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Supporting Information for

# Interaction of Saturn's Hexagon with convective storms

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**Contents of this file**

Text S1 to S3
Figures S1 to S5
Tables S1 toS2

**Text S1.**

Table S1 gives the list of observers and their instrumentation whose images have been used in this study. The full list of observers contributing with their images of Saturn in 2019 and 2020 appear in the databases:

ALPO-Japan: http://alpo-j.asahikawa-med.ac.jp/Latest/Jupiter.htm
PVOL (Planetary Virtual Observatory Laboratory): http://pvol2.ehu.eus/pvol2/search/form

**Table S1**

Instruments descriptions: SC stands for Schmidt Cassegrain, DK for Dall-Kirkham Cassegrain, RC Ritchey-Chretien, (*) Chilescope (http://www.chilescope.com/)

| Observer | Country | Telescope | Filters | Days |
|---|---|---|---|---|
| Luis Amiama Gómez | Santo Domingo | SC 280 mm | R,G,B | 1 |
| Ecleido WS. Azevedo | Brazil | Newton 300mm | R,G,B | 5 |
| Christofer M. Baez | Santo Domingo | Newton 203mm | R,G,B | 3 |
| Trevor Barry | Australia | Newton 408mm | R,G,B,CH4 | 281 |
| Joaquin Camarena | Spain | SC 355mm | R,G,B, CH4 | 2 |
| Andy Casely | Australia | SC 355mm | R,G,B,CH4 | 10 |
| Ethan Chappel | USA | SC 203mm | R,G,B | 2 |
| Jean-Luc Dauvergne | France | DK 250mm | L,R,G,B | 4 |
| Darren Ellemor | Singapore | SC 280mm | R,G,B | 1 |
| Pericles Enache | Brazil | SC 203mm | R,G,B | 1 |
| Clyde Foster | South Africa | SC 355mm | R,G,B, CH4 | 76 |
| Christopher Go | Philippines | SC 355mm | R,G,B,CH4 | 56 |
| Satoshi Ito | Japan | Newton 250mm | R,G,B | 1 |
| Teruaki Kumamori | Japan | SC 355 mm | L,R,G,B | 5 |
| George Lamy | USA | SC 355mm | R,G,B | 1 |
| Mark Lonsdale | Australia | SC 280mm | R,G,B | 1 |
| Bruce MacDonald | USA | SC 355mm | L,R,G,B | 8 |
| Niall MacNeill | Australia | SC 355mm | R,G,B,CH4 | 28 |
| Walter Martins | Brazil | Newton 203mm<br>Newton 305mm | R,G,B | 6 |
| Lucas Magalhaes | Brazil | Newton 317mm | R,G,B | 1 |
| Phil Miles | Australia | Newton 508mm | R,G,B, CH4 | 2 |
| Masaaki Nagase | Japan | SC 235mm | R,G,B | 1 |
| Tiziano Olivetti | Thailand | DK 505mm | R,G,B | 20 |
| Damian Peach | Chile (*) | RC 1000mm | R,G,B | 12 |
| Christophe Pellier | France | SC 305mm | R,G,B | 1 |
| Darryl Pfintzer Milika | Australia | SC 355mm | R,G,B | 6 |
| Vlamir da Silva | Brazil | SC 203mm | R,G,B | 1 |
| Avani Soares | Brazil | SC 355mm | L,R,G,B | 12 |
| Maciel B. Sparrenberger | Brazil | Newton 317mm | R,G,B | 1 |
| Vicenzo della Vecchia | Italy | Cassegrain 300mm | R,G,B | 1 |
| Leandro Yasutake | Argentina | Newton 355mm | R,G,B | 1 |
| Kenkichi Yunoki | Japan | Newton 260mm | R,G,B | 1 |
| Anthony Wesley | Australia | Newton 508mm | R,G,B,CH4 | 4 |
| Michael Wong | Australia | Newton 305mm | R,G,B, CH4 | 26 |

**Text S2.**

Description of the analysis of ground-based and HST images. The images submitted by the observers to the databases were normally, reprocessed for contrast enhancement, navigated for limb determination and measured. We used the WinJUPOS software (Hahn & Jacquesson http://www.grischa-hahn.homepage.t-online.de/) to navigate the images transforming the original pixel coordinates of a point on Saturn's disk to longitude and latitude positions over the planet. This software was also employed to produce polar stereographic maps. For the determination of the longitudes on the planet disk we use System III (period = 9 hr 55 min 29.711 s) (Archinal et al. 2018).

**Text S3.**

We provide here details of the numerical dynamical SW model we have used. The polar storm was simulated using the Shallow Water model (SW) where the weather layer is modeled as a thin sheet of homogeneous fluid. SW models are a simplification of the real atmosphere, but still they preserve a good deal of the large scale dynamics on a rotating sphere or ellipsoid, while allowing a fast computation by explicitly integration of the prognostic variables. Our SW is a parallelized code able to run on supercomputers. Model resolution was 0.02 degrees per control volume and the time step was set to 1 second, which ensured that the CFL condition was not violated. The storm was modeled as a continuous mass injection throughout the whole simulation time. Simulations were run for a Rossby radius of deformation $L_R = (gD)^{1/2} / f \sim 300\,km$, where $g \cong 10\,m\,s^{-1}$, $D = 1000\,m$ is the depth of the model, and $f \simeq 3.2 \times 10^{-4} s^{-1}$ is the Coriolis parameter. Saturn's zonal winds were continuously forced as described in García-Melendo and Sánchez-Lavega (2017).

**Table S2. Shallow Water model simulations: parameter space ranges**

| ***Parameter*** | ***Value or range of values*** |
|---|---|
| Horizontal resolution | $\Delta x = \Delta y = 0.05$ deg pix$^{-1}$ |
| Time step | 1 second |
| Layer depth | 1000 m |
| Simulation domain (long, lat) | Long [0º, 180º]; Lat [63º, 83º] |
| Storm major and minor semiaxes dimensions | 1º × 1º |
| Latitude range | 73.0 to 77.0 in 0.5 deg steps |
| Continuous mass flow injection Q range | $1\times10^{8}$ to $1\times10^{12}$ $m^3\,s^{-1}$ |
| Number of simulations | 50 |

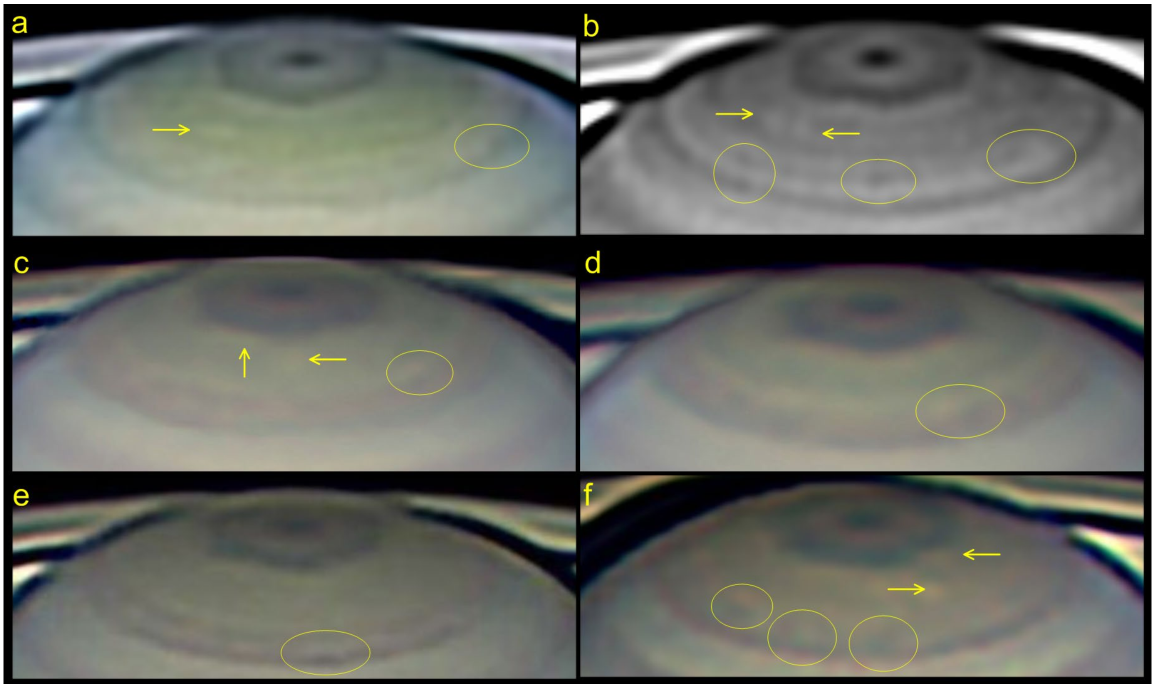


**Figure S1.** Color composite images of the North Polar Region of Saturn in 2019. The hexagon wave is easy to identify and the lower dark belt locates at latitude 60ºN. The arrows mark the spots at the hexagon southern edge and in close latitudes. The circles enclose long-lived spots tracked along the year as shown in Figure S3. Dates and observers: (a) 8 April 10:23UT, D. Peach; (b) 20 April 21:03 UT, T. Olivetti; (c) 25 April 19:49 UT, N. MacNeill; (d) 27 April 18:09 UT, N. MacNeill; (e) 24 May 18:14, N. MacNeill; (f) 15 September 12:13 UT, N. MacNeill.

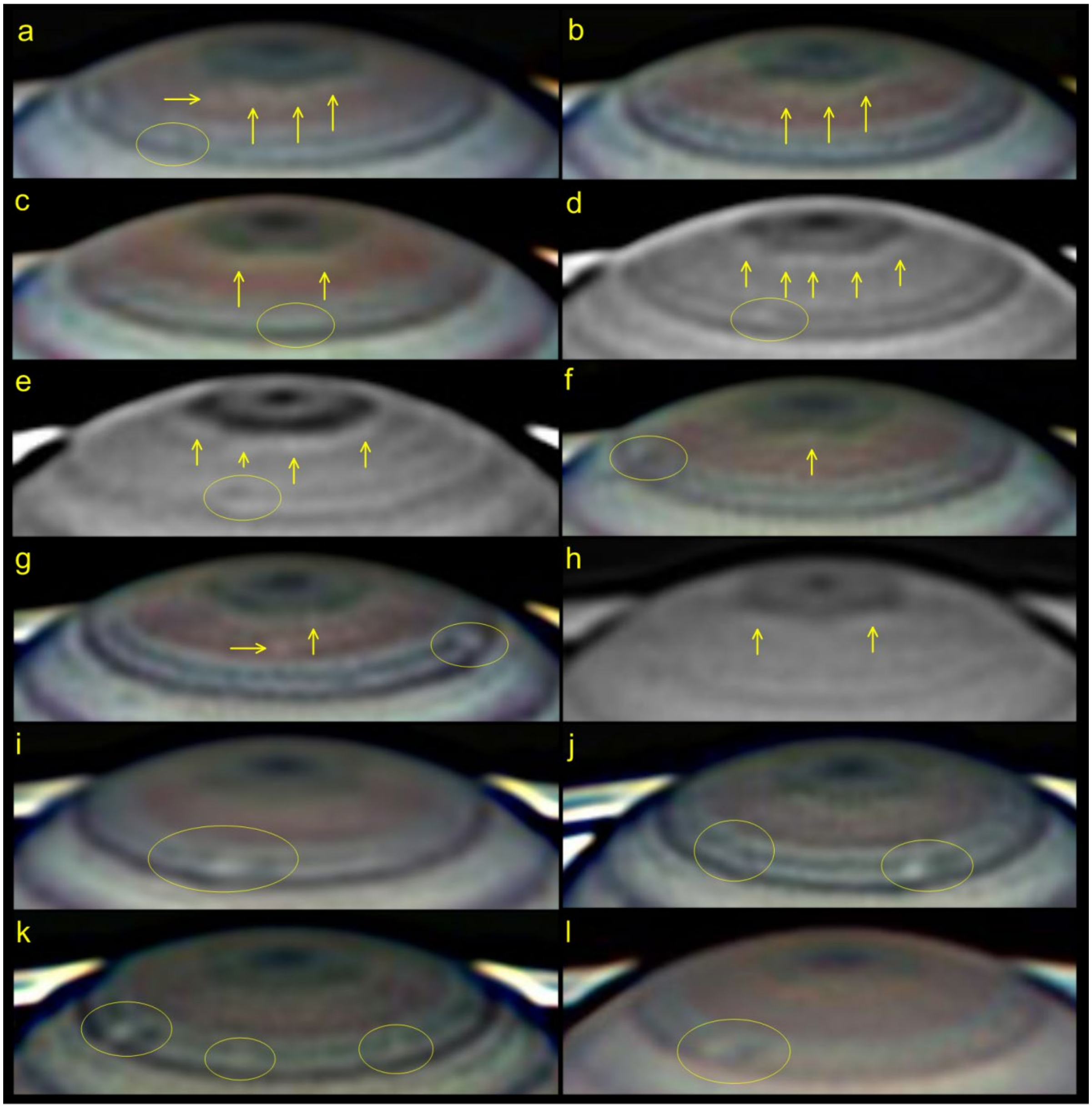


**Figure S2**. Color composite images of the North Polar Region of Saturn in 2020. The hexagon wave is easy to identify in (a-h) due to the combination of filters used. The lower dark belt locates at latitude 60ºN. The arrows mark the spots at the hexagon southern edge (latitudes 75ºN-76ºN) and in close latitudes. The circles enclose long-lived spots tracked along the year as shown in Figure S4. Dates and observers: (a) 9 May 20:20 UT, C. Go;(b) 11 May 30:34 UT, C. Go; (c) 12 May 20:00 UT, C. Go; (d) 15 May 20:48 UT, T. Olivetti; (e) 16 May 21:48 UT, T. Olivetti; (f) 27 May 18:39 UT, C. Go; (g) 8 June 18:35 UT, C. Go; (h) 6 July 15:01 UT, T. Barry; (i) 9 July 17:26 UT, C. Go; (j) 17 July 15:33 UT, C. Go; (k) 20 July 14:41 UT, C. Go; (l) 31 July 13:41 UT, N. MacNeill.

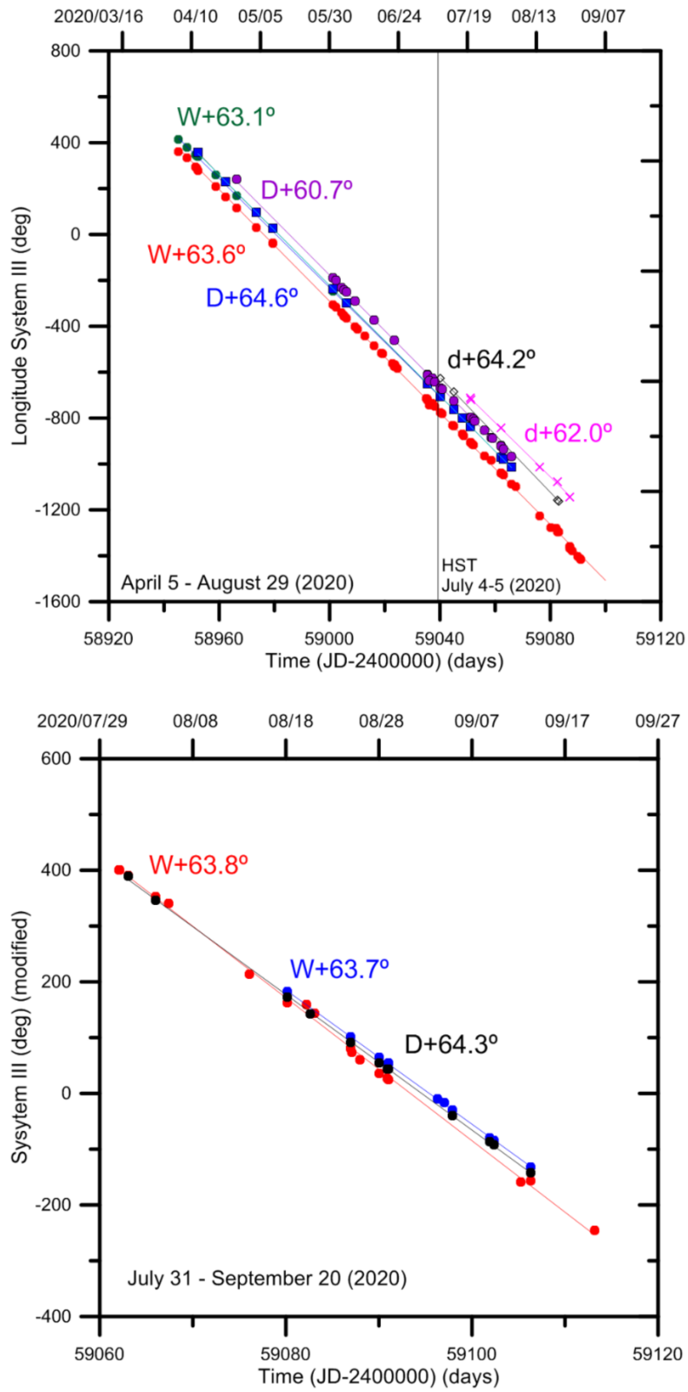


**Figure S3.** Long-term drift in System III longitudes during 2020 of various large white (W) and dark (D) spots and smaller dark spots (d) observed at red wavelengths (~ 650 – 900 nm) on the double jet between latitudes ~ 60ºN and 67ºN. The W and D spots form a system of cyclones and anticyclones as described in del Rio-Gaztelurrutia et al. (2018). The planetographic latitudes of the spots are indicated. Their velocities in the wind profile are shown in Figure 2. The upper x-axis gives the date (year/month/day).

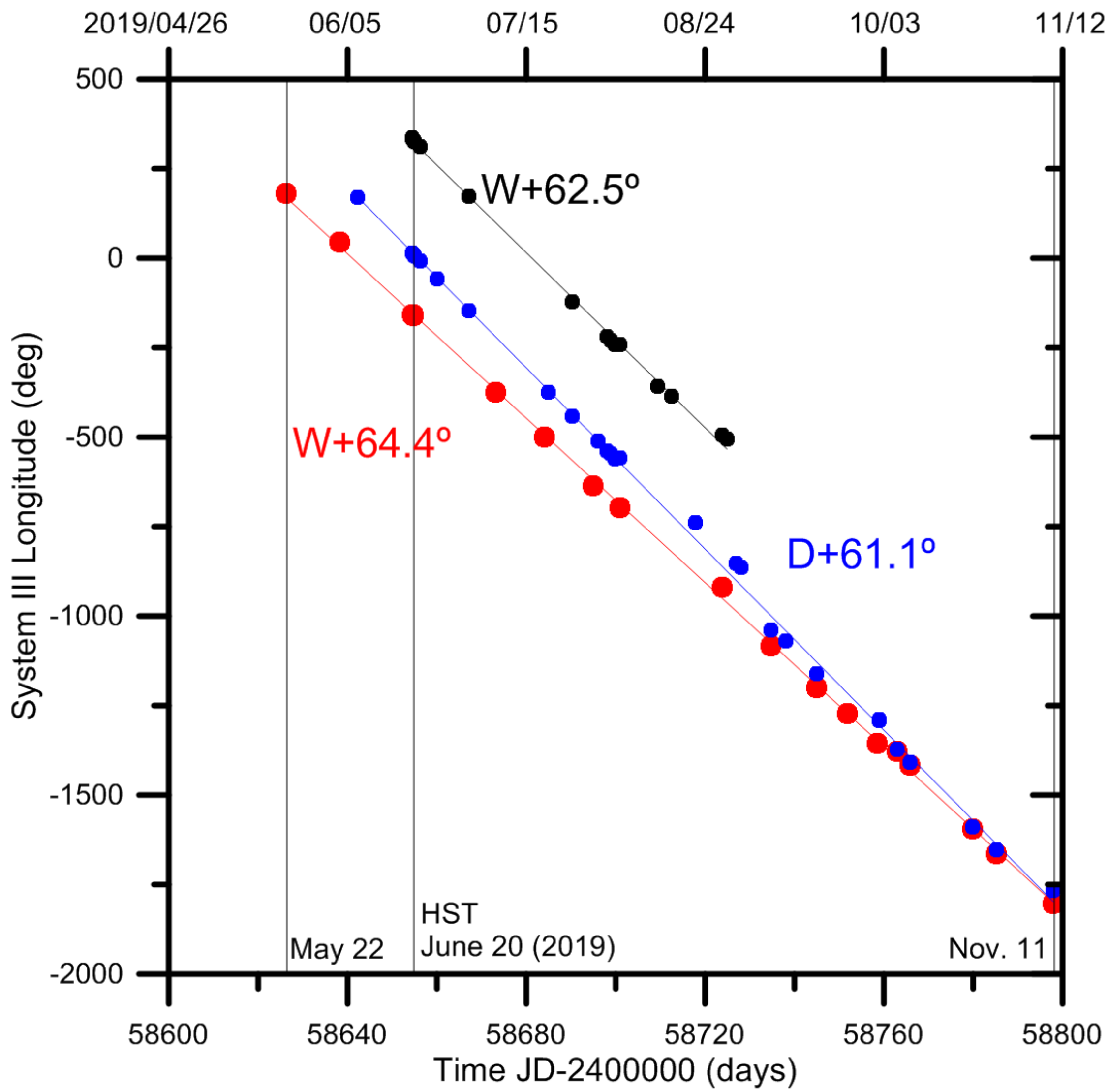


**Figure S4.** Long-term drift in System III longitudes during 2019 of three white (W) and dark (D) spots observed at red wavelengths (~ 650 – 900 nm) on the double jet between latitudes ~ 60ºN and 67ºN. These spots form a system of cyclones and anticyclones as described in del Rio-Gaztelurrutia et al. (2018). The planetographic latitudes are indicated. Their velocities in the wind profile are drawn in Figure S5. The upper x-axis gives the date (year/month/day).

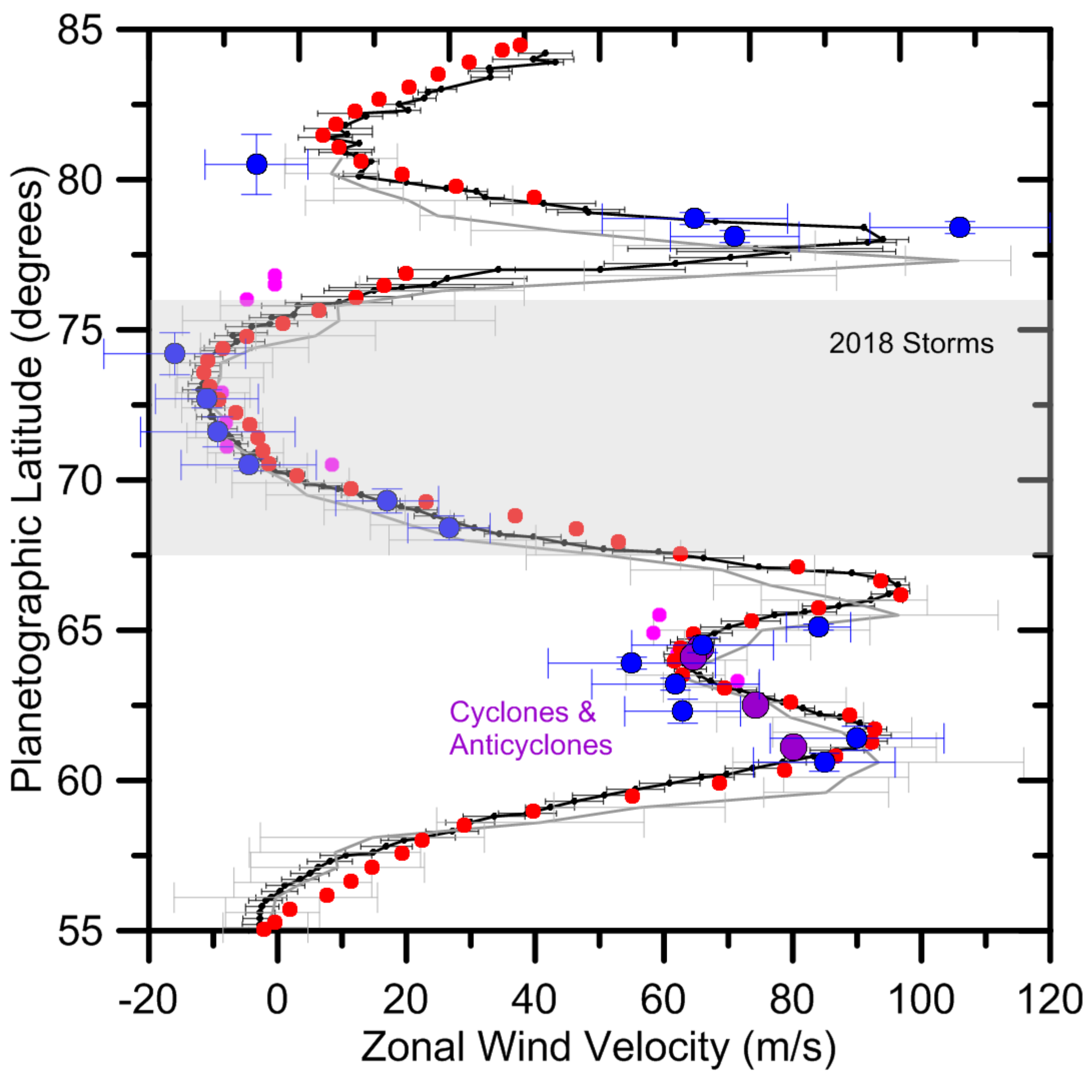


**Figure S5.** Zonal wind profile in Saturn's North Polar Region measured in 2019 relative to System III rotation frame. The red dots are from the correlation velocimetry on HST images in 19-20 June 2019 (Simon et al., 2021) and blue dots from motions of major features manually tracked and binned in latitude bands with a width 0.5º - 1º from the same HST images (error bars indicated). The magenta dots are spots tracked in ground-based images in 2019. The three large purple dots correspond to the long-lived spots (Figs. S1 and S3). The black profile and dark dots is the wind profile from Cassini ISS measurements [García-Melendo et al. 2011] and the grey profile from Voyagers 1 and 2 [Sánchez-Lavega et al. 2001]. The shadowed area indicates the latitude band where the 2018 storms evolved.