Determining vertical cloud structure on Venus using near-infrared spectroscopy

J. K. Barstow[1*], F. W. Taylor[1], C. C. C.Tsang[1], C. F. Wilson[1], P. G. J. Irwin[1], P. Drossart[2], G. Piccioni[3]. Email* barstow@atm.ox.ac.uk

(1) Atmospheric, Oceanic and Planetary Physics, Clarendon Laboratory, University of Oxford, UK; (2) LESIA, Observatoire de Paris, Meudon, France; (3) INAF-IASF, Rome, Italy

Near-infrared spectra from the Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) on Venus Express provide the opportunity for remote sounding of the lower cloud over a wide area of the planet. A small peak between 2.5 and 2.6 microns has been recently discovered in VIRTIS nightside spectra, and this is shown by modelling, using the *Nemesis*[1] radiative transfer and retrieval tool, to be sensitive to variations in both cloud base altitude and water vapour abundance within the cloud layer.

1. The infrared window region between 2.1 and 2.6 µm as discovered by Allen and Crawford (1984)[2] is sensitive to the total amount of sulphuric acid cloud present, the altitude of the lower cloud base, and the abundances of CO, H_2O and OCS. Different parts of this spectrum have different sensitivities, so using the whole spectrum of this window region allows the simultaneous constraint of these parameters.

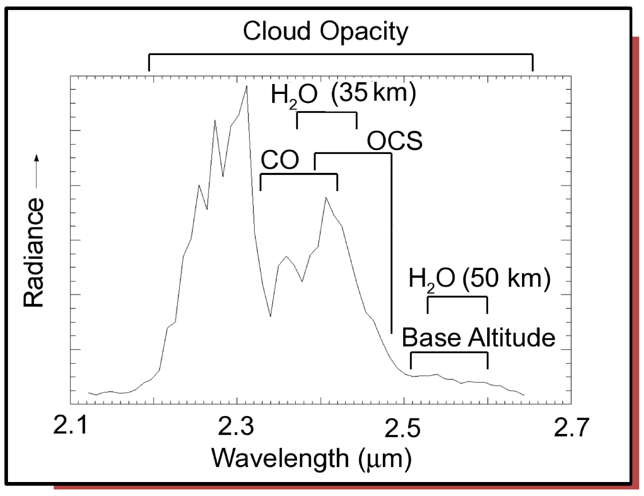

Fig 1: An example VIRTIS-M spectrum with indications of regions of sensitivity to different species and cloud base.

2. Comparing radiances at 2.4 and 2.53 µm for data and for radiative transfer models indicates variation in base altitude, correlated with the total cloud opacity. If water vapour abundances at 35 and 50 km are coupled, the ratio between these radiances is independent of H_2O abundance and a base altitude can be calculated.

3. A best-fit solution for the fractional cloud opacity, fractional abundances of CO, H_2O and OCS, and the altitude of the lower cloud base is obtained using *Nemesis,* which utilises a non-linear optimal estimation technique[1]. Results appear to support the conclusions above, although the errors are large (~10 % or higher for some data points) and further work is required. The possibility that water vapour abundances at 35 and 50 km may be decoupled or subject to a spatial offset has also not yet been fully explored. These results suggest that mesoscale convective cells may be responsible for the variation in cloud opacity that we observe on Venus, as suggested by McGouldrick and Toon (2008)[3].

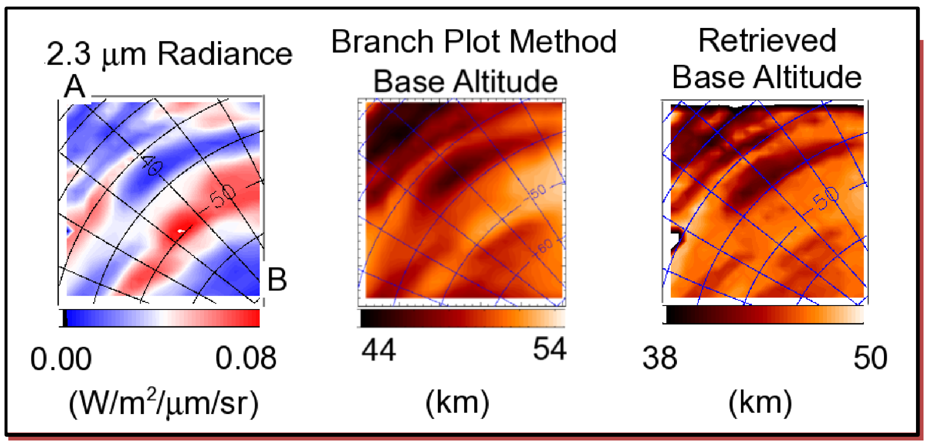

Fig 3: 2.3 µm radiance and derived cloud base altitudes for the branch plot and retrieval methods. The absolute values differ, but similar correlation is observed using both methods.

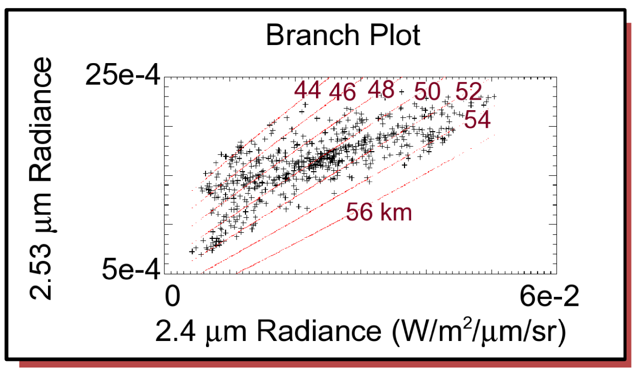

Fig 2: Branch plot for observation VI0319_00. Model branches shown in red. Points with a higher 2.3 µm radiance fall on model branches with higher cloud base altitudes.

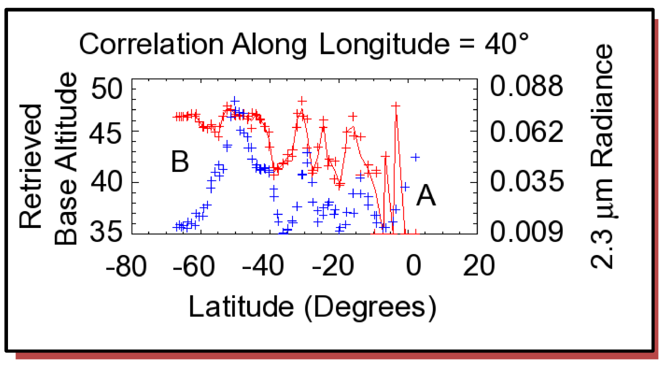

Fig 4: Correlation (with a slight offset in latitude) along the line longitude=40° between cloud base altitude (red) and 2.3 µm radiance (blue) is observed.

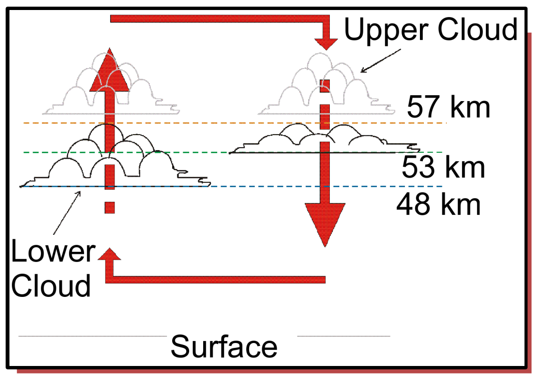

Fig 5: Correlation between cloud opacity and base altitude may indicate the presence of mesoscale convective processes. Orange line: top of lower cloud. Green line: base for thin cloud. Blue line : base for thick cloud.

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