Activities of seasonal modelling at the Euro-Mediterranean Center on Climate Change (CMCC)

Stefano Materia, Andrea Borrelli, Alessio Bellucci, Silvio Gualdi, Enrico Scoccimarro

LONG-RANGE FORECASTING TRAINING (LRF Training)
Belgrade, 14 November 2013

cmcc
Centro Euro-Mediterraneo sui Cambiamenti Climatici

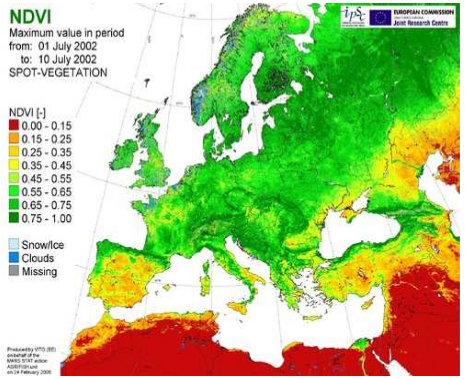
The Euro-Mediterranean Center on Climate Change (CMCC)

- an Italian research centre on **climate science and policy**
- a network of Italian public and private research institutions
- funded by the Italian Ministries MIUR (university & research), MATTM (environment) and MEF (economy & finance), within the framework of the National Research Plan

Mission:

to **investigate and model the climate system and its interactions with society** to provide reliable, rigorous, and timely scientific results to stimulate sustainable growth, protect the environment and to develop science driven adaptation and mitigation policies in a changing climate.

The CMCC Divisions

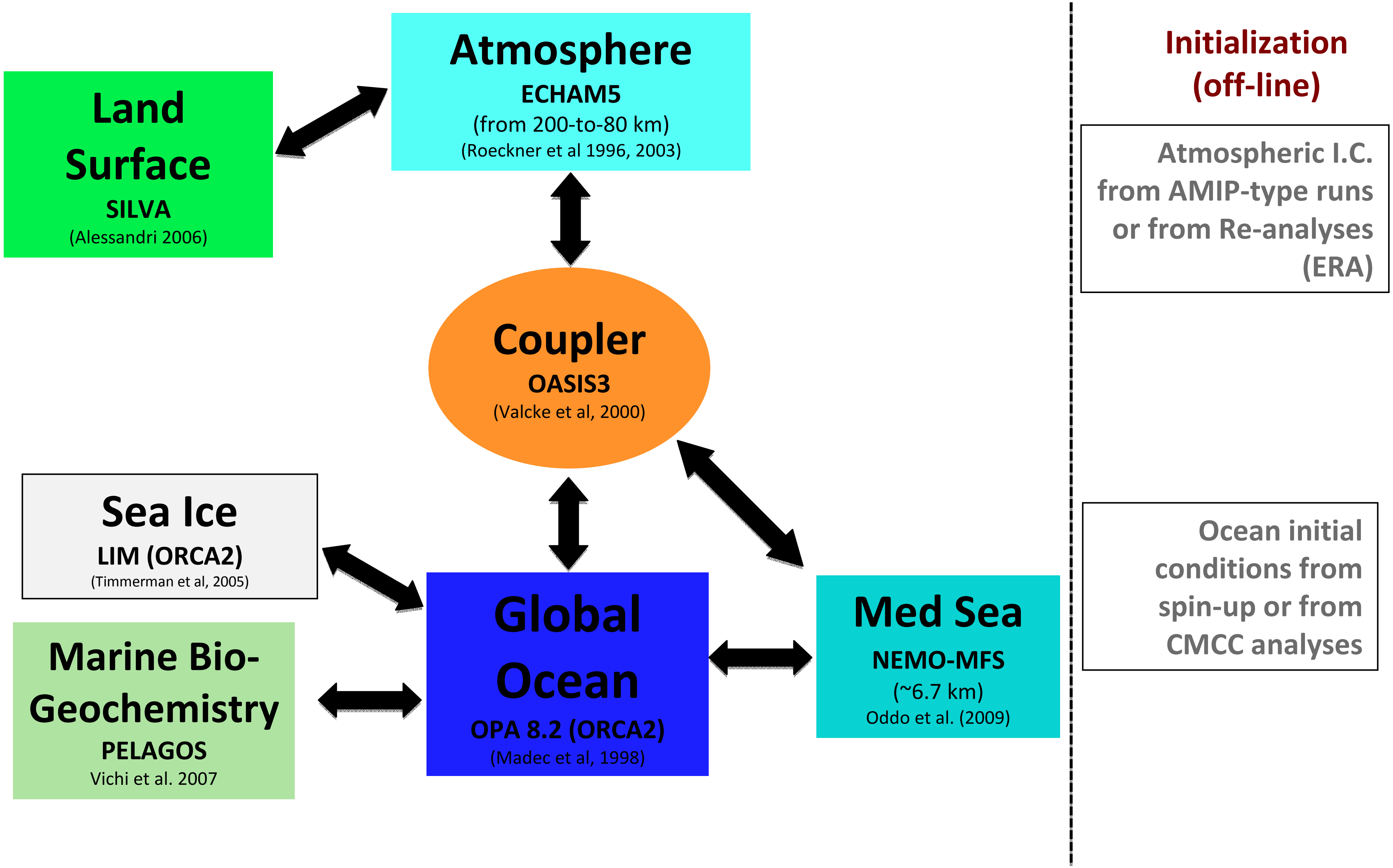


Climate Services (SERC)

Activities:

- Production of climate predictions at seasonal to decadal time-scale and climate change projections (global scale, regional focuses).
- Communication of the results and information obtained to a broad range of users: decision makers and stakeholders, political bodies and public administration, researchers from other disciplines.
- Coordinate research on adaptation policies to climate change and provide technical and scientific support to the institutions for multilateral negotiation processes in the field of climate change (EU, IPCC, UNFCCC).

The CMCC Climate Model

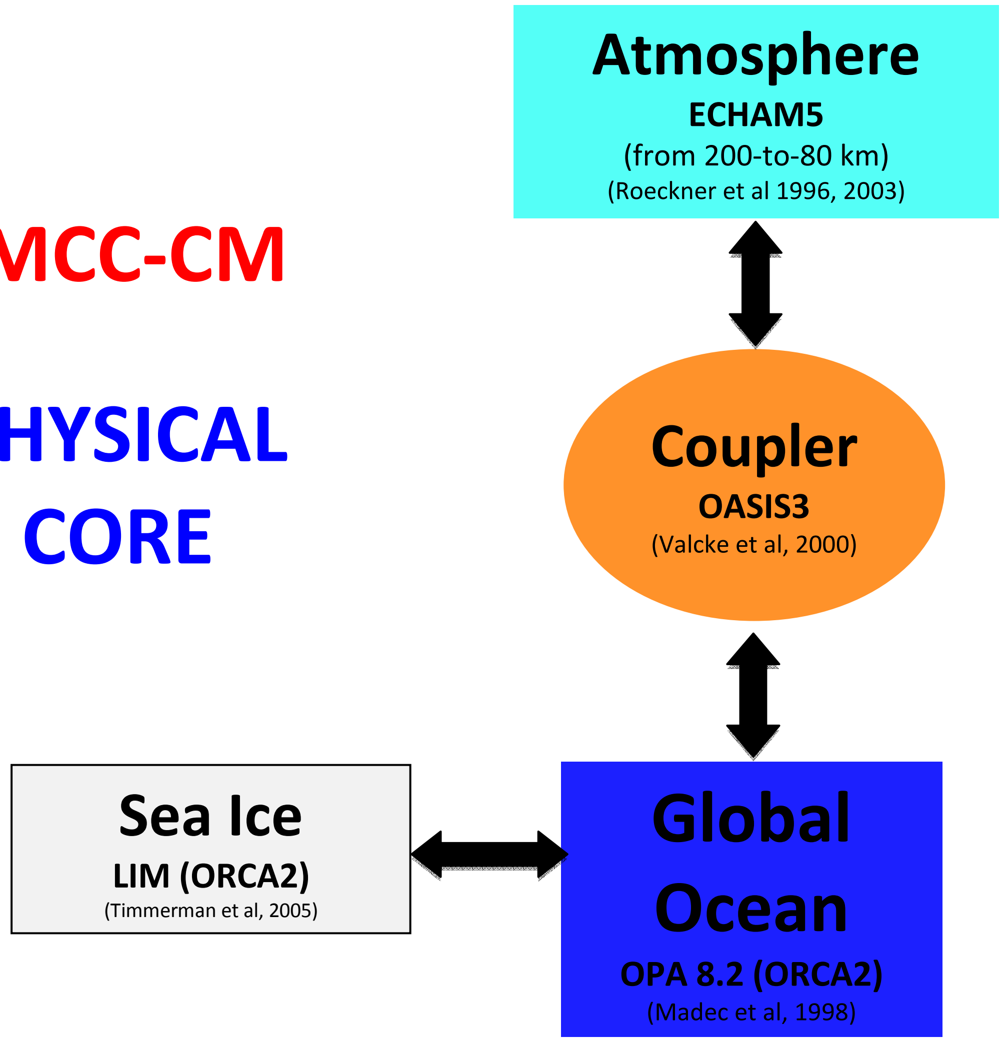


<u>Coupling Daily (or higher frequency) & no flux adjustment</u>

The CMCC Climate Model (CMIP5 configuration)

CMCC-CM

PHYSICAL CORE



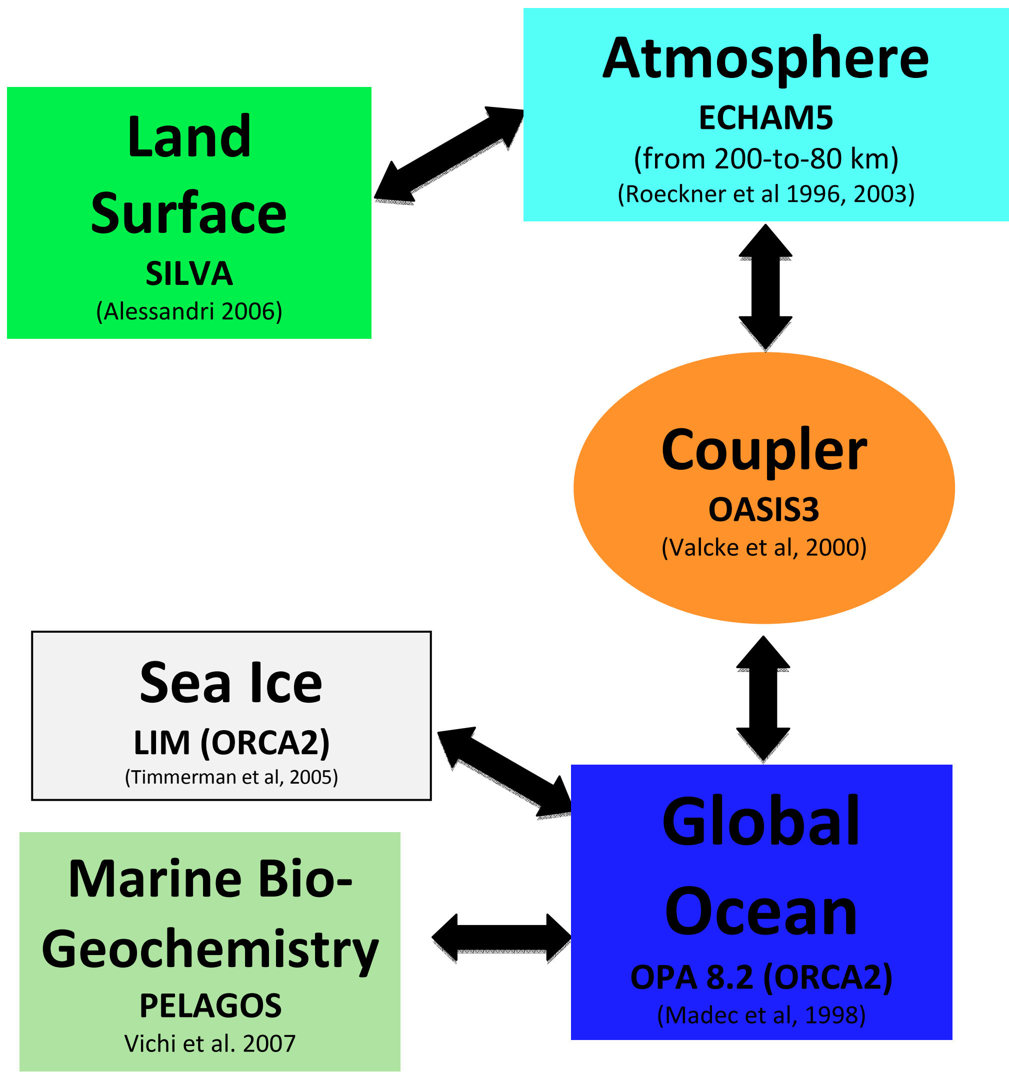
Fogli et al. (2010, CMCC Sci. Rep.)

Scoccimarro et al. (J. Climate. 2011)

Bellucci et al. (Clim. Dyn., 2012)

<u>Coupling Daily (or higher frequency) & no flux adjustment</u>

The CMCC Climate Model (CMIP5 configuration)



CMCC-CESM

CARBON CYCLE

Vichi et al. (Clim. Dyn. 2011)

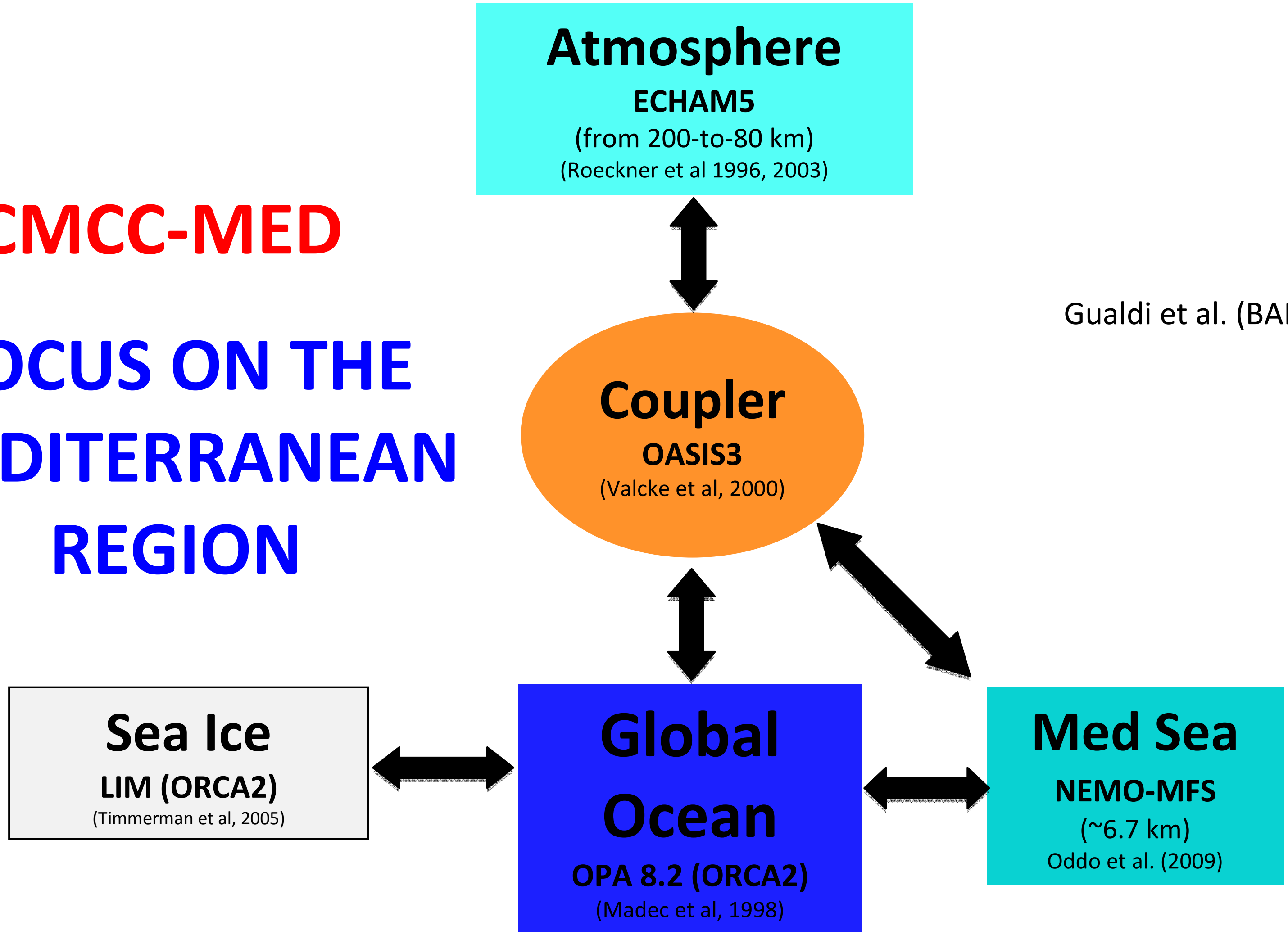
Coupling Daily (or higher frequency) & no flux adjustment

The CMCC Climate Model (CIRCE configuration)

CMCC-MED

FOCUS ON THE MEDITERRANEAN REGION

Gualdi et al. (BAMS, 2013)



Coupling Daily (or higher frequency) & no flux adjustment

How do we use our climate model?

Climate simulations: **explore the mechanisms** that drive the climate variability and climate change. Process oriented investigations on a **wide range of spatial and temporal scales**.

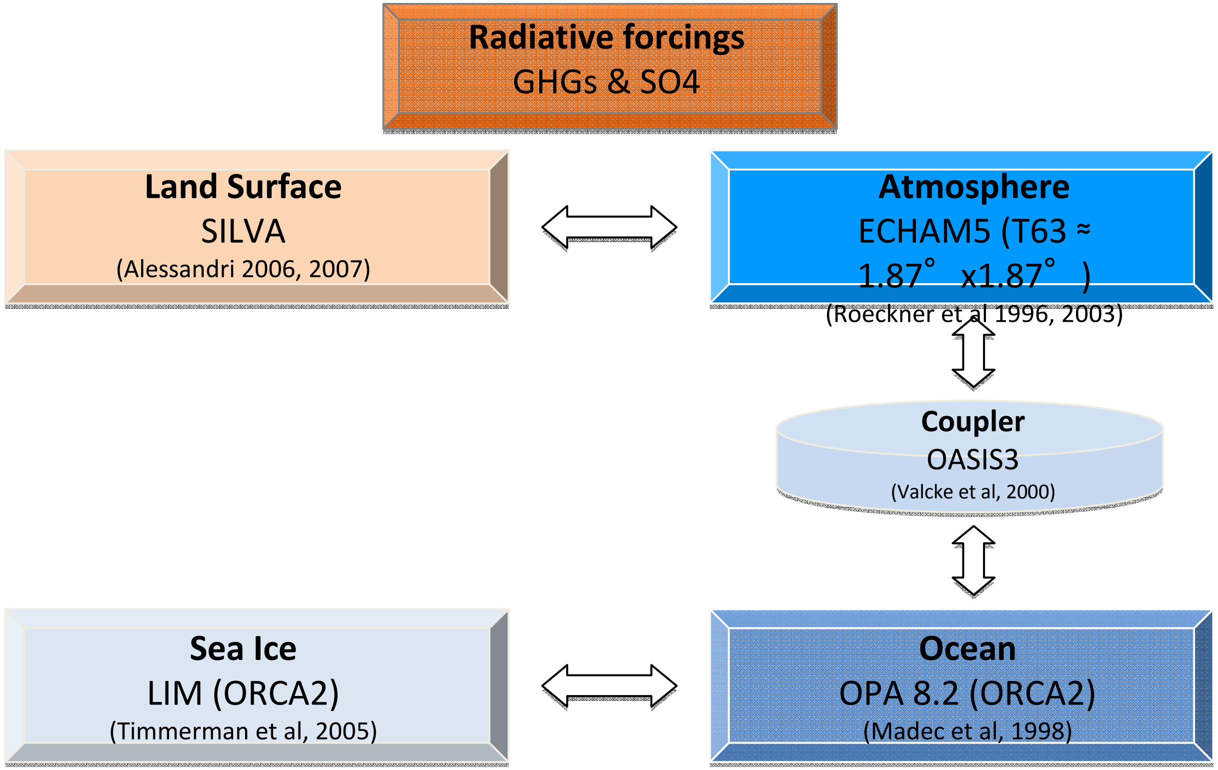
Climate projections: assess the climate change signal according to prescribed scenarios of radiative forcing. Generally long simulations **starting from spin-up initial conditions**. **Identification of long-term trends and changes in the statistics** of parameters of interest.

Short-term projections: assess the climate variations due to both the internal variability and changes in the external forcings. Ensembles of short-term (~10-to-30 years) projections, but **initialized with observed conditions** (specific start date). **Change in the statistics** of parameters of interest.

Seasonal predictions: assess the climate variations mostly due to the internal variability of the climate system. **6-to-12 month simulations initialized with observed conditions** (specific start date). **Prediction of possible anomalous conditions in the "current statistics"** (current climate).

The CMCC Seasonal Prediction System

Coupled Model component



Coupling Daily No flux adjustment

Off line Initialization Tools

The CMCC Global Model represents the various components of the Earth system.

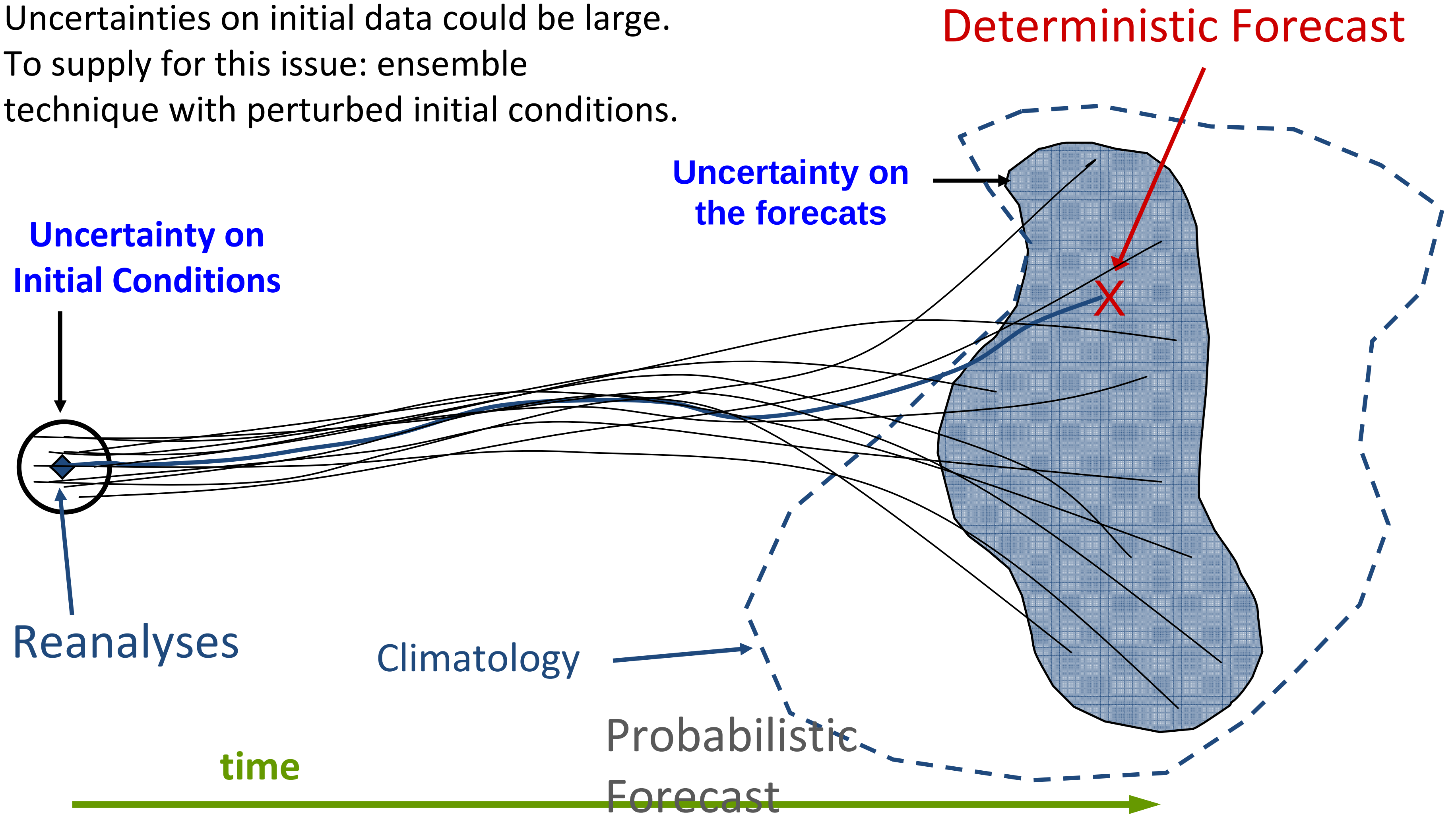
SPSv2

SPSv1

The **CMCC Seasonal Prediction System** is initialized with the "closest to reality" state of the ocean (SPSv1) and land-atmosphere (SPSv2), which drive the model towards a state affected by the initialization itself other than boundary conditions and its internal physics.

Approaching seasonal forecasts

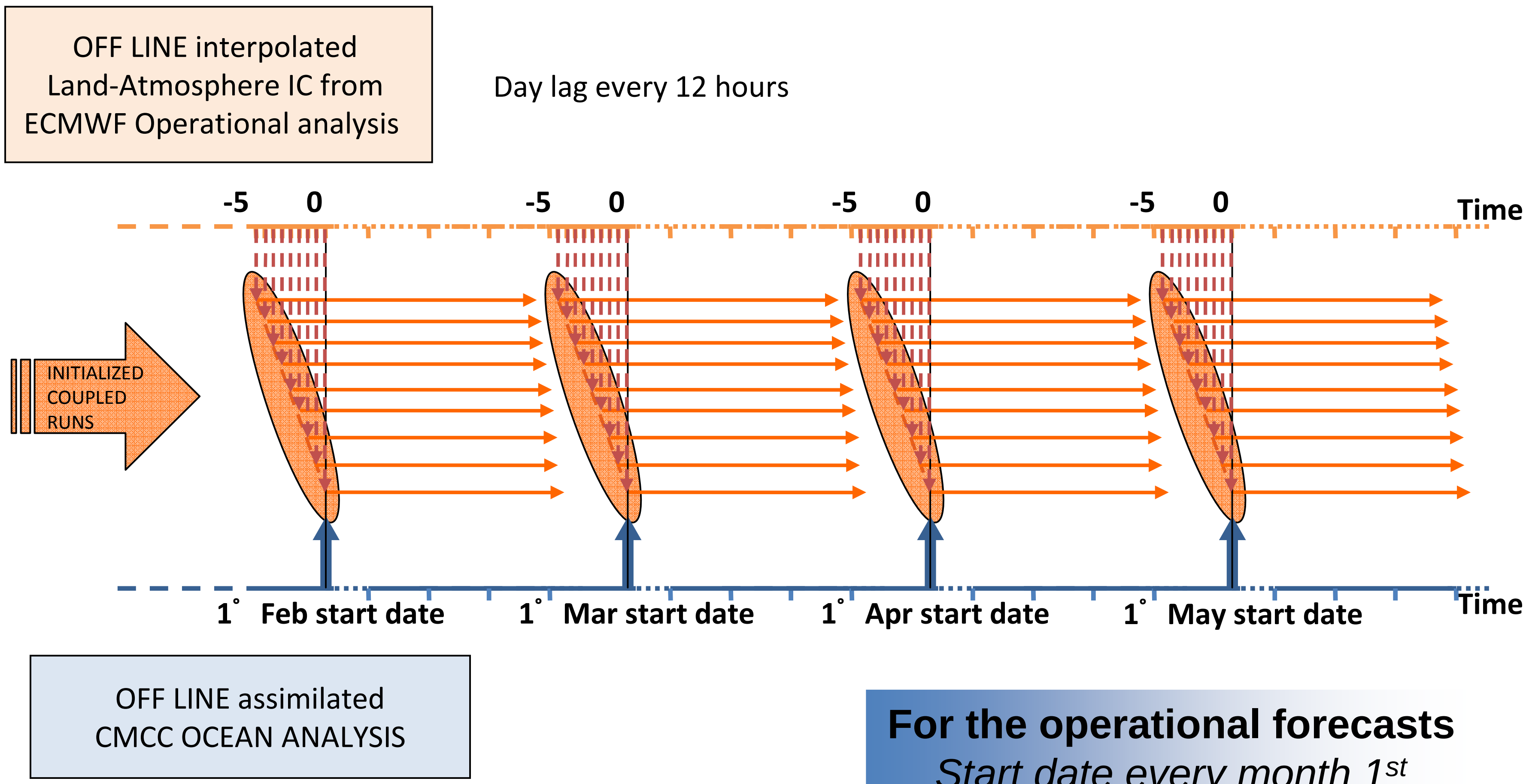
Uncertainties on initial data could be large.
To supply for this issue: ensemble technique with perturbed initial conditions.



Readapted from Trzaska (http://portal.iri.columbia.edu)

The experimental setup

Retrospective forecasts (hindcasts) for validation



For the operational forecasts
Start date every month 1st

- 6-month-integration for the period 1989-2010
- 12 start dates per year (once a month)
- 9 ensemble members for each start date

Results from three different versions of the CMCC-SPS

Experiment / Initialization	SPS1	SPS1.5	SPS2
Ocean	CIGODAS	CIGODAS	CIGODAS
Atmosphere	No	ERA Interim	ERA Interim
Land surface	No	No	ERA Interim

Materia et al., 2013

CIGODAS is the CMCC-INGV Global Ocean Data Assimilation System
ERA Interim is the ECMWF Re-Analysis product at T255 (about 60 km).

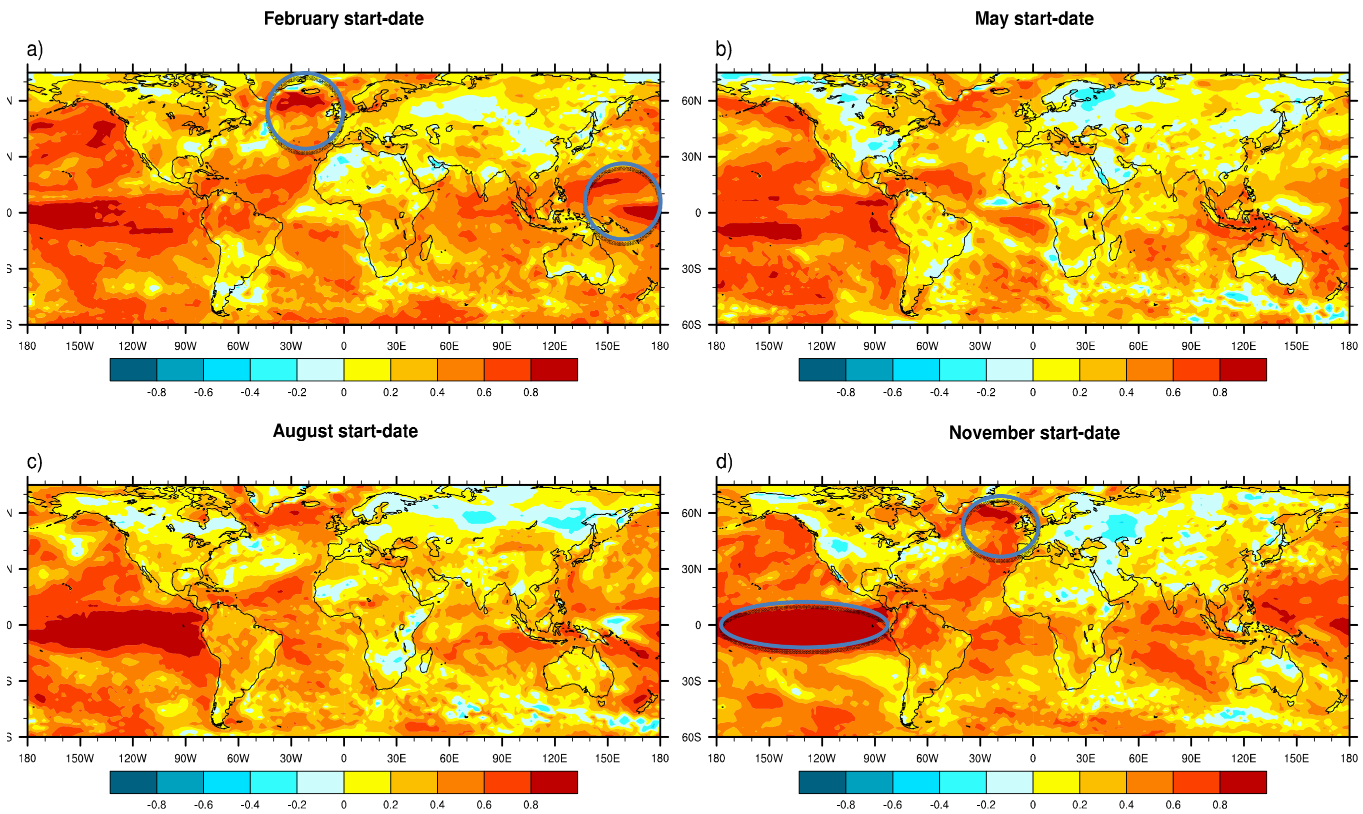
Atmosphere initialization: Temperature, Winds, Specific Humidity, etc on the atm. Lev.

Land surface initialization: Soil moisture, Temperature, Snow

Validation of the CMCC-SPS

Tsurf Anomaly Correlation (ACC) lead time 1

Lead time 1 refers to the season starting one month after the start date (e.g. Feb lead 1 = MAM)



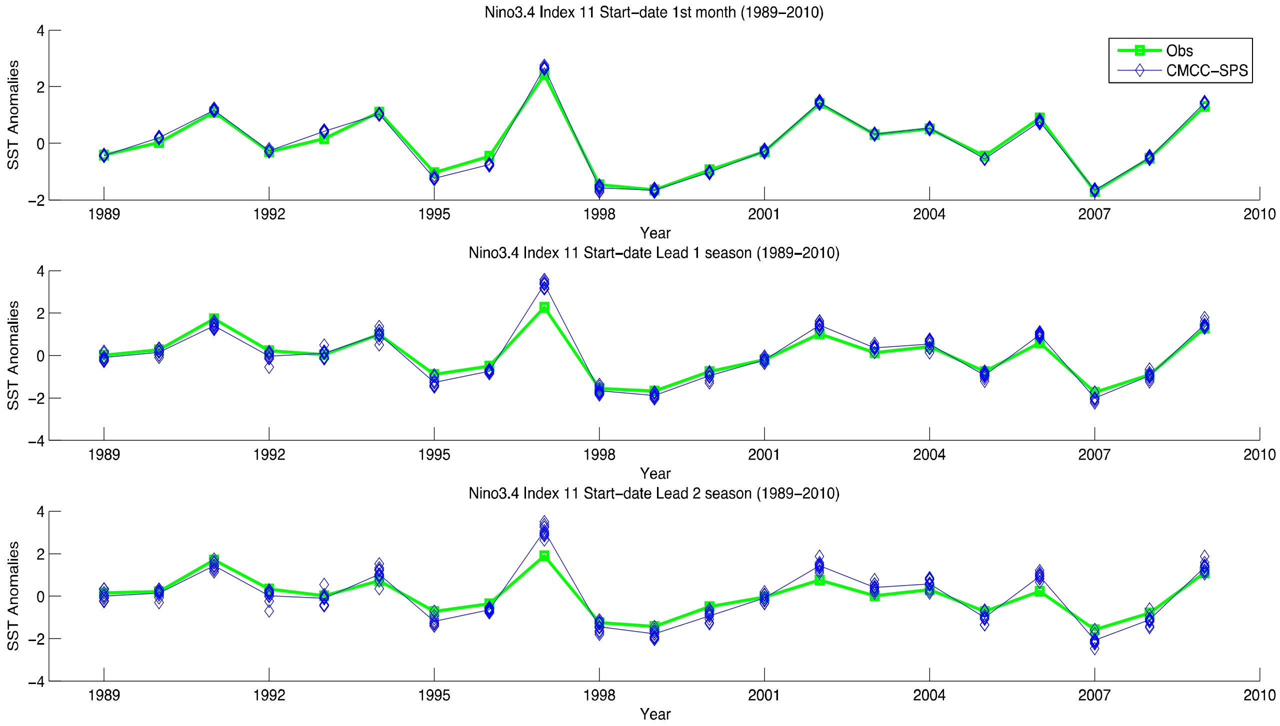
ACC is a measure of the skill of the system, indicating the correlation between forecast and ERAinterim reanalyses between 1989-2010. Values close to 1 => high predictability.

•Predictability is higher in the Tropics and in the oceans than on continents.

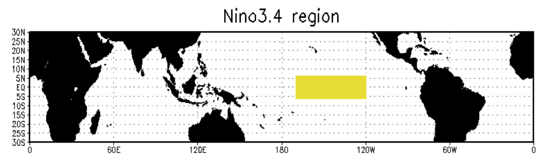
- High skill in the ENSO area and teleconnected regions.
- Good skill in the northern Atlantic region, particularly in the winter and the spring

Validation of the CMCC-SPSv2

Predictability of ENSO



SST anomalies in the NINO 3.4 region

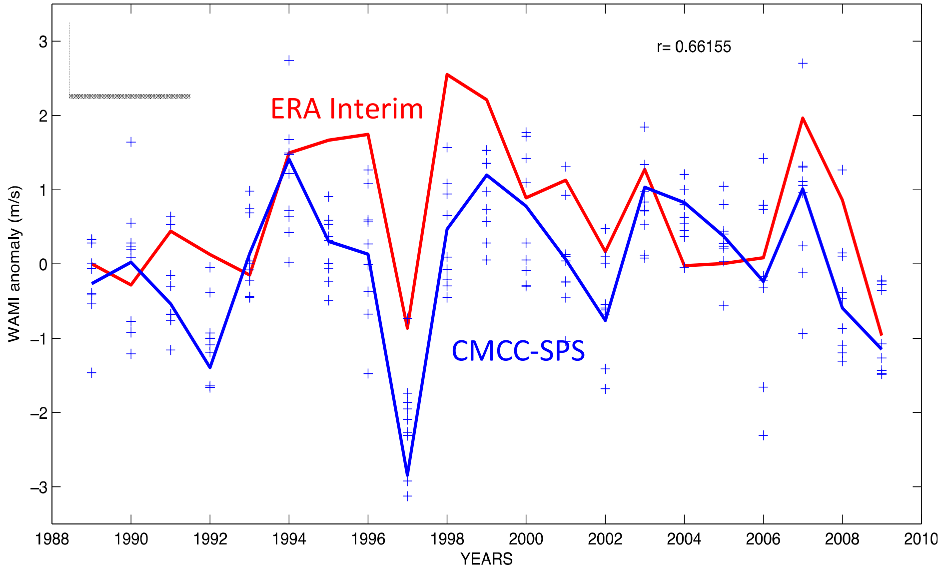


Lead 1 (2) refers to the season starting one (two) month after the start date (here, Nov lead 1 (2) = DJF (JFM))

The ENSO signal is well predicted by the CMCC-SPS, with anomaly correlation coefficients higher than 95% in the NINO3.4 region

Validation of the CMCC-SPSv2

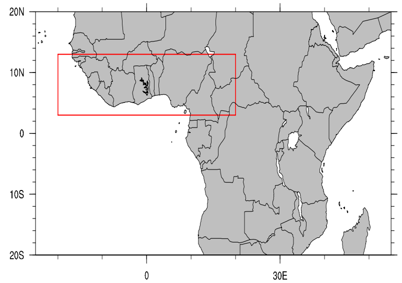
WAMI anomaly (m/s) May start date, lead 1 (JJA)



Predictability of the West African Monsoon

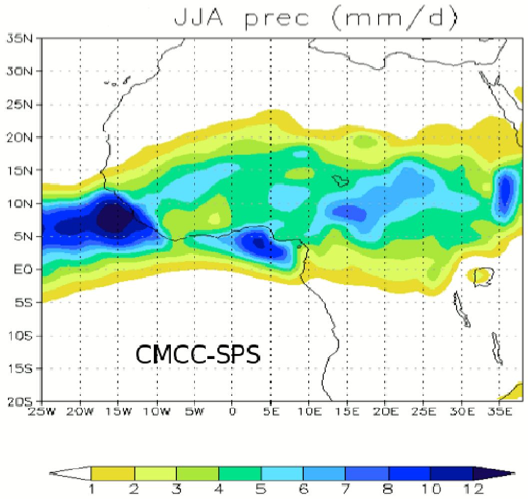
WAMI = $u_{850hPa} - u_{200hPa}$

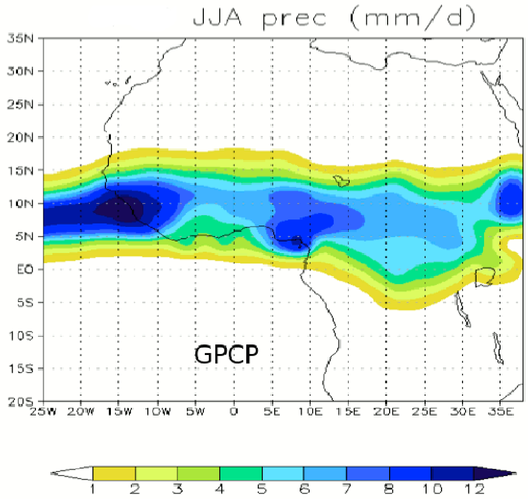
Fontaine et al., 1995 J.Clim



CMCC-SPSv2 intercepts the interannual variability of Monsoon winds.

CC model/obs = 0.66





Nevertheless, precipitation during the summer, turns out to be too weak and to penetrate too much northward compared to GPCP observations.

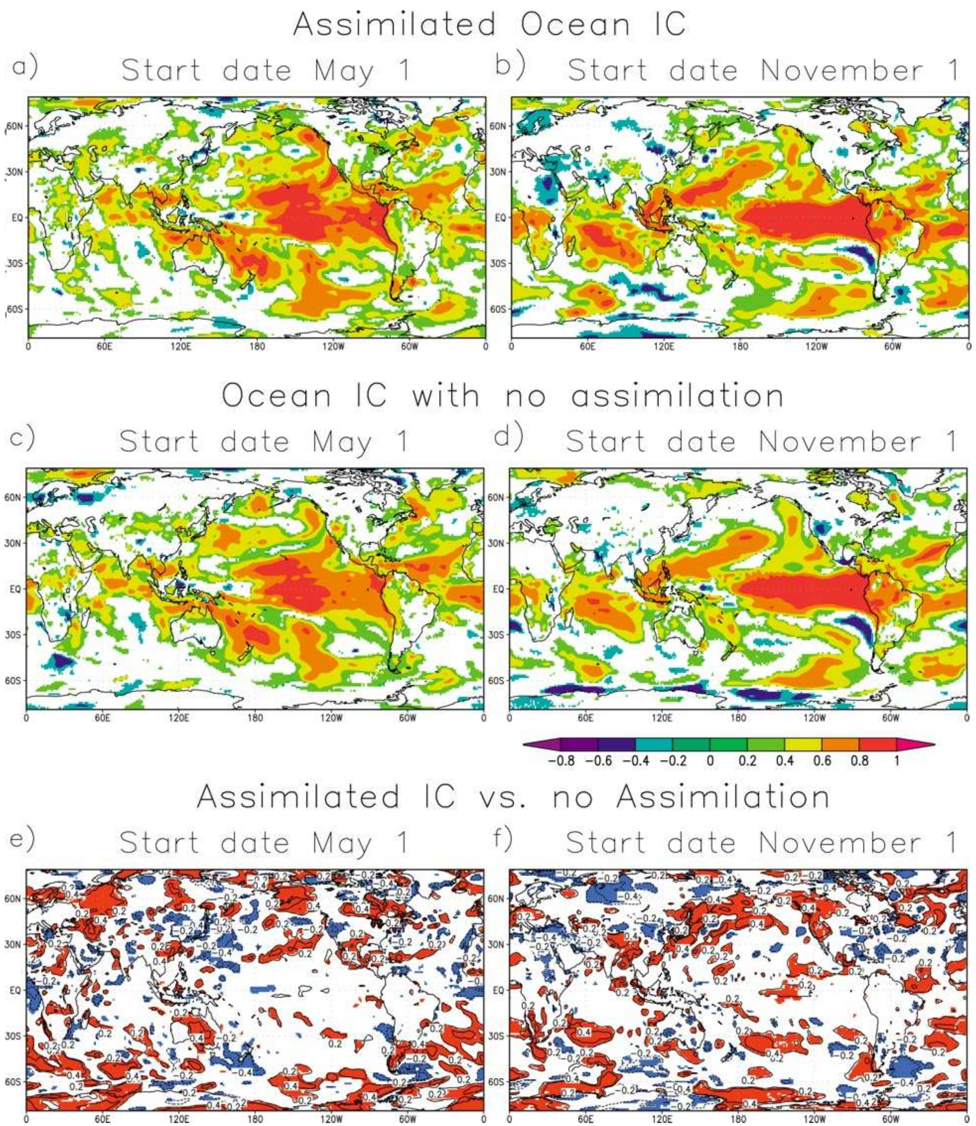
The importance of an accurate ocean (CIGODAS Reanalysis)

MAY **NOVEMBER**

Ocean IC **with** Assimil.

Ocean IC **without** Assimil.

Difference

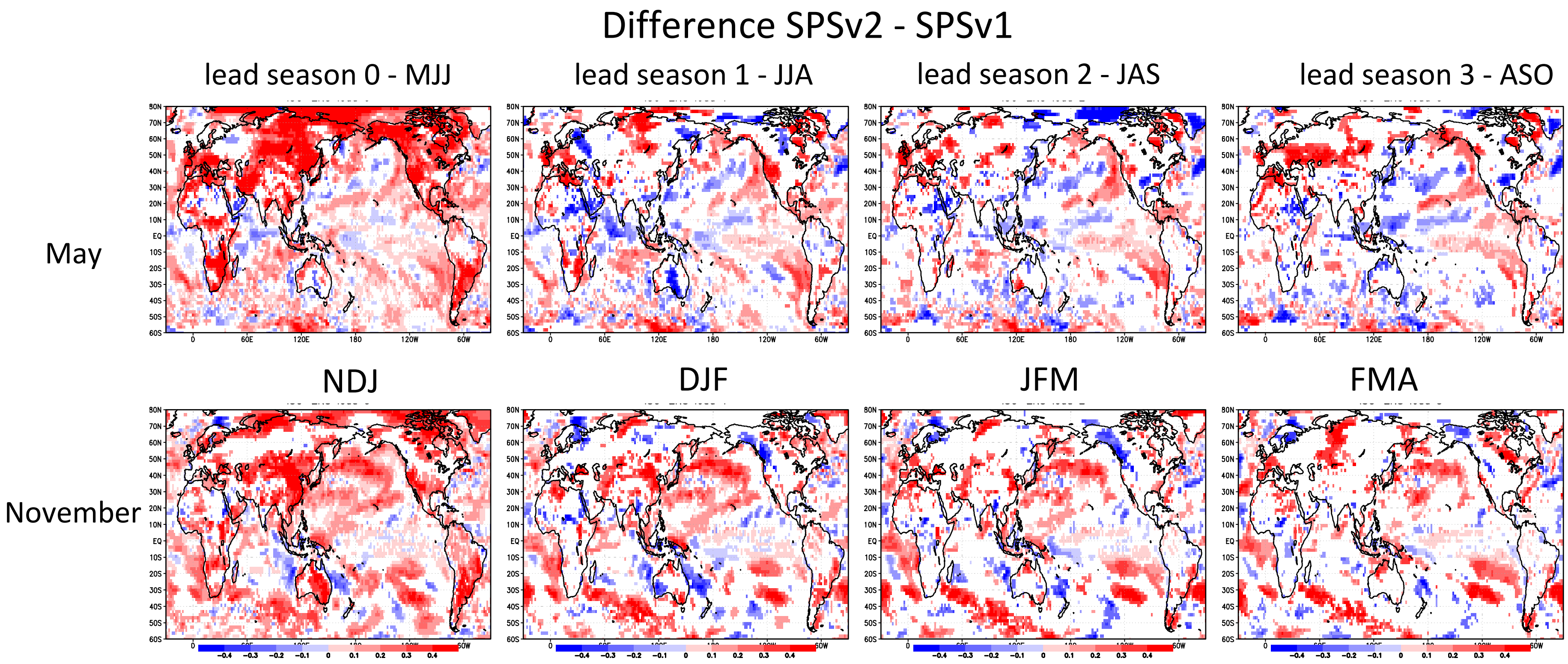


ACC for the start date of May and November (SPSv1) which assimilates observed profiles of temperature and salinity through the water column of the global configuration of the OPA8.2 ocean model.

Comparison with an AMIP-like initialization, performed by prescribing observed SST (HadISST1.1; Rayner et al. 2003) boundary forcing to the atmospheric model.

From Alessandri et al., 2010

The introduction of land-atmosphere initial state

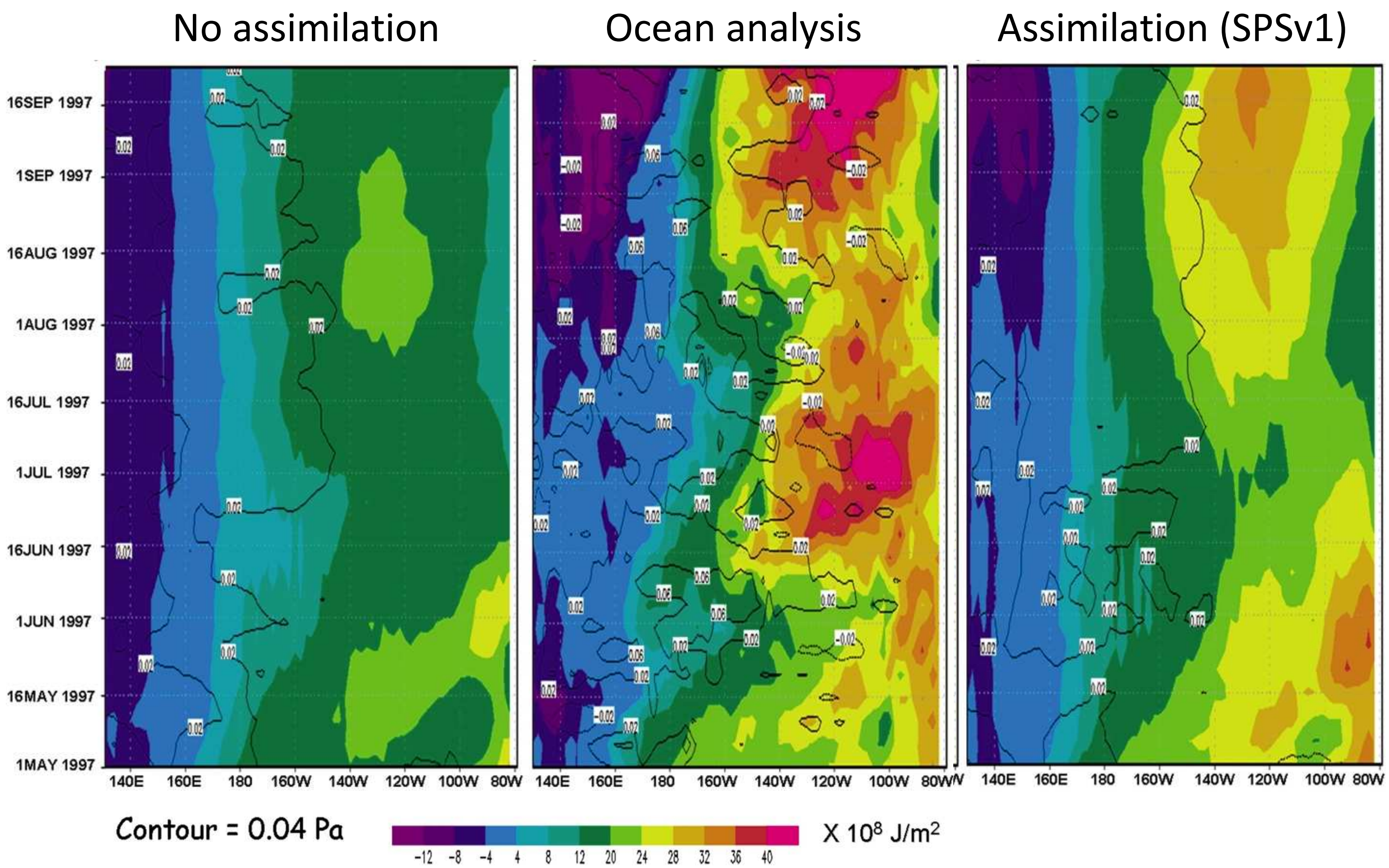


Surface temperature ACC (reference ERAinterim), difference between SPSv2 and SPSv1

SPS2 provides a remarkable improvement of the forecast skill at lead-season 0, where the effect of initialization is clearly reflected. Continental areas benefit the most from the more realistic initial state, but enhancements are mainly lost after lead-season 0. In the ocean instead

- northern Pacific, long-lasting skill improvements due to strong air-sea coupling in the region during the fall. SSTAs force a PNA pattern response, atmo reaction could in turn change SSTs
- ENSO region in May. In the season of major upwelling, SSTs are mostly determined by upwelling of deep water, which does not change in the two experiments

El Nino 1997/1998: onset



Evolution of the heat content anomaly (shaded) and zonal wind stress anomaly (contour) averaged between 5S and 5N. Forecast anomalies are ensemble means.

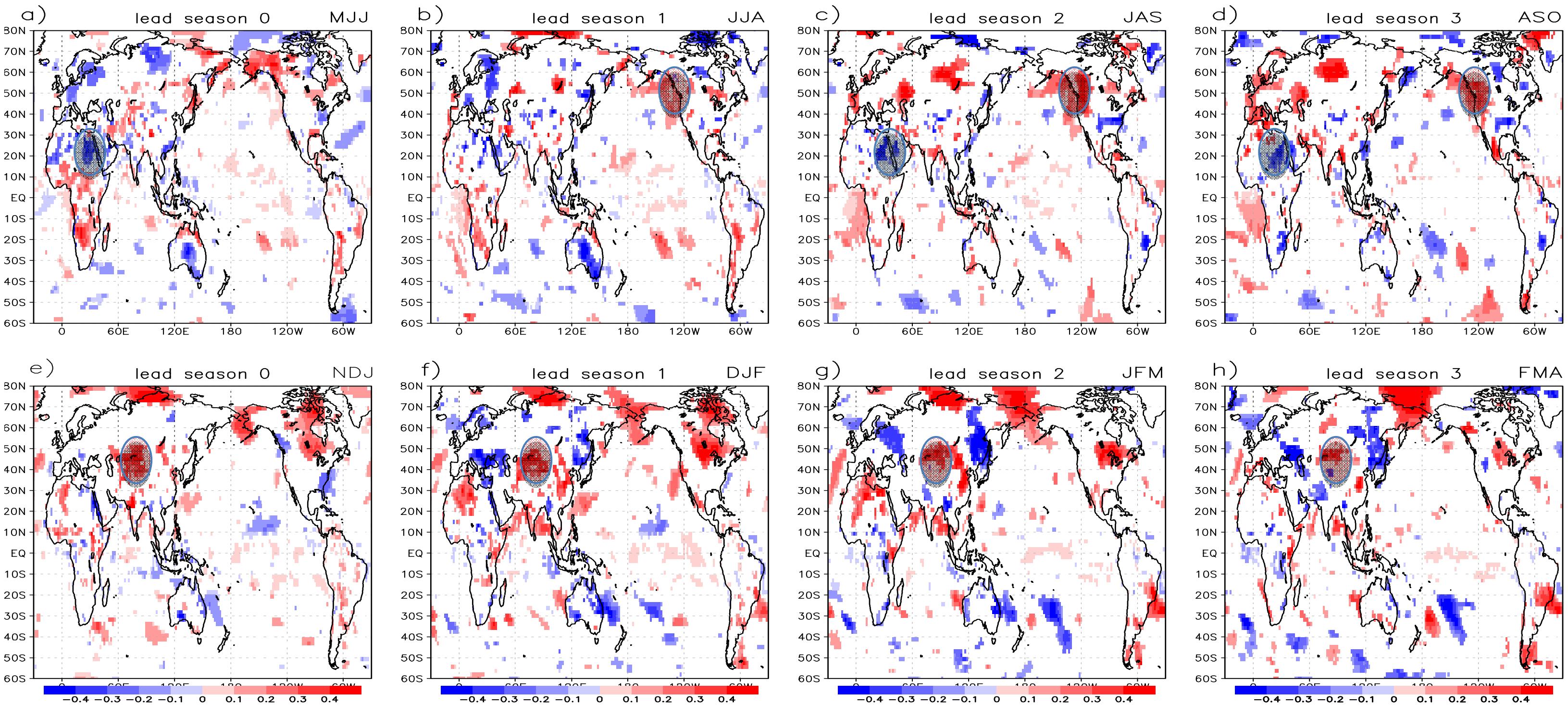
From Alessandri et al., 2010

Separating the contribution of atmosphere and land surface initial state

The SPSv1.5 experiment maintains the atmosphere initial conditions, but excludes the prior knowledge of land-surface state.

May

Nov



SPSv2-SPSv1.5, May/Nov start dates: **Surface temperature ACC**

Differences in ACC are larger on continents than over ocean, and improvements carried by SPSv2 are season and region dependent. Sometimes better land surface IC degrade the quality of the forecast, most likely due to the initialization technique (Materia et al. 2013)

The seasonal forecast bulletin

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

Research Papers
Issue 2012
August 2012

SERC – Climate SERvice Division - c/o Istituto Nazionale di Geofisica e Vulcanologia Viale Aldo Moro 44 - 40122 Bologna

CMCC-SPSv2.0 Seasonal Forecast August 2012

SUMMARY

In the upcoming six months a permanent warm conditions from the current state is predicted for Equatorial Pacific. The extra-tropical North Pacific will be warmer than the average in the western sector, colder alongside the American coast. Below normal temperature will characterize Western Canada and Australia. While a transition from the current warm state to colder conditions is predicted for North-Western Europe. Warm conditions for Northern Asia is predicted. Central and West Africa, East Indian Ocean, Australia, Indonesia and Philippines are expected to undergo a dry season, while wet conditions are predicted for Western Central Pacific.

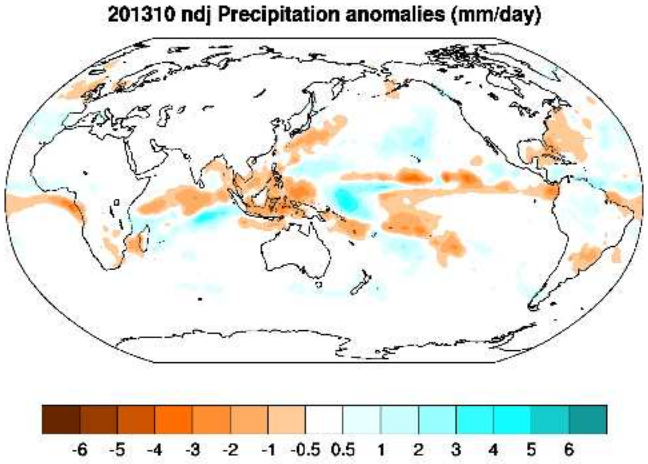
This bulletin is based on model simulations performed with the Seasonal Prediction System developed at CMCC (CMCC-SPSv2). A 6-month forecast is produced every month starting from a synthesis of the current state of the ocean and the atmosphere. Both deterministic and probabilistic predictions are provided for global precipitation and surface temperature fields. A regional focus on the equatorial Pacific (NINO3 region) is also supplied.

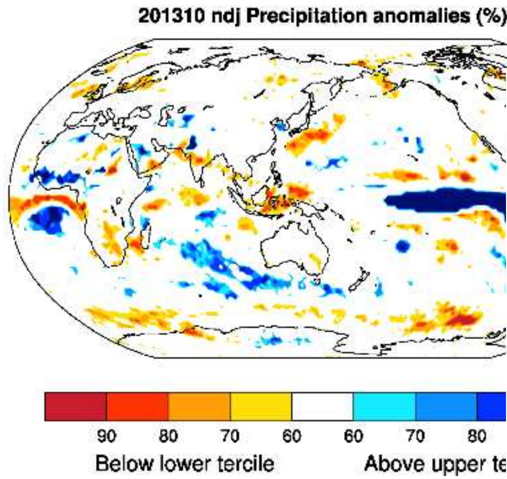
Important! Seasonal Forecasts do not provide any detailed spatial information, but only give a general sense of the character of the season by providing a forecast of seasonal temperature and rainfall anomalies probability of occurrence.

- Quasi-monthly product
- Still a scientific exercise (not operational yet)
- It provides updates about actual situation, verification versus the latest season, and the forecast for the next one
- Available upon request, on-line soon

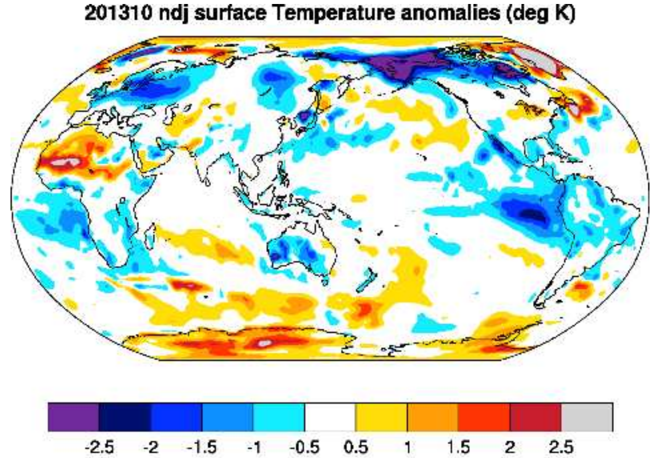
Seasonal forecast for late autumn-early winter (NDJ)
GLOBAL VIEW

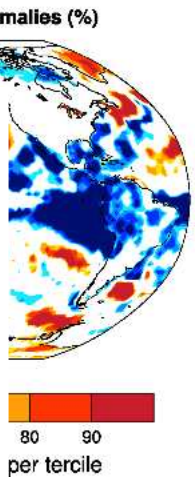
PRECIPITATION

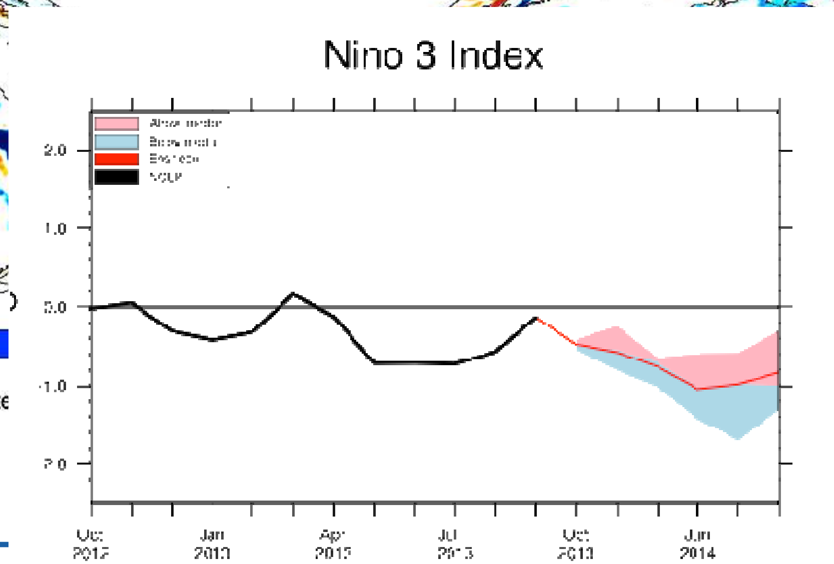




TEMPERATURE

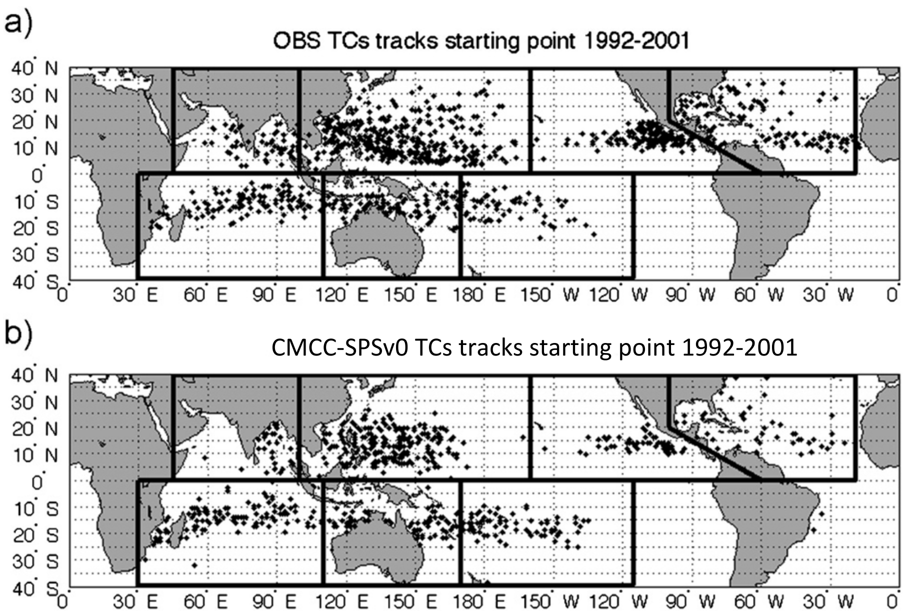






The CMCC Seasonal Prediction System

Seasonal Predictions of Tropical Cyclone Activity

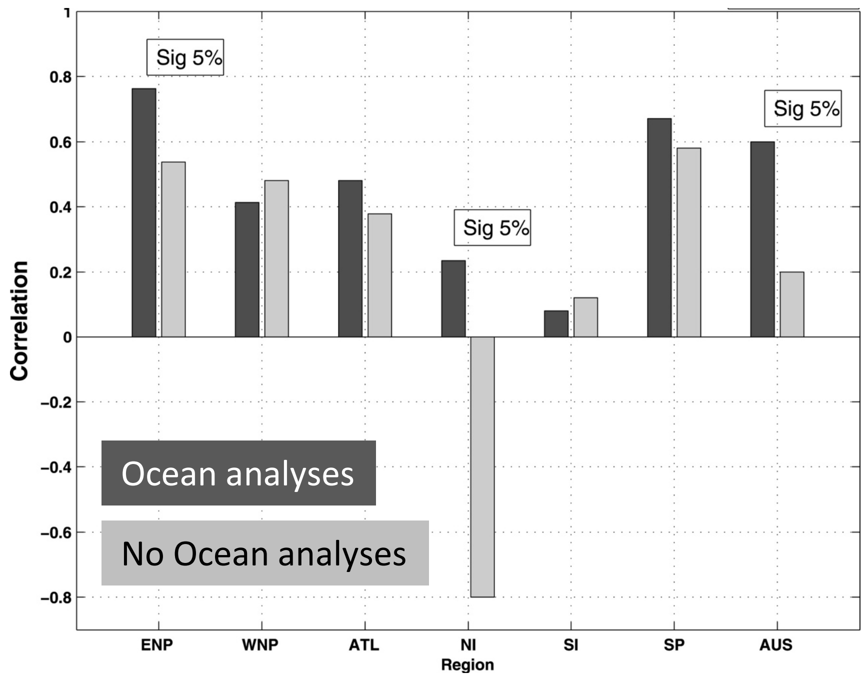


Number of TCs	OBS	DAS	NODAS
ToT	678	438	403
Mean	67.8	43.8	40.3
STD	7.0	4.9	4.8

Although CMCC-SPS underestimates the number of Tropical Cyclones, their location is well detected.

Correlation between predicted and observed number of TCs increases significantly when the **ocean analyses are used to initialize the forecasts**

Ocean Initialization vs. no Ocean Initialization



Alessandri et al. J. Climate 2010 Gualdi et al. J. Climate 2008 Scoccimarro et al. J. Climate 2011

Thanks!

enrico.scoccimarro@bo.ingv.it

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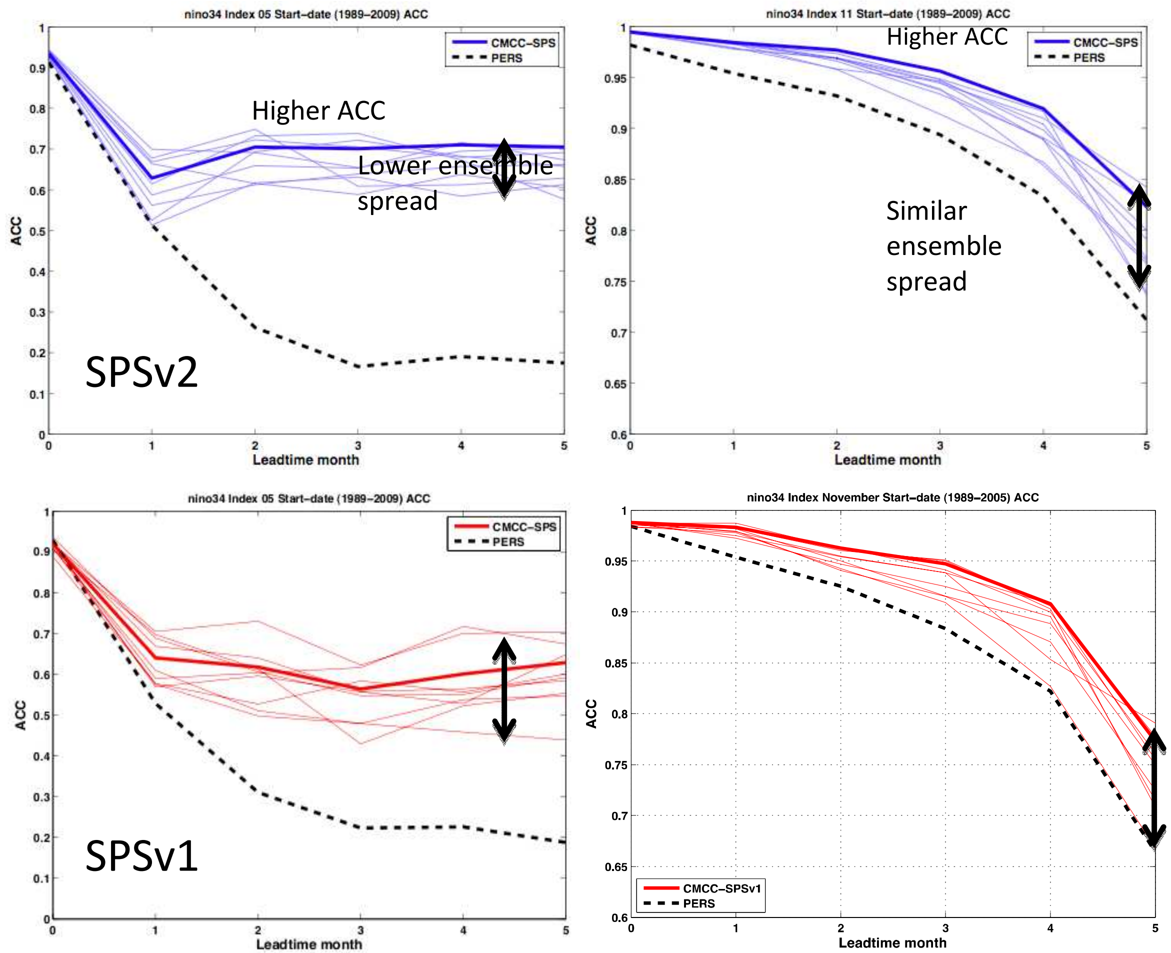
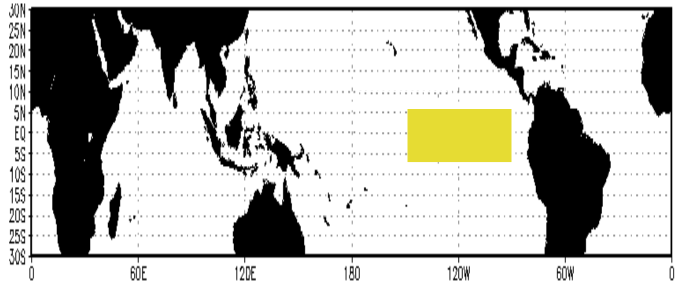
NINO3 Index

SST ACC

May | November



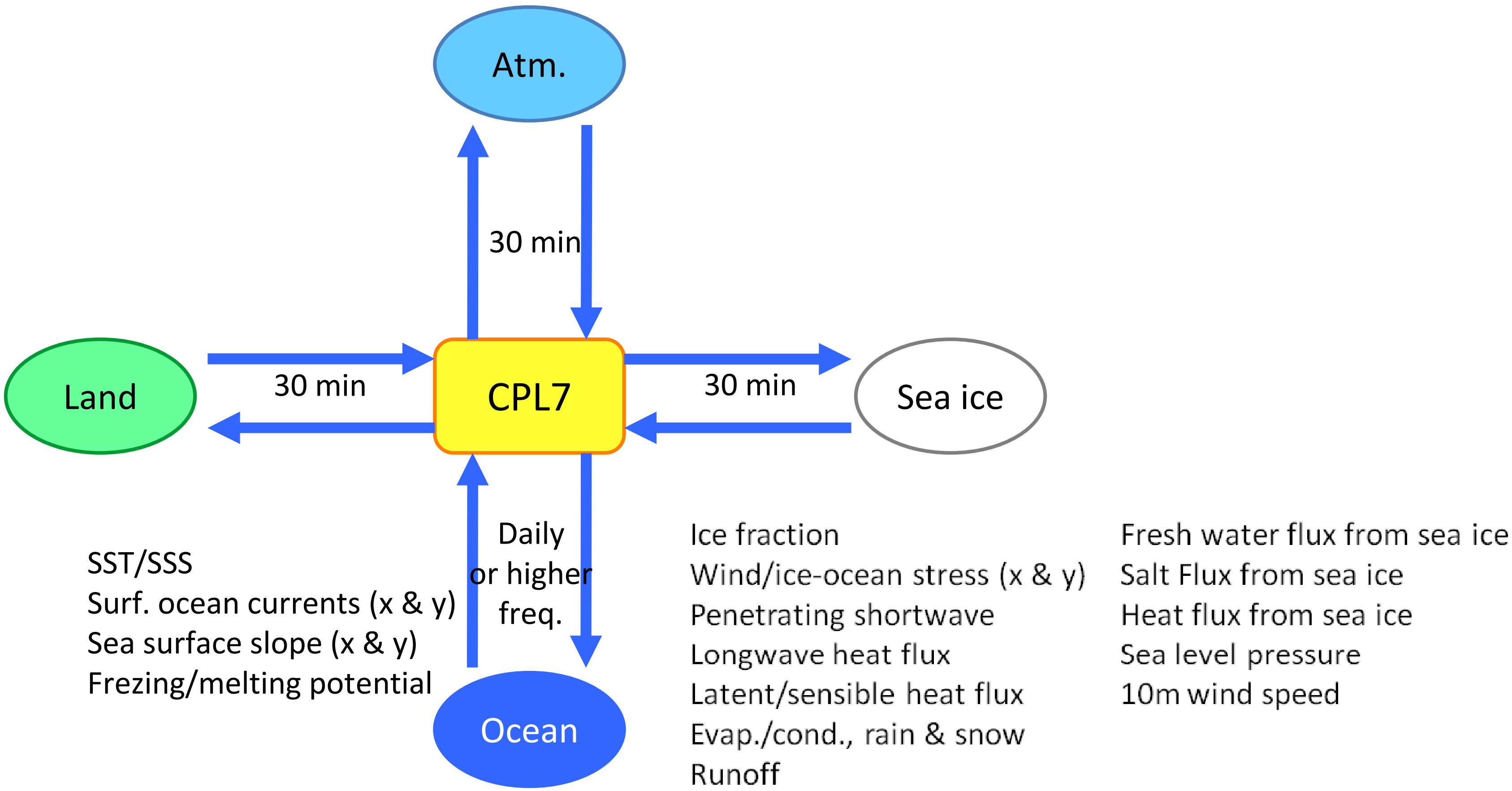


The introduction of land-atmosphere initial condition demonstrates an important and potentially predictable impact on the forecasts of equatorial Pacific SST (particularly in May), either as a result of the intra-seasonal stochastic component of the atmospheric initial state (Shi et al., 2011), or for the amplification of initial condition error in such a coupled system (Hudson et al., 2011).

Future Plans

NEW COUPLED MODEL: NEMO-CAM

Coupling interface

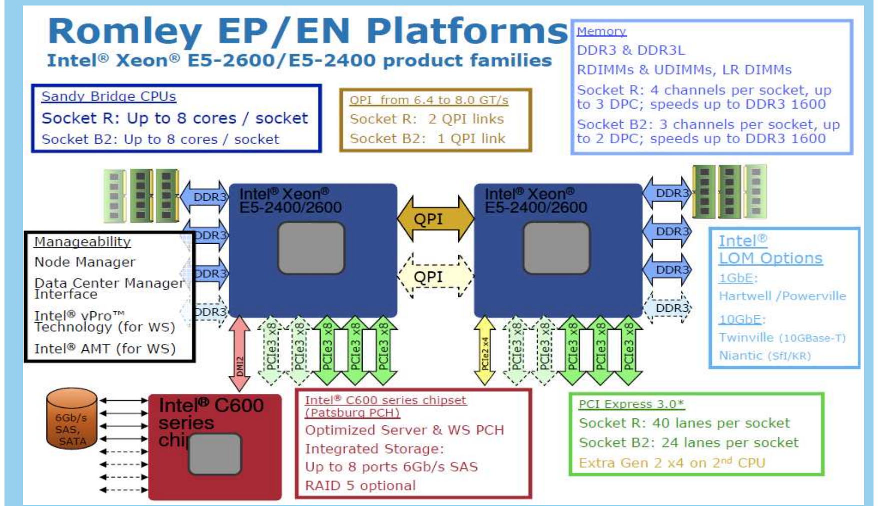


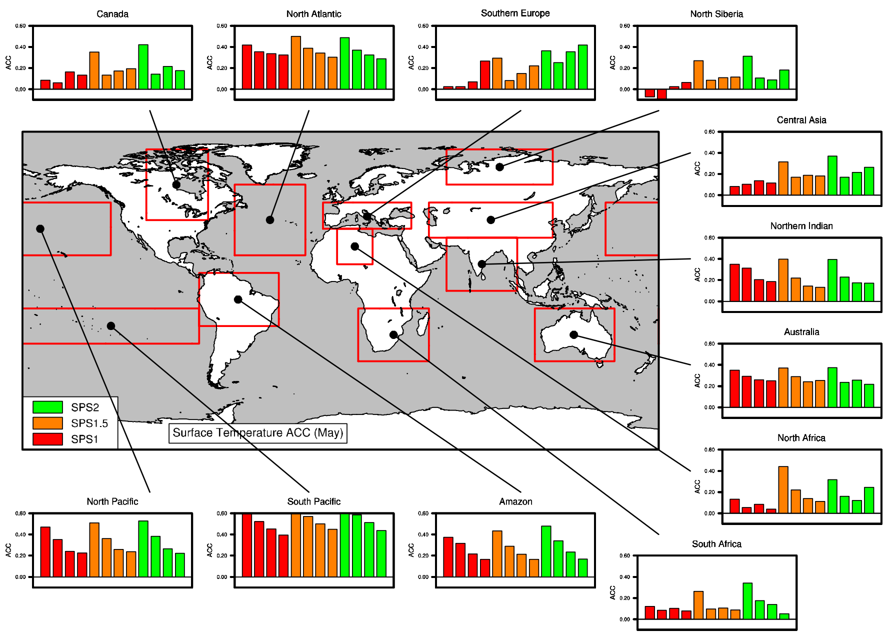
The CMCC supercomputing facility

- 482 nodes IBM dx360 M4
- 7712 cores Intel Xeon Sandy Bridge 2,6GHz
- 30,1 TB of RAM (4GB RAM per core)
- peak performance: 160 TFlops
- Infiniband 4x FDR Interconnection
- workload manager: LSF
- operating system: Linux CentOS x86_64

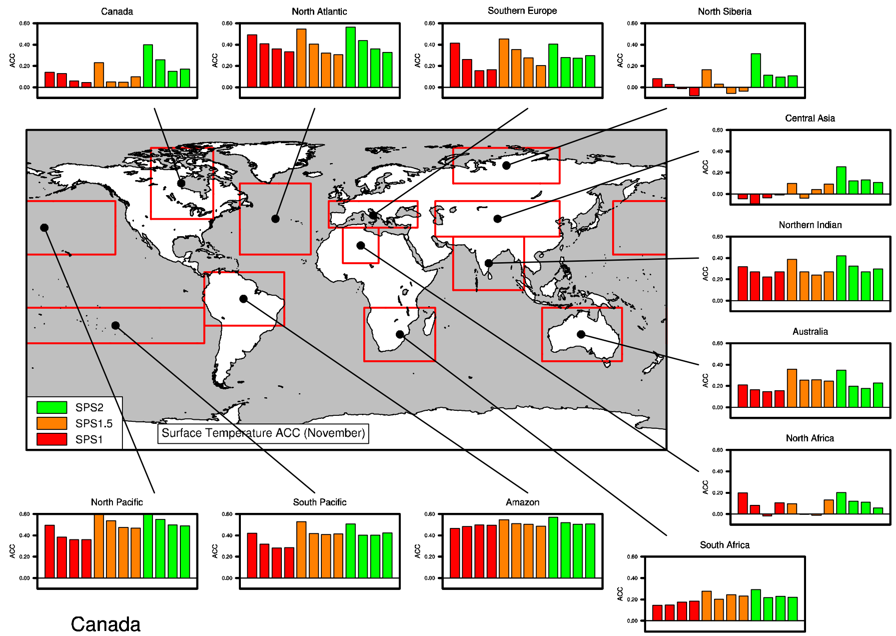
- two DDN SFA10000 storage systems
- 840TB raw space
- 6 GB/s I/O throughput per disk array

Intel Xeon E5-2600 basic architecture

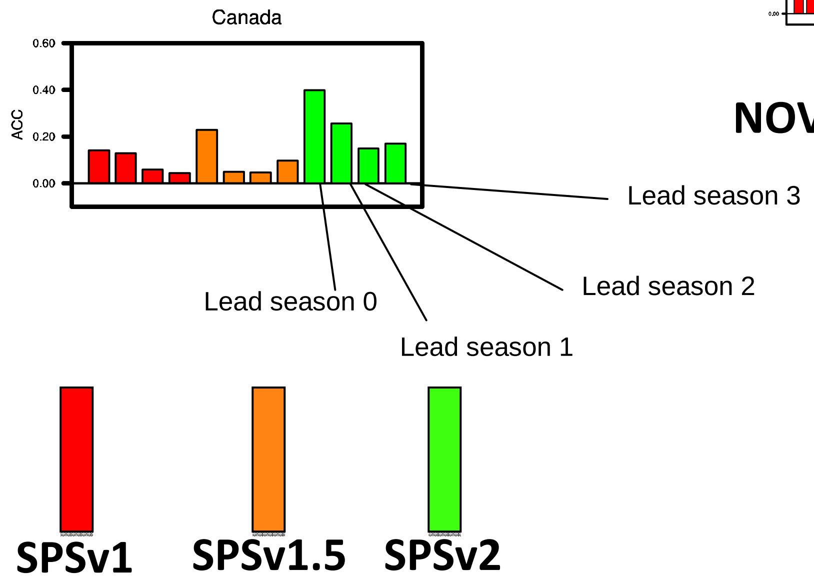




MAY



NOVEMBER

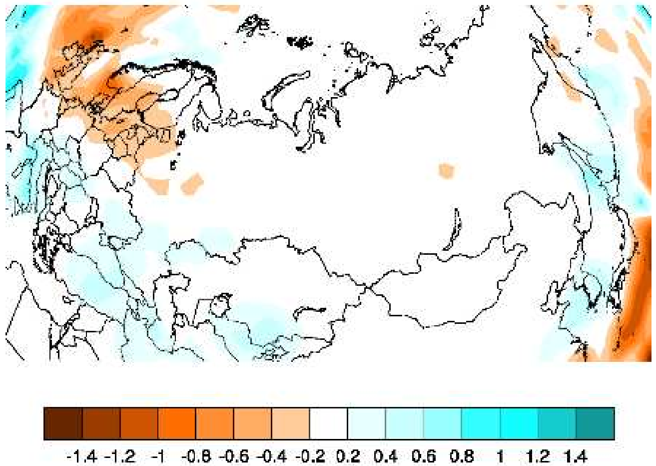


Anomaly correlation for the tree different version of CMCC-SPS

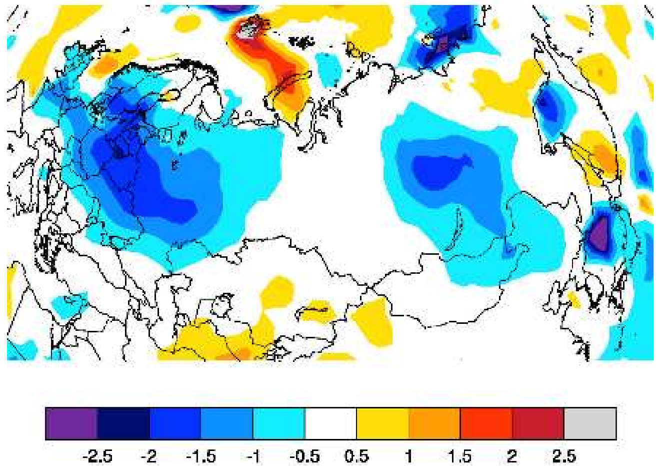
Materia et al., 2013

Seasonal forecast for late autumn-early winter (NDJ)
NORTH EURASIAN REGION

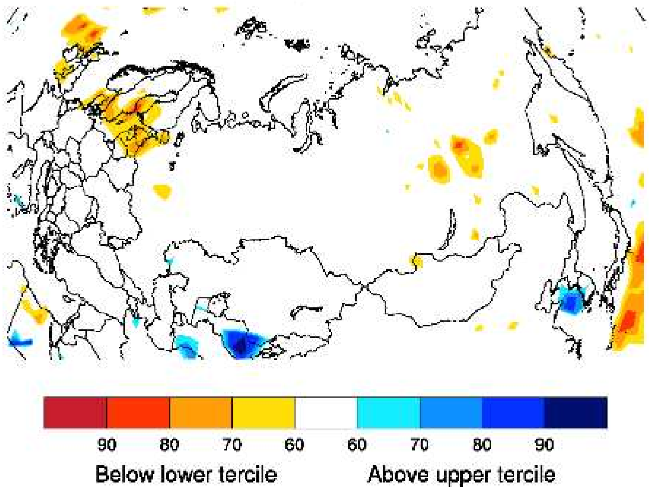
201310 ndj Precipitation anomalies (mm/day)



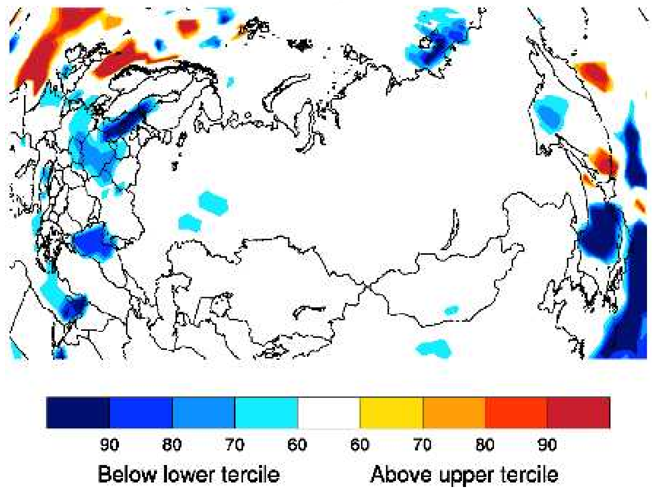
201310 ndj surface Temperature anomalies (deg K)



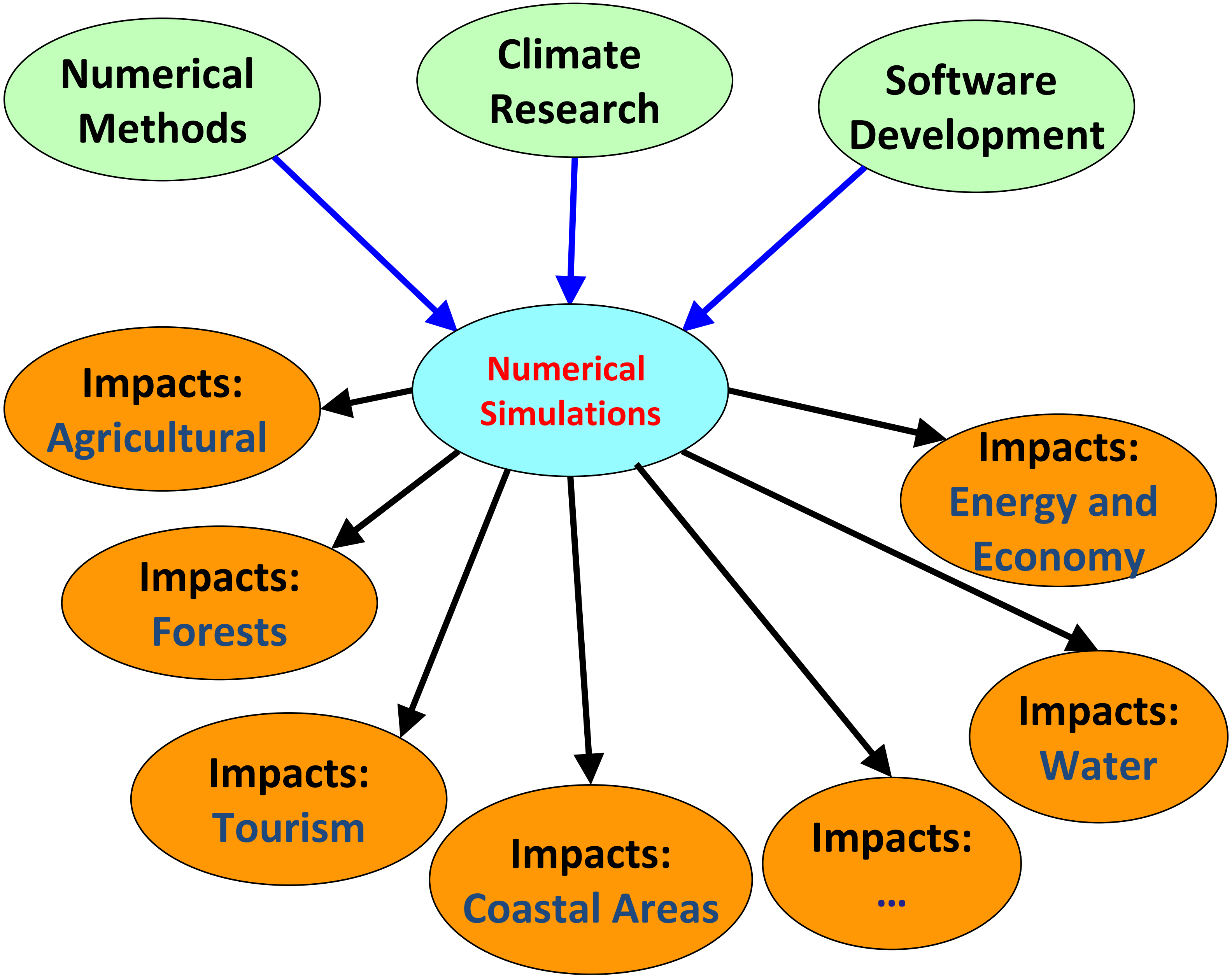
201310 ndj Precipitation anomalies (%)



201310 ndj surface Temperature anomalies (%)



The CMCC Approach



The CMCC Network

CMCC has a network structure composed by Research Divisions and Partners, which are distributed along seven Italian headquarters

- Fondazione Eni Enrico Mattei – FEEM (Milano)
- Università Ca' Foscari (Venezia)
- Istituto Nazionale di Geofisica e Vulcanologia – INGV (Bologna)
- Università della Tuscia (Viterbo)
- Università di Sassari (Sassari)
- Centro Italiano Ricerche Spaziali – CIRA (Capua)
- Università del Salento (Lecce)