The central few square degrees of the Galaxy are full of interesting and energetic phenomena on many size scales[16-19], in the middle of which lies the unique Sgr A*, coincident to within 0.5 arc s of IRS16 centre. IRS16 may be the primary source of the $\sim 10^7\ L_\odot$ of infrared and ionizing radiation from the centre[20-22]. A $3\times 10^6\ M_\odot$ point mass within 0.5 pc of the centre is suggested by the latest Ne II observations (E. Serabyn and J. H. Lacy, in preparation). Furthermore, a large velocity ($\pm 750\ \mathrm{km\ s^{-1}}$) outflow[23,24] and, possibly, a compact source of positronium[25] are also identified with the central 0.2 pc ($\sim 5\times 10^{17}$ cm, or ≤ 4 arc s).

Although the luminosity and ionization over the 10^{20}-cm scale of the galactic centre may be explained by a recent burst of star formation[26], the activities within the central 5×10^{17} cm require an alternative source of energy, such as a massive collapsed object in a quiescent state of low-level accretion[27]. The unique compact radio source and the other phenomena at the centre would be natural consequences of the presence of such an object.

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Middle atmospheric NO and NO_2 observed by the Spacelab grille spectrometer

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Almost 20 years after Nicolet[1] suggested the presence of nitric oxide in the upper atmosphere as a source of D-region ionization by solar Lyman α-radiation, this trace species was first observed[2] by the resonance fluorescence method; almost 10 years later, its vertical distribution was observed in the stratosphere by means of balloon-borne infrared absorption spectrometry[3]. Since then much emphasis has been placed on odd nitrogen compounds in the stratosphere, partly because of their role in controlling the ozone abundance. Many measurements have been made of NO, NO_2, HNO_3 and NO_3 in the stratosphere with inferences on the N_2O_5 abundance. Meanwhile, several determinations of NO in the mesosphere and in the lower thermosphere[4-10] have used resonance fluorescence and mass spectrometry[11]. We report here the first observation of NO from the low thermosphere down to the low stratosphere by instrumentation similar to that used previously on board balloon gondolas, but on this occasion the observation platform was Spacelab I, which gave access to higher altitudes. As before[12], NO and NO_2 were observed simultaneously.

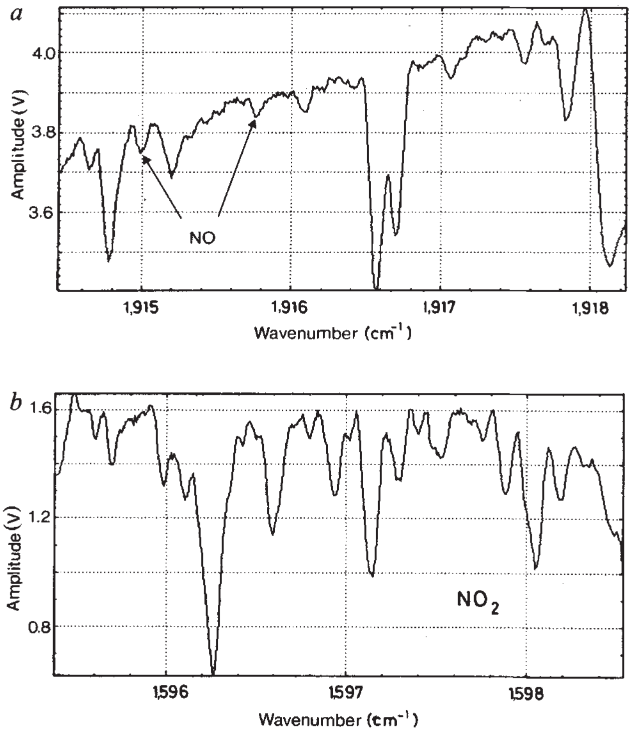

Fig. 1 *a*, Solar spectrum recorded at sunlight-tangent altitude equal to 86 km. Two NO absorption lines are indicated; all the other spectra lines are attributable to solar absorption features. *b*, NO_2 absorption spectrum recorded at sunlight-tangent altitude equal to 26 km. In this spectral region, the solar spectrum is a continuum. Most of the spectral features are attributable to nitrogen dioxide. In *a* and *b*, amplitudes are in arbitrary units and the origin of the scale is the level of total absorption for the solar radiation.

The infrared grille spectrometer on board the space shuttle during the first Spacelab mission has been described elsewhere[13]. During this mission, one Earth-limb solar occultation run was devoted to the observation of NO and NO_2 in the respective wavenumber ranges, $1{,}914.5$-$1{,}918\ \mathrm{cm^{-1}}$ and $1{,}595$-$1{,}598.5\ \mathrm{cm^{-1}}$. The corresponding wavelengths were selected in the sixth and fifth orders of the grating by two interference filters, one for each of the two liquid nitrogen temperature-cooled detectors.

This observation took place over the southern Pacific Ocean on 1 December 1983, at sunrise after the very short nights of the high southern latitudes in their late spring. For the 20- and 100-km tangent-altitude locations, the solar depression angles did not exceed 0.3° and 1.4° respectively, during the course of the day. The geographical coordinates of the tangent points of the solar rays in the atmosphere were respectively 68° S, 129° W and 67° S, 118° W. Thus, the observations took place in almost full daylight; almost all the odd nitrogen was in the form of NO in the mesosphere and NO, NO_2 and HNO_3 in the stratosphere, according to our present knowledge of atmospheric photochemistry. NO and NO_2 spectra (examples are shown in Fig. 1*a*, *b*) were recorded every 2 s and the measured equivalent

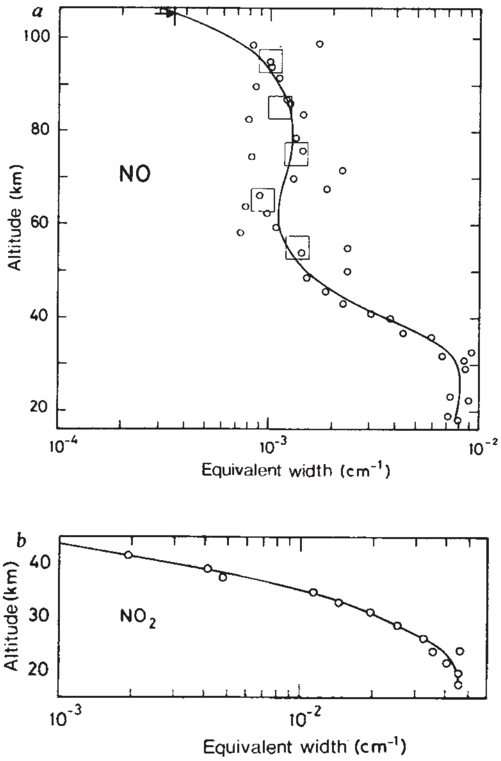

Fig. 2 Equivalent widths versus grazing-sunlight altitude for *a*, the NO absorption doublet at 1,914.99 cm^{-1} (the squares represent five kilometres averages) and *b*, the NO_2 multiplet centre at 1,597.15 cm^{-1}.

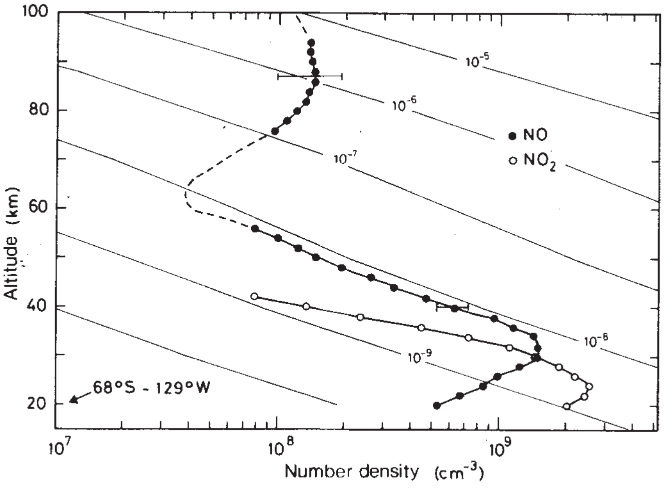

Fig. 3 Number densities of NO and NO_2 versus altitude (1 December 1983). The near straight lines indicate constant volume mixing ratios from 10^{-10} to 10^{-5}. Error bars are related to the scattering of the measured equivalent widths.

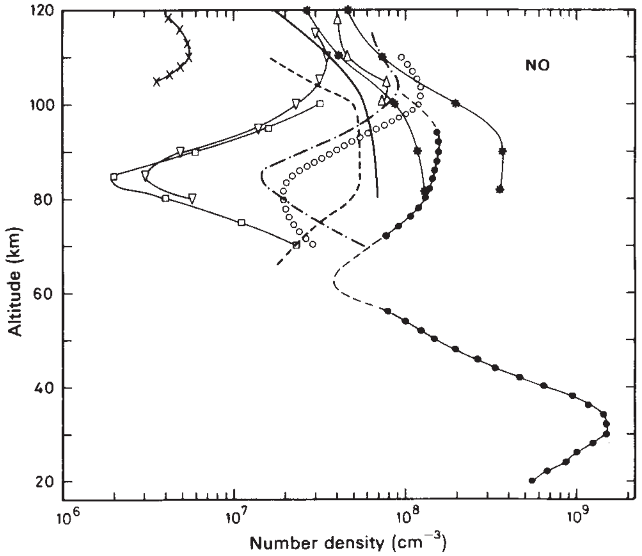

Fig. 4 Nitric oxide number densities presented in this paper are compared with the results of other authors: Barth[2] (——); Meira[4] (—·—·); Tisone[5] (----); Witt *et al.*[6] (○); Backer *et al.*[8] (□); Thomatsu-Iwagami[7] (▽); Thomas[9] (×); Trinks *et al.*[11] (△); this work (·—·—·); Massie[10] (*—*, sunrise).

widths versus tangent heights in the atmosphere are shown in Fig. 2*a*, *b*.

The data, represented by the smooth curves in Fig. 2*a*, *b*, were invented using the molecular-line parameters of Rothman *et al.*[14] in the 'onion peeling' inversion method, which leads to the vertical distributions of NO and NO_2 shown in Fig. 3. Above 98 km altitude, the scanned wavelength intervals broadened to observe broader band solar spectra. The 1,914.99-cm^{-1} NO line region was observed again at 105 km tangent altitude where the NO signal was too weak to be detected. From 55–75 km of altitude a dashed line represents inverted NO number densities, so low that the slant absorption must be attributed to NO at higher altitudes. Hence, at this altitude the NO abundances can only be given tentatively and probably represent an upper limit.

The stratospheric portion of the observation is characterized by a high signal-to-noise ratio for the absorption lines. Hence, the uncertainty on the volume concentrations is small and the values, which will be discussed elsewhere, are in the range of previous observations. Our results are compared in Fig. 4 with other observations in the mesosphere and in the low thermosphere. Although our results are in rather good agreement with other observations at the highest altitudes, the differences become very large at 85 km, particularly with the vertical profiles exhibiting a minimum volume concentration at that altitude. The shape of the vertical profile compares as well as possible with the results of Barth[2] and Tisone[5]. The only other absorption measurements to compare with our data are those of Massie[10], based on OSO-8 observations of the (1.0) δ band at 182.94 nm, which are in good agreement.

Slight modifications of our new data may be necessary if further refinement were to alter significantly the orbit parameters of the shuttle during the first Spacelab mission. More observations will be possible when the instrument is flown in a mission dedicated to atmospheric studies. When this happens we should gain understanding of the the distribution of NO in the mesosphere, which shows a disagreement between the NO abundances derived from different observation methods. This has important consequences for modelling neutral and charged-particle abundances in the upper-middle atmosphere and ionospheric D and E regions.

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