Auxiliary Material

Auxiliary Material for the Paper:

Simulations over South Asia using the Weather Research and Forecasting model with Chemistry (WRF-Chem): Chemistry Evaluation and Initial Results

Rajesh Kumar[1,], Manish Naja[1,], G. G. Pfister[2], M. C. Barth[2], C. Wiedinmyer[2] and G. P. Brasseur[3]

[1]Aryabhatta Research Institute of Observational Sciences, Nainital, 263129, India

[2] Atmospheric Chemistry Division, NCAR, Boulder, CO 80307-3000, USA

[3] Climate Service Center, GKSS, Hamburg 20146, Germany

Manish Naja

ARIES, Manora Peak, Nainital

Uttarakhand – 263129, India

Ph: 05942-233735

E-mail: manish@aries.res.in

Statistical Metrics:

Five statistical metrics namely index of agreement (d), root mean square error (RMSE), mean normalized gross error (MNGE), mean bias (MB) and mean normalized bias (MNB) are used here to assess the model performance and to quantify the errors and biases in model simulations. The index of agreement determines the model skill in simulating the variations around the observed mean and is defined as

$$d = 1 - \frac{N.RMSE^2}{\sum_{i=1}^{N}(|O_i - \overline{O}| + |M_i - \overline{O}|)^2}$$

where the summations are performed over the total number of model-observations pair values (N) while O_i and M_i represent the ith observed and modeled values respectively. The over bars over O and M indicate the average values in the observation and model respectively. The index of agreement is a dimensionless quantity and varies between 0 (no agreement between model and observations) and 1 (perfect agreement). The mean bias provides the information on the overestimation/underestimation of any variable by the model and is defined as

$$MB = \frac{1}{N}\sum_{i=1}^{N}(M_i - O_i)$$

MNB provides the information about the relative mean bias and is calculated as

$$MNB = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{M_i - O_i}{O_i}\right) \times 100\%$$

The RMSE considers error compensation due to opposite sign differences and is calculated as

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(M_i - O_i)^2}{N}}$$

Although RMSE encapsulates the average error produced by the model but it does not illuminate the sources or the types of errors. The MNGE represents the gross error in model simulations relative to the observations and is estimated as

$$MNGE = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{|M_i - O_i|}{O_i}\right) \times 100\%$$

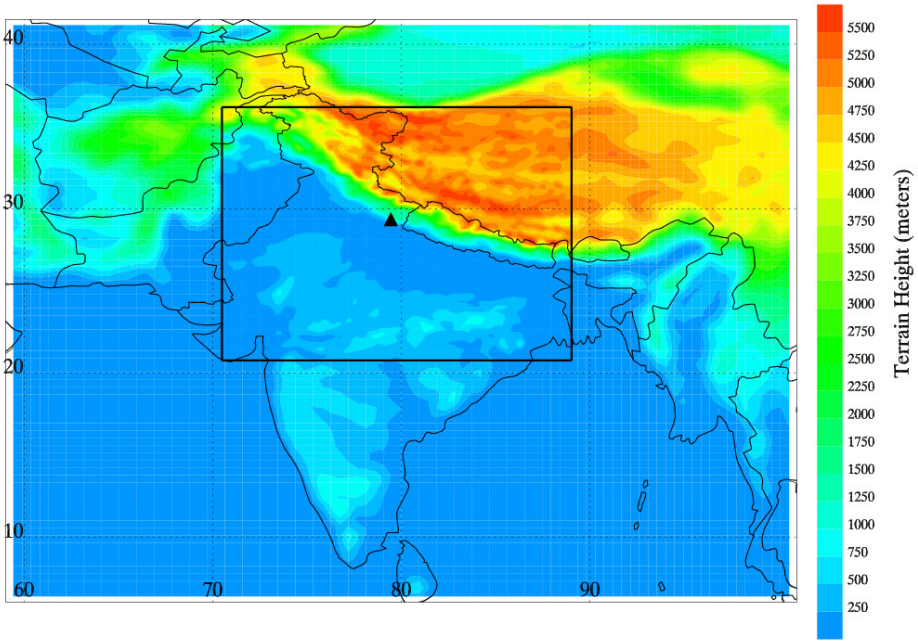

Figure S1: Parent and nested domain used in the sensitivity simulation. The location of Nainital is shown by a triangle.

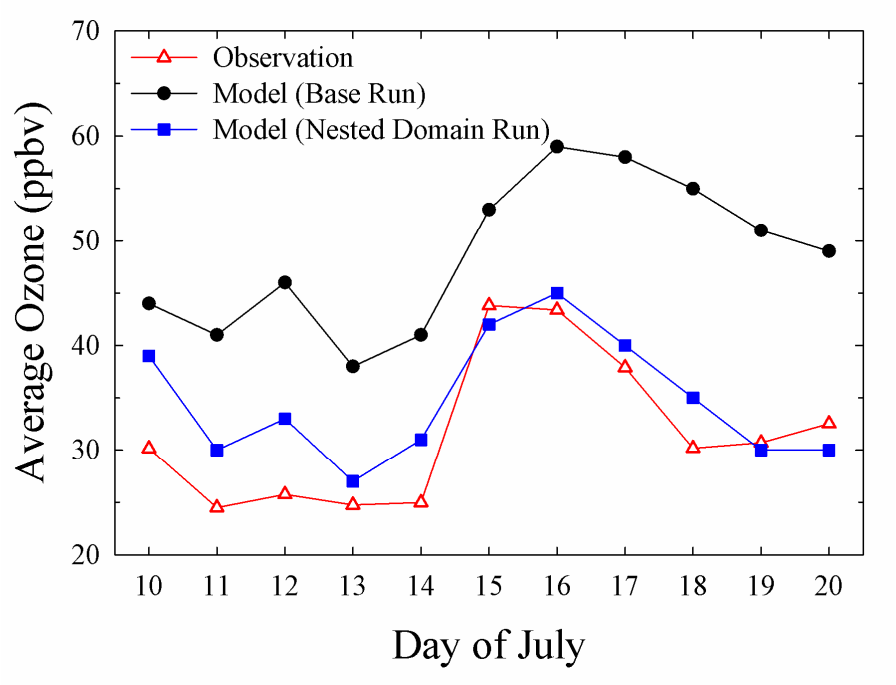

Figure S2: Day to day variations in surface ozone at Nainital during 10-20 July with output from base and nested domain model run.

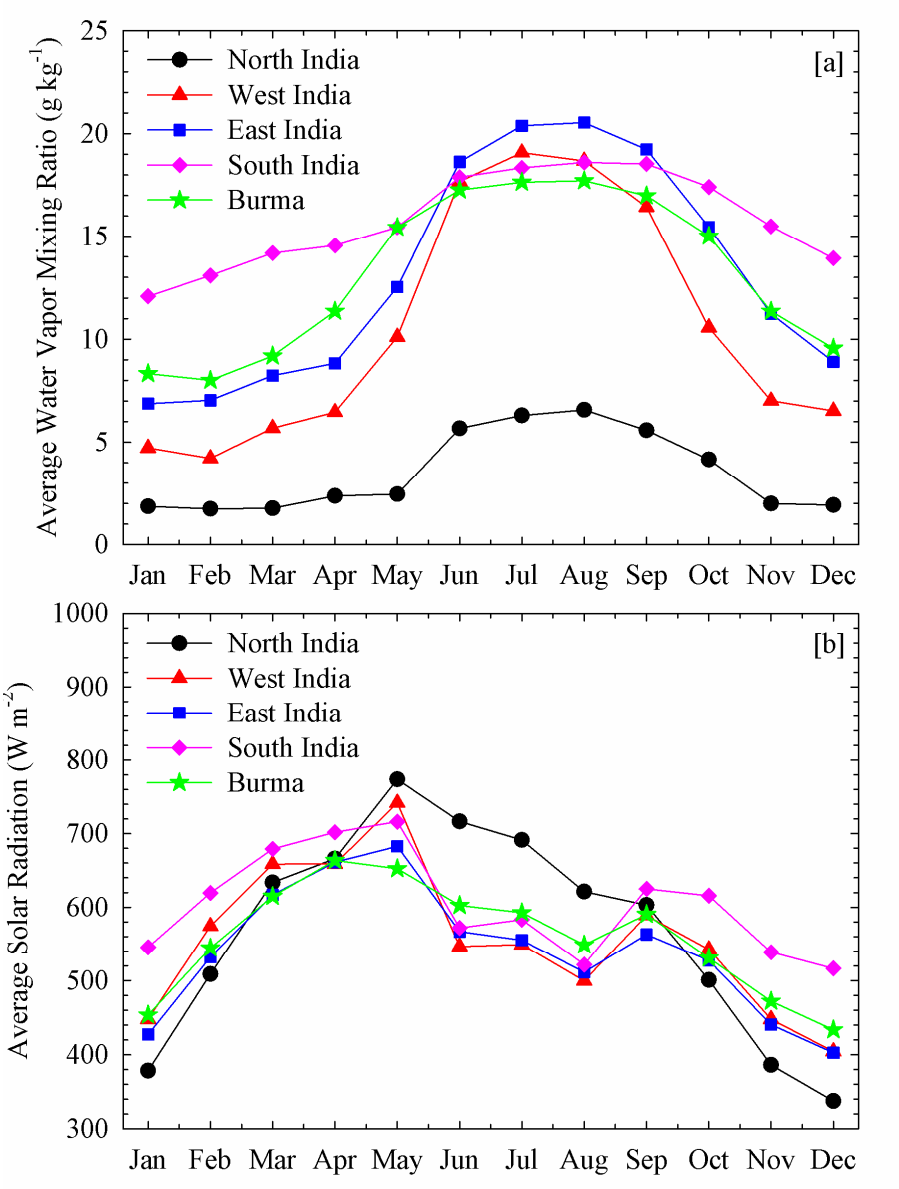

Figure S3: Variations in monthly average [a] 2m water vapor mixing ratios and [b] surface reaching daytime (0730-1730 IST) solar radiation over North India, West India, East India, South India and Burma regions.