ORCA12, a global ocean-ice model at 1/12°:
successes, shortcomings and their impact on ocean forecasting

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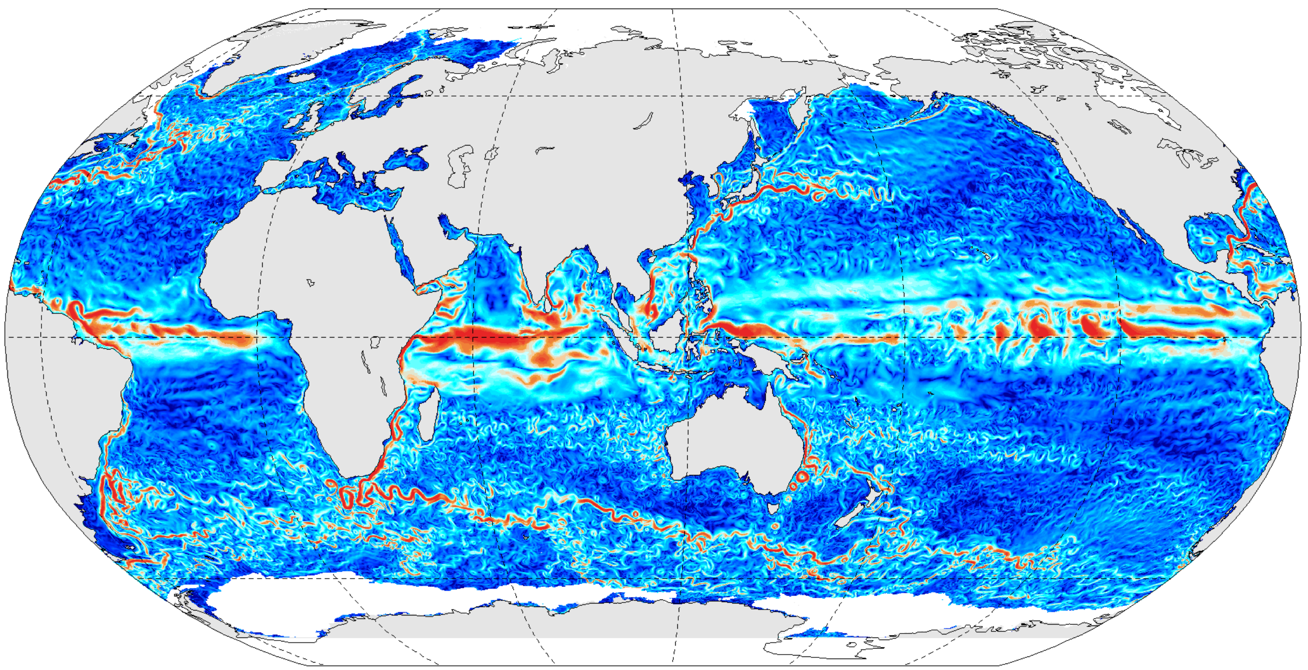


Snapshot of velocity at the surface in the ORCA12 ocean model.
A. Lecointre and J.M. Molines, LGGE, France

Drakkar group objective: assess and improve ORCA12 for climate and operational applications

Drakkar, European research group (NOC-UK, Geomar-Kiel, CNRS and Ifremer, France)

2014-2017: Global model configurations based on **NEMO**, focus on ORCA12

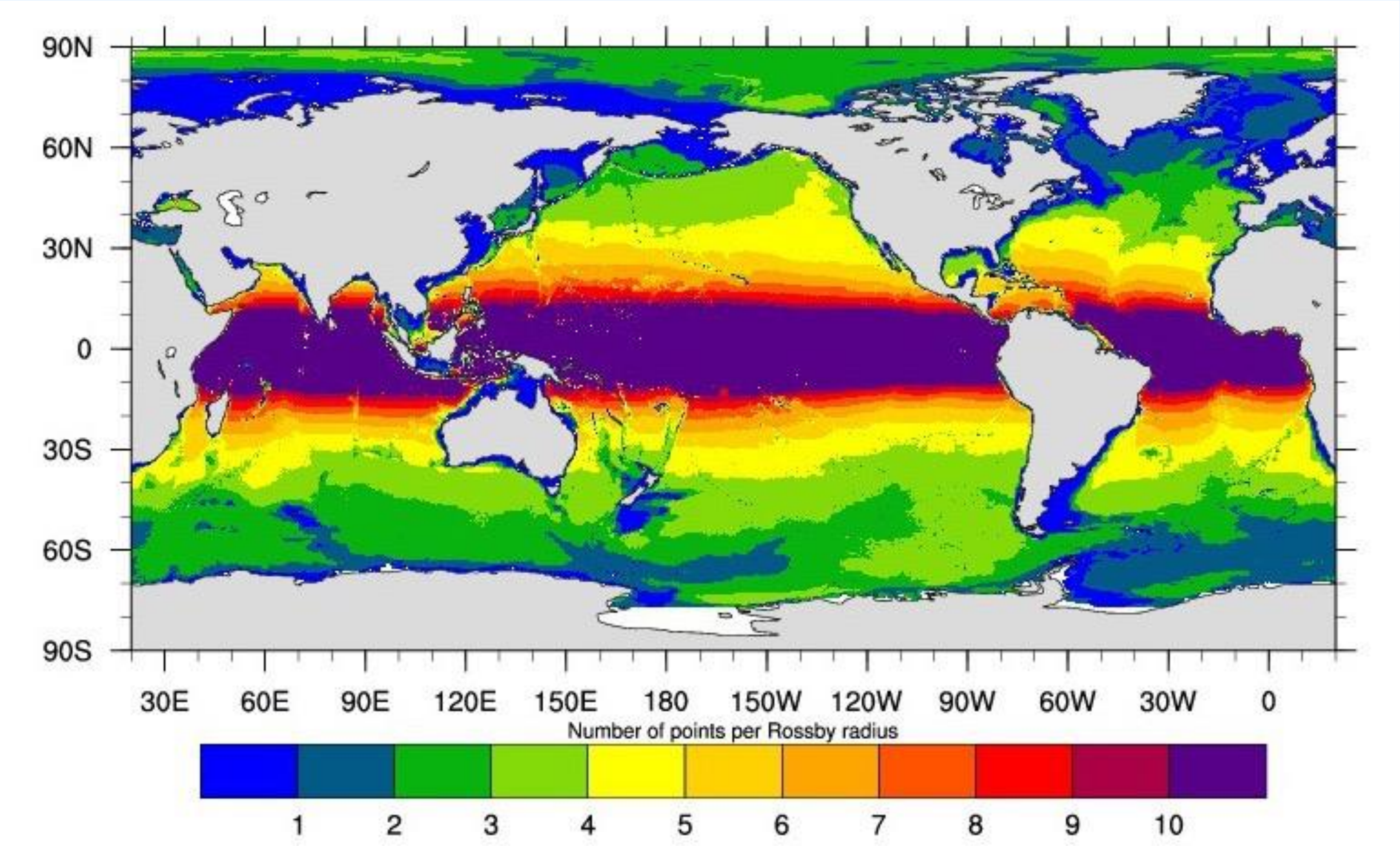
- for operational forecasts (Mercator-Ocean, CMEMS, U.K MetOffice)
- for climate scenarios (UK MetOffice)
- for research questions

Long ORCA12 forced simulations (Drakkar Forcing Set, DFS)

- 84 years with climatological forcing (IGE Grenoble)
- **Two 67-years simulations, 1958-2015 (IGE)**
- Other simulations at NOC and GEOMAR.

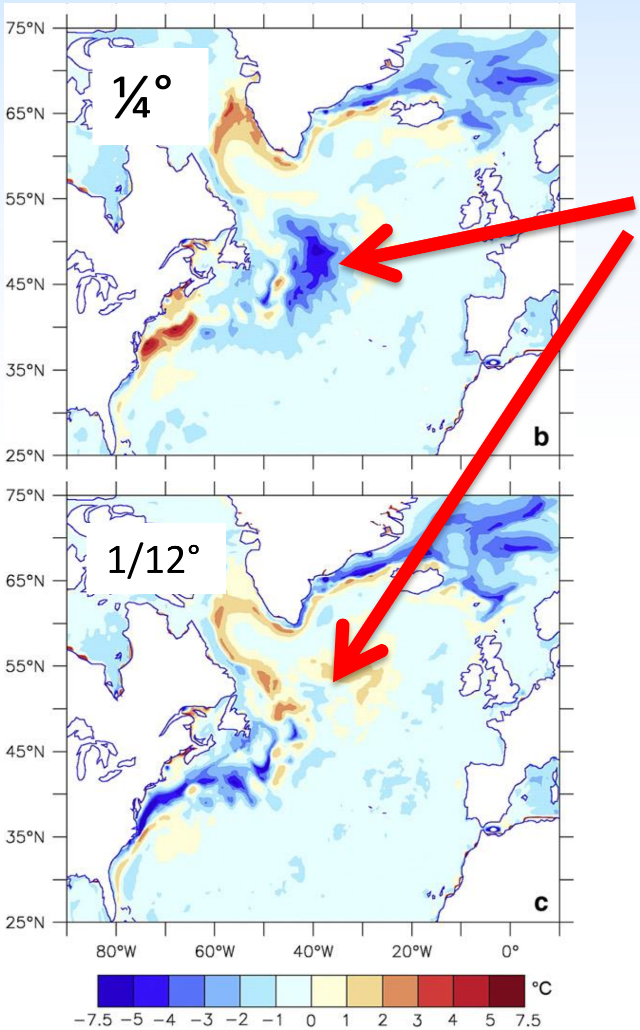
Multidecadal simulations are necessary to assess the robustness of the processes responsible for ocean variability.

Benefits of 1/12° resolution



ORCA12 grid: number of grid points per Rossby Radius. The Rossby radius is estimated from the climatological ORCA12 simulation.

Benefits of 1/12° resolution



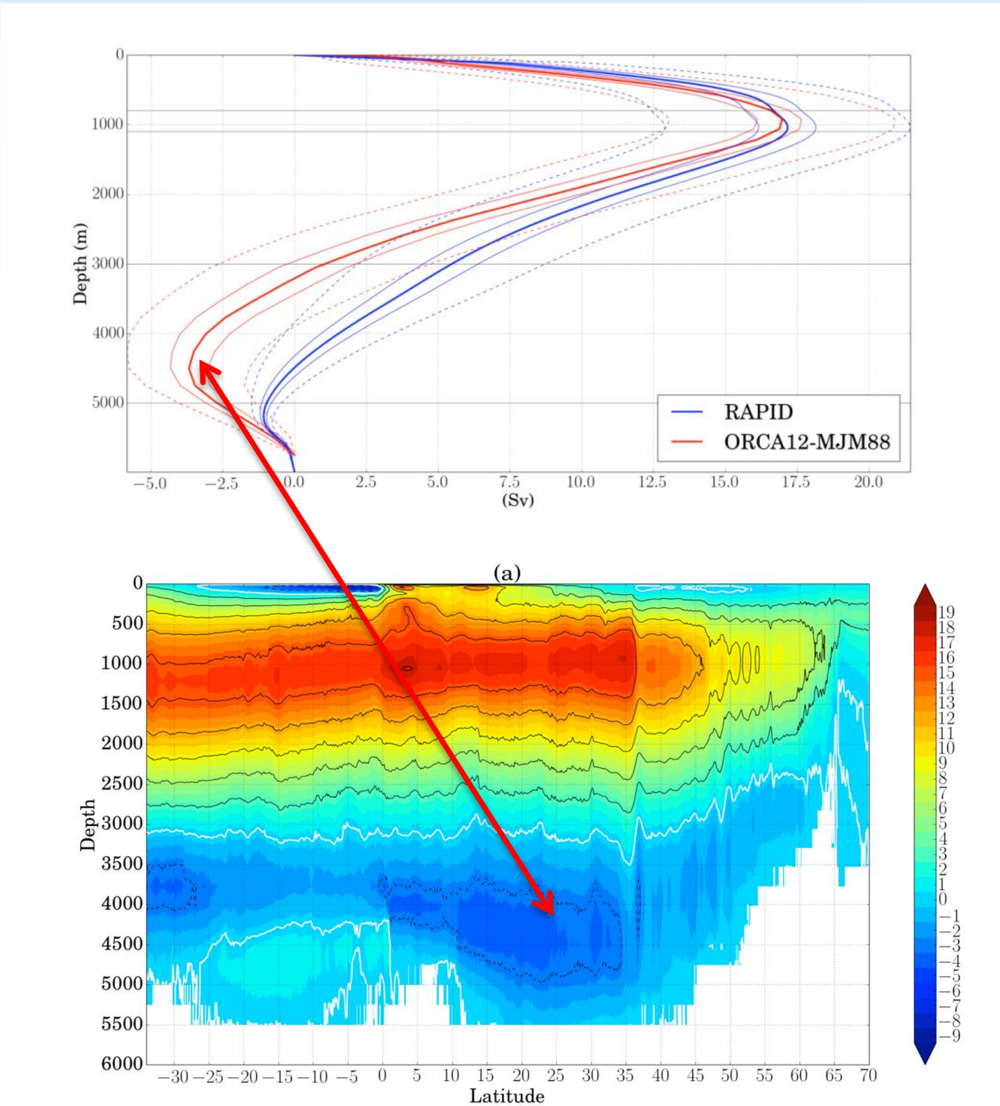
Modelled-observed SST,average for year 2007

Why 1/12°? One example, the NW corner (Marzocchi et al, JMS, 2015)

ORCA12 results (33 publications, 2014-2016)

- Dynamics of ocean turbulence (meridional transports, anisotropy**,** seasonal cycle)
- Instrinsic vs forced ocean variability
- Boundary condition for regional models
- Coupled ocean-atmosphere simulations with ORCA12 (UK Met Office and NOC, Hewitt et al, 2016)
- **AMOC**: from the South Atlantic to 26°N to 26°N and the subpolar gyre
- **Southern Ocean** currents and variability

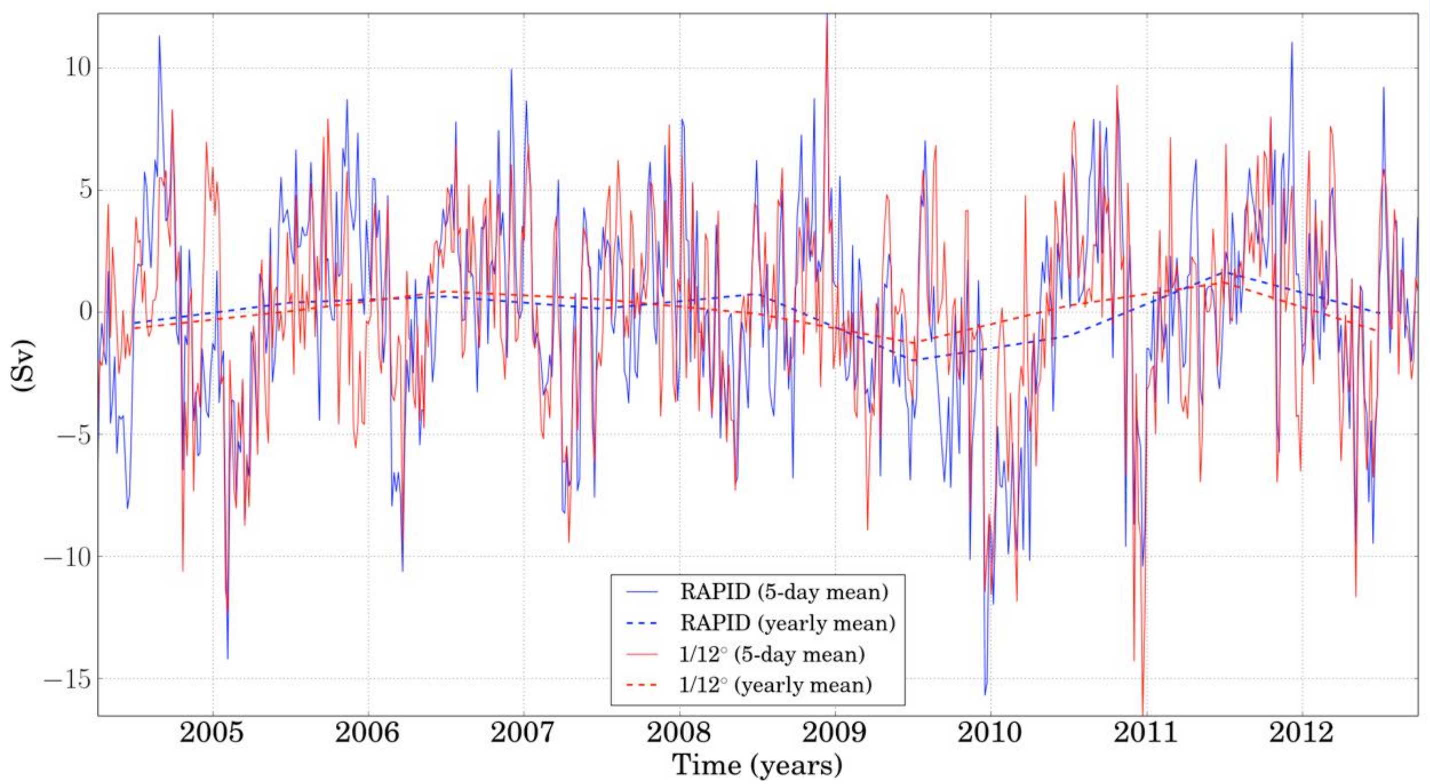
The Atlantic Meridional Overturning Circulation



Meridional transport at 26°N cumulated from the bottom. Average 2004-2012 (thick lines)

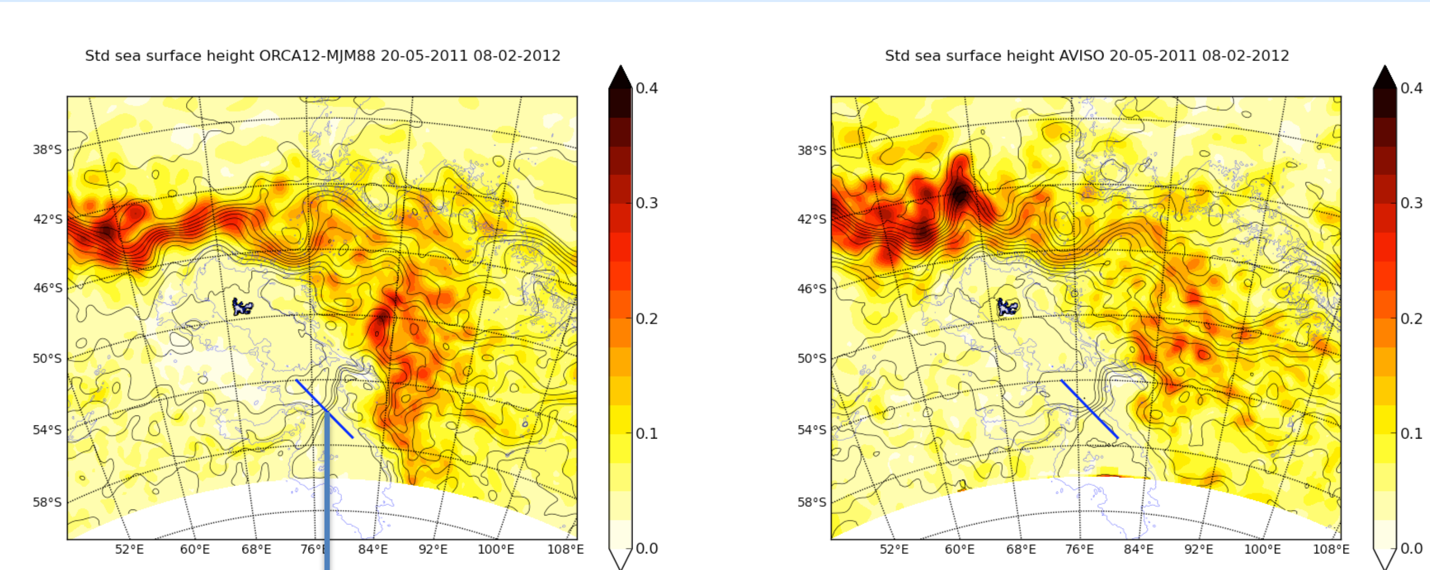
AMOC as a function of latitude in ORCA12, averaged for 2004-2012

AMOC variability



- AMOC upper cell anomalies in ORCA12 (red) compare well with RAPID (blue) *(Julie Deshayes)*
- Forced simulations perform better than reanalyses *(Karspeck et al, Clim Dyn, 2015)*
- Forced variability > intrinsic variability (*Gregorio et al 2015)*

Southern ocean dynamics (J. Deshayes)

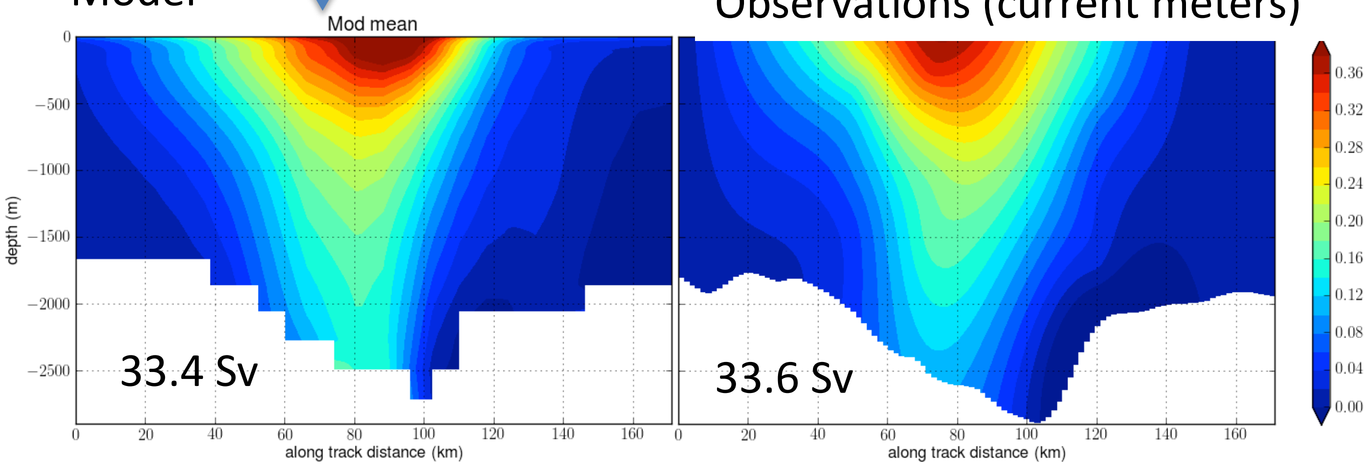


Mean and std of SSH compare well with observations *(1/8° special AVISO product, KEOPS2 project)*

Fawn Trough

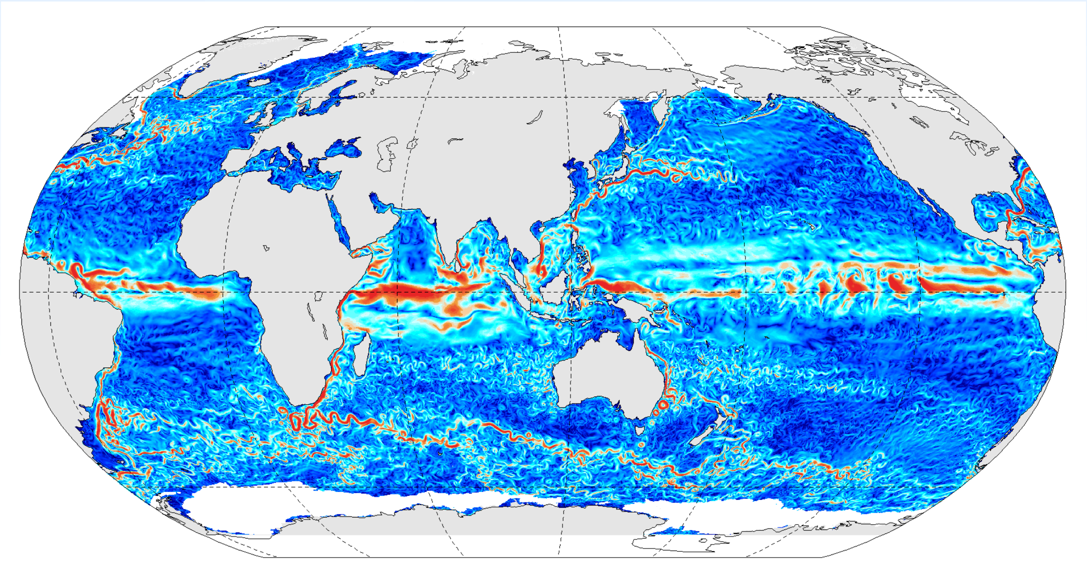
Model

Observations (current meters)



Fawn Trough current (annual mean 2009): ORCA12 represents the vertical structure, width and intensity.

ORCA12, successes…



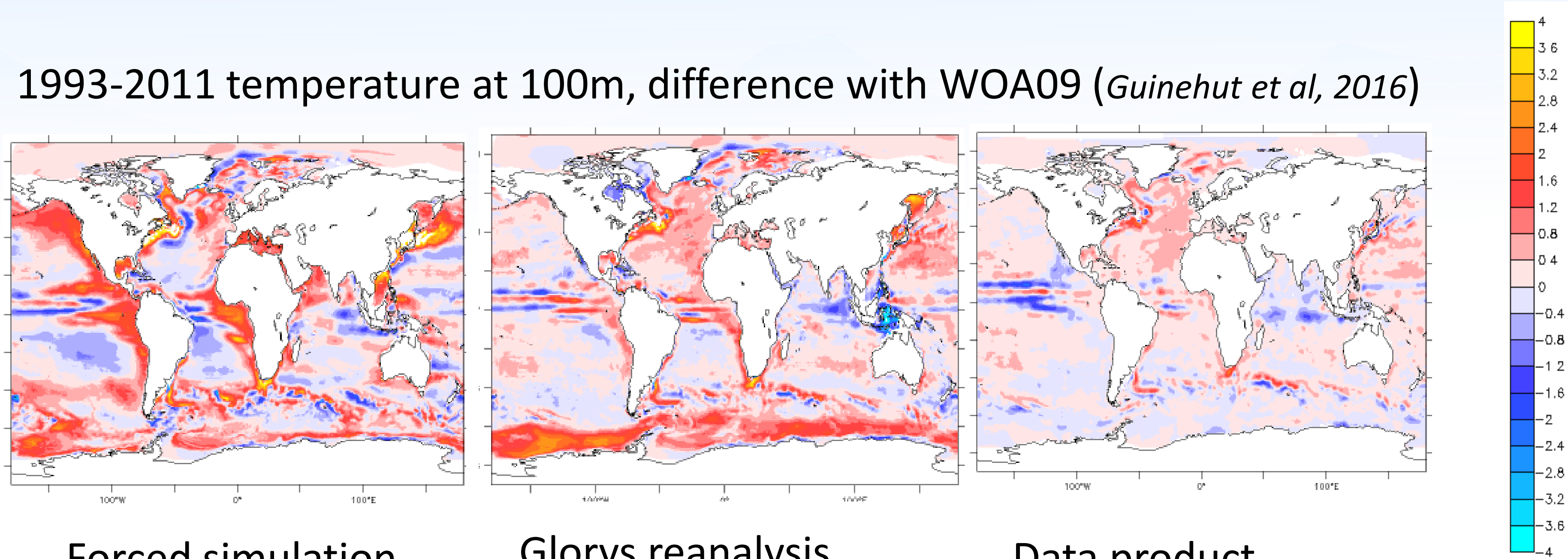
… and shortcomings

- Biases in temperature and salinity
- Sensitivity to the model numerics and physics

Model biases in temperature and salinity

Model biases are not entirely eliminated by data assimilation.
Exemple at ¼°:

1993-2011 temperature at 100m, difference with WOA09 (*Guinehut et al, 2016*)



Forced simulation

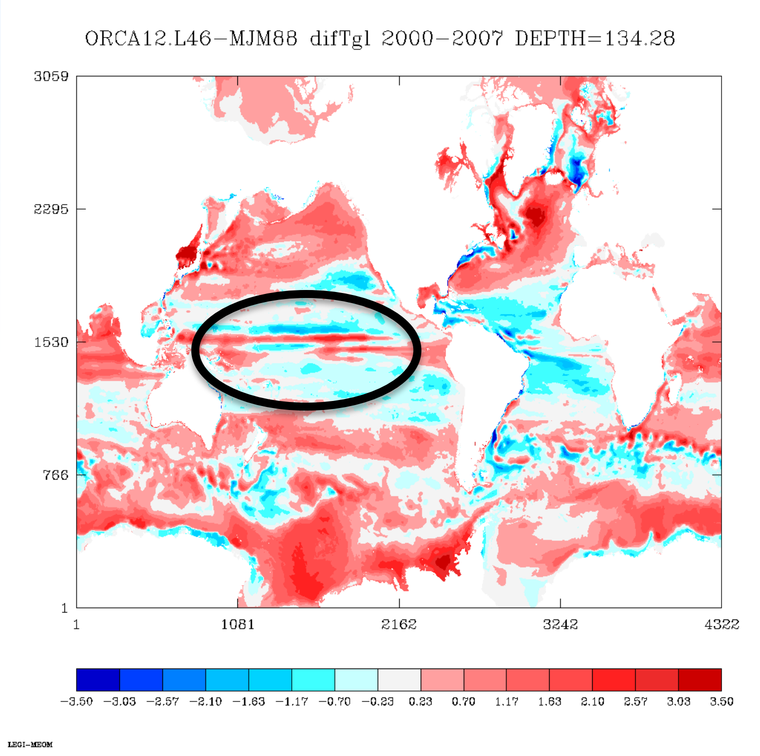
Glorys reanalysis

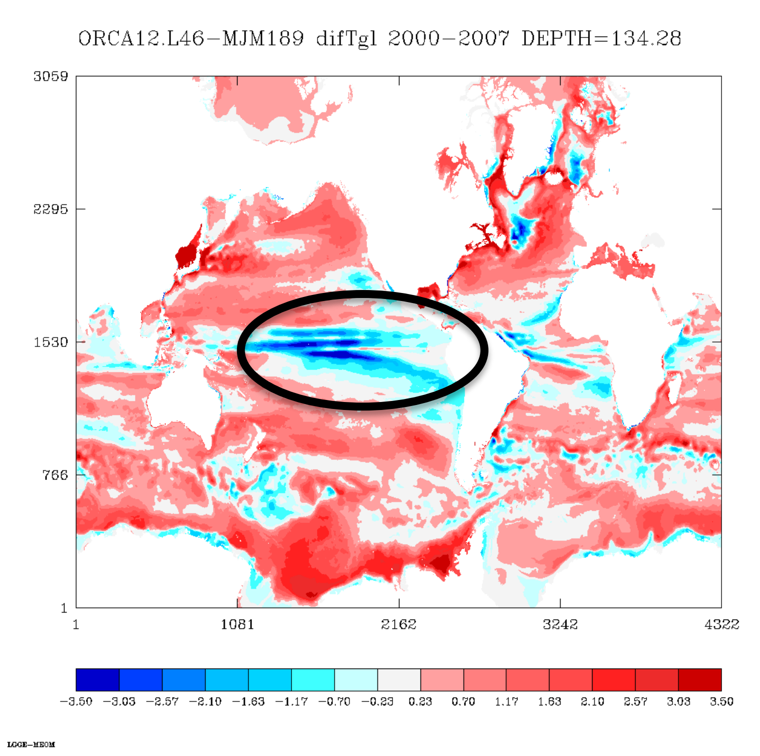
Data product (ARMOR3D)

=> It is necessary to reduce biases in physical models to improve reanalysis.

Biases: two Drakkar ORCA12 simulations

Temperature difference with climatology, 2000-2007, 134m depth





Some differences due to the atmospheric forcings

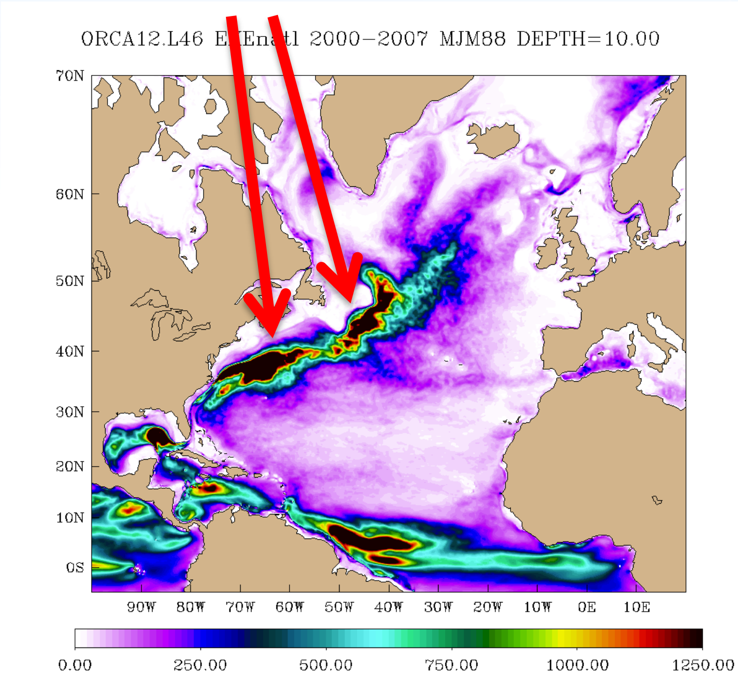
DFS4.4 (ERA40+analysis)
No ocean currents in wind stress calculation

DFS5.2 (ERA-Interim)
Ocean currents taken into account in wind stress calculation.

Biases : dependency on advection scheme

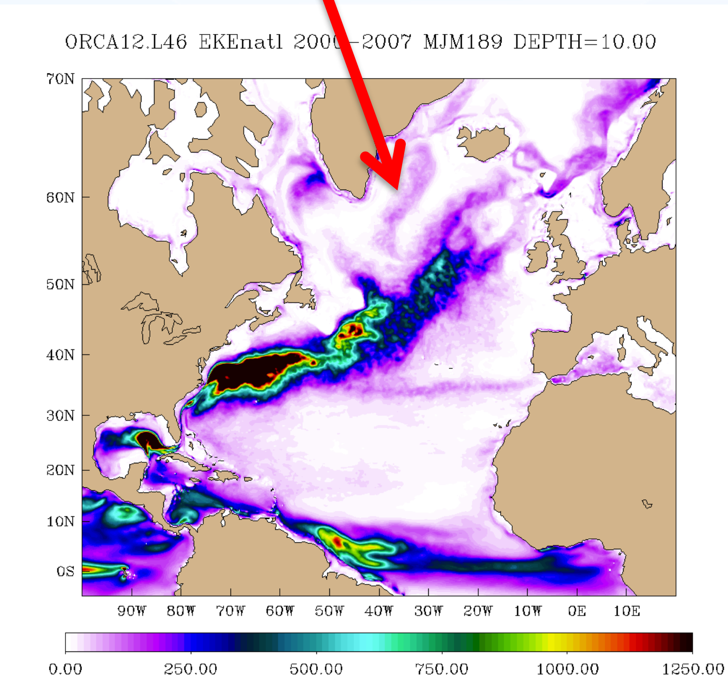
Eddy Kinetic Energy in the North Atlantic, averaged 2000-2007

Old schemes are better...



NEMO 3.4, vector form EEN advection

New schemes are better...



NEMO 3.5 new EEN (Hollingsworth instability suppressed+ new BC)

Conclusion
Future development of ORCA12 for forecasts

ORCA12 performs better compared with lower resolution models :

- Most current systems (Kuroshio, ACC, Gulf Stream...)
- Variability, both forced by the atmosphere and intrinsic
- Eddy generation and eddy transports

Further improvements are needed :

- Better understanding of the robustness (to numerical schemes, parameterizations)
- Wind stress accuracy
- Reduce biases in temperature and salinities, for climate studies

Future DRAKKAR plans, 2018-2021

Development of global forced NEMO-based ice-ocean models:
A workshop and publications to document sensitivities

Quantify uncertainties and their propagation in solutions
Use ensembles, promote stochastic parameterizations

Develop and generalize the use of grid refinement techniques
perform frontier high resolution simulations (NATL60, 300 levels)
Fine scale dynamics, upscaling/downscaling

Improve the representation of surface air-sea-ice interactions
JRA55 forcings, boundary layer parameterizations, atmospheric coupling….

Drakkar annual workshops are held in january in Grenoble