A SEARCH FOR ACTIVE VOLCANOES AND COMPOSITIONAL VARIATION IN CRUST ON VENUS USING NIGHTSIDE NEAR-INFRARED THERMAL RADIATION.

G. L. Hashimoto[1], S. Sugita[2], and T. Imamura[3], [1]Center for Climate System Research, University of Tokyo, 4-6-1 Komaba, Meguro, Tokyo 153-8904, Japan, [2]Department of Earth and Planetary Science, University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113-0033, Japan, [3]Institute of Space and Astronautical Science, 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229-8510, Japan.

Introduction: The thick atmosphere and clouds of Venus restrict methods to observe the surface. However, new spectral windows were discovered at the near-infrared wavelengths, in which thermal radiation emitted from the planetary surface penetrate through the thick Venus atmosphere and clouds [1, 2, 3, 4]. Although, thermal radiation emitted by the venusian surface is disturbed by reflected sunlight on the dayside, it can be observed on the nightside from above the clouds. The calculation of atmospheric radiative transfer model demonstrates that virtually all (>95%) of the radiation observed within the 1.0 μm window is emitted by the surface [3]. This near-infrared window will allow us to measure the venusian surface based on spacecraft observation and ground-based telescopic observation. In this paper, we discuss the feasibility of detecting both active volcanic activity and crustal compositional heterogeneity on Venus using near-infrared observation through this window.

Active Volcanoes: Active lava eruptions can be observed using the 1.0 μm window, since the intensity of thermal emission strongly depends on temperature [5]. A hot surface produced by a lava eruption emits intense radiation compared to the relatively cool surroundings. The excess emission from the hot surface is regarded as evidence of active volcanism.

The detection limit of hot surface is evaluated by the 3-dimensional Monte Carlo simulation [5]. This simulation shows that a typical lava flow (~100 km^2) is detectable when the surface temperature is higher than 915 K. Even if crust temperatures were lower than this critical temperature, we have a chance to detect a lava flow. During eruptions, a hot radiative area typically appears on lava flows [6]. Although such areas are only a few percent of the total eruption area in the case of the Kilauea eruption, a large amount of hot thermal radiation is nevertheless emitted and remarkably contributes to observe excess emission [5]. It is also worth to note that their detection limit is rather conservative, since the temperature of the surrounding surface is assumed at 750 K, which is higher than the average surface temperature of 735 K.

A lava lake, which forms in the crater of an active volcano, is also likely to be detected, even though it is a small feature [5]. Surface temperatures of lava lakes are kept relatively high due to the continuous supply of heat from underneath. When the surface temperature is higher than 1200 K, lava lakes as small as 1 km^2 are detectable [5]. Since the liquidus temperature of basalt is about 1500 K, it seems probable that the surface temperature of lava lake is sufficiently high for detection.

Rapid cooling of exposed lava restricts the detection of lava eruption. According to the results of numerical modeling [7], the timescale of lava cooling is about 1 Earth day. This indicates that an eruption event becomes undetectable one Earth day after cessation of the eruption. A Venus orbiter stationed six Venus radii from the planet's center, which

orbits the planet in about 1 Earth day, will detect most of the eruptions on the nightside. However, it is difficult to detect short-term eruptions on the dayside, since the timescale of lava cooling is much shorter than half a Venus day.

Compositional Variation in Crust: The intensity of thermal radiation emitted by the surface is controlled by not only temperature but also the surface emissivity. Since emissivity is a function of the mineralogy of the surface, the measurement at the 1.0 μm window is useful to estimate the rock types of the venusian surface. Emissivities at 1.0 μm wavelength is practically determined by the content of FeO. Since granitic rocks and basaltic rocks are significantly different in the content of FeO, observation of the 1.0 μm window may be able to distinguish granitic rocks from basaltic rocks.

Variations in the surface emissivity of the venusian surface have been searched by some groups, but they found no signature of large variations at near-infrared wavelength [2, 3]. To estimate the actual variation in the surface emissivity, they correct the spatial variations in the cloud thickness and surface temperature. However, their analysis neglects the multiple reflection of thermal radiation between the atmosphere and the planetary surface. Since the multiple reflection between the surface and the atmosphere obscures the variation in the surface emissivity [8], it is likely that the failure in detecting the variation in the surface emissivity is caused by this over simplification [9]. Re-examinatin of the previous analysis demonstrates that there may be a large spatial variation in the surface emissivity as large as 20%, which corresponds to the difference between granitic rocks and baslatic rocks [9].

The relative uncertainty in the estimation of the surface emissivity is determined by the error in the estimation of the surface temepra-ture [9]. The altimetry map and a near-surface temperature lapse rate are used to estimate the surface temperature. Although the error due to the uncertainty in the altimetry data by Magellan is significant, the difference in the emissivities at the 1.0 μm wavelength is large enough to distinguish granitic rocks from basaltic rocks.

Spatial resolution in the estimation of the surface emissivity is limited by the intense scattering by clouds. Numerical calculation demonstrates that it is of the order of 100 km [5]. Although it is inprobable to detect a small feature such as the pancake dome, granitic massifis which are larger than 100 km are detectable [9].

Conclusion: The 1.0 μm window is very useful to observe the venusian surface. Using this window, we will be able to detect active volcanoes and compositional variation in crust on Venus.

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