Australasian total column CO and H_2CO investigated with FTIR measurements, a Chemical Transport Model (GEOS-Chem) and an Earth-System Model (ACCESS)

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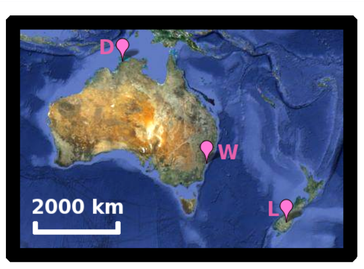
Introduction

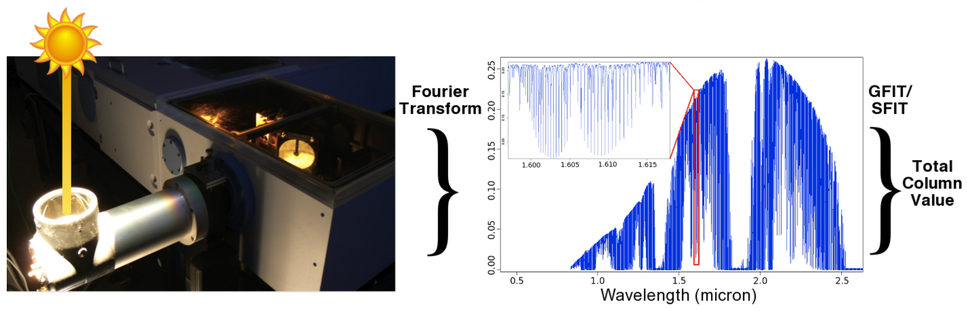
In this study, the tropospheric pollutants carbon monoxide (CO) and formaldehyde (H_2CO) are investigated at three sites in Australasia. Measurements of trace gases using ground based remote sensing Fourier Transform Infrared Spectrophotometers have been compared with simulations from two computational models: the global Chemical Transport Model (CTM), GEOS-Chem and the Australian Community Climate Earth-System Simulator, ACCESS. Comparison of a new Earth-System model with a well established CTM and measurements allows for insight into modelling strengths, as well as indicating areas requiring further development.

Total Column Measurements

- Fourier Transform Infrared Spectrophotometers (FTIR) were commissioned at the University of Wollongong (-34.406, 150.879) in 1996, Darwin (-12.425, 130.892) in 2005 and Lauder (-45.038, 169.684) in 1994.



- Molecules absorb solar radiation in the infrared region.



- Total column values are retrieved from infrared spectra via inverse methods using the programs GFIT[1] and SFIT[2].

Computational Models

ACCESS [3]
(UKCA v7.3)
http://www.accessimulator.org.au

GEOS-Chem [4]
(v8-03-01)
http://www.geos-chem.org

	Earth-System Model	Chemical Transport Model
Resolution	1.25° x 1.875° 38 levels (∼35 km)	2.0°x 2.5° 47 levels (∼80 km)
Years Run	1980 – 2000	2004 – 2009
Meteorology	MetUM simulated driven by SST	NASA GEOS5 reanalysis product
Emissions	Climatological mode: constant at year 2000, based on UKCA emission dataset for IPCC Assessment Report 4.	Biomass Burning, Anthropogenic, Biogenic etc. based on inventories and scaled for appropriate years.
Chemistry	46 species (excluding isoprene)	80 chemical species 150 reactions: Troposphere only
Surface Level Height	approx. 20 m	approx. 130 m

Timeseries Overlay

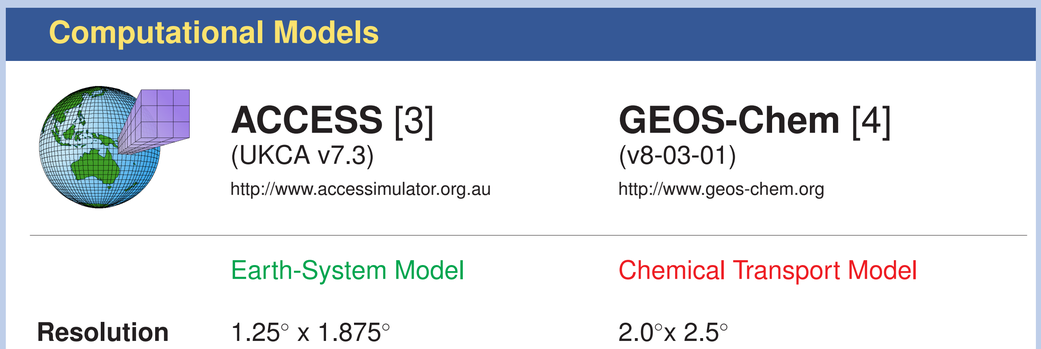
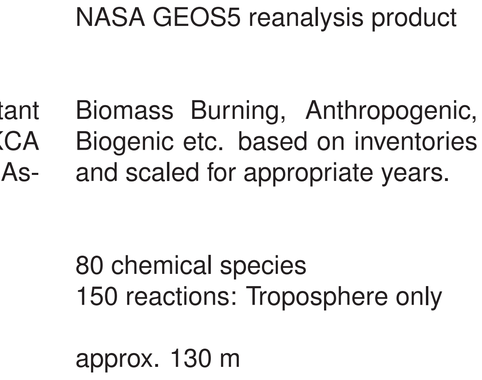


Figure 1: Monthly averaged total column CO over Wollongong.

Model Grid Comparison

- GEOS-Chem and ACCESS grids are mis-aligned.
- Surrounding grid box analysis is required to ensure results are statistically representative.

GEOS-Chem 2° × 2.5°
ACCESS 1.25° × 1.875°



Wollongong

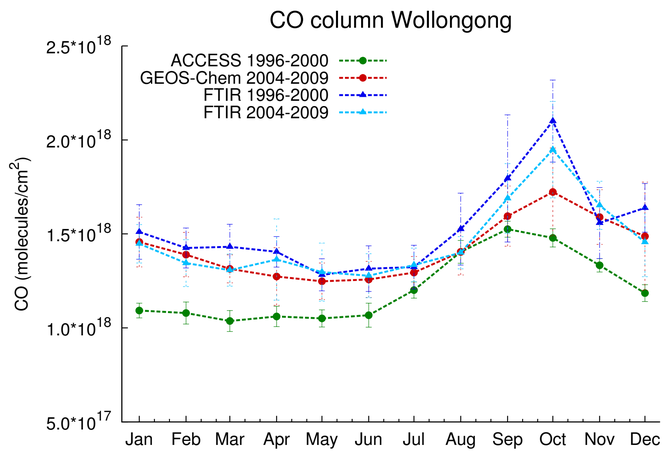


Figure 2: Wollongong CO column mean annual cycle for the overlap periods shown in Figure 1. GEOS-Chem reproduces the CO column well, while ACCESS underestimates and peaks a month early.

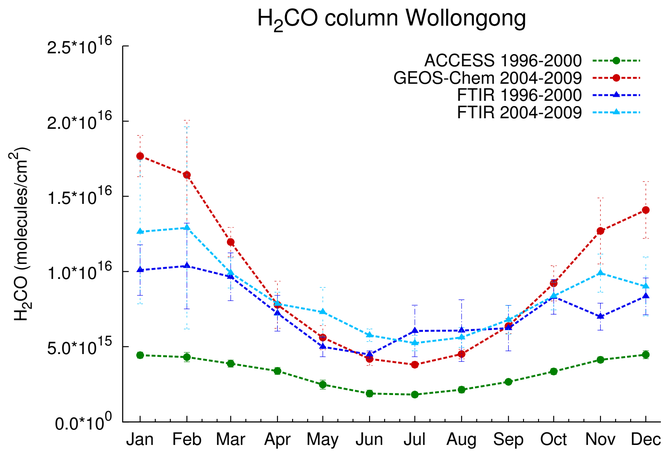


Figure 3: Wollongong H_2CO column mean annual cycle. GEOS-Chem reproduces H_2CO well, but overestimates during summer. ACCESS is consistently low.

Darwin

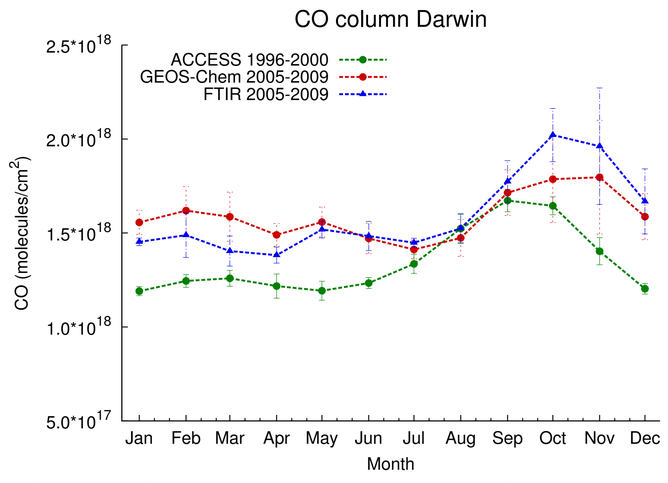


Figure 4: Darwin CO column mean annual cycle. GEOS-Chem reproduces the CO column acceptably while ACCESS underestimates and peaks a month early.

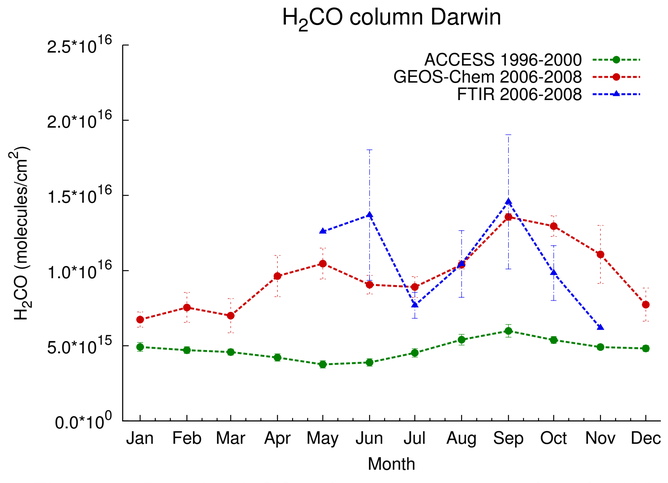


Figure 5: Darwin H_2CO column mean annual cycle. While both models reproduce the general pattern of available measurements, GEOS-Chem does better than ACCESS, which underestimates.

Lauder

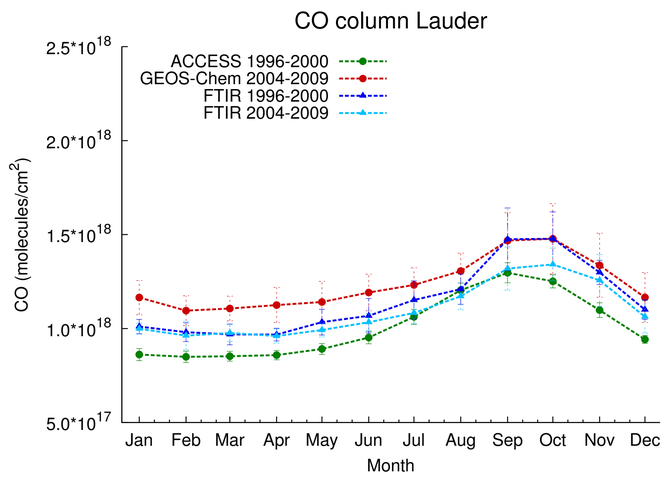


Figure 6: Lauder CO column mean annual cycle. GEOS-Chem overestimates CO column while ACCESS underestimates and peaks a month early. Measurements are from Zeng et al. 2012 [5].

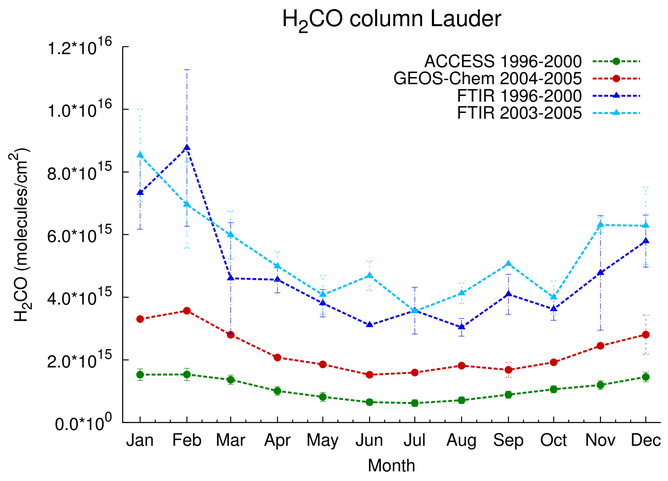


Figure 7: Lauder H_2CO column mean annual cycle. Both ACCESS and GEOS-Chem underestimate H_2CO column. Measurements are from Jones et al. 2009 [6].

Discussion and Further Research

Results indicate areas for improvement in ACCESS:

- **Emissions:** Low estimation for both trace gases at all sites and early annual peak for CO may indicate emission inventory inconsistency. Future simulations will include an emission inventory based on IPCC Assessment Report 5.
- **Chemistry:** Lack of isoprene and related chemistry can greatly affect CO and H_2CO column results (determined in a sensitivity study with GEOS-Chem, not shown). Future ACCESS simulations will implement a new isoprene scheme.
- **Meteorology:** Implementation of a meteorological nudging scheme is necessary to confirm the need for improvement in chemistry and/or emissions.

Overall, this study has analysed model validity and improved our understanding of seasonal variability and background concentrations of the target trace gases in the Australasian region.

References

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