

# Changes of electron density profiles and TEC during extreme manifestation of Solar activity.

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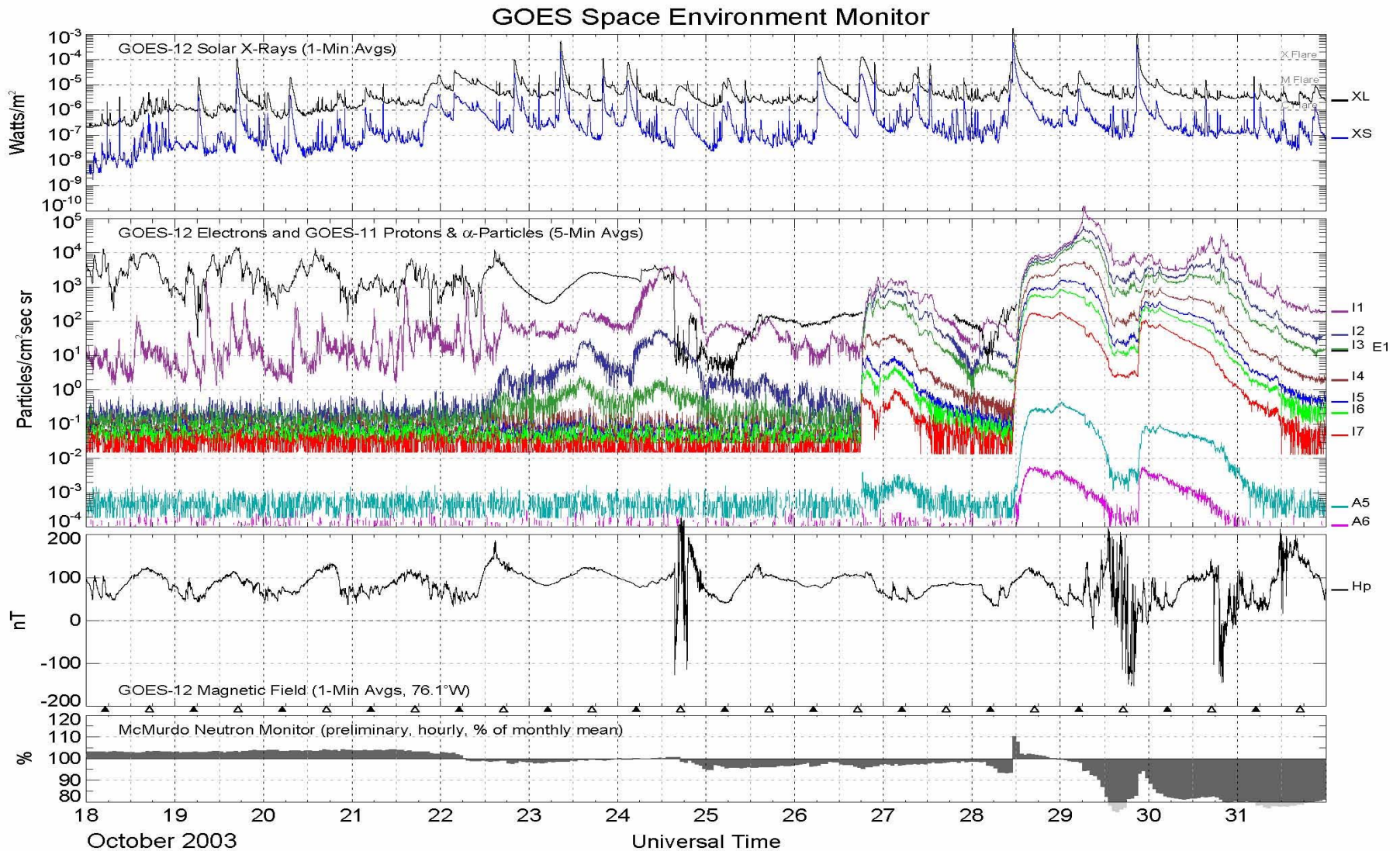
Institut of Atmospheric Physics AS CR

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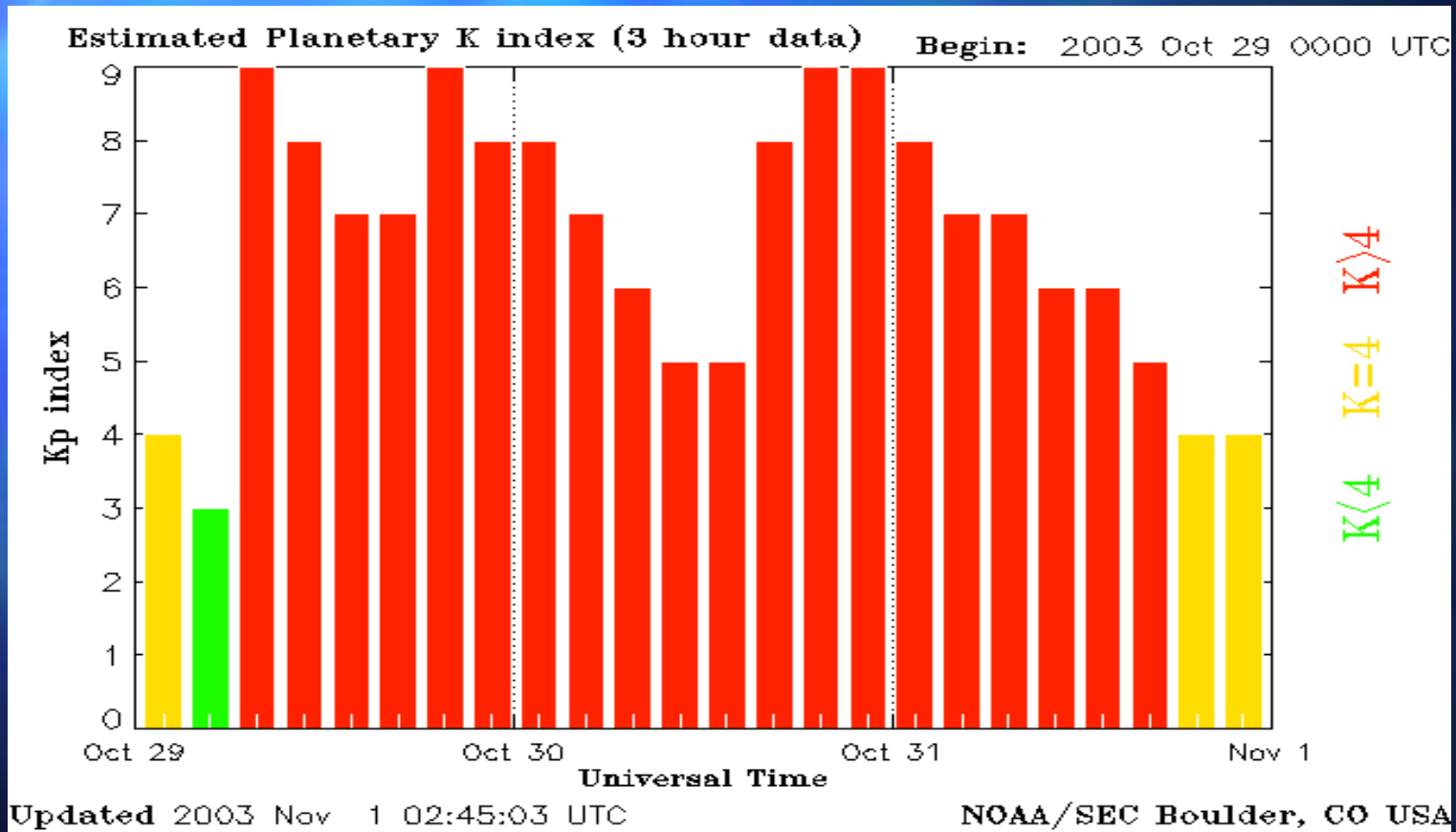
# Introduction.

- This contribution deals with changes in Earth's ionosphere during most extreme events of Solar activity ( $Dst > 200$  nT).
- During October - November 2003, in descending phase 11-year Solar sunspot cycle, two periods of suddenly enhanced solar activity was observed. Two geomagnetic storms (28.10. – 5.11. 2003 and 19.11. – 23.11. 2003) with  $Kp = 9$  was accompanied by strong disturbances in Earth's ionosphere. The effects of these strong ionospheric storms as was observed at Průhonice observatory (49.59 N; 14.33 E) and other European ionospheric stations are described at this paper.

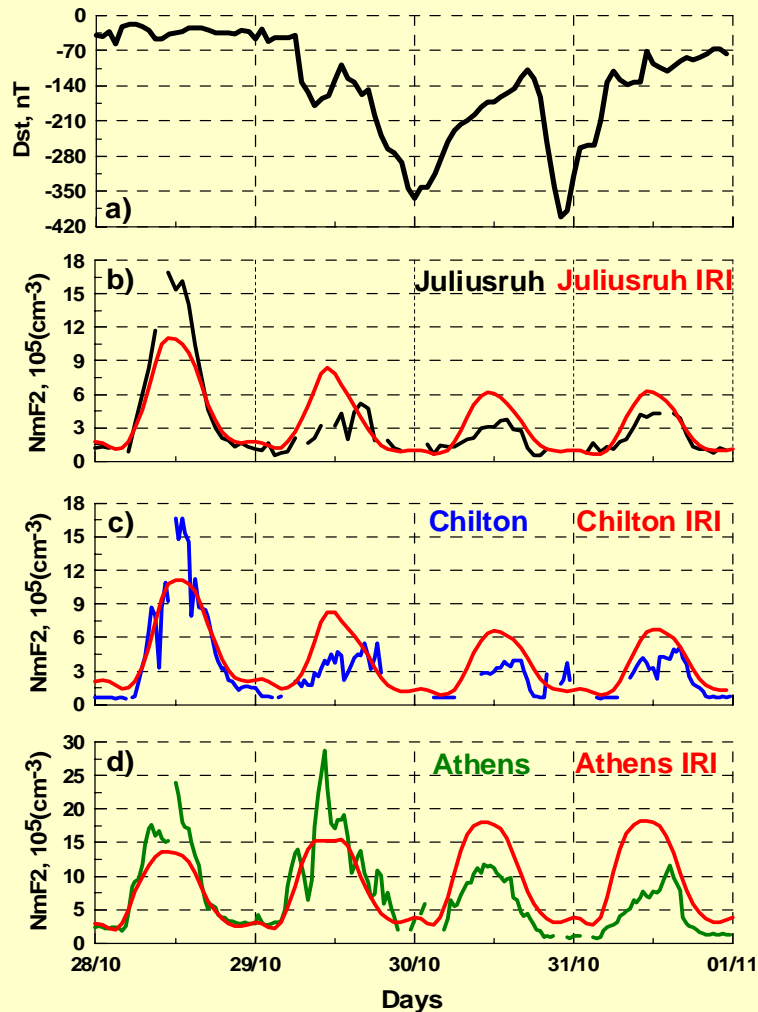
# Geomagnetic storm 28.10. – 1.11. 2003.



# Geomagnetic storm 29.10. – 1.11.2003 Kp index reached maximum value 9 during 30.10. – 31.10.2003 (Dst –383).

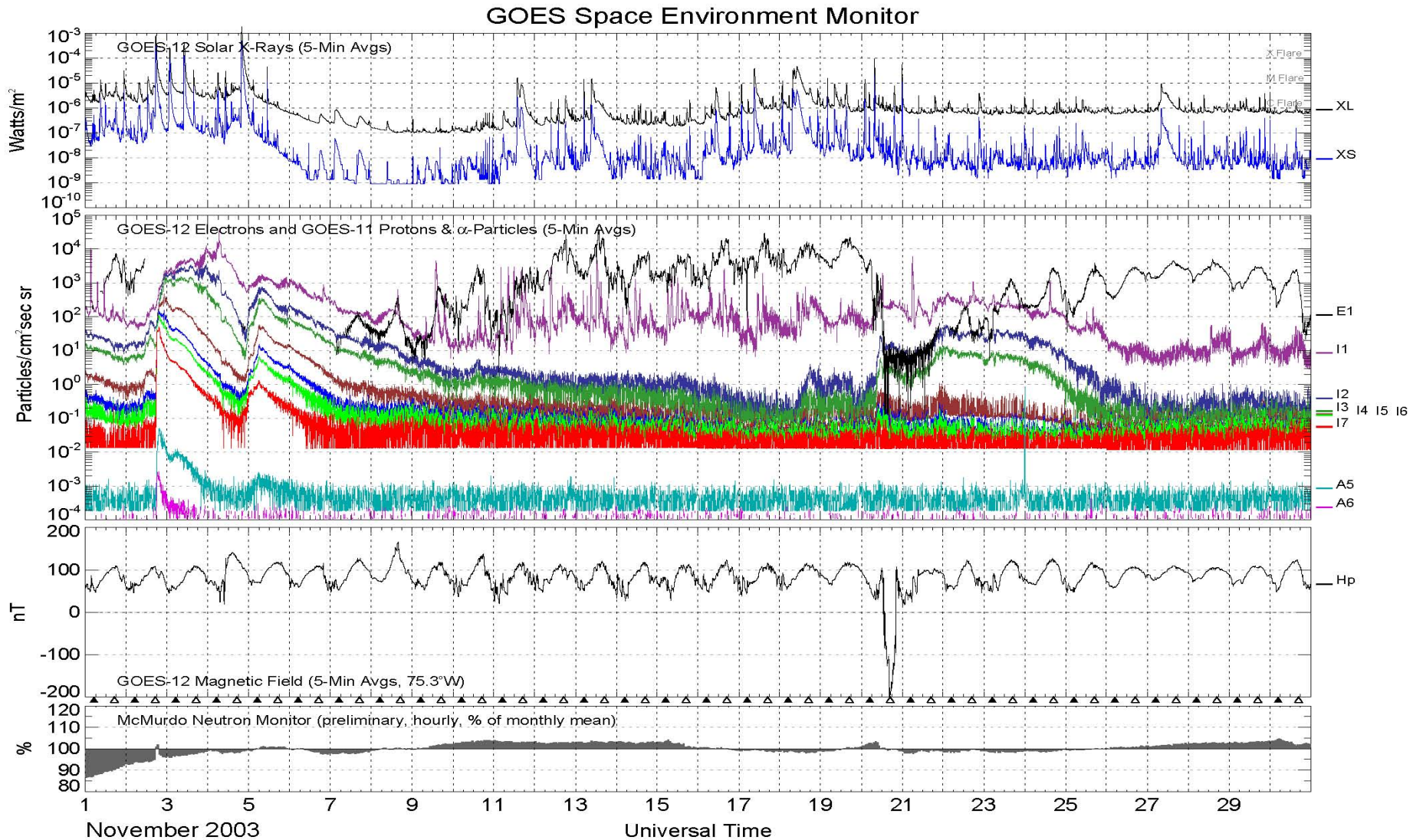


# Ionospheric storm October - November 2003, critical frequency of the F2 ionospheric layer.

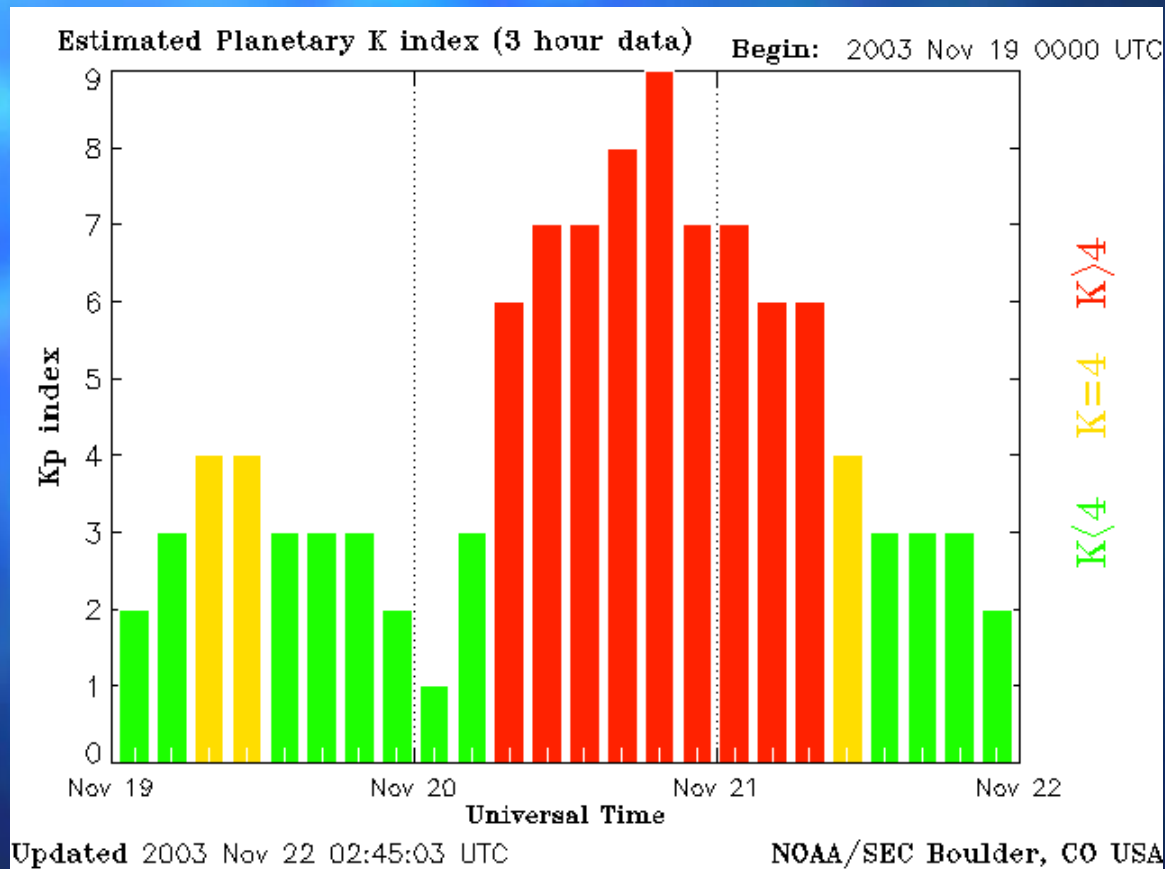


- Juliusruh (54.6N, 13.4E)
- Chilton (51.5N, -1.3E)
- Athens (38.0N, 23.6E)
- IRI model data

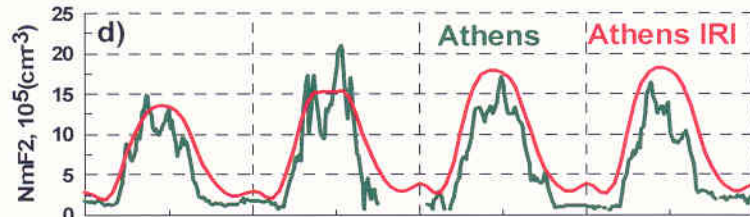
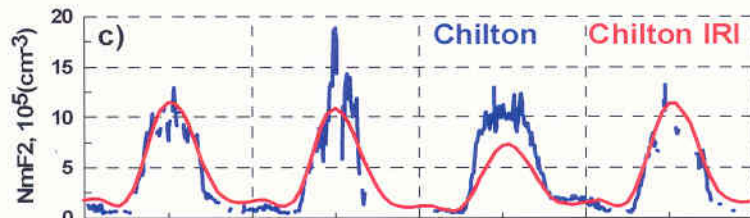
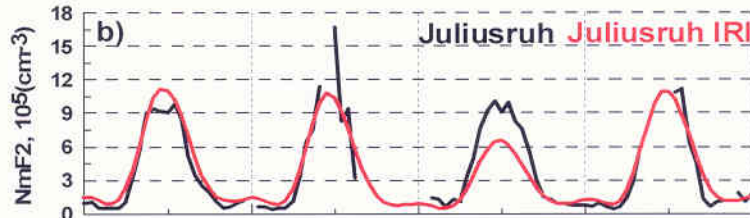
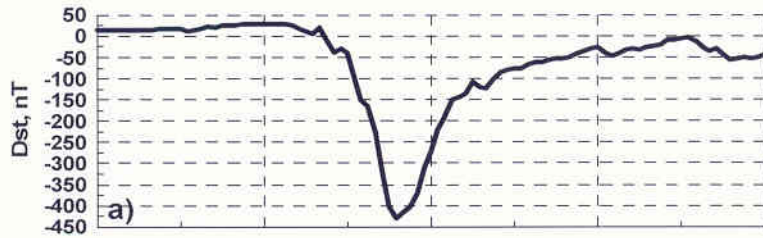
# Geomagnetic storm 20.11.- 23.11. 2003



# Geomagnetic storm 20.11. – 23.11.2003 Kp index (Dst -422).



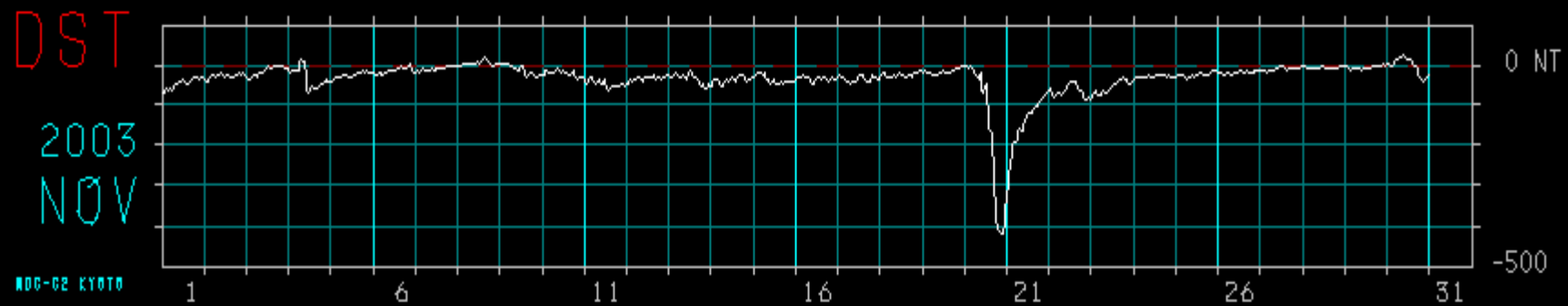
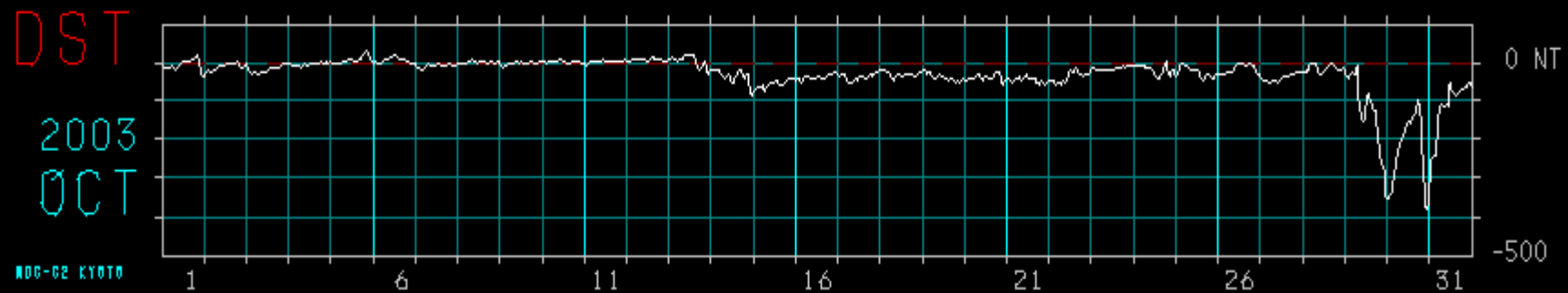
# Ionospheric storm 20.11. – 23.11.2003



19.11. 20.11. 21.11. 22.11.

- **Juliusruh (54.6N, 13.4E)**
- **Chilton (51.5N, -1.3E)**
- **Athens (38.0N, 23.6E)**
- **IRI model data**

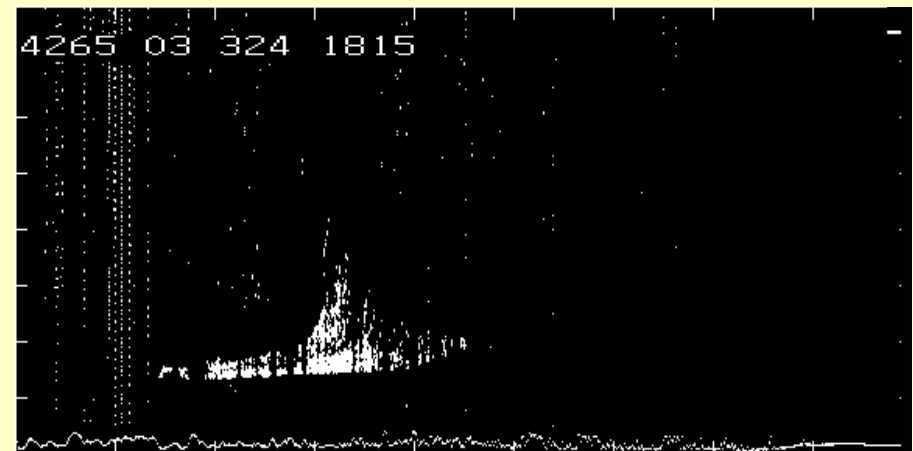
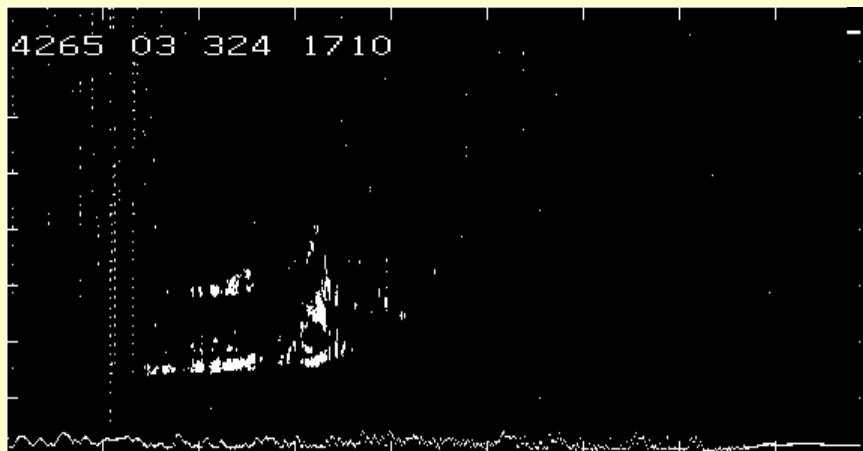
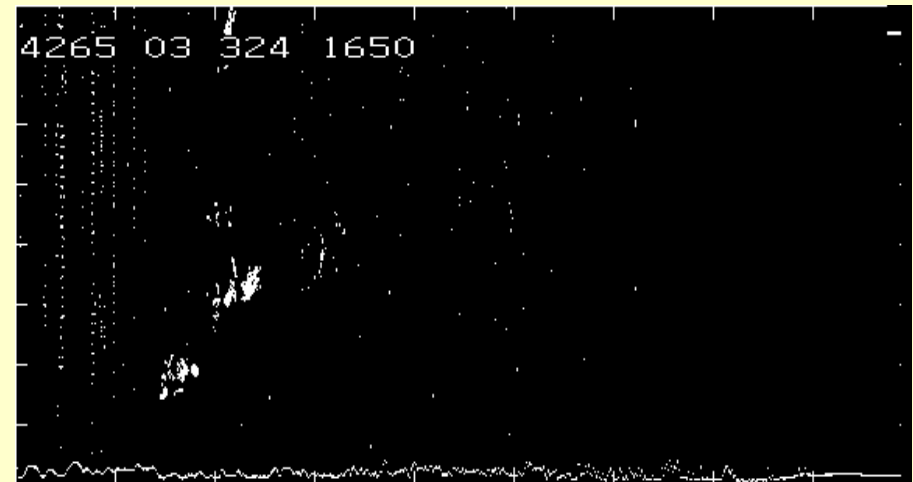
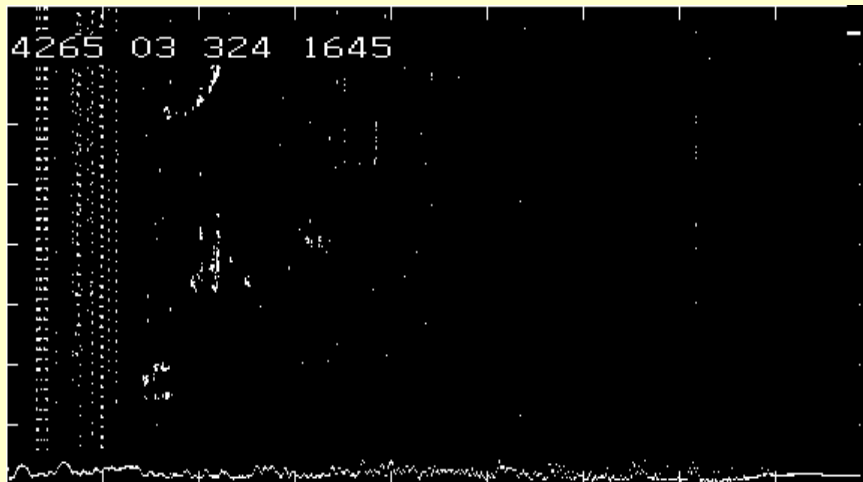


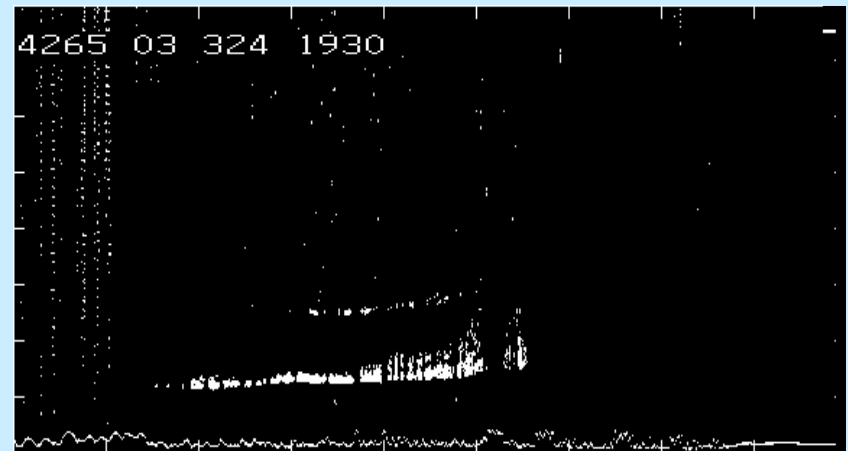
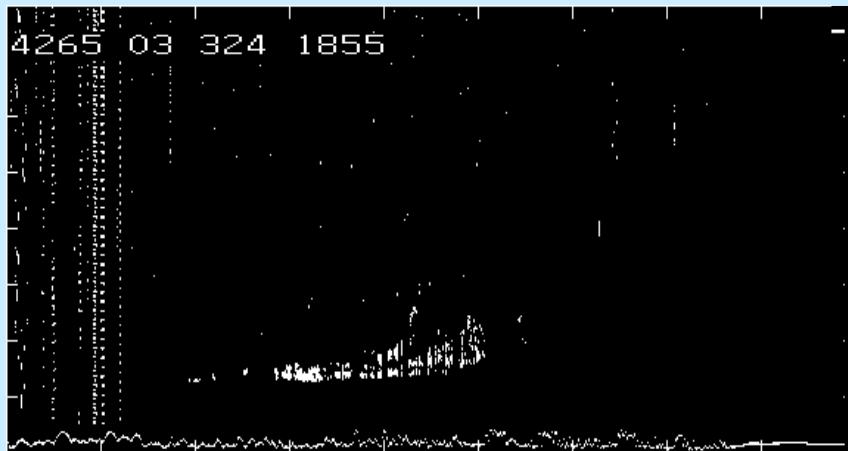
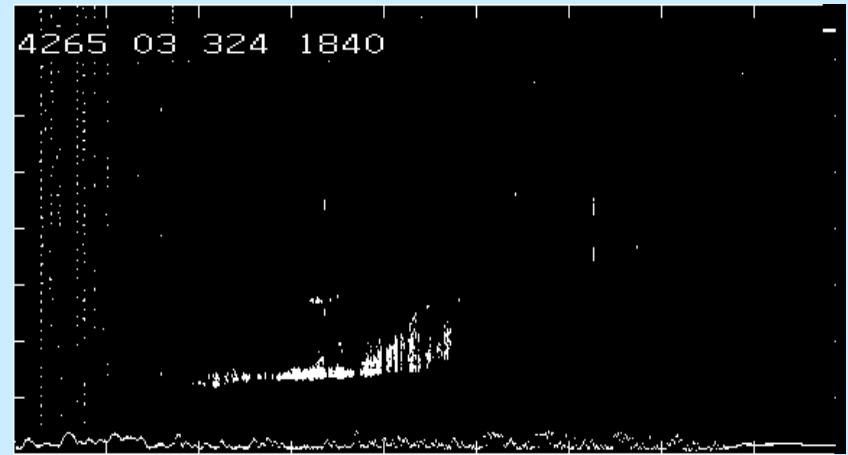
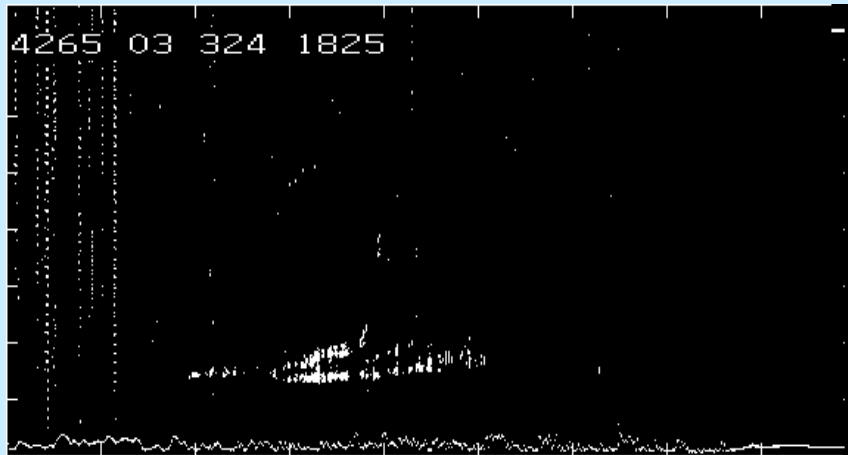


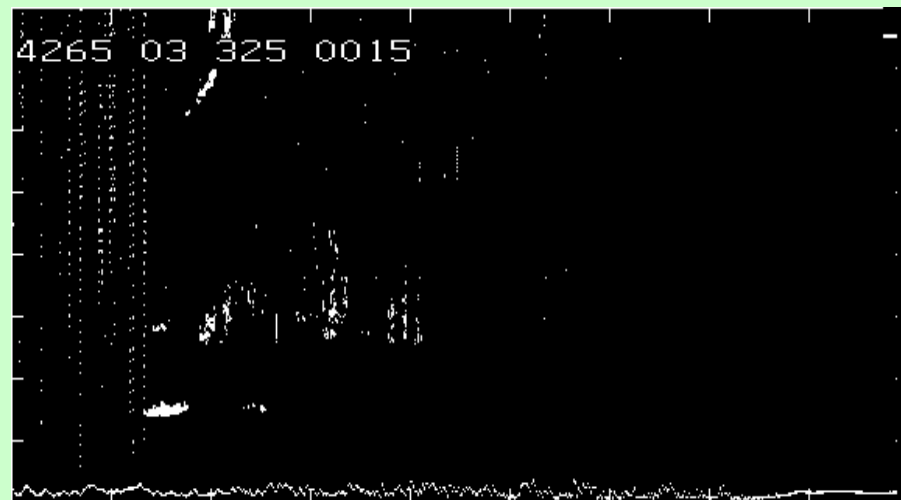
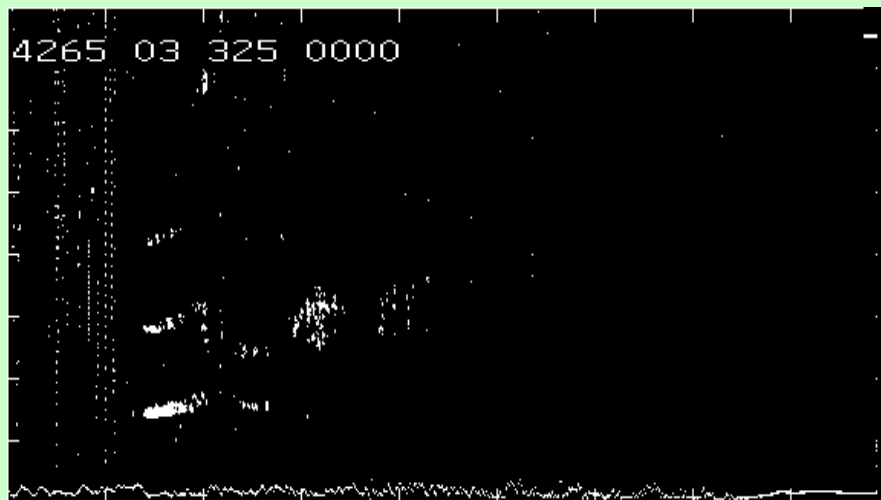
- 30.10.2003 Dst -383.
- 20.11.2003 Dst -422



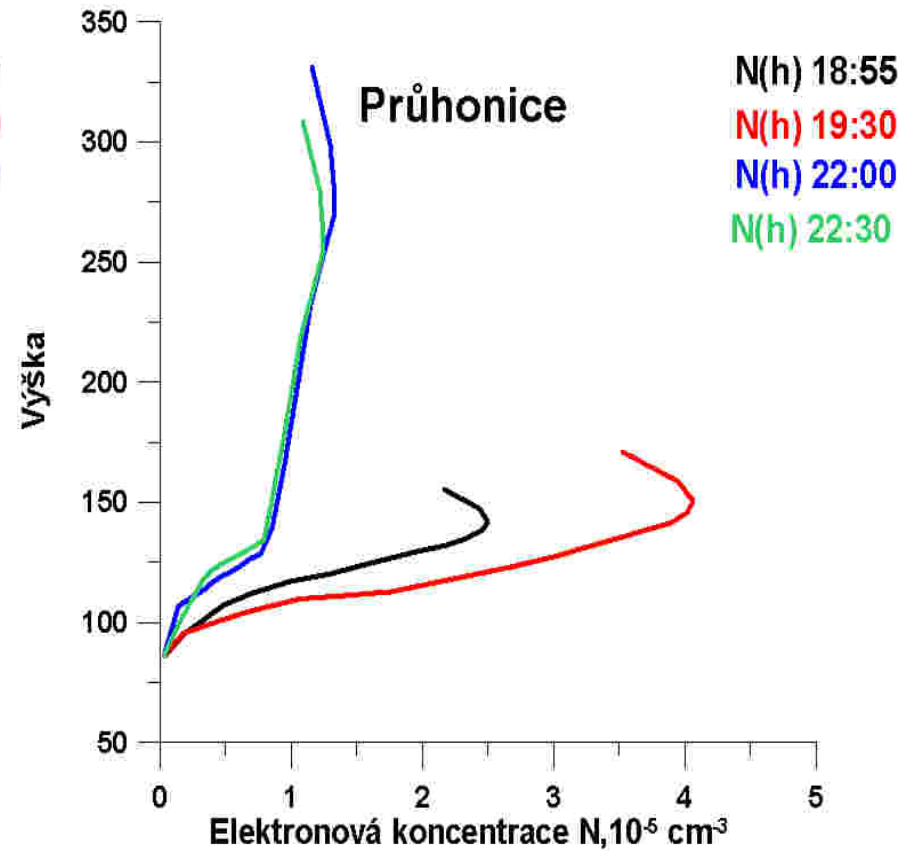
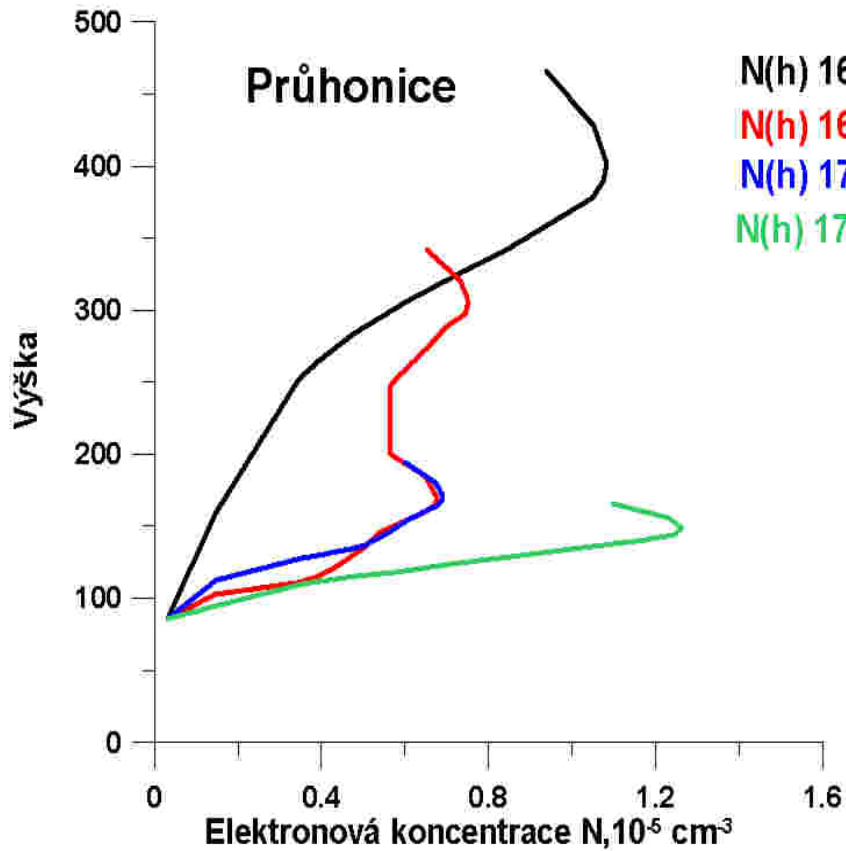
**A serie of ionograms observed at Průhonice observatory during second storm 20.11.2003; 16:00 – 24:00 UT. Quite unusual ionospheric layer, (formed most probably by particle ionization) with virtual heights about 150 – 200 km were observed. The layer existed for several hours. This types of effects was observed at midlatitude stations Průhonice.**

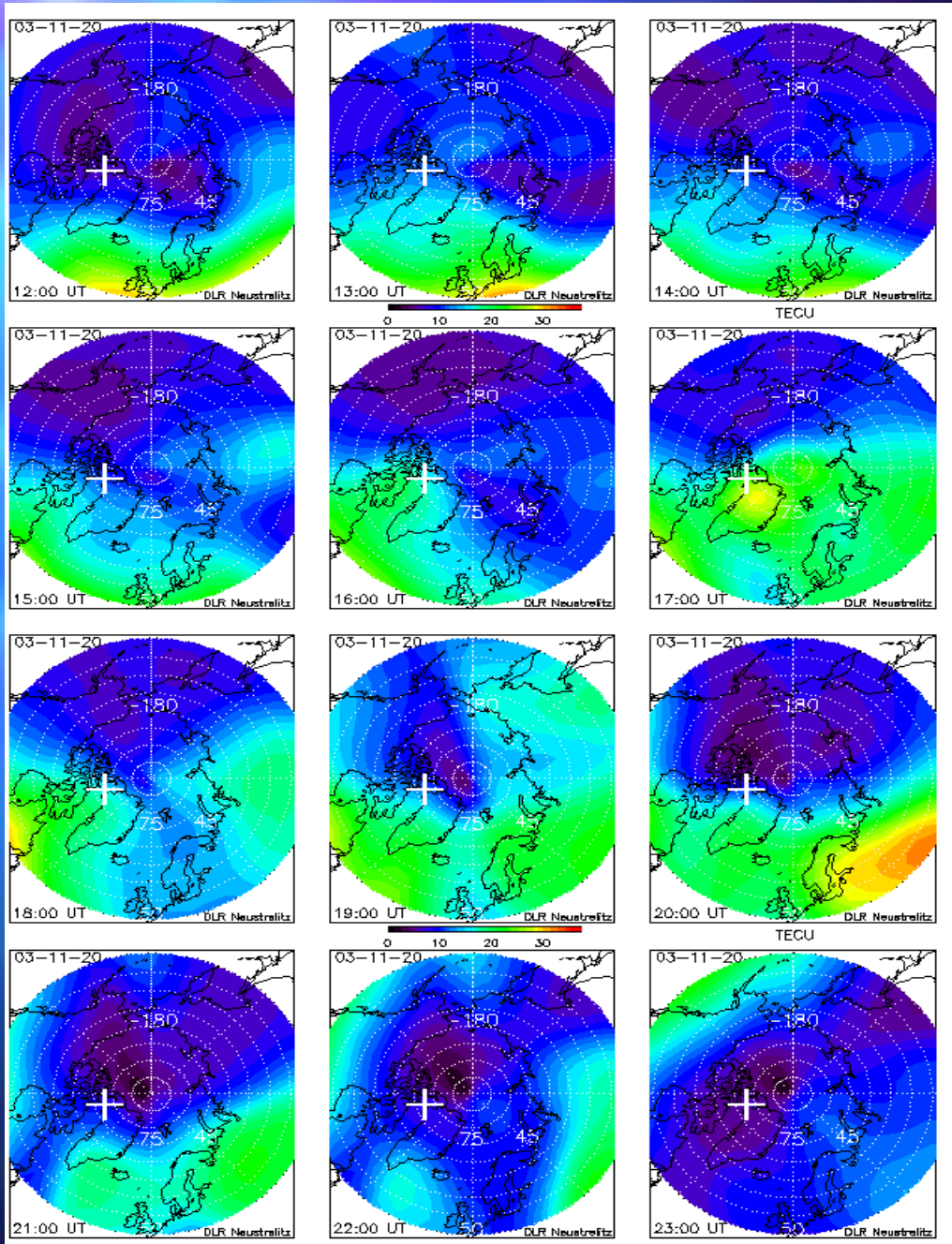






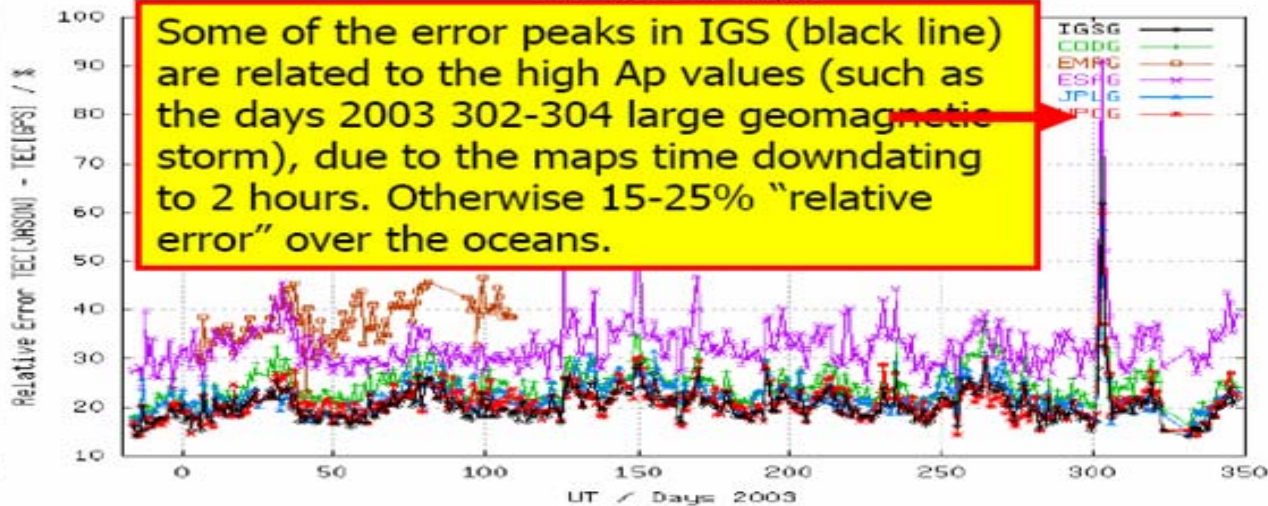
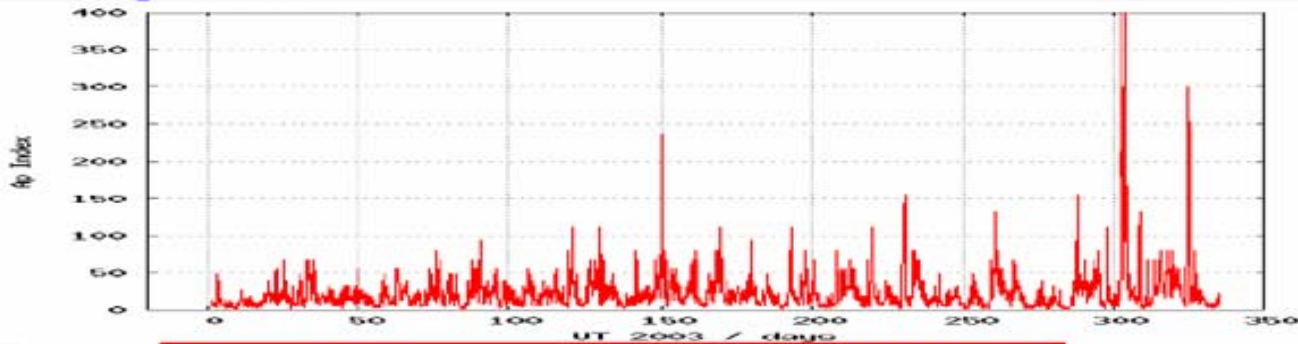
**Electron density profiles computed from ionograms 20.11.2003 16:30 – 22:30. The value of maximum of electron concentration changed very quickly and reached about 19:30 daily values. The height of extraordinary layer is typical for particle layers. Normal night time height of F2 layer is about 350 km.**





TEC maps  
over North pole  
area  
20.11.2003  
Neustrelitz

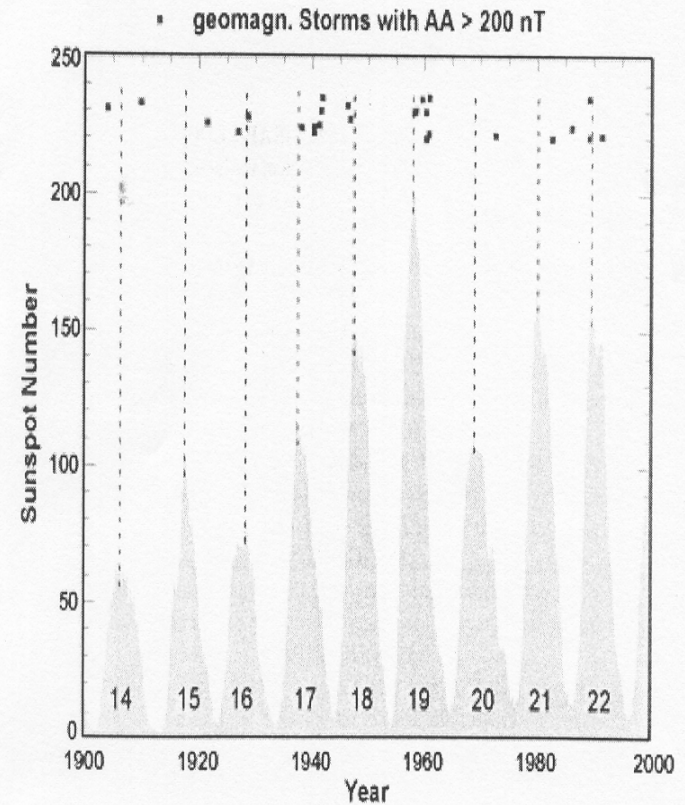
## Ap index vs. "Relative Error"



- ( M. Hernández-Pajares; COST 271 Final Meeteng; Abingdon 2004)

# The Strongest Geomagnetic storms of the 20.Century

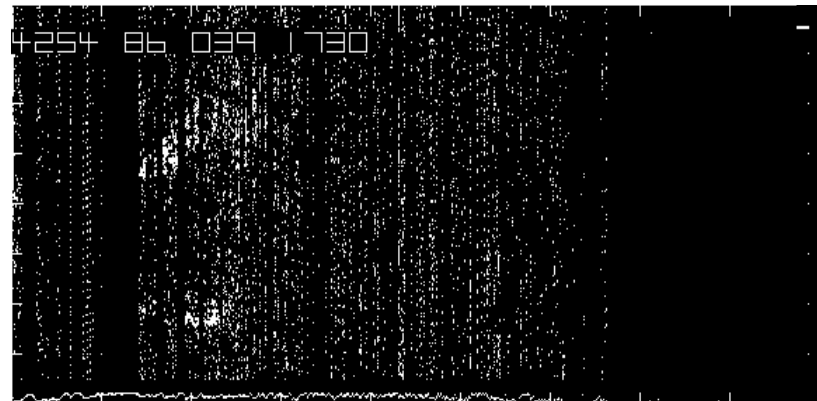
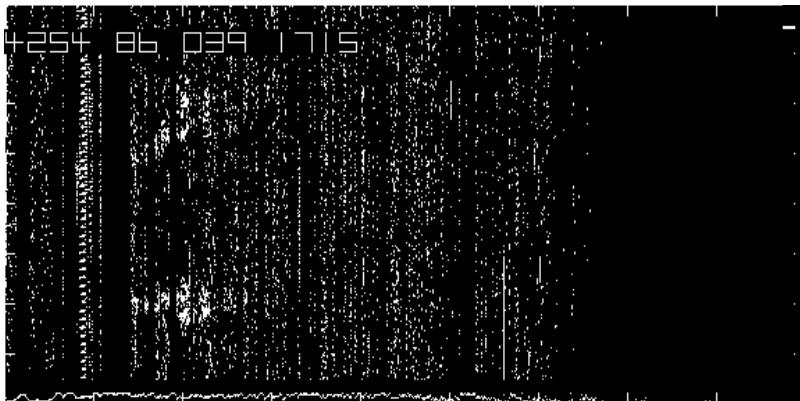
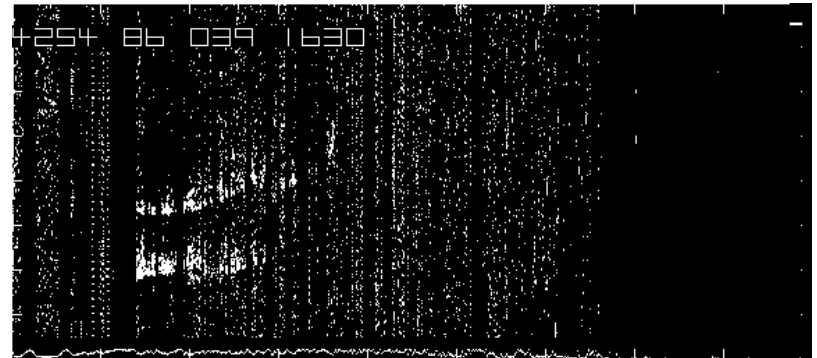
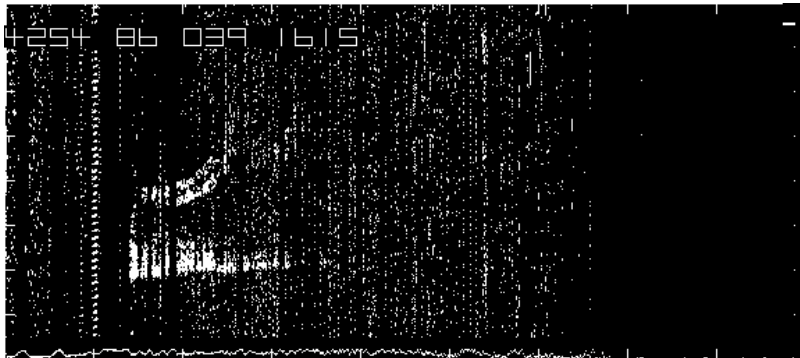
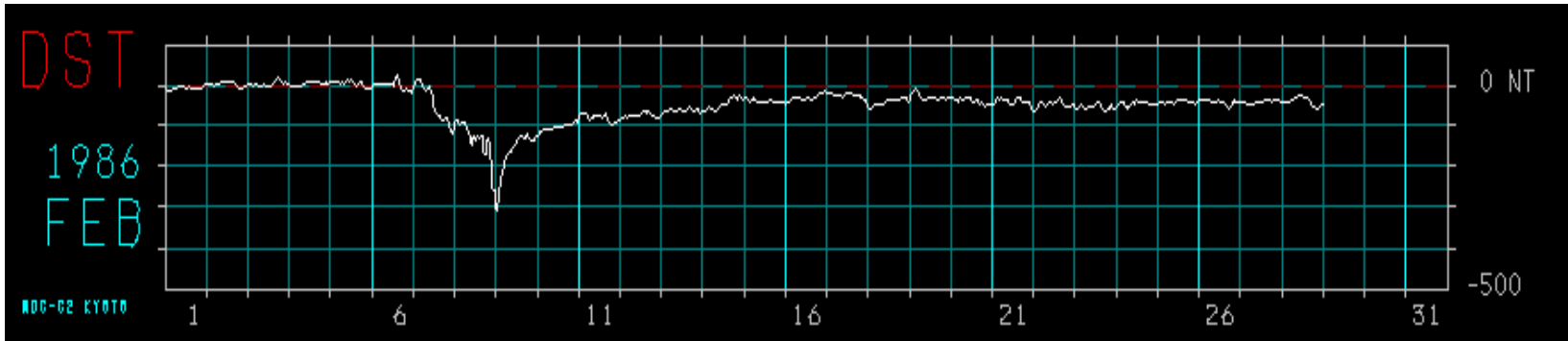
Date	AA	max K <sub>p</sub>	min Dst	aurora
13 - 14.3.1989	441	9 <sub>o</sub>	-589	24 N
18 - 19.9.1941	429	9 <sub>-</sub>	-	29 N
24 - 25.9.1940	377	9 <sub>o</sub>	-	39 N
12 - 13.11.1960	372	9 <sub>o</sub>	-339	28 N
15 - 16.6.1959	357	9 <sub>o</sub>	-429	48 N
14 - 15.5.1921	356	-	-	14 S
25 - 26.9.1909	333	-	-	39 N
28 - 29.3.1946	329	9 <sub>o</sub>	-	27 S
7 - 8.6. 1928	325	-	-	24 N
31.10. - 1.11.1903	324	-	-	50 N
8 - 9.6.1958	314	9 <sub>o</sub>	-330	38 N
31.3 - 1.4.1960	312	9 <sub>o</sub>	-327	36 N
5 - 6.7.1941	302	9 <sub>o</sub>	-	42 N
11 - 12.2.1958	298	9 <sub>o</sub>	-426	25 N
22 - 23.9.1946	295	9 <sub>o</sub>	-	30 N
4 - 5.8.1972	290	9 <sub>o</sub>	-125	48 N
8 - 9.2.1986	287	9 <sub>o</sub>	-307	48 N
25 - 26.5.1967	279	9 <sub>o</sub>	-387	50 N
13 - 14.7.1982	268	9 <sub>o</sub>	-325	50 N
7 - 8.2.1946	256	9 <sub>-</sub>	-	55 N
1 - 2.3.1941	254	9 <sub>o</sub>	-	43 S
6 - 7.10.1960	253	9 <sub>o</sub>	-257	49 N



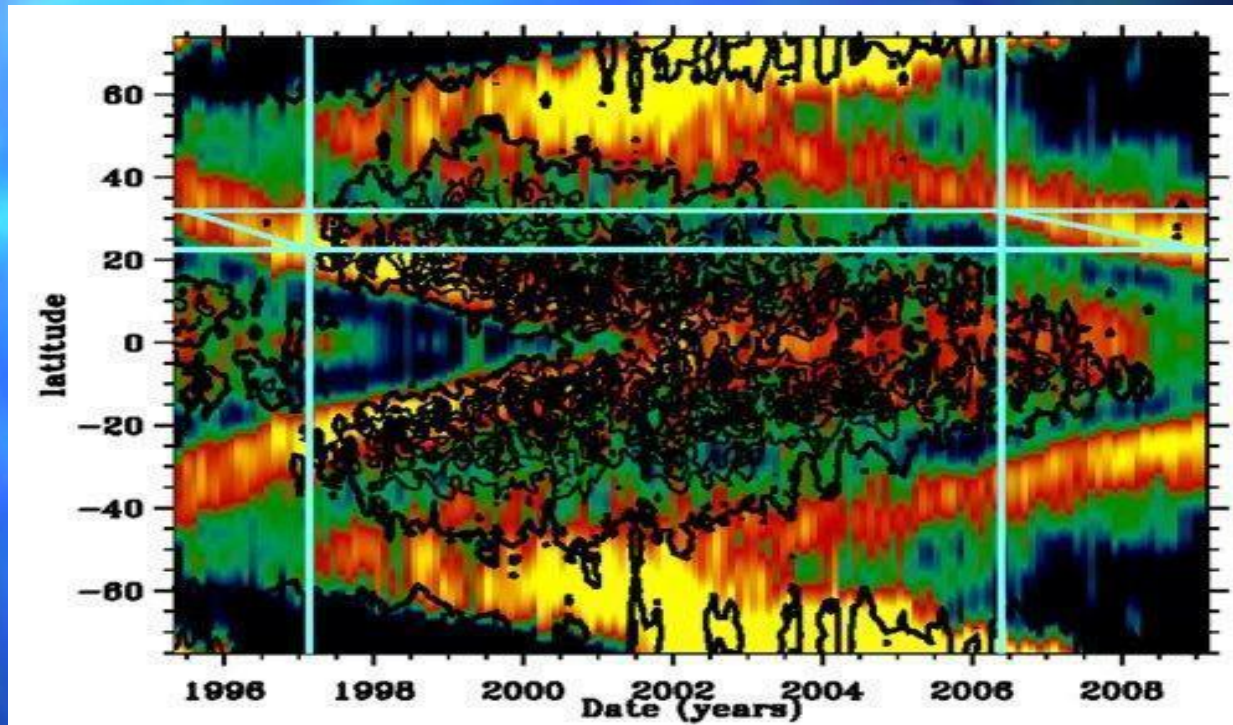
**K<sub>p</sub> since 1932, Dst since 1957 (Schlegel; Rad.Sci.Bull.2001).**



# Ionospheric observations during Storm 8-9.2.1986 Dst -307 (Průhonice)



# Solar cycle 24?



- R. Howe and F. Hill of the National Solar Observatory (NSO) Tucson, (2009), used a technique called helioseismology (combined data from "Global Oscillation Network Group" GONG and SOHO) to detect and track the jet stream down to depths of 7,000 km below the surface of the sun. The sun generates new jet streams near its poles every 11 years. The streams migrate slowly from the poles to the equator and when a jet stream reaches the critical latitude of 22 degrees, new-cycle sunspots begin to appear. Howe and Hill found that the stream associated with the next solar cycle has moved sluggishly, taking three years to cover a 10 degree range in latitude compared to only two years for the previous solar cycle.

# **Conclusion.**

- **Two periods of a suddenly enhanced solar activity in October and November 2003 resulted two strong geomagnetic and ionospheric storms. The effects of these events was increasing of the TEC and degraded GPS position accuracy.**
- **The storm of 20.11.2003 resulted dramatic effects in Earth's ionosphere. During this storm extraordinary particle ionospheric layer at the heights 150 – 250 km was created. This layer existed several hours around sunset. These type of effect was observed during another extreme manifestations of the solar and geomagnetic activity also. (Storms 8.2.1986, 13.3. and 17.11.1989).**
- **These strongest manifestation of the Solar and geomagnetic activity are observed usually during the descending phase of the Solar cycle.**