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Winds and cloud structure on Jupiter's 2009 South Equatorial Belt Fade.

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Abstract

Jupiter's South Equatorial Belt (SEB) is known to suffer global albedo changes with a not well defined period [1]. The transition from a "belt-like" aspect (low albedo at visible wavelengths) to a "zone-like" (bright albedo) is known as a "Fade". During 2009 the SEB suffered a fading process and became completely transformed to a zone by the first observations in 2010. In this work, we study the winds and the vertical cloud structure during the fade process at visual wavelengths from Hubble Space Telescope (HST) and International Outer Planet Watch ((IOPW) images.

1. Observations

We used WFCP2 and WFC3 HST images from 2008 to 2010 to retrieve the absolute reflectivity change of the SEB from a belt to a fade stage (SEBF), in the wavelength range from the near ultraviolet to the near infrared including the methane absorption band at 890 nm. High-quality amateur observations from the IOPW database with a long-term temporal coverage were used to measure winds and study the changes in the morphology of the SEB.

2. Brightness evolution

The evolution of the 2009 SEB phenomenon does not differ too much from previously observed ones [1]. However, the albedo variability depends on the wavelength selected as shown in Figure 1. Those maps have been composed using the techniques explained in [2]. Complementary, blue and methane observations have been compared morphologically.

With respect to the brightness evolution, this work complements what is been shown recently in the infrared radiation [3]. Whereas the near infrared filters at around ~ 930 nm and deep-penetrating continuum filters at ~ 630 nm show the reflectivity change beginning as soon as July 2009, no brightening was found at shorter wavelengths (225 – 300 nm) before 2010. This indicates an upward propagation of the perturbation. Indeed, the methane band filter shows no reflectivity change above its error bars (< 0.01 in reflectivity).

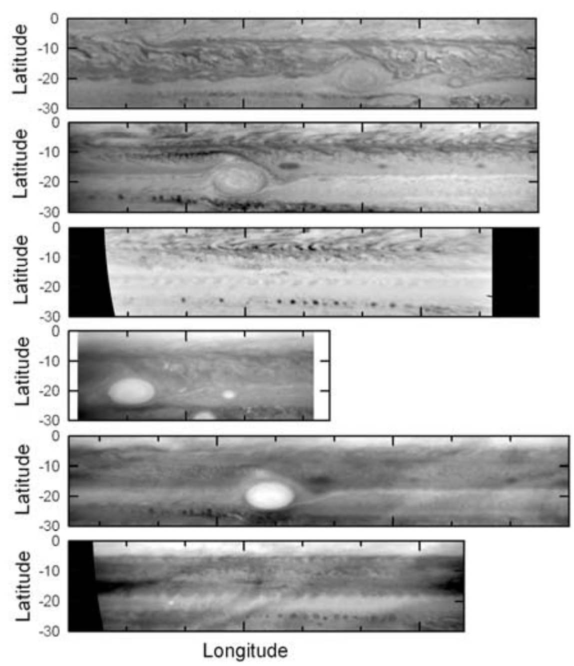

Figure 1: *From top to bottom, cylindrical map projections at 950 nm (2008/2009/2010) and 890 nm.*

3. Wind profile

We have measured the zonal winds before and during the Fade to see if there is a dynamical change accompanying the albedo change. Some of the best images from the IOPW database were used due to the very high temporal coverage although paying for spatial resolution. Cloud tracking of the features was performed on image pairs separated by few Jovian rotations when resolution is good, and on image series along several days for the general case. A third method for wind measurements is based on the correlation of brightness scans at the same latitude in two images close in time [4]. Figure 2 compares our measurements during the Fade with those in previous years when the SEB had a belt aspect. No large changes are observed in the wind profile during both stages.

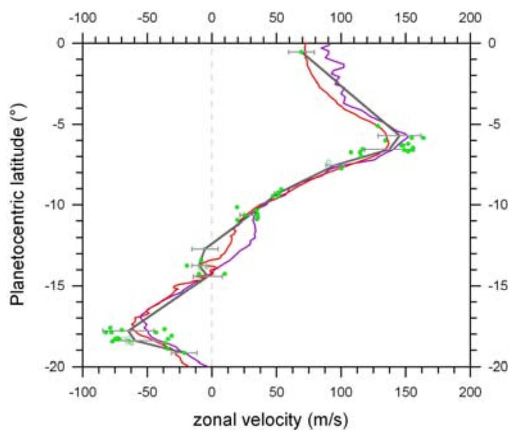

Figure 2: *Red line represents the 2000 Cassini's wind profile [5] and purple line represents the 1995-2000 HST [4] profile. Green circles are our measurements for the SEB period using different methods.*

4. Vertical cloud structure

The geometrical and wavelength dependence of the reflectivity as a function of wavelength was modeled by means of a radiative transfer code to retrieve the accompanying changes in the SEB vertical cloud structure during the event. Our results during the SEBF point out a substantial increase in the cloud density at the ammonia condensation level together with changes in the absorption of the particles located above it.

We calculate a particle optical thickness below the 1 bar level to be about 5 before the Fade and it becomes completely thick $\tau \geq 100$ in the visible wavelengths, in good agreement with infrared results [3].

On the other hand, the particles albedo became much more reflecting in 2010 than in 2009 probably supporting the evidence of an upward injection of fresh ammonia particles. For example, the imaginary refractive index changes from -10^{-3} in 2009 to -5×10^{-4} in 2010 at blue wavelengths.

Finally, a thin layer formed by small white particles at around the tropopause level seems to be required to fit all 2010 observations simultaneously, which again is in good agreement with an upward relatively slow diffusion in which the smaller the particles, the higher they can get into the troposphere.

5. Summary and Conclusions

According to the previous results, the albedo change observed in the SEB at most wavelengths in the visible range is not accompanied by a substantial dynamical change in the zonal wind at the upper cloud level. This is in agreement with previous apparent changes in Jupiter's atmosphere.

On the other hand, the long time scales associated to the SEBF brightness change as sensed at different wavelengths is consistent with a diffusive process of fresh particles (possibly ammonia) slowly shifted upwards from below the 3 bar level [3].

Acknowledgements

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