Regional emission estimates of selected anthropogenic greenhouse gases (HFC-134a, HCFC-22 and CH_4) from California

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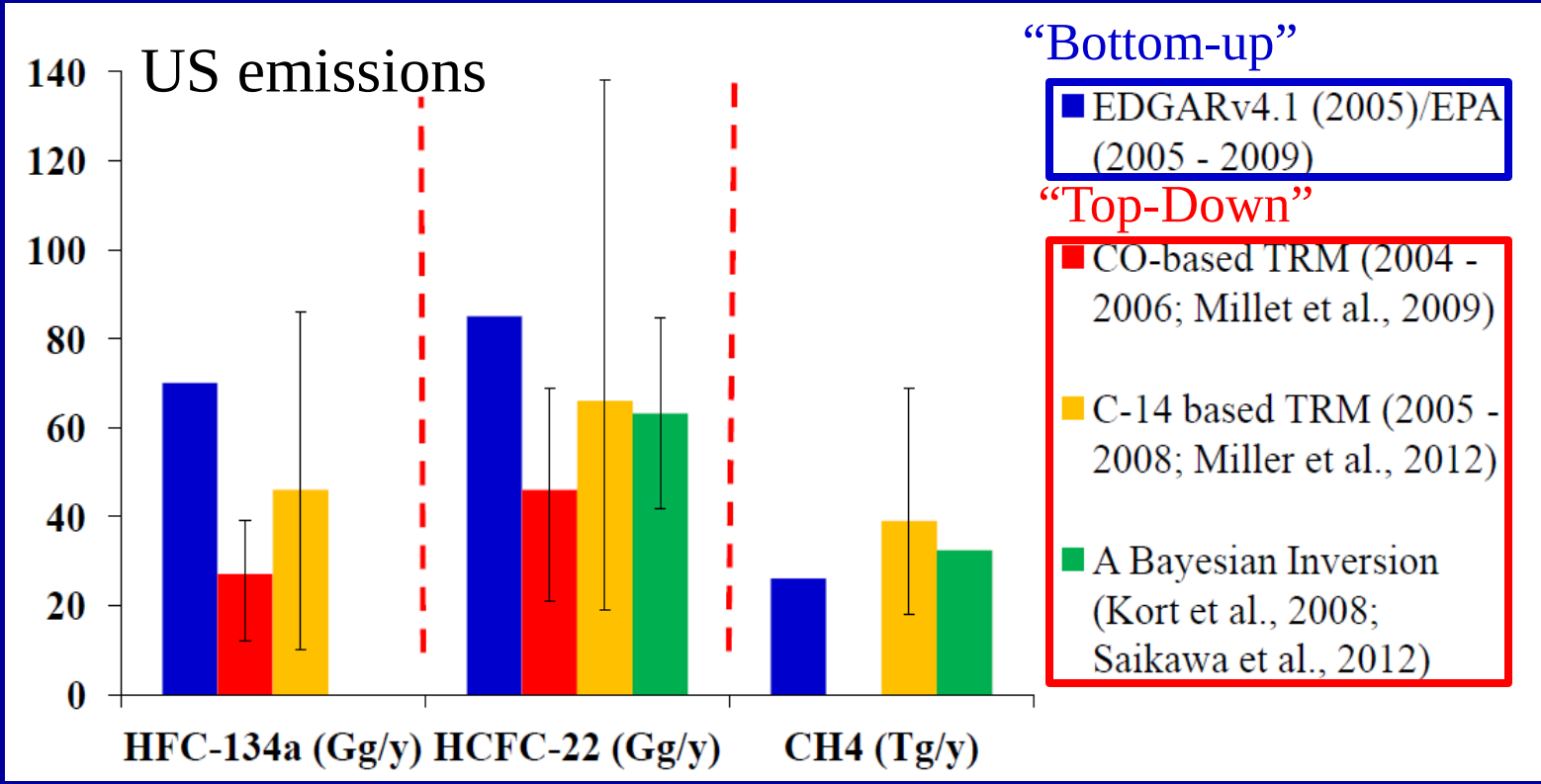
Global Monitoring Annual Conference, May 21 - 22, 2013

Motivation

- Increasing atmospheric burdens of greenhouse gases (GHGs)
- Reducing GHG emissions
- Evaluating the degree to which GHG emissions have been reduced



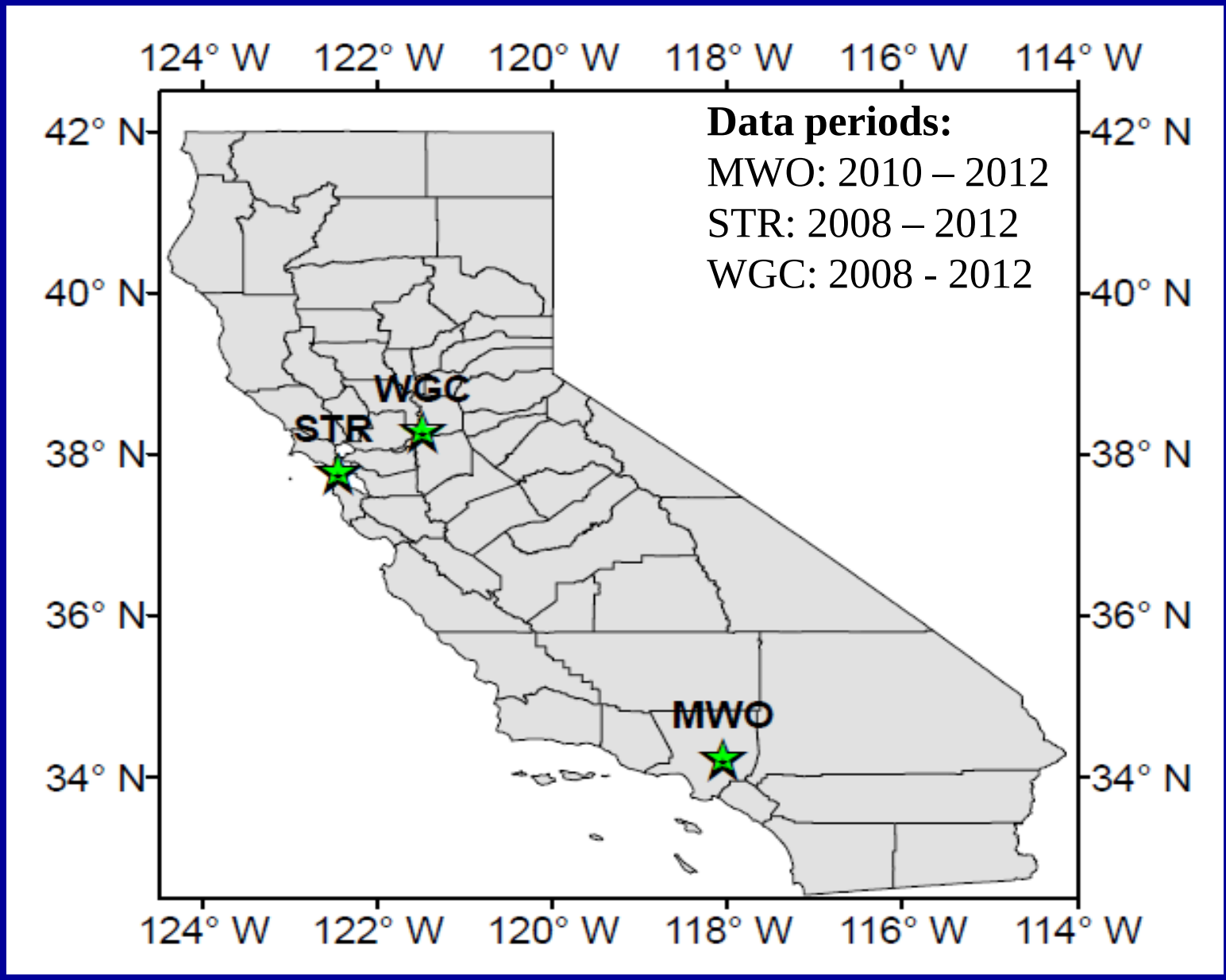
Goals

- To provide accurate emission estimates
- To assess various "top-down" approaches

Outline

- Surface flask sites
- Emission estimates using a CO-based tracer ratio method
- Further constrain fluxes using a Bayesian inversion
- Summary for our preliminary findings

Surface flask sites



A CO-based tracer ratio method

Enhancement:

$$\Delta_{obs} = \chi_{obs} - \chi_{bkg}$$

Emissions of a trace gas (x):

$$E_x = E_{CO} \times \frac{\Delta_x}{\Delta_{CO}}$$

Many studies have used this method, but with different details!

e.g. Li et al. (2005), Reimann et al (2005), Hurst et al. (2006), Yokouchi et al. (2006), Millet et al. (2009), Barletta et al. (2011, 2013), Wennberg et al. (2012)

Multiple approaches were considered and evaluated in the study

Background (χ_{bkg}) :

(1) The 10th percentile of surface data at three sites (e.g. Millet et al., 2009)

(2) Marine background reference (Masarie and Tans, 1995)

(3) "Background curtain" + air back-trajectories (Andrews et al., in prep.)

Three-monthly enhancement ratios (ER, Δ_x/Δ_{CO}):

(1) An orthogonal distance regression (e.g. Hurst et al., 2006; Barletta et al., 2011, 2013)

(2) A median ratio approach (e.g. Miller et al., 2012)

Estimating a state-wide emission:

Approach (1): ER × CO inventory (e.g. Yokouchi et al. 2006; Wennberg et al. 2012)

(a) ER= ER(STR)*0.25+ER(WGC)*0.25+ER(MWO)*0.5

(b) $$ER_{i,j} = \sum_{s=1}^{3} f_{i,j,s} \bullet ER_s \Big/ \sum_{s=1}^{3} f_{i,j,s}$$

(s= site index; i,j=indices of latitudes and longitudes; f=footprints)

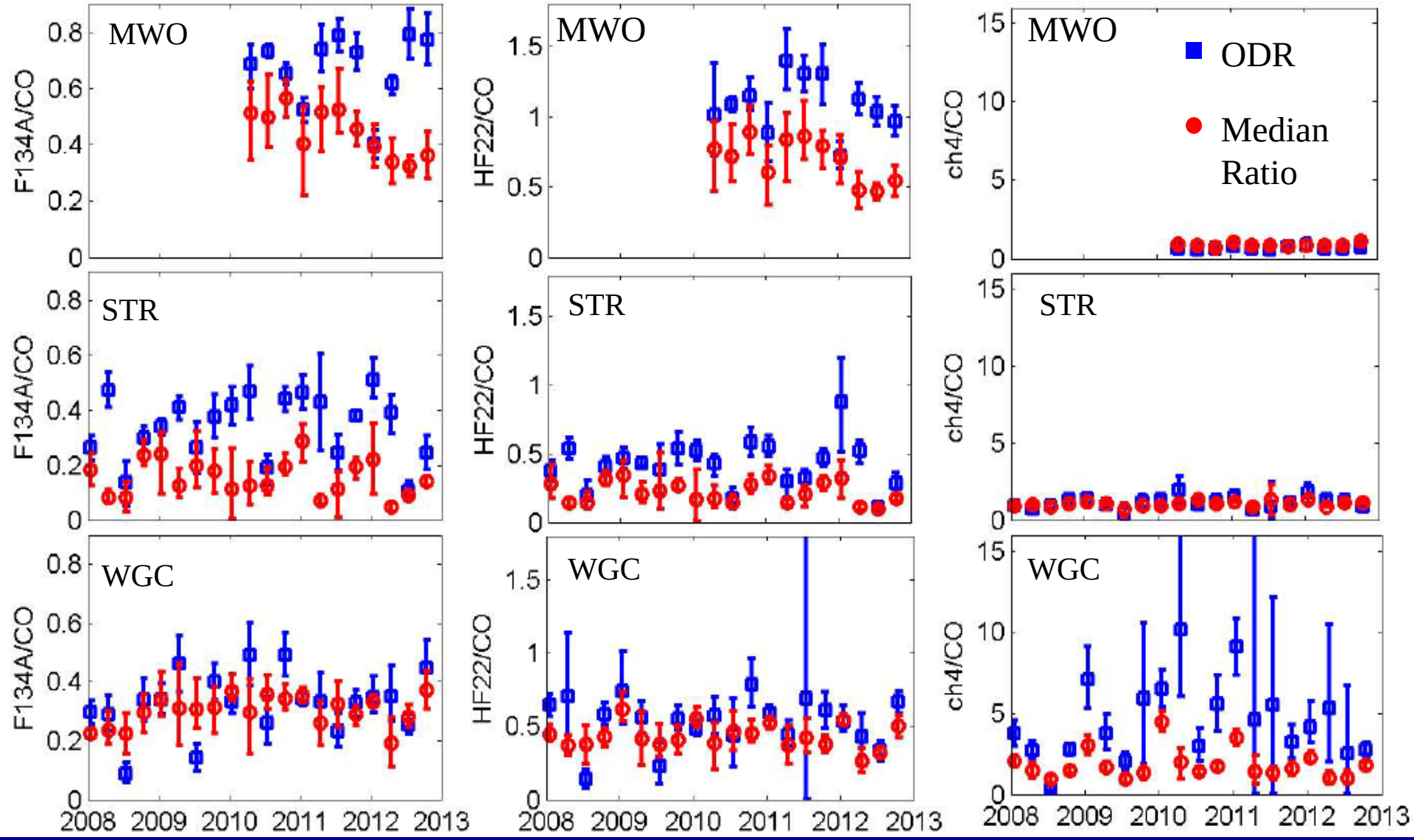
Approach (2): Per capita flux (PCF) × population (e.g. Li. et al. 2006, Hurst et al., 2006; Barletta et al, 2011, 2013)

(a) PCF= PCF(STR)*0.25+PCF(WGC)*0.25+PCF(MWO)*0.5

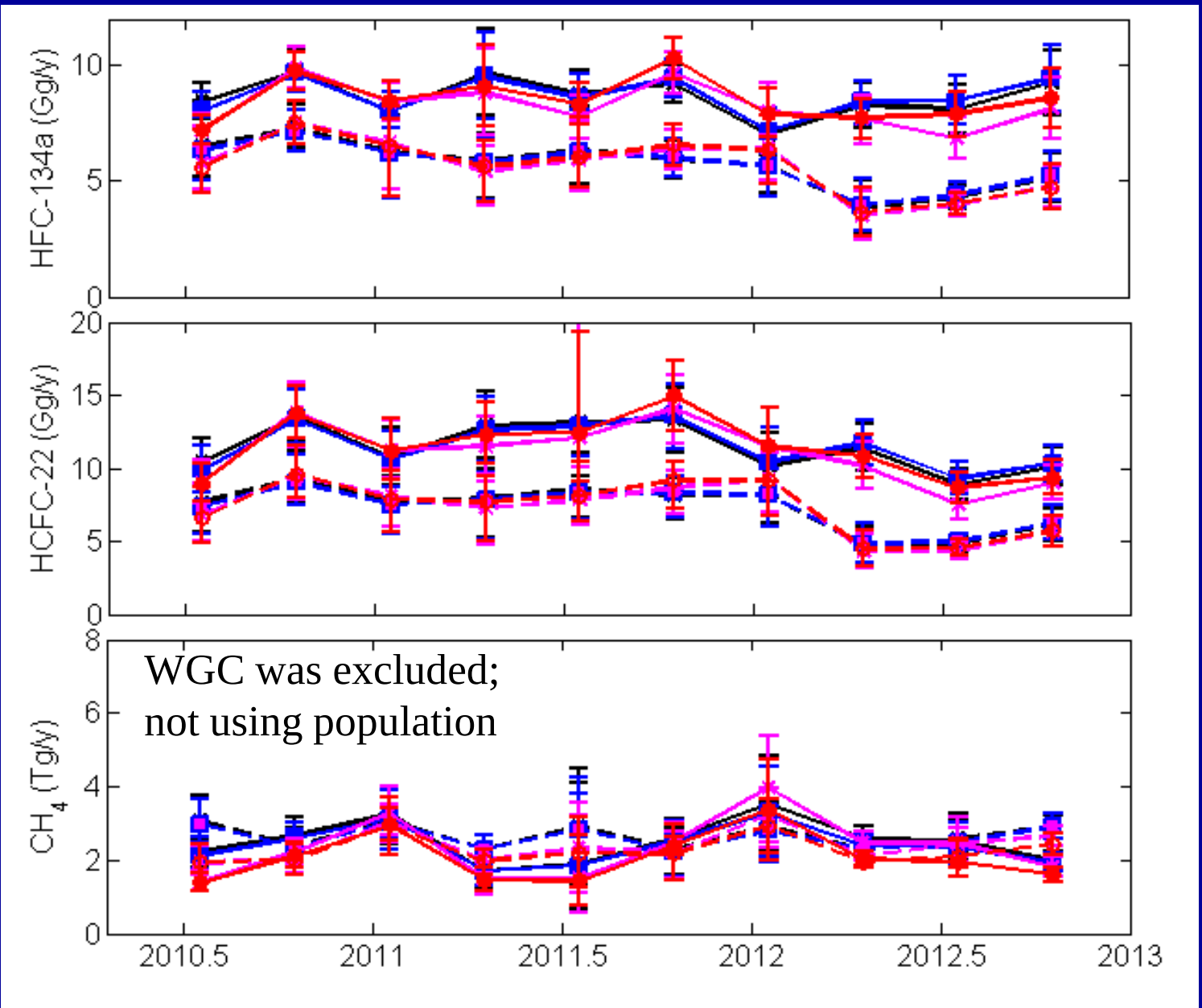
(b) $$PCF_{i,j} = \sum_{s=1}^{3} f_{i,j,s} \bullet PCF_s \Big/ \sum_{s=1}^{3} f_{i,j,s}$$

Three-monthly enhancement ratios at three sites

HFC-134a HCFC-22 CH_4



Emission Estimates



Solid lines: ODR

Dash lines: Median Ratios

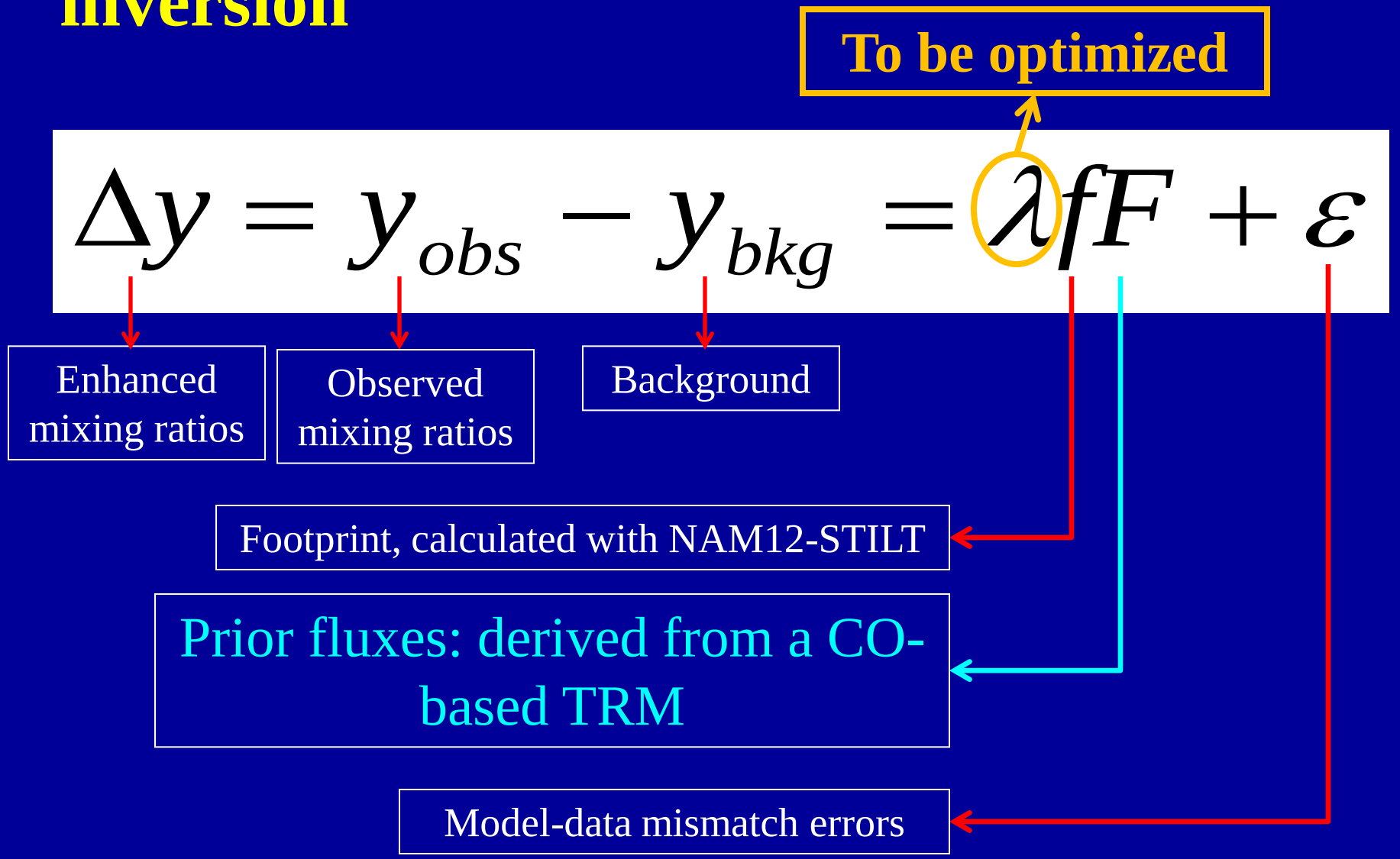
Approach 1a): ER × CO inventory, no footprint

Approach 2a): PCF x Population , no footprint

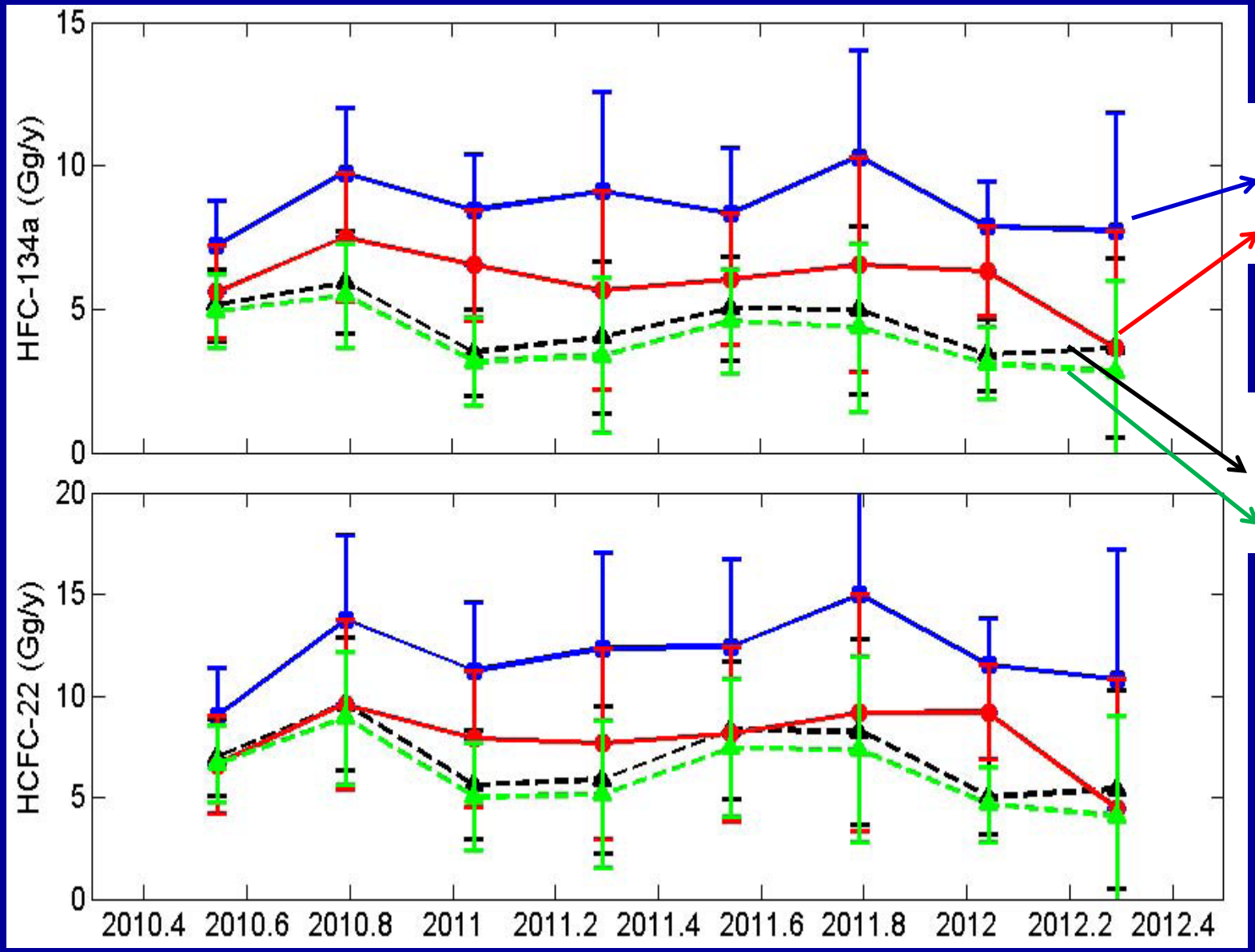
Approach 1b): ER × CO inventory, with footprint

Approach 2b): PCF × population, with footprint

Further constrain fluxes using a Bayesian inversion



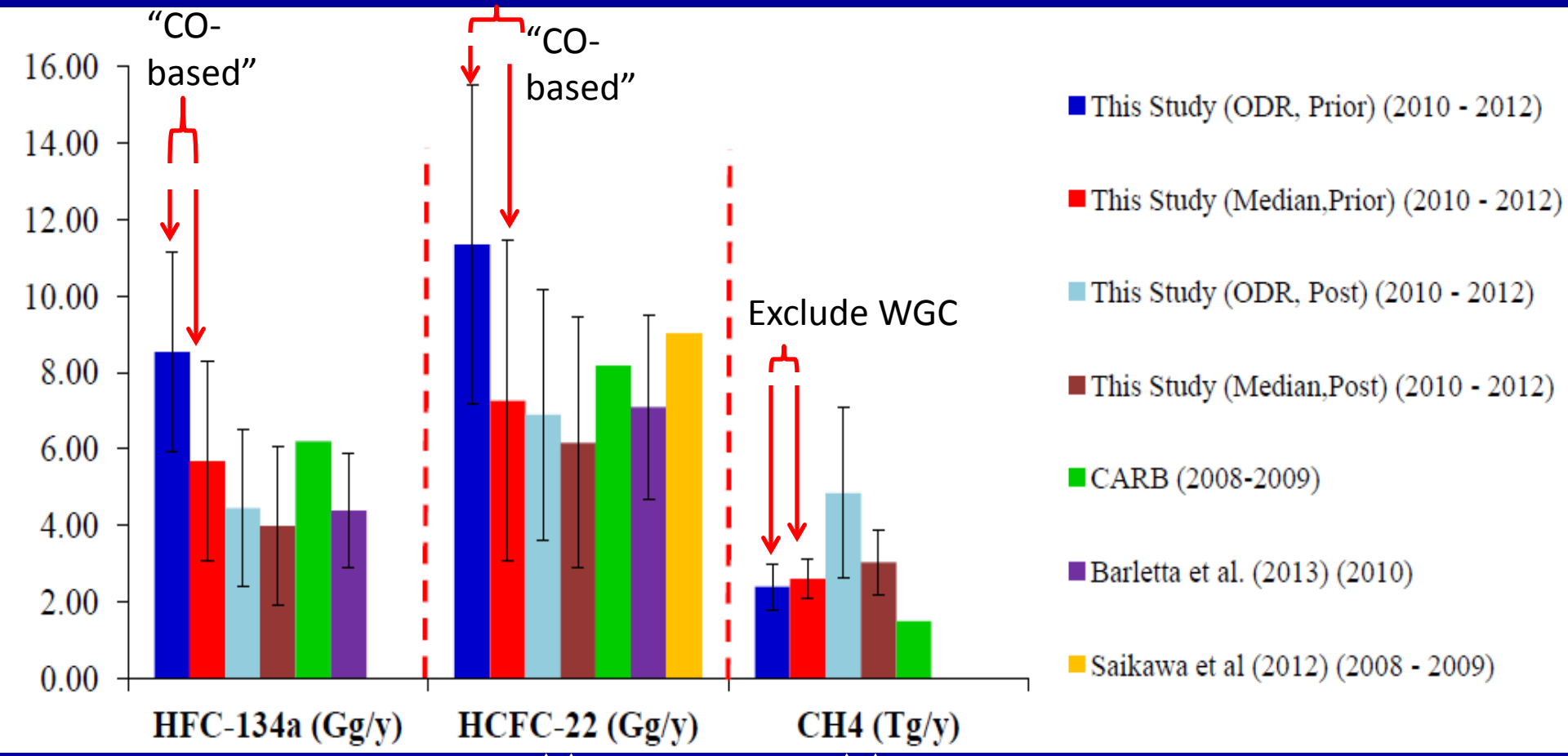
Prior and posterior fluxes



Prior
ODR
Median Ratio

Posterior
ODR
Median Ratio

Comparison with a state inventory and other studies



Preliminary findings

- **Large difference was observed in emissions estimated with** an ODR and a median ratio approach.

- **Emissions of HFC-134a and HCFC-22 from California during 2010 – 2012:** 4.2 (± 2.3) Gg/y and 6.5 (± 2.3) Gg/y (we need to relook at the results after considering transport errors and using different transport)

- **Seasonality for emissions of HFC-134a and HCFC-22 from California:** higher in summer than in winter.

- **CH_4 emissions from California, estimated with a CO-based tracer ratio method:** 2.5 (1.8 – 3.2) Tg/y, about 1.2 – 2.1 times a state inventory (concerns: emissions of CH_4 and CO are not col-located; more work is needed to evaluate this approach).

A median emission ratio approach could be more capable of characterizing "far-field" emissions relative to an orthogonal distance regression.