Using Self-Organizing Map (SOM) Clusters to Create Ozonesonde-based Climatologies and Characterize Linkages among US Ozone Profile Variability and Pollution

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A typical way to formulate O\textsubscript{3} climatologies is to average ozonesonde profiles on a monthly or seasonal basis, either for specific regions (Tilmes et al., 2012) or zonally (Labow et al., 2015). However, the variability we are trying to capture in a tropospheric climatology reflects meteorological conditions that may not be confined to a particular season. We demonstrate the advantages of using a statistical clustering technique, self-organizing maps (SOM; Jensen et al., 2012), over simple averaging, through analysis of more than 4500 sonde profiles taken from the long-term US sites at Boulder, CO; Huntsville, AL; Trinidad Head, CA; and Wallops Island, VA. First, we apply SOM to O\textsubscript{3} mixing ratios from surface to 12 km (above MSL). At all four sites, profiles in SOM clusters exhibit similar tropopause height, 500 hPa height and temperature, and total and tropospheric column O\textsubscript{3}. Second, when profiles from each SOM cluster are compared to monthly O\textsubscript{3} means, near-tropopause O\textsubscript{3} in three of the clusters is double (over +100 ppbv) the climatological O\textsubscript{3} mixing ratio. The three clusters include 13–16% of all profiles, mostly from winter and spring. Large mid-tropospheric deviations from monthly means (-6 ppbv, +7 – 10 ppbv O\textsubscript{3} at 6 km) are found in two highly-populated clusters with a combined 36–39% of profiles. The latter clusters represent both distinctly polluted (summer) and clean O\textsubscript{3} (fall-winter, high tropopause) profiles. Thus, SOM indeed appear to represent US O\textsubscript{3} profile statistics better than conventional climatologies. In the case of Trinidad Head, SOM clusters of O\textsubscript{3} profile data from the lower troposphere (surface–6 km above MSL) can discriminate background vs polluted O\textsubscript{3} and the conditions linked with each. Two of nine O\textsubscript{3} clusters exhibit thin layers (∼100s of m thick) of high O\textsubscript{3}, typically between 1 and 4 km, and residing above a subsidence inversion associated with a northern location of the semi-permanent Pacific subtropical high. Ozone in these clusters is upwind of high-altitude surface O\textsubscript{3} monitors at inland locations. The surface O\textsubscript{3} monitors at Lassen Volcanic and Yosemite National Parks, and Truckee, CA, display a marked impact of the elevated tropospheric O\textsubscript{3}. Days corresponding to the high O\textsubscript{3} clusters exhibit hourly surface O\textsubscript{3} anomalies at these sites of +5 –10 ppbw compared to a climatology; the anomalies can last up to four days.