MUSICA*ctivities*

Newsletter

Issue No. 12
January 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

❖ MUSICA v0.9.0 Release Notes

- ✓ NetCDF Output added to MusicBox
- ✓ Basic plotting is now available using command-line MusicBox
- ✓ The LU decomposition scheme used in CAM-Chem has been added to MICM
- ✓ The Backward Euler solver in MICM is usable in via the MUSICA-Python Interface

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.

❖ MUSICA in CESM

- ✓ 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 global-to-regional air quality, wildfire impacts, and the Asian monsoon system. See the recent publications and presentations.
- ✓ No new major developments.

❖ 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 developments include successfully porting some simple physics configurations into CAM-SIMA. A comparison between CAM and CAM-SIMA of the moist Held-Suarez configuration is shown here.

❖ MUSICA in other atmosphere host models

Both **NSF NCAR MPAS-A with GOCART-2G** aerosols and **NOAA UFS/CATchem** are continuing to be developed.

- ✓ 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.
- ✓ 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

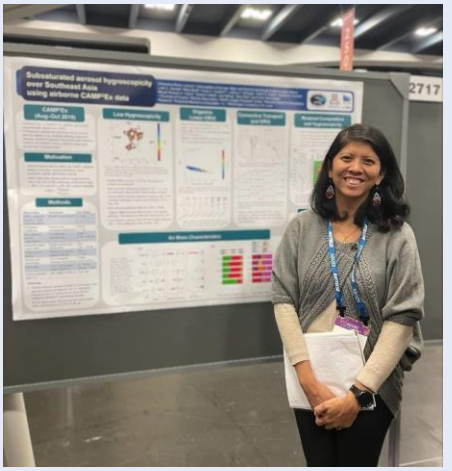
MUSICA Science

Characterization of Aerosol Hygroscopicity during the NASA CAMP²Ex Campaign

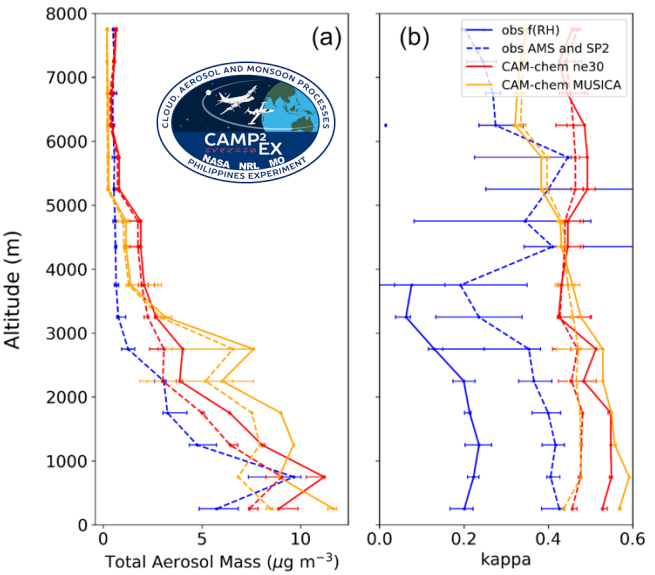
Contributed by **Genie Lorenzo** *(ghl34@miami.edu)*
University of Miami, Florida, USA

Genie Lorenzo

Genie received her PhD from the University of Arizona where she analyzed aerosol particle data from ground sensors, aircraft, and satellites in Southeast Asia and the Northwest Atlantic Ocean with Armin Sorooshian's group. Through the ACOM Cicerone Fellowship and under the mentorship of Mary Barth, Genie evaluated MUSICAv0/CAM-chem simulations for case studies in Southeast Asia. She is currently a postdoctoral associate with Paquita Zuidema's group in the University of Miami. Genie is from the Philippines where she worked with Manila Observatory on air quality and extreme weather research.



Project: We focused on aerosol hygroscopicity in the polluted marine region of Southeast Asia during the NASA CAMP²Ex field campaign for this study. Southeast Asia has abundant cloud cover, diverse emissions, and complex atmospheric conditions that are challenging for remote sensing and understanding of regional climate. We showed that organics, from the smoldering of peat in the Maritime Continent, decreases aerosol hygroscopicity in the region during the summer southwest monsoon such that aerosols there are less hygroscopic than in typical polluted marine environments.



Convective transport changed cloud level hygroscopicity, demonstrating surface aerosol impacts on clouds in the region. Evaluations of two MUSICAv0 CAM-chem simulations with two output grids (ne30 at ~111 km and ne30x4 at ~25 km) for convective case studies during CAMP²Ex show the underrepresentation of organics and the need to better represent shallow convection. Our study highlights the need to improve the vertical characterization and modeling of aerosol particles and clouds in Southeast Asia and other polluted marine regions.

Workshop Presentations and Publications

Publications

Yue, M., et al.: **Weakened aerosol-PBL interactions enhance future air quality benefits under carbon neutrality in China: Insights from the advanced variable-resolution global model.** JGR, https://doi.org/10.1029/2024JD041106, 2024.

Lorenzo, G. R., et al.: **Measurement report: Characterization of Aerosol Hygroscopicity over Southeast Asia during the NASA CAMP2Ex Campaign**, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-2604, 2024.

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)**, submitted to GMD, 2025.

Presentations

Noribeth Mariscal et al., **Quantifying the Contribution of Emissions and Transport to Ozone Production and Loss Processes: A Case Study of Southeast Michigan, United States**, AGU 2024, Washington DC.

Saeideh Mohammadi et al**., Global Multiscale Modeling of Decamethylcyclopentasiloxane (D5) Oxidation in MUSICAv0 Model, Including Secondary Organic Aerosol Formation**, AGU 2024, Washington DC.

Ren Smith, **Impact of East Asian SO2 emission trends on the Modeled Characteristics of the Asian Tropopause Aerosol Layer**, AGU 2024, Washington DC.

Madankui Tao**, Springtime High Ozone Events in the Northeast United States: Placing 2024 in a Climatological Context**, AGU 2024, Washington DC.

Wenfu Tang, **Global Expansion of Wildland-Urban Interface (WUI) and WUI fires and the impact of WUI fires on global air quality**, AGU 2024, Washington DC.

Viswanath Velamuri, et al., **Evaluating the Performance of MUSICAv0 and WRF-Chem in Simulating Air Quality over Delhi, India**, AGU 2024, Washington DC.