



## The onset and expansion of the 2018 Martian Global Dust Storm from ground-based and VMC/MEx imaging

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# 2018 Martian Global Dust Storm (GDS 2018)

## ➤ **Observations (May – July 2018)**

(1) Ground-based images in public repositories:

PVOL (Planetary Virtual Observatory Laboratory) at UPV/EHU

ALPO-Japan (Association of Lunar Planetary Observers)

Contributions from 40 observers



**Mars Section of ALPO-Japan**

(2) Visual Monitoring Camera (VMC) onboard MarsExpress



## ➤ **References for this work:**

(1) A. Sánchez-Lavega, et al., The onset and growth of the 2018 Martian Global Dust Storm, ***Geophys. Res. Lett.***, **46**, 6101-6108 (2019).

(2) J. Hernández-Bernal, et al., The 2018 Martian Global Dust Storm over the South Polar Region studied with MEx/VMC, ***Geophys. Res. Lett.*** (in the press).

# Onset of the GDS 2018

Precursor storm: 27 May – Vastitas Borealis (Longitude =  $347^{\circ}\text{W}$  – Latitude =  $56^{\circ}\text{N}$ )

Onset: 30-31 May - Acidalia Planitia (Longitude =  $18^{\circ}\text{W}$  – Latitude =  $31.7^{\circ}\text{N}$ )

**Orbital Longitude:  $L_s = 184^{\circ}$**



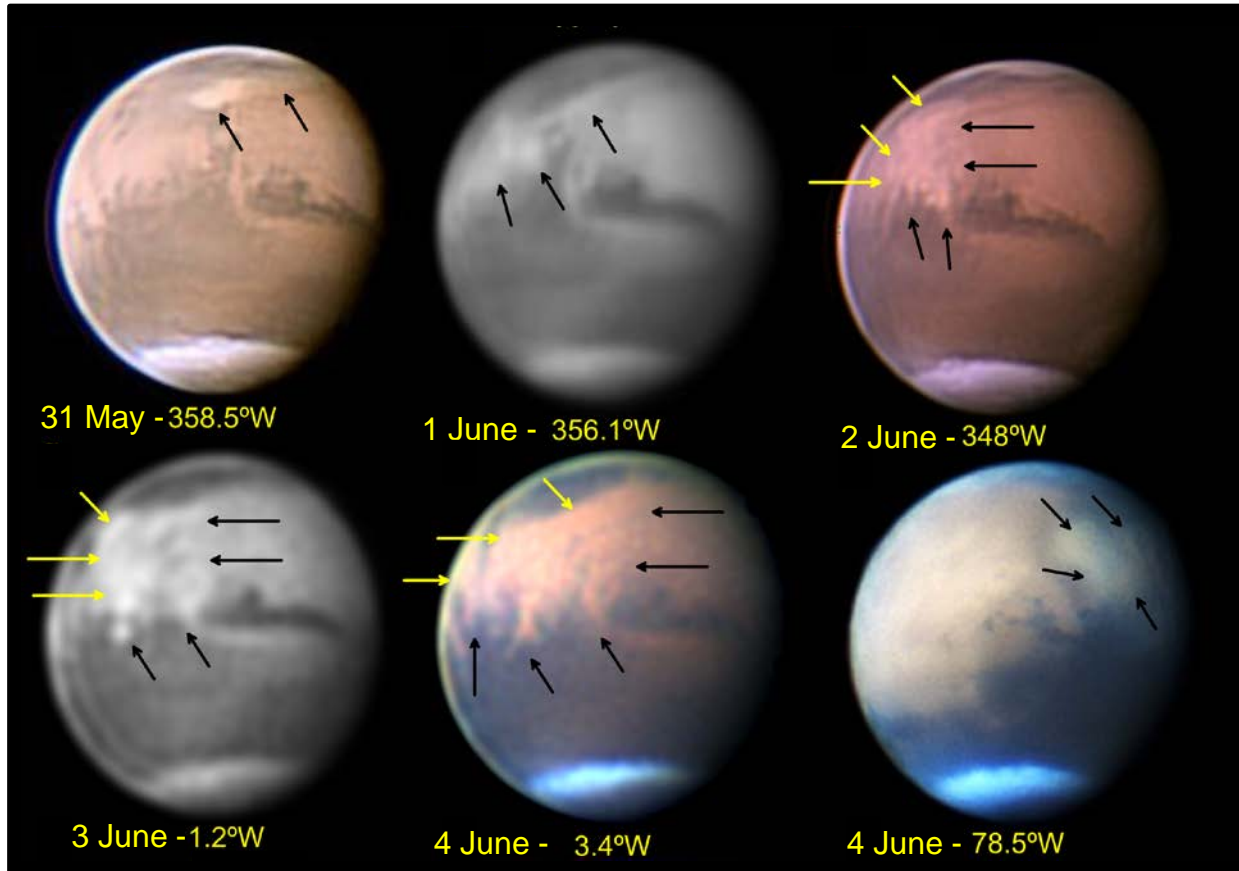
Observers:

T. Olivetti

G. Grassmann

E. Morales

# Early expansion of GDS 2018: 31 May – 4 June



## Meridional:

North → South expansion  
along the Acidalia “corridor”

## Zonal:

Eastward expansion  
Westward expansion

## Observers:

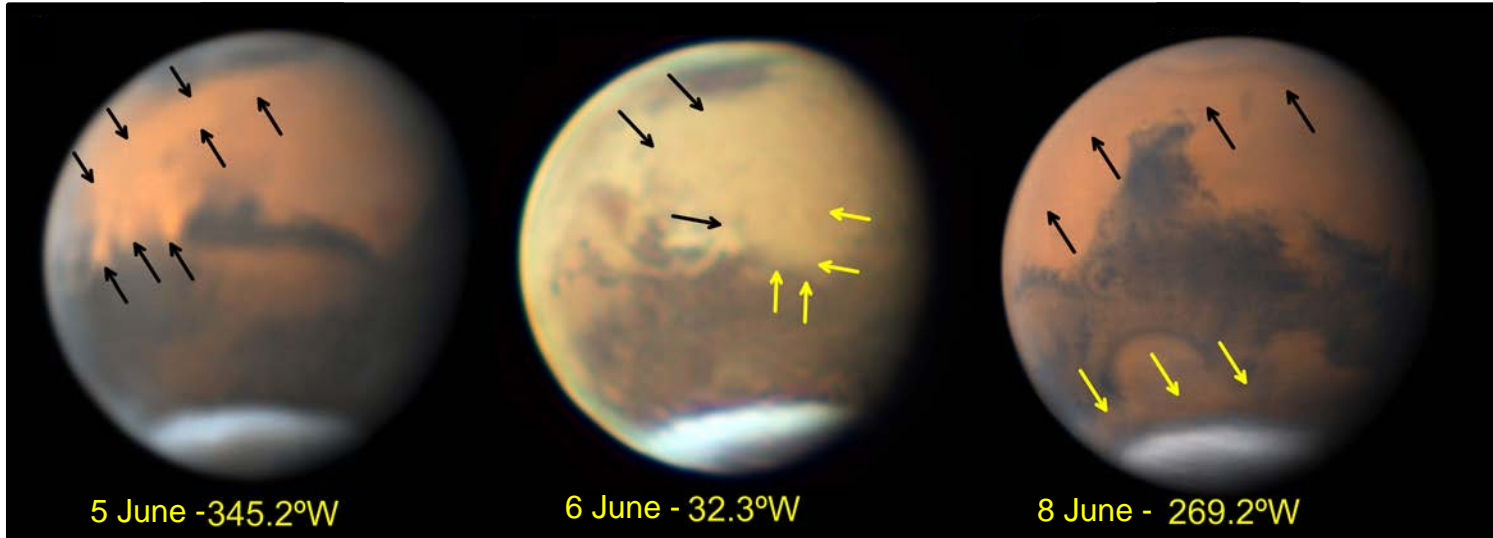
31 May, J. Rueck  
1 June, E. Morales  
2 June, J. Rueck  
3 June, P. Maxon  
4 June, K. Beverage  
4 June, D. Millika & Nicholas

# Expansion of GDS 2018: 5 -8 June

Central expansion

Westward expansion

Eastward expansion



Observers:

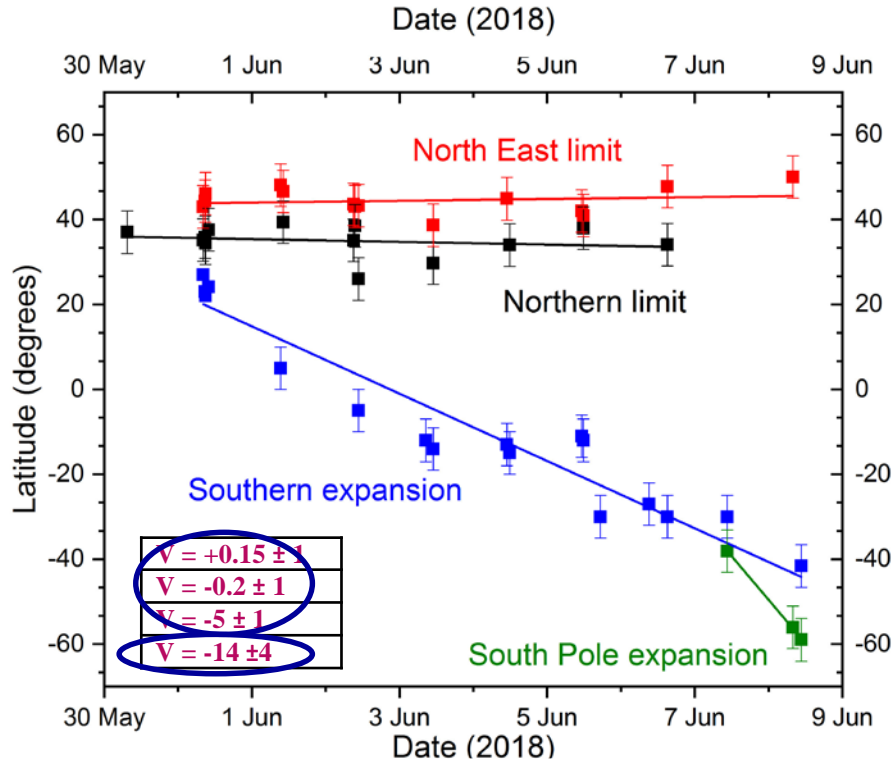
D. Peach

A. Casely

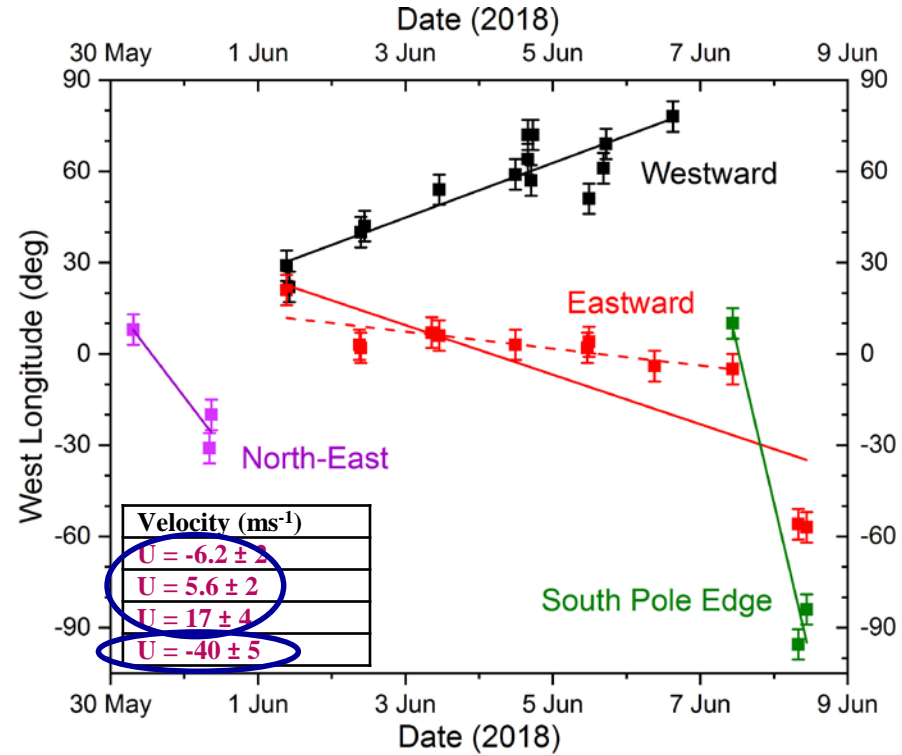
D. Peach

# Dust expansion velocities

**Meridional drift and velocity (North-South)**  
**Specific longitudes**



**Zonal drift and velocity (East-West)**  
**Specific latitudes**

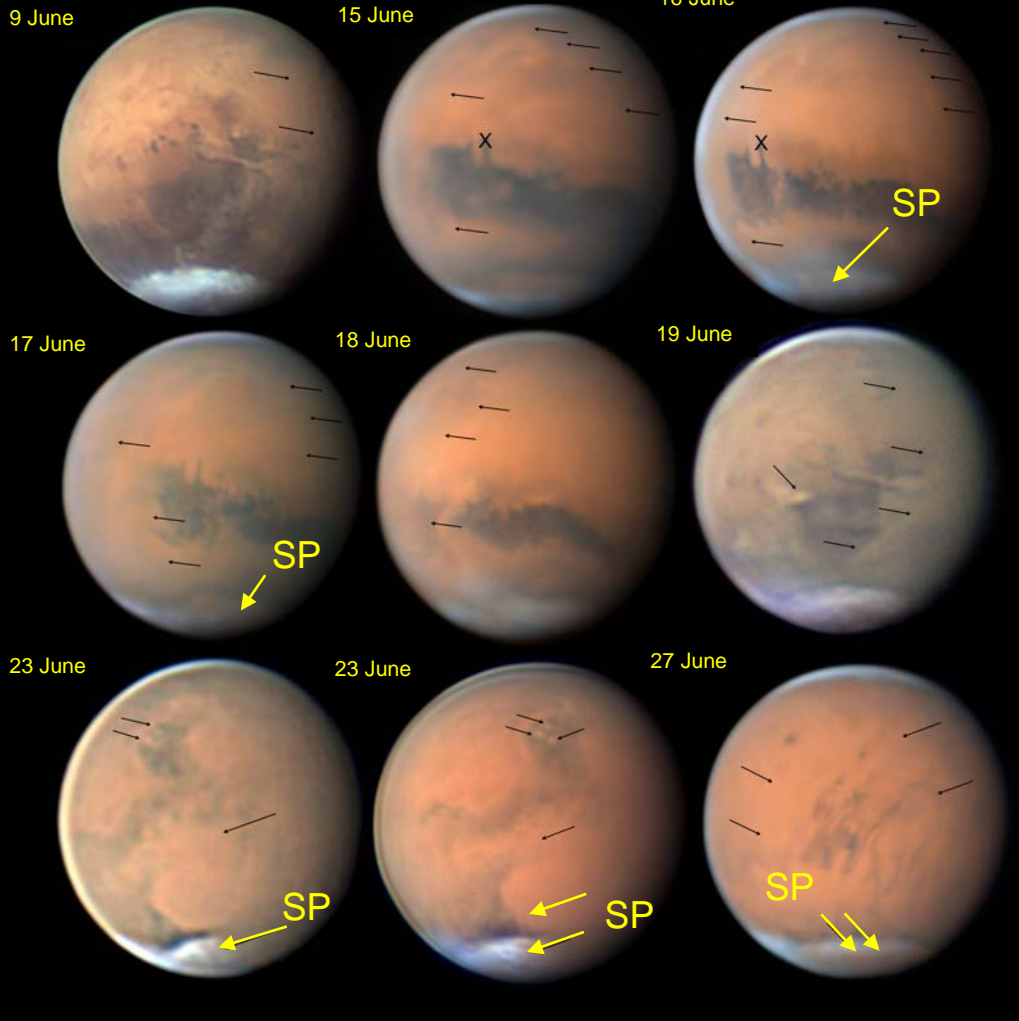


# Global Expansion: 9 – 27 June

E. Morales movie 31 May – 4 July



**GDS reached Curiosity (X) by 8-9 June**  
**GDS penetrated the South Pole (SP) by 9-11 June**



9 June, A. Wesley

15 June, D. Peach **X Curiosity**

16 June, D. Peach **X Curiosity**

17 June, D. Peach

18 June, D. Peach

19 June, C. Foster

23 June, A. Wesley

23 June, C. Go

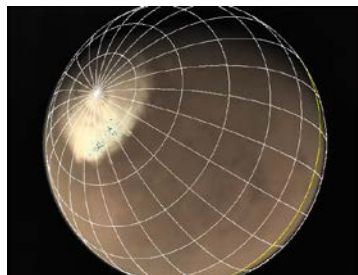
27 June, D. Peach

# GDS 2018 penetrating and expanding in the South Pole: VMC/MEx observations

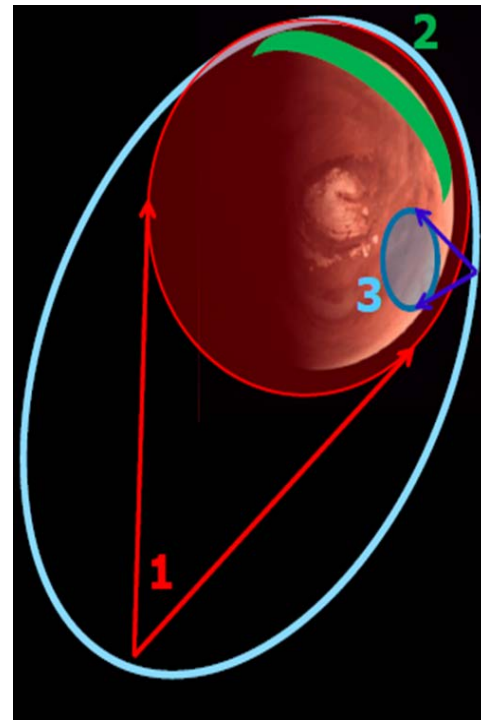
- VMC monitoring starting on June 18 due to technical pause
- ~ 1,000 images until August
- MEx apocenter near the South Pole
- Nadir and limb imaging



- FOV ~  $30^\circ \times 40^\circ$
- Navigation software (J. Hernández-Bernal)
- Science instrument 2017 (Sánchez-Lavega et al., Icarus 2018)
- Ongoing Radiometric Calibration



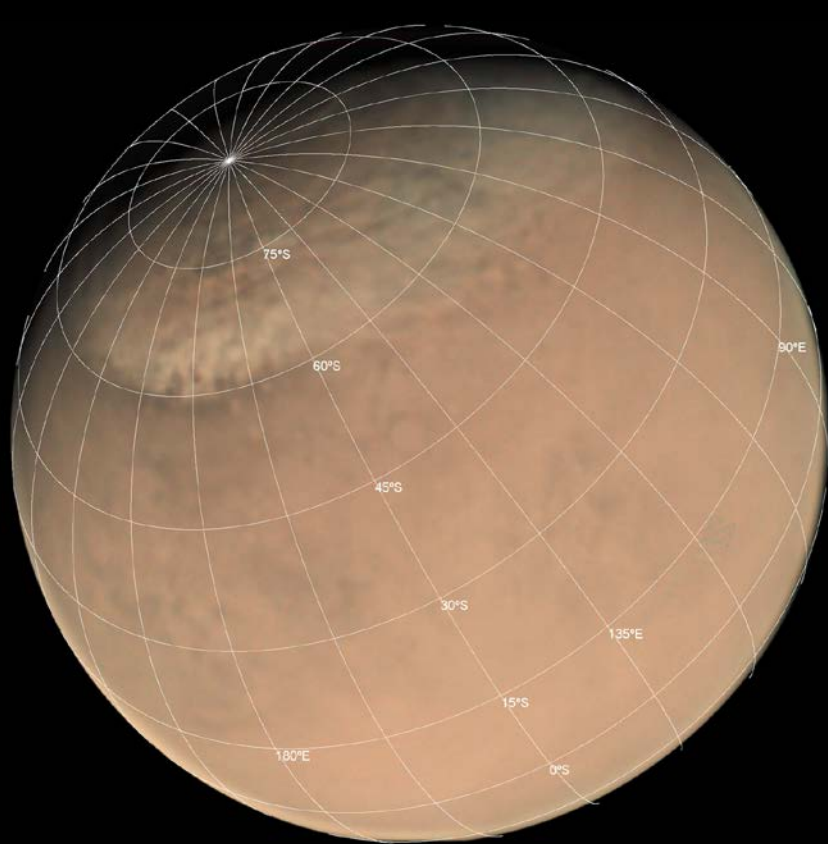
- \* EPSC-DPS2019-924 (E. M. Ravanis et al.)
- \* EPSC-DPS2019-1400 (J. Hernández-Bernal et al.)



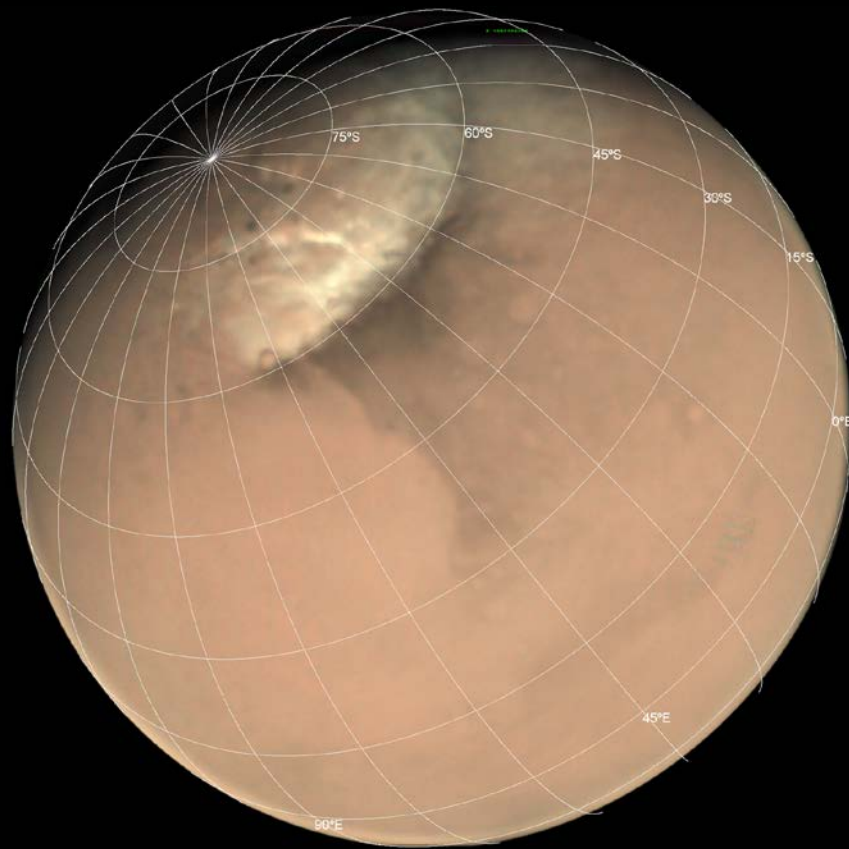
Pericenter ~ 300 km  
Apocenter ~ 10,000 km  
Period ~ 7.5 hr



# VMC full disk images during GDS 2018



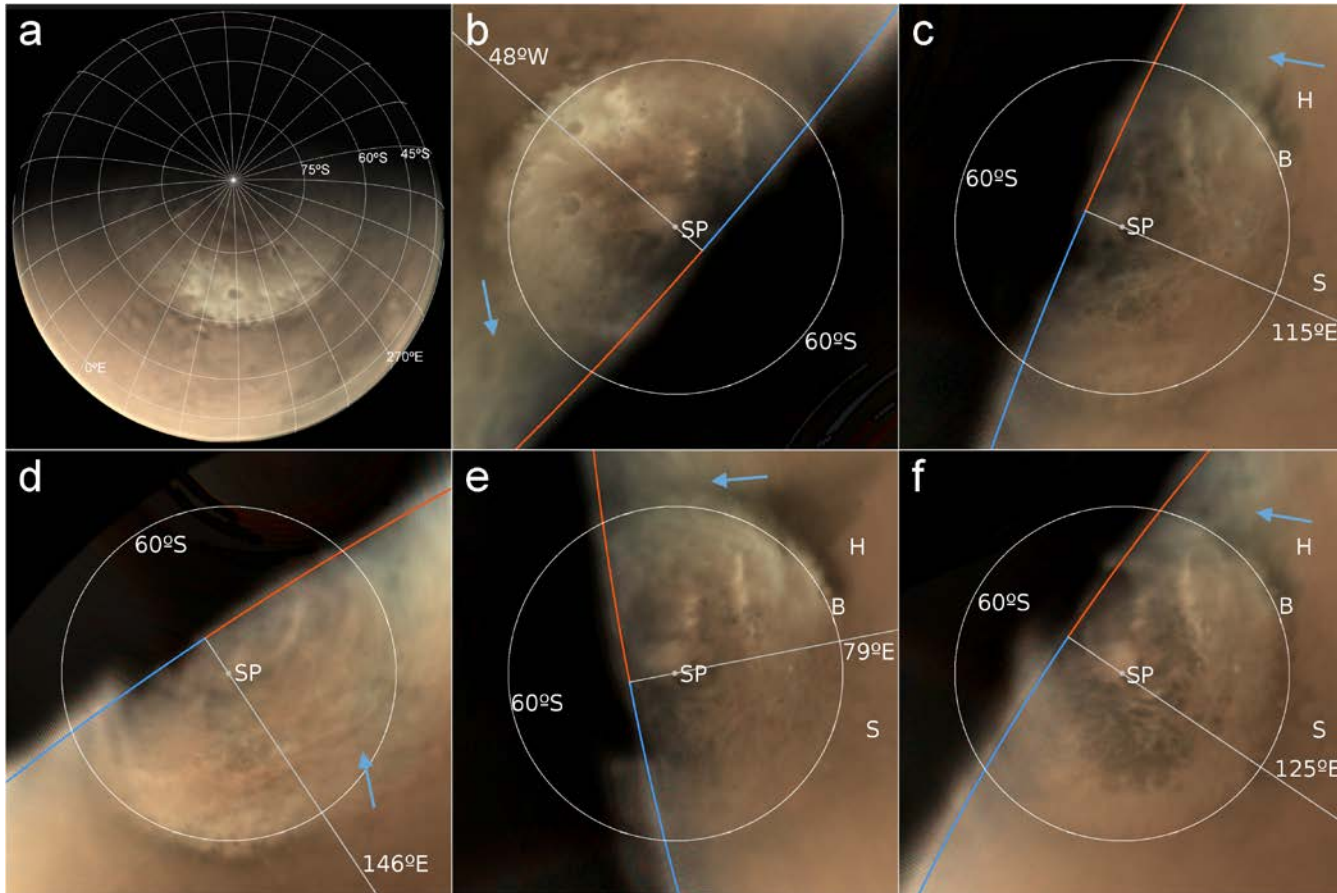
June 23



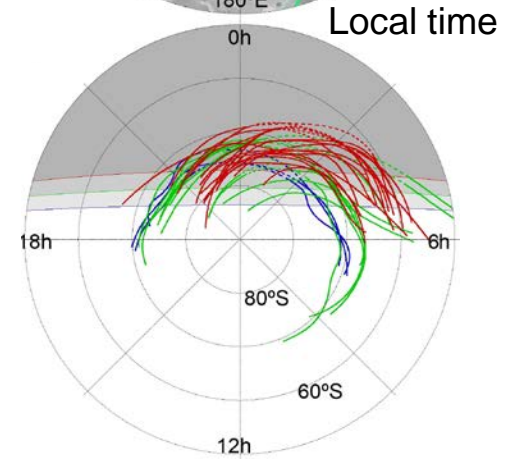
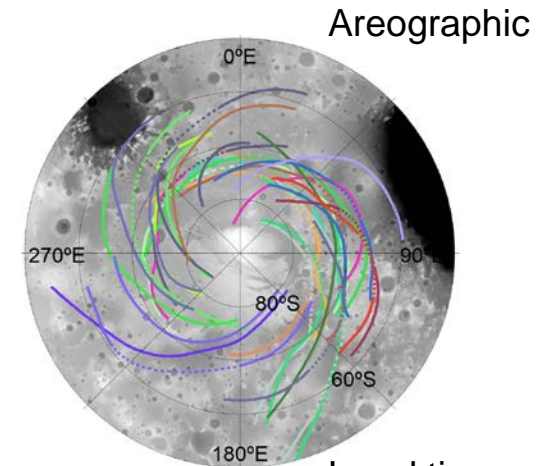
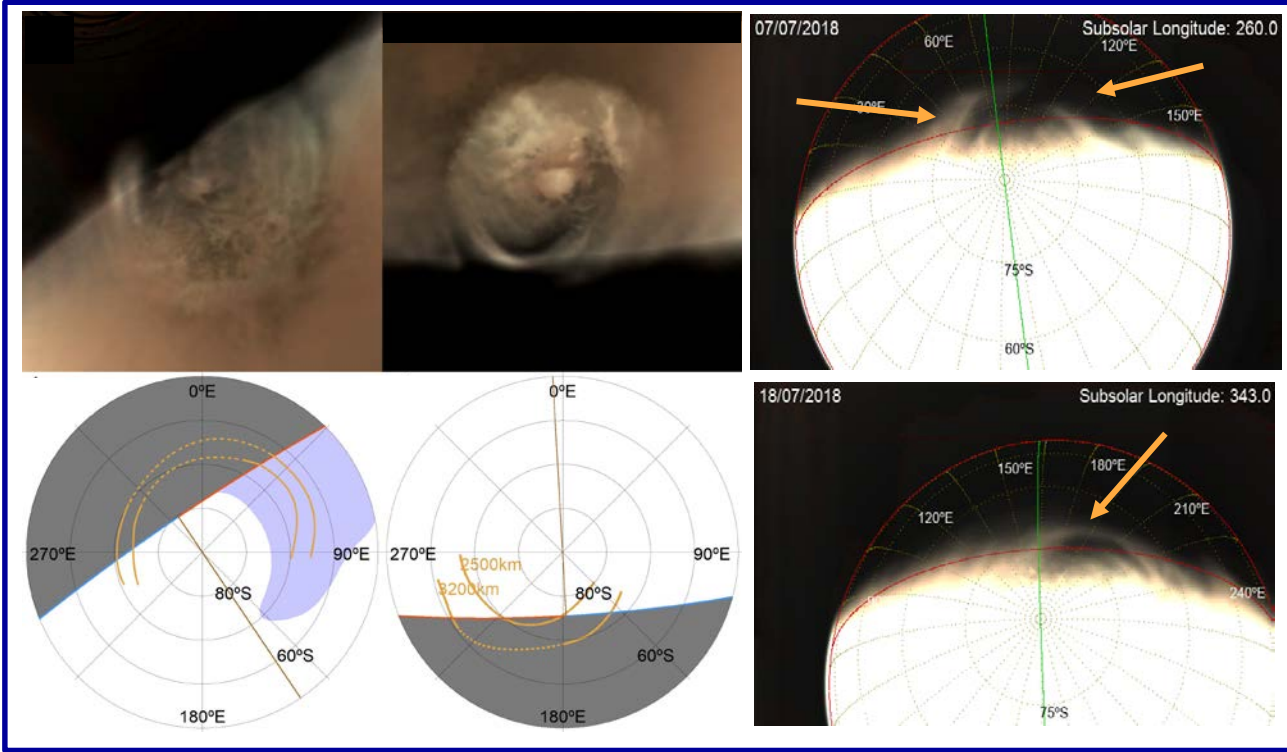
June 25

# GDS over the Southern Polar Region

**Polar projections: Morning water ice hazes and uneven distribution of dust**

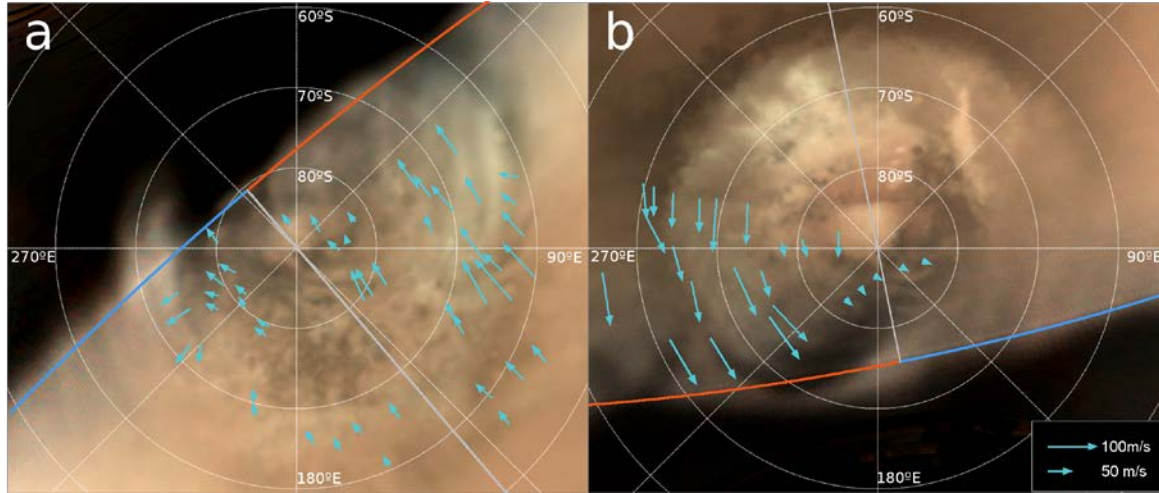


# Spiral & arc-shaped bands crossing the terminator

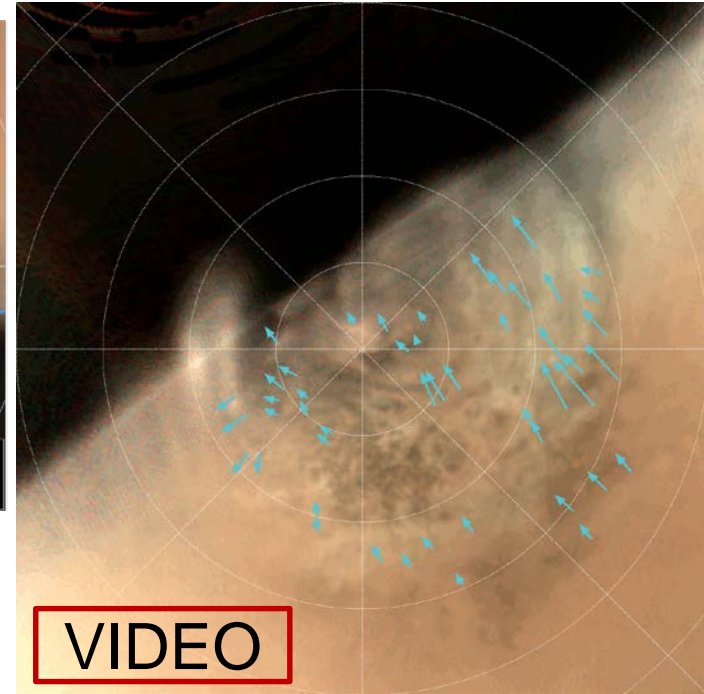


- \* Distance to the pole ~ 300-1500 km
- \* Length ~ 2000-3000 km & width ~ 300-500 km
- \* Altitude ~10-30 km over the surface at Mars terminator

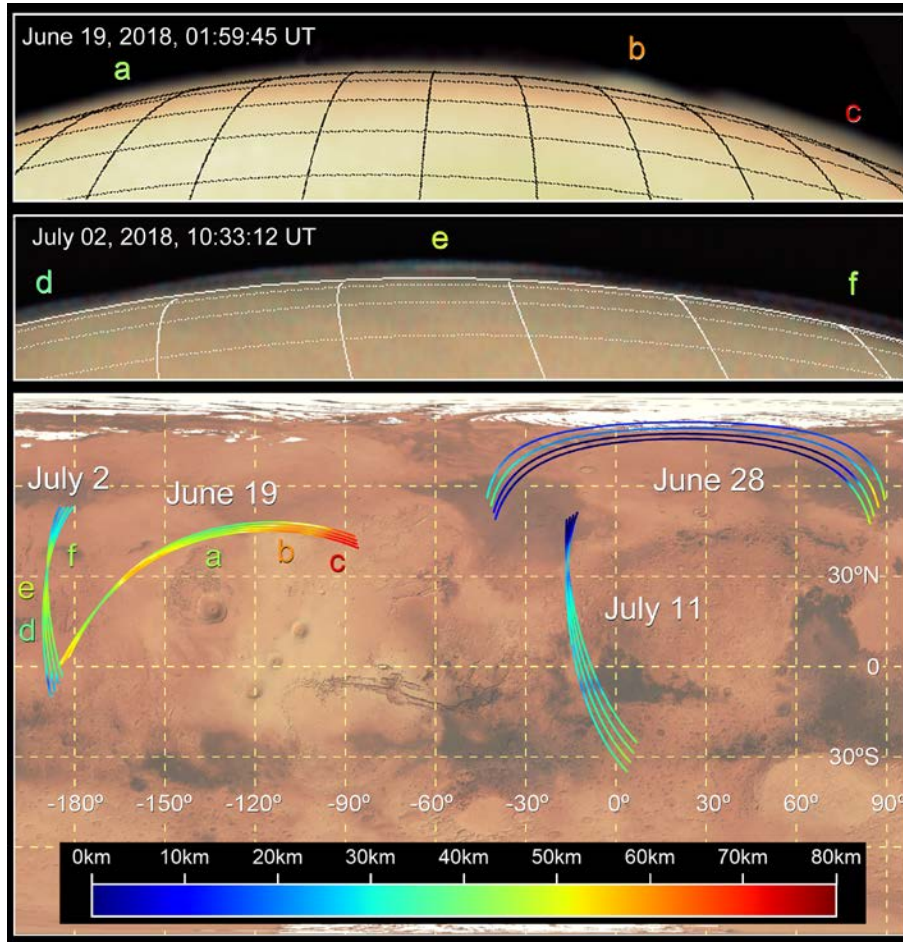
# Dust motions in the South Pole



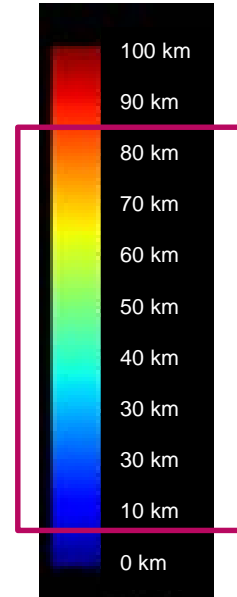
- Dust motions tend to be toward terminator (a, b)
- Sometimes it seems to trace a polar circulation (b)
- $V$  (max)  $\sim 90$  m/s



# Imaging the limb: projected dust (VMC/MEx)



Altitude



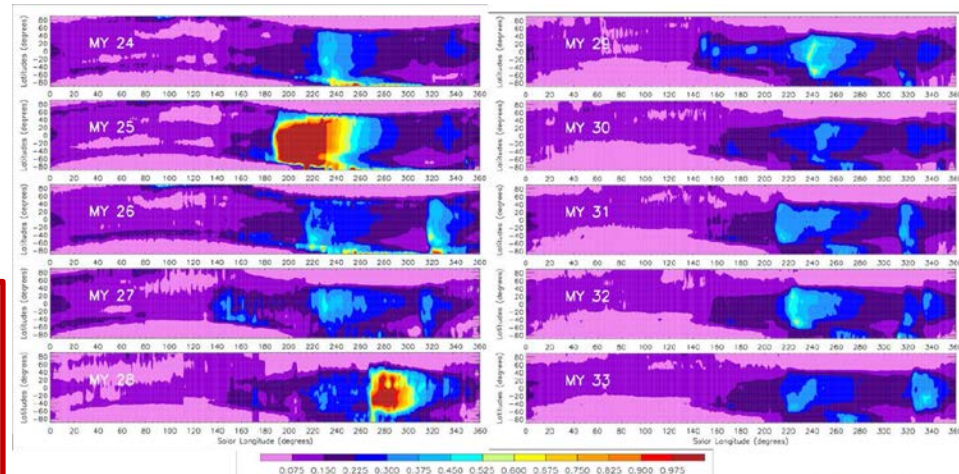
Dust top altitude ~ 70 km

# GDS 2018 in context

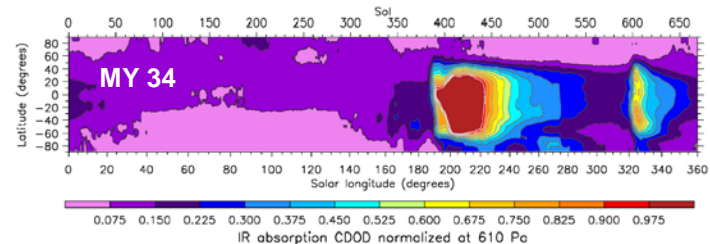
## Confirmed Martian Global Dust Storms or Planet Encircling Storms (\*)

Year	Martian Year (MY)	Ls	Duration	Initiation location
1956.63	1	249°	Aug 19-Nov	31°E, 30°S
1971.72	9	260°	Sep 22-Jan	38°E, 29°S
1973.81	10	300°	Oct 13-Dec	272°E, 24°S
1977.12	12	204°	Feb 15-April	265°E, 40°S
1977.23	12	268°	May 27-Oct	280°E, 48°S
2001.48	25	185°	June 26-Oct	75°E, 55°S
2007.47	28	262°	June 22-Oct	0°E, 45°S
<b>2018.41</b>	<b>34</b>	<b>184.9°</b>	<b>May 30-Aug</b>	<b>348°E, 35°N</b>

(\*) Following Khare et al. (2018)  
adding Sánchez-Lavega et al. (2019)

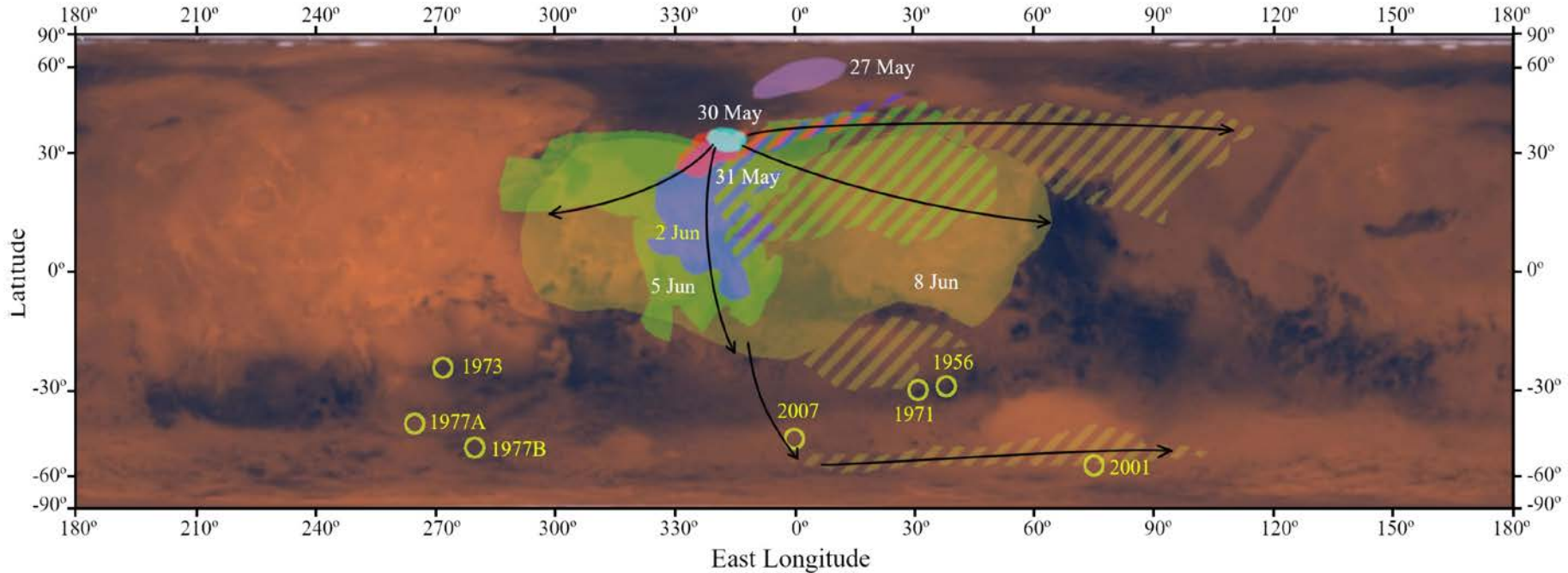


Montabone et al. (2015)



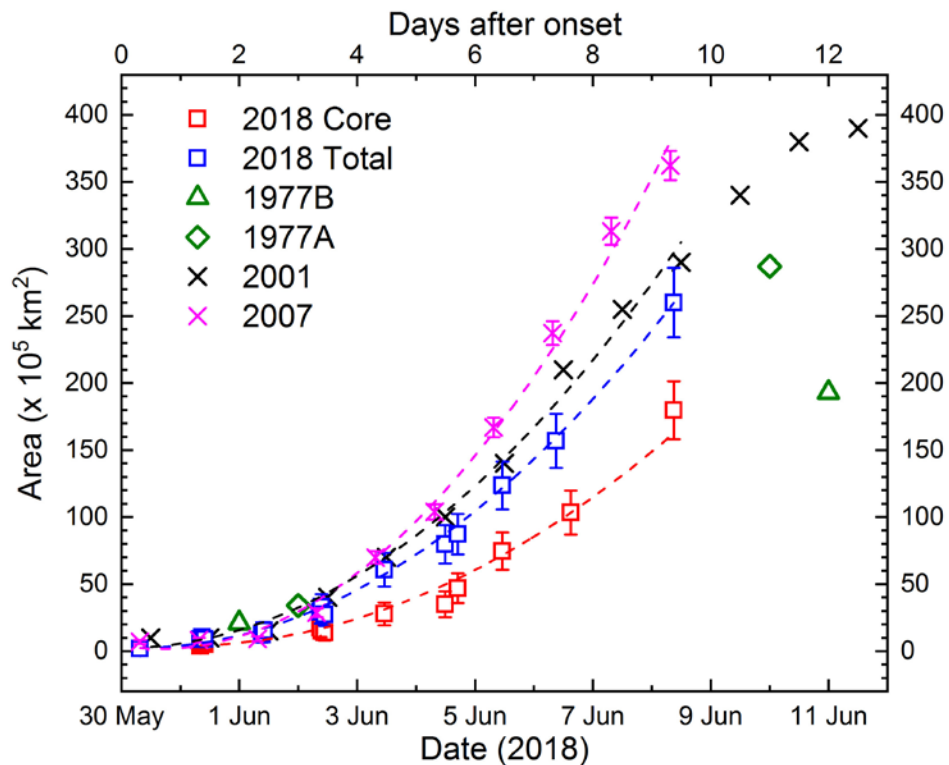
Montabone et al. (2019)

# GDS 2018 in context: Onset location and expansion



Expanding area GDS 2018 from 30 May to 8 June  
Precursor storm on 27 May (purple area)  
Expanding dust direction (arrows)  
Confirmed previous GDS (yellow disks, year indicated)

# GDS 2018 in context: total dust area growth



Expansion rate (after 7 days):

$$dA/dt \sim 4.3 \times 10^6 \text{ km}^2 \text{ day}^{-1}$$

< GDS2007 (MY 28)

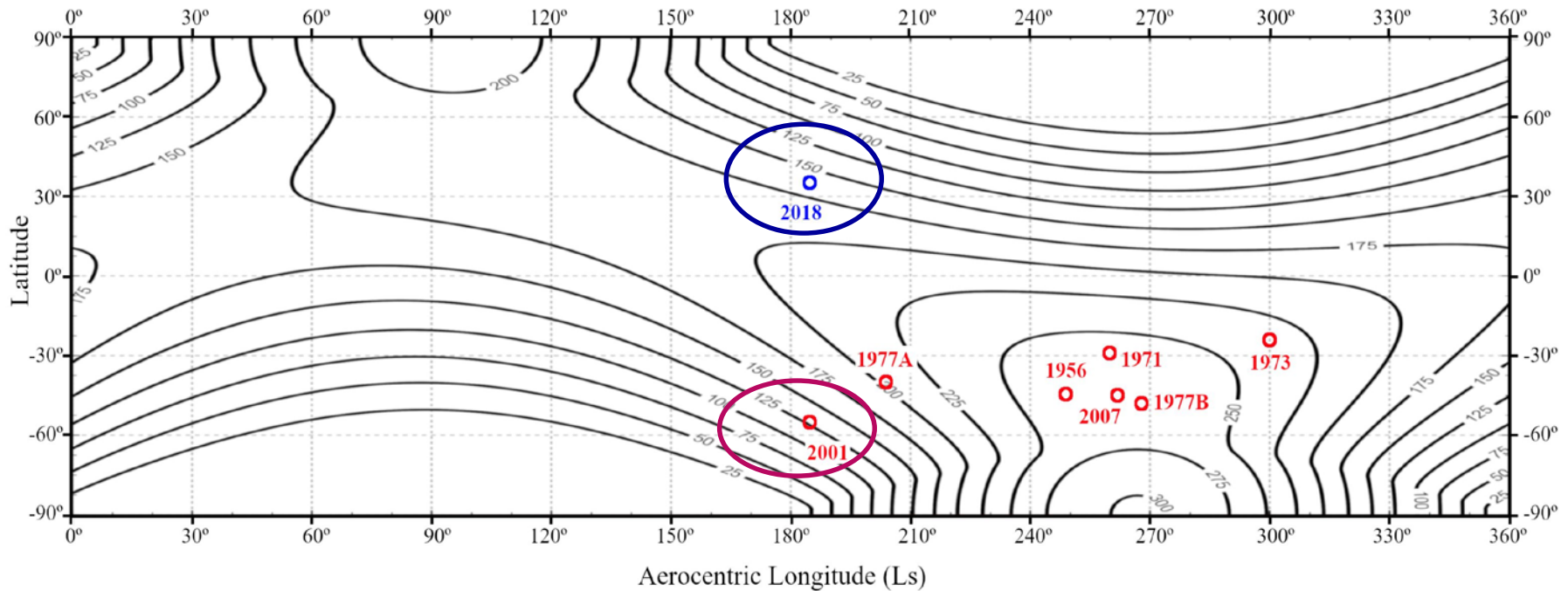
~ GDS2001 (MY 25)



# GDS 2018 in context: The first Northern onset

Mean daily insolation ( $\text{Wm}^{-2}$ ) at the top of the atmosphere along a Martian year

Occurrence for TOA insolation  $\geq 125\text{-}150$  ( $\text{Wm}^{-2}$ )



# Summary GDS 2018

- First northern GDS (+35°N) with precursor at +55°N
- Onset early in the dust season:  $L_s = 185^\circ$
- Expansion velocities:  $U_{\text{zonal}}(\text{max}) \sim 15 \text{ m/s}$  ,  $V_{\text{meridional}}(\text{max}) \sim 40 \text{ m/s}$
- Area expansion rate similar to GDS 2001 but lower than GDS 2007
- Dust top altitudes  $\sim 60 - 70 \text{ km}$
- Penetration in the South Polar Region, motions toward terminator:  $V(\text{max}) \sim 90 \text{ m/s}$
- Spiral & arc shaped aerosol bands penetrating the nightside:  
 $L \sim 2000-3000$  (evening to morning side) and  $H = 10 - 30 \text{ km}$
- Suspected minimum insolation for GDS occurrence  $\sim 125-150 \text{ (Wm}^{-2}\text{)}$