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Progress in evaluating satellite soil moisture products in Great Britain against COSMOS-UK and in-situ soil moisture measurements

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The resolution of satellite of satellite-derived soil moisture data products has matured, notably in recent years due to the Soil Moisture Active Passive mission (SMAP) launched in 2015. Whilst spatial resolutions still fall short of those suitable for field-scale monitoring, there are several 'value-added' RS soil moisture products available at the regional (e.g. SMAP: 36km) to meso-scale (e.g. SMAP: 9km) resolution. Although the intended 3km scale SMAP product did not materialise due to the failure of the L-Band radar, a potential substitute product has recently become available (Das et al. 2019). The SMAP-Sentinel1 product combines data from SMAP and C-Band Sentinel 1A/B SAR data to synthesise global soil moisture at a 3km and 1km resolution (~6 day revisit for Europe).

Evaluation of these products against ground-based measurements in the USA and elsewhere is encouraging, but only preliminary evaluation has been undertaken in the United Kingdom. Evaluation is always challenging because (i) rather than a direct measurement, satellite estimates are based on other measured properties (e.g. brightness temperature) with soil moisture algorithmically inferred, (ii) ground-based measurements are highly localised in comparison with the measurement averaged over the satellites much larger pixel resolution, and (iii) satellite sensors typically estimate only surface soil moisture (0-5cm).

The COSMOS-UK network, under development since 2013, provides high resolution soil moisture data at 51 sites in the UK, corresponding to a variety of climatic, soil and land cover settings. Sites typically contain soil moisture probes at a variety of depths (including 10cm) as well as a cosmic ray sensor. The latter integrates soil moisture over an area of ~12ha, and while not matching the spatial scale or soil depth of satellite measurements, it does avoid some of the field-scale heterogeneity issues associated with point-based measurements.

The 9km SMAP L3 product performs well against 10cm soil probe measurements at most sites (>70% at ubRMSE <0.04), and seasonal patterns in performance are evident. Satellite measurements performed less well in comparison with COSMOS-UK estimates (68% at ubRMSE <0.06). Downscaling the SMAP L3 product based on hydroclimatology improves performance in some cases but worsens it in others. The SMAP-Sentinel 1 product generally performs worse than the 9km SMAP L3 product. Reasons for spatio-temporal variations in correlations and

performance are proposed including reference to soil profile characteristics and properties at each site, as well as vegetation and climatic setting.