Quantifying Regional GHG Emissions from Atmospheric Measurements: HFC-134a at Trinidad Head

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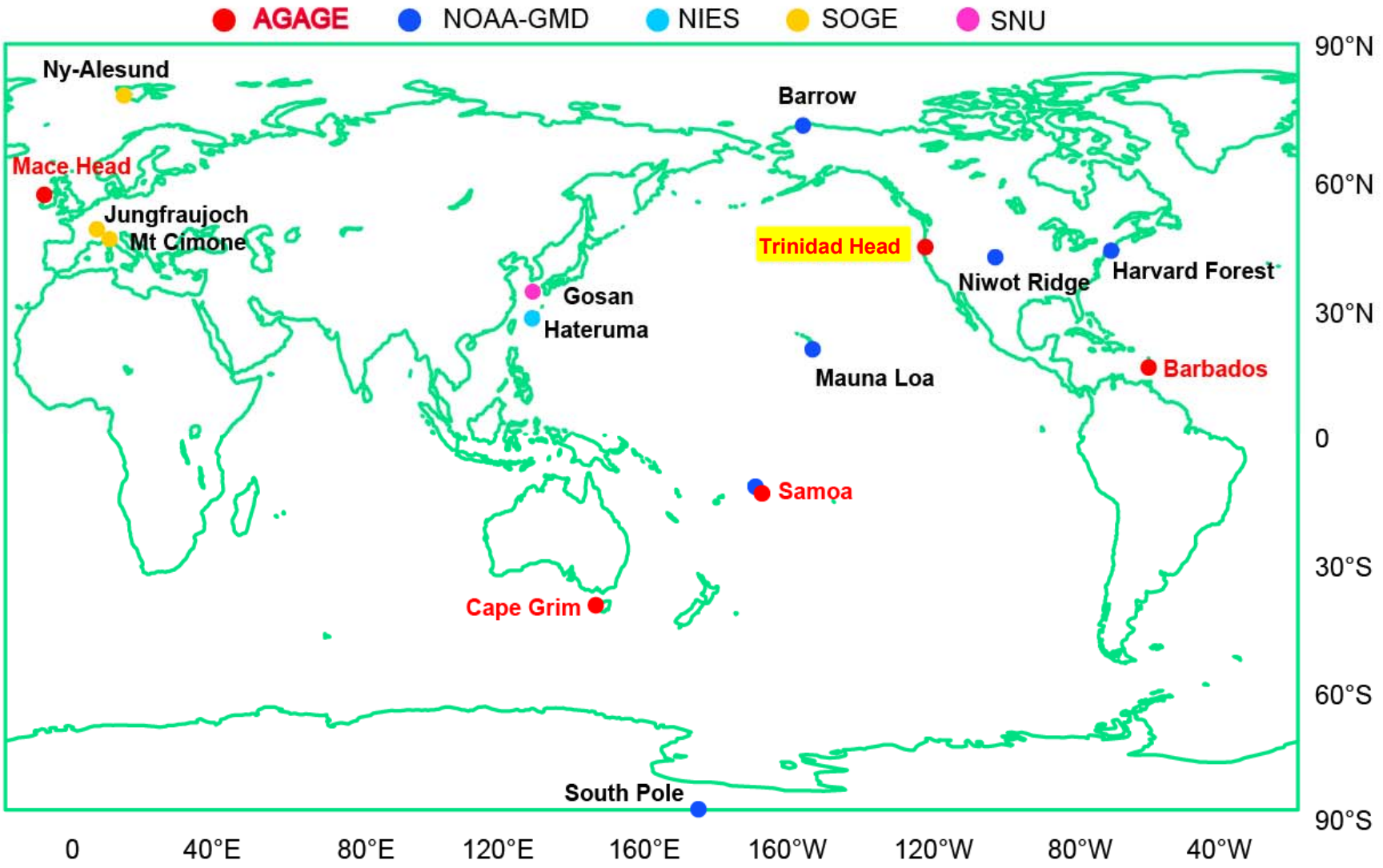
Legislative Action and Emissions Realities

- Nations and states around the world are legislating reductions in GHG emissions in the post-Kyoto period.
- In the US, California's AB-32, the "Global Warming Solutions Act of 2006", leads a 17-state effort to mandate emissions reductions.
- AB-32 requires that the state's emissions of the Kyoto "basket" of gases be reduced (on a GWP basis) to 2000 levels by 2010, to 1990 levels by 2020, and to 20% of 1990 levels by 2050.
- Nearly all such legislation is based on "bottom up" estimates of GHG emissions inventories, which are notoriously inaccurate, especially for biogenic GHG sources.
- Can measurements of GHG accumulation in the atmosphere be used to improve estimated emissions inventories in a "top down" approach?



Real-time *in-situ* trace gas measurement stations associated with AGAGE and collaborative organizations.

Trinidad Head AGAGE Station
Northern California (41°N, 124°W)

AGAGE *Medusa* Cryotrapping GC-MS (left) and GC-Multidetector (right) Instruments at Trinidad Head, California

AGAGE MEASURED SPECIES (*Medusa* in Black, GC-MD in Green, Both in Red)

Compound	~NH (2005) (ppt)	Typical % precision
CF4	74	0.15
HFC23	25	0.7
C2F6	3.5	0.9
C3F8	0.5	3
HFC32	~1	5
SF6	5.3	0.4
SO2F2	1	1.6
HFC134a	29	0.4
HFC152a	4.2	1.2
HFC125	2.9	1
HFC143a	6.5	1.2
HFC365mfc	<1	10
HCFC22	170	0.3
HCFC141b	19	0.4
HCFC142b	15	0.6
HCFC124	1.6	2
CFC11	257	0.15
CFC12	546	0.05
CFC13	-	2
CFC113	80	0.2
CFC114	16.5	0.3
CFC115	8.4	0.8

Compound	~NH (2005) (ppt)	Typical % precision
H1301	3.1	1.5
H1211	4.5	0.5
H2402	>0.5	2
CH3Cl	570	0.2
CH3Br	10	0.5
CH3I	1	2
CH2Cl2	36	0.8
CHCl3	11	0.6
CHBr3	~3	0.6
CCl4	95	1
CH3CCl3	28	1
CHClCCl2	0.8	2.5
CCl2CCl2	5.5	0.5
C2H2	10-200	0.5
C2H4	50-500	2
C2H6	500	0.3
C6H6	10-100	0.3
C7H8	<1-10	0.6
GC-MD Only		
CH4	1850 (***ppb***)	0.05
N2O	320 (***ppb***)	0.05

(CO and H2 are Measured by GC-MD at Mace Head and Cape Grim Only)

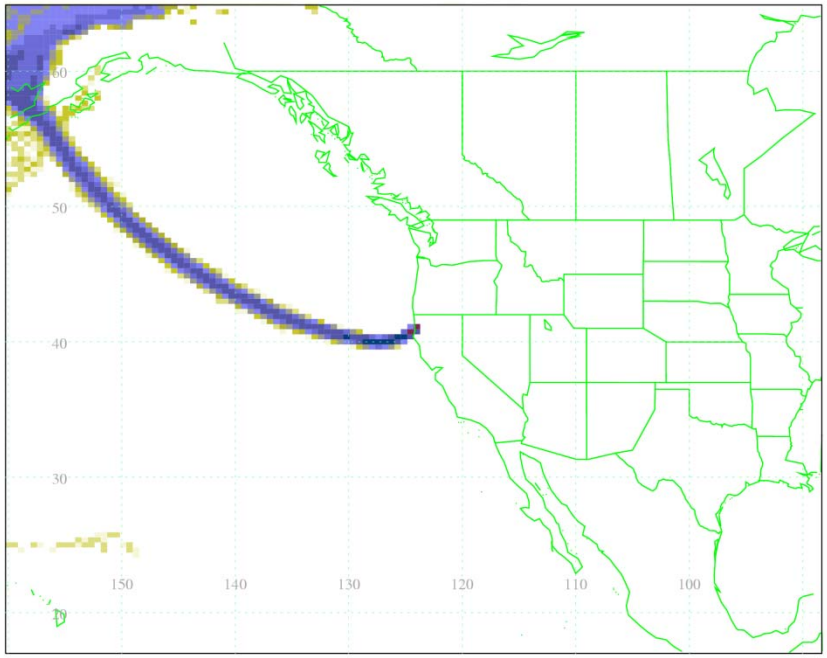
UK Met Office NAME (Numerical Atmospheric-dispersion Modelling Environment) Model

- Developed following the 1986 Chernobyl incident for predicting the atmospheric transport of airborne pollutants
- Lagrangian particle model
- Predicts air concentrations, dosages and surface deposition
- Driven by 3D met data from UK Met Office Numerical Weather Prediction model (33 levels, ~40km horizontal resolution, most at lower levels, extending to 20km)
- NAME can run forwards or backwards:

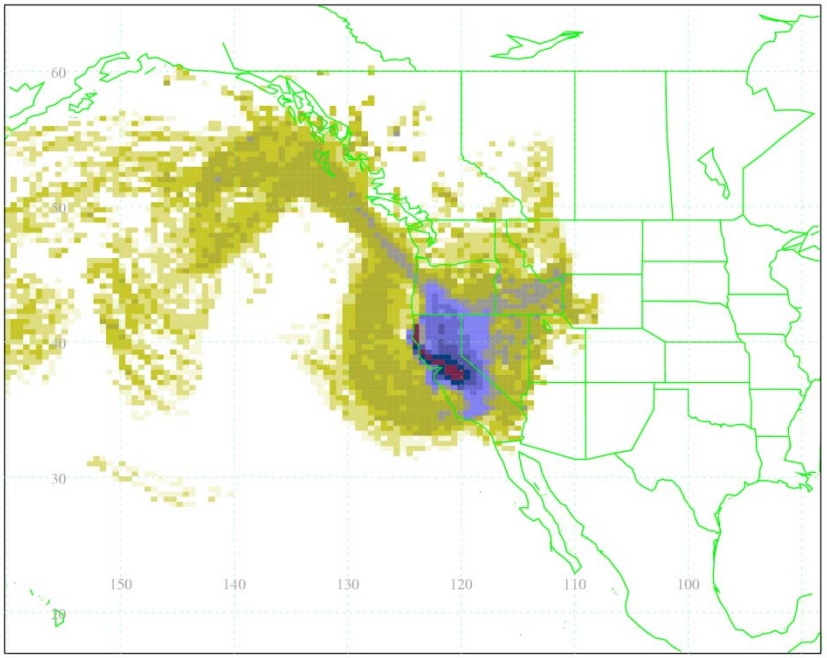
Where did the air come from?

Where are emissions going?

Examples of NAME 10-day Air History Maps for Trinidad Head

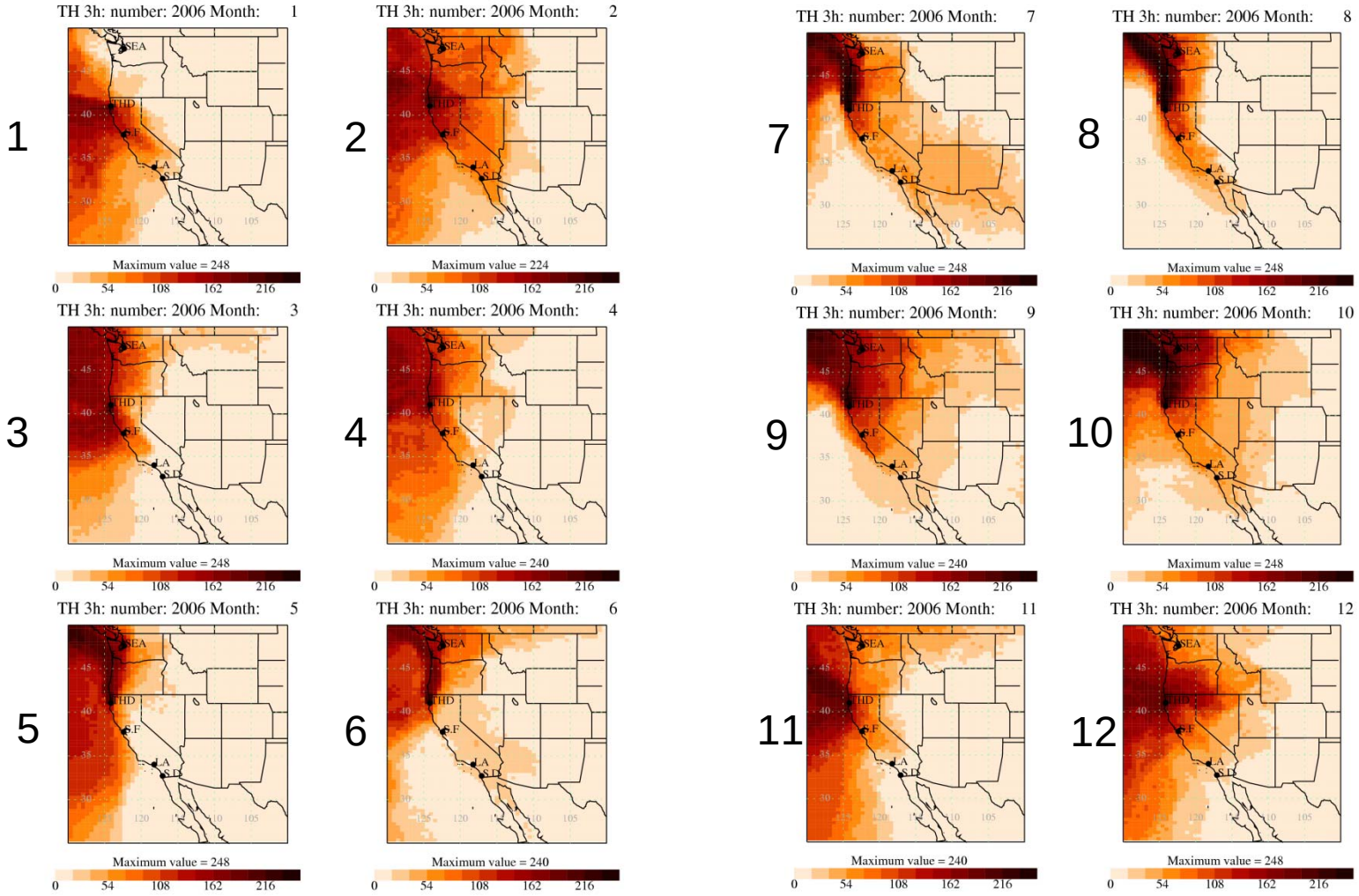


a) Clean air mass

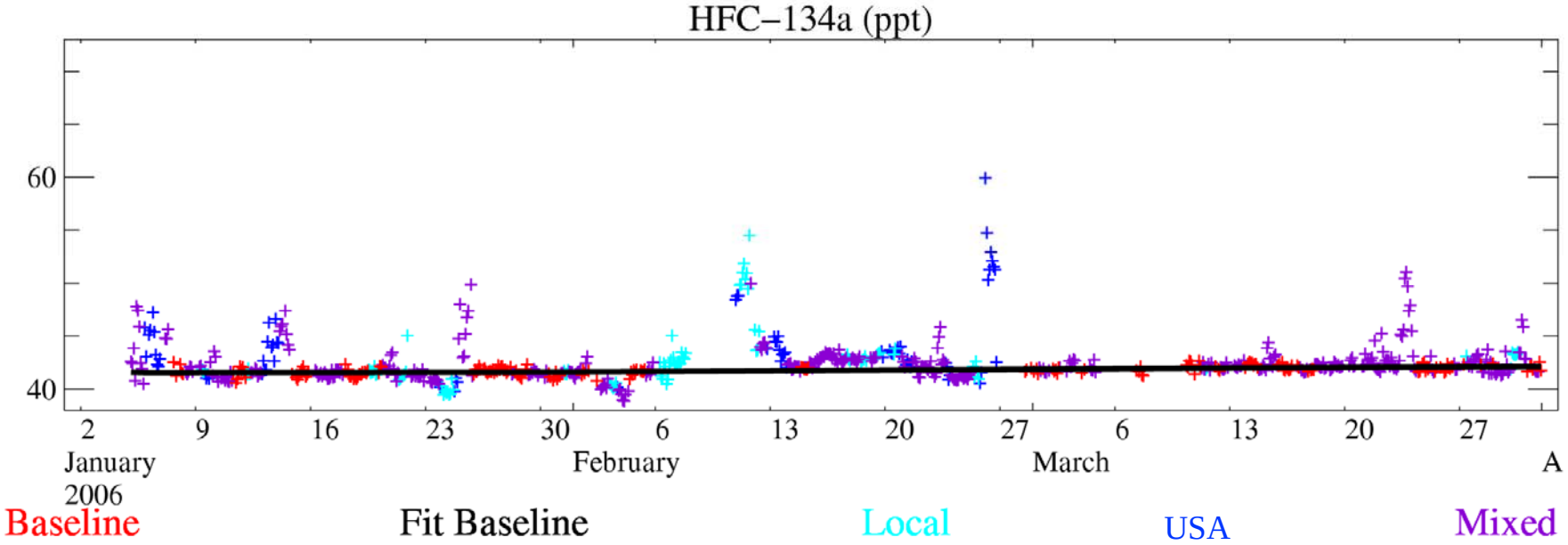


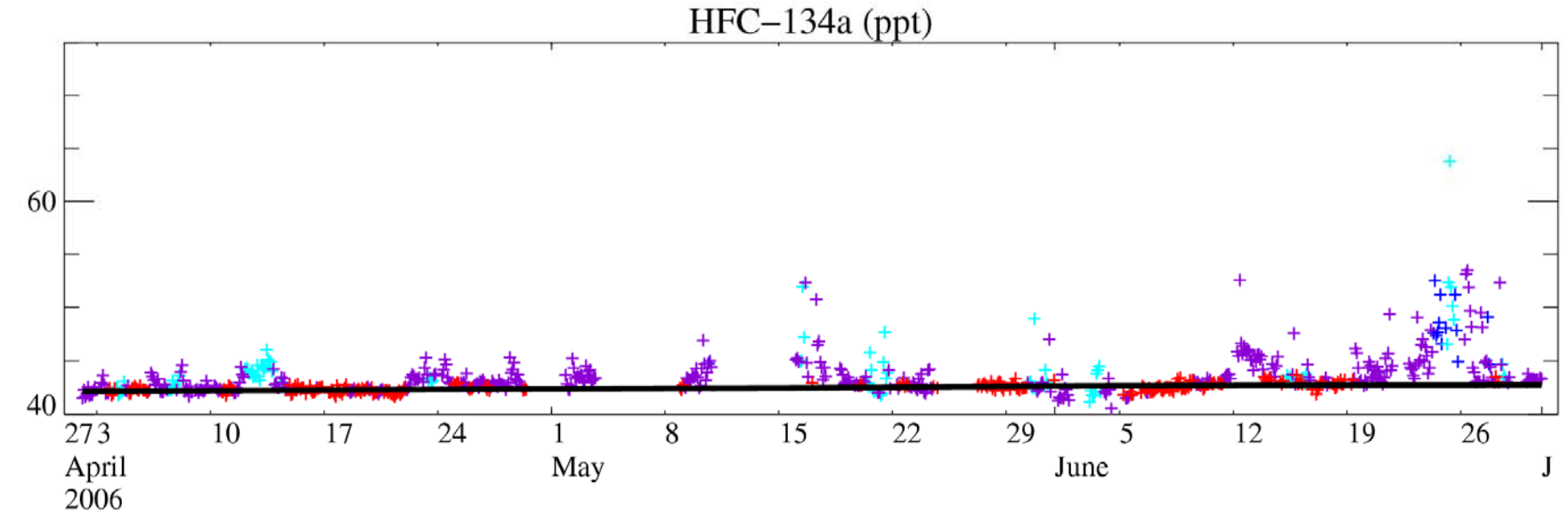
b) Polluted air mass

Number of 3-Hour Intervals Each ~40km Grid Box Contributes to the Air at Trinidad Head for Each Month of 2006

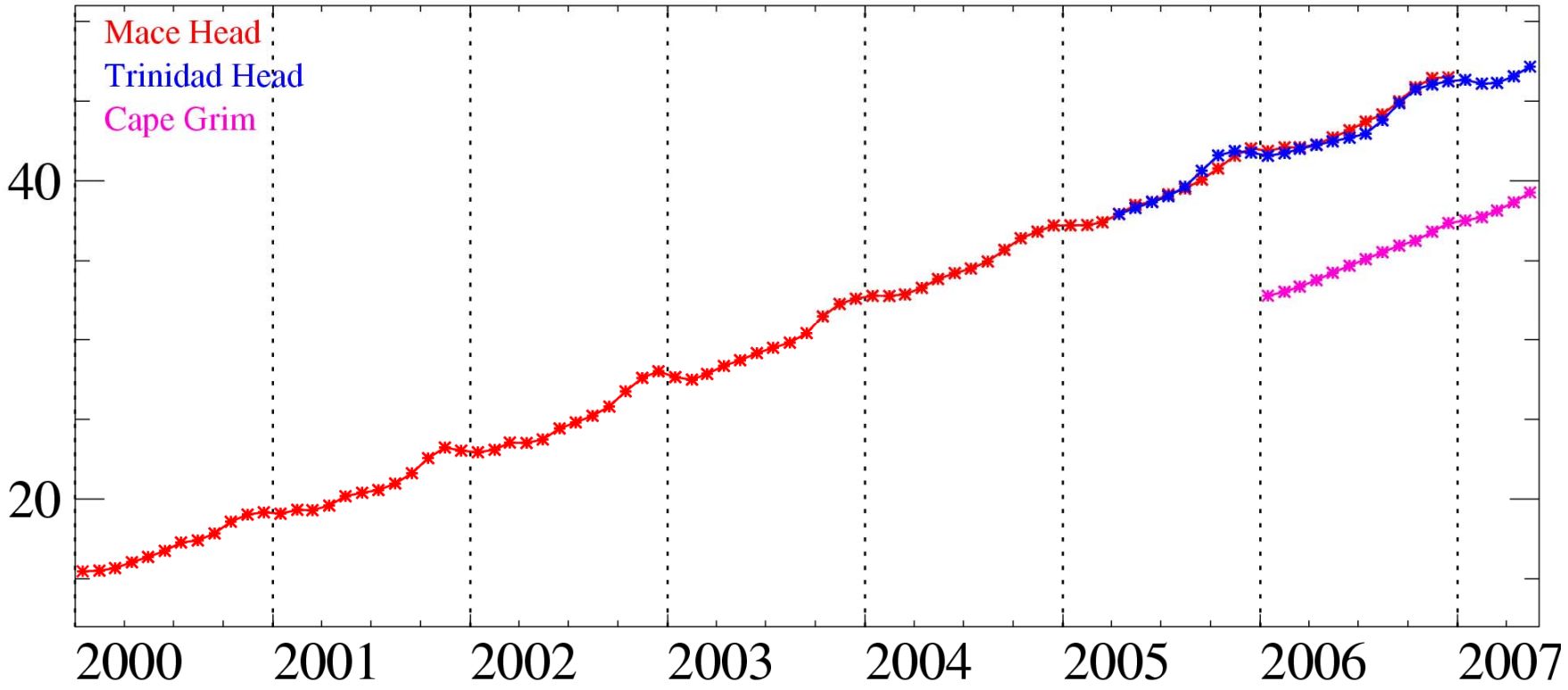


2006 Trinidad Head HFC-134a Measurements Colored by Air History Category

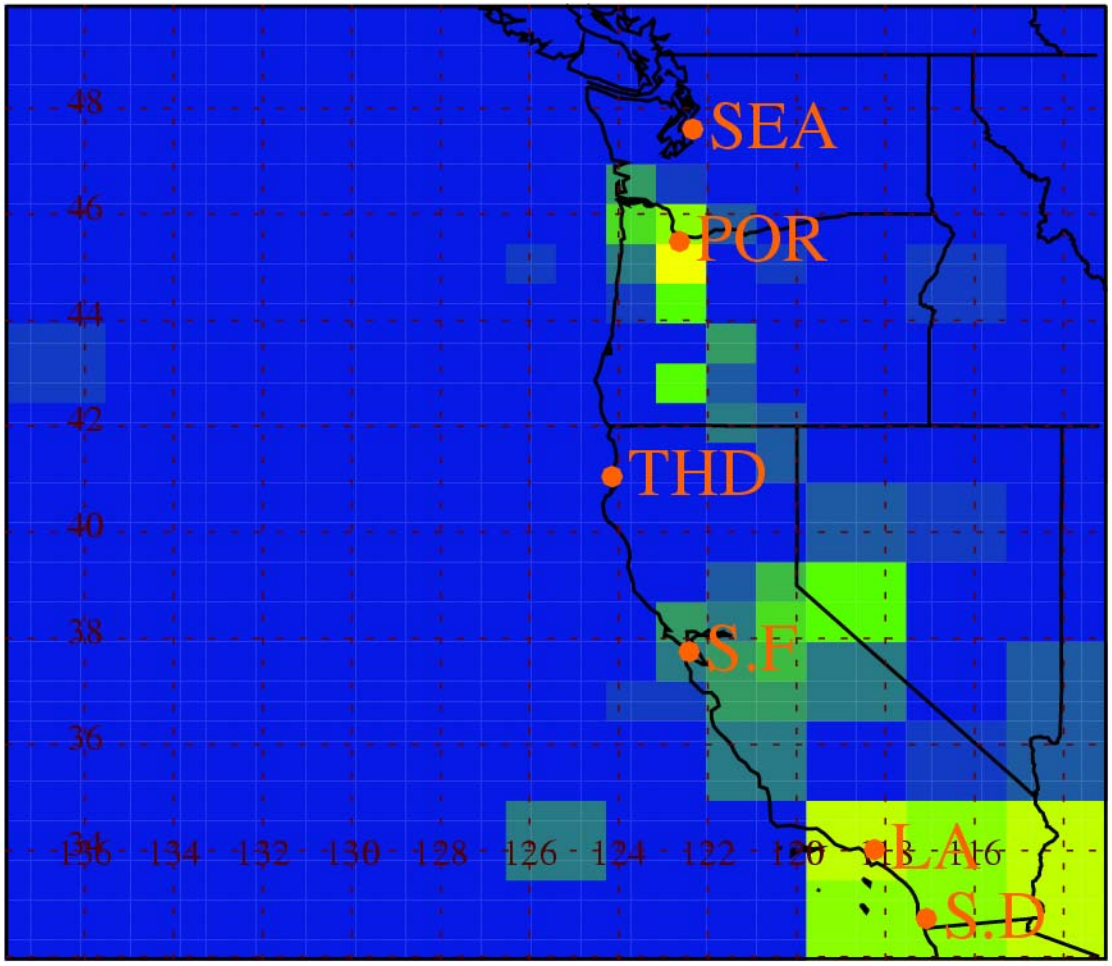




HFC-134a (ppt) Monthly NAME Baseline Estimates at the Mace Head and Trinidad Head (NH), and Cape Grim (SH) AGAGE Stations



2006 Regional HFC-134a Emissions Estimated from Trinidad Head (THD) Air Measurements and the NAME Model



Conclusions and Applications

- The regional HFC-134a emissions pattern is surprisingly reasonable, especially considering that the Trinidad Head station is sited to ***avoid*** anthropogenic emissions.
- The integrated 2006 HFC-134a emissions for the sampled area, scaled by population to the entire US, gives a total of ~43kt (range 22-60kt). An independent estimate of this value (A. McCulloch, pers. comm.) is ~75kt.
- The NAME method is easily adapted for use with multiple observation stations. Proper choice of additional station locations should yield substantial improvements in regional and integrated emissions estimates.
- This method can be applied to a broad range of anthropogenic and biogenic emissions such as those already being measured by AGAGE and other programs.
- These methods can be used for "top down" verification of GHG emissions reductions mandated by California's AB-32 and by similar recent legislation in 16 other US states and in other countries.
- These methods could play an important role in stabilizing the volatile $30 billion global carbon-equivalent trading market.