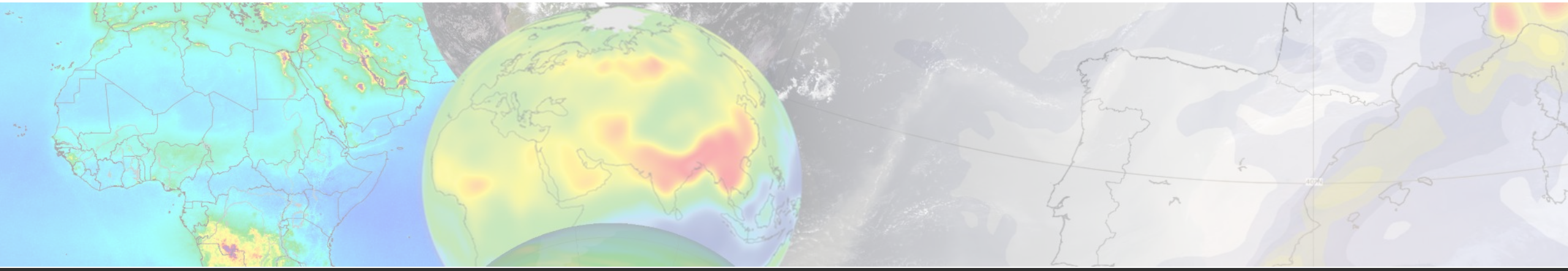


Modeling Air Quality with Variable Resolution in CESM

Louisa Emmons,

Mary Barth, Gabriele Pfister, Simone Tilmes, Matthew Dawson, Wenfu Tang, Duseong Jo & MUSICA Team

Atmospheric Chemistry Observations and Modeling (ACOM) Lab.

National Center for Atmospheric Research

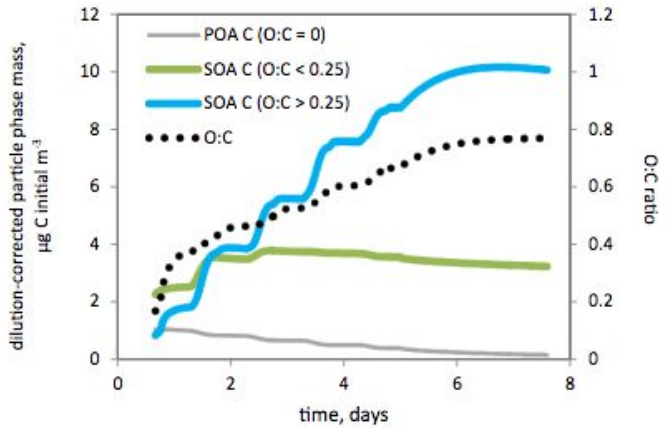
CESM Workshop June 2023

This material is based upon work supported by the National Center for Atmospheric Research, which is a major facility sponsored by the National Science Foundation under Cooperative Agreement No. 1852977.

Past and Current Atmospheric Chemistry Modeling Ecosystem

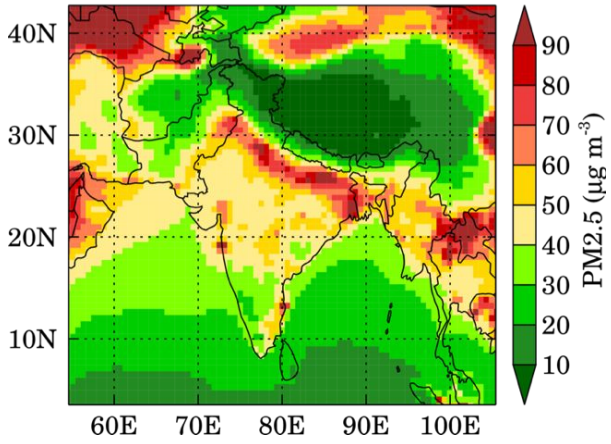
Understanding Air Quality and Chemistry in Detail

Process Models



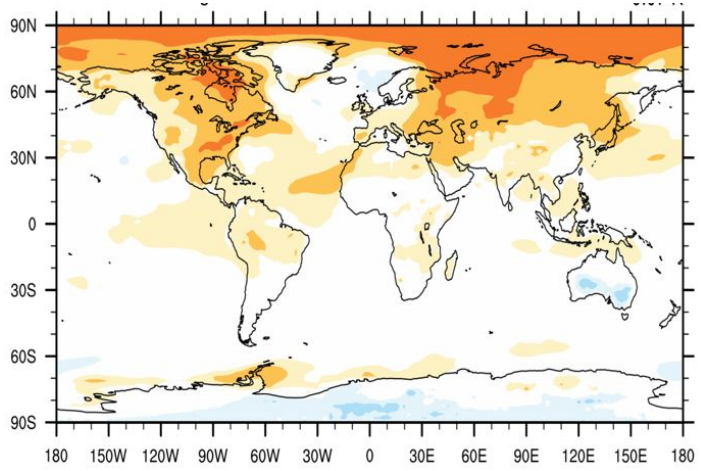
Examining Urban to Regional Scales

Regional Air Quality Models



Global Scale Impacts of Atmospheric Chemistry

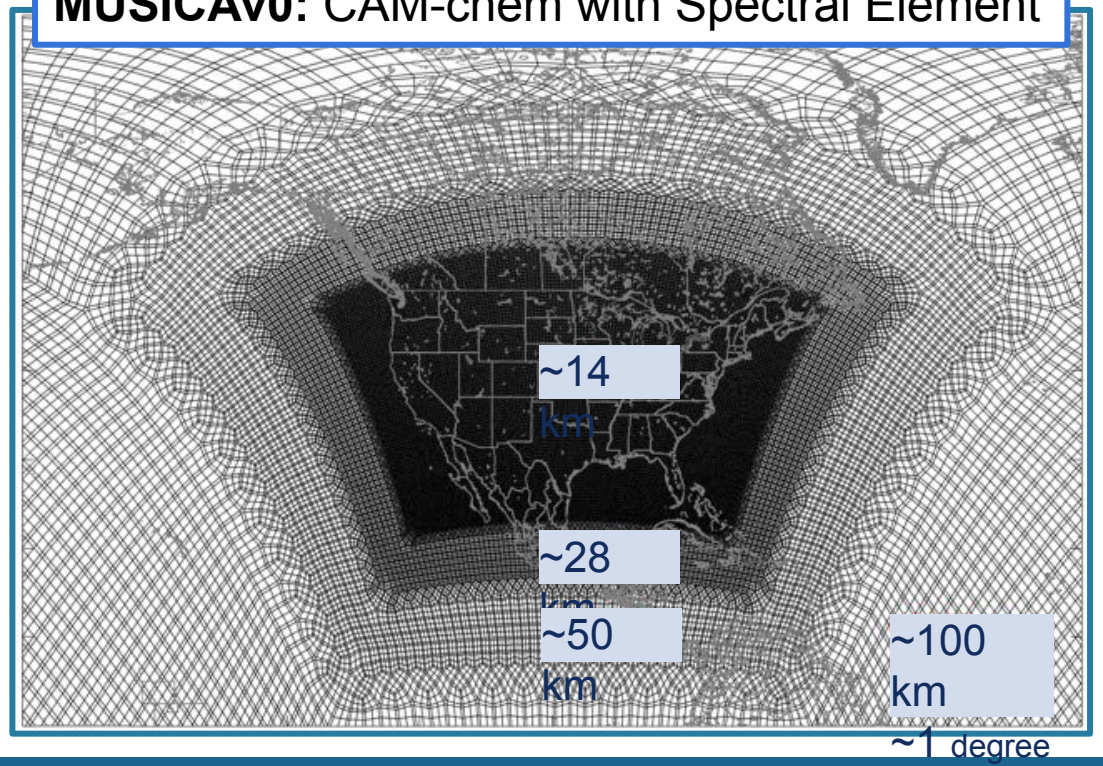
Climate & Earth System Models



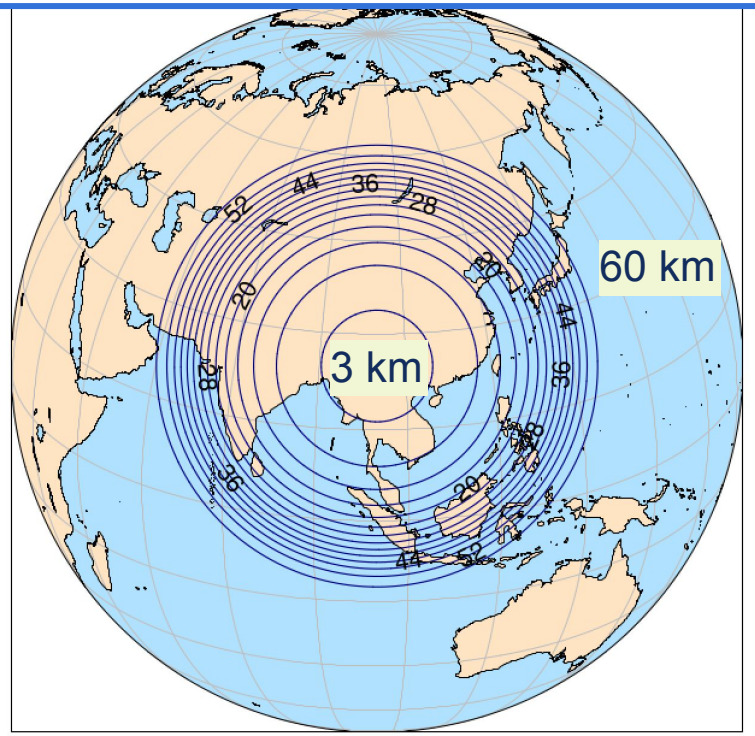
MUSICA: Multi-Scale Infrastructure for Chemistry and Aerosols

- Simulation of atmospheric composition in a global model with regional fine resolution
- Modular treatment of chemistry and aerosol processes

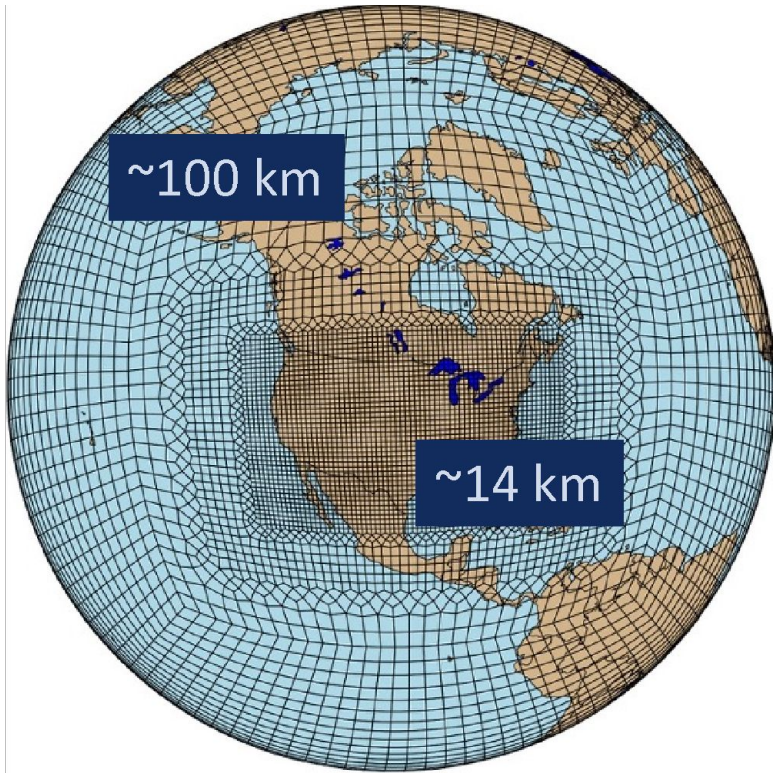
MUSICAv0: CAM-chem with Spectral Element



MUSICAv1: CAM-chem with MPAS



MUSICAv0 - released in CESM2.2



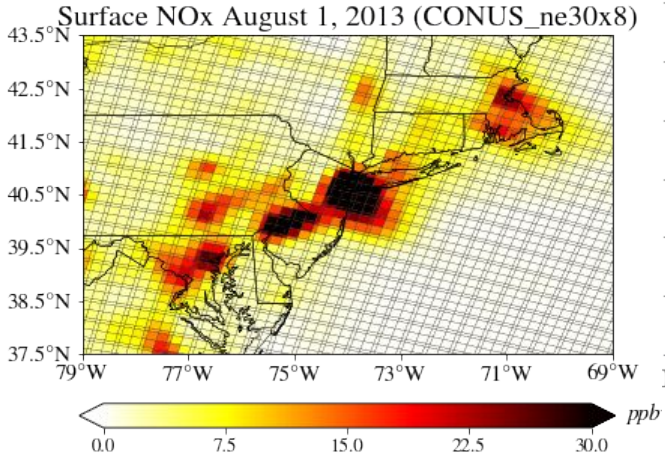
Various grids are available or users can create their own grids

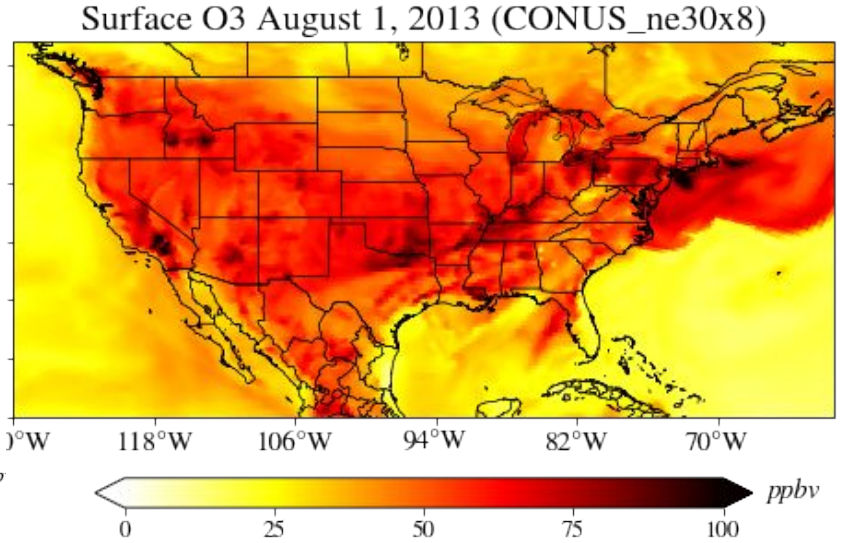
Configuration of Community Earth System Model (**CESM**)

CAM-chem (Community Atmosphere Model with Chemistry) With Spectral Element (SE) dynamical core and Regional Refinement (RR) - **CAM-chem-SE-RR**

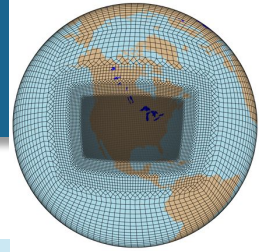
Community MUSICAv0 Simulation

Simulation results available on NCAR GDEX:
https://doi.org/10.5065/tgbj-yv18
Results available for 2012-2013





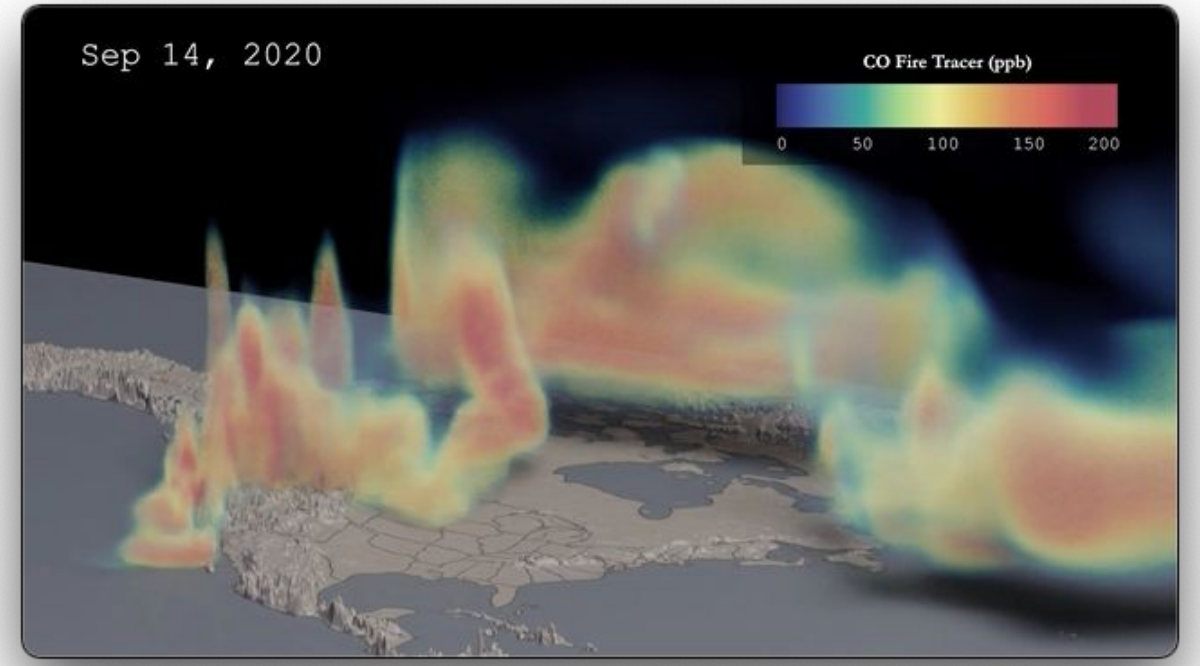
MUSICAv0 Analysis of Fire Plumes



MUSICAv0 (CONUS grid) horizontal resolution matches scale of observations of a fire plume

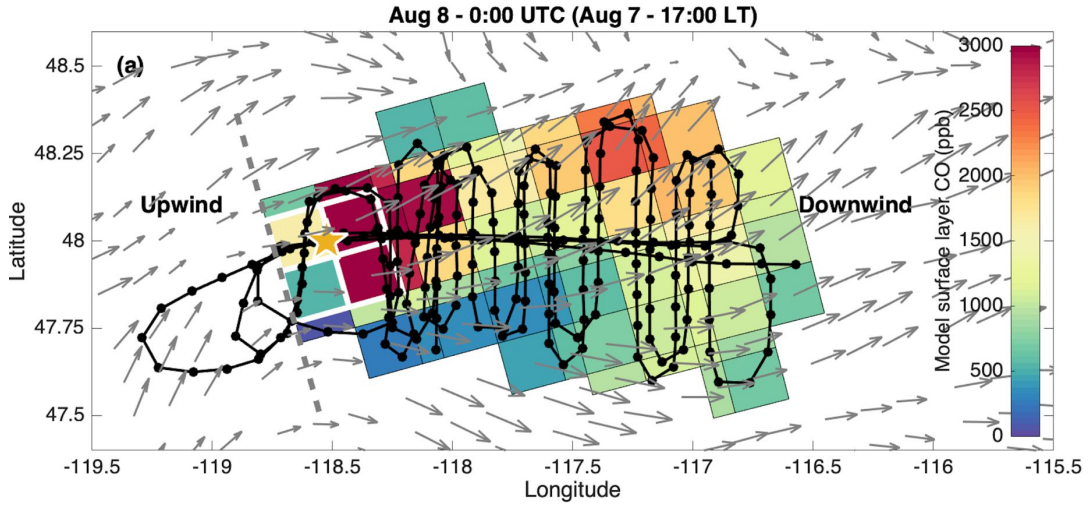
Improving representation of fire emissions

- Diurnal variation of emissions
- Vertical distribution of emissions



from visualization by Matt Rehme, NCAR/CISL

MUSICAv0 Surface CO with FIREX-AQ DC-8 flight

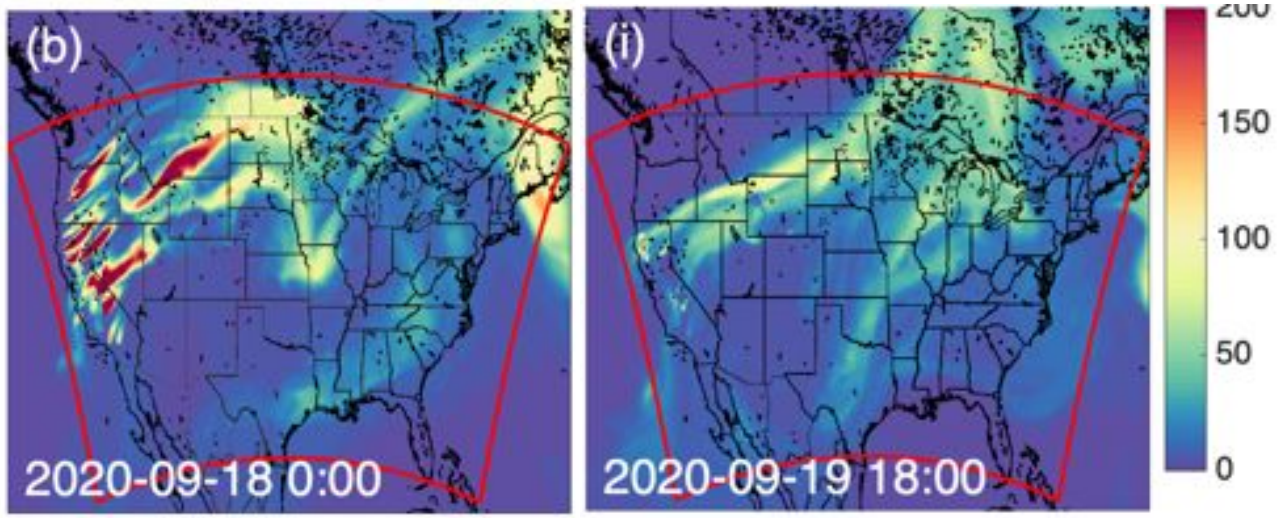


Proper representation of fire plumes on the scale of wildfires is needed for accurate simulation of long-range transport and downwind influence on air quality across the continent and hemisphere

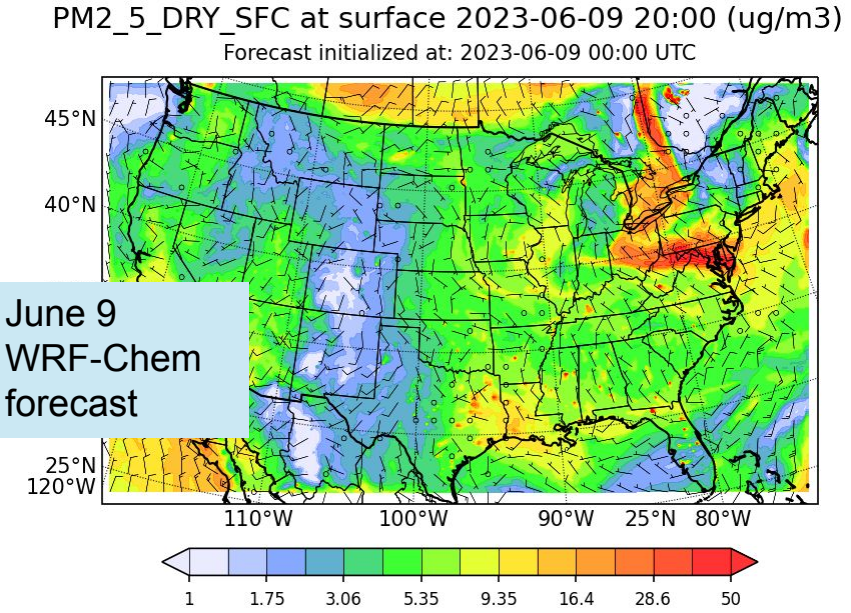
Wenfu Tang et al., JGR, 2022

Benefits of MUSICAv0 over regional models

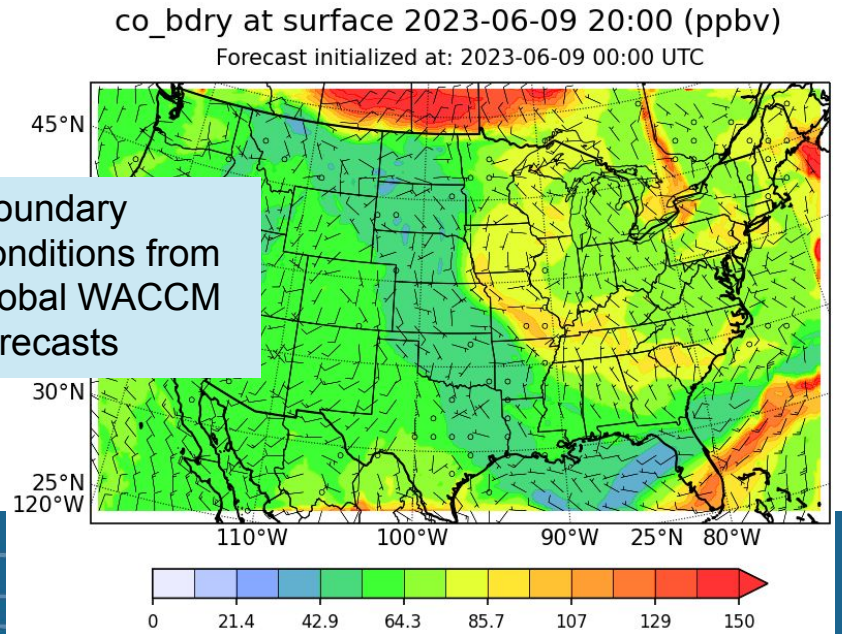
- No inconsistencies due to the use of lateral boundary conditions
- Includes influence of stratospheric ozone on troposphere
- Coupling to all earth system components (land, ocean, ice)



Fire plumes simulated in MUSICAv0 get transported outside of, and back into, the WRF-Chem domain



June 9 WRF-Chem forecast



Boundary conditions from global WACCM forecasts

Wenfu Tang et al., JGR-Atmos., 2023

Air Quality in Africa

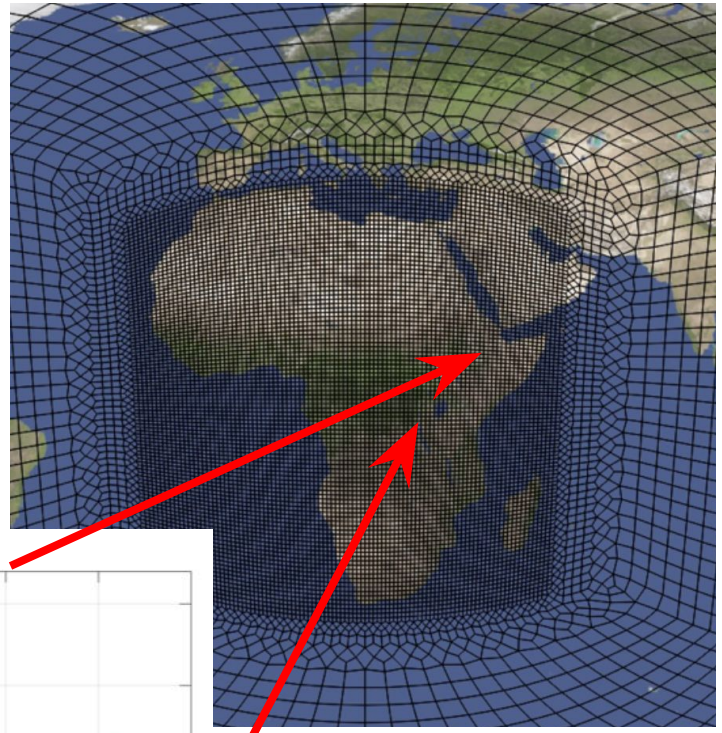
MUSICAv0 grid for Africa

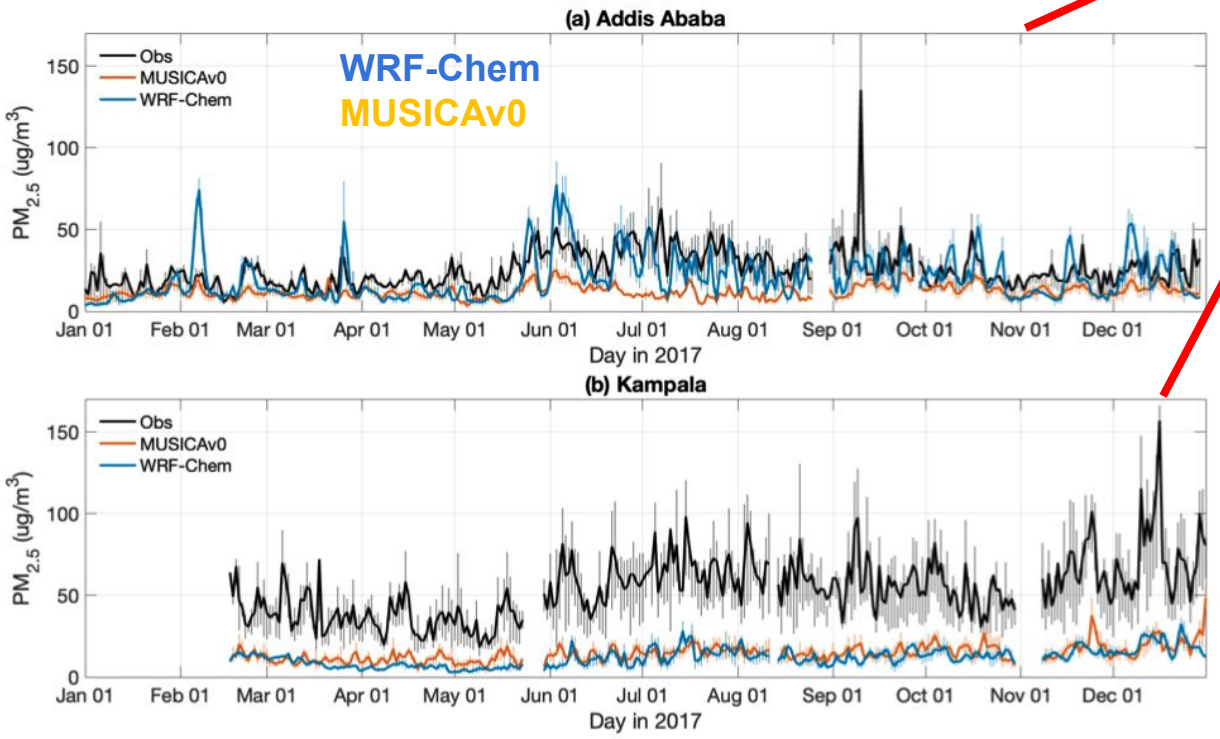
¼ degree (ne30x4) over continent

Comparison to WRF-Chem simulation for similar resolution

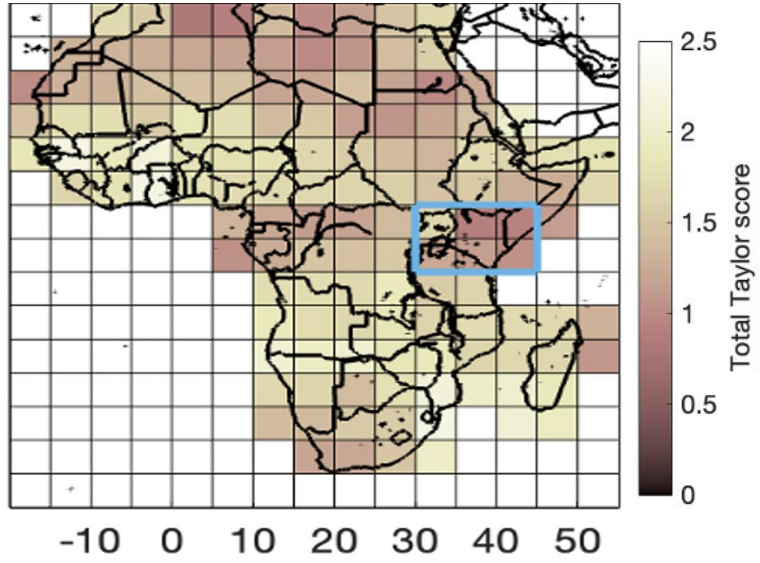
Generally similar to WRF-Chem

Some differences due to boundary conditions and long-range transport





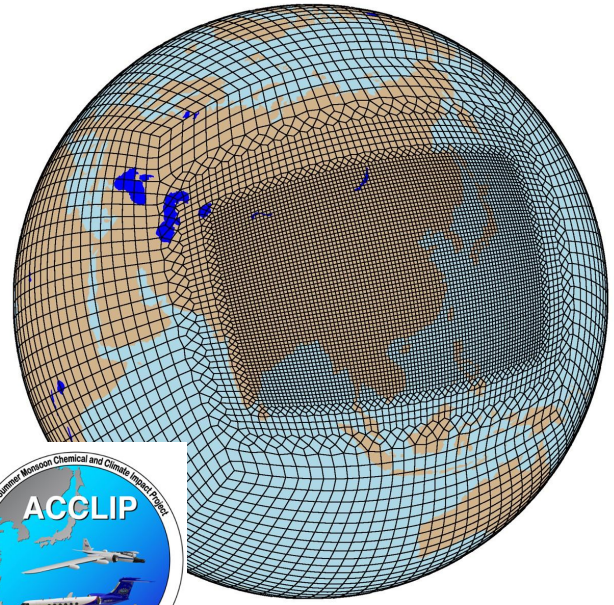
MUSICA-satellite discrepancies

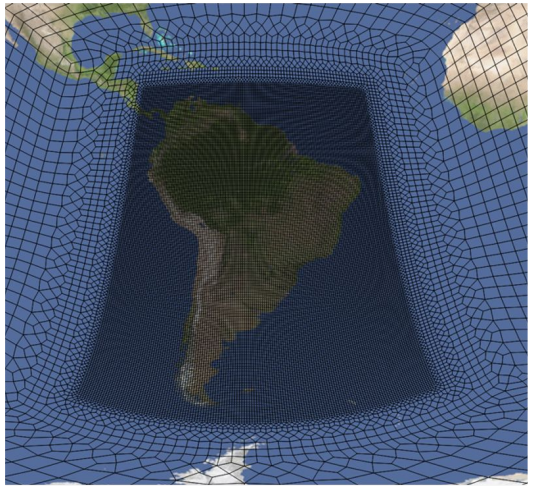


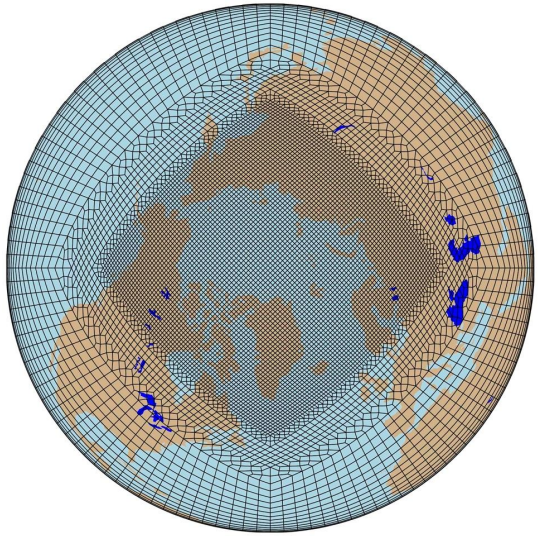
Evaluation with multiple satellite observations shows greatest differences in East Africa

Wenfu Tang et al., GMD, in review, https://doi.org/10.5194/gmd-2023-50

Refined Grids Available for Many Regions







Arctic grid available as standard resolution in CESM2.2

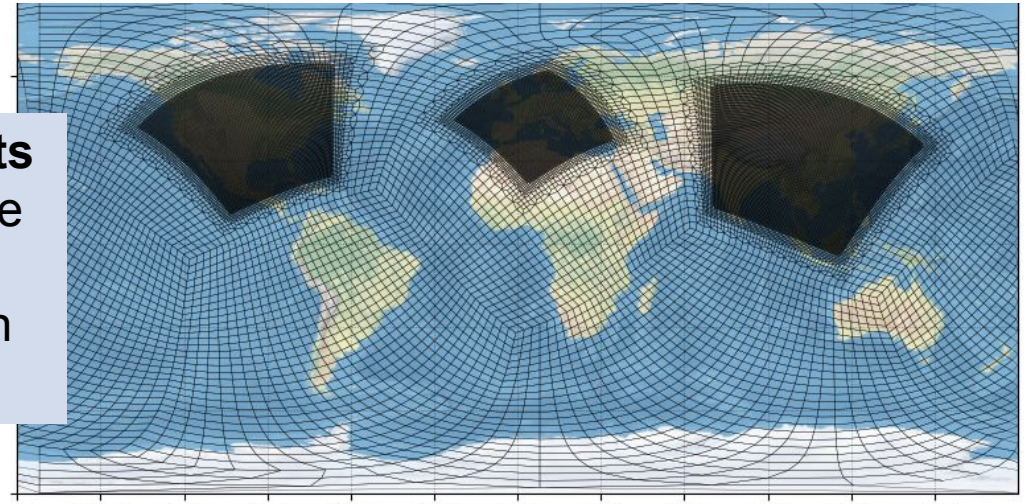
S. America grid being used in WRF comparisons and for air quality studies

~25 km grid over Asia to study Asian Summer Monsoon and convective outflow

ACCLIP aircraft experiment Aug 2022

1/8-degree over 3 continents

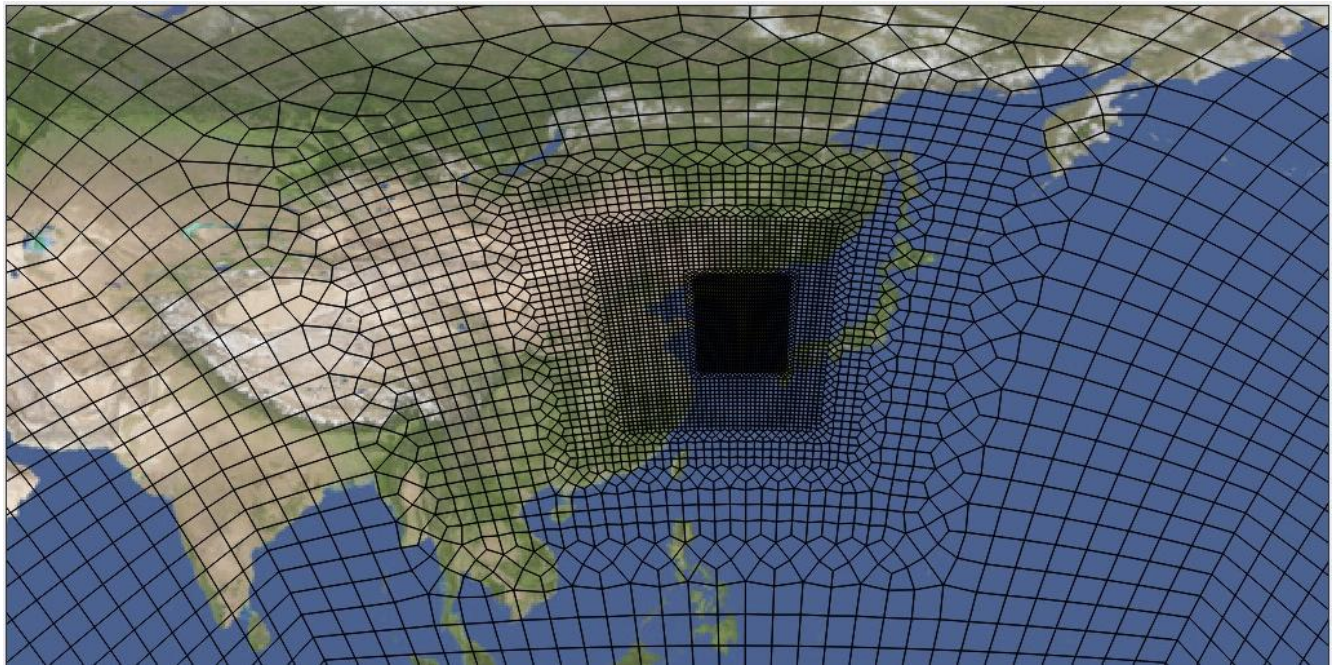
- mimic geostationary satellite constellation
- Study air quality in Northern Hemisphere



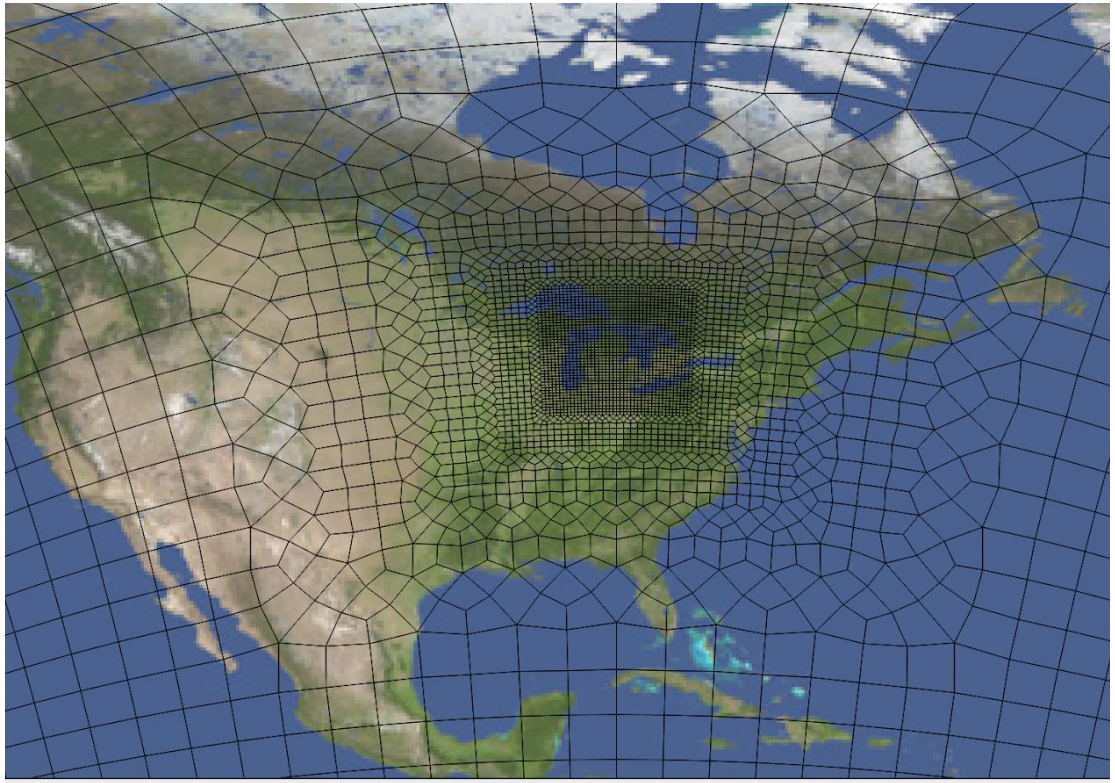
https://wiki.ucar.edu/display/MUSICA/Available+Grids

MUSICAv0 presentations on Wed in ChemCWG

Duseong Jo: S. Korea



Noribeth Mariscal: Michigan



Getting started with MUSICA

MUSICA Tutorial Series

Instructions on creating your own grid, plotting unstructured grid output, etc.

https://www2.acom.ucar.edu/event/workshop/musica-tutorial-2021

https://github.com/NCAR/musica-tutorial

MUSICA wiki page

https://wiki.ucar.edu/display/MUSICA/MUSICA+Home

Sign up for email list and newsletters:

https://www2.acom.ucar.edu/sections/multi-scale-infrastructure-chemistry-modeling-musica

emmons@ucar.edu