Atmosphere-based "top-down" emission estimates of HFC-134a and HCFC-22 from the U.S. over multiple years

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Goal:

• To derive **reliable** "atmosphere-based" national emission estimates of ozone-depleting substances (ODSs) and greenhouse gases (GHGs)
• To assess inventory-based "bottom-up" estimates

Today, regional inverse modeling of HFC-134a and HCFC-22.

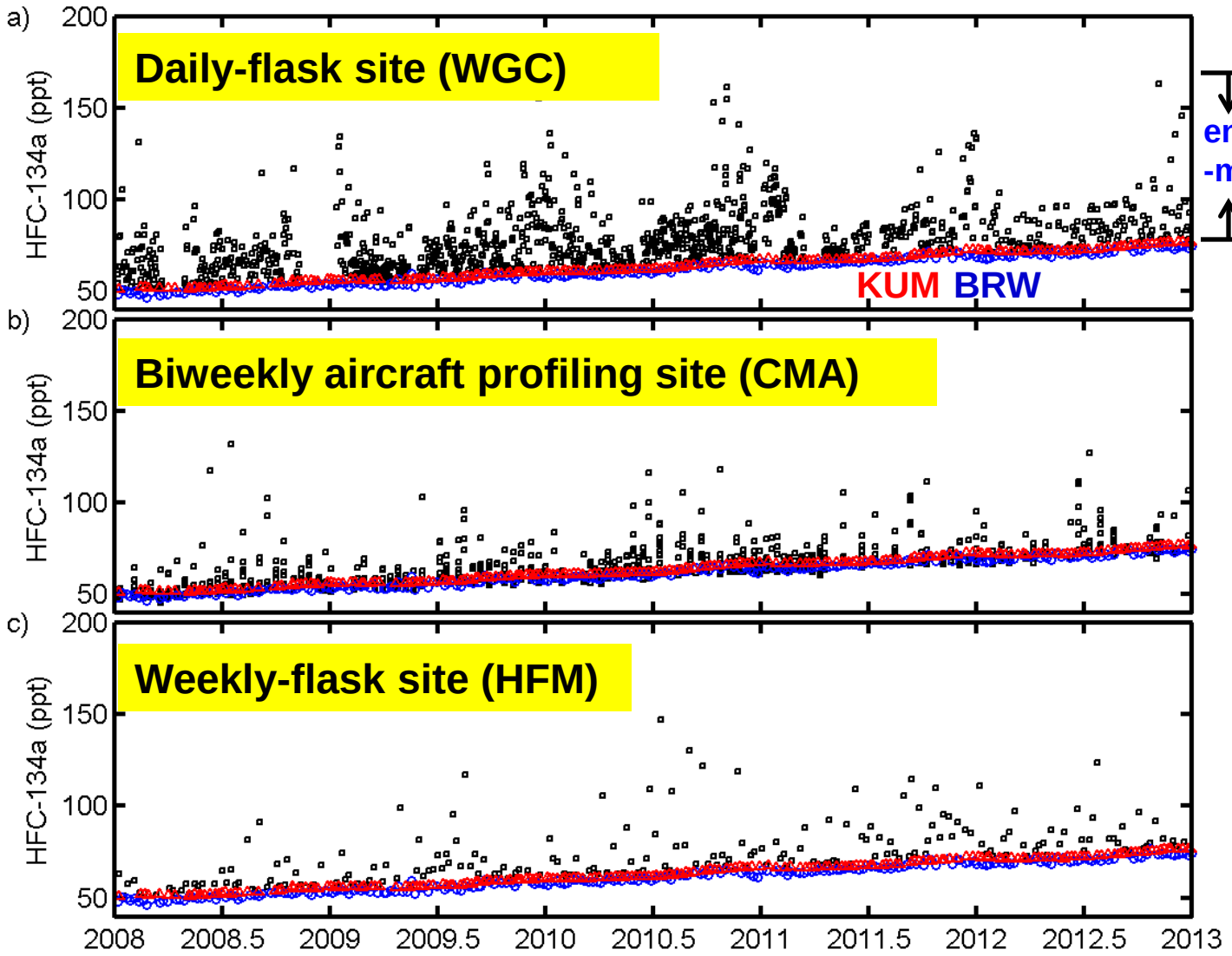
HFC-134a:
• A potent GHG
• Mainly used in mobile air conditioning to replace CFC-12

HCFC-22:
• An ODS and potent GHG
• Mainly used in commercial and residential air conditioning
• US production and consumption currently declining

Key Questions:

US Emission magnitudes? Seasonality & Inter-annual variability? Emission trends?

North American Halocarbon Flask Sampling Network



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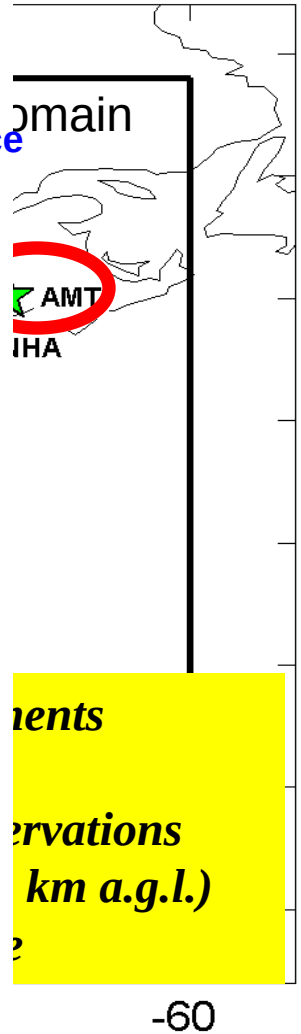

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km a.g.l.)

Surface sites (daily flasks)

Surface sites (weekly flasks)

Biweekly aircraft profiling sites

Aircraft campaigns

Inversion Method

Observed enhancement = Flux X Footprint (sensitivity of observed enhancement to upstream fluxes) + Model-data mismatch errors

HYSPLIT- NAM12 (2008 – 2012)
STILT-WRF (2010)

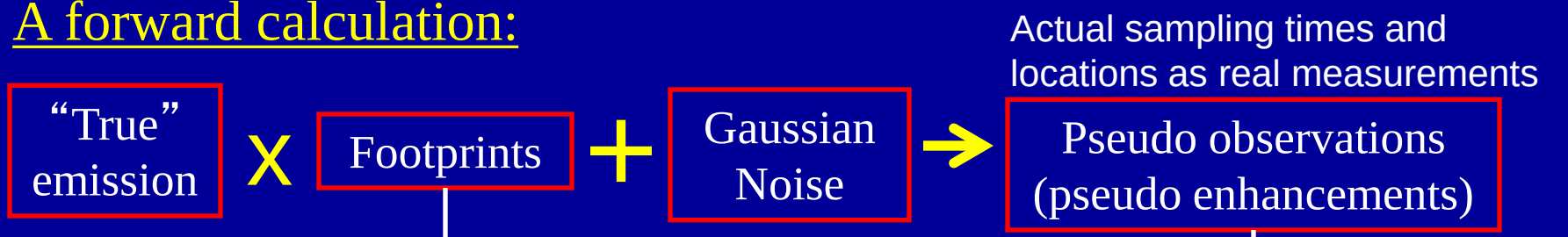
Solve for: monthly $1^o \times 1^o$ scaling factors for a prior emission field using a Bayesian inversion

Synthetic-data inversion

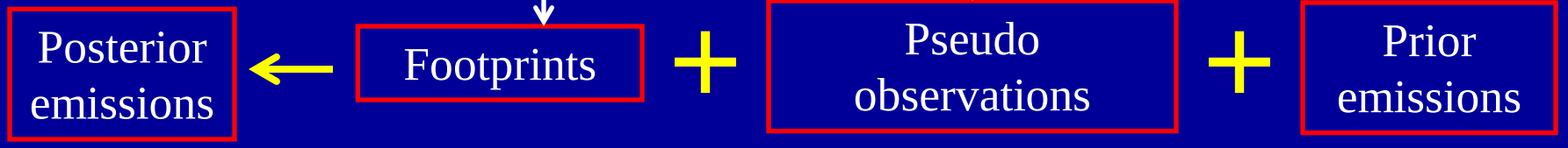
Objective: To test the credibility of our inversion system to derive national fluxes, given our sampling network

Design:

A forward calculation:



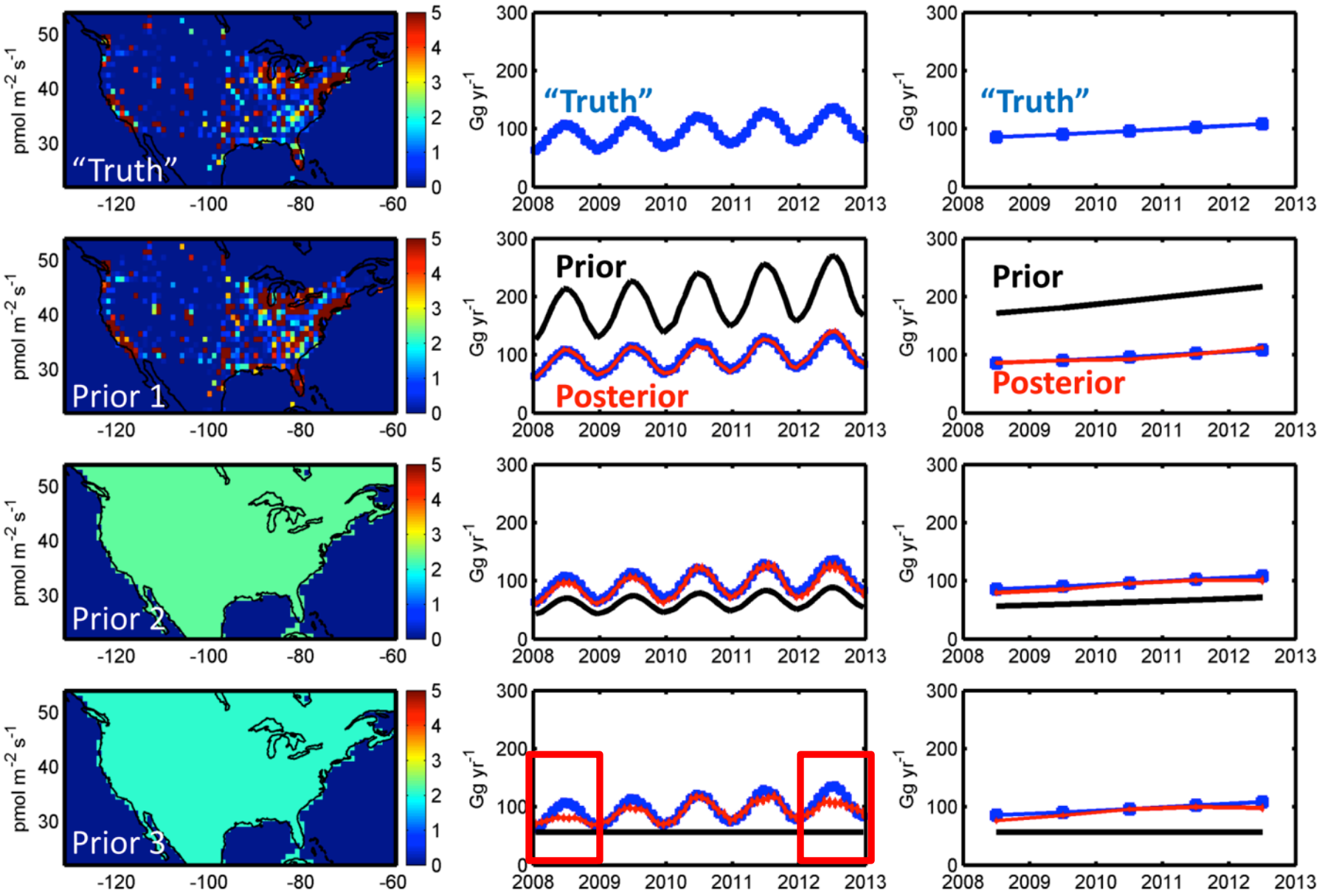
An inverse calculation:



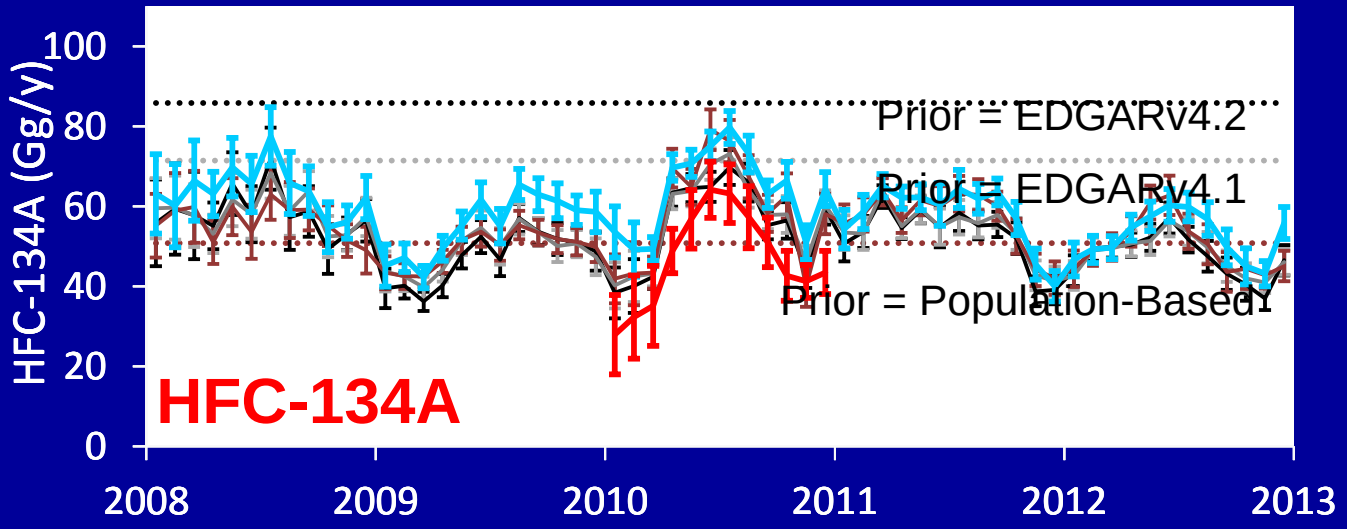
Different emission magnitudes and distributions than "true" emission

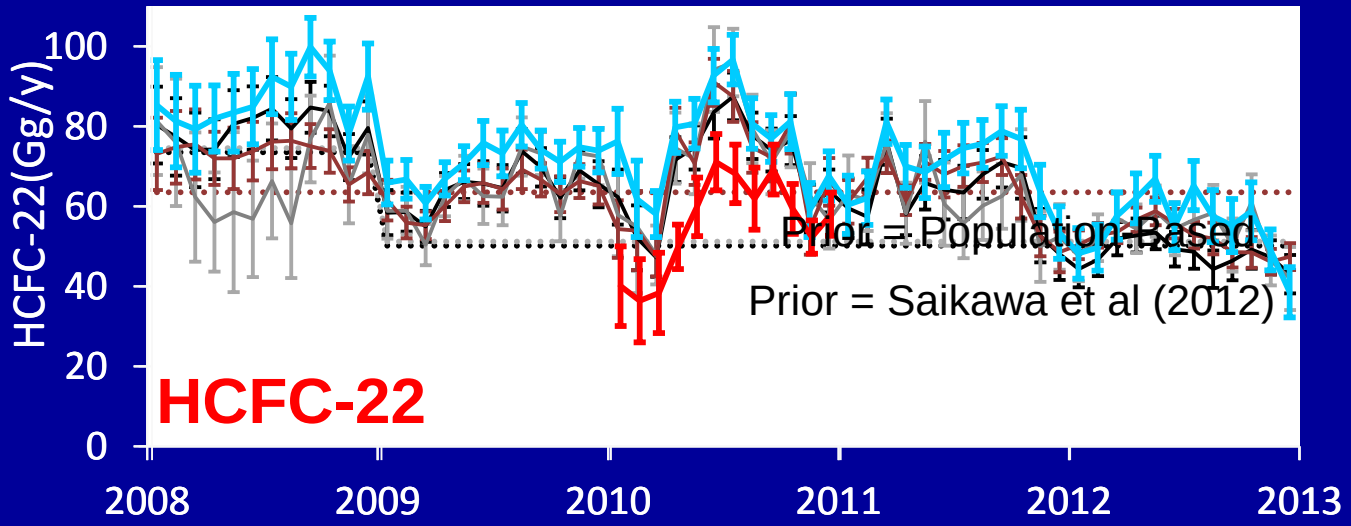
Posterior emissions ? "True" emissions

“Truth” & Priors & Posteriors



Real-Data Inversion: HFC-134a and HCFC-22 (Multiple Priors & Backgrounds & Transports)





* Multiple a-seasonal priors

* Inversion results:

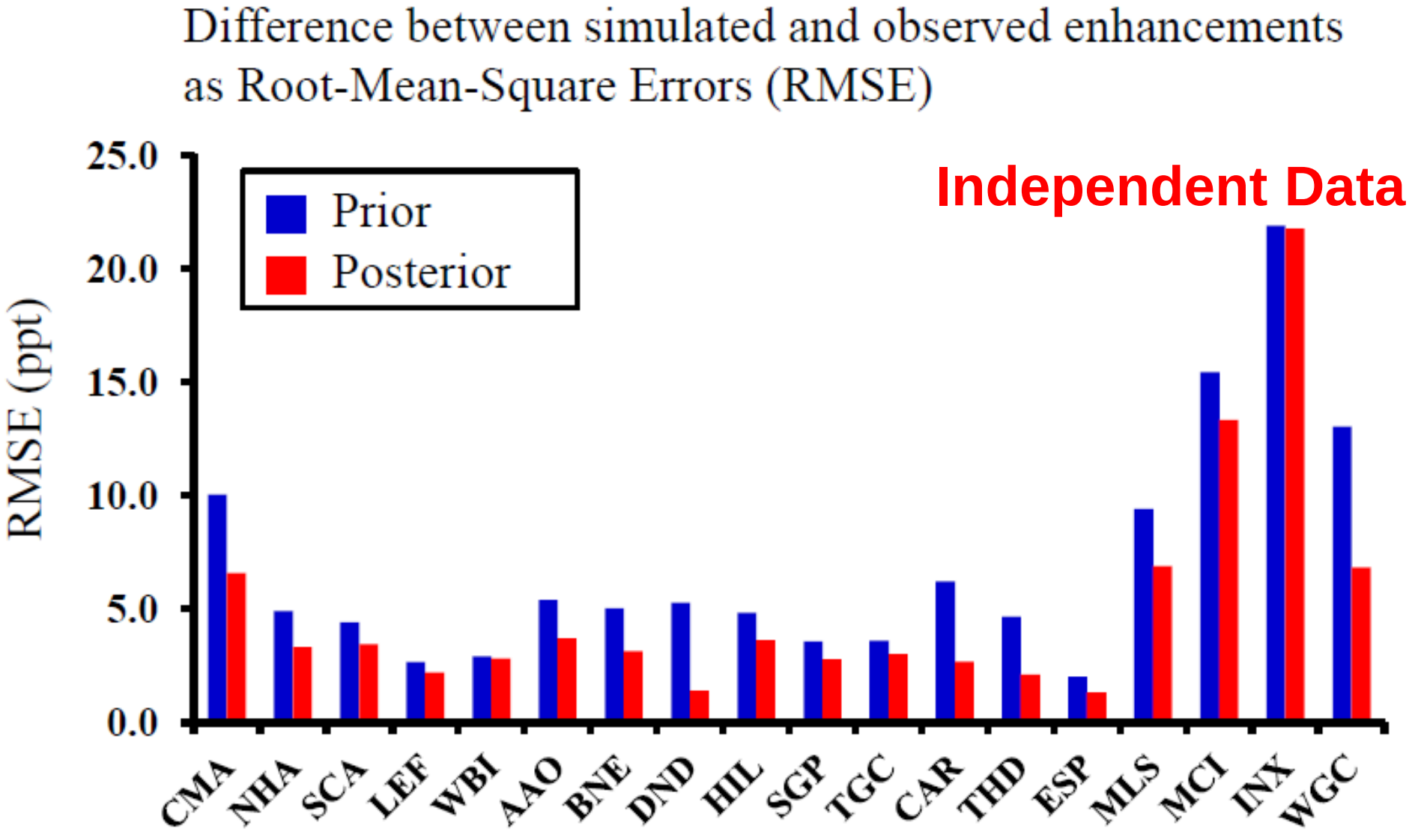
bkg = 10th prtile, **HYSPLIT-NAM12**

bkg = "Curtain" + Air back-trajectory **HYSPLIT-NAM12**

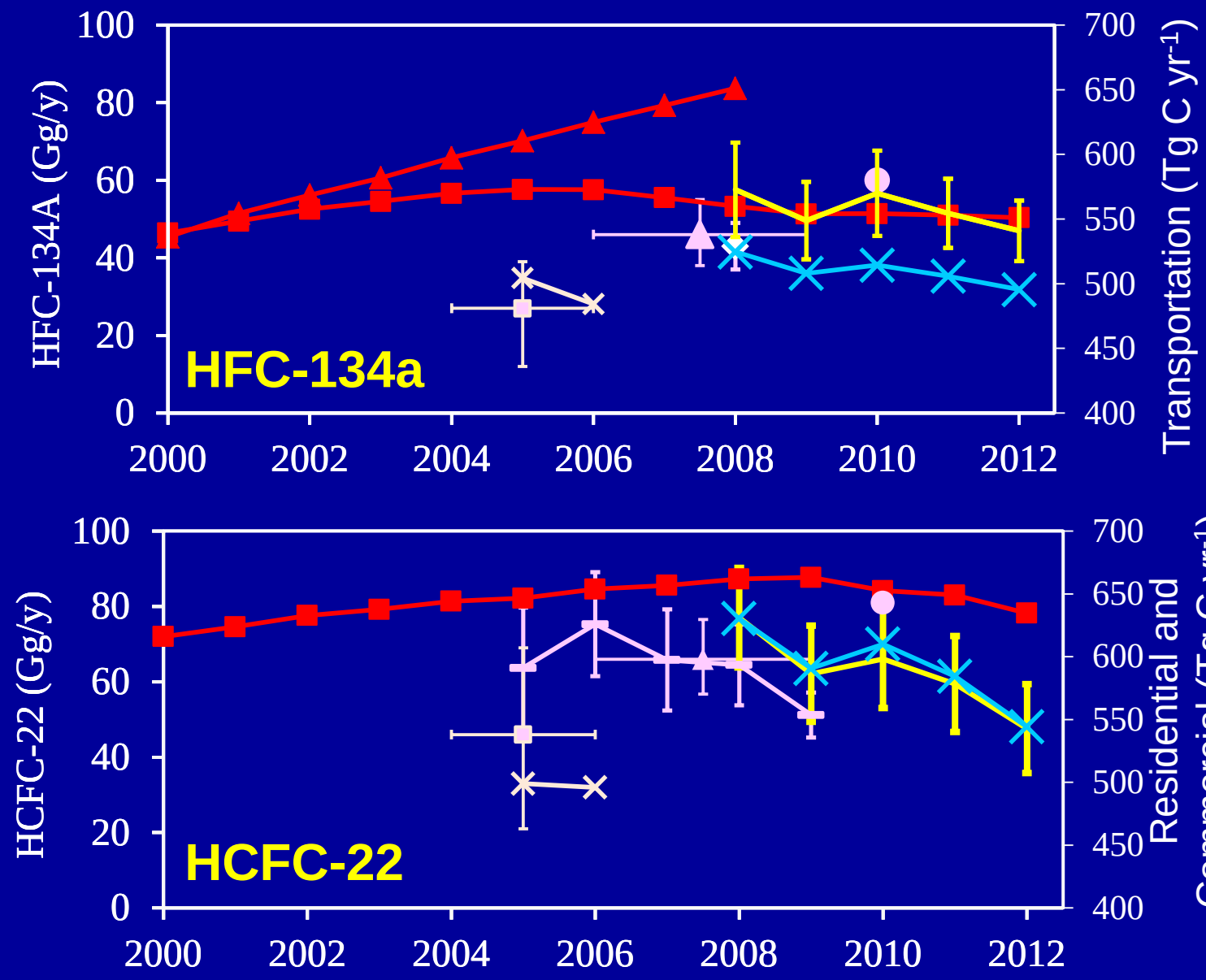
bkg = 10th prtile, **STILT-WRF**

Evaluating derived fluxes

HFC-134a



Comparison with other national estimates



"Bottom-up":

U.S. EPA (■)

EDGARv4.2 (▲)

Fossil Fuel CO_2 Emission (US EIA)

"Top-down":

Millet 2009 (■)

Stohl 2009 (x)

Barletta 2011 (◆)

Saikawa 2012 (–)

Miller 2012 (▲)

Montzka 2013 (●)

This study (—)

Conclusions

- Synthetic-data inversion: Given our sampling network, derived fluxes using our inversion system are fairly insensitive to priors on a national scale.

- Real-data inversion:

  - Derived national emissions of HFC-134a and HCFC-22 are fairly insensitive to priors, backgrounds and transports (within 1sd = ±20%).

  - Seasonally varying emissions: winter emissions are 20 – 50 % lower than summer emissions for both gases.

  - Comparing to US EPA national emission estimates:
    - HFC-134a: comparable.
    - HCFC-22: ~10 – 50% lower; a relatively more rapid decline.

- Future work: apply to other gases (e.g. other HFCs, HCFCs, N_2O, CH_4)

Evaluating derived fluxes

HFC-134a