Dynamical systems theory enhances knowledge of Jupiter's atmosphere

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This is Jupiter's Great Red Spot in 2000 as seen by NASA's Cassini orbiter. Credit: NASA/JPL/Space Science Institute

Jupiter, which has a mass more than twice that of all the planets combined, continues to fascinate researchers. The planet is characterized most often by its powerful jet streams and Great Red Spot (GRS), the biggest and longest-lasting known atmospheric vortex. Although still images provide some insight into the features of Jupiter's atmosphere, the atmosphere itself is unsteady and turbulent, and its features are time-dependent.

In a paper published this month in *SIAM Review*, authors Alireza Hadjighasem and George Haller use video footage to analyze Jupiter's transport barriers and examine prior conclusions about Jupiter's atmosphere.

According to dynamical systems theory, transport barriers exist in complex flows as objects that cannot be crossed by other fluid trajectories. Those in unsteady flows, such as Jupiter's atmosphere, are material surfaces with coherent features in their deformations. These surfaces are called Lagrangian coherent structures (LCSs). Hadjighasem and Haller employ geodesic LCS theory, which generates transport barriers as smooth curves, to search for unsteady transport barriers in the planet's atmosphere.

Using a video from NASA's 2000 Cassini mission, the authors apply an existing algorithm, called Advection Corrected Correlation Image Velocimetry (ACCIV), to obtain a time-resolved, two-dimensional representation of Jupiter's wind-velocity field. From this representation, they construct an unstable velocity field model. Subsequent analysis recognizes - for the first time - unsteady material transport barriers surrounding both the GRS and the jet streams around the GRS caused by Jupiter's fast rotation. These discoveries reinforce prior conclusions about Jupiter's atmosphere.

NASA's Juno mission will reach Jupiter in 2016, and the authors hope that this mission will provide information that will extend their current examinations to three dimensions. Their findings have potential applications for the remote observance of patterns in oceanography, meteorology, crowd surveillance, and environmental monitoring.

More information: Alireza Hadjighasem et al. Geodesic Transport Barriers in Jupiter's Atmosphere: A Video-Based Analysis, *SIAM Review* (2016). DOI: 10.1137/140983665

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