THE CORDEX-WRF initiative in France: simulations, problems and on-going work

S. Bastin, P. Drobinski, E. Flaounas, K. Beranger, A. Colette, K. Goubanova, C. Lebeaupin-Brossier, L. Menut, R. Vautard.

IPSL; LEGOS; INERIS; ENSTA

A french collaborative effort

- 4 CORDEX domains (Africa, Europe, Mediterranean, South America) with different scientific objectives
- Discussions on the set up, the choice of parametrizations, compilation and perfomance, CORDEX requirements, initialisation with IPSL GCM
- A common project to the National Center of Intensive Computing Agency for computing ressources request
- A new coupled model developped for Mediterranean domain: MORCE

AFRICA

- <u>Simulations:</u> RRTMG, WSM5, YSU, KF, RUC.

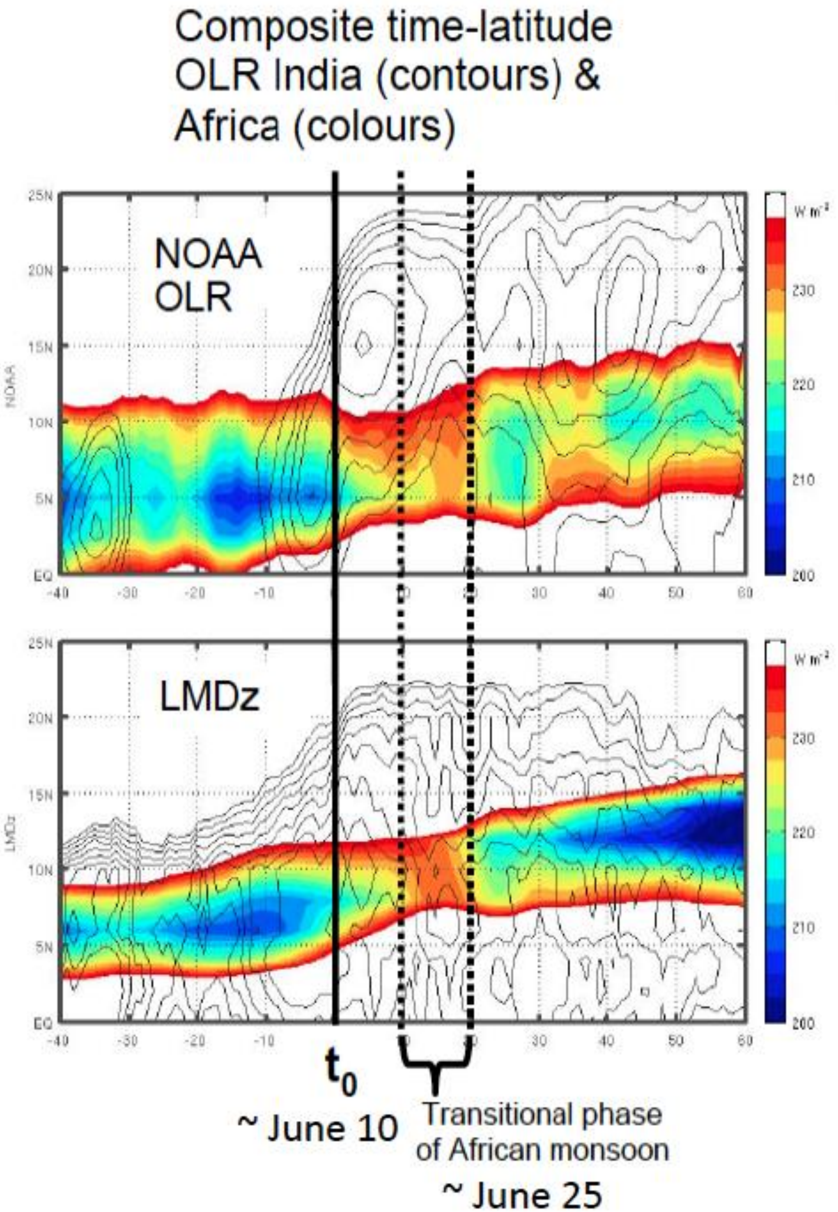
  To be discussed: how to manage aerosols and land use?

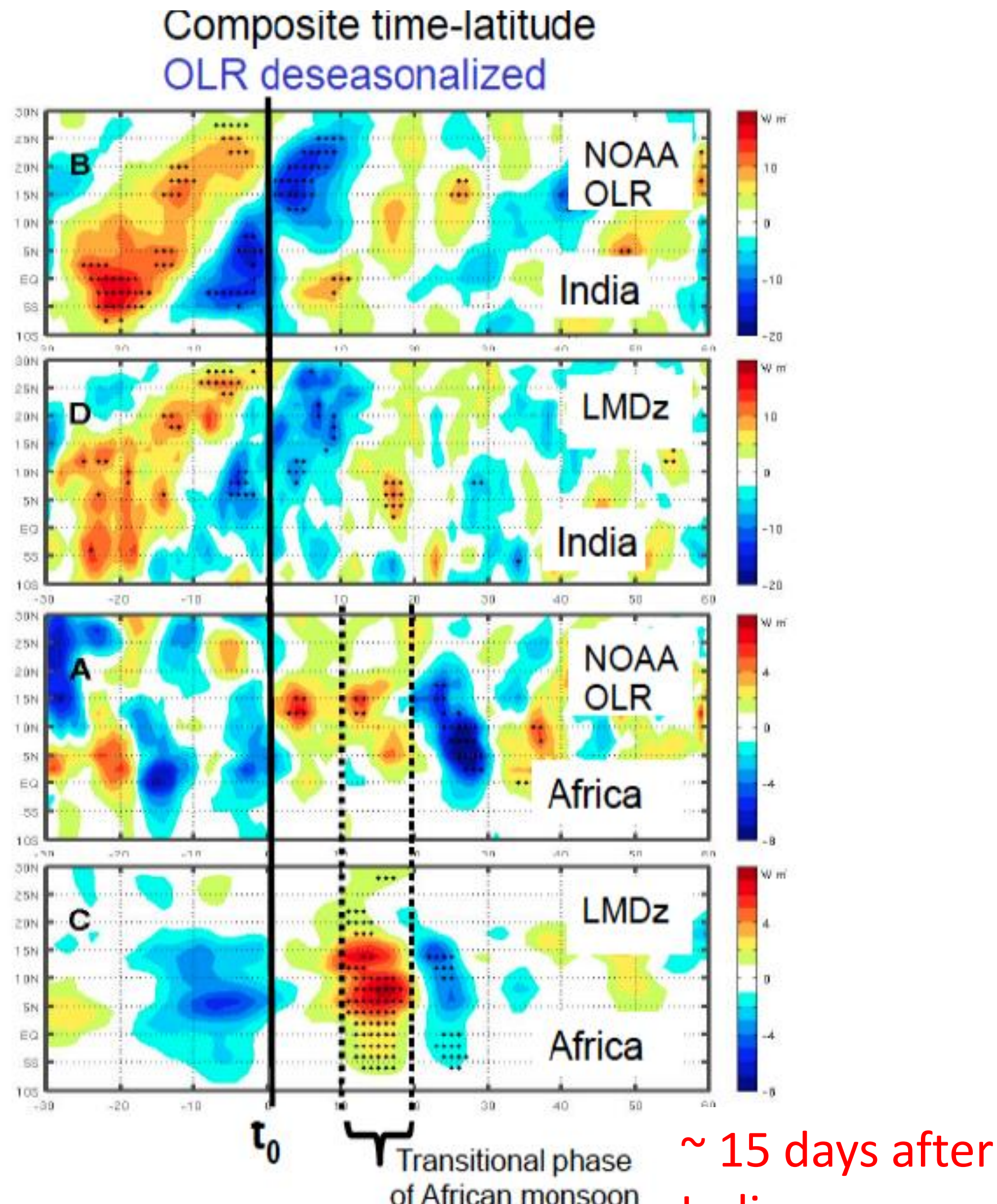
REGION	MODELE REGIONAL	Résolution	GCM forcing	Evaluation 1989-2008	Control period 1951-2005	Scenario 2006-2100	Status	Groupe
AFRIQUE	WRF avec nudging	50km	ERA-Interim				Terminé	IPSL
AFRIQUE	WRF sans nudging	50km	ERA-Interim				Terminé	IPSL
AFRIQUE	WRF	50km	IPSL-CM5AMR-1				1970-2005 En cours	IPSL

- <u>Scientific objectives</u>
  - Mecanisms of the monsoon onset with focus on the role of Indian monsoon onset (Flaounas et al., 2011)
  - Intraseasonal and interannual variabilities of West African Monsoon with special focus on surface-atmosphere interactions (Gulf of Guinea and continental surface)

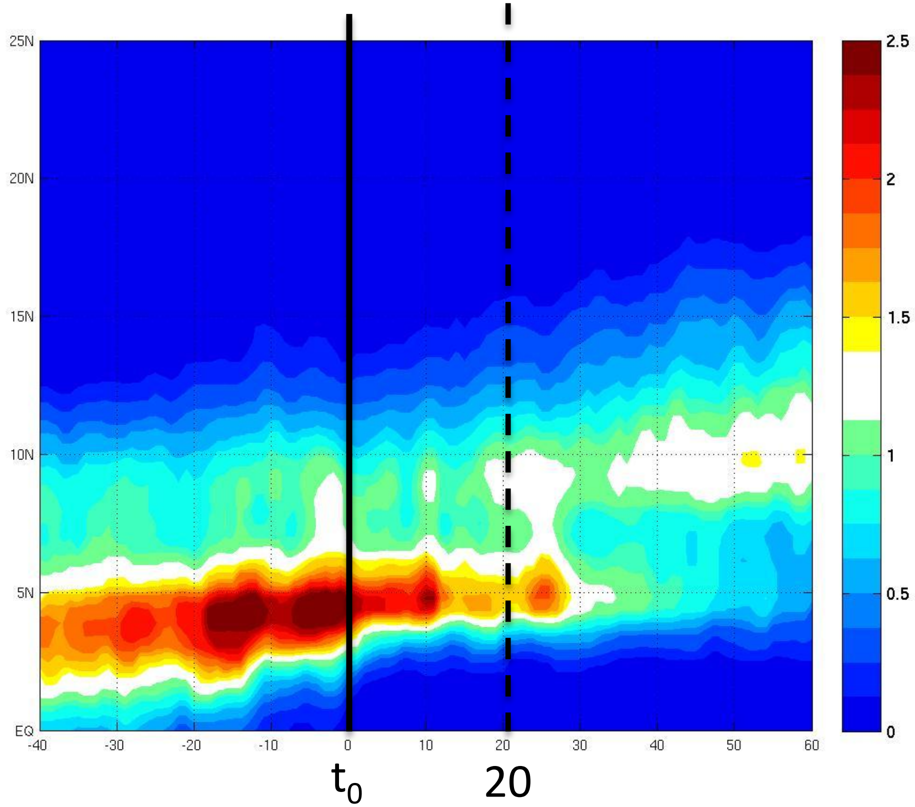
AFRICA-illustration: impact of Indian monsoon

From Flaounas et al., 2011



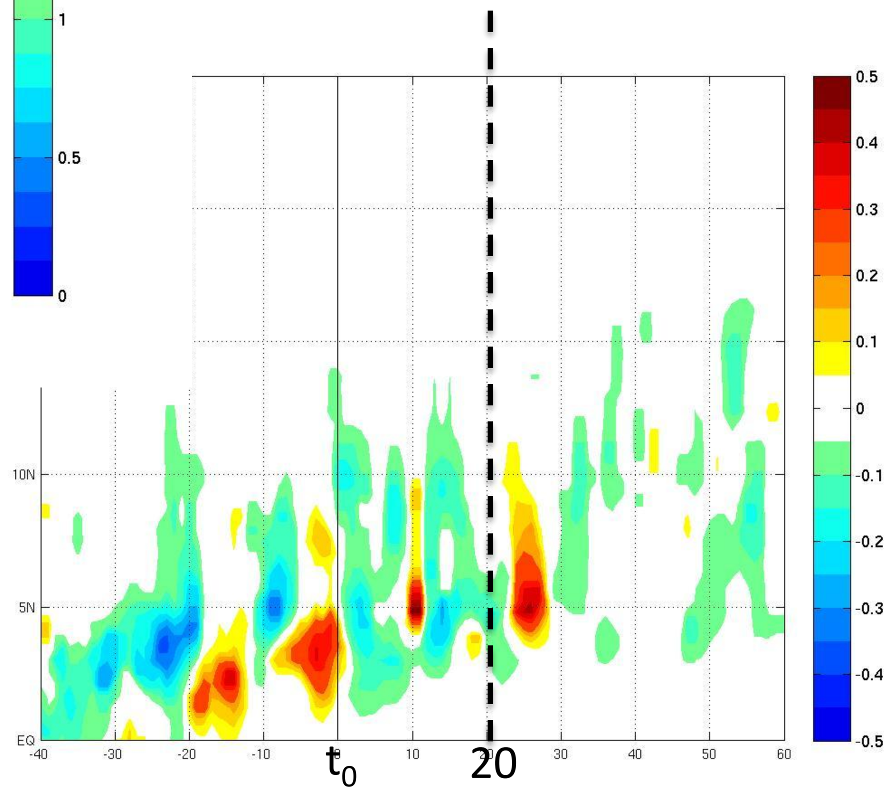


AFRICA-illustration: impact of Indian monsoon



WRF-CORDEX, nudged simulation:

- Onset of WAM over Sahel ~ 20 days after India
- Convection does not stop over Guinea



EUROPE

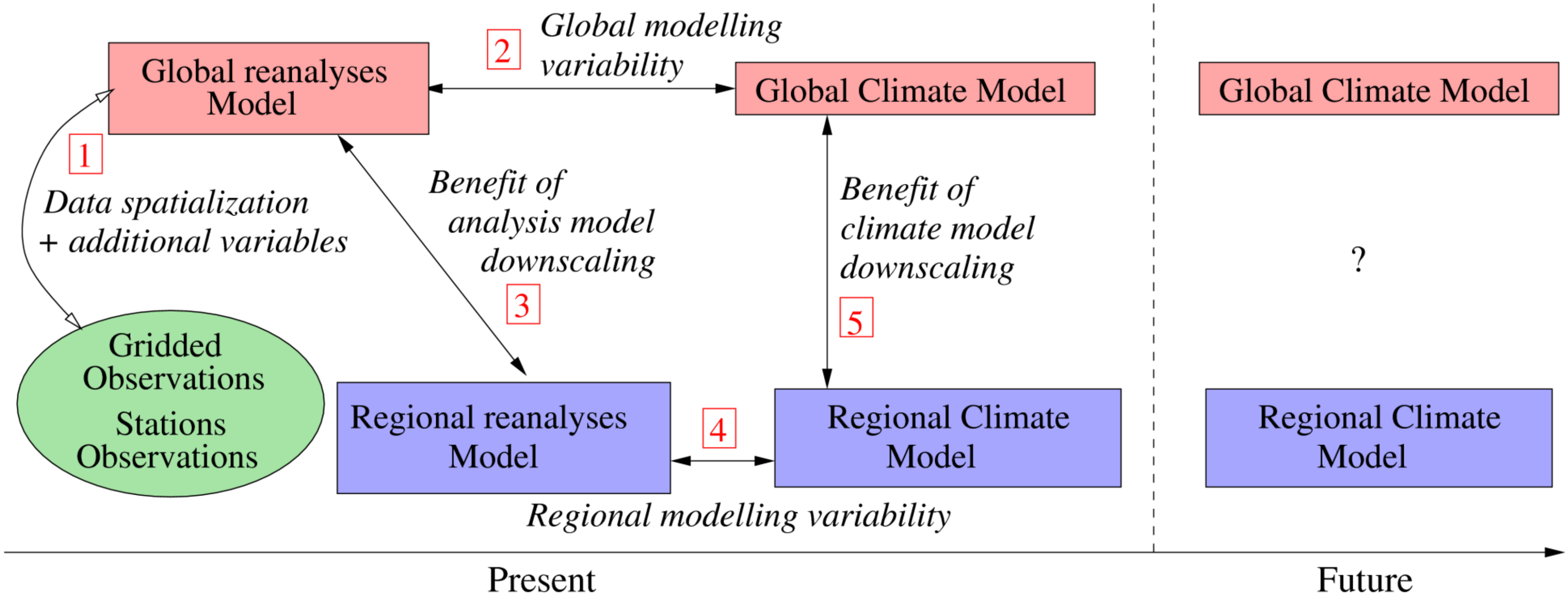
- **Simulations**:

REGION	MODELE REGIONAL	Résolution	GCM forcing	Evaluation 1989-2008	Control period 1951-2005	Scenario 2006-2100	Status	Groupe
EUROPE	WRF	50km	ERA-Interim				Terminé	IPSL+INERIS
EUROPE	WRF	50km	IPSL-CM5MR-1				Terminé 1971-2005	IPSL+INERIS
EUROPE	WRF	50km	IPSL-CM5MR-1			RCP4.5	Terminé	IPSL+INERIS
EUROPE	WRF					RCP8.5	En cours 2006-2060 actuellement	IPSL+INERIS
EUROPE	WRF	12km	ERA-Interim					IPSL+INERIS
EUROPE	WRF	12km	IPSL-CM5AMR-1				Terminé 1971-2005	IPSL+INERIS
EUROPE	WRF	12km	IPSL-CM5AMR-1			RCP4.5	En cours 2006-2060 actuellement	IPSL+INERIS

- Scientific objectives: Evaluation of regional climate simulations for air quality modelling purposes
- Methodology:
  - Investigate the changes in the statistics of meteorological variables when moving from reanalyses-forced to GCM-forced regional climate simulations.

- Publications: Colette et al., GRL, 2012; Vautard et al., in revision to Clim. Dyn. 2012; Menut et al., AGU 2011.

EUROPE



50km x 50km horizontal resolution ➔ 119x116 grid points

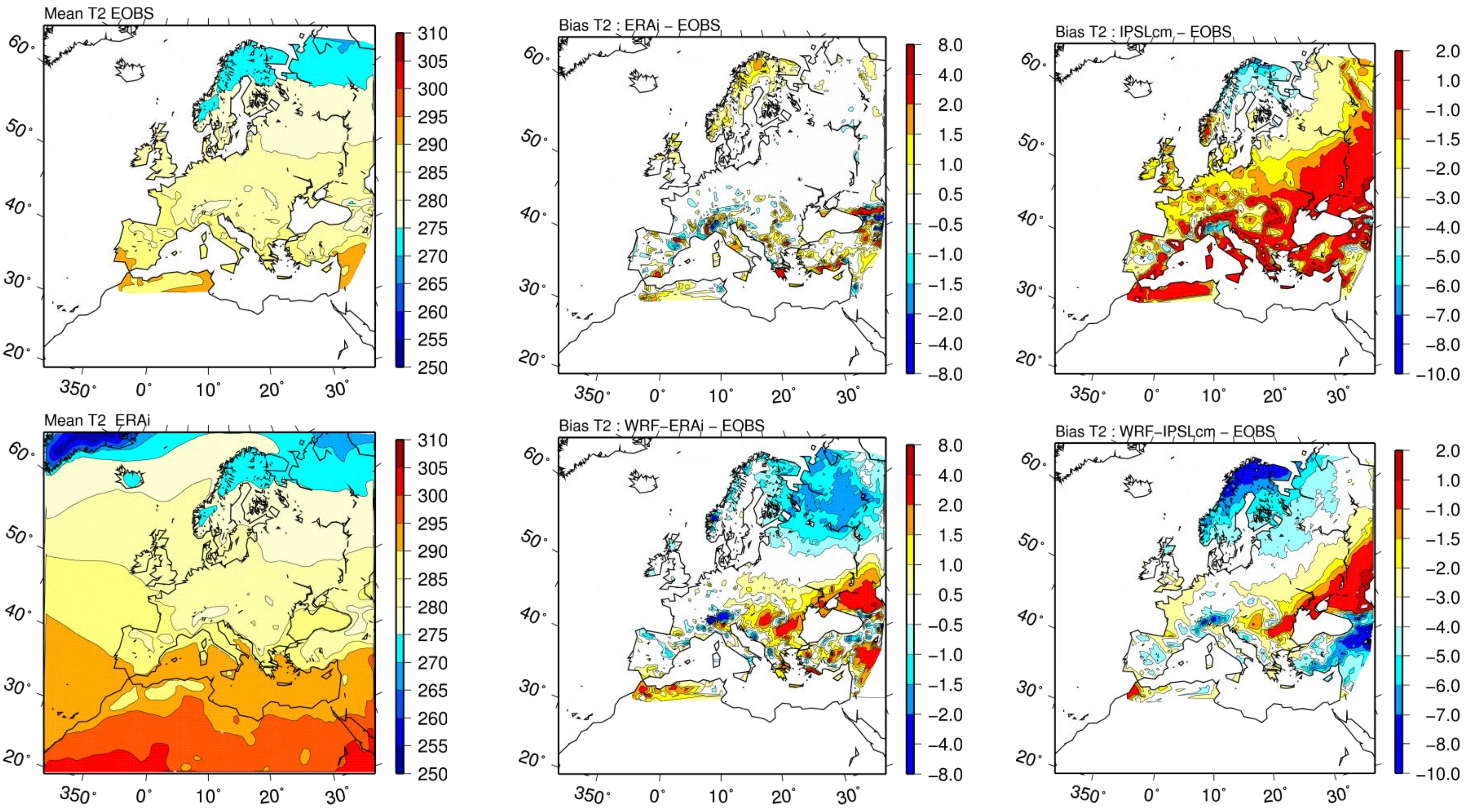
32 vertical levels

Noah ➔LSM

GRELL ➔convection scheme

YSU ➔PBL scheme

Mean values and biases of 2m temperature



The bias is low between E-OBS and ERAi and shows that the ERAi modelled temperature is the best field for analysis. WRF forced by ERAi induces a bias of +-8K.

IPSLcm has itself a bias of +2 to -10K. Finally, due to errors compensation the WRF-IPSLcm exhibits a bias of +2 to -10K.

Synthesis of all differences between the model configurations and expected impact on air quality.

Parameter	WRF-IPSLcm / WRF-ERAi	Expected impact on air quality
Mean values		
T2m	$<$ (-4K winter, -1K summer)	Less biogenic emissions, less photochemistry
WS	$>$ 0.5m/s (winter) and $<$ 1m/s (summer)	Low impact, less natural particles emissions in summer
BLH	$>$ (+20%)	More dilution, less surface concentrations
SWR	$>$ (+10%)	More photochemistry, more ozone
RAIN	$>$ (+1mm/day)	More scavenging, less pollutants in the atmospheric column (gas and particles)
Variability and extremes		
T2m	$\approx$	Negligible impact
WS	$<$	More stagnation episodes
SWR	$>$	More fluxes leading to more photochemistry

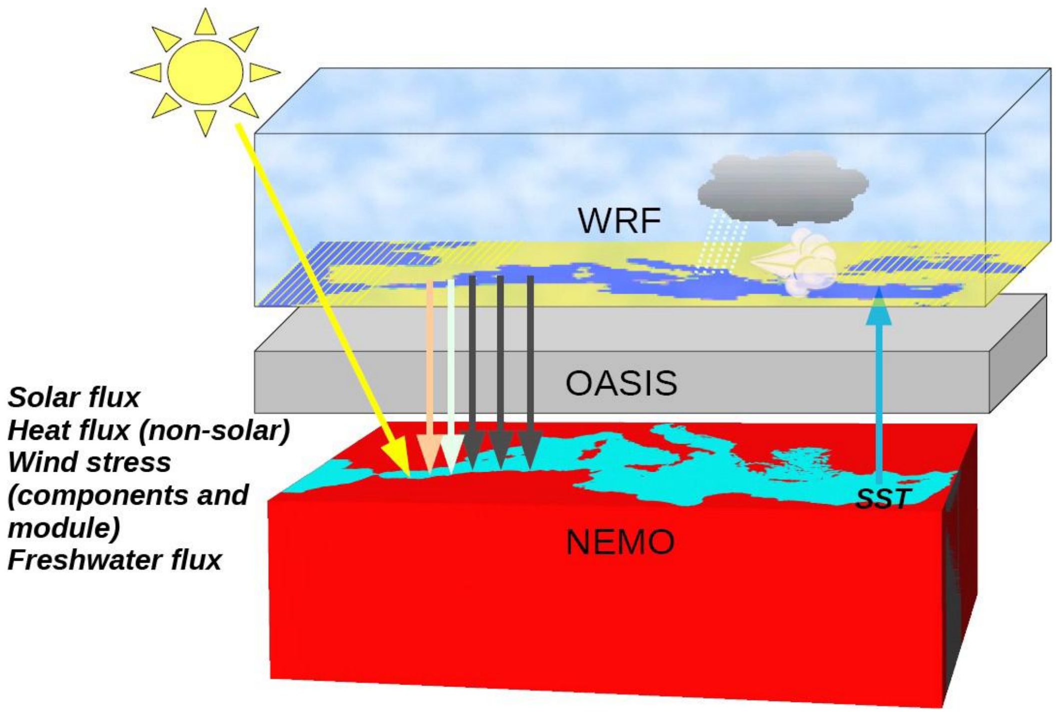
Med-CORDEX

- Focus on extreme events: heat wave/droughts, heavy precipitation/flash floods, strong winds/deep oceanic convection
- Development of a new coupled model: MORCE (Drobinski et al., 2012) coupling WRF, an ocean model (NEMOD-MED 12), a new SLAB with dynamical vegetation (ORCHIDEE)

Med-CORDEX

- <u>Simulations</u>: YSU, WSM5, RUC, RRTMG

REGION	MODELE REGIONAL	Résolution	GCM forcing	Evaluation 1989-2008	Control period 1951-2005	Scenario 2006-2100	Status	Groupe
MEDITERRANEE	WRF	50km	ERA-Interim				Terminé	IPSL
MEDITERRANEE	WRF	20km	ERA-Interim				Terminé	IPSL
MEDITERRANEE	WRF-NEMO	20km	ERA-Interim				Terminé	IPSL
MEDITERRANEE	WRF	20km	IPSL-CM5AMR-1				Terminé 1989-2005	IPSL
MEDITERRANEE	WRF	20km	IPSL-CM5AMR-1				En cours fin prévue mars 2013	IPSL



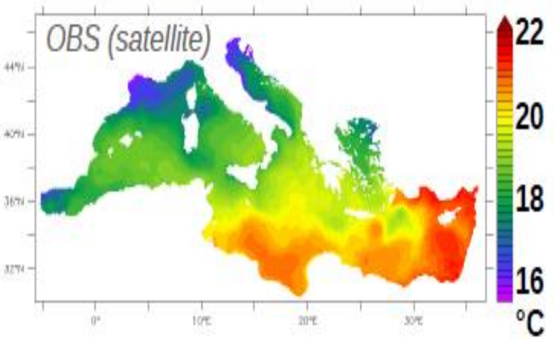
WRF-ARW
Version 3.1.1
resolution: 20km
grid-points: 240 x 130 x 28
Δt=60s
initial and boundary conditions: ERA-interim (1989-2008)

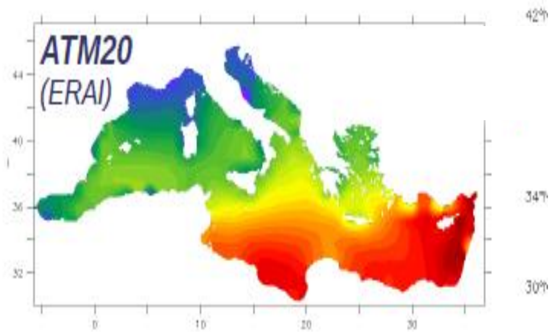
Coupler
OASIS3
frequency: 3h
interpolation: bicubic
landmask extend: Atlantic Ocean, Black, Marmara & Red Seas, Leman Lake...

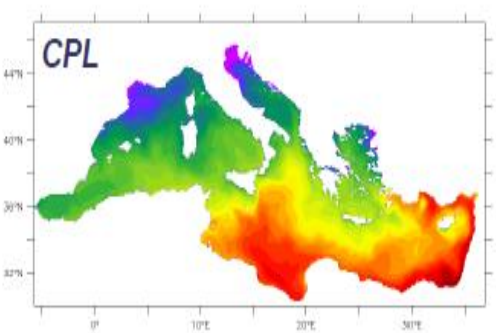
NEMO: *MED12 config*
Version 3_2_beta
resolution: 1/12°
grid-points: 567 x 264 x 50
Δt=720s
Initial conditions: MODB4
Atlantic boundary: θ,S,SSH restoring

Med-CORDEX

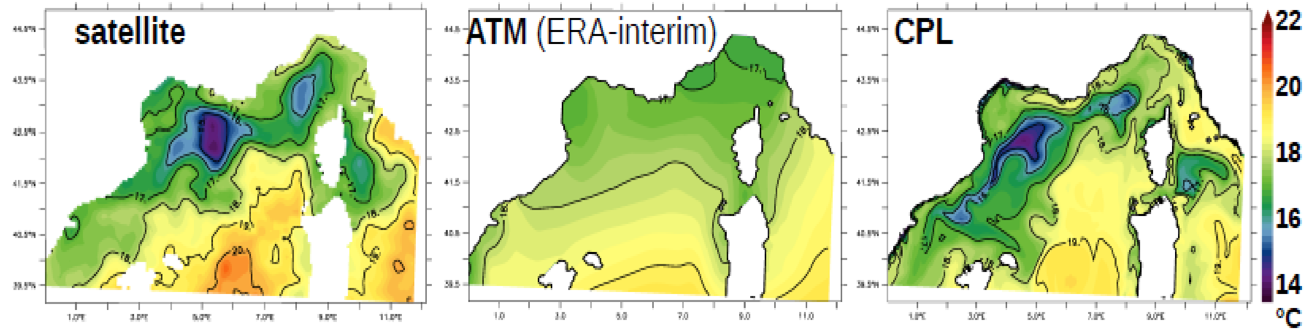
SST validation:
(1999)







SST 12 November 1999:



A ***more realistic SST*** in CPL with a cold anomaly induced by mistral and local circulation

Evaporation and wind speed are decreased in the coupled simulation

Coupling role for intense precipitation:

- direct effect over sea (less rainfall over cold area)
- indirect effect over land (modulation of the low-level jet supply and of rainrates)

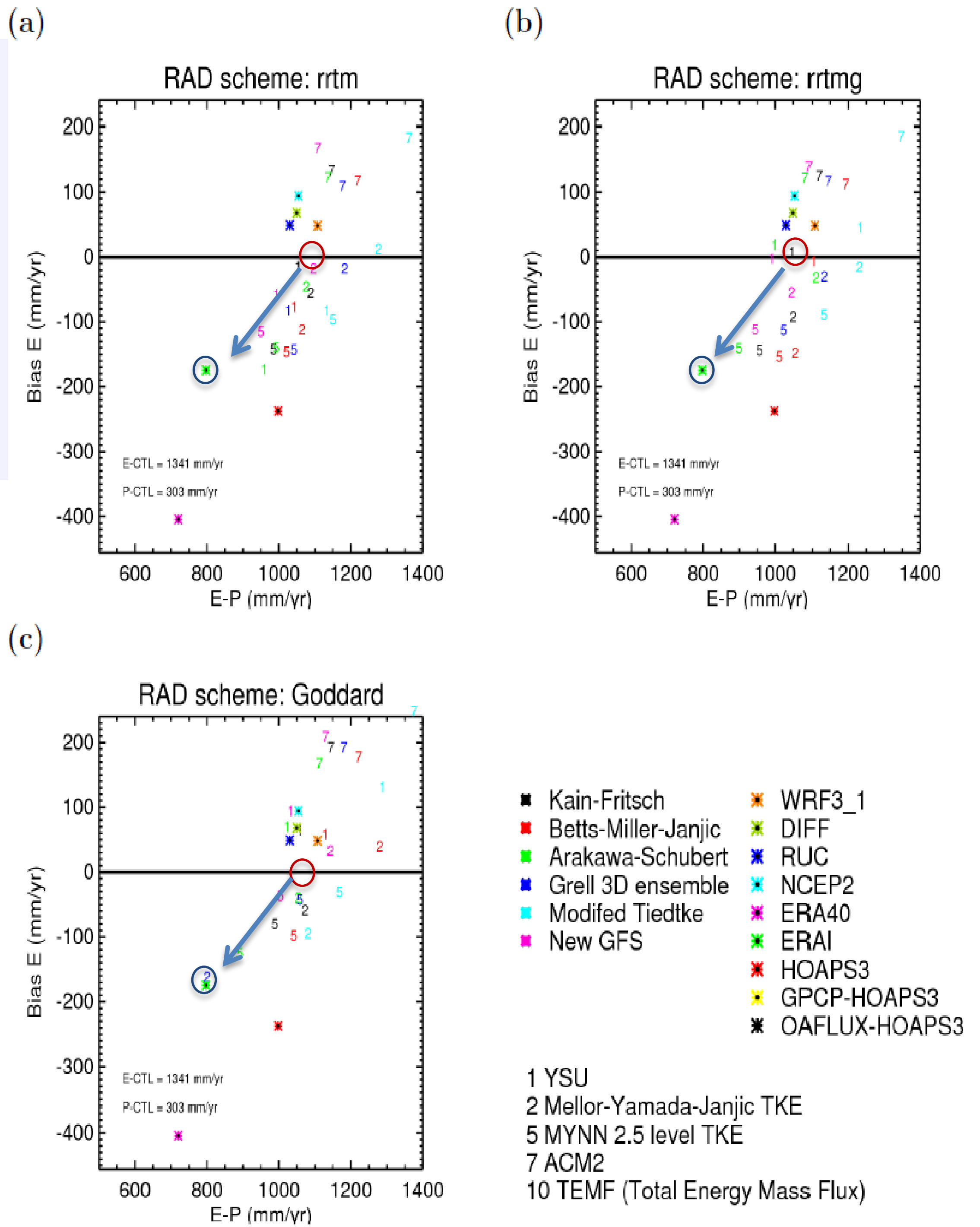
SST is the key controlling factor for Evaporation and Precipitation: **budgets, variability and extremes**.

Water budget is decreased in the coupled simulation

Coupling most significant role is the redistribution of water at mesoscale

Budget Med. Sea *(mm/yr)*	ATM50	ATM20	CPL
	resolution →	coupling →	
E	1448	1532 ↑	1442 ↓
P	422	499 ↑	482 ≈
E-P	***1026***	***1033*** ≈	***960*** ↓

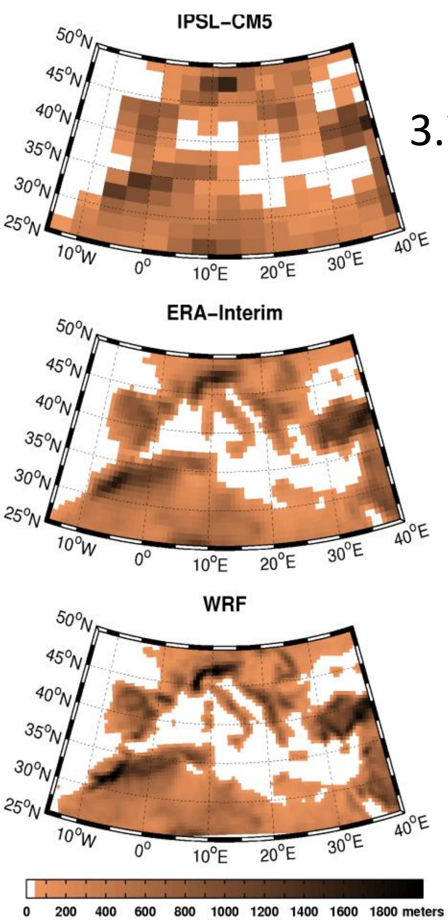
- 90 simulations
- 50 km horizontal resolution
- 1 year of integration



Med-CORDEX

What benefits we get from downscaling with WRF?

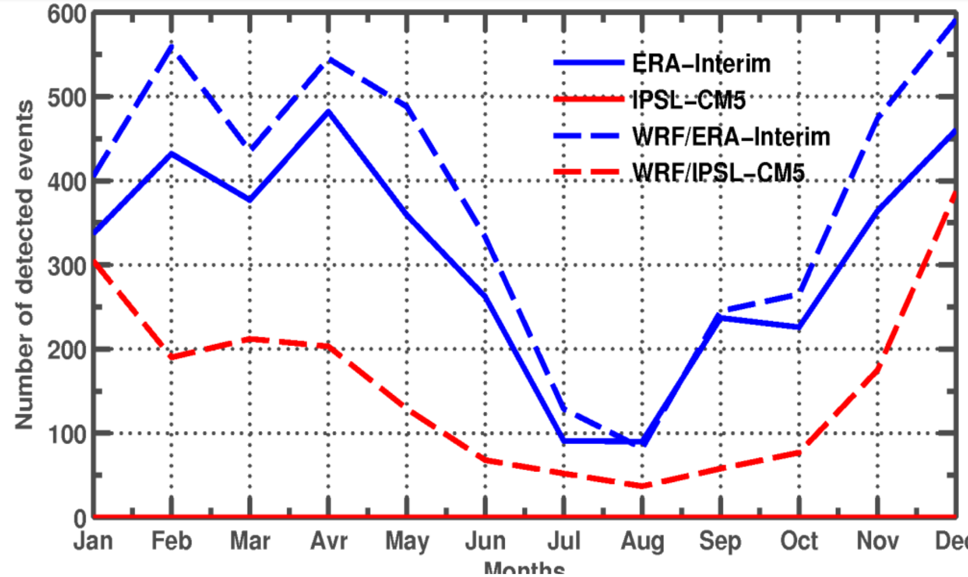
-Application on Mediterranean cyclones (period 1989-2005)

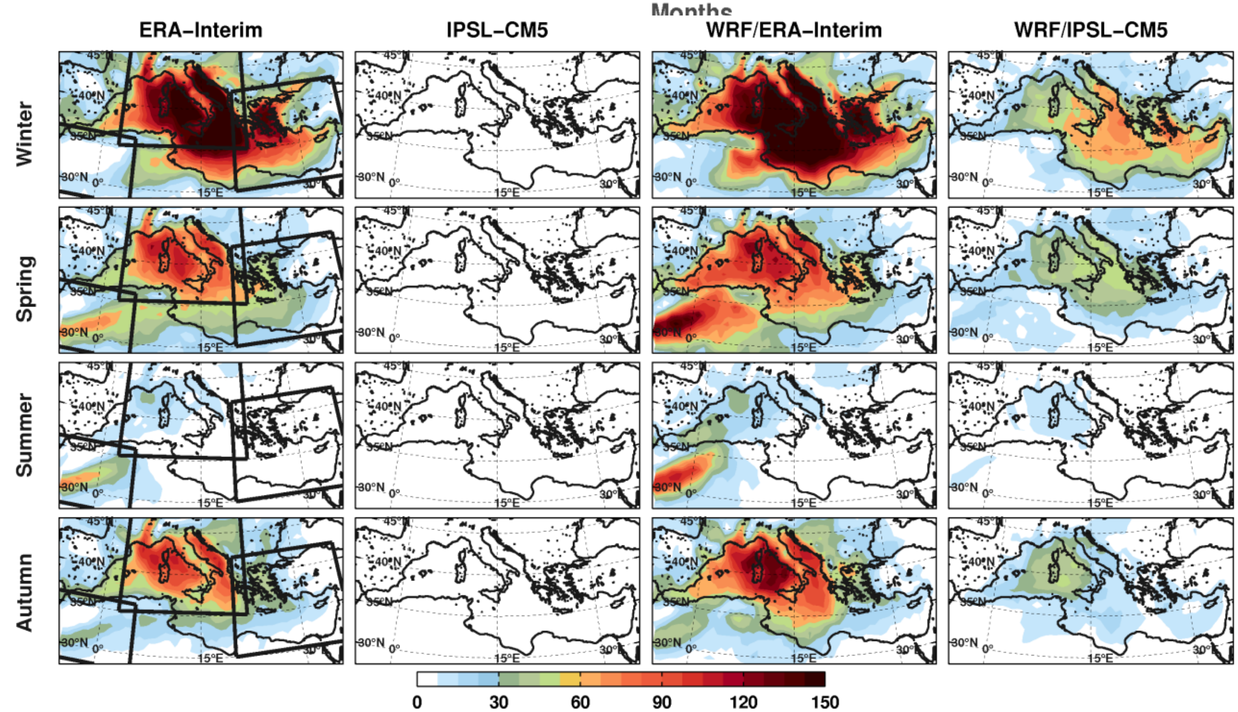


3.75°x1.25°

~80 km

50km





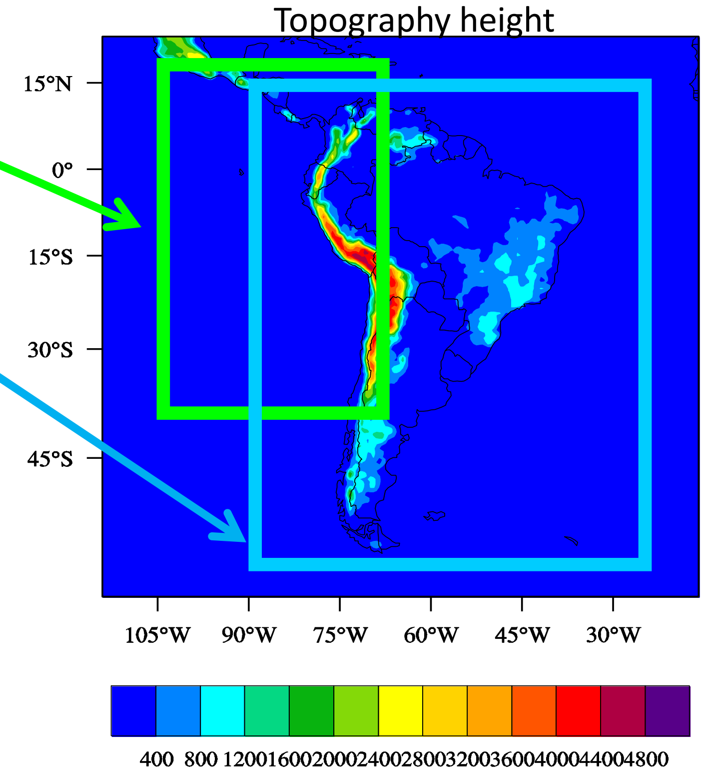
WRF-CORDEX-IPSL
Region: South-America
Related project: ANR PEPS (Peru Ecosystem Projection Scenarios)

Set-up:

Domain **110W°-35°W, 20°N-60°S**
includes CORDEX S.America region + PEPS region

Vertical levels **35**
TOA **50hPa**
Resolution **50km (196x210)**

Microphysic **WSM 5-class**
Radiations **RRTMG**
Land surface **Pleim-Xiu**
Surface layer **Pleim-Xiu**
PBL **ACM2 (Pleim)**
Cumulus **Grell-Devenyi**



Simulations status:

- **ERA-Interim Evaluation 1989-2008** ***finished***

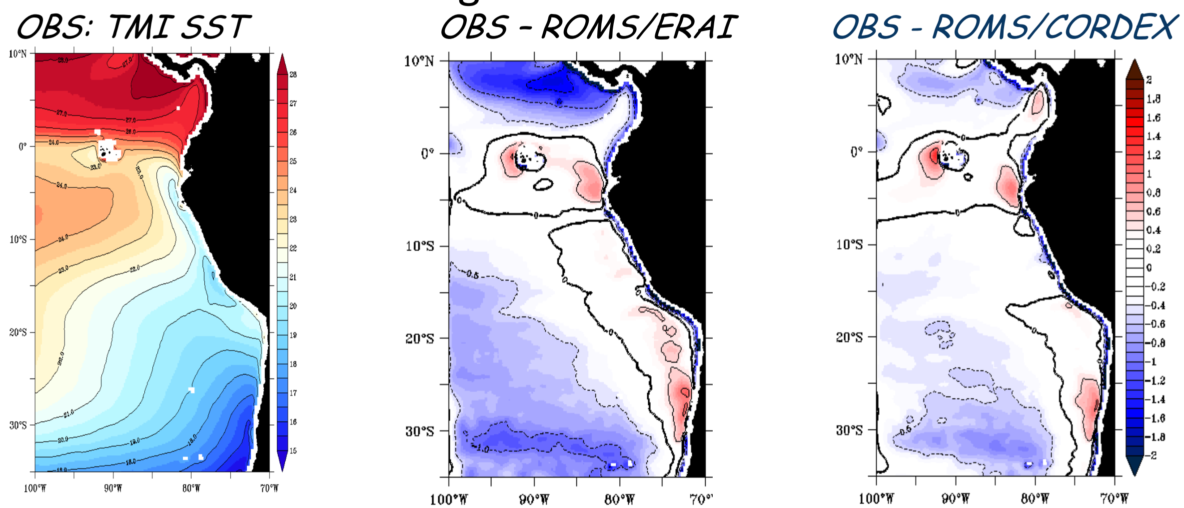
- **Control IPSLCM5-MR1 1981-2000** ***in progress*** **(10 years finished)**
- **RCP8.5 IPSLCM5-MR1 2081-2100** ***to be done***

Scientific objectifs

1. Impact of the climate change on the wind-driven upwelling off the coast of Peru/Chile and on the regional ecosystem *(work in progress)*

- Using atmospheric flux from WRF to force a regional oceanic model ROMS

Fig1. SST off Peru-Chile



2. Evaluation of the dynamical and statistical methods for downscaling the upwelling favorable along-shore surface wind *(work in progress)*

- Statistical method (Goubanova et al. 2010) was used in previous studies to derive regional wind change from a CMIP3 CGCMs ensemble and to obtain wind forcing for ROMS (Echevin et al. 2011; Cambon et al. 2012)

3. A study of extreme temperature and precipitation over South America in global and regional models *(work to be done)*

-collaboration with LMDZ-CORDEX-IPSL (L.Li)

-looking for collaborations with other S.America groups!

Main problem

Coarse resolution of CGCM SST to force WRF !

-> narrow coastal band of upwelling cold water is not well resolved by CGCM -> this impact coastal atmospheric circulation in WRF (in particular surface wind and wind curl are not realistic) -> bias in atmospheric forcing for the regional oceanic model

Possible solutions?

a) Apply a statistical downscaling to CGCM SST in order to resolve fine-scale feature near the coast ?

b) Control run: forcing by *observed SST*

RCP85: forcing by *observed SST + CGCM SST anomalies between RCP8.5 and control runs ?*

Any idea/suggestion are welcome !