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Use of CO_2 & Other Tracers for Determination of Biogenic & Biomass Burning Emissions

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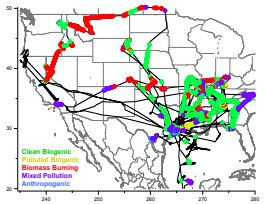
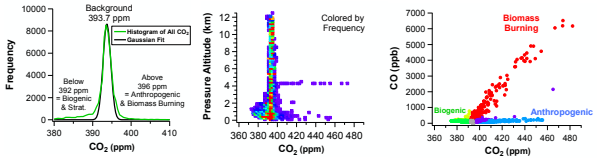
SEAC⁴RS

The atmospheric chemistry of the Southeastern United States is complex with a mixture of seasonally-dependent vegetation emissions, anthropogenic activity and sporadic biomass burning. Carbon dioxide in conjunction with other gas-phase and aerosol tracers can be used to differentiate these sources.

The NASA SEAC4RS mission was intended to give a broad survey of the atmospheric composition of the southeastern United States:

- Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys
- 23 flights in August & September 2013
  - Biomass burning – wildfires and agricultural burning
  - Biogenic regions of the southeast U.S.
  - Anthropogenic sources – Atlanta, GA & Birmingham, AL
- NASA DC-8 flying out of Houston, TX
  - CO_2 measured via differential absorption
  - CO measured via DACOM (differential absorption)
  - VOCs measured by proton transfer mass spectrometry
  - Additional gas-phase, aerosol and radiative measurements

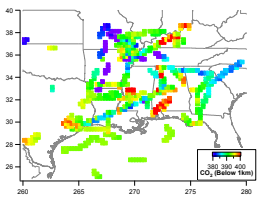


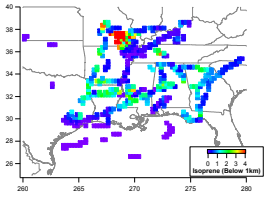


Carbon dioxide is used as a conserved tracer:

- Anthropogenic – high CO_2 emissions relative to CO (lowest 1 km)
- Biomass Burning (BB) – low CO_2 emissions relative to CO
  - Plumes measured primarily in lowest 1 km but also at ~2 and ~4 km
- Biogenic – reduced CO_2 (below 392 ppm)
  - Carbon uptake signal measured up to 2 km

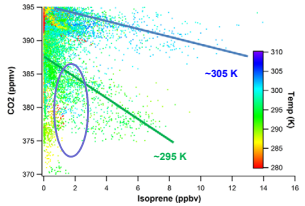
Biogenic Uptake & Emissions



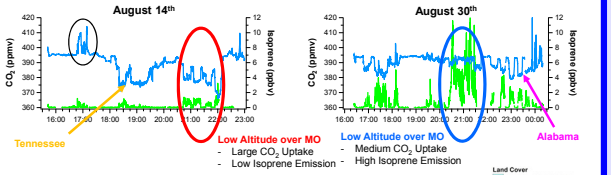


The uptake of CO_2 and emission of VOCs (such as isoprene) by vegetation is dependent on:

- Vegetation type
  - location of greatest CO_2 reductions offset from location of 'isoprene volcano'
- Temperature
  - higher temperatures can cause greater isoprene emissions but reduce CO_2 uptake
  - additional data with reduced CO_2 but no isoprene (purple circle)

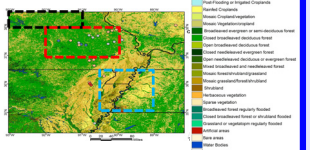


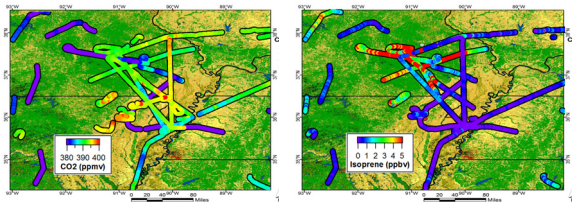
Southeast Missouri: "The Isoprene Volcano"



Variable carbon uptake and isoprene emission in the region

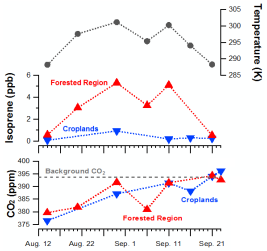
- Dependent on land cover, temperature, time of day, precipitation, photosynthetic primary production
- Region included deciduous forest (red box), herbaceous cropland/grassland (blue box) and a mixture of the two (black box)





Isoprene Emissions

- Greatest over deciduous forest (red boxes)
  - None over herbaceous cropland/grassland (blue box)
  - Consistent with MEGAN inventories
- Large dependence on temperature

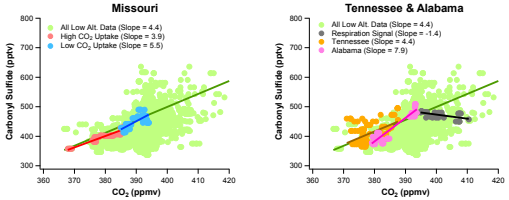


Carbon Dioxide Uptake

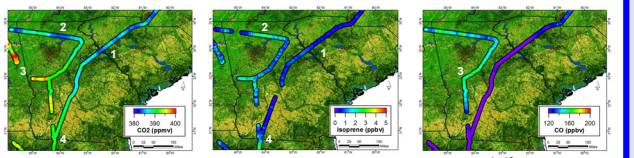
- Less dependence on vegetation type
- Greatest uptake measured in beginning half of the campaign

Carbonyl Sulfide (OCS) Uptake

- Uptake of OCS and CO_2 have a common pathway but OCS is not respired by vegetation (unlike CO_2)
  - Blake et al. (JGR, 2008) reported a OCS-to-CO_2 ratio of 5 pptv/ppmv over the Eastern U.S.
- Thus, the ratio can be used to determine the presence of:
  - Mixtures of CO_2 uptake and respiration or other emission signals
  - Differing uptake processes
- Ratio is relatively constant
  - In MO, independent of the amount of CO2 uptake (left, red and blue lines below)
  - In other regions – TN and AL (right, orange and purple lines below)
  - Clear respiration signal (right, black line) with little OCS uptake

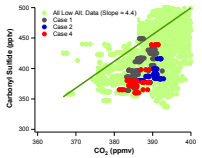


Georgia



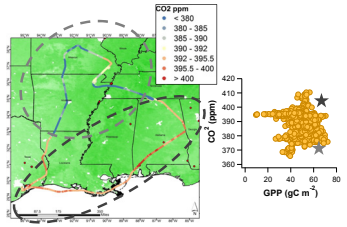
Seven flights in the region. Case Studies:

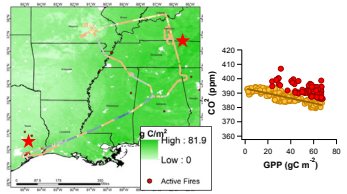
1. CO_2 uptake with no isoprene emissions over mixed forest
2. CO_2 uptake and isoprene emissions over deciduous forest north of Atlanta
3. Urban pollution (with high CO_2) southwest of Atlanta
   - no urban pollution over forested areas east of Atlanta (1)
4. Isoprene emissions with little CO_2 uptake near Florida border
   - temperatures ~300 K



- OCS-to-CO_2 ratio is higher than measured in the Missouri region
  - Shows a mix of CO_2 uptake and emissions (including respiration)
- Large spread in data suggests a region with diverse emission sources

Gross Primary Production (GPP)





GPP – measure of the productivity of the region

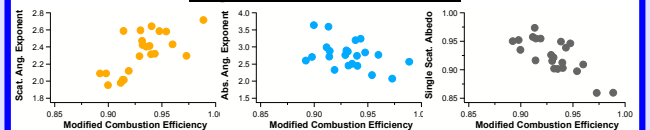
Aug. 14th Flight

- no correlation between GPP & CO_2 due to the varying vegetation types
- More uptake in the northern section of the flight path

Aug. 30th Flight

- **Negative correlation** between GPP & CO_2 (more photosynthesis results in lower CO_2)
- **Areas with elevated CO_2:**
  - Near Houston & on the eastern edge of the flight path
  - Urban influence

Agricultural Fires



Changes in aerosol intensive properties with flame conditions (MCE)

- Flaming conditions (high MCE) gives:
  - higher scattering angstrom exponent (smaller aerosol)
  - lower absorption angstrom exponent (less organic coating)
  - lower single scattering albedo (darker smoke)

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