A possible explanation for varying measurements of Venus's rotation rate

June 20 2018, by Bob Yirka

Credit: CC0 Public Domain

A trio of researchers with the University of California and Sorbonne Universités has found a possible explanation for why Venus probes have found different day lengths for the planet. In their paper published in the journal *Nature Geoscience*, T. Navarro, G. Schubert and S. Lebonnois describe a theory they have developed based on observational data.

Measurements of the rotation speed of Venus have varied over the years for unknown reasons. It is known that it takes 243 Earth days for the planet to spin just once, but exact measurements have varied by an average of seven minutes. Prior research has also shown that the atmosphere circulates around the planet much faster—getting all the way around in just four Earth days. In this new effort, the researchers suggest they might have found at least one of the characteristics causing the planet to spin at variable speeds, and it has to do with atmospheric circulation.

The researchers started with a long-standing wave that has been observed in Venus's cloud formations—a wave approximately 10,000 kilometers long. They noted that similar waves have been seen on Earth, due to air colliding with mountains, but those typically dissipate rapidly due to air currents. But the atmosphere on Venus is notably thicker than on Earth, an observation that intrigued the researchers. They created a simulation to recreate the cloud formations seen on Venus and introduced the idea of mountains on the surface as the cause. After adding in all known ingredients in Venus's atmosphere and accounting for the planet's size and density, they finished by adding mountains on the surface. They then ran the simulation.

The researchers report that the simulation did show a wave formed in the cloud tops, similar to that seen on the actual planet. But they also found that the braking effect caused by the atmosphere running into the mountains actually slowed the spin of the planet—the amount depended on the time of day. They found that on average, though, the effect was enough to cause up to two minutes of variation in planet spin speed—not enough to account for the observed seven minutes of variability, but enough to suggest other physical features could be playing a similar role.

More information: T. Navarro et al. Atmospheric mountain wave generation on Venus and its influence on the solid planet's rotation rate, *Nature Geoscience* (2018). DOI: 10.1038/s41561-018-0157-x

Abstract
The Akatsuki spacecraft observed a 10,000-km-long meridional structure at the top of the cloud deck of Venus that appeared stationary with respect to the surface and was interpreted as a gravity wave. Additionally, over four Venus solar days of observations, other such waves were observed to appear in the afternoon over equatorial highland regions. This indicates a direct influence of the solid planet on the whole Venusian atmosphere despite dissimilar rotation rates of 243 and 4 days, respectively. How such gravity waves might be generated on Venus is not understood. Here, we use general circulation model simulations of the Venusian atmosphere to show that the observations are consistent with stationary gravity waves over topographic highs—or mountain waves—that are generated in the afternoon in equatorial regions by the diurnal cycle of near-surface atmospheric stability. We find that these mountain waves substantially contribute to the total atmospheric torque that acts on the planet's surface. We estimate that mountain waves, along with the thermal tide and baroclinic waves, can produce a change in the rotation rate of the solid body of about 2 minutes per solar day. This interplay between the solid planet and atmosphere may explain some of the difference in rotation rates (equivalent to a change in the length of day of about 7 minutes) measured by spacecraft over the past 40 years.