SGEPSS 2015, Nov. 3, R009-P13

Time and vertical variation of the wave structure in Jupiter's south polar region observed with ground-based telescope

Yuya Gouda; Yukihiro Takahashi; Makoto Watanabe [1]
[1] Hokkaido University

In the Jupiter stratosphere, the polar cup hazes exist in the both hemispheres whose edges show the wave structure. The wave structure, which was discovered by the Voyager. The time variation of the wave structure was captured every one or two years by the Hubble Space Telescope (HST) and the Cassini ISS. [Barrado-Izagirre at al., 2008].

In previous observation with the Hubble Space Telescope (HST) and the Cassini ISS, it has shown that the wavenumber of Jupiter polar wave at 67º S was 12 - 14 and the westward phase velocity in SystemⅢ was 0 - 10 m/s. It is pointed out that this wave is a planetary Rossby wave.

In this paper, we introduce the observational results about the wave structure in Jupiter's polar regions from 2011 to 2015. We succeeded in capturing the wave structure at the edge of polar haze at 67º S with the ground-based telescope for the first time. We show that the time and vertical variation of the wave structure. First, it was possible that another structure affects this wave structure for time variation of wavy amplitude. Second, the wave structure at 889 nm and 727 nm is similar that the sensitivity altitude of 889 nm is near that of 727 nm. The wave structure in the stratosphere wasn't seen in the deep troposphere.

1. Introduction

In the Jupiter polar stratosphere, there is stratospheric haze that formed by scattering aerosol particles (Fig. 1.1). This structure can be seen as bright cap at deep methan absorption band (889 nm), whose edges show a wave structure propagating in the longitudinal direction in latitudinal range of 60º S- 70º S.

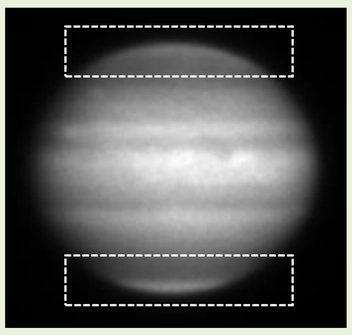

Fig. 1.1 Jupiter image with the Pirka telescope (889 nm)

Observations with the HST and Cassini ISS showed that those wavenumbers were 12 - 14 and westward velocity of the wave structure in SystemⅢ was 0 - 10 m/s [*Barrado-Izagirre et al*., 2008].

In the previous works, the propagation velocity of this wave was shown, but the variance of short time (monthly and weekly) and the wave structure in the vertical direction aren't clear.

<Final goal>

We determine whether or not the wave observed at the edge of the stratospheric haze in polar regions is Rossby wave. We investigate the meridional / vertical wavenumbers and phase speed of the observed wave structure and zonal wind speed.

<Purpose>

In this poster presentation, our purpose is revealing the variation of the wave structure in several days and the vertical variation of the wave structure. Those information relate to restrict the wave structure in the vertical direction and find another structure whose lifetime is shorter.

Therefore, we show the time variation of the wave structure at multiwavelength which include some methan absorption band with the ground-based telescope.

2. Observation

We have observed Jupiter since 2011 with the 1.6 m Pirka telescope and Multi-Spectral Imager (MSI). We can obtain images at multiwavelength (infrared and visible wavelength regions) with a short time exposure, which enables a high spacial resolution. (longitude of 5º at 67º S in the best)

< Spec. of MSI >

Minimum exposure time (Full frame, EM-CCD mode)		31 ms
LCTF VIS-10		400- 720 nm
	Bandwidth	5- 19 nm
LCTF SNIR-10		650- 1100 nm
	Bandwidth	5- 15 nm

Fig. 2 The 1.6 m Pirka telescope and Multi-Spectral Imager (MSI)

<Observational data>

Date	Jupiter angular diameter (arcsec)	Seeing size (arcsec)	Wavelength (nm)	Exposure time (ms) × Number of images
Oct. 19 2011	49.5	2.0- 2.6	727, 750, 889	500 ms × 200
Oct. 29 2011	49.6	1.6- 2.0	727, 750, 889	30 ms × 1000
Nov. 16 2011	48.8	2.3- 2.7	727, 750, 889	30 ms × 1000
Mar. 27 2014	38.8	1.8- 2.0	619, 727, 750, 889	30 ms × 1000
Apr. 8 2015	40.6	2.0- 2.2	889	11 ms × 3000 30 ms × 1000
Apr. 9 2015	40.4	1.8- 2.2	619, 727, 750, 889	
Apr. 13 2015	39.9	1.8- 2.2	619, 727, 750, 889	

3. Analysis

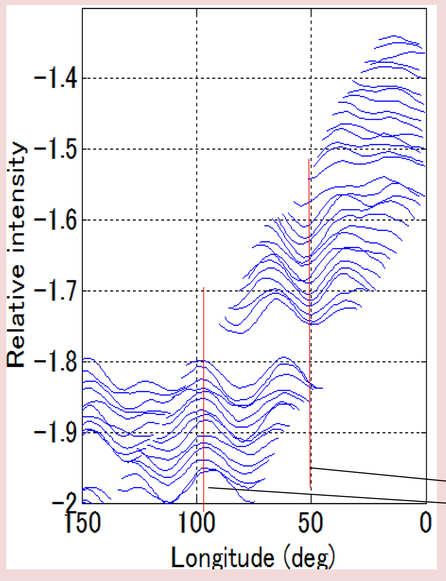

Fig. 3 The polar waves

We produce Jupiter images by composite of the serial of short exposure frames for reducing atmosphere turbulence. Number of Jupiter images to make composite images that was decided by more than SN~300.

We plotted the brightness of Jupiter image observed by the Pirka telescope at 67º S. Fig. 3 is the polar waves, which were taken per between 5 and 15 minutes.

We can see the positive or negative peaks at the same longitude.

We can observe the wave structure at 67º S whose wavenumber is 12.

4. Results & Discussion <Time variation>

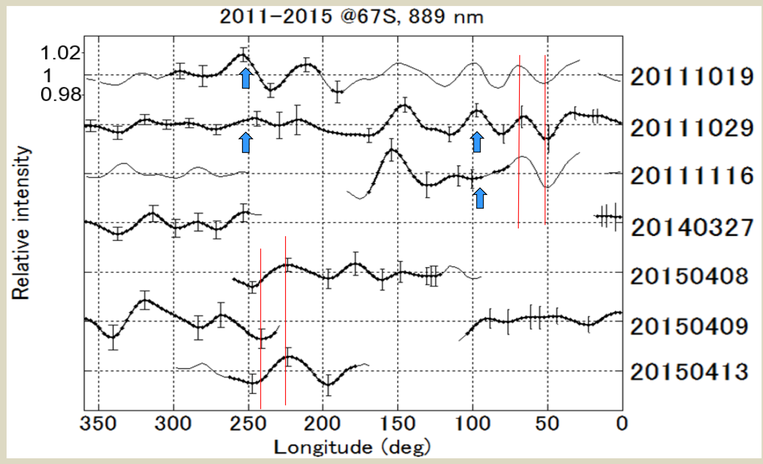

Fig. 4.1 Time variation of the wave structure

The positive and negative peaks didn't move in longitude.(red lines in Fig. 4.1)

In 2011, there was variation of the wavy amplitude seen in some specific longitudes (blue arrows in Fig. 4.1).

It was possible that another structure whose size is less than longitude of 15 degree (The half wavelength of wave number of 12) affect this wave structure.

<Vertical variation>

We get the wave structure at three or four wavelengths each observational days and calculate the cross-correlation function of the wave structure at each wavelength.

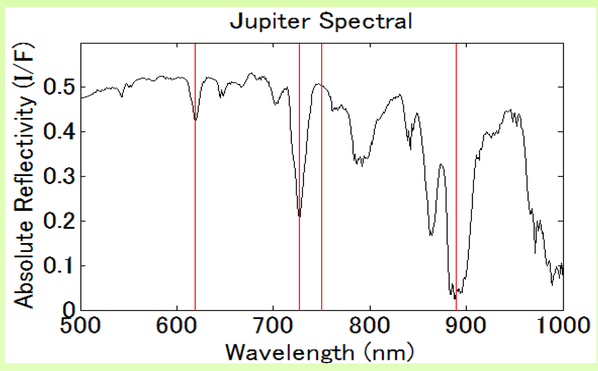

Fig. 4.2 Jupiter Spectrum by the European Southern Observatory [Karkoschka, 1994]

We can get information of Jovian cloud and haze in the different altitude using observation at wavelengths that absorption by methan are different.

Four red lines in Fig. 4.2 are some methan absorption band (889 nm, 727 nm, 619 nm) and a continuum (750 nm).

In decreasing order of the sensitive altitude is 889 nm, 727 nm, 619 nm, 750 nm.

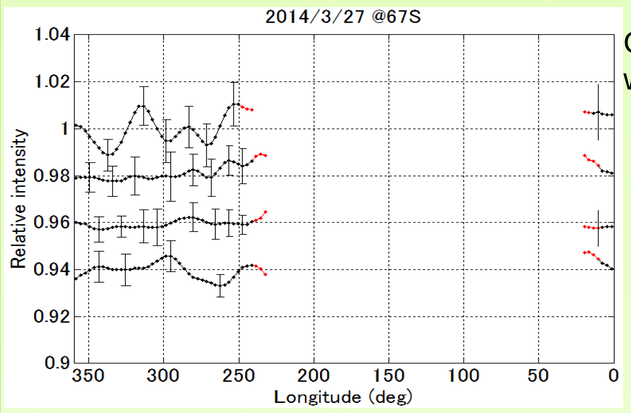

Fig. 4.3 Vertical variation of the wave structure on Mar. 27th, 2014

Observational wavelength	Sensitivity altitude
889 nm	→ 361 mbar: tropopause
727 nm	
619 nm	Lower altitude
750 nm	→ 750 mbar: deep troposphere

<The cross-correlation coefficient>

Wavelength (nm)	2011/ 10/19	2011/ 10/29	2011/ 11/16	2014/ 03/27	2015/ 04/09	2015/ 04/13	
889 & 727	0.346	0.662	0.714	0.638	0.576	0.707	→ high correlation
727 & 619				0.398	0.159	0.137	
619 & 750				-0.338	0.536	0.496	
889 & 619				0.063	0.069	0.302	
889 & 750	0.178	0.068	-0.128	0.061	0.393	0.560	
727 & 750	0.098	0.661	-0.067	0.136	0.593	0.324	→ large variation

A high correlation with 889 nm and 727 nm reflects that the sensitivity altitude of 889 nm is nearer that of 727 nm than other observational wavelength.

The cross-correlation coefficient of 750 nm and another wavelength has a large variation. Especially 727 nm sometimes has a relativity high correlation with 750 nm. The wave structure in the stratosphere wasn't seen in the deep troposphere.

5. Conclusions & Future Work

We investigate the wave behavior at the polar regions between 2011 and 2015. It becomes clear that (1) The variation of wavy amplitude was found within ten days. It was possible that another structure affect this wave structure. (2) The wave structure at 889 nm and 727 nm are usually similar. This structure wasn't seen in the deep troposphere.

In the future work, we will analysis meridional variation of Jupiter and restrict the wave structure at 67º S in meridional direction.

< Reference >

・Sanchez-Lavega, A., and R. Hueso (1998), A system of circumpolar waves in Jupiter's stratosphere, *Geophysical Research Letters*, 25, 4043-4046.
・N. Barrado-Izagirre, A. Sanchez-Lavega, S. Perez-Hoyos, R. Hueso (2008), Jupiter's polar clouds and waves from Cassini and HST images: 1993-2006, *Icarus*, 194, 173-185.
・Watanabe, M., Y. Takahashi, M. Sato, S. Watanabe, T. Fukuhara, K. Hamamoto, A. Ozaki (2012), MSI: visible multi-spectral imager for 1.6-m telescope of Hokkaido University, *SPIE*, 8446, 84462O-84462O-10.
・ N. Barrado-Izagirre, J. F. Rojas, R. Hueso, A. Sánchez-Lavega, F. Colas, J. L. Dauvergne, D. Peach, and the IOPW Team (2013) - Jupiter's zonal winds and their variability studied with small-size telescopes
・Li, Liming et al .,(2006), Waves in Jupiter's atmosphere observed by the Cassini ISS and CIRS instruments, *Icarus*, 185, 416- 429.
・Erich Karkoschka (1994), Spectrophotometry of the Jovian Planets and Titan at 300- to 1000-nm Wavelength: The Methane Spectrum, *Icarus*, 111, 174-192.