IVC2019: P17

The global variation of Venus cloud investigated from IR1 onboard AKATSUKI

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1. Introduction

- **Venus** is our nearest neighbor, and has a size very similar to the Earth's. However, previous observations discovered an extremely dense (90 atm at the surface) and CO_2–rich atmosphere, with H_2SO_4 thick clouds (47–70 km). The haze layer on Venus lies above the main cloud surrounding the planet.
- In 1983, near-infrared (1–2.4 μm) windows of the CO_2 atmosphere were discovered [Allen and Crawford, 1984]. These windows allow radiation to penetrate the whole atmosphere and thick clouds.
- **On the dayside,** IR1 visualizes the distribution of clouds illuminated by sunlight. Although the dayside disk at 0.90 μm appears almost flat, small-scale features with contrasts of 3 % are thought to originate in the middle and lower cloud region [Belton et al., 1991](Fig.2, 3).

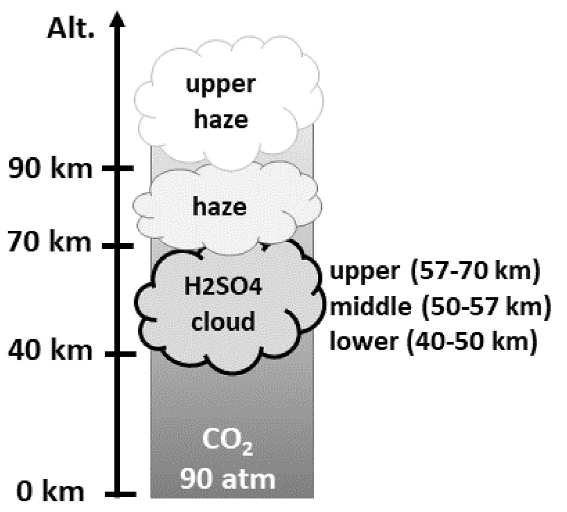


Fig.1 Venus atmosphere and clouds structure.

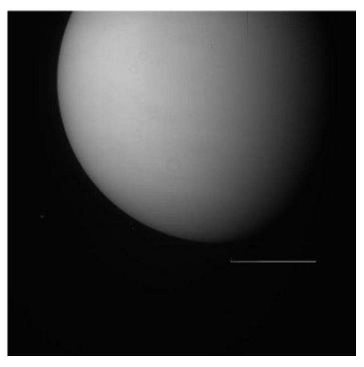


Fig.2 A 0.986 μm Venus dayside image taken by SSI/Galileo (from NASA website).

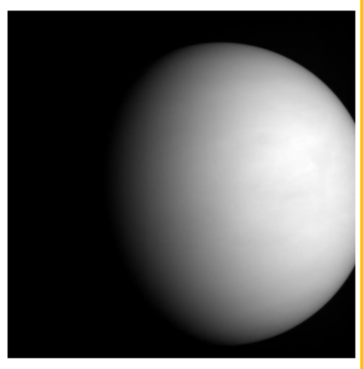


Fig.3 An example of 0.90 μm dayside image taken by IR1 (Dec. 7, 2015).

【Venus cloud model】

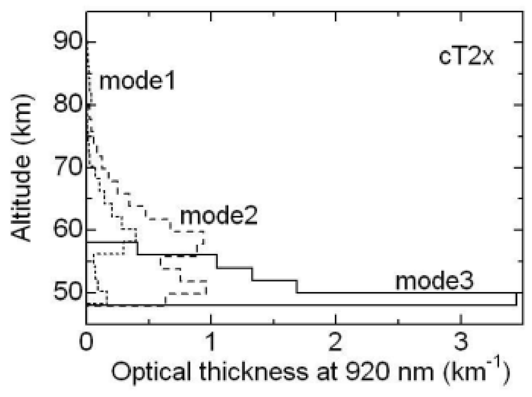


Fig.4 Averaged cloud model from previous entry probes.

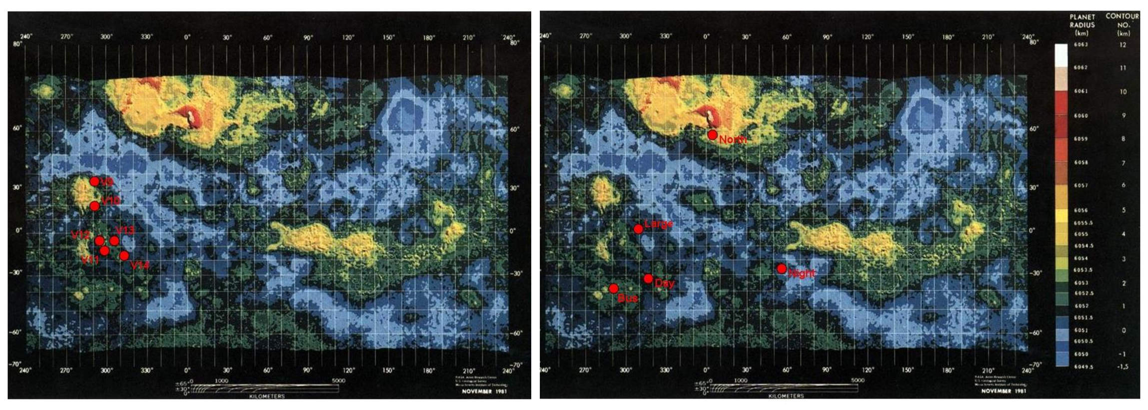


Fig.5 Locations of entry probes landing points of (Left) Veneras (Right) Pioneer Venus.

【Radiative transfer calculation】

- Synthetic spectra were calculated by means of line-by-line method using the HITRAN 2004, HITEMP, VIRA 1985 model.
- Venus dayside spectra in the 0.90 μm region are calculated with various total cloud optical thickness, altitude, and temperature.
- Fig.6 shows an example of calculated brightness B_λ and the transmission of filters T_λ.
- The integrated brightness I may be calculated as

$$I = \int T_\lambda B_\lambda d\lambda$$

where λ is wavelength.

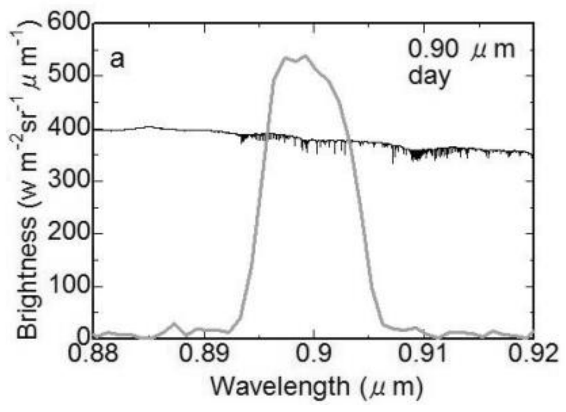


Fig.6 An Example of calculated brightness (thin solid curve) and the transmission profiles of the filter (thick solid curve).

- Fig.7 shows integrated brightness I as a function of the total cloud optical thickness, cloud altitude, and temperature.
- A 50 % increase in the optical thickness is found to cause a 4.1 % increase in brightness, while a 50 % decrease cause a 8.7 % decrease in brightness.
- Fig.7 may be concluded that the source of the 3 % contrast expected in the 0.90 μm image is variation in the cloud optical thickness.

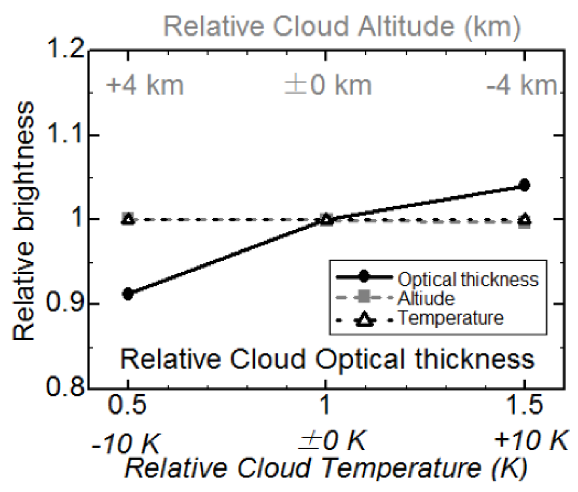
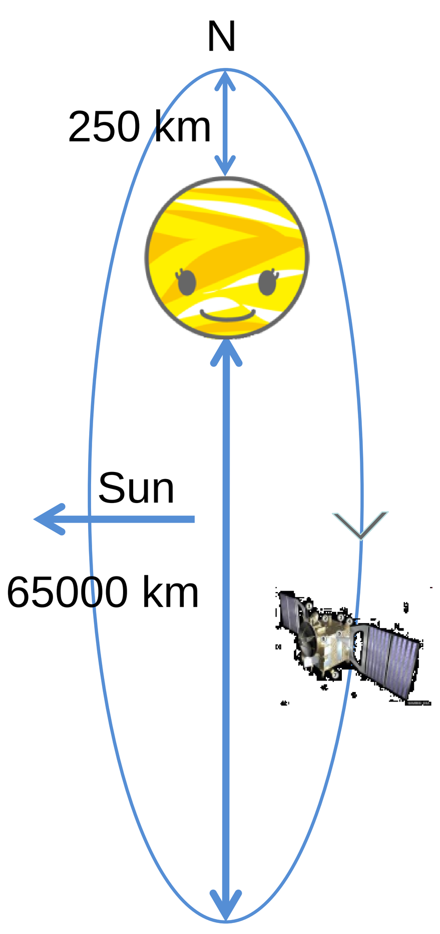
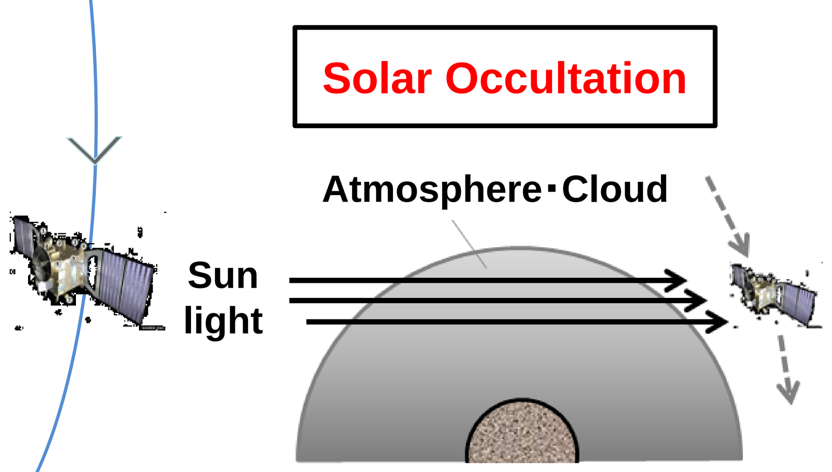


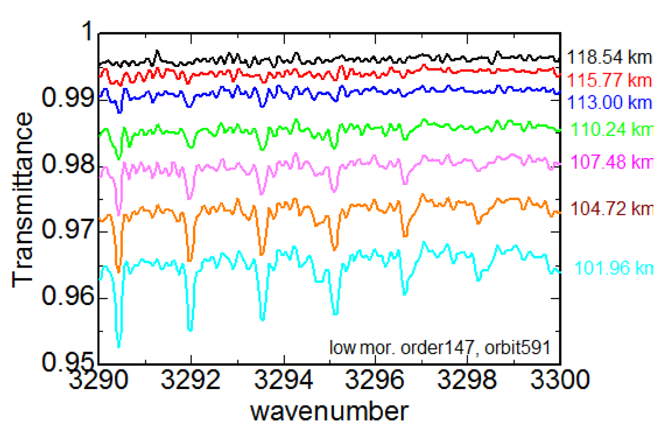
Fig.7 Calculated and normalized 0.90 μm integrated brightness as a function of the normalized cloud total optical thickness(●), altitude(■), and temperature(△).

2. Venus Express/ SOIR



- **S**olar **O**ccultation at **I**nfra**R**ed (**SOIR**)
  - Wavelength: 2.3-4.2 μm
  - Wavelength resolution: 0.06 nm
- Venus atmosphere and haze at high altitude (70-220 km) are observed continually.





- Upper haze exists at altitude above 90 km although it has been recognized so far that the top of the upper haze is 90 km.
- **Extinction** profiles fold at around 95 km.
- Their values at low latitude are larger than those at high latitude.

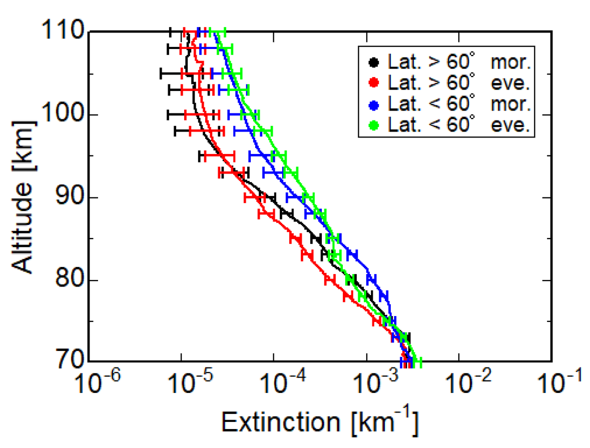


Fig.8 Averaged vertical distribution of extinctions obtained from SOIR [Takagi et al., submitted].

3. Cloud model update

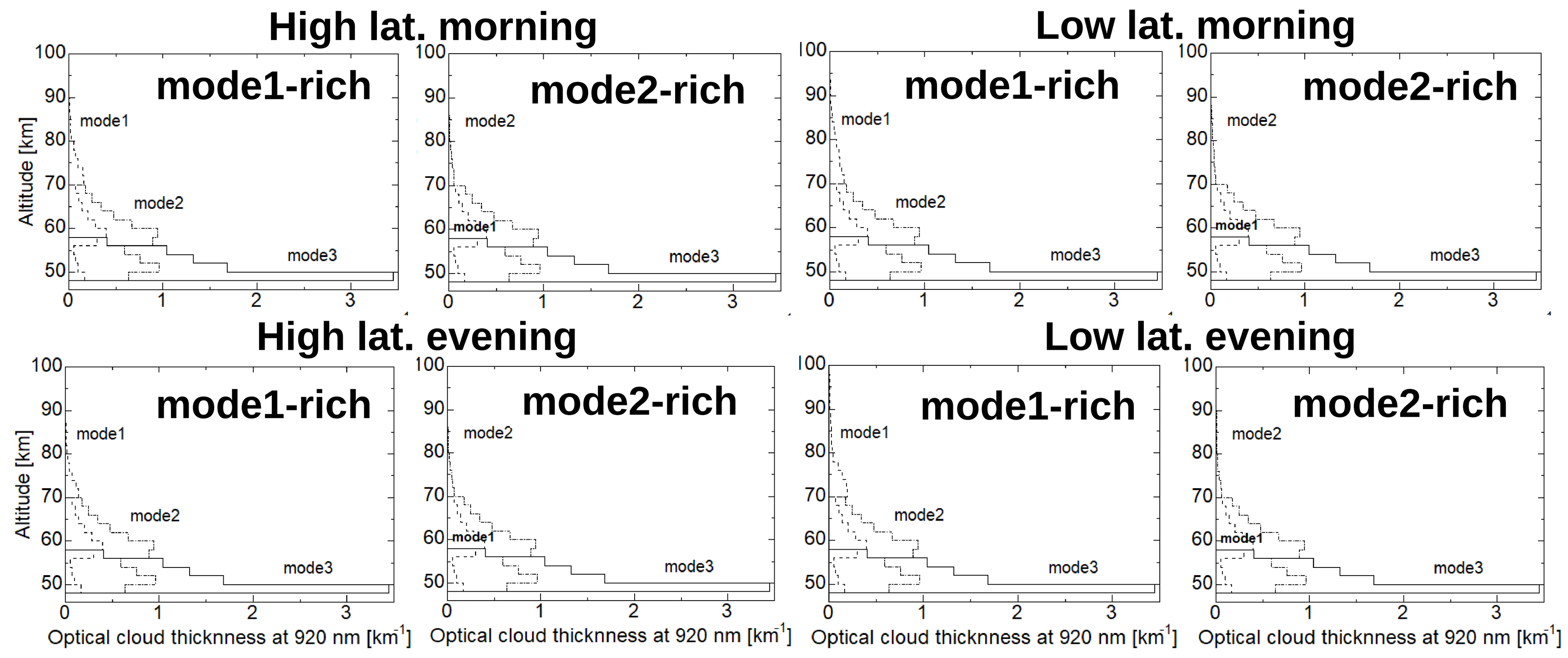


Fig.9 Optical thickness of three cloud layers measured by the entry probes summarized by James et al.(1997) at below 70 km and SOIR observation at above 70 km.

4. Brightness variation

- Fig.10 shows integrated brightness as a function of the total cloud optical thickness.

Tab.1 Brightness variation

Low mor.	mode1-rich	mode2-rich
τ × 0.1	- 35.2 %	- 32.5 %
τ × 0.5	- 9.9 %	- 8.3 %
τ × 2	+ 6.8 %	+ 5.6 %
τ × 5	+ 11.2 %	+ 9.5 %

- In case of mode1-rich cloud at low latitude morning, a 50 % increase in the optical thickness is found to cause a 6.8 % increase in brightness, while a 50 % decrease cause a 9.9 % decrease in brightness.

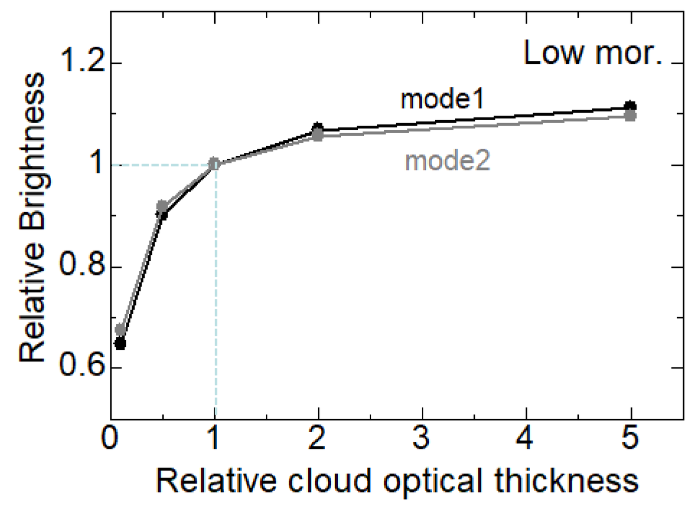
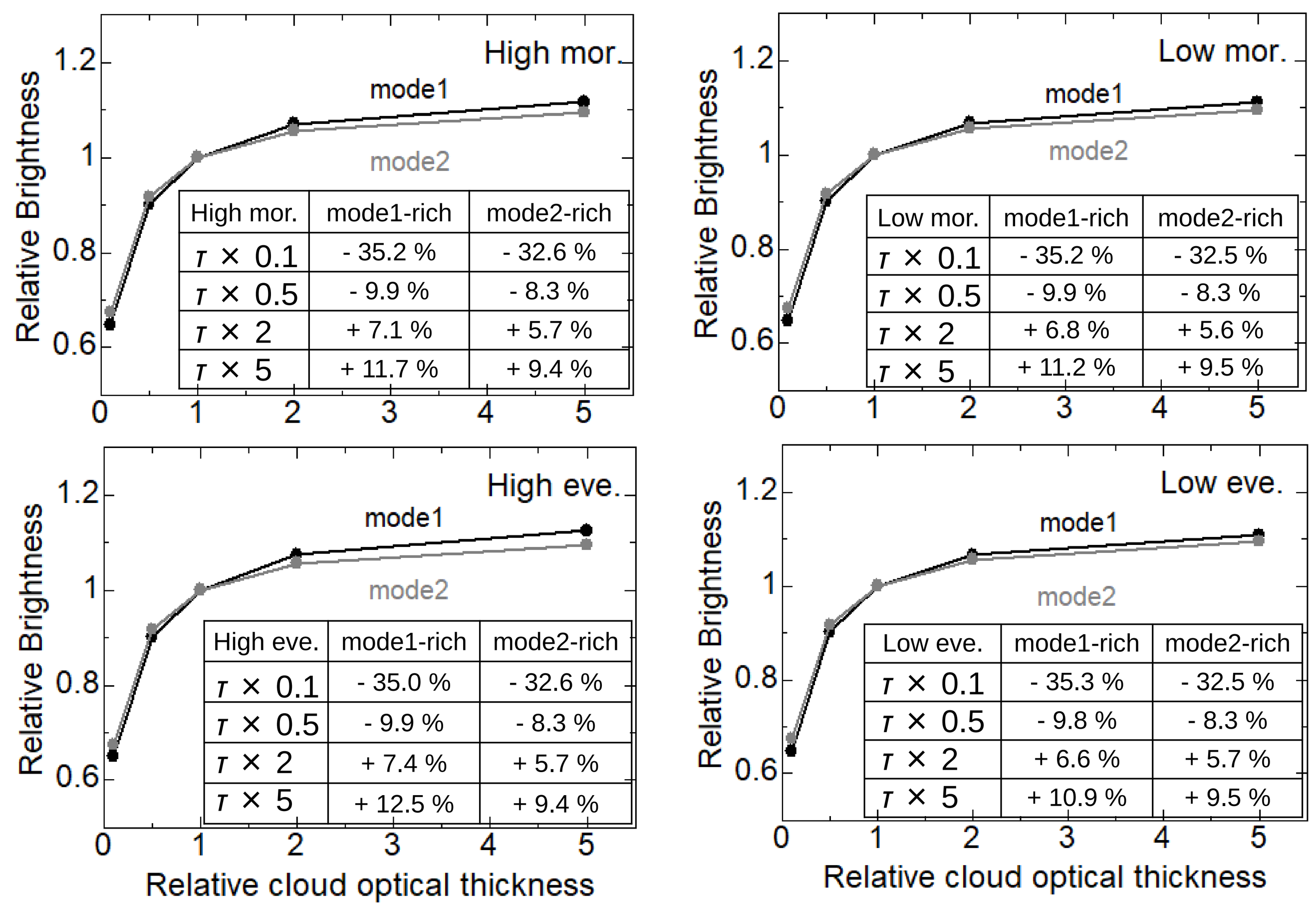


Fig.10 Calculated and normalized 0.90 μm integrated brightness as a function of the normalized total optical thickness.



High mor.	mode1-rich	mode2-rich
τ × 0.1	- 35.2 %	- 32.6 %
τ × 0.5	- 9.9 %	- 8.3 %
τ × 2	+ 7.1 %	+ 5.7 %
τ × 5	+ 11.7 %	+ 9.4 %

Low mor.	mode1-rich	mode2-rich
τ × 0.1	- 35.2 %	- 32.5 %
τ × 0.5	- 9.9 %	- 8.3 %
τ × 2	+ 6.8 %	+ 5.6 %
τ × 5	+ 11.2 %	+ 9.5 %

High eve.	mode1-rich	mode2-rich
τ × 0.1	- 35.0 %	- 32.6 %
τ × 0.5	- 9.9 %	- 8.3 %
τ × 2	+ 7.4 %	+ 5.7 %
τ × 5	+ 12.5 %	+ 9.4 %

Low eve.	mode1-rich	mode2-rich
τ × 0.1	- 35.3 %	- 32.5 %
τ × 0.5	- 9.8 %	- 8.3 %
τ × 2	+ 6.6 %	+ 5.7 %
τ × 5	+ 10.9 %	+ 9.5 %

IR1 (0.9 μm) dayside images

Jun. 17, 2016

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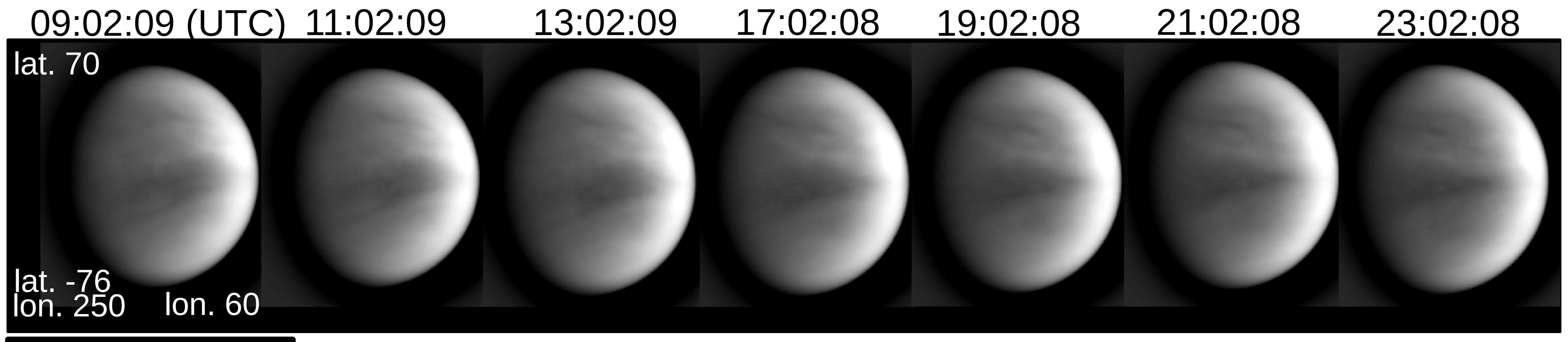

Jun. 18, 2016

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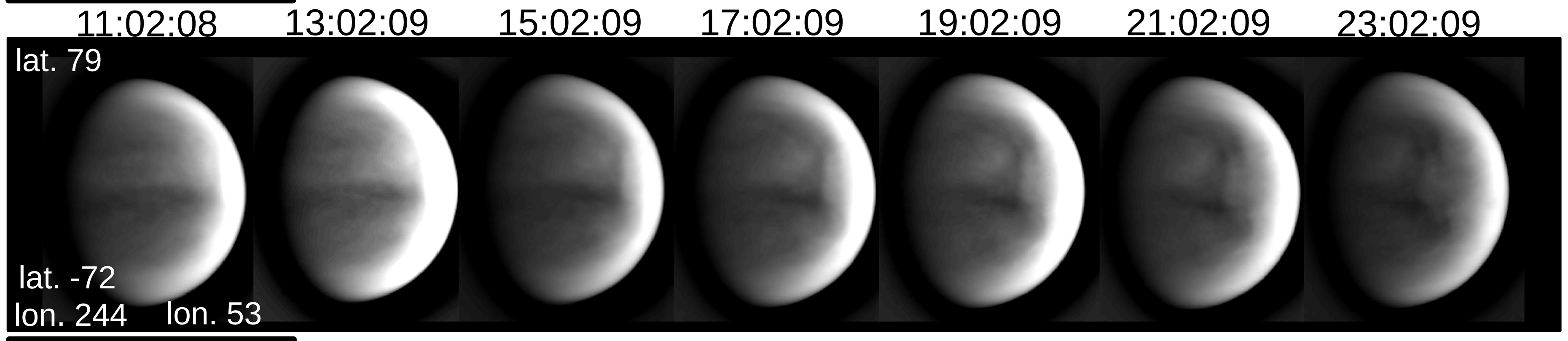

Jun. 23, 2016

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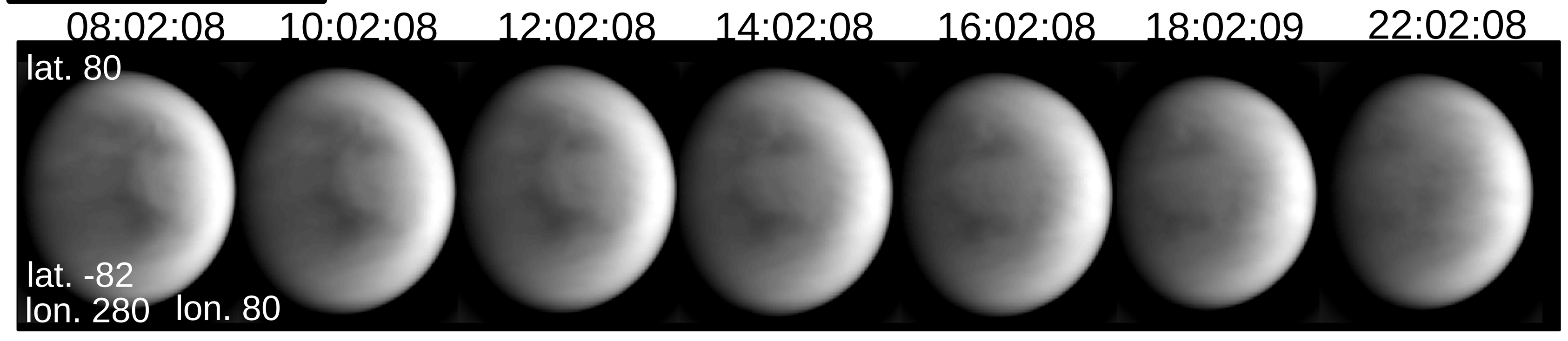

UVI (283 nm) images

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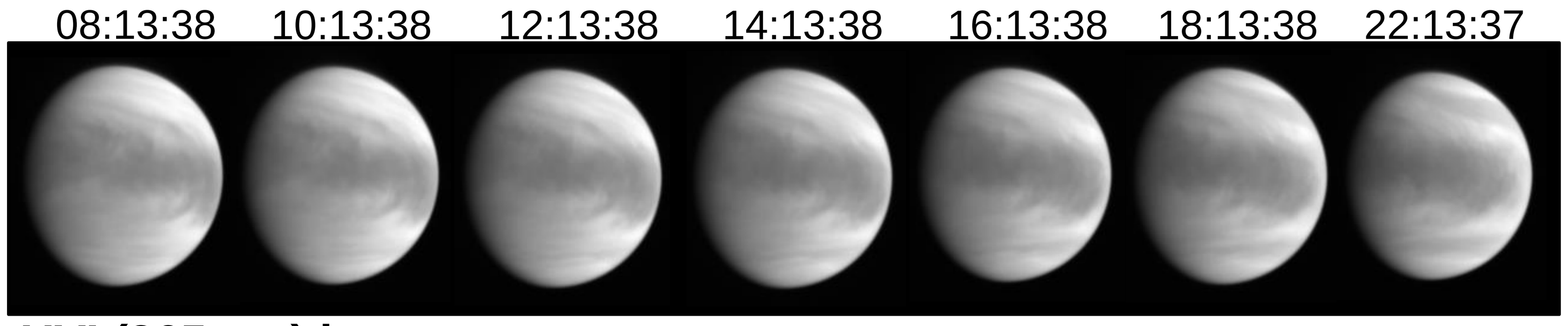

UVI (365 nm) images

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