PTYS544

Physics of the High Atmosphere
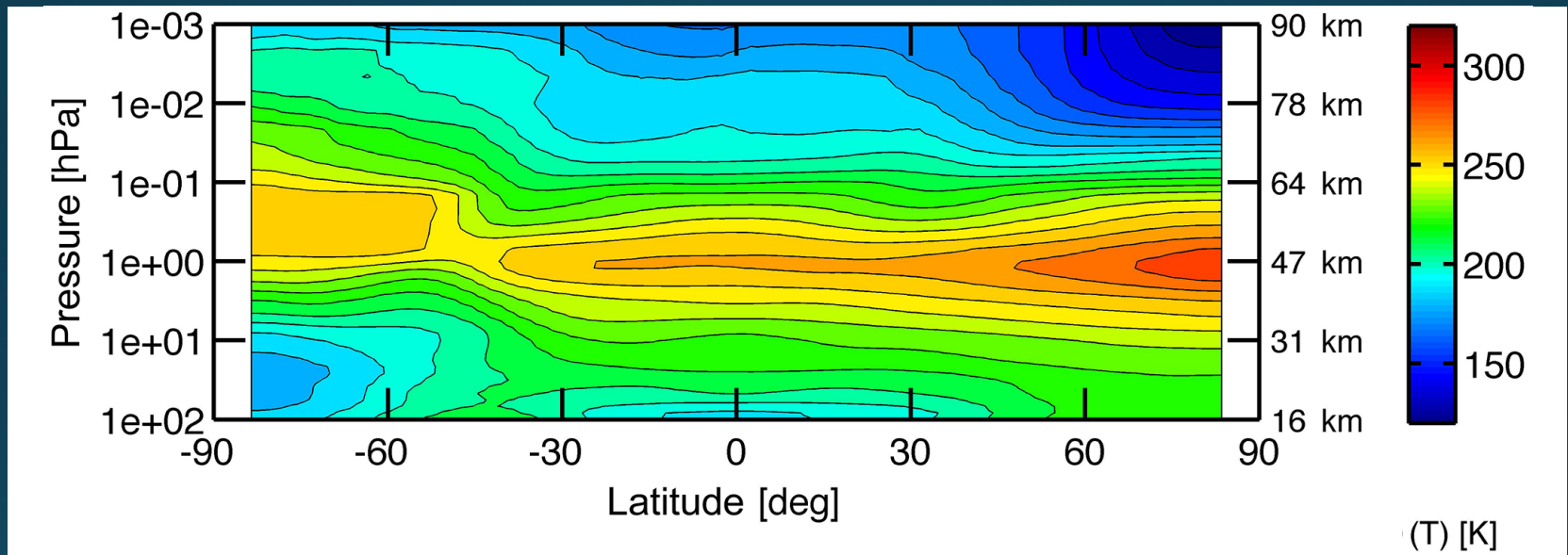
Basic details

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

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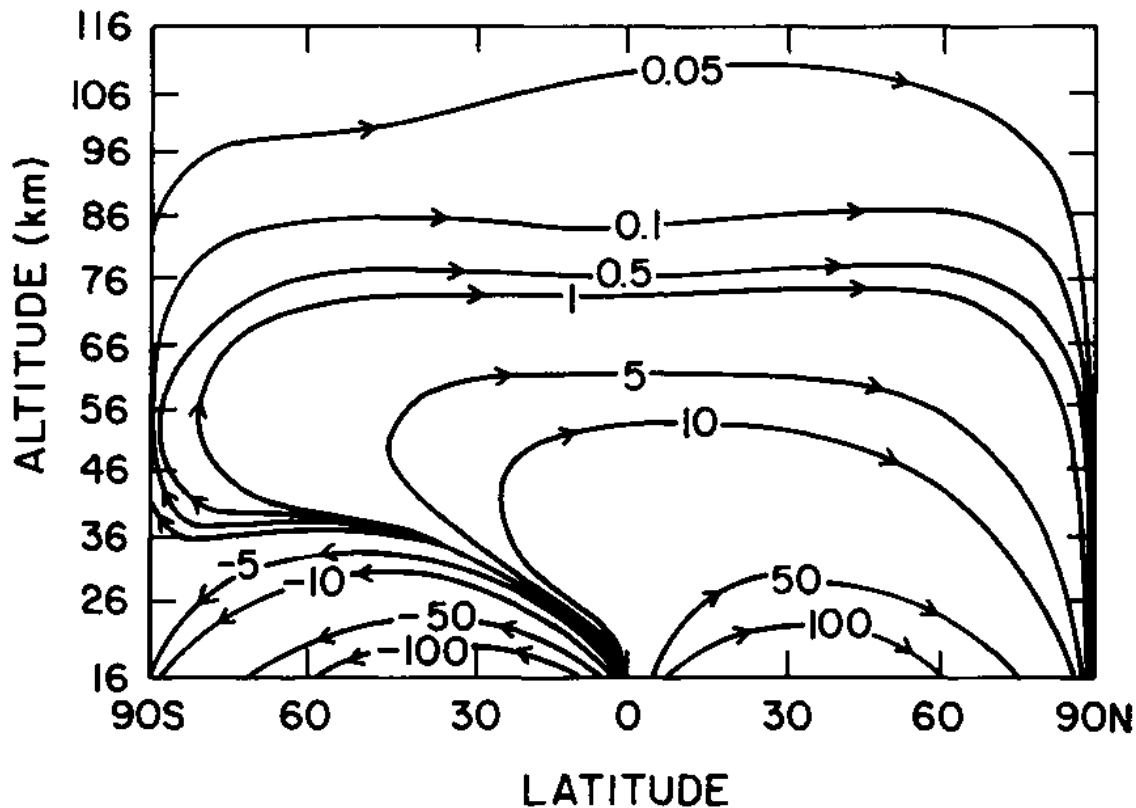- tommik@email.arizona.edu

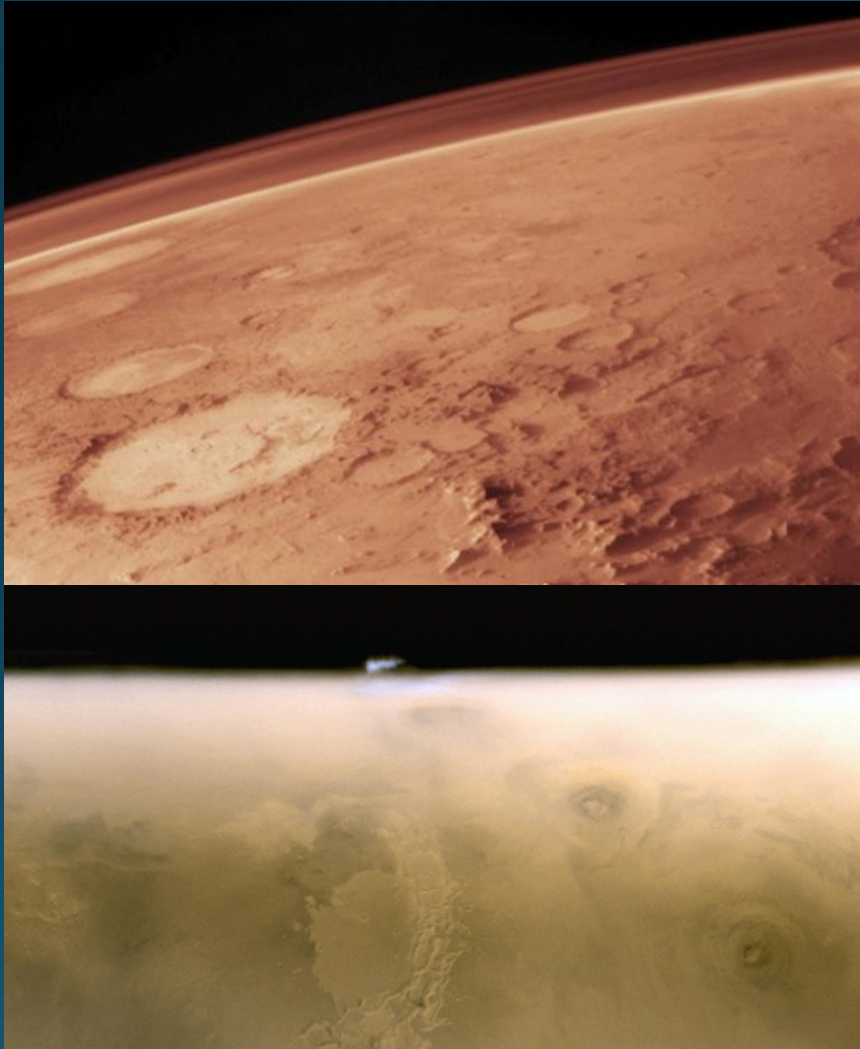# MUA temperatures (zonal mean)

From Hocke et al. (2016), zonal mean temperatures measured by the Aura/MLS satellite experiment.

Brewer-Dobson circulation

Streamlines of mean meridional circulation in the middle atmosphere (Salby 1996): i.e., mass meridional stream function (kg m-1 s-1)

The Martian atmosphere

Surface temperature:
220 K
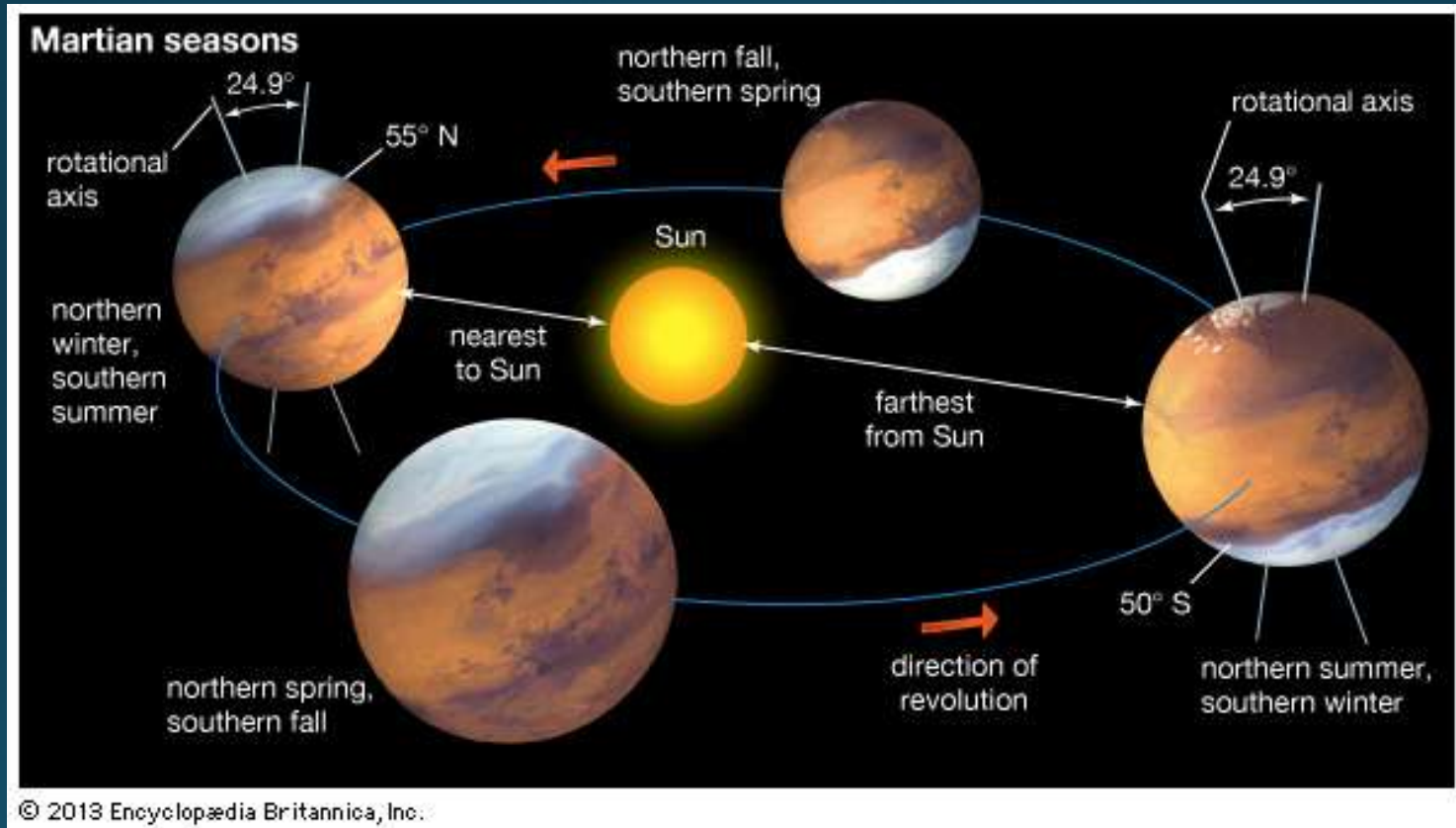Surface pressure:
0.006 bar
Composition:
95% CO_2
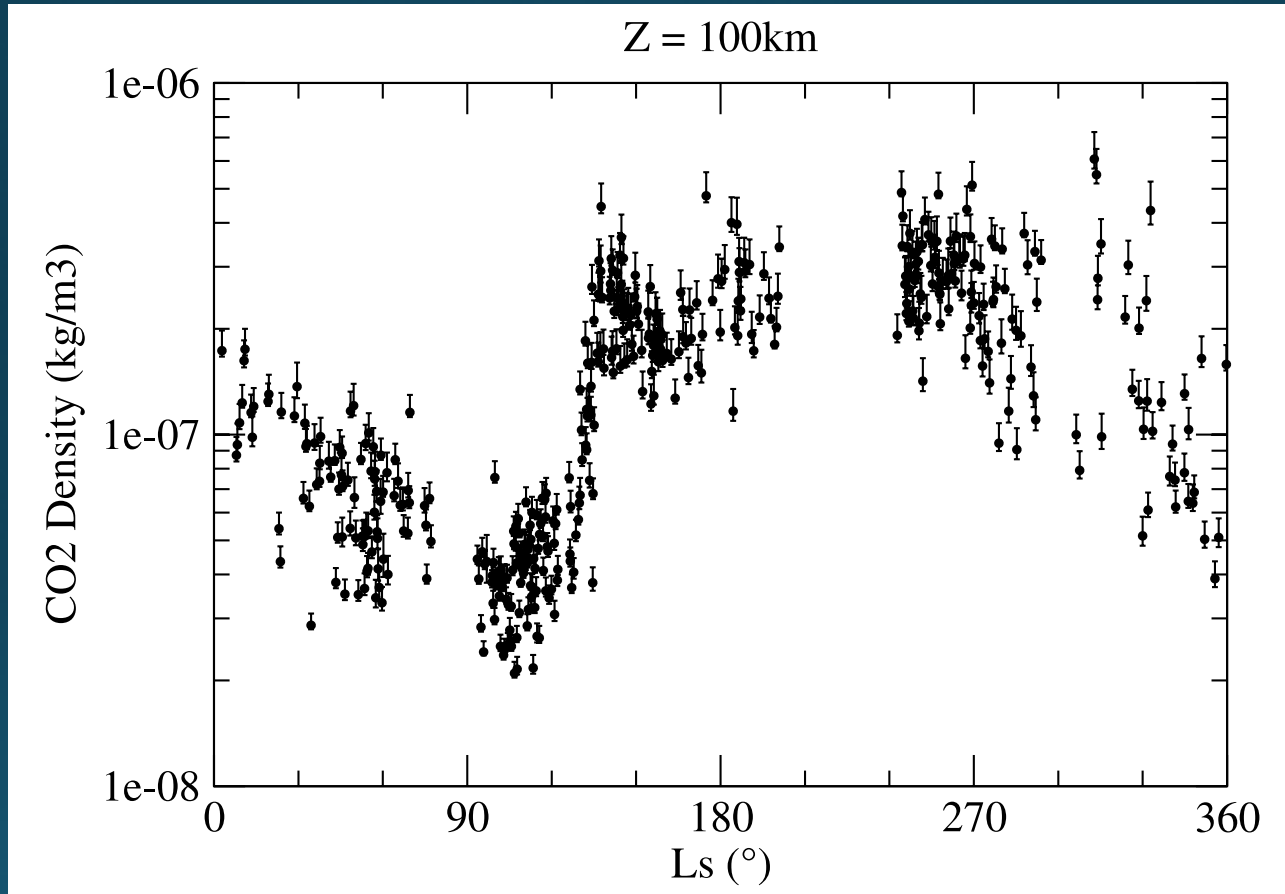2.7% N_2
1.6% Ar
Conditions:
Winds, dust storms, clouds of H_2O and CO_2

Small greenhouse effect, cannot support liquid water.

Orbit of Mars

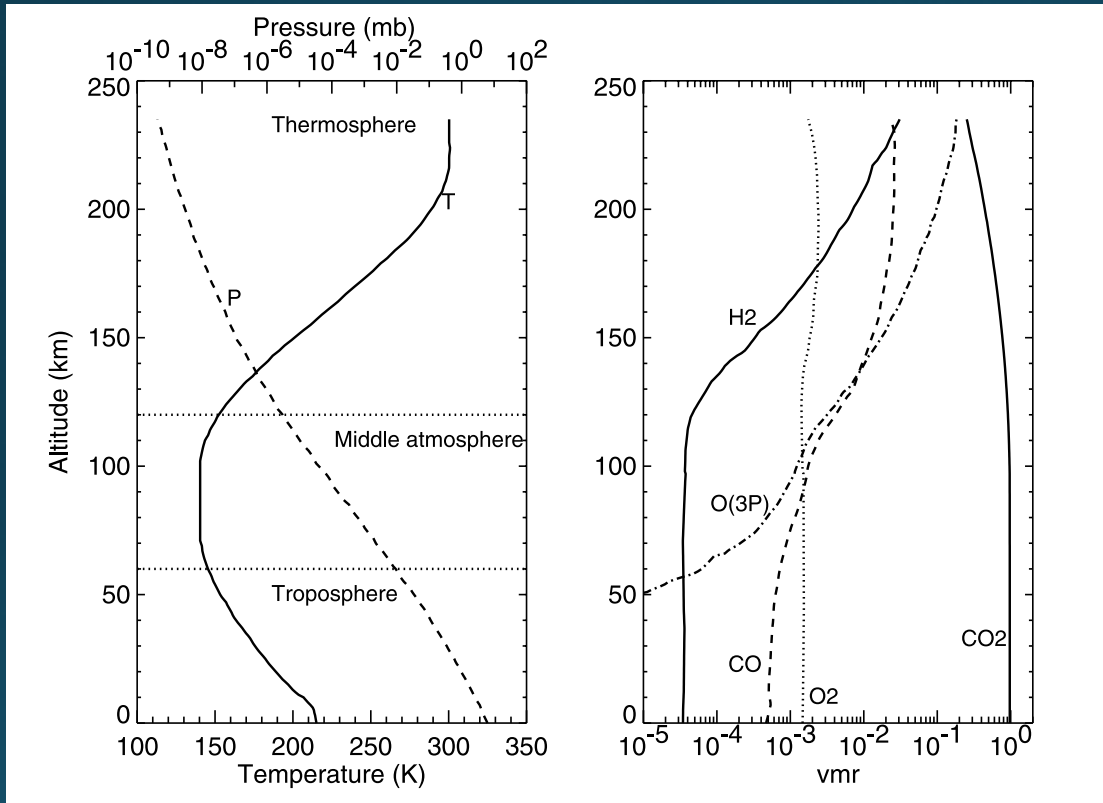Martian seasons. © 2013 Encyclopædia Britannica, Inc.

The axial tilt (obliquity) of Mars is 25°. The solar day is about 25 hr long. Perihelion ~1.4 AU, aphelion ~1.7 AU.

Seasonal variation in density

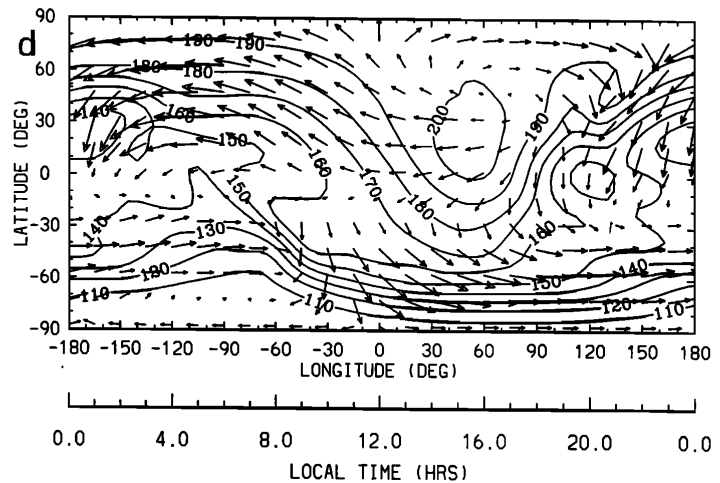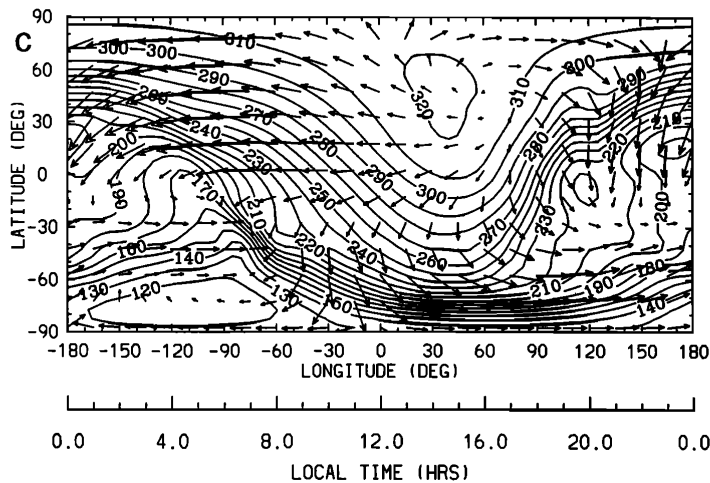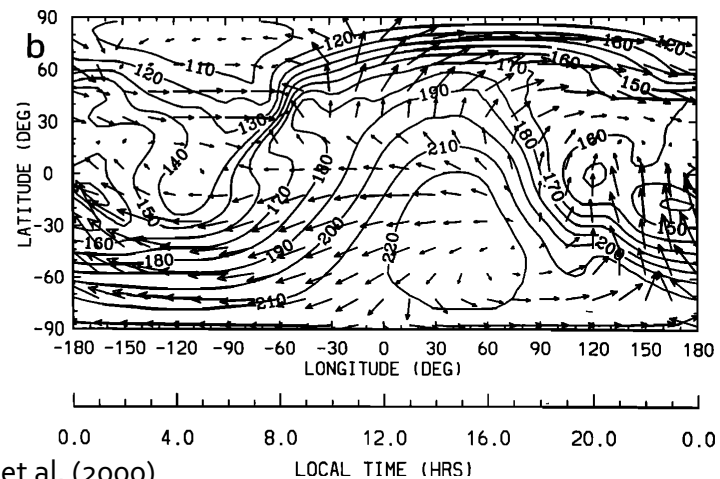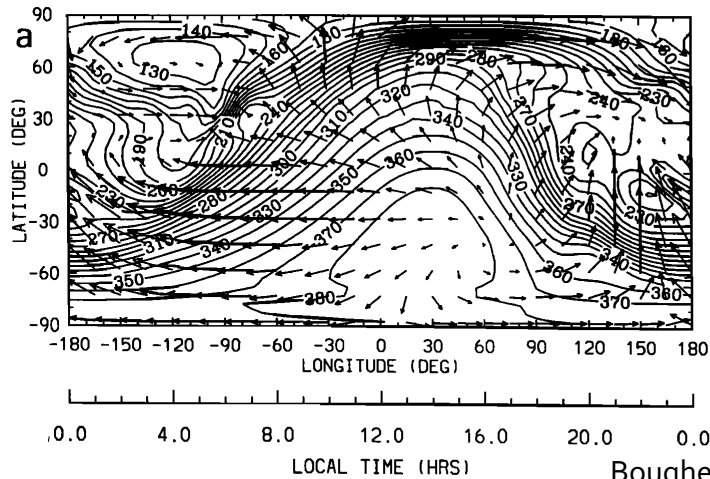From Forget et al. (2009): MEX/SPICAM stellar occultations

Basic atmospheric structure

Middle atmosphere energy balance:
- Absorption in the CO_2 near-IR bands
- Absorption and emission in the CO_2 15-µm band
- Absorption and scattering by dust

Plot from Gonzales-Galindo et al. (2005)

Changes in the thermosphere

Bougher et al. (2000)

Figure 5. (continued)
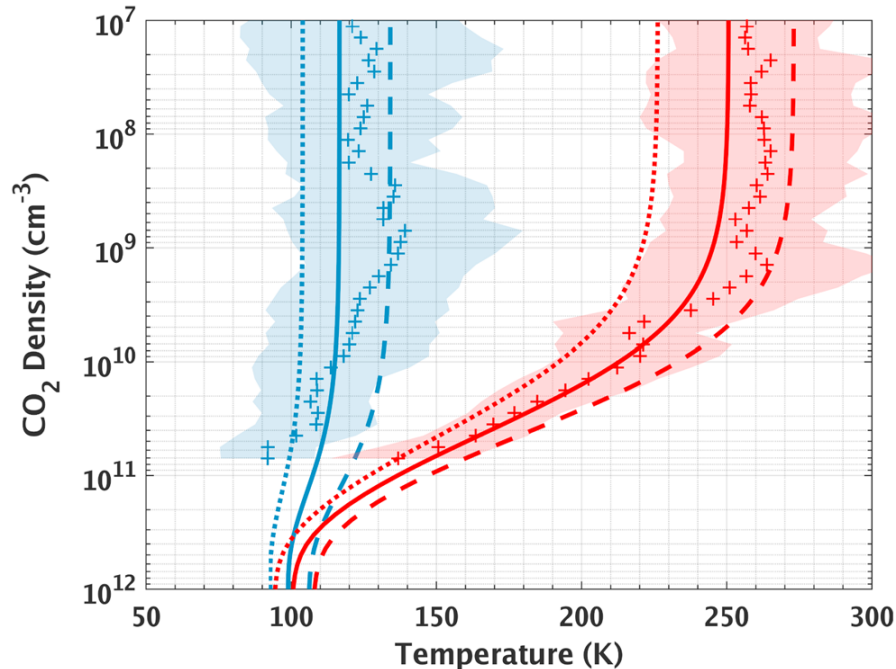
Temperatures from MAVEN/NGIMS

Figure 19. Comparison of modeled temperature profiles with NGIMS data. The model temperature profiles for equatorial latitudes at 12 p.m. (red lines) and 12 a.m. (blue lines) compared to DD2 (red +) and DD6 (blue +) NGIMS temperature profiles. The solid lines are for models calculated with the nominal O-CO_2 collisional deexcitation rate of $k = 3 \times 10^{-12}$ cm^{-3} s^{-1}, the dotted lines for $k = 6 \times 10^{-12}$ cm^{-3} s^{-1}, and the dashed lines for $k = 1.5 \times 10^{-12}$ cm^{-3} s^{-1}. The shaded regions represent 1 σ variabilities of the NGIMS temperatures. NGIMS = Neutral Gas and Ion Mass Spectrometer; DD = Deep Dip.

From Stone et al. (2018)

Note that the expected solar cycle and seasonal variation in dayside exospheric temperature is about 150 K (Bougher et al. 2015a).
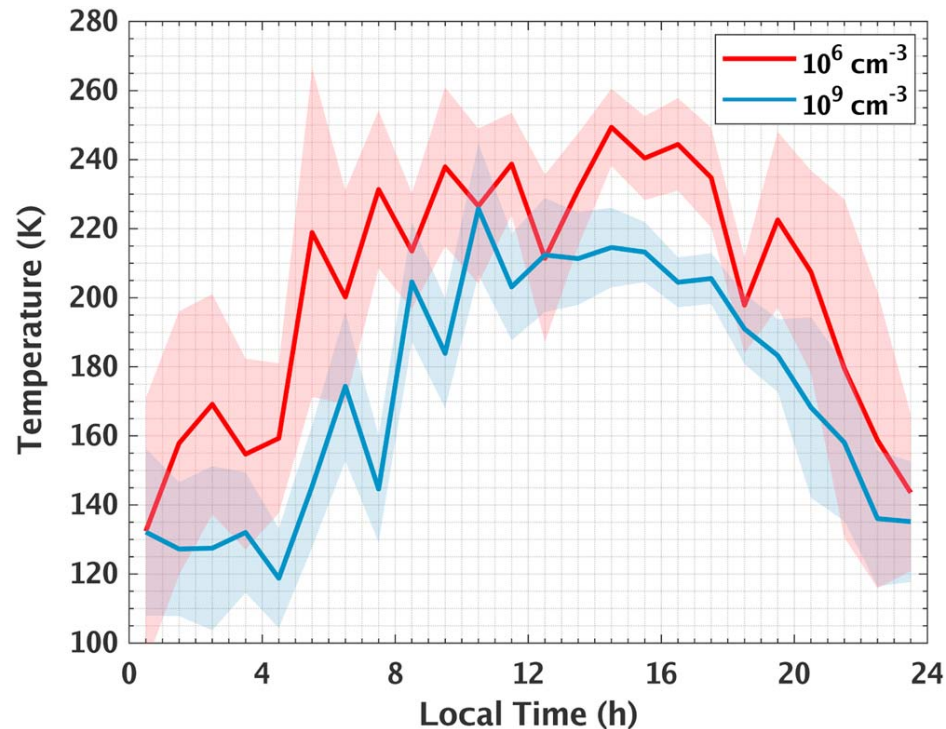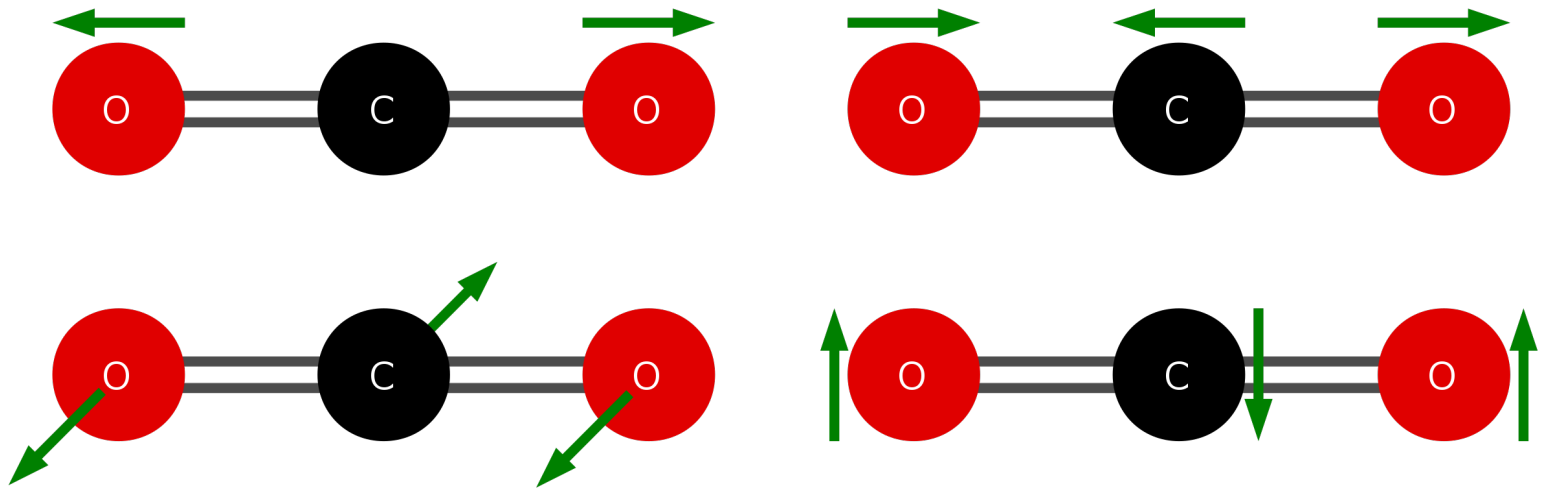
Temperature peak and time lag

Figure 16. Temperature as a function of Martian local time at two constant CO_2 density levels: 10^6 cm^{-3} (red) and 10^9 cm^{-3} (blue). Measurements are constrained to latitudes between 60°N and 60°S. The shaded regions represent 1 σ variabilities.
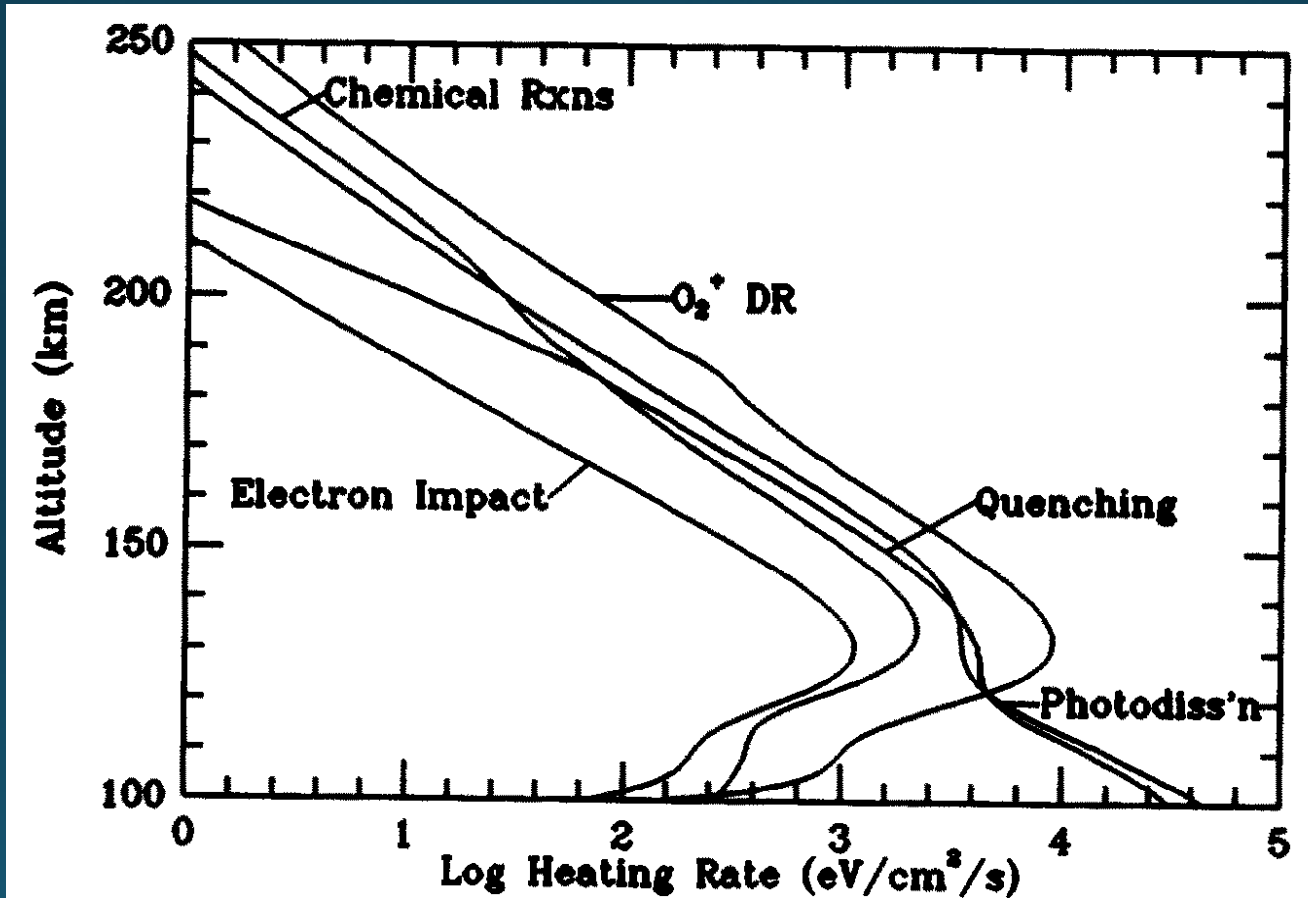
From Stone et al. (2018)

Carbon dioxide: Normal modes of vibration

Symmetric stretch mode (ν_1):
1388 cm^{-1} (7.2 µm)
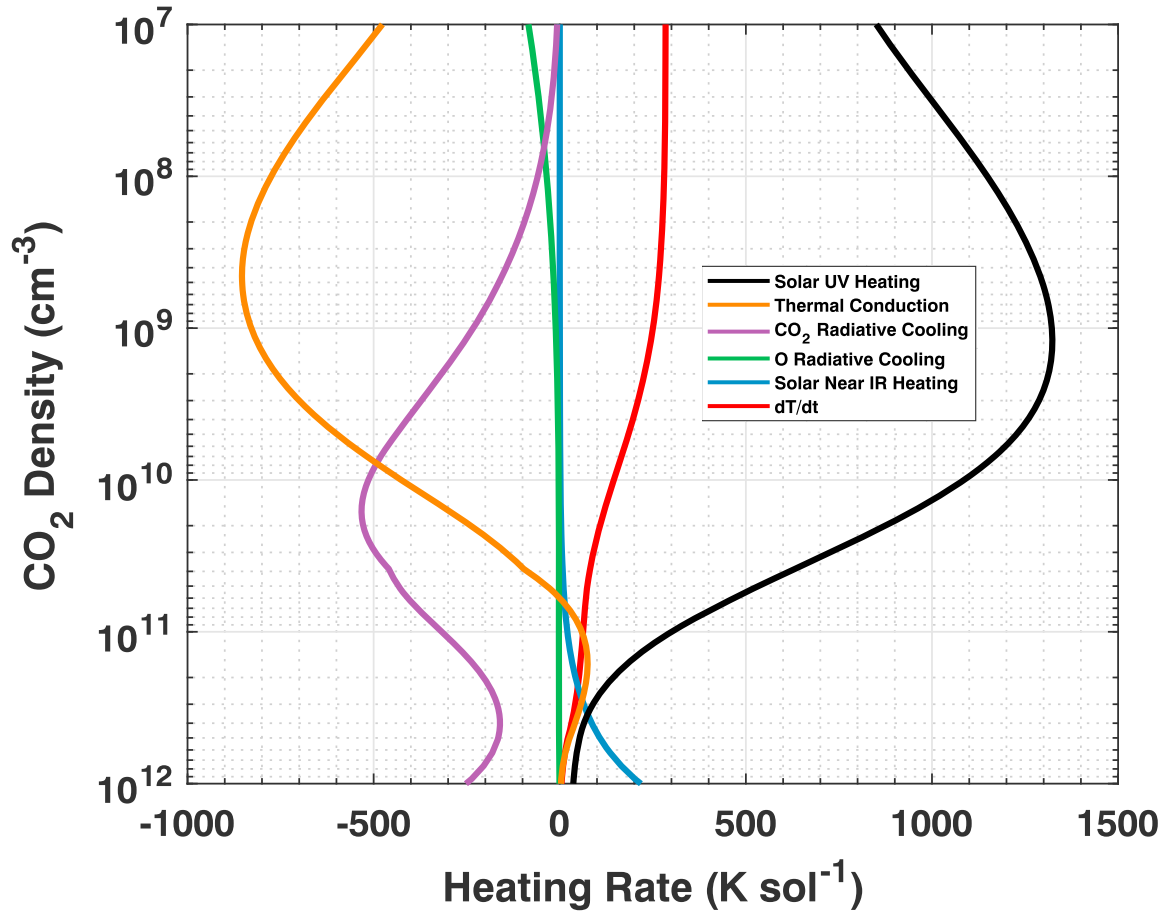and a degenerate bending mode (ν_2):
667 cm^{-1} (15 µm)

Antisymmetric stretch mode (ν_3):
2349 cm^{-1} (4.26 µm)
and a degenerate bending mode (ν_2):
667 cm^{-1} (15 µm)

Heating rates
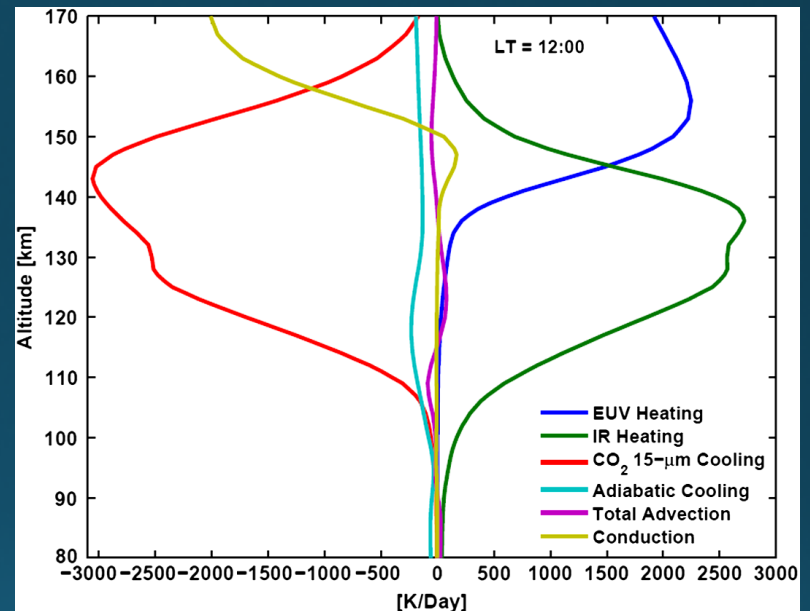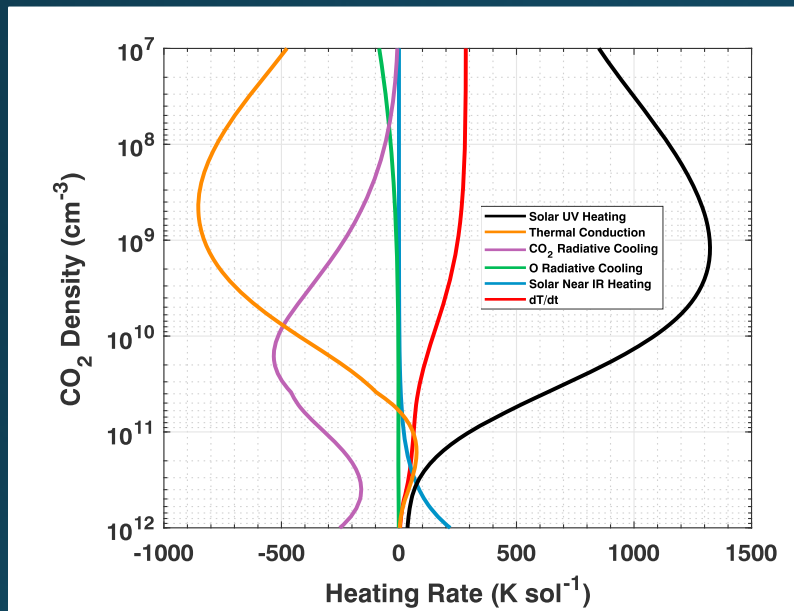

Heating rates from Fox (1996). The EUV/UV heating efficiency is about 20%.
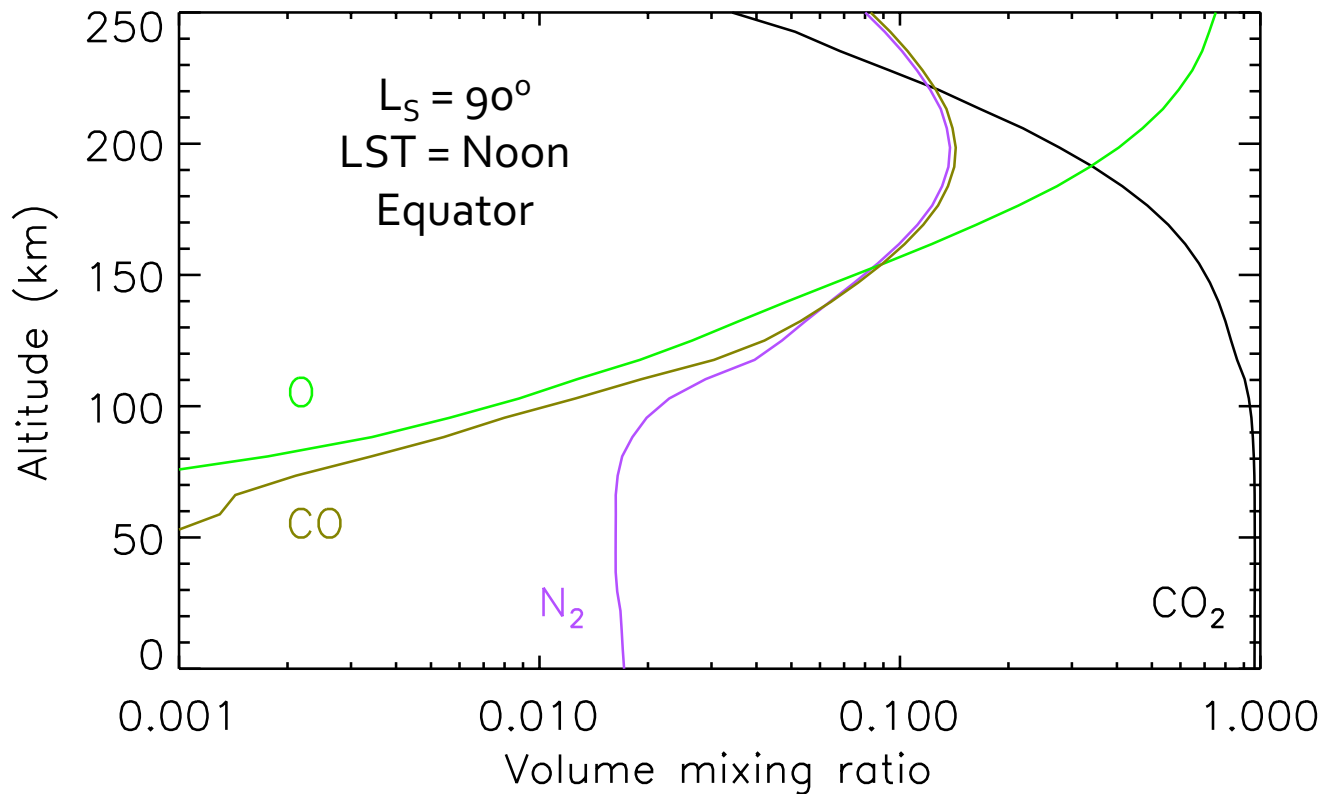
Energy balance

From Stone et al. (2018)

Compare with Venus

The CO_2 thermostat is less efficient on Mars, probably because the Martian O/CO_2 density ratio is smaller (Garcia Munoz et al. 2017).

Neutral composition

Neutral densities in the thermosphere

Bougher et al. (2015b)