



# Chemistry-Climate Working Group Current Status – February 2019

**Co-chairs:** Louisa Emmons (NCAR)  
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*Chemistry-Climate Working Group Session – 21 February 2018*



# Chemistry-Climate Working Group Status

## **CESM2 (CESM2.1.0 released)**

- CAM6 with MAM4 aerosols, CLM5
- MOZART-T1 tropospheric chemistry in TS1 (CAM-chem) and TSMLT1 (WACCM), VBS-SOA
- CAM-chem and WACCM compsets

## **Description papers**

- MOZART-TS1 chemistry (Emmons et al., in prep. for JAMES)
- VBS-SOA (Tilmes et al., in prep. for JAMES)

## **Simulations available**

- CMIP6 (WACCM, CAM) – on /glade/
- CAM-chem-SD (2001-2016), QFED fire emissions – ACOM/CAM-chem website

# CCWG and CAM-chem webpages

## New wiki page for new and experienced users:

<https://wiki.ucar.edu/display/camchem/Home>

- Points to User's Guide, Scientific Guide, Quick start guide
- Provides additional information for customizing simulations, modifying chemistry and code, etc.
- Identifies current users to promote collaboration

Send info, publications for

[http://www.cesm.ucar.edu/working\\_groups/Chemistry/](http://www.cesm.ucar.edu/working_groups/Chemistry/)

and

<https://www2.acom.ucar.edu/gcm/cam-chem>

The screenshot shows the left sidebar of the CAM-Chem wiki. At the top is the CAM-Chem logo and name. Below it are links for 'Pages' and 'Blog'. A section titled 'CHILD PAGES' contains a 'Pages' link with a sub-menu for 'Home'. The 'Home' sub-menu includes links for 'How to Get an account on Chey...', 'Run CAM-Chem on Cheyenne', and 'Run CAM-chem on your home ...'. A dropdown arrow indicates '12 more child pages'. At the bottom of the sidebar is a 'Space tools' menu.

Pages

## Home

Created by WEG Administrator, last modified by Rebecca Buchholz on Jun 13, 2018

**CESM2 is Released!!!**

Welcome to the CAM-chem Wiki

(Community Atmosphere Model with chemistry)

<b>Run</b>	<ul style="list-style-type: none"><li>• Get a Cheyenne Account</li><li>• Run on Cheyenne (the NCAR HPC)</li><li>• Home Machine (fully coupled version in CESM)</li><li>• Nomenclature (Glossary for those new to the CESM world)</li><li>• Release Versions and Compsets</li></ul>
<b>Easy Changes</b>	<ul style="list-style-type: none"><li>• Namelist changes<ul style="list-style-type: none"><li>• Changing Dates of Run</li><li>• Changing Emissions Input</li><li>• Changing Output (time and species)</li><li>• Defining Nudging Amount for Specified Dynamics</li></ul></li><li>• All CAM Namelist Variables</li></ul>
<b>Advanced Changes</b>	<ul style="list-style-type: none"><li>• Data Assimilation</li><li>• Online Air-Sea Interface for Soluble Speces</li><li>• Updating Gas-phase Chemistry</li><li>• Adding Tags</li><li>• Prescribed Oxidant Fields</li><li>• Branch or Clone</li></ul>
<b>Model Component Descriptions</b>	<ul style="list-style-type: none"><li>• Wet Deposition (User Guide/Science Guide)</li><li>• Dry Deposition (User Guide/Science Guide)</li><li>• Chemistry</li><li>• Emission Inventories</li><li>• Aerosols</li></ul>
<b>Processing</b>	<ul style="list-style-type: none"><li>• Pre-processing</li><li>• Post-processing</li><li>• Automated CESM diagnostic package</li><li>• GitHub Tutorial</li></ul>
<b>User Community</b>	<ul style="list-style-type: none"><li>• Current Users/Projects</li><li>• Chemistry-Climate Working Group Publications</li><li>• UCAR Publications</li></ul>
<b>Other links and documents</b>	<ul style="list-style-type: none"><li>• Development Blog</li><li>• Quick Start User Guide</li><li>• CAM User Guide</li><li>• CAM Scientific Guide</li><li>• ACOM CAM-chem page</li><li>• CESM Chemistry Climate Working Group</li><li>• Benchmarks and Production Experiment Diagnostics</li></ul>

# Users and Projects

Created by Rebecca Buchholz, last modified on Oct 10, 2018

Share what you are working on with CAM-chem: [submit your details with this google form](#).

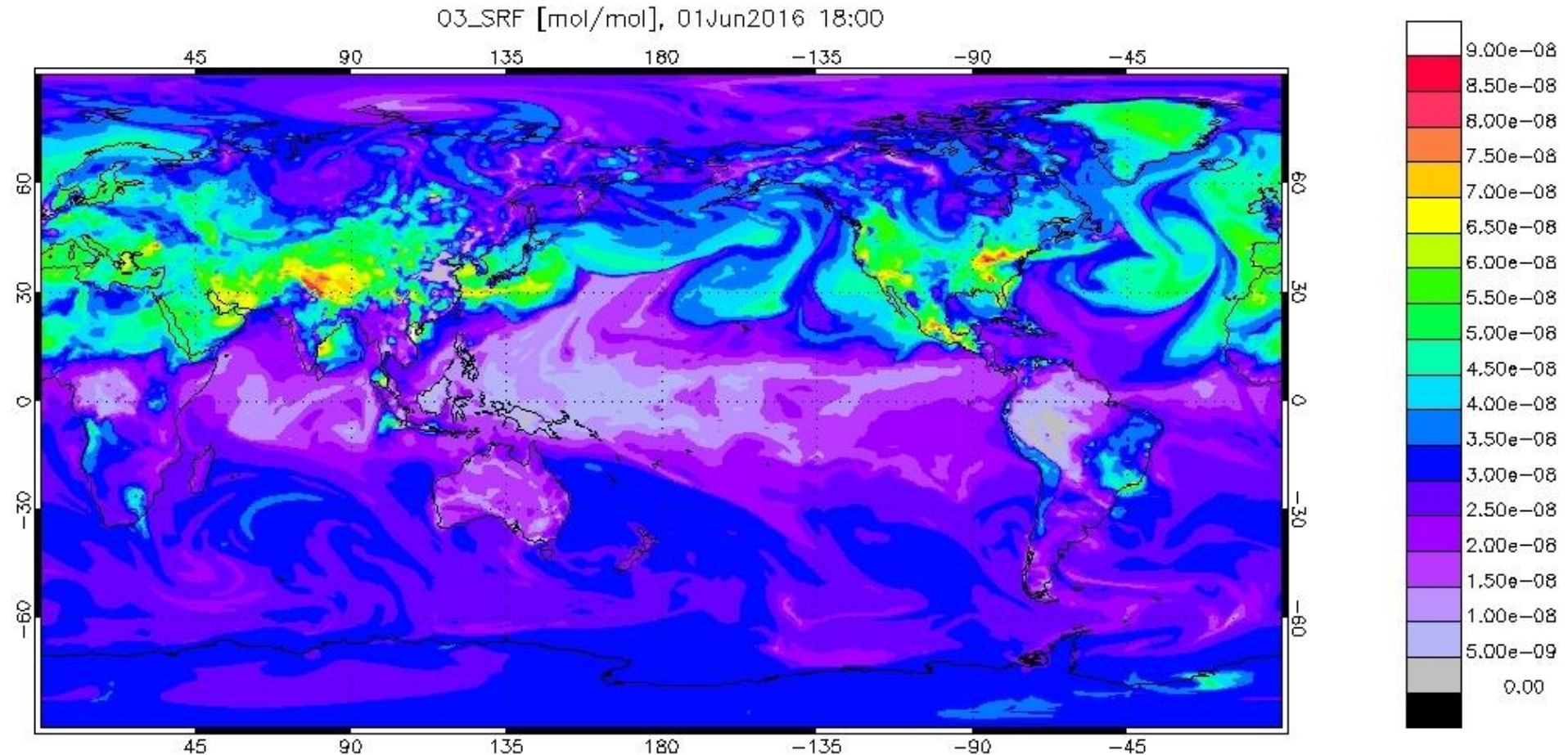
Name/contact	Institute/ Organization	Description of project/s	Date updated
<a href="#">Rebecca Buchholz</a>	NCAR/ACOM	Understanding biomass burning and local versus distant contributions to pollution, with a focus on CO. Also interested in climate-chemistry links. Experiments include: 1. Full chemistry simulation from 1979 to present; 2. Intercomparison of BB inventories; 3. Tagged CO for pollution event attribution; 4. Using the interactive fire module and comparing to inventories.	2018-04-03
Louisa Emmons	NCAR/ACOM	Co-chair of CESM Chemistry-Climate Working Group; evaluating updated chemistry mechanisms with field campaign observations; analysis of KORUS-AQ observations.	2018-05-14
Benjamin Gaubert	NCAR/ACOM	Chemical data assimilation, ensemble forecasting, model evaluation and intercomparison.	2018-05-01
<a href="#">Duseong Jo</a>	University of Colorado, Boulder	Investigating the sources, properties, processing, and removal of organic aerosols under current and future climate scenarios.	2018-04-26
<a href="#">Forrest Lacey</a>	NCAR/ACOM	Implementing chemistry into spectral elements grid with regional refinement. Research focus includes modeling anthropogenic influences on ambient air quality and estimating the related health impacts.	2018-06-13
Rebecca Schwantes	NCAR/ACOM	Improving simulated surface Ozone in CAM-chem by 1) Updating and adding more complexity to the current chemical mechanism for isoprene and terpene oxidation, 2) Testing different NO emission inventories and assumptions, and 3) Testing the impact of model resolution including using the new Spectral Element version of CAM-chem, which has the capability for regional refinement.	2018-04-03
Wenfu Tang	University of Arizona	1) KORUS-AQ field campaign analysis, 2) CO2 simulation in CAM-chem.	2018-07-11
Simone Tilmes	NCAR/ACOM	CESM Chemistry Climate Working Group Liaison / User Support for CAMchem. Works on CAM-chem development, evaluation, chemistry-aerosol-climate interactions.	2018-06-20
<a href="#">Siyuan Wang</a>	NCAR/ACOM	Developing an online air-sea exchange module for trace gases for CESM, in order to better understand the broader impacts of ocean on the atmospheric budgets of an array of compounds of interests, such as oxygenated volatile organic compounds (OVOCs), halogenated VOCs, etc.	2018-04-15
<a href="#">Najib Yusuf</a>	NASRDA Centre for Atmospheric Research, Nigeria	Using CAM-chem with different emissions inventories to compare with ground-based, aircraft and satellite observations in order to study AQ and climate impacts over Nigeria.	2018-09-28
<a href="#">Haipeng Zhang</a>	Nanjing University	Using CAM-chem to investigate what causes the variation in low-cloud cover over China in recent years.	2018-09-29
<a href="#">Yuqiang Zhang</a>	Duke University	Using CAM-Chem to investigate regional emission changes on global tropospheric ozone burden; To study the intercontinental transport of air pollution from China to western US.	2018-10-10

We encourage users to share their current research and development activities on the wiki page



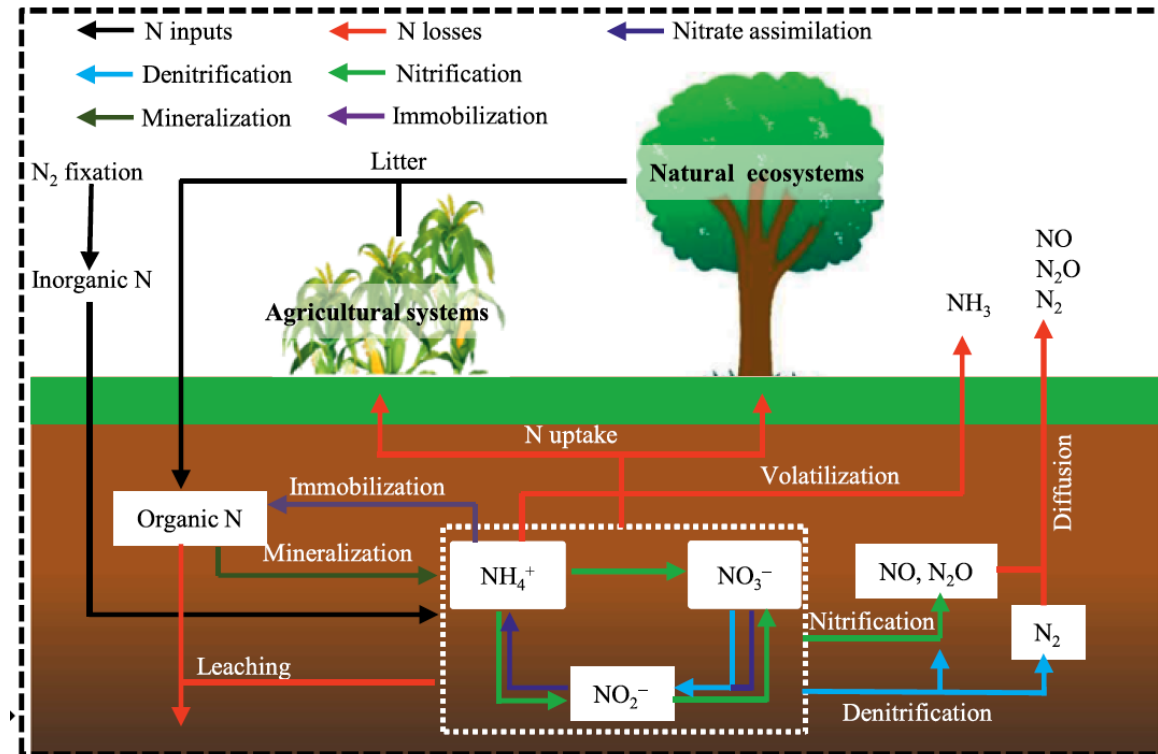
# KORUS-AQ & 0.5deg CAM-chem {work in progress}

- CAM-chem-SD: 0.47x0.63, 2016
- CMIP6 Emissions with KORUS inventory for East Asia



# Update on soil nitrogen emissions in CESM2

(Maria Val Martin, University of Sheffield)



Tian et al, (2018)

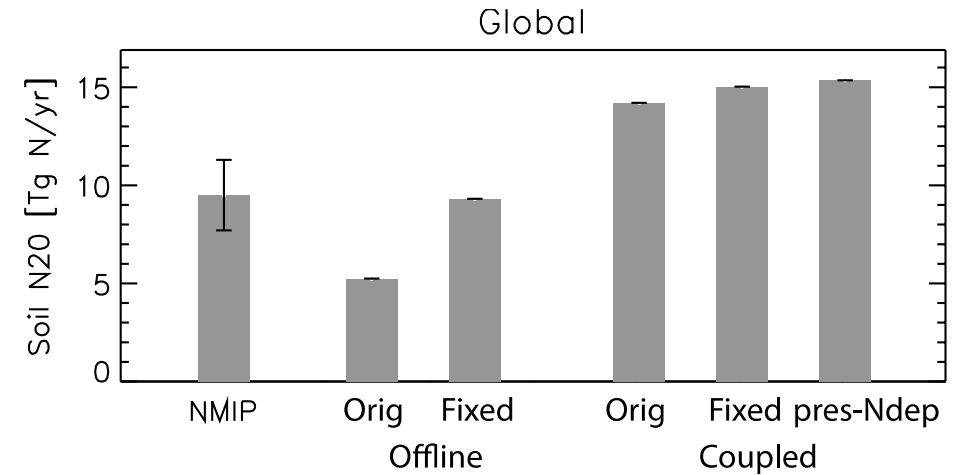
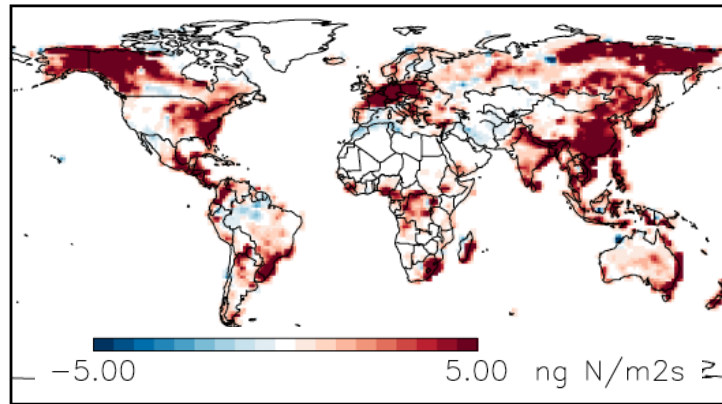
- Fixed low N<sub>2</sub>O fluxes in tropical regions (with Cynthia Nevison, CU)
- Implemented soil NO emissions (Parton et al., 2001 scheme)
- Implemented soil NH<sub>3</sub> volatilization (with Victor Fung, CUHK)
- Coupled N<sub>2</sub>O, NO and NH<sub>3</sub> from CLM5 to CAM-chem (with Francis Vitt)

# Update on soil nitrogen emissions in CESM2 (cont.)

(Maria Val Martin, University of Sheffield)

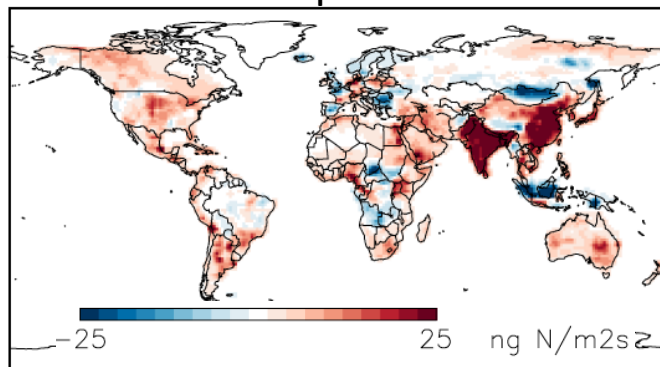
- Soil N<sub>2</sub>O and NO fluxes in CLM5 are within estimates (not shown)
- Large positive bias of soil N<sub>2</sub>O (and NO and NH<sub>3</sub>) when CLM5 and CAM-chem are coupled.

Coupled - Offline  
Soil N<sub>2</sub>O Emissions

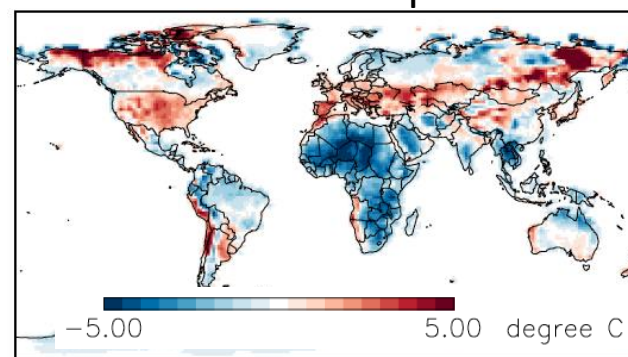


- Issue with higher soil temperature and water content in northern latitudes?
- Too much N deposition in east Asia and India?

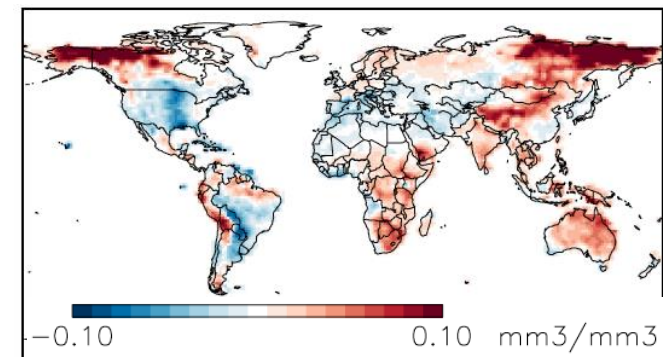
N deposition



Soil Temp



Soil Water



# **MU**lti-Scale Infrastructure for Chemistry & Aerosols (**MUSICA**)

Within five years develop, *jointly with the community*, a computationally feasible **global modeling framework** that allows for simulation of large-scale atmospheric phenomena, while still **resolving chemistry at emission and exposure relevant scales**.

MUSICA is being built on

## **SIMA: System for Integrated Modeling of the Atmosphere**

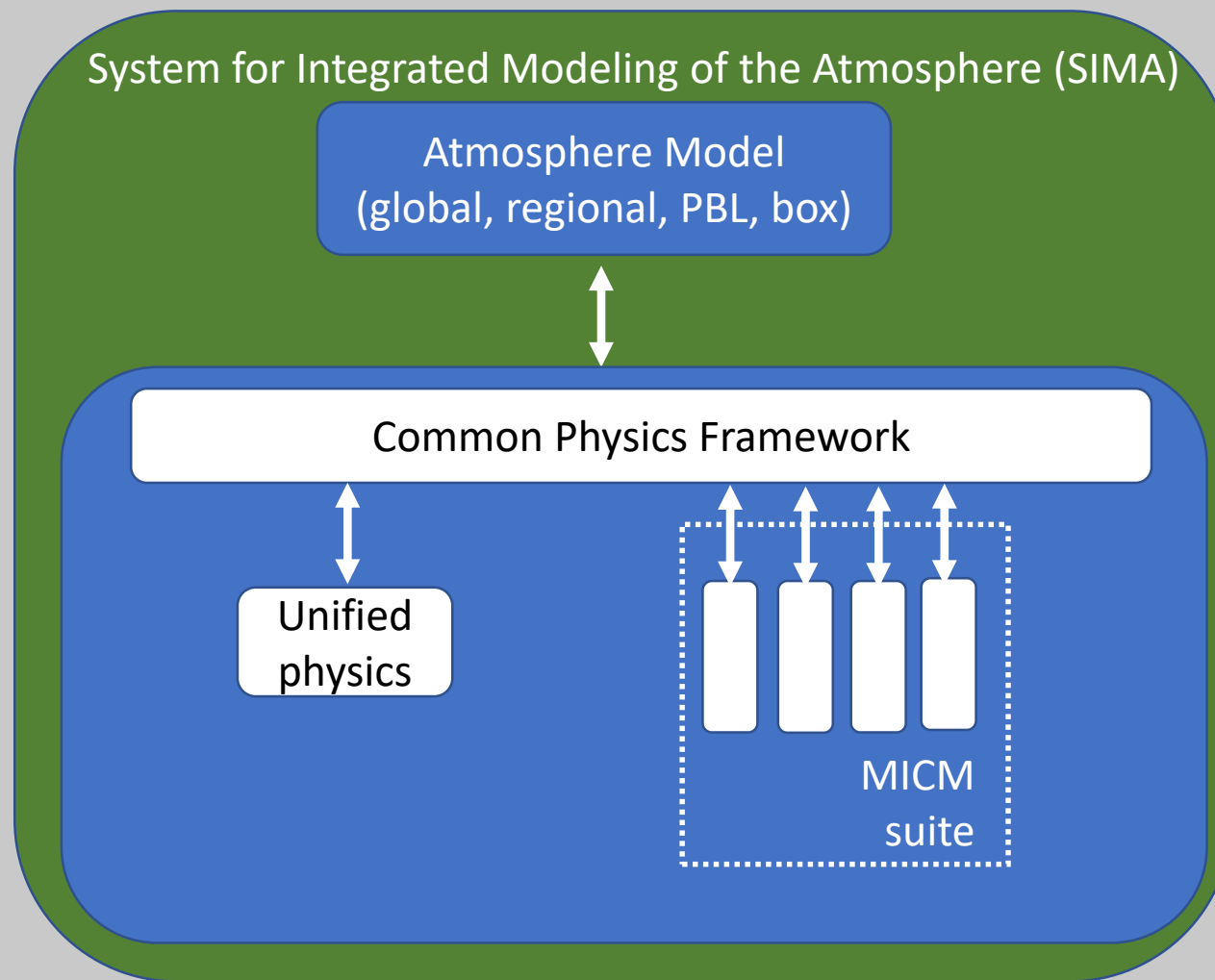
**SIMA Vision**: An integrated global & regional atmospheric modeling system capable of simulating cloud to global scales in a community earth system model

- Encompass Climate, Weather, Chemistry & Geospace Applications
- Prediction (Initialized and Forecast) capabilities
- Complement & extend existing applications (CESM/WRF/MPAS)
- One community system: shared infrastructure and components



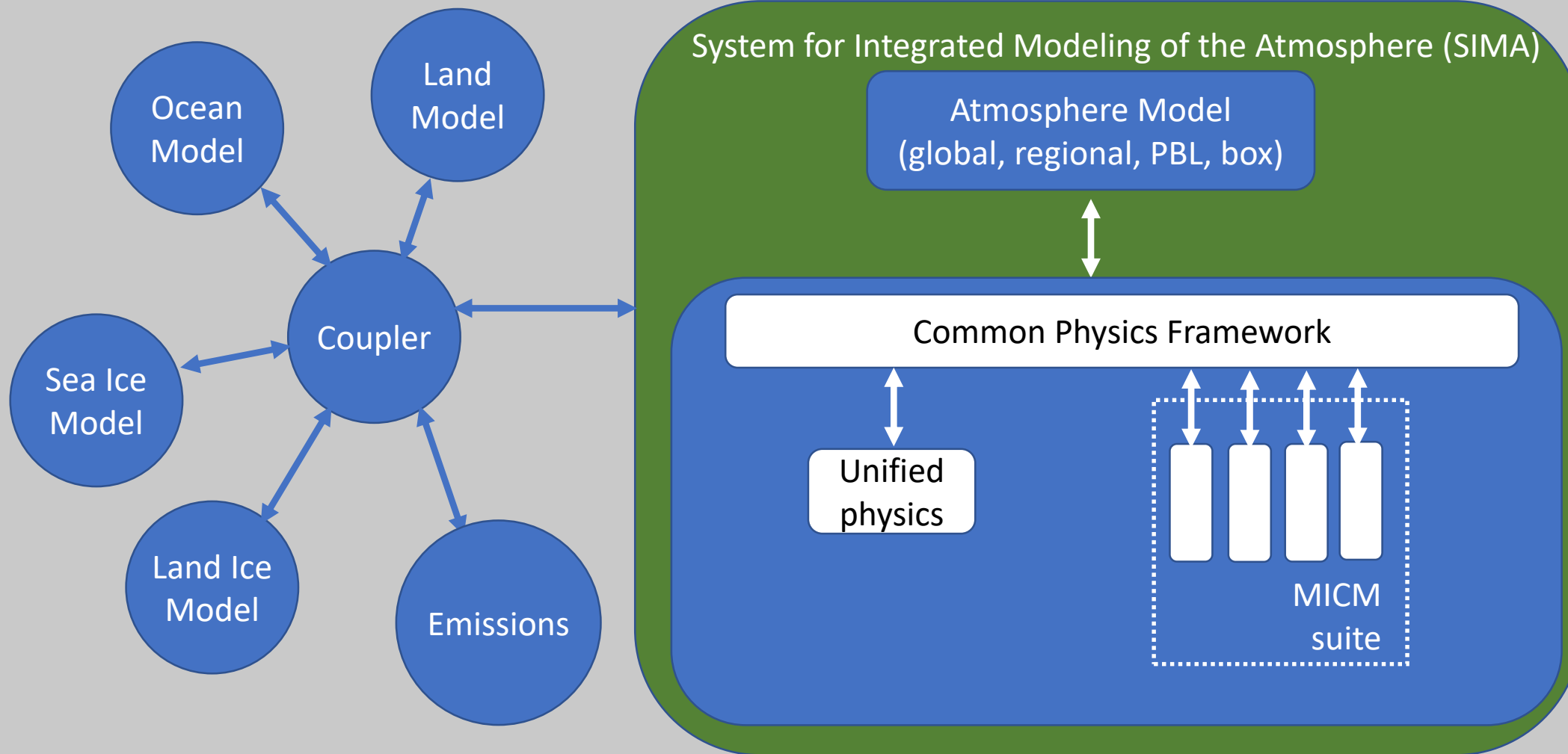
## SIMA (System for Integrated Modeling of the Atmosphere) Activities

- Development of Common Physics Framework
- **Development of MICM = Model Independent Chemistry Module**
- Remapping to Geomagnetic Grid
- Data assimilation capabilities
- Placing MPAS dynamics in CESM



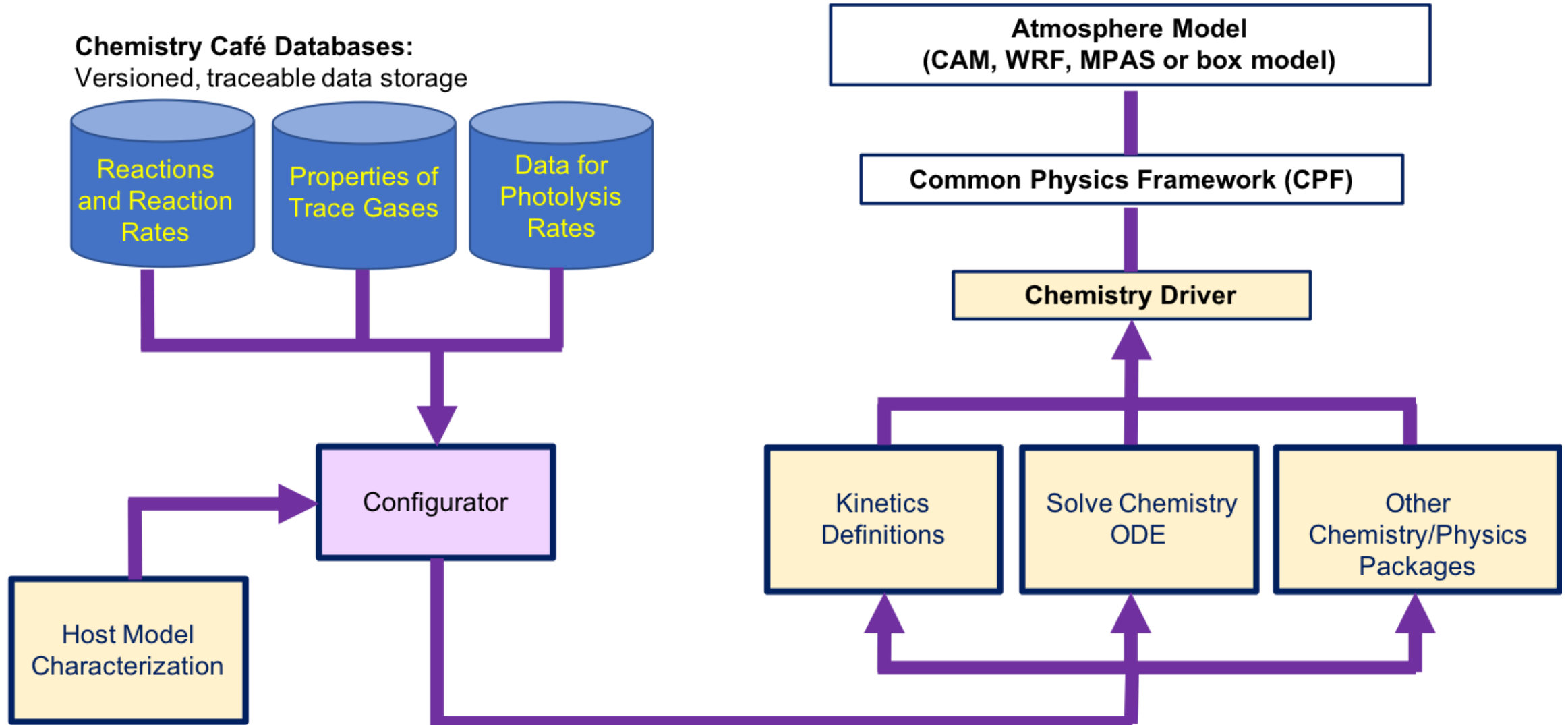
CESM = Community Earth System Model  
MPAS = Model for Prediction Across Scales

## MUSICA configuration



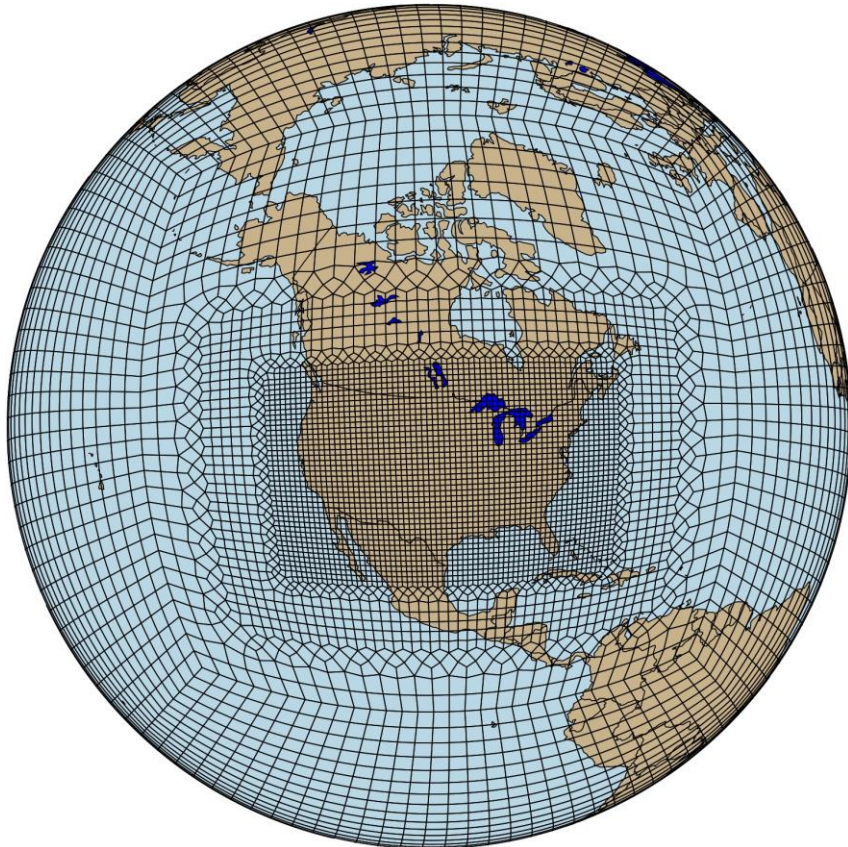
# Model-Independent Chemistry Module (MICM)

Same infrastructure for box models, regional-scale models, and global models



# MUSICA V1: CAM-chem-SE with regional refinement (RR) *{in development}*

**CAM-chem-SE-RR team** includes Forrest Lacey, Becky Schwantes, Simone Tilmes, Louisa Emmons, Ben Gaubert, Gabi Pfister, Dan Marsh, Stacy Walters and collaborators in MMM & CGD



- Community Atmosphere Model with Chemistry (CAM-chem)
- Spectral element: approx.  $1^\circ$  for the globe, with CONUS at 14 km ( $\sim 0.125^\circ$ )
- Full tropospheric and stratospheric chemistry (as in CESM2)

*Forrest's talk in Joint WA-CC WG session Wed*

# Development Activities and Plans

- Sea Salt Tuning needed for emissions for CESM2
- Specified Dynamics at 32 Levels - MERRA2 interpolated to 32L, investigating nudging factors, fields to constrain, etc.
- Inorganic nitrate aerosols and MOSAIC (Zavieri et al., Zheng Lu, Duseong Jo)
- Brown carbon (published in CAM5.4, need to move to CAM6)
- Improved wet scavenging in convective clouds (Pengfei Yu, Yunpeng Shan)
- Improved dust representation (Xiaohong Liu et al.)
- Online ocean emissions of VOCs, DMS, NO (Siyuan Wang)
- Updated chemistry: terpenes, higher alkanes, fire compounds and their oxidation (Becky Schwantes)
- VSL halogen chemistry (Doug Kinnison, Alfonso Saiz-Lopez, Siyuan Wang, et al.)
- Spectral Element/refined grid with chemistry (Forrest Lacey, Becky Schwantes, et al.)
- CAM-chem-SE-RR with meteorology nudging (Simone)
- Online TUV and/or Fast-J (helpers welcome!)
- Update MEGAN biogenic emissions (in CLM) (Alex Guenther, UCI)
- CARMA implementation (Pengfei and NCAR)
- VBS improvement: add high NO<sub>x</sub> environment (especially for higher horiz. resolution)
- Updated SOA from Isoprene/IEPOX & Terpenes (Duseong Jo)



# CAM-chem updates for CESM2.2+

## Desired compsets

- Specified dynamics at 32L
- CAM-chem with full VBS (source types)
- T1 only (specified stratospheric chem.)
- 0.5 degree
- Tagged CO
- Tagged NO<sub>x</sub>/O<sub>3</sub>
- ?

## After first publication or additional testing/evaluation:

- MOSAIC gas-aerosol exchange with nitrate aerosols
- Expanded terpene chemistry
- Expanded alkane chemistry
- Interactive fires (*not working yet*)

# Feedback to the AMWG

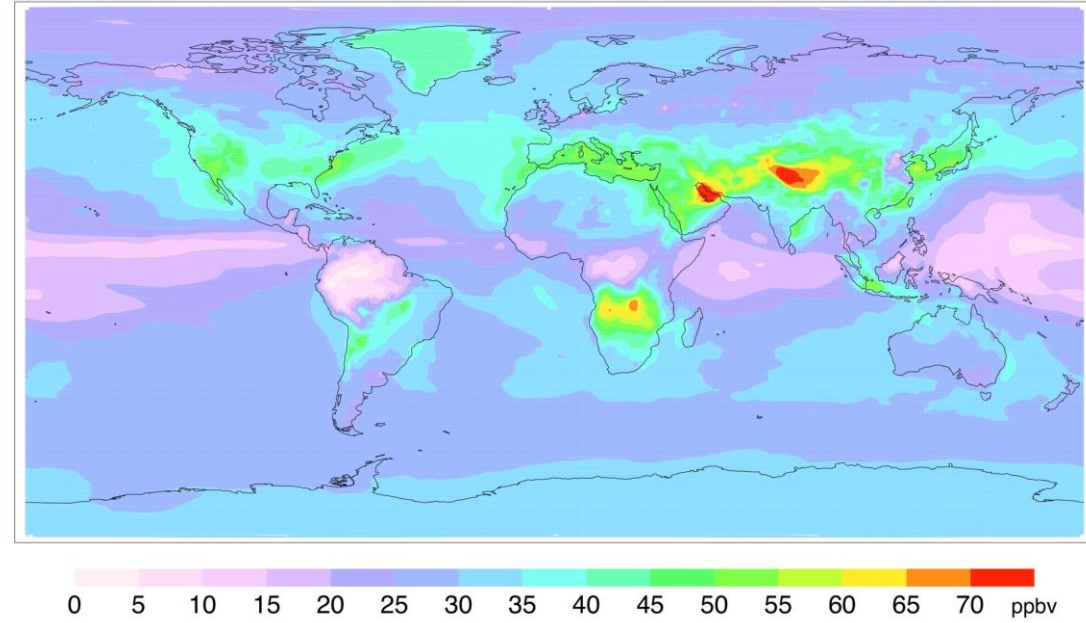
- Improvements to BL needed for Air Quality, including:
  - More levels in BL
  - More realistic mixing in BL
- Scale-aware parameterizations for dust and sea salt emissions
- ...



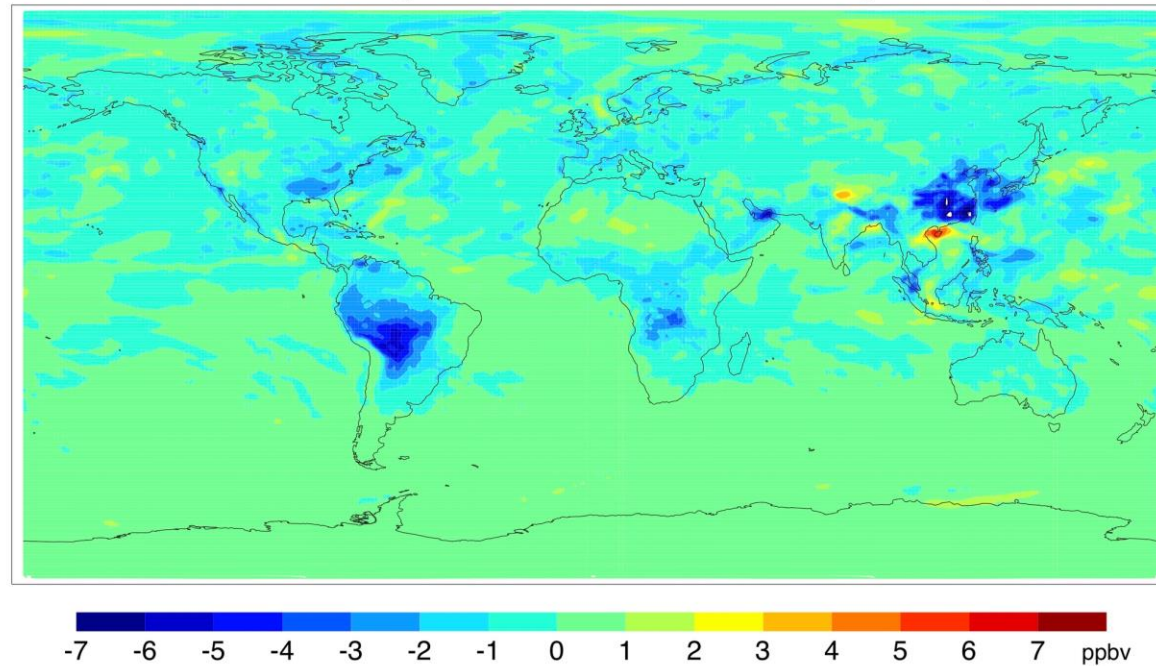
# Impact of new T1 chemistry

Ozone is reduced in high-isoprene regions

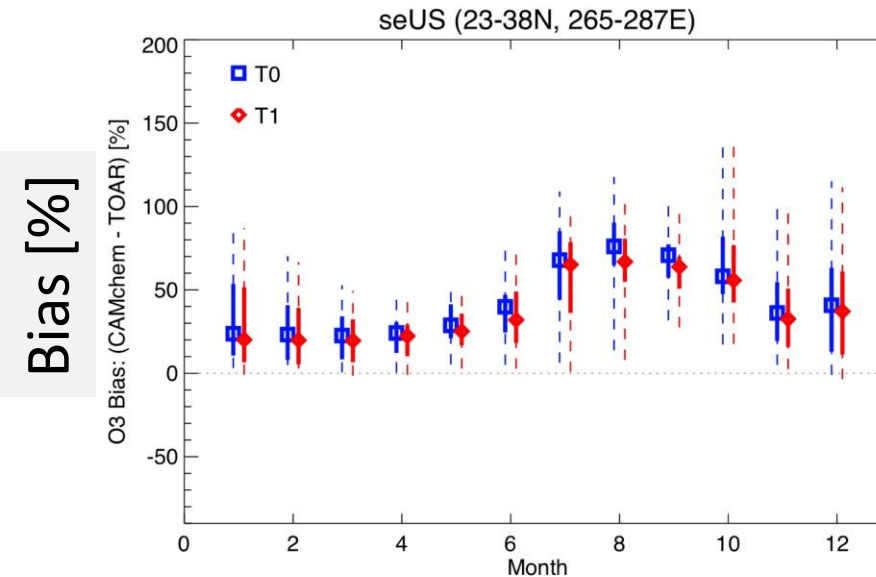
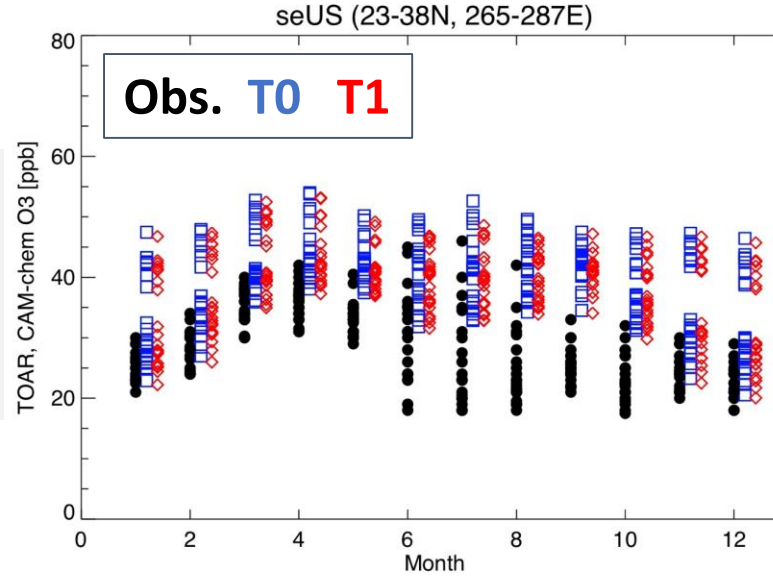
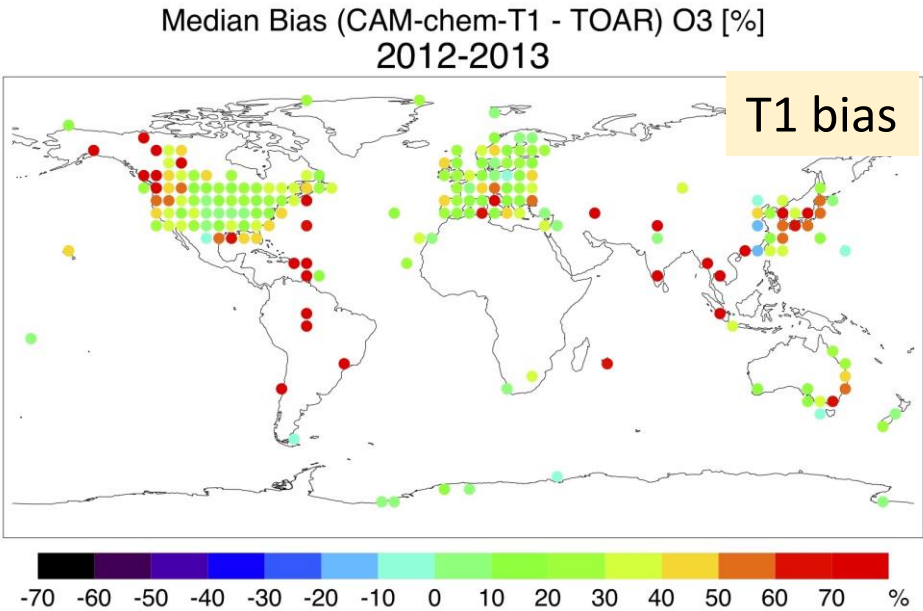
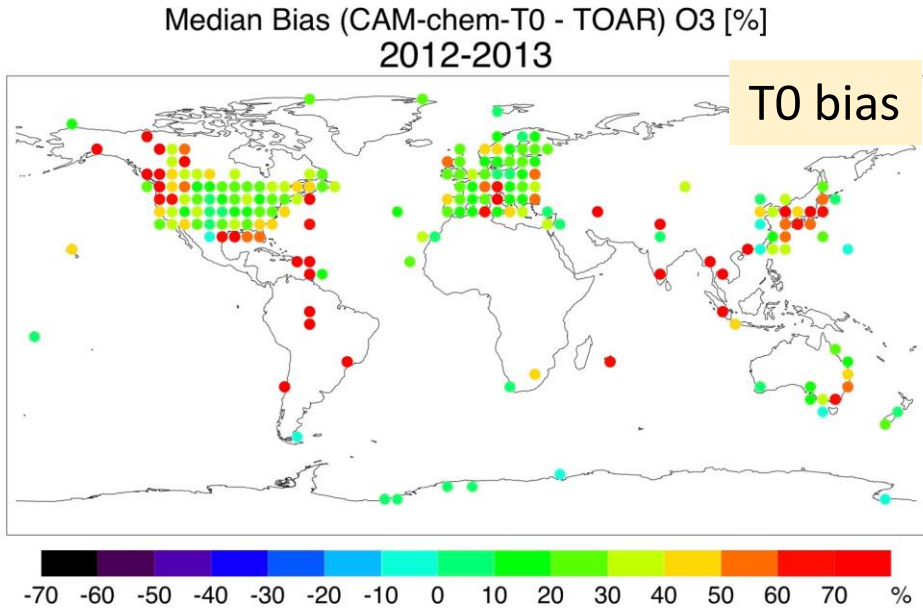
CESM2 Aug 2013 Surface Ozone - T1



CESM2 Aug 2013 Surface Ozone - (T1-T0)



T1 chemistry slightly reduces surface ozone bias, such as Summer in Southeast U.S.

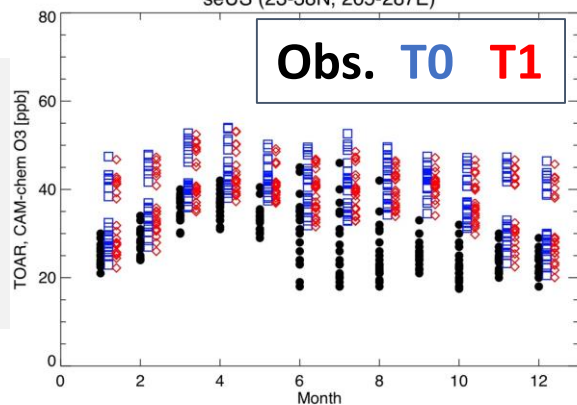




## SE U.S.

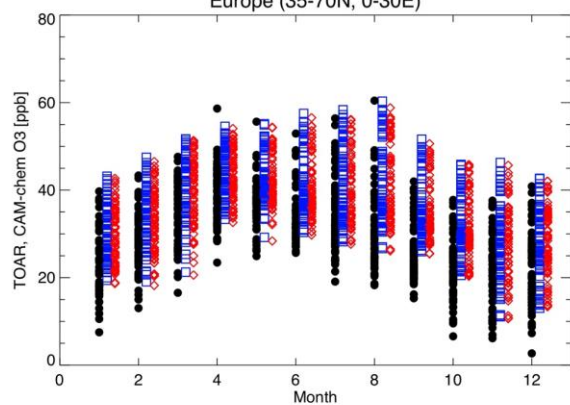
seUS (23-38N, 265-287E)

O3 [ppb]



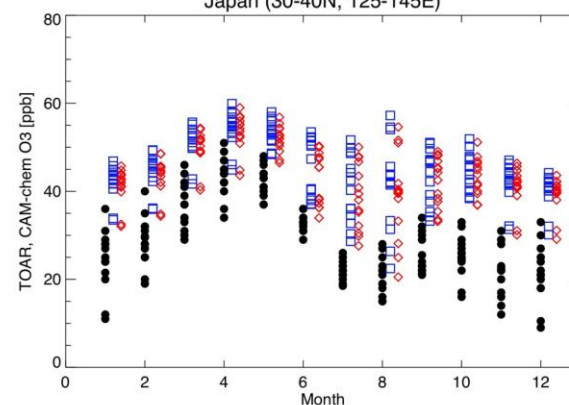
## Europe

Europe (35-70N, 0-30E)



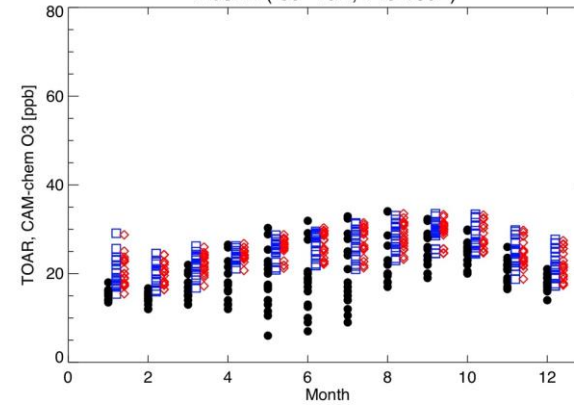
## Japan

Japan (30-40N, 125-145E)



## Australia-NZ

AusNZ (-50--15N, 140-180E)



Bias [%]

