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A remote sensing technique for measuring spatio-temporal rainfall patterns in a mountainous region with a low density rain gauge network

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In drought years, millions of Ethiopians are dependent on assistance, not only because of deficient total rainfall amounts but also because of long dry spells within the rain season. The semi-arid to subhumid mountain climate of the North Ethiopian Highlands is especially vulnerable to rainfall anomalies. In this research spatio-temporal rainfall patterns are analyzed on a regional scale in the North Ethiopian Highlands using NOAAs satellite-derived Rainfall Estimates (RFE). To counter the weak correlation in the dry season, only the rain season rainfall from March till September is used, responsible for ca. 91% of the annual rainfall. Validation analysis demonstrates that the RFEs are well correlated with the Meteorological Station (MS) rainfall data (81% for RFE 1.0 (1996-2000) and 80% for RFE 2.0 (2001-2006)). However discrepancies indicate that RFEs generally underestimate MS rainfall and the scatter around the trendlines indicates that the estimation by RFEs can be in gross error. A local calibration of RFE with rain gauge information is validated as a technique to improve the RFEs for a regional mountainous study area. Slope gradient, slope aspect and elevation have no added value for the calibration of the RFEs. The estimation of monthly rainfall using this calibration model improved on average by 8%. Based upon the calibration model, annual rainfall maps and an average isohyet map for the period 1996-2006 were constructed. The maps show a general northeast-southwest gradient of increasing rainfall in the study area and a sharp east-west gradient in its northern part. Slope gradient, slope aspect, elevation, easting and northing were evaluated as explanatory factors for the spatial variability of annual rainfall in a stepwise multiple regression with the calibrated average of RFE 1.0 as dependent variable. Easting and northing are the only significant contributing variables (R2: 0.86), of which easting has proven to be the most important factor (R2: 0.72). The scatter around the individual trendlines of easting and northing corresponds to an increase of rainfall variability in the drier regions. The improved estimation of spatio-temporal rainfall variability in a mountainous region by RFEs is, although the remaining underestimation of rainfall (especially in the southern part of the study area), valuable as input to a wide range of scientific models.

Keywords: RFE, North Ethiopian Highlands, Calibration, Rainfall patterns