Response to Reviewer # 4
Review of hess-2013-294 A Large-Scale, High-Resolution Hydrological Model Parameter Dataset for Climate Change Impact Assessment for the Conterminous United States

This is a rather technical paper on the implementation of hydrological simulations at a continental scale and at a daily time step. A number of model parameters are tuned in order to fit river discharge observations.

We would like to thank the anonymous reviewer for his/her comments and constructive criticism, which we believe have led to an improved manuscript. Below are specific answers to reviewer comments.

The overall impression is that the optimization of the parameters is rather crude (only three parameter values are tested).

Given that this study is conducted at very fine resolution and on a large scale, calibrating the model is computationally intensive. Because of this limitation, we selected three parameter values based on previous literature and our initial results. We eventually selected the parameters that give us the best Nash-Sutcliffe coefficient values.

While 3 parameter values may sound limited, the calibration was conducted on 5 variables for 2107 HUC8s independently (3^5 * 2107 = 512001 runs), and it has resulted in the use of 1.5 million CPU-hours. Given our limited computational resources, it is perhaps the most we can do for the conterminous US dataset preparation. We have stated clearly in the manuscript that the purpose of this calibration is mainly to help reduce further calibration time. Depending on the future research questions, the default parameters can be improved via more detailed calibration.

From a scientific point of view, is there anything new? Is the impact of the progress in spatial resolution really meaningful?

(Below is the same response to Reviewer #2, comment #2)

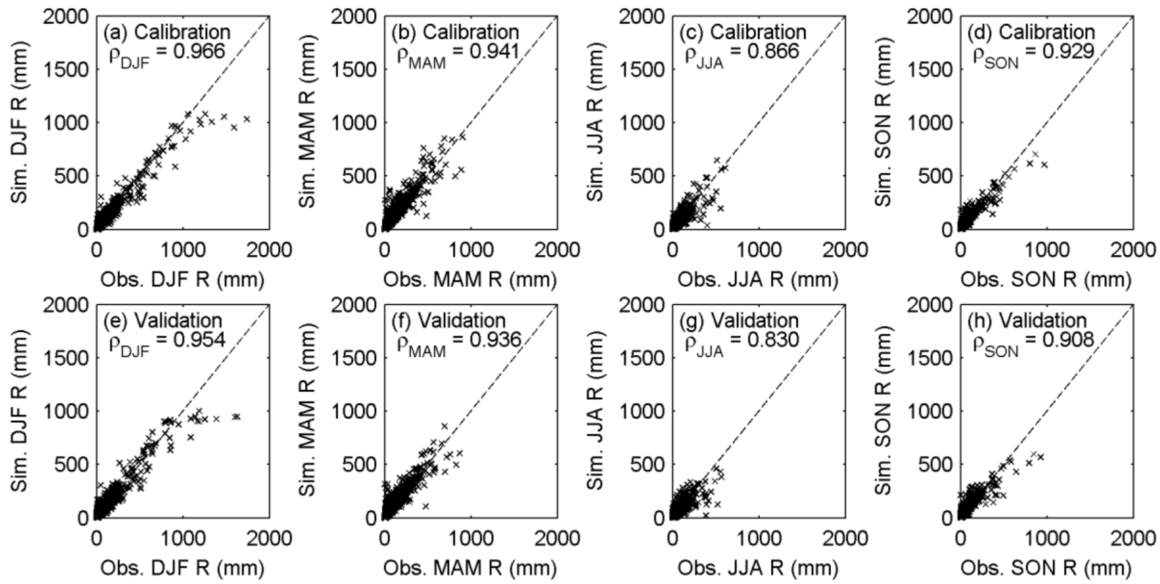
It is well documented in previous studies that runoff is sensitive to spatial variations in soil properties, precipitation inputs, and topography (Haddelenad et al., 2002; Nijssen et al., 2001, Sharif et al., 2007; Dooge and Bruen, 1997; Merz and Plate, 1997; Shah et al., 1996; Wolock and Price, 1994). Additionally, high-resolution land hydrology is needed to address questions such as identifying climatic controls on the spatial variability of hydrologic parameters and the scale at which they are most dominant; examining the spatial scaling properties of the hydrologic parameters; performing statistical analysis between climatic variables and land surface processes and states, such as soil moisture and evapo-transpiration (ET); and developing subgrid parameterization approaches for the hydrologic parameters, particularly in the wet and dry conditions.

Another motivation for this study is, however, not simply to reconstruct the past observations at higher resolution, but rather to be able to evaluate the effects of long-term changes in extreme hydrologic events, for which an evaluation can only be conducted through refined spatial resolution. Moreover, it is necessary to accurately predict spatial variations in watershed hydrology at the subbasin scale in order to identify regionally specific management strategies to mitigate the potential impacts of climate changes on water resources at the regional scale.

Moreover, the analysis of the results is rather superficial (only mean annual scores are considered). What about seasonal effects?

We appreciate this constructive criticism, but we think that it is a misunderstanding. As shown and discussed in the manuscript (e.g., Fig. 9 and Table 3 in the revised manuscript), the calibration was performed on monthly time series (i.e., simulated VIC total runoff to USGS WaterWatch runoff), so the seasonal pattern is part of the calibration. The scatter plot shown in Fig. 7 (now Fig. 8) is merely a quick way to visualize the results across 2107 HUC8s. It does not mean that we used only the annual mean for calibration.

In the revised manuscript, we have included a new scatter plot (Fig. 10) to show the model performance across various seasons. The results showed that the model performed best in winter, then spring, fall, and summer, from the wettest season to the driest season. It is somewhat expected because we are calibrating monthly time series across different seasons, and the Nash–Sutcliffe coefficient is mainly controlled by the wetter months (winter) and less by the drier months (summer).



New Figure 10 in the revised manuscript. The USGS WaterWatch observed runoff (x-axis) versus the VIC simulated seasonal total runoff (surface runoff+baseflow, y-axis) for both calibration [panels (a)–(d)] and validation [panels (e)–(f)] periods for each HUC8 subbasin. Winter runoff from December to February is plotted in panels (a) & (e), spring runoff from March to May in panels (b) & (f), summer runoff from June to August in panels (c) & (g), and fall runoff from September to November in panels (d) & (h).

Finally, I found no indication in the manuscript on the availability of the simulations or of the parameter database resulting from this work.

As stated in the manuscript (P. 9595, lines 11-12), the meteorological and hydrological datasets that resulted from this work will be made available to the public. This statement is now emphasized in the abstract.

Recommendation: Major revisions.
Particular comments:
*- P. 9580, L. 11: 3 * 3 = 9*

This confusion was brought up by multiple reviewers, and it has been clarified in the revised manuscript. We agreed that the 1/24° grids would result in exactly 9 times of the computational resources when compared with the 1/8° grids. However, given the expanded data flow, there will be some additional computational demand for data management and quality control, which were not required for the simpler 1/8° grids.

- P. 9580, L. 14: is the 4 km resolution grid of the PRISM atmospheric analysis the result of an interpolation or do we have actual observations of surface atmospheric variables every 4 km?

PRISM was created at 4km resolution by interpolating surface observation from ~13000 stations for precipitation and ~10000 stations for maximum and minimum temperature. As suggested in the name of PRISM (parameter-elevation regressions on independent slopes model), a dynamic knowledge-based framework was developed for the effective accumulation, application, and refinement of climatic knowledge to better estimate meteorologic forcings at locations without observation (Daly, 2002). The reference has been provided in the manuscript.

- P. 9581, L. 16: is the 1 km resolution grid of the DAYMET atmospheric analysis the result of an interpolation or do we have actual observations of surface atmospheric variables every km?

Similar to PRISM, Daymet is another interpolated dataset using station data. According to Thornton et al. (1997), the mean absolute errors (MAEs) for predicted annual average maximum and minimum temperature were 0.7℃ and 1.2℃, with biases of +0.1℃ and −0.1℃, respectively. The MAE for predicted annual total precipitation was 13.4 cm, or, expressed as a percentage of the observed annual totals, 19.3%. The reference has been provided in the revised manuscript.

- P. 9582, L. 6: at the end of Sect. 2.2, it would be good to mention, for the sake of clarity, what is the objective for the final meteorological dataset (4 km, daily?).

We appreciate this comment. The last section of Sect. 2.2 has been revised for clarity.

- P. 9582, L. 15-16: "commonly used soil characteristics", please detail.

Some CONUS-SOIL variables are listed in the revised manuscript as examples.

- P. 9583, L. 22: LAI values available on an 8-day basis are degraded to a monthly basis. Why? It seems that valuable information is lost.

We synthesized monthly LAI values since they are the required VIC model inputs. All of the original 8-day data are kept and can be reprocessed for different models when needed.

- P. 9588, L. 23-25: Testing 3 parameter values sounds imprecise, especially for soil depth, a critical, very sensitive parameter in hydrological models.

While 3 parameter values may sound limited, please note that the calibration was conducted on 5 variables for 2107 HUC8s independently (3^5 * 2107 = 512001 runs), and it has resulted in the usage of 1.5 million CPU-hours. Given our limited computational resources, it is perhaps the most we can do for the conterminous US dataset preparation. We have stated clearly in the manuscript that the purpose of this calibration is mainly to help reduce further calibration time. Depending on the future research questions, the default parameters can be improved via more detailed calibration.

- P. 9589, L. 18: "a one-layer elevation band was used", has the impact of this approximation been quantified?

We tested both selections (one band versus five bands) during calibration. For monthly HUC8 total runoff, the difference is negligible.

- P. 9589, L. 20 and below: "matrices"? Do you mean "metrics"?

We intend to use “matrices”.

- P. 9590 (Sect. 3): it seems that a presentation/discussion of the obtained spatial distribution of the model parameters is lacking.

While we agree with this comment, given the limited space we have for this paper (i.e., it has been overly long after including several new analyses), we do not intend to provide such information. In our view, the multipanel illustration in Fig. 8 (now Fig. 11 in the revised manuscript) should be sufficient for the readers to understand the limitation across different subbasins.

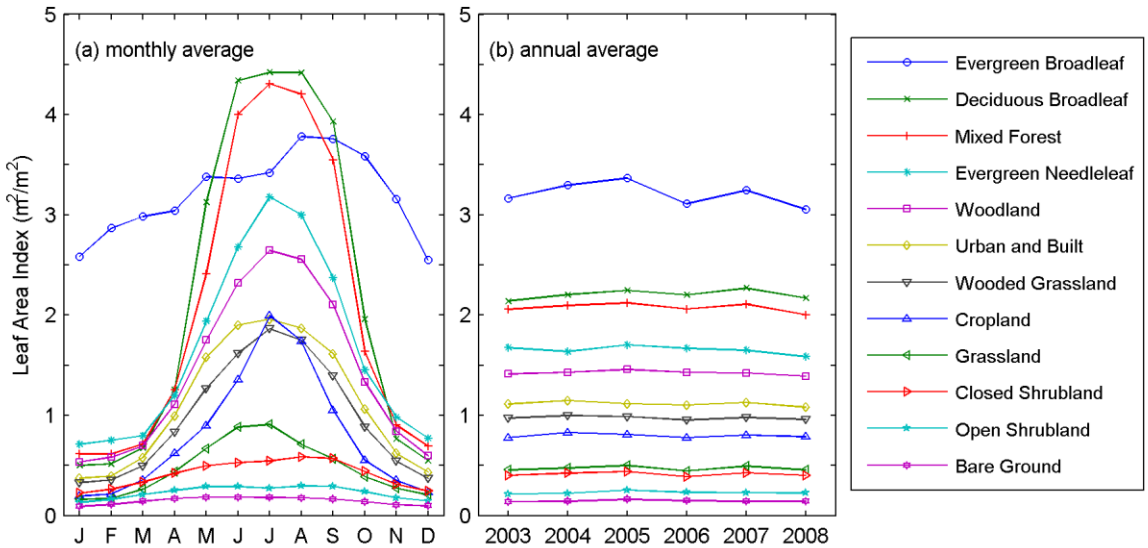
- P. 9590, L. 11: "NARR seems to be warmer", more than 10◦C for the last percentiles of the distribution. This is more than "warmer"!

Agree. The original statement is now strengthened in the revised manuscript. Royer and Poirier (2010) is also included for NARR’s warm bias.

- P. 9591, L. 11-12: "the annual variability is not significant at the conterminous US scale". Such a conclusion may be valid considering average monthly values over all the US. This cannot be true at finer spatial/temporal scales.

To support our statement, a new figure (Fig. 6) has been added in the revised manuscript to show the annual average LAI from 2003 to 2008 for each US hydrologic region. Consistent with Fig. 5b, the annual variability is also not significant at 18 hydrologic regions. Therefore, our original conclusion holds.

Please note that our intention here is mainly to prepare the vegetation parameters for VIC modeling. Since the current VIC does not allow dynamic vegetation simulation, we must specify the average monthly LAI values based on the best-available data. For models with more flexible vegetation parameter inputs, this simplification will not be required.



New Figure 6 in the revised manuscript. The MODIS leaf area index summarized by the UMD land cover classification.

- *P. 9592, L. 27 (Fig. 7): "model performance" cannot be completely quantified using yearly means only*

As discussed earlier, the calibration was performed on monthly time series (i.e., simulated VIC total runoff to USGS WaterWatch runoff), so the seasonal pattern is part of the calibration. The scatter plot shown in Fig. 7 (now Fig. 8) is merely a quick way to visualize the results across 2107 HUC8s. It does not mean that we used only the annual mean for calibration. In the revised manuscript, we have included a new scatter plot (Fig. 10) to show the model performance across various seasons. The results showed that the model performed the best in winter, then spring, fall, and summer, from the wettest season to the driest season. It is somewhat expected because we are calibrating monthly time series across different seasons and the Nash–Sutcliffe coefficient is mainly controlled by the wetter months (winter) and less by the drier months (summer).

- *P. 9593, L. 11 (Table 3): it should be noted that for the validation period, more than half of the basins present inadequate simulations (Nash < 0.5).*

Since we have noted the limitations of the current simulation clearly in the manuscript, no further action was performed for this comment. Please note that the runoff evaluation has never been conducted comprehensively for the entire conterminous US at the HUC8 scale. Therefore, although there is still great room for further advancement, it has been a big improvement, as illustrated in Fig. R1.

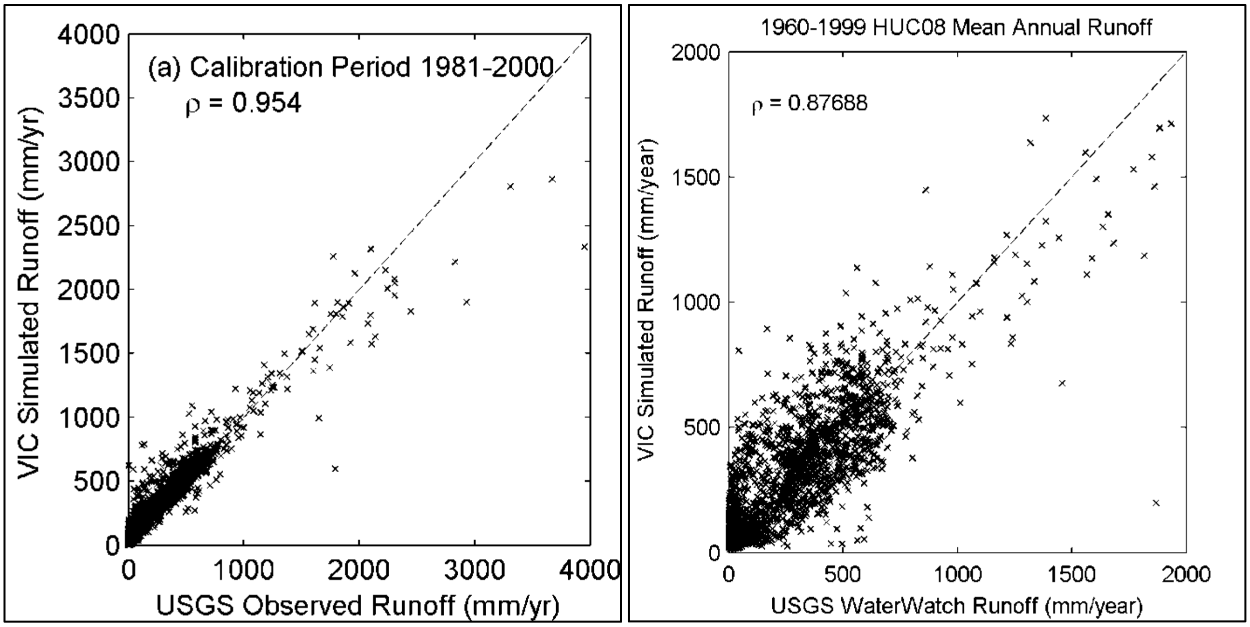
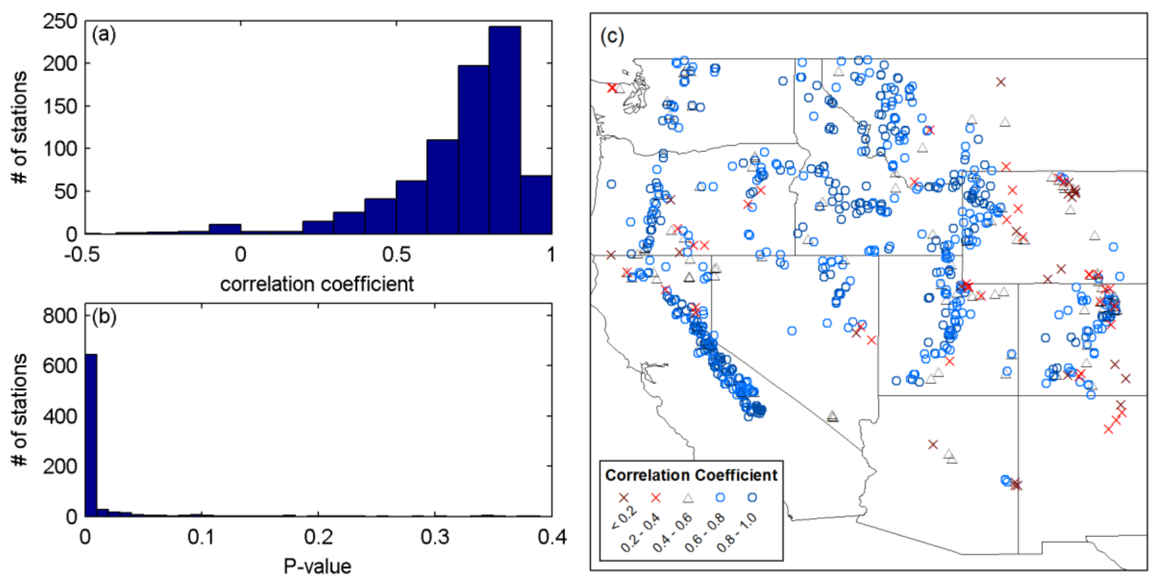


Figure R1: The USGS WaterWatch observed runoff versus the VIC simulated annual total runoff (surface runoff+baseflow) using spatial resolution of (a) 1/24 degree and (b) 1/8 degree.

- P. 9612 (Fig. 9): Fig. 9c color scale is not readable, Fig. 9b is not precise enough (the 0.05 binning is a bit crude, use a log10 scale?).

The color scale in Fig. 9c (now Fig. 11c) has been revised. Fig. 9b (now Fig. 11b) is also re-plotted using 0.01 bin value. We did not use the log scale in Fig. 9b (now Fig. 11b) since log(P-value) does not have a clear statistical meaning for significance tests.



New Figure 12 in the revised manuscript. Correlation coefficients between observed and simulated 1981–2000 April 1st snow water equivalent: (a) histogram of correlation coefficients from 784 selected stations, (b) histogram of P-value, and (c) spatial pattern of correlation coefficients for all selected stations.

Additional References

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