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Geoscientific Model Development Discussions

Interactive comment on "Evaluation of improved land use and canopy representation in BEIS v3.61 with biogenic VOC measurements in California" *by* J. O. Bash et al.

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We would like to thank anonymous referee 2 for his/her constructive and generally positive recommendations. The quality and clarity of this manuscript has been improved due to the referee's inputs. The response to the referee's suggestions are in blue to better distinguish them from the referee's text.

1. (Section 2.2) It is not clear what underlying Leaf Area Index (LAI) data was used in the BEIS simulations (2006 MODIS?) and how that data differs from the LAI data used in the MEGAN simulations? LAI directly

impacts biogenic emission estimates and can change substantially from year-to-year (see http://acmg.seas.harvard.edu/presentations/aqast/nov2012/Cohan_tiger_team_biogenics_Nov_2012.pdf slide 10). If there are differences between the BEIS and MEGAN LAI data, please discuss how those differences may influence the results. In addition, assuming that year-specific LAI data was not used (e.g., the LAI data is not from the same year as the field studies used to evaluate the biogenic emissions) please discuss how using year-specific LAI data would influence the results.

   Currently we are using the Kinnee, Geron and Pierce 1997 Ecological Applications 7(1), 46-58 where pant genus types are assigned a fixed summer and winter LAI like the earlier versions of BEIS. LAI is also important in determining the meteorological surface energy balance and we are working to connect the BVOC LAI with the values used by the meteorological model to be consistent across models, and incudes modeled (for future or scenario simulations) or satellite (for retrospective analysis) derived LAI depending on the meteorological simulation. This requires a restructuring the BEIS code and BELD data that could not be done in time for the 3.61 release but will likely be in the next revision of the model. The following text was added to section 2.2 "Plant genus type LAIs for summer and winter are estimated following Kinnee et al. (1997).".

2. (Section 2.4 and Section 2.5) CMAQ modeling was conducted from 3 June through 31 July 2009 and results were compared to measurements made during BEARPEX (which coincides with the modeling time period) and CARES, which occurred during June 2010 (Figures 6 and 7). I find it problematic to compare modeling from 2009 with observations from 2010 since meteorology has such a strong influence on biogenic emissions and can lead to large variability in emission estimates from year-to-year. Please discuss what implications differences in meteorology from 2009 to 2010 may have on the findings of this work.

The authors agree that meteorology influences biogenic emissions and have included text recognizing that relationship. Since the measurements made during 2010 do not correspond to specific modeled days in 2009 only the distribution of observations from 2010 are compared to the distributions of modeled mixing ratios from the 2009 simulation. Figures 1 has been added to the supporting information that shows temperatures at Cool and Sacramento during the CARES 2010 field study were very similar to the temperatures during the 2009 BEARPEX simulation at those locations. This comparison further supports the adequacy of our comparison of 2010 measurements with 2009 modeled mixing ratios where matching is done in space but not in time.

3. (Section 3.1) Figure 1 shows that MEGAN predicts a higher leaf temperature than does BEIS at the higher end of the distribution (i.e., at higher temperatures). This is of critical importance since it's these peak temperatures that drive higher biogenic emissions (and is likely a major cause of the difference between the BEIS and MEGAN emissions presented in this study). Some discussion about the difference between the canopy models in BEIS and MEGAN would be useful to help to better interpret the results.

   MEGAN did indeed predict higher leaf temperatures than BEIS for the Duke Forest grassland sight. It is not clear if that is the cause of the biases in the California simulations but it is possible. The following text has been added to section 3.4 "MEGAN 2.1 overestimated the peak midday leaf temperature observations from Duke Forest (Figure 1). This could be a potential factor in the model Isoprene bias if MEGAN behaved similarly during the BEARPEX simulations".

4. (Section 3.2) The authors state that there are currently no databases to quantitatively evaluate the fractional tree species data coverage. The California Gap Analysis Project (http://www.biogeog.ucsb.edu/projects/gap/gap_home.html) may provide the needed information. Although this data is also a bit outdated, it

would be more up to date than the Critchfield and Little (1966) and Little Jr. (1971, 1976) data cited in the manuscript. Davis, F. W., D. M. Stoms, A. D. Hollander, K. A. Thomas, P. A. Stine, D. Odion, M. I. Borchert, J. H. Thorne, M. V. Gray, R. E. Walker, K. Warner, and J. Graae. 1998. The California Gap Analysis Project–Final Report. University of California, Santa Barbara, CA. [http://legacy.biogeog.ucsb.edu/projects/gap/gap_rep.html]

   We agree that the California GAP Analysis Project does represent more up to date species data than cited in the manuscript. The current structure of the CA GAP data (polygons of dominate and subdominant species versus species range maps) makes it difficult to fit within our analysis without redeveloping the tools used in this paper for this analysis. We clearly state that the analysis against the current datasets is qualitative. The wording in section 3.2 has been changed to reflect the CA GAP data and the reference provided by the referee. We intend on using GAP Analysis results to further refine the BELD dataset.

5. (Section 3.4 and Table 3) It would be useful if the meteorological model evaluation was expanded to include additional monitors in the study areas covered by CARES and BEARPEX, with a particular emphasis on predicting peak temperatures. Average temperatures provide little useful information with regard to biogenic emission estimates since the magnitude of the emissions is driven by peak temperatures rather than average temperatures. In addition, CMAQ model output at any location is potentially impacted by emissions throughout the entire region, not just by emissions at a single location. Therefore, it would be useful to know how well WRF is able to predict peak temperatures on a regional basis and not just at a few select monitors.

   The authors agree that the presentation of additional temperature evaluation of WRF model estimates at monitors both at the field sites and nearby provide a more confidence in local to regional biogenic emissions estimates with respect to temperature influences. Additional time series plots have been added to the

Supporting Information (Figures 2 to 4 below) showing hourly temperature observations paired with WRF estimates for the CARES and BEARPEX locations, Figure 2. In addition, temperature Figure 3, and incoming shortwave solar radiation, Figure 4, evaluation has been included for sites near the BEARPEX field site to provide greater confidence in model estimates for that region. The WRF model compares very well against ambient measurements of daily maximum temperatures which increases confidence in biogenic emissions estimates.

6. Please also discuss the potential uncertainties associated with using photochemical model output to validate a biogenic inventory (e.g., errors in the WRF meteorological field – temperature, PBL heights, wind speed/direction – or uncertainties in the chemical mechanism could lead to what looks like an over/under-prediction compared to the ambient mixing ratios even if the emissions were perfect).

   The evaluation of biogenic emission models and inventories is difficult. Models can be evaluated on a processes level against flux and meteorological measurements. However, these models are typically used to gain insight into regional photochemical processes involving secondary gaseous and aerosol species, e.g. ozone and secondary organic aerosols, and not for site specific applications. We did incorporate site specific modeling into this study to evaluate the canopy models. Additionally we evaluated the models on a regional scale using meteorological and photochemical models. This type of evaluation is influenced by biases in the modeled meteorology and the representation of atmospheric chemical processes in the chemical transport model. However, this is also how these models are typically applied for research and regulatory purposes. The potential impact of the meteorological model biases (Table 3) are discussed in the second paragraph in section 3.4. Additionally, we have added new text to the manuscript to the discussion of meteorological model performance that recognizes uncertainty in surface mixing layer and local to regional transport pattern representation can influence CMAQ model estimates of BVOC even if emission factors were perfect.

   The new text follows: "While mixing layer depth has been shown to be well represented by WRF for California using the configuration used here (Baker et al, 2013), mixing layer depth was not continuously measured at these field sites so could not be directly evaluated meaning that differences between modeled and actual surface layer mixing depth and also differences in local to regional scale transport could impact CMAQ estimates of biogenic VOC."

7. I find it interesting that Table 3 shows significantly more isoprene in the two CMAQ/MEGAN simulations compared to the three CMAQ/BEIS simulations, but that the simulated ozone only shows minor differences. Is this due to the photochemical regime in the area (i.e., NOx limited), so that large changes in isoprene do not have an appreciable effect on ozone or is it an artifact from only showing isoprene at the Blodgett Forest site while showing ozone results for the entire region? To put these results into a bit better context it would be useful to compare regional emission totals from the different biogenic inventories to see if the differences seen at Blodgett are consist with regional differences in the inventories.

   The referee is correct. The Blodgett Forest Research Station (BFRS) in is a relatively remote area in the foothills of Sierra Nevada Mountains and ozone values here are mostly in a NOx limited regime. Additionally, Figures 5 and 6 illustrate the spatial heterogeneity and magnitude of the isoprene emission changes due to the BEIS sensitivities.

8. P. 8122, lines 1-3: Please update the references to: "methods of Jenkins et al. (2003) and Chojnacky et al. (2014). Plot level tree biomass estimates were corrected for sampled bole biomass and scaled to a per hectare basis following O'Connell et al. (2012)." Also note that "bases" was changed to "basis".

   The referee's suggestions were incorporated into the manuscript.

9. P. 8132, lines 8-12: Please update the references to: "Figure 2 shows the BELD 4 and Blackard et al. (2008) estimates of forest biomass for this model domain

at 4 km resolution. The Blackard et al. (2008) 250 m grid resolution data set was projected and aggregated to the CMAQ 4 km grid resolution projection using rgdal and raster libraries in R (Bivand et al., 2014). The BELD 4 estimates evaluated well against those of Blackard et al. (2008) with a".

The referee's updates were incorporated into the manuscript.

Interactive comment on Geosci. Model Dev. Discuss., 8, 8117, 2015.

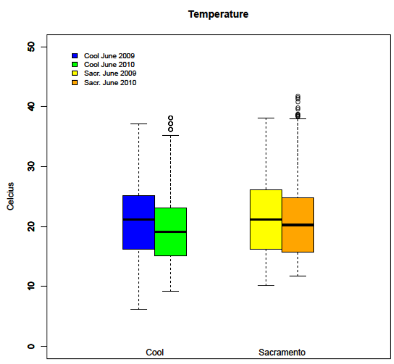

Fig. 1. Distribution of hourly temperatures at the Cool and Sacramento sites during the 2009 and 2010 field campaign periods.

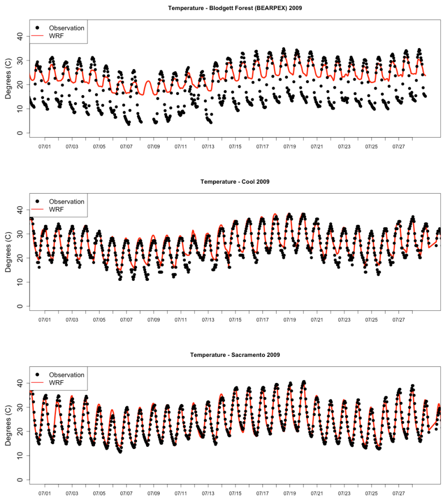

Fig. 2. Hourly observed and modeled temperature at the core field study sites during the 2009 period.

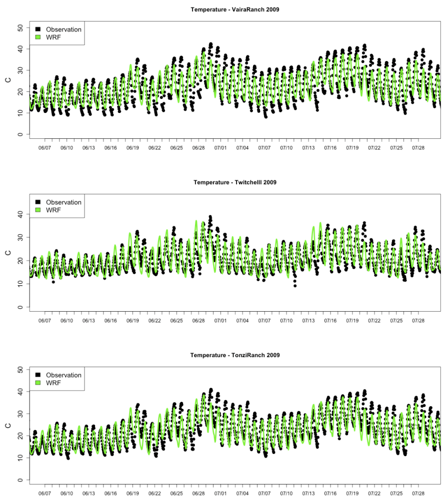

Fig. 3. Hourly observed and modeled temperature at Ameriflux tower sites in northern California during the 2009 period. http://ameriflux.lbl.gov/

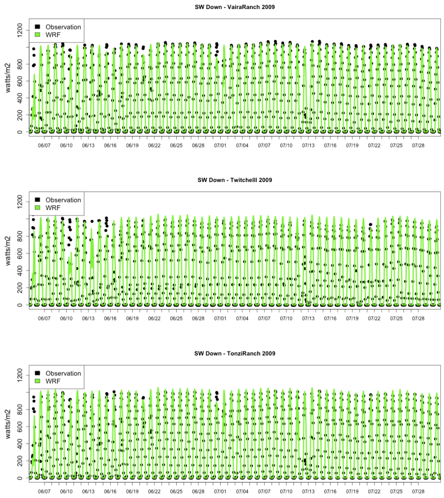

Fig. 4. Hourly observed and modeled shortwave downward radiation at Ameriflux tower sites in northern California during the 2009 period. http://ameriflux.lbl.gov/