NRIAG

Monitoring the impact of solar event along Europe – African west chain by GIM/CODG Maps

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Aim

- **Study the ionospheric spatial variation along west Europe – African GPS-Chain cross the North Crest Equatorial Anomaly associated to solar event.**
- **Understand the response of VTEC during the magnetic disturbance of November 2012 by the GIM/CODG maps.**
- **Separate and compare between the effect of the CME and HSSW on TEC.**
- **Compare the variation of the disturbed magnetic observations and GPS-VTEC with the variation of quiet days during the same month in order to obtain the characteristics of GPS-VTEC and magnetic disturbances due to the solar event effect.**

Outlines

- **Data sets and Data processing**
- **Event of 09-15 November 2012-**

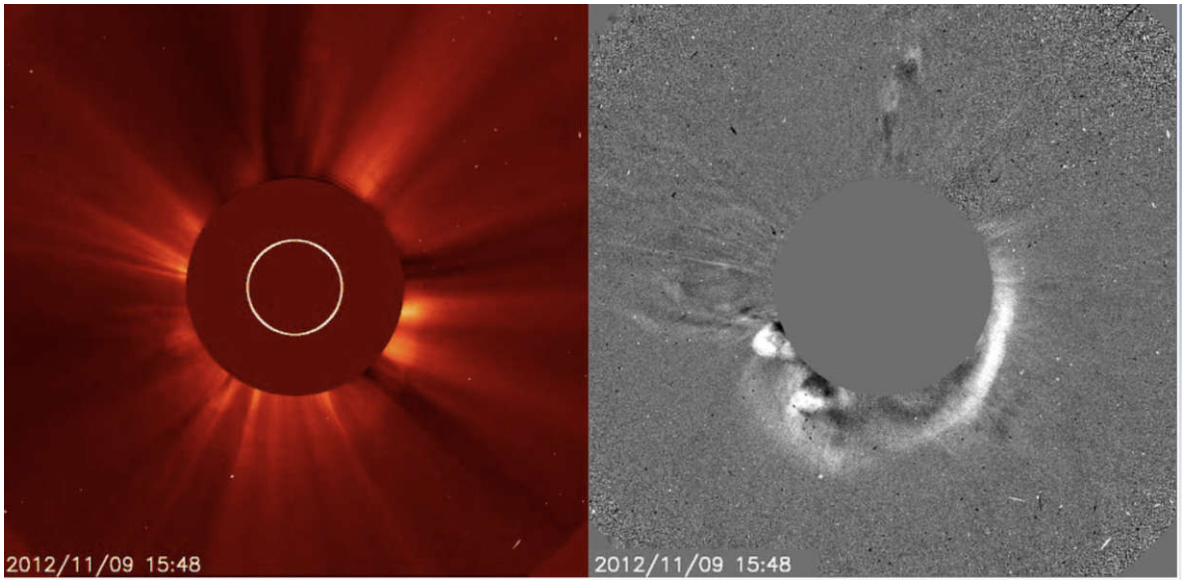
  CME storm + HSSW
- **Interpretation**
- **Conclusion and future prospects**

Data sets

- Solar Data(Coronal Hole-SOHO SAT.)
- Solar Wind Data (ACE SAT.)
  - Solar Wind speed Vx
  - IMF Bz
- Magnetic Indices

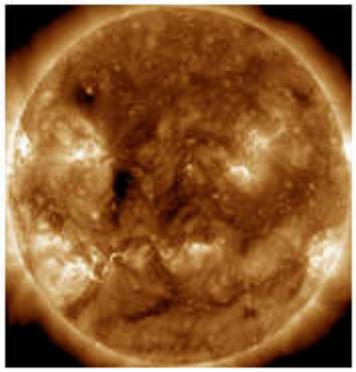
  (World Data Center for Geomagnetism, Kyoto+ ISGI website)
  - SYM_H index (Magnetospheric currents)
  - AU and AL (Auroral currents)
  - Am index (level of magnetic activity)
- Ionospheric Data
  - GPS (vTEC along west Europe - African chain)
  - The GIM/CODG maps(vTEC along 3 sector Brazilian ,African and Australian)

Solar event :
CME + Coronal Hole -> Nov.2012

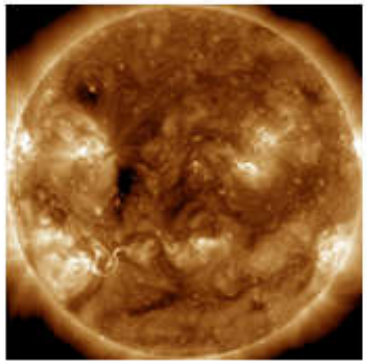


CME starting from the Sun on November 9 impact the Earth on November 12

High speed solar wind flowing from a coronal hole on November 10 impact the Earth on November 14



09-Nov-2012
There are no large coronal holes on the Earthside of the sun.



09-Nov-2012
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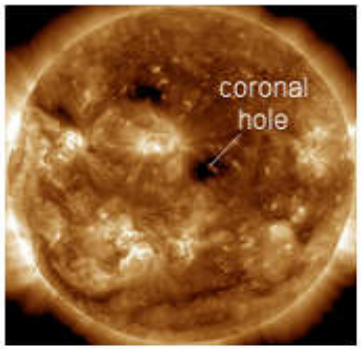
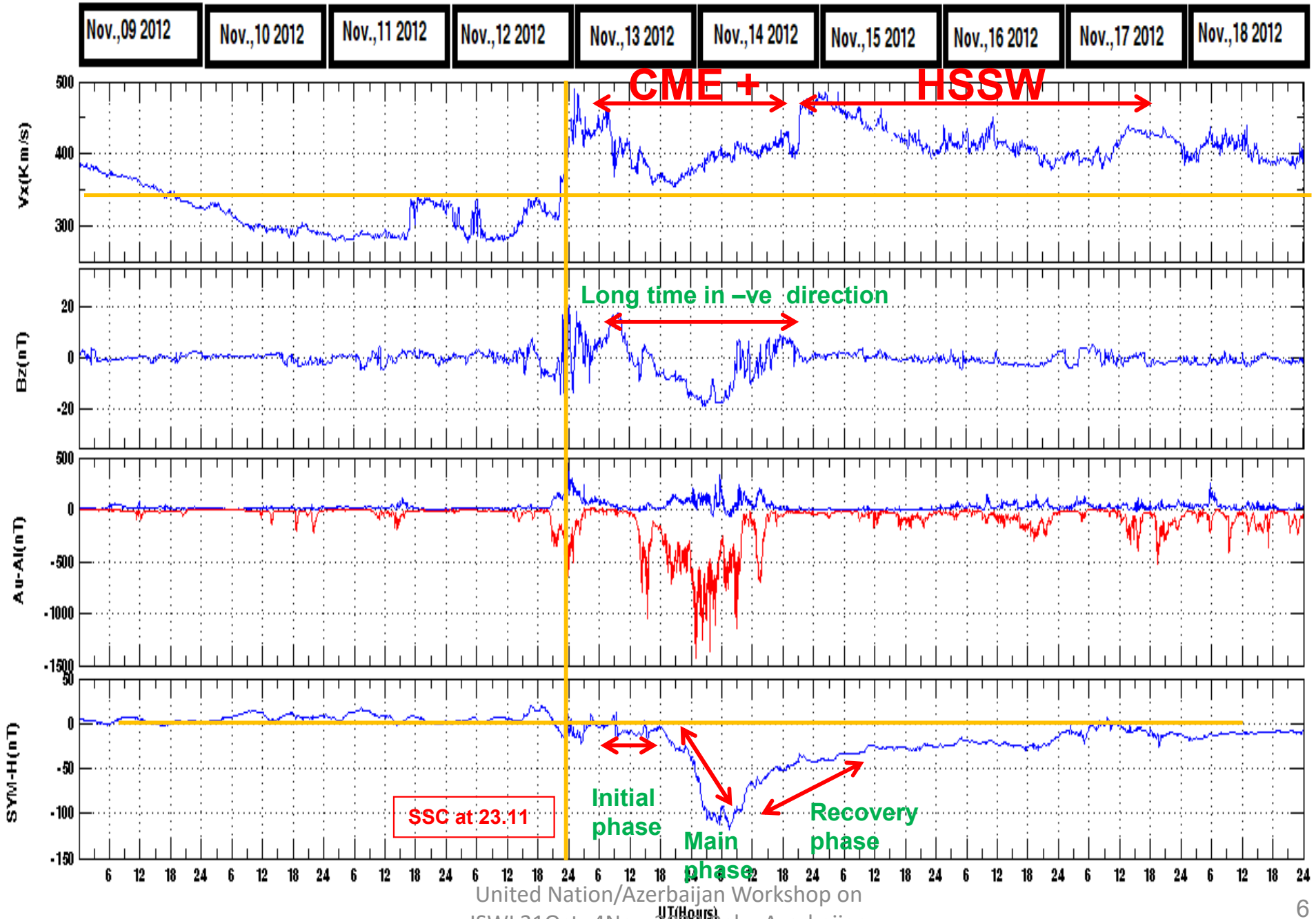


11-Nov-2012
Solar wind flowing from the indicated coronal hole should reach Earth on Nov. 14-15.


Nov.,09 2012
Nov.,10 2012
Nov.,11 2012
Nov.,12 2012
Nov.,13 2012
Nov.,14 2012
Nov.,15 2012
Nov.,16 2012
Nov.,17 2012
Nov.,18 2012
CME +
HSSW
Vx(Km/s)
Long time in –ve direction
Bz(nT)
Au-Al(nT)
SYM-H(nT)
SSC at 23.11
Initial phase
Main phase
Recovery phase
UT(Hours)

Regular variation of magnetic and ionospheric parameters during quiet magnetic days are necessary to analyses the disturbances due to the CME and the Coronal Hole

Ionisation

Disturbed TEC = TEC - <meanTEC>

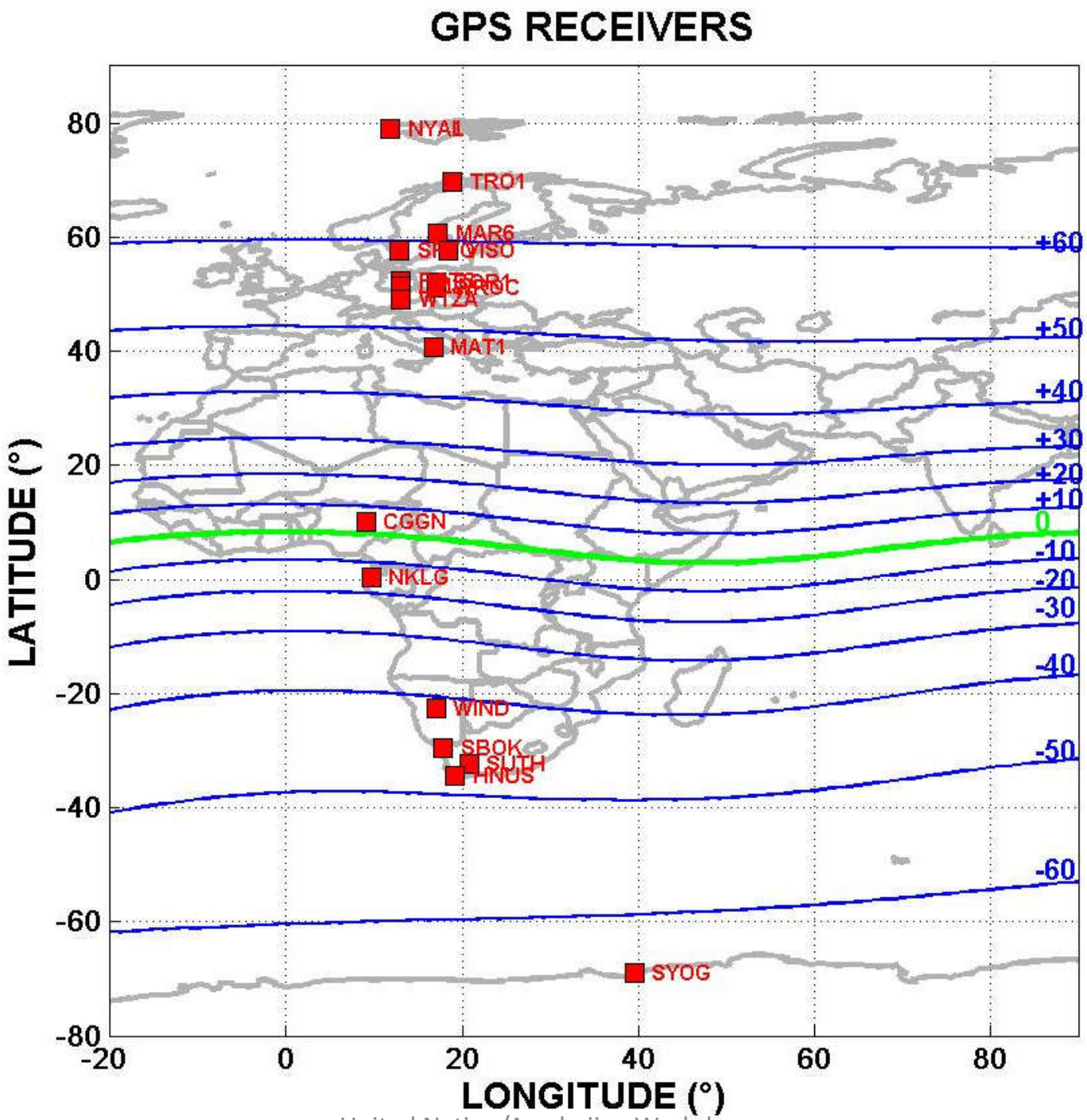
Magnetic field

Mean value calculated for the days with Am = 4 or <4 :

Day	DOY		Am index
09	314	most quiet	1
10	315	most quiet	4
11	316	most quiet	4
12	317	Quiet	11
13	318	most disturbed	31
14	319	most disturbed	47
15	320	quiet	5

Year	Month	Most Quiet Days										Most Disturbed Days				
		q1	q2	q3	q4	q5	q6	q7	q8	q9	q0	d1	d2	d3	d4	d5
2012	11	9	30	28	4	11	22	3	29	10	8	14	1	13	20	24
		314	335	333	309	316	327	308	334	315	313	319	306	318	325	329

Most quiet days
http://wdc.kugi.kyoto-u.ac.jp/cgi-bin/qddays-cgi
Am index
http://isgi.latmos.ipsl.fr/cgi-bin/isgi/sc5.exe
DOY calculator
http://webmodis.iis.u-tokyo.ac.jp/doy_calc.php
http://mistupid.com/calendar/dayofyear.htm

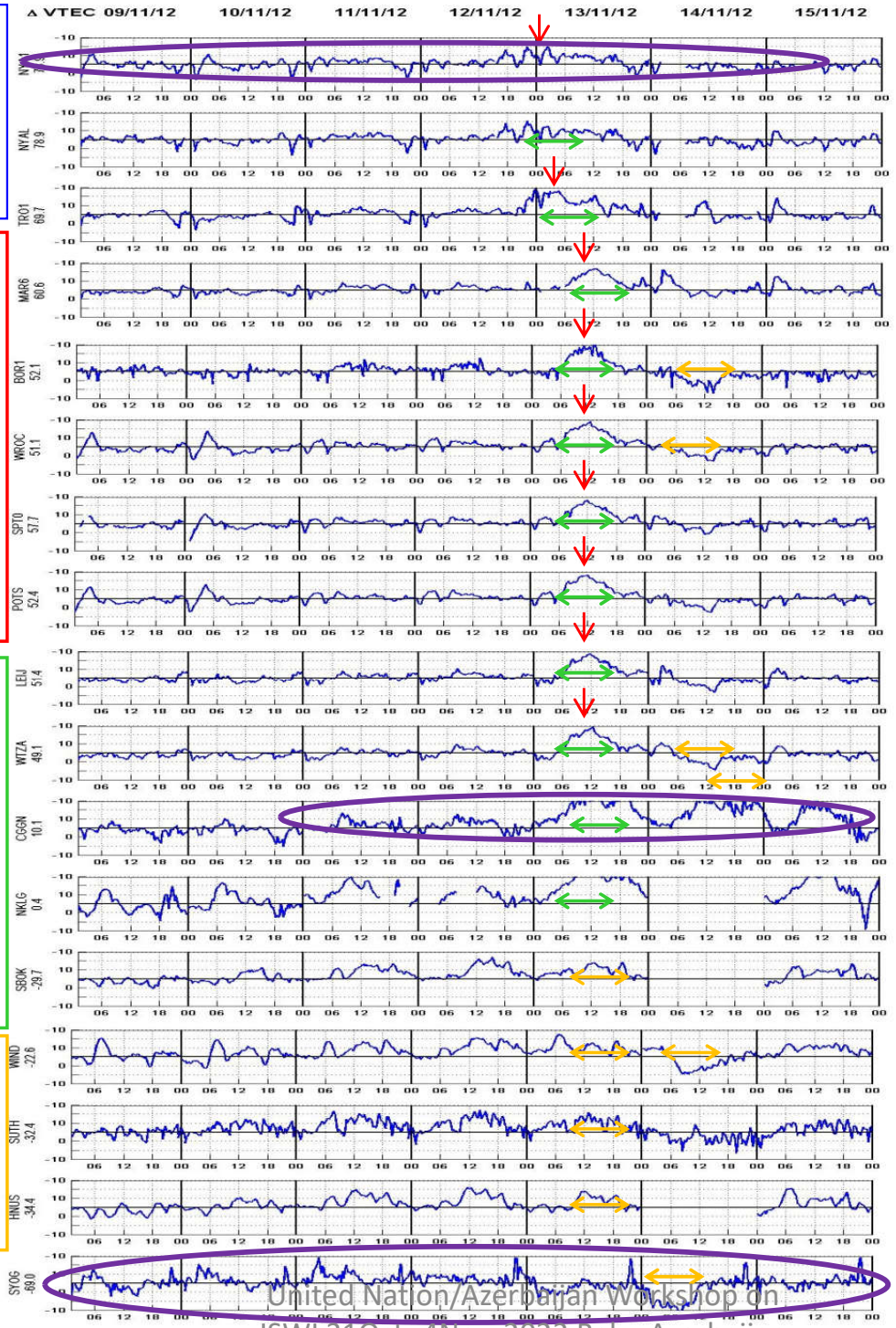

GPS RECEIVERS
NYAL
TRO1
MAR6
MAT1
CGGN
NKLG
WIND
SBOK
SUTH
HNUS
SYOG
+60
+50
+40
+30
+20
+10
0
-10
-20
-30
-40
-50
-60
80
60
40
20
0
-20
-40
-60
-80
-20
0
20
40
60
80
LATITUDE (°)
LONGITUDE (°)

Differential vTEC latitude variation of Euro-African Chain GPS Station during the geomagnetic stormed interval days

The red arrow points to the increase in TEC created by an penetration intense electric field.
The location of this arrow changes by the time produced large-scale TIDs develop at subauroral region during geomagnetic storms .

As the response to the geomagnetic storm, The green arrow points to the **positive phase** of the ionospheric storm due to the increase of electron density as we see Positive phase ionospheric storms have a longer duration.

The yellow arrow points to the **negative phase** of the ionospheric storm due to depletion in the electron density



The TEC experiences more fluctuations & so more scintillations

4 stations at High latitudes
NORTH

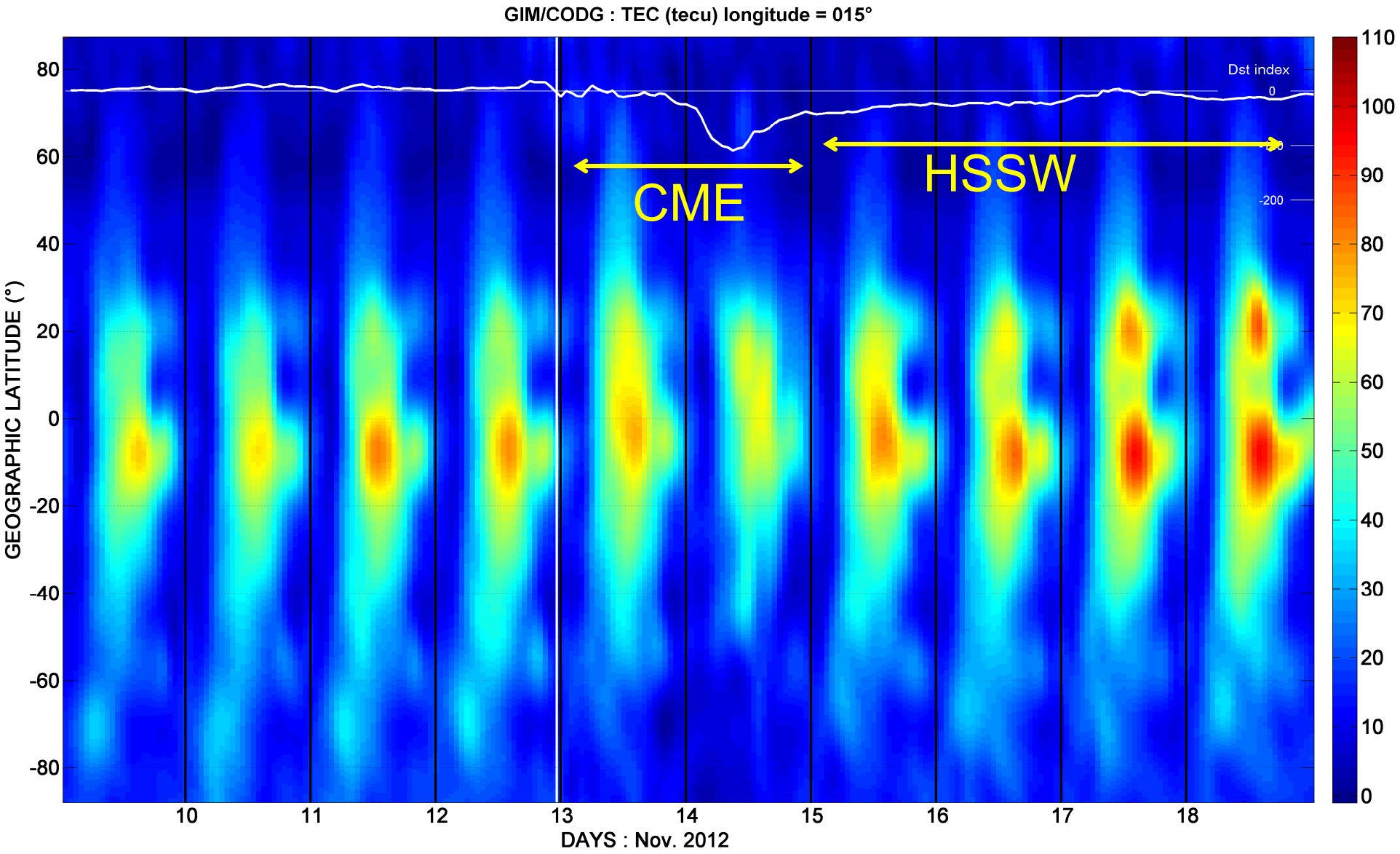
6 stations at middle latitudes
NORTH

Low latitudes
1 NORTH
1 SOUTH

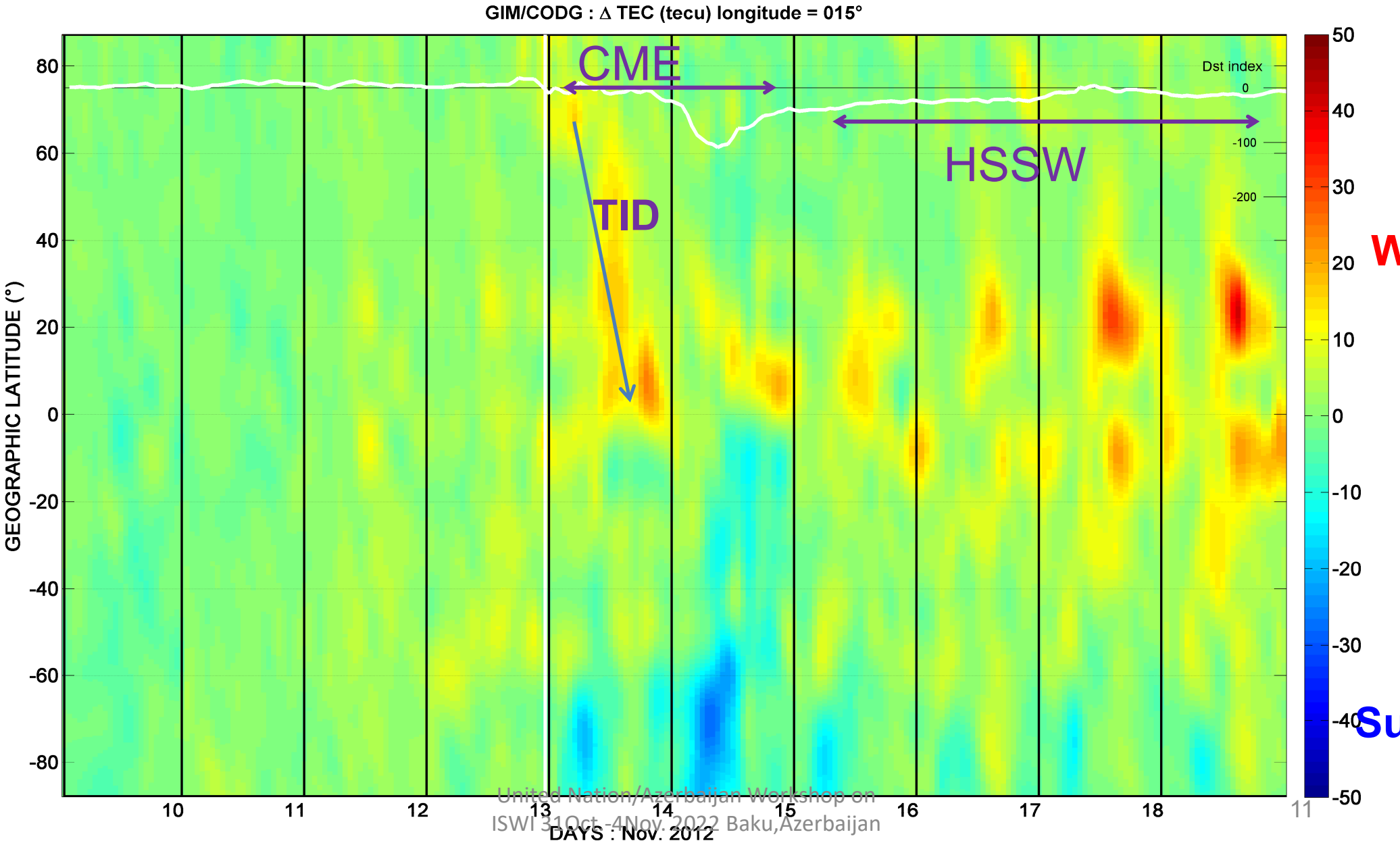
4 stations middle latitudes
SOUTH

1 station High Latitudes
SOUTH

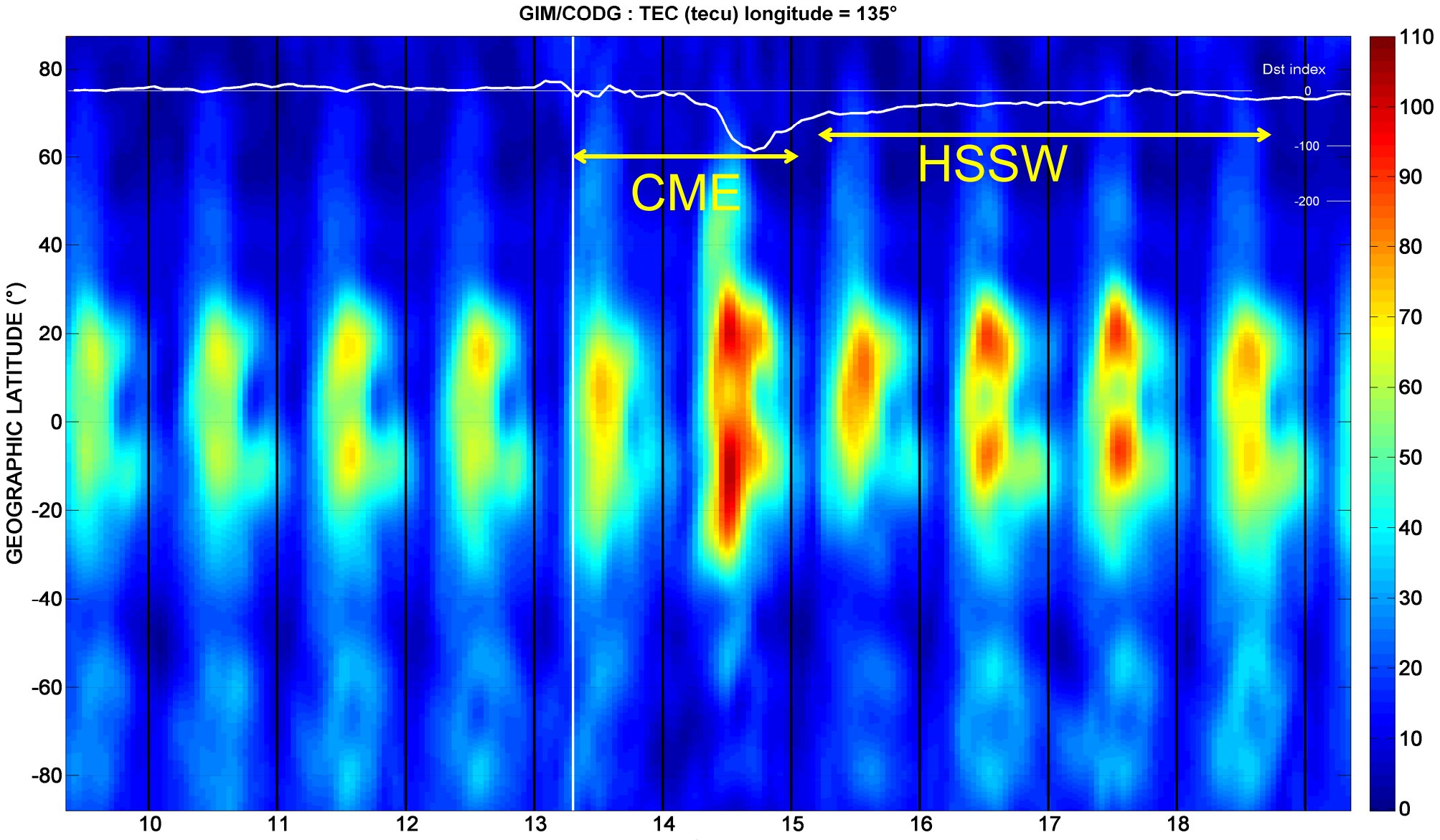
0:00 LT-15˚E


GIM/CODG : TEC (tecu) longitude = 015°
GEOGRAPHIC LATITUDE (°)
80
60
40
20
0
-20
-40
-60
-80
10
11
12
13
14
15
16
17
18
DAYS : Nov. 2012
Dst index
0
-200
CME
HSSW
110
100
90
80
70
60
50
40
30
20
10
0

0:00 LT-15˚E


GIM/CODG : Δ TEC (tecu) longitude = 015°
CME
HSSW
TID
Dst index
0
-100
-200
GEOGRAPHIC LATITUDE (°)
80
60
40
20
0
-20
-40
-60
-80
10
11
12
13
14
15
16
17
18
DAYS : Nov. 2012
50
40
30
20
10
0
-10
-20
-30
-40
-50
W
Su

08:11LT 135˚E


GIM/CODG : TEC (tecu) longitude = 135°
Dst index
0
-100
-200
CME
HSSW
GEOGRAPHIC LATITUDE (°)
80
60
40
20
0
-20
-40
-60
-80
10
11
12
13
14
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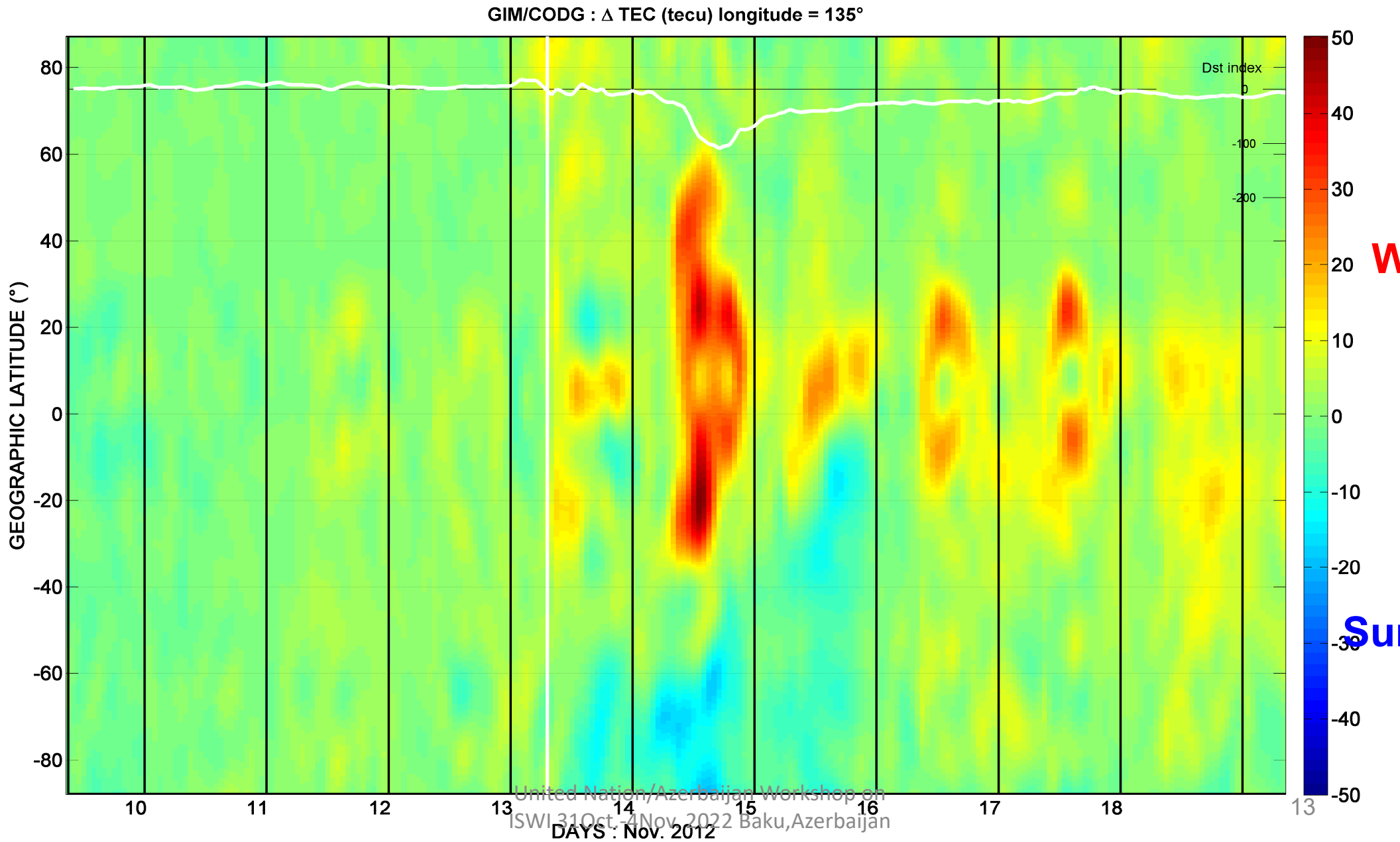
17
18
DAYS : Nov. 2012
110
100
90
80
70
60
50
40
30
20
10
0

08:11LT 135˚E


GIM/CODG : Δ TEC (tecu) longitude = 135°
Dst index
0
-100
-200
GEOGRAPHIC LATITUDE (°)
80
60
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0
-20
-40
-60
-80
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14
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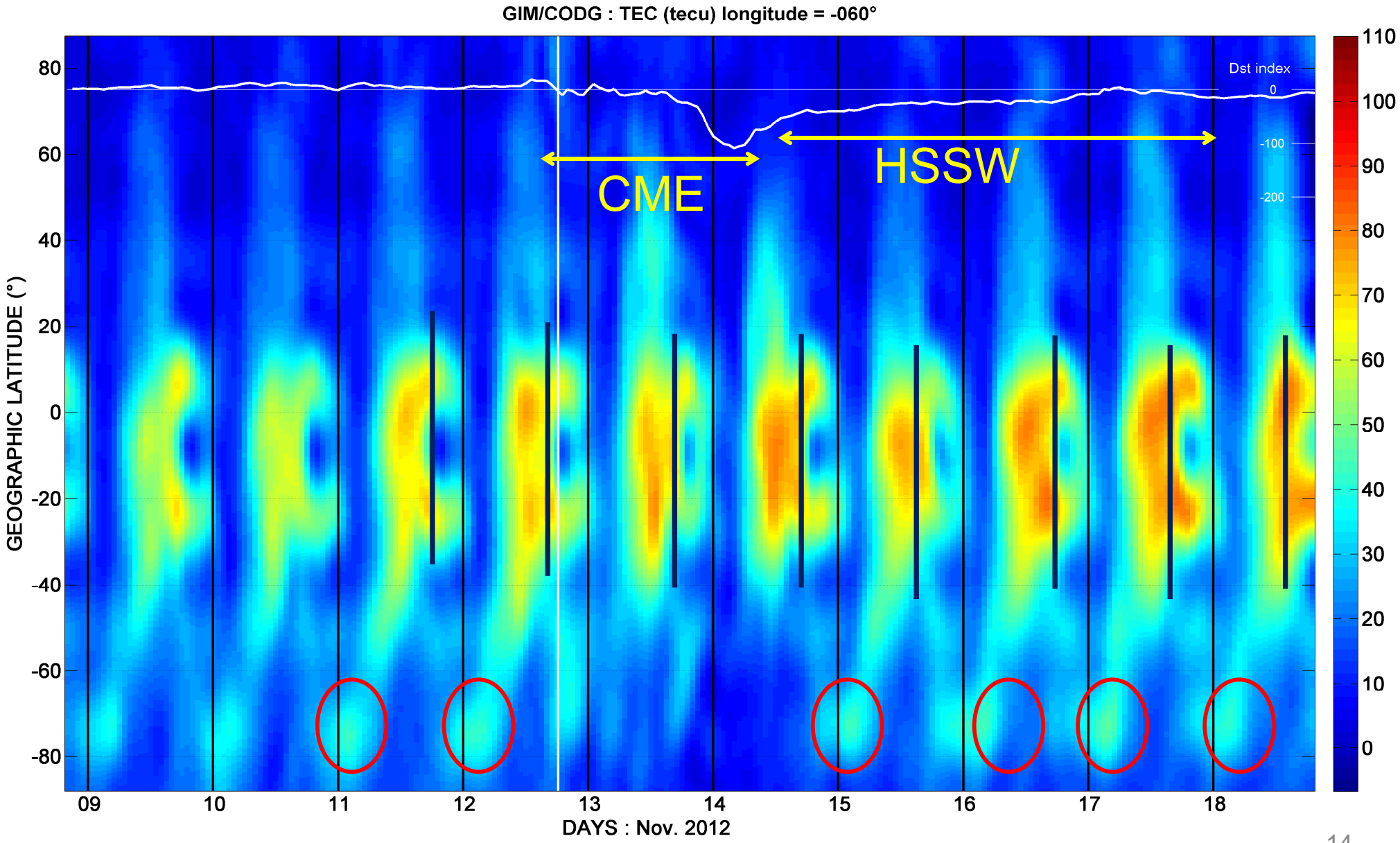
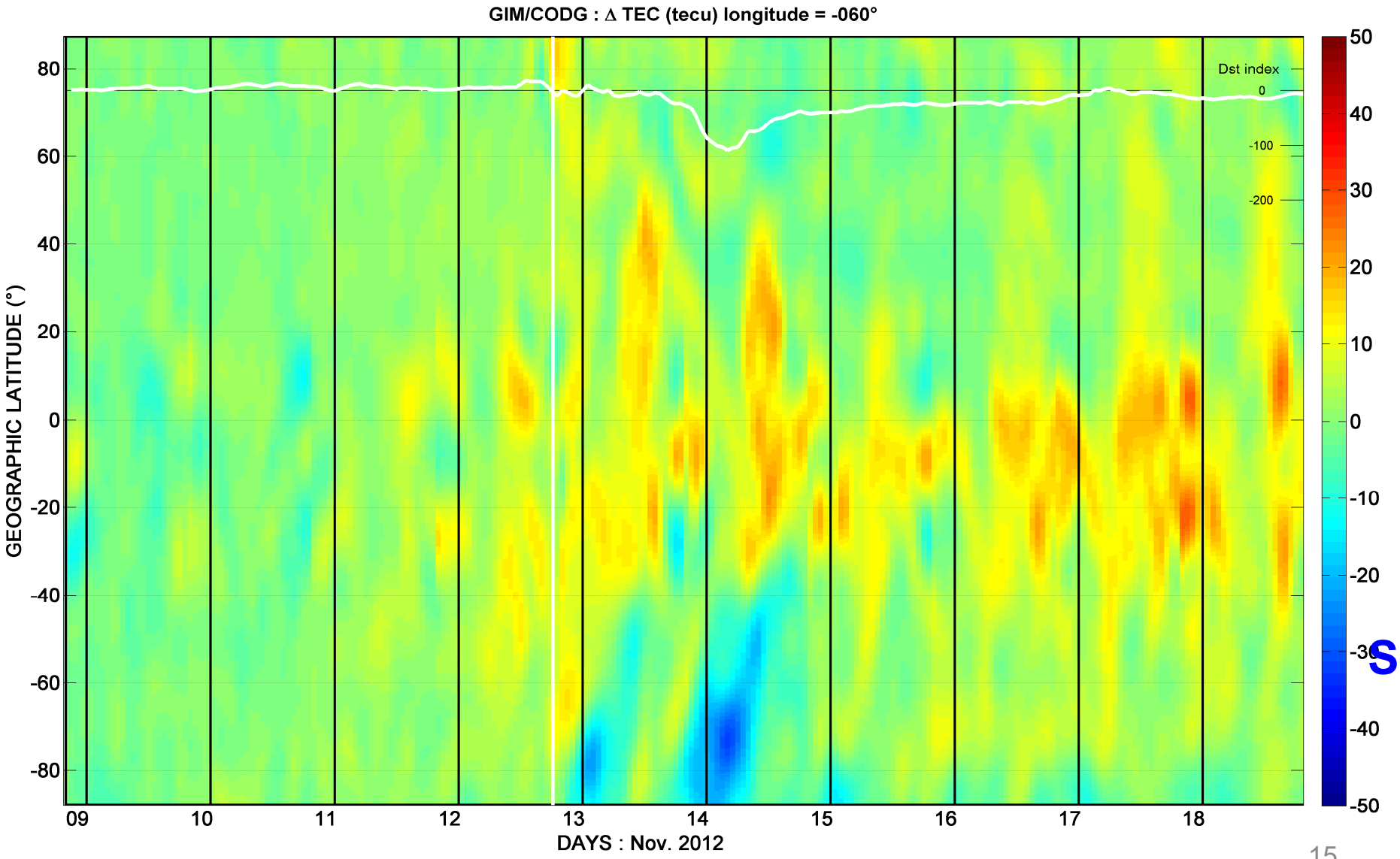
17
18
DAYS : Nov. 2012
50
40
30
20
10
0
-10
-20
-30
-40
-50
W
Su

20:00LT 300˚E


GIM/CODG : TEC (tecu) longitude = -060°
Dst index
0
-100
-200
CME
HSSW
GEOGRAPHIC LATITUDE (°)
80
60
40
20
0
-20
-40
-60
-80
09
10
11
12
13
14
15
16
17
18
DAYS : Nov. 2012
110
100
90
80
70
60
50
40
30
20
10
0

20:00LT 300˚E


GIM/CODG : Δ TEC (tecu) longitude = -060°
Dst index
0
-100
-200
GEOGRAPHIC LATITUDE (°)
80
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-20
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-80
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DAYS : Nov. 2012
50
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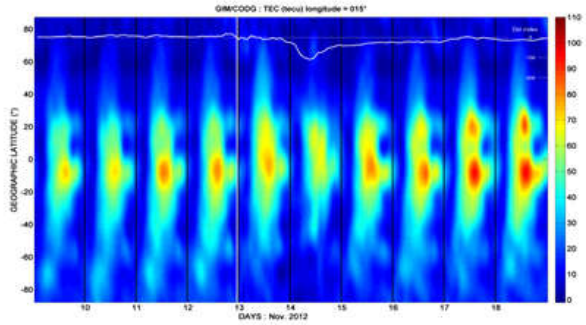
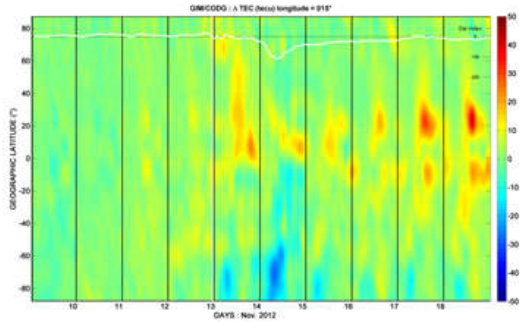
-10
-20
-30
-40
-50

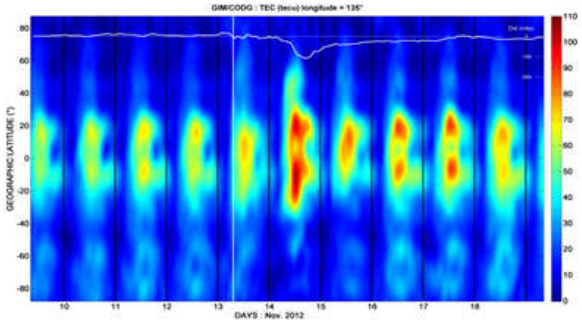
0:00 LT-15˚E

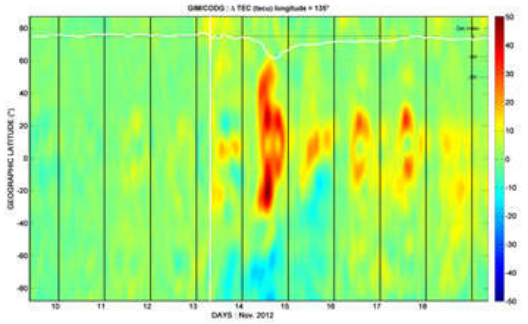
08:11LT 135˚E

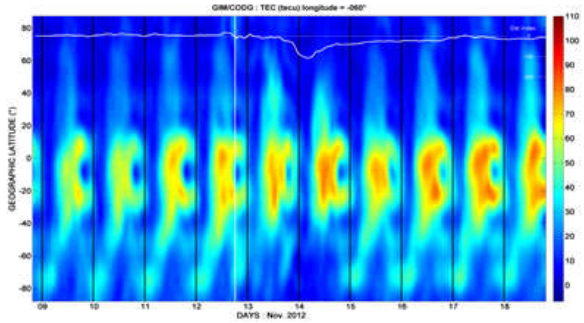
20:00LT 300˚E

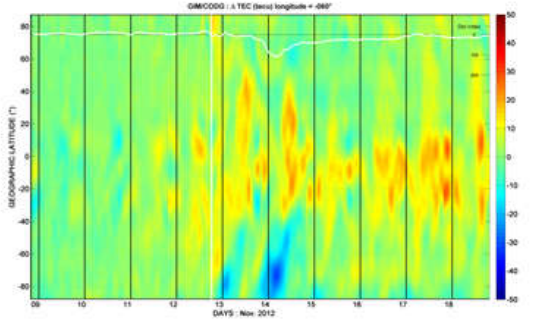








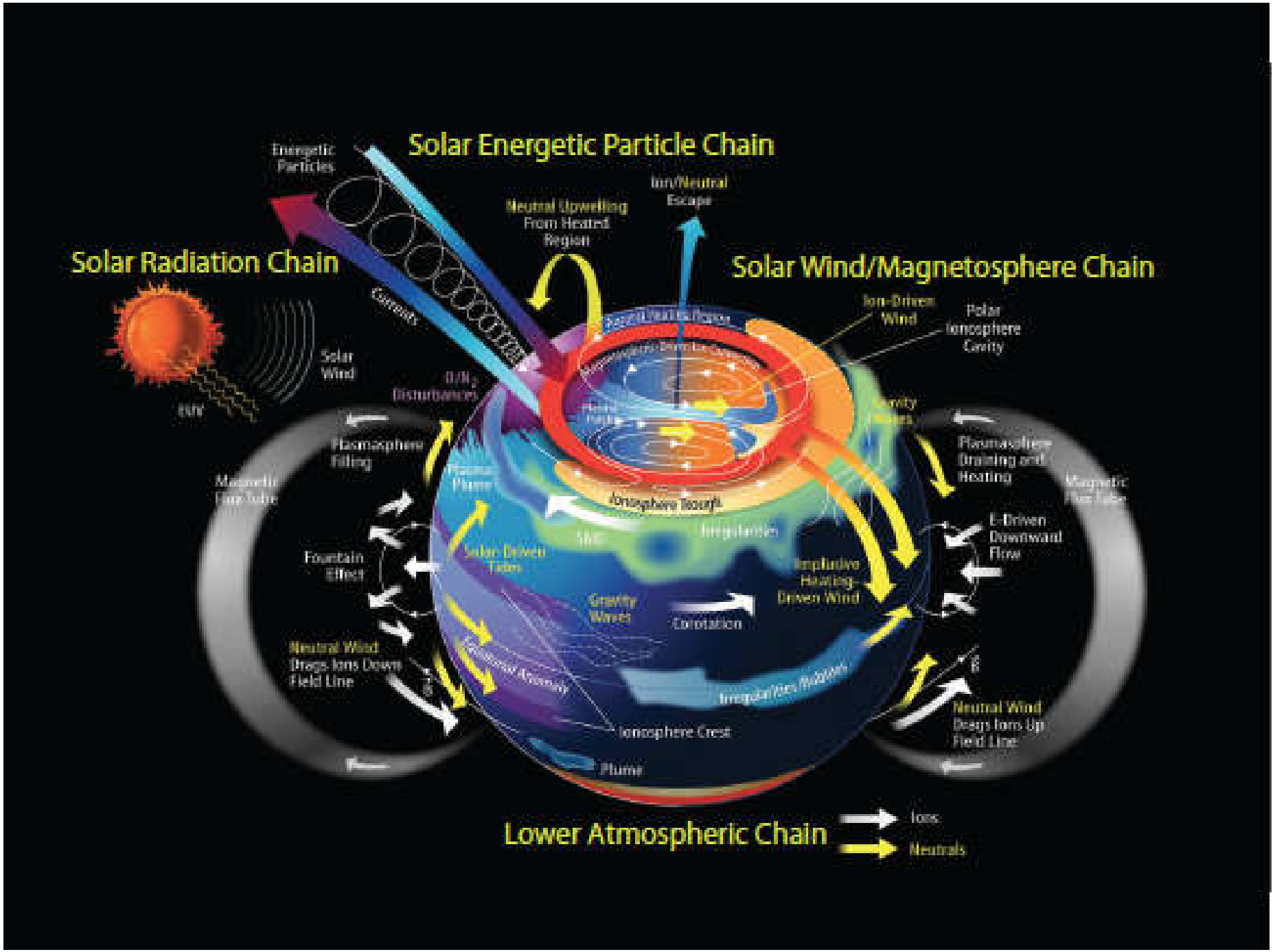




Conclusion

- Typical ionospheric storm +ve phase followed by –ve phase for the mid-latitude When we reach south hemisphere we get Anti-Semitic
- The most dominate effect on the magneto –ionospheric disturbance is the magneto (CME+ Coronal hole) dynamo during this event.
- Positive phase of the ionospheric storm appears after 5 hours as a response to the magnetic storm due to CME
- Recorded the effect of the long period of coronal hole and south Bz corresponding to the recovery phase of the storm
- **The Comparison according to the local time on the 3 longitudes was reported.**
- ***At High-Latitude Region:***
  - –The TEC experiences more fluctuations & so more scintillations.
- ***At Mid-Latitude Region:***
  - –A large asymmetry between the two hemispheres was observed.
- ***At Low-Latitude Region:***
  - –V x B effect Prompt Penetration Effect PPE may be responsible for enhanced TEC observed
  - –Clearly, pre-reversal phenomena was observed at sunset.
- A Traveling Ionospheric Disturbance (TID) in the Northern hemisphere on Nov.,13 was detected .The propagation time of the TID from high to low latitudes and its speed was determined.

Thank you for your attention


Solar Energetic Particle Chain
Energetic Particles
Ion/Neutral Escape
Neutral Upwelling From Heated Region
Solar Radiation Chain
Solar Wind/Magnetosphere Chain
Ion-Driven Wind
Polar Ionosphere Cavity
Solar Wind
EUV
Plasmasphere Filling
Plasmasphere Draining and Heating
Plasma Plume
Magnetic Flux Tube
E-Driven Downward Flow
Fountain Effect
Solar Driven Tides
Impulsive Heating-Driven Wind
Gravity Waves
Coriolis
Neutral Wind Drags Ions Down Field Line
Ionosphere Crest
Plume
Neutral Wind Drags Ions Up Field Line
Lower Atmospheric Chain
Ions
Neutrals

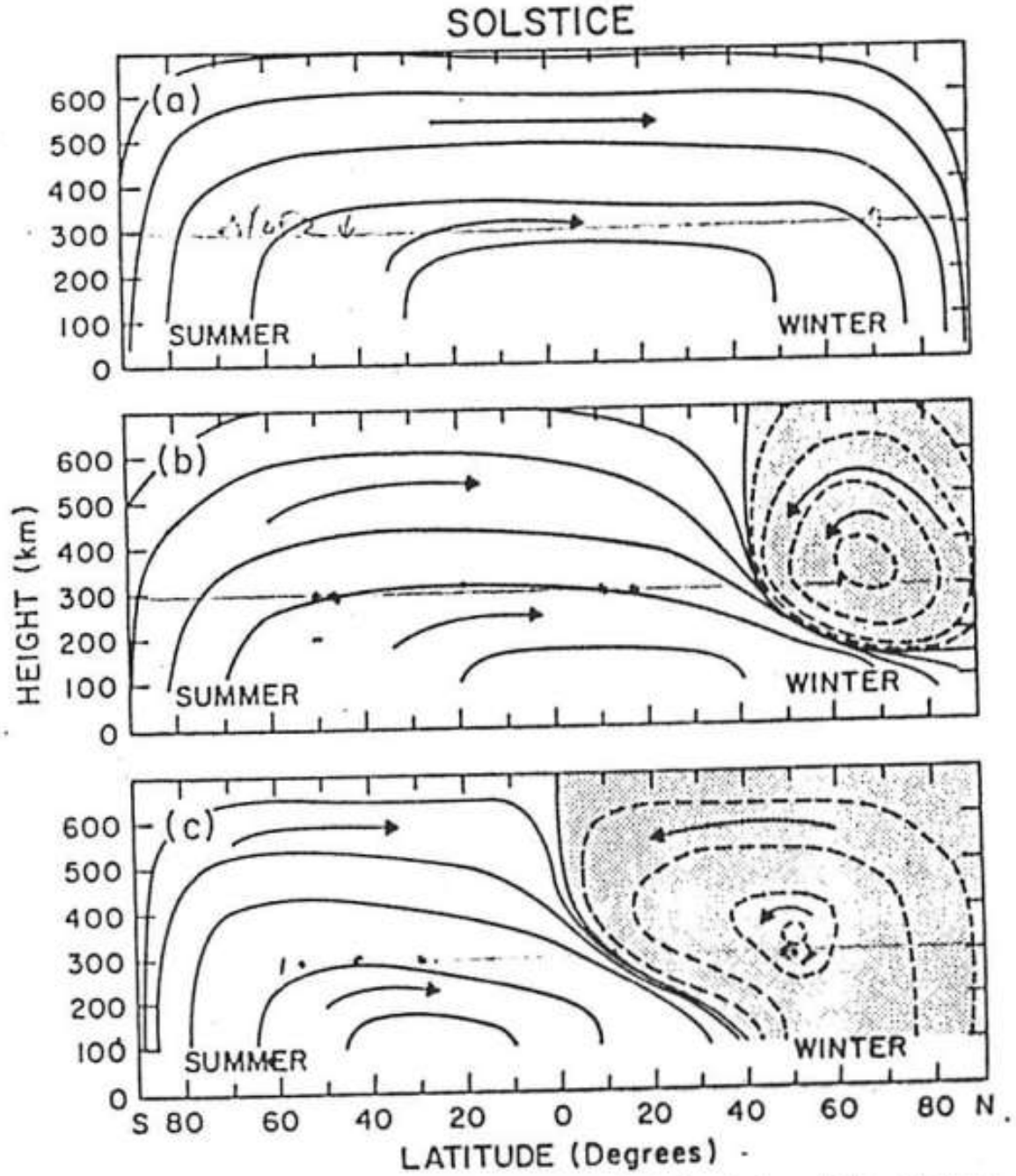


Fig. 2 Schematic diagram of the mean thermospheric circulation during solstice. The upper panel shows the circulation during quiet geomagnetic conditions, the middle panel is for average conditions, and the bottom panel is for geomagnetic storms.

GIM –introduction

- -The IGS Ionosphere Working Group was founded in 1998, then the classical IGS Associated Analysis Centers (IAACs) started to compute and release Global Ionospheric Map (GIM), including CODE, ESA, JPL, NRC and UPC (Feltens and Schaer, 1998; Schaer et al., 1998),and
- -GIM products released by CAS and WHU began to be widely used later (Li et al., 2017; Ang, et al., 2018; Zhang and Zhao (2018)).
- -The accuracy of GIM products is about 2–8 TECU (Total Electron Content Unit), which provides abundant data for the research and application of the ionosphere (Feltens, 2003; Herna´ndez-Pajares et al., 2009; Li et al., 2017).
- - The GIM is mainly based on the comparison of TEC value, , comparing with VTEC and validation with dSTEC (differential slant total electron contents) derived from GNSS observation of IGS station (Li et al., 2017; Herna´ndez-Pajares et al., 2017; Ang, et al., 2018; (Roma-Dollase et al., 2017); Ren et al., 2019; Chen et al., 2020).
- -The quality of the GNSS-based GIMs has been improved since the start of their generation in the nineties of the last century,
- -The difficulties to provide reliable values still exist in most of the ionosphere, such as the oceans, southern hemisphere and somewhere far from permanent GPS receivers since VTEC values are mostly based on the interpolation techniques (Herna´ndez-Pajares et al., 2017).
- -the effect of GIM products in correcting ionospheric delay errors needs to be systematically demonstrated.
- -The positioning accuracy reflecting the correction effects is a way to evaluate the performance of GIMs (Orus et al., 2002).
- the positioning accuracy in the mid-latitude regions was better than that in the low latitude regions similar to the other models(Luo et al., 2014).