Seasonal and sub-seasonal rainfall and river flow prediction over Northern Ethiopia

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Abstract

Forecasting regional and local hydro-meteorological variables at a sub-seasonal-to-seasonal lead time is possible mainly by investigating the interaction among the atmosphere, land surface and the slowly varying ocean surfaces temperature. However, in Ethiopia, though there are few studies that have shown statistical associations between the Ethiopian JJAS rainfall and remotely SST anomalies and regional (local) atmospheric circulation, the findings are inconsistent both spatially and temporally. Lack of this information influenced the development of agriculture, water management and preparedness mainly for extreme events such as drought. This research is, therefore, set out to improve the forecast skill of the seasonal and sub-seasonal rainfall and river flow with a lead time from 10 days up to 90+ days. The study will be conducted at three stages(Research Objectives (RO)): (RO1) investigate the teleconnection between the major global climate driving factors and seasonal and sub-seasonal rainfall variation over Northern Ethiopia; (RO2) customize numerical model (WRF model) as regional/local climate model for seasonal and sub-seasonal rainfall forecasting over Northern Ethiopia and (RO3) joint atmospheric-terrestrial modeling (WRF-Hydro model) for seasonal and sub-seasonal river flow and soil moisture prediction in Upper Tekeze river basin, Northern Ethiopia. In RO1, the ocean-atmospheric variables that link with the JJAS rainfall over northern Ethiopia will be identified based on correlation studies. For this study, input data such as monthly time series of sea surface temperature, zonal winds (TEJ), and observed rainfall for the time range from 2009 to 2020 will be used. In RO2, three experiments are designed: (1) selection of optimal parameters within the WRF mode physical options, (2) sensitivity analysis of forcing initials from GCM products of ECMWF-ERA5, GFS_FNL and CFSv2 and (3) sensitivity analysis of SSTs, zonal winds and terrain complexity. For RO2, daily input data such as gridded in-situ rainfall observations, forcing initials such as meteorological and static geographical data and, SST and Zonal winds for the time range of 2015-2020 will be used. In RO3, questions such as ''can hydrological variables be reliably forecasted by combining a numerically coupled ocean-atmospheric models with hydrological models?'' will be answered. Herein, the two-way WRF-Hydro coupling will be applied and the weights of four WRF-Hydro parameters that potentially influence the volume and temporal variations of hydrometeorological variables: (1) the infiltration scale (REFKDT), (2) surface retention depth scale (RETDEPRT), (3) overland flow roughness scale (OVROUGHRTFAC) and (4) the channel Manning roughness coefficient (MannN) will be calibrated. For this RO, input data including the in-situ observations daily runoff observations, and daily soil moisture observations and forcing initials such as the meteorological inputs and static geographical data for the time range of 2015-2020 will us used. In addition, watershed characteristics such as land use and land cover, soil properties, digital elevation model (DEM and HydroSHEDS) and water abstractions across the watercourse will be collected and used during the hydrological modelling. At every step of parameter optimization (model calibrations) and verifications, a performance evaluation will be carried out using a series of error statistical methods such as RMSE, Bias, Skill Score, Nash-Sutcliffe Efficiency and Taylor diagram. The main expected outputs from this research will be the teleconnections of oceanic-atmospheric variables with JJAS rainfall variations; and seasonal and sub-seasonal rainfall, river flow and soil moisture prediction models. These outputs are expected to improve the forecasting skill for proper understanding and management of water resources, agriculture, disaster prevention, energy, and food security and thus will be utilized by policy-makers at different sectors in their decision makings.

Keyword: *Teleconnection, sub seasonal-to-seasonal prediction, JJAS rainfall, SST, Zonal Wind, Terrain complexity, initial and boundary conditions, WRF model and Coupled WRF-Hydro modelling.*