



PTYS544

Physics of the High Atmosphere

Basic details

👁 Location / Time

- Tuesday & Thursday, 12:30 – 13:45
- Kuiper Space Science (KSS)

👁 Instructor

- Tommi Koskinen, KSS 421
- tommik@email.arizona.edu



The Earth's atmosphere



Surface temperature:

288 K

Surface pressure:

1 bar

Composition:

77% N₂

21% O₂

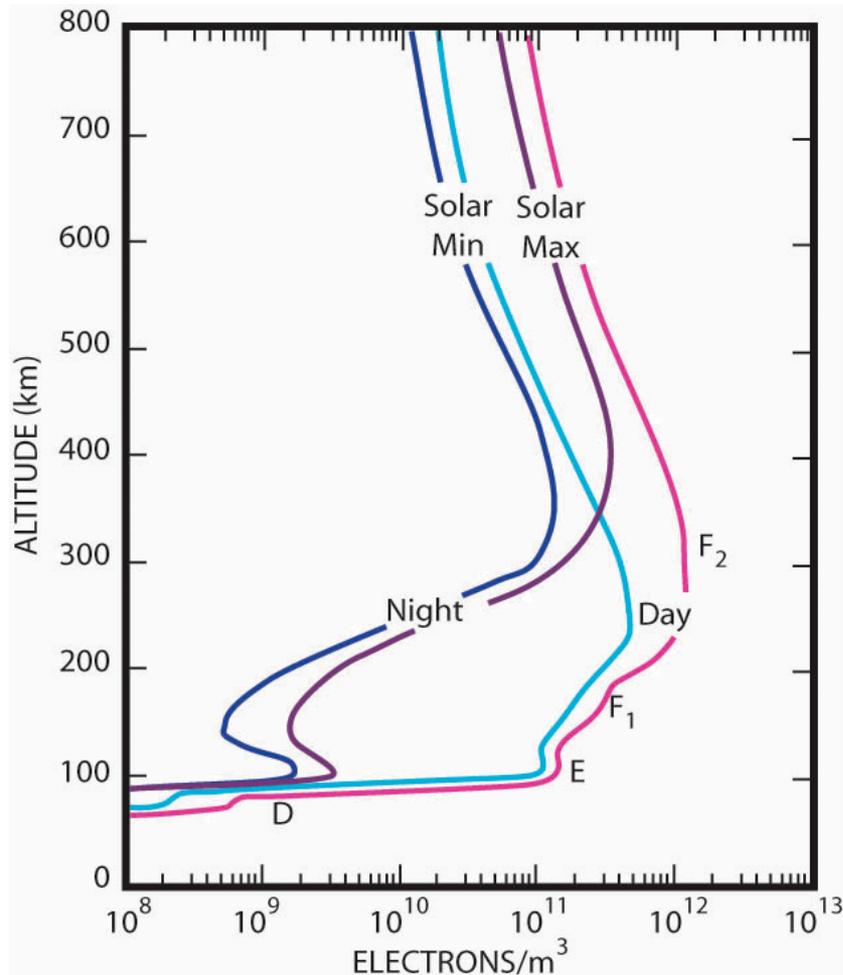
1% Ar

Conditions:

Winds, rain and snow,
clouds of water

Left: Northern lights in the upper
atmosphere.

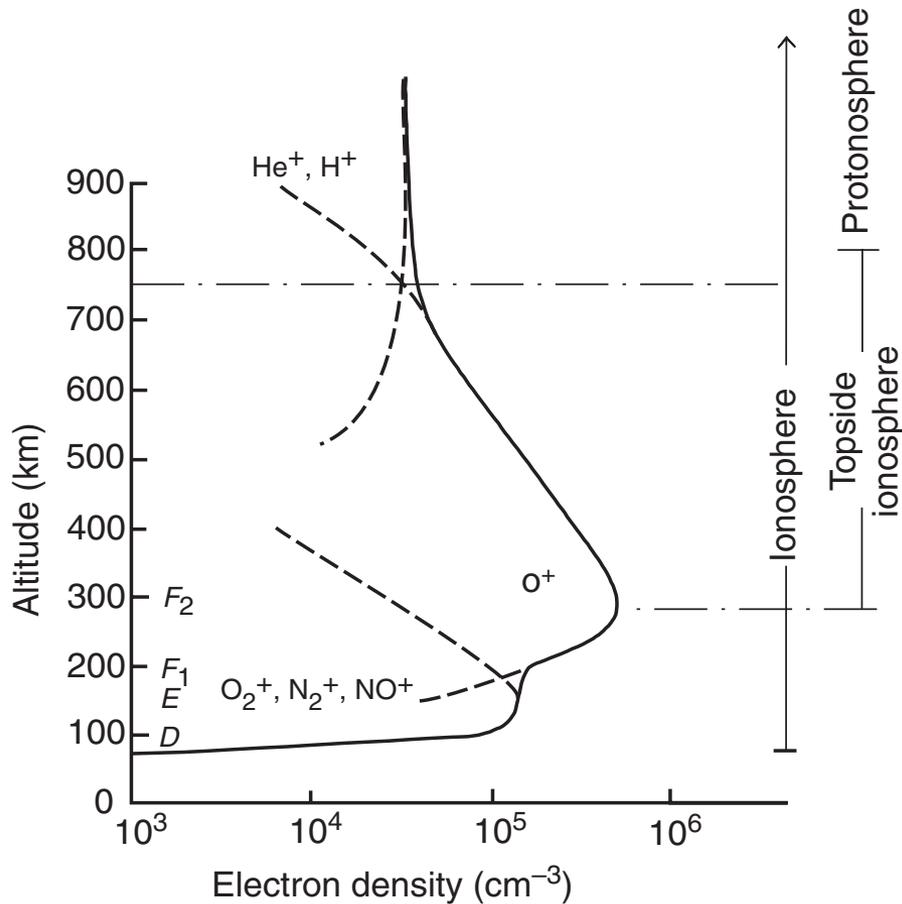
The ionosphere



Representative mid-latitude
electron densities
(Richmond 1987)

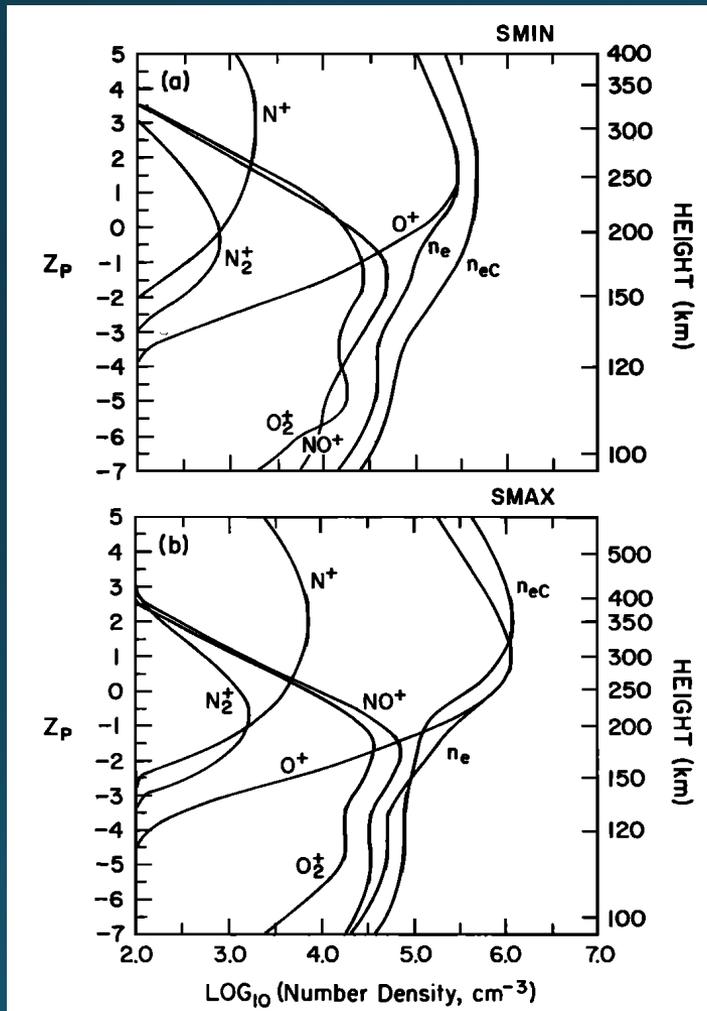
See also
[https://ccmc.gsfc.nasa.gov/
modelweb/models/iri2016_v
itmo.php](https://ccmc.gsfc.nasa.gov/modelweb/models/iri2016_vitmo.php)

Ionosphere: Composition



Schematic of ionospheric layers from Schunk and Nagy (2000)

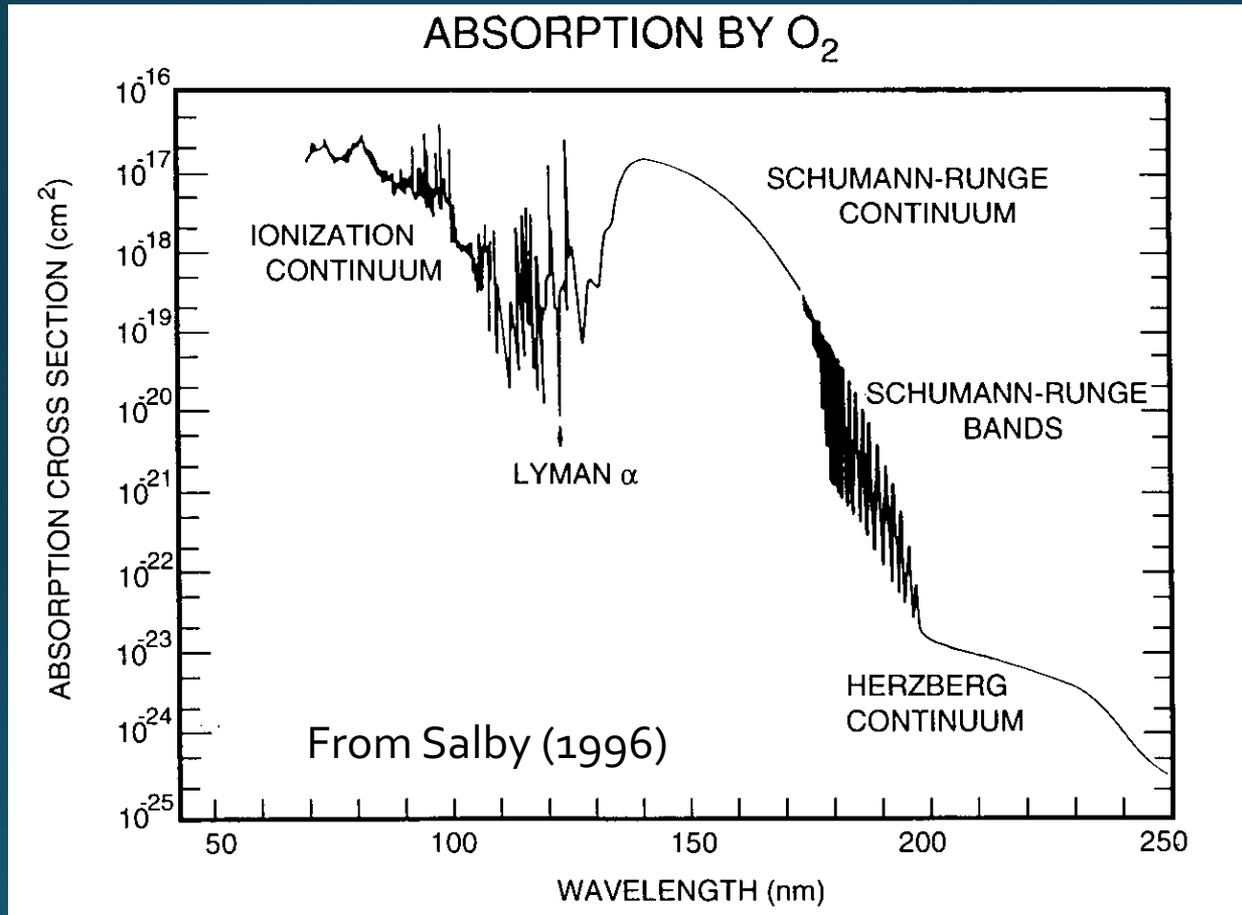
Ionosphere composition



Ion composition for (a) solar minimum conditions and (b) solar maximum conditions from Roble et al. (1987)

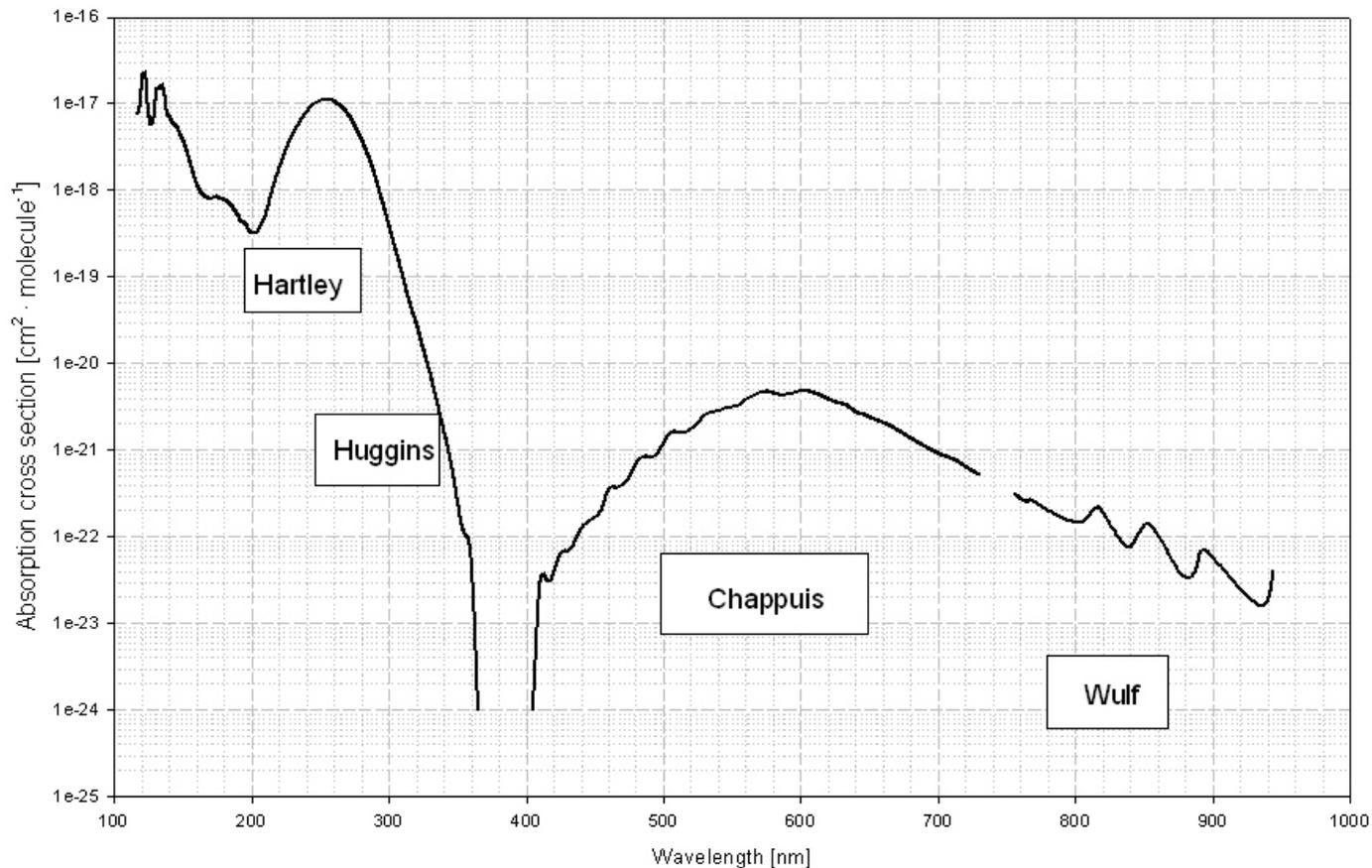
Stratosphere: Ozone

Absorption cross section of O₂



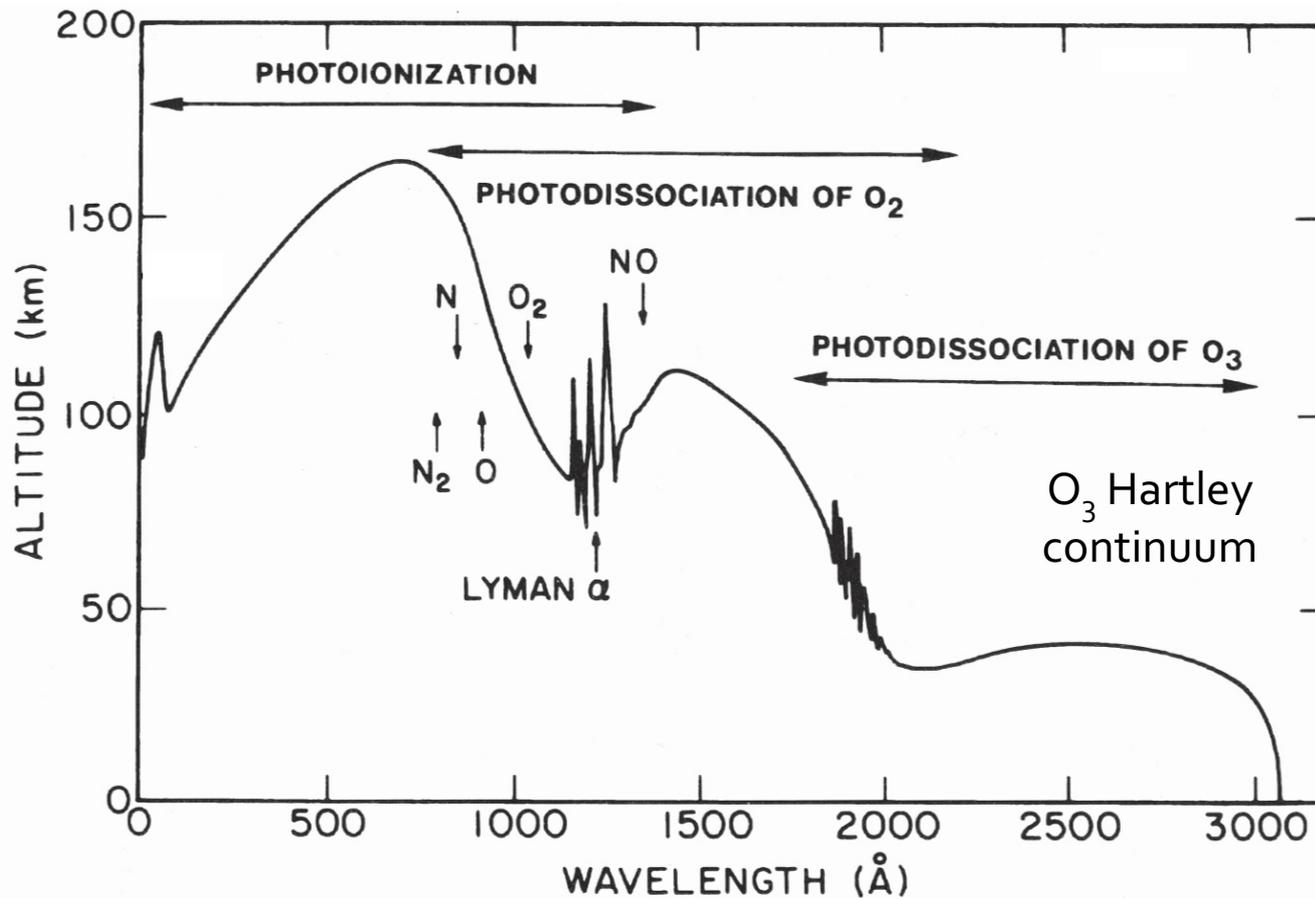
See Heays et al. (2017) for a compilation of cross section references.

Absorption cross section of O₃



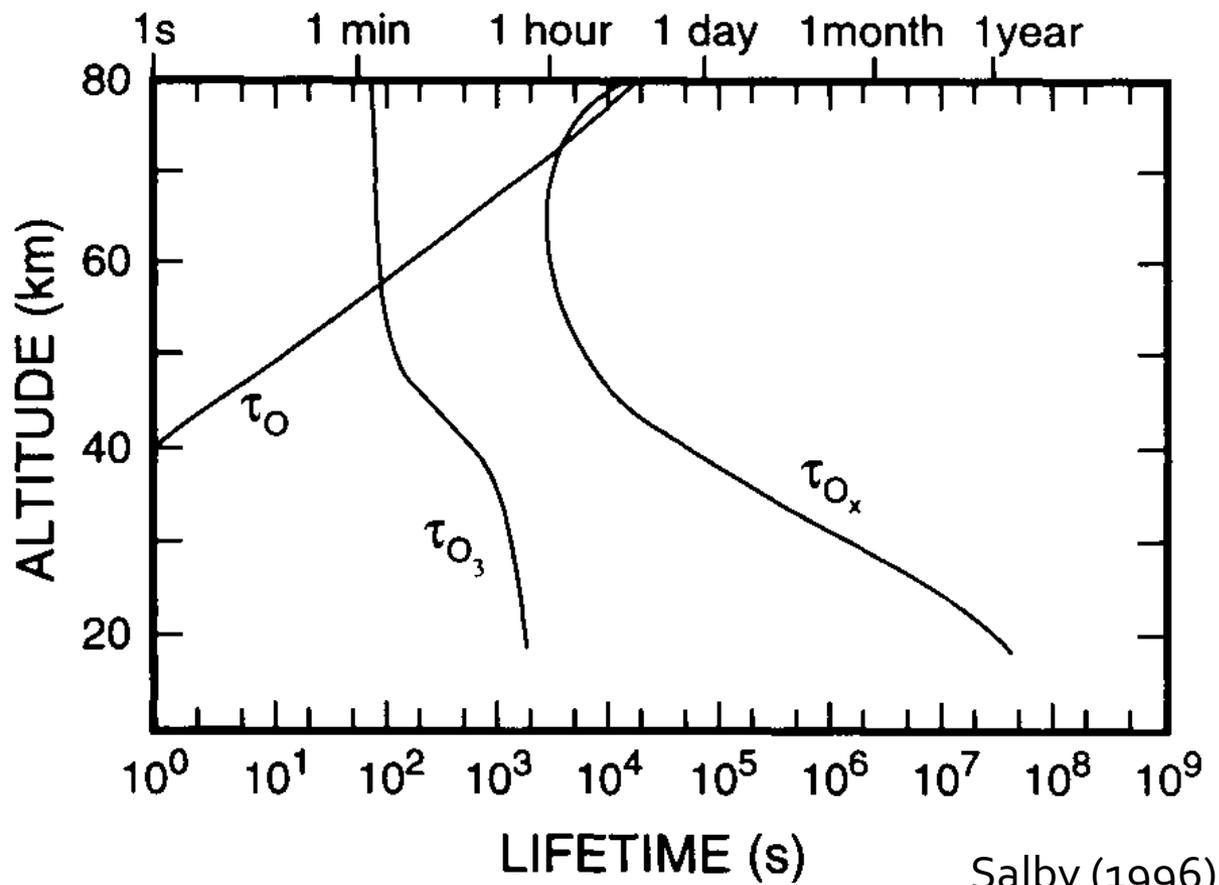
Overview of the absorption spectrum of ozone O₃.

Ackerman, in: Mesospheric Models and Related Experiments (Ed. G. Fiocco, Dordrecht, 1971), pp. 149-159,
Anderson et al., Geophys. Res. Lett. 20 (1993) 1579



Altitude of unit optical depth calculated at zero zenith angle.
 Ionization thresholds are marked by arrows.

O_x lifetimes



Stratosphere: Ozone concentration

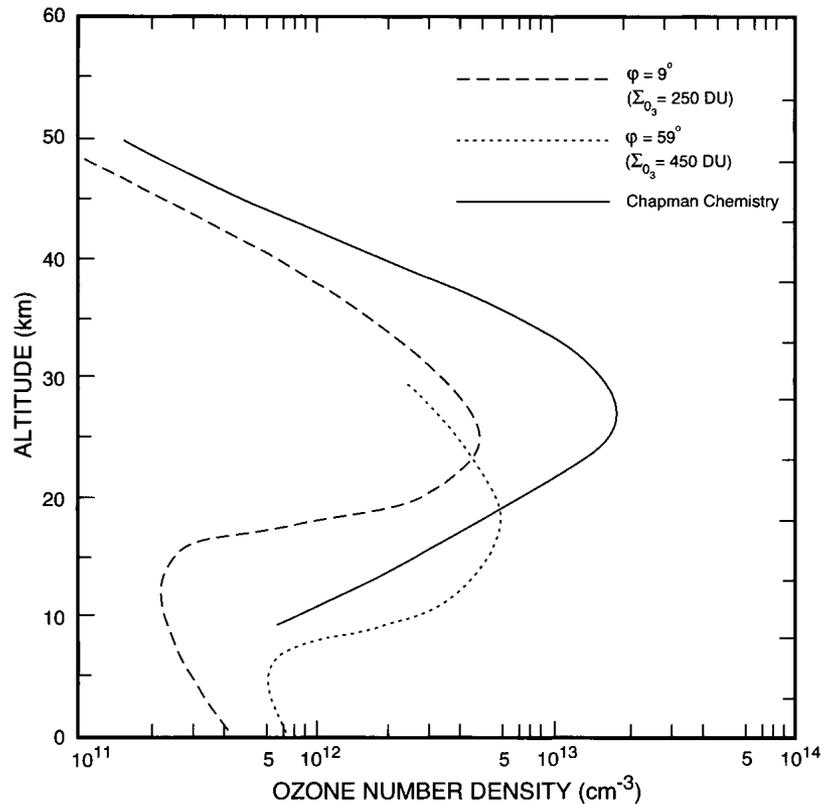


Figure 17.2 Vertical profile of ozone number density under photochemical equilibrium, as calculated from Chapman chemistry (solid line), and observed in tropical (dashed line) and extratropical (dotted line) regions. Chapman chemistry was calculated with rate coefficients from Brasseur and Solomon (1986) and Nicolet (1980). It yields realistic vertical structure, but a column abundance of $\Sigma_{O_3} \cong 1000$ DU. Observed data are from Hering and Borden (1965) and Krueger (1973).

From Salby (1996)

Ozone distribution

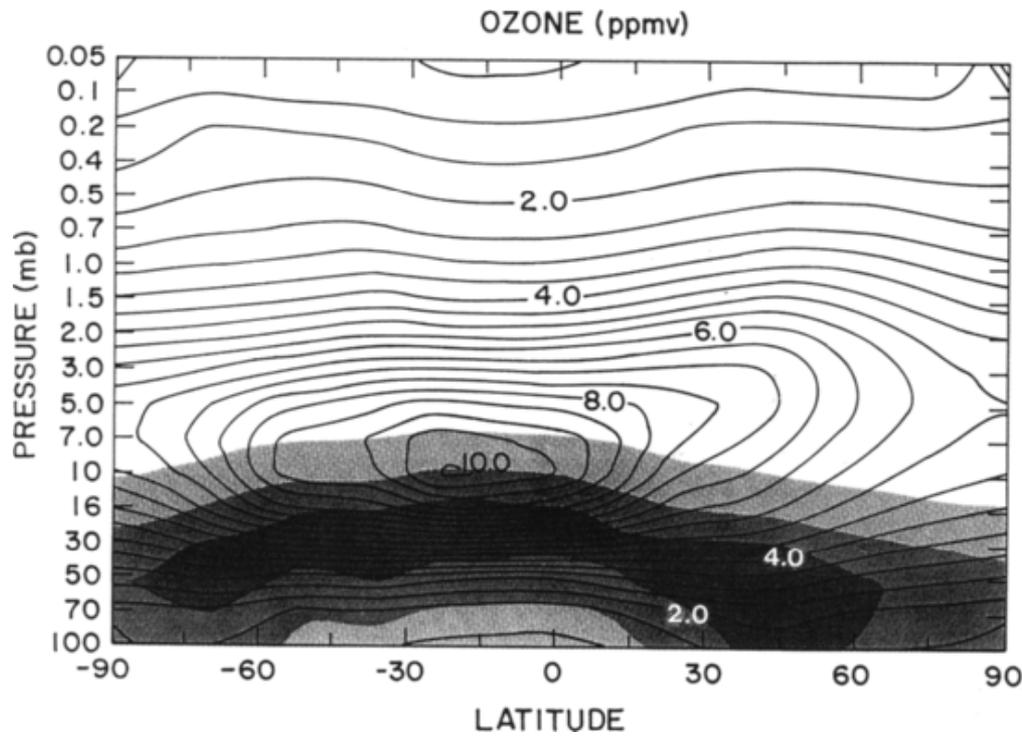


Figure 1.17 Zonal-mean mixing ratio of ozone (contoured) and density of ozone (shaded) averaged over January–February 1979, as functions of latitude and pressure, obtained from the Limb Infrared Monitor of the Stratosphere (LIMS) on board Nimbus-7. The shaded levels correspond to 20, 40, and 60% of the maximum value.

Salby (1996)

Ozone distribution

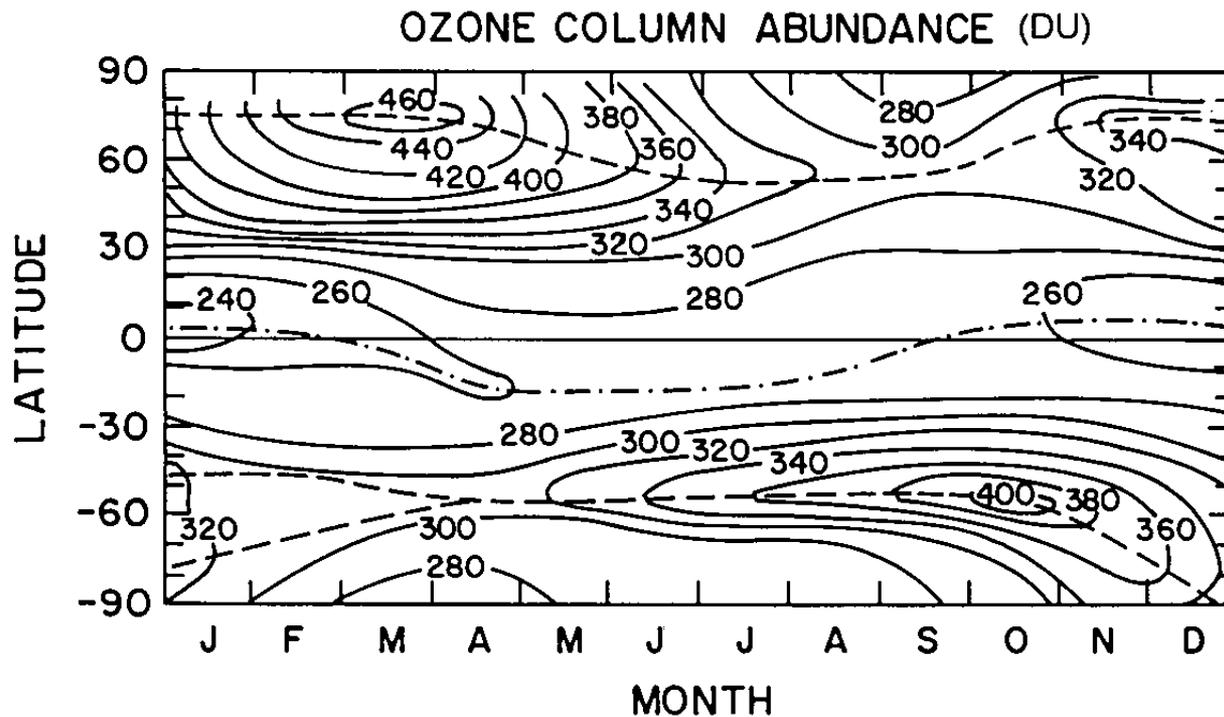
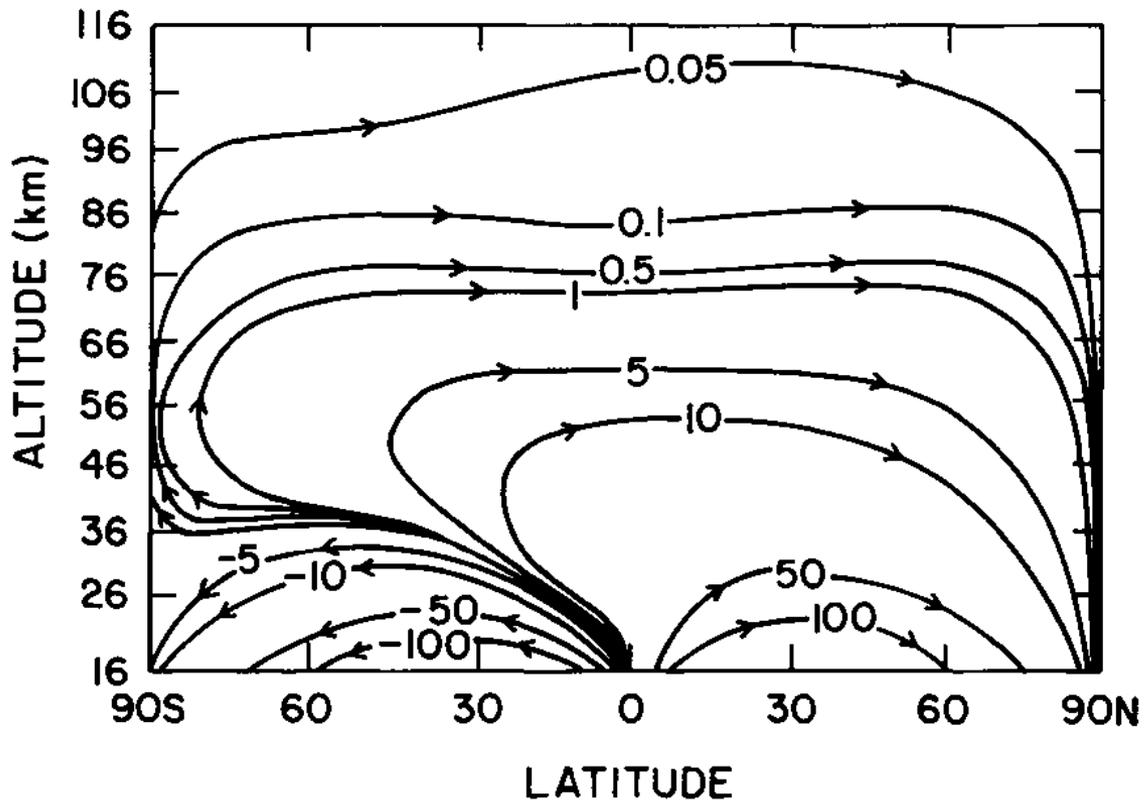


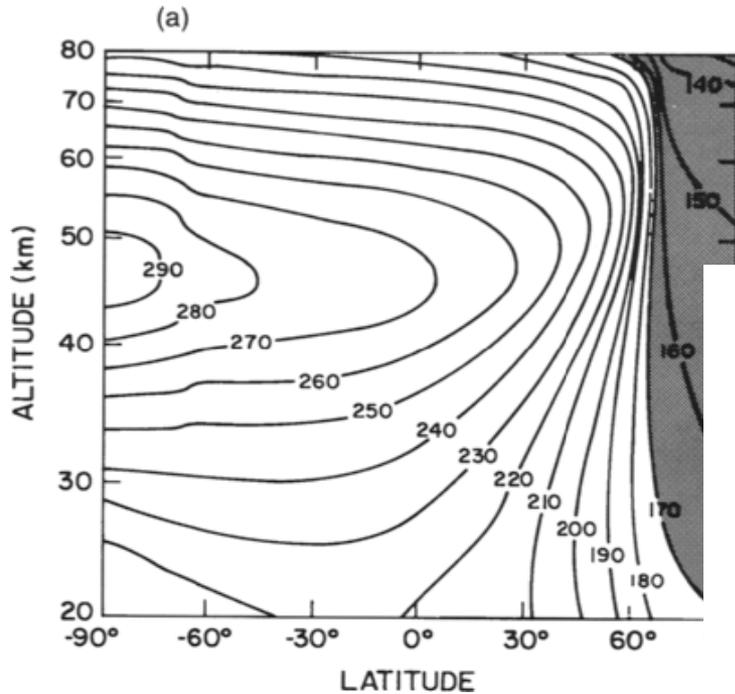
Figure 1.18 Zonal-mean column abundance of ozone, or *total ozone*, as a function of latitude and month. Based on the historical record prior to 1980. From London (1980).

Brewer-Dobson circulation



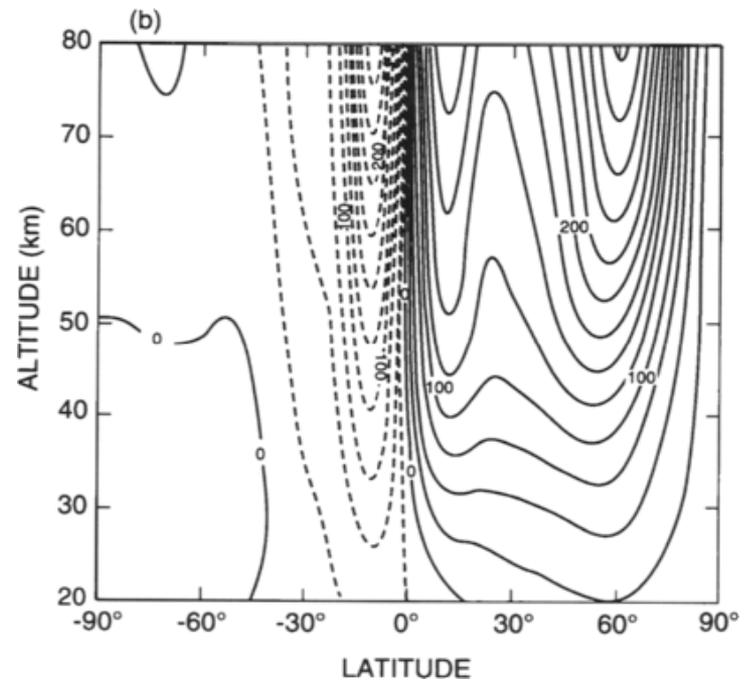
Streamlines of mean meridional circulation in the middle atmosphere
(Salby 1996)

Middle atmosphere dynamics

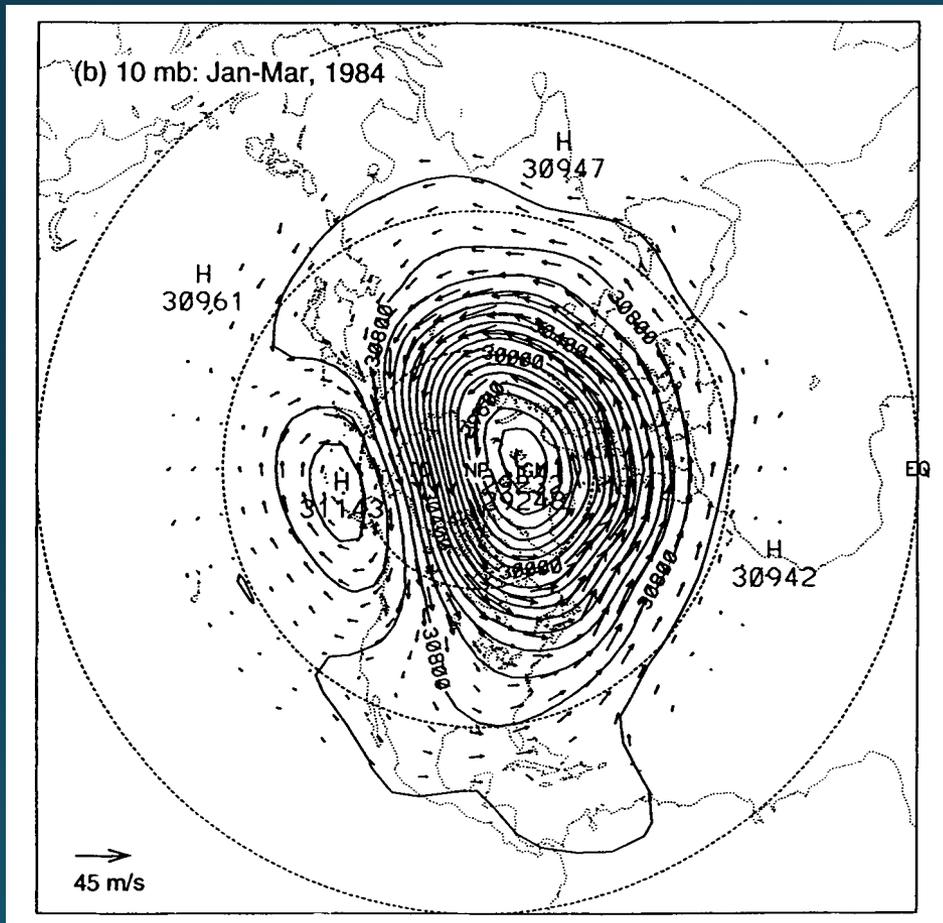


Radiative-equilibrium temperature
northern solstice (Salby 1996)

Zonal winds from thermal wind
balance.

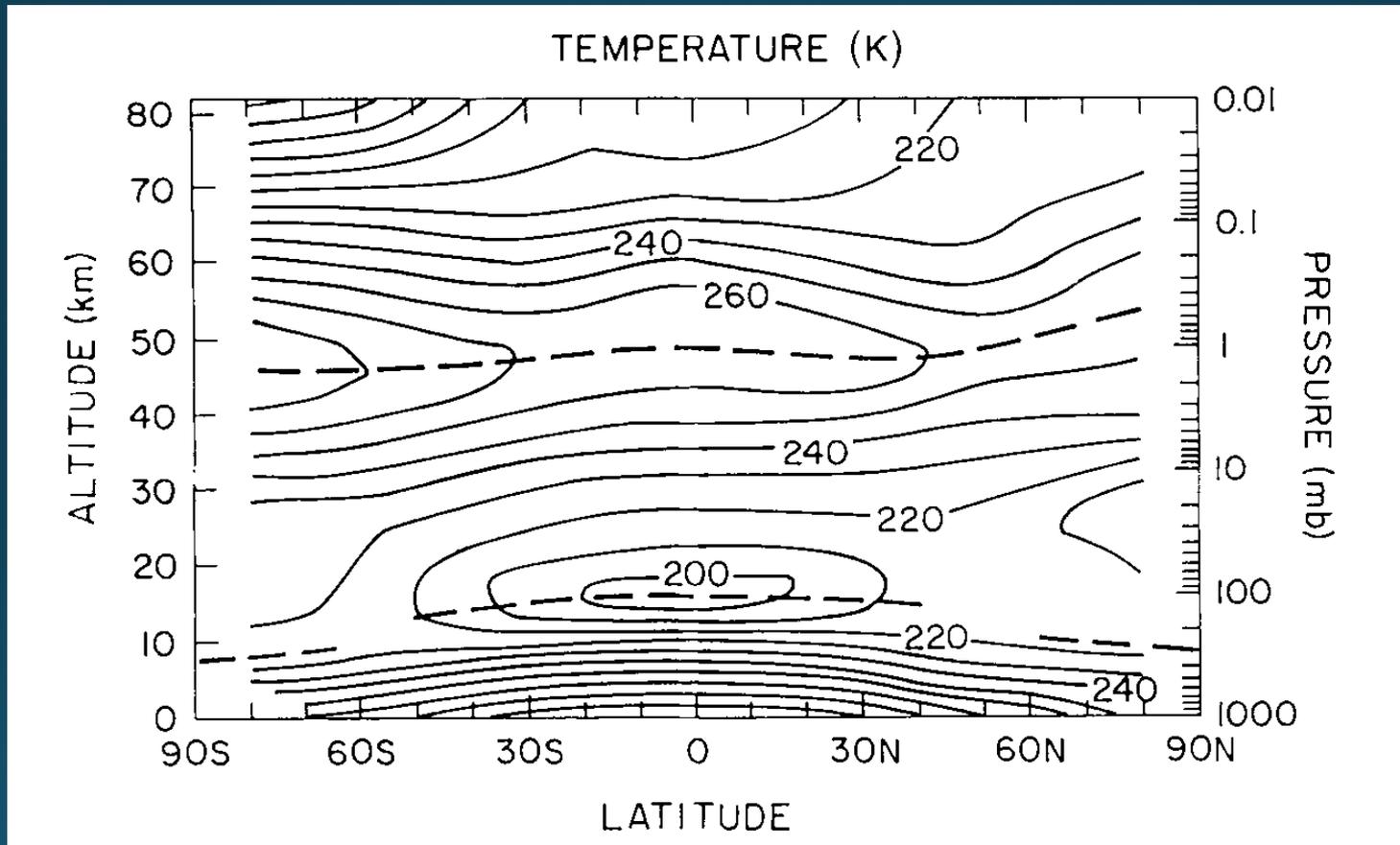


Circumpolar vortex



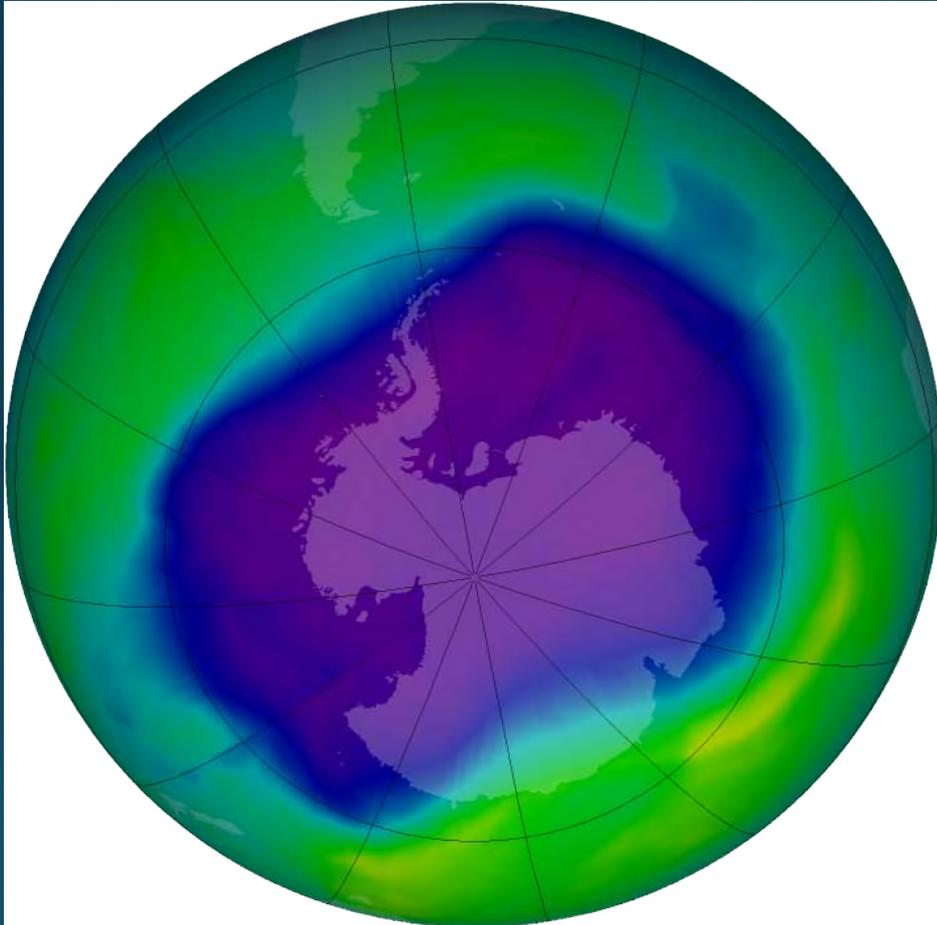
The contours are
isobaric heights
in meters
(from Salby 1996).

Middle atmosphere temperatures



Zonal mean temperature during northern winter (Salby 1996).

Antarctic ozone hole



Late September, 2006
(southern spring),
NASA/NOAA

Ozone hole and polar stratospheric clouds

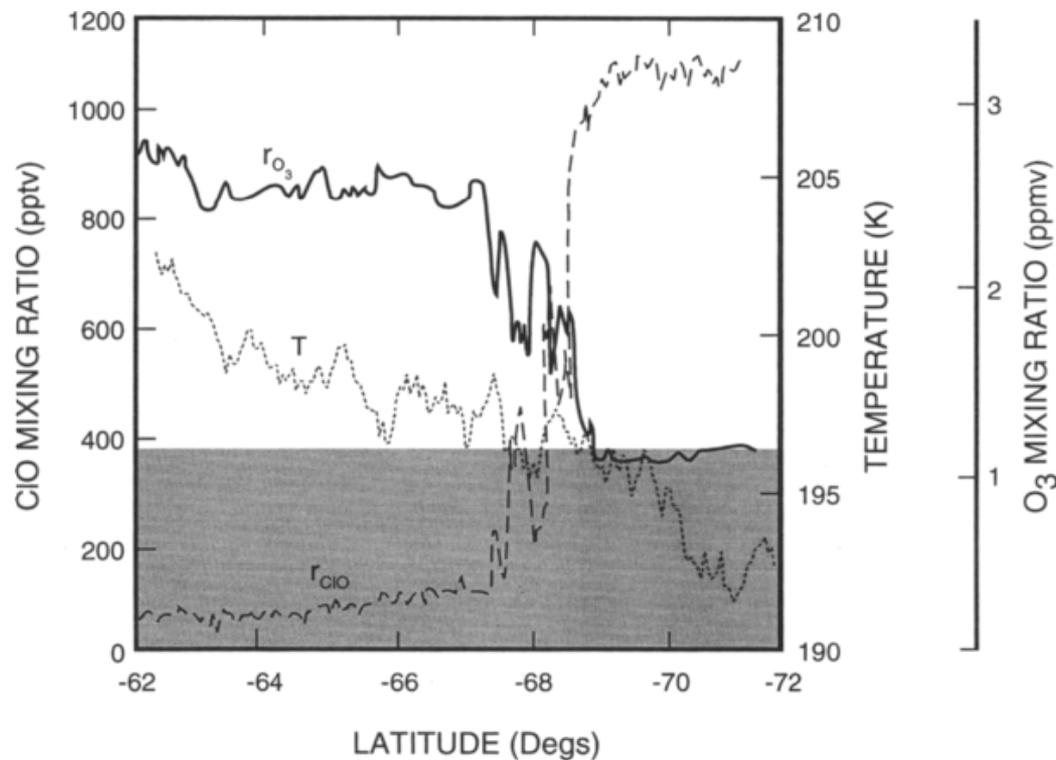


Figure 17.22 Mixing ratios of ozone (solid line) and chlorine monoxide (dashed line) and temperature (dotted line) along a flight path into the Antarctic polar-night vortex. Temperatures colder than about 196 K (shaded) coincide with the formation of type I PSCs. Source of O₃ and ClO profiles: Anderson *et al.* (1989).