THE POLAR ATMOSPHERE AS SEEN BY THE RADIO SCIENCE EXPERIMENT MARS ON MARS EXPRESS. S. Tellmann[1], P. Withers[2], M. Pätzold[1], B. Häusler[3], G.L. Tyler[4] and D.P. Hinson[4], [1] Rheinisches Institut für Umweltforschung, Abteilung Planetenforschung, Universität zu Köln, Aachener Str. 209, 50931 Cologne, Germany (silvia.tellmann@uni-koeln.de), [2]Center for Space Physics, Boston University, 725 Commonwealth Avenue, Boston MA 02215, [3]Institut für Raumfahrttechnik, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577 Neubiberg, Germany, [4]Department of Electrical Engineering, Stanford University, 350 Serra Mall, Stanford, California, USA

Introduction:

The Radio Science Experiment MaRS on Mars Express is sounding the Martian atmosphere and ionosphere using the spacecraft radio signals at X-band and S-band in Earth occultation geometry. Vertical profiles of pressure, temperature and density of the neutral atmosphere can be derived with an altitude resolution of only a few hundred metres [1].

The elliptical orbit of Mars Express allows to examine a large range of local times and locations and can therefore be used to investigate latitudinal, diurnal and seasonal variations.

Observation Method: Within the atmosphere and ionosphere the gradient of refractive index of the gas deflects the direction of propagation, resulting in a curved propagation path. In this way atmospheric refraction alters the path geometry by an amount that is controlled by the radial variation of refractivity. The resulting frequency shift of the signal can be used to calculate the degree of bending, the ray periapsis, and the projection of the ray path onto the planetary surface. The refractivity of the atmosphere at the ray periapsis is obtained from the bending angle via an Abel transform [2]. The neutral number density is directly related to the refractivity profile through a constant factor C_1 which depends on the atmospheric composition of the atmosphere. Temperature and pressure profiles follow by use of the ideal gas law and assuming hydrostatic equilibrium.

The Data Set: MaRS could observe the southern winter hemisphere during the second occultation season (OCC 2) at the end of 2004 (Ls ≈ 130°) and in 2008 (OCC 8, Ls ≈ 94°) (Figure 1).

The northern high latitudes were investigated during the third occultation season in 2005. More than 70 profiles covering all latitudes between 50° N and 76° N at solar longitudes between 259.6° and 289.5° were retrieved (Figure 2).

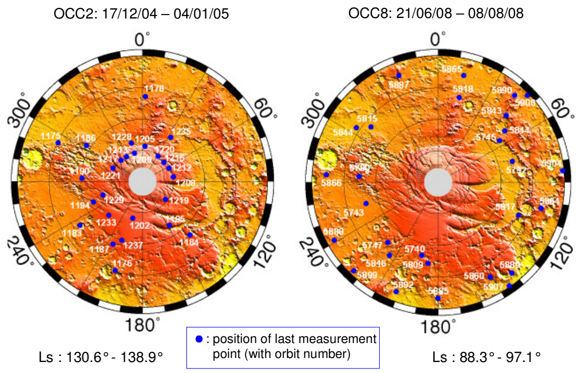

Figure 1: Geographical position of the MaRS measurements from occultation season number 2 (left) and 8 (right) in 2004/2005 and 2008, respectively, in the southern hemisphere. The blue dots indicate the position of the lowest measurement sample above the surface. Each measurement is identified by its orbit number.

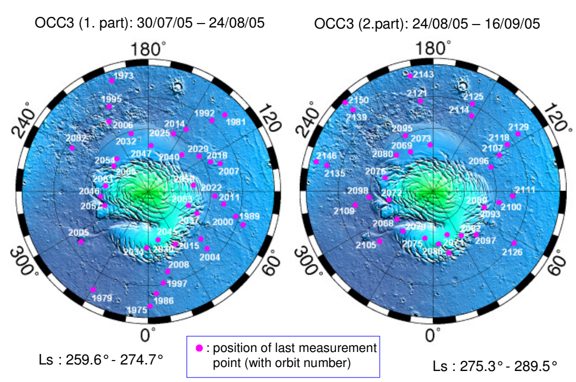

Figure 2: MaRS measurements in the northern middle and high latitudes (OCC season 3, 2005). The first (second) part of the occultation season is shown on the left (right). The pink dots indicate the position of the lowest measurement sample above the surface. Each measurement is identified by its orbit number.

Temperatures: Figure 3 shows a typical temperature profile in the northern winter hemisphere (lat: 75.8° N). The temperature stays close to the CO_2 condensation temperature which indicates CO_2 precipitation up to a pressure level of 70 Pa (≈ 20 km). The data set allows comparisons between both hemispheres for the different seasons, latitudes, and Mars years. Small scale fluctuations indicating atmospheric waves can be found in several temperature profiles.

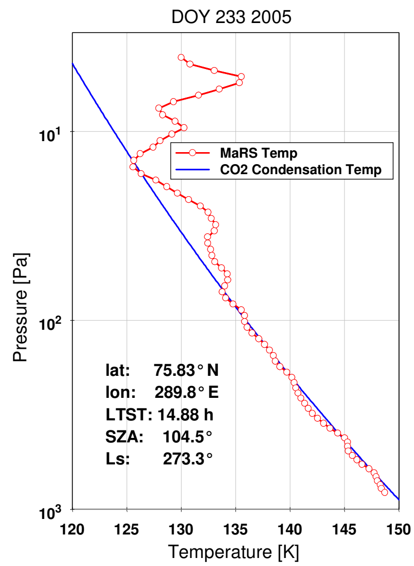

Figure 3: Typical temperature profile from the northern high latitude region (DOY 233 2005) at northern winter solstice. The red curve shows the MaRS profile, the blue line indicates the CO_2 condensation curve. An upper boundary condition of 130 K is used.

Neutral Number Density: The neutral number density profiles can be used to examine the effect of CO_2 condensation in the winter hemisphere at different locations, seasons and altitude levels. Figure 4 shows the neutral number densities at a geopotential altitude of 20 km for parts of the third OCC season. The measurements started at mid latitudes, moved close to the northern polar region and returned to the mid latitudes after winter solstice. Two effects are clearly visible: the density decreases with increasing latitudes and the ongoing CO_2 condensation leads to decreasing densities over the course of the winter season. These effects can be studied for both hemispheres in different Mars years to investigate the interannual variability.

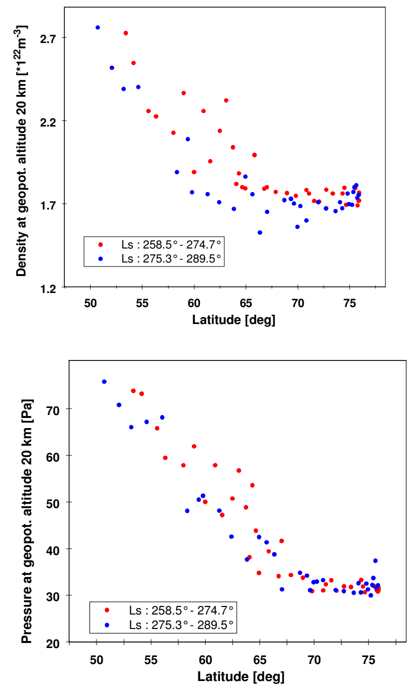

Figure 4: Neutral number densities (upper panel) and pressure (lower panel) at a geopotential altitude of 20 km for the third OCC season in 2005. Each dot indicates one measurement. The red dots show the first part of the OCC season, starting at mid latitudes and moving closer to the pole, the blue dots show the second part of the OCC season starting the high latitudes and coming closer to lower latitudes.

Pressure: The effect of CO_2 condensation leads to a strong pressure gradient in the highly dynamical winter atmosphere (Figure 4). Latitudinal pressure gradients indicate distinctive zonal winds on the winter hemisphere.

Conclusions: The MaRS data set allows to study the effect of CO_2 condensation on the atmospheric pressure, temperature and number density for different Mars Years, seasons, and geolocations. The high vertical resolution can be used to examine the CO_2 condensation and resulting dynamical effects at different altitude levels.

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References:

[1] Pätzold, M. et al. (1994), *ESA Special Publication*, SP-1240.
[2] Fjeldbo, G. et al. (1971), *Astron. J., 76*, 123-140.