Ocean Science Discussions

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Comment on os-2021-80

Edward Zaron (Referee)

Referee comment on "Simultaneous estimation of ocean mesoscale and coherent internal tide sea surface height signatures from the global altimetry record" by Clément Ubelmann et al., Ocean Sci. Discuss., https://doi.org/10.5194/os-2021-80-RC1, 2021

This manuscript describes a new approach to estimating the mesoscale and coherent baroclinic tidal
sea level anomaly from satellite altimetry. It uses a type of Gauss-Markov filtering
on a reduced basis of space-time functions which have been cleverly chosen to approximately diagonalize
the covariance functions. The approach is applied locally to a partitioning of the global oceans, and the
results are stitched together via linear interpolation. Although, the results include estimates of both
the time-dependent mesoscale sea level anomaly and the baroclinic tides, only the tides are examined
in detail.

This is an original approach and the paper does a good job of describing the context, methodology,
and results of the study. I like the paper a lot and I believe it will be of interest to many readers
of Ocean Science Discussions. I recommend publication after minor revisions to address the points below.

Larger comments:

No details seem to be provided about the Q matrices for both the mesoscale and tidal signals. Can you provide,
say, a pseudo-spectrum of variance that shows how Q varies as a function of wavenumber or horizontal mode
number; or do you feel that this is represented equivalently with the physical-space representers
shown in Fig 5? Can you provide maps of the mesoscale and tidal variance (i.e., the diagonal elements of the

Q matrix)? Did you perform any tuning to adjust the ratio of Q and R, or the ratio of the tidal Q and the mesoscale Q?

If I understand correctly, the estimate you compute using eqn (8) or (13) is biased towards zero. A symptom of this bias is the observation that the explained variance is larger than the signal variance (as you noted with regard to the bottom panel of Fig 8). Can you plot a map of this variance ratio and interpret it with regard to either the bias or the tuning of Q? Would you consider using a non-zero estimate of the tide or the mesoscale in order to reduce this bias?

No details are provided with regard to the time-dependence of the tides, except for equation (4). It appears that the nodal modulations have been omitted, but this is a substantial effect over a 25 year record. Properly accounting for this would probably further increase the explained variance of the tidal estimates with respect to both the validation data and the assimilated data; and it should furthermore reduce the (low) bias of the tidal amplitudes.

The English language usage is sometimes awkward or non-standard, especially with regard to capitalization. I am not evaluating it or going to list all the potential edits during this reading.

Smaller comments:

l14-15: Not sure where they get the 70% phase-modulated.

l35: "covariances" --> "spatial covariances"?

l49: specify, "x_i and x_j are uncorrelated for i \ne j"

l62: Here it is specified that x_1 refers to the time-series of a scalar. Aha. But after line 70, it is clear that x_2 is a two-component vector containing the harmonic constants of the high-frequency component.

l75: The reference to localization should either be dropped or explained precisely what is meant.

p4, last line: How does it differ from harmonic analysis? If it is identical, then say so.

l80: By "sequential estimation" do you mean that the low-frequency component is estimated by itself from the entire time series, and then this estimate is subtracted before estimating the high-frequency component? This usage of "sequential" is confusing since the term might also refer to sequential estimation (i.e., a Kalman filter) which sequentially processes the observations in time.

l95-l100: This is very good discussion of bias in this context.

l125: Can you support your assumption that no correlation exists between the components (l116) by saying that the \Gamma_k are chosen to approximately diagonalize the state covariance? If you could provide some observational data to support the choice of \Gamma_k, that would be even better! Aha: now I see the mention of this later, around l130.

l161: I believe the reference should be to Fig 4, not Fig 3? You will probably need a reference or short discussion to explain what is a "representer".

Fig 4: Was the representer shown in the right panels constructed from the 12-equiangular basis elements? I am surprised that it is as radially-symmetric as shown.

l173: This is a good compromise between domain size and degrees of freedom.

Fig 5: Did you subsample or average the observations in the along-track direction? Or did you use 1 Hz data? Why not show the same lat/lon window in each panel?

l231: How were the diagnonals of the Q matrices chosen initially? What information was used to estimate
the variances of the signals?

Fig 8 and discussion: Usually "signal variance" refers to the data, but I believe you are using it to
refer to the variance of the estimated signal. Perhaps this could be clarified. My interpretation
is based on the fact that you note the explained variance is larger than the "signal variance" in
cases 2 and 3.

Maybe I missed it, but no where do I see discussion of what altimeter missions were used. It looks like CryoSat-2
is in the post-2017 validation dataset, but is this the only mission used?

l235: Why are you using only a year for the validation period?

Fig 10: Please state the units of the comparisons (cm^2, I think?).
Why does the bias problem not seem to be as large as suggested by Fig 5? Perhaps I do not
understand your sequential estimates, and they differ more significantly from the approach
used in HRET. Or, maybe your low-frequency solution obtained here is quite different from
the Duacs/Ssalto-based mesoscale correction used in HRET. Based on your Fig 5, I would have expected your estimate to explain a lot more variance than HRET.

Table 1: What do the percentages refer to (is the decimal point placed correctly?)? Please label the
sub-tables with M2 and K1.