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A new method for downscaling of forecasting ocean models - the Red Sea case study

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High-resolution modelling involves a significant increase in the computational cost. We present an efficient tool for ocean model downscaling based on the combination of deterministic and statistical approaches. The deterministic component of the presented method is the use of an output of a standard ocean model such as NEMO, ROMS, Hycom etc. The stochastic element is applied to the areas smaller than the Rossby radius of deformation, where the spatial patterns of parameter distribution are more coherent. The stochastic component is based on the method of objective analysis (Gandin 1963 and following publications), similar to what is used for data assimilation in ocean models.

We present an operational numerical model called the Stochastic Model of the Red Sea (SMORS) that produces high resolution (1/20th degree latitude mesh) oceanographic data (S, T, SSH, UV) of the Red Sea using the output from a coarse resolution (1/12th degree mesh) parent model PSY4V3R1 available from Copernicus Marine Environment Monitoring Service (http://marine.copernicus.eu) and the tidal information from the TOPEX/Poseidon Global Inverse Solution (TPXO, http://volkov.oce.orst.edu/tides/global.html). While this model was developed for the Red Sea, we believe that the presented method can be used efficiently in other areas for high-resolution downscaling.

The model works in two stages, firstly, it produces stochastic downscaling of Mercator PSY4V3R1 daily average data into the high resolution mesh using an Objective Analysis technique. Secondly, tidal currents are added using tidal constituents retrieved from the TPXO model. The stochastic downscaling is based on assimilation of data from the coarse grid onto the high-resolution grid using similar techniques as those used to assimilate the observations into the model runs.

The outputs from the coarse-resolution model are used in conjunction with the auto correlation functions (equivalent to the structure function) to create a cost function at each output node. Then, the value at this node is computed as the one that minimizes the cost function, to minimize the variance of the error and achieve the best possible accuracy of the results. This process is repeated for all the output nodes. The way the structure function is constructed is based on the isotropy and statistical homogeneity (ergodic) assumptions.

The model has been validated against SST and ARGO floats observations over 2016. Comparisons show that the model and observations are in good agreement. The domain-averaged monthly mean bias in SST was between 0.01°C and 0.31°C, while the RMSE ranged between 0.37°C and 0.68°C. The skill of the model to reproduce vertical profiles of temperature was assessed using monthly averaged differences between the SMORS model and ARGO float data. For example, in May 2016 the maximum discrepancy of 1.2°C was at the depth of 700 m. In the dynamically active layer 0-300 m the error was very small not exceeding 0.3°C. Note that SMORS did not assimilate the observational data used for validation.