2016 Biogenic Emissions Inventory Collaborative

Doug Boyer[1], Jeff Vukovich[2], Miranda Kosty[1], Byeong Kim[3]

July 31, 2019

2019 International Emissions Inventory Conference

Dallas, Texas

[1]Texas Commission on Environmental Quality (TCEQ)

[2]United States Environmental Protection Agency (USEPA)

[3]Georgia Department of Natural Resources (GADNR)

Biogenics Workgroup

- **Co-leads**: Jeff Vukovich (USEPA), Doug Boyer (TCEQ)
- **Schedule**: Calls on 3rd Tuesday at 2:00 pm Eastern
- **Wiki**: http://views.cira.colostate.edu/wiki/wiki/9172
- Google drive: https://drive.google.com/open?id=1ulLmJPQ1WkOnsi6_g2nkHLWfqJEw4RSU
- Workgroup consists of one Multi-Jurisdictional Organization (Western Regional Air Partnership) and state and local agencies (TCEQ, GADNR, California Air Resources Board, Maricopa and Pima Counties (Arizona), Alabama, Montana, New York)

2016 Biogenics Workgroup Charge

- Develop 2016 biogenic emissions inventories (EI) for photochemical model input for State Implementation Plans (SIPs) and other regulatory applications
- Document the EI development
- Compare the models' output
- Conduct model performance evaluation

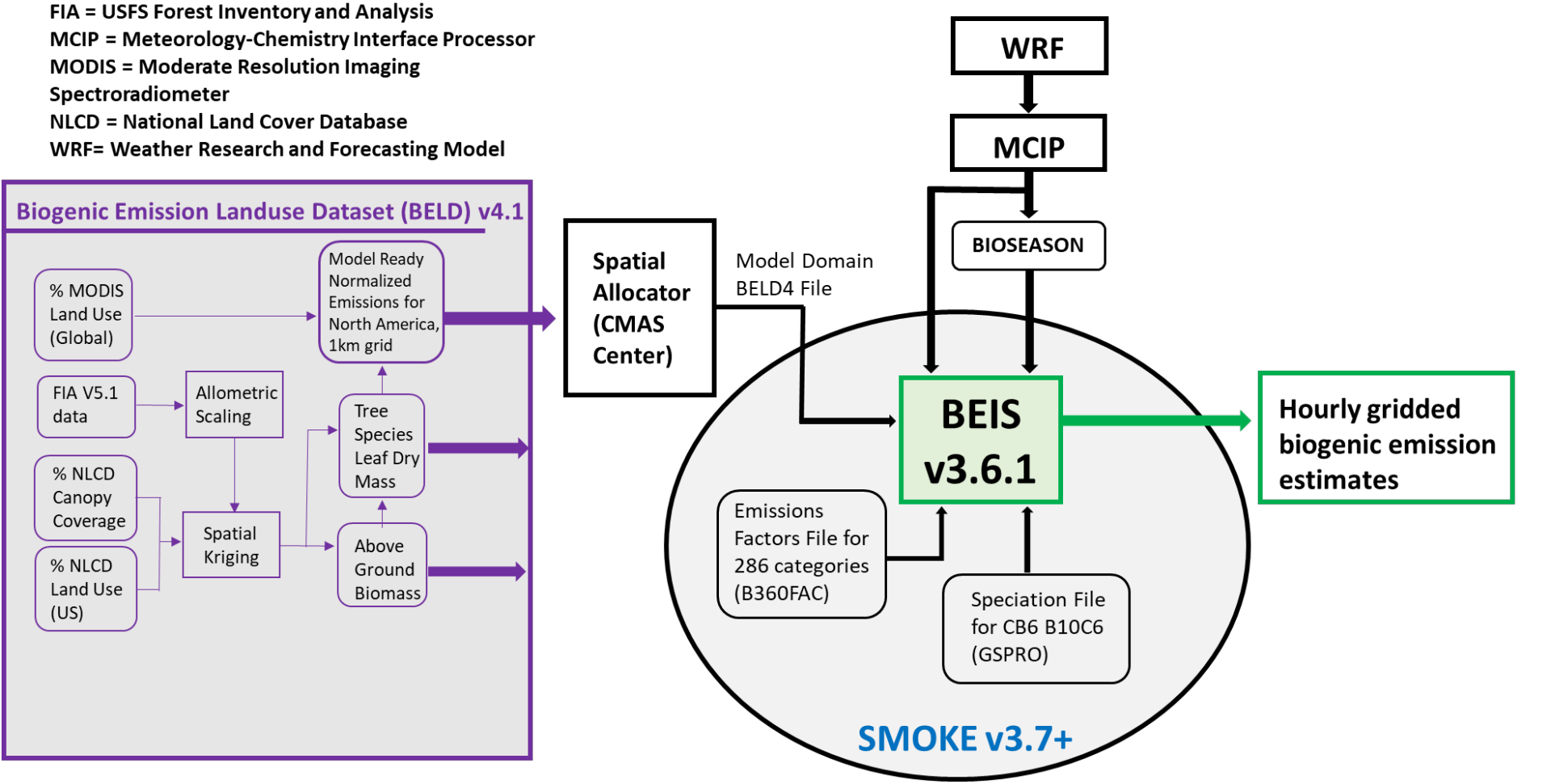
Biogenic Emission Models

- **Biogenic Emission Inventory System (BEIS)**
  - Version 3.61
  - EPA conducted annual 2016 simulation
  - Biogenic Emissions Landuse Database (BELD4.1) land use

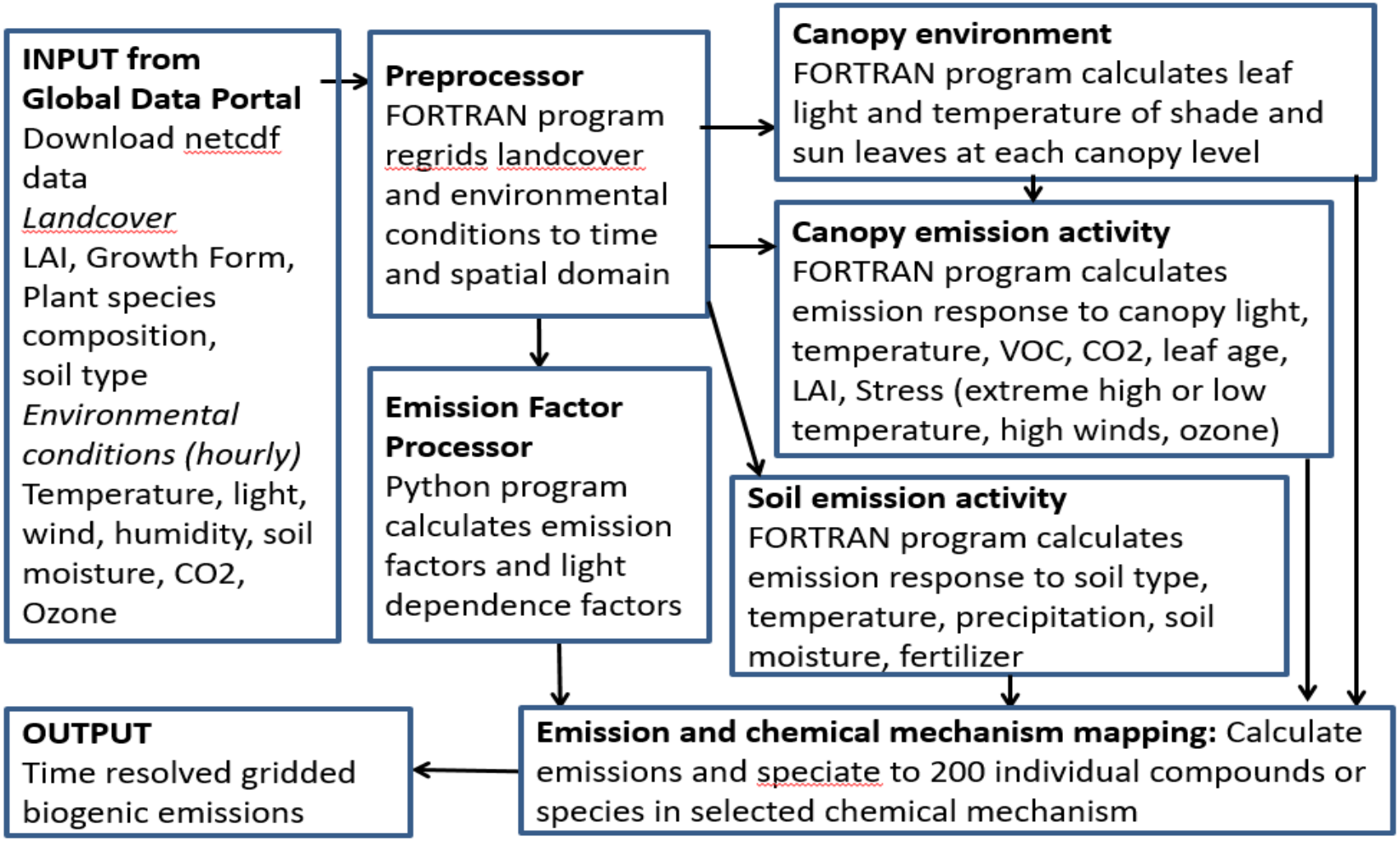
- **Model of Emissions of Gases and Aerosols from Nature (MEGAN)**
  - Version 3.0 (released late 2017)
  - TCEQ conducted annual 2016 simulation
  - Database of growth forms and ecotypes

BEISv3.6.1 Flow Chart

BEIS = Biogenic Emission Inventory System
FIA = USFS Forest Inventory and Analysis
MCIP = Meteorology-Chemistry Interface Processor
MODIS = Moderate Resolution Imaging Spectroradiometer
NLCD = National Land Cover Database
WRF= Weather Research and Forecasting Model



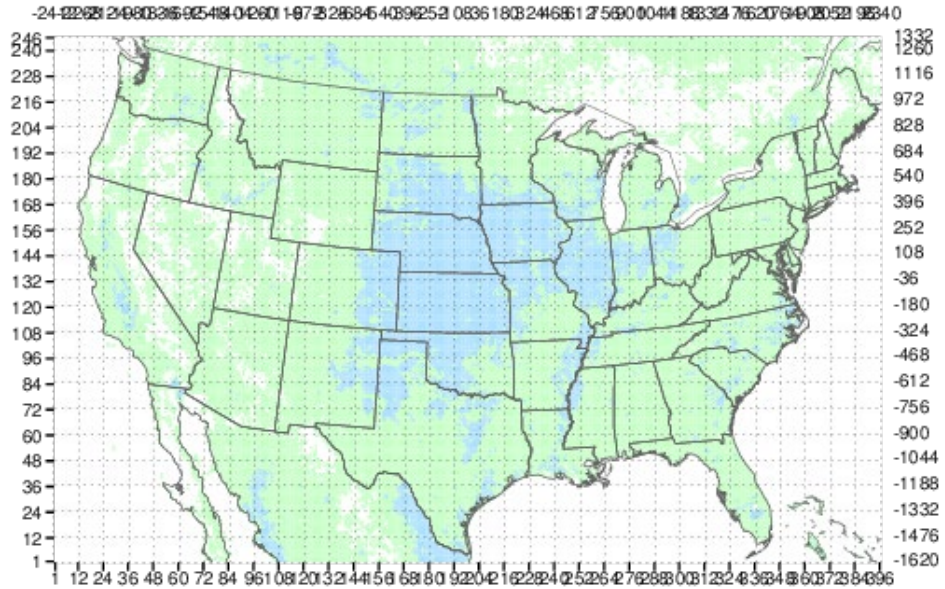
MEGAN3 Flow Chart



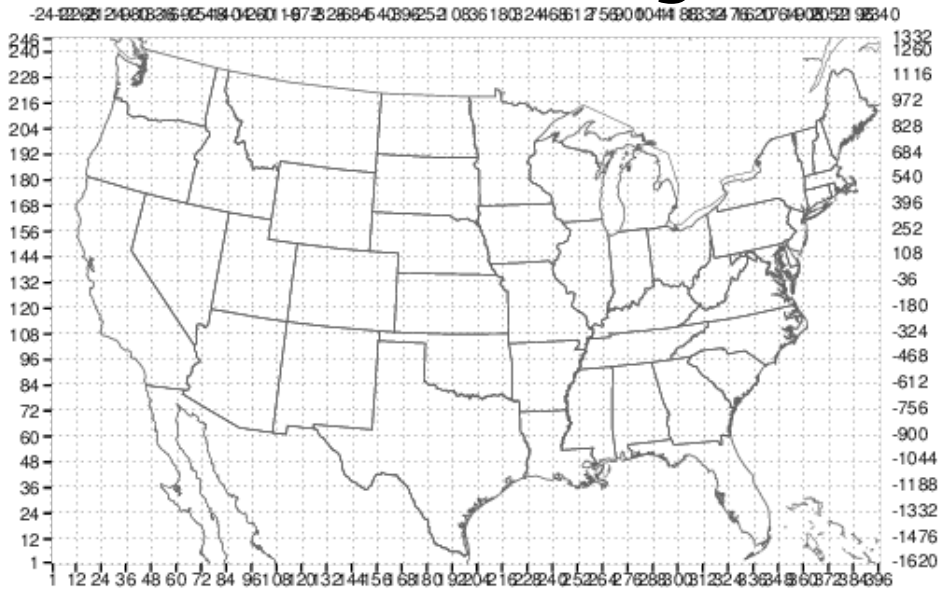
VOC=Volatile Organic Compounds; CO2=Carbon Dioxide; LAI=Leaf Area Index

MEGAN3 Shake-Out: Nitric Oxide (NO)

BEIS3 NO



MEGAN3 NO (Original)



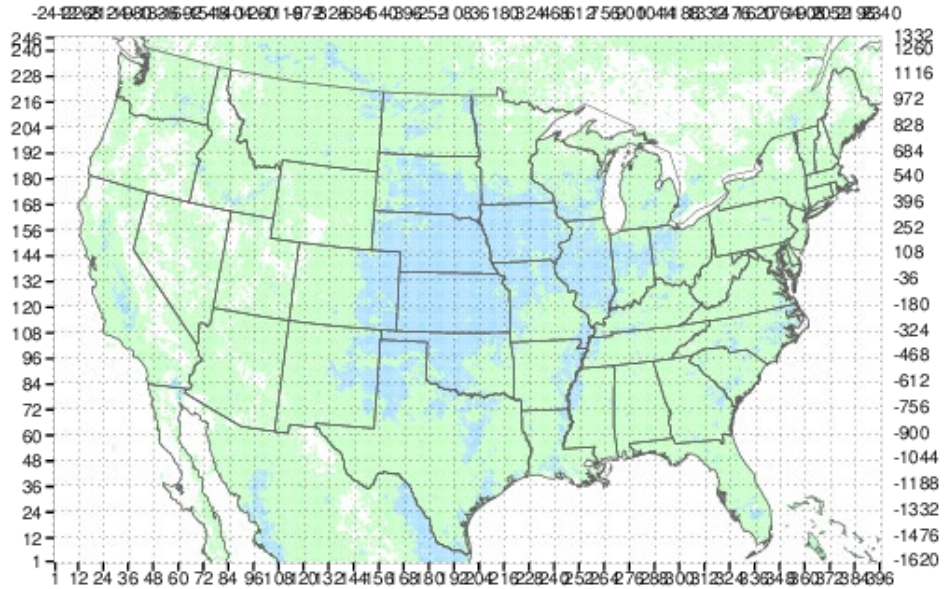
Legend (tons/day)

< 0.02	0.02–0.2	0.2 – 2.0	2.0 – 10
10 – 20	20 – 40	40 – 100	≥ 100

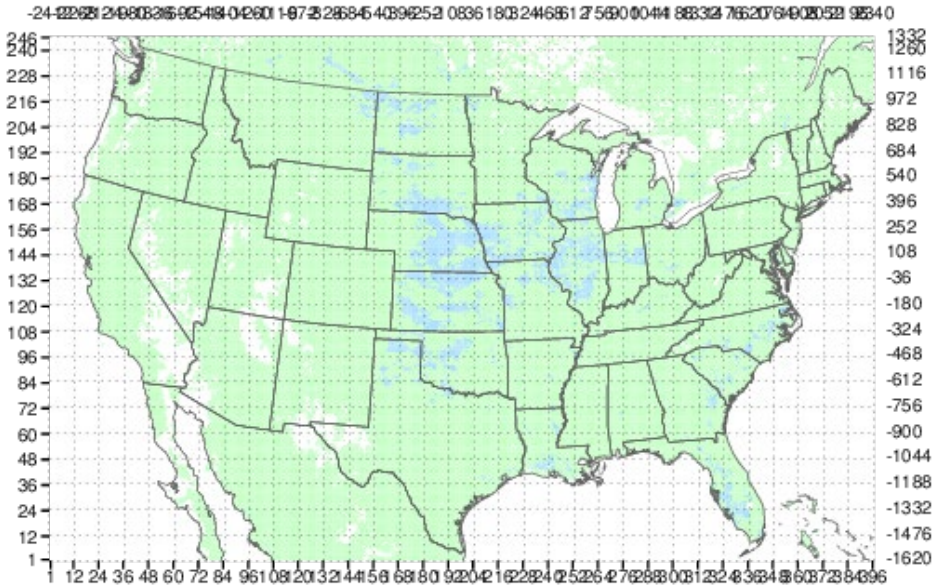
MEGAN3 NO emission factor low by 10000

MEGAN3 Shake-Out: Nitric Oxide (NO) Fixed

BEIS3 NO



MEGAN3 NO

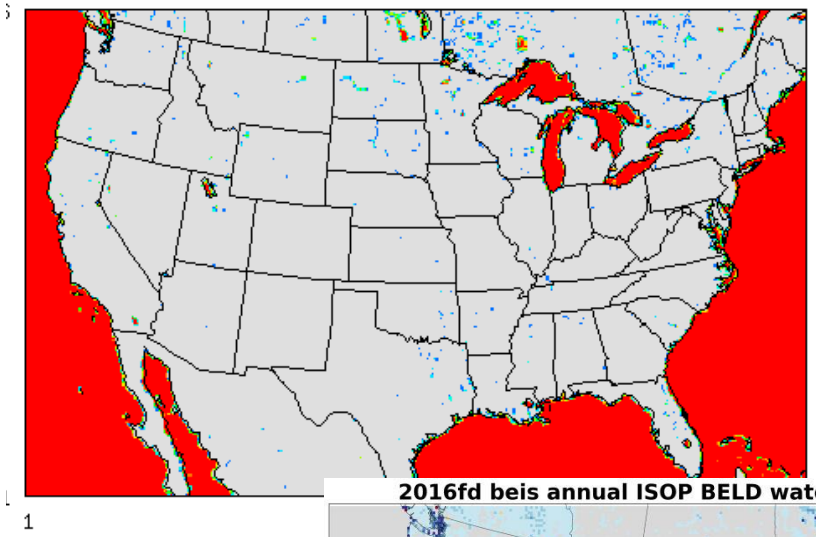


Legend (tons/day)

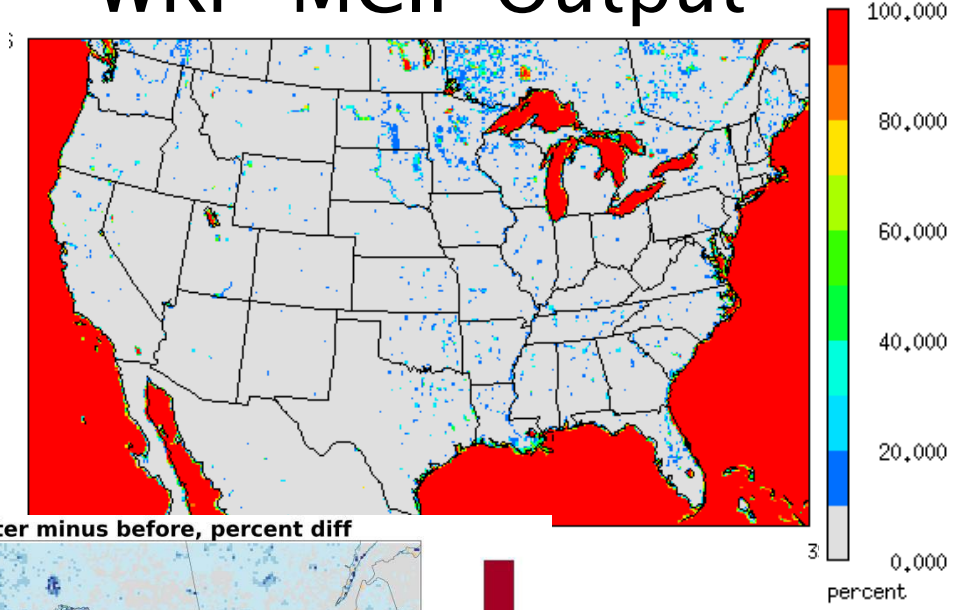
< 0.02	0.02–0.2	0.2 – 2.0	2.0 – 10
10 – 20	20 – 40	40 – 100	≥ 100

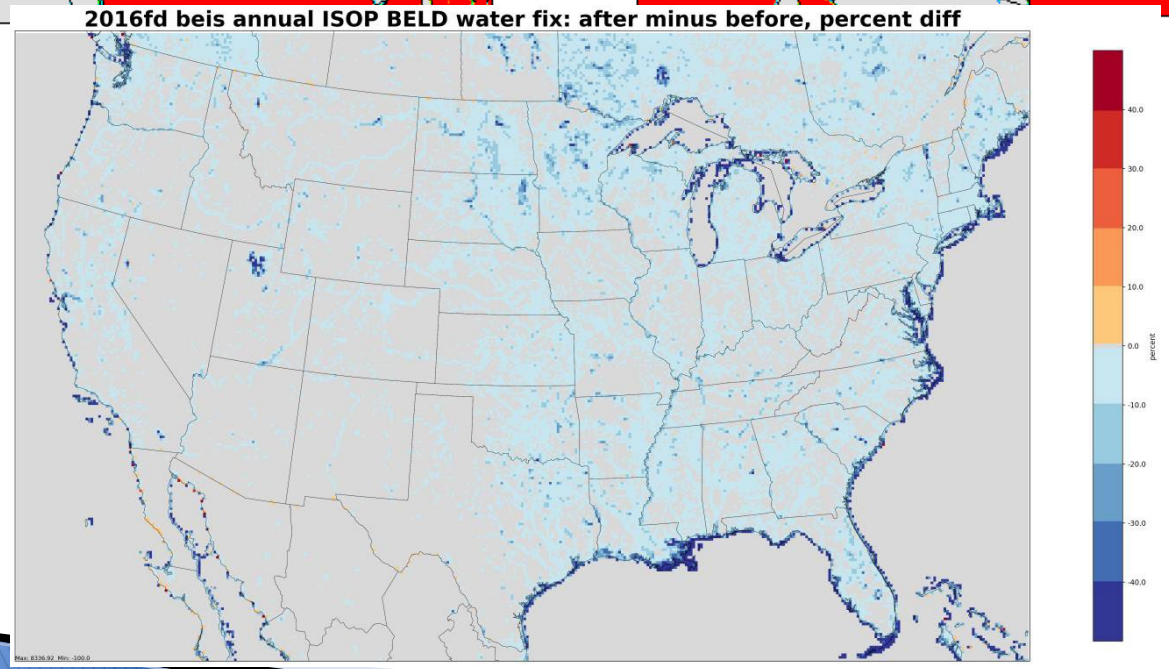
BEIS3 Shake-Out: Missing Water

BELD4 Original



WRF-MCIP Output





WRF = Weather Research and Forecasting model

MCIP = Meteorology-Chemistry Interface Processor

BEIS or MEGAN?

Photochemical Modeling of the Ozark Isoprene Volcano: MEGAN, BEIS, and Their Impacts on Air Quality Predictions

Environ. Sci. Technol., 201145104438-4445

Annmarie G. Carlton[†*] and Kirk R. Baker[‡]

EPA United States Environmental Protection Agency

George Pouliot
7th Annual CMAS Conference

A Tale of Two Models: A Comparison of the Biogenic Emission Inventory System (BEIS3.14) and Model of Emissions of Gases and Aerosols from Nature (MEGAN 2.04)

The Variability of Ozone Sensitivity to Anthropogenic Emissions with Biogenic Emissions Modeled by MEGAN and BEIS3

Atmosphere **2017**, *8*(10), 187; https://doi.org/10.3390/atmos8100187

Eunhye Kim [1], Byeong-Uk Kim [2], Hyun Cheol Kim [3,4] and Soontae Kim [1,*]

Evaluation of improved land use and canopy representation in BEIS v3.61 with biogenic VOC measurements in California

Geosci. Model Dev., 9, 2191-2207, 2016

Jesse O. Bash [1], Kirk R. Baker[2], and Melinda R. Beaver[2]

Improved MEGAN predictions of biogenic isoprene in the contiguous United States

Atmospheric Environment
Volume 148, January 2017, Pages 337-351

Peng Wang [a], Gunnar Schade [b], Mark Estes [c], Qi Ying [a]

A TEXAS BIOGENIC MODEL SHOWDOWN

MEGAN VS BEIS

Biogenic emission inventories were developed for May through September 2012 using the Model of Emissions of Gases and Aerosols from Nature (MEGAN) 2.10 and Biogenic Emission Inventory System (BEIS) 3.61 for Texas State Implementation Plan photochemical modeling. Results from both models were evaluated for isoprene and ozone performance. June 2012 results are shown here as a representative month.

MODEL CONFIGURATIONS

MEGAN 2.10 and BEIS 3.61 were run for May through September 2012 using the same WRF 3.7.1 configuration. The Comprehensive Air Quality Model with extensions (CAMx) was run with each biogenic emission inventory.

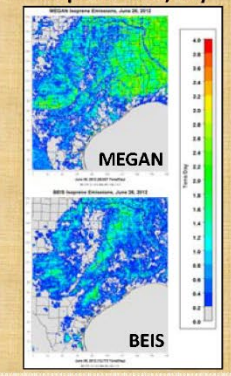
MEGAN was configured with the latest emission factors and plant functional type (PFT) data, developed in 2015 (AQRP, 2015). The 2015 aircraft-based isoprene emission factor is approximately 50% of the default 2011 factor. Leaf Area Index data was created from the MCD15A2 MODIS product with urban corrections (Ying et al, 2015).

BEIS was configured with EPA's Modeling Platform 2011v6_v3, which used the BELD4 land-use, CB05 speciation, and default emission factors.

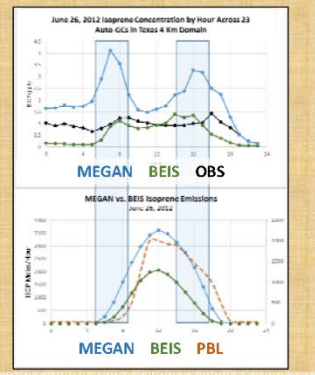
EMISSIONS

MEGAN consistently produced more isoprene emissions than BEIS in Texas during 2012. MEGAN generated emissions earlier and later in the day than BEIS, when low planetary boundary layer heights (PBL) appeared to exacerbate the difference in emission rates and concentrations.

June 26, 2012 Isoprene Tons/Day



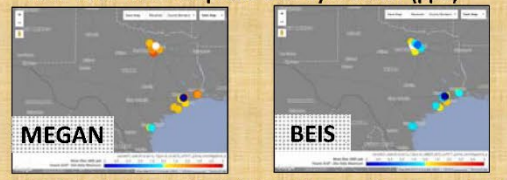
June 26, 2012 Diurnal Emissions vs Concentrations



ISOPRENE PERFORMANCE

23 automatic Gas Chromatographs (auto-GCs) operated in 2012 that measured hourly isoprene and other volatile organic compounds. All auto-GCs were located in urban areas and/or near anthropogenic emission sources; a direct comparison to observed biogenic isoprene wasn't possible.

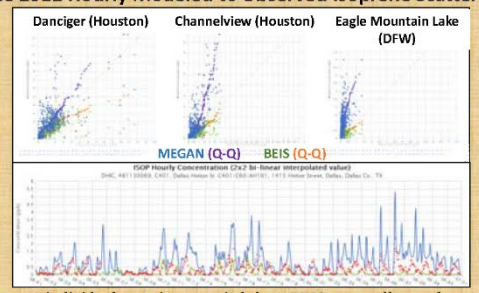
June 2012 Mean Isoprene Bias by Monitor (ppb)



June 2012 Daily Mean Modeled vs Observed Isoprene (ppb)

MEGAN results typically over-predicted isoprene concentrations at Texas auto-GCs while BEIS results showed better agreement (maps and bar chart above).

June 2012 Hourly Modeled vs Observed Isoprene Scatter (ppb)

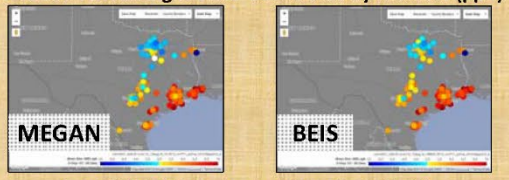


Results at individual monitors varied but BEIS generally performed better. MEGAN performed the best at monitors with the highest observed isoprene.

OZONE PERFORMANCE

Over 100 Texas ozone monitors operating in 2012 were used to evaluate CAMx photochemical model output. While there was a large mean difference in isoprene concentrations between MEGAN and BEIS, mean ozone concentrations were similar as shown in the bias maps below.

June 2012 Mean Eight-Hour Ozone Bias by Monitor (ppb)



June 2012 MDA8 Ozone Mean Error (ppb)

CAMx with MEGAN performed better than BEIS according to maximum daily eight-hour ozone (MDA8) results by monitor for all days.

June 2012 MDA8 Ozone ≥ 60 ppb Mean Error (ppb)

CAMx results with BEIS performed better than MEGAN on high ozone days when observed MDA8 was ≥ 60 ppb.

CONCLUSIONS

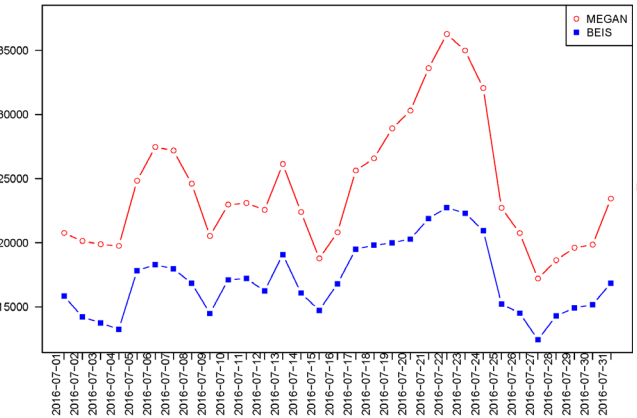
MEGAN consistently over-predicted isoprene concentrations throughout Texas in 2012, with higher emission rates in the morning and evening. BEIS produced isoprene concentrations similar to observed and CAMx ozone results showed better agreement on the important high ozone days.

Doug Boyer, Miranda Kosty, Jim Smith, Ph.D., Marvin Jones, Ph.D., Shantha Daniel, Ph.D. Texas Commission on Environmental Quality

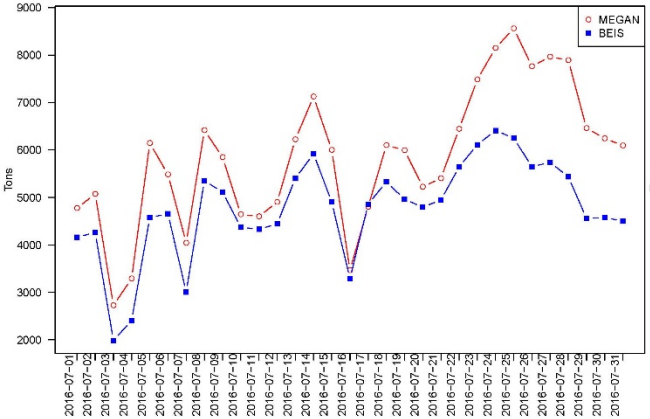
Biogenic Model Comparison: July Isoprene

○ MEGAN3 ■ BEIS3

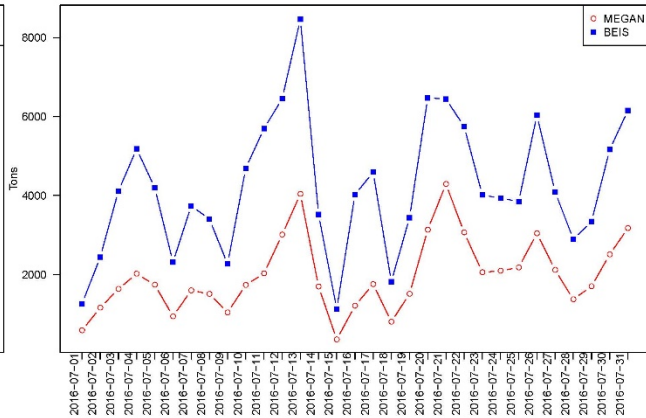
Texas



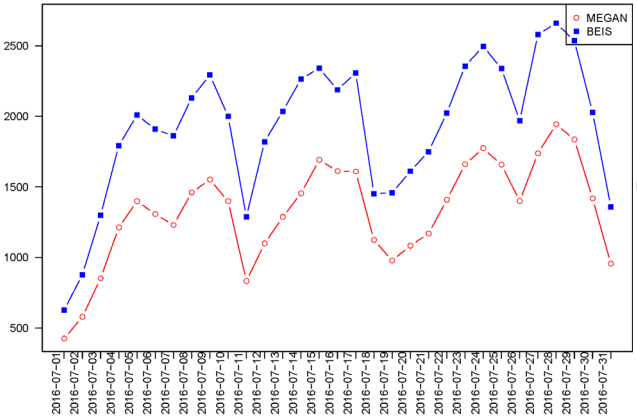
Georgia



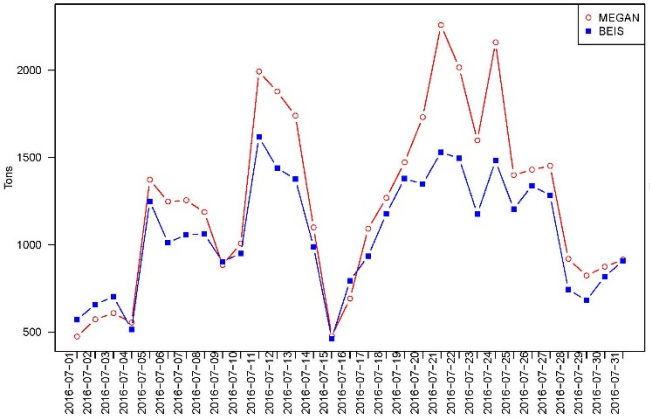
Michigan



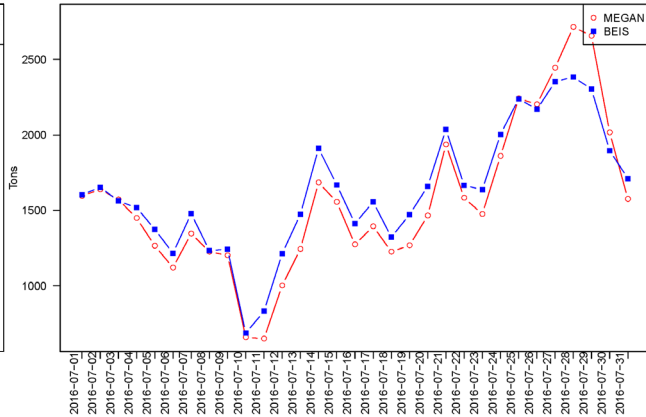
Arizona



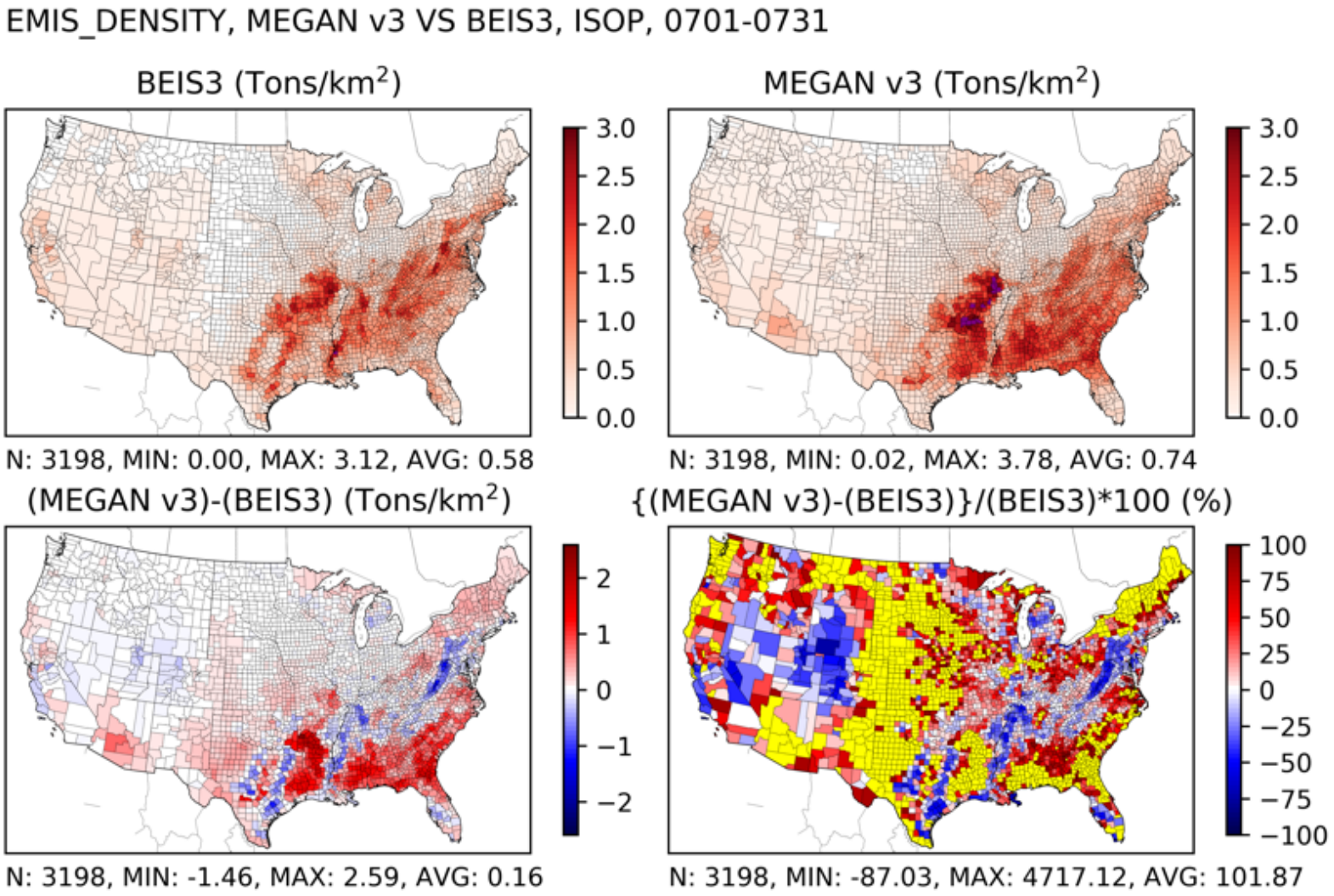
Missouri



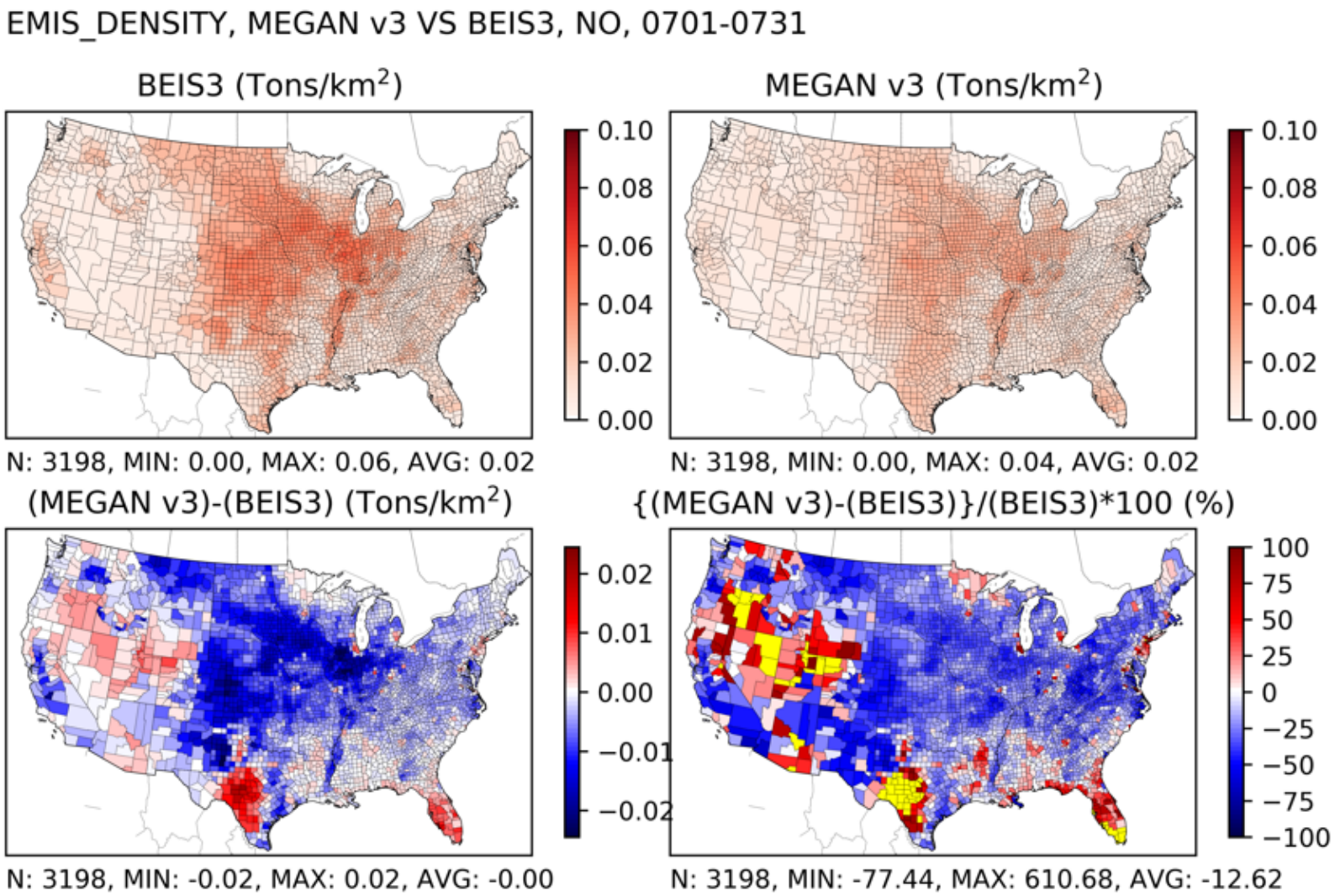
California



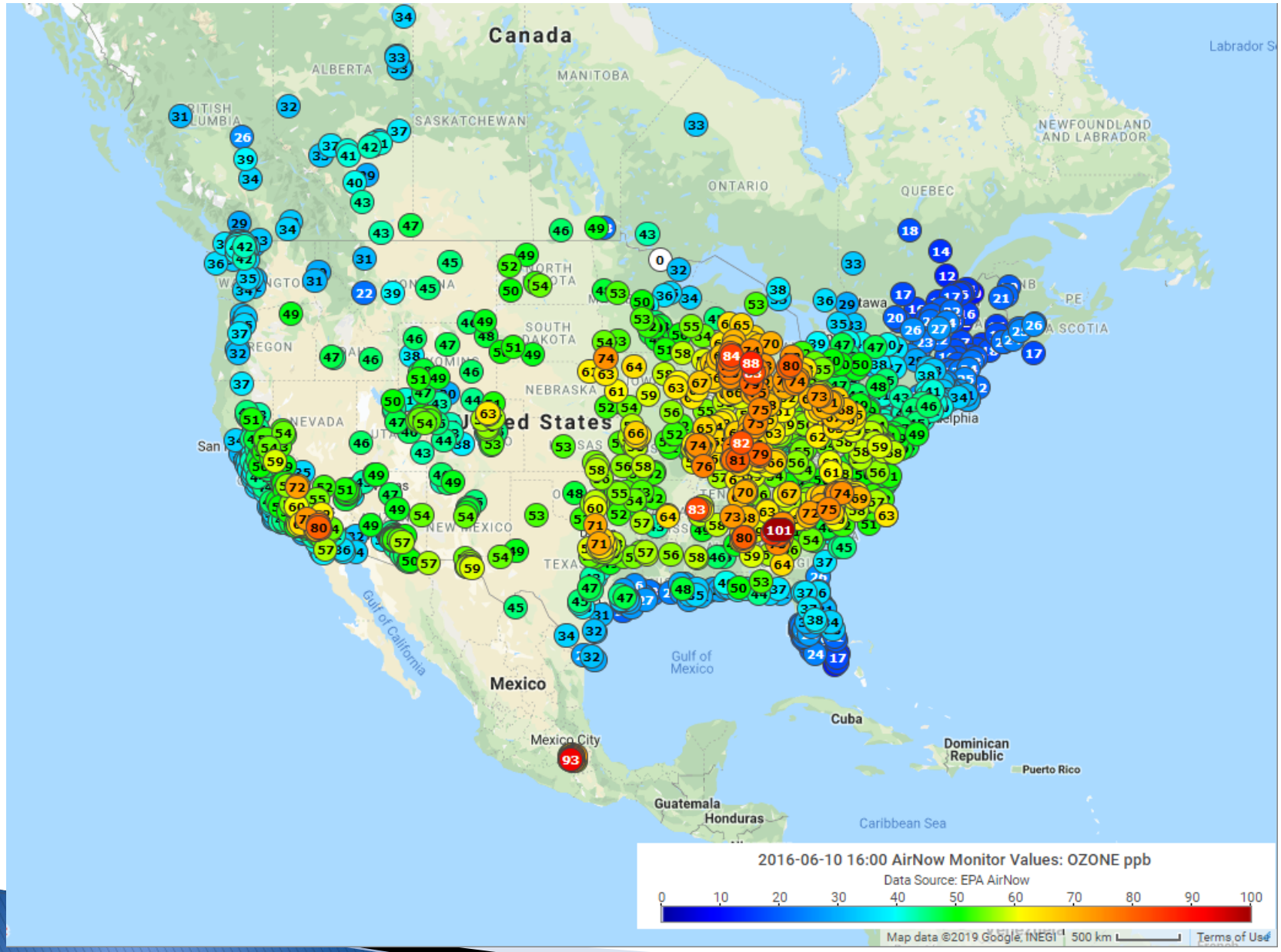
Biogenic Model Comparison: July Isoprene Emission Density



Biogenic Model Comparison: July Nitric Oxide Emission Density



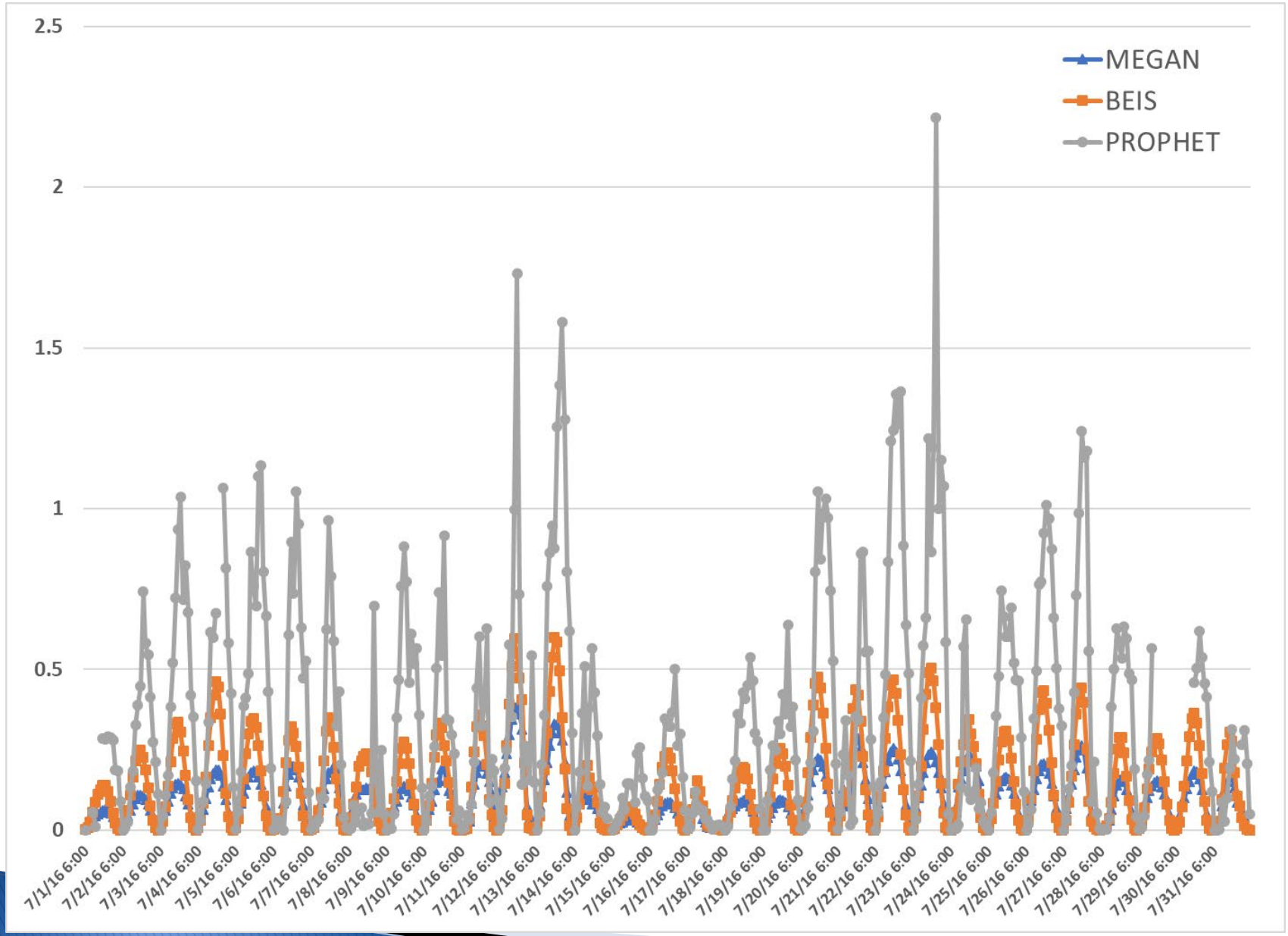
Model Performance Evaluation: 2016 Ozone Observations



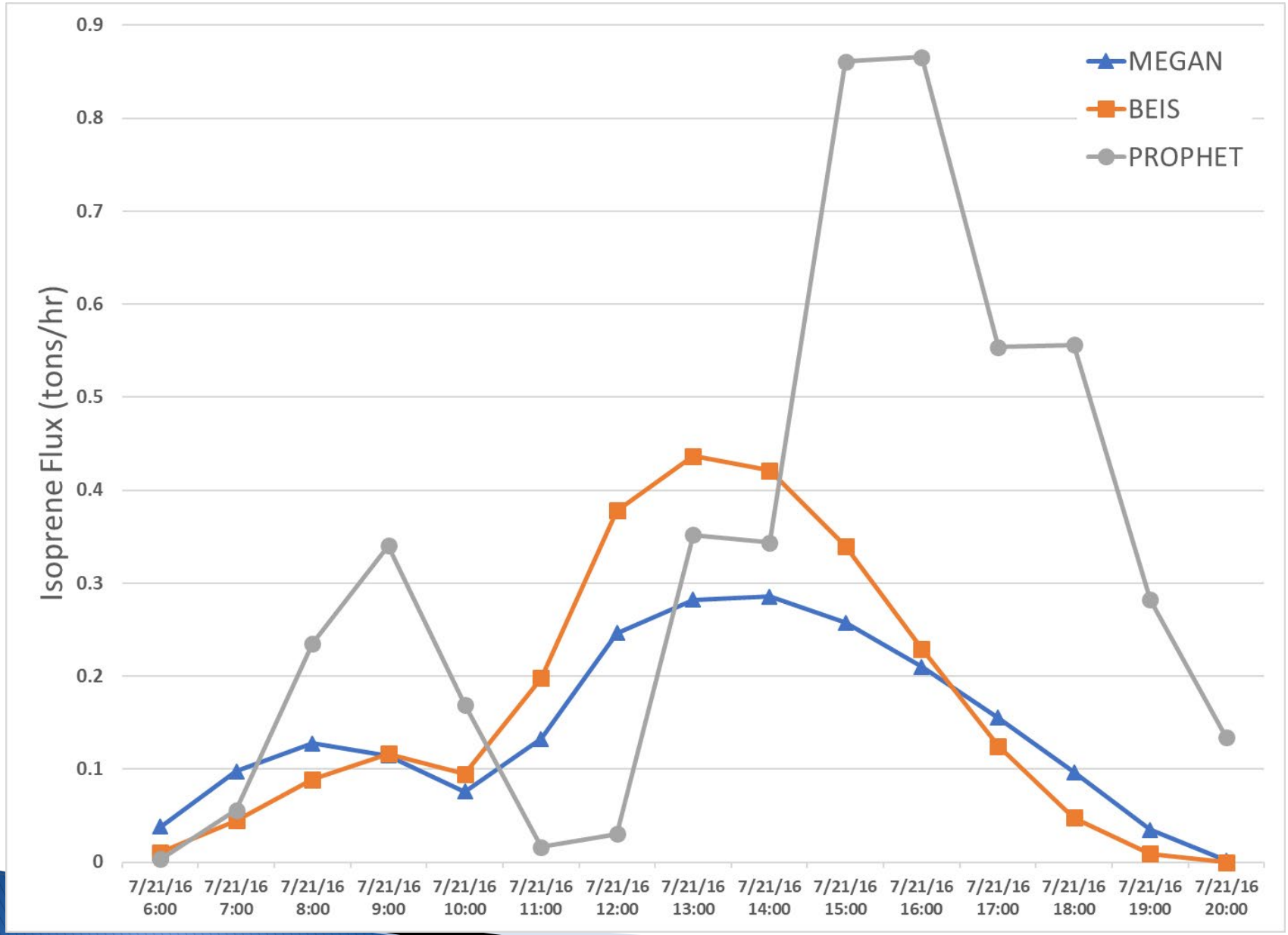
Model Performance Evaluation: 2016 Isoprene Flux Observations

Program for Research on Oxidants: Photochemistry Emissions and Transport (PROPHET) Monitoring Site
Flux data courtesy of Dylan Millet, Professor of Atmospheric Chemistry, Dept of Soil, Water & Climate, Univ of Minnesota

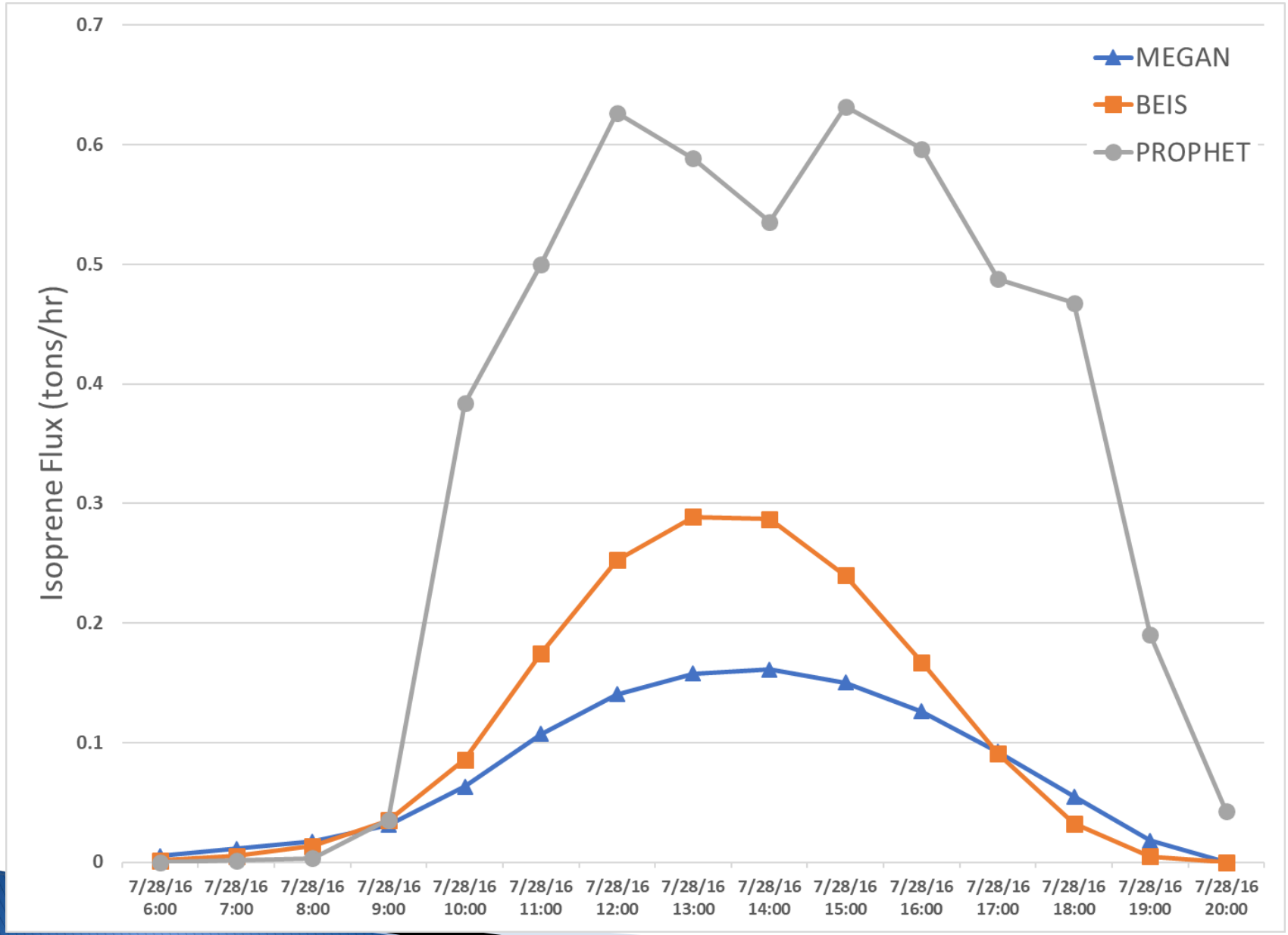
Model Performance Evaluation: July 2016 PROPHET Isoprene Flux Observations



Model Performance Evaluation: July 21, 2016 PROPHET Isoprene Flux Observations



Model Performance Evaluation: July 28, 2016 PROPHET Isoprene Flux Observations



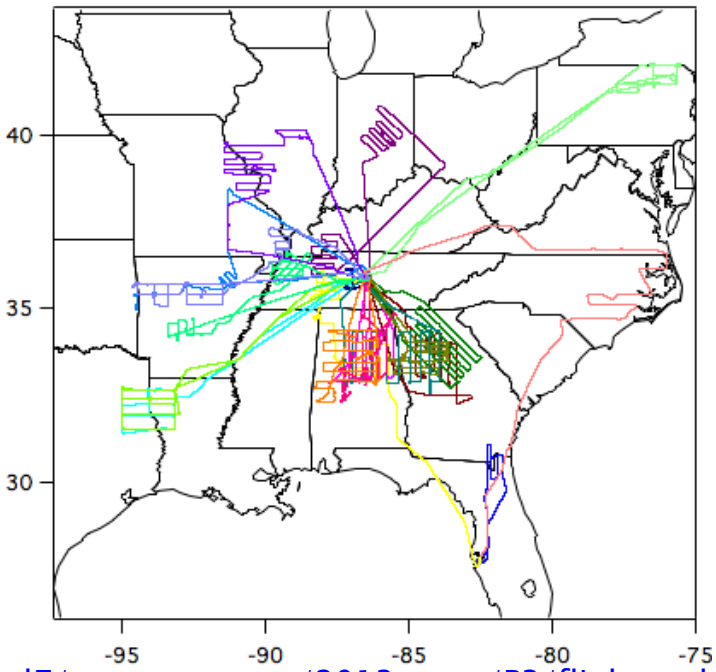
Use our data!

- **12km EPAUS2 domain output for both models on Intermountain West Data Warehouse (IWDW)**
  - January 1 – December 31, 2016
  - Carbon Bond 6 chemical mechanism
  - BEIS 3.61 documentation
  - MEGAN 3.0 documentation

- **New York Department of Environmental Conservation 11:15 AM Presentation**
  - *The 2016 National Emissions Inventory Collaborative: Modeling with the Beta Platform*

Biogenic Workgroup: Next Steps

- **2016 version 1**
  - Environment Canada BELD4 landuse implementation for BEIS3
  - Expected release date: August/September 2019
- **Model Performance Evaluation**
  - Requires air quality model evaluation results (one run with BEIS3 and one with MEGAN3 for comparison)
  - Southeast Atmosphere Study (SAS) 2013 evaluation
    - NOAA P-3 and C-130 aircraft flights
      - Isoprene and monoterpene flux
    - MEGAN3 and BEIS 2013 complete



2013 Flight Tracks
https://www.esrl.noaa.gov/csd/groups/csd7/measurements/2013senex/P3/flighttrack

Biogenics Workgroup: Join Us

- doug.boyer@tceq.texas.gov
- vukovich.jeffrey@epa.gov

- Thanks to the workgroup members for their sustained contributions over the past year and a half!