

Supporting Information for

**Assimilation of blended in situ-satellite snow water equivalent into the National  
Water Model for improving hydrologic simulation in two US river basins**

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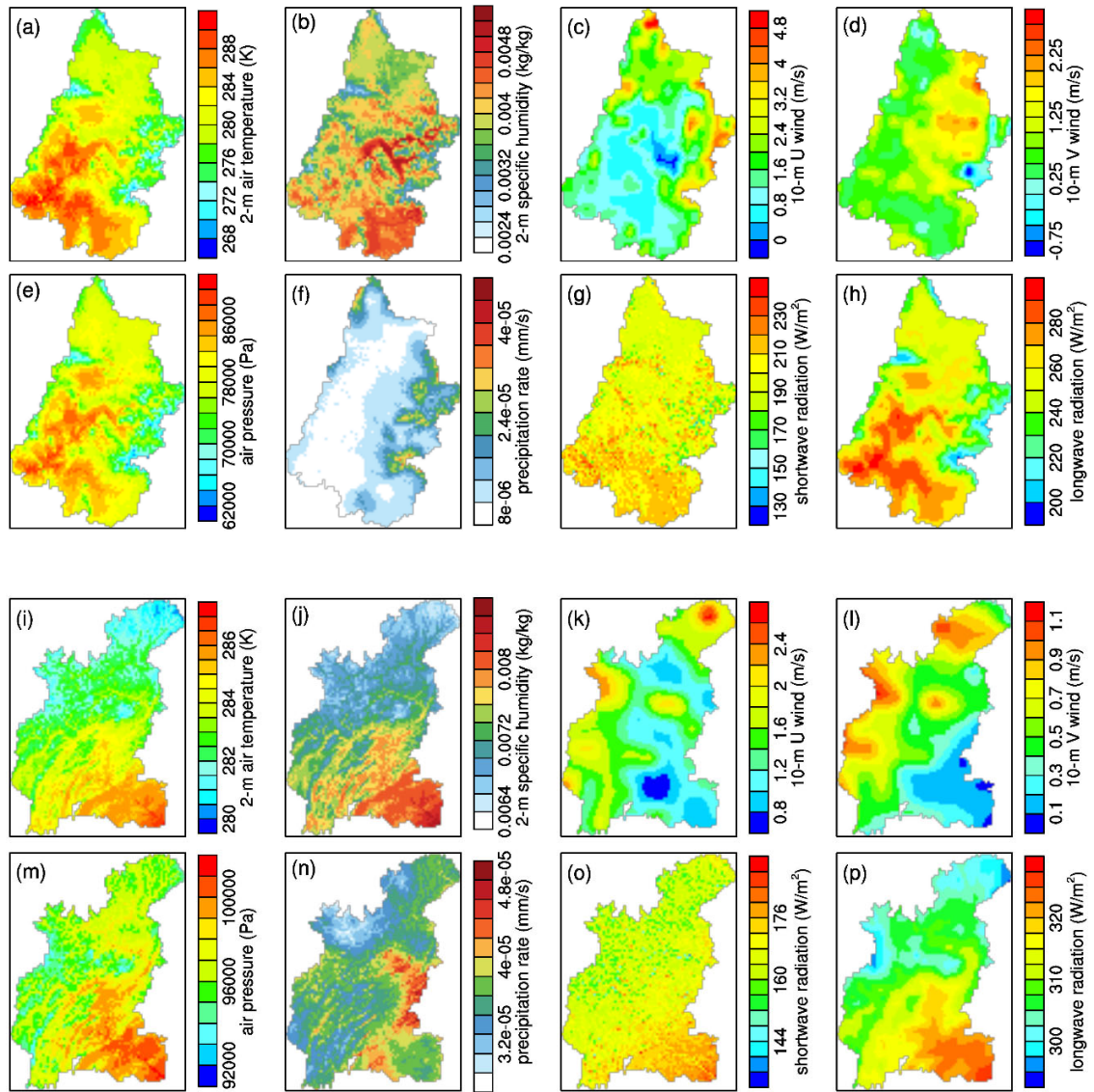
Table S1. Selected subbasins and corresponding USGS stations.

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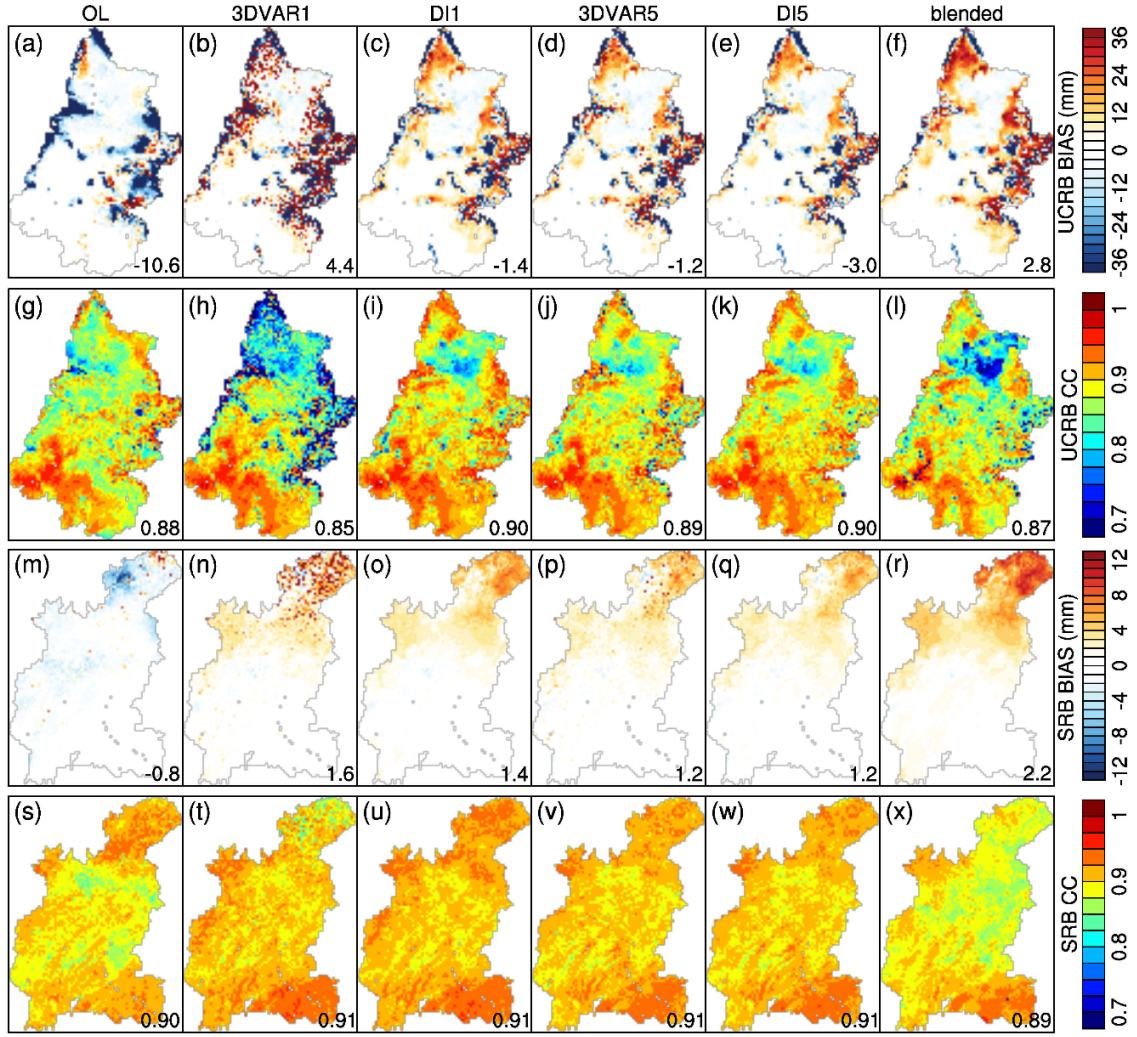
**Table S2.** National Water Model v2.0 physical parameterization schemes.

Physical process	Option
Dynamic vegetation	LAI from lookup table; GVF from climatology
Canopy stomatal resistance	Ball–Berry (Ball et al., 1987)
Soil moisture factor for stomatal resistance	Noah (Chen and Dudhia, 2001)
Runoff and groundwater	Schaake96 (Schaake et al., 1996)
Surface layer drag coefficient	Monin–Obukhov (Brutsaert, 1982)
Frozen soil permeability	Niu–Yang06 (Niu and Yang, 2006)
Supercooled liquid water	Niu–Yang06 (Niu and Yang, 2006)
Radiation transfer	Two-stream applied to vegetated fraction (Niu and Yang, 2004)
Snow surface albedo	BATS (Yang et al., 1997)
Rainfall and snowfall partitioning	Jordan91 (Jordan, 1991)
Lower boundary of soil temperature	Noah (Chen and Dudhia, 2001)
Snow/soil temperature time scheme	Semi-implicit scheme for snow fraction (Yang et al., 2011)
Glacier treatment	Slab treatment (Chen and Dudhia, 2001)
Surface resistance	Snow/non-snow split (Sakaguchi and Zeng, 2009)
Groundwater flow	Exponential storage-discharge function (Gochis et al., 2015)
Surface and subsurface flow routing	Steepest descent (O'Callaghan and Mark, 1984)
Channel routing	Custom-network (NHDPlus) Muskingum-Cunge (Cunge, 1969)
Lake/Reservoir management	Level pool routing (Gochis et al., 2015)

Note: LAI = Leaf Area Index; GVF = Green Vegetation Fraction; BATS = Biosphere-Atmosphere Transfer Scheme.



**Figure S1.** Multi-year (water years 2016–2019) mean data of the forcing variables for UCRB and SRB.



**Figure S2.** Spatial distribution of bias (BIAS) and correlation coefficient (CC) of the daily SWE of different products against SNODAS analysis in the water years 2017–2019 for UCRB and SRB. The number on the bottom right corner of each subfigure presents the spatial average statistic.

## References

- Ball, J.T., Woodrow, I.E., Berry, J.A., 1987. A model predicting stomatal conductance and its contribution to the control of photosynthesis under different environmental conditions, in: Biggins, J. (Eds.), *Progress in Photosynthesis Research*. Martinus Nijhoff, Dordrecht, Netherlands, pp. 221–234.
- Brutsaert, W.A., 1982. *Evaporation into the atmosphere: Theory, history and applications*. Springer Netherlands, Dordrecht, Netherlands.
- Chen, F., Dudhia, J., 2001. Coupling an advanced land surface-hydrology model with the Penn state-NCAR MM5 modeling system. Part I: Model implementation and sensitivity. *Mon. Weather Rev.* 129 (4), 569–585. [https://doi.org/10.1175/1520-0493\(2001\)129<0569:CAALSH>2.0.CO;2](https://doi.org/10.1175/1520-0493(2001)129<0569:CAALSH>2.0.CO;2).
- Cunge, J.A., 1969. On the subject of a flood propagation computation method (Muskingum method). *J. Hydraul. Res.* 7 (2), 205–230. <https://doi.org/10.1080/00221686909500264>.
- Gochis, D.J., Yu, W., Yates, D.N., 2015. *The NCAR WRF-Hydro technical description and user's guide, version 3.0*. National Center for Atmospheric Research, Boulder, Colorado. <https://doi.org/10.5065/D6DN43TQ>.
- Jordan, R.E., 1991. *A one-dimensional temperature model for a snow cover: Technical documentation for SNTHERM.89*. Cold Region Research and Engineering Laboratory, U.S. Army Corps of Engineers, Hanover, New Hampshire.
- Niu, G.-Y., Yang, Z.-L., 2004. Effects of vegetation canopy processes on snow surface energy and mass balances. *J. Geophys. Res. Atmos.* 109, D23111. <https://doi.org/10.1029/2004JD004884>.
- Niu, G.-Y., Yang, Z.-L., 2006. Effects of frozen soil on snowmelt runoff and soil water storage at a continental scale. *J. Hydrometeorol.* 7 (5), 937–952. <https://doi.org/10.1175/JHM538.1>.
- O'Callaghan, J.F., Mark, D.M., 1984. The extraction of drainage networks from digital elevation data. *Computer Vision, Graphics, and Image Processing* 28 (3), 323–344. [https://doi.org/10.1016/S0734-189X\(84\)80011-0](https://doi.org/10.1016/S0734-189X(84)80011-0).

- Sakaguchi, K., Zeng, X., 2009. Effects of soil wetness, plant litter, and under-canopy atmospheric stability on ground evaporation in the Community Land Model (CLM3.5). *J. Geophys. Res.* 114, D01107. <https://doi.org/10.1029/2008JD010834>.
- Schaake, J.C., Koren, V.I., Duan, Q.Y., Mitchell, K., Chen, F., 1996. Simple water balance model for estimating runoff at different spatial and temporal scales. *J. Geophys. Res. Atmos.* 101 (D3), 7461–7475. <https://doi.org/10.1029/95JD02892>.
- Yang, Z.-L., Dickinson, R.E., Robock, A., Vinnikov, K.Y., 1997. Validation of the snow submodel of the Biosphere–Atmosphere Transfer Scheme with Russian snow cover and meteorological observational data. *J. Climate* 10 (2), 353–373. [https://doi.org/10.1175/1520-0442\(1997\)010<0353:VOTSSO>2.0.CO;2](https://doi.org/10.1175/1520-0442(1997)010<0353:VOTSSO>2.0.CO;2).
- Yang, Z.-L., Cai, X., Zhang, G., Tavakoly, A.A., Jin, Q., Meyer, L.H., Guan, X., 2011. The community Noah land surface model with multi-parameterization options (Noah-MP). The University of Texas at Austin, Austin, TX.