MUSICA - Modeling for Chemistry, Weather and Climate

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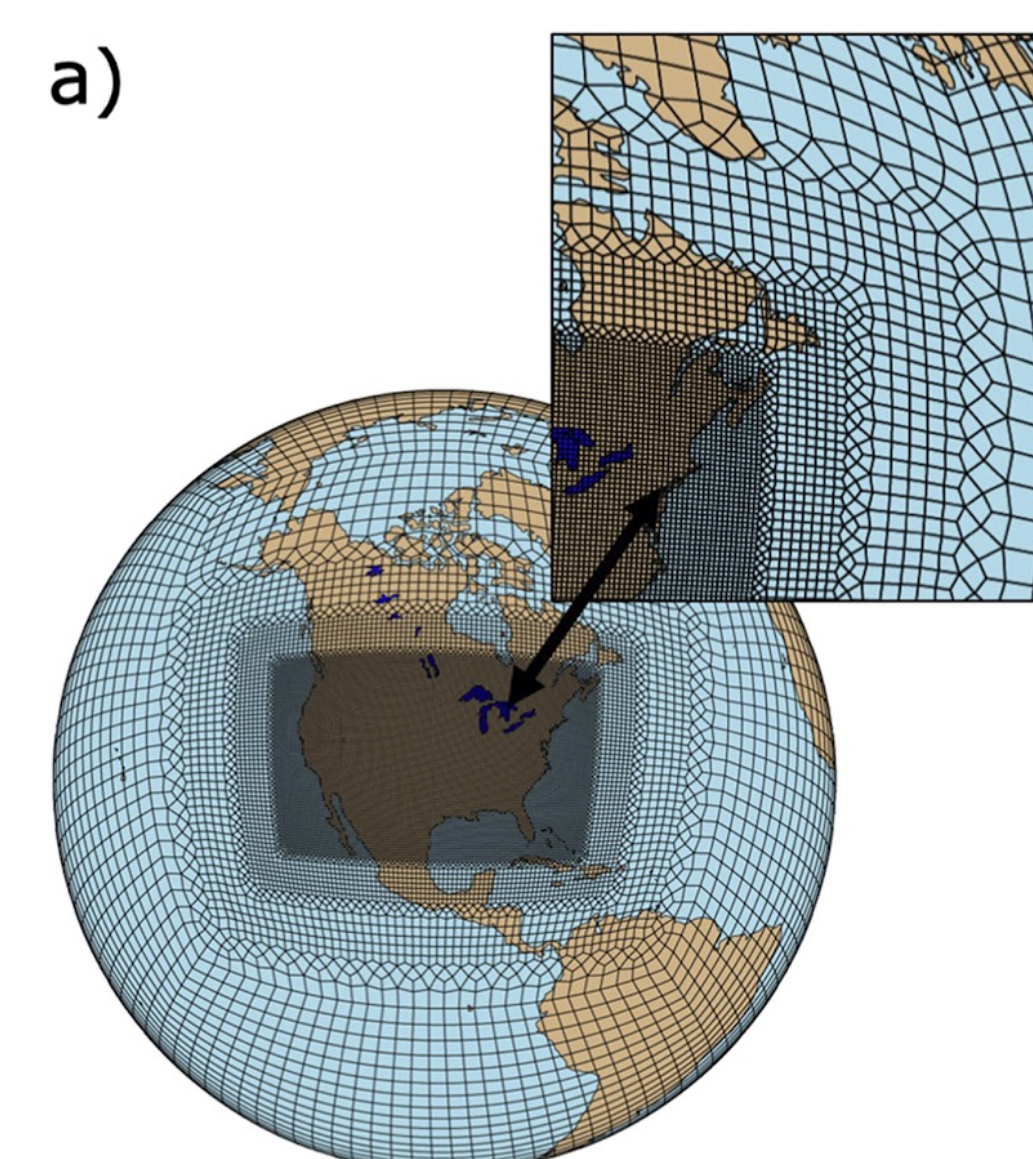*& the MUSICA community*

What and Why?

To explore the various couplings across space, time and between ecosystems in a consistent manner, atmospheric modeling is moving away from the fractured limited-scale modeling strategy of the past towards a unification of the range of scales inherent in the Earth System. The forward-looking MUlti-Scale Infrastructure for Chemistry and Aerosols (MUSICA), is intended to become the next generation community infrastructure for research involving atmospheric chemistry and aerosols. Within the next few years, MUSICA will gradually replace the current suite of community chemistry models supported by NCAR and is envisioned to also integrate the capabilities of other modeling capabilities in the community. The capability of unifying various spatio-temporal scales, coupling to other Earth System components and process-level modularization will allow advances in both on topics ranging from fundamental and applied research in atmospheric composition, to air quality and to climate.

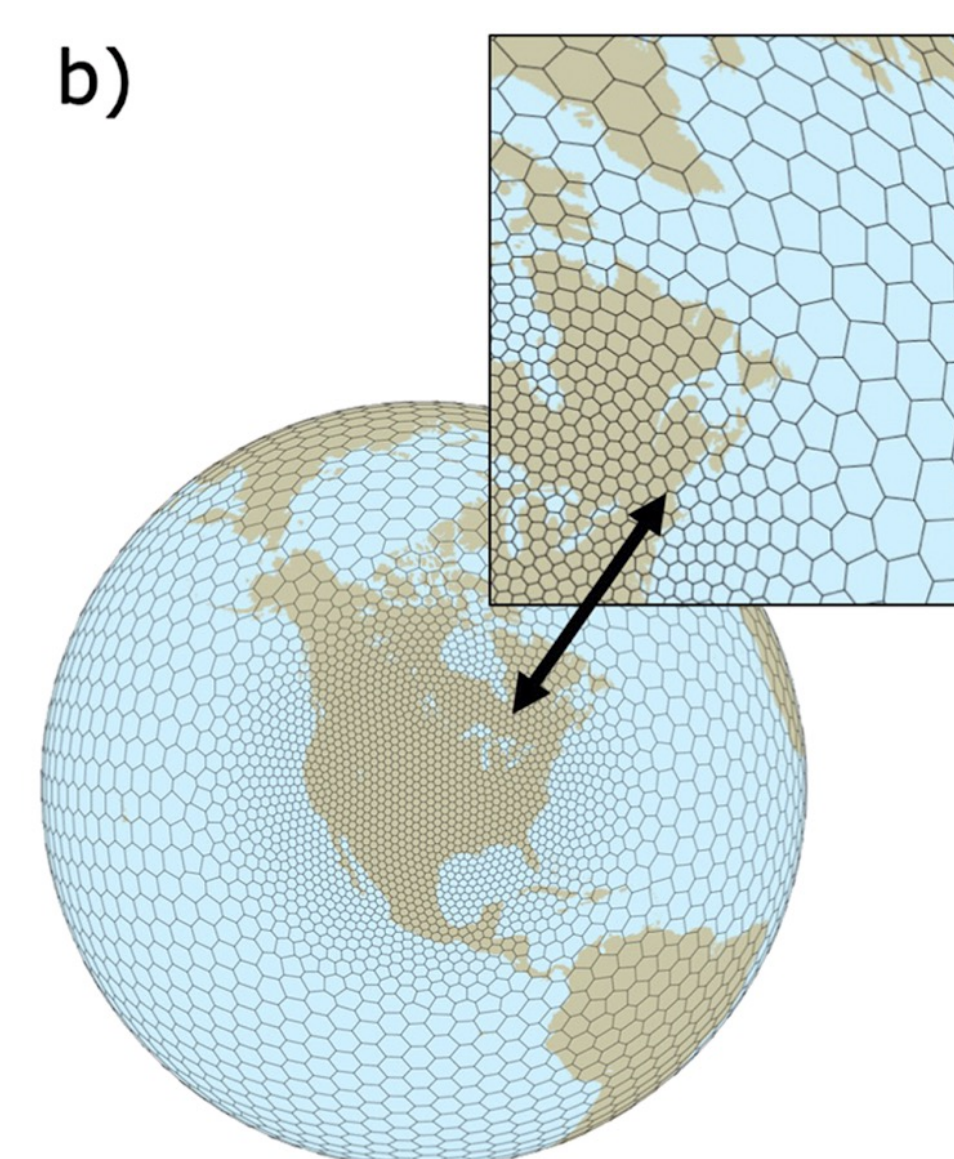A first version – **MUSICA-V0** has been released in fall 2020.

MUSICA Refinement

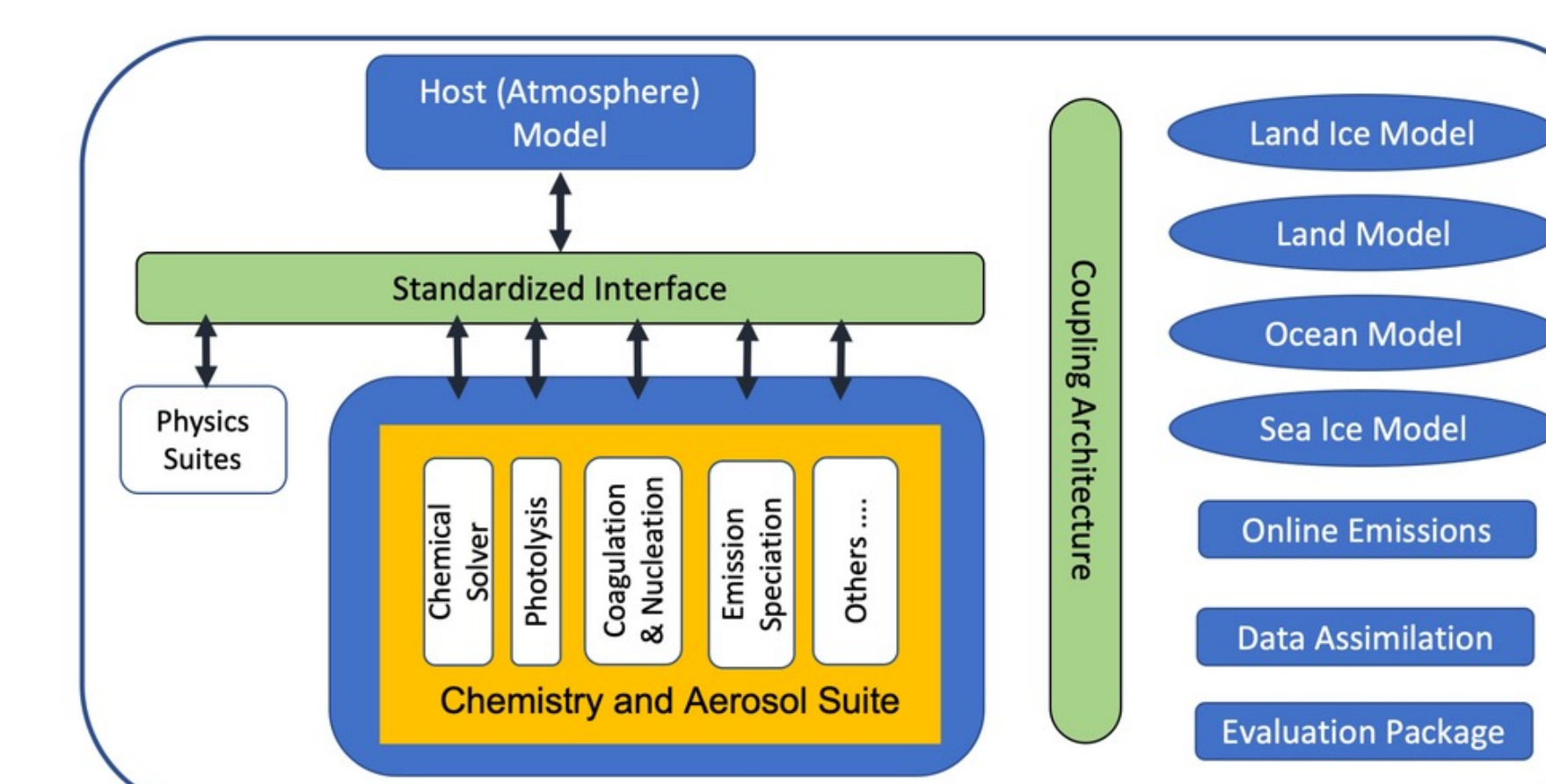Spectral Element (cubed sphere)

MPAS (hexagonal mesh)

a)

b)

Currently running in NCAR's Community Atmosphere Model (CAM) - "MUSICA-V0"

Non-hydrostatic for cloud resolving scales (Implementation in progress)

Realization

The goal of MUSICA is to produce a **flexible and modular model-independent infrastructure** to simulate atmospheric composition at different resolutions in a single, coherent fashion. It **enables coupling** of a stand-alone chemistry component (the **Model Independent Chemistry Module MICM**) to other atmospheric processes and Earth System components (e.g. land/sea atmospheric exchange). Monolithic codes will be broken into separate interoperable modules, thus a user can choose a set of modules during configuration and also change the order of the module calls.

First Results - Examples

- MUSICA gives a consistent framework for local, regional and global simulation and for air quality and climate studies.
- Evaluation of these first simulations is under way but the infrastructure is now at a stage where assessment of individual processes and of scale-awareness is possible and the increased value of a multi-scale framework can be tested. It also gives a framework for the community to become actively engaged.
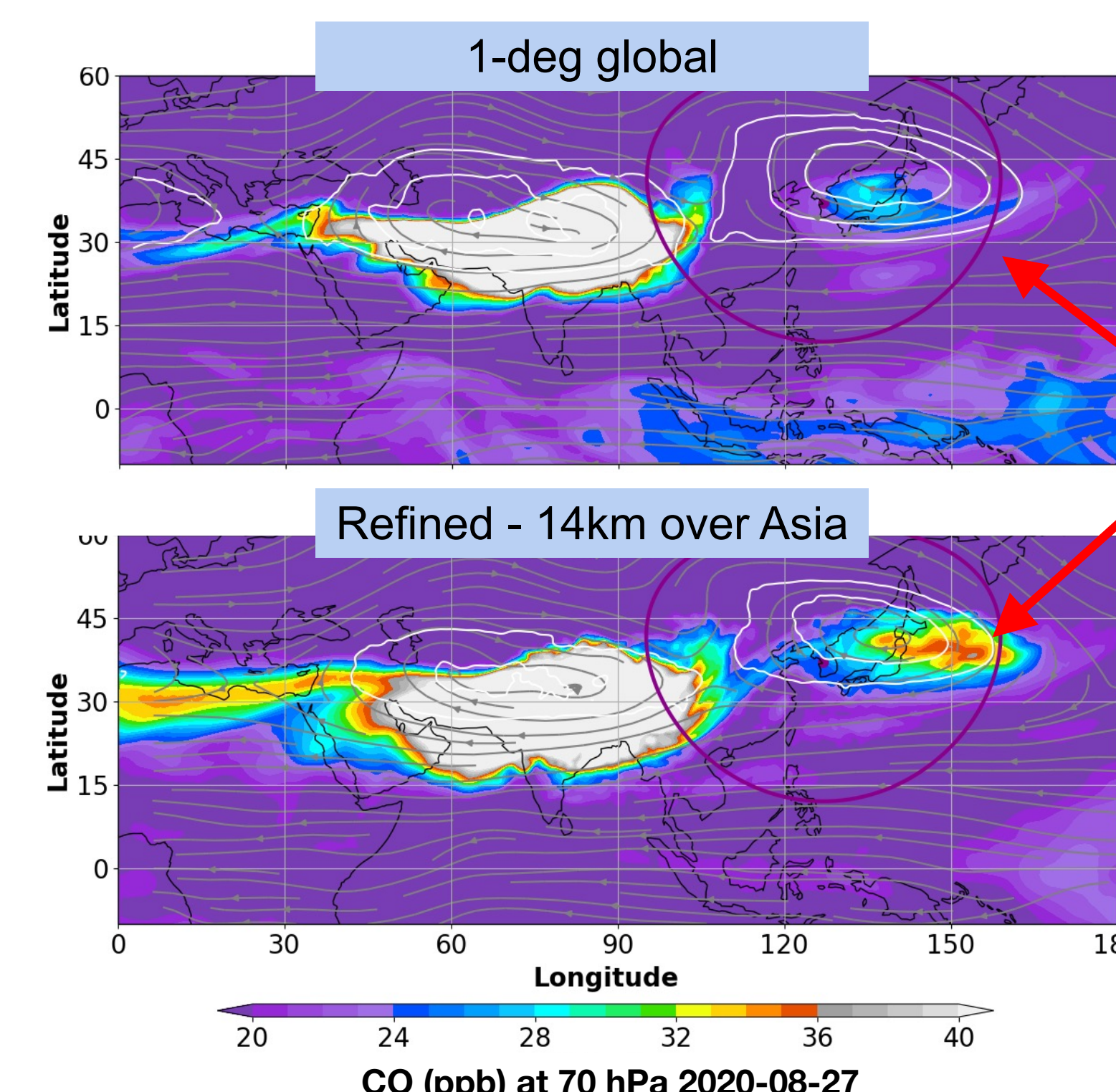
U.S. Air Quality

- Despite the fact that both simulations are nudged to meteorological re-analysis, regional refinement (RR) leads to changes not only over the higher resolution region, but also affects the outflow and leads to differences over the downwind regions.
- Air quality simulations are improved with emissions on more realistic scale, segregation of urban and rural plumes and chemistry and better representation of fire plumes
- Urban pollution more resolved, with lower ozone in rural regions. Higher ozone mixing ratios in continental outflow (over Atlantic, Gulf of Mexico, Baja California.
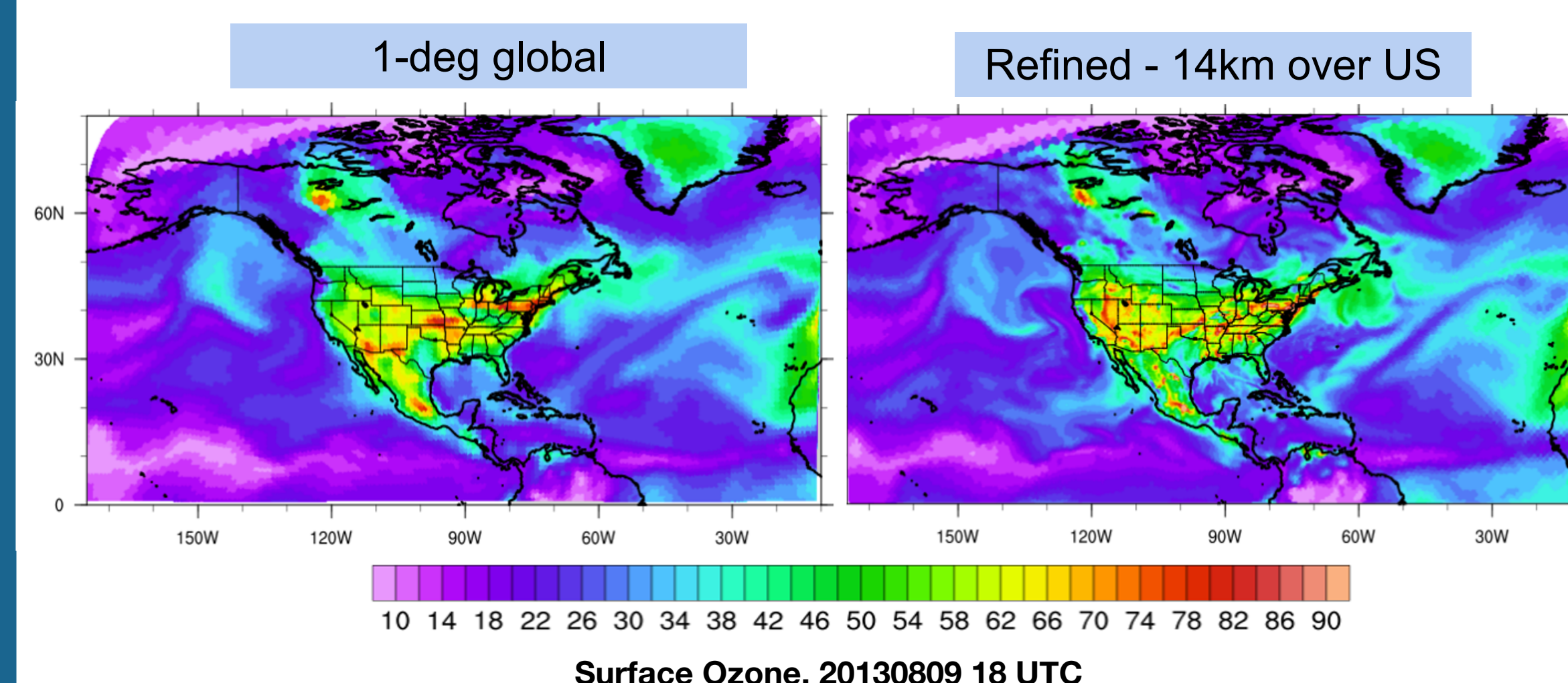
Asian Monsoon

- Refinement over Asia represents the vertical transport of Asian gas and aerosol emissions in the monsoon convection region with high resolutions and the UTLS impacts in a hemispheric scale
- Refined grid run shows stronger shows an enhanced chemical signature over the West Pacific and enhanced monsoon transport into the lower stratosphere

1-deg global

Refined - 14km over US

Surface Ozone, 20130809 18 UTC

1-deg global

Refined - 14km over Asia

CO (ppb) at 70 hPa 2020-08-27

MusicBox

- MusicBox is a box model implementation of MICM with the kinetics specified through a web data base, the "Chemistry Café"
- Runs on a terminal and interactively through a browser based interface
- Integrated Reaction Rate Capability allows tracking of mass flux through different reaction pathways
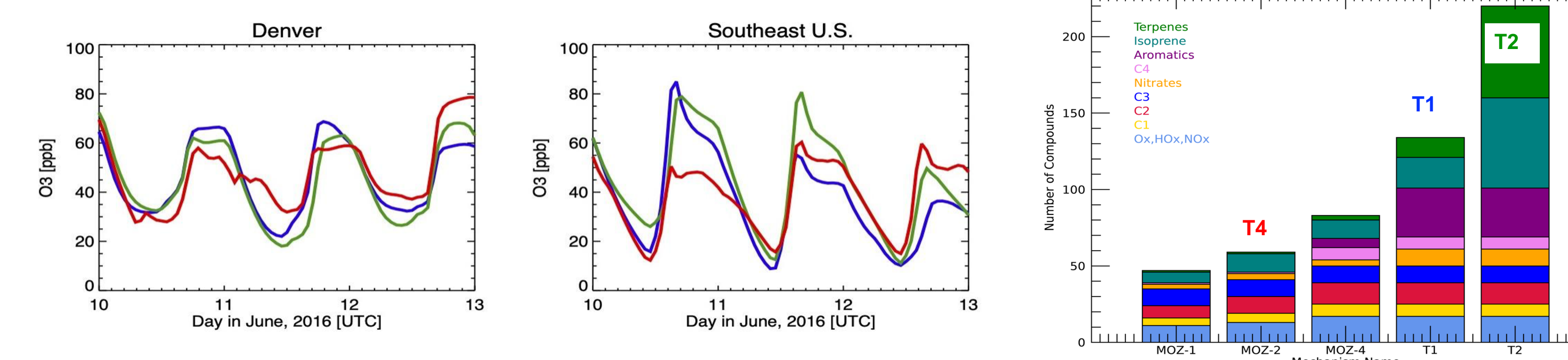
Community

MUSICA Steering Committee - Mary Barth (NCAR), Arlene Fiore (Columbia University), Georg Grell (NOAA), Daniel Jacob (Harvard University), Daniel Marsh (NCAR), Gabriele Pfister (NCAR)

MUSICA Working Groups - If you are interested in actively contributing to MUSICA, sign up for one of the groups on the MUSICA website

- **Model Architecture** - Implementing modular code, sharing data between modules, usability
- **Emissions & Deposition** - *Facilitating use of emissions inventories, improving online emissions, improving deposition schemes*
- **Chemical Schemes** - *Developing chemical mechanisms of varying complexity*
- **Aerosols** - *Implementing a range of aerosol representations*
- **Physics, Transport, sub-scale Processes -** *Addressing multi-scale issues related to convective transport, vertical mixing, and wet scavenging*
- **Whole Atmosphere** - *Developing scale-aware gravity wave parameterizations*
- **Evaluation & Data Assimilation** - *Implementing data assimilation and developing multi-scale evaluation diagnostics*

For more information and to become involved see: https://www2.acom.ucar.edu/sections/multi-scale-chemistry-modeling-musica

MUSICA
Multiscale Infrastructure for Chemistry and Aerosols