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Disruption of Saturn's Equatorial Stratospheric Oscillation by the Great Storm of 2011

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Saturn's equatorial stratosphere exhibits at pattern of periodic oscillations in temperatures and zonal winds with a 15-year period (Fouchet et al., 2008, doi:10.1038/nature06912; Orton et al., 2008, doi:10.1038/nature06897). This pattern is analogous to Earth's Quasi-Biennial Oscillation (QBO) and Jupiter's Quasi-Quadrennial Oscillation (QQO), and may be driven by interaction of the mean zonal flow with waves spawned by tropospheric meteorology. Inversions of Cassini Composite Infrared Spectrometer (CIRS) limb and nadir spectra allowed the construction of a time series of Saturn's equatorial temperatures from 2004 to 2016, revealing the slow downward propagation of the temperature/wind pattern in the 0.1-100 mbar range. However, this pattern was spectacularly disrupted in 2011 at the same time as a large tropospheric storm system and associated stratospheric vortex (the 'beacon') were both active in the Saturn's northern springtime hemisphere (Fletcher et al., 2012, doi: 10.1016/j.icarus.2012.08.024). Temperatures were perturbed throughout Saturn's tropical stratosphere (30N-30S), with substantial cooling (10-K at 1 mbar) at 10N and 10S by 2012. This coincided with the removal of bright near-equatorial bands of methane emission observed from ground-based observatories at 7.8 μm. 1-mbar temperatures at 10N/10S did not recover to their pre-storm levels until 2014-15, when the familiar temperature/wind pattern of Saturn's equatorial oscillation was re-established and had resumed its downward propagation. The 2011 Saturnian storm therefore had a dramatic impact on the equatorial oscillation, shifting it into a new phase whose temporal period is yet to be determined. Horizontally and vertically propagating waves, emanating from both the storm and the beacon near 40N, could have transported momentum into the equatorial wind system to drive temperature changes across the equatorial region. Similar disruption associated with the 1990 equatorial storm could explain why the phase of the oscillation determined by Voyager (1980) did not match that observed by Cassini one Saturnian year later (Sinclair et al., 2014, doi: 10.1016/j.icarus.2014.02.009). A similar wave-momentum transport hypothesis was used to explain the unprecedented disruption of Earth's QBO in 2016 (Osprey et al., 2016, doi:10.1126/science.aah4156), reinforcing the similarities in processes shaping both terrestrial and giant planet middle atmospheres.