Geophysical Research Abstracts
Vol. 13, EGU2011-6541, 2011
EGU General Assembly 2011

Examination of the atmospheric conditions associated with high and low vertical ozone measurements in the lower troposphere over the Eastern Mediterranean

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Vertical ozone profiles measured in the period 1994–2008 in the framework of the MOZAIC project (Measurement of Ozone and Water Vapor by Airbus in Service Aircraft) for flights connecting Central Europe to the Eastern Mediterranean basin (Cairo, Tel-Aviv, Heraklion and Rhodes, Antalya) were analyzed in order to evaluate the observed high rural ozone levels in the Eastern Mediterranean area during summertime. In total 237 summer (JJA) profiles were analyzed with the following distribution: Cairo, Egypt (94 profiles), Tel-Aviv, Israel (85 profiles), Heraklion-Rhodes, Greece (36 profiles) and Antalya, Turkey (22 profiles).
The average profiles for the 7% highest and the 7% lowest ozone mixing ratios for the above mentioned Eastern Mediterranean airports have been examined and the corresponding composite maps of geopotential heights for the height layers 0-500m, 500-1000m, 1000-1500m, 1500-3000m and 3000-5000m, together with the corresponding back-trajectories, have been plotted. In general the highest ozone values in the troposphere of all examined Eastern Mediterranean airports are associated with the strengthening of the north African anticyclone and its extension towards Central Europe or the Balkans, transporting ozone and precursors, in association with subsidence over Eastern Mediterranean resulting to northerly component of the boundary layer flow. On the other hand the lowest ozone values are associated with low-pressure systems covering Central and Eastern Europe leading to westerly circulation over Mediterranean towards the eastern region diffusing the air pollutants but also with the deepening and extension of the permanent summertime Middle-East low-pressure system. It comes out that these characteristic synoptic weather patterns, corresponding to highest and lowest ozone, are quite uniform throughout the lower troposphere, from the ground level to at least 5 km (500 hPa) and usually these characteristic synoptic weather patterns are present for several days before the selected measurement.

For the 7% highest ozone days at 1000-1500m asl, very dry (5-20% relative humidity) air masses are observed from the top of the boundary layer up to 5 km indicating upper-tropospheric (or stratospheric origin), while for the lowest ozone, the relative humidity is substantially higher in the same atmospheric region (up to 60-70%), indicating uplifting of boundary layer air-masses towards the lower troposphere. The wind speeds in the 2-5 km height layer are higher for the lower ozone cases, as would have been expected for cyclonic activity. Also the temperature gradient in the lower troposphere is steeper for the lowest ozone days indicating vertical instability favoring the uplifting of boundary layer air masses to higher levels. The CO profiles corresponding to the highest ozone cases show in general a concentration increase while descending towards the lower troposphere, indicating the presence of polluted air masses favoring photochemistry and producing ozone. In general, the vertical maximum ozone concentrations are observed just above the boundary layer. Within the boundary layer, ozone is decreased on average in all airports, especially in Tel-Aviv and Cairo, which might be attributed mainly to the influence of nitrogen oxides originating from local urban pollution as well as of atmospheric particles of mainly natural origin (desert dust).