The regional Climate System CNRM-RCSM6 : description and first results of a 1980-2013 hindcast simulation

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- First results of a 1980-2013 hindcast simulation : comparison to observations
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  - Wind on the Mediterranean Sea
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  - Mediterranean Sea heat budget
  - Surface Temperature and salinity
  - Sea Surface Height
  - Diurnal cycle of SST
  - Eddy Kinetic Energy
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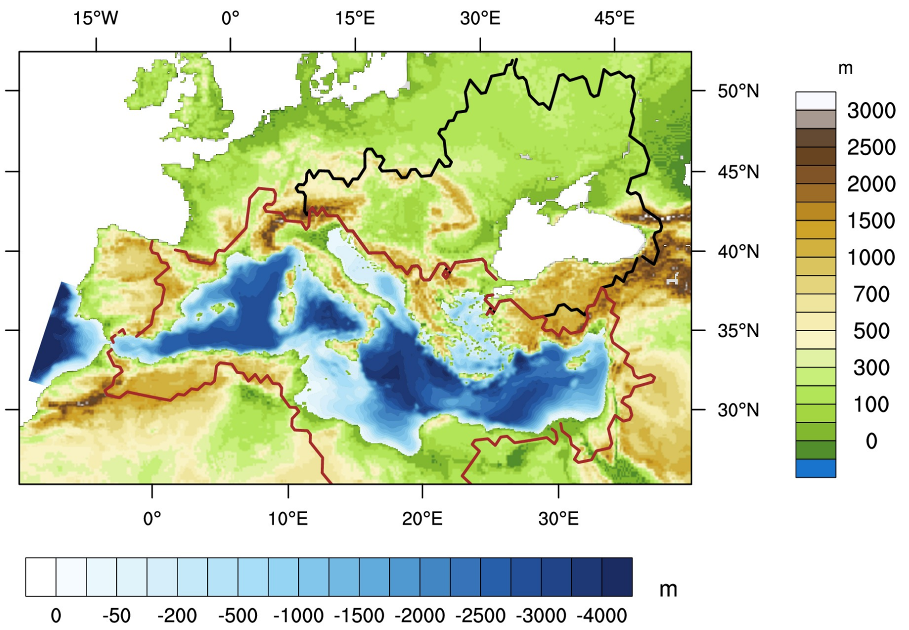
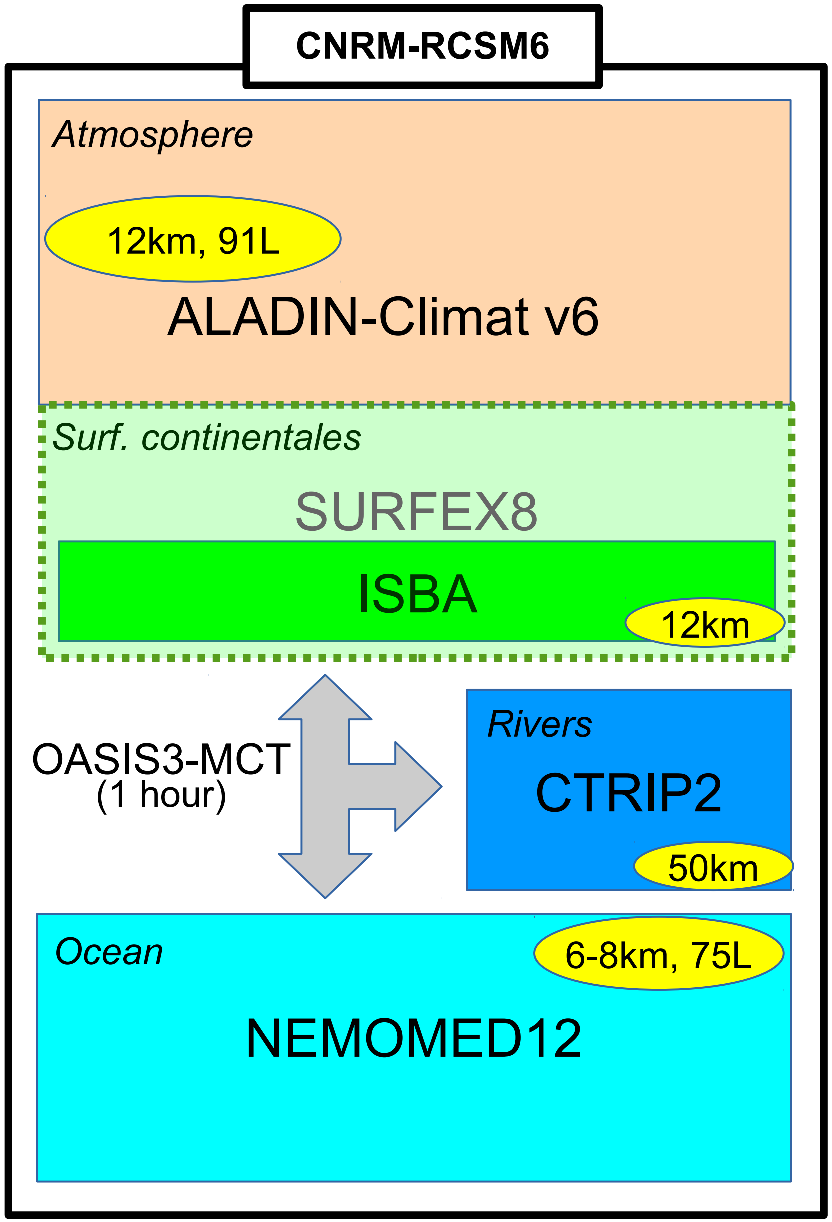


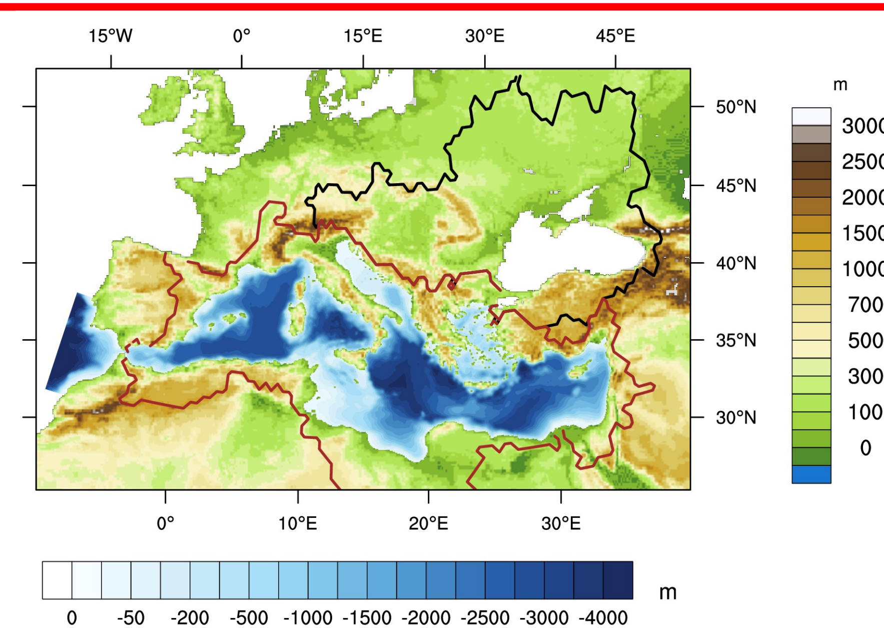
Introduction and scientific choices

- To improve the CNRM coupled model formerly used (climate scenario in *Somot et al., 2008*, the CIRCE project in *Dubois et al., 2011* and *Gualdi et al., 2011*, the impact of the regional climate model configuration on the representation of wind in *Herrmann et al., 2011,* MedCORDEX stream in *Sevault et al., 2014*, direct and semi-direct aerosol radiative effect on the Med climate variability in *Nabat et al., 2015,* characterizing, modelling and understanding the climate variability of the deep water formation in the North-Western Med Sea in *Somot et al., 2016*)
- To follow the last version of the CNRM GCM, used for the CMIP6 intercomparison (*Voldoire et al., 2017*): ALADIN-Climate V6, NEMOMED12 v3.6, CTRIP, SURFEX v8, OASIS3-MCT
- To follow the MedCORDEX recommendations for the inter-comparison
- To improve the horizontal and vertical resolutions : 1/12° and 75 vert. levels for NEMOMED12, 12 km and 91 levels for ALADIN-Climate
- To use up-to-date components as lateral boundary conditions (LBC) and initial conditions
- To improve the coupling frequency (from daily to 1h) in order to represent the diurnal cycle of Sea Surface Temperature (SST)

CNRM-RCSM6 configuration : model components



- ALADIN_Climate V6 *(Daniel et al., in revision)* : new physics, turbulence, convection, radiation scheme, clouds...
- SURFEX v8 *(Masson et al. 2013, Voldoire et al. 2017)* : new physics, new bulk formula, lake model FLAKE
- CTRIP2 *(Decharme et al., 2010)* : floodplains, groundwater diffusive scheme, variable velocity
- NEMOMED12 *(Beuvier et al., 2012 for v3.2)* : regional version of NEMOv3.6 *(Madec et al., 2008)*, new physics
- OASIS3-MCT *(Craig et al., 2017)*



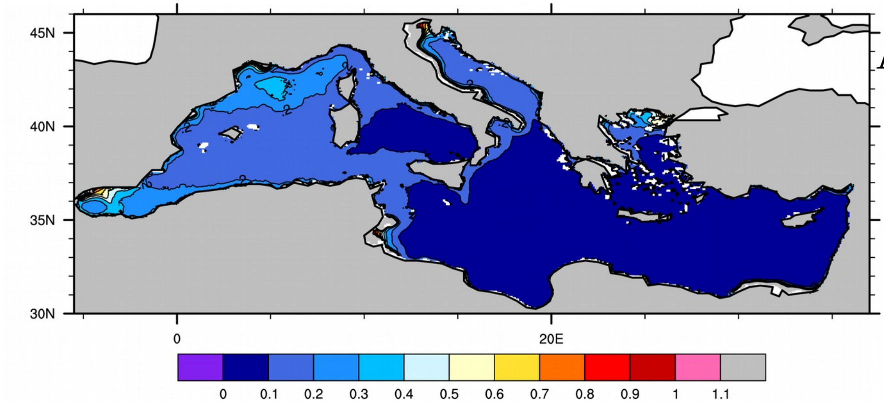
CNRM-RCSM6 configuration : simulation setup

Hindcast simulation 1980-2013 :

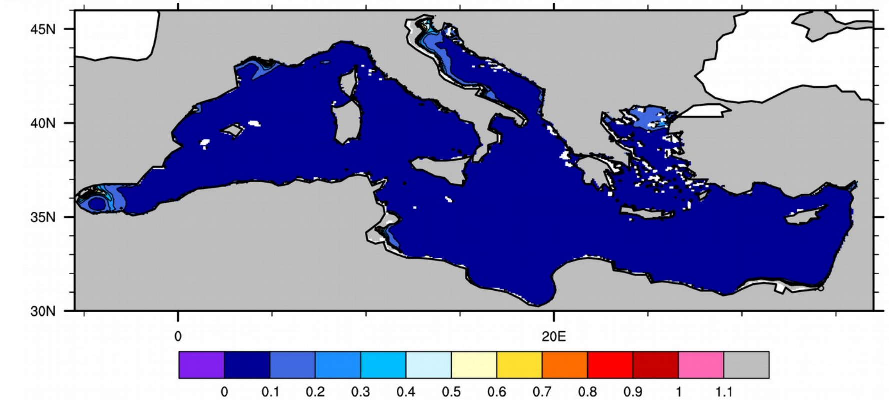
- Aerosol monthly interannual climatology *(Nabat et al., 2013)*
- LBC: reanalysis (ERA-Interim, ORAS4) + Spectral nudging in ALADIN-Climate
- CI ocean : Med-Atlas-II pre-EMT (*Rixen et al. 2005*, 1960f10), ORAS4 in the Atlantic *(Balmaseda et al., 2013)*
- SSH in the Atlantic : ORAS4 + seasonal cycle of CCI-ECV *(Adloff et al., 2017)*
- Black Sea: coupled, simple parametrization (E-P-R)
- Nile: climatological (12 values, 2 river mouths, 1141 m^3/s)
- Ocean spin-up: 7 years (3D damping)
- No coupled spin-up
- Coupling frequency 1h
- Monthly climatology of Chlorophyll concentration (2003-2011 ESA-CCI , T. Arsouze for NEMOMED12)

CNRM-RCSM6 configuration : focus on the Chlorophyll concentration in NEMOMED12

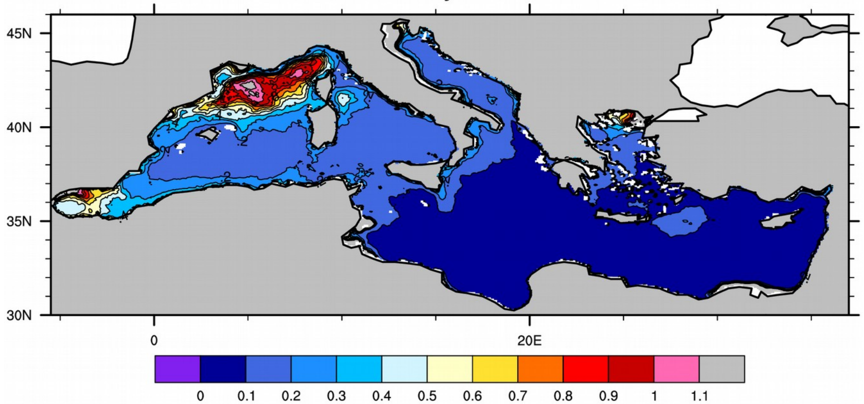
- Default value in NEMO : 0.05 g Chl/L
- L3 ESA-CCI (2003-2011, provided by T. Arsouze for NEMOMED12)



Average

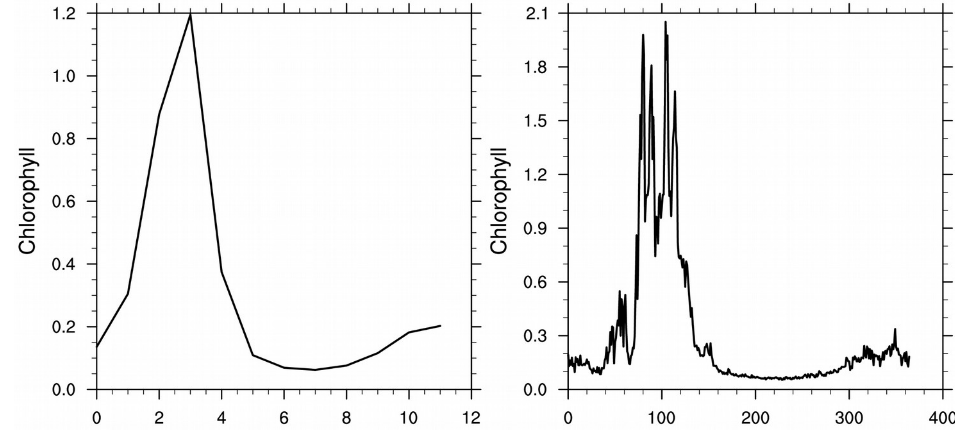


July August



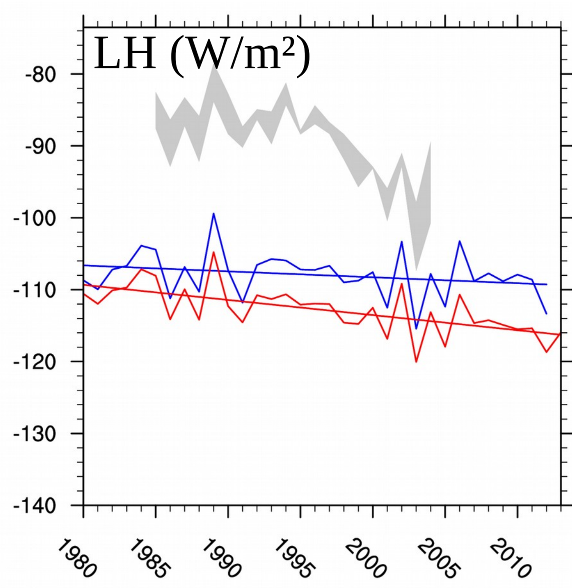
March April

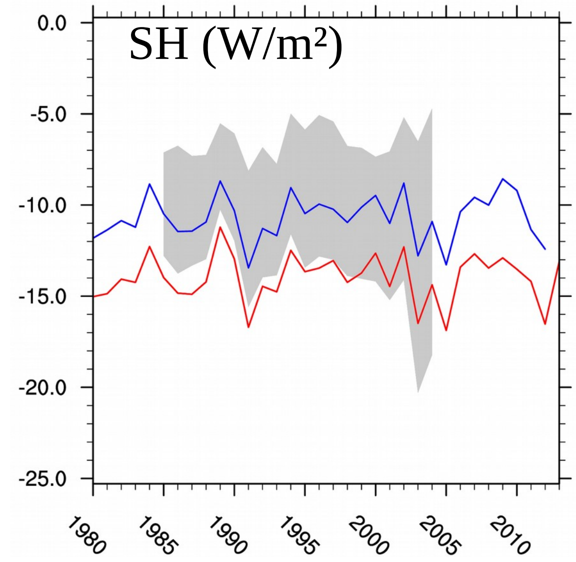
Seasonal cycle and daily average at the Lion Buoy

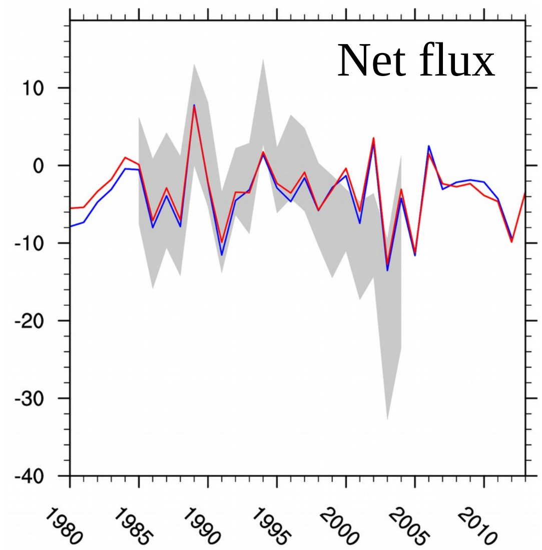


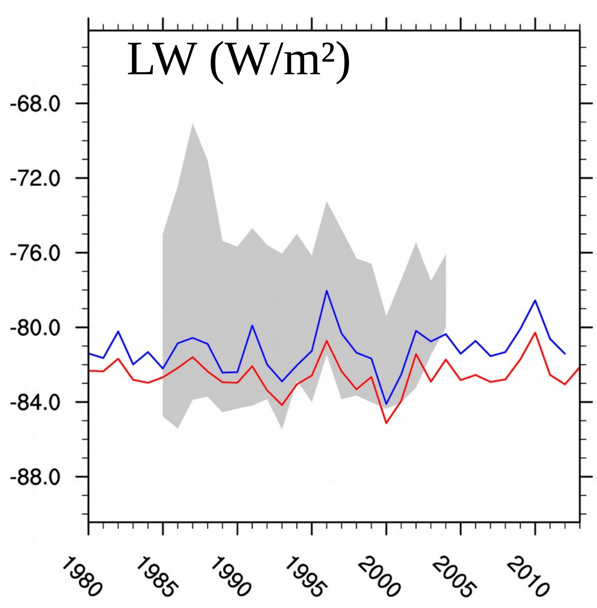
- Strong seasonal variation, especially in the NorthWest
- Much above the default value
→ use a 2D climatology

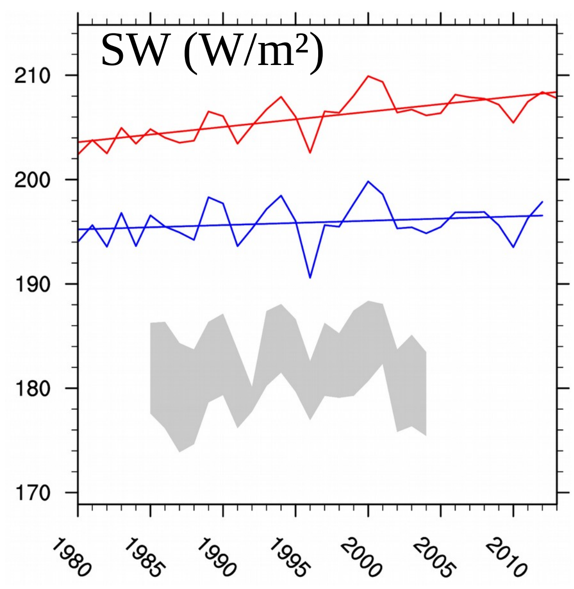
Mediterranean Atmospheric heat budget
CNRM-RCSM4 vs CNRM-RCSM6





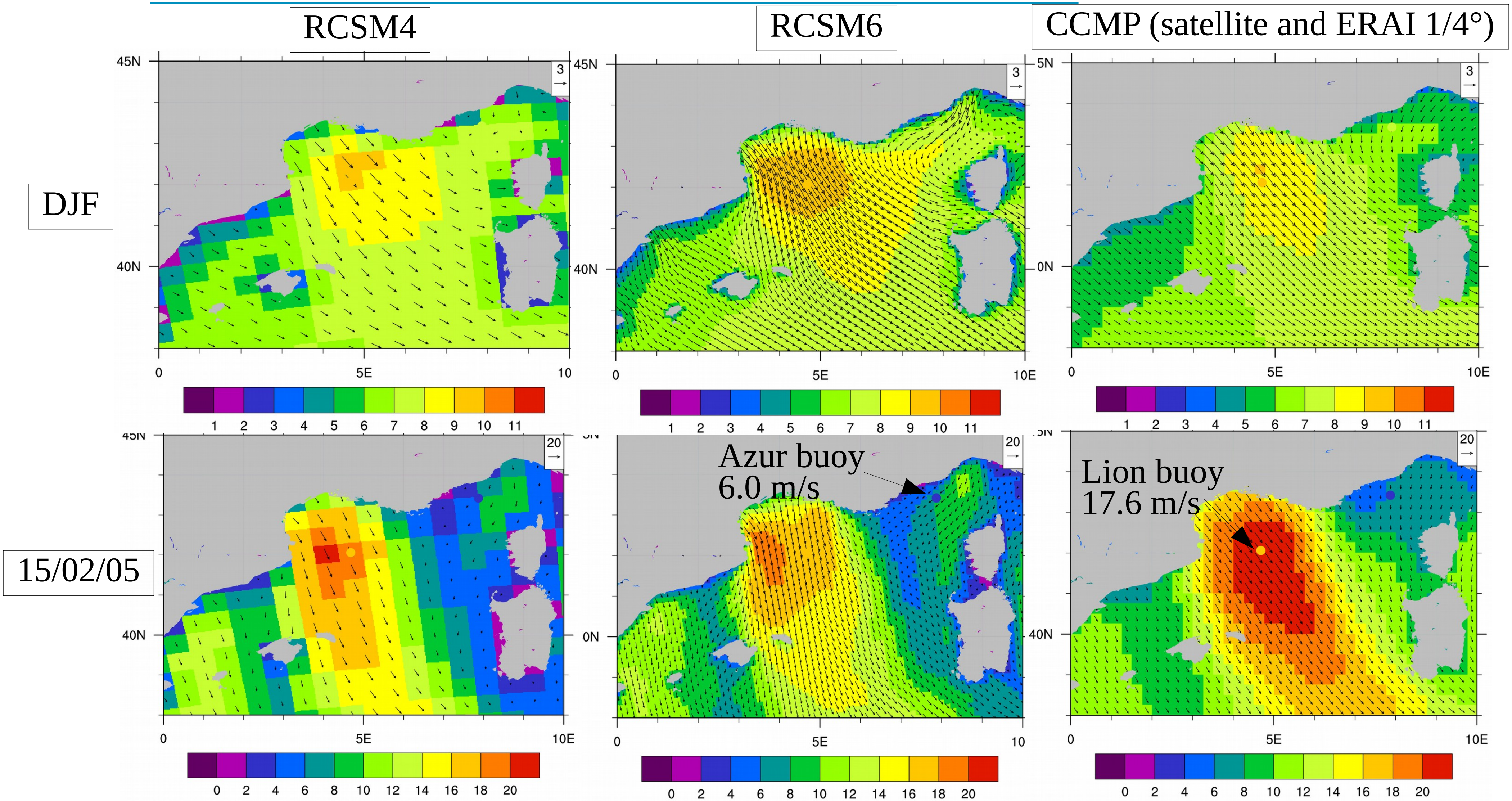






- Net : -4 W/m², -3 W/m²
- Strong SW : low cloudiness, SW trend with the new aerosol clim *(Nabat et al., 2014)*
- better LH trend linked to SW trend

Wind in North West Med, DJF and 15/02/2005



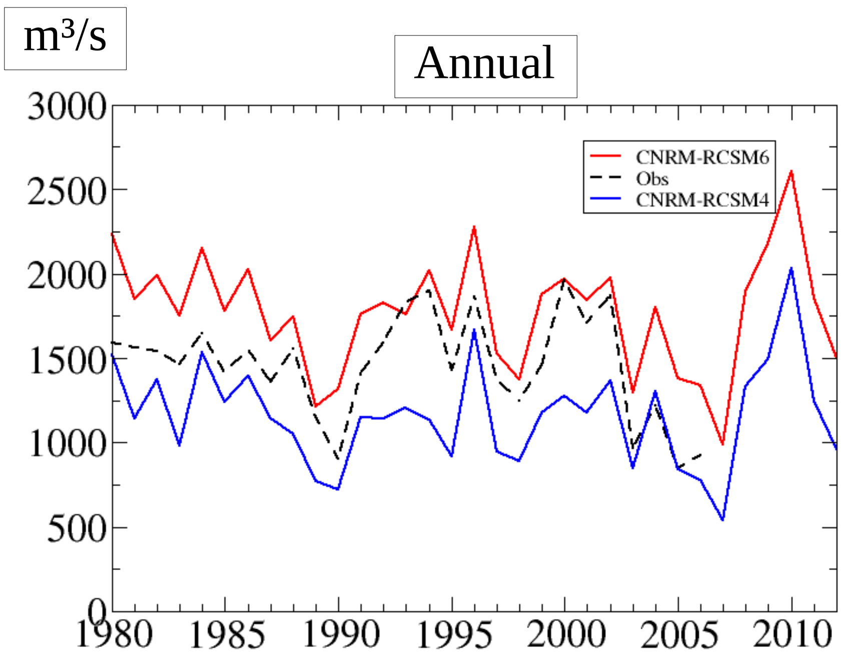
RCSM6 : better resolution near the coast due to the mountains
RCSM4 and RCSM6 : correct comparison to the buoys, CCMP (*www.remss.com*)
overestimation (but 6H obs compared to timestep wind speed in the models)

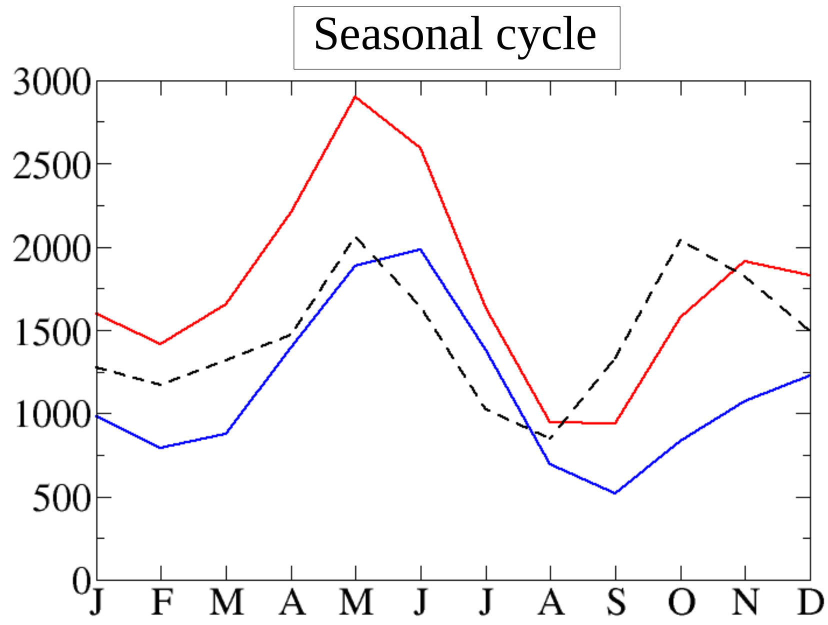
Mediterranean Sea water budget

	CNRM RCSM4 1980-2012	CNRM-RCSM6 1980-2013	Observations
Net flux at Gibraltar	0.05 Sv (-0.80 / +0.85)	0.05 Sv (-0.80 / +0.85)	[0.04 ; 0.10] Sv *(ref. in Beuvier et al. 2010)*
Evaporation – Precipitation (E-P)	0.89 m/yr	1.04 m/yr	[0.5 ; 0.88] m/yr *(Sanchez-Gomez et al. 2011)*
Evaporation	1.39 m/yr	1.44 m/yr	[1.10 ; 1.14] m/yr *(Sanchez-Gomez et al. 2011)*
Precipitation	0.50 m/yr	0.40 m/yr	[0.26 ; 0.59] m/yr *(Sanchez-Gomez et al. 2011)*
River Runoff (R)	0.13 m/yr	0.24 m/yr	0.13 m/yr *(Ludwig et al. 2009)*
Black Sea (B)	0.09 m/yr	0.16 m/yr	0.11 m/yr *(Stanev et Peneva 2002)*
Surface water budget (E-P-R -B)	0.67 m/yr	0.64 m/yr	[0.43 ; 0.66] m/yr *(Sanchez-Gomez et al. 2011)*

RCSM6 : improved precipitations on sea, not on land, too much river runoff and evaporation, same surface water budget as RCSM4

Po river discharges 1980-2012





Daily statistics

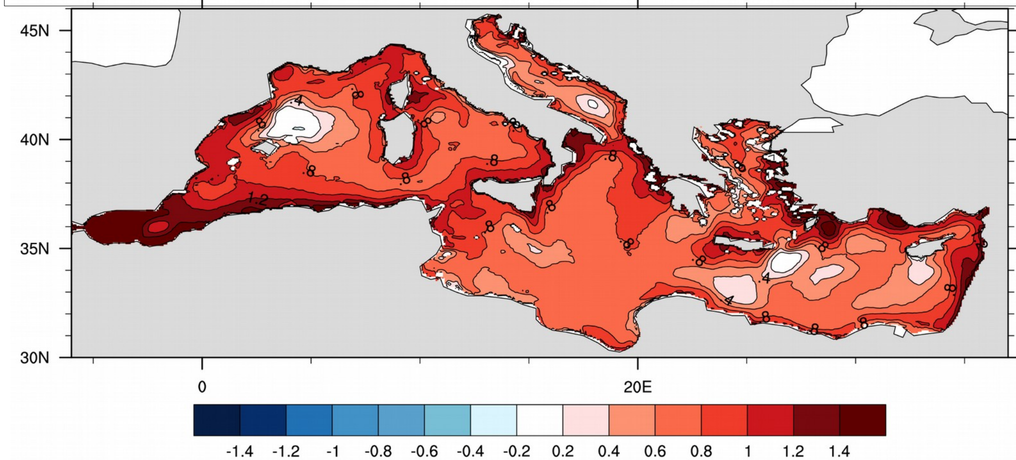
M³/s	Min annual	Max annual	Mean	stdev	Correlation with obs
Obs	526 [168-730]	5655 [2770-9517]	1481	1024	
RCSM4	110 [6-433]	3202 [1438-5842]	1167	882	0.50
RCSM6	492 [242-832]	5302 [2703-7263]	1777	1089	0.82

Obs provided by C. Albergel, personal com.

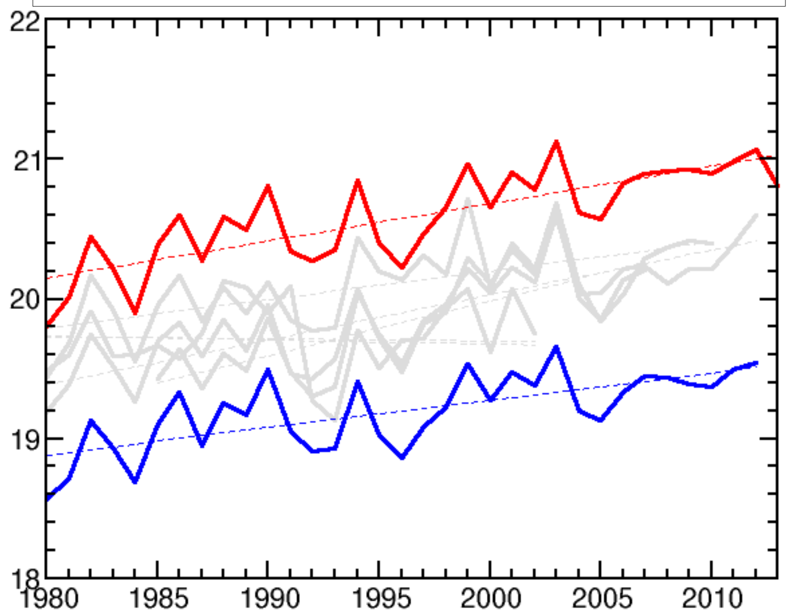
- RCSM6 : overestimation in average, better daily min and max
- RCSM4 : Daily minimum not realistic
- daily maximum always underestimated despite the absence of dams in the model
- better correlation for RCSM6 (daily data, all days with obs)

Sea surface temperature

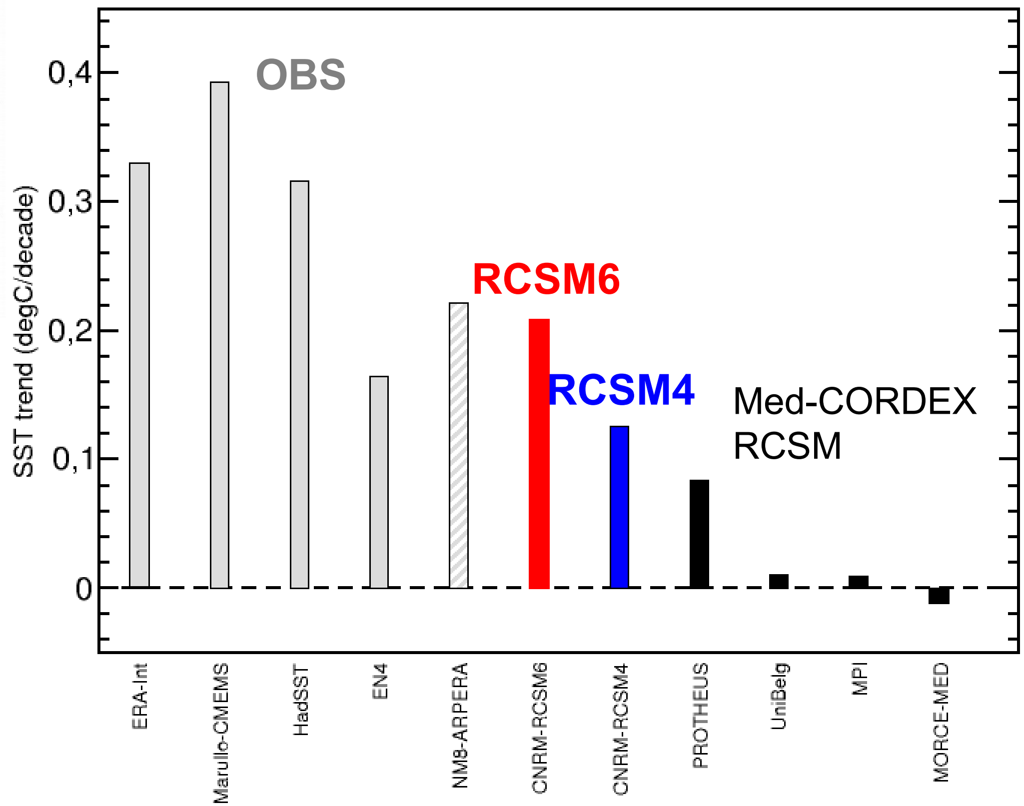
CNRM-RCSM6 – Marullo climatology (1985-2007)



Mediterranean Sea annual mean SST



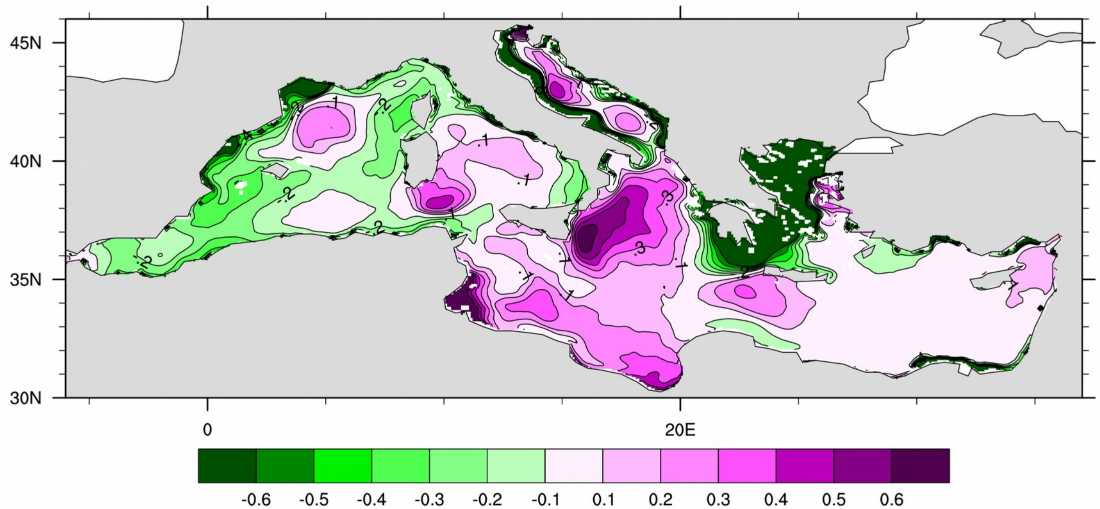
Mediterranean Sea SST 1985-2007 trend



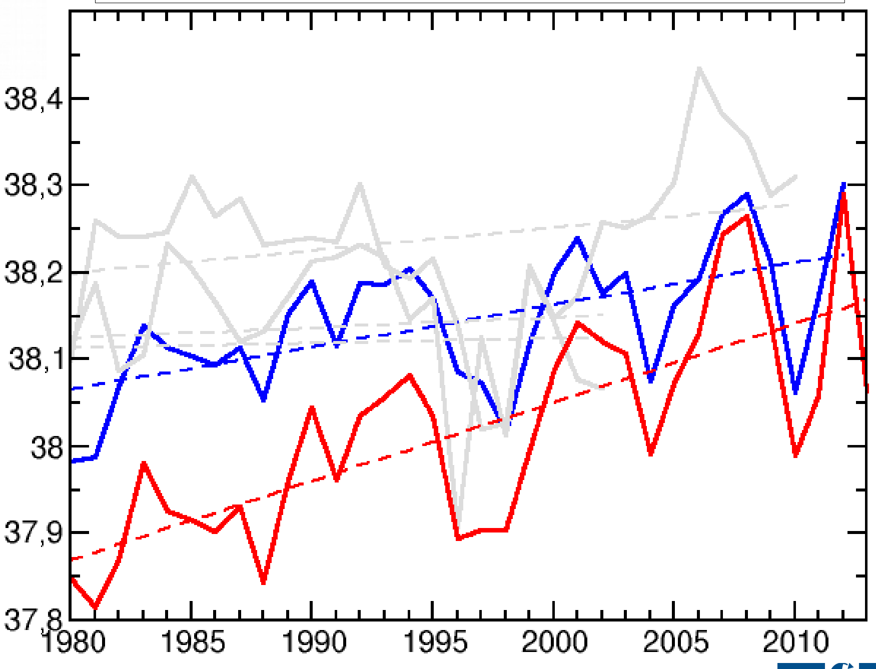
Better SST trend with RCSM6, linked with the trend in SW and LH.

Sea Surface Salinity

CNRM-RCSM6 – EN3 climatology (1985-2010)

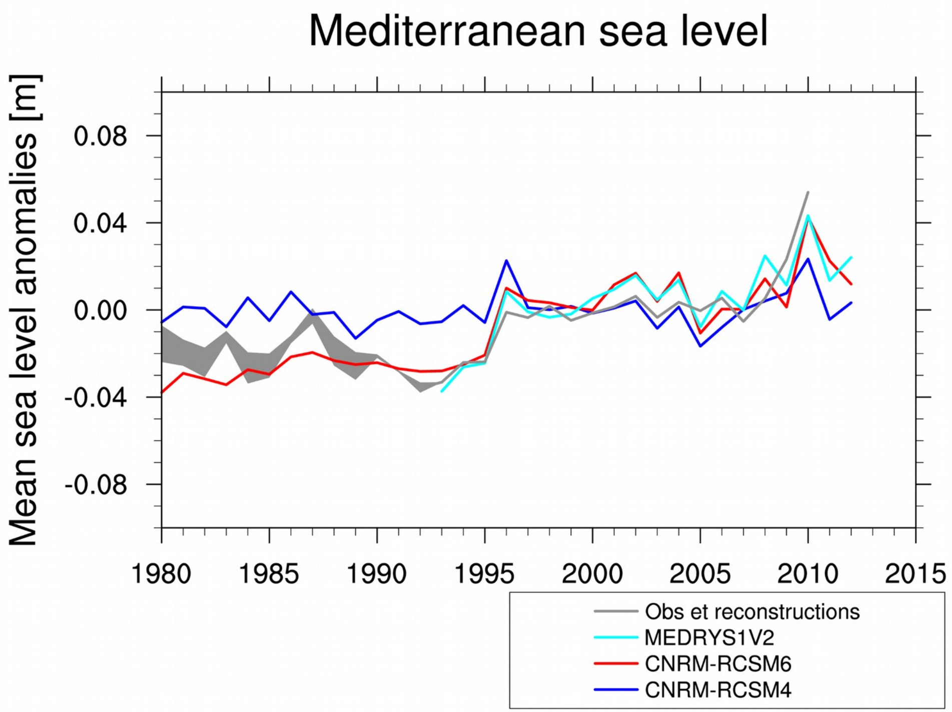


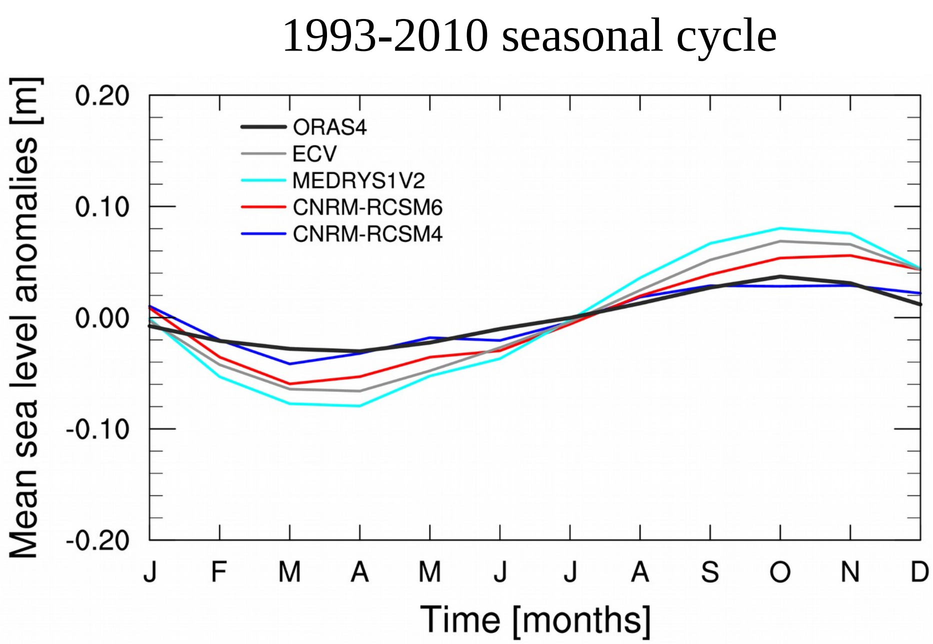
Mediterranean Sea annual mean SSS



Stronger trend in RCSM6, lack of observations.

Sea Surface Height anomaly

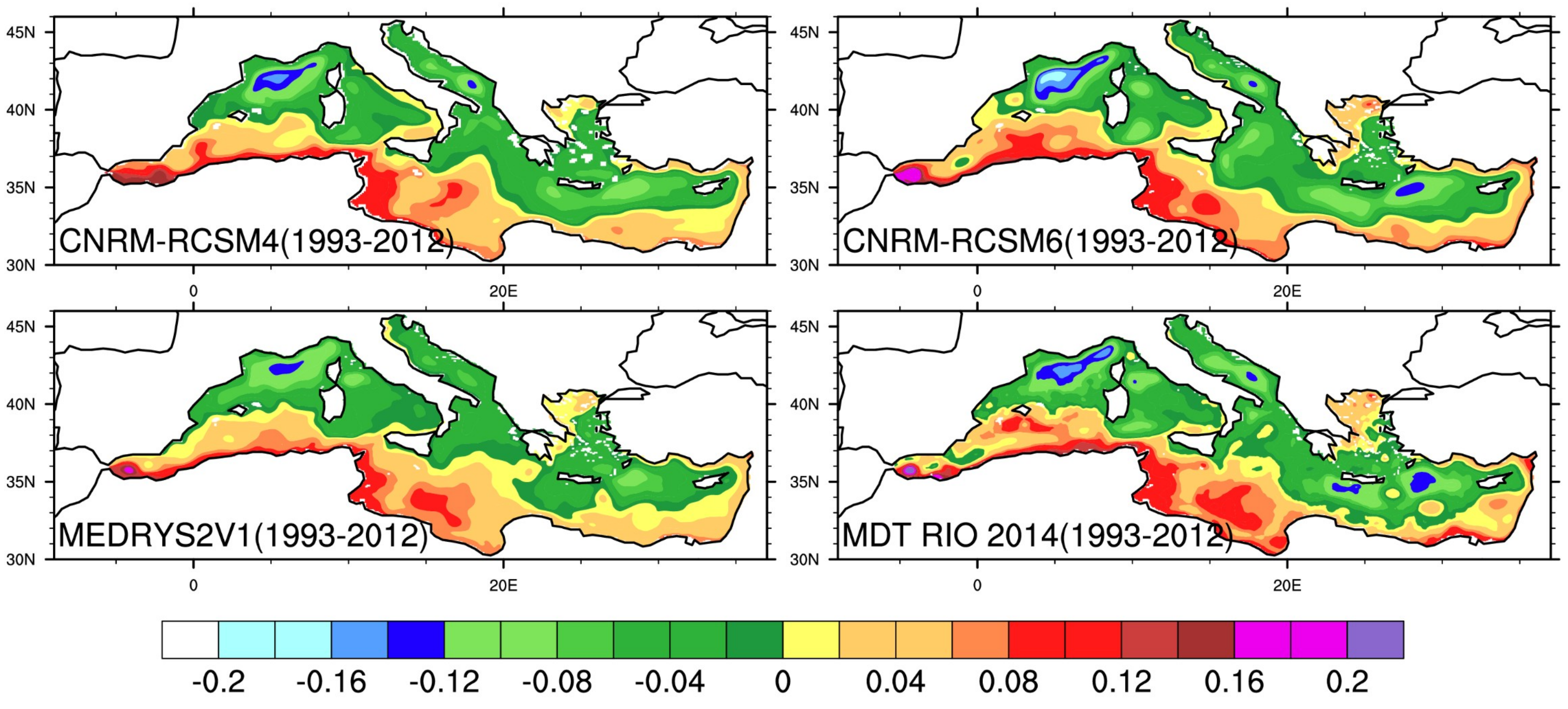




Better representation thanks to the corrected ORAS4 SSH in the Atlantic part of the domain *(Adloff et al., 2017)*

Sea Surface Height Anomaly

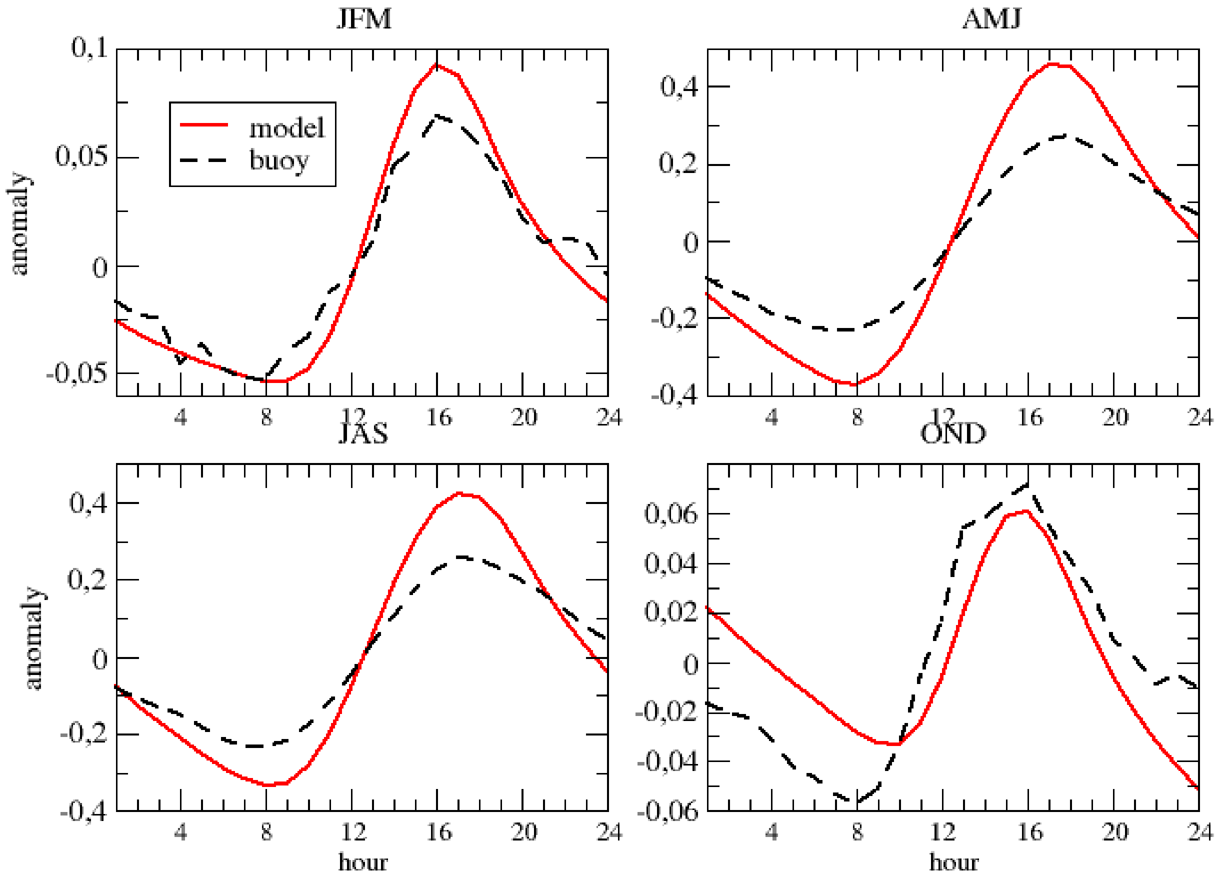
Comparison to observations



Diurnal cycle of SST at the Lion buoy (Météo-France)

- Hourly SST 2006-2013 at the Lion buoy (HyMeX database, 90 % of 2006-2013 days with no missing value)
- first level 1m in the model and 1-hour coupling frequency : allows to compare to the buoy
- best variability in the Chlorophyll concentration
- select days when max-min > 0.1°

Mean diurnal cycle at the Lion buoy position



- the model gives a realistic diurnal cycle
- correct position of min and max except in autumn
- overestimation of the amplitude

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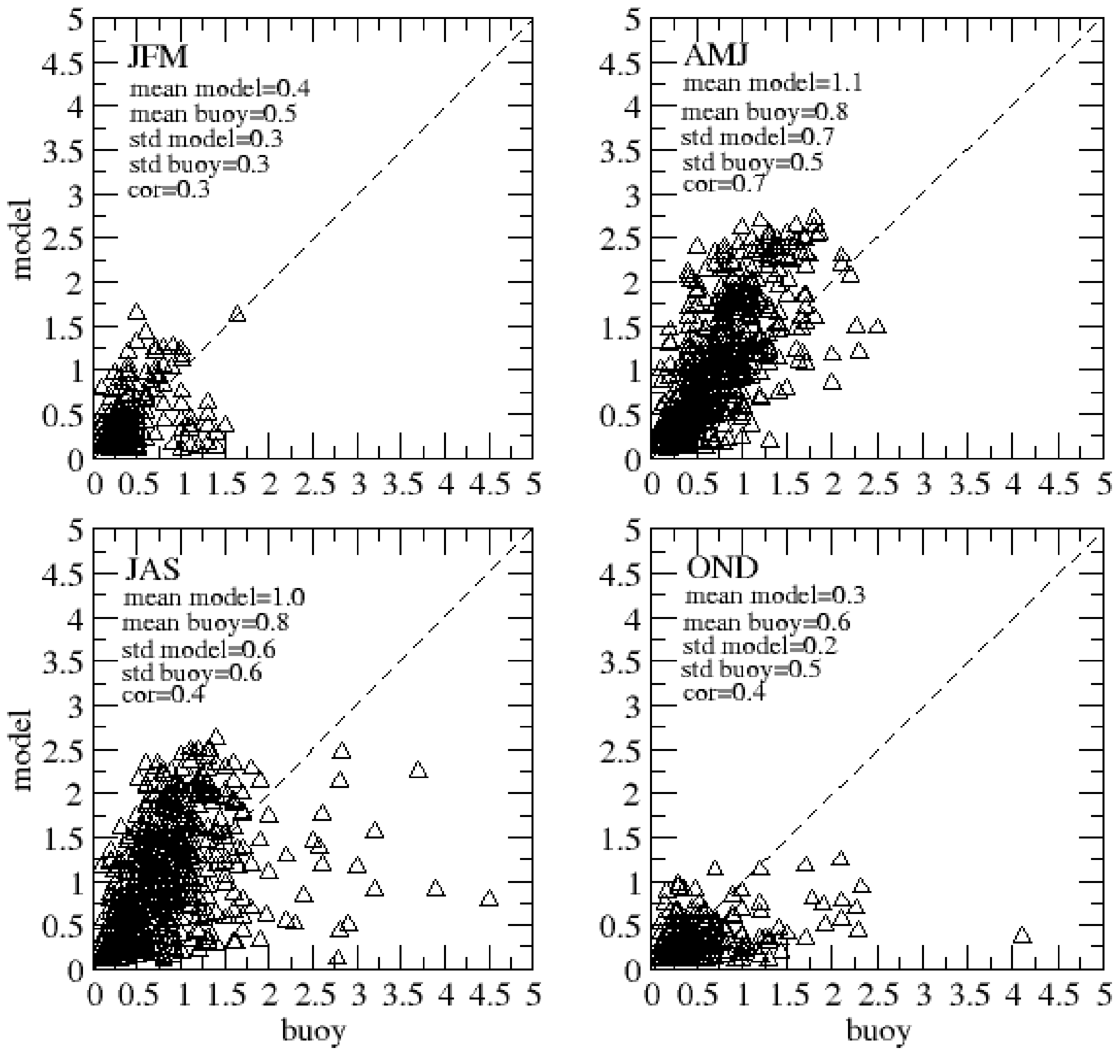
Amplitude of the diurnal cycle at the Lion buoy

- select the same days in both series (model and buoy), with no missing value at the buoy, and amplitude > 0.1°
- Amplitude = max (9h to 17h) – min (18h previous day to 8h)



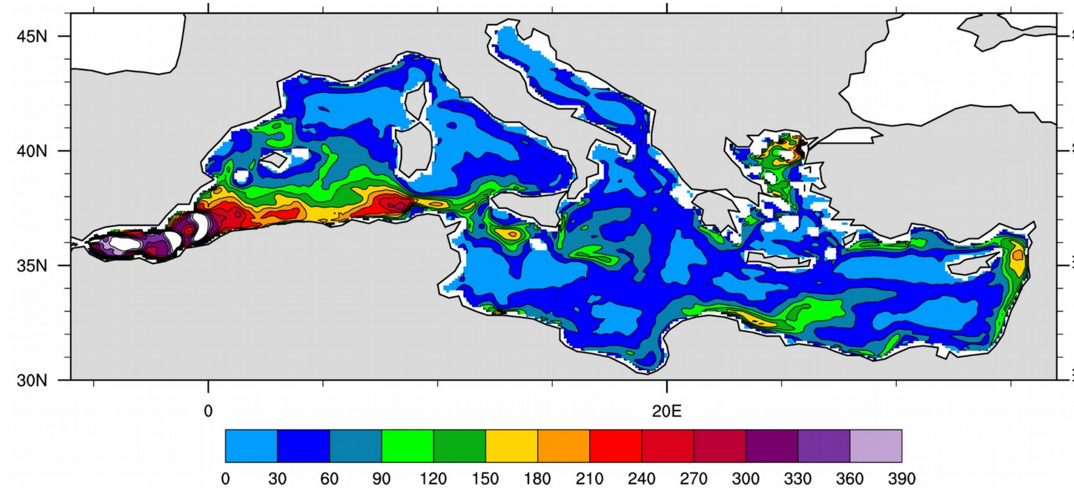
%age of days with no missing value and amplitude > 0.1°

	JFM	AMJ	JAS	OND
buoy	80 %	91 %	90%	78 %
model	37 %	87 %	82 %	38 %
both	34 % (215 days)	84 % (524 days)	79 % (554 days)	34 % (216 days)

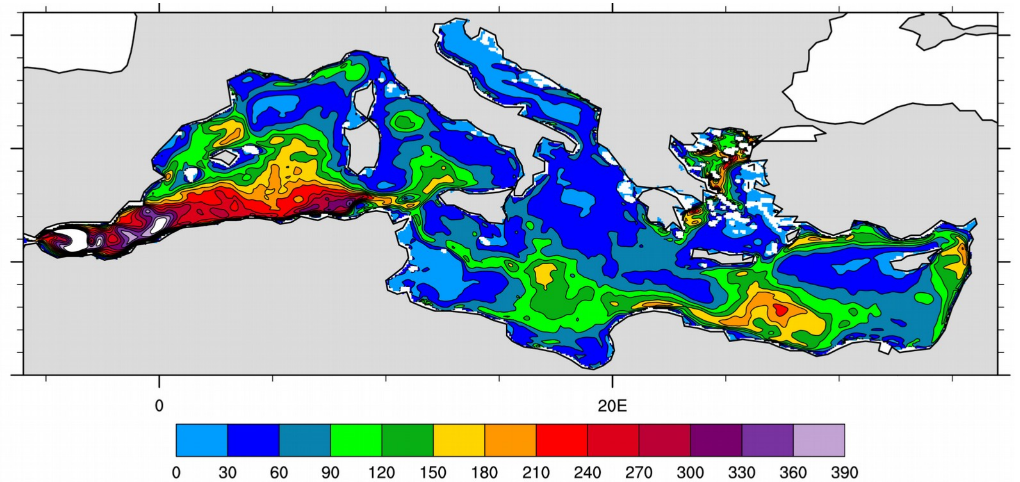
- many days in the model simulation where amplitude ≤ 0.1°
- overestimation of the amplitude by the model in spring and summer
- underestimation in automn and winter

Eddy Kinetic Energy

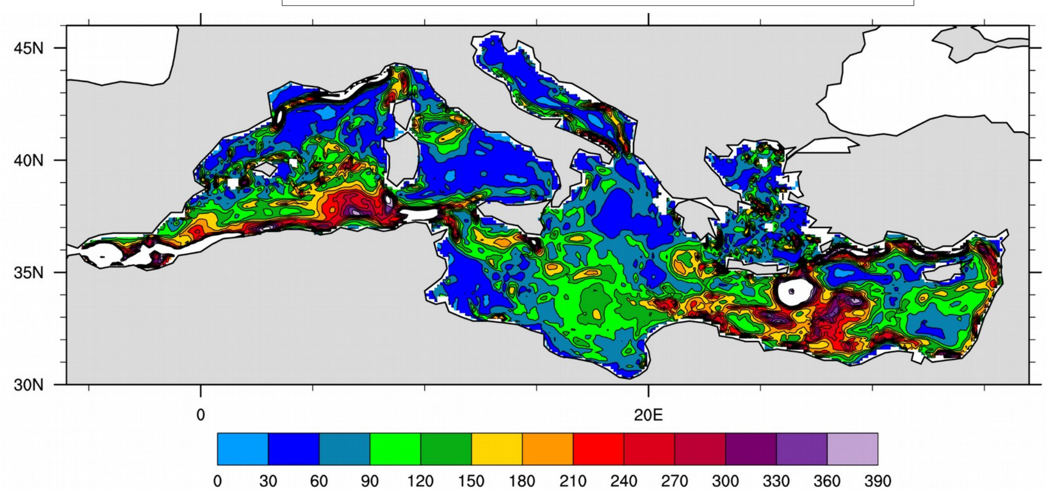
RCSM4 1993-2012



RCSM6 1993-2013



SSALTO/DUACS 1993-2013



cm^2/s^2

- Characterize the mesoscale activity of the ocean, identify regions with eddies
- RCSM4 very smooth despite the same resolution as SSALTO/DUACS
- RCSM6 stronger but still some missing spots

DT merged all satellites Mediterranean Sea Gridded SSALTO/DUACS Sea Surface Height L4 product and derived variables, 1/8° resolution

Conclusion and perpectives

- CNRM-RCSM6 is composed of new versions of each component (atmospheric, oceanic, river routing model, coupler), same versions as CNRM-CM6
- Some aspects improved : resolution, AOD-SW-SST-LH trends, SSH representation, diurnal cycle of SST, EKE
- Some aspects to improve : overestimation of SW on sea, of the runoff, of SST, temperature and salinity in subsurface and intermediate water (not shown)
- To be coming soon in preparation of the FPS air/sea : test of new initial conditions (IMEDEA medhymap v2), new values for the Nile (lower than the current ones)
- scenario runs
- Later : linked to the FPS air/sea : TACTIC interactive aerosol scheme, AGRIF mesh refinement in NEMO
- 12 km resolution in CTRIP