Planetary Atmospheres

November 2017

Ingo Mueller-Wodarg

Literature list

- Chamberlain and Hunten: Theory of Planetary Atmospheres (Sections 1.1, 1.8, 1.9)
- Strobel: Aeronomic Systems on Planets, Moons and Comets, in: Mendillo, Nagy and Waite: Atmospheres in the Solar System – Comparative Aeronomy, AGU Monograph, 2002.

You can download all Lecture material, including presentation and literature from http://tinyurl.com/aswc5xm

Questions:

(A) Lecture 1: Neutral Atmospheres in the Solar System

1. State which bodies in the solar system have permanent atmospheres and name examples for those who don't. What basic parameters determine whether or not a body has an atmosphere and whether or not it hangs on to it?

2. For the terrestrial planets solar radiation constitutes overall the major energy source. The solar constant denotes the energy flux per unit area (in W/m^2) at 1 AU distance from the Sun. A typical value is 1366 W/m^2.

   a. Calculate the average energy flux you expect to find for Venus and Mars

   b. Calculate and compare the average solar energy that you would expect to be intersected by Earth, Mars and Venus (using cross sections of each planet).

   c. Compare values under (a) with actual exospheric temperatures in the atmospheres of Earth, Mars and Venus. Do the temperatures follow the same trend with distance from Sun as the energy flux? If not, briefly discuss any possible reasons for discrepancies.

3. Assume an atmosphere composed of gases O and CO_2 with molecular weights of m_1=16 AMU and m_2=44 AMU. Assume a height-independent gravity of g=8.47 m/s^2 and constant temperature of T=300 K. The mixing ratio X_i of gas *i* is defined as $X_i = n_i/n$, where n_i and n are number densities of gas *i* and of the total atmosphere, respectively. At the homopause (120 km) the gas densities are n_1=3.17x10^{10} cm^{-3} and n_2=1.64x10^{13} cm^{-3}.

   a. Calculate the CO_2 and O densities and mixing ratios at 200 km altitude. One efficient way of doing this is with a small computer routine, or alternatively an Excel spreadsheet. Use a vertical integration step of 5 km.

   b. At which approximate altitude are both gases equally abundant?

   c. On Venus' nightside temperatures can reach 200 K. What are the CO_2 and O mixing ratios at 200 km on Venus' nightside? At which altitude are both gases equally abundant?

   d. Compare your results from (c) with those from (a) and (b) and briefly discuss your findings.

   e. Estimate what would happen to the CO_2 and O mixing ratios at 200 km if further mixing occurred in Venus' atmosphere due to waves and the homopause moved to a higher altitude?