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Preliminary analyses on a LGM simulation using MIROC-ESM :climate and dust aerosol representation

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Future Projection using Earth System Model (ESM) is an important contribution for Intergovernmental Panel on Climate Change Assessment Report 5 (IPCC AR5) from the modelling studies. Therefore, it is important to investigate ability of models and improve them. Especially, Last Glacial Maximum (LGM, 21,000 years before present) is recognized as a benchmarking period because it is the coldest time during relatively recent past. We report the preliminary analyses on climate and dust aerosol representation of the LGM experiment using an ESM, MIROC-ESM (Watanabe et al. 2011).

MIROC-ESM which contributed to IPCC AR5 was used for the study. The resolution of the Atmosphere General Circulation Model is T42 with 80 layers for the vertical levels and the resolution of the Ocean General Circulation Model part is about 1 o with 44 vertical levels. An aerosol module SPRINTARS (Takemura et al. 2000, 2002, 2005) is calculated online.

Following the protocol of Coupled Model Intercomparison Project phase 5, we performed two experiments. One experiment is called PI, which corresponds to pre-industrial time, i.e., 1850 A.D. The other is called LGM, which is supposed to represent climate at LGM (Sueyoshi et al. 2013). The differences of the boundary condition from PI are lower greenhouse gases, the orbit of the Earth and the topography (ice sheets and sea level drop).

The climate of PI is reasonably well represented as a state-of-the-art model (Watanabe et al. 2011). The sea surface temperature drop at LGM is reasonably comparable with MARGO dataset (MARGO project members 2009). However the 7 to 10 oC temperature drop suggested by the Antarctic ice cores (Stenni et al. 2010, Uemura et al. 2012) is reasonably represented, the 21 to 25 oC cooling suggested by the Greenland ice cores (Cuffey et al. 1995, Jonsen et al. 1995, Dahl-Jensen et al. 1998) is not enough simulated in the model. The modelled net cooling over the Greenland summit is about 15 oC. Tackling this defect is important to improve future projection. One of the conceivable reasons is the problem on representing enhancement of mineral dust aerosol in the model, which has been pointed out in IPCC AR5. We have compared the modeled dust amount with a dataset called DIRTMAP (Kohfeld and Harrison 2001). As a result, there are problems on the representation of dust over the Greenland both for PI and LGM. In the LGM experiment, the plant functional types (PFT) are basically unchanged from PI. Taking into account the change of PFT may lead more dust generation at LGM and enhance the cooling. The Antarctic dust is significantly lower than the dataset at LGM. The dust emission from Patagonia, the major dust source of the Antarctic ice core, is too low in the LGM experiment. This seems to be caused by too high soil moisture. The precipitation over Patagonia is already too high in the PI. Improving the PI precipitation amount may also affect the LGM precipitation amount and improve the soil moisture conditions.

We present the preliminary analyses on the dust at LGM using MIROC-ESM. As a result, there is a difficulty on representation of the dust enhancement over the ice sheets. Further improvements of the model, for example, taking into account the PFT change or better representation of the precipitation at PI may work to better representation of dust amount/distribution at LGM. Over the Antarctica, the cooling at LGM is expressed in the model but the dust amount is far from the estimation of the ice core data, i.e., the current simulated cooling may be a result of wrong reasons. We are going to improve the processes of the dust emission and investigate deposition procedures and estimation of radiative forcing.

Keywords: LGM, dust, climate sensitivity, Earth System Model