MEDRYS
Mediterranean Sea reanalysis over the period 1992-2013

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5 - LTHE, Grenoble, France

OUTLINE

Configuration of MEDRYS

Results of MEDRYS1 (V1 and V2)

- Assimilation statistics
- Heat and salt contents variability
- Surface circulation and Gibraltar transports
- High-frequency variability

Use cases of the reanalysis and of its twin free run

Conclusions and outlook

Regional oceanic reanalyses MEDRYS1

Hamon et al. 2016, Ocean Science

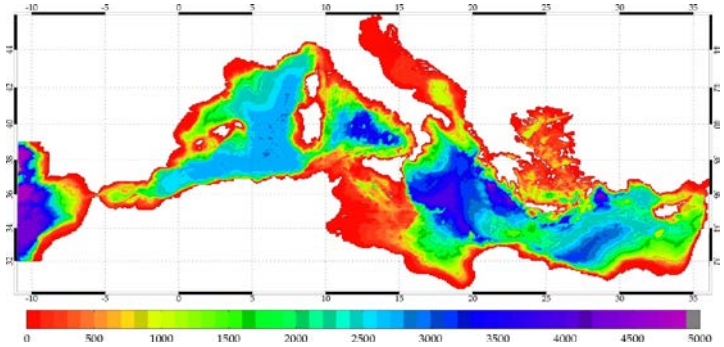
MEDRYS1V1 **MEDRYS2**

Ocean model:

NEMOMED12v75 model,
ALDERA atmospheric forcing (12km/3h fluxes)
interannual BC for Atlantic (T, S, SSH) and rivers

Assimilated observations:

In-situ (Coriolis CORA4.0/CORA4.1 database) and satellite data (SST AVHRR-AMSR and SLA from SALTO/DUACS)



Data assimilation scheme
(Lellouche et al., 2013)

One analysis per several days (7-day/5day cycle) + no shock thanks to repartition of the anaylsis correction over the cycle (IAU)

SEEK Analysis

Modal Space (Reduced Space)

3D modes acting on 3D space

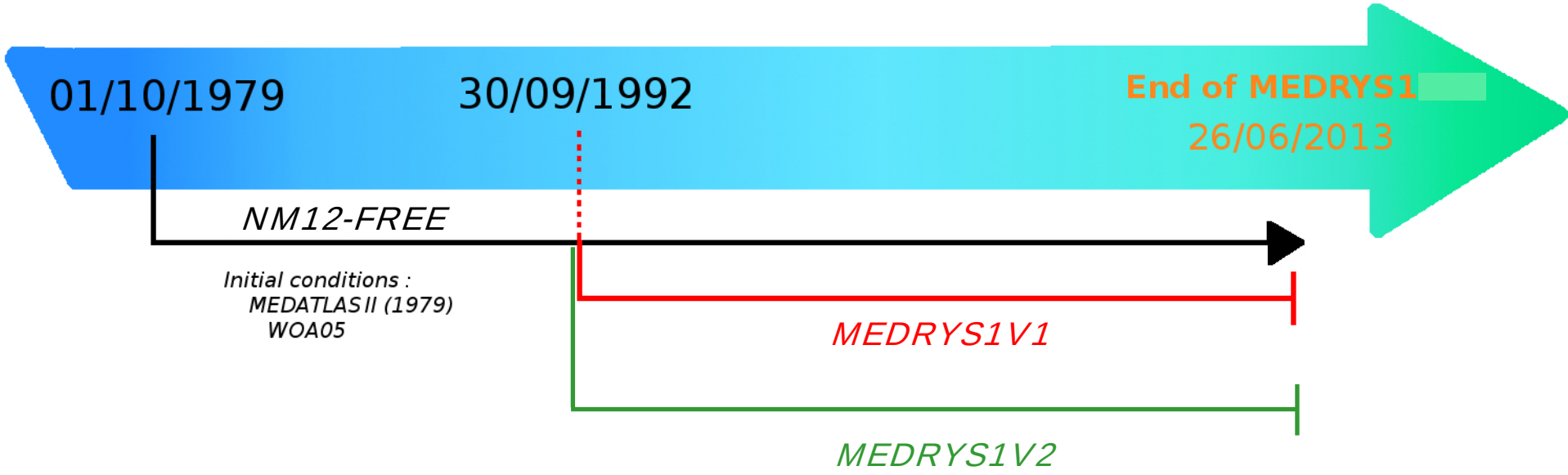
Control Space

- δSSH + δSSH_{bias}
- $\delta T(k)$ + $\delta T_{bias}(k)$
- $\delta S(k)$ + $\delta S_{bias}(k)$
- $\delta U(k)$
- $\delta V(k)$

multivariate multidata SEEK filter algorithm

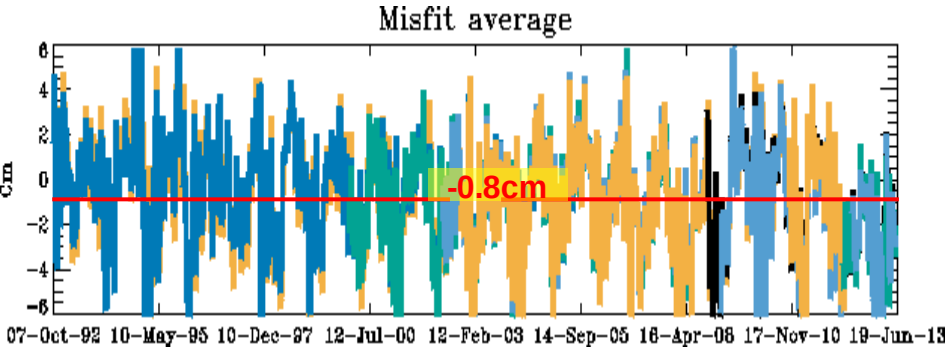
3DVAR correction at large space- and time-scale

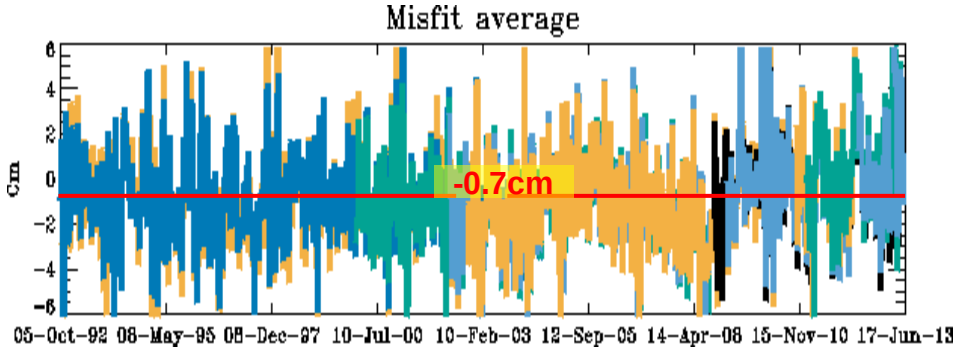
Experimental design for MEDRYS1 reanalyses



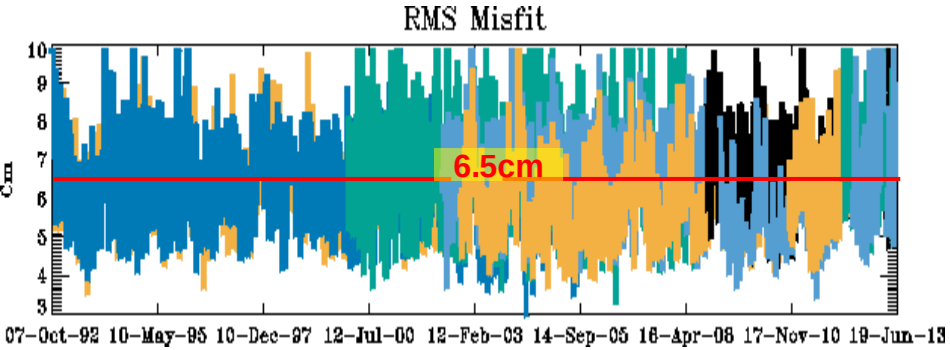
Statistics on assimilated data: SLA

e1 e2 tp tpn g2 j1 en j2 j1n enn c2 j1g al

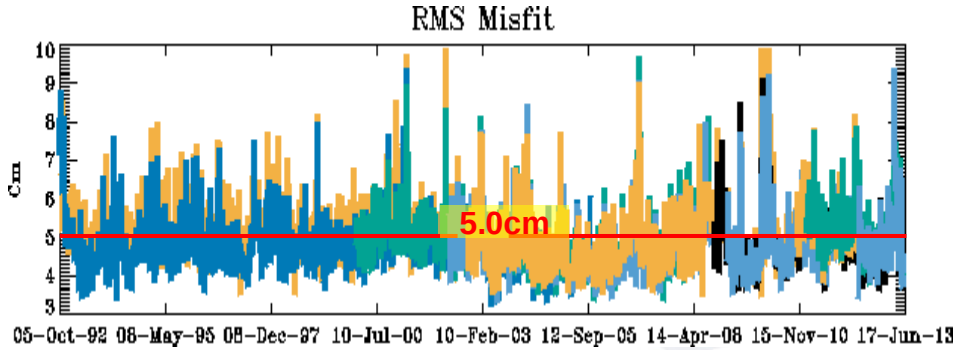




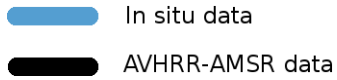
MEDRYS1V1

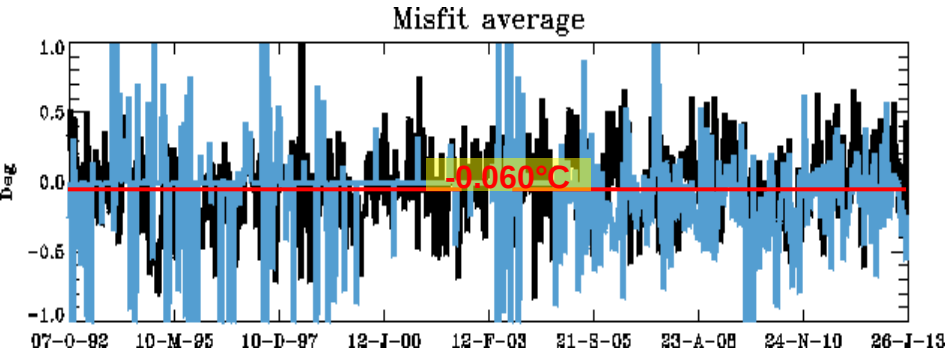


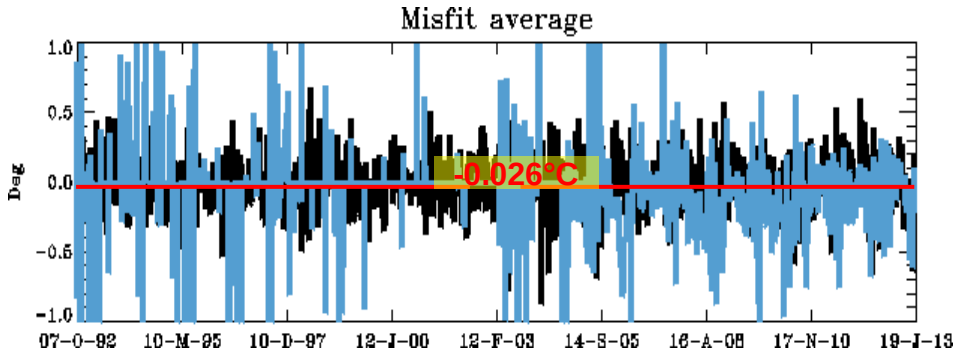
MEDRYS1V2



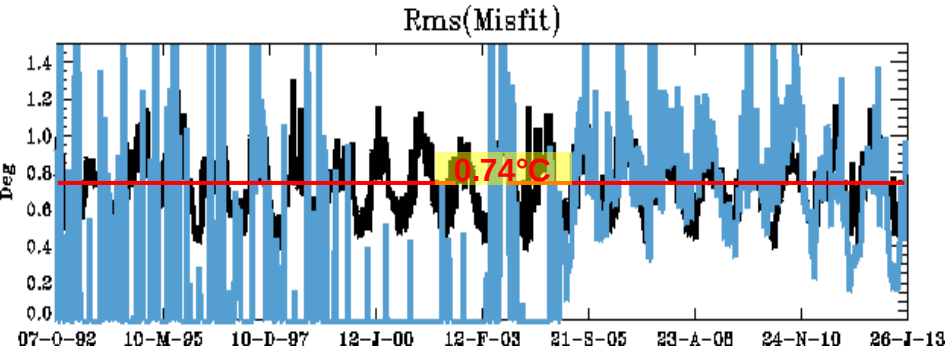
Statistics on assimilated data: SST



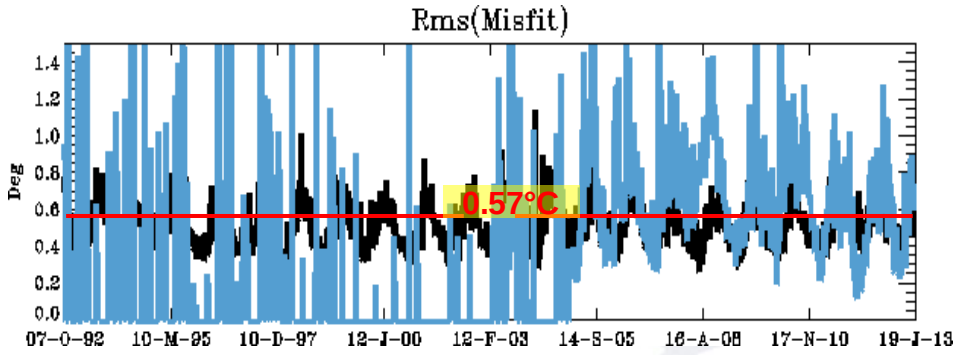




MEDRYS1V1

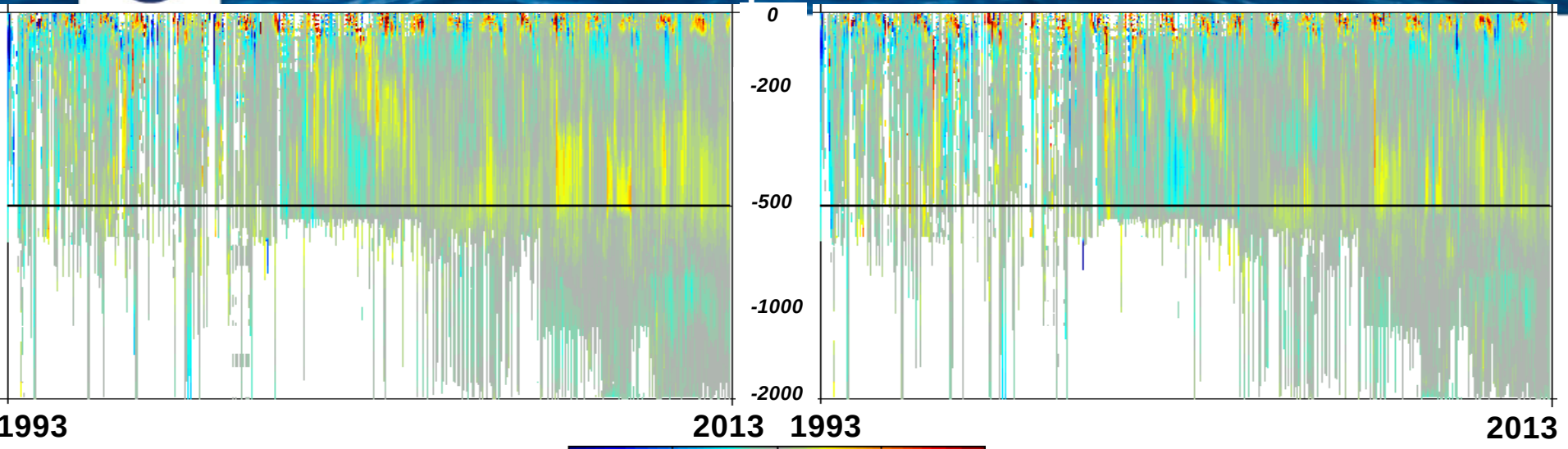


MEDRYS1V2

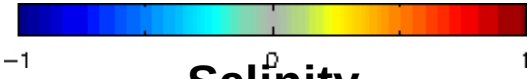


Statistics on assimilated data: in-situ

Temperature

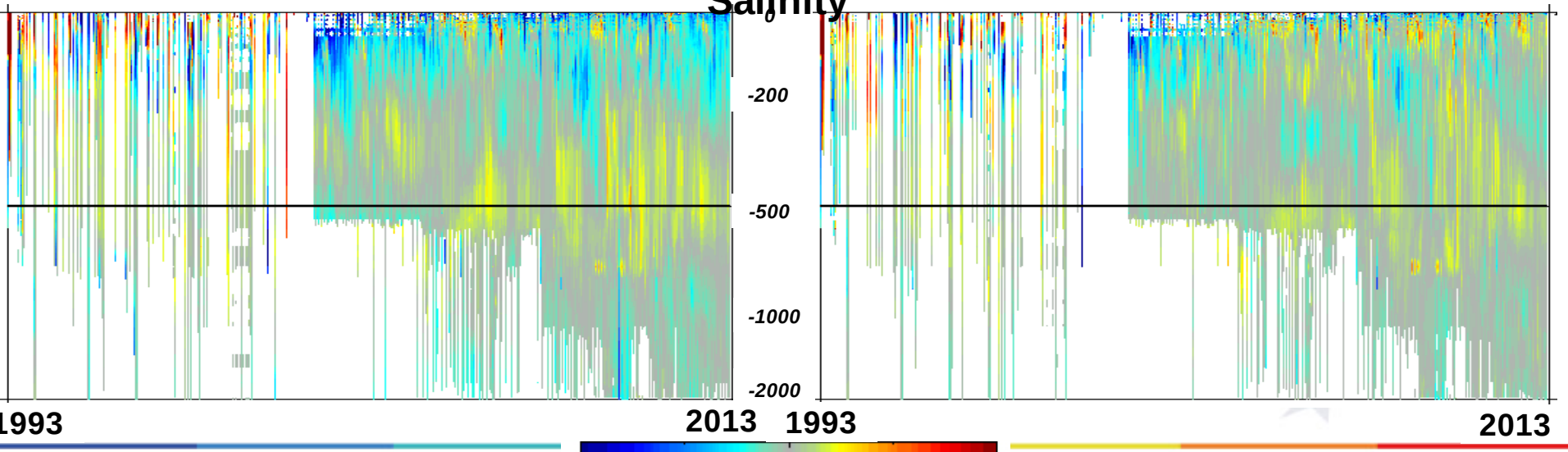


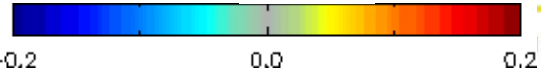
MEDRYS1V1



MEDRYS1V2

Salinity



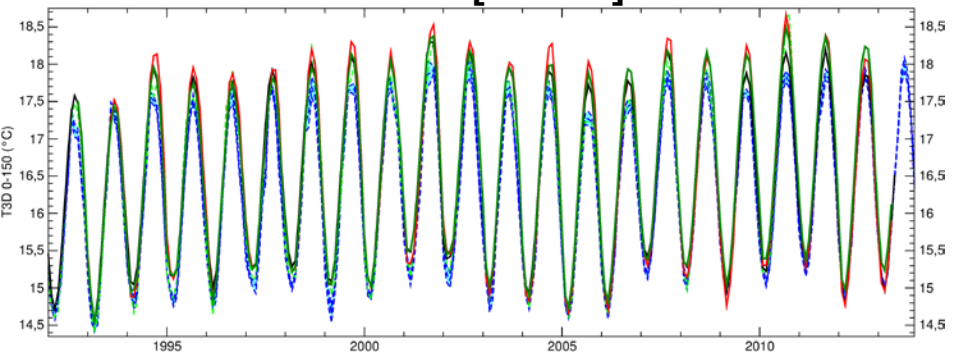


Monthly heat and salt contents

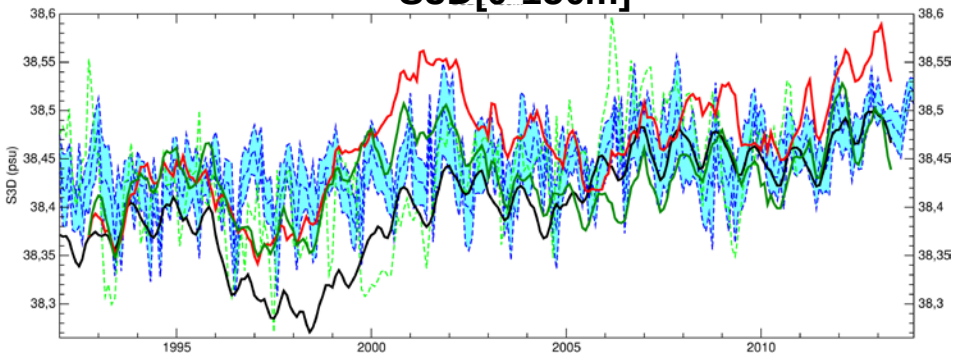
(courtesy G. Jorda for the IMEDEA construction [Llasses et al. 2015])

IMEDEA reconstruction
EN3 reconstruction
NEMOMED12 free run
MEDRYS1V1 reanalysis
MEDRYS1V2 reanalysis

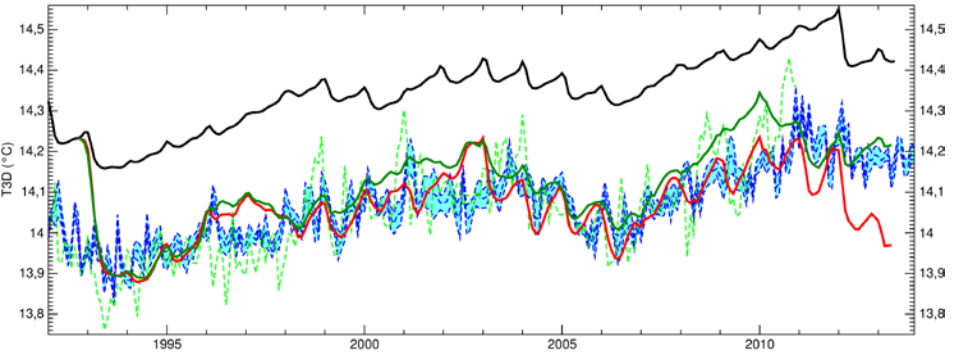
T3D[0-150m]



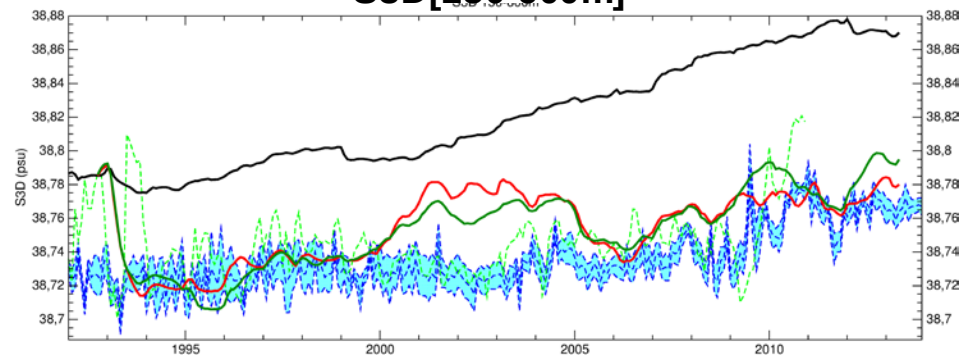
S3D[0-150m]



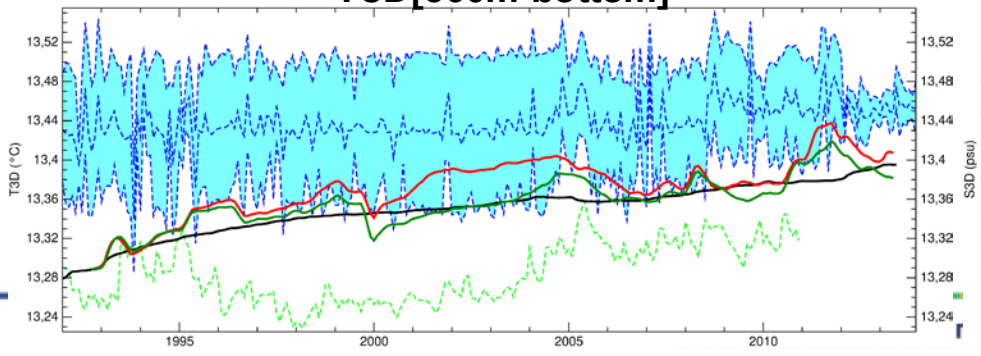
T3D[150-600m]



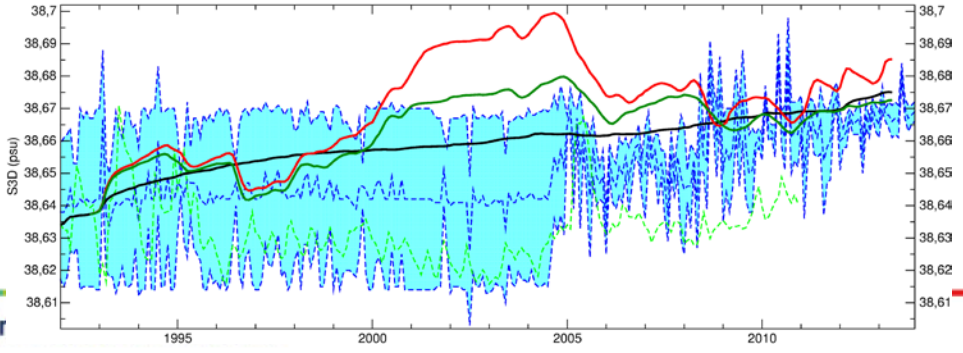
S3D[150-600m]



T3D[600m-bottom]



S3D[600m-bottom]



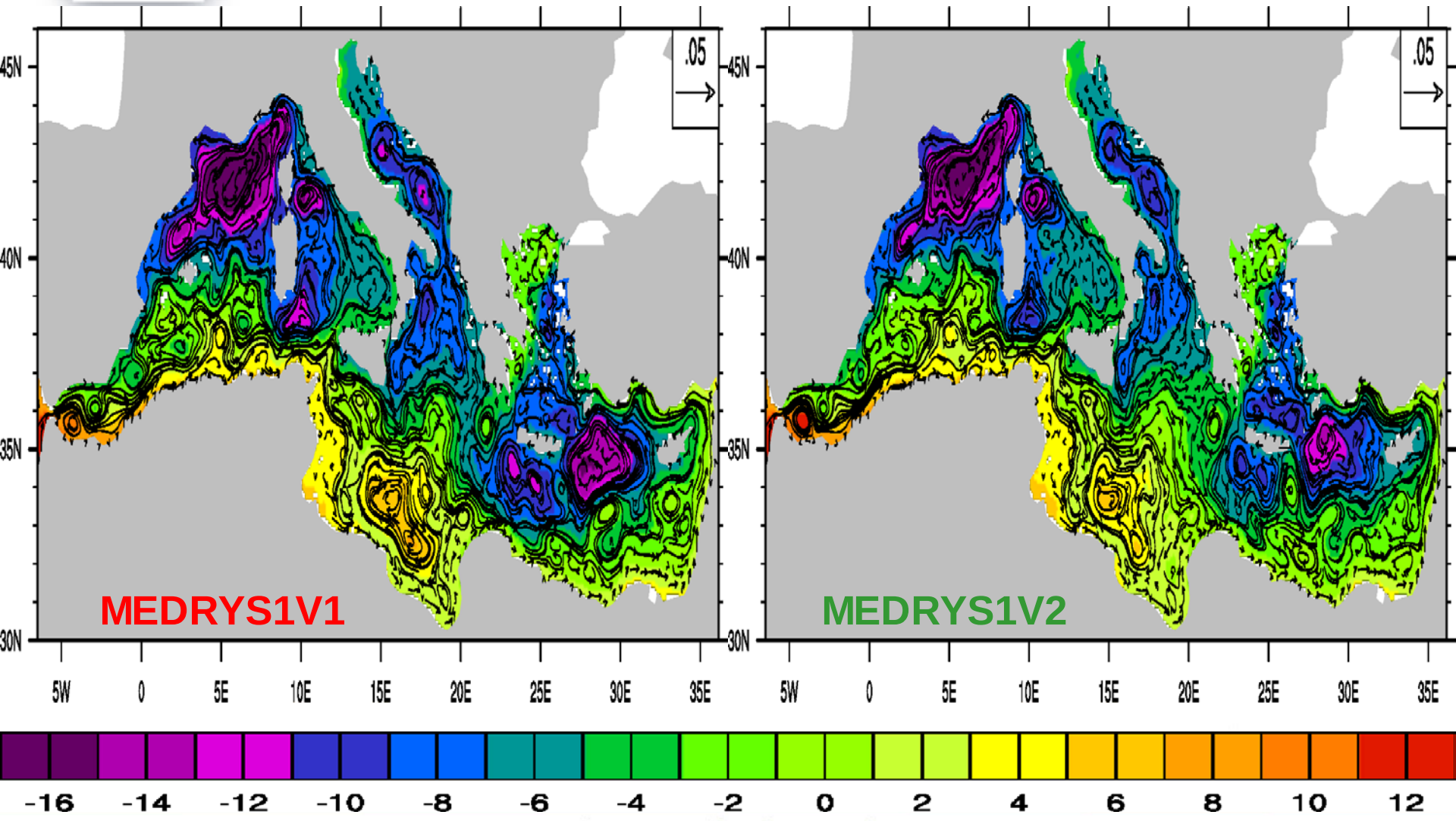
Transports through the Strait of Gibraltar: average over 1993-2012 and annual standard deviation

Refs: Soto-Navarro et al. 2010, 2014 ; EN3 and IMEDEA reconstructions for the net salt transport

	IN	OUT	NET
Water *(Sv)*			
NM12-FREE	**+0.70 ± 0.03**	**-0.65 ± 0.03**	**+0.047 ± 0.009**
MEDRYS1V1	**+0.81 ± 0.03**	**-0.77 ± 0.03**	**+0.048 ± 0.009**
MEDRYS1V2	**+0.81 ± 0.03**	**-0.76 ± 0.03**	**+0.048 ± 0.009**
Heat *($W.m^{-2}$)*			
NM12-FREE	**+19.6 ± 0.9**	**-14.1 ± 0.6**	**+5.5 ± 0.4**
MEDRYS1V1	**+22.8 ± 0.9**	**-16.2 ± 0.6**	**+6.6 ± 0.4**
MEDRYS1V2	**+22.6 ± 0.9**	**-16.0 ± 0.6**	**+6.5 ± 0.4**
Salt *(10^{-3} psu.$year^{-1}$)*			
NM12-FREE	**+208 ± 8**	**-205 ± 9**	**+3.0 ± 2.6**
MEDRYS1V1	**+243 ± 9**	**-241 ± 10**	**+1.8 ± 2.8**
MEDRYS1V2	**+240 ± 8**	**-238 ± 9**	**+1.8 ± 2.7**

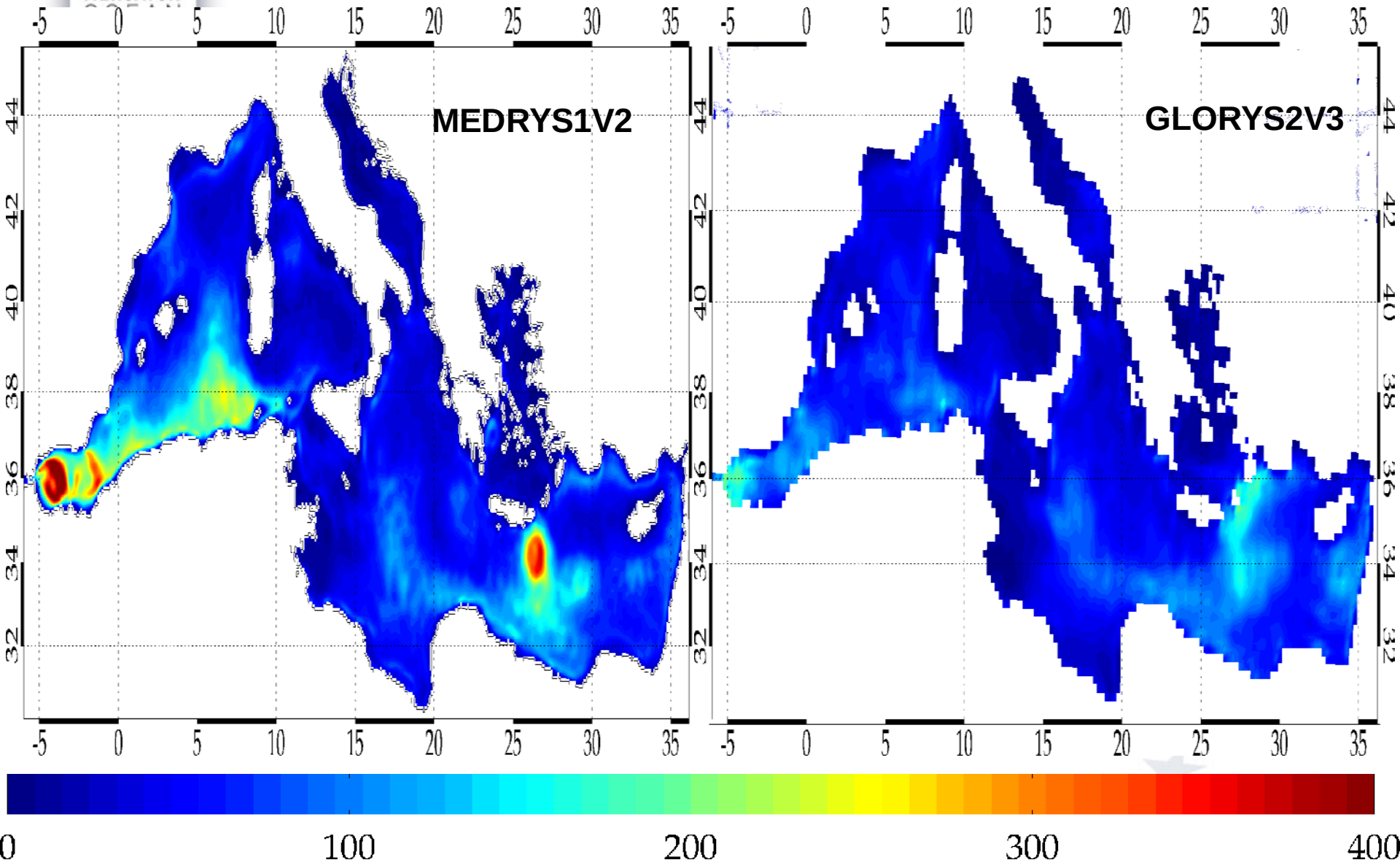
Surface circulation : mean currents

SSH (cm) and 40-m depth currents (m.s^{-1}), average over 1993-2012



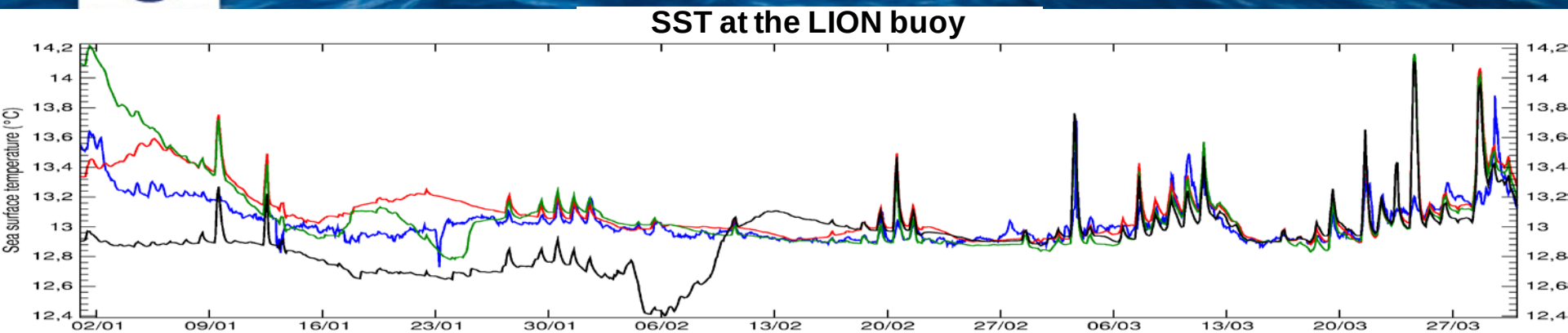
Comparison with GLORYS2V3

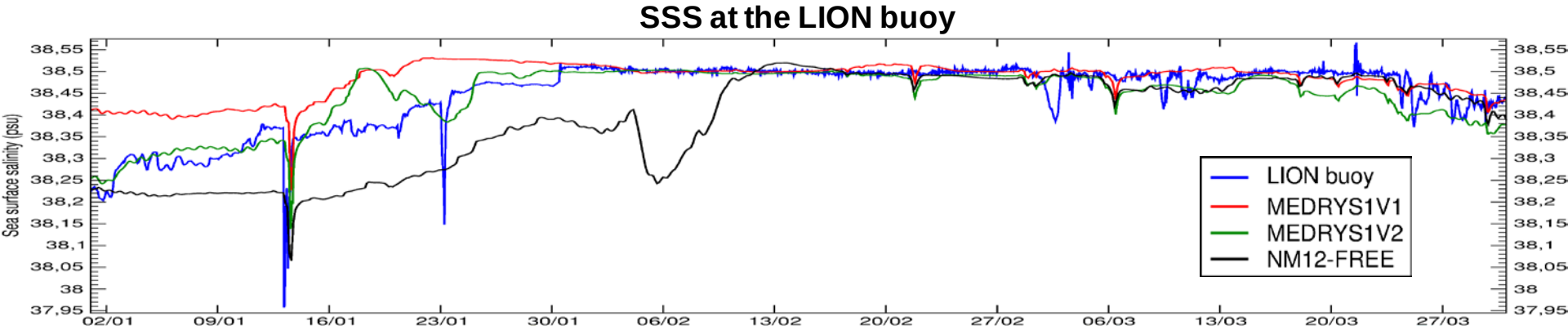
40-m depth EKE ($cm^2.s^{-2}$), average over 1993-2011

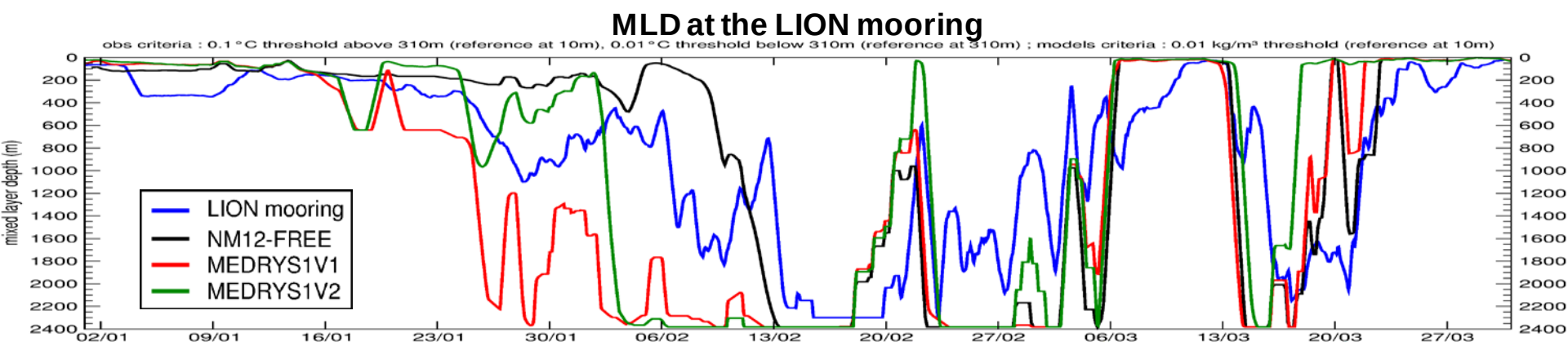


High-frequency variability: comparison at LION buoy in winter 2013

(courtesy L. Houpert for the mooring data and M.-N. Bouin for the buoy data)







Use cases of MEDRYS and NM12-FREE in regional climate studies

Group	Simulations used	Thematics	Projects
Météo-France/CNRM (G. Caniaux, R. Waldman, S.Somot)	MEDRYS1V1 2012-2013 (HyMeX EOP+ period)	budgets of the NWMED; sensitivity of dense water formation to the initial conditions in summer	HyMeX R. Waldman PhD
Météo-France/CNRM (F. Adloff, S. Somot)	MEDRYS1V1 1993-2012	evaluation of sea level and surface circulation in regional coupled models	REMEMBER MedCORDEX
LTHE (K. Béranger)	NM12-FREE MEDRYS1V1 autumn 2012 (HyMeX SOP1 period)	sensitivity of spatio-temporal distribution of precipitations to the SST field in a regional coupled model	HyMeX REMEMBER
INSTM Tunis (A. Harzallah)	NM12-FREE 1979-2013	long term evolution of heat budget from forced and coupled regional simulations	HyMeX/MedCORDEX Harzallah et al. *in rev.*
ENEA Rome (M.-V. Struglia)	NM12-FREE 1979-2013	multi-model analysis of the interannual variability of the thermohaline circulation	HyMeX/MedCORDEX Struglia et al. *to be resubmitted*

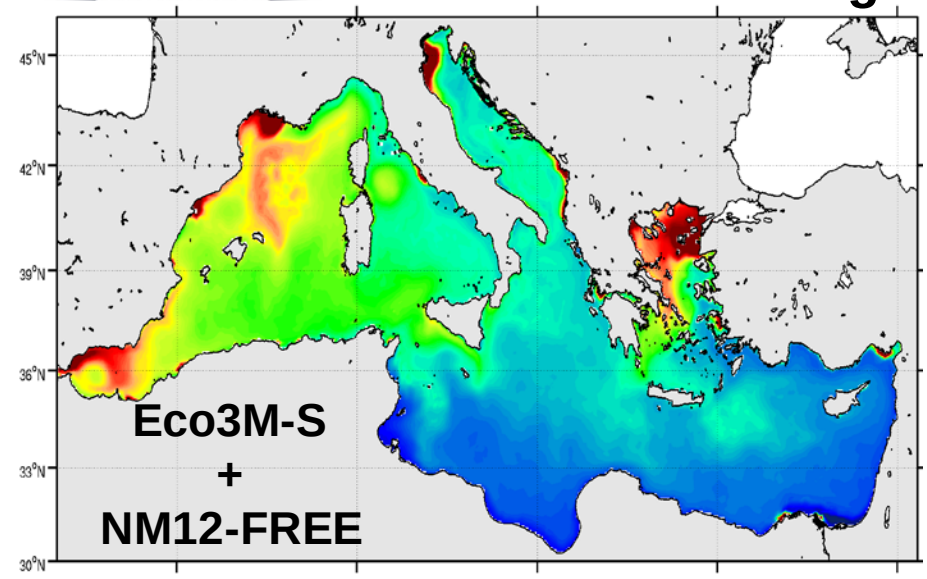
Use cases of MEDRYS and NM12-FREE to force biogeochemical models

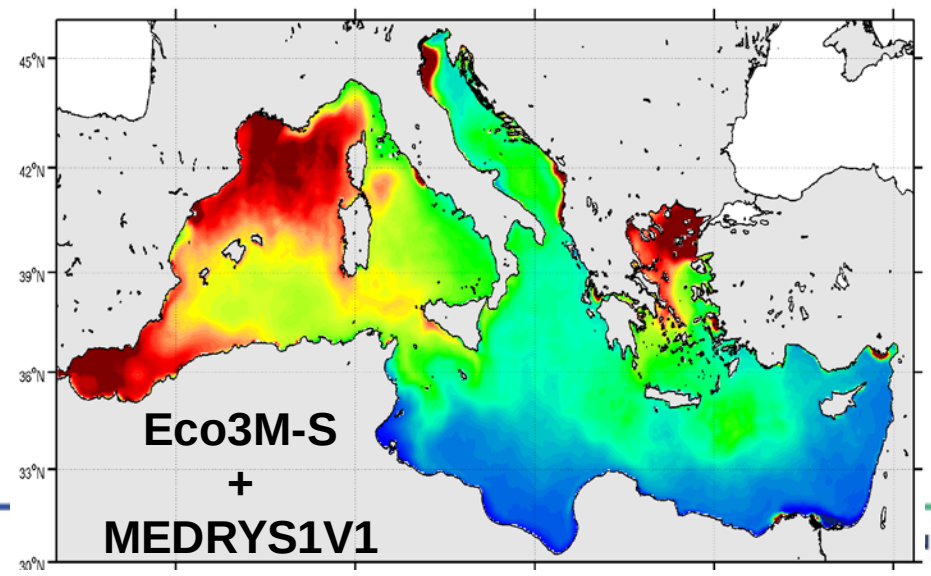
Group	Simulations used	Thematics	Projects
OMP/LA (C. Ulses, F. Kessouri, C. Estournel)	NM12-FREE and MEDRYS1V1 2000-2013 with Eco3M-S	seasonal variability of biochemistry; budget of nutrients; CO_2 fluxes at the air-sea interface; carbon budget at the Med basin scale; IC+LBC of a western basin configuration; link with the real-time simulations forced by the operational Mercator PSY2	F. Kessouri PhD MISTRALS (SiMED, MerMeX) Collaboration Mercator & OMP/LA
OO Banyuls LEEB (K. Guizien)	NM12-FREE 2010-2012 with Symphonie at 100m resolution	larval dispersal study to assess the current spatio-temporal variability of connectivity between benthic invertebrates populations dwelling in the rocky habitat of the Gulf of Lions for conservation practice evaluation	RocConnect (Liteau IV project of the French Ministry of Environment)
IPLS/LSCE (J.-C. Dutay, M. Ayache, C. Richon)	NM12-FREE 1982-2012 with PISCES	impacts of aerosol deposition on the Mediterranean biochemistry	C. Richon PhD MISTRALS (SiMED, MerMeX, CharMeX) PEACETIME
MIO (M. Baklouti)	NM12-FREE 1982-2012 with Eco3M-Med	carbon export and sequestration by the biological pump; impact of the stoichiometry of organic and mineral matter on the structure of the planktonic trophic web	MISTRALS (SiMED, MerMeX) LabeX OT-MED

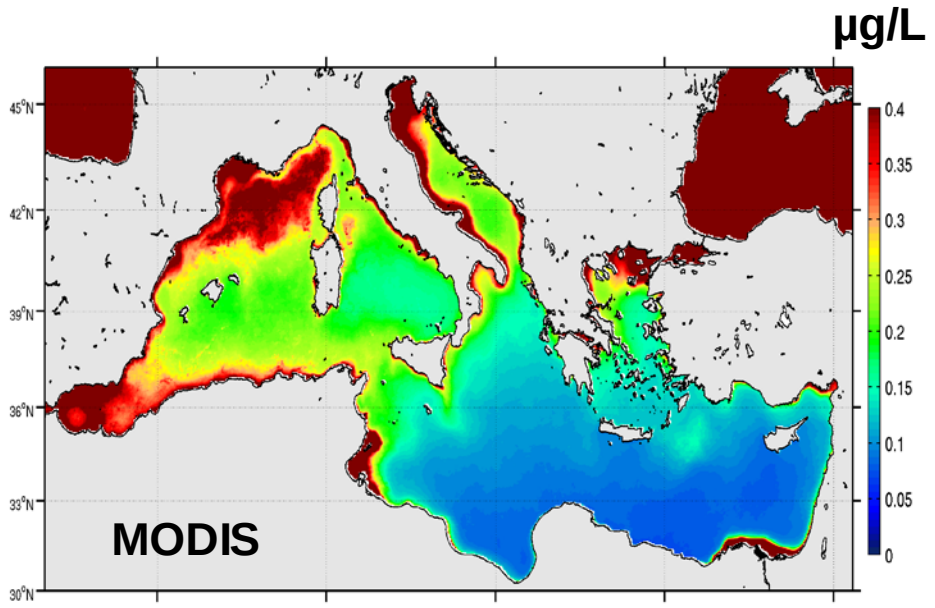
Use case in a biogeochemical model

courtesy Caroline Ulses, OMP/LA

2003-2013 average of surface chlorophyll







Study to be continued with MEDRYS1V2 …

Conclusions and outlook

High-resolution regional ocean model NEMOMED12, with an homogenous high-resolution atmospheric forcing over 1979-2013 (12km/3h ALADIN-Climate), giving a stable 34-year free simulation.

MEDRYS1, 21-year regional reanalyses with assimilation of SST, altimetry and in-situ data.

MEDRYS1V1 presented and validated in *Hamon et al. 2016 [Oc. Sci.]* :

- good surface circulation and variability (mean state and small scales features),
- realistic trends and interannual variability in the surface and intermediate layers,
- deeper layers variability still need to be investigated.

=> available on the Mercator catalog, on the HyMeX and IPSL databases.

MEDRYS1V2 under validation :

- smaller biaises in SLA, SST, T3D and S3D,
- dense water formation process improved, especially in the Levantine sub-basin,
- on-going tests to provide a reference for the 2012-2013 (HyMeX/EOP^{+}) period.

Towards MEDRYS2 :

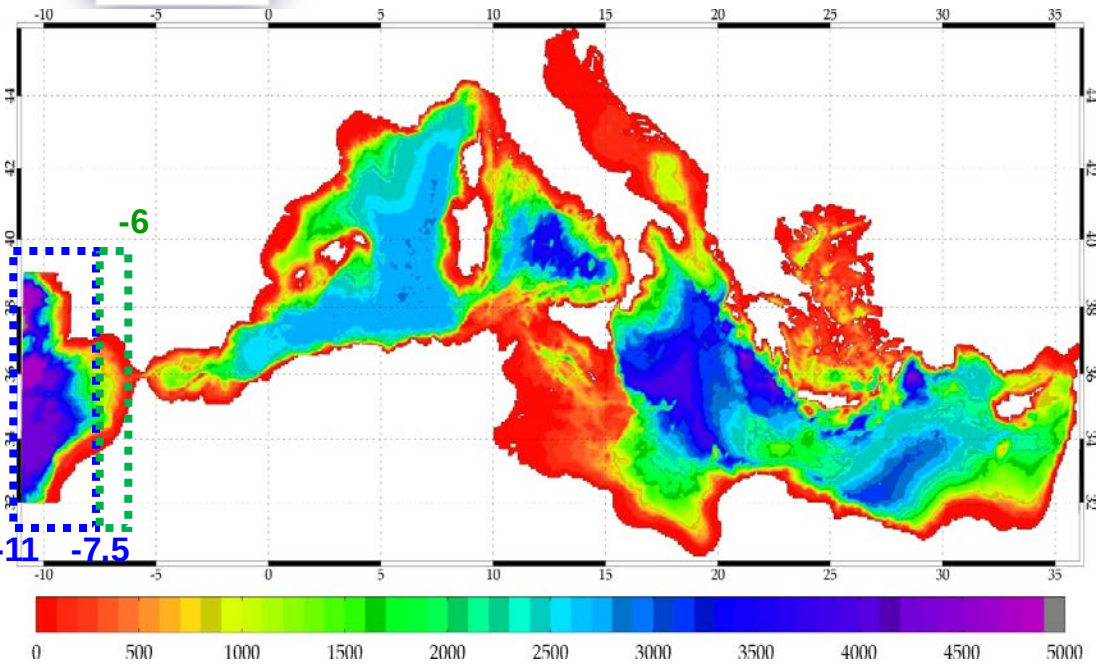
- new free run (NEMO3.6, new IC+LBC, param. changes),
- reanalysis starting in 1979 ? BGC coupling ?

MERCATOR OCEAN
OCEAN FORECASTERS

Merci pour votre attention !

Des questions ?

Regional oceanic configuration: NEMOMED12 model



Bathymetry (m)

Atlantic buffer zone :
Newtonian dampings to ORAS4 monthly anomalies with following time scales τ :
θ and S (3D) : τ between 2 days -> 90 days
SSH : τ between 1.7 second -> 90 days

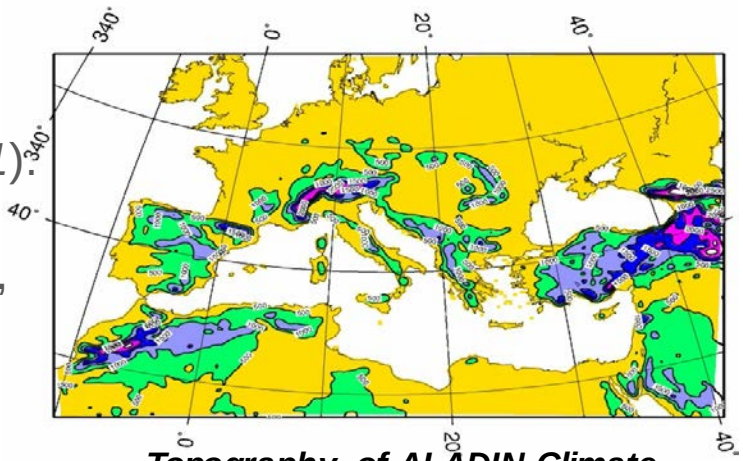
- NEMO v3.1 code (Mercator oper version at Météo-France HPC)
- Horizontal grid from ORCA12 at **6-8 km** < Rossby deformation radius ~10-15 km
(eq. to a 1/14°-1/18° regular grid)
- Z vertical grid with **75 levels** (1m to 135m thickness)
- New high resolution bathymetry (MERCATOR-LEGOS v10 product at 1/120° resolution)
- **Closed boundary at 11°W**

Atmospheric forcings, initial and boundary conditions

- Free simulation starting in **October 1979** from Medatlas-1979 (*Rixen et al., 2005*) in the Mediterranean side and from WOA05 (*Levitus et al., 2005*) in the Atlantic side. The reanalysis starts from the state of the free run on the **30th September 1992** (beginning of the altimetry era).

- **12-km** and **3h**-atmospheric **fluxes** from ALDERA (CNRM), dynamical downscaling of the ERA-Interim reanalysis with ALADIN-Climate (*Herrmann et al. 2011*).

  SST retroaction for the free run (*Barnier et al. 1995*), coefficient of -40 W/m²/K (*CLIPPER Project 1999*). The total heat flux of the free run is used for the reanalysis (including the retroaction term).



Topography of ALADIN-Climate

No SSS damping, 2D water flux correction in the water flux.

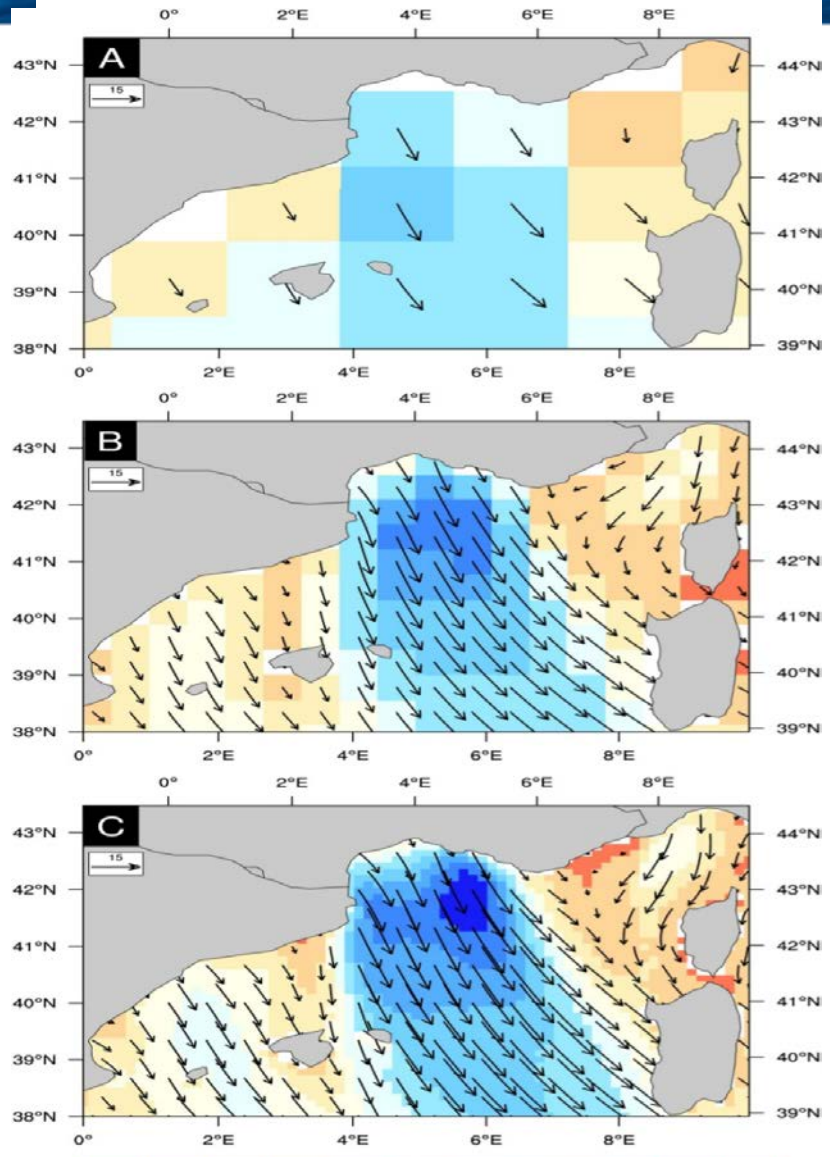
33 main rivers + Black Sea (**interannual** datasets from *Ludwig et al., 2009* and *Stanev & Peneva, 2002*): freshwater added as precipitation at mouth points + coastal runoff (residual land-surface freshwater budget).

Added value of the high-resolution in ALDERA

Hamon et al. 2016, Ocean Science

Wind and heat flux on the 14th March 2013

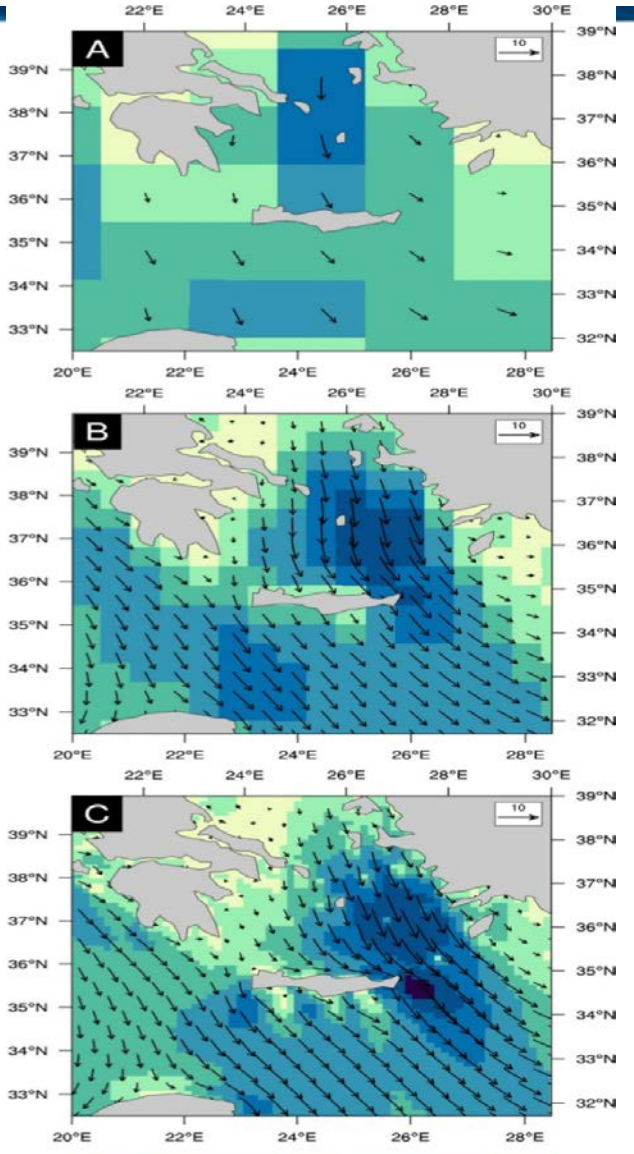
Wind direction and speed on the 16th September 2012



ALADIN-150km

ALADIN-50km

ALADIN-12km (ALDERA)



Changes made for MEDRYS1V2 1992/09/30 – 2013/06/26

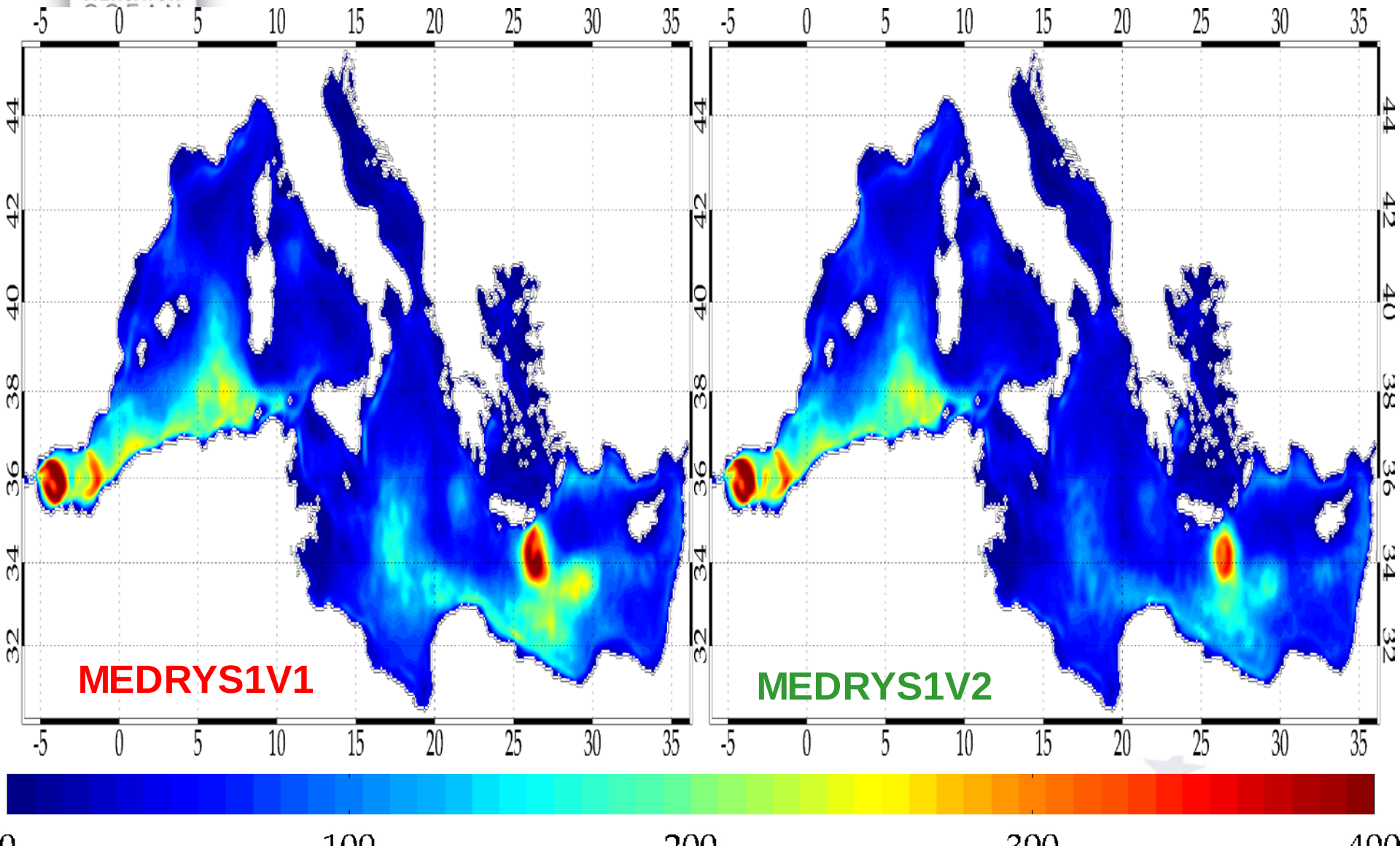
- 5-day analysis cycle (instead of 7).
- New model equivalent for SLA + HDYN reference added :

$$\mathbf{INNOV} = \mathbf{SLA}^{d} - \mathbf{correctif}(volume) -$$
$$[\, c1 * \mathbf{SSH} + c5 * \mathbf{DIFFBAR} + c4 * \mathbf{HDYN} - c1 * \mathbf{MSSH} - c4 * \mathbf{HDYN}(ref)]$$
avec $c1$=0.75, $c4$=0.25, $c5$=–1.0

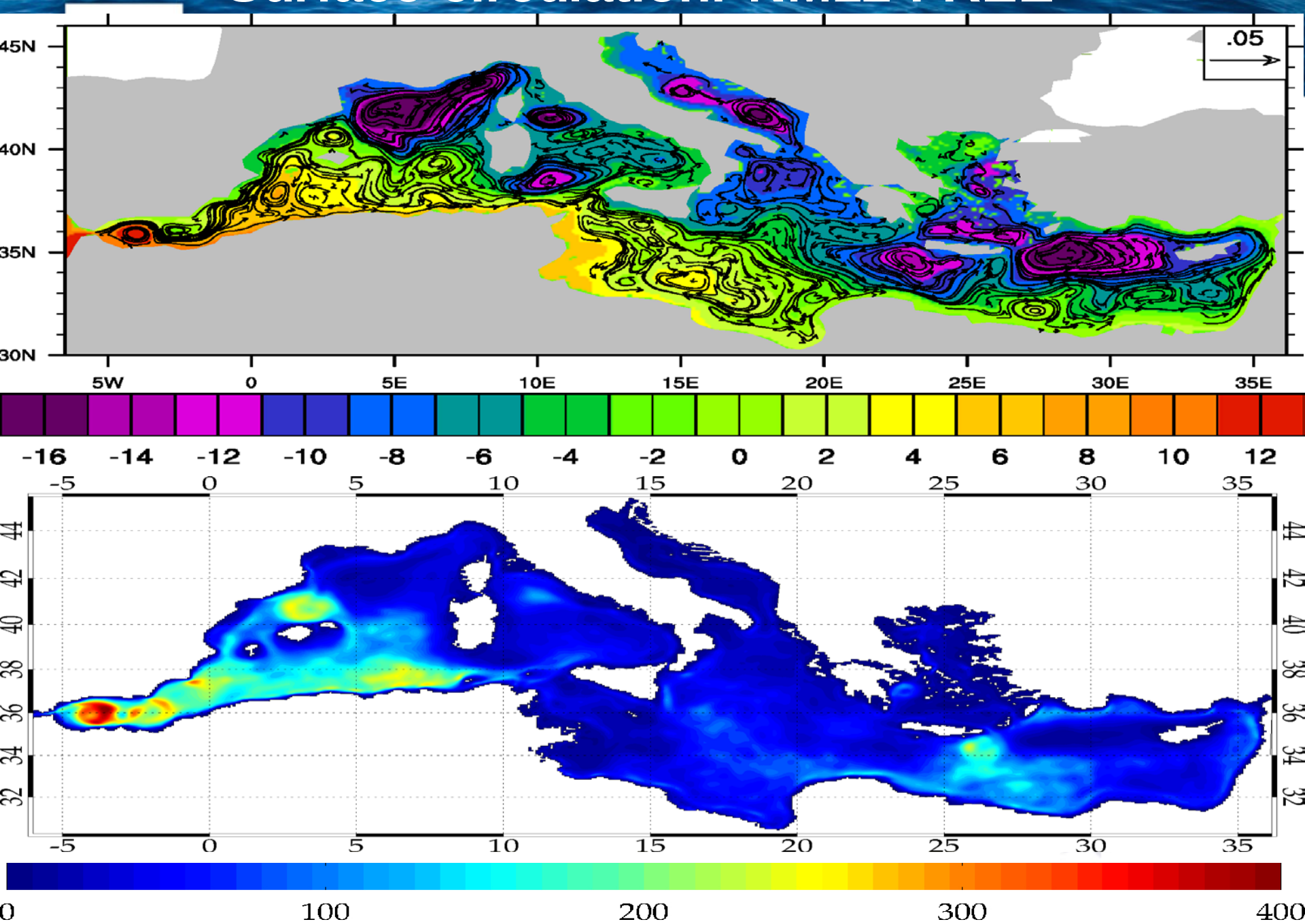
- New MSSH reference (hydrid of the new MED MDT + systematic errors from GLORYS2V3)
- Better adjusted PGR correction + corrected monthly cycle of the Atlantic SSH
- CORA4.1 (delayed time data for all the period)

Surface circulation : EKE

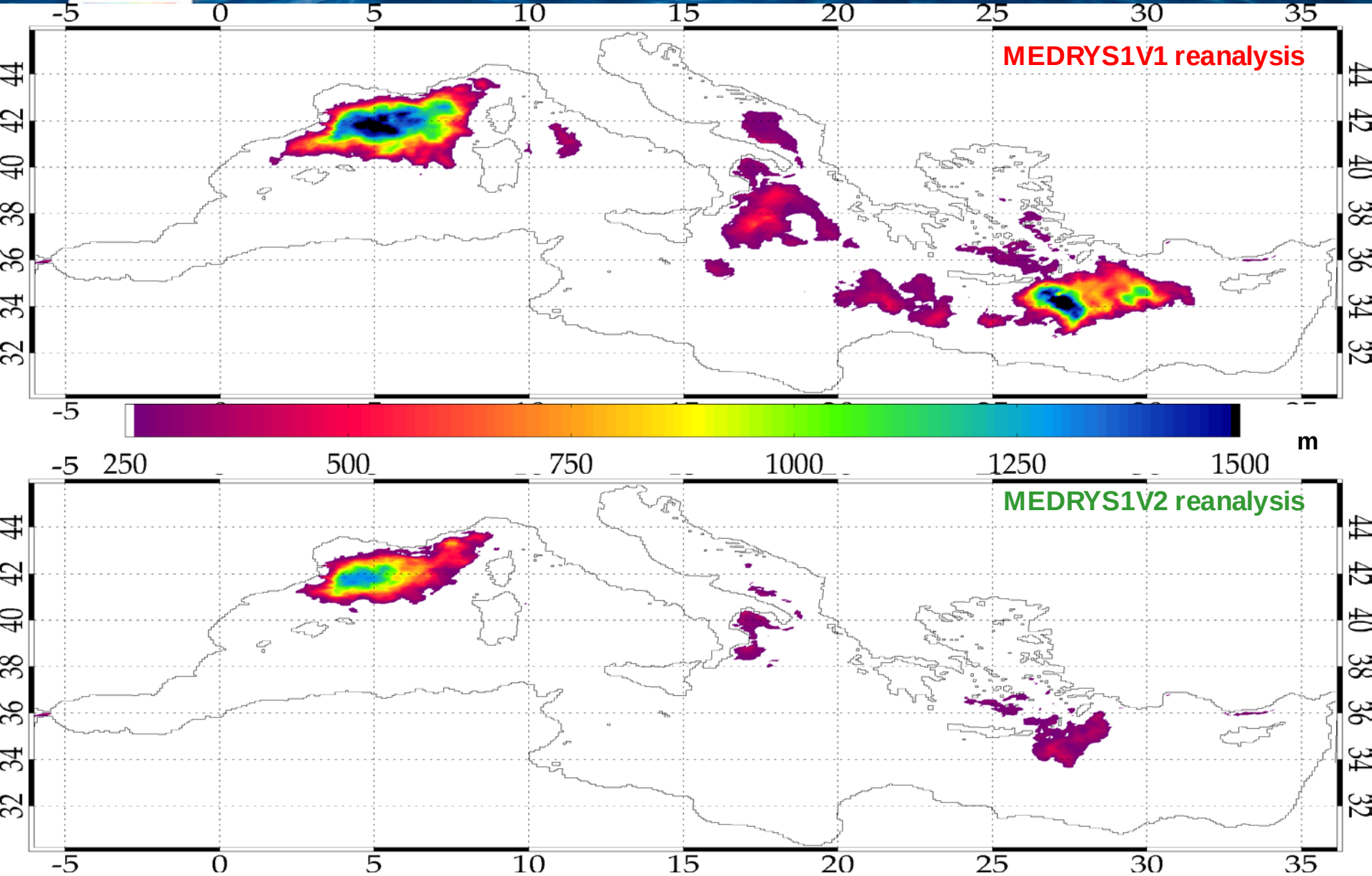
40-m depth EKE (cm²/s²), average over 1993-2011



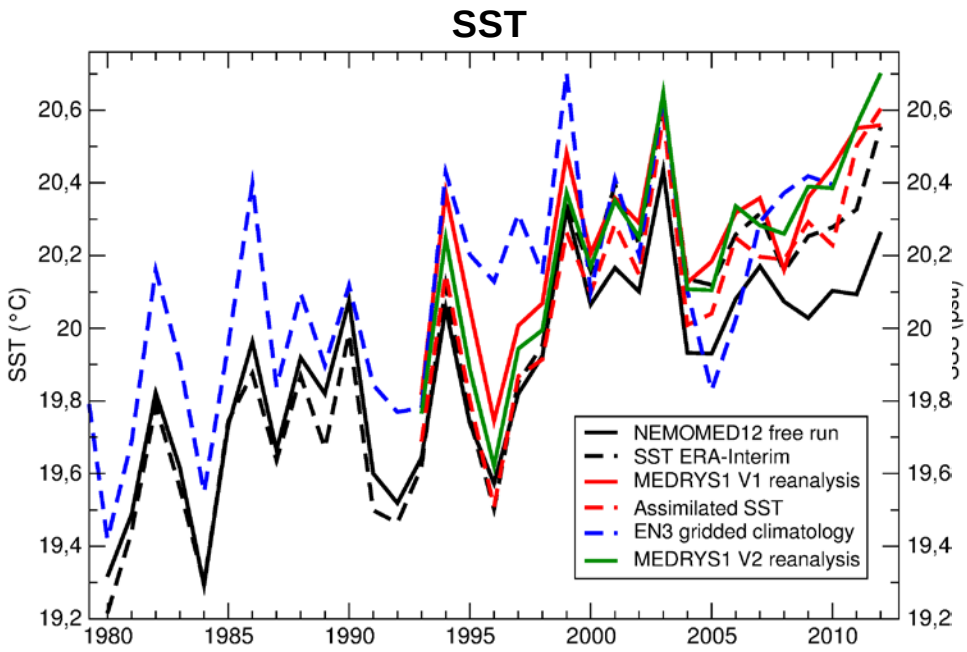
Surface circulation: NM12-FREE

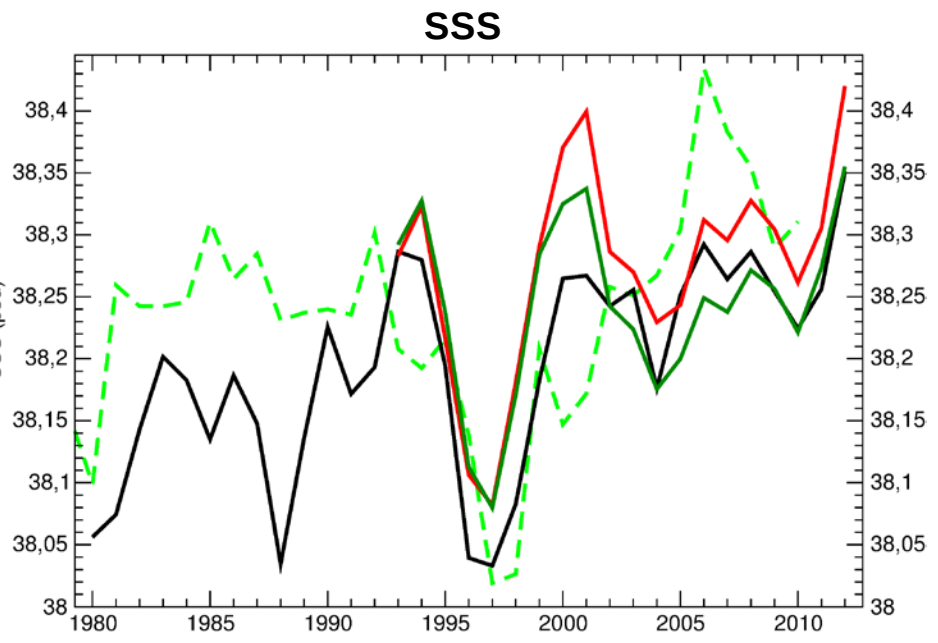


Winter convection (averages of winter maxima over 1993-2013)



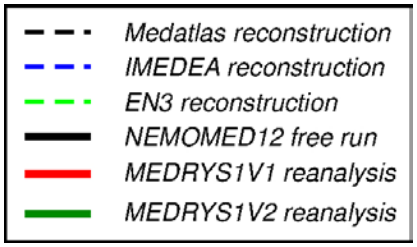
Annual SST and SSS



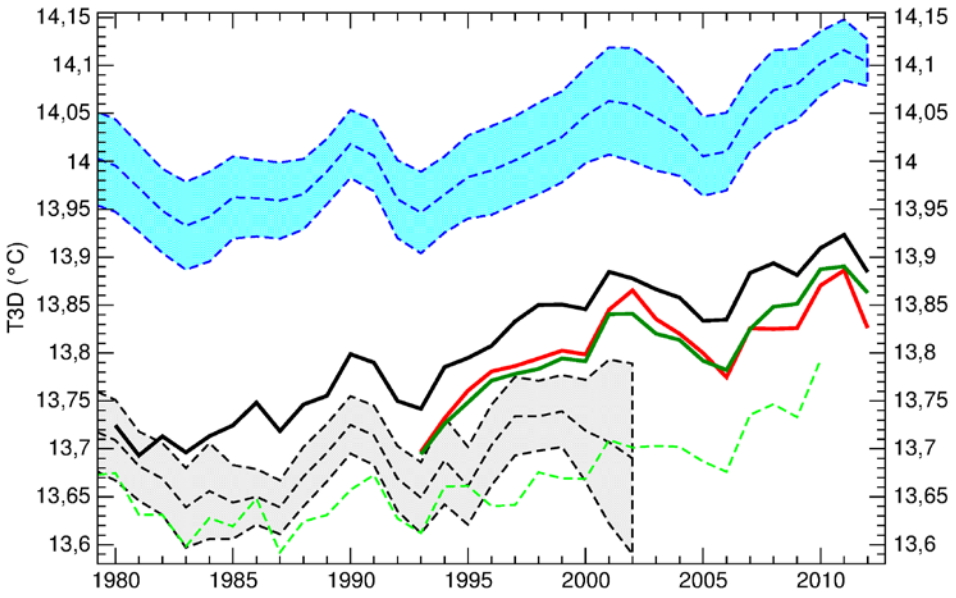


Annual heat and salt contents

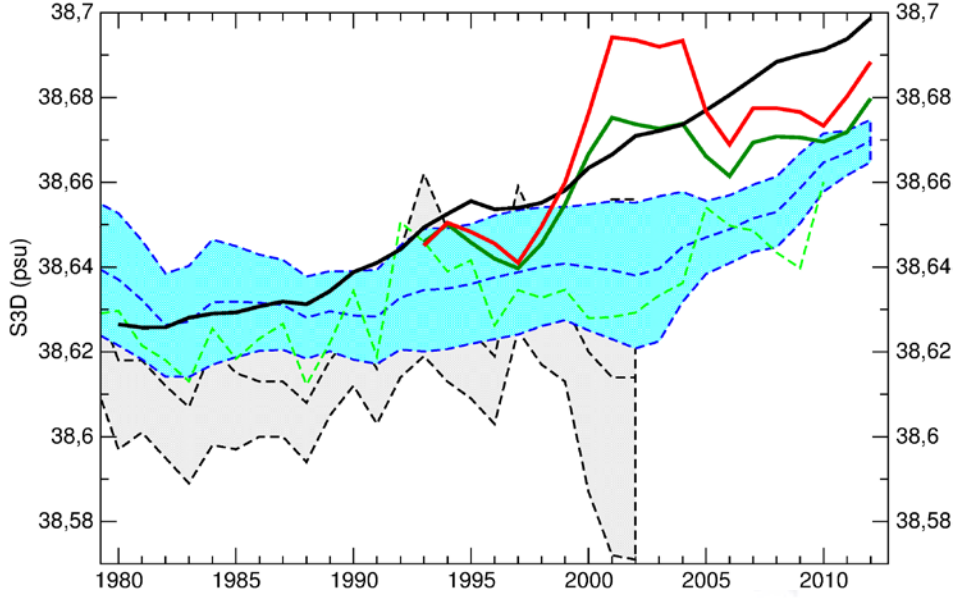
(courtesy G. Jorda for the IMEDEA construction)



T3D[0m-bottom]

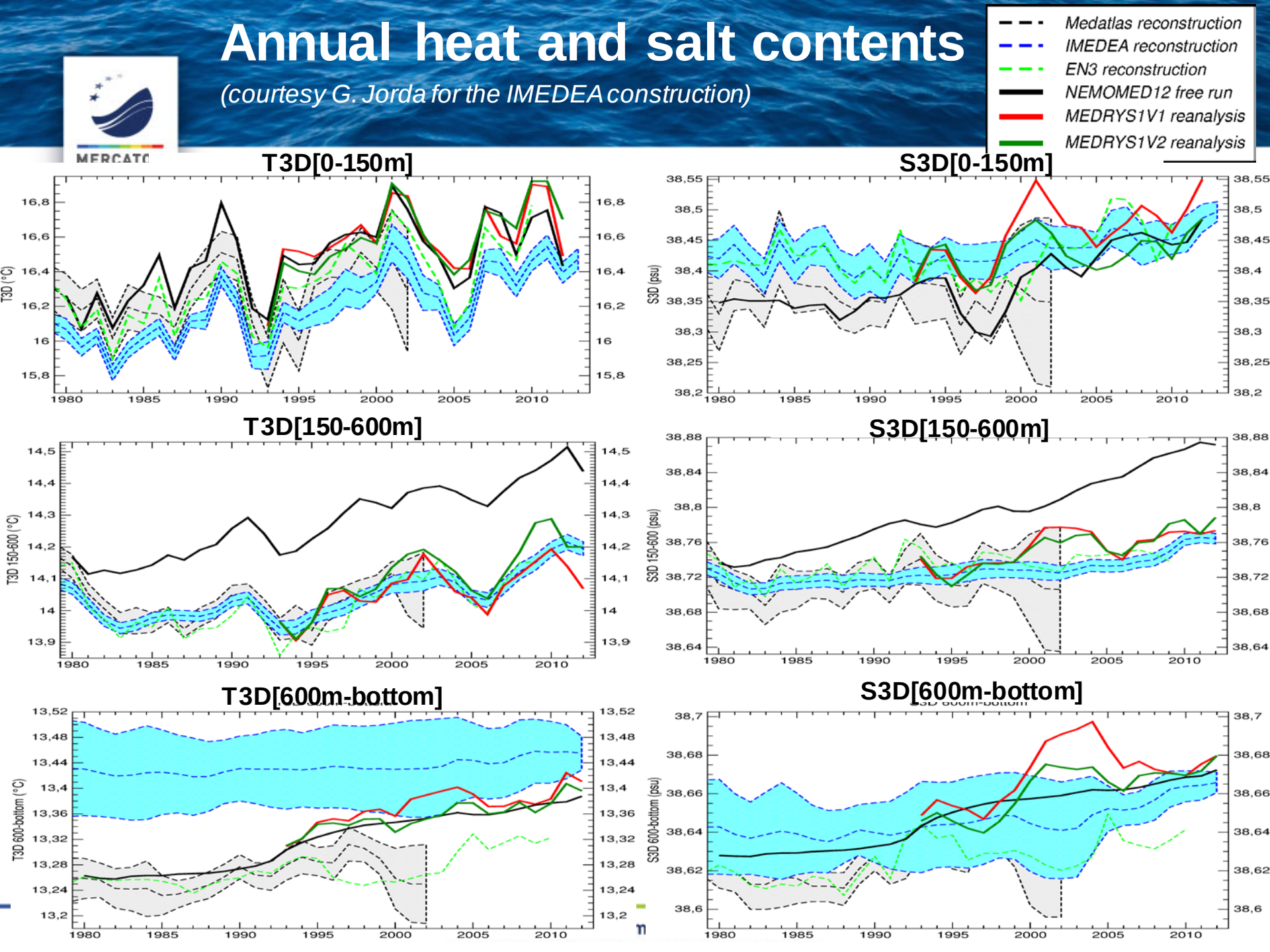


S3D[0m-bottom]



Annual heat and salt contents

(courtesy G. Jorda for the IMEDEA construction)



SSS Golfe of Lions