

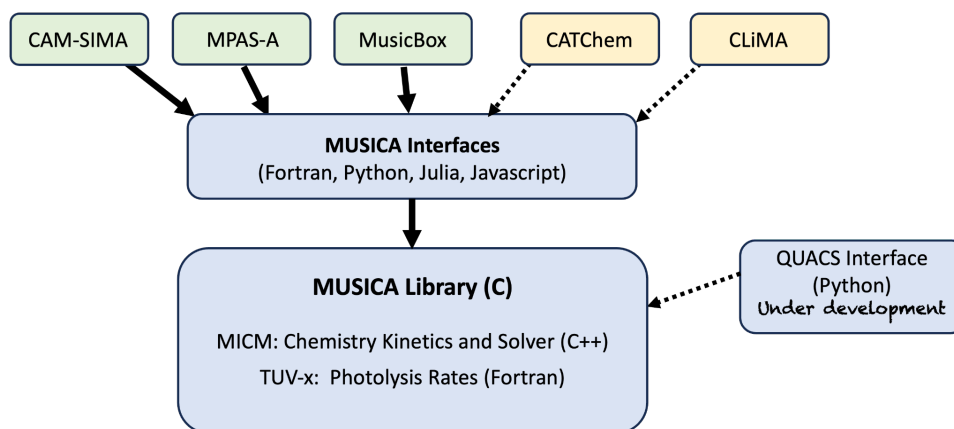
Newsletter

Issue No. 17
Oct 2026

of the Multiscale Infrastructure for Chemistry and Aerosols - MUSICA

The Multiscale Infrastructure for Chemistry and Aerosols (MUSICA) Project's goal is to create infrastructure for representing chemistry in any atmosphere model (i.e., model independent chemistry representation), including global models with variable grid resolutions. The MUSICA system includes a software library and APIs in different languages to accommodate atmosphere models written in different software languages. [MUSICAv0](#) and [MUSICAv1](#) are configurations of the CESM Community Atmosphere Model with chemistry that provide variable resolution grid meshes and allow evaluation of atmospheric chemistry across spatial scales.

[MELODIES-MONET](#) is a modular framework to compare model results with observations. The [MUSICA Library](#) contains refactored code that can interface with any atmosphere model as seen in the schematic. The MUSICA Library release version is available at <https://github.com/NCAR/musica>.



In this issue

- ❖ MUSICA software updates
- ❖ Meeting summaries: QUACS, MUSICA AI
- ❖ 3 student interns advance the software
- ❖ 2 new publications, 18 presentations

MUSICA news

❖ MUSICA Project Organization News

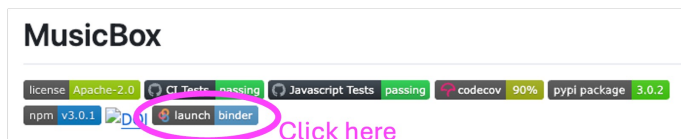
The NSF NCAR/ACOM modeling team has been discussing priorities for the MUSICA Project over the next 5 years. The discussion revolved around moving to science-themed working groups and creating a governance structure compatible with the atmosphere host models (e.g., CESM and MPAS-A). After more feedback from NCAR-internal leaders and collaborators, the discussion will open up to the external community with the expectation that a new structure is in place by the end of the calendar year.

❖ QUACS Community meeting summary

ACOM held a Community Workshop on June 22 as part of the NSF CSSI Project QUACS. Participants included the project team, collaborators and selected invitees from the wider community. The objective of the meeting was to collect and analyze community feedback for refining the requirements for the python QUACS scripting capability and the set of target parameterizations to be used for the design phase. Overall collaborations on the MUSICA infrastructure development and CheMPAS-A were also discussed. The Python-scripting approach resonated broadly, with over half of the participants interested in contributing an existing scheme to the project. One of the priorities for QUACS going forward that resulted from the meeting was the need for a steel-thread demonstration of QUACS's scripting capability within CheMPAS-A to demonstrate how the system will work.

❖ 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 news & software updates

❖ MUSICA AI

In April 2026, NSF NCAR hosted a community workshop, "Advancing Earth System Science with and for the Community," to gather input from the broader research, academic, and commercial communities on needs and priorities for artificial intelligence and machine learning in Earth system science. The workshop consisted of 12 virtual sessions dedicated to each of the six cornerstone priorities of the NSF NCAR AI Initiative: Earth System Science with AI, AI-Enabled Modeling & Tools, AI-Ready Data and Cyberinfrastructure, Benchmarking and Evaluation, Responsible and Reliable AI Practices, and Community and Workforce Development. Each session included an overview presentation followed by breakout discussions designed to solicit community input on gaps, opportunities, and potential roles for NSF NCAR in supporting AI-enabled Earth system science. A total of 392 external participants from universities, federal agencies, national laboratories, industry, and international organizations attended the meeting. Alma Roux led the discussions on Our Science with AI; the slides from that session are available [here](#). Key themes and recommendations from the workshop are summarized in a Meeting Summary published in the *Bulletin of the American Meteorological Society* (Richter et al., 2026, BAMS, DOI: [10.1175/BAMS-D-26-0202.1](https://doi.org/10.1175/BAMS-D-26-0202.1)).

✓ 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.
- *MusicBox Interactive is now more stable and has new features: faster results, units can be configured in SI or molecules cm⁻³, more flexibility on what conditions to select and edit, all plots can be downloaded directly, and ability to install as a standalone application.*

✓ MUSICA Library

- MICM documentation can be found at the [MICM github page](#).
- MUSICA v0.17.0 was released in early October 2026.
- MICM is now able to solve gas, cloud, and aerosol chemistry together. This configuration is currently being tested.
- A new emissions module, MIEM, is being piloted and tested through MUSICA and is available in this release.

MUSICA news

✓ 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 and DART DA systems, and offline meteorology. Its LES capability is in development.
- *[The NSF NCAR MPAS-A with GOCART-2G aerosols development release to the community in early November 2026.](#)*
- *[The MPAS-A model has been connected to the MUSICA library allowing for gas-phase chemistry and reading emissions files via the Model Independent Emissions Module.](#)*
- *[Validation of this configuration is underway.](#)*

✓ 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 fall 2026.](#)* This will coincide with companion submissions for two manuscripts describing observational comparisons for (1) satellites, and (2) surface and aircraft measurements.

✓ 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](#)
- *[Exploring ways to leverage model development between CATChem and the MUSICA library. An outcome of an initial meeting discussing dry deposition is to test whether the MUSICA library and the GOCART dry deposition that is in CATChem can be connected.](#)*

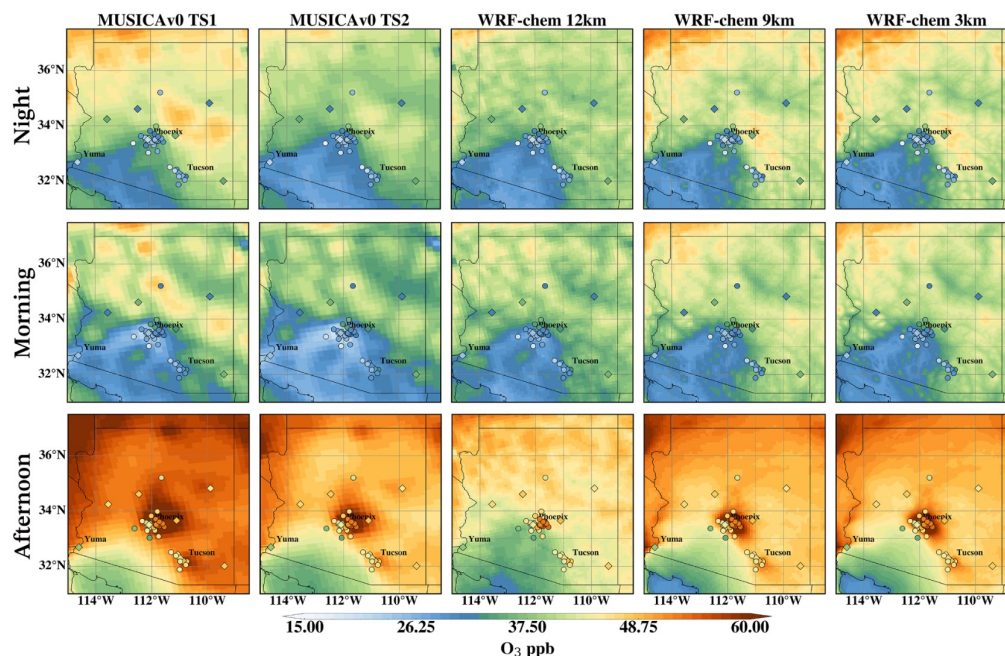
MUSICA news

✓ MUSICA in CESM – MUSICA_{v0}

- MUSICA_{v0} 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>

MUSICA_{v0} Publications

1. Mirrezaei, A. M., Tang, W., Gaubert, B., Guo, Y., Emmons, L. K., Sorooshian, A., and Arellano, A. F. Jr., (2026). **Multiscale Modeling of Ozone Formation and Chemical Regimes in Arizona during the North American Monsoon.** *ACS ES&T Air*. <https://doi.org/10.1021/acsestair.6c00170>
2. Visaga, S. M. A., Pierce, R. B., Holz, R., Tang, W., Emmons, L., Pfister, G., et al. (2026), **Impacts of maritime continent forest and peat fires on regional air quality during 2019 CAMP2Ex using MUSICA_{v0},** *Journal of Geophysical Research: Atmospheres*. <https://doi.org/10.1029/2025JD046143>



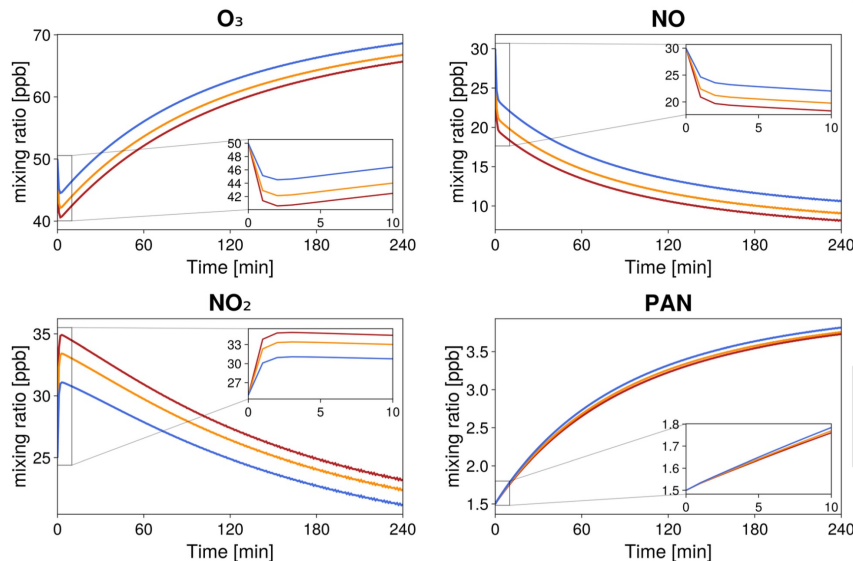
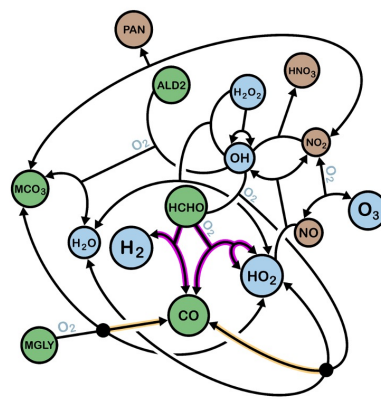
Monthly mean O₃ concentrations (ppb) during night (21:00–04:00 LT), morning (05:00–11:00 LT), and afternoon (12:00–19:00 LT) from MUSICA_{v0} (TS1, TS2) and WRF-Chem simulations over Arizona. Figure from Mirrezaei et al., (2026).

❖ Obin Sturm (SIParCS)

Obin Sturm is a PhD candidate from the University of Southern California. He joined NCAR as a SIParCS intern this summer and successfully integrated the musica-julia bindings into the [CliMA model](#), a Julia-based climate model.



His efforts were the first to introduce atmospheric chemistry capabilities into CliMA. He verified analytical systems both in a column and 3D aquaplanet configuration of CliMA, as well as a more complex photochemical mechanism simulating a heavily polluted planet. His success shows the model-independence of the MUSICA library. He uses the Julia photochemical mechanism (JPM) to represent a real process: photochemical ozone formation, also known as smog, which degrades air quality. Though simplified, JPM contains the essential aspects of daylight ozone formation, including cycling of nitric oxides NO and NO₂ with O₃ as well as highly reactive radical species formed from volatile organic precursors.



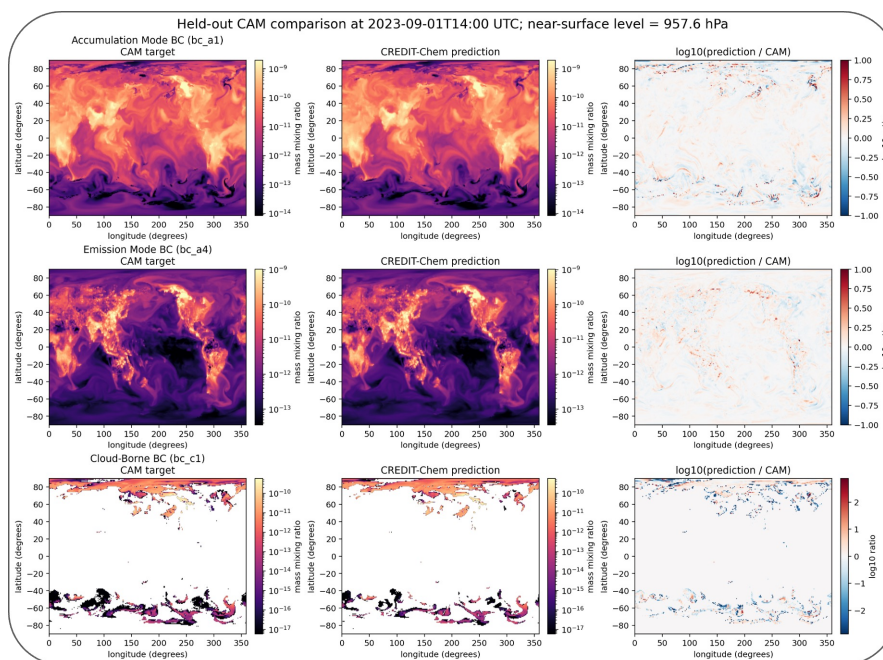
The Julia photochemical mechanism through MUSICA in CliMA captures the essential behavior of tropospheric chemistry. This includes fundamental nonlinear responses on different timescales: initial titration of O₃ before sustained production.

❖ LJ Dunphy, Development of CREDIT-Chem (SIParCS)

A prototype of CREDIT-chem, a hybrid physics–machine learning framework for atmospheric chemistry and aerosol modeling built within the Community Research Earth Digital Intelligence Twin (CREDIT) platform, was developed through an ACOM–CISL collaboration led by Alma Roux (ACOM) and Charlie Becker (CISL), with work by LJ Dunphy (internship at NCAR from Florida State University).



The framework applies an advection/physical transport scheme to aerosol species, then uses an ML model to solve local column chemistry and microphysics. This columnar architecture allows for independent, parallelized column evaluation, scales runtime linearly with grid resolution, and enables explicit physical constraints. The team trained an emulator of CAM6-chem at $\sim 1^\circ$ global resolution with 1-hour time steps, focusing on black carbon (BC) lifecycles as a first step. Single-step evaluations yield correlation coefficients of 0.98 for airborne BC, and a 1-hour forecast completes in 2 seconds on a single A100 GPU which is orders of magnitude faster than CAM6-chem. Ongoing work focuses on expanding the framework to a full aerosol module, as well as to sub-degree resolution and coupling with other ML-based Earth system models. This work was presented at the iCACGP-IGAC 2026 Science Conference in Heraklion, Crete (September 2026) and will be presented at the 107th AMS Annual Meeting in Denver (January 2027).

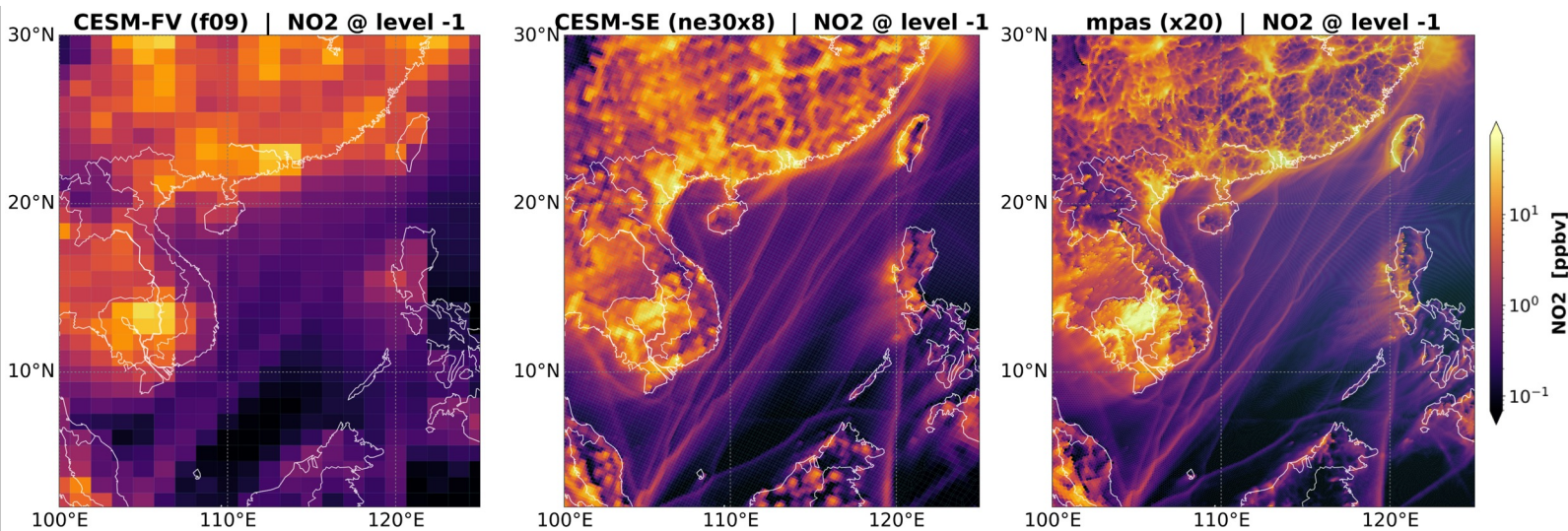


❖ Liam Thompson, a generalized framework for the evaluation and comparison of atmospheric chemistry models with observations

The launch of geostationary (GEO) satellite instruments to monitor air quality, such as NASA TEMPO, have provided atmospheric chemistry research and regulatory communities unprecedented availability of space-based observations. A key workflow constraint for modelers is evaluating atmospheric chemistry models against different sources of observations. To facilitate quick, fair, and accurate comparison of surface, aircraft, and satellite observations to atmospheric chemistry models, we present new unstructured grid developments within [MELODIES MONET](#), a Python-based, open-source, model- and observation-agnostic model evaluation toolkit developed by NSF NCAR and NOAA.



We highlight updates to MELODIES MONET's ability to compare unstructured model grids to observations, by integrating UXarray, which requires users to provide model-specific grid geometry.



We illustrate this capability by comparing Community Earth System Model (CESM) outputs made on three grids: finite-volume (CESM-FV), spectral element (CESM-SE), and the MPAS dynamical core (CESM-MPAS). Critically, the integration of UXarray into MELODIES MONET removes the need for users to regrid their models. This facilitates an understanding of model biases strictly due to the model itself rather than those that can be introduced during the regridding step.

Presentations

iCACGP-IGAC 2026, September 2026:

- ✓ Shane Marie Visaga, **Integrating FINNv2.5 peat emissions into MUSICAv0: implications for air quality and radiative impacts over the Maritime Continent**
- ✓ Bianca Meotti, **Assessing the Impact of Temporal and Spatial Emission Variability on Air Quality Simulations Using MUSICAv0 and NASA TEMPO**
- ✓ Jerrold Accdan, **Comparison of Air Pollution Formation and Transport in Atlanta, Georgia, USA, and Mexico City, MX**
- ✓ Mary Barth, **NSF NCAR's Transition from WRF-Chem to MPAS-A with Chemistry and Aerosols**
- ✓ Ave Arellano, **QUACS: A Scripting Framework for Next-Generation Atmospheric Chemistry Modeling Cyberinfrastructure**
- ✓ Nattamon Maneenoi (Jeep), **Improving Fire Emission Estimates over Southeast Asia Using Himawari-9 and Multi-VIIRS Sensor Integration: Implications for Regional Air Quality Modeling (received Poster Award)**

Earth System Modeling Symposium, August 12-14, 2026:

- ✓ Mary Barth, **Multiscale Modeling of Atmospheric Chemistry within CESM/CAM**

AOGS Conference, August 3-7, 2026:

- ✓ Wenfu Tang, **Modeling Interactions Between Meteorology, Long-range Transport, and Local Air Pollution During the ASIA-AQ Field Campaign Using MUSICA-MPAS**
- ✓ Jun Zhang, **Improved Representation of Aerosol Photolysis Interactions in CESM-MUSICAv0 Using Inline TUVx During ASIA-AQ**

MPAS/WRF Users Workshop, June 22–26, 2026:

- ✓ Mary Barth, **Updates on the Development of MUSICA**
- ✓ Ave Arellano, **From WRF-Chem to CheMPAS-A: Building Next-Generation Atmospheric Chemistry Modeling Capabilities with QUACS**
- ✓ David Fillmore, **CheMPAS-A: Integrating MUSICA Chemistry into MPAS-Atmosphere**
- ✓ Soyoung Ha, **Satellite aerosol data assimilation with MPAS-GOCART2G-JEDI**
- ✓ Gabriele Pfister, **MELODIES-MONET: A User Friendly, Open-Source Python Tool for Model Evaluation**
- ✓ Chayan Roychoudhury, **Developing Modular Atmospheric Chemistry Parameterizations for MPAS-A via the QUACS Framework: A Dust Mobilization Example**
- ✓ M. Amin Mirrezaei, **Multiscale Modeling of Ozone Formation in Arizona: Insights from Variable-Resolution Global and Regional Simulations**

31st CESM workshop, June 15-18, 2026:

- ✓ Ren Smith, **Convective Transport by the Asian Summer Monsoon with MUSICAv1**
- ✓ Maria Val Martin, **Development and Application of a UK Regionally Refined MUSICA Configuration with Soil NO_x Emissions for Air Quality and Land–Atmosphere Interactions**
- ✓ Bianca Meotti, **Assessing Temporal Emission Variability Using MUSICAv0 and NASA TEMPO**