Road to the first star : Venus orbiter from Japan (37)
-- Akatsuki to complete the puzzle of the deeper winds of Venus --

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Abstract: Winds at the lower-cloud levels of Venus and their variation were revealed by IR2 onboard Akatsuki.

Venus is a planet permanently covered by clouds whose velocity can reach more than 360 km/h, implying that they can circle the planet in just 4 days. This is surprising since, unlike the Earth that rotates with a period of 1 day, the planet Venus rotates much slower than its own atmosphere with a period of 243 days. The fact that the atmosphere of Venus can “super-rotate” sixty times faster than the solid surface is one of the most famous mysteries of our Solar System, and discovering the mechanism is the main challenge of JAXA’s Akatsuki mission.

For this purpose, the Akatsuki spacecraft is equipped with four cameras that can observe the motions of the clouds at several altitudes in the Venusian atmosphere. Using the sunlight reflected and absorbed by the clouds, the motions of the upper clouds of Venus (located at altitudes higher than 60 km) have been studied for nearly a century. Unfortunately, photons of the sunlight do not easily penetrate down to the deeper clouds, so the winds at these lower-cloud levels were a long-time mystery until several descending probes performed direct measurements of the wind at the end of the 1970s, and when Allen & Crawford discovered in the 1980s that these deep clouds could be observed on the nightside using some atmospheric “windows” where some part of the infrared radiation from the surface can escape through the lower clouds. Precisely, one of the cameras onboard Akatsuki, the IR2 camera, can observe the lower clouds of Venus taking images of the night side at these infrared windows, and it enabled to visualize these clouds with unprecedented detail during the year 2016 (Figure 1). Now, a work published in *Astrophysical Journal Supplement Series* [1] presents one of the most detailed survey ever made for the deeper winds of Venus, publishing thousands of measurements, as well hundreds of images and animations. This work has been undertaken by an international team composed by the Japan Aerospace Exploration Agency (JAXA), the Universities of Tokyo, Hokkaido, the Basque Country (UPV/EHU), Kyoto Sangyo, Colorado Boulder, Wisconsin-Madison and Shiga Prefecture, the School of Physical Sciences of Sokendai, and the Institutes of Astrophysics and Space Sciences of Portugal, Southwest

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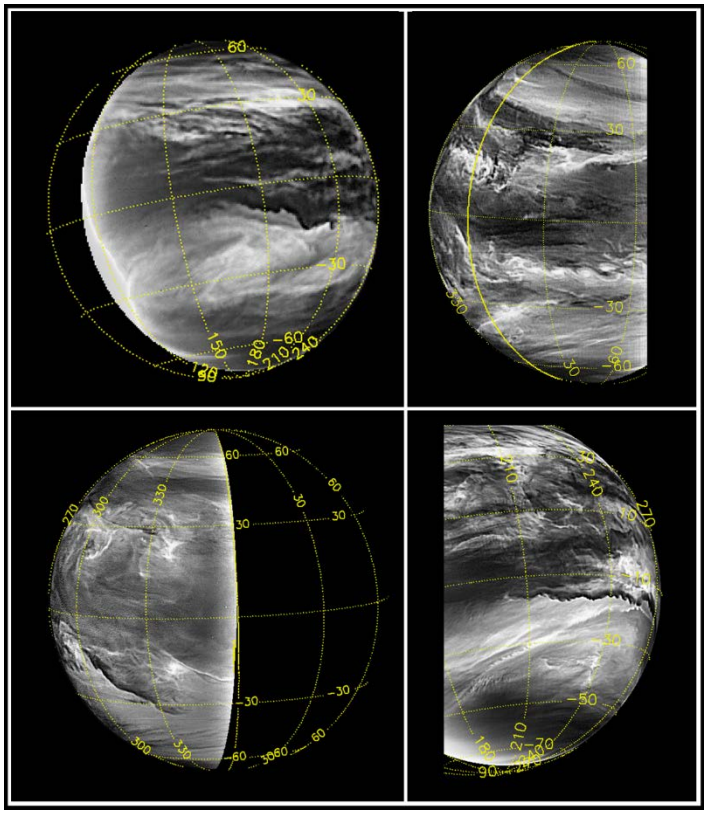

Figure 1. The varied morphologies of the deeper clouds on the night side of Venus as shown in 2.26-μm images from the camera IR2 on board Akatsuki. (Based on [1])

Thanks to previous findings of stationary waves at the upper clouds with Akatsuki and Venus Express missions, we know now that the surface of Venus plays a fundamental role in the atmospheric circulation of Venus, and the deeper clouds of Venus may give us a clue to understand the mechanism of the super-rotation. Our new results not only confirm that the equatorial jets discovered with Akatsuki [2] are a recurrent phenomenon at the deeper clouds, but also that the surprisingly variable cloud morphology is definitely associated to variations in the winds (Figure 2). Such variations may determine the shapes of the deeper clouds, and even affect the clouds' transparency to the thermal radiation escaping from the warmer surface.

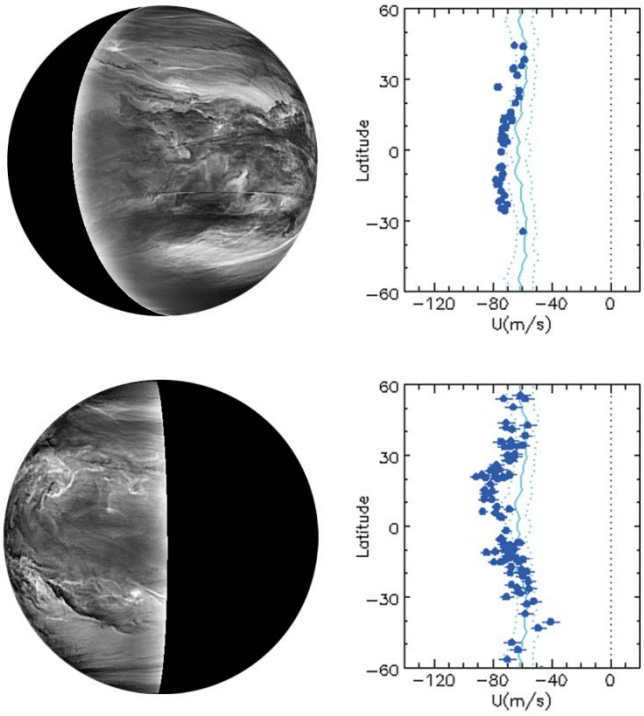

Figure 2. Examples of how different patterns on the night side lower clouds seem to be associated to changes in the profile of East-West winds. (Based on [1])

Controversy arises when discussing about the influence of the surface over the deeper clouds and their winds. While at about 70 km of altitude, the upper clouds exhibit abundant stationary waves and wind perturbation apparently caused by surface elevations, no stationary wave can be found between 50–60 km where the deeper clouds are. For the moment, Akatsuki show inconclusive results relative to an influence of the surface over the winds. Nevertheless, the deeper winds on the night side seem to be affected by the solar tides, a crucial fact missed during the past Venus Express mission.

Also, taking advantage of wide set of wind results acquired during decades with ground-based telescopes, in-situ probes and so on, they were combined with the winds from Akatsuki and new measurements from the Telescopio Nazionale Galileo (TNG/NICS) in Spain and NASA's Infrared Telescope Facility (IRTF/SpeX) in Hawaii, to study the decadal behaviour of the deep winds of Venus for the first time (Figure 3). As a result, we discovered that the winds at the lower clouds seem to have oscillated in up to 30 m/s between 1978 and 2017. This might indicate an interaction (torque) between the surface and the atmospheric circulation after all since the period of rotation of the Venus globe has been reported to vary along time too.

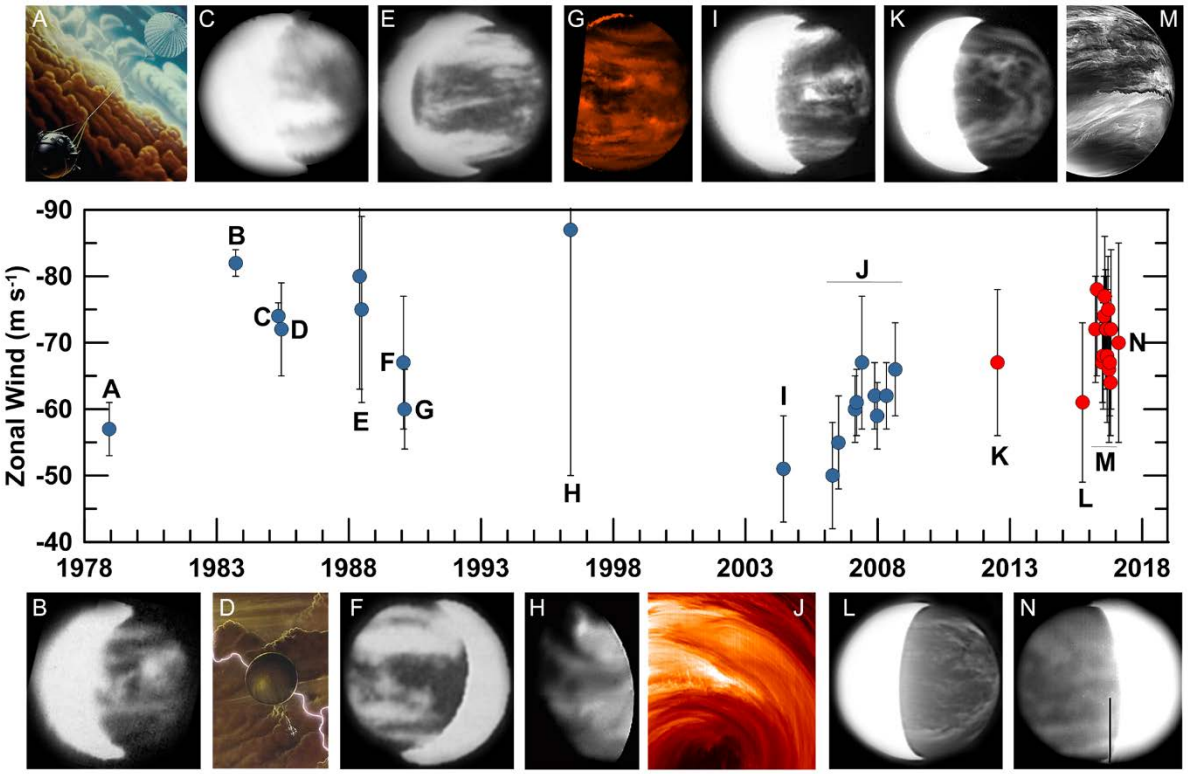

Figure 3. Behaviour of the deep winds of Venus along several decades. Blue dots represent winds from past publications, while red dots are new wind measurements. CREDITS: JAXA, ESA and NASA. (Taken from [1])

Reference

[1] Peralta, J. et al., 2018, Astrophys. J. Suppl. Ser. 239, 29.

[2] Horinouchi, T. et al., 2017, Nature Geo. 10, 646.