INVESTIGATION OF VENUS' ATMOSPHERIC THERMAL STRUCTURE AND CLOUD FEATURES OVER THE NORTHERN NIGHTSIDE HEMISPHERE APPLYING SELF-CONSISTENT RETRIEVAL PROCEDURES

R. Haus (1), D. Kappel (2), G. Arnold (2)

(1) University Münster, Institute for Planetology, Münster, Germany; (2) DLR, Institute of Planetary Research, Berlin, Germany

rainer.haus@gmx.de/ Phone: +49-30-53011092

1

SCOPE

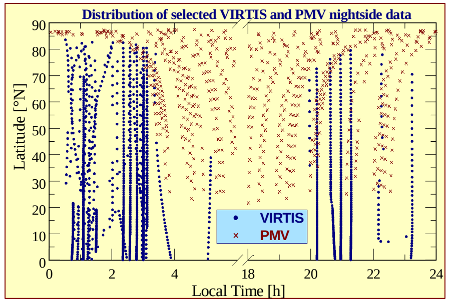
Determination of constraints on atmospheric parameter variations using comparative analyses of data independently recorded by VIRTIS and PMV

METHOD

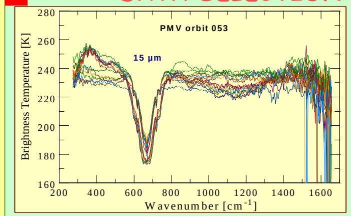
Radiative Transfer Simulation (RTS) and Multi-Window Retrieval (MWR) procedures for self-consistent retrieval of air temperature and cloud parameters

INTRODUCTION

NIR spectroscopic measurements (1.0-5.1 μm) were performed by the Visible and InfraRed Thermal Imaging Spectrometer (VIRTIS-M-IR) aboard ESA's Venus Express space probe, while the Profile Measuring Instrument for Venus (PMV, Fourier spectrometer FS-1/4) on the earlier Soviet Venera-15 satellite covered the spectral range 6-36 μm. A detailed comparative investigation of Venus' thermal structure and cloud composition based on these two experiments has not been done before. The data sets are complementary in the sense that any initial cloud model and retrieved actual parameters must allow to generate reasonable fits in both spectral ranges. Due to PMV data coverage, present investigations are restricted to the northern hemisphere of Venus. The NIR range shortward of 5 μm strongly responds to insolation changes, and deep atmosphere signatures are not detectable at daylight. Thus, only nightside data from both experiments is used.

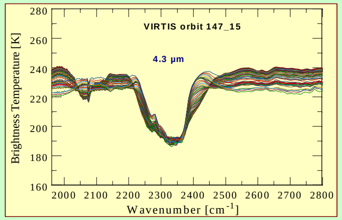


2 DATA SELECTION



Zasova, L.V., et al., (1999), Structure of the Venus middle atmosphere: Venera 15 Fourier spectrometer data revisited, *Adv. Space Res., 23(9)*, 1559-1568.

Selection of 32 PMV orbits (1100 spectra), northern hemisphere



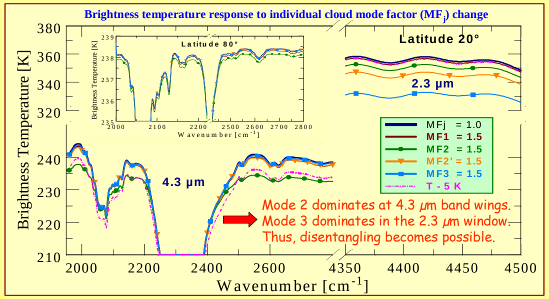
Piccioni, G., et al., (2007), The Visible and Infrared Thermal Imaging Spectrometer, ESA SP,1295.

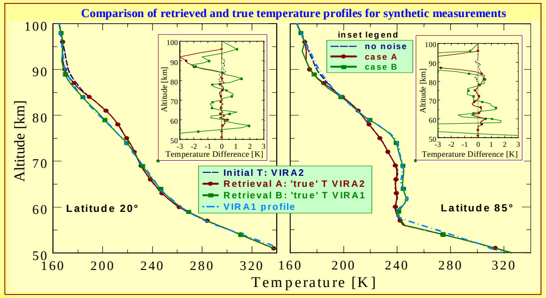
Selection of 34 VIRTIS orbits (1589 spectra), northern hemisphere

3 ALGORITHM VALIDATION

Temperature profiles T(z) are determined from the 4.3 and 15 μm CO_2 bands applying Smith's relaxation method. The bands sound the altitude range of about 60(55)-95 km. An analytically parameterized initial model of four-modal cloud altitude distributions is used. Cloud properties are retrieved from the band wings in terms of single mode factors MFj and upper cloud altitude boundaries that modify the cloud top altitude. In case of VIRTIS, large particle (mode 3) factors are determined at 2.3 μm considering deep atmosphere continuum absorption.

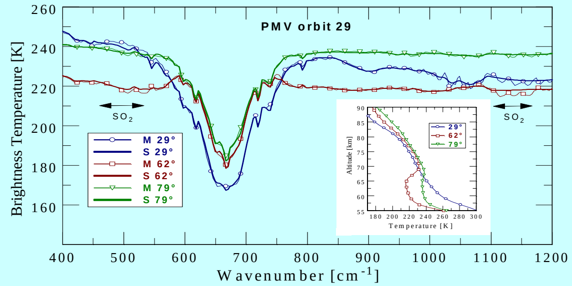
RTS-MWR performance has been investigated by generation of synthetic noisy spectra for different initial T profiles and cloud parameters and subsequent recovery of underlying model parameters. They are very well reproduced (ΔT<1.5 K, cloud parameter differences < 2%).

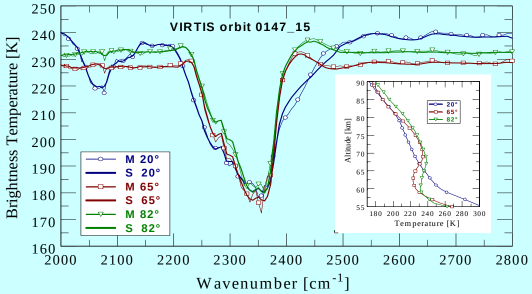


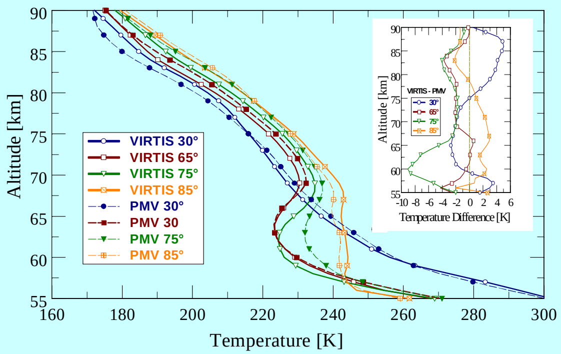


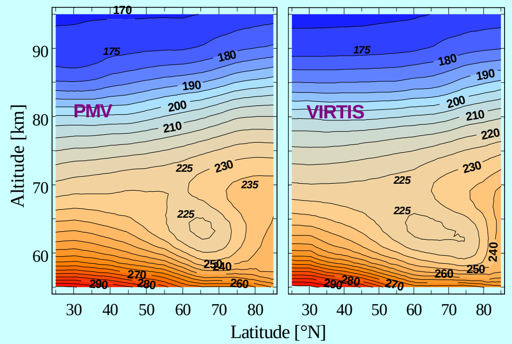
4 REAL SPECTRA RETRIEVALS AND TEMPERATURE RESULTS

The new MWR technique for self-consistent temperature profile and cloud parameter retrieval provides very good spectrum fits 'S' of real measurements 'M'. SO_2 feature variations are not considered in operational analyses. Retrieved temperature profiles are shown in the insets. Retrieved cloud parameters (mode 2 factors / cloud top altitudes): PMV (29, 62, 79°N) 0.95, 0.36, 0.19 / 71.1, 66.0, 60.7 km VIRTIS (20, 65, 82°N) 0.78, 0.29, 0.21 / 70.4, 63.8, 61.0

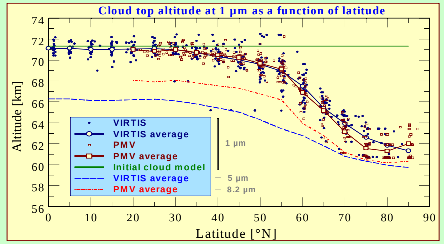


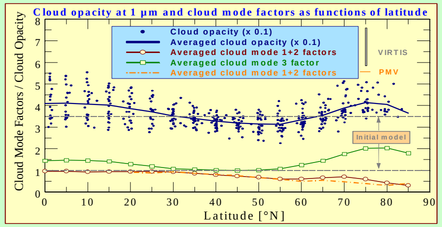






5 CLOUD PARAMETER RESULTS





6 SUMMARY AND OUTLOOK

- Self-consistent temperature profile and cloud parameter retrievals are performed along with complementary analyses of VIRTIS-M-IR and PMV data. This approach considerably improves the determination of constraints on temperature profile and cloud parameter variations.
- The newly proposed initial cloud model incorporates analytical descriptions of four-modal particle altitude distributions. It permits optimum fits of VIRTIS and PMV measurements by retrieval of cloud mode factors and upper altitude boundaries that determine cloud top altitudes.
- Presented retrieval results are based on zonal averages. Prominent features of Venus' mesospheric temperature field like 'cold collar' and 'hot dipole' are re-examined. They are in good quantitative accordance with earlier results. The strong cold inversion layer at 55-75°N and 62-66 km divides the atmosphere vertically. For fixed altitudes below the collar, temperature decreases with increasing latitude, while it increases above 70 km.
- Both VIRTIS-M-IR and PMV data have confirmed a remarkable latitudinal dependence of cloud top altitude that has been previously derived by other authors. It remains almost constant between 71 and 70 km from equatorial to mid latitudes, but quickly decreases northward of 55°N down to about 61.5 km at polar latitudes.
- Present results also confirm that averaged particle size increases from mid latitudes towards the North Pole. A secondary particle size maximum occurs at equatorial latitudes. Hence, equatorial and polar latitudes are covered by much thicker clouds than mid latitudes between 30 and 60°N. The hemispheric average of cloud opacity is 34.7 at 1 μm.
- Subsequent studies will investigate the immense amount of mapping data obtained by VIRTIS-M-IR over the southern hemisphere of Venus. Temperature altitude profile maps will comprise not only variations with latitude, but also with local time and time.
- Future investigations will also comprise a re-examination of the variability of minor constituents in the lower atmosphere. Based on the new temperature, minor gas, and cloud maps, a specification of atmospheric net fluxes and cooling/heating rates will be performed that will eventually be used to obtain improved results on the radiative energy balance of Venus' middle and lower atmosphere.