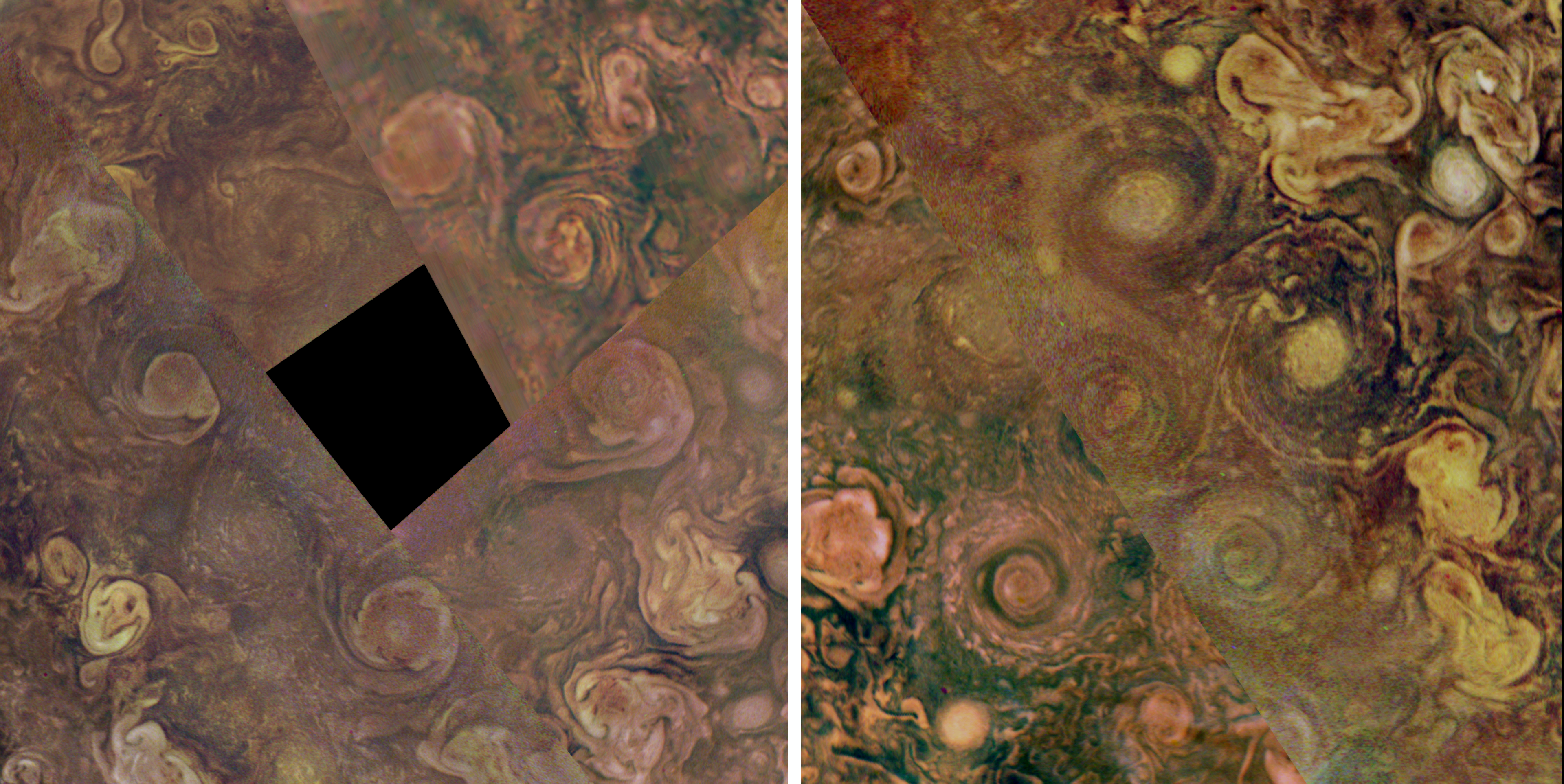


Long-term evolution of circumpolar cyclones on Jupiter’s poles with Juno

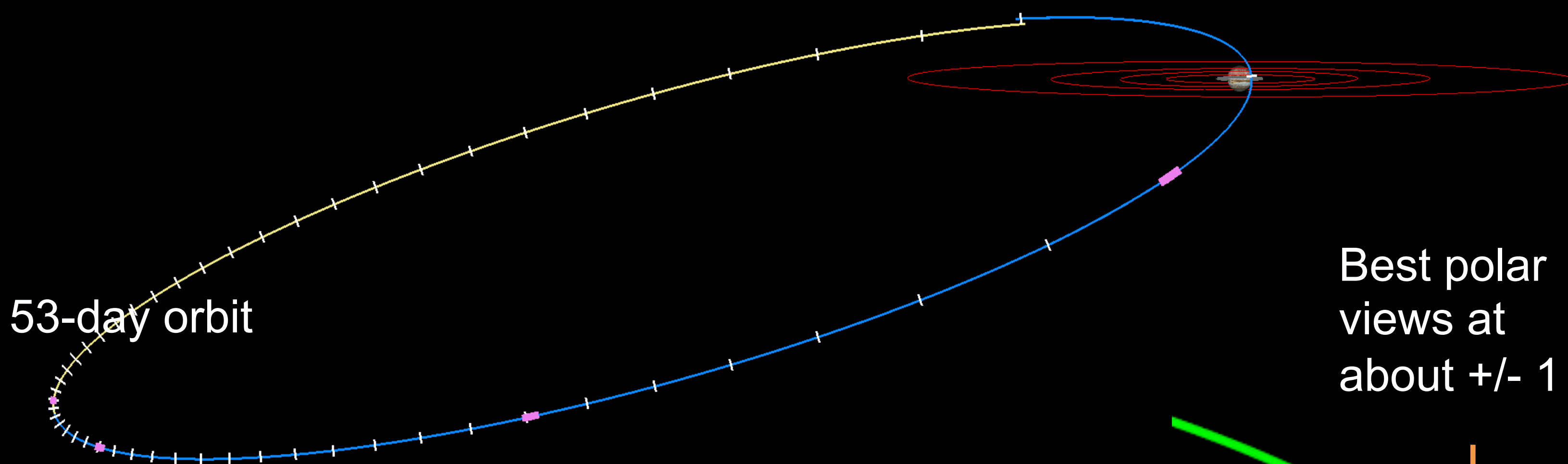
Fachreddin Tabataba-Vakili[1], J.H. Rogers[2], G. Eichstädt[3], G.S. Orton[1], C.J. Hansen[2], T.W. Momary[1], J.A. Sinclair[1], R.S. Giles[1], M.A. Caplinger[5], M.A. Ravine[5], S.J. Bolton[6]

1: Jet Propulsion Laboratory, 2: British Astronomical Association 3: Independent scholar 4: Planetary Science Institute 5: Malin Space Science Systems 6: Southwest Research Institute, San Antonio, Texas, USA

JUNO

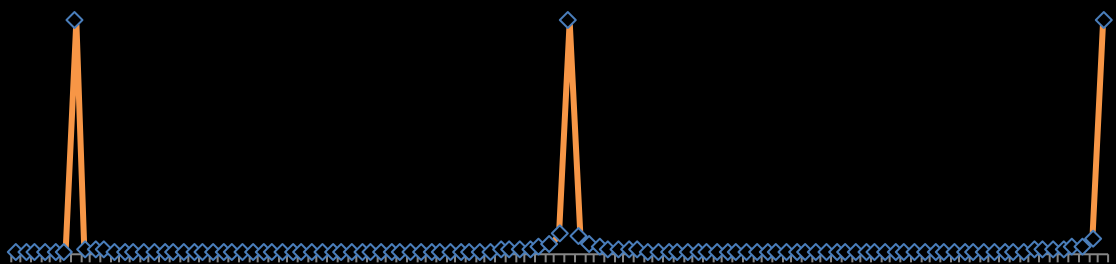
Jet Propulsion Laboratory
California Institute of Technology

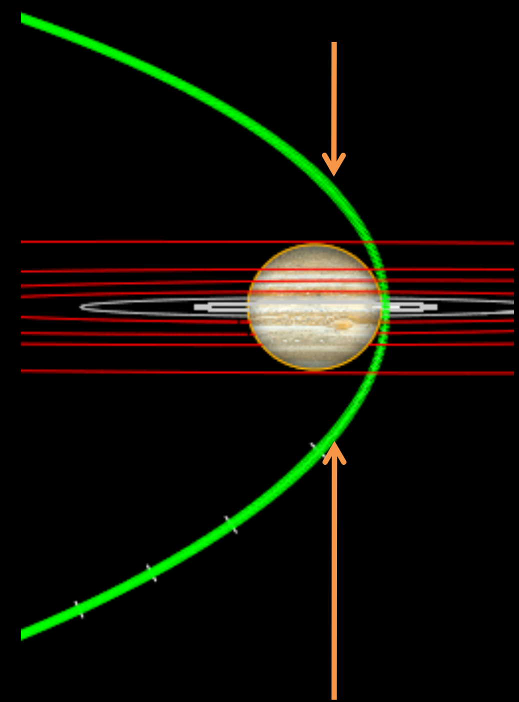
Juno’s Elliptical Polar Orbit



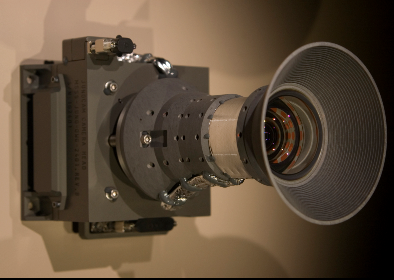
Best polar views at about +/- 1 hr

Jupiter is <50 pixels for most of Juno’s orbit



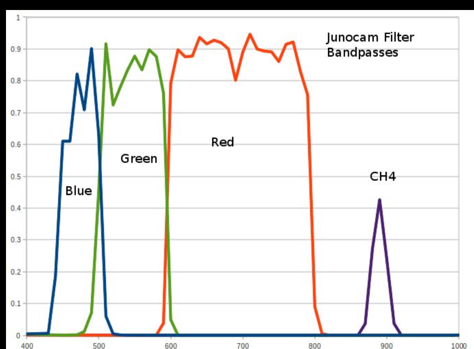


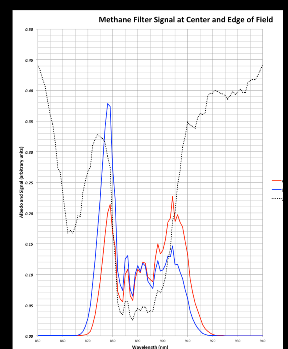
- Perijove swath begins ~1 hr before closest approach
- ~2h from north pole at minimum emission angle to south pole at minimum emission angle



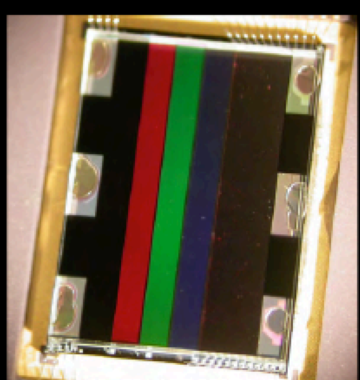
JunoCam Description

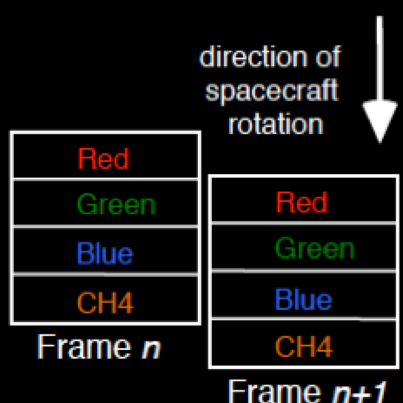
- JunoCam is a fixed-mounted, fixed field of view push-frame visible camera that images in four color bands
  - Broadband blue, green and red
  - Narrow methane band filter centered at 889 nm





- *A JunoCam image is acquired as S/C rotation sweeps the 1600 pixel, 58° wide FOV across Jupiter*





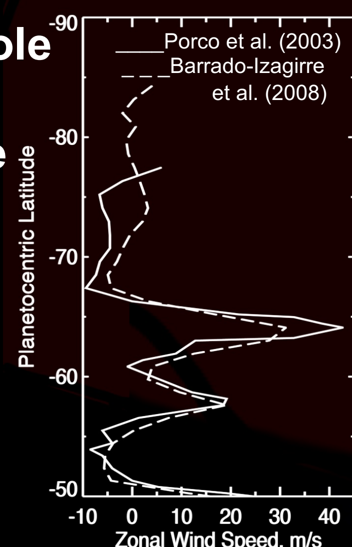
- Time-delayed integration (TDI) used to build up SNR
- Built and operated by Malin Space Science Systems

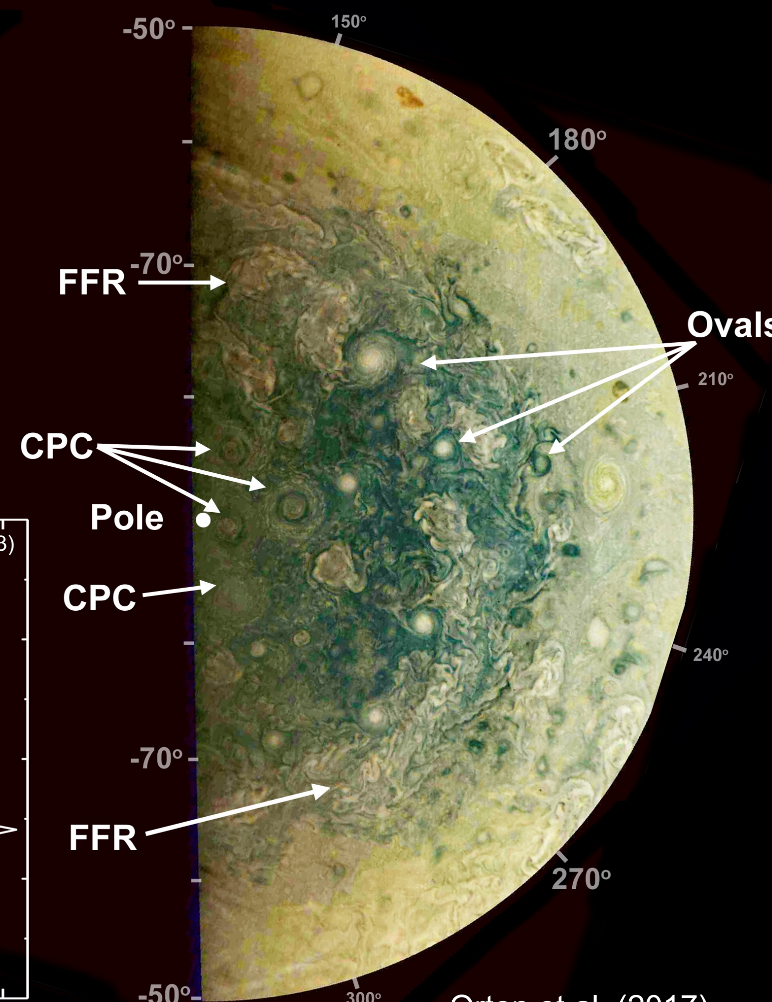
Polar Observations with Juno

JunoCam: South Pole

Perijove 1 (PJ1)

- FFR: Folded Filamentary Regions
  - Longest reaches across 10000 km
  - Colocated with eastward jet near 65°S
- Oval vortices
  - Largest is anticyclonic
- **CPC: Circum-polar Cyclones**
  - **Cyclonic vortices**
  - **Clustered around the pole**
  - **Central cyclone is slightly offset from pole**





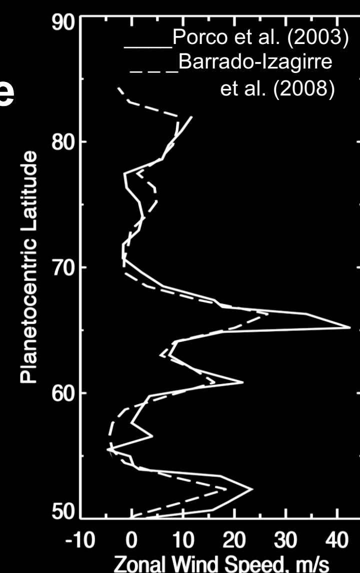
Orton et al. (2017)

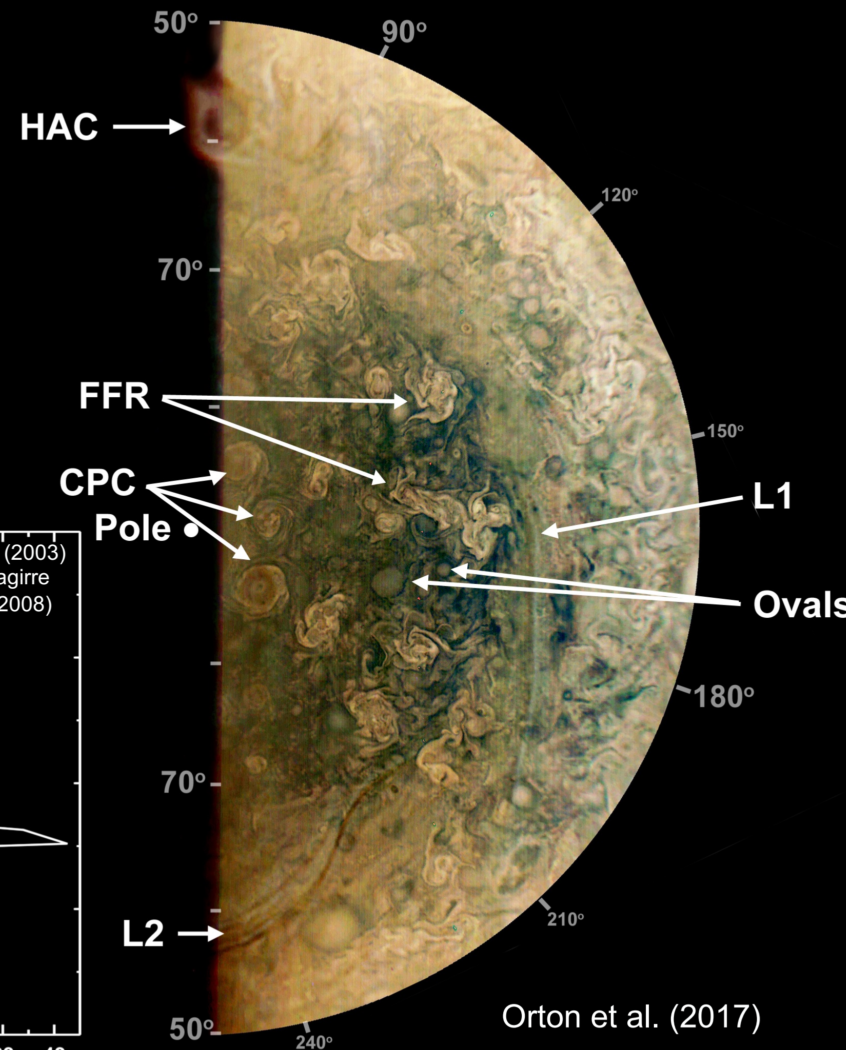
Polar Observations with Juno

JunoCam: North Pole

Perijove 1 (PJ1)

- FFR: Folded Filamentary Regions
  - Longest reaches across 4000-7000km
- Oval vortices
  - Largest is anticyclonic
- **CPC: Circum-polar Cyclones**
  - **Cyclonic vortices**
  - **Clustered around the pole**
  - **Central cyclone is slightly offset from pole**



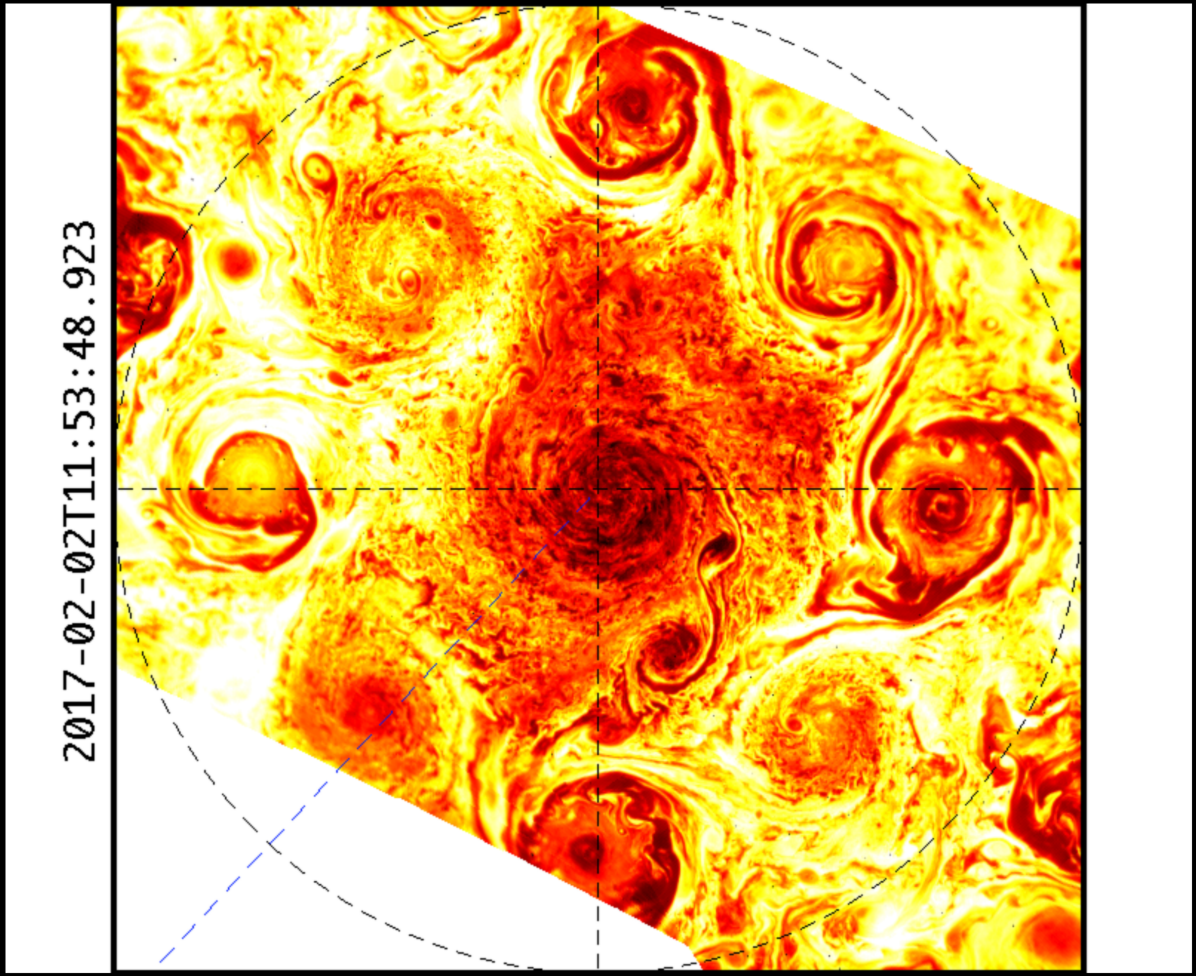


Orton et al. (2017)

Polar Observations with Juno

JIRAM (Jovian Infrared Auroral Mapper)

- Perijove 4
- North pole

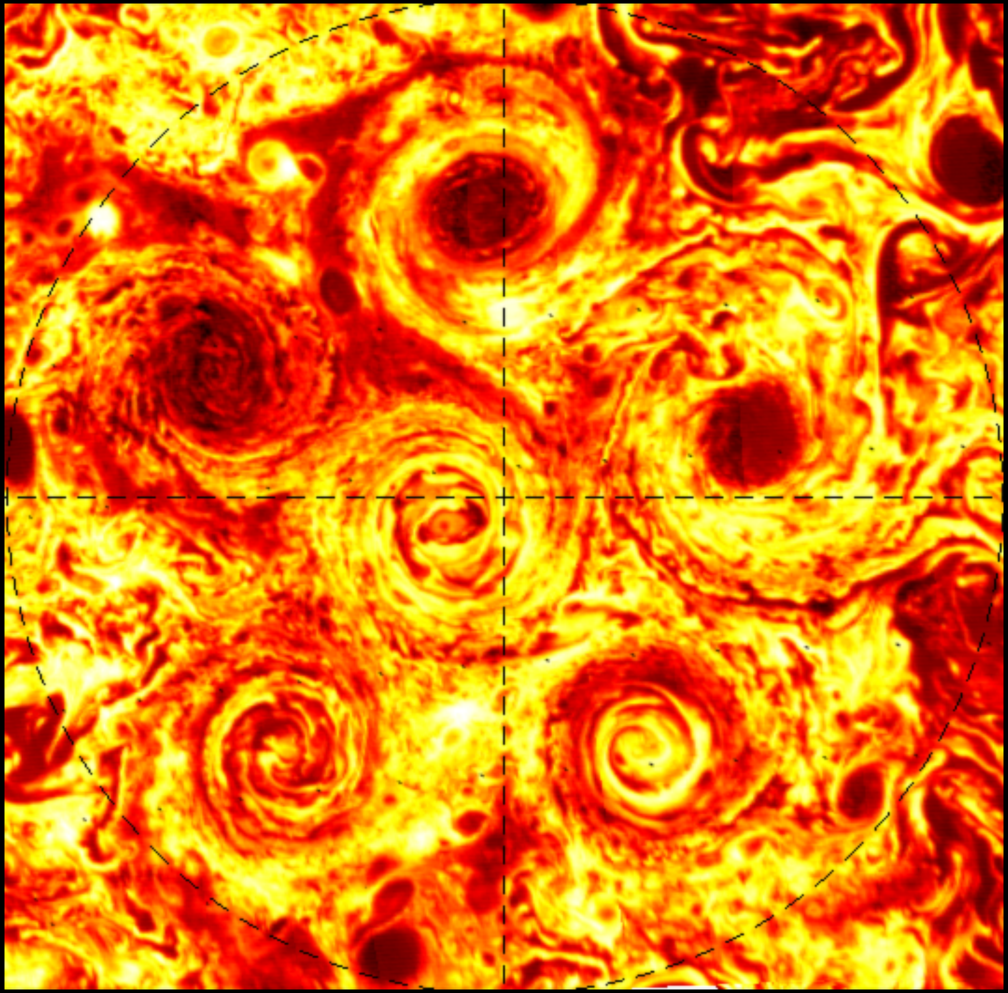


Adriani et al. 2018

Polar Observations with Juno

JIRAM (Jovian Infrared Auroral Mapper)

- Perijove 4
- South pole

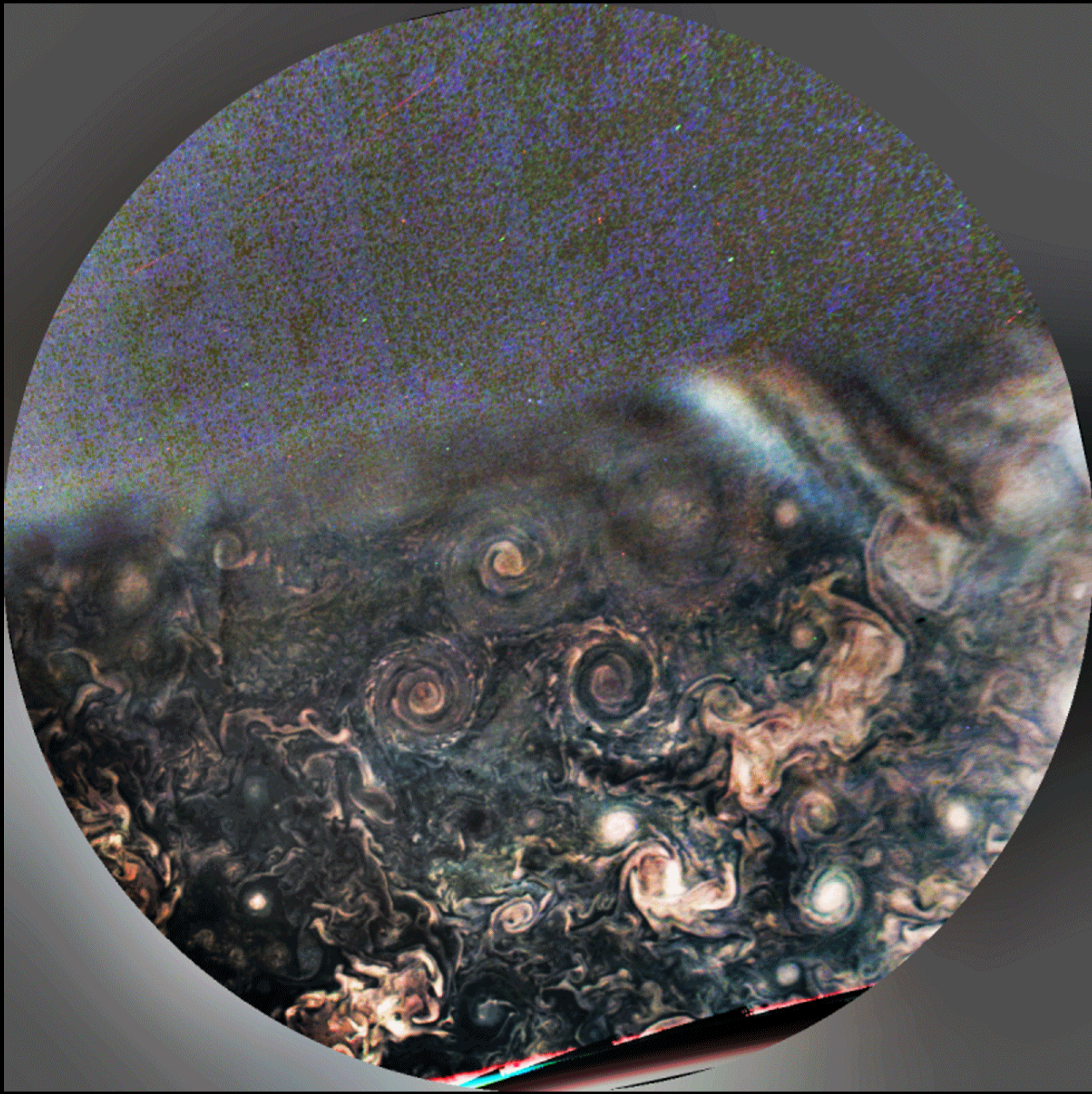


Adriani et al. 2018

Polar Observations with Juno

South Pole: Animations

- Perijove 5

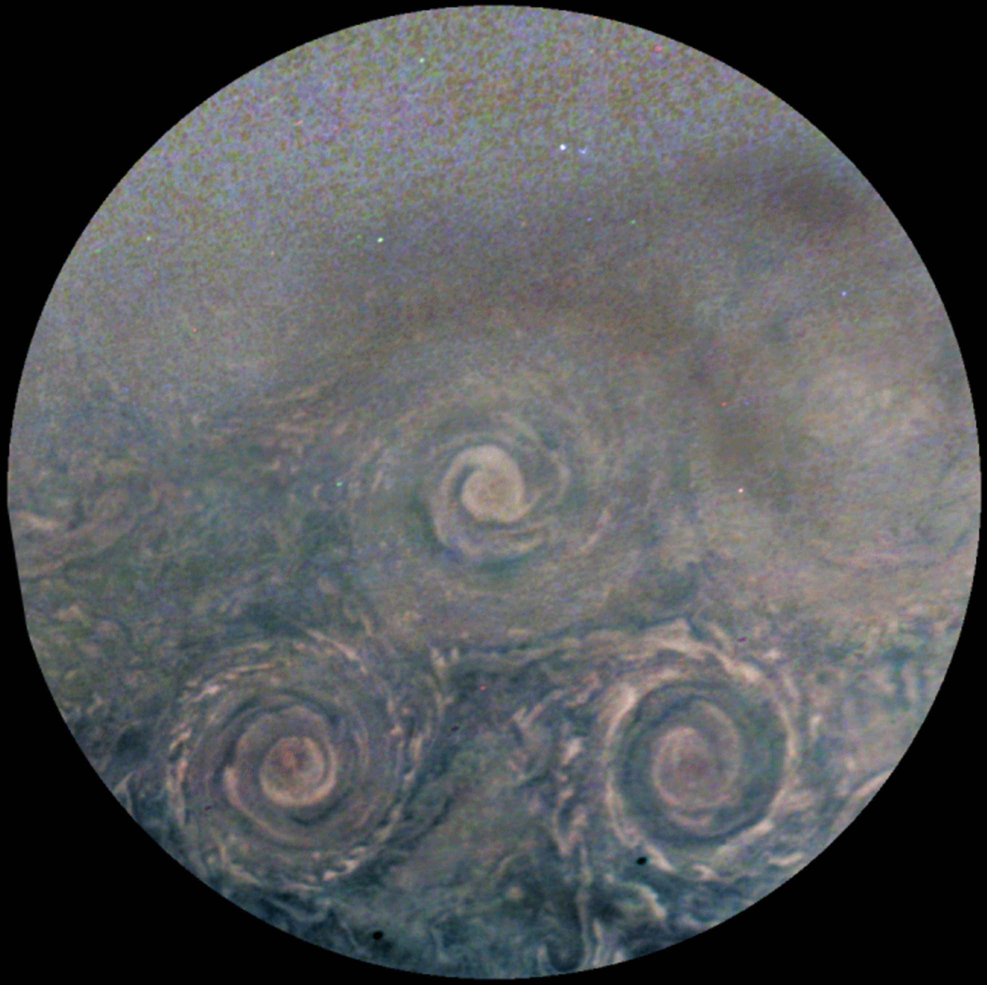


NASA / SwRI / MSSS / Gerald Eichstädt

Polar Observations with Juno

South Pole: Animations

- Perijove 5

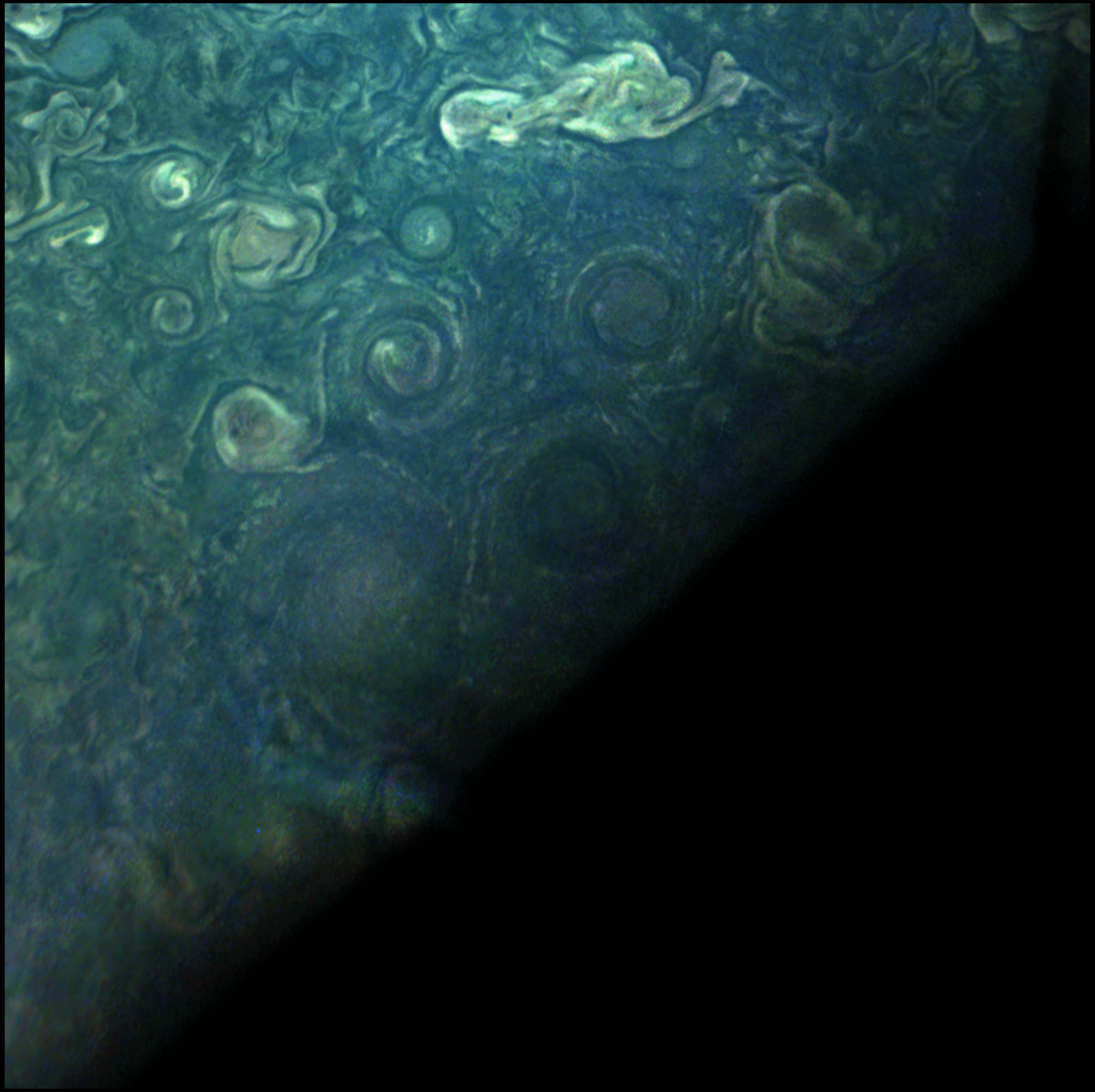


NASA / SwRI / MSSS / Gerald Eichstädt

Polar Observations with Juno

South Pole: Animations

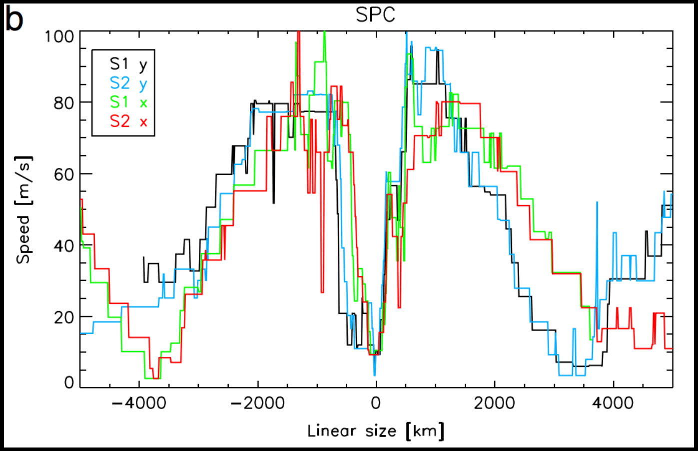
- Perijove 9

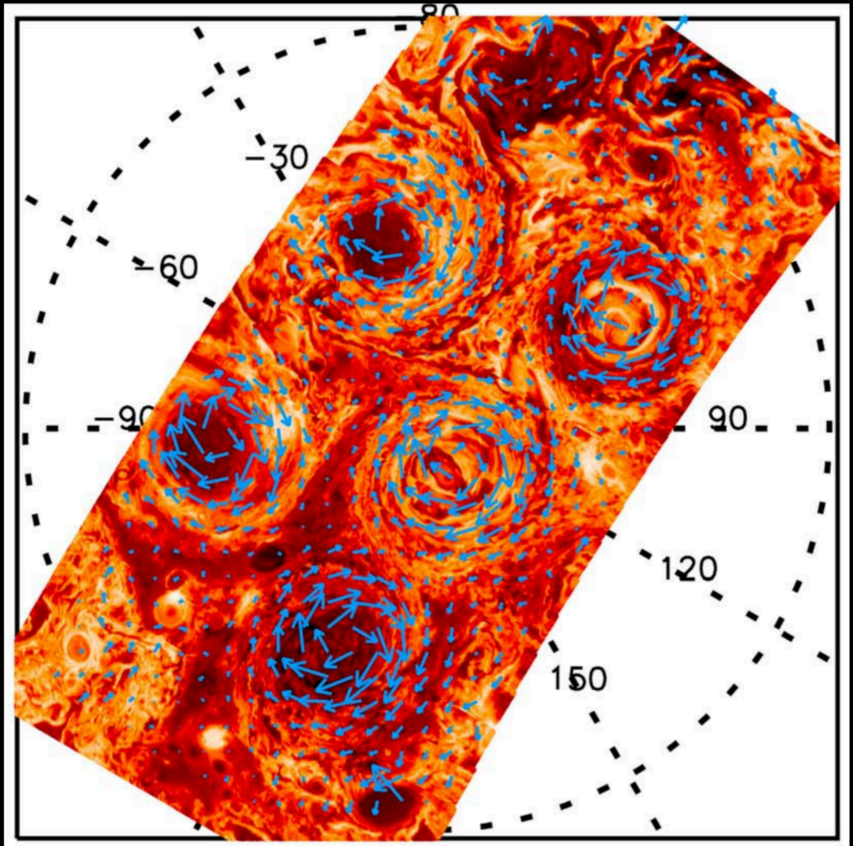


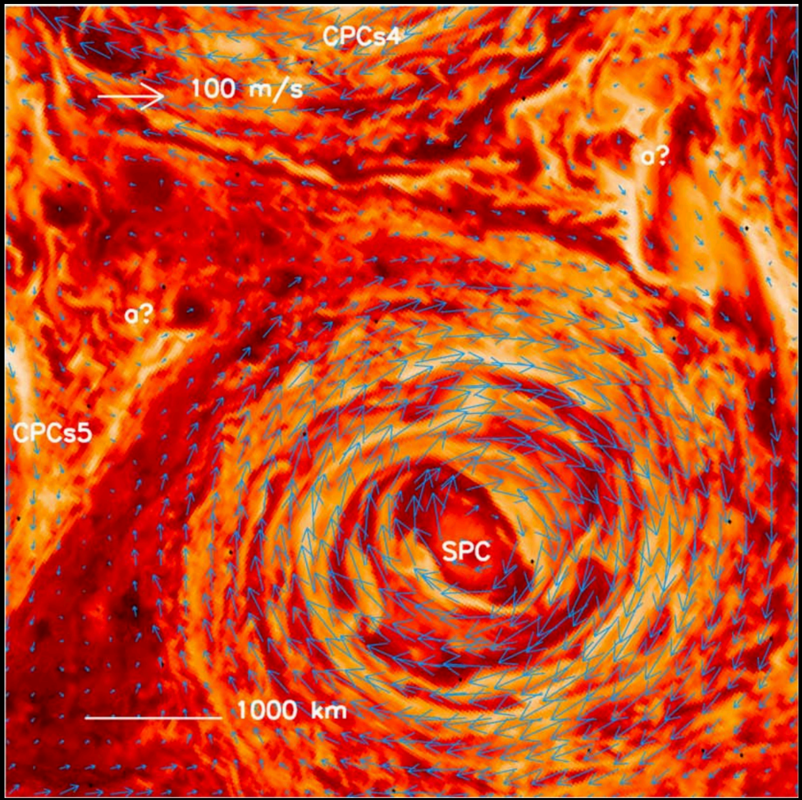
NASA / SwRI / MSSS / Gerald Eichstädt

Polar Observations with Juno

Velocity tracking



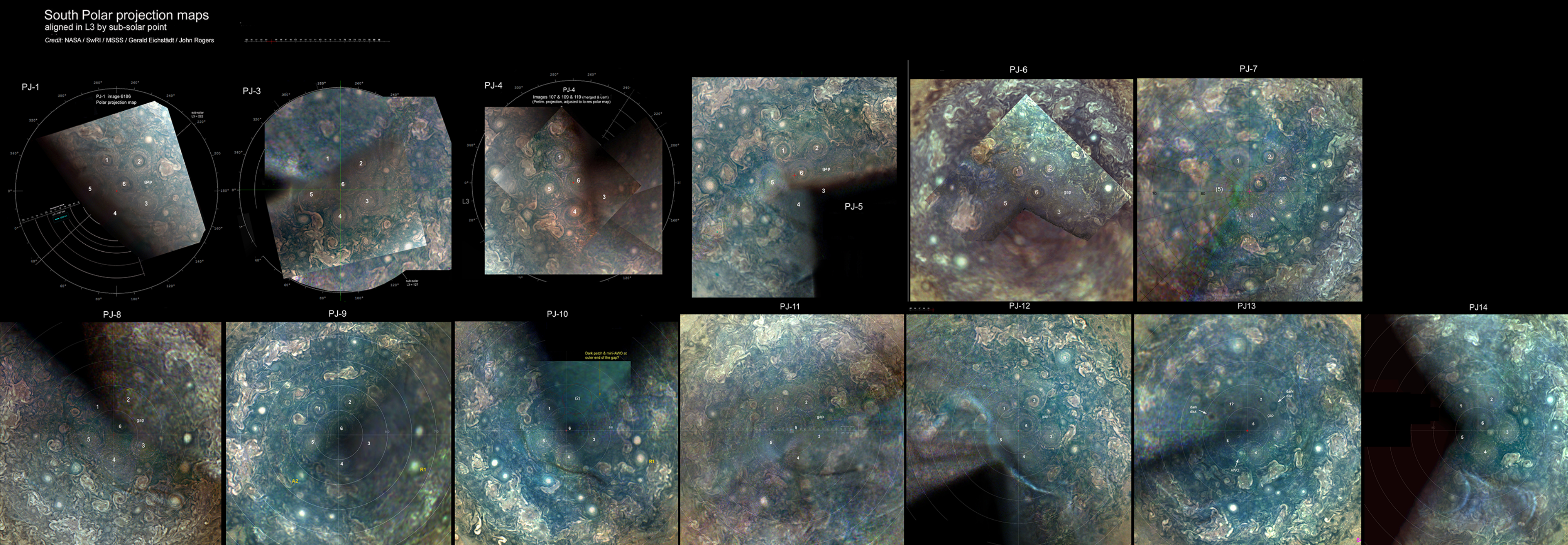




Grassi et al. 2018

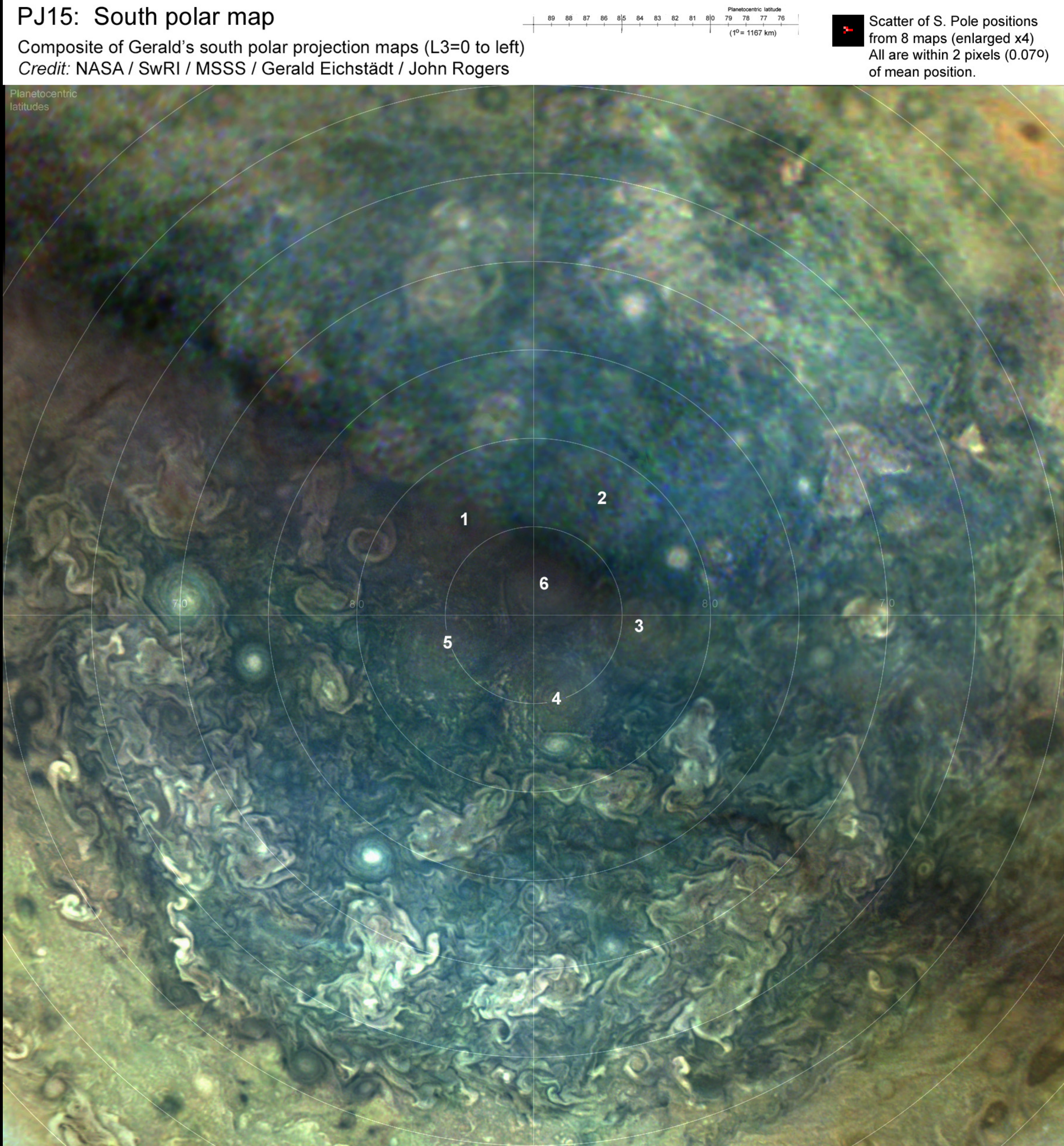
Polar Observations with Juno

South Pole: Long-term evolution



Tabataba-Vakili et al. in prep

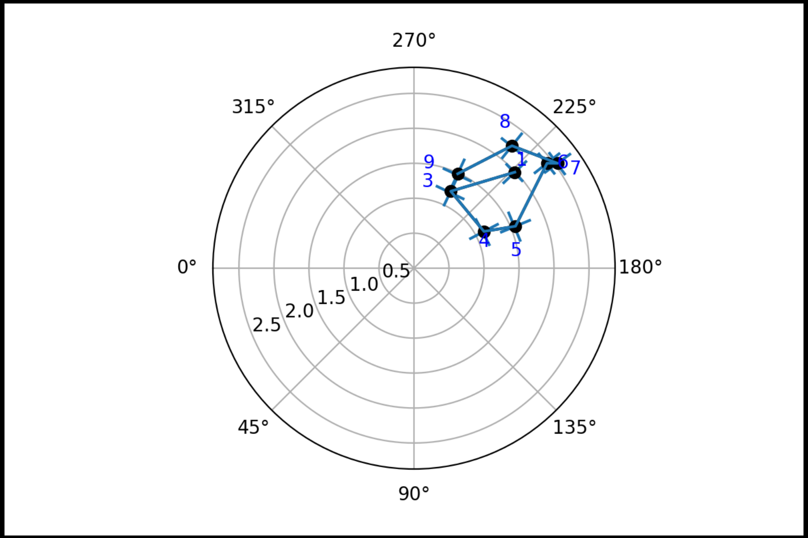
South Polar CPCs

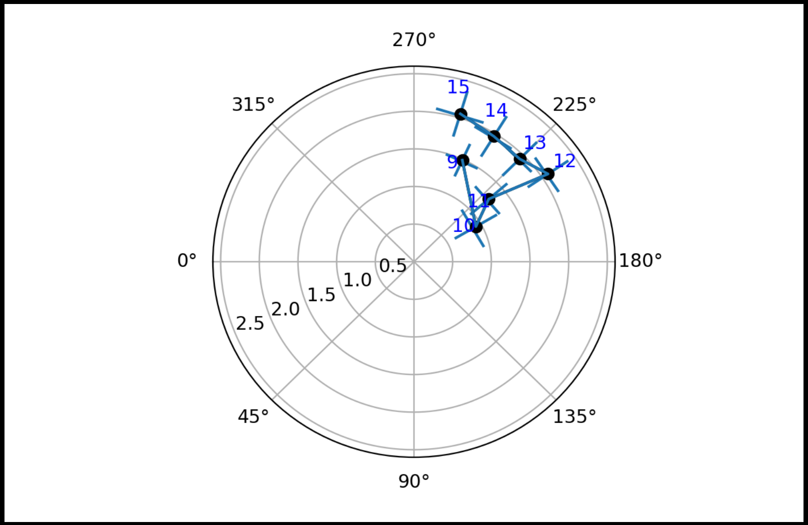


NASA / SwRI / MSSS /Gerald Eichstadt/John Rogers

Polar Observations with Juno

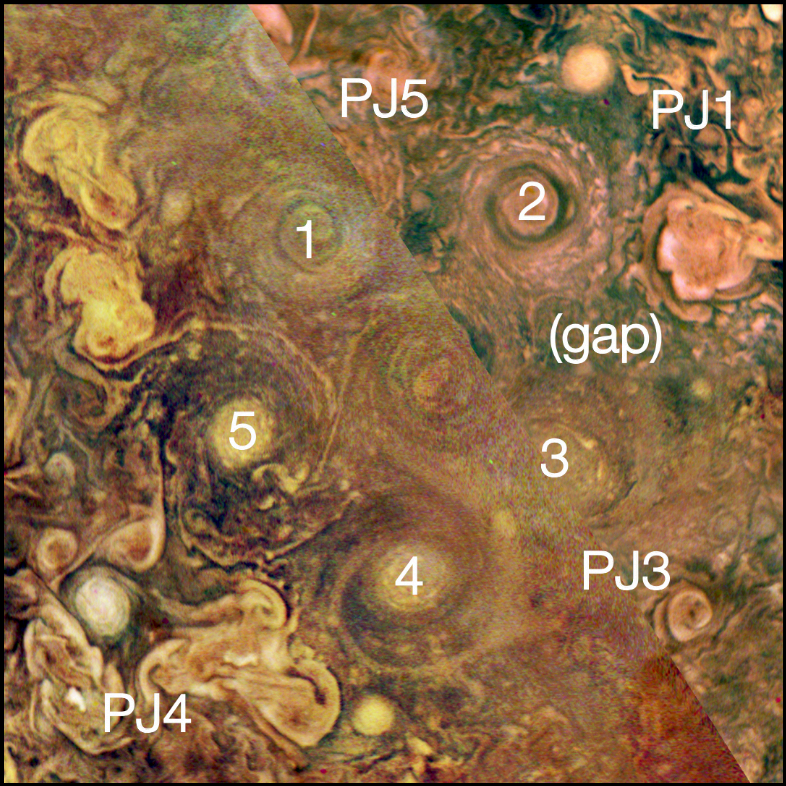
South Pole: Long-term evolution





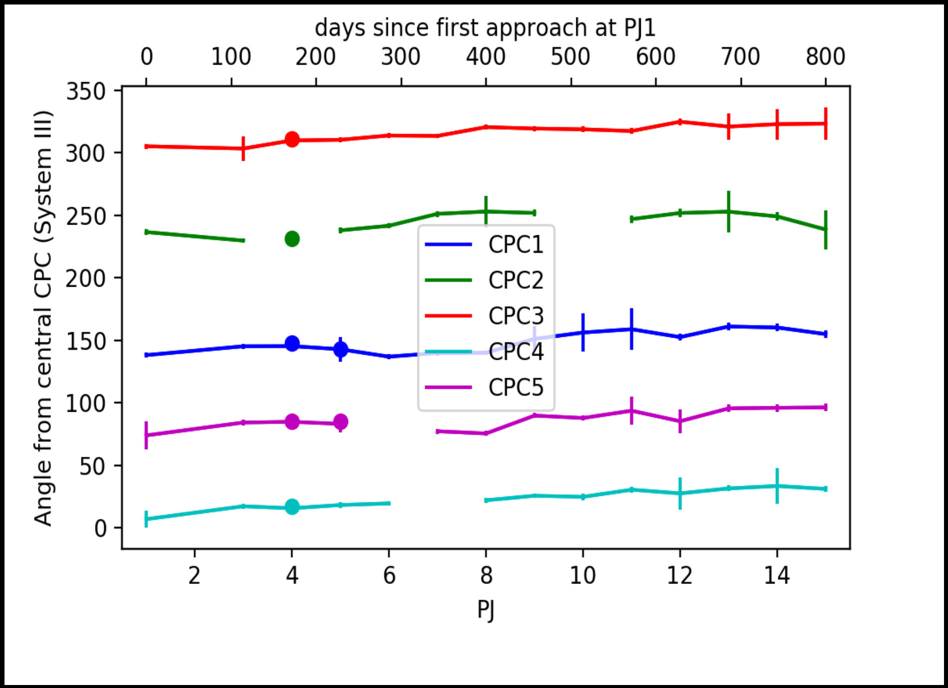
Tabataba-Vakili et al. in prep

South Pole



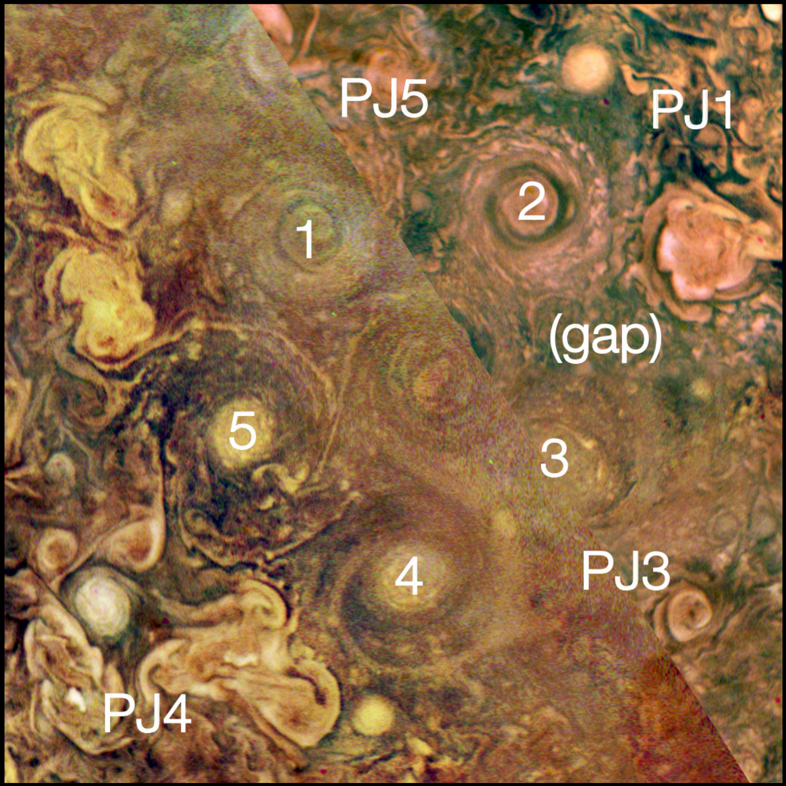
Polar Observations with Juno

South Pole: Long-term evolution



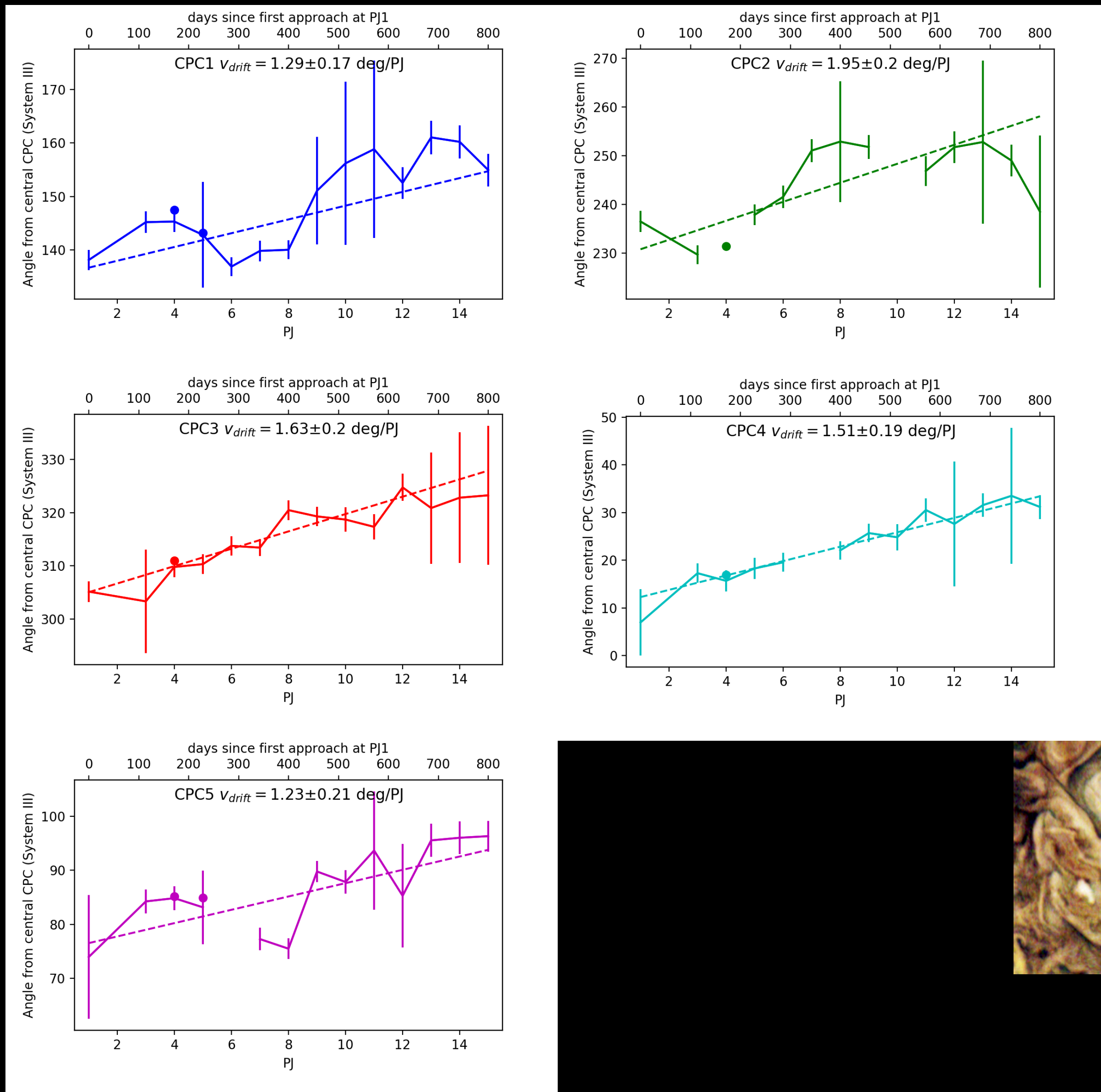
Tabataba-Vakili et al. in prep

South Pole

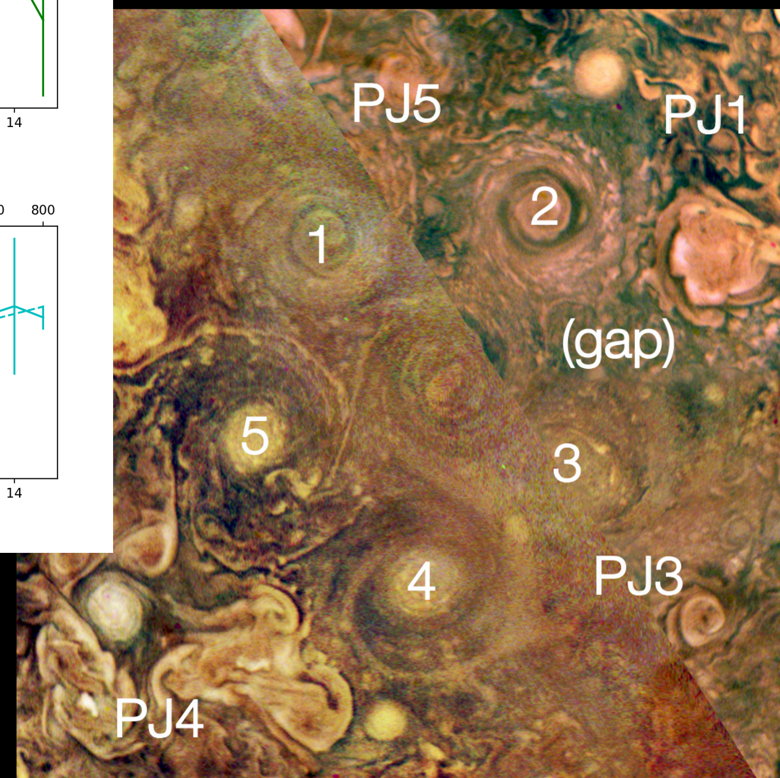


Polar Observations with Juno

South Pole: Long-term evolution



South Pole

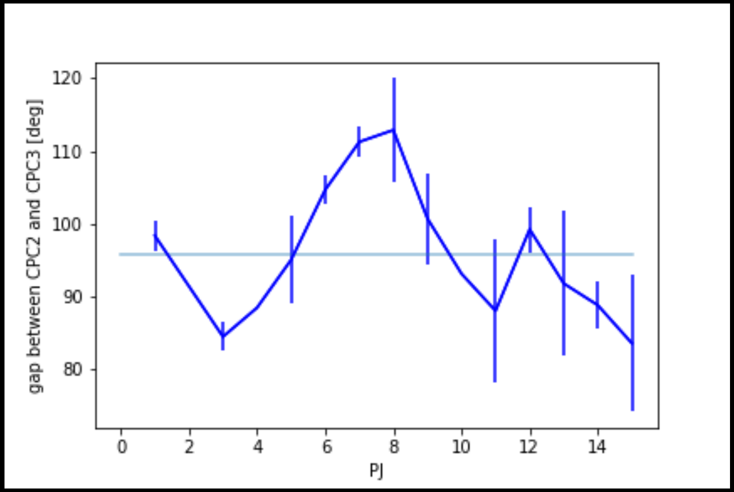


Polar Observations with Juno

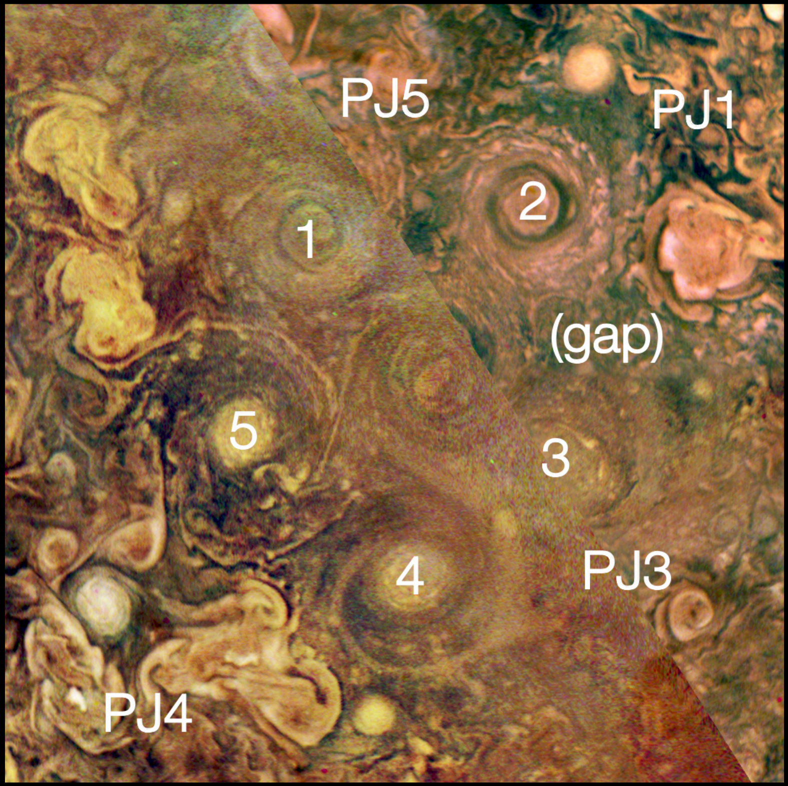
South pole: Long-term evolution

Gap width

CPC (south pole)	1-2	2-3 (gap)	3-4	4-5	5-1
Mean gap width [deg]	70	97	64	63	66



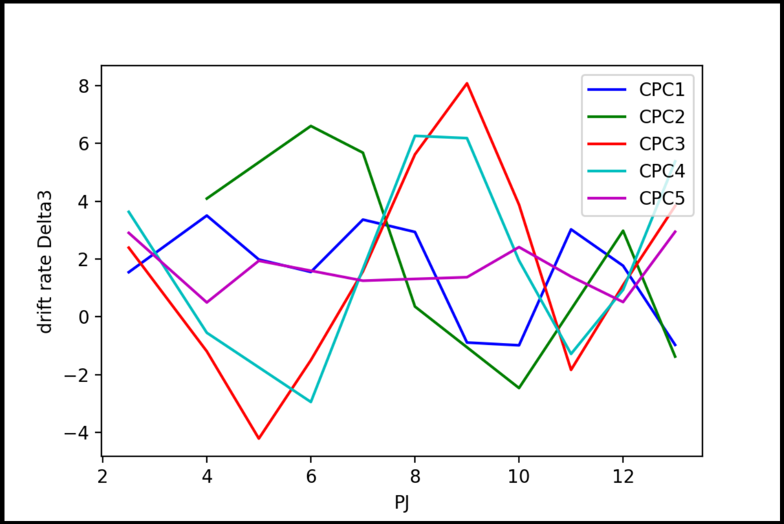
South Pole



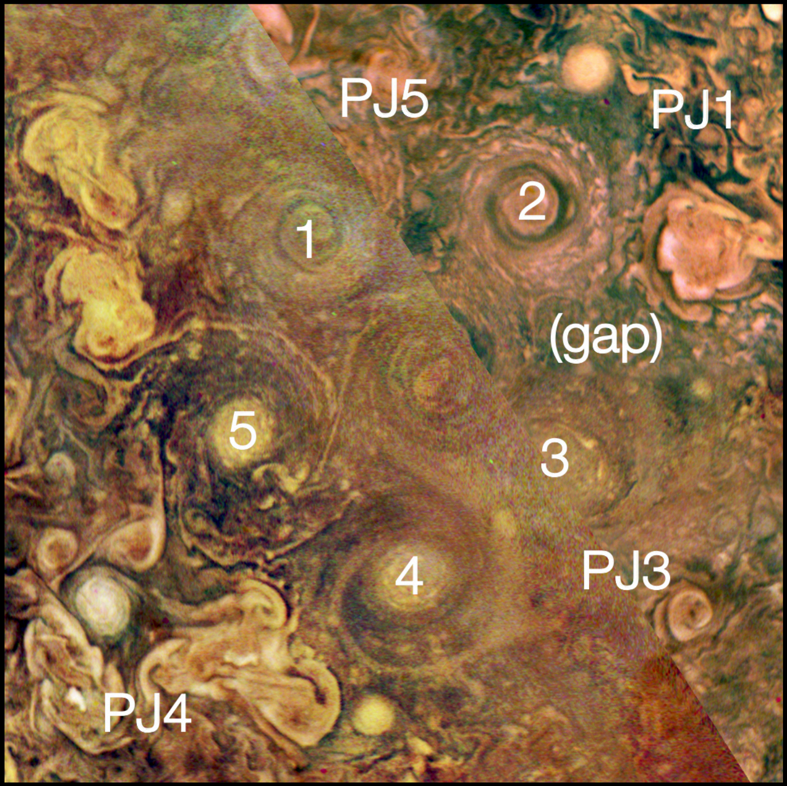
Polar Observations with Juno

South pole: Long-term evolution

Instantaneous drift rate



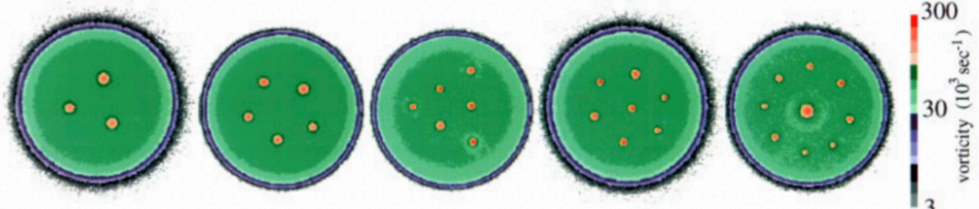
South Pole



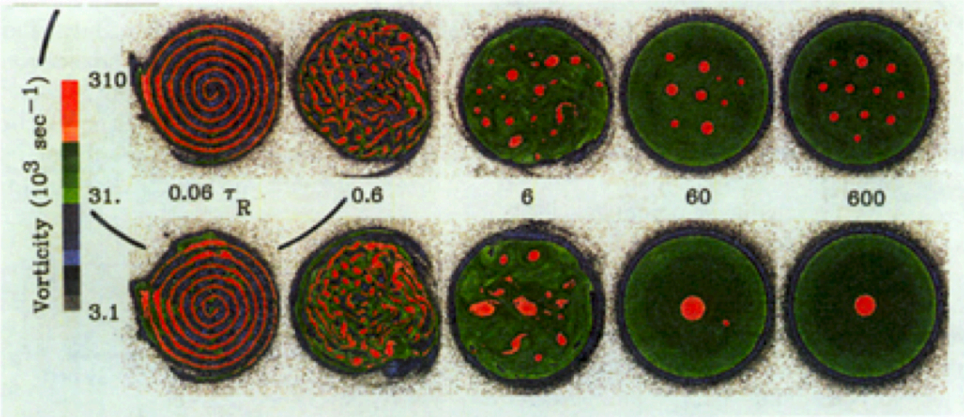
Comparison with Theory

Vortex Crystals

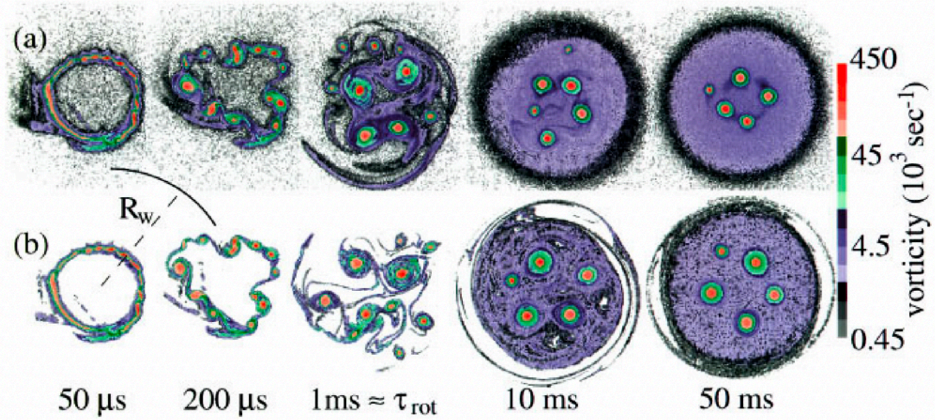
- Constellations of vortices as rare stable solution for initial turbulence.
- Observed in magnetized plasma columns and rotating superfluids to represent 2d turbulence.
- Effect is described by 2d Euler equations.
  - No friction
  - Only positive vorticity
- Formation to achieve maximum entropy.
- In lab and models: stable for around 400 rotations, after which minute frictional effects cause dissipation.



Several stable configurations of vortex crystals. (Fine et al. 2005)



The evolution of two vortex experiments with slightly different viscosities. (Fine et al. 2005)

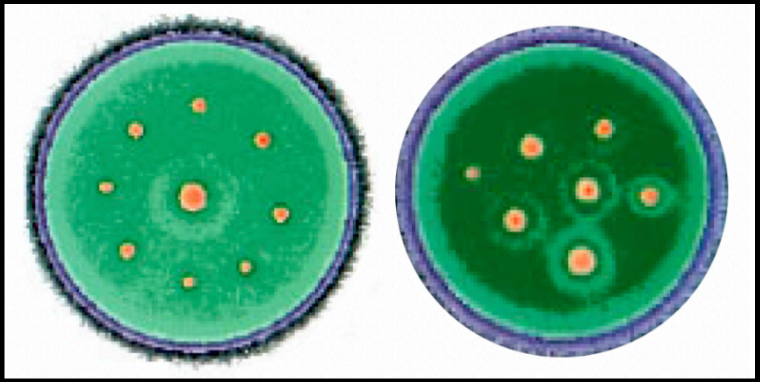


Experiment (a) and simulation (b) of vortex crystal evolution with the same initial conditions. (Schecter et al. 1999)

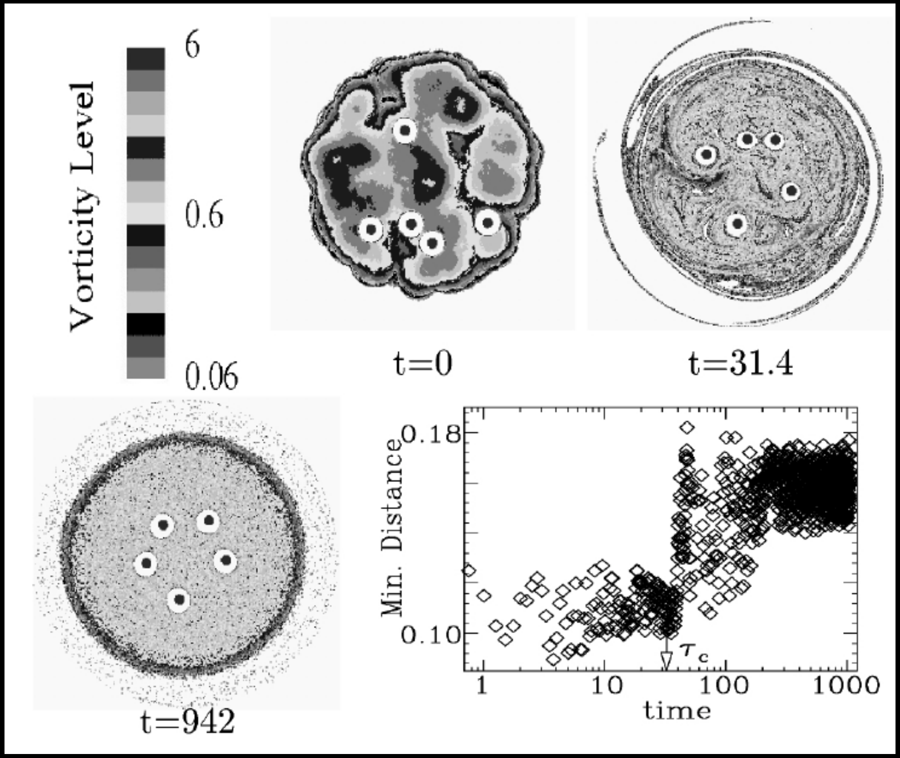
Comparison with Theory

Vortex Crystals

- Constellations and time-evolutions compare well.



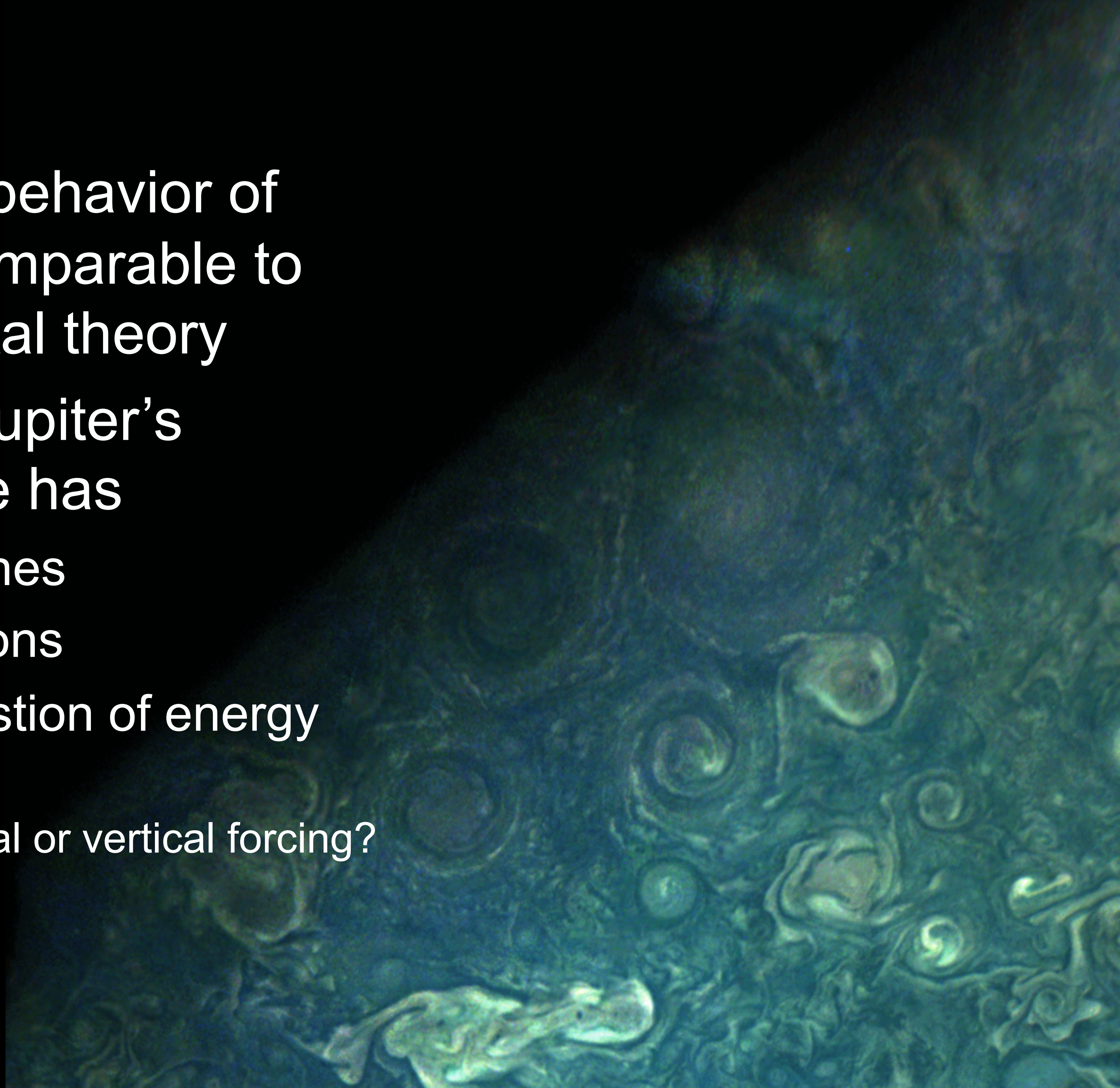
Schecter et al. (1999)



Jin & Dubin (2000)

Summary

- Long-term behavior of CPCs is comparable to vortex crystal theory
- However, Jupiter's atmosphere has
  - Anti-cyclones
  - 3 dimensions
  - Open question of energy source
    - Horizontal or vertical forcing?



Questions?

PJ14 Perijove Pass