Integrated Hydrological Modelling for Sustainable Water Resources Management in Arid Coastal Regions: Case of Essaouira Basin (Morocco).

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Abstract

The impact of climate change (CC) and human activities on groundwater-surface water (GW-SW) interaction under arid and semi-arid conditions are not yet fully understood. This study aims to combine hydrogeochemistry, stable isotope data and hydrological modeling to improve the understanding of drivers controlling GW-SW interactions and how those processes are affected by CC and human-induced impacts in a coastal semi-arid aquifer in Morocco. Hydrogeochemical and isotopic techniques are used to constrain modeled recharge modes of the coastal aquifer. Hydrological modeling involves coupling the SWAT (Soil and Water Assessment Tool) and MODFLOW models to build an integrated hydrological model for the study area. The integrated hydrological model will be used to assess the impact of different scenarios for CC and anthropogenic activities on water resources in the region of interest. To reach this goal, a comprehensive dataset (including geological, topographical, climatic data, etc.) was compiled from different sources.

A preliminary MODFLOW simulation was calibrated based on 1990 piezometric head data, with values of 0.9 for both R^2 and NSE coefficients. A SWAT model was built for the period 2000-2010, before the Mly Abderahman dam was constructed in upstream of the study area. The SWAT model was calibrated for the period 2005-2009 using monthly discharge from the ADAMNA station. The calibration R^2, NSE and PBIAS were good (R^2=0.73, NSE=0.71 and PBIAS=14.2%). The calibrated SWAT model was then validated during 2002–2004 and 2010 with very good performance (R^2 = 0.81, NSE =0.80 and PBIAS=-5.8%).

Two remote sensing Actual Evapotranspiration (AET) data products (SSEBop version 5.0, and MODIS 16) were acquired and preprocessed. The AET estimated by the calibrated SWAT model at the subbasin level was compared with the remote sensing (RS) AET. For the subbasins in the middle and the eastern part of the study area, the AET values estimated by the SWAT model are comparable to the AET values derived from both RS products. For those subbasins, the R^2 of the correlation between the SWAT AET and the two RS products varies between 0.24 and 0.45 for the MODIS AET and between 0.27 and 0.35 for the SSEBop AET. However, for the subbasins in the western side of the study area, the SWAT underestimated the AET, especially during dry months. Those subbasins are characterized by the presence of evergreen forest vegetation. Those results denote the interest in further calibration of the SWAT model using RS AET data.

Keywords

Integrated hydrological modelling, groundwater-surface water interactions, hydro-geochemistry, water scarcity, actual evapotranspiration, remote sensing.