**Response to Editor**

Dear Editor,

Thank you for forwarding the comments from reviewer #2 who emphasised to compare the model-derived soil moisture with remote sensing products. In fact, we have considered the very approach while designing this study but did not include it in the main manuscript because of the following reasons:

1. Estimation of soil moisture from remotely sensed products is different from the model-based soil moisture assessment. For Example, NASA's Soil Moisture Active Passive (SMAP) estimates surface soil moisture within the top 5 cm of the soil and with a 2-3 day repeat cycle (Chan et al. 2016). Table 1 shows the available remote sensing-based soil moisture products. The J2000 model considers soil moisture for variable soil depths of up to 100 cm (depending on root depth of vegetation type) on a daily temporal resolution. The spatial resolution of SMAP is 1296 $km^2$ (36 km × 36 km) and 81 $km^2$ (9 km × 9 km) compared to the 4.7 $km^2$ average modelling unit size of the J2000 model (derived from 90-meter resolution datasets).
2. Remote sensing-based soil moisture estimates are also influenced by artificial water storage, surface irrigation and snow cover. In the plain areas of Koshi, both in Nepal and India, there is an extensive network of irrigation canals which supply water to irrigated lands. The soil moisture provided by irrigation systems would be different from the model-derived soil moisture. Similarly, in the high altitude area, snow cover can also affect the soil moisture signal.
3. Some of the recent remote sensing-based soil moisture products are available only after April 2015 (e.g. the SMAP satellite (Chan et al. 2016; Alemohammad et al. 2018)). We found Climate Change Initiative Soil Moisture product (CCI SM) by European Space Agency (ESA) which is available at 625 $km^2$ (25 km × 25 km) resolution from 1978 to 2015 (Dorigo et al. 2017). We have made a comparison between CCI SM and J2000 soil moisture for the period of 1980 to 2007 (Figure 1).

Figure 1 shows the monthly soil moisture comparison between CCI SM and the J2000 model. Because of their differences in soil depth considered, the comparison is made in a fraction of soil depth (i.e 40 cm for CCI SM and up to 100 cm for the J2000 model). The figure shows that both products illustrate the monthly variation in soil moisture where the soil moisture is high during the monsoon season and low in the spring season. However, the soil moisture volume difference is high. The CCI SM is about half in the trans-Himalaya and plains and one third in mountains compared to the J2000 model-derived soil moisture.

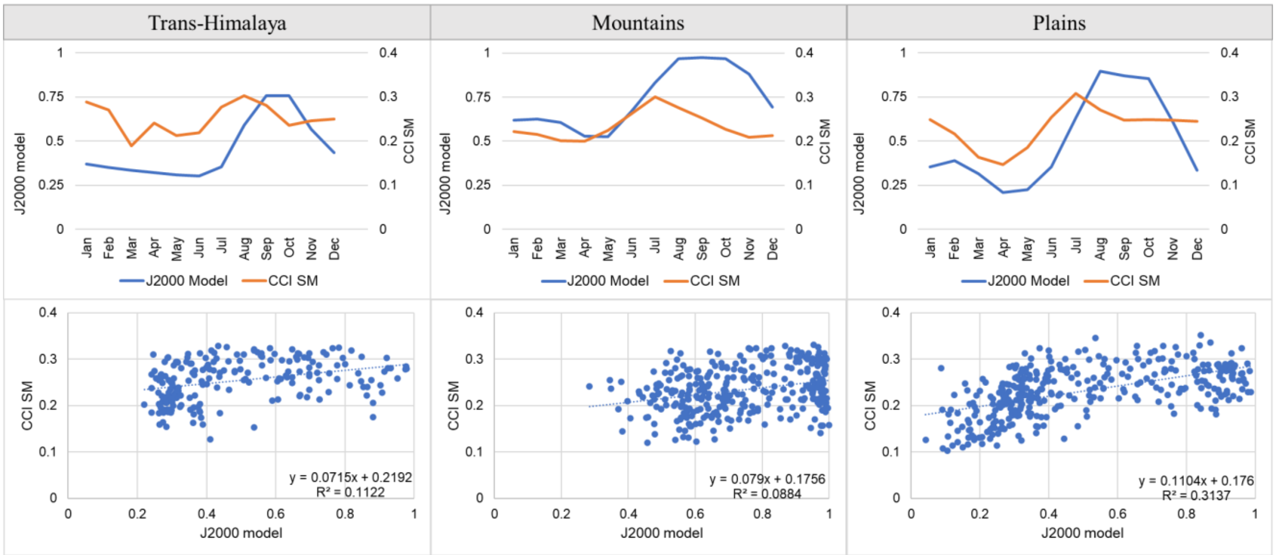



Figure 1: Comparision between soil moisture of CCI SM and J2000 model. First row: an average monthly comparison. Bottom row: scatter plot of monthly values (1980-2007).

As the remote sensing soil moisture is not a suitable basis for the validation of our model results, we opted not to show the comparison between model and remote sensing derived soil moisture in the main results, rather as a supplementary Figure of the comparison.

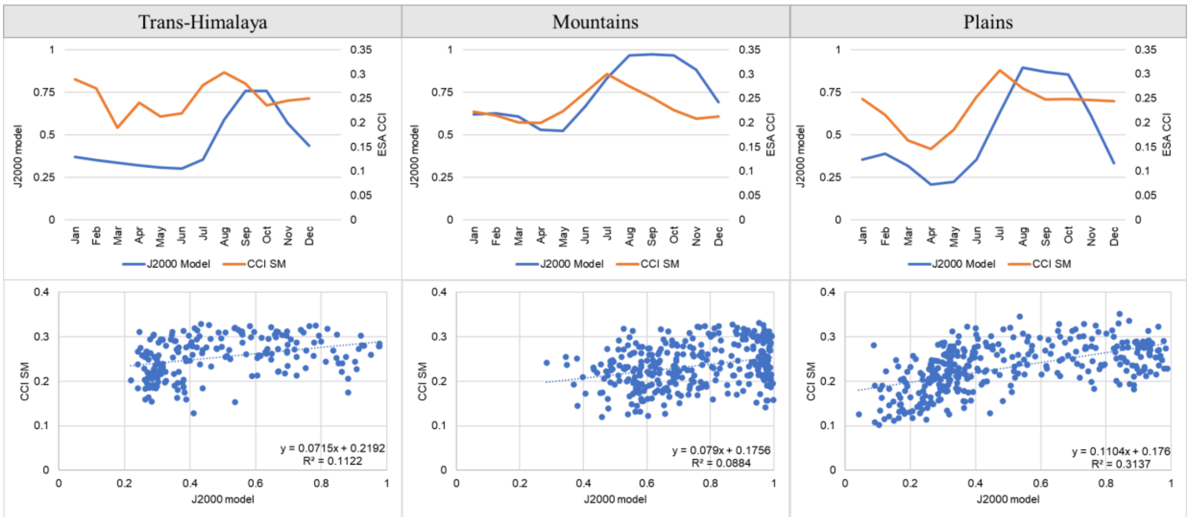
*To address the reviewer's comments, we have added the following lines in section 3.3 Hydrological modelling (last few sentences of the first paragraph) which highlights the limitation of these comparisons, and few sentences in 'uncertainty and limitation' section of 'Discussion' and provided the figure as Supplementary Figure 3.*

**Added portal in section 3.3 Hydrological modelling**

The soil moisture derived from the J2000 model could not be validated directly due to the lack of observed soil moisture data in the basin. While most of the remote sensing-based soil moisture is available only after 2015 (see e.g. Alemohammad et al. 2018), very few like the Climate Change Initiative Soil Moisture product (CCI SM) by European Space Agency (ESA) is available at 25 x 25 km resolution from 1978 to 2015 (Dorigo et al. 2017). Besides, these products differ in considered soil depth when compared to the J2000 model. The spatial resolution of the J2000 model is based on hydrological response units (HRUs) of an average size of 4.7 km$^2$, whereas all available satellite-based soil moisture products feature a distinctly lower spatial resolution. As an example, the CCI SM product has a spatial resolution of 625 km$^2$. Also, remote sensing products might capture artificial water storage, surface irrigation and snow cover, which also affect the spatial and temporal patterns of soil moisture. Because of these differences along with the J2000 model-derived soil moisture which typically considers root depth of vegetation which can reach up to 100 cm soil depth, direct comparison with satellite-derived soil moisture would not be reasonable in this study. However, a monthly comparison with CCI SM is provided in Supplementary Figure 3 and discussed in the 'Discussion' section.

**Added portion in Uncertainties and limitation**

We could not validate soil moisture result with station data due to lack of soil moisture network in the Koshi basin. Validation with remote sensing product was also not reasonable due to differences in soil moisture depth definitions and spatio-temporal resolutions. However, a comparison with CCI SM remote sensing-based soil moisture (Liu et al., 2011; Liu et al., 2012; Dorigo et al. 2017) suggests that both remote sensing and model shows inter-annual variability in soil moisture in which soil moisture is high during the monsoon season and low in the spring season but the absolute volume difference is high. The differences could be due to the different soil moisture depth in CCI SM (40 cm) and the J2000 model (up to 100 cm). Supplementary Figure 3 shows the comparison between CCI SM and J2000 model soil moisture comparison.




Supplementary Figure 3: Comparison between soil moisture of CCI SM and J2000 model. First row: an average monthly comparison. Bottom row: scatter plot of monthly values (1980-2007).

*Note about the figure:*

*CCI SM is a daily surface soil moisture, which has a spatial resolution of 25 km x 25km, as volume percentage for top 40 cm soil layer (Liu et al., 2011; Liu et al., 2012; Dorigo et al. 2017). We extracted the average monthly values separately for three regions. Because of differences in soil depth (i.e 40 cm for CCI SM and up to 100 cm for the J2000 model) in the compared datasets, the fraction volume of soil moisture for each product is presented. In average, CCI SM soil moisture is about half in the trans-Himalaya and plains and one third in mountains compared to the J2000 model.*

Table 1: Available remotely sensed soil moisture product

| **Domain** | **Sensor and Resolution** | **Data available from** | **Reference** |
|---|---|---|---|
| Global | • Soil Moisture Active Passive (SMAP) satellite<br>• 36 km resolution<br>• 5 cm of the soil column | March 31, 2015 and October 26, 2015 | Chan et al. 2016 |
| Global | • Soil Moisture Active Passive (SMAP) satellite<br>• 1 km (after downscaling), original resolution 36 and 9 km | April 2015 | Alemohammad, et al. (2018); Colliander et al. 2017 |
| Global | • **Soil** Moisture **and Ocean Salinity**<br>• 35–50 km | Satellite launched on 2 November 2009 | [SMOS - Earth Online (esa.int)] |
| Global | • *AMSR-E/Aqua L2B Surface Soil Moisture*<br>• 25 km resolution<br>• Surface soil moisture (up to 5 cm depth) | Temporal Coverage: 2002/06/18 to 2011/10/03 | Njoku et al. 2004 |
| Global | • *Climate change initiative Soil moisture by European Space Agency*<br>• *25 km resolution*<br>• *40 cm soil depth* | 1978–2015 | (Liu et al. 2011, 2012); Dorigo et al. 2017; ). |

## Reference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