Geoscientific
Model Development
Open Access
Discussions

Interactive comment on "Downscaling a global climate model to simulate climate change impacts on US regional and urban air quality" *by* M. Trail et al.

M. Trail et al.

mcus2rail@gmail.com

Received and published: 15 July 2013

Response to Referees "Downscaling a global climate model to simulate climate change impacts on US regional and urban air quality" by M. Trail et al.

Anonymous Referee #1 Received and published: 19 May 2013

The authors used spectral nudging technique to downscale the result of large-scale climate model to a spatial resolution of 12 km x 12 km. The downscaling results were evaluated by comparing with in situ observations. They found the high-resolution simulations produce different results than the coarse resolution simulations. They also analyzed the meteorological variables that most strongly influence air quality in the

US for present-day (2006-2010) and future (2048-2052). The manuscript was clearly written and the results were also well discussed. Clearly, this manuscript deserves publication on this journal. Still, there are still several minor suggestions the authors may need to consider:

1. Page 5 line 3: Weaver, et al.

Done

2. Page 9 line 17-19: I suggest add the boundaries of these regions in Fig. 1.

As the reviewer suggests, we have added the boundaries for the four regions to Figure 1. The caption to Figure 1 now reads:

Figure 1: Modeling domains with horizontal grid-spacing resolutions of 36-km and 12-km Northeast (NE) and Southeast (SE). The dashed boxes indicate the four regions where model evaluation was conducted.

3. Page 10 line 2: the names of the regions need to be consistent with what you have defined at the end of section 3.

As the reviewer suggests, we have made the names of the 4 sub regions used for the evaluation as the West (W), the Midwest (MW), the South (S) and the Northeast (NE) USA

4. Page 11 line 19: Why is the unit of the standard deviation K2?

The units should be "K". We have changed all of the standard deviation units to "K".

5. Page 14 line 8: Any reference supporting your choice of 6000 m2/s?

The reference for 6000m2/s (Pielke et al., 1991) is mentioned in the paper on page 4 line 19. However, we have added the reference to the end of the sentence on page 14 as well:

"An unvented hour is an hour during which the ventilation coefficient is less than 6000

m2 s-1 (Pielke et al., 1991). "

6. Page 17 line 5: You need to name the four regions.

Good point. The regions of potentially enhanced ozone are now identified. The section on page 17 line 5 now reads: "...enhance ozone levels in four regions of the U.S. during fall (Western U.S., Texas, Northeastern, and Southeastern U.S), one region during summer (Texas), and one region where changes potentially would lead to better air quality during spring (Northeast)."

7. Page 23: In table 1 and Table 2, you introduced two new terms "bias" and "error". Are they the same as "MB" and "MAGE", respectively? If so, please use consistent terms. If not, you need to define them here.

In Tables 1 and 2, the terms "bias" and "error" are indeed "MB" and "MAGE", respectively. We replaced the terms "bias" and "error" in the tables with "MB" and "MAGE".

8. Page 30: I'm confused by the figures 7-10. It seems that there are more than one curve (4?) for each city under each scenarios. Are they for different seasons? These curves fuse together and are hard to identify. I suggest use thinner curves and use a table to list the percentiles discussed in the text.

The separate curves represent each year for the present and future periods. In other words, there is one curve for 2006, one for 2007, and so on. We have replaced the curves in figures 7-10 with thinner curves. However, since the data near the extremes of the curves are more difficult to see as the curves become thinner, further thinning of the curves will take away from the information shown in the figures. A table (Table 3) has also been added for details summarizing the upper 95th percentile maximum daily temperatures discussed in the text.

Anonymous Referee #2 Received and published: 19 June 2013

Comments on "Downscaling a Global Climate Model to Simulate Climate Change Impacts on U.S. Regional and Urban Air Quality" By Trail et al.

General evaluation

In this manuscript, WRF3.1 was nested within GISS ModelE2 to downscale the climate change information over the U.S. under RCP4.5 scenario. Two periods (2006 to 2010 and 2048 to 2052) were chosen. Several variables were analyzed, including temperature, precipitation, insolation, stagnation events, and ventilation. Based on the downscaled higher resolution data, the impacts of climate changes on regional and urban air quality were discussed. Overall, dynamical downscaling is a useful tool to obtain high resolution climate change information. The discussion about the impacts of climate change on the air quality is also interesting. However, I find that the authors overstated the importance of their study on the air quality aspect, because in the current manuscript all the impacts of climate change on the air quality are implied, since no direct or quantified links between the climate change and the air quality are established, and no air quality model is used. As the authors reviewed, studies on the impacts of climate change on air quality rely on the coupling of regional climate model such as WRF to Multi-scale Air Quality model. Therefore, I believe that the whole paper should be reorganized, and focus of the study should be back to the climate change issue.

We thank the reviewer for this thoughtful and constructive feedback. In response to the suggestion for reorganizing to focus on the climate issue, we have implemented wording changes and removed some statements about air quality impacts. Since these simulations will be used as inputs to drive an air quality model in an upcoming publication, we feel that addressing the potential impacts on air quality provides added perspectives in this study as well.

1. Please state clearly what "consistent changes in regional climate would enhance ozone level" in abstract (line 28).

We have added a sentence in line 31 to state what is meant by "consistent changes in regional climate would enhance ozone level"

"Changes in regional climate that would enhance ozone levels are increased temperatures and stagnation along with decreased precipitation and ventilation."

2. Please consider the following title: "Downscaling a global climate model to simulate climate change over U.S. and the implication on regional and urban air quality".

As the reviewer suggests, the title has been changed to "Downscaling a global climate model to simulate climate change over the U.S. and the implication on regional and urban air quality"

3. L143-L144: I wonder the temporal resolution of SST and sea-ice. Are they monthly data?

The temporal resolution is monthly mean data that are interpolated by a quadratic fit using the end-of-month values, in order to get a daily variability and a smooth transition from one month to the other.

4. L149-150: Please state clearly what "chemical parameters" were produced? Does the GISS model include the atmosphere chemistry model?

GISS only produced 6-hr gaseous and aerosol tracer concentrations. We did not use this data for the downscaling. To more clearly communicate this, we changed lines 149-150 to:

"6-hourly instantaneous outputs of physical parameters were produced for regional downscaling by WRF (section 2.2). 6-hourly instantaneous outputs of gaseous and aerosol tracer concentrations were also produced, but were not used for downscaling."

5. L233-234: "These biases... correspond to..." is a very strong statement. Please list the corresponding biases from GISS model here.

We compared surface temperatures from the GISS model and reanalysis data (NCEP-NARR) and the GISS seasonally averaged surface temperature tend to be biased low in the Western U.S. by up to 8 degrees in some regions (see Figure R1 below). Figure

R1 has not been added to the manuscript.

For accuracy, we have changed the sentence in the paper to read as follows: "The low temperature bias over the Western U.S. corresponds to low biases in the GISS fields"

6. L220-L235: I also wonder how well the stagnation event and ventilation are simulated during the period of 2006-2010. A comparison to the observation is needed.

The number of stagnation days per season was compared to the number of stagnation days calculated from NCEP-NARR reanalysis data for the year 2010 and are shown in Figure R2. The number of simulated stagnation days for the downscaled GISS simulation is biased low in Mexico all year and over the Western U.S. during the summer and fall. Stagnation is biased high in Texas during the summer.

Figure R2 has been added into the supplementary material as "Figure s2" and the following discussion has been added to line 311 of the main paper: "The number of stagnation days was compared to the National Centers for Environmental Prediction – North American Regional Reanalysis data (NCEP-NARR) for the year 2010. Results generally compare well, though with very similar regional spatial patterns. Low biases were found over Mexico and over the Western U.S. during the summer and fall. Stagnation is biased high in Texas during the summer (Figure s2)."

Similarly, the ventilation coefficient was calculated from NCEP-NARR data for comparison (Figure R3). Ventilation simulated from WRF downscaling of GISS is biased low in the West. However, in Northeast and Southeast the simulated coefficient compares well with NARR data.

Figure R3 has also been added to the supplementary material as "Figure s3" and the following discussion has been added to line 311 of the main paper: "Seasonal mean ventilation coefficients were compared with NCEP-NARR data, and similar spatial and seasonal patterns were found. There was a low bias in the Western U.S. while the Northeast and the Southeast compare well with reanalysis data (Figure s3)."

7. L260: "greather" should be "greater"

We apologize for this typo, and have corrected it.

8. L308: please give the clear definition of the stagnation event (The threshold of the wind speed and the precipitation).

We have added a definition for the stagnation even to line 304:

"A stagnation event is defined as at least four consecutive days when the following criteria are met: a) the 10m wind speed is less than 4 m s-1 b) the 500 mb wind speed is less than 13 m s-1 at 7:00 am LST, and c) the total rainfall is less than 0.001 cm for the 4 day period (Korshover and Angell, 1982)."

9. L319 – L322: The differences of the changes in stagnation events between 36km simulation and 12km simulation are evident. Please explain the differences.

The differences in stagnation discussed in the paper can be explained by the decrease in precipitation seen over the same region between the 36km and 12km domains. We have added the following discussion to line 323.

"Increased summertime stagnation in the 12km Northeast domain corresponds to pre-cipitation decreases in the same domain"

10. L340-L342: Some discussions are needed for the difference.

We have added the following discussion to line 345:

"Summertime differences between the two domains occur, in part, due to differences in the resolutions of the land use data since southeast Georgia and South Carolina are scattered with pine forest and cropland and these two land use categories affect surface energy fluxes and PBL height differently, which in turn affects the ventilation in the region"

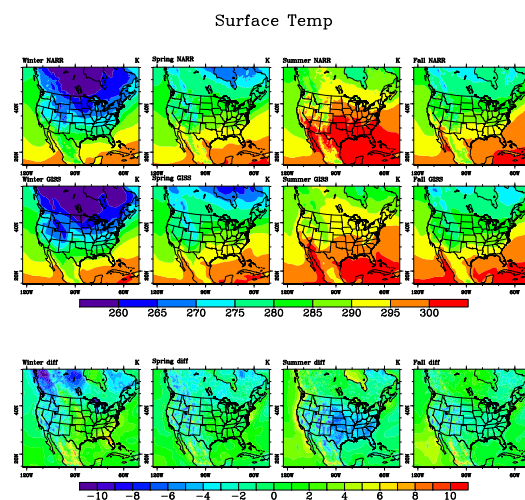Interactive comment on Geosci. Model Dev. Discuss., 6, 2517, 2013.

Fig. 1. Figure R1 Seasonally averaged surface temperature for NCEP-NARR (top) and GISS model (middle) and the difference (GISS minus NCEP-NARR) (bottom). Not added to the main text.
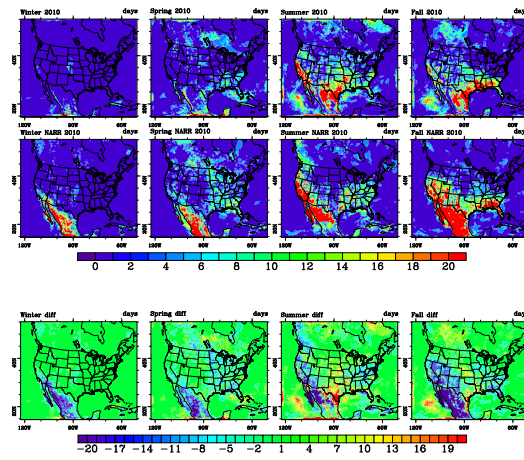
Stagnation Days

Fig. 2. Figure R2 Number of stagnation days per season for GISS model downscaled by WRF (top) and NCEP-NARR (middle) and the difference (GISS minus NCEP-NARR) (bottom). Added to supplementary material as Fig
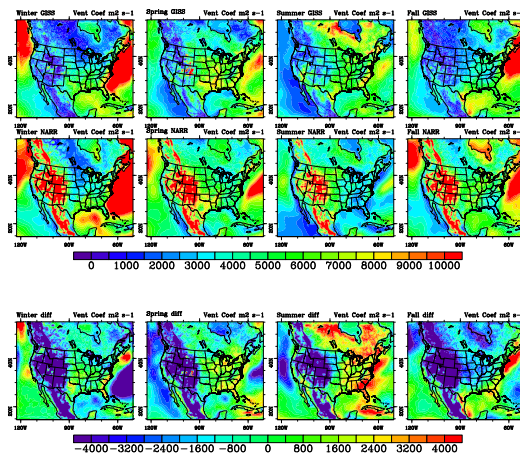
C1007

Unvented Hours

Fig. 3. Figure R3 Ventilation coefficient for GISS model downscaled by WRF (top) and NCEP-NARR (middle) and the difference (GISS minus NCEP-NARR) (bottom). Added to supplementary material as Figure s3.