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Observations and non-linear simulations of Jupiter's 2010 SEBD

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Abstract

We present the evolution, motions and nonlinear simulations of the planetary-scale disturbance that initiated in the South Equatorial Belt of Jupiter (SEBD) on November 9, 2010. Data on motions were obtained from high-resolution images submitted to the PVOL-International Outer Planet Watch database [1]. Non-linear simulations of the disturbance potential vorticity evolution at cloud level were done using the EPIC code [2].

1. Introduction

The South Equatorial Belt (SEB) of Jupiter, located between latitudes 10ºS and 20ºS, change from a zone to a belt-like aspect cyclically [3]. The SEB band is in one of two stages during most of the time: (i) zone-like, as a bright albedo band in the visible wavelengths, usually known as ''SEB Fade'' or (ii) belt-like a low albedo band, the normal SEB appearance. Transition from "Fade" stage to belt takes place through a planetary scale disturbance that begins with a latitudinally localized outbreak of bright clouds in the middle of the belt that generates a turbulent pattern of dark and bright spots that encircle the planet driven by the ambient zonal winds. This phenomenon has been historically known as the SEB disturbance (SEBD). In this work we present the study of the last SEB disturbance initiated on 9 November, 2010.

2. SEBD outbreak development

Figure 1 shows the evolution of the SEBD during its first stages in early November 2010. The outbreak occurred within a singular spot with suspected cyclonic circulation (a "barge"), which had been very dark a year ago, but turned white in 2010 May-June. The first report of the outbreak was on images taken by C. Go and D. Parker on November 9. A bright "white spot" emerged at 17.5ºS (planetographic) and in the next days more white spots emerged close to the first one (144º longitude system III). The SEB "revival" developed vigorously in a classical style, and all three "branches" become distinct: central branch (white spots and turbulence), southern branch (SEBs) and northern branch (SEBn) as shown in Figure 1.

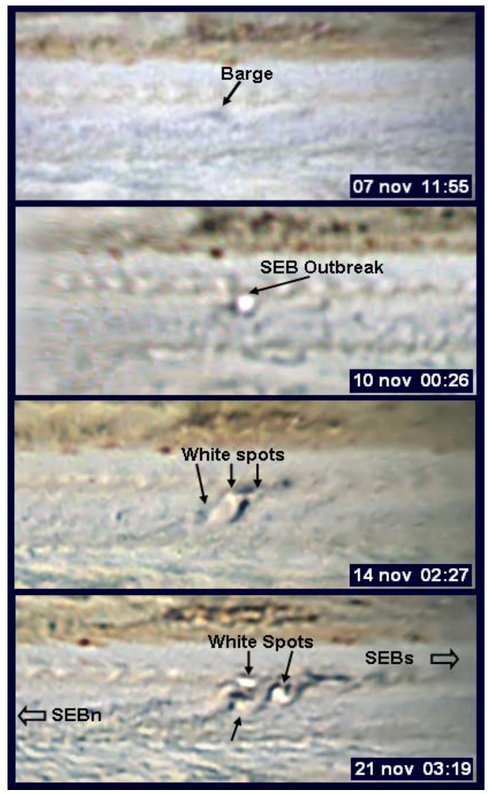

Figure 1: SEBD outbreak during November 2010. South up, East left

3. Observational measures

Figure 2 shows measurements of the motions of the main features of the SEBD from cloud tracking from 9 November 2010 to 15 January, 2011. In general they follow the mean zonal wind profile, but significant velocity differences up to -20 m/s were detected in the central branch between 12ºS and 16ºS. In addition, meridional motions with speeds of 10 m/s, northward and southward from the source, were observed when the bright spots emerged. They were probably related to turbulence in the chaotic pattern of clouds in the central branch.

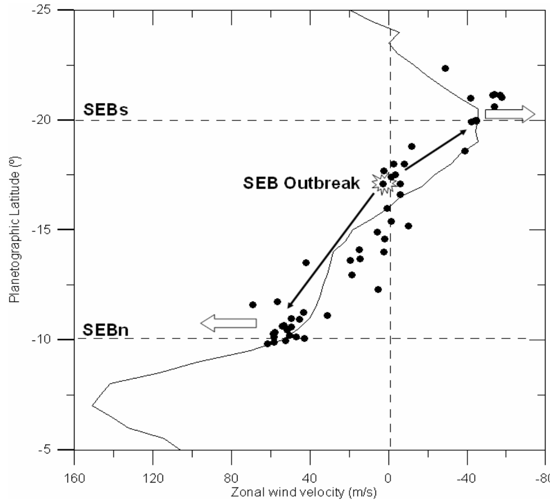

Figure 2: Location in latitude and corresponding wind velocity of the main features of the SEBD. The continuous line is the zonal wind profile measured from HST images [4].

4. Numerical Model results

We used the EPIC (Explicit Planetary Isentropic-Coordinate) [2] model to simulate de onset and development of the SEBD. We mapped at different altitude levels the potential vorticity evolution generated on a reference atmosphere by a continuous (permanent in time for the 100 days of simulation) and vertically extended Gaussian heat source, testing for it different intensities, sizes and latitude locations around the observed initial source. This heat sources tries to mimic the moist convective source that it has been proposed as the origin for the white spot formation [5]. We used 8 layers in the vertical and an horizontal resolution of 0.5º/pixel. We tested different cases for the vertical wind shear and for the vertical thermal structure following our previous schemes [6]. Preliminary result is shown in Figure 3. Using a continuous heat source instead of instantaneous pulses we got a potential vorticity pattern (altitude level of 830 mbar) that strongly resembles the cloud pattern evolution we see at visible wavelengths. For this, the modelled heat source has 2º in size (a column with horizontal Gaussian profile) and extends vertically from 0.5 to 5 bar, and more importantly, as in previous simulations, the vertical shear of the zonal wind must be zero (winds constant with depth) [7].

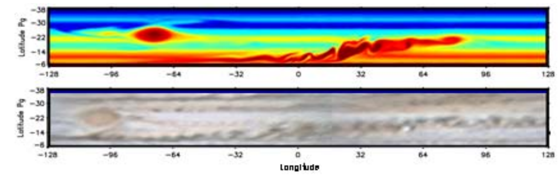

Figure 3: SEBD simulations and observations in comparison. Top: EPIC simulations of the potential vorticity generated by a continuous Gaussian heat source. Bottom: cylindrical map projection of the SEBD disturbance. In both images the GRS locates at latitude 22ºS.

Acknowledgements

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