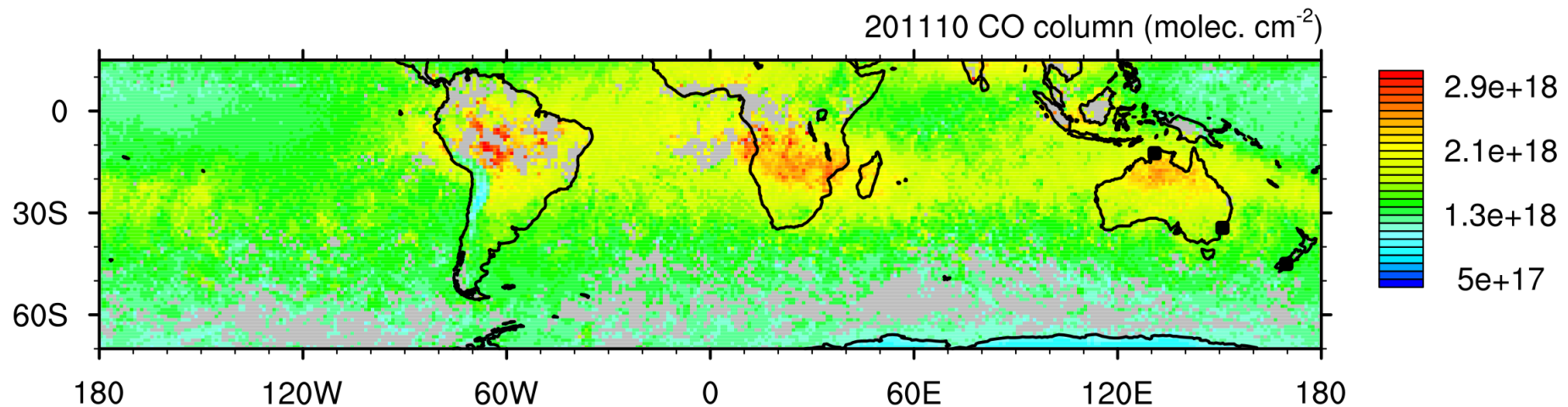
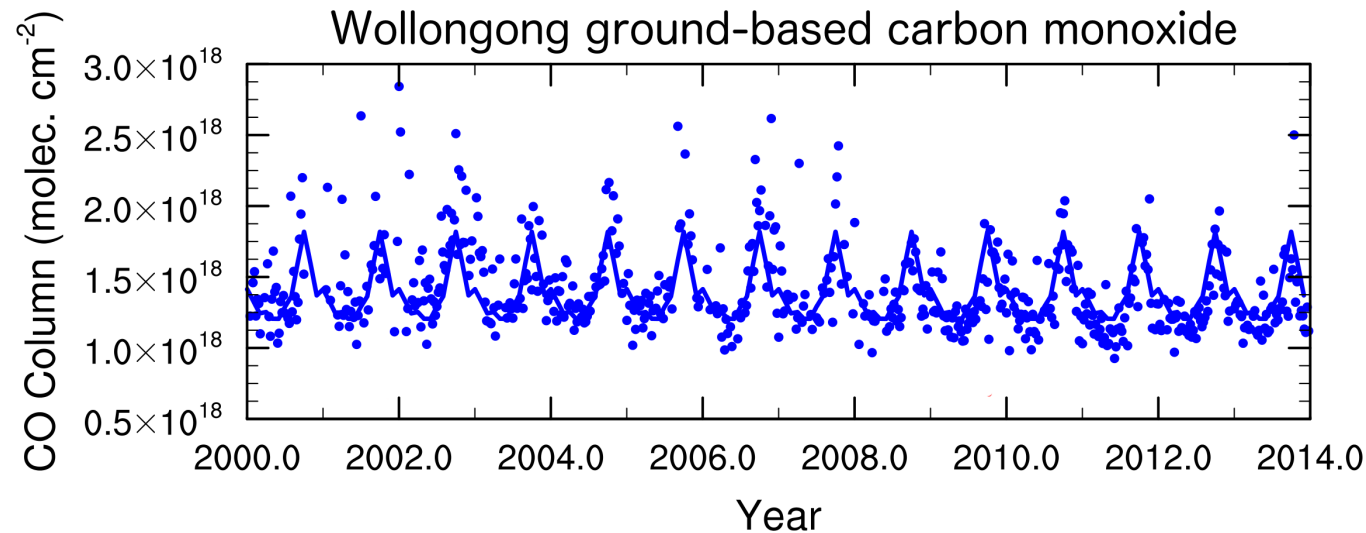


Investigating Transported and Local Carbon Monoxide in the Southern Hemisphere with Satellite and Ground-based Remote Sensing



R. R. Buchholz , D. P. Edwards, M. N. Deeter, H. M. Worden,
L. K. Emmons, N. B. Jones, C. Paton-Walsh, N. M. Deutscher,
V. A. Velazco, D. W. T Griffith, J. Robinson and D. Smale

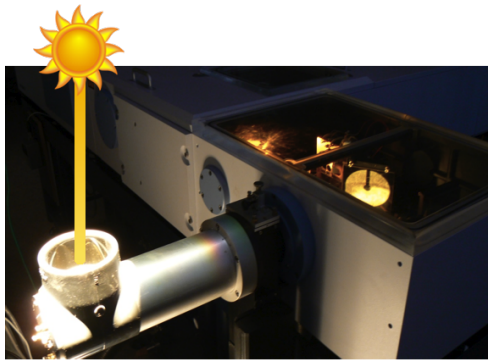
Ground-based measurements in the Southern Hemisphere



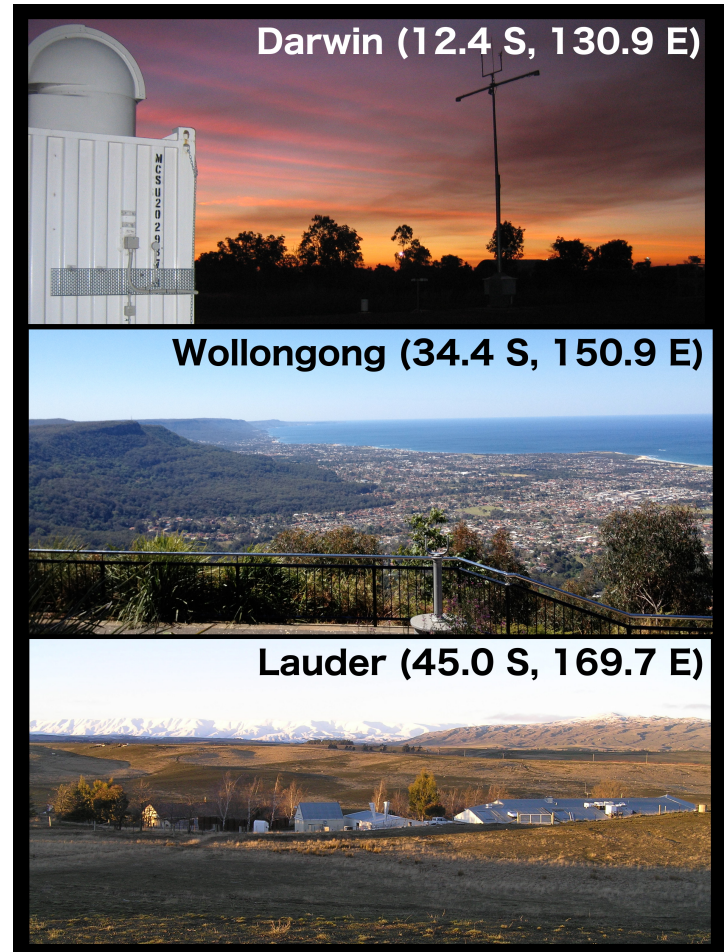
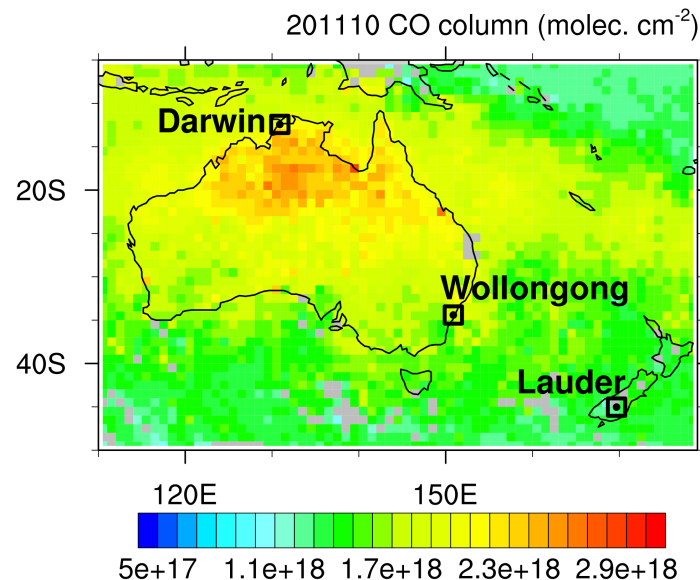
- Long records of column CO (and other trace gases) from stations in the NDACC and TCCON networks.
- Interpret these records using satellite measurements and modeling:
 - Complementary sensitivity of MOPITT to FTS
 - Quantify contributions with CAM-chem

Fourier Transform Infrared Spectrometer (FTS) sites in Australasia

Solar-tracking (daytime measurements)

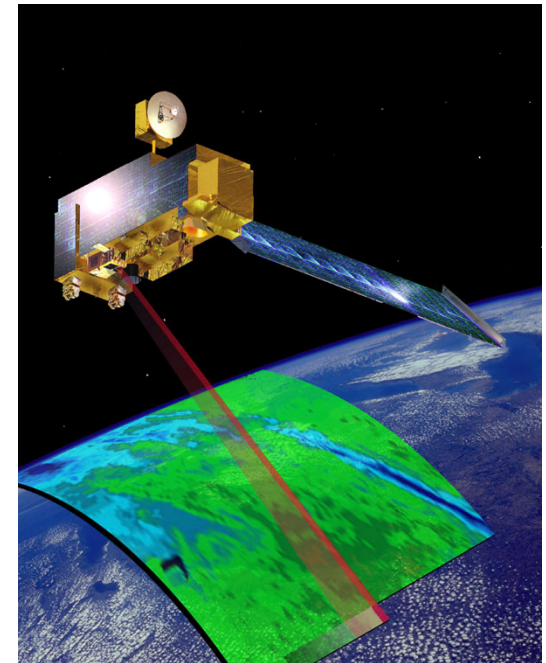


Commission dates:
Darwin – 2005
Wollongong – 1996
Lauder – 1994



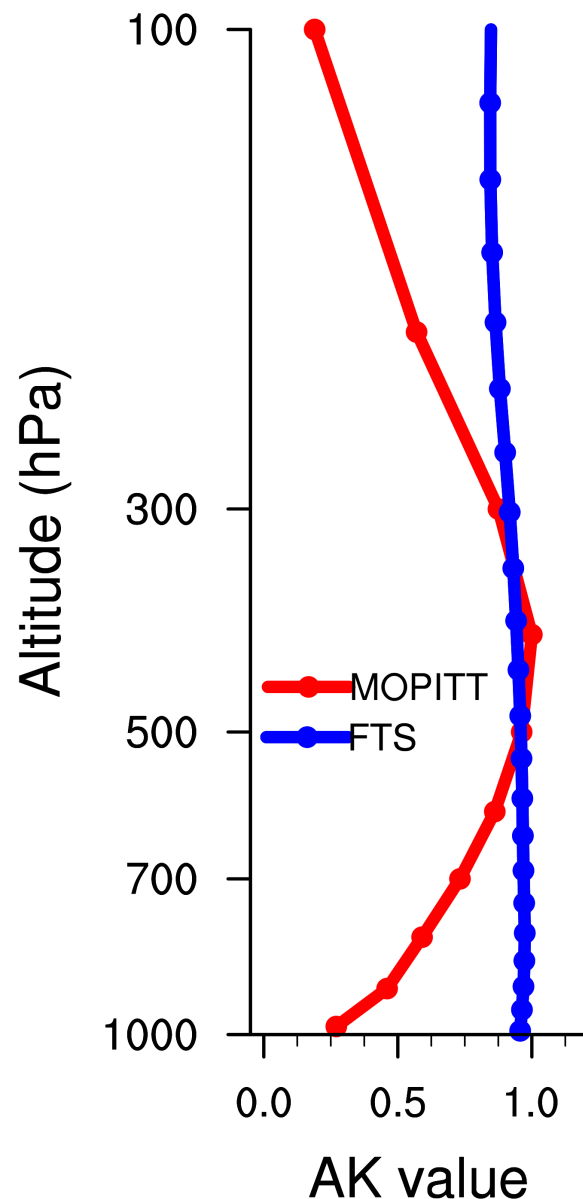
Satellite-based Measurements of Pollution in the Troposphere (MOPITT)

- Aboard Terra, measurements begun 2000
- Gas filter correlation radiometer
- 1° radius around each station
- Version 6, thermal infrared [Deeter, AMT, 2014]
- Daytime only, land pixels



[image:NASA]

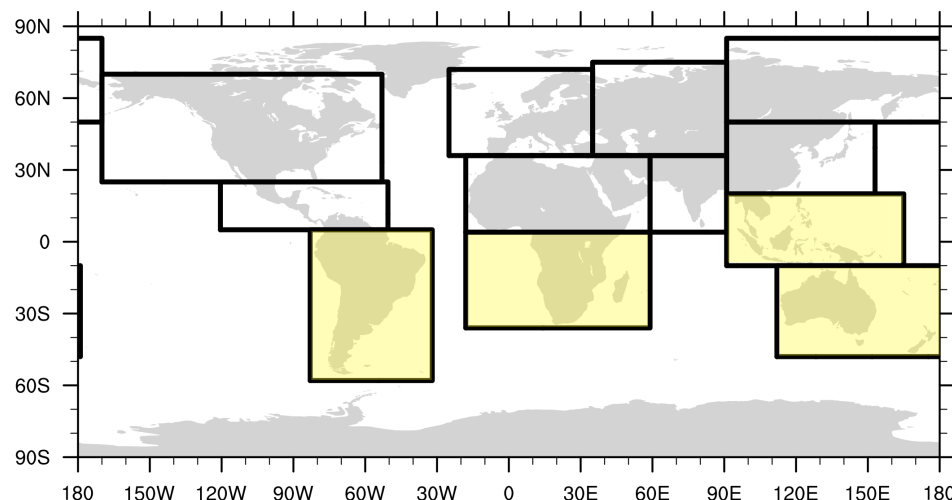
Exploit the different sensitivities of each instrument



- Different vertical sensitivity of instruments is implied by their averaging kernels (AK)
- MOPITT is most sensitive in the free troposphere
- Ground based FTS is sensitive throughout the column, including close to the surface

Quantifying contributions with modeling

- 14 tagged regions for biomass burning and anthropogenic CO
- Based on HTAP Tier 1 (www.htap.org)

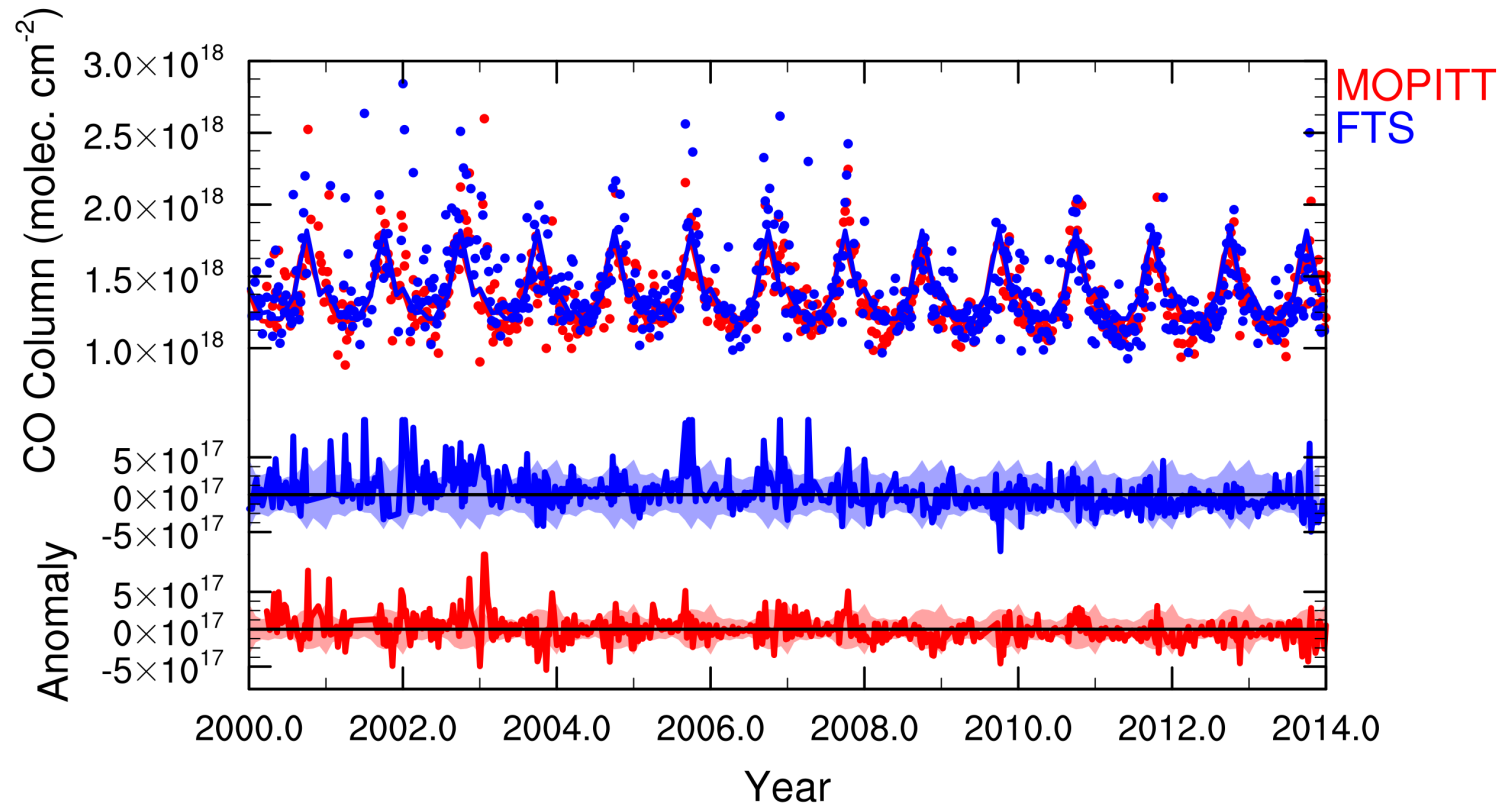


CAM4-chem within the CESM (v1.5 alpha) framework

Resolution	2.5° × 1.9°, 56 levels (~40 km model top)
Years Run	2001-2014 (spin-up 2000)
Meteorology	Nudged to NASA MERRA reanalysis (~10% relaxation)
Emissions	Fires: QFED_CO ₂ × FINN emission factors, Anthropogenic and Ocean: based on RCP 8.5 Biogenic: online MEGAN.
Chemistry	170 species, with over 400 reactions

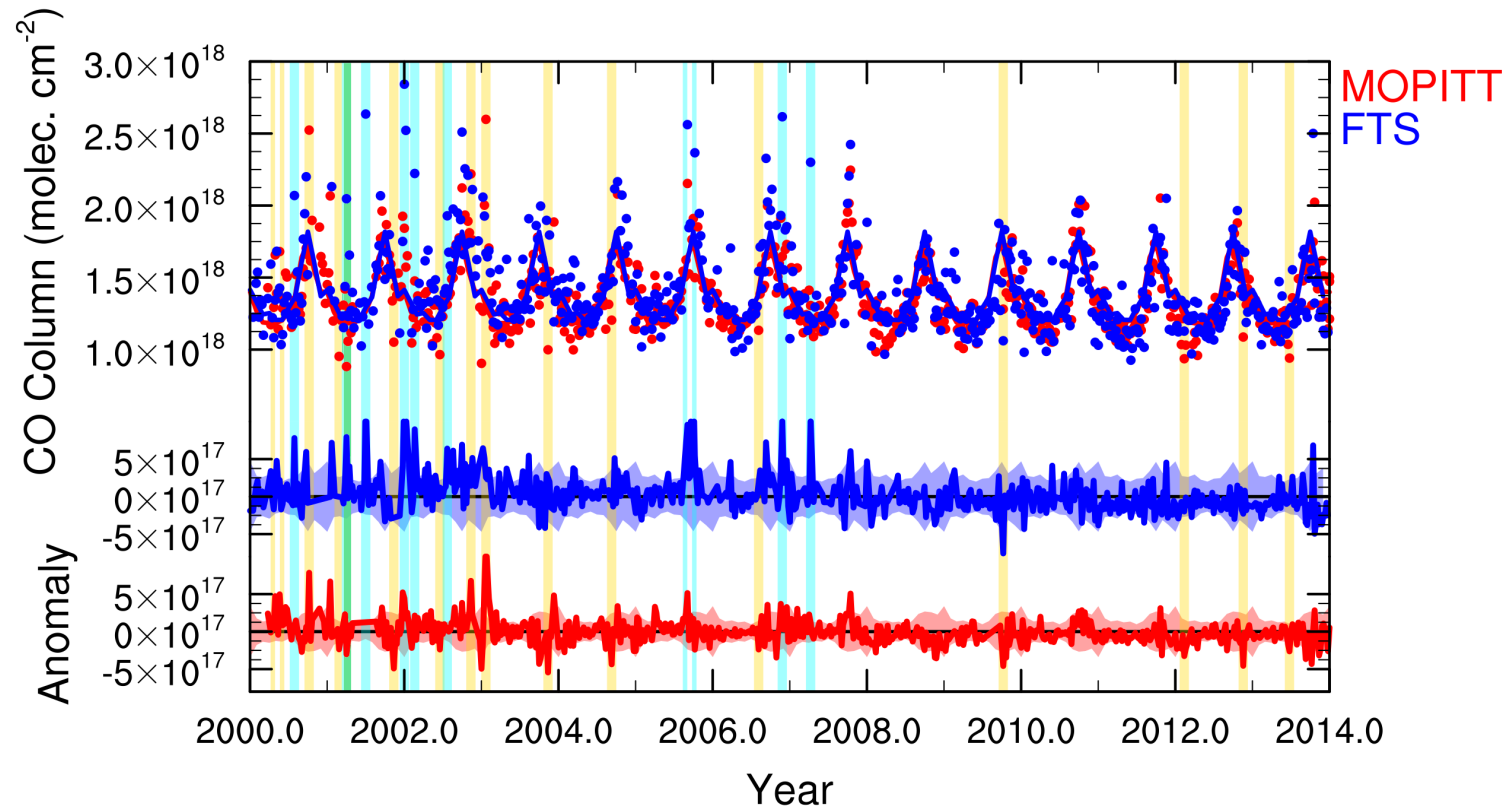
[Lamarque, GMD, 2012; Tilmes, GMD, 2015]

Timeseries and anomaly plots - Wollongong



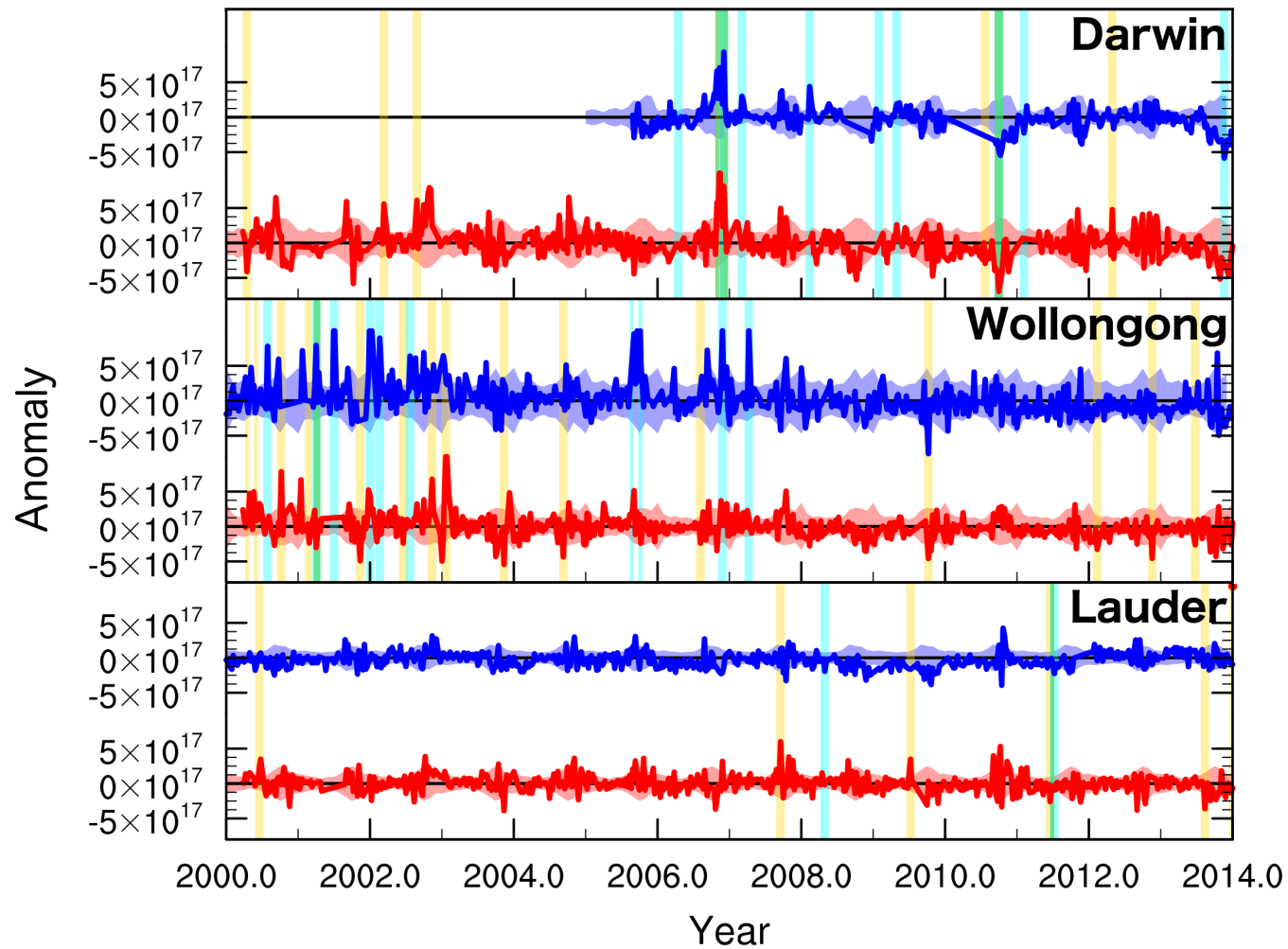
- Timeseries of weekly averaged total column CO.
- Seasonal cycle peaks in Sep–Oct due to Southern Hemisphere biomass burning season [Edwards, JGR, 2006].

Identifying events in the Wollongong records

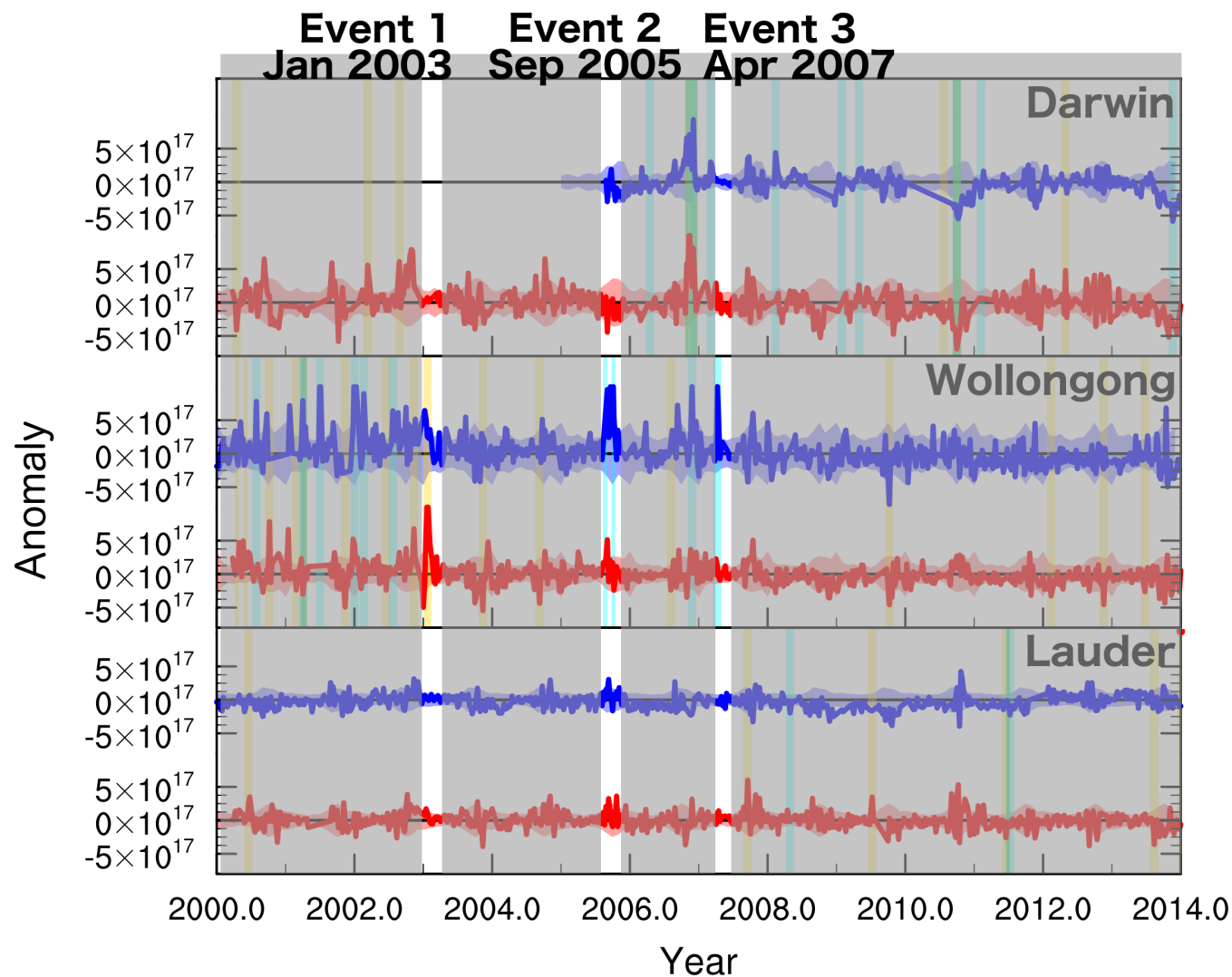


- Events: anomalies departing from seasonal climatology (vertical bars)
- Threshold: 2.5σ above
- Cyan — FTS-only, Gold — MOPITT-only, and Green — Both

Identifying events at all stations

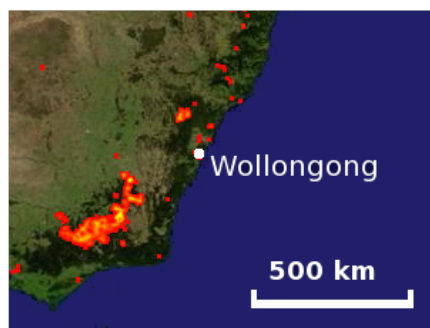
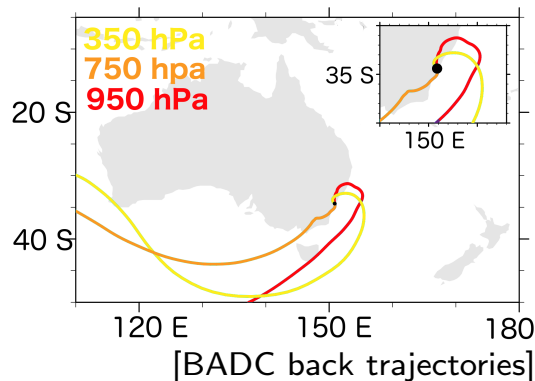
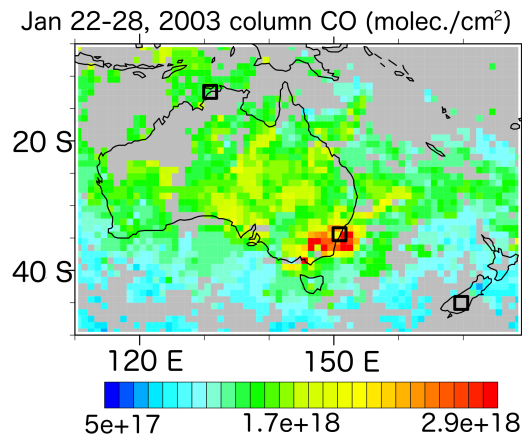


Identifying events at all stations



- Significant anomalies **1**, **2**, and **3** are discussed as case studies.
- Examples of long-distance, regional and local

1: Regional transported pollution (Jan 2003)

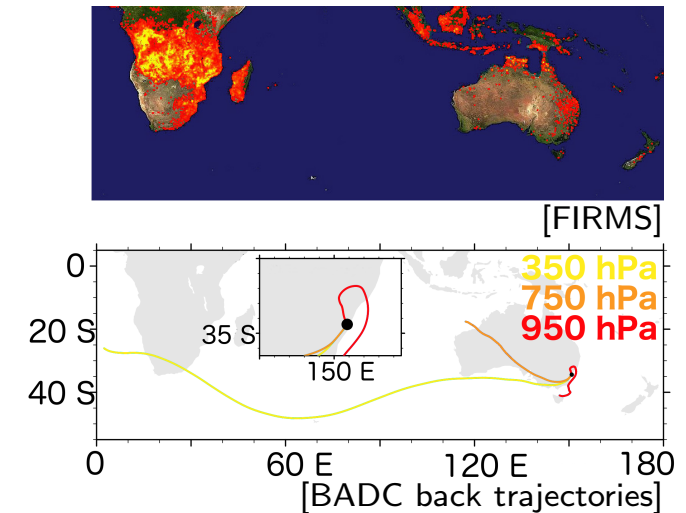
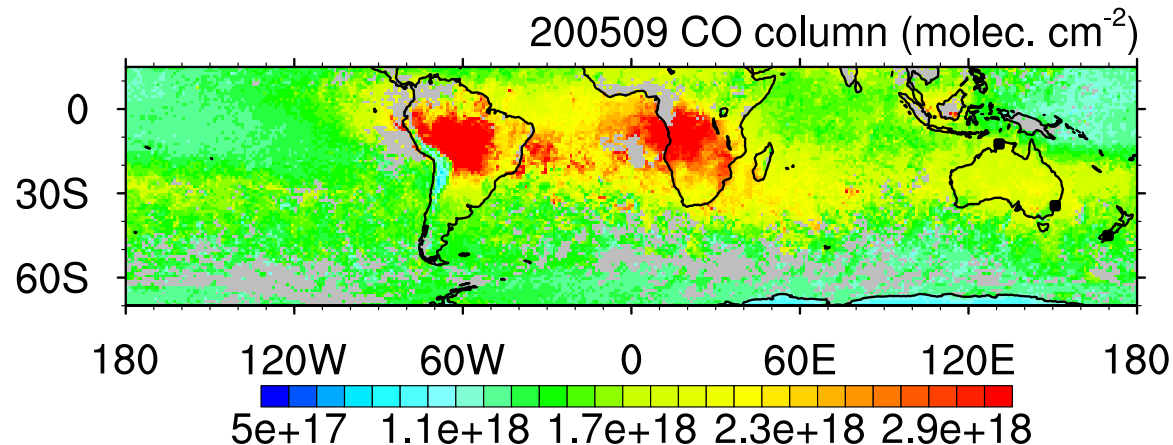


[FIRMS]

- Major fire in Canberra, Australia.
- Pollution injected into the upper troposphere via pyrocumulonimbus formation [Fromm, GRL, 2006].
- Trajectories: 750 hPa transport over fire region.
- CAM-chem: enhanced Australian fire contribution at Wol and Lau. Wol column is double the average.

	Dar		Wol		Lau	
% contribution	<i>Jan</i>	Jan 2003	<i>Jan</i>	Jan 2003	<i>Jan</i>	Jan 2003
All BB sources	12	12	16	49	13	21
Australian	6	6	9	44	5	14
SH Transported	3	3	5	3	6	6
Indonesian	0.4	0.5	0.2	0.1	0.2	0.2

2: Long-distance transported pollution (Sep 2005)

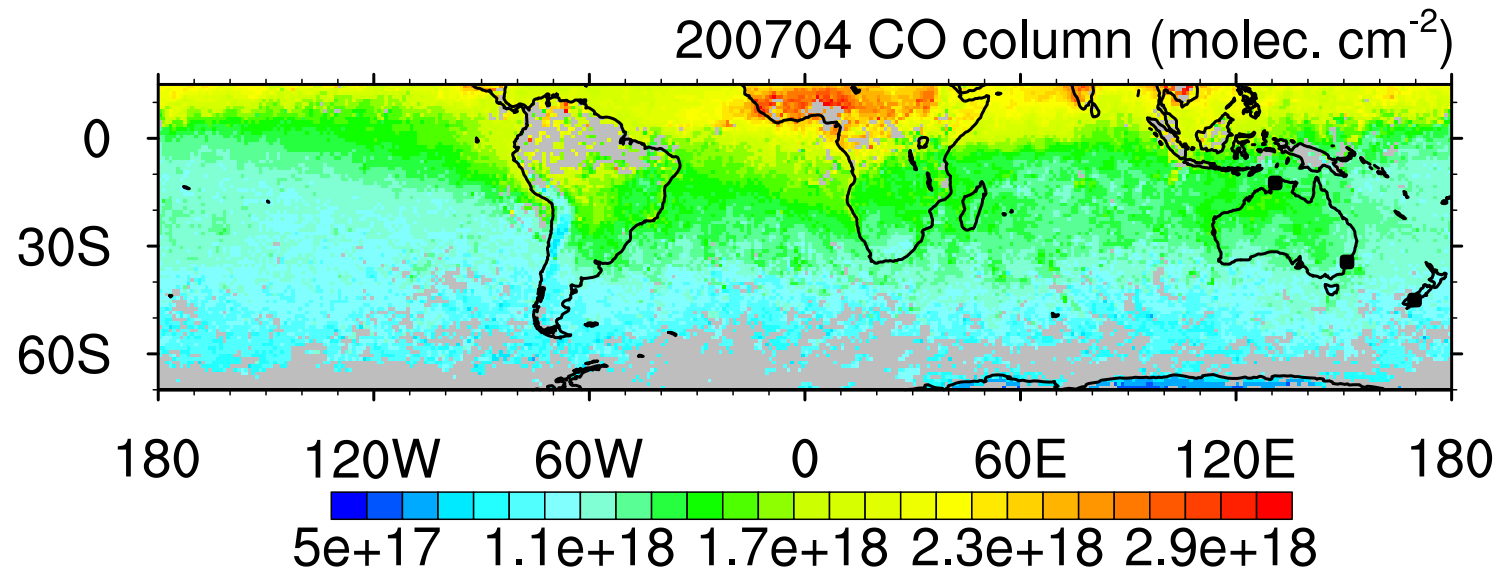


	Dar		Wol		Lau	
% contribution	Sep	Sep 2005	Sep	Sep 2005	Sep	Sep 2005
All BB sources	30	24	24	28	22	24
Australian	21	14	6	2	4	2
SH Transported	7	7	17	25	17	21
Indonesian	1.0	1.2	0.4	0.4	0.4	0.4

- MOPITT anomaly < FTS anomaly
- CAM-chem: transported SH fire influence.

- Trajectories and MOPITT: transported fire emissions from Africa.
- 950 hPa trajectory suggests FTS also samples regional fire.

3: Local Pollution (Apr 2007)



- FTS anomaly, no MOPITT anomaly.
- FTS operator noted a white haze in the Wollongong atmosphere.
- Trapped local urban/industrial pollution, not captured by MOPITT due to poor lower troposphere sensitivity.

- Low biomass burning; southern trajectories.

% contribution	Wol	
	<i>Apr</i>	Apr 2007
All BB sources	10	11
Australian	4	5
SH Transported	3	2
Indonesian	0.3	0.2

Summary

Instrument-specific sensitivities are valuable for interpreting contributions to atmospheric composition.

- Transported plumes of CO captured by satellite and ground based instruments.
- Satellite instrument MOPITT provides a regional (e.g. Canberra fires) and global context (e.g. SH transported fire emissions)
- FTS additionally measures local contributions to pollution in the lower troposphere.

CAM-chem is useful for quantifying source contributions.

Identified interesting events to explore further

- Transport between stations.
- Co-measured species

Acknowledgments:

AMS Mario J. Molina Symposium travel support

NCAR is sponsored by the National Science Foundation

FIRMS/LANCE system is operated by the NASA/GSFC ESDIS

Back trajectories provided by the BADC (British Atmospheric Data Centre) using ECMWF data

References



Deeter, M. N. et al., (2014), The MOPITT Version 6 product: algorithm enhancements and validation *Atmos. Meas. Tech.*, 7(11), 3623–3632



Edwards, D. P. et al. (2006), Satellite Observed Pollution From Southern Hemisphere Biomass Burning *J Geophys Res-Atmos* 111(D14), D14312



FIRMS data & imagery is from the Land Atmosphere Near-real time Capability for EOS LANCE, rapidfire.sci.gsfc.nasa.gov/cgi-bin/imagery/firemaps.cgi



Fromm, M. et al. (2006), Violent pyro-convective storm devastates Australia's capital and pollutes the stratosphere *Geophysical Research Letters* 33(5), 5815



Lamarque, J.-F. et al. (2012), CAM-chem: description and evaluation of interactive atmospheric chemistry in the Community Earth System Model *Geosci. Model Dev.* 5, 369–411



Tilmes, S., et al. (2015), Description and evaluation of tropospheric chemistry and aerosols in the Community Earth System Model (CESM1.2) *Geosci. Model Dev.* 8, 1395–1426