Characterizing solar events

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Overview

- What are the important features that characterize solar events?
- Where do we find the data?
- What do the data tell us about physical processes of solar eruptive events?

Events considered

- Two events were analyzed
  - 20 Jan 2005 (Event 1)
  - 2 Apr 2001 (Event 2)

- The data is contained in various catalogues that provide information on
  - SEP, SXR, CME parameters, Radio bursts, neutron monitor data, evidence of shocks etc.

Getting an overview

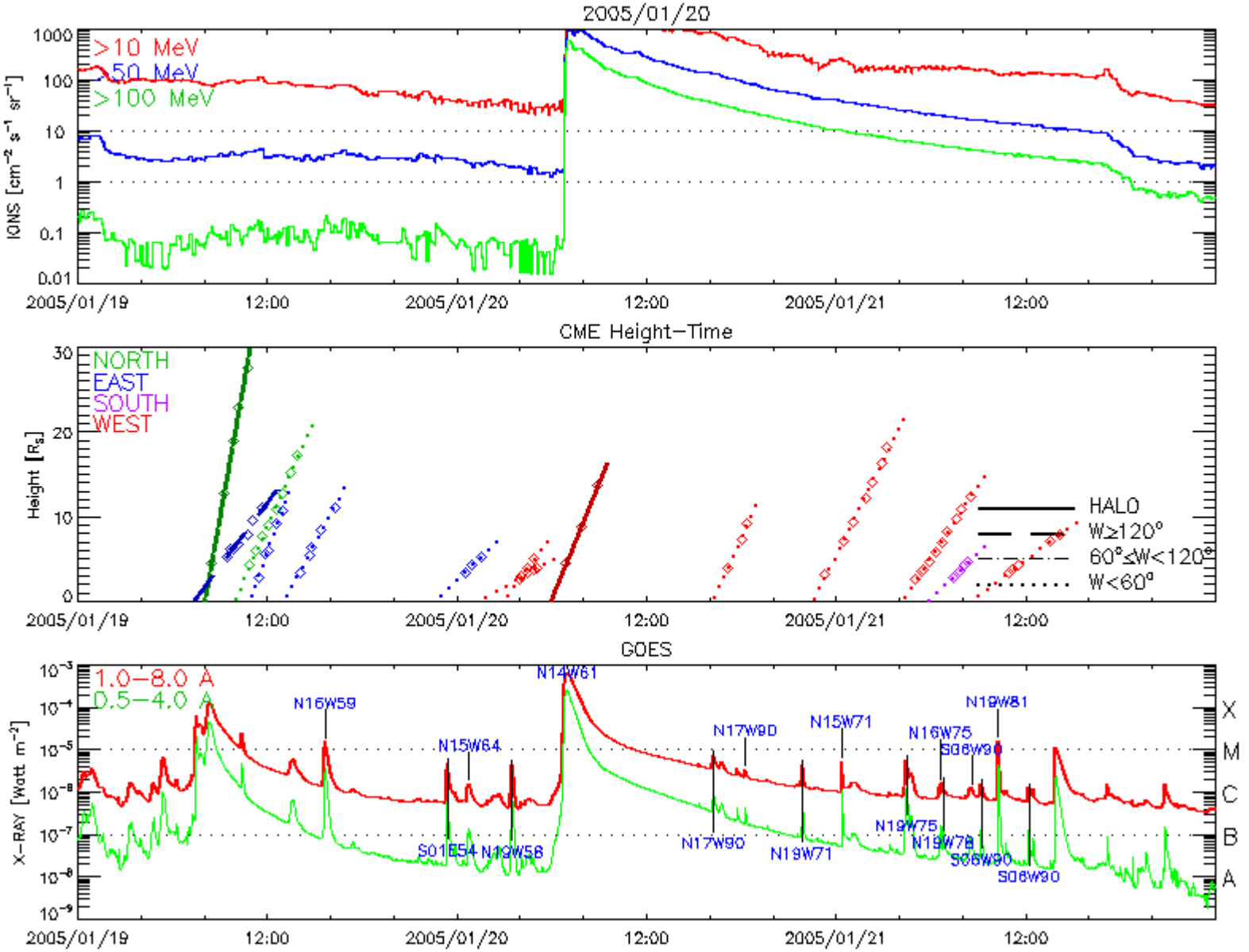
- We start with the 20 Jan 2005 event
- First obtain the data from the site

  http://cdaw.gsfc.nasa.gov/CME_list/

- We look at the graphs found under “PHTX” giving information about SEP, CME and X-Rays.

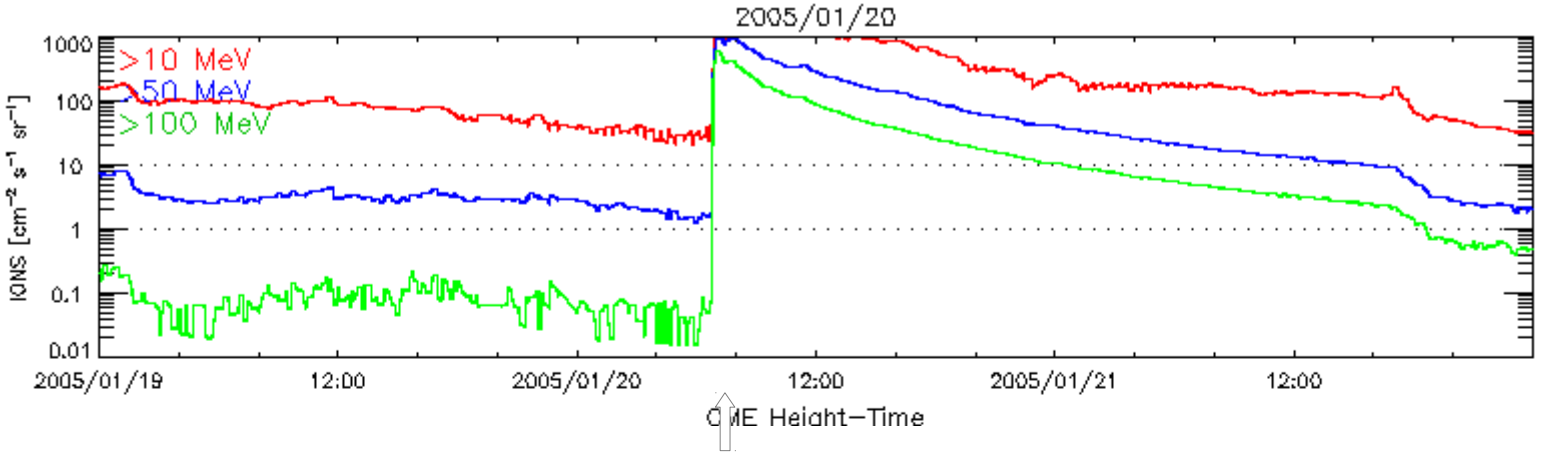
Event 1

Particle, CME and SXR data obtained: Let's interpret



CDAW Catalogue

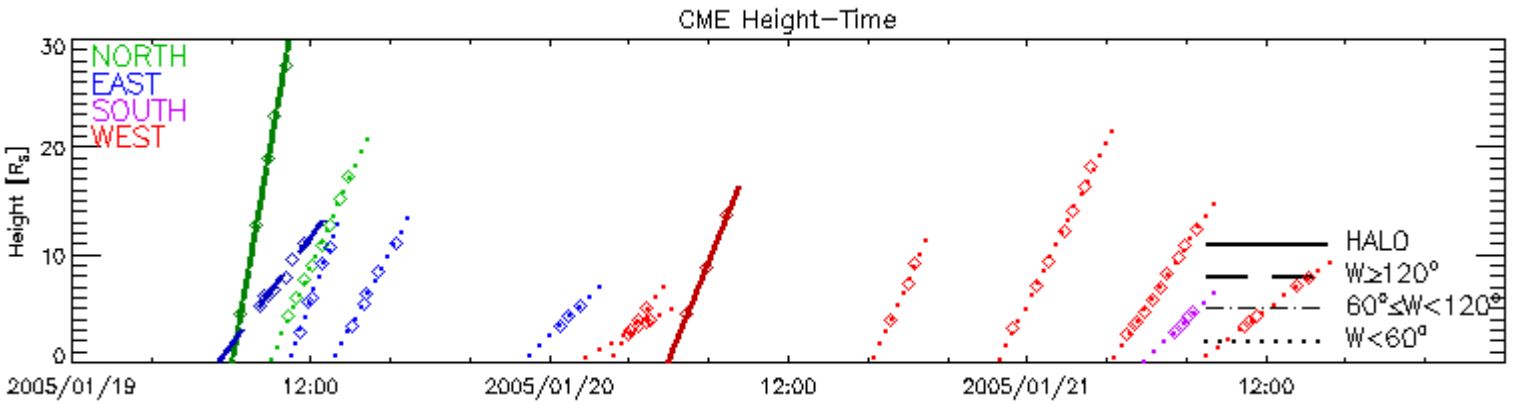
Top figure shows the particle intensity measured against time



Flare start time: 06:36 UT
Flare peak time: 07:01 UT

Information can be obtained from
http://cdaw.gsfc.nasa.gov/CME_list/sepe/

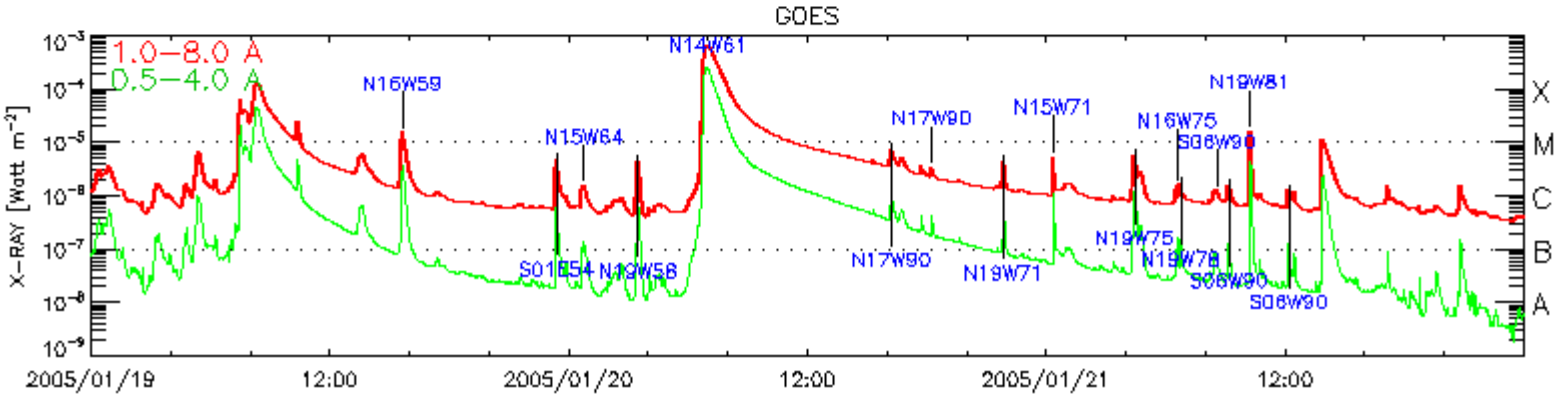
Middle figure shows the dependence of CME height against time



- Many CME recorded on the day but only one produced an SEP event
- The variation with height of the CME can provided the speed and acceleration of the CME
- Calculated values can be obtained from

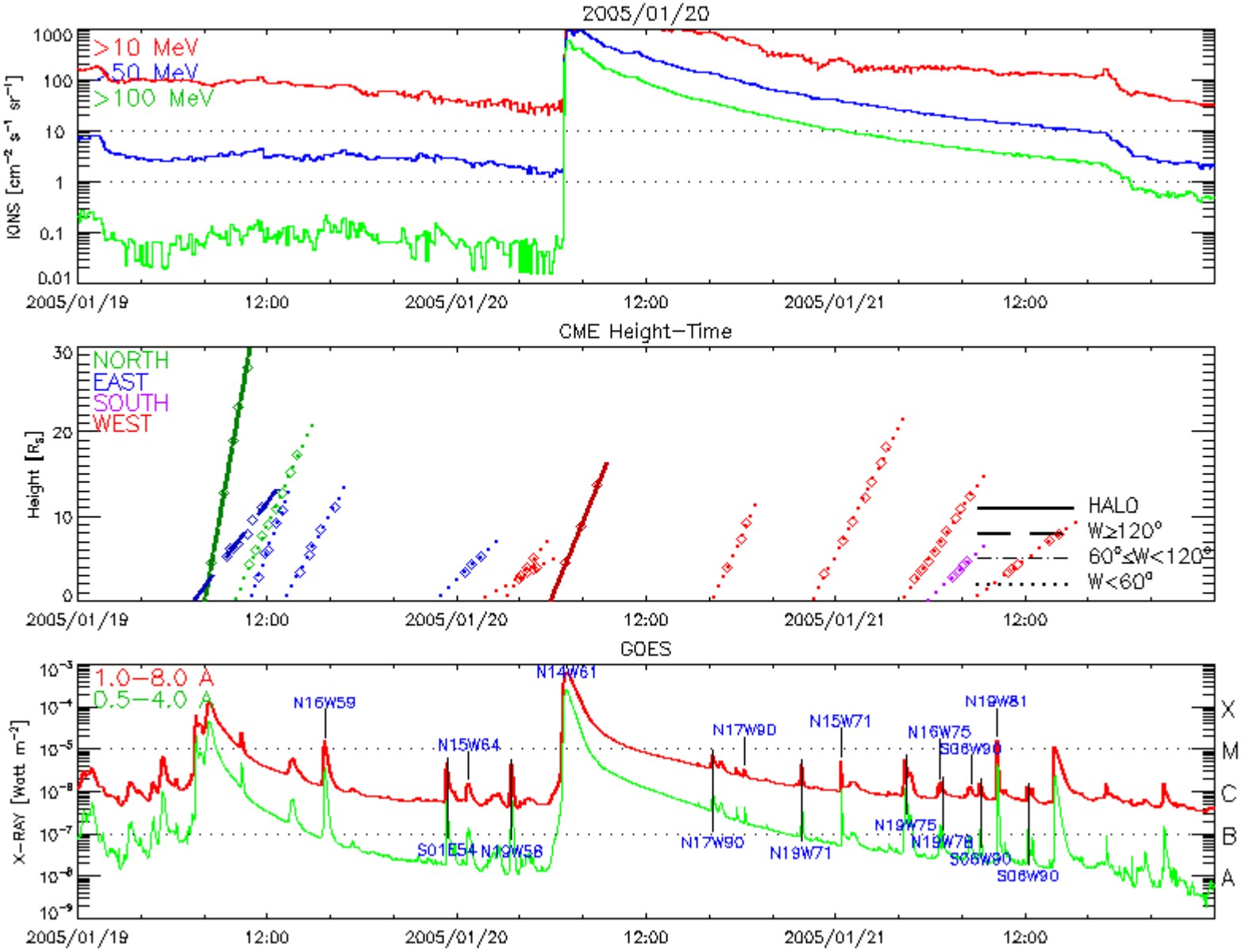
  http://cdaw.gsfc.nasa.gov/CME_list/UNIVERSAL/2005_01/univ2005_01.html

Bottom figure shows the dependence of the X-Ray flux with time.

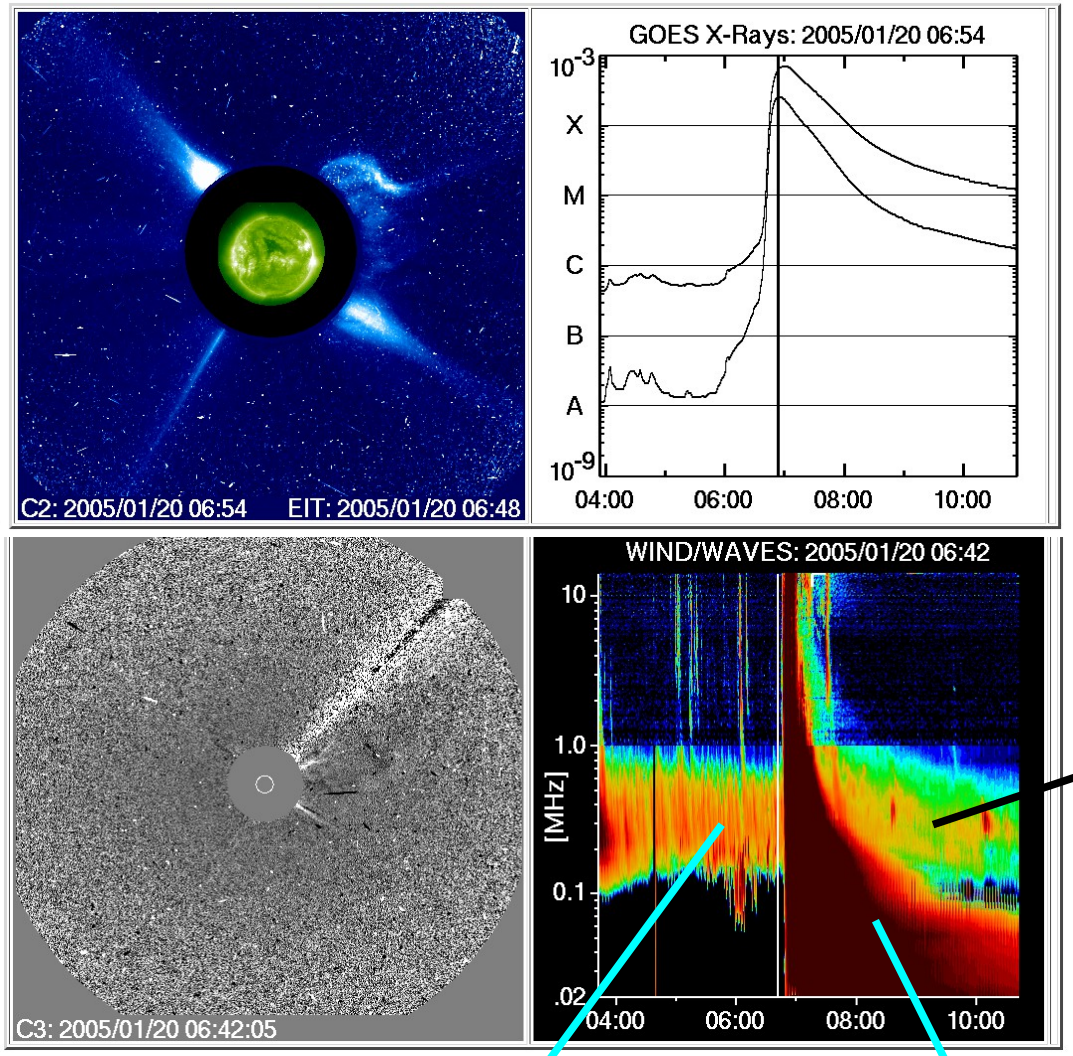


- Various X-Ray brightenings can be observed but only the one at 07:00 UT produced an SEP event.
- X-Ray bursts can be associated with CMEs
- The outburst at 7:00 was an X7.1/2B (see http://cdaw.gsfc.nasa.gov/CME_list/sepe/)
- The blue notation indicates the location on the sun from where the X-Rays originated.
  - The one at 7:00 was tat N14W61

Comparison


2005/01/20
>10 MeV
>50 MeV
>100 MeV
PONS [cm⁻² s⁻¹ sr⁻¹]
1000
100
10
1
0.1
0.01
2005/01/19
12:00
2005/01/20
12:00
2005/01/21
12:00
CME Height−Time
NORTH
EAST
SOUTH
WEST
Height [Rs]
30
20
10
0
HALO
W≥120°
60°≤W<120°
W<60°
GOES
1.0−8.0 A
0.5−4.0 A
X-RAY [Watt m⁻²]
N16W59
N15W64
S01E54
N12W58
N14W61
N17W90
N17W90
N15W71
N19W71
N16W75
N19W75
N19W78
S06W90
S06W90
N19W81
X
M
C
B
A

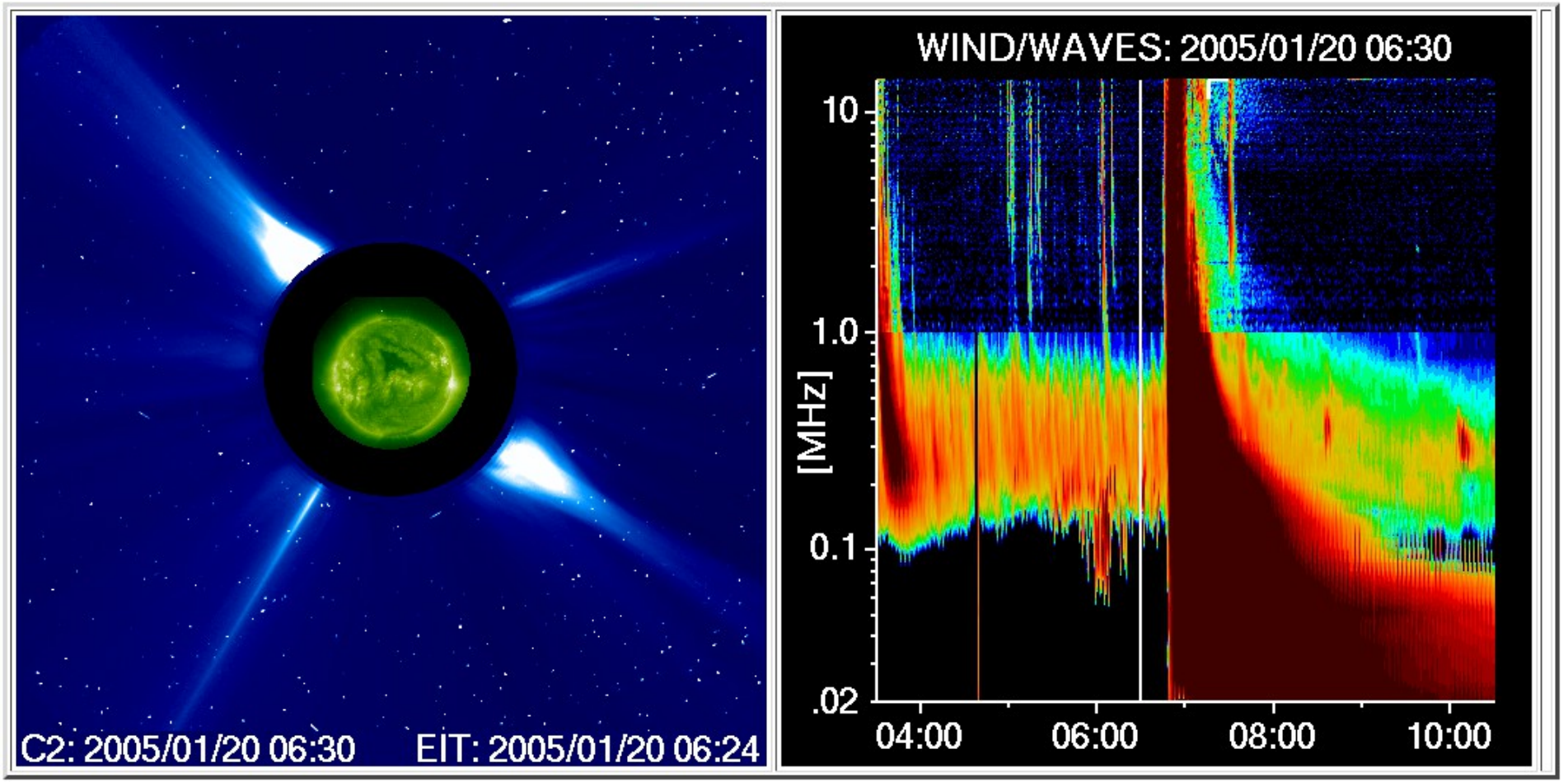
WIND/WAVES data

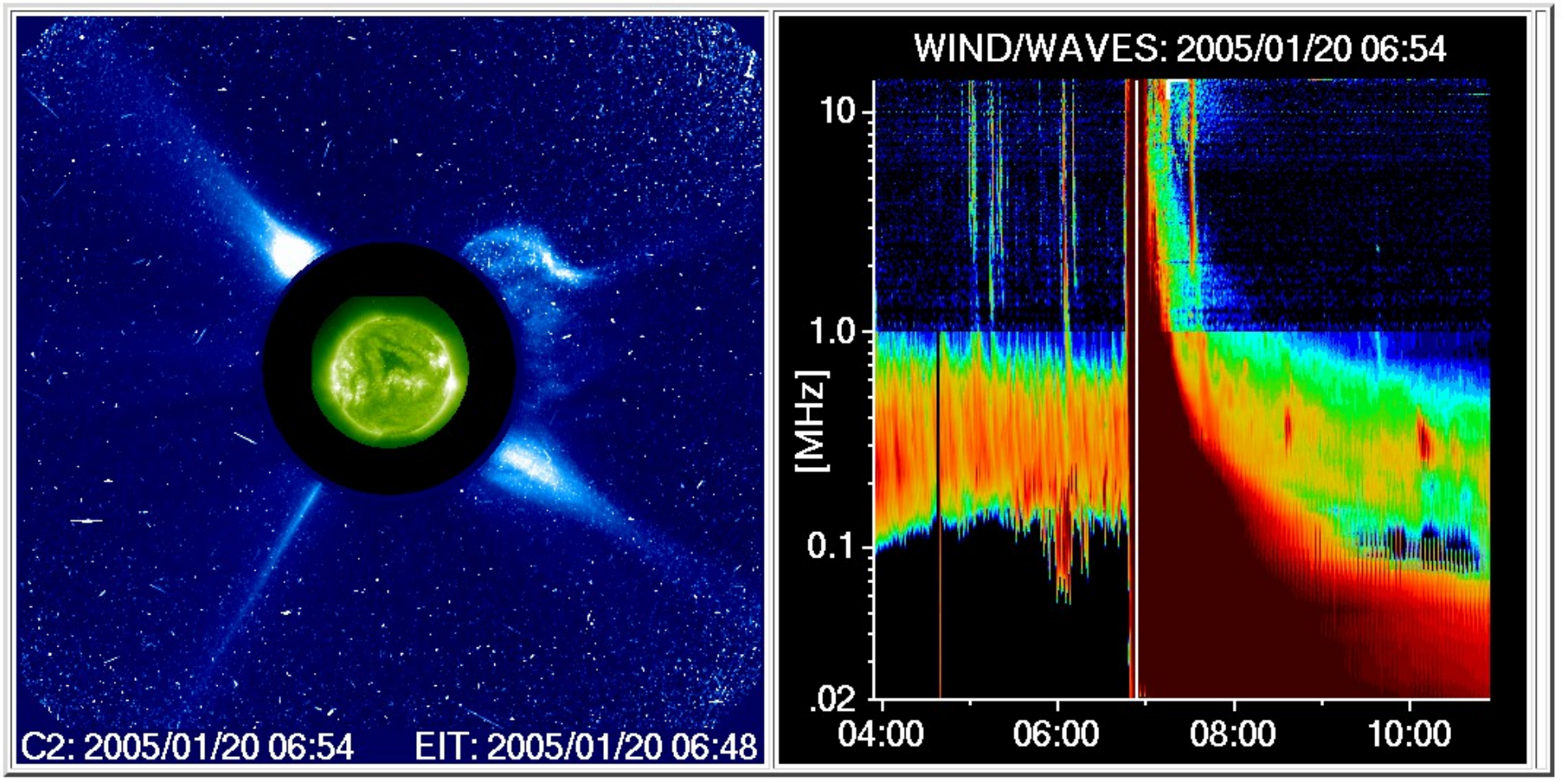


Type II Radio burst
Associated with
shocks

Auroral activity

Type III Radio burst


C2: 2005/01/20 06:30
EIT: 2005/01/20 06:24
WIND/WAVES: 2005/01/20 06:30
10
1.0
0.1
.02
[MHz]
04:00
06:00
08:00
10:00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EIT: 2005/01/20 06:48
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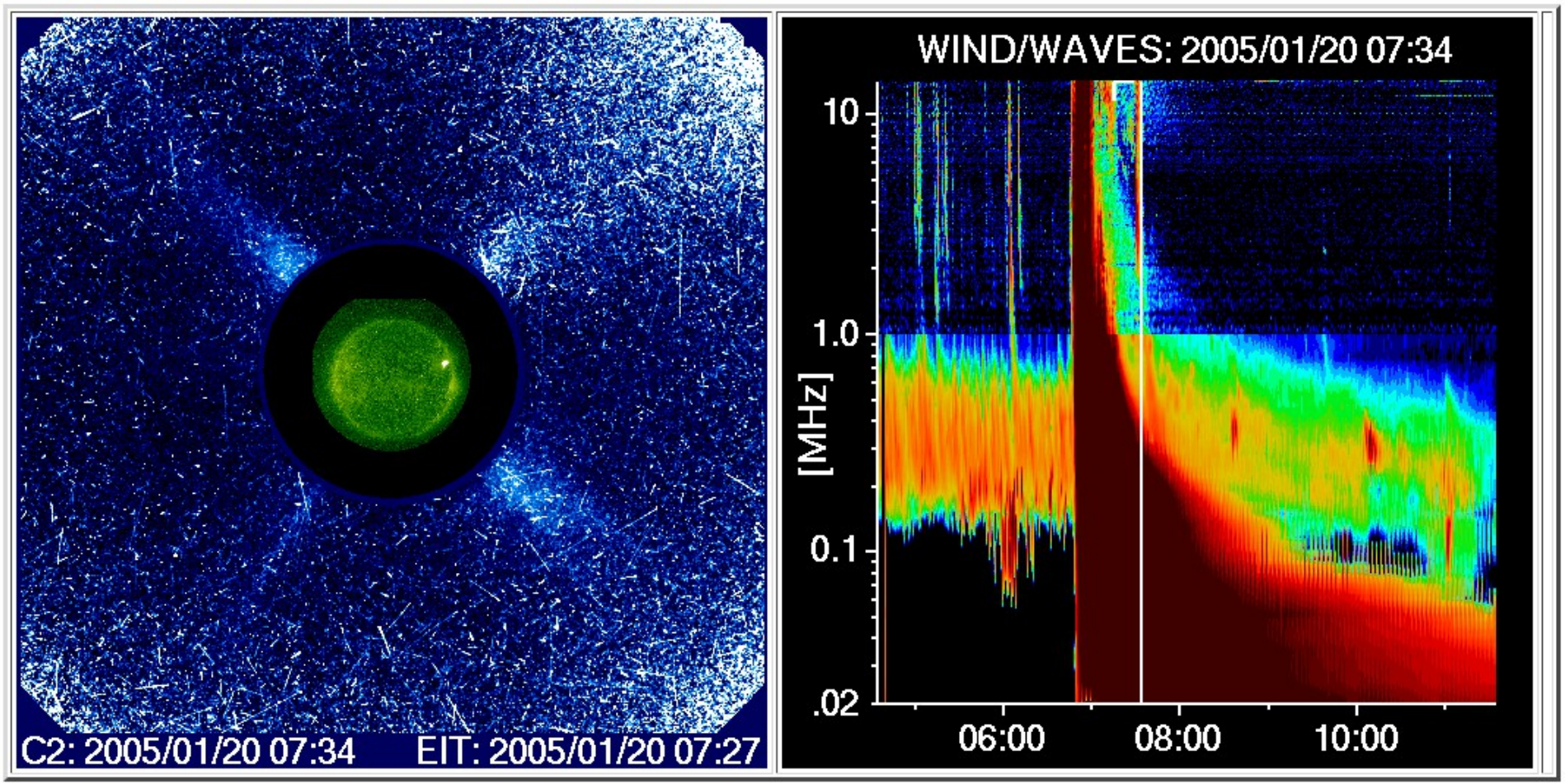
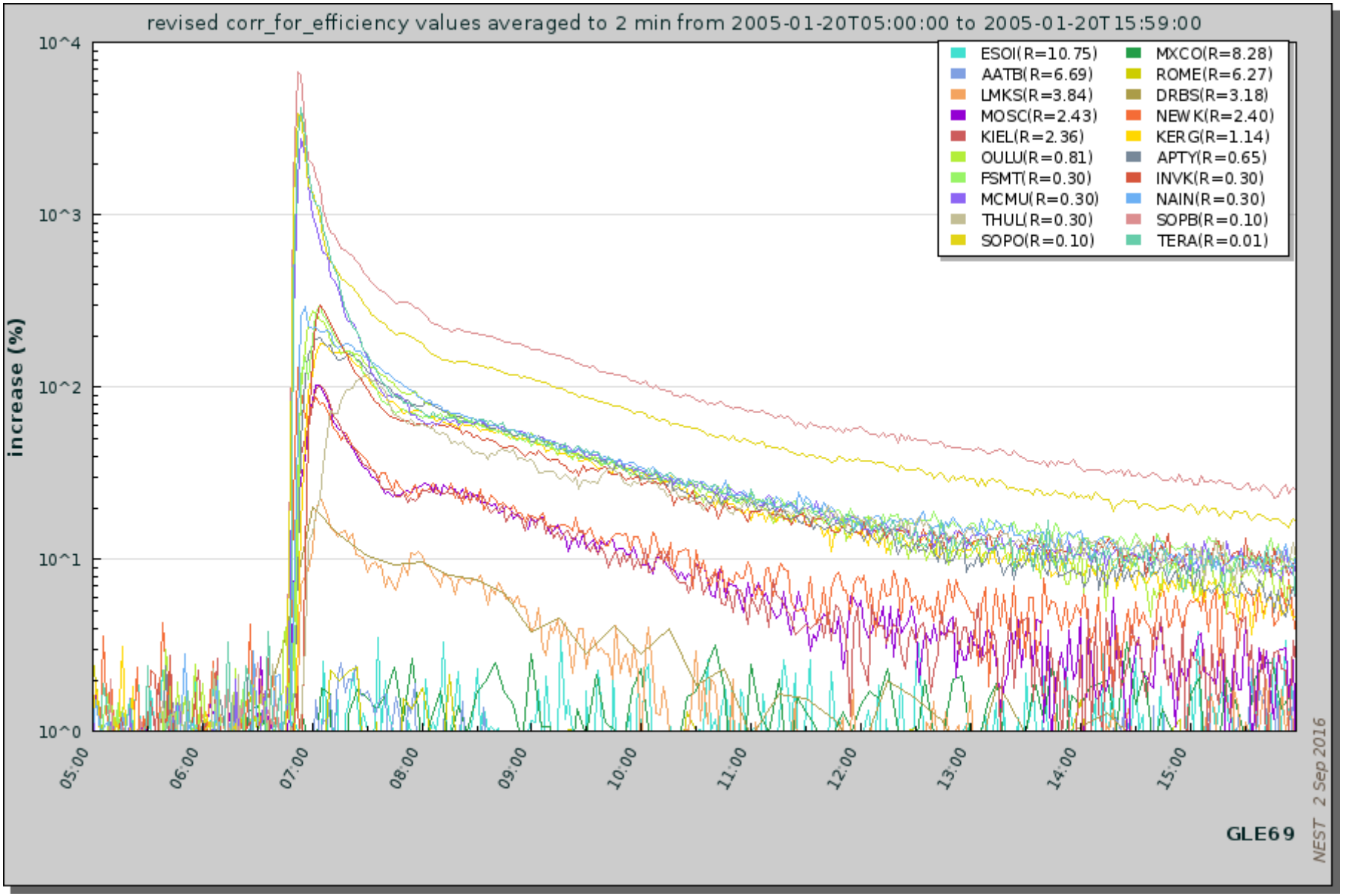
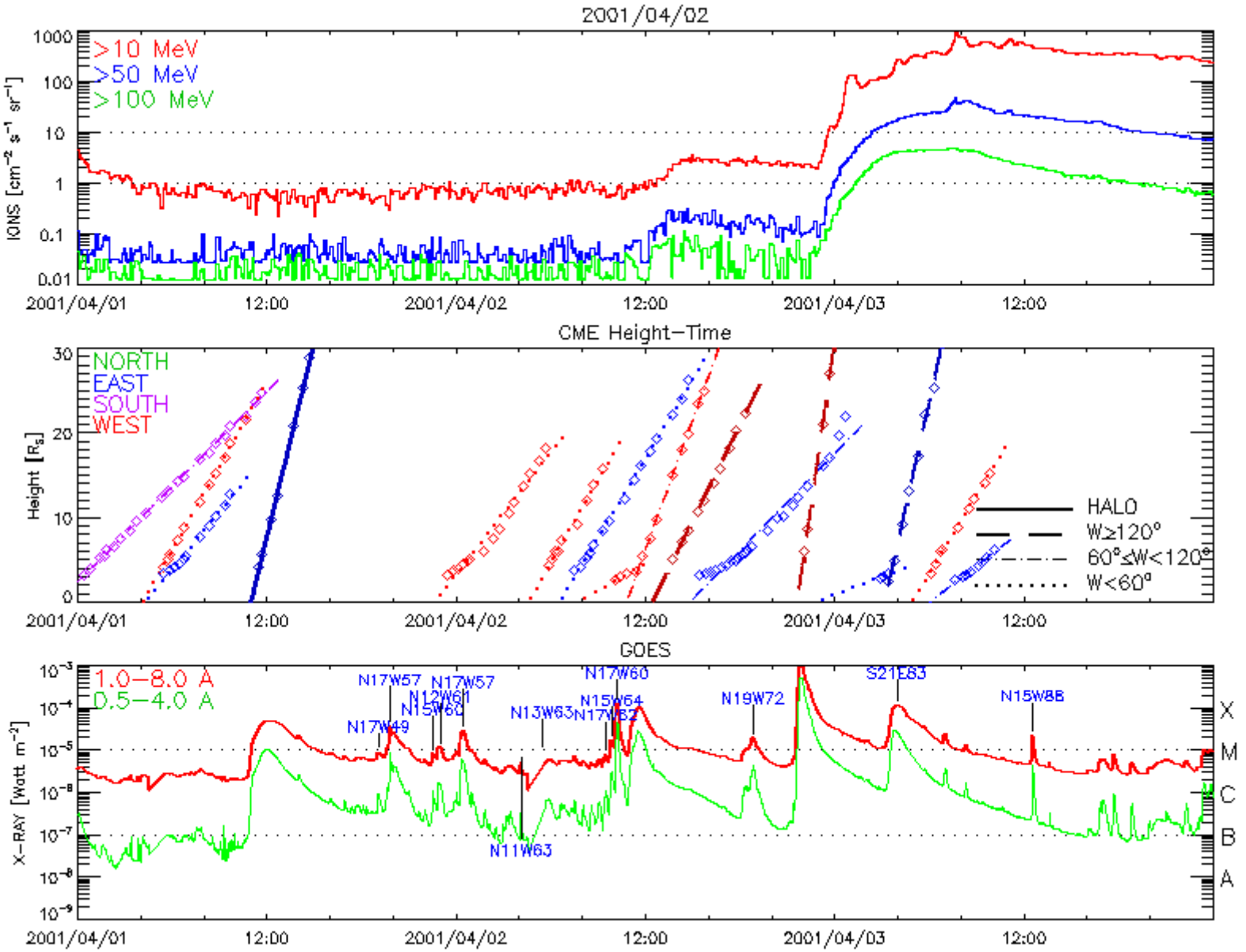
10
1.0
0.1
.02
[MHz]
04:00
06:00
08:00
10:00

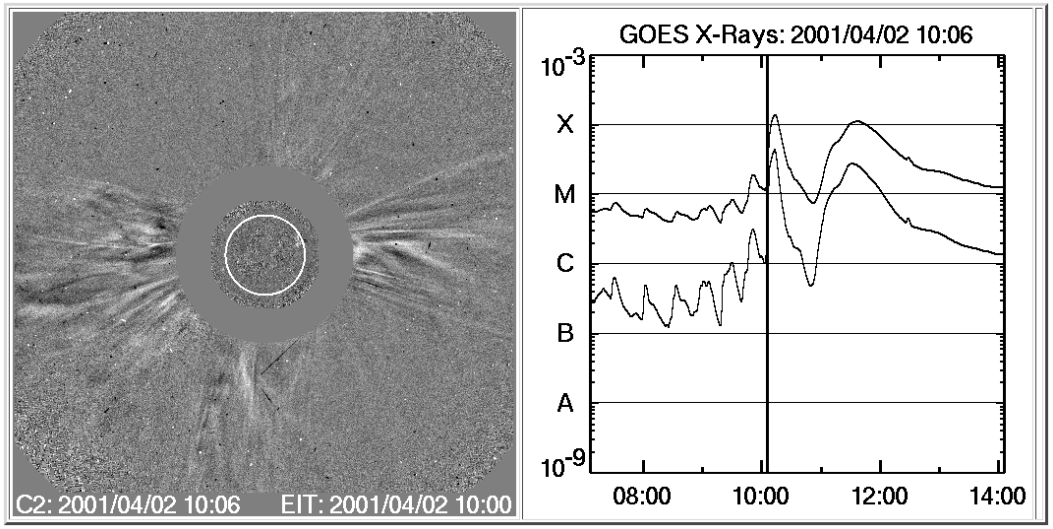

C2: 2005/01/20 07:34
EIT: 2005/01/20 07:27
WIND/WAVES: 2005/01/20 07:34
10
1.0
0.1
.02
[MHz]
06:00
08:00
10:00

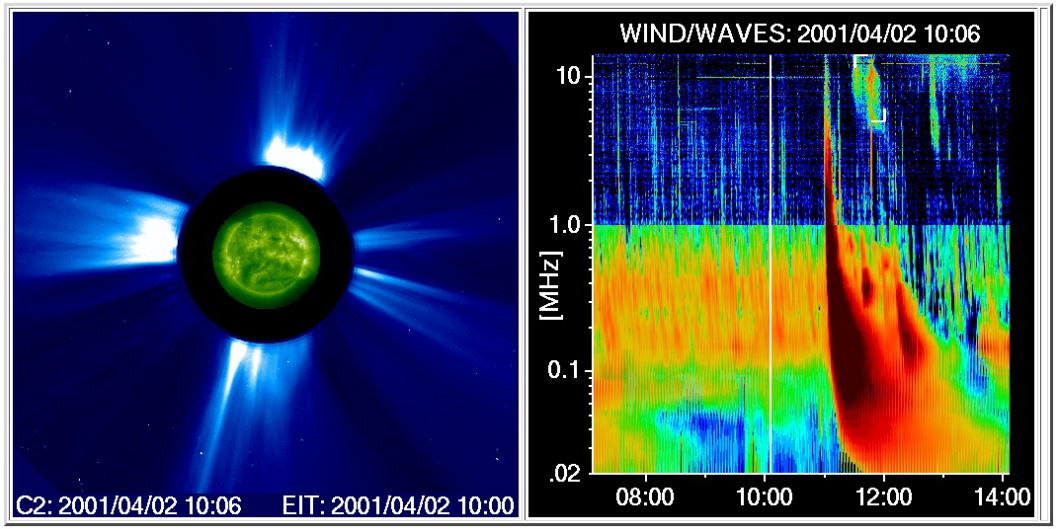
GLE analysis

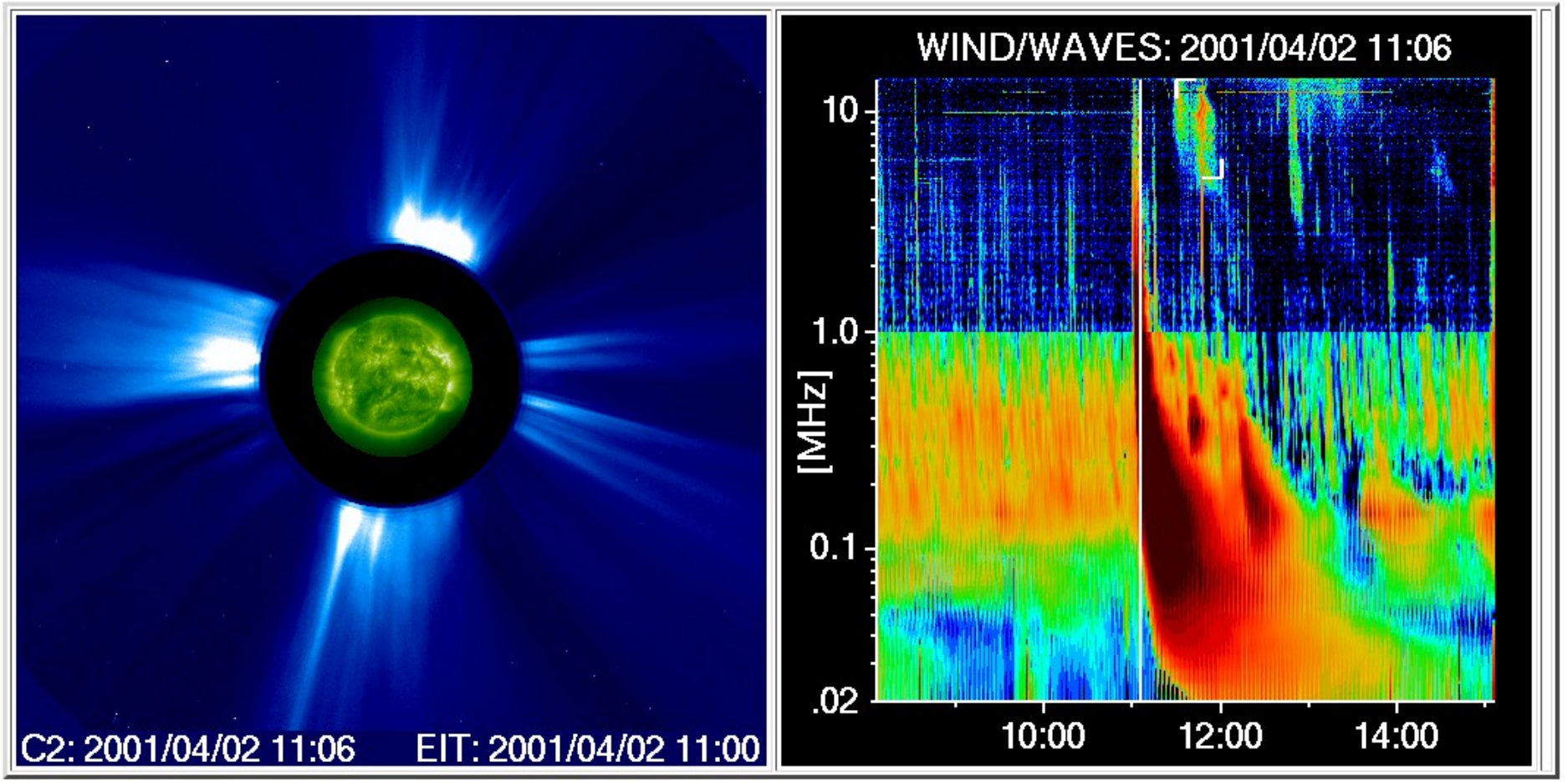


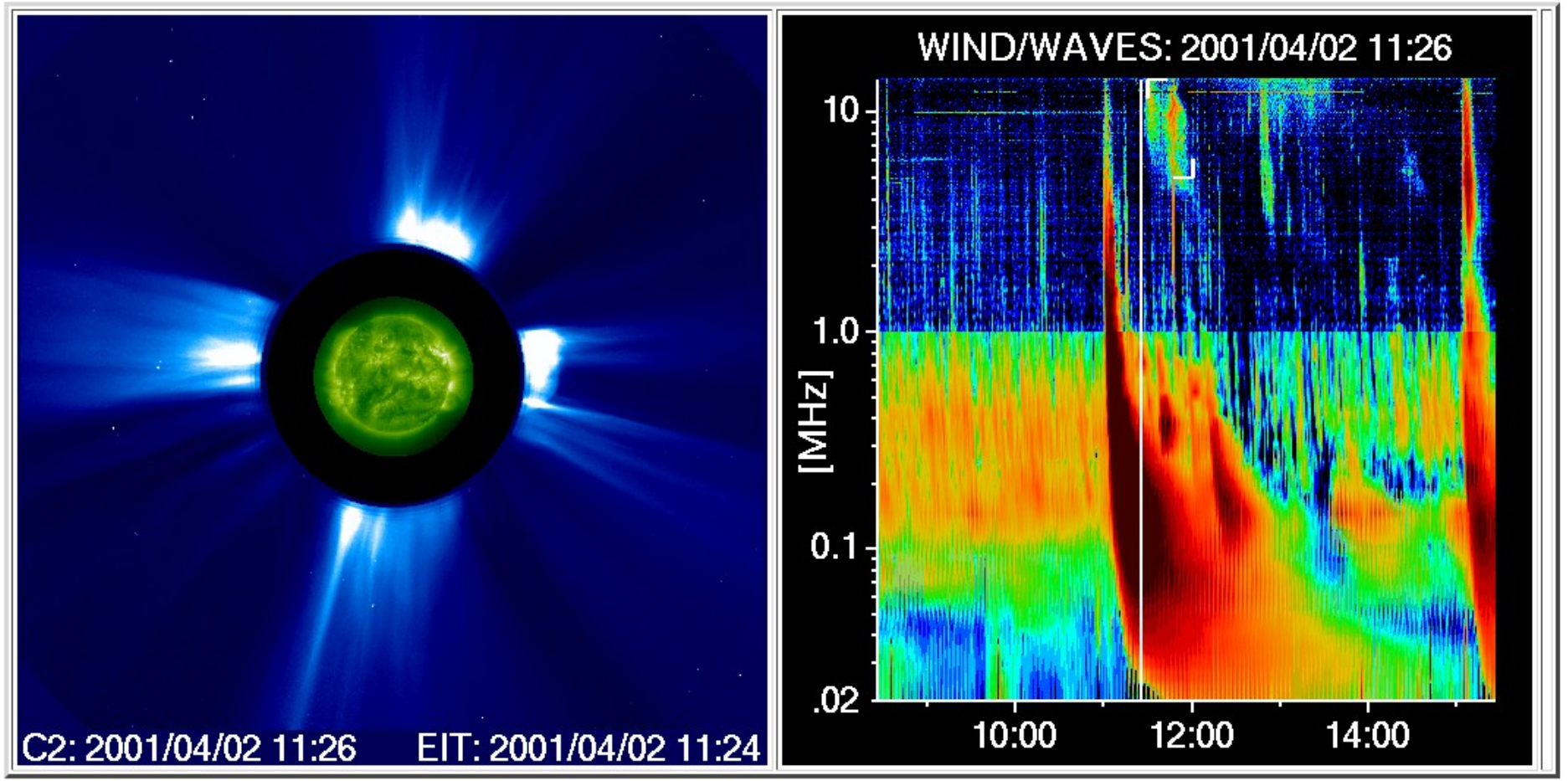
Event 2

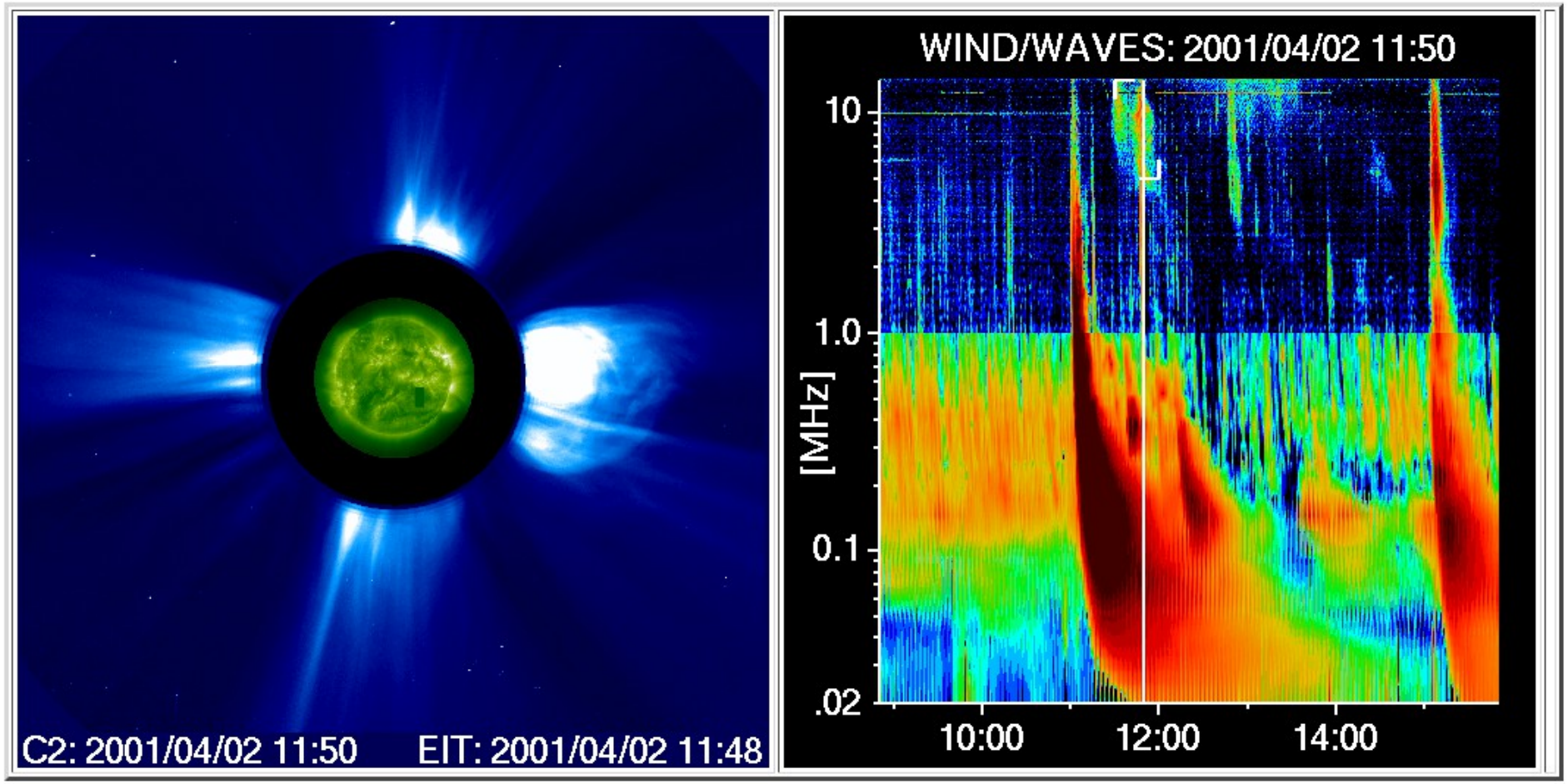

2001/04/02
>10 MeV
>50 MeV
>100 MeV
IONS [cm⁻² s⁻¹ sr⁻¹]
1000
100
10
1
0.1
0.01
2001/04/01
12:00
2001/04/02
12:00
2001/04/03
12:00
CME Height−Time
NORTH
EAST
SOUTH
WEST
Height [R_s]
30
20
10
0
HALO
W≥120°
60°≤W<120°
W<60°
GOES
1.0−8.0 A
0.5−4.0 A
X-RAY [Watt m⁻²]
N17W57
N17W57
N12W61
N15W60
N17W49
N13W63
N17W60
N15W64
N17W62
N11W63
N19W72
S21E83
N15W88
X
M
C
B
A

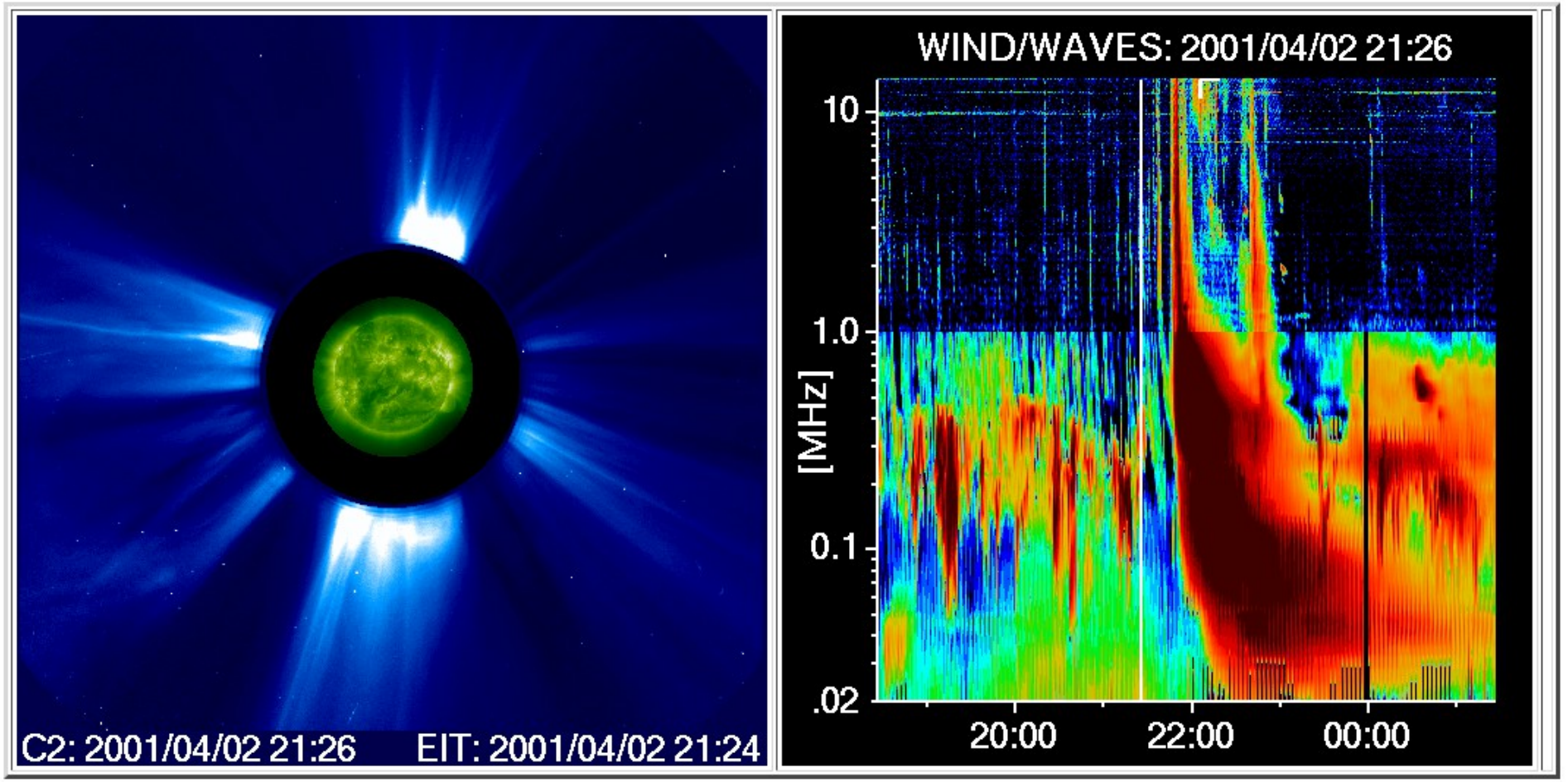

C2: 2001/04/02 10:06
EIT: 2001/04/02 10:00
GOES X-Rays: 2001/04/02 10:06
10^-3
X
M
C
B
A
10^-9
08:00
10:00
12:00
14:00

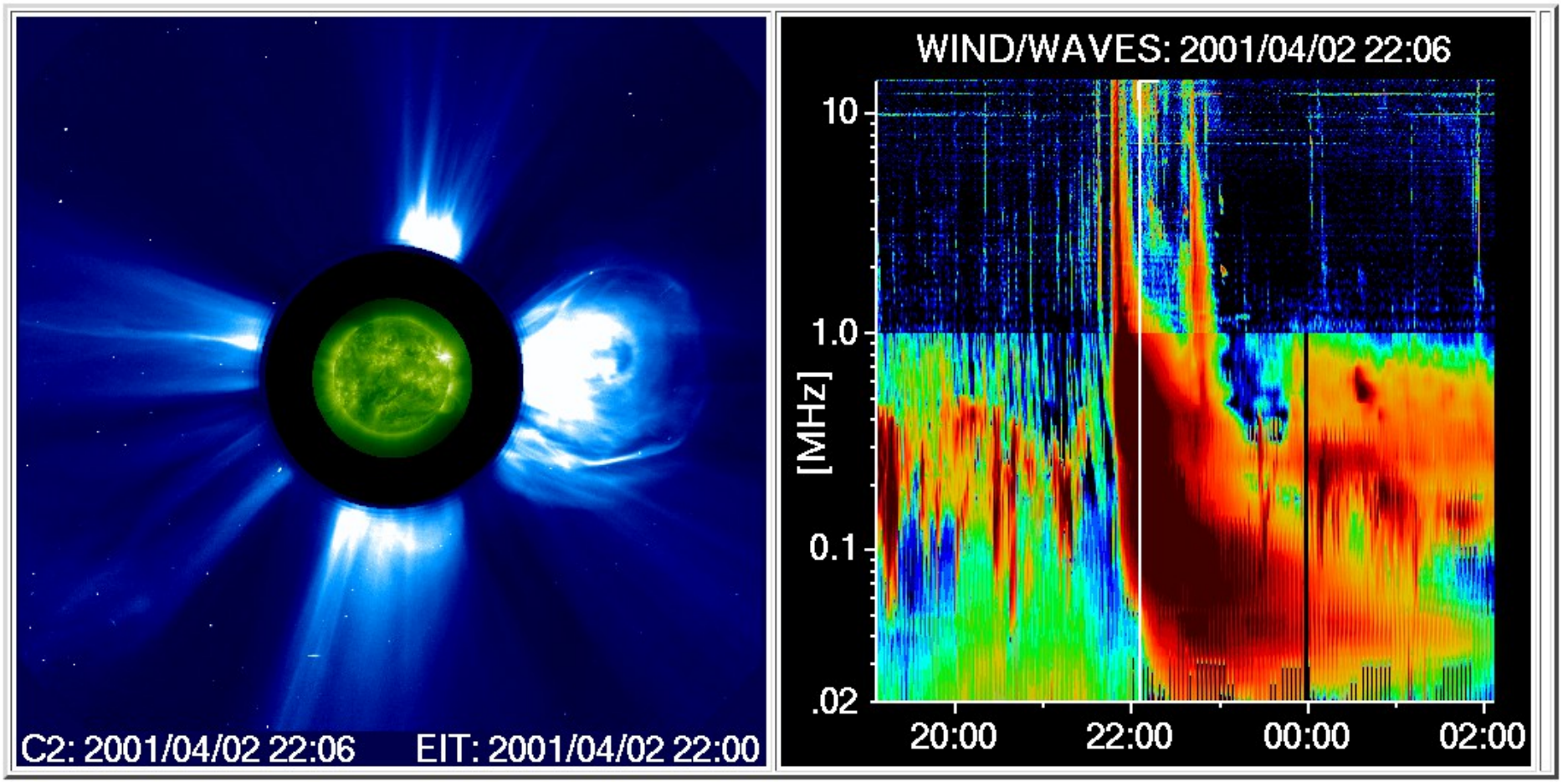

C2: 2001/04/02 10:06
EIT: 2001/04/02 10:00
WIND/WAVES: 2001/04/02 10:06
10
1.0
[MHz]
0.1
.02
08:00
10:00
12:00
14:00

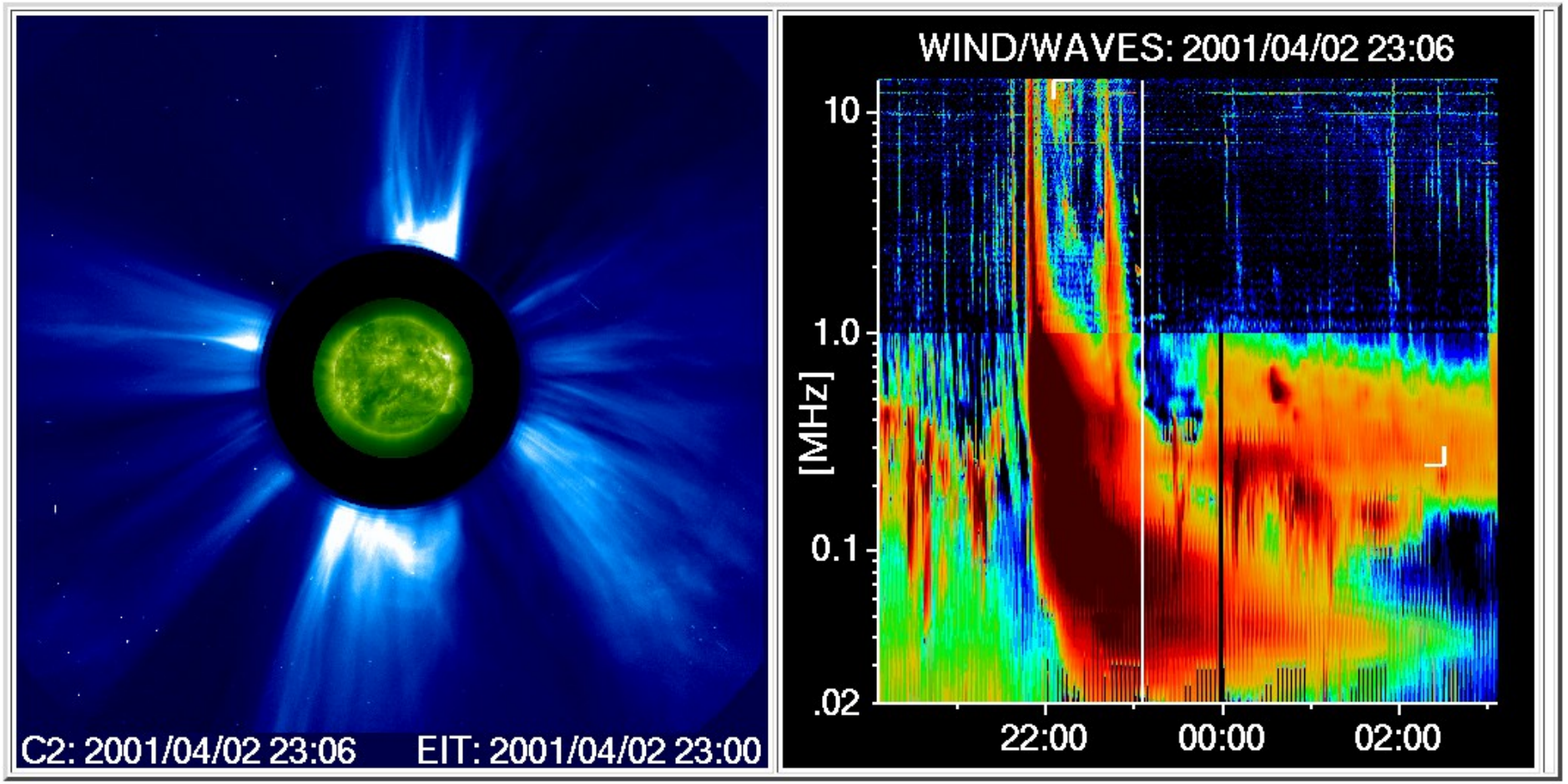

C2: 2001/04/02 11:06
EIT: 2001/04/02 11:00
WIND/WAVES: 2001/04/02 11:06
10
1.0
0.1
.02
[MHz]
10:00
12:00
14:00


C2: 2001/04/02 11:26
EIT: 2001/04/02 11:24
WIND/WAVES: 2001/04/02 11:26
10
1.0
0.1
.02
[MHz]
10:00
12:00
14:00

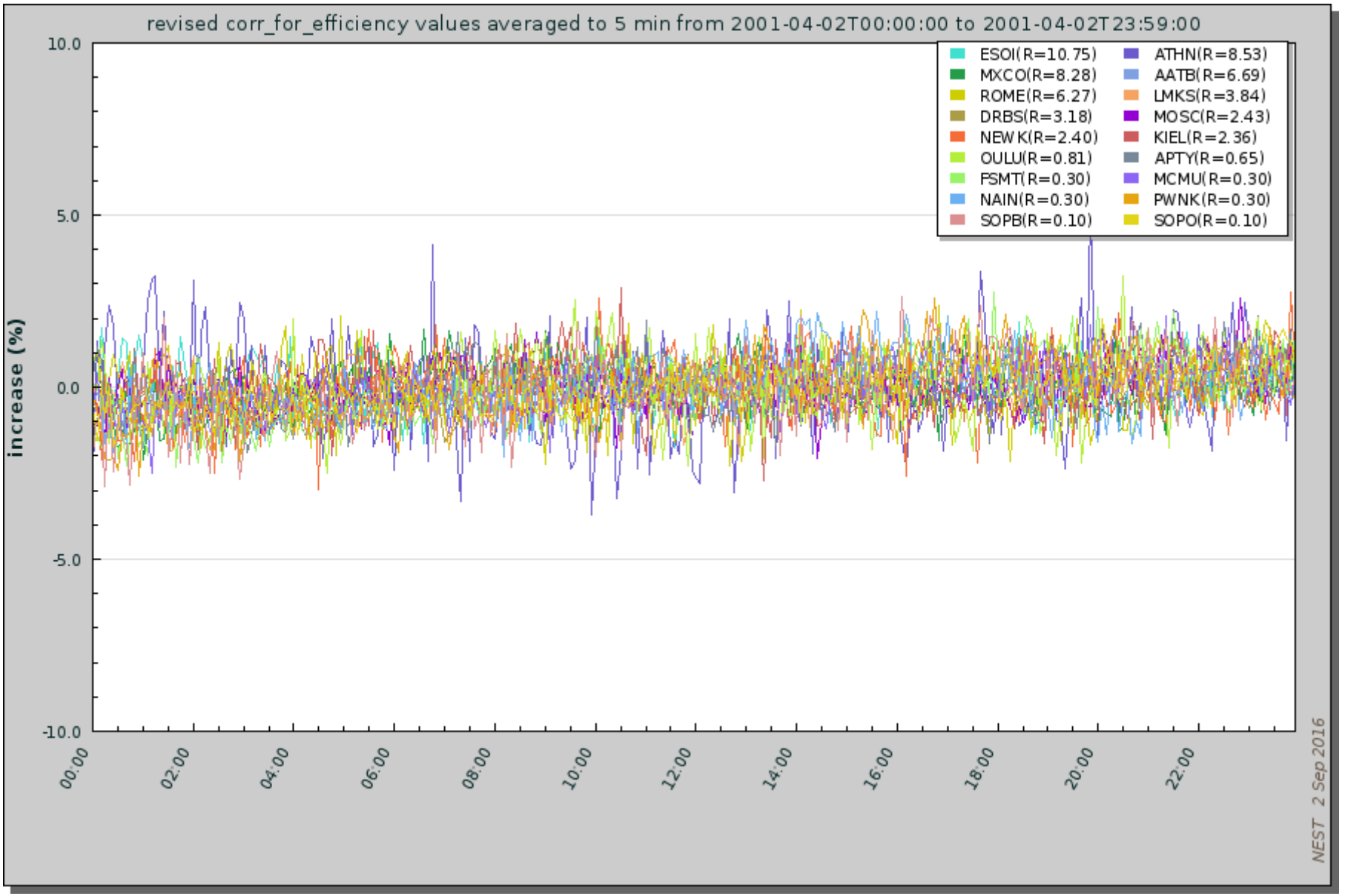

C2: 2001/04/02 11:50
EIT: 2001/04/02 11:48
WIND/WAVES: 2001/04/02 11:50
10
1.0
0.1
.02
[MHz]
10:00
12:00
14:00


C2: 2001/04/02 21:26
EIT: 2001/04/02 21:24
WIND/WAVES: 2001/04/02 21:26
10
1.0
0.1
.02
[MHz]
20:00
22:00
00:00


C2: 2001/04/02 22:06
EIT: 2001/04/02 22:00
WIND/WAVES: 2001/04/02 22:06
10
1.0
0.1
.02
[MHz]
20:00
22:00
00:00
02:00


C2: 2001/04/02 23:06
EIT: 2001/04/02 23:00
WIND/WAVES: 2001/04/02 23:06
10
1.0
0.1
.02
[MHz]
22:00
00:00
02:00

Checking for the GLE



Results

	Event I - 20 Jan. 2005	Event II – 2 April 2001
Flare Location	N14W61	N18W68
Flare Class	X7.1	X20
CME speed	882	2505
RB III.	Yes	Yes (cond.)
RB II.	Yes	Yes (cond.)
GLE	Yes	No

Conclusions

- Solar activity is a series of complex phenomena affecting the local heliospheric envioronmnent causing 'Space Weather'
- Eruptive events such as solar flares and CMEs can be linked to the detected energetic particles in space and at the ground
- The solar activity does not always cause SEP events – this depends on particle injection and propagation conditions

Thank you!