Ozone climatology at two southern subtropical sites: Irene, South Africa, and Reunion Island

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INTRODUCTION

This study is based on a multi-instrumental dataset : **PTU-O_3 radiosoundings, DIAL LIDAR, MOZAIC airborne instrumentation and Dasibi UV ground based measurements.**

Ozone profiles are **available since the early 1990s** at Reunion and Irene. Both sites joined the SHADOZ network in 1998. MOZAIC and LIDAR databases show a great number of profiles (Table 1) but the profiles are sporadically distributed in time compared to the SHADOZ data.

This poster displays a climatological study of tropospheric ozone in the southern subtropics (fig. 2), a comparison between Radiosonde and DIAL LIDAR seasonal profiles (fig. 3) and a comparison between Radiosonde and a Dasibi UV instrument data.

	Number of years of data	Total number of profiles	vertical range of data
SHADOZ Radiosoundings Reunion	8	269	sea level -30 km
SHADOZ Radiosoundings Irene	8	208	1524 m -30 km
LIDAR Reunion	8	265	3 km -16 km
MOZAIC Johannesburgh	9	577	1km – 12 km

Table 1 : Features of the ozone database: period of measurements, total number of ozone profile and altitude range. [3]

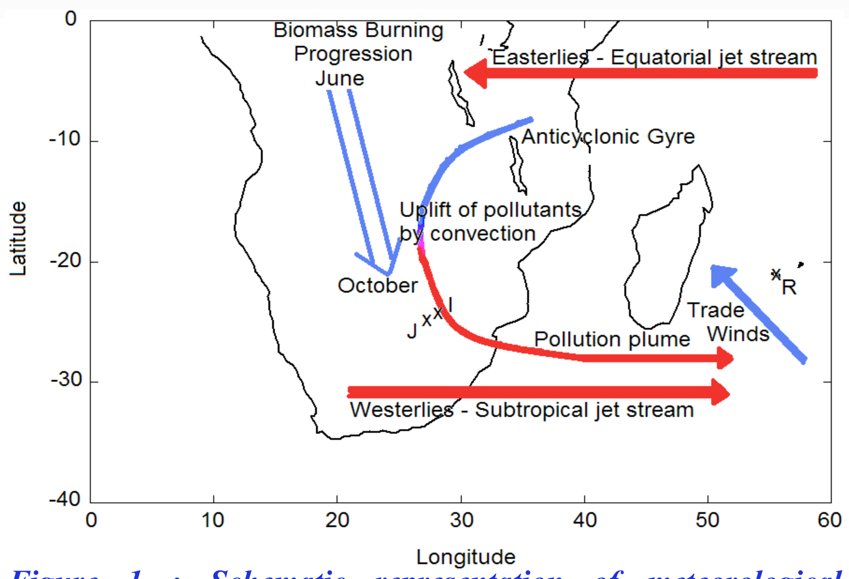

Figure 1 : Schematic representation of meteorological processes and sources affecting tropospheric ozone over subequatorial Africa. [5] *The locations of Johannesburg, Irene, and Reunion are represented by 'J','I'and 'R' respectively.*

GEOPHYSICAL CONTEXT AND OZONE SOURCES

Reunion is located in the subsidence area of the Southern Hemisphere Hadley cell. The island meteorology is subject to subtropical, tropical and temperate influences on the general circulation, namely the south Indian anticyclone, the subtropical jet stream, and perturbations carried in the westerlies [9].

The atmospheric circulation at **Irene** (25.9°S, 28.22°E) is dominated by the subtropical anticyclone within which subsidence and recirculations cause the accumulation of pollutants on large temporal and spatial scales [6,8,10]. A 5km deep haze layer is formed over the southern African subcontinent, capped by a stable and persistent layer [4]. The system is disrupted when a mid-latitude westerly wave crosses the south of the African subcontinent. The 5 km stable polluted layer is then spread out. Trace gases including ozone precursors and aerosols circulate inside the stable layer until they are finally released eastward as a giant plume centred at 31°S along the east coast [10].

Of the **two types of ozone sources** already described, the **photochemical source** of ozone influencing the ozone profile over **Reunion** is mainly due to the long range transport of pollutants and ozone precursors from biomass burning activity in southern Africa and Madagascar [9].

Johannesburg (26,1°S;28,0°E) and **Irene** (25,5°S;28,1°E) are located **closer to photochemical sources**. The site of Irene is less affected by tropical convection but more affected by the subtropical jet stream activity than Reunion. In addition to **stratospheric sources**, regional sources of ozone in **Irene** include: biomass burning, biogenic, lightning and anthropogenic emissions [1].

Ozone increase due to stratospheric intrusions have been detected in South Africa and over the Indian Ocean. These intrusions take place in association with meteorological disturbances such as tropopause breaks induced by the subtropical jet stream, cut off lows, tropical cyclones [2, 7], westerly waves and frontal zones.

OZONE CLIMATOLOGY

In figure 2, each data type show a **springtime maximum linked to biomass burning activities**, that occurs between September and November according to the site. The greatest values are found in the SHADOZ data (Panels (b), (d)).

The LIDAR ozone content at Reunion (Panel (a)) shows greater values in the free troposphere in January than the content derived from SHADOZ data. This result is consistent with summer seasonal profiles shown in figure 3.

Upper tropospheric ozone content at Irene is greater than at Reunion. During austral winter, the ozonopause is lower at Irene.

Figure 3 shows the comparison of the seasonal profiles of tropospheric ozone of Reunion Island obtained from radiosondes and LIDAR data. The two **climatological profiles are generally in good agreement**, except in austral summer with higher values for the **LIDAR profiles** in the free troposphere, and **lower values in the upper troposphere for all the seasons**. Because of the nature of LIDAR data (measurements performed only under clear sky conditions, and an upper limit depending of the signal) the LIDAR profile is not representative of the true ozone climatology in the whole troposphere.

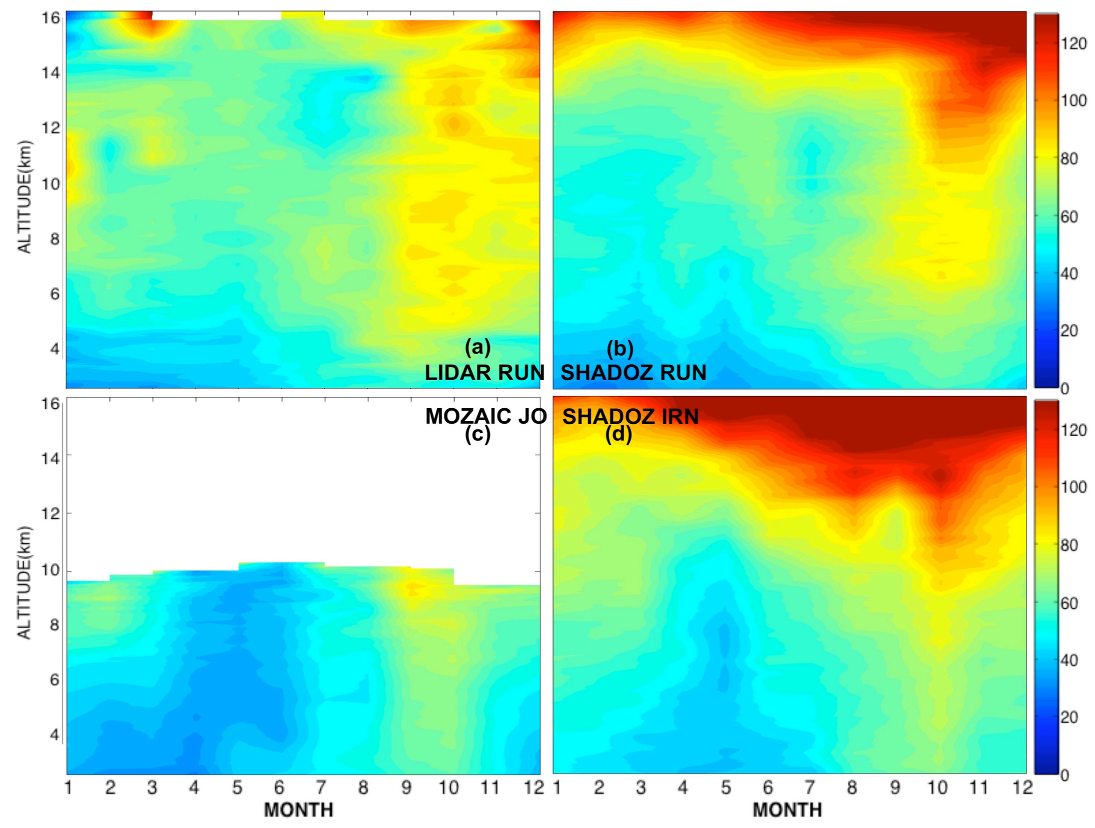

Figure 2: Monthly distribution of the mean tropospheric ozone content (0-130 ppbv) between 3 and 16 km altitude for different sites and different types of data. (a) LIDAR Reunion, (b) SHADOZ Reunion, (c) MOZAIC Johannesburg, (d) SHADOZ Irene. [3]]

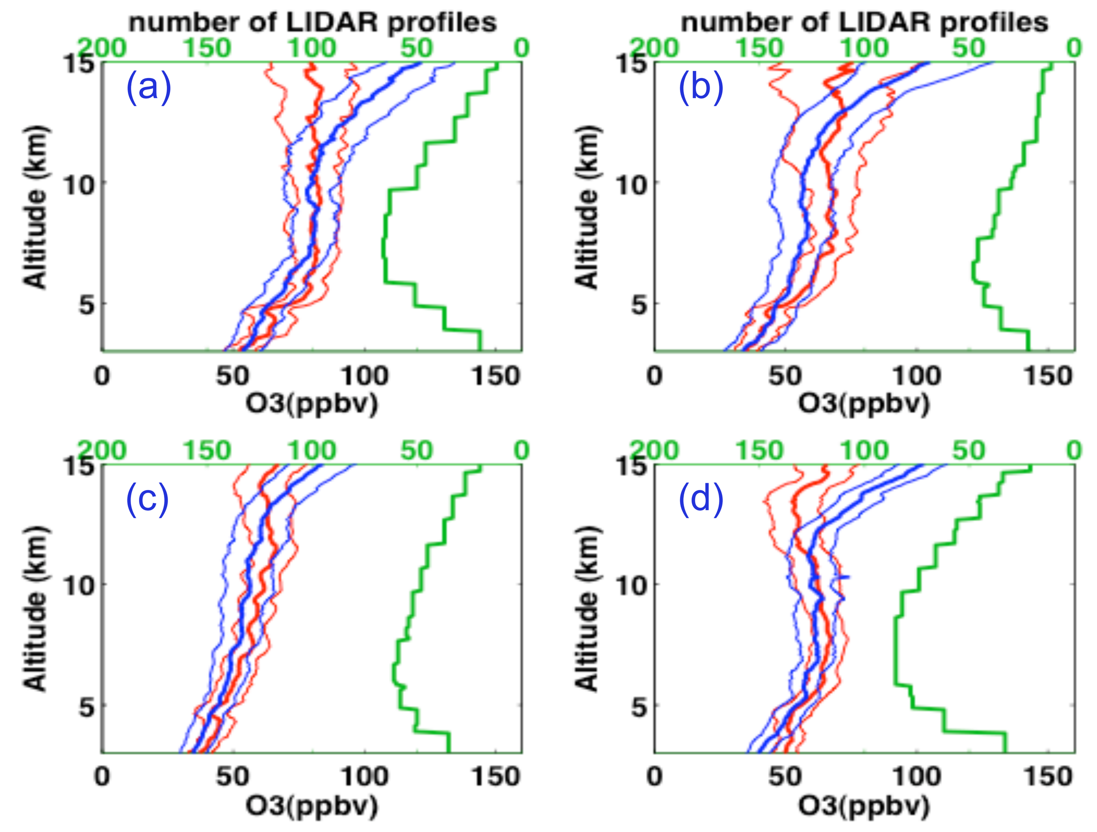

Figure 3 : Seasonal ozone profiles and standard deviation (ppbv) between 3 and 15 km derived from radiosonde data (blue lines) and from LIDAR data (red lines) at Reunion during (a) spring (SON) (b) summer (DJF) (c) autumn (MAM) and (d) winter (JJA). The number of profiles used for each DIAL LIDAR climatological profile is given on the right in green. [3]

GROUND BASED MEASUREMENTS

Climatological ozone values at the altitude of 2100 m from radiosonde measurements have been compared to a one year campaign of ground based measurements from a Dasibi instrument located at a high altitude site (2150 m) at Reunion Island.

The seasonal cycle is comparable for the two datasets, with Dasibi UV values displaying slightly higher values. This suggests that if local dynamical and possibly physico-chemical effects may influence the ozone level, the seasonal cycle can be followed with ground level measurements.

Average ground level concentrations measured on the summits of the island seem to be representative of the lower free troposphere ozone concentration at the same altitude (~ 2000 m) whereas night time data would be representative of tropospheric concentration at a higher altitude (~ 3000 m) due to the subsidence effect.

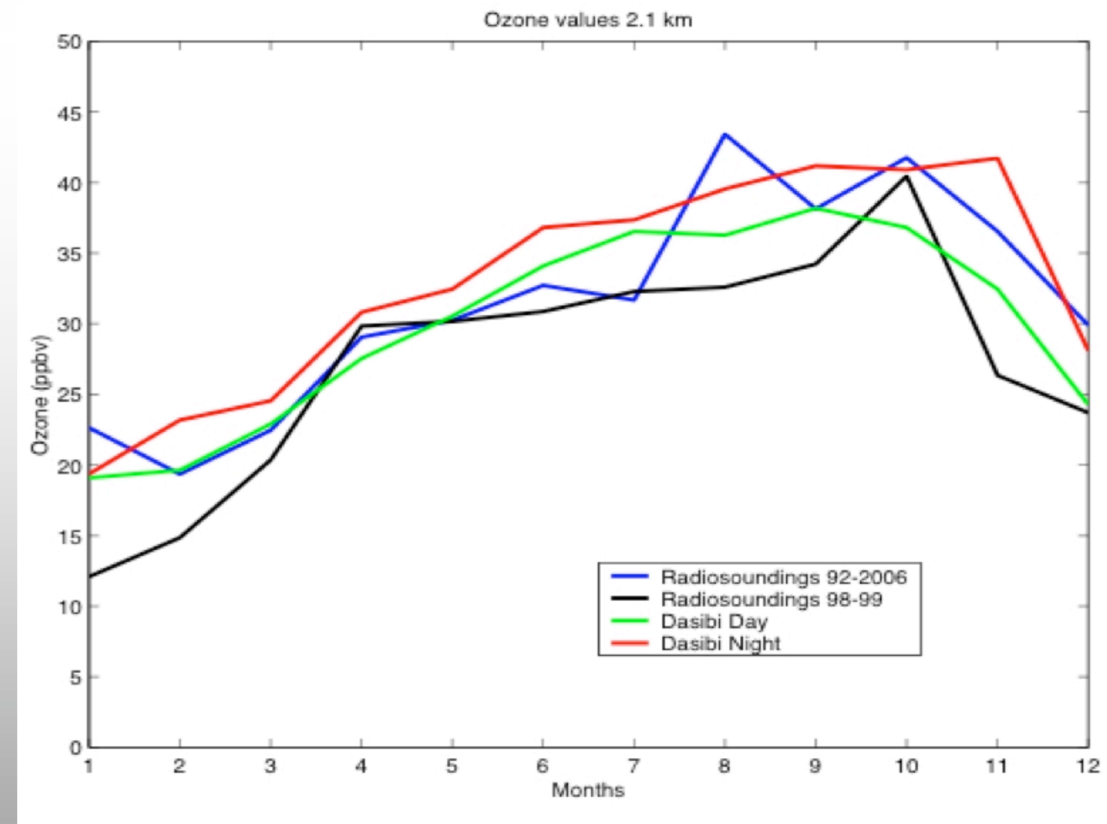

Figure 4: Seasonal variations of ozone mixing ratio at Piton Textor at 2100 m altitude in the South East of Reunion Island during daytime (green curve) and nigh-time (red curve), from October 1998 to October 1999, and average value of ozone concentration at the same altitude from radiosoundings (average monthly data from 1992 to 2006 (blue curve), and monthly data from October 98 to October 99, black curve). [3]

CONCLUSIONS AND PERSPECTIVES

✓The climatological features of tropospheric ozone at two southern subtropical sites have been presented.

✓The differences rising between different types of data have also been studied : DIAL LIDAR and Dasibi UV photometer vs Radiosonde data.

✓Ground level measurements at an altitude station at Reunion Island allows to document seasonal variations of regional free tropospheric ozone concentrations.

✓After focusing on the ozone climatology in the region, our next project is to weight the influence of the stratospheric and photochemical sources on the tropospheric ozone budget using a Lagrangian approach and to compare the results with those obtained from a global chemistry transport model.

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