GLOBAL Eddy-Permitting Ocean Reanalyses and Simulations of the period 1992 to Present

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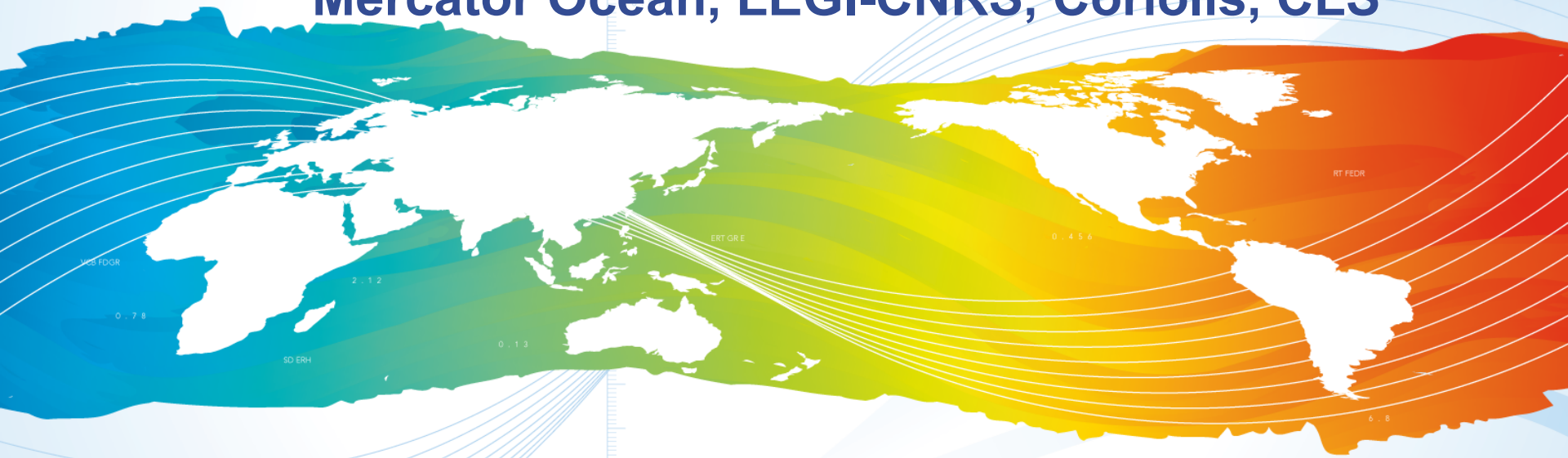
Mercator Océan, LEGI-CNRS, Coriolis, CLS



Mercator Ocean
Ocean Forecasters

myOcean

4th World Climate Research Programme
International Conference on Reanalyses, Silver Spring, Maryland, USA, 7-11th May 2012

Outline

1. **Introduction:**
   The GLORYS project overview and the European context

2. **GLORYS2 : an eddy permitting (1/4°) global ocean reanalyses of the « altimetric era »**
   System overview and performances

3. **End-users applications**

4. **Conclusions & Perspectives**

1. Introduction

GLORYS project: National level

GLORYS: GLobal Ocean ReanalYses and Simulations

- French Reanalysis project, supported by GMMC (Mercator, Coriolis). PI: **B. Barnier**
- main partners: **Drakkar, LEGI, LPO, LOCEAN, CNRM, CORIOLIS, MERCATOR**
- project started at national level in 2008 + cooperation with EU funded FP7 MyOcean project
- ARGO era reanalysis (2002-2008) produced in 2009 : **GLORYS1**

MOTIVATION:

The need for a **realistic description** of the ocean state and variability over the **recent decades**, at the **global scale**, and at the scale of the ocean basins and regional seas.

OBJECTIVES:

- Produce an **eddy permitting** global **ocean/sea-ice** reanalysis spanning the **"altimetric + ARGO" era 1992-2009**
- To iterate / produce different reanalysis along the 1992-today time period
- Start to design the ERA-Interim reanalysis scenario : 1979-today
- Promote the use of reanalysis products in the climate community

Global ocean reanalyses at EU level

MyOcean project : www.myocean.eu.org

MyOcean1: 2009-2012, MyOcean2: 2012-2014

B. Barnier's talk for an overview of this activity

Basic ingredients :

- NEMO Ocean source code, tuned for reanalyses, provided by CNRS
- ERA Interim forcing + some corrections
- Reprocessed historical observations provided by Thematic Assembly Centers
- Different data assimilation methods

Ocean reanalyses : Ocean simulations constrained by reprocessed obs.
→ **CMCC, Mercator, U. Reading**

Ocean free simulation: → **CNRS**

Ocean state estimation based on **observations only** → **CLS**

2. GLORYS2: reanalysis system overview

Model: DRAKKAR ORCA025 configuration

NEMO OGCM + LIM Sea-Ice model :

Resolution:
- Global 1/4°
- **75** vertical levels from **1 m at the surface to 200 m at the bottom**

Initialization: December 1991
- Levitus 1998 climato.+ Sea-Ice Concentration from NSDIC Bootstart products

Parameterizations: Filtered free surface, Partial step, Energy and Enstrophy conserving advection scheme, Isopycnal diffusion for tracers, Biharmonic for momentum, TKE turbulence scheme

Atmospheric forcing:
- **Bulk CORE Formulation** (Large&Yeager, 2004)
- **ERA-Interim** reanalysis products:
  - **3 hourly** for turbulent fluxes
  - Daily for radiation (**analytical diurnal cycle for solar**)
  - In house **correction of the radiation based on GEWEX** satellites fluxes products: **see Poster UA-22, G. Garric**

GLORYS: DATA ASSIMILATION SCHEME

DATA ASSIMILATION SYSTEM: SAM2v1

Singular Evolutive Extended Kalman (SEEK) Filter :

- Reduced order extended Kalman filter family
- Used in a stationary mode: no update of the error modes by the model
- Innovation is calculated at the First Guess at Appropriate Time (FGAT) approximation
- Control vector comprises the barotropic height, T, S, U and V
- Background error covariance calculated from an ensemble of 3D anomalies from a reference simulation
- Adaptive error variance is consistent with innovation vector (a posteriori diagnostic)
- The SEEK filter is weakly sensitive to the number of obs. to assimilate

3D-VAR Bias correction : for T and S

Incremental Analysis Updates (IAU) :

inserting increments over all model time steps → smooth trajectory

Delayed time observations for data assimilation

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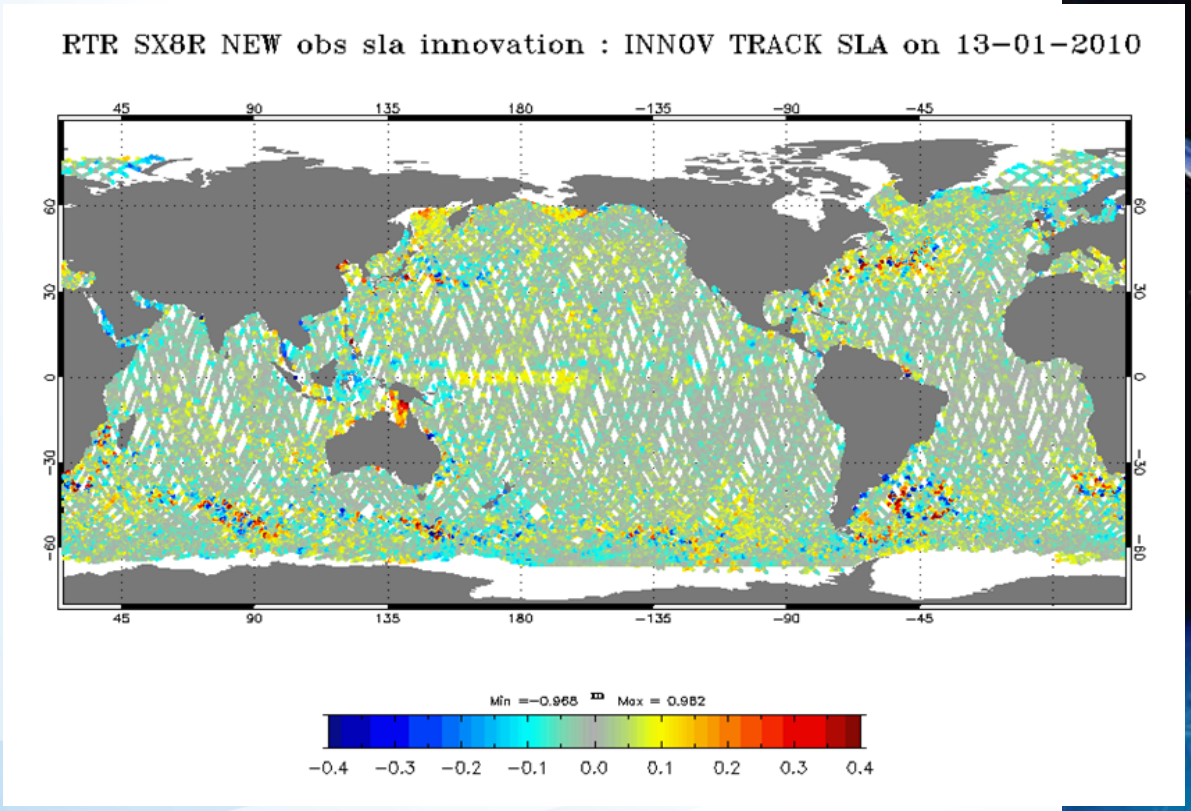
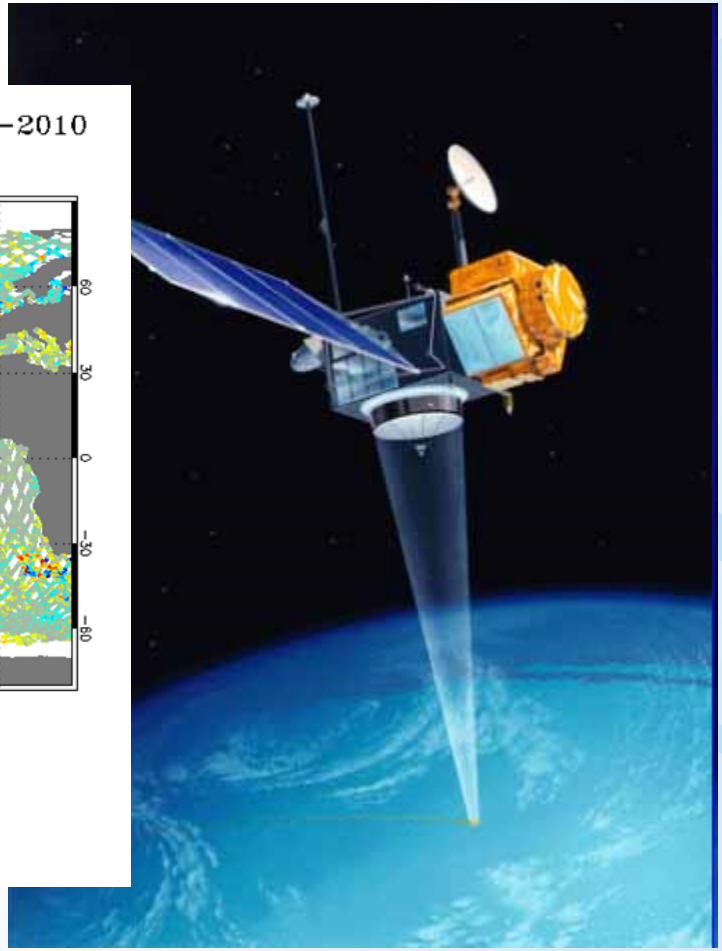
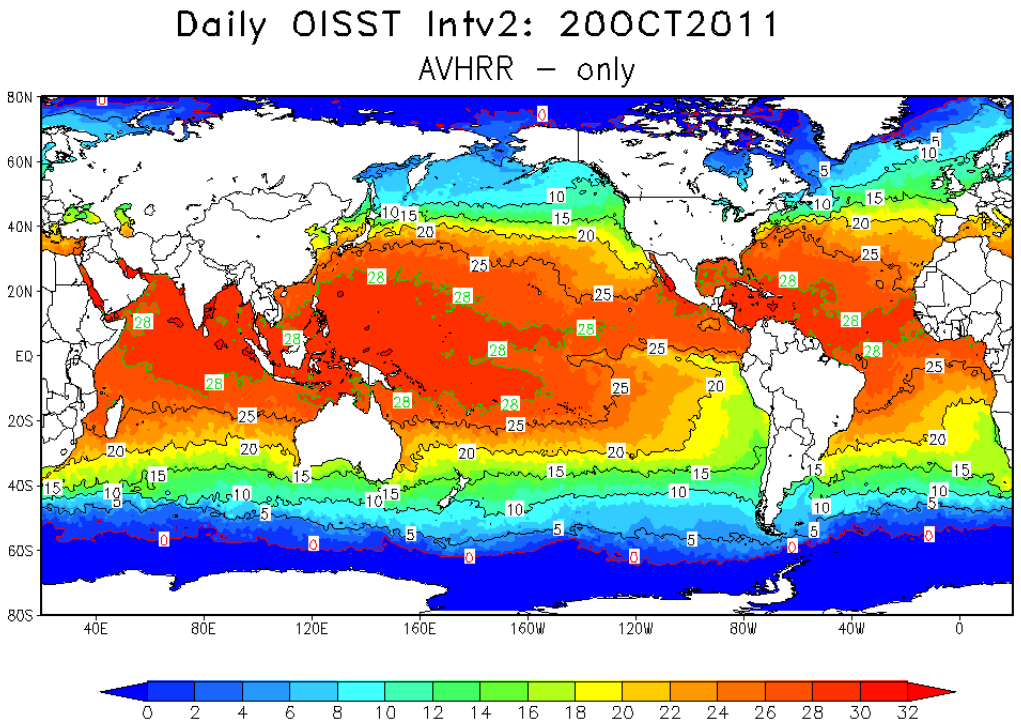
Along track DT SLA (SSLATO/DUACS) : Jason1, Jason2, Envisat, GFO, ERS1, ERS2, Topex/Poseidon





Delayed time observations for data assimilation

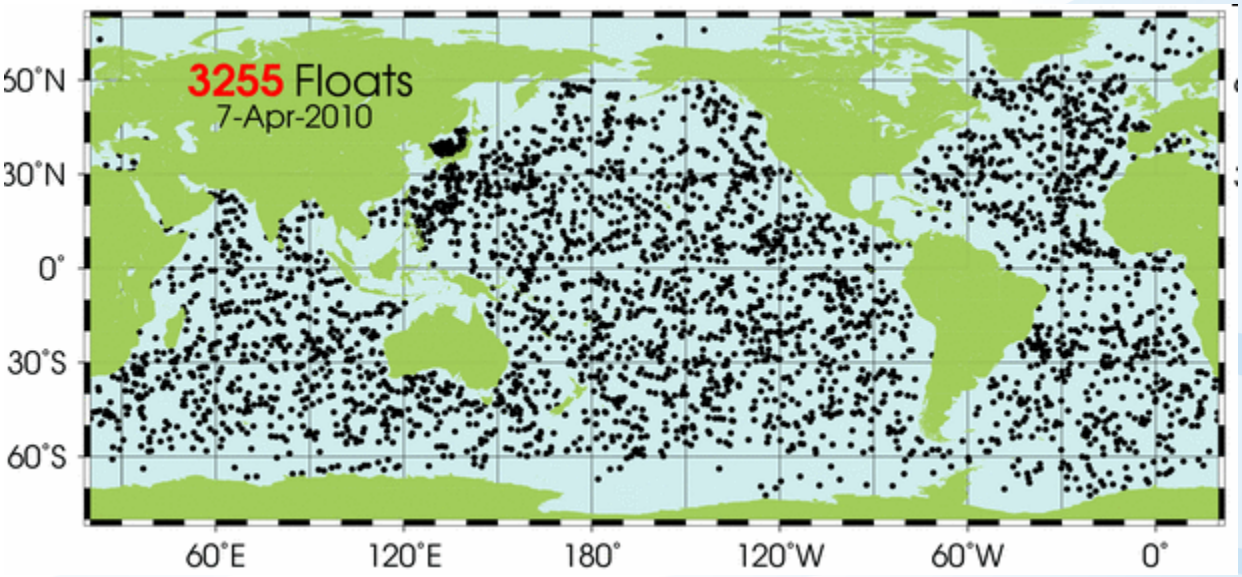
- **Reynolds AVHRR-only 0.25° SST** **ftp://eclipse.ncdc.noaa.gov/pub/OI-daily-v2/NetCDF/**



Delayed time observations for data assimilation

- **in situ temperature & salinity profiles : CORA2.3 data base**

Argo network + Xbts,CTDs, etc…

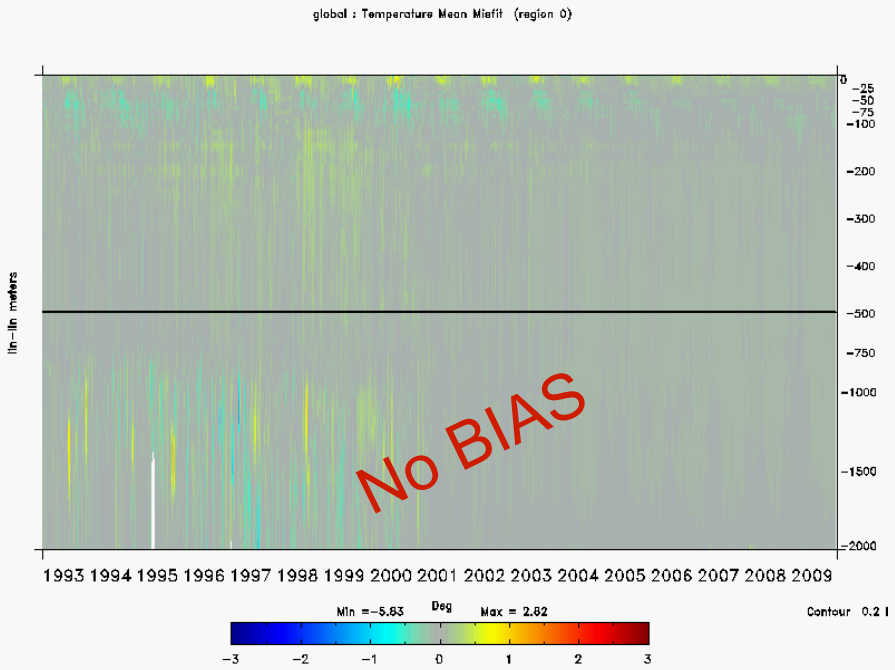


Results: GLORYS2 reanalysis 1992-2009

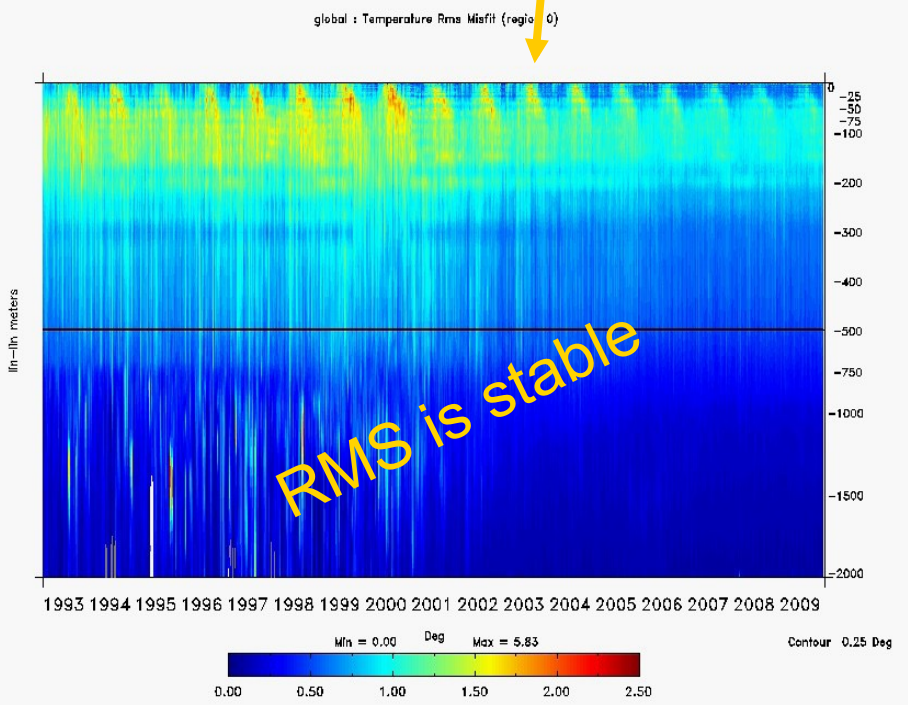
Data assimilation diagnostics for T

ARGO is getting in

Global misfit average

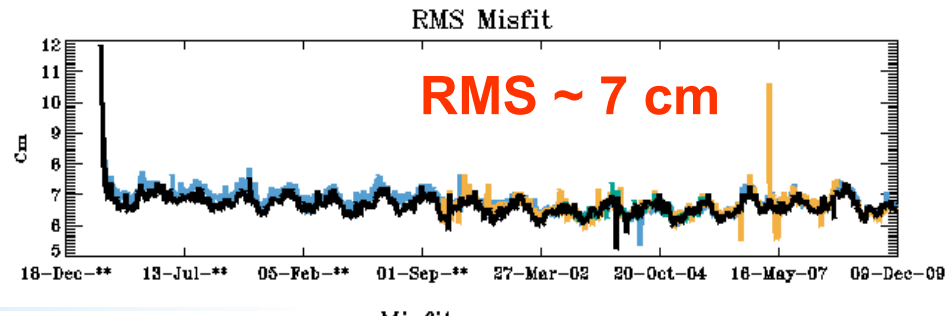


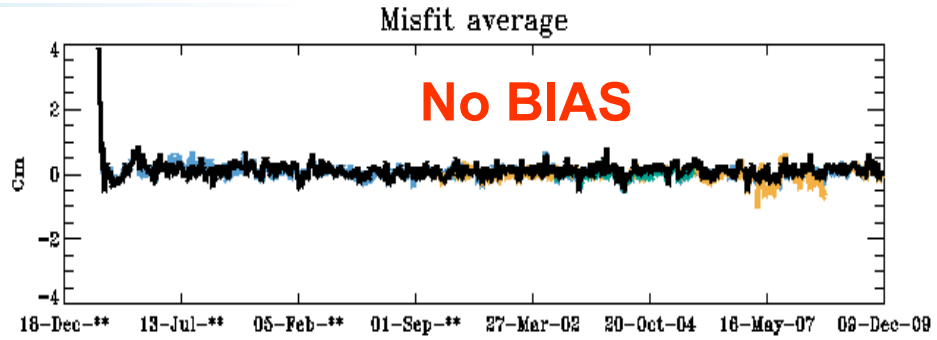
Global rms misfit

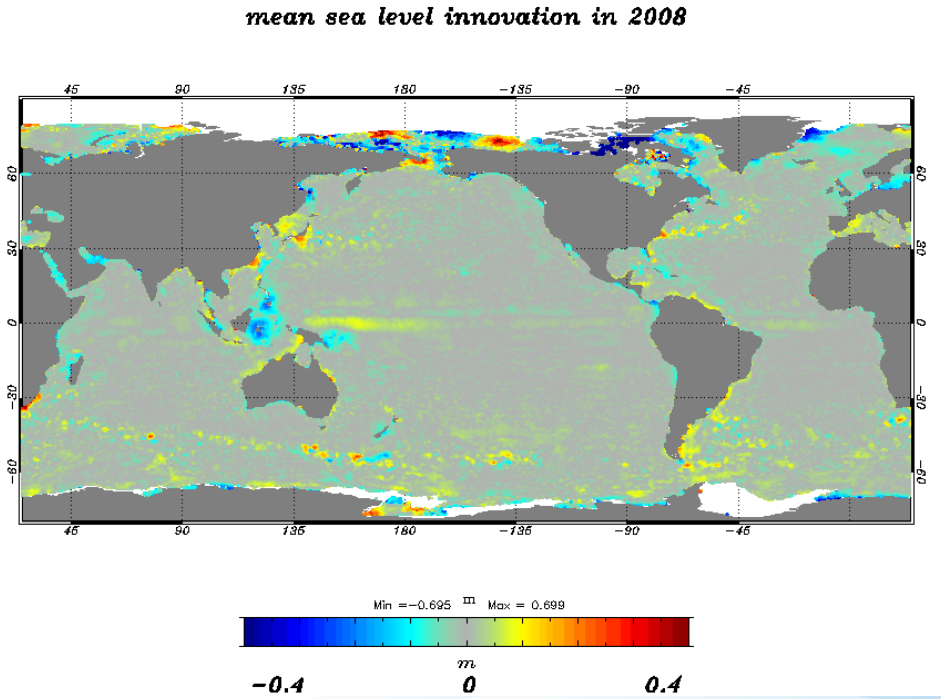


Results: GLORYS2 reanalysis 1992-2009

Data assimilation monitoring : SLA







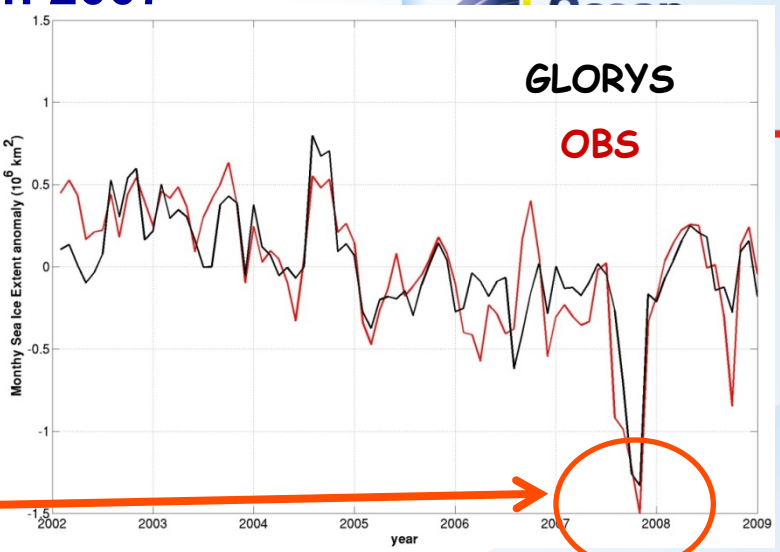
3. End-users applications

Sea-Ice thickness anomalies in the Arctic in 2007

Camille Lique et al., Journal of Climate, 2011:

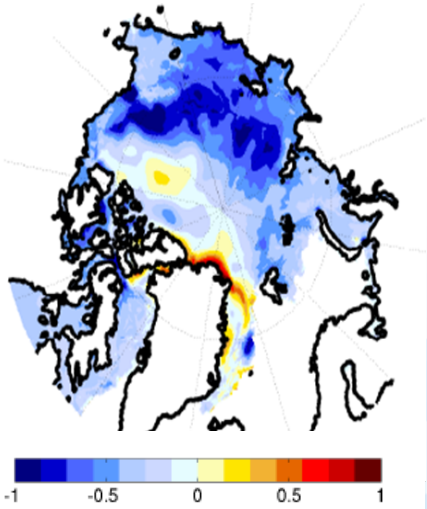
Evolution of the Arctic Ocean Salinity, 2007–08: Contrast between the Canadian and the Eurasian Basins

What caused the 2007 anomaly
- 25%: Sea-ice export at FRAM strait
- 75%: Arctic melt

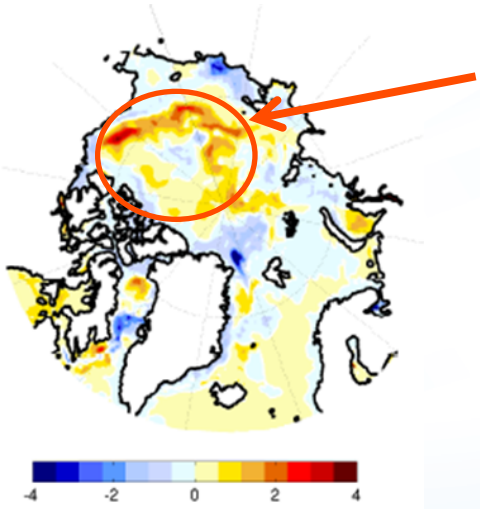


Anomalies of Sea Ice Extent

Sea-ice Thickness 2007 anomaly



Freshwater Content 2007 anomaly



- Redistribution of freshwater after melting:
  - Accumulation of FW in the Beaufort Gyre
  - Salinity increases on shelves
- No change in FW flux through Canadian Archipelago.

Ocean Bottom Pressure from space (GRACE)

Jean-Paul Boy, EOST/IPGS, Strasbourg

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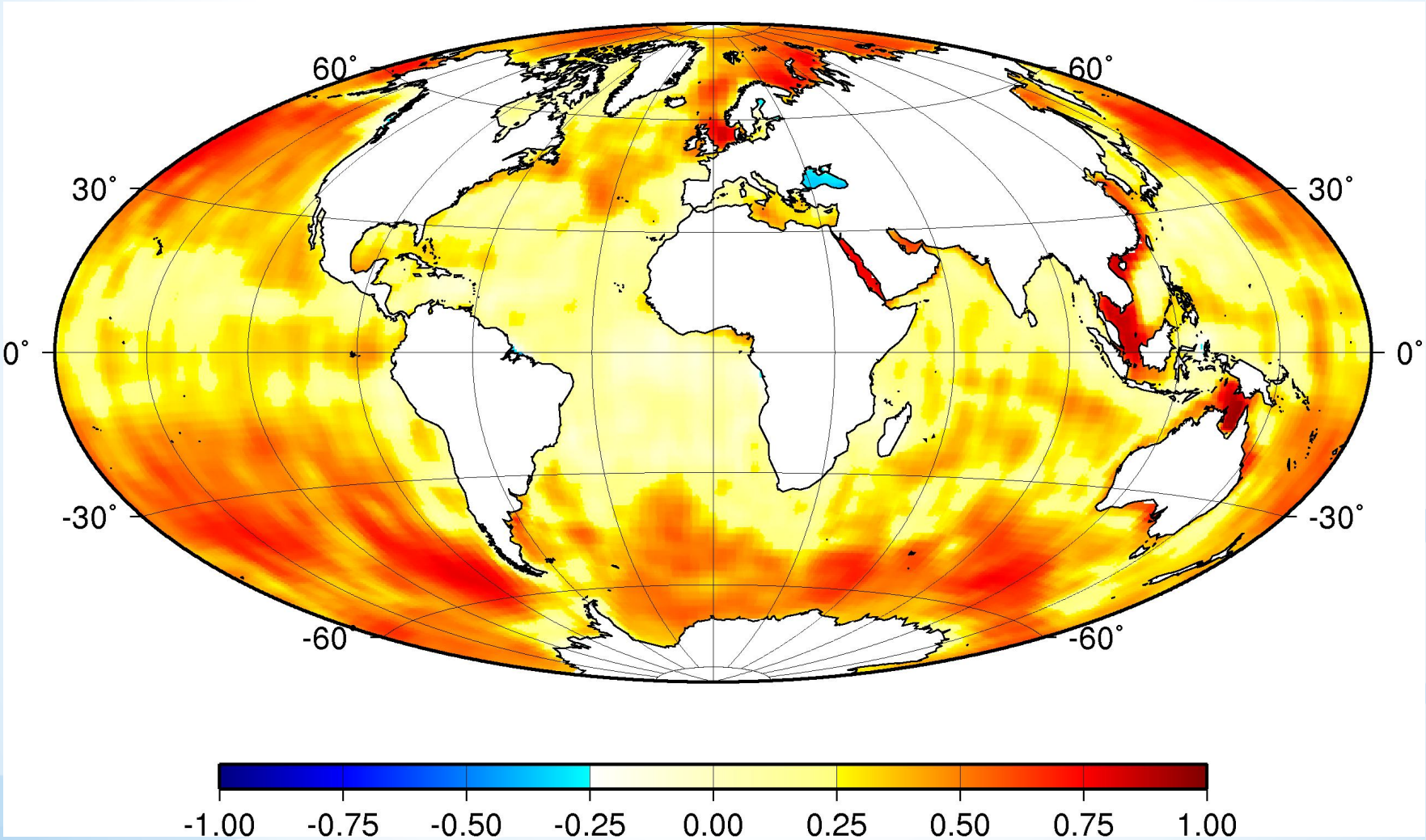
Correlation between GRACE derived and GLORYS modeled (10 days avg) ocean bott. press.



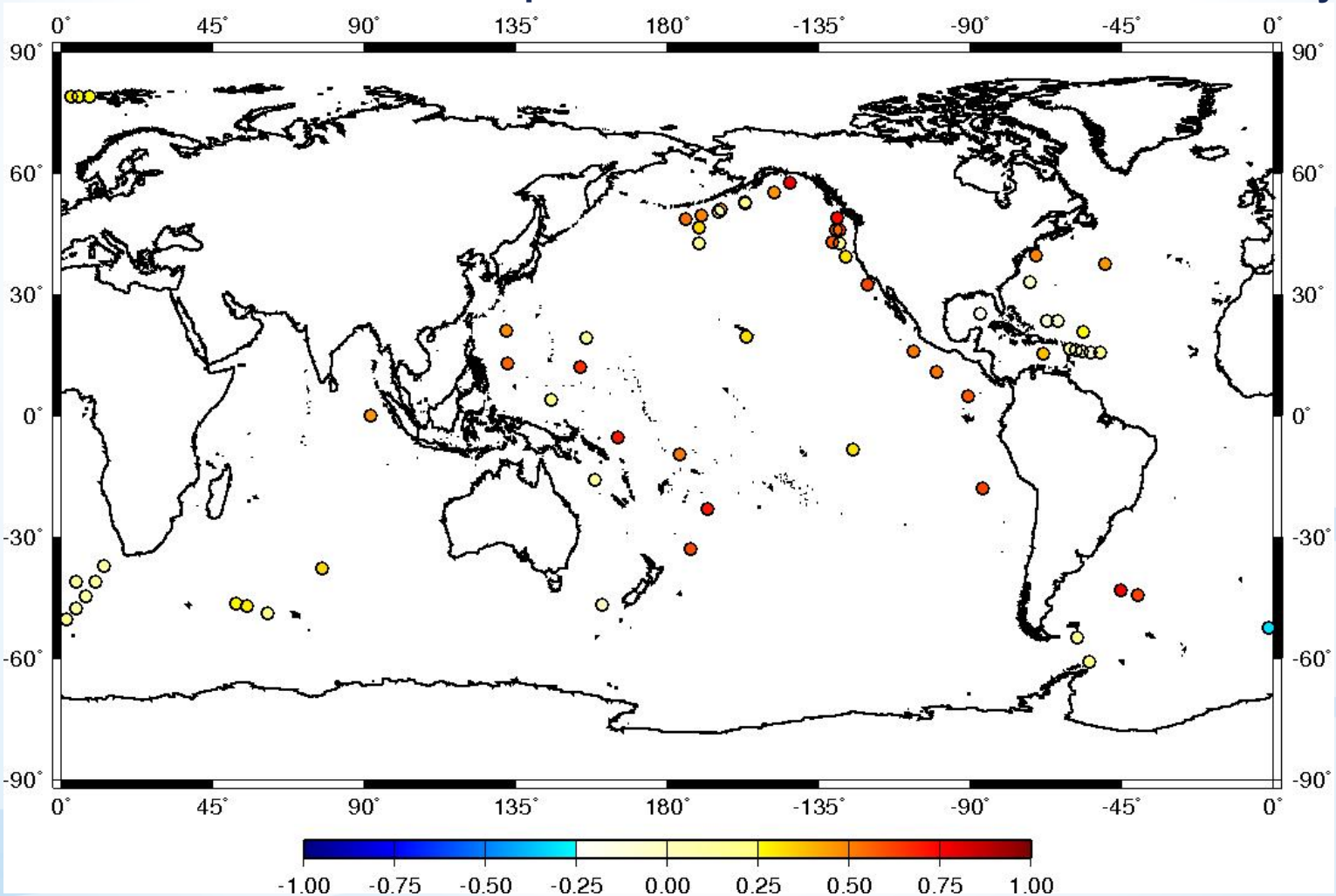
GRACE v06 (hydrology forward modeled) with 20 days & 200 km constraints

Ocean Bottom Pressure measurements

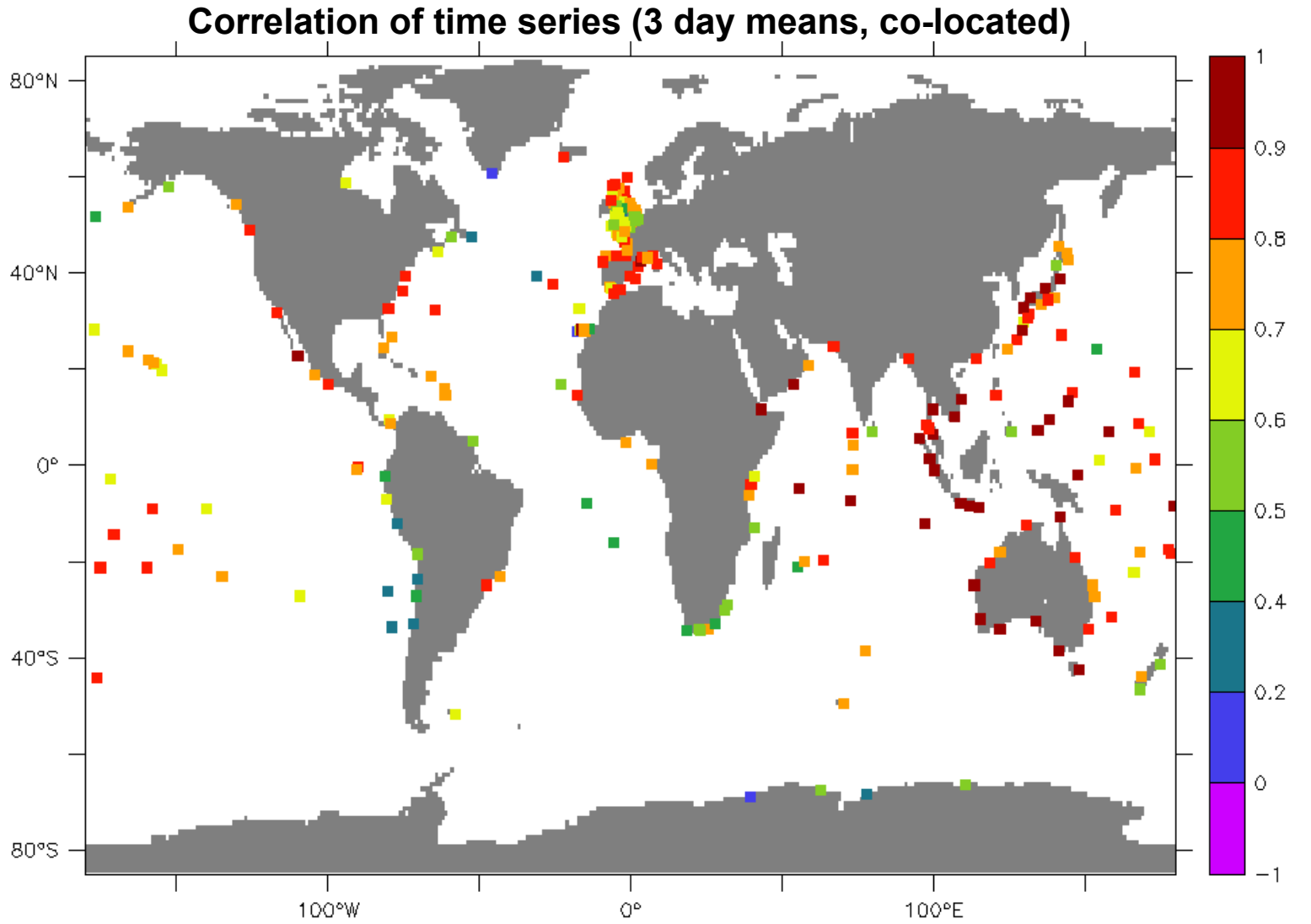
Jean-Paul Boy, EOST/IPGS, Strasbourg

Mercator Ocean
Ocean Forecasters

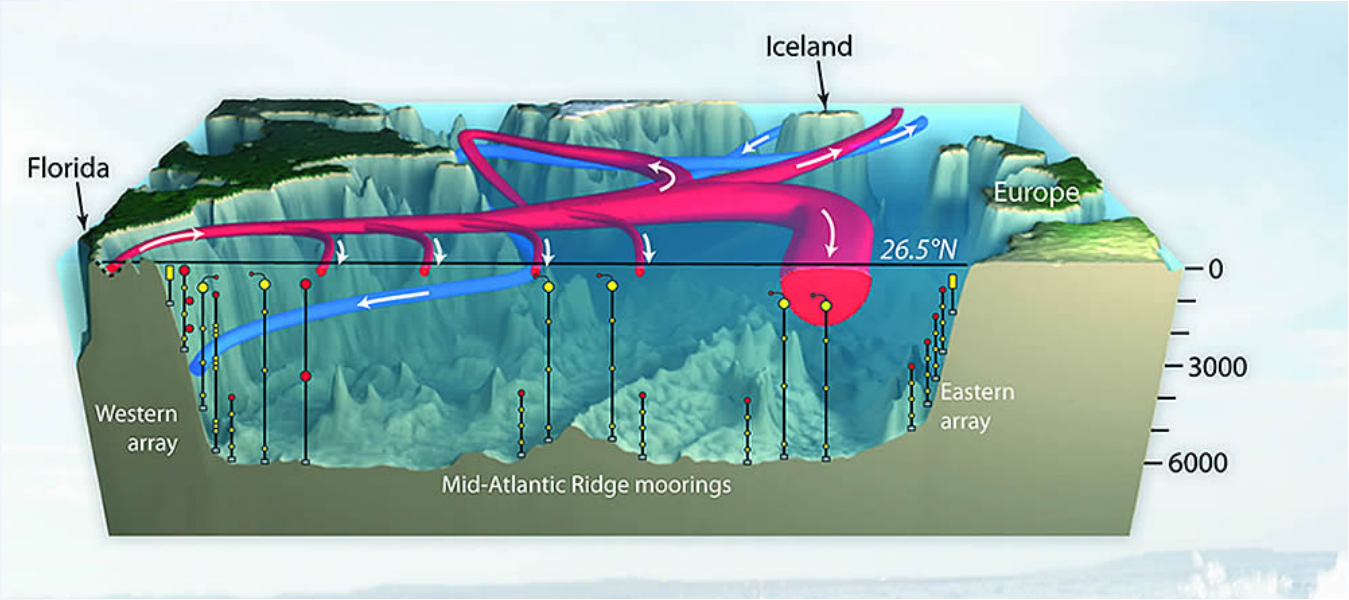
Correlation between ocean bottom pressure measurements and GLORYS reanalysis



Comparison with independent data Tide gauges (GLOSS, SONEL, BODC)

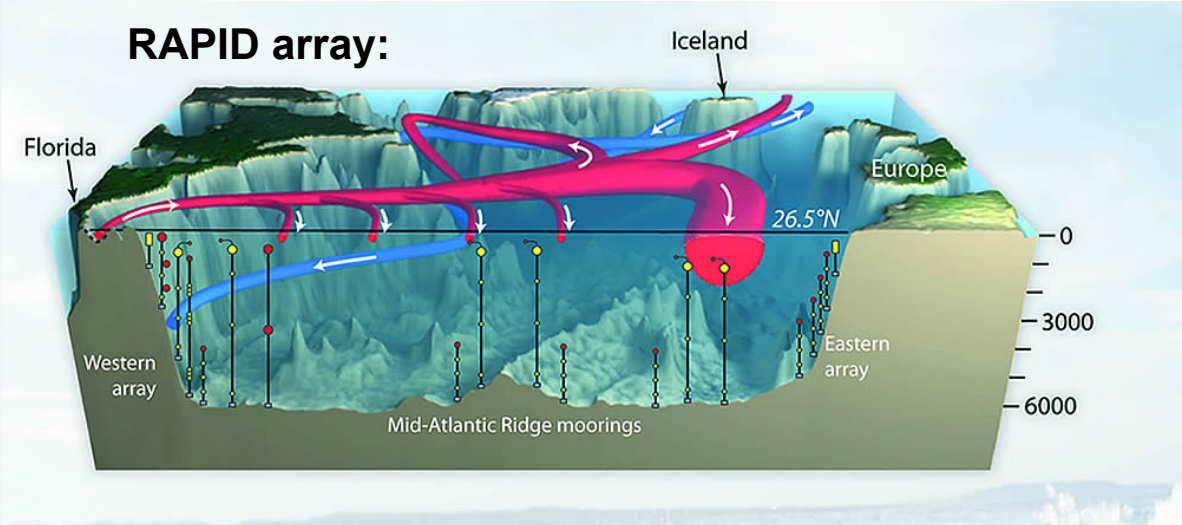


Atlantic Meridional Overturning circulation: comparison with RAPID

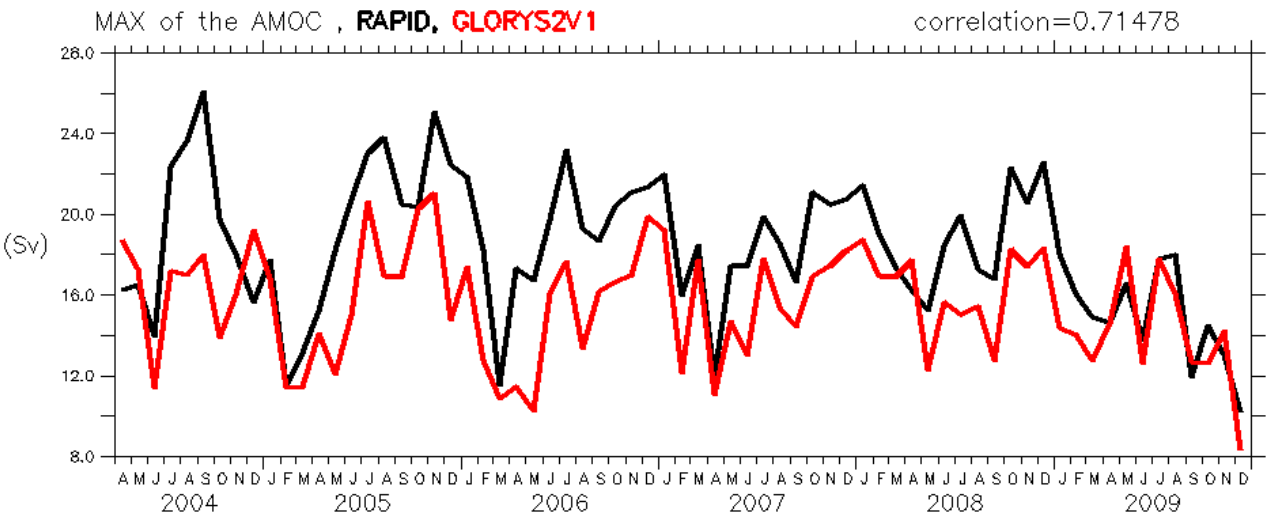


- Monitoring of the MOC is important for climate issues
- RAPID array: way to check the realism of the MOC in models & reanalyses
- Different components of the circulation can be evaluated

Atlantic Meridional Overturning circulation: comparison with RAPID

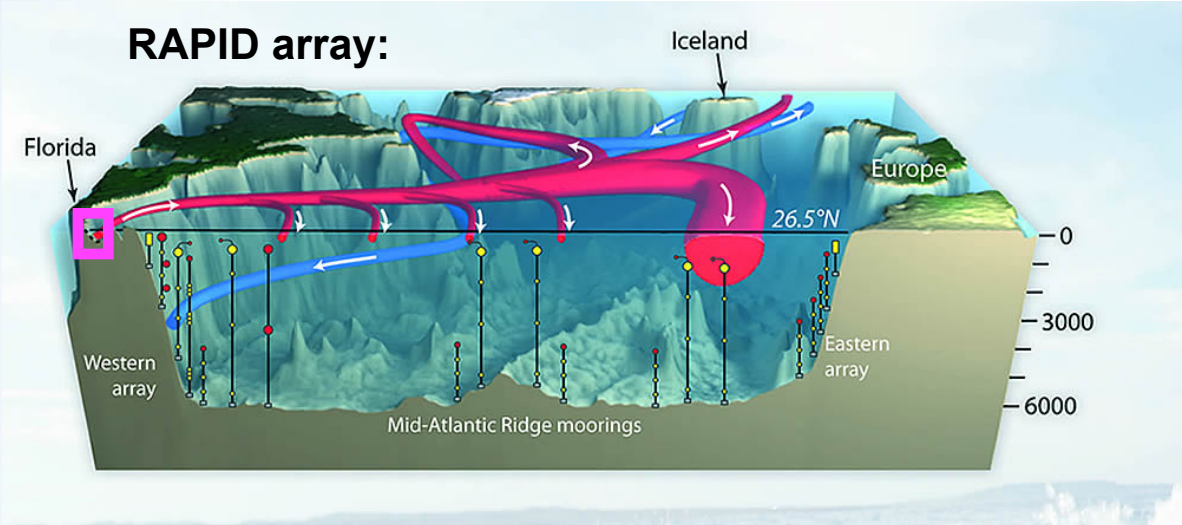


Max of the MOC:

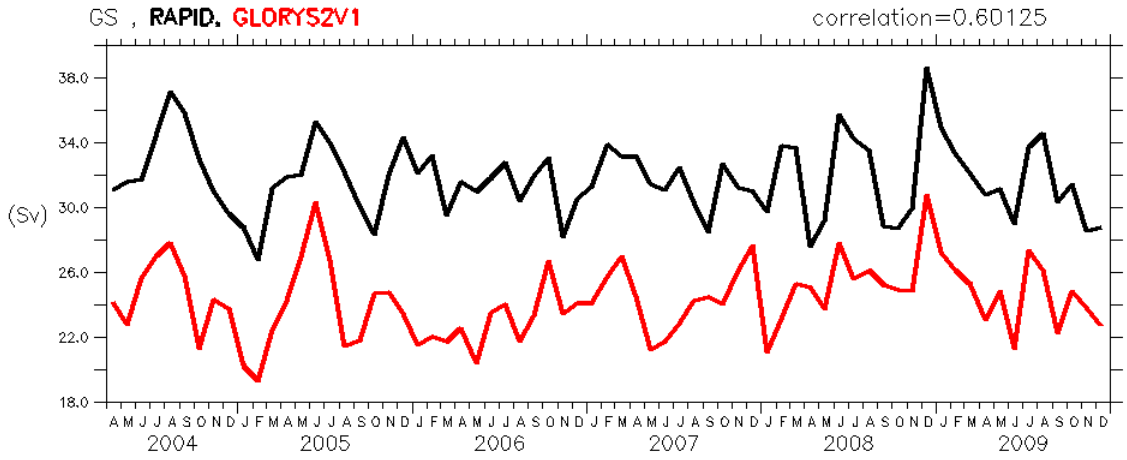


RAPID mean = 18.3 Sv
GLORYS mean = 15.5 Sv
Correl=0.71

Atlantic Meridional Overturning circulation: comparison with RAPID

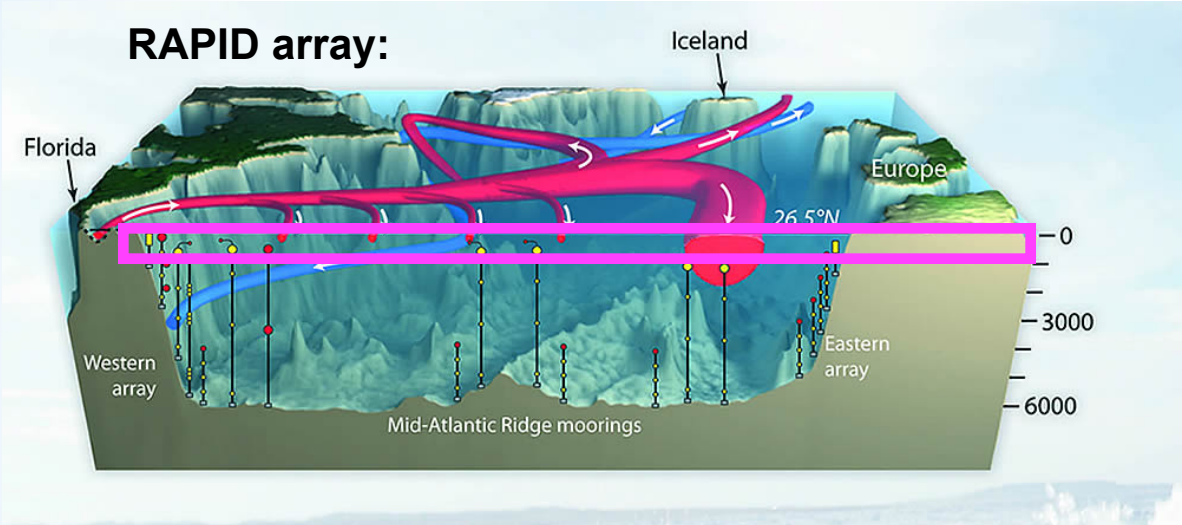


Gulf Stream transport:

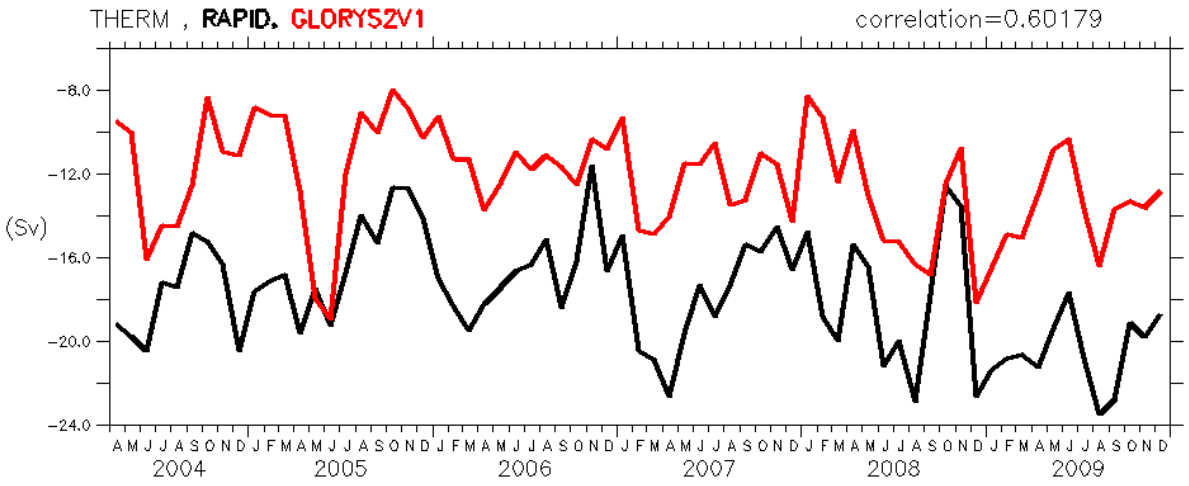


RAPID mean = 31.7 Sv
GLORYS mean = 24.3 Sv
Correl=0.60

Atlantic Meridional Overturning circulation: comparison with RAPID

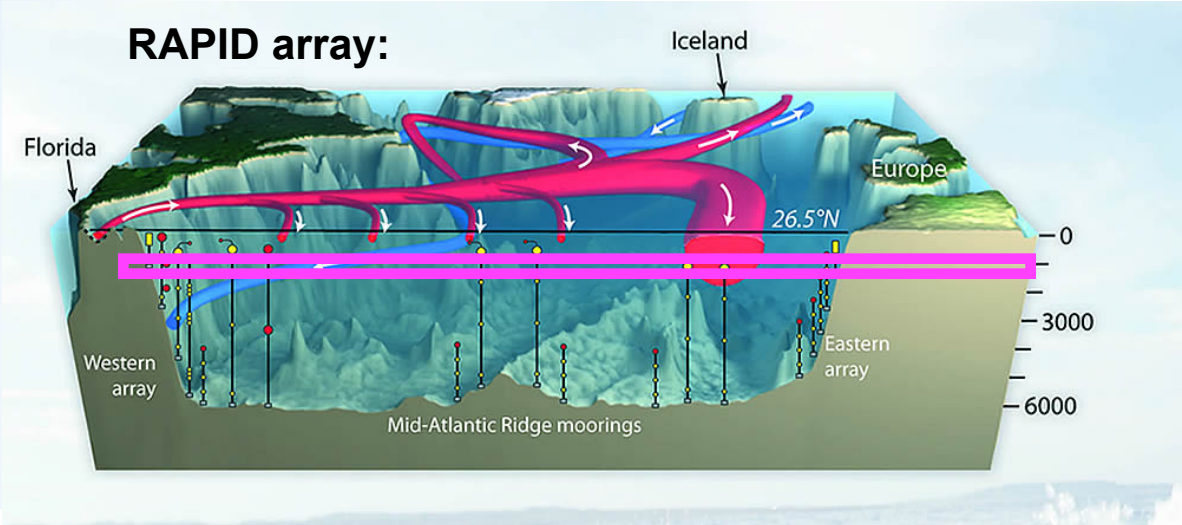


Thermocline recirculation (0-800m):

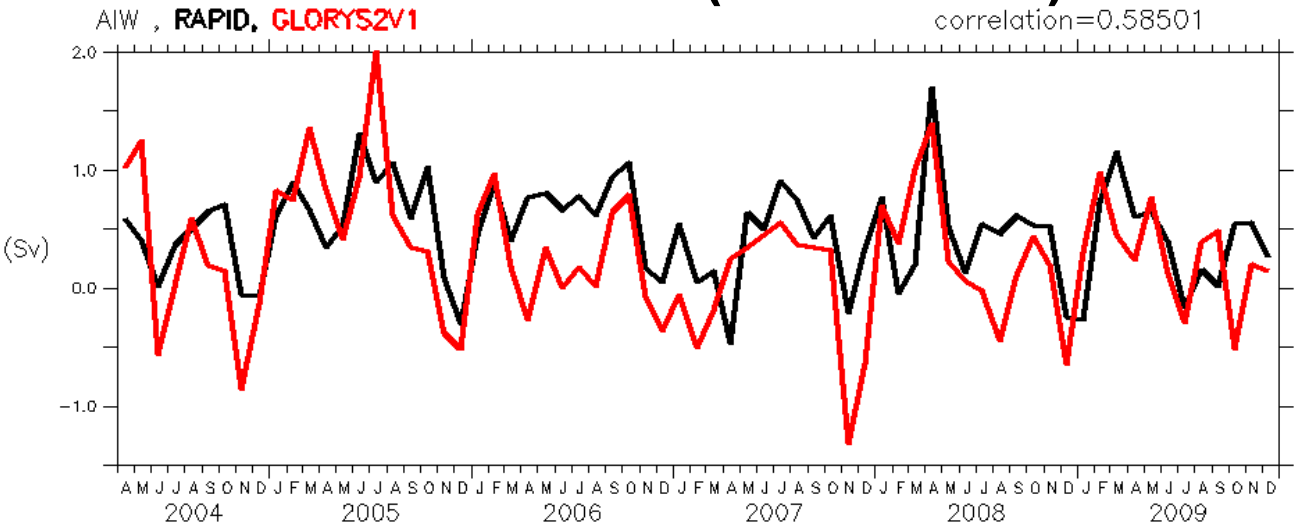


RAPID mean = -17.9 Sv
GLORYS mean = -12.4 Sv
Correl=0.60

Atlantic Meridional Overturning circulation: comparison with RAPID



Intermediate Water (800-1100m):

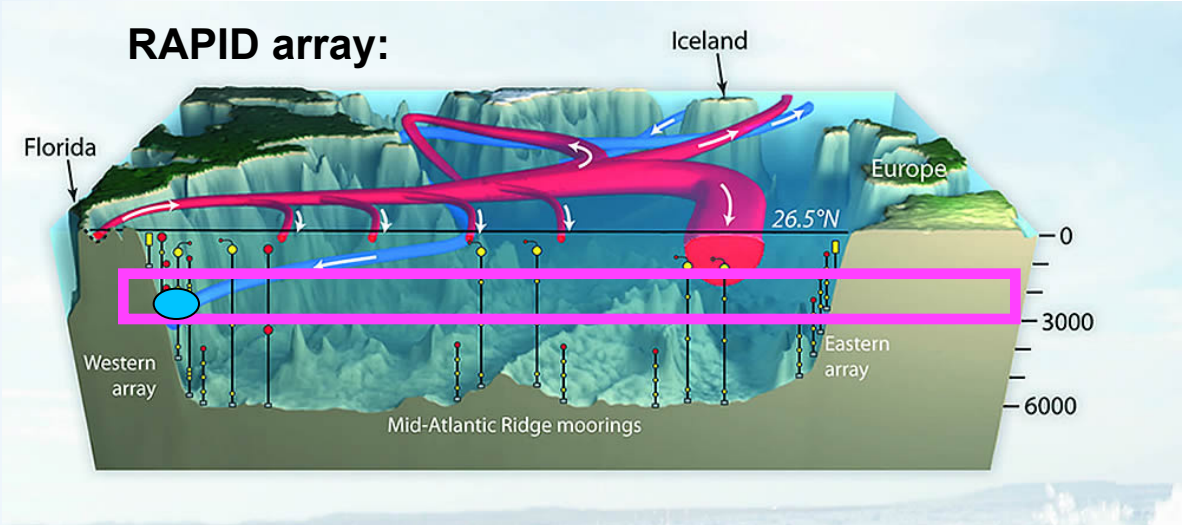


RAPID mean = 0.4 Sv

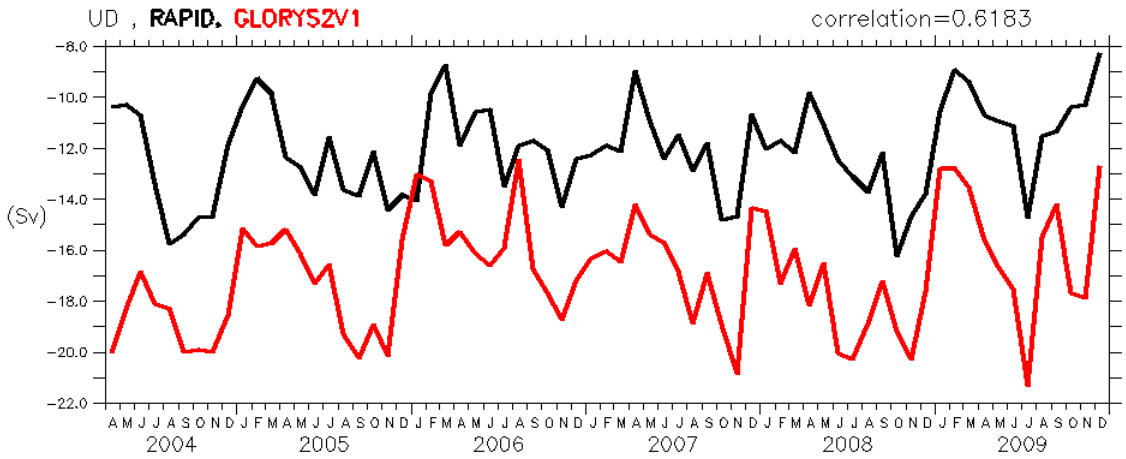
GLORYS mean = 0.3 Sv

Correl=0.58

Atlantic Meridional Overturning circulation: comparison with RAPID



upper North Atl. Deep Water (1100-3000m):



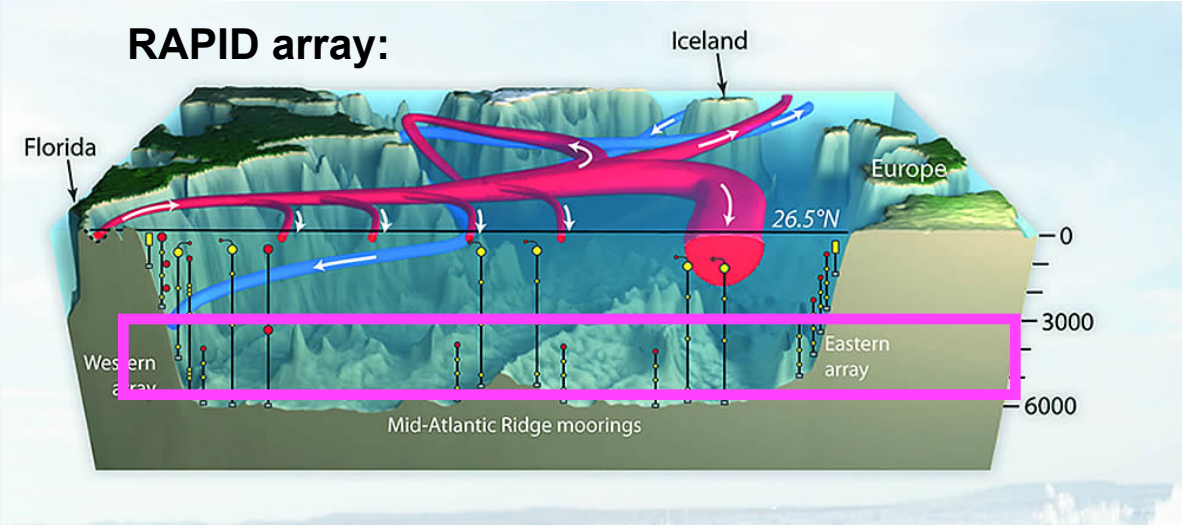
RAPID mean = -12.1 Sv

GLORYS mean = -16.9 Sv

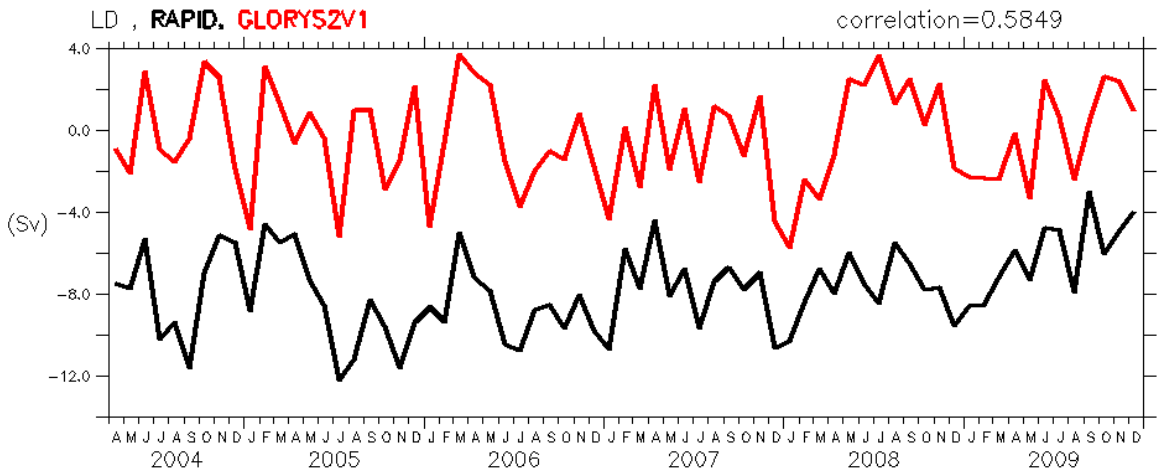
Correl=0.61

Too strong deep western boundary current

Atlantic Meridional Overturning circulation: comparison with RAPID

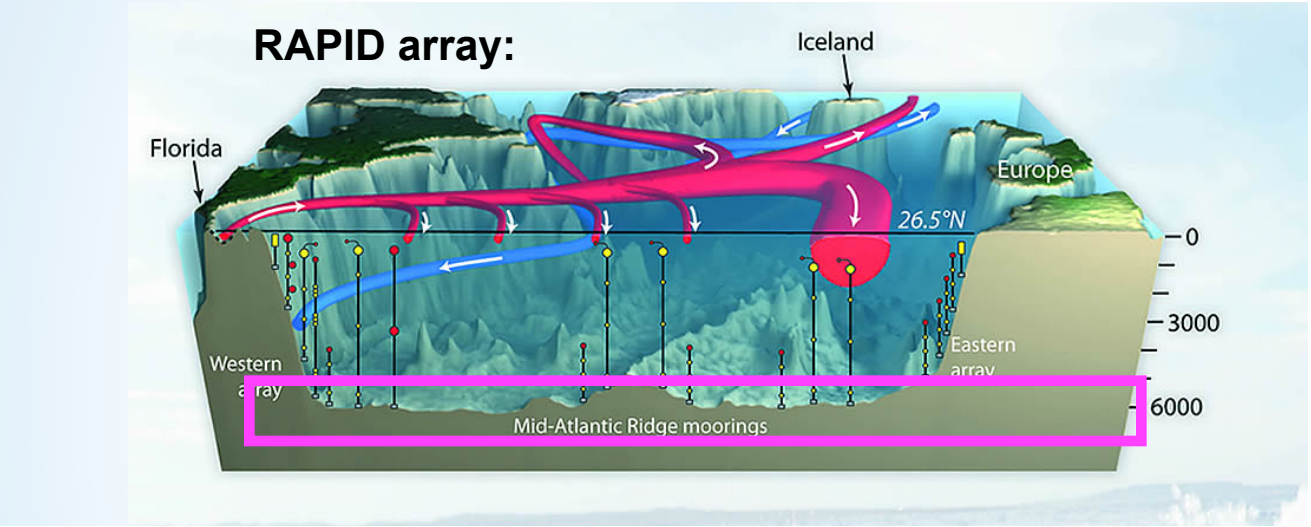


Lower North Atl. Deep Water (3000-5500m):

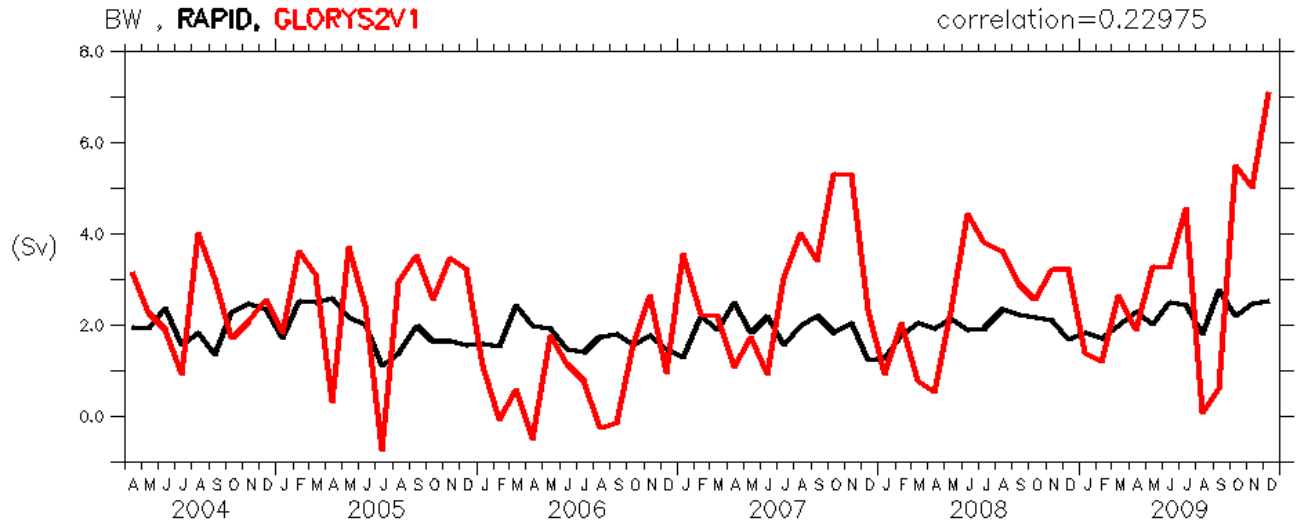


RAPID mean = -7.8 Sv
GLORYS mean = -0.4 Sv
Correl=0.58

Atlantic Meridional Overturning circulation: comparison with RAPID



Bottom Water (5500m-Bottom):

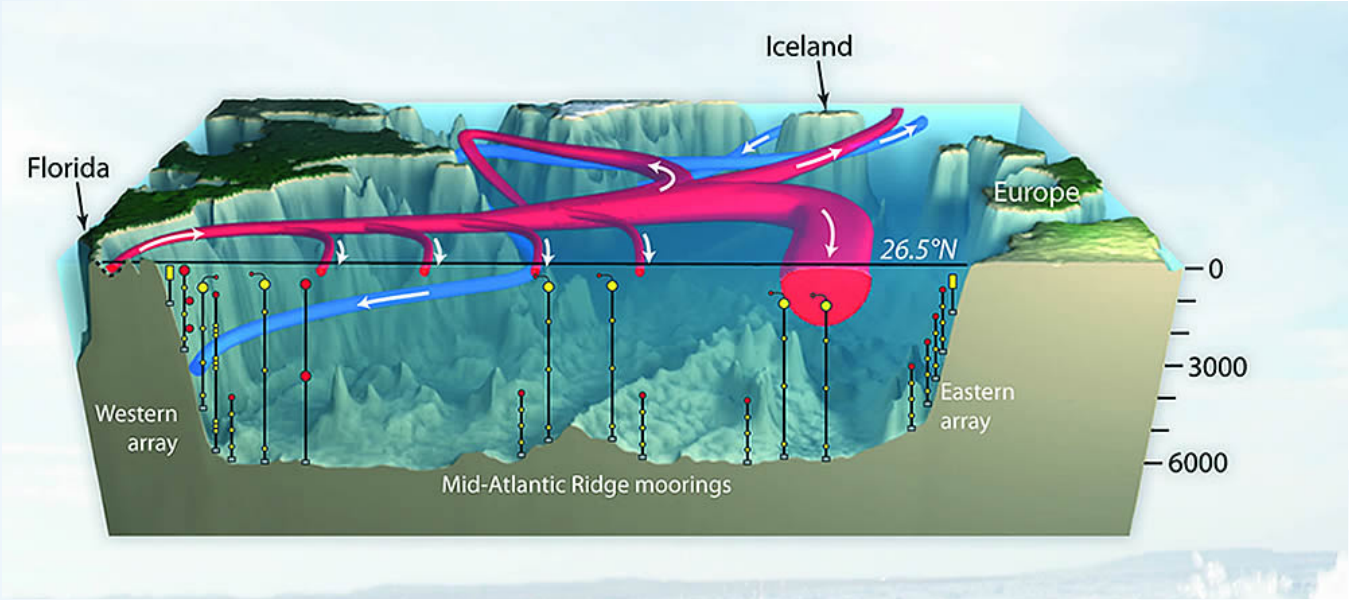


RAPID mean = 1.9 Sv

GLORYS mean = 2.3 Sv

Correl=0.58

Atlantic Meridional Overturning circulation: comparison with RAPID



- MOC variability is realistic and correlates well with the estimates from RAPID measurements.
- some biases exist in the mean circulation.

→ model resolution issue :

¼° resolution with D.A is not sufficient

Ph. Gaspar, CLS,
oceanic dispersal of juvenile leatherback turtles: going beyond passive drift modeling, marine ecology progress series, accepted

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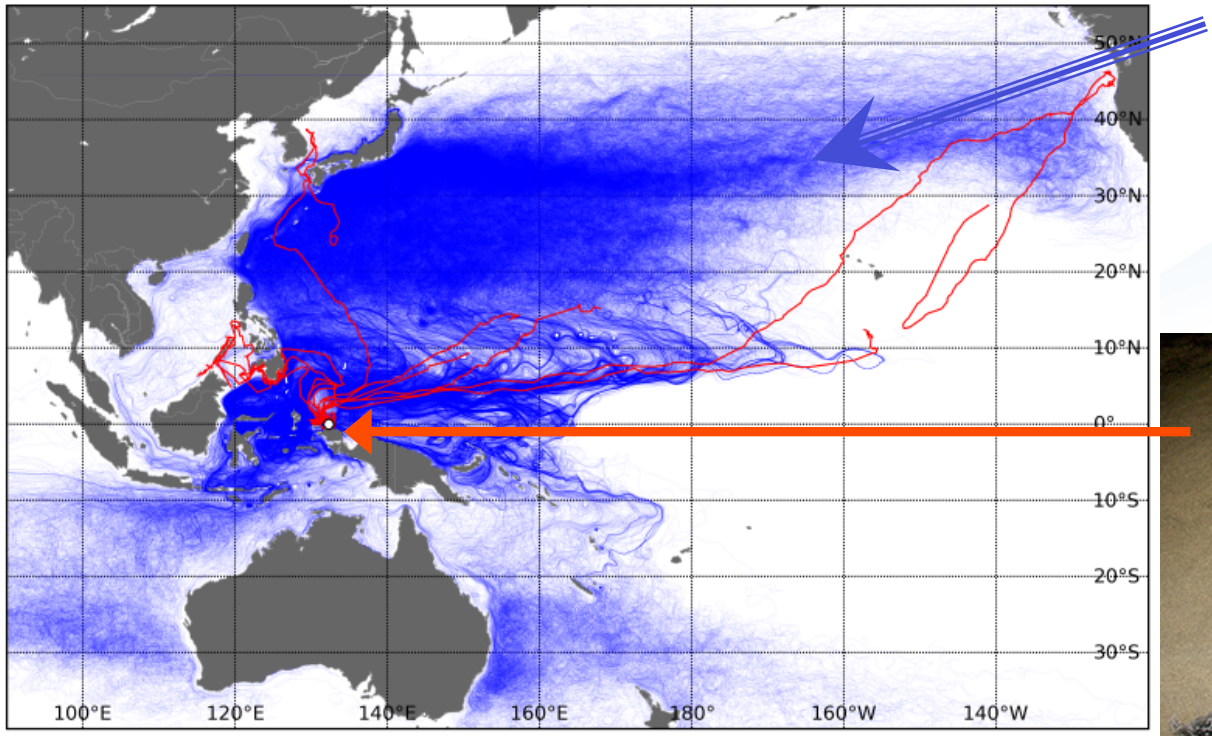
Post-nesting trajectories (in red) of the 9 leatherbacks turtles tracked from Jamursba-Medi beach during 6 years



GLORYS trajectories

4. Conclusions & Perspectives

Conclusions: GLORYS2 (1992-2009)

- Ability to produce global meso-scale reanalysis simulations: Unique collaboration between operational centers (MERCATOR, CORIOLIS) and research Labs (LEGI, …)

- Results: better quality of GLORYS2 compare to GLORYS1. extensively validation through an international framework (MyOcean, Godae)

- > 40 users, various applications

Perspectives: GLORYS2-3

GLORYS2VX (1992-2012) :

- Ongoing effort to improve products and services
- MyOcean2 project: production of reanalyses is still a priority

GLORYS3 (1979-2012) :

- ERAInterim years
- Seasonal forecast, operated by Météo France

GLORYS users

> 40 users, data volume provided > 16 TB

several research areas and application fields:

- Biogeochemical modelling (LSCE, Mercator)
- Ecosystem modeling (CLS/MEMMS)
- Sea Ice (LPO, Mercator)
- TIWs (LEGOS)
- pCO2 (NIES *Japan*, Bjerknes CCR)
- Ocean circulation estimation and validation (CLS, SHOM)
- Ocean Thermal Energy Conversion (EDF, Mercator)
- Boundary / Initial conditions for regional modeling (CNRM, Infocean)
- Mean Dynamic Topography inter comparisons (CLS, China)
- MOC, MHT (RSMAS, UFRPE, CLS, Mercator)
- South Atlantic circulation (NOAA)
- Climate indexes, trends (IMEDEA, *Spain*)
- Global ocean Mass budget (EOST/IPGS, NASA/GSFC)
- object / animal drift (CLS, LPO, U. Texas, U. Hawai)
- Hurricane (LEGI, CERSAT)
- …