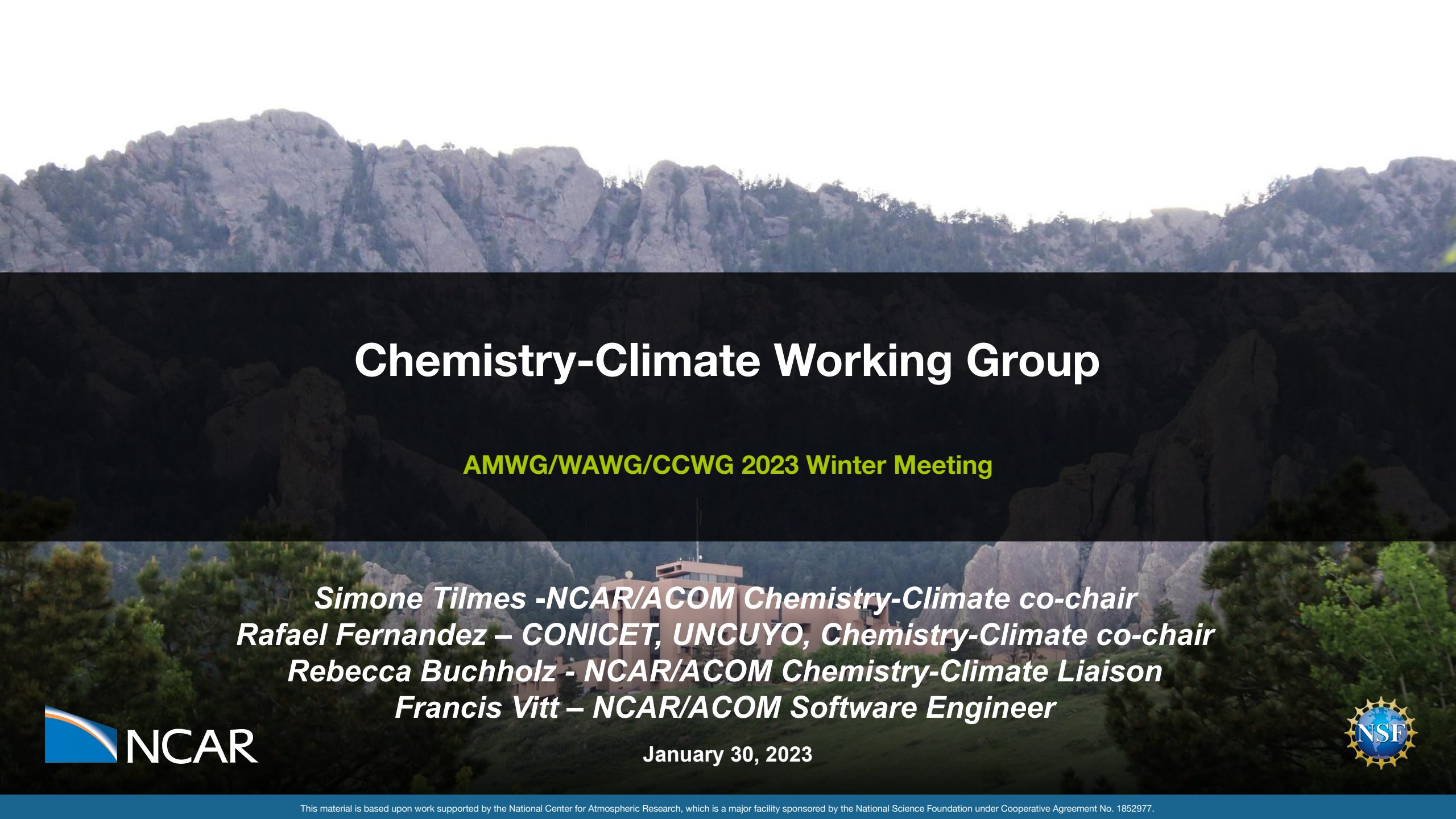


Chemistry-Climate Working Group

AMWG/WAWG/CCWG 2023 Winter Meeting

Simone Tilmes -NCAR/ACOM Chemistry-Climate co-chair
Rafael Fernandez – CONICET, UNCUYO, Chemistry-Climate co-chair
Rebecca Buchholz - NCAR/ACOM Chemistry-Climate Liaison
Francis Vitt – NCAR/ACOM Software Engineer

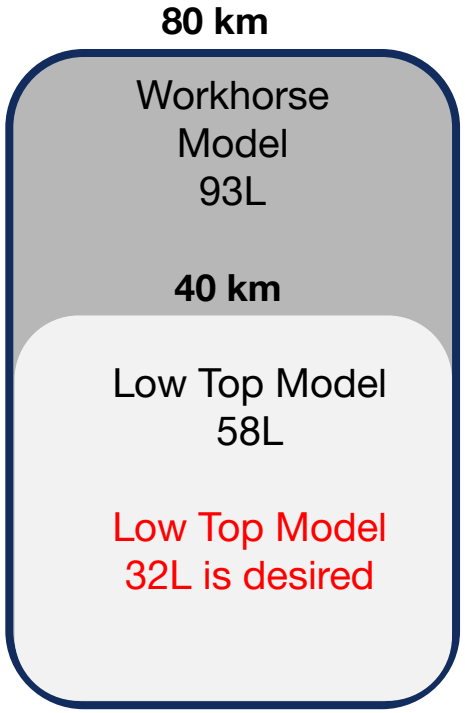
January 30, 2023

This material is based upon work supported by the National Center for Atmospheric Research, which is a major facility sponsored by the National Science Foundation under Cooperative Agreement No. 1852977.

CAM-chem: Full chemistry configuration planned for CAM7

CAM7-chem Workhorse Model: 93L (80km) and 58L (40km) (ne30pg3)

- Default Chemistry: Troposphere + Stratosphere (TS1.2) (Issue #558)
- Default aerosol model: MAM5 (MAM4 + 1 mode for stratospheric sulfate) for all CESM configuration (Issue #663, #664)
- Online DMS emissions based on Online Air-Sea Interface for Soluble Species (OASISS) -> all CESM compsets (CAM, CAMchem, WACCM)
- 58L model: Upper boundary conditions may be required (Issue #533)
- Water vapore update (see earlier talk)



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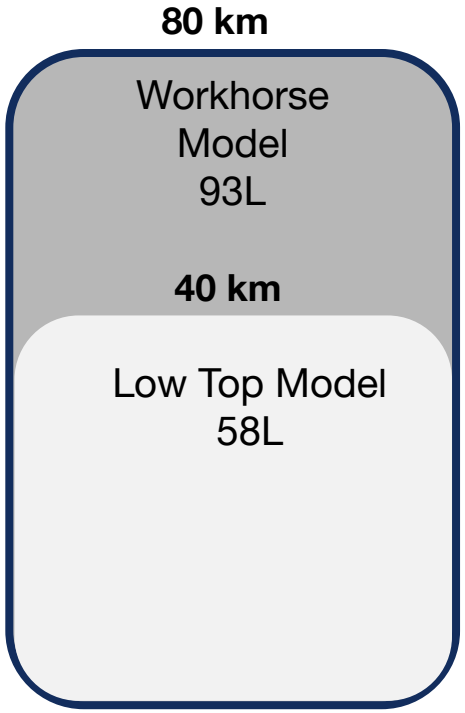


CAM7 Workhorse Model: 93L (80km) and 58L (40km) (ne30pg3)

- Simple chemistry with updated SOA parameterization to support tropospheric aerosol formation (MAM4) (Issue #727) talk by Duseong Jo this afternoon
- Monthly oxidant fields (OH, Ozone, HO2, NO3) are prescribed (from CAMchem)
- Greenhouse gases (CO2, methane, N2O, CFCs, H2O) are interactive
- Prescribed Stratospheric Aerosols from CAM7-chem

Evaluation of CAM-chem Development Code to be started after all other physics updates are included -> in the next month or two

CAM-chem: Full chemistry configuration planned for CAM7

CAM7-chem Workhorse Model: 93L (80km) and 58L (40km) (ne30pg3)

Additional Updates completed or in the Pipeline (to be tested by summer 2023)

- HEMCO Emission Component (Issue #560) (Talk this afternoon by Haipeng Lin)
- New photolysis scheme (TUV-x) -> Talk on Wednesday by Doug Kinnison
- New dust emission scheme in CTSM (Issue #651)
- Marine Organic Aerosol Emissions (Issue #531)
- MEGAN3.1 code in CTSM (Issue #1323) Talk on Tuesday morning by Hui Wang
- Very Short-Lived (VSL) halogen chemistry -> improved halogens in the troposphere (Tuesday morning talks)

CAM-chem: Additional Developments

New Developments (separate Github repositories at this point)

- CARMA sectional aerosol and cloud model -> 2 Talks on Tuesday afternoon
- CESM-GEOS-Chem (CAM issue #424)

Software engineering updates as part of SIMA / MUSICA development

- Model Independent Chemistry Module (MICM) (Matt Dawson, Kyle Shores, Francis Vitt)
  -> Talk by Louisa Emmons this afternoon
- Abstract Aerosol Interface (Francis Vitt, Matt Dawson, Simone Tilmes, Chuck Bardeen, others)
- MPAS chemistry (Francis Vitt, Mary Barth)
- TUV-x (Stacy Walters, Matt Dawson, Francis Vitt, Kyle Shores)

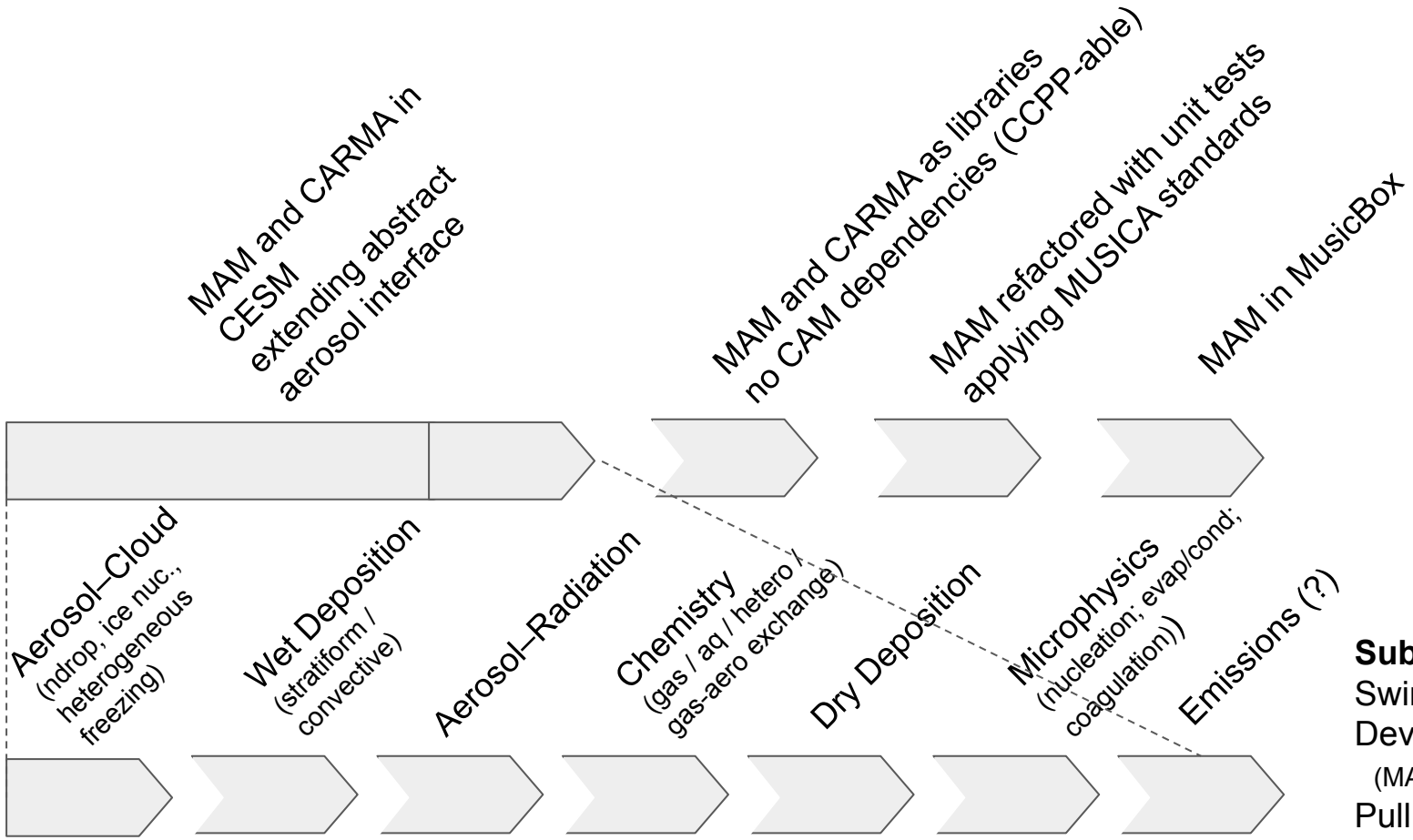
Evaluation beyond the AMWG tool (Justin Richling this afternoon)

- MELODIES/MONET evaluation tool (Rebecca Buchholz's talk on Tuesday)
- ACCLIP campaign (two talks on Wednesday)
- Multi-model Intercomparison projects on-going

SIMA: System for Integrated Modeling of the Atmosphere
Abstract Aerosol Interface

Goals of the design of the flexible aerosol interface in CAM:

- Identify and separate aerosol model specific calculation from host model (CAM)
- Keep interactions with aerosols in various place in the code independent of the aerosol model
- Allow easy way for adding new aerosols in one place in the code
- Move code to CCPP (no CAM dependencies)



Substeps:
Swimlane Development
(MAM, CARMA)
Pull Request

Work by Francis Vitt, Matt Dawson, various others

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Aerosol Properties (abstract aerosol properties class)

- Defines the configuration of any aerosol package (user specifications)
- Aerosol packages have to implement/extend all components of the abstract aerosol properties)
- Values are set during initialization

Example: number of modes or bins, number of species, ..

Aerosol State Class

- Defines time varying aerosol state variables (mixing ratios, number concentration, cloud-borne aerosols, mean radius)
- Aerosol packages have to implement/extend all components of the aerosol state class.

Host model (CAM) routines are generalized to perform calculations **independent on the aerosol model** while using information from **Aerosol Properties and Aerosol State**

Work by Francis Vitt, Matt Dawson, various others

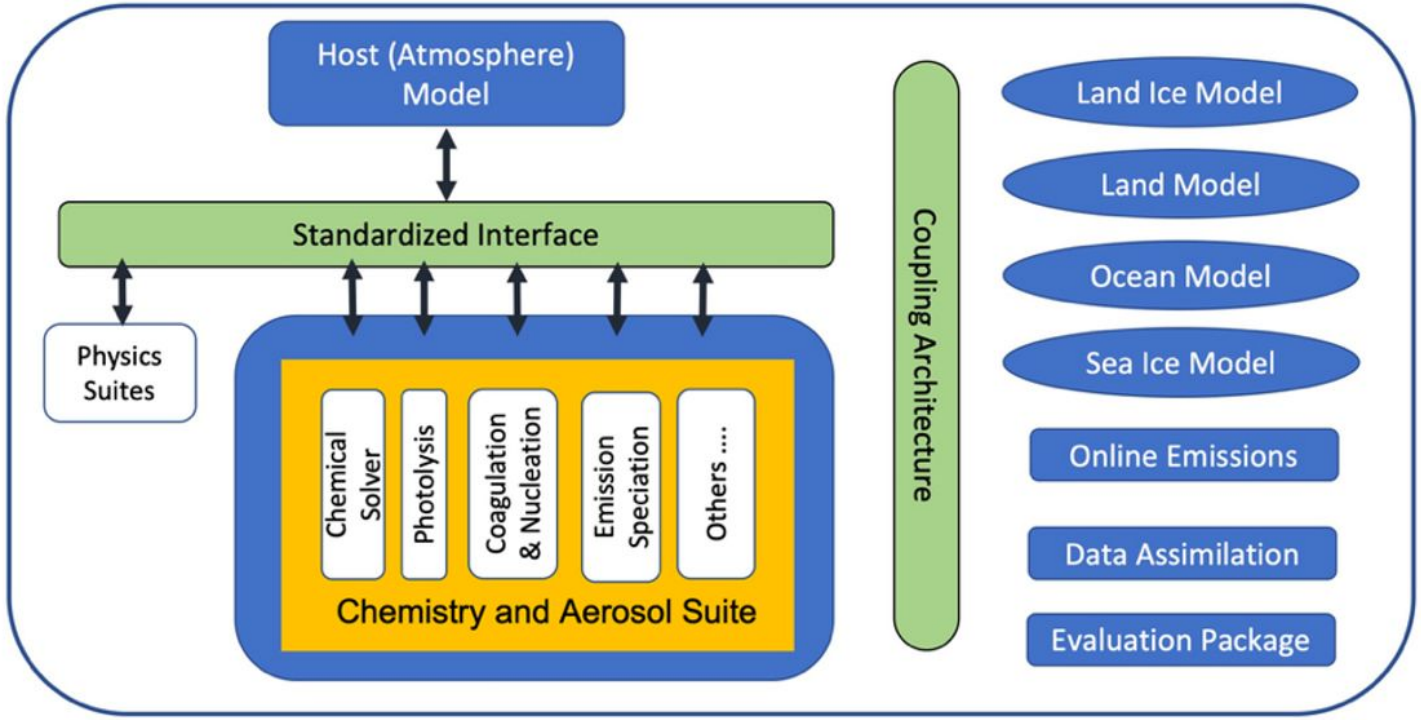
MUSICA: MUlti-Scale Infrastructure for Chemistry & Aerosols

A new model-independent infrastructure, which will enable chemistry and aerosols to be simulated at different resolutions in a coherent fashion

Will **facilitate use of a variety** of chemistry schemes, physics parameterizations and atmospheric models

Coupled to other **earth system** component models (land, ocean, sea ice, etc.)

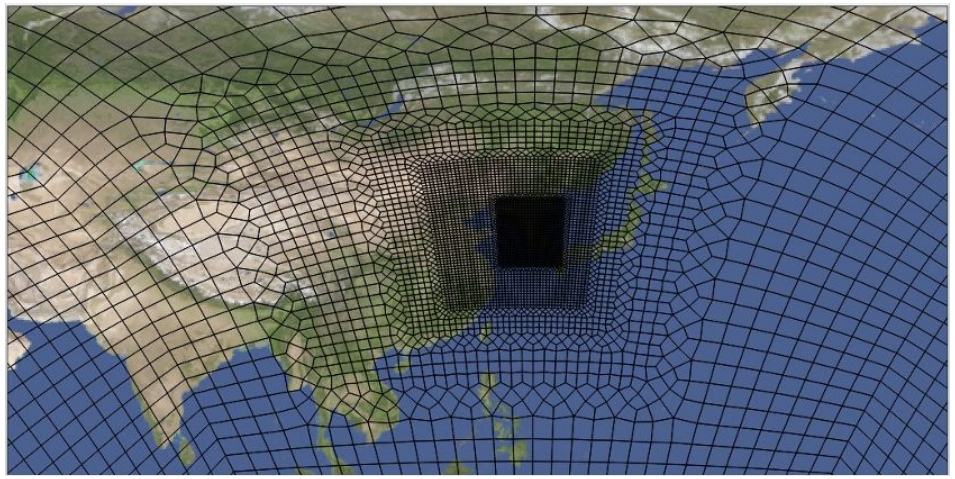
Whole atmosphere framework: troposphere to thermosphere

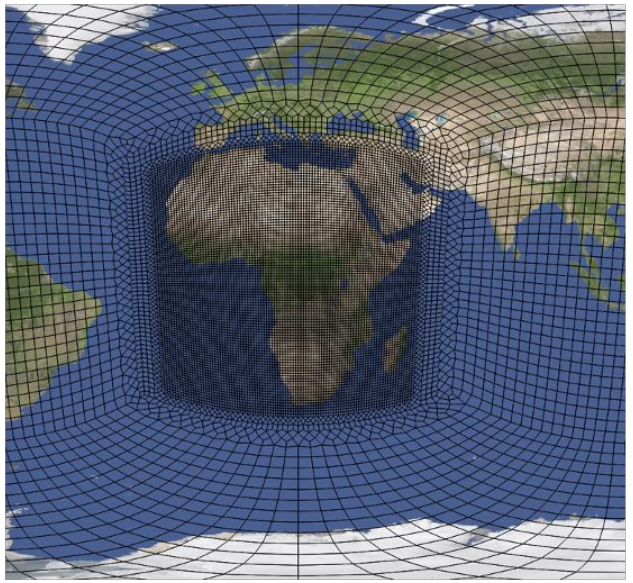


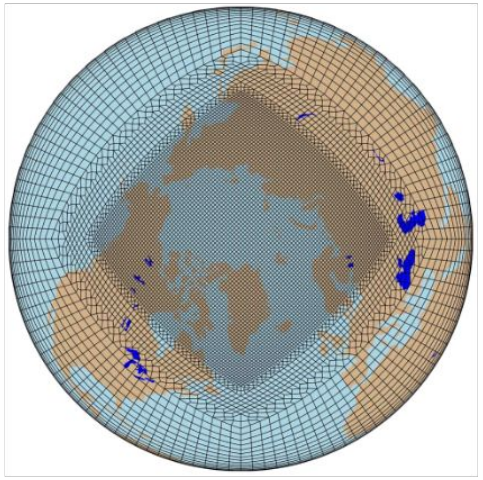
https://www2.acom.ucar.edu/sections/multi-scale-chemistry-modeling-musica

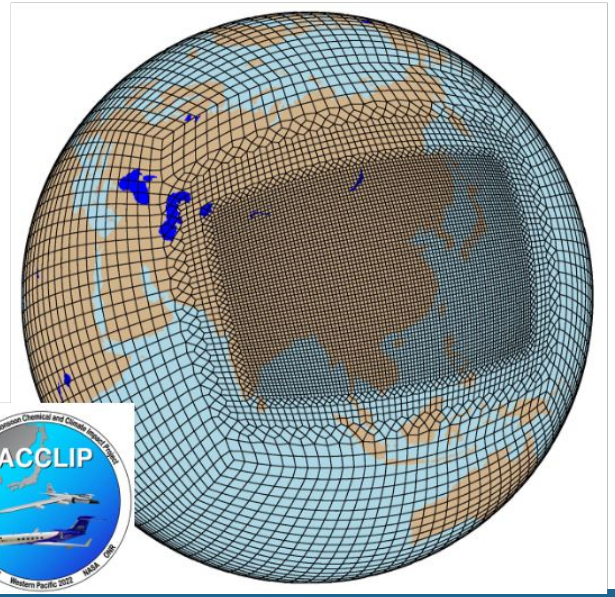
MUSICA Vision paper published in BAMS (Pfister et al., 2020: https://doi.org/10.1175/BAMS-D-19-0331.1)

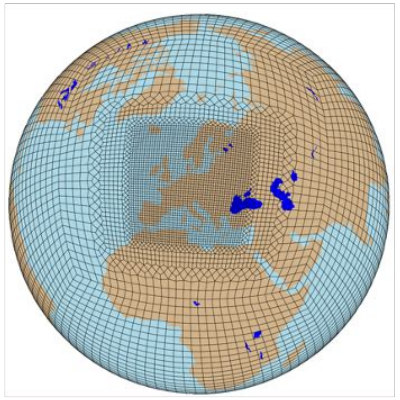
Refined Grids Available for Many Regions (MUSICA-V0)

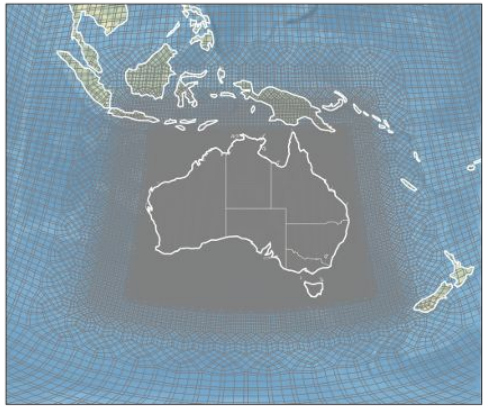








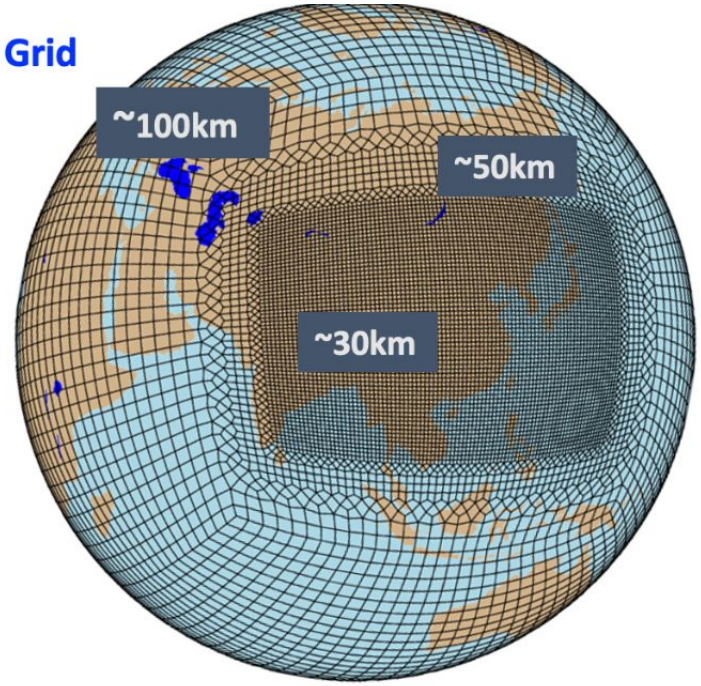




https://wiki.ucar.edu/display/MUSICA/Available+Grids

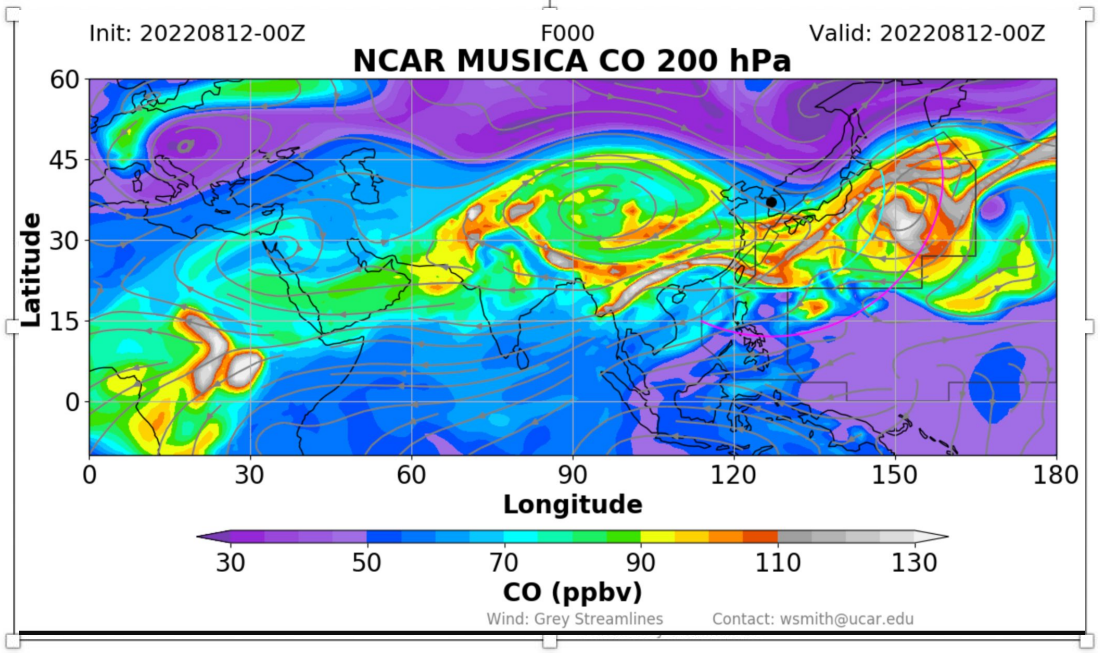
Regional Refinement for Asian Summer Monsoon in support of the NSF/NASA ACCLIP Field Mission

MODEL Grid



Scientific Objectives: Obtain a comprehensive suite of dynamical, chemical, and microphysical measurements in the ASM anticyclone to address: 1) transport pathways to the global UTLS; 2) chemical content; 3) aerosol size and composition for determining radiative impact

- Cube sphere grid; resolution around 1-Deg down to a fine resolution of 0.25 degree.
- Covers the ASM deep convection; anticyclone over the Tibetan Plateau and eastward eddy shedding over the western pacific region.
- Allows for better representation of regional processes and chemistry of surface emissions. This model had detail tropospheric and stratospheric chemistry.



talks by Ren Smith, Jun Zhang

CAM-chem MPAS (SIMA)

Tests of CAM-MPAS-Chem over the Asian Summer Monsoon

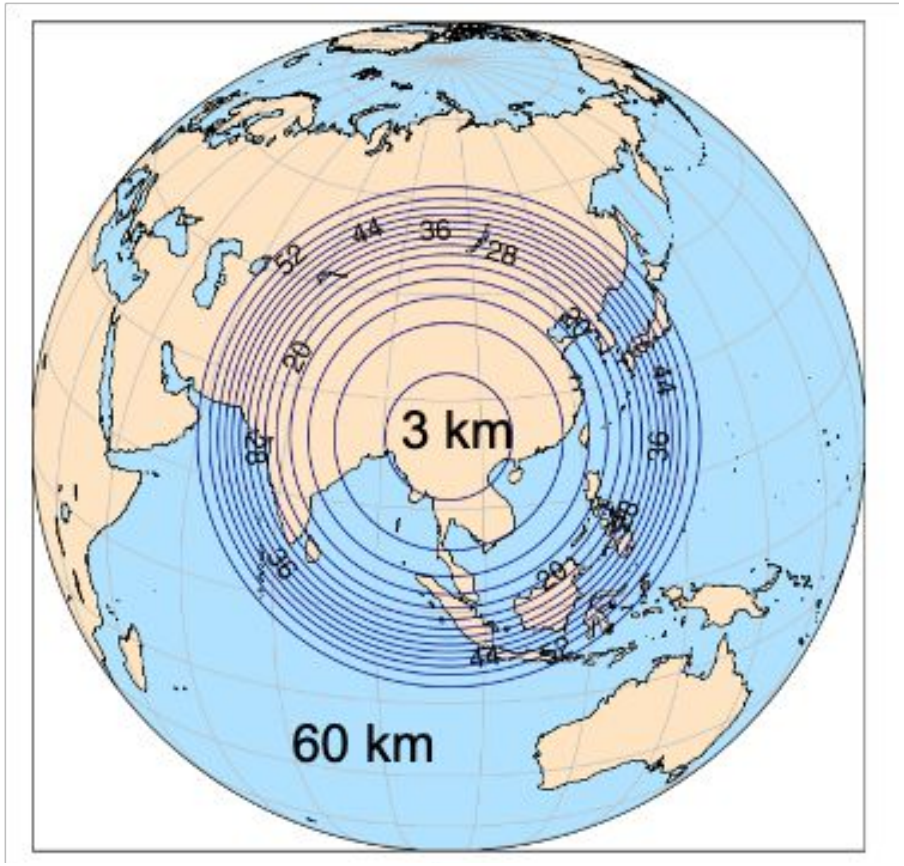
Goal: Connects local-scale phenomena (convection) to hemispheric-scale phenomena using MPAS with Chemistry

Example: Asian Summer Monsoon in support of ACCLIP

- Initial tests with full chemistry is in progress: mpasa60-3 km grid mesh (0.84 million grid columns), 32 vertical layers, 168 trace gases & aerosols
- Run for 1 day, with CAMchem Initial Conditions

Next steps:

- Run with interpolated emissions (HEMCO)
- Run with frontogenesis Gravity Waves
- Run with more vertical layers (58 levels) (1-month simulation)
- Compare with WRF and Spectral Element Simulations



Work by Mary Barth and Francis Vitt