Geophysical Research Abstracts
Vol. 16, EGU2014-9747, 2014
EGU General Assembly 2014

Inter-comparison of rainfall seasonality simulated by several RCMs over Denmark

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Global mean temperature has risen significantly over the past half century. The water vapor content in the atmosphere has risen and global hydrological cycle has been intensified accordingly. Owing to the amplification of hydrological cycle, the anthropogenic forced warming changed not only the mean state of precipitation but also its seasonal distribution. Such changes, in turn, have led to change of the length of 'dry' and 'wet' seasons and rainfall contrasts during the year. However, the attribution of the observed warming to rainfall seasonality change remains less clear. In this study, a global measure of seasonality derived by Walsh and Lawler was used to identify the seasonal distribution of precipitation over Denmark.

Regional Climate Models (RCMs) can describe more detailed characteristics of the temperature, rainfall distribution and inter-annual variation than global climate models can. In the present study, the performance of several RCMs was investigated in simulating the seasonal distribution of precipitation and long-term change of rainfall seasonality over Denmark. The study was based on a rainfall seasonality index by comparing modeled precipitation to observation. The RCMs include: HIRHAM5 (forced with BCCR-NorESM climate model, EC-EARTH climate model, and ERA-Interim reanalysis), WRF3.31 (forced with BCCR-NorESM climate model, and ERA-Interim reanalysis). Here we use output from two 21 year simulation (1990 - 2010) using the RCMs forced with SSTs from the ECMWF reanalysis ERA-Interim at a model resolution of 8km*8km, and three 30 year simulation (1981 - 2010) using the RCMs forced with GCMs. Observations from DMI (Danish Meteorological Institute) 96 stations of precipitation were applied in the validation of the RCMs.

Through comparisons of the model results among the RCMs and with the observations, the ability of RCMs to reproduce rainfall seasonality was evaluated. The results show that all models can simulate the seasonal cycle of the mean precipitation over Denmark. Furthermore, the seasonality index of precipitation was well captured in HIRHAM5, either forced with EC-EARTH climate model or with ERA-Interim reanalysis. However, seasonality was over estimated in HIRHAM5 forced with BCCR-NorESM with relative higher rainfall seasonality index, which means precipitation tends to concentrate in a few months but with long drier season. The summer precipitation simulated by WRF was more than the observations with over estimated seasonality index. In addition, the ensemble result of the RCMs was closer to the observation than that of any single model. This study highlights the importance of investigating the seasonal distribution of precipitation in assessment of RCMs.