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Hydrology and Earth System Sciences Discussions

Interactive comment on "A comparison of ASCAT and modelled soil moisture over South Africa, using TOPKAPI in land surface mode" *by* S. Sinclair and G. G. S. Pegram

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It is a pleasure to have received four such constructive, insightful and helpful reviews as the paper attracted; these add significantly to its interpretation. Although it might not be possible to accommodate all of the suggestions in the rewrite for publication in HESS, the ideas will provide added impetus and perspective to the 3-year follow-on project about to commence in April 2010, supported by the South African Water Research Commission. In this response, the major issues raised by the review are addressed in the next few paragraphs.

1 TOPKAPI

The TOPKAPI model was designed (Liu Todini, 2002) as a physically-based distributed hydrological model, specified by parameters derived from a DEM and field data. This is in contrast to many other hydrological models whose parameters are model dependent. It could be argued that TOPKAPI's parameters are model dependent, but to a much lesser extent than others. In our experience, they often need only minor adjustment (within the range of parameter uncertainty) to provide good hydrological responses. In the paper, we referred to previous work done with TOPKAPI in hydrological mode applied to a medium-sized catchment (4500 km^2 - see Vischel et al., 2008 a b). In this paper, we (conceptually) placed isolated 1 km square TOPKAPI cells at the grid intersections of the approximately 12 km square Unified Model (UM) grid - the TRMM 3B42RT rainfall product is twice as coarse as UM. The isolated TOPKAPI cells are not connected to any other cells (as they would be in catchment mode) and are designed to drain laterally under the influence of the local ground slope and local soil properties. In the follow-on project, one of the tasks will be to coalesce these cells back into a hydrological catchment model (where we have runoff data available) against which to test their drained output after calibration. By contrast, in this paper, the cells have not been calibrated at all, but are parameterised by local slope, soil depth and conductivity and land cover, available to us in detail over the country; the forcing variables are rainfall and Potential Evapotranspiration.

2 Length of paper

Concern was expressed by reviewers 3 and 4 about the length of the paper and the number of figures. In the paper, we did not give a description of TOPKAPI, however in the light of the reviewers' comments and suggestions, it is intended to add a section including a flow chart to indicate how it comes together. This may mean sacrificing

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some of the material, so we will be guided by the recommendations of the Editor in this regard.

3 Forcing data

Concern was expressed about (inter alia) the TRMM estimates of rainfall. We are aware of the imperfections of this source (we referred to Huffman et al., 2007 in the text on the matter) but at this juncture, we are treating the rainfall estimates as the "least worst", available, online, data source of spatial rainfall estimates in near real time. It is one of the tasks of the follow-on project to evaluate the local bias and error structures of the TRMM 3B42RT product over Southern Africa, but at this stage, the matter was not addressed in the paper.

We are gratified that the correspondence with ASCAT estimates are so good (in parts of the country), which suggests that there may be errors, possibly of scale, but that the characteristics of both the ASCAT and TOPKAPI based soil moisture estimates are generally valuable.

4 Soil data

The soil data-set (depth and conductivity in detail over the country) is an omission to be dealt with in the rewrite of the paper - they were glossed over because they had been presented in the earlier work (Vischel et al., 2008 a b). These have been mapped in detail over the country and with the Editor's guidance, we shall have to decide whether to add more figures or settle for a short description of the data sets.

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5 Azimuth angle

In the light of the remarks of reviewers 2 3, section 5 and its figures will be revisited. We had referred to Figa-Saldaña et al. (2002) in the paper and admit that the issue of incidence angle is a vexing problem in the context of the 29-day cycle. Reviewer 2 gives a valuable critique of the issue, but addressing it detail as suggested there is well beyond the scope of this expository paper, which attempts to bridge the gap between the hydrological and remote sensing paradigms.

6 ASCAT and filtering

The ASCAT data-set available to us at the time these comparisons were started (mid 2009 onwards) was the historical unfiltered product that we sourced directly from EUMETSAT. We filtered the “surface skin” ASCAT observations with an exponential filter with a linear store with constant residence time T = 20d. We chose this on the basis of the work done by Wagner et al. (1999) with ERS data, so the thinking should carry over to the ASCAT product. The soils whose soil moisture were averaged have depths between 400 and 1000 mm, hence do not merit a shorter time constant as obtained by Albergel et al. (2009) for depths of 300 mm. Turning to the issue of filtering raised by reviewers 3 4, we offer the following explanation. In the context of linear system theory, the response of a linear store (e.g. soil) fed by an input (e.g. rain) can be solved either by convolution (as done in equation (2) of Albergel et al., 2009) or equivalently by a discretely coincident difference equation over equally spaced time intervals (our equation (6)). The former is computationally intensive, whereas the latter is simple, fast and produces the same results. For two contrasting proofs of this relationship, please see Pegram (1980) and Diskin and Pegram (1987).

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7 Penman-Monteith

Reviewers 2 3 questioned the relevance of the Penman-Monteith equation used for calculating the forcing variable Reference Crop Evapotranspiration (ET_0), summarised in our equation (2). It is used to calculate ET_0 at all the sites where Meteorological data are available, both at Automatic Weather Stations and also using the UM forecasts. The calculation of ET_0 is well known and described in detail in the FAO56 manual, (Allen et al., 1998). In the paper we described the technique we used to compute actual evapotranspiration (ET_a) from the base values of ET_0. The ET_0 is based on the evapotranspiration that would occur from well-watered grass-like vegetation. In contrast, ET_a is affected by vegetation type and health, as well as being limited by the available soil water.

Reviewer 2 requested clarification on the use of UM forecast fields instead of analysis fields. Our choice was largely driven by the operational processes of the SA Weather Service (SAWS). The UM analysis fields (results of observational data assimilation) are available twice daily and the model produces hourly forecasts from these times. There is no post-processing (commonly known as re-analysis) of the model runs. As discussed in the paper, we were able to satisfy ourselves that the model forecasts of the major environmental variables resulted in sufficiently accurate estimates of ET_0 to justify the use of the forecast fields in our real-time product.

8 Error analysis and validation

Reviewer 2 suggested using Root Mean Square Differences (RMSD) to complement the R^2 plots given in figure 16. We have decided not to do this, because the R^2 value embodies more than the RMSD: it expresses the degree of linearity as well as the precision of the relationship between two random variables. The importance of figure 15

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(we will drop the unfiltered diagrams as suggested by Reviewer 4), on which figure 16 is based, is that there is a linear relationship between the filtered ASCAT and TOPKAPI estimates which is very strong over a large part of the country. The "correct" estimate can only be judged in the future by ground-truthing using probes.

9 Conclusion

The remaining issues raised by the reviewers will be addressed under the Editor's guidance when the rewrite of the paper is given the go-ahead. We trust this will be the case, based on the very useful and positive recommendations of the reviewers.

10 References

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