Tidal effects in a global OGCM: comparison between coarse and high resolution configurations

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EGU conference (Wien) May 23rd, 2022

MOTIVATIONS

- ✓ When barotropic tides flow over topographic features in a stratified ocean they perturb the background flow and lose a portion of their energy into baroclinic modes

- ✓ Increasing the model resolution
  - improves the representation of complex coastlines and steep bathymetry
  - resolves a larger number of baroclinic modes and mesoscale features

- ✓ Implementing tidal parametrizations includes tidal processes that are unresolved by the model

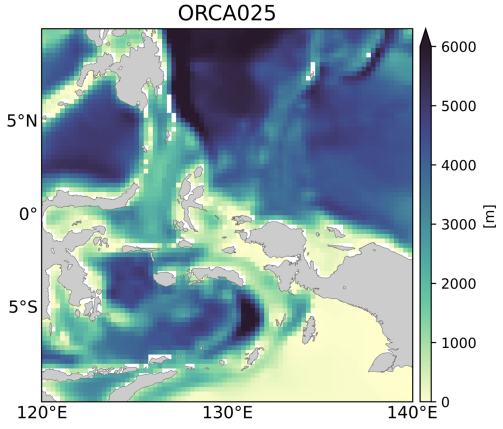
Do these improvements enhance the simulation of tides at global and regional scales?

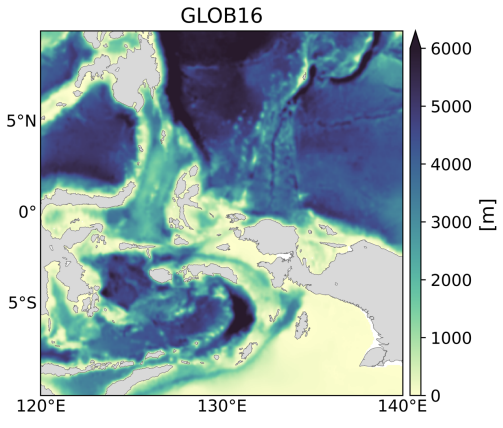
MODEL SETUP

Model : global configuration of NEMO-LIM2 v3.6

Tidal comp : M2, S2, N2, K2, K1, O1, P1, Q1, Mm, Mf, M4

	TIDE025	TIDE025_TWD	TIDE16
Grid	ORCA025	ORCA025	GLOB16
Horizontal res.	1/4°	1/4°	1/16°
Vertical res. (z* coord.)	75 levels	75 levels	98 levels
Time step	600 sec	600 sec	200 sec
Topog. wave drag	--	Shakespeare (2020) for dissip. waves	--
period	Jan 2016 – Jun 2017		
Atm. Forcing	JRA55 v1.4		
Init. Cond.	climatology from WOA13		

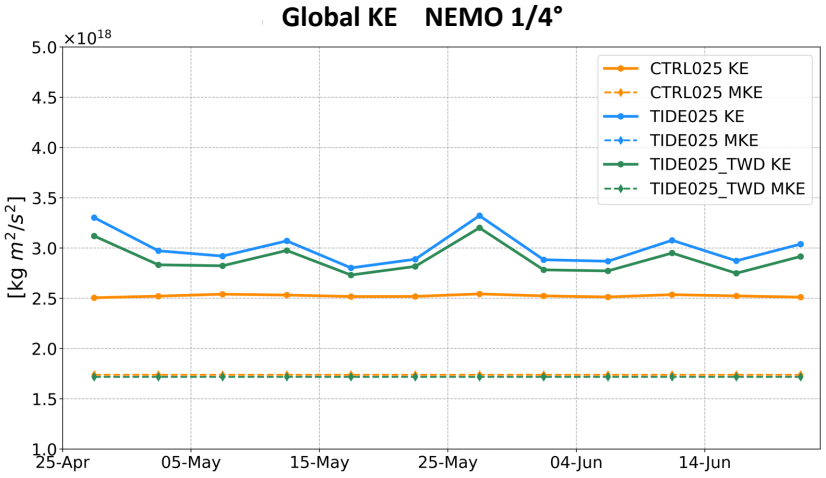


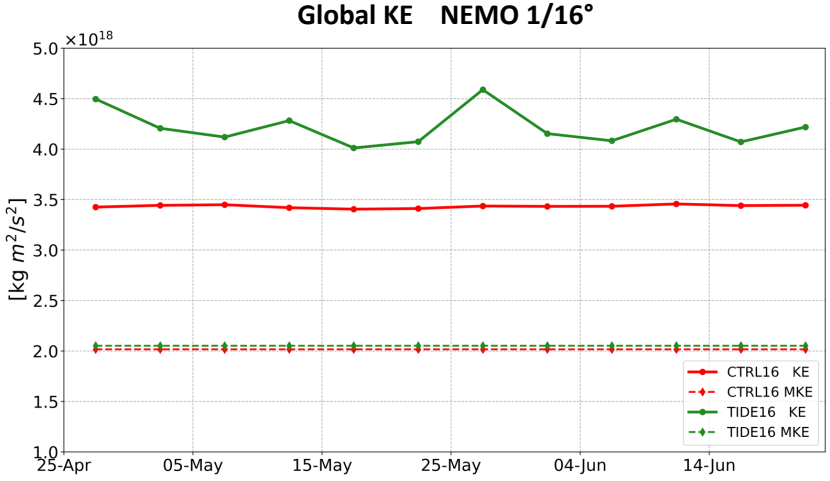


RESULTS: global KE

$$KE = \int_{V_{tot}} \frac{1}{2}\rho_0 \left[(\overline{\mathbf{u}} + \mathbf{u}') \cdot (\overline{\mathbf{u}} + \mathbf{u}')\right] \, dV = MKE + EKE$$

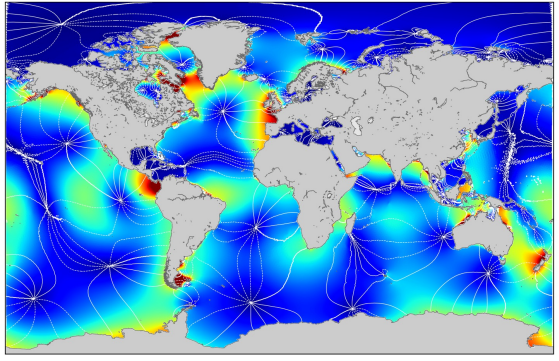
- The MKE is almost unperturbed by tides
- Increasing the resolution slightly increases the MKE and strongly increases the EKE
- Propagating internal tides interact with mesoscale features changing the EKE



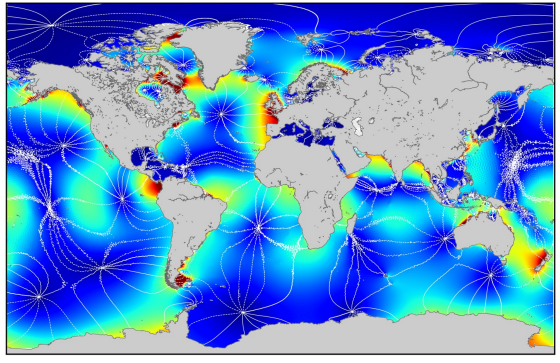


RESULTS: harmonic analysis M2

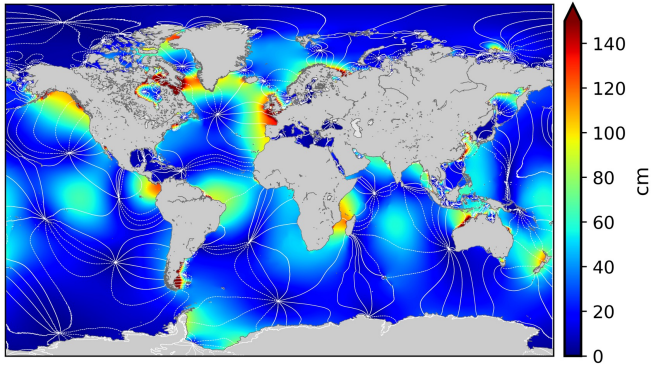
TIDE025



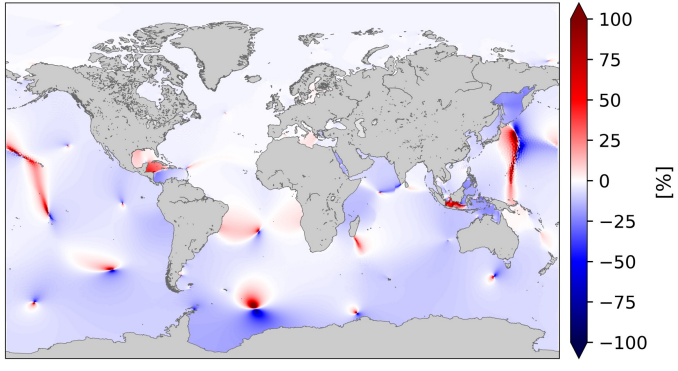
TIDE16



TPXO9

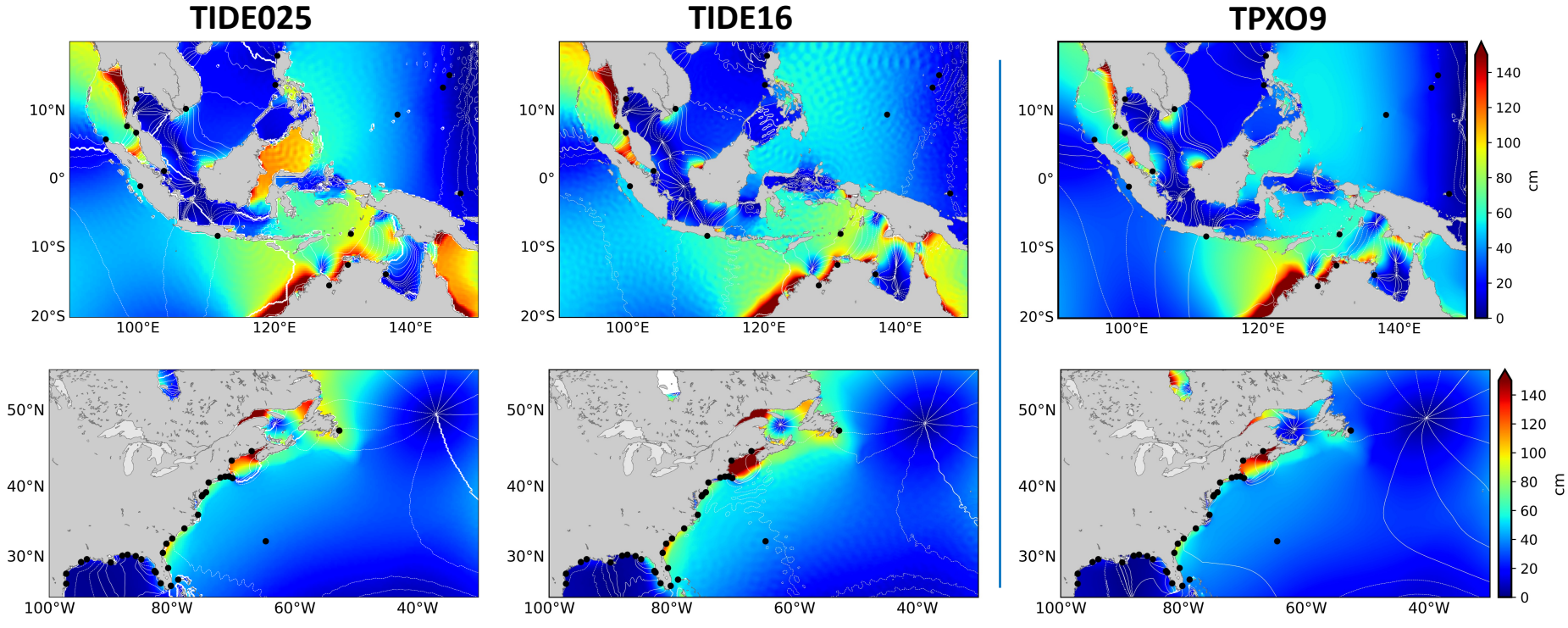


TIDE025_TWD – TIDE025



- NEMO model overestimates the M2 amplitude
- Highest differences are placed in the Southern Ocean
- The TWD decreases the M2 amplitude almost everywhere

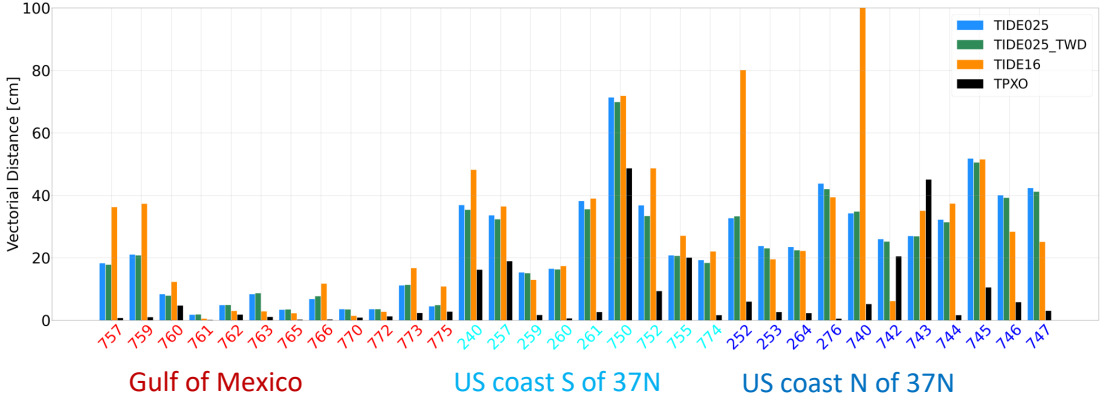
RESULTS: harmonic analysis M2

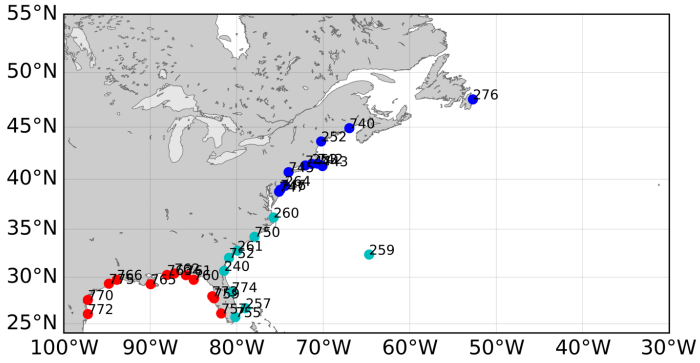


- TIDE16 performs better in regions of complex topography, but strong biases are still present compared to data-constrained tidal models

RESULTS: tide gauges comparison

North-west Atlantic Ocean: vectorial distance M2



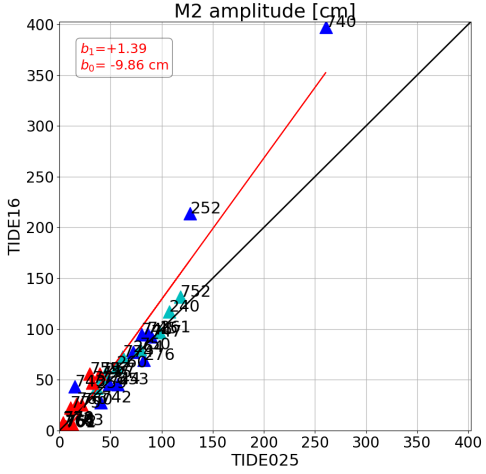


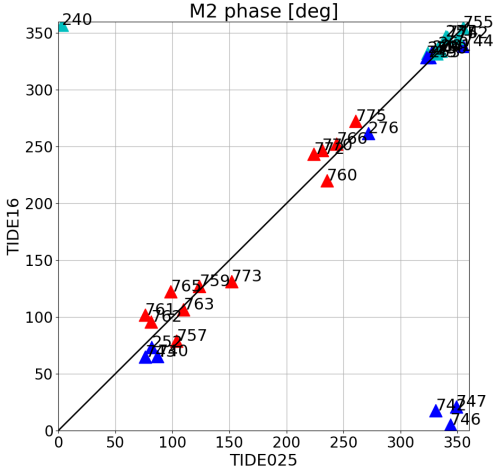
- In regions of complex coastlines TIDE025 performs better than TIDE16
- Improvements are obtained at the lower resolution when the TWD is implemented

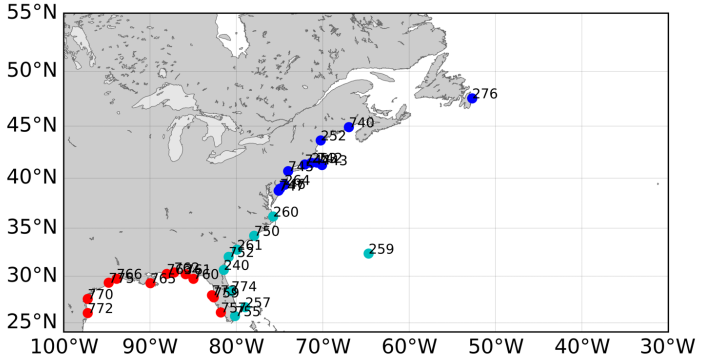
Tide gauges from the UHSLC dataset [Caldwellet al., 2015]

RESULTS: tide gauges comparison

North-west Atlantic Ocean: scatter plots of M2 amplitude and phase





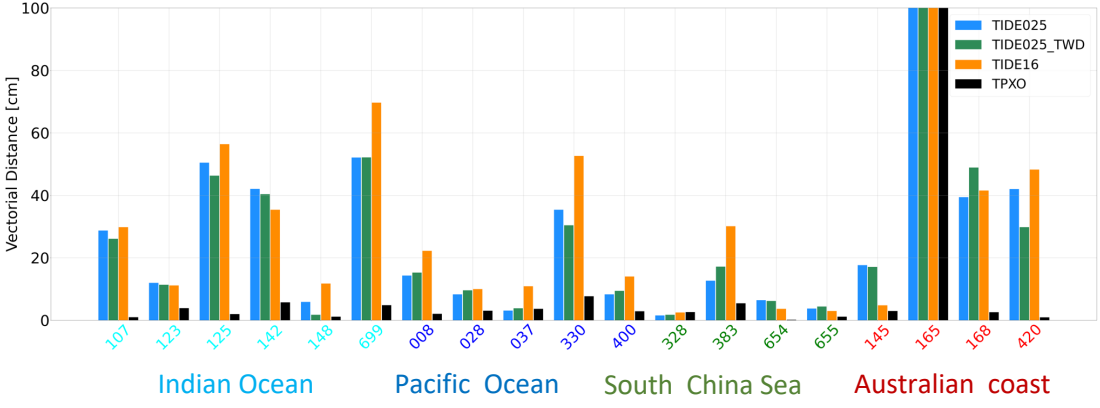


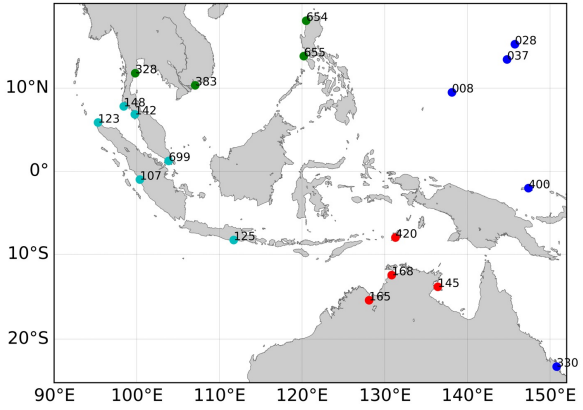
- TIDE16 strongly overestimates the M2 amplitude in the Bay of Fundy compared to TIDE025
- TIDE16 shows a weak phase lag compared to TIDE025 north of 37°N

Tide gauges from the UHSLC dataset [Caldwellet al., 2015]

RESULTS: tide gauges comparison

Indonesian region: vectorial distance M2





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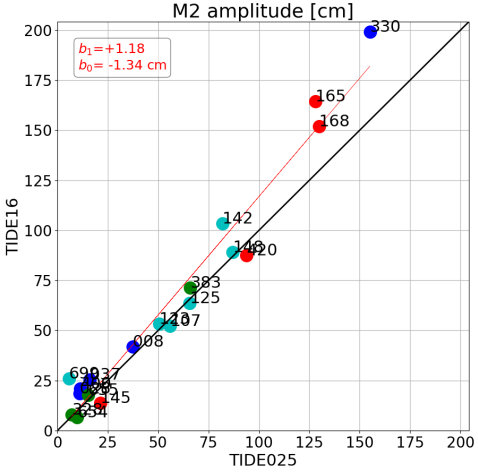

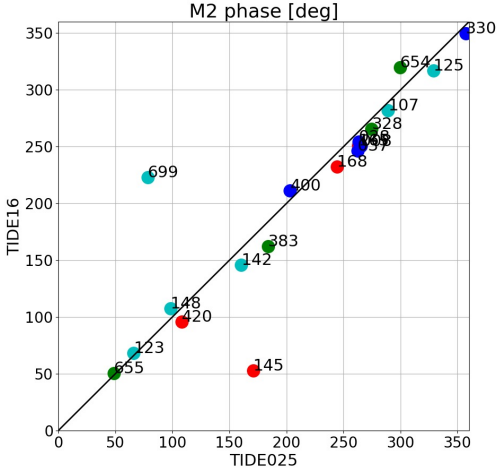

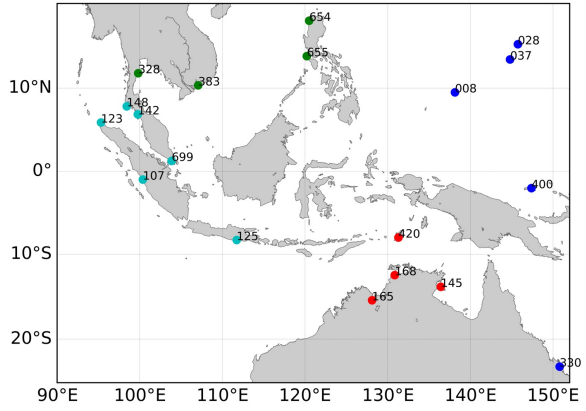

- TIDE16 simulates higher M2 amplitudes along the Australian coast compared to TIDE025

Tide gauges from the UHSLC dataset [Caldwellet al., 2015]

CONCLUSIONS

- ✓ Increasing the vertical resolution resolves a greater number of baroclinic modes, reinforcing the signal of internal tides at the sea surface
- ✓ The increased resolution enhances the interaction processes between tides and the background flow, worsening the comparison with tide gauges data
- ✓ Although coastal geometry and bathymetry are crucial factors in reproducing tides, many tidal processes are still missing into the model. When tidal parametrization of bottom drag is implemented in the 1/4° configuration, the agreement with observations is better than in the 1/16° case