



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

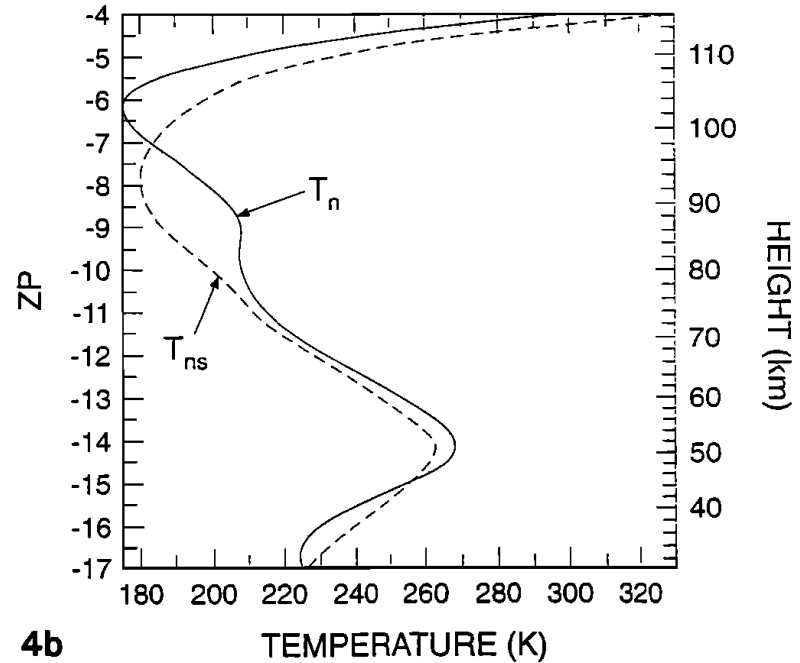
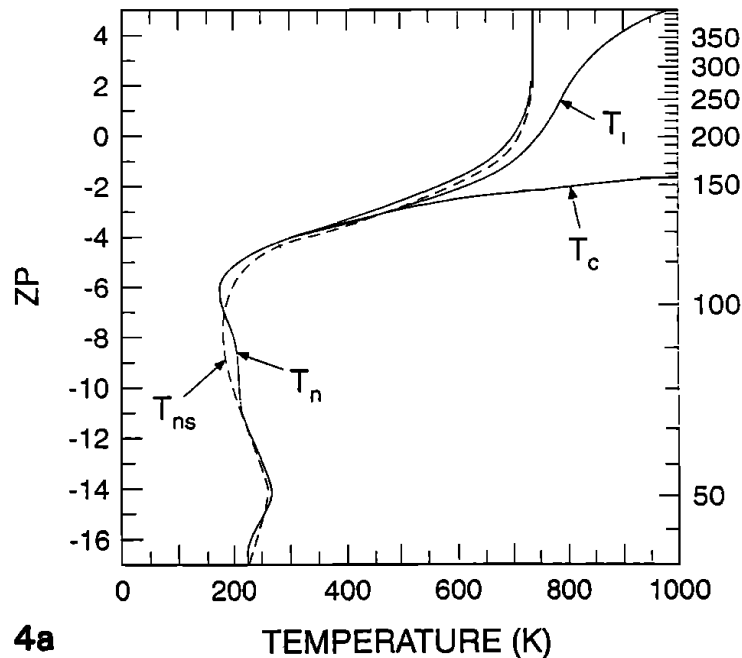
1% Ar

Conditions:

Winds, rain and snow,
clouds of water

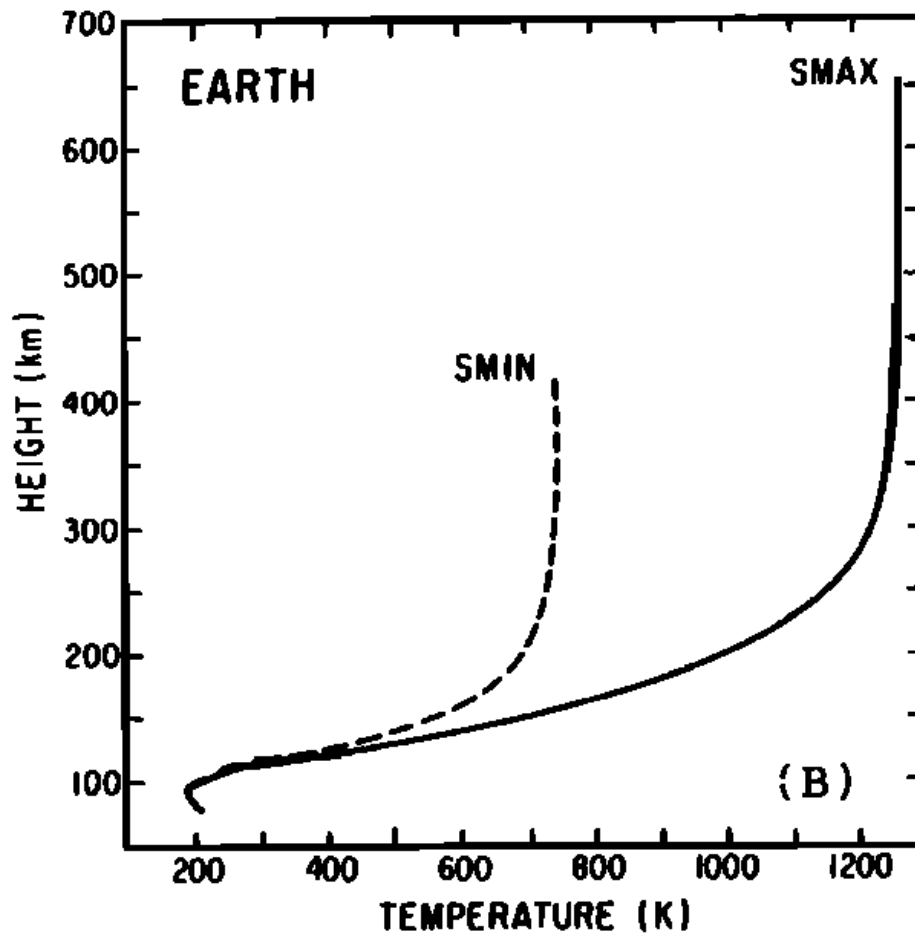
Left: Northern lights in the upper
atmosphere.

Basic atmospheric structure



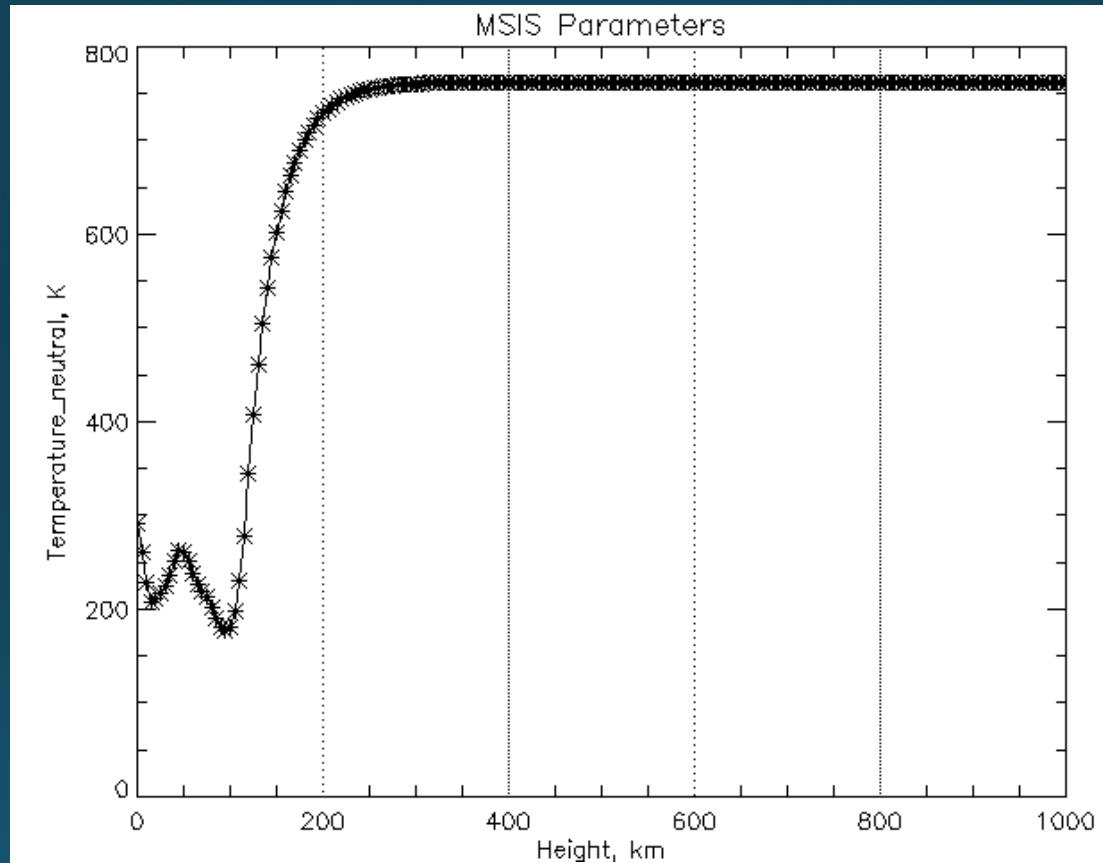
Solar minimum conditions from Roble (1995). T_n , T_i and T_e are simulated global mean neutral, ion and electron temperatures. T_{ns} is the empirical MSIS-90 model temperature profile.

Solar cycle variation



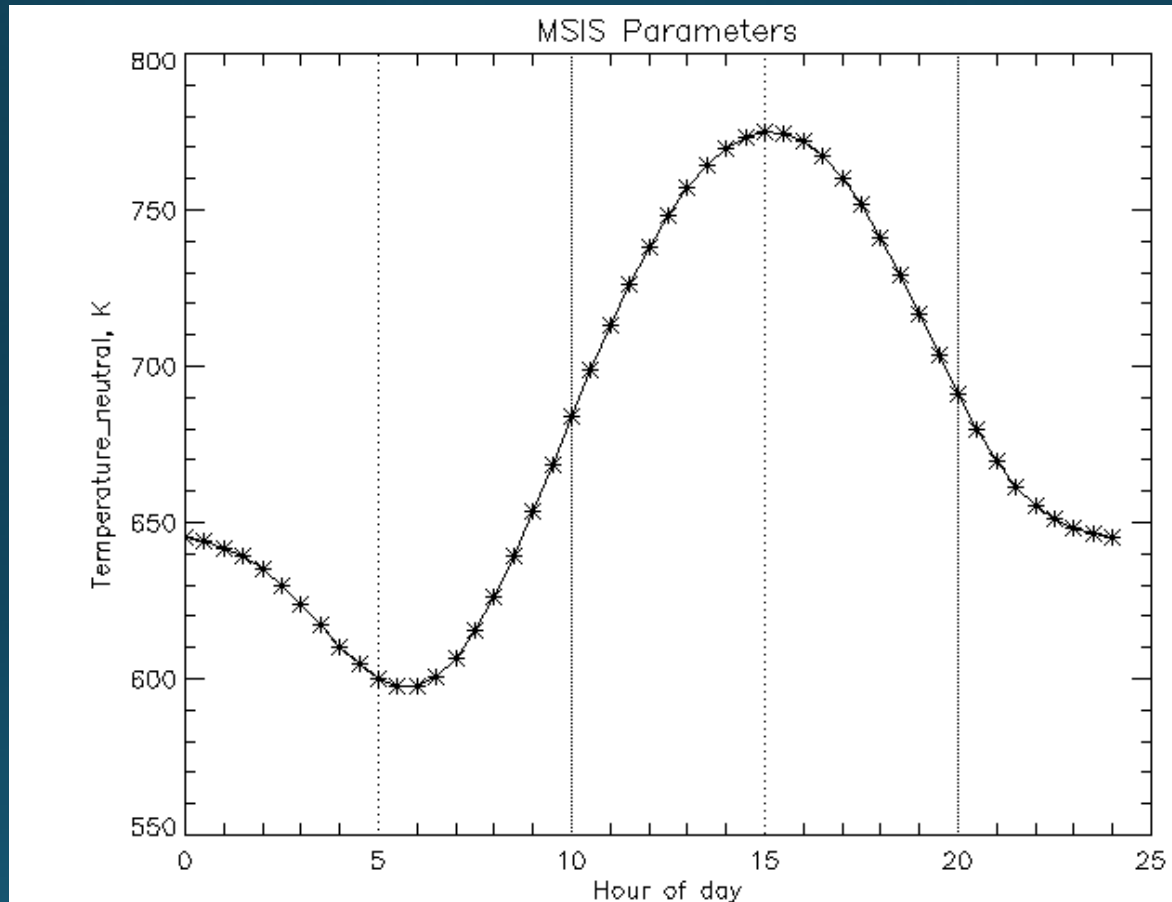
From Bougher et al.
(1991)

The NRLMSISE00 model



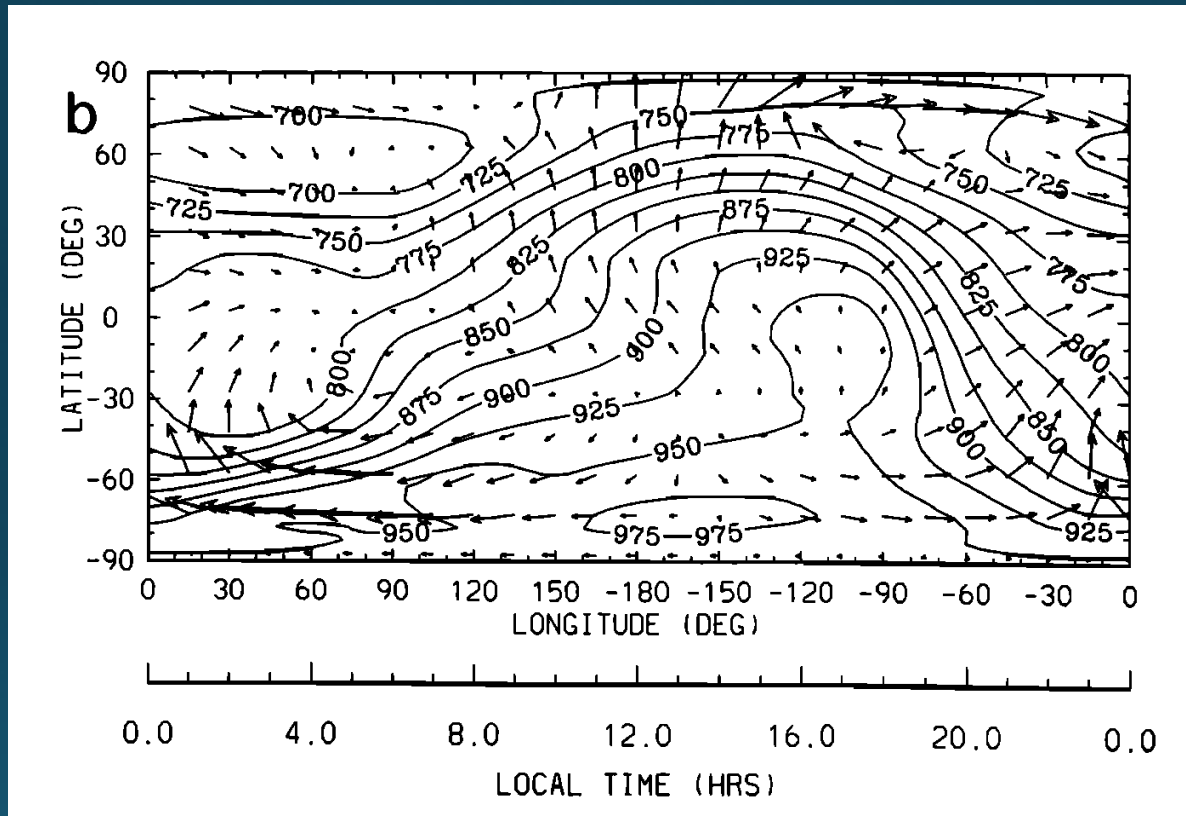
The noon temperature profile above Tucson on January 1, 2018. See:
<https://ccmc.gsfc.nasa.gov/modelweb/models/nrlmsise00.php>

Local time variation



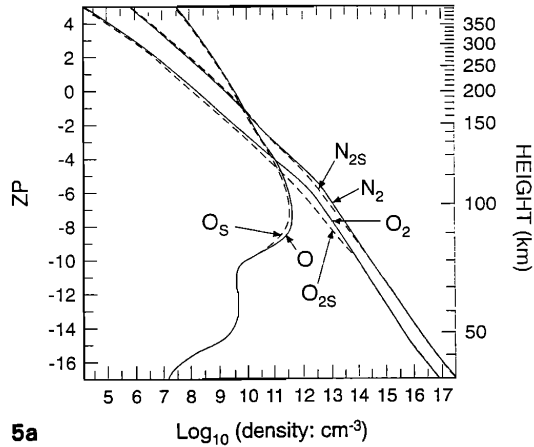
Local time variation for the latitude of Tucson on January 1, 2018. See:
<https://ccmc.gsfc.nasa.gov/modelweb/models/nrlmsiseoo.php>

Global temperatures and winds: thermosphere

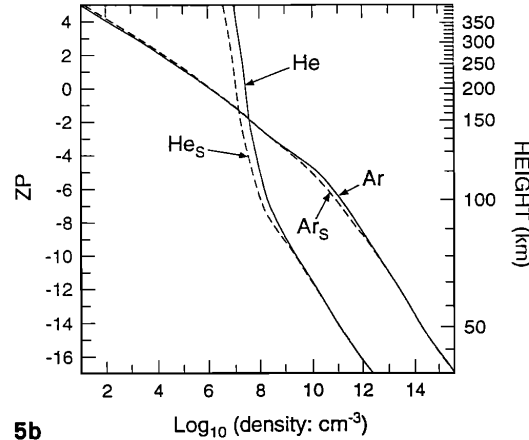


Temperature and wind map from TIE-GCM simulation of Bougher et al. (2000) for northern winter solstice during solar minimum.

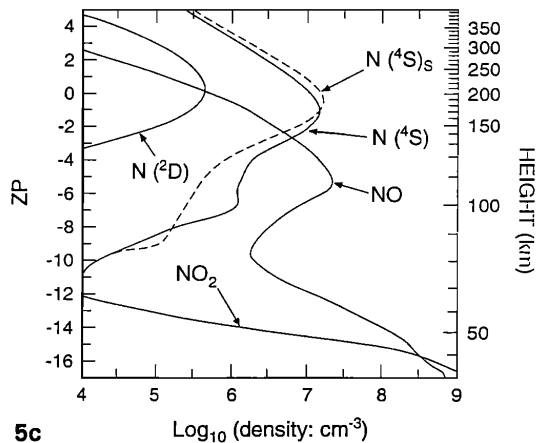
Neutral composition



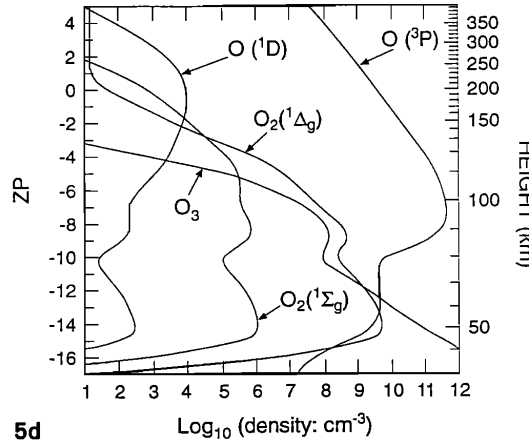
5a



5b



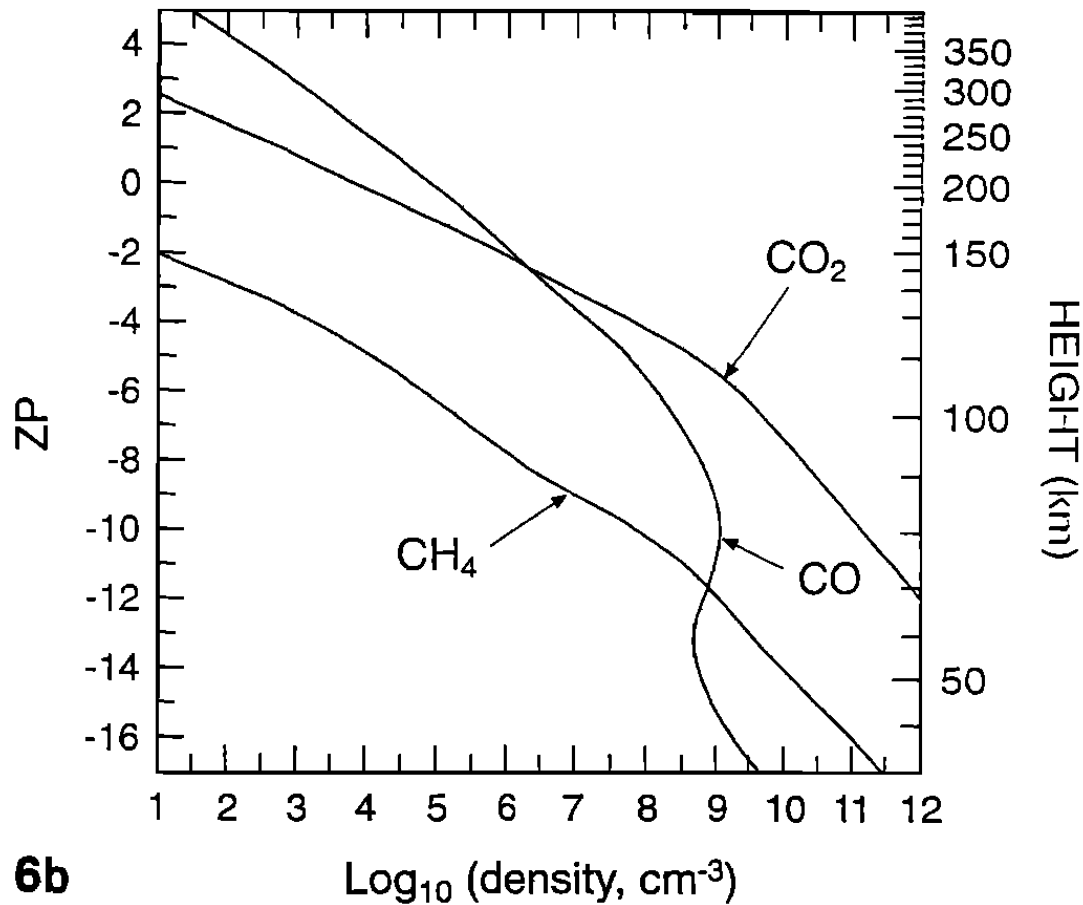
5c



5d

Solid lines are simulated profiles from Roble (1995). Dashed lines show MSIS-90 profiles.

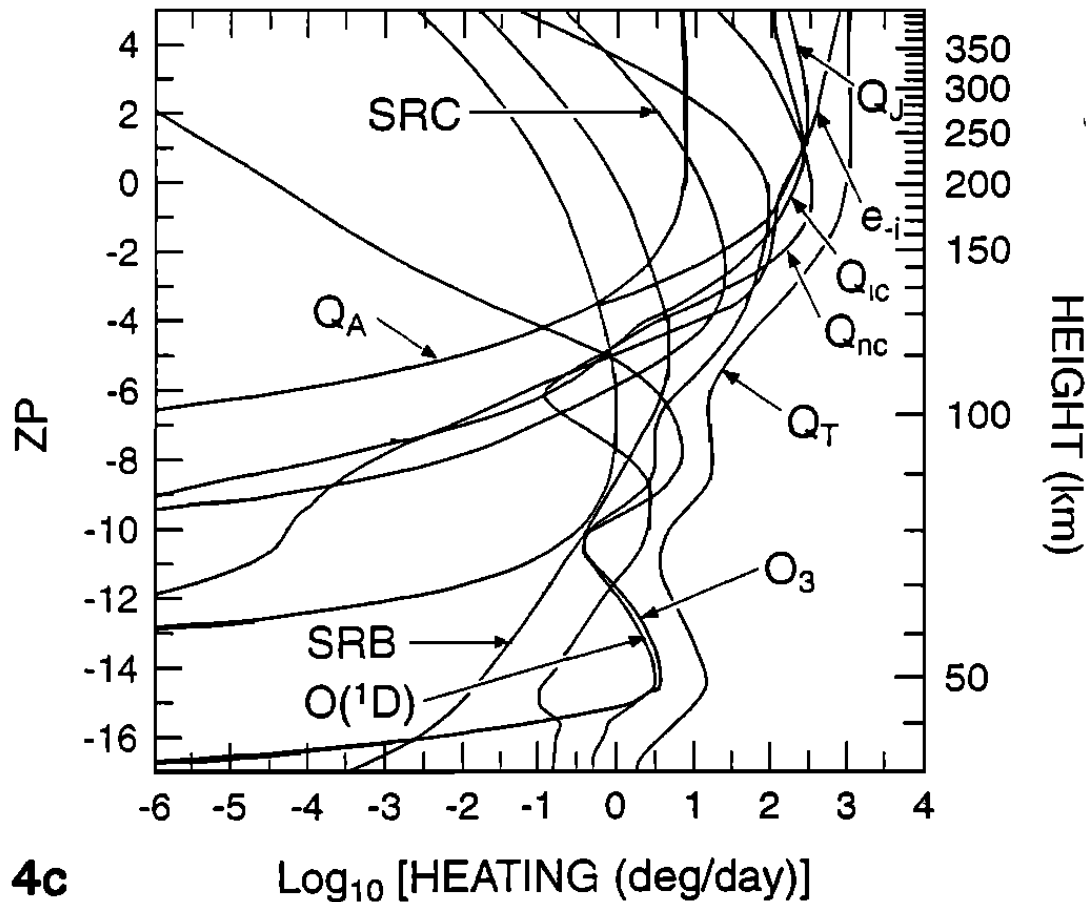
Neutral composition



Simulated profiles
from Roble (1995).

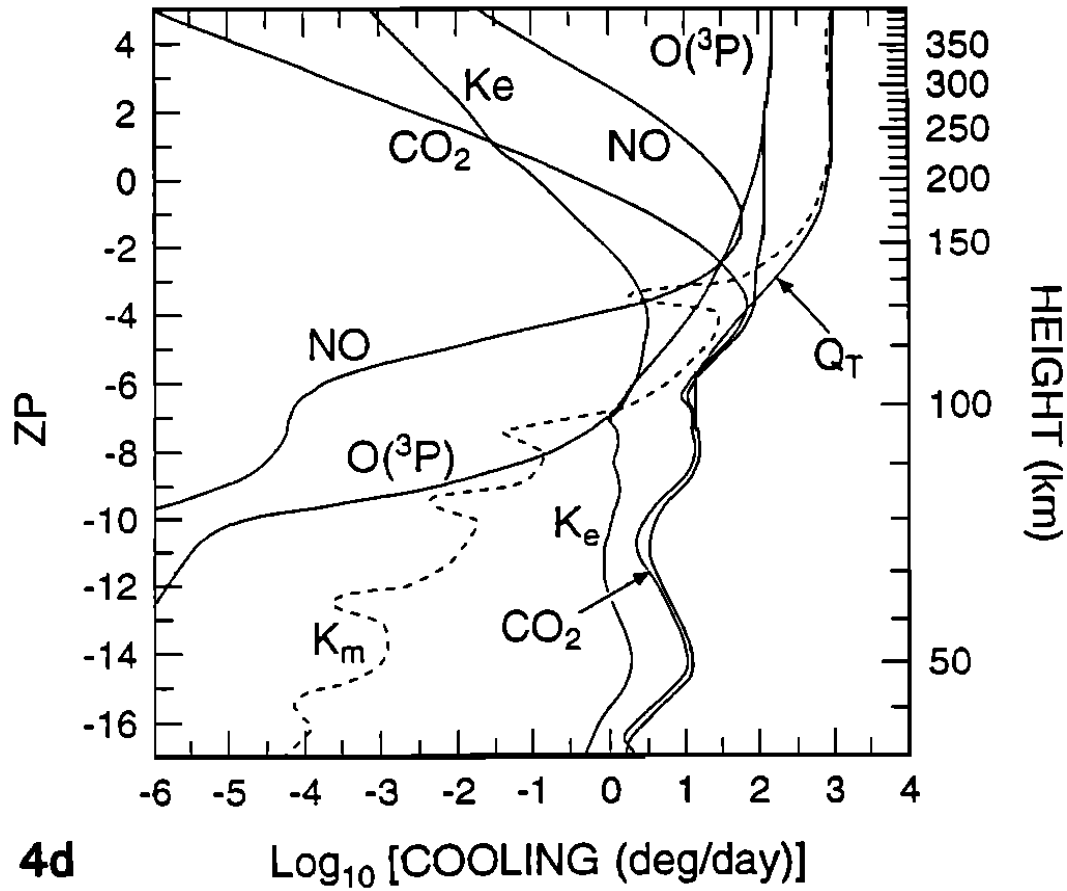
6b

Energy balance: Heating



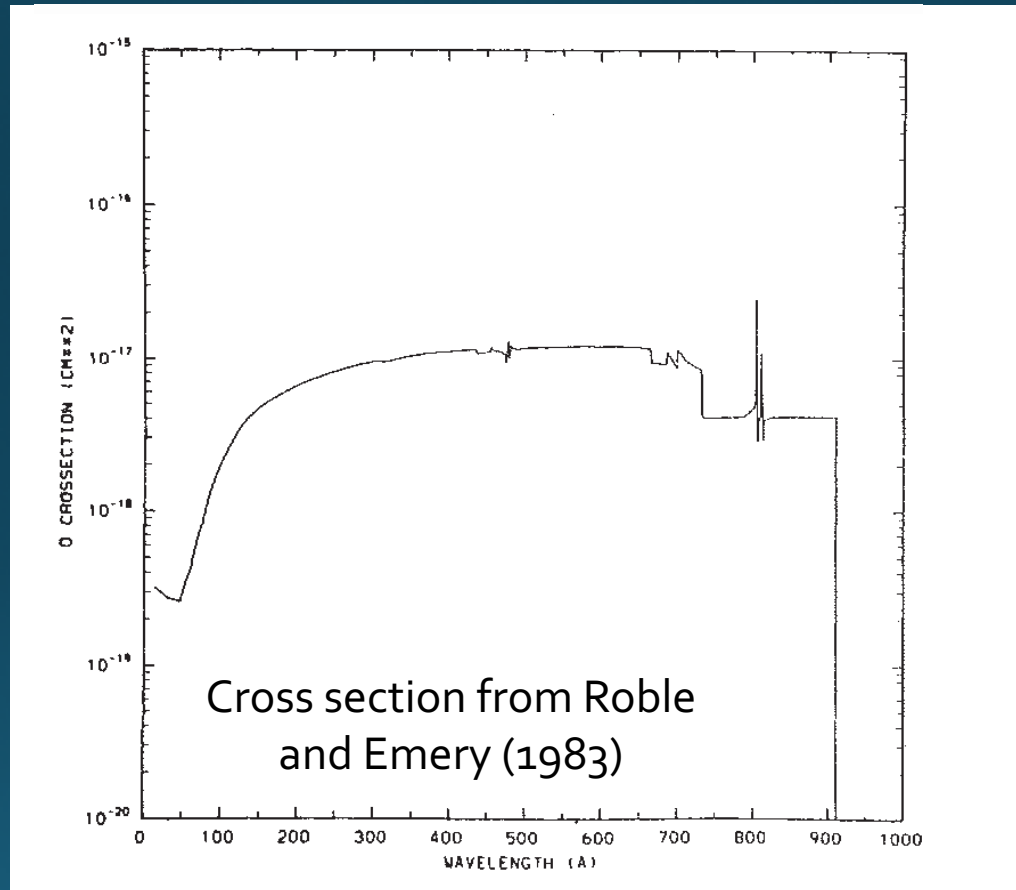
Basic heating terms from Roble (1995), see Roble et al. (1987) for the thermosphere.

Energy balance: Cooling



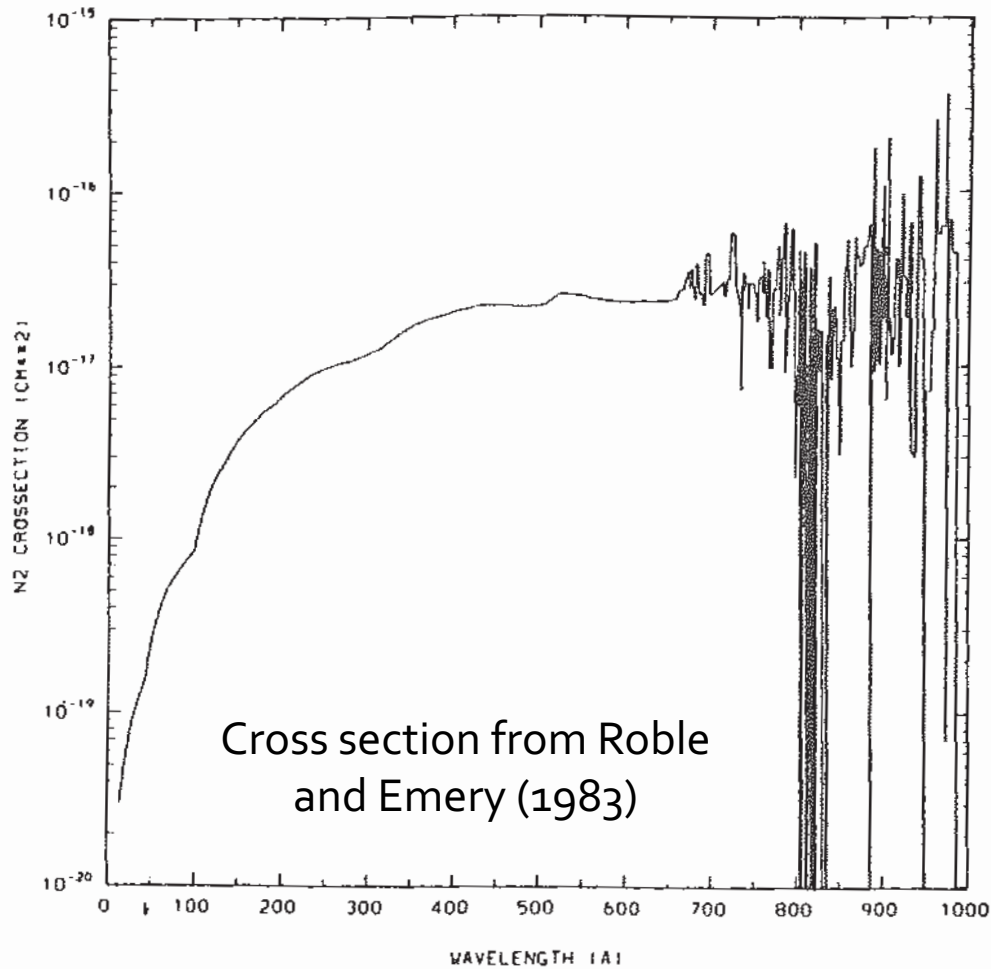
Basic cooling terms
from Roble (1995).

Photoionization cross section of O



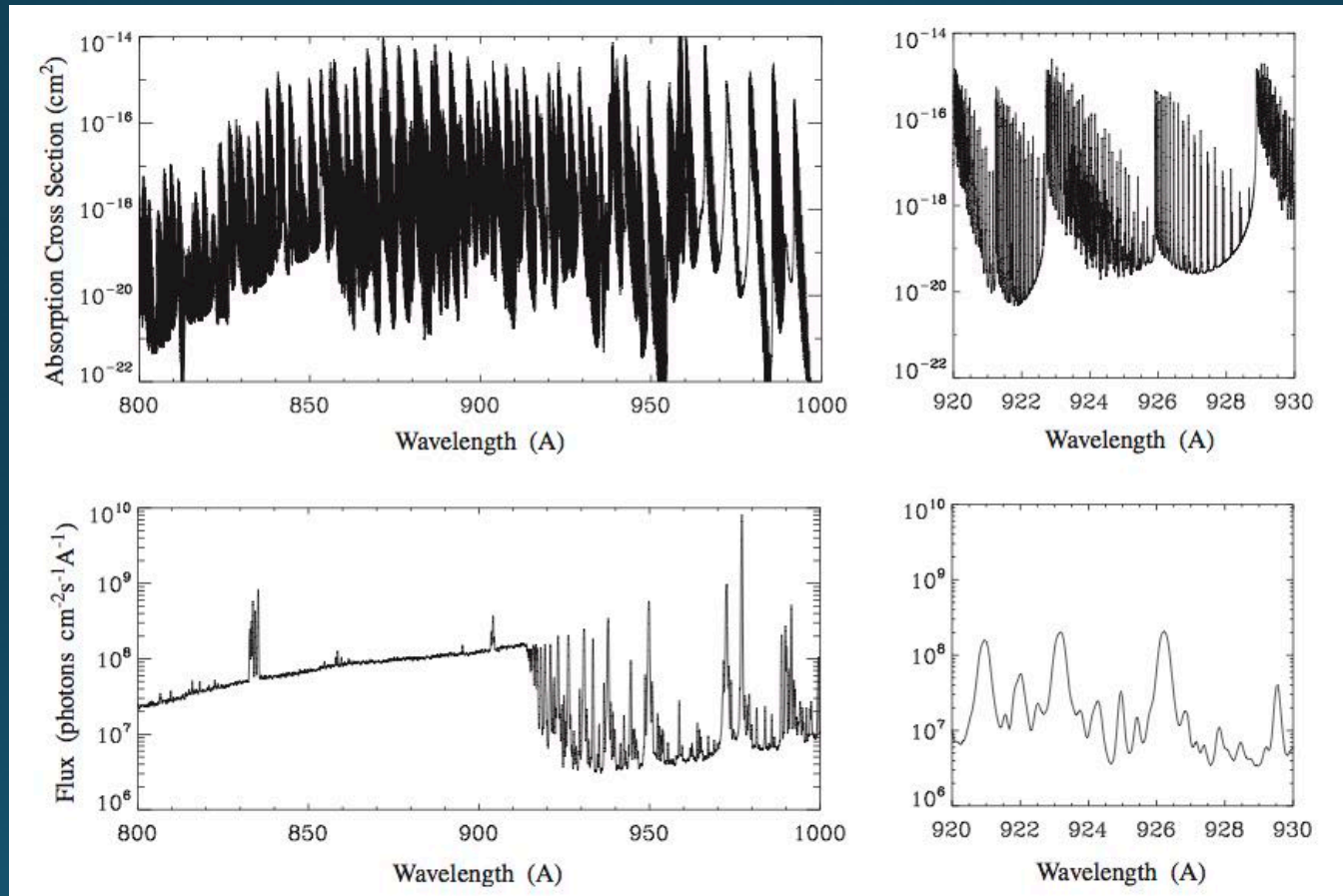
See Verner et al. (1996) for analytic fits to photoionization cross sections.

Photo-absorption cross section of N₂



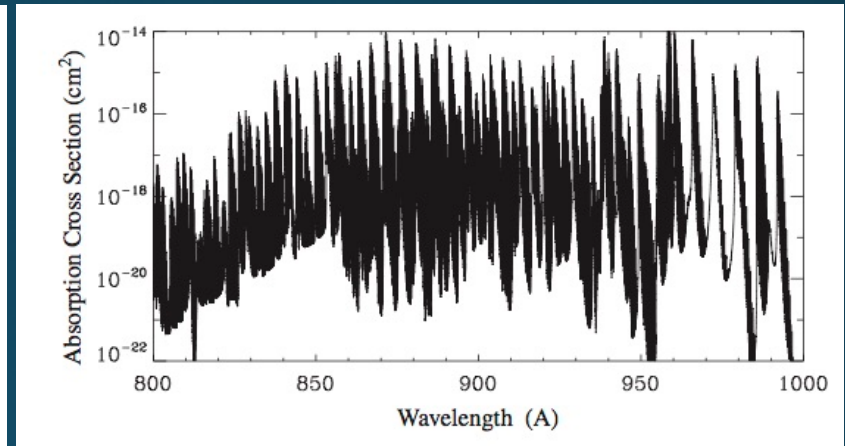
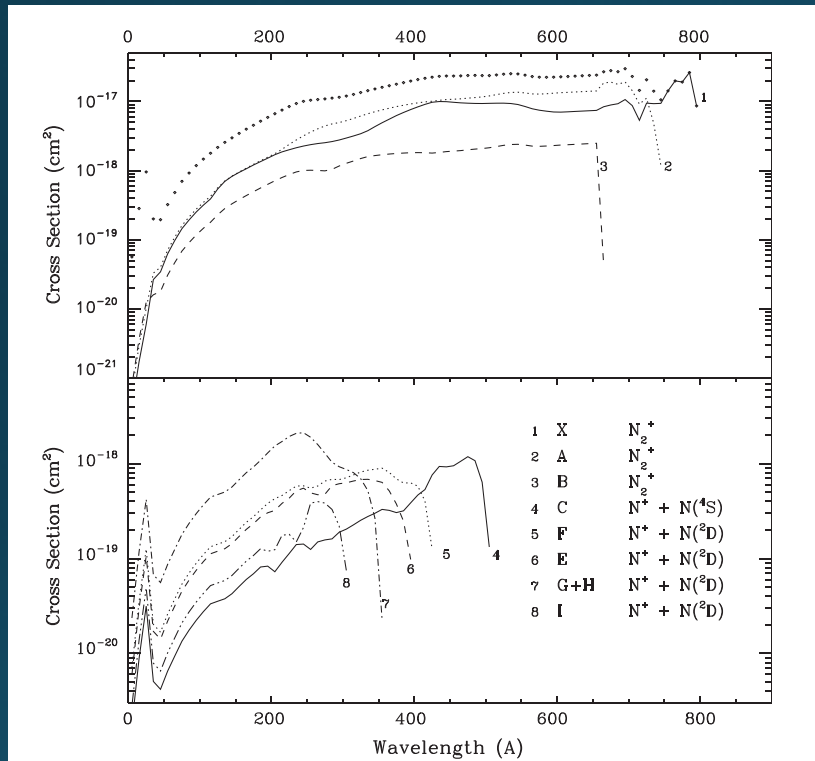
Ionization potential
15.58 eV (79.58 nm)

Absorption cross section of N₂ bands



High resolution N₂ band cross section compared with SOHO/SUMER spectrum of the sun (Lavvas et al. 2011)

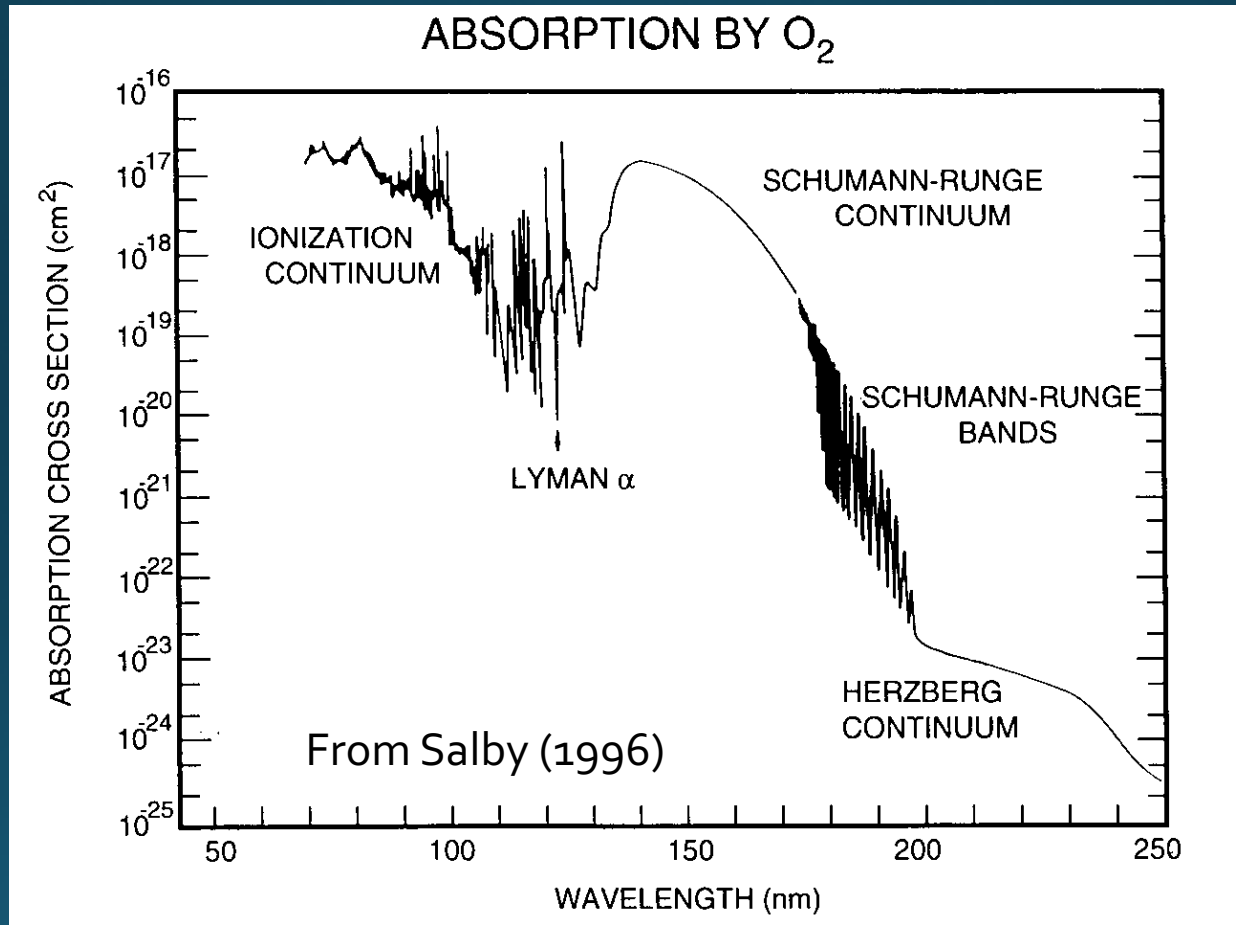
N₂ ionization/band absorption cross section



From Lavvas et al.(2011)

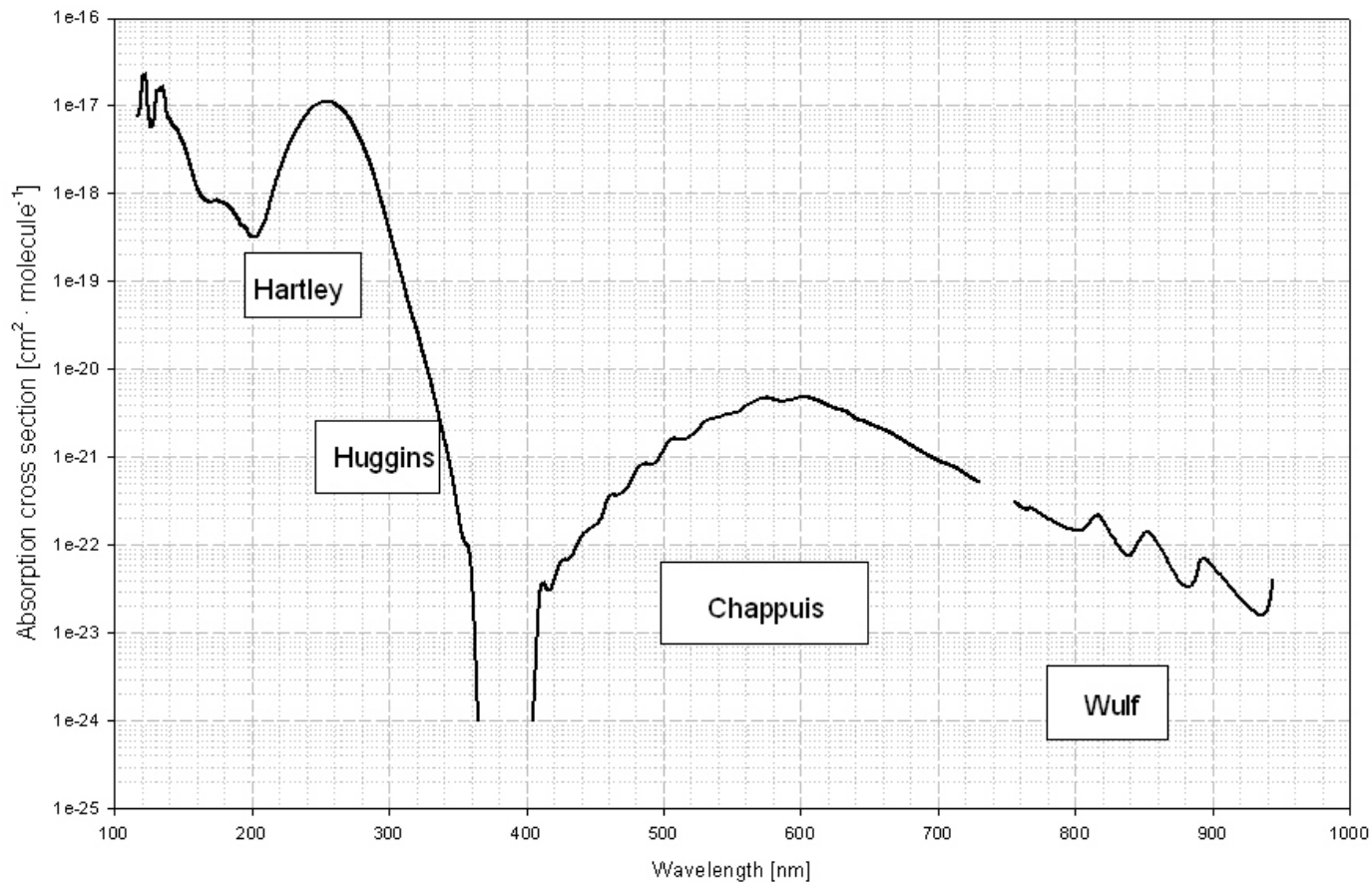
The dissociation and ionization thresholds are 9.8 eV (126.5 nm) and 15.58 eV (79.58 nm), respectively.

Absorption cross section of O₂



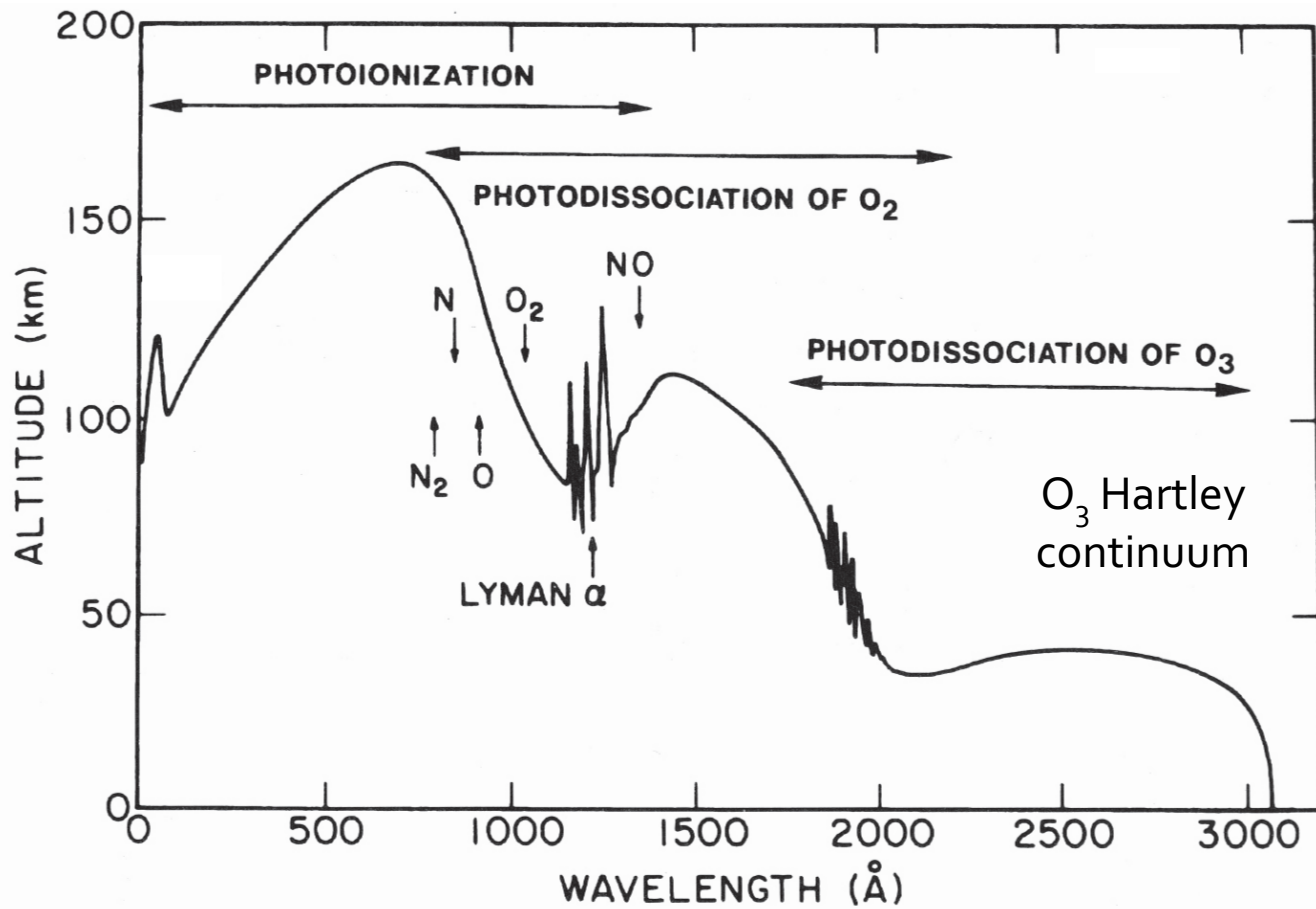
See Heays et al. (2017) for a compilation of cross section references.

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.