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Interconnection of water, food, bio-energy, and land investigated with MIROC-INTEG: a global bio-geophysical land surface model with human components

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Future climate changes possibly affect water resources, food production, energy supply, and eco-system services. It is critical to better understand the interactions between the changes in these complicated factors. While earth system models and integrated as-sessment models are applicable to explore this topic, parts of their natural and/or hu-man processes tend to be simplified depending on their scope. As such, it still remains a challenge to realistically model the human-natural interface. In this context, the MI-ROC integrated terrestrial model (MIROC-INTEG) was developed. One of the features of MIROC-INTEG is that the natural ecosystem and human activity models are cou-pled to a global land surface model MATSIRO (Nitta et al. 2014, Journal of Climate), which is a component of a state-of-the-art global climate model, MIROC (Watanabe et al. 2010, Journal of Climate). As a natural ecosystem model, we use a global vegeta-tion model, VISIT (Ito and Inatomi 2012, Biogeosciences). As human activity models, we use a global land-surface model with anthropogenic water regulation modules, HiGW-MAT (Pokhrel et al, 2012, Journal of Hydrometeorology), and a global crop model, PRYSBI2 (Sakurai et al, 2014, Scientific Reports). In HiGW-MAT, models of human water regulations such as water withdrawal from river, dam operation, and irri-gation (Hanasaki et al. 2008, Hydrol. Earth Syst. Sci.) are incorporated to the above-mentioned global land surface model, MATSIRO. In PRYSBI2, the growth and yield of four crops (wheat, maize, soybean, rice) are calculated. In addition to these models, a global land use model (Terrestrial Land-use Model, TeLMO) is newly developed in the present study. TeLMO calculate the grid ratio of cropland (food and bio-energy crops), pasture, forest (managed and un-managed), as well as their transition. Output variables of each sub-model are passed to other sub-models during the time integration.

We will present an analysis of historical and future simulations with a focus on the interactions between water, food, energy, and land. In the historical simulations, we validated the model output such as irrigated water, crop yield, ecosystem productions, and cropland area by comparing to the observed or reanalysis data. In the future simu-lations, we investigated the role of uncertainties in climate (Representative Concentra-tion Pathways) and socio-economic (Shared Socio-economic Pathways) scenarios. We also investigate the role of uncertainties in model parameters, and found that an uncer-tainty in the fertilization effect of crop growth model PRYSBI2 strongly affect uncer-tainty in future projection of crop yield and land use change in TeLMO.