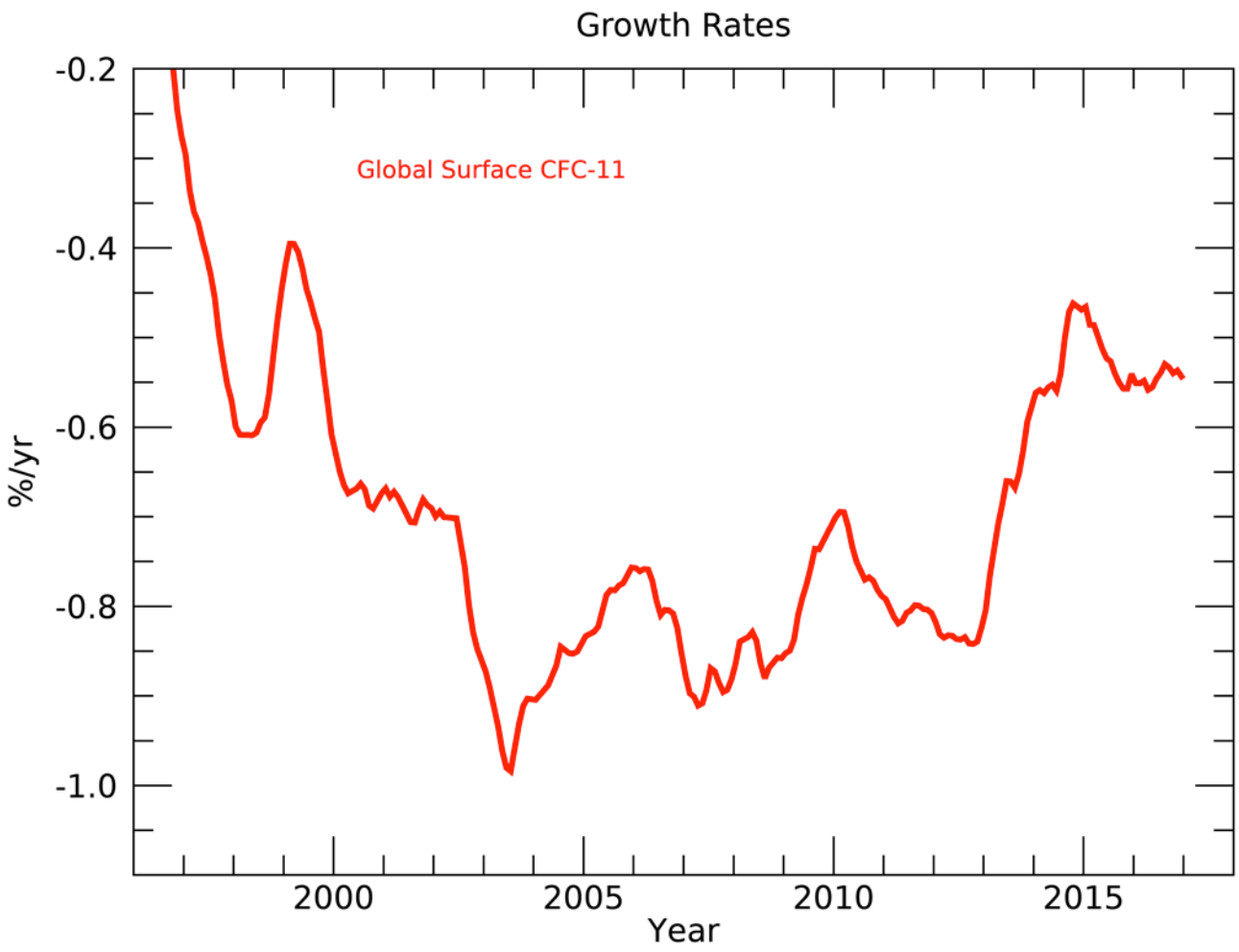
Possible influences of stratospheric transport variability on emission estimates of long-lived trace gases

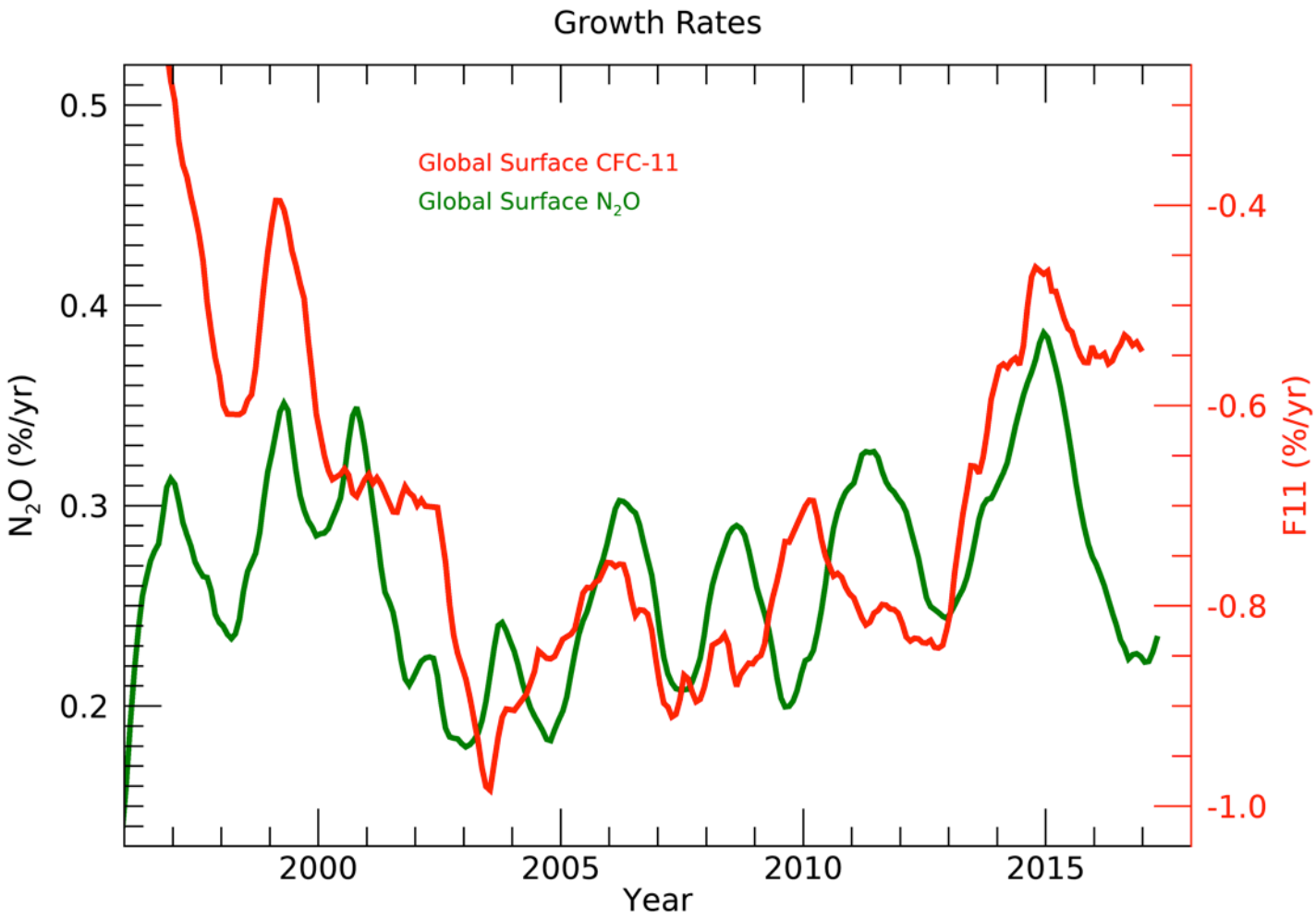
E. Ray, J. Daniel, S. Montzka, R. Portmann, P. Yu, K. Rosenlof and F. Moore
NOAA/CSD, NOAA/GMD, CIRES/CU

Measured Interannual Variability



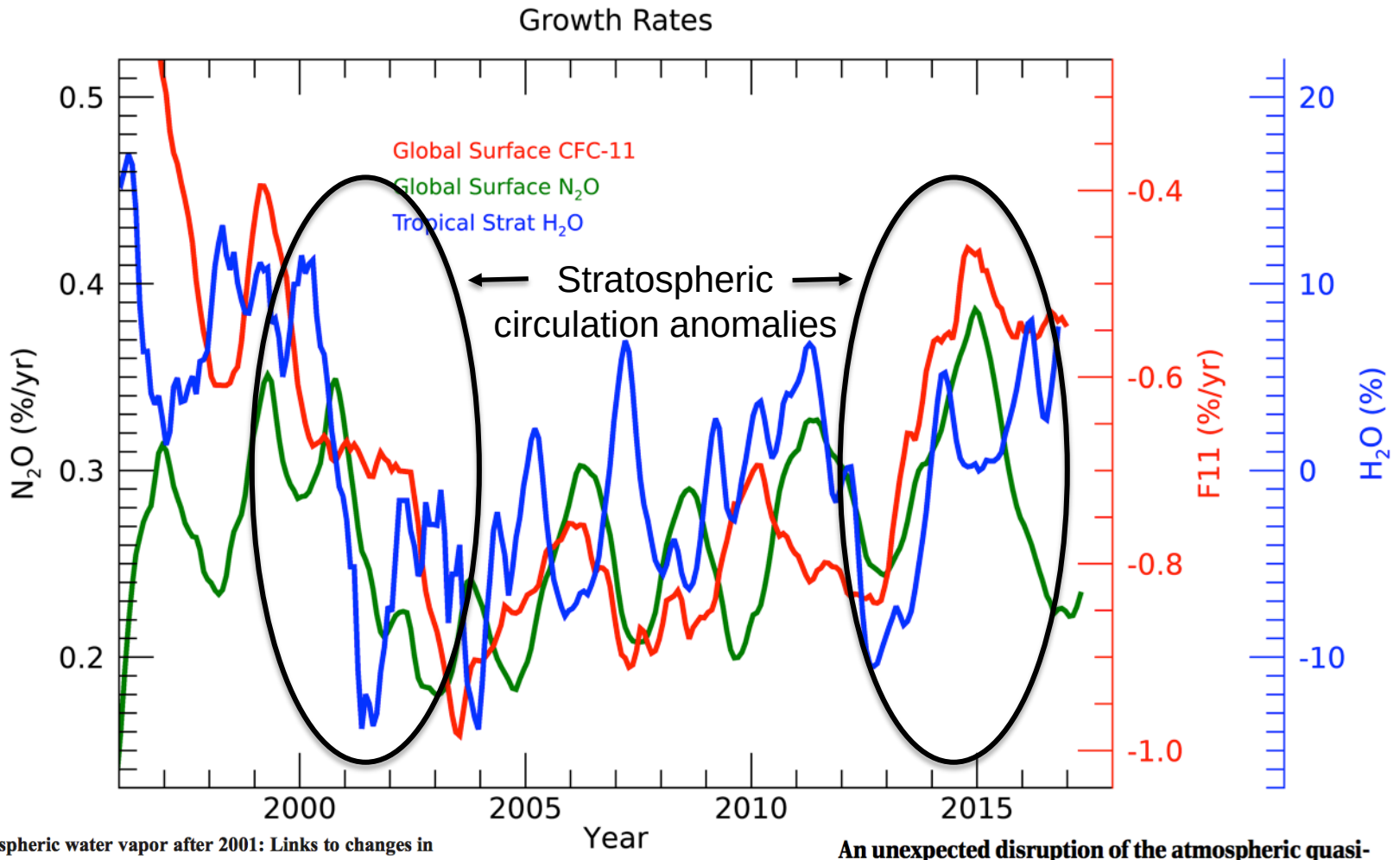
From NOAA/GMD ECD flask measurements

Measured Interannual Variability



From NOAA/GMD combined measurements

Measured Interannual Variability



Decreases in stratospheric water vapor after 2001: Links to changes in the tropical tropopause and the Brewer-Dobson circulation

William J. Randel,[1] Fei Wu,[1] Holger Vömel,[2] Gerald E. Nedoluha,[3] and Piers Forster[4]

Trends in the temperature and water vapor content of the tropical lower stratosphere: Sea surface connection

Karen H. Rosenlof[1] and George C. Reid[1]

From satellite measurements (swoosh, S. Davis)

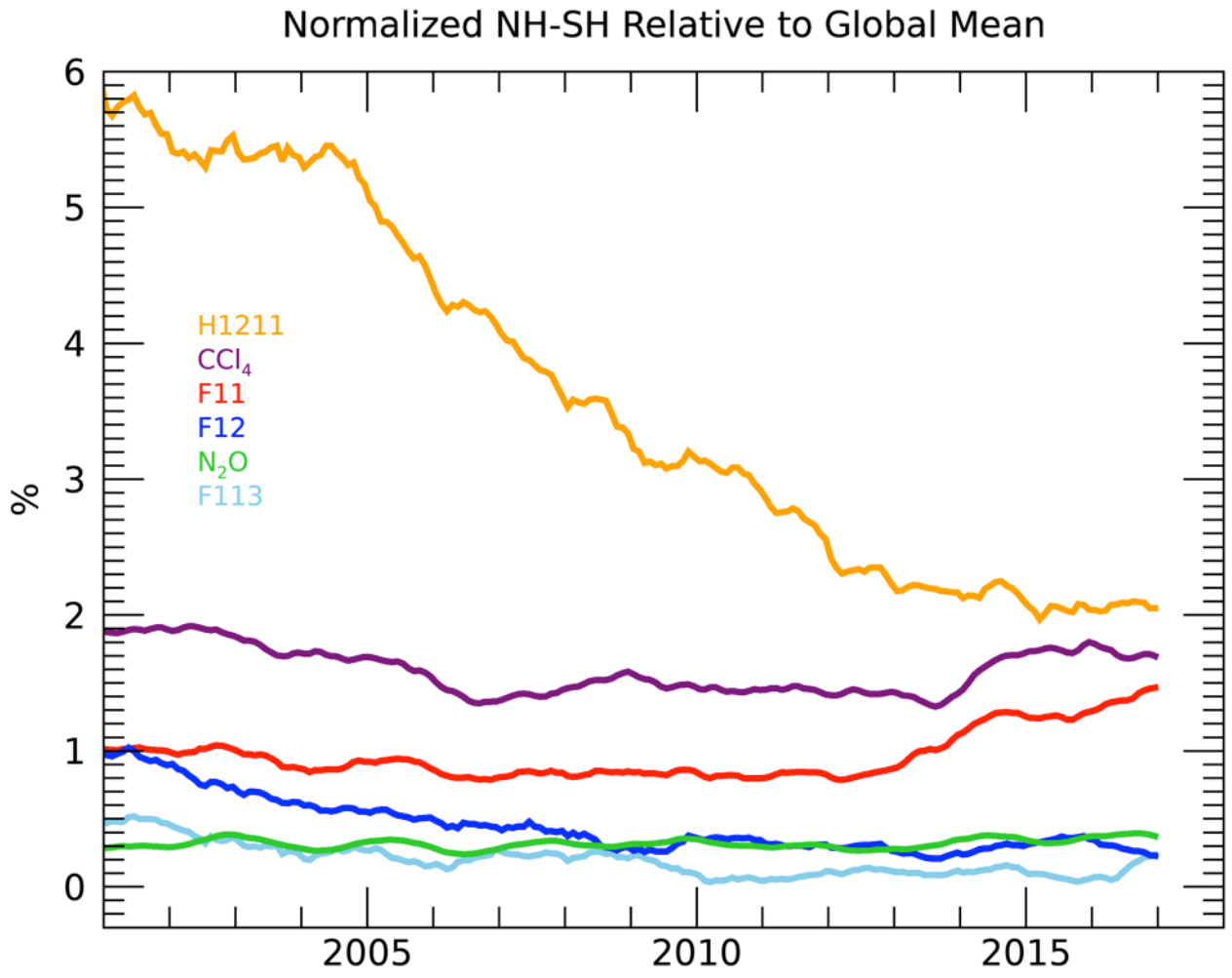
An unexpected disruption of the atmospheric quasi-biennial oscillation

Scott M. Osprey,[1*] Neal Butchart,[2] Jeff R. Knight,[2] Adam A. Scaife,[2,3] Kevin Hamilton,[4] James A. Anstey,[5] Verena Schenzinger,[1] Chunxi Zhang[4]

Shift of subtropical transport barriers explains observed hemispheric asymmetry of decadal trends of age of air

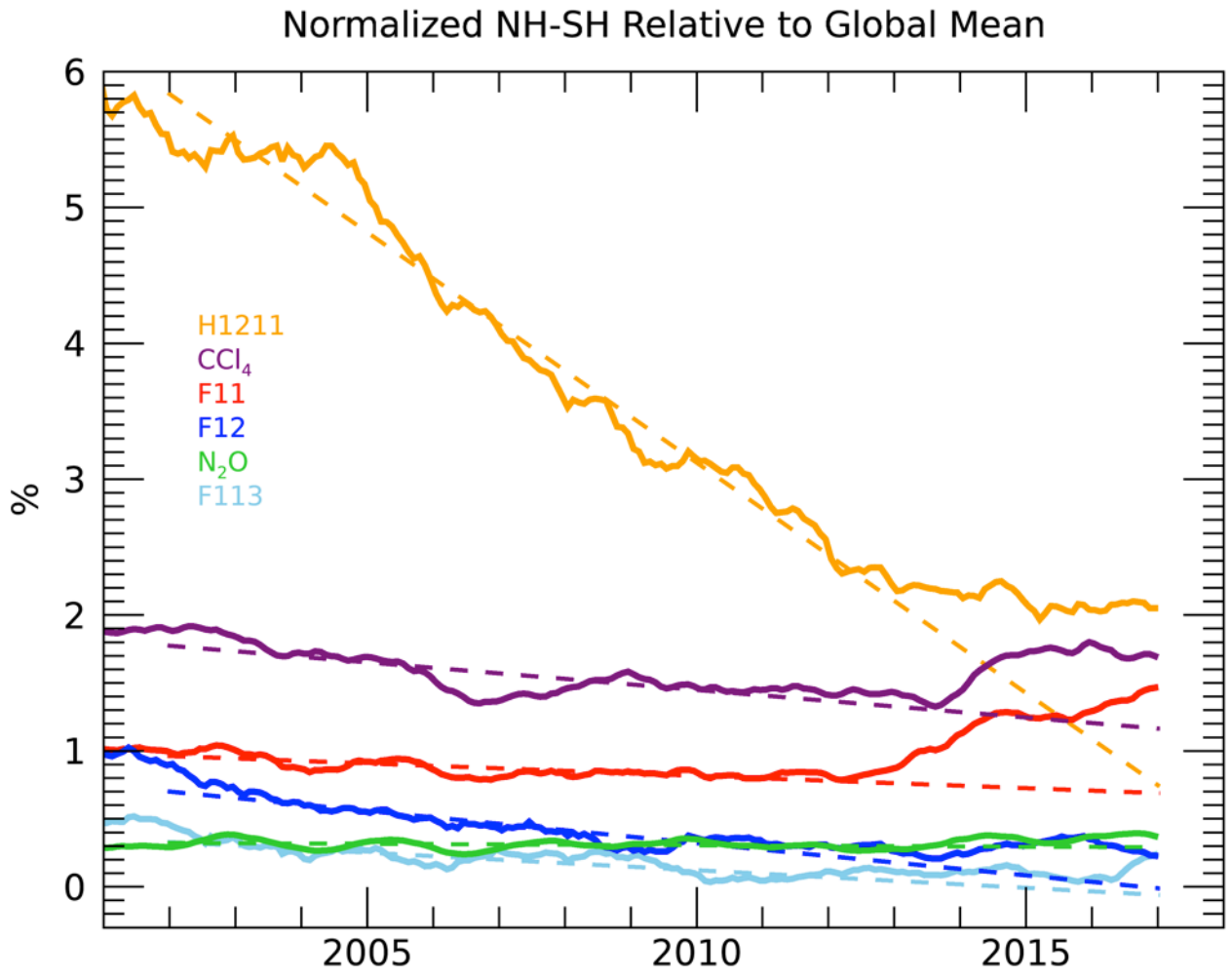
Gabriele P. Stiller[1], Federico Fierli[2], Felix Ploeger[3], Chiara Cagnazzo[2], Bernd Funke[4], Florian J. Haenel[1], Thomas Reddmann[1], Martin Riese[3], and Thomas von Clarmann[1]

Measured Interannual Variability



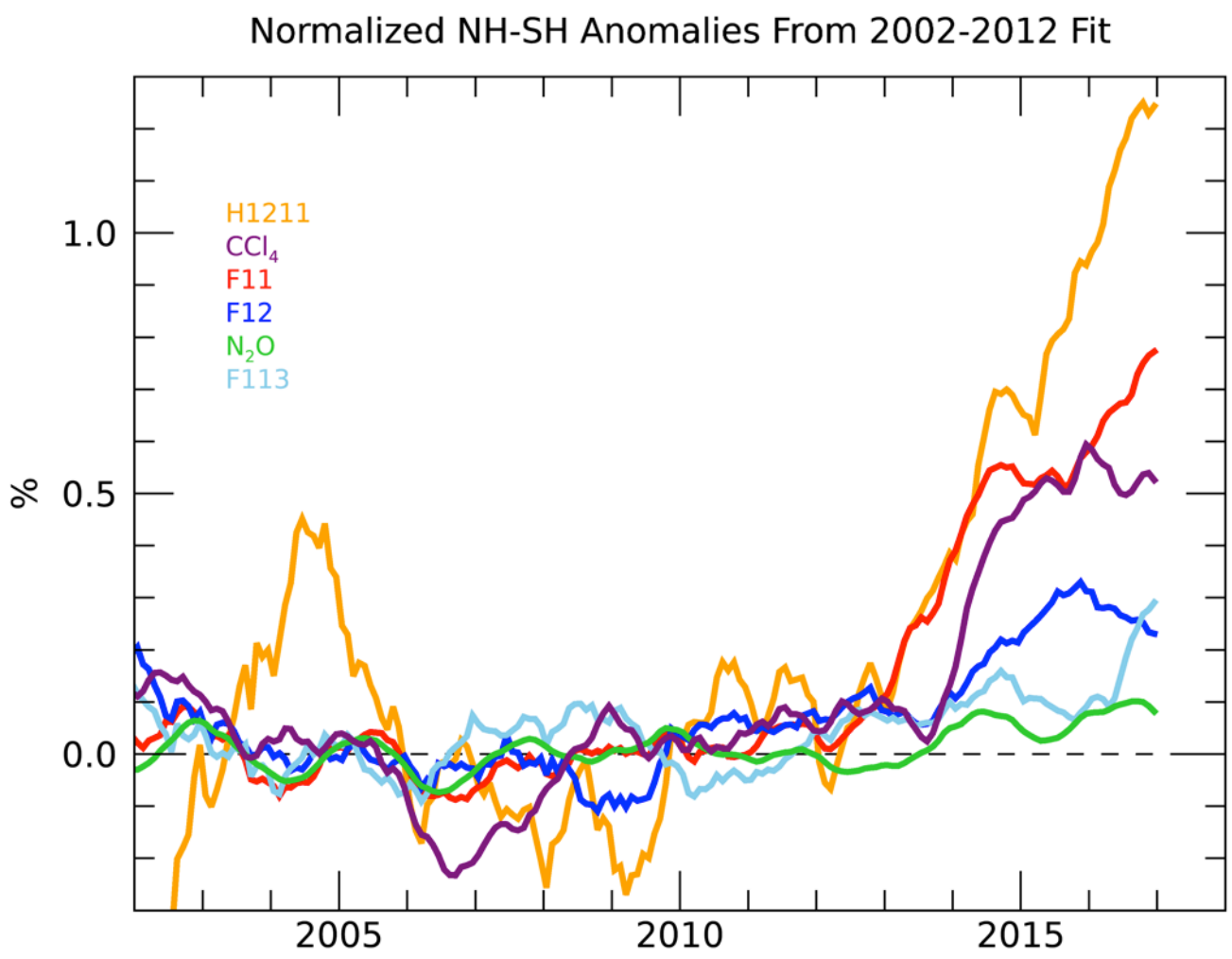
From NOAA/GMD flask and *in situ* measurements

Measured Interannual Variability



Dashed lines are linear fits to the NH-SH time series from 2002-12.

Measured Interannual Variability



Stratospheric lifetimes:

~30 years

~50 years

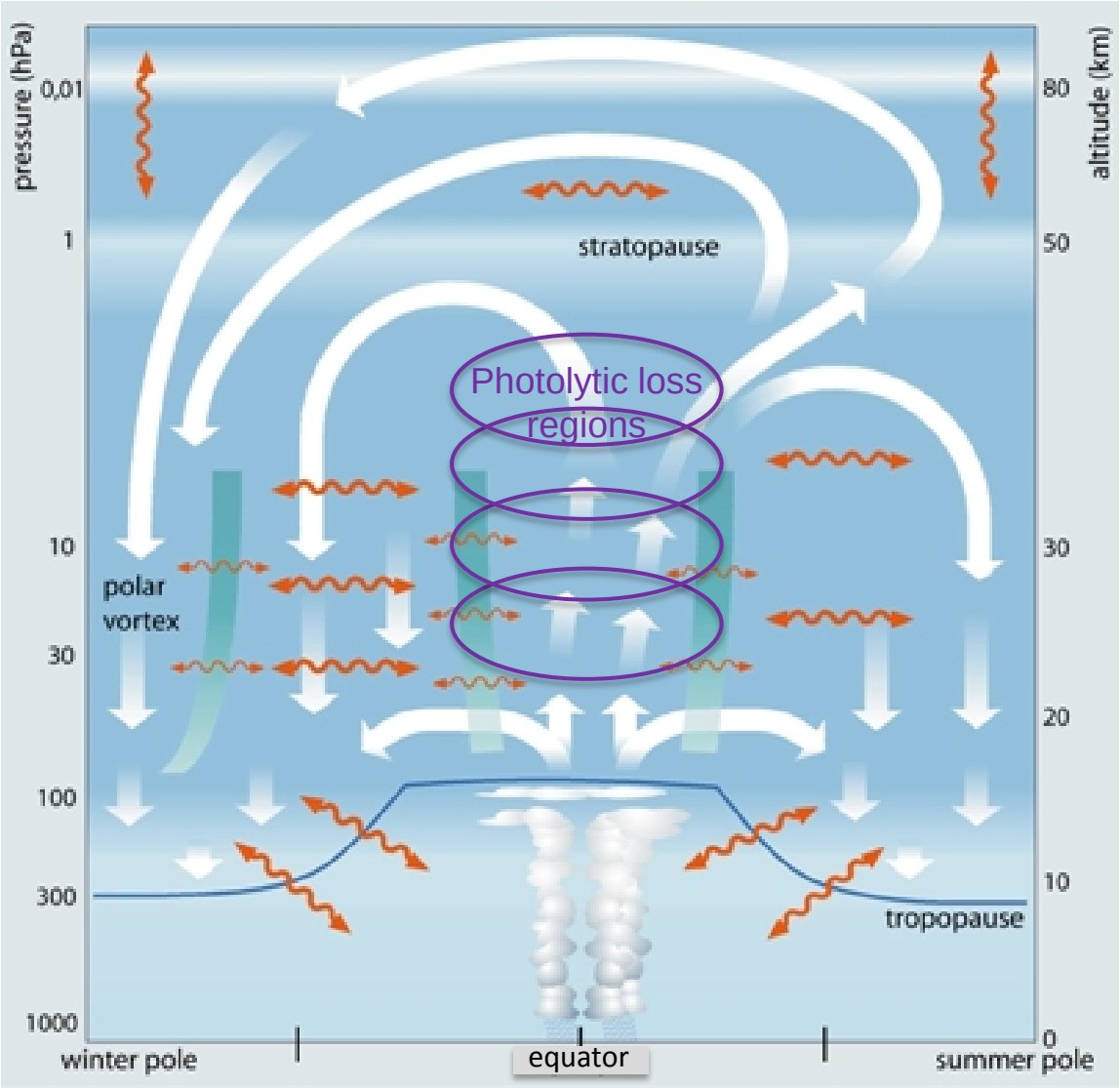
~50 years

~100 years

~100 years

~115 years

Stratospheric Circulation

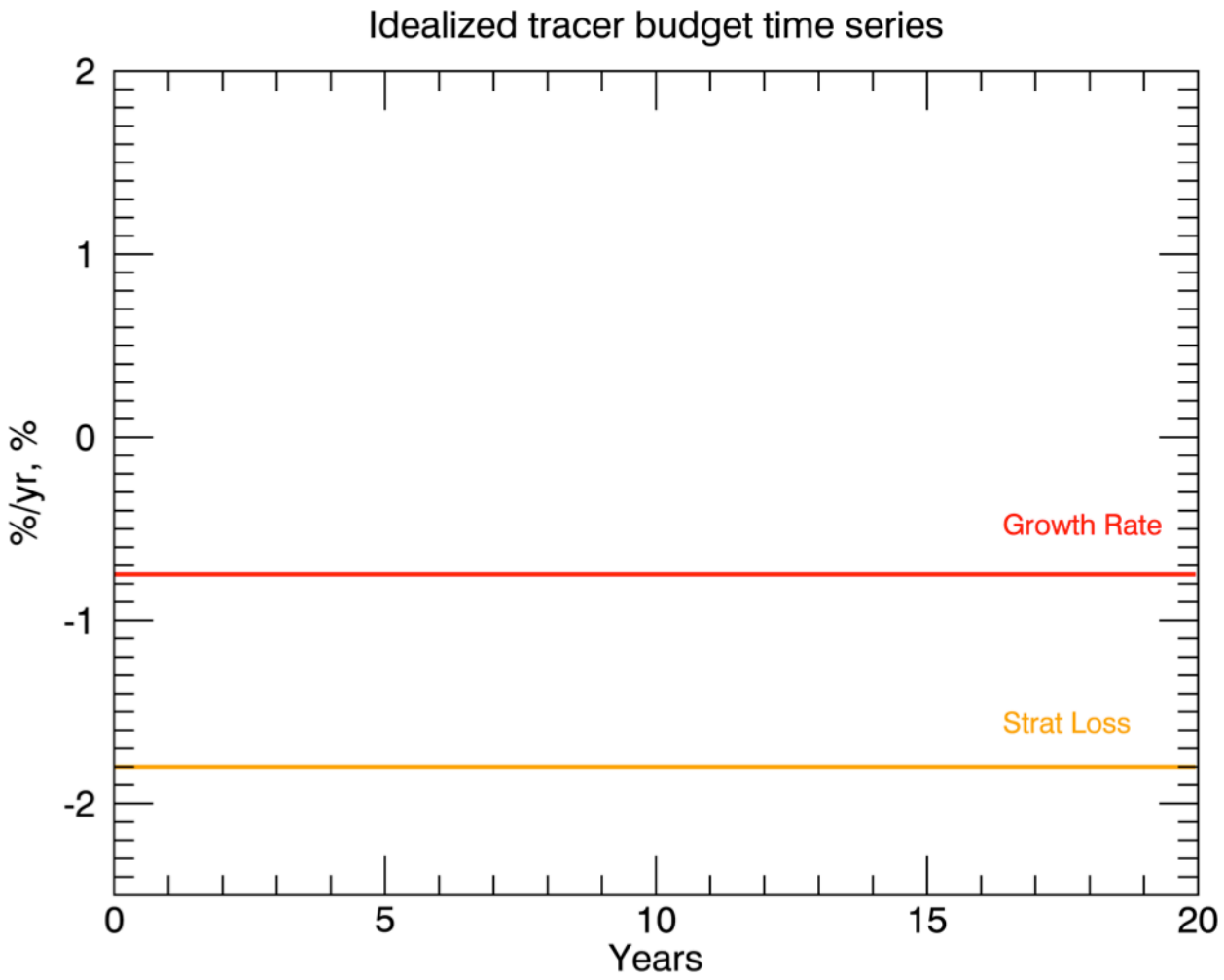


Photolytic loss is determined by transport through the loss regions in the stratosphere.

How much can stratospheric transport variability (both globally and NH vs. SH changes) affect surface trace gas variability?

We use an idealized model to try to quantify the impacts of the stratospheric variability.

Idealized Modeling

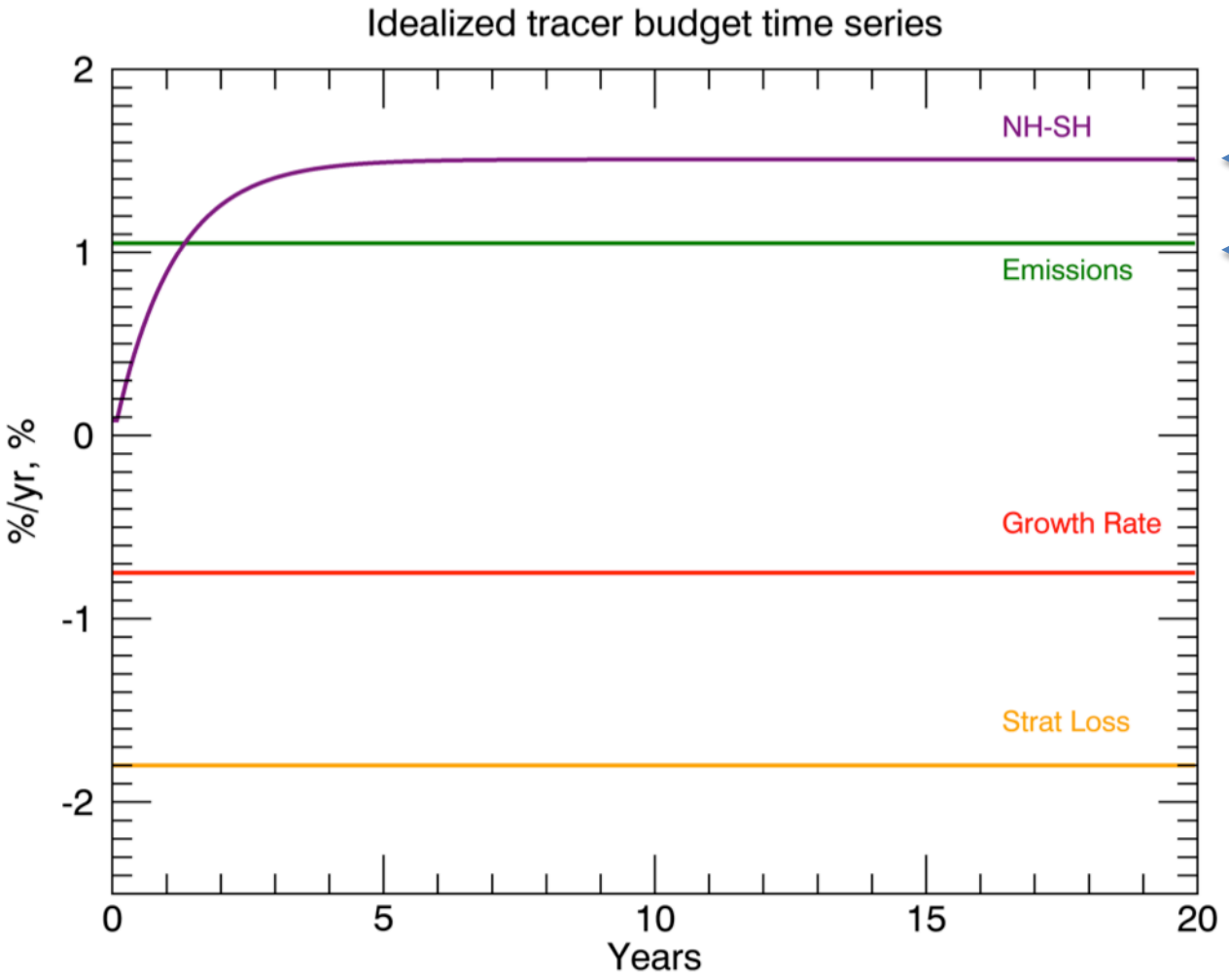


F11-like molecule

← Imposed growth rate

← and stratospheric lifetime

Idealized Modeling

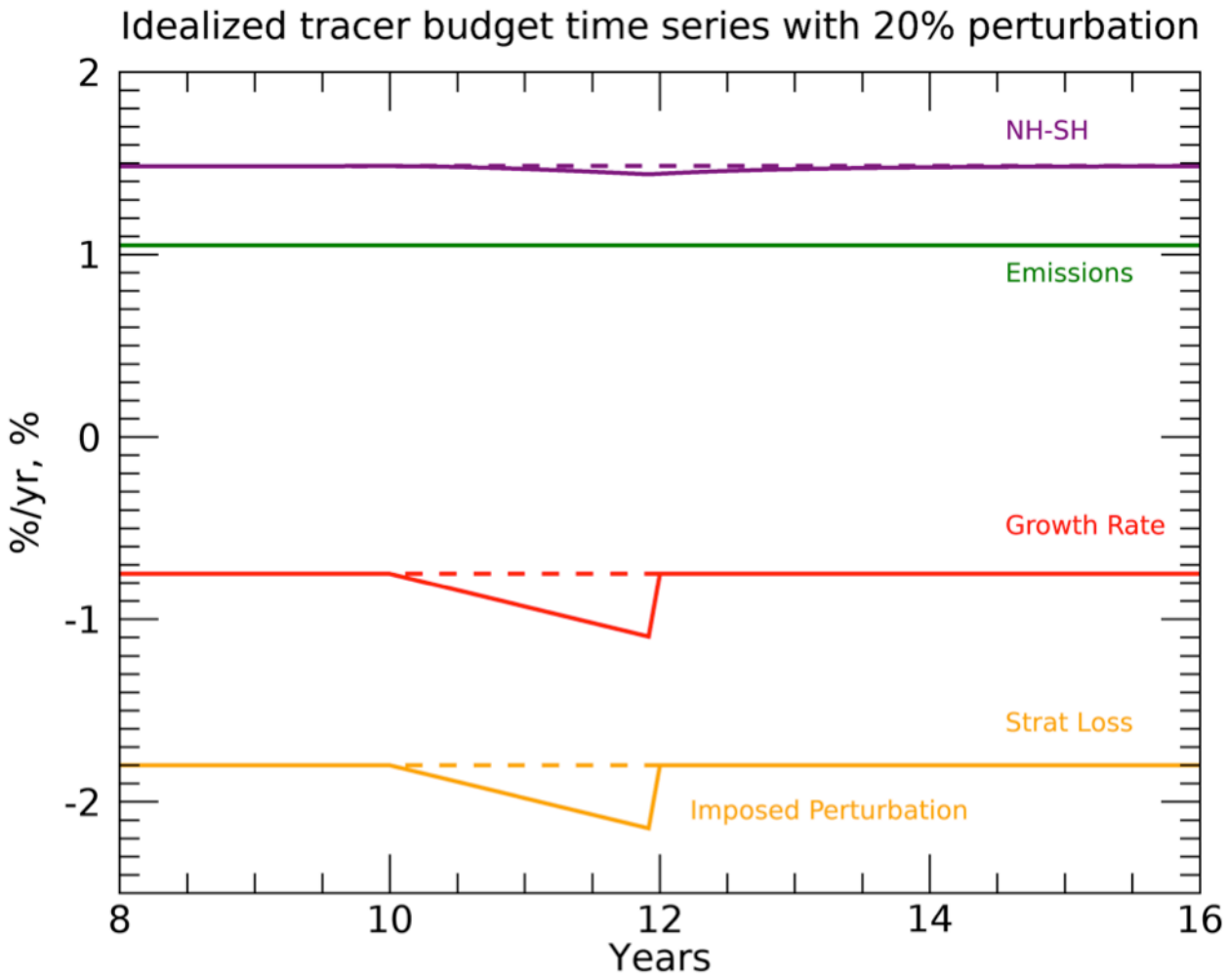


F11-like molecule

Derived NH-SH gradient

and emissions

Idealized Modeling



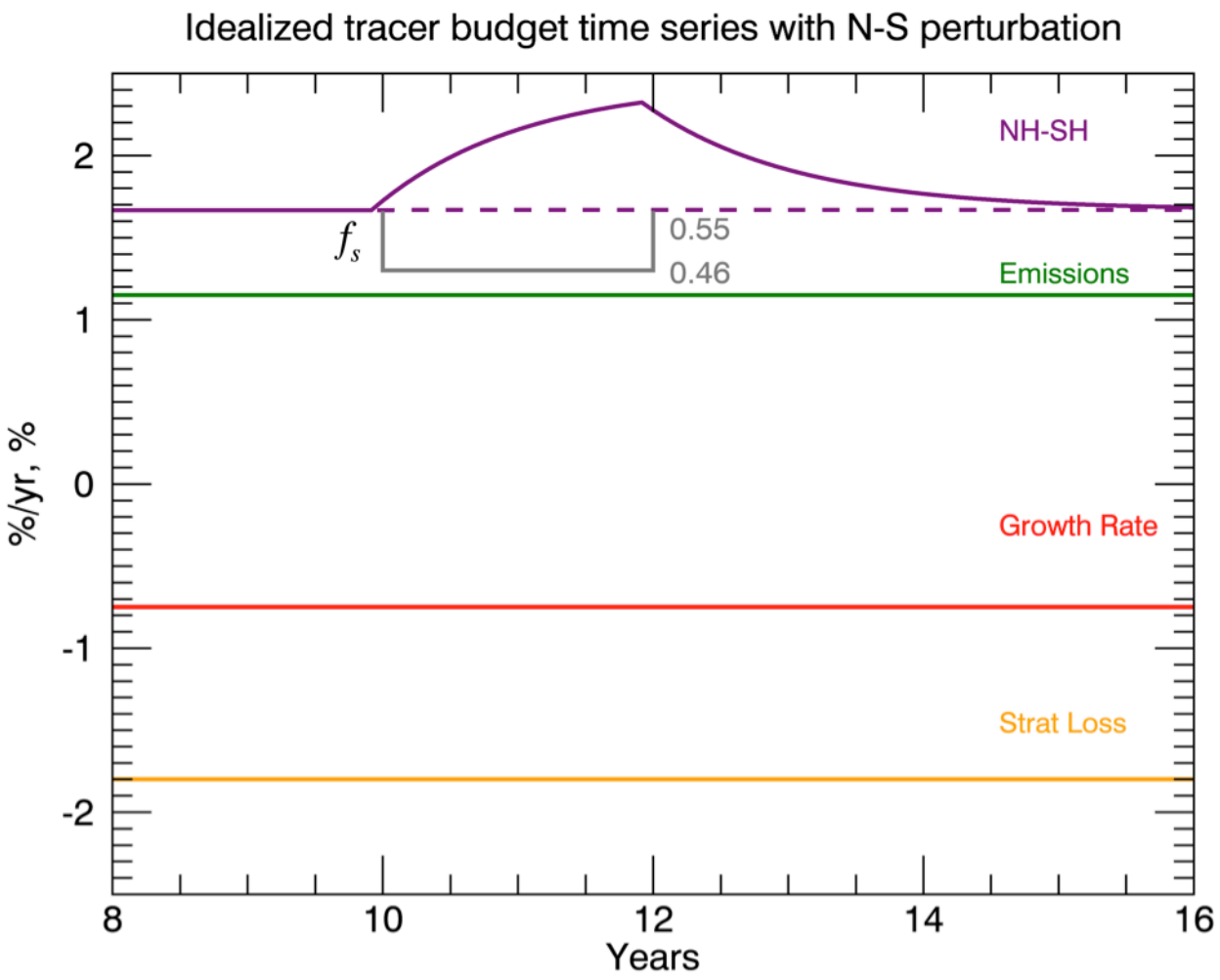
For F11-like molecule, imposed 20% stratospheric circulation speed up causes:

~35% decrease in global growth rate

Negligible decrease in N-S gradient since the stratospheric circulation is close to symmetric

No emission change

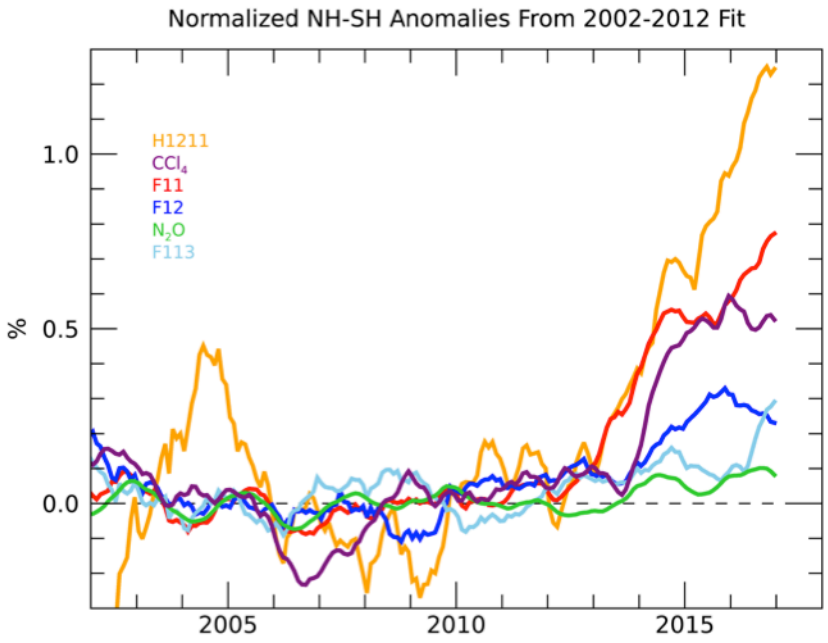
Idealized Modeling



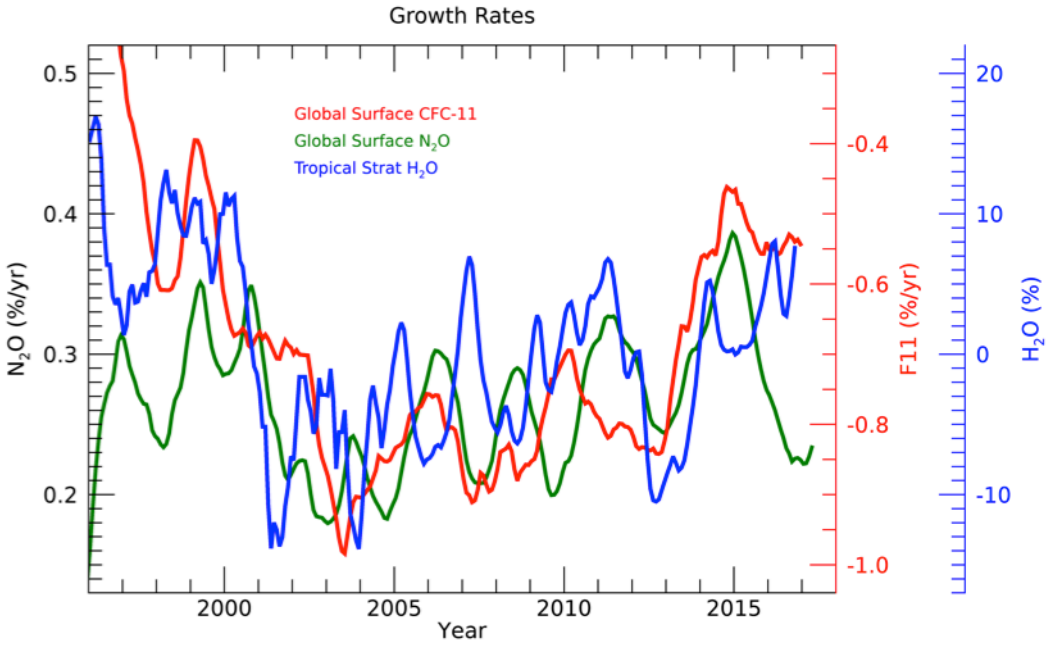
For F11-like molecule, imposed ~20% stratospheric circulation NH-SH change causes a large increase in N-S gradient with time lag

Can Observed Tracer Variability be Caused by the Stratosphere?

NH-SH Anomalies

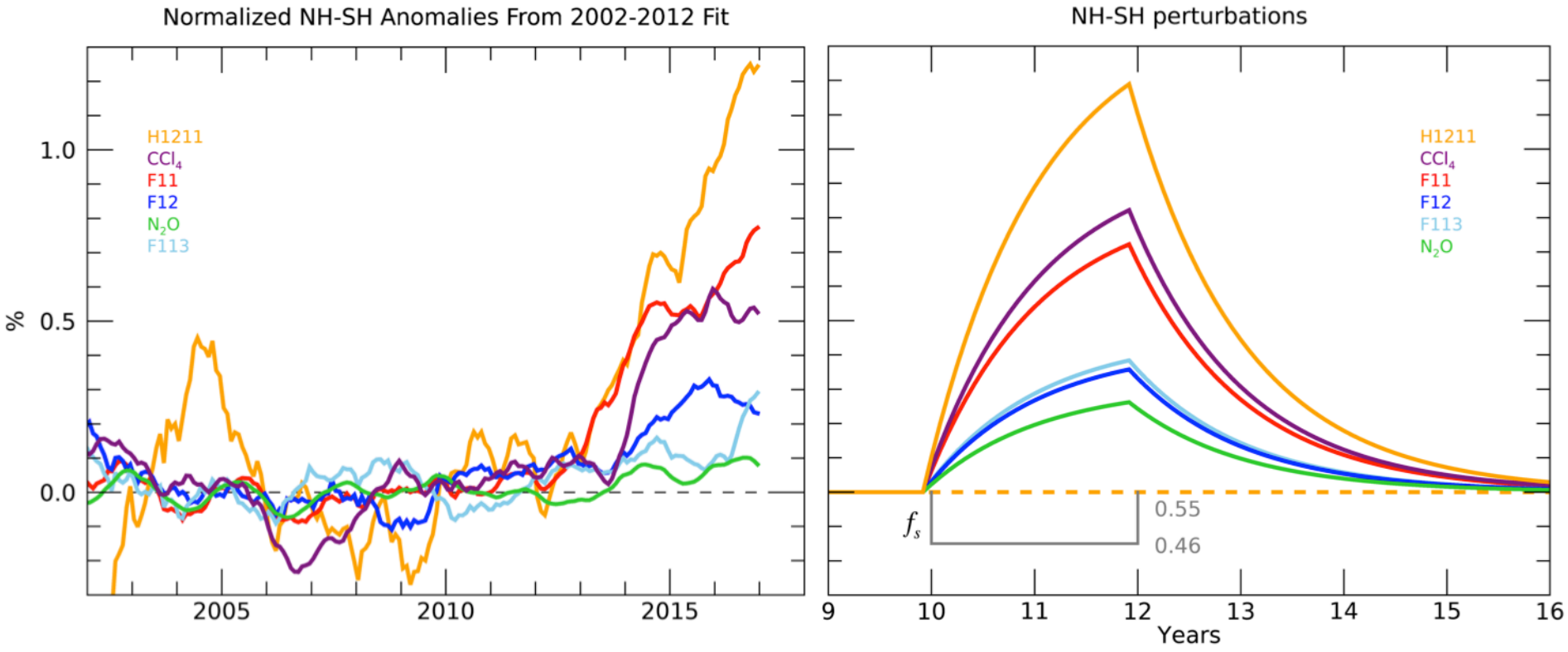


Global Growth Rate Changes



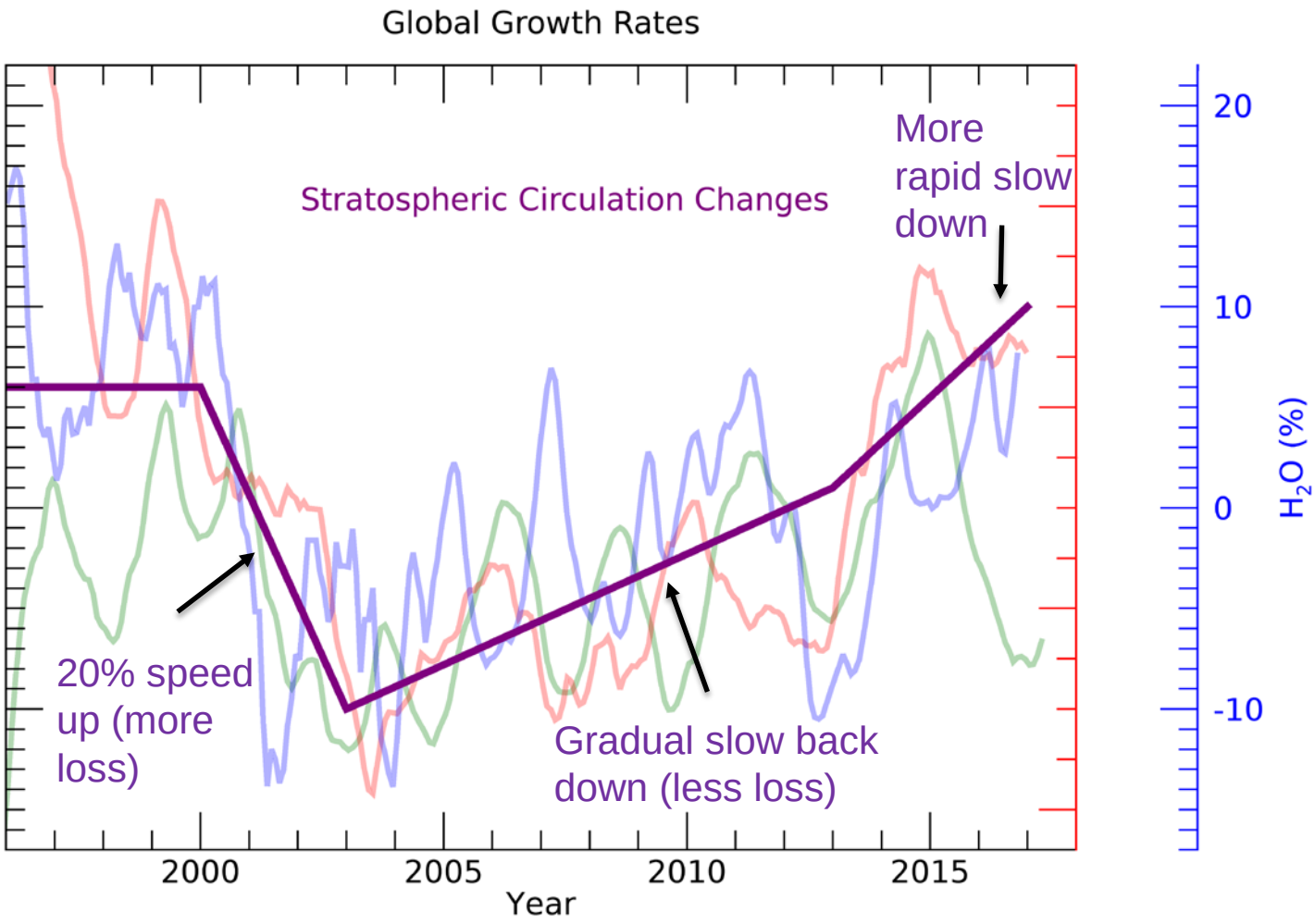
Idealized Modeling of Recent Stratospheric Circulation Anomalies

NH-SH Gradient

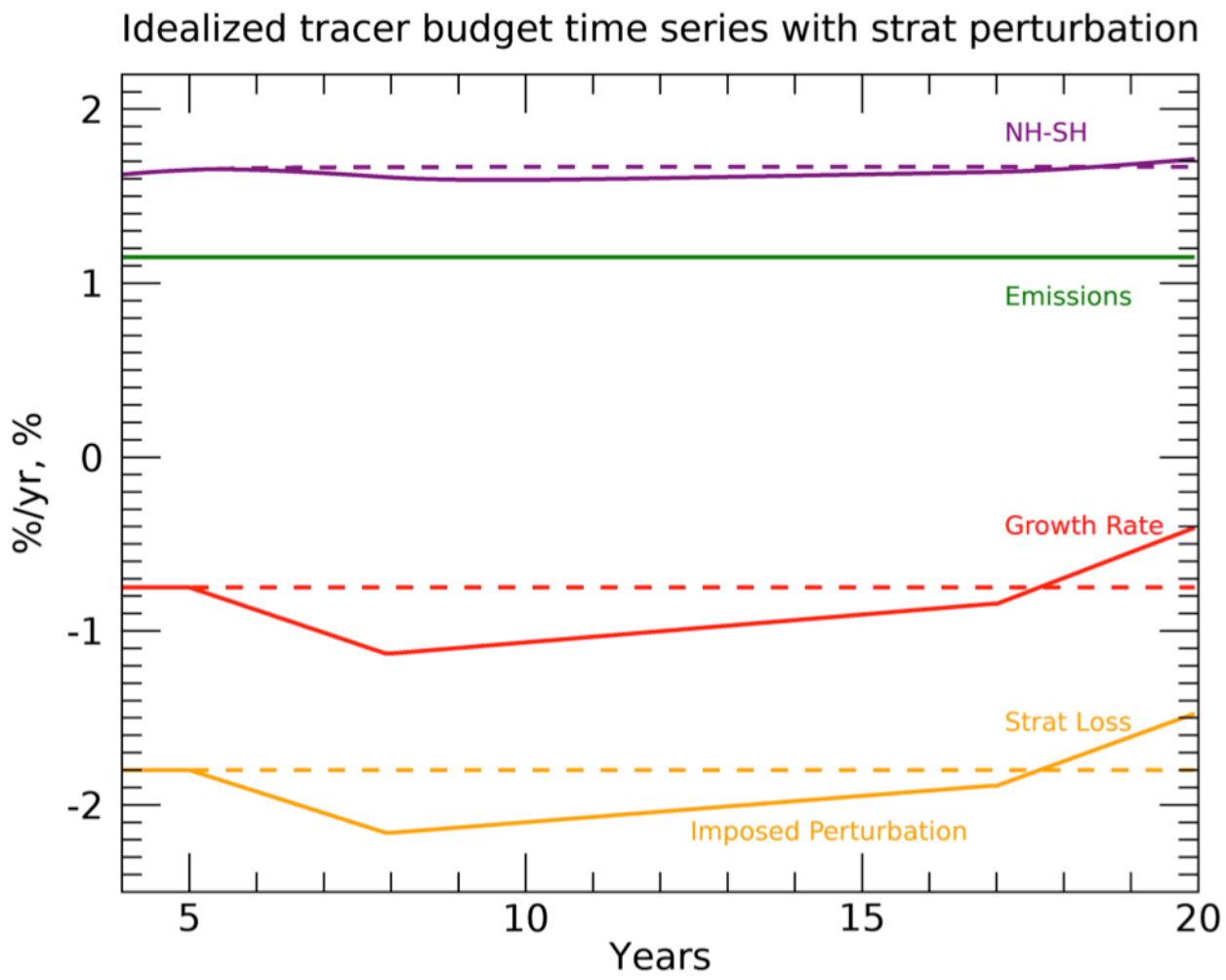


The recent NH-SH gradient changes scale roughly by inverse lifetime and could be well explained by a shift in stratospheric NH vs. SH transport.

Idealized Modeling of Recent Stratospheric Circulation Anomalies



Idealized Modeling of Recent Stratospheric Circulation Anomalies



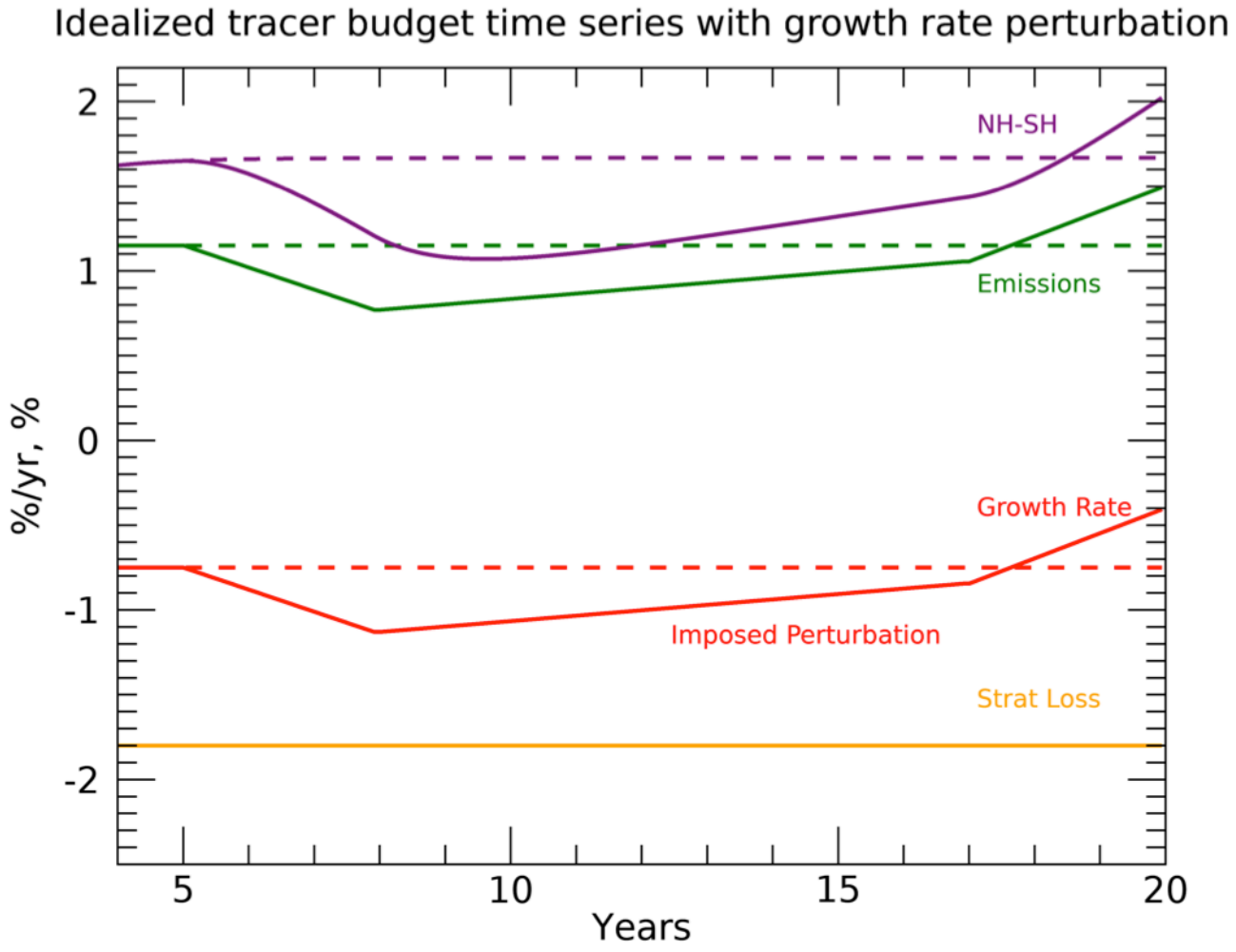
For F11-like molecule, imposed stratospheric circulation changes causes:

global growth rate decrease and then increase

Negligible changes in N-S gradient

No emission anomalies

Idealized Modeling of Recent Stratospheric Circulation Anomalies



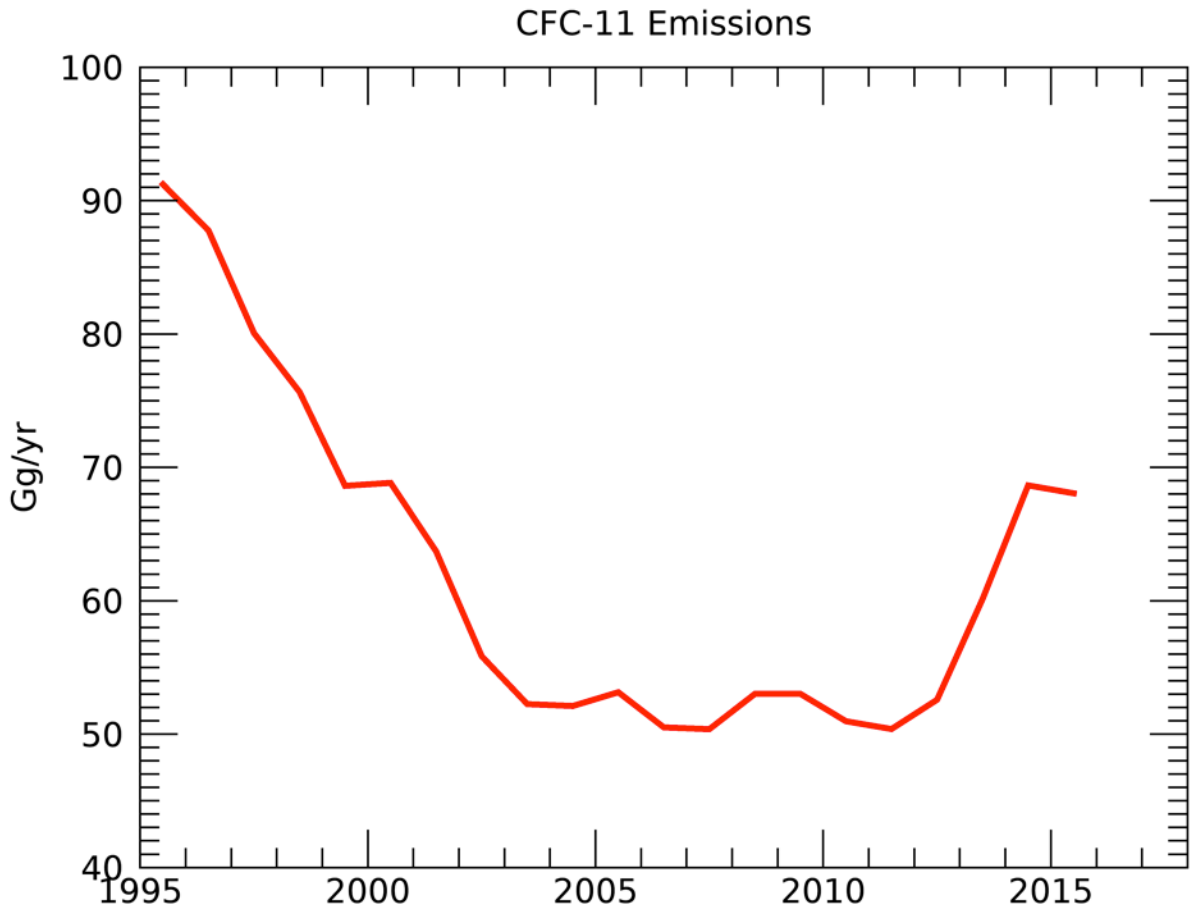
For F11-like molecule, imposed global growth rate decrease and then increase due to unaccounted for stratospheric changes causes:

Large emission decrease then increase

Large N-S gradient decrease then increase

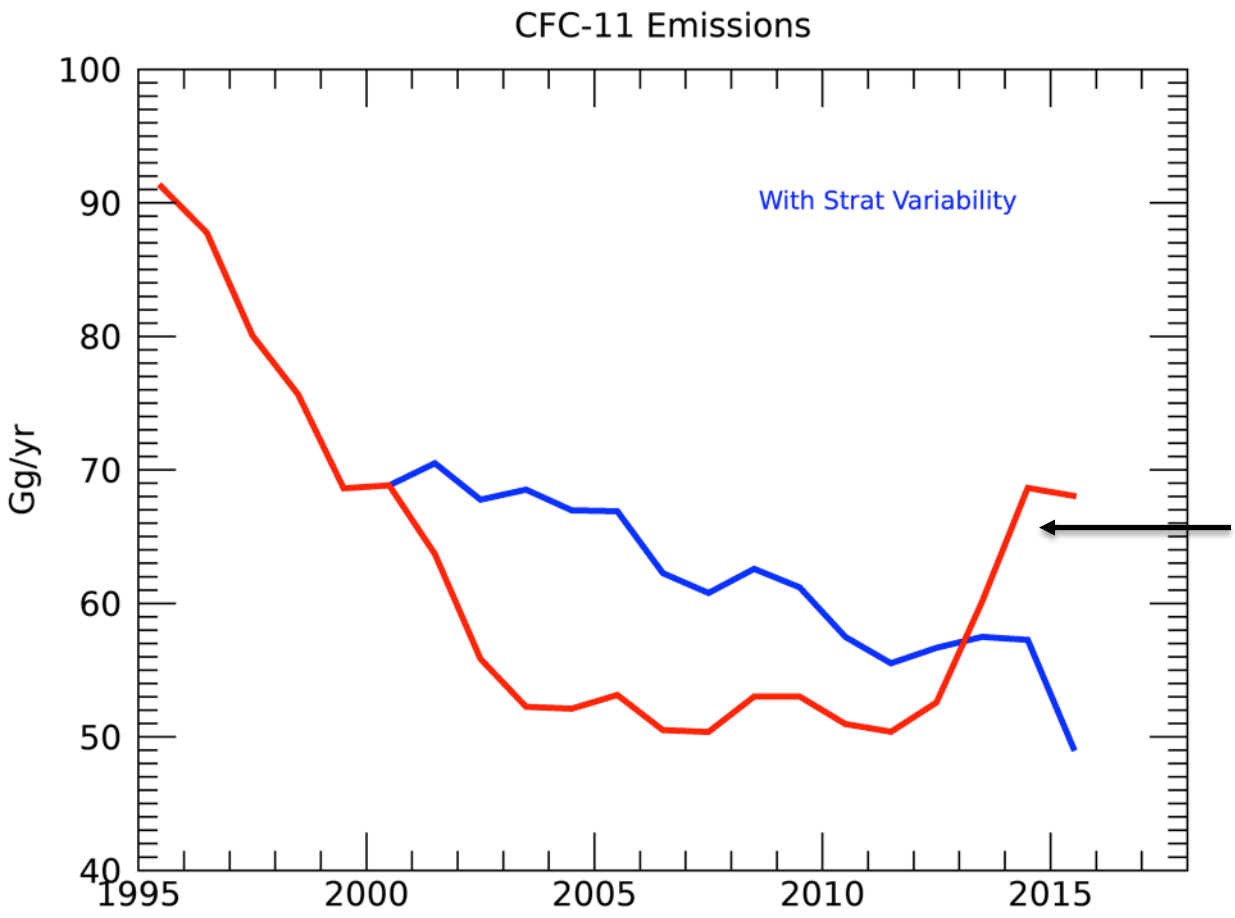
Idealized Modeling of Recent Stratospheric Circulation Anomalies

Emissions Impact



Idealized Modeling of Recent Stratospheric Circulation Anomalies

Emissions Impact



This emission structure could be explained by stratospheric variability

Conclusions

- The stratospheric circulation matters, even down here at the surface!

- Imperfect knowledge of the variability of the stratospheric circulation can have significant impacts on trace gas emission estimates for many years.

- Recent stratospheric circulation variability has been unpredictable, we can't assume the stratosphere will continue doing what it's been doing.

- Precise, accurate, long-term measurements provided by GMD can help us better understand the changing stratospheric influence on the troposphere.