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Dynamic time warping analysis of the evolution of SMOS surface and in-situ soil moisture time series

Christoph Herbert[1,2], Miriam Pablos[2,3], Mercedes Vall-llossera[1,2], and Adriano Camps[1,2]
[1]CommSensLab, Universitat Politècnica de Catalunya (UPC) and Institut d'Estudis Espacials de Catalunya (IEEC/CTE-UPC), Jordi Girona 1-3, 08034, Barcelona, Spain (herbert@tsc.upc.edu)
[2]Barcelona Expert Center (BEC), Passeig Marítim de la Barceloneta 37-49, 08003, Barcelona, Spain
[3]Institute of Marine Sciences (ICM), Consejo Superior de Investigaciones Científicas (CSIC), Passeig Marítim de la Barceloneta 37-49, 08003, Barcelona, Spain

A comprehensive understanding of temporal variability of root-zone and surface soil moisture (SM) and the relationship with the underlying soil characteristics is of great importance in hydrological and agricultural applications. For the last ten years, global and frequent satellite SM observations have been available to investigate SM dynamics. However, validating remote sensing retrievals against in-situ observations based on the comparison of collocated SM time series is complicated. While satellite retrievals are approximated from inversion models over an area, in-situ measurements are determined at point-scale. This usually produces different SM dynamic ranges and biases in the corresponding time series. Moreover, the influence of soil properties and meteorological conditions can cause SM time series obtained from indirect remote sensing techniques and direct in-situ observations to be non-linearly related. Dynamic Time Warping (DTW) is a dynamic programming technique, capable of coping with temporal distortions by aiming for finding the optimal match between time series.

In this study, DTW was used to provide a time lag evolution as a continuous dissimilarity measure comprising the main temporal variability features of two time series. The DTW technique was applied to SM time series from the Soil Moisture and Ocean Salinity mission (SMOS) L4 product developed at Barcelona Expert Center (BEC) with in-situ measurements at top- and subsoil-representative depth levels, located in the Soil Moisture Measurements Station Network of the University of Salamanca (REMEDHUS) in Western Spain. DTW parameters were customized to the particular input time series to obtain a robust and meaningful time lag. Seasonal differences in SM dynamics were analyzed in a clustering approach by investigating the link between SM time series and SM-regime-related parameters including precipitation and categorical features such as soil type and land use. Since the technique resolves the non-linear behaviour of time series, it has the potential to generally assess major differences in SM acquisition techniques. It could also be useful to investigate spatial SM variability in heterogeneous regions and to make informed choices in future sensor deployment in SM networks.