# Chemistry-Climate Working Group
# Current Status – June 2016

Co-chairs: Louisa Emmons (NCAR),
Xiaohong Liu (U. Wyoming), Noelle Selin (MIT)

Liaison: Simone Tilmes (NCAR)

Software Engineer: Francis Vitt (NCAR)

*Chemistry-Climate Working Group Session – 23 June 2016*

# CAM-chem published versions

## CESM1.1.1 for CCMI (CAM4)

Tilmes, S., Lamarque, J.-F., Emmons, L. K., Kinnison, D. E., Marsh, D., Garcia, R. R., Smith, A. K., Neely, R. R., Conley, A., Vitt, F., Val Martin, M., Tanimoto, H., Simpson, I., Blake, D. R., and Blake, N.: Representation of the Community Earth System Model (CESM1) CAM4-chem within the Chemistry-Climate Model Initiative (CCMI), *Geosci. Model Dev., 9*, 1853-1890, doi:10.5194/gmd-9-1853-2016, 2016.

***CCMI and HTAP2 CAM-chem simulations have been posted on their respective archives, available for analysis***

## CESM1.2 (CAM4 or CAM5/MAM)

Tilmes, S., et al., Description and evaluation of tropospheric chemistry and aerosols in the Community Earth System Model (CESM1.2), *Geosci. Model Dev., 8*, 1395-1426, doi:10.5194/gmd-8-1395-2015, 2015.

## Scientifically validated release is available

https://www2.cesm.ucar.edu/models/scientifically-supported

- Includes updates for CCMI, MAM4, MEGAN corrections

# CCMI, HTAP2, Geo-engineering analyses


Heggelin, M. et al., Review of the global models used within the Chemistry-Climate Model Initiative (CCMI), *in preparation*.

Strode, S. A., Worden, H. M., Damon, M., Douglass, A. R., Duncan, B. N., Emmons, L. K., Lamarque, J.-F., Manyin, M., Oman, L. D., Rodriguez, J. M., Strahan, S. E., and Tilmes, S.: Interpreting space-based trends in carbon monoxide with multiple models, *Atmos. Chem. Phys., 16*, 7285-7294, doi:10.5194/acp-16-7285-2016, 2016.

Stjern, C. W., Samset, B. H., Myhre, G., Bian, H., Chin, M., Davila, Y., Dentener, F., Emmons, L., Flemming, J., Haslerud, A. S., Henze, D., Jonson, J. E., Kucsera, T., Lund, M. T., Schulz, M., Sudo, K., Takemura, T., and Tilmes, S.: Global and regional radiative forcing from 20 % reductions in BC, OC and $SO_4$ – an HTAP2 multi-model study, *Atmos. Chem. Phys. Discuss*., doi:10.5194/acp-2016-443, in review, 2016.

Tierno Doumbia et al., Temporal variability and long-term trends in tropospheric constituents distributions during the last decades simulated by the Community Atmospheric Model (CAM4-chem), *in preparation*.

Rafael P. Fernandez et al., Impact of natural very short-lived bromocarbons on the evolution of the Antarctic ozone hole during the 21st century, *in preparation*.

Lili Xia et al., Geoengineering studies using prescribed sulfates and solar dimming and its impact on tropospheric chemistry and crops, *in preparation*.

# CAM-chem development

- CESM1.5 development versions
  *- available for developers*
  - Expanded tropospheric chemistry (“TS1” - speciated aromatics, terpenes, updated isoprene oxidation, organic nitrates)
  - New SOA-VBS framework
  - Gas and aerosol emissions from CLM fire model, with vertical distribution applied in CAM (evenly distributed to an altitude dependent on PFT)
  - Ability to read 2 emissions files (different sectors, frequency) for a single compound

# Tropospheric Chemistry Mechanism

Improved treatment of SOA precursors:

- Speciated terpenes (C10H16 replaced with APIN, BPIN, LIMON, MYRC, BCARY, and products) with MEGAN emissions
  ***OR* new lumped monoterpenes with improved oxidation**
- Added MBO
- Replace lumped aromatic "TOLUENE" with specific BENZENE, TOLUENE, XYLENES
- Updates to isoprene oxidation scheme
- Improved treatment of organic nitrates (replace ONIT with more specific nitrates)

SOA –VBS framework uses this chemistry

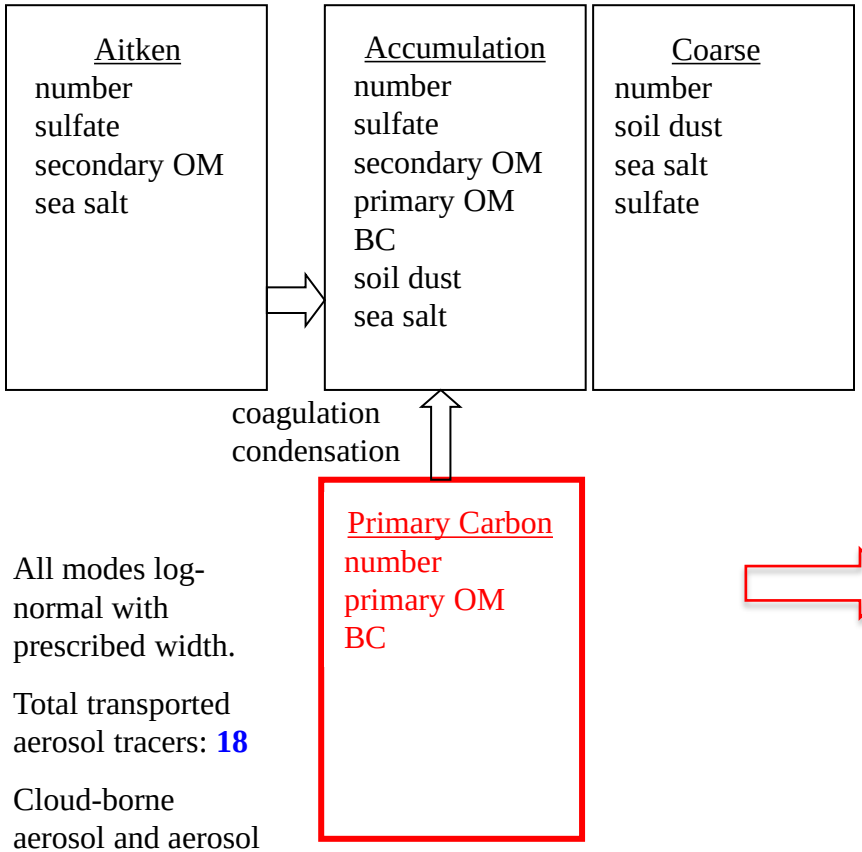
(Simone's talk, next)

Will work on an SOA-VBS for specified oxidants

Time to update to newest JPL recommendations

# 4-mode version of Modal Aerosol Module (MAM4)

Liu et al., GMD (2016)



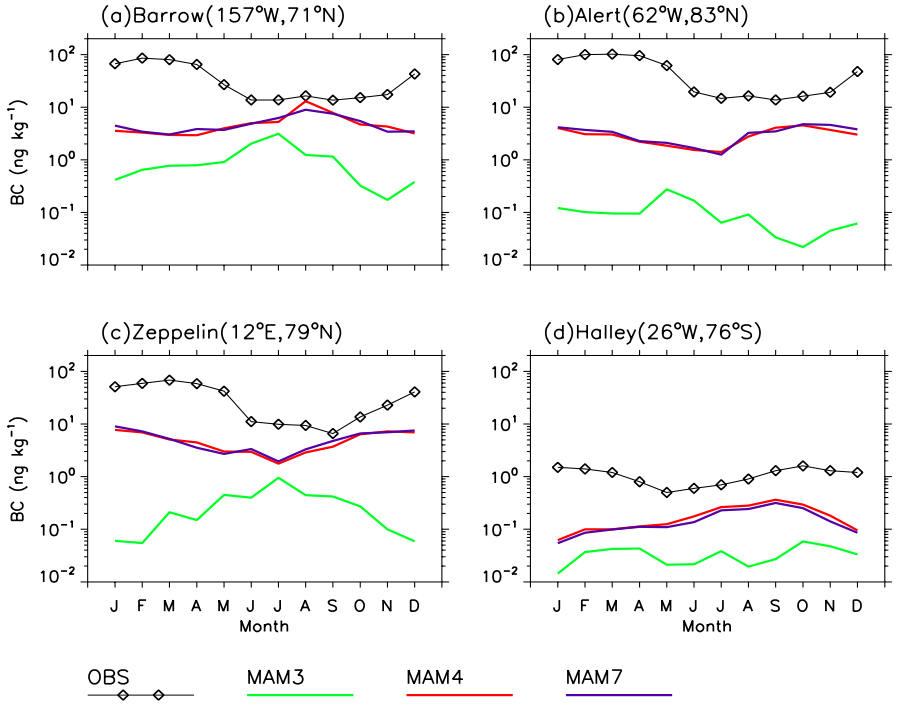

All modes log-normal with prescribed width.

Total transported aerosol tracers: **18**

Cloud-borne aerosol and aerosol water predicted but not transported.

Adding a primary carbon mode in MAM4, and computer time is ~10% higher than MAM3

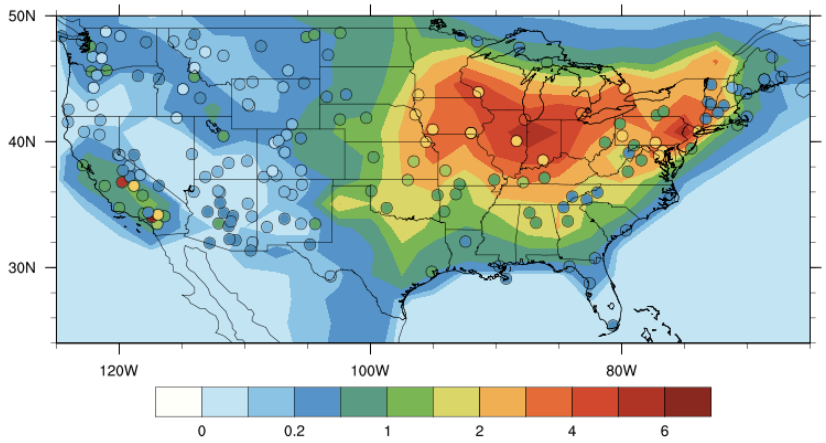
**MAM4 significantly increases (and improves) BC concentration in Arctic compared to MAM3 (and agrees with MAM7).** The remaining underestimation of BC concentration in Arctic in MAM4 is very likely due to wet scavenging by precipitation and/or emissions.



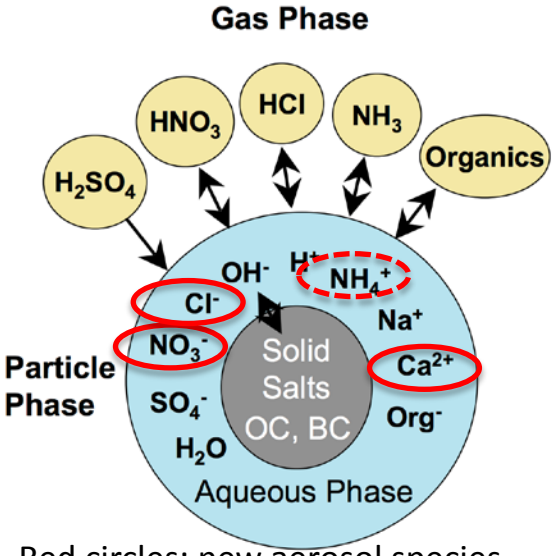

Comparison of model results (MAM3, MAM4, MAM7) with seasonal BC observations at surface in high latitudes

# Nitrate aerosol in CESM

- MOSAIC (Model for Simulating Aerosol Interactions and Chemistry ) aerosol scheme developed by Zaveri et al. [2008] has been implemented in CAM/CESM to treat nitrate ($NO_3$).
- The MOSAIC scheme
  - can be run with MAM4 or MAM7 and with MOZART chemistry.
  - treats gas-aerosol exchange (other aerosol processes, such as coagulation, wet/dry removal are still treated by MAM).
  - treats new aerosol species, including $NO_3$, $Cl^-$

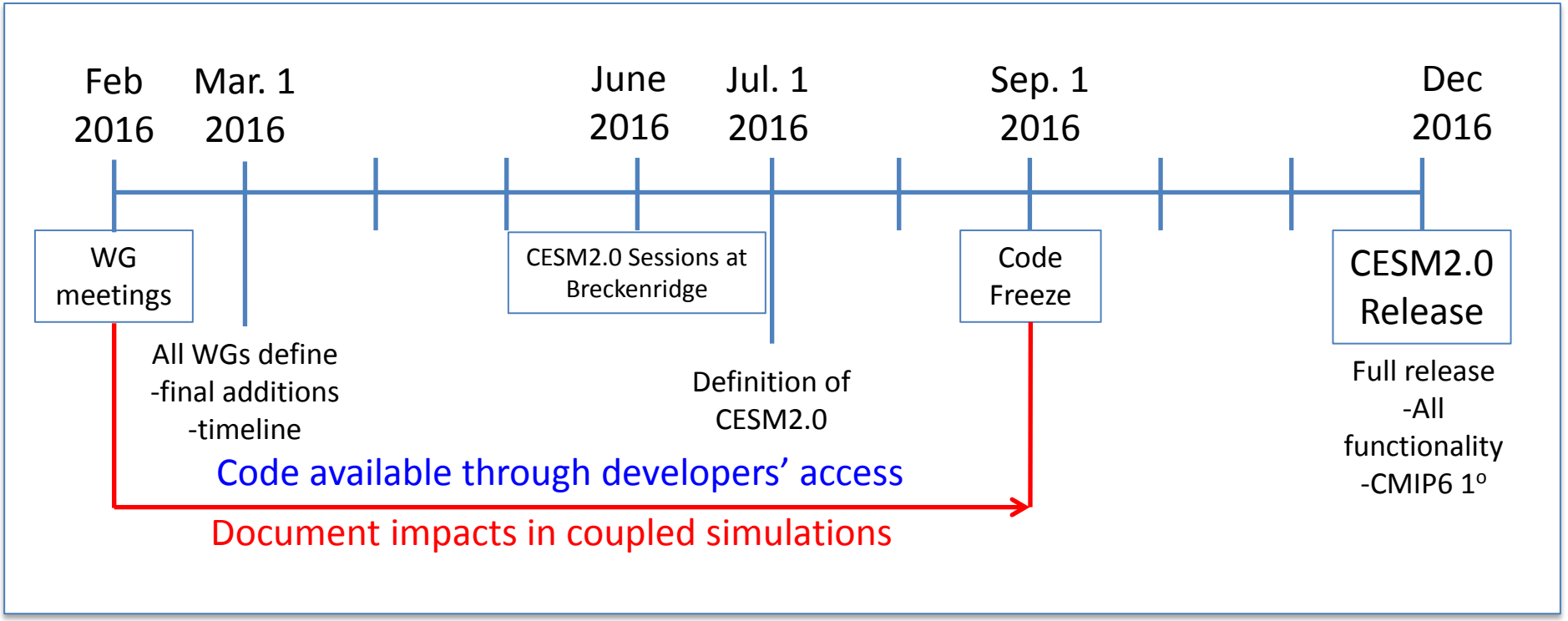



Mass concentration of $NO_3$ (μg/m$^3$) at surface modeled by MOSAIC-MAM7 in comparison with IMPROVE dataset




Red circles: new aerosol species
Source: the presentation by Zaveri, WRF tutorial, 2008

# Timeline


Feb 2016
Mar. 1 2016
June 2016
Jul. 1 2016
Sep. 1 2016
Dec 2016
WG meetings
All WGs define
-final additions
-timeline
CESM2.0 Sessions at Breckenridge
Definition of CESM2.0
Code Freeze
CESM2.0 Release
Full release
-All functionality
-CMIP6 1°
Code available through developers' access
Document impacts in coupled simulations

# Plans for CESM2 (for CMIP6)
## *Code freeze Sept 1 → Release Dec 2016*

Final tunings of SOA-VBS implementation – photolysis

Nitrate aerosol in MAM

Test couplings of land, biogeochemistry and atmospheric chemistry (after CLM has been frozen)

- Including methane, biogenic VOCs, fire emissions, crops

Test chemical representation in CAM6/CLUBB at 1-degree

# Post CESM2 Development Plans

- Evaluate chemistry in CAM/WACCM with new dynamics (e.g., CLUBB-Deep)
- Test next generation dynamical cores: Spectral Element/CSLAM and CESM-MPAS
- Improve MEGAN biogenic emissions (in CLM) and adapt to Ecosystem Demography representation in CLM (Alex Guenther, UCI)
- Continue to improve fire emissions vertical distribution (CLM+CAM)
- Fast-J

# Discussion

- What is going to make it into the CMIP6 WACCM simulations (there will be no CAM-chem simulations)?
- Unifying CAMchem/WACCM chemical mechanism
- Beyond CMIP6, which compsets do we want to have for CAM-chem in CESM2? and which mechanisms?
- Improved meteorological nudging in CAM-chem/WACCM
- Interactive fires (depends on land model)
- Who will have time/resources to implement FAST-J? And When?
- CSL proposal – CMIP6/AerChemMIP and other development and science