MUSICActivities

Newsletter

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

Mark your calendar:

- CESM workshop (June 15-17)
- MPAS/WRF workshop (June 23-26)
- **iCACGP-IGAC 2026 Joint Conference**
  7–11 September 2026
  Cultural & Conference Center of Heraklion, Crete, Greece
  https://icacgp-igac2026.org/

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

MUSICA updates

❖ MUSICA Organization News

- Welcome to Zhonghua Zheng (University of Manchester) who is joining the Evaluation and Data Assimilation Working Group Chairs.
- MUSICA Current and Future Activities: As the MUSICA Project now has more mature products (e.g., MusicBox, MUSICAv0, the MUSICA library working with CAM-SIMA and MPAS-A) and some new capabilities that will soon be available (MUSICAv1, MPAS-GOCART2G, and CheMPAS-A as a minimum viable product), the NSF NCAR/ACOM modeling team is currently discussing priorities for the MUSICA Project over the next 5 years. This discussion will open up to the external community over the next few months.

❖ MUSICA-Related Projects with Summer Internships in Parallel Computational Science (SIParCS)

- Simulating atmospheric chemistry with MUSICA in Julia
  - ✓ Create and test a Julia wrapper for the MUSICA library
- AI Weather and Atmospheric Chemistry Prediction with Physical Constraints
  - ✓ Contribute to building an emulator for TUV-x
- Generalized framework for the evaluation and comparison of atmospheric chemistry models with observations
  - ✓ Extend the MELODIES MONET regridding tools so that any grid can be ingested without prior processing by refactoring code to use the UXarray Python library

❖ Tutorials

- *MusicBox tutorial:* Instructions on how to install and run MusicBox from the command line. Go to https://github.com/NCAR/music-box and launch the binder.

- *MUSICA Library tutorial:* MUSICA Python package tutorial is available at its github page using the launch binder option. https://github.com/NCAR/musica. View the recording of using the MUSICA tutorial.
- *MUSICAv0 tutorial:* See the web page for the 2024 tutorial held in Nanjing.

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.
- *Beginning testing phase of scripts that can extract output from WACCM and WRF-Chem to produce MusicBox input files.*
- *Currently testing MusicBox-CARMA, which is available in the python package.*

❖ MUSICA Library

- Documentation of how to install and use MICM can be found at the MICM github page.
- *MICM is now able to solve gas, cloud, and aerosol chemistry together. This configuration is currently being tested.*

❖ 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.
- *The NSF NCAR MPAS-A with GOCART-2G aerosols development testing continues. It is on schedule to be released to the community in late spring or early summer 2026.*
- *The MPAS-A model has been connected to MICM in the MUSICA library.*
- *Successfully tested MICM and TUV-x with two simple chemical mechanisms: The NO-NO2-O3 triad, and the basic Chapman mechanism.*
- *Designing a Model Independent Emissions Module (MIEM) for the MUSICA library.*

❖ MELODIES MONET

MELODIES MONET is a modular evaluation framework written in Python that compares existing and future diverse atmospheric chemistry observational datasets with chemistry model results for the evaluation of air quality and atmospheric composition.
MELODIES MONET Version 1.1 will be released in late spring 2026.

MUSICA updates

❖ 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

❖ 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

❖ 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

❖ Publications and Presentations

- Tao, M., Fiore, A. M., Emmons, L. K., Scott, J. R., Pfister, G. G., Jo, D. S., and Tang, W. (2026). **Contrasting air pollution responses to hourly varying anthropogenic NO emissions in the contiguous United States.** Atmos. Chem. Phys., 26(10), 6683–6702. https://doi.org/10.5194/acp-26-6683-2026

- *Zhou, Yichao and Xuewei, Hou and Yue, Man and Zhan, Chenchao,* ***Impact of stratospheric ozone intrusion on near-surface ozone in eastern China under Typhoon Lekima: a high-resolution CESM-MUSICA simulation analysis****.* *http://dx.doi.org/10.2139/ssrn.6049737*

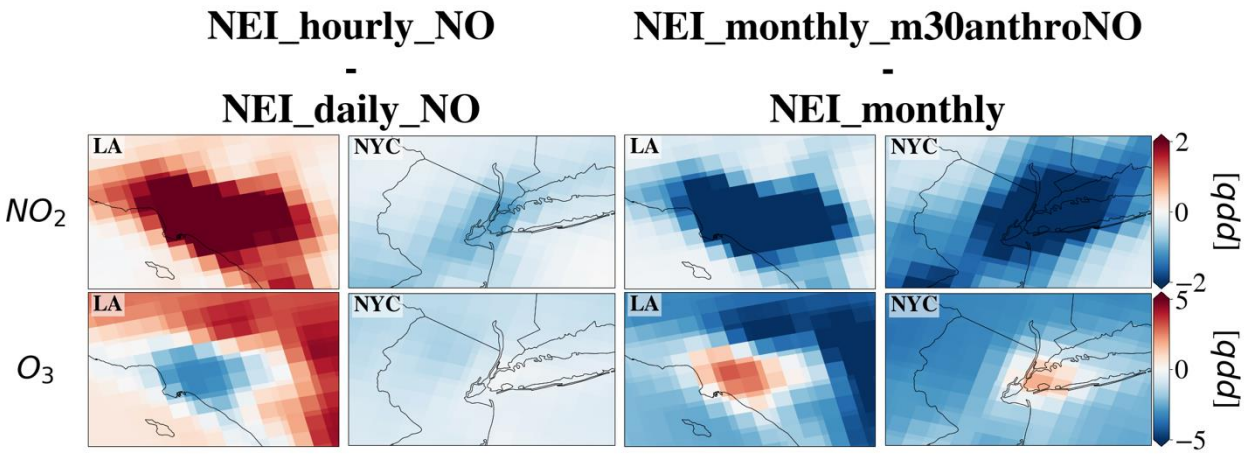
❖ ***Presentations:*** *Barth, NSF NCAR's Transition from WRF-Chem to MPAS-A with Chemistry and Aerosols, European WRF-Chem Workshop 2026, Rijeka, Croatia, May 12-14, 2026*

MUSICA Science

Air Pollution Responses to Hourly Varying Anthropogenic NOx Emissions in the Contiguous United States

Contributed by Madankui Tao (taoma528@mit.edu), Center for Astrophysics | Harvard & Smithsonian. This work was completed while she was a Postdoctoral Associate at MIT.

Using MUSICAv0 with ~14 km regional refinement over the contiguous United States (CONUS), this study shows that representing anthropogenic nitric oxide (NO) emissions at hourly rather than monthly temporal resolution leads to substantial changes in simulated air pollutant concentrations. Even when monthly total emissions are unchanged, resolving hourly variability changes monthly mean surface concentrations of nitrogen dioxide (NO_2), ozone (O_3), and tropospheric NO_2 vertical column densities, with grid-cell differences ranging from -49% to +86% for surface NO_2 and from -22% to +11% for O_3. These changes are comparable in magnitude to those from an idealized 30% reduction in anthropogenic NO emissions, but their spatial patterns differ markedly across the CONUS, with clear contrasts between the western and eastern United States and between urban and rural areas. During daytime (9 a.m. - 5 p.m. local time), surface NO_2 increases by up to ~6 ppb in parts of the west coast but decreases by up to ~1 ppb in eastern urban areas such as New York City, while surface O_3 changes range from -7 to 5 ppb (see Figure). Using a simplified scaling approach, we further show that neglecting hourly emission timing can bias nitrogen oxides (NO_x) emission estimates inferred from satellite tropospheric NO_2 columns, with local pixel-level differences exceeding 50%.



The figure shows July monthly mean surface NO_2 and O_3 concentration differences over Los Angeles (LA) and New York City (NYC) produced by switching anthropogenic NO emissions from daily to hourly temporal resolution (left) as compared to a uniform 30% reduction in monthly mean anthropogenic NO emissions (right).