A method to speed-up passive tracer simulation in NEMO, run offline

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question :

   How to initialize passive tracers models by a 3D initial state which is not far to the final equilibrium solution ?

- Initialization with observations ?
  No sufficient data which are synoptic and without errors

- Long time integration to spin-up the model (several thousand years) ?
  The computing cost limits the integration time

- global runs with coarse resolution models ?
  They have a certain number of deficiencies

principle :

   have initial conditions for relative high resolution models, which are closed to the final equilibrium solution

3 steps :

- Average onto a coarser grid, high resolution dynamical fields without losing conservations properties : **degradation**

- Make off-line simulations to equilibrium with coarser resolution model obtained by degradation

- Initialize the original model with output obtained from the lower resolution model : **integration**

- 2 factors of degradation : nx, ny which are the number of grid cells on which the fields are averaged
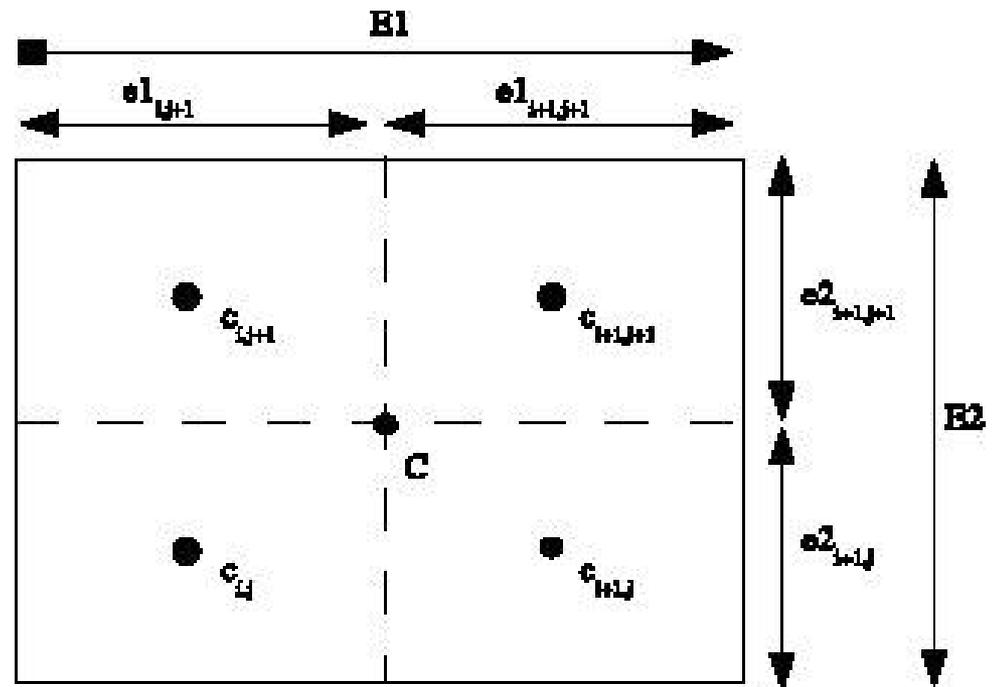
- dimensions

$$jpdi = {jpi}/{nx} \quad ; \quad jpdj = {jpj}/{ny}$$

- coordinates :

$$C_{IJ} = \frac{\sum_{i=1}^{nx} \sum_{j=1}^{ny} c_{ij}}{nx * ny}$$
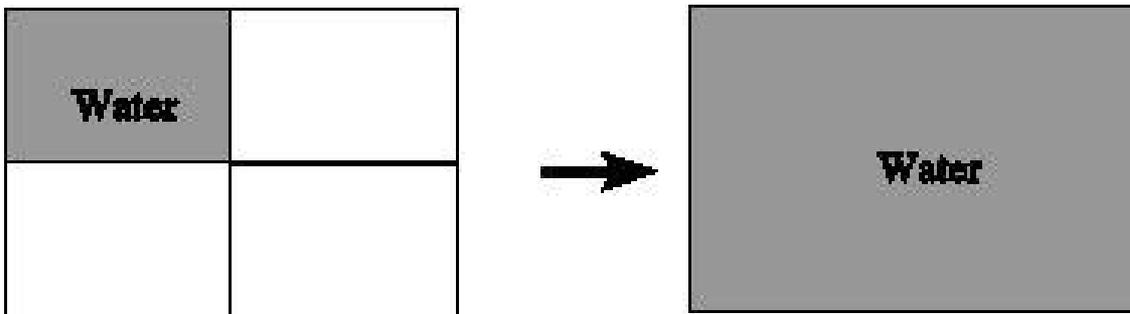

Definition of the degraded grid

- horizontal scales factor :

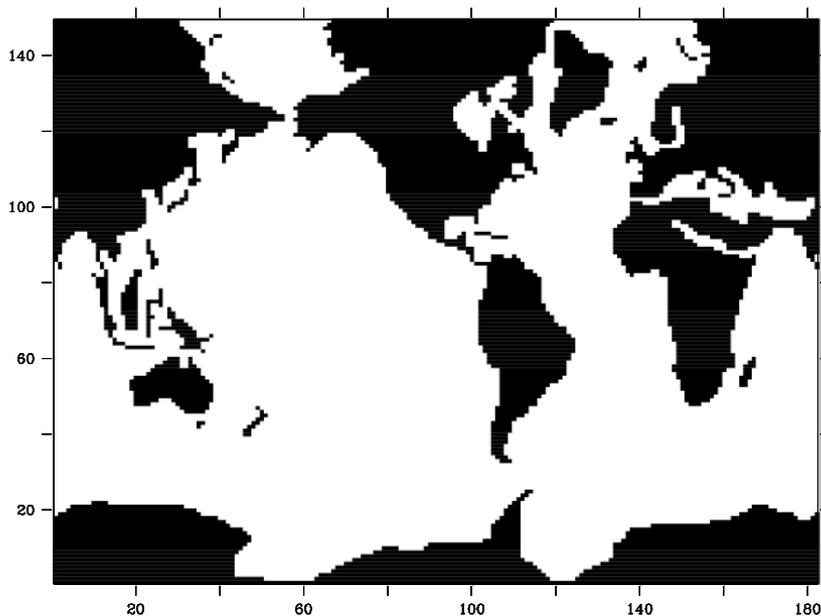$$E1_{IJ} = \sum_{i=1}^{nx} e1_{ij+1} \quad ; \quad E2_{IJ} = \sum_{i=1}^{ny} e2_{i+1j}$$
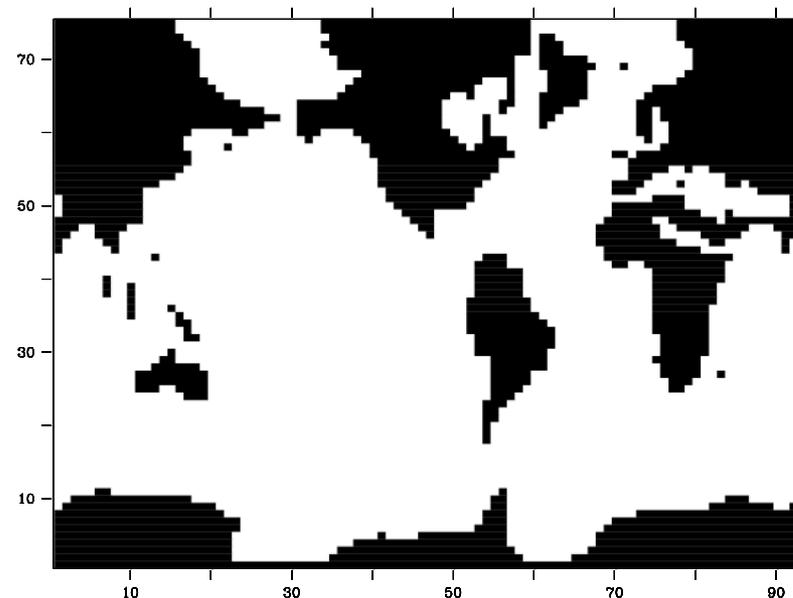
- vertical resolution remains unchanged

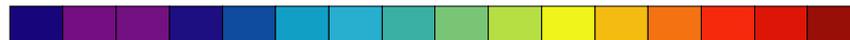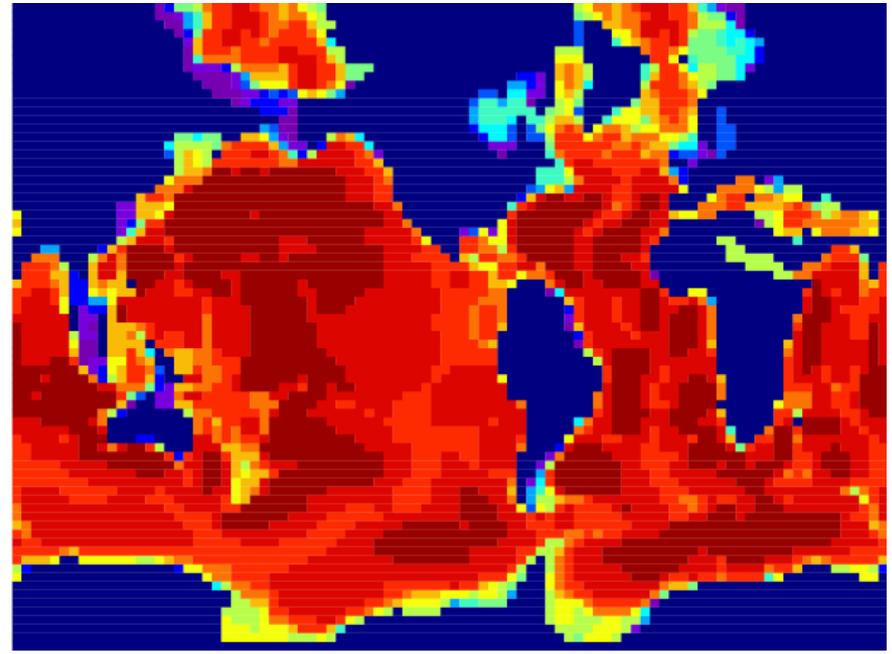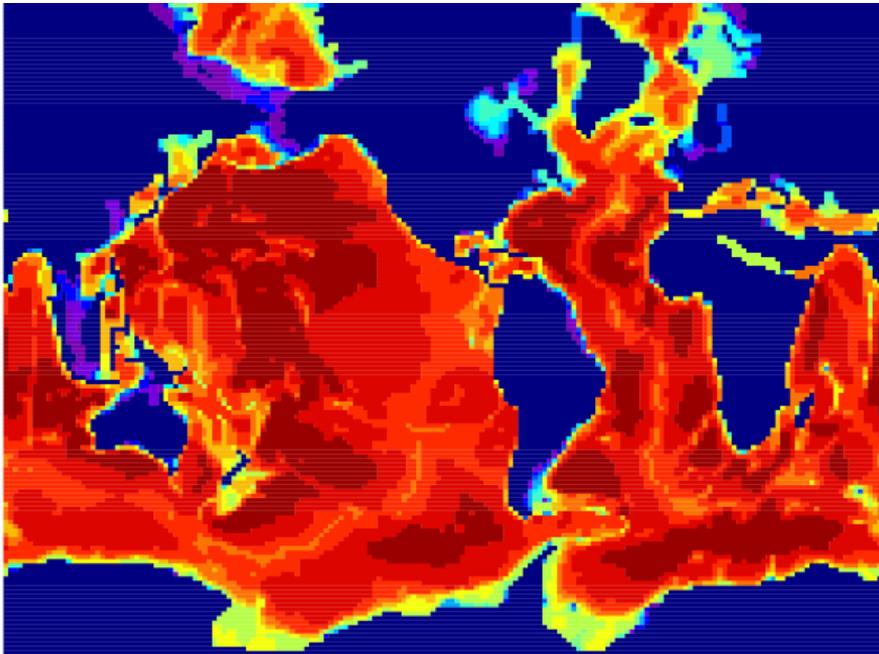*Construction of the mask*

tmask at surface in ORCA2 grid

tmask at surface in "degraded" ORCA2 grid by a factor of 2

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**little discrepancies : disappearance of some isthmuses**

- Recomputed on the coarse grid from the "degraded" mask
(number of ocean levels that are not masked at a selected location)

Degradation: Tracers

Tracers are averaged over the corresponding boxes of the parent model according to their respective volume :

$$T_{IJ} = \frac{\sum\limits_{i=1}^{nx} \sum\limits_{j=1}^{ny} t_{ij} * e1t_{ij} * e2t_{ij} * tmask_{ij}}{\sum\limits_{i=1}^{nx} \sum\limits_{j=1}^{ny} e1t_{ij} * e2t_{ij} * tmask_{ij}}$$
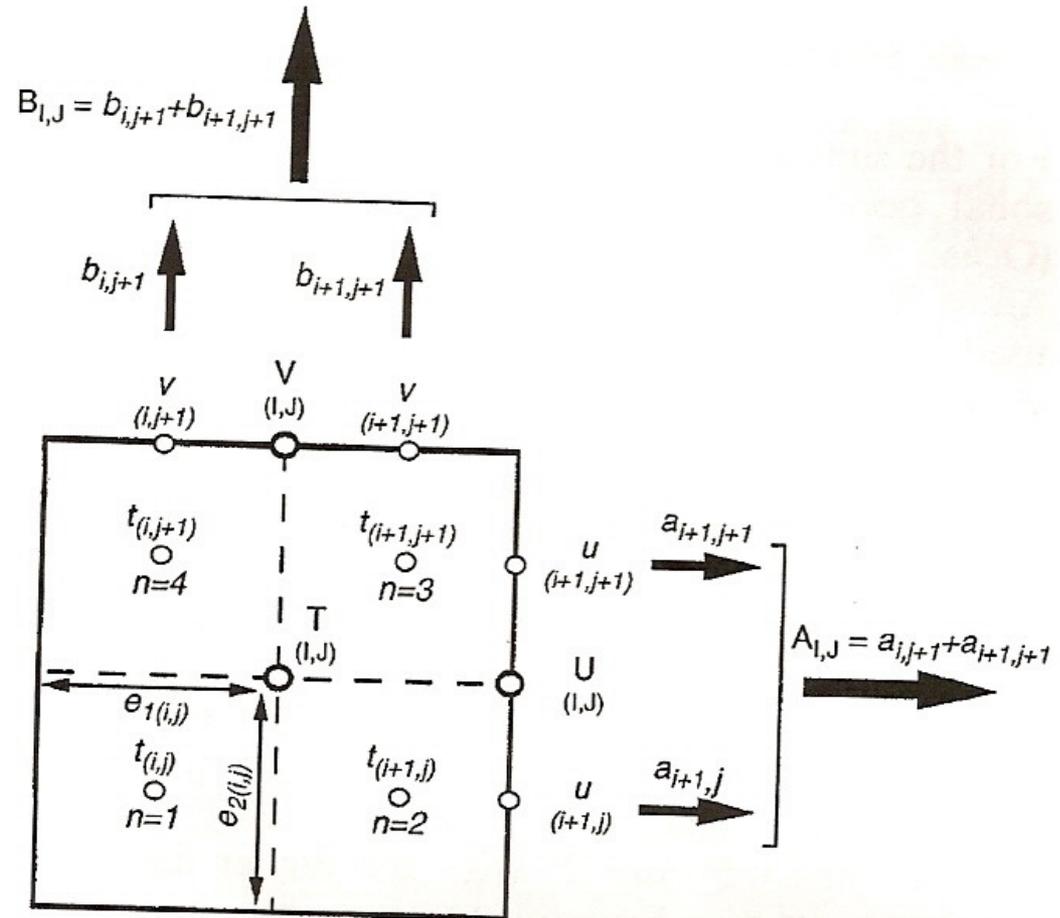
- deduced from the conservation of water fluxes at the border of the domain composed by the boxes which are assembled :
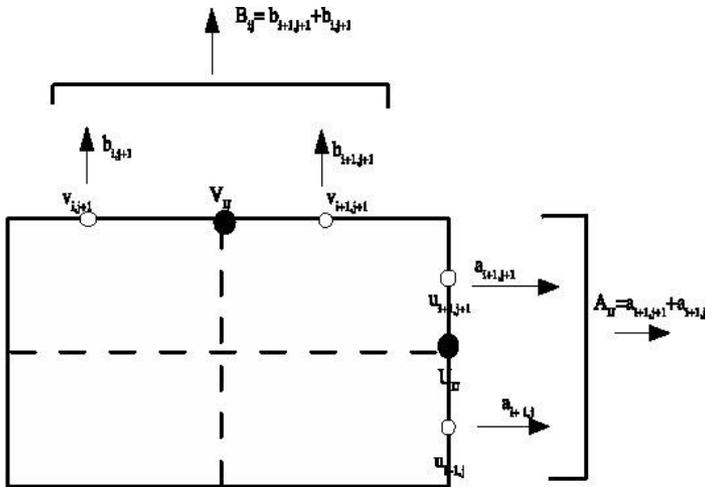

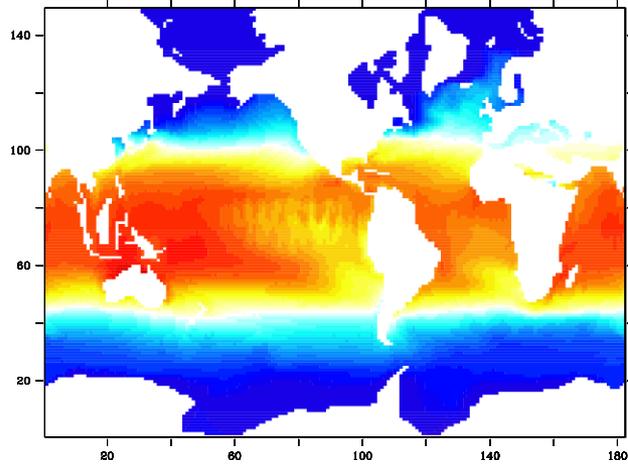**illustration of the conservation of water fluxes**

$$U_{IJ} = \frac{\sum_{j=1}^{ny} u_{i+1j} * e2u_{i+1j} * umask_{i+1j}}{\sum_{j=1}^{ny} e2u_{i+1j} * umask_{i+1j}}$$

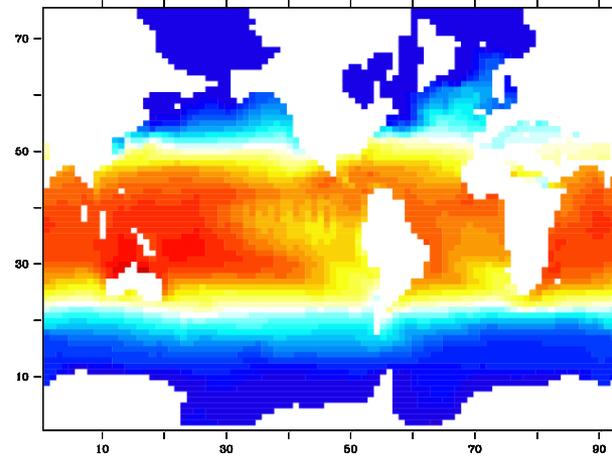$$V_{IJ} = \frac{\sum_{j=1}^{nx} v_{ij+1} * e1v_{ij+1} * vmask_{ij+1}}{\sum_{j=1}^{nx} e1v_{ij+1} * vmask_{ij+1}}$$

- Vertical velocity is computed so that one respect a fundamental properties : non-divergence of velocities

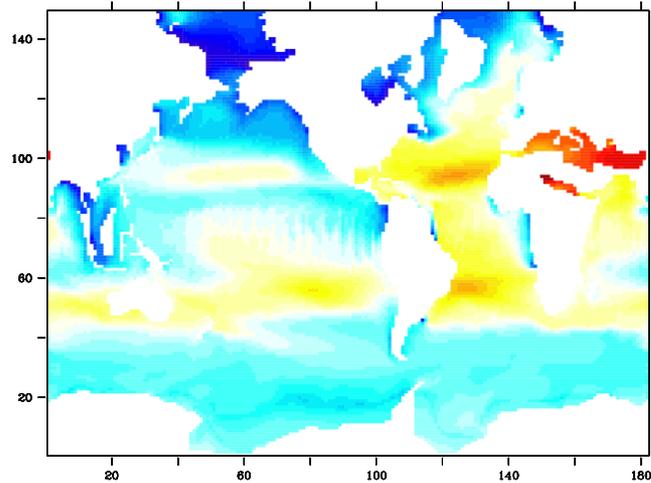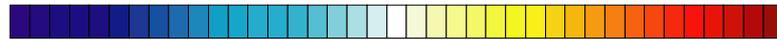$$\left. \frac{\partial W}{\partial z} \right|_{IJ} = -\text{hdiv}_{IJ}$$
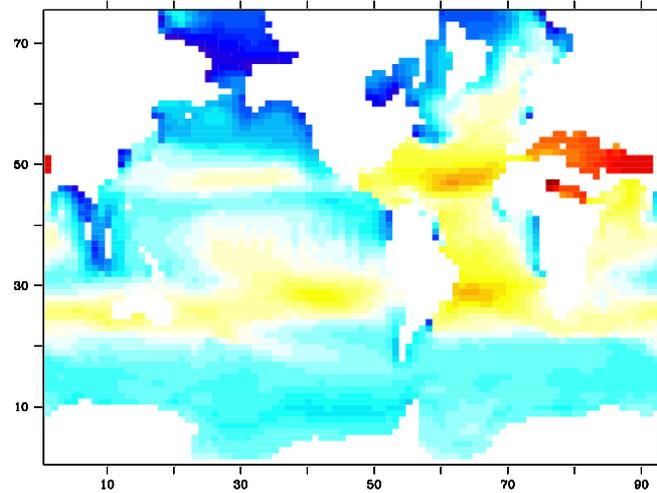
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sst in ORCA2 grid   sst in "degraded" ORCA2 grid by a factor of 2

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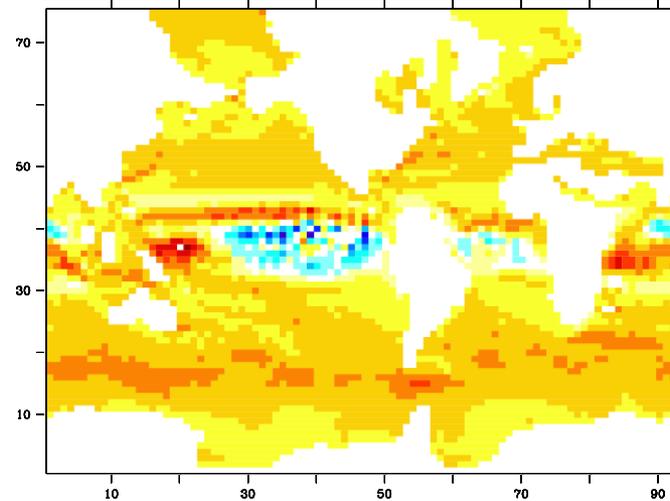sss in ORCA2 grid   sss in "degraded" ORCA2 grid by a factor of 2
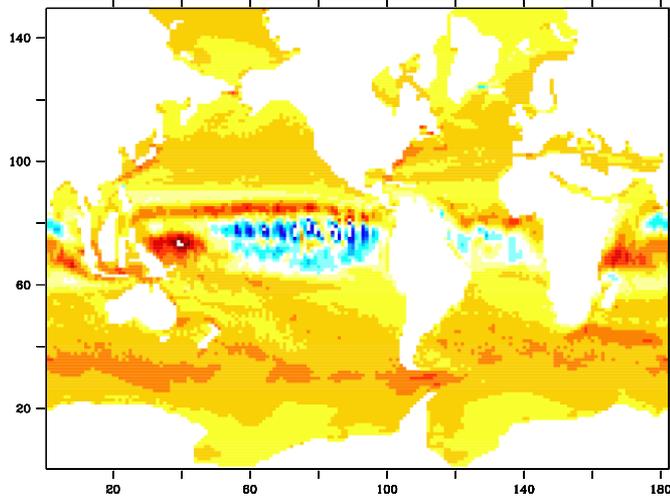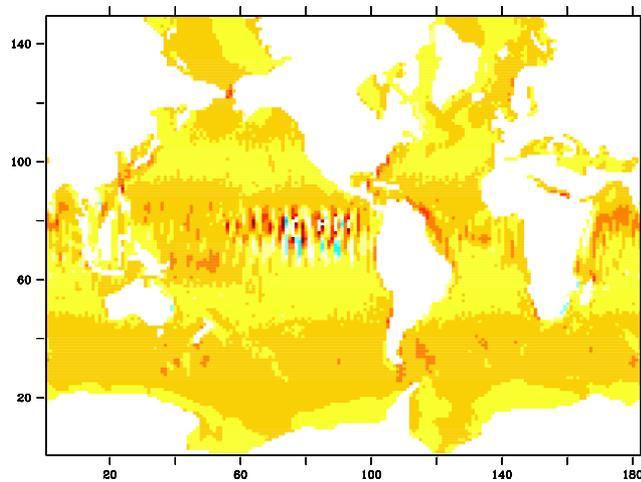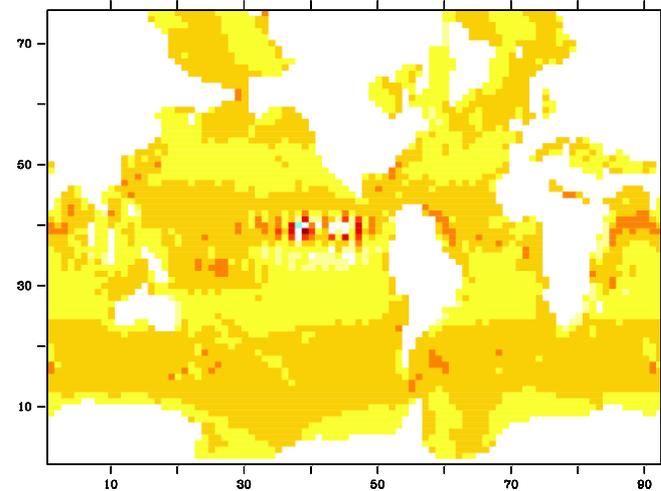
u-velocity in ORCA2 grid

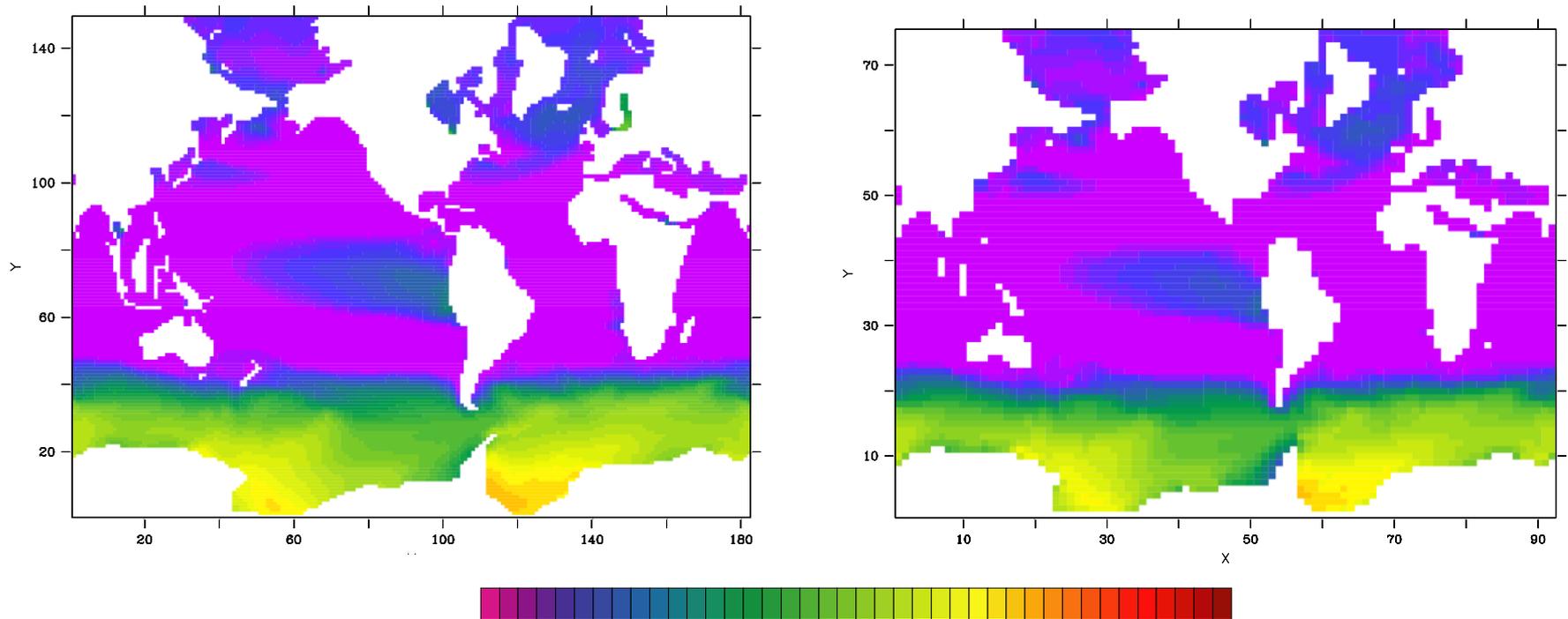u-velocity in "degraded" ORCA2 grid by a factor of 2

v-velocity in ORCA2 grid

v-velocity in "degraded" ORCA2 grid by a factor of 2

Good representation of large scale features
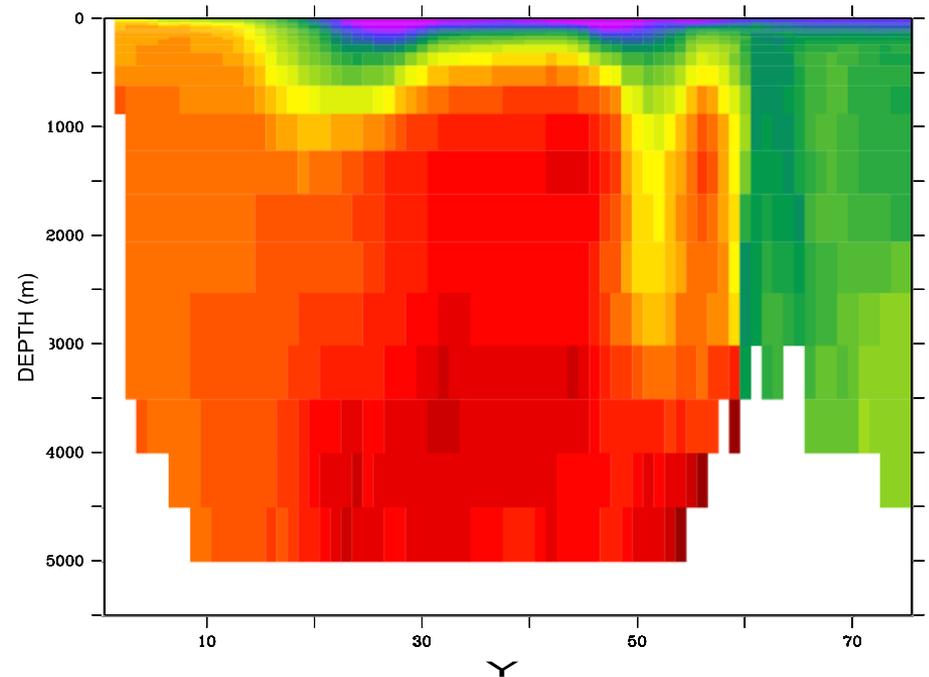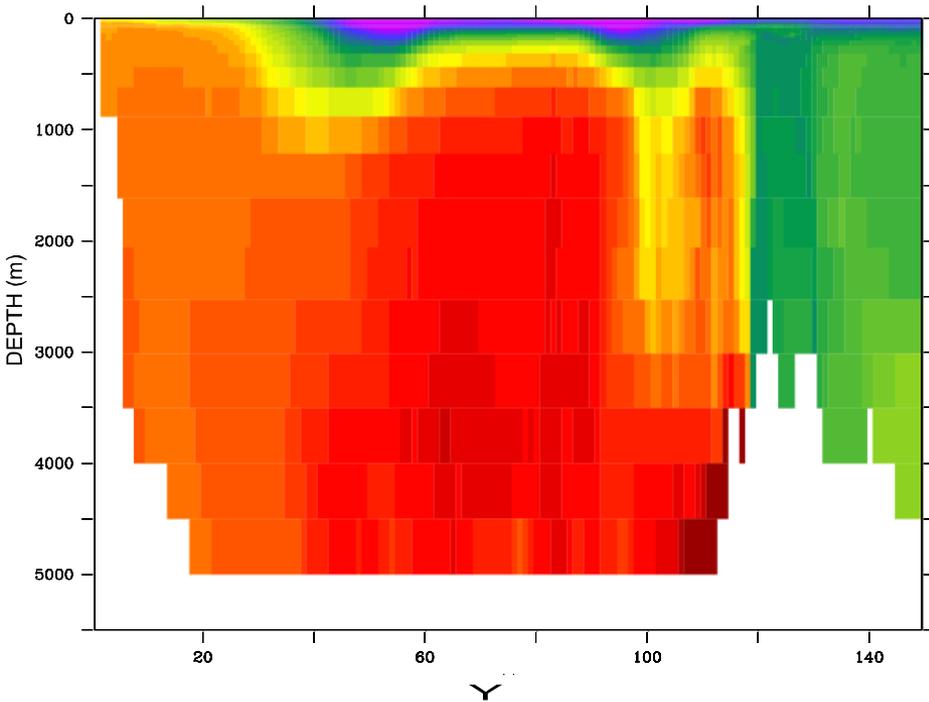
• 100 years of NEMO-PISCES run offline in ORCA2 configuration and with its degraded version by a factor of 2 [nx = 2; ny = 2]
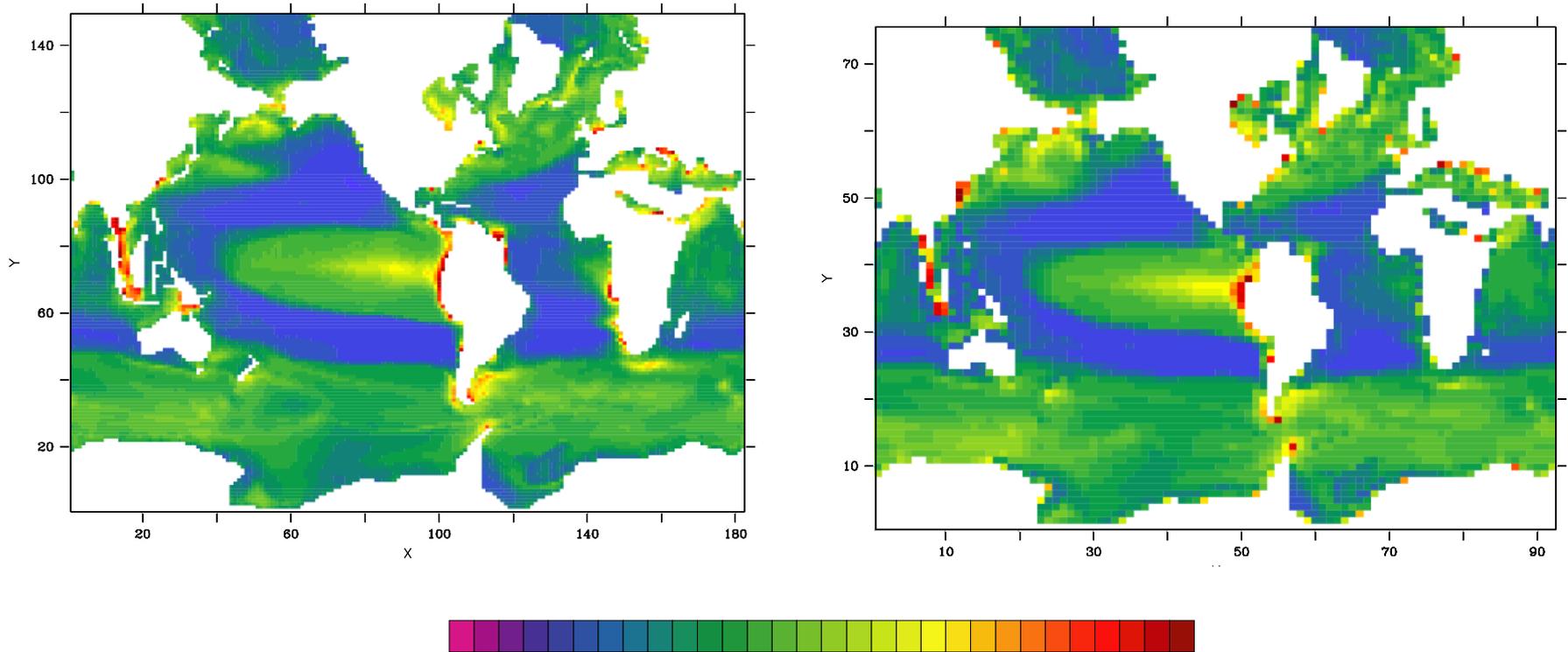
• just a look of preliminary results

Nitrates at surface

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Vertical distribution of Nitrates

Phytoplankton at surface

Most of the large scale features of all the tracers distribution are very well reproduced

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performances

	ORCA2	ORCA2 degraded [nx=2, ny=2]	ORCA2 degraded [nx=3, ny=3]
Memory size	1.7 Gb	500 mb	250 mb
CPU elapsed (100y)	120 h	20 h	10 h
Acceleration factor	1	6	12

Computational times for offline version of NEMO-PISCES on NEC-SX6 after 100 years simulations with DEGINT

perspectives

- Use this tool for postprocessing of both dynamics and biogeochemistry outputs for very high resolution models

- Performs 2 steps of degradation for higher resolution models (ORCA05, ORCA025)

- Include sophisticated means to transform small scales dynamics features into subgrid-scale mixing in the degraded model