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A review of recent super-ensemble multi-model challenges, developments, results, and perspectives for the coastal ocean

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An increasing number of models are now able to provide forecasts for the coastal ocean. Nevertheless, due to the nature of coastal ocean dynamics (multi-processes, multi-scales, multi-interactions, multi-forcings), the predictive skill of these numerical models is inevitably limited, affected by (i) an incomplete representation of ocean processes, (ii) a scale-limited formulation of ocean physics, (iii) a number of simplifying hypothesis which tend to de-couple processes, and (iv) uncertainties in the atmospheric and boundary forcings. To improve forecast skills, data assimilation is generally used to integrate information from satellite and in-situ measurements into the forecasting system. Observations of the ocean surface are routinely provided by Sea Surface Temperature (SST) and Sea Surface Height (SSH) operational satellites. High-frequency coastal radars also measure coastal surface currents in an increasing number of littoral regions. Moreover, when deployed in the area of interest, mooring measurements, ship-based XBT/CTD profiles and autonomous underwater vehicles (gliders) provide additional information about the vertical structure of oceanic variables.

Based on the idea that (i) different models may have different skills in reproducing the ocean state, and (ii) these skills probably evolve in time due to the temporal variability of coastal ocean dynamics, multi-model fusion methods have been developed with the aim to improve our ocean forecast skill. One of such method, known as Super Ensemble (SE), produces an optimal weighted model combination which minimizes the mismatch with observations over a specified learning period. This optimal combination is then used to produce an optimal ocean forecast. The SE approach was demonstrated to improve the forecast skills with respect to single models and to the model Ensemble Mean when applied for surface drift and acoustic profile prediction. It was also shown to improve the temperature predictions in a coastal ocean environment.

After a brief review of recent achievements in the field, we will present a further evolution of the SE technique allowing for the dynamic and multivariate evolution of model weights in the three spatial directions. This new three-dimensional Super Ensemble method (3DSE) uses a 3D Kalman Filter in the space of model weights, which eventually exploits the multivariate covariance of underlying numerical models and assimilated in-situ glider data and SST. The method has been validated for coastal temperature predictions using the LSCV08 sea trial data collected in the Ligurian Sea. Results and ideas for improvements will be discussed.