Top Down Objective: Retrieve regional scale fluxes from atmospheric CO_2 concentration measurements with source/sink attribution

Backbone Observations:

- Tower
- Aircraft
- “Permanent” Virtual Tall Tower

Campaign Observations:

- COBRA-style Aircraft
- Supplemental Backbone Aircraft
- Temporary Virtual Tall Towers

Analysis:

- Carbon Budget by Mass Balance
- Eularian Model Data Assimilation – 4D-var, Kalman filter
- Lagrangian Particle Dispersion Analysis – e.g., STILT
- Bayesian Synthesis Inversion –e.g., TRANSCOM
- Any of above with Parameter Estimation

Overview of the draft Mid-continental regional intensive science plan: Top-down perspective

Bottom-up:

Flux-tower -- very local

Biometry -- labor-intensive, long-term

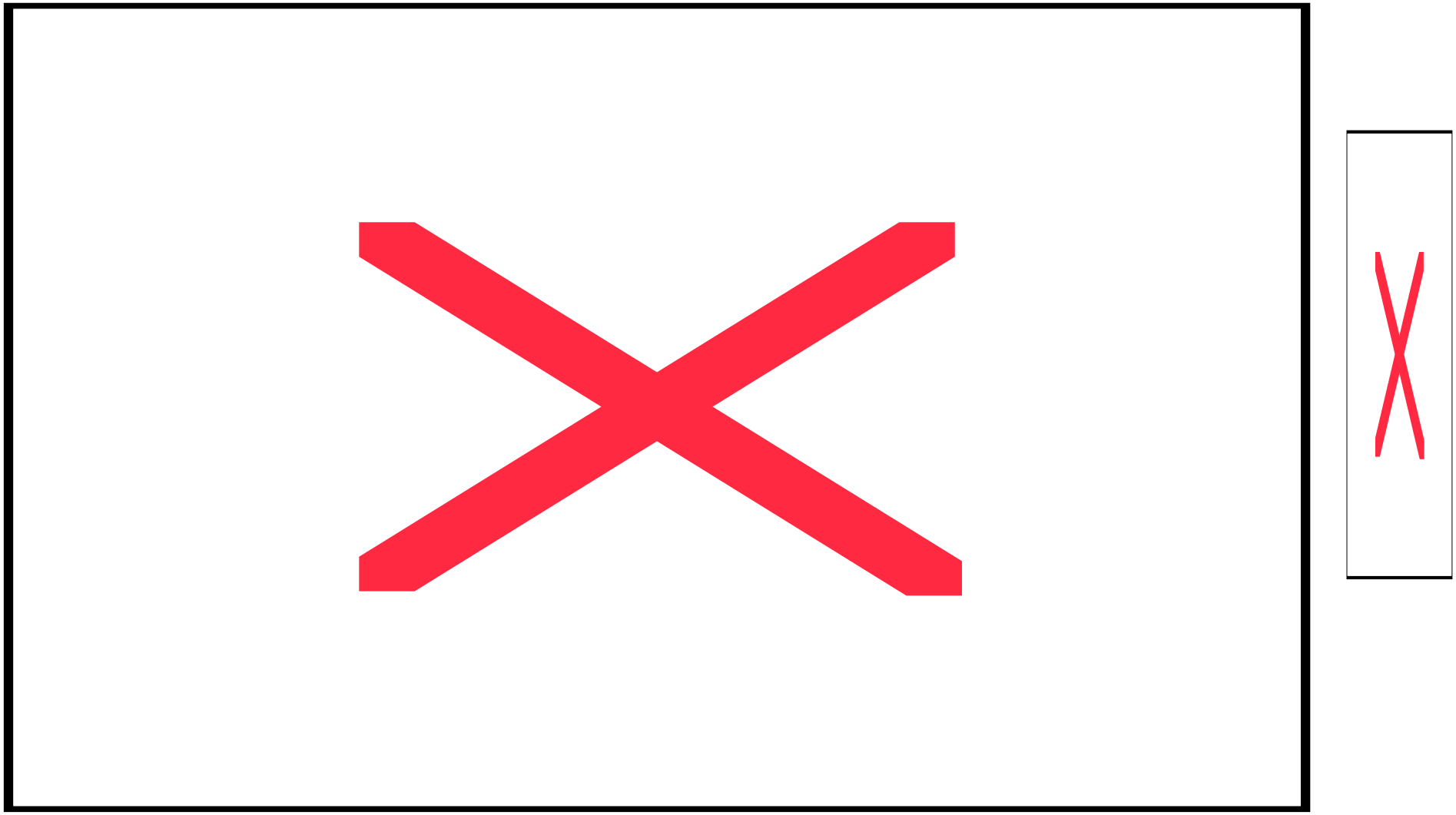
Top-down:

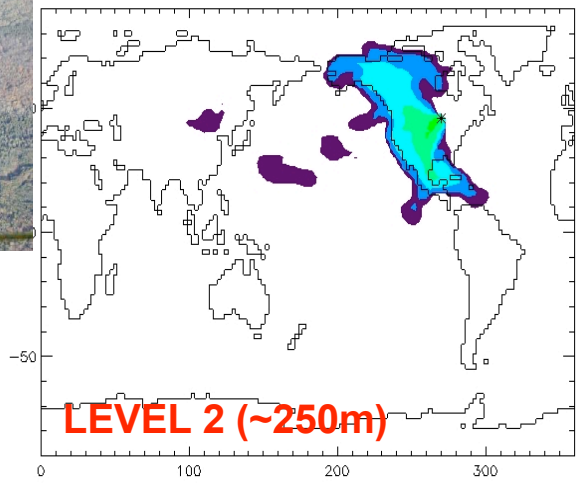
- Can provide direct constraint on regional scale fluxes
- Inverse methods can be applied over a range of spatial and temporal scales
- Discrepancies between top-down & bottom up provide insight into processes
- Regional scale is most policy relevant--need to provide seasonal, annual & decadal flux estimates to evaluate carbon management strategies

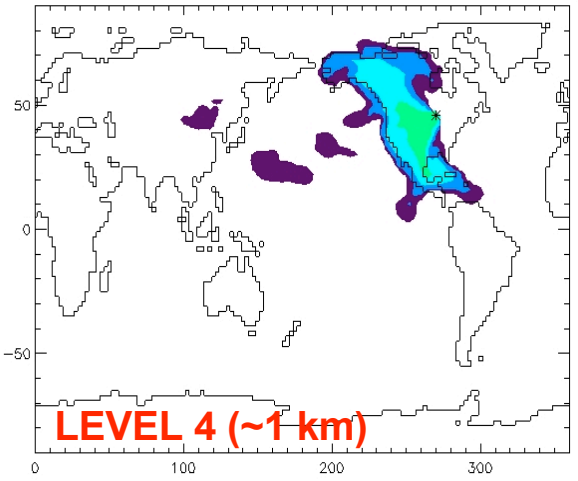
Need combination to elucidate mechanisms!

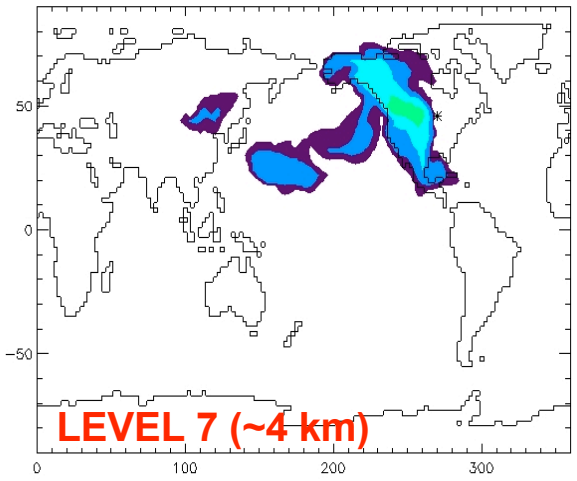
Concentration Measurement Footprints:

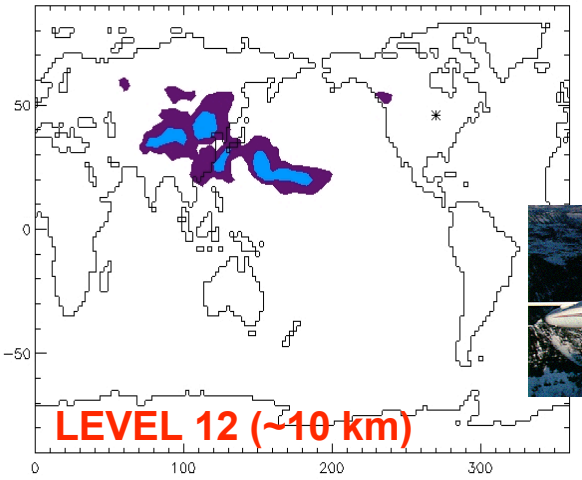
From Adjoint to GSFC 3-D Parameterized Chemistry & Transport Model, Kawa et al.

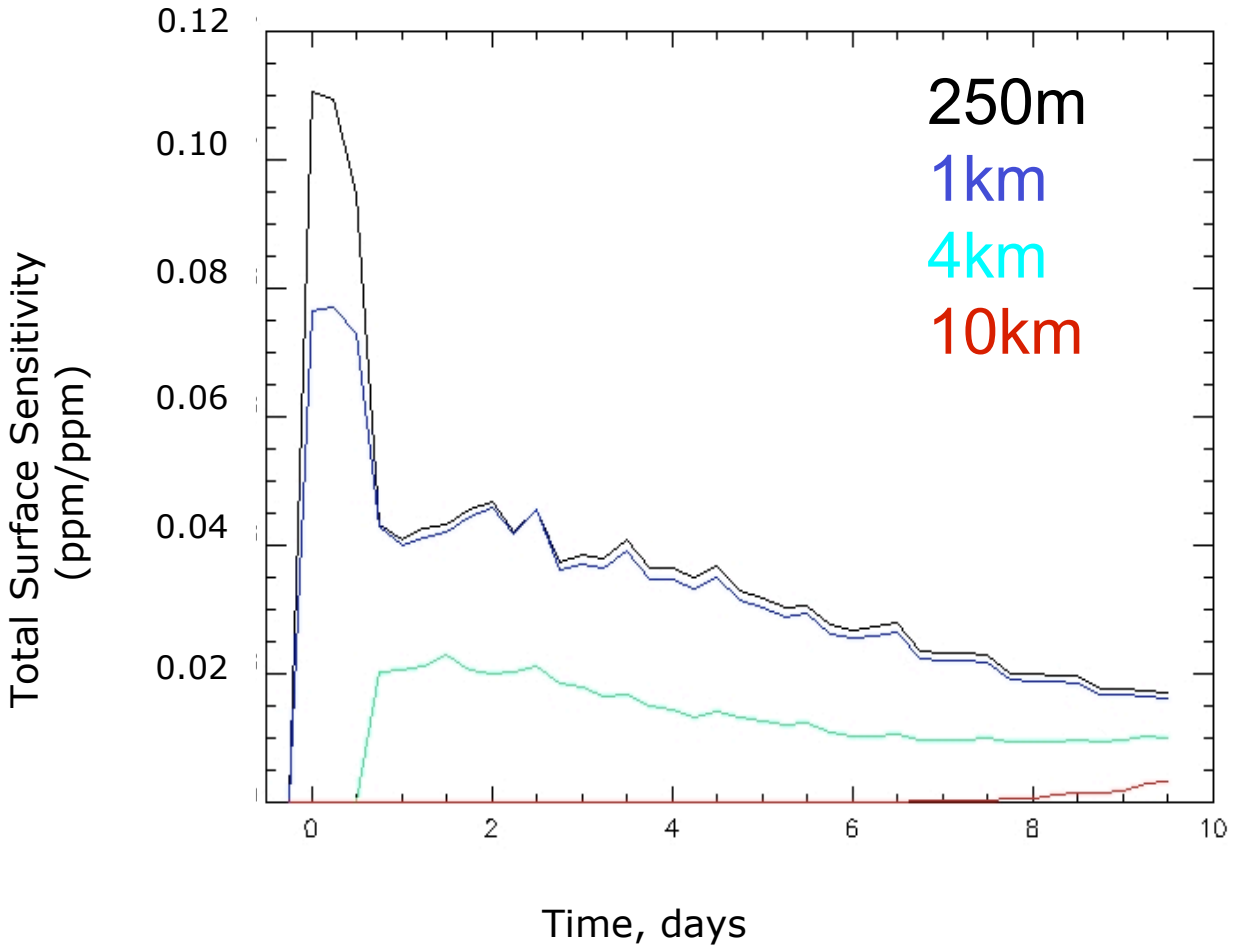



LEVEL 2 (~250m)
50
0
−50
0
100
200
300


LEVEL 4 (~1 km)
50
0
−50
0
100
200
300

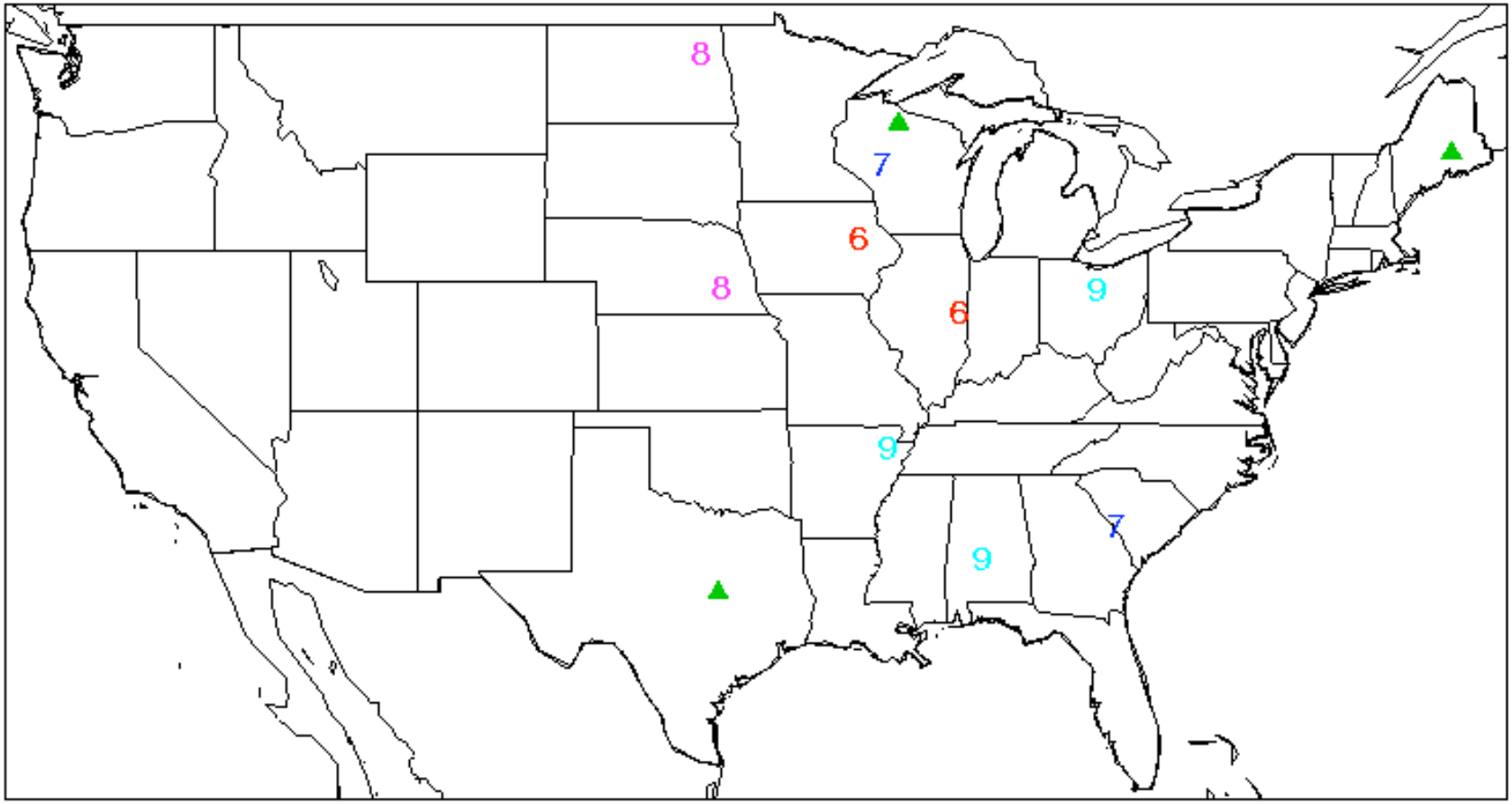

LEVEL 7 (~4 km)
50
0
−50
0
100
200
300


LEVEL 12 (~10 km)
50
0
−50
0
100
200
300


0.12
0.10
0.08
0.06
0.04
0.02
Total Surface Sensitivity
(ppm/ppm)
250m
1km
4km
10km
0
2
4
6
8
10
Time, days

Backbone:

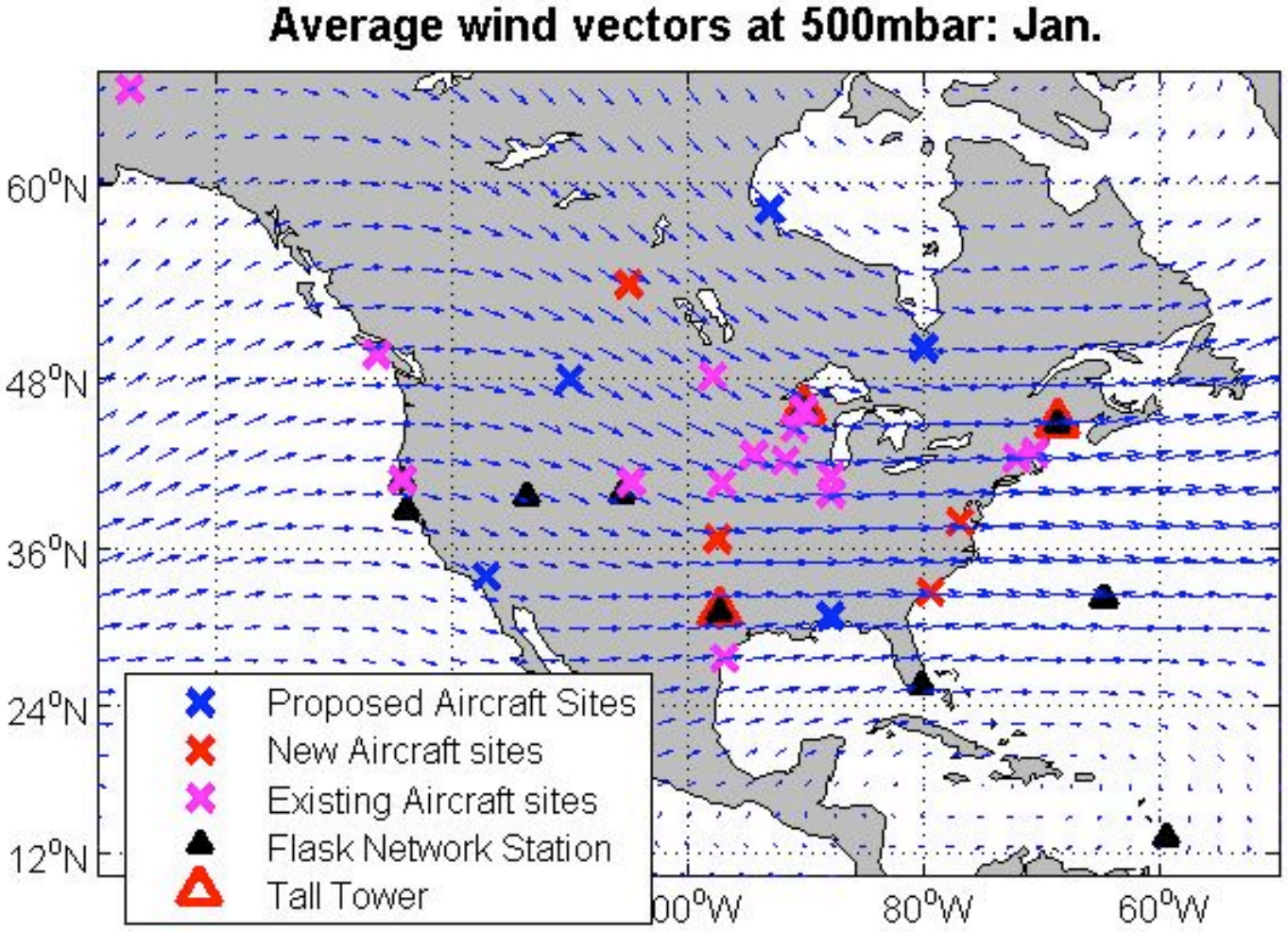
Planned NOAA ESRL Tall Tower Network



Continuous CO2, CO, met at ~30m, 100m, ≥400m

Daily Flask Samples: CO2, CO, CH4, SF6, H2

Planned NOAA ESRL Aircraft Network



Tower

Continuous Observations:
CO_2, CO, horizontal wind, T, RH
3 levels: 30, 100, 500m
PAR, Rainfall, Surface Pressure

Flask Samples:
Daily mid-afternoon from top level
(+5 extra per week)
Weekly aircraft profiles

Species: CO_2, CO, CH_4,
N_2O, SF_6, isotopes,
Halocarbons, COS, …

Aircraft

Flask Samples:
Weekly aircraft profiles
(right now every 3 weeks)

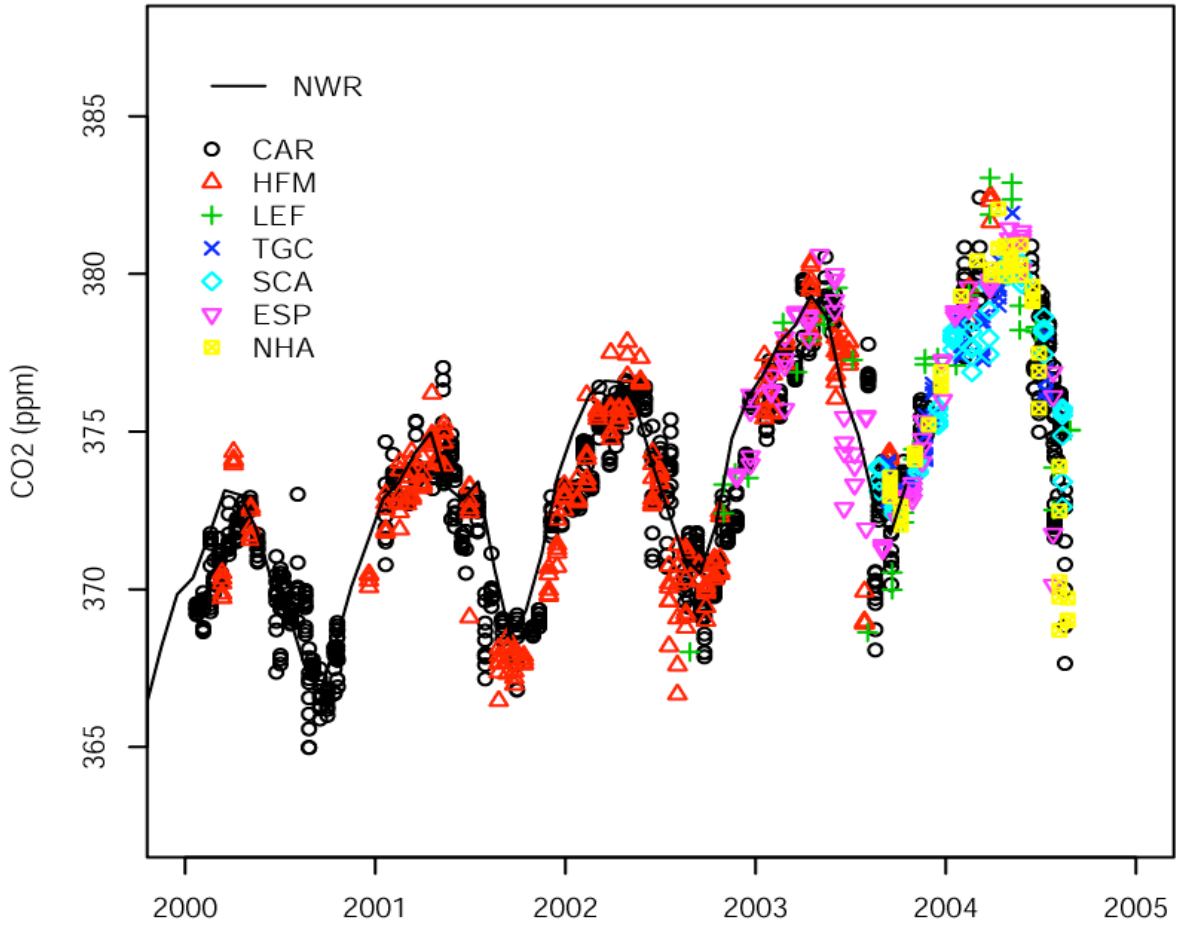
Species: CO_2, CO, CH_4,
N_2O, SF_6, isotopes,
Halocarbons, COS,
limited $^{14}CO2$

GPS, temperature, pressure

Continuous Observations on some flights: CO_2, O_3

Aircraft Measurements:

NOAA/ESRL: Aircraft Observations



PRELIMINARY

Virtual Tall Tower Measurements:

$$\Delta C = -\frac{\overline{wc_0}}{w_* z_i}\int_{z_0}^{z_{VTT}} g_b\left(\frac{z-d}{z_i}\right)dz - \alpha\frac{\overline{wc_0}}{w_* z_i}\int_{z_0}^{z_{VTT}} g_t\left(\frac{z-d}{z_i}\right)dz$$

where

ΔC is the correction to the 30m CO_2 mixing ratio

g_b and g_t are the bottom-up and top-down gradient functions from the empirical fit of Wang et al. (in preparation)

z_0 is the measurement height, 30m

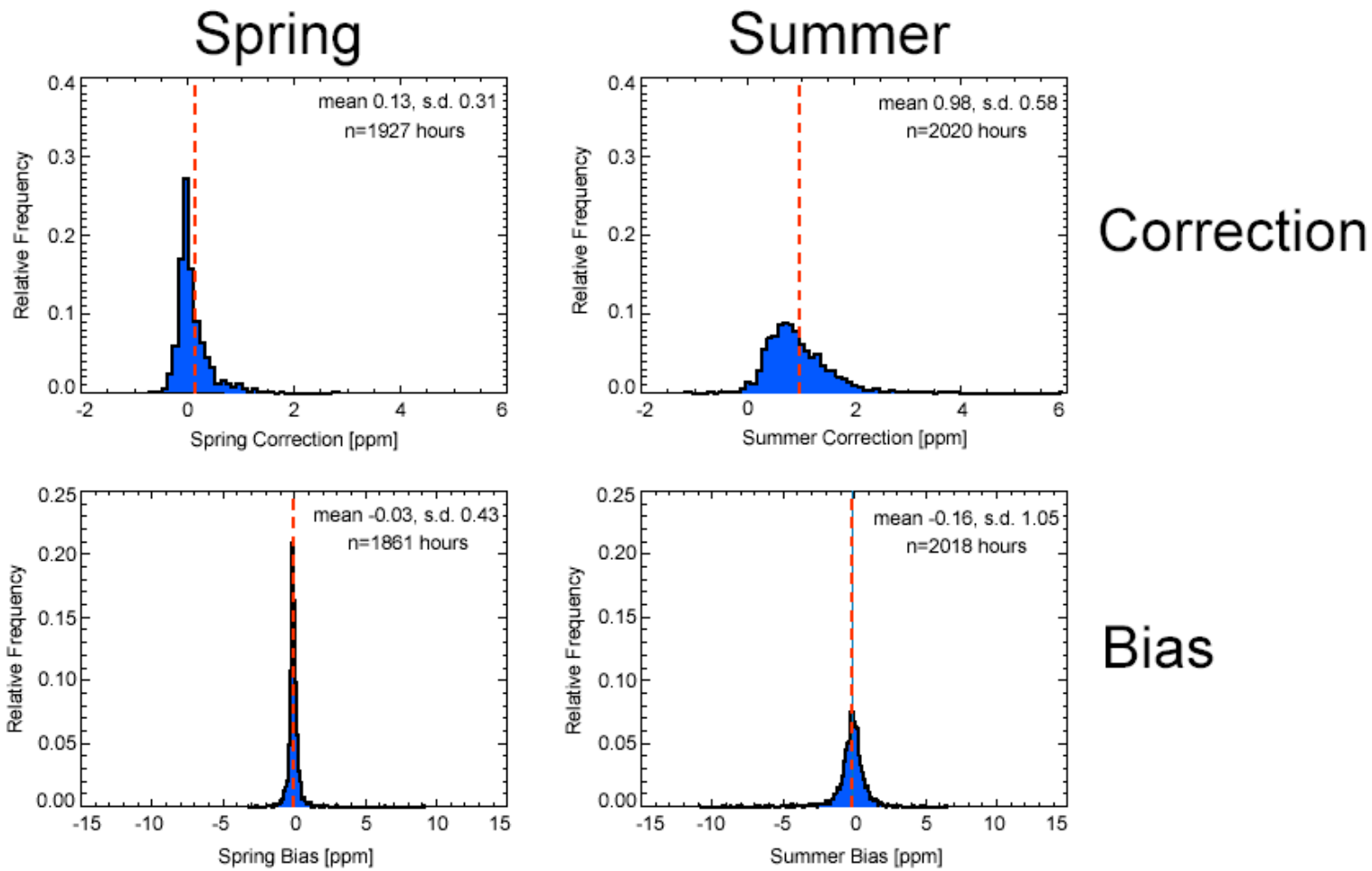
z_{VTT} is the virtual tall tower height, 396m

z_i is the boundary layer depth calculated after Yi et al. (2001)

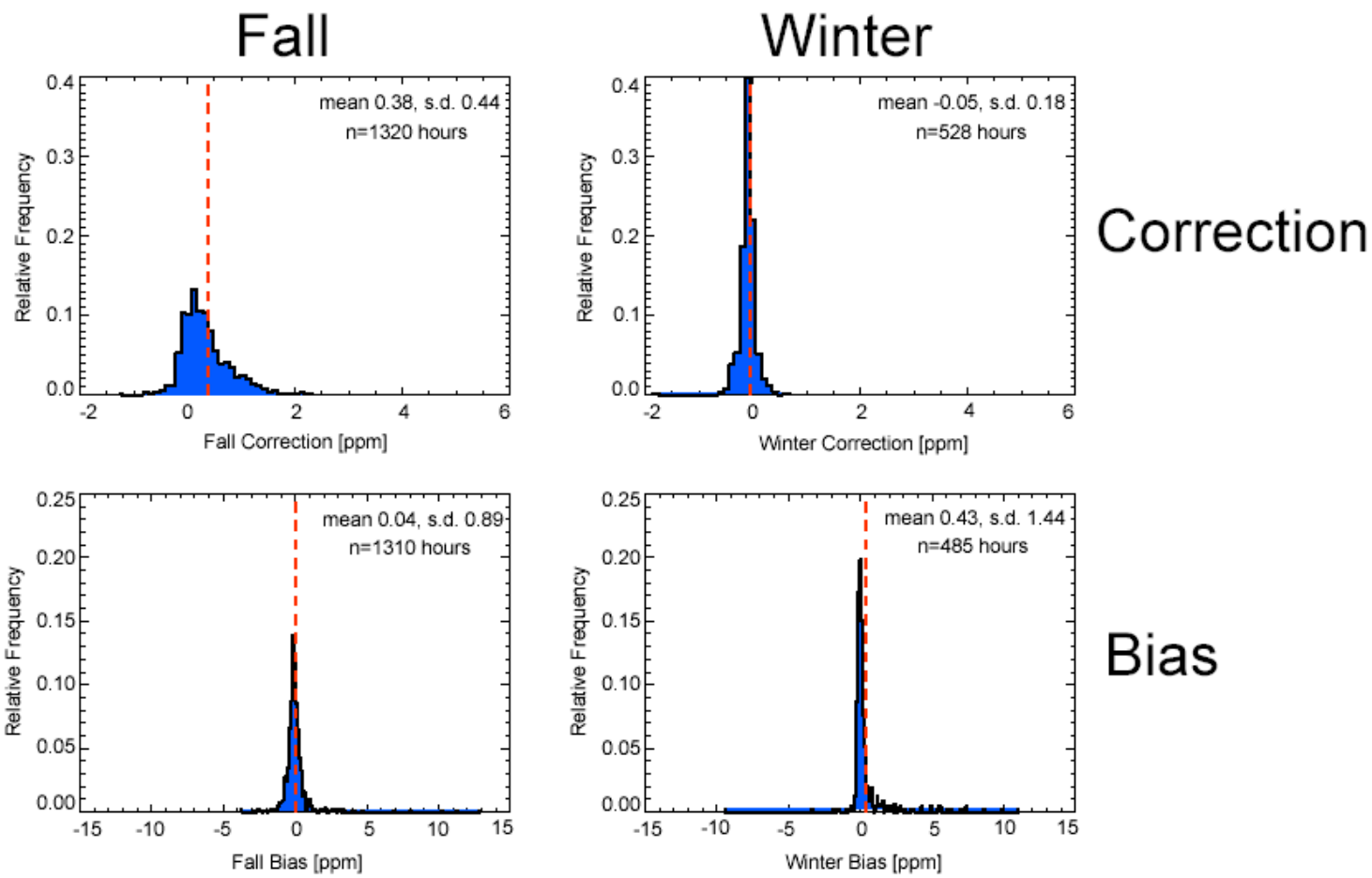
α is a fraction of the surface flux representing entrainment flux

From Butler et al., ICDC7, Sept 2005

Virtual Tall Tower Test at WLEF:
Calculated VTT based on 30m data vs actual 396m data



Butler et al., ICDC7, Sept 2005…



Butler et al., ICDC7, Sept 2005…

VTT WLEF TEST SUMMARY

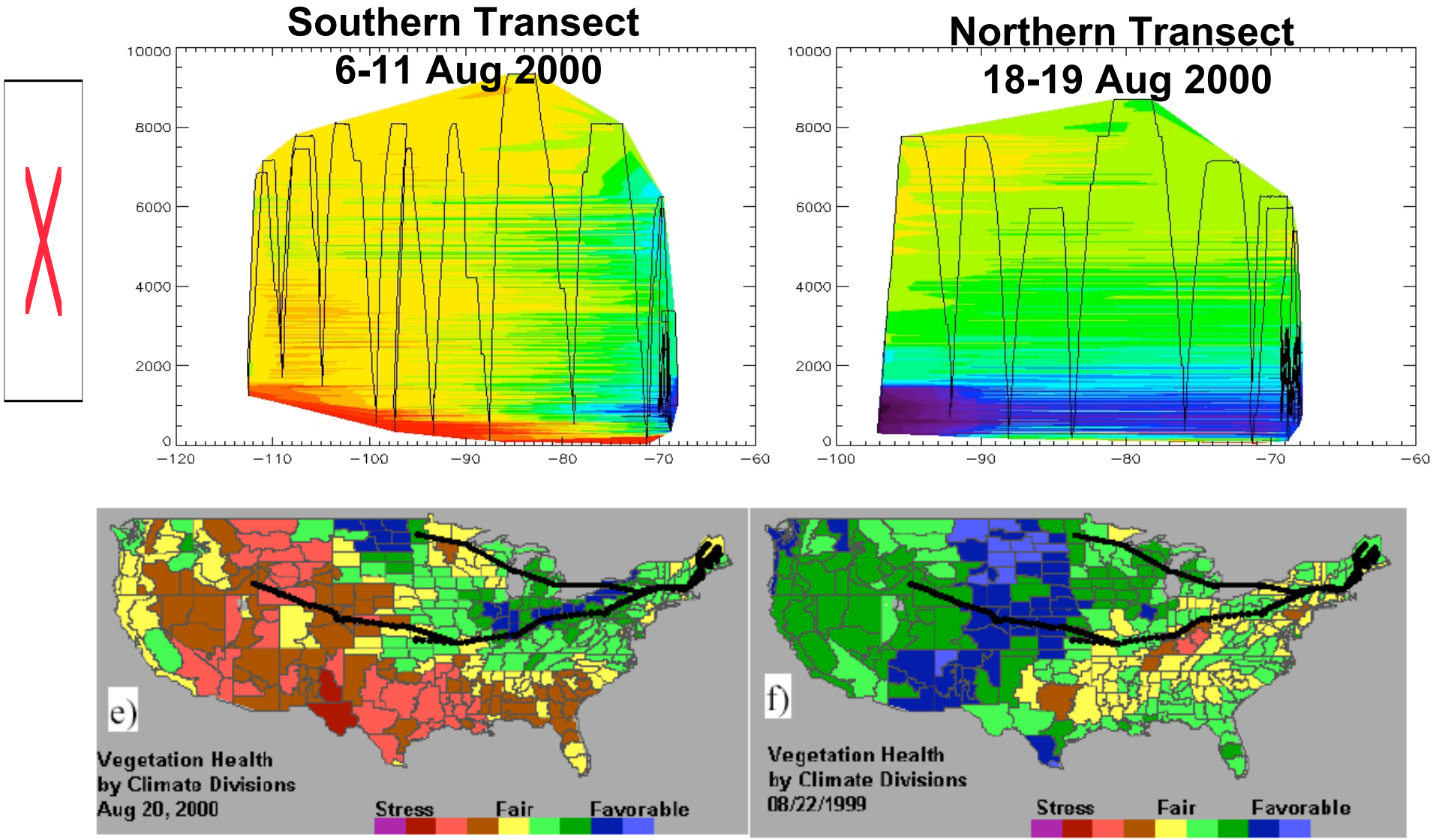
	CORR	BIAS	~n
Spring:	0.13±0.31	-0.03 ±0.43	1900
Summer:	0.98 ±0.58	-0.16 ±1.05	2000
Fall:	0.38 ±0.44,	0.04 ±0.89	1300
Winter:	-0.05 ± 0.18	0.43 ±1.44	500

Cautions:

- Winter & Summer Bias relatively large.
- Correction & Bias Distributions not Gaussian
- Only _ number of obs/criteria met cases in Winter

Butler et al., ICDC7, Sept 2005…

Campaign: e.g. COBRA 2000



From Gerbig et al., 2003

Top-Down Critical Needs For Mid-continent Intensive:

Funding & schedule for the backbone deployment—NOAA/ESRL has available hardware, but no money for tower leases (~40K/year/site) & installation (~20K/site).

Funding & schedule for campaign-style aircraft measurements.

Mesoscale meteorological data products that avoid some of the known pitfalls of currently available operational products from numerical weather prediction models (lack of mass conservation, failure to output convective mass fluxes).