

Astronomers discover spectacular increase in the deuterium to hydrogen ratio in Venus's atmosphere

August 20 2024

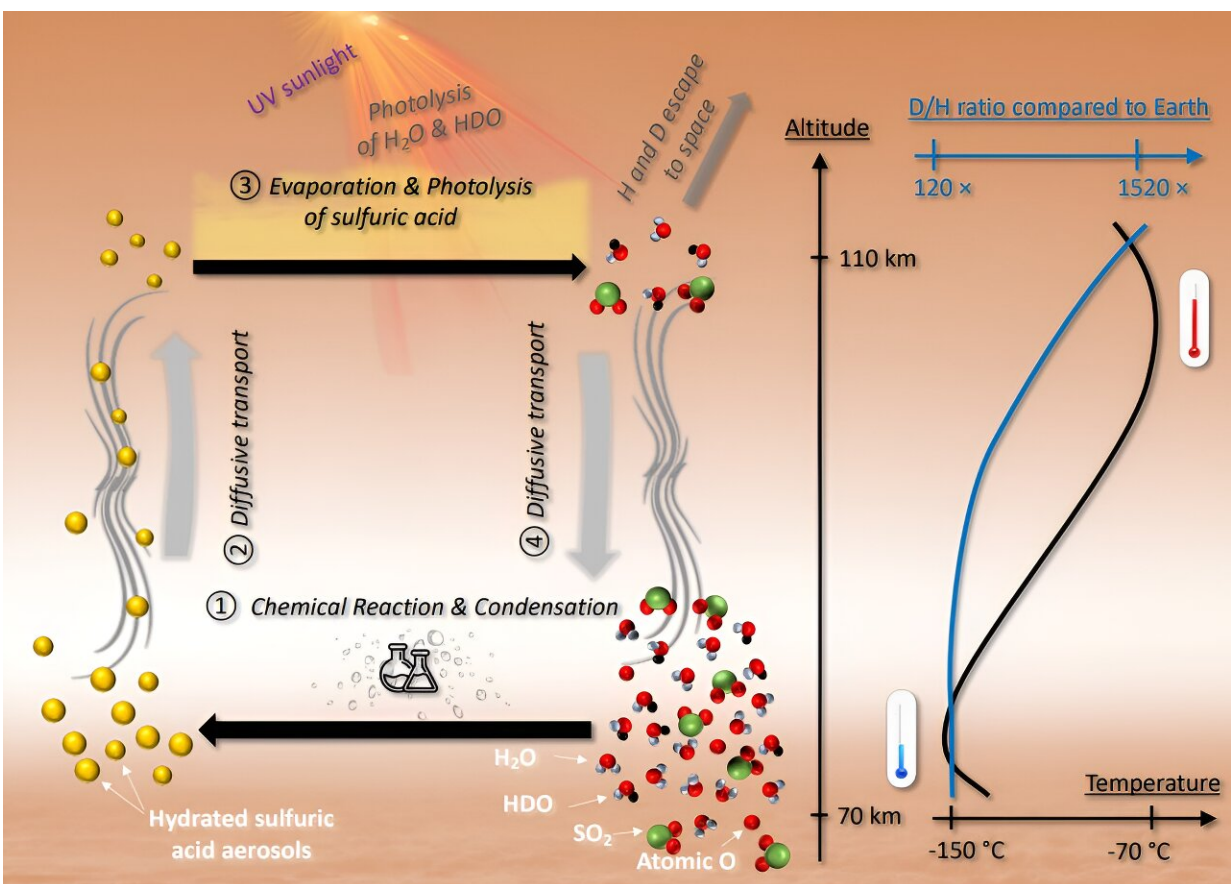


Diagram of the proposed Venus mesospheric water cycle mechanism to sustain the observed HDO and H₂O VMR and HDO/H₂O ratio increase with altitude.

Credit: *Proceedings of the National Academy of Sciences* (2024). DOI: 10.1073/pnas.2401638121

Thanks to observations by the Solar Occultation in the Infrared (SOIR) instrument on the Venus Express space probe of the European Space Agency (ESA), researchers have discovered an unexpected increase in the abundances of two water molecule variants—H₂O and HDO—and their ratio HDO/H₂O in Venus's mesosphere.

This phenomenon challenges our understanding of Venus's water history and the potential that it was once habitable in the past.

Currently, Venus is a dry, hostile planet. It has pressures nearly 100 times higher than those of Earth and temperatures of about 460°C. Its atmosphere, covered by thick clouds of sulfuric acid and [water droplets](#), is extremely dry. Most water is found below and within these cloud layers. However, Venus may have once supported just as much water as Earth.

"Venus is often called Earth's twin due to its similar size," remarks Hiroki Karyu, a researcher at Tohoku University, "Despite the similarities between the two planets, it has evolved differently. Unlike Earth, Venus has extreme surface conditions."

Investigating the abundances of H₂O and its deuterated counterpart HDO (isotopologues) reveals insights into Venus's water history. It is generally accepted that Venus and Earth initially had a similar HDO/H₂O ratio. However, the ratio observed in Venus's bulk atmosphere (below 70 km) is 120 times higher, indicating significant deuterium enrichment over time.

This enrichment is primarily due to [solar radiation](#) breaking down water isotopologues in the [upper atmosphere](#), producing hydrogen (H) and deuterium (D) atoms. Since H atoms escape into space more readily due to their lower mass, the HDO/H₂O ratio gradually increases.

To determine how much H and D are escaping into space, it is crucial to measure the water isotopologue amounts at heights where sunlight can break them down, which occurs above the clouds at altitudes larger than ~70 km.

The study, now [published](#) in the *Proceedings of the National Academy of Sciences*, found two surprising results: The concentrations of H₂O and HDO increase with altitude between 70 and 110 km, and the HDO/H₂O ratio rises significantly by an order of magnitude over this range, reaching levels more than 1,500 times higher than in Earth's oceans.

A proposed mechanism to explain these findings involves the behavior of hydrated sulfuric acid (H₂SO₄) aerosols. These aerosols form just above the clouds, where temperatures drop below the sulfurated water dew point, leading to the formation of deuterium-enriched aerosols.

These particles rise to higher altitudes, where increased temperatures cause them to evaporate, releasing a more significant fraction of HDO compared to H₂O. The vapor is then transported downwards, restarting the cycle.

The study emphasizes two key points. First, variations in altitude play a crucial role in locating the D and H reservoirs. Second, the increased HDO/H₂O ratio ultimately increases deuterium release, impacting long-term evolution of the D/H ratio. These findings encourage the incorporation of altitude-dependent processes into models to make accurate predictions about D/H evolution.

Understanding the evolution of Venus' habitability and water history will help us understand the factors that make a planet become inhabitable, so that we know how to avoid letting the Earth follow in its twin's footsteps.

More information: Arnaud Mahieux et al, Unexpected increase of the

deuterium to hydrogen ratio in the Venus mesosphere, *Proceedings of the National Academy of Sciences* (2024). [DOI: 10.1073/pnas.2401638121](https://doi.org/10.1073/pnas.2401638121)

Provided by Tohoku University

Citation: Astronomers discover spectacular increase in the deuterium to hydrogen ratio in Venus's atmosphere (2024, August 20) retrieved 20 August 2024 from <https://phys.org/news/2024-08-astronomers-spectacular-deuterium-hydrogen-ratio.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.