Geophysical Research Abstracts
Vol. 14, EGU2012-698, 2012
EGU General Assembly 2012

Development of a Dynamic Downscaling strategy for Ganga Basin and Investigation of the Hydrological Pattern

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The interaction between climate and hydrology is highly complex and non-linear. In India, the synoptic scale atmospheric flow, diversity of local topography, vegetation, climatic conditions, and high population density, etc., interact with one another to give a unique weather distribution. The interaction between the large scale climate and local scale hydrologic cycle is very important in regional scale hydrological modelling. The Weather Research and Forecasting (WRF) model is a numerical weather prediction and atmospheric simulation system designed to resolve this interaction at regional scale. WRF has been used earlier to investigate the downscaling methodology over the United States (Lo et al., 2008). We study the impact of climatic condition on Ganga basin hydrologic cycle using WRF. A single domain with a resolution of 25 km was used to cover the whole of India and the region of interest and validation is the entire Ganga basin. We performed the downscaling for the year 2010 with five configurations: (1) one continuous time integration with single initialization, (2) time integration with monthly reinitialization, (3) single initialization but with 3-D nudging without relaxation of PBL (4) same as 3 but with relaxation of PBL and (5) same as 4 but with spectral nudging relaxation. The results are compared against the synoptic observations taken over the Ganga basin. The 5th method has the best skill, followed by 4th, 3rd , 2nd and 1st . The results show that the nudging generates realistic regional climatic pattern which cannot be achieved simply by updating the boundary conditions.
To find out the Hydrological interaction, trend and pattern over the Ganga Basin, the Hydrological fields of the best model (Spectral Nudging) are analysed. The rainfall patterns are compared with TRMM 3B42 daily data. The precipitation, surface temperature, and the regional wind pattern is reasonably simulated. The study reveals the power of WRF in resolving the climatic and hydrological interactions and also shows that the WRF can be used in making an accurate forecast. The rainfall distribution shows some degree of correlation with the TRMM at the middle Indo-Gangetic plane, along the foothills of Himalaya, and over some portion of Tibetian Plateau. The seasonality index of Hydrologic variables like Rainfall, Surface runoff and Soil moisture show a level of seasonal pattern over the Indo-Gangetic plane but the degree of seasonality pattern is weak at the foothills of Himalaya. The hydrological fields like surface run off, base flow, soil moisture distribution and soil temperature show the expected regional variations and seasonal patterns. The dynamical downscaling outperforms the interpolation of climatic variables over space and time. This implies the suitability of WRF to study the hydrological cycle over a data sparse region and, probably, to study the effect of potential climate change on it.

Reference:

Jeff Chun-Fung Lo, Zong-Liang Yang, and Roger A. Pielke Sr., 2008, Assessment of three dynamical climate downscaling methods using the Weather Research and Forecasting (WRF) model, Journal of Geophysical Research, Vol 113, D09112