DIAGNOSING CFC-11's EMISSIONS IN A CHEMISTRY-CLIMATE MODEL

PENGFEI YU

Robert Portmann, Eric Ray, John Daniel, Geoff Dutton, Brad Hall, David Nance, Sean Davis, Nicholas Davis, James Elkins and Steve Montzka

Cooperative Institute for Research in Environmental Sciences, University of Colorado

Chemical Science Division & Global Monitoring Division, NOAA

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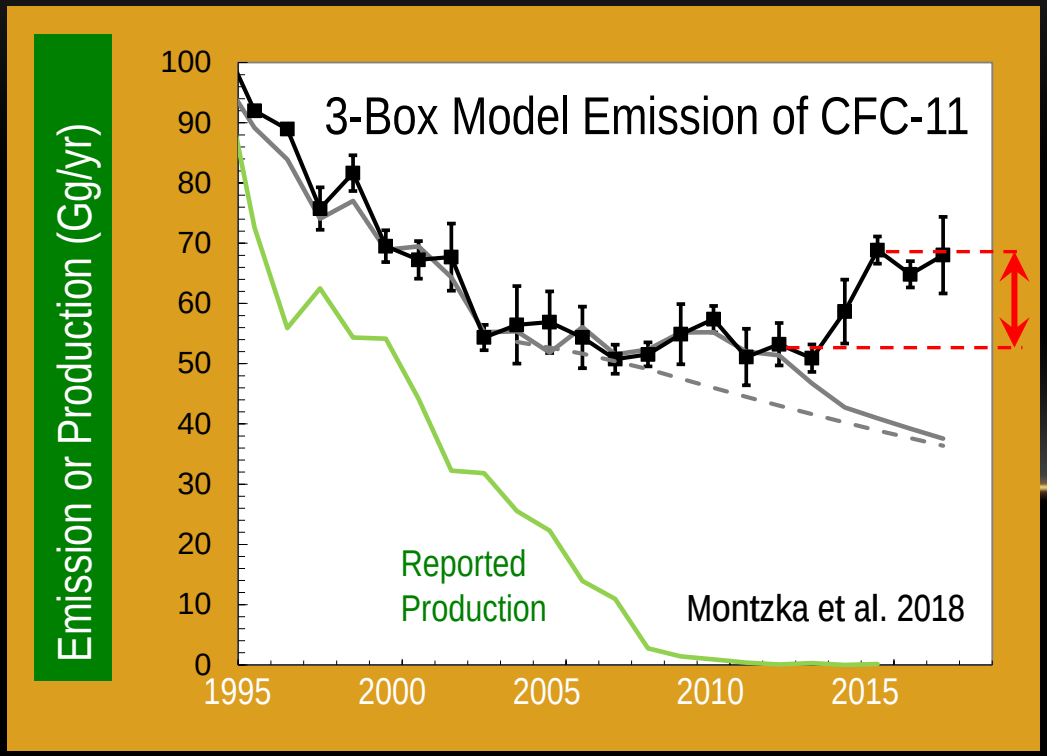
Use NSF/DOE Climate Model CESM to revisit the emission from the 3-Box model

Emission



13 ± 5 Gg/yr
(25%) increase

Meteorology:
Wind & temp

MERRA2

MERRA1

GEOS5

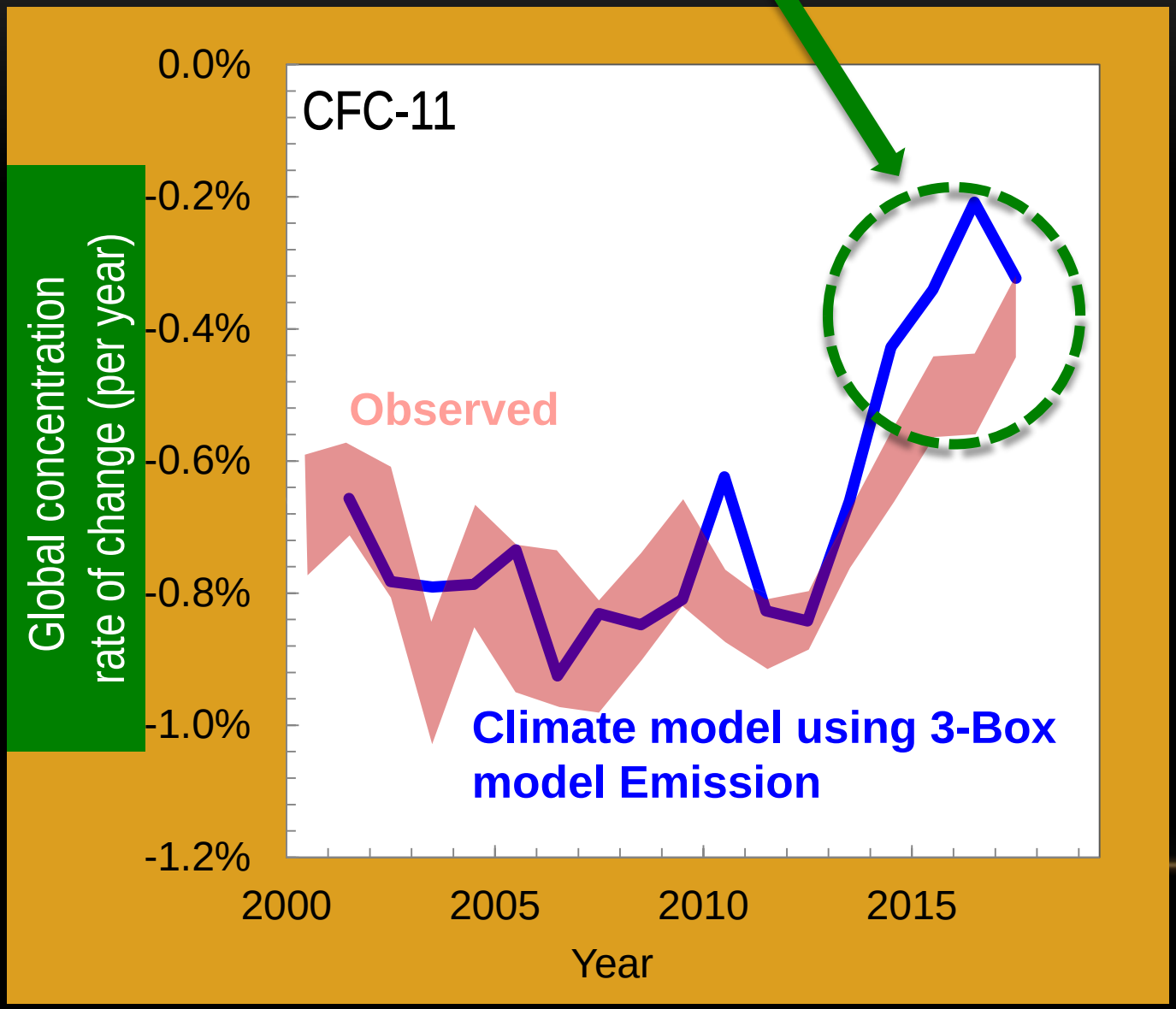
Climate Chemistry Models (CCM)

CAM5

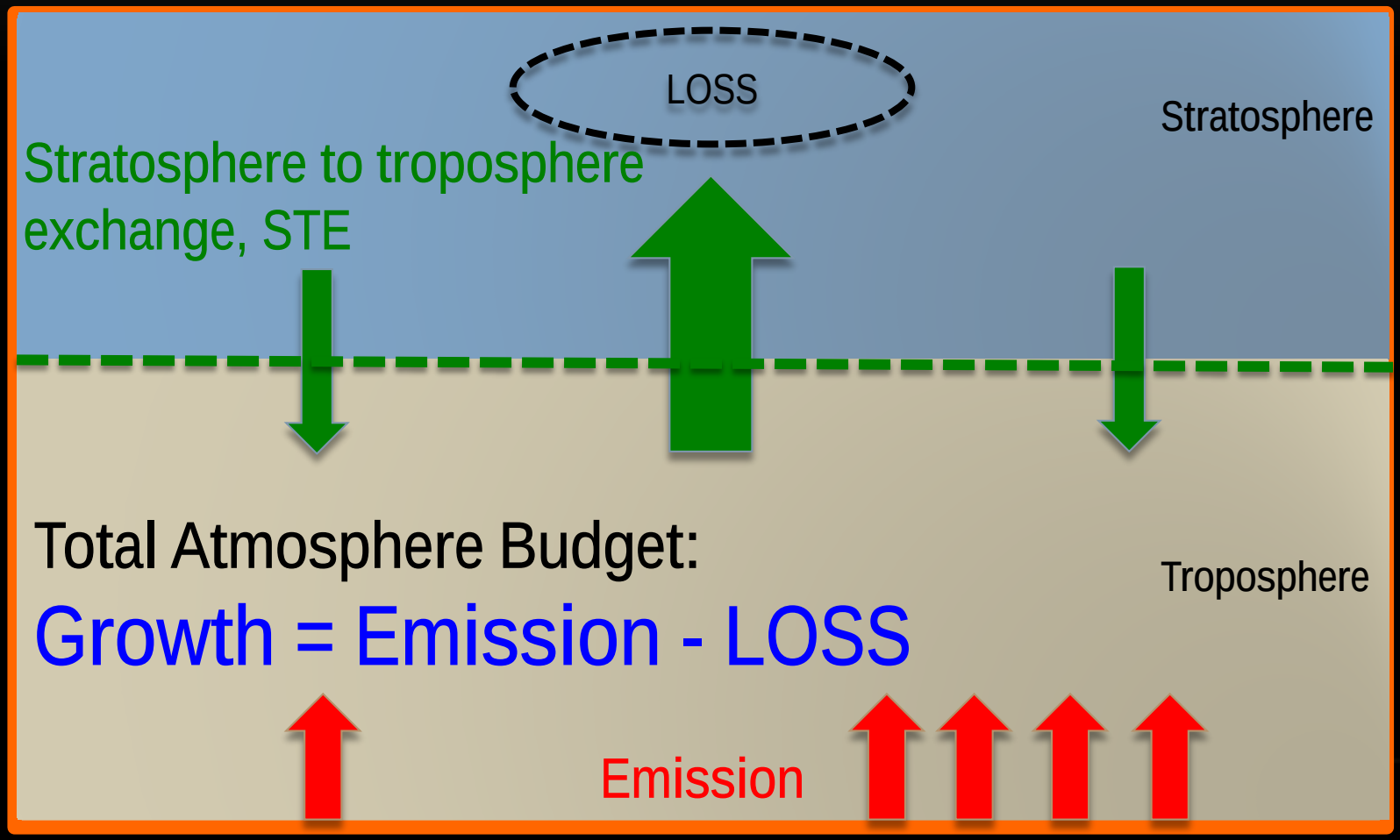
WACCM

HOW RELIABLE IS 3-BOX MODEL EMISSION?

→Emission increase seems too large after 2012

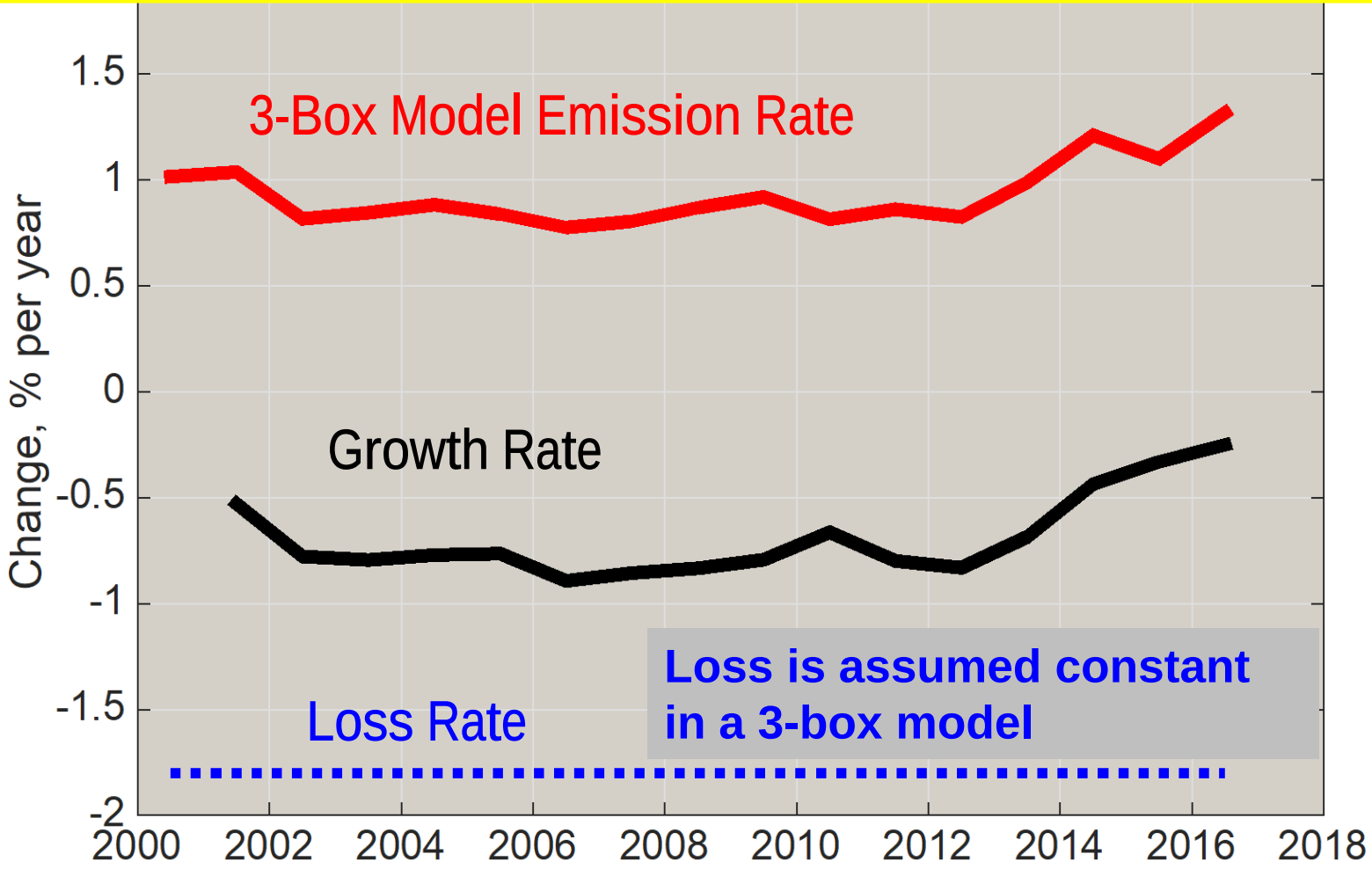


HOW WE DERIVE EMISSION? CFC-11's MASS BUDGET

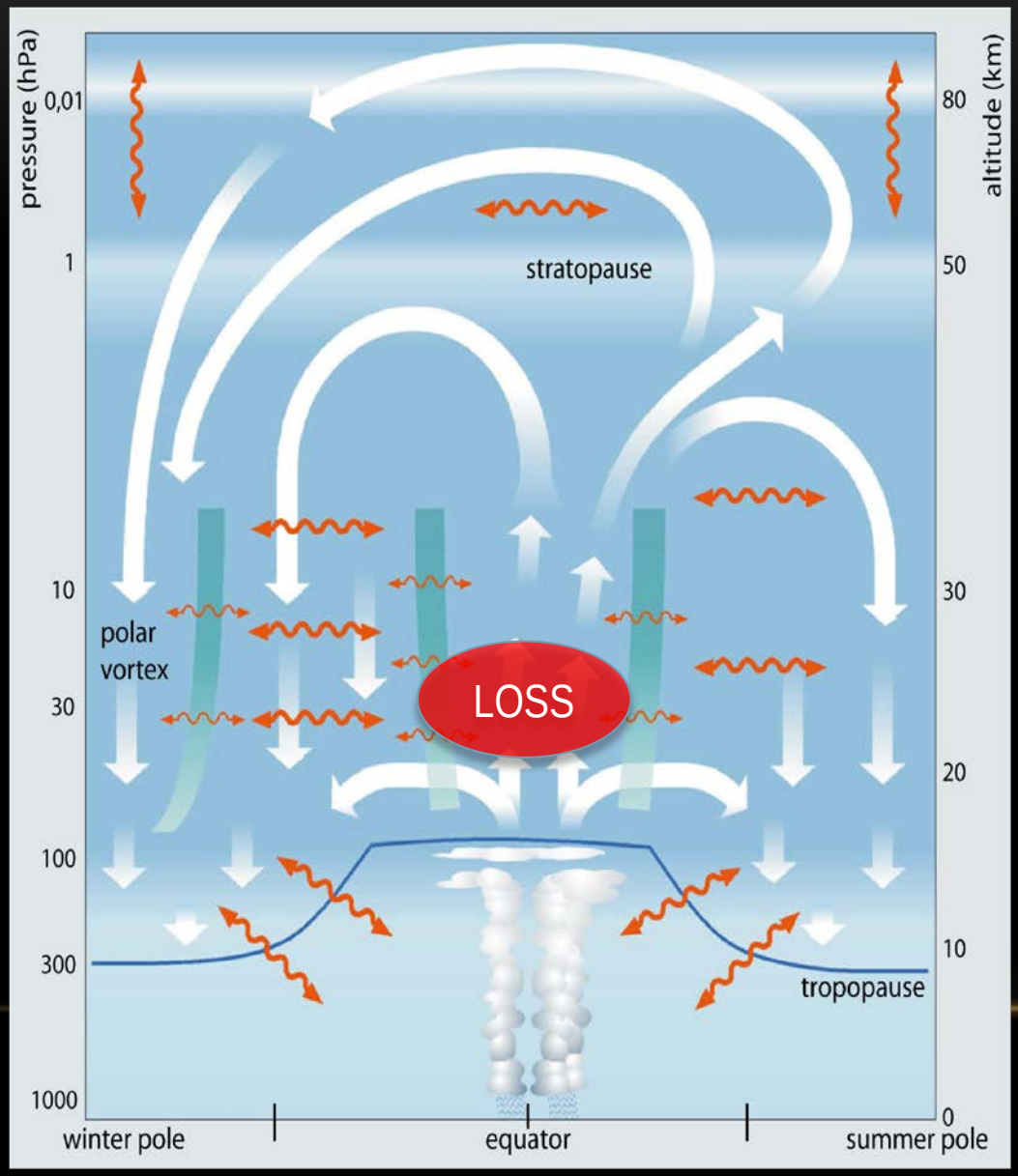


EMISSION, LOSS AND GROWTH RATE IN A 3-BOX MODEL

Budget Eq.→→ Emission = Growth - Loss



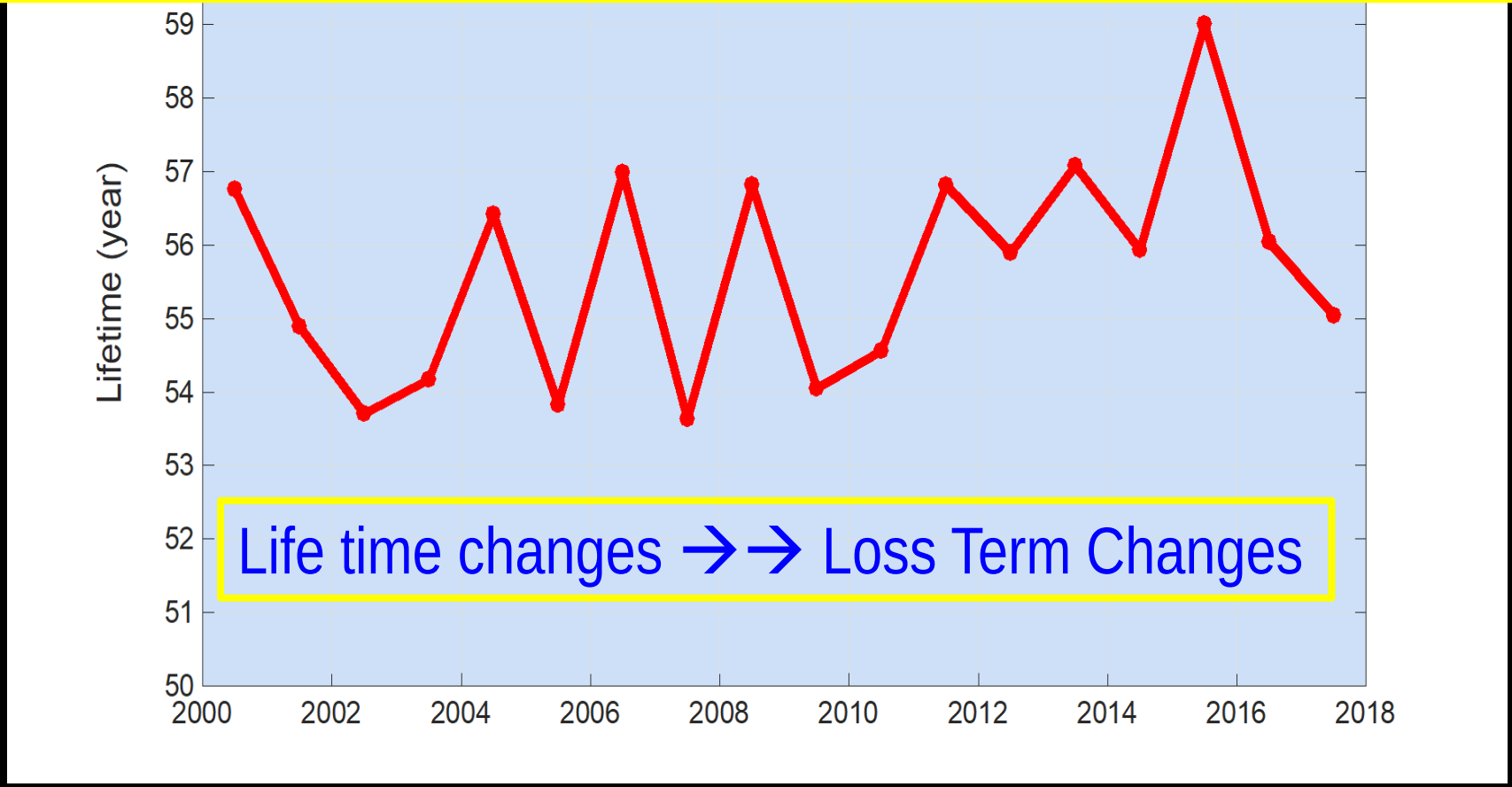
LIFETIME VARIABILITY IS MOSTLY DRIVEN BY DYNAMICS



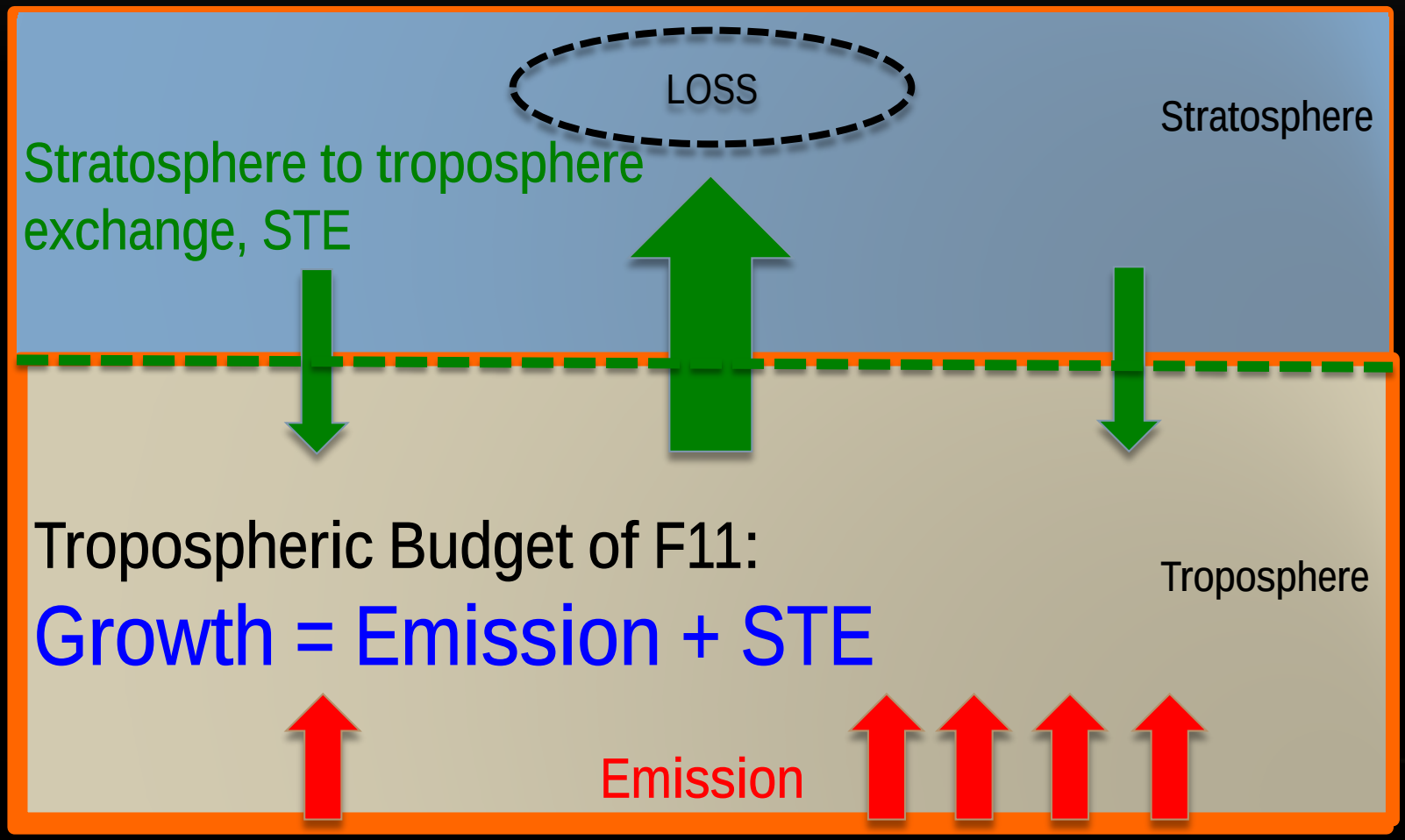
Bonisch et al., 2001, ACP

THE LIFETIME OF CFC-11 IS NOT CONSTANT IN A CCM BECAUSE OF VARYING DYNAMICS

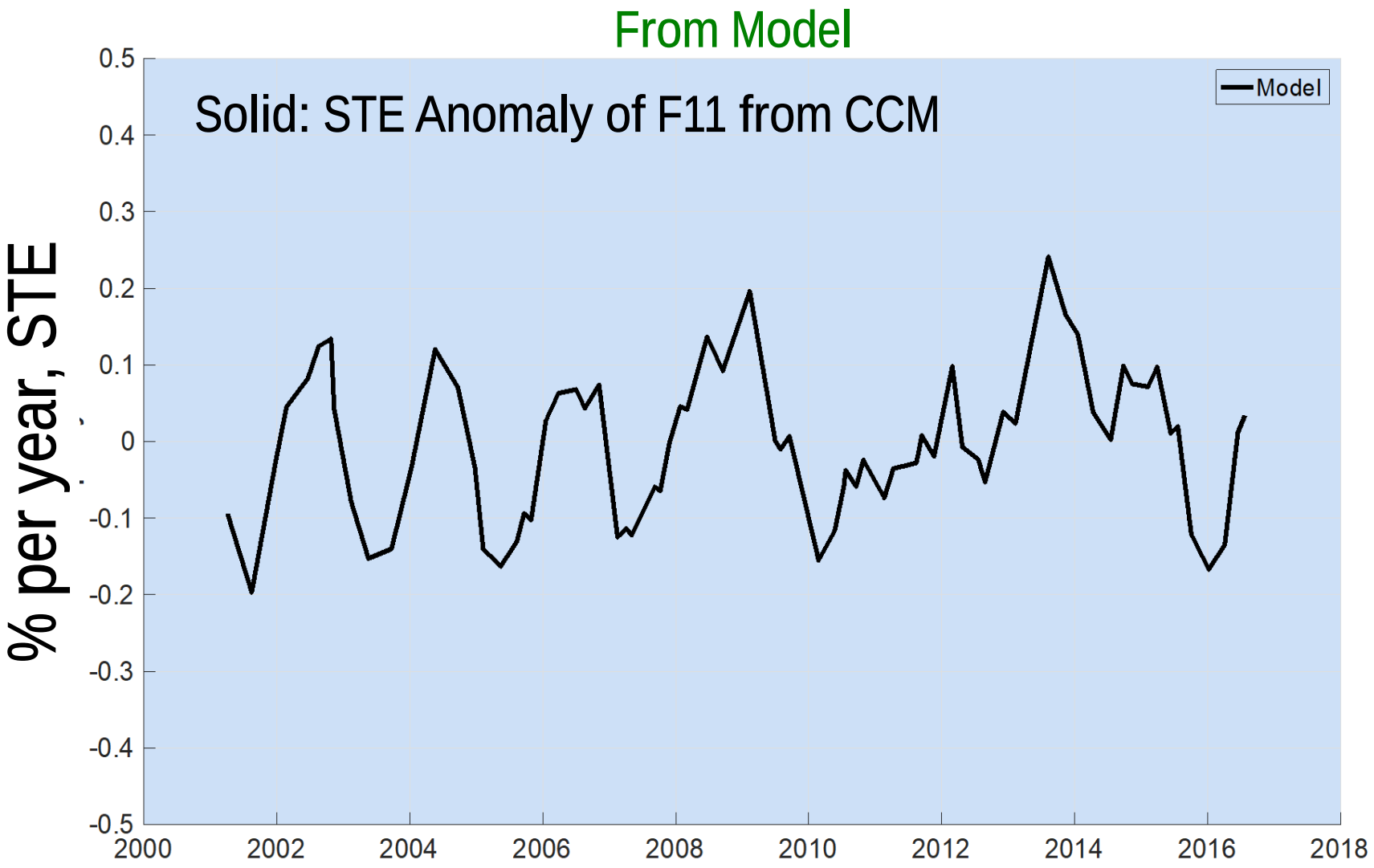
Budget Eq.→→ Emission = Growth - Loss



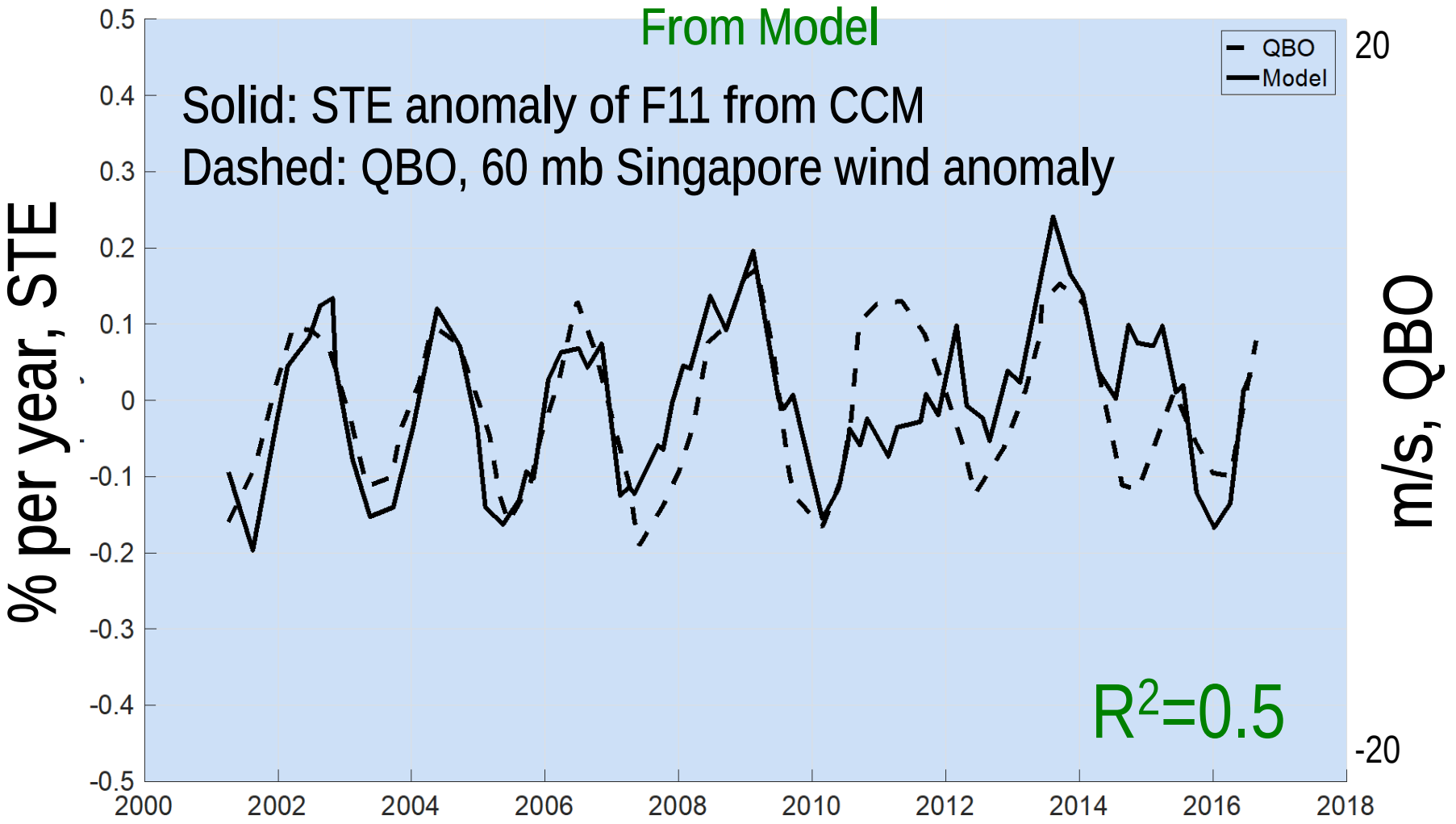
CAN WE QUANTIFY THE INFLUENCE OF DYNAMICS ON OBSERVED TRENDS AND DERIVED EMISSIONS?



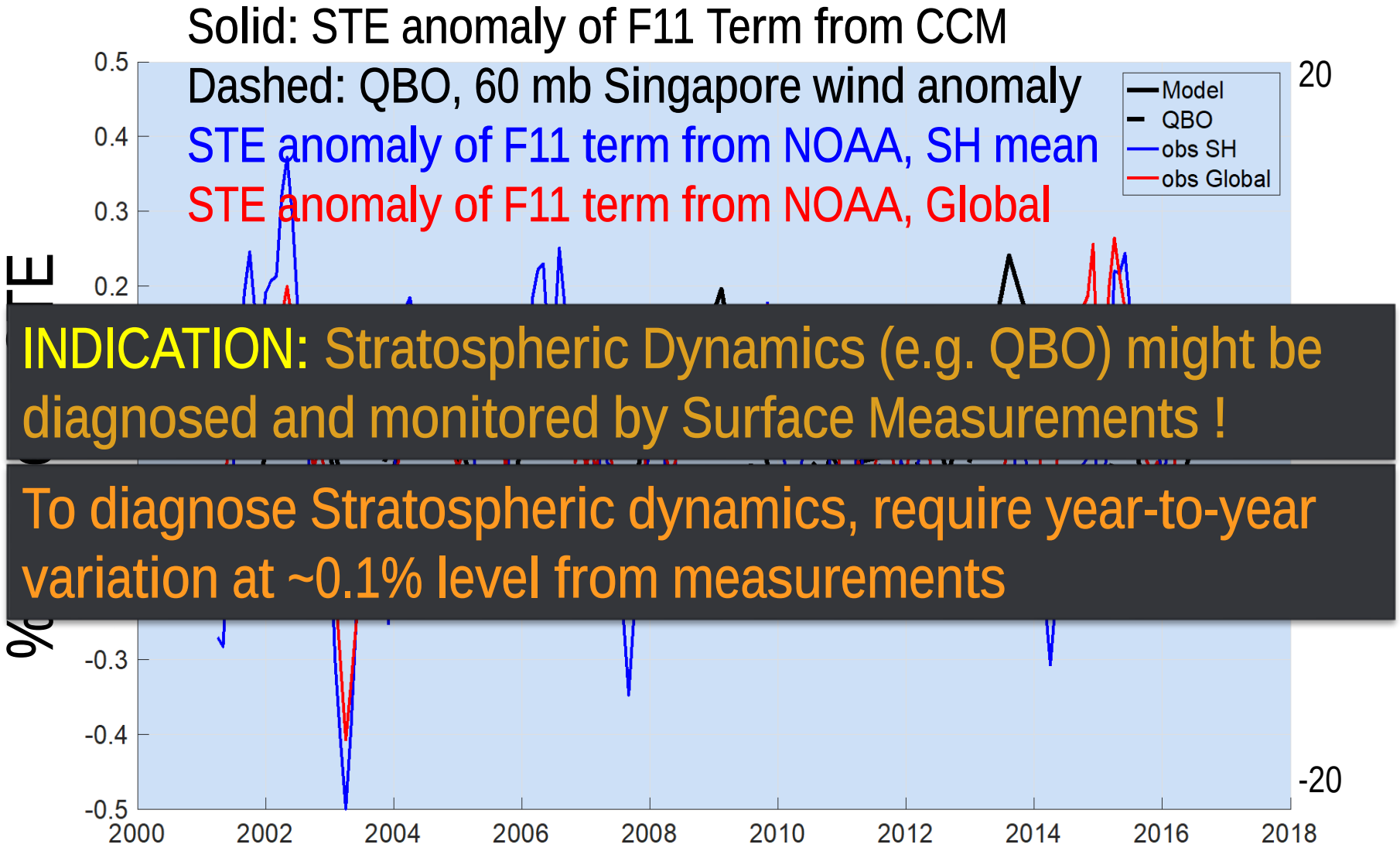
Is dynamical variability (STE) derived in a CCM realistic?



STE CFC-11 vs. QBO: strong correlation



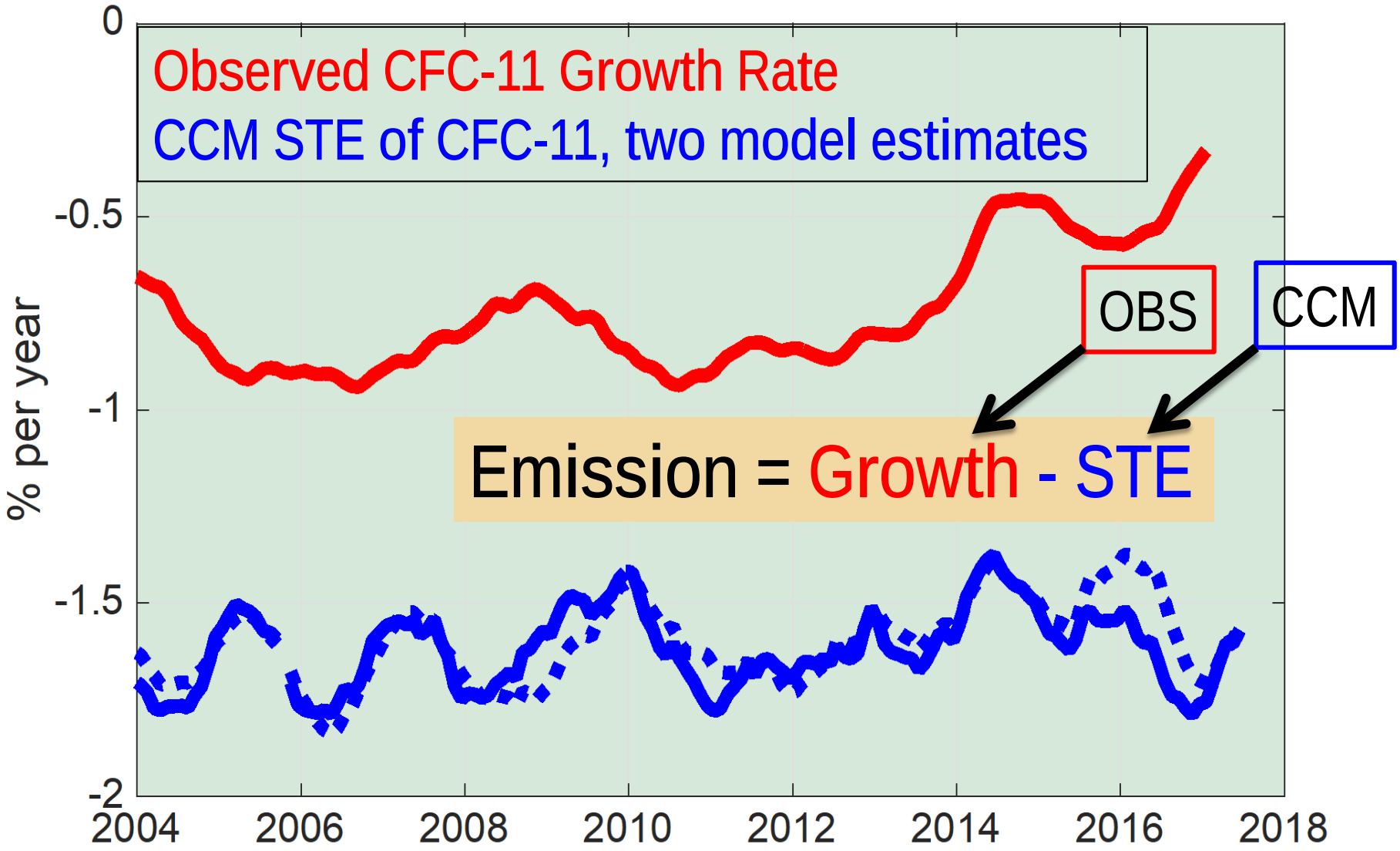
SURFACE OBSERVATIONS ALSO SHOWS CORRELATION WITH QBO AND MODELED F11



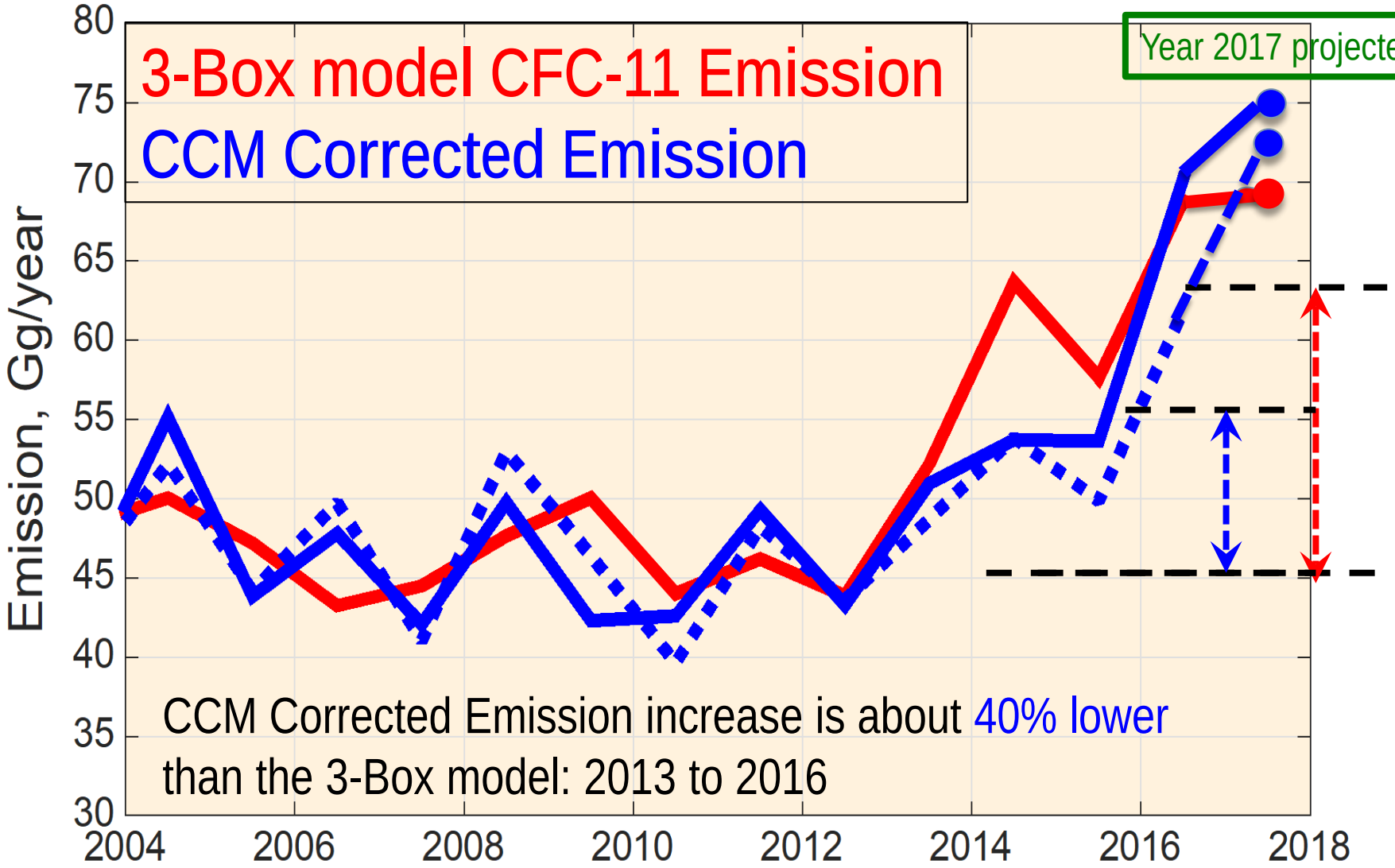
INDICATION: Stratospheric Dynamics (e.g. QBO) might be diagnosed and monitored by Surface Measurements !

To diagnose Stratospheric dynamics, require year-to-year variation at ~0.1% level from measurements

ESTIMATE CORRECTED EMISSION

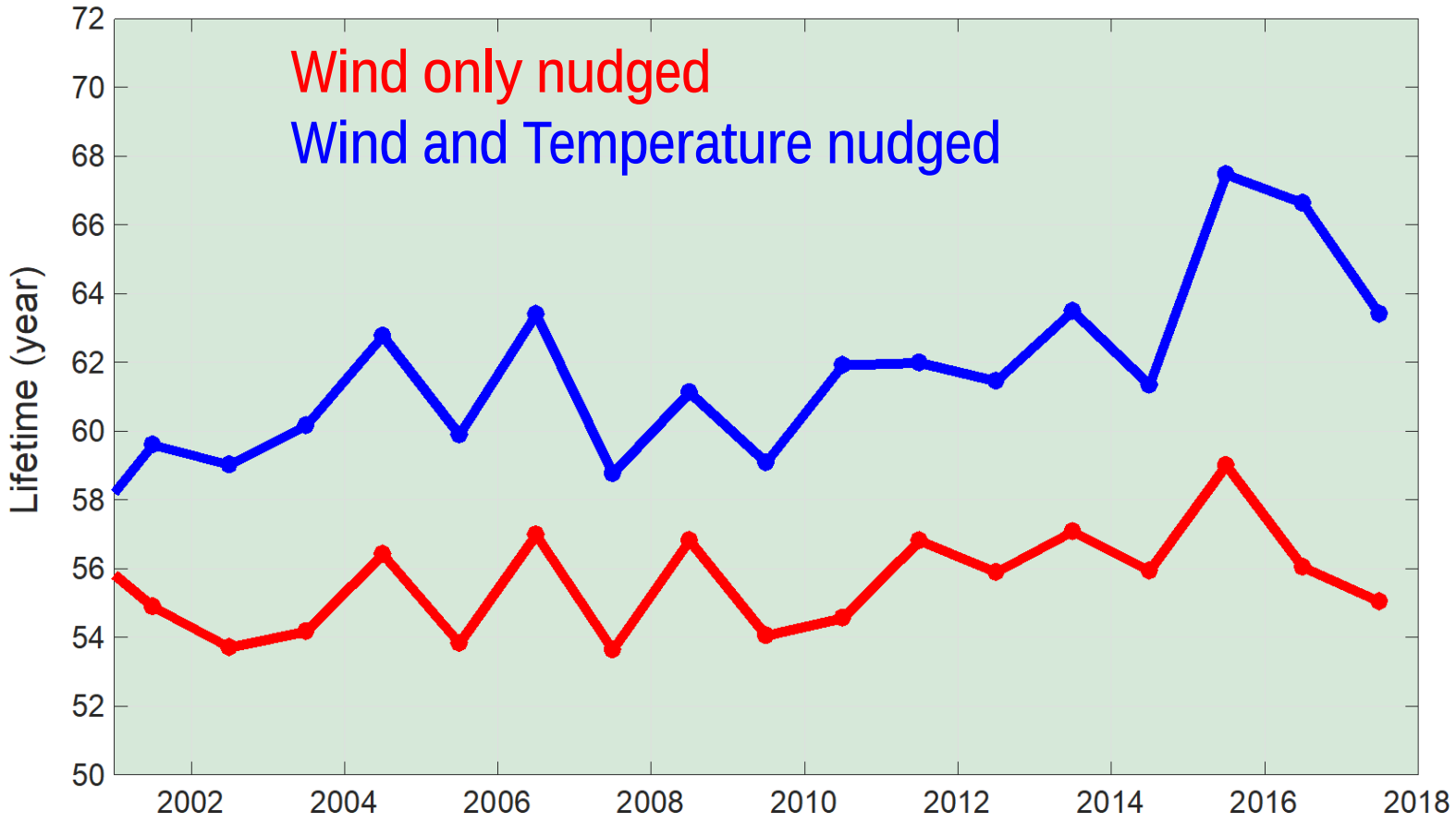


CORRECTED INFERRED EMISSIONS



MODEL PUZZLES

- Nudging Methods change modeled dynamics significantly (lifetime changes by 10%), why?



SUMMARY

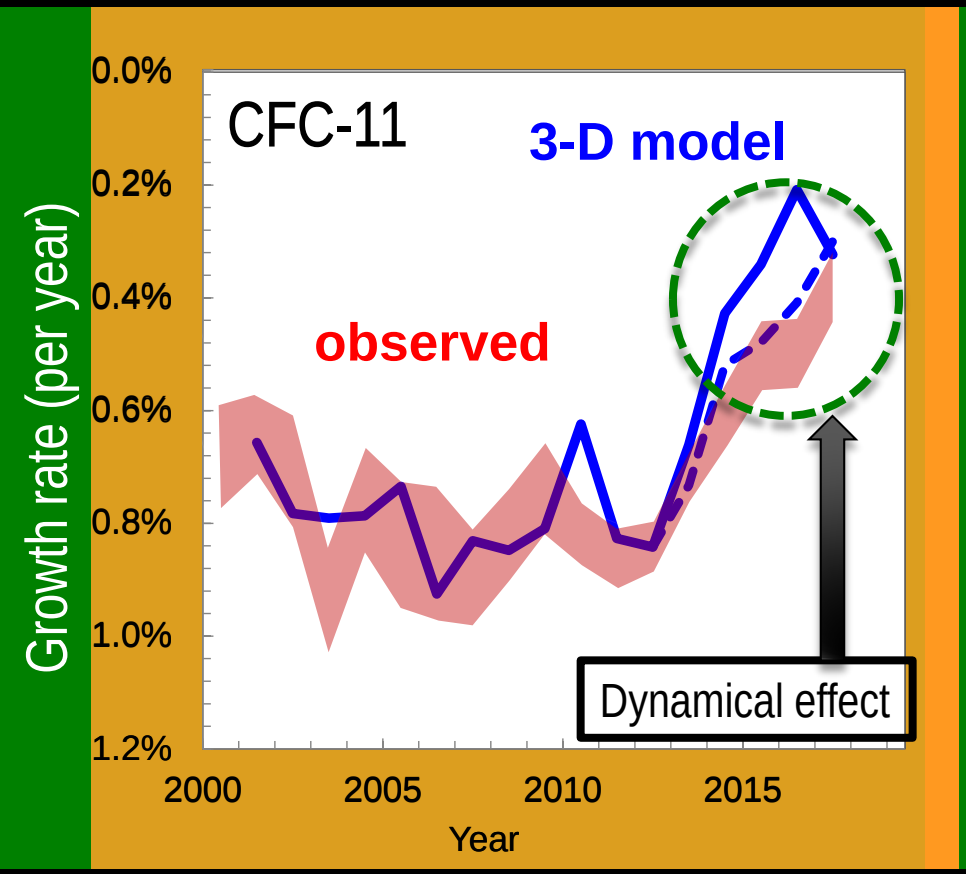
- An increase in CFC-11 emission is required for a Climate Model to reproduce the slowdown of CFC-11's decline (Montzka et al., 2018, *Nature*)
- Climate model suggests dynamical effects (e.g. QBO) are aliased into the emission derived by the 3-Box model.
- The CCM corrected CFC-11 emission increase since 2012 is about 40% lower than 3-Box. In 2017, corrected emission is higher
- Stratospheric dynamical variability including QBO seem to be reflected in surface measurement records of CFC-11
- STE and emission estimates of chemicals require year-to-year variation at about 0.1% level from measurements
- Model and reanalysis dataset's puzzles are revealed and need to be solved

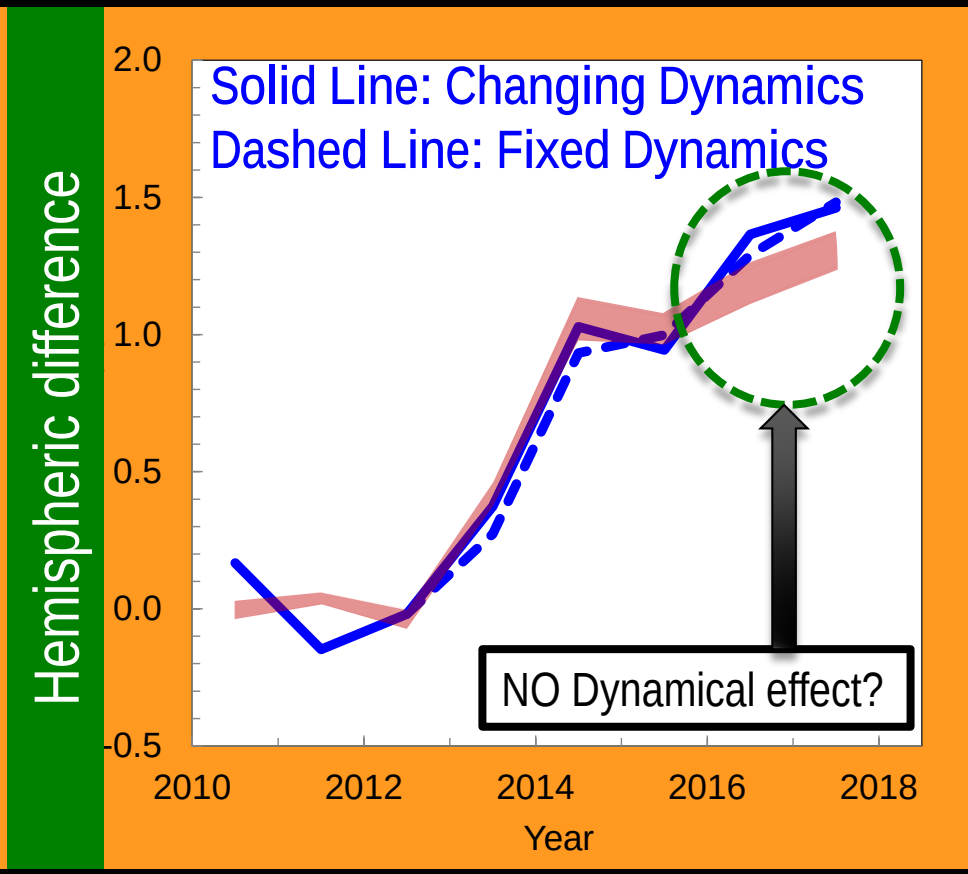
Future Work

- How to identify the source regions of the "unexpected" emissions of CFC-11?

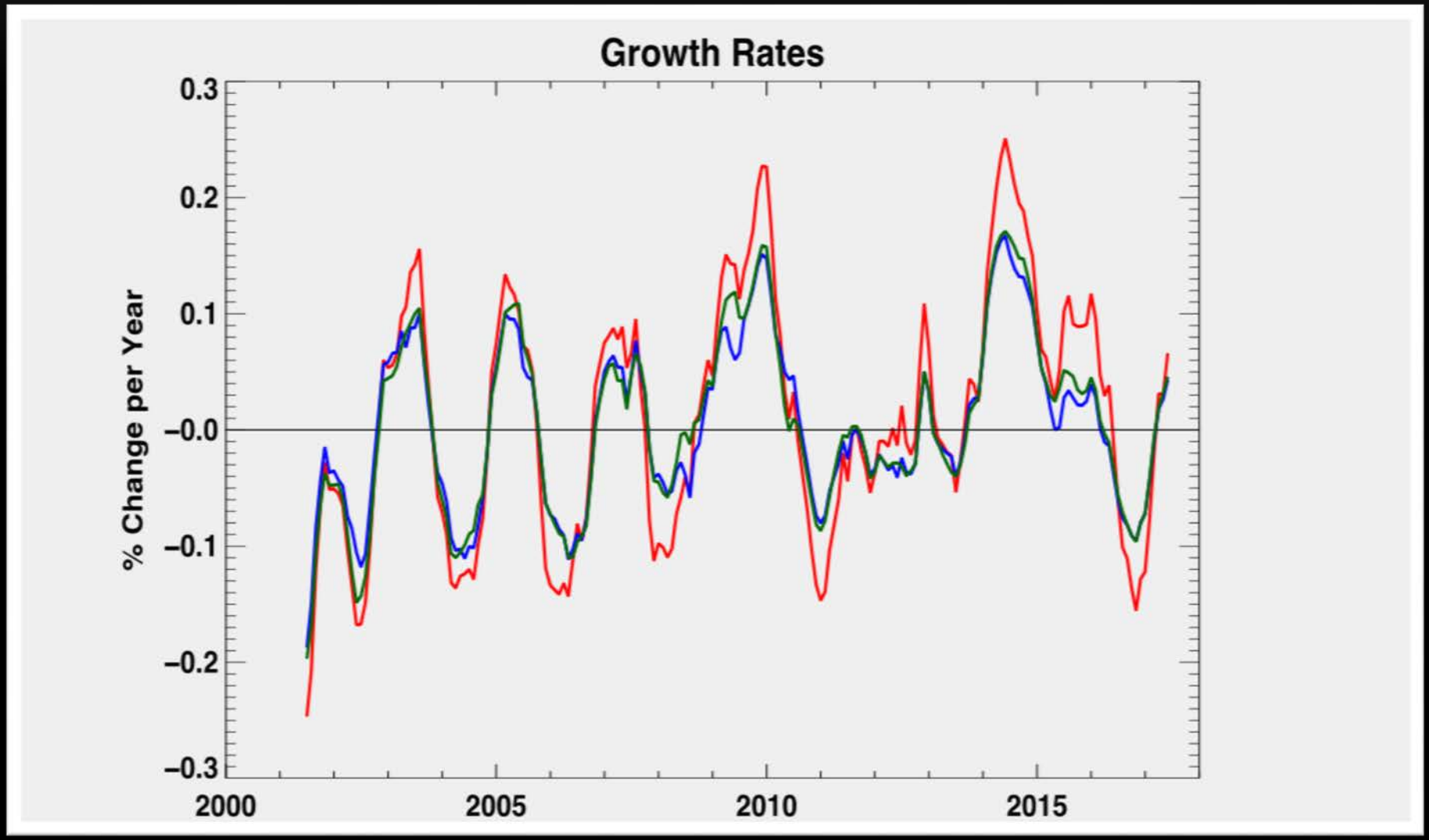
MODEL PUZZLES

- Dynamics affects global growth rate, but not Hemispheric difference, why?





STE TERMS FOR F11, F12 AND F113



OBSERVED GROWTH RATE – FITTED EMISSION