4.2. Special Projects

4.2.1. Evidence for the Influence of Biomass Burning on Tropospheric Ozone in Both the Eastern and Western Tropical Pacific

Beginning in August 1995, as part of the Pacific Exploratory Mission (PEM) Tropics A, ozone vertical profile measurements were started at the airport in Pago Pago, American Samoa (14.5°S, 170.5°W) and Papeete, Tahiti (14.5°S, 150.5°W). Profile measurements were continued at Tahiti and Samoa through PEM Tropics B with the program at Tahiti completed in December 1999. At Samoa weekly soundings continue as part of the SHADOZ project. During most of the measurement period, soundings were done weekly. During two aircraft field campaigns in September-October 1996 (PEM Tropics A) and March-April 1999 (PEM Tropics B), soundings were done twice a week. In January 1997 weekly soundings were begun at Suva, Fiji (18.0°S, 170.0°W). As part of the SOWER project, ozone profile measurements were started on a campaign basis in March 1998 at San Cristóbal, Galapagos, and were upgraded to biweekly soundings in September 1998, and to weekly soundings as part of SHADOZ early in 1999. The ozone vertical profiles were obtained using the electrochemical concentration cell (ECC) ozonesonde [*Komhyr et al*., 1995]. This has become a standard technique for obtaining ozone profiles with high vertical resolution in both the troposphere and stratosphere to altitudes of approximately 35 km. For the purpose of characterizing the tropospheric airflow patterns influencing transport to the tropical sites, isentropic trajectories were calculated. The trajectories are computed from the ECMWF analysis using the model described in *Harris and Kahl* [1994].

Variations on the order of several days and the seasonal cycle are the two largest sources of the variability seen in tropospheric ozone at the Pacific tropical sites studied here. These variations were studied from surface observations at Samoa [*Harris and Oltmans*, 1998] and were found to result from changes in airflow to the site that tapped different sources and sinks. In the middle troposphere (2-10 km) both the shorter term and seasonal variability are primarily associated with the appearance of layers with enhanced (>70 ppbv) ozone mixing ratios (Figures 4.6 and 4.7). These peaks occur primarily during the August-October time period. This leads to a seasonal maximum in this layer during the austral spring at both the western and eastern Pacific sites. At the western Pacific sites there is prominent westerly flow during all times of the year, but it is more frequent and more vigorous during the austral spring. At the Galapagos, on the other hand, easterly flow dominates in the midtroposphere and is particularly pronounced in the austral spring. An important difference between the western and eastern Pacific is the very low ozone amounts throughout the troposphere during the summer and early autumn (December-April) in the western Pacific. Although this is also the time of the seasonal minimum in the troposphere at the Galapagos, mixing ratios do not get nearly as low above the boundary layer as in the western Pacific. This reflects the greater influence of convection in the west in mixing boundary layer ozone throughout the troposphere.

The tropics are known to be a significant area of biomass burning (see TRACE A and SAFARI, Special Issue of the *Journal of Geophysical Research*, *101*, 1996). An ozone profile with an enhanced midtropospheric layer, often seen during the September and October period, is shown in Figure 4.6 for a sounding done at SMO. The peak ozone mixing ratio of 105 ppbv at ~6 km for the October 30, 1998, profile at SMO has a trajectory that reaches back to southern Africa 10 days prior to the sounding. Biomass burning heavily influences ozone in this region [*Fishman et al*., 1996]. Trajectories identified with peaks greater than about 70 ppbv do not always reach back to Africa in 10 days, but they always have paths that have a strong westerly component that goes to the west of Australia into the Indian Ocean. On many occasions the trajectories pass over Australia but usually through the middle or southern part of the continent.

In the Galapagos the profiles also show a similar midtropospheric peak, e.g., October 9, 1999 (Figure 4.7). The trajectory for this event crosses Brazil in less than 10 days over a region that is also heavily impacted by biomass burning [*Fishman et al.*, 1996]. Investigation of each profile with an enhanced ozone layer in the midtroposphere during this time of the year showed a trajectory that passed over Brazil.

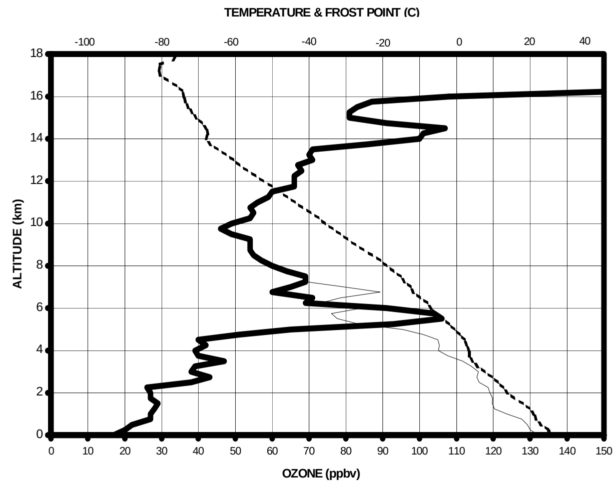

Fig. 4.6. Ozone mixing ratio (thick line), temperature (dashed line), and frost-point temperature (thin line) profiles at Pago Pago, American Samoa, for October 30, 1998.

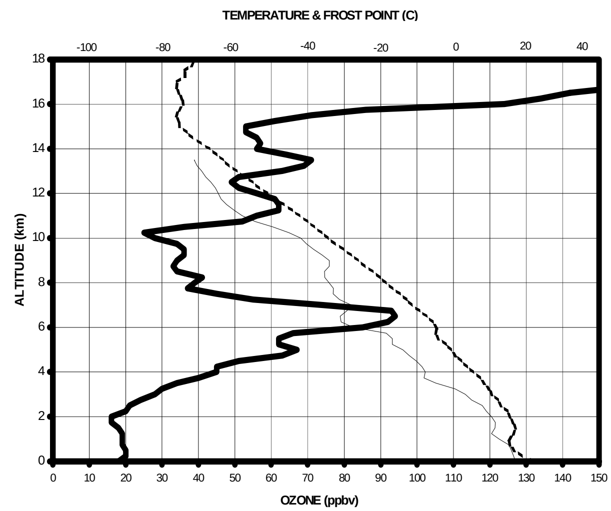

Fig. 4.7. Ozone mixing ratio (thick line), temperature (dashed line), and frost-point temperature (thin line) profiles at San Cristóbal, Galapagos, for October 9, 1999.

In 1997 extensive burning took place in Indonesia associated with drought conditions that were a consequence of the strong El Niño. Several studies have shown high ozone amounts in Indonesia and Malaysia in connection with the burning in the region [e.g., *Fujiwara et al*., 1999]. At the western Pacific sites, the incidences of elevated midtropsopheric ozone begin to decline in most years by mid-November. On November 19 and 20 at Fiji and Samoa, some of the highest tropospheric ozone amounts were seen for any event recorded at these sites, and they extended from above the boundary layer to the tropopause. These enhancements increased the total tropospheric column by about 20 DU or more than 70% over average values for the month. The trajectories show that at both sites the air was coming from Indonesia. Although these profiles were the only ones measured during the event, the trajectories show that the flow persisted for about 5 days around the time that the profiles were obtained.