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

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PROTHEUS: a Regional Coupled Earth System for climate change assessment in the Mediterranean region

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

2 June 2010

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 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
**RegCM** is developed and maintained at ICTP (Trieste)

**Oceanic boundary layer**: Zeng et al., 1998

**Cumulus parameterization**: Grell, 1993

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

**MedMIT**: Implemented by Sannino et al., OM 2009

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

**Horizontal diffusivity and viscosity**: biharmonic \(1.5 \times 10^{10} \text{ m}^4\text{s}^{-1}\).

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

**Viscous coefficient**: \(1.5 \times 10^{-4} \text{ m}^2\text{s}^{-1}\).
Lateral BC
- ERA40 reanalysis 1958-2000
- ERA-Interim 1989-2007 (MED-CORDEX)

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

Ocean initialization
- MEDATLAS 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

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

Vincenzo Artale, Sandra Calmanti, Adriana Carillo, Alessandro Dell' Aquila, Mariacristina Di Lorenzo, Giorgio Piazzante, Paolo M. Rutini, Giannmario Santini, Maria Vittoria Squillo, Filippo Giorgi, Xiuqiang 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 heat 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

PROTHEUS

Temperature (°C)

PROTHEUS-GISST

Temperature (°C)

PROTHEUS-OISST

Temperature (°C)
PROTHEUS Validation: Present climate simulation

PROTHEUS SST Climatology vs. Observations

GISST
OISST
PROTHEUS

Winter

Spring

Summer

Autumn

DJF vs MED

MAM vs MED

JJA vs MED

SON vs MED

OISST 15.94±0.2
PROTHEUS 15.22±0.2
GISST 15.1±0.2

GISST 15.84±0.3
PROTHEUS 16.04±0.4
GISST 15.4±0.4

GISST 24.24±0.4
PROTHEUS 24.2±0.5
GISST 24.1±0.4

GISST 22.1±0.4
PROTHEUS 22.1±0.4
GISST 22.7±0.4
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).
Total sea level anomalies for the Mediterranean sub-basins. Values computed from **PROTHEUS ERA40** (blue line) & altimeter data (black line).
SPATIAL CORRELATION PROTHEUS-OISST 1985-2000 (Seasonal cycle removed)

MAX CORRE .72

TEMPORAL CORRELATION
(Seasonal cycle removed)

PROTHEUS-OISST 1985-2000
PROTHEUS Validation: Present climate simulation

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

Data:
QuikSCAT LEVEL3 wind data (Physical Oceanography DAAC, GuideDocument, 2001)
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.
PROTHEUS Validation: Present climate simulation

Precipitation
CLIMATOLOGY
PROTHEUS

Precipitation
CLIMATOLOGY
differences

DJF

JJA

PROTHEUS – ERA40

PROTHEUS – CRU

PROTHEUS – RegCM3 stand-alone

Precipitation differences

(mm/day)

(mm/day)
In collaboration with CNMCA

Model grid & Weather Station (Air Force National Service)
PROTHEUS Validation: Present climate simulation

Grid point

Weather Station
PROTHEUS Validation: Present climate simulation

**PRECIPITATION**

Standardized annual means: all the stations

**Tmax**

**Tmin**

PROTHEUS simulated fields (red line) and weather stations (black line).
Station no 400: Ustica
Seasonal cycle
Station no 008:
S. Valentino alla Muta (alpine region)
seasonal cycle
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
• Planned simulations in the framework of **Med-Cordex** (ERA-Interim, METEO-FRANCE, ECHAM5-MPIOM, CMCC…)

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

**PROTHEUS SCENARIO Simulation: preliminary analysis**

**Surface Temperature**

**PROTHEUS trend**

**PROTHEUS-ECHAM5 global driver**

- **DJF**
- **MAM**
- **JJA**
- **SON**
**PROTHEUS SCENARIO Simulation: preliminary analysis**

**E-P FLUX TREND**

- **PROTHEUS trend**
  - DJF
  - MAM
  - JJA
  - SON

**Difference**

**PROTHEUS-ECHAM5**

**River Discharge**

- Rhone climatology
  - 1981-1986
  - 2021-2050

- PO climatology
  - 1981-1986
  - 2021-2050
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.

Salinity contribution

Temp contribution

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)