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Ocean Science
Discussions

Interactive comment on "Ensemble smoother for optimizing tidal boundary conditions by assimilation of high-frequency radar surface currents – application to the German Bight" *by* A. Barth et al.

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The authors present a methodology for estimating tidal boundary condition by assimilating HF radar surface current and M2 tidal parameter. Boundary perturbations are produced with a variational approach, in order to ensure physical consistency. The optimal boundary conditions are estimated over one assimilation cycle of 40 days, using a scheme similar to an EnKS. The "optimal boundary conditions" are then used in a rerun to ensure physical consistency of the result. The method improves 1) result comparison with HF radar surface current (both assimilated and not assimilated); 2)

comparison with a tidal atlas; and ranges of phase and amplitude at two tide gauges.

The manuscript addresses several interesting problems, i.e. assimilation of HF radar data, and assimilation for improving tidal signal. Most of the problems are treated in an elegant manner and with rigor. The part concerning data assimilation is in my view, the weakest part of the paper. Hypotheses are not well described, and the method used should be replaced in the context of ensemble smoother. I've included some comments below that the authors should address before this paper is finalized, but I recommend that the paper be accepted. It's a good contribution, with important implications for operational oceanography.

Comments:

More details about the smoother should be given in the introduction. A lot of paper has addressed the problem of smoother namely: Hunt et al. 2004 (Phys D) Hunt et al. 2007 (Tellus) Sakov et al. 2009(Tellus) How would the authors place his method among these recent studies? I believe the method used here is an EnKS (or a AEnKF or a LETKF) in terms of the estimation of boundary conditions. Here, the model state is extended with boundary perturbations; the present study consists of 1 assimilation cycle of 40 days that minimizes the surface current innovation and M2 tidal parameter. The optimal boundary perturbation is a combination of the ensemble boundary perturbation. The only difference with these methods is the rerun step. Such procedure is commonly used in petroleum application. They estimate parameters (porosity, permeability, etc, . . .) ; observe pressure and rproduction rate at wells (no observation error), and at the end make a rerun in order to have a physically consistent and continuous simulation. They still claim using an EnKF /EnKS as they consider that the rerun does not make a new approach (See for example Evensen 2006 Data assimilation: The Ensemble Kalman Filter). Therefore, I would refer to this method as new, and merge section 4.2 and 4.3.

There is little information about the data assimilation problematic (except for the noise)

and hypothesis made. I would expect in the introduction or in the data assimilation part, a discussion explaining the problematic, and then explain why the chosen data assimilation method is adapted for the problem. For example, I understood that the "optimal boundary perturbation" is a combination of the different boundary perturbation obtained by minimizing variance of the surface current innovation and M2 tidal parameters innovations. This implies that the surface current depends linearly on the boundary condition? Is this reasonable? Furthermore, making the comparison with other method clear, a lot of sparse comments that can be considered as erroneous depending on the context can be removed. (e.g. "unlike Ensemble Kalman Filter" in page 2435, or "unlike classical Kalman Filters" in page 2433 . . .)

In the introduction, the authors detail to my view too much engineering methods for reducing assimilation noise that is out of the scope of the paper. For the purpose of the study, one must use a method that does not produce assimilation noise. A smoother is an appropriate solution, and this paragraph is to my view not needed.

It is assumed that error in tidal signal is only originating from boundary condition, but a part from it is also originating from inaccuracy in the bathymetry. I believe that this deserve a comment in the text. You could mention as a future perspective that the method can perturb not only boundary condition but also the bathymetry as done in Mourre et al 2004 (http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VCR-4DKH0WS-1&_user=615901&_rdoc=1&_fmt=&_orig=search&_sort=d&_docanchor=&view=c&_searchS
In addition information about the bathymetry is missing in the model part ?

One of the main problem using HF radar is the presence of the Stoke drift in the data but not in the model. Stoke drift is mentioned in the abstract, but not in the rest of the paper.

Page 2425 line 3: It is not the frequency of assimilation that creates noise, but the way the assimilation is done. In the case of the EnKF it is the linear approximation (and rank

issue) that causes most of problems. One can even think opposite: the more frequent the assimilation, the less strong the assimilation, and thus the less the assimilation noise.

It is not clear how the tides are force in the model. Are they forced by the outer Nordic Sea model (u, v eta). Which tidal atlas has been used: EOT08a ?, FES2004 ?

The model resolution (0.9 km , sigma, time) differs from observation (3km, 0.5 m, 18min). Is this taken into consideration with H ?

I understood that the values optimized by data assimilation are ζ', u', v', is this correct? Those vary spatially, but are constant in time? Maybe it can be interesting to have a figure of the final optimized boundary M2 perturbation ?

In 4.2 it is said that x is an ensemble of forcing field. I understand that this part is theoretical as it intends to introduce a new method. For this application, the forcing fields perturbs are only M2 tidal parameters? I find it confusing to have the theory and the application split, and I would rather explain clearly what is x, y, R , their dimensions for this particular application.

Page 2435 line 21: "Also for every . . . complex tidal parameter are interpolated at the grid of EOT08a data". Is it correct that you assimilate both model surface current vs HF radar, and model M2 tidal parameter vs EOT08a ? I guess this would become more obvious by defining clearly x,y, R. I would rather pace the definition of observation error in the data assimilation part instead of page 2429.

Figures: It is a policy of the journal to put the variables and units on the axis.

Figure 2: I think it would be nice to add the model's boundary.

Figure 6: I would put a line at the value retained (0.2). (Similar comment could apply to Figure 7)

Interactive comment on Ocean Sci. Discuss., 6, 2423, 2009.