A novel approach for Limb Darkening Correction on Venus nightside NIR spectrum : results and implications

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We define Limb Darkening as the decrease of the radiance emerging from atmosphere at increasing emergence angle (i.e. angle between the direction of observation and the normal to the surface). The retrieval of radiance that would be measured in a Nadir observation (i.e. the Limb Darkening Correction) is a fundamental process of data reduction, because it allows to eliminate the radiance variations due to the different atmospheric column depth crossed by radiation. To this aim, it is necessary to predict the behaviour of radiance emerging from atmosphere with the emergence angle.

Limb Darkening Correction has been already performed in previous works at one or two wavelengths, only. For the first time, we present here a five wavelengths simultaneous analysis of Limb Darkening effect that allows to characterise the extinction efficiency of the atmosphere at different altitudes. Our approach, differently from the previous works mostly based on synthetic data analysis, consists in a statistical analysis of VIRTIS data, therefore it is independent on assumptions needed in theoretical models. We performed a Limb Darkening Correction to the Venus nightside infrared images, provided by the VIRTIS-VeX instrument. The five wavelengths considered for this analysis are 1.03 μm, characterised by surface emission, 1.31 μm, 1.74 μm and 2.30 μm, characterised by lower atmosphere emission, orginated from between 0 and 30 km, 15 and 30 km and 25 and 45 km respectively, and 3.72 μm, characterised by the upper atmosphere (62-73 km) emission.

It is found that radiance has a linear dependence on emergence angle for the first 4 wavelengths and a quadratic dependence at 3.72 μm, confirming what obtained in previous works. Moreover, the inferred relations at 1.03 μm and at 1.74 μm are in agreement with those obtained by Muller et al (2008) and Carlson et al (1993) respectively. Differently, at 1.31 μm, 2.30 μm and 3.72 μm our results lead to corrected radiances that can differ up to 31% from those retrieved according to previous approaches.

An important implication of our results is that the relation between radiance and emergence angle depends strongly on altitude, h_0, where emission comes from. In particular, it is found that the ratio between radiation emerging at $\cos\theta = 0.4$ and radiation emerging at Nadir ($\cos\theta = 1$) is lower at 1.03 μm (where h_0 is minimum) and then increases with increasing h_0. This can be explained by the higher atmospheric portion crossed, and hence a higher suffered extinction, by the radiation originated at the lowest heights and vice versa.