Global Soil N_2O Emissions in a Future Climate

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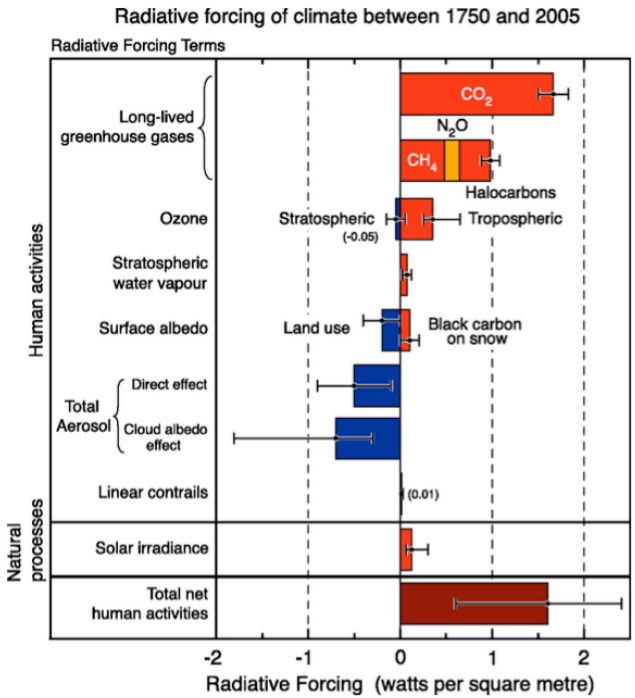
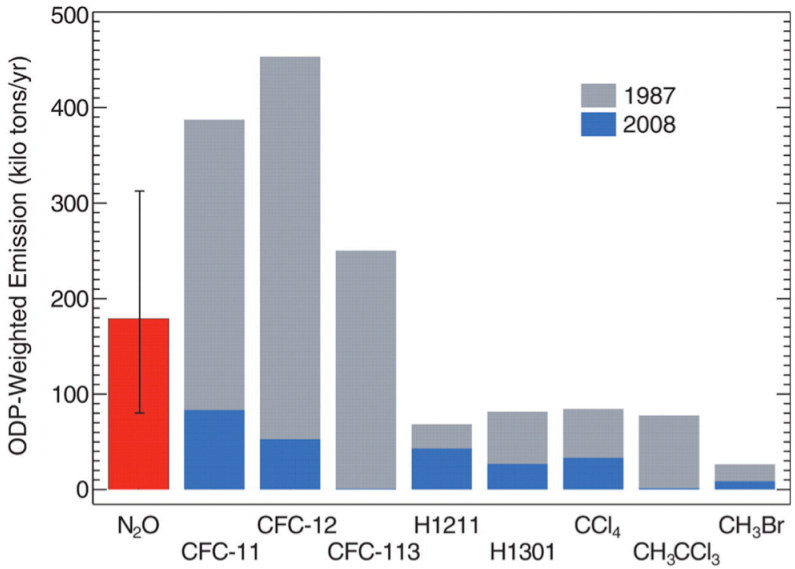
Importance of N_2O

- Major Greenhouse Gas (Third largest after CO_2 & CH_4)
  - Global Warming Potential: 296
- Becoming a major Ozone-Depleting Substance

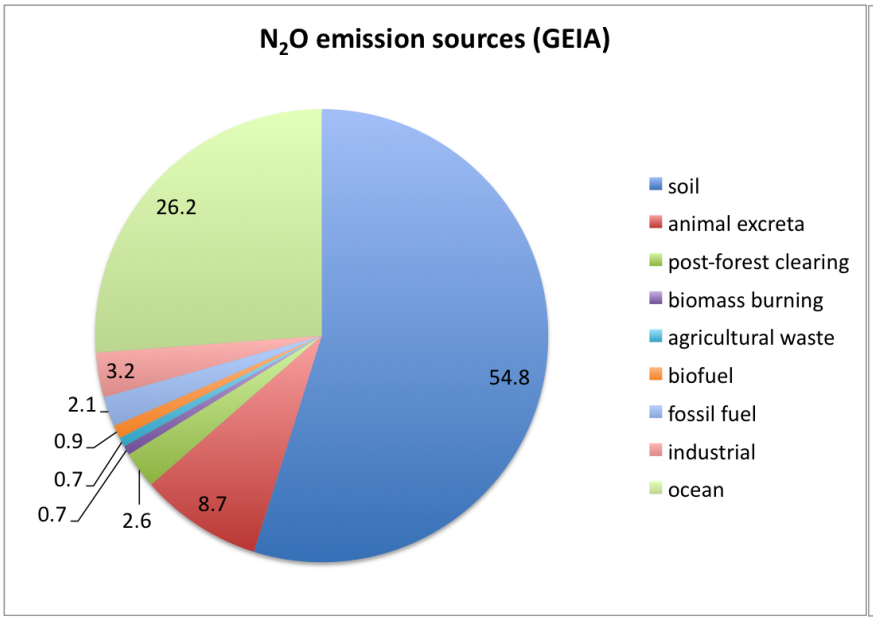


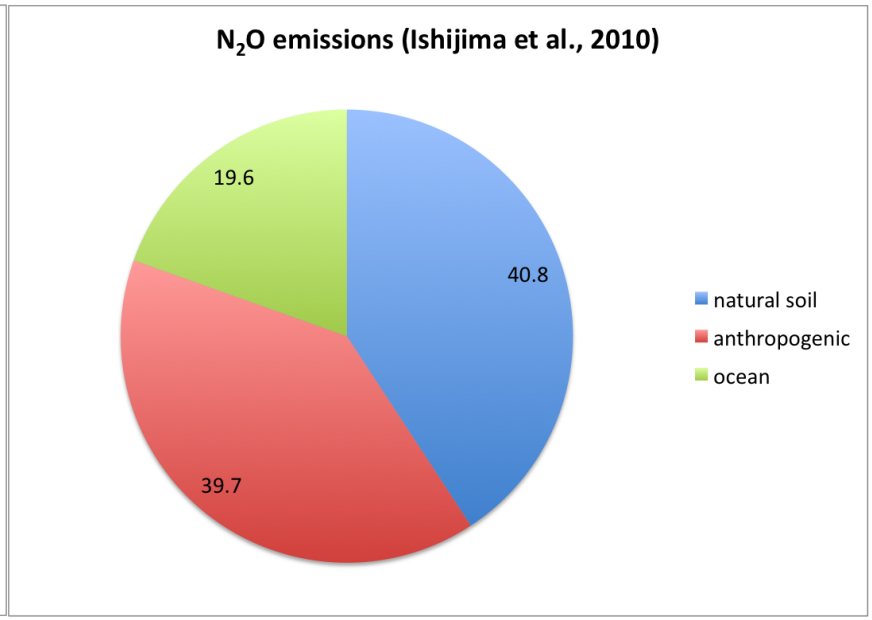


Source IPCC AR4; Ravishankara et al., 2009

Source and Magnitude of N_2O Emissions

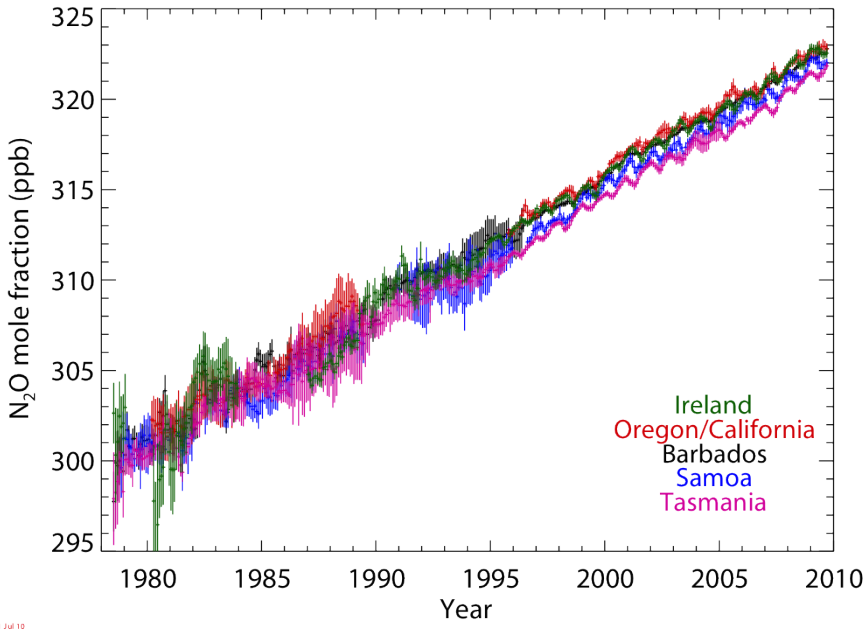
- Large Natural Sources (Soil + Ocean)
- Global Total: 15-20 $TgN_2O\text{-}N\ year^{-1}$

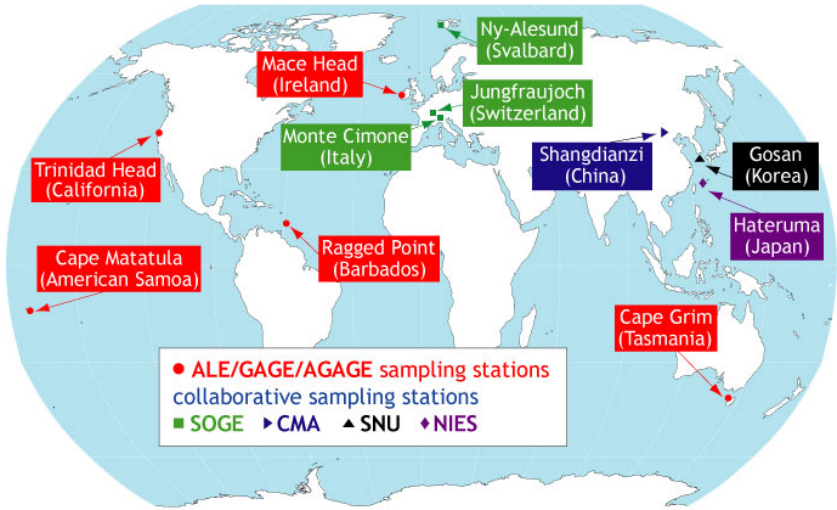




N_2O Mixing Ratio Increasing

- 270ppb in 1850, 280ppb in 1905, 300ppb in mid-1970s.
- The current mixing ratio is over 320ppb.





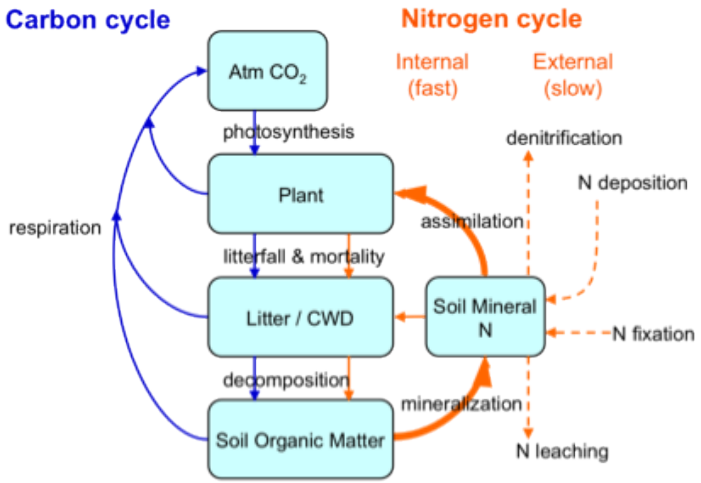
Source: Advanced Global Atmospheric Gases Experiment

Research Questions

- How much does natural soil contribute to global N_2O emissions?
- How much natural soil emissions do we see in a future climate?

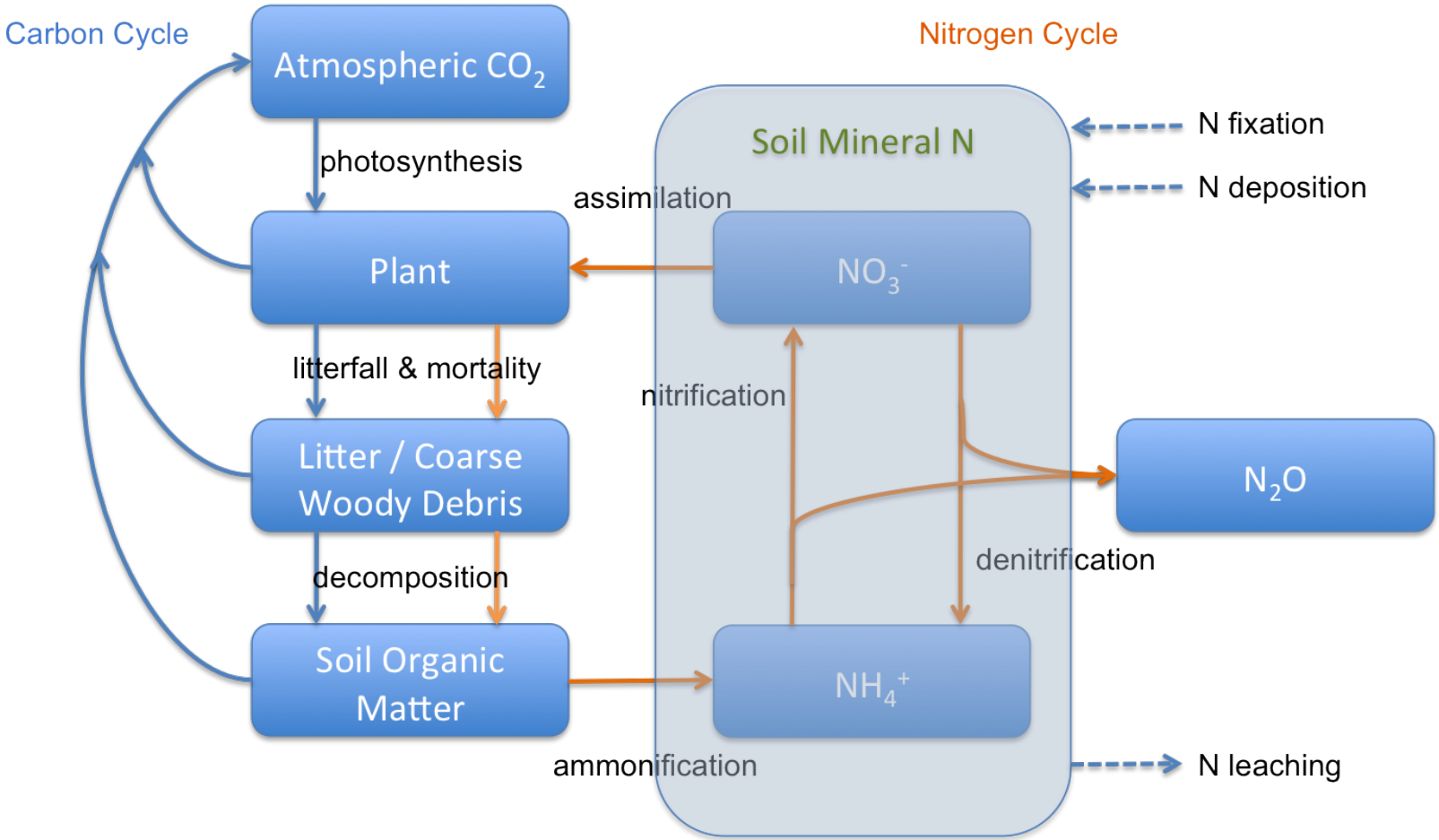
Process Modeling of N_2O using CLM-CN v3.5

- Community Land Model (CLM) v3.5 with prognostic Carbon and Nitrogen
- CLM-CN model represents land terrestrial water, carbon and nitrogen balances, and it is nominally run at an hourly time scale.
- 1.9° latitude and 2.5° longitude horizontal resolution



Source: Thornton et al., 2009

DeNitrification-DeComposition (DNDC) Model in CLMCN



Li et al., 1992

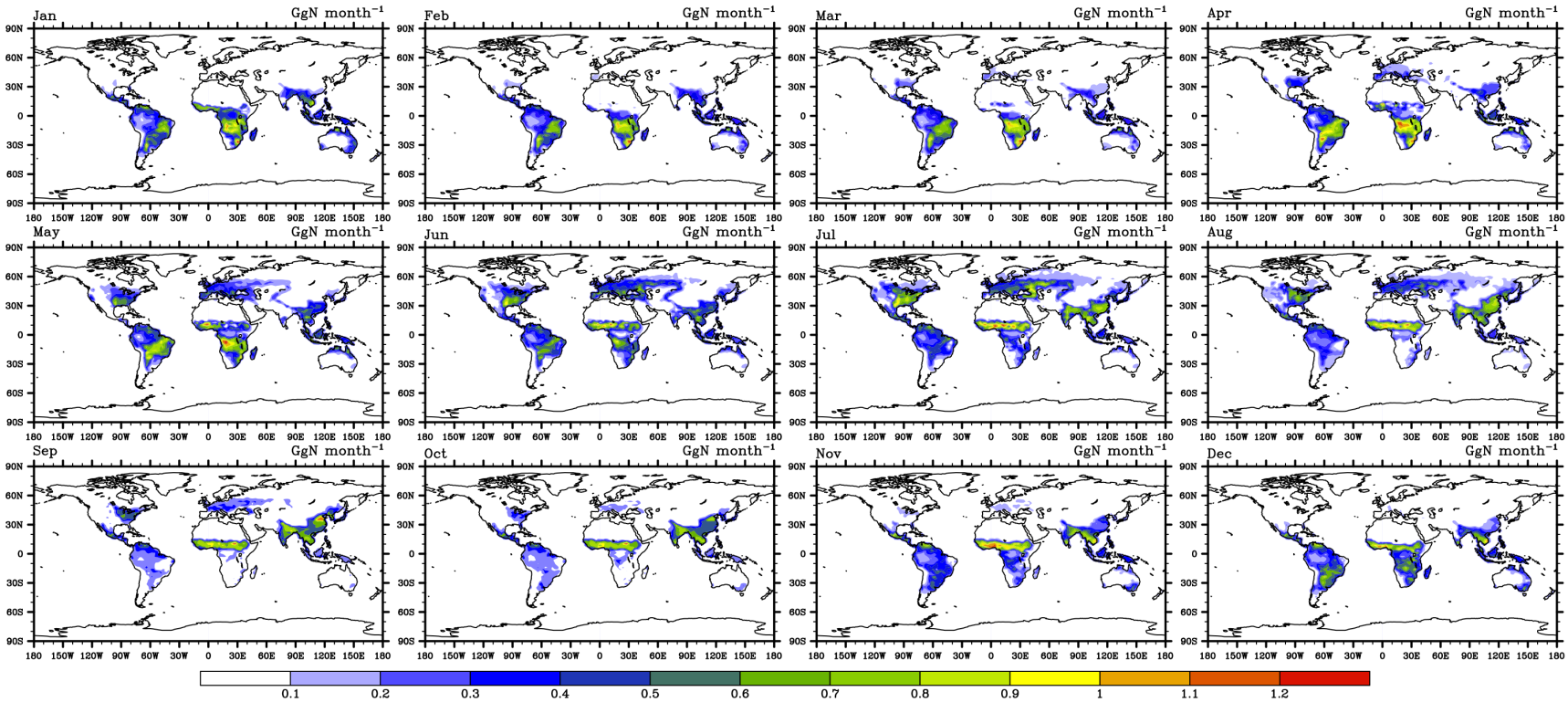
CLMCN-N_2O

- Equilibrium run, followed up by a transient run.
- Analyzed years 1975-2008.
- Nitrogen deposition is taken from Community Atmosphere Model (CAM) for the year 2000.
- 4 forcing datasets are used:
  - NCEP Corrected by CRU (NCC)
  - Climate Analysis Section (CAS)
  - Global Offline Land-Surface Dataset (GOLD)
  - Global Meteorological Forcing Dataset (GMF)

Results: N_2O Emissions Estimated from CLMCN-N_2O

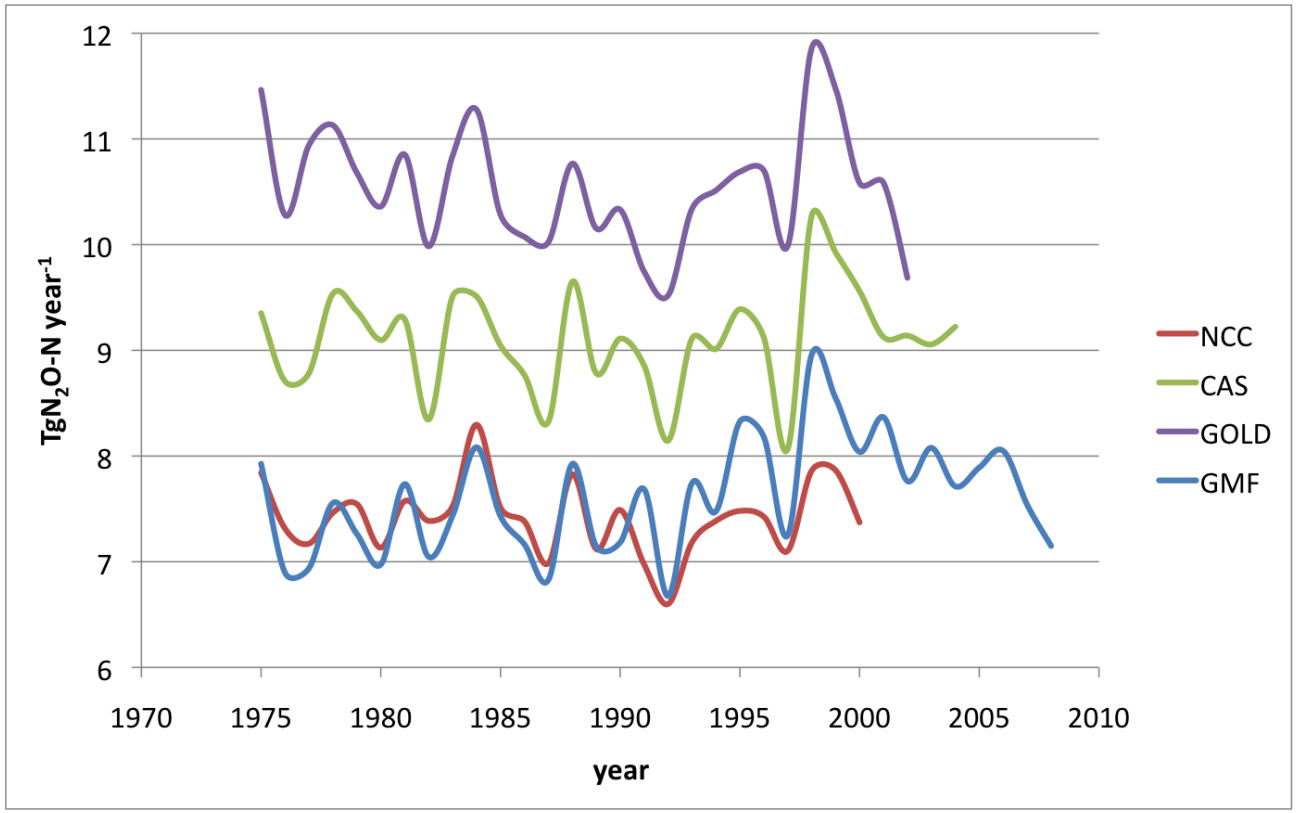
(CLMCN-N_2O)

Results: Seasonality in 2000



Results: Inter-annual Variability

4 different forcing data sets produce similar trends.



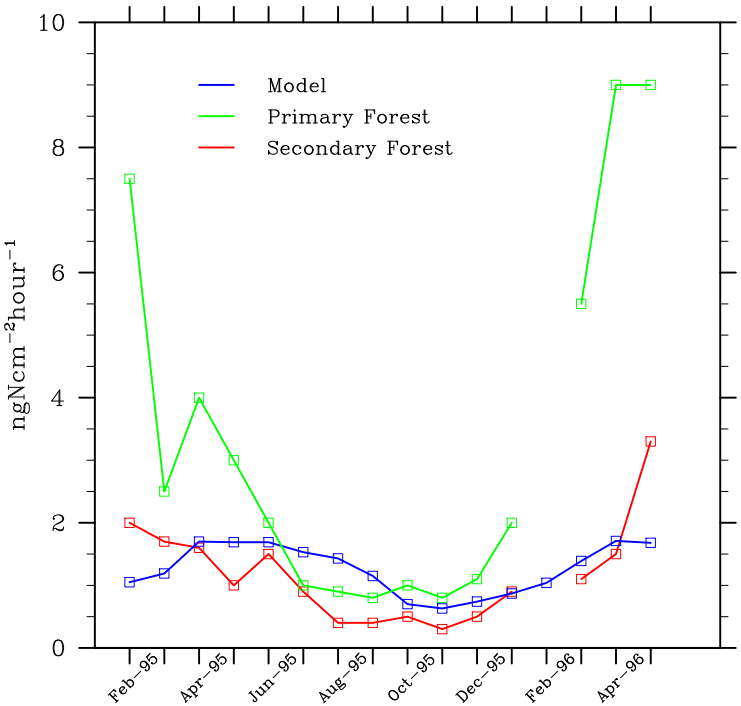
Comparison with other models

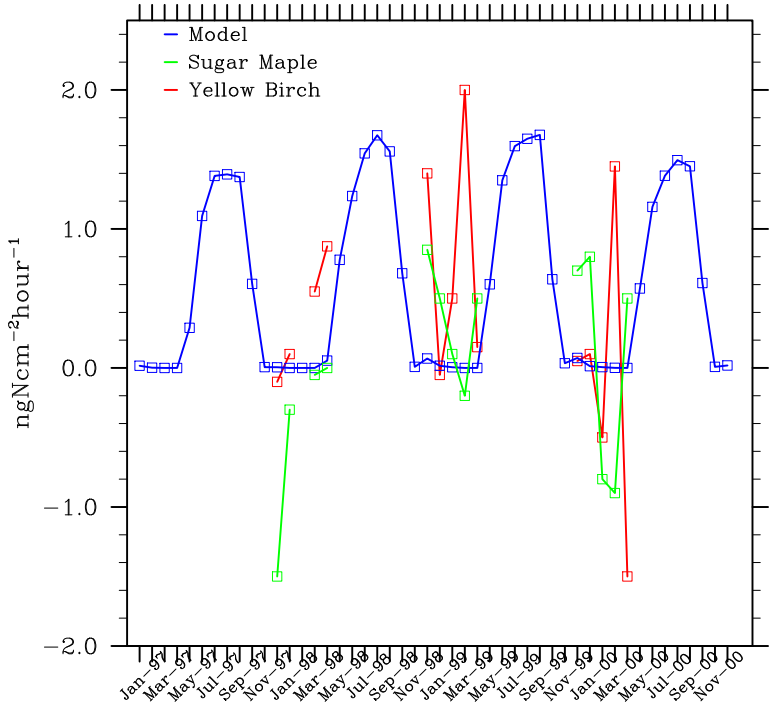
Global Soil N_2O Emissions (TgN_2O-N $year^{-1}$)

- CLMCN-N_2O: 6.6-11.9
- NASA-CASA: 6.18
- GEIA: 7.53
- O-CN: 10.83 (including agriculture)
  - Agricultural soil: approximately 2.5 TgN_2O-N $year^{-1}$

Model-Obs Comparison: Soil N_2O emissions

- Model reproduces the soil N_2O emissions well in the tropics (Fazenda Vitoriá), but cannot reproduce winter emissions in the upper latitudinal region (White Mountain National Park).



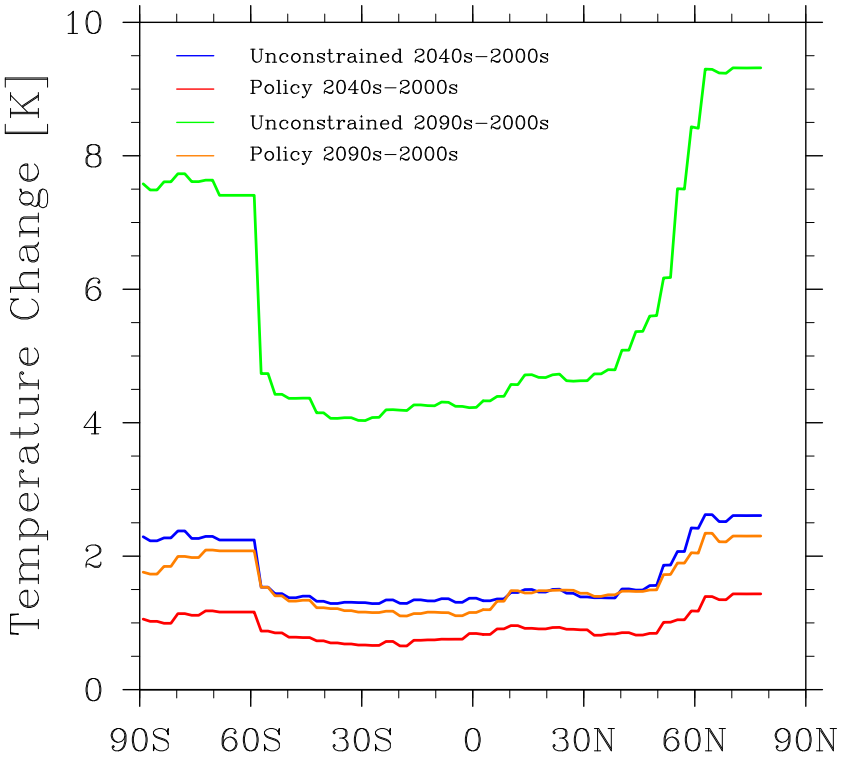


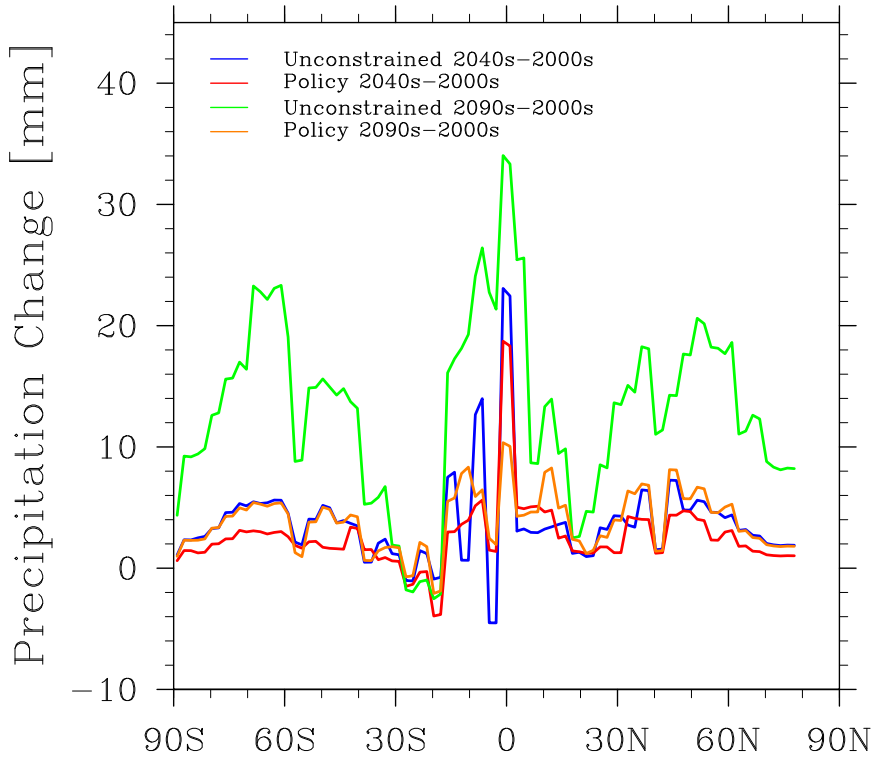
Source: Verchot et al., 1999, Groffman et al., 2006

Future Soil N_2O Emissions

- How much emissions do we expect in the future?
- Would emissions change depending on the climate?

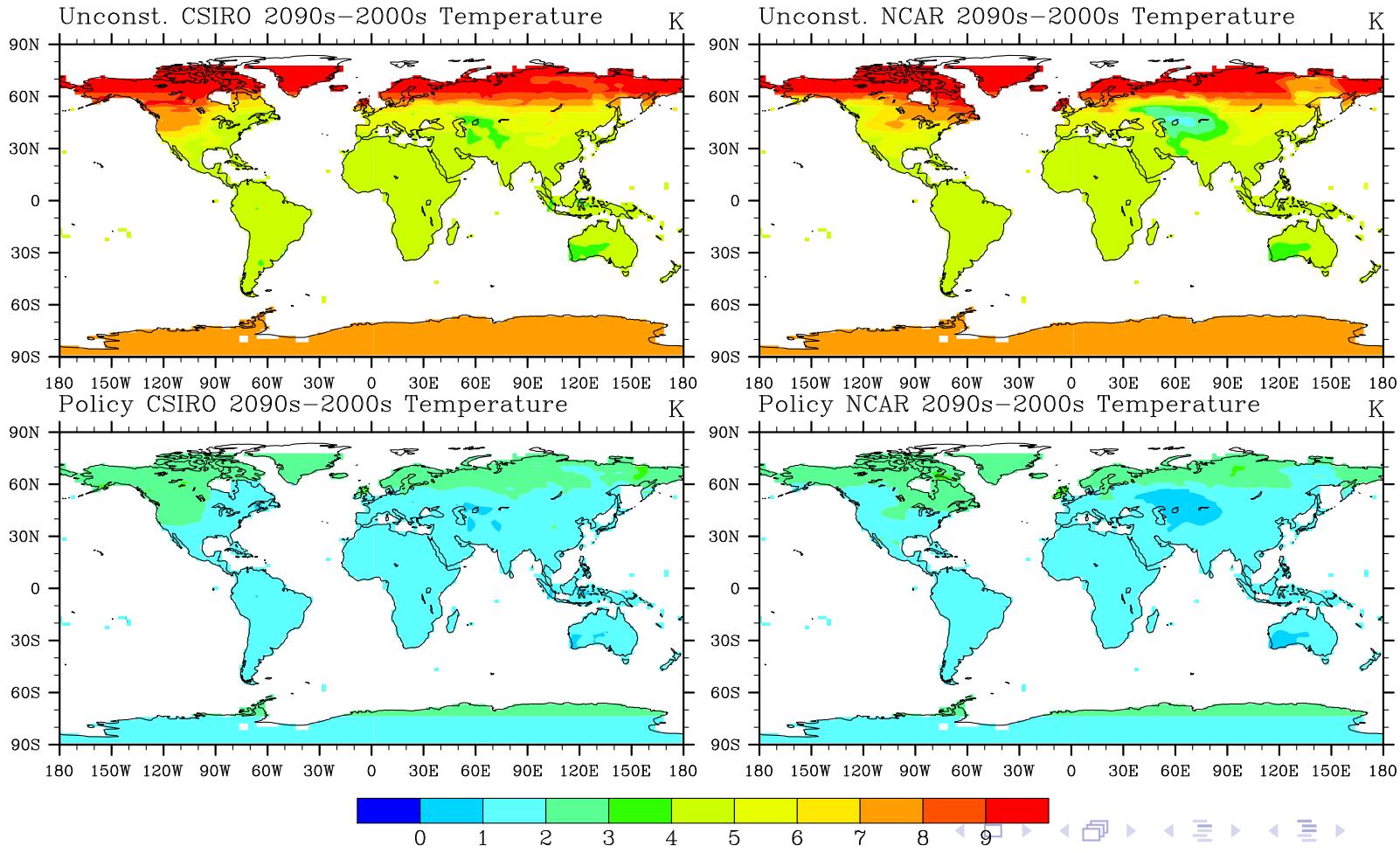
Under 2 different scenarios in the future....





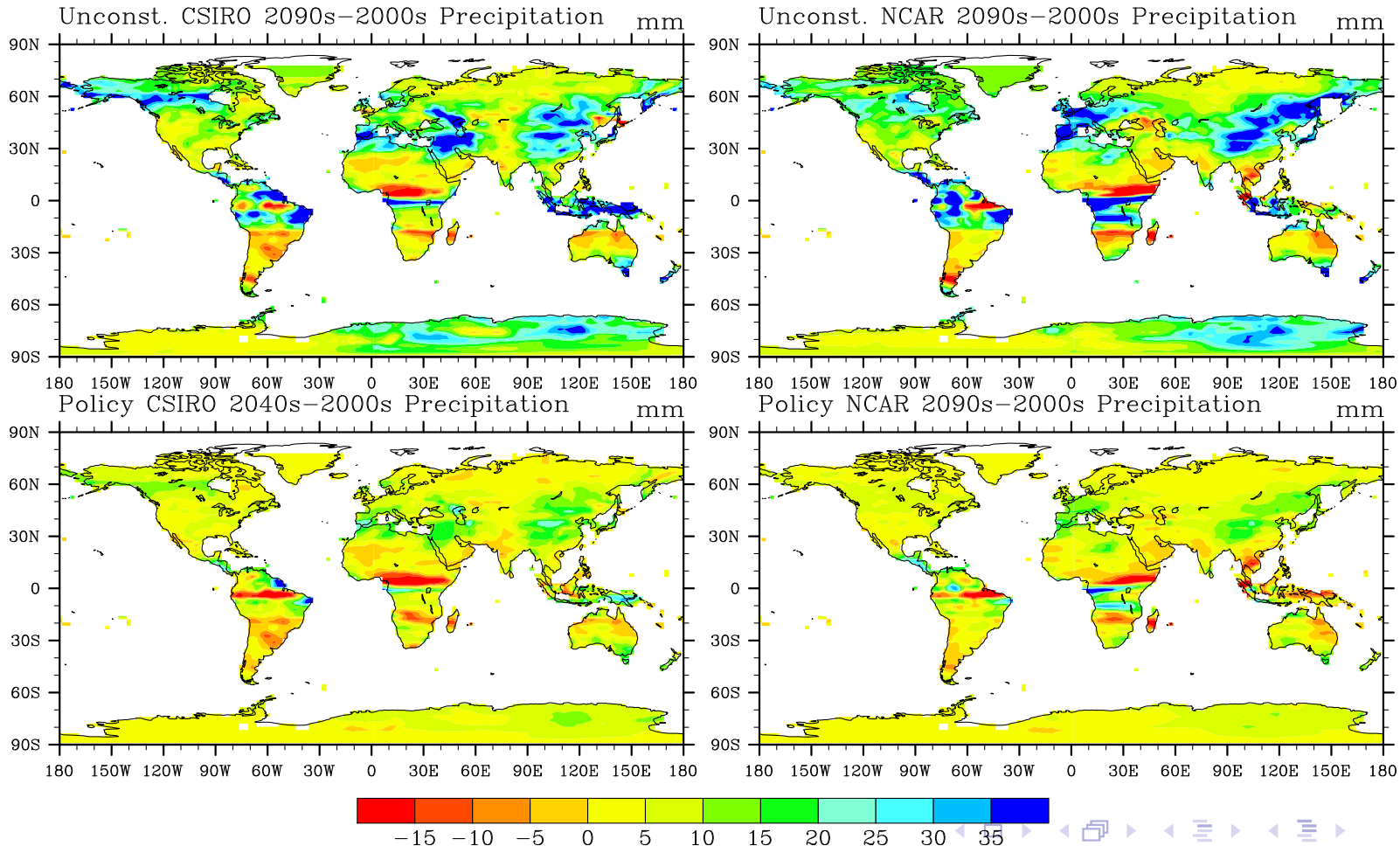
Created 2 other forcing patterns in the future....

- Temperature patterns

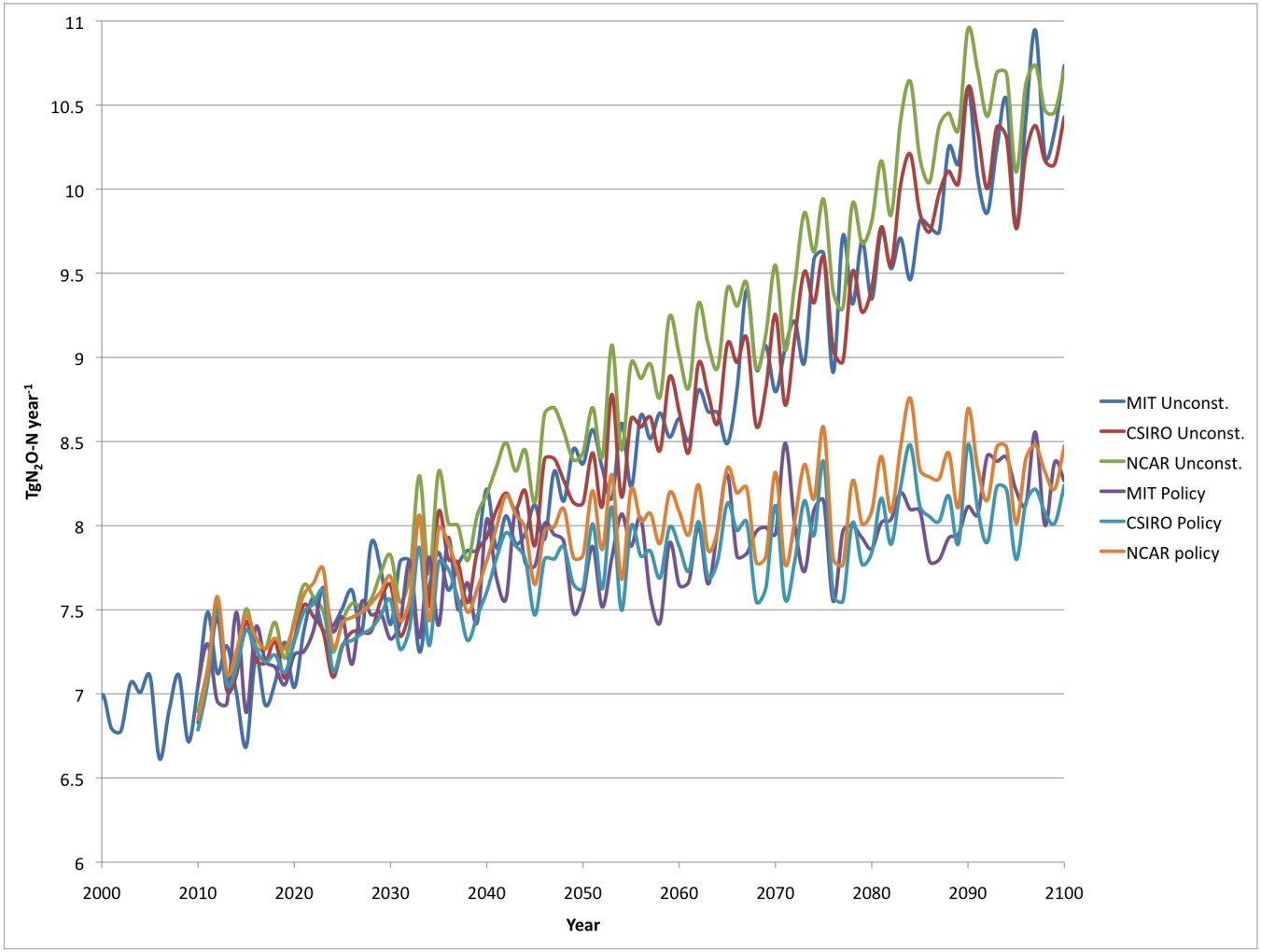


Created 2 other forcing patterns in the future....

- Precipitation patterns



Natural soil N_2O emissions in the future



Conclusion

- We inserted an N_2O module into CLM-CNv3.5 and quantified natural soil N_2O emissions.
- Process modeling results show clear seasonality and El Niño years have low natural soil N_2O emissions.
- Our model results indicate that there will be significant increase in natural soil N_2O emissions in the future without policy to regulate GHGs.