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Long-range Prediction of climatic Change in the Eastern Seaboard of Thailand over the 21st Century using various Downscaling Approaches

Werapol Bejranonda (1), Manfred Koch (1), and Sucharit Koontanakulvong (2)

(1) Department of Geohydraulics and Engineering Hydrology, University of Kassel, Kassel, Germany (sun2child@yahoo.com), (2) Department of Water Resources Engineering, Chulalongkorn University, Bangkok, Thailand

Triggered by a long drought, a huge water supply crisis took place at the Eastern Seaboard of Thailand (east of the Gulf of Thailand) in 2005. In that year no rainfall occurred for four months after the beginning of the rainy season which led to the situation that the industrial estates of the Eastern Seaboard were not able to fully operate. Normally, most of the urban and industrial water used in this coastal region along east of the Gulf of Thailand, which is part of the Pacific Ocean, is surface water stored in a large-scale reservoir-network across the main watershed in the region. Thus the three major reservoirs usually gather water from monsoon storms that blow from the South and provide accumulative 80% of the annual rainfall during the 6 months of the rainy season which normally lasts from May-October. During the dry season (November - April) the winds are blowing from northern Indo-China land mass and rain drops only a few days in a month. Because of this typical tropical climate system, surface water resources across most of the southeastern Asia-Pacific region and the Eastern Seaboard of Thailand, in particular, rely on the annual occurrence of the monsoon season.

There is now sufficient evidence that the named extreme weather conditions of 2005 occurring in that part of Thailand are not a singularity, but might be another signal of recent ongoing climate change in that country as a whole. Because of this imminent threat to the water resources of the region, and for the set-up of appropriate water management schemes for the near future, a climate impact study is proposed here. More specifically, the water budget of the Khlong Yai basin, which is the main watershed of the Eastern Seaboard, is modeled using the distributed hydrological model SWAT. To that avail the watershed model is coupled sequentially to a global climate model (GCM), whereby the latter provides the input forcing parameters (e.g. precipitation and temperature) to the former. Because of the different scales of the hydrological (local to regional) and of the GCM (global), one is faced with the problem of "downscaling" the coarse grid resolution output of the GCM to the fine grid of the hydrological model. Although there have been numerous downscaling approaches proposed to that regard over the last decade, the jury is still out about the best method to use in a particular application.

The focus here is on the downscaling part of the investigation, i.e. the proper preparation of the GCM's output to serve as input, i.e. the driving force, to the hydrological model (which is not further discussed here). Daily ensembles of climate variables computed by means of the CGCM3 model of the Canadian Climate Center which has a horizontal grid resolution of approximately the size of the whole study basin are used here, indicating clearly the need for downscaling. Daily observations of local climate variables available since 1971 are used as additional input to the various downscaling tools proposed which are, namely, the stochastic weather generator (LARS-WG), the statistical downscaling model (SDSM), and a multiple linear regression model between the observed variables and the CGCM3 predictors. Both the 2D and the 3D versions of the CGCM3 model are employed to predict, 100 years ahead up to year 2100, the monthly rainfall and temperatures, based on the past calibration period (training period) 1971-2000. To investigate the prediction performance, multiple linear regression, autoregressive (AR) and autoregressive integrated moving average (ARIMA) models are applied to the time series of the observation data which are aggregated into monthly time steps to be able compare them with the downscaling results above. Likewise, multiple linear regression and ARIMA models also executed on the CGCM3 predictors and the Pacific / Indian oceans indices as external regressors to predict short-term local climate variations. The results of the various downscaling method are validated for years 2001-2006 at selected meteorological stations in the Khlong Yai basin, assuming the IPCC's A1B and A2 emission scenarios.

The performance of the monthly climate prediction has been evaluated by comparison with observed data using the Nash–Sutcliffe model efficiency measure. Among the statistical/stochastical downscaling and the forecasting methods used, the climate prediction by the ARIMA model with ocean indices and CGCM predictor included as external regressors are the most reliable. Thus for the verification period 2001-2006 Nash–Sutcliffe coefficient of 0.84, 0.47 and 0.50 are obtained for the minimum and maximum temperatures and the rainfall, respectively, whereas the corresponding 1-year ahead predictions are 0.77, 0.43 and 0.48, respectively. The best external regressor for the prediction of the minimum temperatures in the basin is, surprisingly, the El Niño 1.2 SST anomaly time series; for the prediction of the maximum temperatures, the minimum surface air temperature predictor in CGCM3 (tasmin); and for the prediction of the rainfall, the 850hPa eastward-wind predictor in CGCM3 (p8_uas). Based on year 2000, the downscaling results show that the average minimum temperature will be higher by 0.4 to 5.9 ˚C by year 2100, while the average maximum temperature will be rather stable, with only little change between -0.2 to +0.3˚C. As for the rainfall at year 2100, a possible change from +0.2 to 12.0 mm/month is obtained. These climate prediction results mean that, although there will be more rainfall in the future, the much higher temperature will lead to more evapotranspiration, i.e. more agricultural water demand. Besides, the increasing rainfall will most likely lead to unexpected flood events in the future that will require precautionary planning at the watershed-scale. This will be further analyzed during the course of the ongoing study using the SWAT hydrological model mentioned above.