Assimilation and Combination of SMAP-enhanced and SMAP/Sentinel-1A/B soil moisture estimates with land surface models
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1 Abstract
Prediction of water-related natural disasters such as droughts, floods, wildfires, landslides, and dust outbreaks on a regional-scale can benefit from the high-spatial-resolution soil moisture (SM) data of both satellite and modeled products. The reason is that the amount of surface SM controls in the partitioning of outgoing energy fluxes into latent and sensible heat fluxes. Recently, NASA’s SMAP mission has been implemented, in order to provide the partitioning of outgoing energy fluxes into latent and sensible heat fluxes. When SMAP and NoahMP36 were combined, the R-values for SS1, SS3, and SE9 were 0.722, 0.636, and 0.610 for SMAP-9-km, SMAP/Sentinel-3-km, and SMAP/Sentinel-1-km, respectively. (6-2) The variability from combined products is similar to or a bit lower than that of in-situ SM data alone. Additionally, the combined products always produce a higher R-value than the individual parent products. (6-3) SS1 (A.M), SS1 (A.M/P.M.), and SE1 assimilation can be used to improve the temporal pattern of fine SM spatial resolutions estimated from LSMs.

2 Problem Statement
1) Coverage of satellite-based SM observations is not spatially or temporally continuous.
2) Soil moisture in LSMs would be affected by the model’s parameters and formulations, as well as by errors in the meteorological forcing variables.
3) Description of the fundamental processes that control the terrestrial hydrological cycle across both time and space domains is limited.

3 Study areas

3-1. In-situ SM networks
Choptank River watershed, U.S.A
Kim et al. (2020)

3-2. AmeriFlux network
Contiguous United States and Canada

4 Data sets

Product name & Variable Spatial resolution (degree) Abbreviation
SMAP-Enhanced SM 0.01 SE9
SMAP/Sentinel-1A/B SM 0.03 SS9
SMAP/Sentinel-1B SM 0.01 SS1
SMAP Disaggregated GPM 0.1 GPM
SMAP Enhanced MODIS NC1 0.01 NC1
LSM NoahMP36 SM 0.09 NS9
Forcing ERA5-2 0.1 0.1
In-situ SM USD P N/A
AmeriFlux ET

5 Methodology

5-1. TCA
Gruber et al. (2016)

\[ SWR_{\Delta(t)} = 10 \log \left( \frac{cov(SM_{\text{SMAP}} - SM_{\text{MOD}}) \cdot cov(SM_{\text{SMAP}}, SM_{\text{MOD}})}{cov(SM_{\text{SMAP}}, SM_{\text{MOD}}) \cdot var(SM_{\text{SMAP}})} \right) \]

where SM_{\text{MOD}} indicate SM data from SMAP or SMAP/Sentinel, SM_{\text{SMAP}} indicate SM data from model, and SM_{\text{SMAP}} indicate SM data from ground observations.

5-2. Maximize R
Kim et al. (2015)
The combined SM data (i.e., NS9, NS3, and NS1) were calculated by applying a weighting factor (w) with a normalized range of 0-1 as follows:

\[ SM_{\text{max}} = w \times SM_{\text{MOD}} + (1 - w) \times SM_{\text{SMAP}} = \left( k, 9, 3, 1 \right) \]

References

Kim et al. (2020)

7 Conclusion
Through this study, we have shown a potential application of SMAP/Sentinel SM data to improve the estimation of SM from models. By combining SS1, SS3, and SE9 data, we were able to improve the quality of SM data. Furthermore, by assimilating SS1 into NoahMP36, we were able to reduce bias in ET at some points. In a future study, we will conduct similar analyses of all AmeriFlux points, and we will also spatially compare assimilated ET data with other spatial ET data sources.

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