[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

2019年5月27日(月) 10:45 ~ 12:15 | A03 東京ベイ幕張ホール

[P-PS05] Recent advances of Venus science

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)、堀之内 武(北海道大学地球環境科学研究院)、山本 勝(九州大学応用力学研究所)、Kevin McGouldrick(University of Colorado Boulder)、座長:Takehiko Satoh

Akatsuki, being in Venus orbit since December 2015, has acquired a volume of high-quality data, unveiled many new phenomena and is allowing researchers to investigate the underlying mechanisms. As the data accumulate, numerical models and theories are being advanced as well. We are no doubt living in the new golden era of Venus studies. This session invites papers of the new scientific results with Akatsuki data and the latest results of theoretical and numerical works. We expect participants of this session share the latest research results through presentations and discussion.

10:45 ~ 11:05

[PPS05-07] 金星マントルの二段階進化モデルと地球への応用

★招待講演

*小河 正基[1] (1.東京大学大学院総合文化研究科広域科学専攻)

11:05 ~ 11:20

[PPS05-08] Interaction between the thermosphere and the cloud-level atmosphere of Venus studied with simultaneous observations by Hisaki and Akatsuki

*奈良 佑亮[1]、今村 剛[1]、吉川 一朗[1]、吉岡 和夫[1]、益永 圭[2]、山崎 敦[3]、渡部 重十[4]、山田 学[5]、Lee Yoen Joo[1]、寺田 直樹[6]、関 華奈子[1] (1.東京大学大学院、2.Swedish Institute of Space Physics、3.宇宙航空研究開発機構 宇宙科学研究所、4.北海道情報大学、5.千葉工業大学、6.東北大学)

11:20 ~ 11:35

[PPS05-09] Mesoscale Dyanmics in the Venus Atmosphere

*Kevin McGouldrick[1]、Javier Peralta[2]、Takehiko Satoh[2] (1.University of Colorado Boulder、2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:35 ~ 11:50

[PPS05-10] Periodicity analysis of Venus' cloud-top temperature measured by Akatsuki LIR

梶原 直也[1]、*今村 剛[1]、田口 真[2]、福原 哲哉[2]、神山 徹[3] (1.東京大学大学院　新領域創成科学研究科、2.立教大学　理学部、3.産業技術総合研究所)

11:50 ~ 12:10

[PPS05-11] Modeling Venus-like Worlds Through Time: The habitable zone, and the evolution of Venus' atmosphere.

★Invited Papers

*Michael Way[1,2,3]、Anthony Del Genio[1] (1.NASA Goddard Institute for Space Studies、2.GSFC Sellers Exoplanet Environments Collaboration、3.Department of Physics and Astronomy, Uppsala University, Sweden)

12:10 ~ 12:15

Discussion

金星マントルの二段階進化モデルと地球への応用
A two-stage evolution model of Venus’ s mantle and its implication for the Earth

*小河 正基[1]
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1. 東京大学大学院総合文化研究科広域科学専攻
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There are two elementary processes that exert control over the evolution of the mantle in Venus and the Earth. The first is the magmatism-mantle upwelling (MMU) feedback: Suppose an upwelling flow in the solid mantle generates magma by decompression melting. The buoyancy of the magma boosts the upwelling flow itself. This positive feedback makes the magmatism and the upwelling flow vigorous. The second is mantle burst. The solid-solid phase transitions at the top of the lower mantle makes the convective flow across the phase boundaries pulsating, provided that the mantle is hot enough to cause an active magmatism. When coupled with the MMU feedback, this pulse of mantle upwelling flow causes an extensive magmatism in the upper mantle. Because of these two elementary processes, the mantle of Venus evolves in two stages. On the earlier stage when the mantle is strongly heated by radioactive elements, mantle bursts repeatedly occurs to episodically resurface Venus. As the radioactive elements decay, however, the mantle evolves into the later stage. Mantle bursts subside, and only a mild magmatism occurs at the top of the mantle to continuously resurface the planet. When a model of tectonic plates is added to this model of Venus, I obtained a two-stage evolution model of the Earth. On the earlier stage, mantle bursts repeatedly occur to make plate motion chaotic and the mantle compositionally rather homogeneous. On the later stage, in contrast, mantle bursts subside, and plate motion becomes more steady; ridge magmatism differentiates the mantle, and basaltic materials accumulate on the core-mantle boundary to form thermo-chemical piles similar to the Large Low Shear wave Velocity Provinces.

キーワード：金星、内部進化、数値シミュレーション
Keywords: Venus, Evolution of the interior, numerical simulation

Interaction between the thermosphere and the cloud-level atmosphere of Venus studied with simultaneous observations by Hisaki and Akatsuki

*奈良 佑亮[1]、今村 剛[1]、吉川 一朗[1]、吉岡 和夫[1]、益永 圭[2]、山崎 敦[3]、渡部 重十[4]、山田 学[5]、Lee Yoen Joo[1]、寺田 直樹[6]、関 華奈子[1]
*Yusuke Nara[1], Takeshi Imamura[1], Ichiro Yoshikawa[1], Kazuo Yoshioka[1], Kei Masunaga[2], Atsushi Yamazaki[3], Shigeto Watanabe[4], Manabu Yamada[5], Yeon Joo Lee[1], Naoki Terada[6], Kanako Seki[1]

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1. The University of Tokyo, 2. Swedish Institute of Space Physics, 3. ISAS/JAXA, 4. Hokkaido Information University, 5. Chiba Institute of Technology, 6. Tohoku University

In the thermosphere of Venus, the flow directing from sub-solar to anti-solar (SS-AS) is dominant driven by large temperature gradient associated with a long Venusian solar day which is ~117 Earth days. According to a numerical study by Mayr et al. (1985), the SS-AS flow without drag would exceed 300 m s^{-1} at the maximum.
It is believed that the drag force generated by gravity waves breaking effectively decelerates the thermospheric wind speed. Zalcucha et al. (2013) developed a Venus Thermosphere General Circulation Model in the presence of the gravity wave-drag, which accelerates the atmosphere when the gravity waves are broken. The model showed the SS-AS flow speed of 100-200 m s^{-1}.
The periodical variation that indicates the atmospheric waves in the thermosphere was observed by Masunaga et al. (2017). They analyzed OI dayglow variation using data obtained by the Extreme Ultraviolet Spectroscope for Exospheric Dynamics (EXCEED) on-board the Hisaki spacecraft and detected the periodicity of ~4 days only on the dawn side. They pointed out planetary-scale waves in the middle atmosphere which are expected to be exist in Venus might responsible for the variations in the thermosphere, while the existence of the planetary-scale waves at that time was not confirmed.
In this study, we investigated the vertical coupling between cloud-level atmosphere and the thermosphere of Venus, focusing on the role of atmospheric waves. To find the evidence for the wave propagation, we used data that are obtained simultaneously by Hisaki and Akatsuki spacecraft on the dawn side of Venus in June 2017.
Analyzing the time series of the atomic O dayglow emissions measured by the EXCEED and the UV images which reflect the spatial distribution of unidentified absorbers at the cloud top (~70 km) obtained by the Ultraviolet Imager (UVI), we identified characteristic periodicities of 3.5 days in both data. The wind velocity deduced with cloud tracking from UV images suggests that the 3.5-day periodicity can be associated with Kelvin waves at the cloud top; however, Kelvin waves should decay with height through radiative damping and will not reach the thermosphere. We propose an indirect process in which the Kelvin waves change the wind field periodically and examine how the vertically propagating small-scale gravity waves influence the thermospheric dayglow with a simplified numerical model.

キーワード：金星、熱圏、雲層、上下結合、重力波
Keywords: Venus, Thermosphere, Cloud level, Vertical coupling, Gravity waves

Mesoscale Dyanmics in the Venus Atmosphere

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The Akatsuki Spacecraft is capable of observing the full disk of Venus at a number of filter-specified wavelengths, with time cadence on the order of an hour, and for up to nine days at a time (until the orbit brings the spacecraft so close that Venus exceeds the instrumental fields of view). Because of this, it is capable of supporting the elucidiation of both global atmospheric dynamics (i.e., the super-rotation) and mesoscale atmospheric dynamics. Here, we describe the analysis of the driving dynamics associated with mesoscale features observed in the Akatsuki IR2 camera data. This work focuses on just a single orbit of Akatsuki, but the features and behaviors we describe appear to be common in the Venus atmosphere. We make comparisons with similar terrestrial phenomena; and assess the implications for energy and momentum transport that may affect the overall global atmospheric dynamics. Three of the four filters in Akatsuki's IR2 camera image the night side of the planet in emitted radiation. These filters have central wavelegnths of 1.74 micron, 2.26 micron, and 2.32 micron, which are most sensitive to the conditions between about 50 km and 60 km altitude, in the midst of the lower and middle, condensational, cloud deck of Venus.

Keywords: Venus, Akatsuki, Meteorology, Clouds, Atmospheric Dynamics, Infrared Observations

Periodicity analysis of Venus' cloud-top temperature measured by Akatsuki LIR

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Planetary-scale waves are thought to play crucial roles in the maintenance of the general circulation of the Venusian atmosphere. However, observational clues are limited, and the nature of such waves is poorly constrained. Here we analyze for the first time the cloud-top temperature field to deduce the periods (frequency) and the spatial structures of planetary-scale waves using LIR image data acquired continuously. Since the systematic (absolute) error in LIR data of around 3 K is larger than the expected amplitudes of the temperature oscillations of around 1 K, the waves are hard to detect by deducing temperature variations with time. In this study, we analyze oscillations of the zonal gradient of the temperature in each image associated with planetary-scale waves. The small random (relative) error in LIR data of 0.3 K enables detection of such small-amplitude waves with this method. Through spectral analyses of the time series of the temperature gradient spanning 142 Earth days from 18 May 2017, distinct oscillations with periods of 3.5 days, 4.9 days and 5.2 days were discovered. All of these modes show almost constant phases along the latitude, indicating that they are planetary-scale waves. Based on the wave period and the latitude dependence of the amplitude, the 3.5-day wave is identified as a Kelvin wave and the 4.9-day and 5.2-day waves seem to be hemispherically-symmetric Rossby waves. The amplitudes of these waves changed with time during the observation period.

キーワード：金星、あかつき、大気
Keywords: Venus, Akatsuki, atmosphere

Modeling Venus-like Worlds Through Time: The habitable zone, and the evolution of Venus' atmosphere.

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Using a modern three-dimensional general circulation coupled atmosphere/ocean model [1] we recently demonstrated [2] that climatic conditions may have permitted liquid water on Venus' surface for ~2 billion years in its early history. Similar such conditions on Earth are believed amenable to the rise of life. Several assumptions were made based on what little data we have for early Venus such as; the type of solar spectrum extant at that time, orbital parameters, estimates of a shallow ocean from Pioneer Venus D/H ratios, and topography from the Magellan Mission. We also assumed that it would have had an atmosphere similar to modern day Earth: 1 bar N2, 400ppmv CO2, 1ppmv CH4. I will discuss the motivations behind these assumptions and additional parameter space studies with direct relevance to hypothetical exoplanetary Venus-like worlds found at the inner edge of the liquid water habitable zone. Finally, I will show how our studies demonstrate that the reason for Venus' present climatic state is unlikely to be related to the gradual warming of our sun over the past 4Gyr as is commonly believed

[1] Way, M.J. et al. (2017) Astroph Journ Suppl, 231, 1
[2] Way, M. J., et al. (2016) Geophy Res Lett, 43, 8376-838

Keywords: Venus, Habitabilty, Exoplanets