# Transported and local contributions to atmospheric carbon monoxide at Wollongong, Australia.

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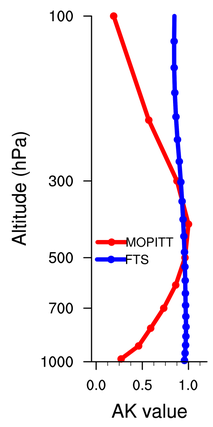
## Introduction

The approximate two month lifetime of atmospheric carbon monoxide (CO) makes it ideal for tracking transported pollution. CO is also useful for identifying local sources of pollution due to the relatively low background amounts. Here, we use the complementary sensitivities of two instruments that measure CO to investigate local and transported pollution at Wollongong, Australia (-34.406, 150.879).

## Total column measurements

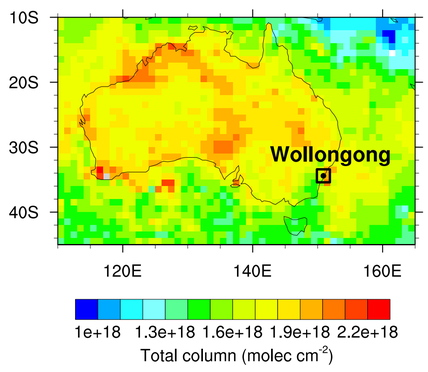
Observations of column CO are made with ground-based and satellite-borne instruments. Both instruments use the property that CO molecules absorb solar radiation in the infrared (IR).

- Columns are independent of PBL height.
- Different vertical sensitivity of instruments is implied by their averaging kernels (AK).



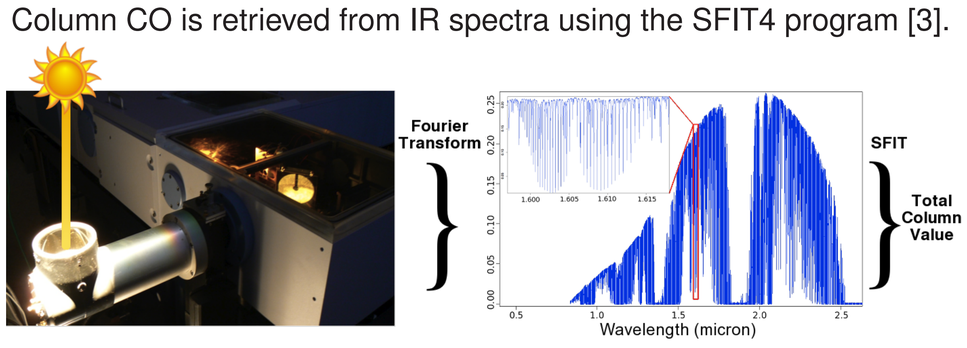

### Satellite-borne Measurements of Pollution In The Troposphere (MOPITT)

- Gas filter correlation radiometer launched in 2000 [1].
- Optimal estimation inverts the IR signal into CO amount.
- V6 TIR-only daytime, land-only pixels [2].
- Observations averaged in a one degree radius around Wollongong.




### Ground-based remote sensing Fourier Transform infrared Spectrometer (FTS)

- Commissioned at the University of Wollongong in 1996 as a part of the NDACC network (`www.ndacc.org`).
- Column CO is retrieved from IR spectra using the SFIT4 program [3].




## Simulations with CAM-chem

Contributions to pollution events are quantified using the chemistry transport model CAM-chem within the Community Earth-System Model (CESM v1.5 alpha) framework.

**CAM4-chem** [4]
`www2.cesm.ucar.edu`

| | |
|---|---|
| **Resolution** | 2.5° longitude x 1.9° latitude, 56 levels (∼40 km model top) |
| **Years Run** | 2001-2014, spin-up in year 2000 |
| **Meteorology** | Nudged to NASA MERRA reanalysis product at ∼10% relaxation |
| **Emissions** | Biomass burning emissions are from QFED_$CO_2$×FINN emission factors, Anthropogenic and ocean sources are based on RCP 8.5, online MEGAN biogenic emissions |
| **Chemistry** | 170 species, with over 400 reactions |
| **Tagged region** | Biomass burning and anthropogenic CO is tagged in 14 regions, based on HTAP Tier 1 regions (`http://www.htap.org/`). |

## Model output

**Percent contribution to the CO total column for events:**

| | a Jan 2003 | b Sep 2005 | c Apr 2007 | d Oct 2009 |
|---|---|---|---|---|
| Biomass Burning (BB) | | | | |
| All BB sources | 47% | 27% | 11% | 17% |
| Australian | 43% | 2% | 5% | 3% |
| SH Transported | 3% | 24% | 2% | 13% |
| Anthropogenic | | | | |
| All anth. sources | 6% | 11% | 11% | 11% |
| Australia | 1% | 1% | 2% | 1% |
| SH Transported | 2% | 5% | 4% | 5% |
| Other sources | | | | |
| Methane oxidation | 20% | 28% | 43% | 37% |
| Ocean and NMHC oxidation | 25% | 31% | 32% | 31% |

## Wollongong MOPITT and FTS timeseries

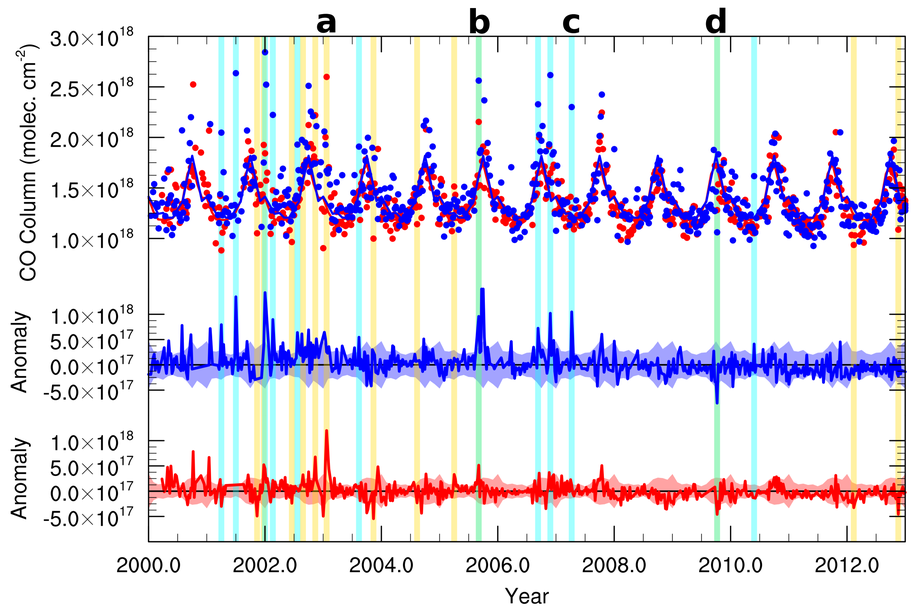



Figure 1 : Top panel shows column CO at Wollongong from FTS (blue) and MOPITT (red). Middle and bottom panels show FTS and MOPITT anomalies, respectively.

Timeseries of weekly averaged total column CO. Seasonal cycle peaks in Sep–Oct due to SH biomass burning season [5].

- Events = anomalies departing from the seasonal climatology (vertical bars)
- Event threshold: $2\sigma$ above, $1.5\sigma$ below
- Three event types:
  Cyan— FTS-only
  Gold— MOPITT-only
  Green— Both
- Significant anomalies **a** to **d** are discussed below.

## Transported and local contributions

### a Regional-scale Australian fire (Jan 2003)

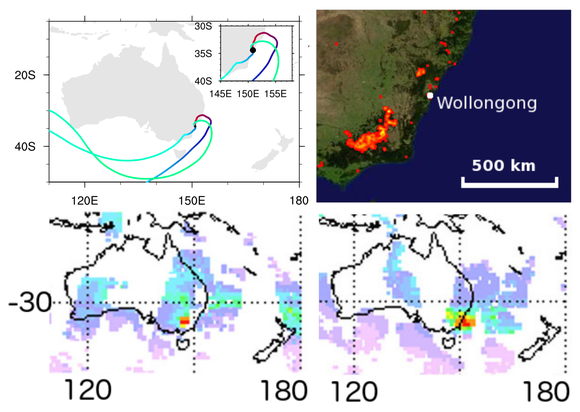



Figure 2 : Clockwise from top left: BADC back trajectories for Jan 25; FIRMS [6] Jan fire count; MOPITT measurement on Jan 26; and Jan 22.

- Major fire in Canberra, Australia injected pollution into the upper troposphere via pyrocumulonimbus cloud formation [7].
- Trajectories show transport over fire region at 650 hPa, while 950 hPa transports cleaner air from the northeast.
- CAM-chem shows major contribution from Australian fire.

### b Southern Hemisphere fire season (Sep 2005)

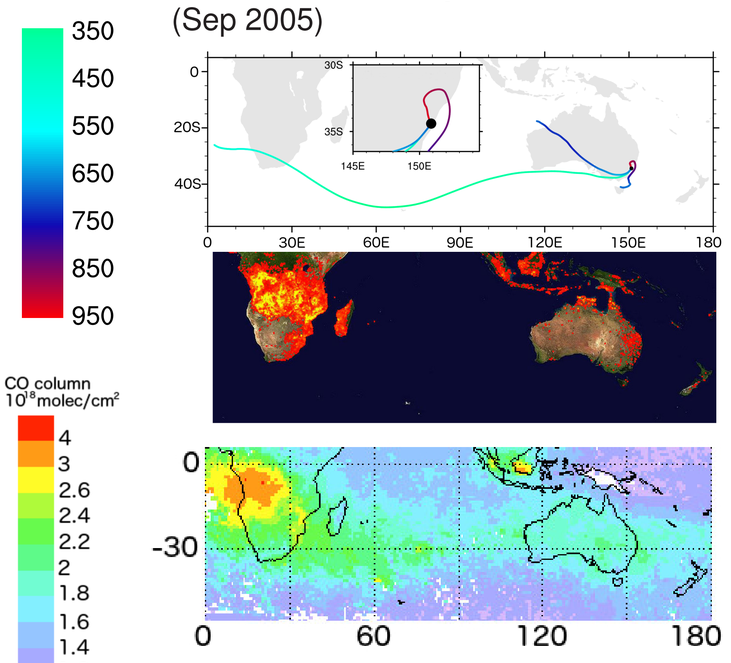



Figure 3 : Top: BADC back trajectories for Sep 7; Middle: FIRMS fire count and Bottom; MOPITT measurements for Sep.

- MOPITT anomaly < FTS anomaly
- Trajectories and MOPITT measurements indicate transported fire emissions from Africa.
- Circulation in 950 hPa trajectory suggests FTS also samples local fire and/or urban emissions.

### c Local pollution (Apr 2007)

- Large enhancement in FTS CO, and no enhancement in MOPITT CO.
- Expect low CO due to southern trajectories and low biomass burning.
- FTS operator noted a white haze in the Wollongong atmosphere.
- Trapped local pollution under an inversion, not captured by MOPITT due to poor sensitivity in the lower troposphere.

### d Southern Ocean low CO (Oct 2009)

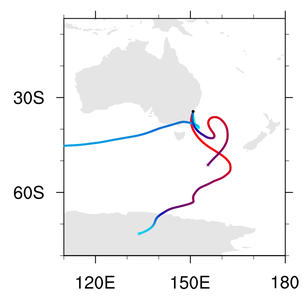



Figure 4 : Example BADC back trajectory sourcing low CO.

- Several days show back trajectories sourcing low CO from Southern Ocean air.

## Summary

This study demonstrates the successful use of instruments with different vertical sensitivities for interpreting contributions to atmospheric composition.

- Both instruments can capture large-scale transported plumes of high or low CO.
- The satellite instrument MOPITT provides a regional and global context.
- FTS additionally measures local contributions to pollution in the lower troposphere.

## References

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[6] FIRMS data and Rapid Response imagery is from LANCE, rapidfire.sci.gsfc.nasa.gov/cgi-bin/imagery/firemaps.cgi
[7] Fromm, M. et al. (2006), *Geophysical Research Letters* 33(5), 5815

## Acknowledgements

• NCAR is sponsored by the National Science Foundation • ARC • LANCE system is operated by the NASA/GSFC ESDIS • Back trajectories provided by the BADC (British Atmospheric Data Centre) using ECMWF data •

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