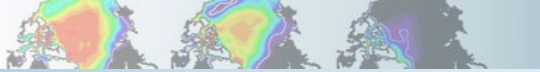


Status of CAM -chem

Chemistry -Climate Working Group

Co-chairs: Louisa Emmons (NCAR)
Xiaohong Liu (Texas A&M University)
Liaison: Simone Tilmes (NCAR)
Software Engineer: Francis Vitt (NCAR)

Louisa Emmons
ACOM, NCAR

9 March 2020

NCAR

NSF

CAM-chem Status

Papers describing chemistry and aerosols in CESM2

- MOZART-T1 chemistry (Emmons et al., *JAMES,* in review)
- VBS-SOA (Tilmes et al., *JAMES*, 2019)
- WACCM6 (Gettelman et al., *JGR-Atmos*, 2019)

Implementing for CESM2.2

- Aerosol wet scavenging improvements
- Brown Carbon radiative effects
- MOSAIC-MAM aerosols (includes ammonium, nitrate aerosols)
- NOx-dependent SOA formation
- Online photolysis (TUV) [*Bardeen talk on Tuesday*]
- Online ocean emissions (OASISS) of DMS, VOCs [Siyuan Wang, GRL, 2019]
- MOZART-T2 (expanded isoprene & terpene oxidation) (Schwantes et al., *ACP*, 2020) [*Schwantes talk Tuesday*]

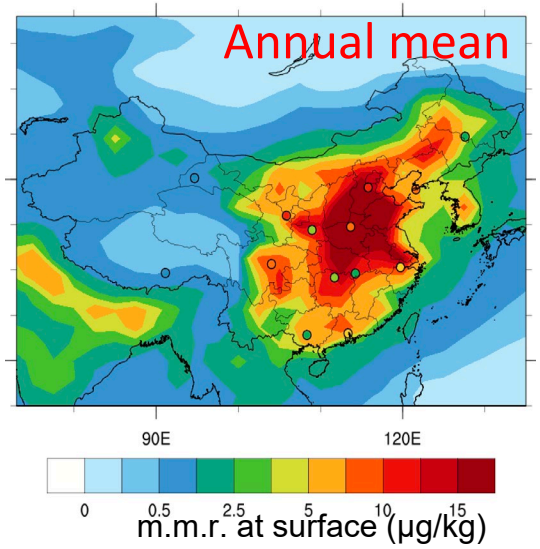
Nitrate Aerosols in CESM2

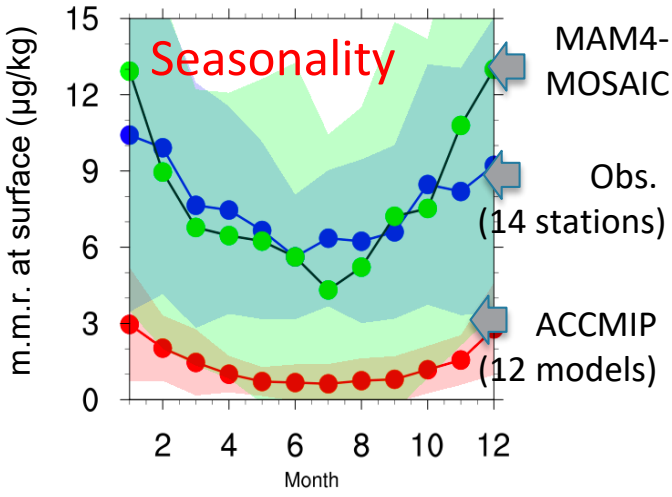
- In order to better treat nitrate (NO_3^-) aerosols, Model for Simulating Aerosol Interactions and Chemistry (MOSAIC) module [Zaveri et al., 2008] is coupled with MAM7 and MAM4 in CESM [Zaveri et al., in prep.; Zheng Lu et al., in prep.]
- In the version of MAM coupled with MOSAIC, gas-aerosol exchange is treated by MOSAIC. The other processes are handled by MAM.

Mode	BC	POM	SOA	SO4	NH4	NO3	Cl	Na	Dst	Ca	CO3	total
a1	X	X	X	X	X	X	X	X	X	X	X	11
a2			X	X	X	X	X	X	X	X	X	9
a3				X	X	X	X	X	X	X	X	8
a4	X	X										2

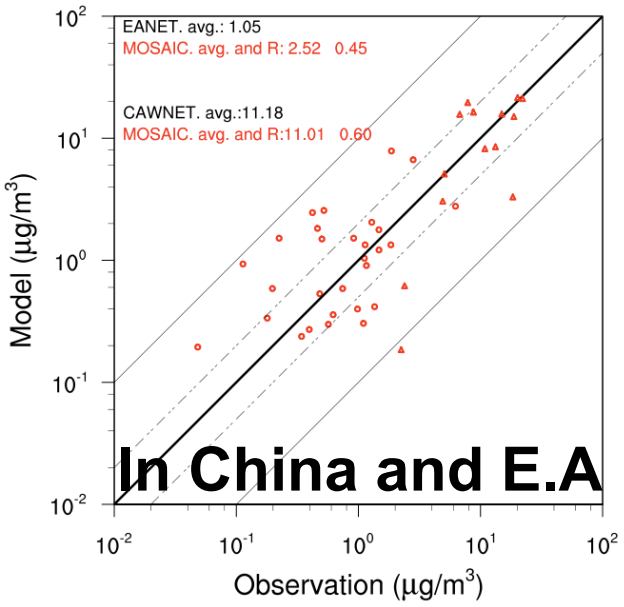
Red crosses: new aerosol tracers in MAM4-MOSAIC
a1: accumulation
a2: Aitken
a3: coarse
a4: primary carbon

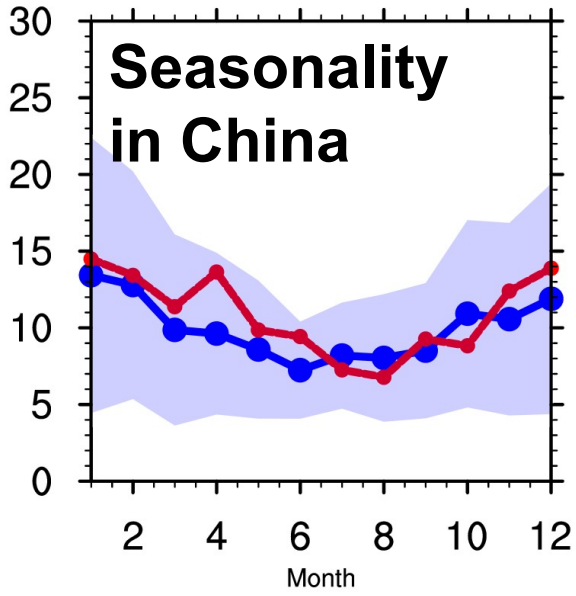
Modeled NO3 vs. observation over China

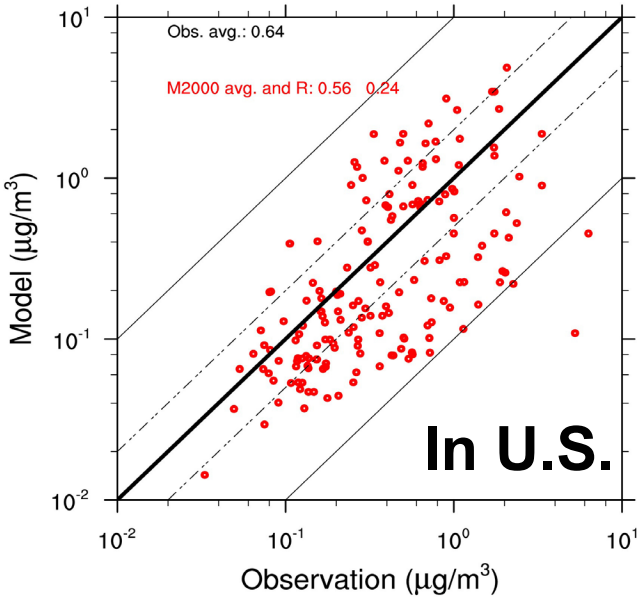




Validation of nitrate aerosol simulation in CESM2







Modeled surface mass concentration of nitrate aerosol in good agreement in E. Asia, including China, U.S. and E.U.

Brown Carbon (BrC) in CESM2

Based on Brown et al. ACP, 2018

Organic aerosols from biomass and biofuel burning can contribute to shortwave radiation absorption

BrC parameterization

From Saleh et al. (2014):

$1.7\ (\pm\ 0.2) + k_{OA} i\ =$
$1.7\ (\pm\ 0.2) + k_{OA,550}(550/\lambda)^{w}\ i$

$k_{OA,550} =$
$0.016 * \log_{10}(\text{BC-to-OA}) + 0.04$

$w = 0.21\ /\ (\text{BC-to-OA} + 0.07)$

modal_aer_opt.F90

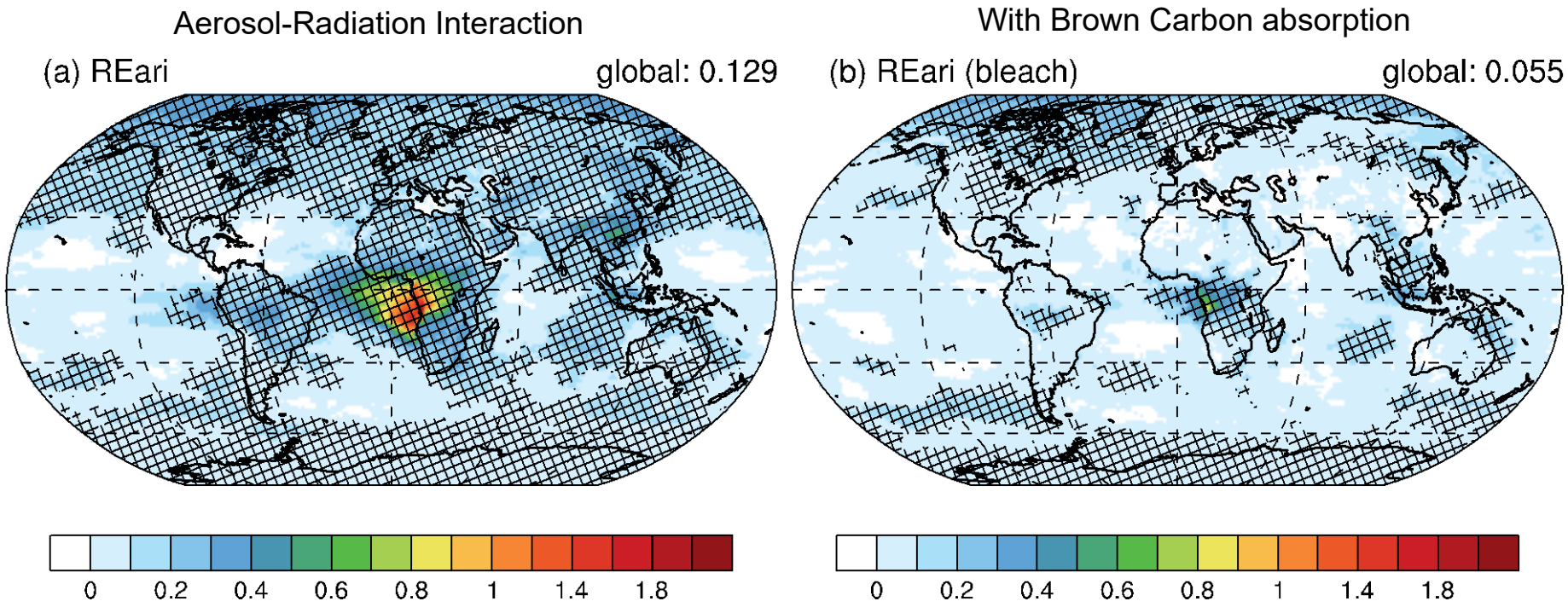
Call the different species optical properties at each mode, level, wavelength, lat/lon

Calculate bulk refractive index for each mode

Modify refractive index for *biomass burning* and *biofuel POM* based on BC-to-OA ratio calculated at each timestep, grid cell.

Saleh et al. (2014). "Brownness of Organics in Aerosols from Biomass Burning Linked to Their Black Carbon Content." *Nature Geoscience* **7**, 647–650.

Brown Carbon Direct Radiative Effect (DRE)



Brown carbon DRE from chemical transport models:

DRE (w/o bleaching)

Feng et al., 2013: **0.04–0.11 W m^{-2}**

Wang et al., 2014: **0.11 W m^{-2}**

Saleh et al., 2015: **0.13 W m^{-2}**

Jo et al., 2016: **0.11 W m^{-2}**

DRE (w/ bleaching)

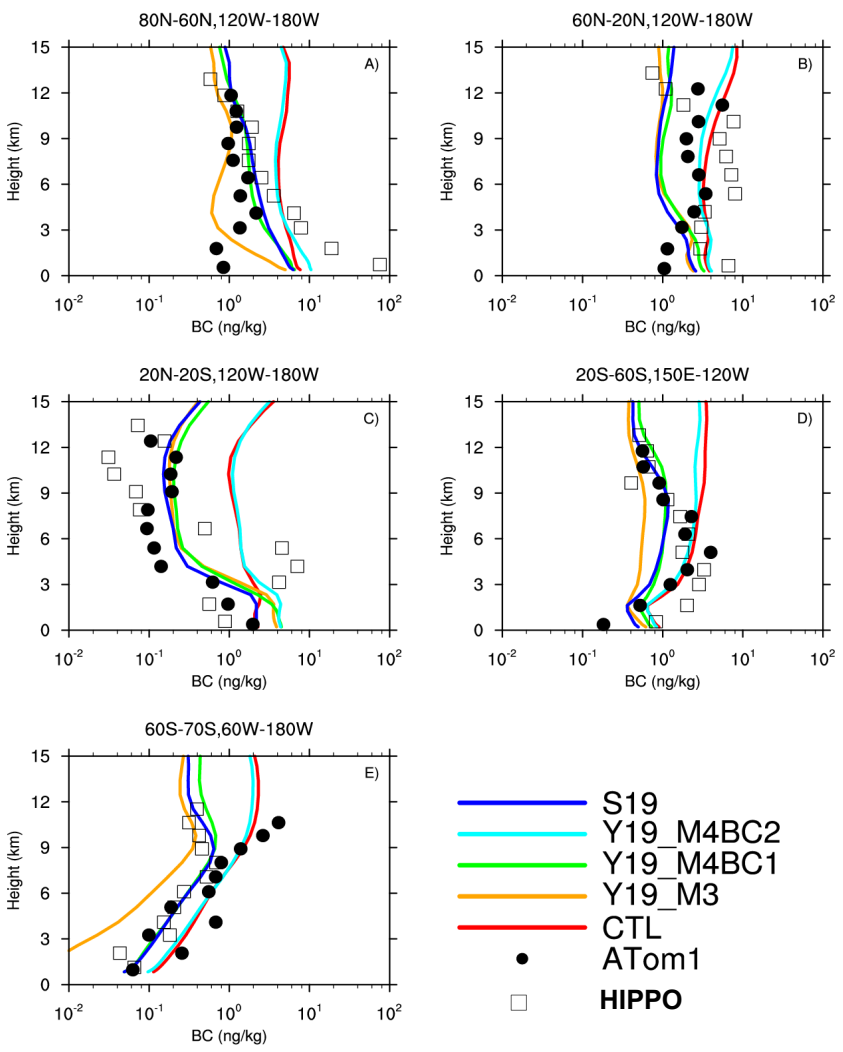
Wang et al., 2018: **0.05 W m^{-2}**

Based on Brown et al. ACP, 2018

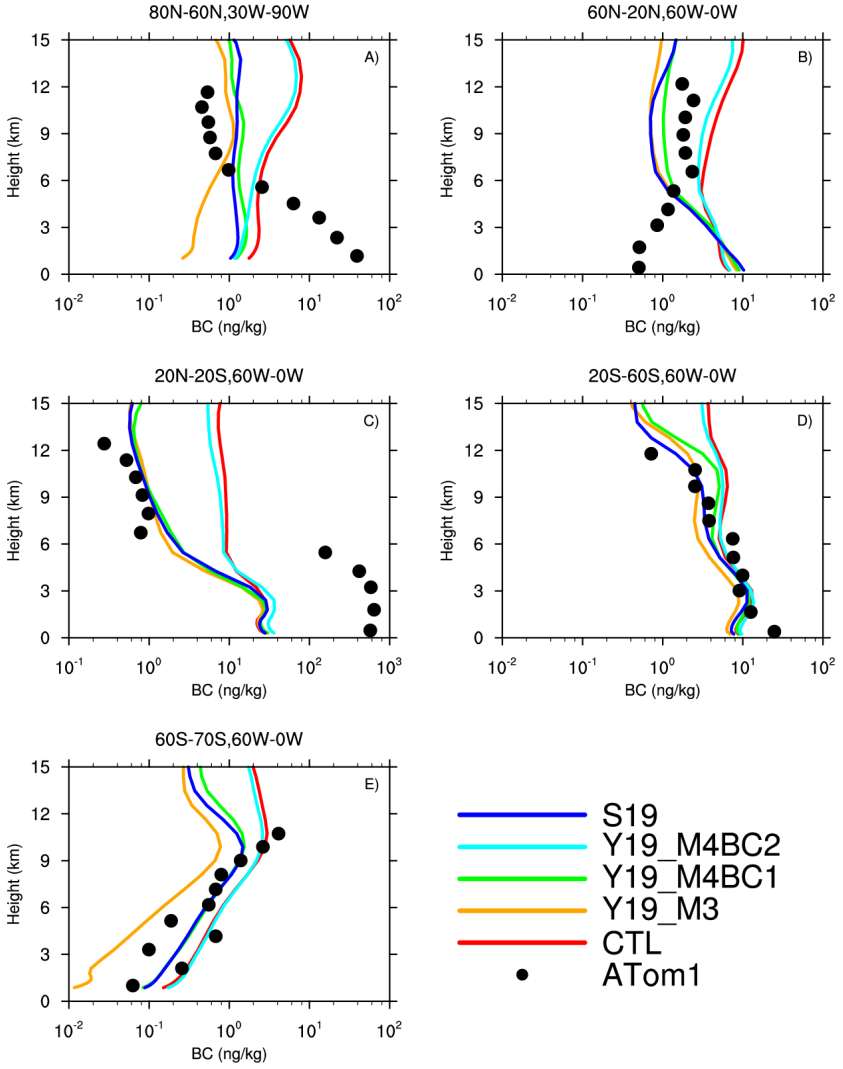
Improved aerosol profile by changing wet removal scheme

Schemes by Yunpeng Shan (S19) and Pengfei Yu (Y19)

Pacific Ocean

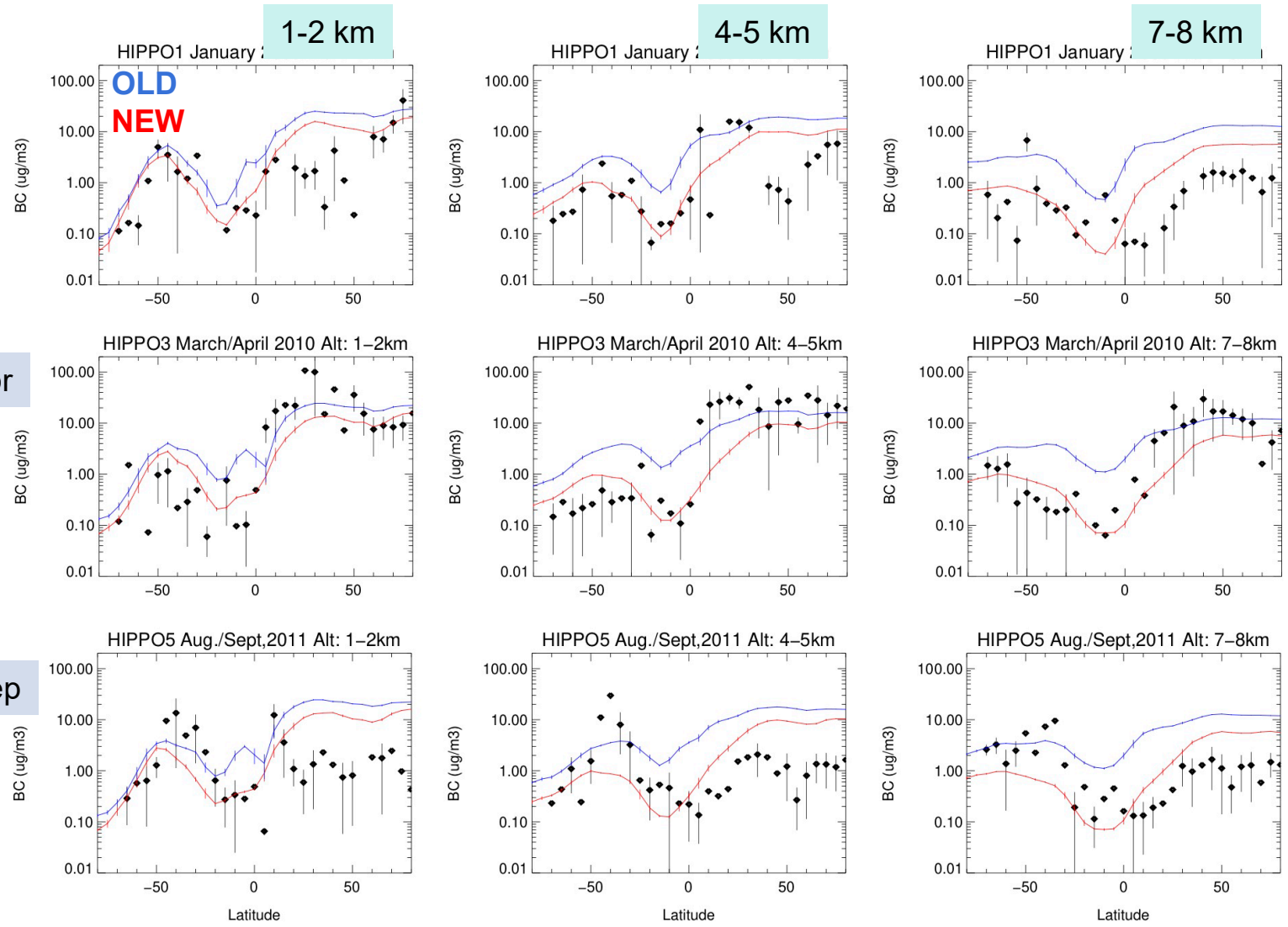


Atlantic Ocean

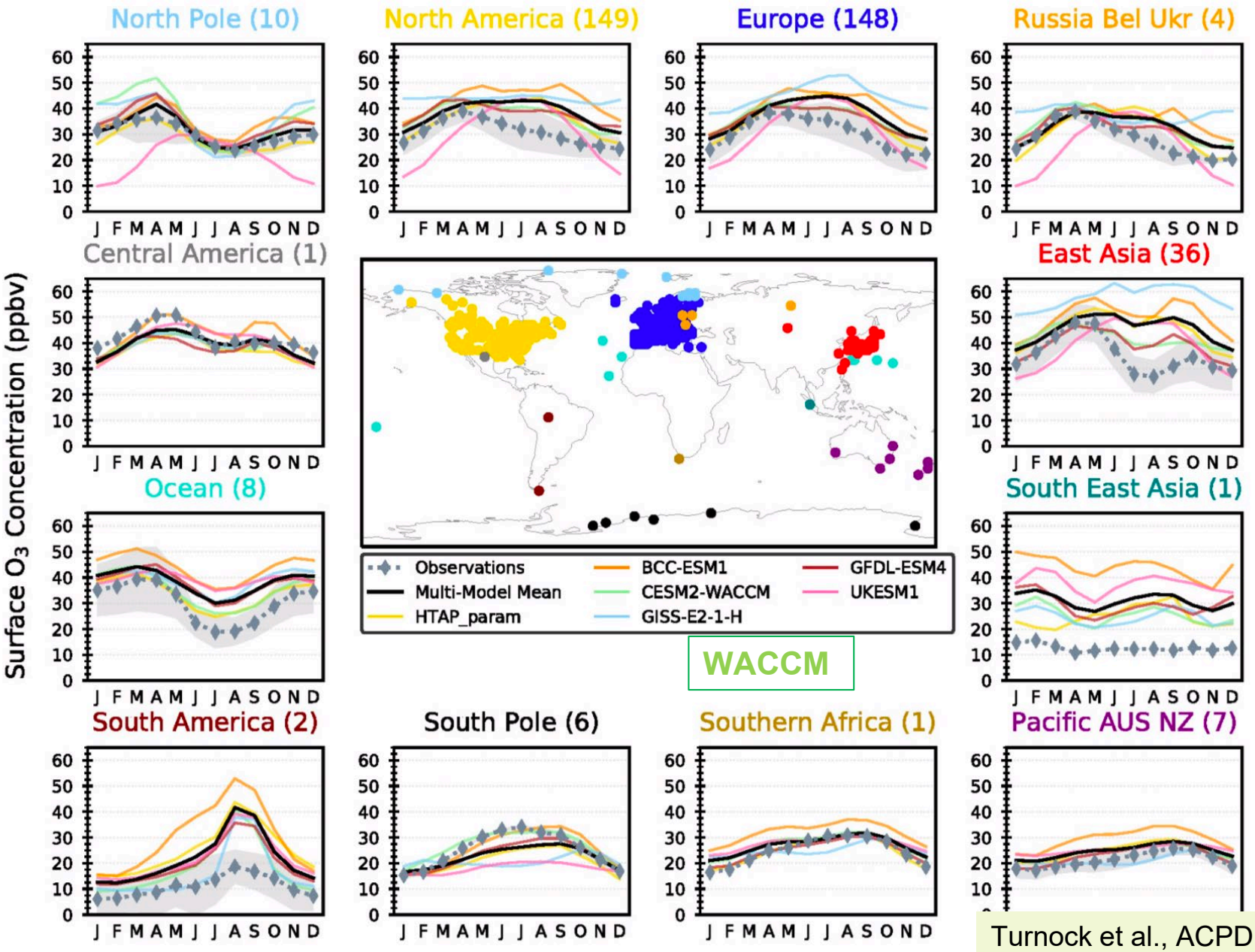


Improved Aerosol Scavenging for CESM2.2

Yunpeng Shan's scheme in CESM2.1 (Simone Tilmes)

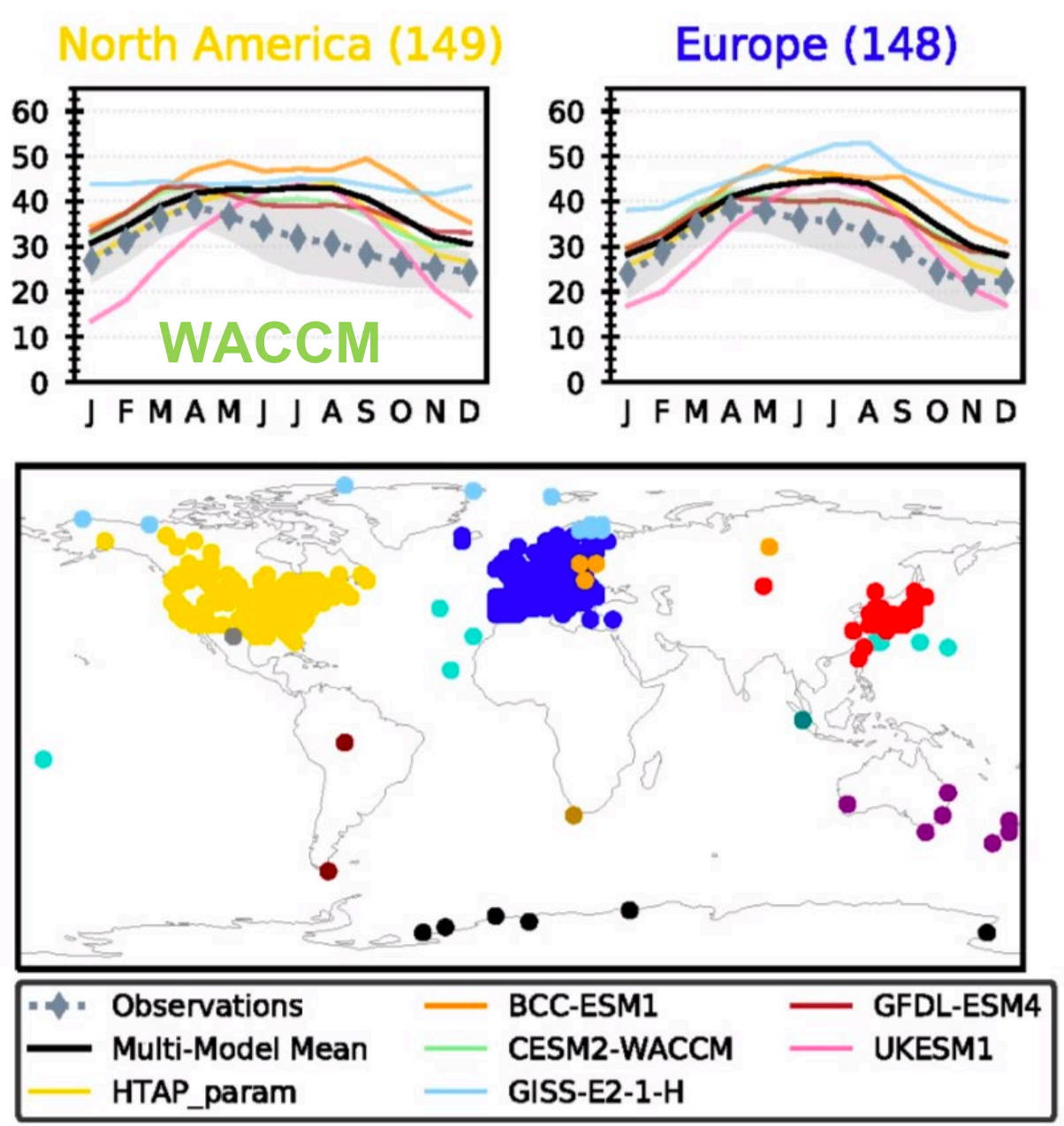


Surface Ozone evaluation for CMIP6 models



Turnock et al., ACPD, 2020

Surface Ozone evaluation for CMIP6 models

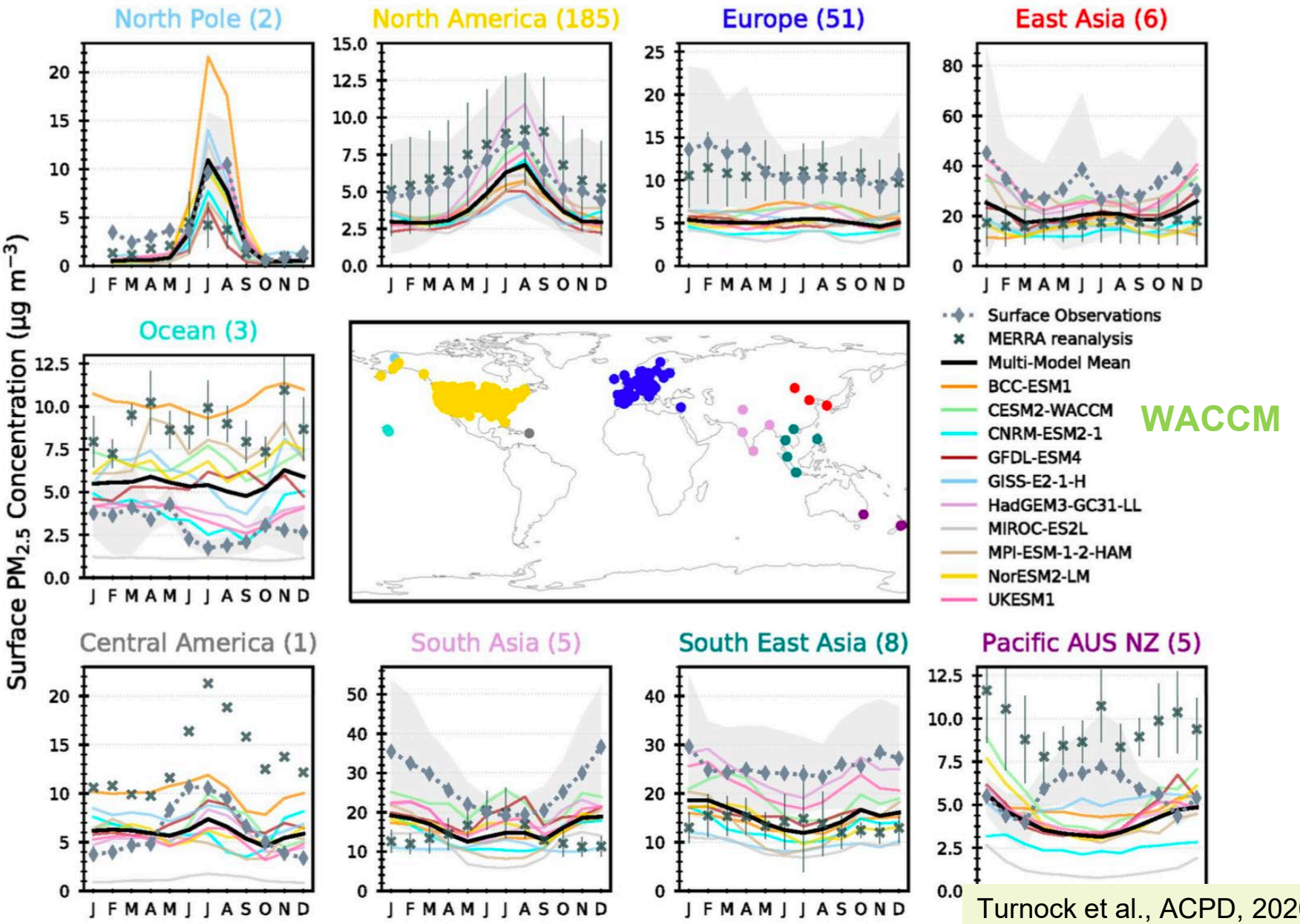


N. America, Europe – WACCM matches model mean, higher than obs in summer (long-time problem for models)

E.Asia – WACCM closer to obs than most models

Turnock et al., ACPD, 2020

Surface PM2.5 evaluation for CMIP6 models

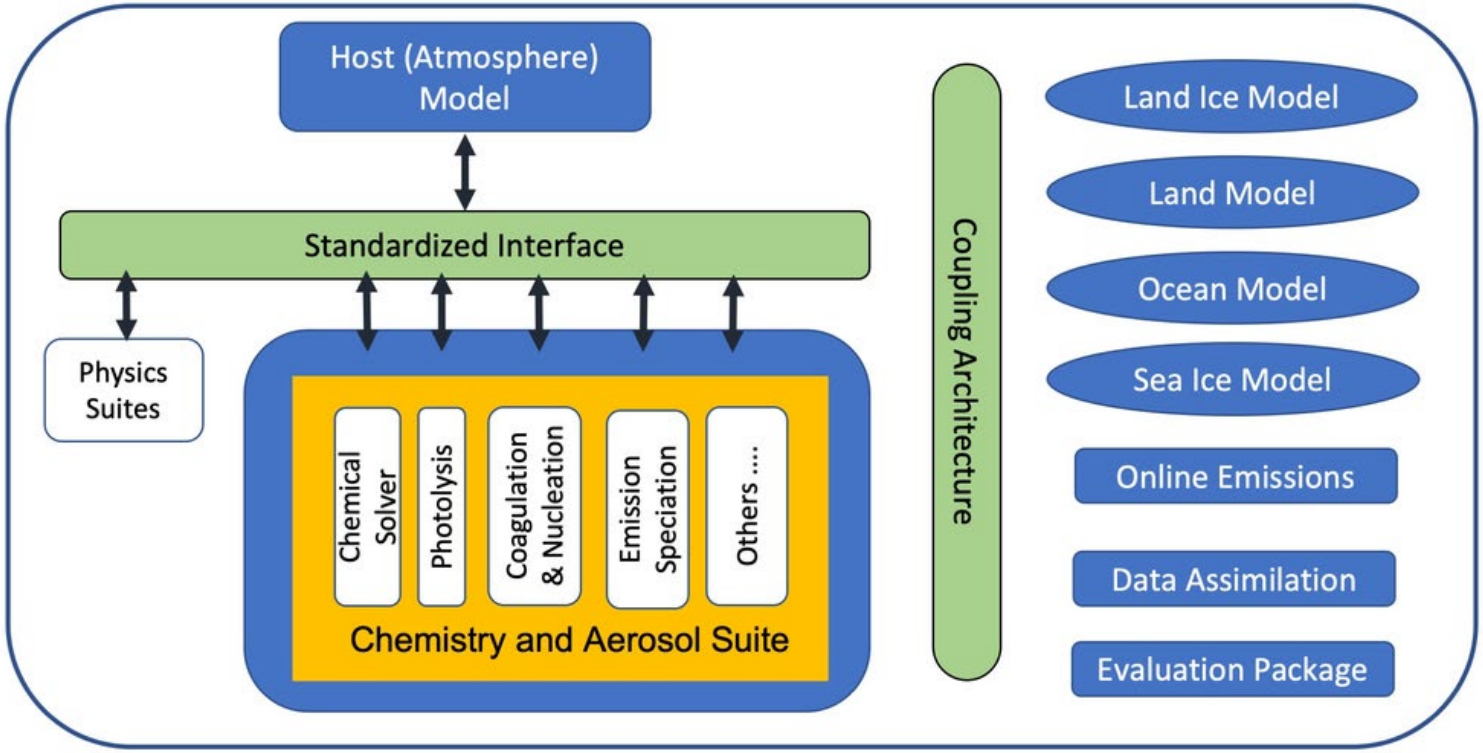


Turnock et al., ACPD, 2020

MUSICA: MUlti -Scale Infrastructure for Chemistry & Aerosols

MUSICA
Multiscale Infrastructure for Chemistry and Aerosols

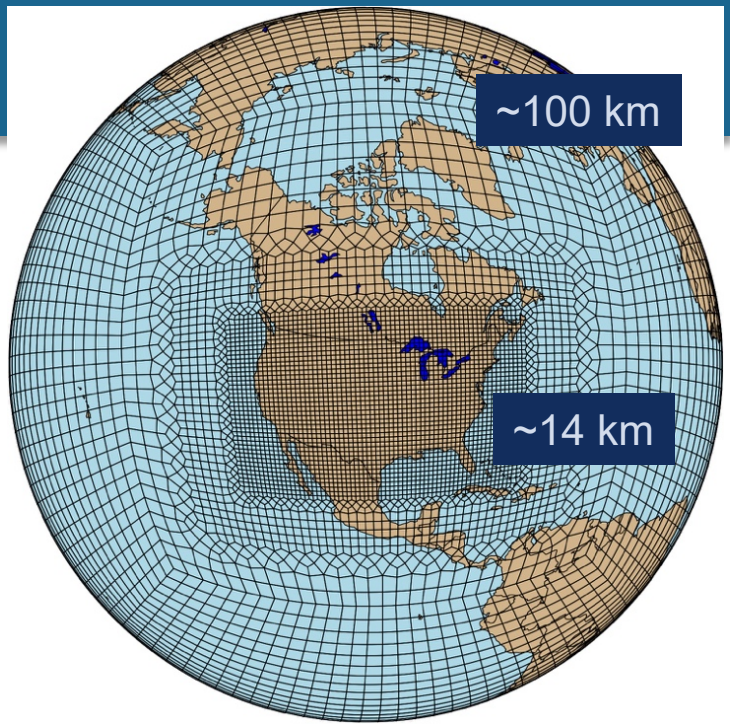
A new model-independent infrastructure, which will enable chemistry and aerosols to be simulated at different resolutions in a coherent fashion

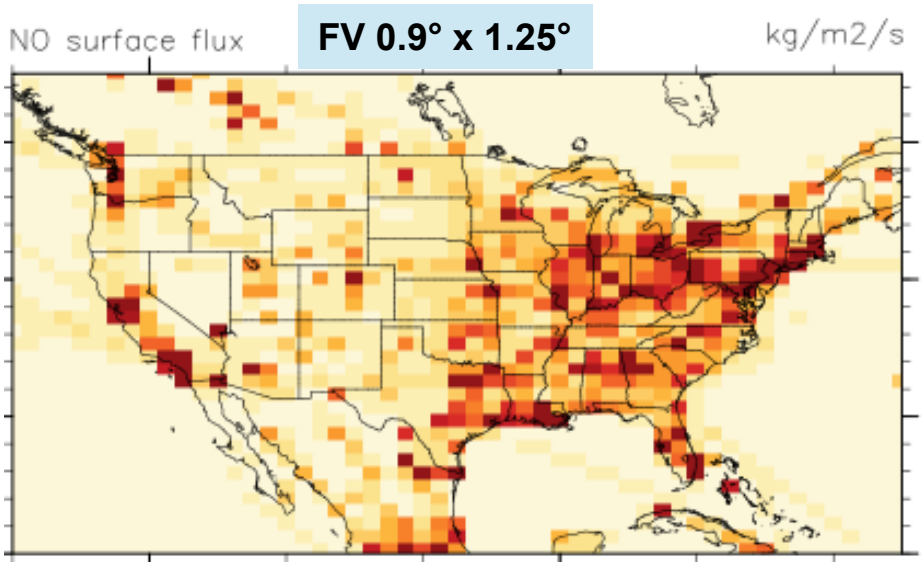


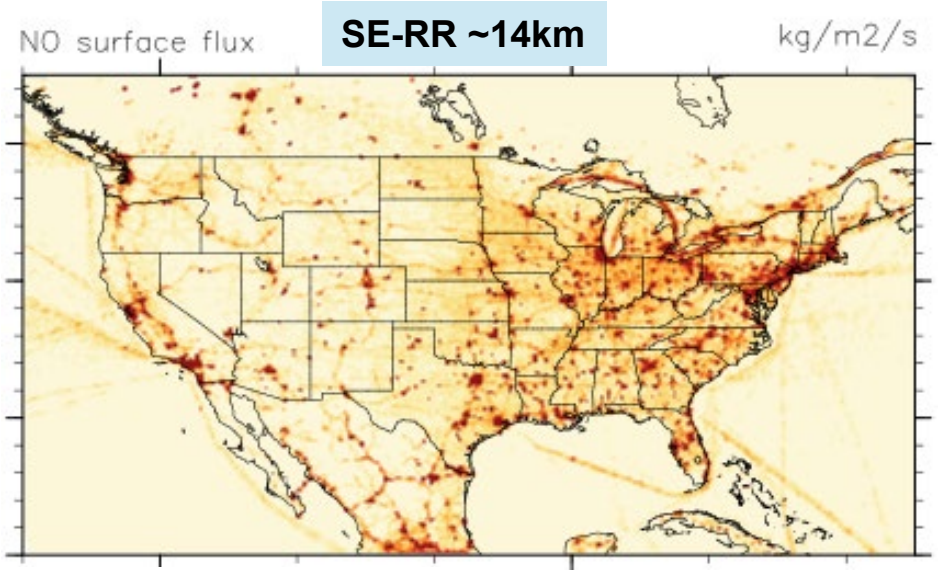
- Tutorial: June 18-19 – Application deadline May 1
  https://www2.acom.ucar.edu/workshop/musica -tutorial-2020
- MUSICA-V0 (CAM-chem-SE-RR) release in June 2020

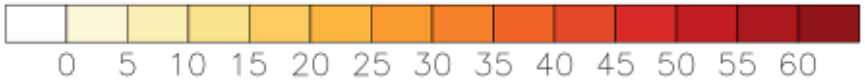
Emissions at Model Resolution

Anthropogenic emissions at 0.1 degree horizontal resolution are conservatively regridded to standard CESM 1 degree and SE Regionally Refined approximately 1/8 degree (14 km)

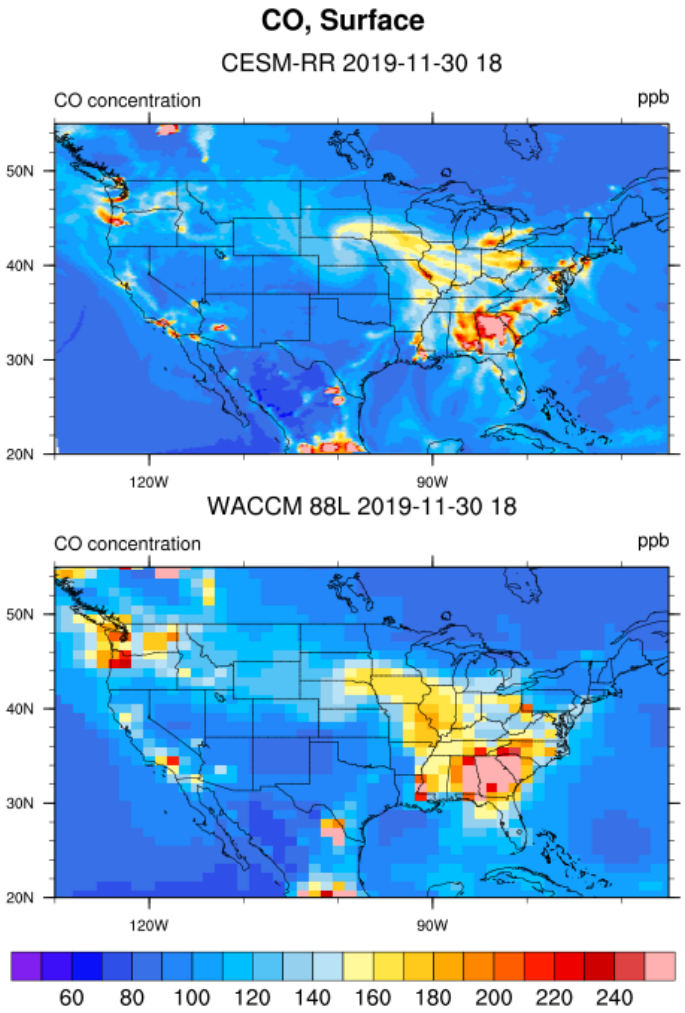


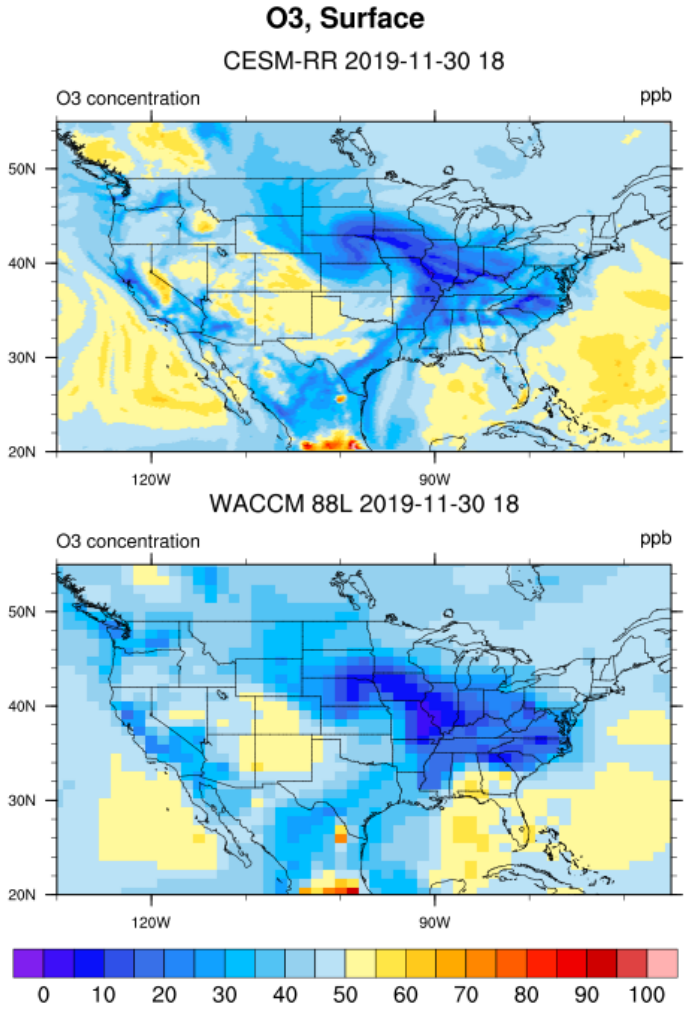






Regionally Refined vs 1 -degree



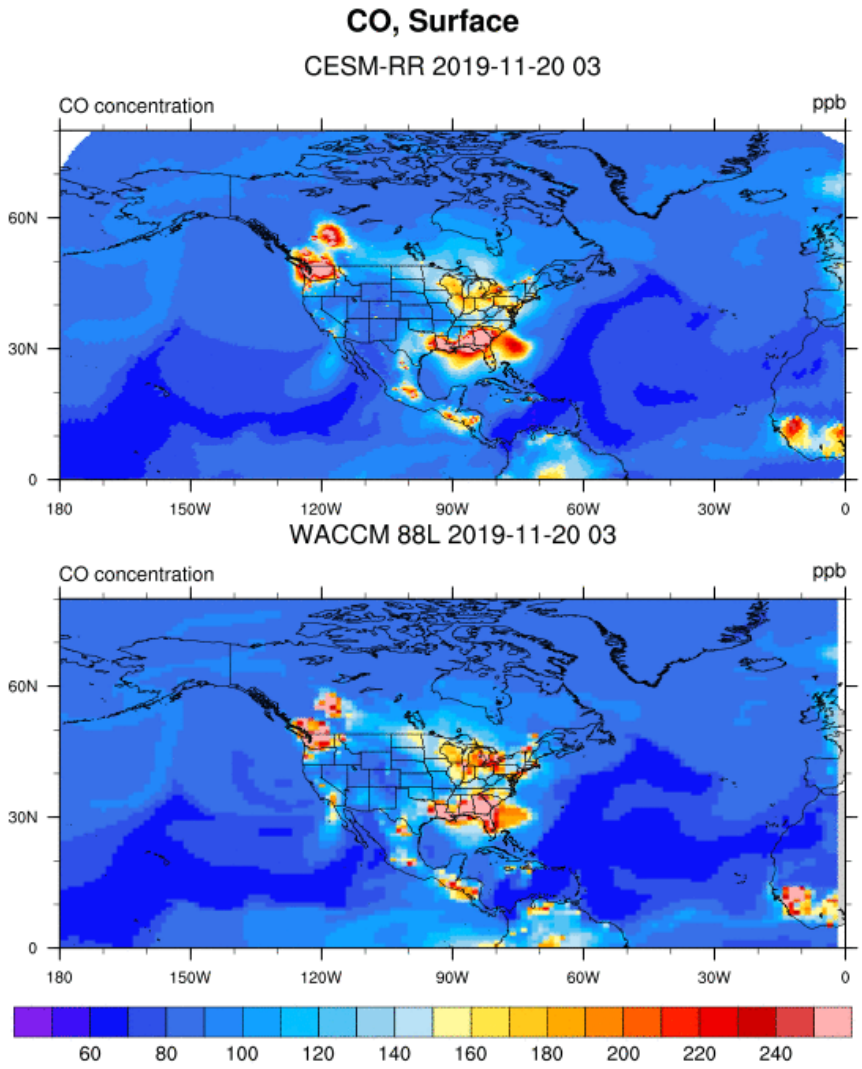


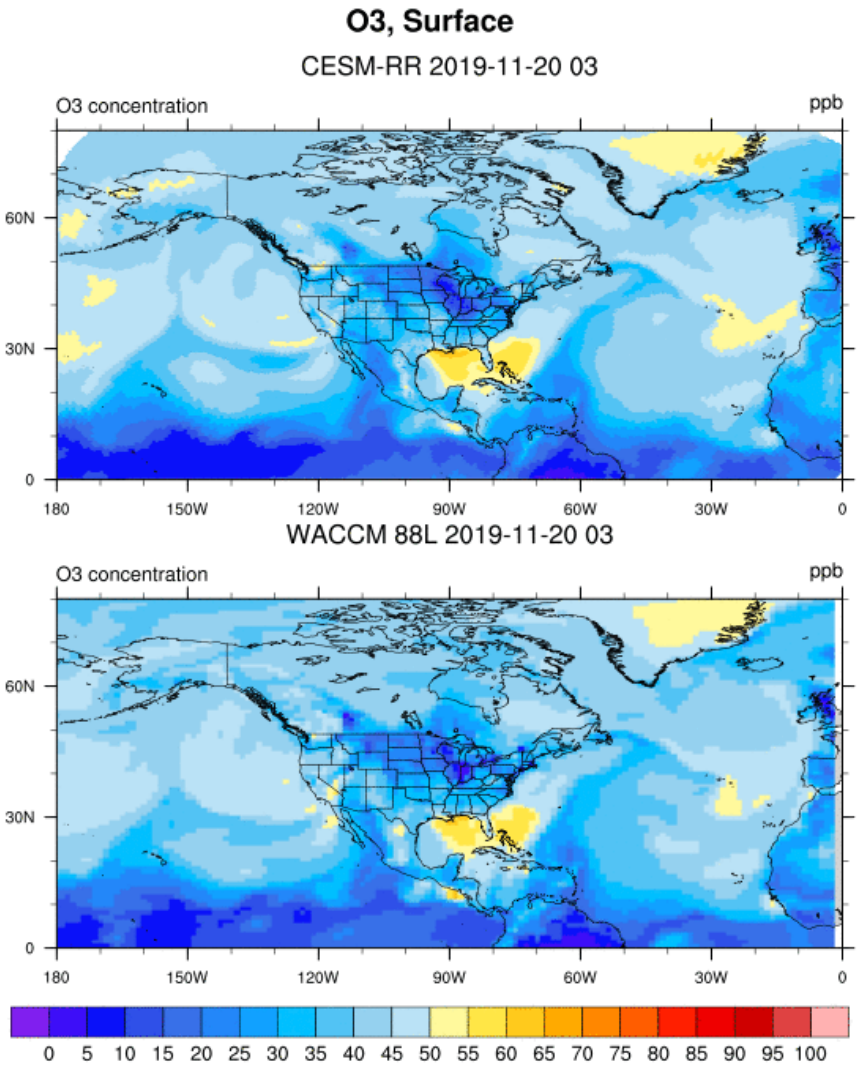
CO urban sources and pollution plumes are more refined in CAMchem-SE-RR than 1-degree

Slightly higher ozone over Atlantic and Pacific in RR

- change in chemistry and dynamics (stratospheric contribution)

MUSICA-V0: CAM-chem-SE-RR -- Nov 20-30, 2019



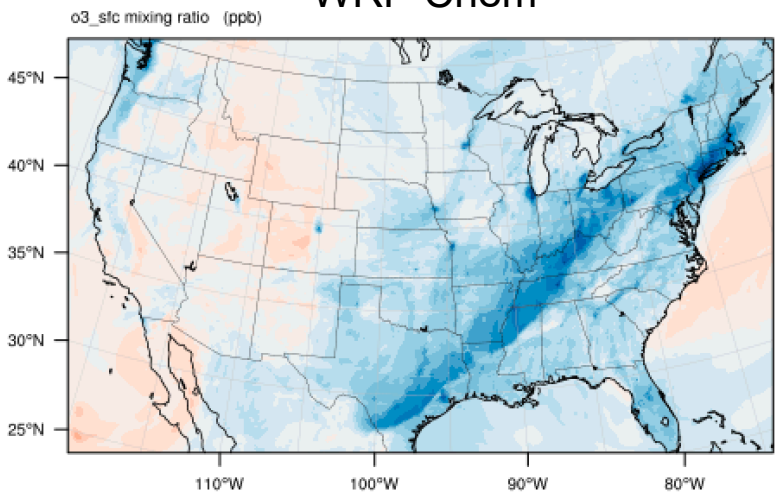


Chemical Forecasts – Surface Ozone

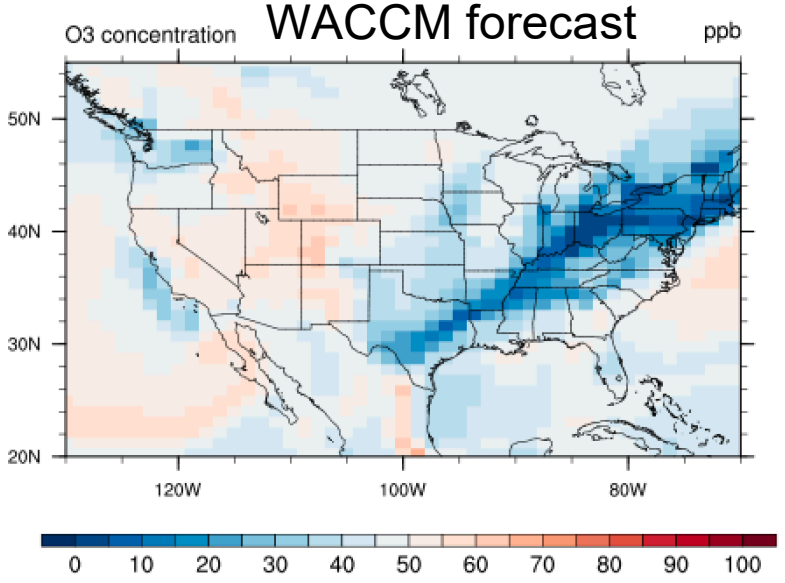
February 11th

https://www2.acom.ucar.edu/acresp/forecasts-and-near-real-time-nrt-products

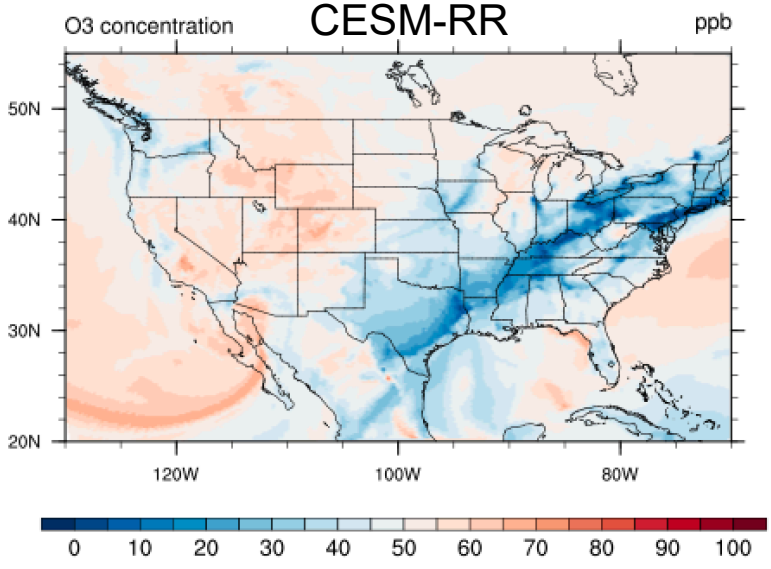
WRF-Chem



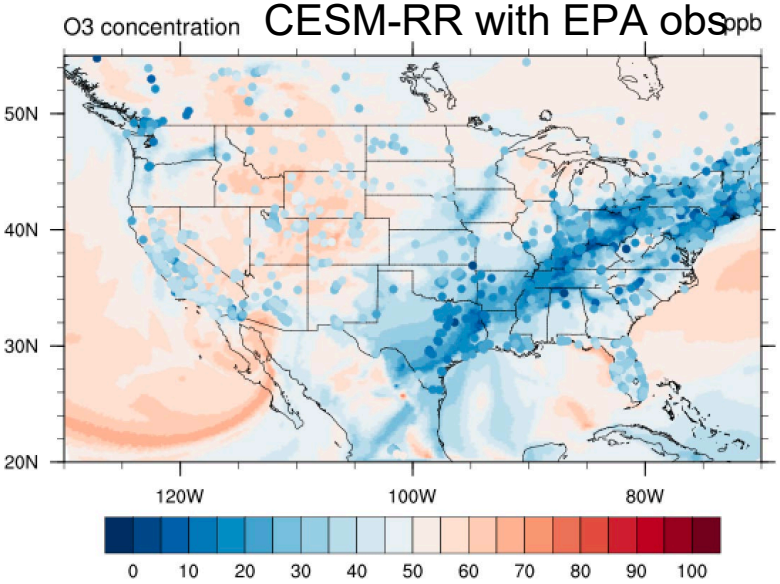
WACCM forecast



CESM-RR



CESM-RR with EPA obs



Development Activities

- Expanded alkane chemistry [R. Schwantes, paper in prep.]
- VSLS Halogen Chemistry
- Connecting GEOS-Chem module to CESM (MIT & Harvard)
- Connecting HEMCO emissions module to CESM2 (Harvard)
- Simpler chemistry for climate simulations
  (e.g., reduced HC, MOZART-2) – Discussion on Tuesday AM