MERCATOR OCEAN INTERNATIONAL

# The current Copernicus Marine Service global ocean monitoring and forecasting real-time system and the updates planned for the future system

Lellouche Jean-Michel, E. Greiner, O. Le Galloudec, G. Garric, R. Bourdalle-Badie, C. Régnier, M. Drévillon, M. Benkiran, Y. Drillet, and Pierre-Yves Le Traon

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mercator-ocean.eu/marine.copernicus.eu

# Outline

- Description of the Mercator Ocean global system
- Focus on some of the specifics of the system
- Performance and quality of the system
- Updates planned for the future system

# Current global system operated by Mercator Ocean

Physical Model (ocean + sea-ice)

- NEMO 3.1 OGCM coupled with LIM2_EVP sea-ice model
- Horizontal resolution 1/12° and 50 vertical levels (1m at the surface)
- 3h ECMWF atmospheric forcing
- **Ice-sheets and glaciers melting added to the runoffs**
- **Large scale correction of precipitations**
- **Global steric effect added to SSH**

Assimilation & Data assimilated (SAM2 code)

- SEEK (Kalman filter)
- 3D-Var large scales bias correction
- SLA (SL TAC) + **Hybrid MDT** from « CNES-CLS13 » MDT
- In Situ T/S profile (INS TAC)
- SST OSTIA (OSI TAC)
- **Sea-ice concentration (OSI TAC)**
- **New Quality Control on 3D T/S observations**
- **Adaptive tuning of SLA and SST observation errors**
- **WOA 2013 “weak assimilation” below 2000m**

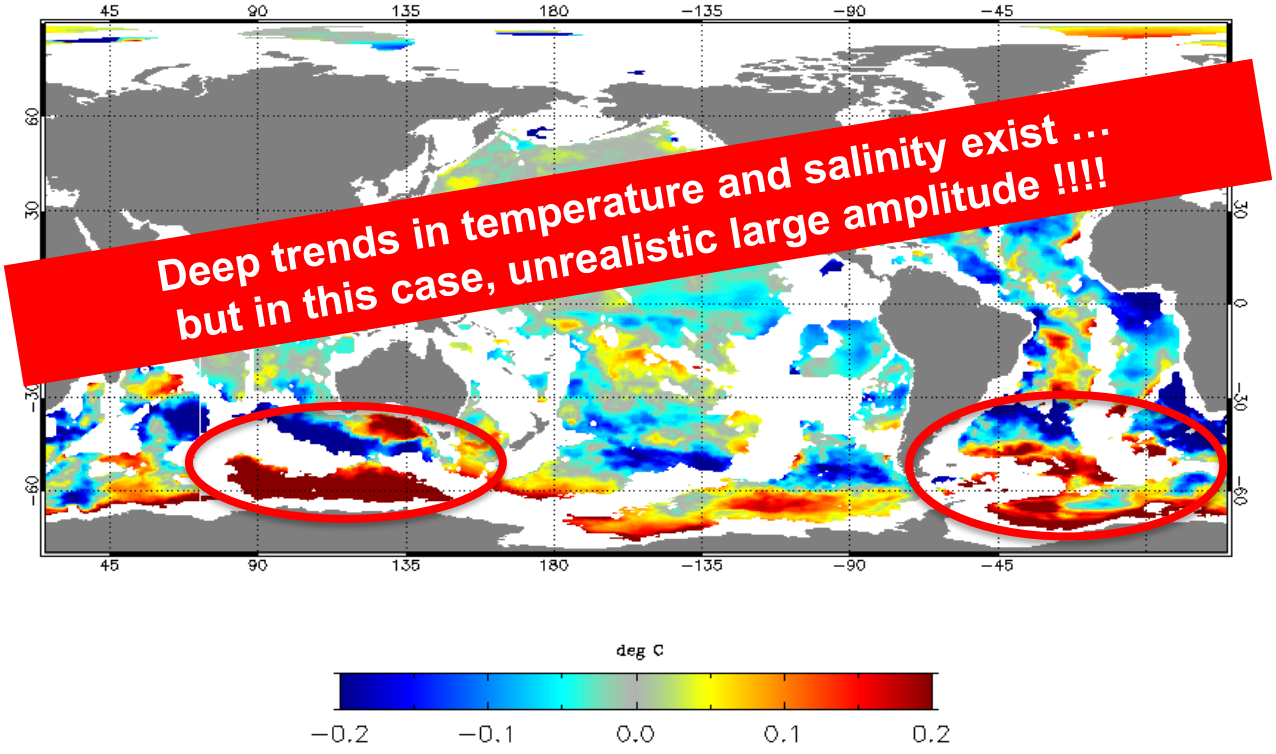
Service

- Weekly 7-day analyses and daily **10-day forecasts** at 1/12°
- Available Period: **2007** → now
- “FREE”, “BIAS only” and “OPER” simulations

# Assimilation of climatological deep profiles

**Objective: prevent model drifts in very sparsely observed depths**

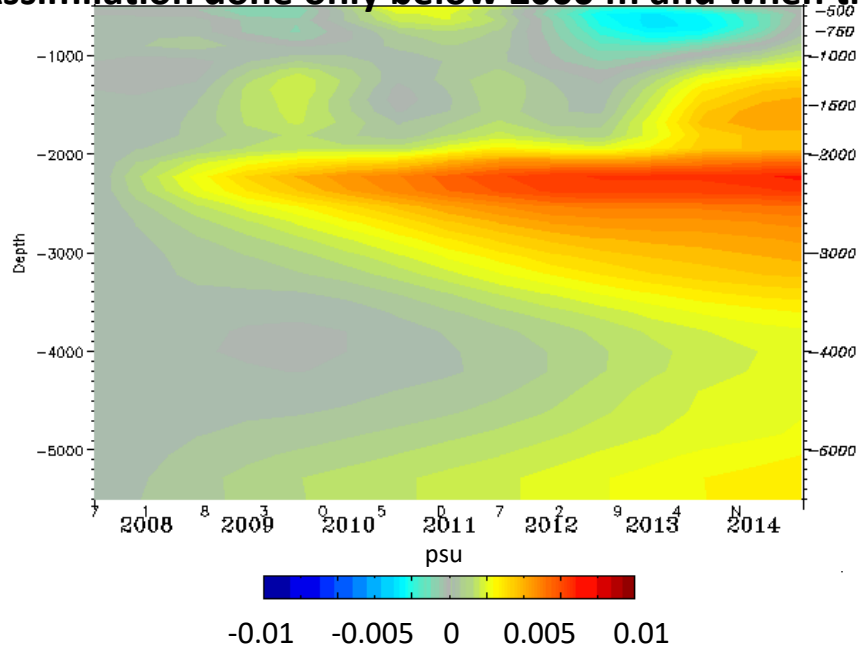
**Cumulated trend temperature at 4000 m depth (2007-2014)**
**Free simulation (without any data assimilation)**

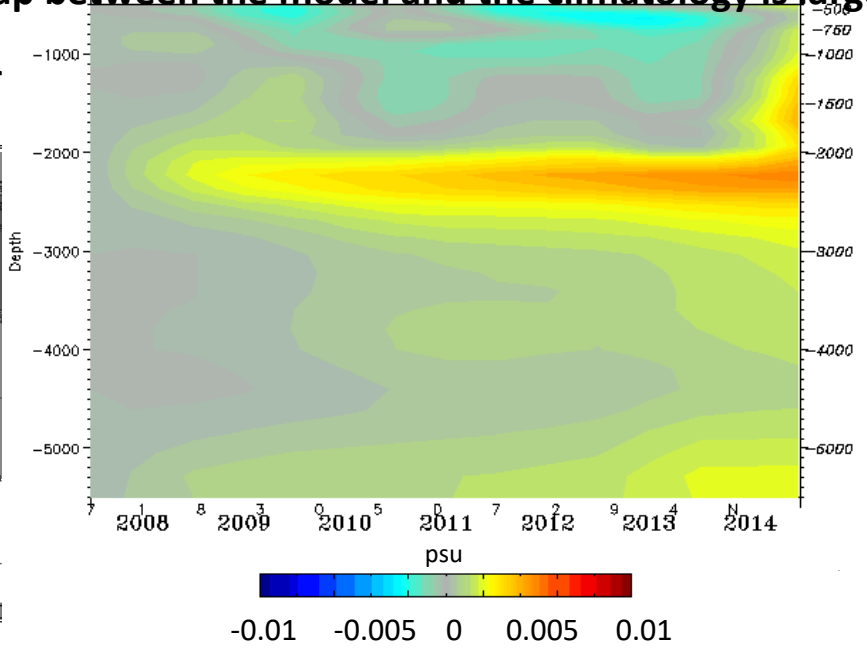


# Assimilation of climatological deep profiles

**Objective: prevent model drifts in very sparsely observed depths**

**Assimilation done only below 2000 m and when the gap between the model and the climatology is large**




psu

-0.05 0 0.05

**Drift in salinity (same in temperature) is reduced**

**Fresh Antarctic Bottom Water is maintained**

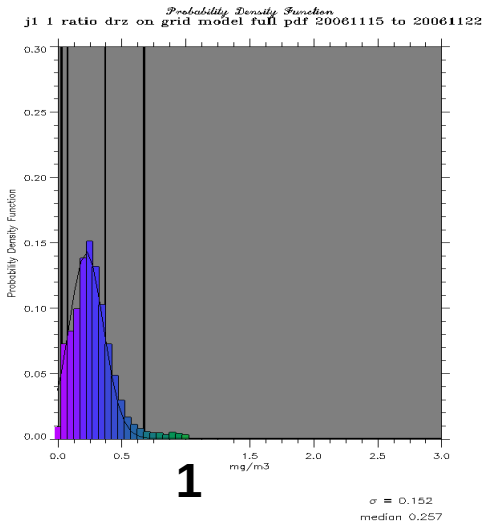
# Adaptive tuning of observation errors

The prescription of observation errors in the assimilation systems is often too approximate...

$$\text{Ratio} = \frac{\text{residual (innovation)}^T}{\alpha \ \text{obs error}}$$

- Ideally, ratio=1
- ratio < 1 => obs error overestimated
- ratio > 1 => obs error underestimated

Jason1

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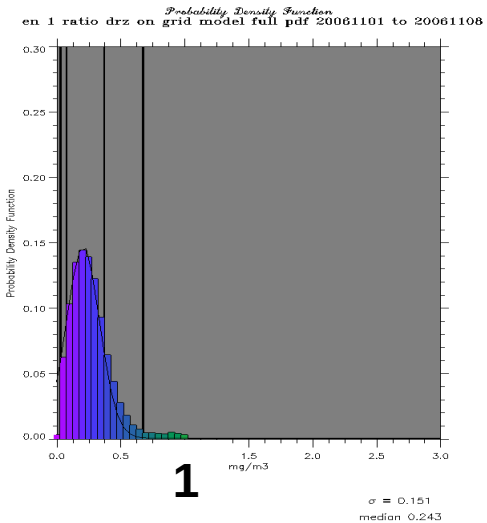
Envisat




1

The objective of this diagnostic is to improve the error specification by tuning **an adaptive weight coefficient $\alpha$** acting on the error of each assimilated observation

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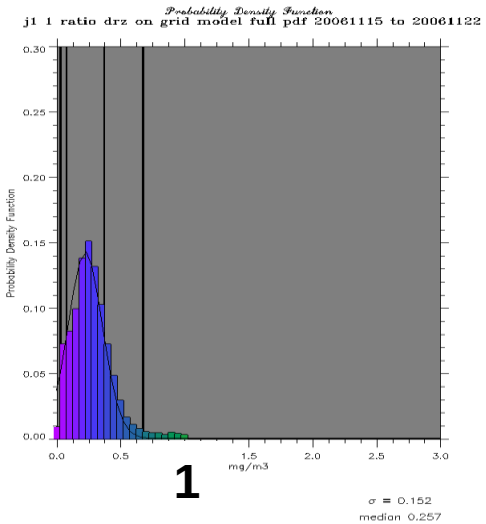


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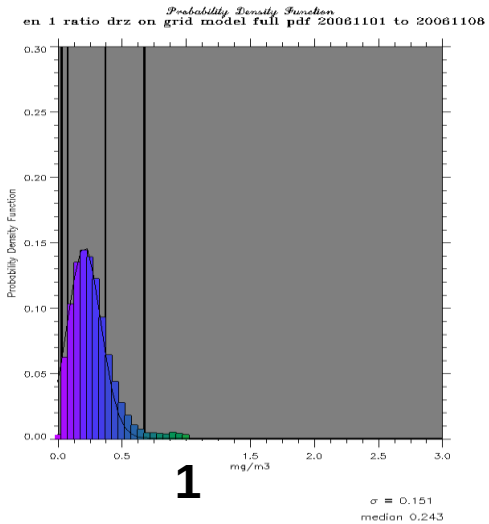
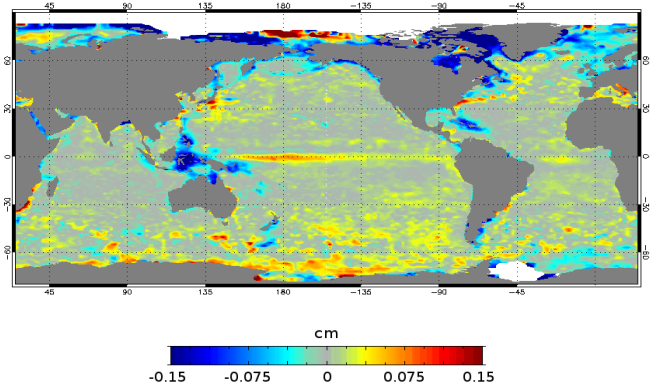



1

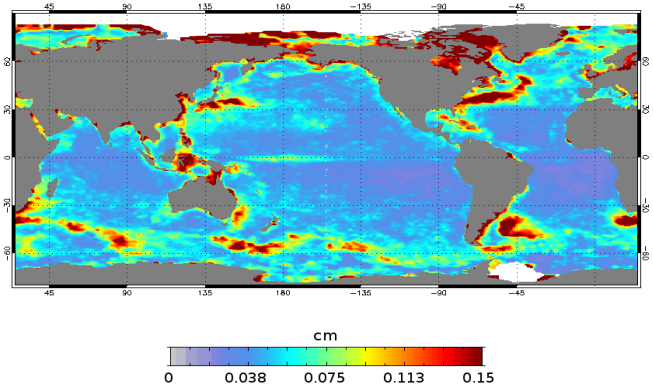
# SLA (year 2015)

## Previous system

Mean SLA residual in 2015 for PSY4V2

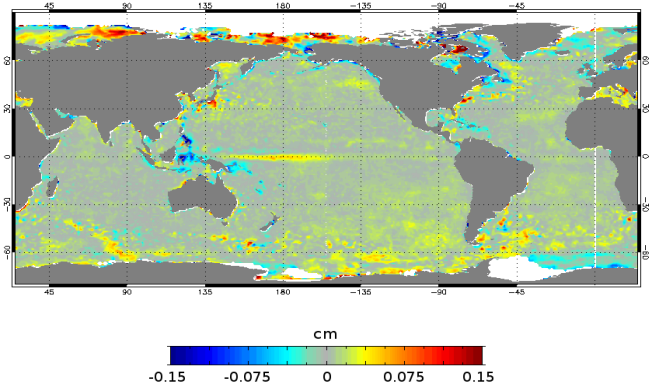



RMS SLA residual in 2015 for PSY4V2

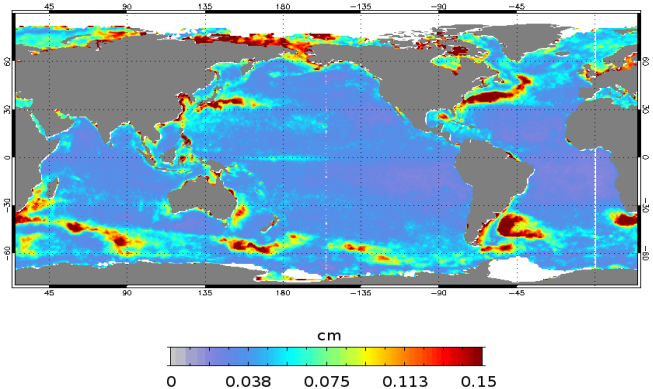



## Current system

Mean SLA residual in 2015 for PSY4V3

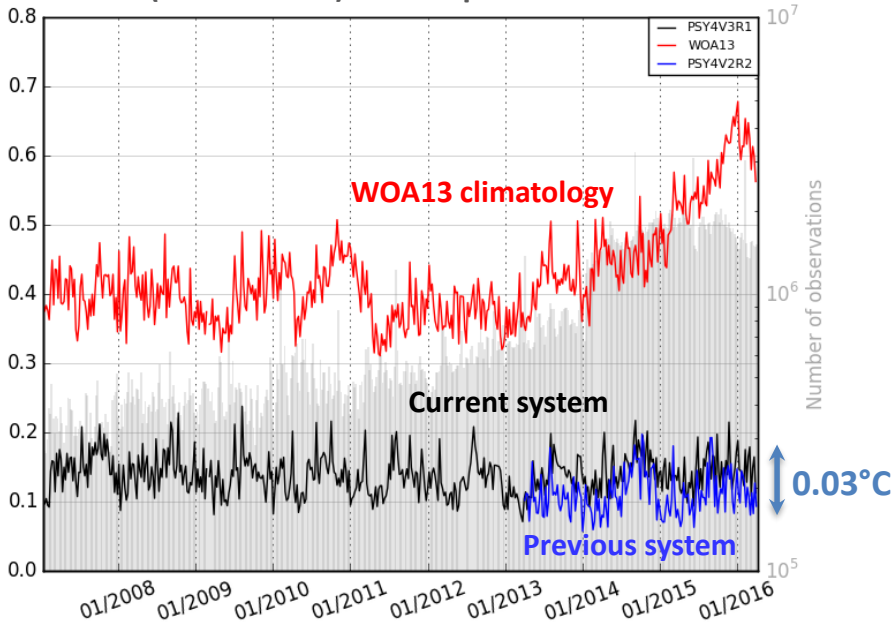



RMS SLA residual in 2015 for PSY4V3

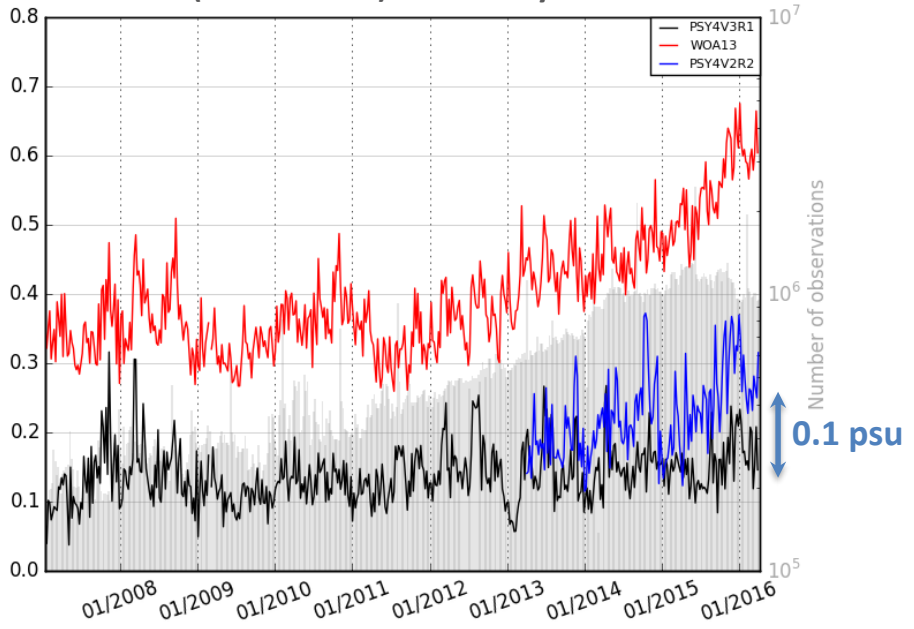


# 3D T/S : RMS (analysis-obs)

RMS (model – obs) for Temperature 0-5000m

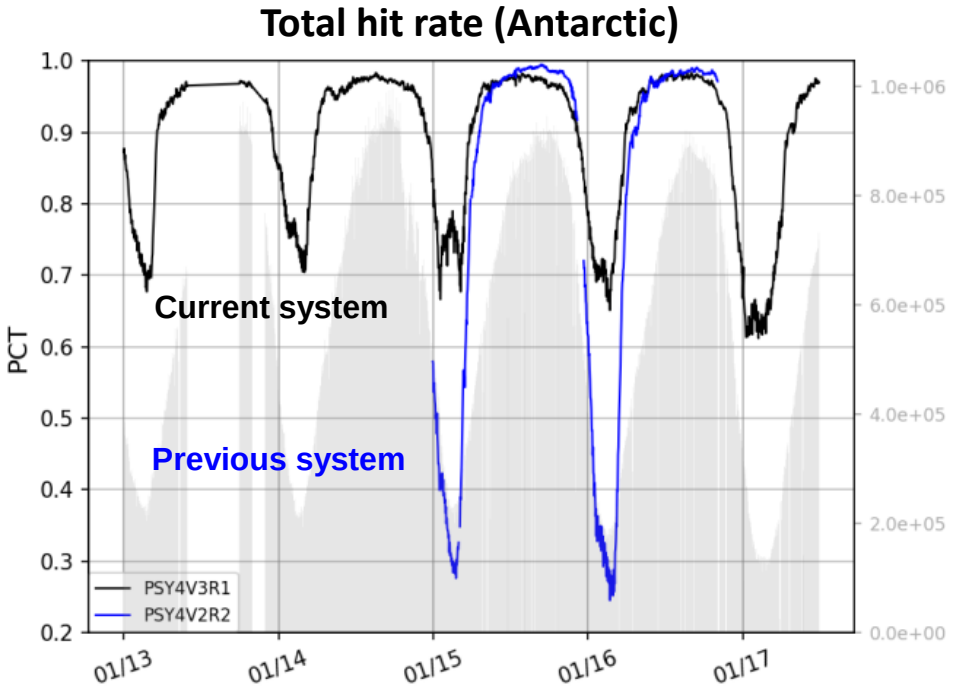



RMS (model – obs) for Salinity 0-5000m




→ **This allows having more accurate description of the water masses**

# Sea-ice concentration




## Contingency table analysis

| | Obs AMSR ICE | Obs AMSR WATER |
|---|---|---|
| Model forecast ICE | Hit ice | False alarm |
| Model forecast WATER | Miss | Hit water |

**Total hit rate** = statistical number of successes in the forecast of sea-ice or open water … **Best score = 1**

→ **Improvement of Total Hit rate (>60%) especially during Austral summer**

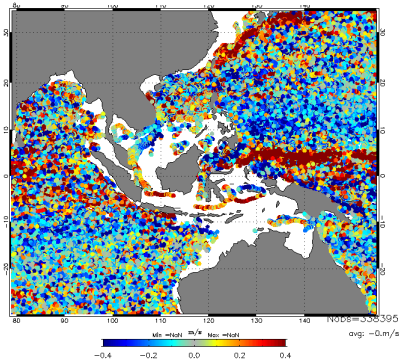
# Mean surface currents (2007-2015)

**<u>Available Observations</u>: Argo surface floats and AOML surface drifters (not yet assimilated …)**

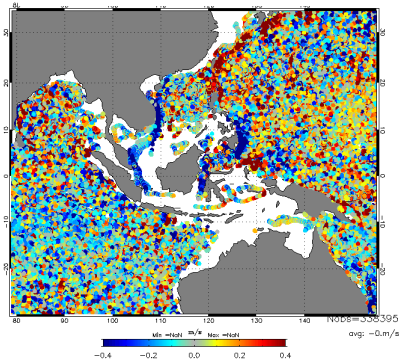
**<u>Indonesian region</u>: currents are very difficult to resolve because of the many narrow straits and the strong tidal mixing**

**OBS**

Zonal velocity

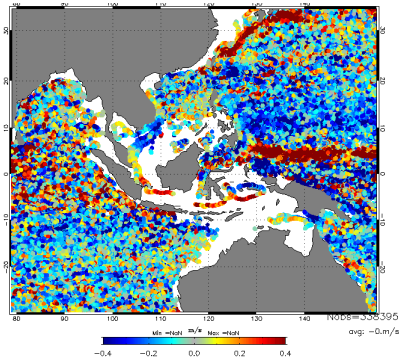


Meridional velocity

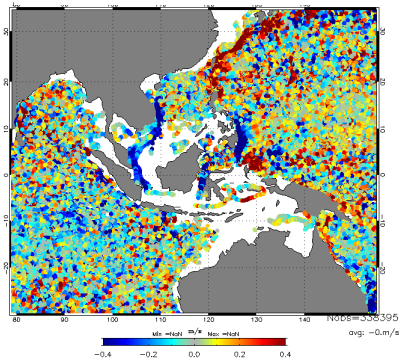


**Correlation ~ 0.7**

Zonal velocity



Meridional velocity

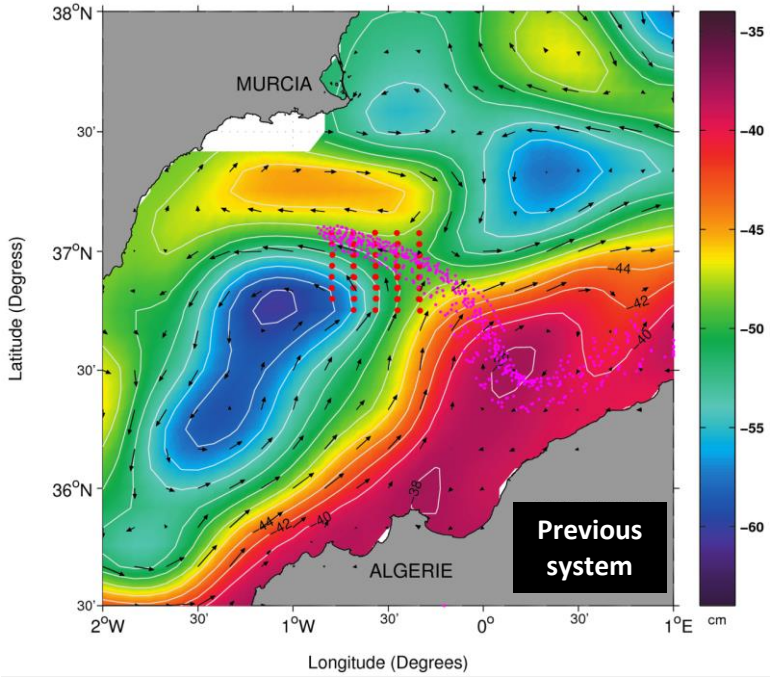


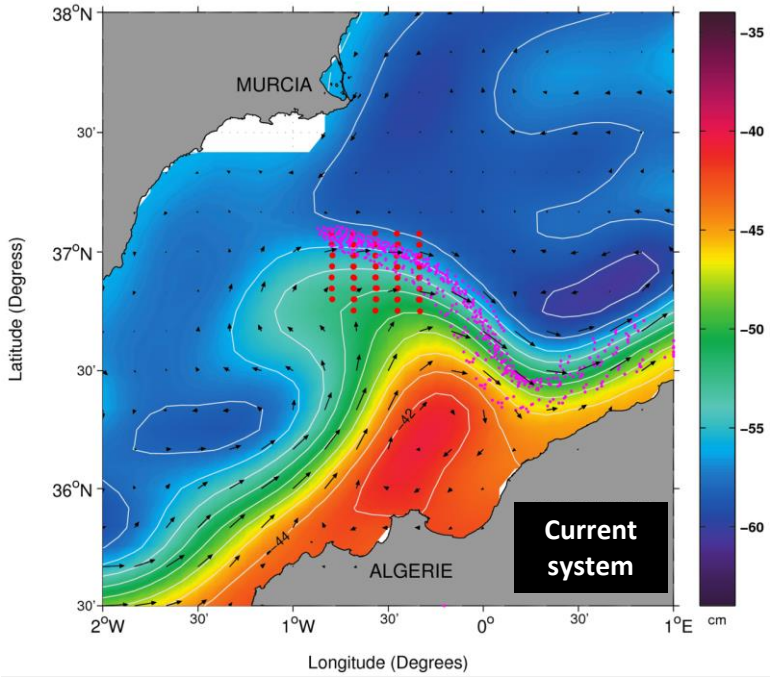
**MODEL**

# Improvement of currents (2014)

## SSH and velocity field from previous and current system

*Courtesy S. Ruiz*




Magenta dots corresponds to ALBOREX drifters positions from 25 May to 1 June 2014

# Updates planned for the future system …

- Update of the **NEMO** model with the possibility to activate **new numerical schemes** (Time-splitting, VVL) and **new functionalities** (parallel I / O management), update of sea-ice model (LIM2 → **LIM3**) and use of **multi sea ice categories**

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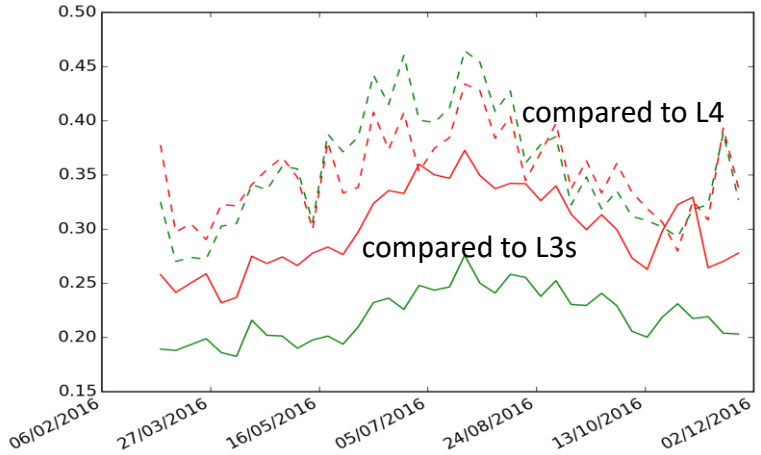
- **Assimilation** higher resolution **SST L3s** data

# Assimilation of CMEMS ODYSSEA L3s SST (1/10°)

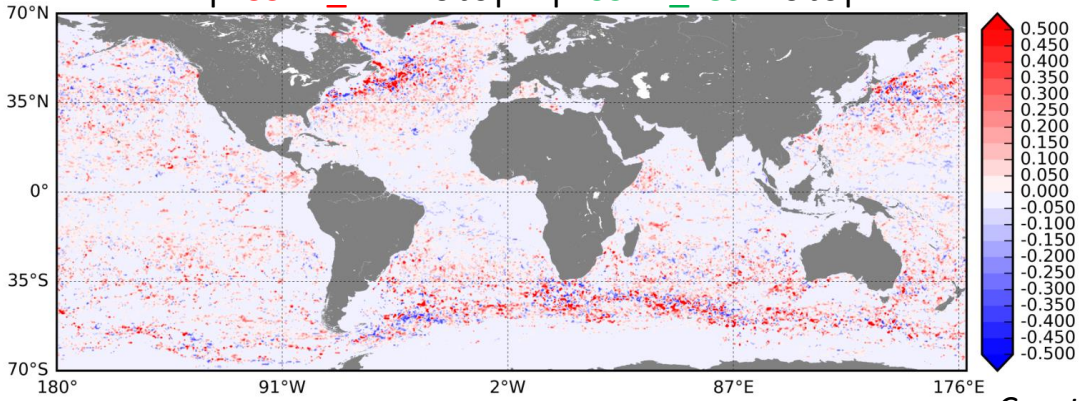



**Current system: assimilation of L4 SST (OSTIA)**
**Future system: assimilation of L3s SST (ODYSSEA)**

Evolution of the RMS forecast SST error compared to the L4 (dashed line) and L3s (plain line) observations for the experiments ASSIM_L4 and ASSIM_L3s.

→ the assimilation of L3s product allows to reduce the forecast error from 0.35°C to 0.25°C.

|ASSIM_L4 - obs| - |ASSIM_L3s - obs|




→ Reduction of the analysis error from ASSIM_L4 to ASSIM_L3s compared to **surface drifters temperature (not yet assimilated in the system).**

*Courtesy M. Hamon*

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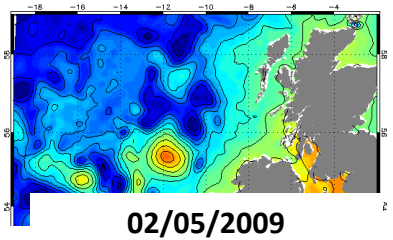
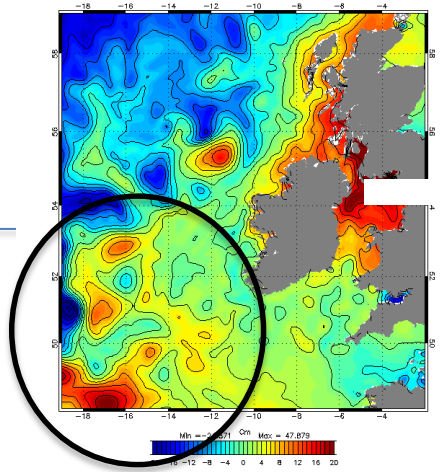
# 3D vs 4D analysis (Observing System Simulation Experiment)

SSH (Truth)

22/04/2009



02/05/2009



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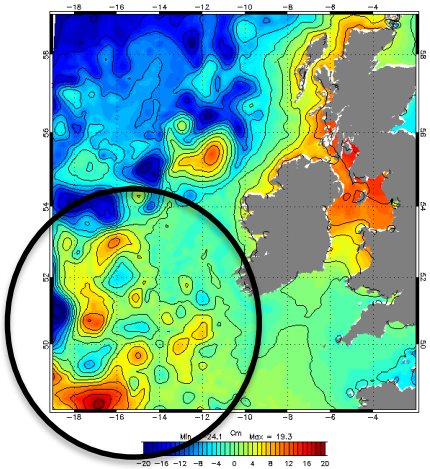
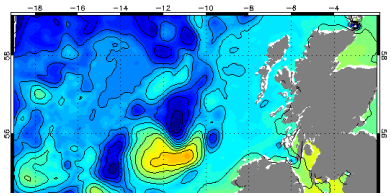


*Courtesy M. Benkiran*

12/05/2009



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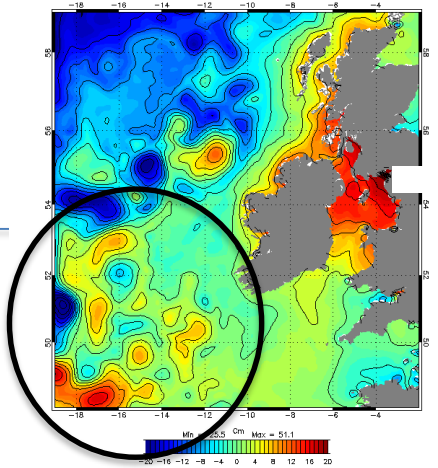

**Using 4D analysis , the model is able to better reproduce mesoscale activities**

**Model forecast after <u>3D analysis</u>**

**Model forecast after <u>4D analysis</u>**

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- Increase the number of **vertical levels** (50→75) and use **eORCA** grid (South extension)
- **Assimilation** higher resolution **SST L3s** data
- Use for global ocean configuration a **4D version of SAM2 scheme**
- **New hybrid MDT** and adapt the **“Desroziers” method** to the 4D version of SAM2

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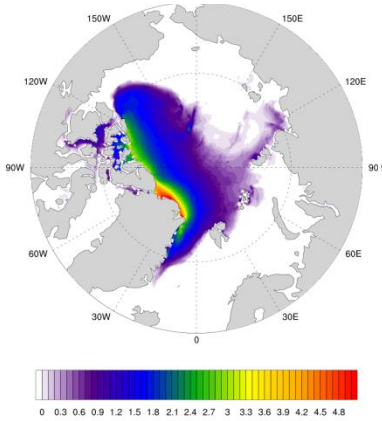
- **Multivariate** sea-ice analysis

# Multivariate Sea Ice Analysis (Only SIC Observations are assimilated)

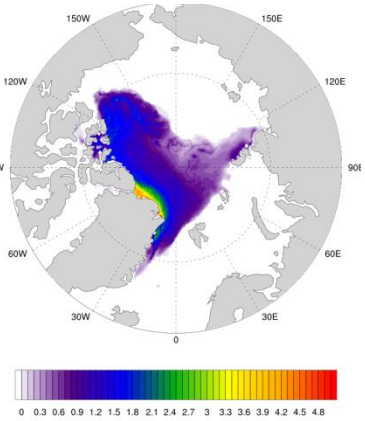
**Several experiments where various sea ice state vector are tested …**

**SIVOLU(m) 20070915**

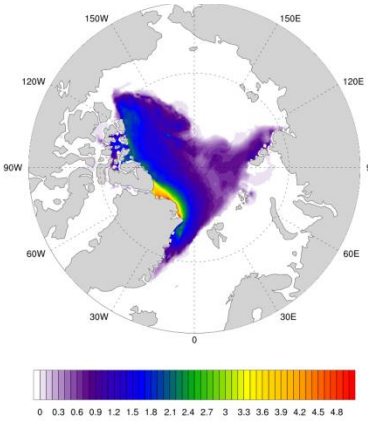
**REA100**
**Free run**



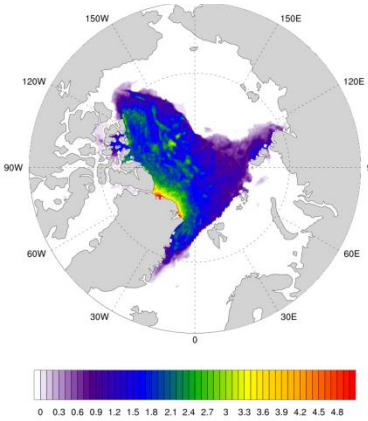

**REA120**
**[SIC]**
**siconcat/sivolucat from current shape**



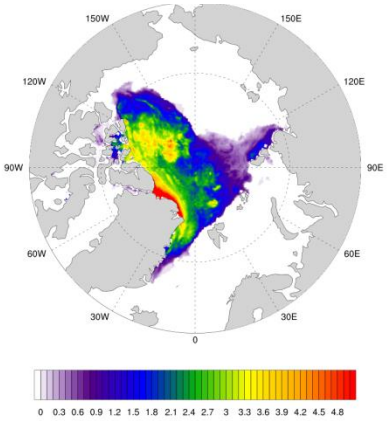

**REA121**
**[SIC]**
**siconcat/sivolucat from fixed distribution**




**REA130**
**[SICONCAT]**
**sivolucat from fixed distribution**




**REA150**
**[SICONCAT,SIVOLUCAT]**




*Courtesy C.-E. Testut*

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- **Multivariate** sea-ice analysis
- Better represent **interactions between components of the system** (ocean, wave, atmosphere, biogeochemistry, sea ice) and quantify the improvements on ocean analyses and forecasts

# Scientific valorisation of the current global HR system


- Koenig et al., 2017. Atlantic Waters inflow north of Svalbard: insights from IAOOS observations and Mercator Ocean global operational system during N-ICE2015, J. Geophys. Res. Oceans, 122, 1254–1273, doi:10.1002/2016JC012424.
- Verrier et al., 2018. Assessing the impact of SAR altimetry for global ocean analysis and forecasting, J. Operational Oceanography, 11:2, 82-86, DOI: 10.1080/1755876X.2018.1505028.
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- Lellouche et al., 2018. Recent updates on the Copernicus Marine Service global ocean monitoring and forecasting real-time 1/12° high resolution system, Ocean Sci., 14, 1093-1126, https://doi.org/10.5194/os-14-1093-2018.
- Gasparin et al., 2018. A global view of the 2007-2015 oceanic variability in the global high resolution monitoring and forecasting system at Mercator-Ocean, Journal of Marine Systems, 187, 260-276, https://doi.org/10.1016/j.jmarsys.2018.06.015.
- Artana et al., 2018. Fronts of the Malvinas Current System: surface and subsurface expressions revealed by satellite altimetry, Argo floats, and Mercator operational model outputs, Journal of Geophysical Research – Oceans, doi: 10.1029/2018JC013887.