Modeling ionosphere response to Solar Proton Events in the whole atmosphere model EAGLE

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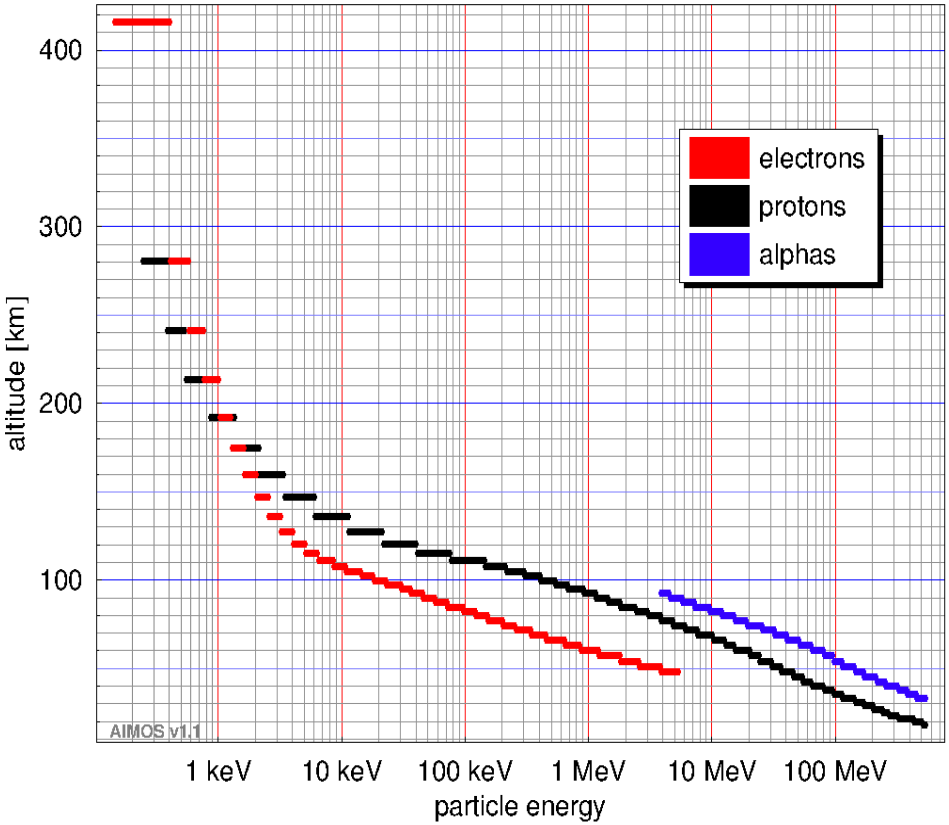
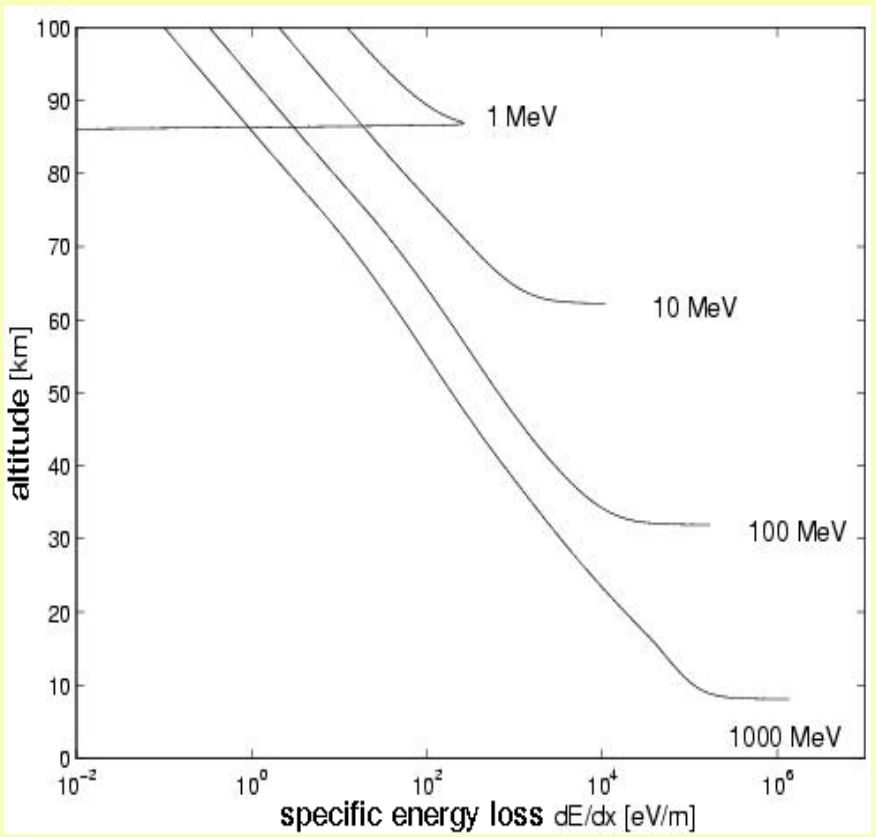
3. IAC ETH Zurich, Switzerland
4. IAA-CSIC, Granada, Spain

Altitude of maximum energy deposition

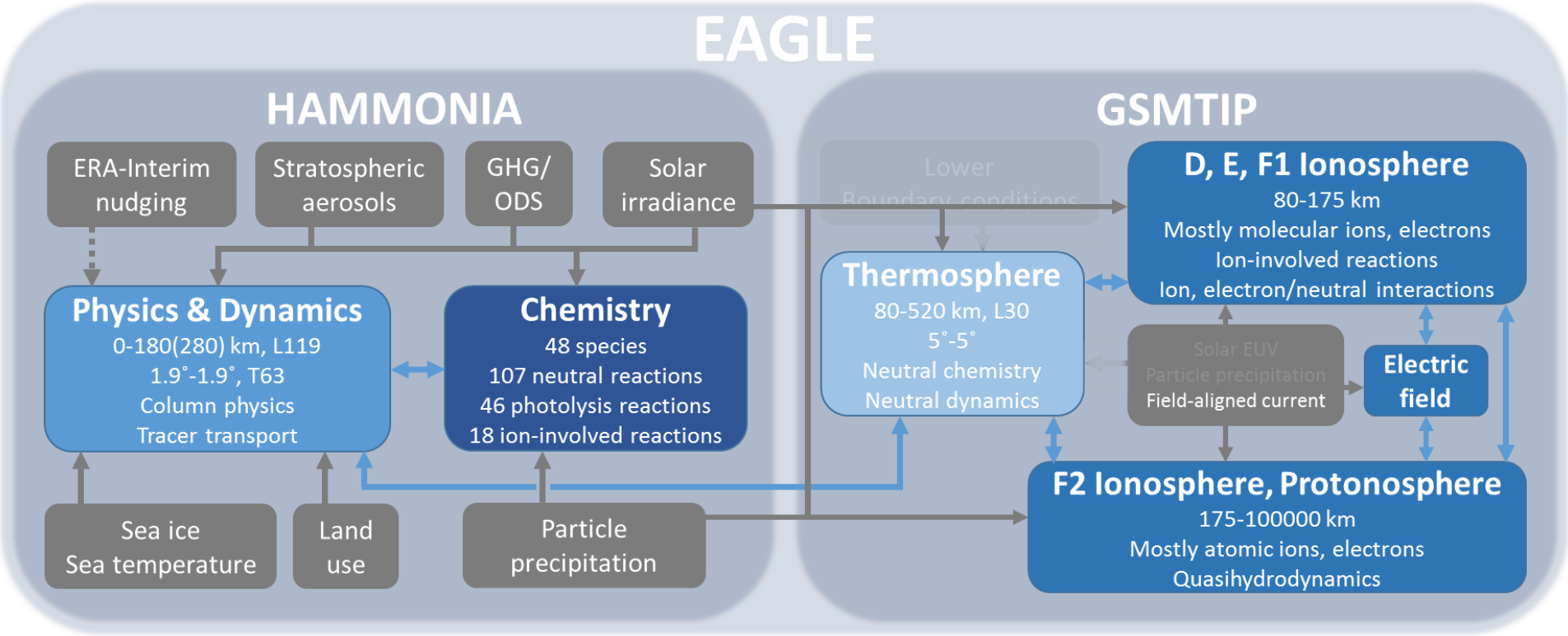
(Wissing and Kallenrode 2009)



(Quack, 2005)



Entire Atmosphere Global Model



Atmospheric Ionization Module Osnabrück (AIMOS)

- AIMOS models of ion pair production due to precipitating part… origin.
- AIMOS is designed … tic solar and magneto… GOES) into a 3-D… ere.
- AIMOS consists of t… e Carlo simulation a… observations from… horizontal precipi… netic activity.

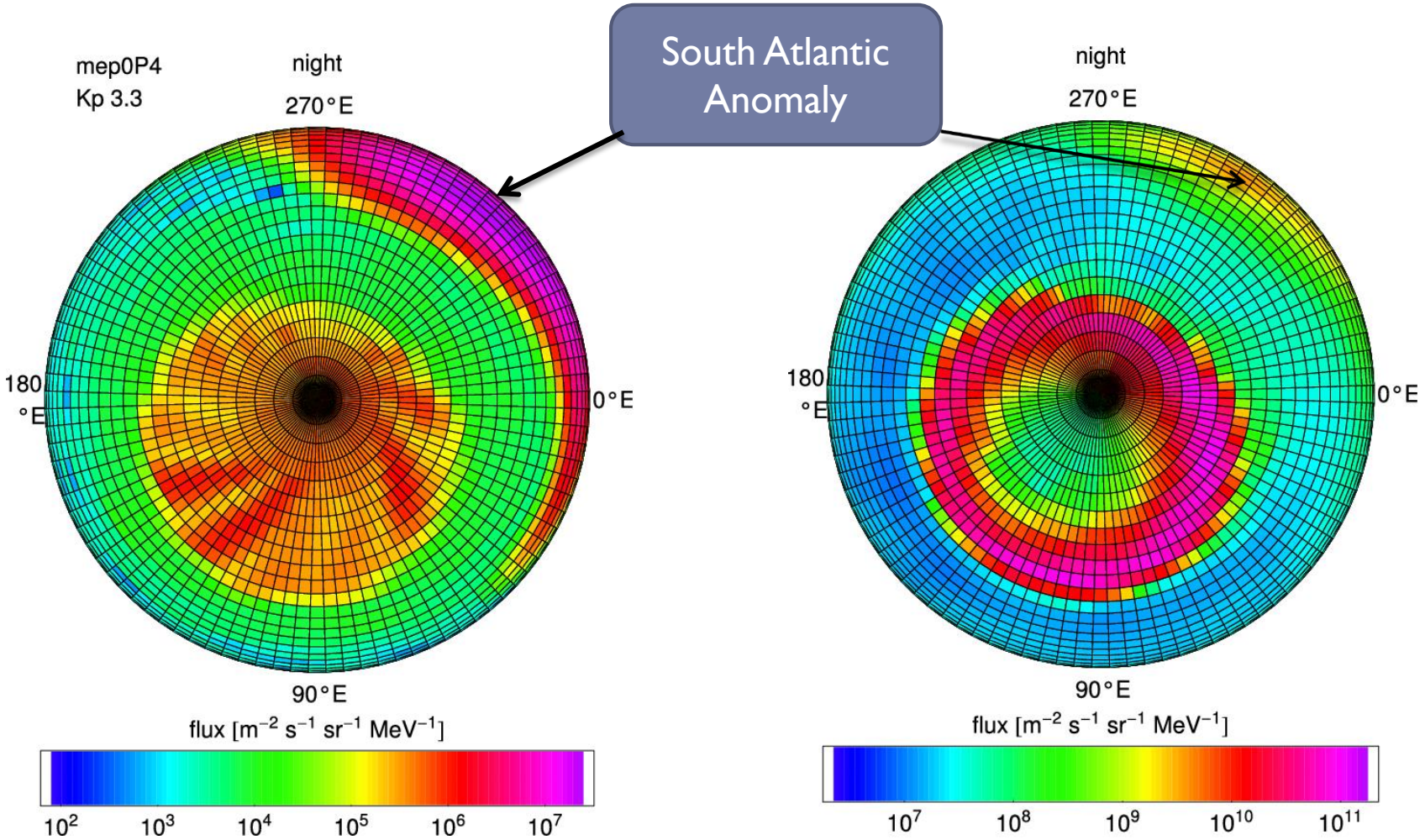
The POES satellites (POES: Polar Orbiting Environmental Satellite) are polar-orbiting satellites in a Sun synchronous orbit with a height of 850 km and an inclination of 98

The GOES satellites (GOES: Geostationary Operational Environmental Satellite) are in geostationary orbit located at W135 and W104.

AIMOS

Higher energetic particles (0.8– 2.5 MeV protons) flux.

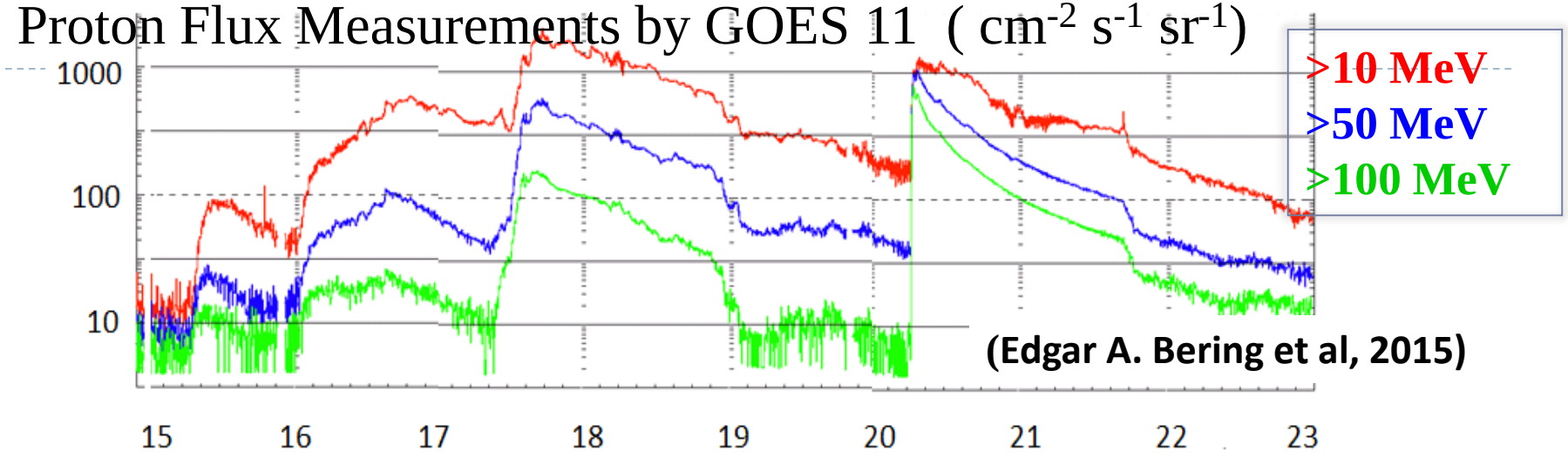
Low energetic particles (30–80 keV protons) flux



A view on the south pole is shown.

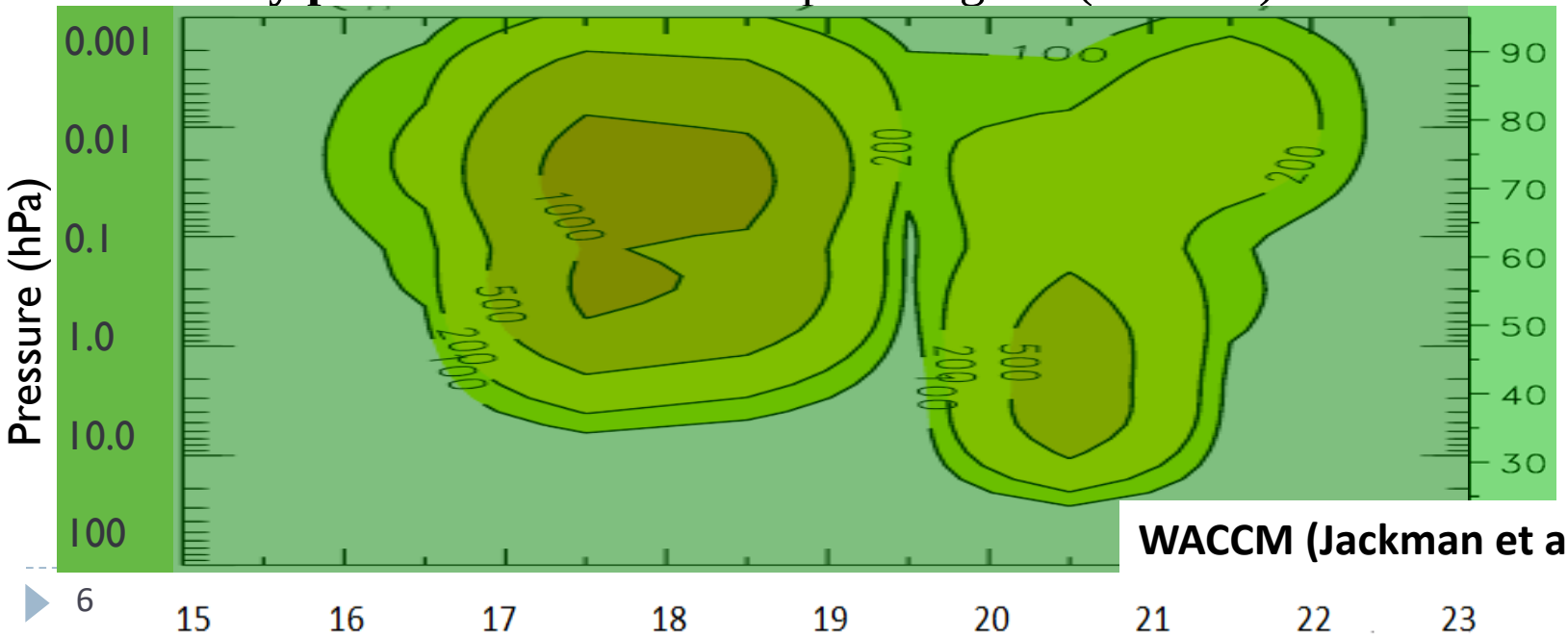
Solar Proton Events, January of 2005

Proton Flux Measurements by GOES 11 (cm^{-2} s^{-1} sr^{-1})



(Edgar A. Bering et al, 2015)

Ion rates by protons in the northern polar region (cm^{-3} s^{-1})



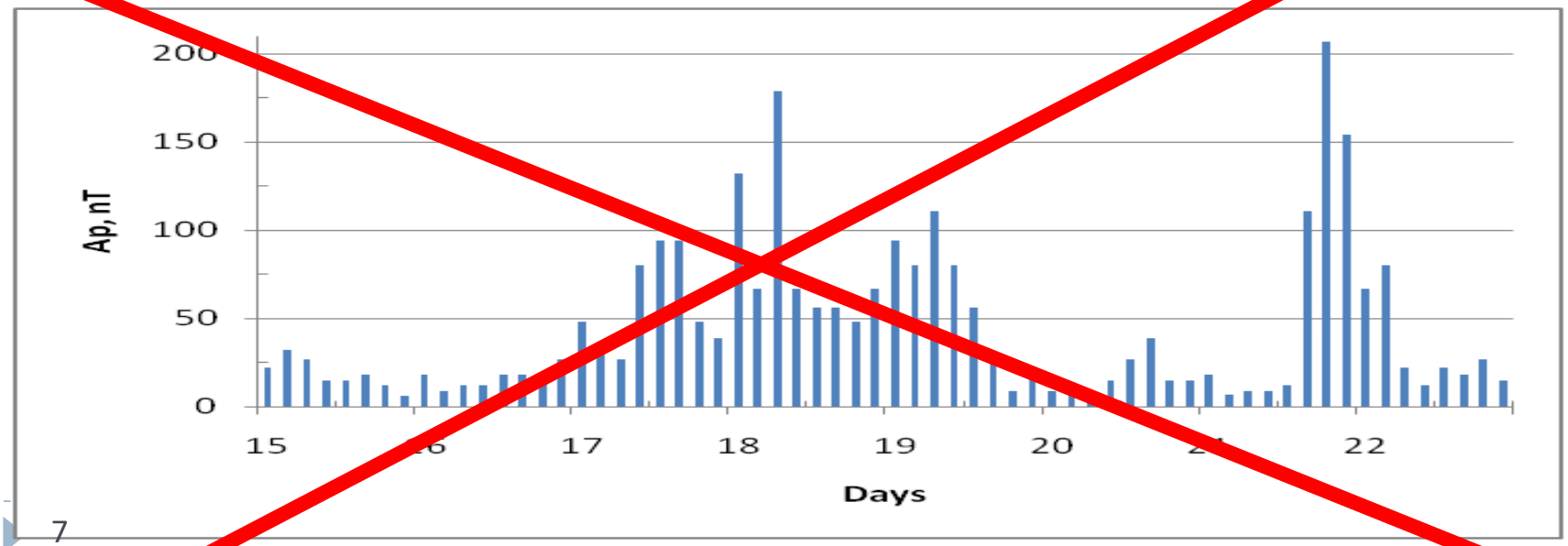
WACCM (Jackman et al., 2011)

EAGLE simulations

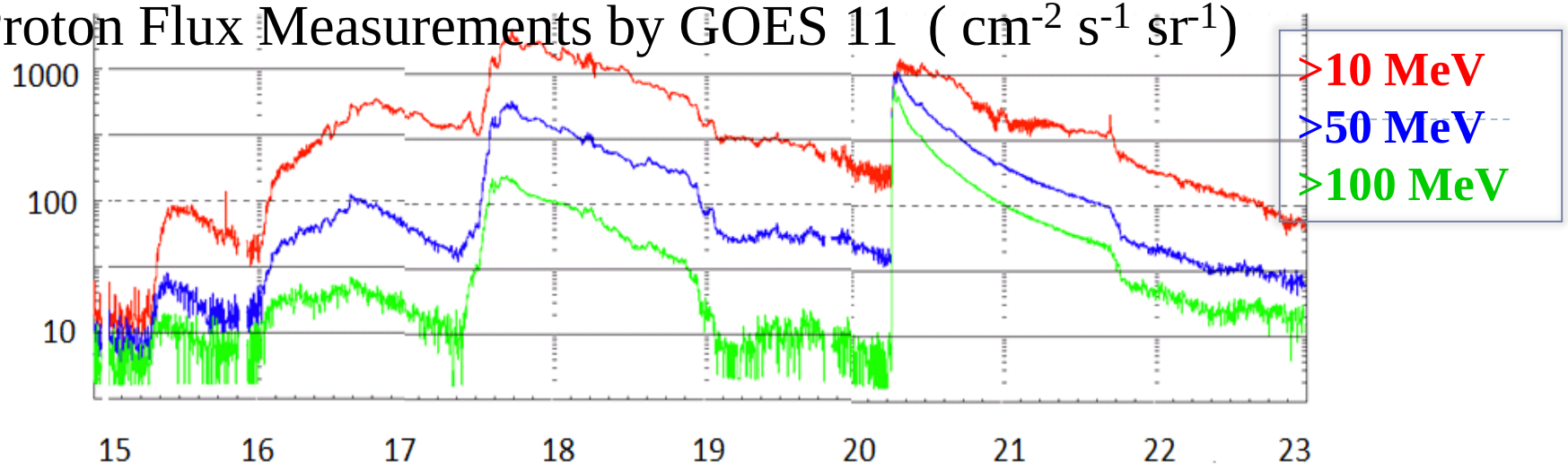
Data comparisons for two model runs:

- reference model simulation (quiet conditions)
- SPE simulation.

ONLY the proton flux was changed

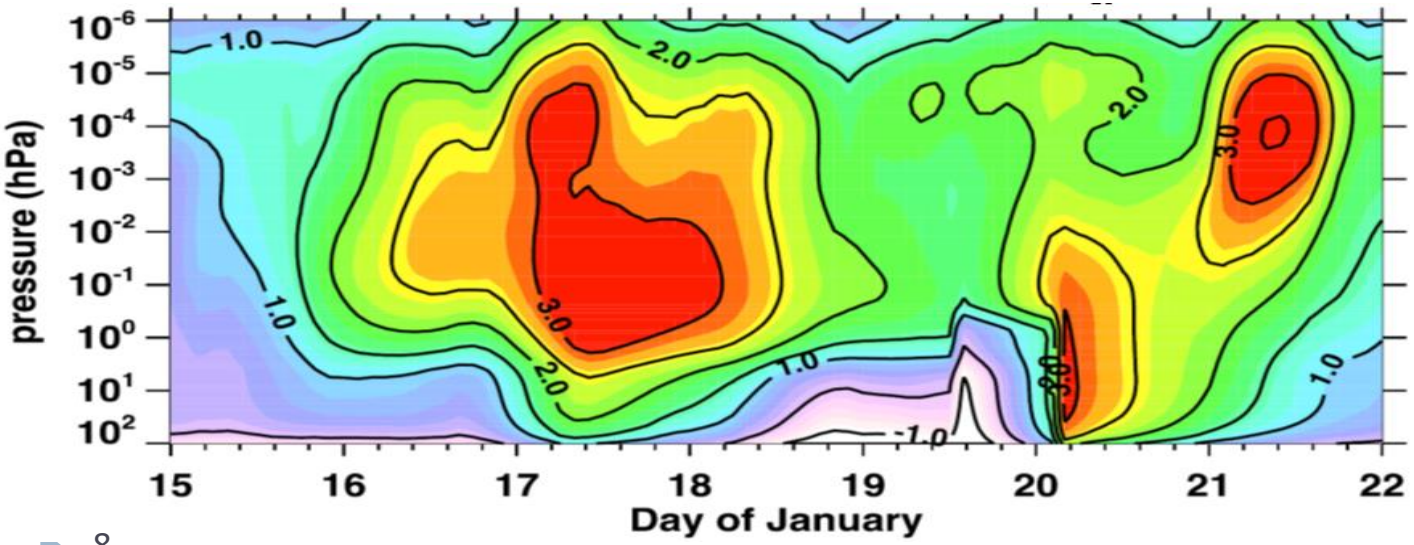


Proton Flux Measurements by GOES 11 (cm^{-2} s^{-1} sr^{-1})

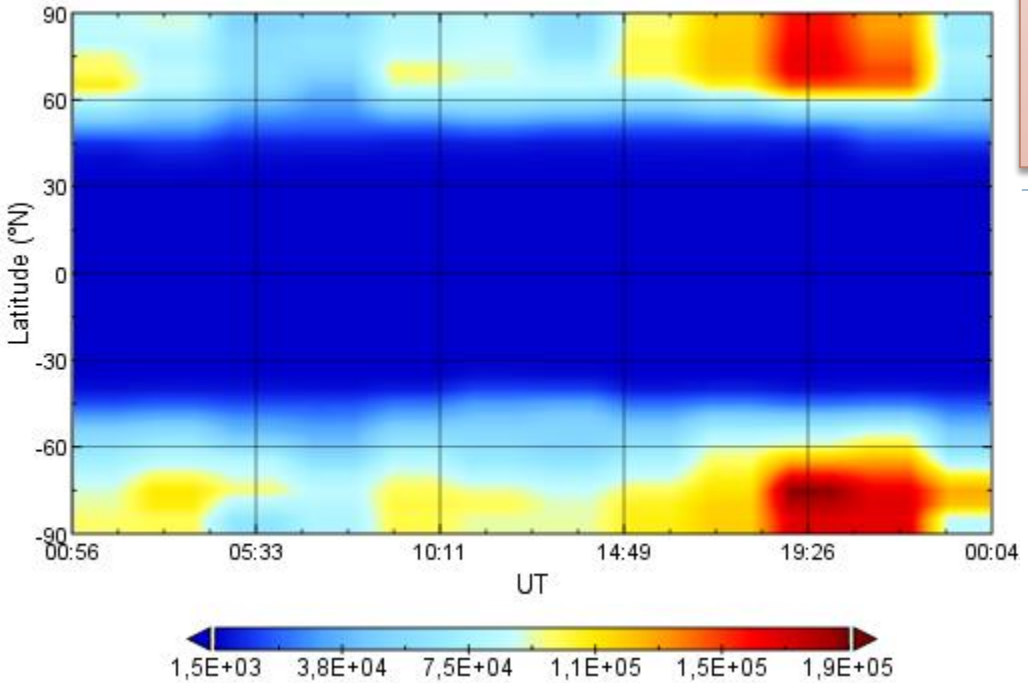


EAGLE log-ionization rates by protons (AIMOS)

at 80 N (ion pairs cm^{-3} s^{-1})

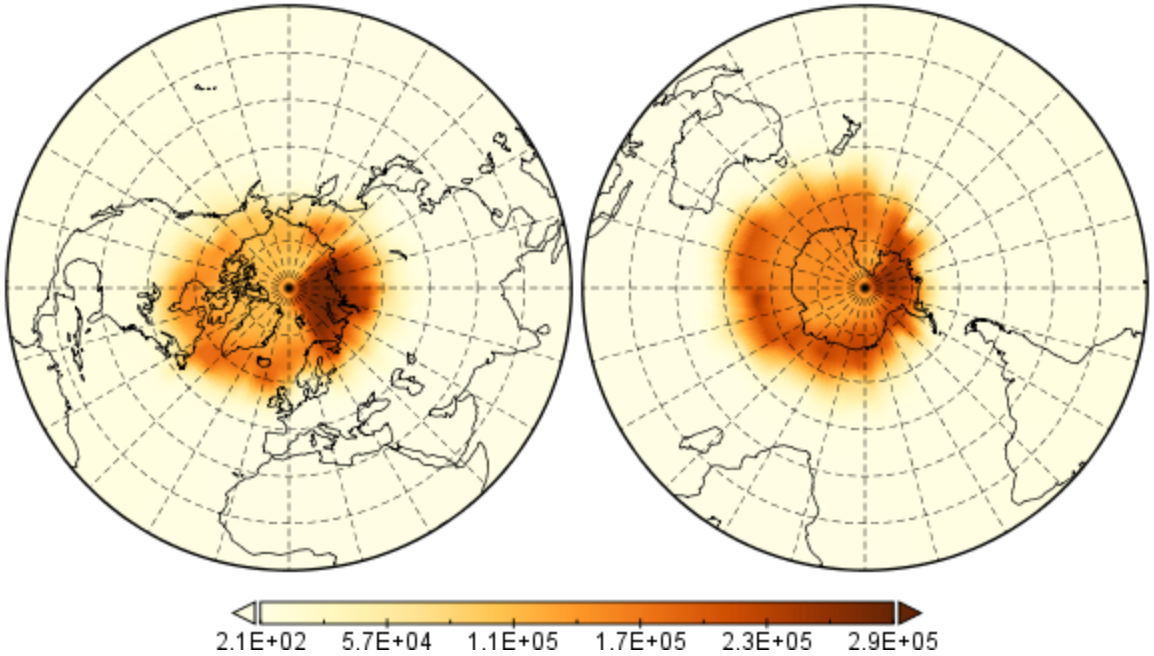


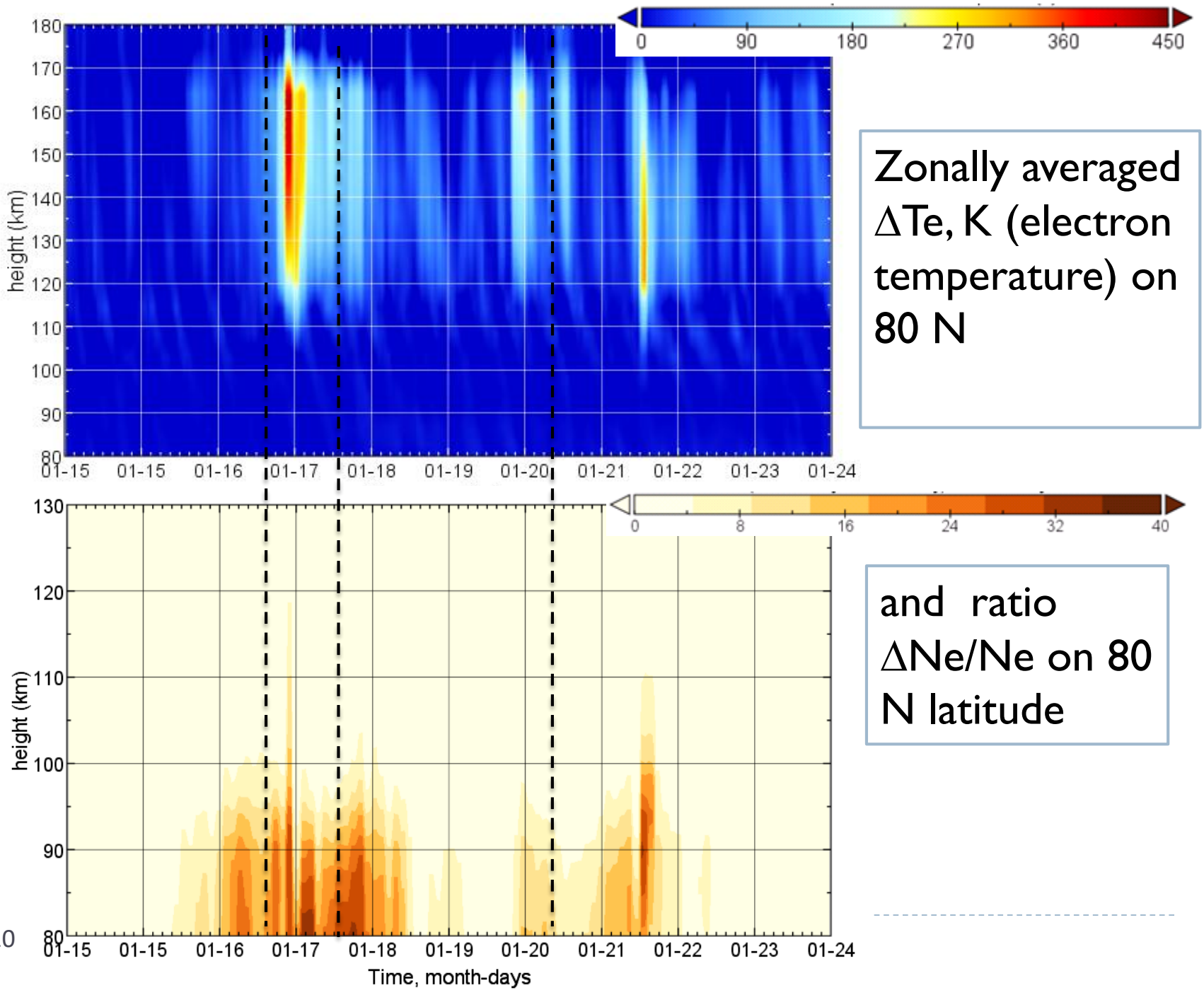
SOLAR PROTON EVENT, EAGLE model simulation



Zonally averaged Ne,cm-3 at 83 km, January, 17

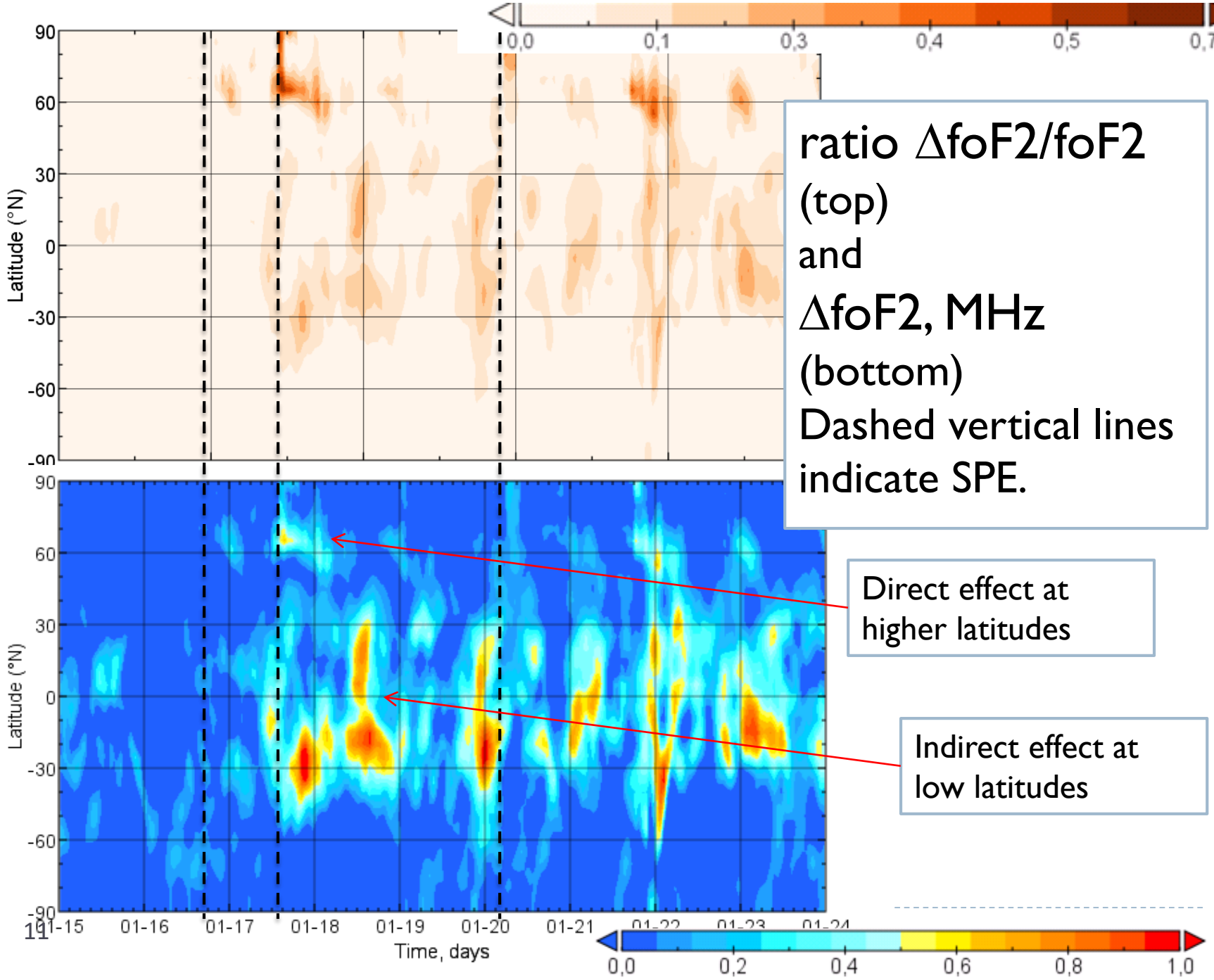
Ne,cm-3 at 83 km, 17 of January, 19 UT

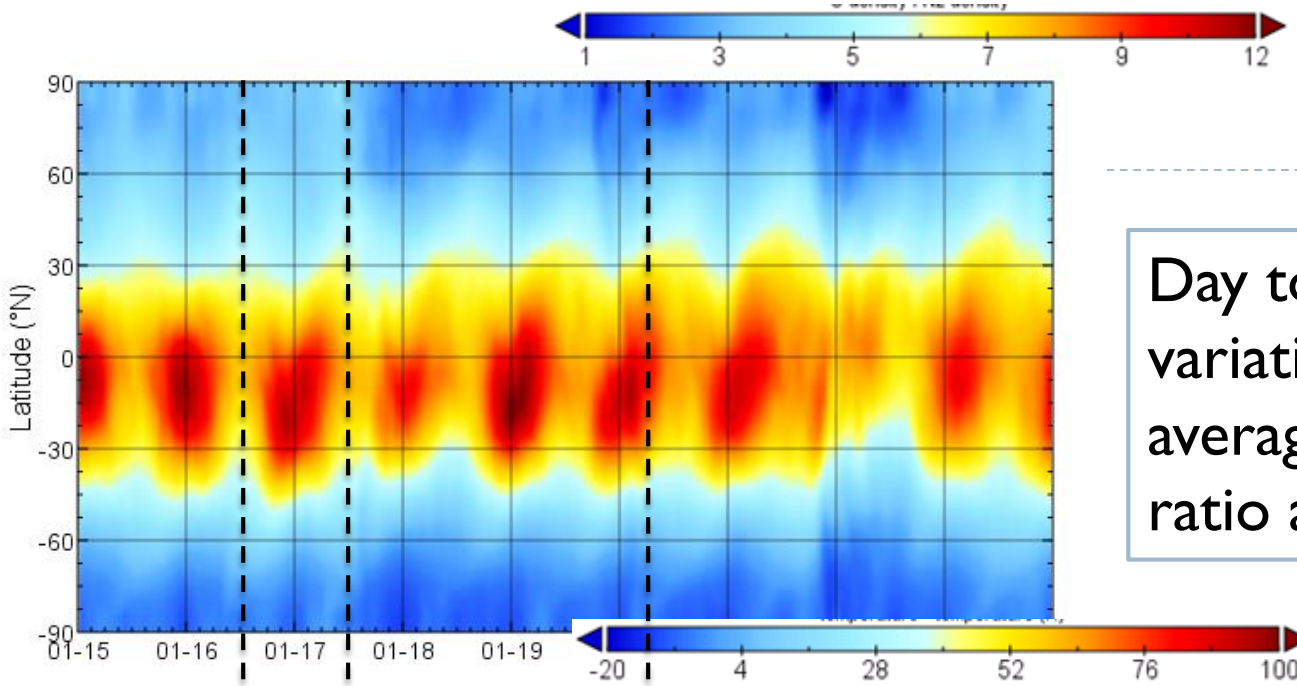




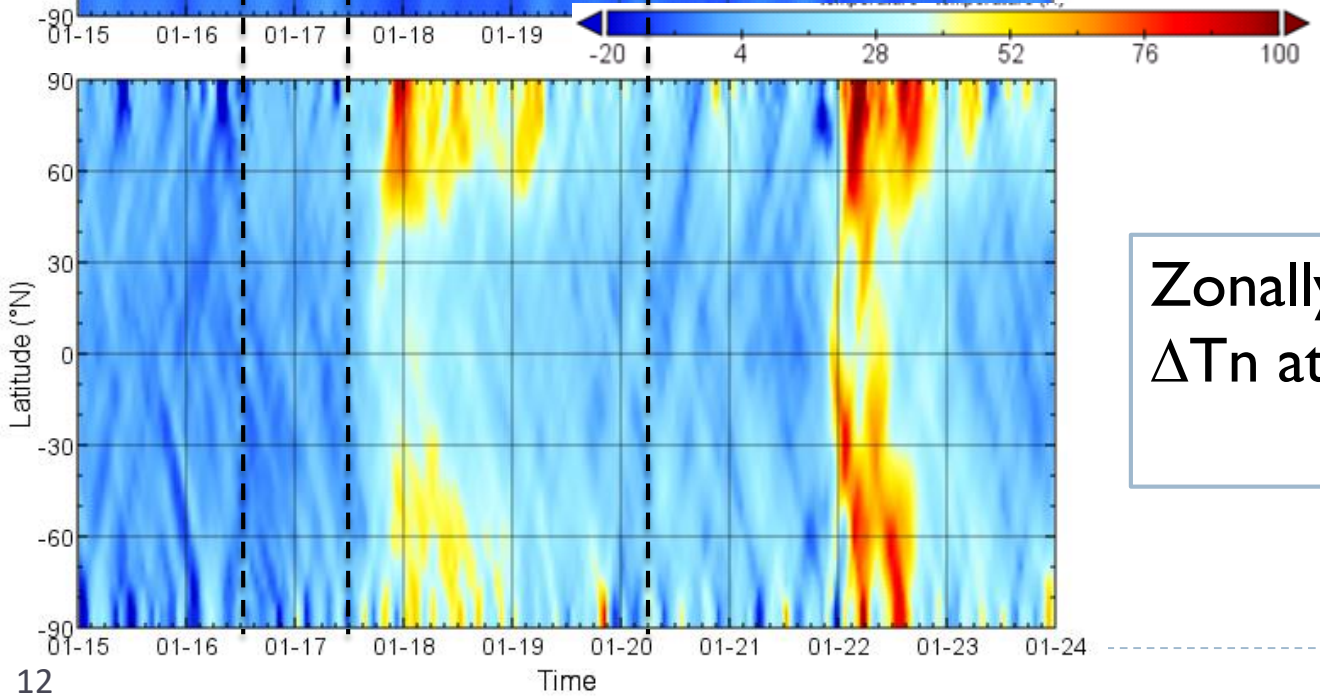
Zonally averaged ΔTe, K (electron temperature) on 80 N

and ratio ΔNe/Ne on 80 N latitude


0,0
0,1
0,3
0,4
0,5
0,7
90
60
30
0
-30
-60
-90
Latitude (°N)
ratio ΔfoF2/foF2
(top)
and
ΔfoF2, MHz
(bottom)
Dashed vertical lines
indicate SPE.
Direct effect at
higher latitudes
Indirect effect at
low latitudes
01-15
01-16
01-17
01-18
01-19
01-20
01-21
01-22
01-23
01-24
Time, days
0,0
0,2
0,4
0,6
0,8
1,0

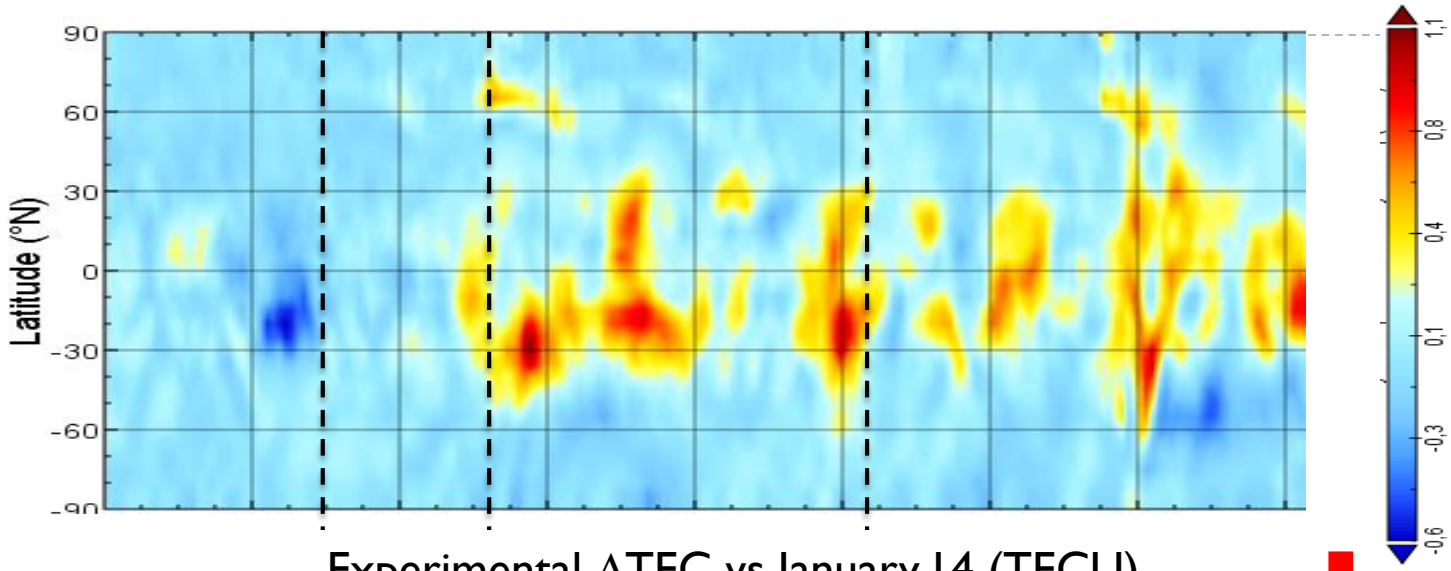


Day to day variation zonally averaged O/N2 ratio at 300 km

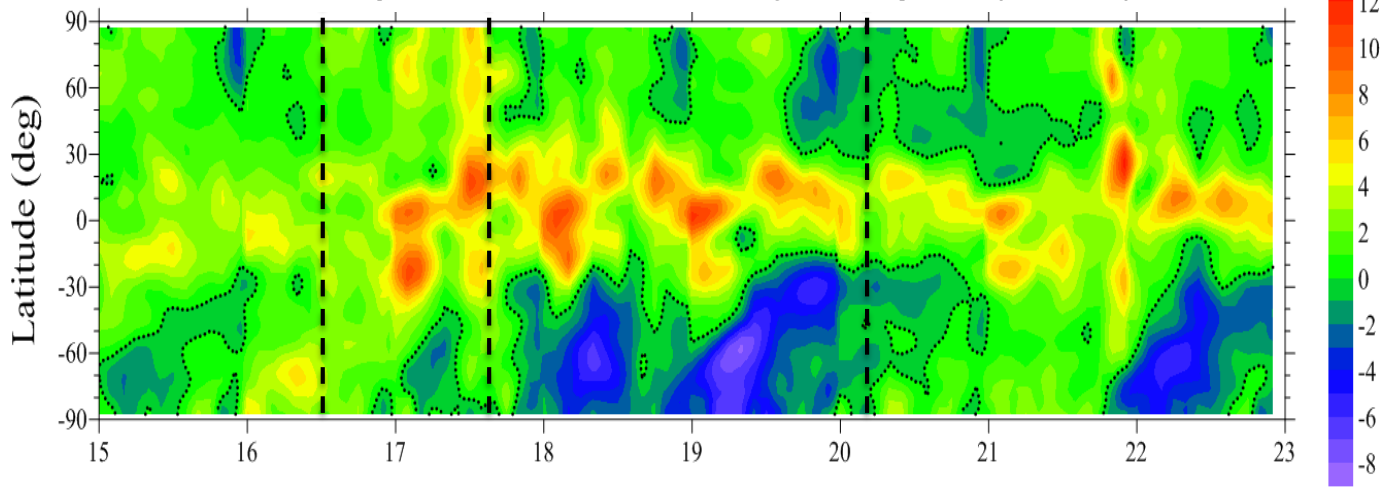


Zonally averaged ΔTn at 300 km

EAGLE ΔfoF2 (foF2spe –foF2ref), MHz



Experimental ΔTEC vs January,14 (TECU)



Summary

- The whole atmosphere model (EAGLE) allows to investigate large-scale phenomena covering all layers of the atmosphere.
- The response of the ionosphere to the proton event of January 2005 is considered.
- Despite the relative transparency of the thermosphere to the high-energy particles, ionospheric response on SPE was obtained.
- The direct and indirect effects of the proton event due to ionization and variations of the atmosphere parameters, respectively, should be noted.

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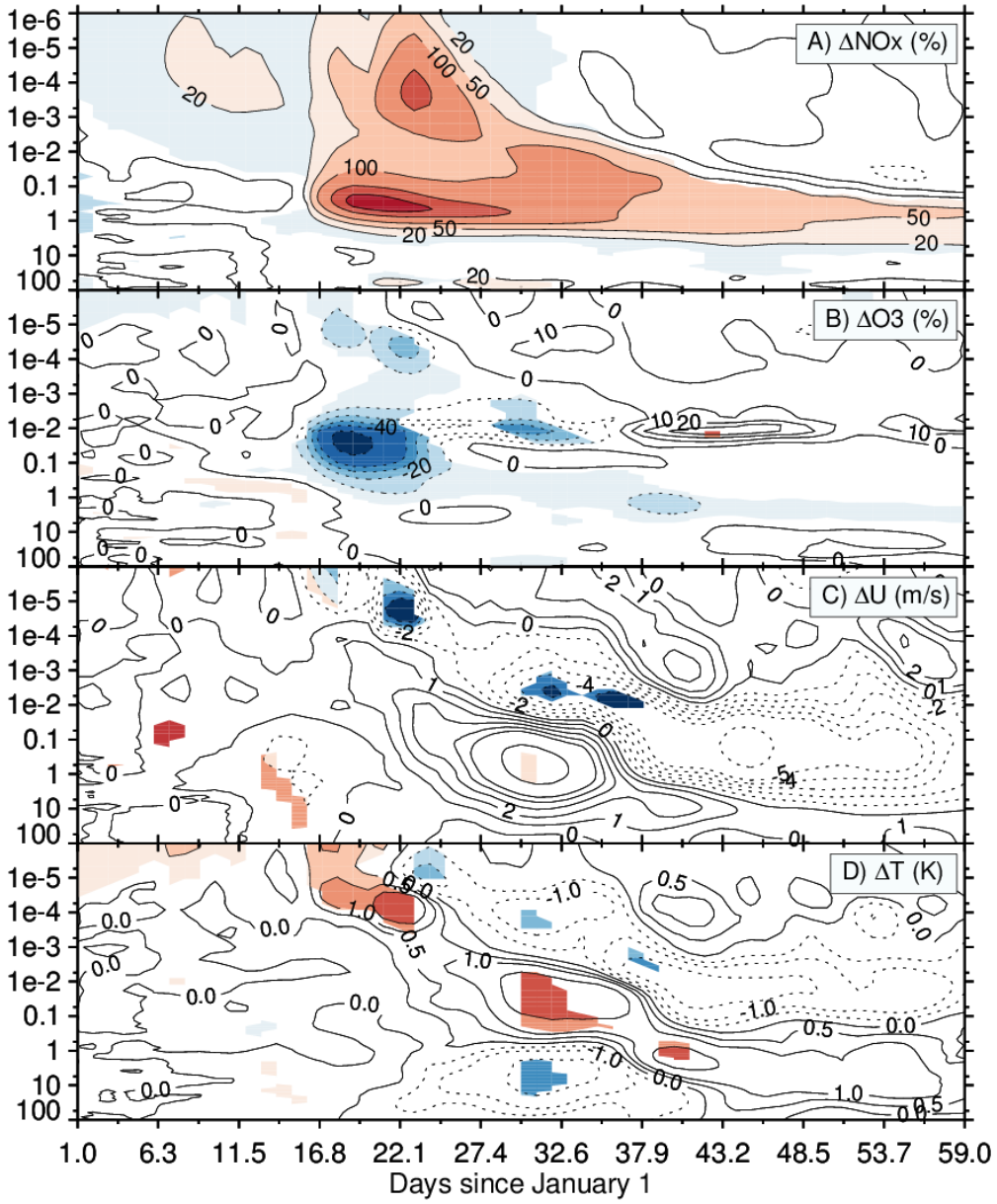
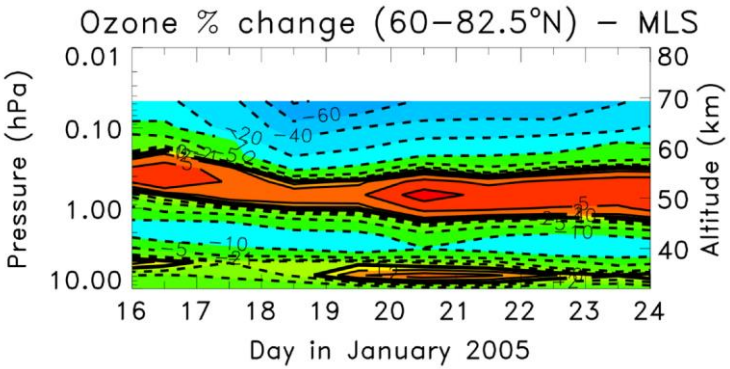
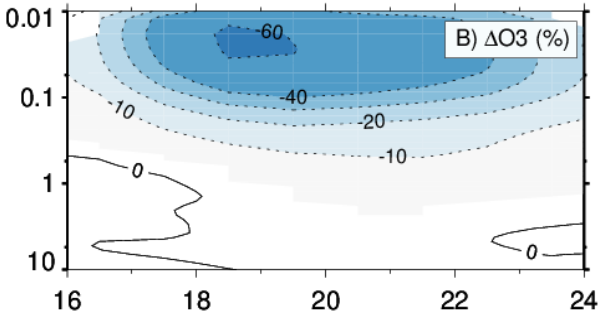
70-90N
20 ensemble members



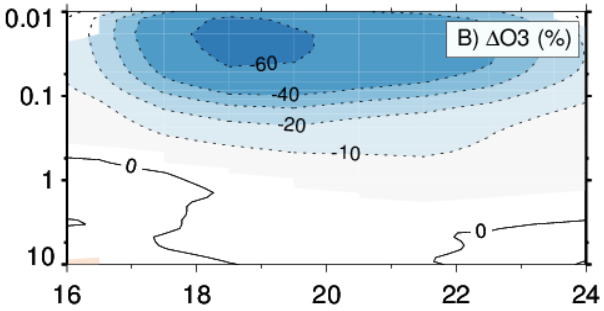
MLS from Jackman et al. (2011)



EAGLE (60-82.5N)



EAGLE (68N Sodankyla)



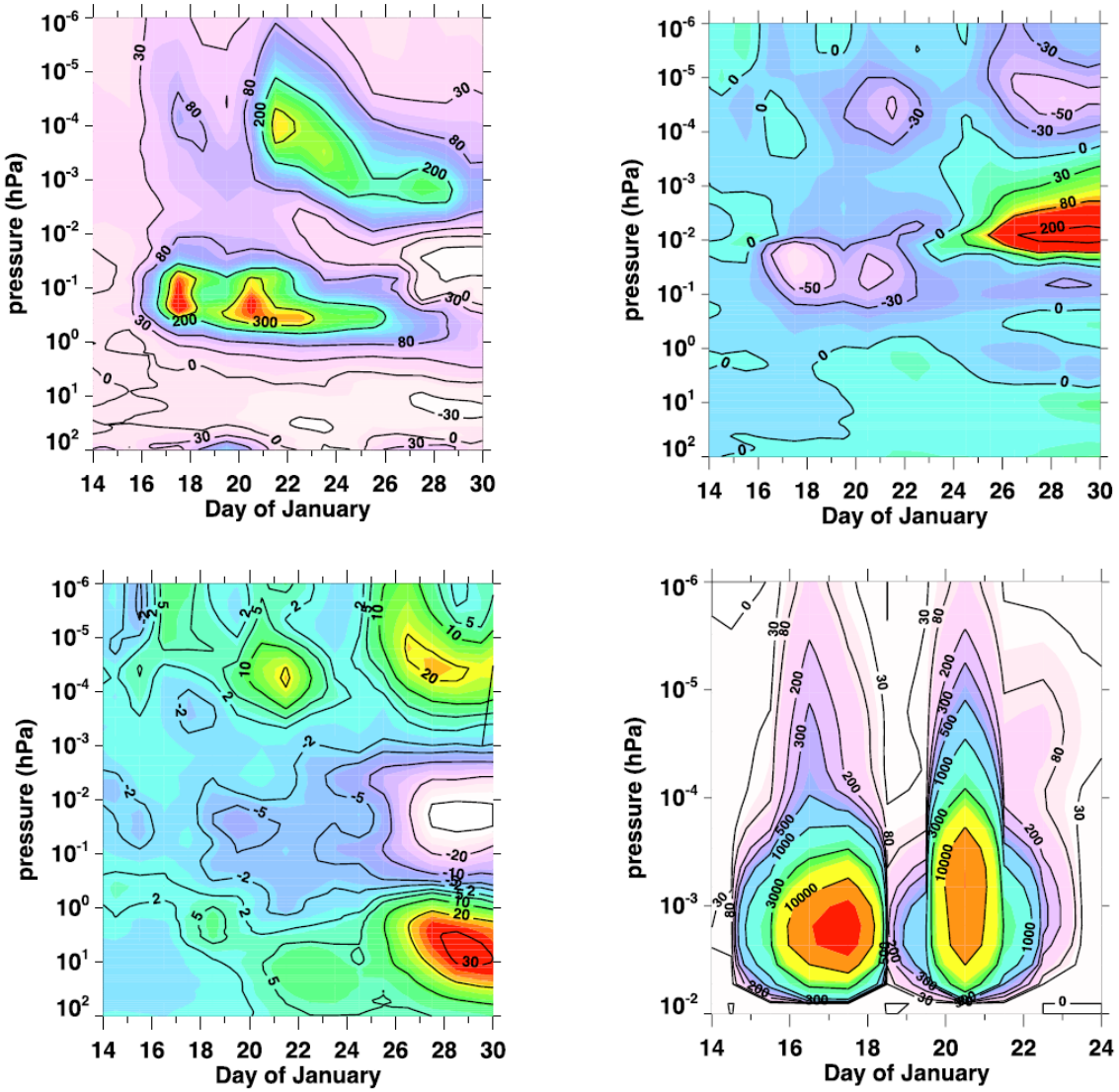


Рисунок 3. Высотное распределения отклика NO (%, верхняя левая панель), O3(%, верхняя правая панель), температуры (K, нижняя левая панель) и O+ (%, нижняя правая панель) в северной полярной области (80°с.ш.) на солнечное протонное событие в январе 2005 года.

Zonal mean ensemble mean temperature at 10 hPa
5 ensemble members