OUTER MAGNETOSPHERIC RESONANCES IN EXPERIMENT AND MHD MODEL

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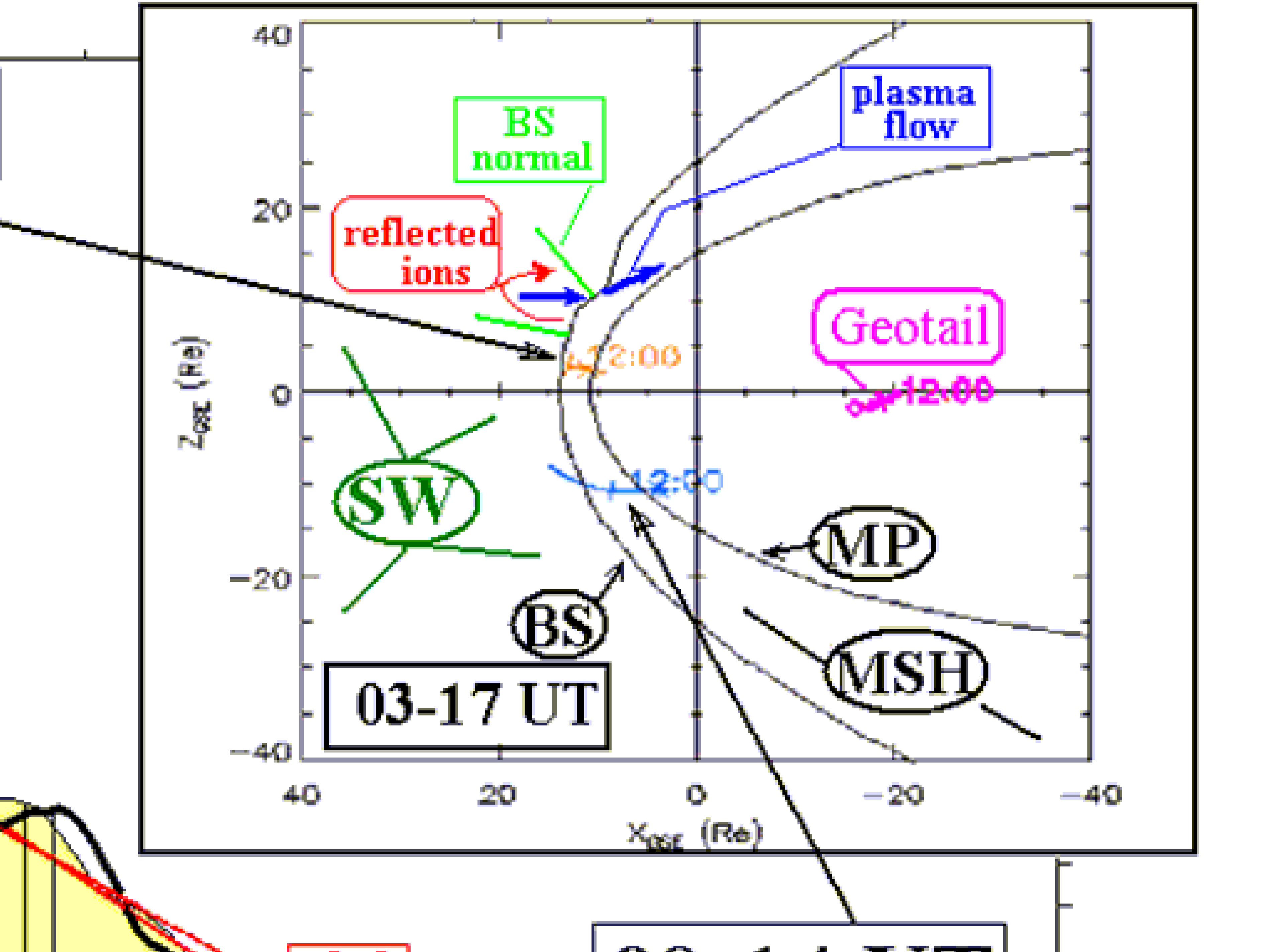
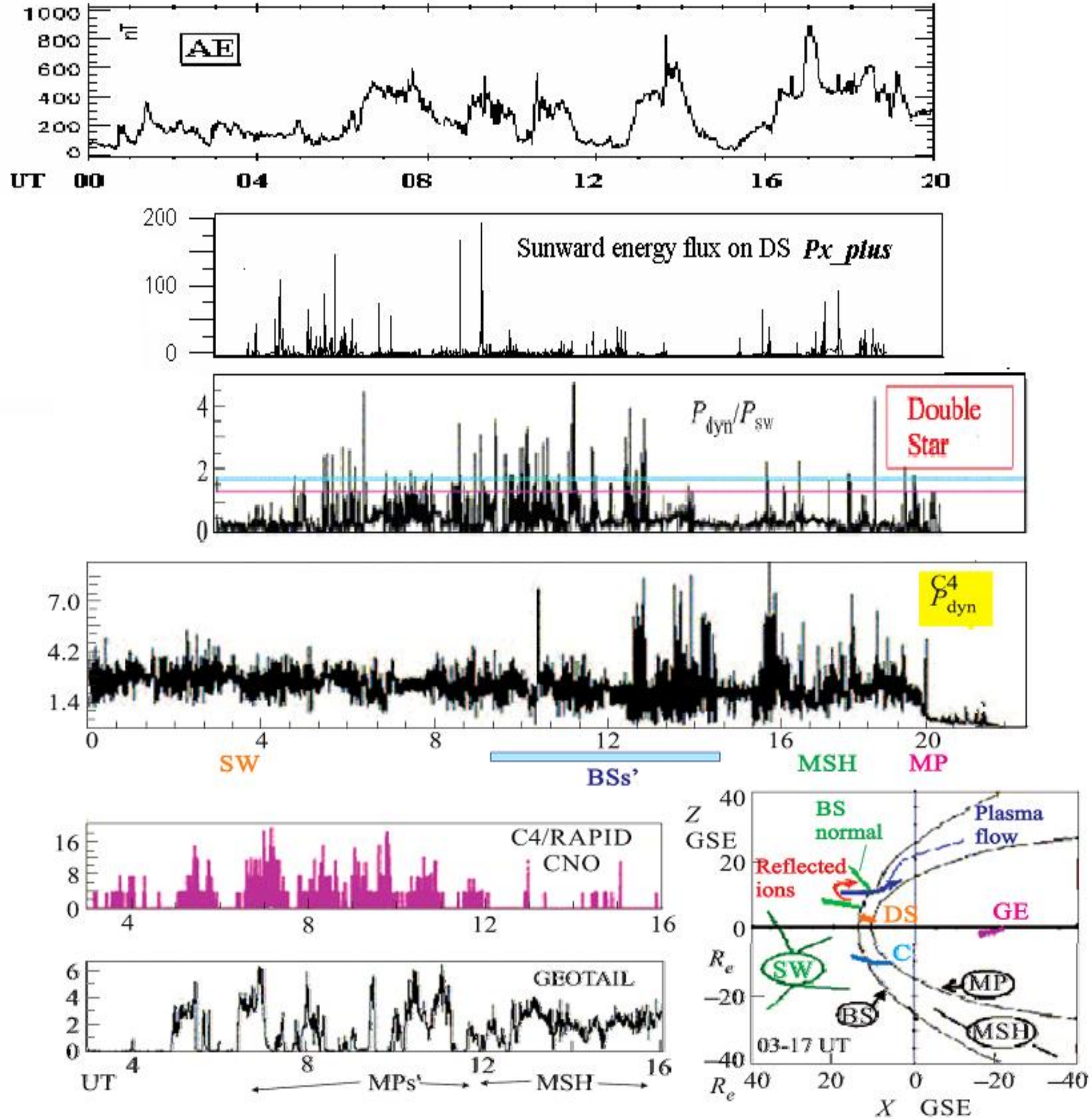


plasma flow
BS normal
reflected ions
Geotail
12:00
12:00
12:00
SW
MP
BS
MSH
03-17 UT
40
20
0
−20
−40
Z_{GSE} (Re)
X_{GSE} (Re)



March 27, 2005, from top to bottom:

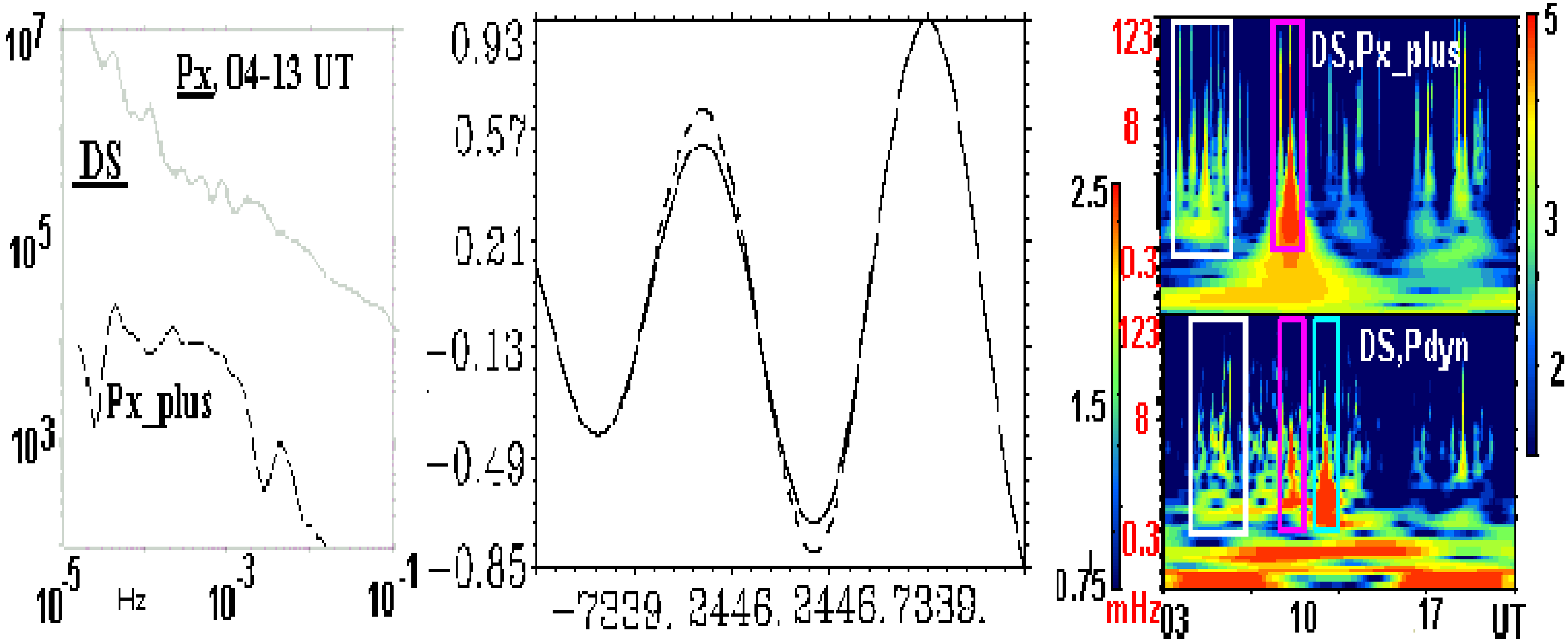
-CLUSTER-4 (C4), magnetic field |*Bx*|/|***B***|, *X* axis is pointed to the Sun. shadowing indicates |*Bx*|/|***B***| > *0.5*;

-DOUBLE STAR (DS) dynamic pressure normalized by the SW one, *Pdyn/ PSW;*

-C4, *Pdyn*

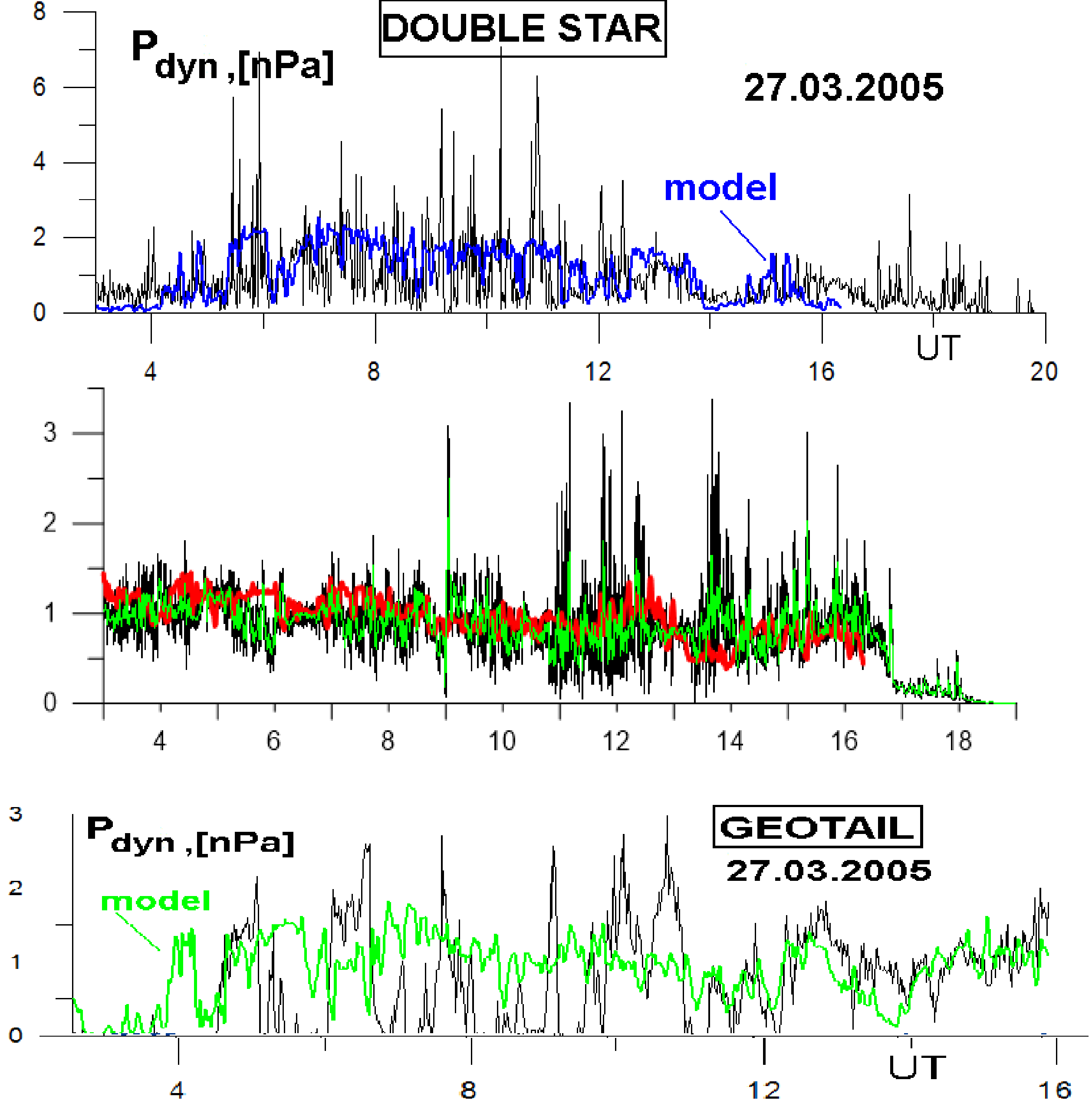
-C4, CNO – channel of energetic particles (>274 keV, units – 1/cm2 sr s keV)

-Geotail *Pdyn* (MP – magnetopause, MSH – magnetosheath)

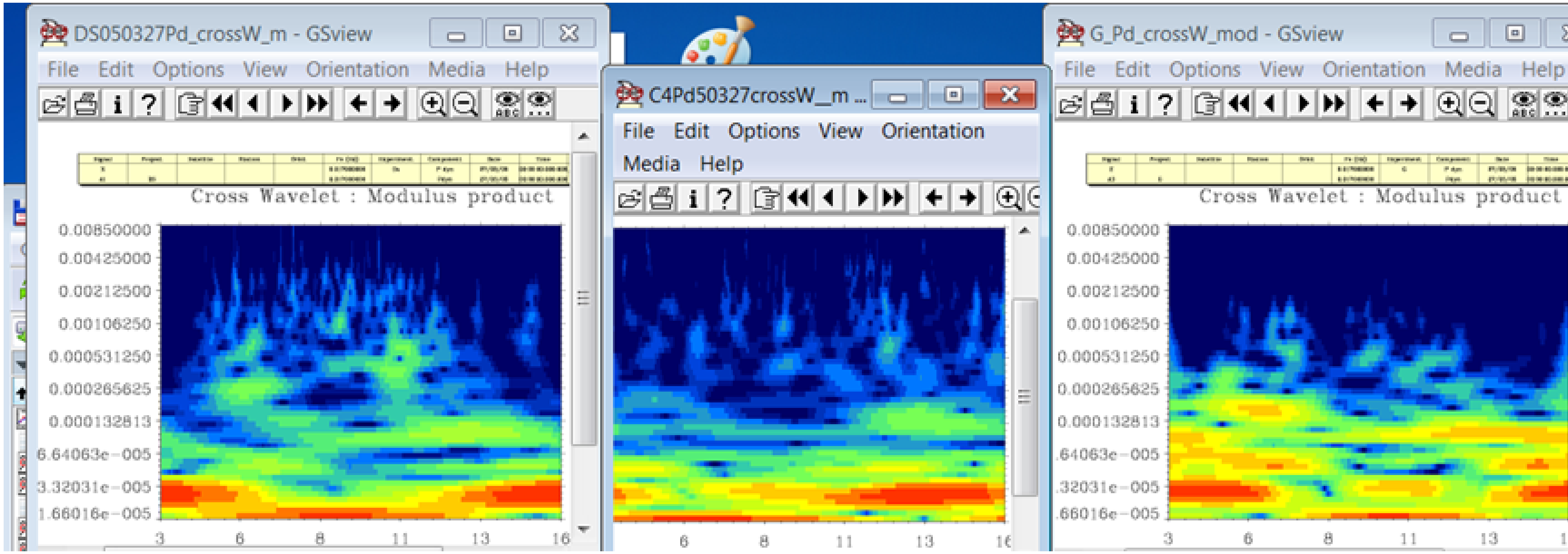


DS: comparison of Poyting flux and dynamic pressure in the *X* direction (pointed to the Sun):

- wavelet spectra of DS Poynting vector component *Px* (upper curve on left panel) and that of its positive (sunward) part *Px_plus* (lower dashed curve) at 04-13 UT;
- cross- correlation of *Pdyn* and Poynting vector positive part *Px_plus* at 03-20 UT; dashed line – the same for 03-13 UT; the signals being filtered in 0.05-0.1 mHz range by the 5th – order filter (middle panel);
- wavelet spectrogram of DS Poynting vector positive part *Px_plus* (i.e. sunward propagating energy flux with sampling once per 4 s, top part in right panel) in MSH; vertical axis – log- scale frequency 0.03-123 mHz (red digits), color log- power scale - to the right; bottom part: the same for *Pdyn* , the color scale – to the left.

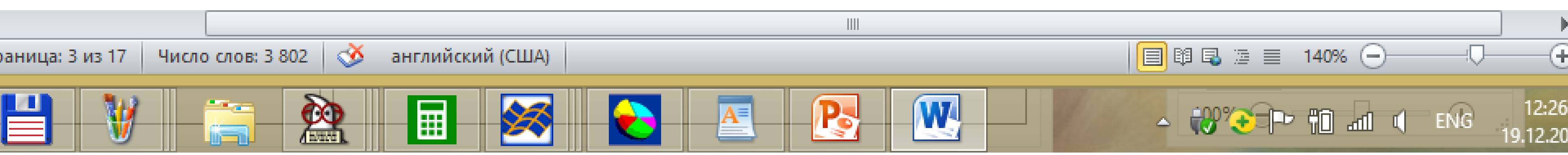


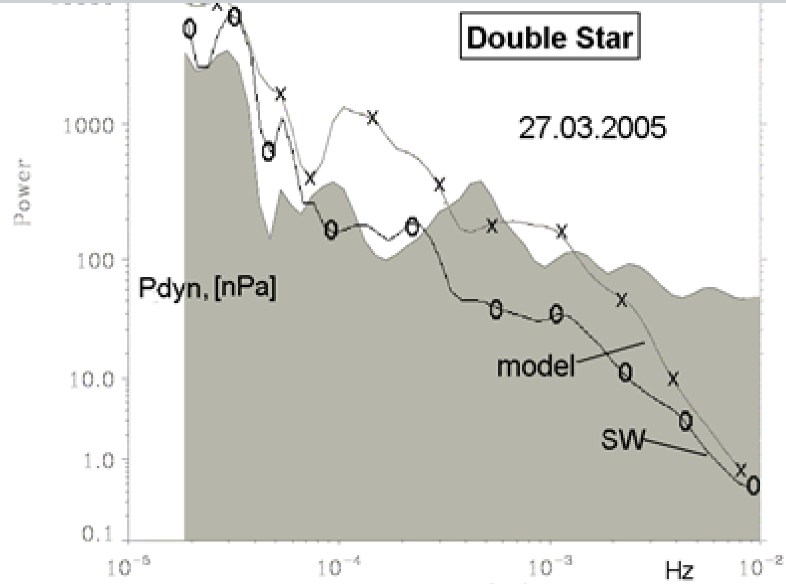
DOUBLE STAR
P_{dyn} ,[nPa]
27.03.2005
model
UT
8
6
4
2
0
4
8
12
16
20
3
2
1
0
4
6
8
10
12
14
16
18
GEOTAIL
P_{dyn} ,[nPa]
27.03.2005
model
UT
3
2
1
0
4
8
12
16



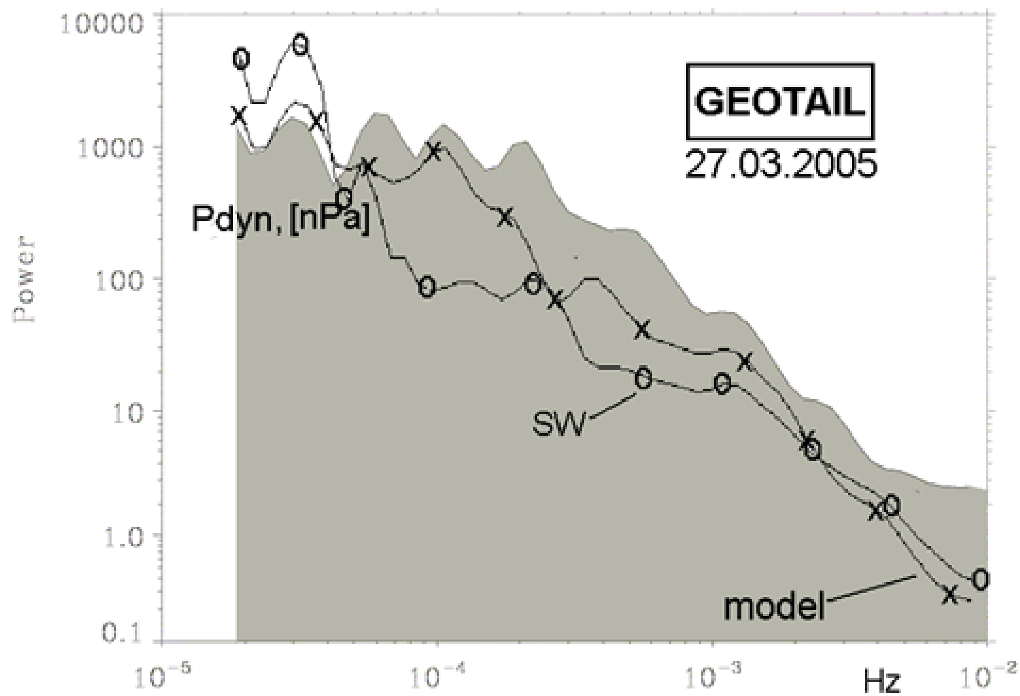
Cross- spectrograms of the dynamic pressure (P_{dyn}, from left to right):

DS/ model; C4/model; G/model.



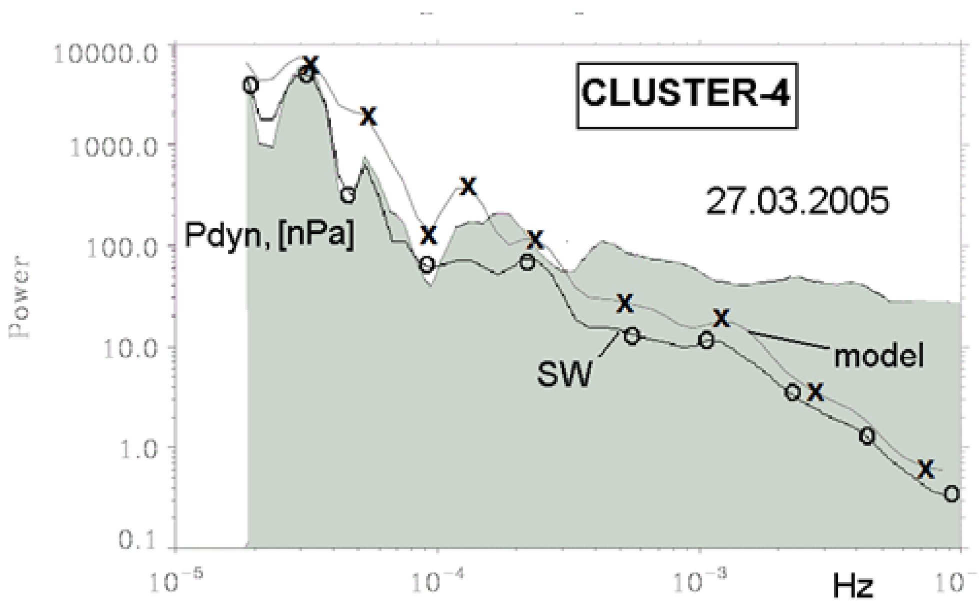


P_{dyn} wavelet power spectra on Double Star in low latitude MSH (shadowed) versus model and SW data at ~ 03-16 UT. Both model and DS spectra look to demonstrate the direct SW driving (as the SW power in maxima are larger than that in MSH) starting from the lowest frequencies until ~0.07 mHz (cf. the bottom maxima in the color spectrograms above). Further towards the higher frequencies both model and DS spectra dominate in power till ~3 mHz. While DS and model frequencies differ in the frequency band of 0.07-3 mHz, we think that the model could reproduce the main features of the outer magnetospheric resonances in this band (see also comments to following spectra).In the classification of [Savin e a, 2017] it includes BS and MP surface and waveguide resonances. At the frequencies above 3 mHz the model spectrum goes fast down towards the SW level (cf. the following figures). It infers that the MHD model is not reproducing the resonances at these high frequencies.



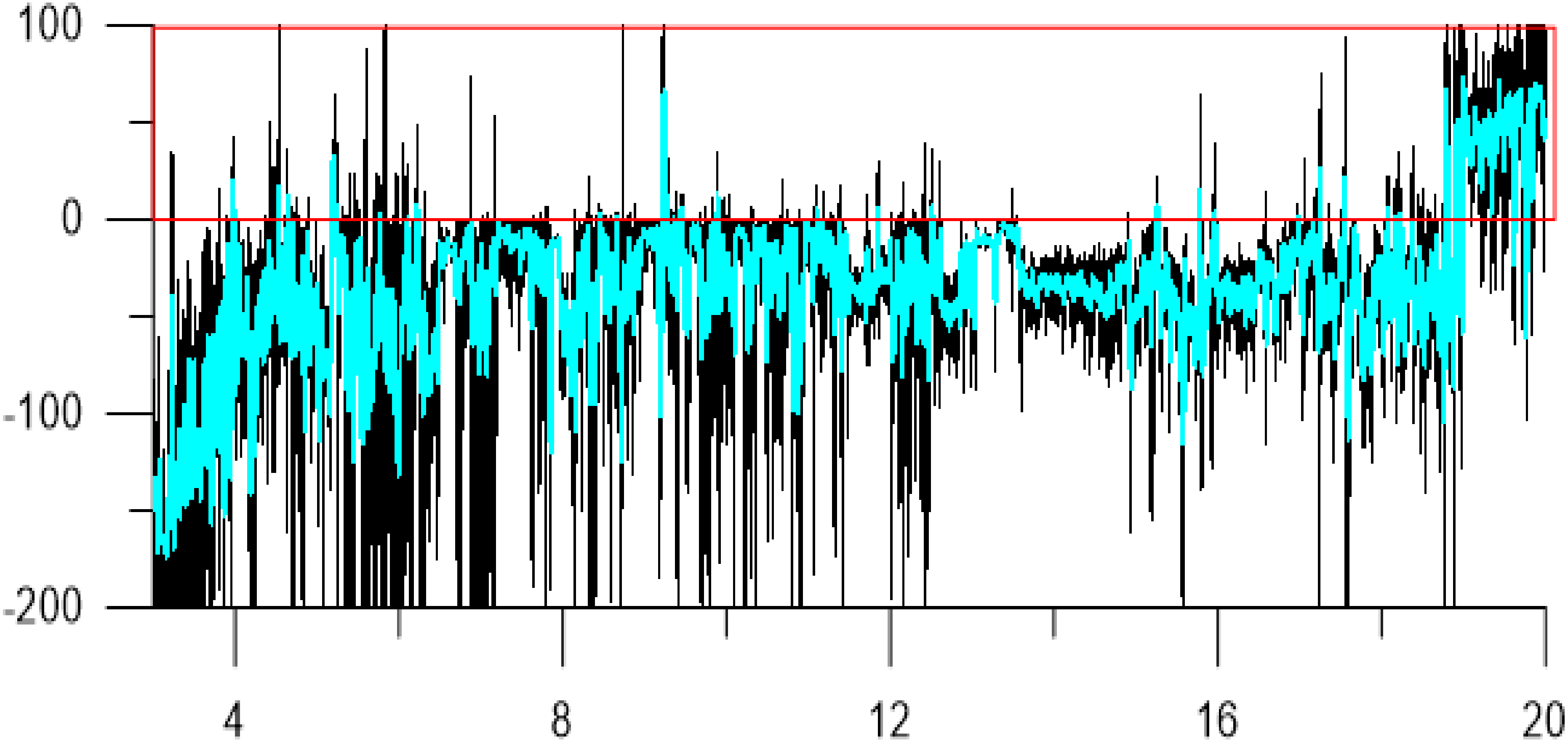
G in low latitude MP, skewed by the plasma jets (04-12 UT, see waveforms above), then in MSH (12-16 UT). At ~0.03 mHz G suffers also the direct SW driving (attenuation versus SW, cf. DS in the first figure with the power spectra). The rest spectral model maxima at 0.07-1.3 mHz have the closest frequencies to the G ones (compared to DS and C4), while their power is substantially lower versus experimental data from G.

data from G.

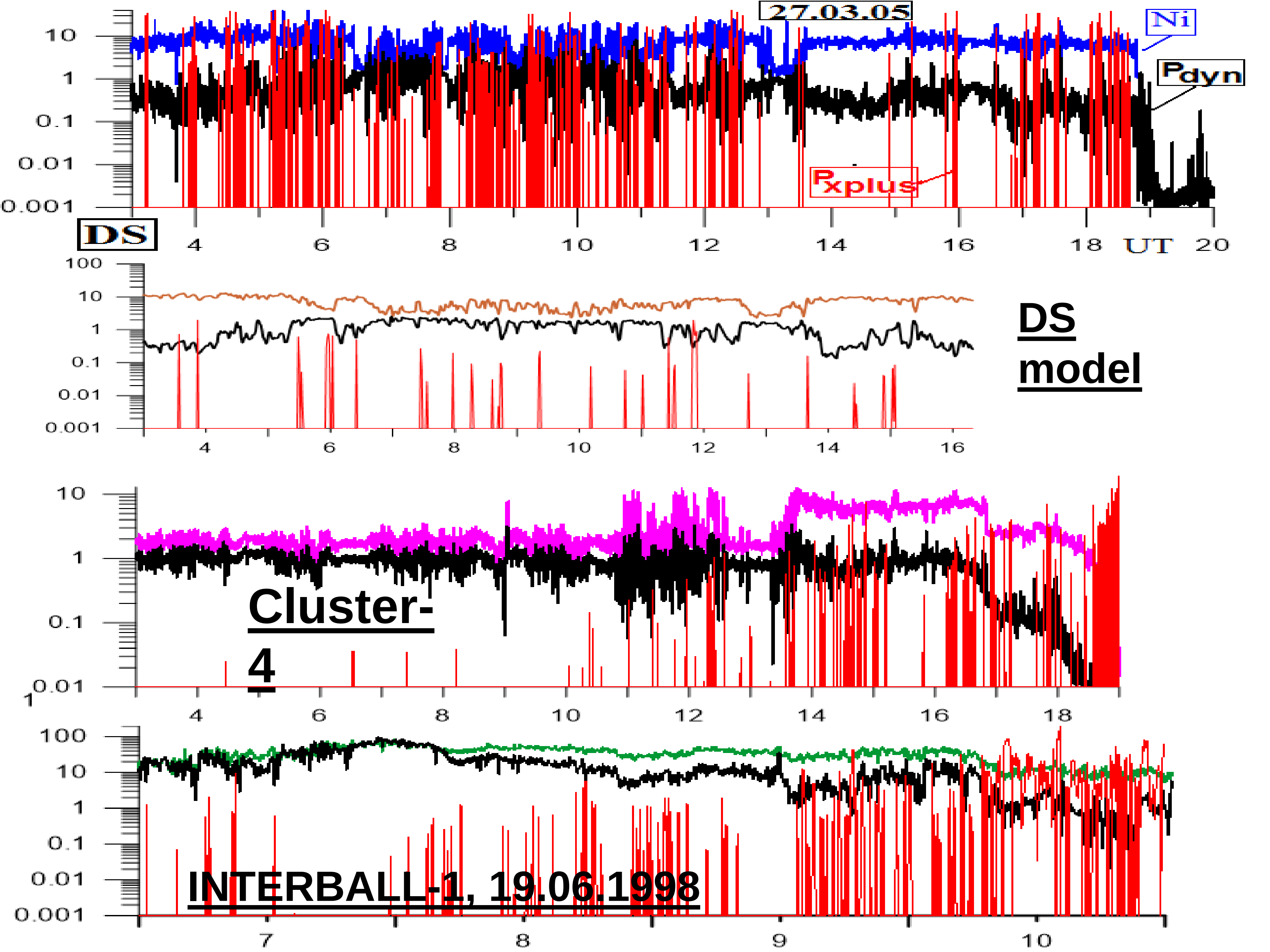


The same for C4 (shadowed).

C4 was in the high- latitude foreshock at 03-11 UT (the BS breath touching was at ~08:50 UT), at 13:40-16 UT it was in the high- latitude MSH (at 11-13:40 UT BS crossings, see the waveform in the figure above). The model spectra are mostly defined by the periods of being in SW, excluding 0.05- 1.5 mHz (cf. figures below). C4 spectra have the local magnetospheric nature above 0.1 mHz (cf. figures below).



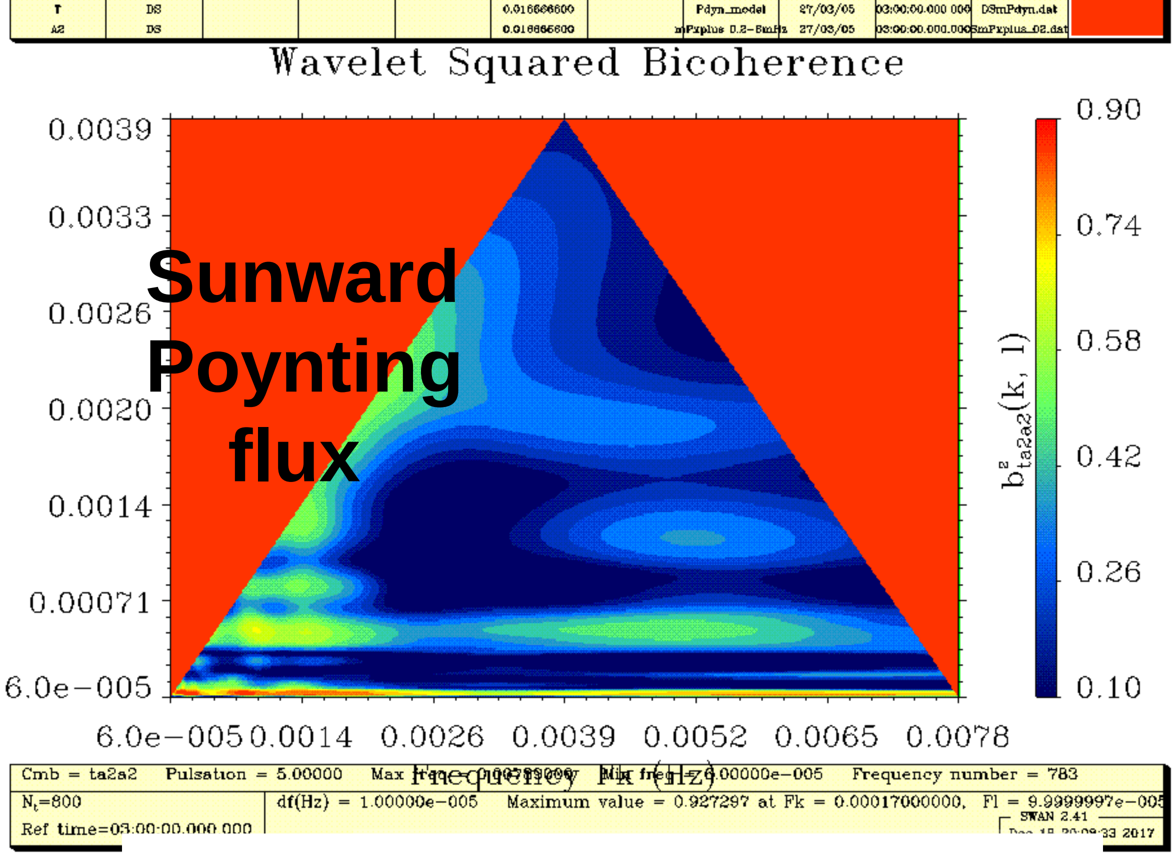
DS, X-component of Poynting flux

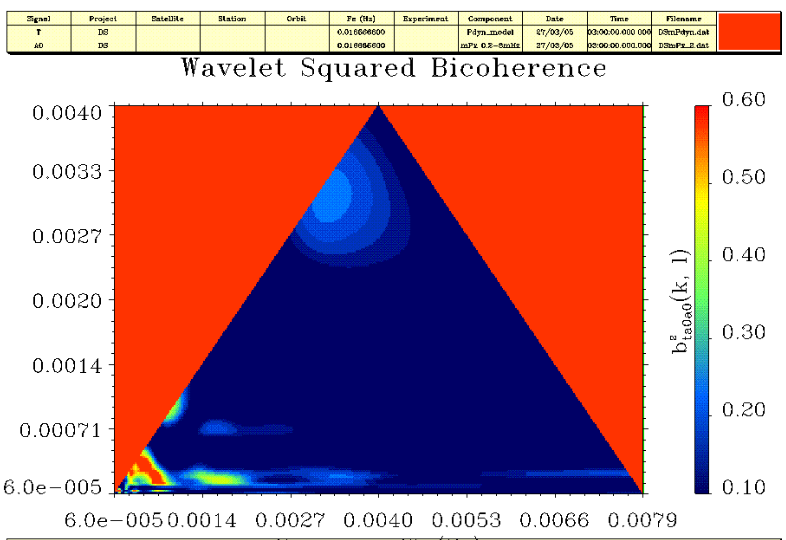

27.03.05
Ni
Pdyn
Pxplus
DS
UT
DS model
Cluster-4
INTERBALL-1, 19.06.1998

DS, model

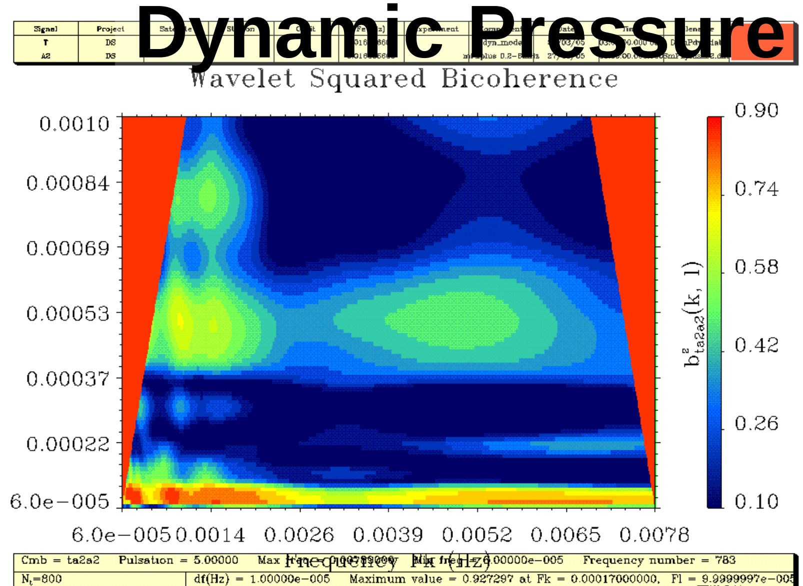
Fvertical + Fhorizontal = Fsum

Sunward Poynting flux

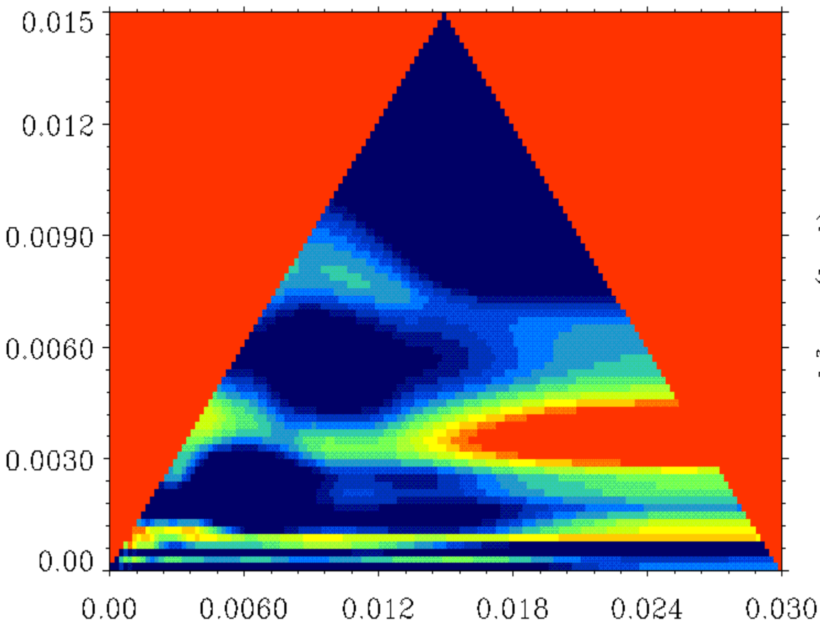


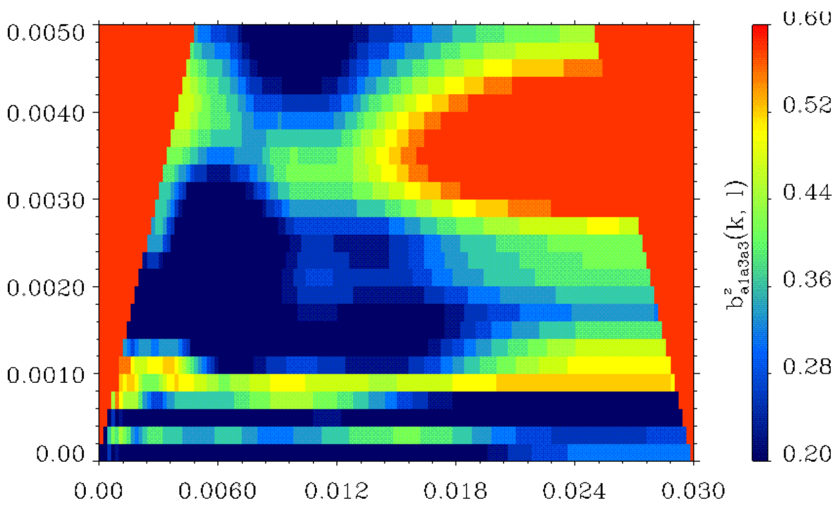


Dynamic Pressure



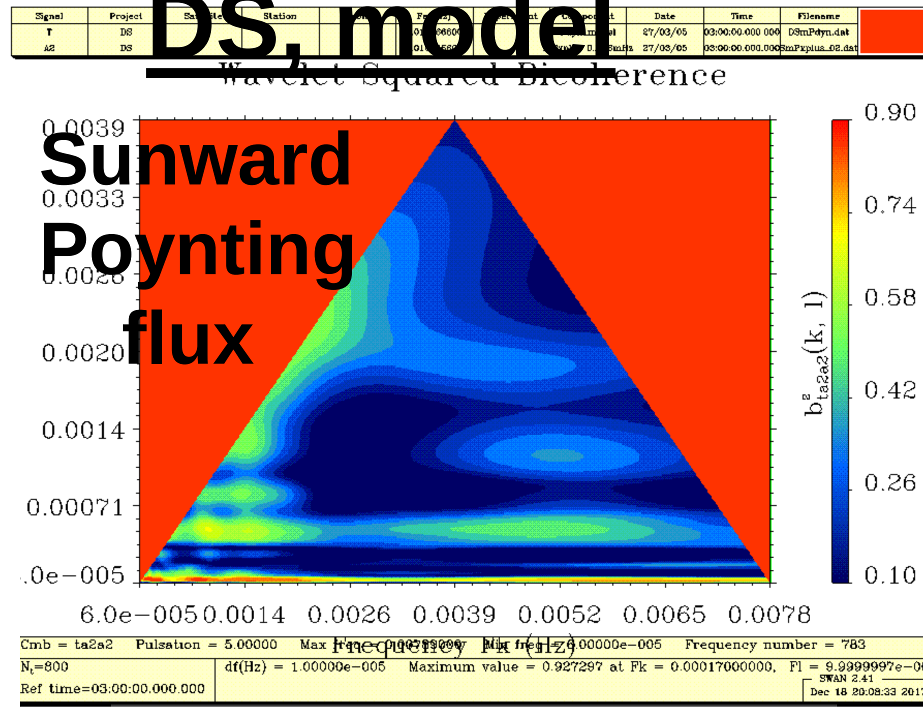
DS



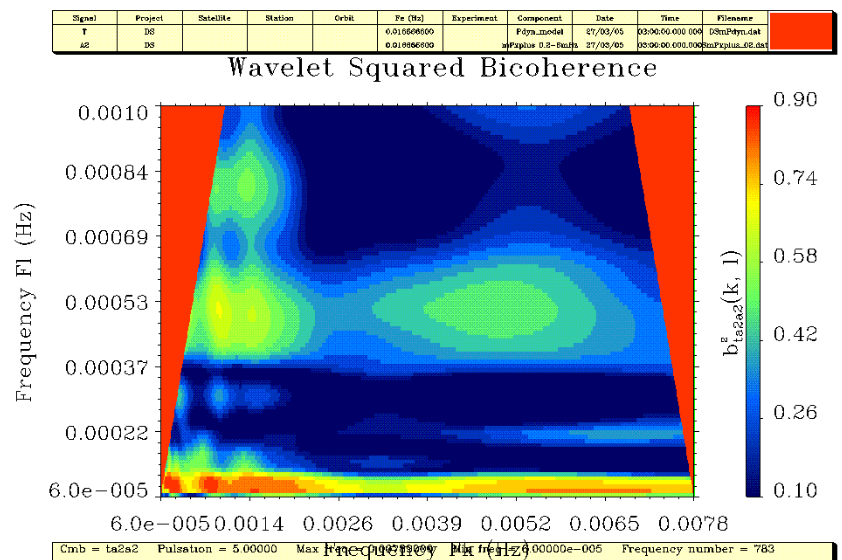


DS, model

Sunward Poynting flux

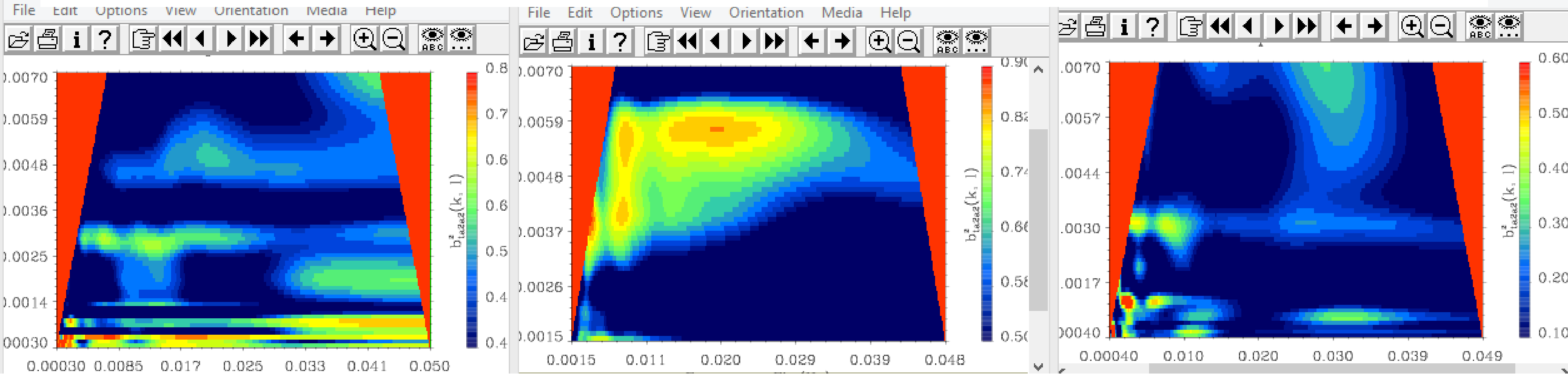


Dynamic Pressure

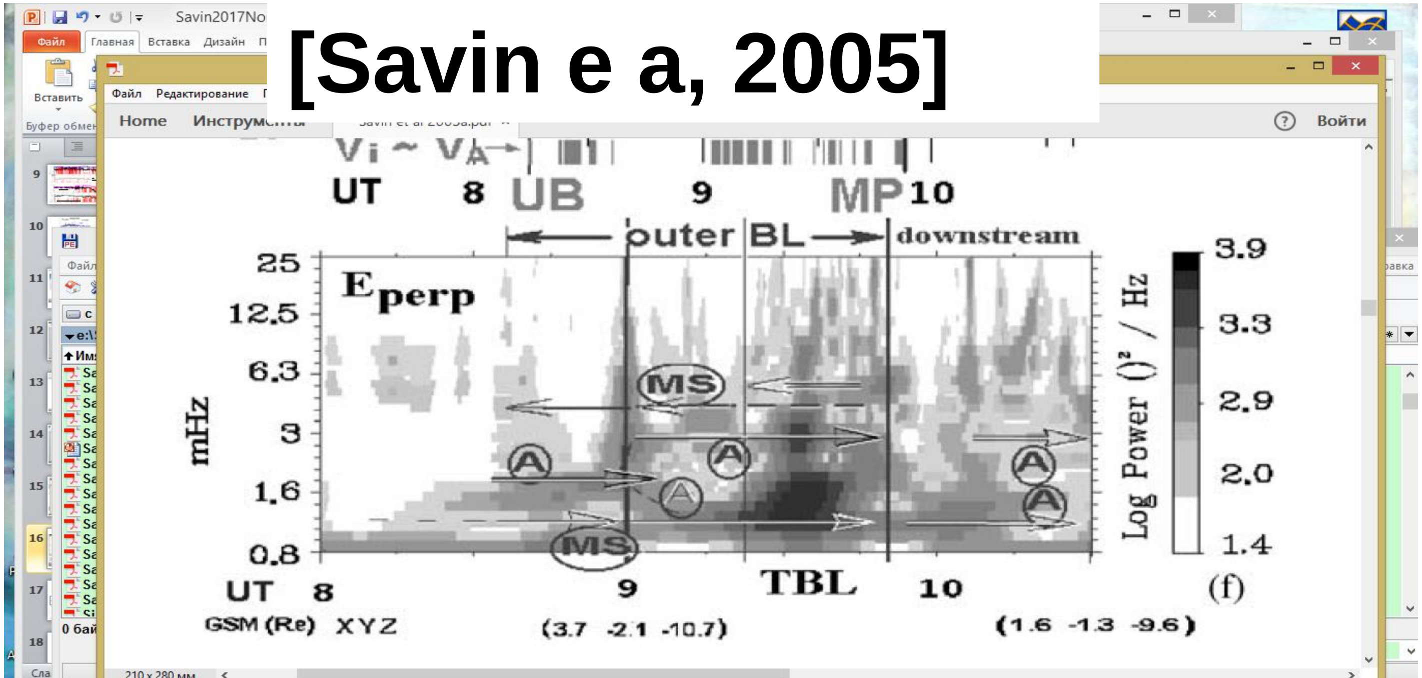


INTERBALL-1, 19.06.98

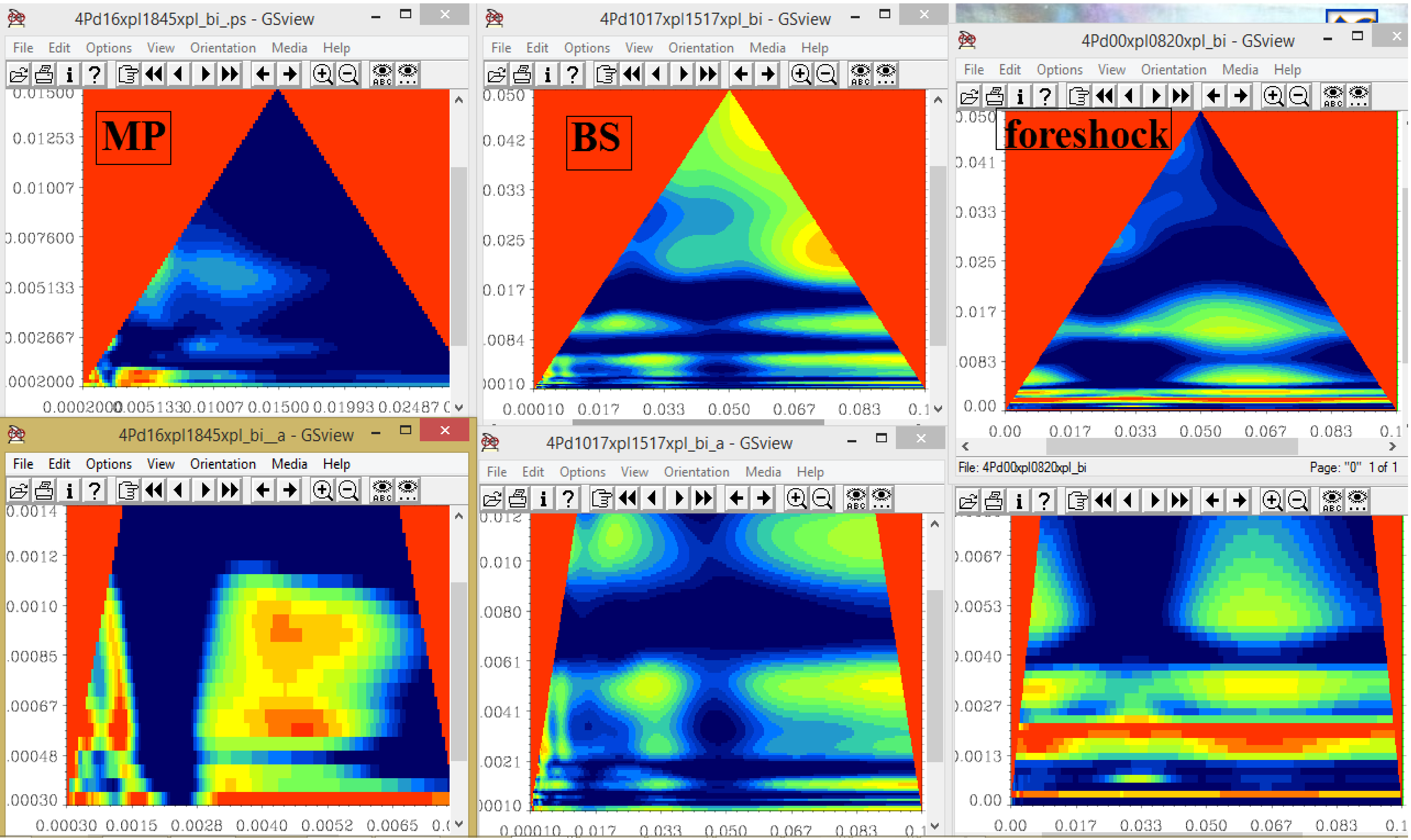
Bow shock- MSH MSH- MP MSH-MP-cusp



[Savin e a, 2005]



CLUSTER-4 dynamic pressure - - sunward Poynting flux bi-spectra



CONCLUSIONS

We do a multi-point study of the influence of the lowest frequency resonances (0.02-10 mHz) at the outer magnetospheric boundaries and in the solar wind on the fluctuations inside the magnetosphere and ionosphere in situ and using Chinese MHD model with input from the solar wind every minute.

i) the waves generated by boundary resonances and their harmonics are seen at 0.07-3 mHz both in situ and in the MHD model;

ii) correlations between the dynamic pressure fluctuations near the magnetospheric boundaries can exceed 80%;

iii) As we know, fot the first time we detect the fast magnetosonic waves via sunward Poynting flux, which regulate both boundary positions and resonance generation throughout magnetosheath and foreshock.
It operates through cascade- like 3-wave interactions at discreate (resonance) frequences, most well visible in bi-spectra of {Dynamic pressure / sunward Poynying flux/ sunward Poynting flux}