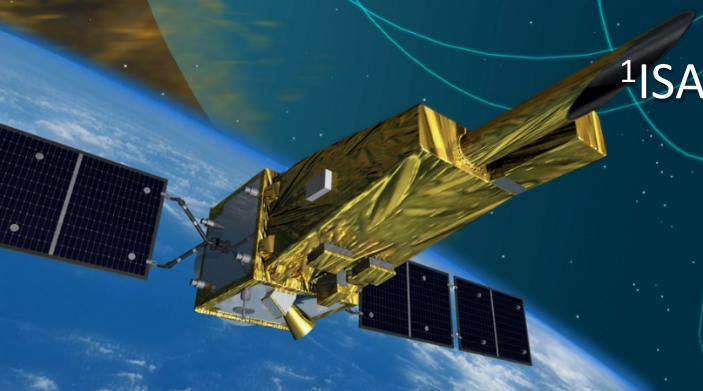
10:30-11:00

10 October 2017
Planetary Space Weather
Europlanet NA1 workshop @Toulouse, France

Response of Jupiter's inner magnetosphere to the solar wind derived from Hisaki observation

Go Murakami[1], K. Yoshioka[2], T. Kimura[3], A. Yamazaki[1], F. Tsuchiya[4], C. Tao[5], M. Kagitani[4], Y. Kasaba[4], I. Yoshikawa[2], and M. Fujimoto[1]

[1]ISAS/JAXA, [2]Tokyo Univ., [3]Riken,
[4]Tohoku Univ., [5]NICT



Jovian magnetosphere

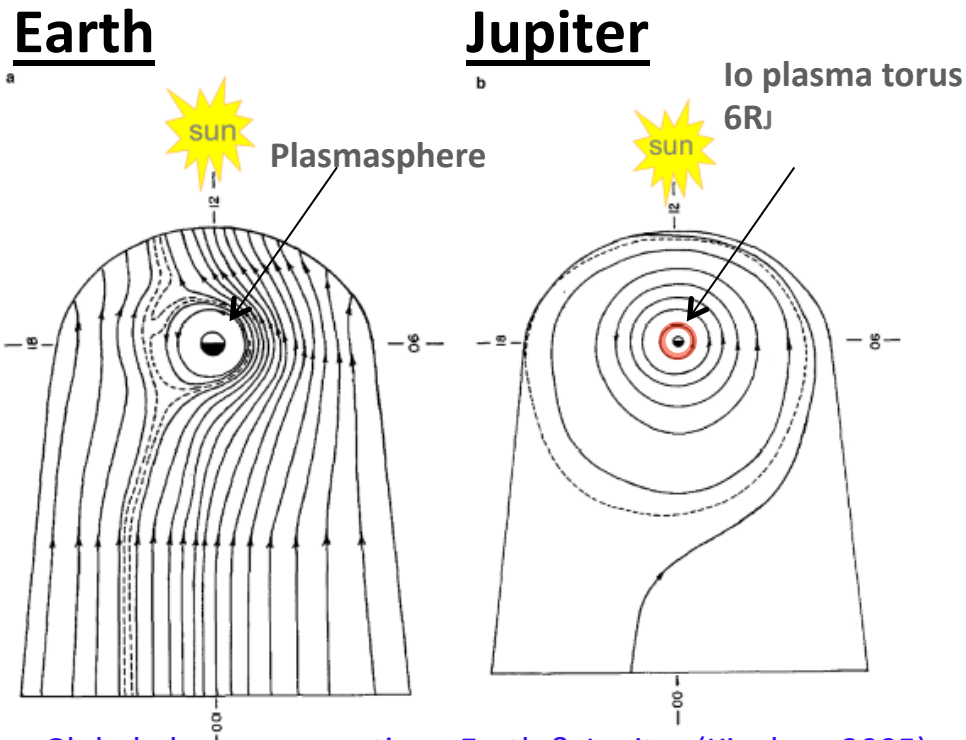
Rotationally dominant magnetosphere

-Strongest magnetic field

-Rapid rotation (9.9 hours)

→**Corotation >> solar wind @inner magnetosphere**

Electric field	Earth (6 Re)	Jupiter (6 Rj)
Corotation	0.4 mV/m	**150 mV/m**
Solar wind	4 mV/m	**0.4 mV/m**



Global plasma convection : Earth & Jupiter (Kivelson 2005)

Effect of the solar wind to the Jovian inner magnetosphere is thought to be negligible

Dawn/dusk asymmetry of Io plasma torus

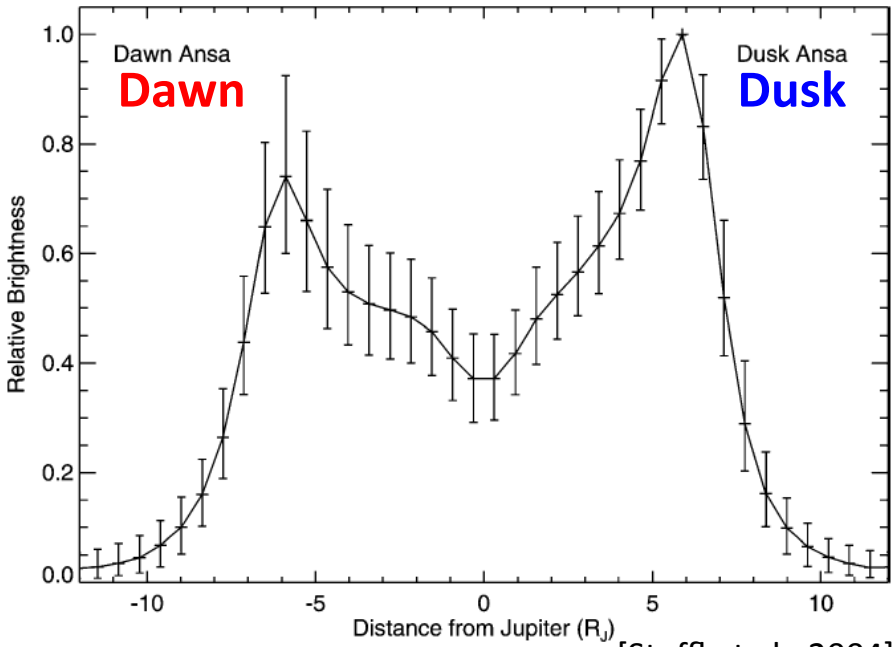
EUV flux asymmetry

-**Dusk side is 30% brighter** than dawn side (in average)

Position asymmetry

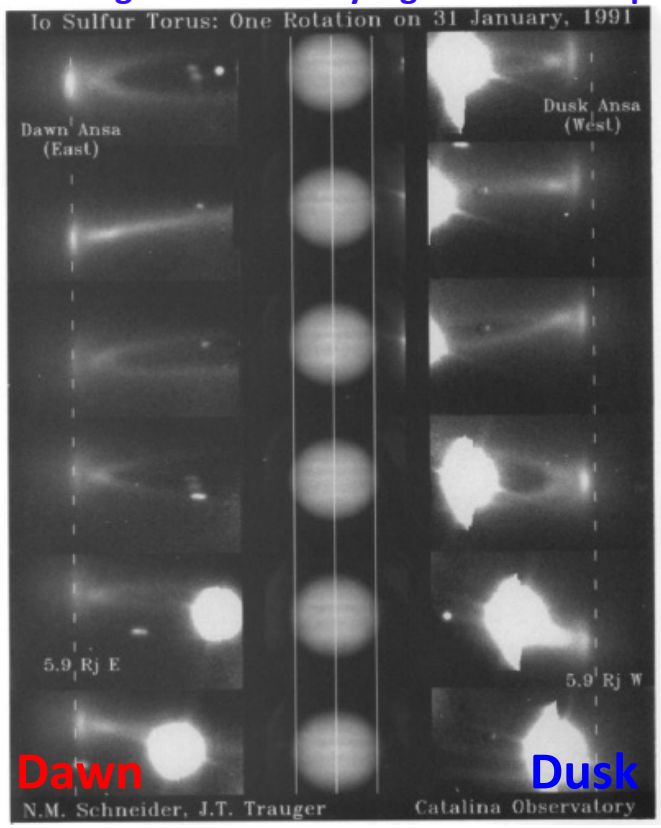
-The radial structure of IPT is offset ~0.2 Rj **toward the dawn side**

IPT radial profile of EUV flux observed by Cassini



[Steffl et al., 2004]

IPT images observed by a ground telescope (visible)



[Schneider and Trauger, 1995]

Dawn/dusk asymmetry of Io plasma torus

Possible explanation: Dawn-to-dusk electric field [e.g., Ip and Goertz, 1983]

Dawn-to-dusk electric field in the inner magnetosphere

↓

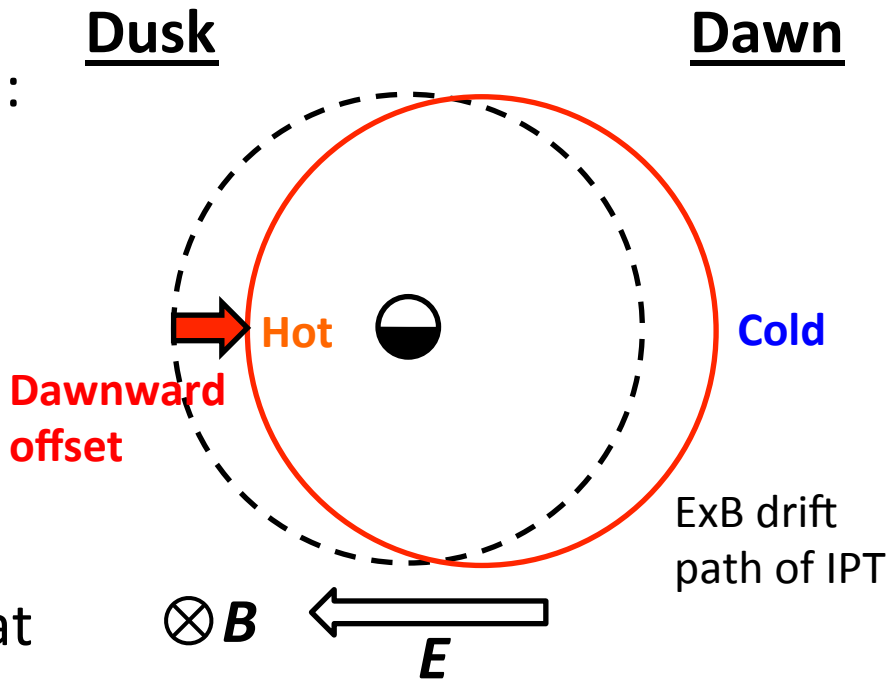
Offset of ExB drift paths toward dawn: **position asymmetry of IPT**

↓

Due to adiabatic heating, low energy electrons and ions get hotter at dusk than at dawn

↓

Brighter EUV emissions at dusk than at dawn: **EUV flux asymmetry**



But…

How can such a electric field exist? What is a source mechanism?

Can solar wind influence Jupiter's inner magnetosphere?

Rotationally dominant magnetosphere ($E_{corotation}$ is 400 times stronger than E_{sw})

How?

Dawn-dusk asymmetry in IPT suggests **dawn-to-dusk electric field** → **Can solar wind influences reach deep into the magnetosphere?**

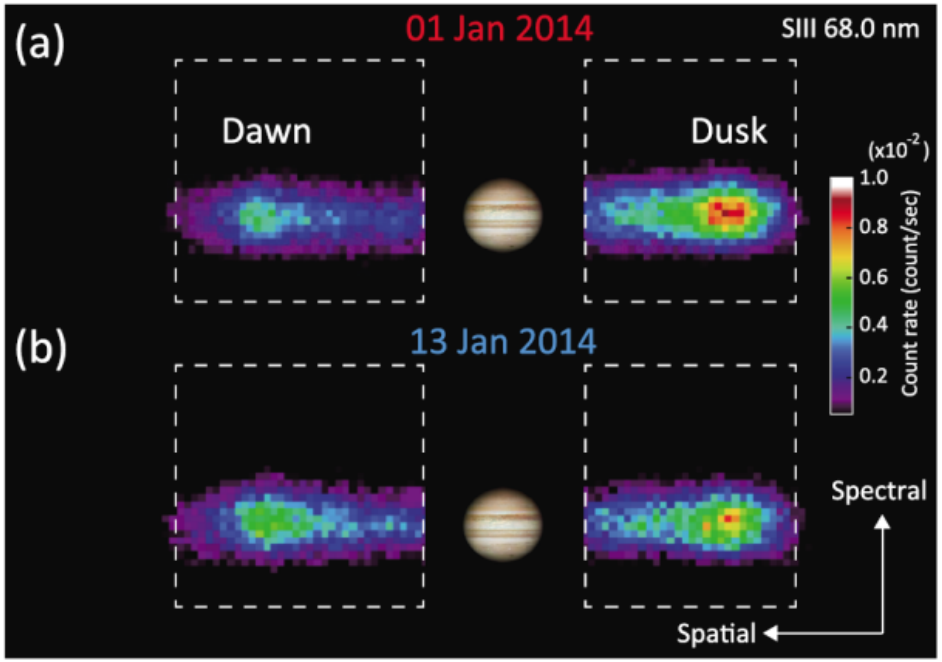
Major open question

-Investigating temporal variations in the inner magnetosphere is a key observation to know the influence of solar wind

-There have been no long and continuous monitoring of EUV flux from IPT

EUV spectroscopy by HISAKI/EXCEED can solve this problem!

EUV spectral images observed by HISAKI

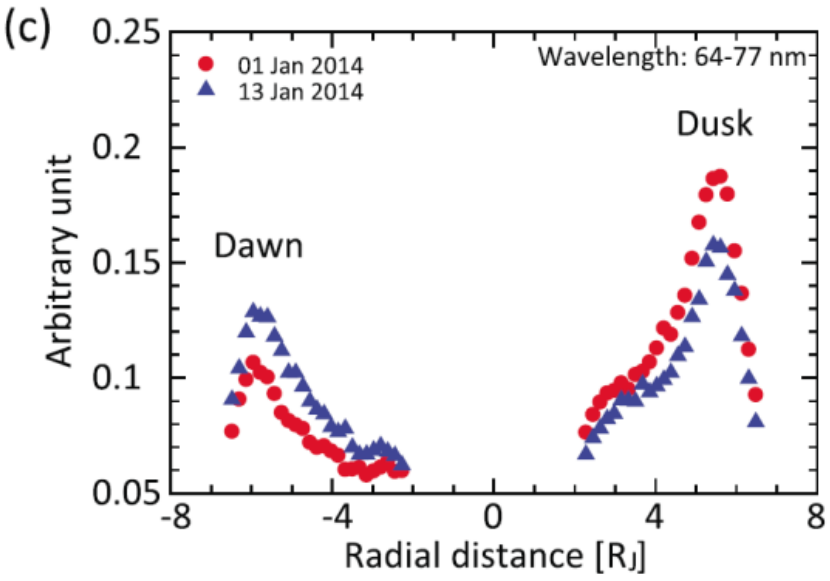


Specifications

Spectral range: 55-148 nm

Spatial resolution: ~0.7 Rj

Temporal resolution: ~50 min



Dawn-dusk asymmetry is detected

The dusk/dawn brightness ratio clearly changed!

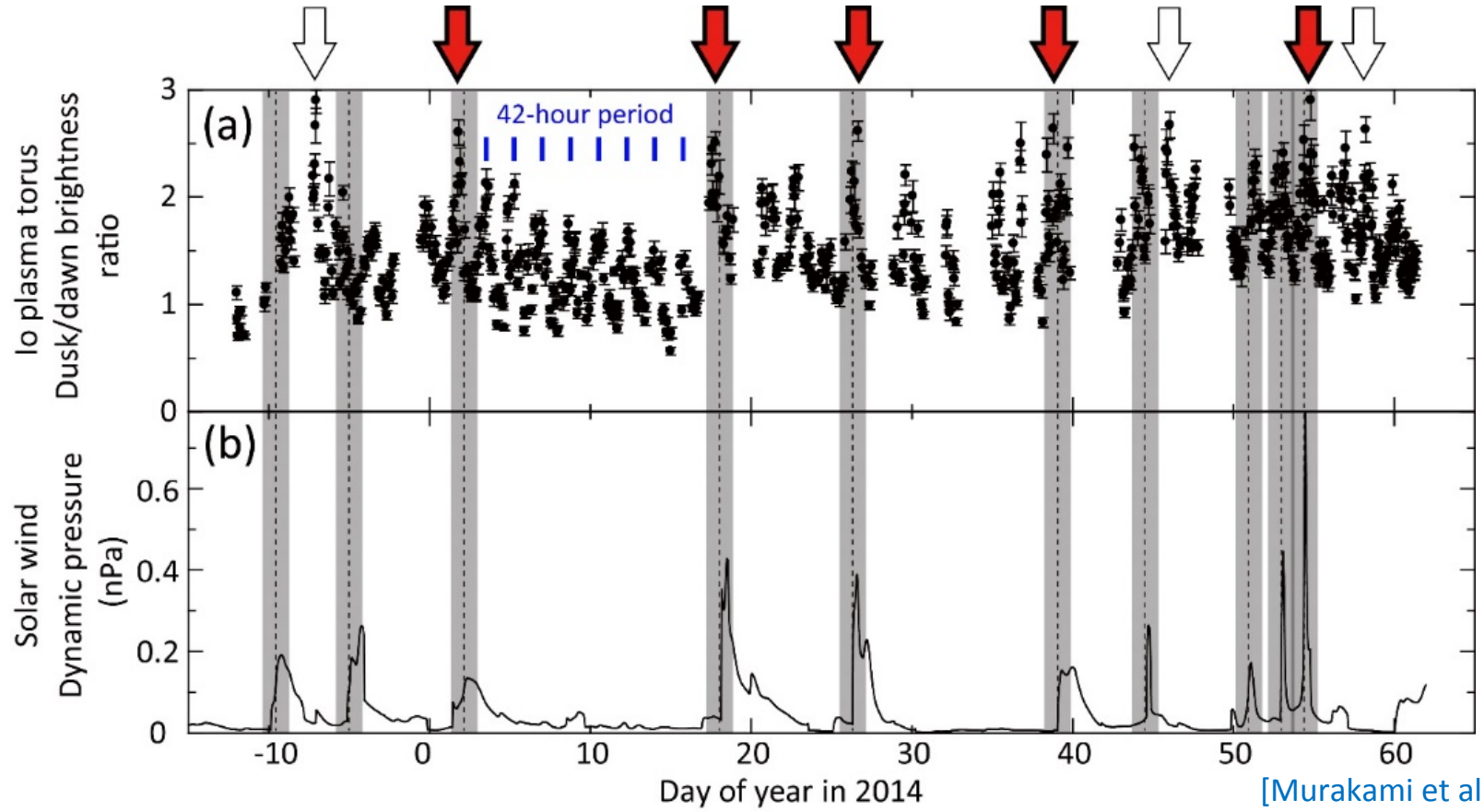
[Murakami et al., GRL, 2016]

Response of IPT to the solar wind observed by Hisaki

Evidence of the solar wind influence deep inside Jupiter's magnetosphere

Observation

Obs. + simulation

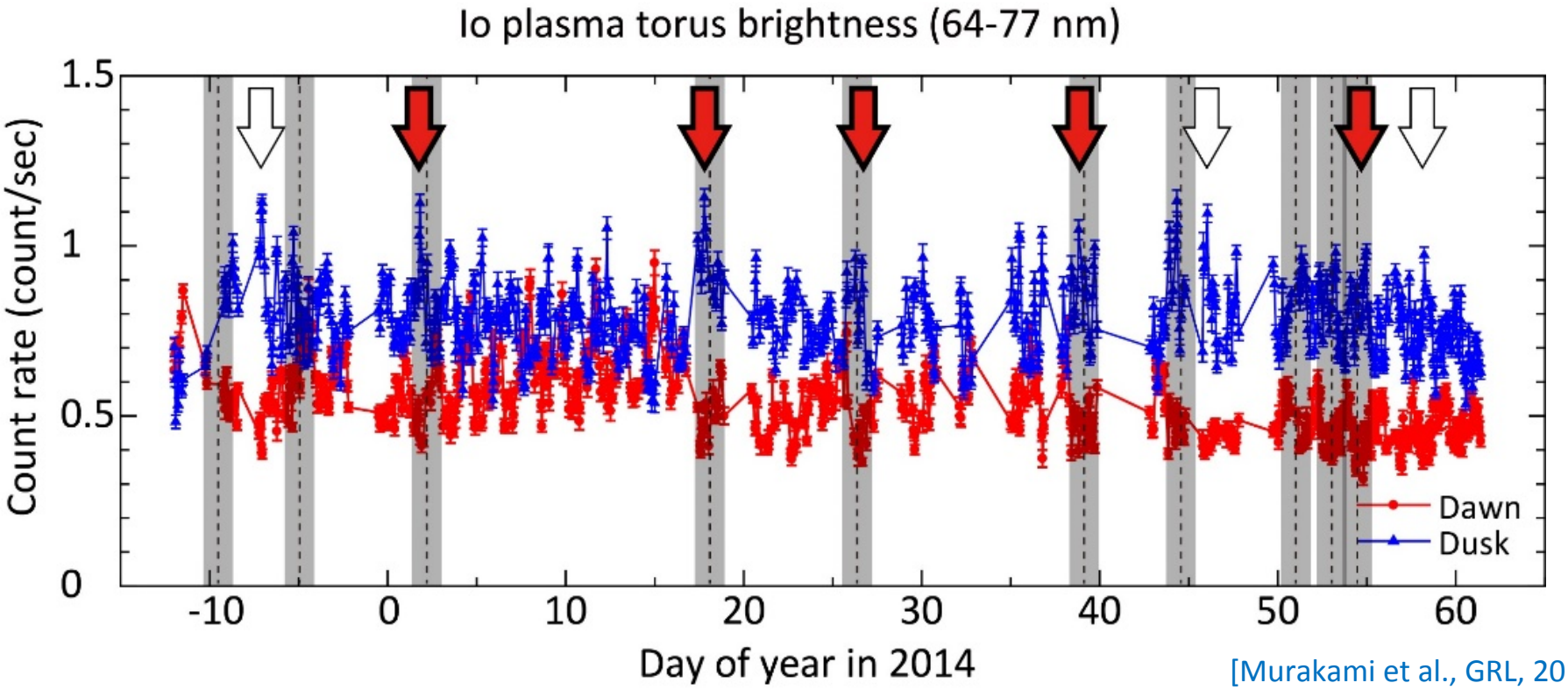


[Murakami et al., GRL, 2016]

- **The solar wind influence on the Io plasma torus brightness is detected by Hisaki**
- **Long-term monitoring revealed that enhanced dawn-dusk brightness ratio is seen when solar wind dynamic pressure increased**

Response of IPT to the solar wind observed by Hisaki

- **Our result suggests that solar wind influences the dawn-to-dusk electric field in Jupiter's inner magnetosphere**

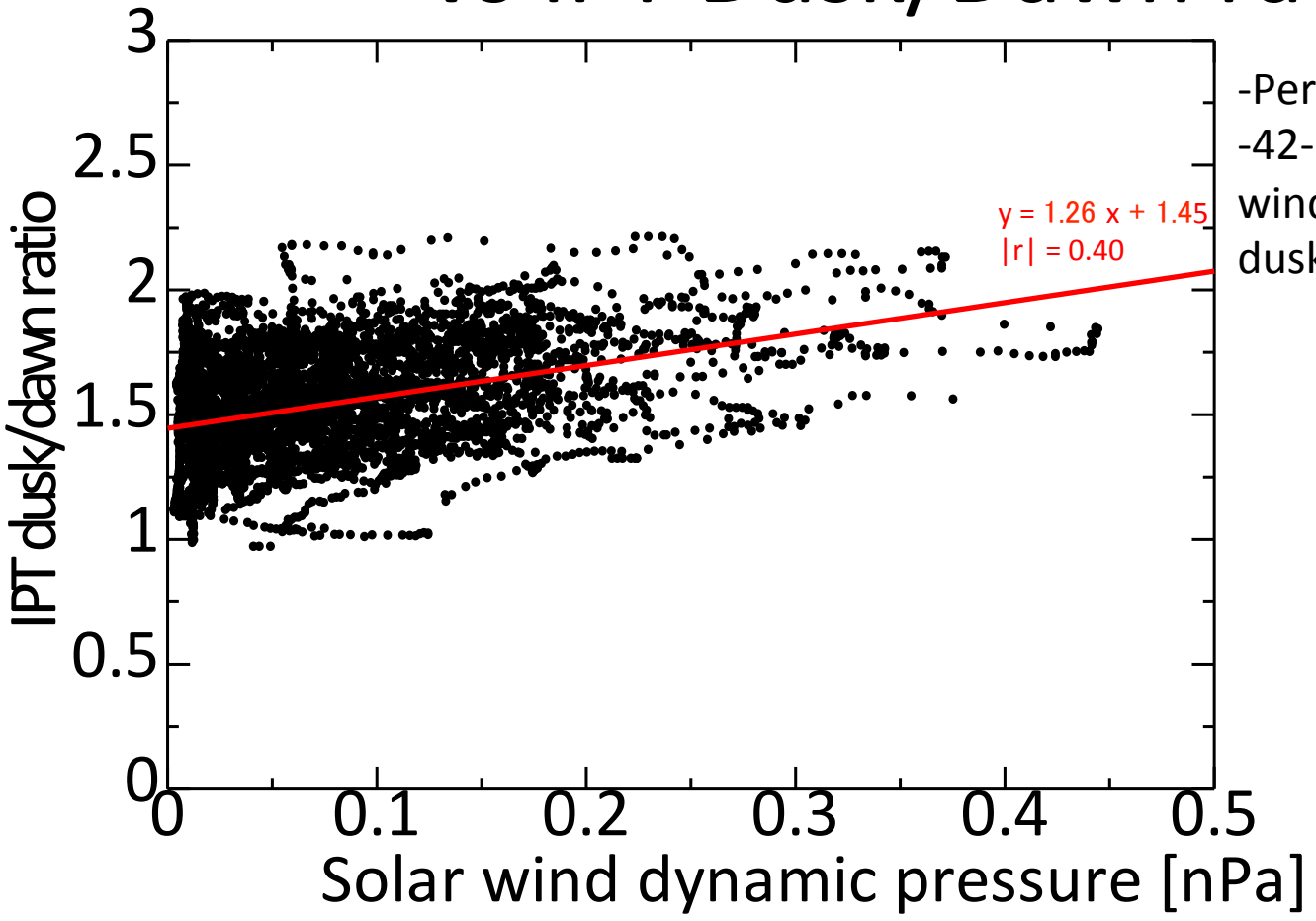


[Murakami et al., GRL, 2016]

Anti-correlation between dawn and dusk

→ExB drift paths of IPT plasmas shifted toward dawn side by dawn-to-dusk electric field (plasmas become hotter at dusk)

Statistical analysis: SW dynamic pressure vs IPT Dusk/Dawn ratio

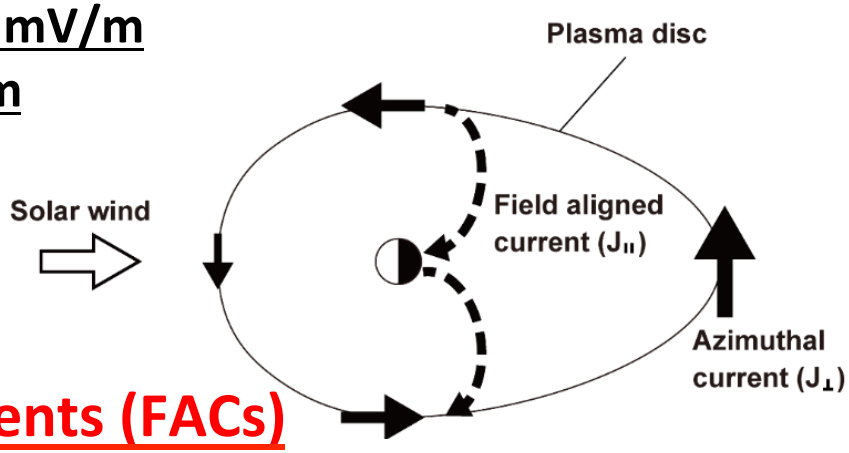


-Period: Dec. 2013 – Aug. 2016
-42-h running averages of solar wind dynamic pressure and IPT dusk/dawn ratio are used

Positive correlation between SW dynamic pressure and IPT D/D ratio

Cause of dawn-to-dusk electric field

Estimated dawn-to-dusk electric field: **~3-9 mV/m**
Solar wind electric field @Jupiter: **0.4 mV/m**
→Different sauce process from the Earth's convection electric field is needed



Possible process by field aligned currents (FACs)

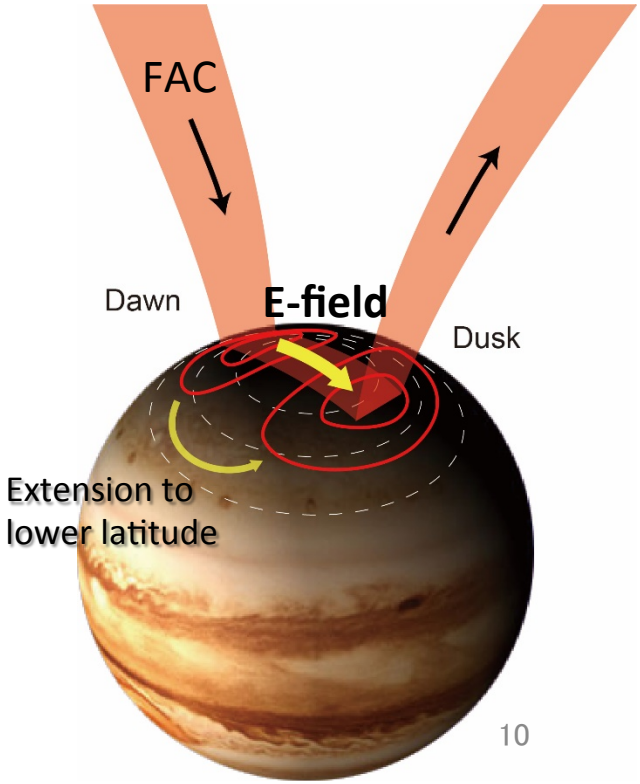
[Goertz and Ip, 1984]

- Azimuthal current (disc current) @~20 Rj
- Solar wind compress Jupiter's magnetosphere

→Azimuthal current increases at night side
decreases at dayside
→**Divergence of azimuthal current**
→**Field aligned current close the system**
→Dawn-to-dusk electric field in the ionosphere

- FAC increases with high dynamic pressure

→**This agrees with our results**



Dawn-to-dusk E-field can exist even in the inner region, i.e., radiation belt (<3 RJ)
-> **Contribution for the radial diffusion?**

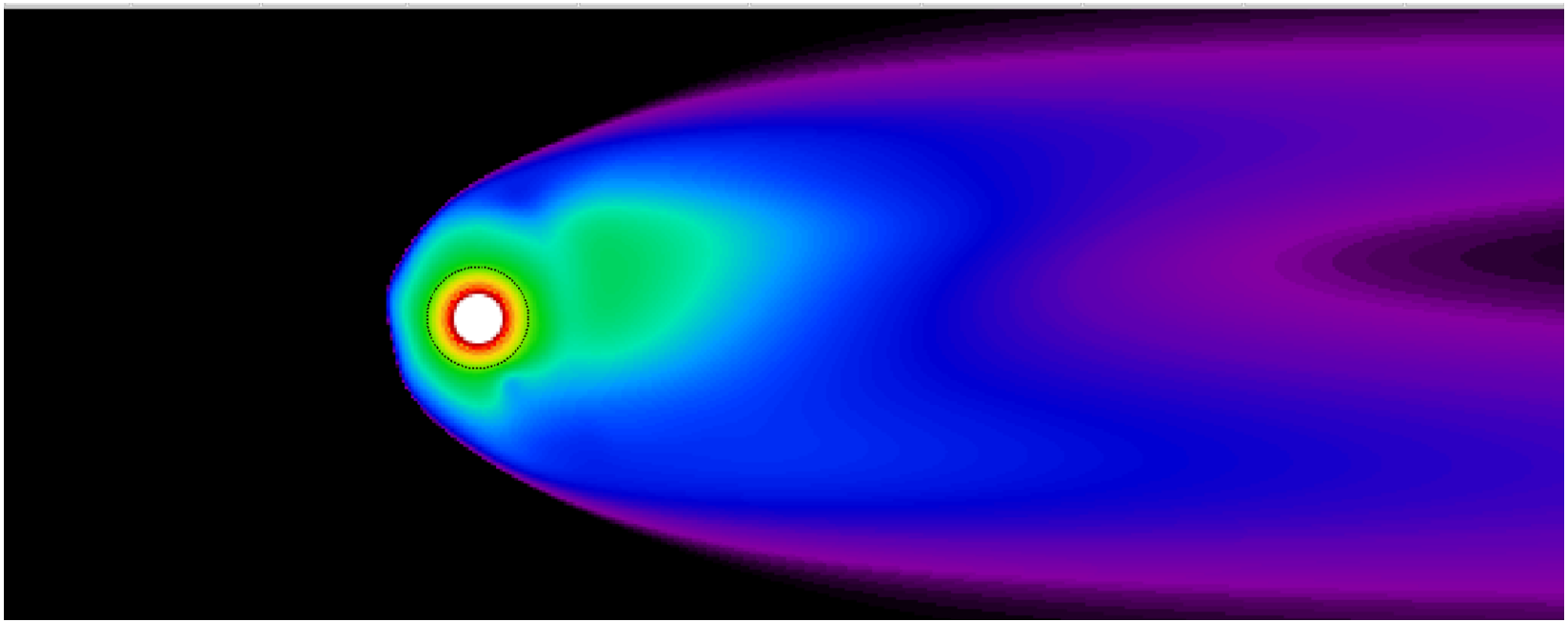
Comparison with global MHD simulation

What physical process can generate a dawn-to-dusk electric field in Jupiter's inner magnetosphere?

<u>3-D global MHD simulation of Jupiter's magnetosphere [e.g., Fukazawa et al., 2010]</u>

-Grid size: 1.5 Rj

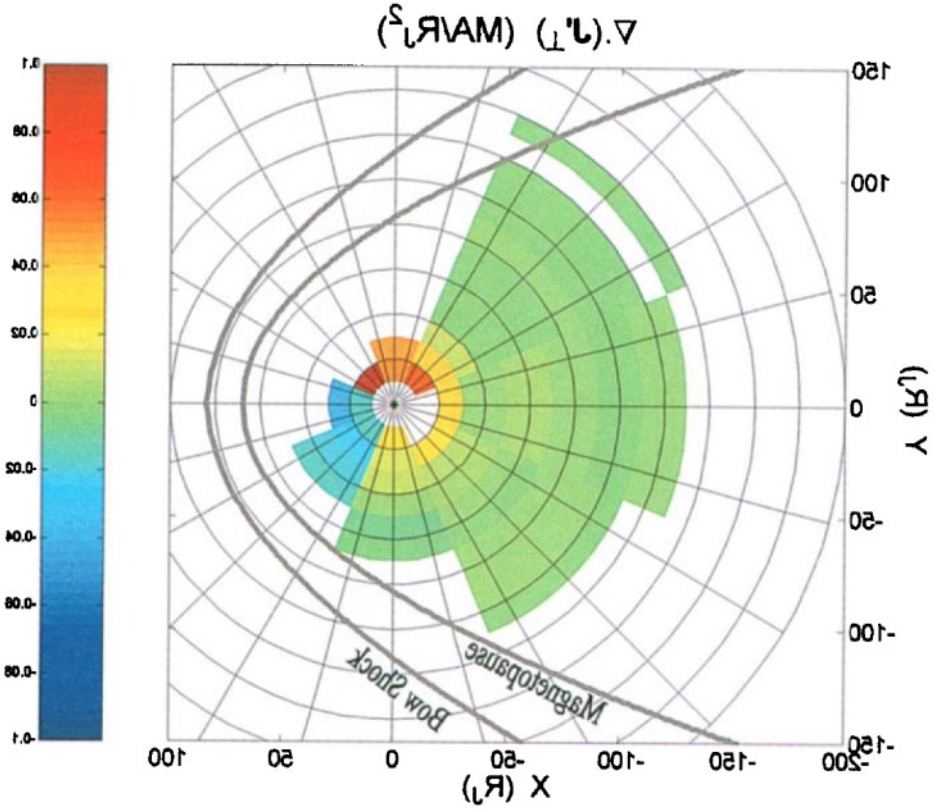
-Inner boundary: 15 Rj



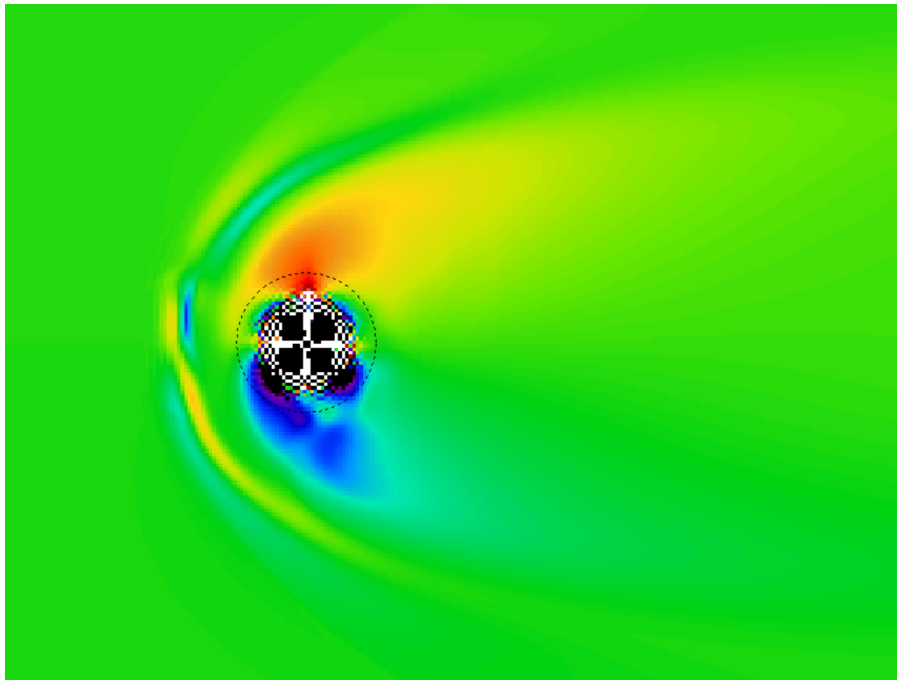
We checked solar wind effects on FACs

FACs in the simulation

Khurana 2001



MHD simulation

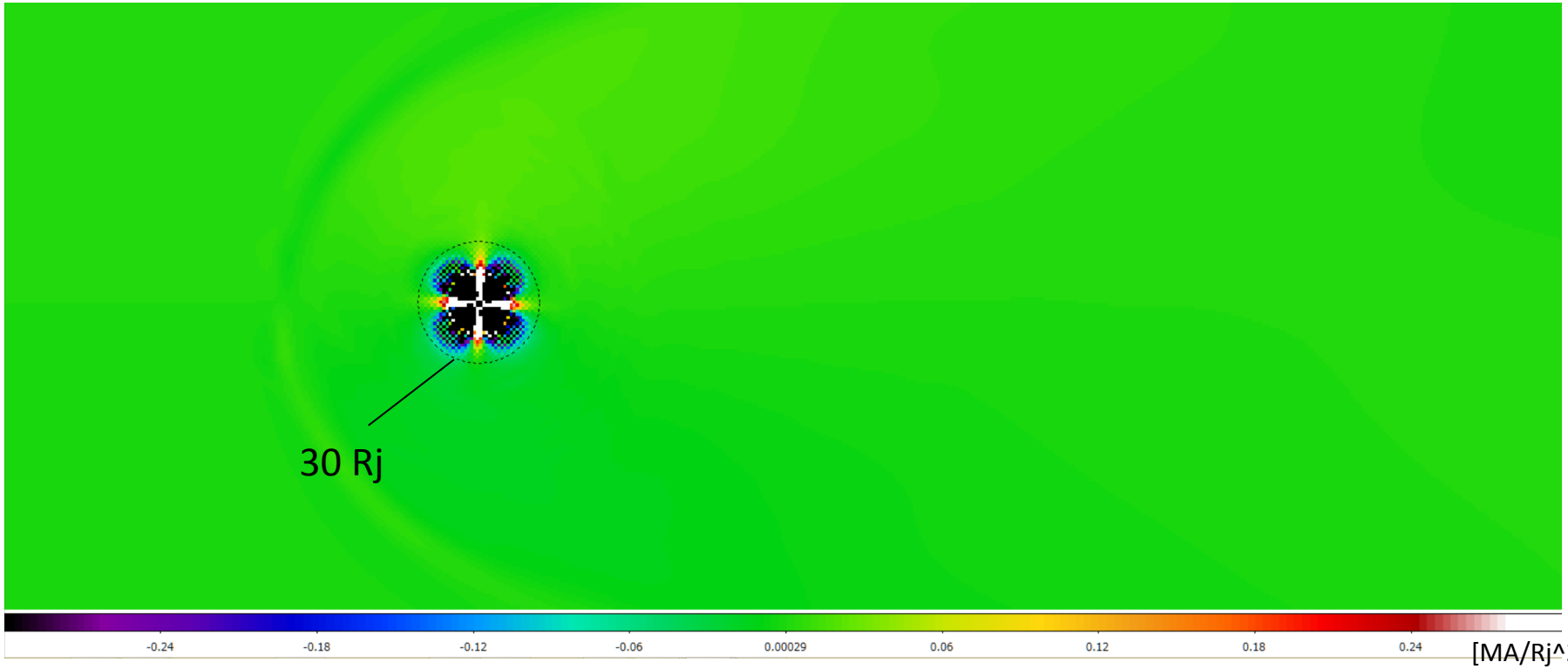


Color bar range is same as Khurana [2001]

Dawn-to-dusk FAC is generated

Initial result from MHD simulation: Divergence of $J_{\perp}$

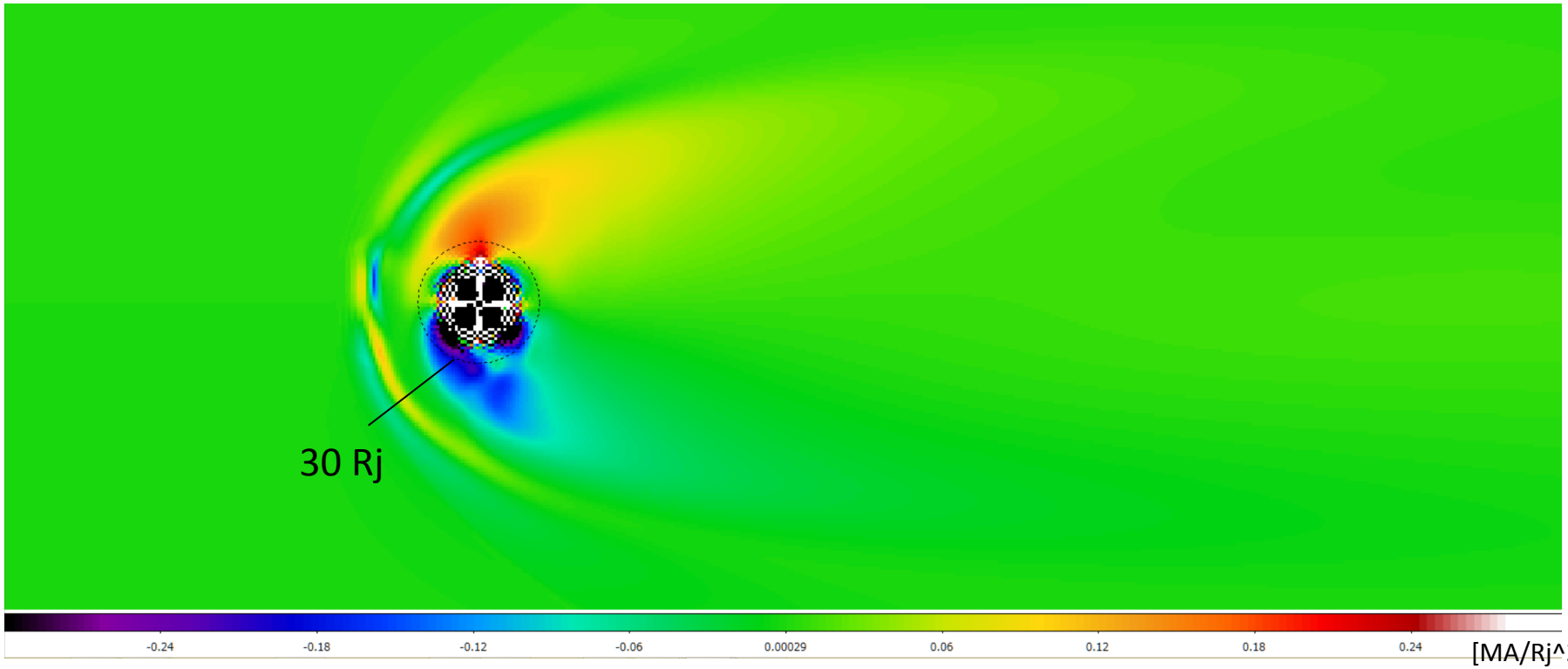
Solar wind Pdy: 0.01 nPa



Northward at equator: positive

Initial result from MHD simulation: Divergence of $J_{\perp}$

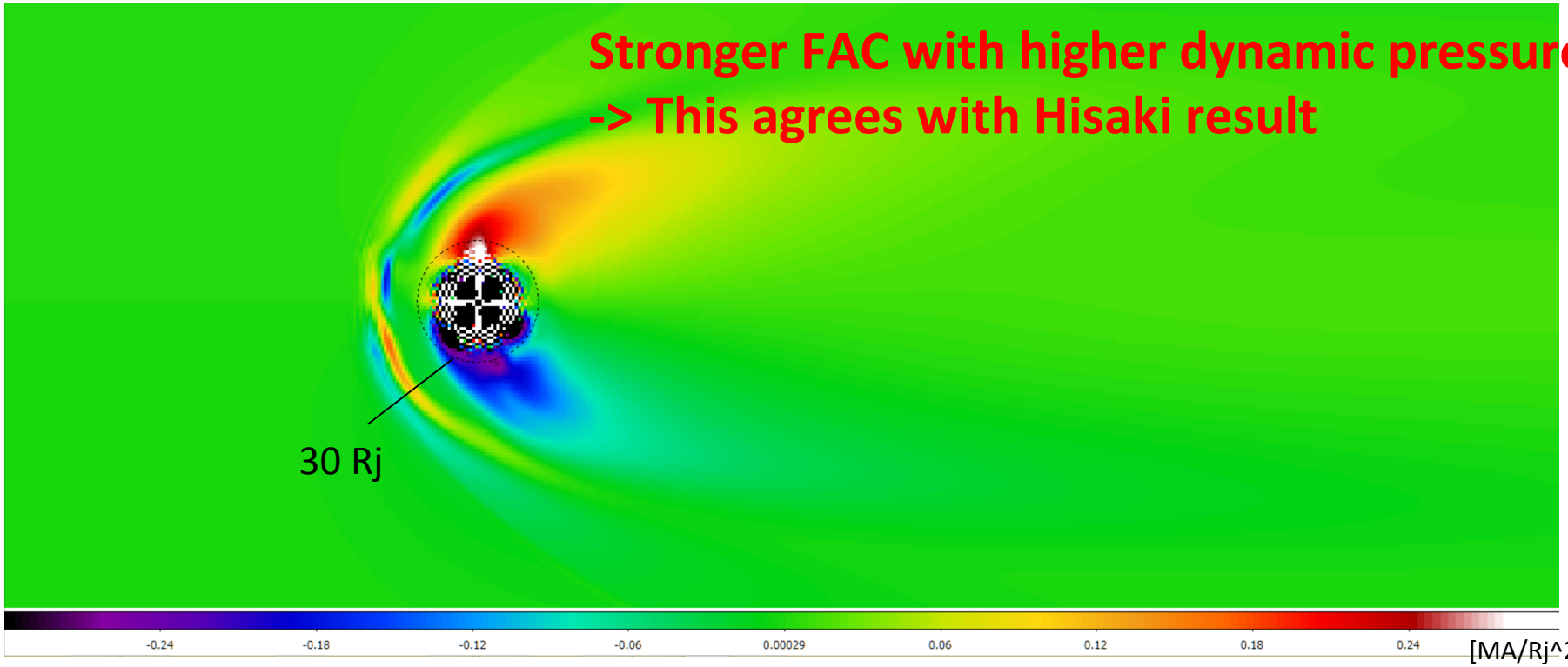
Solar wind Pdy: 0.36 nPa



Northward at equator: positive

Initial result from MHD simulation: Divergence of $J_{\perp}$

Solar wind Pdy: 0.72 nPa



Northward at equator: positive

Summary

We found a clear evidence of the solar wind influence in Jupiter's inner magnetosphere!

- We compared the temporal variations of dusk/dawn brightness ratios observed by HISAKI/EXCEED to that of solar wind dynamic pressure
- →**Clear responses of IPT to rapid increases of solar wind dynamic pressure are found**
- The temporal variations of EUV brightness at dawn and dusk have anti-correlation
- →Suggesting **dawn-to-dusk electric field exists**
- Statistical analysis of 3-years data showed **a positive correlation between SW dynamic pressure and IPT dusk/dawn ratio**
- Possible source mechanism due to field aligned current into the ionosphere agrees with our observation results

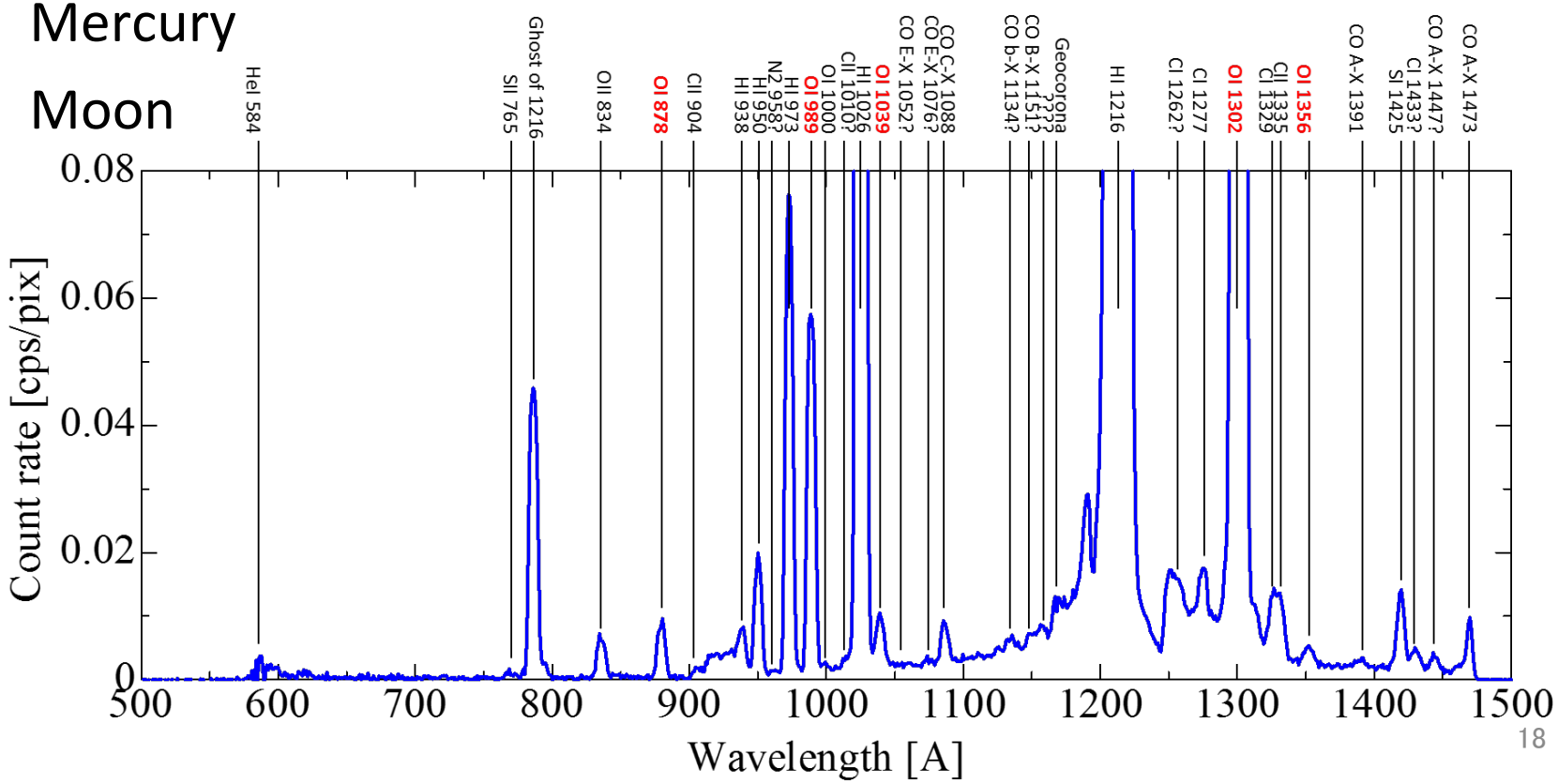
Solar wind can play an important roll even in the Jupiter's deep inner magnetosphere

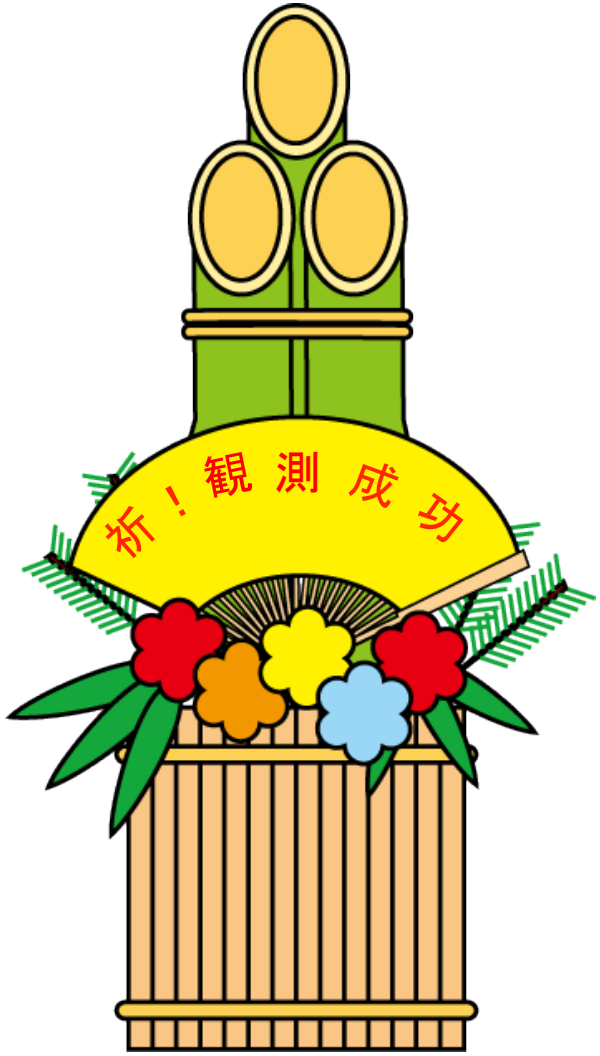
Future works

- **Statistical study** -> investigate correlations with several parameters of SW (e.g., dynamic pressure, duration of high pressure, quiet period etc…)
- **Effect of Io volcanic activity** -> comparison before and after volcanic eruption
- **Time scale of response** (and decay) -> depending on temporal accuracy of solar wind model (-> **under analysis with JUNO SW data**)
- **Estimation of field aligned current** -> under analysis with MHD simulation and ionospheric potential solver
- **Correlation with radiation belt**: effect on radial diffusion?

Appendix: other targets of Hisaki

- Venus
- Mars
- Comets (67P, C/2013 US10, C/2013 X1, C/2015 ER61, and C/2015 V2)
- Mercury
- Moon





Thank you!