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Venus Express: three years of atmospheric observations

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Venus Express is the first European (ESA) mission to the planet Venus. It aims at the global and long-term remote and in-situ survey of the atmosphere and the plasma environment from orbit. The spacecraft, based on the Mars Express bus modified for the conditions at Venus, provides a versatile platform for nadir and limb observations as well as solar, stellar, and radio occultation. The payload consists of seven experiments and includes a powerful suite of imagers and spectrometers, instruments for in-situ analysis of the planetary plasma, and a radio science experiment [1, 2]. Since April 2006 Venus Express has been performing detailed monitoring of the Venus atmosphere providing new and deep insight in the physics of our mysterious sister-planet and significantly contributing to the field of comparative planetology. Here we present the highlights of the Venus Express atmospheric observations during 3 years of the nominal and extended missions.

Venus Express uses three remote sensing techniques for temperature sounding: thermal emission spectroscopy in 4.3 µm CO_2 band, radio- and stellar occultation [3,4]. They cover altitude range from 140 km to 40 km at all latitudes. From equator to pole the atmospheric temperature increases above 70 km and decreases below 60 km with "cold collar" in between characterized by deep temperature inversions at the cloud tops (fig. 1). The atmosphere was found to be convectively unstable within the main cloud deck (50-60 km) and stable above and below this region. A warm layer caused by adiabatic heating in descending flow was discovered at the mesopause [5]. VIRTIS and SPICAV spectrometers study vertical and latitudinal distribution of trace gases

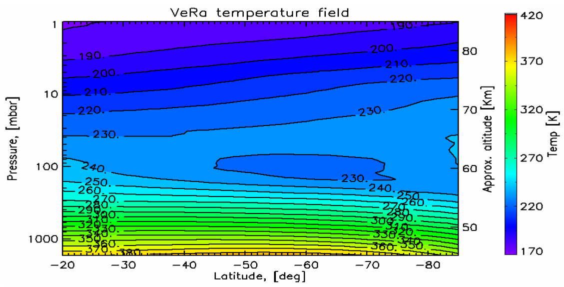

Figure 1: Temperature field from the VeRa sounding

in the mesosphere (70-100 km) and middle and lower troposphere (< 40 km) [6,7]. Figure 2 shows the summary of Venus Express composition investigations.

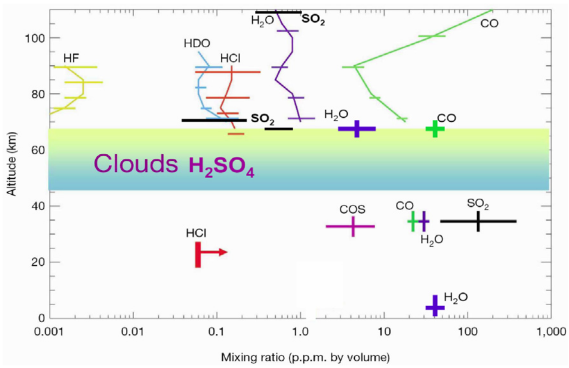

Figure 2: Summary of the Venus Express composition results

The imaging experiments VIRTIS and VMC monitor the cloud morphology in the broad spectral range from UV to thermal IR thus sounding different altitudes within the cloud deck [8,9]. The observations suggest that convective and eddy processes dominate in the tropics giving way to non-turbulent flow at high latitudes. Temperature and dynamic conditions at the cloud

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tops were found responsible for the observed global UV pattern (fig. 3) [10]. Mapping the cloud top altitude discovered global polar depression[11].

The general circulation has vortex organization with its "eye" at the pole (fig. 3) [12]. Wind velocities derived at 70-50 km from tracking cloud features are almost constant up to ~50S and quickly fade out to the pole [13,14] in general agreement with the cyclostrophic balance in the middle latitudes [2].

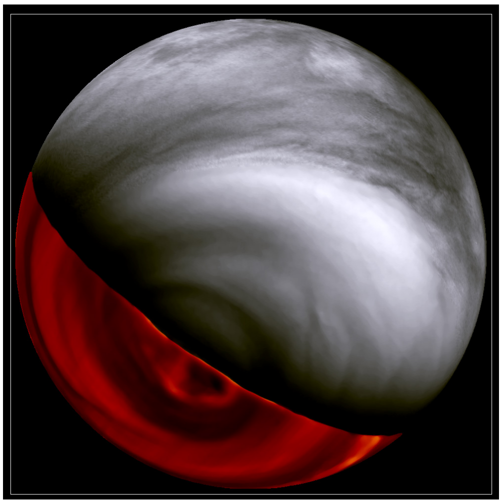

Figure 3: Composite of the VMC UV image of the day side (grey) and VIRTIS near-IR image of the night side (red)

VIRTIS and SPICAV spectrometers study non-LTE emissions of O_2, NO, OH and CO_2. The airglows originate at the mesopause level (~100 km). Observations of their morphology and variability give a clue to the dynamics and composition of the upper atmosphere [15].

Vertical structure of the ionosphere is studied by the radio-science experiment VeRa [16]. Electron density peaks at ~ $4 \cdot 10^5$ cm^{-3} at about 140 km and ionization completely disappears by ~120 km. The electron density abruptly drops by 1-2 orders of magnitude behind terminator. The plasma investigations by magnetometer and ASPERA experiments indicated that the ion escape occurs mainly through plasma wake [17]. The main escaping ions are O^+, H^+, and He^+ (fig. 4) with H^+/O^+~2 – stoichiometric ratio of water. These observations have important implications for the evolution of the Venus atmosphere and the role of magnetic field.

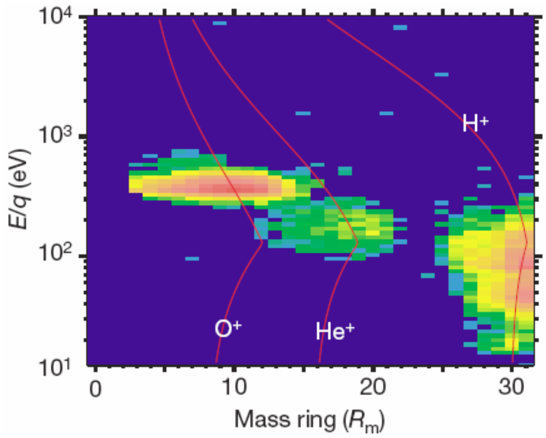

Figure 4: Detection of escaping ions by ASPERA

Future Venus Express observations have a goal to continue atmospheric survey to gain statistics and study long-term variations, to extend plasma observations into the period of increasing solar activity, and to perform joint observations with Japanese Planet-C orbiter expected to arrive at Venus in the end of 2010.

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