

# Observations and trends of Hydrofluorocarbons (HFCs)

## Atmospheric observations:

Provide a means for quantifying and analyzing the climate consequences of the Kigali Amendment to the Montreal Protocol

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With help from many others at

NOAA

AGAGE

NIES

EMPA

U Colorado (CIRES)

UC Irvine

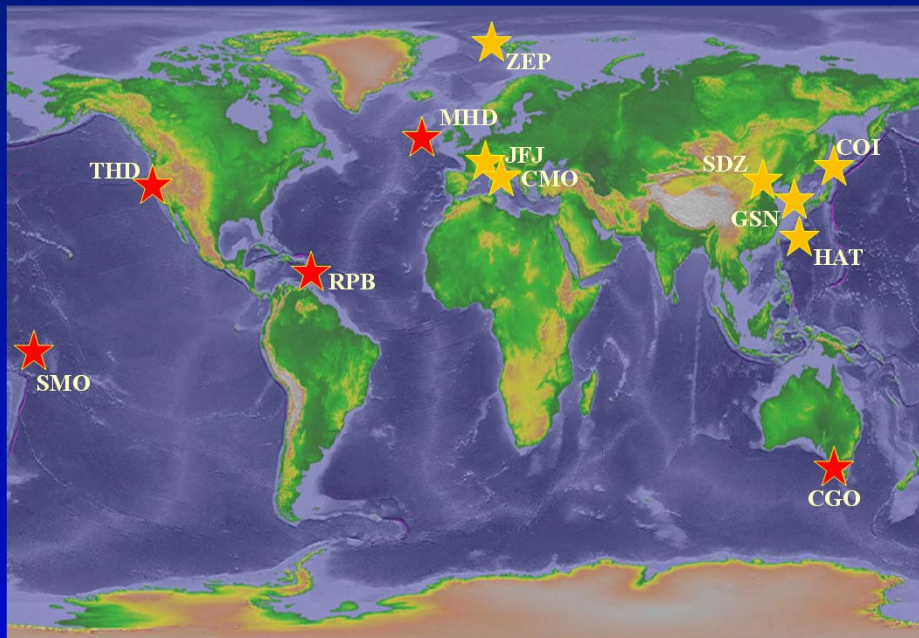
CAMs

U Bristol

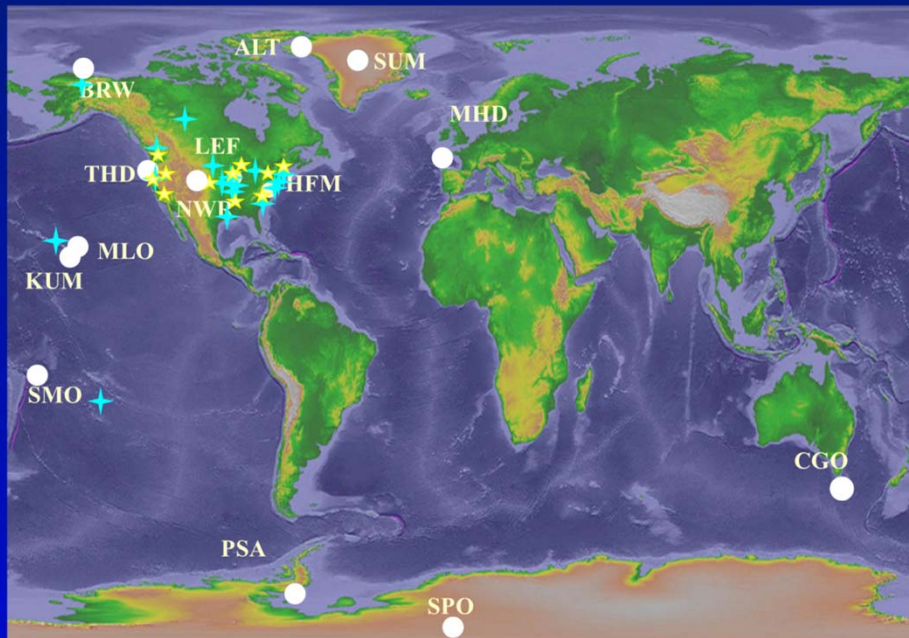
# Global-scale measurements of HFCs

Two main networks:

## NASA's AGAGE and affiliate sampling network

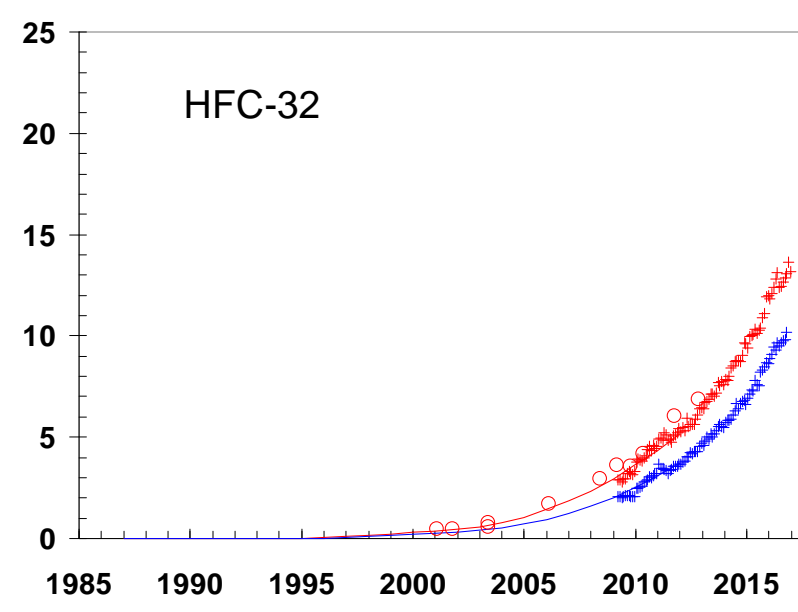
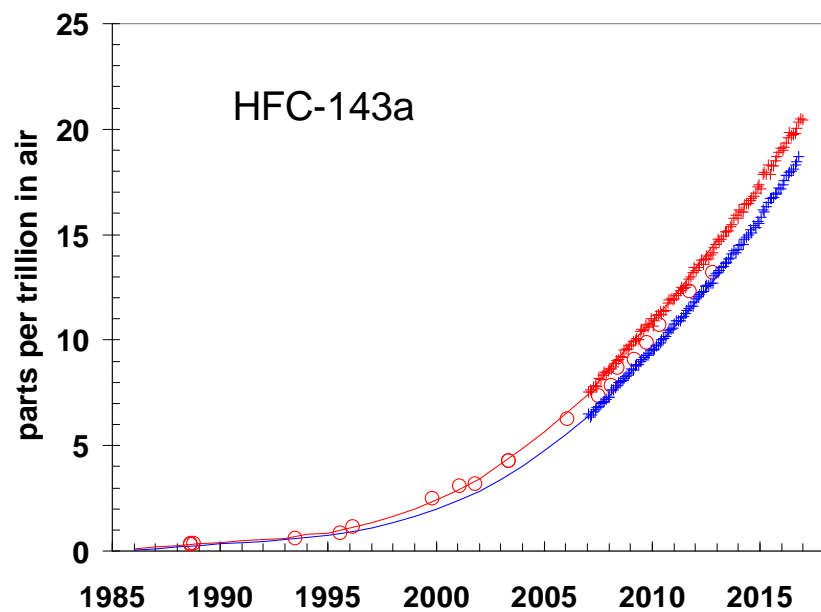
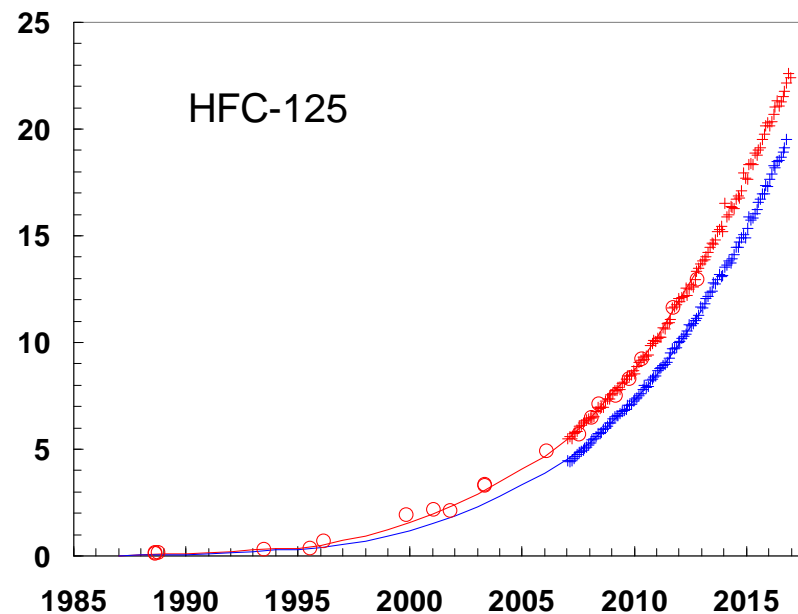
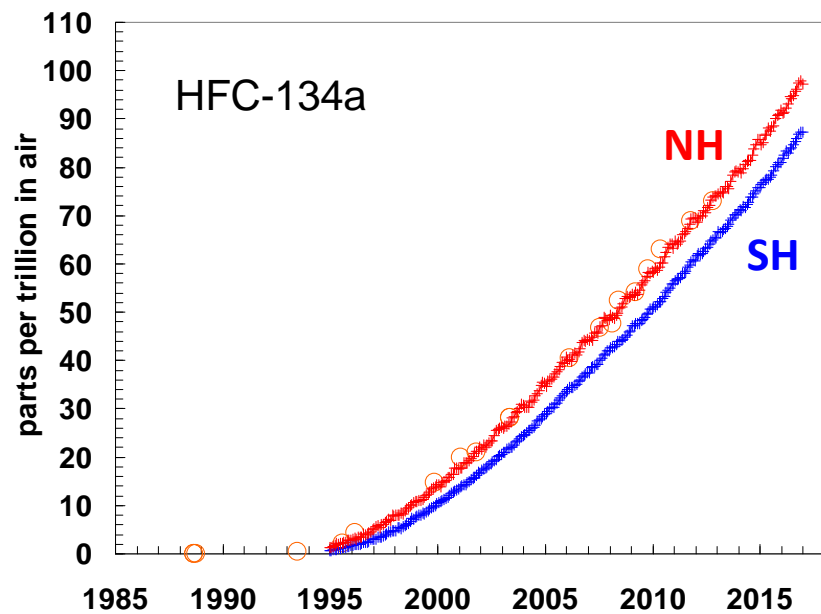


## NOAA's cooperative sampling network

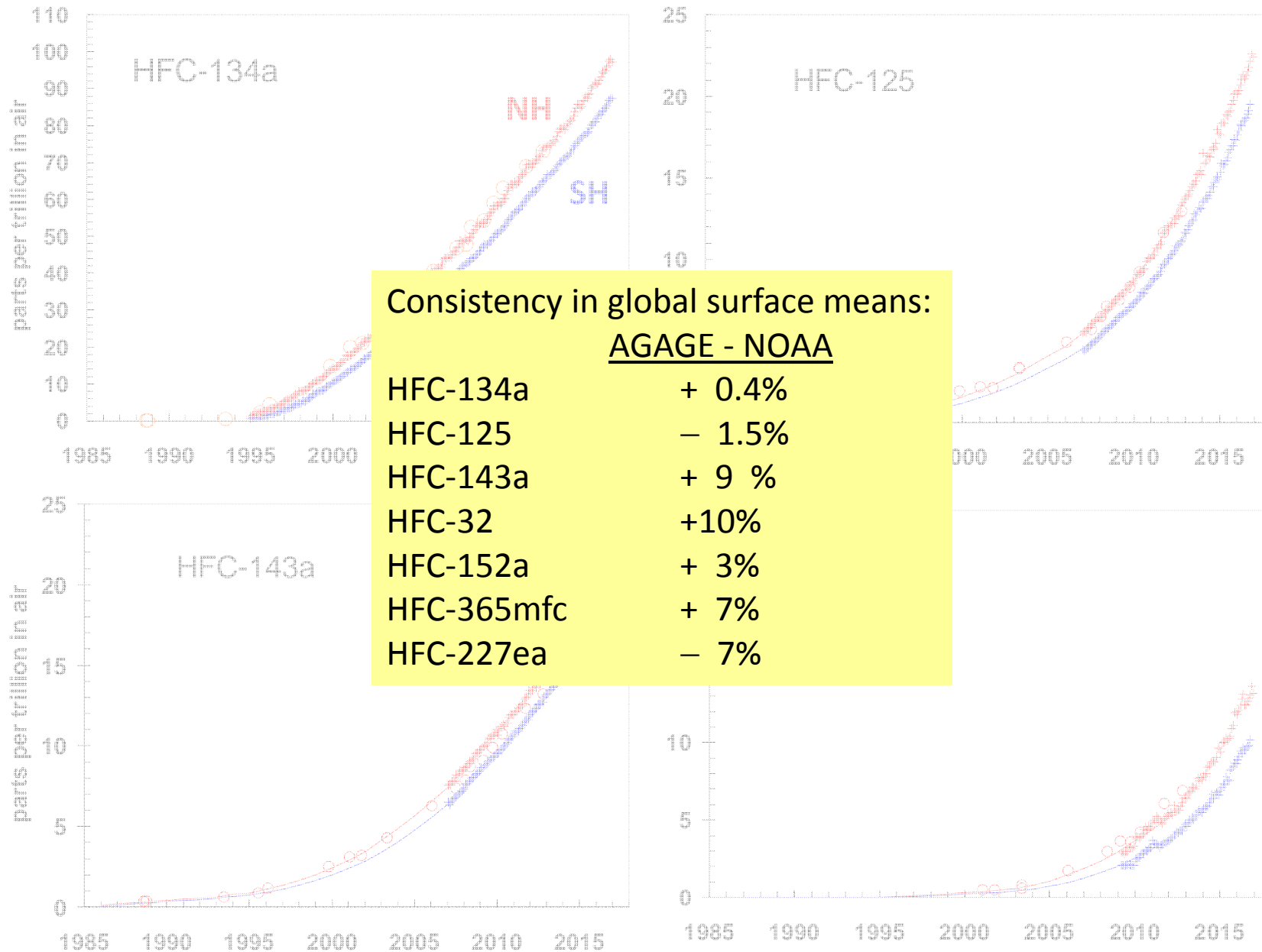


- Provide present-day background-atmosphere HFC concentrations  
→ climate warming today
- Provide estimates of current HFC emissions  
→ climate warming in the future

# HFC concentrations in the background atmosphere

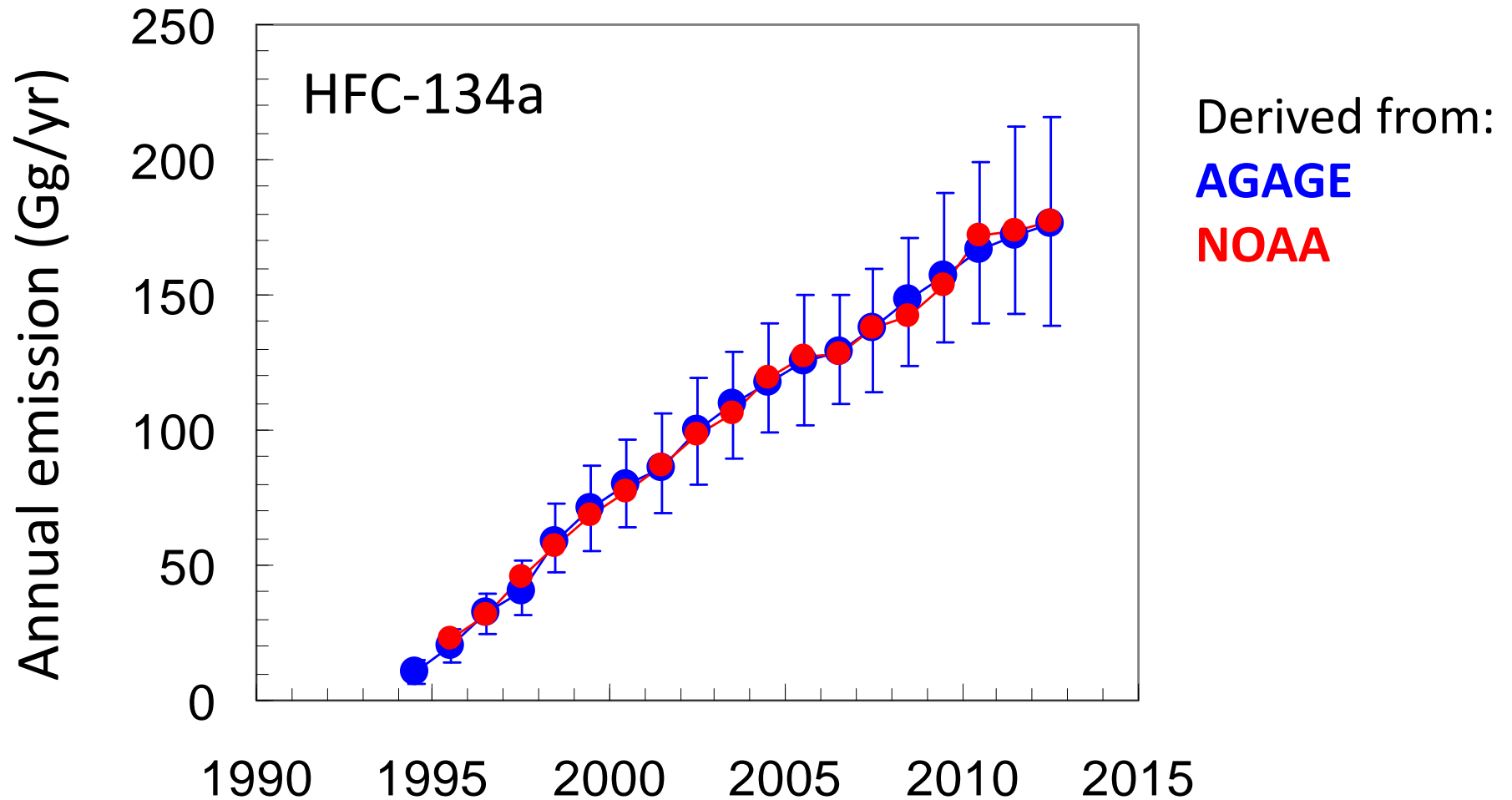


# HFC concentrations in the background atmosphere



# Global emission derived from observations

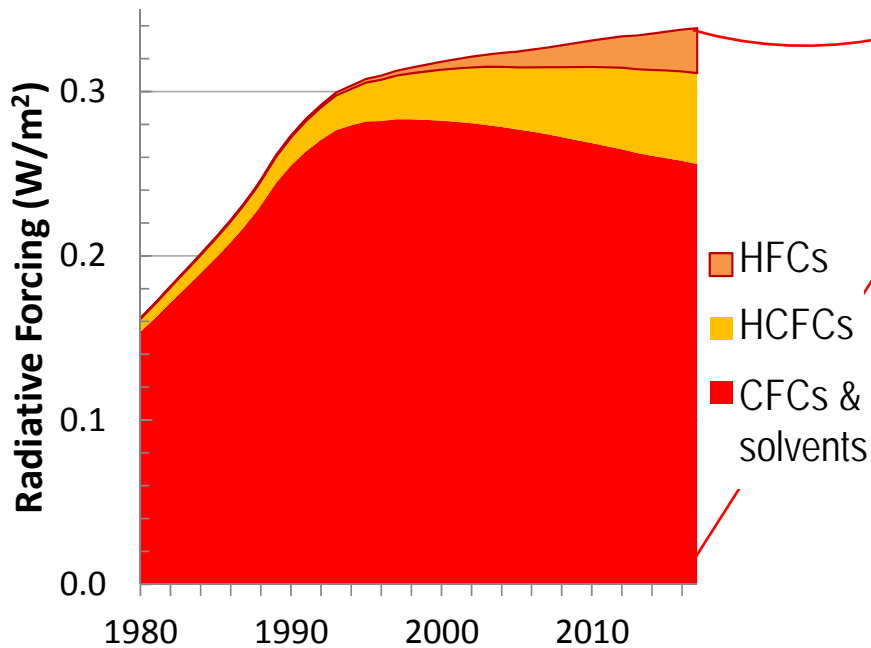
-derived with different modeling approaches



## HFC Impacts:

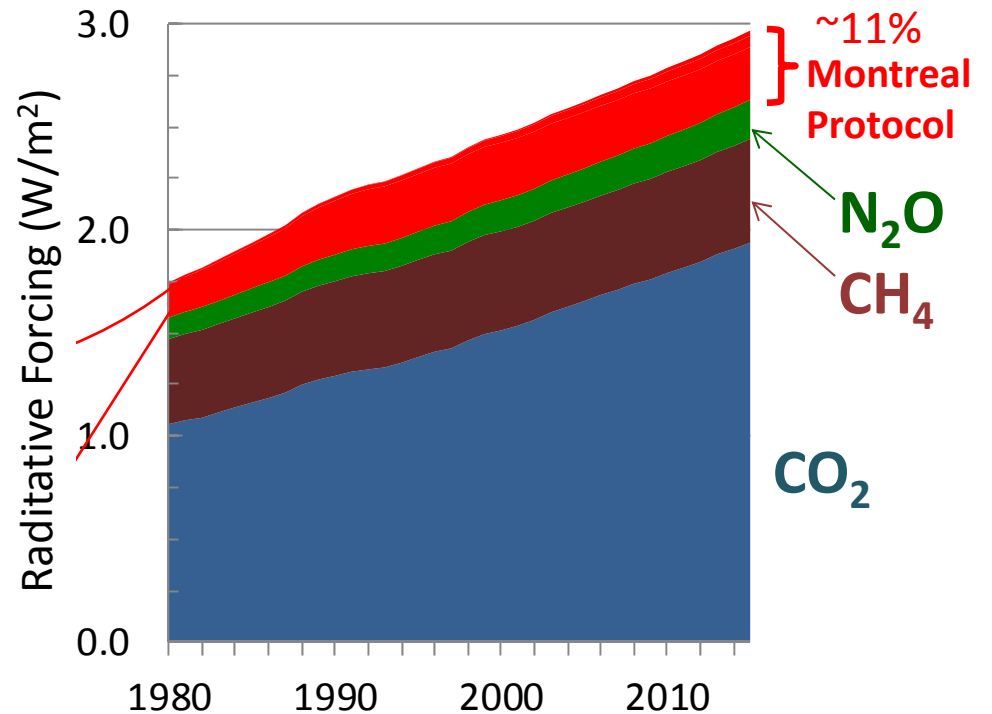
Current climate warming  
from long-lived gases  
(as radiative forcing)

### Montreal Protocol Gases



**HFC total in 2016 = 0.028 W/m<sup>2</sup>**  
50% from HFC-134a

### Long-lived greenhouse gases



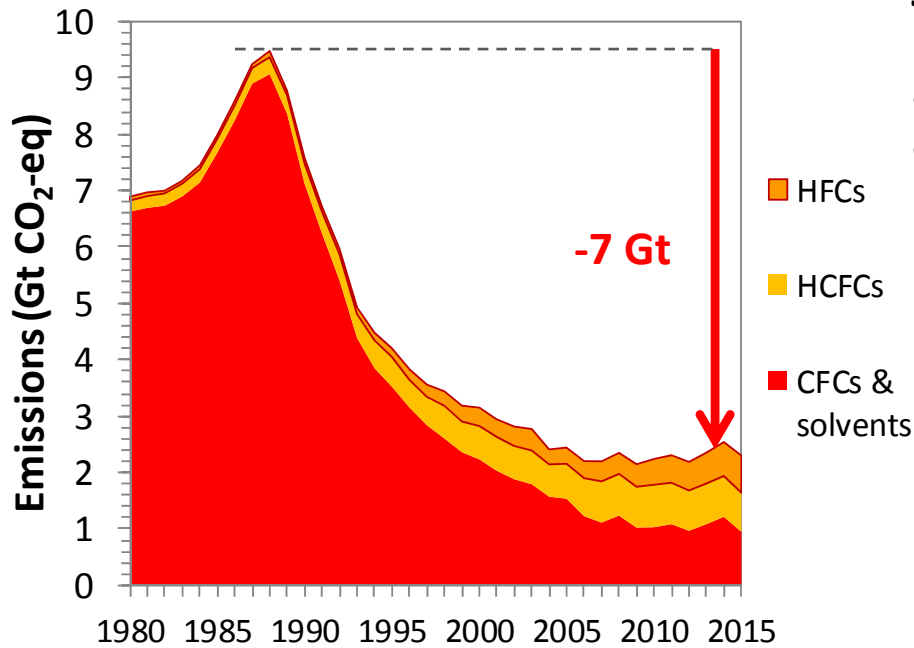
**The Kigali amendments are  
anticipated to limit this  
increase...**

# HFC Impacts:

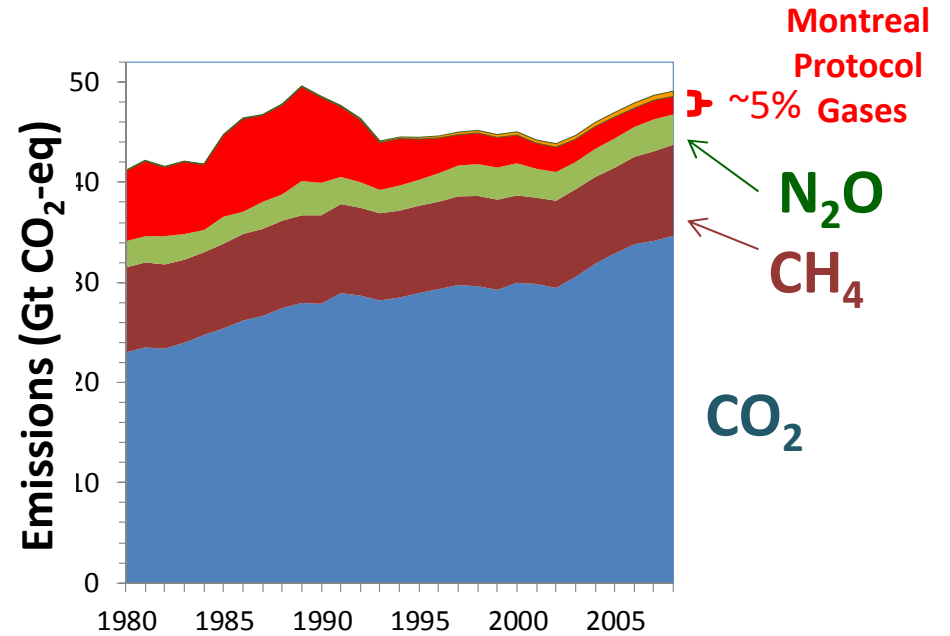
## Emissions

(as CO<sub>2</sub>-equivalents)

### Montreal Protocol Gases

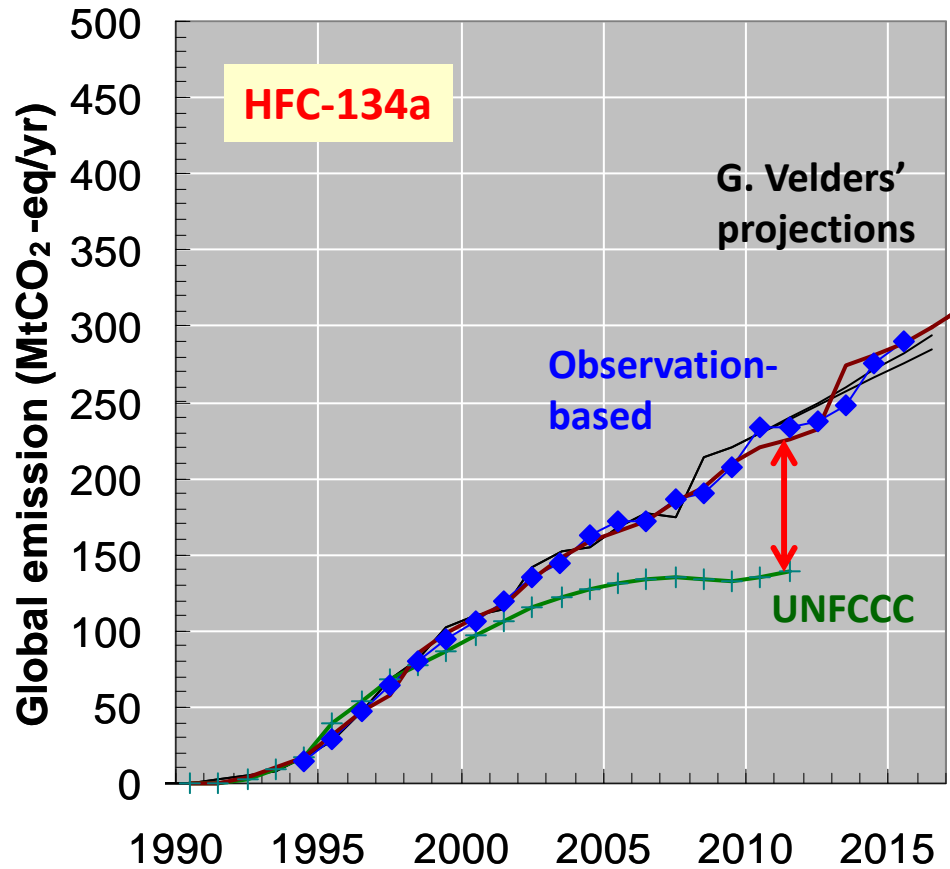


### All long-lived greenhouse gases



**Kigali Amendment anticipated to reverse this trend...**

# Are observed changes happening as expected?

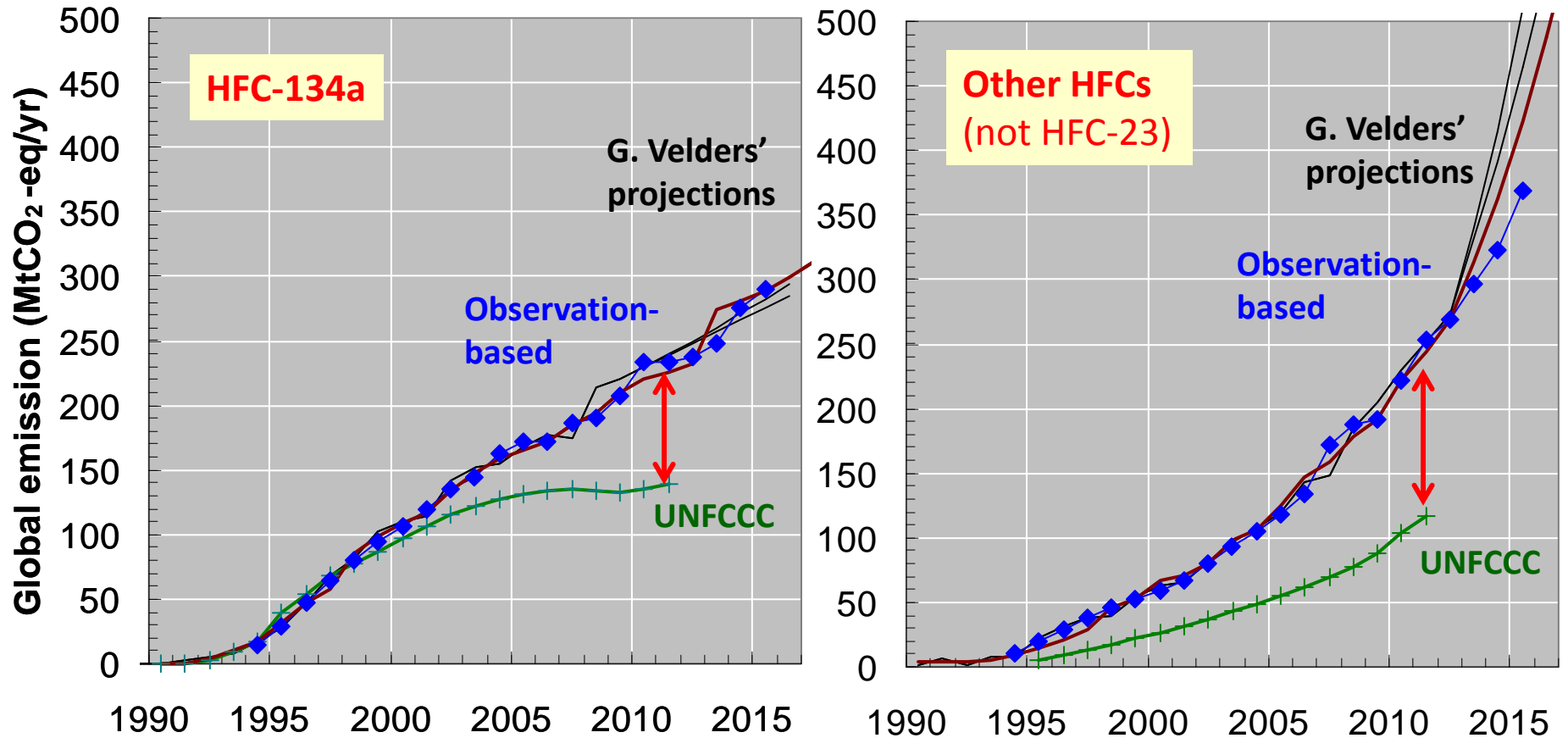


← Consistent with expectations

← Shortfall in reporting to UNFCCC...



# Are observed changes happening as expected?

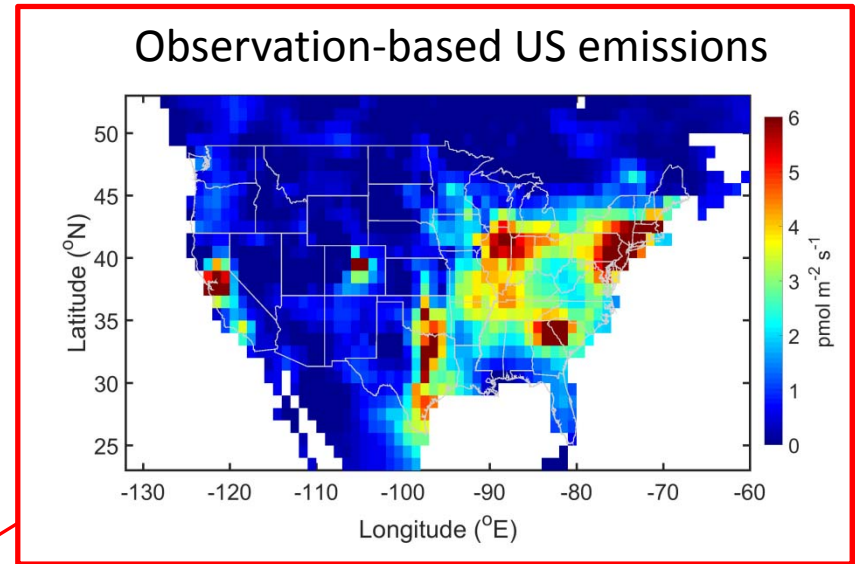
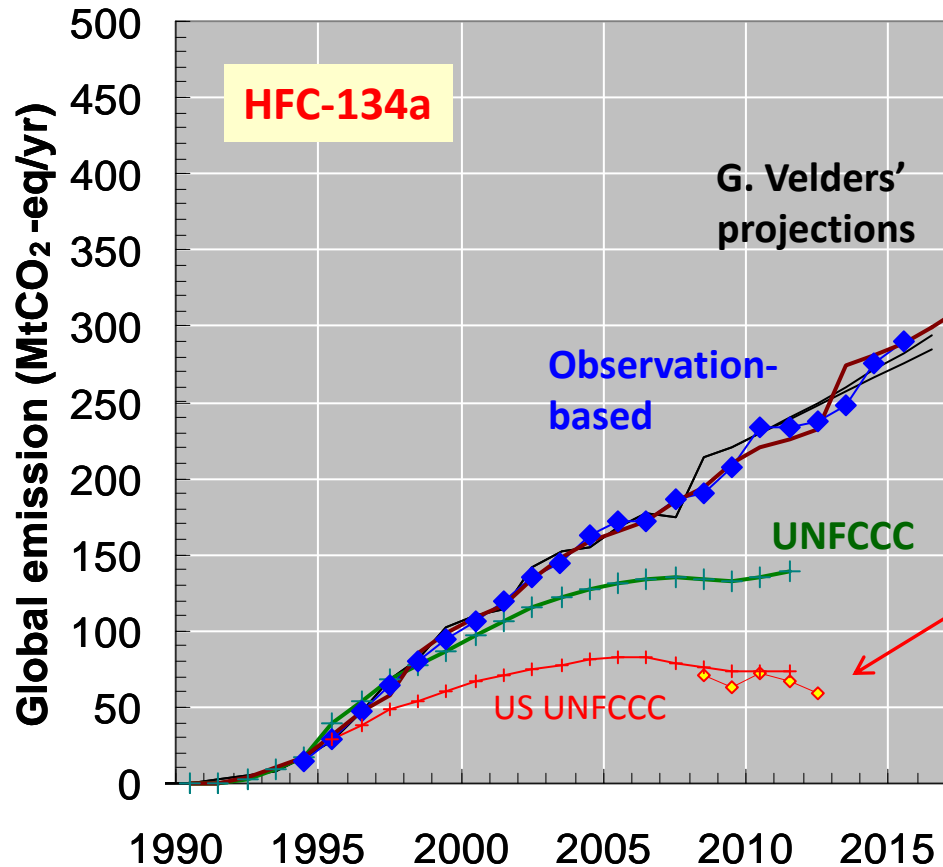


**A) Recent projections: accurate for HFC-134a, overestimating other HFCs...**

**B) Shortfall: ~100 Mt CO<sub>2</sub>-eq for HFC-134a  
~150 Mt CO<sub>2</sub>-eq for other HFCs**

**This result has been noted independently by results from both networks**

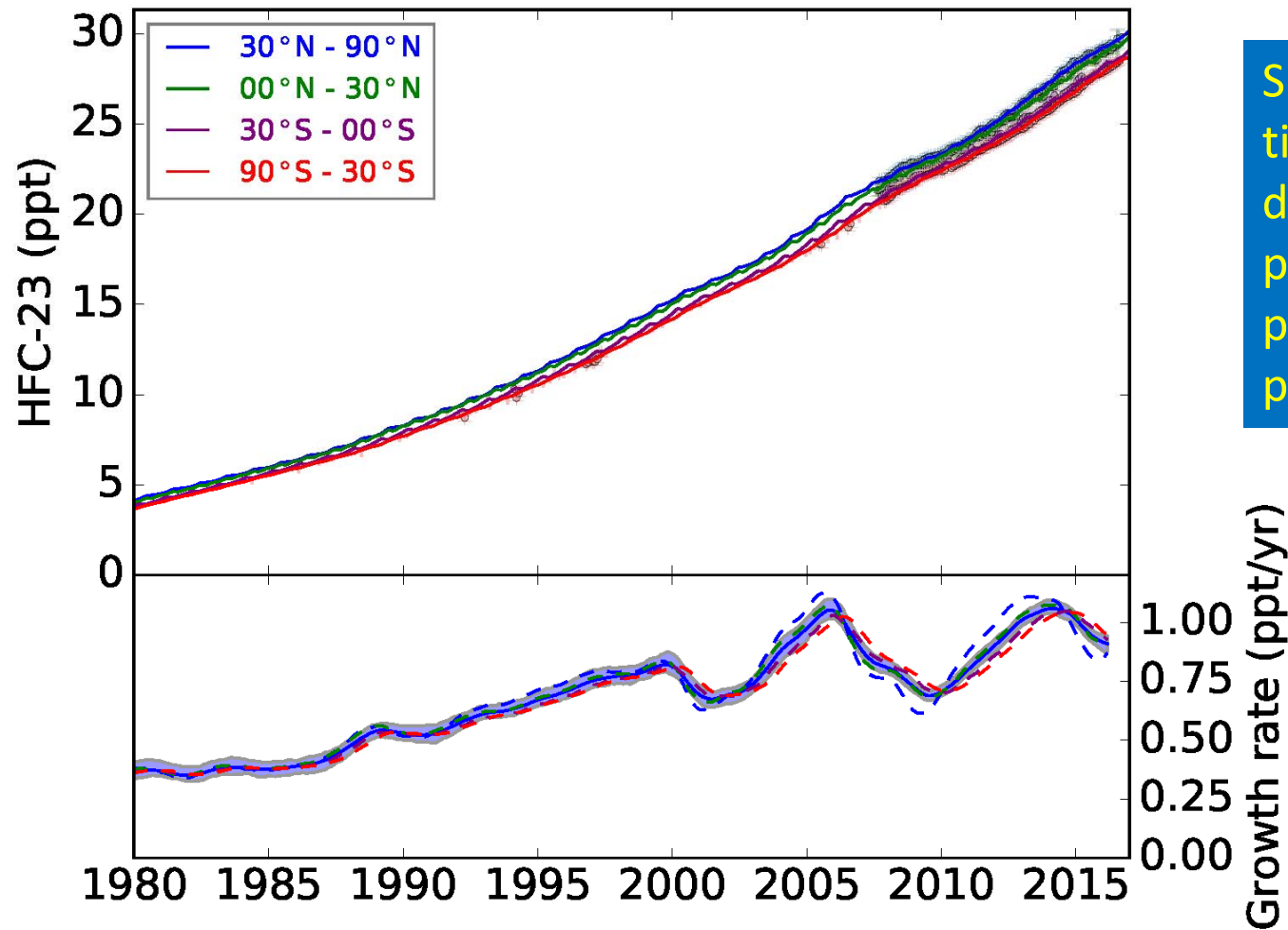
# Are observed changes happening as expected?



Consistency between inventory and atmosphere-derived regional emissions  
(also observed in Australia and EU)

→ implies significant HFC-134a emissions outside reporting to UNFCCC

# HFC-23 increases in the global atmosphere:



Substantial  
time-  
dependent  
perturbations,  
probably  
policy-induced

*AGAGE data, analysis by M. Rigby*

## Summary:

- \* Concentrations and emissions of nearly all HFCs are increasing owing to the Montreal Protocol phase out of CFCs and HCFCs.
- \* Increases in HFCs have offset some of the climate gains achieved by the Montreal Protocol.
- Increases of HFC-134a are consistent with earlier projections; those for other HFCs are not keeping pace with those projections.
- \* Observations imply substantial HFC emissions not included in UNFCCC reporting.
- \* Observational networks are well positioned to detect reductions in global HFC emissions owing to the Kigali-Amendment controls on production...