BEOBAL Project conference

- “Global Changes, Environment,
- Sustainable Development of the Society
- and High Mountain Observatories Network”
- March 21 - 25, 2007
- Gyuletchitsa, Rila Mountain, Bulgaria

Effects of Galactic and Solar Cosmic Rays on Ozone and Other Minor Constituents in the Atmosphere

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Effects of Galactic and Solar Cosmic Rays on Ozone and Other Minor Constituents in the Atmosphere

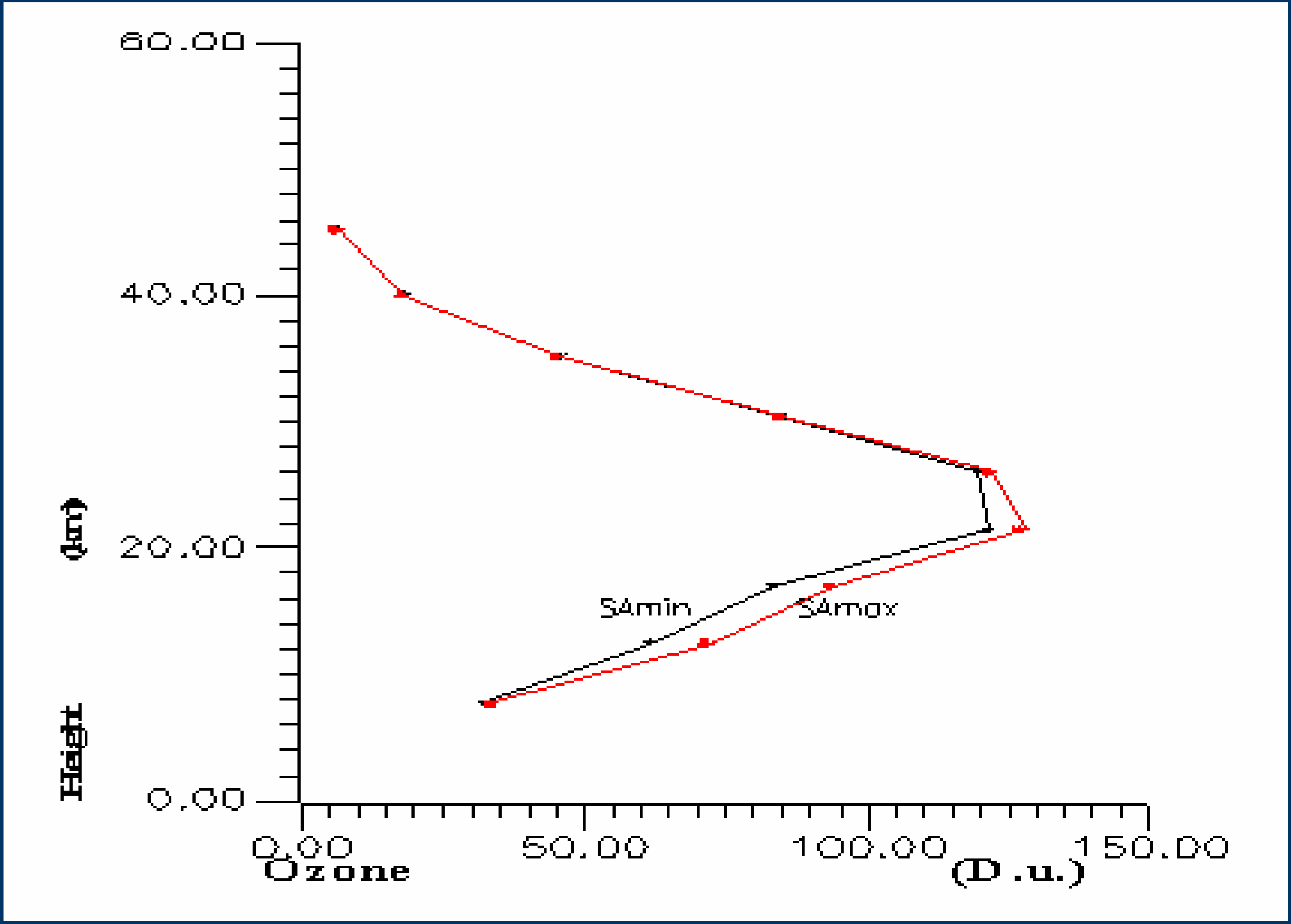
- ABSTRACT - part I
- The variations of the concentration of various small constituents in the middle atmosphere (18-40km): ozone O_3, chlore Cl, nitric oxides NOx, fluor F compounds, also of brome Br, hydrogen H and freons during and after strong solar protone flares are analysed in this paper. The obtained results are from statistical analysis of satellite data from Halogen Occultation Experiment (HALOE), which is realized on the Upper Atmosphere Research Satellite (UARS). This analyze show distributions of investigated minor constituents during proton flares, which are in some contrast to recently accepted theory. An attempt is made in this paper to explain these results. Possible realizations of some reactions are given, based on quantitative and qualitative analysis. Evaluations are made for some endothermic reactions and their possible realization during the precipitation of high-energetic solar particles. The results obtained show that an increase of ozone concentration together with a decrease of some of the freon constituents is possible. These results demonstrate for the first time that a compensation of the ozone concentration during proton flares can take place.

Resultant from OZONE

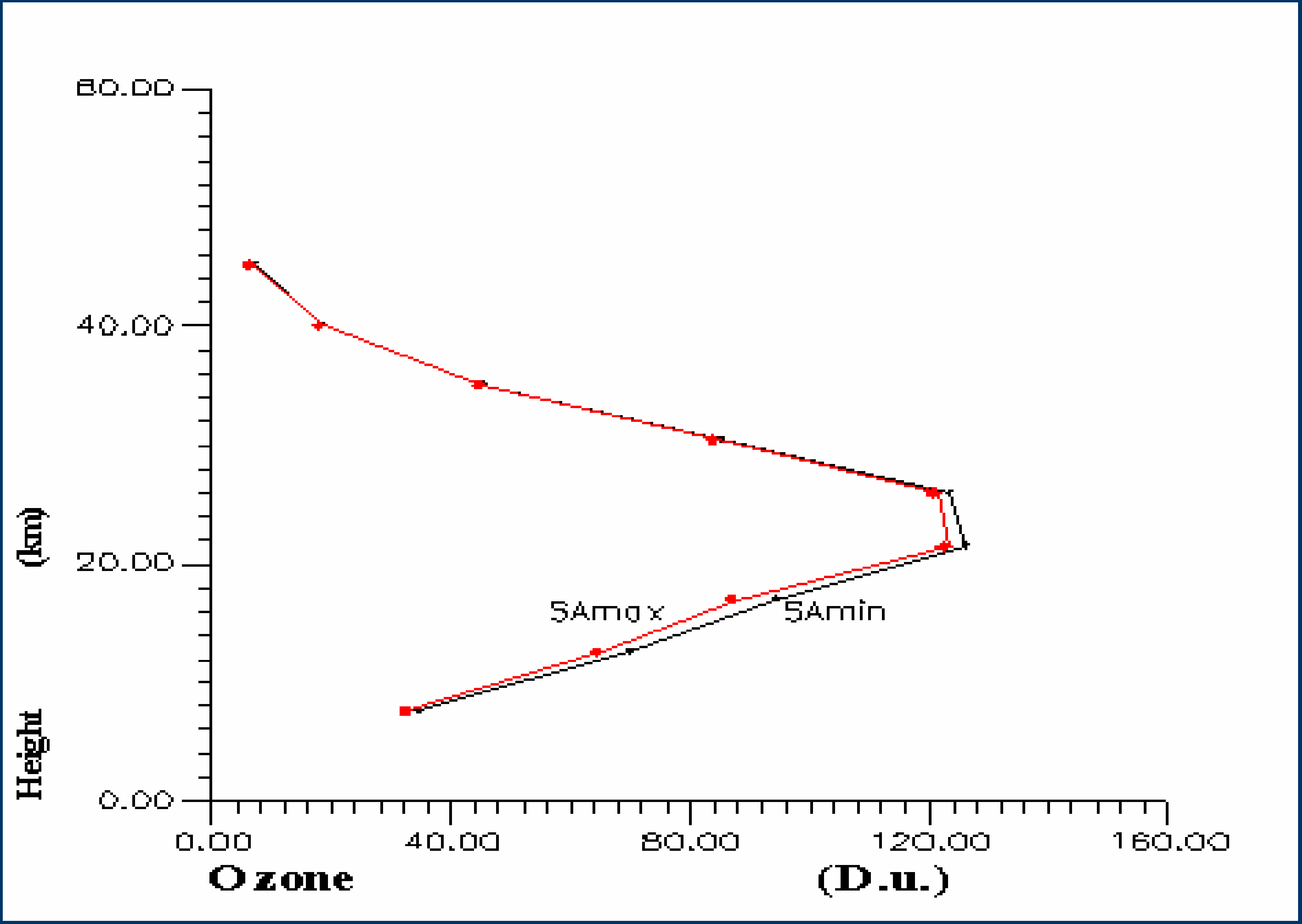
- Ozone Profile Behaviour over South-Eastern Europe During Solar Maximum and Minimum

- Ozone Behaviour in the Summer
- Ozone Behaviour in the Winter

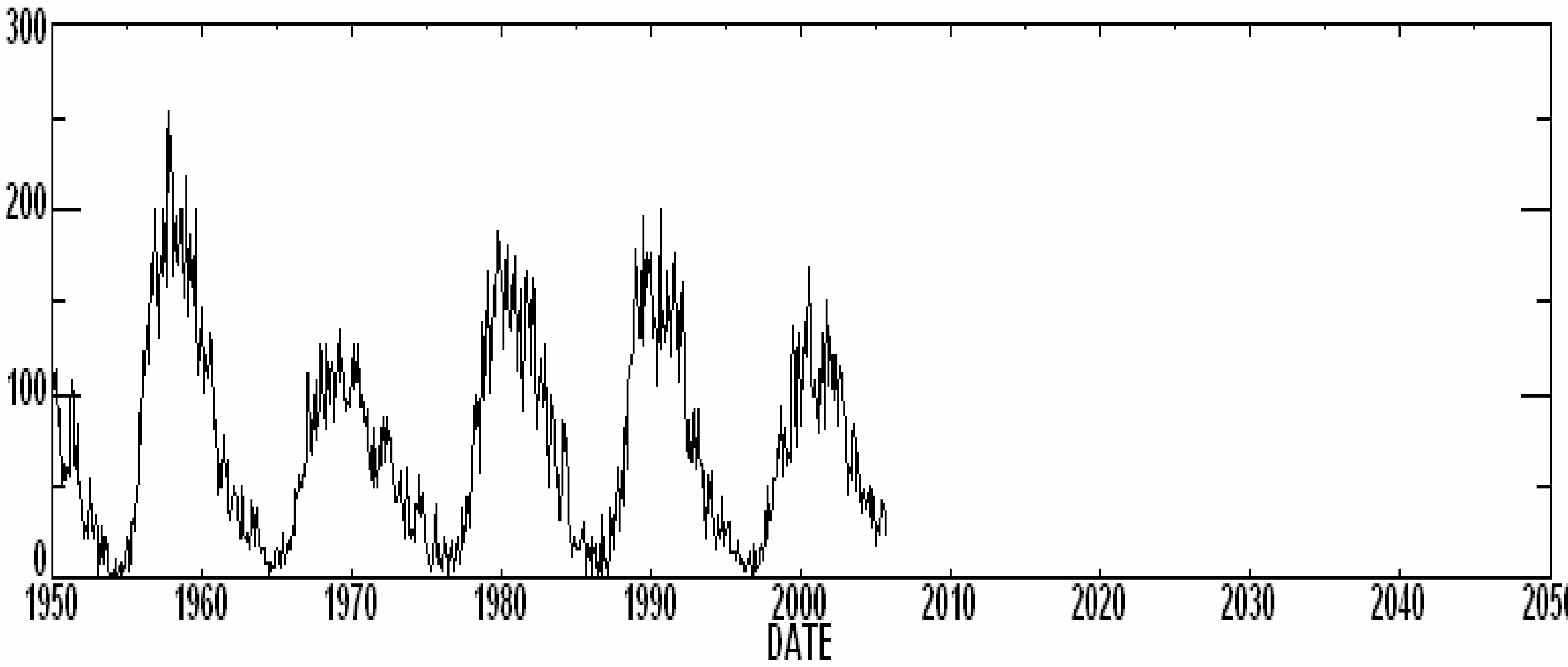
Ozone Behaviour in the Summer



Ozone Behaviour in the Winter



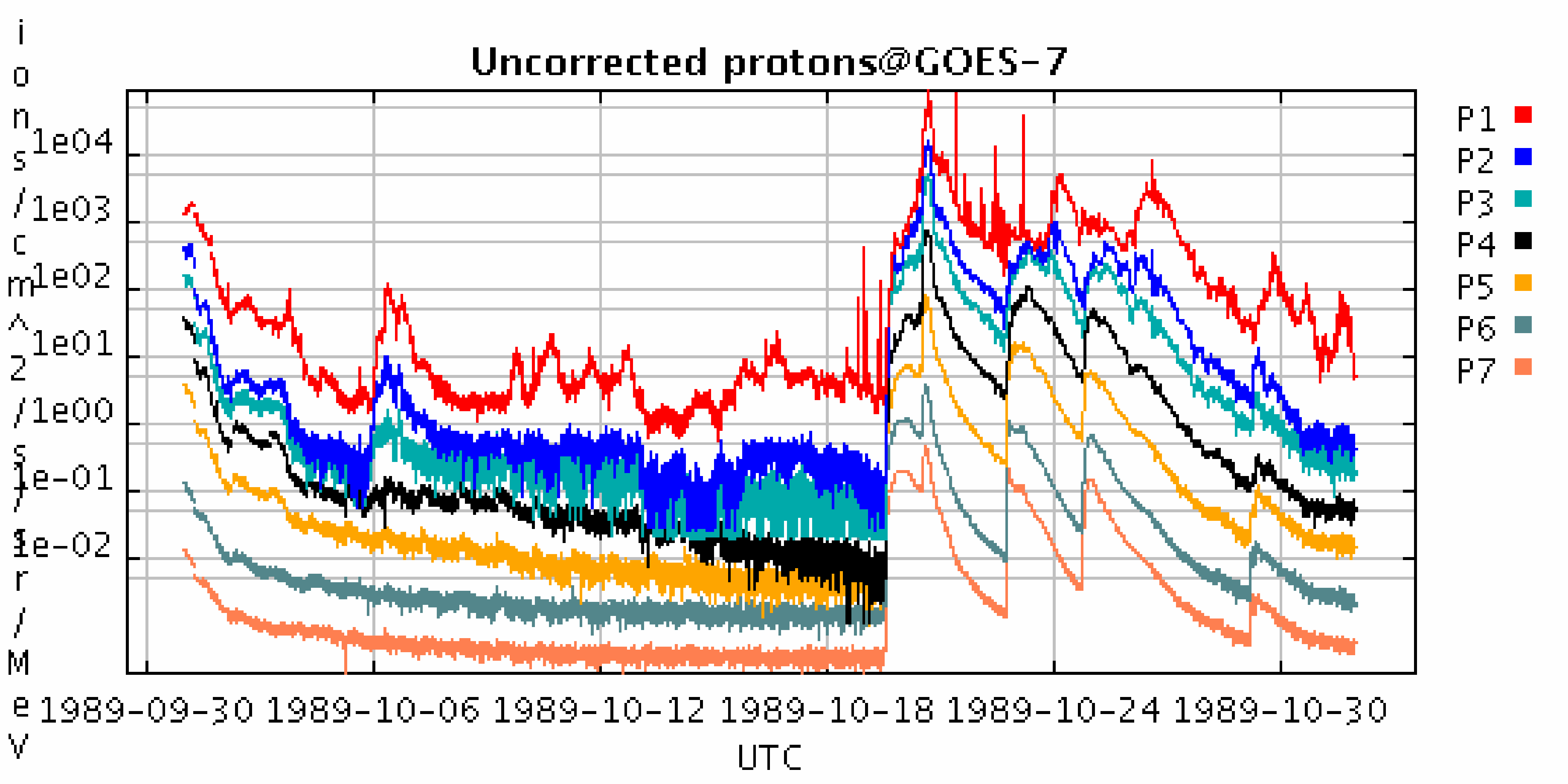
Monthly Average Sunspot Number



ABSTRACT - part II

- It is assumed that by penetration of solar cosmic rays (SCR) into the middle atmosphere the ozone is destructed. However we suppose that at certain altitudes ozone can be created as a result of chain ion reactions taking part in the stratosphere. In this investigation satellite data for ozone density in the atmosphere during SCR on 19 October 1989 were used. The values of ozone concentration (partial pressure) were taken from profiles of the following heights: 25.5 km, 24.5 km, 23.5 km, 19.5 km, 18.5 km and 11.5 km. The orbits of the satellites passed latitudes from 30 to 90 ° N and longitudes from 20 to 40 ° E. Data for the high energy protons were taken from Solar Geophysical Data - Boulder, Colorado. Cosmic ray measurements obtained from the neutral monitor in Kiel, Germany were utilized also. The influence of solar protons from seven energetic intrervals from 4.2 MeV till 850 MeV were studied. As a result of cross correlation analysis direct cause-effect relationships between ozone creation and SCR at heights 18.5-19.5 km have been obtained. These heights are situated near to the Pfotzer maximum due to the galactic cosmic rays.

Variations in ozone profiles during the period of solar proton events from October 19-31, 1989



Correlation Coefficient between Ozone density and Proton flux energy

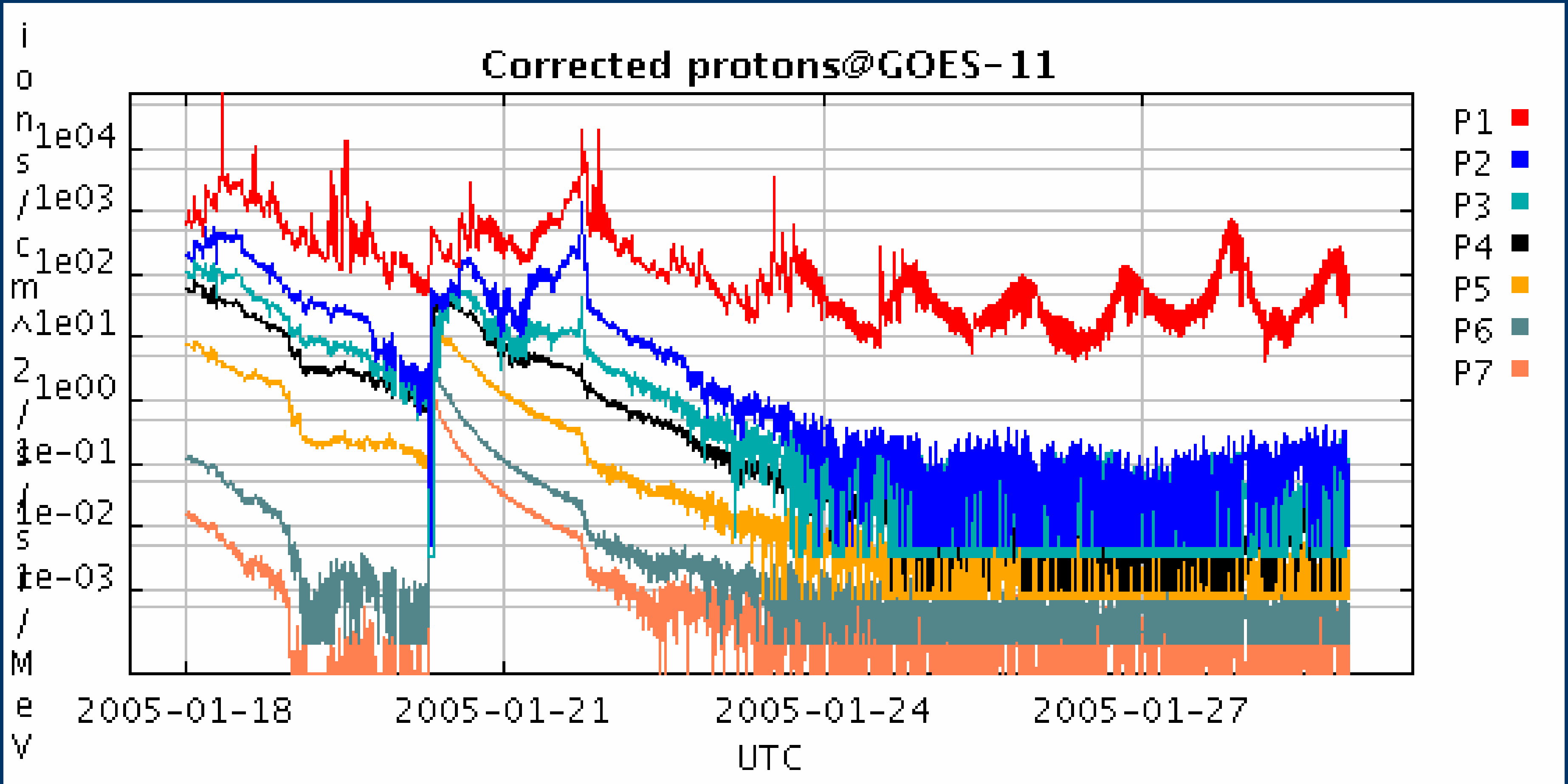
H \ E	4.2-8.7 MeV	8.7-14.5MeV	15 - 44MeV	39 - 82MeV	84-200MeV	110-500MeV	640-850MeV
25.5km	**-0.5493**	**-0.5671**	**-0.5636**	**-0.5340**	**-0.5719**	**-0.5680**	**-0.5621**
24.5km	**-0.5391**	**-0.5042**	**-0.5472**	**-0.5294**	**-0.5270**	**-0.4712**	**-0.5665**
23.5km	**+0.3067**	**+0.2325**	**----------**	**------------**	**+0.2801**	**+0.3760**	**+0.3428**
19.5km	**+0.4602**	**+0.4200**	**+0.4316**	**+0.4376**	**+0.4775**	**+0.5051**	**+0.5287**
18.5km	**+0.3905**	**+0.4074**	**+0.4629**	**+0.4488**	**+0.5209**	**+0.6324**	**+0.6450**

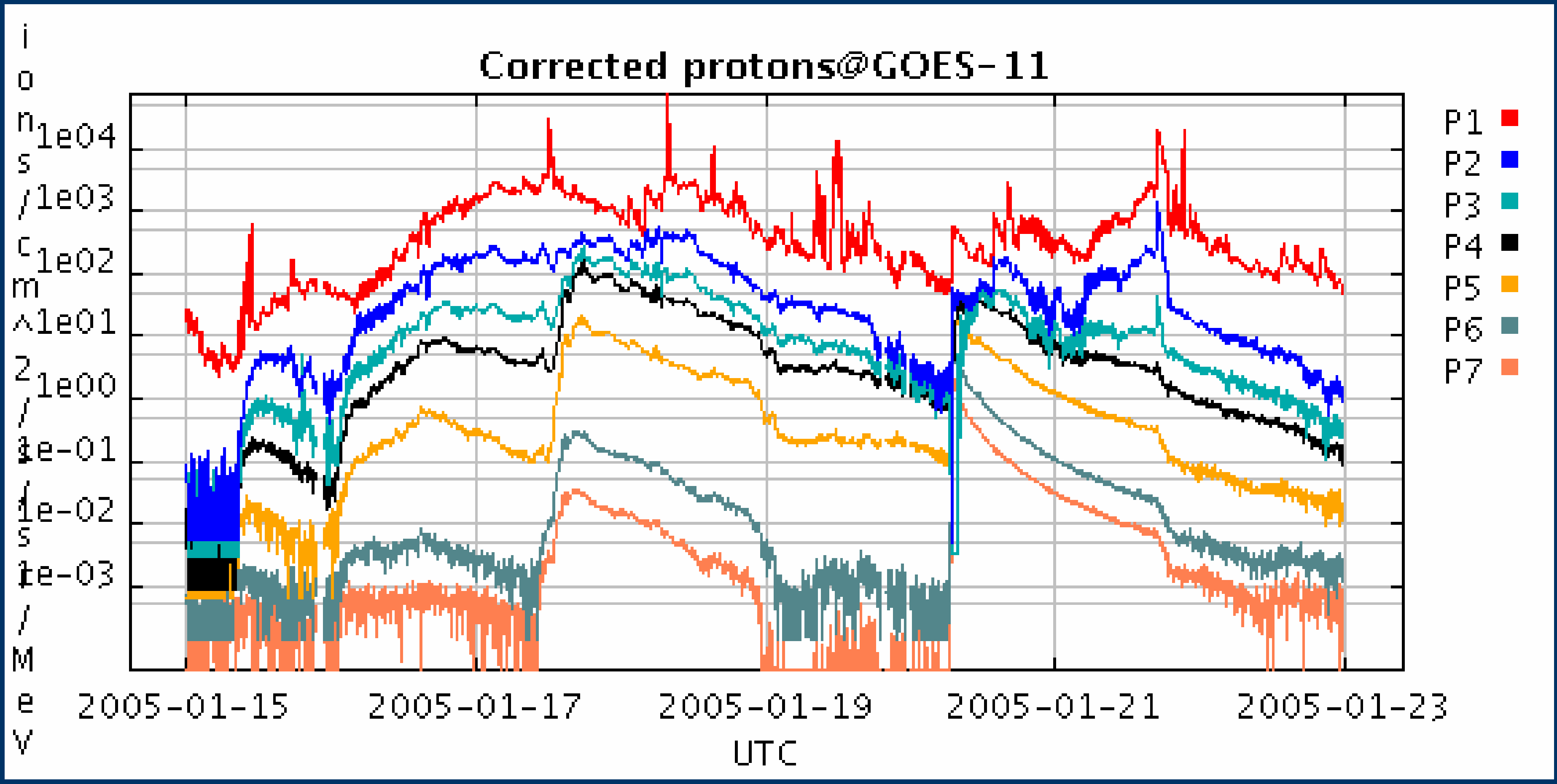
Abstract - part III

- The effect of solar particle event from period 18-28 January 2005 on the stratospheric ozone profiles is investigated. We try to prove the distribution of the influence of the different factors during solar proton flare on the ozone profiles. Ozone depletion was the main effect revealed up to now after penetration of Solar Cosmic Rays (SCR) in the middle atmosphere. Making use of satellite data (collected from 18 to 28 January 2005) to examine the ozone profiles we established an effect of ozone increase. The used data are aboard the EOS Aura spacecraft. The Microwave Limb Sounder (MLS) aboard the EOS Aura spacecraft was launched in July 15, 2004. The instrument scans the Earth's limb in the forward direction of flight, viewing microwave emissions at the 118, 190, 240 and 640 GHz, and 2.5 THz spectral regions from the stratosphere into the upper troposphere. These measurements are used to derive vertical profiles of ozone mixing ratios. The vertical resolution of these data is about 3 km, and the spatial coverage is near-global (-82 to +82 latitude), with each profile spaced 1.5° (about 165 km) along the orbit track.
- Some data from MLS for the relation of the ozone mixture are used at the following altitudes: 15.45 km, 18.54 km, 24.72 km, 30.90 km, 37.08 km, 43.26.km, 46.35 km. The data account a region at latitude 50 ° N and from longitude 0.2 ° E to 40 ° E. The proton flux is taken from the satellite GOES 11 in the following energy intervals: E=0.8 – 4 MeV, E=9 – 15 MeV, E=15 – 40 MeV, E=40 – 80 MeV, E=80 – 165 MeV, E=165 – 500 MeV . Some combinations from pairs of series were created, the ozone values for each of the mentioned altitudes with each of the energy intervals of the proton fluxes.

INCREASE OF STRATOSPHERIC OZONE DUE TO SOLAR ENERGETIC PARTICLES DURING GROUND LEVEL ENHANCEMENT

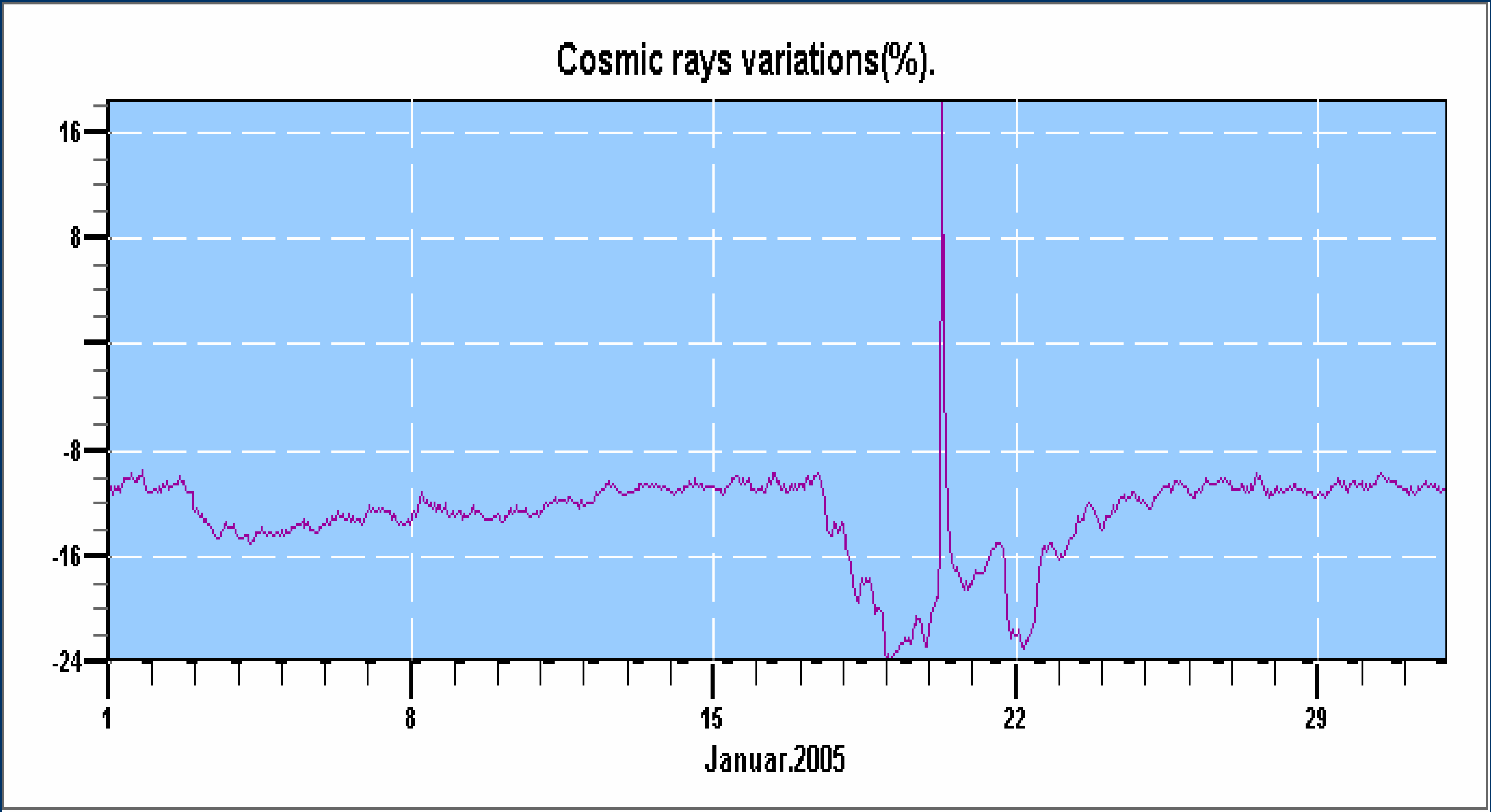
ON 20 JANUARY 2005





Corrected protons@GOES-11
ions/cm^2/s/sr/MeV
1e04
1e03
1e02
1e01
1e00
1e-01
1e-02
1e-03
2005-01-15
2005-01-17
2005-01-19
2005-01-21
2005-01-23
UTC
P1
P2
P3
P4
P5
P6
P7

Kiel Neutron Monitor Cosmic Rays During 1-31 January 2005



The distribution of all cross correlation coefficients between solar particle fluxes and ozone in different altitudes and energy intervals.

E H	0.8 – 4 MeV	4 -9 MeV	9 – 15 MeV	15 – 40 MeV	40 – 80 MeV	80 – 165 MeV	165 – 500 MeV
46.35 km	- 0.250	- 0.56	- 0.077	- 0.123	- 0.147	**- 0.370**	**- 0.411**
43.26 km	- 0.087	- 0.052	- 0.56	- 0.034	- 0.089	- 0.073	- 0.068
37.08 km	+ 0.144	- 0.067	- 0.084	- 0.097	+ 0.08	- 0.068	- 0.083
30.90 km	+ 0.358	- 0.56	- 0.057	- 0.047	+ 0.01	**+ 0.403**	**+ 0.446**
24.72 km	+ 0.128	- 0.057	- 0.034	- 0.052	- 0.259	+ 0.288	+ 0.289
18.54 km	+ 0.169	- 0.047	- 0.097	+ 0.25	+ 0.158	**+ 0.454**	**+ 0.511**

Diurnal destruction ozone reactions from protons and α-particles of SCR

$$e + N_2 \rightarrow N_2^+ + 2e$$

$$e + N_2 \rightarrow N + N + e$$

$$N^+ + O_2 \rightarrow NO^+ + O$$

$$N + O_2 \rightarrow NO + O$$

$$N + O_3 \rightarrow NO + O_2$$

$$NO + O_3 \rightarrow NO_2 + O_2$$

$$NO_2 + O \rightarrow NO + O_2$$

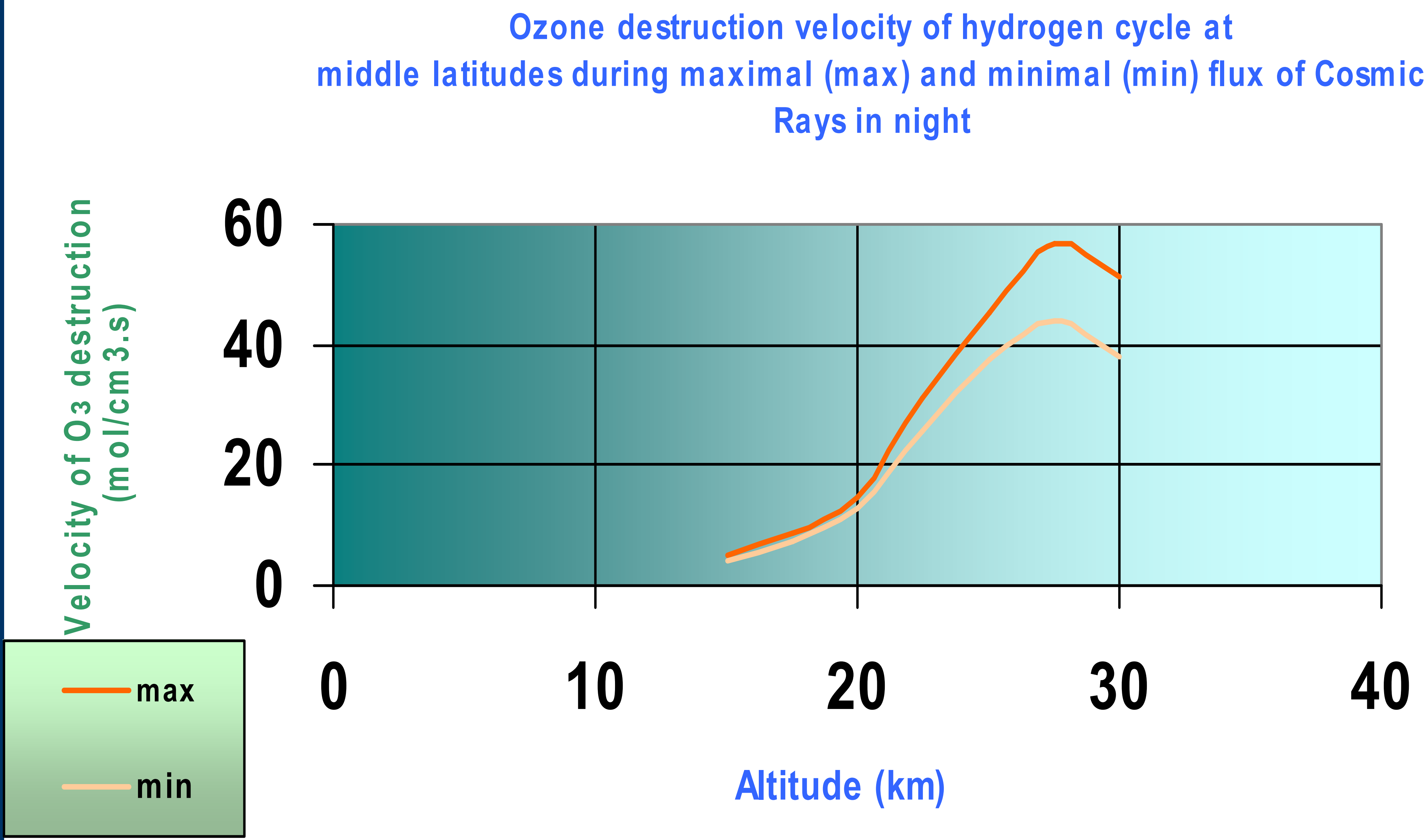
Hydrogen cycle

$$HO + O_3 \xrightarrow{k20} HO_2 + O_2$$

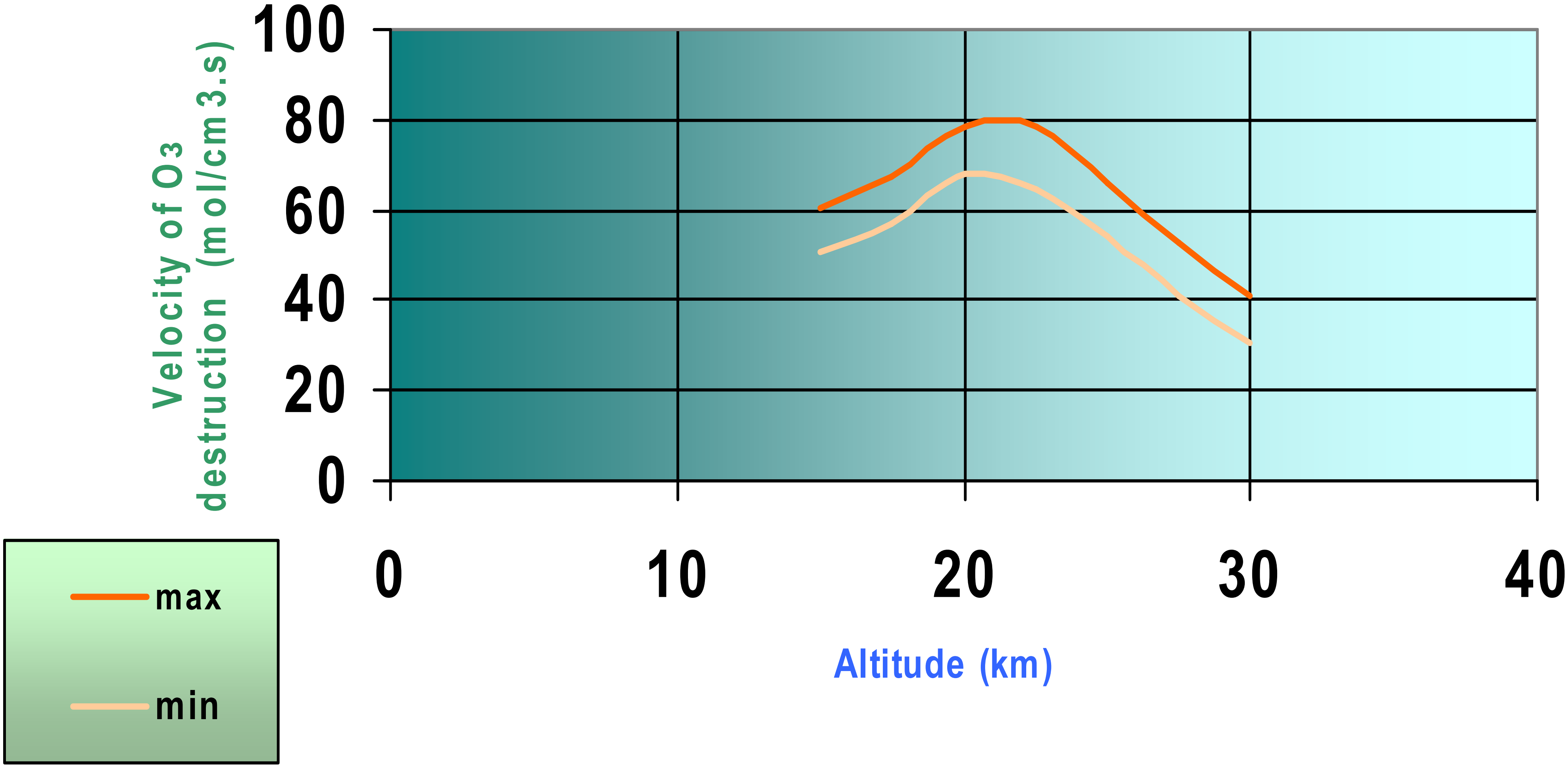
$$HO_2 + O_3 \xrightarrow{k21} HO + 2O_2$$

$$(\nu_{HO_x})_H = \frac{k_{20}[O_2]}{k_{27}[NO_2].[M] + k_{25}[CH_4] + k_{26}[HCl]}$$

$$\frac{d[O_3(z)]}{dt} = q_i(z).\{\frac{M}{N}(z)\}.\nu_{HO}(z)$$


Ozone destruction velocity of hydrogen cycle at
middle latitudes during maximal (max) and minimal (min) flux of Cosmic
Rays in night
Velocity of O3 destruction
(mol/cm 3.s)
60
40
20
0
0
10
20
30
40
max
min
Altitude (km)

Ozone destruction velocity of hydrogen cycle at high and polar latitudes during maximal (max) and minimal (min) flux of Cosmic Rays in night



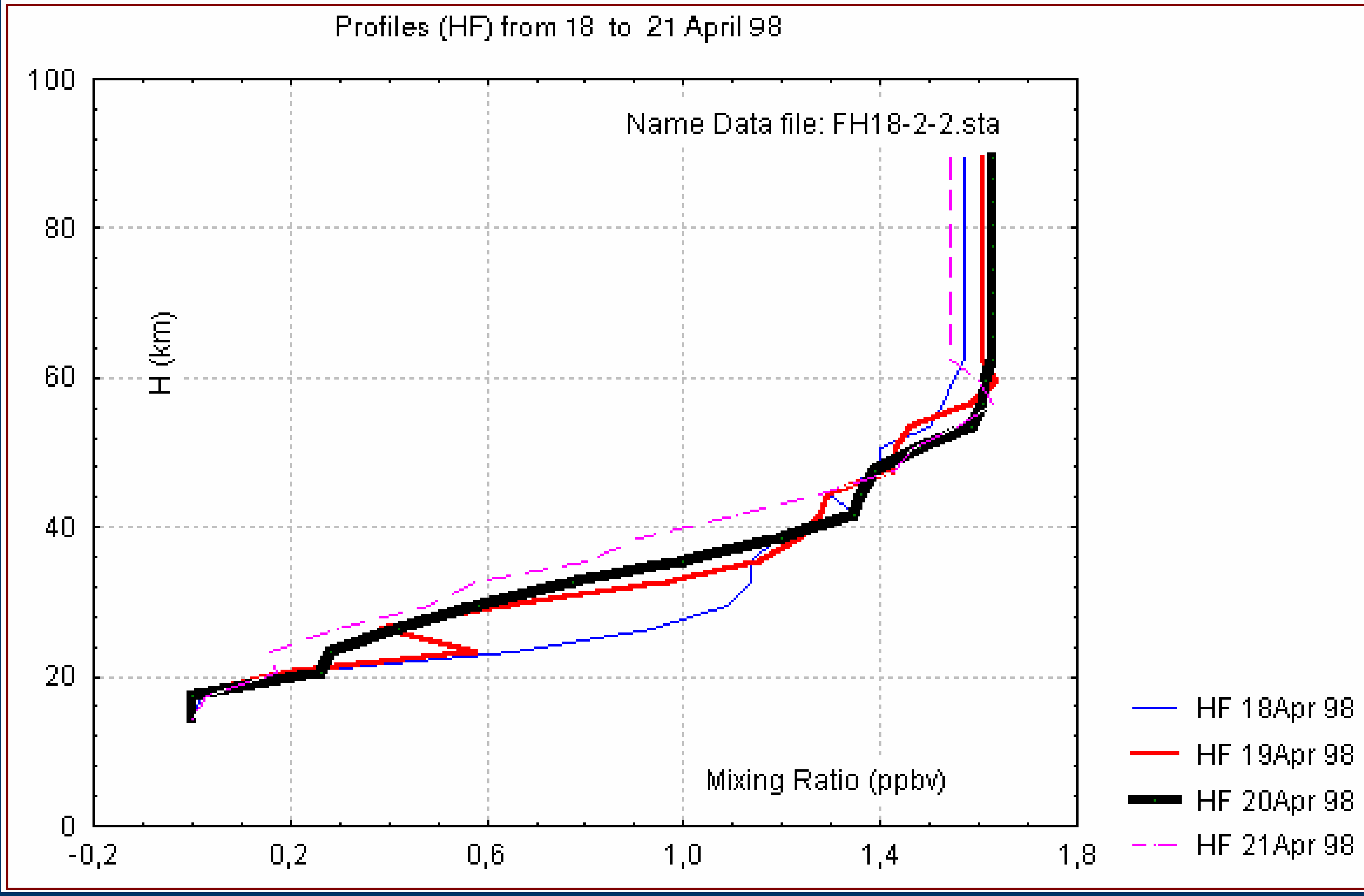
Chain reactions for OZONE production

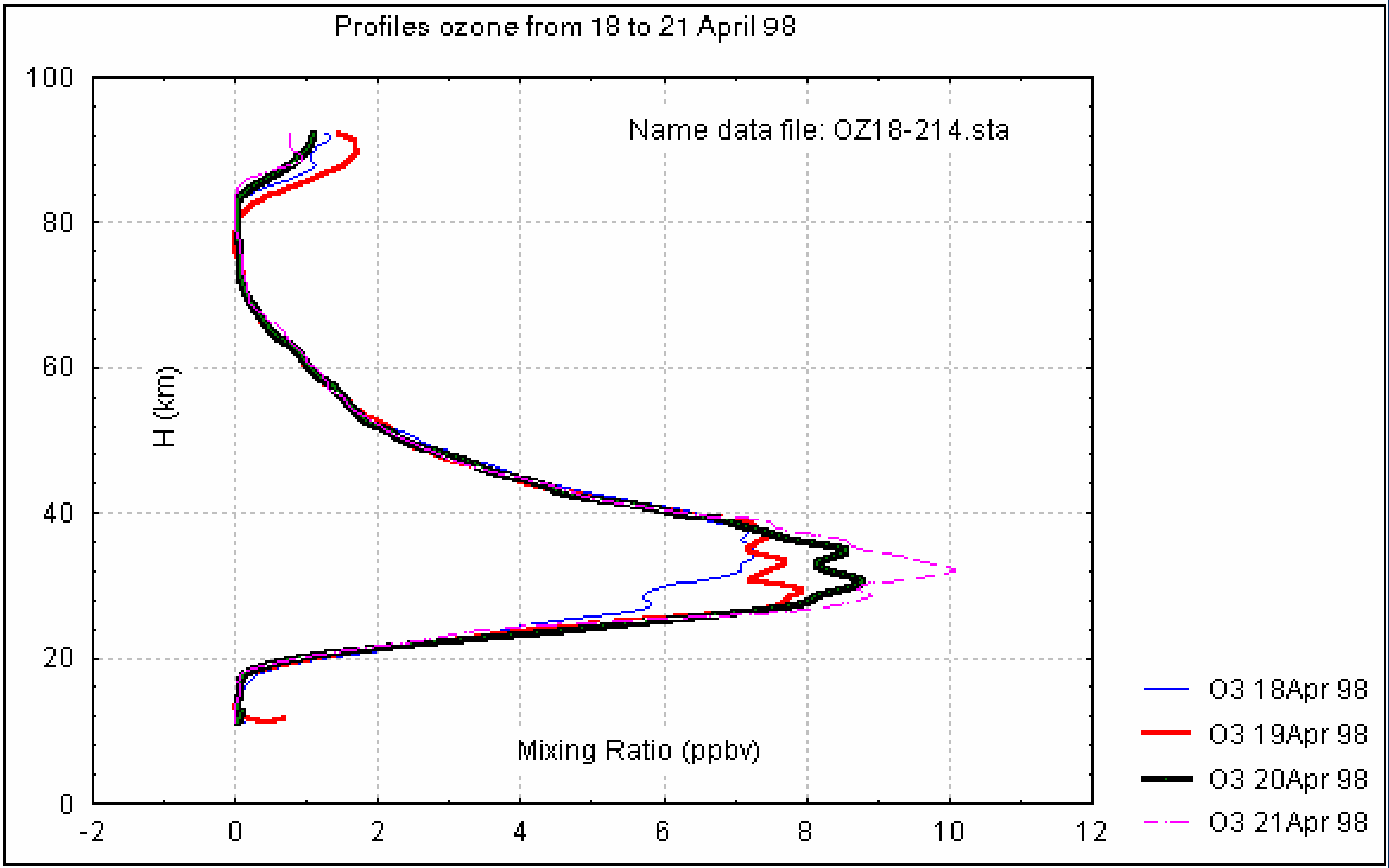
$$O_2^- + O \rightarrow O_3 + e$$

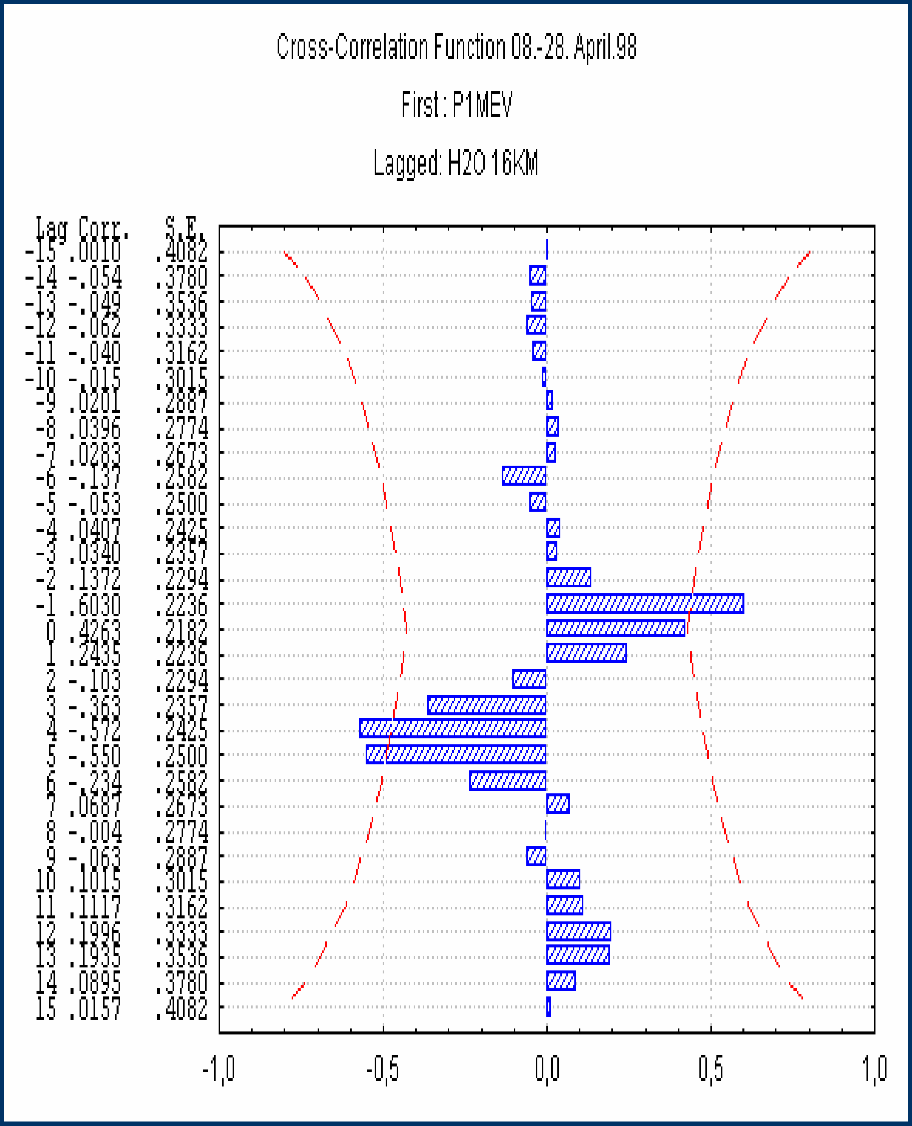
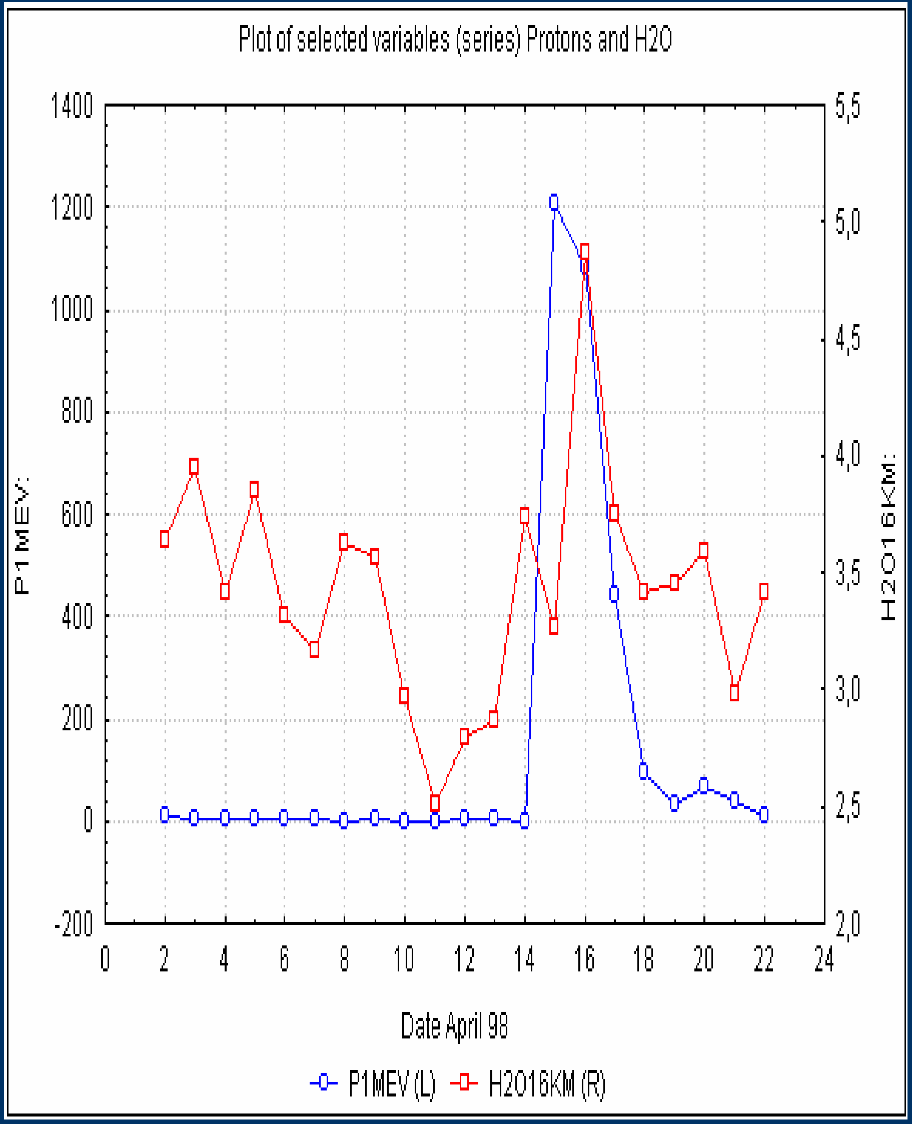
$$e + 2O_2 \rightarrow O_2^- + O_2$$

$$O_4^+ + O \rightarrow O_3 + O_2^+$$

$$O + 2O_2 \rightarrow O_3 + O_2$$


Profiles (HF) from 18 to 21 April 98
Name Data file: FH18-2-2.sta
H (km)
Mixing Ratio (ppbv)
100
80
60
40
20
0
-0,2
0,2
0,6
1,0
1,4
1,8
HF 18Apr 98
HF 19Apr 98
HF 20Apr 98
HF 21Apr 98


Profiles ozone from 18 to 21 April 98
Name data file: OZ18-214.sta
H (km)
Mixing Ratio (ppbv)
100
80
60
40
20
0
-2
0
2
4
6
8
10
12
O3 18Apr 98
O3 19Apr 98
O3 20Apr 98
O3 21Apr 98


Cross-Correlation Function 08.-28. April.98
First : P1MEV
Lagged: H2O 16KM
Lag Corr. S.E.
-15 .0010 .4082
-14 -.054 .3780
-13 -.049 .3536
-12 -.062 .3333
-11 -.040 .3162
-10 -.015 .3015
-9 .0201 .2887
-8 .0396 .2774
-7 .0283 .2673
-6 -.137 .2582
-5 -.053 .2500
-4 .0407 .2425
-3 .0340 .2357
-2 .1372 .2294
-1 .6030 .2236
0 .4263 .2182
1 .2435 .2236
2 -.103 .2294
3 -.363 .2357
4 -.572 .2425
5 -.550 .2500
6 -.234 .2582
7 .0687 .2673
8 -.004 .2774
9 -.063 .2887
10 .1015 .3015
11 .1117 .3162
12 .1996 .3333
13 .1935 .3536
14 .0895 .3780
15 .0157 .4082
-1,0
-0,5
0,0
0,5
1,0

Plot of selected variables (series) Protons and H2O
P1MEV:
H2O16KM:
Date April 98
P1MEV (L)
H2O16KM (R)

Thank you for your kindness !!!