The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
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IAEA
International Atomic Energy Agency

2210-16

MedCLIVAR Workshop on: "Scenarios of Mediterranean Climate Change under Increased Radiative Active Gas Concentration and the Role of Aerosols

23 - 25 September 2010

Ocean-atmosphere interaction: from air-sea coupling to baroclinic instability

RUTI Paolo Michele

Enea Centro Ricerche della Casaccia
Via Anguillarese 301
S. Maria di Galeria, 00060
Roma
ITALY

Sea level rise over the Mediterranean: present climate and scenario simulations & c

Adriana Carillo, Paolo Michele Ruti, Volfango Rupolo, Gianmaria Sannino, Sandro Calmanti, Alessandro Dell'Aquila, and Vincenzo Artale

ICTP Sep 2010

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SUSTAINABLE ECONOMIC DEVELOPMENT

- **Sea level rise**
- **Validation issues**

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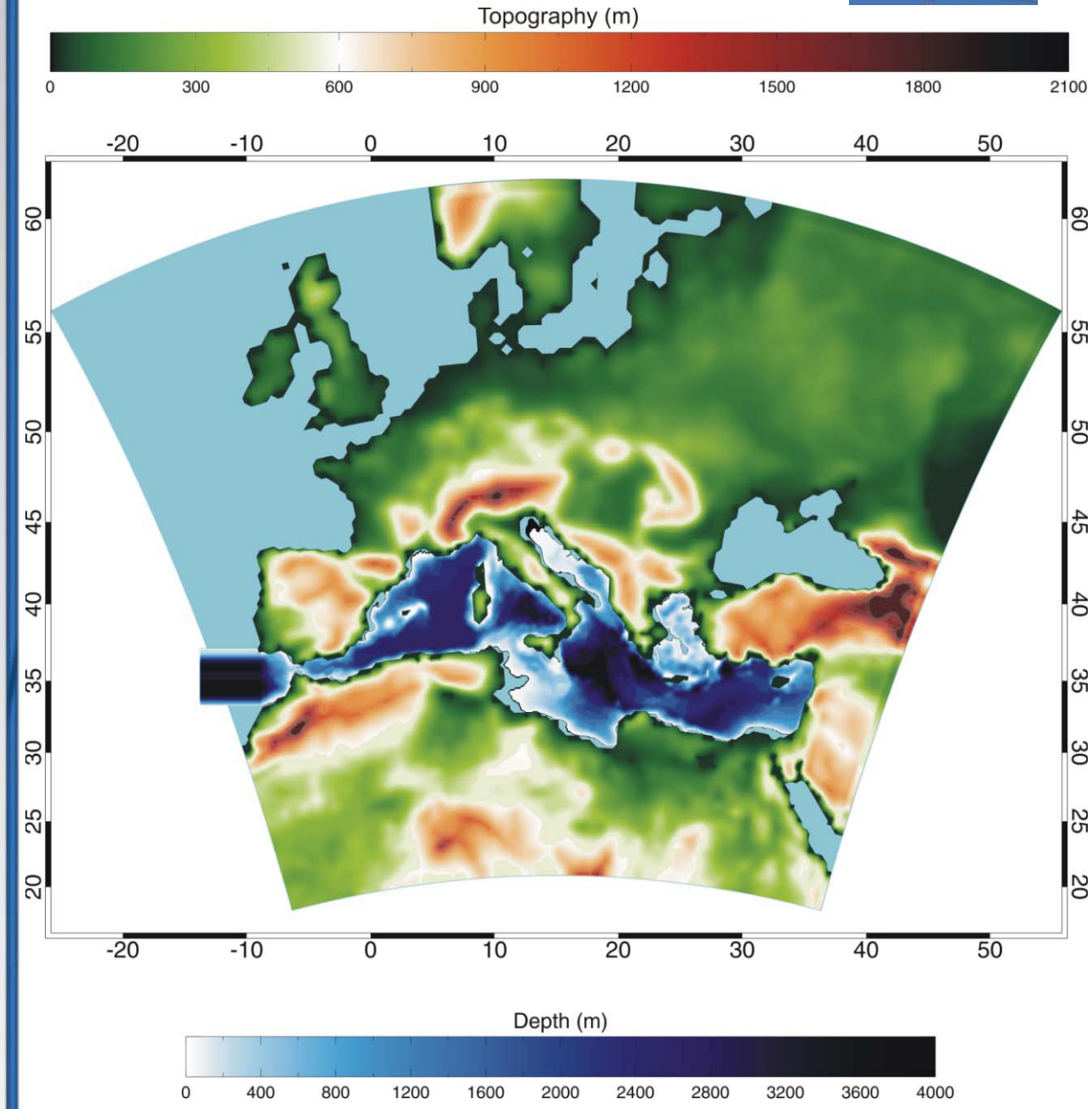
Sea level rise

PROTHEUS System



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

OASIS 3
Freq. 6h

SST

MedMIT

42 zeta vertical levels (partial cell)

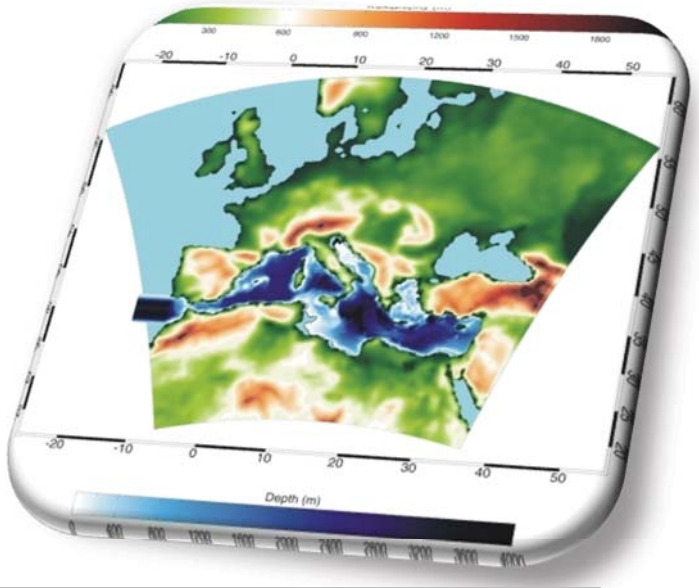
1/8° x 1/8° horizontal resolution

PROTHEUS Validation

Lateral BC
- ERA40 reanalysis 1958-2000
- interactive river runoff

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

Ocean initialization
- MEDATLAS Climatology



- **Stand-alone** configuration of the atmospheric model RegCM3 (forced by GISST data)
- **ERA40** Reanalysis
- **Observational datasets**

  OISST (daily 1/16°x1/16° SST for the period 1985-2000, Marullo et al. 2007)

  HOAPS (Hamburg Ocean Atmosphere Parameters and fluxes from Satellite data)

  CRU (Climatic Research Unit, UK)

An Atmosphere-Ocean Regional Climate Model for the Mediterranean area:Assessment of a Present Simulation Climate 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 – Clim Dyn DOI 10.1007/s00382-009-0691-8

PROTHEUS Validation

Run 1958-2001

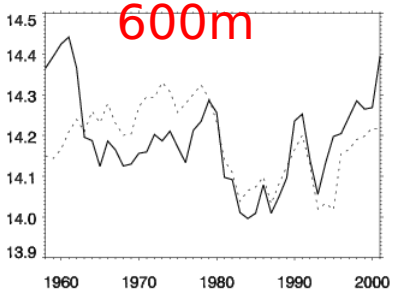
Comparison with MEDATLAS data

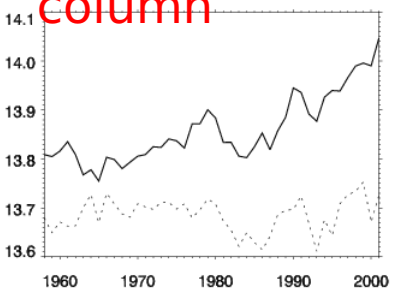
Time series of temperature averaged over the entire Mediterranean basin, the Western basin the Eastern Basins and Adriatic Sea

Model (solid line)
MEDATLAS II database (dotted line).

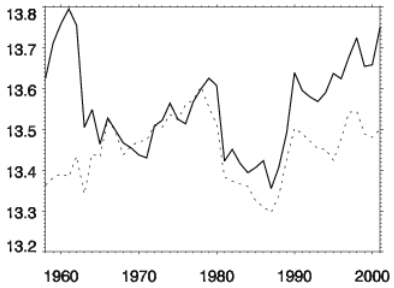
100-600m

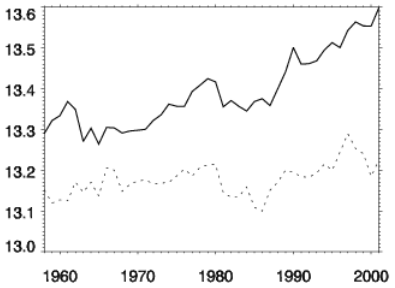
Entire water column



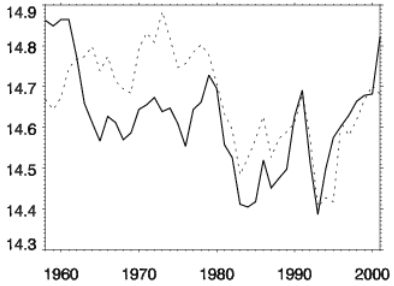


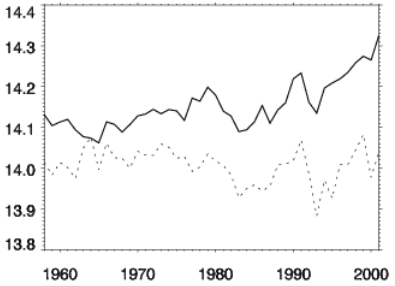
TOT





West





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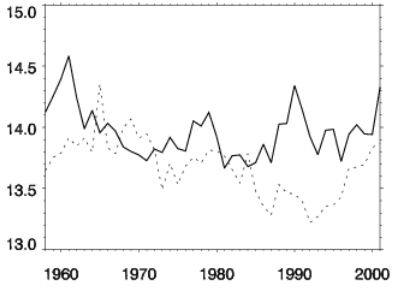
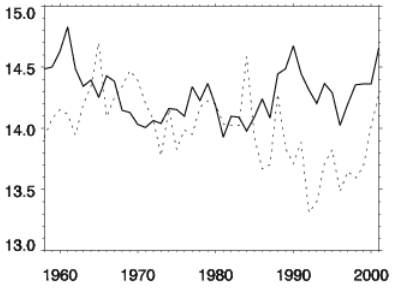
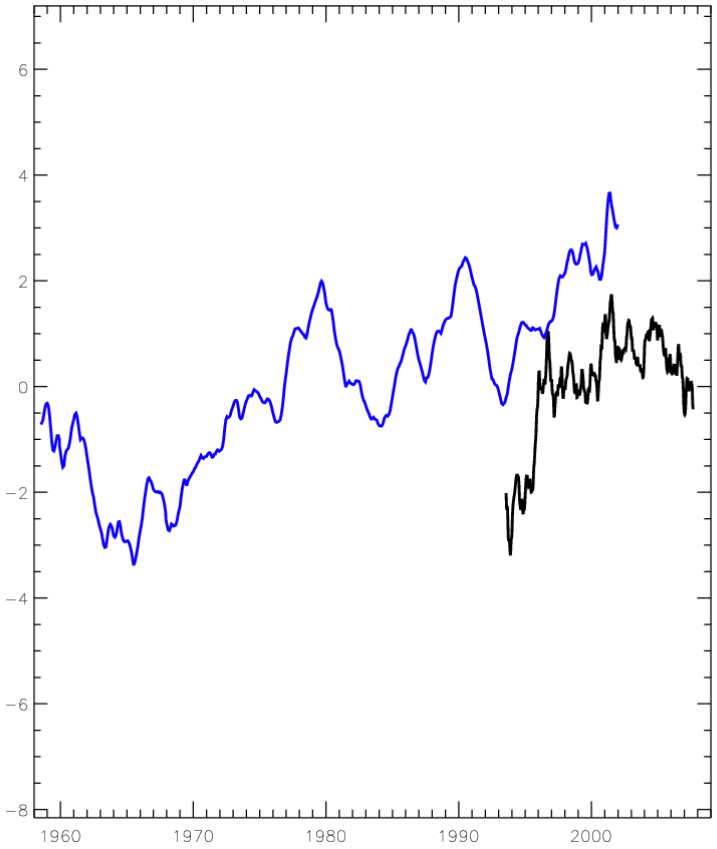




Adr

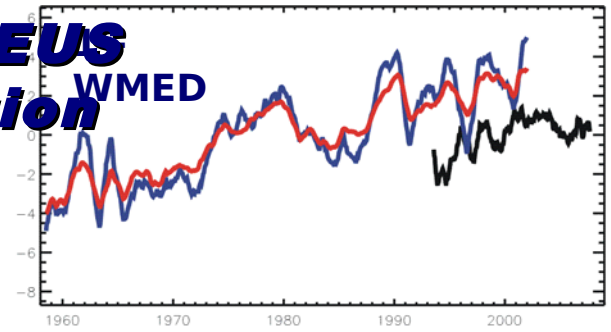
PROTHEUS
Validation

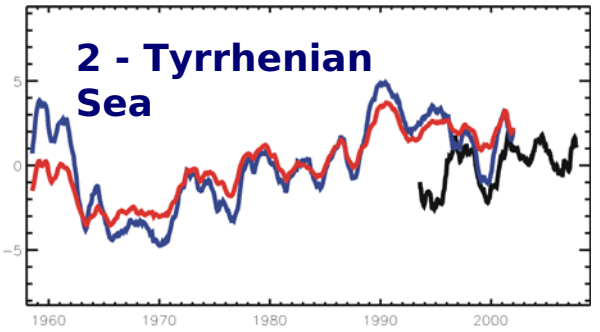
Steric sea level component compared with satellite data

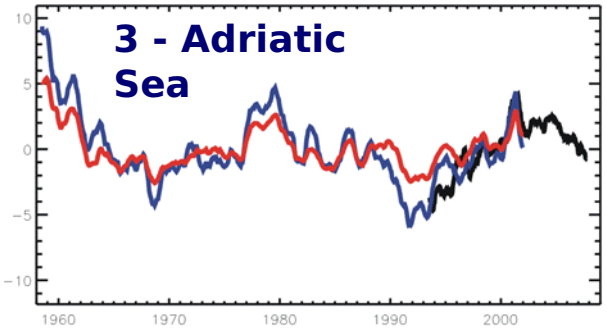


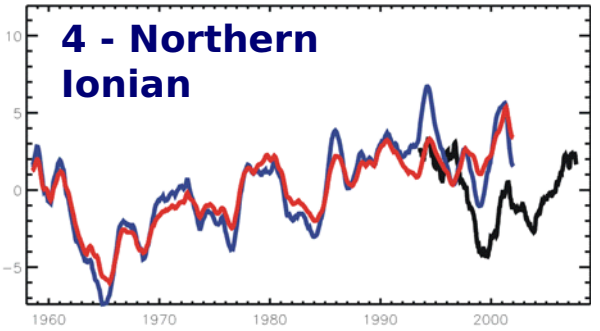
Mediterranean sub-basins

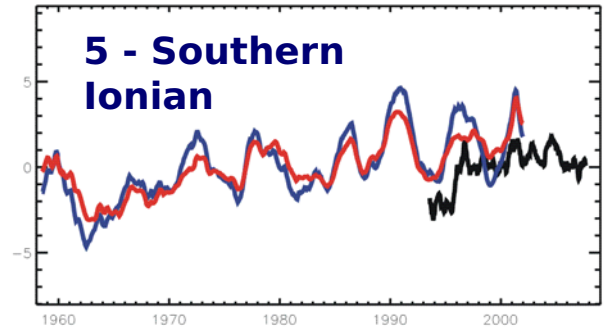
PROTHEUS Validation

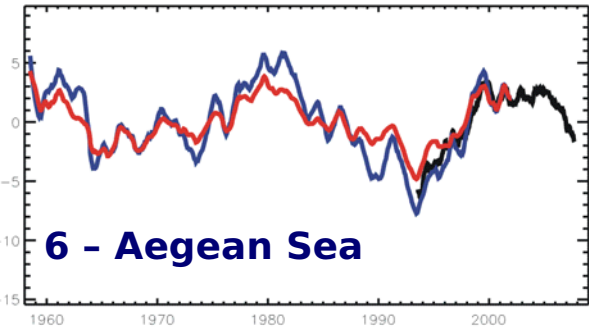


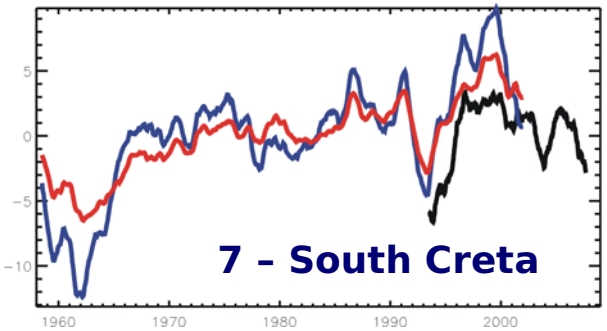


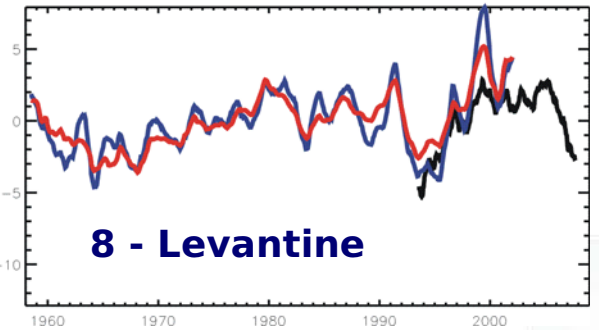










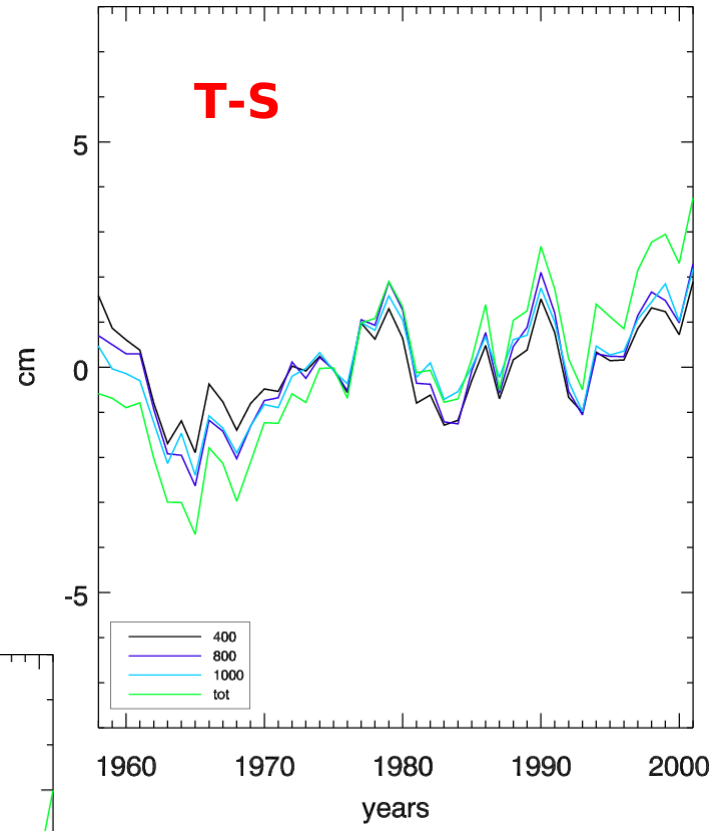


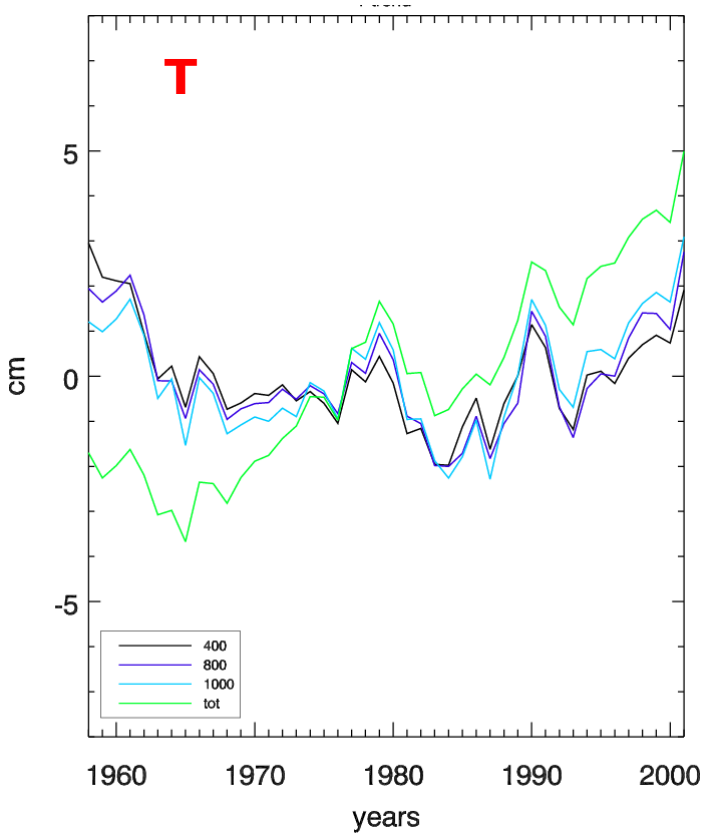
Black satellite data

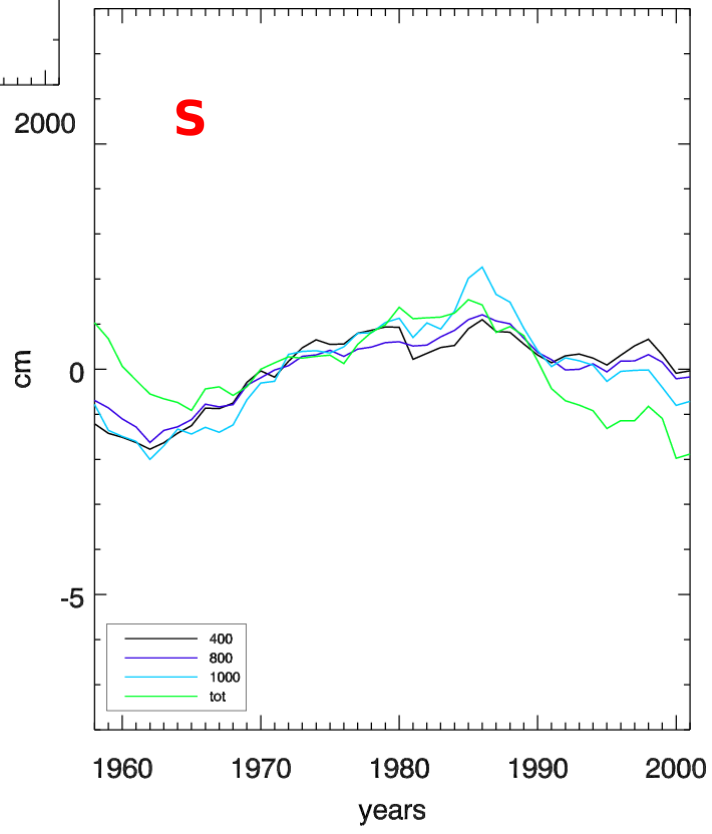
Red steric

Blue steric + circulation

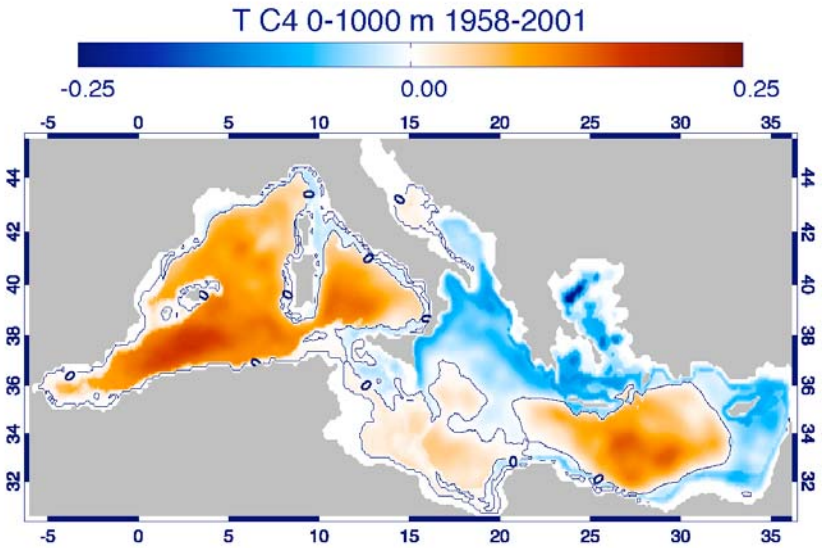
Sea level trend

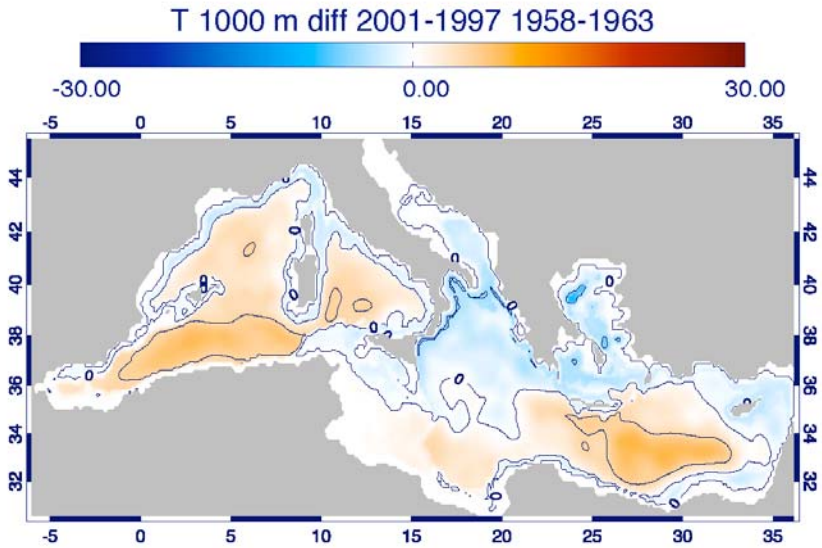


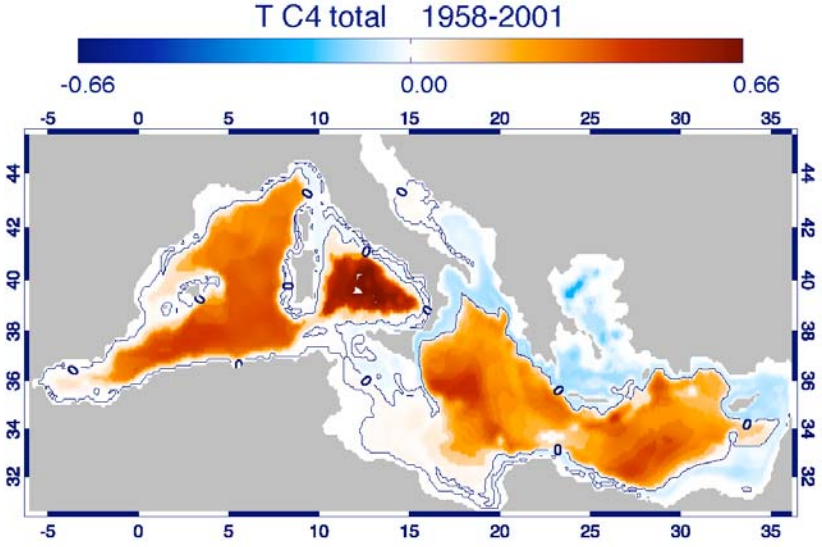


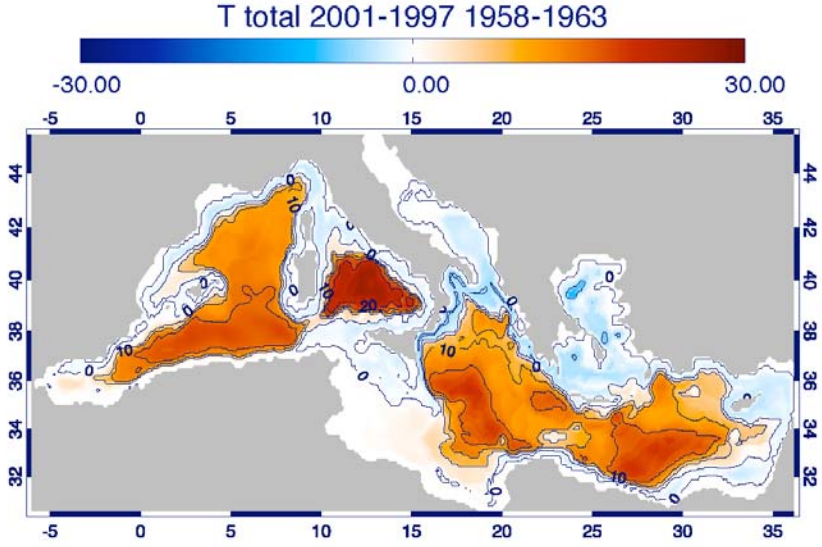


Sea level trend

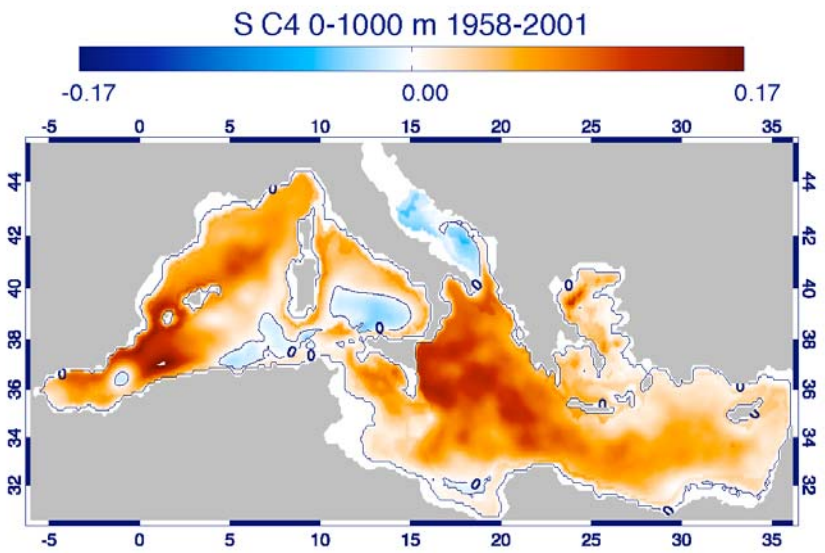


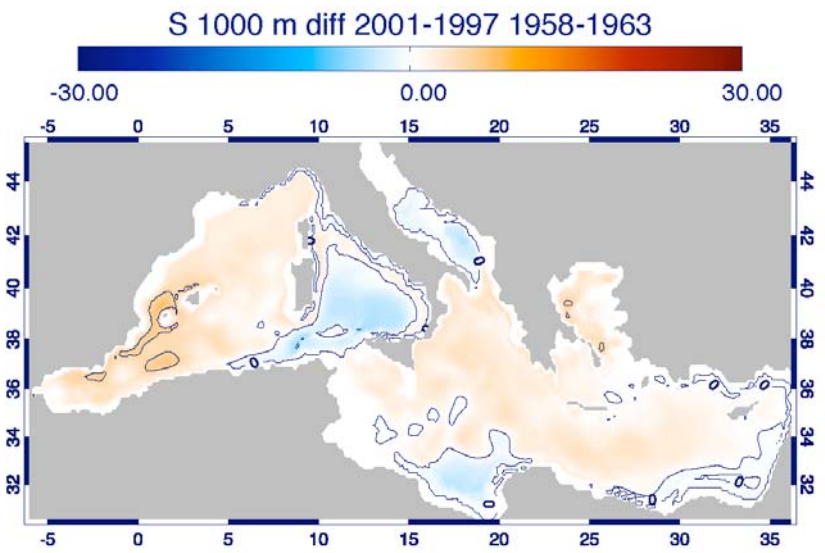


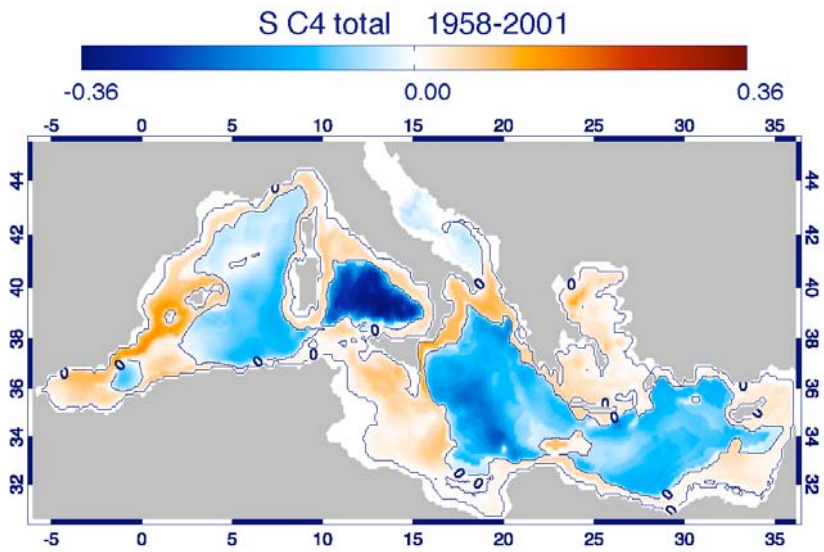


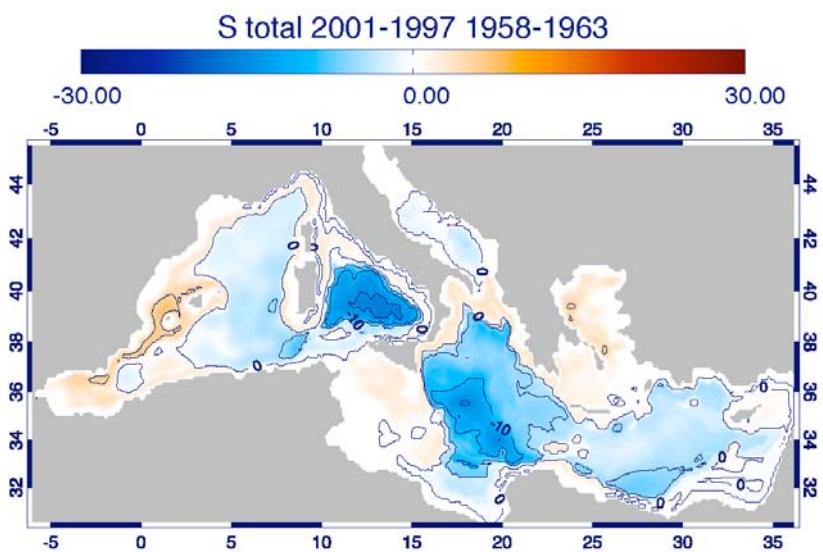


Sea level trend

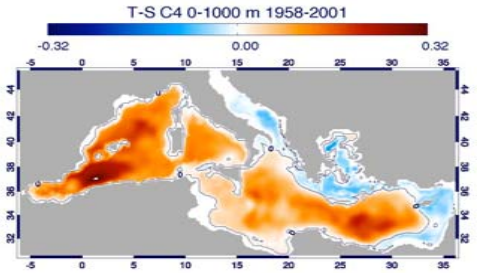


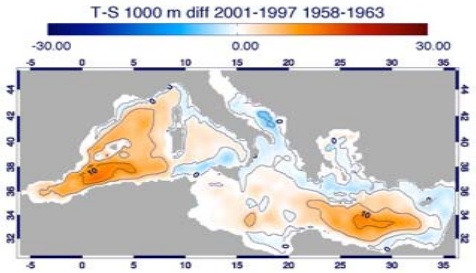


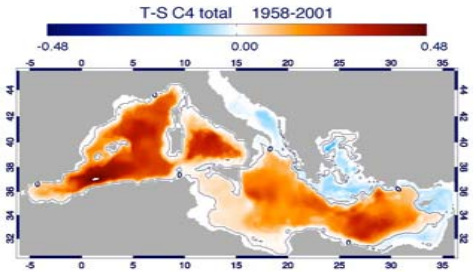


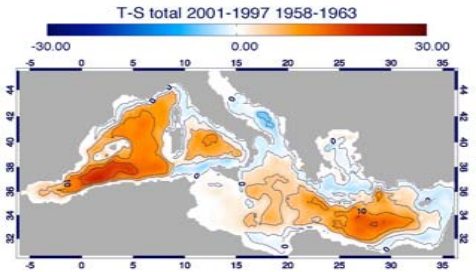


Sea level trend









PROTHEUS Validation: Present climate simulation

- The oceanic component of the coupled system represents quite well the interannual variability of vertically integrated Temperature.

- A positive trend is present in temperature vertically averaged from top to bottom

- Comparison with satellite data in the period 1993-2001 has shown a good agreement on the Mediterranean scale and on the different sub-basins.

- It is present the regular sea level increase in the Eastern Mediterranean Sea and the decrease in the Northern Ionian Sea.

- The worst results are found in the western part of the Mediterranean probably due to the not correct inflow through the Gibraltar Strait

PROTHEUS SCENARIO Simulation

Simulation characteristics:

Boundary condition from ECHAM5-MPIOM run performed in ENSEMBLES project:

20C3M: 1951-2000 climate of the 20th Century experiment

SRES A1B: 2001-2051 720 ppm stabilization experiment

Impose SRES A1B conditions and initialize with conditions from the end of the 20C3M simulation.

ECHAM5-MPIOM model characteristics:

Atmosphere (ECHAM5; Roeckner et al., 2003) resolution: T63 L32

Ocean (Marsland et al., 2003) resolution: 1. deg, conformal mapping grid with grid poles over Greenland and Antarctica, 41 vertical levels

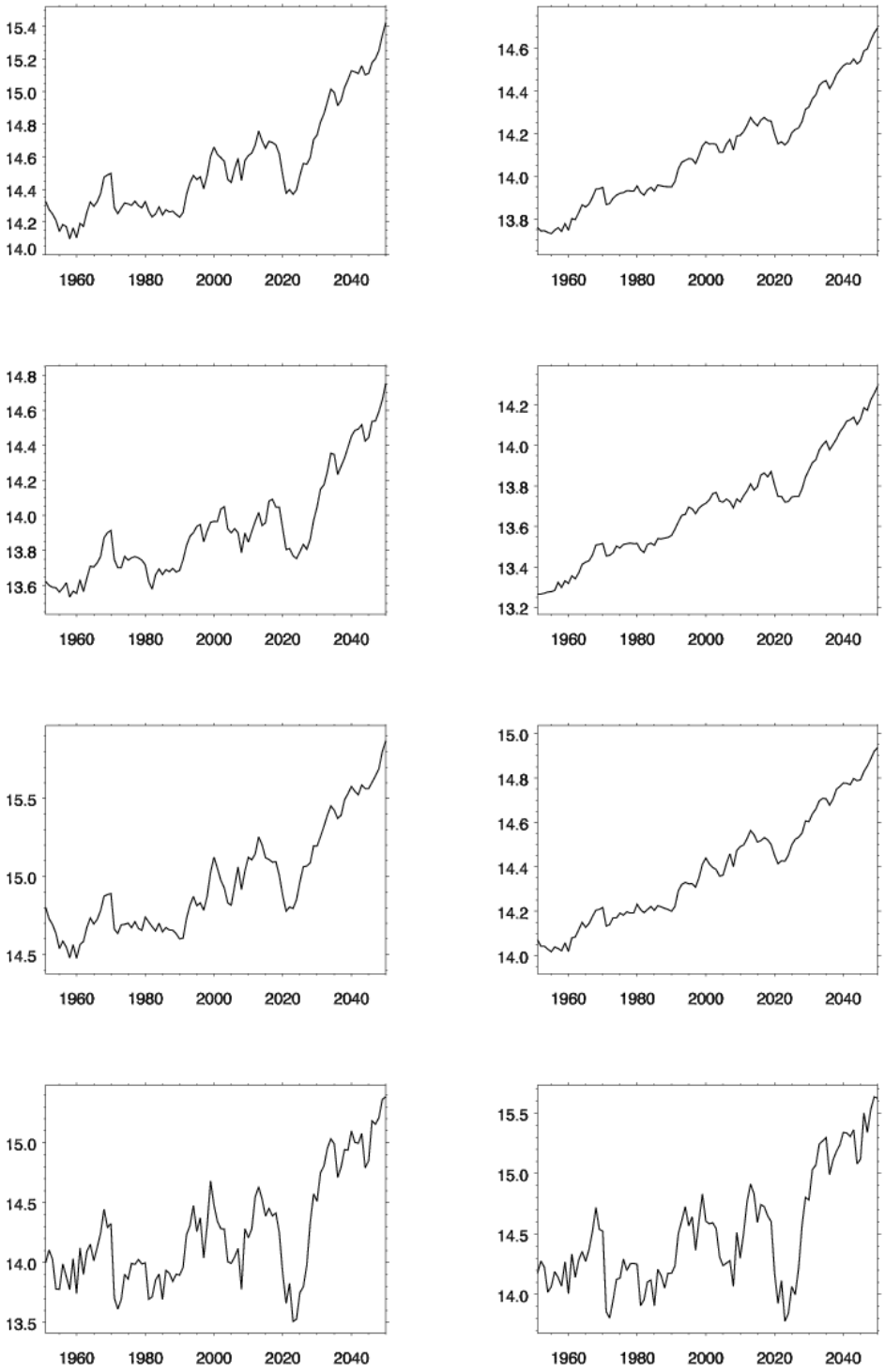
BC for MITgcm

Temperature and salinity are relaxed in the Atlantic box to climatological monthly Levitus data in the present climate simulation and to monthly mean anomalies obtained from the oceanic component of the coupled global run in the scenario simulation.

MEAN VALUES Validation

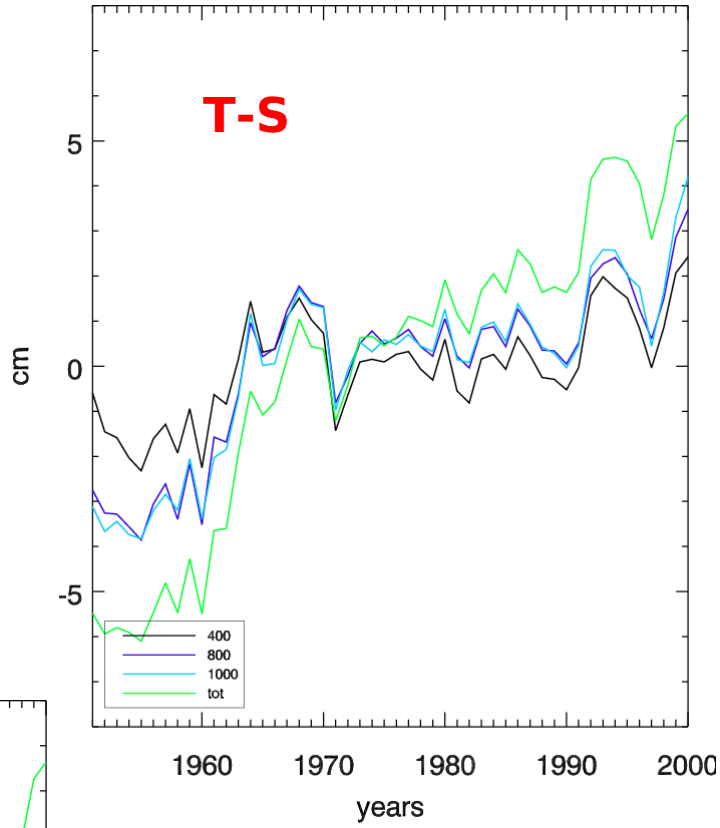
		$\langle T \rangle$	$\langle S \rangle$	$\langle 0-100T \rangle$	$\langle 0-100S \rangle$	$\langle 100-600T \rangle$	$\langle 100-600S \rangle$
Mediterranean Sea	OBS	13.68	38.62	17.15	38.27	14.19	38.67
	ERA40	13.86	38.62	16.30	38.28	14.19	38.60
	20C3M	13.91	38.60	16.17	38.27	14.31	38.56
	EHA1B	14.33	38.63	16.71	38.30	14.78	38.60
Western Med	OBS	13.18	38.42	15.92	37.77	13.45	38.43
	ERA40	13.39	38.39	15.32	37.72	13.56	38.32
	20C3M	13.48	38.38	15.30	37.74	13.73	38.29
	EHA1B	13.90	38.40	15.77	37.73	14.12	38.30
Eastern Med	OBS	14.00	38.74	18.07	38.58	14.67	38.83
	ERA40	14.15	38.76	17.00	38.61	14.62	38.78
	20C3M	14.18	38.73	16.81	38.59	14.71	38.74
	EHA1B	14.60	38.78	17.39	38.65	15.22	38.80
Adriatic Sea	OBS	13.95	38.61	15.22	38.44	13.66	38.68
	ERA40	14.28	38.76	15.37	38.69	13.96	38.80
	20C3M	14.26	38.64	15.13	38.49	14.02	38.71
	EHA1B	14.76	38.70	15.71	38.58	14.49	38.76

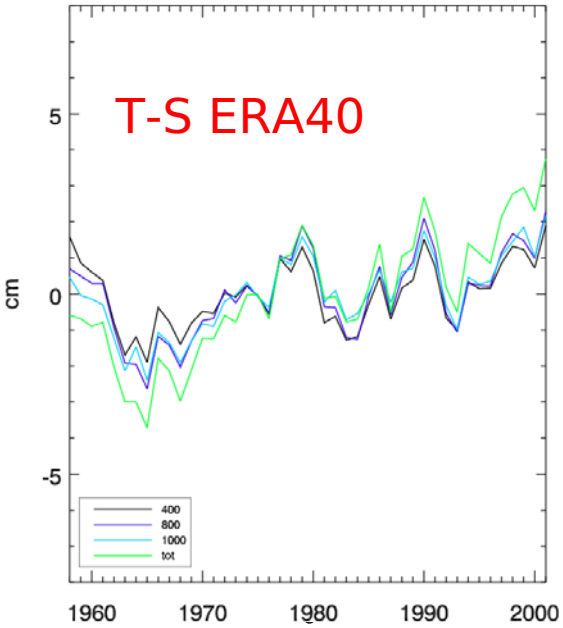
T trend 1951-2050 simulation

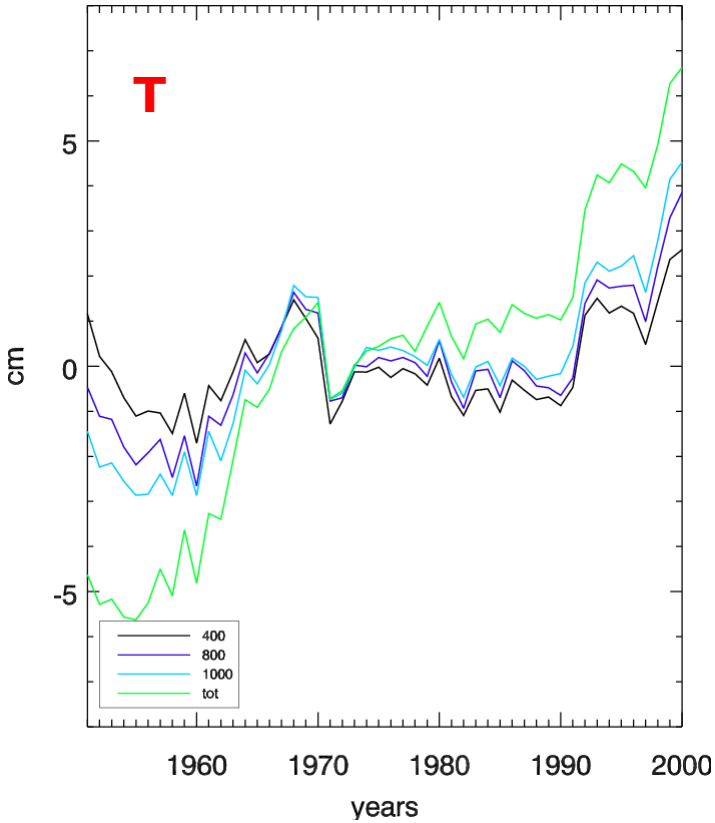


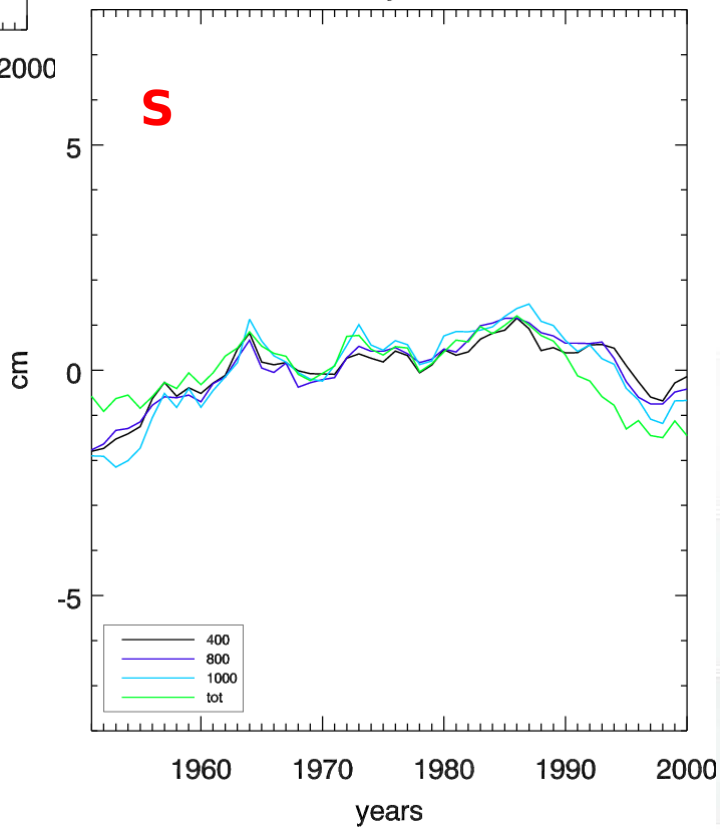
Steric sea level trend

Present climate period



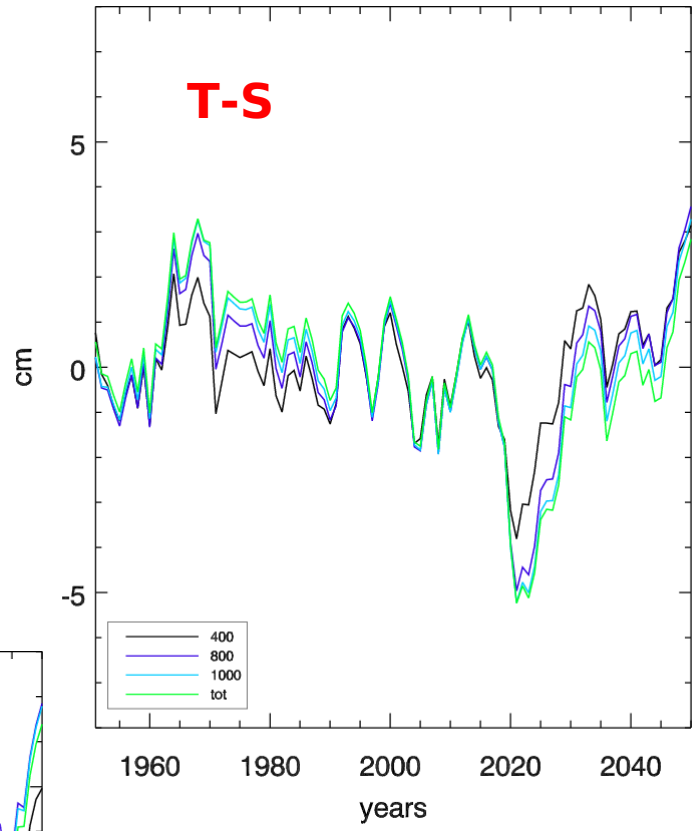


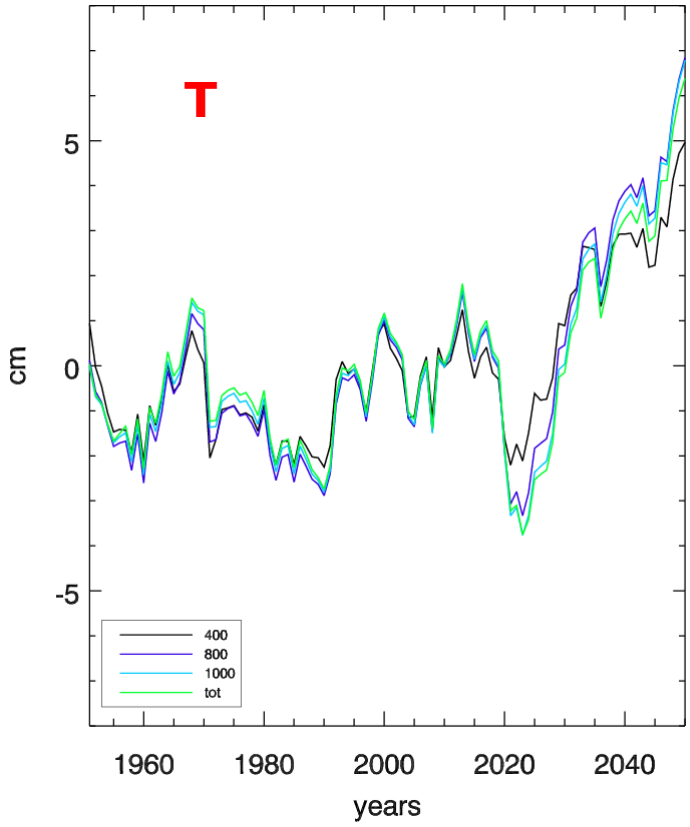


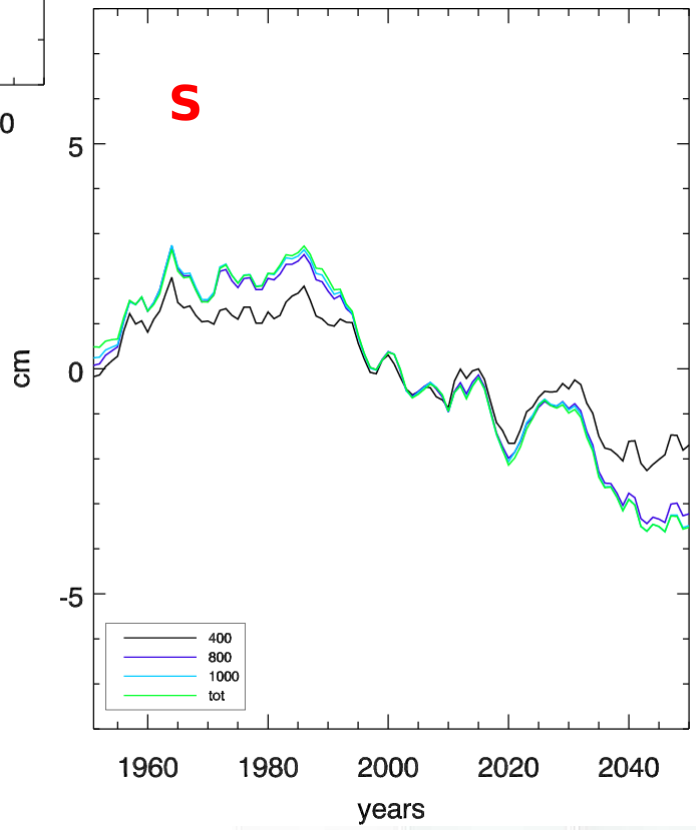


Steric sea level detrended

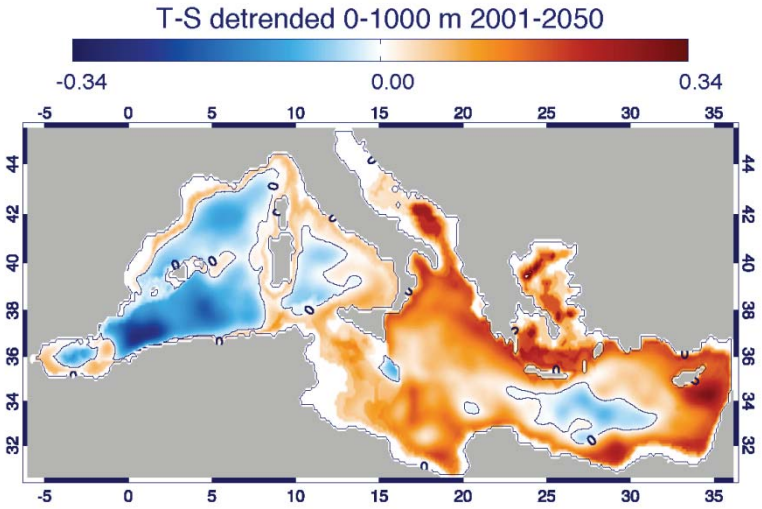
Linear trend computed on the 50-year present climate period has been subtracted

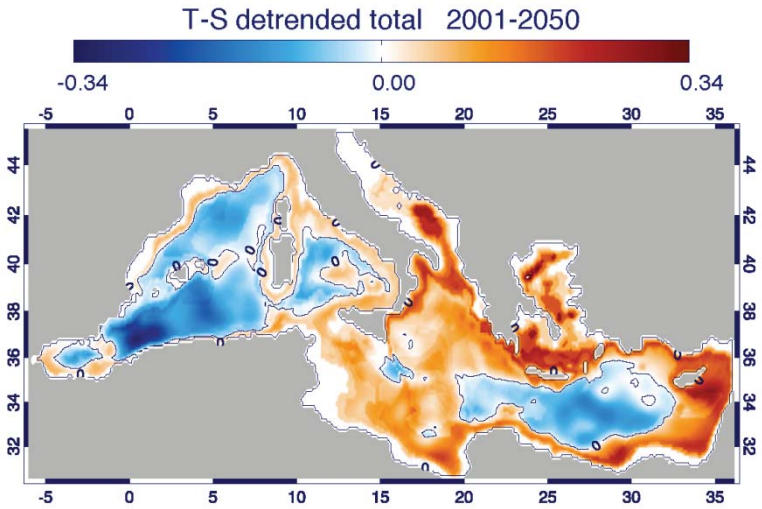


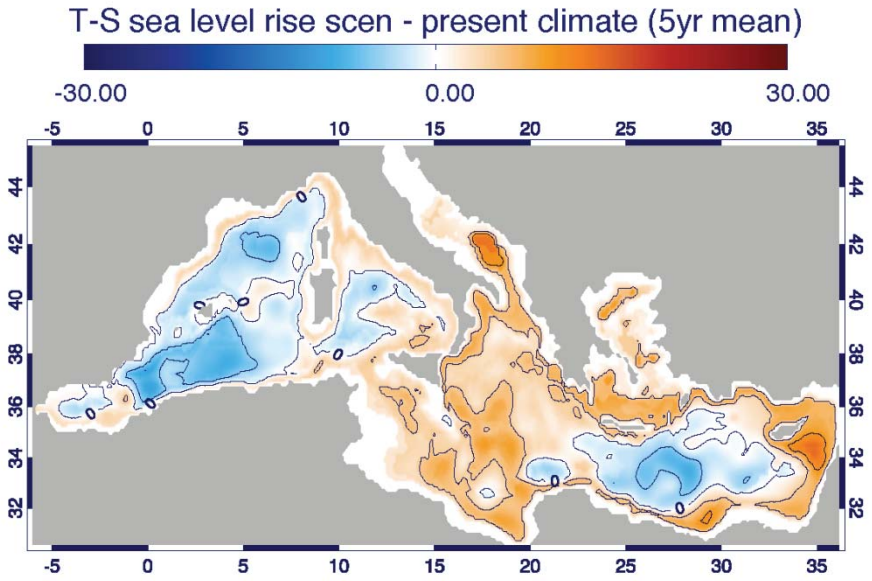




Sea level trend for the scenario period







Cav eat for intepreting the western basin due to uncertainties related to the Atlantic water inflow

The Ionian and Adriatic Sea will experience the strongest sea level rise after 2040

Conclusion

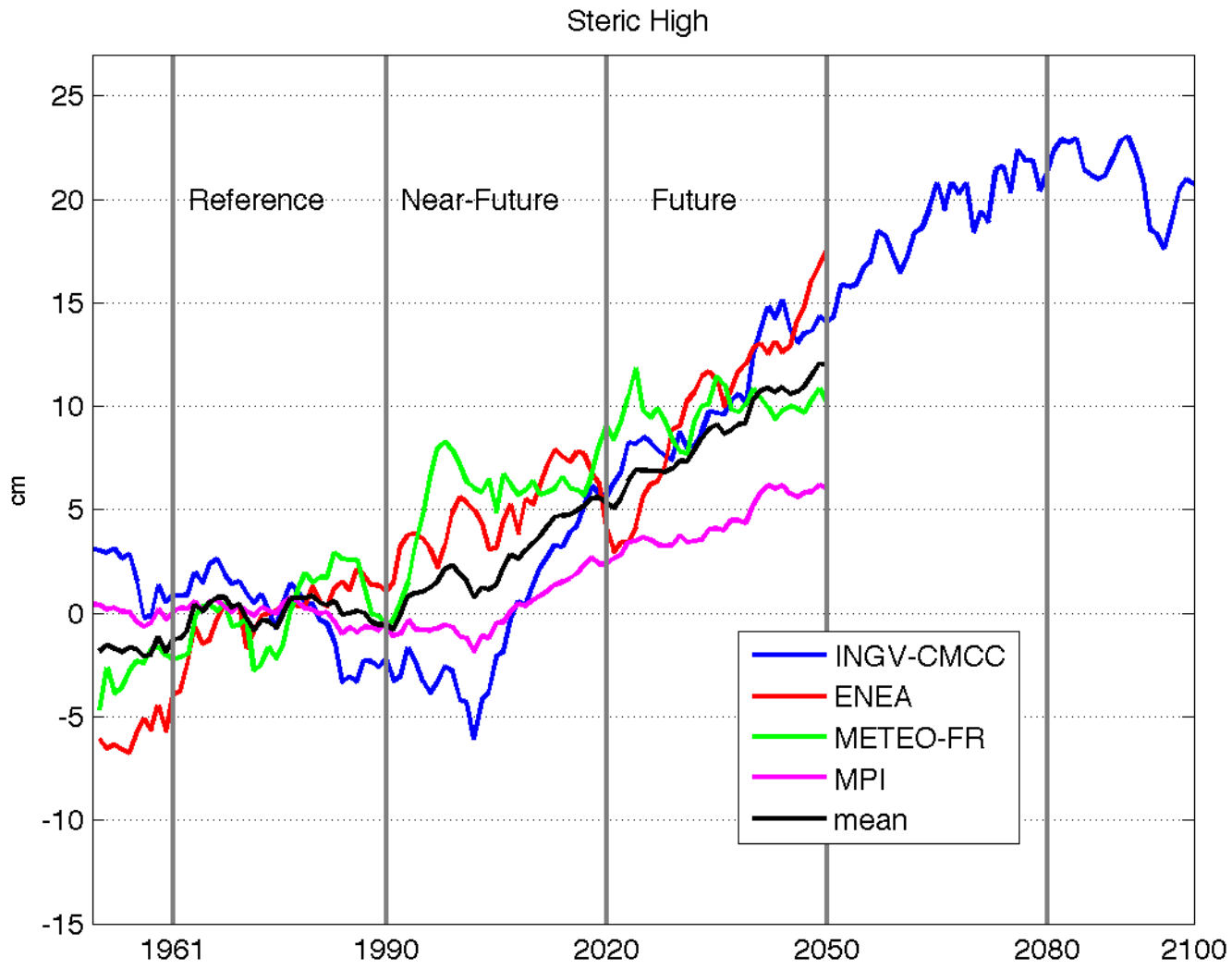
- A regional coupled model has forced by ERA40 covering the period 1958-2001. Vertically integrated values of temperature have been checked against MEDAR data, the steric sea level component has shown good agreement with satellite data in different Mediterranean sub-basins

- A 100 year simulation for the period 1951-2050 has been forced using boundary conditions from the coupled model ECHAM5-MPIOM. In the period 2000-2050 the scenario SRES A1B was used.

- The steric sea level trend ranges in the basin from -0.32 cm/yr to 0.34 cm/yr , with a mean over the Mediterranean of 0.028 cm/yr . An important aspect is the large spatial variability of the trend with negative values over most of the Western basin and part of the Eastern and positive values principally in the Southern Adriatic and the Ionian Sea.

- A strong increase in the sea level trend due to the thermal component is observed in the second part of the 50 year simulation.

Circe intercomparison



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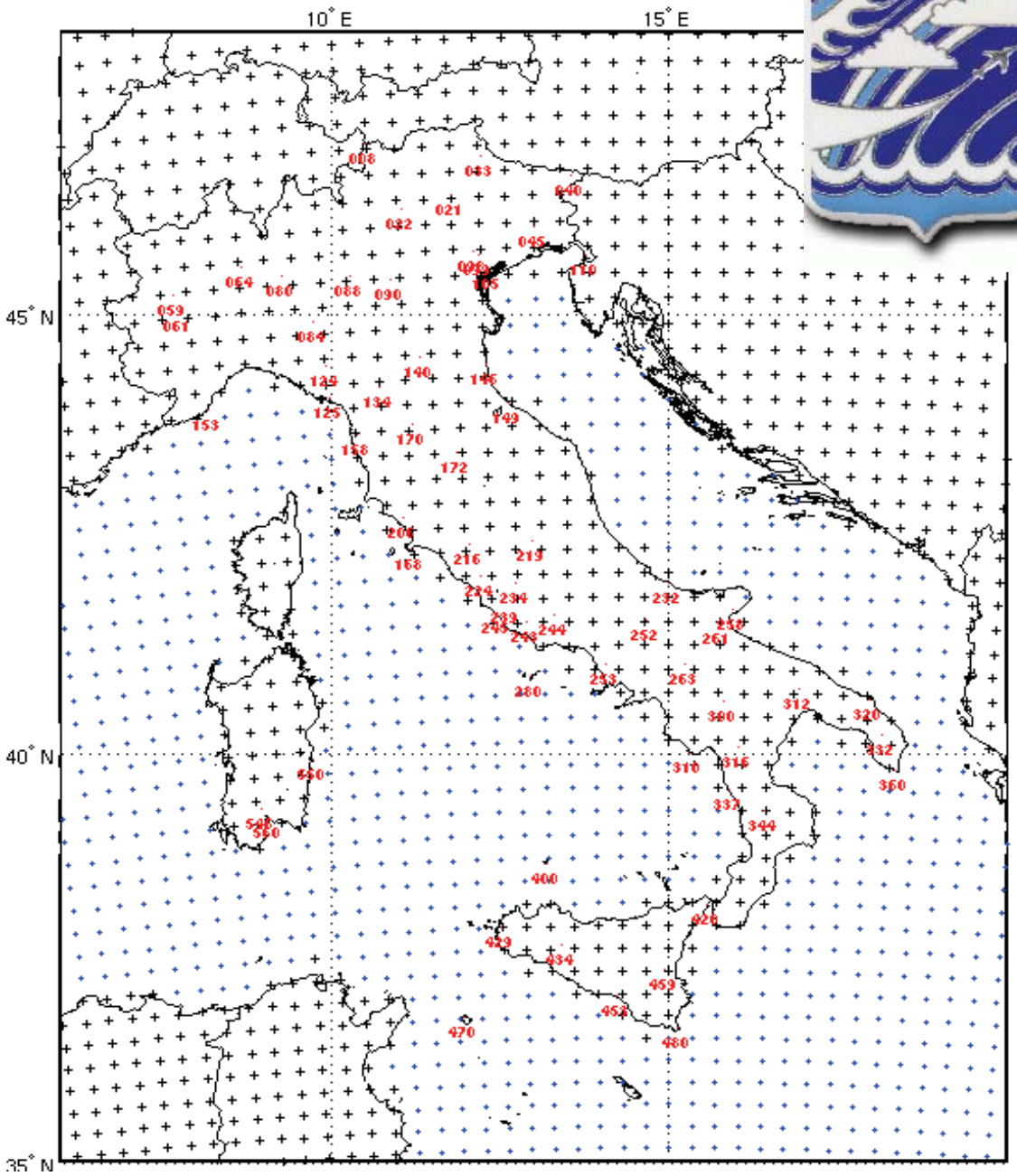
Validation Issues

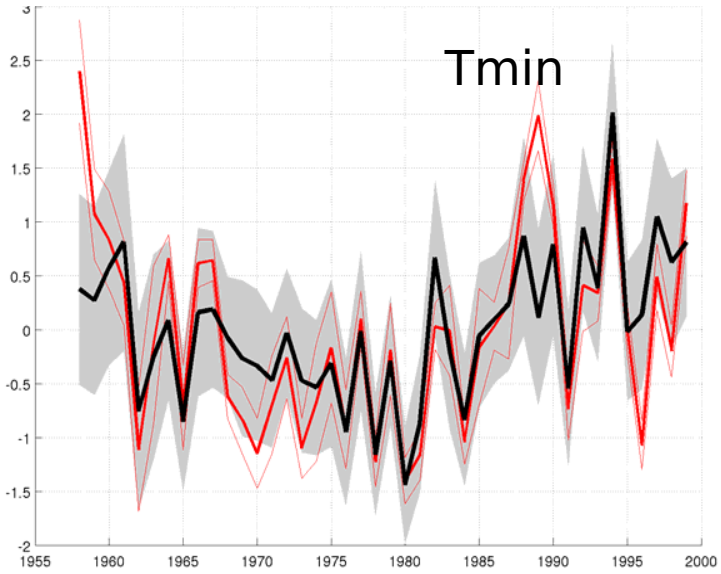
Model validation

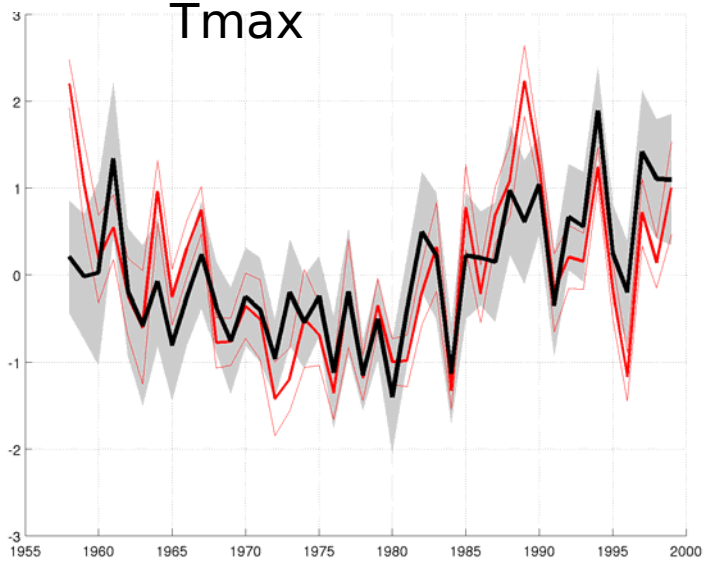


Observational dataset consists of daily time series of maximum and minimum temperatures, as measured by 64 weather stations belonging to the Italian Air Force network from 1st Jan 1958 to 31th Dec 1999 **(Fig. 1)**. These data are encoded within the SYREP meteorological message protocol, which consists of daily reports. The employed stations form a subset of the actual stations (about 100) managed by the Italian Air Force, and have been chosen to optimize data coverage and continuity.

S. Calmanti (1), A. Dell'Aquila (1), F. Maimone (2), and V. Pelino (2)

Model validation – inter-annual var





A first evaluation of the model's skill in representing climate variability in the target area is done by comparing the standardized series of annual temperatures with the corresponding model output. The standardization of time series makes the comparison independent from both model bias and RMSE at each comparison site

The analysis identifies patterns of variability characterized by large scale mismatches between model and observations. Years 1989 and 1996 should be considered as good candidates for case studies aimed at improving/tuning model performances.

Model validation – seasonal cycle

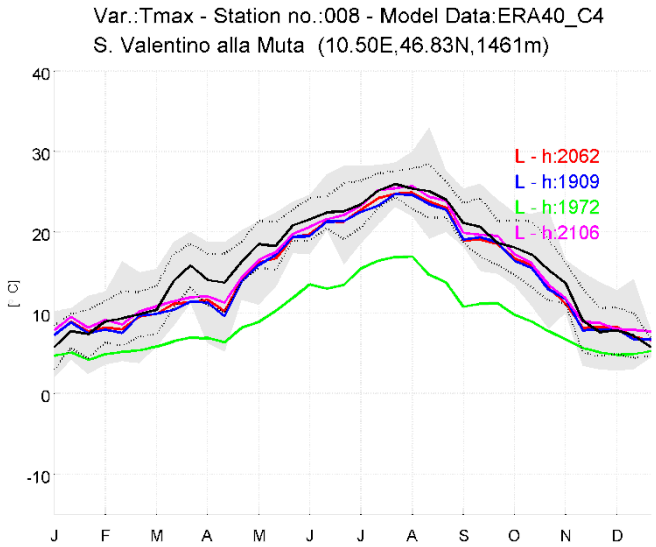
We consider the 40-year average seasonal cycle of Tmin and Tmax. **Table** reports the mean bias and the averaged root mean squared deviation (RMSD) between the seasonal cycle observed at each weather station site and the nearest four neighbouring model grid points. Temperatures have been homogenized by rescaling all values to the elevation of the corresponding weather station with dry adiabatic lapse rate. The RMSD is computed after removing the bias between the observed and modelled seasonal cycle. The largest biases for Tmin and Tmax is observed at the stations 008 (in the Alps, too cold) and 134 (Mount Cimone, Appennini, too warm). The largest RMSD is observed at the same locations. The lowest biases and RMSDs are observed over coastal areas and over small islands. The model has better performances fo Tmin and overall better description of the range of intraseasonal variability fro grid points closer to the ocean.

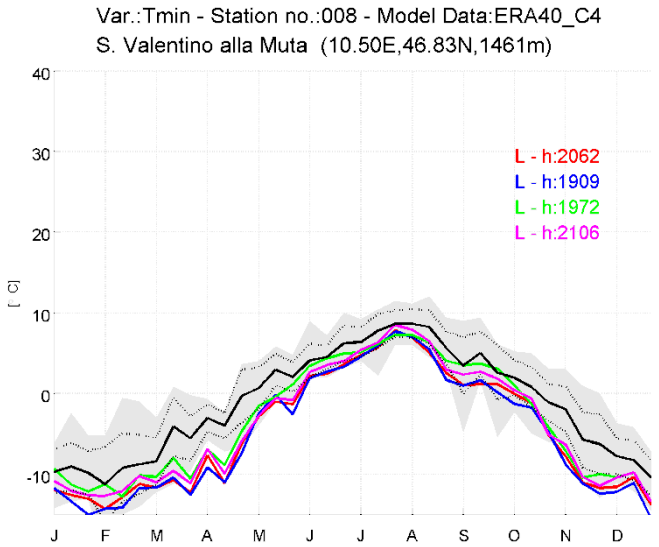
				Tmax			Tmin		
ID	Lat	Lon	Hgt	Ave	Bias	RMSD	Ave	Bias	RMSD
008	10.5	46.83	1461	15.8	-7.8	1.7	-1.3	-8.4	1.6
021	11.78	46.3	2006	10.8	+2.8	1.5	-4.1	+0.1	1.5
022	11.03	46.15	2129	9.5	+4.3	1.6	-3.9	+0.1	1.4
033	12.2	46.7	1226	15.6	-3.9	1.8	-3.4	-3.3	1.6
040	13.55	46.5	778	17.7	-2.9	1.7	0.0	-1.6	1.0
045	13	45.95	52	22.1	-2.9	1.6	4.9	-1.9	0.8
059	7.65	45.22	301	21.3	-3.1	2.0	3.8	-2.6	1.2
061	7.73	45.03	710	19.3	-1.0	1.8	5.4	-4.3	1.0
560	9.07	39.25	2	25.3	-1.2	2.0	8.4	+0.5	0.9
		Mean		**21.5**	**-0.7**	**2.1**	**6.1**	**-0.3**	**1.0**

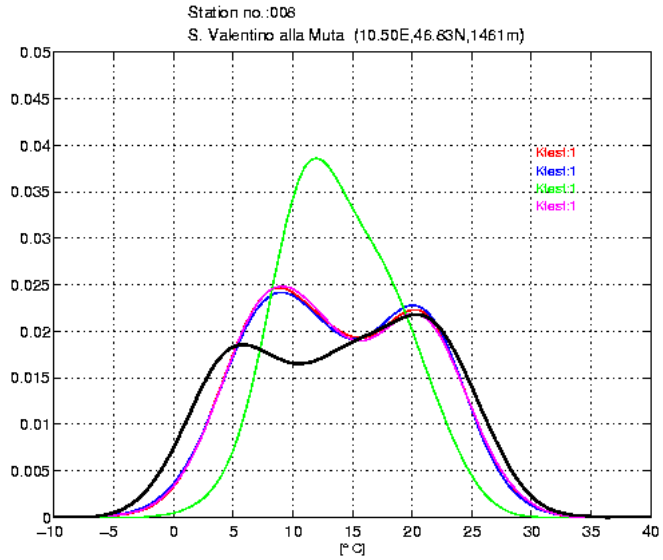
Tab. 1

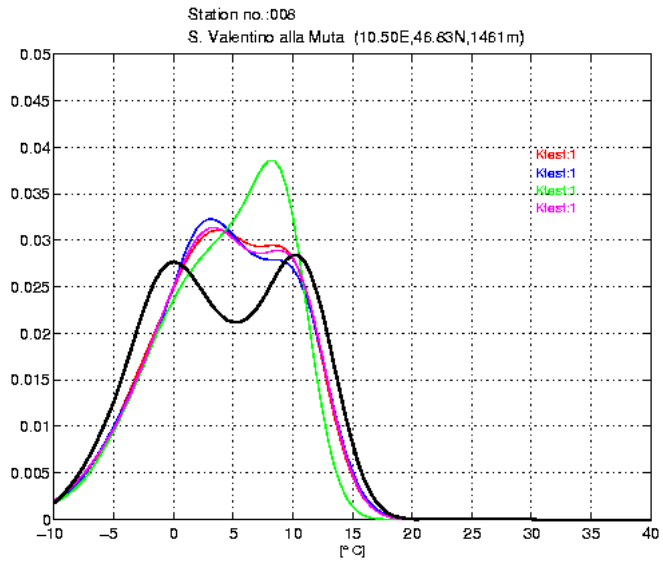
320	17.95	40.65	10	24.4	-0.2	2.7	9.9	-0.5	1.0
332	18.15	40.23	53	25.3	-1.1	2.2	7.1	+2.7	0.9
337	15.88	39.58	485	23.2	-1.7	2.1	9.5	+0.2	0.9
344	16.4	39.33	1677	15.4	+7.5	2.8	0.8	+4.4	0.9
360	18.35	39.82	112	22.3	+0.3	2.1	11.4	+0.3	0.8
400	13.18	38.7	243	23.4	-3.2	1.2	12.9	+0.1	0.5
420	15.55	38.2	54	24.2	+1.6	2.5	14.4	-7.1	1.2
429	12.5	37.92	9	25.7	-2.0	2.0	10.0	+2.0	1.0
434	13.42	37.72	1035	20.6	+4.8	2.0	6.1	+1.3	1.0

Model validation – seasonal cycle

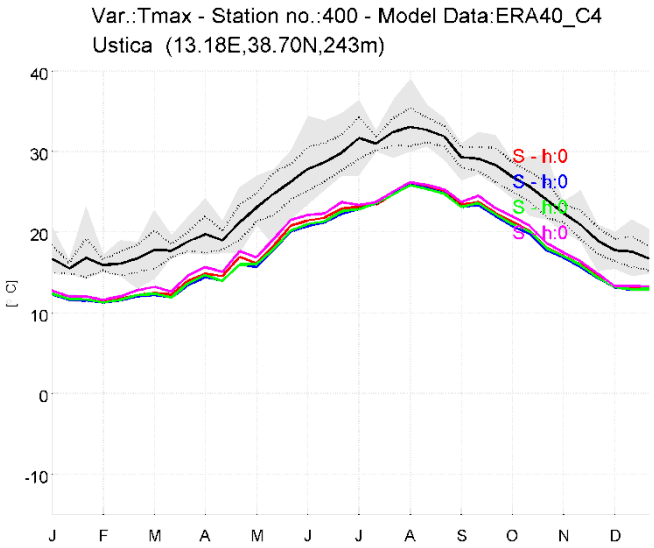


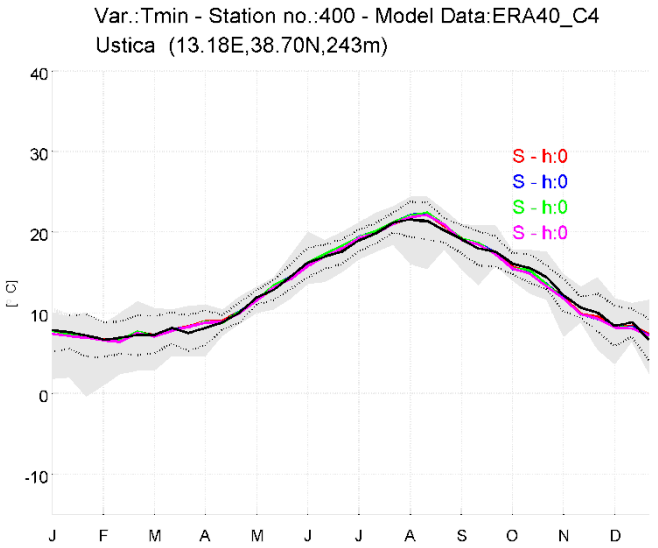


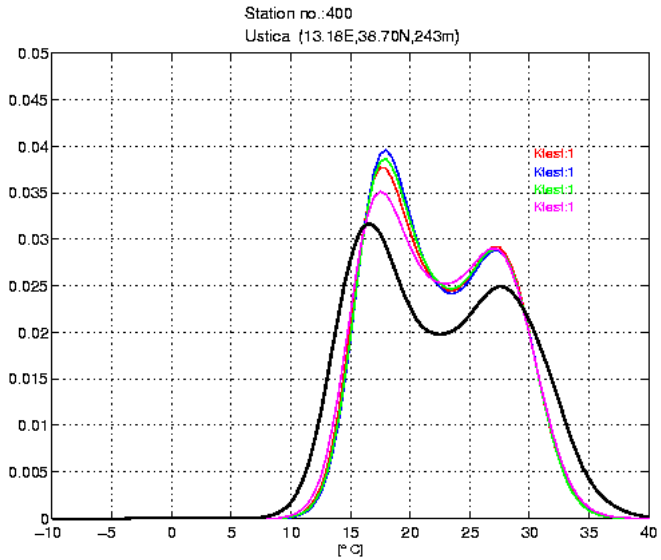


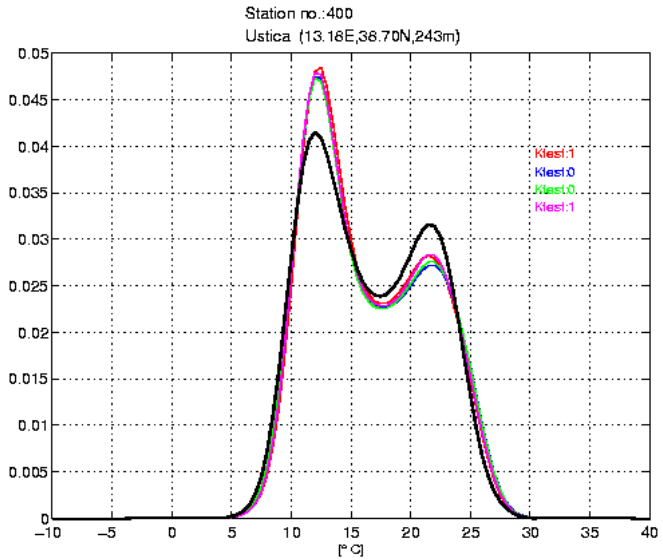


Model validation – seasonal cycle









Model validation – seasonal cycle

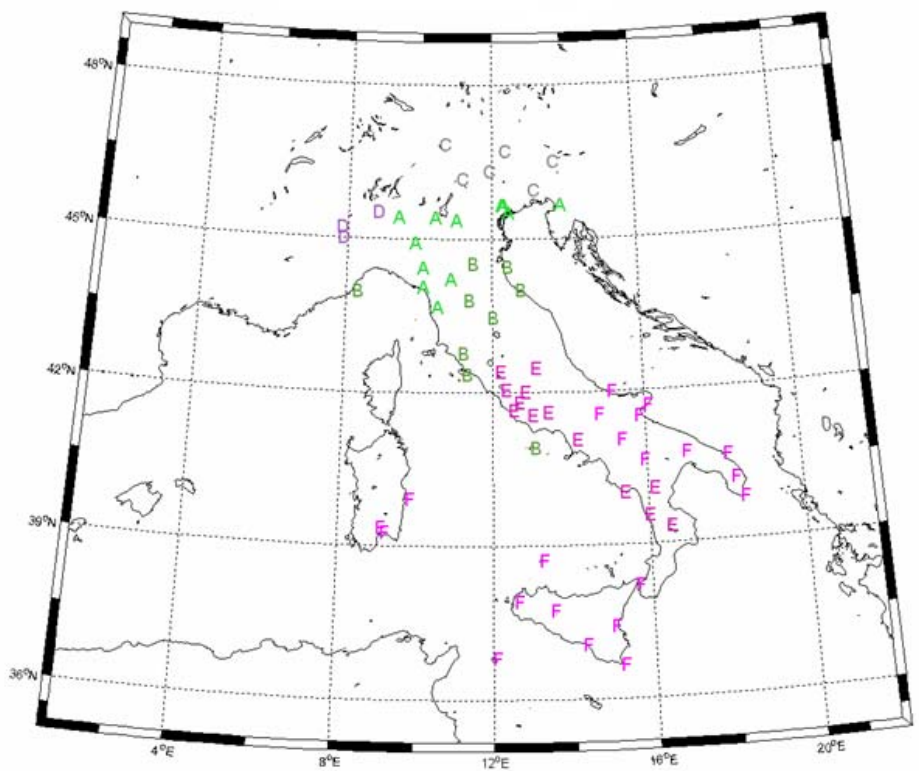
Parameters: monthly mean Tmax+Tmin

Period: 1958-1999 (all months)

Clustering method : WARD

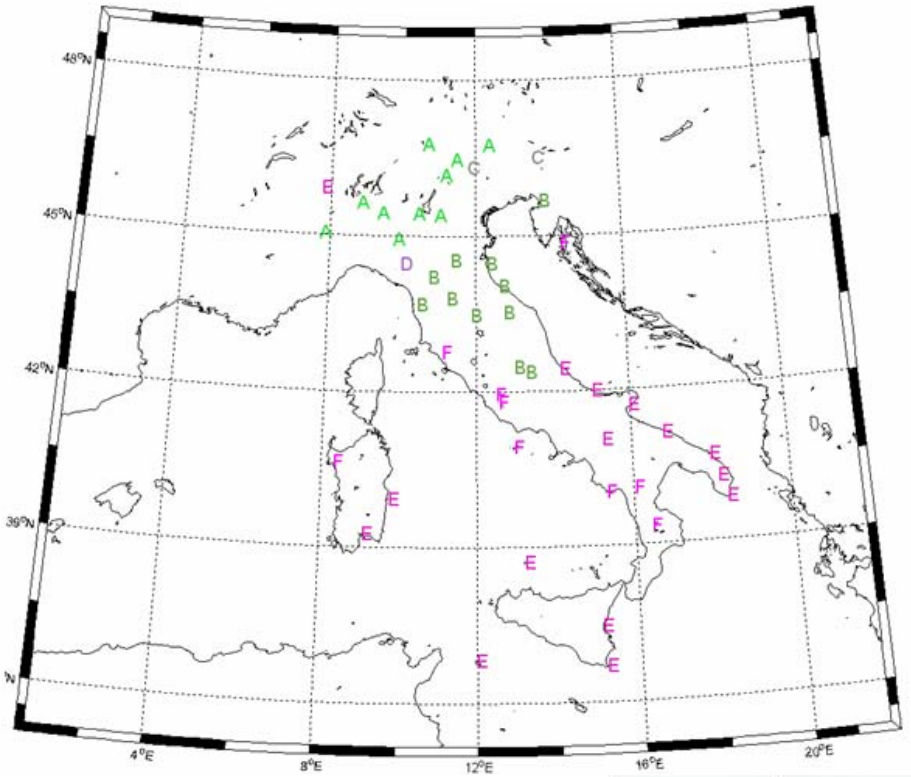
 # Clusters : 6

MODEL

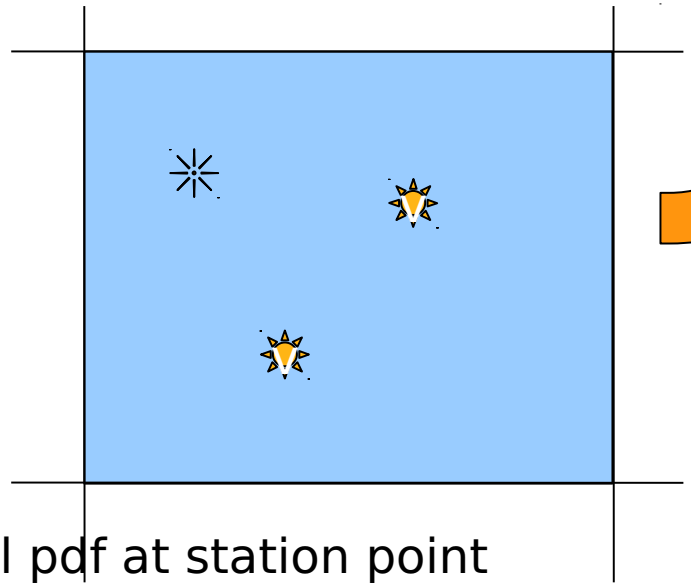


OBS

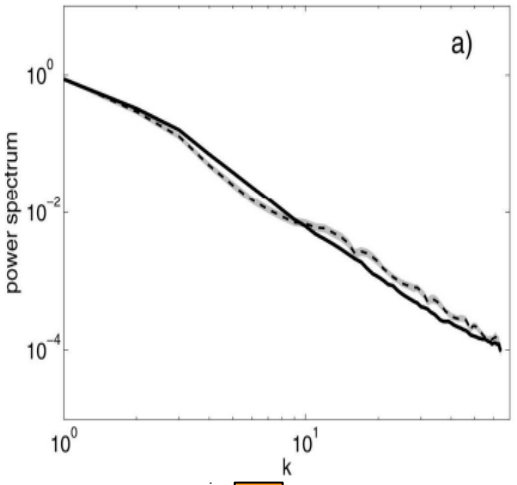
(extended network)

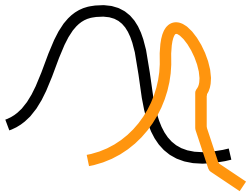


Model validation – rainfall issue

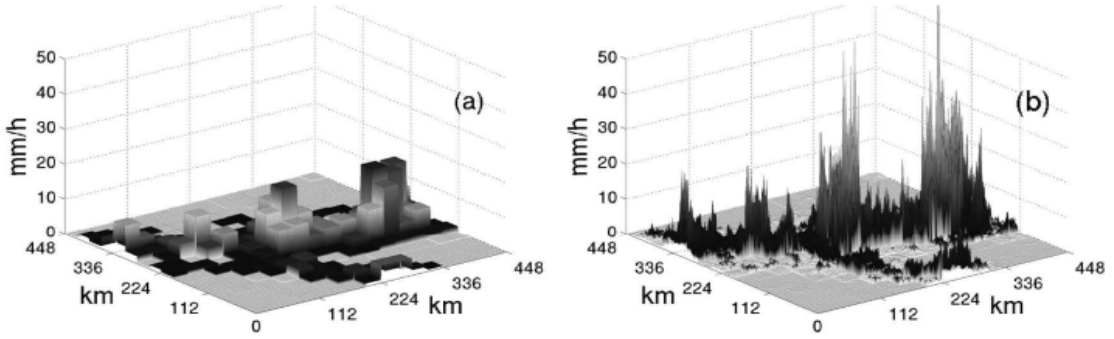


Model pdf at station point





Station pdf



RainFARM: Rainfall Downscaling by a Filtered Autoregressive Model

NICOLA REBORA AND LUCA FERRARIS

Centro di Ricerca Interuniversitario in Monitoraggio Ambientale, University of Genoa, Savona, Italy

JOST VON HARDENBERG AND ANTONELLO PROVENZALE

Istituto di Scienze dell'Atmosfera e del Clima, CNR, Torino, and Centro di Ricerca Interuniversitario in Monitoraggio Ambientale, University of Genoa, Savona, Italy

utmea.enea.it