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Analysis of MESSENGER/MASCS data during second Venus flyby

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Abstract

In June 2007, the MESSENGER spacecraft performed its second Venus flyby during its travel to Mercury. The spacecraft acquired several spectra of the reflected sunlight from the equatorial region of the planet and covering from the middle ultraviolet (195nm) to the near infrared (1450 nm) using the MASCS instrument (MUV-UVVS and VIRS channels). In this work we present an analysis of the data and their spectral and spatial variability following the mission footprint on the Venus disk. In order to reproduce the observed reflectivity and obtain information on the upper clouds and the unknown UV absorber, we use XtraRT, a radiative transfer code based on DISORT and the HITRAN database, which includes SO, SO2, CO2 and H2O absorption together with absorption and scattering by mode-1 and mode-2 cloud particles. We discuss the sensitivity of our models to key atmospheric parameters and some preliminary results. The MASCS observations of Venus mean a valuable opportunity for cross-calibration with VIRTIS, the spectrometer on board the Venus Express mission.

1. MESSENGER/MASCS

The Mercury Atmospheric and Surface Composition Spectrometer (MASCS) onboard MESSENGER mission is basically the combination of an ultraviolet spectrometer (UVVS) and an infrared spectrograph (VIRS). UVVS covers the range from 115 nm to 600 nm in three bands (FUV, MUV and VIS) at an average resolution of 1 nm, while VIRS spectral range goes from 0.3 up to 1.45 μm in two bands (VIS, NIR) at an average resolution of about 4 nm [3]. During the second Venus flyby on 2007 June 5, MASCS acquired data from Venus equatorial atmosphere for around seven minutes using the MUV band in UVVIS detector and both the VIS and NIR bands in the VIRS spectrograph.

2. Data analysis

Radiance measurements obtained were tranformed into absolute reflectivity (I/F). Since our radiative transfer codes are restricted to work under the plane-parallel approximation, we restricted the 960 available spectra (VIRS channels) to 318 usable spectra with moderate values for the illumination/observation angles. Those spectra were acquired at latitudes located in the band from the Equator to 10º S while the spacecraft footprint moved from the limb of the planet close to the sub-solar point to the terminator and close to the sub-observer

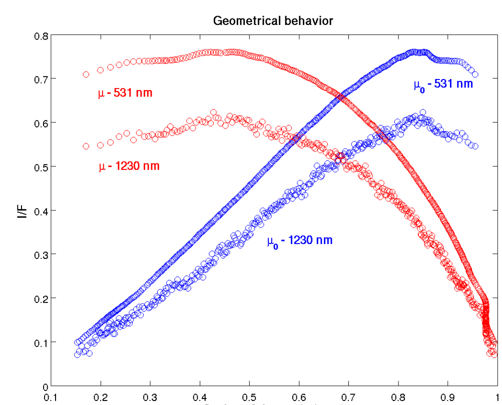

Figure 1: Limb-darkening behaviour of observed reflectivity at two selected wavelengths as a function of the cosine of the zenithal illumination angle (μ_0) and observation angle (μ)

point. Phase angle was around 90º for all observations. MUV data are less abundant although they cover a similar geometry. We show in Figure 1 an example of the geometrical behavior of observations, which is well reproduced by a Lambertian law for most of the cases. One of the most conspicuous problems with this data is the cross-calibration between VIS and NIR bands, as it is evident in Figure 2. We are working on this issue by including data from other missions in the same spectral range.

3. Radiative transfer code

In this work we use the XtraRT code for Radiative Transfer modelling of the observed radiance as a function of geometry and wavelength. To date, XtraRT has been utilized in the modelling of the Earth and Venus atmospheres [1, 2], but it can be easily adapted to other planetary atmospheres. XtraRT is based on DISORT [6], which solves the radiative transfer equation in a plane-parallel atmosphere. The optical properties of the gases are read from HITRAN08 [5] or, in the cases when the relevant molecular transitions are not included in HITRAN08, from alternative parameterizations specific to the Venus atmosphere. The optical properties of the aerosols are calculated from Mie scattering theory. By the time of this writing, we are developing an inversion algorithm based on a gradient-search technique [4].

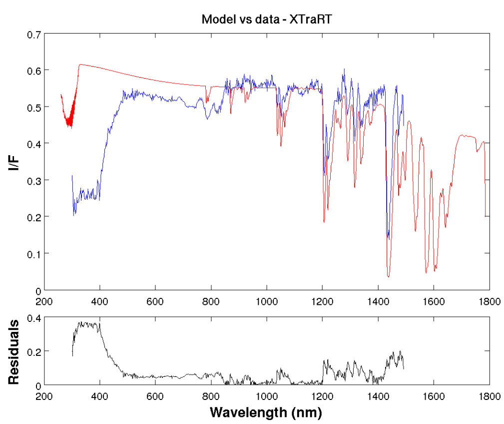

Figure 2: Comparison between observed spectrum (blue) and synthetic model (red) of the atmosphere not including the UV absorber. Residuals indicate the contribution of such agent to the observed reflectivity in the near-UV and blue wavelengths.

4. Model atmosphere

From our preliminary analysis performed so far we find our model atmosphere to be sensitive to vertical distribution of mode-1 and mode-2 particles, particularly above the 50 km level. The model also shows some sensitivity to the concentration of SO and SO2 above the clouds. One of the most interesting atmospheric parameters is the distribution and opacity of the UV-absorber which dominates the observed reflectivity below 500 nm. These data are unique and provide a very useful insight into the nature of such mysterious absorber.

Acknowledgements

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