DEVELOPMENT OF INTEGRATED WATER RESOURCES MODEL TO ESTIMATE ANTHROPOGENIC IMPACTS ON TERRESTRIAL WATER CYCLE

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In recent years, rapid growths of the world population and economy have increased anthropogenic impacts on global water cycles. The aim of this study is to develop an integrated water resources model to estimate anthropogenic impacts on terrestrial water cycle. The authors have developed water resources model, which comprises a hydrological land surface, river routing, irrigation, and reservoir operation models. A land surface model (Simple biosphere model including urban canopy [1]) calculates the hydrological land surface and irrigation processes. River routing model uses kinematic equations to calculate river discharge with intakes and drainages in channels. The reservoir operation model [2] has been integrated into river routing process. Terrestrial impacts of irrigations and reservoir operations have been estimated using the model in this study. The authors have performed terrestrial water cycle simulation from 1994 through 2003 using reanalyzed meteorological forcing and land surface parameters.

Irrigation maintains water levels in paddy fields and soil moisture on croplands within the appropriate ranges for each crop defined by crop calendars. The crop calendars, which are used in hydrological land surface analysis, have been generated by phonological analysis of normalized difference vegetation index (NDVI). Our crop calendars generated for six crops (rice, spring wheat, winter wheat, maize, cotton, and soybean) agree well with crop calendars commonly used in many countries. To estimate vapor supply from irrigated croplands, the authors have performed global land surface simulations with and without irrigation using the crop calendars. The vapor supply from the land surface has been also estimated by the atmospheric water balance method using reanalyzed climate conditions. The estimated vapor supply differs by 40% between estimation with and without irrigations on large scale irrigation fields. The vapor supply estimated with irrigation agrees well with estimated vapor supply from atmospheric water balance on irrigated fields in north China and United States, suggesting that land surface models including irrigation reproduce vapor supply better than with the models including no irrigation. Our study demonstrates that atmospheric conditions in global and regional climate models can be improved by adding irrigation process into their land surface modeling.

Reservoirs regulate river discharge in order to satisfy water demands in downstream, to prevent floods and inundations, and to generate electric powers. A global river channel networks have been scaled up from 1 km resolution flow direction map to the model mesh size of 20 km resolution, which agree well with statistical catchment areas. Large reservoirs, whose locations are obtained from a global database [3], have been allocated on the global river channel networks. To estimated impacts of reservoir operations, the authors have performed global river discharge simulations with and without reservoirs and irrigations. The simulation with reservoir operation model agrees recorded river discharge better in many stations than the model without the operations. Reservoir operations reduce peak river discharge and increase low river discharge. Reservoir operations have a strong impact on river discharge compared to intakes for irrigated croplands.

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[3] Lehner B, Doll P. 2004. Development and validation of a global database of lakes, reservoirs and wetlands. *Journal of Hydrology* 296: 1-22. DOI:10.1016/j.jhydrol.2004.03.028.