Multi-species analyses of carbon enhancements during the ACT-America campaign

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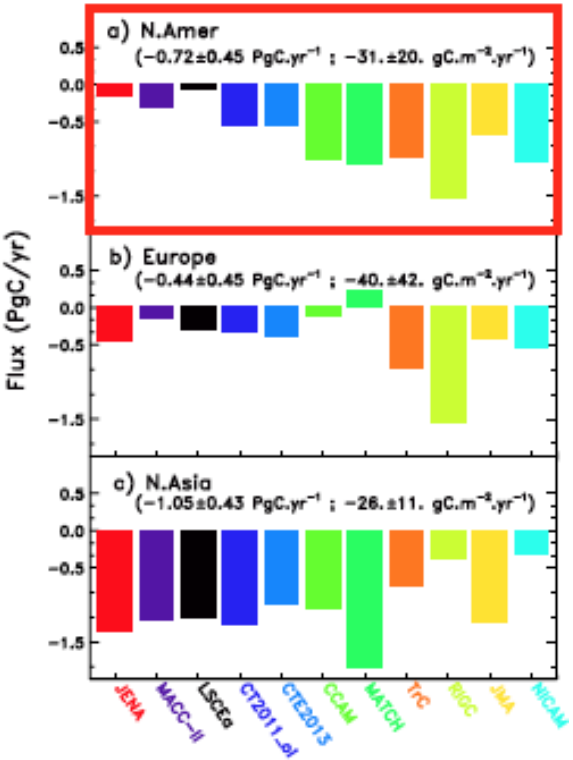
PennState NOAA NASA University of Colorado Boulder

Regional inversion modeling

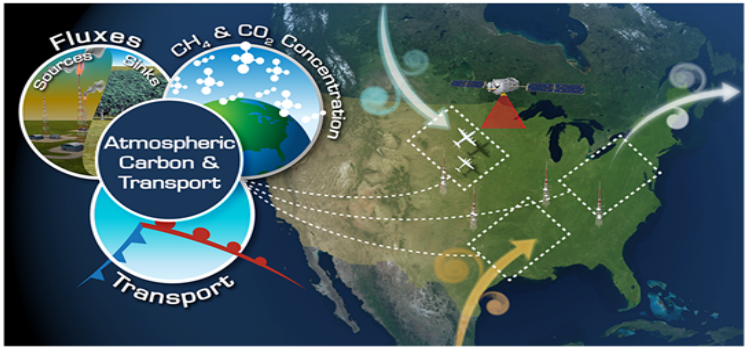
- Need to improve inversion model estimates of carbon (C) fluxes at regional scales to better predict future climate
- Our ability to accurately quantify fluxes on smaller scales is limited by model uncertainties
- Uncertainties in regional inversions:
  -**regional transport,**
  -**background estimation,**
  -**assigning prior flux uncertainties in time/space,**
  -**sparse observations**



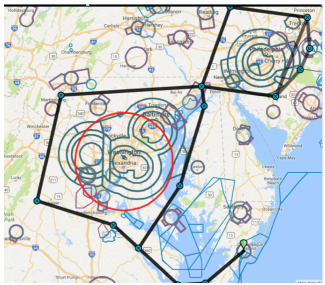
Peylin et al. (2013)

ACT-America campaign

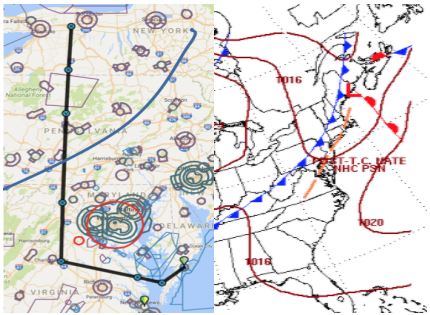
Atmospheric Carbon and Transport - America



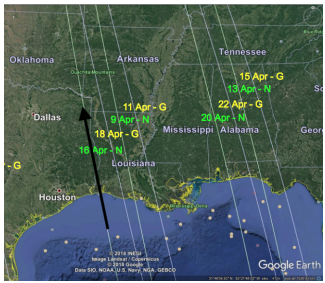
Schematic: act-america.larc.nasa.gov



Fair-weather (sources)



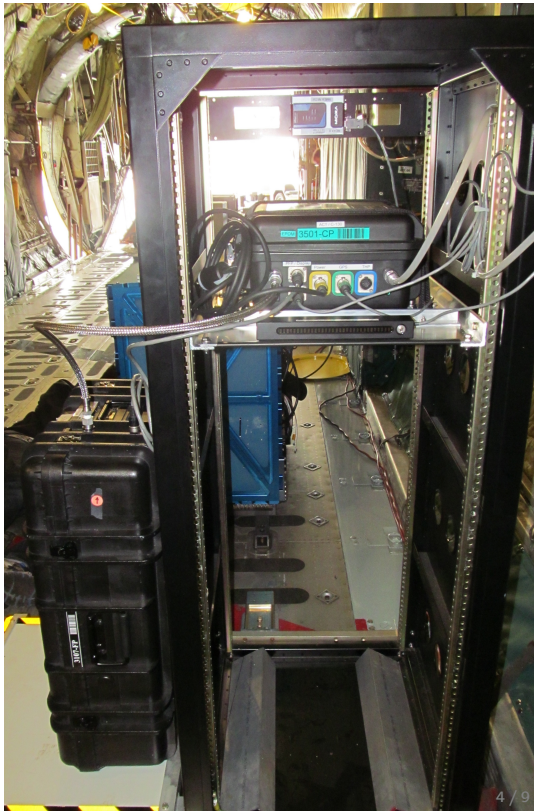
Frontal-crossing (transport)



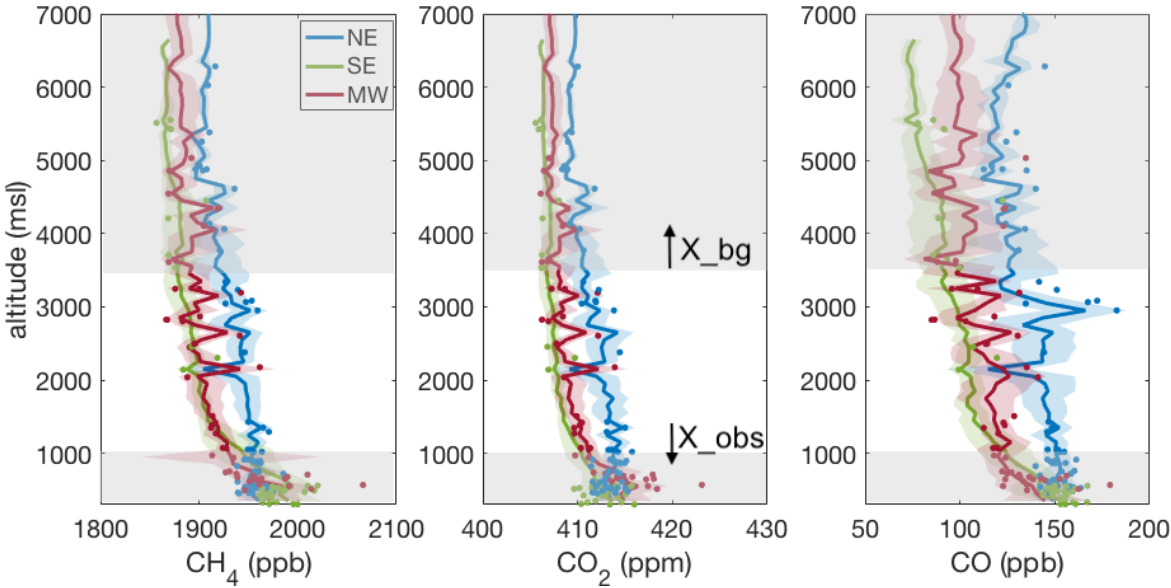
OCO-2 underpass (retrieval evaluation)

Fair weather flask analyses

- What do species measured in NOAA/GMD flasks tell us about regional CO_2 and CH_4 sources?
- Can flask samples approximate background carbon levels?
- Focus on fair weather flights for winter 2017

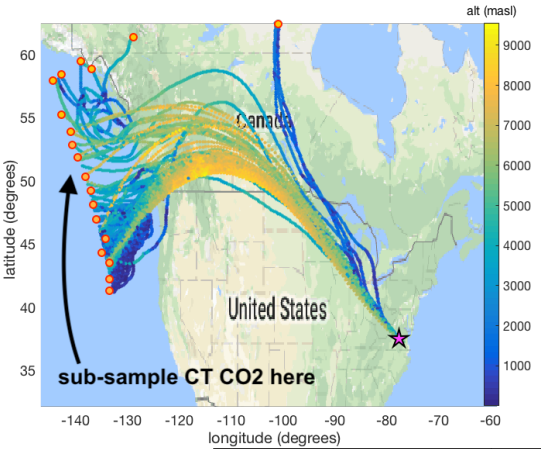


Vertical greenhouse gas distributions: WT 2017

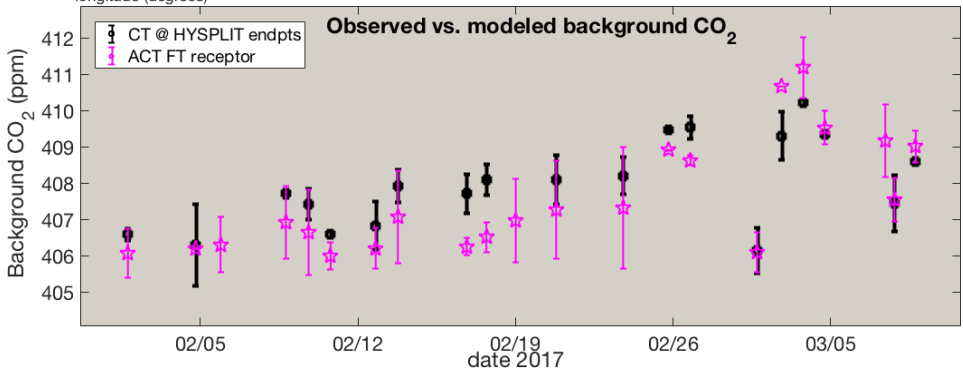


- Column GHGs and CO increase moving NE throughout ACT domain: shift in air mass origin from lower latitudes (lower C) to higher latitudes (higher C)
- Important to quantify background contribution to regional sources
- Boundary layer enhancements ($\Delta[X] = [X]_{obs} - [X]_{bg}$) inform about local sources/sinks in each region

Estimating background C levels using flasks

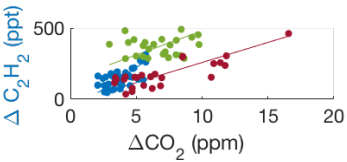


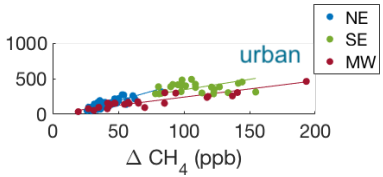
- Incorrect background determination can result in biased C fluxes within inversion domain
- Upper-atmospheric flask CO_2 vs. modeled background shows overlap (1σ), but some disagreement due to incorrect tracer transport

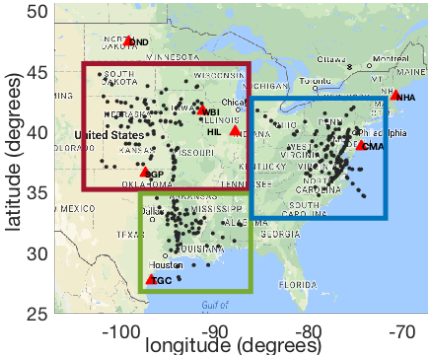


Multi-species analysis

In total, approximately 50 species measured in flasks:







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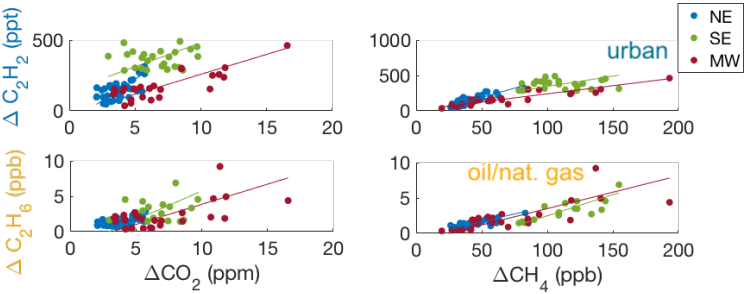

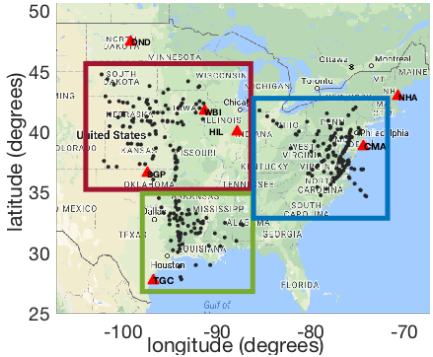

- **Northeast/Midwest:** source signatures from fossil fuel/ONG

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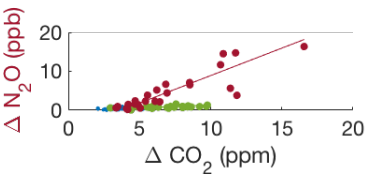

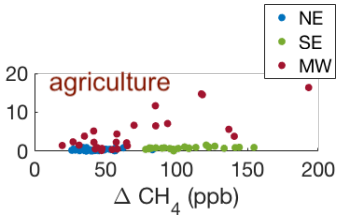

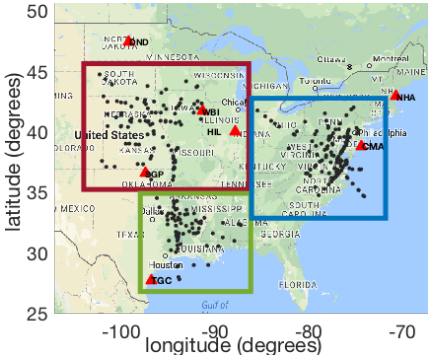

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- **Midwest:** large agricultural influence

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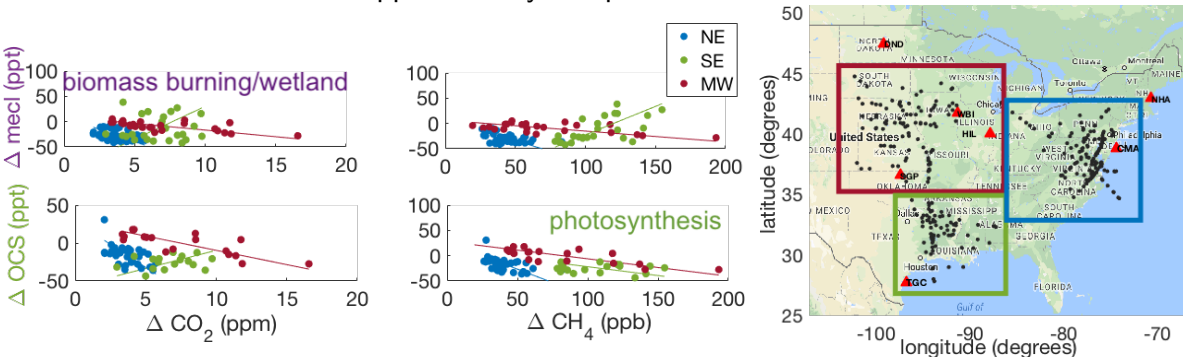

- **Northeast/Midwest:** source signatures from fossil fuel/ONG
- **Midwest:** large agricultural influence
- **Southeast:** weaker correlations with anthropogenic species, suggesting biogenic influence

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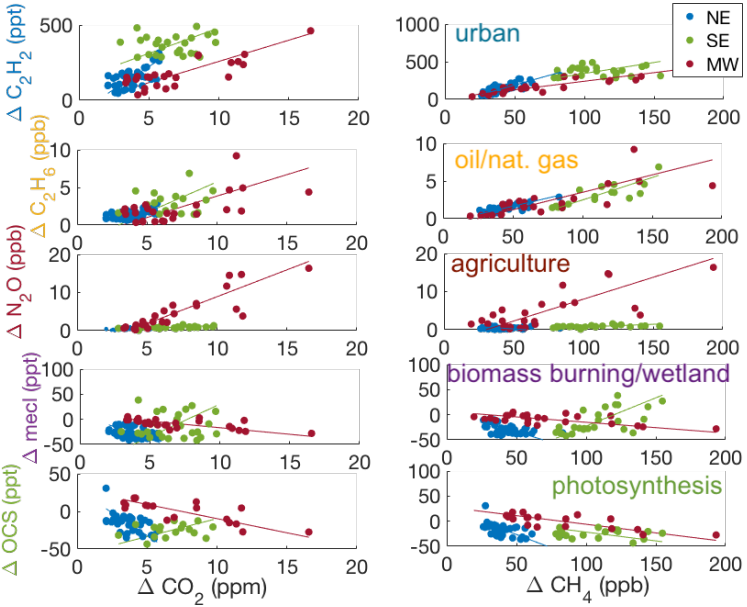

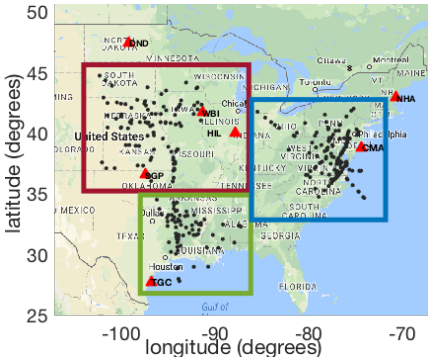

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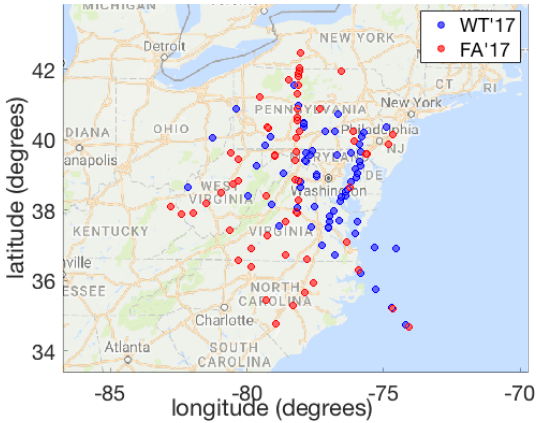
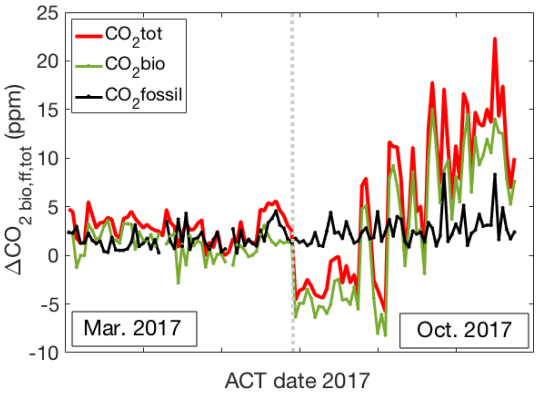
Radiocarbon: Northeastern U.S.

We know $^{14}CO_2$ is a tracer for recently-added fossil fuel CO_2 emissions:

$$CO_{2obs} = CO_{2bg} + CO_{2ff} + CO_{2bio}$$





- Radiocarbon sampling during ACT concentrated in Northeast
- Biogenic CO_2 dominating CO_{2tot} signal, while fossil fuel CO_2 constant

Summary and future work

- For ACT WT'17, use *GMD measurements in flasks* for regional-scale source attribution, determining background levels → *apply to CCGG network*
- Regional transport:
  -Because sources well-known, use $^{14}CO_2$ to evaluate tracer transport in inversions

  Utilize knowledge gained through campaign collaborations:
  -Apply understanding of transport via weather for more informed assimilation of network data in inversions (i.e. NOAA CarbonTracker)