A new polar storm system in Saturn’s atmosphere during 2018


European Planetary Science Congress, Berlin, 18 September 2018
SATURN’S CONVECTIVE STORMS

Voyager 1 & 2
Latitude 38° N

Cassini (2004-2009)
Latitude 38° S

Bright & irregular cloud systems ~ 2,000km

GWS 2010

Dyudina et al., 2009-13

Assisted lightening and radio emission (SED)
→ Moist convection (NH₃, H₂O)

STORMS IN THE WIND PROFILE AT CLOUD LEVEL

Reference frame: Voyager System III

García-Melendo et al., 2011; Sánchez-Lavega et al., Saturn Cassini, CUP, 2018
POLAR STORMS IN 2018: THE OBSERVATIONS
FIRST STORM WS1 – Planetographic latitude 67°N

Length = 10° x Width = 4° → 4,400 x 1760 km

Drift in S-III Longitude = -11.55°/day
SECOND STORM WS2 (25 May, ∆ t= 56 days - latitude 69°N)

Hubble Space Telescope – WFPC (OPAL): 6-7 JUNE

WS2: S-III Longitude drift = -3°/day

2018-06-06 13:11:47 F631N
THIRD STORM WS3 (18 June, $\Delta t = 81$ days - latitude 72°N)

WS2 & tail
June 17
D. Peach

WS3
June 18
D. Peach

WS3
June 18
M. Wong

WS3: S-III Longitude drift = +1.28°/day

WS3
WS2 & tail
June 22
A. Casely

WS1
WS3
June 23
T. Barry
ENCOUNTER 1: WS1-WS3 (29 June, $\Delta t = 93$ days)

June 28
D. Peach

June 30
D. P. Millika & Nicholas

WS1-WS3 interaction $\rightarrow$ zonal disturbance $\Delta L \sim 100^\circ$

ENCOUNTER 2: WS1-WS2 (8 July, $\Delta t = 102$ days)

July 11
B. Macdonald

July 14
B. Macdonald

July 16
W. Martins
ENCOUNTER 3: WS1-WS2 (15 August, Δt = 140 days)

Zonal disturbance: Latitude = 67°, ΔL = 100°, λ = 7,500 km
S-III LONGITUDE DRIFT OF STORMS WS1 – WS2 – WS3

Data from:
ALPO Japan (repository)
PVOL 2 (repository)
HST-OPAL Program
Planetcam @ 2.2 m

N. images analyzed: 320 (reprocessed)

Cloud tracking:
N. measurements ~ 1,500
WS1 FORMED INSIDE A CYCLONE

Observed in Jupiter cyclones:
South Equatorial Belt Disturbance 2010-11 (Fletcher et al., 2017)
South Temperate Belt (Iñurrigarro et al., Poster 13 –OPS4)
MODELS
<table>
<thead>
<tr>
<th>Waveband (nm)</th>
<th>Absolute reflectivity calibration (I/F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>225</td>
<td></td>
</tr>
<tr>
<td>343</td>
<td></td>
</tr>
<tr>
<td>395</td>
<td></td>
</tr>
<tr>
<td>467</td>
<td></td>
</tr>
<tr>
<td>502</td>
<td></td>
</tr>
<tr>
<td>631</td>
<td></td>
</tr>
<tr>
<td>727</td>
<td>CH$_4$</td>
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</tbody>
</table>

STORMS AT WAVELENGTHS 225 nm – 727 nm (HST-WFPC)
Storm: brighter particles than surroundings in UV-red

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Latitude 69° N (2018)</th>
<th>Storm WS1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau$ (stratosphere)</td>
<td>0.02±0.01</td>
<td>0.04±0.01</td>
</tr>
<tr>
<td>$\tau$ (troposphere)</td>
<td>10.1±2</td>
<td>32.9±2</td>
</tr>
<tr>
<td>$\tau$ (cloud)</td>
<td>7.2±2</td>
<td>7.8±2</td>
</tr>
<tr>
<td>$P_{\text{Haze}}$ (base)</td>
<td>320±50 mbar</td>
<td>270±50 mbar</td>
</tr>
<tr>
<td>Haze thickness</td>
<td>33.3±2 km</td>
<td>30.2±2 km</td>
</tr>
<tr>
<td>$N_{\text{max}}$</td>
<td>49±10 cm$^{-3}$</td>
<td>216±10 cm$^{-3}$</td>
</tr>
<tr>
<td>$H/H_{\text{aerosol}}$</td>
<td>0.47±0.1</td>
<td>0.34±0.1</td>
</tr>
<tr>
<td>Particle size (a)</td>
<td>0.10±0.1 µm</td>
<td>0.18±0.1 µm</td>
</tr>
</tbody>
</table>
EPIC code (T. Dowling, U. Louisville): U(z), T(z), N(z), domain size, spatial resolution

Outburst inside a cyclone

Pulse as a Gaussian spot (size = 0.35°) & Intensity = 1 - 20 W/ m²

Storms as isolated localized pulses
COMPARISON TO GWS

Flow: $10^{10} - 10^{11} \text{ m}^3 \text{s}^{-1}$ (GWS2010) - $10^{12} \text{ m}^3 \text{s}^{-1}$ (GWS1990)
Amplitude: 200m/1500m - Gaussian size: 3.5°

→ Intensity: GWS = 100 × WS

Gaussian spots: $a = b = 0.5°$
Amplitude = 5 m/1500 m (H)
Intensity (flow) = $6.0 - 18 \times 10^8 \text{ m}^3 \text{s}^{-1}$

Shallow Water - 1 layer model
DISCUSSION & CONCLUSION

• The bright spots can be explained if their cloud tops are at the tropopause (~ 100 mbar) with no overshooting, brighter and larger particles, and number density x 4 surrounding clouds.

• Dynamical models suggest they could be formed by moderate convective activity implying energies ~ 0.1- 0.01 those required to form a GWS.

• The first storm emerged in a compact coherent cyclone representing another example of such phenomena as observed in Jupiter.

• This system of three interacting storms can be considered dynamically as an intermediate case of disturbance between a GWS planetary-scale phenomenon and the small-scale convective activity observed by Voyager 1 &2 and Cassini at northern and southern mid-latitudes, respectively.

• This phenomenon looks like the one that occurred in 1994 at latitude 56°S (Sánchez-Lavega et al., Science, 271, 631. 1996).
THANK YOU VERY MUCH FOR YOUR ATTENTION
SATURN & STORMS IN ROTATION (2-3 hrs)

July 27, B. Macdonald

August 4, B. Macdonald

July 28, B. Macdonald
LONGITUDE & LATITUDE OF WS1

Drift rate = $-11.55^\circ/d$ (S-III)
N = 186 ($r=0.99993$)
Mean latitude = $66.7 \pm 0.7$
Zonal velocity: $u = 59.8 \pm 1 \text{ ms}^{-1}$