

Newsletter

Issue No. 13
June 2025

of the Multiscale Infrastructure for Chemistry and Aerosols - MUSICA

MUSICA is a computationally feasible global modeling framework currently in development that allows for the simulation of large-scale atmospheric phenomena, while still resolving chemistry at emission and exposure relevant scales (down to 4 km). MUSICA will replace and extend the current community chemistry modeling efforts at NSF NCAR (e.g., WACCM, CAM-Chem, WRF-Chem) paralleling other activities to streamline and unify model developments.

MUSICAv0 is an initial configuration based on the CESM Community Atmosphere Model with chemistry using the Spectral Element with Regional Refinement dynamical core.

MusicBox is a box model using a model independent chemistry module.

MELODIES is a modular framework to compare model results with observations.

MUSICA is part of SIMA (System for Integrated Modeling of the Atmosphere).

Summary of this issue

- ❖ MUSICA updates
- ❖ MUSICA science: Early career scientist spotlight
- ❖ Publications and presentations

MUSICA Library Release Version is available at
<https://github.com/NCAR/musica>

We want to hear what you are doing with MUSICA! Please send us contributions to the newsletter (please email gaubert@ucar.edu)

MUSICA Updates

❖ MusicBox Interactive

- ✓ Chemistry box model using prescribed atmospheric conditions. It currently runs gas-phase chemistry only.
- ✓ Current chemical mechanisms available are Chapman, simple wall loss example for flow tube reactors, CB05, and MOZART-TS1. See [MusicBox interactive](#)
- ✓ Used to test chemical schemes, for classroom teaching or summer schools, or research focused on chemical sources and sinks.
- ✓ Current work has been testing and evaluating the MOZART-TS1 scheme.

In progress:

- *Development of scripts to extract output from WACCM and WRF-Chem to produce MusicBox input files.*
- *Development of a tutorial and user's guide for MusicBox and the MUSICA Python package as part of a NCAR NSF/CISL summer internship program.*

❖ MPAS-A

- ✓ MPAS-A is a standalone atmosphere model used for numerical weather prediction. MPAS-A can be run as a global or regional model, used with the JEDI DA system, and offline meteorology. Its LES capability is in development.

In progress:

- *NSF NCAR MPAS-A with GOCART-2G aerosols development is nearly finished – initial simulations presented at the MPAS/WRF Users Workshop.*
- *Towards full chemistry in MPAS-A: The MPAS-A build now includes the MUSICA library. This is a first step to adding chemistry to MPAS-A.*

❖ MUSICA v0.12.0 Release Notes

- ✓ Released MUSICA python library with CUDA solver support on Linux
- ✓ Added the ability to export chemical mechanisms made in code
- ✓ Added README python example for the MUSICA library
- ✓ Some initial MusicBox tutorials are written and released, more are to come
- ✓ MusicBox supports running a box model using a chemical mechanism defined entirely in code at runtime
- ✓ MusicBox can use the CUDA GPU solver on Linux
- ✓ Various minor updates in MICM which allowed for a more flexible API with Fortran and Python

MUSICA Updates

❖ NOAA UFS/CATchem

- ✓ CATChem is a chemistry driver and chemistry & aerosol components planned to connect to the NOAA UFS. It will provide a consistent modeling system for air quality forecasting and research. About CATChem
- ✓ *Recent achievement: The UFS-chem build now includes the MUSICA library. This is a first step to adding chemistry to UFS.*

❖ MUSICA in CESM – MUSICAv0

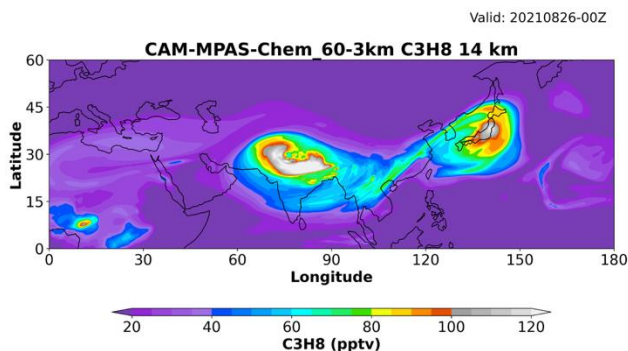
- ✓ MUSICAv0 is a current configuration of CESM/CAM-chem with the spectral element dynamical core that allows global-to-regional variable resolution simulations.
- ✓ Used to study regional air quality, wildfire impacts, and the Asian monsoon system. See the recent publications and presentations.
- ✓ MUSICA Tools: <https://github.com/NCAR/MUSICA-Tools>
- ✓ Code datasets: <https://wiki.ucar.edu/spaces/camchem/pages/646317602/Code+locations>

In progress:

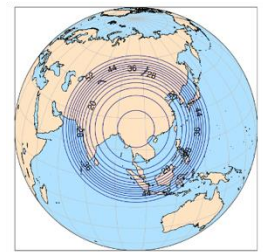
- *Completing TUV-x photolysis scheme; Testing HEMCO; Evaluating T4S chemistry.*

❖ Development of CAM-SIMA as part of the SIMA Project

- ✓ CAM-SIMA will replace CAM as the atmosphere component of CESM, using the spectral element and/or MPAS grid mesh – both with regional refinement capabilities.
- ✓ Its use of CCPP allows interoperability among schemes and easier maintenance of code. About CAM-SIMA.
- ✓ *Recent achievement: The MUSICA Library with its MICM and TUV-x modules have successfully been connected to CAM-SIMA.*



Propane mixing ratios at 14 km altitude simulated with CAM-chem using the MPAS dynamical core. The simulation employs a regionally refined mesh with 60–3 km resolution (right).



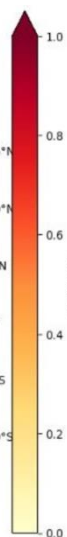
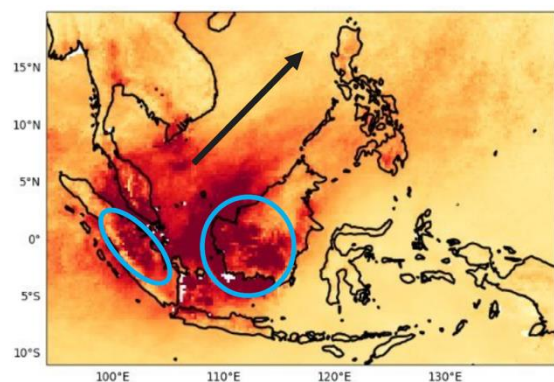
Air Quality Impacts of Biomass Burning Transport Using MUSICA_{v0}

Contributed by **Shane Marie Visaga** (visaga@wisc.edu), University of Wisconsin-Madison

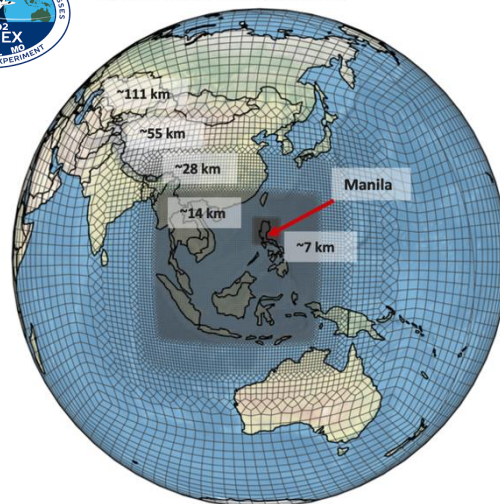


Hi! I am Shane Visaga, a 3rd year PhD Atmospheric and Oceanic Sciences in UW-Madison. I study air quality impacts of fires over the Maritime Continent (MC). I am mainly interested in this region because I am from the Philippines, and we are impacted by the smoke transport from the MC fires. I participated in the NASA CAMP²Ex field campaign, based off the Philippines in 2019. It sampled the smoke transport through aircraft measurements together with significant geostationary satellite AOD retrieval support.

Measurement Aug 24- Oct 5, 2019
AHI Dark Target Aerosol Optical Depth (every 10-min.)
Mean = 0.39



MUSICA_{v0} Regional Refinement Domain developed during NSF NCAR visit last July 2024



The figure on the left shows the burning period average Aerosol Optical Depth (AOD) from 10-minute satellite retrievals, revealing the hotspot burning regions (encircled in blue) and how the smoke is transported to the ocean and further downwind to the Philippines. We use these satellite measurements to understand how well atmospheric chemistry models can capture burning events. I use NSF NCAR MUSICA_{v0} that can resolve from global to local scales. The figure on the right shows the refinement domain I developed during my visit to ACOM last summer as part of the Cicerone Fellowship. The highest resolution is ~7 km × 7 km over Luzon Island, Philippines including the megacity Manila, followed by ~14 × 14 km resolution to cover the MC fire regions. Initial comparisons of the MUSICA_{v0} control run using the simple Secondary Organic Aerosol (SOA) Scheme (Jo et al., 2023) with CAMP²Ex reveal exceptional performance in capturing OA lamina at ~0.25 km and ~1.3 km for the dense smoke sampling flight on 16 Sep 2019. Future work will focus on further improving the MC peat fire emissions and continue working with ACOM this summer as a Cicerone fellow.

Workshop Presentations and Publications

Publications

1. Mariscal, N., et al.: **Evaluation of Ozone and its Precursors using the Multi-Scale Infrastructure for Chemistry and Aerosols Version 0 (MUSICAv0) during the Michigan-Ontario Ozone Source Experiment (MOOSE)**, EGU sphere, <https://doi.org/10.5194/egusphere-2025-228>, 2025.
2. Tang, W., et al.: **Disproportionately Large Impacts of Wildland-Urban Interface Fire Emissions on Global Air Quality and Human Health**, Science Advances, <https://doi.org/10.1126/sciadv.adr2616>, 2025.
3. Lorenzo, G. R., et al.: **Measurement report: Characterization of aerosol hygroscopicity over Southeast Asia during the NASA CAMP2Ex campaign**, Atmos. Chem. Phys., 25, 5469–5495, <https://doi.org/10.5194/acp-25-5469-2025>, 2025.

Presentations

- ✓ Louisa Emmons, **Analysis of ASIA-AQ observations with MUSICAv0**. 30th Annual CESM Workshop. Boulder, CO, June 2025.
- ✓ Saeideh Mohammadi, **Modeling Investigation of Volatile Methyl Siloxane Oxidation, Secondary Organic Aerosol Formation, and Aging Using CESM-MUSICA**. 30th Annual CESM Workshop. Boulder, CO, June 2025.
- ✓ Samantha Lee, **Model-measurement comparisons during Australian extreme bushfires: MUSICA and AQFx**. 30th Annual CESM Workshop. Boulder, CO, June 2025.
- ✓ Shawn Honomichl, **The CESM Chemical Forecast System: A Summary of Capabilities and What's Next**. 30th Annual CESM Workshop. Boulder, CO, June 2025.
- ✓ Pablo Lichtig, **MELODIES MONET: A User-Friendly, Open-Source Python Tool for Model Evaluation**. MPAS-WRF workshop, Boulder CO, June 2025 (slides).
- ✓ Laura Fowler, **Implementation of the GOCART-2G aerosol model in MPAS-Atmosphere**, MPAS-WRF workshop, Boulder CO, June 2025.
- ✓ Ren Smith, **Application of Asian monsoon UTLS observations toward improved chemistry model representation**, 6th ACAM Workshop in Bali, Indonesia, June 2025
- ✓ Amin Mirrezaei et al.: **Can Global Chemistry-Climate Models Capture Salient Features of an Urban Atmosphere?** 105th Annual AMS Meeting, New Orleans, 2025
- ✓ Wenfu Tang et al.: **Global Expansion of Wildland-Urban Interface (WUI) and WUI Fires and the Impact of WUI Fires on Global Air Quality**. 105th Annual AMS Meeting, New Orleans, 2025
- ✓ Madankui Tao et al., **Springtime High Ozone Events in the Northeast United States: Placing 2024 in a Climatological Context**. 105th Annual AMS Meeting, New Orleans, 2025
- ✓ Shane Visaga et al., **Air Quality Impacts of Biomass Burning Transport During the 2019 CAMP2Ex Using MUSICAv0 with Regional Refinement over Southeast Asia**. 105th Annual AMS Meeting, New Orleans, 2025