Carbon Dioxide Measurements on the DC-8: Tracers for Tropospheric Air Mass Transport

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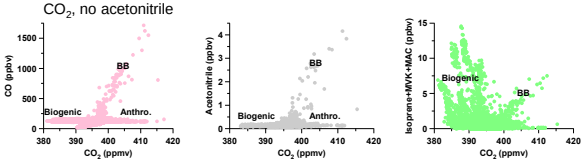
Carbon Dioxide Measurement

AVOCET: Atmospheric Vertical Observation of CO_2 in the Earth's Troposphere
- CO_2 measured via differential absorption by a Non-Dispersive Infrared Spectrometer (4.26µm)
- All measurements are calibrated to WMO standards with an accuracy of 0.25 ppmv and a precision of less than 0.1 ppmv.
- 1 Hz data is reported and has been corrected for a 4 second time delay to the DLH water vapor measurement

Carbon dioxide is used as a conserved tracer along with other tracers (CO, acetonitrile, isoprene) in order to:
- Characterize storm inflow
  - Anthropogenic – CO and CO_2 correlate, no acetonitrile
  - Biomass Burning (BB)– high acetonitrile, dCO > dCO_2, some isoprene
  - Biogenic – high isoprene and its products (MVK and MAC), anti-correlated with CO_2, no acetonitrile

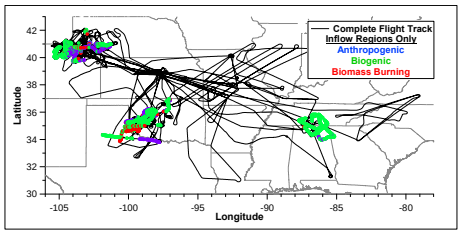


- Identify related inflow and outflow
- Characterize processing of un-conserved species in convection

Inflow Characterization

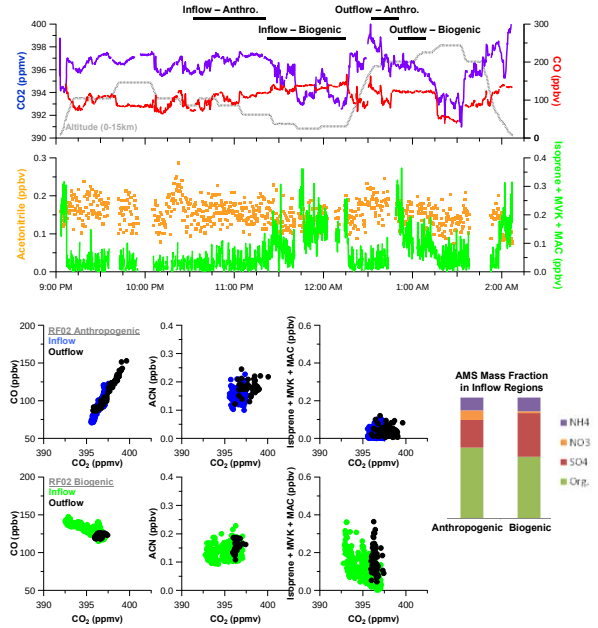
RF	Date	Storm Location	Inflow (UTC)	Outflow (UTC)	Pollution Type
1	May 18	CO	21:42 - 22:52	23:17 - 23:48	Anthropogenic & Biogenic
2, #1	May 19	OK	22:33 - 23:20	24:30 - 24:45	Anthropogenic
2, #2	May 19	OK	23:20 - 24:14	24:46 - 25:00	Biogenic
3	May 21	AL	18:15 - 20:15	21:15 - 22:00	Biogenic
4	May 25	OK	23:42 - 24:54	25:17 - 25:27	Biomass Burning & Biogenic
6	May 29	OK	22:09 - 23:15	23:40 - 24:13	Biogenic & Anthropogenic
8	June 1	OK	24:32 - 25:22	25:38 - 26:00	Biogenic & Anthropogenic
9	June 2	CO	20:08 - 21:30	21:58 - 23:09	Biogenic
10	June 5	CO	23:08 - 23:42	24:03 - 24:38	Biogenic
11, #1	June 6	CO	20:35 - 21:23	21:47 - 21:57	Biogenic & Anthropogenic
11, #2	June 6	CO	22:12 - 23:00	23:27 - 23:52	Anthropogenic
13	June 11	AL	19:00 - 20:00	21:15 - 22:00	Biogenic
14	June 15	CO	21:18 - 21:38	22:13 - 22:36	Anthropogenic & Biogenic
15	June 16	OK	24:02 - 25:21	25:42 - 26:02	Biogenic
18	June 22	CO	22:34 - 23:55	24:16 - 25:39	Biogenic & Anthropogenic

15 Cases of Storm Inflow and Outflow
- Preliminary identification of inflow and outflow based on flight notes.
- Air masses characterized based on:
  - Stratospheric: Ozone > 90 ppbv (outflow only)
  - Biomass Burning: Acetonitrile > 0.2 ppbv
  - Biogenic: Isoprene + MVK + MAC > 0.1 ppbv
  - Anthropogenic: CO_2 > 397 ppmv
  - A large fraction of data was a mix of the various types
  - Dust was also a major source of aerosol
- Biogenics dominate in Alabama while Colorado & Oklahoma have a mix of anthropogenic and biogenic air masses
  - Biomass burning during RF01, RF04 and RF18



Transport During RF02

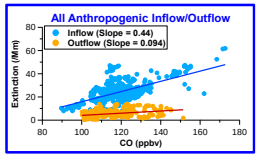
RF02 (May 19th) – Flight to OK
- Both anthropogenic (CO and CO_2 correlated) and biogenic (CO_2 uptake and production of isoprene and its products)

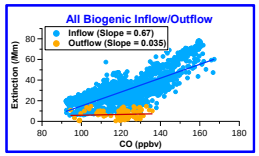


RF02	Anthropogenic	Biogenic
f(RH)	1.07	1.51
Inflow Extinction	14	33
OutFlow Extinction	3	6
Inflow / Outflow	0.22	0.17

- Anthropogenic aerosols had a higher organic mass fraction (58% of the AMS mass) than the aerosols in the biogenic airmass (51%)
  - The higher ammonium sulfate in the biogenic air mass is likely aged pollution mixed with fresh biogenic gas-phase tracers (isoprene and its photochemical products)
- Higher organic mass → Lower f(RH) → Less aerosol removal during convection

Inflow/Outflow Transport

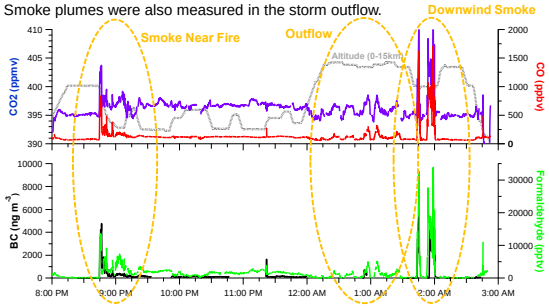




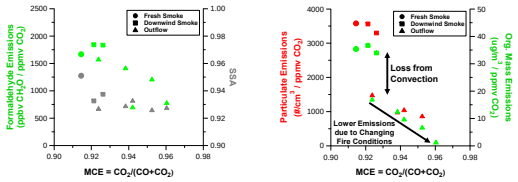
- Outflow screened for:
  - Cloud sampling (by IWC)
  - Stratospheric air (by ozone)
- Aerosol transport efficiency is lower for biogenic air masses
  - Anthropogenic: 21%
  - Biogenic: 5%
- Transport efficiencies are similar to those reported by Ziemba et al. (poster) based on region
  - Colorado & Oklahoma: 25-37%
  - Alabama: 5%
  - Consistent with increased biogenic air masses in the Alabama study region

Biomass Burning Plumes

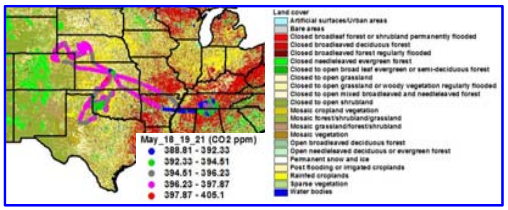
RF18 (June 22nd) – Fires
- Measured fresh smoke twice – near the fire and in the plume downwind from the fire. Smoke plumes were also measured in the storm outflow.



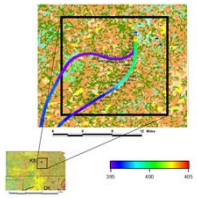
- Modified combustion efficiency (measured from CO and CO_2) gives an indication of fire type
  - <0.9 is smoldering (more incomplete combustion)
  - >0.9 is flaming (more complete combustion)



On-Going Work



Land Use
- Linkage between vegetation and land use to study carbon dioxide sinks and sources.
- Above: Flight tracks from RF01 through RF03 to the three study regions. Significant CO_2 uptake was measured over Oklahoma and Alabama.



Left: Close up of RF02 near Salina, KS.
- Take-off heading west over a mix of grassland and crops (mosaic vegetation) - resulting in significant carbon uptake (<393 ppmv)
- During descent (heading north) over grasslands - no carbon uptake (~400 ppmv)
- High CO_2 near Salina as expected

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