Hydrol. Earth Syst. Sci. Discuss., 6, C2548–C2551, 2009
www.hydrol-earth-syst-sci-discuss.net/6/C2548/2009/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Assimilation of satellite information in a snowpack model to improve characterization of snow cover for runoff simulation and forecasting" *by* L. S. Kuchment et al.

Anonymous Referee #3

Received and published: 7 November 2009

Summary

The study area is a 200,000 km2 region in Russia, with flat terrain and mixed vegetation cover. This study consists of application of two modeling schemes. The first modeling scheme is a (presumably one-layer) energy balance "snowpack model". The model is forced with meteorological data measured at 19 stations in the domain and interpolated over the domain. The model uses MODIS products for albedo and surface temperature inputs. The model is run only during the spring melt, i.e. from 1 March through 30 June.

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Interactive Discussion
Discussion Paper

The model is initialized on 1 March using the AMSR SWE product. The snowpack model is calibrated and validated at 19 locations within the domain, during the period from 1 November 2001 – 30 May 2002. An estimate of model SCA is apparently constructed by tallying the pixels over two 2500 km2 areas that have snow versus those that do not have snow; this estimate of SCA is compared to the MODIS SCA product. The model is run at 0.01 degree spatial resolution and 1 day timestep.

The second modeling scheme is a runoff generation model and a routing model. In the runoff generation model, when soil becomes saturated, runoff occurs. This model would presumably require an input of liquid meltwater leaving the snowpack. The authors claim that both the snowpack model and the AMSR SWE product is "used as the inputs" (p.5519, line 7-8) to the runoff model. The routing model uses a kinematic wave scheme to route runoff through channels. The runoff generation and routing model is calibrated using data from 1940-1959, while validation was performed from 1960-1980.

The study is essentially an ad-hoc combination of modeling and remote sensing elements. The manuscript is not sound, in that it makes conclusiosn that are not warranted: see Issue #1, below. The manuscript is confusing, because it is very difficult to tell exactly how the various data sources are pulled together: see Issue #2, below. The manuscript is misleading, because the SWE figures are apparently only shown at the places where meteorological data are available, leading to what are surely overly optimistic results: see Issue #3, below. The manuscript is misnamed, because no assimilation is performed, such that the title is incorrect; see Issue #4, below.

Issues

1. The authors simulate snow ablation; in other words, they only simulate between March – June. They use the AMSR SWE product during snowmelt to drive their runoff generation model. They then claim, ". . . utilizing the AE DySno SWE data leads to significant runoff underestimation. This underestimation can be explained mainly by errors in estimating SWE in forested areas. These results can be viewed as in indication that

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reconstruction of fields of snow cover properties with the proposed model-based technique improves the representation of spatial distributions of snow characteristics as compared snow cover fields obtained directly from satellite data." This is simply not a fair comparison, as it is well-known that the AMSR product has significant errors during snowmelt, which is partially acknowledged by the authors on p.5509, line 21-22. As soon as the pack becomes isothermal and liquid water is generated, the snowpack emits as a blackbody and all information about SWE is essentially lost. Driving the runoff generation model using the AMSR SWE product is fundamentally ill-conceived, and does not support the authors' conclusion. Moreover, the authors' suggestion that the errors are due to forest is most likely incorrect.

2. It is very difficult to tell what the authors have done. After carefully studying the paper, I don't understand what data sources were pulled together in what ways. For instance, how was the snowpack model used to calculate SCA shown in Figure 7? How did the authors use the AMSR SWE product to drive the runoff generation model to get the results shown in Figure 10? Besides things that are not given, things are not well-laid out: it took me quite a while to figure out that AMSR SWE product is used in two totally different ways: 1) to initialize the snowpack model; 2) in parallel with the snowpack model estimates to force the runoff generation model. The authors paragraph on page 5508, lines 16-25 needs to describe exactly how each of the datasets are pulled together and used. This could be done relatively easily; as is, this paragraph conveys very little information about what the authors have done. As is, the paragraph seems to imply that the authors are doing data assimilation, which they are not, and is thus very confusing.

3. It seems that the snowpack model was calibrated and validated using snow depth measurements at 19 stations within the basin, which are presumably the same 19 stations where meteorological data are available. This must NOT be used to develop an estimate of the overall performance of the model. Inevitably, at pixels where the meteorological data are interpolated rather than measured, the uncertainties and the

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errors will be larger. The only fair comparison here would be to use 18 stations to calculate meteorological data by interpolation at a location where snow depth data are available, and use that to calibrate and to validate. Otherwise, accuracy estimates are surely overly optimistic.

4. The title of the paper is “Assimilation of satellite information in a snowpack model”. Assimilation schemes function by comparing a modeled and measured estimate of the same quantity (e.g., SWE or SCA) and using that difference to correct the modeled estimate, model parameters, etc. The authors of this manuscript do not take the step of correcting the modeled estimate by differencing the modeled and measured estimate. Instead, they simply use remote sensing measurements to initialize the model, to drive the model, and to compare with final model output. This is common practice in the snow hydrology literature, such as the ubiquitous use of snow runoff models. In short, the paper has nothing to do with assimilation, but the authors package it as if it has. I recommend the removal of all mentions of the word “assimilation” or “assimililate”. A more appropriate title might be something like: “Characterization of snowpack and runoff using models and remote sensing measurements”.

Minor comments

1. p. 5508, Line 18: “physical based” should be “physically based” 2. p. 5009, Line 20: Cite something peer-reviewed on AMSR accuracy, in addition to or instead of the internal NASA report; the internal report accuracy is not adequate, here. 3. Eqn. 26 is clearly empirical, maybe a bit more explanation of the parameters is in order 4. Section 5 title is grammatically incorrect and confusing: “Using spatial snow characteristics into the distributed model of runoff generation of the Vyatka River basin” Please reword. 5. P. 5517, line 4-5: “from hydrometeorological literature”: be more specific 6. Figure 8: not legible

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 5505, 2009.