Assessment & intercomparison of numerical simulations in the Western Mediterranean

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Introduction and objectives

The Balearic Islands Coastal Observing & Forecasting System (SOCIB[1]) is developing high resolution numerical simulations (WMOP, 1/50°) in the Western Mediterranean. WMOP uses a regional configuration of ROMS[2]. Theses simulations are able to reproduce (sub-)mesoscale features that are key in the Mediterranean since they interact with the basin & sub-basin circulations. They are initialized from & nested in the larger scale **Mediterranean Forecasting System[3] (MFS, 1/16º)** or **Mercator-Océan simulations[4] (Mercator, 1/12º)**.

MFS & Mercator are evaluated using **multi-platform observations**. A **quantitative comparison** is necessary to (1) evaluate the capacity of the simulations to reproduce observed ocean features, (2) quantify the possible simulations biases, (3) improve the simulations to produce better ocean forecasts, to study ocean processes and to address climate studies. To this end, various statistical diagnostics have been developed to assess the simulations at **sub-basin scale** in terms of surface circulation and variability as well as water masses.

Methodology

- Use of **available observations**: satellite products & *in situ* data (Argo, XBTs, CTDs, gliders).
- **Spatial and temporal interpolation** of simulations at the observations points.
- Development **of statistical metrics** to assess simulations at various spatial & temporal scales, in sub-regions with typical sub-basin dynamics[5] (Fig1), along key sections.

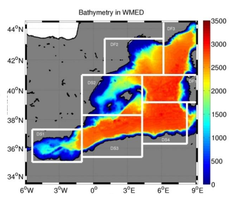


Fig1

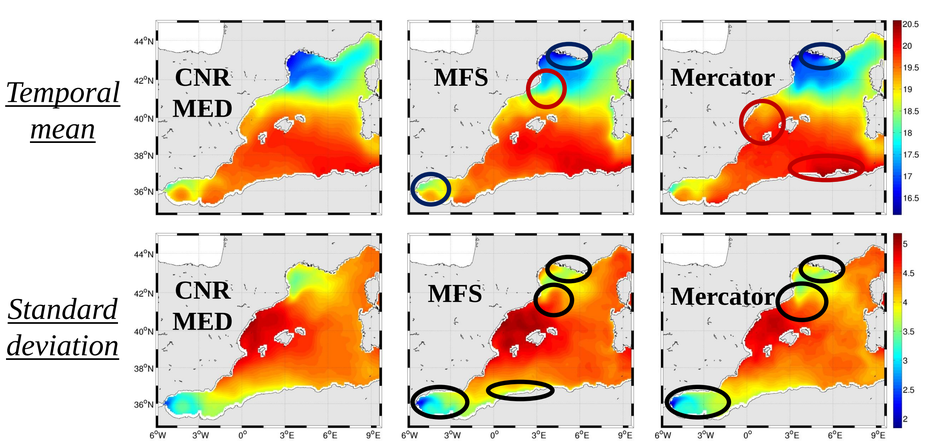
Numerical simulations

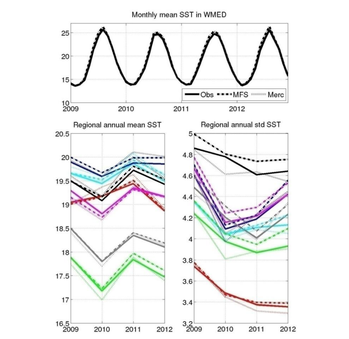
	MFS[3]	Mercator[4]
Version	Sys4b2	PSY2V4R4
Model	NEMO3.2-OPA	NEMO3.1-OPA
Spatial Resolution	1/16ºx1/16º	1/12ºx1/12º
Vertical resolution	72 vertical levels	50 vertical levels
Temporal resolution	Daily mean	Daily mean
Atmospheric forcing	ECMWF (6h, 0.25º) Bulk formulae	ECMWF (3h) Bulk formulae
Runoff	Monthly mean *Fekete*, 1999; *Raicich*, 1996	Monthly climatology *Dai & Trenberth*, 2002
Initial conditions	T/S SeaDataNet	T/S *Levitus* (2009)
Boundary conditions	Monthly climatology *Drevillon et al.*, 2008	PSY3V3R3
Assimilation scheme	OceanVAR	SAM2v1
Assimilated data	SLA, SST, *in situ* T/S profiles	SLA, SST, *in situ* T/S profiles, MSSH

Surface conditions and general circulation

CNR MED: satellite products L4, 1/16º, daily
AVISO: mapped satellite products, 1/8º, daily

Sea Surface Temperature (°C) over 2009-2012

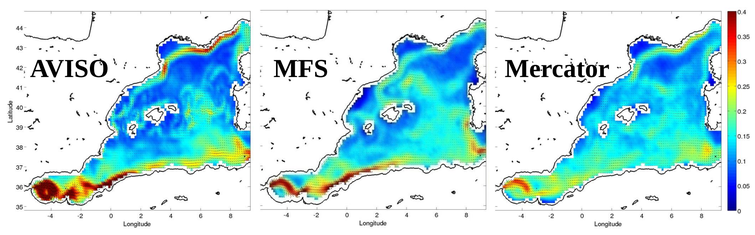




Regions (Fig1)
DS1: Alboran Sea
DS2: Balearic Sea
DS3: west Algerian
DS4: east Algerian
DF1: Algero-Prov.
DF2: Liguro-Prov.
DF3: Gulf of Lion

➢ Spatial structure of SST mean & variability is reasonably well reproduced in MFS & Mercator, as well as the seasonal and interannual variability at basin and sub-basin scales. Although SST data assimilation, persistent differences found in areas with high mesoscale (Alboran, Algerian), with strong river & air-sea interactions (Gulf of Lion), with high SST variability (Balearic Sea).

Geostrophic Currents (m/s) over 2009-2012



➢ The geostrophic currents weaker in simulations than in satellite, especially in high mesoscale regions (Alboran, Algerian & Northern Currents).
➢ Mean circulation bias in the Balearic Sea & the western Corsica Current.

Vertical structure of temperature/salinity misfits

Positions of available profiles over 2009-2012
(from ENACT-ENSEMBLES[7])

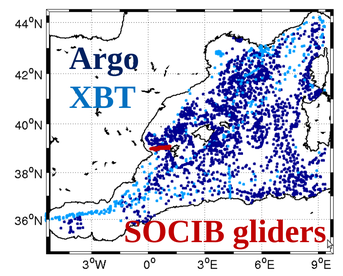
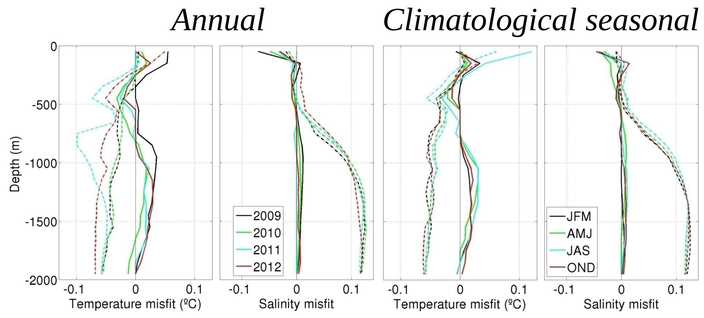


Fig2

Medians of T/S misfits (model -obs) distribution as a function of depth over 2009-2012 in Western Med

Annual *Climatological seasonal*



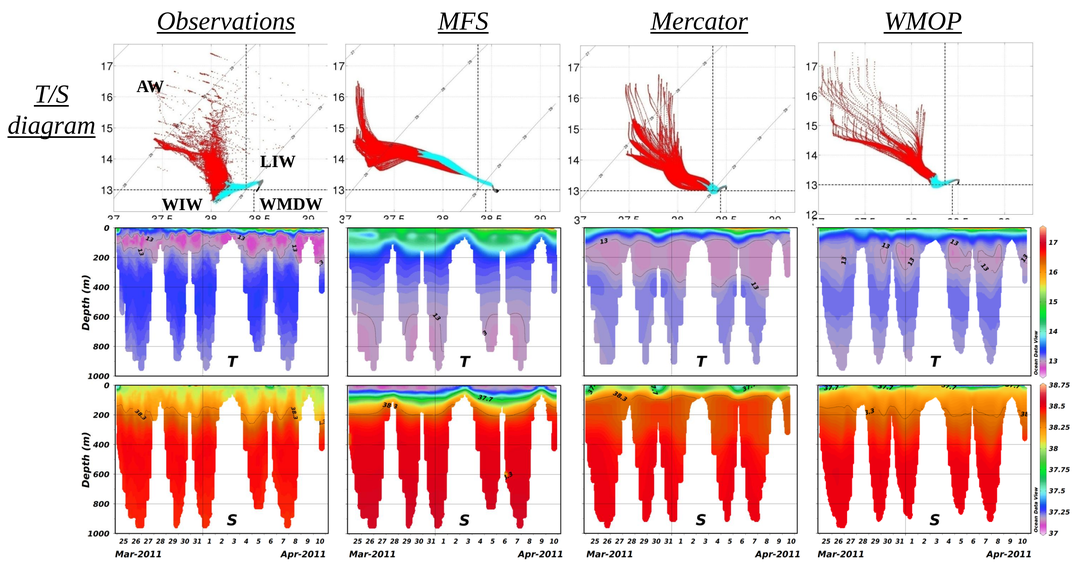
Obs = Argo, XBTs. Solid: Mercator. Dashed: MFS

➢ Basin-scale: (1) Strong surface T/S biases in Mercator & MFS: warm in summer, fresh throughout the year. (2) Persistent significant cold & salt biases in deep layer (>600m) in MFS.
➢ Regional (not shown): (1) Surface: seasonal & regional T biases in simulations; fresh bias in all regions. (2) Intermediate & deep layers: general findings over WMED persistent in all regions.

Water masses

AW: Atlantic Water
LIW: Levantine Intermediate Water
WIW: Winter Intermediate Water
WMDW: Western Mediterranean Deep Water

Glider section in Ibiza Channel
March-April 2011 (Fig2)

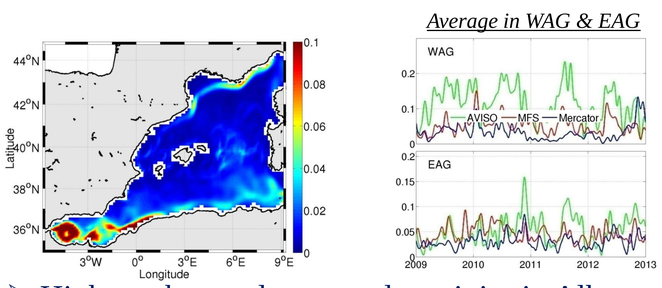


➢ The observed T/S diagram & associated sections reveal the typical water masses of WMED & the presence of WIW (formed in North-western Med[8]).
➢ MFS has strong surface T/S biases, does not well represent the T maxima associated to LIW & does not reproduce the presence of WIW in Ibiza Channel.
➢ Although T/S biases are found, Mercator represents the presence of WIW.
➢ The high-resolution simulation WMOP (initialized and nested in Mercator) better reproduces the water masses in the Ibiza Channel.

Mesoscale variability (Alboran Sea)

WAG: Western Anticyclonic Gyre
EAG: Eastern Anticyclonic Gyre

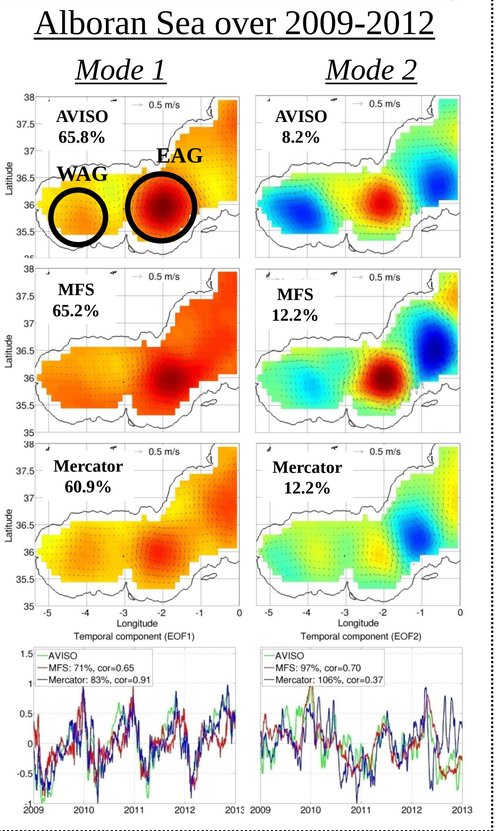
Kinetic Energy (m2/s2) over 2009-2012



Average in WAG & EAG

➢ Highest observed mesoscale activity in Alboran.

Sea Level Anom. (cm) variability Alboran Sea over 2009-2012



➢ Observed SLA/KE variability in agreement with literature[6]: **(1)** Mode1: steric contribution of seasonal cycle, WAG & EAG intensification (weakening) in spring-summer (winter-fall). **(2)** Mode2: WAG intensification (weakening), EAG weakening (intensification) in opp. phase, apparition of cyclonic eddy east of EAG, separated by the Almeria-Oran Front. **(3)** KE: KE[WAG]>KE[EAG], stronger KE[WAG,EAG] the 2nd half of the year, quasi-persistence of WAG whereas EAG disappears in winter (replaced by cyclonic eddy at east).

➢The main observed modes of SLA variability are in simulations. The KE[WAG] is weaker in simulations than in altimetry. MFS better represents persistence & annual periodicity of WAG than Mercator. The amplitude of KE[EAG] well simulated, but quasi-persistence found in MFS.

Conclusions and perspectives

➢ Multi-variable and sub-basin-scale assessment highlights sub-regional biases in the MFS and Mercator simulations.
➢ This work is reported in Juza et al. (2014): "Sub-basin scale assessment and intercomparison of numerical simulation in the western Mediterranean Sea", to be submitted to *J. Mar. Sys.*
➢ Quantitative comparisons between WMOP (nested in MFS and Mercator) and parents models are under investigation.
➢ Process studies using obs. & WMOP simulations in a realistic context[8].

[1] Tintoré et al. (2013)
[2] Shchepetkin and McWilliams (2005)
[3] Tonani et al. (2012)
[4] Lellouche et al. (2013)
[5] Manca et al. (2004)
[6] Renault et al. (2012)
[7] Good et al. (2013)
[8] Juza et al. (2013)