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Are satellite based rainfall estimates accurate enough for crop modelling under Sahelian climate?

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Agriculture is considered as the most climate dependant human activity. In West Africa and especially in the sudano-sahelian zone, rain-fed agriculture - that represents 93% of cultivated areas and is the means of support of 70% of the active population - is highly vulnerable to precipitation variability.
To better understand and anticipate climate impacts on agriculture, crop models - that estimate crop yield from climate information (e.g rainfall, temperature, insolation, humidity) - have been developed. These crop models are useful (i) in ex ante analysis to quantify the impact of different strategies implementation – crop management (e.g. choice of varieties, sowing date), crop insurance or medium-range weather forecast - on yields, (ii) for early warning systems and to (iii) assess future food security. Yet, the successful application of these models depends on the accuracy of their climatic drivers. In the sudano-sahelian zone , the quality of precipitation estimations is then a key factor to understand and anticipate climate impacts on agriculture via crop modelling and yield estimations.
Different kinds of precipitation estimations can be used. Ground measurements have long-time series but an insufficient network density, a large proportion of missing values, delay in reporting time, and they have limited availability. An answer to these shortcomings may lie in the field of remote sensing that provides satellite-based precipitation estimations. However, satellite-based rainfall estimates (SRFE) are not a direct measurement but rather an estimation of precipitation. Used as an input for crop models, it determines the performance of the simulated yield, hence SRFE require validation.

The SARRAH crop model is used to model three different varieties of pearl millet (HKP, MTDO, Souna3) in a square degree centred on 13.5°N and 2.5°E, in Niger. Eight satellite-based rainfall daily products (PERSIANN, CMORPH, TRMM 3b42-RT, GSMAP MKV+, GPCP, TRMM 3b42v6, RFEv2 and EPSAT-SG) are integrated using a crop model, then compared and tested against simulations obtained using in situ data. As in situ data, kriged rain gauge measurements are computed from about 50 rain gauges within the square degree. We show that direct use of SRFE does not reproduce the yield variability obtained from in situ observations.
In a second time, different satellite products errors (e.g. annual bias, accuracy at the beginning of the rainy season) are corrected before yield modelling to assess their impact on crop yield simulation and to be able to know which improvement in SRFE will be useful for crop yield estimation. We show that corrected satellite products enable a better yield variability representation and that error correction does not have the same impact on the different varieties computed.
Finally, simulated yield quality versus precipitations temporal resolution is assessed - as well as SRFE accuracy versus SRFE temporal resolution - in order to sort out the best agreement between temporal resolution and SRFE accuracy.