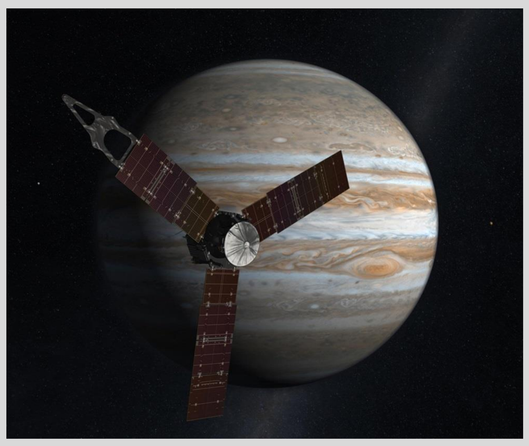

Properties of lightning induced electromagnetic waves detected close to Jupiter

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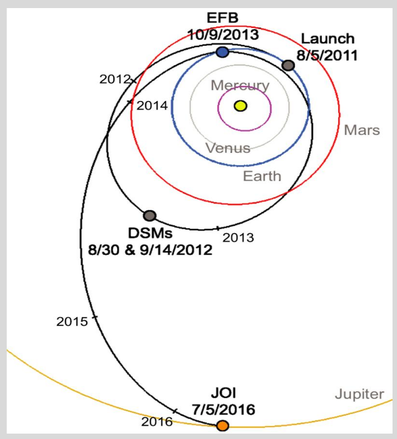
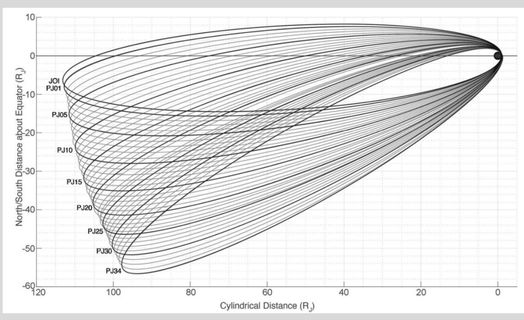
JUNO MISSION (NASA)

Launch - Aug 5, 2011
Deep Space Maneuvers - Aug/Sep 2012
Earth flyby gravity assist - Oct 2013
Jupiter arrival - Jul 2016



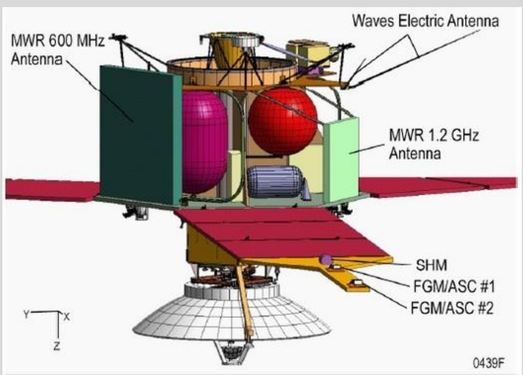
Goals:
- to understand the origin of Jupiter;
- to map gravitational and magnetic fields;
- to map variations in the deep atmosphere;
- to explore the magnetosphere and aurorae.

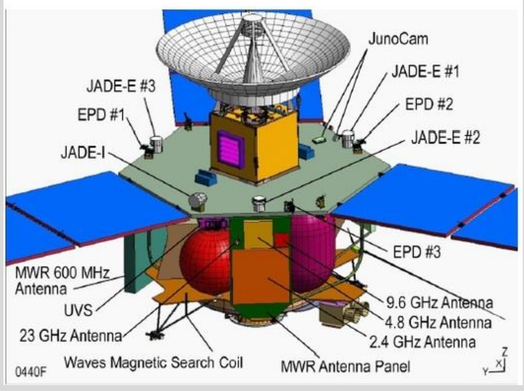
Juno's orbit



- A highly excentric polar orbit;
- the perijove varies from orbit to orbit but stays within a range of 3500–8000 km above the cloud tops;
- an orbital period of approximately 53 days;
- an apojove of 113 Jovian radii.

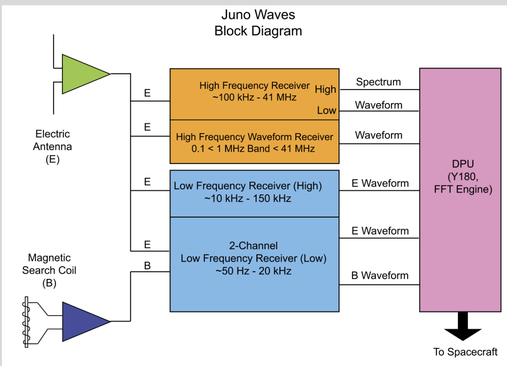
Juno's scientific payload





- A gravity/radio science system (Gravity Science)
- A six-wavelength microwave radiometer for atmospheric sounding and composition (MWR)
- A vector magnetometer (MAG)
- Plasma and energetic particle detectors (JADE and JEDI)
- A radio/plasma wave experiment (Waves)
- An ultraviolet imager/spectrometer (UVS)
- An infrared imager/spectrometer (JIRAM)

A radio/plasma wave experiment (Waves)

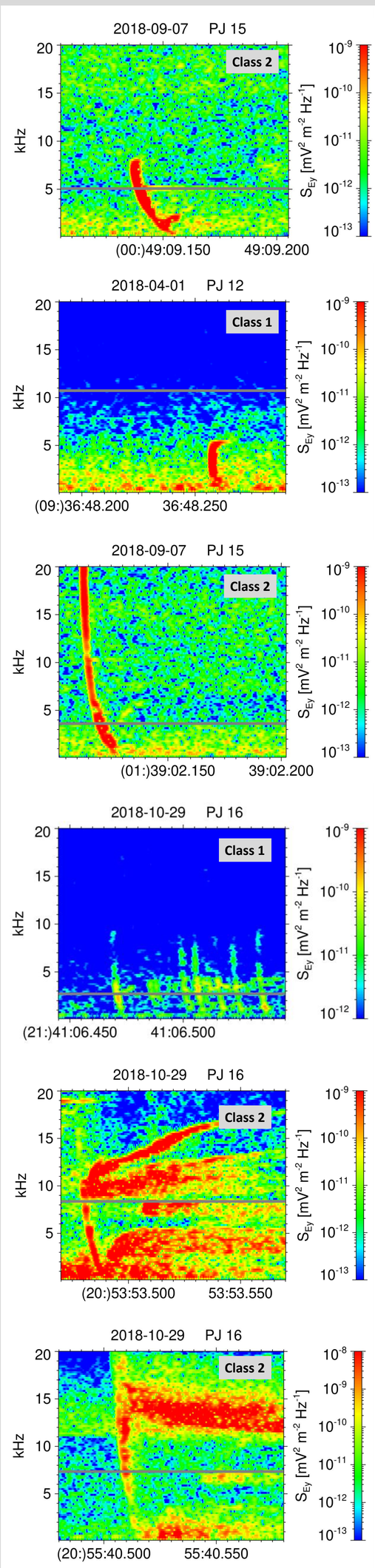


E - field 50 Hz - 41 MHz
B - field 50 Hz - 20 kHz

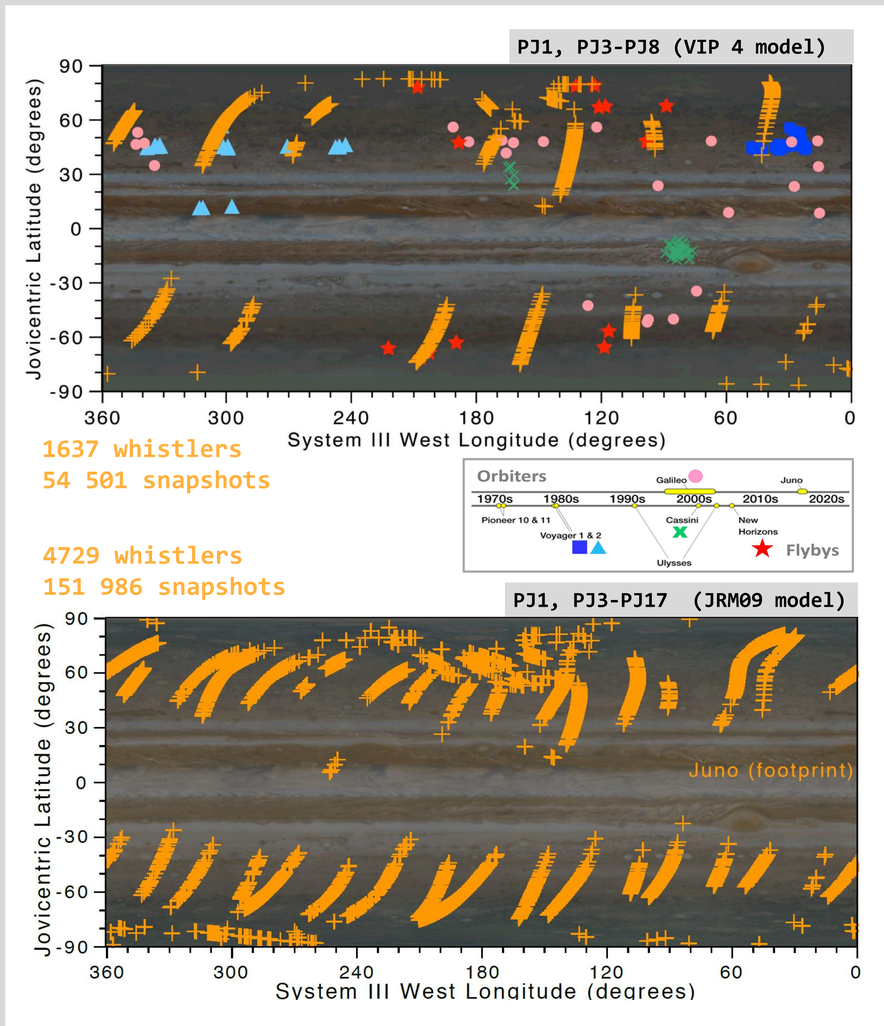
123 ms long snapshots of electric and magnetic field waveforms approximately once per second near periapsis, sampling frekvency 50 kHz

Examples of spectral shapes of lightning whistlers

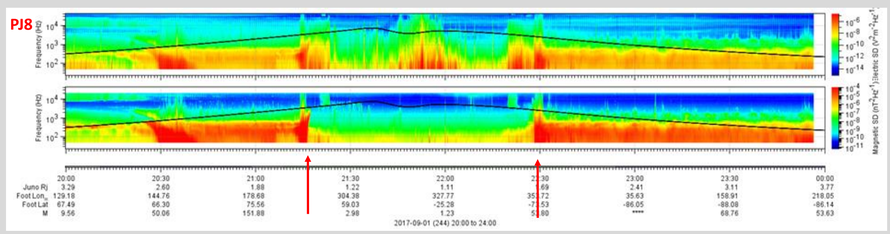
(152 thousand of waveform captures recorded during the first half of the mission)



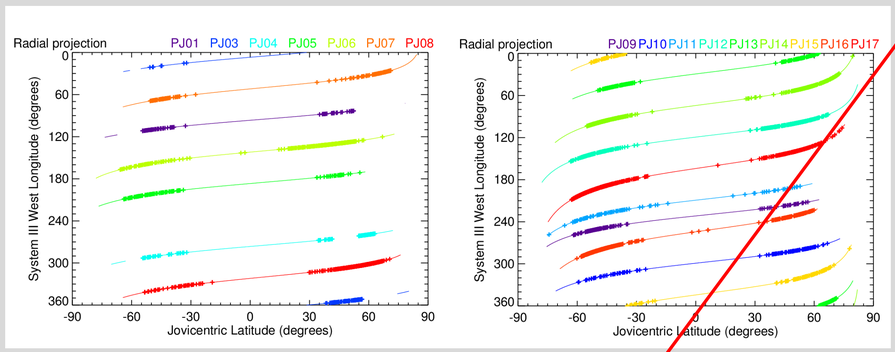
Spatial distribution of lightning whistlers (<5Rj)



Power spectral density of el and mag. fields (4 hours)

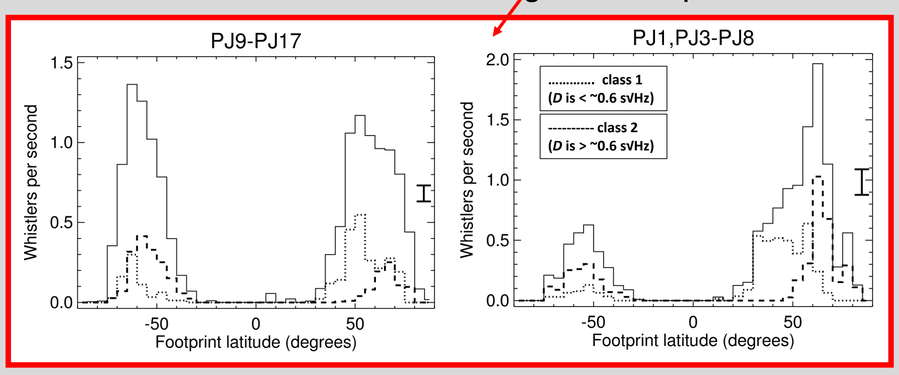


Radial projection, within auroral ovals

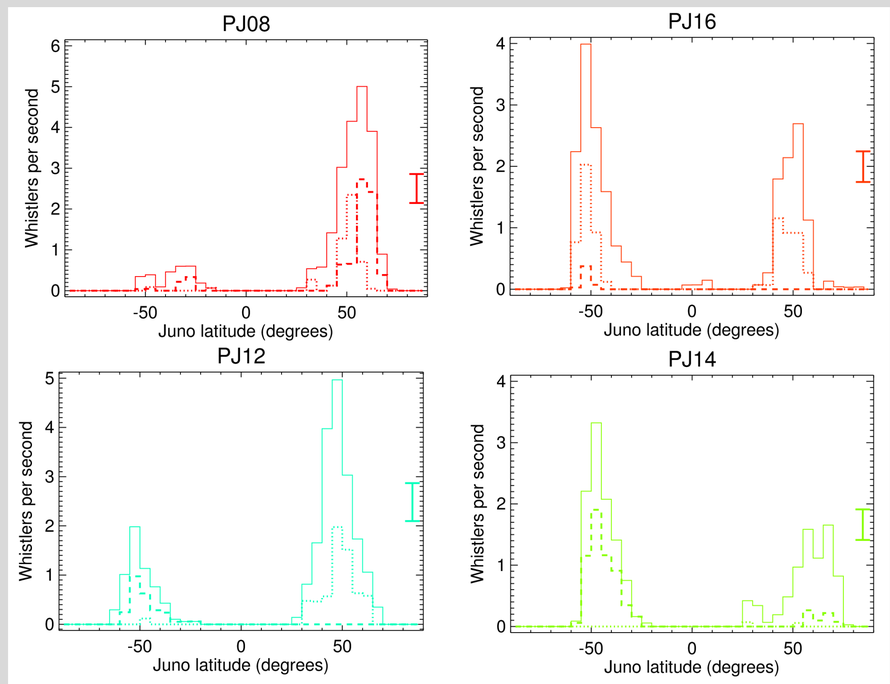


Below 5Rj	number of snapshots	number of snapshots with whistlers	number of whistlers	% of snapshots with whistlers
PJ1, PJ3-8	54501	1319	1637	2.4
PJ1, PJ3-8 AUR	27105	1098	1396	4.1
PJ9-17	97485	2429	3092	2.5
PJ9-17 AUR	44238	2045	2783	4.6

Whistler rates as a function of magnetic footprint latitude



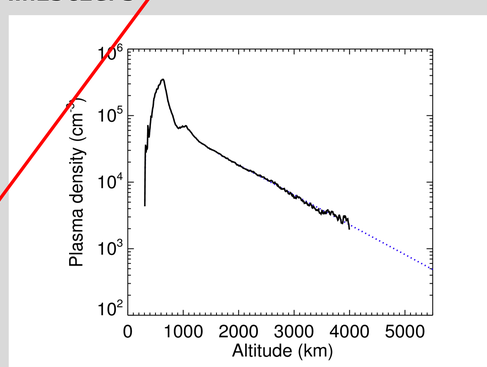
Max. whistler rates as a function of latitude



Summary

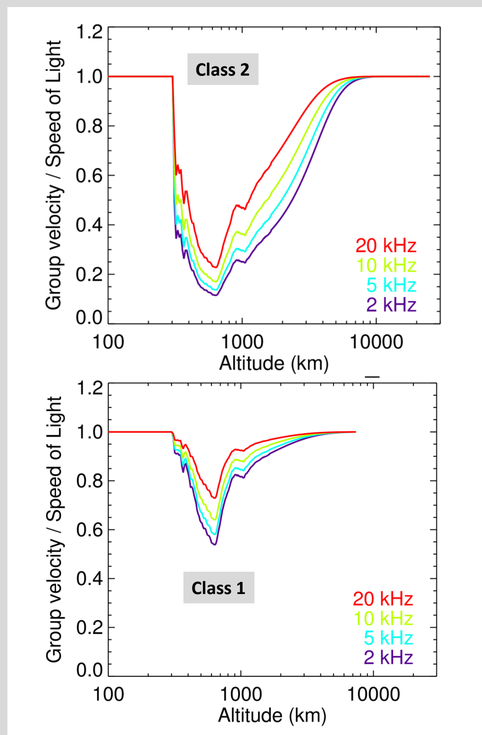
- the Waves instrument onboard the Juno spacecraft collected nearly five thousand lightning detections during the first half of the mission, the largest set obtained up to now
- observed peak occurrence rates of 4-5 whistlers/s in short orbital segments and an average rate of more 1 whistler/s in midlatitudes are similar to thunderstorms at Earth
- lack of whistlers in the tropics might be a consequence
  a) of their propagation in field-aligned ducts which would not allow them to reach the Juno altitude
  b) of an internal source of the atmospheric heat
- a mysterious North-South asymmetry in lightning occurrence observed during the first quarter of the Juno mission disappeared in the second quarter: random distribution of thunderstorms

Calculations of the frequency dependent propagation delay of whistlers



Jovian ionospheric plasma density model from Voyager 2 entry radio occultation

Profiles of the group velocity calculated at 4 selected frequencies.



For the dispersion Class 1 the density model has been reduced by one order of magnitude and the rescaled magnetic field model gives almost twice larger field strengths compared to the dispersion Class 2.

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Kolmasová, I. et al.(2018), Discovery of rapid whistlers close to Jupiter implying lightning rates similar to those on Earth, *Nature Astronomy*, 2, 7, pp. 544-548.

Brown, S. et al. (2018), Prevalent lightning sferics at 600 megahertz near Jupiter's poles, *Nature*, 558, 87, pp. 87-90.

Imai, M. et al. (2018). Jupiter lightning-induced whistler and sferic events with waves and MWR during Juno perijoves. *Geophysical Research Letters*, 45, 7268-7276.

Imai, M. et al. (2019). Evidence for low density holes in Jupiter's ionosphere. *Nat. Commun.* 10, 2751.

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