Hydrology and Earth System Sciences Discussions

Hydrol. Earth Syst. Sci. Discuss., referee comment RC1
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Comment on hess-2022-61

Anonymous Referee #1

Referee comment on "Challenges and benefits of quantifying irrigation through the assimilation of Sentinel-1 backscatter observations into Noah-MP" by Sara Modanesi et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2022-61-RC1, 2022

General comments:

This study provides valuable insights on how to optimally merge remotely sensed observations with a widely used land surface model (Noah-MP) using an irrigation scheme to improve simulated irrigation and effected hydrologic states and fluxes. The study concluded that the evaluated data assimilation system is largely affected by errors in simulated irrigation. The authors pose that inclusion of dynamic crop information and the assimilation of backscatter data per orbit can improve the results presented in this study. A very interesting aspect of this study is the assimilation of backscatter (rather than soil moisture) which allows assimilation to be performed in the observation space. It would be helpful for the authors to elaborate on this decision and if they think there would be degraded performance if SM was assimilated instead. Specific comments and questions are included below.

Specific comments:

C1: Were any bias correction methods employed (e.g., LSM calibration)? If not were there any steps taken to check if there are systematic biases between the observed and modeled backscatter that could violate the Kalman filter assumption (i.e., line 236). It seems it would be useful to run an open loop Noah-MP simulation forced with precipitation + known irrigation to see if simulated backscatter errors are truly random relative to the observations.

C2: The relationship between Noah-MP simulated soil moisture and vegetation with the assimilated variable, backscatter, is vitally important to this analysis. It would be very beneficial to include equations that show how backscatter is related to these variables, and then how the assimilation is used to ‘correct' each state. What assumptions are made within these steps that can affect irrigation estimates?

C3: The EnKF is a commonly used data assimilation algorithm and certainly has proven useful. However, from a mass-balance perspective, particle assimilation algorithms (e.g., Abolafia-Rosenzweig et al., 2019) may be more appropriate. For instance, in particle DA algorithms, all model states are corrected in a physically consistent manner (e.g., rather than choosing to only update surface soil moisture or empirically decide how to update states and fluxes related to the observation). Can you discuss why the EnKF was used and potential limitations of this data assimilation strategy in the context of irrigation quantification and simulating irrigation signals? In future steps that seek to employ the lessons of this study, considering other DA algorithms can also be beneficial.

Reference:

Abolafiaâ□□Rosenzweig, R., Livneh, B., Small, E.E., Kumar, S.V., 2019. Soil Moisture Data Assimilation to Estimate Irrigation Water Use. J. Adv. Model. Earth Syst. 11, 3670–3690. https://doi.org/10.1029/2019MS001797

C4: The timing of irrigation (e.g., continuous vs. applied only during morning hours) can greatly affect the amount of irrigation required to achieve a specified (or observed) soil and vegetation moistness. Is the irrigation timing assumed from Noah-MP reasonable, or is this likely to introduce errors? If so, are ‘corrected' errors from DA a sign of skill or are they compensating for other errors?

C5: What is the footprint of irrigation at the study sites relative to the observed footprint? How could this affect the amount of information provided to the LSM via observations?

C6: Why use ASCAT to evaluate Noah-MP surface soil moisture instead of finer resolution data such as SMAP-S1 (which has been shown to have irrigation signals in Jalilvand et al., 2021) or SMAP which was shown to have irrigation signals in Lawston et al. (2017) and provide more reliable data than ASCAT (Kumar et al., 2018)?

References:

Kumar, S.V., Dirmeyer, P.A., Peters-Lidard, C.D., Bindlish, R., Bolten, J., 2018. Information theoretic evaluation of satellite soil moisture retrievals. Remote Sens. Environ. 204, 392–400. https://doi.org/10.1016/j.rse.2017.10.016

Kumar, S.V., Peters-Lidard, C.D., Santanello, J.A., Reichle, R.H., Draper, C.S., Koster, R.D., Nearing, G., Jasinski, M.F., 2015. Evaluating the utility of satellite soil moisture retrievals over irrigated areas and the ability of land data assimilation methods to correct for unmodeled processes. Hydrol. Earth Syst. Sci. 19, 4463–4478. https://doi.org/10.5194/hess-19-4463-2015

Lawston, P.M., Santanello, J.A., Kumar, S.V., 2017. Irrigation Signals Detected From SMAP Soil Moisture Retrievals: Irrigation Signals Detected From SMAP. Geophys. Res. Lett. 44, 11,860-11,867. https://doi.org/10.1002/2017GL075733

C7: The paragraph from lines 75-86 (or the following paragraph) could benefit from discussion of Abolafia-Rosenzweig et al. (2019) which designed a system to assimilation remotely sensed soil moisture with land surface models to quantify irrigation water use as well as Jalilvand et al. (2021) which compliments Lawston et al. (2017) by evaluating irrigation signals from SMAP-S1 soil moisture retrievals (i.e., from Das et al., 2019).

References:

Abolafiaâ□□Rosenzweig, R., Livneh, B., Small, E.E., Kumar, S.V., 2019. Soil Moisture Data Assimilation to Estimate Irrigation Water Use. J. Adv. Model. Earth Syst. 11, 3670–3690. https://doi.org/10.1029/2019MS001797

Das, N.N., Entekhabi, D., Dunbar, R.S., Chaubell, M.J., Colliander, A., Yueh, S., Jagdhuber, T., Chen, F., Crow, W., O'Neill, P.E., Walker, J.P., Berg, A., Bosch, D.D., Caldwell, T., Cosh, M.H., Collins, C.H., Lopez-Baeza, E., Thibeault, M., 2019. The SMAP and Copernicus Sentinel 1A/B microwave active-passive high resolution surface soil moisture product. Remote Sens. Environ. 233, 111380. https://doi.org/10.1016/j.rse.2019.111380

Jalilvand, E., Abolafia-Rosenzweig, R., Tajrishy, M., Das, N.N., 2021. Evaluation of SMAP-Sentinel1 High-Resolution Soil Moisture Data to Detect Irrigation over Agricultural Domain. IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens. 1–1. https://doi.org/10.1109/JSTARS.2021.3119228

C8: Please reference the following when introducing NASA's LIS:

Kumar, S., Peters-Lidard, C., Tian, Y., Houser, P., Geiger, J., Olden, S., Lighty, L., Eastman, J., Doty, B., Dirmeyer, P. Land information system: An interoperable framework for high resolution land surface modeling. Environmental Modelling & Software 21, 1402–1415. https://doi.org/10.1016/j.envsoft.2005.07.004 (2006).

Peters-Lidard, C.D., Houser, P.R., Tian, Y., Kumar, S.V., Geiger, J., Olden, S., Lighty, L., Doty, B., Dirmeyer, P., Adams, J., Mitchell, K., Wood, E.F., Sheffield, J. High-performance Earth system modeling with NASA/GSFC's Land Information System. Innov. Syst. Softw. Eng. 3, 157–165. https://doi.org/10.1007/s11334-007-0028-x (2007).