Opportunities for monitoring PBL properties using the GGGRN Aircraft Network

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eGMAC
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Global Monitoring Laboratory
Earth System Research Laboratories

CIRES

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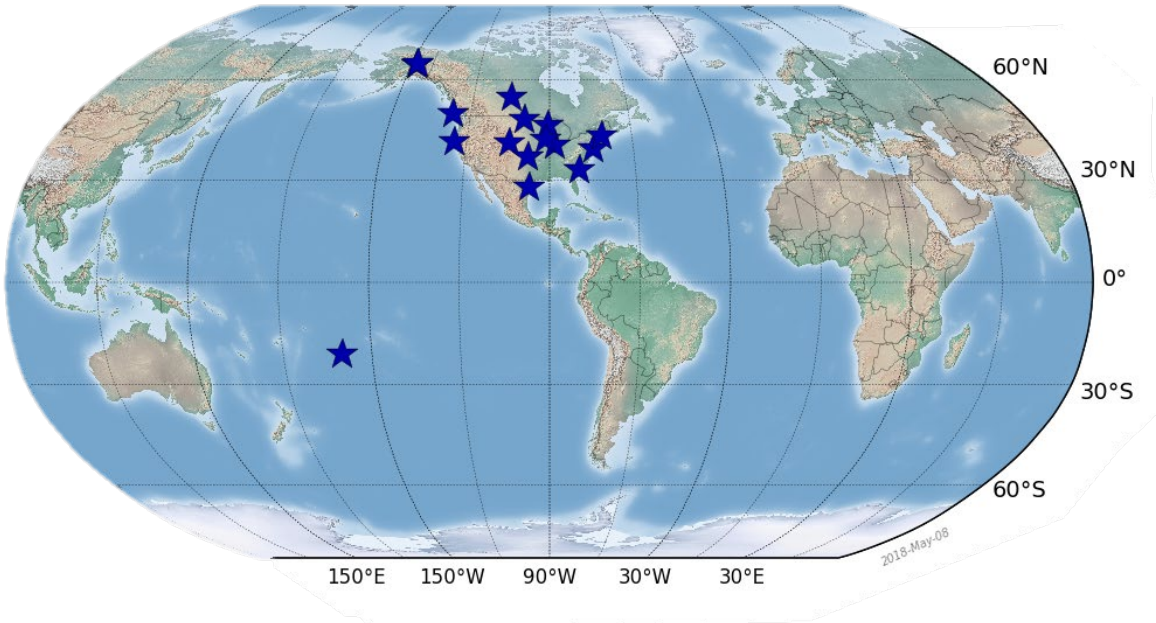
NOAA Greenhouse Gas Reference Aircraft Network



- 13 sites in N. Am. currently
- 15+ yr record at each site
- Private pilots flying small aircraft
- 1-2 profiles per month
- 12-17 h LT
- Sites co-located with surface measurements: SGP, LEF


Flask, pump, & battery packages

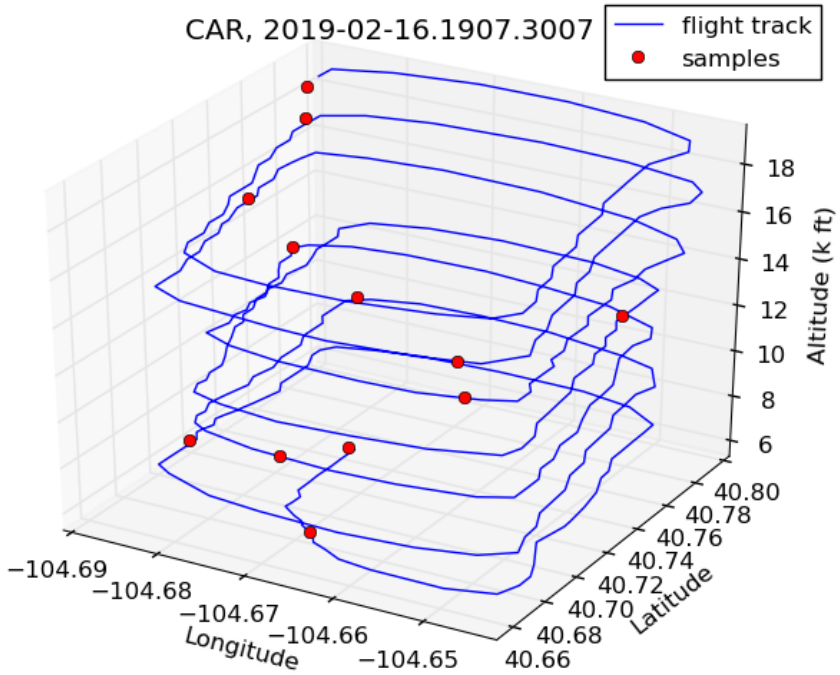

Inside of Programmable Flask Pack (PFP)

Cessna T210 at NHA

NOAA Greenhouse Gas Reference Aircraft Network

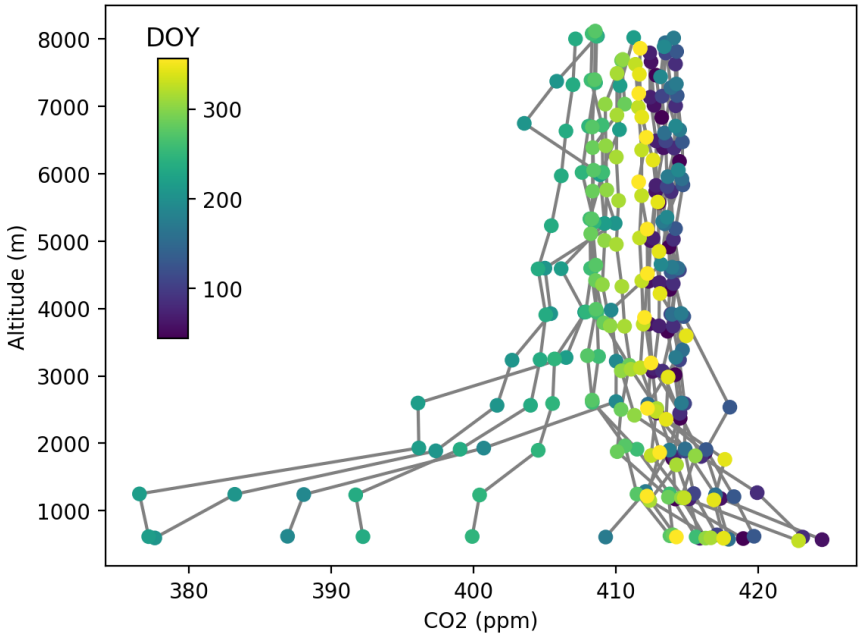
12 flask samples per profile are collected at pre-determined altitudes

Example flight path during sample collection



Flight paths are designed to hold altitude steady while a flask is filling and to collect flasks over a fixed point on the ground.

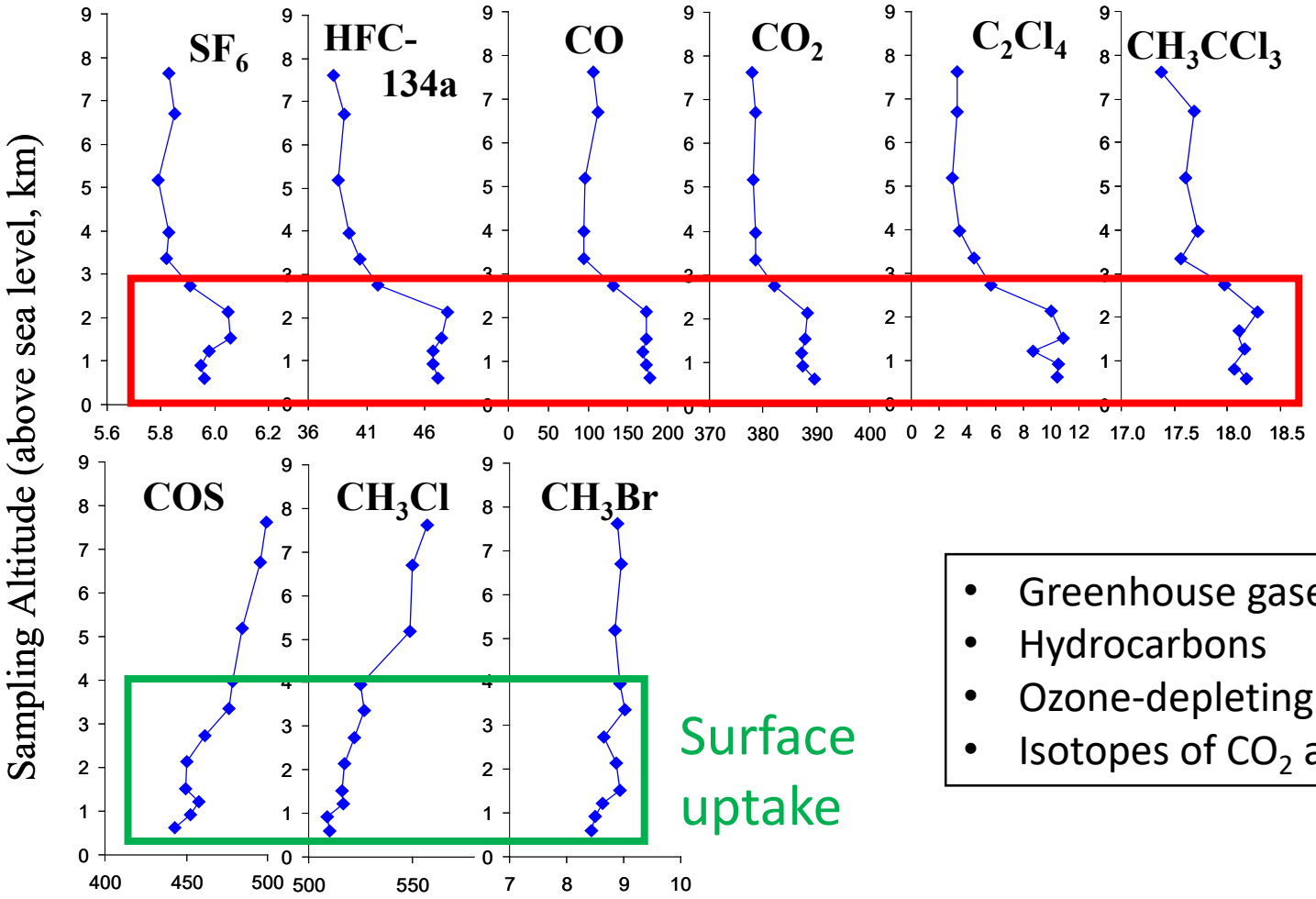
1-year of CO_2 profiles from 1 site



Lower altitude samples reflect surface fluxes and mixing depth. Higher altitude samples reflect seasonal and long-term distributions and synoptic transport.

NOAA Greenhouse Gas Reference Aircraft Network

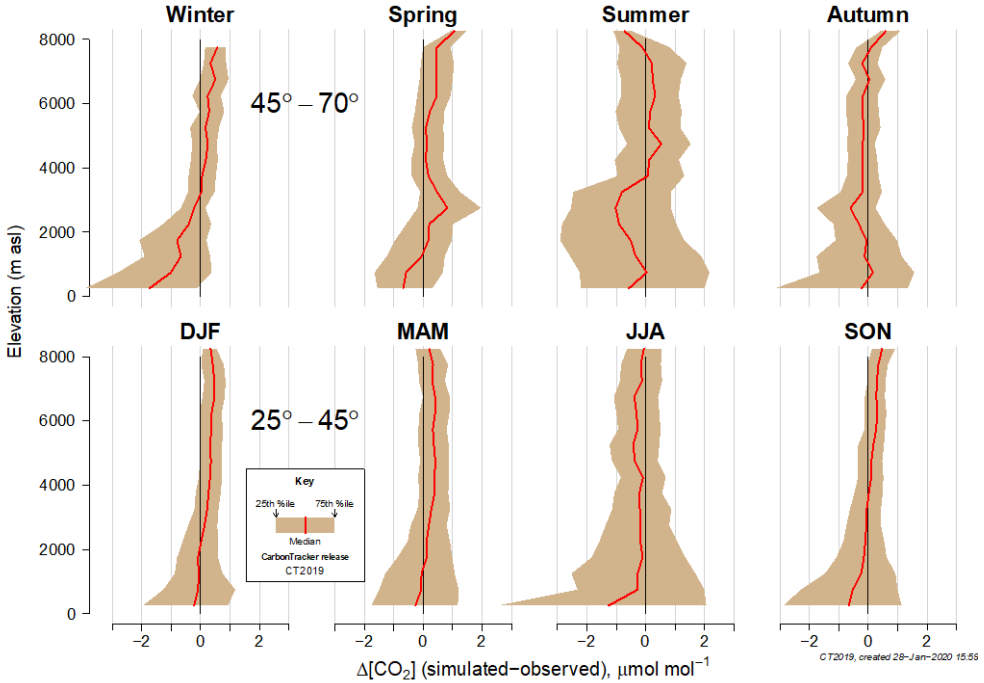
Flask samples are analyzed for 55+ trace gases and isotopes



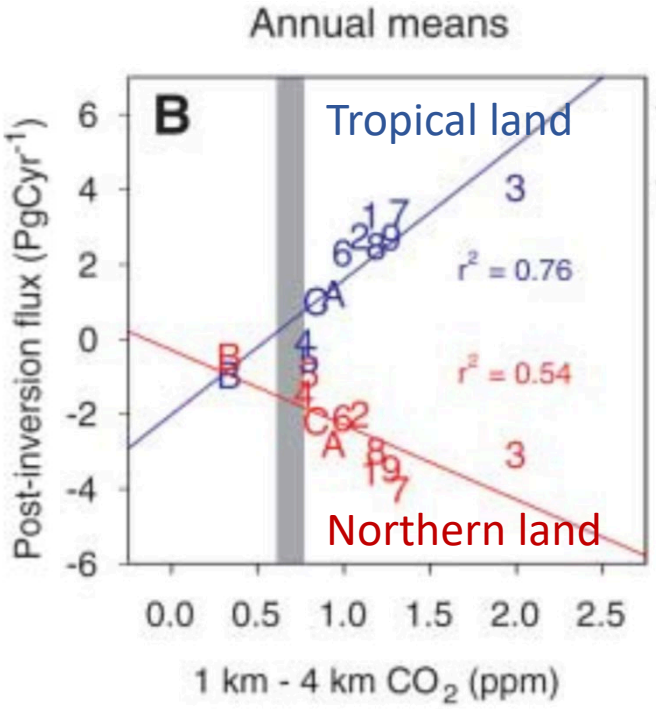
- Greenhouse gases
- Hydrocarbons
- Ozone-depleting gases
- Isotopes of CO_2 and CH_4

Aircraft network profile data are often used to evaluate large-scale transport and vertical mixing

CarbonTracker-2019 residuals against unassimilated aircraft data by altitude, season, and latitude bin



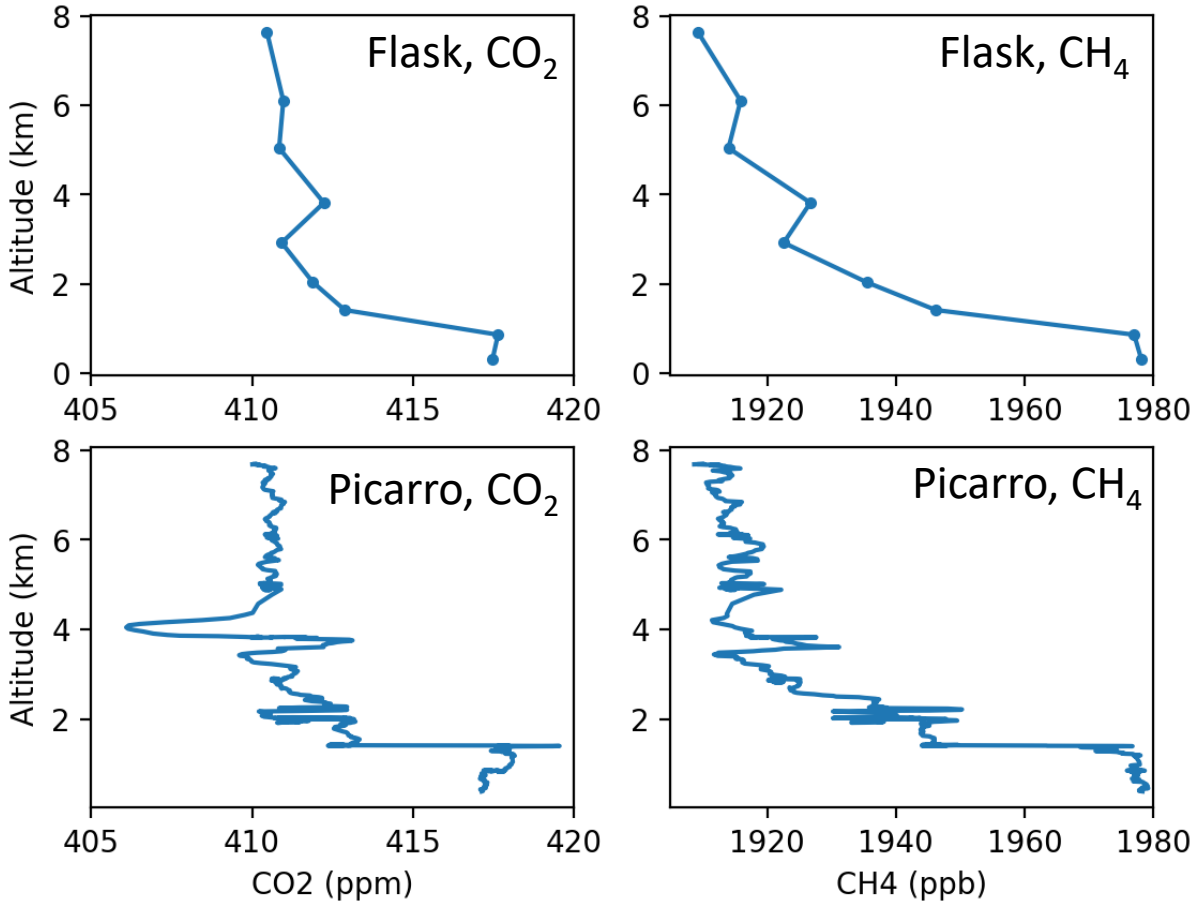
Stephens et al., 2007, *Science*
Demonstrated that observations of the vertical distribution of atmospheric CO_2 constrain latitudinal distribution of carbon fluxes



NOAA Greenhouse Gas Reference Aircraft Network

Continuous high-resolution trace gas profiles better resolve features related to mixing and transport than flask measurements

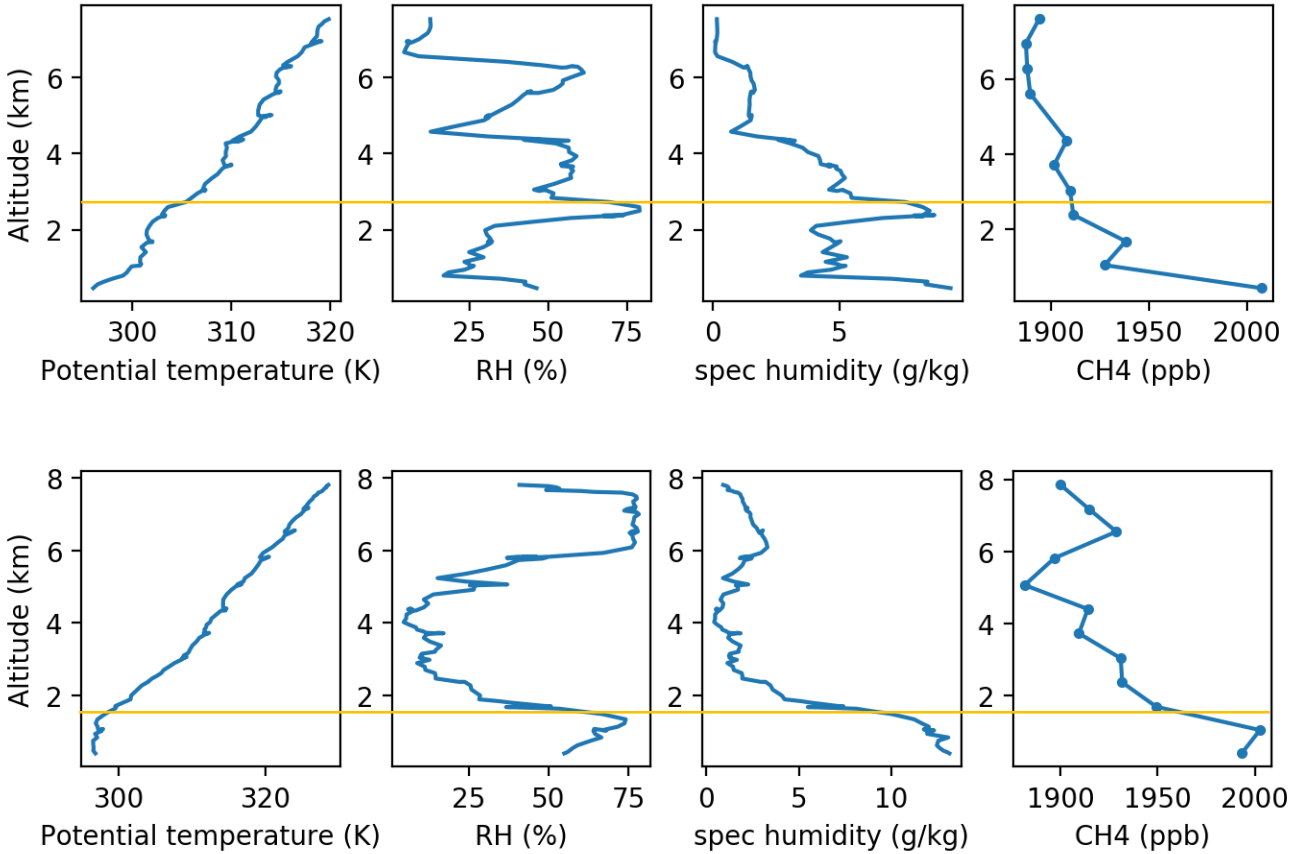
Offshore Cape May, New Jersey (CMA), Nov 2019



Continuous temperature and relative humidity measurements are made on each aircraft network profile

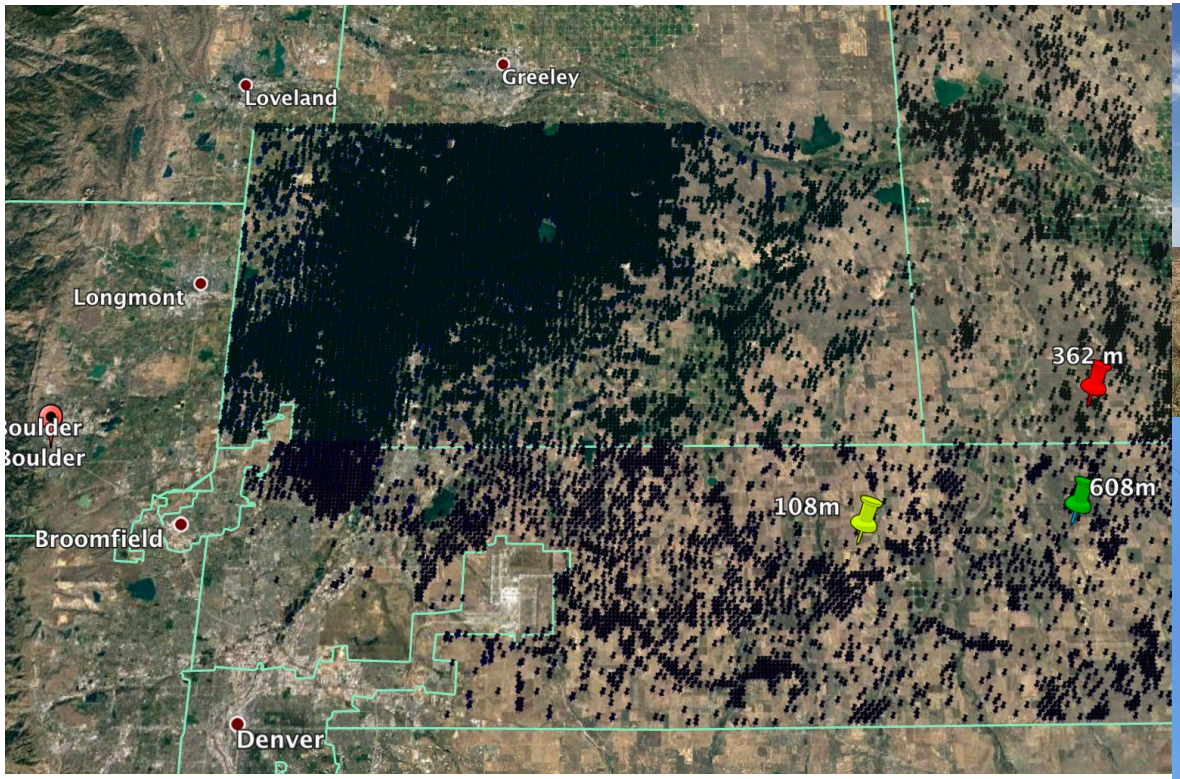
Vaisala HMP50 in vented housing next to air inlets

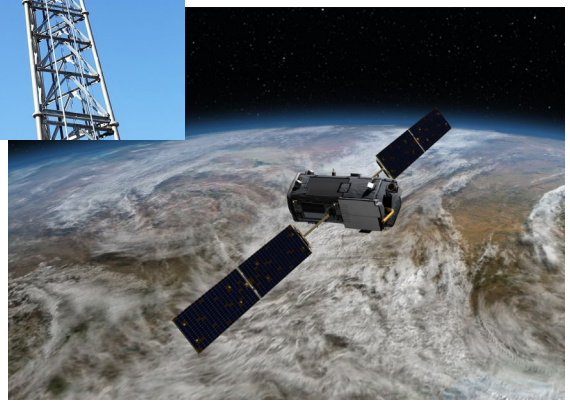
Mid-western site (HIL) in April (top) and July (bottom)



Meteorology measurements from the aircraft network are under-utilized for mixing height quantification and diagnosis

GGGRN Tower Network – Planning new tower in NE Colorado

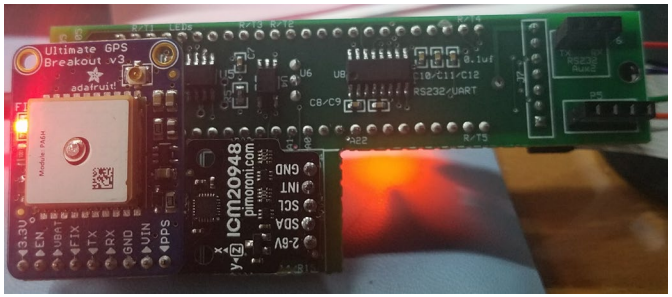


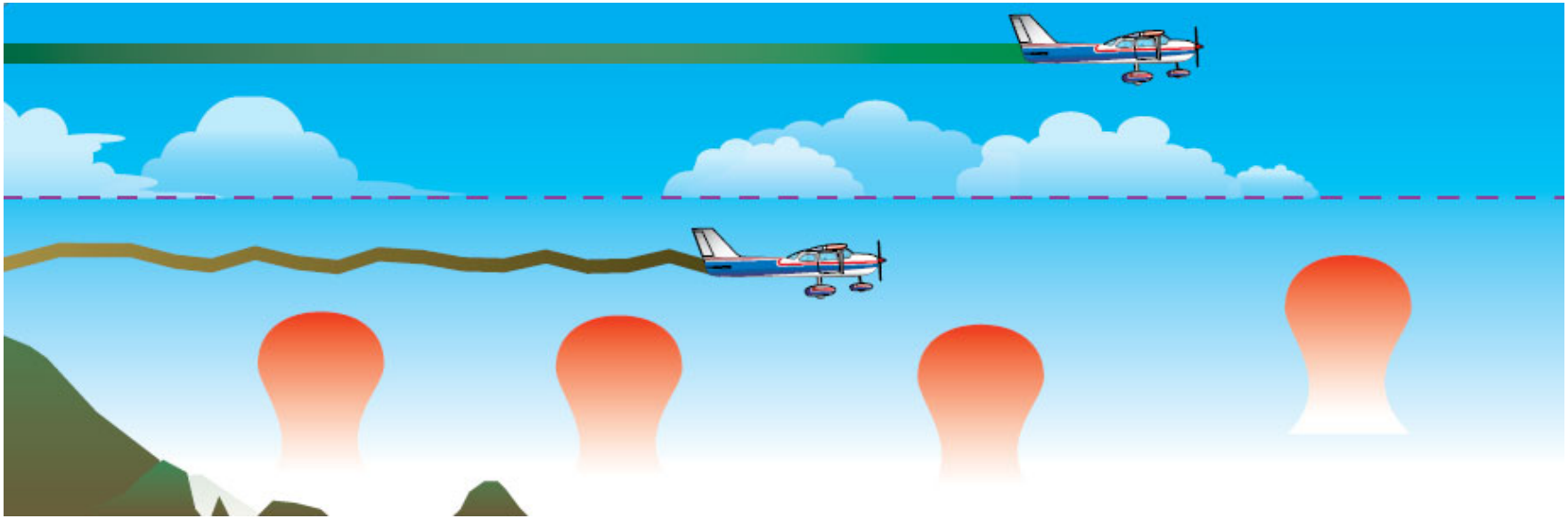


- Evaluating 3 potential tower locations ~2 hr east of NOAA/ESRL in Boulder
- Planned measurements:
  - AirCore profiles + EM27/SUN + A-train overpasses (CO_2/CH_4/CO/N_2O)
  - In situ measurements of CO_2/CH_4/CO
- Soliciting interest in adding measurements of:
  - PBLH, surface radiation, air quality, other in situ measurements

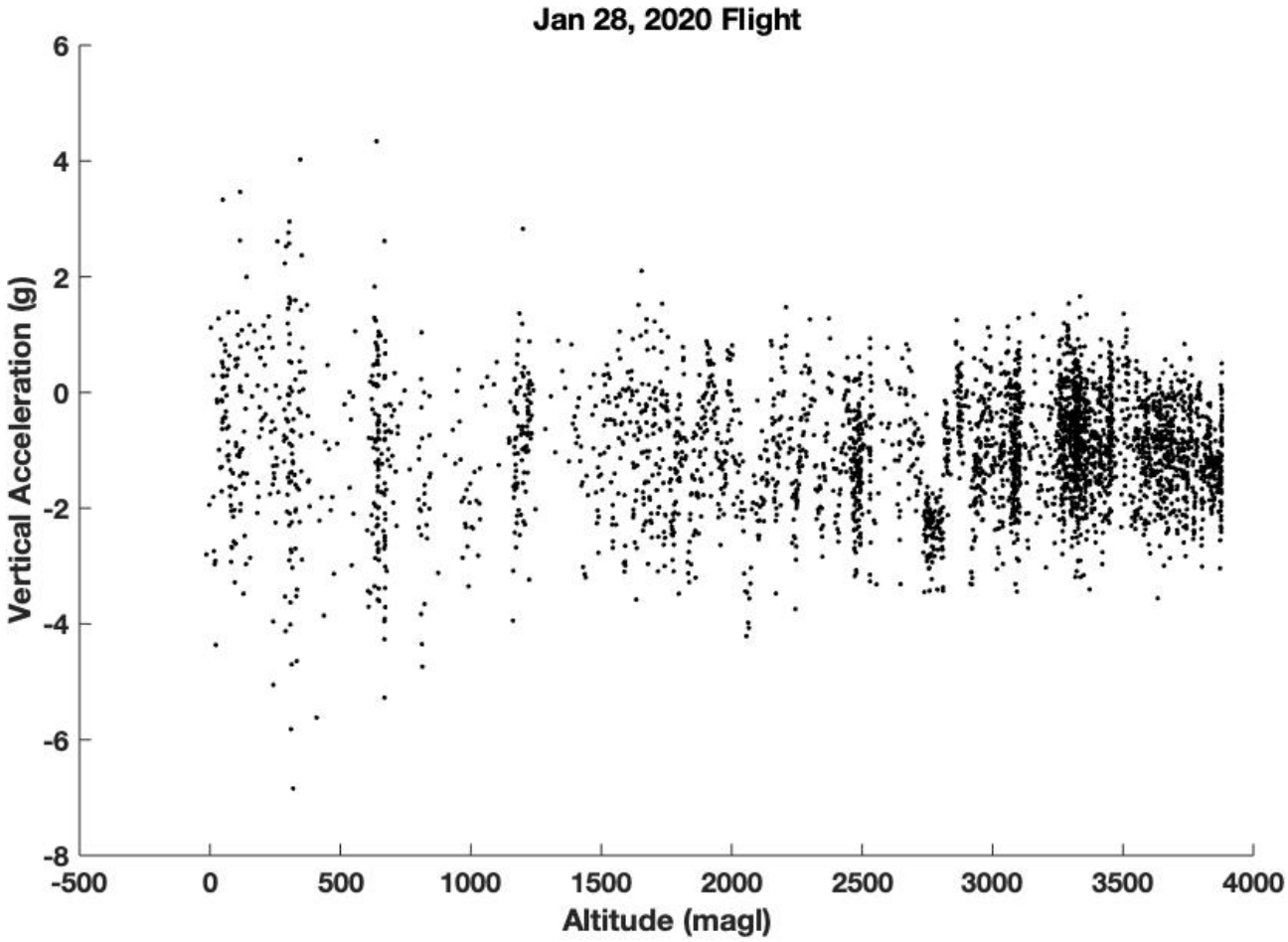
Accelerometers in the Aircraft Network to determine turbulent layer height

CIRES Innovative Research Project





First challenge: Interpret the data



Current progress

First prototypes flown on a few Aircraft Network flights at Colorado (CAR) site

Questions

Using this tool, how do we:

a) Determine the turbulent layer height?

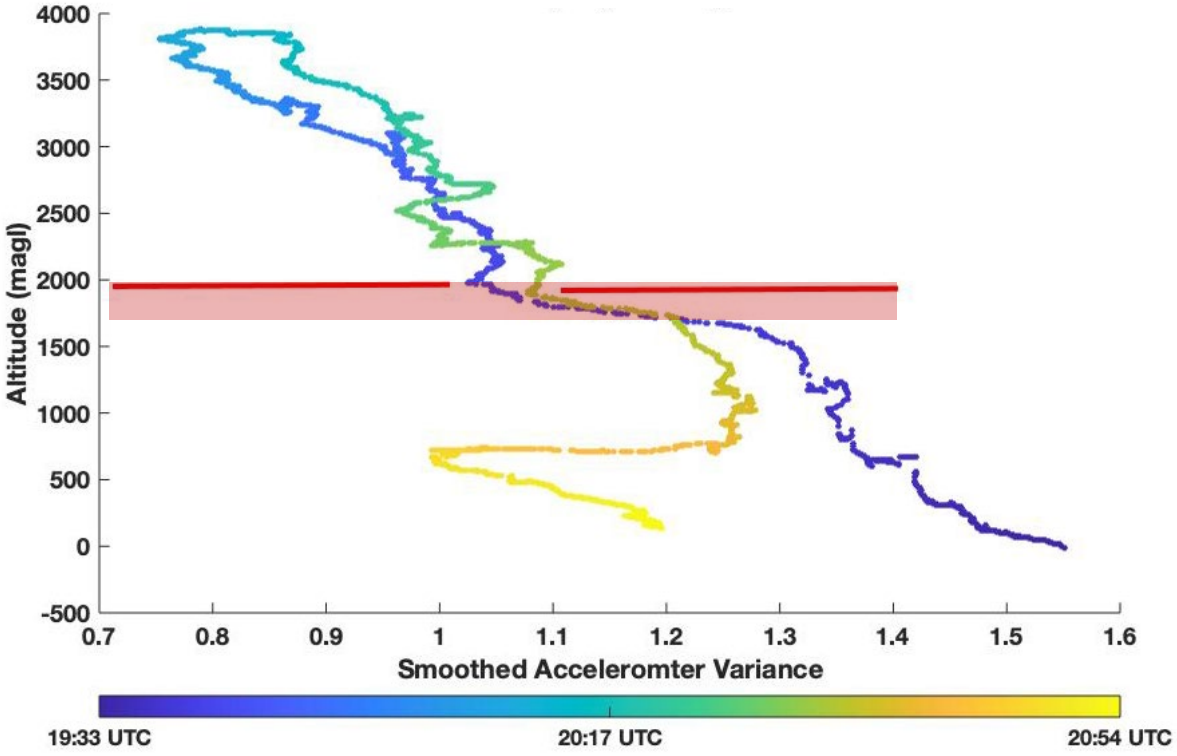
b) Assess its accuracy? Through comparison to:
   - Trace gas profiles?
   - T & RH profiles?
   - Lidar?
   - Reanalysis?
   - Other?

c) Do we get good data while spiraling on the descent?

28 Jan 2020 Flight, v1 prototype

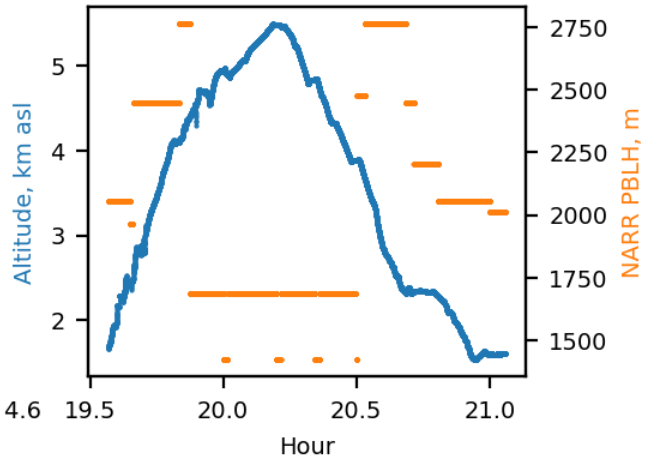
Accelerometer Variance Approximation

1700 - 1970 m

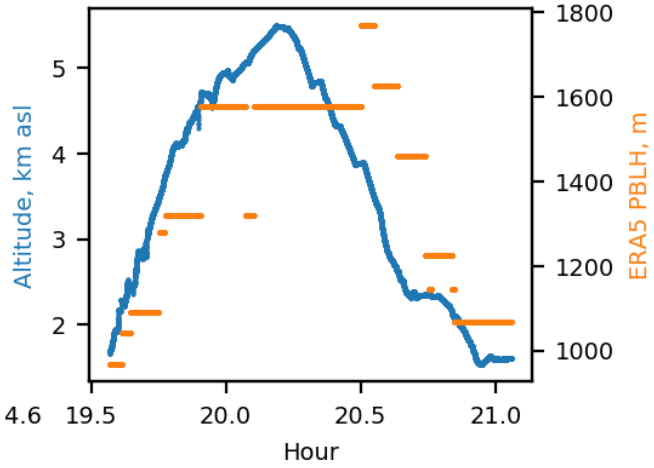


Comparison to Reanalysis

NARR: ~1420 – 2800 m



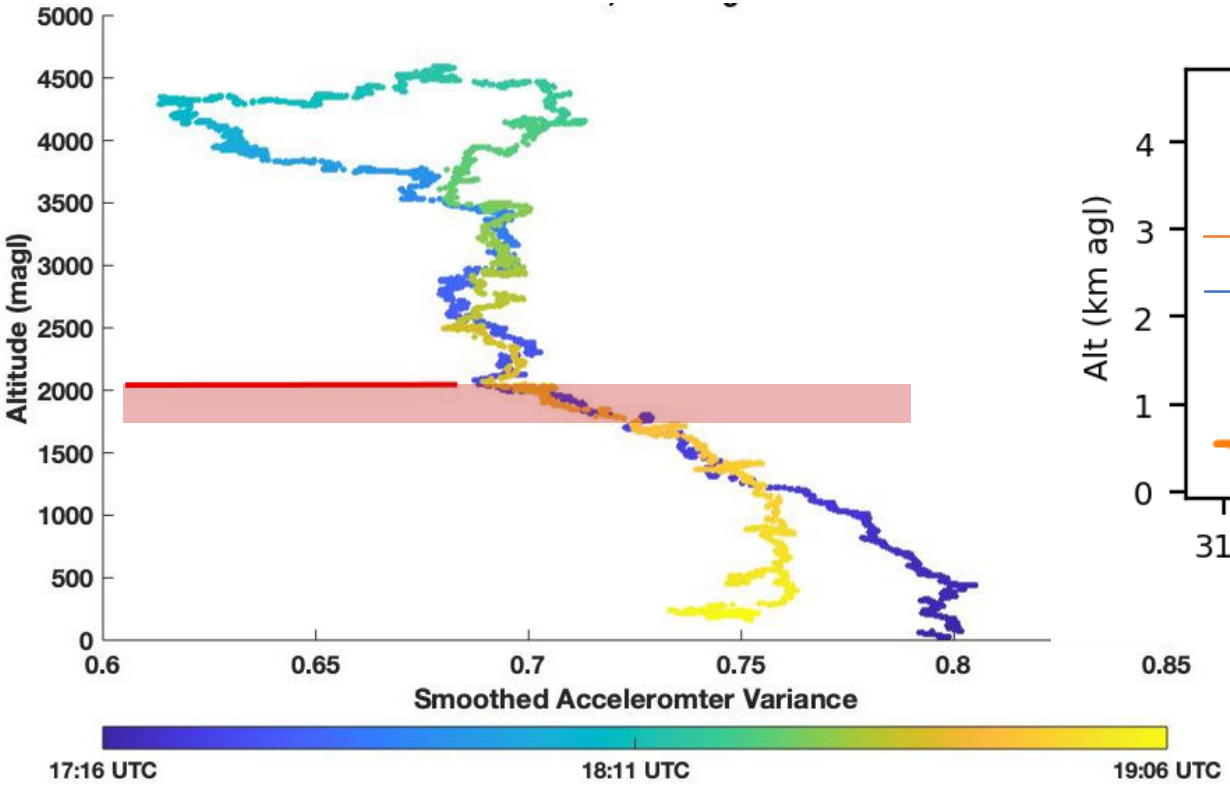
ERA5: ~1000 – 1800 m



4 June 2020 Flight, v2 prototype

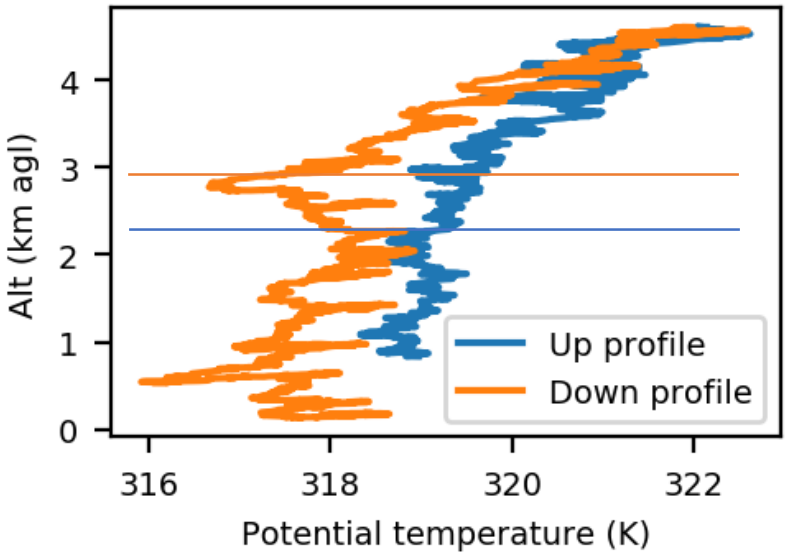
Accelerometer Variance Approximation

1750 - 2075 m



Measured θ Approximation

2200 - 2900 m



Summary and Next Steps

- Accelerometer
  - Deploy to additional Aircraft Network sites:
    - SGP – comparisons with lidars and sondes at DOE-ARM
    - HIL & WBI – 2 sites flown with same plane
  - Develop algorithm for identifying turbulence inflection points
  - Statistical comparison to other measures of mixing height

- Aircraft network datasets are under-utilized for quantifying and assessing PBL heights

- Our group is pursuing new ideas and opportunities to do routine PBL height measurements at GGGRN sites