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 data. We find that GEOS-Chem can accurately reproduce seasonal CO distributions at three Australasian sites ranging from the tropical north to the remote mid-latitude.

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 for updated treatment of CO production in the tagged CO simulation.

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

Our motivating questions:
• Are there the relative influence of anthropogenic sources, but these have relied on satellite (MOPITT, SCIAMACHY) and ground-based data. The emphasis has been on massive, episodic biomass burning events, implying biomass burning is the dominant source of atmospheric pollution in the region. The potential influence of transported anthropogenic sources has largely been ignored.

Long-range transport of pollution to Australasia has previously been observed using satellite (MOPITT, SCIAMACHY) and ground-based data. The emphasis has been on massive, episodic biomass burning events, implying biomass burning is the dominant source of atmospheric pollution in the region. The potential influence of transported anthropogenic sources has largely been ignored.

A few studies have addressed the potential influence of anthropogenic sources, but these have relied on models validated only at northern mid-latitudes and have not assessed the relative influence of anthropogenic versus biomass burning sources.

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

Anthropogenic emissions are from EDGAR (globally), overwritten by Streets (Asia) and NPI (Australia). Biomass burning emissions are from GFED-3.

Initial simulations are for 2009, a year with no major Southern Hemisphere fires as well as available FTIR data.

The major CO at all Australasian sites is produced chemically from precursor emissions (CH4, VOCs). True attribution of pollution influence will require an updated treatment of chemical production in the tagged CO simulation (see box).

Direct emissions show similar contributions from anthropogenic and biomass burning sources at all sites. Biomass burning is large in the tropics during the burning season, and fossil fuel sources dominate in austral summer.

We suggest an updated implementation:
1. Run tagged CO with archived P(CO)
2. Remove special scaling factors
3. Assume all other CO produced comes with full chemistry in a number of ways:
   - Short-lived VOCs are accounted for with yields
   - CH4 chemical production in the tagged CO simulation (already assumed in tagged CO)
   - CH4 emissions from Indonesia and Southeast Asia, 2.000 E+6 peterfs. The burning influence is minimal outside this region.

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The figure compares simulated GEOS-Chem monthly mean CO total columns with observed CO from FTIR sensors at Darwin (tropical northern Australia: -12°S), Wollongong (urban southeast Australia: -34°S), and Lauder (remote New Zealand: -45°S).

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Direct emissions show similar contributions from anthropogenic and biomass burning sources at all sites. Biomass burning is large in the tropics during the burning season, and fossil fuel sources dominate in austral summer.

We suggest an updated implementation:
1. Save P(CO) and L(CH4) from full chem
2. Assume the CO yield from CH4 is 100% (already assumed in tagged CO)
3. Assume all other CO produced comes from lumped NMOCs
4. Then P(CO) = L(CH4)
5. And P(CO) = CO / (P(CO) - P(CH4))
6. Remove special scaling factors
7. Run tagged CO with archived P(CO)
8. Tag CO produced from NMOCs by location of production (like for Ox)

Note: in the tropical lower troposphere, L(CH4) > total P(CO) - likely due to vertical transport of intermediate products. Extratropical CO impacts should be small.

References:

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Future Directions:
• Update simulations with new tagged chemical production (see box)
• Use GEOS-Chem combined with satellite data (MLS + IASI) to identify meteorological regimes that facilitate inter-hemispheric transport
• Characterise seasonal & interannual variability in interhemispheric transport
• Use results from Southern Hemisphere Model Intercomparison Project (UKCA, TM5, CAM-chem, GEOS-Chem) to test robustness of results