Evaluation of Model Simulated Ozone and its Precursors Using High-Resolution Model Simulations during the Michigan-Ontario Ozone Source Experiment (MOOSE)

2023 CESM Working Group

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MOTIVATION

Michigan 8-hour Ozone Nonattainment Areas (2015 Standard)

US EPA, 2016
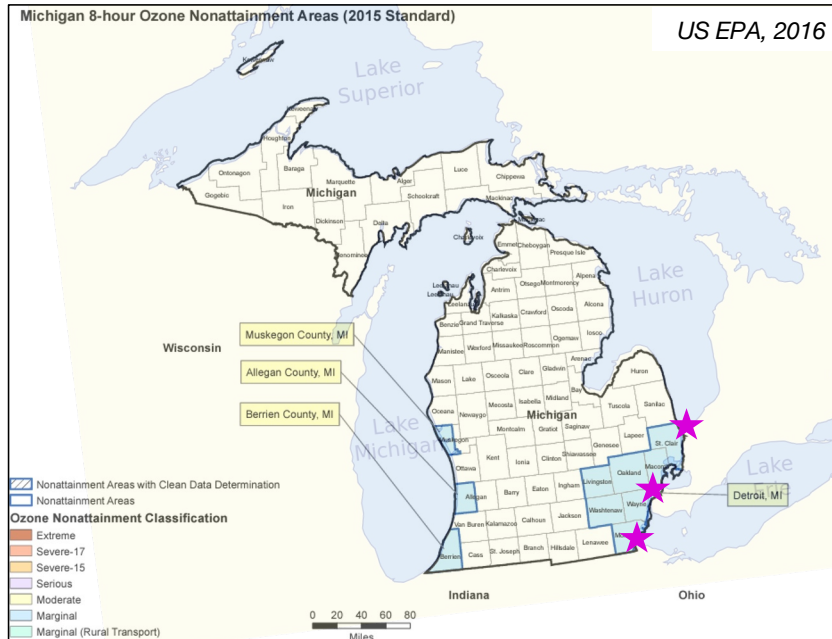
- O$_3$ levels continue to exceed NAAQS standards in SEMI.

- Many factors are associated with O$_3$ exceedance (e.g., precursor emissions, long-range transport, meteorology, land-lake interactions).

- More detailed and innovative measurements and modeling studies are necessary for understanding O$_3$ production and loss in SEMI.

Monroe, MI
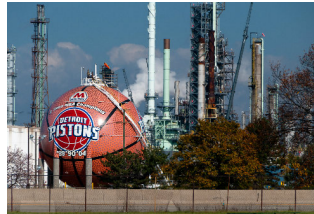
Detroit, MI

Sarnia, ON

OBJECTIVES

A. **Investigate the sensitivity of model simulated O_3 and its precursors to model horizontal grid resolutions in MUSICAv0.**

  1. *Create ~7 km (1/16°) grid over Michigan.*
  2. *Implement and evaluate new grid.*

B. **Quantify the drivers of O_3 nonattainment in Southeast Michigan using optimal MUSICAv0 model grid.**

  1. *Identify and quantify physical and chemical drivers of O_3 production and loss in SEMI through emission sensitivity experiments.*

MOOSE FIELD CAMPAIGN

- **Michigan-Ontario Ozone Source Experiment**

- Led by Michigan Department of Environment, Great Lakes, and Energy (EGLE), with participants from universities, federal agencies, and Environment Climate Change Canada.

- Seeks to define potential attainment strategies in SEMI region and better understand what contributes to excess O_3.

- **Phase I: May 24 – June 30, 2021**

- Phase II: June 6-28, 2022

- Varied, High-Resolution Measurements
 - Aircraft (NASA G-III), Mobile Lab (Aerodyne), Stationary

SW Detroit
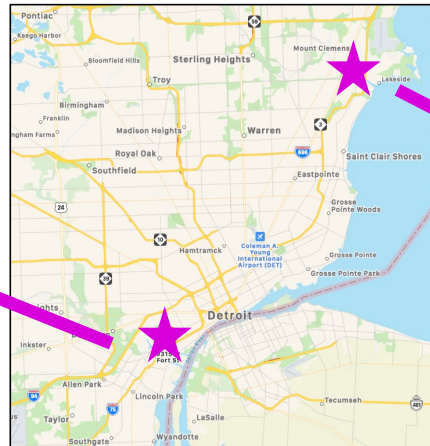
New Haven

MUSICAv0

MUSICAv0

- Multi-Scale Infrastructure for Chemistry and Aerosols, Version 0
- Configuration of CAM-Chem
- Uses Spectral Element (SE) Dynamical Core
- Regional Refinement (RR)
- Described in *Pfister et al (2020)*
- 14 km latitude x 14 km longitude (1/8°) over CONUS

Refinement over Michigan
- **ne30x8 CONUS → ne30x16 MICH**
- Community Mesh Generation Toolkit
 - https://github.com/ESMCI/Community_Mesh_Generation_Toolkit
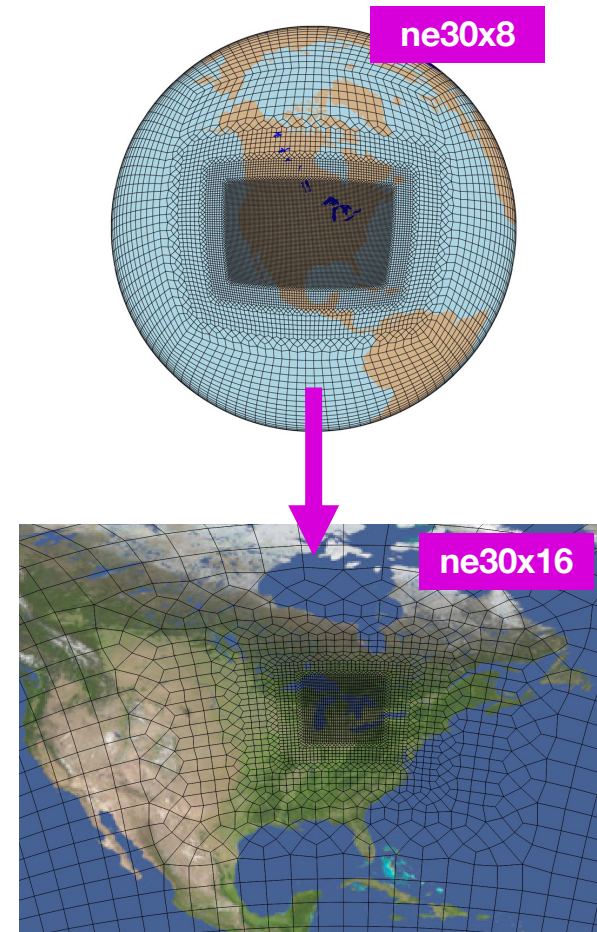
ne30x8

ne30x16

MODELING APPROACH

Model Configuration

- ne30x8 (CONUS) → ne30x16 (Michigan)

- April – August 2021

- TS2 Chemical Mechanism (*Schwantes et al (2020)*)

- MERRA2 (Meteorological Fields)

- Emissions:
    - CAMS-GLOB-ANTv5.1 (Anthropogenic)
    - CAMS-GLOB-AIRv2.1 (Aircraft)
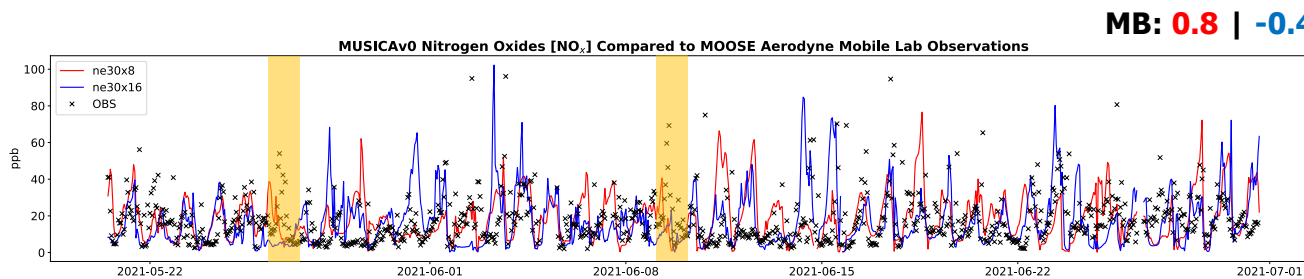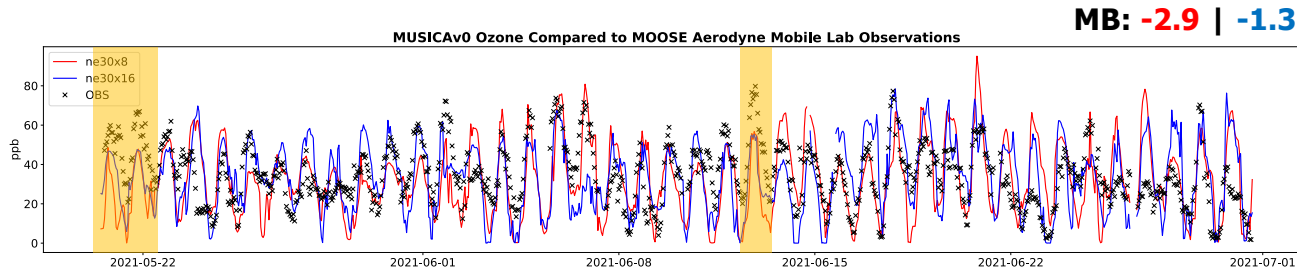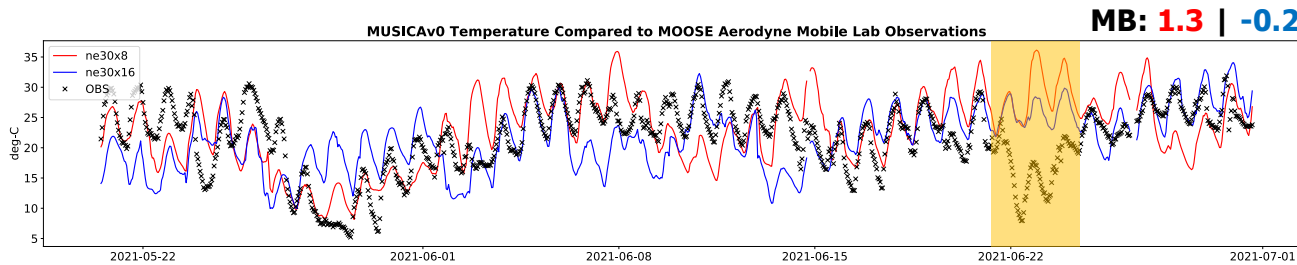   - QFED & FINN (Biomass Burning)

Mariscal et al., In Prep., 2023
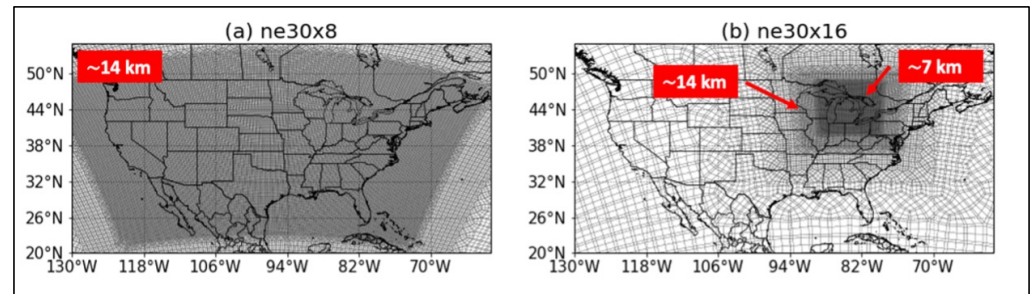
Model Cost (ne30x8):
~28000 core-hr/sim-month

Model Cost (ne30x16):
~18000 core-hr/sim-month

Carbon Monoxide [CO] over Michigan, US [2021-06-01 00:00 UTC]
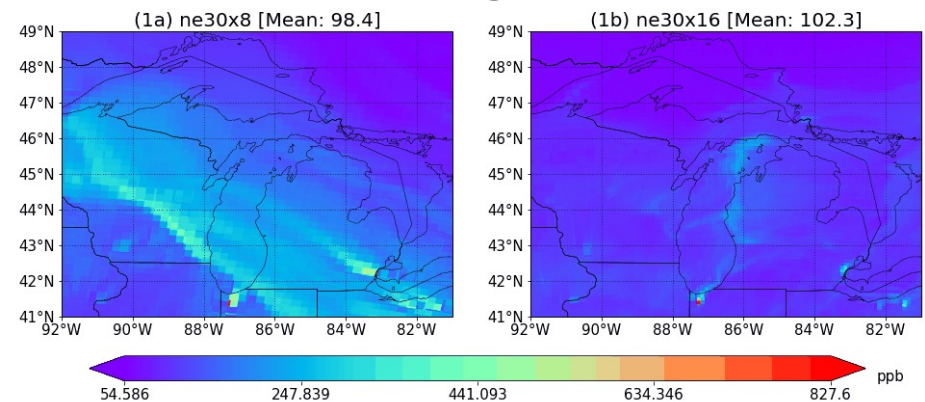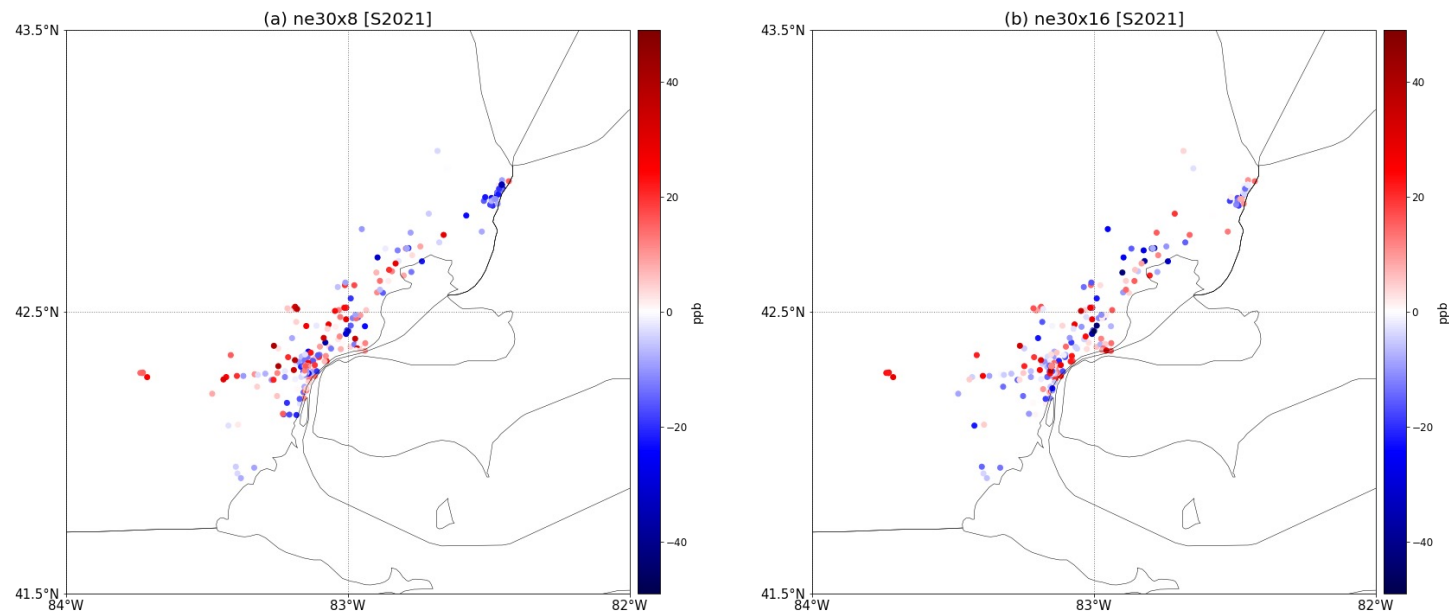
PRELIMINARY RESULTS

Mariscal et al., In Prep., 2023

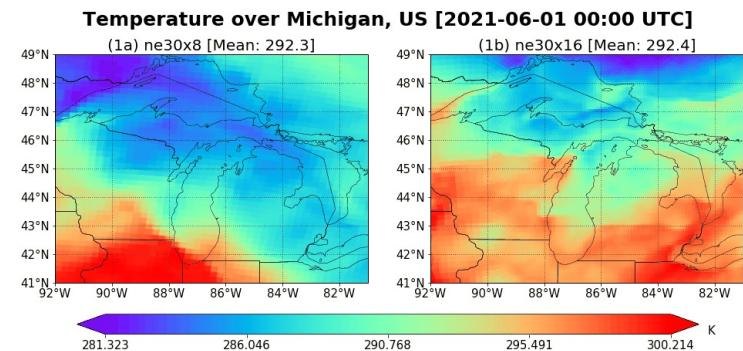Mean Bias (MB) = MDL − OBS
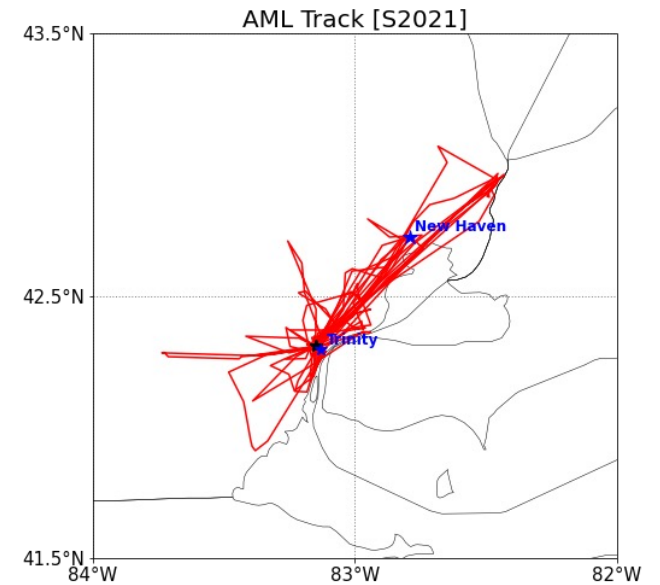
PRELIMINARY RESULTS

Ozone (O$_3$) Mean Bias Along AML Track (S2021)

**Overestimated in urban regions;
Underestimated in rural/suburban areas.**

On-Going & Future Work

- Continue evaluating the performance of MUSICAv0 model simulations (ne30x8 vs ne30x16) using observational constraints from MOOSE Phase I.
  - Meteorology

- Run sensitivity experiments to understand impact of emission sectors on O_3 production in SEMI.

- Combine MUSICAv0 with an exposure model to study impacts of O_3 nonattainment on human health in SEMI.

Temperature over Michigan, US [2021-06-01 00:00 UTC]
(1a) ne30x8 [Mean: 292.3]   (1b) ne30x16 [Mean: 292.4]

ACKNOWLEDGEMENTs

THANK YOU!

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