COMPARISON OF BIOGENIC EMISSION ESTIMATES FROM BEIS AND MEGAN MODELS FOR TEXAS AND THE CONTINENTAL U.S.A.

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BACKGROUND

Biogenic emissions have a substantial influence on the production of ground-level ozone. Biogenic volatile organic compounds (BVOC), such as isoprene and terpenes emitted by vegetation, and nitrogen oxide compounds (NO_x) produced by soil microorganisms, directly interact with the ozone cycle. There are two well-known biogenic models with a variety of options and evaluating them is crucial for choosing the best biogenic model for air quality modeling. The Biogenic Emissions Inventory System (BEIS) is the model currently used to generate biogenic emissions by most states and the EPA within the continental U.S. Another biogenic model also used by the states and EPA, especially to estimate biogenic emissions outside of the U.S. and Canada, is the Model of Emissions of Gases and Aerosols from Nature (MEGAN), which differs from BEIS in several ways (Guenther 2006). One major difference is that MEGAN can use a soil NO_x algorithm called BDSNP (Berkeley-Dalhousie Soil NO_x Parametrization) (Hudman et al. 2012), in addition to the YL (Yienger and Levy 1995) algorithm, which is used in BEIS. The BDSNP offers several advantages over the YL algorithm, including a more continuous soil temperature and moisture dependence function, incorporation of wet and dry nitrogen (N) deposition and more accurate pulsing by utilizing soil moisture.

METHODS

In this study, biogenic models BEIS version 4 with BELD6 and MEGAN version 3.2 are used to estimate air emissions including NO_x and isoprene. This was done for a 4-km modeling domain that covers central and southeastern Texas, as well as a continental U.S. 12-km domain on July 15, 2022, and October 15, 2022. The dates were chosen to represent seasonal variation of emissions within the ground-level ozone season. Within MEGAN, we tested the sensitivity to drought and different soil NO_x parameterization settings. MEGAN isoprene emissions with drought sensitivity turned off are then compared to BEIS isoprene emissions. Finally, MEGAN NO_x emissions using either the YL or BDSNP soil mechanism option are compared to BEIS NO_x emissions.

MODEL OUTPUTS

As expected, due to the dense forests of pines and other trees, isoprene emissions were higher in the eastern part of Texas compared to the western part in both the BEIS and MEGAN models for both domains. Isoprene emissions were also higher on July 15 than on October 15 for both models and domains. MEGAN estimated higher isoprene emissions on July 15 (38%) and on October 15 (30%) than BEIS across most of the 4-km domain. Peak average isoprene emissions in MEGAN were 59% higher on July 15 and 44% higher on October 15 for the 4-km domain. While for the 12-km domain, MEGAN peak average emissions were 33% and 15% higher on July 15 and October 15, respectively.

When drought sensitivity was enabled in MEGAN, it reduced MEGAN peak average isoprene emissions by 41% on July 15 and by 44% on October 15 for the 4-km domain. Turning on drought sensitivity decreased MEGAN isoprene emissions on average by 7% on July 15 and 24% on October 15. Turning on drought sensitivity for MEGAN reduced isoprene emission differences between MEGAN and BEIS by 4% on July 15 and by 6% on October 15 for the 4-km domain.

Drought sensitivity did not affect NO_x emissions. There were no major seasonal differences in NO_x emissions between July 15 and October 15 for both models using the YL algorithm, although MEGAN with BDSNP showed higher emissions during July 15. Average NO_x emissions from MEGAN using the YL algorithm were 15% lower on July 15 and 27% lower on October 15 than from BEIS for the 4-km domain. MEGAN with BDSNP produced higher NO_x emissions overall, with peak emissions being 5x higher on July 15 and 3x higher on October 15 than in BEIS for the 4-km domain.

CONCLUSIONS

Biogenic model choice had the highest impact on isoprene emissions, with the estimates from MEGAN tending to be higher. However, turning on drought sensitivity attenuated these differences. Soil mechanism choice showed to have the largest impact on output differences between MEGAN and BEIS NO_x emissions. These findings warrant further evaluation of biogenic emissions against monitor data from 2022 as well as investigating how these options and the resulting emission estimates impact performance of photochemical models.

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