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Impact of stratospheric ozone on paleoclimate reconstruction: Mid-Holocene experiment by using MRI Earth System Model

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Numerical experiment of mid-Holocene (6000 years before present) is performed by using Meteorological Research Institute Earth System Model (MRI-ESM) to investigate the impact of ozone distribution which is modulated by orbital elements on the tropospheric climate. The result of interactive ozone calculation is compared to those of mid-Holocene and pre-industrial control experiments in CMIP5/PMIP3, in which the ozone distribution was fixed to the value of 1850. Contribution of the chemical processes shows anomaly up to +1.7 K in the Antarctic regions for the annual mean zonal mean temperature at 2 m from the surface. This impact is caused by decrease in the area of sea ice, and the interrelationship in the trend is found to be opposite to that of sea ice and the Antarctic ozone hole as observed in these decades.

Stratospheric warming in the Antractic spring due to the positive anomaly of ozone causes negative westerly anomaly of the polar night jet by the thermal wind balance, and the annular mode response brings westerly anomaly near the surface. The decrease of the surface westerly weakens the northward component of the Ekman transport in the ocean, suppresses the sea ice transport to lower latitudes, and produces the warming in the polar region.

The importance of chemical feedbacks is supported by a correction of cold bias of SST in the southern hemisphere which is commonly seen in results of CMIP5/PMIP3 models. The comparison between the time variation of the sea ice distribution and that of the stratosphere-troposphere coupling patterns show the importance of coupled chemistry process related to ozone in the reconstruction of mid-Holothese climate.

Keywords: ozone, solar radiation, paleoclimate, earth system model, sea ice