Notes and News

Jupiter Section

Jupiter in 2008: Aftermath of the global upheaval

In 2007, Jupiter displayed the spectacle of a 'global upheaval', with large-scale changes in colour and vigorous outbreaks of fast-moving spots in several latitude bands. In 2008 the planet is gradually returning to normal, but not without exciting new phenomena, which have been discovered now as we are observing this phase of the climatic cycle in far greater detail than ever before. The main features are indicated on Figure 1; compare with appearances in 2007 (*Journal*, 2007 June, p.113; 2007 Oct., p.226; 2008 Feb., p.9). Full details of the events in this report are on our web site, **http://www.britastro.org/jupiter/2008reports.htm**

South Tropical Region: The Baby Red Spot is shredded by the Great Red Spot

The South Equatorial Belt (SEB) had almost fully revived by the end of 2007, but there is again intense turbulence within it, arising in three sectors. One is the usual 'wake' following the GRS, and the other sectors arose as mid-SEB outbreaks on March 8 (at L2= 100, just preceding the GRS) and March 21 (at L2= 258). The persistence of this intense convective activity may explain why the SEB has not yet developed the red colour that usually follows Revivals.

The South Tropical Zone has shown an unusual eddying tendency since summer 2006, which in 2007 was manifested as two South Tropical Disturbances, which in turn led to spectacular circulating current. By early 2008, this vorticity had evolved into yet another novel form: two dark anticyclonic ovals. They were probably derived from the jet-stream vortices that recirculated and merged in summer 2007, and they belonged to a rare class of ovals that emerge drifting east from a STropD. Remarkably, one of them had a vivid red core (dubbed the Baby Red Spot, BRS). It was alongside a third red spot (Oval BA, now only pale or-

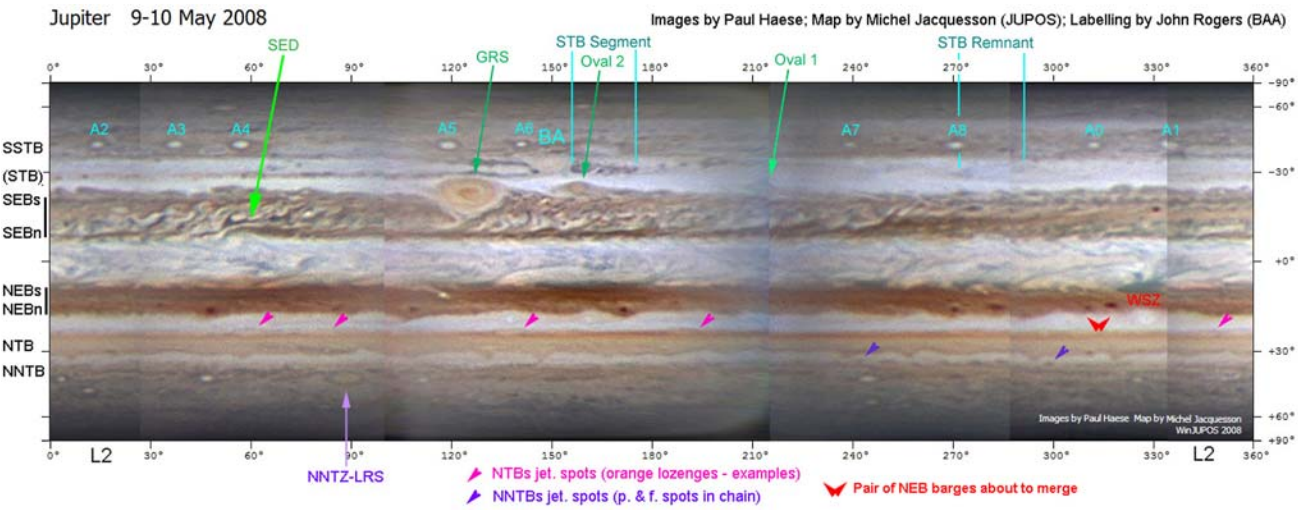

Figure 1. Map of the planet, 2008 May 9–10. Images by Paul Haese (Australia), map by Michel Jacquesson using the *WinJUPOS* program. Long-lived anticyclonic ovals and some other features are labelled. The 'Baby Red Spot' is Oval 2.

Figure 2A. Jupiter on 2008 June 6, 16:40 UT; Anthony Wesley (Australia). The three red spots are at upper left (GRS, BRS, and Oval BA).

ange), and both were moving towards the GRS (Figure 2A).

These ovals are huge anticyclones, whose reddish cloud colour may indicate that they are particularly vigorous and deep-rooted, and this was a unique opportunity to see what would happen when they came into contact. The event was watched intently by both amateur and professional observers (Figure 2B). The BRS approached the GRS from the west, and encountered its periphery on June 30 - by coincidence, just as oval BA was passing. The BRS was suddenly swept up by the powerful winds around the GRS, and by July 2 it was being pulled apart as it squeezed into the very narrow jetstream that separated the GRS from oval BA. Two main parts of it then emerged. The leading part was marked by several bright spots orbiting rapidly on the north rim of the GRS on July 4–6, and was apparently still present in an image on July 8–9 from the Hubble Space Telescope (HST), connected to the trailing part by a 360° spiral around the GRS. The trailing part – the main remnant of the BRS – re-emerged more slowly preceding (east of) the GRS on July 5–6, becoming a slightly orange bright spot at the preceding end of a dark grey streak (red arrow in Figure 2B).

Amateur images in the near-infrared methane band were invaluable in showing that a high-altitude cloud cap was again present over or adjacent to this spot (July 7–15), as it was over the original BRS. This remnant drifted north and then west, colliding with the GRS again on July 16. Images from July 17–25 showed probable remnants of it orbiting slowly and irregularly around the north side of the GRS. Thus the BRS itself seems to have ended up being swallowed (in at least two gulps) by the GRS. However the dark streak, which emerged from the GRS rim following the BRS remnant, continued extending east; and there may be persistent smaller-scale effects both within and preceding the GRS.

Equatorial Region: Stable dark features give way to fast-moving spots

In the Equatorial Zone, all the exceptional darkness of 2006–2007 has disappeared, leaving only faint tenuous streaks, which however are complex and beautiful in hi-res images.

The south and north edges of the EZ have evolved to unusually similar states, with numerous tiny spots showing rapid speeds ahead of the few major features. On the SEBn edge the South Equatorial Disturbance is still an impressive feature, with small but high-contrast projections accelerating ahead of it up to DL1= –67°/mth. On the NEBs edge, the typical large projections have become subdued and few in number, and the space vacated by them is occupied by small spots and projections with unprecedentedly fast speeds, up to DL1= –60°/mth. We wait to see whether this will be more than a passing phase.

North Tropical Region: Barges and ovals, appearing and merging

The North Equatorial Belt (NEB)is still strongly reddish (as in 2007) and has also acquired numerous small dark cyclonic spots called ‘barges’ on its north edge. Both phenomena typically occur about a year after a major episode of activity in the NEB. Although the NEB had not shown any outbreak as dramatic as in other belts in 2007, there was actually much activity in it: a large, long-lived rifted region grew to encompass one third of the circumference, and with other rifts elsewhere, plus the extreme turbulence on its north side during the NTBs outbreak, most of the

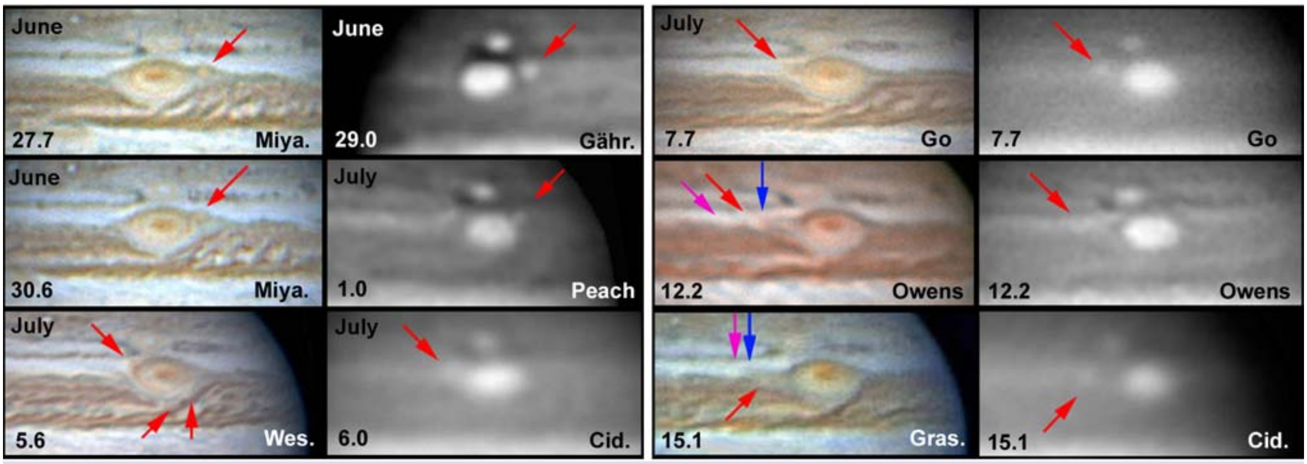

Figure 2B. The collision between the Baby Red Spot (red arrow) and the Great Red Spot. *Left*, colour images; *right*, images in the methane absorption band at 0.89 microns, which detects high-level haze. Oval BA is directly above the GRS; both are bright in methane images. In the later images, the blue arrow indicates the p. end of a dark grey band extending from the GRS with the BRS remnant, and the purple arrow indicates a pre-existing white spot. (The last methane image was rotated in *Photoshop* to improve visibility.) Full names of observers are as follows: Antonio Cidadão (Portugal); Bernd Gährken (Germany); Christopher Go (Philippines); Guilherme Grassmann (Brazil); Isao Miyazaki (Japan); Larry Owens (Georgia, USA); Damian Peach (UK); Anthony Wesley (Australia).

pre-existing barges and white ovals were destroyed. In summer 2007 there appeared both strong reddish colour and some new barges, and by early 2008 there were at least nine barges (though many were small), and eight white bays between them.

Although most were slow-moving in L2, there was still white spot Z, with DL2= –11°/mth. Some of the barges and white ovals preceding it shared this rapid drift, and were colliding with others which did not. In April there was a collision between white ovals, in which one of them was destroyed; then in April and May there were four mergers between barges, which confirmed the general pattern of such mergers that we have recently reported.

North Temperate Region: The belt revives and the jetstream decelerates

Last year's dramatic outburst of super-fast storms on the NTBs jetstream led to the revival of the North Temperate Belt South [NTB(S)] component as a prominent orange belt, which is still very strong. The reddish colour is a typical aftermath of such an outburst. Hi-res images detect pale 'lozenges' on its south edge, possibly incipient vortices, with a speed of DL1= –78°/mth (133 m/s in System 3). These are enabling us, for the first time, to follow the deceleration of the jetstream to its more normal state (Figure 3), and to gain insight into the deep structure of the jetstream.

The rapidity of the change, together with HST observations and modelling published by A. Sanchez–Lavega and colleagues, supports a model in which the deep jetstream has a permanent speed of at least DL1~ –160°/mth (170 m/s), but the wind speed at cloud-top level alternates between two stable states. In one state (1991–2002), the cloud-top jet speed is ~135 m/s, linked to shallow vortices travelling at 125 m/s. In the other state (1970–1990, and 2007), the vortices are absent and the cloud-top speed accelerates towards the underlying permanent jet speed of ~170 m/s, allowing vigorous convective storms to erupt upwards from a deep cloud layer.

These discoveries also imply more similarity than was previously recognised between the major components of a global upheaval: the outbreaks in the NTB and the SEB. Both start with a convective upsurge resembling a giant thunderstorm which can rise up from a deep level – probably the hypothetical water cloud layer – only when special conditions prevail in the upper cloud layer. Moreover, the proximity of these two outbreaks in 2007 February and May is consistent with other global upheavals since 1970, in which the super-fast NTBs outbreak and the SEB Revival outbreak commonly occur within a few months of each other. So these two outbreaks may be triggered by a single global process, which is not understood but which manifests in the global upheaval.

Meanwhile the NTB(N) has been reviving as a sinuous grey band, faint at the start of the year but quite strong now (2008 August). Its remarkable wavy pattern was actually present though faint in HST images before the 2007 outbreak, but has become conspicuous as the belt darkened, and dark grey streaks or barges are now forming in some of the waves. The orange colour, the sinuous N edge, and the formation of barges by eddying within the waves, all resemble the phenomena of the NEB, and may be a similar response to the vigorous outbreak within the previous year.

John H. Rogers, *Director*

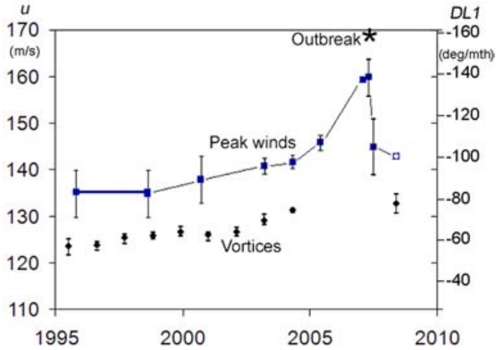

Figure 3. Chart of the NTBs cloud-top speed, 1995–2008. Data from HST, *Cassini*, and *JUPOS* (1995–2001); *JUPOS* (2002–2005); *New Horizons* and HST (2007, pre- and post-outbreak); JHR & *JUPOS* (2008). *Diamonds:* Speed of vortices. *Squares:* Peak jet speed from smaller cloud tracers. The present speed can be estimated as 143 m/s by assuming that the orange lozenges are vortices, again travelling 10 m/s slower than the peak jet speed.