[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

2021年6月3日(木) 10:45 ~ 12:15 | Ch.02 Zoom会場02

[P-PS02] Recent advances of Venus science and coming decades

コンビーナ:佐藤 毅彦(宇宙航空研究開発機構・宇宙科学研究本部)、Thomas Widemann(Observatoire de Paris)、Kevin McGouldrick(University of Colorado Boulder)、佐川 英夫(京都産業大学)、座長:佐藤 毅彦(宇宙航空研究開発機構・宇宙科学研究本部)

Akatsuki, Japan's Venus Climate Orbiter, has been operational in the Venus orbit for more than 5 Earth years, advancing our knowledge mostly about the atmospheric dynamics by feature tracking in the high-resolution imagery. Together with 8 years of coverage made by ESA's Venus Express (2006 - 2014), including spectroscopic information plus plasma measurements, we are in another golden age of Venus science decades after the landing missions of the USA and the former USSR in the 1970's. In addition, the Venus community has been eager to realize next generation missions to Venus. This session will cover all aspects of science related to Venus, either by observationally (including future missions) or by theoretically, about the planet itself or its surrounding environment or even implications to the exoplanets. Contributions by experts and by early-career researchers are all welcome.

10:45 ~ 11:00

[PPS02-07] Microphysics Implications of the Venus Bow Wave seen by LIR on Akatsuki

*Kevin McGouldrick[1] (1.Laboratory for Atmospheric and Space Physics, University of Colorado Boulder)

11:00 ~ 11:15

[PPS02-08] Barotropic instability and traveling linear features detected in the near-infrared images from Akatsuki

*堀之内 武[1]、佐藤 毅彦[2]、Vun Choon Wei[2]、Young Eliot F.[3] (1.北海道大学地球環境科学研究院、2.宇宙科学研究所、3.Southwest Research Institute)

11:15 ~ 11:30

[PPS02-09] Statistical analysis of the morphology of Venusian clouds

*須田 智也[1]、今村 剛[1] (1.東京大学大学院 新領域創成科学研究科)

11:30 ~ 11:45

[PPS02-10] Simulation of sulfuric acid cloud distributions by a Venus GCM for the comparison with observations

*狩生 宏喜[1]、黒田 剛史[1]、寺田 直樹[1]、笠羽 康正[1]、山本 勝[2]、高橋 正明[3]、池田 恒平[4] (1.東北大学、2.九州大学、3.東京大学、4.国立環境研究所)

11:45 ~ 12:00

[PPS02-11] 金星大気向け広帯域放射伝達モデルMstrn-Venusの開発

*関口 美保[1]、栗原 礼子[1]、眞子 直弘[2]、高木 征弘[3]、佐川 英夫[3]、松田 佳久[4] (1.国立大学法人東京海洋大学、2.国立大学法人千葉大学、3.京都産業大学、4.国立大学法人東京学芸大学)

12:00 ~ 12:15

[PPS02-12] Discussion

Microphysics Implications of the Venus Bow Wave seen by LIR on Akatsuki

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The first scientific discovery by Akatsuki following its successful Venus Orbit Insertion in Decmber, 2015 was of a global-scale "bow wave" feature seen in data from the Longwave Infrared Bolometer. This instrument senses the region of the cloud tops at about 65 km altitude in thermal infrared in a 4 micron wide band centered at 10 microns. This feature (and others like it subsequently observed) was found to be stationary with respect to the surface topography. Work by others has demonstrated that the wave is likely very large orographically-launched buoyancy wave (sometimes referred to as planetary gravity wave). Here, we present a microphysics modelling analysis of the long-term and short-term influence that such a wave would have as it propagates through the deeper cloud decks between 50 km and 65 km.

Keywords: Venus, Clouds, Microphysics, Atmospheric Dynamics

Barotropic instability and traveling linear features detected in the near-infrared images from Akatsuki

Barotropic instability and traveling linear features detected in the near-infrared images from Akatsuki

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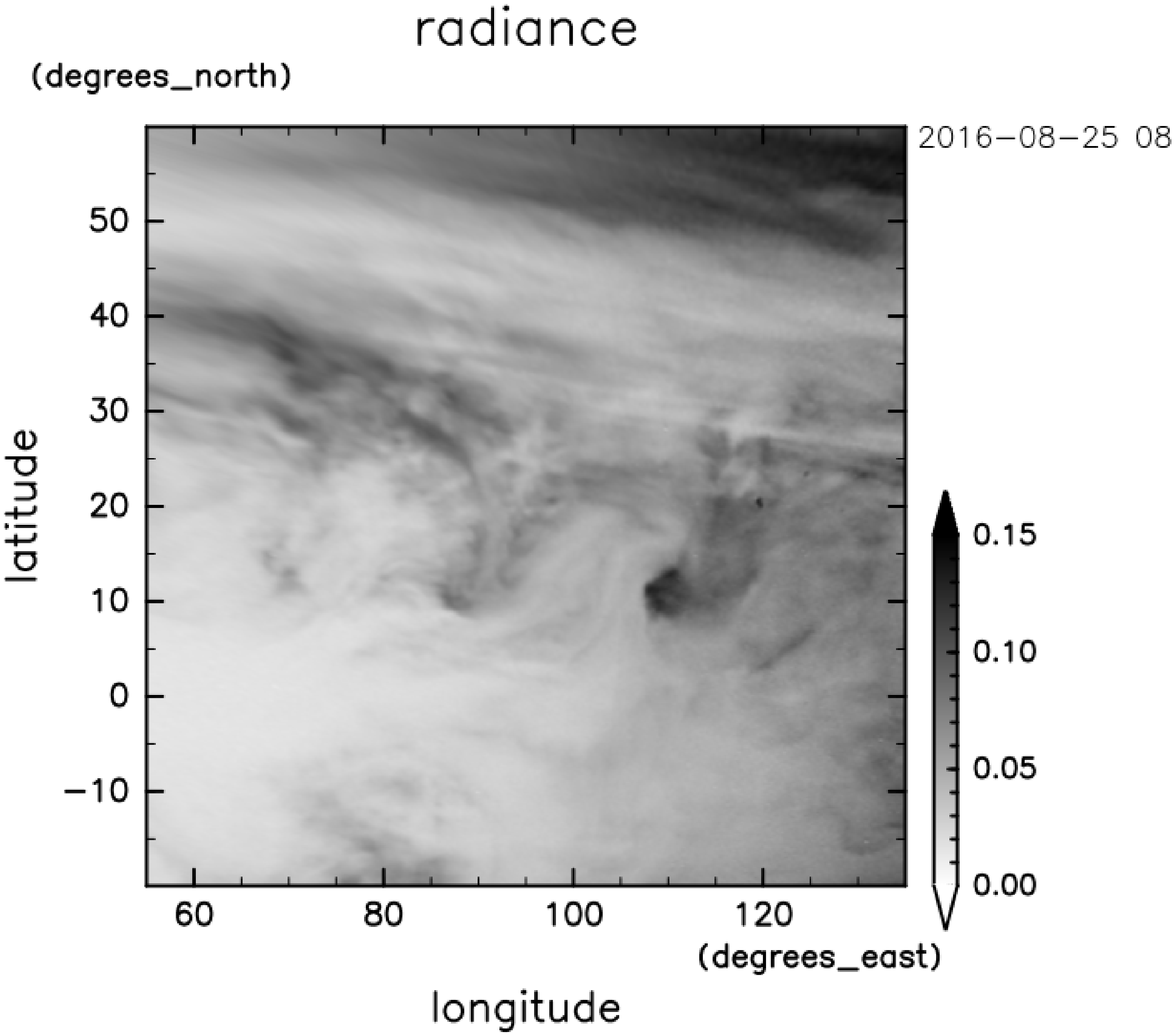
The Akatsuki IR2 camera provided images of the nightside of Venus, which captures cloud morphology illuminated by the near-infrared (NIR) thermal radiation from the lower part of the Venusian atmosphere. The nightside NIR features reveal the optical thicknesses of mid- and lower-level clouds as back-lit silhouettes. Previous studies using the nightside IR2 images reported rich features including those like barotropically unstable vortices [1] and sharp boundaries which are part of long-lasting planetary-scale waves [2]. Here, we report further morphologies indicative of dynamical processes in the cloud layer of Venus. We used data obtained on August 25, 2016. The data on this day have been difficult to treat, since the planetary limb in the images are particularly obscure, hindering the navigation-data correction needed for geographical mapping. In this study, we used a cloud tracking program to detect the apparent wind variation caused by the inaccurate mapping and corrected the navigation data to compensate it. It enabled us to study time evolutions in depth. We found gigantic (~2000 km) barotropic instability-like billows that actually exhibited rotation consistent with the shape. We also found many linear features that propagate westward relative to the motion of other features such as the billows. The linear features may be due to waves that potentially reside at relatively high altitudes.

[1] Peralta, J. et al. (2019) Icarus, 333, 177-182.

[2] Peralta, J., et al. (2020) Geophys. Res. Lett., 47, e2020GL087221.

キーワード：Venus、Cloud、Barotropic instability、Wave
Keywords: Venus, Cloud, Barotropic instability, Wave


radiance
(degrees_north)
2016−08−25 08
50
40
30
20
10
0
−10
latitude
0.15
0.10
0.05
0.00
60
80
100
120
(degrees_east)
longitude

Statistical analysis of the morphology of Venusian clouds

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In order to understand the mechanism by which Venus’ s cloud is maintained, it is necessary to clarify the transport of atmospheric constituents at various temporal and spatial scales. In the ultraviolet images of Venus, various small-scale patterns indicative of convention and waves are seen at the cloud top. Though their relation to material transport has been drawing attention, their dynamical properties and contribution to transport are not known. These patterns will evolve over time while being advected by the high-speed easterly wind called the superrotation. To obtain clues to the processes, we analyzed ultraviolet images at the wavelength of 283 nm taken continuously by UVI onboard the Venus probe Akatsuki. SO_2 is the dominant absorber at the wavelength of 283 nm on Venus, and the horizonal distributions of SO_2 and clouds near the altitude of 65 km can be observed. By analyzing the images separately for each local time, we extracted convective patterns dependent on the local time. The complexity of the pattern was evaluated quantitatively with Fractal dimension, thereby examining the statistical tendency of the local time variation. We also performed the same analysis using IR images at the wavelength of 2.02 μm taken by IR2 onboard Akatsuki. CO_2 is the dominant absorber at 2.02 μm on Venus, and the cloud top altitude can be observed at this wavelength. The comparison between the wavelengths would lead to the elucidation of the processes controlling small-scale patterns such as convection.

キーワード：金星、雲、あかつき
Keywords: Venus, clouds, Akatsuki

Simulation of sulfuric acid cloud distributions by a Venus GCM for the comparison with observations

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The coupling between the mode distributions of sulfuric acid clouds and atmospheric dynamics is a key to understand Venusian cloud structures, but has not well been investigated. Haus et al. (2014) detected the meridional distributions of the total cloud opacity observed by the Visible and InfraRed Thermal Imaging Spectrometer (VIRTIS) aboard Venus Express (VEX), and showed that the cloud optical thickness reached the maximum in both equatorial and polar region.

Previously we have implemented the scheme of condensation, evaporation, and sedimentation processes of sulfuric acid clouds (cloud droplets are assumed to be composed of 75 % sulfuric acid, and supersaturation is not considered) together with the atmospheric chemistry for the formation of H_2SO_4 vapor into a Venus general circulation model (VGCM) for the investigation of the cloud formation and circulation systems, and showed that the total cloud thickness became the largest in the equatorial region and decreased towards the pole (Kasaba et al., 2016 AGU Fall Meeting, https://agu.confex.com/agu/fm16/meetingapp.cgi/Paper/140404). On the other hand, a recent study by Ando et al. (2020) using a different VGCM showed that the cloud mass loading was significantly larger in the polar region than in the equatorial region. The difference of the cloud implementation method between those two studies is the treatment of cloud particle distributions. Crisp (1986) defined four modes of cloud particle sizes from the Pioneer Venus observation, as mode 1 (effective radius of 0.49 μm, mode 2 (1.18 μm), mode 2’ (1.40 μm) and mode 3 (3.65 μm). Kasaba et al. (2016) considered the formations of all four modes, while Ando et al. (2020) considered only modes 1 and 2, which resulted in the difference of sedimentation velocity. As both results were partly consistent with the VIRTIS observations, so the combination of the two studies would produce better fits.

In this study, we have improved the cloud formation scheme from our previous study (Kasaba et al., 2016) for a better reproduction of observed cloud distributions. In Kasaba et al. (2016) the cloud particle formation ratios in the middle and lower altitude (~50-60 km) are uniform in all latitudes, but in this study we decreased the formation of mode 3 clouds in higher latitudes. The newly implemented mass formation ratio of mode 3 was defined to be a half of Kasaba et al. (2016) in the latitudes of >70 degrees, and replaced to mode 2’ for another half, to mimic the particle size of formed clouds defined in Ando et al. (2020) in the polar region. Also, a linear interpolation of the ratio from the original one was implemented between 50 and 70 degrees, and the vertical eddy diffusion coefficient in the cloud layer is set to be lower than Kasaba et al. (2016).

In comparison with Kasaba et al. (2016), this study produced improved latitudinal distribution of cloud opacity at 1 μm wavelength, which was qualitatively consistent with the VIRTIS observation (Haus et al., 2014). Also, the latitudinal distributions of cloud mode factors seen in Fig. 18 of Haus et al. (2014) are also well reproduced. The thickness of mode 3 clouds are the highest in poles, nevertheless of the lower production rate than in low-latitudes.

For the investigations of the cloud formation process, we are analyzing cloud production and loss rates due to advection, sedimentation, and vertical eddy diffusion. Because of the low vertical eddy diffusion coefficient, more H_2SO_4 vapor remains in the upper cloud. Consequently, the H_2SO_4 vapor is transported to the polar region by the downwelling of the Hadley circulation, and the thickness of polar clouds increases. Cloud formation around 40 km also increases slightly. This may be the result of coupling between the increase of polar clouds and equatorward advection by the return branch of the Hadley cell extended from the pole to the equator.

In addition, we are conducting spectrum analyses on temperature, wind, and cloud mode distributions to investigate the relationship between waves and cloud fluctuation. Equatorial Kelvin-wave-like structures are found in the lower cloud layer, and cloud fluctuation is synchronized with the waves. It could be useful to understand cloud morphology observed by Akatsuki, such as disruption in the lower cloud layer interpreted as a Kelvin wavefront (Peralta et al., 2020). Although other types of waves exist and seem to be correlated with cloud fluctuation, further investigation is needed to interpret the causality between them.

キーワード：金星、硫酸雲、大気大循環モデル
Keywords: Venus, Sulfuric acid cloud , General Circulation Model

金星大気向け広帯域放射伝達モデルMstrn-Venusの開発

A development of a broadband radiative transfer model "Mstrn-Venus" for Venus atmosphere

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1. Tokyo University of Marine Science and Technology, 2. Chiba University, 3. Kyoto Sangyo University, 4. Tokyo Gakugei University

Venus has a dense atmosphere entirely covered by a thick cloud layer (ranging over 50 –70 km altitude). Due to the high opacity of the atmosphere, there is almost no remote-observational access to the lower atmosphere below the cloud. Past (only a few, though) in-situ measurements suggest that a convective layer appears 18 to 32 km, but the nature of such a thermal structure is still not understood clearly.

To better knowledge on the thermal structure (radiative transfer of the thermal flux), we developed a newly developed 1-D radiative transfer model "MSTRN-Venus". The absorption coefficients of the molecular gases in the Venus atmosphere (CO_2, H_2O, CO, SO_2, HF, HCl, and OCS) are calculated in each 0.005cm^{-1} wavenumber, and correlated k-distribution are calculated and applied. The settings of radiative parameters for gas absorption and scattering processes are mainly based on Haus et al. [2015] for shortwave and Lee et al. [2016] for longwave region. The spectroscopic parameters such as the transition position and line strength are taken from the recent compilations of HITRAN 2012, HITEMP, and UCL08 catalogs. In addition, the collision-induced absorption of CO_2 is also included. We prepared the absorption coefficients under several pressure and temperature conditions within the ranges of 0.01 - 100 bar and 100 - 800 K, respectively. The results are kept in a look-up table of (p, T) domain so that we can interpolate the absorption coefficient for any pressure and temperature condition without repeating computational burdens. The sulfuric acid clouds, Rayleigh scattering, and UV unknown absorber are also considered. The upward and downward flux density is calculated for a given atmospheric profile using the MSTRN code. This code has been successfully applied in several studies of our terrestrial atmosphere, and also adopted as the radiation calculation module of several global circulation models.

The presentation will discuss the sensitivity of the radiative-convective temperature profile concerning the abundance of minor species, incoming solar heating, and cloud opacities.

キーワード：金星、放射伝達モデル
Keywords: Venus, radiative transfer model

[E] 口頭発表 | セッション記号 P (宇宙惑星科学) | P-PS 惑星科学

[P-PS02] Recent advances of Venus science and coming decades

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2021年6月3日(木) 10:45 〜 12:15 Ch.02 (Zoom会場02)

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12:00 〜 12:15

[PPS02-12]Discussion