Replies to reviews

"Revisiting parameter sensitivities in the Variable Infiltration Capacity model across a hydroclimatic gradient"

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We thank the Editor and the reviewers for their time in commenting on our paper. We provide responses to each individual point below. For clarity, comments are given in italics, and our responses are given in plain blue text.

Anonymous Referee #2

The authors assessed application results of the VIC model on 101 basins in Chile to test how sensitive model results were to variations in 43 calibration parameters. They explained how some parameters could be adjusted by model users and others were hidden inside the coding of the model. Their results showed that 12 parameters exhibited significant sensitivity in soil, vegetation, and snow input variables. Their work seems to provide insight into the inner workings of the model and to contribute useful guidance for future advancement in the popular VIC model.

The paper is long and detailed with an extensive set of graphs and tables that will be of interest to modelers working on the finest details of the VIC model. The writing and presentation are excellent.

We thank the reviewer for his/her positive feedback.

The paper would be more useful to hydrologists and modelers who are not part of the mainline VIC users if the authors would include brief information about the model's history and accessibility. Very little information of this nature is included. See Line 142 as an example of how the model is introduced.

We have included additional information about the model's history and accessibility, following the reviewer's recommendation. Please, see the new updated section 3.1 (L143-L156):

"The Variable Infiltration Capacity (VIC; Liang et al., 1994) model is a semi-distributed, physically-based hydrological model that simulates snow accumulation and melt, evapotranspiration (ET), canopy interception, surface runoff, baseflow, and other hydrological processes at daily or sub-daily time steps. While the model was originally designed as a land surface scheme for coupled simulations within earth system models (Liang et al., 1994), most applications have involved uncoupled simulations for hydrological characterizations and, accordingly, the literature reports many attempts to improve process representations (e.g., Liang et al., 1996, 1999; Cherkauer et al., 2003; Andreadis et al., 2009). VIC is predominantly used in the United States (Addor and Melsen, 2019), with many studies focused on water and energy balances (e.g., Andreadis and Lettenmaier, 2006; Cayan et al., 2010); however, its use has expanded to other geographical domains, including China (e.g., Zhao et al., 2013; Gou et al., 2021), Chile (e.g., Vásquez et al., 2021; Vicuña et al., 2021), Europe (e.g., Lohmann et al., 1998; Roudier et al., 2016) and globally (e.g., Shukla et al., 2013; Yang et al., 2021). Ongoing

community efforts using the VIC model include the NASA Land Information System (LIS; https://lis.gsfc.nasa.gov/, last access: 25 January 2022), NASA's Land Data Assimilation System (LDAS; https://ldas.gsfc.nasa.gov/, last access: 25 January 2022), and the Regional Arctic System Model (RASM; https://www.oc.nps.edu/NAME/RASM.htm, last access: 25 January 2022). This study uses VIC version 4.1.2.g, which can be downloaded from https://github.com/UW-Hydro/VIC/releases, along with other versions".

References:

Addor, N., & Melsen, L. A. (2019). Legacy, Rather Than Adequacy, Drives the Selection of Hydrological Models. *Water Resources Research*, *55*(1), 378–390. https://doi.org/10.1029/2018WR022958

Andreadis, K. M., & Lettenmaier, D. P. (2006). Trends in 20th century drought over the continental United States. *Geophysical Research Letters*, *33*(10), 1–4. https://doi.org/10.1029/2006GL025711

Andreadis, K. M., Storck, P., & Lettenmaier, D. P. (2009). Modeling snow accumulation and ablation processes in forested environments. *Water Resources Research*, *45*, W05429. https://doi.org/10.1029/2008WR007042

Cayan, D. R., Das, T., Pierce, D. W., Barnett, T. P., Tyree, M., & Gershunov, A. (2010). Future dryness in the southwest US and the hydrology of the early 21st century drought. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(50), 21271–6. https://doi.org/10.1073/pnas.0912391107

Cherkauer, K. A., Bowling, L. C., & Lettenmaier, D. P. (2003). Variable infiltration capacity cold land process model updates. *Global and Planetary Change*, *38*(1–2), 151–159. https://doi.org/10.1016/S0921-8181(03)00025-0

Liang, X., Lettenmaier, D. P., Wood, E. F., & Burges, S. J. (1994). A simple hydrologically based model of land surface water and energy fluxes for general circulation models. *Journal of Geophysical Research*, *99*(D7), 14,415.14.428. https://doi.org/10.1029/94jd00483

Liang, X., Wood, E. F., & Lettenmaier, D. P. (1996). Surface soil moisture parameterization of the VIC-2L model: Evaluation and modification. *Global and Planetary Change*, *13*(1–4), 195–206. https://doi.org/10.1016/0921-8181(95)00046-1

Liang, X., Wood, E. F., & Lettenmaier, D. P. (1999). Modeling ground heat flux in land surface parameterization schemes. *Journal of Geophysical Research: Atmospheres*, *104*(D8), 9581–9600. https://doi.org/10.1029/98JD02307

Lohmann, D., Raschke, E., Nijssen, B., & Lettenmaier, D. P. (1998). Hydrologie à l'échelle régionale: II. Application du modèle VIC-2L sur la rivière Weser, Allemagne. *Hydrological Sciences Journal*, *43*(1), 143–158. https://doi.org/10.1080/02626669809492108

Roudier, P., Andersson, J. C. M., Donnelly, C., Feyen, L., Greuell, W., & Ludwig, F. (2016). Projections of future floods and hydrological droughts in Europe under a +2°C global warming. *Climatic Change*, *135*(2), 341–355. https://doi.org/10.1007/s10584-015-1570-4

Sheffield, J., Andreadis, K. M., Wood, E. F., & Lettenmaier, D. P. (2009). Global and continental drought in the second half of the twentieth century: Severity-area-duration analysis and temporal variability of large-scale events. *Journal of Climate*, *22*(8), 1962–1981. https://doi.org/10.1175/2008JCLI2722.1

Shukla, S., Sheffield, J., Wood, E. F., & Lettenmaier, D. P. (2013). On the sources of

global land surface hydrologic predictability. *Hydrology and Earth System Sciences*, *17*(7), 2781–2796. https://doi.org/10.5194/hess-17-2781-2013

Vásquez, N., Cepeda, J., Gómez, T., Mendoza, P. A., Lagos, M., Boisier, J. P., et al. (2021). Catchment-Scale Natural Water Balance in Chile. In *Water Resources of Chile* (pp. 189–208). https://doi.org/10.1007/978-3-030-56901-3_9

Vicuña, S., Vargas, X., Boisier, J. P., Mendoza, P. A., Gómez, T., Vásquez, N., & Cepeda, J. (2021). Impacts of Climate Change on Water Resources in Chile. In *Water Resources of Chile* (Vol. 13, pp. 347–363). https://doi.org/10.1007/978-3-030-56901-3_19

Wang, G. Q., Zhang, J. Y., Jin, J. L., Pagano, T. C., Calow, R., Bao, Z. X., et al. (2012). Assessing water resources in China using PRECIS projections and a VIC model. *Hydrology and Earth System Sciences*, *16*(1), 231–240. https://doi.org/10.5194/hess-16-231-2012

Zhao, Q., Ye, B., Ding, Y., Zhang, S., Yi, S., Wang, J., et al. (2013). Coupling a glacier melt model to the Variable Infiltration Capacity (VIC) model for hydrological modeling in north-western China. *Environmental Earth Sciences*, *68*(1), 87–101. https://doi.org/10.1007/s12665-012-1718-8