EPSC Abstracts
Vol. 14, EPSC2020-303, 2020, updated on 26 Jun 2022
https://doi.org/10.5194/epsc2020-303
Europlanet Science Congress 2020

How waves and turbulence maintain the super-rotation of Venus' atmosphere – results from Akatsuki

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How the super-rotation of the Venusian atmosphere is maintained is an outstanding question of the Venus science and geophysical fluid dynamics. We tackled it by using data from Akatsuki. Prior to that, we revisited the meridional circulation by using past observational data: downward solar flux from entry probe and satellite-based radiation observation. With a very simple assumption, we obtained a meridional circulation consistent with the earlier studies based on radiative transfer computation. The result allowed us to order-estimate the eddy angular-momentum forcing needed to maintain the present super-rotation. We derived the eddy forcing by using cloud-tracking winds and thermal infrared data from Akatsuki. In particular, we focused on the pivotal question on the maintenance of the presentation, which is how the angular momentum (per unit mass) is supplied at its peak around the equatorial cloud top to compensate the deceleration by the meridional circulation. It was revealed that the thermal tides provide it, acting to accelerate the super-rotation, through both the horizontal and the vertical angular-momentum transport. Other waves and large-scale horizontal turbulence are found to counteract it to a weaker degree, in contrast to the earlier expectation from the classical Gierasch-Rossow-Williams mechanism. This study provided a number of by-products, such as the detection of turbulent motion and spectra of wind disturbances.

This study was published recently as Horinouchi et al. 2020, Science, 368 (6489), 405-409 and its online supplementary material.