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Atmospheric Measurement Techniques Discussions

Interactive comment on "Kalman filter physical retrieval of geophysical parameters from high temporal resolution geostationary infrared radiances: the case of surface emissivity and temperature" *by* G. Masiello et al.

Anonymous Referee #3

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This paper applies a Kalman Filter (KF) approach for temporally successive point retrievals of surface emissivities and temperature from infrared measurements at 8.7, 10.8, and 12 micrometers of the SEVIRI geostationary satellite instrument at intervals usually of 15 minutes (and for up to one month); the exception for the latter is the consequence of the presence of clouds. This is followed by an evaluation of its results. The retrieval (and data assimilation) of surface emissivities and temperature has been, and stills remains, an active area of research and the application of KF to this problem is certainly relevant and worth exploring - especially considering the increasing use of

KF approaches in weather prediction data assimilation. The 'novel' aspect of the paper is, for me, the application of KF for the retrieval of surface emissivities and temperature. As such, this work does contribute to the advancement in this area and merits publication. The presentation of the material and its orientation is lacking in a few ways (most being minor). Some, if not most, of the related issues are identified under the following section. As initial example, the paper seems to suggest that the general application of KF to geostationary satellite measurements is a/the novel aspect of this paper - the application to surface emissivities and temperature being just the example used. Different KF approaches are already applied in assimilation of such data sources (for retrieving atmospheric temperatures for example), simultaneously to multiple others, in numerical weather prediction (NWP). The KF setup applied here can take advantage of the a priori when the diurnal variations are weak (this essentially since H is set to the identify matrix) and the forecast error covariances are set accordingly. It would have been useful to identify the impact of temporal information propagation from the KF versus the case without this propagation, this to better justify the merit of the KF application for this problem. Significant improvements to grammar and composition would be beneficial in various parts of the text. These are not identified in this review (except for a few lines at the beginning of the paper) considering the large number of such occurences. Major revisions are recommended to encourage improving the grammar and composition and to allow sufficient some time in addressing points in the following section. Specific Comments Title: Considering some of the above and following statements, a title such as "Kalman filter retrieval of surface emissivities and temperature from geostationary infrared radiances" might possibly be more appropriate. Abstract: The suggested changes in the abstract provides some insight on the need for a more careful presentation of the context of the material. First sentence: "which could be suitably used" might suggest to some/many that such data (and capability) have not been previously applied (and made use of) in retrievals – which may not be entirely correct. A suggested alternative is "The high temporal resolution of the data acquisition by geostationary satellites and their capability to resolve the diurnal cycle are a

valuable source of information in retrieving geophysical parameters."

Second sentence: The intended meaning of the second sentence needs to be in accordance to the third sentence. As such, "is for the most part considered uncorrelated" does hold when considering data assimilation applied in numerical weather prediction. The latter, which uses such data, applies spatial constraints through the background error covariances. Time constraints are additionally imposed with the 4DVar and the Ensemble KF (if not other KF approaches). An alternative sentence(s) to precede the remainder of the abstract is needed. A suggestion is to focus on the retrieval of surface emissivities and temperature being an active area of research.

Third and fourth sentence: The KF implementation applied as is in this paper does not apply spatial constraints. Also, as KF approaches have been used, and are being used, with radiance measurements, the emphasis here should be on its application to the retrieval of surface emissivities and temperature. As example "In this paper, we implement a Kalman filter approach for applying temporal constraints on the retrieval of surface emissivities and temperature from radiance measurements made from geostationary platforms. This is applied to SEVIRI ...."

The abstract could/should include a short summary of the results.

Introduction:

Considering above comments, it is suggested that the introduction (and the way the material is presented/introduced for some of the other sections) revolve on the retrieval of surface emissivities and temperature (with reference to other works in that area) for which a KF approach was implemented to introduce temporal correlation as oppose to this being a paper on the KF approach itself. The introduction does not mention other KF uses/applications in retrievals and, particularly, NWP data assimilation, Note that some have referred to KF-type applications in atmospheric remote sensing as sequential estimation (e.g., as with MLS-UARS in the 1990s)

P3, lines 5-6: Temporal continuity/constraints are part of the 4D-Var (within each window) and of Ensemble KF used in NWP data assimilation. This contradicts somewhat the first of these two sentences. P3, lines 15-20: Shouldn't this information instead be mentioned in the results section and not the introduction? Section 2.1 P4, lines 10-11: "The KF methodology will be applied, in this paper, for the retrieval of surface emissivities and surface temperature from ..." P7, lines 7-11: There is mention of the background vector and its related covariance matrix without any explanation or reference of what is meant by "background vector". It might be worth adding something here. It might be worth mentioning, in some cases, in which sections some additional details of some data are given (e.g., section 3 for the background vector and covariance matrix), Section 2.2 P10: Including equation (3) is not essential (but it's ok) - as long as the averaging is mentioned since it is not referred anywhere else in the paper except for section 2.2. By the way, some re-phrasing is needed with "In the following of this section the angular brackets, ,<.> will ..". Maybe something like this would help: "Considering the larger channel bandwidths of the SEVIRI measurements, averaging is applied over the spectral wavenumber band of each channel. This averaging is identified by the angular brackets <.>." P10: The left-hand side of equation (4) is not really needed. Section 3 The definition of data assimilation used in Wikle and Berliner (2007) is very broad and not what may be usually implied in NWP. It would be worth mentioning the definition used in that paper - and in this application. In NWP data assimilation (referring here to improving temporally successive short-term forecasts at the model grid points using information from observations), KF and its variants are considered as one/some of the different approaches used in data assimilation. And so, KF is not distinct from data assimilation but a method available for data assimilation, just as KF is considered an approached using in retrievals. Might the same be said of the Wikle and Berliner definition? The position taken on this may affect text in following subsections. Note that many readers will come from an NWP data assimilation background where the notation is a bit different than in Rodgers (i.e., M instead of H; H instead K: xa instead of x-hat; Sb instead of Sa; ....). Using the notation in Rodgers is still per-

fectly fine. Section 3.2.1 P13: Equation (13) is not really needed since it is the same (10) - but it depends on author's preferences. The equivalence could just be said in words. There is one equation is missing. Sa(t+1)=HShat(t)HˆT + S_eta combined with xa(t+1)=Hxhat(t), which reduces to Sa(t+1)=Shat(t)+S_eta since H=I in this paper. This is important.

Section 3.3 P19, line 16: As set of only ten samples is used to derive the starting covariances, this implies an uncertainty of 30% for the covariances in addition to any uncertainties of the UW/BDEMIS database content. This should be mentioned/discussed. P19, line 22: Tables 1 and 2 imply that element (5,5) is for the channel at 9.7 microns (not 8.7). This mismatch is also found in the caption of Table 2, P20, lines 1-3: The 'down-scaling' (of line 4) is said to be being done to "take correctly into account the expected variation of emissivity on a time scale comparable to the SEVIRI repeat time". This statement is unclear when it comes to justifying a 'down-scaling'. The variances from the sample set of 10 cases would/may (?) give variability variances - which would be expected to be larger than 15 min forecast error variances given accurate start values hence serving as justification for a down-scaling to estimate S_eta. The down-scaling was ultimately needed to get S_eta so that results obtained were more acceptable (i.e., the tuning referred in lines 12-13) - this refers to the application of Sa(t+1)=Sa(t)+S_eta with the KF. P20, Equations 28 and 29 could be combined into a single equation: S_eta_e(i,j)=S_e(i,j)/fˆ2 There is also no need for Sˆ{s)_e. P21: line 1: As will be suggested later, this choice of 1K (over land) implies very little impact by the a priori temperature. Smaller values would have been possible if H would have been chosen to be able to reflect the diurnal variation. P21: It would help if some estimate of the error std dev implied from the measurements for emissivities and temperature were provided. For temperature, this appears to be $\sim$0.2K based on the results section. It might be useful to know the equivalent brightness temperature error std. dev. associated to S_epsilon for example. P22: lines 5-6: The comparison of the time of the maximum temperature with ECMWF (max at 12 UTC) is not valid as the ECMWF fields are only available here at 00, 06, 12, and 18UTC. While mentioning that daytime

ECMWF temperatures are larger is fine, the mention of the time of max temperature from ECMWF should be removed. P24: lines 17-18: What does the following mean: ", if not that considered through the ECMWF reference state.". P24: lines 19-22: Is this statement relevant here? If so, how is this connected to the previous statements? It may just be that the statement may need to be made clearer in the context that it is presented. Section 4.1 P25, line 19: A resulting temperature precision of 0.2K or better (variance of 0.04 or less) implies that a priori xa for temperature has little to no impact since S_eta=1Kˆ2 for points over land. This and its implications should discussed (and mentioned also in the Conclusions section). Missing results: (statement also found in the "General comments" section above) The KF setup applied here can take advantage of the a priori when the diurnal variations are weak (this essentially since H is set to the identify matrix) and the forecast error covariances are set accordingly. It would be useful to identify the impact of temporal information propagation from the KF versus the case without this propagation, this to better justify the merit of the KF application for this problem. Conclusions P31: See earlier comments regarding suggested focus of the paper which would impact on how parts of the conclusions section are presented. This work would benefit from quantitatively showing how much benefit the temporal information propagation component of KF contributes to the retrieval solutions. (see comment on missing results above). This benefit could be shown via the increase in the precision and also the differences in solutions (to see both random and bias impact).

Technical Corrections Only occasional typographical, grammatical, and composition, corrections in the introduction (and figure captions) are pointed out below. One frequent issue is the placement of commas (not always at the correct places or missing). A review by the authors for the purpose of making other similar improvements in all sections is recommended. Different sections seem to require different levels of corrections. Introduction: The following corrections may be irrelevant if this section is re-structured. The text of the introduction is often laborious to read P2, line 19: "Currently" instead of "However". P2, line 19: "for the Meteosat .... (MSG) satellite (or mission)" P2, line 20:

"on board" not needed. P2, line 21: "...point and 16 channels (8 in the thermal band), and..." P2, line 24: "The IRS will have ..." (if that is the correct one) since the previous sentence refers to two instruments. P3, lines 3-4: "cycle, and hence to .... of observations, is ..." (added commas) P3, line 21: "calls for". P3, line 25: "a time constraint" or "time constraints" P3, line 27: "to convey" what? The sentence may need re-phrasing. P3, lines 4-5: Re-phrasing needed. Example: "the precise form of the evolutionary equation is not important for the estimation problem as long as the error covariance appropriately reflects the uncertainty of the current state estimate."

P3, lines 6-10:

P3, line 18: "agree within 1K"

P3, line 19: "with differences normally of"

P4, lines 5 and 7: "section 4" and "section 5"

Section 2.1:

P6, line 15: ", the Sahara desert, and"

P6, line 16: "which have a size of"

P6, line18: "(e.g., see Fig. 3)"

.....

P7, line 20: "analyses" for the plural form (since one analysis per day is used) .....

Tables:

Table 2: caption: "(5,5) corresponds to the channel at 9.7 microns"

Table 2: Extra commas after two elements, (1,4) and (4,5), in the table should be removed.

Figures:

Legends and or axes labels are too small for some of the figures.

Figure 5: caption: "Retrieval exercise using simulations..."

Figure 6: caption: "is shown by the +/-...."

Figure 7: caption: "of the stochastic term Ts is"

Figure 9: caption: "pair" instead of "couple"

Figure 12: caption: "to identify the times of the emissivity minima as compared to noon."

Figures 13-14: caption: "The retrievals included are only those which correspond to"

Figure 15: caption: "retrievals have been" (plural)

Figure 18: caption: " according to this work:

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