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Towards the integration of GNSS, SAR and NWP for heavy rainfall forecast in sub-Saharan Africa within the TWIGA project

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The H2020 TWIGA - Transforming Weather Water data into value-added Information services for sustainable Growth in Africa - project aims to establish various services in sub-Saharan Africa for a better management of water resources by linking satellite, in-situ and modelled information. The delivery of timely and accurate weather forecasts is one of the envisaged services. GNSS (Global Navigation Satellite Systems) and SAR (Synthetic Aperture Radar) data provide information on the atmospheric water vapor content, which can be assimilated into Numerical Weather Prediction (NWP) models. The assimilation enables these models to exploit observations for a better simulation of the atmospheric dynamics and the subsequent improvement of the forecasts. The activities related to GNSS, SAR and NWP integration are presented in what follows.

As for GNSS, the modeling of ionospheric errors was investigated for the recently deployed single-frequency low-cost sensors in Uganda. A quality assessment of three different algorithms (ANGBAS, SEID, goSEID) for synthetic L2 observations reconstruction, evaluating the impact on the Zenith Total Delay (ZTD) estimation, was carried out. The three methods show good performances with an overall accuracy ranging between 0.1 and 1 cm when the corrections are computed from geodetic stations at distances up to 65 km from the target receiver. Additionally, an operational system for the retrieval of near real-time GNSS ZTD was implemented. It shows a precision lower than 1 cm, compatible with the target requirements for the assimilation into NWP models.

GNSS is also used to perform the orbital corrections of the SAR products, reducing the large-scale errors like phase trends and biases. The merging of multiple Sentinel-1 frames to cover extended areas requires large computational resources. Work is ongoing to deal with the computationally intensive unwrapping of large interferograms. Moreover, the removal of ionospheric delays, which are not related to the water vapor content, is under development.

Concerning NWP, the Weather Research and Forecasting (WRF) model has been used, at cloud-resolving scales, to test the sensitivity of the simulations of three heavy rainfall events (in Uganda and in South Africa) to the Planetary Boundary Layer (PBL) and the microphysical numerical

schemes. Non-local PBL schemes are found to outperform the local PBL scheme considered in the study, because they better describe the vertical atmospheric mixing. In parallel, by exploiting a multiphysics set of numerical simulations in West Africa, it was found that the spatial variability of the surface heat fluxes significantly affects the lower atmospheric dynamics. This happens through a differential heating of the atmosphere across soil moisture gradients. Experiments on the assimilation of water vapor data are ongoing.