

SF₆ in the Atmosphere: Using Top-Down Measurements to Inform Public Policy

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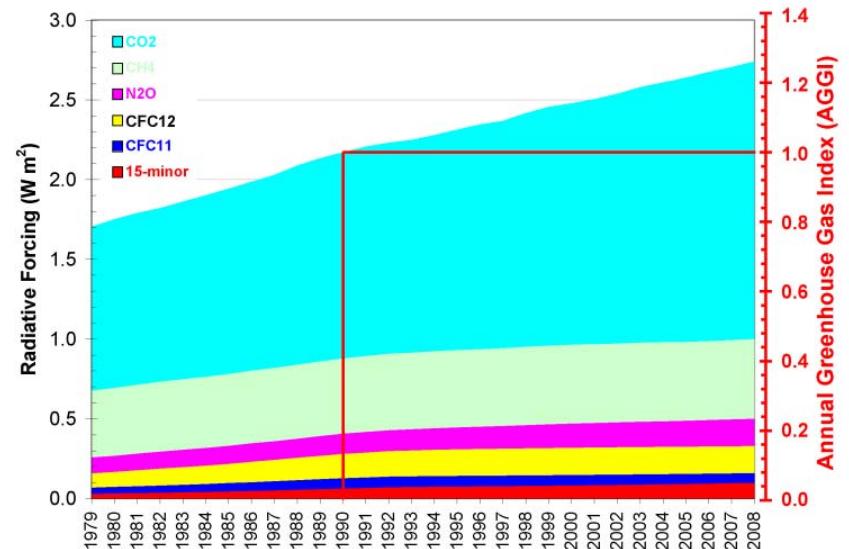
- Goals
- SF₆ Observations
- SF₆ Growth Rates
- Inferred Emission
- Challenges



Atmospheric Science Community

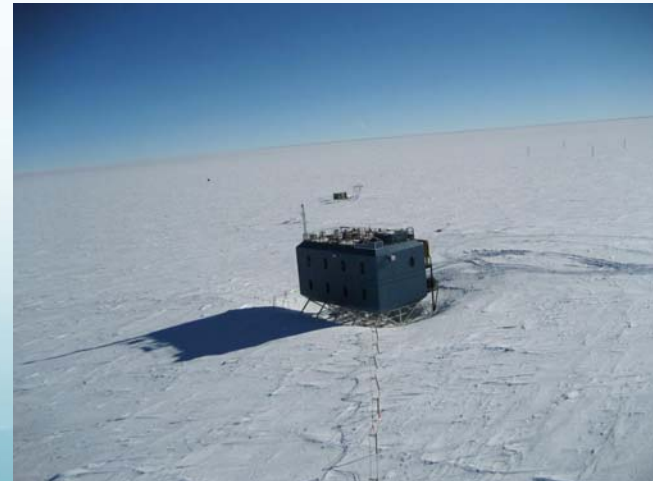
- Observations of Trace Gases
 - Long-term Trends
 - Sources/Sinks
 - Independent Verification
 - does policy have the desired effect?
 - e.g.. Montreal Protocol
 - (CFCs)

- Requirements
 - Long-term commitment
 - High Precision
 - Cooperative Effort
 - Reliable, Traceable Standards



NOAA's Contribution

- Global Background Observing Sites
- US regional Sites (CO₂ focus) but also SF₆, HCFCs, HFCs
- Profiles (aircraft)
- World Calibration Standards

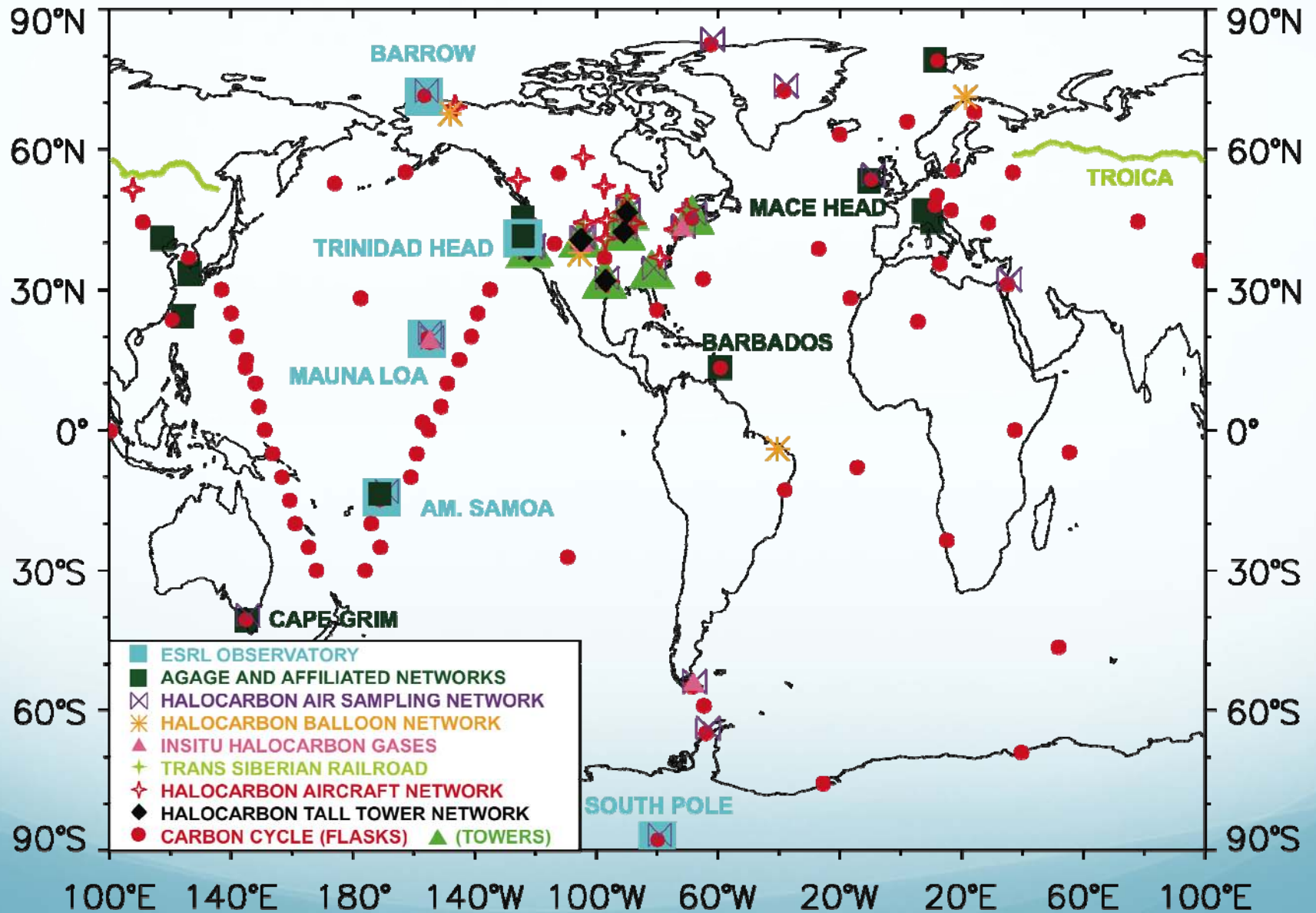


Calibration: An Essential Element

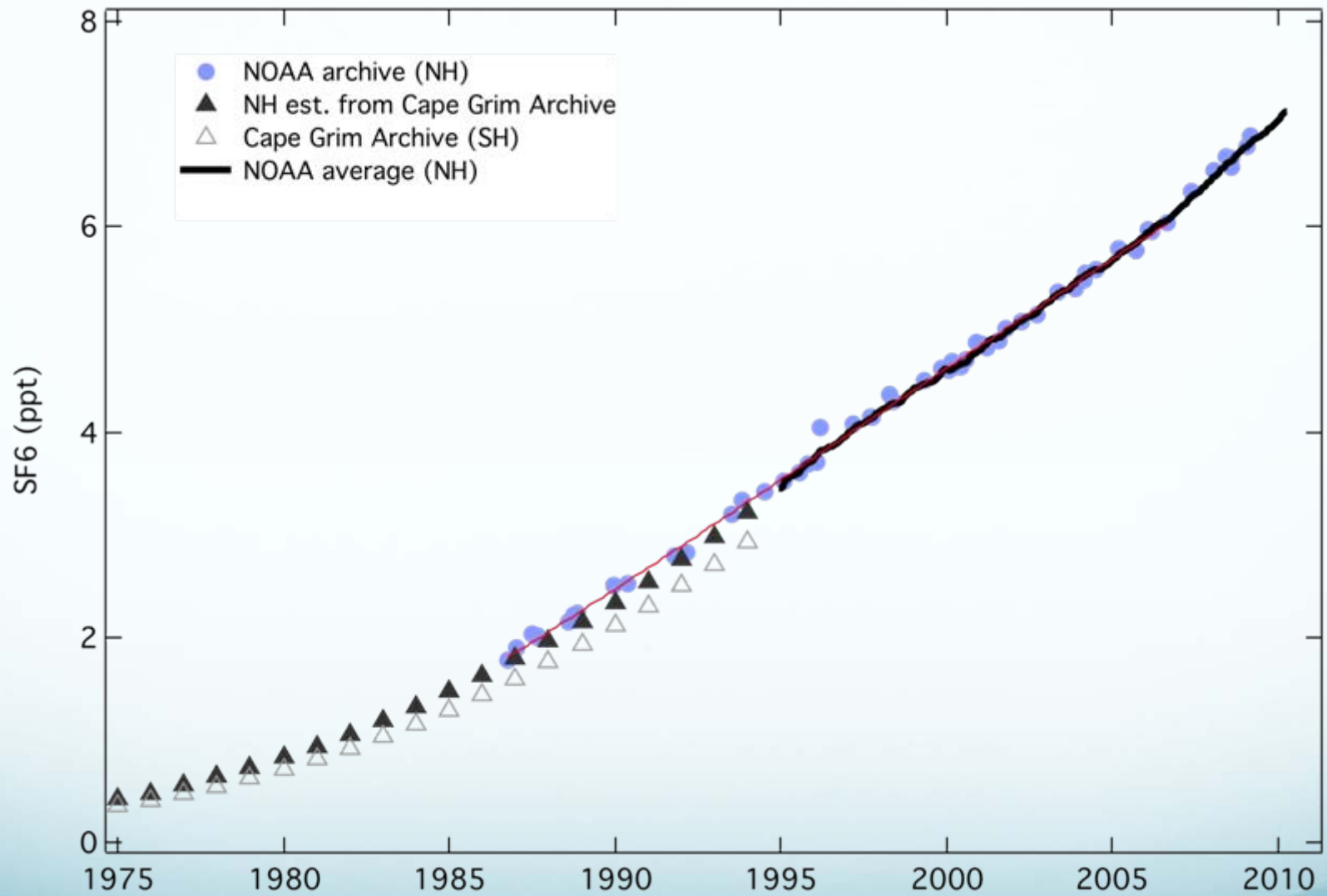
- NOAA serves as the Central Calibration Laboratory for
 - CO₂, CH₄, CO, N₂O, SF₆
 - Develop and maintain calibration scales for use by the WMO/GAW community



Global Networks that Measure SF₆

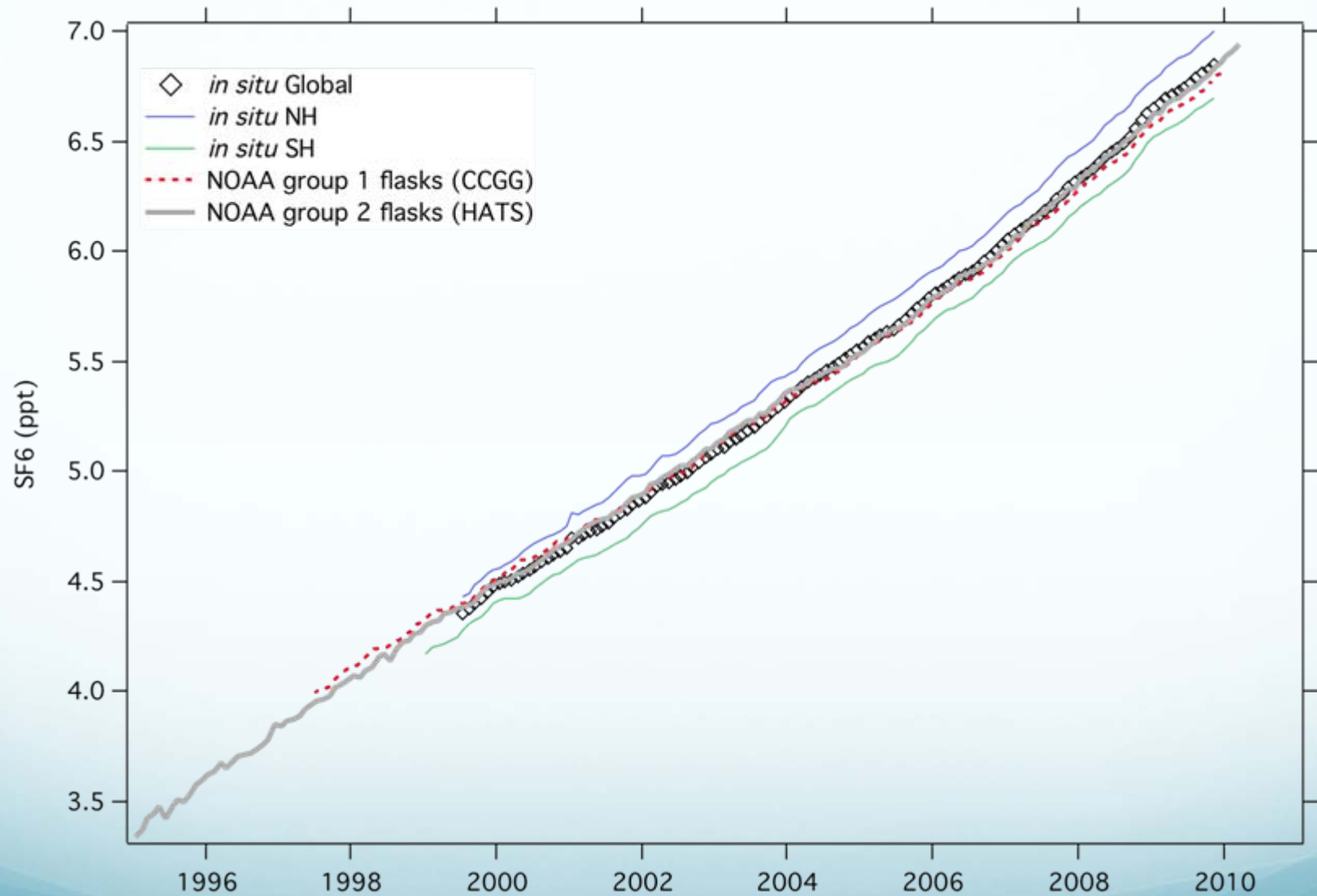


History of SF₆ in the atmosphere

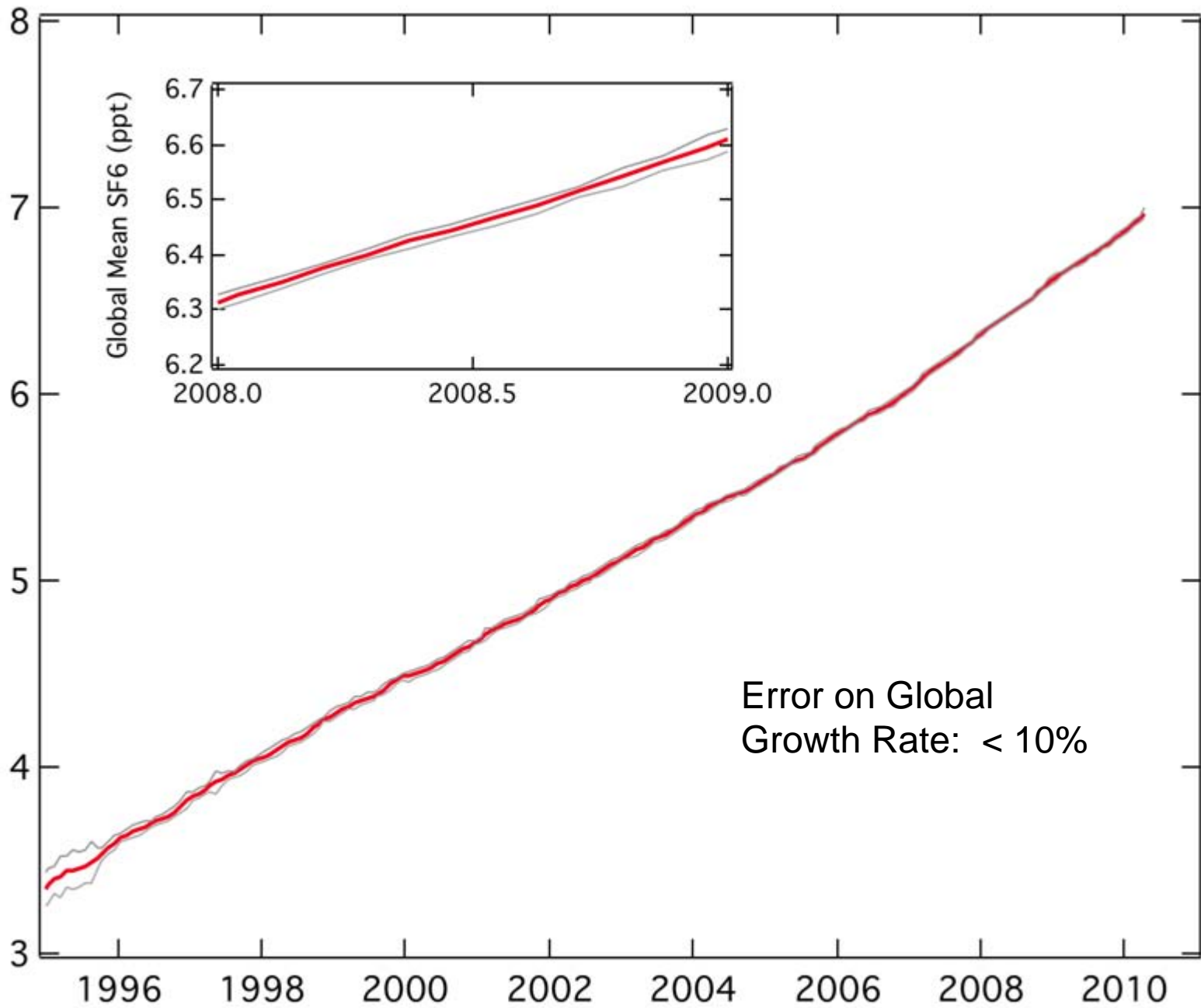


Cape Grim and NH est. from Maiss and Brenninkmeijer, *Env. Sci. Tech.*, 1998.

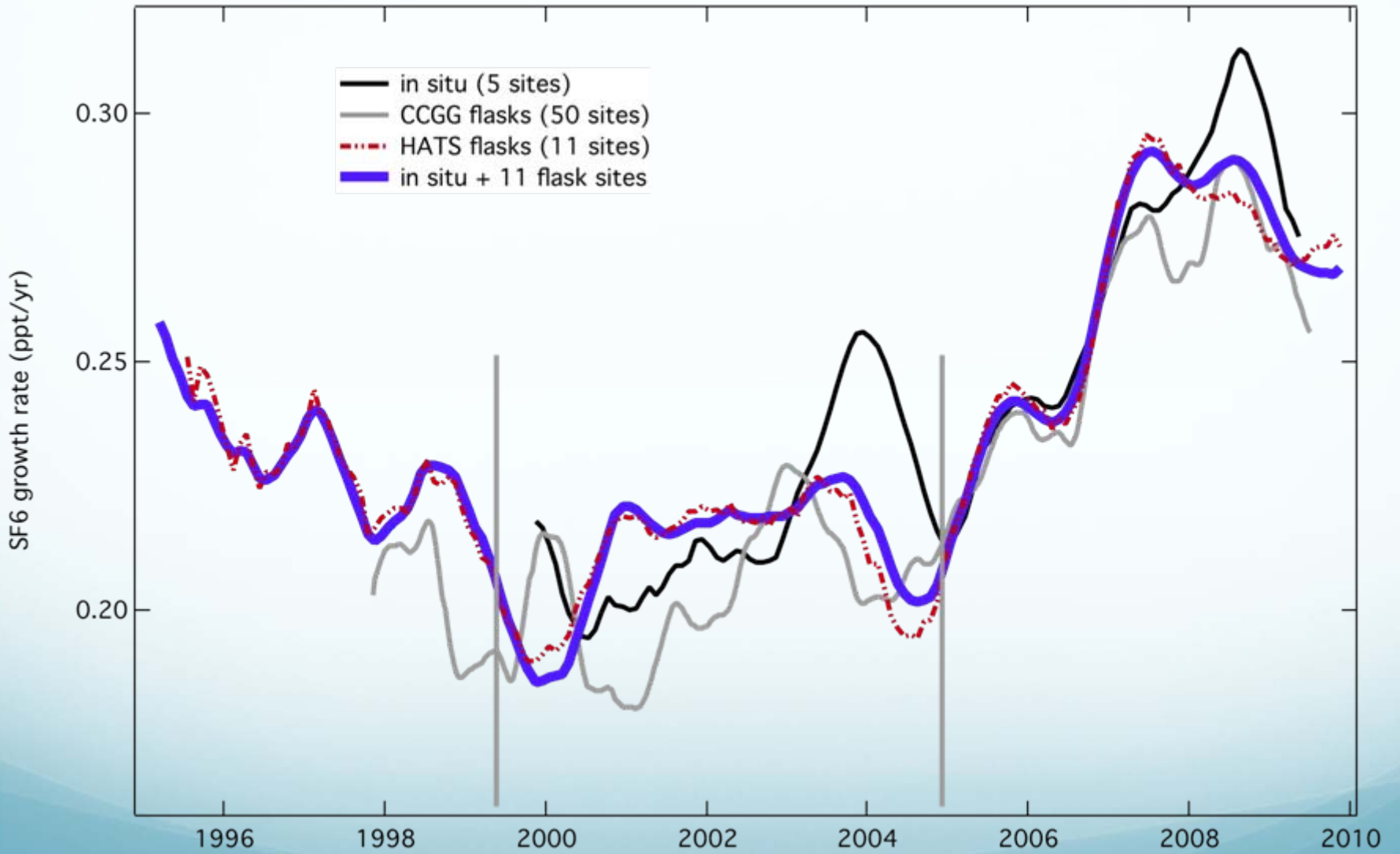
Recent NOAA SF₆ Observations



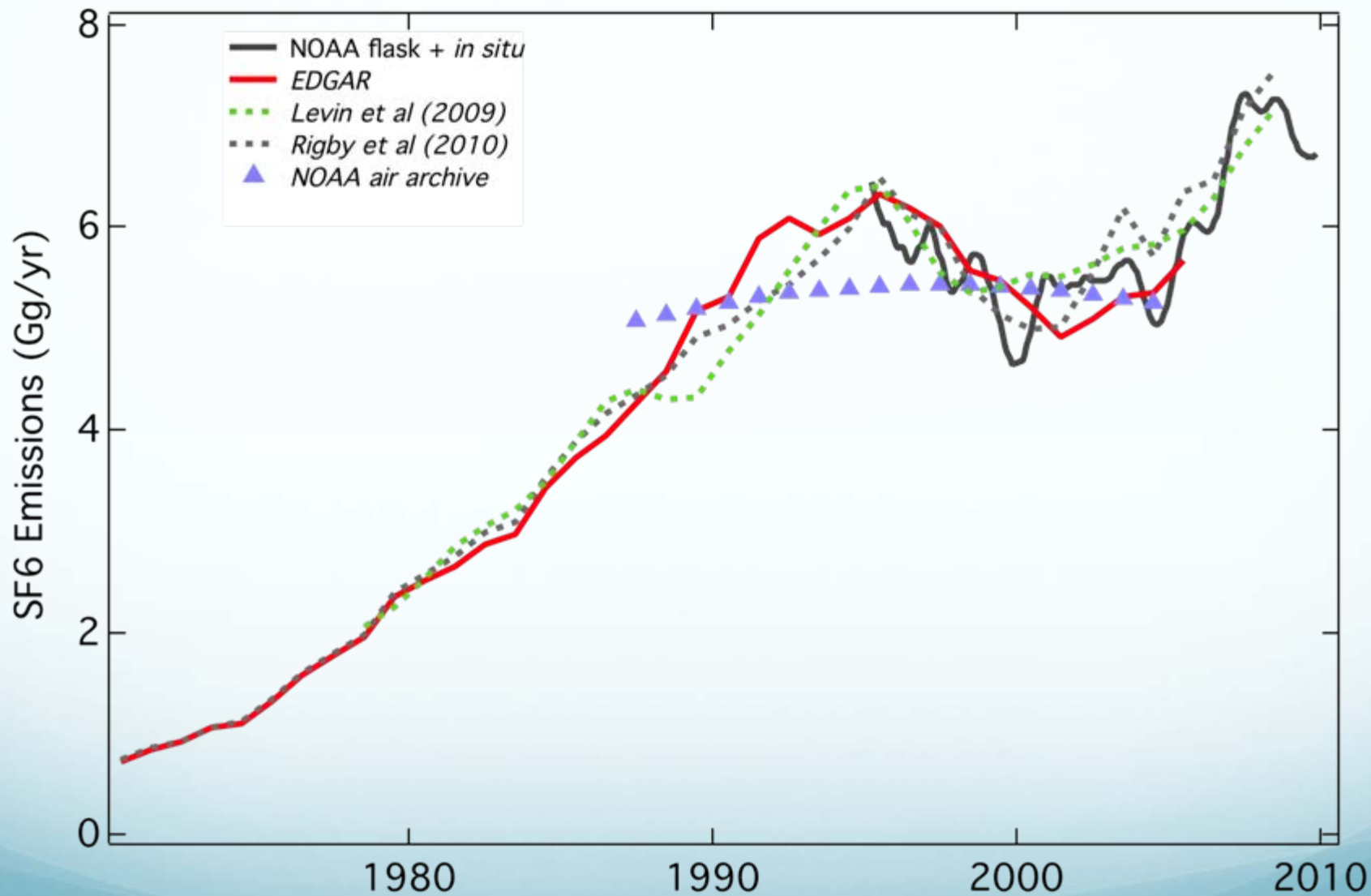
Global Mean SF6 (ppt)



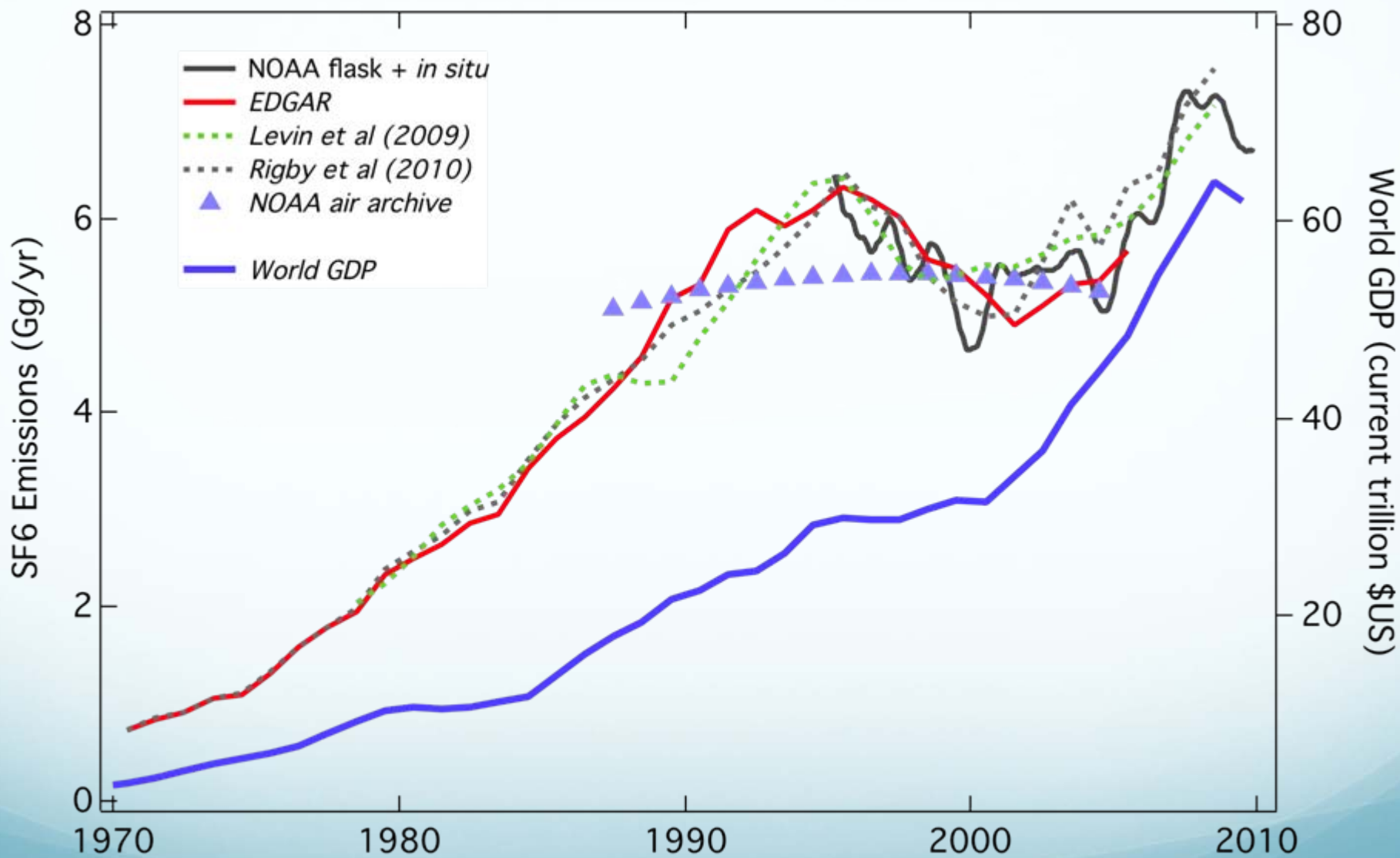
Global Growth Rate of Atmospheric SF₆



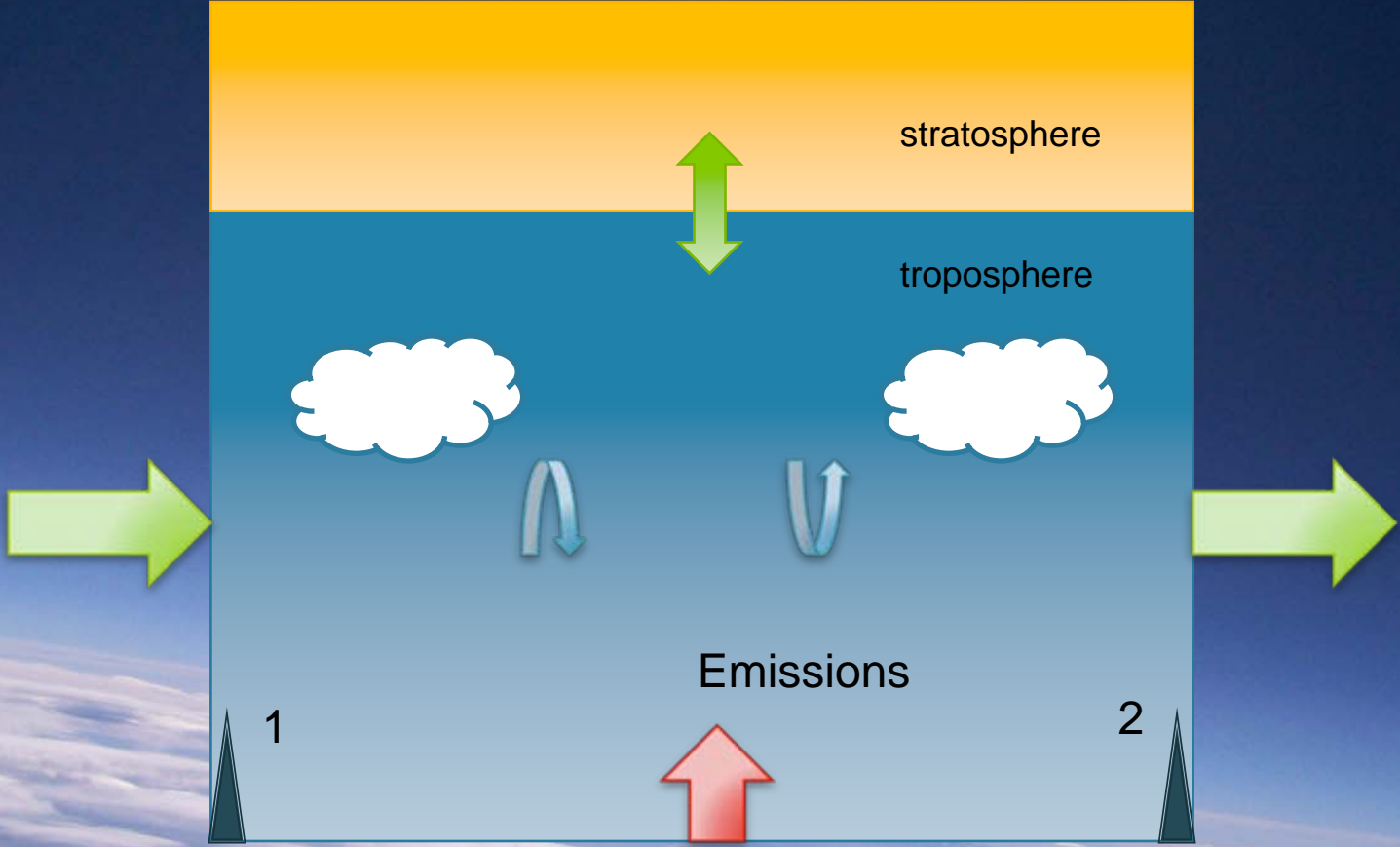
Global SF₆ Emissions



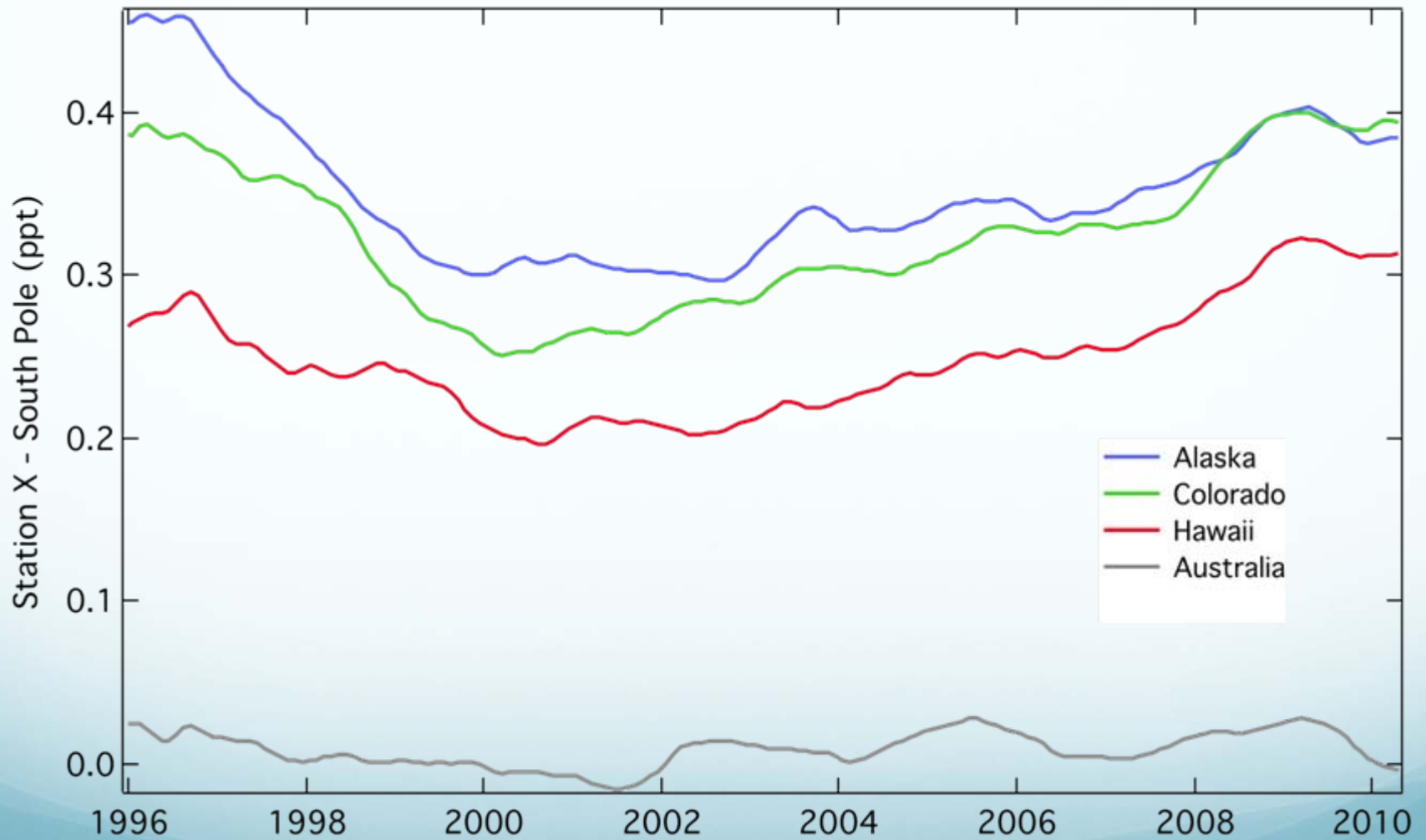
Global SF₆ Emissions



Regional Emissions

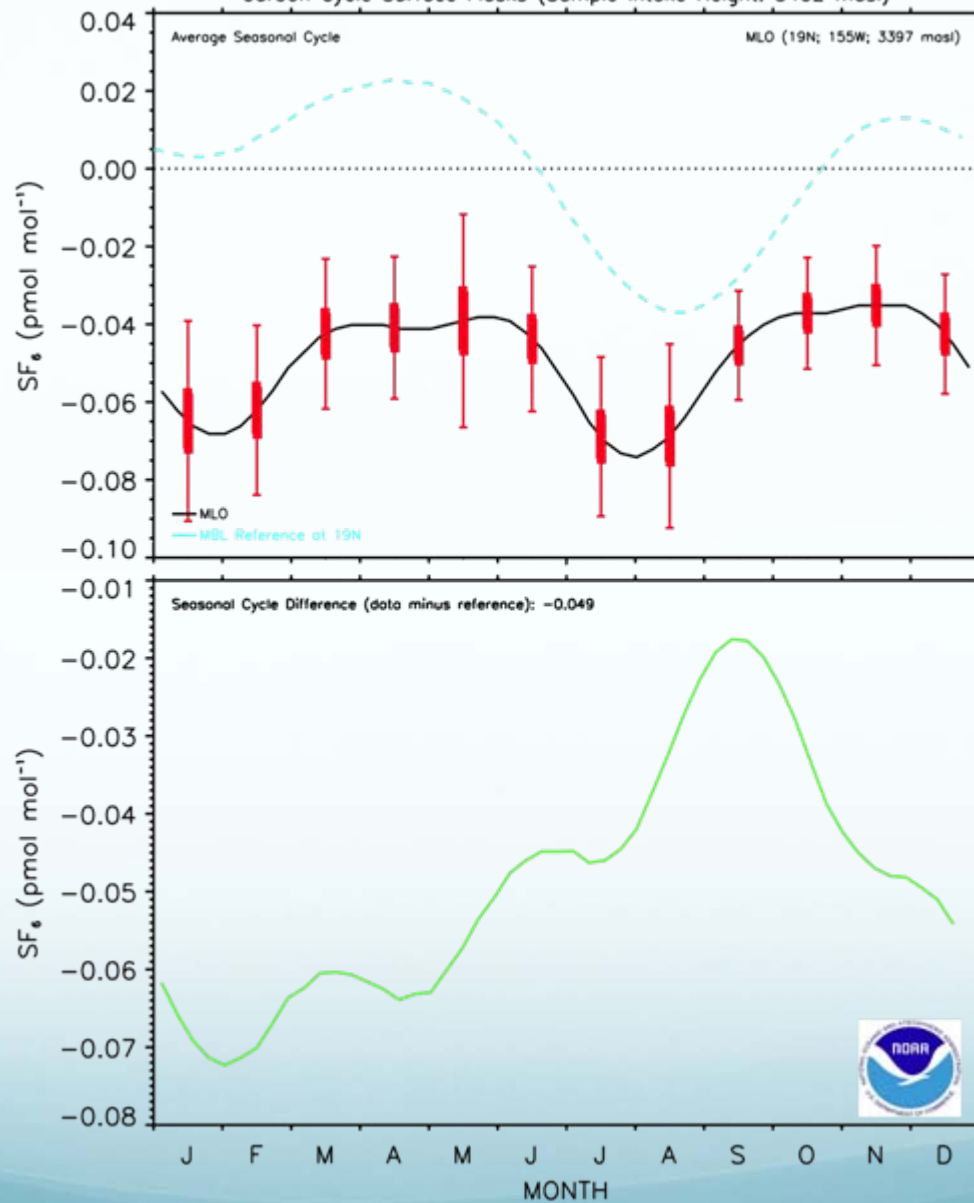


SF₆ at different latitudes



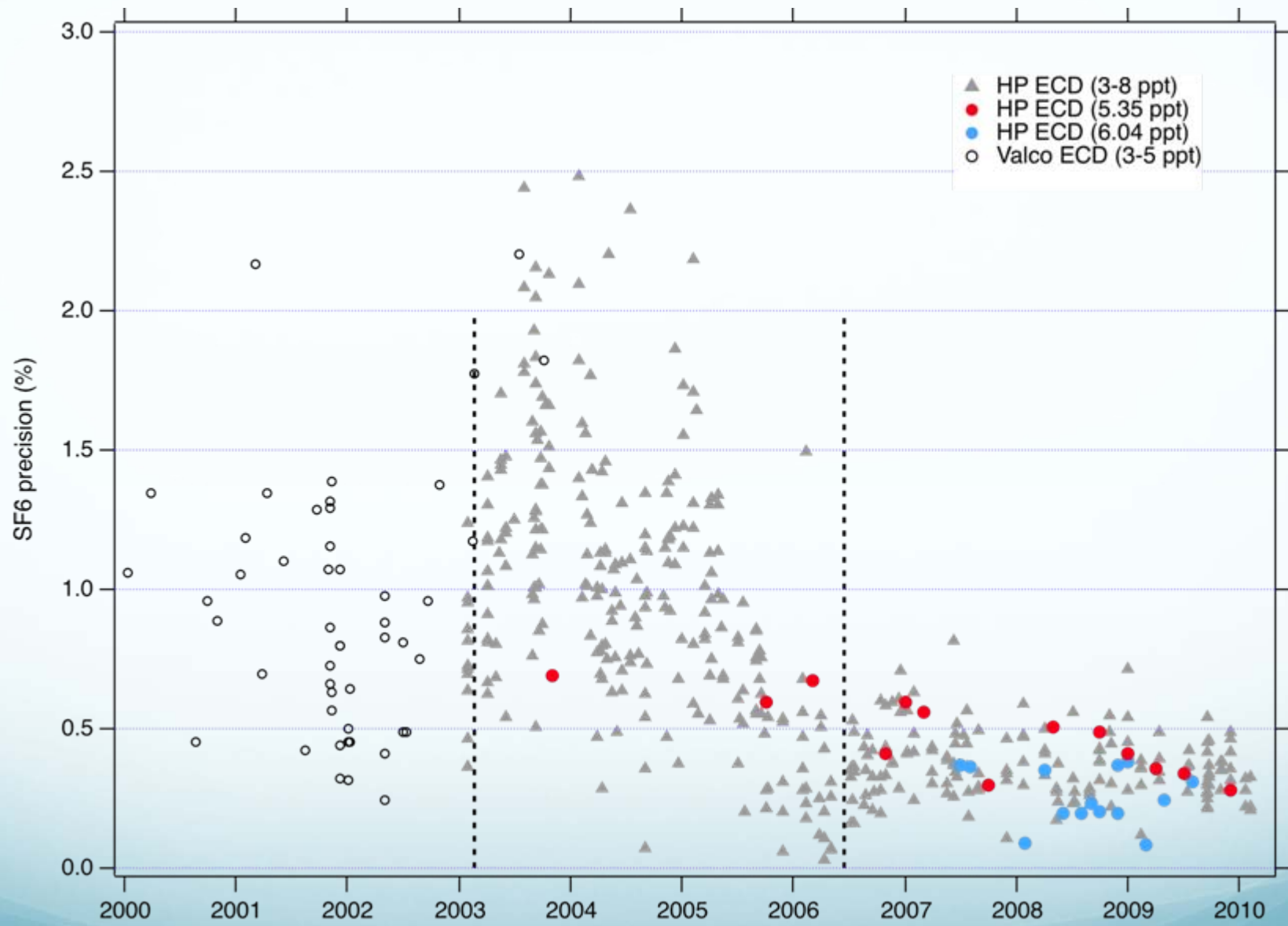
Mauna Loa, Hawaii, United States

Carbon Cycle Surface Flasks (Sample Intake Height: 3402 masl)



What's Needed?

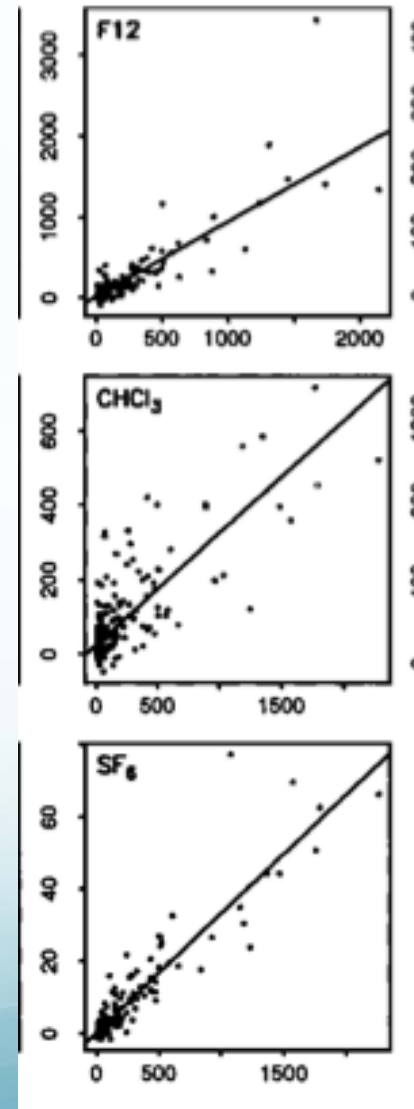
- Good Measurements
- Good Models
- Cooperative Efforts
- Extensive Comparisons



Regional Emissions

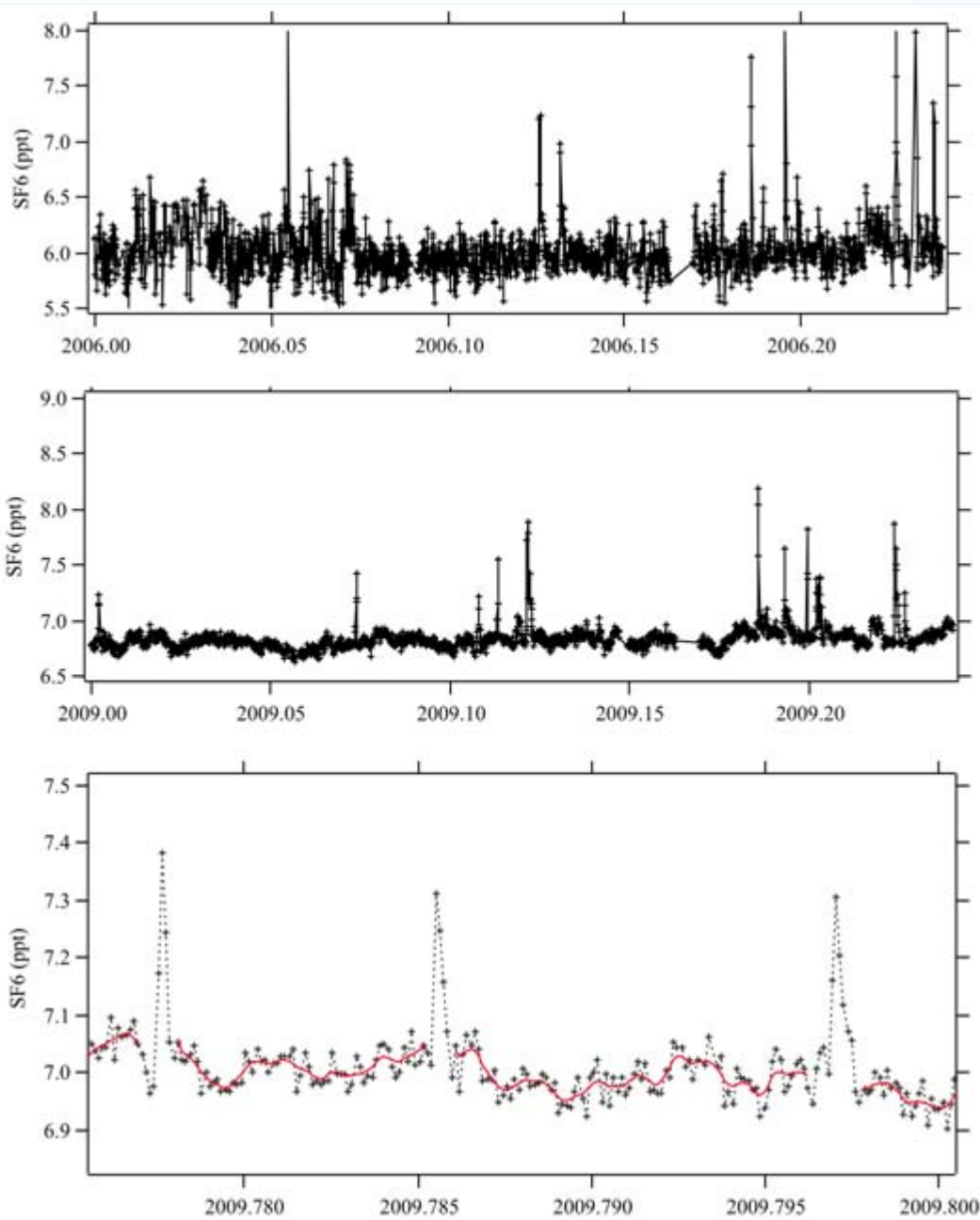
- Correlate “Pollution Events” with other trace gases
- Infer “unknown” emissions to “known” emission by ratio

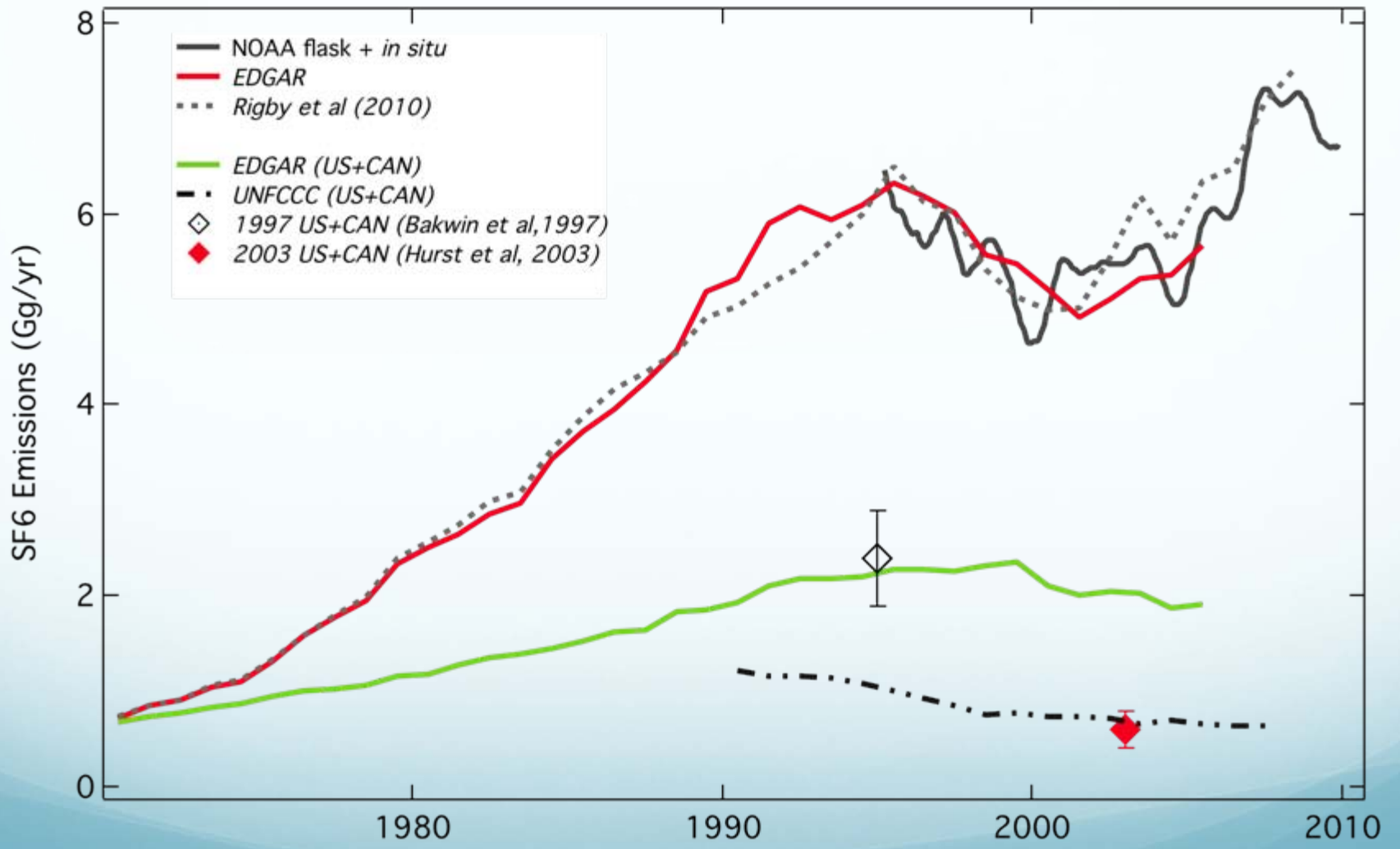
e.g., dichloromethane,
carbon monoxide



from Bakwin *et al*, 1997

SF₆ measured at
Niwot Ridge, Colorado





Recent Work

Levin *et al.*, 2010

“...which suggests, that Annex I reported UNFCCC emissions during the 1990s (and possibly until today) are too low. “

Top-down estimates complicated by uncertainties in model transport

More measurement sites are needed to resolve regional or country emissions.

Rigby *et al.*, 2010

Emissions growth 2004-2008 can be attributed to non-UNFCCC Asian countries

Current data not sufficient to resolve differences between EDGAR and UNFCCC reported emissions for the U.S.

Emissions are poorly constrained in most regions.

Levin *et al.*, The global SF₆ source inferred from long-term high precision atmospheric measurements and its comparison with emission inventories, *Atmos. Chem. Phys.*, 10, 2655–2662, 2010

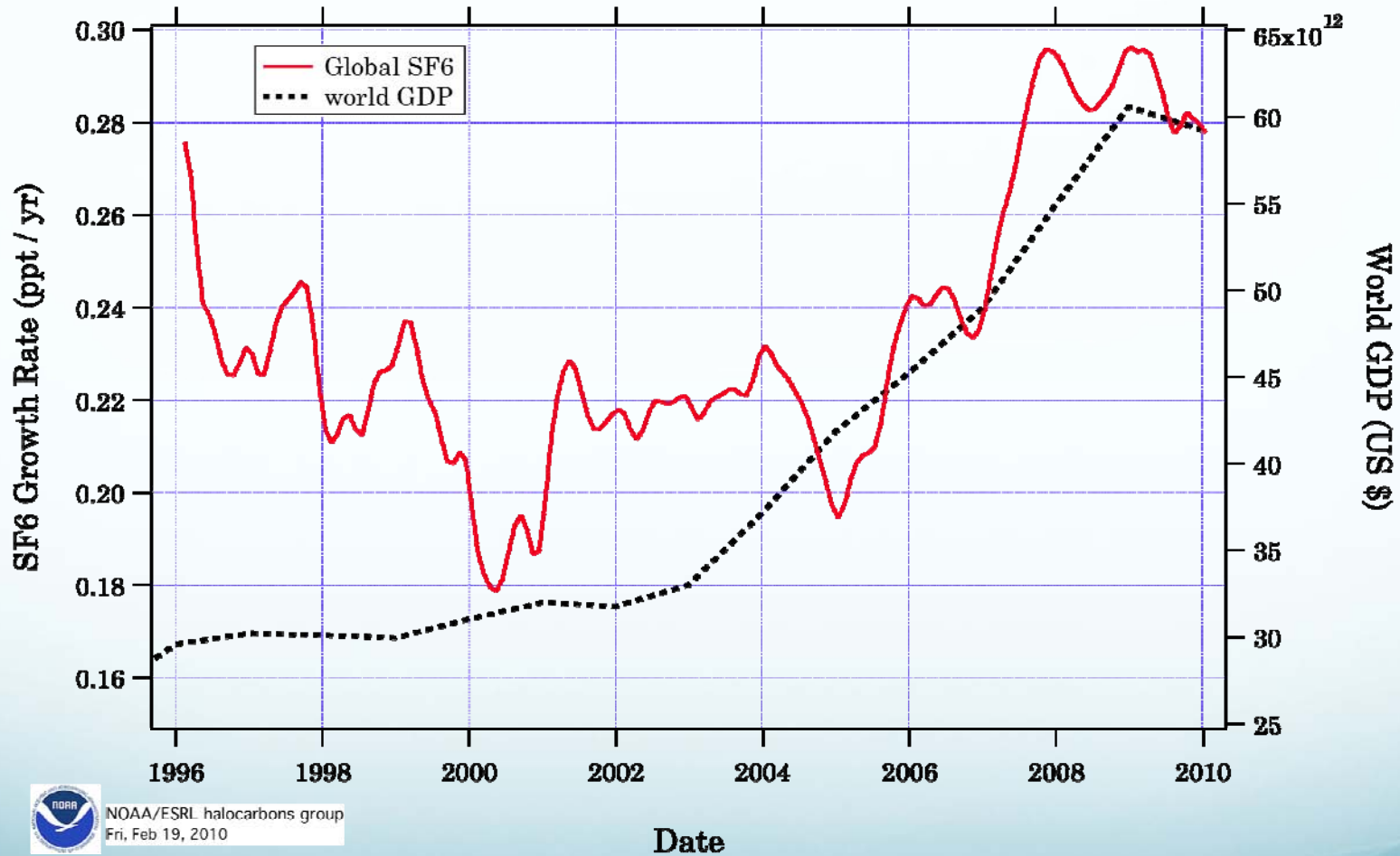
M. Rigby *et al.*, History of atmospheric SF₆ from 1973 to 2008. Submitted to *Atmos. Chem. Phys. Discuss.*, May 2010.

Summary

- NOAA collaborates with other groups to measure SF₆ around the globe
- Global SF₆ emissions increased gradually from 1999-2005 rapidly from 2005-2008. The rapid increase may be ending.
- Inferring regional emissions will be challenging
 - ① more observing sites
 - ② better precision, better models, and strategic site placement
 - ③ 1 and 2 go hand in hand with other GHG

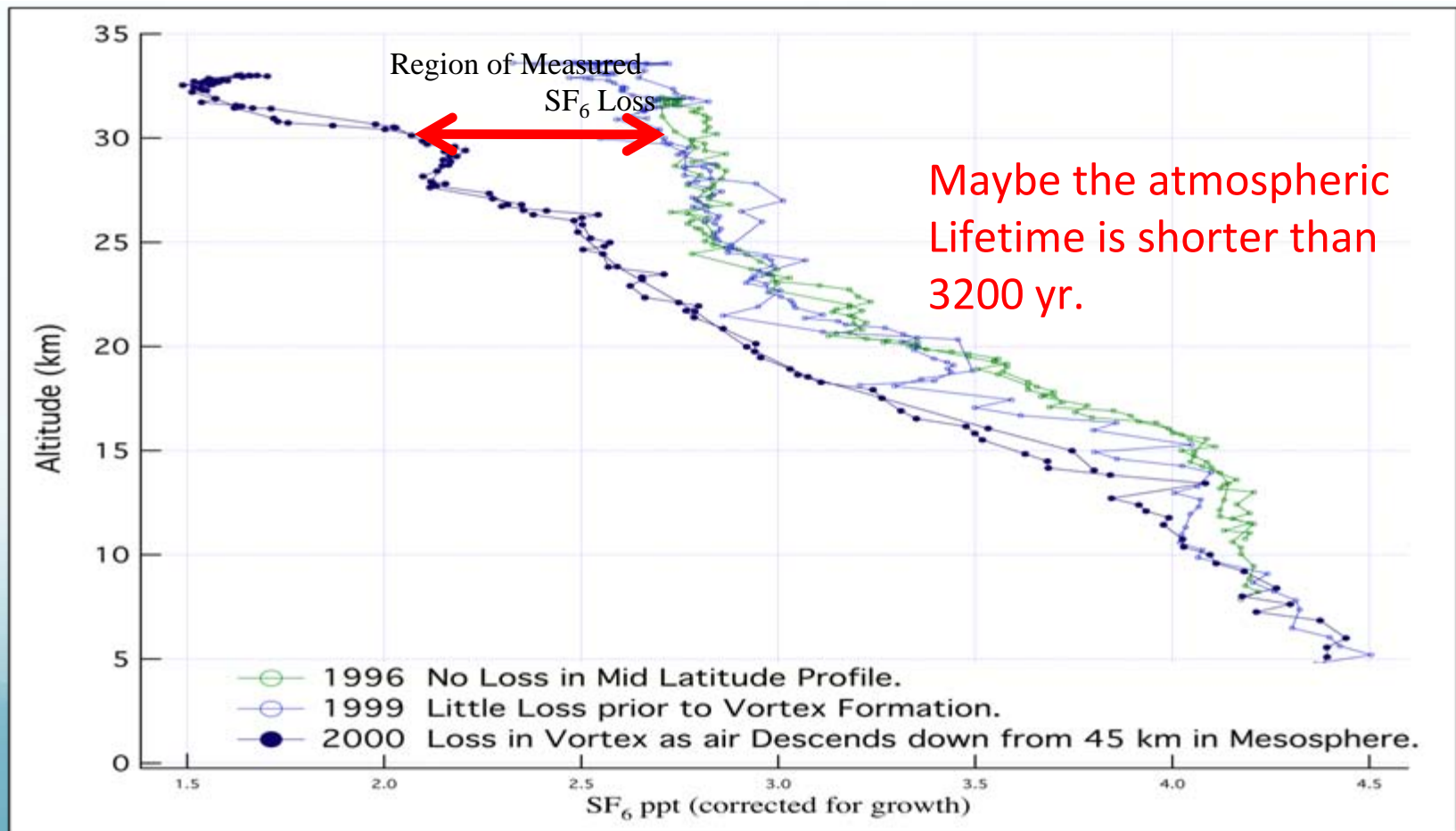
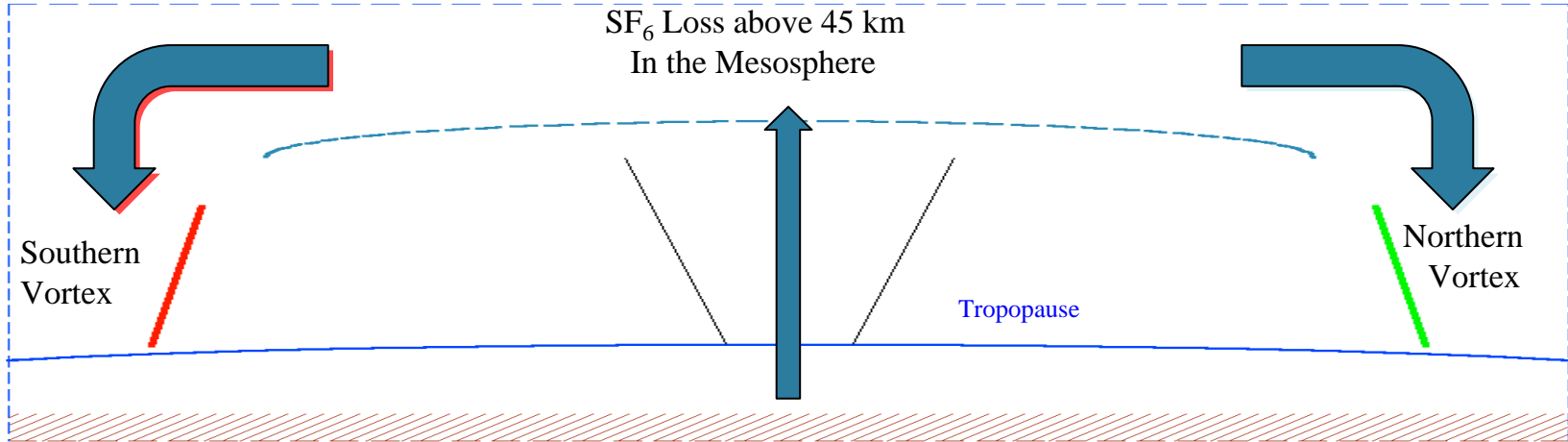
Extra Slides

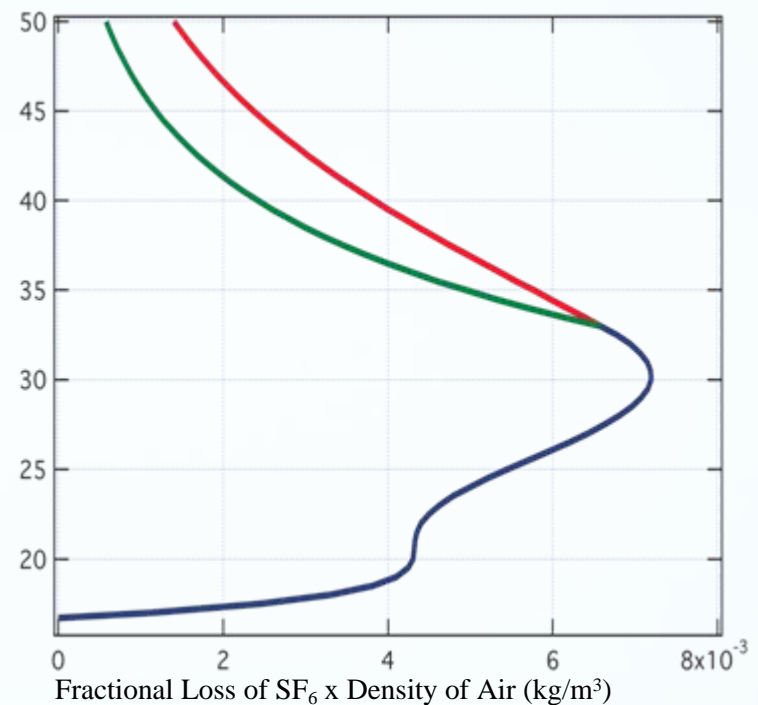
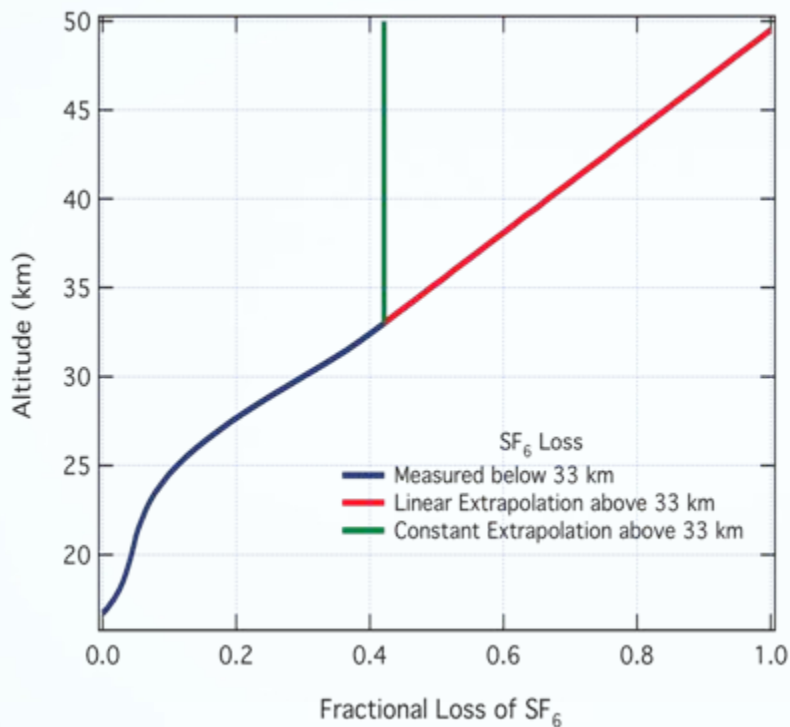
Atmospheric SF₆ and World GDP



NOAA/ESRL halocarbons group
Fri, Feb 19, 2010

Date





- SF₆ loss rate (1/t) is estimated as 2 times the integral over the northern vortex of the measured fractional loss, times the mass density, divided by total atmospheric mass.

SF₆ atmospheric lifetime (t) calculated from:

Linear extrapolation $t = 595 \pm 105$ years

Error includes in quadrature:

- ± 35 years for statistical uncertainty in SF₆ measurements.
- ± 65 years for residuals of smooth fit to flight profiles.
- ± 76 years for uncertainty in the vortex size.

Constant extrapolation $t = 747$ years

* Vortex size used is an average between Manney's estimate for this year and Waugh's climatological mean.

* The above assumptions only leave room for unmeasured loss. Thus, the above measured lifetimes represent an upper limit.