

Development status of metadata server and data archives at Tohoku University for collaborative studies using planetary radio and spectroscopic data

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ABSTRACT

Data archive of Jovian radio emissions in decametric wavelength range (DAM, 20-40 MHz) measured at ground stations of Tohoku University was started in 2004. Metadata services for IUGONET (Inter-university Upper atmosphere Global Observation NETWORK, supported by the Special Educational Research Budget, and the Special Budget Project from MEXT (the Ministry of Education, Culture, Sports, Science and Technology), Japan in 2009-2014) and EuroPlanet/VESPA (Virtual European Solar and Planetary access) were also started in collaborations with IUGONET-member organizations, and Paris Observatory team. In 2016, we developed data archives of solar radio waves in VHF/UHF range obtained by IPRT (Iitate planetary radio telescope), and planetary spectroscopic data obtained by Hisaki spacecraft, and started providing their metadata for VESPA. We are planning to add metadata of Jovian radio wave data from observatories of Kochi National College of Technology, and Fukui University of Technology, planetary spectroscopic data from Tohoku University observatories in Hawaii, and solar wind parameters from Tao's model.

Ground-based observations with multi-longitudinal stations enable us 24-hour continuous track of the activity variation of the Jovian auroral radio emissions. By using Spectrograms of Jovian decametric radiation obtained at Nancay and Iitate observatories, and spectroscopic data from Hisaki spacecraft, we are performing analyses of the effects of the Io's volcanic activity in 2015 on the occurrence timing of the arc structures in the spectrogram of Jovian decametric radiations. Another merit of the ground-based observations is that we can use facilities such as large antenna array, high time/frequency resolution receivers, high-speed networks, and large amount storages, which are difficult to use in the spacecraft observations. We participate Juno ground support team and exchange the information on support observation schedules.

Acknowledgements: This study was supported by JSPS France-Japan Bilateral Joint Research Program "Coordinated observational and theoretical researches for Jovian and Kronian auroral radio emissions" (2016-2017).

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B. Cecconi (Obs. de Paris)**

Collaborative observation of Jovian decametric radiation (DAM) from the ground stations

Jovian DAM

Useful for monitoring Jovian magnetosphere and auroral activity

Merits of Ground-based obs.

Possible to use enough facilities

- Large array antenna
- Receivers with high frequency & time resolutions
- High-speed networks & huge storages

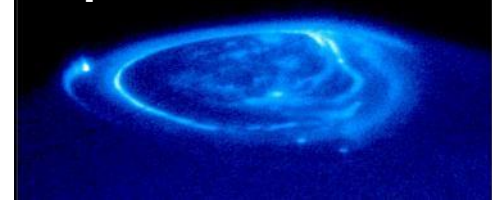
Demerits of Ground-based obs.

- Weak signal due to distance
- Artificial noises on the Earth
- Possible only while the Jupiter is above the horizon

Avoidable by observation with multiple ground stations

→ **Integrated data archives will be an effective solution.**

Jupiter



Juno



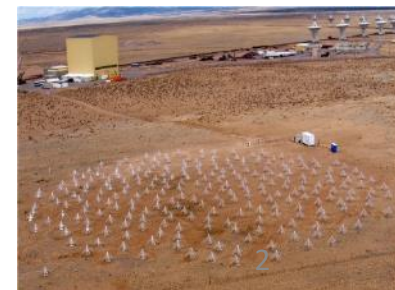
litate
(140°E)



Nancay
(2°E)



LWA
(107°W)



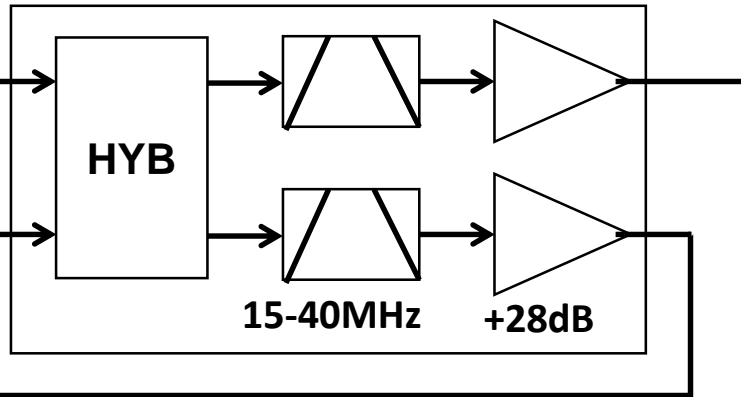
litate Continuous HF radio wave monitor

Location (**140.40E**, 37.42N)

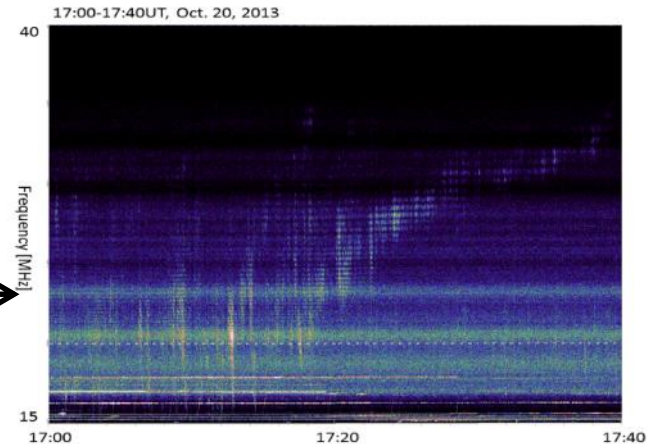
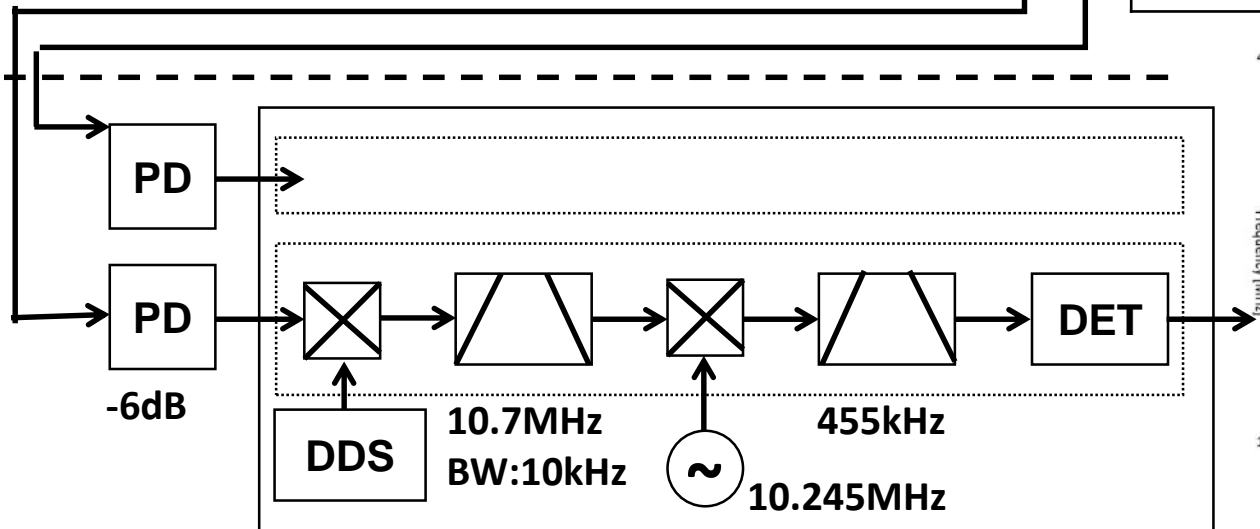
http://ariel.gp.tohoku.ac.jp/~jupiter/it_hf/cdf/



Log-periodic Antenna



Polarization	R&L
Interval	0.5 s
BW	10kHz
Step #	700
F range	15-40 MHz
Sensitivity	$-200\text{dBWm}^{-2}\text{Hz}^{-1}$
Precision	12 bit
Data Rate	470MB/day
Format	CDF



Vertex Early Arc of Io-B DAM



Metadata database developed in a six-year research project, Inter-university Upper atmosphere Global Observation NETwork (**IUGONET**, 2009-2015).



UDAS (The iUgonet Data Analysis Software): A plug-in software for **SPEDAS**, which is written in IDL.



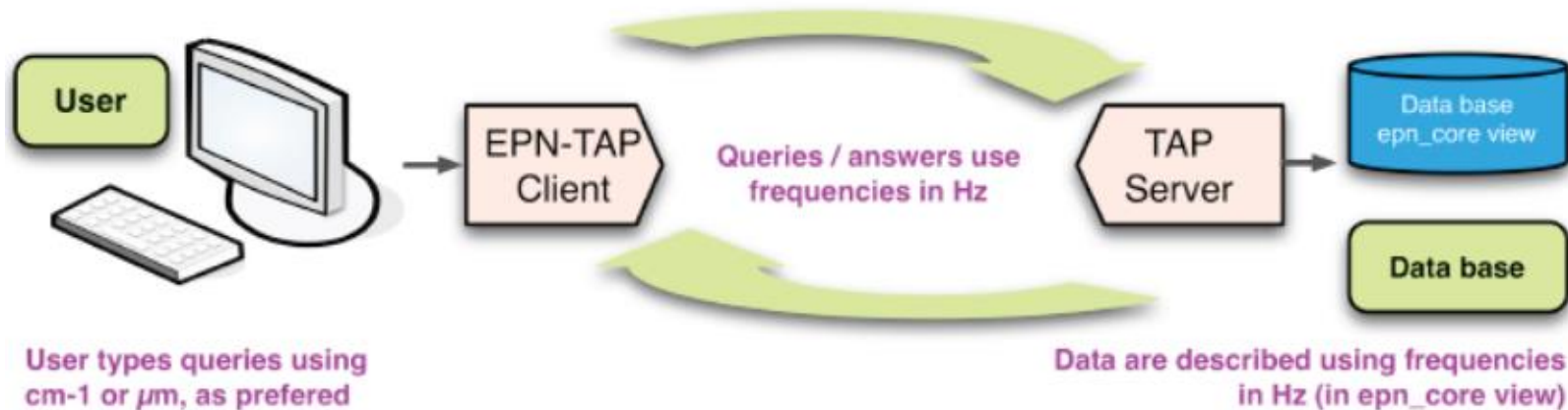
Metadata of **Jovian DAM spectrogram from Tohoku U.** were developed in this project.

- **The first development** of the **metadata** of Jovian DAM data from Tohoku U.
- Development already **ended in 2015**. (Automatic update continues.)
- The project mainly focused on **the Earth' upper atmosphere data**.



VESPA (Virtual European Solar and Planetary Access): An activity for building a **Virtual Observatory** for **Planetary Science** in the **Europlanet 2020** Research Infrastructure programme.

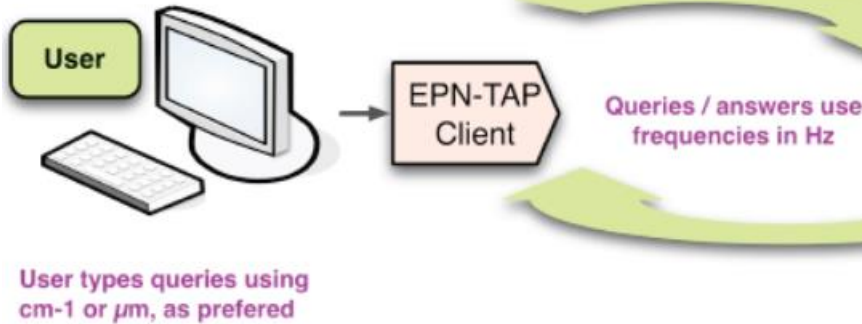
Metadata service with EPN-TAP protocol



[Erard et al., 2014]

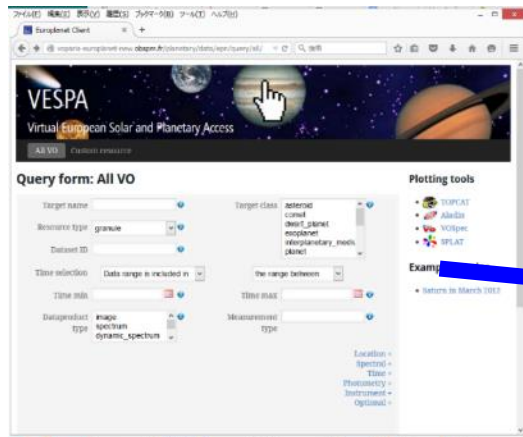
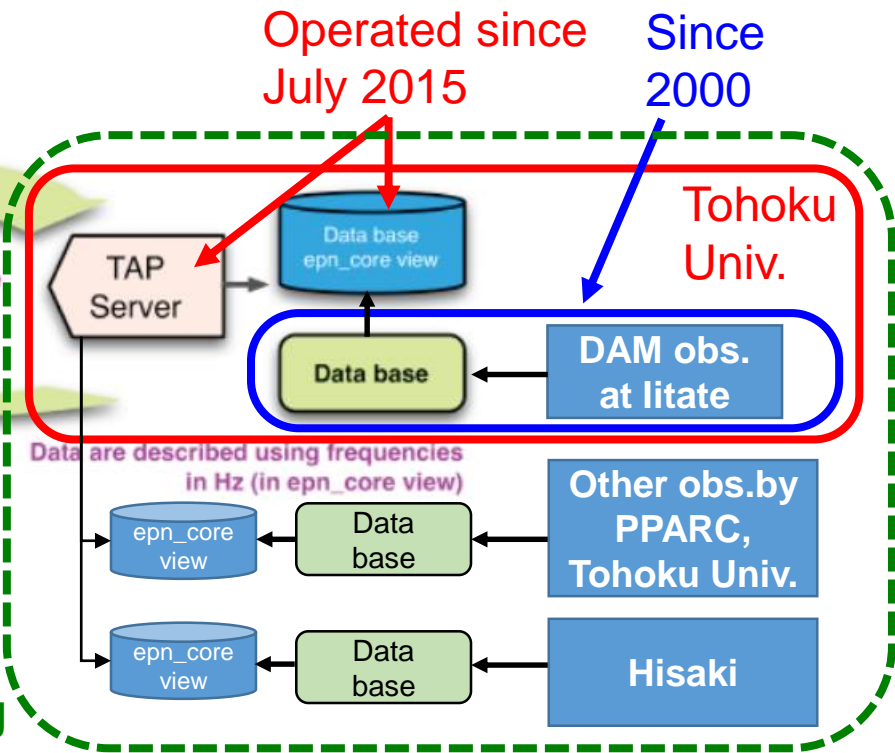
- **Distributed** metadata server system.
Data provider can maintain own metadata server.
- The project mainly focuses on **planetary science**.

Europlanet/VESPA



[modified from Erard et al., 2014]

Developing



Results in service iitate

dataproduct_type	target_name	time_min (s)	time_max (s)	access_url
dynamic_spectrum	Jupiter	2016-05-01T0000:00	2016-05-01T13:39:59.500	lit_it_inf_20160501_y01.cdf
dynamic_spectrum	Jupiter	2016-05-02T0000:00	2016-05-02T13:39:59.500	lit_it_inf_20160502_y01.cdf
dynamic_spectrum	Jupiter	2016-05-03T0000:00	2016-05-03T13:39:59.500	lit_it_inf_20160503_y01.cdf
dynamic_spectrum	Jupiter	2016-05-04T0000:00	2016-05-04T13:39:59.500	lit_it_inf_20160504_y01.cdf
dynamic_spectrum	Jupiter	2016-05-05T0000:00	2016-05-05T13:39:59.500	lit_it_inf_20160505_y01.cdf
dynamic_spectrum	Jupiter	2016-05-06T0000:00	2016-05-06T13:39:59.500	lit_it_inf_20160506_y01.cdf
dynamic_spectrum	Jupiter	2016-05-07T0000:00	2016-05-07T13:39:59.500	lit_it_inf_20160507_y01.cdf

Showing 1 to 5 of 5 entries

Plotting tools: TOPCAT, Aladin, VOIper, SPLAT

Example queries: Saturn in March 2012

SELECTED DATA: No data selected

PREVIEW: [Spectral plot]

© Paris Observatory 2015 - Licensed for search interface
 Contacts: support@vo-paris.fr, europe@vo-paris.fr
 Layered based on TAP2

Portal web site for VO query

<http://voparis-europlanet-new.obspm.fr/>

Joint research program between France and Japan: “Coordinated observational and theoretical researches for Jovian and Kronian auroral radio emissions” (2016-2017)

France

B. Cecconi , L. Lamy, P. Zarka

C. Louis (LESIA, Observatoire de Paris)

N. Andre, P. Louarn, M. Blanc (IRAP)

P. Le Sidaner, C. Chauvin

(DIO, Observatoire de Paris)

Japan

F. Tsuchiya, A. Kumamoto, Y. Kasaba,
H. Misawa, H. Kita, Y. Katoh (Tohoku-U)

K. Fukazawa (Kyoto-U)

T. Kimura (RIKEN)

C. Tao (NICT)

M. Yagi (U Tokyo)

Y. Miyoshi (Nagoya-U)

K. Imai (Kochi National Collage Tech)

M. Imai (U Iowa, USA)

T. Nakajo (Fukui Tech U)

<http://c.gp.tohoku.ac.jp/sakura/>

JSPS Sakura Project

c.gp.tohoku.ac.jp/sakura/

Joint research program between France and Japan
Coordinated observational and theoretical researches
for Jovian and Kronian auroral radio emissions

- Meeting
 - May 25, 2016
 - Jul. 14-16, 2016
 - Oct. 28, 2016
- Data/Database
- Tools
- Member
- Publication

JSPS Sakura project: Joint research between France and Japan

- * Two-year project (2016-2018) funded by JSPS (Japan) and MAEDI (France) joint Sakura exchange programme.
- * Proceeding of our understanding on physical processes of Jupiter's and Saturn's aurora as well as transient and periodic processes in their magnetospheres which control morphology and time variability of the auroral phenomena.
- * Sharing observed data from spacecraft and ground-

Data/Metadata Server at Tohoku Univ. for VO



EPN-TAP Client

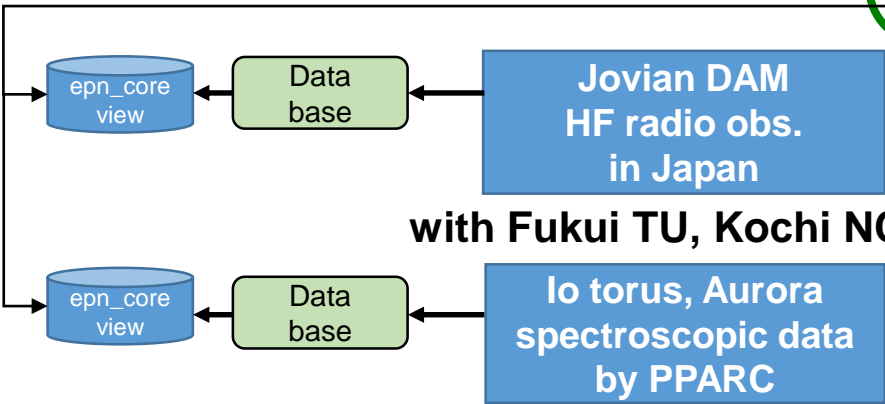
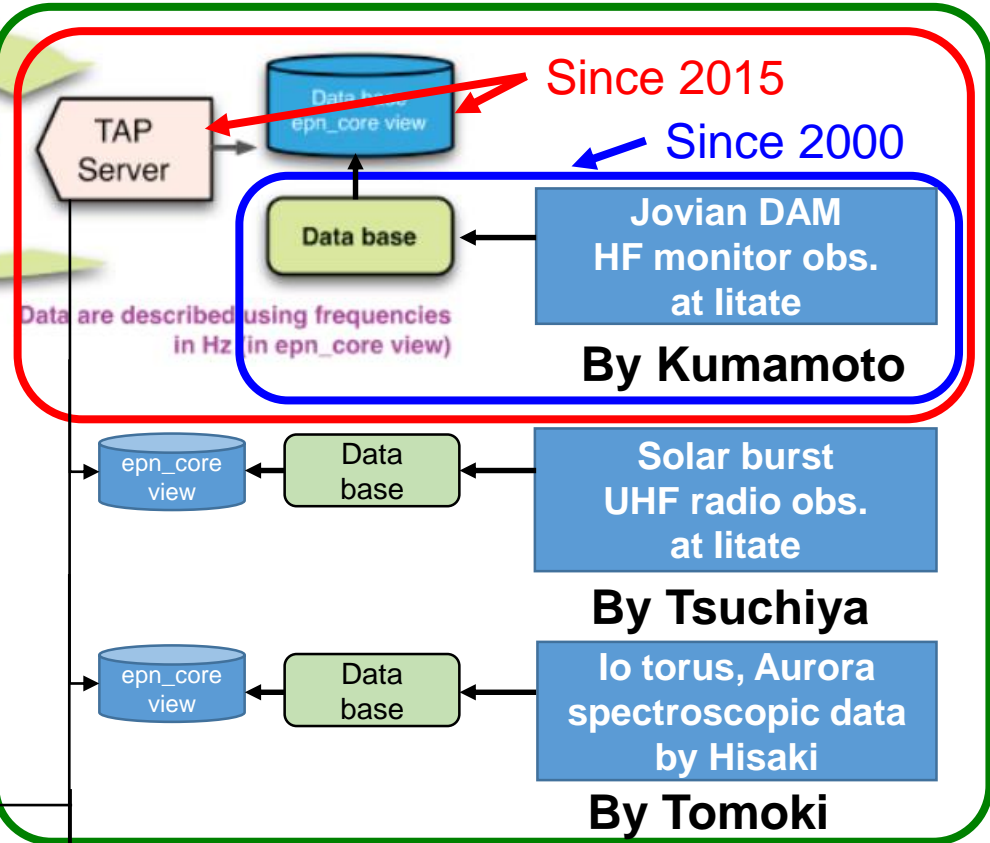
Queries / answers use frequencies in Hz

User types queries using cm-1 or μm , as preferred

[modified from Erard et al., 2014]

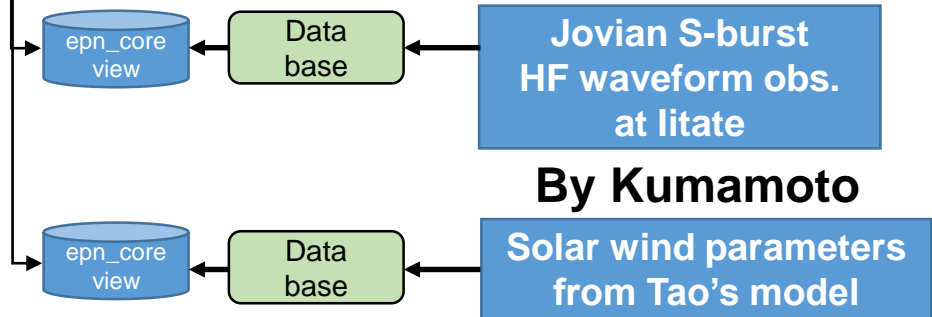
Tohoku U. Data/Metadata Server

Since 2016 (with support of SAKURA members)



with Fukui TU, Kochi NCT

Tohoku U



Ongoing

By Tao

Datasets

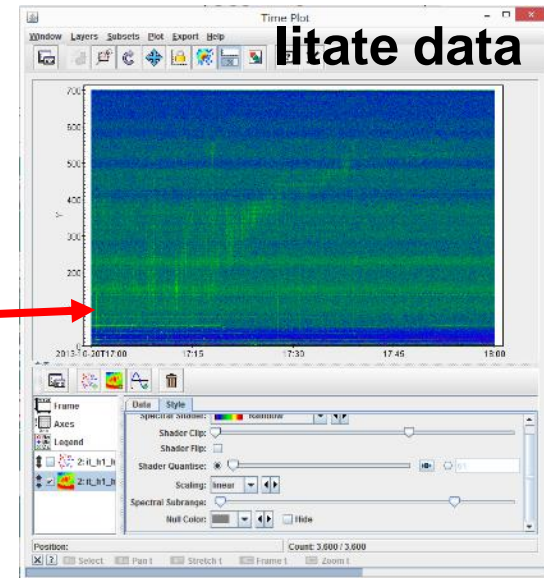
Type	Name	Station Data Manager	Meta Data		Data	
			IUGO NET	EuroPlanet VESPA	On line	On req.
Radio	Jovian DAM/Solar radio Spectrogram (litate)	Tohoku U. A. Kumamoto	○	○	○	
Radio	Solar radio/JSR spectrogram (litate)	Tohoku U. F. Tsuchiya	○	○	○	
Radio	Jovian DAM Interferometer (Awara)	Fukui U. Tech. T. Nakajo		△	△	○
Radio	Jovian DAM Spectrogram (Agawa)	Kochi NCT K. Imai		△	△	○
Spectroscopic	Hisaki	Hisaki T. Kimura		○	○	
Spectroscopic	Jupiter Neutral Sodium Cloud (Haleakala)	Tohoku U. M. Yoneda		△		○
Spectroscopic	Jupiter Io Plasma torus (Haleakala)	Tohoku U. M. Kagitani		△		○
Spectroscopic	Mercury Sodium Exosphere (Haleakala)	Tohoku U. S. Kamada		△		
Simulation	Solar wind parameters at Jupiter/Saturn	NICT C. Tao		△	△	○

Data/Metadata Server for VO

VESPA
Virtual European Solar and Planetary Access

Results in service iitate

Observatory type	target_name	time_max (jd)	time_min (jd)	access_url
dynamic_spectrum	Jupiter	2016-08-01T06:00:00	2016-05-01T12:00:00	h_i_h_m_20160801_v01.ccd
dynamic_spectrum	Jupiter	2016-08-02T06:00:00	2016-05-02T12:00:00	h_i_h_m_20160802_v01.ccd
dynamic_spectrum	Jupiter	2016-08-03T06:00:00	2016-05-03T12:00:00	h_i_h_m_20160803_v01.ccd
dynamic_spectrum	Jupiter	2016-08-04T06:00:00	2016-05-04T12:00:00	h_i_h_m_20160804_v01.ccd
dynamic_spectrum	Jupiter	2016-08-05T06:00:00	2016-05-05T12:00:00	h_i_h_m_20160805_v01.ccd
dynamic_spectrum	Jupiter	2016-08-06T06:00:00	2016-05-06T12:00:00	h_i_h_m_20160806_v01.ccd
dynamic_spectrum	Jupiter	2016-08-07T06:00:00	2016-05-07T12:00:00	h_i_h_m_20160807_v01.ccd
dynamic_spectrum	Jupiter	2016-08-08T06:00:00	2016-05-08T12:00:00	h_i_h_m_20160808_v01.ccd



Display (TOPCAT)

Portal web site of Virtual Observatory (VO)
<http://voparis-europlanet-new.obspm.fr/>

APIS
Auroral Planetary Imaging and Spectroscopy

Search for data - APIS - / x

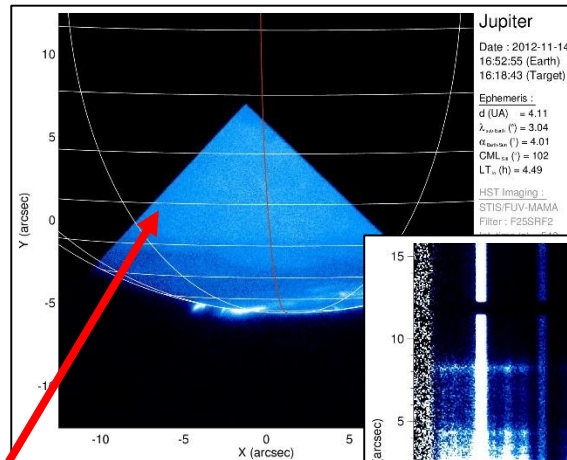
Search for data - APIS - / x

Search for data - APIS - / x

21 results.

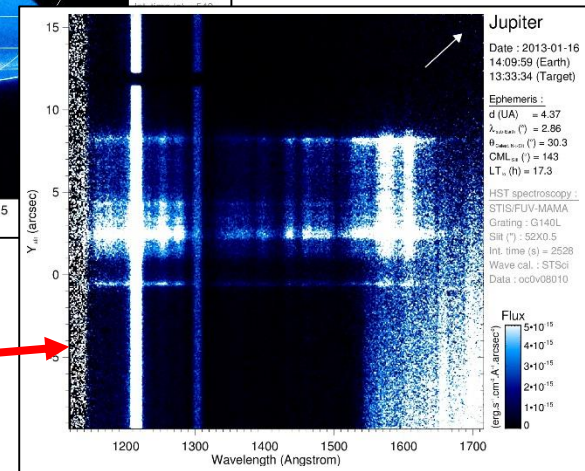
Observation summary

Target : Jupiter
 Start date : 2012-11-14
 Start time : 16:52:55
 Int. time : 540.01975 s
 Instrument : HST / STIS
 Obs. type : IMAGING
 Filter : F255RP2



HST data (Hisaki data will be added)

Display



Portal web site for Image and Spectroscopic data (APIS)
<http://apis.obspm.fr/>

Planning Tool of Juno Ground Support

<http://maser.lesia.obspm.fr/outils-services/juno-ground-radio/juno-decametric-observations.html>

MASER

Outils & Services | Bases de données | Ateliers | Enseignement & Gr

SERPE | SILFE | HELIO-HFC | JU

Accueil > Outils & Services > JUNO Ground Radio

JUNO-Ground-Radio / Planning Tool

jeudi 30 juin 2016, par Baptiste Cecconi, Renaud Savalle

The JUNO-Ground-Radio Observation Support team provide radio observatories all over the Earth. We have set up a Planning Tool.

The JUNO-Ground-Radio Planning Tool has been set up for data observations. Registration is required.

The same tool can now be used to check for available observations.

TimeLine of planned Juno Ground Radio Observations

Instrument	2016	2017	2018
litate HF radio monitor	Bar chart showing observation periods in 2016 and 2017.		
LWA1	Bar chart showing observation periods in 2016 and 2017.		
Nançay Decameter Array	Bar chart showing observation periods in 2016 and 2017.		
URAN-2	Bar chart showing observation periods in 2016 and 2017.		
UTR-2	Bar chart showing observation periods in 2016 and 2017.		

NB : the time line take a few tens of seconds to load.

Instruments

https://voparis-juno.obspm.fr/juno/instruments

Juno-Ground-Radio Observations Support Logout

JGROSP version 0.8 by RS

Welcome

Instruments

Search:

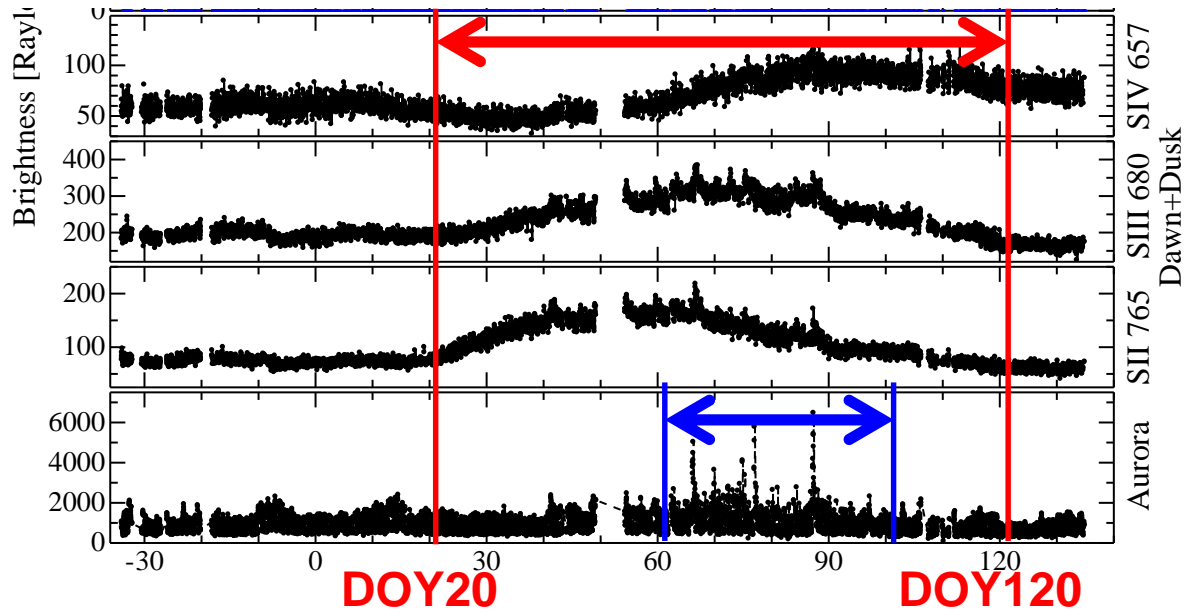
Observation Planning

Id	User	Name	Hostname	Longitude	Latitude	Created	Modified	Actions
8	Atsushi Kumamoto	Waveform receiver	litate HF radio monitor	140.67	37.7	2016-10-26 16:00:58	2016-10-26 16:12:48	Edit Delete
5	Atsushi Kumamoto	Spectrograph	litate HF radio monitor	140.67	37.7	2016-02-17 01:19:56	2016-02-17 01:19:56	Edit Delete
3	Chuck Higgins	Spectrograph	LWA1	-107.628	34.069	2016-01-06 20:05:47	2016-01-06 20:05:47	View
2	Chuck Higgins	Digital Receiver (DRX)	LWA1	-107.628	34.069	2016-01-05 20:38:56	2016-01-06 20:08:44	View
7	Masafumi Imai	DSP-Z	URAN-2	34.825	49.63	2016-04-13 15:41:23	2016-04-13 15:41:23	View
6	Masafumi Imai	Routine	Nançay Decameter Array	2.194	47.381	2016-04-13 15:33:13	2016-04-13 15:40:54	View
4	Philippe Zarka	NewRoutine	Nançay Decameter Array	47.38	2.193	2016-01-19 09:26:15	2016-01-19 09:26:15	View
9	Vladimir Ryabov	DRATFA	UTR-2	37	50	2016-11-08 04:24:42	2016-11-08 04:30:12	View

Showing 1 to 8 of 8 entries

For sharing information of observation schedule at multiple ground stations.

Possible use case: Jovian DAM during Volcanic activity detected by Hisaki



Io plasma torus (SII&SIII):

Increase from DOY20 to DOY120
due to volcanic activity

Aurora:

Increase from DOY60 to DOY100

Jovian DAM:

??? → Analysis of Iitate HF data

Expected relation between Jovian DAM & plasma density

Intensity of Alfvén waves

$$I = 4R_{Io} v_{Io} B \Sigma_A$$

$$= 4R_{Io} v_{Io} B \frac{1}{\mu_0 V_A} \propto \sqrt{n}$$

[Neubauer, 1980]

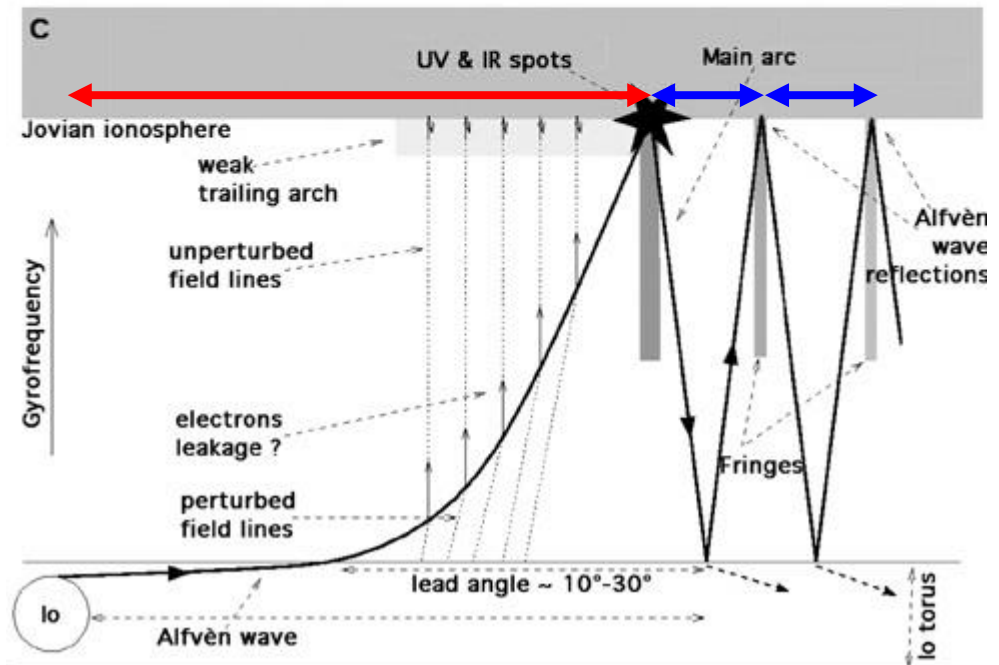
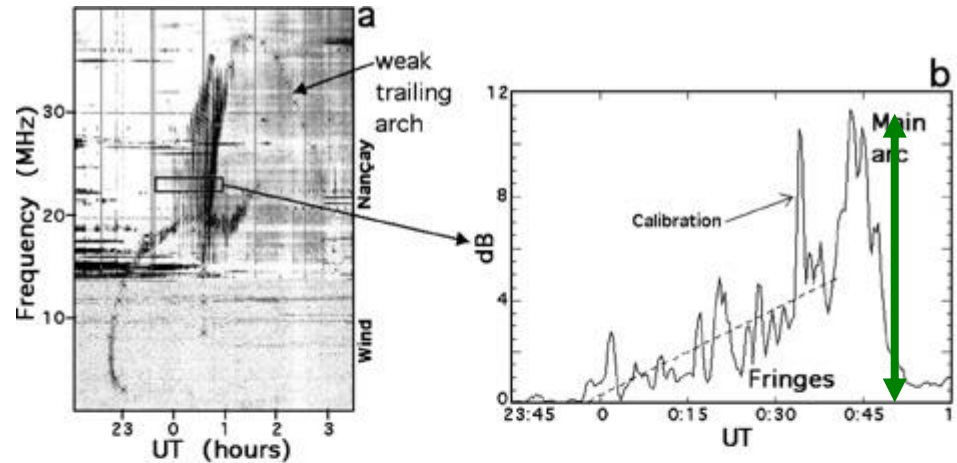
→ Intensity, occurrence probability: Increase?

Alfvén velocity

$$V_A = \frac{B}{\sqrt{\mu_0 m n}} \propto \frac{1}{\sqrt{n}}$$

→ Timing of main arc: Later?

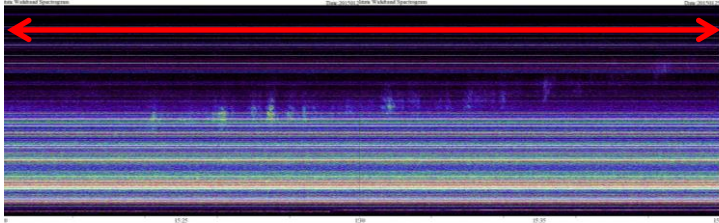
Repetition period of arcs: Longer?



Jovian DAM detected at litate observatory

2015-01-25

1 hour

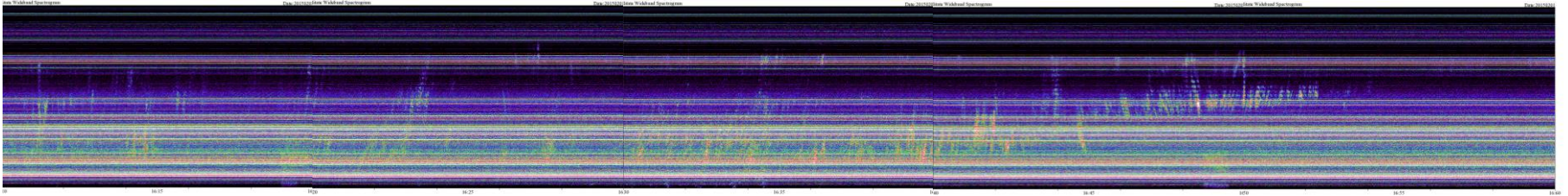


We found

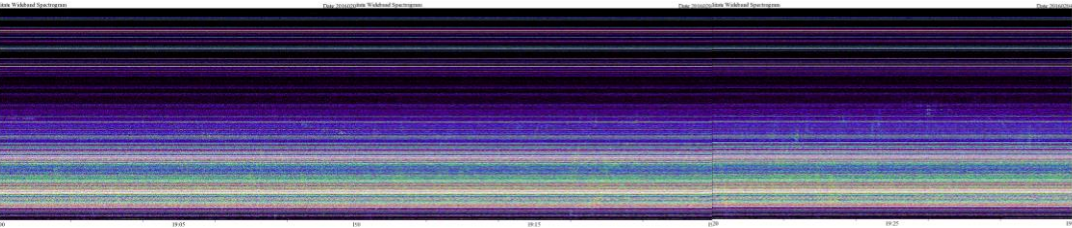
2 Io-B events during Jan. & Feb, 2015, and
2 Io-B events during Feb. & Mar. 2016

2015-02-01

Jupiter's opposition: 2015-2-7

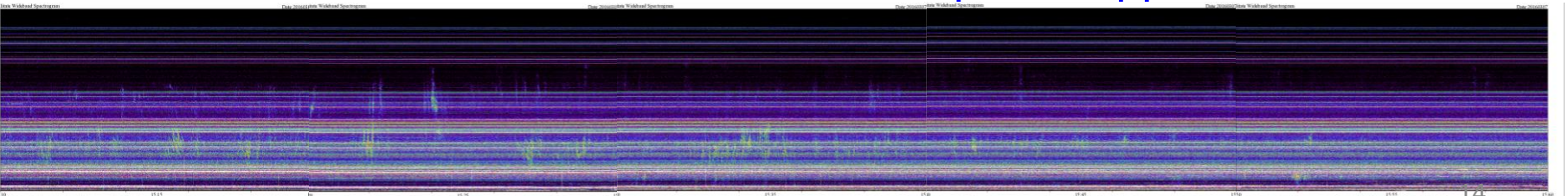


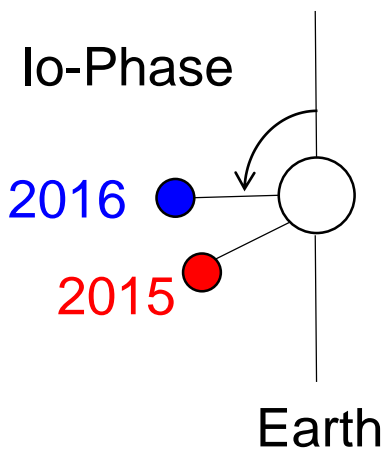
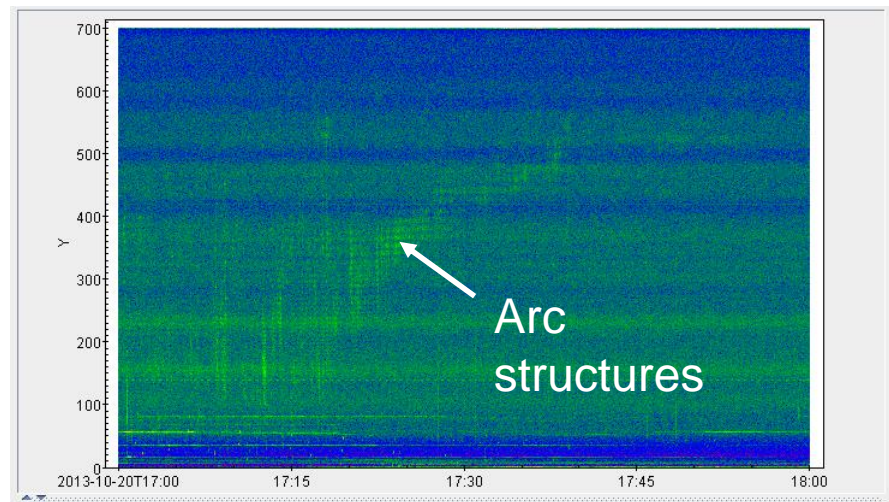
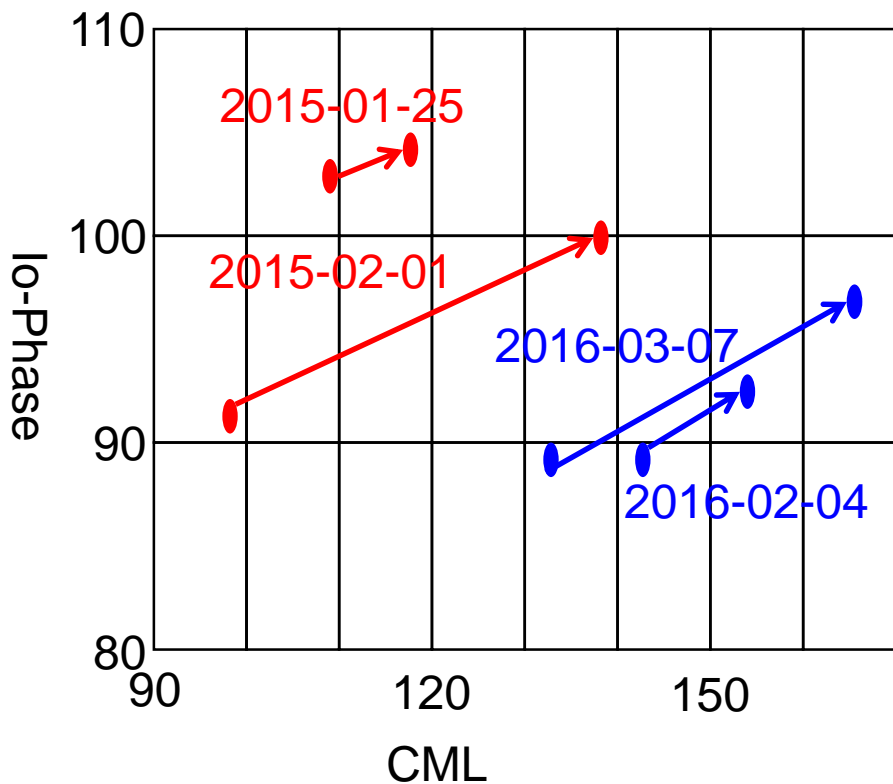
2016-02-04



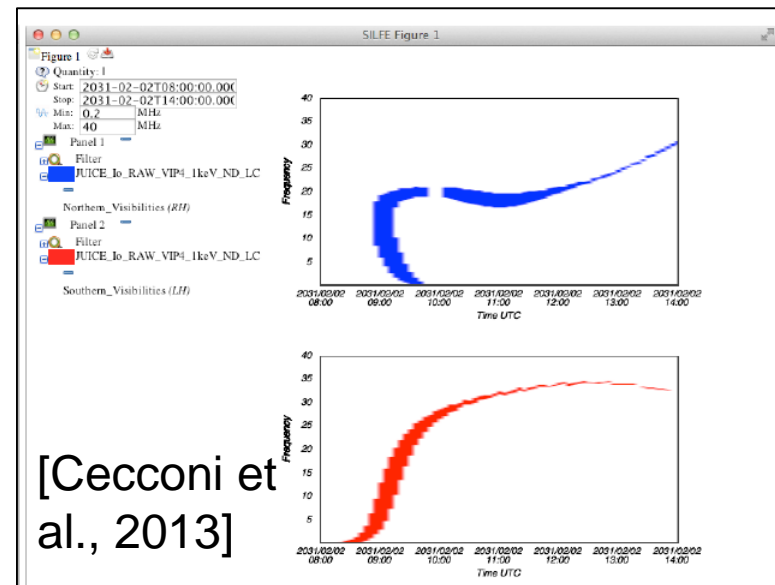
2016-03-07

Jupiter's opposition: 2016-3-6





Due to
Lead angle
increase?



Detailed comparison between obs. & sim.
 → Comparison of source field lines determined in 2015 and 2016.

Summary

- **Integrated metadata servers and data archives from the multiple ground-based observations will be useful, and needed infrastructures in future studies on planetary science.**
- **Metadata of Jovian/Solar radio spectrogram from ground-based observations and spectroscopic data from Hisaki spacecraft have been provided via IUGONET and Europlanet/VESPA. We are planning to add other radio and spectroscopic data from Tohoku Univ. observatories and collaborative projects also.**
- **We have shown an expected use case in analysis of Jovian DAM during Io's volcanic active period found by Hisaki. We will need to analyze intensity, occurrence probability, the occurrence timing of arc structures found in Jovian DAM spectrograms from multiple ground stations.**