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Geoscientific Model Development Discussions

Interactive comment on "Spatio-temporal approach to moving window block kriging of satellite data" *by* Jovan M. Tadić et al.

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We thank the reviewers for their positive assessment of the manuscript and for their helpful comments. In the text below, we include the reviewer's original comments in italics, while our responses are listed in regular font.

Reviewer: The aims of this study are scattered in the introduction and should be clearly presented in the end of the introduction

Authors: We condensed the goals of the study into one paragraph, now Lines 70-77.

Reviewer: As to spatial-temporal approach, it seems some recent developments since 2011 have been missed, which should be included. Please see reference 1 for details.

Authors: Both provided references are included now (Lines 69 and 325)

Reviewer: Samples size is missing for the three datasets. Please provide.

Authors: The sample was specified in Lines 100.

Reviewer: It is not clear what software was used for this study. Please refer your readers to it so that they could apply your method to their study.

Authors: We specified the software package in Line 77.

Reviewer: The accuracy measures used, MAE and RMSE, are data unit/scale and variation dependent as detailed in reference 2. Please see the recommendations in this reference for accuracy measure selection.

Authors: Per reviewer suggestion, we included two unit-independent error measures, RMAE and RRMSE in the revised version of the manuscript., Lines 326-333 and Table 1.

Reviewer: A statistical test of the cross-validation results in Table 1 may provide more convincing evidence to show the difference between the methods compared.

Authors: Please see our response to Review 2, to a similar comment.

Reviewer: The conclusion: it is largely repeating what has been presented in the previous sections. It could be condensed by removing the repetitions.

Authors: We considerably shortened the second paragraph of the Conclusion section, per reviewer request.

Minor issues:

Reviewer: Spell out GOSAT, IASI and GOME-2 in the abstract or delete them.

Authors: Corrected.

Reviewer: Lines 98-99: this sentence suggests that the method is only applicable for a small region. Please revise and clarify.

Authors: The confusing sentence has been deleted.

Reviewer: Lines 144-145: are 'generalized product-sum model' and 'generalized product-sum covariance model' the same? Please keep the name consistent in the paper.

Authors: Corrected.

Reviewer: Line 173: delete one 'then'.

Authors: Corrected.

Reviewer: For XCO2, only 6 day data were used. Is this too short for ST method? Is it a factor for the poor performance of ST method?

Authors: In the study by Hammerling et al., 2012 the authors examined optimal temporal aggregation time periods for XCO2 retrievals by analyzing the tradeoff between not having too much temporal variability vs. having sufficient observations in the context of spatial-only interpolation approach. They reported that 4-days temporal resolution gave the best results which points out to the fact that expected decorrelation temporal "length" of CO2 field is at the order of magnitude of synoptic scales. Based on their analysis, 6d should not be too short. We believe that the factor affecting "poor" performance of ST (in case of XCO2) compared to what could be expected are different. We changed the following paragraph to make it more clear (Lines 391-399): " The difference between the performance of ST and S-approaches obtained through cross-validation becomes most pronounced in processing datasets with measurement errors that are spatially but not temporally correlated. In these cases, an ST approach can use data from adjacent time periods to create the estimate, data that do not have the same regional, spatially-correlated biases. Although the resulting estimate may appear inferior during cross-validation, this is because that estimate will not reproduce regional biases in data from the time slice of interest." Note that the cross-validation errors and true errors are not identical, the former is just an estimate of the latter. The direct con-

clusion from this statement is that ST could perform worse in cross-validation, while in fact it filters regionally correlated measurement errors (not reproduced in time) which brings the focus back on whether the leave-one-out cross validation is the best method for validating this and similar techniques, although it has been used in a series of recent papers (Guo et al., 2013; Zeng et al., 2013, Tadic et al., 2015; Zeng et al., 2016). Please see the response to Reviewer 2. We also checked (not shown in the paper) the timeseries of estimates at selected locations where the difference between S and ST was particularly pronounced. We found that S method produced unrealistically high oscillations in estimates along the temporal axis, while ST kept estimated signal much smoother, which also supports the conclusions. A hypothetical alternative approach to improve the apparent cross-validation performance would be to explicitly model the retrieval error covariance matrix, instead of assuming the independence of retrieval errors, or, in other words, to isolate measurement clusters having regionally correlated errors. However, such information is usually not available. Interestingly, the very difference in performance between ST vs. S could be used to address this important, but still not fully resolved issue.

Reference: Hammerling, D. M., A. M. Michalak, and S. R. Kawa (2012), Mapping of CO2 at high spatiotemporal resolution using satellite observations: Global distributions from OCO-2, J. Geophys. Res., 117, D06306, doi:10.1029/2011JD017015.

Reviewer: Lines 345-346: ST method seems not that poor for GOME-2 data. Please revise.

Authors: Corrected.

References:

Guo, L., Lei, L. and Zeng, Z.: Spatiotemporal correlation analysis of satellite-observed CO2: Case studies in China and USA. Geoscience and Remote Sensing Symposium (IGARSS), 2013 IEEE International, 21-26 July, Melbourne, VIC, 2013.

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