Morphology of Jupiter's Polar Auroral Bright Spot Emissions via Juno-UVS Observations

K Haewsantati
LPAP, STAR
K.Haewsantati@uliege.be
Thesis advisor: Dr. Bertrand Bonfond

Outlines

- Planetary magnetic field
- Magnetosphere
- Jupiter’s auroras
- Juno-UVS observations
- Results: Location and power variation of bright spot emissions
- Summary

Planetary Magnetic Fields

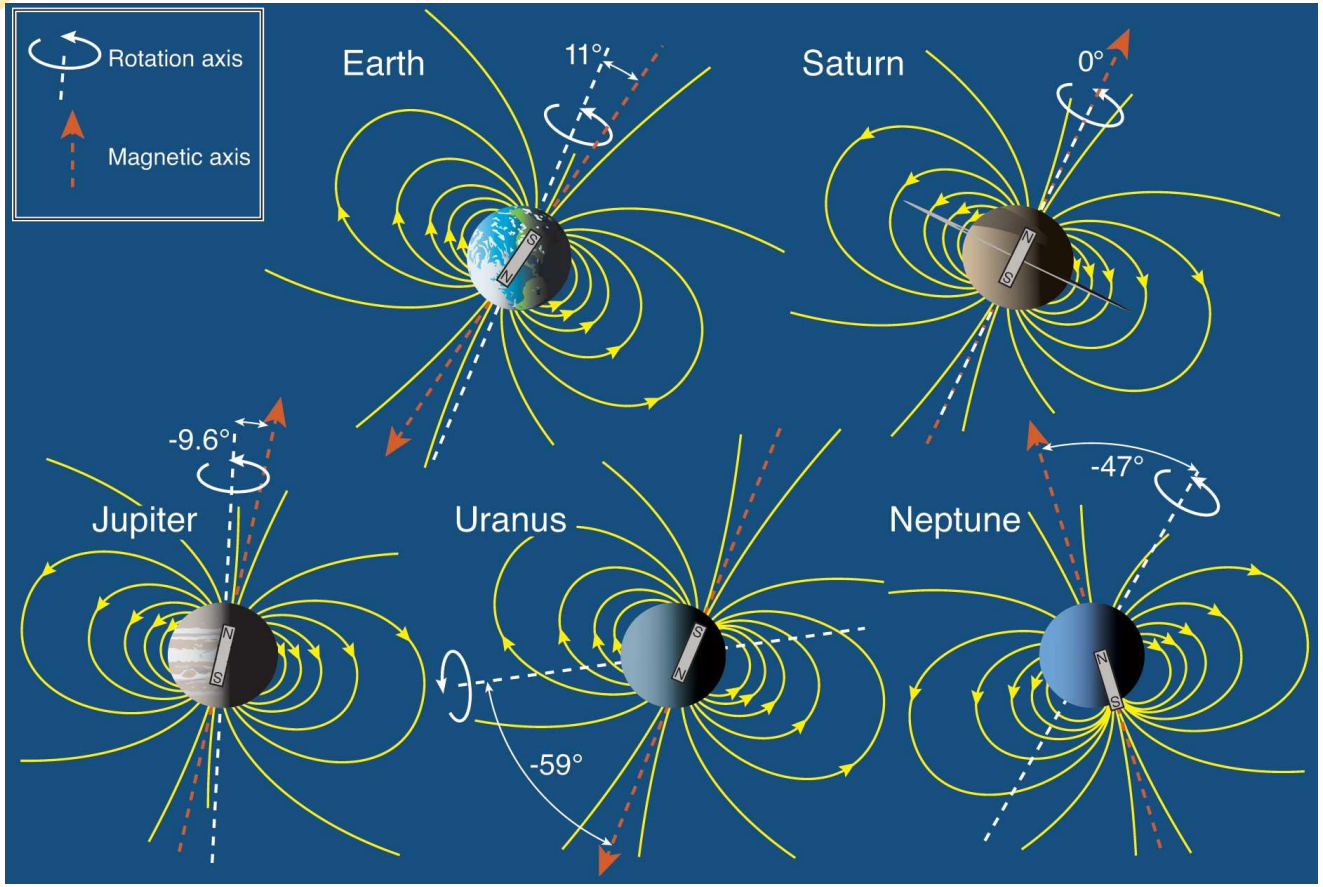
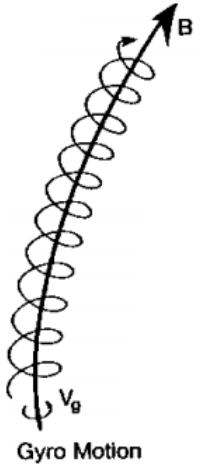


Figure 1. Tilts of planetary magnetic fields with respect to their rotation axes. (Credit: Fran Bagenal & Steve Bartlett)

- **Planetary Magnetic Fields**: generated by an internal dynamo, process which converts mechanical energy to electromagnetic energy through induction
- The simplest structure is dipole model
- Charged particles travel along magnetic field line by gyromotion



Magnetosphere Configuration

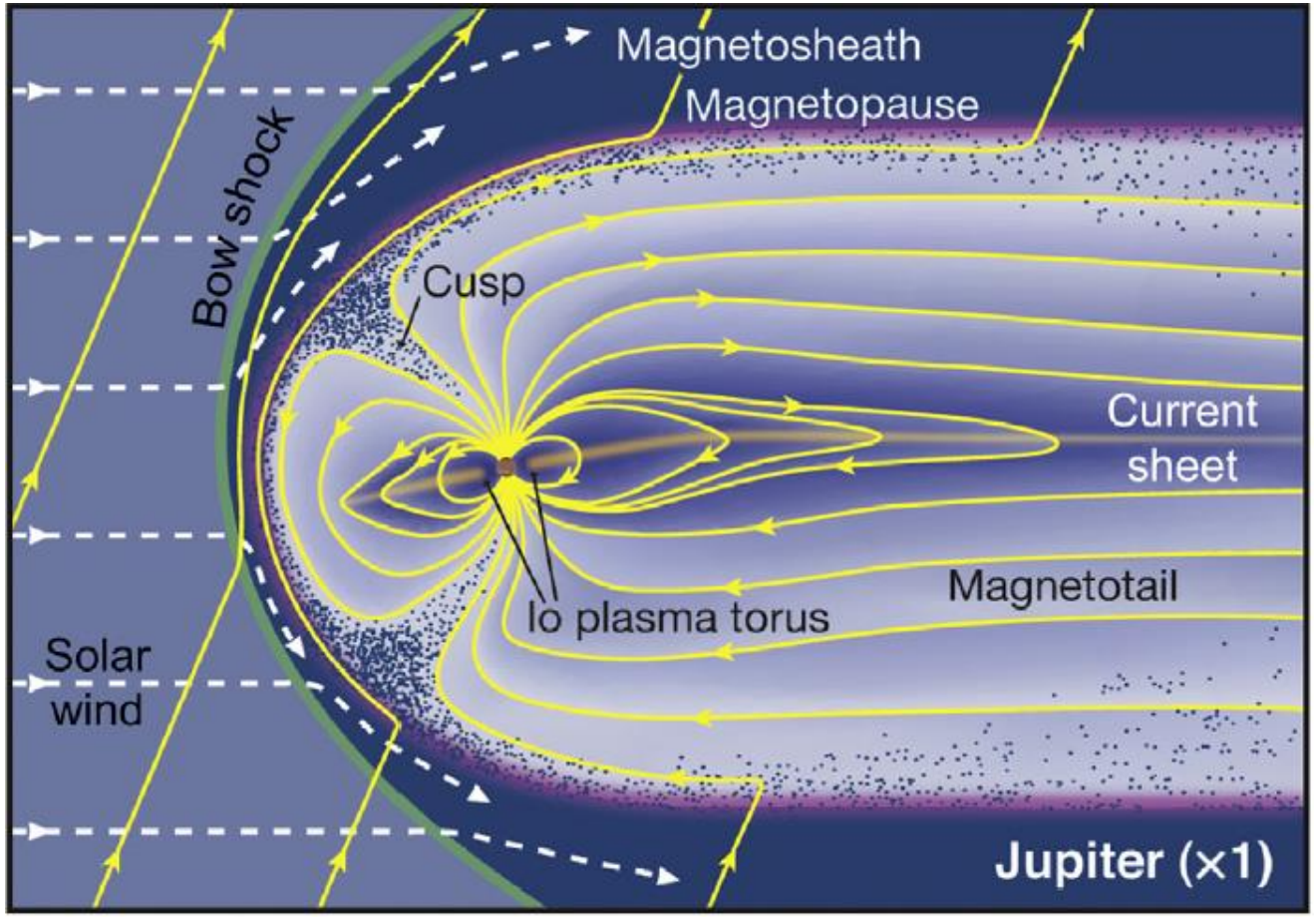


Figure 2. A schematic of Jupiter's magnetosphere. The dayside is located on the left in direction toward the Sun and the nightside is on the right. (Credit: Bagenal & Bartlett)

Planetary Magnetosphere: the region around the planet which the dynamics is predominated by the planetary magnetic field

Bow shock: the region of first impact between the solar wind and the planet's magnetic field

Magnetosheath: the region where shocked solar wind flows around the magnetosphere

Magnetopause: the boundary current sheet which separates the solar wind plasma and the magnetosphere plasma

Cusp: open field line region that shocked solar wind plasma can penetrate to magnetosphere

Jupiter’s auroras

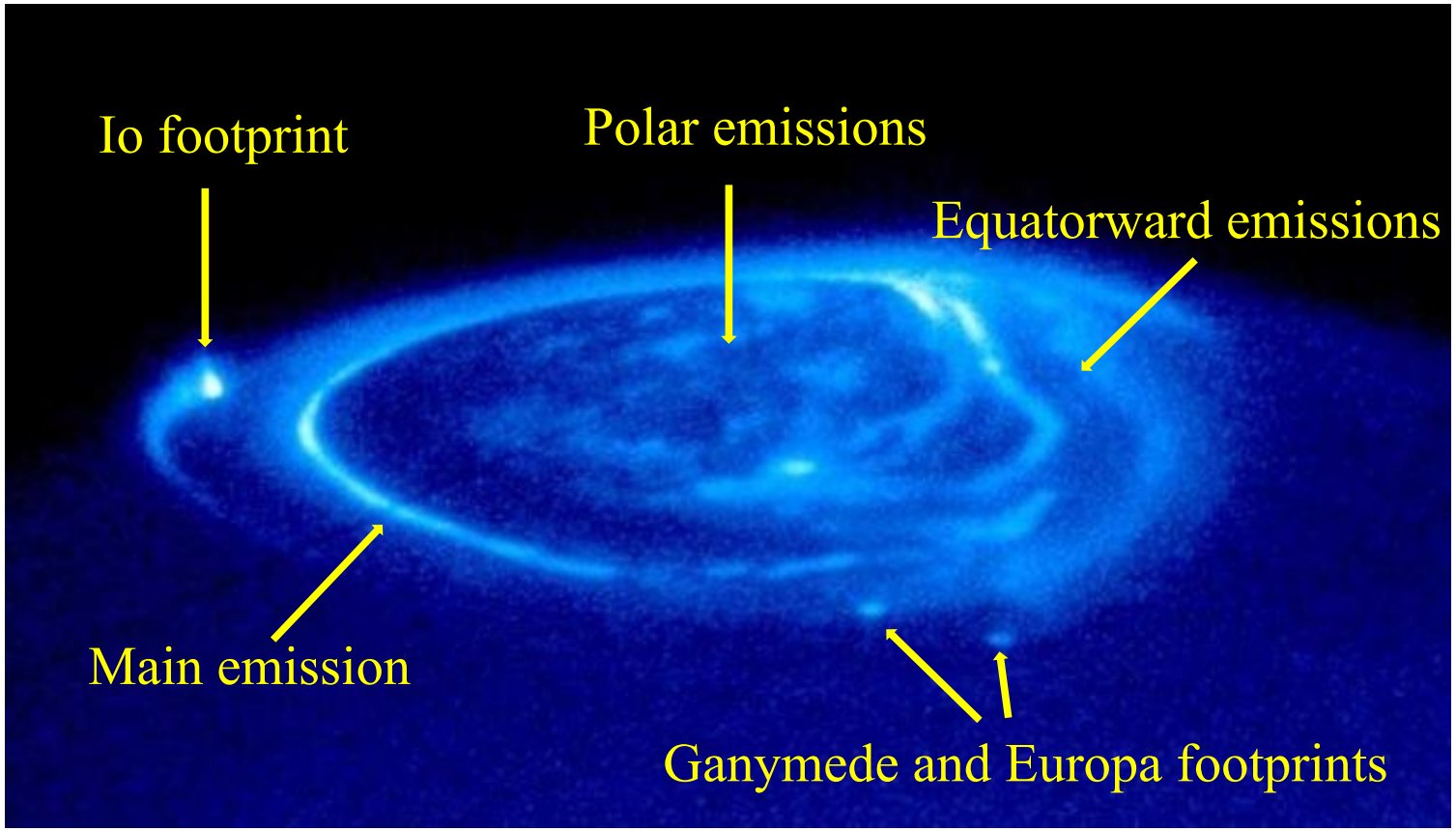


Figure 3. HST FTIS FUV image of Jupiter’s northern aurora with three main regions, taken in 1998. (Credit: Clarke et al., 2004)

- The light emission produced by the interactions between precipitating **high energy particles** and the **atmospheric particles**
- Complex morphology
- Main components: the main emissions, the equatorward emissions, the polar emissions, and the satellites’ footprints

The bright spot features

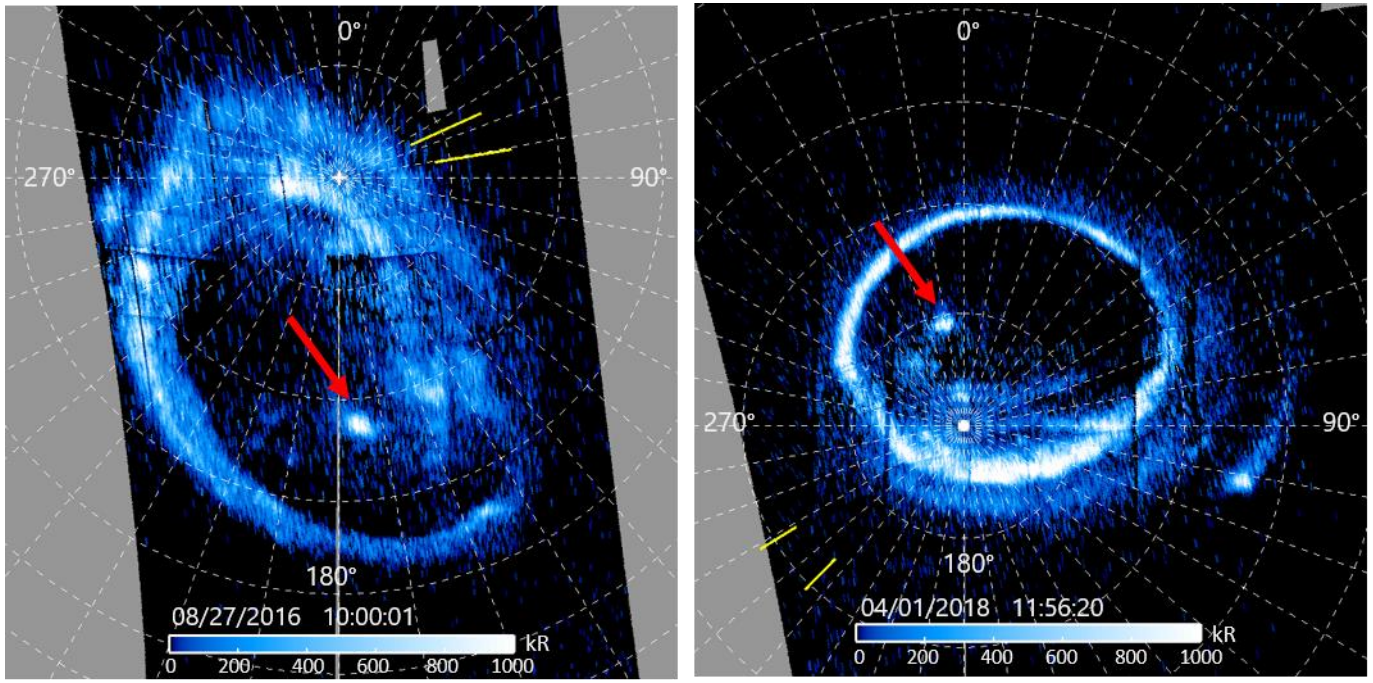


Figure 4. Jupiter's auroras acquired by Juno-UVS contain the bright spot feature in (left) the northern hemisphere and (right) the southern hemisphere.

- The emissions in Jupiter's polar auroras
- Compact shape
- Very dynamic and very bright in UV aurora
- Located closed to magnetic noon local time and related to magnetospheric cusp (Pallier and Prange, 2001)

The bright spot features

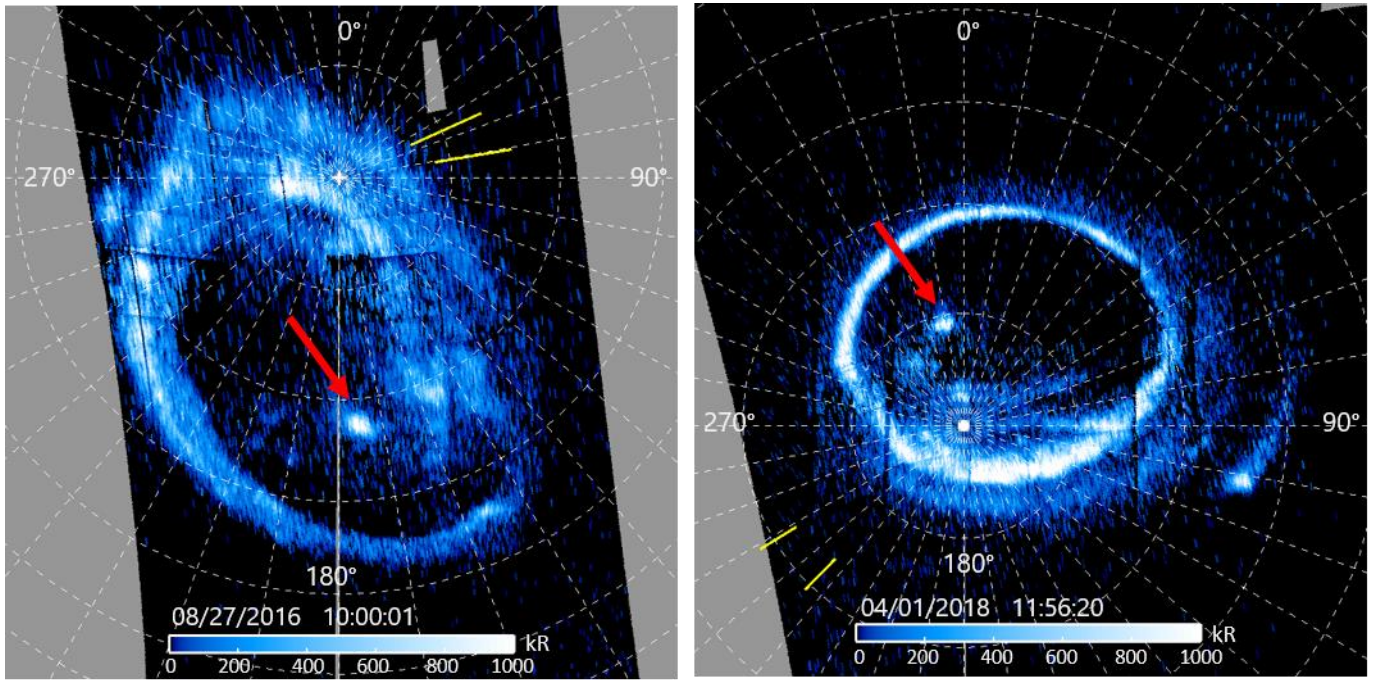


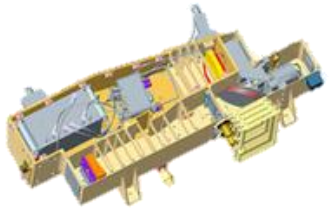
Figure 4. Jupiter's auroras acquired by Juno-UVS contain the bright spot feature in (left) the northern hemisphere and (right) the southern hemisphere.

Main study

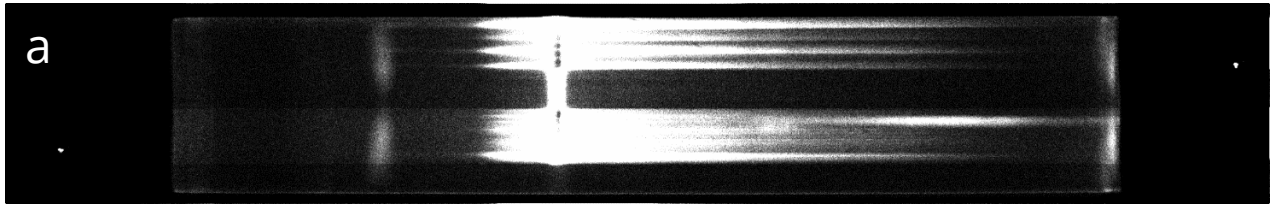
- Positions and local times
- Power emissions
- Behaviors

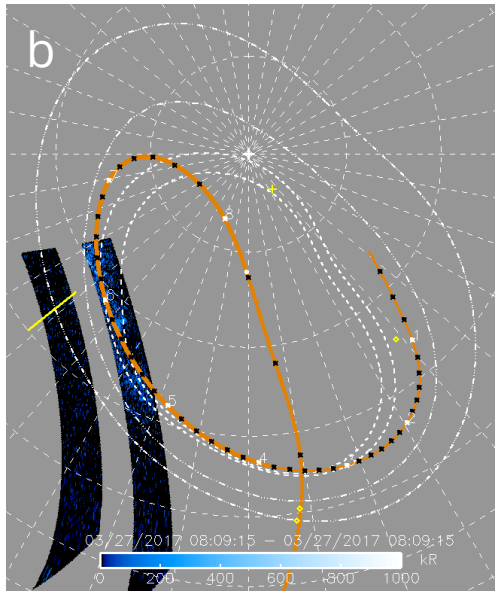
Observations

- Ultraviolet Spectrograph (UVS) instrument on board the Juno spacecraft
- 68-210 nm wavelength range with dog bone-shaped slit
- Acquired a Jupiter's aurora image every ~30 seconds as Juno's spin period
- The first 25 orbits: Aug 27, 2016 to May 29, 2019
- Polar projection: altitude 400 km above 1 bar level



Ultraviolet Spectrograph (UVS) instrument
Credit: NASA/JPL





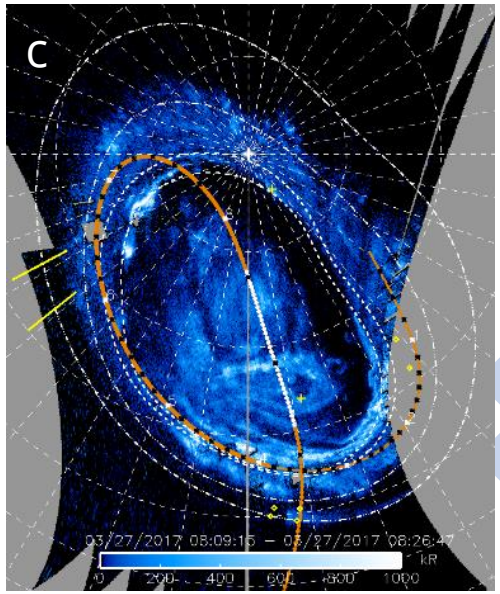
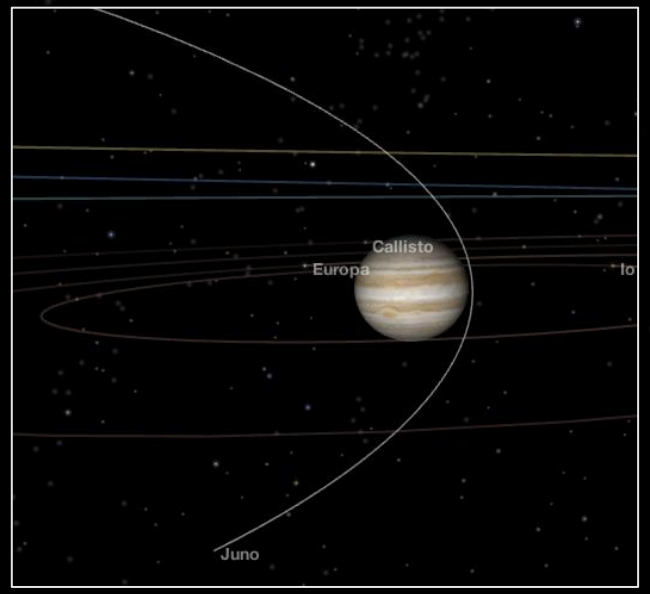


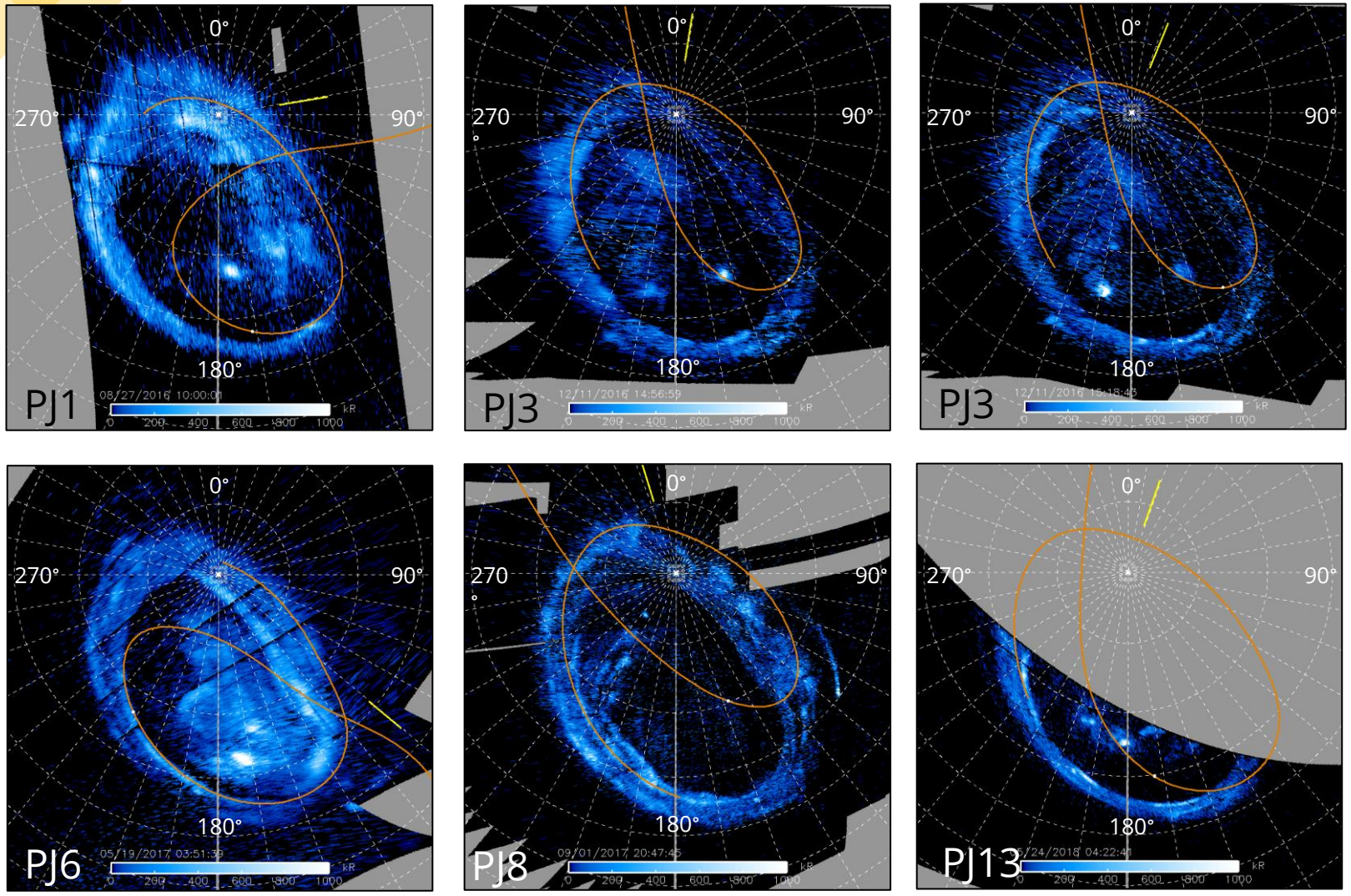
Figure 5.
(a) Photon-count image obtained from Juno-UVS
(b) Polar projection of Jupiter's northern aurora of the data from one spin taken at 27 March 2017, 08:09:15
(c) Full view of Jupiter's aurora created by integration data taken between 08:09:15 to 08:26:47.

Observations

- Orbit ~53-day period
- Perijove (PJ): trajectory when spacecraft orbit close to the planet center



Jupiter’s bright spot emissions



PJ1: Three bright spot emissions within 30 min time range, appeared nearly the same system III position

PJ3: Two distinct bright spot emissions appeared at different SIII longitudes

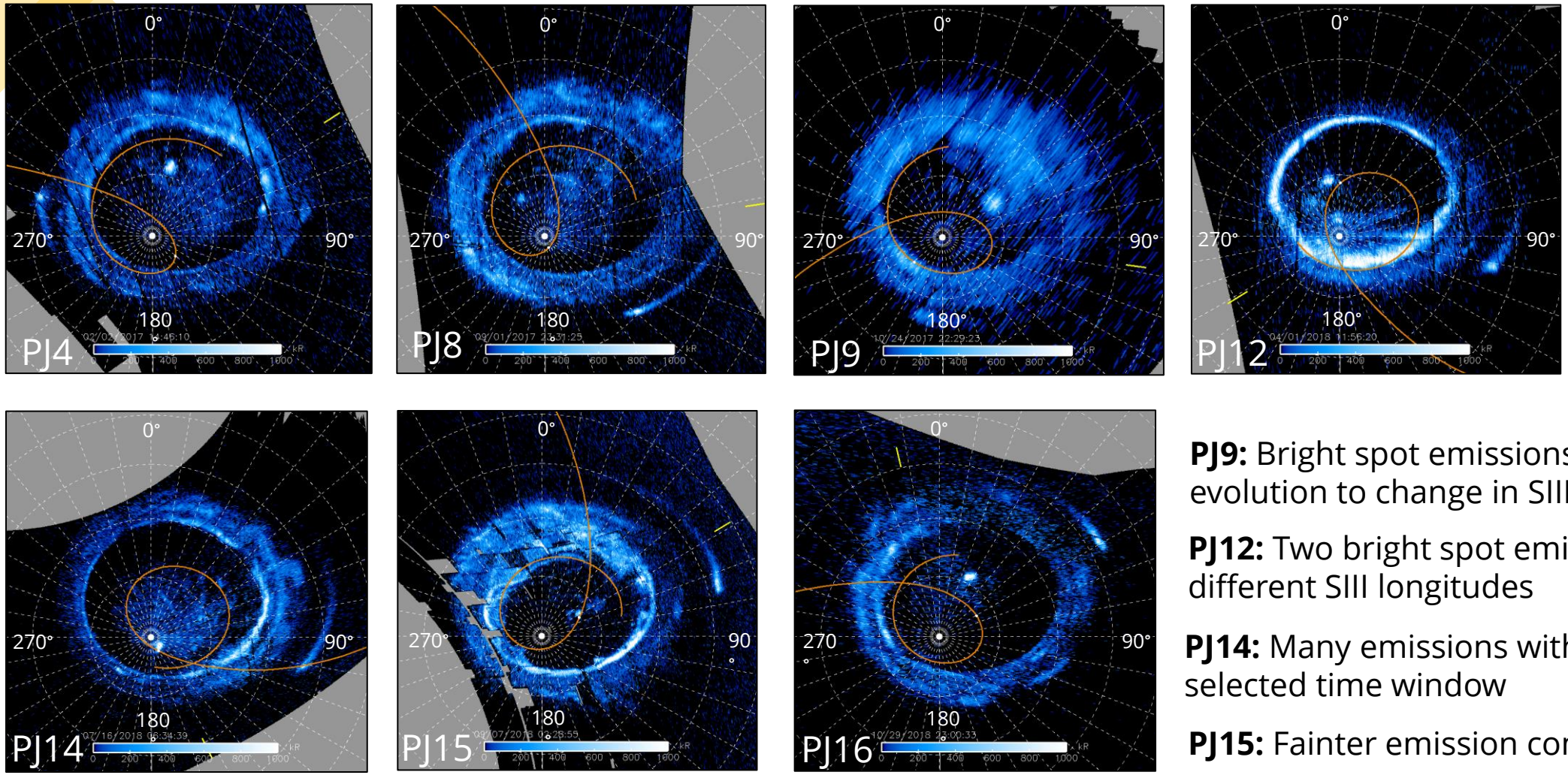
PJ6: Large bright spot emissions

PJ8: A spot at position different from others

PJ13: Two bright spot emissions during 25 min time interval

Figure 6. Bright spot emissions found in Northern hemisphere.

Jupiter's bright spot emissions



PJ4: Six bright spot appearances during ~4-h observation time, quasiperiodic behavior

PJ8: Fainter emission compare to others but appear many times

PJ9: Bright spot emissions with clear evolution to change in SIII longitude

PJ12: Two bright spot emissions appeared at different SIII longitudes

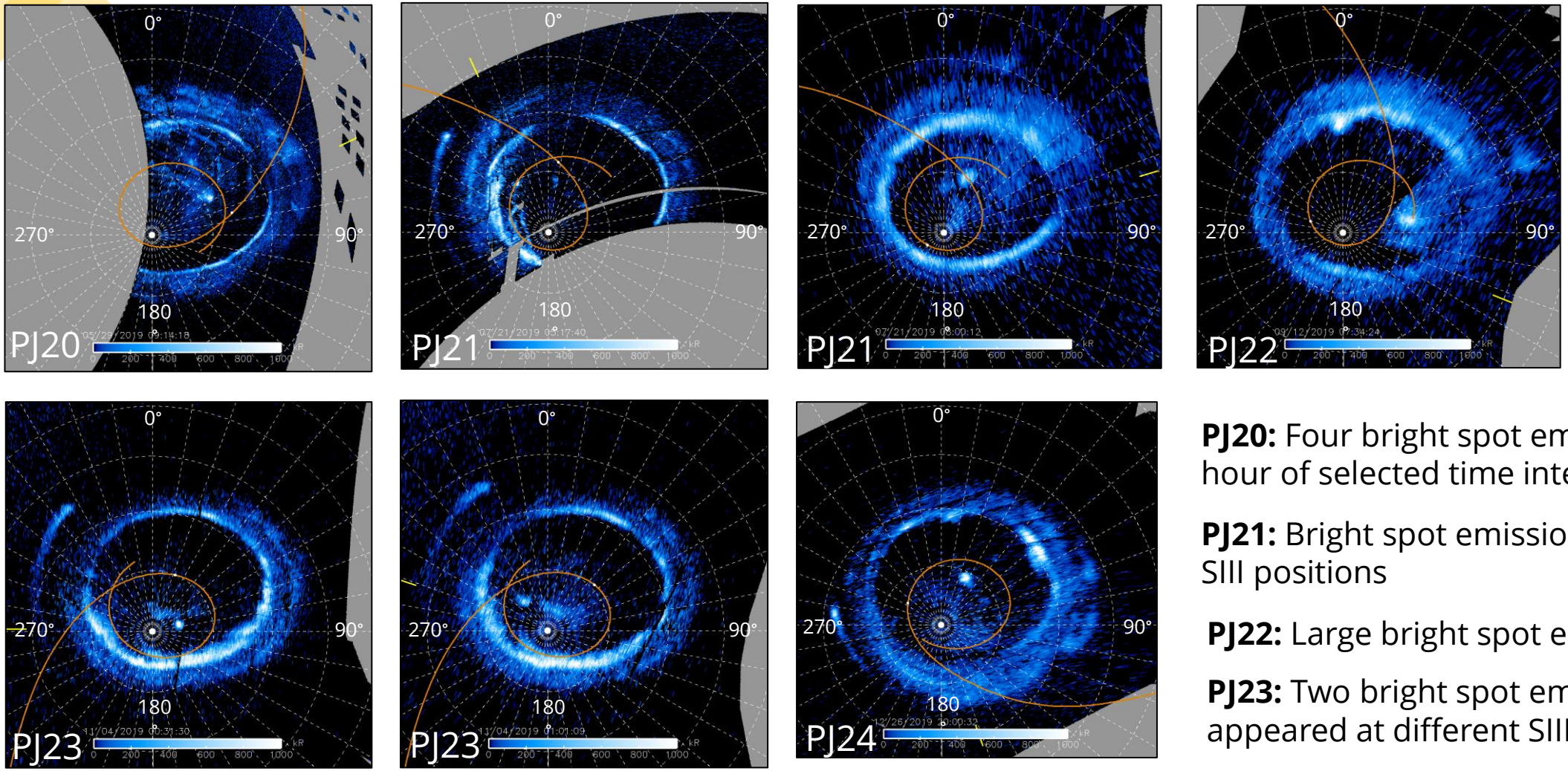
PJ14: Many emissions within 30 min of selected time window

PJ15: Fainter emission compare to others

PJ16: Seven bright spot emissions with quasiperiodic behavior

Figure 7. Bright spot emissions found in Southern hemisphere.

Jupiter’s bright spot emissions



PJ20: Four bright spot emissions during 1-hour of selected time interval

PJ21: Bright spot emissions at different SIII positions

PJ22: Large bright spot emissions

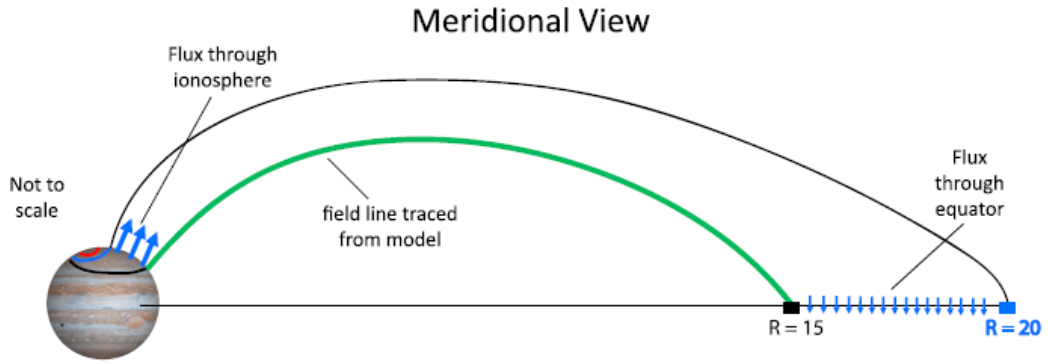
PJ23: Two bright spot emissions appeared at different SIII longitudes

PJ24: Bright spot emissions with clear evolution to change in SIII longitude

Figure 8. Bright spot emissions found in Southern hemisphere (continue).

Locations and local times

- 60°-70° latitude, 160°-190° SIII longitude
- Analogous to X-ray hot spot region
- Approximate local time: Midnight – Noon
- Vogt's mapping model:
  - >110 R_J in magnetosphere, dawn time
  - Unmapped for > 90% of spot data



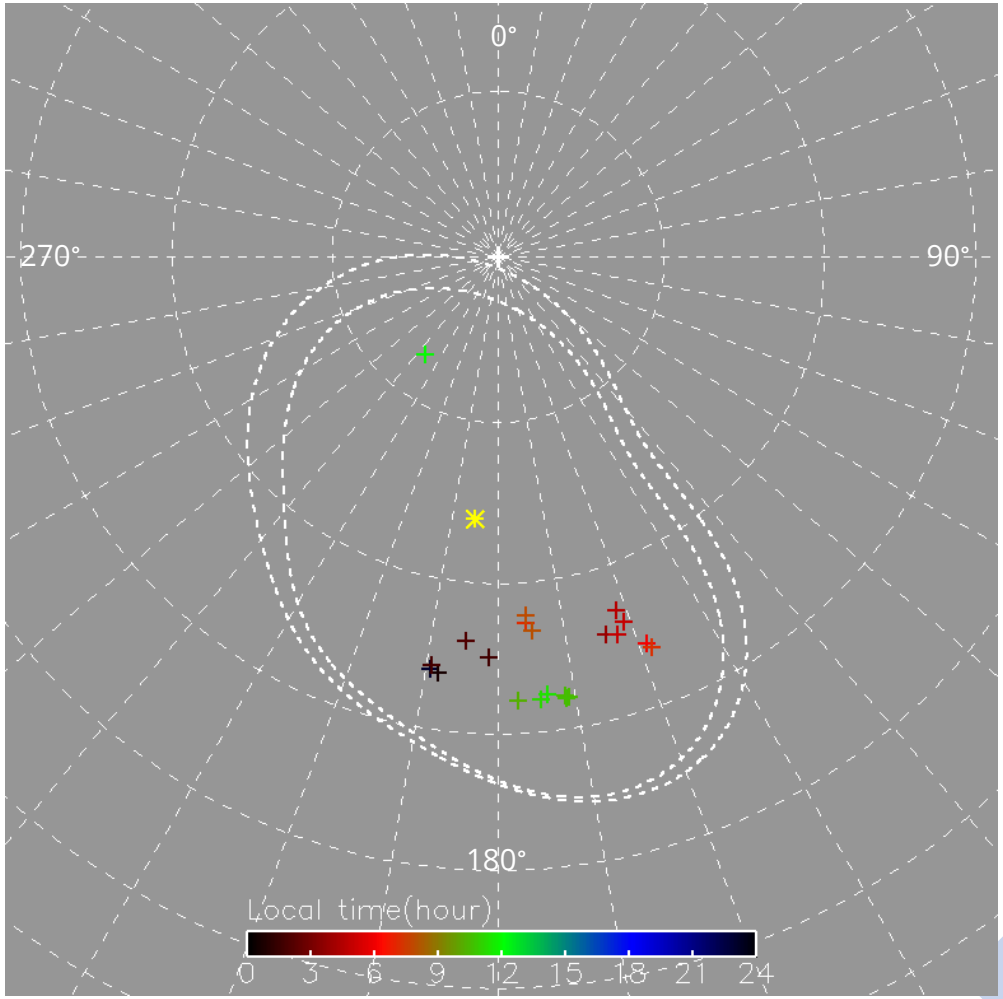
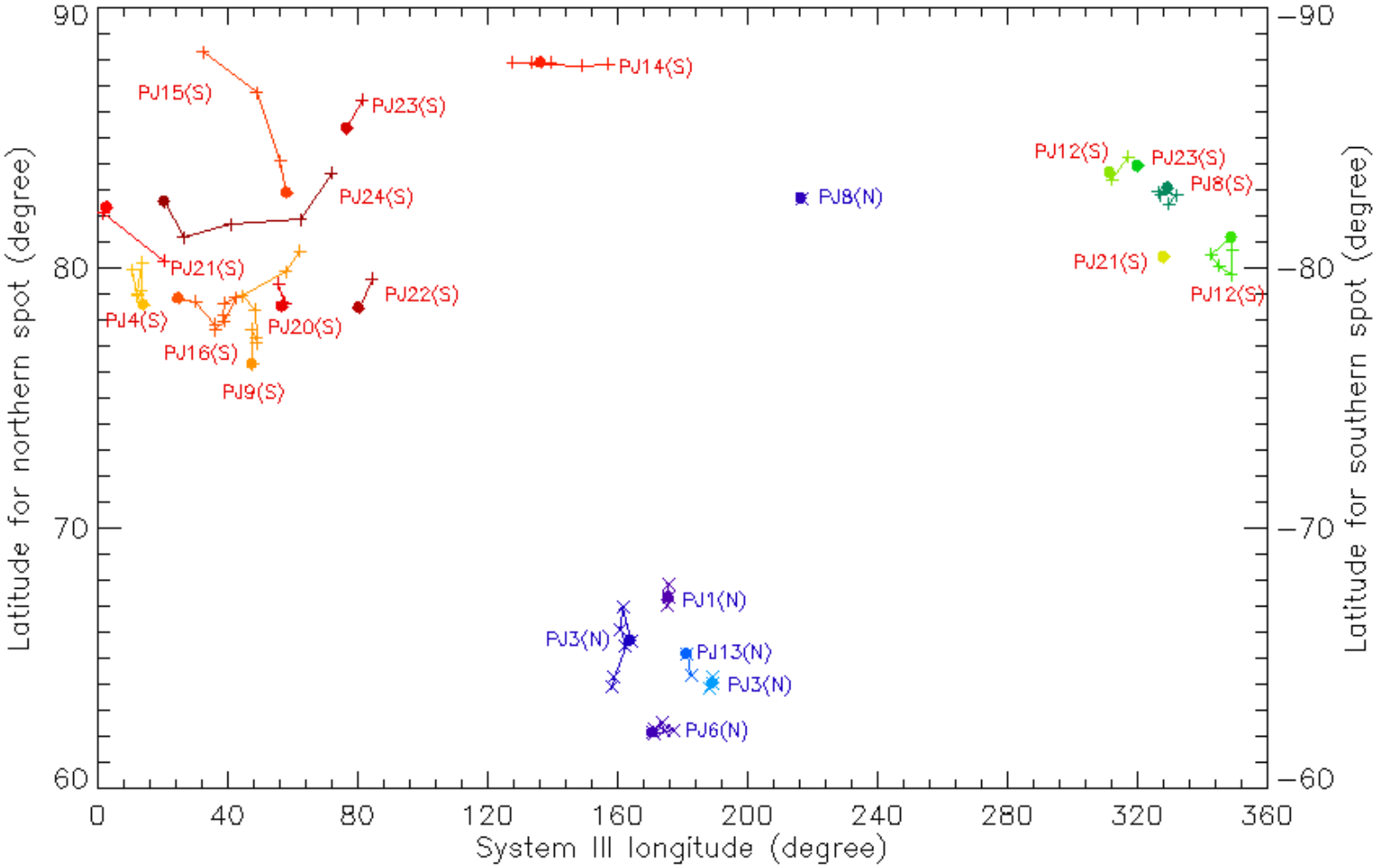
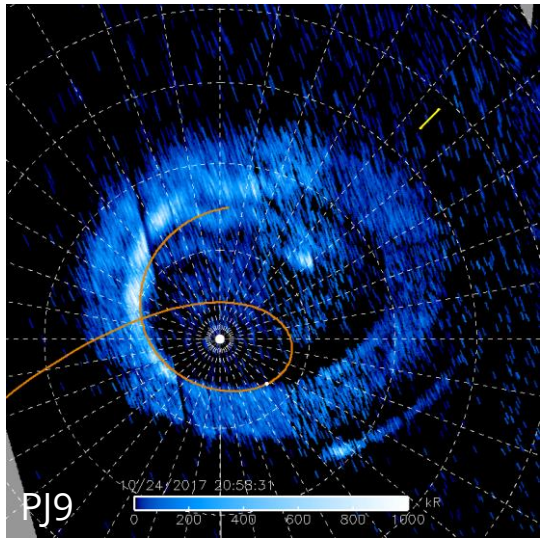


Figure 9. Polar projections shows the positions of bright spots observed in northern hemisphere with the statistical locations of the main emission (dash contours) (Bonfond et al., 2012). The color presents the approximated magnetic local time of bright spot.

Locations





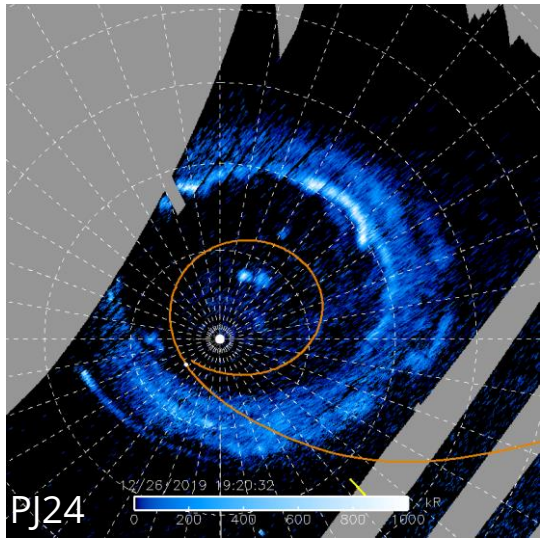
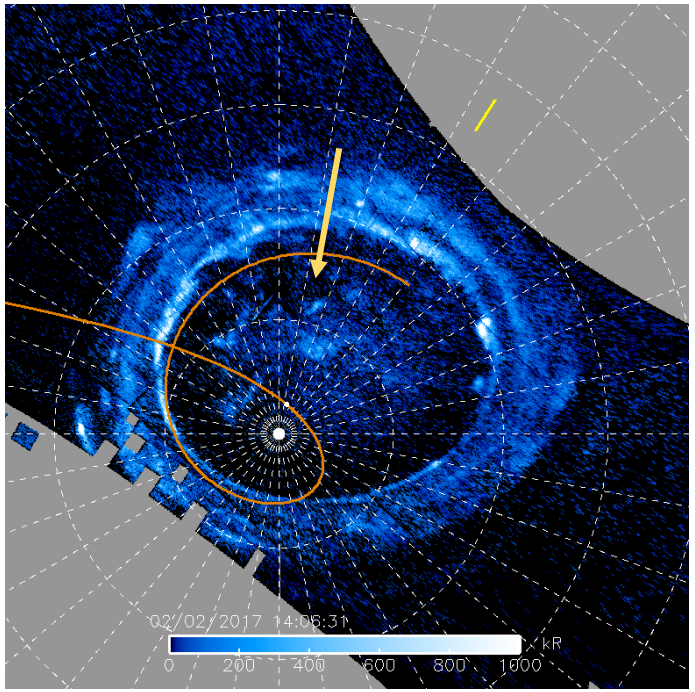


Figure 10. Bright spot position in SIII longitude and latitude map (plus symbol & bluish tone for northern spots and cross symbol & green to red tone for southern spots). The line connecting each data presents the motion of bright spot with observing time order starting from a dot in each plot.

The power variations: PJ4

- time interval between peak: ~ 30 min
- evidence of quasiperiodic behaviors (period ~28 min)



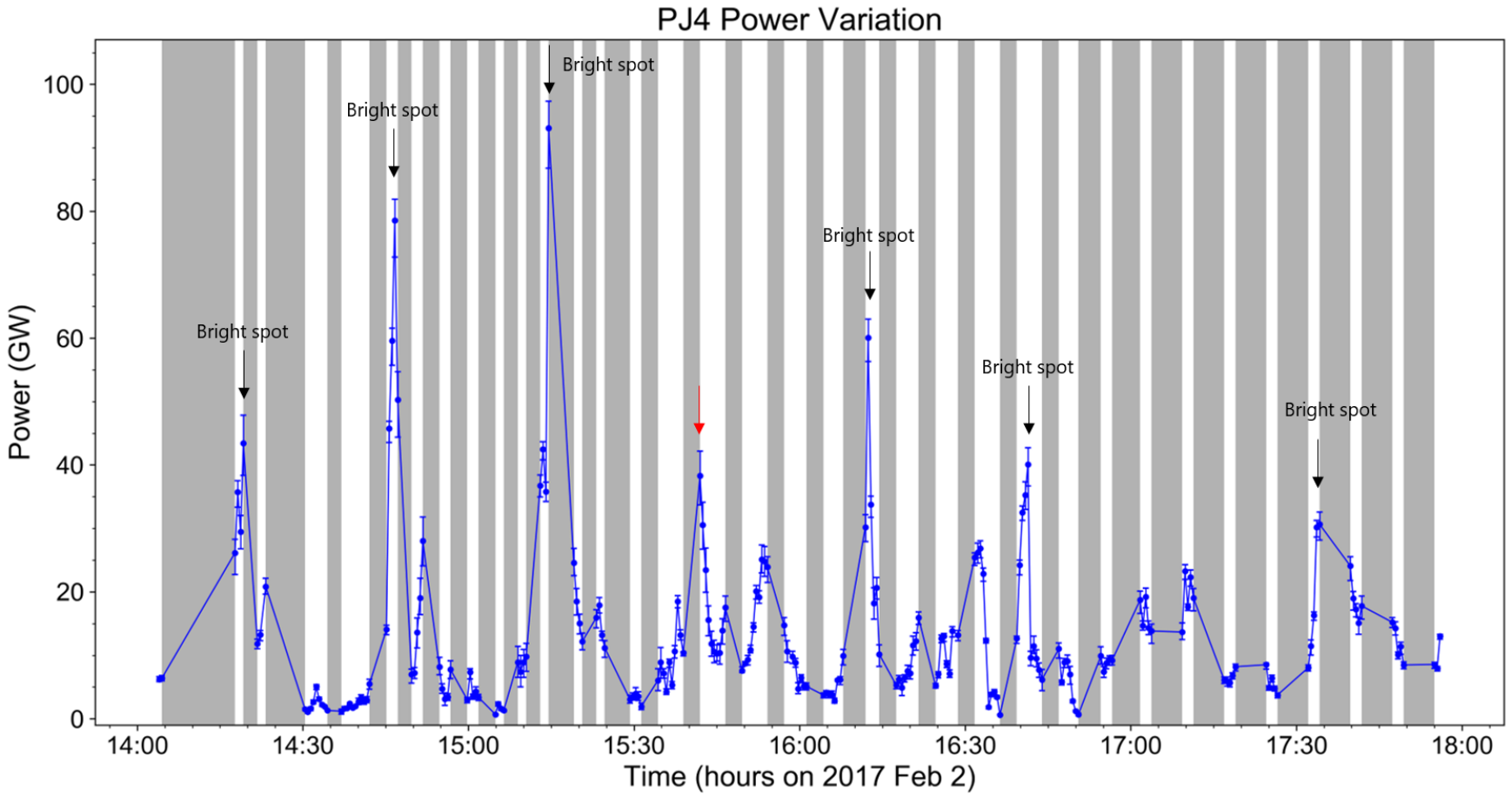


Figure 11. The time variation of power emission of bright spot observed in PJ4. The gray boxes indicate time that the bright spot does not appear in the UVS view.

Summary

- Occurrence from both N&S hemispheres
- The emitted power is tens GWs, some bright spot emissions can reach up to a hundred GWs.
- Reappearance of bright spot emissions within a Juno perijove in the same system III position, indicative of quasiperiodic pulsations
- The time interval between two consecutive brightening: ~3-47 minutes
- The system III positions of bright spots:
  - **Northern hemisphere:** region around 175° system III longitude and 65° latitude.
  - **Southern hemisphere:** scattered around the polar region
- Bright spot emissions can be seen at any local times, contrast from previous studies
- More data and in situ observations are currently under investigation

In-situ observations

- Events: PJ3, PJ15, PJ33
- Instruments: UVS, JEDI, JADE, Waves, MAG

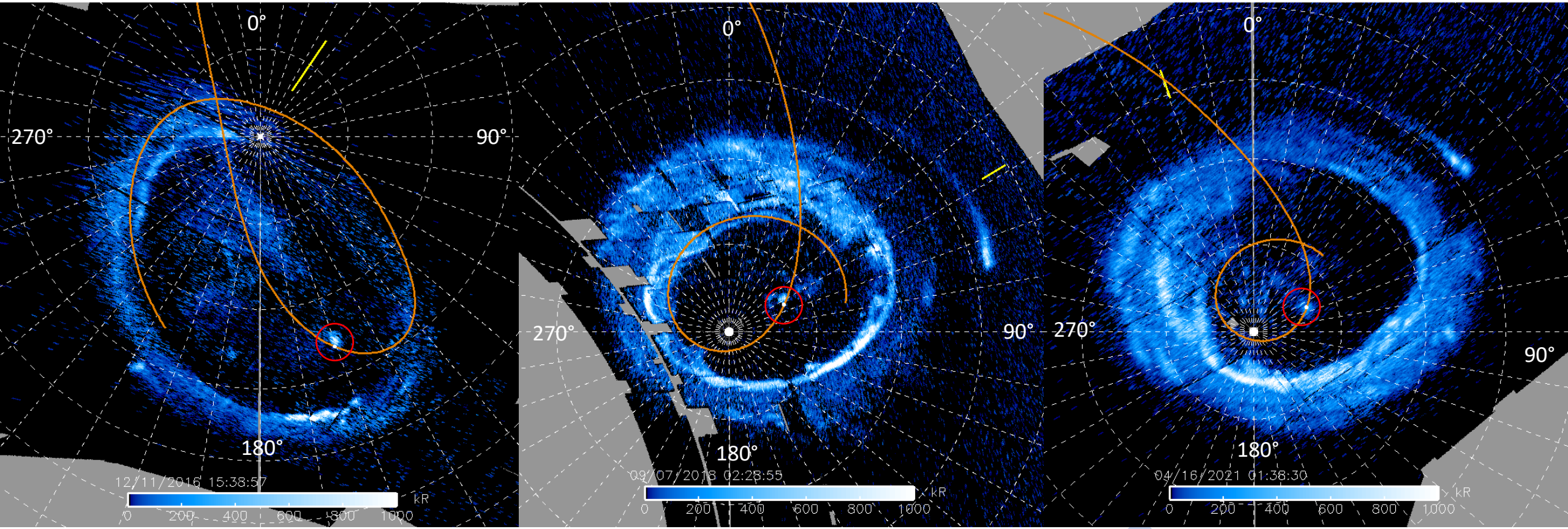


Figure 12. Jupiter's auroras observed by Juno-UVS during PJ3, PJ15, and PJ33

Thank you