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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_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_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_3. Second, when profiles from each SOM cluster are compared to monthly O_3 means, near-tropopause O_3 in three of the clusters is double (over +100 ppbv) the climatological O_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_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_3 (fall-winter, high tropopause) profiles. Thus, SOM indeed appear to represent US O_3 profile statistics better than conventional climatologies. In the case of Trinidad Head, SOM clusters of O_3 profile data from the lower troposphere (surface–6 km above MSL) can discriminate background vs polluted O_3 and the conditions linked with each. Two of nine O_3 clusters exhibit thin layers ($\sim$100s of m thick) of high O_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_3 monitors at inland locations. The surface O_3 monitors at Lassen Volcanic and Yosemite National Parks, and Truckee, CA, display a marked impact of the elevated tropospheric O_3. Days corresponding to the high O_3 clusters exhibit hourly surface O_3anomalies at these sites of +5 –10 ppbv compared to a climatology; the anomalies can last up to four days.