Quantitative analysis of differences in humidity among GCMs and propagation of uncertainty into irrigational water withdrawal

Yoshimitsu Masaki, Naota Hanasaki, Kiyoshi Takahashi and Yasuaki Hijioka
National Institute for Environmental Studies (NIES)

Abstract

Future water availability is one of key social issues under ongoing climate change. Since 70% of human water abstraction is for irrigational use, accurate evaluation of irrigational water is highly desirable for reliable estimation of water demand. However, recent studies on future hydrological environments projected by different impact models showed that there are substantial differences in their results between the models. A large part of the differences is considered to be attributable to different calculation schemes implemented by different impact models and input data driving the models. To obtain more reliable future projections, it is crucial to identify possible sources of these differences in both meteorological data sets and the impact models.

We investigated possible sources of uncertainty in quantitative evaluation of irrigational water with a global hydrological model, H08. Since irrigational water is primarily lost from croplands via evapotranspiration, we focus on uncertainties in data of the atmospheric humidity, a major determinant of evapotranspiration, generated by general circulation models (GCMs). In fact, although great attention has been paid for GCM biases in the temperature and precipitation in most climate impact studies, less attention has been paid for GCM biases in the humidity. To evaluate propagation of uncertainty in humidity data into irrigational water withdrawal, we used bias-corrected meteorological data, for all meteorological elements but for the humidity, of five GCMs (GFDL-ESM2M, HadGEM2-ES, IPSL-CM5A-LR, MIROC-ESM-CHEM and NorESM1-M).

We detected differences of over 10%RH between the GCMs in monthly humidity data averaged over irrigated croplands over the world. Estimation of annual global irrigational water withdrawal from the five GCMs ranges 1,218--1,341 km^3/yr. We made sensitivity analysis by adding hypothetical humidity biases of 5%RH to the GCM humidity data; annual global irrigational water withdrawal would be changed by 3--4 %, corresponding to 40--50 km^3/yr, at largest. In regions where water availability is limited, small uncertainties in water withdrawal may cause significant uncertainties in water scarcity levels. To improve future projections of irrigational water, we should pay much attention in accuracy in humidity data generated by GCMs.