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Global assessment of 15 satellite- and model-based soil moisture products for operational drought monitoring

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Accurate and timely information about soil moisture is critical for drought monitoring, irrigation scheduling, and prediction of agricultural yields. We comprehensively assessed the temporal dynamics of 15 state-of-the-art (sub-)daily global surface soil moisture products, including five based on satellite retrievals, five based on "open-loop" models (i.e., without data assimilation), and five based on models that assimilate satellite observations. As reference, we used in-situ soil moisture measurements at approximately 5-cm depth from 949 probes globally. Among the three single-sensor satellite products (AMSR2, SMAPL3, and SMOS), the L-band-based SMAPL3 performed best overall by a significant margin. Among the two multi-sensor satellite products (ESACCI and TC), TC achieved superior performance and outperformed SMAPL3 as well. The performance ranking of the five open-loop models (GLDAS, HBV-ERA5, HBV-IMERG, HBV-MSWEP, and VIC-PGF) is consistent with previous precipitation dataset evaluations, with HBV forced with MSWEP precipitation achieving the best performance not just among the open-loop models, but among all 15~products. Overall, the open-loop models performed better than the satellit products, reflecting the precipitation data quality in the conterminous US where most soil moisture probes are situated. The five models that assimilate satellite observations (GLEAM, HBV-ERA5+SMAPL3, HBV-IMERG+SMAPL3, HBV-MSWEP+SMAPL3, and SMAPL4) generally outperformed the open-loop models and exhibited a smaller spread in performance. Data assimilation yielded significantly improved performance when using less accurate precipitation (IMERG), but slightly degraded performance when using more accurate precipitation (MSWEP), demonstrating the value of data assimilation in poorly gauged regions.