The Abdus Salam
International Centre for Theoretical Physics

2148-15

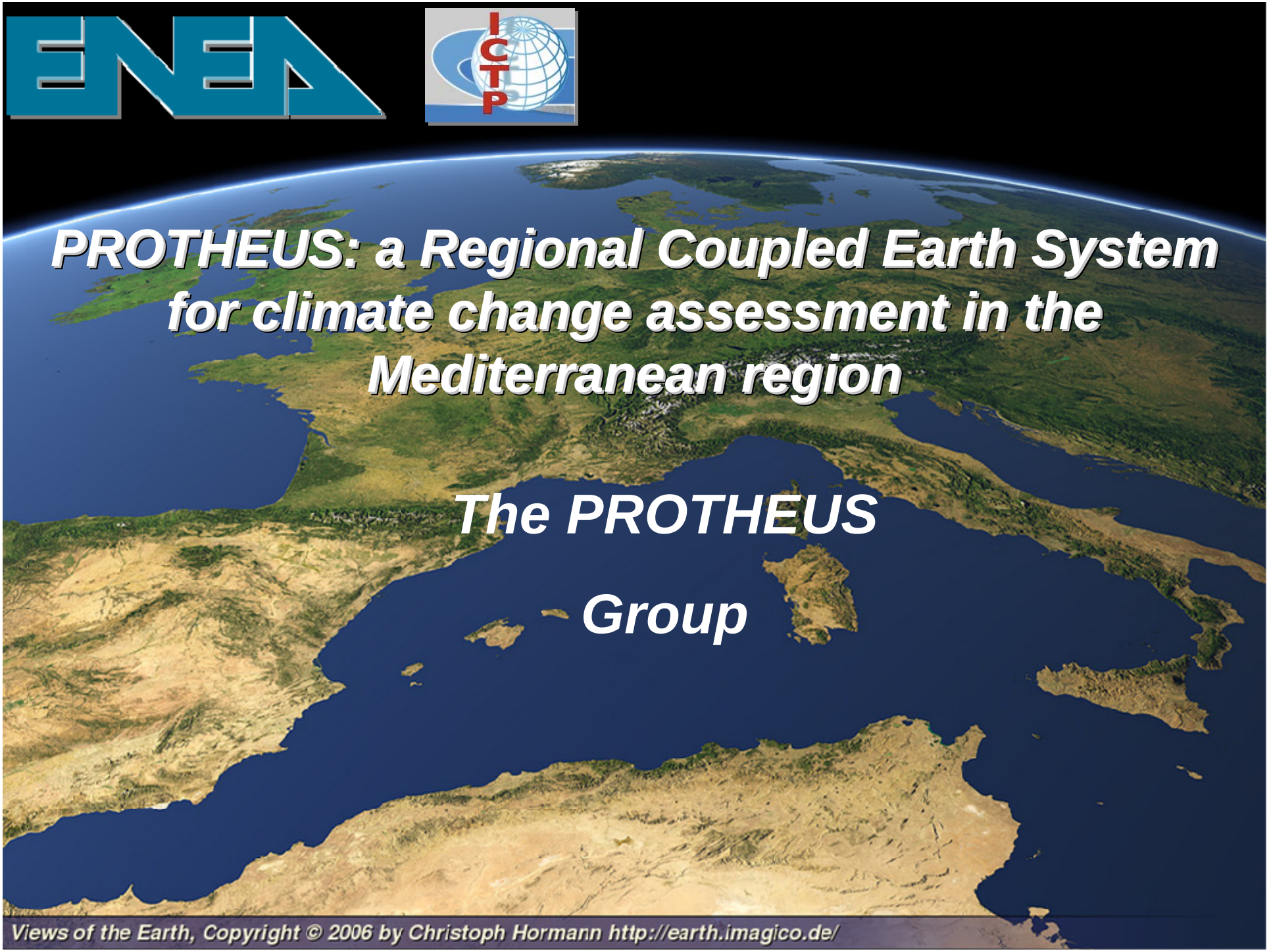
Fifth ICTP Workshop on the Theory and Use of Regional Climate Models

31 May - 11 June, 2010

The PROTHEUS system: A coupled regional climate system model for the Mediterranean

DELL'AQUILA Alessandro

ENEA-CR
Casaccia, Rome
ITALY


PROTHEUS: a Regional Coupled Earth System for climate change assessment in the Mediterranean region
The PROTHEUS Group
Views of the Earth, Copyright © 2006 by Christoph Hormann http://earth.imagico.de/

WEDNESDAY, June 2 (Room:Adriatico Guest House Kastler Lecture Hall) (**Republic's Day**)

2 June 2010

ENEA-CR Casaccia, Rome

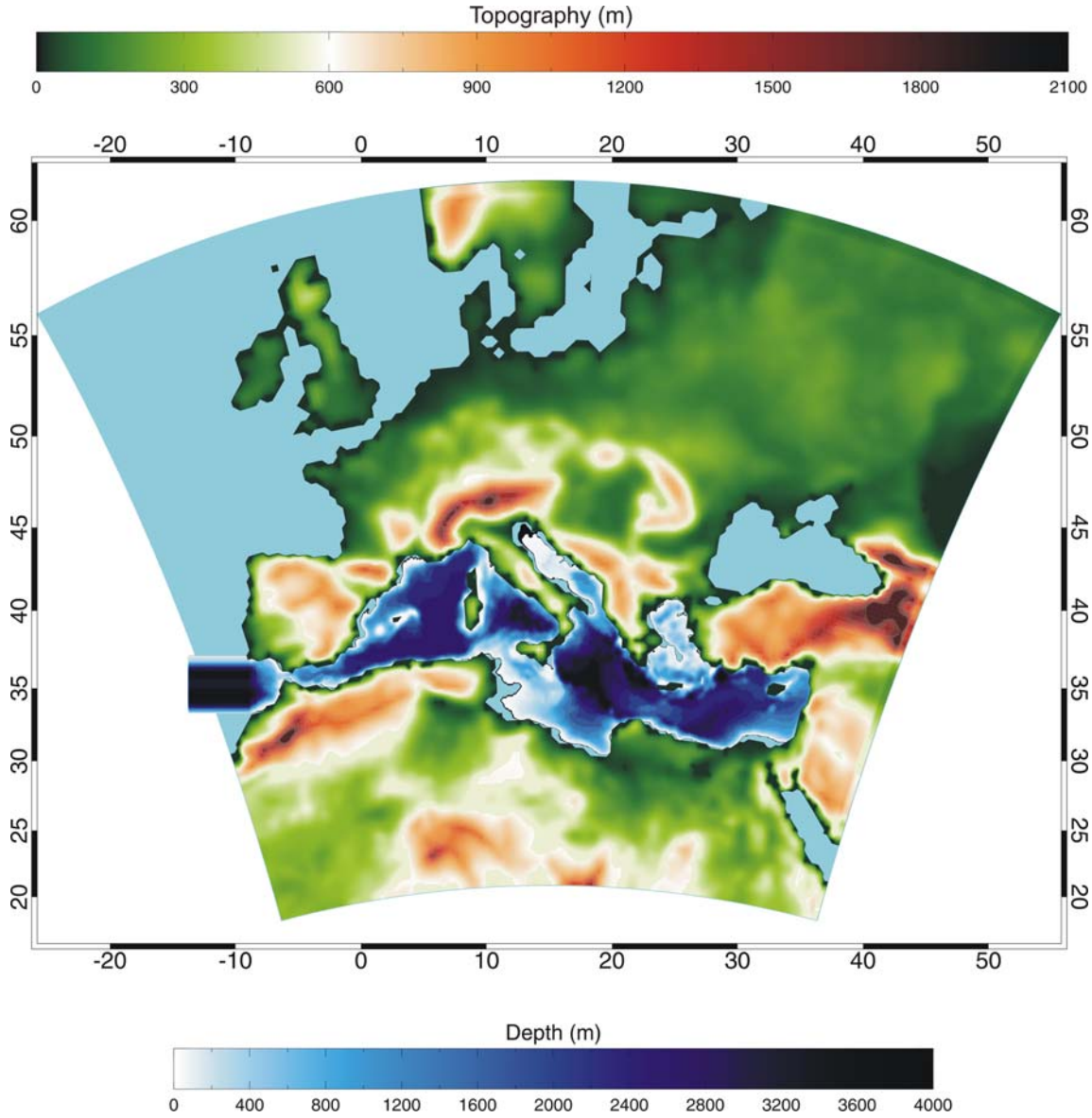
09:00 - 09:30 **A. Dell?Aquila** / *University of Malta*
The PROTHEUS system: A coupled regional climate system model for the Mediterranean

09:30 - 10:00 **E-S. Im** / *Korea Meteorological Administration*
Implementation, testing and sensitivity experiments with a high resolution sub-grid land surface module over the Alpine region.

10:00 - 10:30 **E. Coppola** / *ICTP-ESP*
High resolution RegCM transient simulation for the 21st century over the Alpine region using the land surface sub-grid module

10:30 - 11:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---
Weather permitting

PROTHEUS Model



Model domain

Model components

RegCM3

18 sigma vertical levels

30 Km horizontal resolution

BATS + IRIS

BATS: Biosph.-Atmosph. Transfer Scheme

IRIS: interactive RIvers Scheme

HF-WF-Wind

SST

OASIS 3
Freq. 6h

MedMIT

42 zeta vertical levels (partial cell)

1/8° x 1/8° horizontal resolution

PROTHEUS Model

RegCM is developed and maintained at ICTP (Trieste)

Oceanic boundary layer: Zeng et al., 1998

Cumulus paramterization: Grell, 1993

Lateral BC: 6-hourly, 12-points slice nudging (exp. Method)

Model components

RegCM3

18 sigma vertical levels

30 Km horizontal resolution

BATS Landuse Model: Landuse types 20

IRIS: TRIP database and IRIS numerical scheme

BATS + IRIS

BATS: Biosph.-Atmosph. Transfer Scheme

IRIS: interactive RIvers Scheme

MedMIT: Implemented by Sannino et al., OM 2009

MedMIT is based on MITgcm developed by Marshall et al. 97;

Horizontal diffusivity and viscosity: biharmonic (1.5×10^{10} $m^4 s^{-1}$).

Vertical eddy-viscosity: laplacian (diffusivity: $3.0 \times 10^{-5} m^2 s^{-1}$ at the surface; 1.0×10^{-7} $m^2 s^{-1}$ at the bottom).

Viscous coefficient : 1.5×10^{-4} $m^2 s^{-1}$.

MedMIT

42 zeta vertical levels (partial cell)

1/8° x 1/8° horizontal resolution

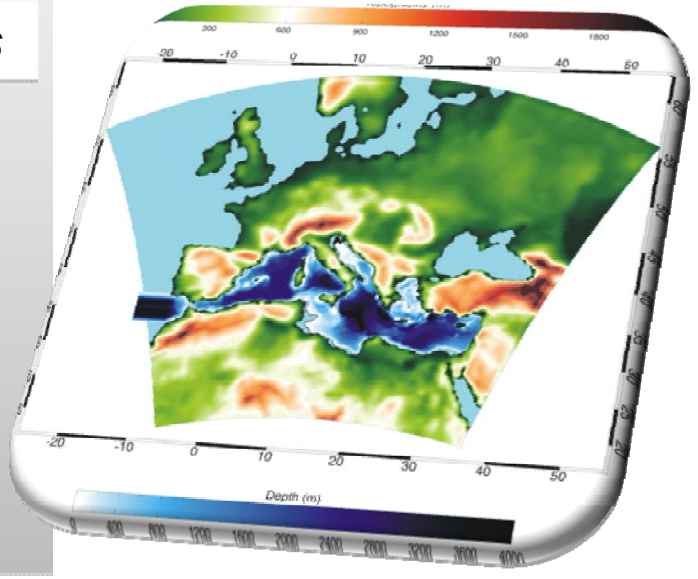
PROTHEUS Validation: Present climate simulation

Simulation details

Lateral BC
oERA40 reanalysis 1958-2000
oERA-Interim 1989-2007 **(MED-CORDEX)**

SST (Atlantic Box)
oGISST - Global Sea Ice Coverage and Sea Surface Temperature data -Met Office

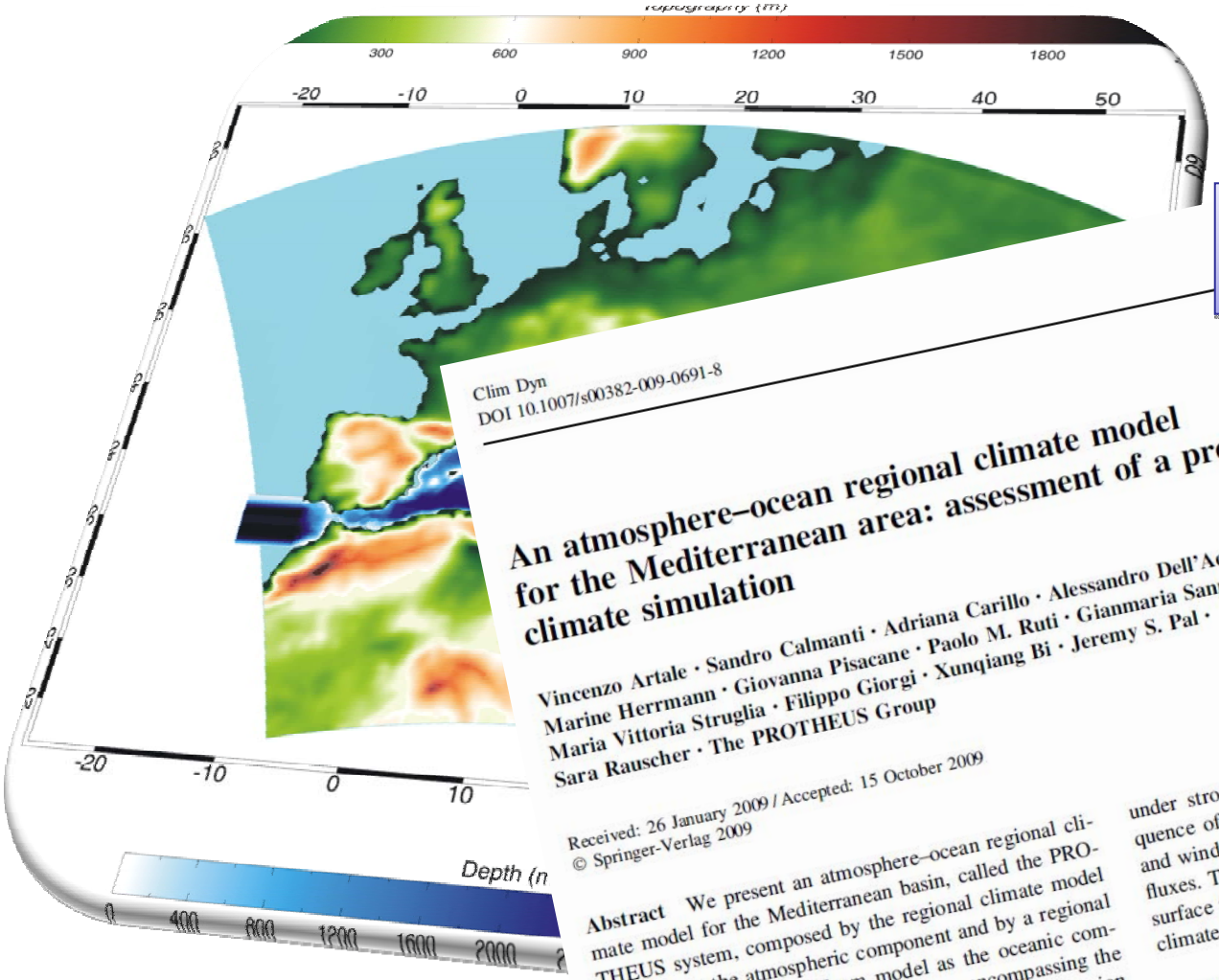
Ocean initialization
oMEDATLAS Climatology at rest; relaxation of SST and SSS during the first 6 years of simulation



Comparison with:

- **Stand-alone** configuration of the atmospheric model RegCM3 (forced by GISST data)
- **ERA40** Reanalysis
- **Observational datasets**
  - OISST (daily 1/16°x1/16°3-hr SST for the period 1985-present, *Marullo et al. 2007*)
  - HOAPS (Hamburg Ocean Atmosphere Parameters and fluxes from Satellite data)
  - CRU (Climatic Research Unit, UK)
  - GPCP (Global Precipitation Climatology Project)

PROTHEUS Validation: Present climate simulation



Artale et al 2009, *Clim Dyn*

Clim Dyn
DOI 10.1007/s00382-009-0691-8

An atmosphere–ocean regional climate model for the Mediterranean area: assessment of a present climate simulation

Vincenzo Artale · Sandro Calmanti · Adriana Carillo · Alessandro Dell'Aquila · Marine Herrmann · Giovanna Pisacane · Paolo M. Ruti · Gianmaria Sannino · Maria Vittoria Struglia · Filippo Giorgi · Xunqiang Bi · Jeremy S. Pal · Sara Rauscher · The PROTHEUS Group

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Abstract We present an atmosphere–ocean regional climate model for the Mediterranean basin, called the PROTHEUS system, composed by the regional climate model RegCM3 as the atmospheric component and by a regional configuration of the MITgcm model as the oceanic component. The model is applied to an area encompassing the Mediterranean Sea and compared to a stand-alone version of its atmospheric component. An assessment of the model performances is done by using available observational datasets. Despite a persistent bias, the PROTHEUS system under strong air–sea interaction conditions. As a consequence of the model's skill in reproducing observed SST and wind fields, we expect a reliable estimation of air–sea fluxes. The model skill in reproducing climatological land surface fields is in line with that of state of the art regional climate models.

Keywords Regional climate model · Mediterranean · Air–sea interaction

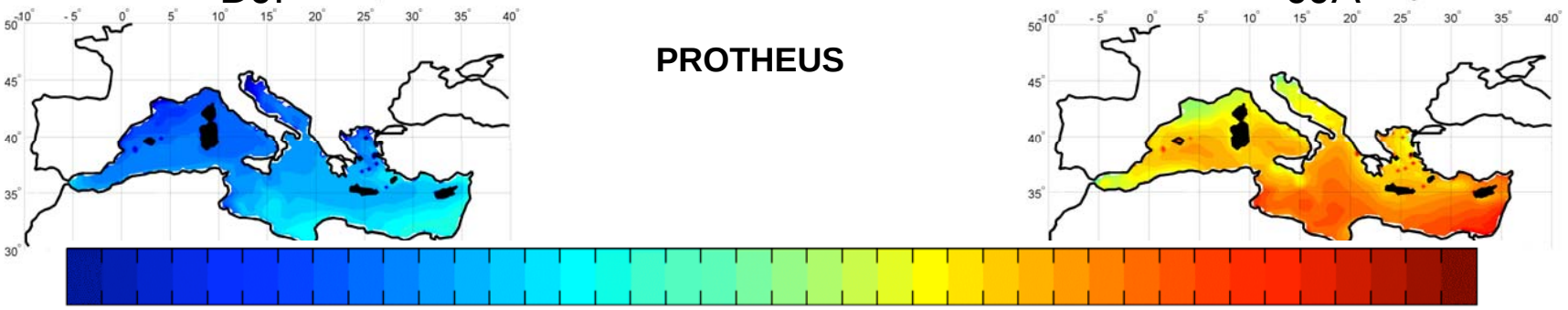
PROTHEUS Validation: Present climate simulation

PROTHEUS SST Climatology vs. Observations

DJF

JJA

PROTHEUS

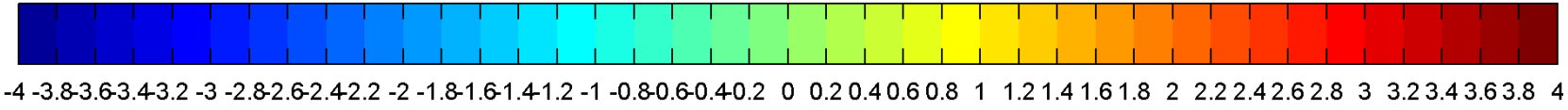


Temperature (°C)

PROTHEUS-GISST

PROTHEUS-OISST

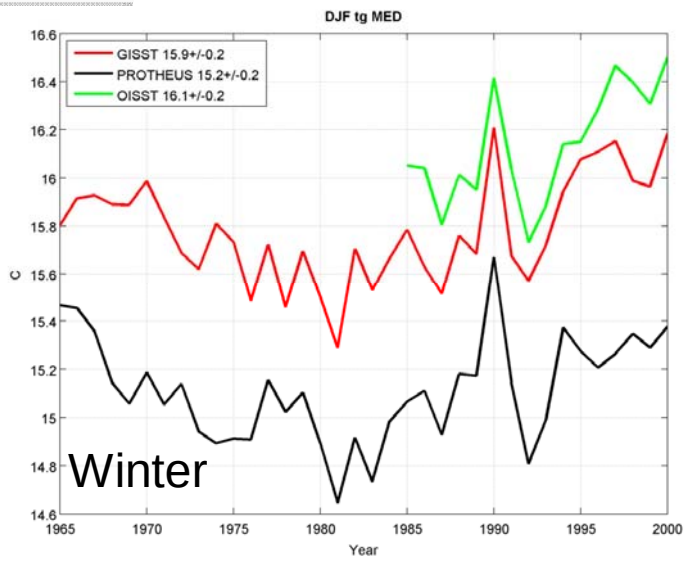
Temperature (°C)

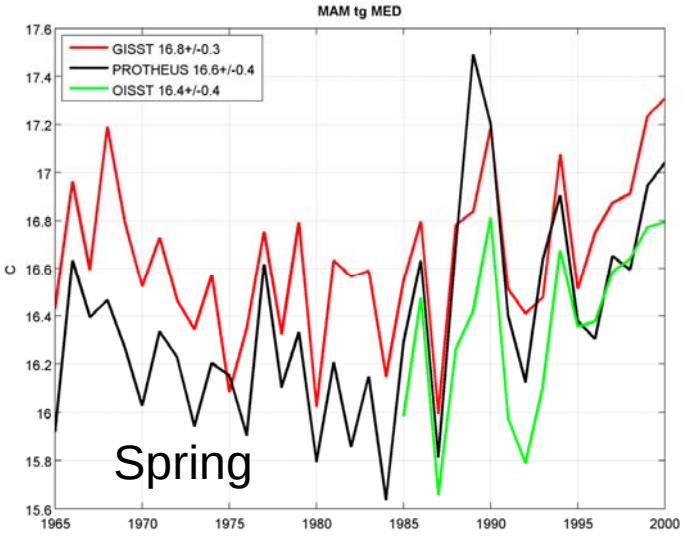


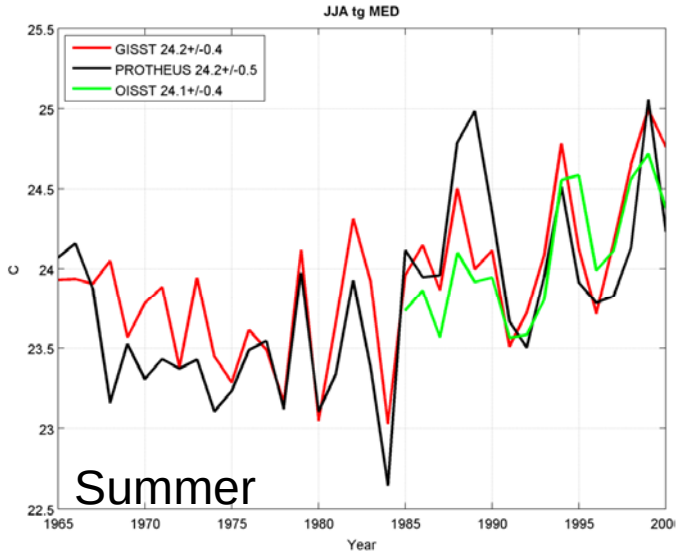
PROTHEUS Validation: Present climate simulation

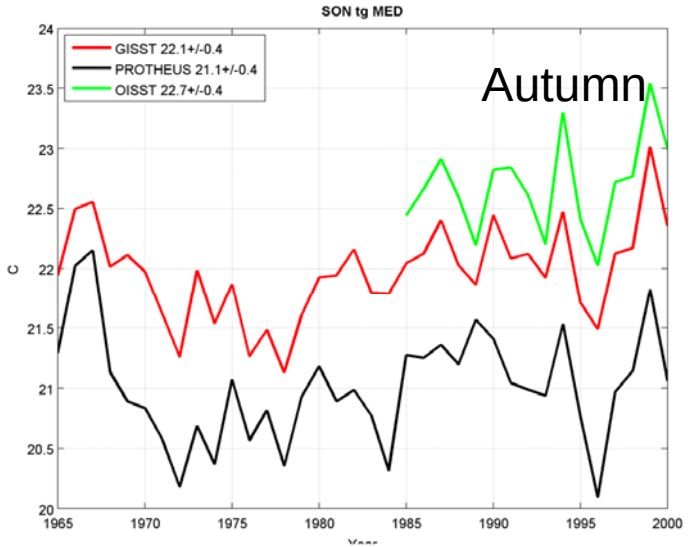
GISST
OISST
PROTHEUS

PROTHEUS SST Climatology vs. Observations







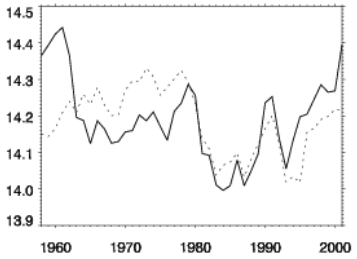
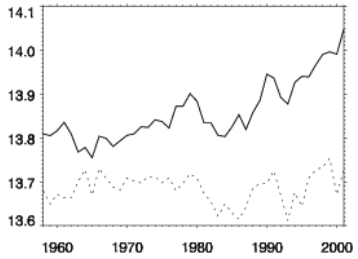
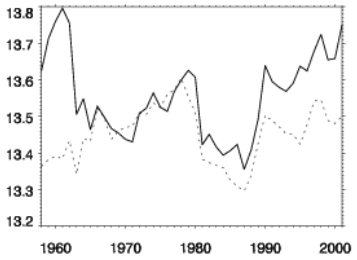
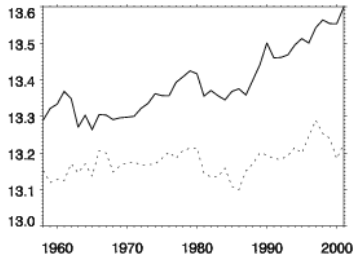
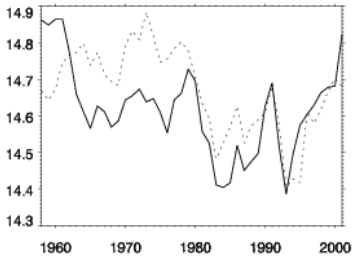
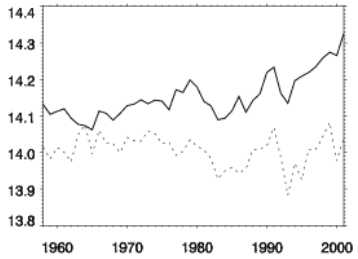
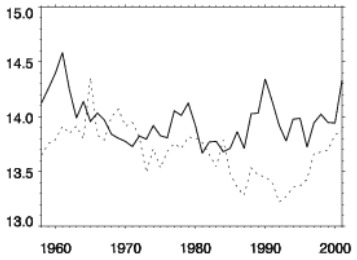
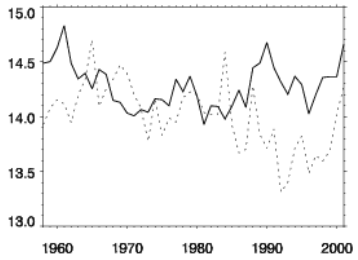


PROTHEUS Validation: Present climate simulation

Ocean Temperature

CLIMATOLOGY

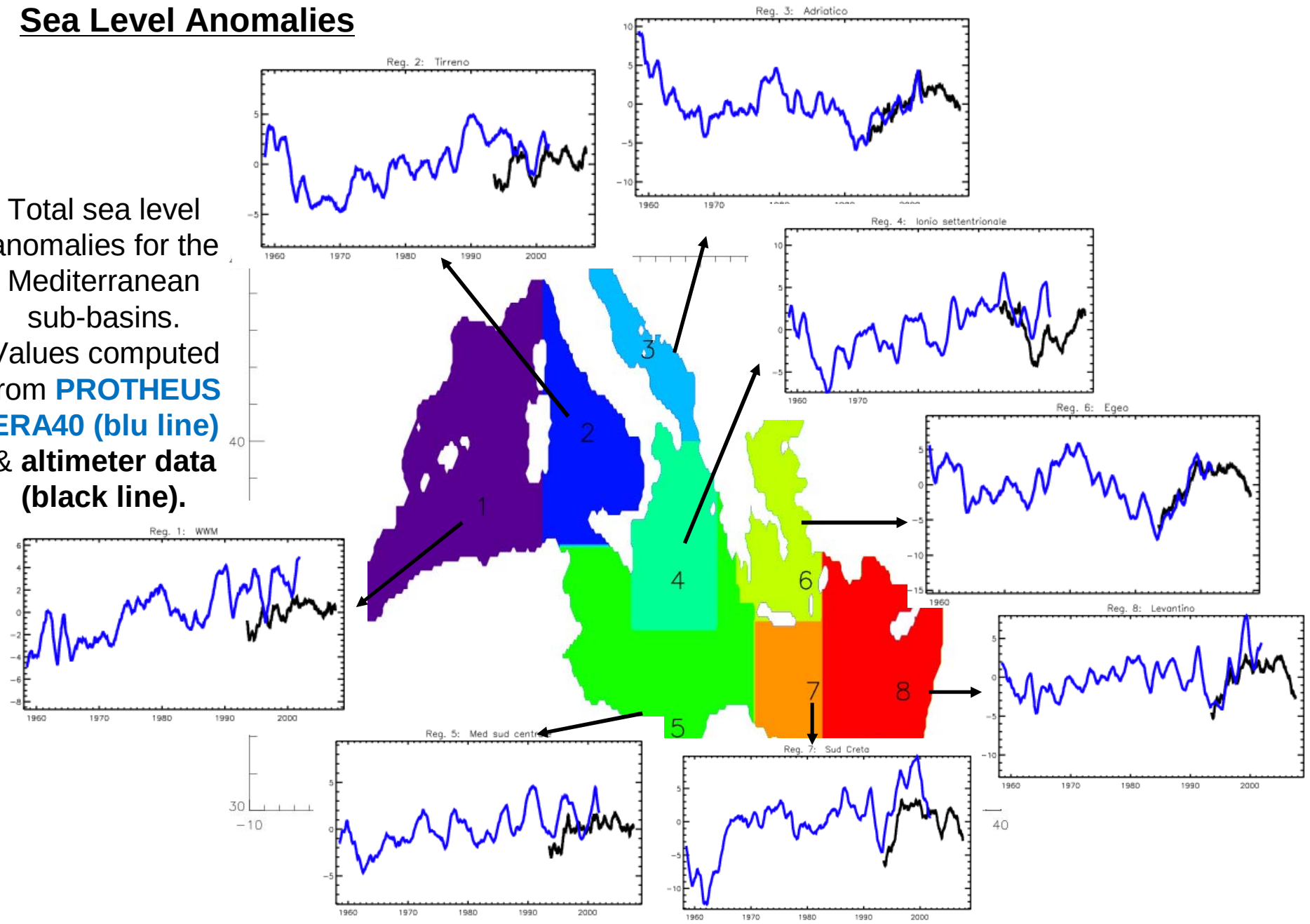
Time series of **temperature anomalies** averaged over the entire Mediterranean basin, the Western basin, Eastern Basin and Adriatic sea.
Model (solid line) data & MEDATLAS II database (dotted line).

150-600 m	entire water column	
		**MED**
		**Western Basin**
		**Eastern Basin**
		**Adriatic sea**

PROTHEUS Validation: Present climate simulation

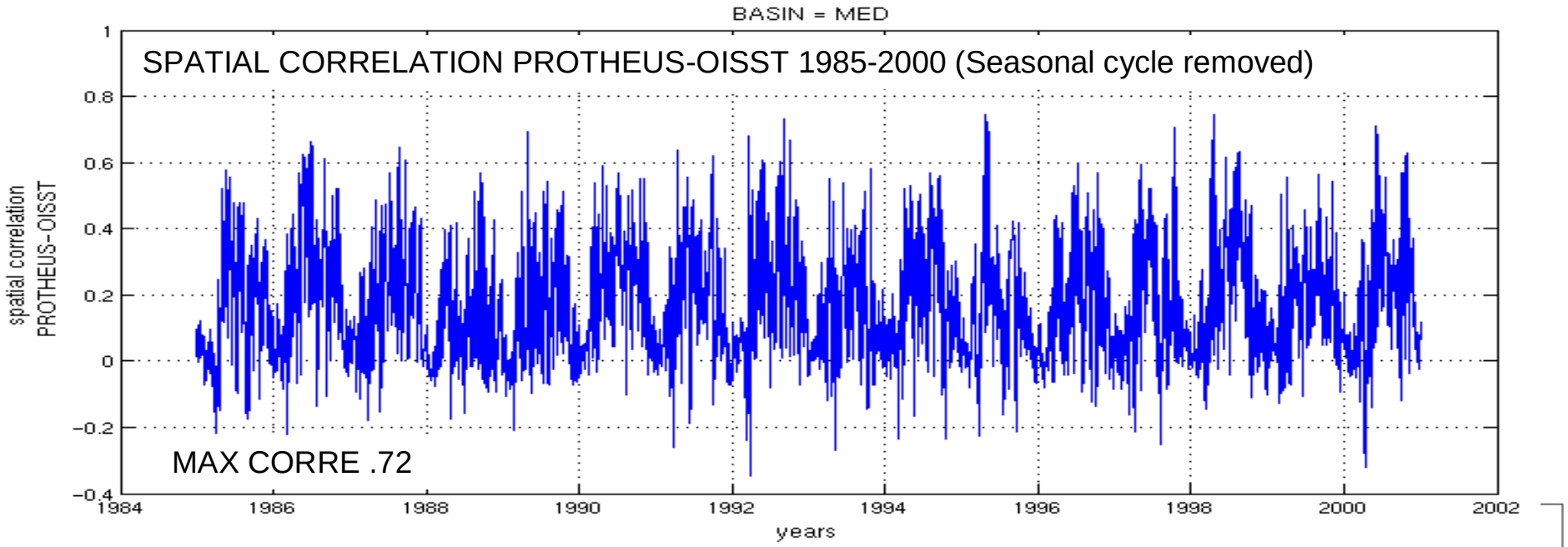
Sea Level Anomalies

Total sea level anomalies for the Mediterranean sub-basins. Values computed from **PROTHEUS ERA40 (blu line)** & **altimeter data (black line).**



PROTHEUS Validation: Present climate simulation

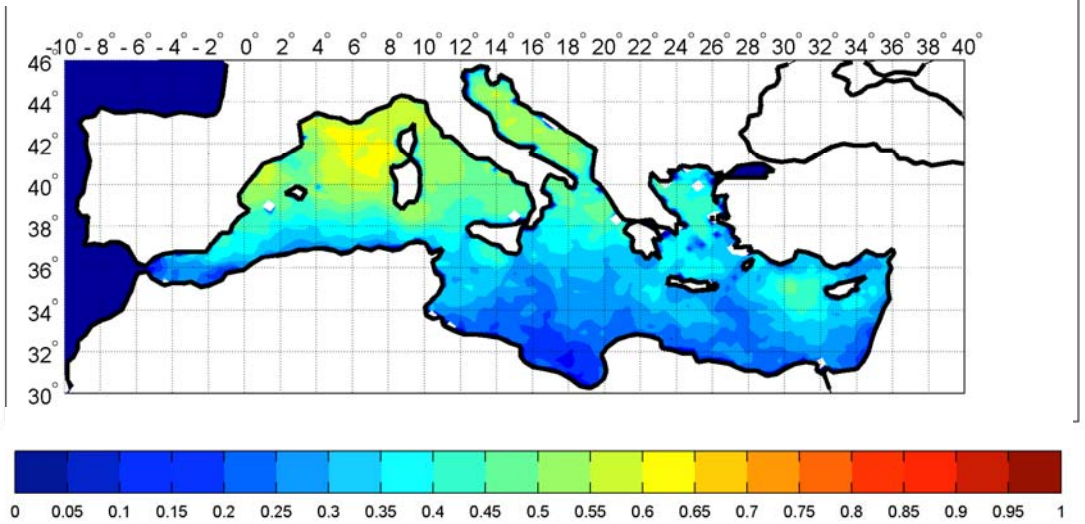
PROTHEUS SST Climatology vs. Observations



TEMPORAL CORRELATION

(Seasonal cycle removed)

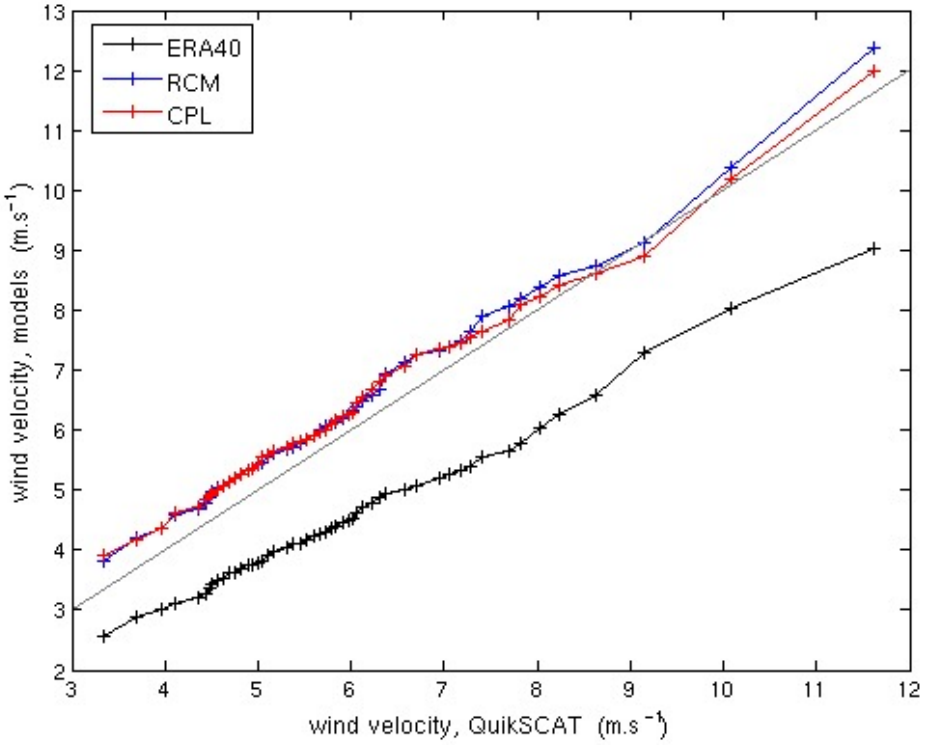
PROTHEUS-OISST 1985-2000

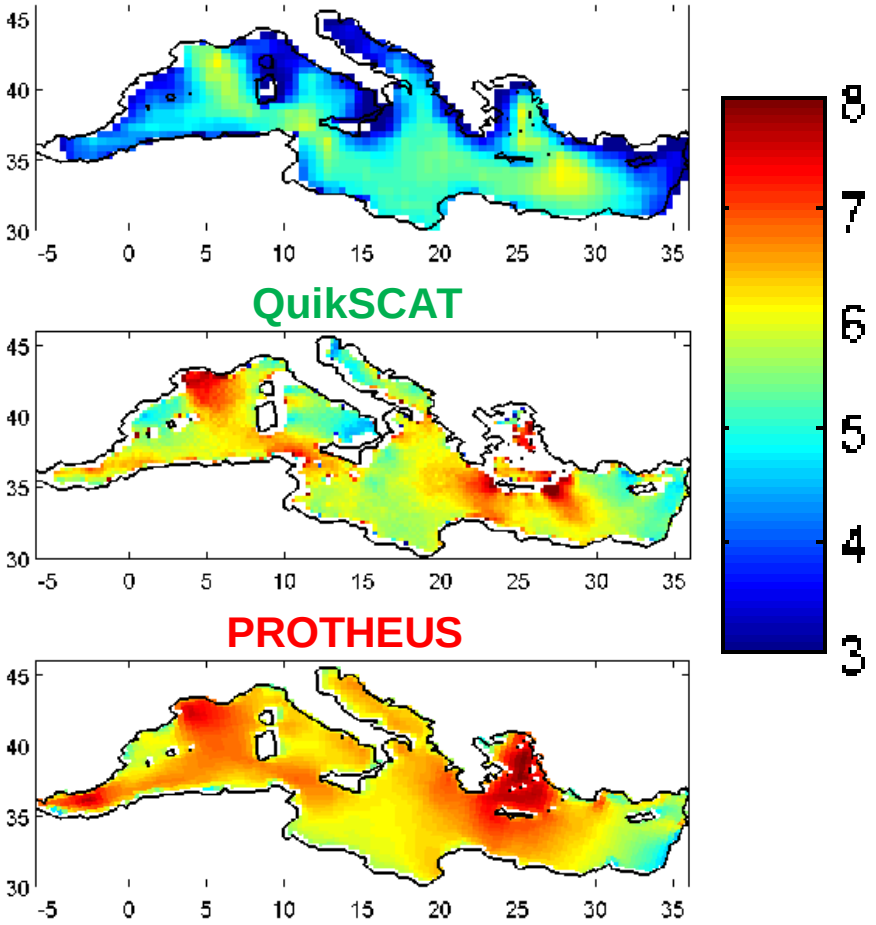


PROTHEUS Validation: Present climate simulation

PROTHEUS
RegCM3-SA
ERA40

PROTHEUS vs. Gridded data : Surface wind
Case study for 2000





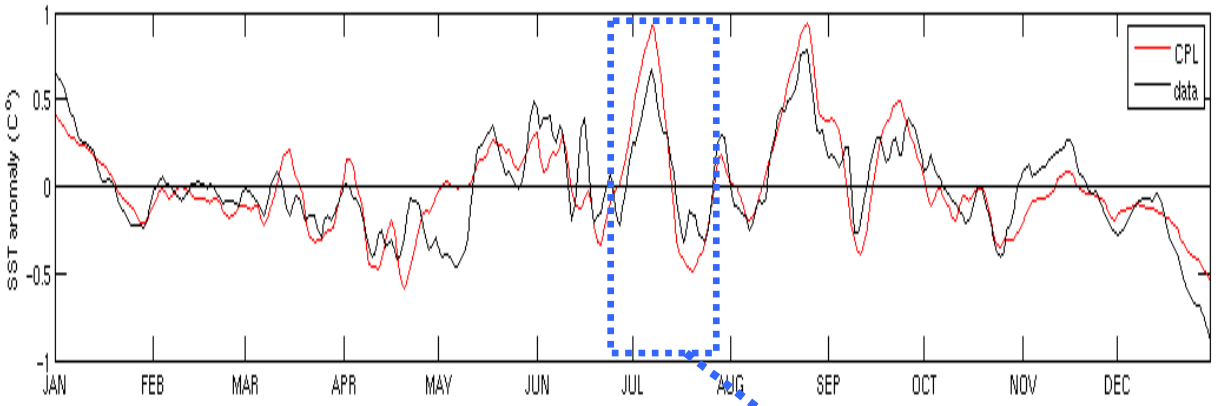
Data:

QuikSCAT LEVEL3 wind data (Physical Oceanography DAAC, GuideDocument, 2001)

Surface wind speed

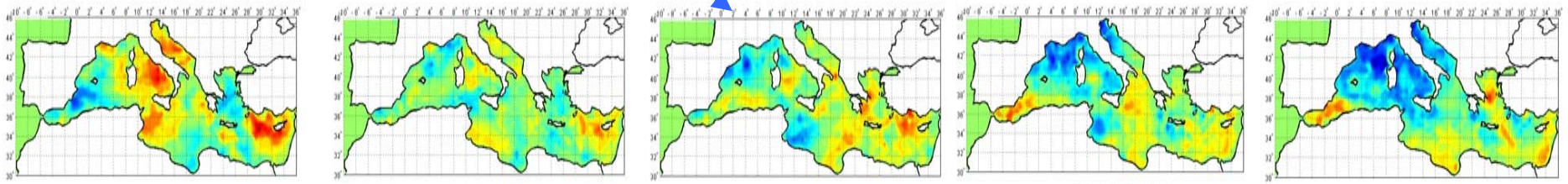
PROTHEUS Validation: Present climate simulation

PROTHEUS vs. Gridded data : Surface wind
Case study for 2000

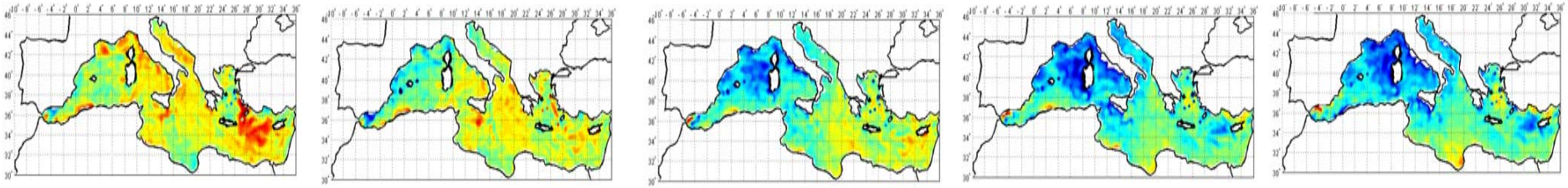


Time series of 2000 **SST anomalies** for PROTHEUS simulation (red line) and **satellite observations (black line).** Values are averaged over the whole basin.

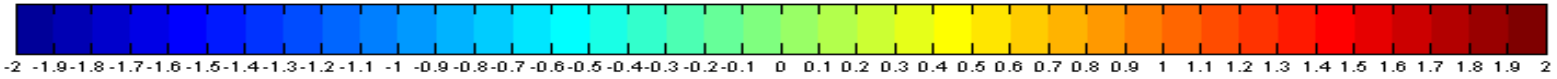
OISST



PROTHEUS



9 July | 11 July | 13 July | 15 July | 17 July



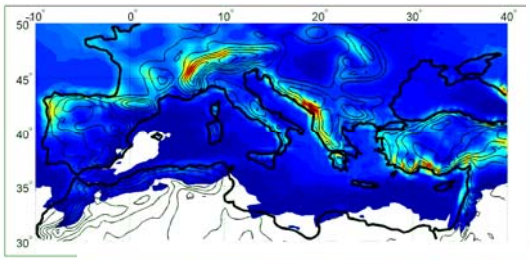
PROTHEUS Validation: Present climate simulation

Precipitation

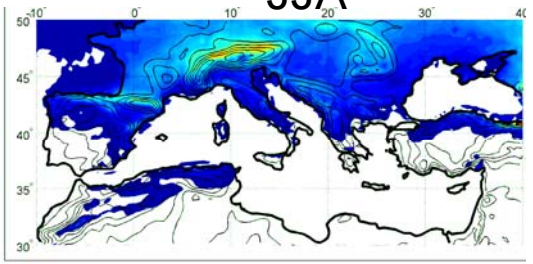
CLIMATOLOGY

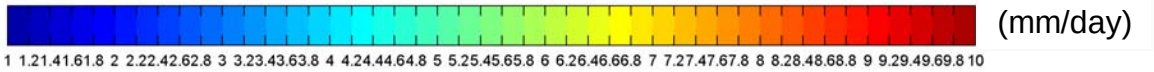
PROTHEUS

DJF

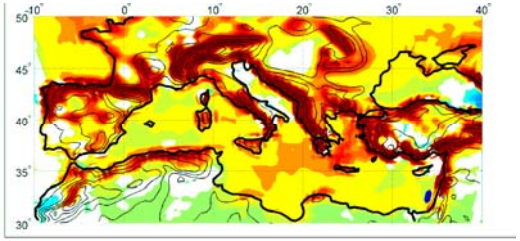


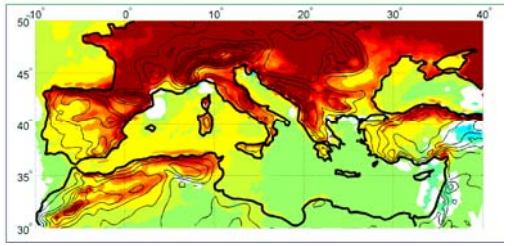
JJA





PROTHEUS –ERA40



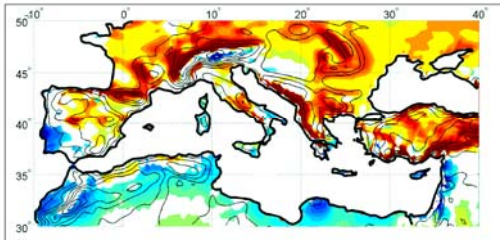


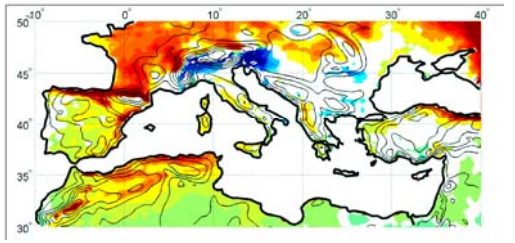
Precipitation

CLIMATOLOGY

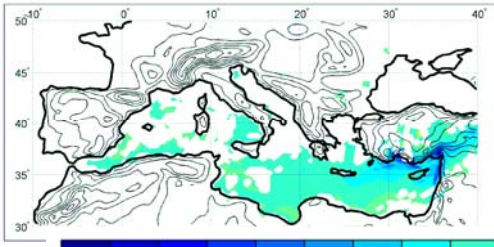
differences

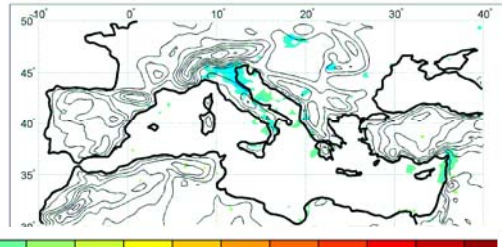
PROTHEUS –CRU

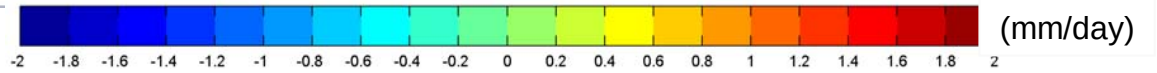




PROTHEUS –RegCM3 stand-alone



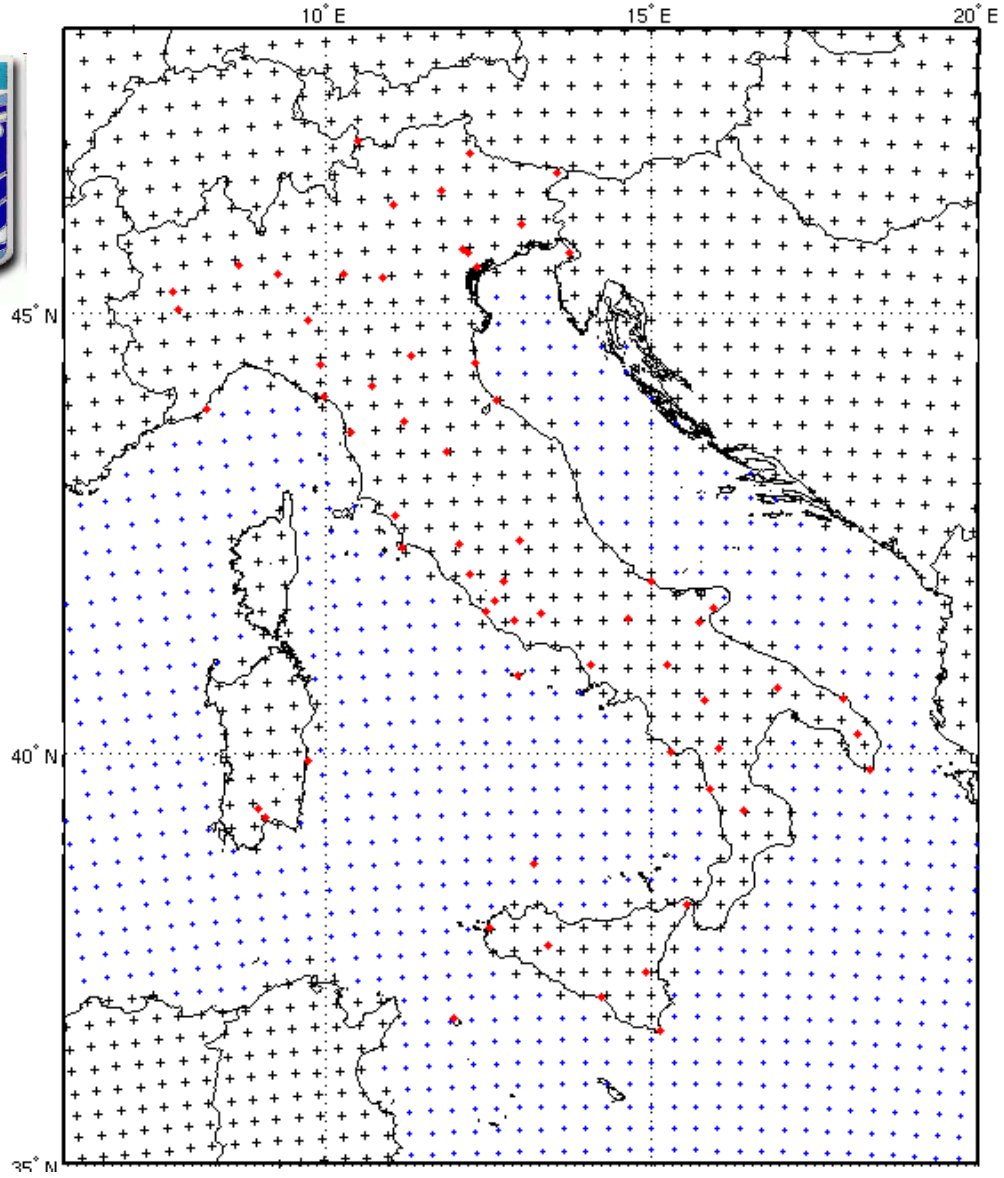




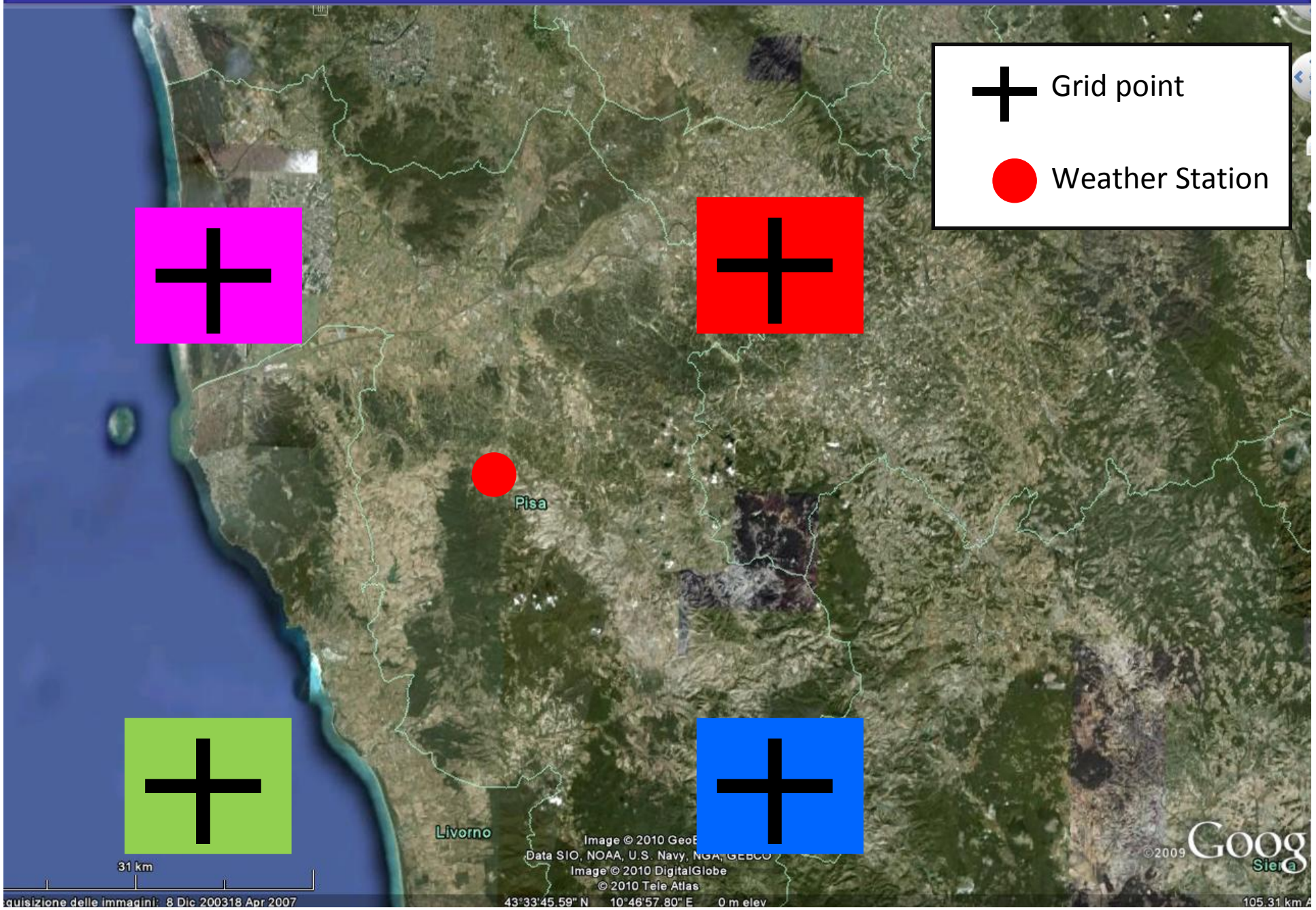
PROTHEUS Validation: Present climate simulation

In collaboration with CNMCA

Model grid
&
Weather Station
(Air Force
National
Service)

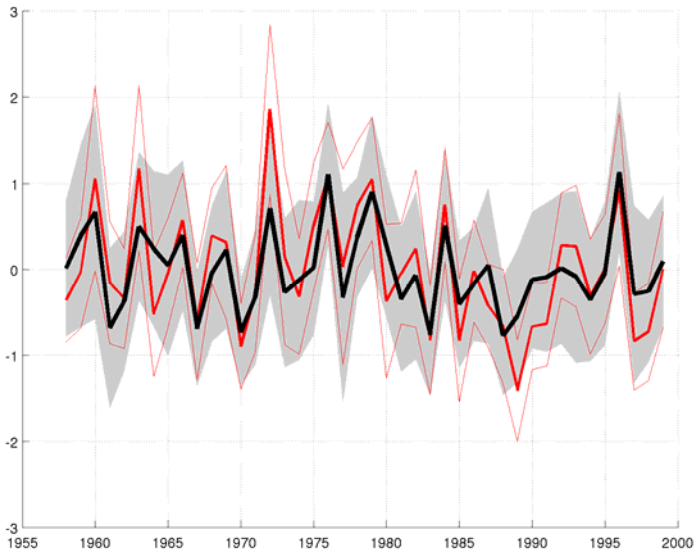


PROTHEUS Validation: Present climate simulation



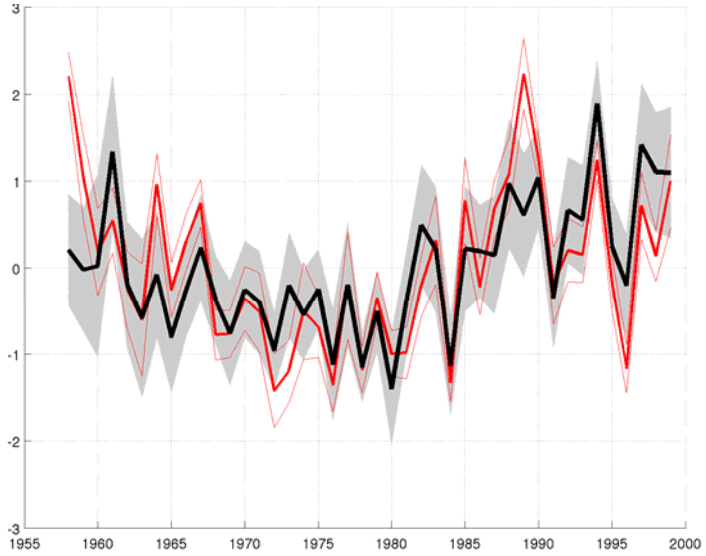
PROTHEUS Validation: Present climate simulation

PRECIPITATION



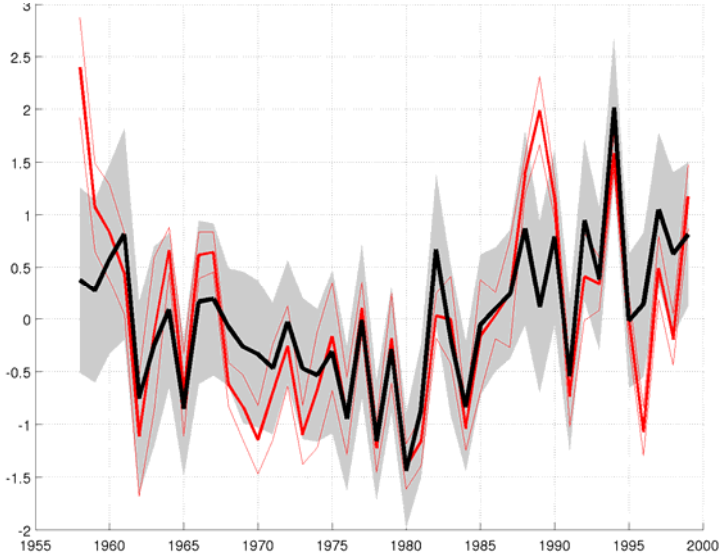
Standardized annual means: all the stations

Tmax



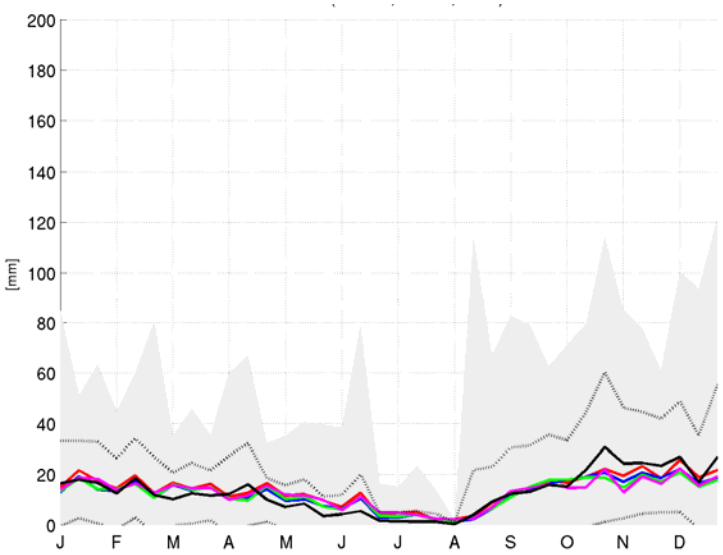
PROTHEUS simulated fields (red line) and **weather stations (black line).**

Tmin

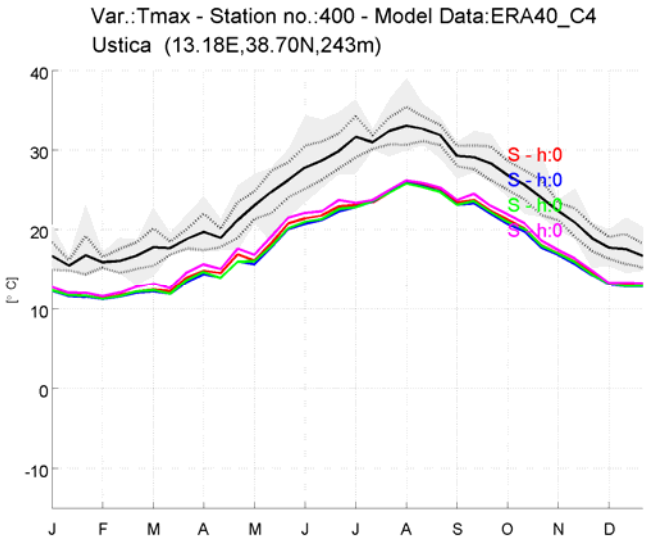


PROTHEUS Validation: Present climate simulation

PRECIPITATION



Tmax



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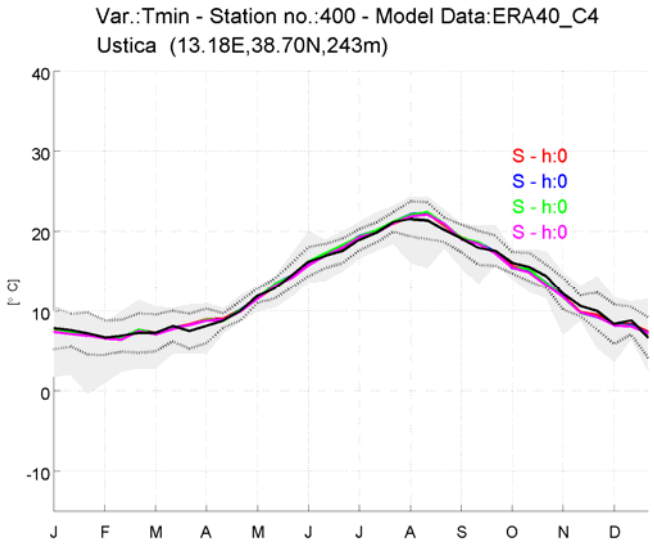
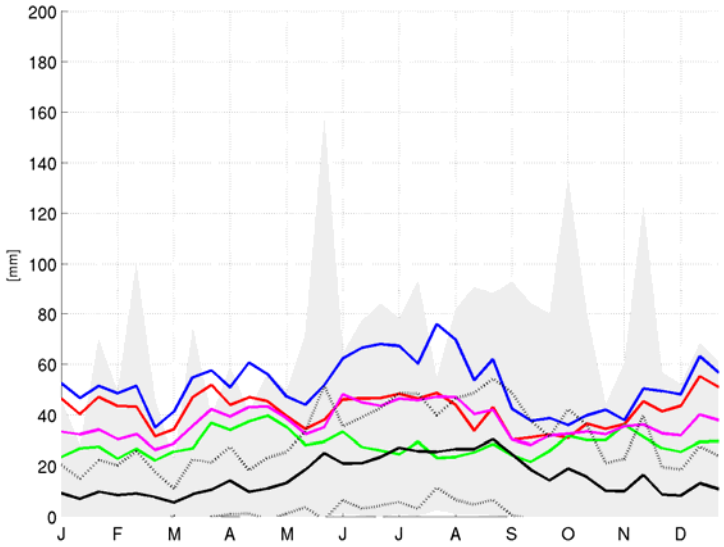


Station no 400:
Ustica

Seasonal cycle

PROTHEUS Validation: Present climate simulation

PRECIPITATION



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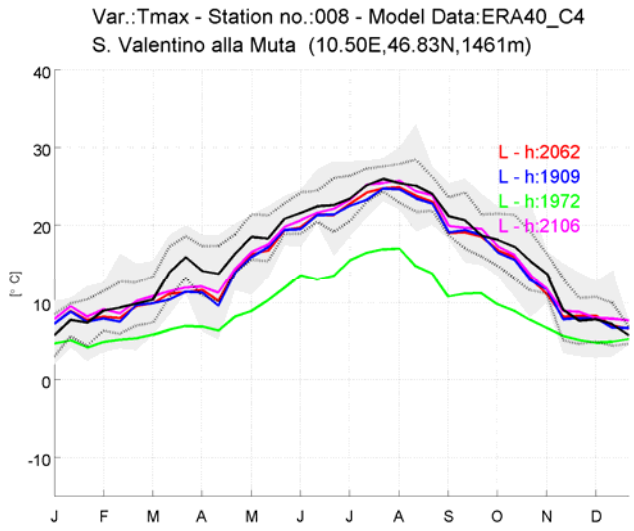
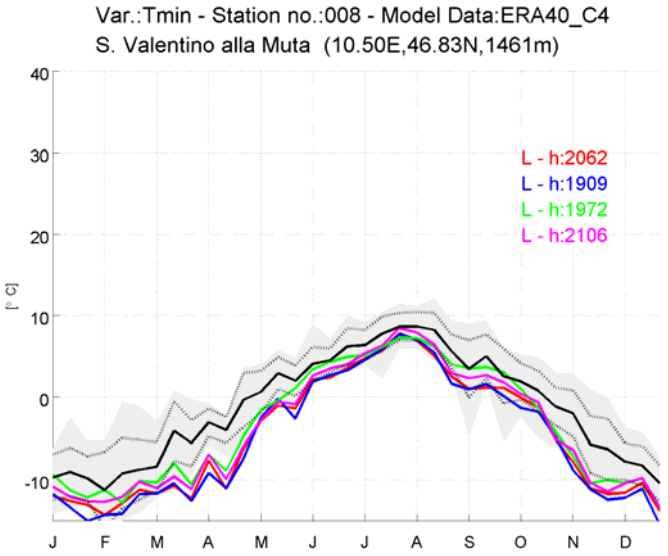


Station no 008:

S. Valentino alla Muta
(alpine region)
seasonal cycle

Tmin

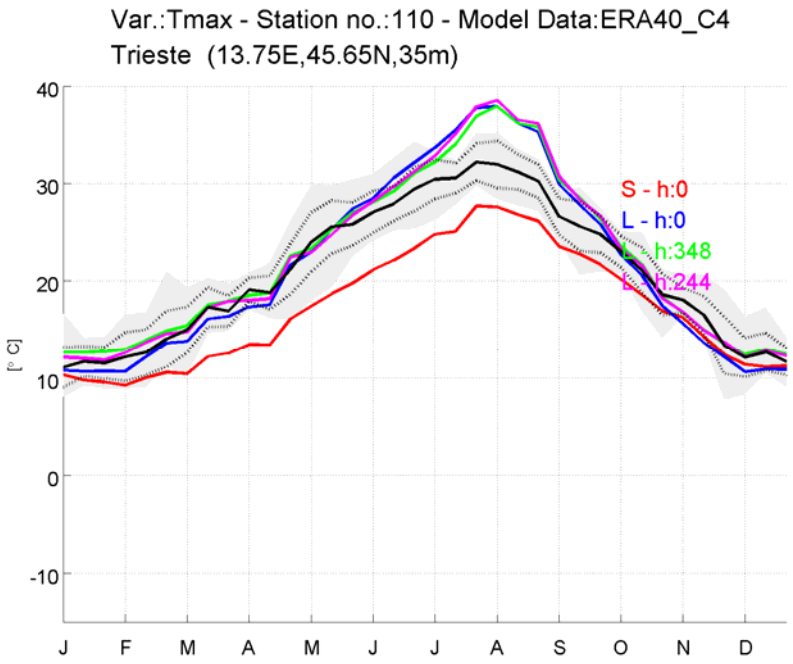


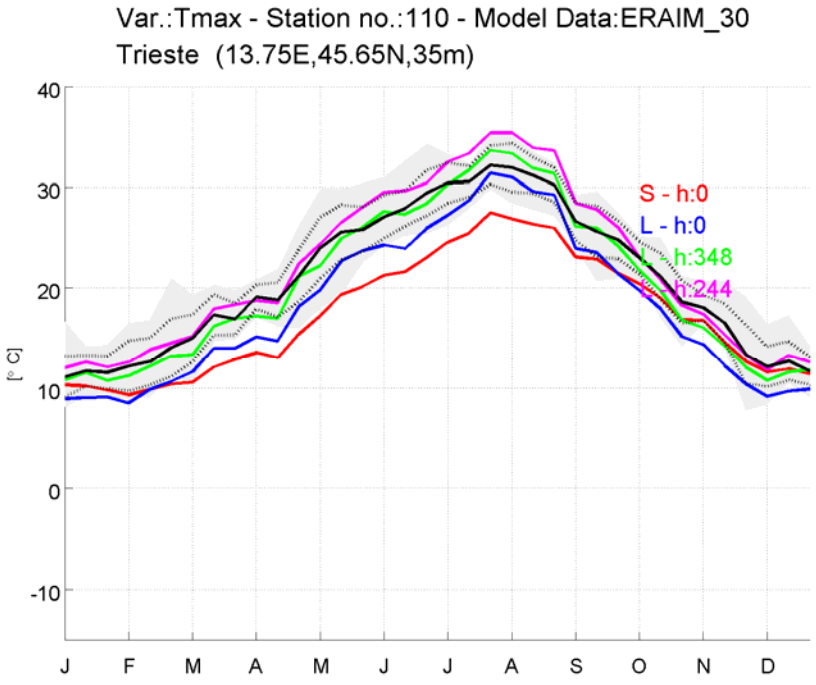
PROTHEUS Validation: Present climate simulation

PROTHEUS ERA40

PROTHEUS ERA-Interim

Trieste





Small changes in land-use…

Present Climate Simulation : Major results

- 40-year simulation driven by ERA40 reanalysis at BC (just begun to analyse ERA-Interim)

- Realistic features reproduced (atmospheric circulations, land surface climate, ocean SST, ocean surface circulations and air-sea fluxes)

- Sea level anomalies correctly reproduced

- The coupling does not affect the bulk characteristics of the atmospheric model

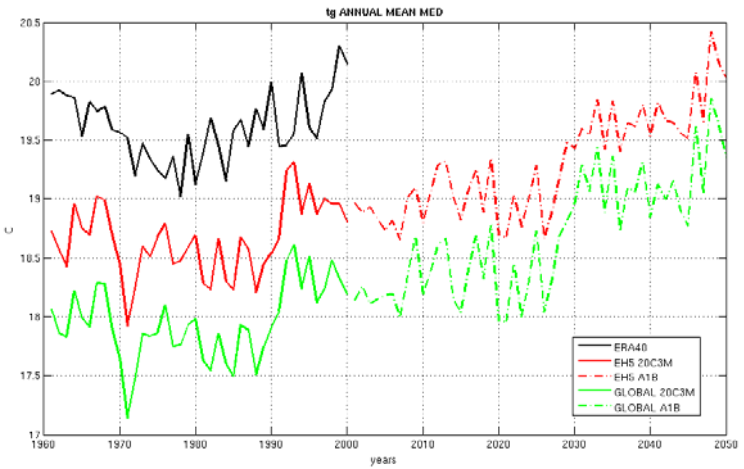
- The coupled model is capable of significantly improve the description of air-sea interactions in terms of sensible and latent heat, especially at small scales and for intense events

- Locally, the coupling could affect the rainfall statistics

PROTHEUS SCENARIO Simulation: preliminary analysis

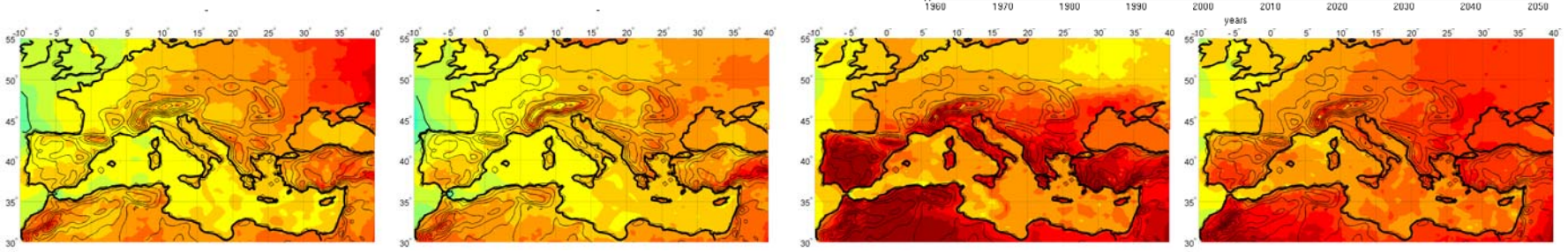
•Planned simulations in the framework of **Med-Cordex** (ERA-Interim, METEO-FRANCE, ECHAM5-MPIOM, CMCC…)

•**Simulations already performed :** IPCC-AR4 ECHAM5-MPIOM



PROTHEUS trend

Surface Temperature



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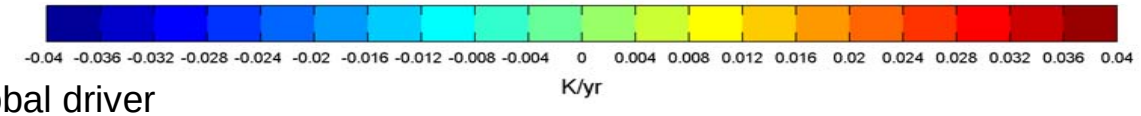
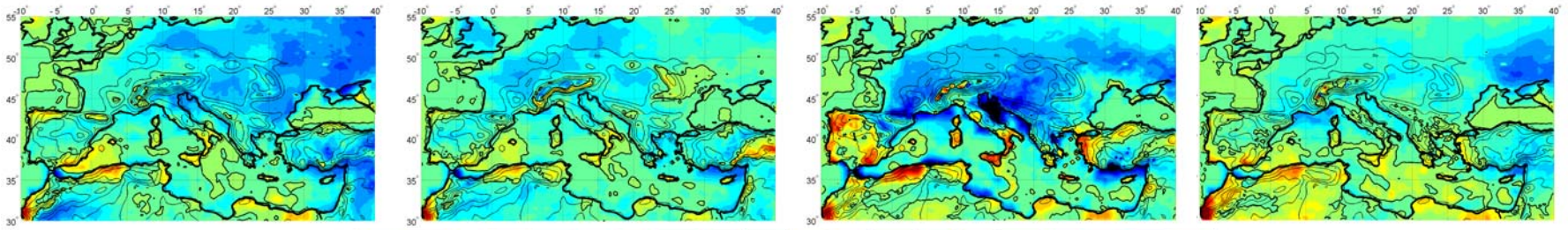
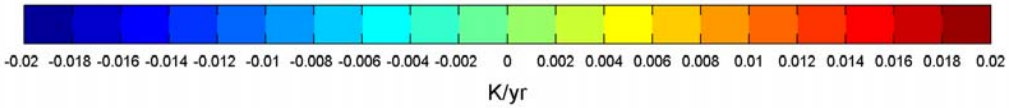


PROTHEUS-ECHAM5 global driver

DJF MAM JJA SON



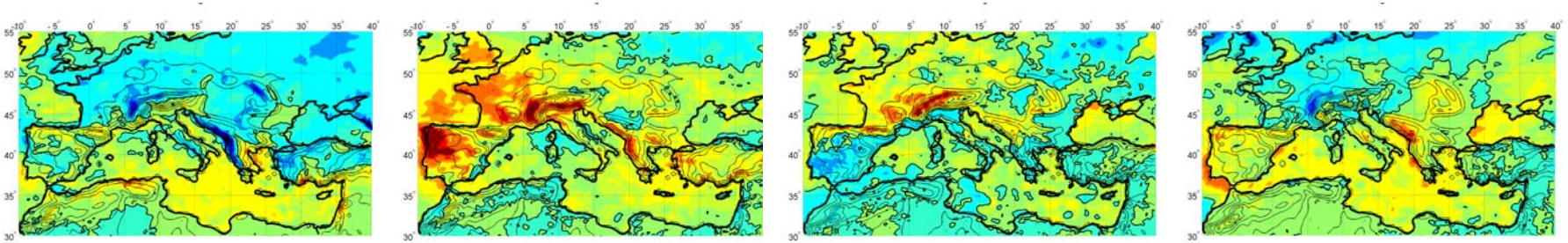


PROTHEUS SCENARIO Simulation: preliminary analysis

E-P FLUX TREND

PROTHEUS trend

DJF MAM JJA SON



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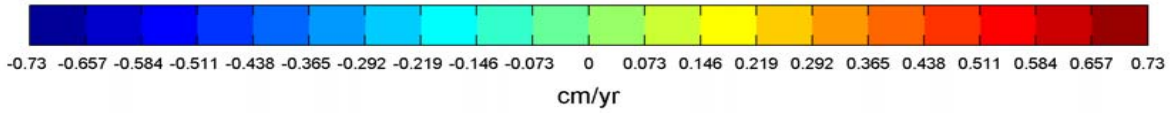
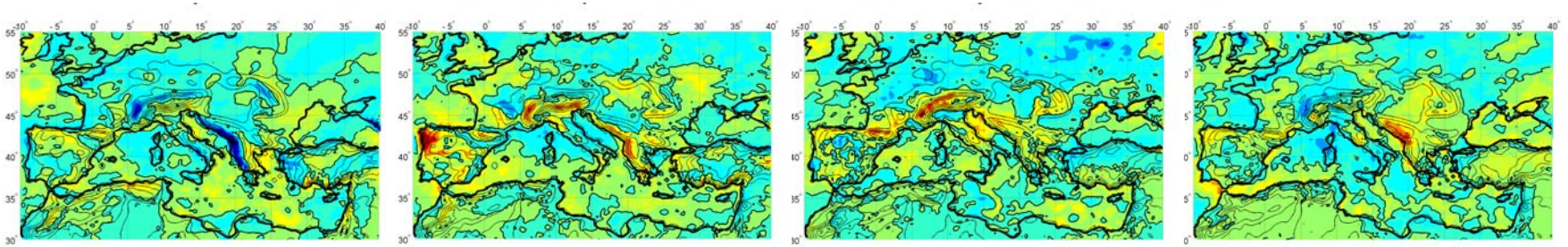
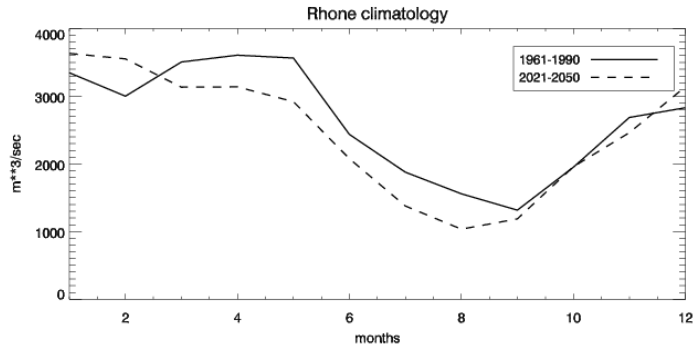
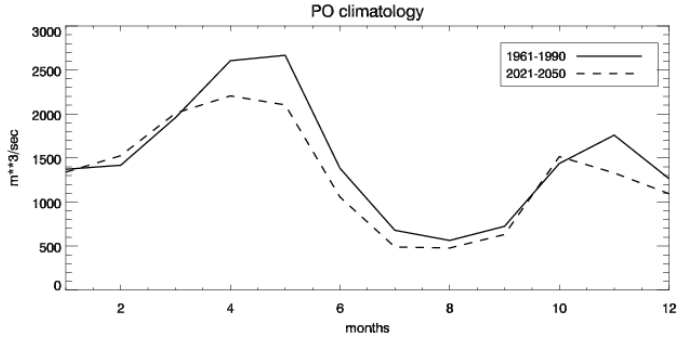


PROTHEUS-ECHAM5



River Discharge



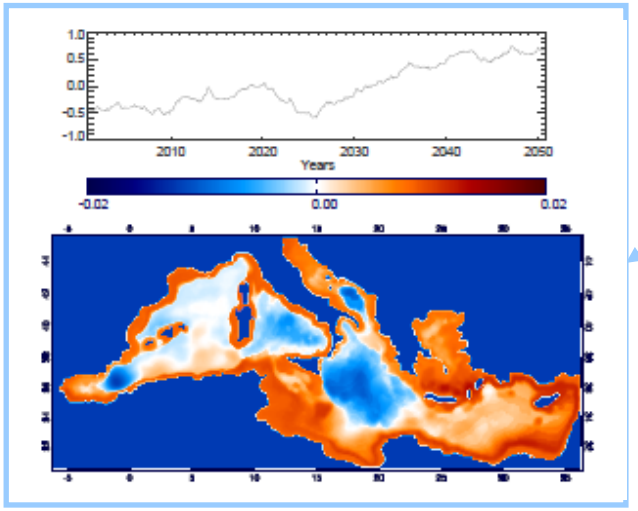


PROTHEUS SCENARIO Simulation: preliminary analysis

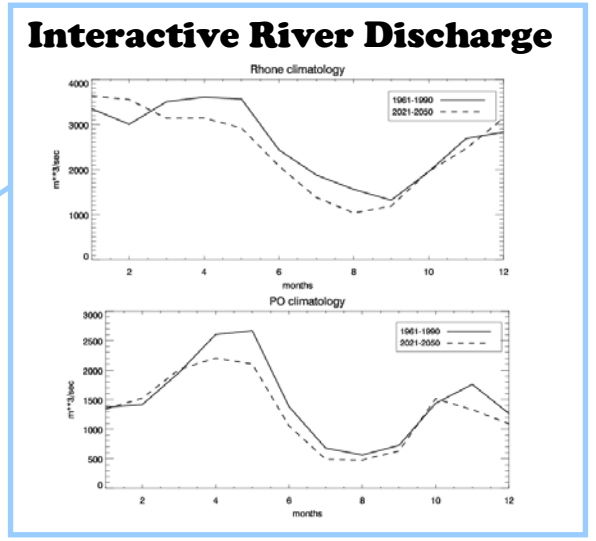
Sea Level Anomalies

Salinity contribution

First mode of the EOF decomposition of the sea level rise for the run forced by the scenario ECHAM5-MPIOM in the period 2001-2050. Spatial pattern and temporal evolution.



Interactive River Discharge



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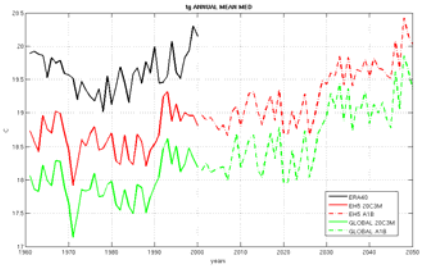
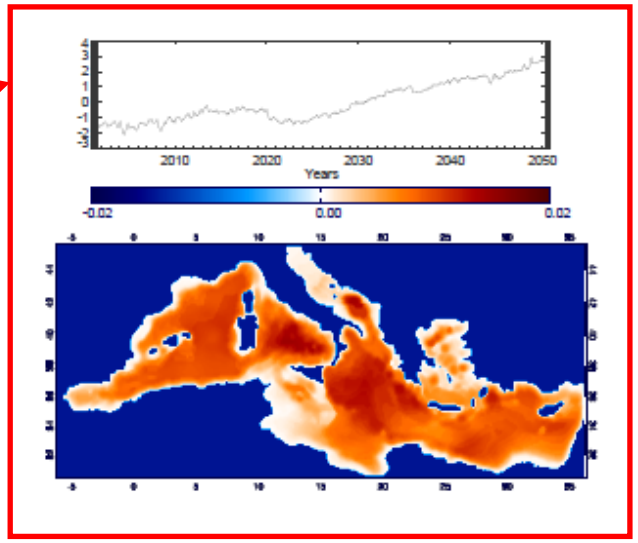


Temp contribution



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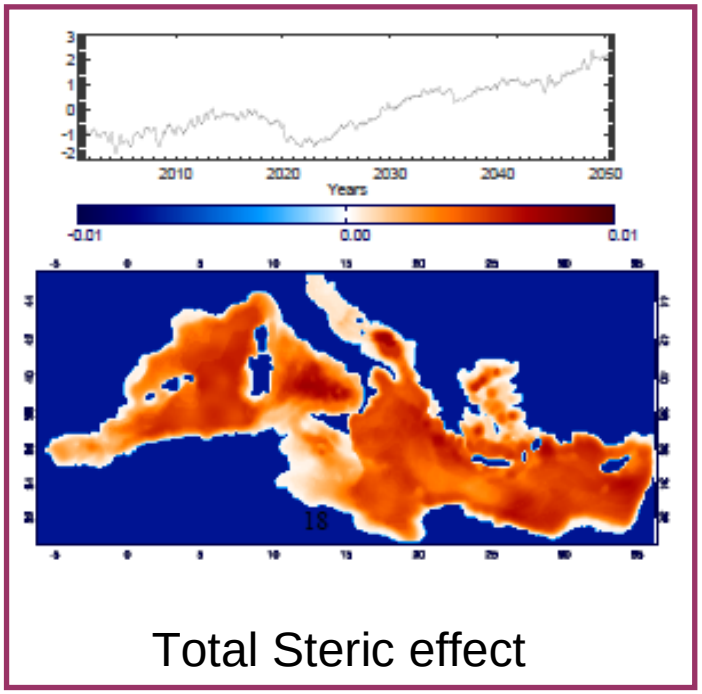

Total Steric effect

Preliminary analysis first SCENARIO Simulation: Major results

- Simulation: 1951-2050 ECHAM5-MPIOM at BC (20c3m for 1951-2000 and SRESA1B for 2001-2050)

- Upward trend in Surface Temperature detected in PROTHEUS Scenario simulation

- Trends in PROTHEUS significantly lesser than the corresponding ones in the global simulation, especially over the sea and over mountain regions

- Strong seasonality in PROTHEUS E-P surface flux trend and, consequently, in river discharges

- Sea level changes detected (steric sea level rise)