

Titre : Improving Soil moisture monitoring at high temporal resolution

Encadrant : Victor Pellet (LMD-X)

Contacts : victor.pellet@lmd.ipsl.fr ; Filipe.aires@obspm.fr ; redouane.lguensat@ipsl.fr

Lieu du stage : Laboratoire de Météorologie Dynamique-École Polytechnique (Palaiseau)

Durée : 6 mois

Niveau: Master 2

Context:

Soil Moisture (SM) is a key variable for boundary layer processes on Earth that couples the water and energy cycles between surface and atmosphere and leads the partitioning of precipitation into runoff and infiltration (Seneviratne et al., 2010). A surplus or lack of SM can trigger the respectively, floods or droughts while the coupling between SM and evapotranspiration is responsible for the occurrence and persistence of heatwaves. The importance of SM has been recognized by the World Meteorological Organization that defined it as an Essential Climate Variable (GCOS, 2010), thus encouraging efforts to obtain better SM monitoring.

The scientific community has made significant progress in estimating SM from satellite-based Earth Observations (EO). Operationally-produced datasets include retrievals from the Advanced Scatterometer (ASCAT) onboard the Metop satellites (Bartalis et al., 2007); the Soil Moisture and Ocean Salinity (SMOS) mission (Kerr et al., 2010); and the Soil Moisture Active Passive (SMAP) mission (Entekhabi et al., 2010a). While there are some effort dedicated to the development of consistent satellite-based long-term climate data records for SM (e.g. European Space Agency Climate Change Initiative for Soil Moisture- ESA CCI), **no tentative has been made to develop a sub-daily product failing in leveraging the different satellite 's passing time that exist in a day and thus neglecting sub-daily processes such as diurnal dry-down from sub-daily precipitation event.**

Objectives:

Initial SM retrievals from singular instrument (SMOS, SMAP, ASCAT) have been done at orbit scale and for respective passing time of each instrument using Neural Network (NN) approaches that account for statistical relationships between satellite Earth Observations (EOs). Instead of explicitly formulating physical relationships, NN are trained on a large database of satellite observations (the inputs) paired with SM estimates (targets) to learn their statistical relationship. The resulting SM retrievals are thus discontinuous in space (only exist on the orbit of the instrument) and time (only for the passing time of the instrument).

The internship intend to i) first **analyze, compare and evaluate the discrepancy between singular instrument SM monitoring** using in situ measurement and other variable (e.g. precipitation) and in order to ii) understand the feasibility of developing a merging/blending approach. Such merging **is challenging and this internship aims at exploring the feasibility to use of deep-learning architectures for this task.** Several approach already exist in the literature often referred as 'Neural Mapping' (Martin et al., 2023; Febvre et al., 2024) to merge sparse observations (here SM singular retrieval) with dense a priori/auxiliary information (e.g. precipitation estimate) to produce gap-free estimate of SM.

Finally, we will carry out an in-depth evaluation of the sub-daily SM record to quantify its ability to monitor small-scale hydrological processes and its link with runoff, flash floods and droughts.

Required skills for the candidate:

This project focusing on highly innovative topics, demands a strongly motivated and curious candidate in particular regarding machine-learning techniques and novel statistical model architectures. In terms of academic background and experience, the candidate is expected to have knowledge of remote sensing and/or hydrology as well as a proven experience in Python for deep-learning tasks, using libraries such as PyTorch, or TensorFlow.

References:

- Seneviratne, Corti, Davin, Hirschi, Jaeger, Lehner, Orlowsky, Teuling, Investigating soil moisture-climate interactions in a changing climate: a review, *Earth Sci. Rev.*, 99, 2010.
- Bartalis, Wagner, Naeimi, Hasenauer, Scipal, Bonekamp, Figa, & Anderson, Initial soil moisture retrievals from the METOP-A Advanced Scatterometer (ASCAT). *Geophys. Res. Lett.*, 34, 2007.
- Kerr et al., The SMOS Mission: New Tool for Monitoring Key Elem. of Global Water Cycle, *Proc. IEEE*, 98 5, 2010.
- Entekhabi, Njoku, et al., The Soil Moisture Active Passive (SMAP) mission, *Proc. IEEE*, 98 (5), 2010.
- Martin, S. A., Manucharyan, G. E., & Klein, P. (2023). Synthesizing sea surface temperature and satellite altimetry observations using deep learning improves the accuracy and resolution of gridded sea surface height anomalies. *Journal of Advances in Modeling Earth Systems*, 15(5), e2022MS003589
- Febvre, Q., Le Sommer, J., Ubelmann, C., & Fablet, R. (2024). Training neural mapping schemes for satellite altimetry with simulation data. *Journal of Advances in Modeling Earth Systems*, 16, e2023MS003959.