EPSC Abstracts
Vol. 8, EPSC2013-384, 2013
European Planetary Science Congress 2013

Jupiter's North Equatorial Belt: An historic change in cyclic behaviour with acceleration of the North Equatorial jet

John Rogers, Gianluigi Adamoli, Grischa Hahn, Michel Jacquesson, Marco Vedovato, & Hans-Jörg Mettig
(JUPOS team and British Astronomical Association, Burlington House, Piccadilly, London W1J ODU, U.K.)

Abstract

Systematic amateur records of Jupiter's atmosphere go back to the 19th century, documenting some large-scale patterns which only recur after many decades. Modern amateur images reveal fine details of the atmospheric dynamics which were hitherto undetectable except from spacecraft. A recent transformation of the North Equatorial Belt (NEB) illustrates the power of these records to identify a large-scale phenomenon that had not occurred for nearly a century – the NEB narrowing and revival – and to reveal a marked apparent acceleration of the associated jet at 7ºN, which deepens our understanding of the atmospheric dynamics.

Introduction

Jupiter's North and South Equatorial Belts (NEB, SEB) are the two largest cyclonic belts, and the jets which delimit them (NEBs, SEBn) are among the fastest on the planet. But they are not symmetrical. For the past century, the SEB has been subject to large-scale cycles of fading and violent revival, while the NEB has shown only modest cycles of narrowing and broadening. Meanwhile the SEBn jet at cloud-top level flows very fast with only one or no large features on it, whereas the NEBs jet usually carries many large dark formations moving more slowly. However, drawings before 1912 showed the reverse situation.

In the 19th century, and especially every 3 years from 1893 to 1915, the NEB underwent cycles [Ref.1] which typically consisted of:
1) Quiescence of the NEBs;
2) Extreme narrowing, sometimes fading of the NEB;
3) Revival, typically involving vigorous disturbance;
4) Formation of large ovals in the northern part over the following year.
Since 1988, the NEB has undergone more modest cycles of narrowing and broadening every 3-5 years. Recently these have amplified to the point where the 2011-12 cycle involved the first major narrowing and revival of the NEB since 1926.

Observations and analysis

Modern data are derived from amateur images as measured by the JUPOS team, using WinJUPOS (http://jupos.org). The observers are listed on this web site. Historical data are from amateur drawings [Ref.1]. Conclusions depend on a synthesis of long-term visual records, and modern hi-res imaging and feature tracking, and continuous observations even close to solar conjunction.

1) Quiescence and jet acceleration

Ground-based observations show three speed ranges for NEBs features (all at 7.0 to 7.7 deg.N):
i) Normal (~105 m/s): The large dark formations (infrared hot spots), widely thought to be Rossby waves.
ii) Fast (~120 m/s): Smaller spots recorded in most years since 2001, possibly closer to the true wind speed at cloud-top level.
iii) Super-fast (~140 m/s): Exceptional speeds recorded only from 2008 onwards in sectors where the large dark formations had disappeared.
(The Cassini flyby showed similar speeds for small infrared-bright clouds, and the Galileo Probe showed that the speed reaches ~170 m/s below the clouds.)

In 2008 July, most large formations were replaced by smaller fast projections, and in one sector, small, tenuous projections moved with ~134 m/s. [Ref.2] Large dark formations reappeared during the NEB expansion event in 2009, but most of them gradually disappeared during 2010, giving way to small features with super-fast speeds, mean 138 m/s, max. 143 m/s.

In 2011, disappearance of the normal NEBs formations resumed and the NEBs became completely taken over by super-fast speeds **(Fig.1)**. Up to Oct.,

just 2 or 3 very small 'normal' features remained, and they modulated the speeds of the super-fast features **(Fig.1)**. By 2012 Jan-Feb., all features were super-fast with mean speed 145 m/s, max. 151 m/s.

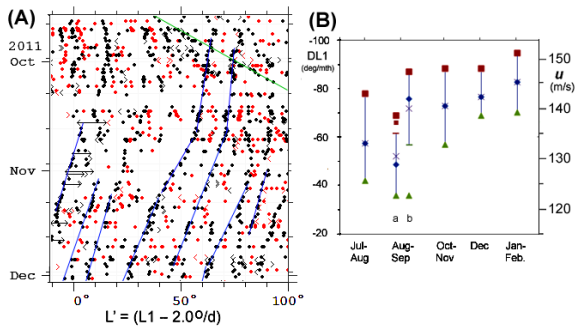

Fig.1. (A) Excerpt from the longitude-vs-time chart for features on NEBs in 2011-12 (lats.+6.0 to +9.5). Black = dark spot, red = white spot; green line = track of one remaining small slow feature. (B) Speed vs time during 2011: full ranges are shown. In Aug-Sep., (a) east of slow features, (b) west of slow features.

Discussion: We infer that the NEBs jet at cloud-top level can become super-fast when there are no slow-moving formations to suppress it. The suppressive effect was shown directly by the remaining slow features which reduced the super-fast speeds to the east, exactly as the S. Equatorial Disturbance modulates the speed of the SEBn jet [Ref.3]. Even a very small feature reduced the speeds over tens of degrees; no doubt, the usual large formations suppress them totally, explaining why super-fast speeds were not observed on the NEBs previously.

2) Narrowing & fading of the NEB

The NEB in 2011 was narrowing as expected after the broadening event of 2009, although it was exceptionally quiet with no 'rifts' (convective white clouds) after 2011 July, and there were the 6 remarkably dark 'barges'. Then, the northern half continued to fade, leaving the NEB narrower and fainter than it had been since the 1920s.

Discussion: It is notable that these developments occurred in the complete absence of convective rifts. Thus we suspect that the NEB cycle, like the SEB cycle, began with the complete cessation of convective activity in the belt.

3) The NEB Revival

The NEB outbreak began on 2012 March 8 with a bright rift which started to generate very dark, slow-moving formations on the NEBs edge. A month later, a major outbreak also began on the North Temperate jet. These disturbances erupted just before Jupiter disappeared behind the Sun, and were only detected thanks to the perseverance of a few observers.

After solar conjunction, in 2012 June, the NEB was found to be in an exceptionally chaotic state, so a vigorous revival was under way **(Fig.2)**. The NEB was broadening to its maximum width, and large dark formations with normal slow drifts were reappearing along the NEBs. By August, the disturbance had largely subsided and new circulations began to appear, both cyclonic (dark barges) and anticyclonic (white spots, emerging from very dark spots). Thus the Revival was distinguished from previous broadening events by intense turbulence and by rapid progress, being completed in only 5 months.

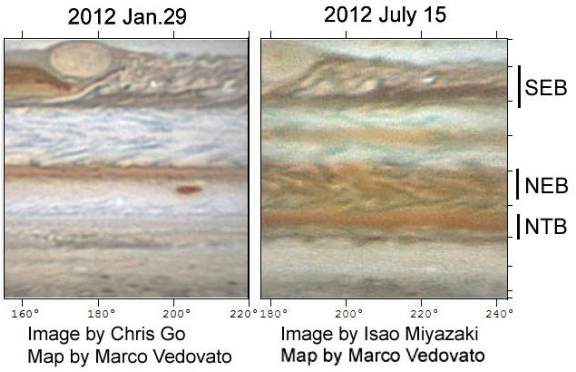

Fig.2. The belts before and during the NEB Revival.

References

[1] Rogers JH, 'The Giant Planet Jupiter'; Cambridge University Press, 1995.

[2] Rogers J, 'Jupiter in 2008: Full Interim Report.' http://www.britastro.org/jupiter/2008report06.htm (2008).

[3] Simon-Miller AA, Rogers JH, Gierasch PJ, Choi D, Allison MD, Adamoli G, & Mettig H-J. 'Longitudinal variation and waves in Jupiter's south equatorial wind jet.' Icarus, vol. 218, pp.817–830; 2012.