Altimetry retrieval from the OMEGA observations

R. Melchiorri[1], P. Drossart[1], T. Fouchet[1], F. Forget[2], J.P.Bibring[3] and the OMEGA Team
1 {LESIA, Observatoire de Paris; 5, place Jules Janssen 92195 Meudon FRANCE}
2 {LMD;Université Paris 7 Denis-Diderot: 2 place Jussieu 75251 Paris Cedex}
3 {IAS; Bâtiment 121, Université Paris XI 91405 Orsay cedex - France}

Introduction:

Mars Express is the first ESA planetary mission and it has successfully entered into an elliptical polar orbit around Mars in December 2003, with a pericenter of few hundred kilometers. OMEGA is an imaging spectrometer devoted to the study of both the diffused solar light and the planetary thermal emission. It acquires a spectrum in 352 contiguous spectral channels from 0.35 to 5.1µm, with a spectral sampling ranging from: 7nm for the spectral range (0.4-1.) µm; 13nm for the spectral range (1.-2.7) µm; to 20 nm for the spectral range (2.6-5.1)µm. With an instantaneous field of view of 1.2 mrad and a spatial resolution that may attaint ~400m. {Bibring et al, 2004}.

We present an atmospheric study of the OMEGA data with the main objective of an analysis of the ground pressure variation. This parameter is used for the altimetry retrieval and for the study of the atmospheric features at low scale.

The 2.0 µm CO_2 band is a sensitive detector for the surface pressure, which is strictly bounded to the altimetry through the barometric equation {Bibring et al, 1991}. We have then developed a simplified atmospheric spectral model to analyze only the gaseous contribution of the atmosphere and the CO_2 band depth variations.

Mars Orbiter Laser Altimeter (MOLA) {Zuber et al, 1992} of the Mars Global Surveyor (MGS) mission has produced a complete topography of the planet with a vertical spatial resolution that may attain the scale of the meter {Soderblom et al, 2003}. Nevertheless the horizontal spatial resolution may vary from region to region (best resolution is 1/128°) and in particular situation OMEGA may observe altimetry variations not revealed at a local scale by MOLA.

Method:

We have developed a line-by-line model to study the 2.0 µm CO_2 band, which is the most sensitive and not saturating band in the OMEGA bandwidth.

In order to synthesize the OMEGA spectra an “a priori” knowledge of the environmental parameters is mandatory, for this reason we have coupled our model with the EMCD (European Martian Climate Database), in order to extract a first approximation of the vertical profiles of temperature and pressure {Forget et al, 1999}.

Since the orbital and illumination parameters are well known (latitude, longitude, season, local time, angles of incidence and emergency), it is possible to simulate the OMEGA observations, by introducing these parameters inside the EMCD and extracting the environmental one, needed to the spectral modeling. Differences between the synthesized spectrum and the observed one may reveal phenomena not included in the EMCD.

The near-infrared martian spectrum is a complex combination of aerosol, gas and ground spectral features; in order to obtain an exhaustive analysis, a complete modeling should be done, but it is an extremely time demanding operation. Besides, in the case of low scattering contribution, it is possible to approximate the result introducing a correction in the calculations.

We have used an iterative procedure. Through a qualitative spectral model of the ground, we remove the features of pyroxenes and ices (if present), together with the continuum {Gendrin, 2005}. Part of the scattering contribution is taken into account as if it was the continuum. Then we proceed by finding a best fit of the synthetic spectrum using, as the only variable, the surface pressure. If a cloud is present, the signal may appear coming from a higher level (in the case of backscattering) or from a lower level (in the case of absorption or diffusion), this means that it is possible to correct the effect of scattering by adjusting the surface pressure value.

The presence of scattering influences our pressure measurement, it is no more possible to assume the absolute value as physical (from now one named as “effective”), but the relative value, in the condition of constant scattering, has still a physical meaning.

We have then translated the OMEGA data in effective barometric maps. In order to retrieve the altimetry we need to re-normalize these data to a value, which is given by the MOLA data.

The complete method is presented together to the influence of the instrumental noise in the calculations.

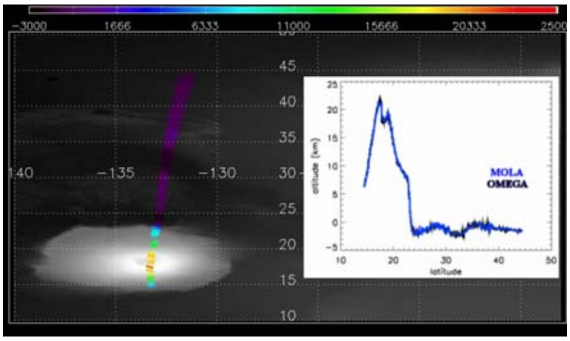

Fig.2: Altimetry retrieved on the Olympus Mons OMEGA session. On the map, in grayscale the MOLA 1/32° data, in colors the OMEGA altimetry retrieved data. In the plot, a slice of the OMEGA observation over the latitude, in blue is represented the OMEGA altimetry and in black the MOLA 1/32°. Some differences may be due to a not prefect superposition between the OMEGA and MOLA data.

References:

Bibring, J.-P. and OMEGA Team. Observatoire pour la Mineralogie,l'Eau, la Glace et l'Activité ; ESA SP, 1240. 2004

Bibring, J.-P. et al. Topography of the Martian tropical regions with ISM. planss, 39:225--236. 1991

Zuber, et al. The Mars Observer laser altimeter investigation. jgr, 97(16):7781—7797, 1992.

Soderblom, L.~A. and Kirk, R.~L. Meter-Scale 3-D Models of the Martian Surface from Combining MOC and MOLA Data. Lunar and Planetary Institute Conference Abstracts, pages 1730--+. 2003.

Forget, F., et al. Improved general circulation models of the Martian atmosphere from the surface to above 80 km. jgr, 104(13):24155—24176, 1999.

Gendrin, A., Minéralogie de Mars : l'éxperience OMEGA. Ph.D thesys University of Paris 11 28 september 2004.