Editor's Comments

After a careful assessment of your revised manuscript and the two referee reports, I agree with both reviewers, that your manuscript will be ready for publication after minor revisions.

Please submit a revised version addressing the comments by reviewer #2, particularly on the methodological aspects related to the simultaneous assimilation of SMOS and SMAP data. Though this is the main issue, please address also the other issues raised by this referee in your revised manuscript.

We thank editor and the reviewer #2 for their thoughtful comments. We have addressed the issues raised by the reviewer below and revised the manuscript accordingly.

Reviewer #2's Comments

The authors have addressed most of my comments in the revised version of the manuscript. Apart from two minor comments, I would like to ask the authors to clarify the simultaneous assimilation of SMOS and SMAP data. How does this would if SMOS and SMAP data are not available for the same time step? And if both are available what does the update equation look like? Notably, the Kalman gain (Eq. 2) has x, y, and z as variables while the Eq (2) has only x and y.

Thank you for the comments. Across the Australian landscape there can indeed be the case where neither SMOS nor SMAP data are available for assimilation. In such cases, the model will run with the initial condition of analysis states from previous time step. State updating only occurs when at least one of the satellite observations are available.

When both observations are available, which is the more common occurrence, equations 2 and 3 can be recasts as:

$$\mathrm{X}_{\mathrm{t}}^{\mathrm{a}} = \mathrm{X}_{\mathrm{t}}^{\mathrm{f}} + [K_{SMAP}, K_{SMOS}] \begin{bmatrix} Y_t^{SMAP} - \mathrm{X}_{\mathrm{t}}^{\mathrm{f}} \\ Y_t^{SMOS} - \mathrm{X}_{\mathrm{t}}^{\mathrm{f}} \end{bmatrix}$$

$$= (1 - K_{SMAP} - K_{SMOS})\mathrm{X}_{\mathrm{t}}^{\mathrm{f}} + K_{SMAP} Y_t^{SMAP} + K_{SMOS} Y_t^{SMOS}$$

$$= K_{AWRA}\mathrm{X}_{\mathrm{t}}^{\mathrm{f}} + K_{SMAP} Y_t^{SMAP} + K_{SMOS} Y_t^{SMOS},$$

where the gain factors are calculated as:

$$K_{AWRA} = \frac{\frac{1}{\sigma_x^2}}{\frac{1}{\sigma_x^2} + \frac{1}{\sigma_y^2} + \frac{1}{\sigma_z^2}}, K_{SMAP} = \frac{\frac{1}{\sigma_y^2}}{\frac{1}{\sigma_x^2} + \frac{1}{\sigma_y^2} + \frac{1}{\sigma_z^2}}, K_{SMOS} = \frac{\frac{1}{\sigma_z^2}}{\frac{1}{\sigma_x^2} + \frac{1}{\sigma_y^2} + \frac{1}{\sigma_z^2}}$$

Since equation 2 contains all cases including (1) single observations, (2) two observations and (3) no observation, we would like to keep the equation as it is. However, we agree that we need to clarify that the gain matrix *K* and observation vector *Y* can include multiple elements.

In the revised manuscript, we have added the following clarification to L190:

"When both SMAP and SMOS observations are available, Equation 2 can be written as a weighted linear combination of model estimates (x_t^f) and satellite observations (y_t^{SMAP} : SMAP observations, y_t^{SMOS}: SMOS observations) as:

$$x_t^a = K_x x_t^f + K_y y_t^{SMAP} + K_z y_t^{SMOS} \quad . \tag{3}$$

The gain factor, *K*, contains the error variances (σ^2) for both model estimates and observations and can be written as:

$$K_x = \frac{\frac{1}{\sigma_x^2}}{\frac{1}{\sigma_x^2}+\frac{1}{\sigma_y^2}+\frac{1}{\sigma_z^2}},\ K_y = \frac{\frac{1}{\sigma_y^2}}{\frac{1}{\sigma_x^2}+\frac{1}{\sigma_y^2}+\frac{1}{\sigma_z^2}} \text{ and } K_z = \frac{\frac{1}{\sigma_z^2}}{\frac{1}{\sigma_x^2}+\frac{1}{\sigma_y^2}+\frac{1}{\sigma_z^2}}, \tag{4}$$

where x, y, z denotes AWRA-L estimates, SMAP and SMOS soil moisture retrievals respectively. If only one satellite observation is available for a time step, the gain factor is calculated using the error variance from the corresponding observation. If neither SMAP nor SMOS are available, the analysis remains the same as the model forecast."

Specific:
L152: influences
Done

Figure 4: the units are in mm. Is this correct? Because a change of 1 mm seems rather small for a month

Yes. The units are in mm. The map represents the average daily top-soil layer for the month. Since Australia it is driest continent, it is expected that most areas have low top-soil moisture during summertime. And the average difference in Figure 4 (c) is small also because it cancels out from daily values containing both positive and negative over a month.

In the revised manuscript, we have changed the figure caption to clarify as below:

Figure 4: Comparison of average daily surface soil water storage estimates (S0) for December 2019 from (a) model open-loop (OL), (b) joint assimilation of SMAP and SMOS with Triple Collocation (DA-TC) and (c) average change between daily estimates from DA-TC and OL.