Ongoing Analysis of Jupiter's Equatorial Hotspots and Plumes from *Cassini*

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Abstract

We present updated results from our ongoing analysis of *Cassini* observations of Jupiter's equatorial meteorology. For two months preceding the spacecraft's closest approach of the planet, the ISS instrument onboard *Cassini* regularly imaged the atmosphere of Jupiter. We created time-lapse movies from this period that show the complex activity and interactions of the equatorial atmosphere. During this period, hot spots exhibited significant variations in size and shape over timescales of days and weeks. Some of these changes appear to be a result of interactions with passing vortex systems in adjacent latitudes. Strong anticyclonic gyres to the southeast of the dark areas converge with flow from the west and appear to circulate into a hot spot at its southwestern corner.

1. Introduction

Jupiter's hot spots, confined between 5°N and 10°N [1], are compact, quasi-periodic areas of strong infrared emission. The quasi-periodic spacing of the hot spots have led some to advocate that an equatorial planetary wave is responsible for their formation and maintenance [2, 3, 4]. Numerical models have reproduced some broad observations of hot spots, lending more credence to the equatorial wave theory as a mechanism responsible for these phenomena. However, details such as the flow pattern around hot spots, interactions between hot spots, and factors influencing hot spot morphology have not been examined in detail and motivate the present study.

We compiled imaging data from *Cassini*'s Imaging Science Subsystem (ISS) [5]. The spacecraft acquired global, multispectral mosaics of the planet at intervals of one or two Jovian rotations for nearly 3 months. We use images observed with a near-infrared continuum filter (CB2, 750 nm) to maximize feature contrast and minimize Rayleigh scattering and gaseous absorption for optimum dynamical and morphological study.

We also constructed time-lapse movies showing the morphological evolution of the key meteorological features. Our movies have a dynamic frame-of-reference that moves east at 103 m s^{-1} to minimize hot spot drift. The regular observations also enable the creation of image pairs covering the same area of Jupiter but separated by the ~100-minute time interval. Such pairs are ideal for analysis using automated cloud feature tracking [6].

2. Morphology and Interactions

Hot spots exhibit a sharply defined eastern edge demarcating a clear division between the dark hot spot region and surrounding cloudy areas. In contrast, the western edge of a hot spot is not as clearly defined as its counterpart to the east. Some portions of the edge mark a gray transition region from the dark hot spot to a bright equatorial plume, whereas other portions clearly establish a boundary between hot spot and plume. The transition complicates measures of hotspot sizes, adds some uncertainty to these measurements, and raises questions over whether a hot spot is growing in size or dividing itself into two. The progression between the North Equatorial Belt and the hotspot is also latitudinally irregular at certain points, with arms or spits of cloud material extending into the hotspot at one corner to the west but not in the other corner adjacent to its north or south.

Storm systems and vortices residing in latitudes both north and south of the hot spots can influence hot spot morphology. Figure 1 shows an example of an indirect interaction between a von Karman vortex street [7] and a hot spot. In a frame of reference traveling with the hot spots, this vortex triplet travels rapidly westward as it is embedded in the westward jet stream of the North Equatorial Belt. The influence of the vortices as they pass near hot spots is evident in the changing sizes and morphologies of the hot spots after interaction. Typically, turbulent cloud patterns accompanying the vortices or associated with bright cloud tops (presumably thunderstorms) generated as the vortices travel interact with the hot spots when they creep southward into the hot spots.

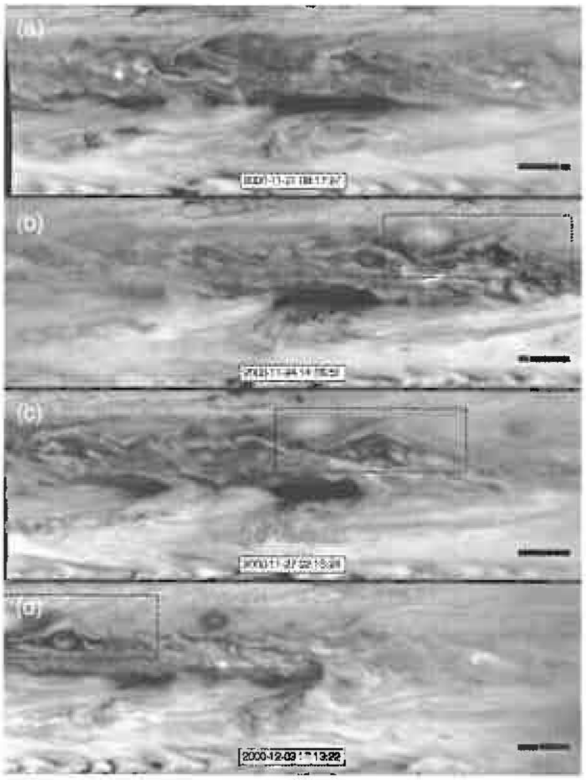

Figure 1: Time series of *Cassini* ISS CB2 images depicting a Jovian hot spot and the effects of a passing vortex street (outlined in a rectangle in panels b-d in figure) to its north. (a) Initial state: hot spot is rectangular and has a relatively large width-to-height aspect ratio. (b) Vortices approach: seemingly turbulent cloud patterns encroach upon the dark spot at its northeastern quadrant. (c) Peak interaction: the vortices and associated clouds buffet against the hot spot, curving its NE boundary. (d) Aftermath: the hot spot's longitudinal extent diminishes. The scale bar at the lower right in each panel denotes 10,000 km.

3 Dynamics

Examination of time-lapse movies uncovered complex flow patterns between all meteorological features located in the equator and in surrounding latitudes, with a mix of turbulent and laminar flow. *Galileo* observed 30–50 m s^{-1} winds flowing southwest-to-northeast near the southwestern quadrant of a hot spot [8]. This flow appeared to be associated with an anticyclonically rotating vortex located to the hot spot's southeast that previous studies could not confirm. Our movies, however, confirm that this flow is associated with anticyclonic gyres present to the south and southeast of hot spots. Furthermore, this flow pattern is consistent to all hot spots in our observations and is not isolated in nature. The overall flow pattern supported by these gyres also resembles the resultant flow pattern in numerical simulations [3].

Other studies [9, 10] report very fast flow within plumes or bright cloud areas to the west of hot spots. Our analysis demonstrates that compact bright, white 'scooter' clouds rapidly traverse across a background plume west of hot spots. Typically, these clouds disappear and presumably evaporate as they enter the dark area of a hot spot. However, the altitude of these clouds is uncertain, raising questions over the nature of the anomalously high speeds relative to the mean jet stream speed.

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