

# A network of HF Doppler sounding systems in Japan

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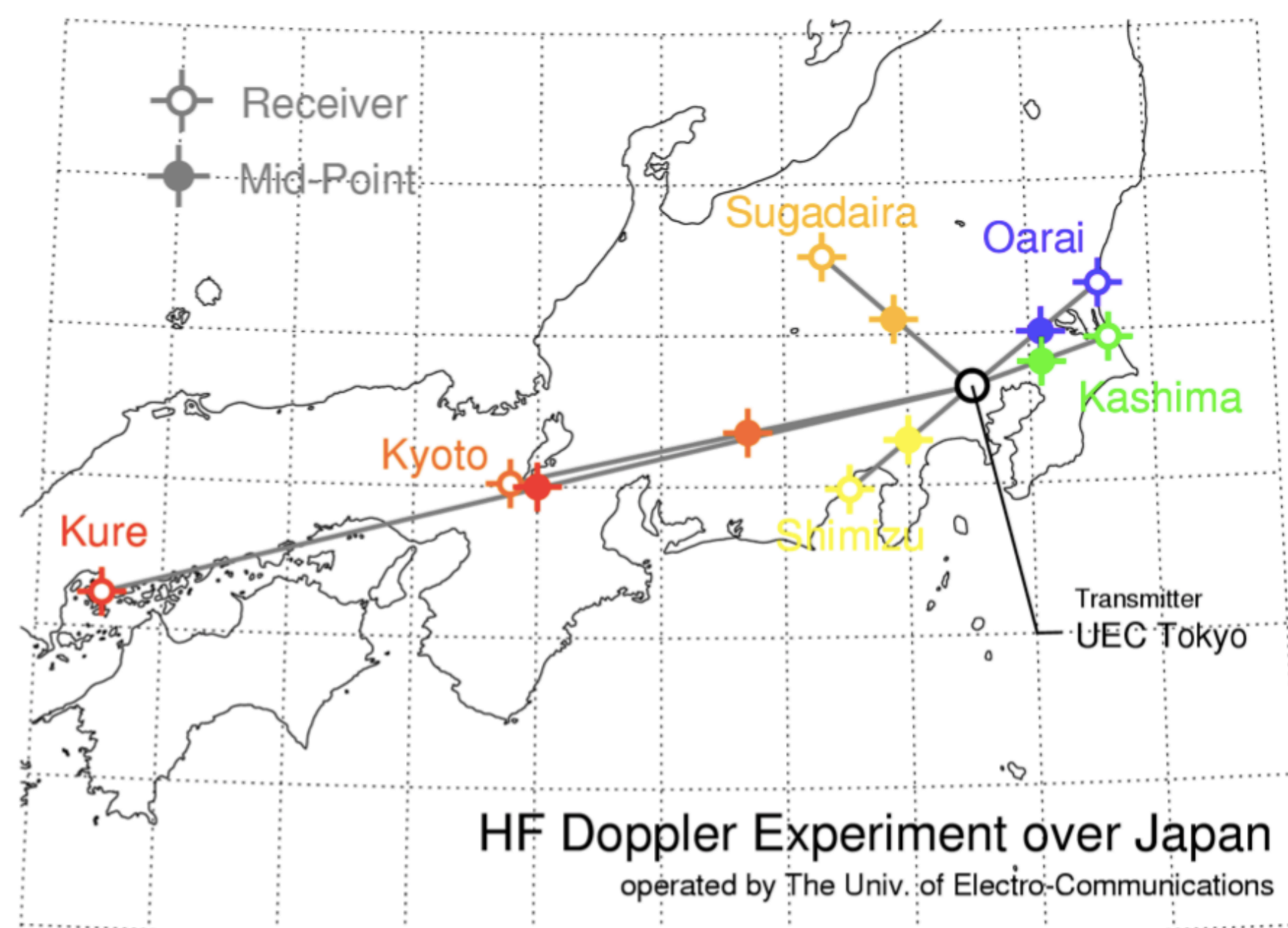


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## HF Doppler Sounding Experiment in Japan

- ★ Since 2003, a network observation of HF Doppler sounding has been operative in Japan for remote-sensing the atmospheric, ionospheric and magnetospheric processes
- ★ Currently, 1 transmitting station (Tx) and 7 receiving stations (Rx) are operative by a collaborative effort of four difference universities (UEC, Chiba Univ., Nagoya Univ. and Kibi International Univ.)



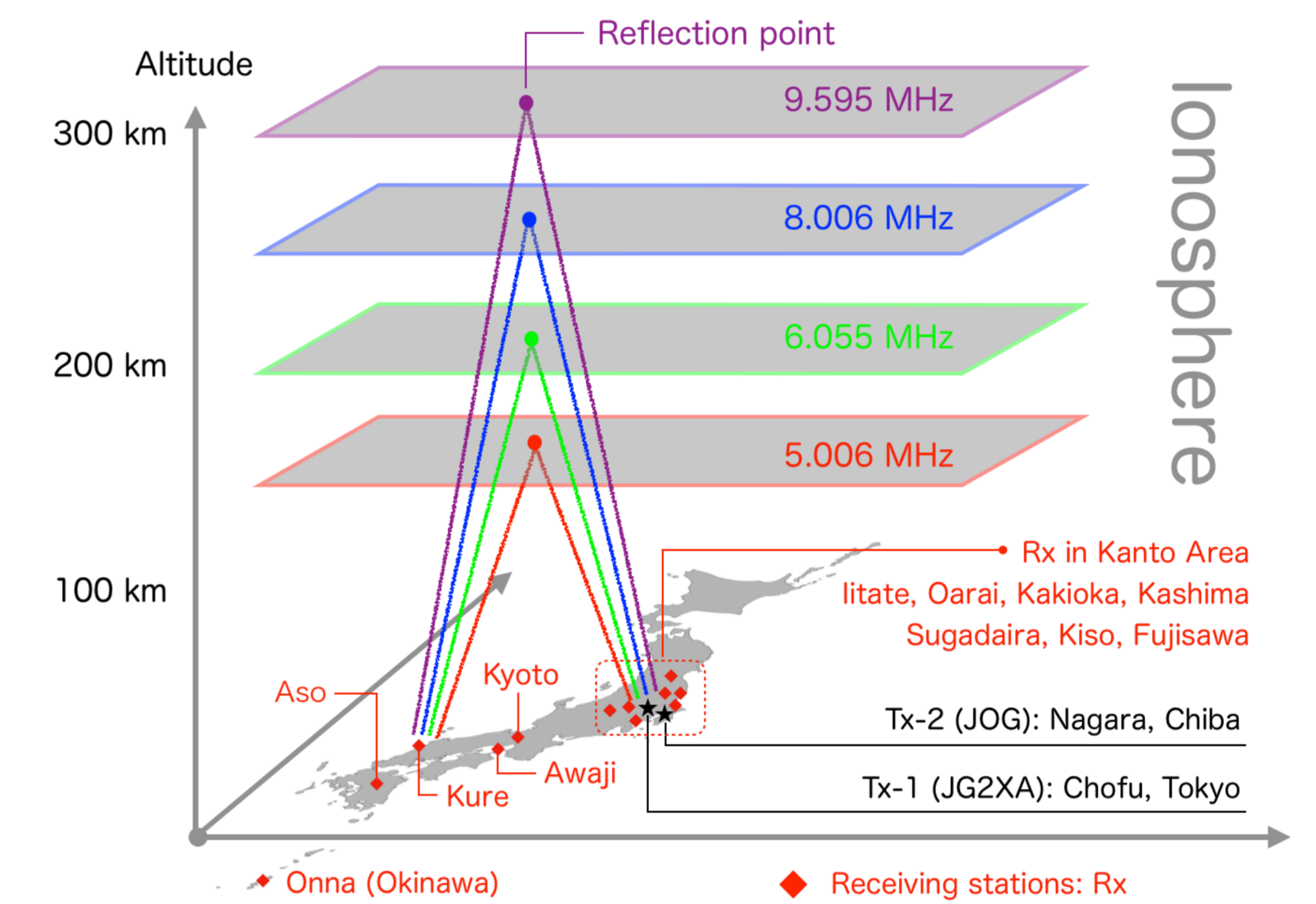
## What we are able to observe using HF Doppler

- ★ We derive the Doppler shift of the received signal every 10 sec through FFT using 4096 data samples collected with a temporal resolution of 100 Hz

$$\Delta f_D = -2 \cdot \frac{f}{c} \frac{d}{dt} \left( \int_0^{z_R} n \cdot dr \right)$$

- ★ We could monitor the vertical motion of the ionosphere from the Doppler shift

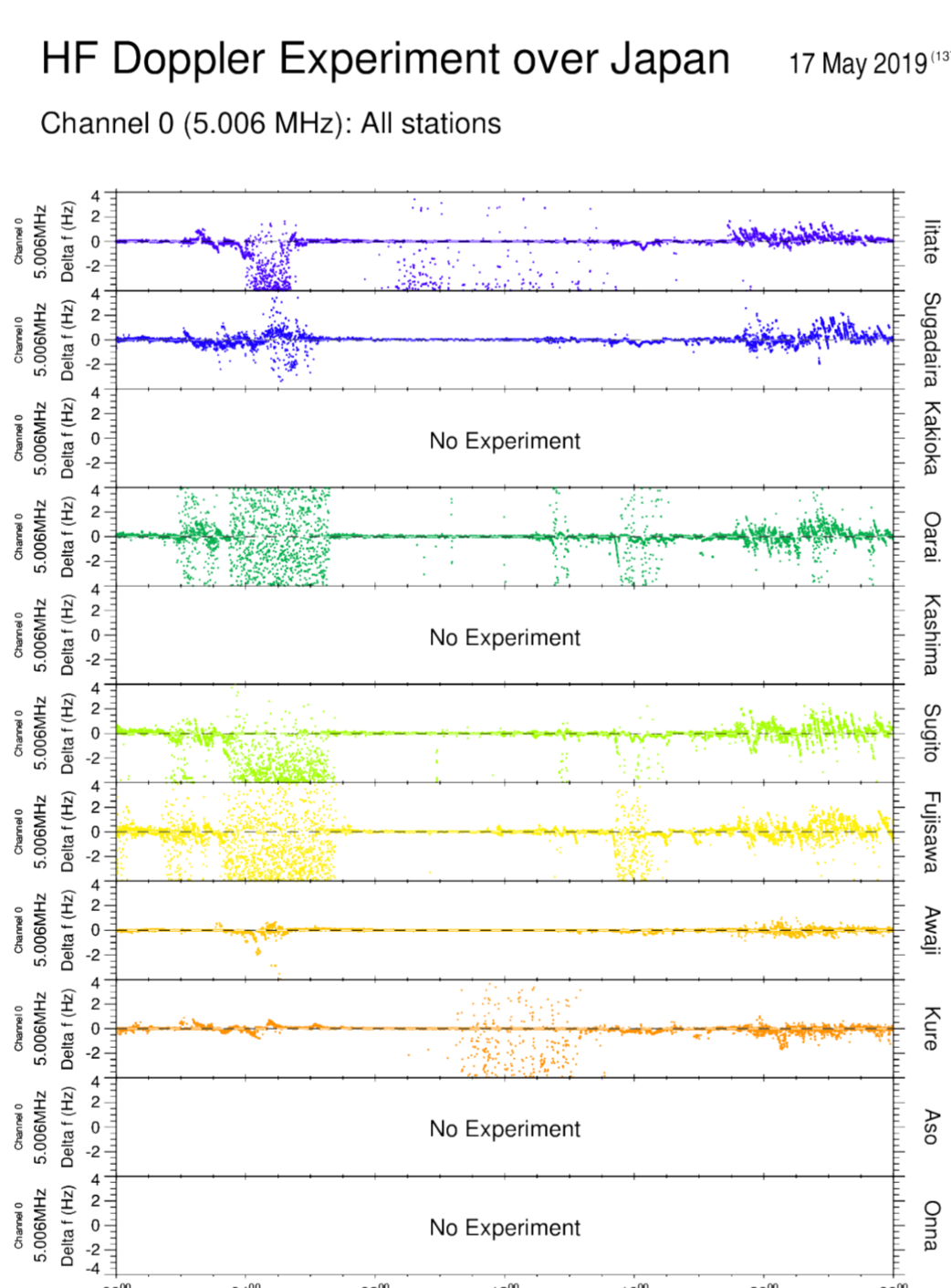
$$\Delta f_D = -2 \frac{f}{c} u_p$$



## Observation sites

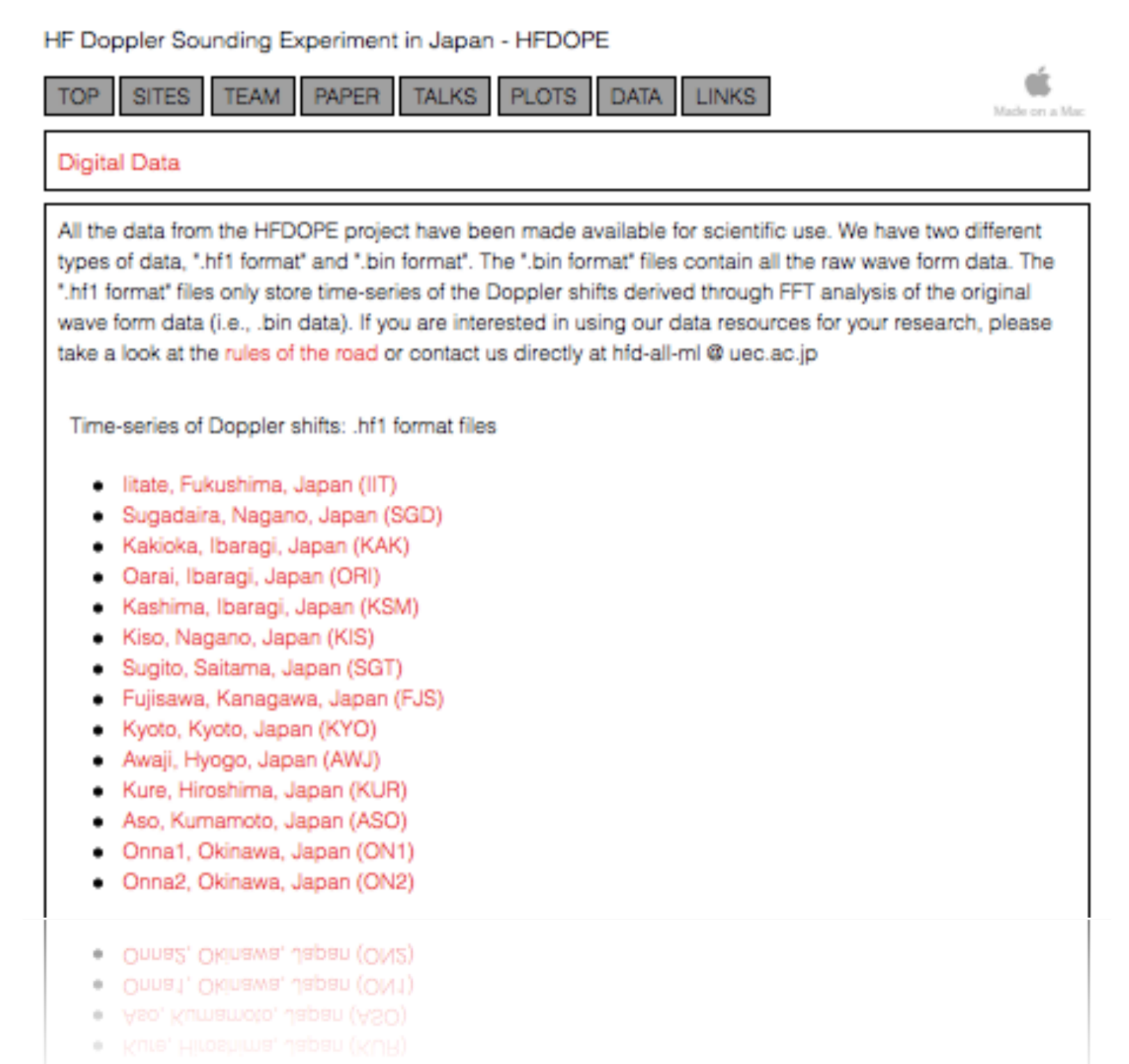
- ★ The main transmitting station is located in Chofu, Tokyo, Japan within the Chofu Campus of UEC (JG2XA). JG2XA transmits continuously with 200 W on 5006 kHz and 8006 kHz
- ★ The station ID is normally transmitted every 5 minutes by amplitude modulation of the carrier in morse code with the callsign JG2XA and its objective "UEC HFD STATION". The type of radio signal is H2A (amplitude modulation with coded tones by single sideband)
- ★ At some stations, we also observe signals from Radio Nikkei 1 (JOZ at 3925 kHz, JOZ2 at 6055 kHz, and JOZ3 at 9595 kHz) transmitted from Nagara, Chiba, Japan

Station	Location	Frequency (kHz)						Period of Operation	
Name	ID	Glat (N)	Glon (E)	CH#0	CH#1	CH#2	CH#3	Start Date	End Date
litate	IIT	37.689	140.673	5006	8006			June 1, 2014	
Sugadaira	SGD	36.423	138.318	5006	8006	6055	9595	Oct 24, 2002	
Kakioka	KAK	36.232	140.186	5006	8006	6055	9595	Feb 14, 2011	Feb 5, 2018
Oarai	ORI	36.331	140.587	5006	8006	6055	9595	May 18, 2004	
Kashima	KSM	35.953	140.663	5006	8006	6055	9595	Mar 9, 2004	
Kiso	KIS	35.797	137.623	5006	8006	6055	9595	Mar 30, 2009	May 6, 2011
Fujisawa	FJS	35.320	139.457	5006	8006	6055	9595	May 29, 2011	
Kyoto	KYO	35.028	135.786	5006	8006	6055	9595	Feb 26, 2004	Aug 3, 2016
Awaji	AWJ	35.293	134.736	5006	8006	6055	9595	Mar 14, 2019	
Kure	KUR	34.243	132.529	5006	8006			Mar 24, 2003	Apr 3, 2017
Aso	ASO	32.885	131.007	6055	8006	5000	9595	Mar 13, 2009	Apr 16, 2016
Onna1	ON1	26.499	127.845	5006	8006	6055	9595	Nov 25, 2010	May 19, 2017
Onna2	ON2	26.499	127.845	5000	10000	15000	3925	Nov 25, 2010	May 19, 2017



## Database

- ★ All the data from the HF Doppler project have been made available online for scientific use
- ★ We have two different types of data, ".hf1 format" and ".bin format". The ".bin format" files contain all the raw wave form data. The ".hf1 format" files only store time-series of the Doppler shifts derived through FFT analysis of the original wave form data (i.e., .bin data).
- ★ All the data are downloadable from the project webpage: <http://gwave.cei.uec.ac.jp/~hfd/dat.html>

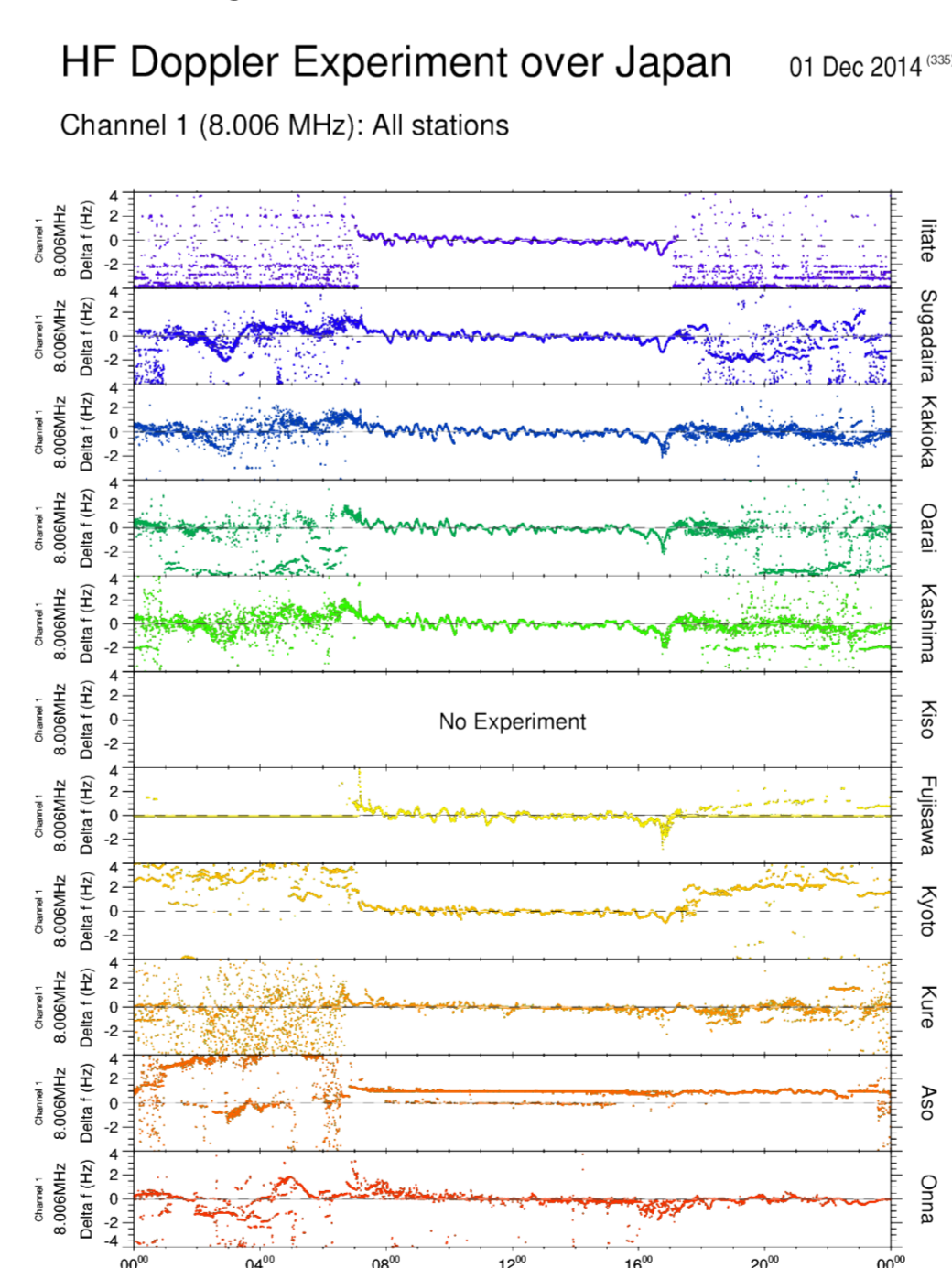


## Possible scientific targets & Future direction

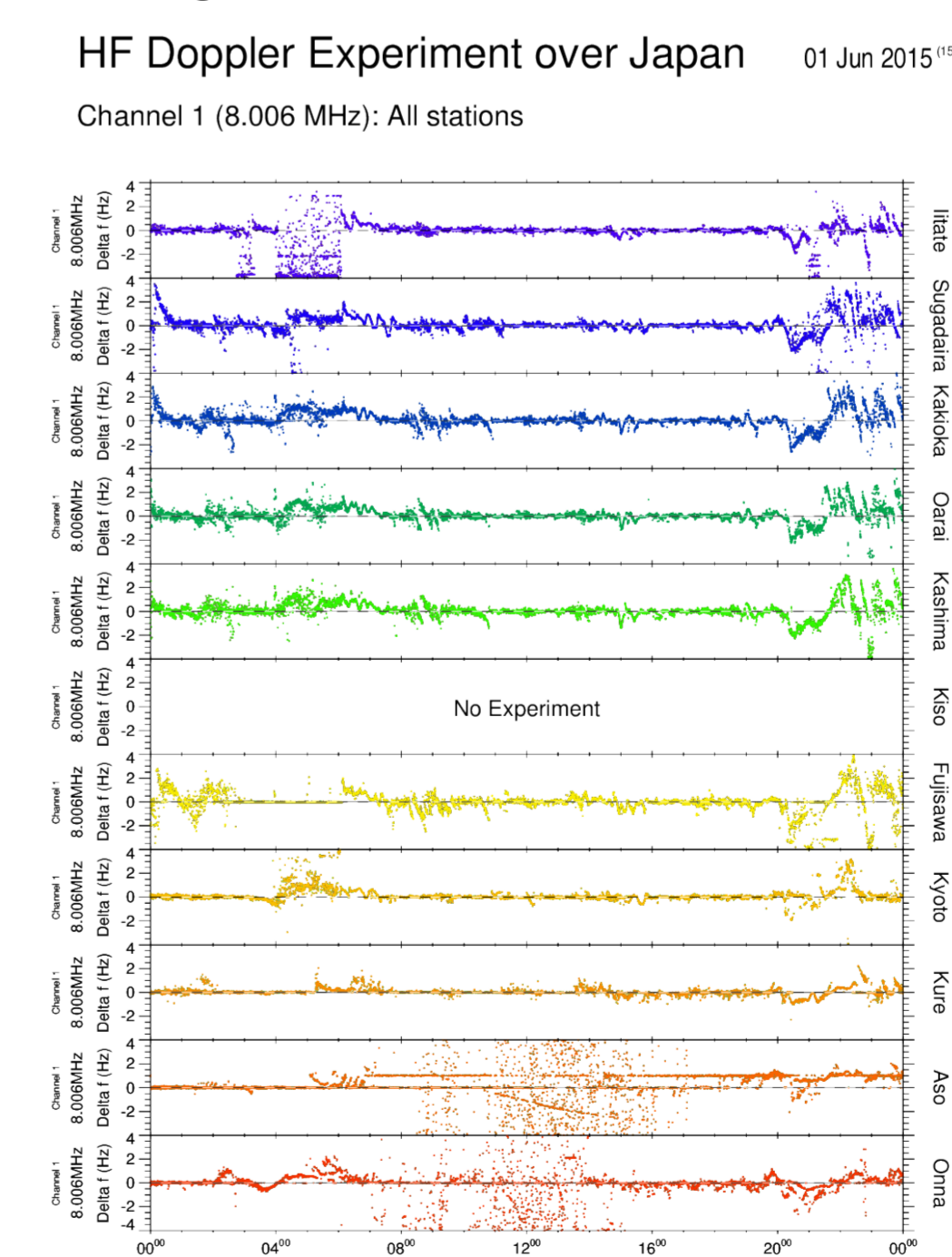
### 1. Ionospheric dynamics

- Medium-scale traveling ionospheric disturbances (MSTIDs)
- Sporadic E-layer (Es)
- Large-scale traveling ionospheric disturbances (LSTIDs)

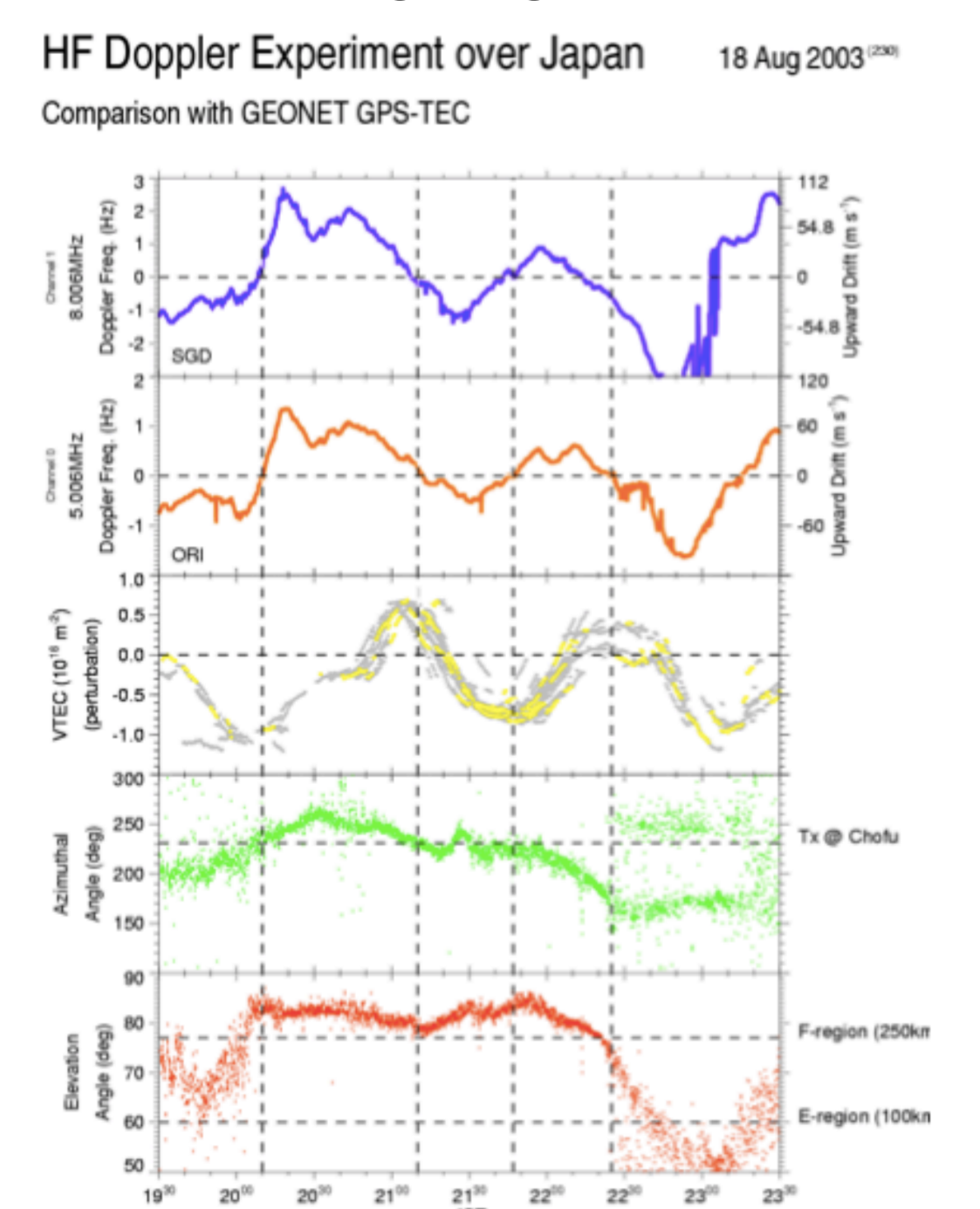
#### Daytime MSTID in winter



#### Nighttime MSTID in summer



#### LSTID during magnetic storm



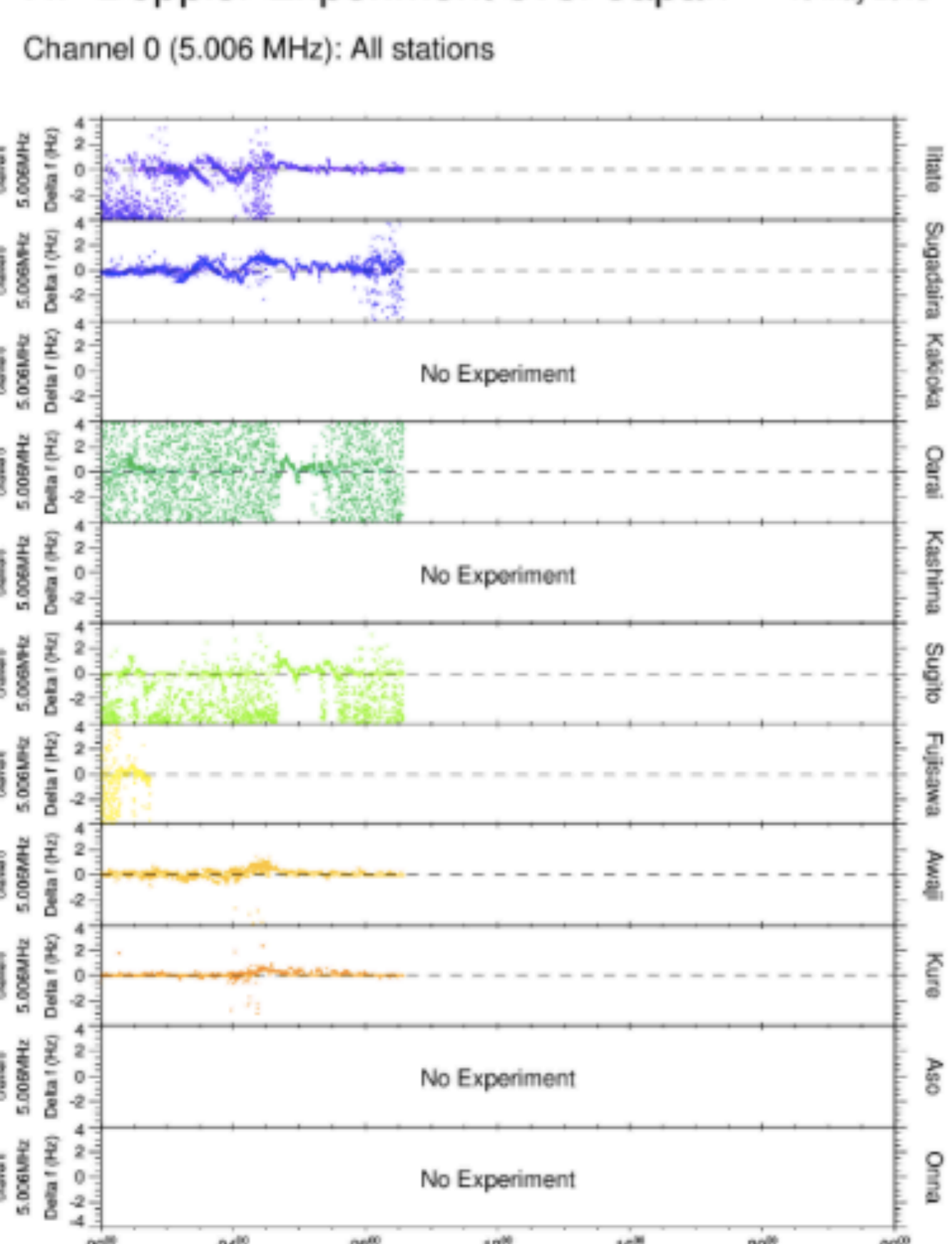
## QL data plots + quasi-realtime monitoring

<http://gwave.cei.uec.ac.jp/cgi-bin/hfd/hfd2.cgi>

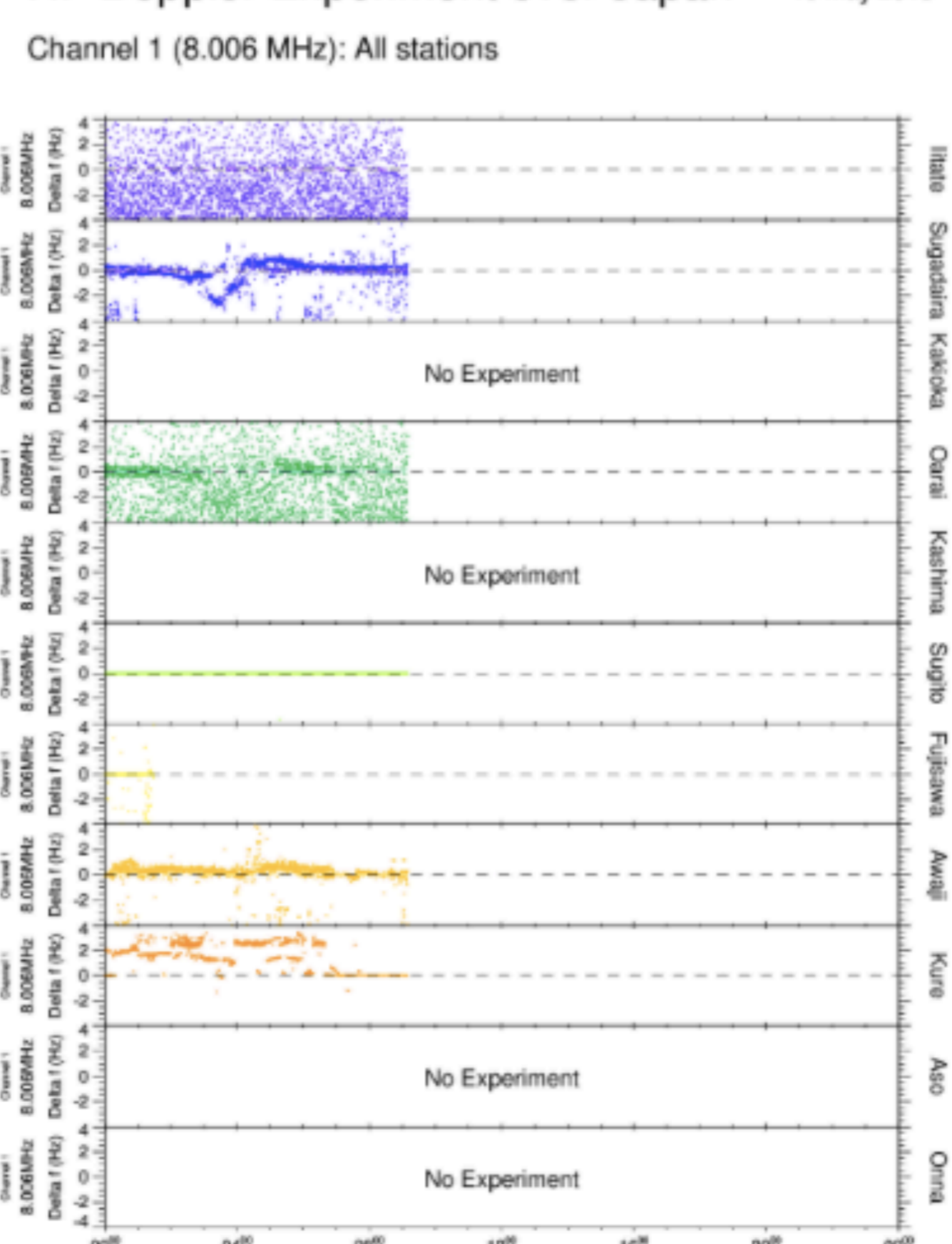
### HF Doppler Experiment in Japan - Data Quick Browser

2019 05 19 Plot Prev Next

#### HF Doppler Experiment over Japan 19 May 2019



#### HF Doppler Experiment over Japan 19 May 2019



### 2. Magnetosphere-lonosphere coupling (M-I coupling)

- Global-scale electric field variation → [PEM12-P21] Hashimoto et al.
- Sudden Commencement (SC)
- Magnetic pulsation (Pc3 - Pc5)

### 3. Vertical coupling in the Atmosphere-lonosphere system (Vertical coupling)

- Ionospheric variation after large earthquakes → [MIS22-P02] Ono et al.
- Ionospheric variation after volcanic eruptions, typhoon → [MTT49-05] Nakata et al.
- Ionospheric variation caused by rocket launch → [PEM16-P09] Yamazaki et al.