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Simulations over South Asia using the Weather Research and Forecasting model with Chemistry (WRF-Chem): set-up and meteorological evaluation

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Abstract. The configuration and evaluation of the meteorology is presented for simulations over the South Asian region using the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem). Temperature, water vapor, dew point temperature, zonal and meridional wind components, precipitation and tropopause pressure are evaluated against radiosonde and satellite-borne (AIRS and TRMM) observations along with NCEP/NCAR reanalysis fields for the year 2008. Chemical fields, with focus on tropospheric ozone, are evaluated in a companion paper. The spatial and temporal variability in meteorological variables is well simulated by the model with temperature, dew point temperature and precipitation showing higher values during summer/monsoon and lower during winter. The index of agreement for all the parameters is estimated to be greater than 0.6 indicating that WRF-Chem is capable of simulating the variations around the observed mean. The mean bias (MB) and root mean square error (RMSE) in modeled temperature, water vapor and wind components show an increasing tendency with altitude. MB and RMSE values are within ±2 K and 1–4 K for temperature, 30% and 20–65% for water vapor and 1.6 m s^{-1} and 5.1 m s^{-1} for wind components. The spatio-temporal variability of precipitation is also reproduced reasonably well by the model but the model overestimates precipitation in summer and underestimates precipitation during other seasons. Such a behavior of modeled precipitation is in agreement with previous studies on South Asian monsoon. The comparison with radiosonde observations indicates a relatively better model performance for inland sites as compared to coastal and island sites. The MB and RMSE in tropopause pressure are estimated to be less than 25 hPa. Sensitivity simulations show that biases in meteorological simulations can introduce errors of ±(10–25%) in simulations of tropospheric ozone, CO and NO_X. Nevertheless, a comparison of statistical metrics with benchmarks indicates that the model simulated meteorology is of sufficient quality for use in chemistry simulations.

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