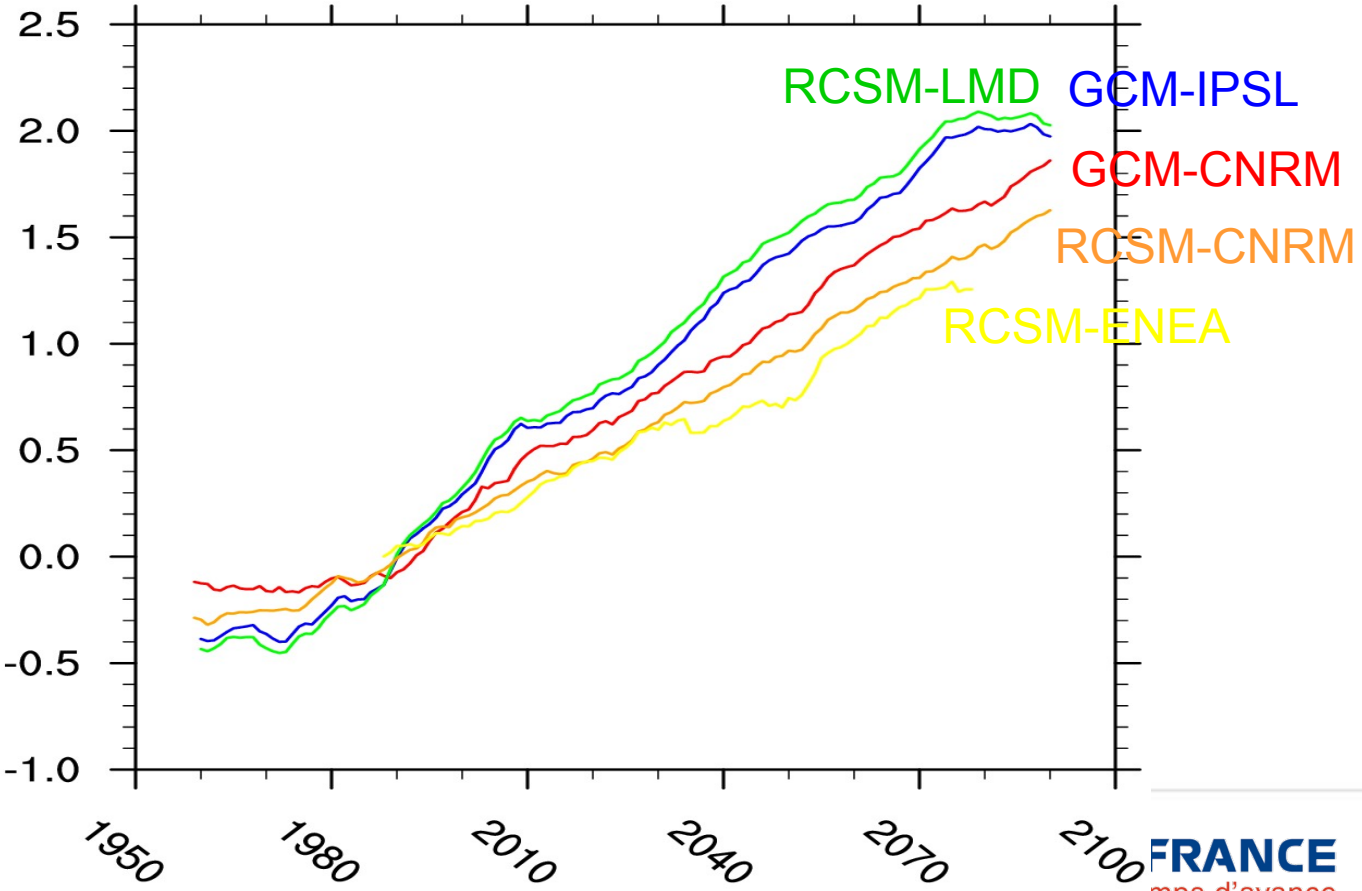


Fig: C. Dubois, CNRM

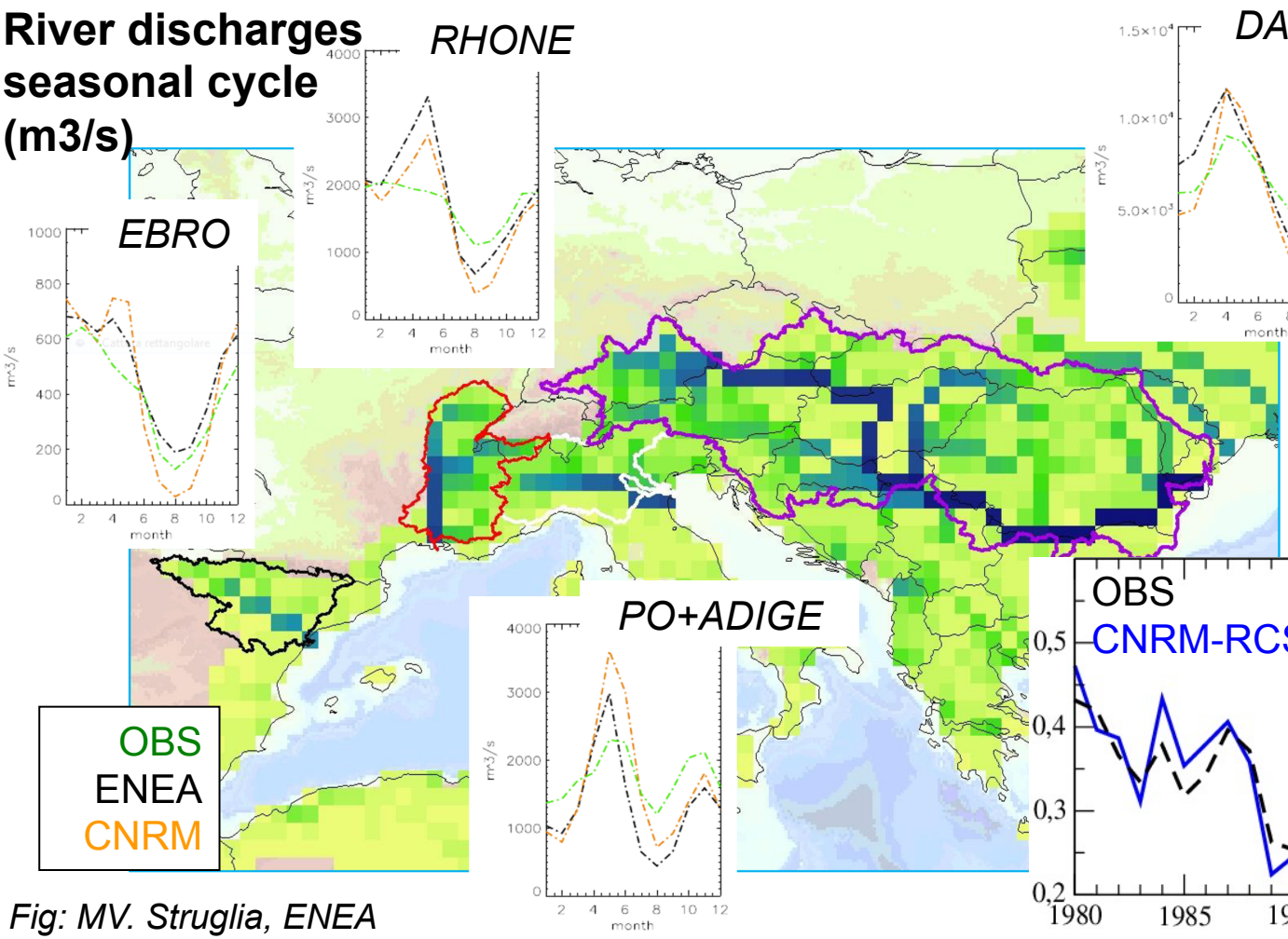
Mediterranean rivers:
RCSM evaluation

Hindcast run using RCSM with interactive rivers

Models: ERA-Int driven run, CNRM, ENEA, 1970-2000

Obs: UNESCO data (*Vörösmarty et al. 1996), Ludwig et al. (2009)*

River discharges seasonal cycle (m3/s)



Interannual Med Sea river discharges (mm/d)

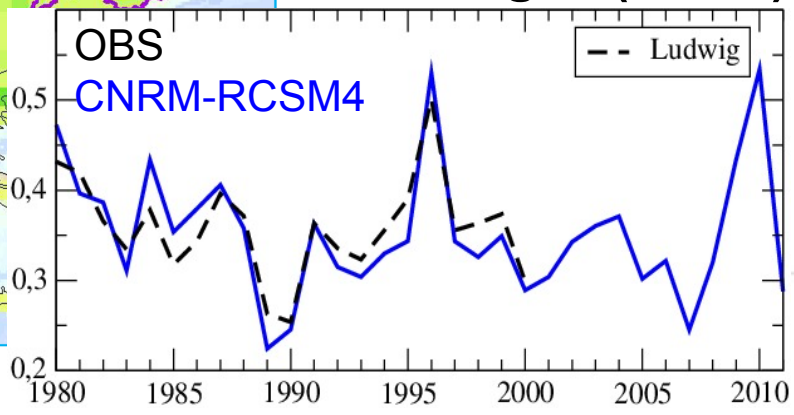


Fig: MV. Struglia, ENEA

Preparing Med-CORDEX 2

WCRP CORDEX

HyMeX HYdrological cycle in Mediterranean EXperiment

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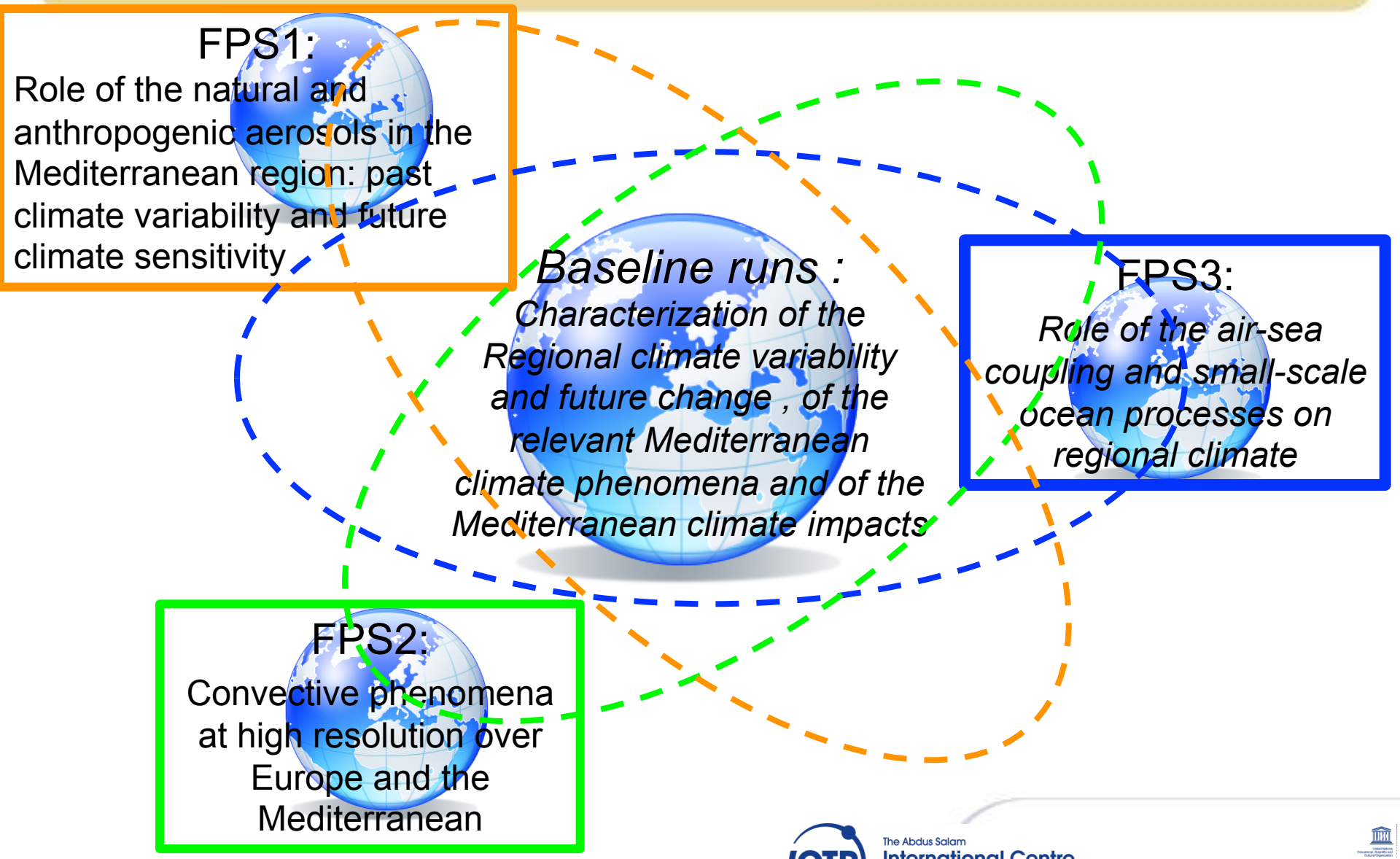
Med-CORDEX-2 : common baseline runs and some few dedicated Flagship Pilot Studies (FPS)



WCRP CORDEX

17TH-20TH MAY 2016 STOCKHOLM, SWEDEN

ICRC-CORDEX 2016

Flagship Pilot Studies (FPS)

Five ready to go forward:

- ✓ EUR+MED: Convective phenomena
- ✓ EUR: Impact of land use changes
- ✓ S. AM: Extreme precipitation events
- ✓ MED: Role of natural and anthropogenic aerosols
- ✓ MED: Role of air-sea coupling and small-scale ocean processes

Three we will work with further.

One that can fit better with other CORDEX activity.

Med-CORDEX-2 baseline runs

➲ Scientific questions

- Characterization of the past regional climate variability and trends
- Characterization (incl. uncertainty) of the future regional climate sensitivity/evolution
- Characterization of the past variability and future evolution of the relevant Mediterranean climate phenomena
- Characterization of the Mediterranean climate change impacts

Experimental protocol: ONLY ONE AND CLEAR PROTOCOL (still in drafting phase)

FPS1 : Role of the natural and anthropogenic aerosols in the Mediterranean region: past climate variability and future climate sensitivity

Scientific questions

(1) Can we fully characterize the Mediterranean aerosol past variability and future evolution at climate scales ? and how RCMs can contribute to this characterization ?

(2) Can we understand the role of the Mediterranean aerosols on the past regional climate variability ? This includes regional climate change attribution issues as well as questions about the best way to represent aerosols (improved aerosol climatology, fullyinteractive module) in climate models (GCM and RCM).

(3) Can we determine the role of the regionally-born aerosols in the future climate sensitivityof the Mediterranean region ? how can RCMs bring new knowledges complementary to GCMs for this topics ?

(4) What is the role of the aerosols in shaping the Mediterranean extreme events ? (continental heat waves, heavy precipitation events, ocean heat waves, strong regional

FPS1 : Role of the natural and anthropogenic aerosols in the Mediterranean region: past climate variability and future climate sensitivity

Expected impact (scientific, end user, policy)

- Better understanding of the **Mediterranean regional climate variability** and change
- Illustration of the role of the **aerosol radiative forcing** in RCMs
- Better representation of **cloud processes** in RCMs
- Better assessment of the past variability and future evolution of the **surface shortwave radiation** in the Mediterranean
- Improvement of the Mediterranean regional **climate change projections**
- Better assessment of the future evolution of the **air quality over the Mediterranean**
- Better assessment of the future evolution of the **marine biogeochemistry of the Mediterranean Sea**
- Better assessment of the future evolution of the **solar energy potential**
- Better assessment of the **potential added value of coupled RCSMs** with respect to standard AtmosphereRCMs (CORDEX challenge on coupled regional climate models)
- Contribute to promote the awareness of the **aerosol climate role** in the regional climate modelling community
- Contribute to some of the WCRP Grand Challenges: Understanding and Predicting Weather and Climate Extremes, Changes in Water availability
- Innovative scientific results and contribution to the regional climate science
- Contribute to **EuroMediterranean climate services**

FPS2 : Convective phenomena at high resolution over Europe and the Mediterranean

Scientific questions

(1) How do Convective events and associated damaging phenomena (heavy precipitation, wind storms, flash-floods) respond to changing climate conditions in different climatic regions of Europe?

(2) Does an improved representation of convective processes and precipitation at convection permitting scales lead to upscaled added value?

(3) Is it possible to replace costly convection-permitting experiments with physically defensible statistical downscaling approaches such as “convection emulators” that mimic CPMs and are fed by output of conventional-scale RCMs?

FPS2 : Convective phenomena at high resolution over Europe and the Mediterranean

Expected impact (scientific, end user, policy)

- Improved understanding of mechanisms and factors that influence **location, intensity, frequency and extent of convective precipitation** events under changing climate conditions;
- Better constrained estimates of **future changes in convective extremes** and associated processes across a range of climatic regions;
- Bridge the **spatial scale gap** between **regional climate models and impact models** (hydrological models, ecosystem models, etc.)
- Provide **added value** for the **decision-making process** through **analysis of risks** and opportunities associated with **changes in extreme convective events**.

FPS3 : Role of the air-sea coupling and small-scale ocean processes on regional climate

Scientific questions

(1) What is the role of the air-sea coupling in both regional climate variability and future projections?

(2) What is the role of small scale oceanic processes in both regional climate variability and future projections?

FPS3 : Role of the air-sea coupling and small-scale ocean processes on regional climate

Expected impact (scientific, end user, policy)

- The **expertise in the air-sea coupling** techniques and implications integrated with efficient and high performance data analysis pipeline/s can be **extrapolated** to **other regions and further to GCMs**.
- Understanding the **impact of small-scale oceanic processes** on air-sea interaction can help **quantifying present uncertainties in the GCMs** and potential improvements. Of special importance is the impact on the heat uptake by the ocean, the most important part of the global heat budget, and on marine environments (i.e. linked to the WCRP grand-challenge on regional sea-level and coastal impacts).
- A common protocol for coupled RCMs will provide a consistent **database to be used for scientific studies** as well as for impact studies.

Med-CORDEX status: conclusions

- One of the largest and most active CORDEX community

- Med-CORDEX is an open community

- 50km RCM, 12km RCM, fully-coupled RCSM, stand-alone ocean and land-hydrology simulations completed (RCP scenarios on-going)

- Outputs available at the ENEA database: www.medcordex.eu

- A reference paper (Ruti et al. BAMS), web site (www.medcordex.eu), 42 scientific articles published, a Med-CORDEX special issue in Climate Dynamics

- Med-CORDEX-2 already planned. A lot of interesting work to be done

-Many opportunity for collaboration

-**The FPS are open groups and it is possible to join.**