

First Look at the NOAA Aircraft-based Tropospheric Ozone Climatology in Colorado

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The Global Greenhouse Gas Reference Network Aircraft Program of ESRL/GMD has, for over a decade, sampled spatial and temporal variability in atmospheric trace constituents, including ozone, in Northern America. The method to derive tropospheric ozone climatology from the light aircraft measurements equipped with the 2B Technology instruments is described in this paper. Since ozone instruments at most of aircraft locations are flown once a month, this raises the question of whether the low sampling frequency allows for a representative vertical ozone climatology that can adequately capture tropospheric seasonal and vertical variability over various locations in U.S. and west coast Canada. An interpretation the representativeness of seasonal and vertical variability of tropospheric ozone climatology is derived from these under-sampled observations using hindcast simulations conducted with the Geophysical Fluid Dynamics Laboratory chemistry-climate model (GFDL-AM3). This study focuses on ozone measurements from monthly aircraft profiles over the Front Range of Colorado and weekly ozonesondes launched in Boulder, CO. The climatology is presented as monthly values separated in 5th, 25th, 50th, 75th, 95th percentiles, and averaged at three vertical levels: lower (1.6-3 km), middle (3-6 km), and upper (6-8 km) troposphere. The aircraft-based climatology is compared to the climatology derived from the co-located ozonesondes launched from Boulder, Colorado, from GFDL-AM3 co-sampled sparsely in time, and from GFDL-AM3 continuous daily samples. This study analyzed the limit in the sampling frequency that is recommended for ozone profile measurements in order to obtain adequate representation of ozone climatology in the free troposphere. The 3-hour sampled AM3 model was used as the benchmark reference for comparisons with less frequent sub-sampled time series. It was found that a minimum of 3 soundings per month was required to match the 95% confidence level of the fully sampled ozone climatology (12 monthly mean values) for vertical profiles averaged over 1.6-3 km. One sounding per month was sufficient frequency for obtaining a monthly climatology for 3-6 km averaged ozone that matched the 95% confidence limit of the daily sampled climatology, while 8 soundings limit was required for ozone climatology averaged over 6-8 km layer. It was also found that months March, April, and May have the highest ozone variability in the Colorado Front Range area that is observed at the altitudes between 6 and 8 km. This concludes that a once-a-month ozone profiling by the light commercial aircraft flown over the Colorado Front Range from 2005 through 2014 provides 95% confidence in the ozone climatology constructed from measurements limited to the altitudes from 3 to 6 km.

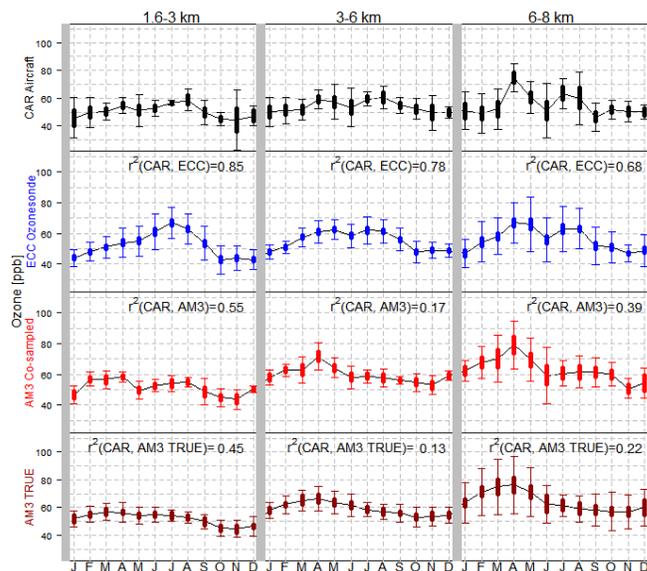


Figure 1. Seasonal ozone climatology along Front Range, CO. Shown are monthly median climatologies derived from ECC ozonesonde observations (O_3So) (blue), simulated results of the continuously daily sampled (O_3AM3) (red) and co-sampled GDFL AM3 model (O_3AM3S) (dark blue). The model is co-sampled to match the dates of ozonesonde flights. The box and arrow plots represent the standard error and standard deviation for each monthly median value. Climatologies are taken at altitudes of 1-6-3 km, 3-6 km, and 6-8 km. Climatologies are compared from 2004 to 2014.