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Numerical Simulation of Dust Aerosol and Its Future Changes over East Asia by a RCM

Dongfeng Zhang (1), Xuejie Gao (2), Ashraf Zakey (3), Filippo Giorgi (4), and Fabien Solmon (5)

(1) National Climate Center, China Meteorological Administration, China (zhangdf@smart.mit.edu), (2) National Climate Center, China Meteorological Administration, China (gaoxj@cma.gov.cn), (3) Abdus Salam International Center for Theoretical Physics, Italy (azakey@ictp.it), (4) Abdus Salam International Center for Theoretical Physics, Italy (giorgi@ictp.it), (5) Abdus Salam International Center for Theoretical Physics, Italy (solf@aero.obs-mip.fr)

The ICTP regional climate model coupled with a dust aerosol model (RegCM3-dust) is employed to simulate dust production, its climatic effects, and the futures changes over East Asia.

Firstly, two sets of experiments are completed with the high resolution global model output data from the Model for Interdisciplinary Research on Climate (MIROC3.2_hires), one for current (1991-2000), the other for future (2091-2100, following the A1B scenario) climate and dust aerosol. Simulated current climates by both MIROC3.2_hires and RegCM3-dust model are inter-compared and evaluated against observations, while the results of climate change (future-current) from above two models are analyzed also. Simulated dust aerosols by RegCM3-dust are compared with the satellite data and the changes of dust aerosols are predicted.

Then, another two experiments with the radiative effects of dust aerosols for different periods are conducted. The modeled dust aerosols climate effect and its regional feedbacks are assessed.

Our main conclusions are as follows:

Both MIROC3.2_hires and RegCM3-dust can reproduce well the atmospheric circulation over East Asia. The simulated multi-years mean surface air temperature is colder/warmer than observations in the range of 1-2ºC by MIROC3.2_hires/ RegCM3-dust. The lesser bias can be found in RegCM3-dust simulation for JJA, while in MIROC3.2_hires for DJF, the RegCM3-dust shows a cold bias over region. Both models overestimate the precipitation in the northern part of the model domain and show a bias of $\pm 25\%$ in the most southern part of model domain. The main inadequacy of models is an underestimate of precipitation over Southeast China in winter. In general, no obvious improvements are shown in RegCM3-dust compared to MIROC3.2_hires.

The pattern of changes (future-current) in surface air temperature by RegCM3-dust is similar to MIROC3.2_hires, characterized with a larger increase in northern part than in southern part and the maximum rise is found in winter. The differences between MIROC3.2_hires and RegCM3-dust are found in the areas covered by snow, where the temperature rise by MIROC3.2_hires is much higher than by RegCM3-dust. The multi-years mean precipitations increase over most simulation region by MIROC3.2_hires, while decrease over Northeast China and the lower-middle reaches of Yangtze River by RegCM3-dust, due to the decrease in JJA and SON. The mean precipitations over Tibet Plateau in snow covered seasons increase by MIROC3.2_hires and decrease by RegCM3-dust.

The seasonally averaged comparisons of simulated AOD and DI to observations show that the RegCM3-dust has the ability of reproduce the averaged seasonal spatial and temporal distribution of dust aerosol over East Asia by the MIROC3.2_hires driven. The modeled dust emission and load are rational also. However, the same model deficiency is found compared to NCEP driven experiments.

The dust emission decreases over the snow free areas and increases over the areas covered by snow in the future. An increase of the multi-years mean dust emission by 2% is shown over the domain, with the increase from December to March due to the decrease of snow amount and reduction from April to November because of the decreased wind speeds. The projected frequencies of high dust emission show the same identities. The multi-years mean dust load increases by 14%, while a little decreases in MAM and August.

The distribution of the surface and TOA radiative forcing from dust aerosol in both current and future run are in agreement with that in NCEP- driven simulation. The surface cooling with a little more cooler in the future run can be found. Unsystematic precipitation change is shown, with the only exception over the Taklimakan Desert, where precipitation increases in both current and future run. The dust radiative forcing induces a negative feedback mechanism on dust emission and dust load, the differences of this feedback between the current and future run are related to the value of dust emission and dust load themselves.