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Impacts of Emission Controls and Perturbations on an Intense Convective Precipitation Event during the 2008 Beijing Olympic Games

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A fully-coupled meteorology-chemistry-aerosol model (WRF-Chem) is used to assess the impacts of emission controls and perturbations on a summer intense convective precipitation event from August 9-11 during the 2008 Olympic Games. A four-nested domain configuration, from 81 km covering the whole China down to 3 km covering Beijing/surroundings, are used. Different emission scenarios are studied, including: (1) emissions targeting the 2008 Olympic period (OLY08); (2) INTEX-B emissions targeting the year 2006 (INTEXB06); (3) a zero-out of BC primary emissions in both anthropogenic (OLY08) and fire emissions (no-BC); and (4) a zero-out of anthropogenic emissions (no-AnthropE). MEGAN biogenic, MODIS fire and WRF-Chem embedded sea salt emissions are employed. INTEXB06 emissions are in general higher than OLY08 due to the long/short-term emission controls, especially for SO_2 and PM.

The WRF-Chem model (OLY08) is able to accurately predict both aerosol mass and number concentrations in the urban area of Beijing. The shapes of particle number size distributions are similar between observations and simulations. Column simulated aerosol optical depth (AOD) is also in a good agreement with MODIS AOD.

The emission scenario simulations suggest that even small perturbations in the concentration and/or compositions of aerosols can lead to either enhancement or suppression of this summer intensive precipitation event.

Compared with a pure WRF run (with no chemistry and feedbacks), WRF-Chem OLY08 simulations, including the coupled feedbacks, improve the predictions of precipitation and compare well with the satellite retrieval, while the WRF simulations predict a shift of $\sim$ 1 to 2 degree in areal precipitation distribution and produces no convective rain in the Beijing area.

The pure WRF run produces the highest accumulated rainfall in the Beijing area. The next highest is produced by the no-AnthropE case, with over 50 mm more than predicted by the OLY08 scenario. Compared with OLY08, the INTEXB06 case produces slightly lower average rainfall accumulation, with nearly no change in convective precipitation but with suppression of non-convective precipitation by $\sim$5 to 10 mm. The reduction of BC emissions makes nearly no change in non-convective precipitation, but suppresses convective precipitation by $\sim$10 to 15 mm.

Without anthropogenic emissions, the predicted precipitation is strengthened in both precipitation area and intensity. Perturbation on emissions leads to a reorganization of precipitation. With OLY08 there are high precipitation patterns that sit at the center of Beijing and to the south. However, with INTEXB06, the precipitation center moves to the northwest mountain area, and with no-BC emissions, the high precipitation center shifts towards northeast of Beijing and with very low precipitation in the downtown area. The convective cloud-system in OLY08 case is more organized than that from INTEXB06 case, with maximum accumulated convective and non-convective precipitations, respectively over 50 and 20 mm more than the INTEXB06 case. With no-BC emission, the cloud-system is even more organized with double the differences in the extreme rainfall accumulation to the INTEXB06 case than the OLY08 case.

References

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