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The new South Tropical Disturbance and its interaction with the Great Red Spot

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Introduction

A South Tropical Disturbance (STropD) is one of the most distinctive phenomena of Jupiter's atmosphere. It is a large dark structure spanning the South Tropical Zone (STropZ), produced by recirculation between the jets at 20ºS (retrograding, SEBs) and 26ºN (prograding, STBn). It was first defined by the great example that appeared in 1901, which first demonstrated visible recirculation between the jets in 1920, and persisted until 1939 [1]. Since then, at least 7 shorter-lived examples have been observed. The best-studied was in 1979, during the Voyager 2 flyby [2]. Since then, STropDs have arisen in 1993 and 2007; these arose when the SEB was fading, and were then destroyed by the turbulence of the subsequent SEB Revivals. A new one appeared in 2017. It must have arisen in a different manner from the 1979 example*, and is the first well-observed one since the 1920s to be passing the Great Red Spot (GRS). We therefore have a unique opportunity to study its dynamics and its interaction with the GRS, from hi-res amateur ground-based images and from JunoCam images.

*The creation of a new STropD was observed by Voyager 2, but it occurred in a different way from the present one, by interactions of large anticyclonic vortices retrograding on the SEBs jet [2]. There are no such vortices at present.

Observations

The new STropD was discovered by JunoCam, at Juno's perijove 9 (PJ9) on 2017 Oct. 24 during geocentric solar conjunction. Juno's outbound images, projected and merged to make a cylindrical map, revealed the unmistakeable form of a STropD. Measurements of ground-based images in preceding months by the JUPOS team, show its probable origin. It was initiated in early August when dark streaks, modestly retrograding in the northern STropZ, merged and recirculated into the mid-STropZ alongside the east end of a cyclonic circulation known as the STB Spectre. It is likely that one or more further mergers with similar dark streaks during solar conjunction led to the complete recirculation that characterises a STropD, with a typical eastward drift rate of 6.5º/30d relative to the GRS. By 2018 Jan. it had distinct ends, 20º apart in longitude. The preceding (east) end (p-STropD) was most conspicuous and was approaching the GRS .

Hi-resolution images revealed unexpectedly intricate turbulence throughout the STropD. This was evident within the SEB, where convective rifts revived alongside and west of the STropD; and within the dark p-STropD itself; and on the stream of material flowing from it past the GRS. As the p-STropD accelerated towards the GRS, the STropD grew longer, reaching 33º in length in early Feb.

On about 2018 Feb.4, the p-STropD arrived at the bright collar of the GRS (Red Spot Hollow, RSH) and halted there. Much dark material from it then started flowing around the S side of the GRS. During Feb. and March, turbulent dark material accumulated in the S. Tropical Band and S. Temperate domain east of the GRS [3].

At PJ12 (2018 April 1), Juno fortuitously flew just 10º east of the east end of the GRS, directly over the large expanse of turbulence that had emanated from the STropD. JunoCam took a series of images of this region over 19 minutes. The images show a chaotic scene, in which the STBn jet cannot be discerned, but many eddies are apparent on different scales. Most of them look cyclonic, but there is a large anticyclonic eddy in contact with the east end of the GRS, dark grey but evidently pulling orange streamers from the GRS around it. There are strong streamlines in this region, including elevated ridges of white cloud, and streaks of different colours crossing each other.

Ground-based images show anticyclonic circulation not only at the ends of the STropD but also within it; on the other hand, both ground-based and JunoCam images suggest that much of the turbulence that has passed the GRS consists of cyclonic eddies. An animation of ground-based images around April 1

shows that the SEBs and STBn jets are still present within the STropD and east of the GRS, despite the apparent chaos. The dynamics east of the GRS will be investigated by animation of the JunoCam images.

Discussion

We are now watching a STropD interacting with the SEB and the GRS in a way that has never before been observed at such high resolution. The encounter with the GRS was keenly awaited because of the remarkable behaviour of the great STropD over a century ago. Whenever it caught up with the GRS, the p-STropD was reported to stream rapidly round the S side of the GRS and to re-form east of the GRS within days or weeks. However, the original BAA publications actually record that in most such encounters, the p-STropD was not observed for some weeks after it arrived at the RSH, and did not re-form in its classic curved dark form for some months. The rapid passage was only inferred by extrapolating its subsequent motion back to the RSH.

Given the observations in 2018, we propose that the re-formation of the p-STropD in these historic observations was actually a stochastic process that was mediated by eddies in the STropZ which, sooner or later, trapped the SEBs jet into the expected recirculation pattern.

As of 2018 April 1 (PJ12), the turbulence east of the GRS had not (yet) crossed the northern STropZ nor perturbed the SEBs jet. In ground-based images, this was still the case up to early May. So, apart from the fact that this disturbance is not obviously dark, it is not inconsistent with what used to happen a century ago. Alternatively, it is possible that the STropD will not re-form east of the GRS, but will dissipate in the STB latitudes instead.

Acknowledgements

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References

[1] Peek, BM (1958) *The Planet Jupiter* (Faber & Faber).
[2] Rogers, JH (1995) *The Giant Planet Jupiter* (Cambridge Univ. Press).
[3] Maps & animation from the amateur images have been posted by S. Mizumoto on the ALPO-Japan web site: http://alpo-j.asahikawa-med.ac.jp/kk18/j180226u.htm

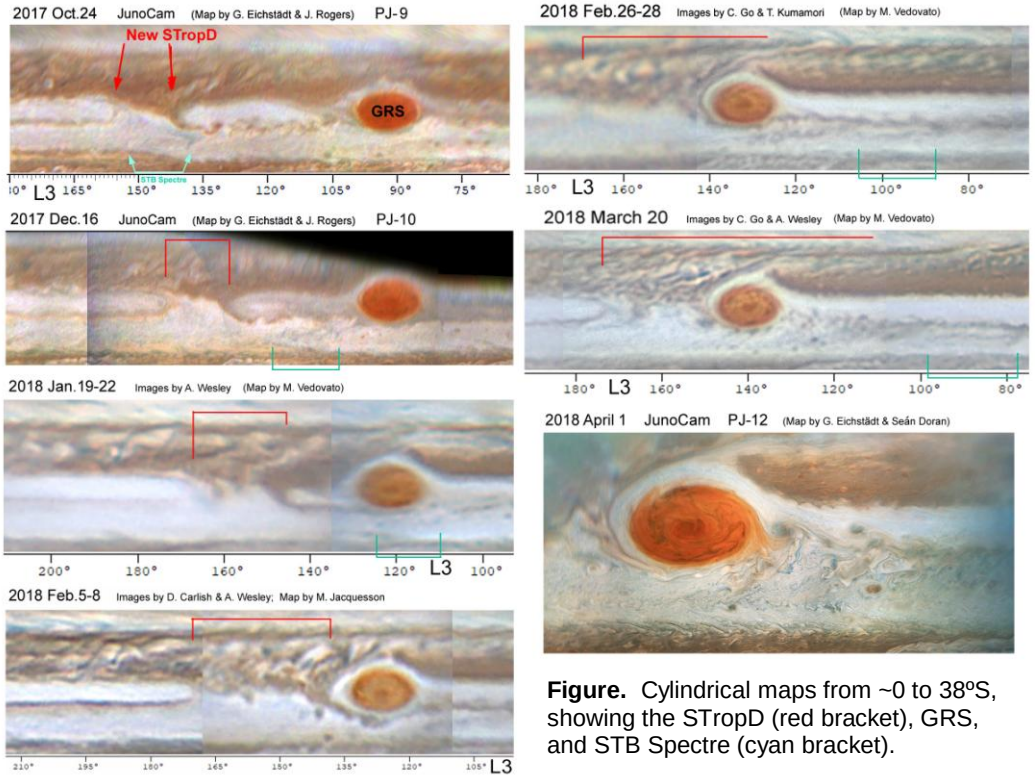

Figure. Cylindrical maps from ~0 to 38ºS, showing the STropD (red bracket), GRS, and STB Spectre (cyan bracket).