REGIONAL VENUS SURFACE TEMPERATURE VARIATIONS IN MODELS AND INFRARED OBSERVATIONS. N. T. Mueller[1], C. Tsang[2], S. Lebonnois[3], S. Smrekar[1]. [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109 USA, nils.muller@jpl.nasa.gov, [2] Department of Space Studies, Southwest Research Institute, Boulder, CO 80302 USA,. [3]Laboratoire de Météorologie Dynamique (LMD/IPSL), Sorbonne Université, UPMC Univ. Paris 06, ENS, PSL Research University, Ecole Polytechnique, Université Paris Saclay, CNRS, 75252 Paris, France

Introduction: The current temperature at and near the surface of Venus is relevant for many open questions regarding its evolution as an Earth like planet. The atmospheric temperature lapse rate is important for the propagation of gravity waves [e.g. 1] that play a role in angular momentum transfer between surface and superrotating atmosphere. Constraints on surface temperature are necessary to derive surface emissivity from near infrared observations, the only current opportunity for global compositional mapping. Current approaches using a simple model of the lower atmosphere temperature [2] result in emissivity trends with surface elevation that have to be corrected for empirically [3,4,5]. This is possible because the relatively high efficiency of convective heat redistribution ensures that lateral temperature contrasts are small [6]. The subsurface temperature gradient (heat flow) would provide insight into the thermal evolution of the planet, but requires the diurnal temperature variation.

In situ data is scarce, especially close to the surface. It cannot provide the global picture and still provides unsolved questions. The Venus International Reference Atmosphere (VIRA) [2] provides laterally and temporally averaged temperature for the lowest atmosphere, with a vertical temperature profile extrapolated from Pioneer Venus and Venera measurements higher up. Yet the only high resolution descent profile from the VeGa-2 lander [7] shows a dynamically unstable superadiabatic lapse rate, which led [8] to hypothesize that the supercritical CO_2 causes a density driven compositional gradient.

In this work we show that the thermal emission observed by VIRTIS on Venus Express indicates lateral and temporal variations in surface temperature and the overlying atmospheric lapse rate. These variations are qualitatively similar to a General Circulation Model (GCM) surface temperatures.

Near Infrared Multispectral Imaging: We correct the VIRTIS data for detector non-linearities and instrumental straylight following the approach of [9]. To invert the data to emissivity we use the radiative transfer model (NEMESIS) developed for Venus by [10] to model the radiances of the near infrared atmospheric windows between 1000 and 1400 nm. The atmospheric temperature and pressure profile is based on [2] as in previous studies of deep atmosphere and surface emissions [4,5]. As in these previous studies the model includes additional opacity in order to match observed spectra. We introduce this as a collision induced absorption (CIA) continuum coefficient for each of the window regions. The value of the coefficient is not constrained and we chose them such that an average derived emissivity of 0.8 is obtained.

The result is a map of surface emissivity in three bands at approximately 1020, 1100 and 1180 nm, all showing some residual trend with topography. Such trends of emissivity have been reported by other studies with the same assumptions on surface temperature [3,4]. The new observation here is that the trend varies with location and local time, and thus has to be corrected for locally. Fig. 1 shows the VIRTIS derived emissivity of the 1020 nm band for two regions at the same latitude of 58S to 42S, and different longitudes -41E to -4E (Themis Regio),-105E to -68E (Lavinia Planitia). The VIRTIS data has to be averaged over many observations to yield reasonable signal to noise. We separate the nightside data set in two wide local time intervals, before and after local midnight. The emissivity trend with topography is qualitatively similar in all three bands. This is consistent with an atmospheric temperature that is different from the assumptions used in NEMESIS. Our model lookup tables were set up to derive surface emissivity and therefore we cannot yet present this result in terms of temperature.

General Circulation Model: We use results of a GCM developed for Venus by [11]. The model is based on an Earth GCM with several modifications. The main modification is the radiative transfer model, developed specifically for Venus, allowing the GCM to provide self-consistent temperatures. In the results shown here the model atmosphere does not include a density driven gradient as modeled by [8]. The surface is included to resemble dense basalt with an elevation based on the Magellan GTDR, and the results used here have a horizontal resolution of 3.7 deg in longitude and 1.9 deg in latitude.

The modeled surface temperatures of the Themis and Lavinia areas are shown for local times of 10 PM and 2 AM, the approximate average local time of the VIRTIS data presented in Fig. 1.

The data is presented relative to the lapse rate assumed for the VIRTIS data reduction and with an offset of 725K, as the model temperature does not quite match the nominal 735K at mean planetary radius [2].

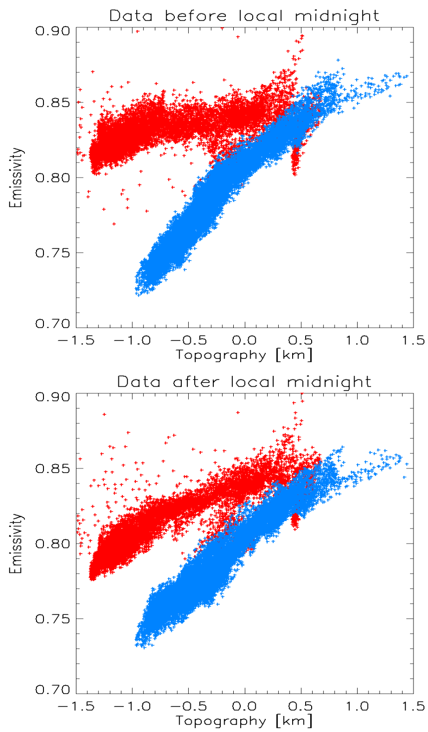

Figure 1 VIRTIS emissivity data for two regions and two local times. Blue: Themis. Red: Lavinia.

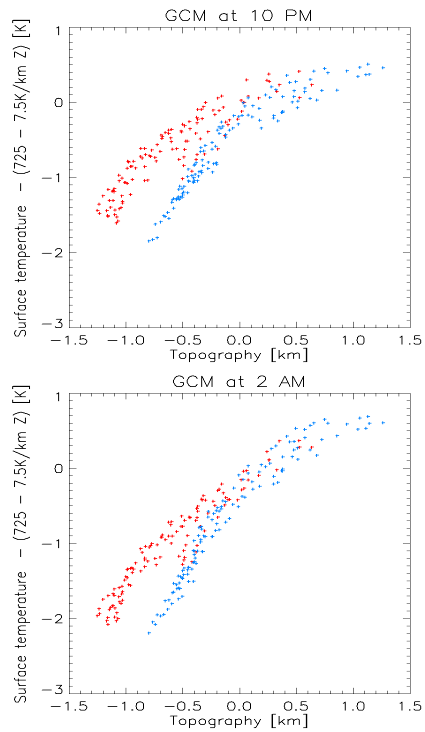

Figure 2 GCM results for two regions and two local times. Blue: Themis. Red: Lavinia.

Discussion and Conclusions: Observations and GCM show a qualitatively similar behavior. At this point a quantitative interpretation is still in progress but simple calculations indicate that the emissivity and temperature deviations are of similar magnitude: a 1 K ΔT corresponds to a 2.6% blackbody radiance difference at 735 K at 1020 nm.

In both data and model, the Lavinia Planitia dataset appears to be closer to the VIRA lapse rate of 7.5K than Themis Regio. Lavinia temperatures in both model and data appear closer to the Themis values at 2 AM than at 10 PM. This cooling effect appears to be more visible in the VIRTIS data than in the model. The effect of local time is smaller than the effect of location.

It is unclear what causes the location effect. The surrounding topography might be a factor. The Lavinia Planitia basin is bounded to the south by 2-3 km high Lada Terra as opposed to only lowlands south of Themis Regio.

The potential impact of these observations is clear. The GCM predictions testable by remote observation were previously limited to the upper boundary winds and atmospheric temperature fields above roughly 40 km altitude [12]. Near infrared data provides constraints for the planetary boundary layer.

On the other hand, the GCM model temperatures differing from the VIRA temperatures provide a physical meaning to the empirical corrections of emissivity trends in previous work [3,4].

[8] model the effects of the hypothetical separation of CO_2 and N_2, which results in somewhat different temperatures than the results presented in this abstract, but at present we cannot show whether this provides a better fit to the VIRTIS data due to the limited altitude range covered in the available data. Future observations could provide a better temporal resolution, a wider range of observed surface elevations, and a much better SNR, each of which will significantly improve the interpretability of the data.

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