

Air quality and chemistry

Presented by

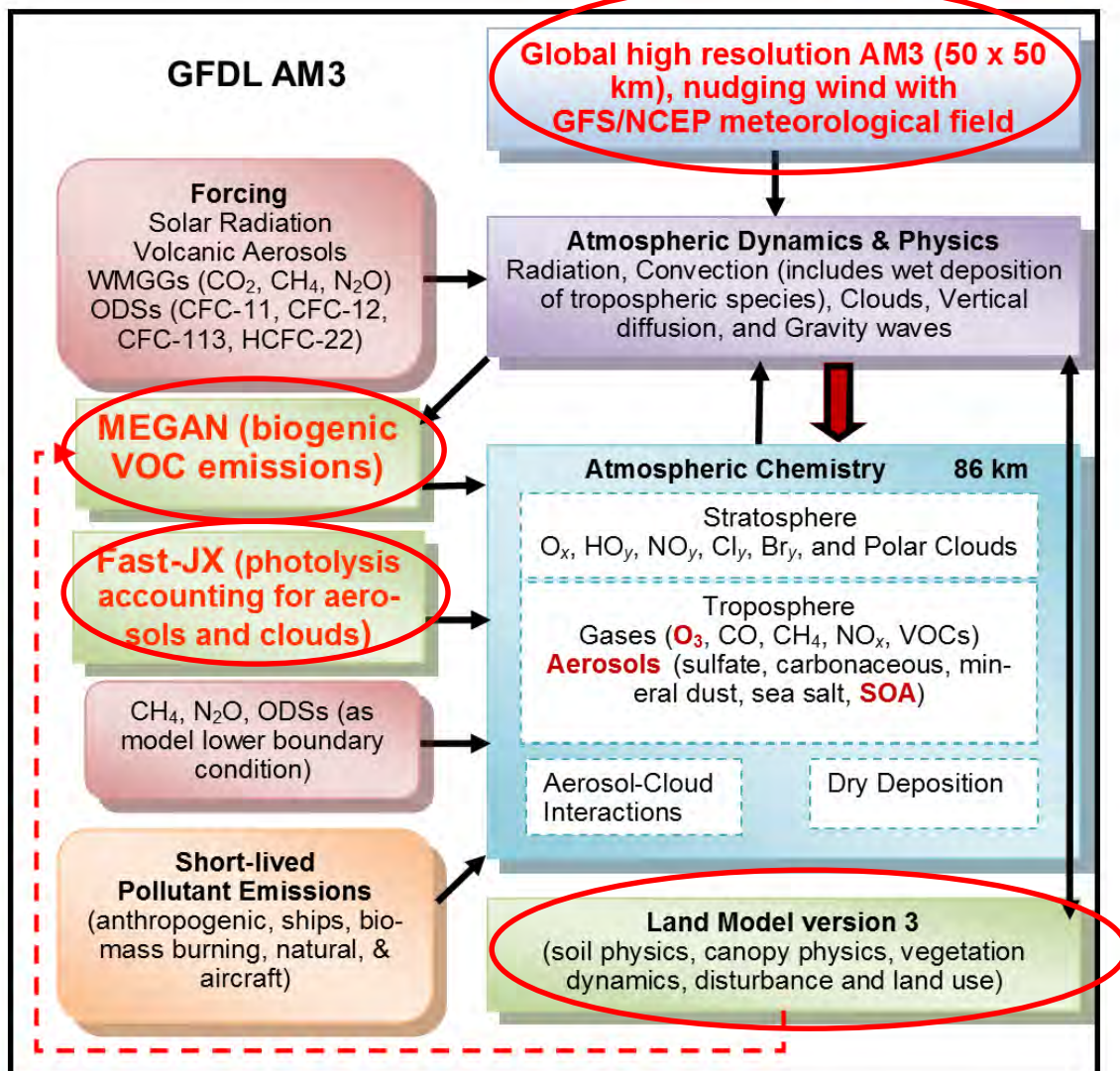
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Geophysical Fluid Dynamics Laboratory Review

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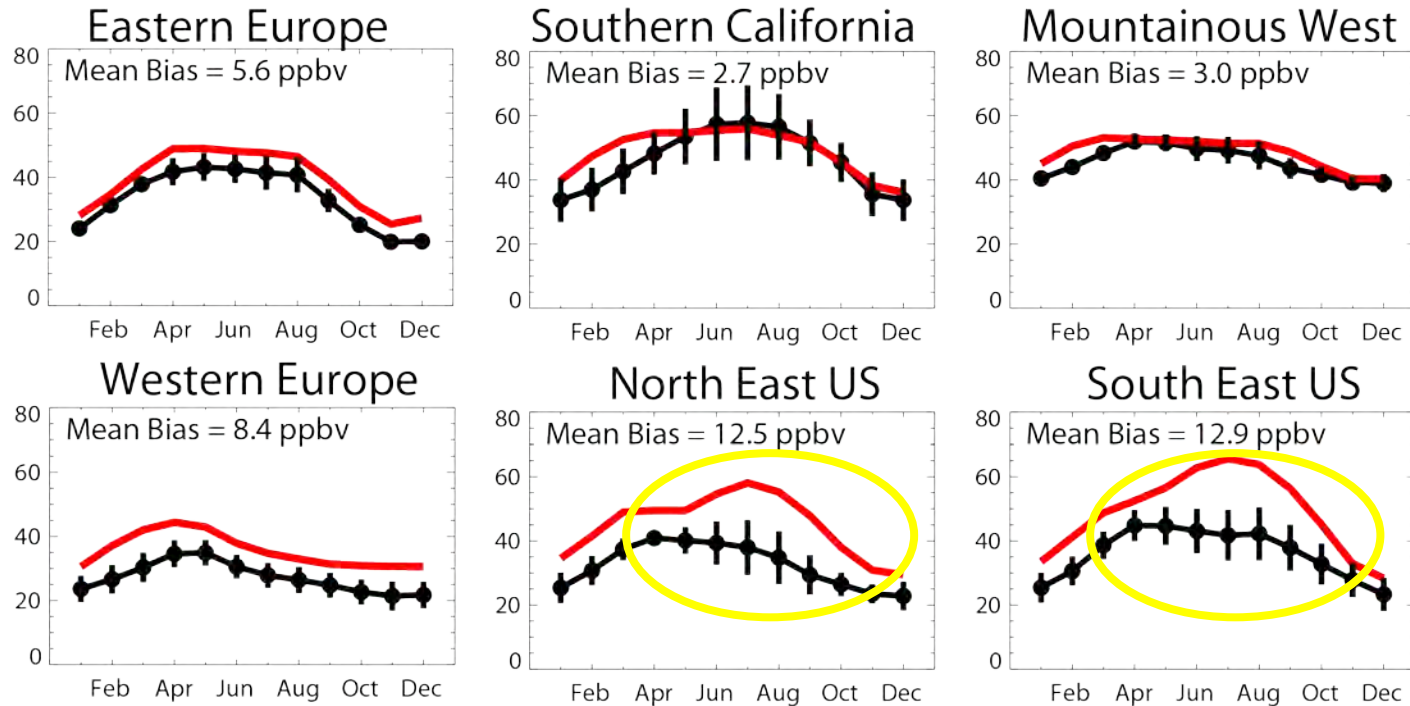
Recent chemistry developments in GFDL AM3 model



New features implemented in GFDL AM3 :

- High resolution with nudging wind (50 x 50 km).
- MEGAN (state-of-science process-based biogenic emission inventory)
 - to be coupled with the land model (LM3/4) for future prediction.
- Fast-JX
 - Account for the effect of aerosol scattering and absorption on photochemistry

Evaluation of surface ozone in GFDL AM3 model



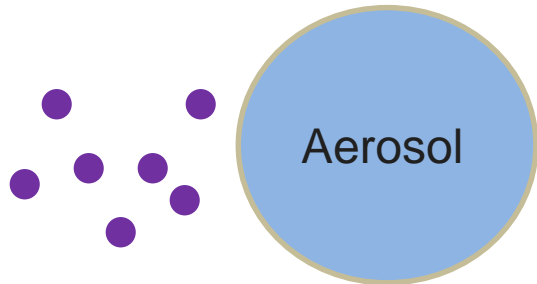
— Surface observations (Regional Mean)
— AM3 simulation (1981-2000)

- AM3 can well reproduce the magnitude and seasonality of surface ozone.
- However, AM3 over predicts summer surface ozone in Eastern US by 20-30 ppbv.
- **This is a long-standing problem for most global models (Fiore et al., 2009).**

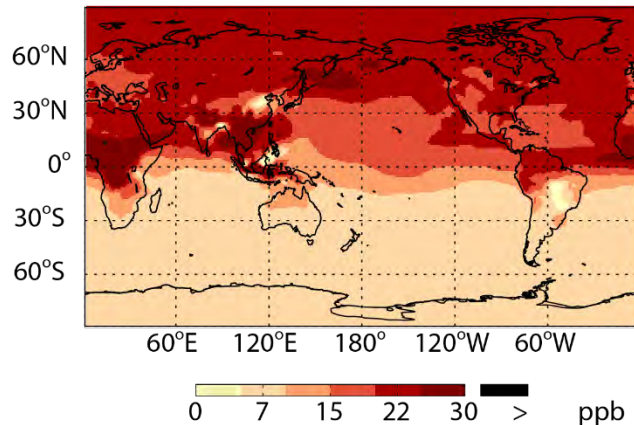
Impact of heterogeneous processes (uptake of trace gases by aerosols)

AM3 (aerosol uptake on) – AM3 (aerosol uptake off)

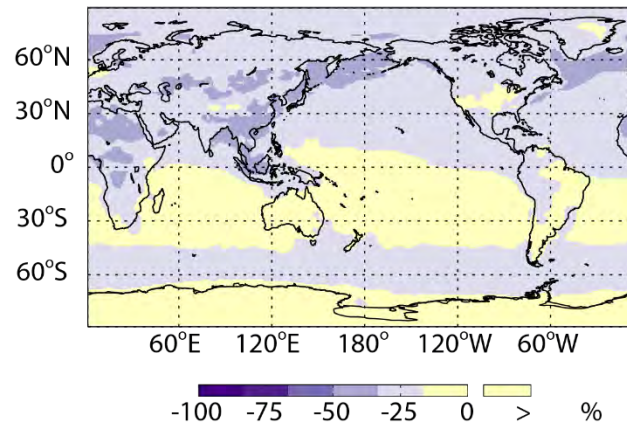
HO_2 , N_2O_5 , NO_3 , NO_2



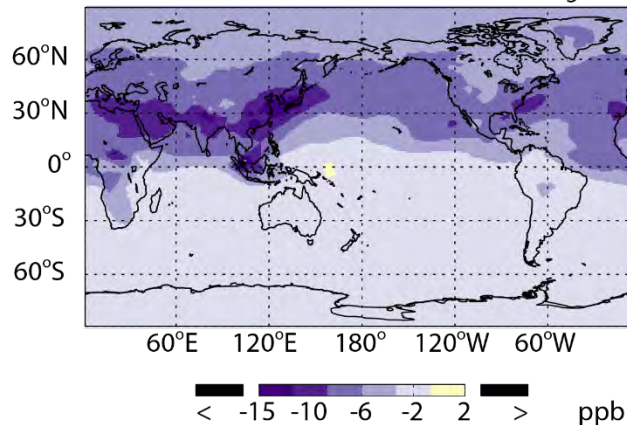
Absolute difference in CO



Relative difference in OH



Absolute difference in O_3



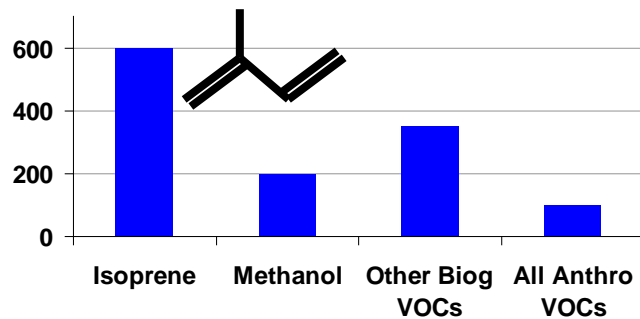
Significant improvement on model CO, mainly over NH (Shindell et al., 2006, JGR).

Significant improvement on model ozone and OH.

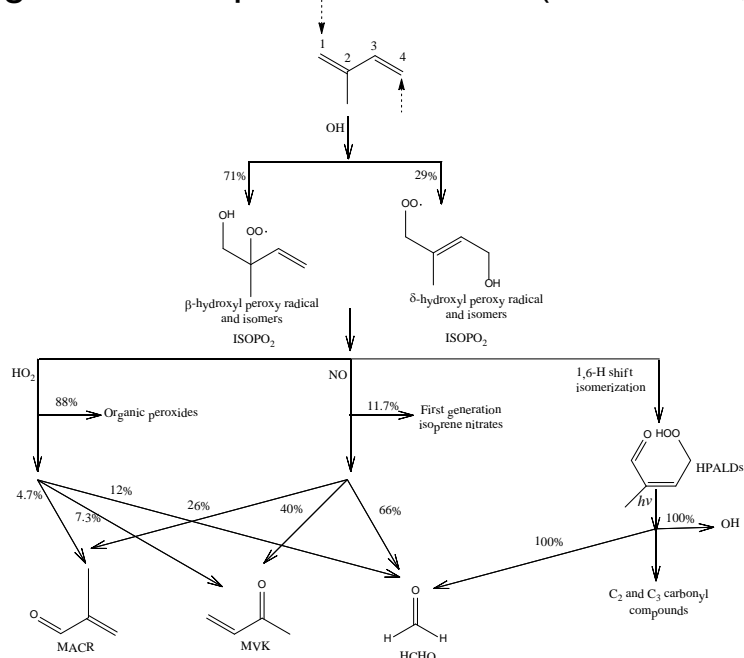
Tropospheric CH_4 lifetime increases from 8.5 to 9.6 years, in better agreement with the observational estimate-- 11.2 years (Prather et al., 2012, GRL)!

A new isoprene chemistry for global models

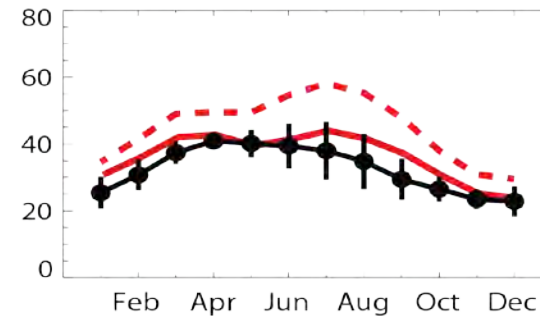
Global Emissions (Tg/yr)



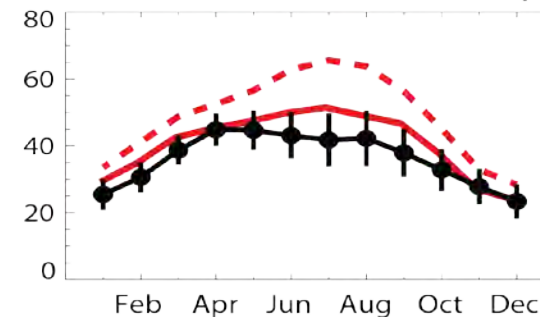
A new mechanism based on recent laboratory progress on isoprene oxidation (Mao et al., 2013)



North East US surface ozone (ppbv)



South East US surface ozone (ppbv)



— Surface observations (Regional Mean)
 — AM3 simulation with new chemistry
 - - - AM3 simulation with old chemistry

Ozone bias is significantly reduced from **13 ppbv** to **3 ppbv** for **SE US**, due to both heterogeneous processes and updated isoprene chemistry.

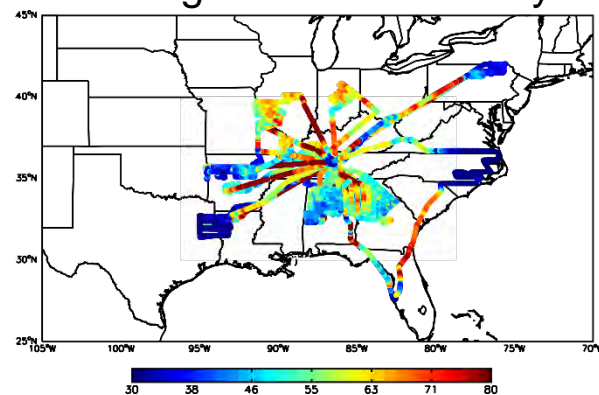
Cross-lab collaboration: SENEX and GFDL AM3

- Southeast Nexus (SENEX) field campaign - NOAA aircraft study over the Southeast U.S. to study **the interaction between anthropogenic and biogenic emissions**.
 - organized by NOAA Earth System Research Laboratory)
- Global high resolution AM3 (50 x 50 km)
 - nudging with GFS wind; new chemical mechanism; MEGAN biogenic emission.

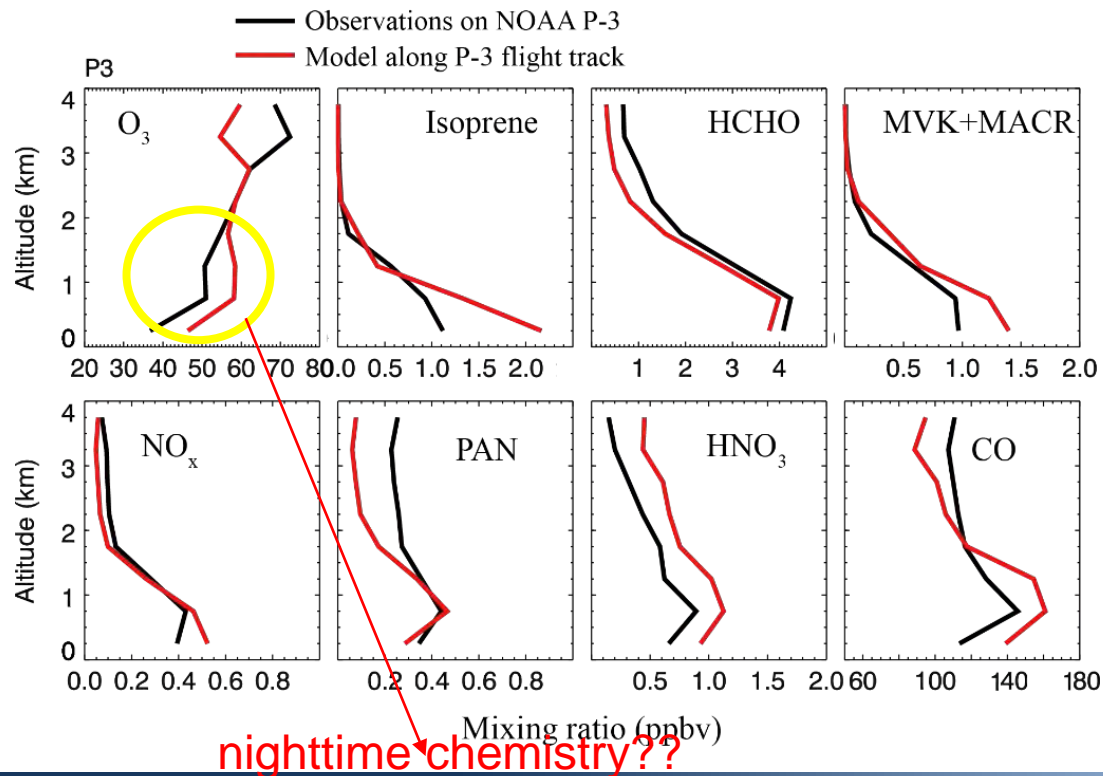
June 3rd to July 10th (2013)



SENEX flight track colored by ozone

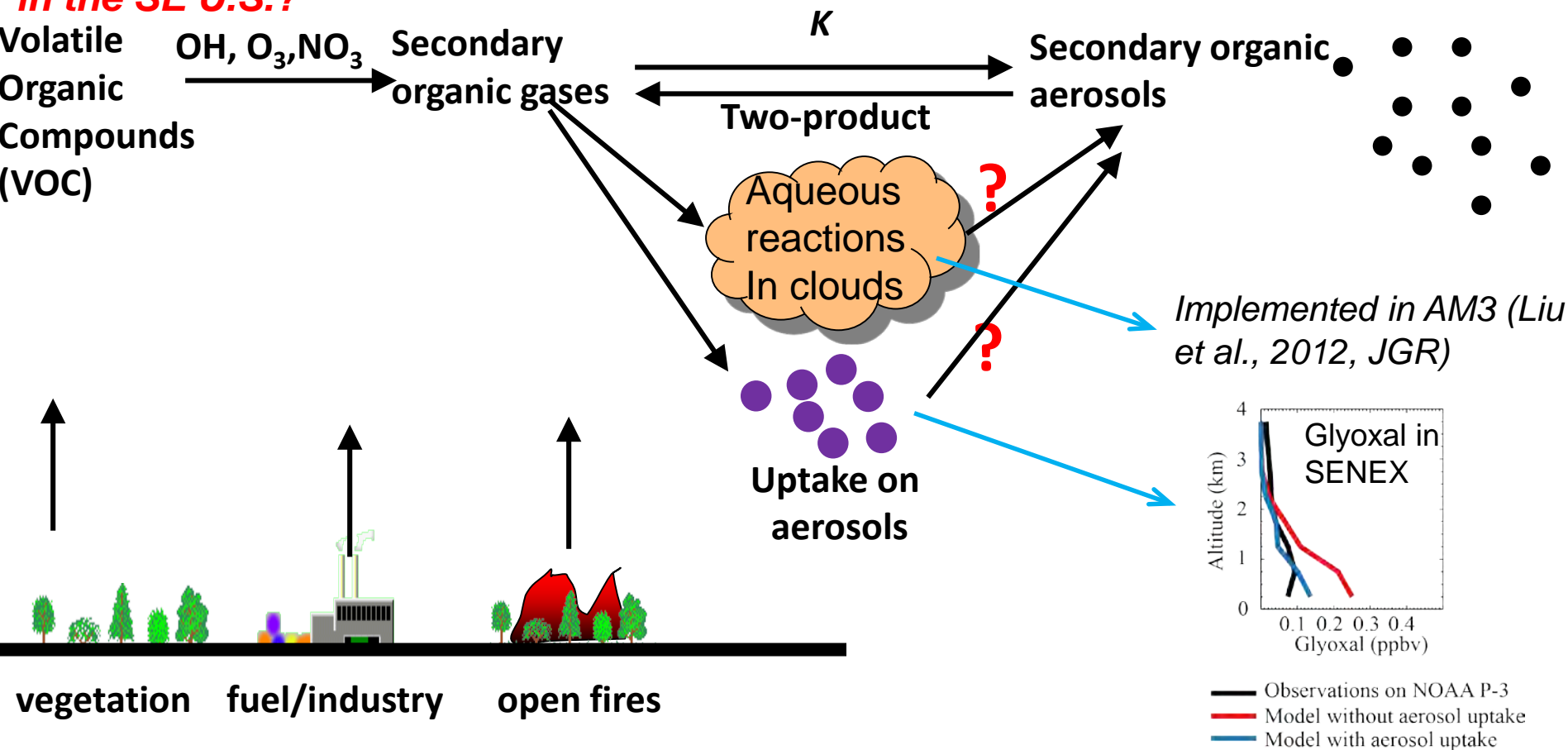


Mean vertical profiles during SENEX



Future work: formation of secondary organic aerosols (SOA)

Question: What are the formation mechanisms of secondary organic aerosols in the SE U.S.?



- The “role of aerosols in regional climate” was recently identified as an important crosscutting research challenge for NOAA.

Conclusions

- We have improved the chemical mechanism in AM3 in both heterogeneous processes and isoprene oxidation mechanism.
 - This leads to significant improvement on ozone, OH, CO in AM3 (and other models too).
- We deploy a high resolution version of AM3 to the SENEX campaign, and model can well reproduce ozone and its precursors.
 - nighttime VOC oxidation may play an important role on daytime ozone.
 - Next step is to evaluate the secondary organic aerosols in GFDL AM3 with SENEX dataset.