Evaluating the influence of interhemispheric transport of Asian emissions on tropospheric composition in the Southern Hemisphere

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SUMMARY

We identify the sources of carbon monoxide (CO) transported to Australasia (Australia & New Zealand) using GEOS-Chem tagged tracer simulations and ground-based remote-sensing column measurements. We find that GEOS-Chem can accurately reproduce seasonal variability of CO at three Australasian sites ranging from the tropical north to the remote mid-latitudes.

Tagged tracer simulations indicate that the majority of observed CO is produced chemically from precursor emissions rather than emitted directly. This dominance points to the need to separate the influence of local versus transported precursor emissions.

Focusing on direct emissions, we find contributions from diverse sources, with biomass burning dominant during austral spring but not at other times of year. Fossil fuel pollution from Asia is predominantly transported in the upper troposphere and contributes to background CO in all seasons. This transport is visible in IASI satellite data. During individual events, the Asian source can be responsible for up to 30% of CO in the tropics and 10-20% at mid-latitudes.

1. Australasia is uniquely placed to evaluate interhemispheric transport

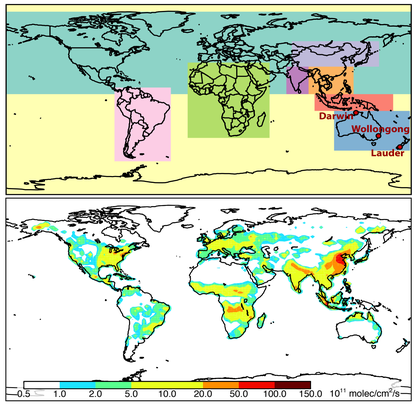
The Southern Hemisphere (SH) is characterised by low anthropogenic, high biogenic, and episodically large biomass burning emissions. Interhemispheric transport (IHT) from large emission sources in the Northern Hemisphere is thought to be inhibited by the transport barrier formed by the Intertropical Convergence Zone. But fossil fuel emissions from megacities in East and Southeast Asia have grown dramatically over recent years, pointing to a potentially growing influence in the SH.

- **Are megacity emissions from Asia sufficiently large to influence SH atmospheric composition, despite the transport barrier?**
- **By what means does IHT from Asia occur?**

Australasia is uniquely placed to address these questions due to geographical proximity and an established network of FTIR observations. Measurements span a latitudinal gradient of 12-45°S.

We use the GEOS-Chem v9-01-03 CO simulation, with regional tags defined to identify potential contributions from different source regions in Asia.

Initial simulations are for 2009, a year with lower-than-average fire emissions in the Southern Hemisphere.



Acknowledgements:
Darwin, Wollongong, and Lauder data are publicly available as part of the Network for the Detection of Atmospheric Composition Change (NDACC). This work was supported by a University of Wollongong Vice Chancellor's postdoctoral fellowship with the assistance of resources provided at the NCI National Facility systems at the Australian National University through the National Computational Merit Allocation Scheme supported by the Australian Government.

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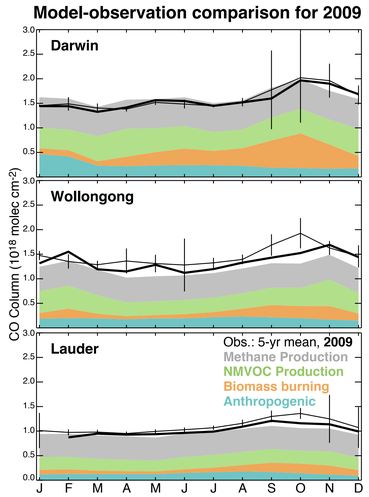
2. CO in the remote SH is dominated by the chemical production source

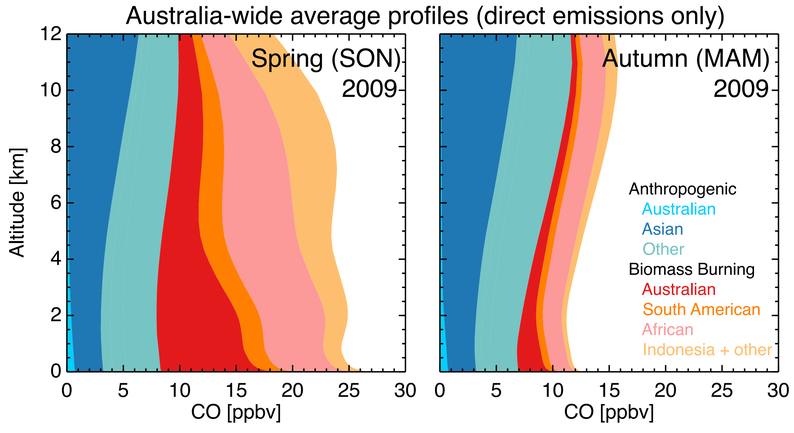


The figure compares simulated GEOS-Chem monthly mean CO total columns for 2009 with observations from FTIR sensors at Darwin (tropical, -12°S), Wollongong (urban, -34°S), and Lauder (remote, -45°S).

The **majority** of CO at all sites is **produced chemically** from precursor emissions (CH_4, NMVOCs).

Direct emissions show **similar** contributions from **anthropogenic and biomass burning sources**. The anthropogenic contribution peaks in austral summer.

3. Direct emissions from diverse sources contribute to Australasian CO



Asian sources contribute to **background** concentrations at all times of year.

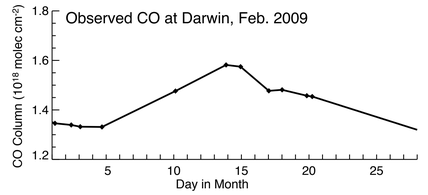
Biomass burning in Australia, South America, and Africa dominates the CO budget **only in austral spring**. (Note that South American burning was anomalously low in 2009, and a much larger influence from South America is seen in spring 2010).

The influence of different sources shows **altitude dependence**:

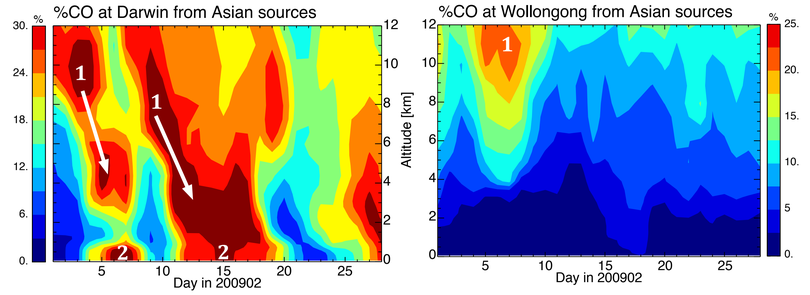
- Asian fossil fuel and Indonesian burning peak in the upper troposphere (>6 km)
- South American and African burning peak in the mid-troposphere
- Australian burning peaks in the lower troposphere (< 4 km).

4. Cross-equator transport of CO from Asia to tropics and mid-latitudes

A case study for February 2009 shows elevated CO at Darwin caused by IHT from Asia.

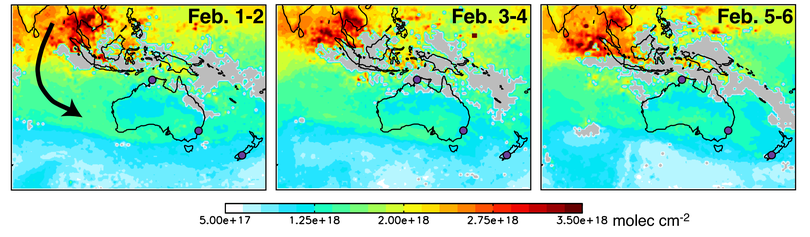


GEOS-Chem highlights **two pathways for interhemispheric transport** of anthropogenic CO from Asia (East Asia + Southeast Asia + India + Indonesia) across the equator to the tropics (Darwin) and mid-latitudes (Wollongong, Lauder).



1. Frequent **high-altitude transport** from East Asia and Southeast Asia, followed by **subsidence**
2. Occasional **surface incursion** of emissions from Indonesia and Southeast Asia, generally limited to the tropics

IASI satellite CO columns (weighted to mid- and upper troposphere) also show transport from NH sources across the Indian Ocean to sites in the SH mid-latitudes.



Ongoing work is focused on (1) identifying meteorological regimes that facilitate IHT; (2) characterising interannual variability in IHT; (3) analysing influence of transported chemical precursors; and (4) testing robustness using results from a new Southern Hemisphere model intercomparison (GEOS-Chem, UKCA, TM5, CAM-chem).

Interhemispheric transport of pollution from Asia can have large regional influence on Southern Hemisphere composition.

More work is needed to understand the pathways of this transport, as well as the role of local versus transported chemical precursors.