Diagnostic package for analyses of kinetic energy budget of the Gulf Stream in presence of submesoscale dynamics

Jamet Q., Dewar W. K., Penduff T., Julien Le Sommer J., Leroux S., Molines J.-M., Gula J.

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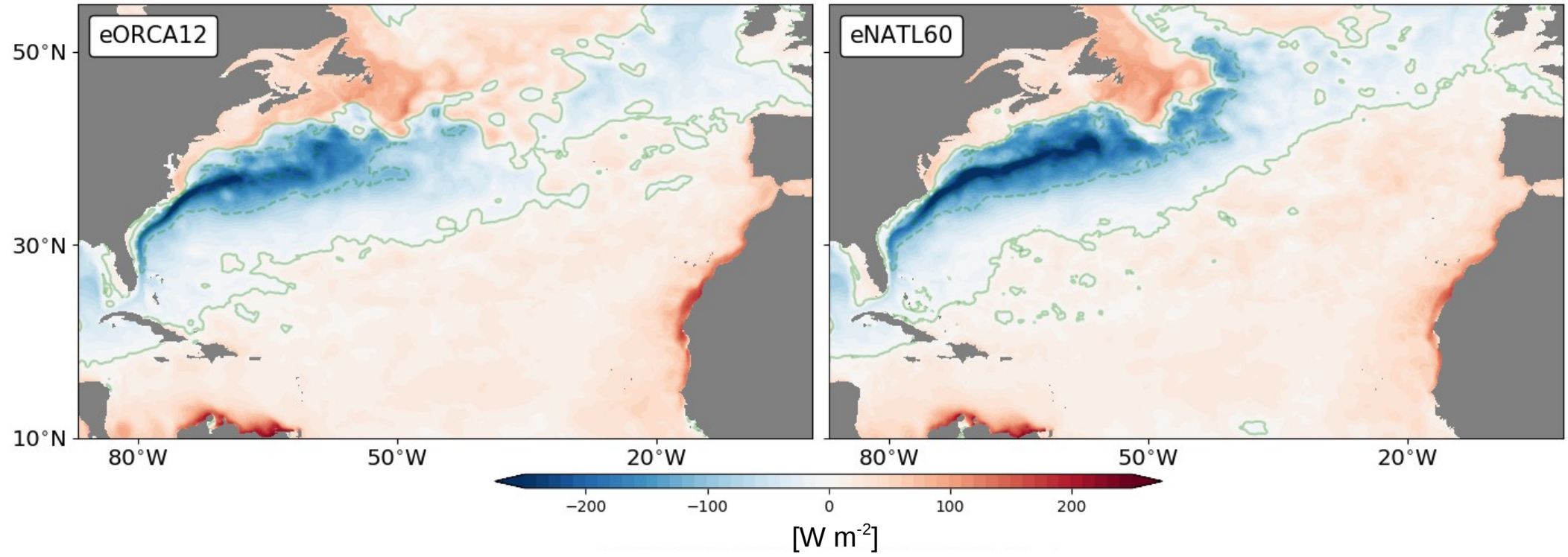
Context

- Gulf Stream ocean turbulence plays a critical role for air-sea interactions at various (including climat) time scales.

➔ Needs to better understand its dynamics,
and the focus is placed here on its energetics in presence of submesoscale.



Time mean (07/2009-07/2010) net heat fluxes into the ocean for the mesoscale resolving eORCA12 (1/12°, left) and the submesoscale permitting eNATL60 (1/60°, right) simulations. Both are based on NEMO model plateform and forced at the surface by the Drakkar Forcing Set.

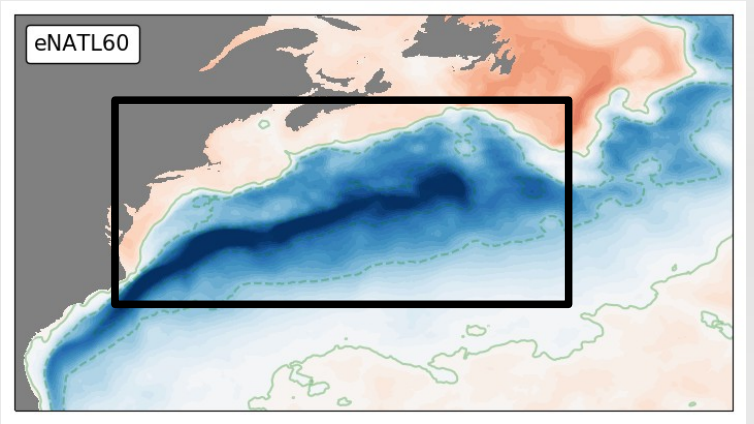
Objective, method and results

Objective

- Diagnose de Kinetic Energy (K) budget

$$\partial_t K = -\nabla \cdot \mathbf{u}K - \frac{1}{\rho_0}(u\partial_x p + v\partial_y p) + u\mathbf{D}_u^{vm} + v\mathbf{D}_v^{vm}$$

of the Gulf Stream in its separated jet extension region.



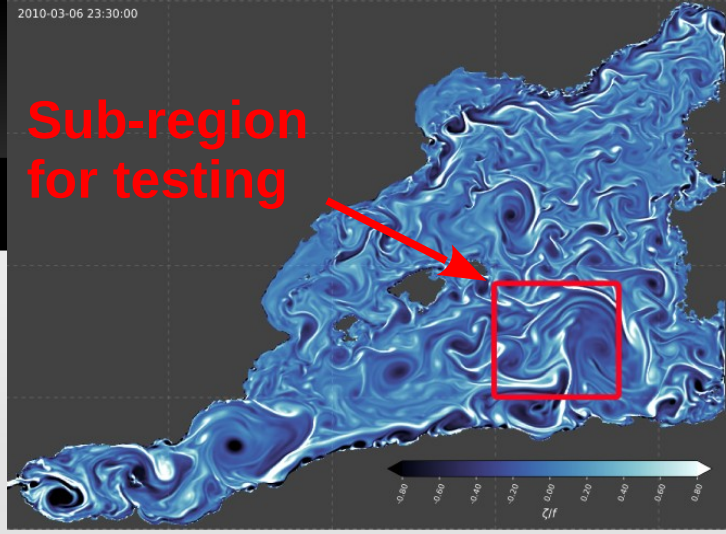
Method

- Develop offline tools under the FORTRAN based CDFTOOLS diagnostic package for the analysis of NEMO model output.
- Test the accuracy of the offline computation against online model outputs in a sub-sample region in the Mediterranean Sea.

Preliminary results

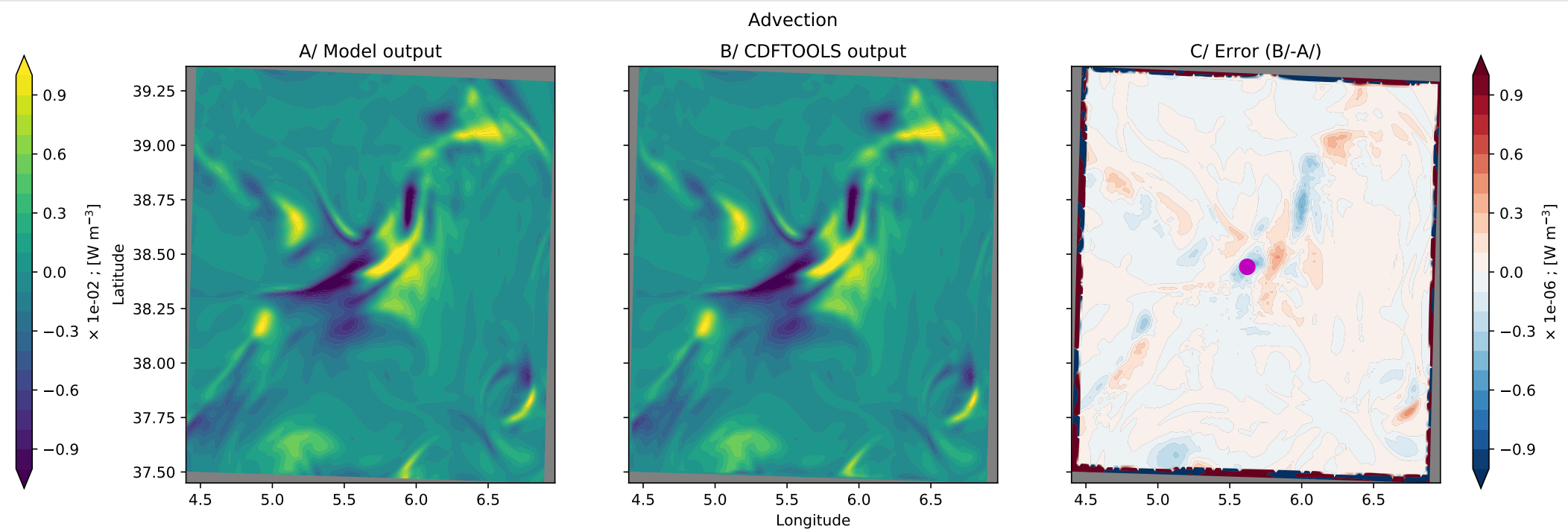
- Accuracy up to 10^{-3}-10^{-4} for time derivative, advection, pres. gradients
- Issues with surface pressure correction and vertical dissipation.

Results



- A first example of offline recomputation and associated errors for the 3D advection of Kinetic Energy.

→ The recomputation performs decently for time rate of change, advection, pressure gradients.



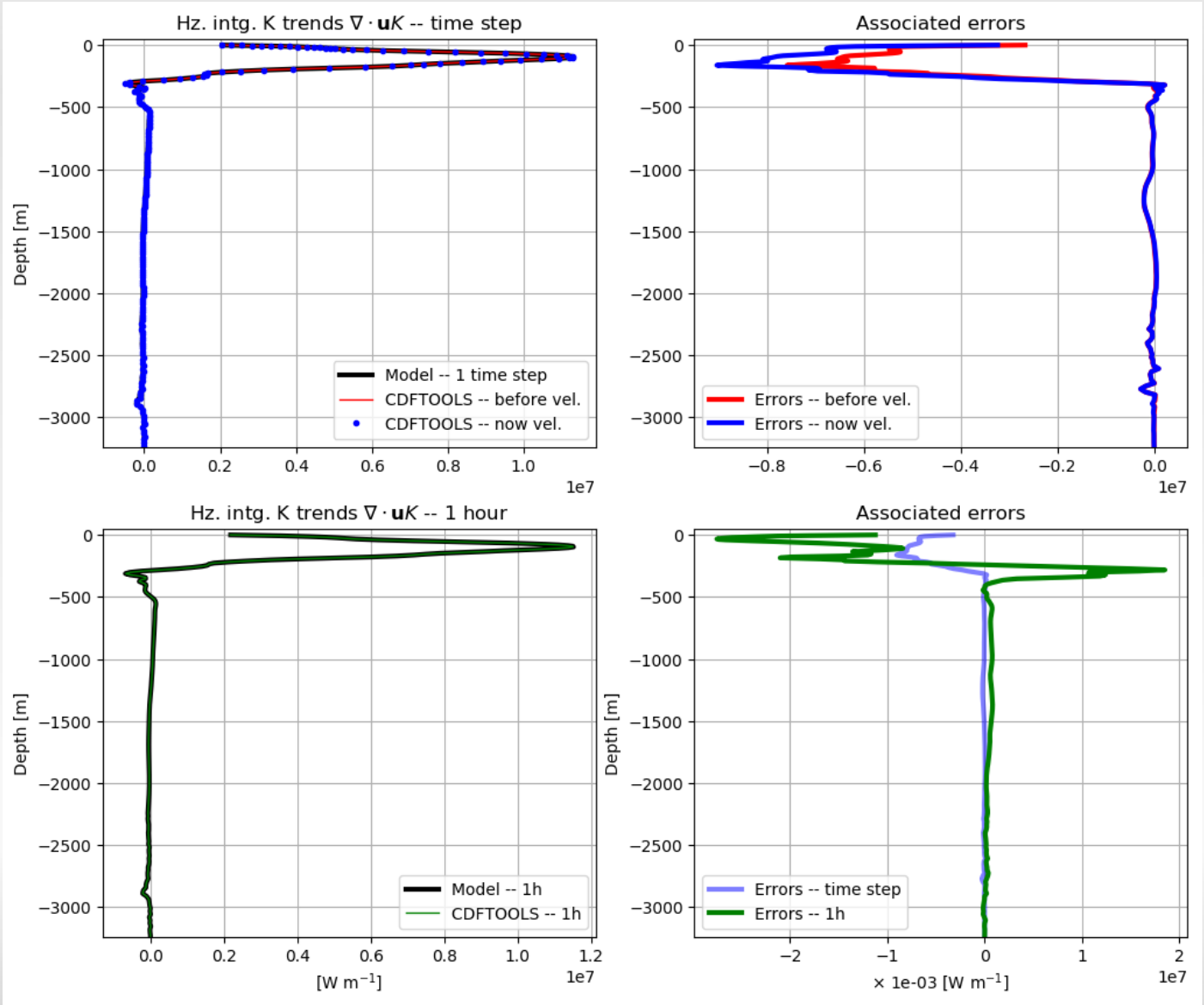
Kinetic Energy trends at model time step associated with 3D advection based on MEDWEST60 model outputs (gauche), for its offline recomputation (center), and associated errors (right). Note the different scale factor for errors.

Results

- Test the sensitivity to time discretization and time averaged model output:
  - For numerical stability reasons, some terms of the KE budget in NEMO are evaluated forward in time, such as the diffusion part of the UBS advection scheme. Such numerical details are unimportant for the offline computation, but affect the accuracy.
  - Currently tested at model time step, these diagnostics will be deployed on the eNATL60 simulation, which provides hourly model outputs. The effects of this time averaging is evaluated.

Results

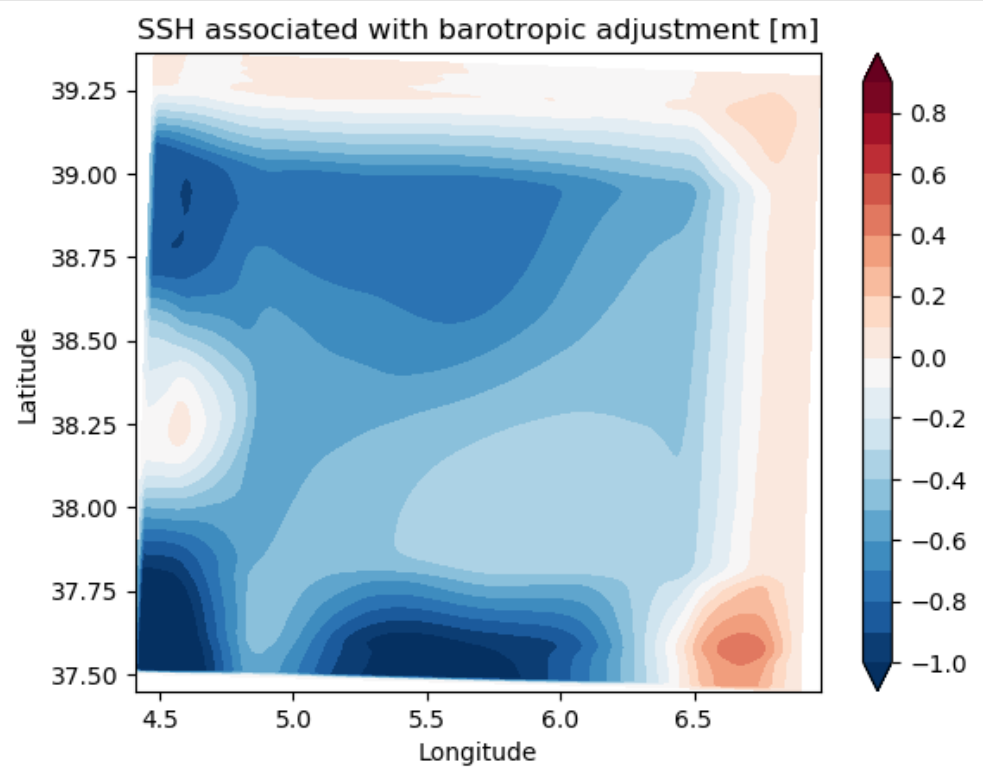
- Test the sensitivity to time discretization and time averaged model output:



- Sensitivity to time discretisation are relatively weak when averaged over the domain.
- Sensitivity to hourly model outputs can be locally large (1 order of magnitude), but decreases when integrated.
- It remains an important source of error.

Results

- In eNATL60, pressure gradients associated with surface height are first included in the hydrostatic pressure gradient computation through the use of a variable volume level.
- A correction is then applied to correct barotropic modes, and to include atmospheric surface pressure loading, evaporation, precipitations, runoff.



Sea Surface Height (SSH, [m]) associated with the recomputation of the surface pressure gradient correction.

- In our recomputation, we have:
  - Development of instabilities due to unbalanced boundary conditions.
  - Issues with the interpolation of atmospheric fields on the model grid (not shown).

→ Currently looking for some ways to correct these issues.