

Interactive comment on “Assimilation of SST data in the POSEIDON system using the SOSSTA statistical-dynamical observation operator” by Gerasimos Korres et al.

Anonymous Referee #1

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1 general comments

The manuscript “Assimilation of SST data in the POSEIDON system using the SOSSTA statistical-dynamical observation operator” posits a new observation operator (the SOSSTA operator) that accounts for diurnal warming of the water column in the near surface. The suggested method is statistical and uses pre-estimated functional forms, which depend on the wind speed and insolation, to extrapolate the model temperature to the surface. The extrapolated observations are then compared to satellite observations, with the observation minus model differences used in a data assimilation scheme. Results from a test of the system are shown using a model of the Aegean

sea.

I found the scientific ideas in this paper to be reasonable and worth pursuing. I also, despite the clear need for additional proof reading (eg every figure reference in the text was wrong), found the paper to be written to a reasonable standard. Unfortunately, I believe the methodology used when actually applying their ideas to be seriously flawed. In particular, the decision to throw away the data over most of the domain is questionable. Additionally, the authors have also failed to show that their method has any benefit over just using a simpler observation operator—an absolutely vital requirement for a paper of this type.

To fix the problems I believe the authors will need to rerun all of their experiments and include at least one more. Obviously this will require a rewrite of the results section as well. This will be a very substantial amount of work and probably not feasible as part of this submission of the paper. I am thus recommending the paper be rejected. However, as I believe the underlying ideas to be sound, a resubmission of the paper at a later date should be acceptable if actions are taken to remedy the identified issues.

2 specific comments

- The single biggest flaw with the manuscript is the lack of a control experiment where the SEVIRI data are assimilated by just comparing the SST values directly with the top model level (as is done with the AVHRR data). The authors scheme is supposed to be an improvement on this simple method, so not including such a test is a massive omission.
- The justification for discarding SEVIRI data where the top model level is deeper than 1.55 m is poor. It is clear from their figure 7 that this choice has resulted in most of the data in the domain simply being thrown away, and it is difficult to see this as anything other than a major flaw with the method. It is a reasonable

assumption that the night time diurnal signal is small so, at the very least, night time SEVIRI data should have been used everywhere.

- I also think that excluding AVHRR data when the model level is deeper than 6 m is a poor decision, and throws away significant numbers of perfectly good observations. Firstly, the choice of 6 m seems arbitrary and is not justified (GHRSSST tend to use 10 m as representative of the foundation temperature). Secondly, once you get below the warm layer, the temperature should be fairly constant down to the base of the mixed layer. I don't know the depth of the mixed layer in the study area, but unless it is shallower than 6 m the observations should be used.
- From reading the paper it is clear that the canonical operators depend on the atmospheric conditions. However, this wasn't really apparent until the results section. I think this fact needs to be given much greater prominence and discussion earlier in the paper. Also, how many sets of operators were produced, and what were the associated weather conditions?
- (L92-93) I found it surprising that the RMS errors against SEVIRI directly were smaller than the diurnal magnitude errors (which is difference between two noisy numbers, with additive errors). This is probably correct, but needs further comment.
- (Sec 2.1) You talk about the RMS error, but it would be good to see how the error splits into bias and random parts.
- (Sec 2.1) I don't see the point in the first training set. Using the average temperature rather than the morning temperature will bias everything warm. To my mind this is not scientifically justifiable, so should not be included.
- (Sec 2.2) I think this section should be re-written to make things clearer. In particular:

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- You seem to have written the equations assuming a single observation (although you don't state this). In reality this will rarely be the case. It would be better to consider the multiple observation case and state the size of the vectors and matrices.
 - In general your \mathbf{a} and \mathbf{b} will be matrices, not vectors, and so should be in capitals. Likewise, your \mathbf{X} , and \mathbf{Y} are vectors and should be in lower case.
 - It doesn't really matter, but it is more common to write the observation operator as a left hand multiplication, rather than a right hand multiplication.
 - \mathbf{U} and \mathbf{V} are not sufficiently described. I believe that they are model and observation measures of the same canonical variable, but more time should have been spent describing them.
 - Does $\text{trace}(\mathbf{D}) = 1$? I think it does, but it's not clear and should be stated.
 - on Line 112 you state that the intercept has to be zero. It is not obvious why this is the case, why can't the intercept be non-zero?
 - When you write 'mean' be clear if you mean the time mean or space mean.
- (Fig 1) Show all of the SEVIRI data, and hash out the area deeper than your cut off.
 - (Sec 4) More details need to be given about the quality control procedures. In particular I am not clear if different observations were rejected in each of the experiments. The aim of the paper is not to test the QC, so the same observations should have been used in every experiment.
 - (Sec 4.1.2) More discussion is needed here. The aim of the proposed method is to improve results when there is a large diurnal cycle in SST. However, this section seems to show that the proposed method produces the best improvement in winter when the diurnal cycle is small. The authors need to put more effort into

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explaining this contradiction (which, I believe, arises because of the lack of a proper control experiment).

- (Sec 4.2.1) The SEVIRI data cannot be used as independent validation of your system because it is assimilated in your experiments using the SOSSTA system. This is true even if SEVIRI is not used in your control. What your results show is that assimilating SEVIRI data brings the model closer to SEVIRI data, which is not a surprising result. Better questions to ask are: Does it degrade/improve the results to other data sources? What are the impacts on the forecasts. Are there genuinely independent data sources that can be used? Is it worth withholding data to use for validation?
- (Line 334) Do you really only assimilate SEVIRI data if no other observations are available? This seems wrong.
- (Line 345) I can see no justification for only assimilating SEVIRI data if you have more than 200 observations. After QC you should assimilate everything that is left, even if that is only a few observations.
- Too much focus is given in the results section on the change in the analysis with respect to the assimilated variables. The analysis should be closer to the assimilated observations, if it's not then something is very wrong indeed. What is more interesting is the effect on the forecast (including the background) and comparisons to independent observations.

3 technical corrections

- The figure numbering has gone badly wrong. It's fine in the captions, but wrong everywhere in the main text.

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- (L18) In the abstract I don't understand what you mean by misfits. Do you mean the innovations?
- (L20) state what specific skill scores you use. Just saying 'skill scores' is not informative.
- (L28) "weather and climate" not "weather or climate".
- (L33) Rewrite as "...through to the present with the launch of several satellite missions, both polar orbiting and..."
- (L37) "10 μm depth" not "10 μm of depth".
- (L29) Reynolds is not an analysis of foundation SST. It is an estimate of the daily mean SST, which is not the same thing. OSTIA, however, is a foundation estimate.
- (L43) "in model physics" not "in the model physics".
- (L46) I think you need more than one example if you're going to say 'majority'.
- (L50) The While et al 2015 reference is to a conference proceedings not a paper. The work is covered in the 2014 and 2016 while et al references, so the 2015 reference should be removed.
- (L54) Spurious bracket before coupled.
- (L55) SST data are observations, they are not an observing network—this should be reworded.
- (L62) "with their model equivalent" not "with model equivalent".
- (L66) I don't think there should be brackets around "skin and subskin". Incorporate this directly into the sentence.

- (L74) “of the SOSSTA” not “of SOSSTA”.
- (L93) At this point in the paper you have not defined what you mean by diurnal magnitude (I know it’s defined later in the paper). It is therefore unreasonable to expect the reader to know what it is.
- (Sec 2.1) Rewrite this section. It is not clear if your second training set uses average temperature or morning temperature for initialisation.
- (L109) I think you should say “combination of skin SST and subsurface SST”, not just “combination of SST”
- (L230) “was also” not “were also”.
- (Everywhere) Do not use the term “offline” to mean “without data assimilation”.
- (L240) What does V3 differ from?
- (Sec 4) It will be easier for the reader if you summarise the differences between V1,V2,V3, and V4 in a table.
- (L312) Comma after ‘performance’.
- (Fig 3 caption) Write the criterion in full in the caption.
- (L362) I don’t think “Error! Reference source not found” should appear.
- (L323) Don’t count time using just days containing SEVIRI data and ignoring gaps, it is likely to confuse.
- (L446) “as is shown below” not “also as it will be shown below”

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- (L471) “SSH which, with respect to the other model state variables, varies on shorter” not “SSH which with respect to other model state variables varies on shorter”. Note the commas in my version; they mark out the sub clause and are important.
- (Figs 9 and 11) Please include difference plots as well as images of the absolute values.
- (L500) “...SSH, other model variables...” not “...SSH, also other model variables”

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