

# Vertical motion analysis through combined model, satellite and in situ data. Preliminary results of the MESCLA project

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## Introduction: importance of vertical motion

Vertical motion associated with **mesoscale** and **sub-mesoscale** oceanic features is of fundamental importance for the exchanges of heat, fresh water and biogeochemical tracers between the surface and the ocean interior. Unfortunately, direct measurements of the vertical velocity are difficult to obtain for usual values (order 10's m/day). Various indirect methodologies have thus been proposed to estimate vertical velocity from observed density and geostrophic velocity fields. The most used technique is based on the solution of the quasi-geostrophic (QG) Omega equation.

## The MESCLA approach: a MyOcean R&D proposal

The MESCLA project, funded in the framework of the MyOcean 2009 R&D Call, is focused on the estimation and analysis of the vertical exchanges associated with mesoscale dynamics and of their interannual variability. MESCLA aims at:

- (1) Applying QG diagnostics to MyOcean products (model and observation based).
- (2) Comparing its results with corresponding primitive equation solutions.
- (3) Testing alternative techniques to combine satellite and in situ observations.

## Method for estimating QG vertical velocities

### Omega equation. Vector Q formulation

$$f^2 \frac{\partial^2 \omega}{\partial z^2} + \left( \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \right) (N^2 \omega) = \nabla_h Q$$

$$Q = \left[ 2f \left( \frac{\partial V}{\partial x} \frac{\partial U}{\partial z} + \frac{\partial V}{\partial y} \frac{\partial V}{\partial z} \right), -2f \left( \frac{\partial U}{\partial x} \frac{\partial U}{\partial z} + \frac{\partial U}{\partial y} \frac{\partial V}{\partial z} \right) \right]$$

Hoskins et al (1978)  
Holton (1979)

$$\frac{|u_a|}{|U|} = O(\varepsilon) \quad \varepsilon \ll 1$$

where (U,V) are the geostrophic velocity components, N Brunt-Vaisala frequency and f the Coriolis parameter.

By assuming a BC for  $\omega$  and from a 3D snapshot of the density field, the vertical velocity can be inferred.

First tests:

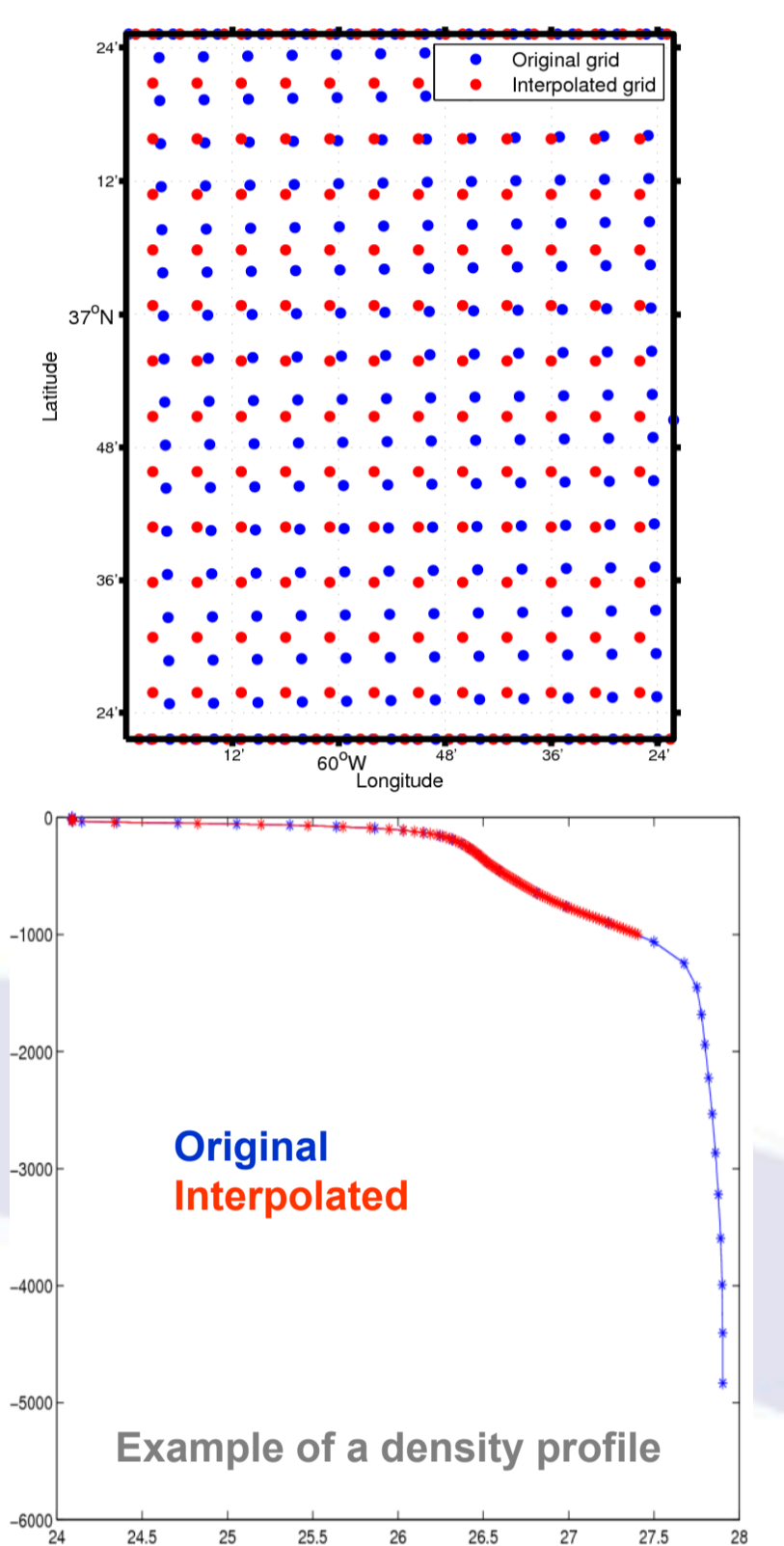
w = 0 at the upper, lower and lateral boundaries

N is considered to vary only in the vertical: N = N(z).

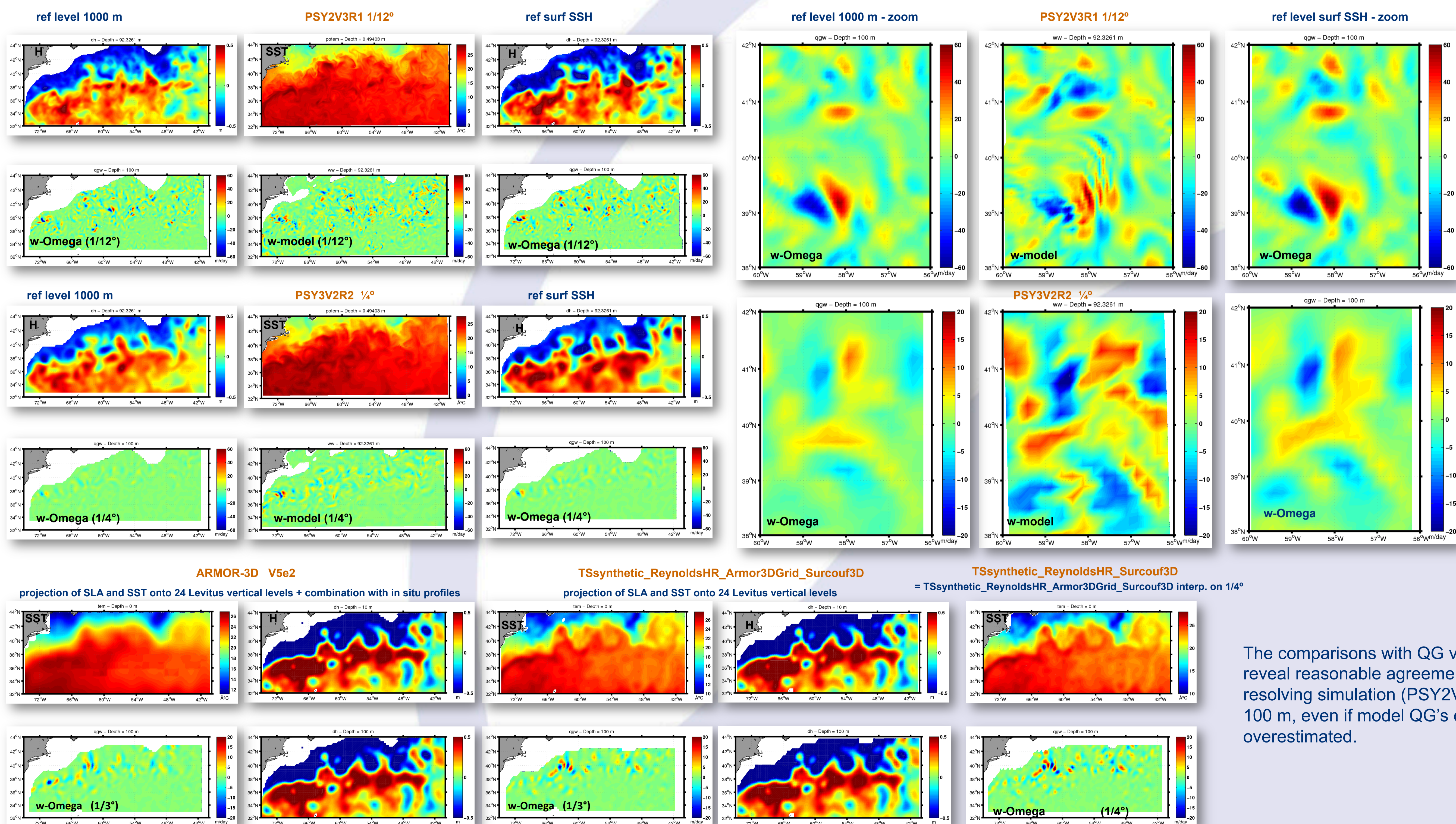
## Datasets

### Adaptation of the Omega equation to MyOcean products

- **Selection of input data:**
  - PSY3V2R2: 1/4° resolution on mercator grid. 50 vertical levels
  - PSY2V3R1: 1/12° resolution on mercator grid. 50 vertical levels
  - ARMOR3D – V1 (v5e1 and v5e2)
  - Domain: NW Atlantic, Gulf Stream
  - Date test: 17/10/2007
- **Computation of geostrophic velocities. Sensitivity to the reference level:**
  - 1000 m
  - surface SSH
- **Vertical interpolation:**
  - 10:10:1000 m
- **Horizontal interpolation:**
  - regular grid (1/3°, 1/4°, 1/12°)
- **Conversion of data files to be ingested into the fortran code for the estimation of vector Q and vertical velocity**
- **Estimation of vector Q and vertical velocity**



## Preliminary results in the Gulf Stream



Preliminary estimations of vertical velocities, in the Gulf Stream, a well-known area characterized by intense mesoscale and sub-mesoscale signals, show high sensitivity, both in terms of shape and intensity, to the spatial resolution of the model.

Indeed, vertical velocities directly obtained from the 1/12° (PSY2V3R1) model are a factor of 2-3 larger than the 1/4° (PSY3V2R2) version (maximum upward and downward motion of the order of 40-60 m day<sup>-1</sup> versus 20-30 m day<sup>-1</sup>, respectively).

The comparisons with QG vertical velocities reveal reasonable agreements for the eddy resolving simulation (PSY2V3R1) at a depth of 100 m, even if model QG's can values can be overestimated.

## Future work

Further steps include performing a thorough comparison and analysis of the vertical velocities estimation, as well as assessing the impact of spatial resolution, boundary conditions and sensitivity on the spatial dependence of Brunt-Vaisala frequency.

The QG vertical velocities obtained from the purely observational approach (ARMOR fields with 1/4° resolution) are of the same order of magnitude as PSY3V2R2 ones but the patterns shape and location are very different.