High-resolution satellite soil moisture evaluation and estimation

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Outline

- Several high spatial resolution satellite soil moisture products at several kilometers are available
- Evaluation of these methods/products is essential and highly required by research communities

Objectives

- Inter-compare high-resolution satellite soil moisture products using triple collocation approach and COSMOS-UK measurements
- Investigate the potential of merging existing soil moisture products to obtain the best high-resolution soil moisture estimate



Study area and data

Soil moisture product	Temporal resolution	Grid size	Original band/ frequency
SMOS	Daily	1 km	L-band (1.4 GHz)
SMAP	Daily	9 km	L-band (1.41 GHz)
Sentinel-1	Daily	1 km	C-band (5.405 GHz)
Sentinel-1/SMAP combined	Daily	3 km	/
JULES-CHESS	Daily	1 km	/



COSMOS-UK (Cosmic-ray soil moisture monitoring network)

38 sites







Validation against COSMOS measurements

Error statistics for each station

Direct comparison



Validation against COSMOS measurements

Error statistics for each station

Anomaly comparison



Validation against COSMOS measurements

Comparison based on collocated samples



Direct comparison



Triple collocation analysis













Triple collocation merging scheme

$$w_x = \frac{\sigma_y^2 \sigma_z^2}{\sigma_x^2 \sigma_y^2 + \sigma_x^2 \sigma_z^2 + \sigma_y^2 \sigma_z^2}$$
$$w_y = \frac{\sigma_x^2 \sigma_z^2}{\sigma_x^2 \sigma_y^2 + \sigma_x^2 \sigma_z^2 + \sigma_y^2 \sigma_z^2}$$
$$w_z = \frac{\sigma_x^2 \sigma_y^2}{\sigma_x^2 \sigma_y^2 + \sigma_x^2 \sigma_z^2 + \sigma_y^2 \sigma_z^2}.$$

$$S_m = w_x S_x + w_y S_y + w_z S_z$$





Spatial pattern of merged soil moisture







Evaluation of merged soil moisture product





Evaluation of merged soil moisture product

Direct comparison 0.14 1.0 0.12 0.8 0.10 $\begin{array}{c} \text{ubRMSE} \\ (m^3 \ /m^3 \) \end{array}$ 0.08 0.6 Ч 0.06 0.4 0.04 0.02 0.2 0.00 0.0 NAP Nerge_TC SMOS SMAP SMOS SMAP Nerge_TC Anomaly comparison 0.14 1.0 0.12 0.8 0.10 $\begin{array}{c} \text{ubRMSE} \\ (m^3 \ /m^3 \) \end{array}$ 0.08 0.6 Ч 0.06 0.4 0.04 0.02 0.2 0.00 MAN Merge_TC 0.0 SMAP JULES-CHESS Merge TC SMAP SMOS SMOS





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Conclusion

- SMAP soil moisture product outperforms other existing satellite products compared to COSMOS-UK measurements
- Merged soil moisture integrates the benefit of satellite observations and JULES-CHESS output, based on TC error estimation and least square merging scheme
- 9 km and 1 km integrated and gapless soil moisture product will be generated over the UK mainland



