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Capturing future soil-moisture droughts from irregularly distributed ground observations

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With a rapidly warming climate, future droughts are predicted to increase in frequency, duration, extent, and severity for many regions, whilst uncertainty of drought predictions in CMIP6 ensembles remains high. Monitoring the occurrence of agricultural and ecological droughts (i.e. soil moisture droughts), in present and future climate is therefore vital. However, available drought monitoring products do not use information from soil moisture ground observations, although those are the only observations available that extend into the vegetation-relevant root zone.

A central challenge of these ground observations (included in the international soil moisture network ISMN) is that they are not evenly distributed across the globe, favoring Europe and the US. Upscaling these observations to global soil moisture estimates for drought monitoring can lead to underrepresented areas suffering from misrepresentation of drought occurrences. Installing new measurement stations is costly, therefore placing them should focus on alleviating the problem of these underrepresented regions and ecosystems.

We apply a statistical learning method to identify under-represented ecosystems and environmental conditions to inform future station placement. We overlay these maps with future drought occurrence maps and drought uncertainty maps to scan for regions that are especially vulnerable in the future given the current station net. The analysis is built around an up-scaling approach where the model is trained to predict station-level soil moisture as a function of gridded atmospheric precipitation and temperature. The resulting model can be used to estimate soil moisture at locations without observations. For doing so we rely on the CMIP6 ensemble as a laboratory, which enables us to create virtual soil moisture stations based on continuously available soil moisture simulations.

The first results show that strategically placing new soil moisture observation stations where the climate space is most under-sampled leads to an increase of drought estimation accuracy. We are planning to further investigate hypothetical station configurations and follow up with the question of where future “station measurement years” should optimally be distributed around the globe to increase drought monitoring from ground observation in areas with low station coverage but high drought risk and high uncertainty in future projections.