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Time series of CO, CO2 and CH4 as a function of altitude above Molokai, Hawaii and Rarotonga, Cook Islands

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Since 1999, vertical profiles of carbon monoxide (CO) have been determined as part of the validation plan for the MOPITT instrument (positioned on the TERRA satellite). Air samples were collected bimonthly with 300-500 m resolution between 0.5 and 8 km above Poker Flats, Alaska (65.1N 147.5W), Harvard Forest, Massachusetts (42.5N 71.2W), Molokai, Hawaii (21.4N 157.2W) and Rarotonga, Cook Islands (21.2S 159.8W). Carbon dioxide (CO2) and methane (CH4) were also measured. The data provide unique insight into the distributions, seasonal cycles and interannual changes of these gases above the surface. A key feature of the over 500 measured profiles is their high degree of variability in both time and vertical distribution. Within a profile, discreet enhancements in one species are often mirrored in the other carbon gases suggesting a common source. Back-trajectory analysis typically fails to identify source regions. In this paper, we compare results from above Hawaii and Rarotonga. Above Molokai, the seasonal cycles of the three gases are well defined The timing of the seasonal maximum and minimum at altitude lag up to a month behind the surface and amplitudes of the cycles decrease with altitude. In the low Southern Hemisphere, the seasonal amplitude is greater at altitude and more similar in timing throughout the column. Seasonal cycles simulated with the TM5 chemical transport model compare well with the measurements. Average trends for one km vertical bins were determined from a smooth curve fit to the measurements. Average rates of change in CO and CH4 above Hawaii appear greatest near the surface and decrease with altitude, while above Rarotonga changes in CO and CH4 were greater at the higher altitudes. Changes in CO2 were nearly constant with altitude at both sites. The gas distributions and trends at the two locations are discussed in light of their surface sources and vertical and meridional transport.