BALLOON-BORNE OZONESONDE FLIGHTS MADE FROM FARADAY STATION

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Abstract. A series of ozonesonde flights was made, in association with NASA, at Faraday (65° 15′ S, 64° 16′ W) from March 1982 to April 1983. The flight procedures are described and the results obtained from the flights presented in graphical form.

Introduction

Faraday station (Lat. 65° 15′ S, Long. 64° 16′ W), (formerly known as The Argentine Islands), had been a radiosonde station since the I.G.Y. The station therefore had facilities for (a) the generation of hydrogen for filling balloons, (b) the reception of telemetry signals from the radiosondes, and (c) the tracking of sondes by a radar. NASA required ground calibration stations for ozone sensors mounted on the NIMBUS 7 and Solar Mesosphere Explorer (SME) satellites at widely spaced locations over the globe. Faraday station was a suitable location with pre-existing launching and data collection facilities. Therefore a joint project between NASA and BAS was set up to launch ozonesondes from Faraday, at times that instrumented satellites were passing overhead, throughout the year.

Sixty sondes and ground calibration equipment were provided by NASA. BAS provided the logistic support and the personnel to launch and record data from the ozonesondes. Sondes were released at the rate of five to six a month, thus providing a year's continuous coverage.

Procedures

The ozonesondes provided by NASA were Electrochemical Concentration Cell (ECC) mark 3A sondes manufactured by Science Pump Corporation. These were linked to VIZ 403 MHz radiosondes to transmit data back to the station. The radiosondes were checked for faults and then modified to take the signal link from the ozonesonde. Sensing solutions for the ozonesondes were prepared on base from pre-weighed chemicals.

Calibration of the radiosondes followed normal BAS practice. Calibration of the ozonesondes was carried out as laid down in manuals provided by NASA and rewritten for BAS use. The ozonesonde calibration was checked against a Dasibi ozone monitor, prior to flight. This cross-check was, however, not used if a Dobson spectrophotometer measurement had been made.

On launch the sonde target was acquired by radar and the radiosonde flight data computed in the usual way. The ozonesonde data for the flight were computed separately. Data from the standard pressure levels and levels selected for significant points on the ozone profile were processed on an HP41CV calculator to give the ozone partial pressure, the integrated ozone amount between successive levels and the cumulative amount of ozone up to that height.

The complete flight information was then coded and transmitted to Cambridge where it was decoded and checked for errors. Ozonograms of each flight were then plotted, with the data being stored on computer so that mean profiles for each month and season could also be derived and plotted.

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OZONESONDE PERFORMANCE

The ECC 3A sondes are not very accurate. Factors affecting accuracy are the type of pressure sensor on the radiosonde, variability in pump manufacture and uncertainty over background current corrections (W. D. Komhyr and others, private communication; Thornton and Niazy, 1983). The descent profile, on the few occasions when it was obtained, agreed in outline with the ascent profile (Fig. 1). The descent trace shows a higher ozone partial pressure below the height of the maximum ozone concentration. This may be because the sondes take a longer time to respond to decreasing ozone than to increasing ozone and because the descent was rapid as the sondes were not equipped with parachutes, or perhaps the result of variation in background current.

Whenever Dobson spectrophotometer measurements of total ozone amount were available, the ozone partial pressure indicated by the sonde has been multiplied by a correction factor, so that the total ozone amount measured by the sonde agrees with that measured by the Dobson instrument. In determining this factor, the ozone mixing ratio is assumed to be constant above the maximum height reached by the balloon. During the winter, when the sun is too low for Dobson measurements, the Dasibi calibration was used instead. A comparison of the sondes' Dasibi and Dobson calibrations, relative to the pre-flight calibrations, showed the Dasibi factors to be fairly consistent (0.939 ± 0.046), whereas the Dobson factors showed a larger variation (0.895 ± 0.087). There was little agreement between the two methods. This suggests that, whereas the sonde calibration may be good on the ground, errors manifest themselves during flight. Discrepancies in time and space between the ozone profile seen by the sonde and that seen by the Dobson instrument may introduce errors.

RESULTS

The data show significant seasonal differences (Figs. 2–5):

(1) In summer (December–February) the partial pressure of tropospheric ozone is roughly constant at about 15 nbar, whereas in winter (June–August) it declines from a surface value of about 25 nbar to about 15 nbar at the tropopause. This lower summer surface ozone value could be due predominantly to greater destruction of ozone at the surface in summer. Alternatively, transport in the troposphere could be due primarily to horizontal winds or to diffusive processes, rather than to vertical motions. The winter gradient in tropospheric ozone may be influenced by a mechanism proposed by Wexler and others (1960) in which ozone formed in the stratosphere is transported to lower altitudes and higher latitudes through a tropopause gap, descends over the pole and is then transported equatorwards by katabatic winds. It has also been suggested (Rubin, 1962) that ozone is generated in the continental interior by static electricity generated in the dry air during winter blizzards. This relatively ozone-rich air is then transported equatorwards by katabatic winds.

(2) The winter (June–August) profile shows a fairly uniform increase in partial pressure from the tropopause up to a maximum of just less than 150 nbar between 100 and 40 mbar (15–20 km). It then declines with a roughly constant mixing ratio of 7 ppmm.

(3) The summer profile has a step in the partial pressure on the way up to the maximum. This is at a partial pressure of 60 nbar and persists from 250 to 150 mbar (10–13 km). This suggests little vertical exchange here, with horizontal motion as the main transport process in this lower stratospheric layer. The maximum ozone partial pressure is around 140 nbar and persists from 80 to 30 mbar (17–24 km), above which the partial pressure declines with a roughly constant mixing ratio of about 8 ppmm.

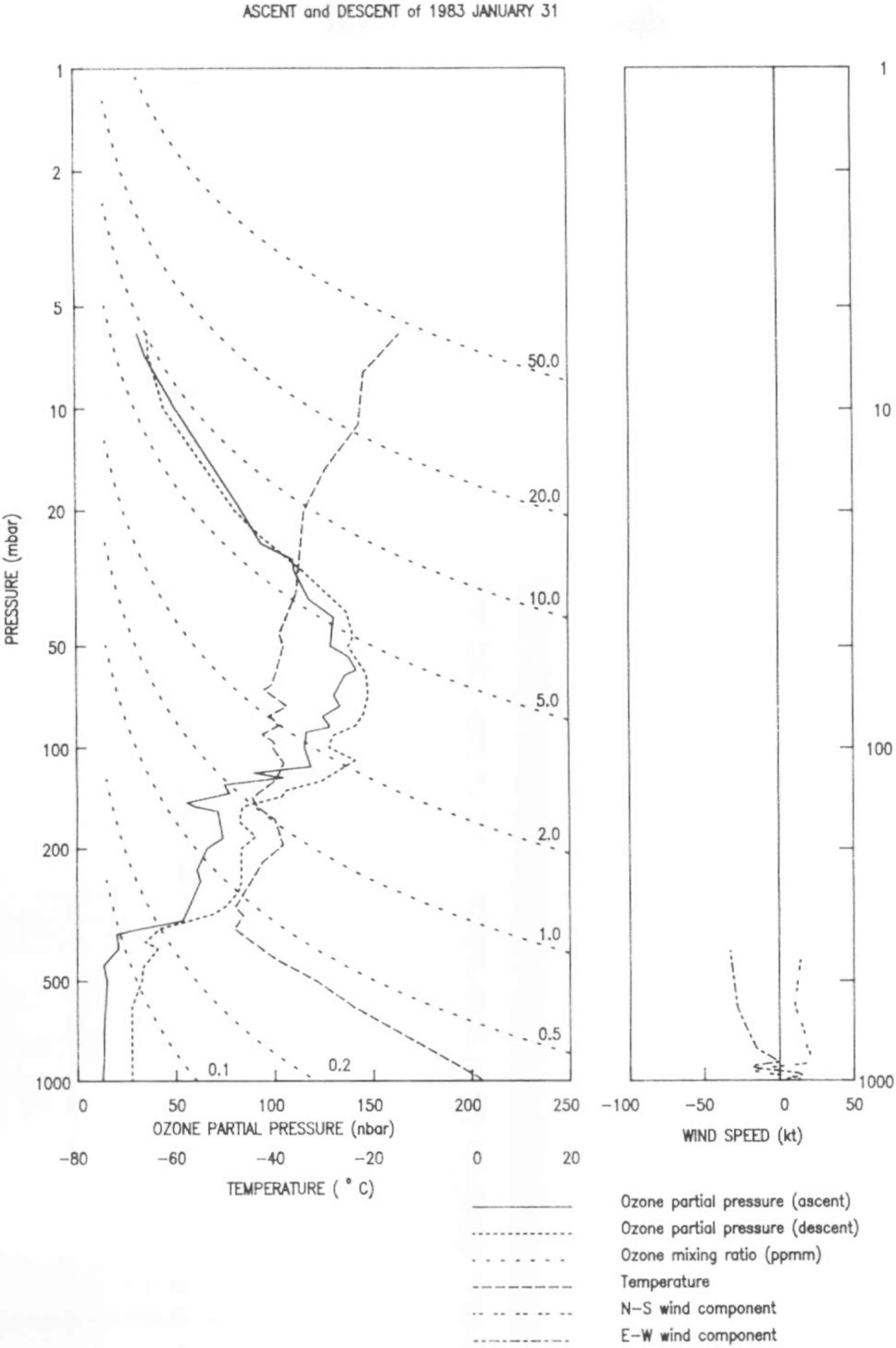

Fig. 1. Ascent and descent profiles of 31 January 1983.

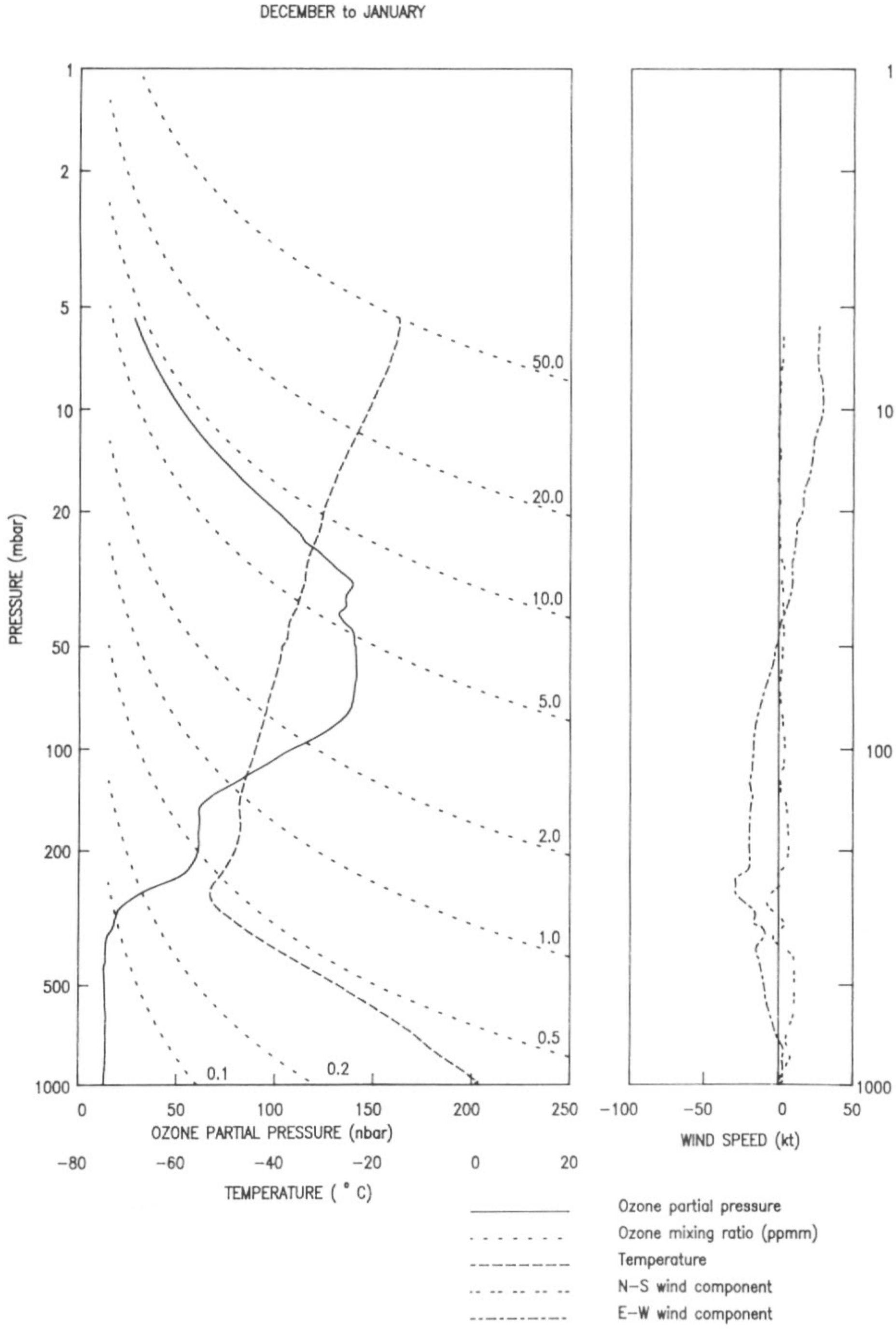

Fig. 2. Mean summer profile (10 flights).

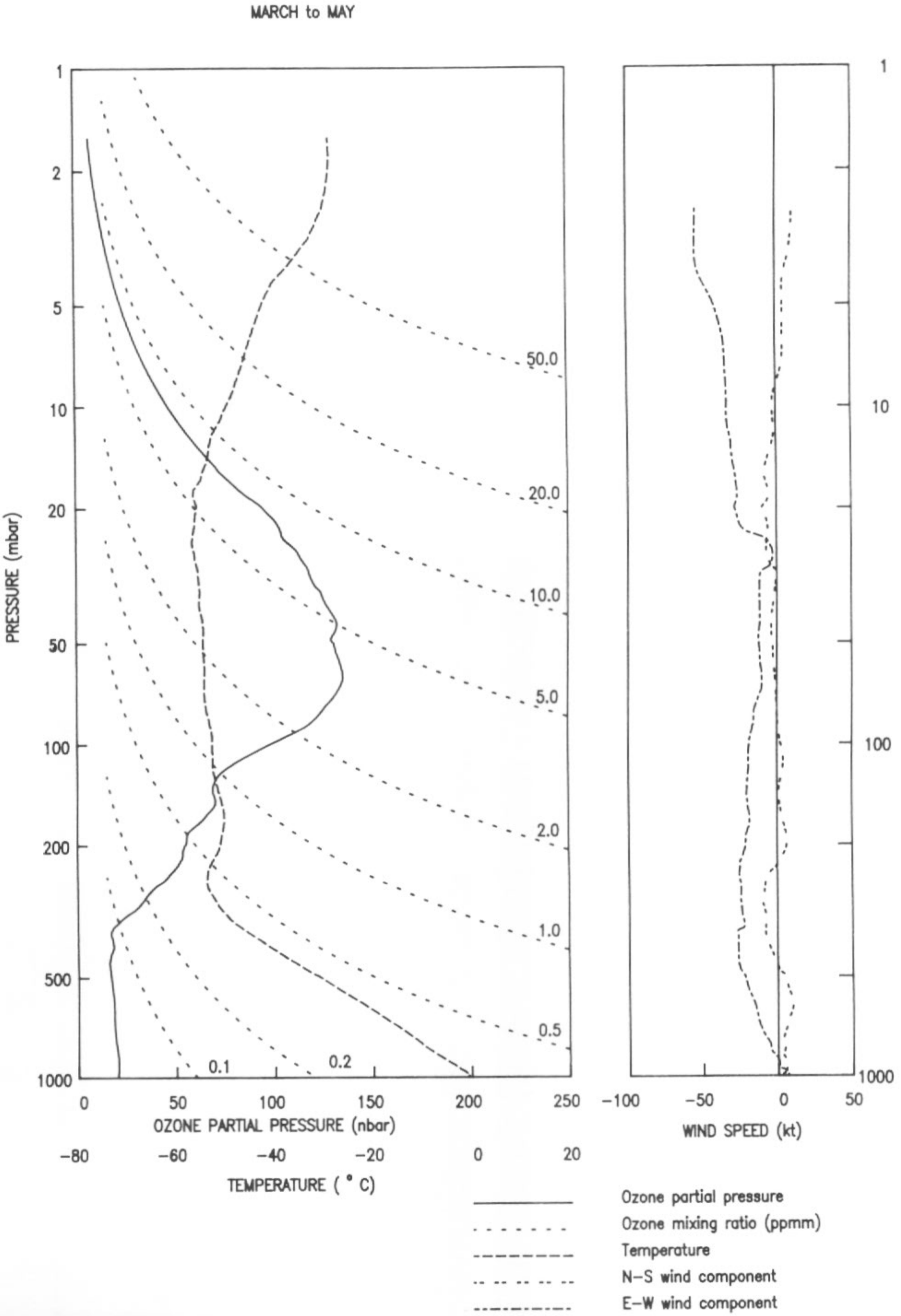

Fig. 3. Mean autumn profile (16 flights).

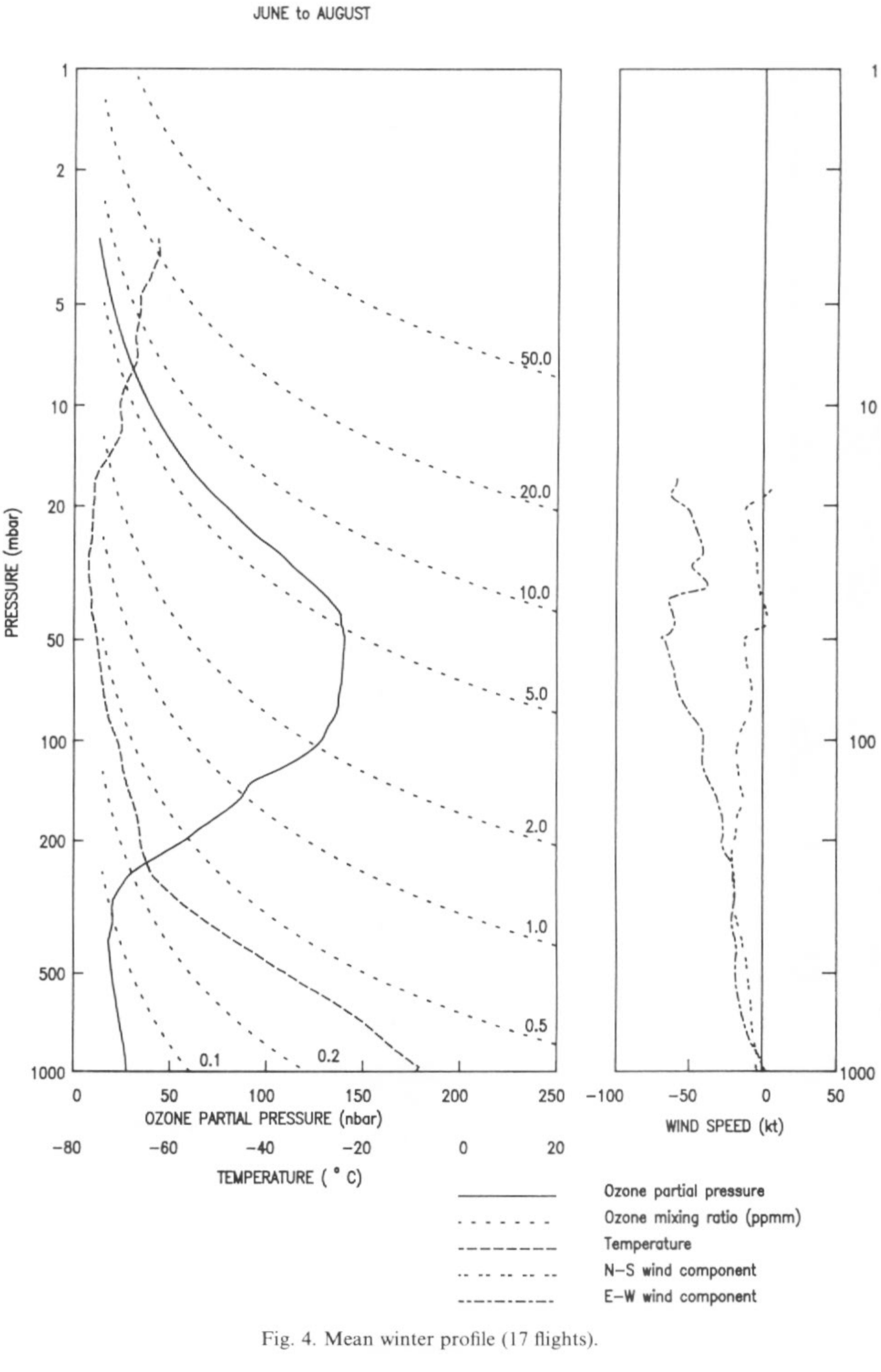

Fig. 4. Mean winter profile (17 flights).

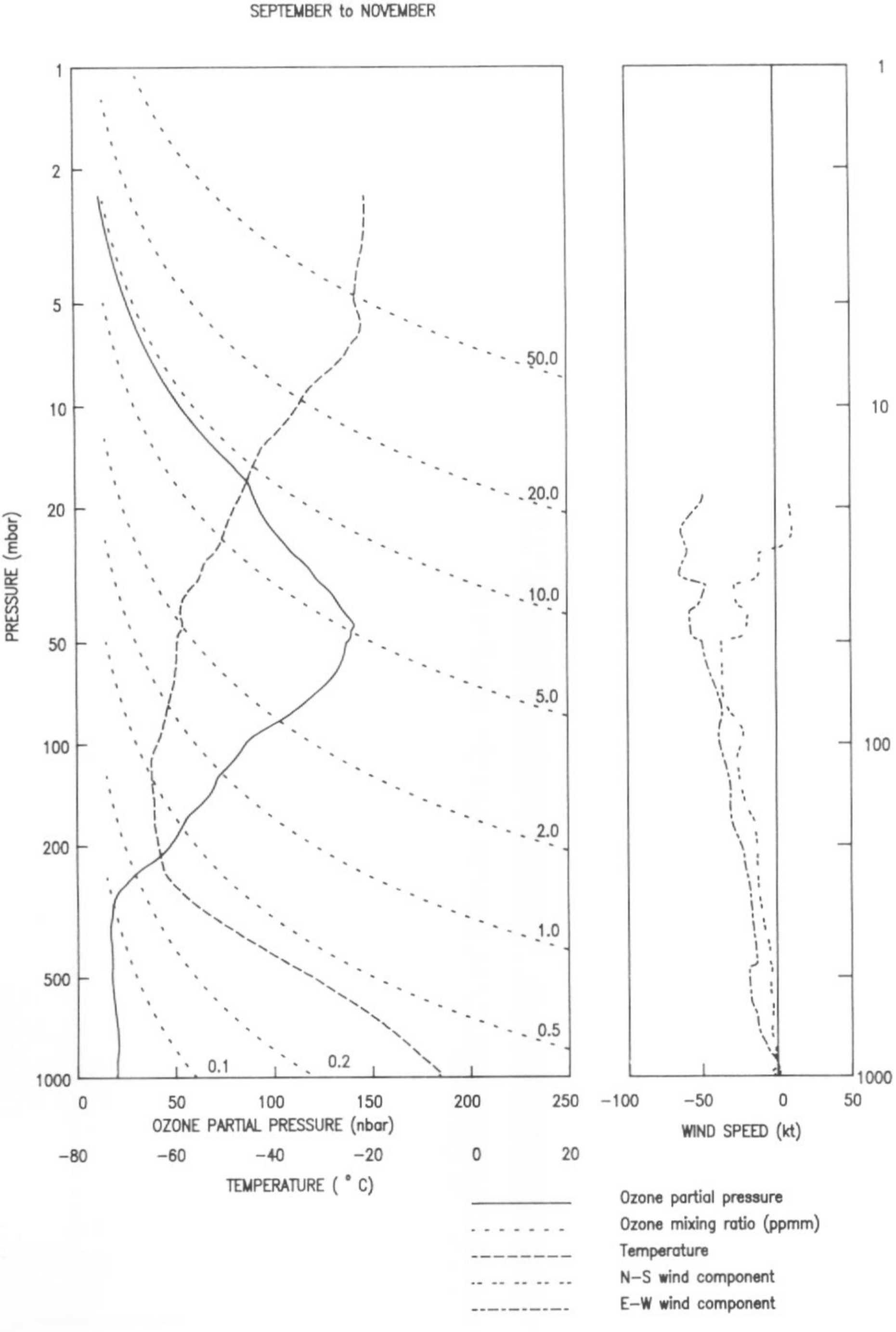

Fig. 5. Mean spring profile (14 flights).

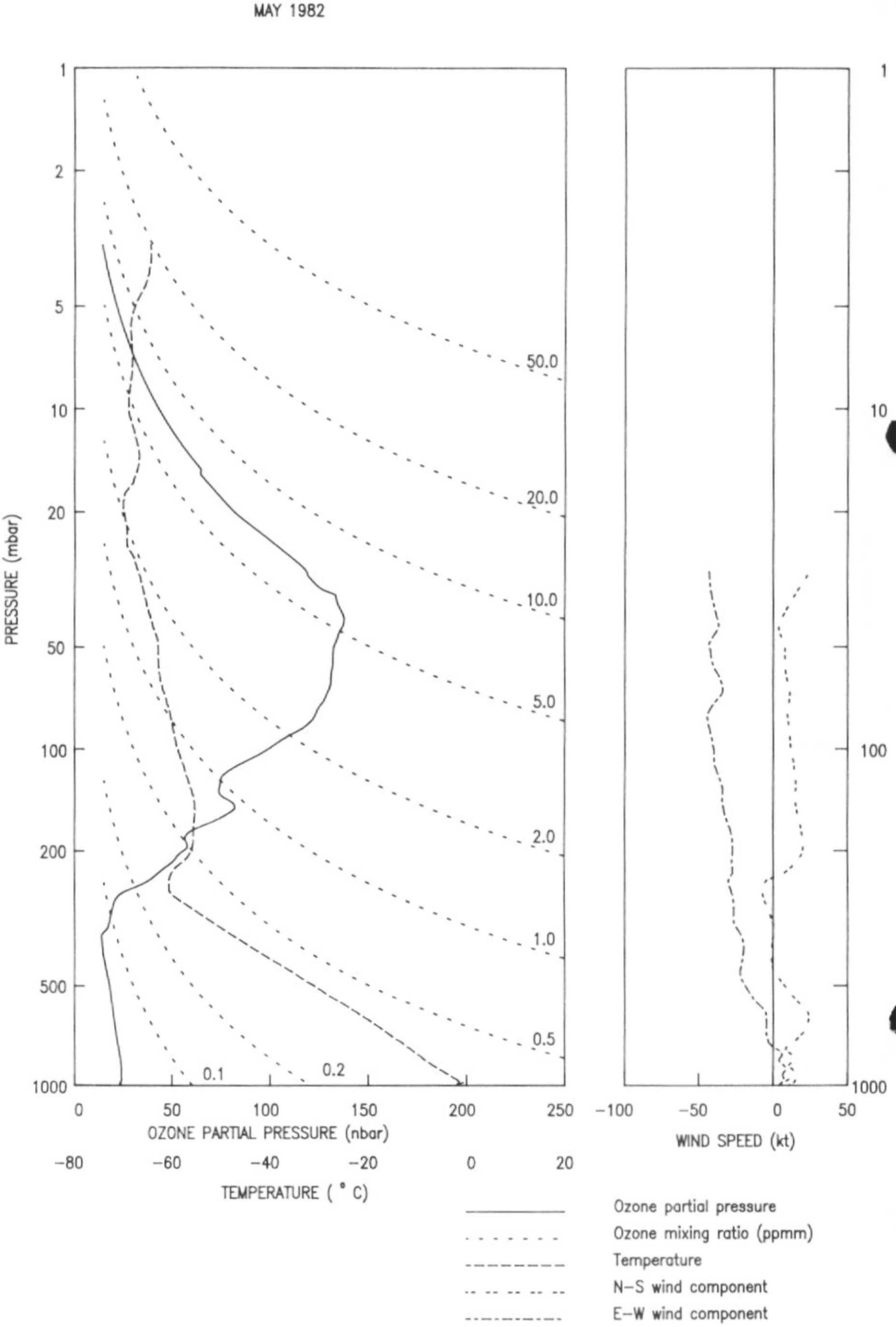

Fig. 6. Mean profile for May 1982 (6 flights).

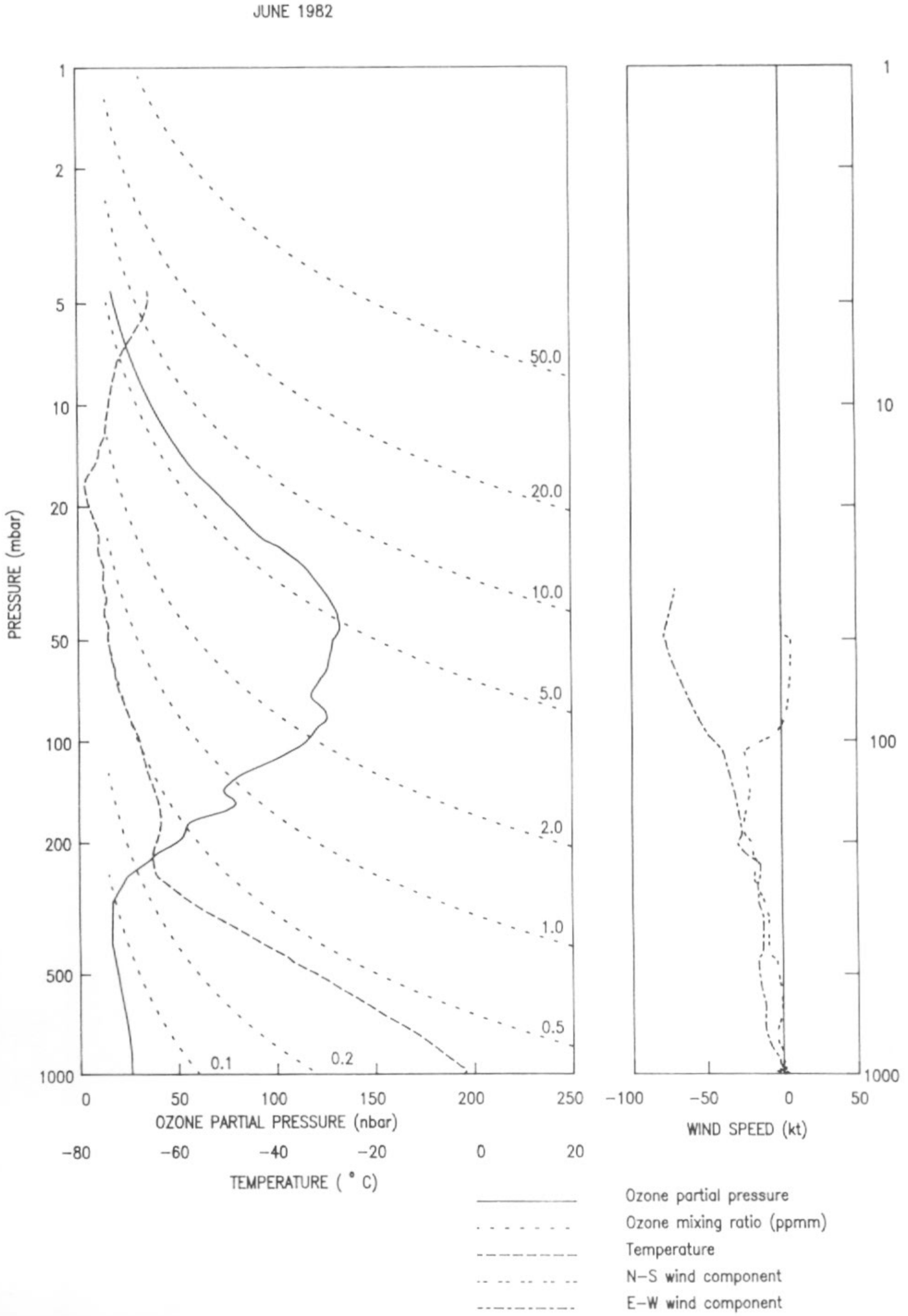

Fig. 7. Mean profile for June 1982 (5 flights).

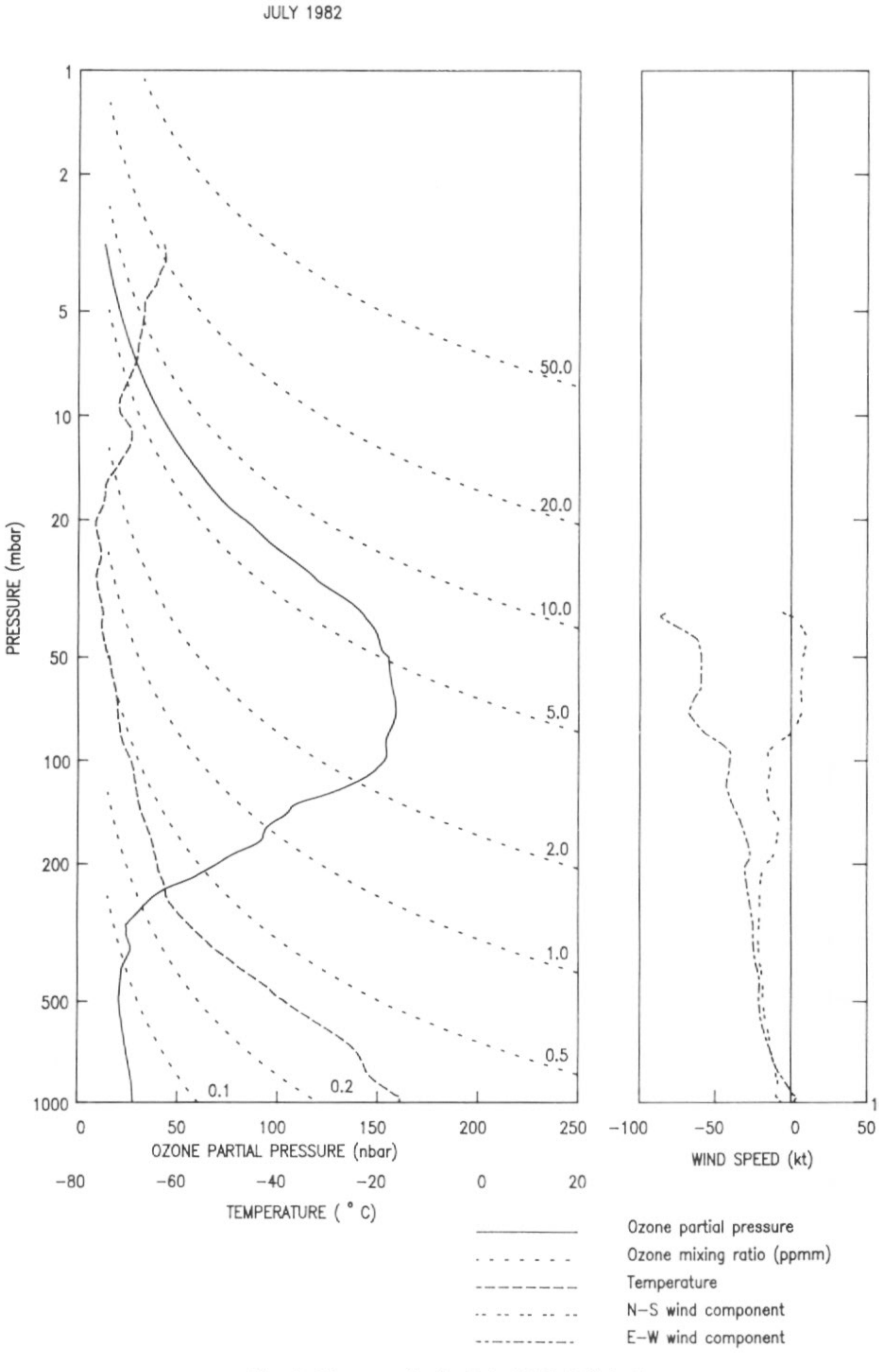

Fig. 8. Mean profile for July 1982 (6 flights).

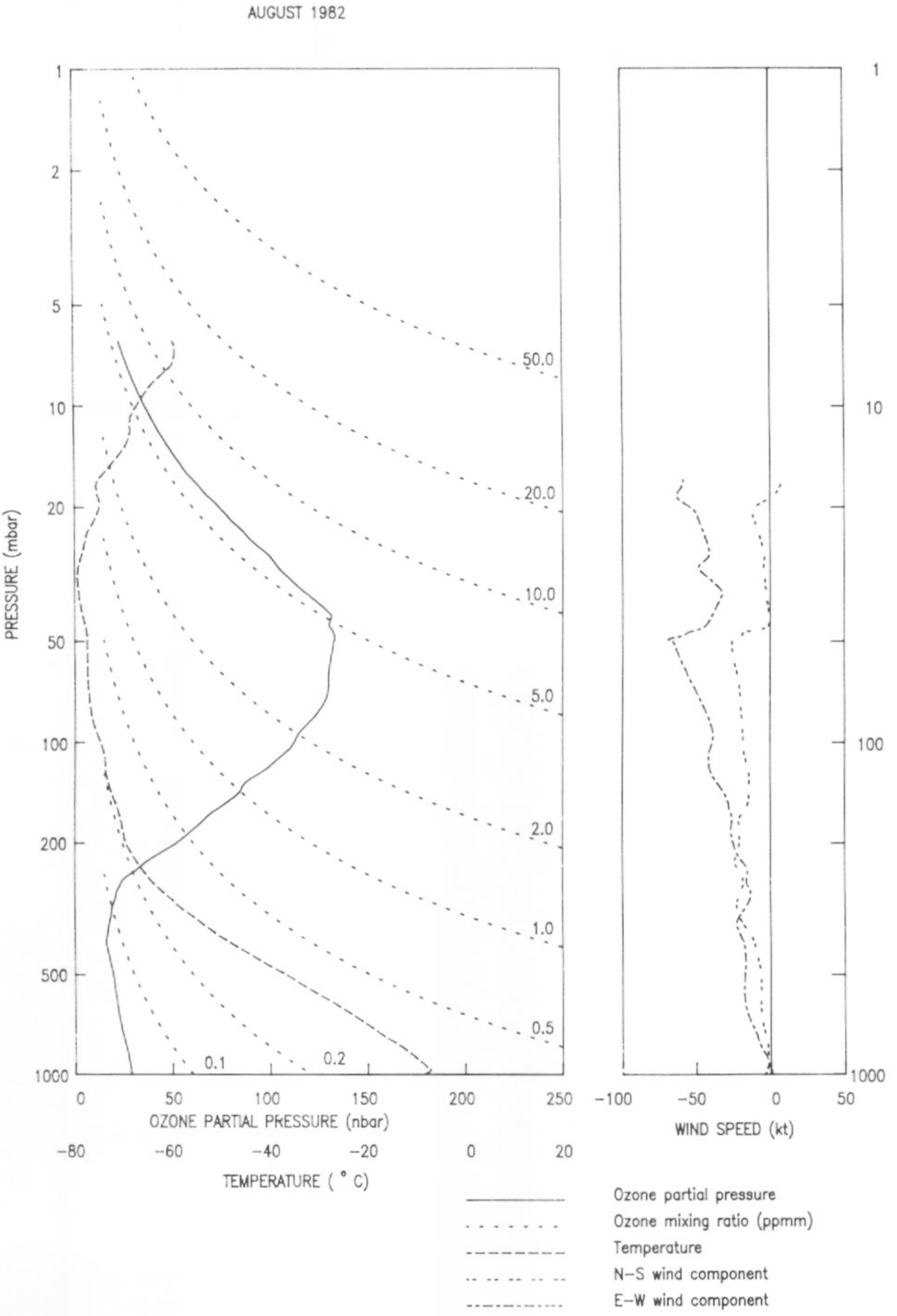

Fig. 9. Mean profile for August 1982 (6 flights).

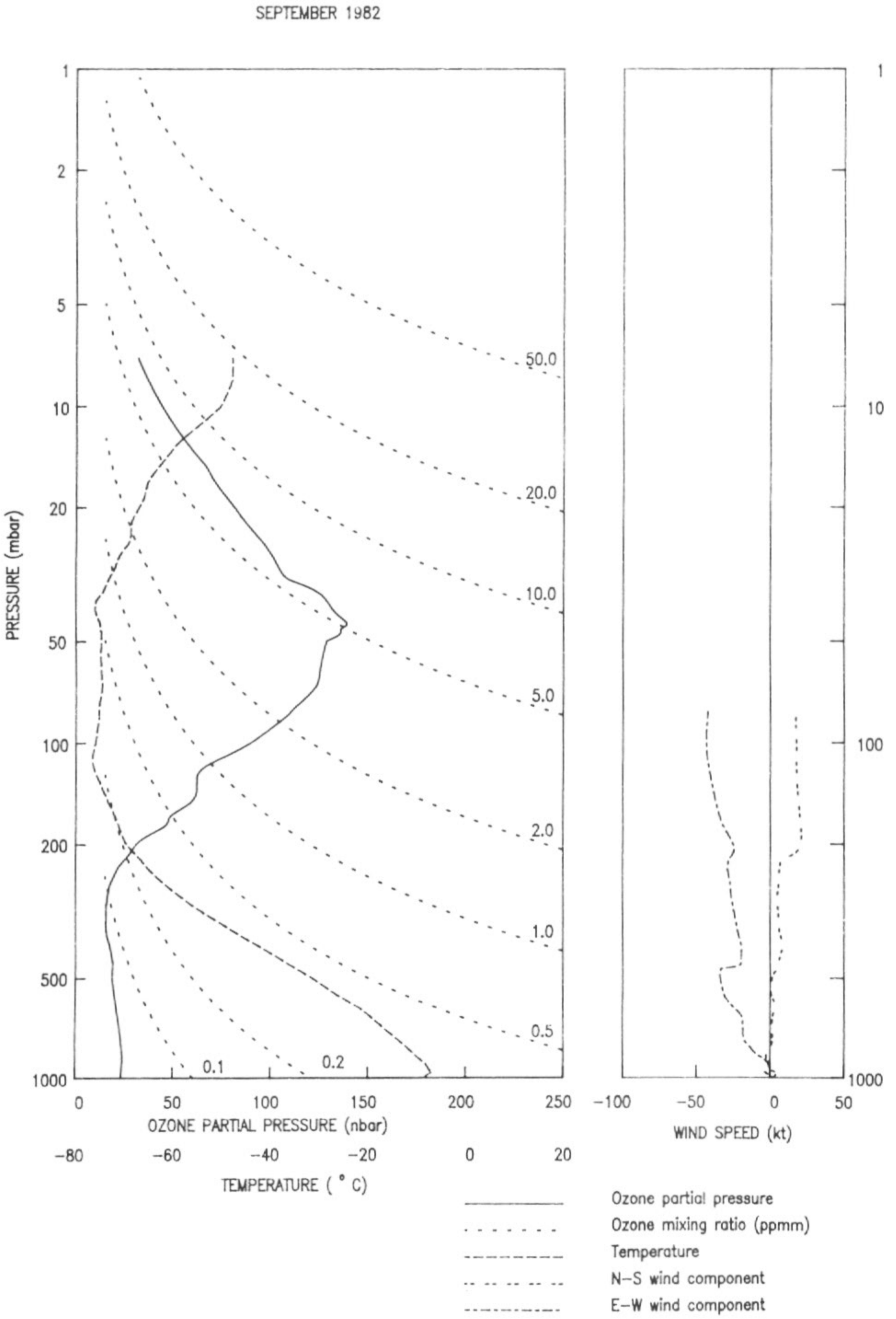

Fig. 10. Mean profile for September 1982 (5 flights).

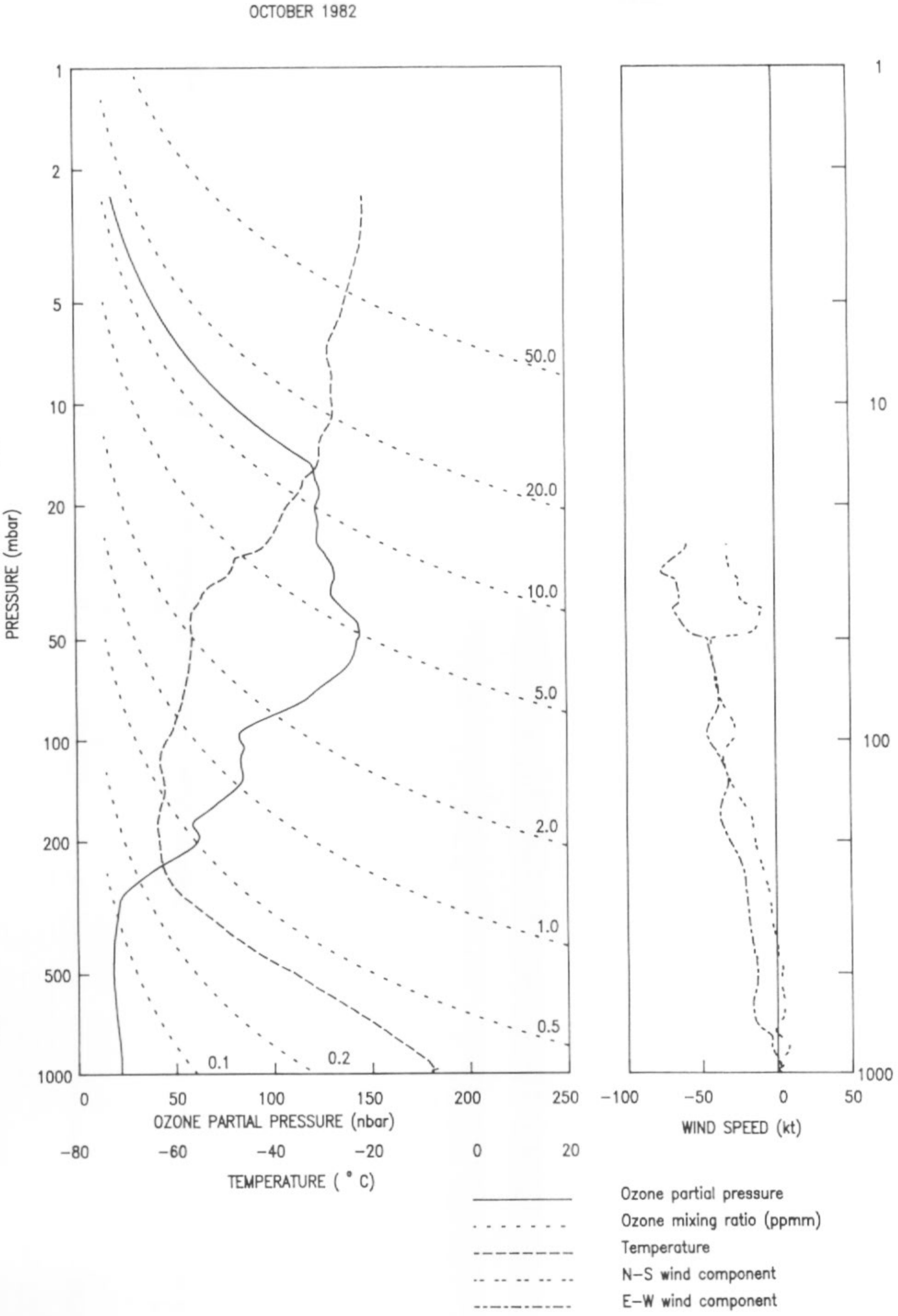

Fig. 11. Mean profile for October 1982 (4 flights).

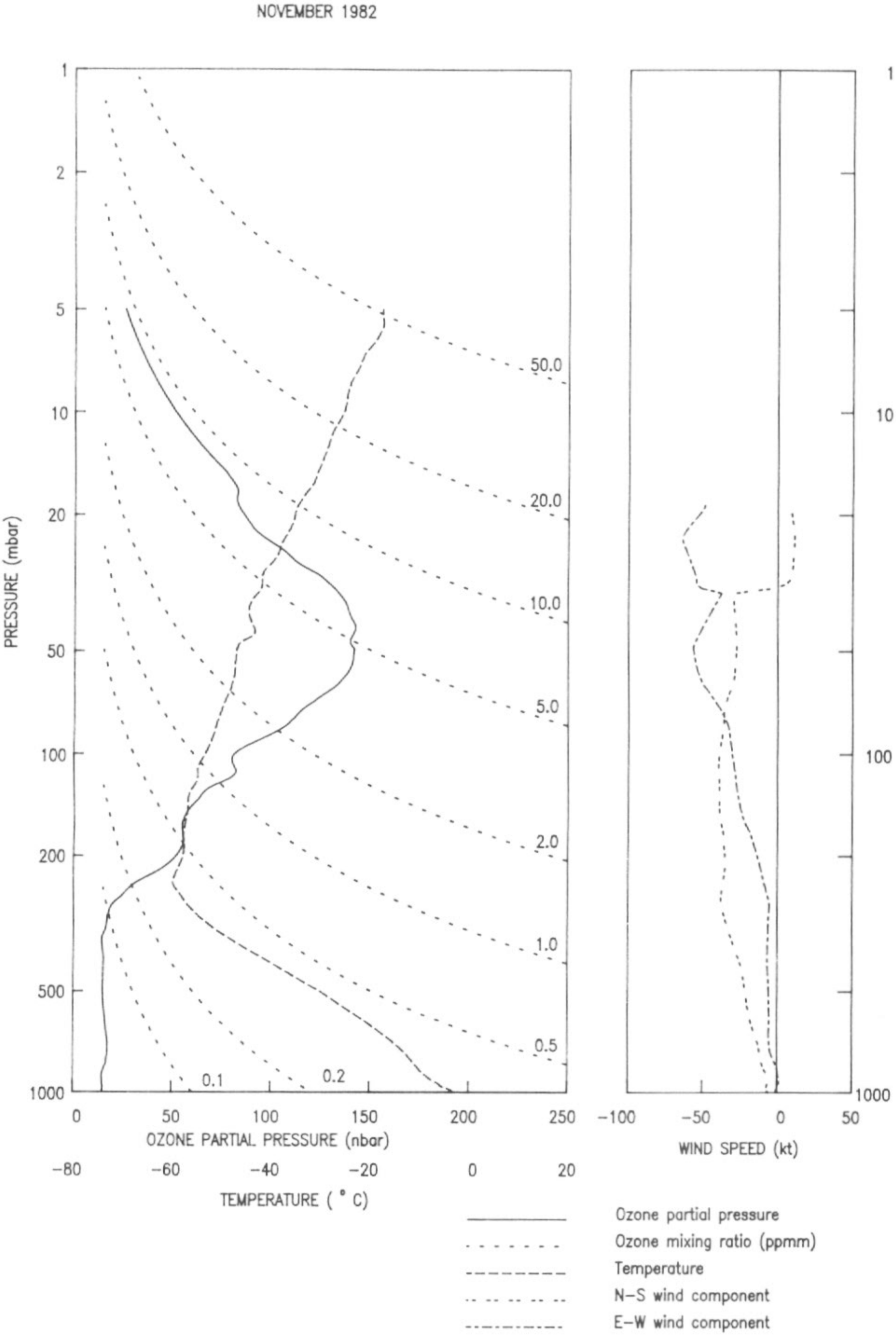

Fig. 12. Mean profile for November 1982 (5 flights).

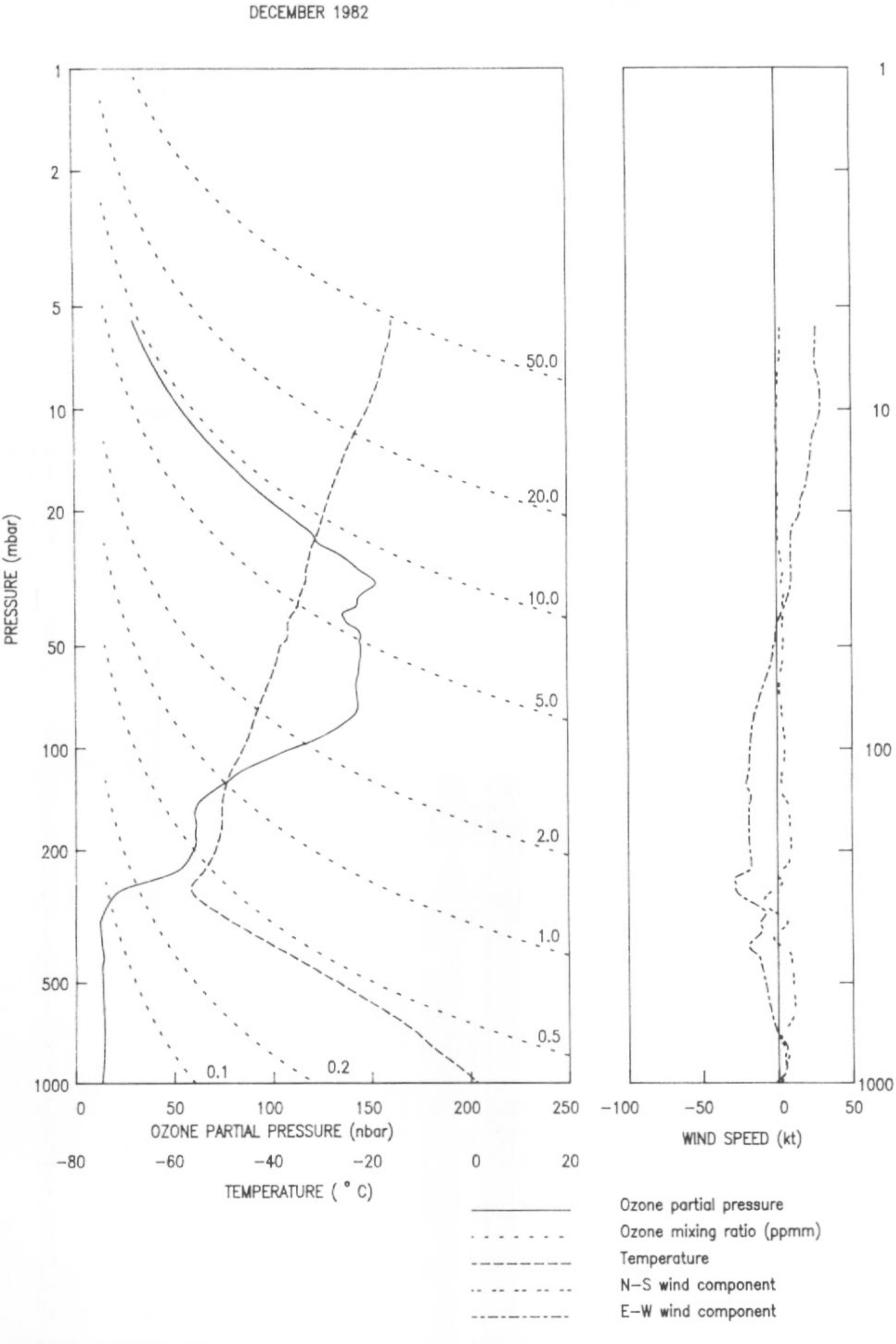

Fig. 13. Mean profile for December 1982 (6 flights).

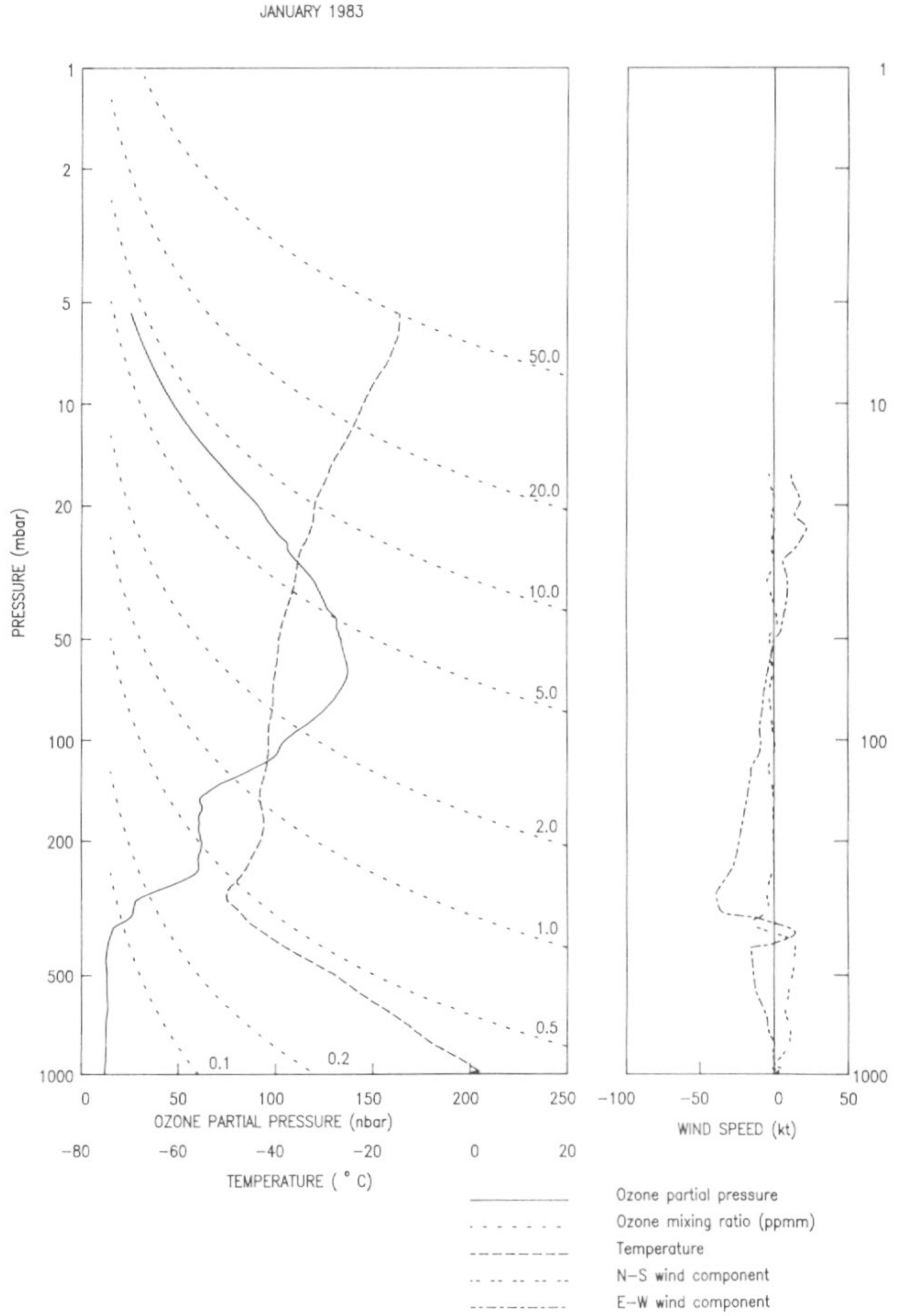

Fig. 14. Mean profile for January 1983 (4 flights).

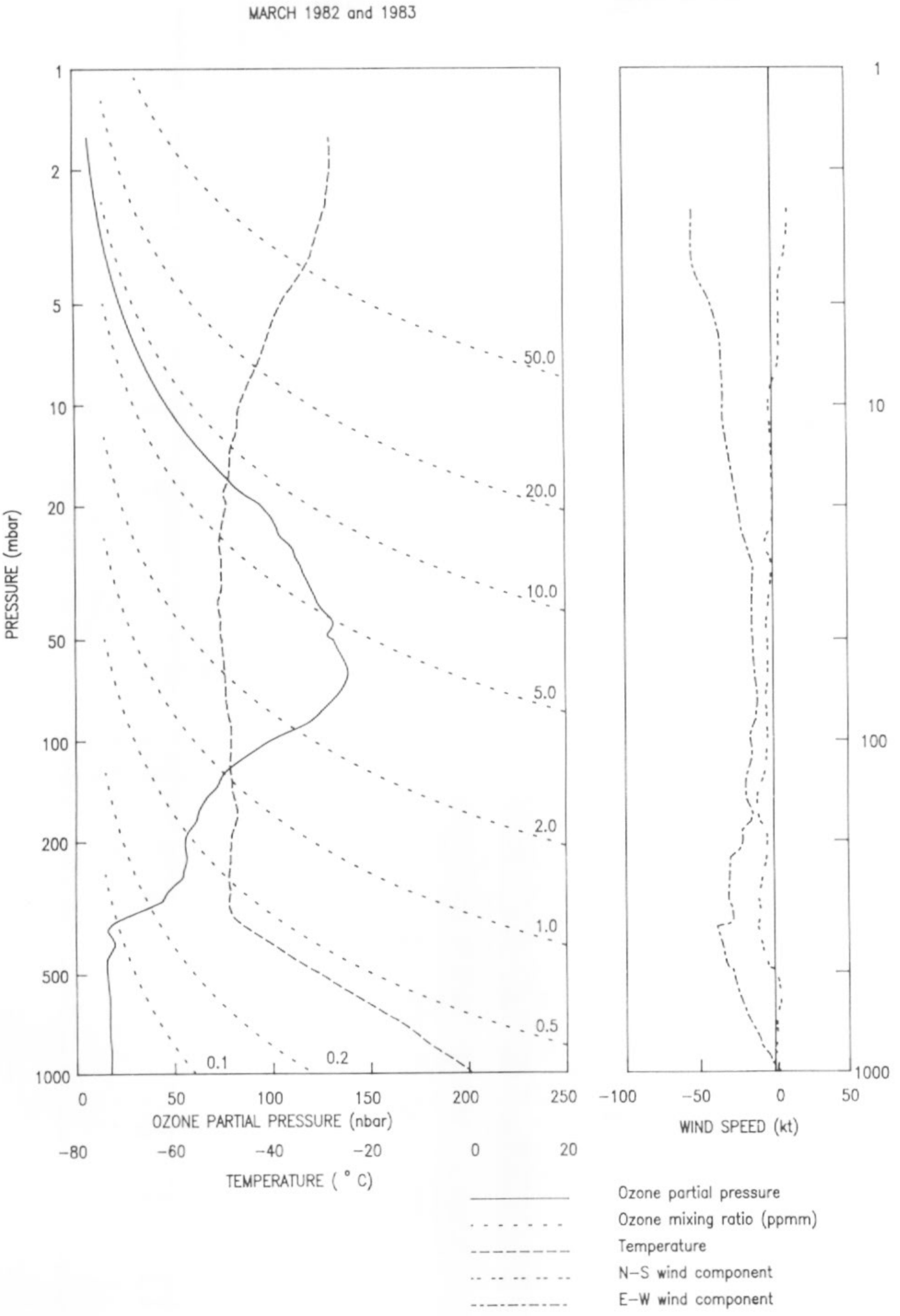

Fig. 15. Mean profile for March 1982 and 1983 (8 flights).

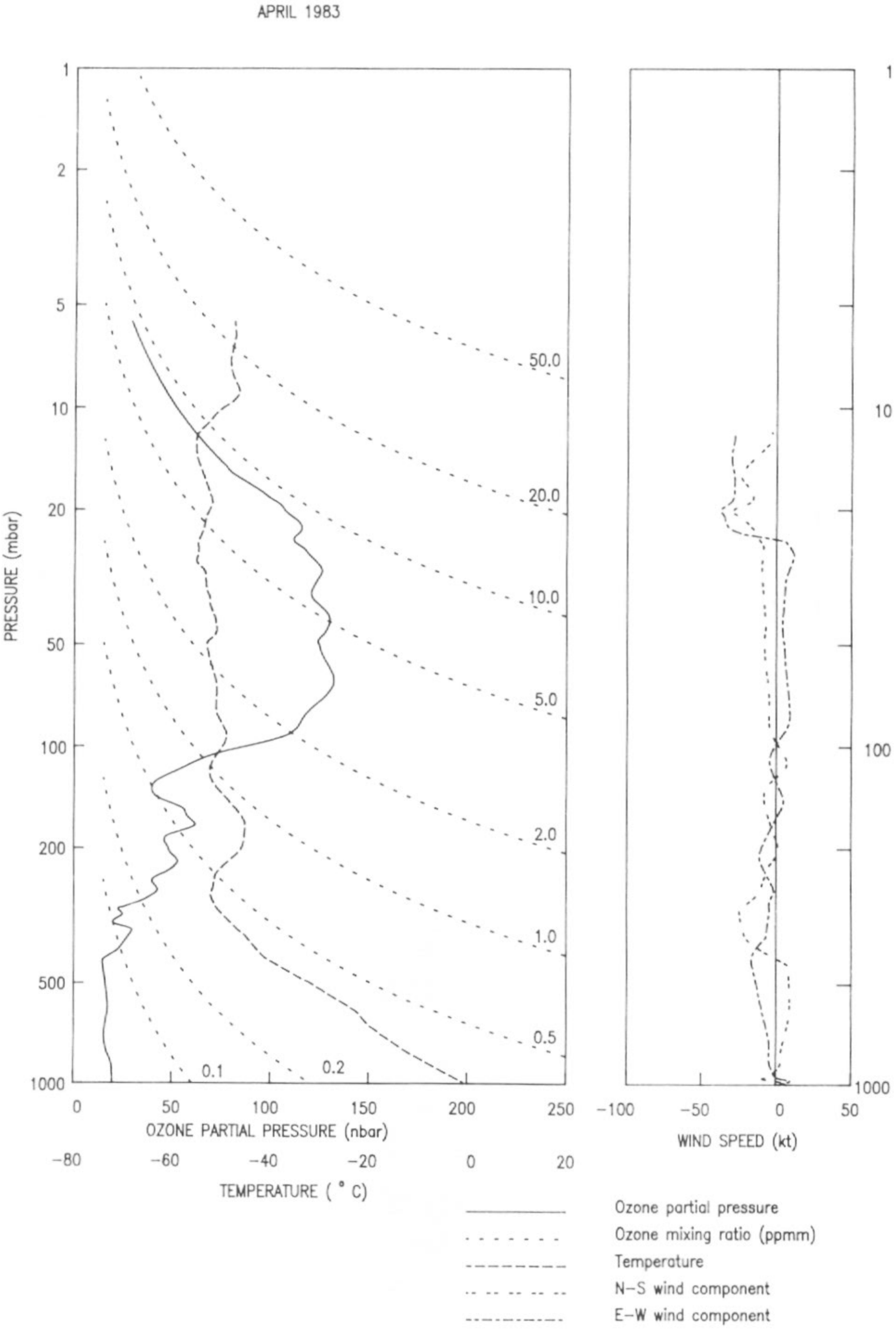

Fig. 16. Mean profile for April 1983 (2 flights).

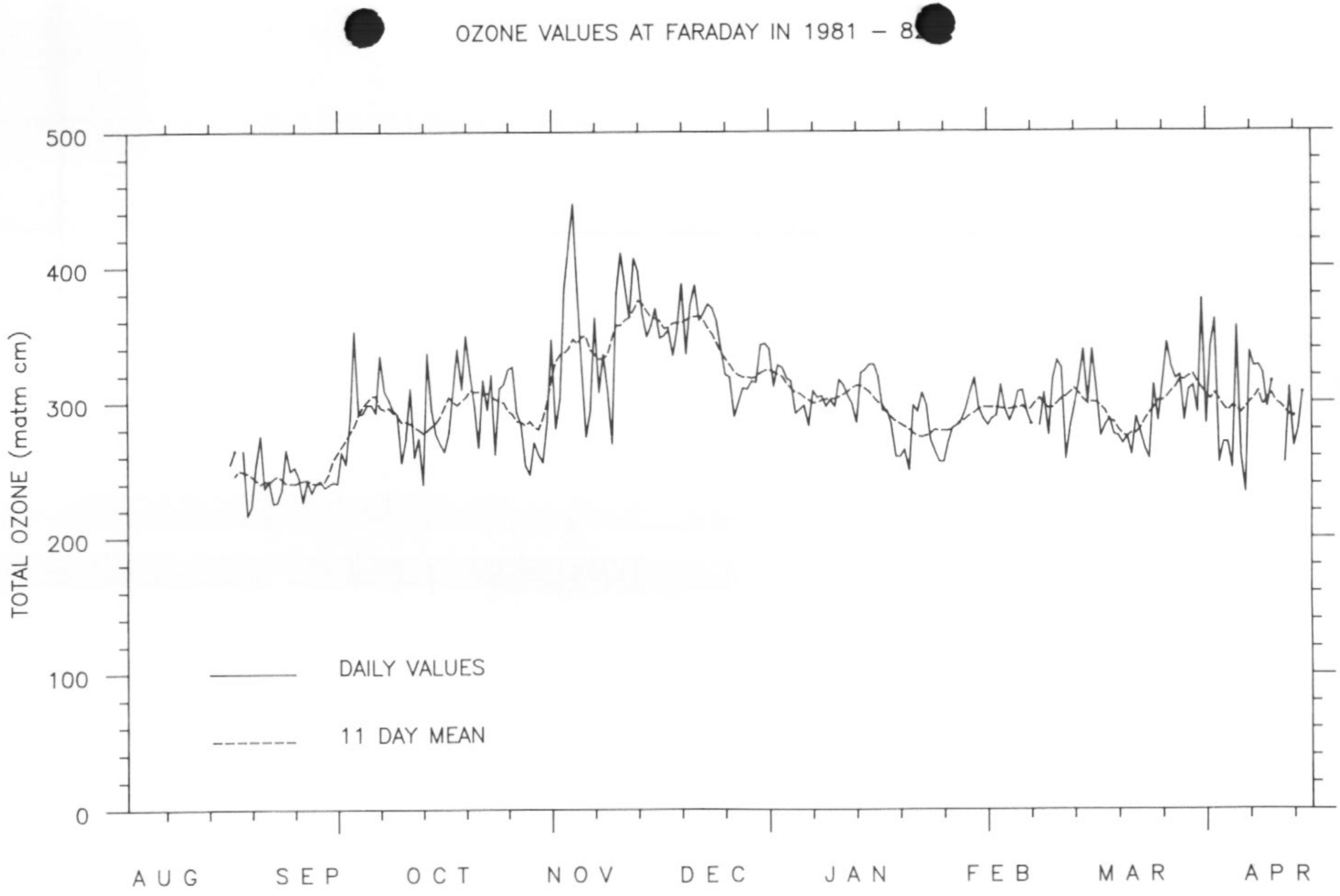

Fig. 17. Total ozone values for the 1981–82 season.

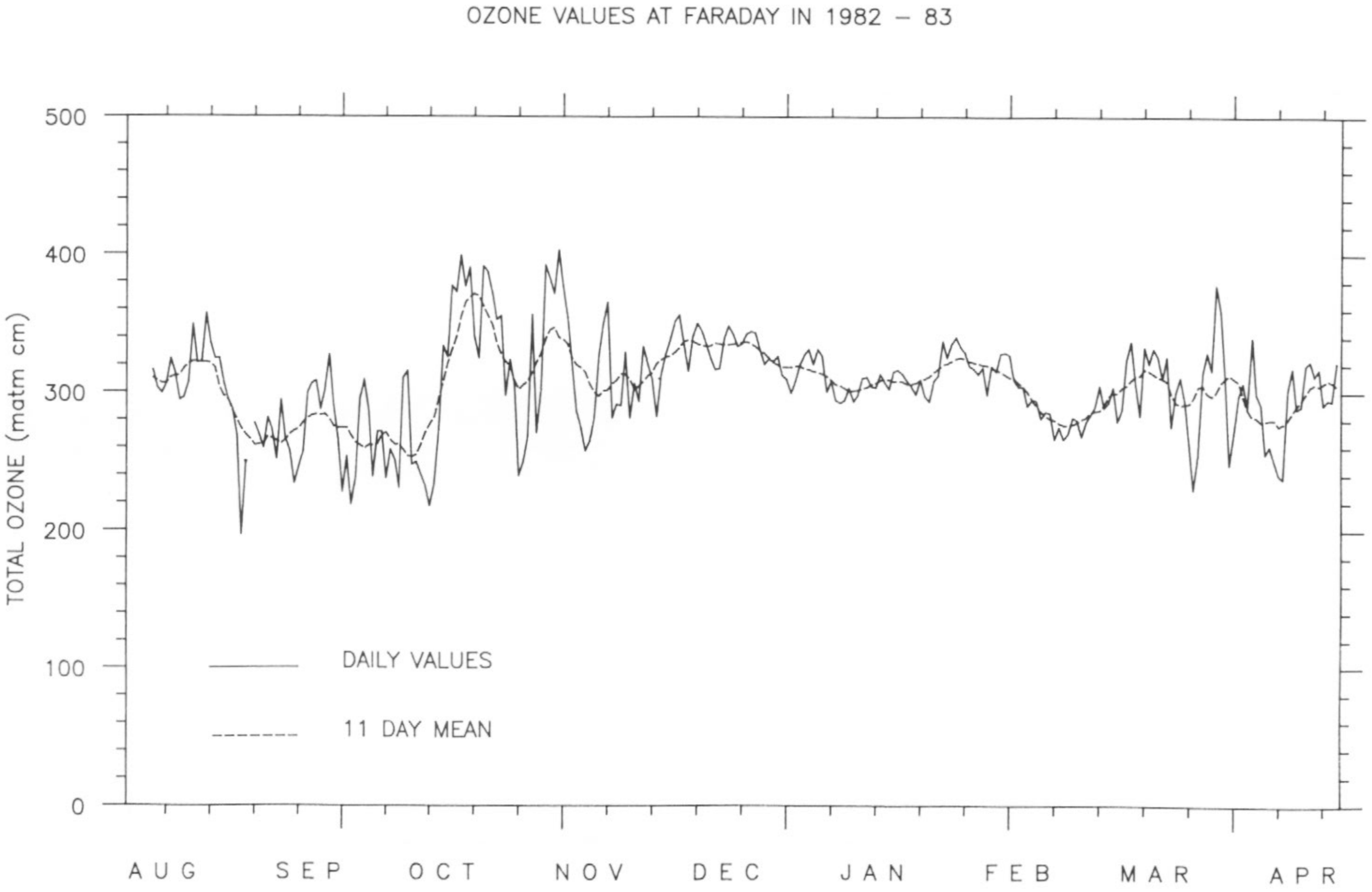

Fig. 18. Total ozone values for the 1982–83 season.

Mean ozonograms are presented for the individual months (Figs. 6–16). These show the progression from the mean summer profile to the mean winter profile. The ozone mixing ratio has been held constant above 15 mbar as the pressure sensors were not considered reliable above this height. The wind components are shown so that a wind blowing from the north or east is positive. No flights were made in February 1983 because of a failure of the hydrogen generator.

Graphs showing the variation of total ozone over the period are presented in Figs. 17 and 18. The spring warming in October shows in the vertical profile as a large increase in the mixing ratio above 20 mbar to 13 ppmm.

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