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First global extraction of mesospheric Venusian O_3 and SO_2 concentrations from the entire SPICAV-UV/VEX stellar occultations dataset

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Abstract

The SPICAV spectrometer was a part of the ESA's Venus Express spacecraft functioning on the Venus orbit in 2006-2014 [1]. Its UV channel worked in a spectral range of 118-320 nm that covered gaseous absorption bands of SO_2, O_3 and CO_2. Observations of stellar occultations in the UV allowed to study nighttime vertical distributions of these gases within altitude range of 80-110 km corresponding to Venus upper mesosphere. Temporal and spatial variations of the gaseous content are able to be analyzed considering the SPICAV dataset accumulated for the entire mission period.

In our work we present results of O_3 and reprocessed SO_2 retrievals based on the whole SPICAV UV dataset. The data processing pipeline was improved since the recent studies [2] that allowed to extend the number of considering observations.

1. Introduction

Minor gases (SO_2, O3, H_2O, etc.) have a great influence on chemical processes originated in the CO_2 atmosphere of Venus. An oxidation of the sulphur dioxide (SO_2) in the mesosphere produces the concentrated H_2SO_4 acid forming aerosol particles of a thick cloud layer (50-70 km). Moreover, SO_2 is a product of volcanic activity. Thus, variations of its abundance in the mesosphere may indicate the recent volcanic activity events on the Venus surface [3]. The high temporal and spatial variability of SO_2 volume mixing ratio (VMR) in the atmosphere over clouds was observed by SPICAV UV both on the day and night sides [4, 5]. Solar occultations measurements show the strong SO_2 variations from 10 to 200 ppb (one particle per billion) at the pressure level of 0.1 mbar (90-95 km) on the planet's terminator. In the night mesosphere the fluctuations behavior corresponds to one observed on the terminator, however the VMR values are 3-4 times higher due to the photolysis absence.

Ozone layer was discovered for the first time by SPICAV UV stellar occultations in 2006-2010 [6]. It was observed at the altitude about 100 km in nighttime atmosphere with corresponding VMR values of few tens in ppb. O_3 formation is a result of the Sub-Solar to Anti-Solar (SSAS) circulation bringing oxygen atoms to the anti-solar point.

Analysis of the temporal and spatial fluctuations of sulphur dioxide and ozone in the nighttime mesosphere may improve understanding of the SSAS circulation regime on Venus.

2. Data processing improvements

The stellar occultation method was implemented for the first time for Venus atmosphere by SPICAV UV. In this mode the planet is ascending or descending in the field of view of the spectrometer while the instrument is observing one star through the atmosphere. Spectra of stellar light partly absorbed in the atmosphere were measuring. However, the stellar spectra were superimposed by UV emissions of different extended sources around Venus (nitric oxide airglow, Lyman-α) in many cases.

Gaseous concentrations are retrieved from the atmospheric transmission spectra by resolving spectral and vertical inversion problems. Recently, the main improvements of the data processing algorithm for stellar occultation measurements were considered in details [2]. They combine a precise wavelength to pixel assignment based on the spectral features of measured stars and an extraction of emission spectra. Thus, the accuracy of conversion from the SPICAV raw data to the atmospheric transmission spectra is significantly increased. It

results in 20-40% better precision of gaseous concentration retrievals.

3. Preliminary results

The whole SPICAV-UV stellar occultation dataset is currently being processed taking into account the improvements of the pipeline described above. Thus, the number of statistically significant SO_2 detections is increased by 30% comparing with the previous study [5]. Moreover, the ozone absorption is considered in spectral inversion problem. The study of O_3 content were proceeded for the entire observational period of SPICAV UV.

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