Carbon Monoxide Climatology derived from the Trajectory Mapping of Global MOZAIC-IAGOS Data

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Abstract

A three-dimensional gridded climatology of carbon monoxide (CO) has been developed by trajectory mapping of global MOZAIC-IAGOS in situ measurements from commercial aircraft data. CO measurements made during aircraft ascent and descent, comprising nearly 41,200 profiles at 148 airports worldwide from December 2001 to December 2012 are used. Forward and backward trajectories are calculated from meteorological reanalysis data in order to map the CO measurements to other locations, and so to fill in the spatial domain. This domain-filling technique employs 15,800,000 calculated trajectories to map otherwise sparse MOZAIC-IAGOS data into a quasi-global field. The resulting trajectory-mapped CO dataset is archived monthly from 2001-2012 on a grid of 5° longitude×5° latitude×1 km altitude, from the surface to 14 km altitude.

The mapping product has been carefully evaluated, first by comparing maps constructed using only forward trajectories and using only backward trajectories. The two methods show similar global CO distribution patterns. The magnitude of their differences is most commonly 10% or less, and found to be less than 30% for almost all cases. The ~~trajectory-mapped CO dataset~~method has also been validated by ~~comparison~~ comparing profiles for individual airports with those produced by the mapping method when data from that site are excluded. While there are larger differences below 2 km, the two methods agree very well between 2 and 10 km with the magnitude of biases within 20%. Finally, the mapping product is compared with global MOZAIC-IAGOS cruise-level data, which were not included in the trajectory-mapped dataset, and with independent data from the NOAA aircraft flask sampling program.

Maps are also compared with Version 6 data from the Measurements Of Pollution In The Troposphere (MOPITT) satellite instrument. Both data sets clearly show major regional CO sources such as biomass burning in central and southern Africa and anthropogenic emissions in eastern China. While the maps show similar features and patterns, and ~~agreement is good~~relative biases are small in the lowermost troposphere, ~~the MOPITT CO profile shows negative biases~~we find differences of ~20% in CO volume mixing ratios between 500 hPa and 300 hPa. These upper troposphere biases are not related to the mapping procedure, as almost identical differences are found with the original in situ MOZAIC-IAGOS data. The total CO trajectory-mapped MOZAIC-IAGOS ~~climatology~~ column ~~agrees with~~is also higher than the MOPITT CO total column, by ~~within ±5~~12-16%~~, which is consistent with previous reports~~.

~~The maps clearly show major regional CO sources such as biomass burning in the central and southern Africa and anthropogenic emissions in eastern China.~~ The dataset shows the seasonal CO cycle over different latitude bands and altitude ranges ~~that are representative of the regions~~ as well as long-term trends over different latitude bands. We observe a decline in CO over the northern hemisphere extratropics and the tropics consistent with that reported by previous studies using other data sources.

~~Similar maps have been made using the concurrent O_3 measurements by MOZAIC-IAGOS, as the global variation of O_3-CO correlations can be a useful tool for the evaluation of ozone sources and transport in chemical transport models.~~ We anticipate use of the trajectory-mapped MOZAIC-IAGOS CO dataset as an a priori climatology for satellite retrieval, and for air quality model validation and initialization.