Hydrol. Earth Syst. Sci. Discuss., 5, S1124–S1135, 2008
www.hydrol-earth-syst-sci-discuss.net/5/S1124/2008/

Hydrology and Earth System Sciences Discussions

HESSD

5, S1124–S1135, 2008

Interactive Comment

Interactive comment on “From near-surface to root-zone soil moisture using an exponential filter: an assessment of the method based on in-situ observations and model simulations” *by* C. Albergel et al.

C. Albergel et al.

Received and published: 10 September 2008

The authors thank the anonymous referee #1 for his review of the manuscript and for his fruitful comments. For an easier comprehension, general comments of the referee are also reported (1.XX).

1.1 [What is the (dis)advantage of this exponential filter compared to other techniques for low pass filtering? Why even consider studying this filter and its single parameter T, if it is known in advance that the filter is not very sensitive to T (Wagner 99)? The authors find a little sensitivity as well, so how useful is this study? How would this filter compare to other simple techniques like CDF-matching or a simple linear (or higher order) relationship between surface soil moisture and root-zone soil moisture? The latter techniques allow to convert the surface soil moisture climatology to the root zone climatology, while the exponential filter only smooths the surface observations (i.e. changes the temporal variability) without changing the absolute level of estimated soil moisture.]

Response 1.1

This study does, for the first time, apply the exponential filter to daily observed in-situ data, which allows to study the relationship between the parameter T and soil properties such as density, clay and sand % or organic matter. It is also the first time that the SMOSMANIA network and data are presented in a peer reviewed journal. While it is said in Wagner (1999) that T is little sensitive (based on the use of ERS data), we obtain significant spatial differences of T over France based on land surface model simulations, and it has to be determined which parameters drive the level of T. While the CDF matching technique is used for un-biasing two surface soil moisture products, it does not provide any information on the deeper soil profiles. Also, methods assuming direct relationships between the surface and profile soil moisture (be it linear or non-linear) relate the instantaneous value of surface soil moisture to the profile soil moisture at the same time, which is wrong. Using a low-pass filter as presented in this paper, allows to implicitly take into account the preceding climatological conditions when calculating the soil moisture profile.

1.2 [What is the practical use of a SWI-value [0,1] when obtained from satellite data and given that no other information on the deeper soil is available?]

Response 1.2

A scaled SWI does allow to combine the different dynamic ranges of surface soil moisture and profile soil moisture. This is essential, as the surface may well show soil moisture values below the wilting point and above field capacity, while the profile soil moisture is generally bound by those two parameters. It is also possible that different soil horizons exist throughout the soil profile. Using a scaled value does alleviate this problem, assuming that the hydrologic response is the same in all soil types.

1.3 [It is not very clear which variables are compared or analysed: are the SWI results scaled to [0,1] and are all soil moisture observations also scaled to [0,1], i.e. SWIobs? This is not explained in the paper and units are missing. Note that an indication of no units [-] versus something like [m3/m3] for soil moisture can be very helpful already to distinguish between the different soil moisture related variables: scaled info [-] would fall in [0,1], while soil moisture vol% or m3/m3 would be bounded by physical minimum and maximum soil water content.]

Response 1.3

Yes, we agree that the different soil moisture definitions may be confusing. wg is the water content of a surface soil layer [m3/m3], 5cm for SMOSMANIA stations, 0-6cm for SMOSREX, a few mm for SIM. w2 is the root-zone soil moisture content [m3/m3], measured at 30cm (SMOSMANIA), at various depths (SMOSREX), or integrated over the root-zone profile (SIM and SMOSREX). Prior to filtering, soil moisture wg observations or simulations are scaled between [0,1] using maximum and minimum values of each time series (ms, dimensionless). The dimensionless SWIobs used in Eq.(7) to assess the quality of the results is the reference w2 (either observed in situ or simulated by SIM) scaled to [0,1] using maximum and minimum values of each time series. SWIm is the result of the exponential filter. It is dimensionless and ranges from 0 to 1.

1.4 [Just a thought: I have some doubts about using a RMSE and Nash-Sutcliffe measure for comparing scaled time series. Both measures include some notion on the bias between time series, while that bias seems to be artificially removed in this study. A simple comparison (difference) of the correlation length and the temporal variance in the time series might be more justified. Also, through scaling, the variability is altered. Since I am not entirely sure about the actual applied operation of scaling or normalization of the observations, it is hard to know if the validation measures are justified.]

HESSD

5, S1124–S1135, 2008

Interactive Comment

Response 1.4

The soil moisture observations are scaled between minimum and maximum values. In Wagner et al. 1999, correlation, bias and RMSE are used to quantify the errors, we introduced the Nash-Sutcliffe score in order to assess the overall performance of the filter in terms of a time series. The reviewer is correct to point out that the Nash-Sutcliffe coefficient is particularly sensitive to the bias, but it is also a good tool to compare two time series. Moreover, the Nash-Sutcliffe is a more robust score as it does not require a normal distribution of the data sets, whereas a variance assumes such a distribution, which may not always be given.

1.5 [It is not justified to make a general statement that T would be linked with climate effects, based on entirely synthetic profile simulations. The finding tells something about the model physics, NOT about nature (how well is the LSM calibrated/validated?). Also for the relation between T and the soil depth, it should be recognized that T is smaller for the simulated profiles at the coarse scale than for observed ones at the point scale, because the correlation between modelled profile layers (definitely at the coarse 8 km resolution) is generally larger than reality (here at a point scale). Both the issue of the scale effect and the fact that the link of T with soil depth and climate is more a model related conclusion should be more stressed on. Is there any chance to average some point profile observations to a coarser scale and compare those profiles to simulated ones (at that same coarse resolution)?]

Response 1.5

Indeed, it is difficult to find a climate effect on T in our simulations. The Rhône valley example is a rather extreme case. The Rhône gradient found on T from model simulations only suggests that a climate factor may exist. Further investigation is needed to consolidate this result. For the relation between T and the soil depth: the T derived from the simulated profiles are consistent with the observed ones at SMOSREX. In Figure 9, the SMOSREX Topt is plotted vs soil depth whereas the SIM Topt is plotted

HESSD

5, S1124–S1135, 2008

vs soil thickness. An attempt to plot the SMOSREX Topt vs soil thickness gave results similar to SIM.

1.6 [I do not agree with (the reference to) Stroud (1999) on the idea that the exponential filter resembles the Kalman filter and I would rather like to see any reference to Kalman in the paper under review being removed, because it gives a false and confusing impression on the actual paper contents. The exponential filter in this study has no specific feature of the Kalman filter at all, the only common feature is the shape of its update (filter, recursive) equation, but that is something that all recursive linear filters have in common! The proposed exponential filter is simply a low pass smoother, nothing else. It is a smoother in a recursive formulation.]

Response 1.6

We acknowledge that reference to Kalman may not be entirely accurate in this context.

1.7 [The technique is proposed for use with RS data. However, it requires time series of available data over a relatively limited time window (to allow smoothing over that window): how realistic is that for France? I assume that small scale radar data will be cancelled out often, because of precipitation events? What RS data were you thinking of?]

Response 1.7

In another study (Albergel et al. 2008, HESSD) ASCAT soil moisture time series are used over southwestern France. For various reasons and following the findings of Wagner et al. (1999) only morning passes are used, resulting in one value every 3 days for southwestern France. Remote sensing soil moisture data from the future SMOS mission, with a similar sampling time, could also be used.

1.8 [Even though intuitively it might seem right, it is not justified to make a general statement that T would be linked with climate effects, based on entirely synthetic profile simulations. The finding tells something about the model physics, NOT about nature

HESSD

5, S1124–S1135, 2008

Interactive Comment

(the model is not truly calibrated/validated).]

Response 1.8 Yes, we agree that too much emphasis is put on this result. See Response 1.5.

1.9 [p. 1605, l. 9-14. Why would the lack of info on model parameters at global scale and uncertainties related to the physical description of the water and energy balance be a disadvantage to 1DVar or other assimilation techniques other than the Kalman filter? For the issues you might have in mind, 1DVar, Kalman and other filters are essentially identical.]

Response 1.9

The lack of information to run a land surface model has implications on the implementation of any data assimilation in the model, as it introduces an artificial model bias, which cannot easily be removed from the simulations.

1.10 [p. 1605, l. 12. #Moreover, the analysed profile soil moisture is model-dependent#. Therefore, the authors choose to use a #method which solely relies on remotely sensed soil moisture#. It should be recognised that each conversion from surface soil moisture to some other soil moisture is done through some operator, i.e. a model: consequently, the results from the exponential filter are also #model#-dependent and are thus not solely relying on remotely sensed data, but also -as is extensively discussed later- on the structure and parameters (e.g. T) of the transformation model, i.e. the exponential filter.]

Response 1.10

Yes. In a land surface model, the conversion from surface to root-zone soil moisture may depend on multiple factors and parameters (Calvet and Noilhan 2000). A single parameter (T) has to be determined in the case of the exponential filter, which implicitly takes all these factors into account. However, using an exponential filter to analyse the root-zone soil moisture is not completely straightforward and the result is not entirely

HESSD

5, S1124–S1135, 2008

Interactive Comment

driven by the remotely sensed data only, as the value of the T parameter may influence the results.

1.11 [p. 1610, l. 13. ISBA parameters were aggregated to 8 km probably, it is meant that the ECOCLIMAP parameters are aggregated to 8 km and the ISBA model simulations were performed at this resolution?]

Response 1.11

Yes. For the purpose of the land surface simulations, the ISBA parameters, provided by ECOCLIMAP at a resolution of 1km, were aggregated to the model resolution of 8 km. The ISBA model simulations were performed at this resolution.

1.12 [p. 1610, l. 25. SWI is compared to w2: do both variables end up with the same units? Probably, the comparison is performed after scaling? Please, do mention that in the text.]

Response 1.12

In Sect.4, the retrieved SWI is compared to the reference w2, scaled to [0,1] using maximum and minimum values of the time series.

1.13 [p. 1611-1612. Eq.2-3: in Eq.2 the integration is up to time t, while in Eq. 3 tn is introduced. I think that tn in Eq. 3 can be simply t or vice versa for clarity. In any case: tn is not explained in the text.]

Response 1.13

Remotely sensed data provide measurements at irregular intervals of time ti (with i ranging from 1 to n, for the first and the last observation of the time series, respectively).

1.14 [p. 1612. Eq. 3: ms(ti) is normalised: do explicitly state how that is done. Do you mean it is scaled to [0,1]? That is different from subtracting the mean and dividing by the variance (=classical normalization).]

HESSD

5, S1124–S1135, 2008

Interactive Comment

Response 1.14

To retrieve surface moisture from ERS data Wagner (1999) proposed to compare the backscattering coefficient extrapolated to a reference angle at 40 degrees to the lowest and the highest values ever measured. Thus ms is scaled to [0-1].

1.15 [p. 1612, l. 17. Pellarin uses the interval [tn-3T, tn], but Wagner uses [tn-5T, tn]: what is the criterion behind the 3 or 5?]

Response 1.15

Tests performed by Pellarin et al. 2006 had shown that using the [tn-3T, tn] interval instead of [tn-5T, tn] had negligible influence on the filter. Therefore the [tn-3T, tn] interval was used as shorter intervals are more tractable (less observations have to be stored) and as a shorter period of time is required to initialise the filter. The recursive formulation suppresses the need to prescribe an integration interval and to store past time series.

1.16 [p. 1612, l. 21. RMSE of 0.0022 m3/m3 by comparing SWI with root-zone soil moisture: here the RMSE is expressed in m3/m3, so probably no scaled SWI is used (I did not check the referred paper). I am confused about the units used for SWI, please clarify somewhere.]

Response 1.16

RMSE of 0.0022 m3m-3 is a typo. The actual value is 0.022 m3m-3. In Wagner et al (1999) a plant available water (PAW) content is derived from the SWI by using auxiliary information about the soil physical properties (wilting point, field capacity and total water capacity), and thus converting relative values into absolute moisture content. Ceballos et al (2005) found a RMSE of 0.022 m3m-3 when comparing the PAW values derived from scatterometer and area-averaged field measurements (0-100cm).

1.17 [p. 1612, l. 23-24. I do not agree with Stroud (1999) on the idea that the exponential filter resembles the Kalman filter and I would rather like to see any reference to

HESSD

5, S1124–S1135, 2008

Interactive Comment

Kalman in the paper under review being removed for clarity. The exponential filter in this study has no specific feature of the Kalman filter at all, the only common feature is the shape of its update (filter, recursive) equation, but that is something that all linear filters have in common! The applied filter shows more resemblance to something like nudging, thas no reference to dynamical updating of states and uncertainties. Even referring to nudging is wrong: this exponential filter is simply a low pass smoother, nothing more, nothing less.]

Response 1.17

We acknowledge that reference to Kalman may not be entirely accurate in this context.

1.18 [p. 1613, l. 12. the original exponential filter: that is Eq. 3? Please do refer to that different expression and line 17 #it was checked# is redundant, because both expressions should be mathematically equal.]

Response 1.18

The #original exponential filter# refers to Eq.(3) and the #recursive formulation# refers to Eqs. (4)-(6). Both expressions are mathematically equal. However, the initialisation and the implementation of the recursive and non-recursive filters differ (the recursive formulation suppresses the need to prescribe an integration interval and to store past time series).

1.19 [p. 1614. Eq. 7: variable p is not explained]

Response 1.19

p is the number of values of the considered time series.

1.20 [p. 1614, l. 12. SWIobs is never really explained. Again: what are the units, are they scaled [0,1] observed soil moisture?]

Response 1.20

HESSD

5, S1124–S1135, 2008

Interactive Comment

SWIobs represents the time series of the scaled root-zone soil moisture observed in-situ. SWIobs is scaled to [0,1] by using the minimum and maximum values of the considered time series. See response 1.3.

1.21 [p. 1614-1614, Why would you choose 30 cm soil moisture, while you can as well calculate the actual root zone soil moisture? The reasoning of the high correlation with the other layers is not really convincing: if root zone soil moisture is available as well, then there is no justification for taking a proxy. Furthermore, for the SMOSREX experiment, all different soil layers and the integrated profile were studied.]

Response 1.21

In the case of SMOSMANIA, soil moisture observations are available from 5 to 30 cm, only. Soil layers below 30cm are not observed, and the scaled root-zone soil moisture (integrated value) cannot be computed. At SMOSREX soil moisture observations are available from the surface down to 90 cm, and a SWI representing the scaled root-zone soil moisture can be computed. The analysis of the SMOSREX data indicate that individual soil moisture observations, at depths ranging from 20cm to 50cm, are significantly correlated to the integrated root-zone soil moisture. In the SMOSMANIA network, it is assumed that scaled soil moisture observations at 30cm are a good proxy of the scaled root-zone soil moisture.

1.22 [p. 1617. SMOSREX, inter-annual variability of T: does that show some non-stationarity in the error which is filtered?]

Response 1.22

The non-stationarity of T can have a number of reasons. First, as the reviewer pointed out, it may be due to a variability in the error, second it may be due to different climatological conditions between the years, and third, as the range of T may produce quite similar Nash scores, it may simply be due to a slight change in the observed data, without any further significance, as the optimisation may have found a local minimum.

HESSD

5, S1124–S1135, 2008

However, an in-depth analysis of this variability and its sources is beyond the scope of this paper, as it focuses on finding optimal values for T.

1.23 [p. 1618. Fig.6, line 14-15: text description is confusing: in the figure, scaled observations are shown. How are the better results obtained? Through which normalization? Again: what is meant by normalization of the observations? Also, through scaling, the variability is altered. Fig.6 suggests that the filter still passes too much high frequency information. Would another low pass filter (with a more narrow band) give better results? See major comments: would any other filter or operator work equally well or better?]

Response 1.23

Minimum and maximum values of the 7 year period are used to scale the observations. Minimum soil moisture values are found during the severe drought of 2003. This kind of extreme event affects the scaling and may alter the variability. An average Topt of 6 days is a compromise. The resulting filter may tend to pass too much high frequency information at some periods or, on the contrary, attenuate the variability too much at other periods. Another filter may well perform better, in particular more physically-based ones. However, we are deriving Topt values using the OPERATIONAL filtering method for ERS and ASCAT data, which is the main purpose of this paper. A detailed comparison study of various filters should be published by itself.

1.24 [p.1619. How well are the SIM simulations calibrated/validated?]

Response 1.24

Prescribing soil depth in land surface models is challenging, as this quantity is seldom observed. However, the hydrology component of SIM (e.g. river flow) was extensively assessed by Habets et al. 2008. This is an indirect validation of the representation of the root-zone in the model. For the relation between T and the soil depth: the T derived from the simulated profiles are consistent with the observed ones at SMOSREX.

In Figure 9, the SMOSREX Topt is plotted vs the depth of the validating root-zone observation, whereas the SIM Topt is plotted vs soil thickness. An attempt to plot the SMOSREX Topt vs soil thickness gave results similar to SIM.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 5, 1603, 2008.

HESSD

5, S1124–S1135, 2008

Interactive Comment