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Oval BA (and the Great Red Spot) extend down to a supersolar water cloud layer in Jupiter's atmosphere

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Abstract

To constrain the properties of Oval BA before and after it reddened, we extract velocity fields from Cassini and Hubble data, showing that there were no significant changes in the horizontal velocity field of Oval BA in 2000, 2006, and 2009. Based on models of the oval's dynamics, the static stability of the oval's surroundings was also unchanged.

The vertical extent of the oval did not change, based on our measurements of unchanged haze reflectivity and unchanged stratification. Published vortex models require Brunt-Väisälä frequencies of about 0.08 s^{-1} at the base of the vortex, and we combine this value with a review of prior constraints on the vertically variable static stability in Jupiter's troposphere to show that the vortex must extend down to the condensation level of water in supersolar abundance.

1. Velocity fields

We measured the velocity fields of Oval BA using data from the Cassini spacecraft in 2000 before the color change, and from Hubble's ACS (2006) and WFC3 (2009) cameras after the color change. Velocities were extracted using the Advection Corrected Correlation Image Velocimetry technique [1]. Figure 1 shows the distribution of velocities within the maximum-velocity collar at each epoch. A richer description of the results described here may or may not be available in *Icarus* at the time of this meeting [8].

2. Static stability

Vortex models are sensitive to the static stability in the surroundings of the vortices (e.g., [5]). But static stability varies with altitude in Jupiter's troposphere, with stable layers near cloud bases [4,6,7]. We use these two results to determine where the base of the vortices lies, by determining pressure levels where the atmospheric static stability matches the static stability derived from vortex models. Figure 2 compares a wide range of static stability estimates for Jupiter's troposphere with results from models of Oval BA and the Great Red Spot (GRS). Static stability has been expressed as the Brunt-Väisälä frequency in each case.

The pink horizontal band in Fig. 2 shows that vortex-model derived static stability (white bars) is consistent with measured static stability in the upper troposphere from Cassini CIRS and Voyager radio occultations. This makes sense because haze atop the vortices indeed shows that they extend up to these levels. Condensation of cloud layers of NH_3 or NH_4SH, or water in solar [3] abundance, produces too little static stability to be consistent with the

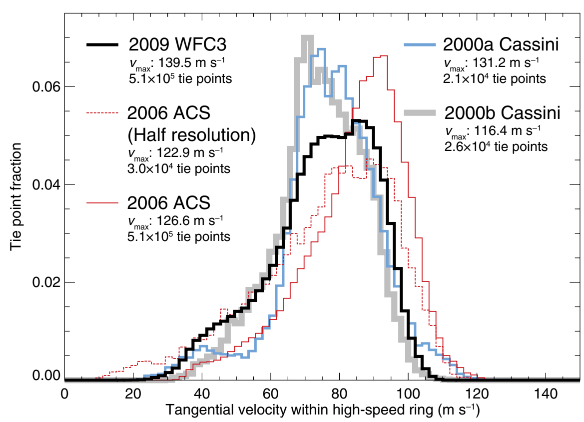

Figure 1: Distribution of velocities within the maximum-velocity collar (defined as the region between 2500 and 4500 km from the vortex center) at three epochs. Given the systematic uncertainty demonstrated by comparing the 2006 full-resolution and half-resolution results, there are no changes greater than about 15 m s^{-1} in the velocity field of Oval BA between 2000 and 2009.

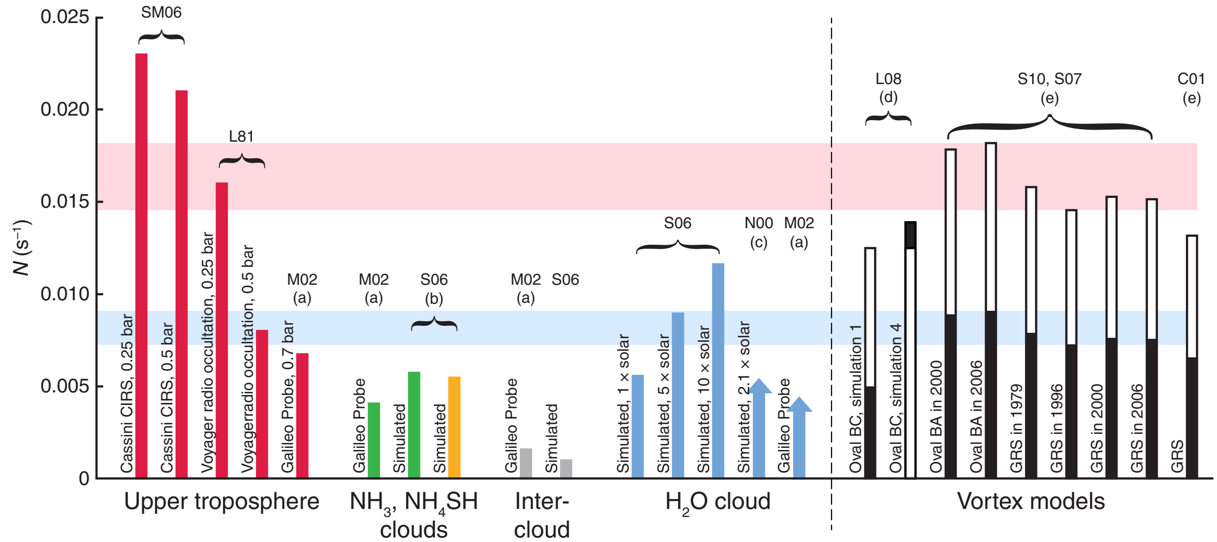

Figure 2: Estimates of static stability in Jupiter's atmosphere. Shaded bars (to the left of the dashed line) are from measurements and models of Jupiter's vertical structure; black and white bars (to the right of the dashed line) are for vortex surroundings as determined by numerical models of the GRS, Oval BA, and the progenitor Oval BC. At the left, results are grouped into regions: top of the tropophere, in the cloud decks, and between clouds. Galileo probe results have been scaled to lower pressure following [7]. Due to space constraints, please see [8] for references to original data sources.

vortex models deeper in the troposphere (black bars). Only a supersolar water cloud layer produces enough stability to match model results for the deeper troposphere (blue horizontal band). A deep base in the water cloud is also consistent with observations of persistent 5-µm bright arcs to the south of the GRS and Oval BA [2], which must be cloud-free to ~4 bar.

Vortex models thus provide a new constraint that Jupiter's oxygen abundance is supersolar, in addition to constraints from infrared spectroscopy, lightning, cloud depths, and CO [9].

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