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Comparison and correction of three satellite precipitation estimates products to improve flood prevention in French Guiana

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The French Guiana (80 000 km^2) is highly vulnerable to flooding during the rainy season but the hydrological prevision is limited. In fact, the region cannot be cover by a dense network of rain gauges because of the difficulties to install and maintain monitoring stations in the primary forest. In that case, meteorological satellites could be really useful. Their large spatial cover offers the opportunity to estimate rainfall at a regional scale, with a temporal resolution of 30 minutes. The use of daily satellite precipitation estimates products in hydrological modelling are not very developed but could lead to reduce spatiotemporal uncertainties of rainfall and improve simulations of hydrological models. In this study, we have tested three satellite-based rainfall estimation algorithms: TRMM-TMPA 3B42 (Tropical Rainfall Measuring Mission Multi-Satellite Precipitation analysis) V7 (spatial resolution: 0.25°), IMERG (Integrated Multi-satellitE Retrievals) for GPM (Global Precipitation Measurement) (spatial resolution: 0.1°) and STAR Satellite rainfall estimates Hydro-Estimator (spatial resolution: 0.045°). Then, we applied several methods for biases correction in order to improve daily rainfall estimates in comparison with measures from available rain gauges.

The performance was evaluated at a daily time scale for the period running from 01/04/2015 to 30/03/2016 with validation data from 32 rain gauges managed by Meteo France and 59 rain gauges managed by the Surinam. Before biases correction, GPM IMERG obtained the better percentage of detection (POD) with 70% and a false alarm ratio (FAR) of only 10% in comparison with TRMM performance (POD: 60% ; FAR: 30%) and Hydro-Estimator (POD: 30% ; FAR: 30%). Biases (Psat-Pgau) were negatives with the three satellite products which mean that rainfall estimates by satellite images were underestimated. Better daily performances were obtained with TRMM (mean absolute biases: 7.1 mm; RMSE = 13.4 mm) and GPM (mean absolute biases: 6.2 mm; RMSE: 13.2 mm).

Two corrections methods have significantly improved satellite precipitation estimates products: the additive correction of residuals by inverse distance weighted (IDW) interpolation and the correction by power transformation (PT). These two corrections led to obtain absolute biases lower than 10 mm for each rainfall satellite products. RMSEs calculated after correction by IDW of biases and by PT were less than 15 mm. Rainfall estimates by satellite images were better at stations located along the coast at the north of French Guiana with absolute biases lower than 7 mm. Daily rainfall estimates with GPM obtained the better performance after correction with a mean RMSE of 10 mm and a clearly better estimation of heavy rain in comparison with TRMM and H-E.

To conclude, the correction method of satellite precipitation estimates could be easily implemented in an operational case with the aim to prevent flood and protect population. A first test was conducted and the corrected daily rainfall has been introduced in the lumped rainfall-runoff model GR4J in order to simulate the discharge of 8 rivers in French Guiana. The model has shown a good capacity to simulate the daily discharge with a Nash-Sutcliffe criterion higher than 75% for the three satellite products (period 2015-2016).