Plasma bubbles observed by DEMETER and statistical study of occurrence

Tatsuo ONISHI[1], Jean-Jacques BERTHELIER[1] and Michel MALINGRE[2]
1 : LATMOS/IPSL, CNRS-UPMC-UVSQ
2 : LPP, Ecole Polytechnique-CNRS-UPMC

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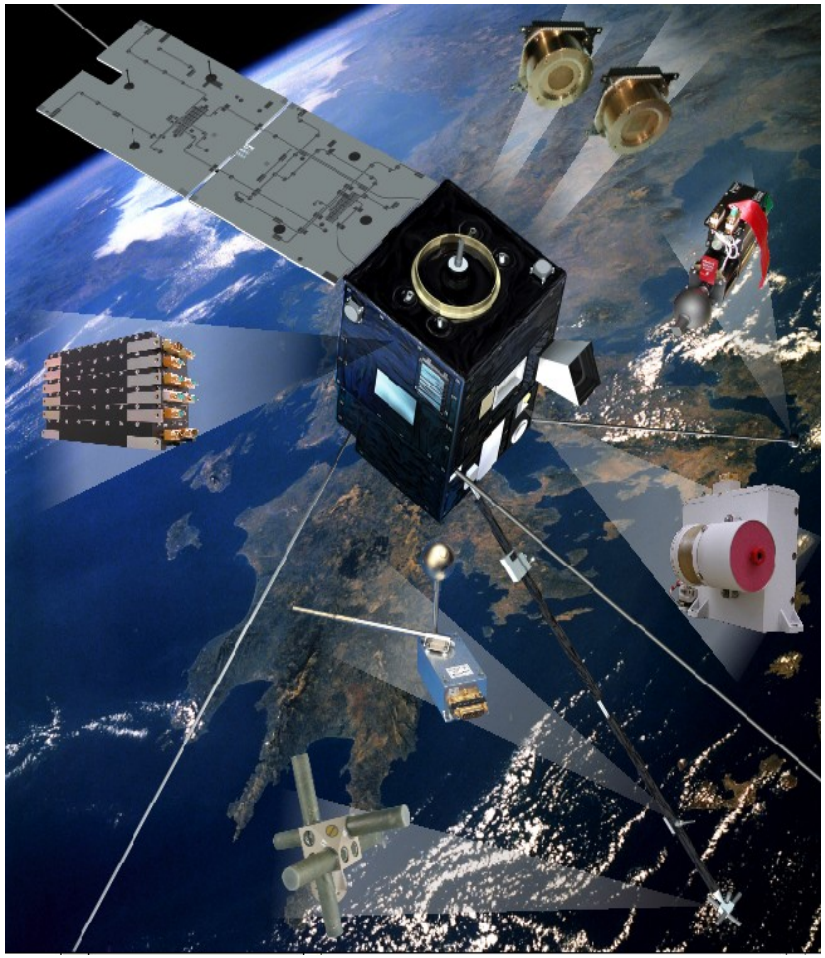
Agenda

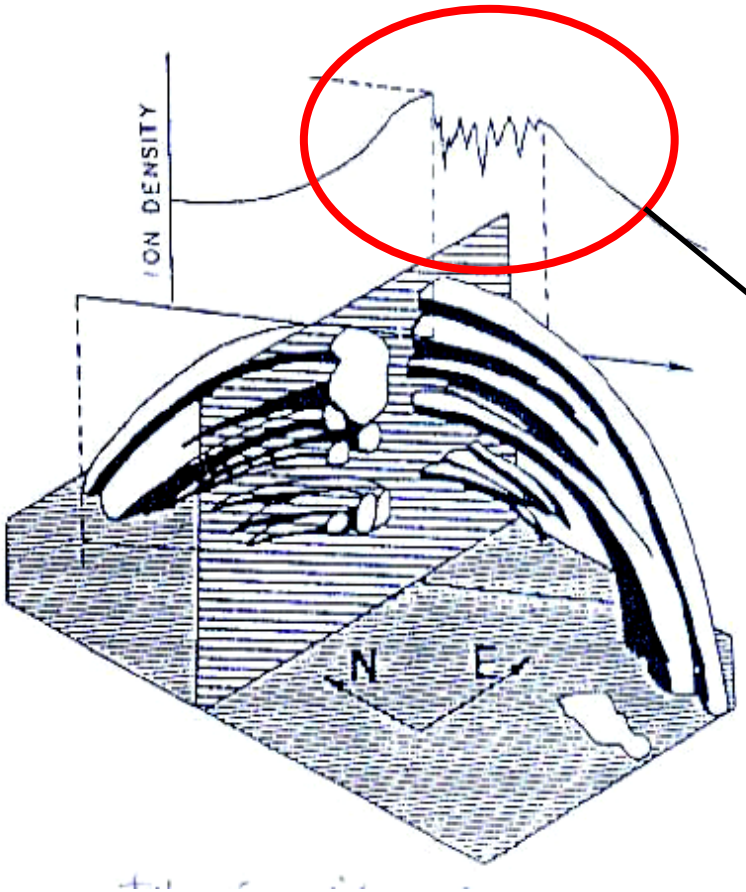
- DEMETER/Plasma Bubbles (PB)
- On-board instruments (ICE,IAP,ISL)
- Detection : Criteria
- Detection : Results
- Other phenomena
- Statistics : Results
- Work in progress
- Conclusion

DEMETER

- Micro-satellite:
  - 130kg
  - Height:80cm
  - Base:60cm x 60cm
- 5 Experiments on board
  - **ICE (Electric field)**
  - IMSC (Magnetic Field)
  - **IAP (Ion Analyzer)**
  - IDP (Energetic Particle)
  - **ISL (Langmuir Probe)**
- Altitude:
  - 710km → 660km(Dec. 2005)
- Inclination: 98.3°
  - Sun synchroneous circular orbit
  - 10h30 and 22h30 at local time.



Plasma Bubble

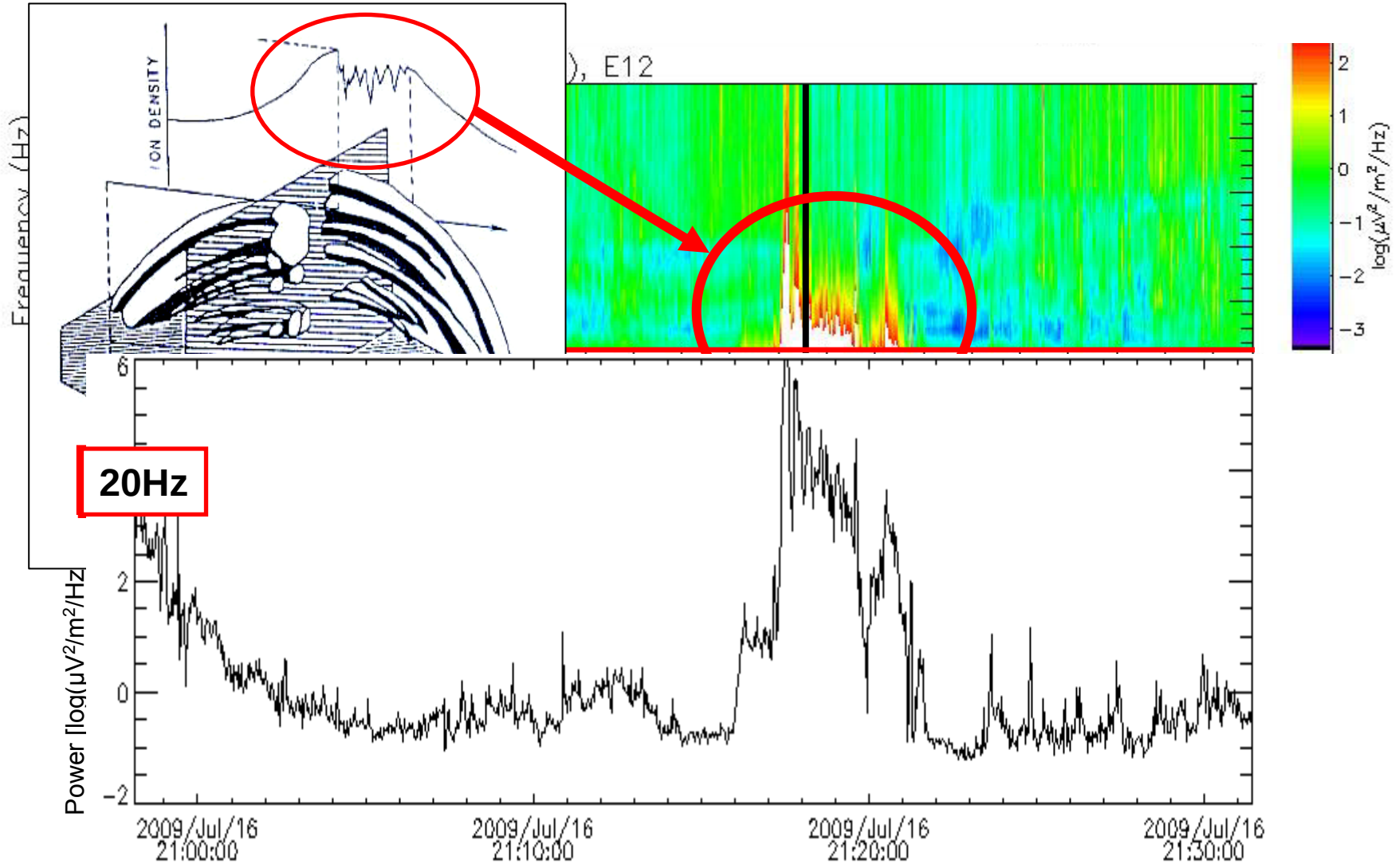


Plasma bubble (plasma density depletion region) elongated along the geomagnetic field line. [E.R.Younget al, 1984]

Plasma density (and Temperature) fluctuations

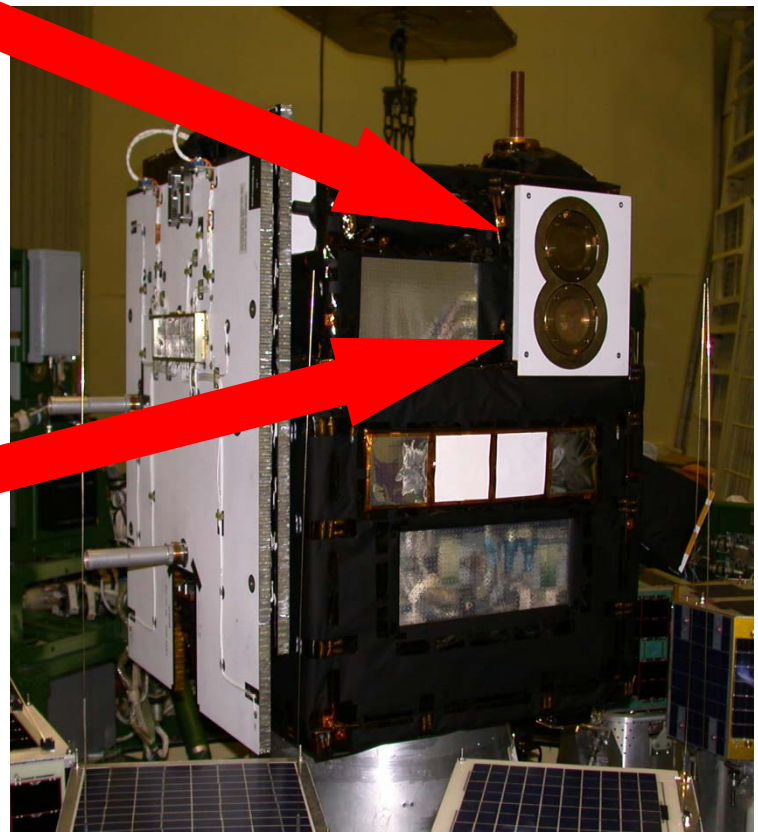
Electrostatic Turbulence

ICE (Champs electrique)

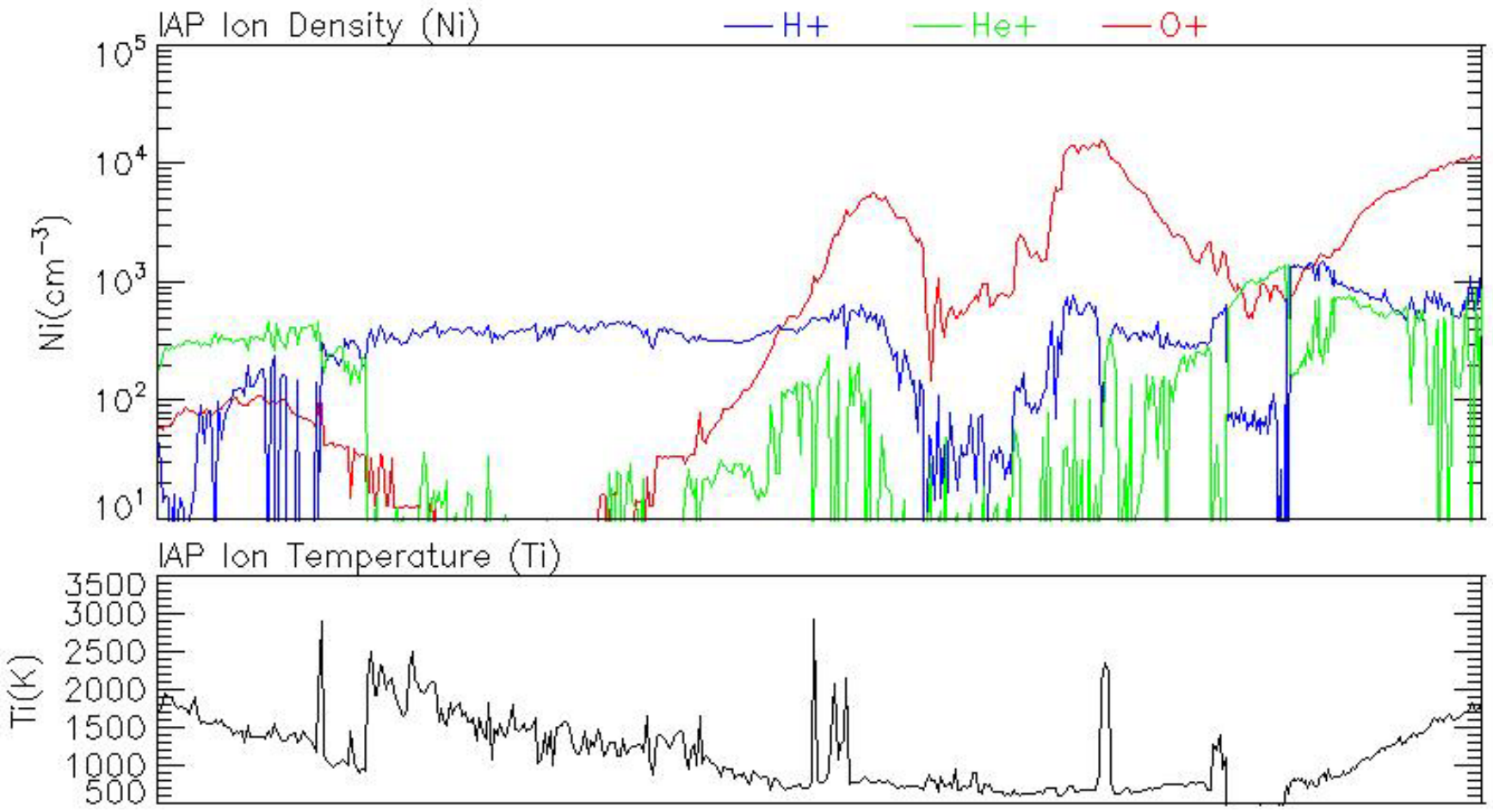


IAP

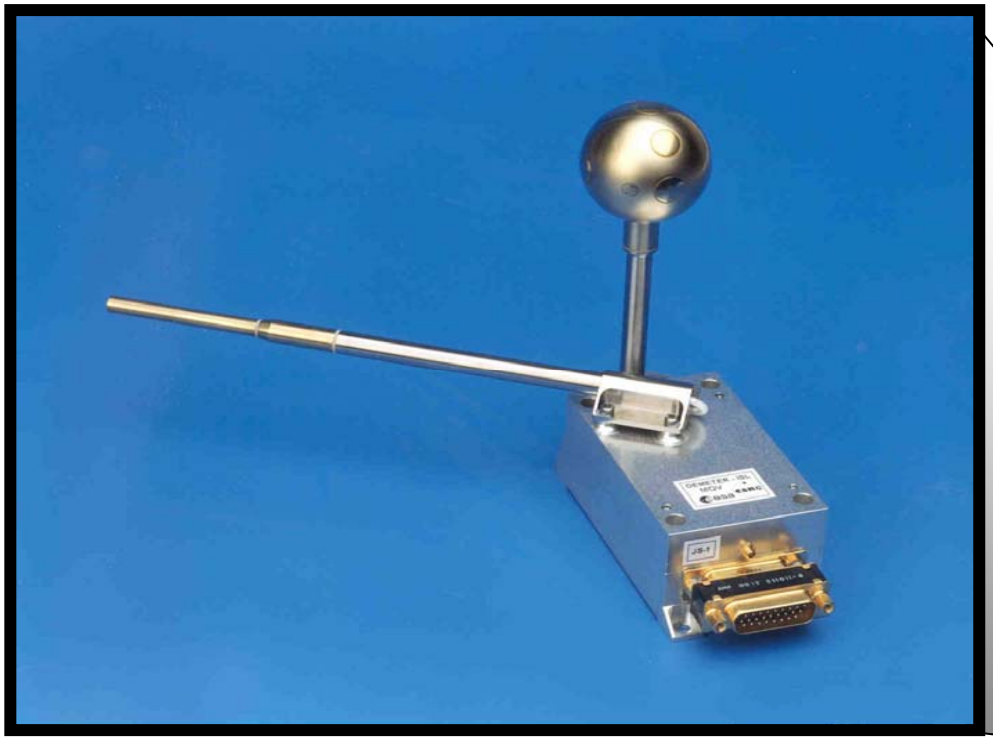
- APR (for *Analyseur à Potentiel Retardateur, Retarding Potential Analyzer*) performs the energy analysis of the rammed ionospheric ions.
  - H+, He+ and O+
  - **Density**
  - **Temperature**
  - Ion Ram speed
- ADV (for *Analyseur pour Direction de Vitesse, Velocity Direction Analyzer*) determines the average angles of arrival of the ions.
  - Velocity direction

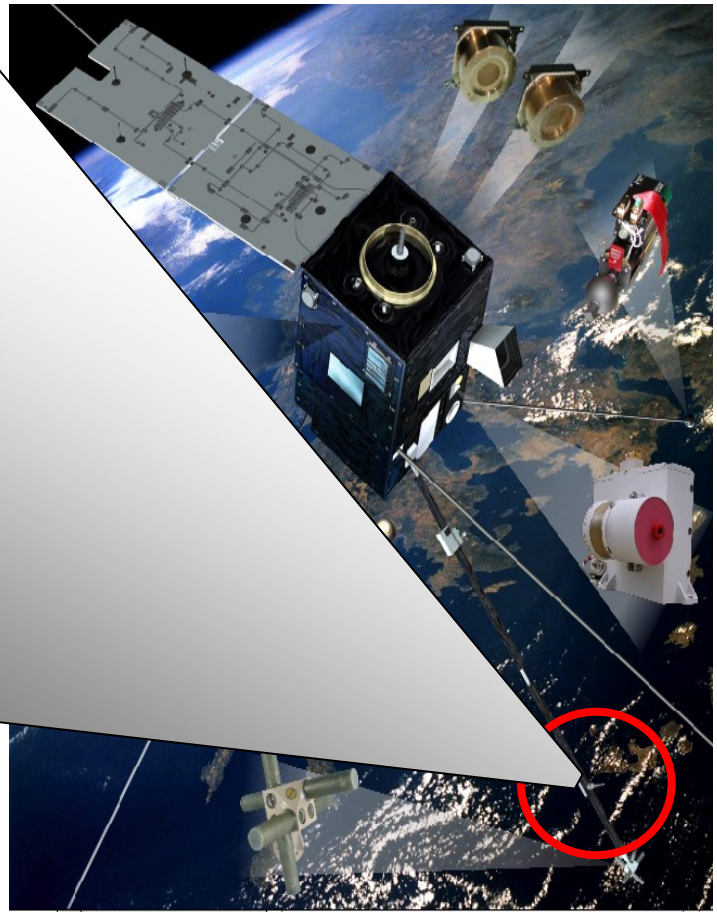


IAP

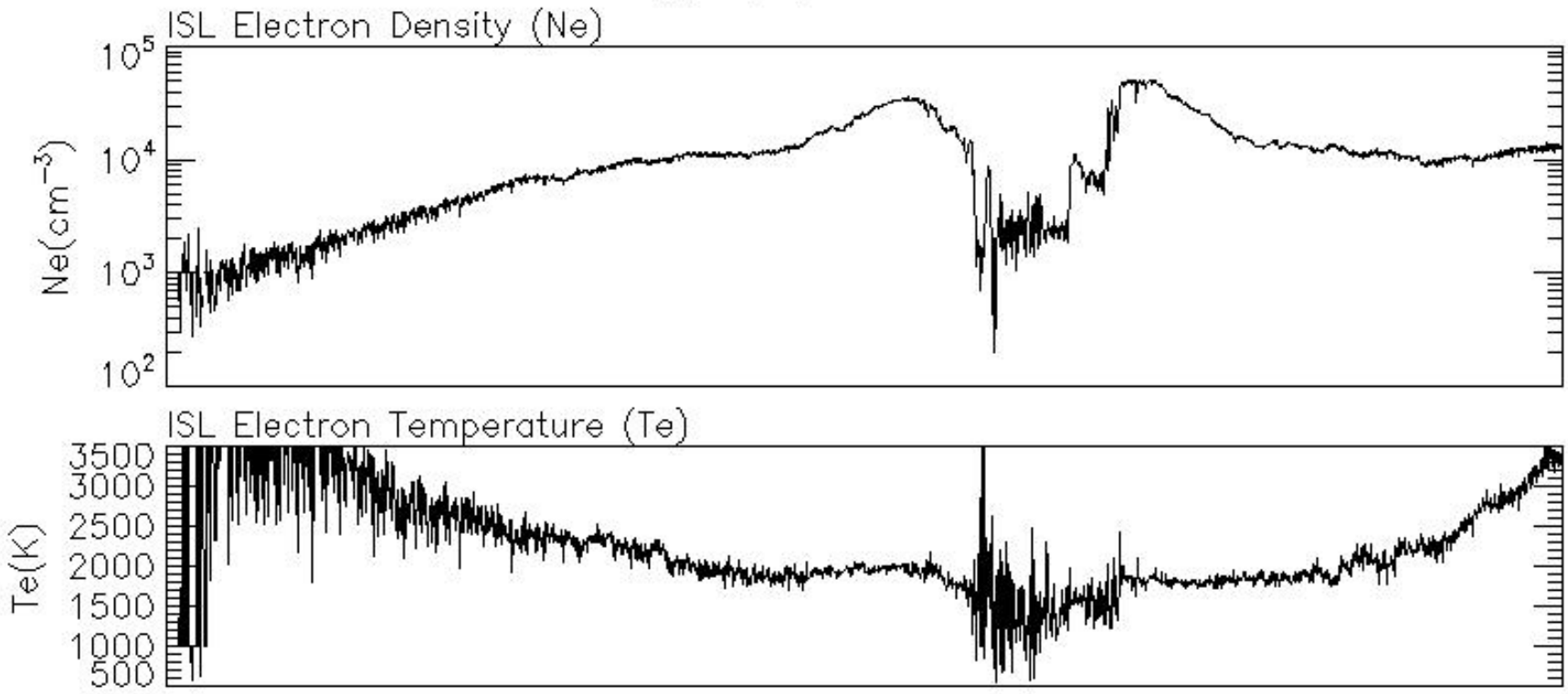

IAP Ion Density (Ni)
H+
He+
O+
Ni(cm⁻³)
10⁵
10⁴
10³
10²
10¹
IAP Ion Temperature (Ti)
Ti(K)
3500
3000
2500
2000
1500
1000
500

ISL (Langmuir Probe)

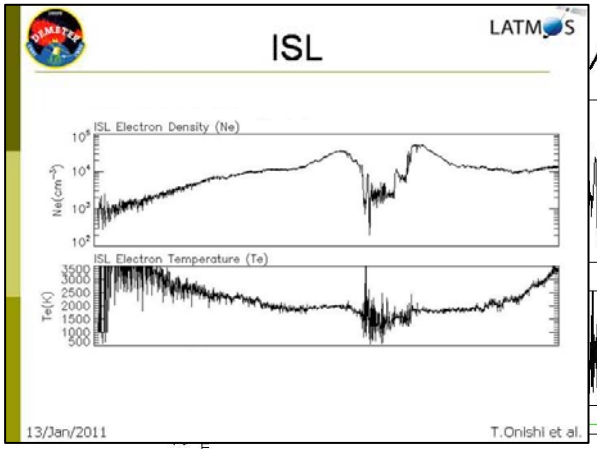


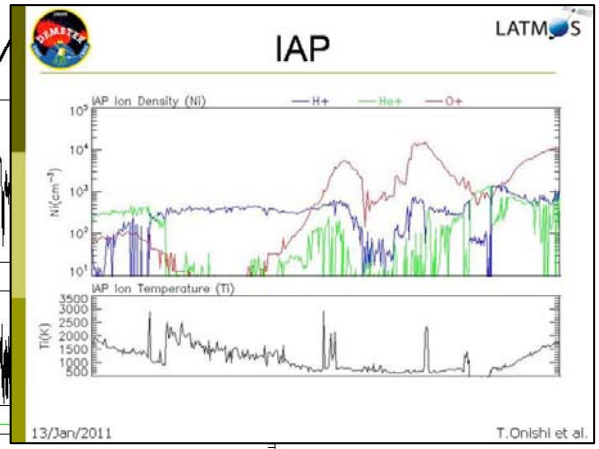


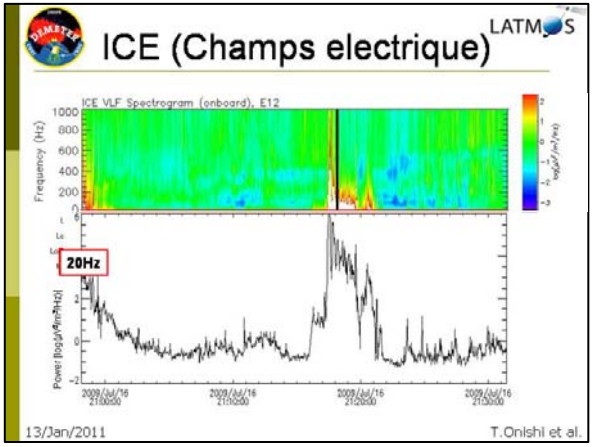
ISL

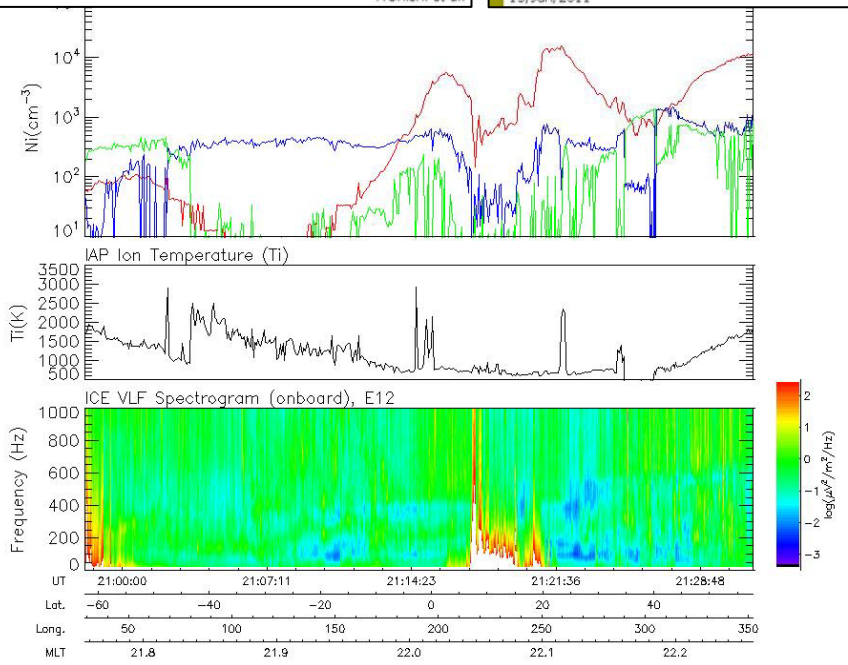

ISL Electron Density (Ne)
Ne(cm^{-3})
10^5
10^4
10^3
10^2
ISL Electron Temperature (Te)
Te(K)
3500
3000
2500
2000
1500
1000
500

Data

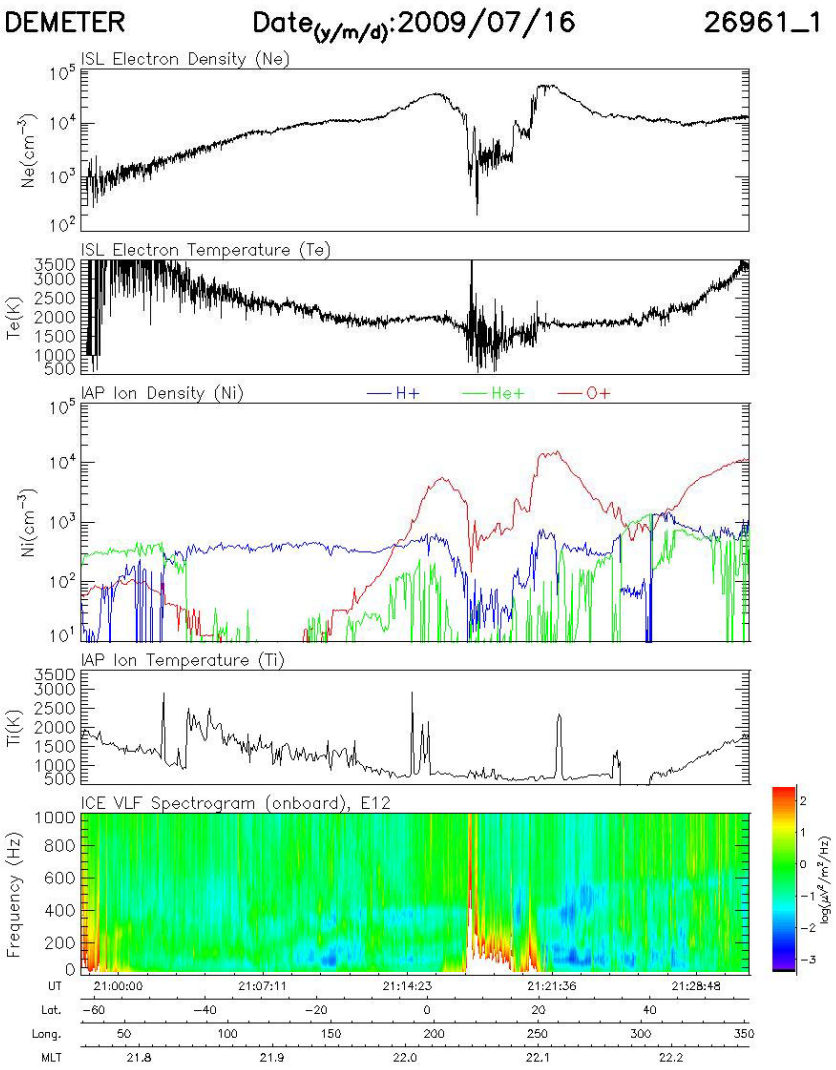

ISL
LATMOS
ISL Electron Density (Ne)
Ne(cm⁻³)
ISL Electron Temperature (Te)
Te(K)
13/Jan/2011
T.Onishi et al.


IAP
LATMOS
IAP Ion Density (Ni)
H+
He+
O+
Ni(cm⁻³)
IAP Ion Temperature (Ti)
Ti(K)
13/Jan/2011
T.Onishi et al.


ICE (Champs electrique)
LATMOS
ICE VLF Spectrogram (onboard), E12
Frequency (Hz)
20Hz
13/Jan/2011
T.Onishi et al.


Ni(cm⁻³)
IAP Ion Temperature (Ti)
Ti(K)
ICE VLF Spectrogram (onboard), E12
Frequency (Hz)
UT
21:00:00
21:07:11
21:14:23
21:21:36
21:28:48
Lat.
Long.
MLT

Detect Data & Criteria



Criteria (ISL)

$$\tilde{N}_e = N_e - \overline{N}_e$$

1: $\left|\tilde{N}_e\right| > N_{seuil}$

2: $\sigma\left(\tilde{N}_e\right) > \sigma_{seuil}$

Criteria (IAP)

$$\tilde{N}_i = N_i - \overline{N}_i$$

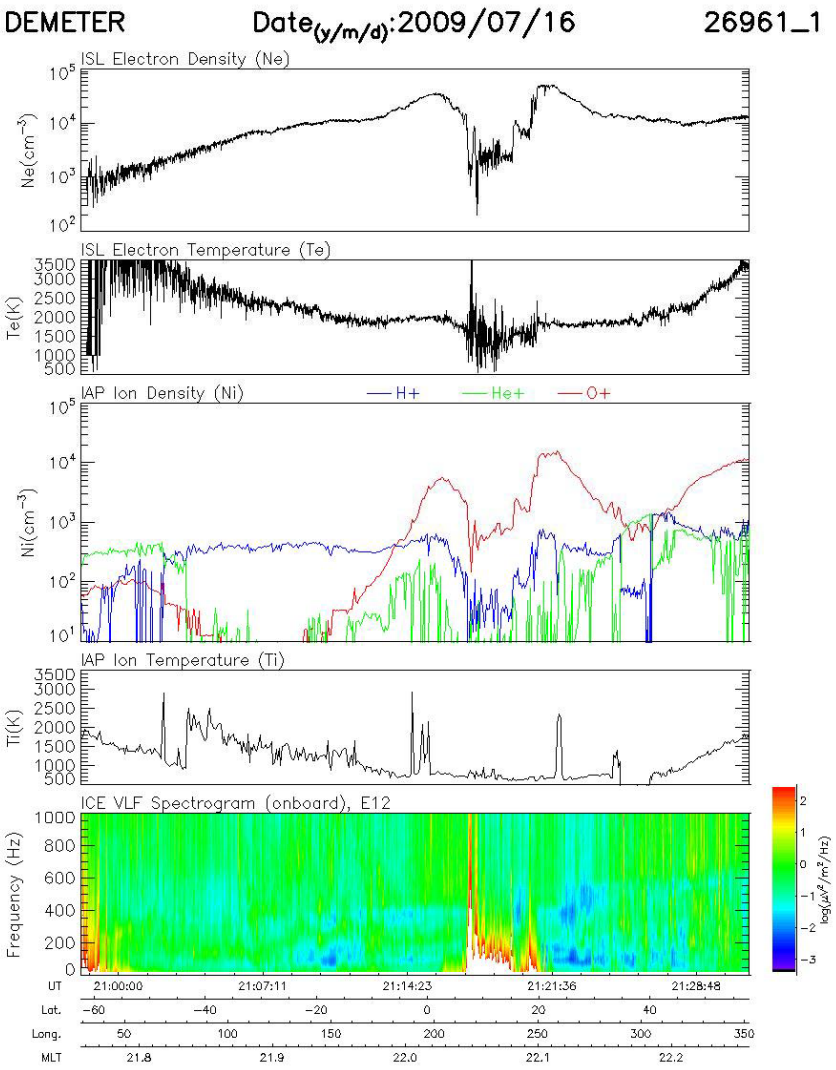
1: $\left|\tilde{N}_i\right| > N_{seuil}$

Criteria (ICE)

$$\tilde{P}_{20} = P_{20} - \overline{P}_{20}$$

1: $\tilde{P}_{20} > 1.5\,(\text{en log})$

Detection Criteria



Criteria (ISL)

$$\tilde{N}_e = N_e - \overline{N}_e$$

1: $\left|\tilde{N}_e\right| > N_{seuil}$

2: $\sigma\left(\tilde{N}_e\right) > \sigma_{seuil}$

Criteria (IAP)

$$\tilde{N}_i = N_i - \overline{N}_i$$

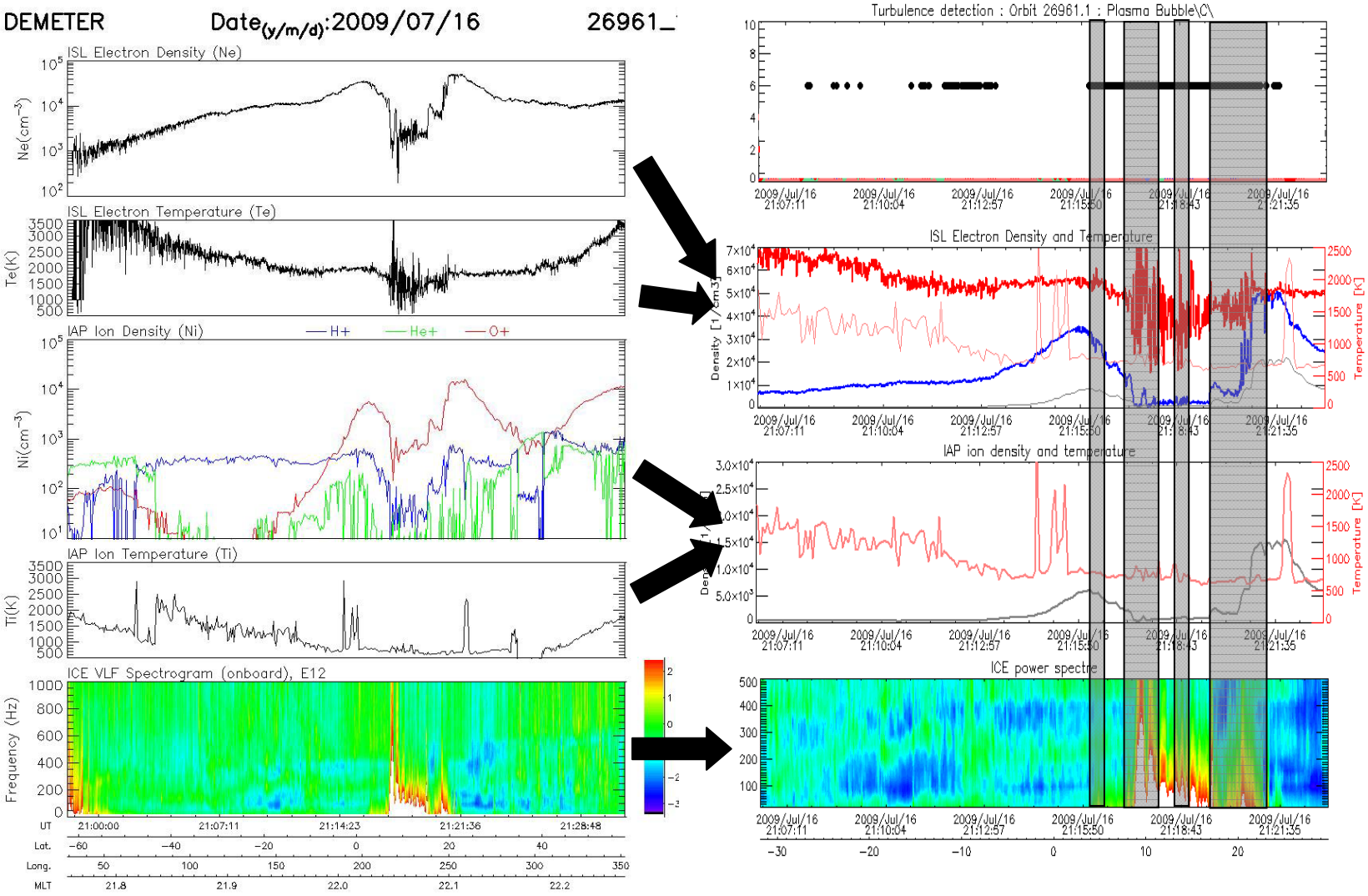
1: $\left|\tilde{N}_i\right| > N_{seuil}$

Criteria (ICE)

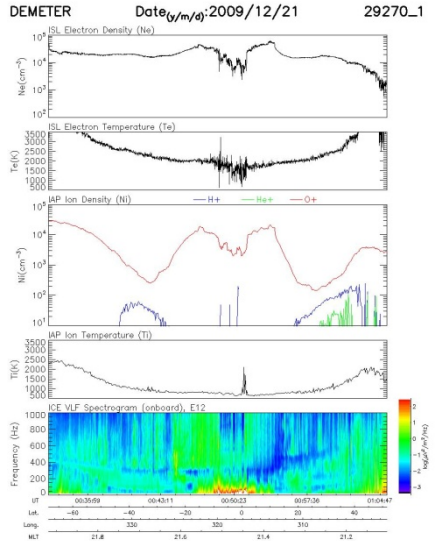
$$\tilde{P}_{20} = P_{20} - \overline{P}_{20}$$

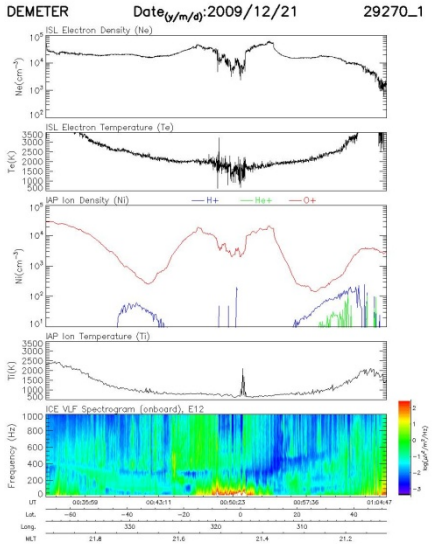
1: $\tilde{P}_{20} > 1.5\,(\text{en log})$

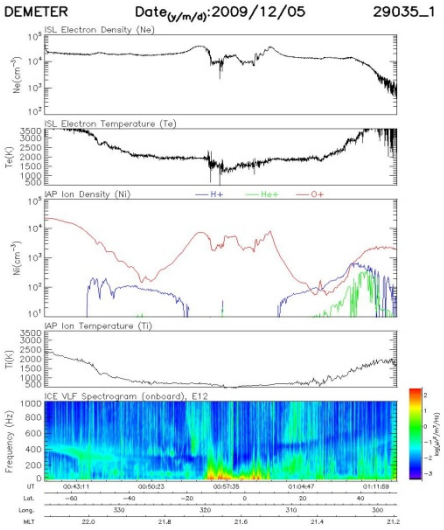
Detection Criteria

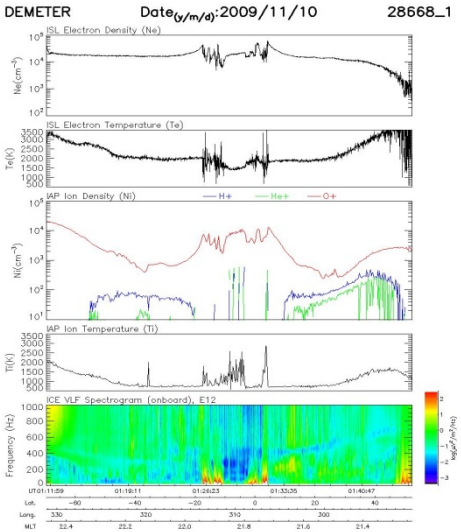


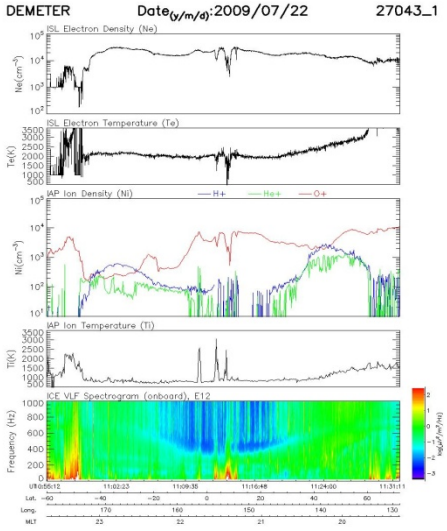
Results

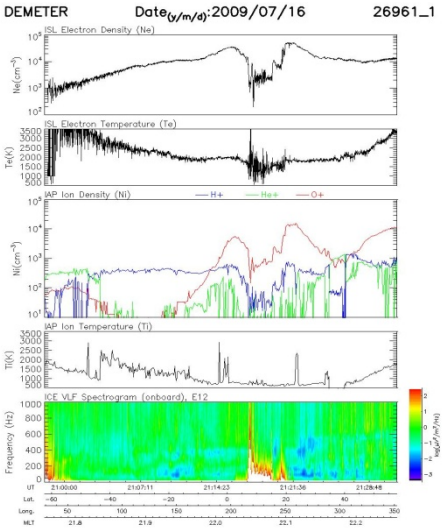

DEMETER
Date(y/m/d):2009/12/21
29270_1
ISL Electron Density (Ne)
ISL Electron Temperature (Te)
IAP Ion Density (Ni)
H+
He+
O+
IAP Ion Temperature (Ti)
ICE VLF Spectrogram (onboard), E12


DEMETER
Date(y/m/d):2009/12/21
29270_1
ISL Electron Density (Ne)
ISL Electron Temperature (Te)
IAP Ion Density (Ni)
H+
He+
O+
IAP Ion Temperature (Ti)
ICE VLF Spectrogram (onboard), E12

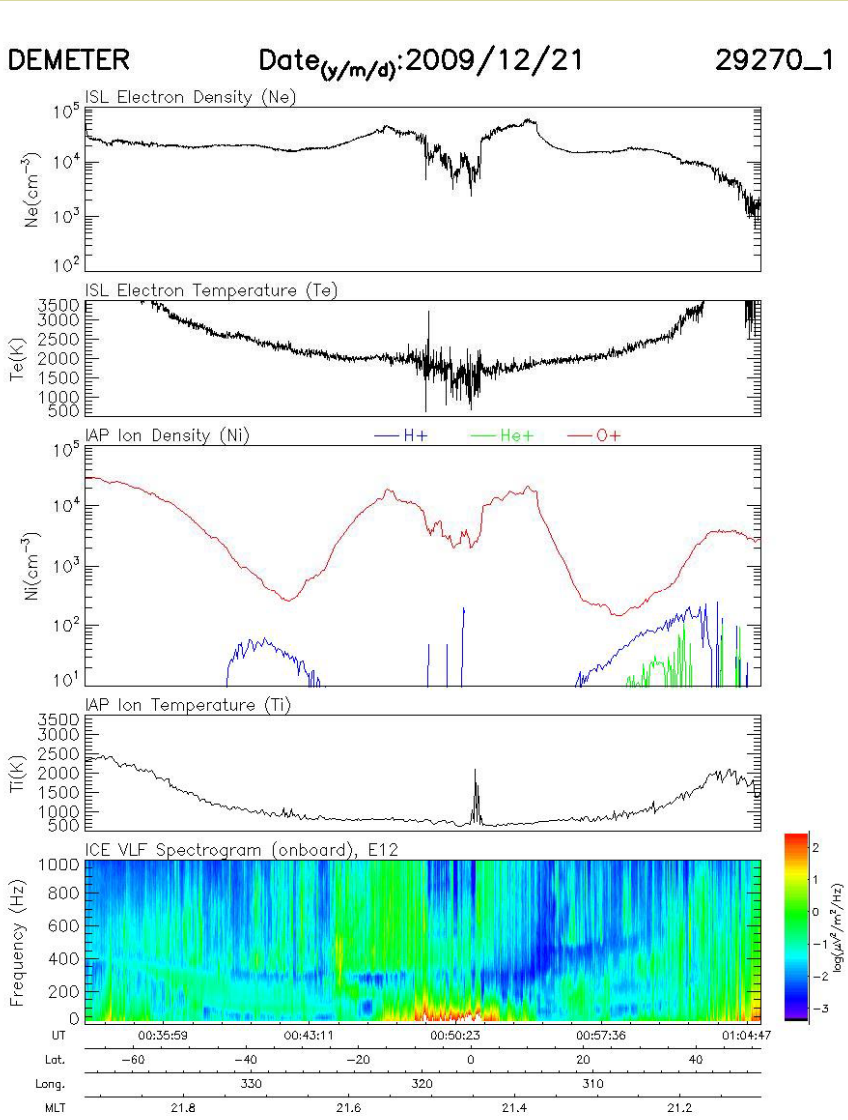

DEMETER
Date(y/m/d):2009/12/05
29035_1
ISL Electron Density (Ne)
ISL Electron Temperature (Te)
IAP Ion Density (Ni)
H+
He+
O+
IAP Ion Temperature (Ti)
ICE VLF Spectrogram (onboard), E12

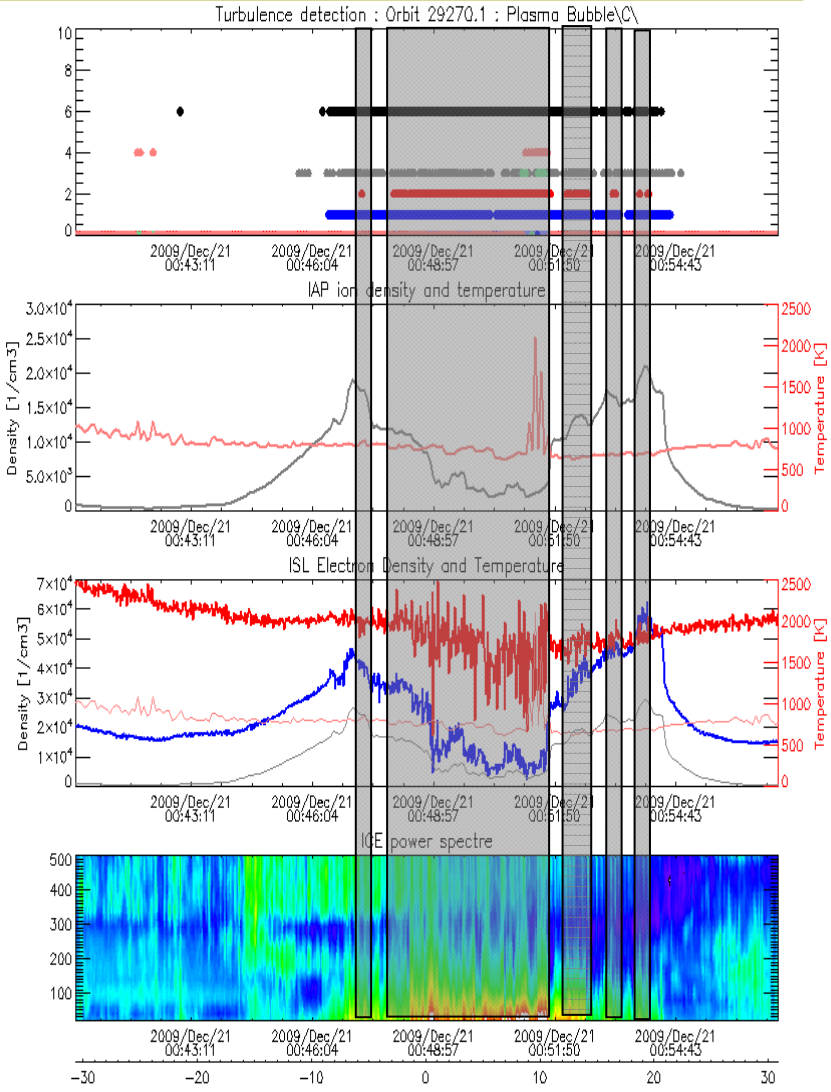

DEMETER
Date(y/m/d):2009/11/10
28668_1
ISL Electron Density (Ne)
ISL Electron Temperature (Te)
IAP Ion Density (Ni)
H+
He+
O+
IAP Ion Temperature (Ti)
ICE VLF Spectrogram (onboard), E12


DEMETER
Date(y/m/d):2009/07/22
27043_1
ISL Electron Density (Ne)
ISL Electron Temperature (Te)
IAP Ion Density (Ni)
H+
He+
O+
IAP Ion Temperature (Ti)
ICE VLF Spectrogram (onboard), E12

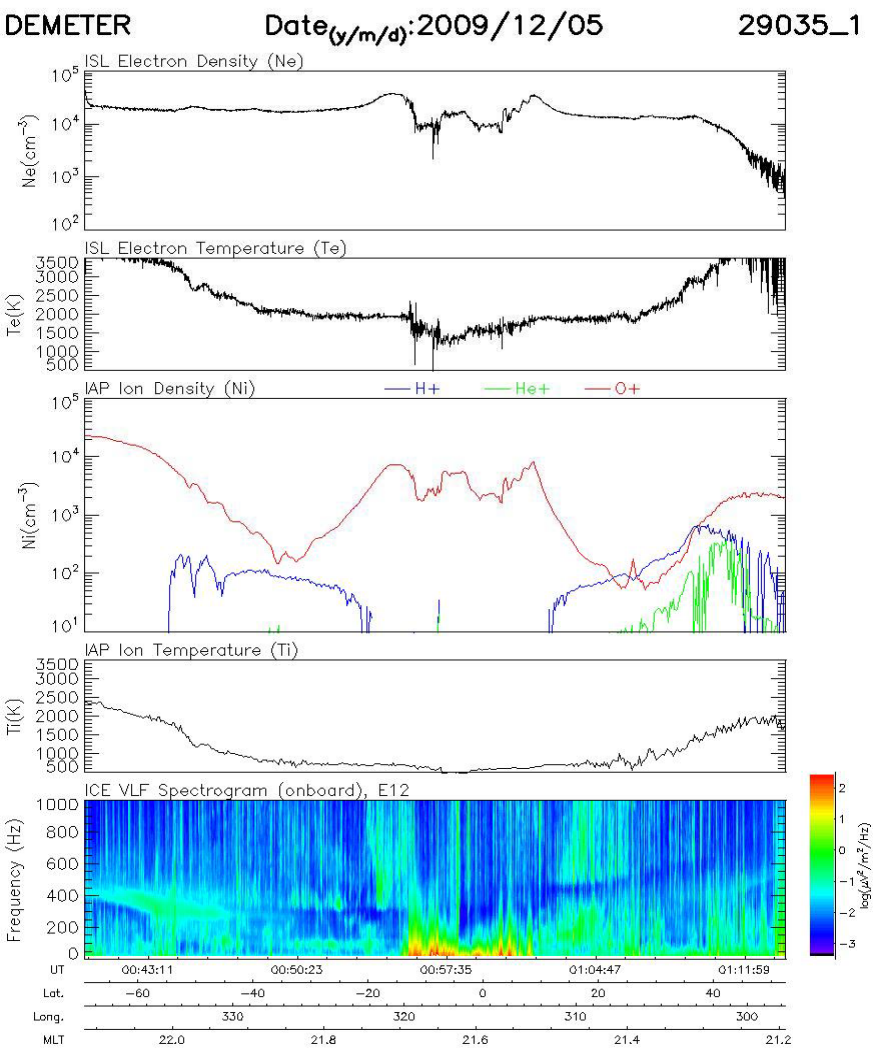

DEMETER
Date(y/m/d):2009/07/16
26961_1
ISL Electron Density (Ne)
ISL Electron Temperature (Te)
IAP Ion Density (Ni)
H+
He+
O+
IAP Ion Temperature (Ti)
ICE VLF Spectrogram (onboard), E12

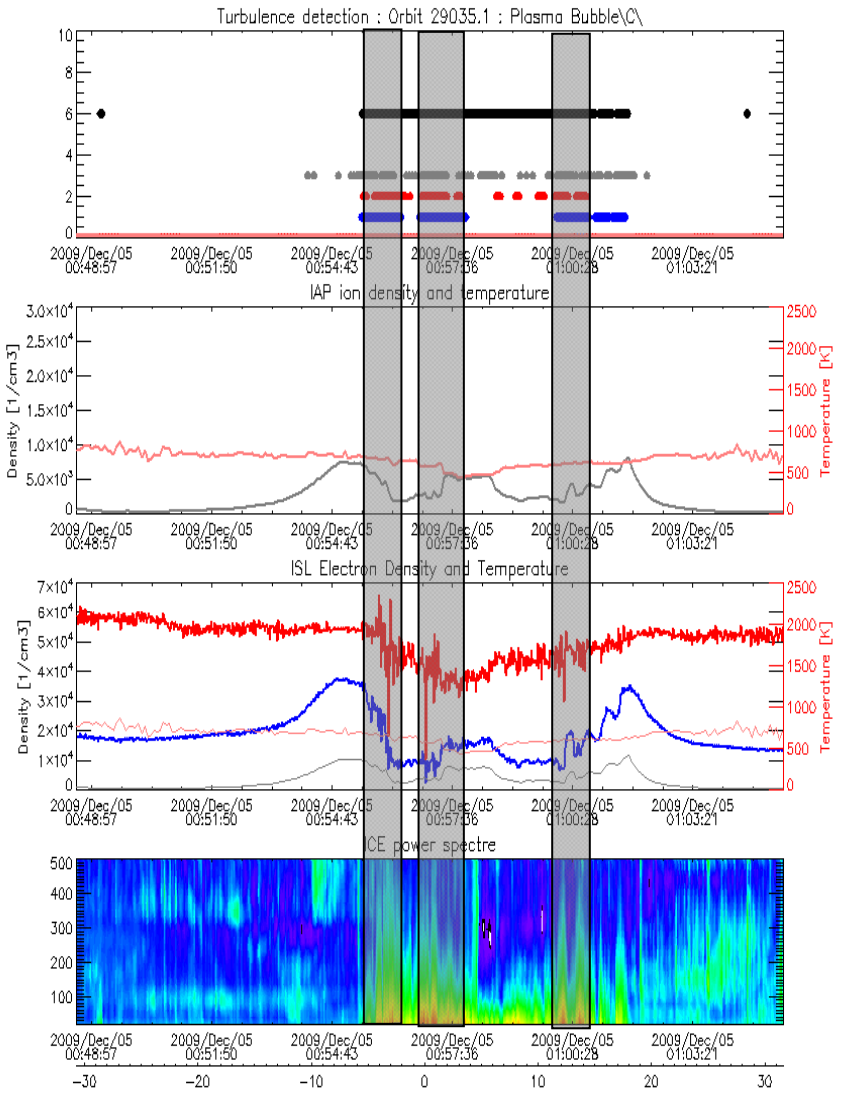
Results


DEMETER
Date(y/m/d):2009/12/21
29270_1
ISL Electron Density (Ne)
Ne(cm-3)
ISL Electron Temperature (Te)
Te(K)
IAP Ion Density (Ni)
H+
He+
O+
Ni(cm-3)
IAP Ion Temperature (Ti)
Ti(K)
ICE VLF Spectrogram (onboard), E12
Frequency (Hz)
log(μV²/m²/Hz)
UT
00:35:59
00:43:11
00:50:23
00:57:36
01:04:47
Lat.
Long.
MLT

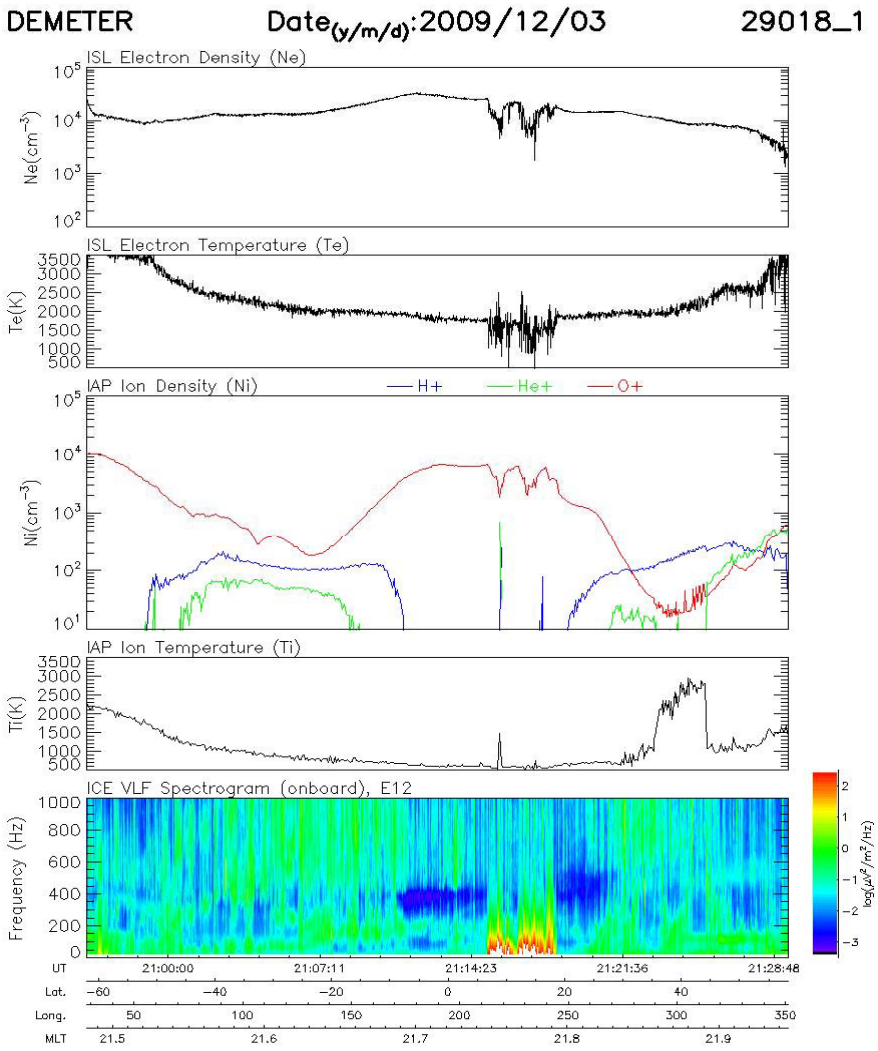

Turbulence detection : Orbit 29270.1 : Plasma Bubble\C\
IAP ion density and temperature
Density [1/cm3]
Temperature [K]
ISL Electron Density and Temperature
ICE power spectre
2009/Dec/21
00:43:11
00:46:04
00:48:57
00:51:50
00:54:43

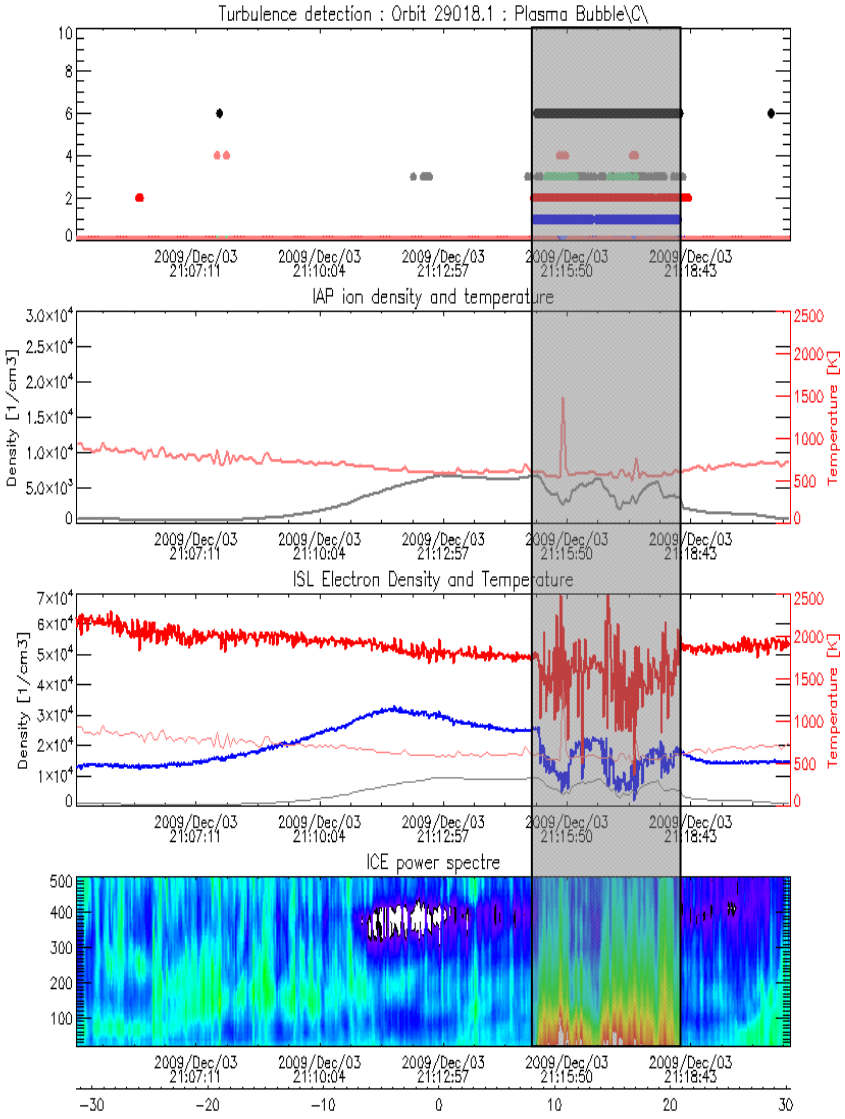
Results


DEMETER
Date(y/m/d):2009/12/05
29035_1
ISL Electron Density (Ne)
Ne(cm-3)
ISL Electron Temperature (Te)
Te(K)
IAP Ion Density (Ni)
H+
He+
O+
Ni(cm-3)
IAP Ion Temperature (Ti)
Ti(K)
ICE VLF Spectrogram (onboard), E12
Frequency (Hz)
log(μV²/m²/Hz)
UT
00:43:11
00:50:23
00:57:35
01:04:47
01:11:59
Lat.
Long.
MLT
22.0
21.8
21.6
21.4
21.2

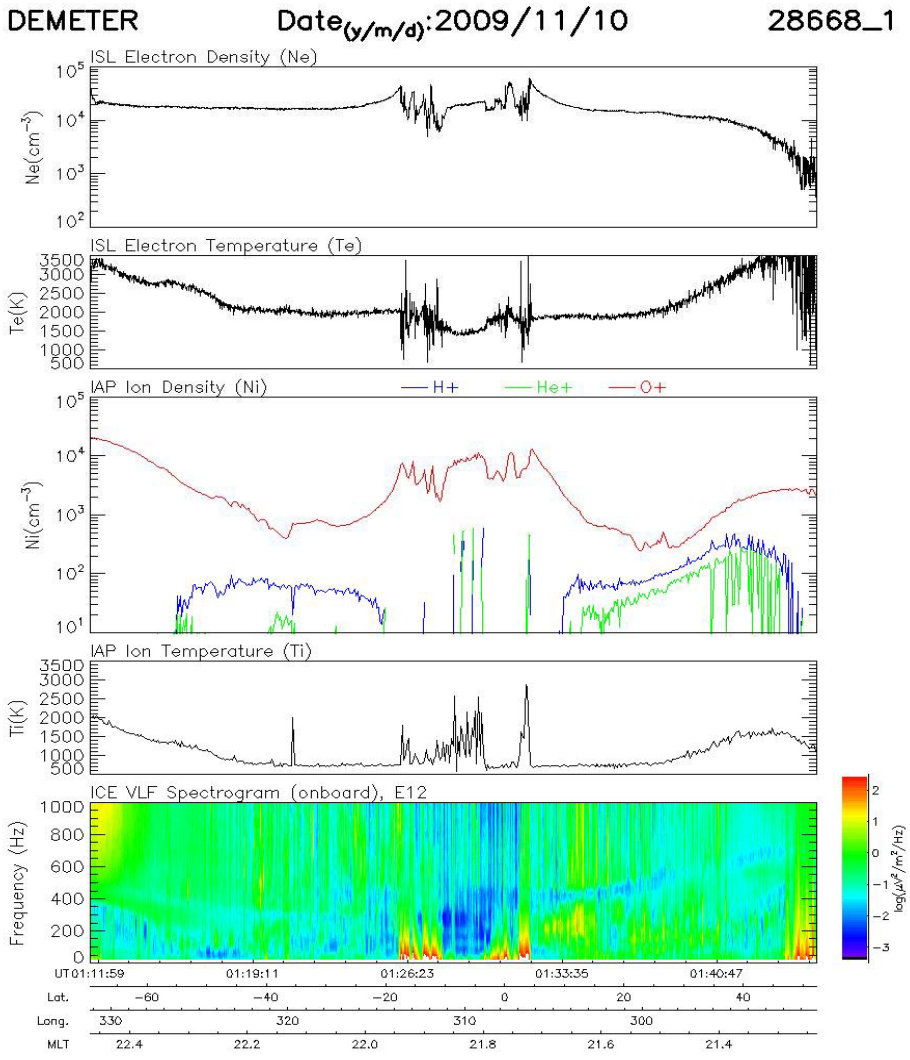

Turbulence detection : Orbit 29035.1 : Plasma Bubble\C\
IAP ion density and temperature
Density [1/cm3]
Temperature [K]
ISL Electron Density and Temperature
ICE power spectre
2009/Dec/05
00:48:57
00:51:50
00:54:43
00:57:36
01:00:28
01:03:21

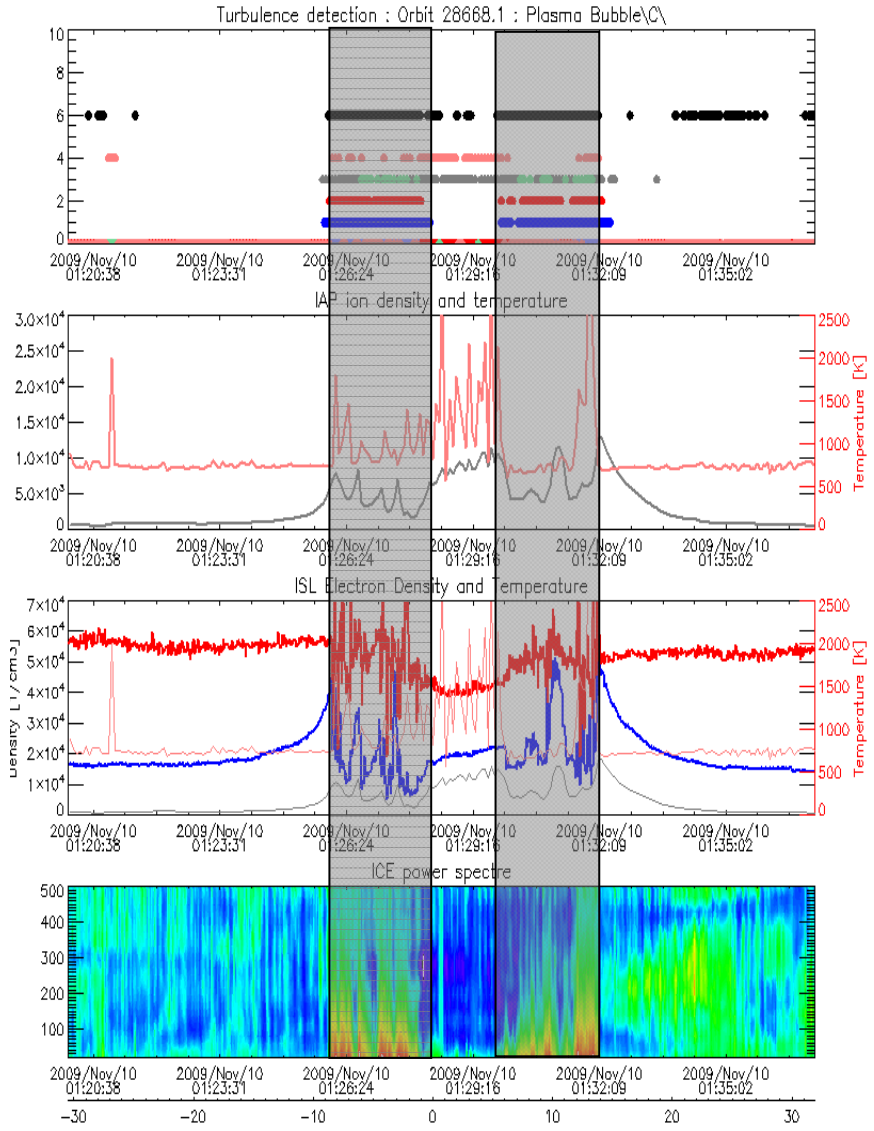
Results


DEMETER
Date(y/m/d):2009/12/03
29018_1
ISL Electron Density (Ne)
Ne(cm-3)
ISL Electron Temperature (Te)
Te(K)
IAP Ion Density (Ni)
H+
He+
O+
Ni(cm-3)
IAP Ion Temperature (Ti)
Ti(K)
ICE VLF Spectrogram (onboard), E12
Frequency (Hz)
log(μV²/m²/Hz)
UT
21:00:00
21:07:11
21:14:23
21:21:36
21:28:48
Lat.
Long.
MLT

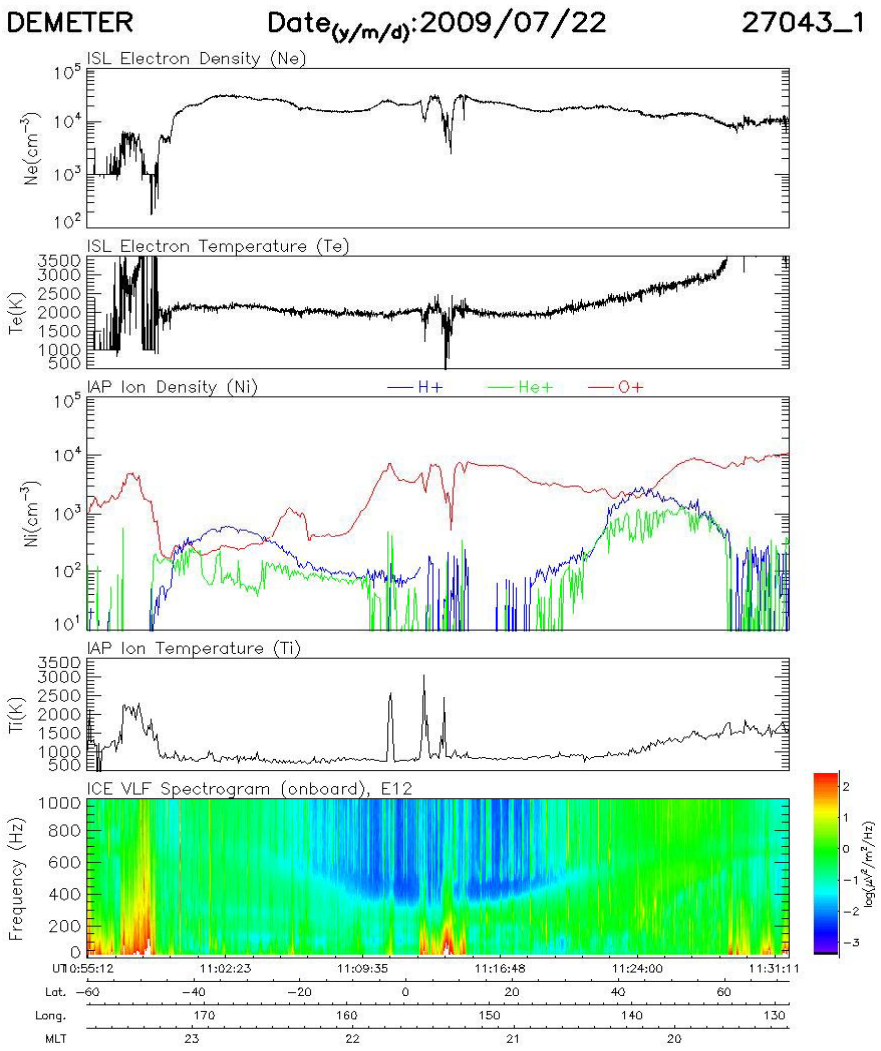

Turbulence detection : Orbit 29018.1 : Plasma Bubble\C\
IAP ion density and temperature
Density [1/cm3]
Temperature [K]
ISL Electron Density and Temperature
ICE power spectre
2009/Dec/03
21:07:11
21:10:04
21:12:57
21:15:50
21:18:43

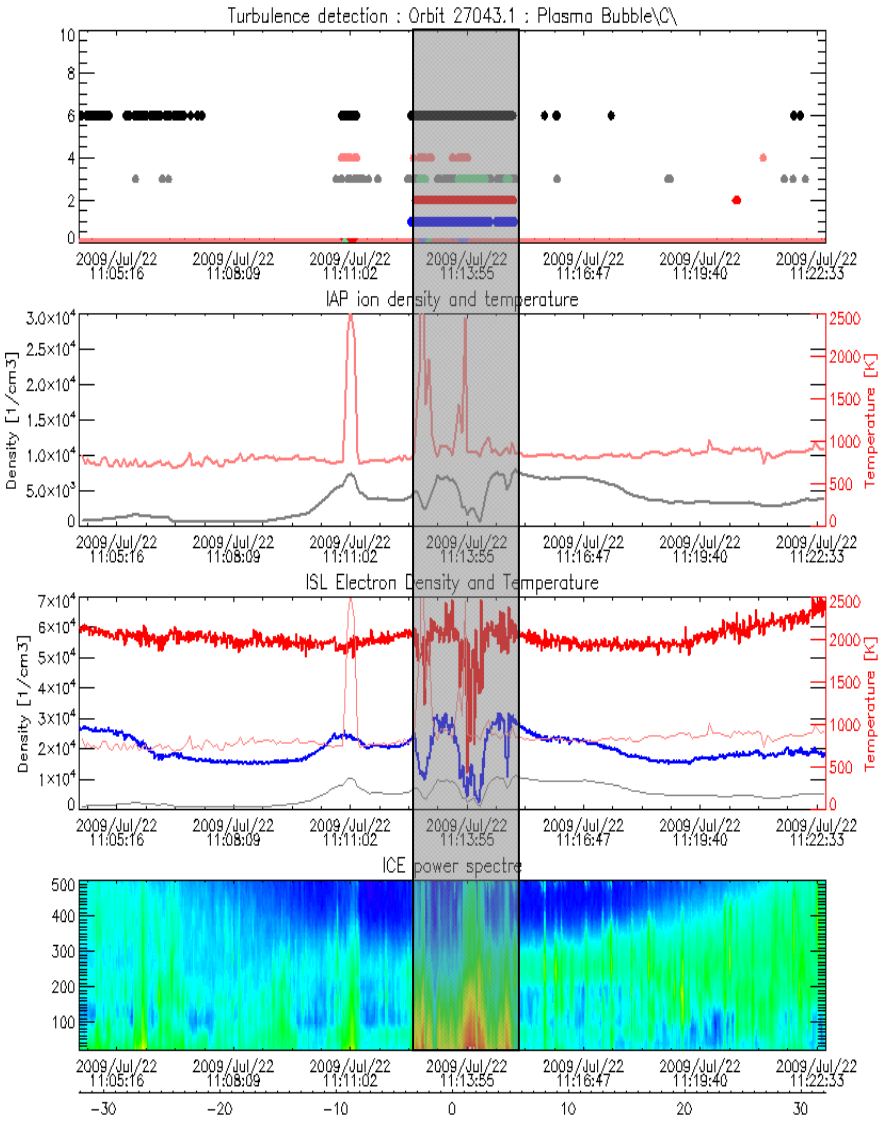
Results


DEMETER
Date(y/m/d):2009/11/10
28668_1
ISL Electron Density (Ne)
Ne(cm-3)
ISL Electron Temperature (Te)
Te(K)
IAP Ion Density (Ni)
H+
He+
O+
Ni(cm-3)
IAP Ion Temperature (Ti)
Ti(K)
ICE VLF Spectrogram (onboard), E12
Frequency (Hz)
UT 01:11:59
01:19:11
01:26:23
01:33:35
01:40:47
Lat.
Long.
MLT

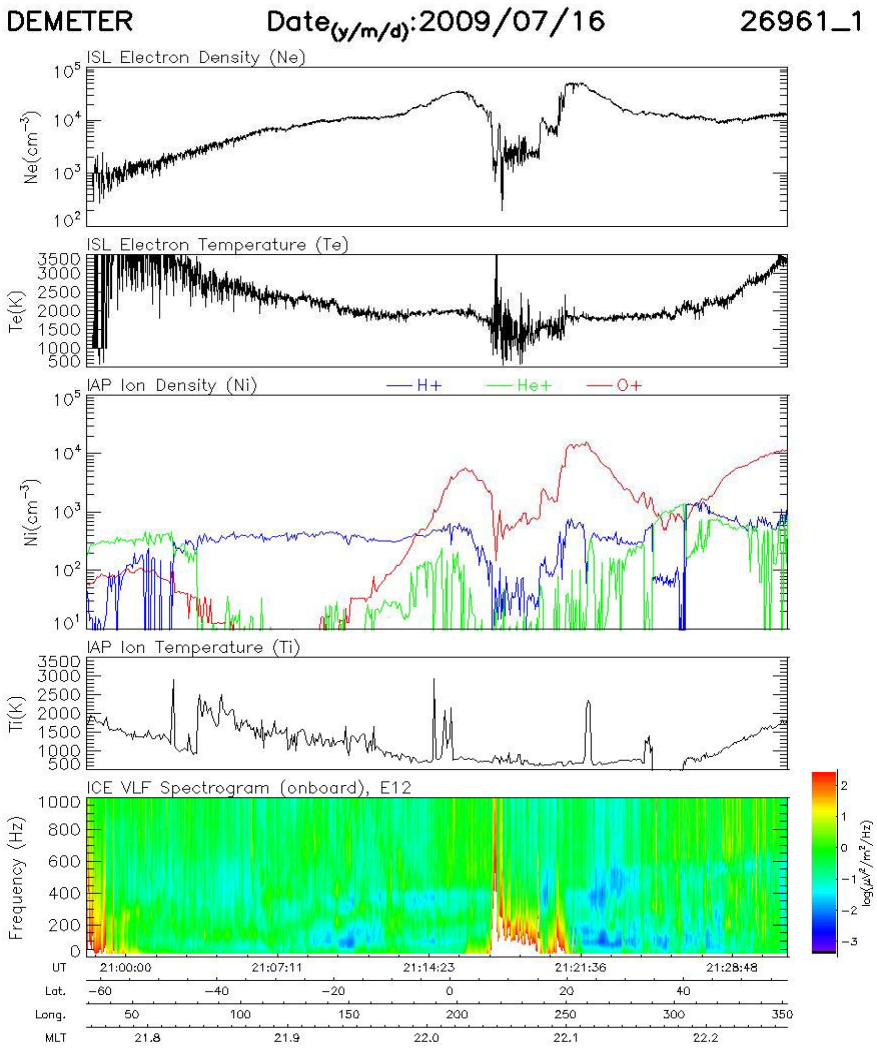

Turbulence detection : Orbit 28668.1 : Plasma Bubble\C\
IAP ion density and temperature
ISL Electron Density and Temperature
ICE power spectre
Temperature [K]
2009/Nov/10 01:20:38
2009/Nov/10 01:23:31
2009/Nov/10 01:26:24
2009/Nov/10 01:29:16
2009/Nov/10 01:32:09
2009/Nov/10 01:35:02

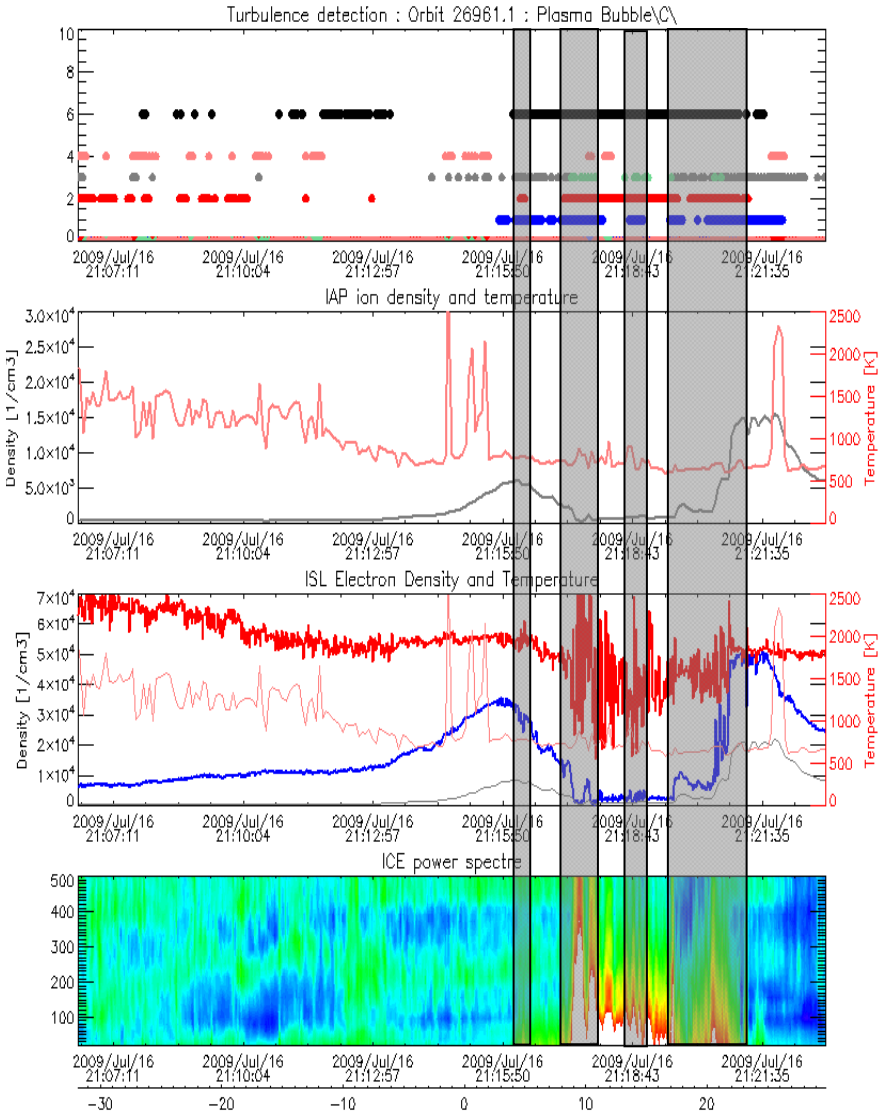
Results


DEMETER
Date(y/m/d):2009/07/22
27043_1
ISL Electron Density (Ne)
Ne(cm-3)
ISL Electron Temperature (Te)
Te(K)
IAP Ion Density (Ni)
H+
He+
O+
Ni(cm-3)
IAP Ion Temperature (Ti)
Ti(K)
ICE VLF Spectrogram (onboard), E12
Frequency (Hz)
UT 0:55:12
11:02:23
11:09:35
11:16:48
11:24:00
11:31:11
Lat.
Long.
MLT

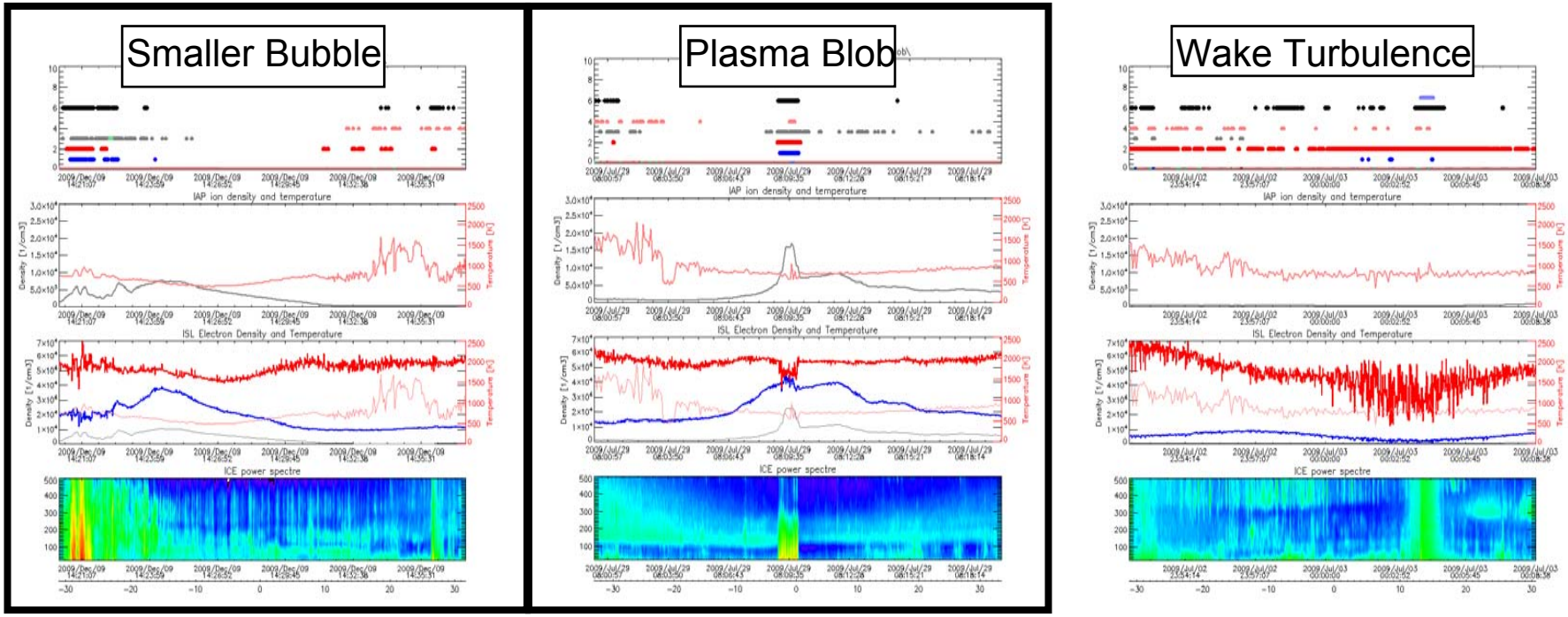

Turbulence detection : Orbit 27043.1 : Plasma Bubble\C\
IAP ion density and temperature
Density [1/cm3]
Temperature [K]
ISL Electron Density and Temperature
ICE power spectra
2009/Jul/22
11:05:16
11:08:09
11:11:02
11:13:55
11:16:47
11:19:40
11:22:33

Results


DEMETER
Date(y/m/d):2009/07/16
26961_1
ISL Electron Density (Ne)
Ne(cm-3)
ISL Electron Temperature (Te)
Te(K)
IAP Ion Density (Ni)
H+
He+
O+
Ni(cm-3)
IAP Ion Temperature (Ti)
Ti(K)
ICE VLF Spectrogram (onboard), E12
Frequency (Hz)
log(μV²/m²/Hz)
UT
21:00:00
21:07:11
21:14:23
21:21:36
21:28:48
Lat.
Long.
MLT

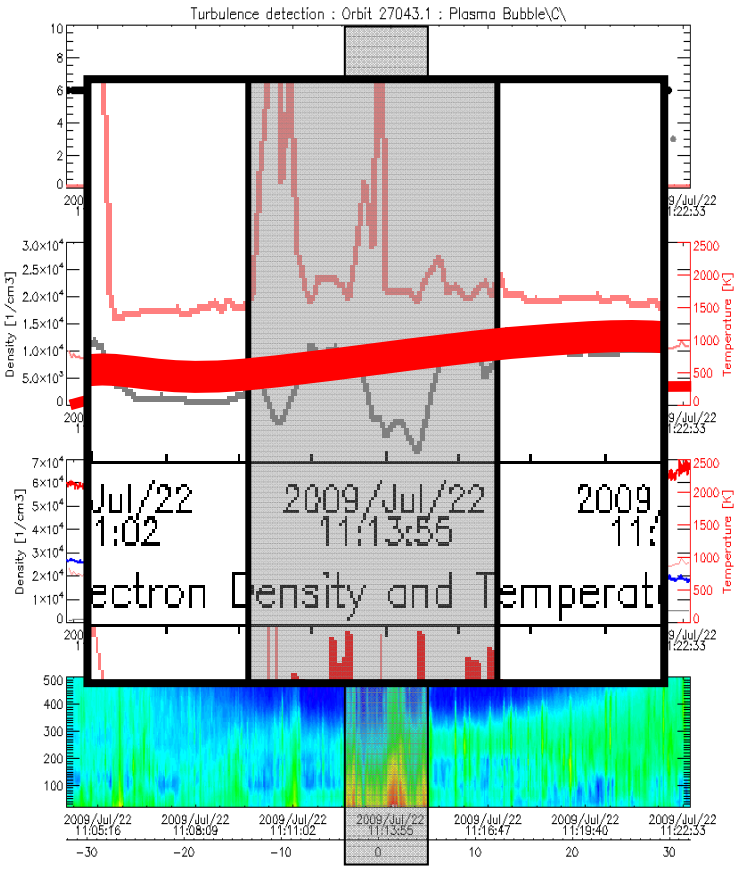

Turbulence detection : Orbit 26961.1 : Plasma Bubble\C\
IAP ion density and temperature
Density [1/cm3]
Temperature [K]
ISL Electron Density and Temperature
ICE power spectra
2009/Jul/16
21:07:11
21:10:04
21:12:57
21:15:50
21:18:43
21:21:35

Other phenomena

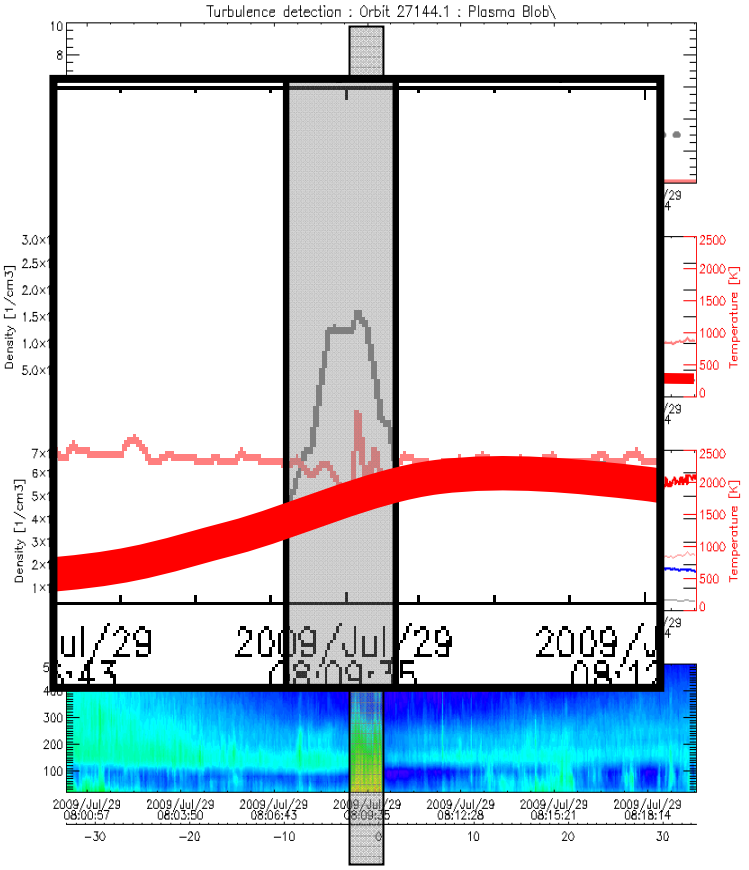


Bubble or Blob

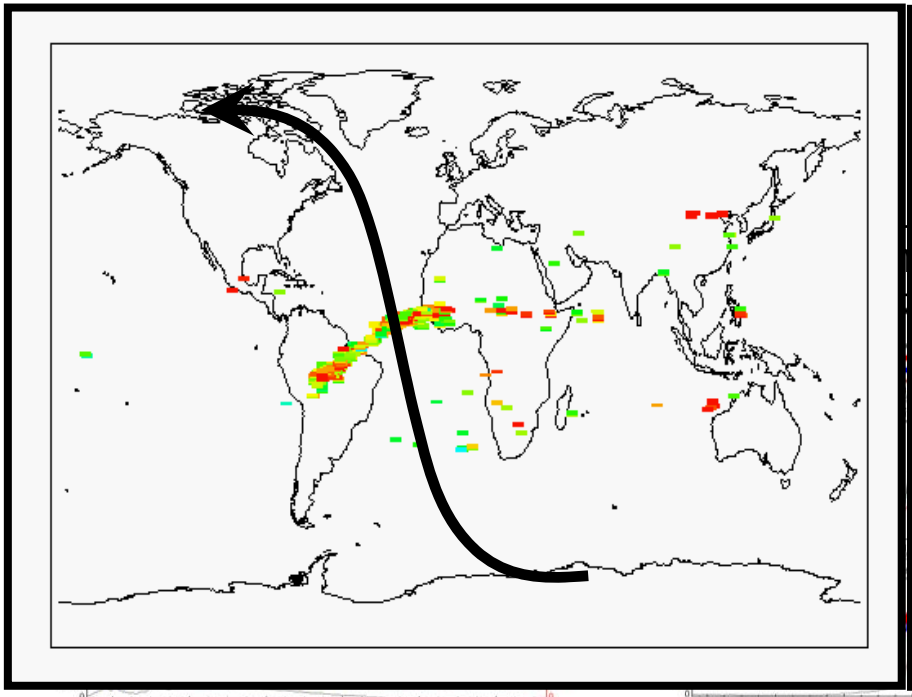
Plasma Bubble

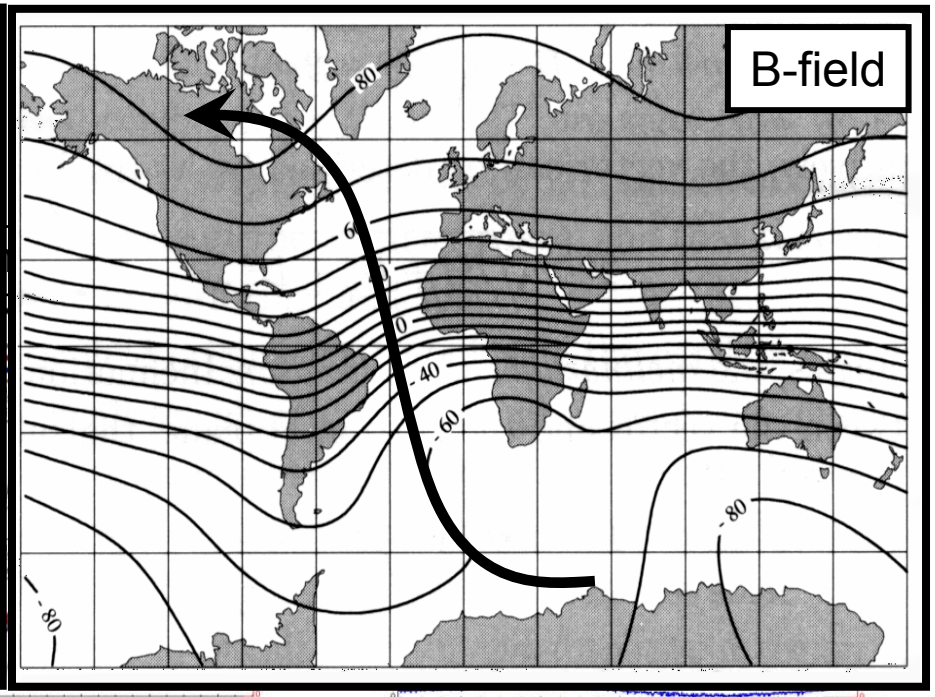


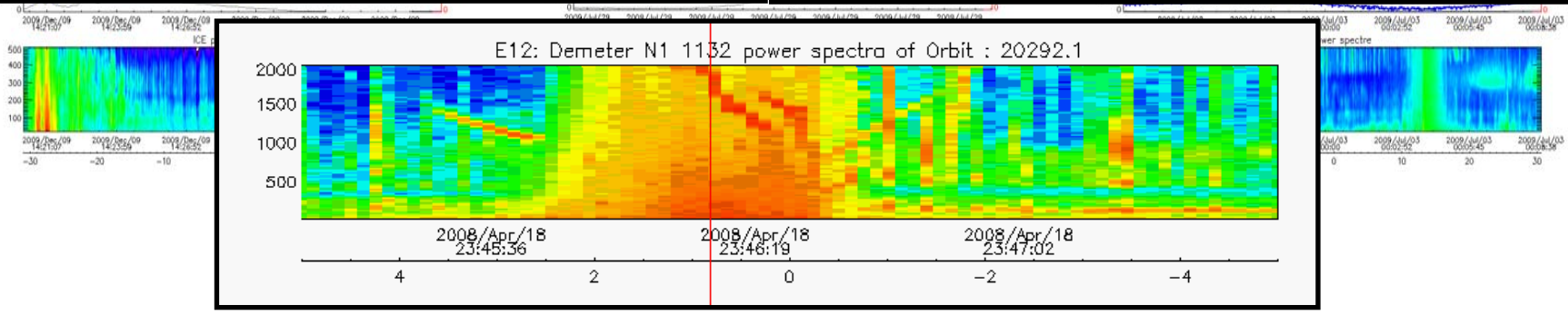
Plasma Blob



Other phenomena

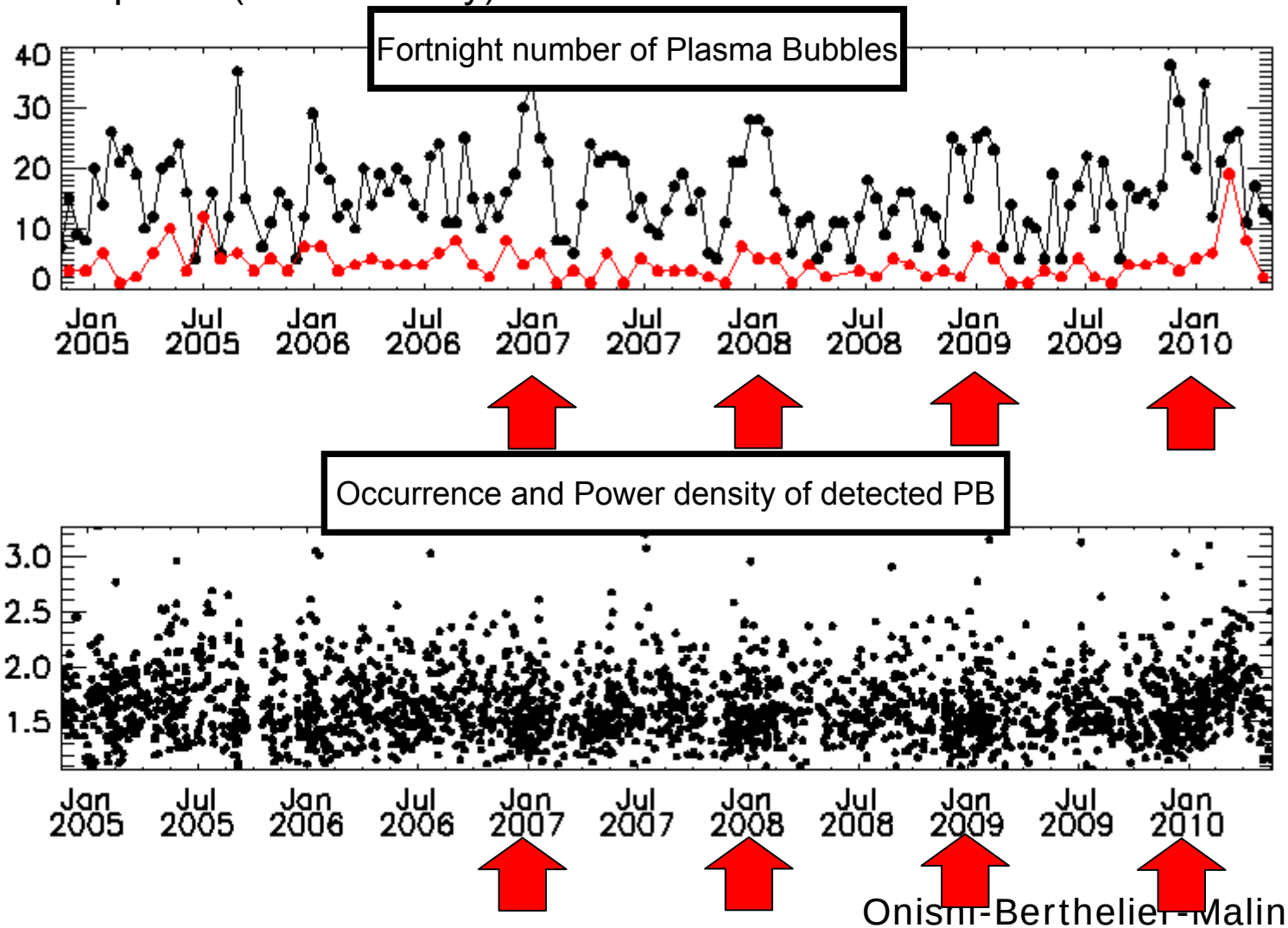






Global variation

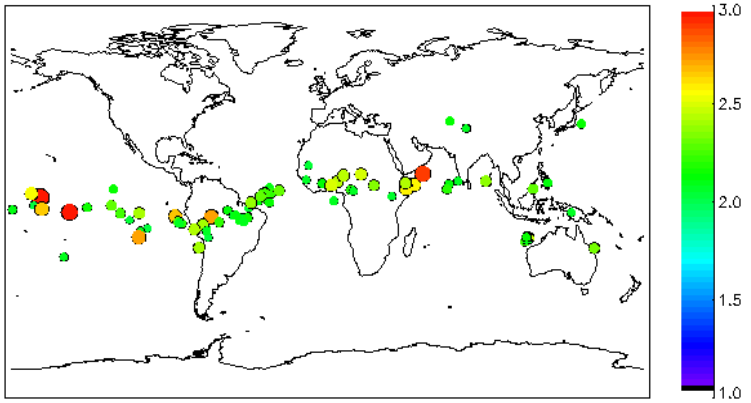
- Peaks are observed in total occurrence of plasma bubbles in summer in the Southern hemisphere (i.e. ~January)



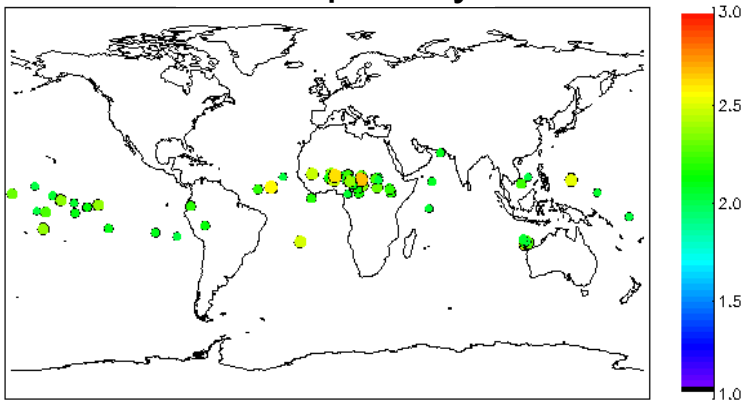
Seasonal variation

Seasonal distribution (2007-2010) of detected plasma bubbles with power density ≥ 10 $\mu V^2/m^2/Hz$

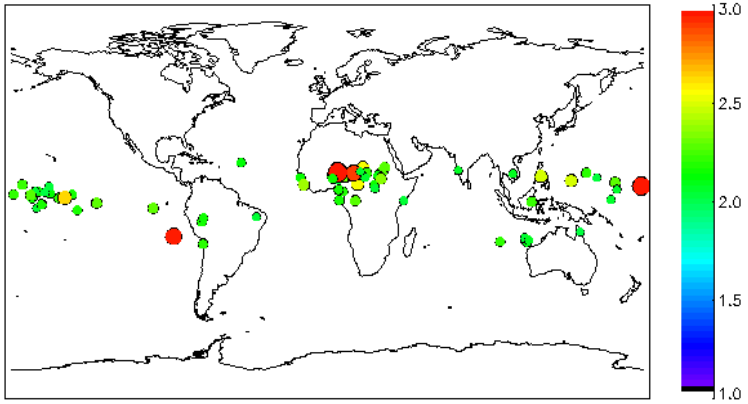
Dec-Jan-Feb



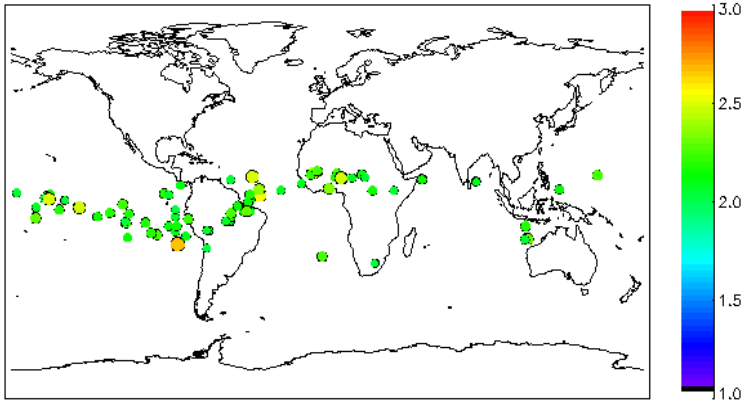
Mar-Apr-May



Jun-Jul-Aug



Sep-Oct-Nov



Work in progress

1. IAP calibration
2. Wake effects
3. Better Classification (Bubble/Blob, etc…)
4. ISL data for detection

Conclusion

- Plasma bubble detection has been performed automatically.
- Data from ICE, IAP and ISL.
- Distinction between bubbles and blobs.
- Distinction from wake effects.
- Improvement in IAP calibration is necessary for a better detection.
- ISL data will be exploited more importantly than IAP data, due to its finer time resolution.

LATMOS

END OF PRESENTATION