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Influence of future changes in atmospheric temperature distributions on Asian dust phenomana

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Climate model projections show that global warming leads to the spatial difference in increases of atmospheric temperature. The spatial difference in atmospheric temperature increment results in changes of the temperature gradients in the horizontal and vertical directions. Changes in atmospheric temperature gradients can influence various atmospheric phenomena such as the tropical and extratropical cyclone activities. Asian dust emission and transport are also expected to be influenced by future changes in atmospheric temperature gradients. The purpose of this study is, therefore, investigations into the influence of future changes in the horizontal and vertical temperature distributions on Asian dust phenomena.

The Weather Research and Forecasting model (WRF) coupled with a chemical transport model (WRF-Chem, version 3.1) was used for simulations of dust emission and transport. In this study, a significant Asian dust event that occurred during the period from March 29 to April 2, 2007 was reproduced by use of WRF-Chem (CTL-Run). The spatial reproducibility was evaluated quantitatively, using various data obtained from field observations (LIDAR, SPM, PM10, etc.). Also, monthly averaged data (March and April) from the Model for Interdisciplinary Research On Climate (MIROC) version 3.2-hires were analyzed for making the "Global Warming Difference (GWD)". The GWD was defined as the difference between the 10-year averages of the 21st century A1B-scenario projections in the period from 2091 to 2100 and the 20th century simulations from 1991 to 2000. The GWDs of the atmospheric temperature and the geopotential height were added on each variable of the NCEP final analysis data used for executing the CTL-Run, after considerations for the future changes of atmospheric temperature gradients in the meridional and vertical directions. The name of a numerical experiment by use of the modified NCEP data is "Pseudo Global Warming Run (PGW-Run)".

A result of the PGW-Run showed that the simulated dust amount decreased especially in the Taklimakan Desert, compared with that in a result of the CTL-Run. The dust reduction related to a weakening of an easterly wind system, which originates from the north of the Tienshan Mountains and frequently induces extensive dust outbreaks in the Taklimakan Desert. The main cause of a weakening of the easterly wind can be considered to be a decrease of difference in atmospheric pressure between the Taklimakan Desert and the north of the Tienshan Mountains, i. e, Kazakhstan, which appears to be associated with a relatively small increase in atmospheric temperature in the desert.

The result of this study supports historical records shown in the previous studies that indicate an opposite correlation between the atmospheric temperature and the dust storm frequency in China.

Keywords: Asian dust, Global warming, WRF, MIROC, Downscaling, Remote sensing