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Use of FerryBox surface temperature and salinity measurements to improve model based state estimates for the German Bight

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A FerryBox is an autonomous measurement, data logging and transmission system, which operates continuously while the carrying ship is on its way. Measurements are made using devices, which are either in direct contact with or sample from a continuous flow of seawater taken from a water depth of 4-6 m. The potential of FerryBox sea surface temperature (SST) and salinity (SSS) measurements for the improvement of state estimates in the German Bight is investigated. A Kalman filter approach is applied to extrapolate the one-dimensional FerryBox data acquired along the ferry route from Cuxhaven to Immingham to larger two-dimensional areas. The method makes use of a priori information about the background statistics provided by a numerical model. The impact of the special FerryBox sampling with a revisit time of typically 36 hrs is investigated based on synthetic data. In particular the aliasing problem associated with the M2 tidal signal is discussed. We found that with a careful selection of the measurement errors a good performance of the extrapolation method can be achieved for SST. The extrapolation and assimilation of SSS data turned out to be more demanding because the natural variability of SSS along the FerryBox track is small compared to the measurement errors and the errors resulting from the specific FerryBox sampling.
In order to asses the significance of FerryBox measurements for the simulation of SST and SSS characteristics in the German Bight we present two dimensional maps of extrapolation error estimates based on model statistics. It is shown that the extrapolation method makes use of certain correlation properties of the SST and SSS fields, which change significantly during the annual cycle. During autumn and winter, which are characterised by mixed conditions, spatial patterns of error estimates reflect the water column depth implying a significant influence of storage processes. From spring to summer the transport processes associated either with the propagation of low salinity water originating from the Elbe Estuary or warmer coastal water become more important because of the stronger stratification.
Finally, FerryBox measurements acquired in 2007 are used for assimilation experiments with a 3-D primitive equation model. A localised optimal interpolation (OI) technique is applied for this purpose. We asses the skill of the assimilation run by comparisons with independent observations from up-to-date remote sensing products, and classical in-situ observations. It is demonstrated that an assimilation of FerryBox SST data leads to a qualitative improvement of the SST state estimates over large areas while FerryBox SSS data seem to provide valuable information on processes taking place on synoptic and short time scales.