Observations of Venus Cloud top by Longwave Infrared Thermal Camera (LIR) on board Akatsuki.
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Introduction:

The thick atmosphere on Venus is one of the major factors contributing to extremely high surface temperatures (~ 743 K) resulting from the runaway greenhouse effect. Vertical convection currents caused due to heating of the lower clouds on Venus produces prospects of strong coupling between cloud condensation and atmospheric motion [1]. The Venusian upper atmosphere is well known to exhibit super-rotation, with winds reaching upto 220 miles per hour, sweeping the planet once every four Earth days. Observations show that the cloud layer absorbs solar radiation, which can drive various atmospheric motions that would play a central role in the momentum balance of the super rotation. Using LIR data from Akatsuki, we present the analysis of the variations observed in the cloud top brightness temperatures measured over Venus.

Venus Climate Orbiter "Akatsuki" is the first Japanese probe to observe Venus. A thermal camera, named Longwave Infrared (LIR) Camera on board Akatsuki is measuring the thermal emissions from the cloud top in the Mid-Infrared regions (8-12 μm specifically). Mid-infrared images of the entire Venus night side taken by LIR reveal that the cloud-top temperatures show variations from 237 K in the cold polar collars to 243 K in the equatorial regions [2]. An inter-hemispheric bow-shaped structure at the cloud-top level of Venus was also discovered recently by LIR [3], having a horizontal scale of about 10,000 km in a north-south direction in December, 2015. This bow-shaped structure is interpreted as the result of atmospheric gravity wave generated in the lower atmosphere by mountain topography that then propagated upwards.

Data Used:

Brightness temperature data of 25th Aug, 2016 at 02:16:05 from LIR onboard Akatsuki is used. The longitude range of this image is from 62.35^{o} to 153.64^{o} and the latitude range is from -51.02^{o} to 23.93^{o}. Right Ascension (RA) and Declination (DEC) of the image center (J2000) are 104.89 and 36.93, respectively. Sub solar latitude and longitude of the image are 1.44151 deg and 229.53 deg, respectively. The brightness temp varies from 220 K to 245 K (approx.) on the Venus disk.

Results:

Figure 1 shows the Brightness Temperature (BT) disk of Venus on 25th August, 2017 at 02:16:05 obtained from LIR. This observation date is different than the already reported dates in [3] and [4]. The variations in the BT over Venus is observed to be in the range of 220-245 K, as is depicted in the histogram shown in figure 2. Applying a Gaussian Laplace High pass filter with sigma = 3 pixels, we can observe the bow shaped structure previously reported by [3] and [4] on different dates. The structure, as presented in figure 3, is located in the Thetis Regio (Aphrodite Terra) lying between 117^{o}-138^{o} East Longitude and -16^{o} to -2^{o} Latitude. The distinct black dots in the image are due to the dead pixels [(81,215), (185,143), (200,68), (127,55)]. Figure 4 shows the location of the bow shaped structure on the topography map for Venus taken from Magellan Global Topography 4641 m for Venus [5].

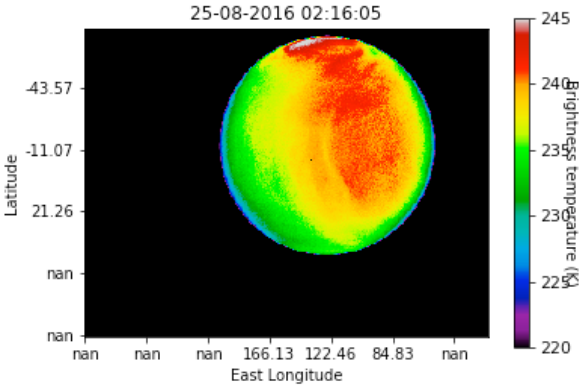

Figure 1. Brightness temperature disk of Venus on 25th Aug, 2016 at 02:16:05 obtained from LIR.

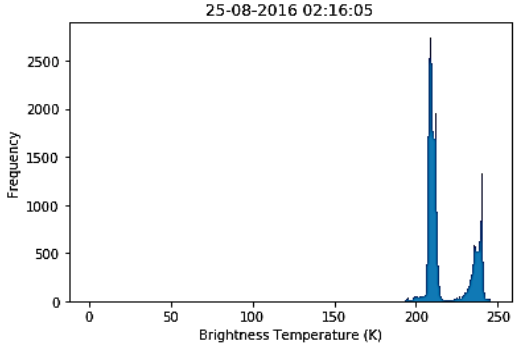

Figure 2: Histogram plot showing variations of Brightness Temperature (BT) on the above mentioned date. The BT is seen to range from 220 K to 245 K.

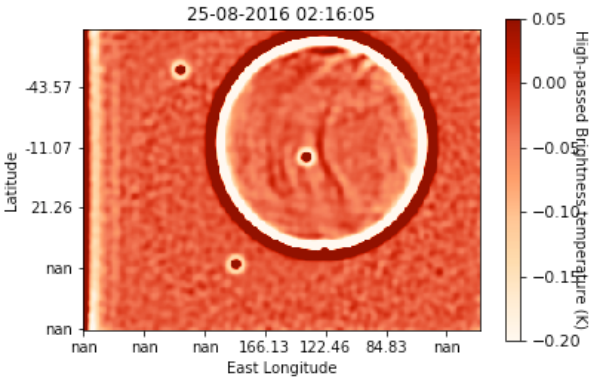

Figure 3: High pass filter applied on the BT image in Figure 1. A bow shaped feature is clearly seen at about 122.46 East Longitude (Thetis Regio in Aphrodite Terra), Limb correction is not performed on this image.

The Level 2B brightness temperature data of LIR has been observed to contain background bias due to the thermal coupling of the Baffle (hood) and Ge lens [3]. We have attempted to correct the bias using the Baffle Temperature values as depicted in [3].

$$I_c = I_s - C_b\,(B(T_b) - B(T_{b0}))$$

But, due to unavailability of deep sky images and lack of knowledge on the coefficient (C_b) describing contribution ratio of blackbody radiation due to the baffle temperature on each pixel, we were unable to complete the procedure. We will be attempting to apply the bias corrections along with limb darkening corrections in our future work as per [2].

Discussions:

The brightness temperature on the Venus disk shows a variation from 220-240 K for the observation date chosen. Moreover, the bow shaped feature has also moved to 122.46 East Longitude on 25th Aug, 2016 at 02:16:05 from its earlier reported position in [3] and [4]. The bow shaped structure may indicate a planetary scale atmospheric gravity wave as discussed by [3] and [4] which occur mostly in the high land regions of Venus. Monitoring this structure over the periods of observation might give us more insight into the dynamics and properties of the Venusian atmosphere along its trajectory.

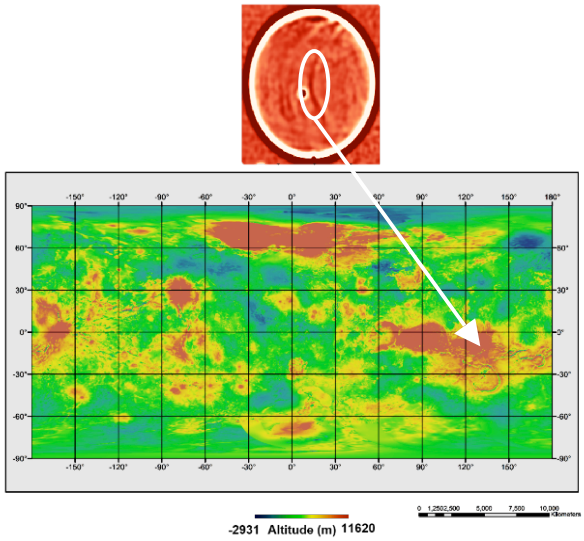

Figure 4: Locating the bow shaped feature on the Magellan Global Topography 4641 m for Venus. The arrow points to the Thetis Regio in Aphrodite Terra on Venus.

References:

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