Chemistry-Climate Interactions

Presented by

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Geophysical Fluid Dynamics Laboratory Review

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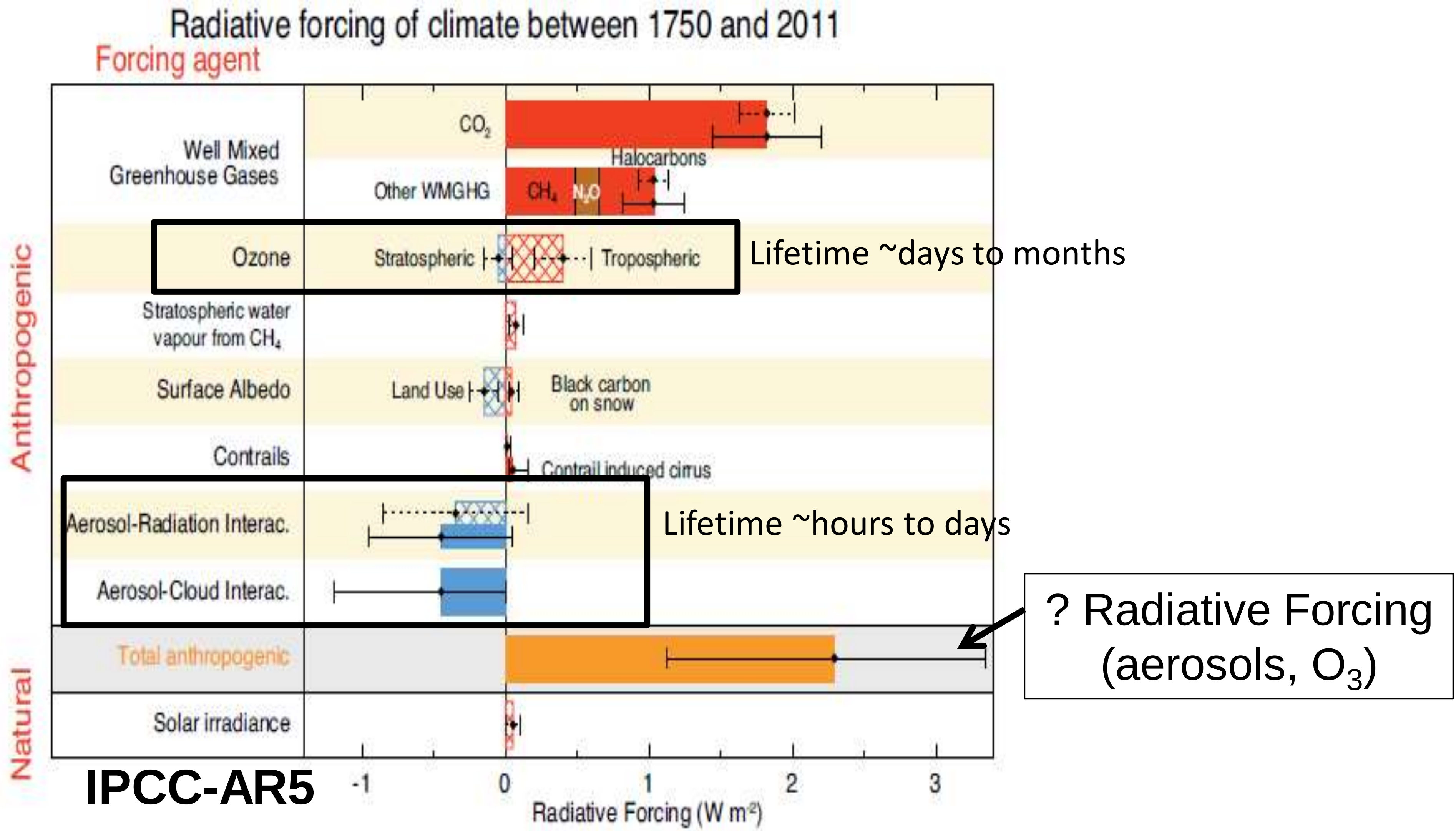
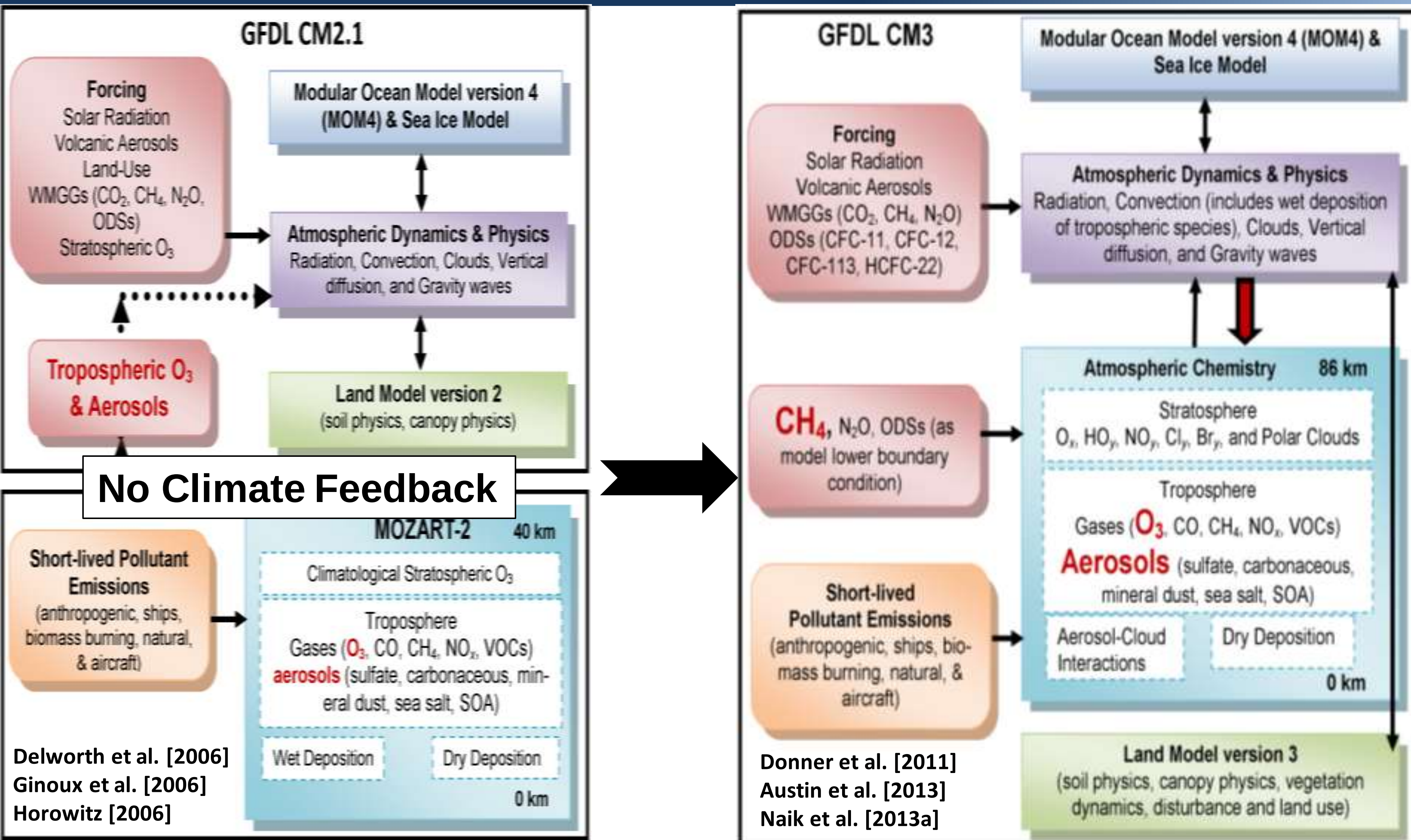
Atmospheric Chemistry plays a key role in the Climate System

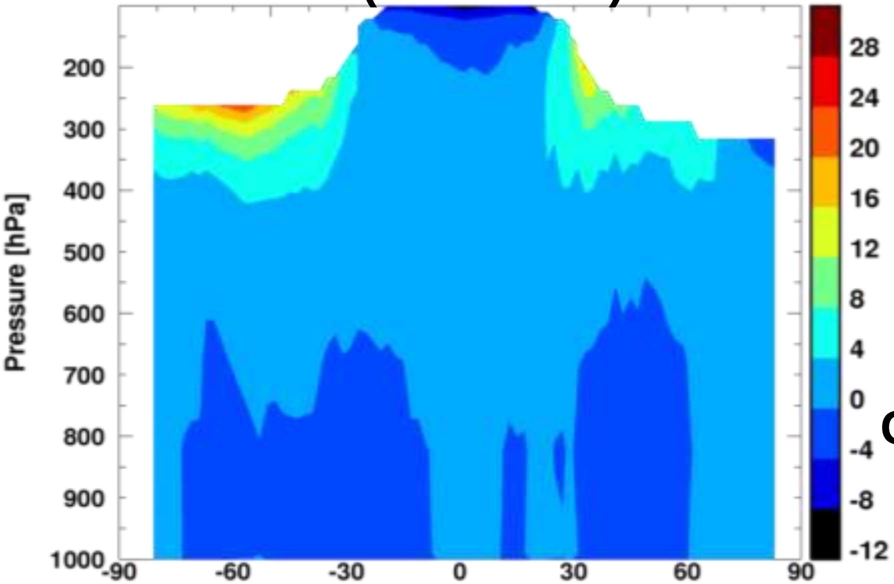


Seamless Atmospheric Chemistry in CM3



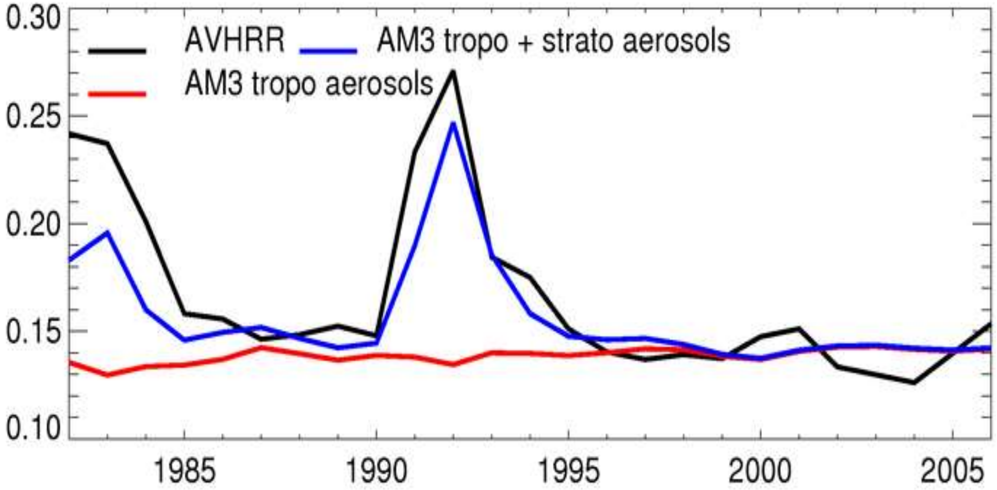
AM3 (observed SST and Sea Ice) Captures Observations

AM3 – TES Tropospheric O_3 (ppbv) (2005-2007)



AM3 captures the observed zonal mean O_3 to within ± 4 ppbv in much of the troposphere

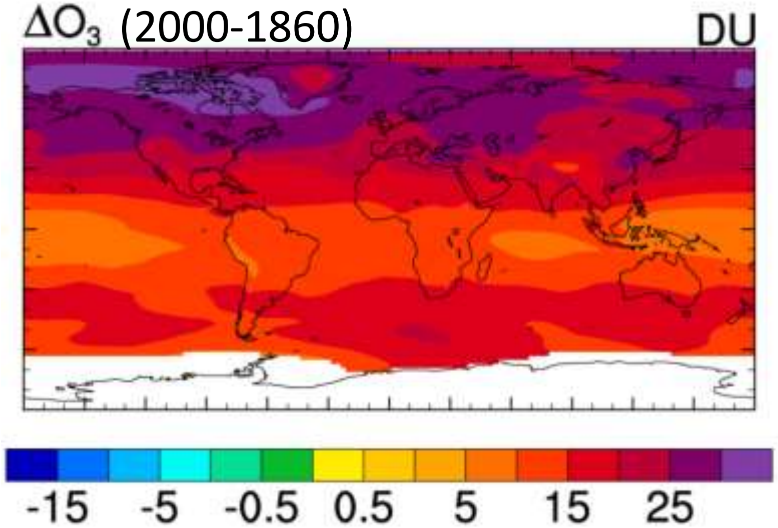
Global Mean Oceanic Aerosol Optical Depth (AOD) @ 550 nm



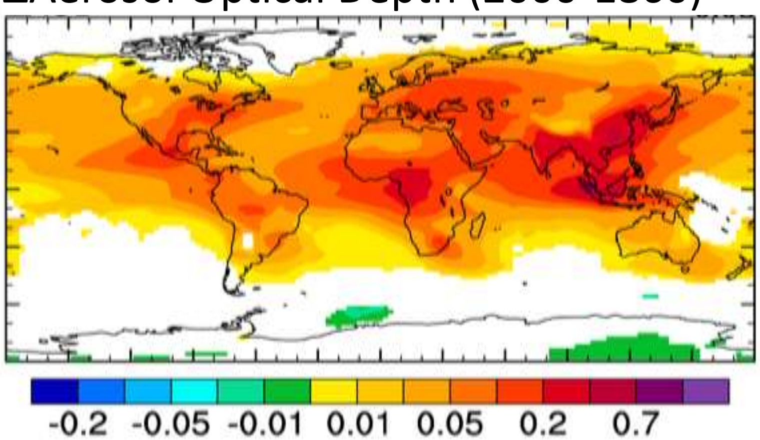
AM3 reproduces the observed evolution of total AOD over the ocean from 1982-2006

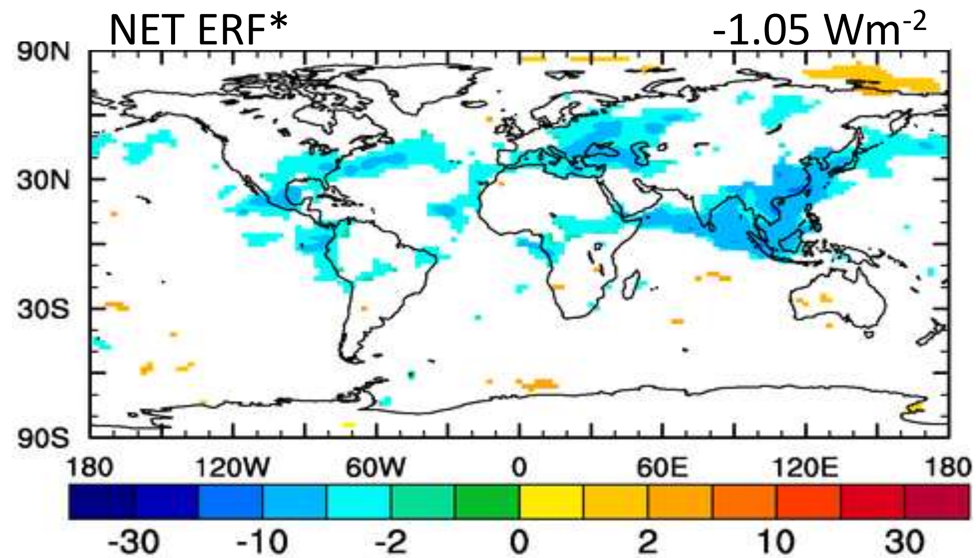
Naik et al. JGR [2013a]

Net Negative Radiative Forcing (RF) due to Preindustrial to Present-day Increases in Tropospheric O_3 and Aerosols



ΔAerosol Optical Depth (2000-1860)





Multi-model Mean [Shindell et al., 2013]

O_3 RF = 0.33±0.18

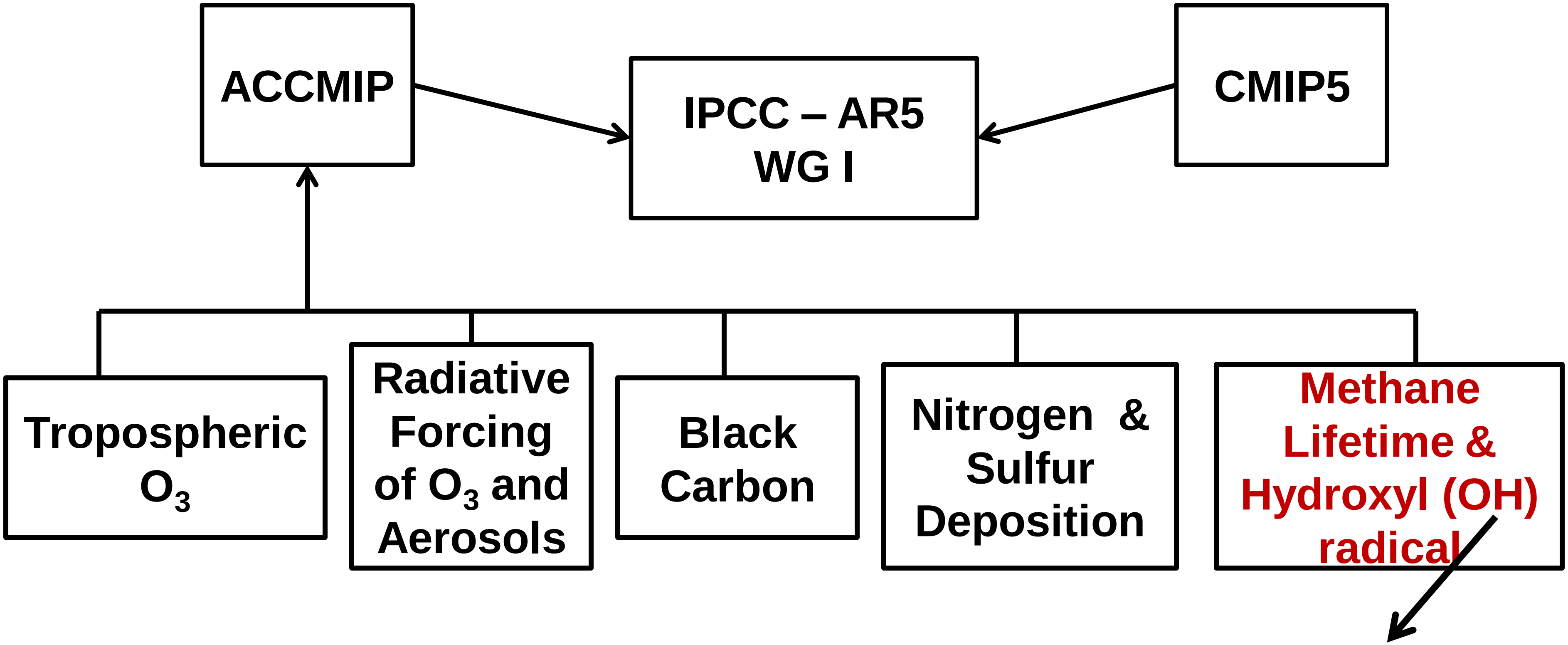
Aerosol ERF* = −1.17±0.4

NET RF = −0.84 ± 0.50 W m^{-2}

***NET EffectiveRF**: Change in TOA net radiative flux with fixed sea surface temperature

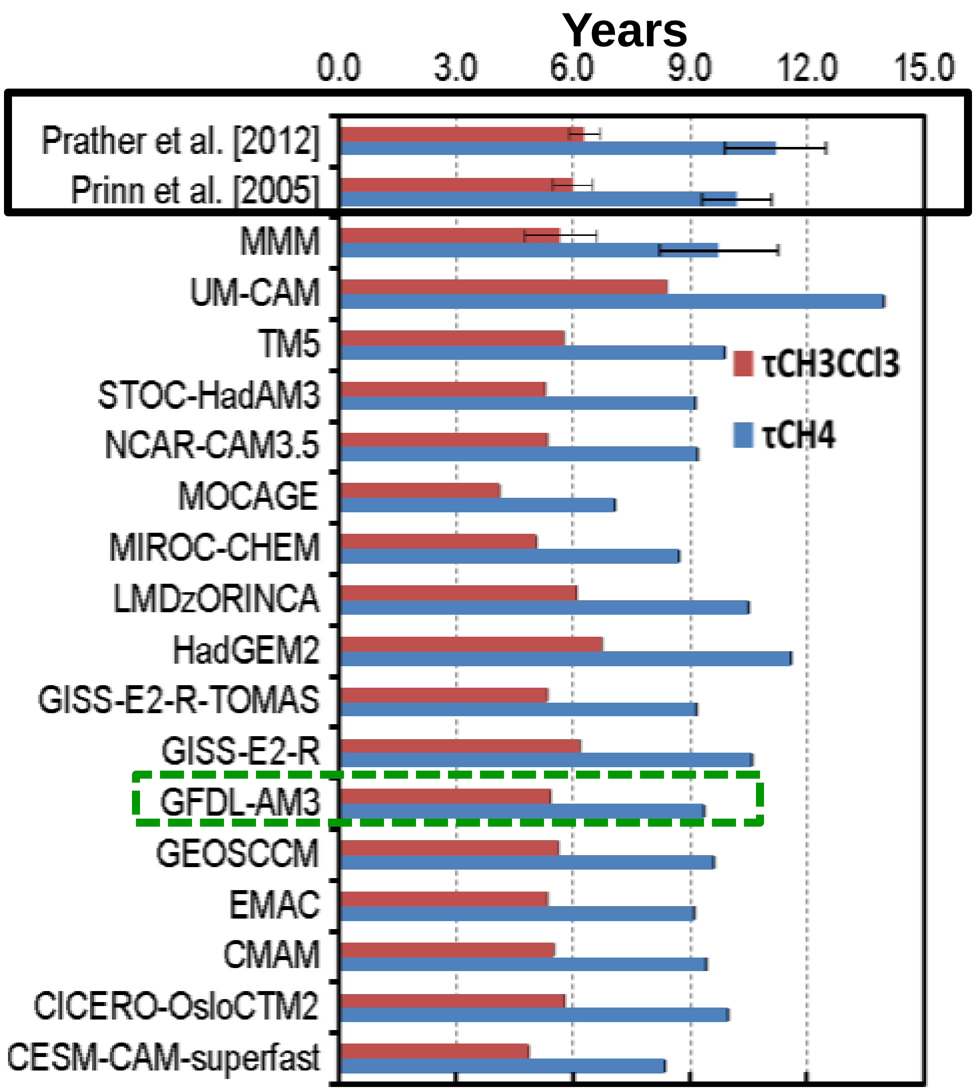
Naik et al. JGR [2013a]

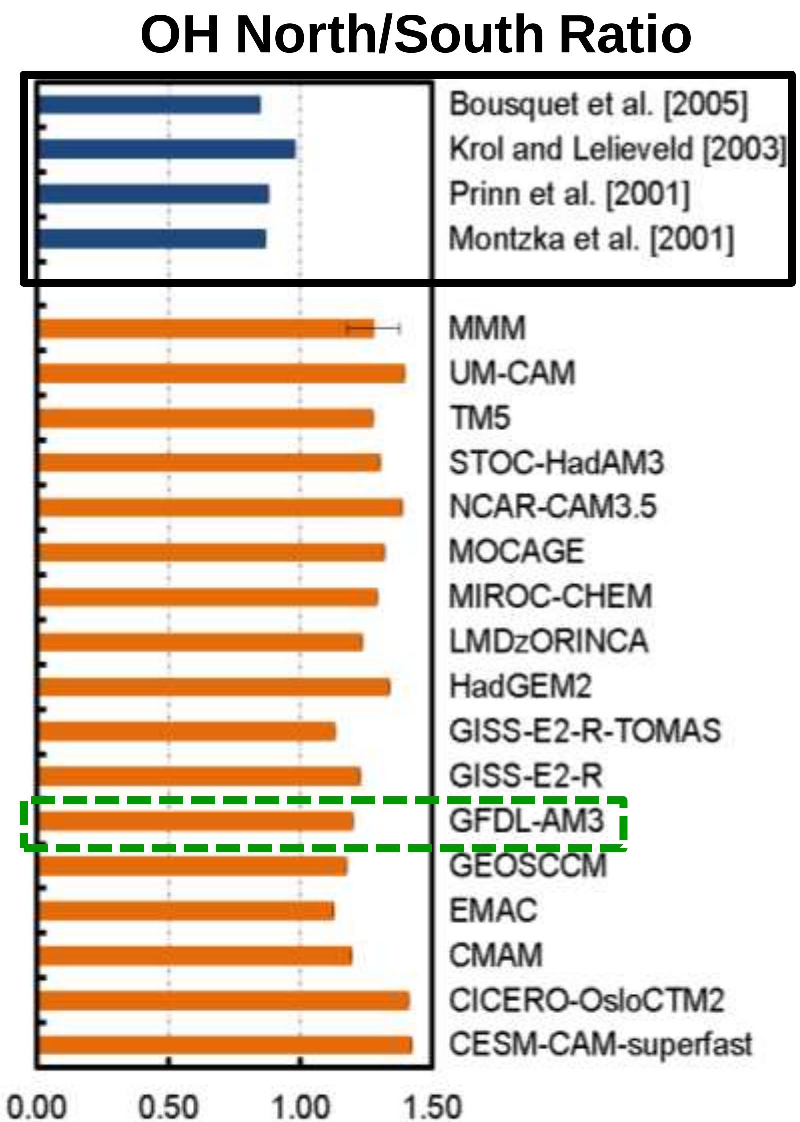
Contribution to the Atmospheric Chemistry Climate Model Intercomparison Project (ACCMIP)



- **Dominant atmospheric oxidizing agent →** abundance and lifetime of radiatively active species (e.g. CH_4, ozone depleting substances)
- **Extremely short-lived (~1s) →** global measurements are hard to make, rely on proxy methods (e.g. CH_3CCl_3 lifetime) or forward models to estimate global mean OH

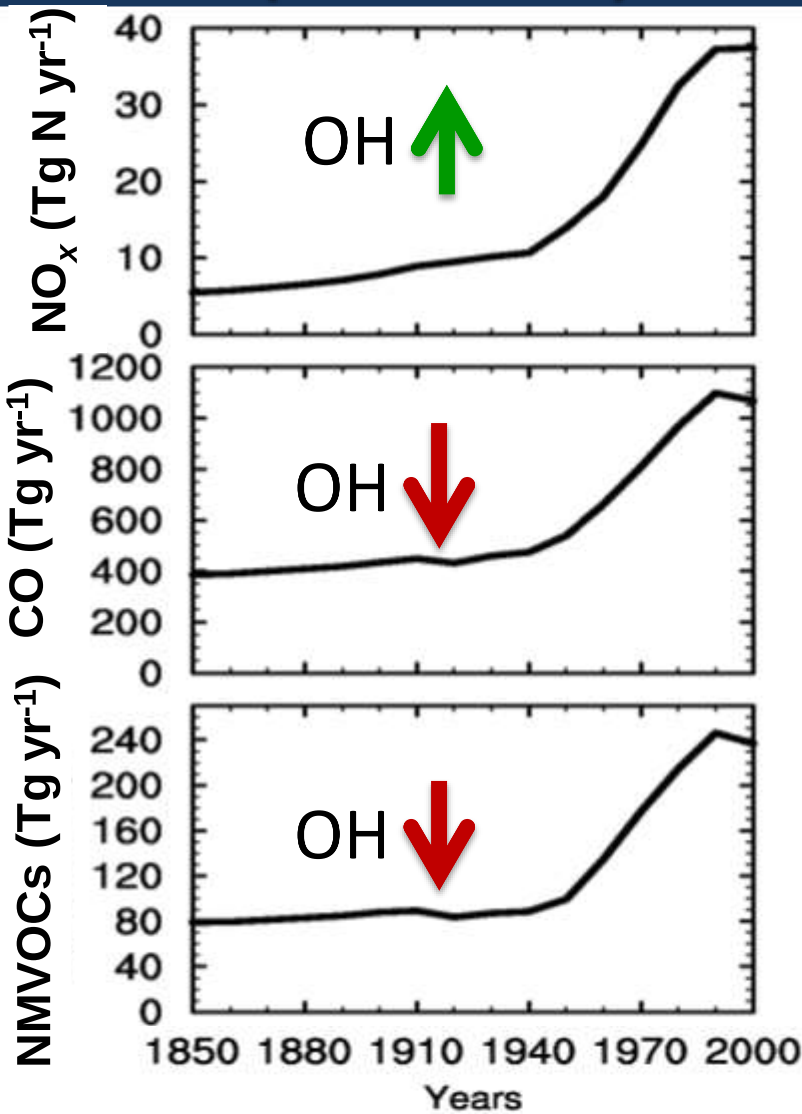
Global Chemistry Climate Models (CCMs) overestimate mean OH relative to observational constraints

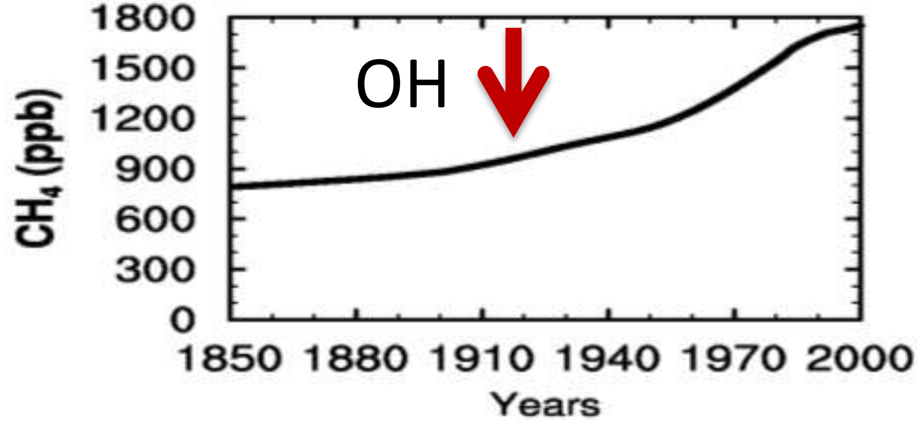


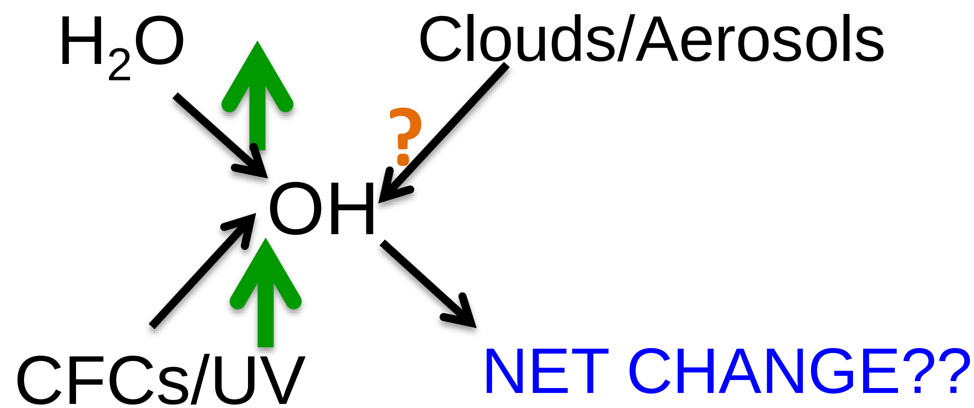


Naik et al. ACP [2013b]

How has global mean OH changed in response to historical (1850-2000) emission increases and climate change?



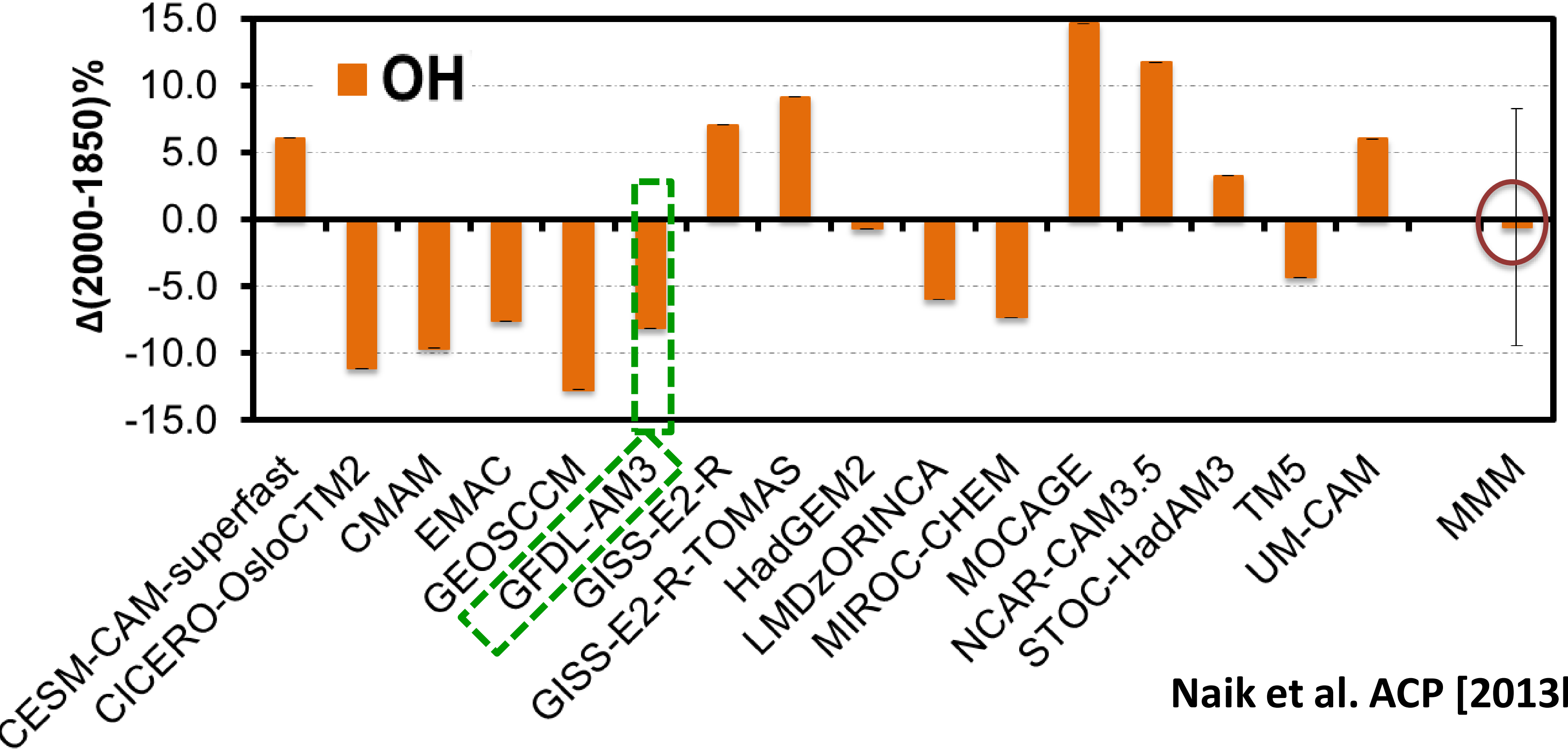




No consensus amongst prior modeling studies (1991-2012)

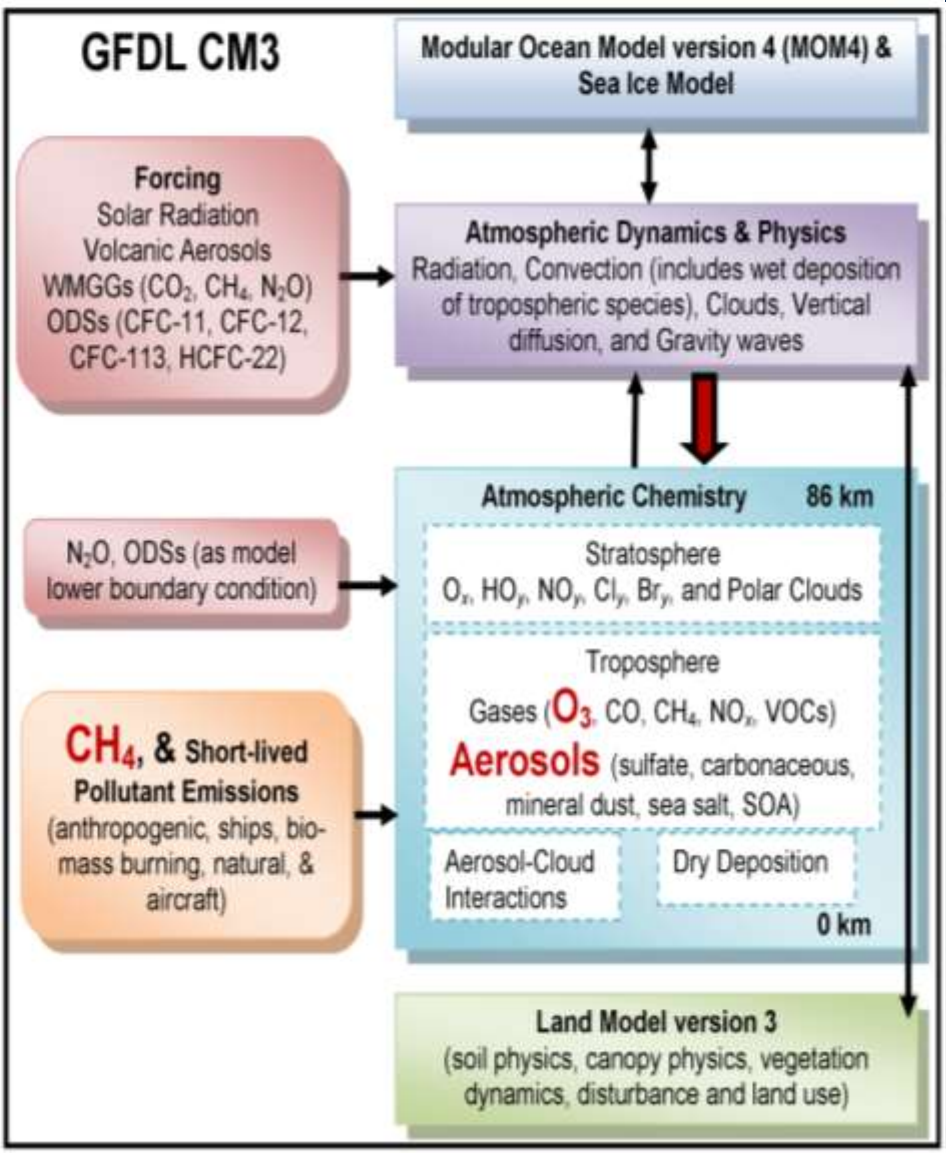
Large intermodel diversity in the sign of OH change over the historical period with no clear trend

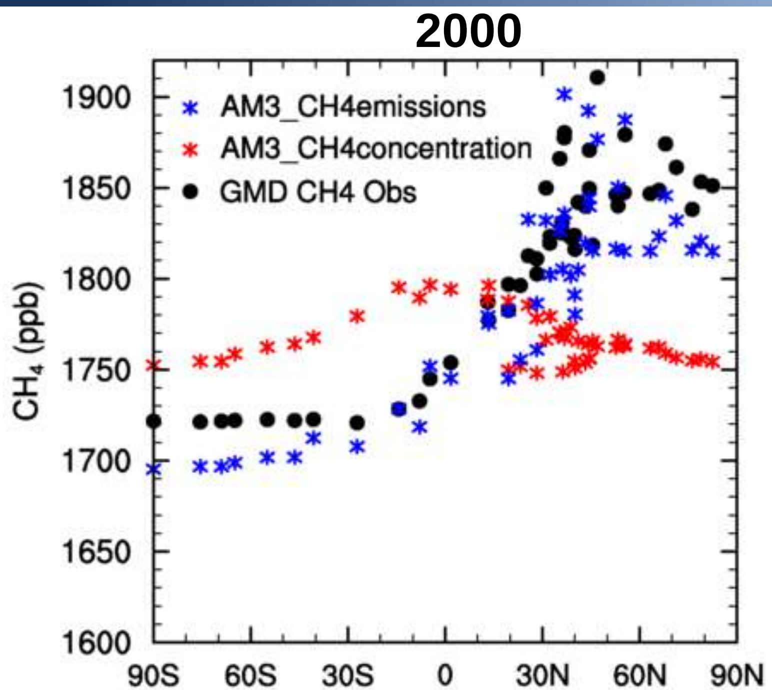
Global mean OH is well-buffered against perturbations [Lelieveld et al. 2004, Montzka et al. 2011]



Naik et al. ACP [2013b]

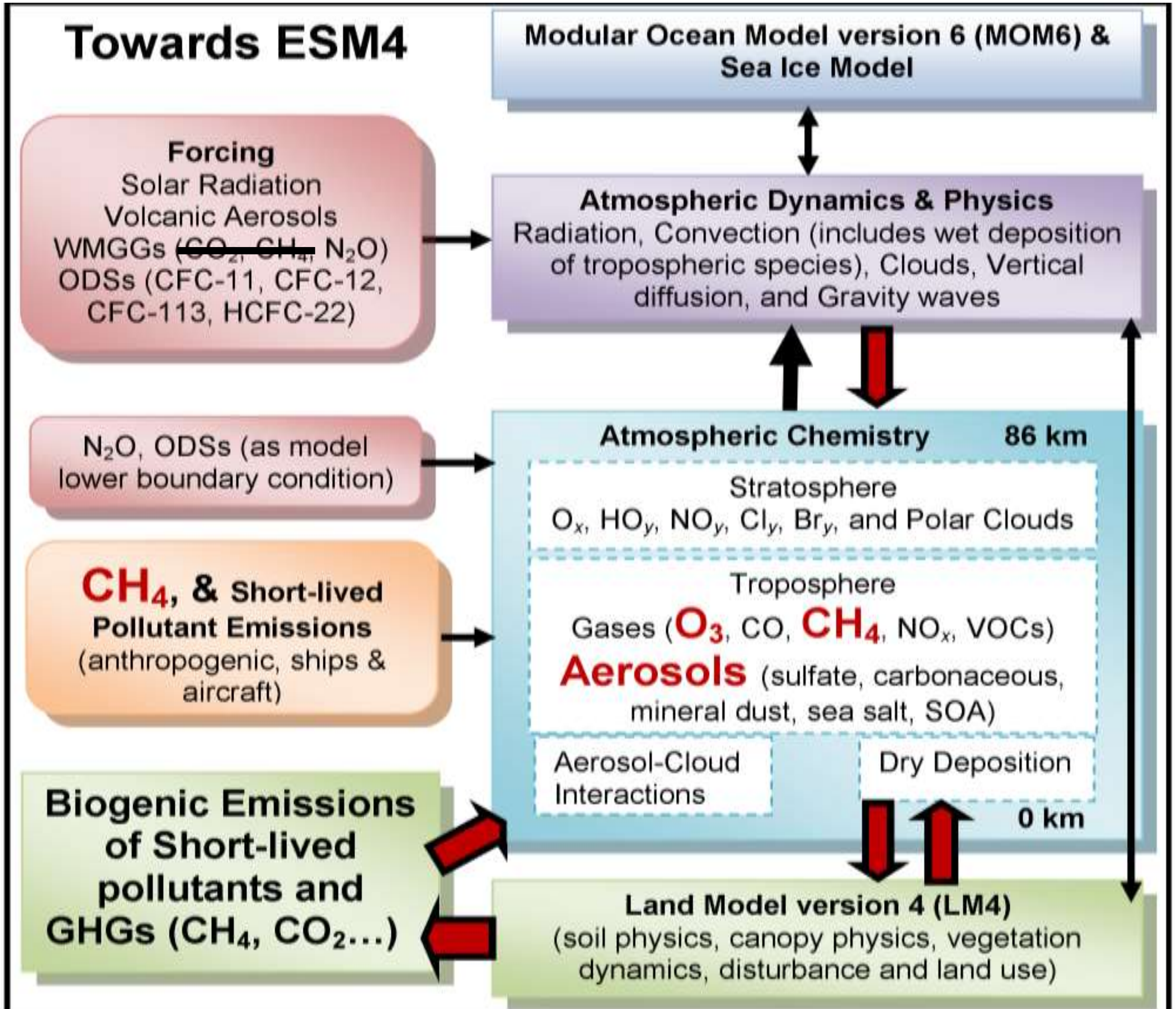
Future Directions: Realistic CH_4 Simulation





- Realistic simulation of CH_4 will allow us to investigate:
  - drivers of past and future changes in atmospheric CH_4
  - impact on other chemical species, e.g., tropospheric O_3 and its RF

Future Directions: Atmospheric Chemistry in the Earth System



Summary

- A **comprehensive treatment of atmospheric chemistry** within **GFDL's global climate model (CM3)** allows us to advance the scientific understanding of the effect of short-lived pollutants on climate
- **GFDL helped lead** a multi-model investigation of the global mean OH historical trend
  - Models do not give clear indication of global OH trend; multi-model mean change is consistent with recent observational inference
- **Integrating atmospheric chemistry within the Earth System Model** opens up the possibility of addressing whole new sets of questions within the broader **Earth System Science**