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Comparative evaluation of multiple satellite rainfall products over the complex terrains of Tekeze-Atbara sub-basin, Nile River basin

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Abstract: Satellite rainfall products are considered an important source of rainfall data in the absence of ground measurements. However, estimates from these products need to be validated as their accuracy can be affected by geographical position, topography, climate and embedded algorithms. Five satellite rainfall products (TRMM, CHIRPS, RFEv2, PERSIANN and CMORPH) were evaluated against ground observations over the complex topography of the Tekeze-Atbara basin in Ethiopia. The performance was evaluated at various temporal and spatial scales over the period 2002-2015. Results show that CHIRPS, TRMM, and RFEv2 give estimates that are closest to rainfall measured from rain gauges at all spatiotemporal scales. The percentage bias (PBIAS) and correlation coefficient (r) of these products were within $\pm$25% and >0.5 for all time and space domains. The remaining products performed poorly at daily time step with PBIAS up to $\pm$100% and lower r (<0.5) at all spatial scales. However, the performance of all products improved at monthly and seasonal scale in both point and aerial comparisons. Compared to the lowland, the PBIAS at highland sub-basin increased by 35% whilst r dropped by 28%. CHIRPS and TRMM products showed best agreement in the mountainous area. CMORPH and TRMM overestimated while the remaining products underestimated rainfall in all conditions. The performance of the products did not show a uniform pattern with respect to space. Their performance improved from point to aerial comparisons in the lowlands whereas it slightly reduced in highland areas. Unlike all other products, CHIRPS and TRMM estimates improved at basin level compared to point data. Our results show that rainfall estimates by CHIRPS and TRMM have a consistently good agreement with ground rainfall at all spatio-temporal scales. Though, interpolation of ground measurements of sparse gauge network over the rugged terrains of the Upper Tekeze-Atbara basin may introduce unknown uncertainties. Considering the complex topography and limited gauges, the performance of CHIRPS and TRMM indicates that both products can be applied for any hydrological and overall water management applications in the region.

Keywords: Rainfall estimation, Satellite products, validation, Tekeze-Atbara Basin, Nile River Basin, Ethiopia