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Improved Soil Moisture SMOS Retrieval using the next generation of AI inversion schemes

Victor Pellet[1,2], Filipe Aires[1,2], and Eulalie Boucher[1]
[1]LERMA, observatoire de paris, remote sensing, PARIS, France (victor.pellet@obspm.fr)
[2]Estellus, Paris, France

Land surfaces are characterised by strong heterogeneities of, among other variables, soil texture, orography, land cover, snow, or Soil Moisture (SM). SM is of broad scientific interest due to its role in the Earth system and its capital practical value for a wide range of applications from flood forecasting to agriculture. The scientific community has made significant progress in estimating SM from satellite-based passive MicroWave (MW). Most of SM estimates relie on a physical-based inversion to retrieve SM from passive MW. As an alternative to physical-based inversions, Neural Network (NN) retrieval algorithms have been successfully implemented for several sensors in recent years (Aires et al., 2005; Kolassa et al., 2016). The Soil Moisture and Ocean Salinity (SMOS) L3BT product (Al Bitar et al. 2017) uses an angle-binning scheme to organize the measured Brightness Temperature (BT) data. Three points that could improve SM retrieval will be considered in this presentation. (1) For coarse resolution MW instruments such as SMOS, NN algorithms are currently defined at the pixel level. Using the strong spatial patterns at the surface should help the SM retrieval, and we intend here to use an image-processing-based retrieval to investigate its potential. (2) Despite the important scanning angle information available on SMOS, not all angles are available for every pixel: The need to specify a limited angle configuration can drastically reduce the number of retrieved pixels, and the potential use of some large angle information is lost (Rodriguez-Fernandez et al. 2015). These missing data (both pixels and some angle configurations) could impede the use of image-based retrieval approaches. To tackle this issue, innovative machine learning techniques, such as “partial convolutional layers”, have been suggested very recently (Boucher et al. 2023), where missing data can be managed for both the spatial and the angle dimensions. This expands significantly the spatial coverage of the SMOS retrieval, especially for pixels with incomplete angle information. (3) A concept called “Localization” is also exploited, helping the ML retrieval to adapt its behaviour to specific local conditions to reduce local retrieval biases. By specializing its behaviour to local conditions, the relation between passive MW and SM is “simplified” over a particular pixel, this allows to reduce the impact of missing local information needed for a truly global model. We propose several NN and ML architectures to incorporate localization information into the networks, reducing significantly local biases.

Experiments are conducted over the CONUS using several years of SMOS data. Impacts of the image- versus the pixel-scale processing is measured, as well the spatial extension of the SM retrieval due to better missing-data handling, and the effect of the localization is analysed too. The best configuration for a global-scale retrieval is yet to be found because the spatial domain to consider is strategic for image-processing schemes, but original and important technical solutions are proposed here that could pave the way for the next generation of SM retrievals.