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Three-Dimensional Reconstruction of Ocean Current Circulation from Coastal Marine Observations: Challenges and Methods

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Monitoring and investigating the dynamics of coastal currents is crucial for the development of environmentally sustainable coastal activities, in order to preserve marine ecosystems as well as to support marine and navigation safety. Multiplatform observing systems are arising in several areas of the coast and this work investigates the feasibility of combining observations from independent and complementary platforms providing data at different spatio-temporal scales.
We investigate two methods to reconstruct the Three-Dimensional current velocity field: the Reduced Order Optimal Interpolation (ROOI) and the Discrete Cosine Transform Penalized Least Square (DTC-PLS). ROOI is an Optimal Interpolation method fed, in our case, with a spatial covariance matrix extracted from a realistic numerical oceanic model. DCT-PLS is a gap-filling method based on penalized least squares regression, relying on a purely statistical approximation that balances fidelity to the data and smoothness of the solution.
As a proof of concept we test the methods' skills by using pseudo-observations of currents, extracted from the IBI CMEMS model. The test set-up simulates the real observatory configuration in the study area (SE Bay of Biscay) which includes water column in-situ observations (ADCPs) as well as sea surface remote measurements (HF radars). The outputs of the methods are compared with the corresponding IBI CMEMS model fields, which are also used as the synthetic 'truth'.
In the case of the ROOI method, different historical datasets have been tested to infer spatial covariances independent to the pseudo-observations obtained from IBI CMEMS. For the DCT-PLS method, the only input are the pseudo-observations obtained from the IBI CMEMS model.
Globally, the ROOI method provides the best results for the zonal component, if we consider the whole study area. Similar results using both methods are obtained for the meridional component and, in general, in the areas with high density of observations. The advantage of the ROOI method is that physical relationships are used to carry out a more robust blending in areas where there is low density of observations (i.e. through the spatial covariances obtained from the model). On the other hand, the disadvantage is that a model for the covariance matrices is needed; and therefore, the DCT-PLS method seems to be a good option if there is high density of observations and/or absence of an appropriate model in the area. Both methods could be used to obtain new operational products integrating complementary observations as well as broadening the applications of the observational data for coastal risk assessment, for model validation, and for the optimal planning of future coastal infrastructures.