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Results from Multispectrum Retrieval of VIRTIS-M-IR Measurements of Venus' Nightside

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Abstract

A new retrieval approach is applied to Venus nightside measurements from VIRTIS-M-IR on Venus Express. This is used to improve former analyses in order to refine estimates on the surface emissivity and deep atmosphere of Venus.

1. Introduction

The nightside spectra of Venus carry information on the surface and deep atmosphere, which, on a global scale, cannot be obtained from other data sources at the moment. But due to the high gaseous opacity and the thick clouds in the spectral range covered by VIRTIS-M-IR (1 - 5 μm), most emissions originating below the cloud deck are totally blacked out, and only a few narrow spectral windows probe this domain.

The inversion of the radiative transfer equation is mathematically an ill-posed problem, and using different parameter sets for the simulation of the spectra, it is possible to fit the measurements equally well, especially for the sparse utilizable spectral ranges in question. Additionally, some physical parameters necessary for the modeling of the atmosphere, like the CO_2-opacity in the extreme near-surface environment, are not yet constrained well enough.

2. Data and Forward Model

The Venus nightside measurements acquired by the Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) aboard Venus Express [2, 4] are an excellent resource of data for the extraction of deep atmosphere and surface parameters. The high diversity of different measurement conditions probing almost the entire Venus surface, with a partly high repetition rate, make them an ideal base for multispectrum retrievals. The difficult retrieval of surface parameters necessitates a sophisticated data preprocessing, including a detailed detector responsivity analysis and an advanced stray light removal. In order to reduce the number of spectra for the time-consuming retrieval process and to increase the signal-to-noise-ratio, the data is binned to a lower spatial resolution matching the expected surface feature resolution.

The forward model used in the retrieval algorithm is a line-by-line radiative transfer code, taking into account gaseous and particulate absorption, emission and multiple scattering [3].

3. Coupled Retrieval

To improve the significance of the retrieval results, it should be made use of as much *a priori* information as possible during the retrieval process. For each individual spectrum, the parameters to be retrieved, as well as the measurements, are assumed to follow a Gaussian probability distribution with certain expectation values and standard deviations. The Bayesian *a posteriori* Gaussian distribution is then determined through an iterative procedure [5]. But there is still further *a priori* information available: For spatially and temporally contiguous measurement footprints, atmospheric and surface parameters are expected to be correlated. When retrieving several measurements simultaneously, and providing information like correlation lengths and times for each parameter, the results can be estimated more reliably due to their consideration of the *a priori* constraints and due to the attenuation of noise effects and of the probability to identify subsidiary solutions.

4. Common Parameters

Further pursuing this line of thought, it is also possible to gain information on uncertain constant ('global') atmospheric parameters, like the broad band CO_2-continuum contributing to the gaseous opacity. A spectrum may be considered as a measurement of these properties, with the local variations of the atmospheric composition or surface properties as interfering factors. In contrast to the locally varying variables, parameters like the CO_2-continuum are common to all spectra. When simultaneously fitting multiple spectra originating from highly diverse conditions, it can thus be possible to discriminate global parameters, by retrieving them as parameters common to all spectra. In case of repeated measurements with overlapping footprints, the surface properties, assumed as temporally largely stable, can also be thought of as common parameters.

5. Summary and Conclusions

Compared to an earlier approach [1], an increased confidence in the data analysis can be provided. This is based on a sophisticated multispectrum retrieval algorithm developed for this purpose and taking advantage of the high diversity and repetition rate of the VIRTIS measurements, and on an improved data evaluation customized to the extraction of deep atmosphere and surface parameters of Venus' nightside. This opens up improved surface data evaluation possibilities.

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