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Neural network retrieval of soil moisture: application to SMOS

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We present an efficient statistical soil moisture (SM) retrieval method using SMOS brightness temperatures (BTs) complemented with MODIS NDVI and ASCAT backscattering data. The method is based on a feed-forward neural network (hereafter NN) trained with SM from ECMWF model predictions or from the SMOS operational algorithm.

The best compromise to retrieve SM with NNs from SMOS brightness temperatures in a large fraction of the swath ($\sim$ 670 km) is to use incidence angles from 25 to 60 degrees (in 7 bins of 5 deg width) for both H and V polarizations. The correlation coefficient (R) of the SM retrieved by the NN and the reference SM dataset (ECMWF or SMOS L3) is 0.8. The correlation coefficient increases to 0.91 when adding as input MODIS NDVI, ECOCLIMAP sand and clay fractions and one of the following data: (i) active microwaves observations (ASCAT backscattering coefficient at 40 deg incidence angle), (ii) ECMWF soil temperature. Finally, the correlation coefficient increases to R=0.94 when using a normalization index computed locally for each latitude-longitude point with the maximum and minimum BTs and the associated SM values from the local time series.

Global maps of SM obtained with NNs reproduce well the spatial structures present in the reference SM datasets, implying that the NN works well for a wide range of ecosystems and physical conditions. In addition, the results of the NNs have been evaluated at selected locations for which in situ measurements are available such as the USDA-ARS watersheds (USA), the OzNet network (AUS) and USDA-NRCS SCAN network (USA). The time series of SM obtained with NNs reproduce the temporal behavior measured with in situ sensors. For well known sites where the in situ measurement is representative of a 40 km scale like the Little Washita watershed, the NN models show a very high correlation of (R = 0.8-0.9) and a low standard deviation of 0.02-0.04 m^3/m^3 with respect to the in situ measurements. When comparing with all the in situ stations, the average correlation coefficients and bias of NN SM with respect to in situ measurements are comparable to those of ECMWF and SMOS L3 SM (R = 0.6). The standard deviation of the difference (STTD) of those products with respect to in situ measurements is lower for NN SM, in particular for the NN models that use local information on the extreme BTs and associated SM values, for which average STDD is 0.03 m^3/m^3, twice as low as the average STDD values obtained with ECMWF and L3 SM (0.05-0.07 m^3/m^3).

In conclusion, SM obtained using NN give results of comparable or better quality to other SM products. In addition, NNs are an efficient method to obtain SM from SMOS data (one year of SMOS observations can be inverted in less than 60 seconds). These results have been obtained in the framework of the SMOS+NN project funded by ESA and they open interesting perspectives such as a near real time processor and data assimilation in weather prediction models.