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Nested high resolution models for the coastal areas of the North Indian Ocean

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Oceanographic processes at coastal scales require much higher horizontal resolution from both ocean models and observations as compared to deep water oceanography. Aside from a few exceptions such as land-locked seas, the hydrodynamics of coastal shallow waters is strongly influenced by the tides, which in turn control the mixing, formation of temperature fronts and other phenomena.

The numerical modelling of the coastal domains requires good knowledge of the lateral boundary conditions. The application of lateral boundary conditions to ocean models is a notoriously tricky task, but can only be avoided with global ocean models. Smaller scale regional ocean models are typically nested within global models, and even smaller-scale coastal models may be nested within regional models, creating a nesting chain. However a direct nesting of a very high resolution coastal model into a coarse resolution global model results in degrading of the accuracy of the outputs due to the large difference between the model resolutions. This is why a nesting chain has to be applied, so that every increase in resolution is kept within a reasonable minimum (typically by a factor of 3 to 5 at each step).

Global models are traditionally non-tidal, so at some stage of the nesting chain the tides need to be introduced. This is typically done by calculating the tidal constituents from a dedicated tidal model (e.g. TPXO) for all boundary points of a nested model. The tidal elevation at each boundary location can then be calculated from the harmonics at every model time step and the added to the parent model non-tidal SSH. This combination of harmonics-derived tidal SSH and non-tidal parent model SSH is typically applied to the nested domain using the Flather condition, together with the baroclinic velocities from the parent model.

The harmonics-derived SSH cannot be added to an SSH signal that is already tidal, so the parent model SSH has to be either detided or taken from a non-tidal model. Due to the lack of effective detiding methods and the prevailing view that harmonics-derived SSH provide a cleaner tidal signal over the SSH taken from a tidal parent model it has traditionally only been the last model in a nesting chain that is tidal. But to our knowledge these assumptions haven't been sufficiently tested and need to be re-visited. Furthermore, the lack of tides in the larger-scale regional models limits their capability and we would like to push for a nesting chain where all regional models (including the intermediate ones) are tidal.

In this study we have conducted a number of numerical experiments where we have tested whether a tidal regional model can effectively force a tidal nested model without resorting to detiding techniques and the use of a dedicated tidal model such as TPXO. We have tested whether it's possible to use a tidal parent model and use the total SSH (combined geostrophic SSH and tidal component) to force the child model at the boundary. We call this strategy "tidal nesting" as opposed to TPXO tidal forcing which is used in "traditional nesting".

For our experiments we have developed 2 models based on the same NEMO 3.6 codebase. The medium resolution AS20 model covers the Arabian Sea at 1/20 ° with 50 layers using a hybrid s-on-top-of-z vertical discretisation scheme (Shapiro et al., 2013); and the high resolution AG60 model covers the Arabian/Persian Gulf at 1/60 ° with 50 layers. The AS20 model is "traditionally" nested within the UK Met Office non-tidal large-scale Indian Ocean model at 1/12 ° resolution and tidal constituents at the boundary are taken from the TPXO7.2 Global Tidal Solution.
Our "tidal nesting" experiments use different forcing frequencies at which the tidal SSH is fed from the larger-scale AS20 into the smaller-scale AG60 model. These strategies are compared with "traditional nesting" where the inner AG60 uses boundary conditions from a non-tidal AS20 parent model and tides are computed from TPXO harmonics.

The results reveal an optimal tidal nesting strategy which forces tidal SSH from the parent model at 1-hourly intervals whilst non-tidal parameters are forced at 24-hourly intervals. The analysis includes comparisons with tidal gauges in the Gulf of Oman and inside the Arabian Gulf. The accuracy of tides inside the Gulf is inhibited by the narrow Straits of Hormuz, and tidal nesting doesn't achieve the same level of agreement with observation as traditional nesting. We also found that a further increase in the SSH forcing frequency to 30 minutes does not further improve the results. The forcing at intervals of 1h/24h for tidal/non-tidal parameters shows that a 2-step tidal nesting chain is viable and thus tides can be represented in more than just the last model of a nesting chain.

References:

Shapiro, G., Luneva, M., Pickering, J., and Storkey, D.: The effect of various vertical discretization schemes and horizontal diffusion parameterization on the performance of a 3-D ocean model: the Black Sea case study, Ocean Sci., 9, 377-390, doi:10.5194/os-9-377-2013, 2013.