Anonymous Referee #1

This study concerns the application and evaluation of a regional climate-chemistry modeling system. This is certainly an interesting topic and represents an advancement in climate-chemistry modeling. The evaluation of the system for both climate model driven simulations and re-analysis driven simulations are reasonably thorough and successful.

Response: We thank Referee #1 for the positive comments. Please see below our point-by-point replies to other comments.

My primary criticism of this paper is the lack of detailed description of the GCM model, the downscaling, regional model configuration, and execution. Even though references are given for the CESM modeling and the chemical and aerosol processes are briefly described I would like to see further description of the CESM physics, spin-up, constraints, etc. I do not understand how this represents a climate scenario when it is for past years and is evaluated against observations. What does RCP4.5 for these years represent. Do these runs use observation based SSTs? If these runs were spun-up from pre-industrial times without any observed data constraints, there would be no reason to expect agreement with observations. If bias corrections are made to both the meteorology and chemistry, then how do these runs substantially differ from re-analysis driven runs? Please explain the rationale and expectations of these runs.

Response: The CESM-NCSU model development, application, and evaluation have been published in several journal papers (e.g., He and Zhang, 2014; He et al., 2015a, b; Gantt et al., 2014; Glotfelty et al., 2017a, b; Glotfelty and Zhang, 2017). Since CESM-NCSU has been well documented, it is a common practice for us to cite those references rather than repeat the CESM-NCSU model description in our paper. To address the reviewer's comment, we have added a brief description on the CESM-NCSU's configuration, initial conditions and the application mode in Section 2.2. We have also included a Table (Table S1) in the supplementary material to summarize the model configuration including physical schemes and chemical options used in CESM-NCSU applications under the RCP scenarios. More detailed descriptions can be found in He and Zhang (2014) and Glotfelty et al. (2017a, b).

The CESM-NCSU model has been applied for decadal global climate and air quality predictions to simulate the "current" climate (2001–2010) and the "future" climate (2046-2055) driven with the RCPs emissions for both the current and future decades (Glotfelty et al., 2017a and Glotfelty and Zhang, 2017). The CESM simulation for 2001–2010 is performed with fully-coupled CESM with CESM1.2.2 B_2000_STRATMAM7_CN configuration (rather than using prescribed SST), which represents a fully-coupled CESM configuration including prognostic simulation of the atmosphere, ocean, land, and sea ice from the various component models.

Global climate/chemistry models applied at a coarse spatial resolution may not well resolve mesoscale features over a regional domain of interest or well predict local air quality and thus are not suitable for high-resolution regional climate, air quality and health impact studies. Therefore, we have planned to downscale CESM runs with a regional model, which is the two-way coupled WRF-CMAQ for both a current period (2006-2010) and a future period (2046-2050) to study the impacts of projected changes in climate and anthropogenic emissions under the RCP4.5 scenario. In this paper, multi-year downscaling applications from CESM-NCSU simulations under RCP 4.5 were conducted to simulate regional climate and air quality in current year period (2006-2010) and evaluated against observations during this 5-yr period, which is the first part of the study. The results for future years will be presented in a future paper. The results from this Part I paper will establish a baseline for a future Part II paper. The WRF-CMAQ simulations are driven with CESM-NCSU downscaling data under RCP 4.5, and the projected emissions for 2046-2050 WRF-CMAQ simulations are based on MIX2008 and RCP4.5, so the downscaling simulations during 2006-2010 represent multi-year climatological baseline simulations under RCP4.5, and they will be further used to investigate future regional climate and air quality change in a future paper. To avoid confusion, we have revised the paper to clarify the above points in several places including abstract, Section 1, and conclusion.

This study presents the first application and evaluation of the two-way coupled WRF-CMAQ model for multi-year climatological simulations using the dynamical downscaling technique. Because GCMs generally suffer from systematic biases to a certain extent, bias correction to the GCM (i.e., CESM) initial and boundary conditions was applied in this study to improve the model performance in simulating regional climate. The bias-correction method corrected the mean climatological biases in temperature, water vapor, geopotential height, wind, and soil moisture variables using the NCEP reanalysis data following the approach of Xu and Yang (2012), and allowed the retention of the CESM-NUSU simulated climatic changes in the mean seasonal state, diurnal cycle, and variance of inter-annual variation. The bias-correction method used for the initial and boundary conditions derived from CESM-NCSU is described in Yahay et al. (2016). As described in Section 2.2, in this bias-correction approach, monthly climatological averages for ICs and BCs are first derived from both NCEP and CESM_NCSU cases. The differences between the ICs and BCs from the NCEP and CESM_NCSU climatological averages are then added onto the CESM_NCSU ICs and BCs to generate bias-corrected CESM_NCSU ICs/BCs. WRF-CMAQ simulations using bias-corrected meteorological ICs/BCs from CESM-NCSU are therefore different from the simulations using the NCEP reanalysis for meteorological ICs/BCs. The bias-correction method corrected the major biases in the meteorological variables that can cause serious issues for regional climate downscaling while retaining climate variability within the GCM for both current and future simulations. So we do not expect the climatological runs achieve the same performance as the re-analysis driven runs. Note that previous studies (Xu and Yang, 2012; Bruyère et al., 2014; Done et al., 2015) have shown that the improved dynamical downscaling method with GCM bias corrections greatly improves the downscaled climate. The bias-correction technique is also used in the NCAR CESM global bias-corrected CMIP5 output to support WRF/MPAS research (https://rda.ucar.edu/datasets/ds316.1/).

I'm also wondering about data assimilation in WRF. Our experience has been that long runs of WRF (one month or longer) need some sort of DA or frequent re-initialization. If not in this case, how were the meteorology statistics this good? Even downscaling from GCMs often use data assimilation from the GCM. Also, an important omission from the WRF physics description is the LSM.

Response: In order to simulate regional meteorology as accurately as possible and preserve the chemistry–meteorology feedbacks, re-initialization in WRF was used in the multi-year climatological application. The climatological simulations were reinitialized every 15 days in this work, which provides a compromise to allow the simulation of mesoscale features and aerosol feedbacks while periodically constraining the meteorological fields not significantly deviated from the GCM. Qian et al. (2003) found that frequent re-initialization with frequencies of 10 days to 1 month improved the accuracy in regional climate downscaling. Data assimilation in WRF was not used to allow chemistry–meteorology feedbacks within the system. We have clarified this in the Section 2.1 of the revised manuscript. The land surface model is the Pleim–Xiu land surface model. We have added them into Table 1.

Overall, I think that this study is worthy of reporting in GMD, especially the sensitivities of AQ and meteorology to aerosol direct radiative effects, and also the effects of dynamic BCs and biogenic and dust emissions. However, more explanation and description is needed particularly to help the reader understand the significance of the climate runs.

Response: We have added more explanation and description to help the readers understand the significance of the climate runs. Please refer to the above responses.

Specific comments:

P4lns21-22: This statement about "correcting the roughness length by increasing the friction velocity by 1.5 times when calculating wind speeds in the ACM2 PBL scheme to reduce the overpredictions of wind speeds" needs more explanation. First, if the roughness lengths need correcting why not change them and not the friction velocity. Second, what is the problem with roughness lengths? How are they specified and what are they? Our experience has not shown general overpredictions in windspeed. Windspeed and friction velocity are strongly affected by the LSM and surface layer scheme which are not even mentioned here. Also the LU scheme and data are important. The USGS 24cat data is way out of date especially for China where urbanization has been dramatic. Why not use MODIS LU?

Response: Large overpredictions in WS10 with NMBs of 48.7%-101.0% from WRF simulations have been reported in the literature (Penrod et al., 2014; Cai et al., 2016; Zhang et al., 2016a) because of unresolved subgrid-scale topographic features and uncertainties in parameterizations of turbulent fluxes in WRF (Hanna and Yang, 2001; Rontu, 2006; Mass and Ovens, 2011). The overpredictions in WS10 are likely caused by low surface drag due to the inappropriate representation of surface roughness because the detailed surface structure cannot be reproduced at a coarse grid resolution of 36-km. However, a rigorous surface roughness correction algorithm is not available in WRF v3.4 that is used in the two-way coupled WRF-CMAQ. To correct the WS10 bias, following Mass and Ovens (2010) and our previous studies (Zheng et al., 2015; Zhang et al., 2016b), a highly simplified indirect correction method is used in this study, namely, the surface drag is increased by 1.5 times (which is applied to the friction velocity) when calculating wind speeds in the ACM2 PBL scheme. The simple wind correction method effectively reduces the overpredictions of wind speeds. To address the reviewer's concern, we have indicated the highly simplified wind bias correction method as a limitation of this work in the conclusion section. A more rigorous method should be used for future work.

The USGS 24-category land use data is indeed way out of date for China where urbanization has been dramatic, which would also partly contribute to the overprediction in WS10. We have indicated this in the Section 3.1 of the revised manuscript.

We used Pleim–Xiu land surface model (PX-LSM, Xiu and Pleim, 2001) and Pleim–Xiu surface layer scheme. For best consistency between the WRF and CMAQ model, the PX-LSM and the ACM2 PBL scheme were used in the two-way coupled WRF-CMAQ model (https://www.airqualitymodeling.org/index.php/CMAQ_version_5.1_(November_2015_release)_Techn ical_Documentation). We have added them into Table 1.

P5ln11-12: Why not use same vertical structure for WRF-CMAQ as CESM?

Response: The vertical coordinate in CESM is a hybrid sigma-pressure system, which is different from the WRF sigma coordinate. Thus we do not use the same vertical structure for WRF-CMAQ as CESM. We have clarified this in the Section 2.2 of the revised manuscript.

P5ln27: what is TOR?

Response: TOR represents tropospheric ozone residual. We have clarified this in the Section 2.2 of the revised manuscript.

Page 6: I don't understand what is the point of using RCP projections when modeling retrospectively. It seems that 2008 emission inventories are used for more detailed spatial-temporal allocation. Then why not just use these inventories? What is an RCP projection for past years? Please explain the logic here.

Response: RCP emissions are available for current and future decadal periods. The CESM-NCSU model has been recently applied for decadal global climate and air quality predictions to simulate the "current" climate scenario (2001–2010) and the "future" climate scenario (2046-2055) driven with the RCPs emissions for both current and future decades (Glotfelty et al., 2017a), therefore those "current" and "future" simulations represent multi-year climatological simulations under RCPs. The regional climatological simulations were driven with CESM-NCSU downscaling data under RCP 4.5. In order to achieve better performance for the regional WRF-CMAQ simulation, the MIX 2008 emission inventory is used for current years, and the emissions of some sectors that were not available from MIX 2008 were taken from RCP4.5. As we explained above, this paper only focuses on current year simulations which will be used as a baseline simulation for a future paper. We have clarified this in the Section 2.3 of the revised manuscript.

P8ln1-2: Should also report RMSE or MAE. Small biases don't tell whole story. Large over and under predictions could cancel out.

Response: As suggested, we have added the root mean square error (RMSE) in the statistics tables (Table 3, 4 and S3) in place of the normalized mean error (NME), and added the mean absolute gross error (MAGE) in Table 3. The model performed well for T2 and RH2, with MBs of -0.6 ℃ and 0.8%, correlation coefficients of 0.97 and 0.72, MAGEs of 2.4 ℃ and 9.7%, and RMSEs of 3.2 ℃ and 12.6%, respectively. WS10 was moderately overpredicted by 22.2%, with an MB of 0.6 m/s, an MAGE of 1.2 m/s and a RMSE of 1.6 m/s. Emery et al. (2001) suggested the benchmarks for satisfactory performance for T2 (MB within $\pm$0.5 ℃, MAGE of $\leq$ 2.0 ℃) and WS10 (MB within $\pm$0.5 m/s, MAGE and RMSE of 2.0 m/s). In the climatological application, the MB and MAGE of T2 and the MB of WS10 are close to the benchmark, the MAGE and RMSE of WS10 are within the benchmark, and hence the performance is deemed acceptable. We have added this in the Section 3.1 of the revised manuscript.

P8ln15-16: saying that large errors could be attributable to KF and Morrison schemes is pretty *meaningless.*

Response: The convective precipitation dominated the overprediction of total precipitation in the southern oceanic area, which may be possibly due to overprediction of convective precipitation intensity by the Kain–Fritsch cumulus scheme. The non-convective precipitation dominated the overprediction of total precipitation in the northeastern oceanic area, which could be attributed to possible errors in the Morrison double-moment microphysics scheme. We have clarified this in the Section 3.1 of the revised manuscript.

P8ln28: Are the results shown in Fig5 averages for all 5 years?

Response: Yes, they are. We have clarified this in the Section 3.1 of the revised manuscript.

P9ln16: what are "upper BCs"? and where do they come from? And why are they particularly uncertain?

Response: Upper BCs represent upper layer boundary conditions (BCs) of O_3, which are derived from CESM. Because total column O_3 is mainly determined by O_3 concentrations in upper troposphere (Tang et al., 2009; Zhang et al., 2016a, c), the overpredictions of TOR (column O_3) can be largely attributed to the inappropriateness of the upper layer BCs of O_3. From the results of Tang et al. (2009), we could also find large uncertainties in upper layer BCs of O_3. We have clarified this in the Section 3.1 of the revised manuscript.

P9ln16-17: Another meaningless statement about uncertainties in about everything possibly causing errors in NO2 column. Can you provide more insightful analyses?

Response: Column NO_2 was moderately overpredicted by 18.3%. Potential uncertainties in NO_x emissions and the model treatment of deposition and chemistry processes may contribute to the model-observation difference. As discussed by Lin et al. (2010) and Han et al. (2015), there are several uncertainties in the modeled NO_x lifetime. Uncertainties in the NO_2 column retrievals from OMI (with a relative error of 25%, Boersma et al., 2011) and the averaging kernels (Han et al., 2015) could also help to explain the bias. We have added this in the Section 3.1 of the revised manuscript.

P9ln28-30: Please clarify this sentence.

Response: For the air quality application driven with NCEP-FNL data, the observation and simulation data pairs for surface meteorological variables against NCDC observational data were on an hourly basis. The high correlations for major meteorological variables in Table S3 indicated that the model showed good skills in hourly meteorological predictions, thus NCEP-FNL data were sufficient to support the air quality applications for hourly air quality predictions. We have clarified this in the Section 3.2 of the revised manuscript.

P10ln23-24: If a figure is important enough to be discussed in the text (S2) it should be in the main paper and not in the supplement. The reader should not need to see the supplement to follow the *discussion.*

Response: We think that Figure S2 is not so important to be discussed in the text. So we have removed Figure S2 and the corresponding discussion in the revised manuscript.

P11ln12-13: The names of the simulations are confusing. The "baseline" is NCEP_BASE_Imp but the sensitivity is NCEP_BASE which sounds more like it should be the base.

Response: The names of the simulations have been changed from CESM_BASE_Imp, CESM_BASE_Imp_Sens, NCEP_BASE_Imp and NCEP_BASE to CESM_BASE, CESM_BASE _Sens, NCEP_BASE and NCEP_BASE_WoImp.

P11ln25-26: How are the fixed BCs derived?

Response: The fixed BCs are provided by the operational CMAQ system. We have clarified this in the Sections 2.1 and 3.3 of the revised manuscript.

P12ln4: S4 should be in main paper.

Response: As suggested, we have moved Figure S4 to the main paper (i.e., Figure 11 in the revised manuscript).

P12ln15: "close" should be "closer"

Response: Revised as suggested.

P13ln11-12: Aerosol effects on photolysis in CMAQ do not depend on aerosol feedback in the WRF-CMAQ system. The more likely cause for ozone decline in the feedback run is increased NOx titration in cities due to reduced PBL mixing. Table 1: what LSM and surface layer scheme? Table 3 and 4: Better to have un-normalized error for T2, RH2, WS10, WD10

Response: The decrease in O_3 concentrations in the feedback run may be attributed to the increased NO_x titration resulted from increased atmospheric stability and reduced PBL height. We have clarified this in the Section 3.4 of the revised manuscript. Table 1: The land surface model is Pleim–Xiu land surface model (Xiu and Pleim, 2001). The surface layer scheme is Pleim–Xiu surface layer scheme. We have added them into Table 1. Table 3 and 4: We have added the mean absolute gross error (MAGE) in Table 3, and added the root mean square error (RMSE) in place of the normalized mean error (NME) in Tables 3 and 4.

Reference

Boersma, K. F., Eskes, H. J., Dirksen, R. J., van der A, R. J., Veefkind, J. P., Stammes, P., Huijnen, V., Kleipool, Q. L., Sneep, M., Claas, J., Leitão, J., Richter, A., Zhou, Y., and Brunner, D.: An improved tropospheric NO2 column retrieval algorithm for the Ozone Monitoring Instrument, Atmos. Meas. Tech., 4, 1905–1928, doi:10.5194/amt-4-1905-2011, 2011.

Bruyere, C. L., Done, J. M., Holland, G. J., and Fredrick, S.: Bias corrections of global models for regional climate simulations of high-impact weather, Clim. Dynam., 43, 1847–1856, doi:10.1007/s00382-013-2011-6, 2014.

Cai, C., Zhang, X., Wang, K., Zhang, Y., Wang, L., Zhang, Q., Duan, F., He, K., and Yu, S.: Incorporation of new particle formation and early growth treatments into WRF/Chem: Model improvement, evaluation, and impacts of anthropogenic aerosols over East Asia, Atmos. Environ., 124, 262–284, doi:10.1016/j.atmosenv.2015.05.046, 2016.

Done, J. M., Holland, G. J., Bruyere, C. L., Leung, L. R., and Suzuki-Parker, A.: Modeling high-impact weather and climate: lessons from a tropical cyclone perspective, Climatic Change, 129, 381–395, doi:10.1007/s10584-013-0954-6, 2015.

Emery, C., Tai, E., and Yarwood, G.: Enhanced meteorological modeling and performance evaluation for two texas episodes, Report to the Texas Natural Resources Conservation Commission, prepared by ENVIRON, International Corp., Novato, CA, available at: http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/mm/EnhancedMetModelingAndPerformanceEvaluation.pdf, 2001.

Gantt, B., He, J., Zhang, X., Zhang, Y., and Nenes, A.: Incorporation of advanced aerosol activation treatments into CESM/CAM5: model evaluation and impacts on aerosol indirect effects, Atmos. Chem. Phys., 14, 7485–7497, doi:10.5194/acp-14-7485-2014, 2014.

Glotfelty, T., He, J., and Zhang, Y.: The Impact of Future Climate Policy Scenarios on Air Quality and Aerosol/Cloud Interactions using an Advanced Version of CESM/CAM5: Part I. Model Evaluation for the Current Decadal Simulations, Atmos. Environ., 152, 222–239, doi:10.1016/j.atmosenv.2016.12.035, 2017a.

Glotfelty, T., He, J., and Zhang, Y.: Improving Organic Aerosol Treatments in CESM/CAM5: Development, Application, and Evaluation, Journal of Advances in Modeling Earth Systems, in review, 2017b.

Glotfelty, T., and Zhang, Y.: The Impact of Future Climate Policy Scenarios on Air Quality and Aerosol/Cloud Interactions using an Advanced Version of CESM/CAM5: Part II. Future Trend Analysis and Impacts of Projected Anthropogenic Emissions, Atmos. Environ., 152, 531-552, doi: 10.1016/j.atmosenv.2016.12.034, 2017.

Han, K. M., Lee, S., Chang, L. S., and Song, C. H.: A comparison study between CMAQ-simulated and OMI-retrieved NO2 columns over East Asia for evaluation of NOx emission fluxes of INTEX-B, CAPSS, and REAS inventories, Atmos. Chem. Phys., 15, 1913-1938, doi:10.5194/acp-15-1913-2015, 2015.

Hanna, S. R., and Yang, R. X.: Evaluations of mesoscale models' simulations of near-surface winds, temperature gradients, and mixing depths, J. Appl. Meteorol., 40, 1095–1104, doi:10.1175/1520-0450(2001)040<1095:EOMMSO>2.0.CO;2, 2001.

He, J., and Zhang, Y.: Improvement and further development in CESM/CAM5: gas-phase chemistry and inorganic aerosol treatments, Atmos. Chem. Phys., 14, 9171–9200, doi:10.5194/acp-14-9171-2014, 2014.

He, J., Zhang, Y., Glotfelty, T., He, R., Bennartz, R., Rausch, J., and Sartelet, K.: Decadal simulation and comprehensive evaluation of CESM/CAM5.1 with advanced chemistry, aerosol microphysics, and aerosol-cloud interactions, J. Adv. Model. Earth Sy., 7, 110–141, doi:10.1002/2014MS000360, 2015a.

He, J., Zhang, Y., Tilmes, S., Emmons, L., Lamarque, J. F., Glotfelty, T., Hodzic, A., and Vitt, F.: CESM/CAM5 improvement and application: comparison and evaluation of updated CB05_GE and MOZART-4 gas-phase mechanisms and associated impacts on global air quality and climate, Geosci. Model Dev., 8, 3999–4025, doi:10.5194/gmd-8-3999-2015, 2015b.

Lin, J.-T., McElroy, M. B., and Boersma, K. F.: Constraint of anthropogenic NOx emissions in China from different sectors: a new methodology using multiple satellite retrievals, Atmos. Chem. Phys., 10, 63–78, doi:10.5194/acp-10-63-2010, 2010.

Mass, C., and Ovens, D.: WRF model physics: progress, problems, and perhaps some solutions, in: The 11th WRF Users' Workshop, NCAR Center Green Campus, http://www.mmm.ucar.edu/wrf/users/workshops/WS2010/presentations/session%204/4-1_WRFworkshop2010Final.pdf (last access: June 2014), 21–25 June, 2010.

Mass, C., and Ovens, D.: Fixing WRF's High Speed Wind Bias: a New Subgrid Scale Drag Parameterization and the Role of Detailed Verification, Preprints, 24th Conference on Weather and Forecasting/20th Conference on Numerical Weather Prediction, American Meteorological Society, Seattle, W.A., 9B.6. Available online at: http://ams.confex.com/ams/91Annual/webprogram/Paper180011.html, 2011.

Penrod, A., Zhang, Y., Wang, K., Wu, S., and Leung, L. R.: Impacts of future climate and emission changes on US air quality, Atmos. Environ., 89, 533–547, doi:10.1016/j.atmosenv.2014.01.001, 2014.

Qian, J. H., Seth, A., and Zebiak, S.: Reinitialized versus continuous simulations for regional climate downscaling, Mon. Weather Rev., 131, 2857–2874, doi:10.1175/1520-0493(2003)131<2857:RVCSFR>2.0.CO;2, 2003.

Rontu, L.: A study on parametrization of orography-related momentum fluxes in a synoptic-scale NWP model, Tellus A, 58, 69–81, doi:10.1111/j.1600-0870.2006.00162.x, 2006.

Tang, Y., Lee, P., Tsidulko, M., Huang, H., McQueen, J. T., DiMego, G. J., Emmons, L. K., Pierce, R. B., Thompson, A. M., Lin, H., Kang, D., Tong, D., Yu, S., Mathur, R., Pleim, J. E., Otte, T. L., Pouliot, G., Young, J. O., Schere, K. L., Davidson, P. M., and Stajner, I.: The impact of chemical lateral boundary conditions on CMAQ predictions of tropospheric ozone over the continental United States, Environ. Fluid Mech., 9, 43–58, doi:10.1007/s10652-008-9092-5, 2009.

Xiu, A., and Pleim, J. E.: Development of a land surface model. Part I: Application in a mesoscale meteorological model, J. Appl. Meteorol., 40, 192–209, doi:10.1175/1520-0450(2001)040<0192:doalsm>2.0.co;2, 2001.

Xu, Z., and Yang, Z.: An Improved Dynamical Downscaling Method with GCM Bias Corrections and Its Validation with 30 Years of Climate Simulations, J. Climate, 25, 6271–6286, doi:10.1175/JCLI-D-12-00005.1, 2012.

Yahya, K., Wang, K., Campbell, P., Glotfelty, T., He, J., and Zhang, Y.: Decadal evaluation of regional climate, air quality, and their interactions over the continental US and their interactions using WRF/Chem version 3.6.1, Geosci. Model Dev., 9, 671–695, doi:10.5194/gmd-9-671-2016, 2016.

Zhang, Y., Zhang, X., Wang, L., Zhang, Q., Duan, F., and He, K.: Application of WRF/Chem over East Asia: Part I. Model evaluation and intercomparison with MM5/CMAQ, Atmos. Environ., 124, 285–300, doi:10.1016/j.atmosenv.2015.07.022, 2016a.

Zhang, Y., Zhang, X., Wang, K., Zhang, Q., Duan, F., and He, K.: Application of WRF/Chem over East

Asia: Part II. Model improvement and sensitivity simulations, Atmos. Environ., 124, 301–320, doi:10.1016/j.atmosenv.2015.07.023, 2016b.

Zhang, Y., Hong, C., Yahya, K., and Zhang, Q.: Multi-Year Application and Evaluation of WRF/Chem-MADRID for Real-Time Air Quality Forecasting over Southeastern United States, Atmos. Environ., 138, 162-182, doi:10.1016/j.atmosenv.2016.05.006, 2016c.

Zheng, B., Zhang, Q., Zhang, Y., He, K. B., Wang, K., Zheng, G. J., Duan, F. K., Ma, Y. L., and Kimoto, T.: Heterogeneous chemistry: a mechanism missing in current models to explain secondary inorganic aerosol formation during the January 2013 haze episode in North China, Atmos. Chem. Phys., 15, 2031–2049, doi:10.5194/acp-15-2031-2015, 2015.