Jupiter's South Equatorial Jet: Speed variations with and without the South Equatorial Disturbance

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Abstract

Amateur observers are now producing frequent high-quality images of Jupiter to give a near-continuous record of its weather systems, with sufficient resolution to record zonal wind profiles in many regions.

As an example of the level of detail now obtainable from amateur imaging and analysis, we show recent results on the diverse speeds within the jet at 7ºS (SEBn), and their modulation by the South Equatorial Disturbance (SED). The SED is a large-scale wave in the jet [ref.1]. From analysis of amateur images, we have previously shown that there are substantial longitudinal variations in the peak speed, as traced by the motions of the small chevron-shaped features on the SEBn edge [ref.2]. When the SED is present and conspicuous, the speed of the jet is markedly reduced east of the SED and sometimes, to a variable extent, at all longitudes. When the SED is absent or inconspicuous, the maximum jet speed is observed all around the planet, but some individual features move more slowly over shorter intervals.

Here we present new data which confirms these phenomena at higher resolution and provides some insight into the underlying dynamics. In 2008, the SED was prominent, and the speed gradient to its east was clearly demonstrated by numerous chevrons; many of them were seen to accelerate. In 2010, the SED disappeared as the SEB whitened, and the alternative regime was observed: there were long-lived bands of disturbance moving with the peak jet speed, and many individual spots moving with the same speed, but many others were moving more slowly. Characteristics of the slower spots suggested that they were partially detached from the regular array of chevrons in the jet peak.

1. Introduction

Amateur programmes have systematically tracked atmospheric features on Jupiter for over 120 years, initially using visual observations, and now using hi-res imaging and digital measurement and analysis. Images are taken on every possible night by numerous amateur observers around the world, often with resolution better than 1º on the planet. Measurements of cloud features are done by the JUPOS project. For the 2010 apparition, >100,000 measurements were entered into the JUPOS database.

The improved resolution in recent years has allowed us sometimes to measure the peak speeds of the fastest jets, which agree with the speeds determined by spacecraft imaging. We also detect temporal and longitudinal variations in the jets. This is the case with the three super-fast prograde jets, at 7ºS (SEBn) [ref.2], 7ºN (NEBs), and 24ºN (NTBs), and the single rapid retrograde jet, at 20ºS (SEBs) [*see abstract for session GP1*]. In each case, there are sometimes two or more speeds visible simultaneously at cloud-top level. These could represent wave patterns with different phase speeds, and/or could represent disturbances arising at different depths.

Here we present results on the SEBn jet, which characterize these speed variations with higher spatial and temporal resolution than in previous years.

2. Methods

This work depends on images from numerous observers, whose names are posted on the BAA web site: <http://www.britastro.org/jupiter/reports.htm>
Images are taken with a variety of telescopes, mostly with apertures 20-40 cm, using webcams to record hundreds of images within 1-2 minutes. They are processed with software such as Registax:
<http://www.astronomie.be/registax/>
which selects and aligns the best frames and excludes those taken in poorer seeing. Further processing is done to enhance small-scale detail and contrast.
Measurements of ‘spots’ are done on-screen using the WinJUPOS program (created by G. Hahn & H-J.M.): <http://jupos.org>. Data are then selected by latitude, plotted as longitude-vs-time charts, and further analysed in Microsoft Excel to provide more precise drift rates and latitudes for individual spots. Measurements have a typical standard deviation of ~0.4º on the planet.

3. The SEBn with SED in 2008

The SED was conspicuous in 2008 (Figure 1a). Its mean speed was u_3 = 88 m/s (DL1 = +36 deg/month). The chevrons were also conspicuous, especially in a regular array east of the SED. The chart of longitude versus time (Figure 1) confirms the pattern previously reported: the chevrons move faster with increasing longitude east of the SED. A summary of measured speeds is given in Table 1 (excluding 5 slow-moving spots at high elongations).

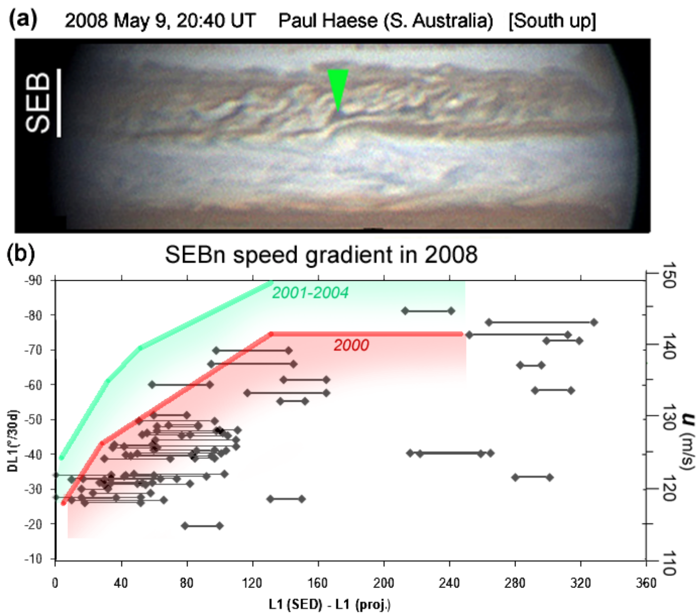

Figure 1. The SEBn in 2008.
a) Image showingthe SED (green arrowhead) with chevrons east (left) of it. [South is up]
b) Measured speeds of chevrons, vs distance east of the SED. Start and end of each measured track segment are shown. Coloured lines approximately indicate the gradients observed for starts of tracks in 2000 and 2001-2004 [ref.2]; the 2000 gradient agrees well with the 2008 data.

Table 1. Speeds measured in 2008

Longitudes (*deg. E of SED*)	*U* (*m/s*)	*+/-SD*	*Lat.*	*+/-SD*	*N*
0-45	120,0	1,3	-7,46	0,28	12
45-110	126,0	3,1	-7,15	0,24	26
110-160	135,2	2,8	-7,36	0,18	5
220-320	139,9	4,0	-7,18	0,28	6

4. The SEBn in 2010

The SED became quiescent in late 2008, and disappeared in May 2010, as the SEB was 'fading'. The alternative regime then took over the SEBn, as in 2005 and some other years [ref.1]. There were long-lived bands of disturbance, moving with the peak jet speed, and some individual spots moving with the same speed, but many other chevrons were moving more slowly (Table 2). The slower ones tended to occur in dense clusters of spots, and were shorter-lived (Table 2), and often relatively darker on their northern side. Morphological changes suggested that these slower features were detached from the main dynamical pattern in the jet.

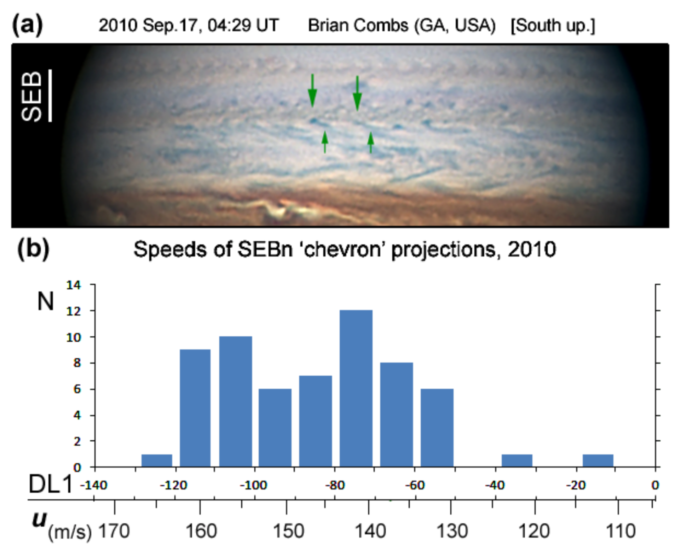

Figure 2. The SEBn in 2010.
a) Image of chevrons on the SEBn, showing an example where two adjacent spots in a cluster were each emitting a short-lived slower-moving spot.
b) Measured speeds of chevrons: Histogram showing bimodal distribution.

Table 2. Speeds measured in 2010

		U (*m/s*)	*Lat.*	*N*	*Duration* (*days*)
Faster	*Mean:*	156,4	-7,43	26	17,6
spots	*+/-SD:*	3,6	0,15		13,5
Slower	*Mean:*	139,6	-7,35	34	8,6
spots	*+/-SD:*	5,0	0,24		4,6

References

[1] Rogers JH et al. (2005) J.Brit.Astron.Assoc.115, 70-78. Jupiter in 2000/2001, Part III: The South Equatorial Disturbance: A large-scale wave in a prograde jet.

[2] Rogers JH & Mettig H-J (2008), J.Brit.Astron.Assoc. 118, 326-334. Influence of Jupiter's SED on jet-stream speed.