UNIWERSYTET WARMIŃSKO-MAZURSKI W OLSZTYNIE

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

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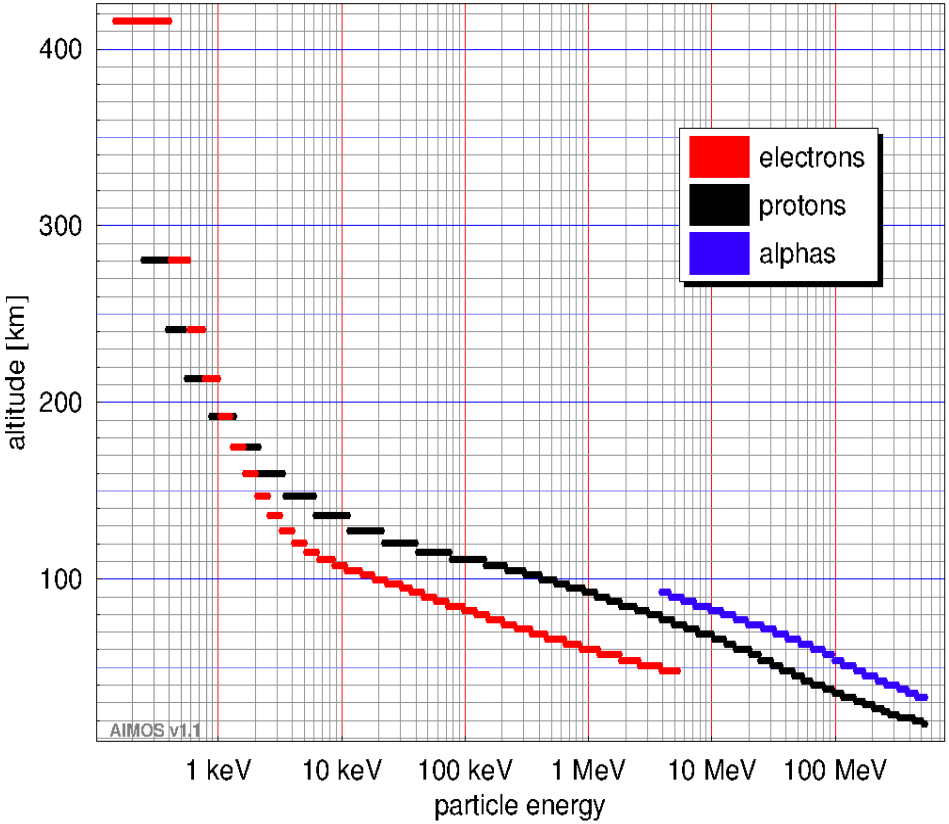
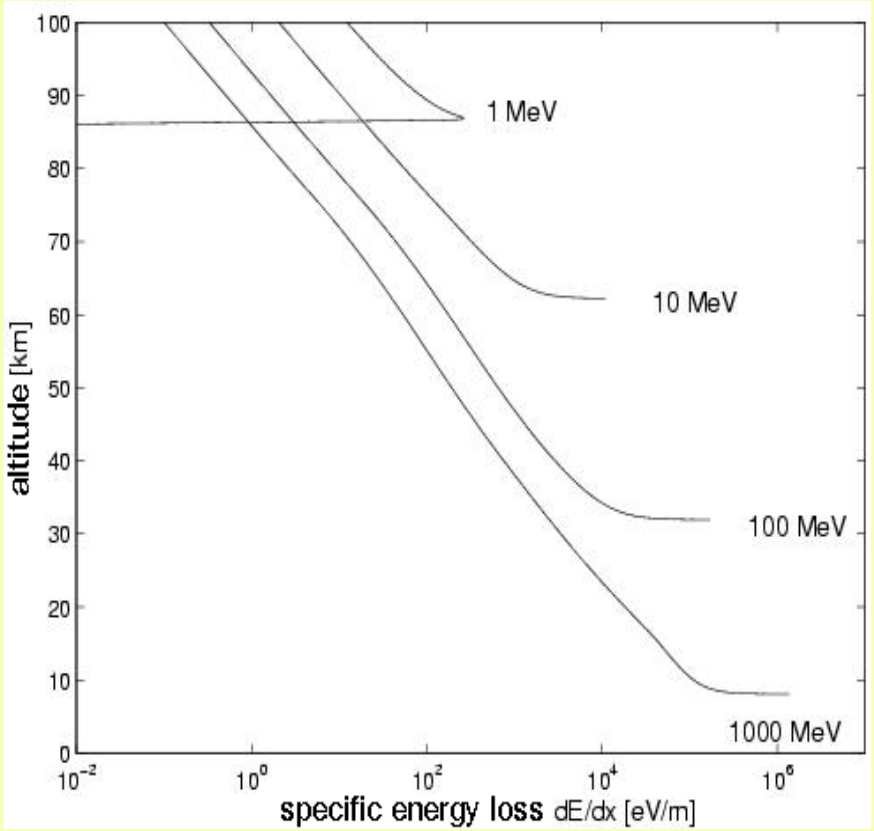
3. IAC ETH Zurich, Switzerland
4. IAA-CSIC, Granada, Spain

Altitude of maximum energy deposition

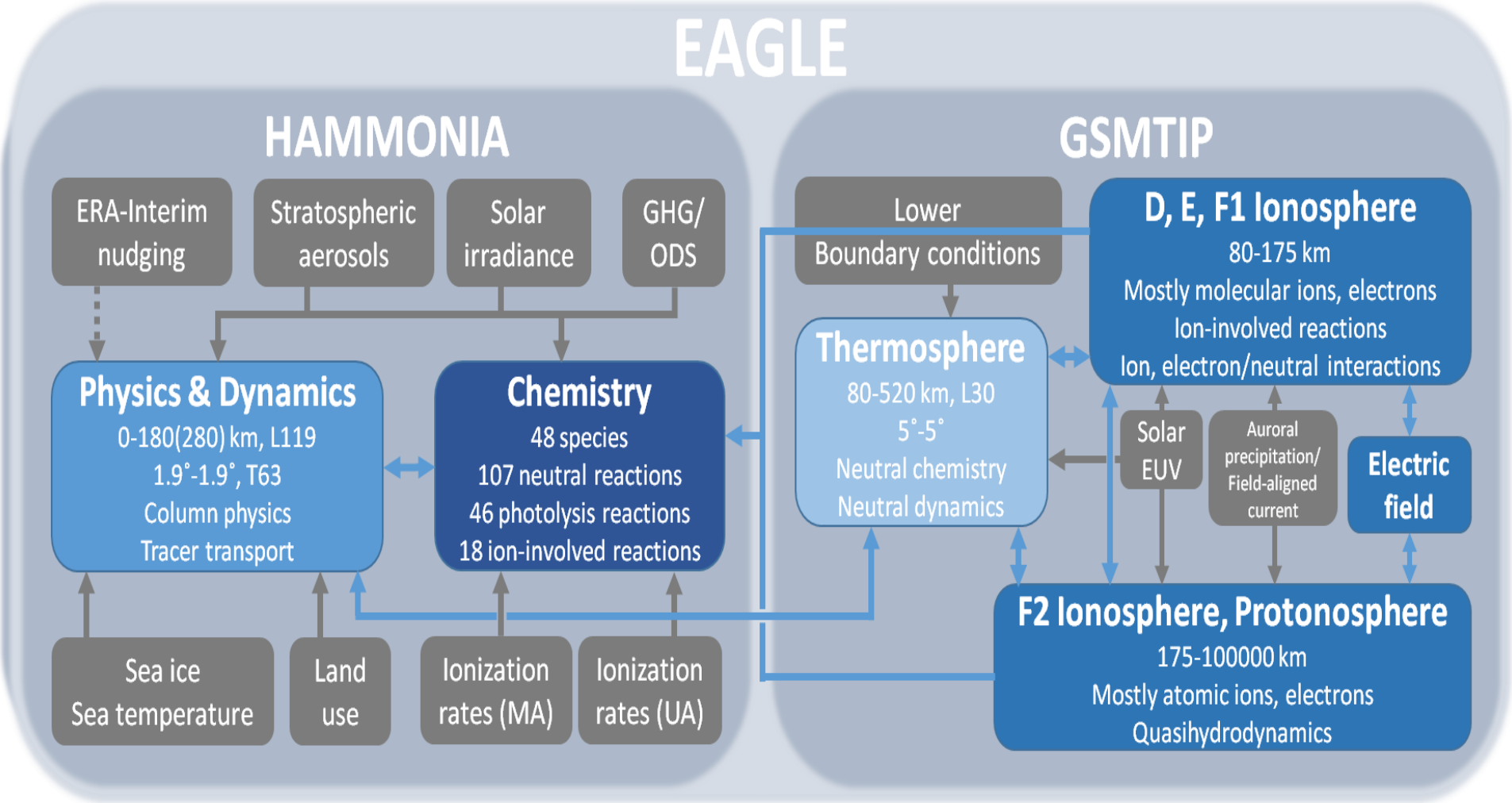
(Wissing and Kallenrode 2009)



(Quack, 2005)



Whole Atmosphere Global Model



Atmospheric Ionization Module Osnabrück (AIMOS)

AIMOS models of ion pair production due to precipitating particles solar and

AIMOS is designed to olar and magnetospheri to a 3-D ionization patt

AIMOS consists of tw rlo simulation and a so s from two polar-orbiting s ells, depending on geom

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

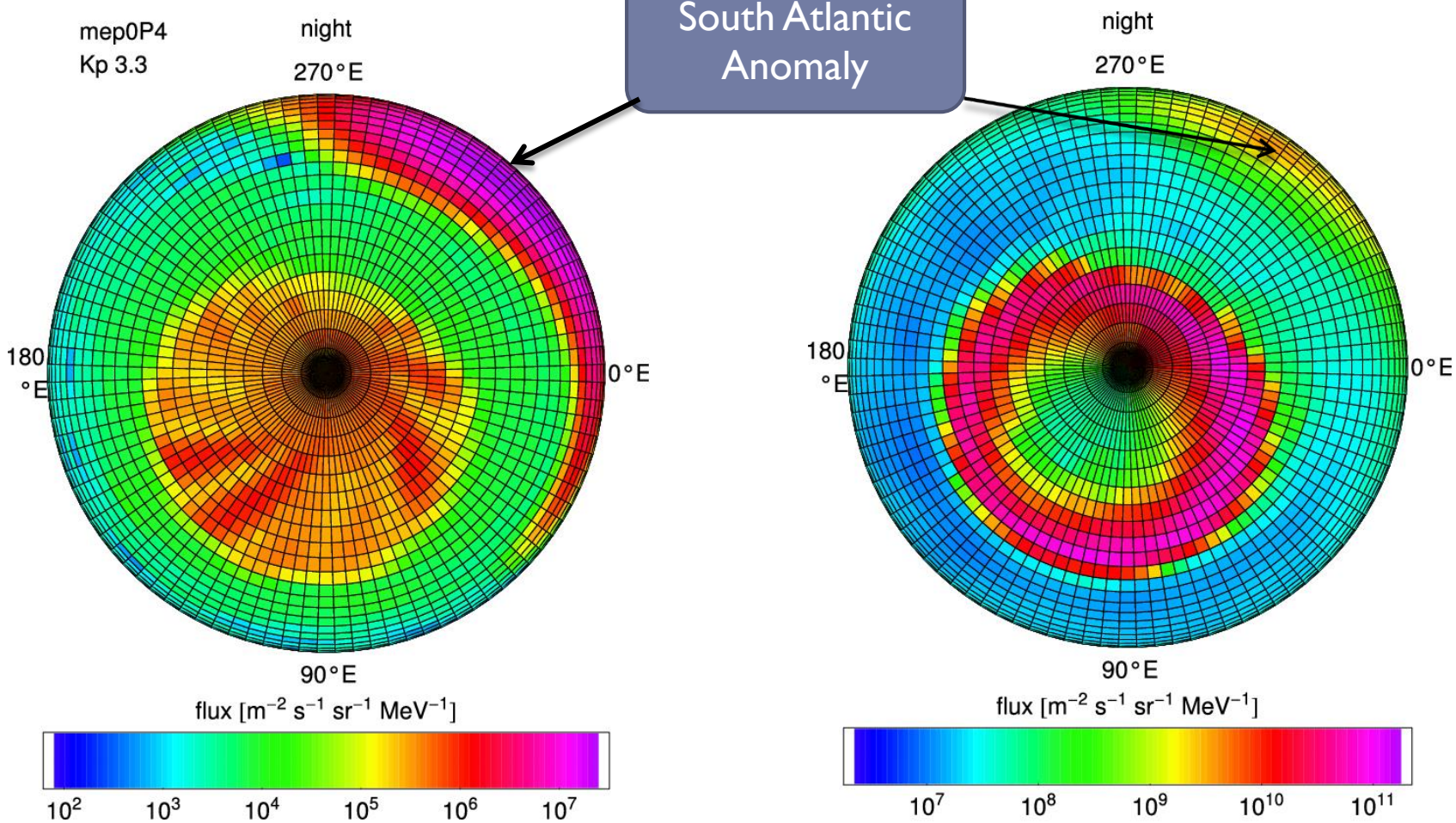
The GOES satellites (GOES: Geostationary Operational Environmental Satellite) are in geostationary orbit located at W135 and W104.

AIMOS

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

Low energetic particles (30–80 keV protons) flux

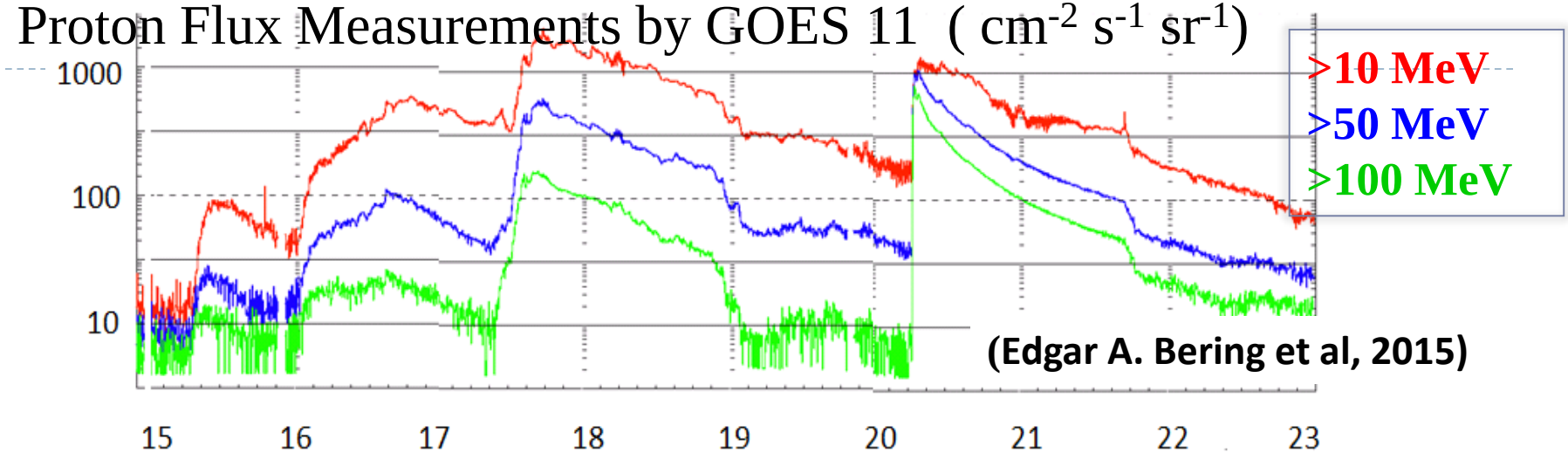
South Atlantic Anomaly



A view on the south pole is shown.

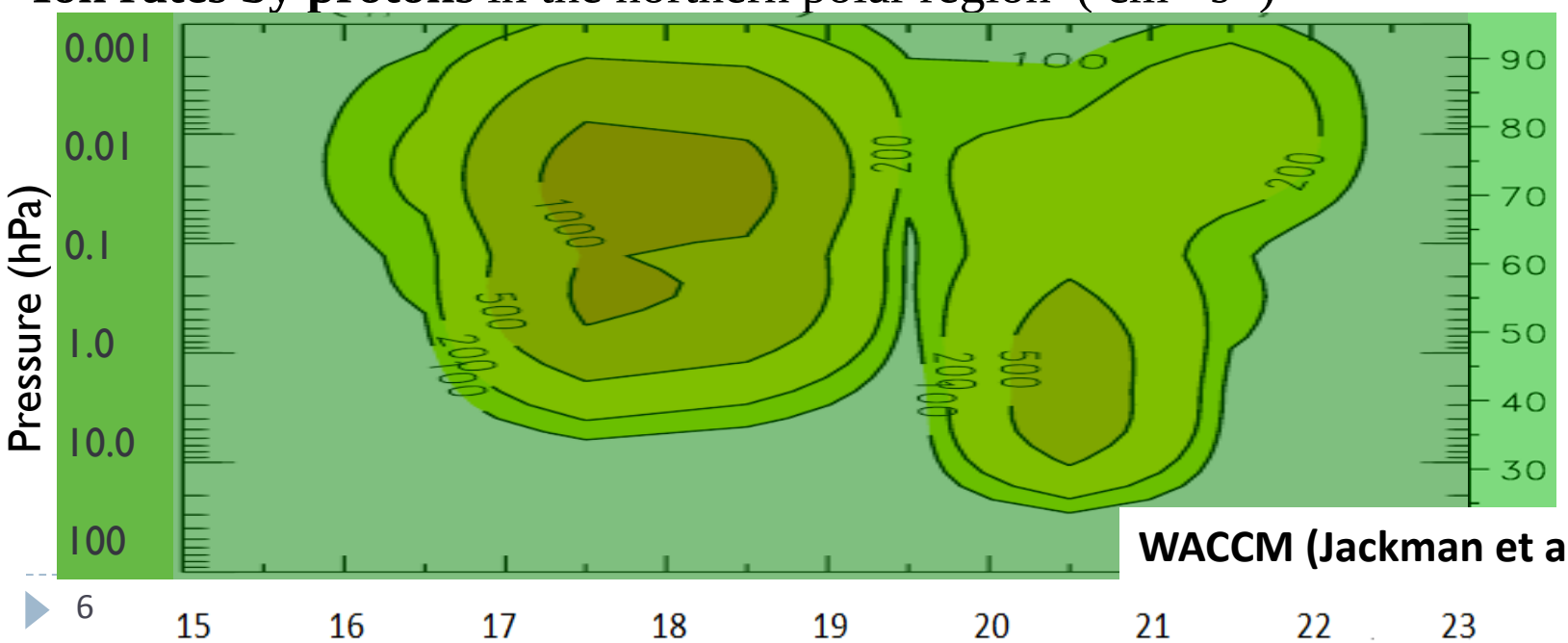
Solar Proton Events, January of 2005

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})



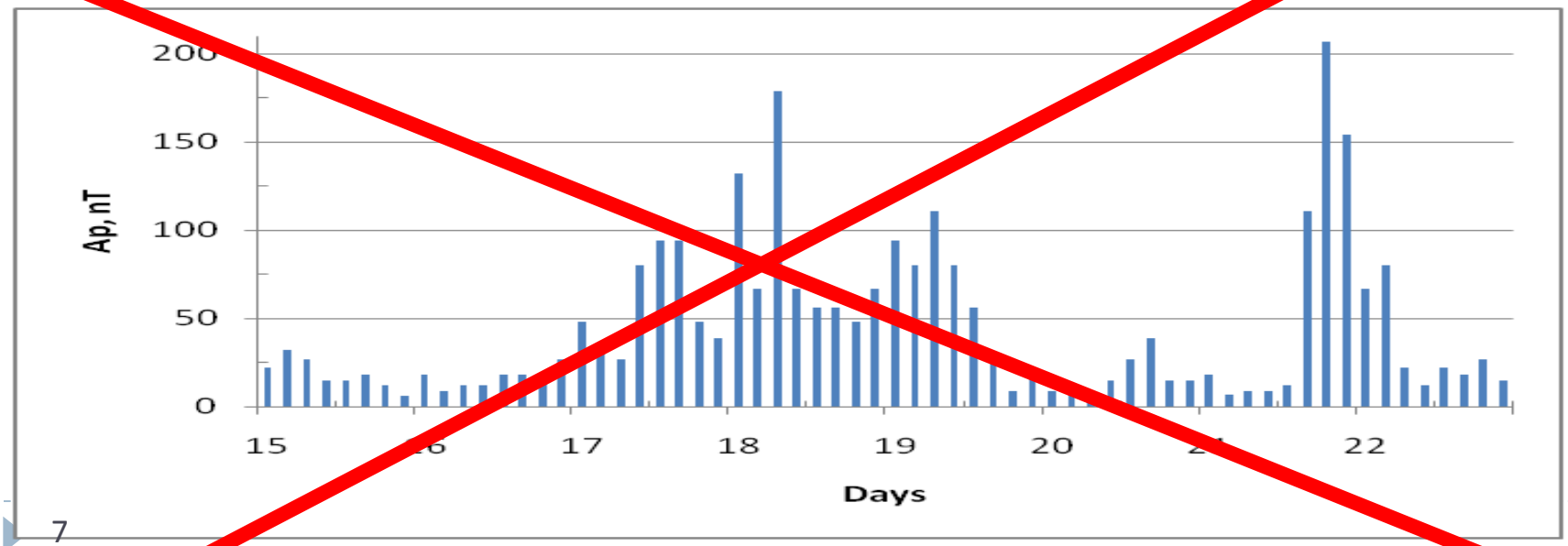
WACCM (Jackman et al., 2011)

EAGLE simulations

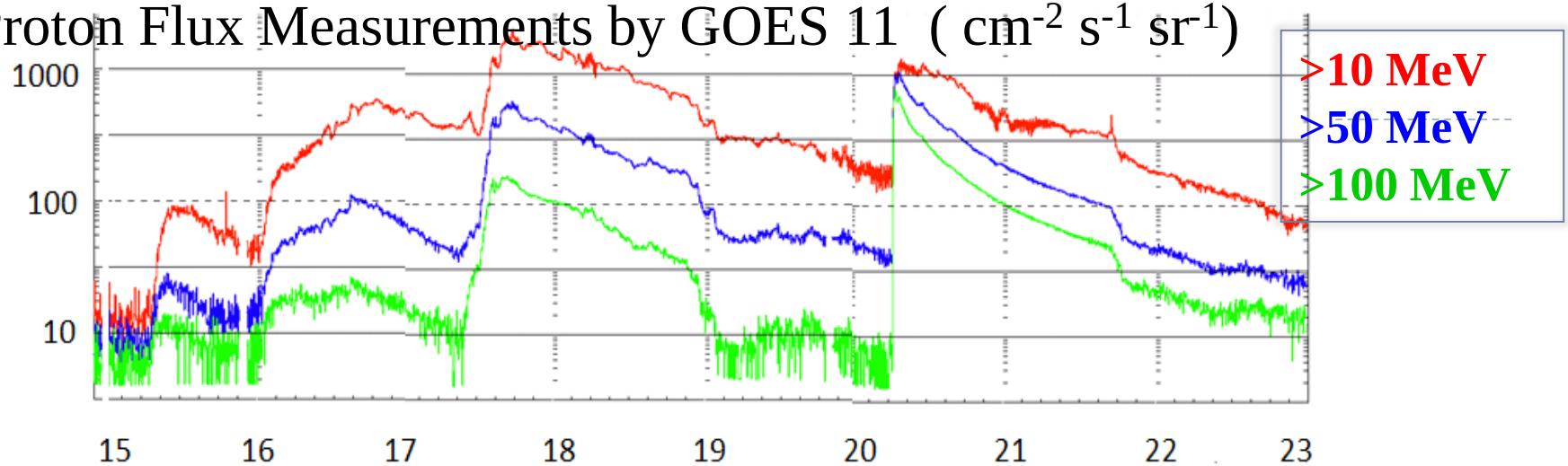
Data comparisons for two model runs:

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

It was changed ONLY proton flux in AIMOS

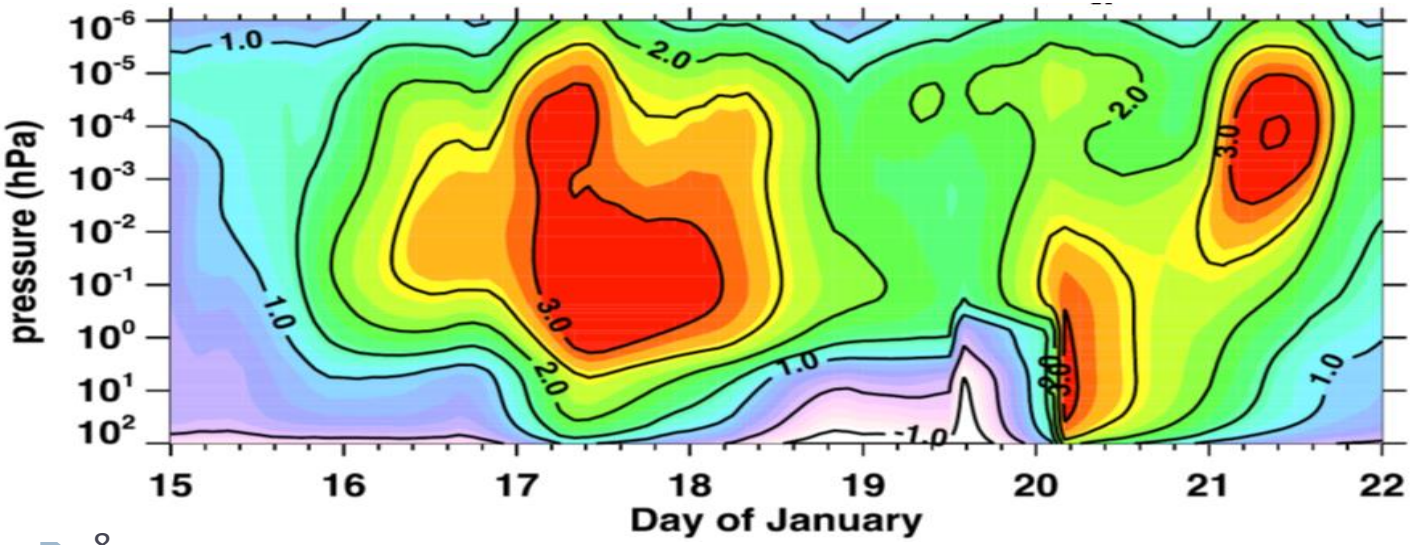


Proton Flux Measurements by GOES 11 (cm^{-2} s^{-1} sr^{-1})

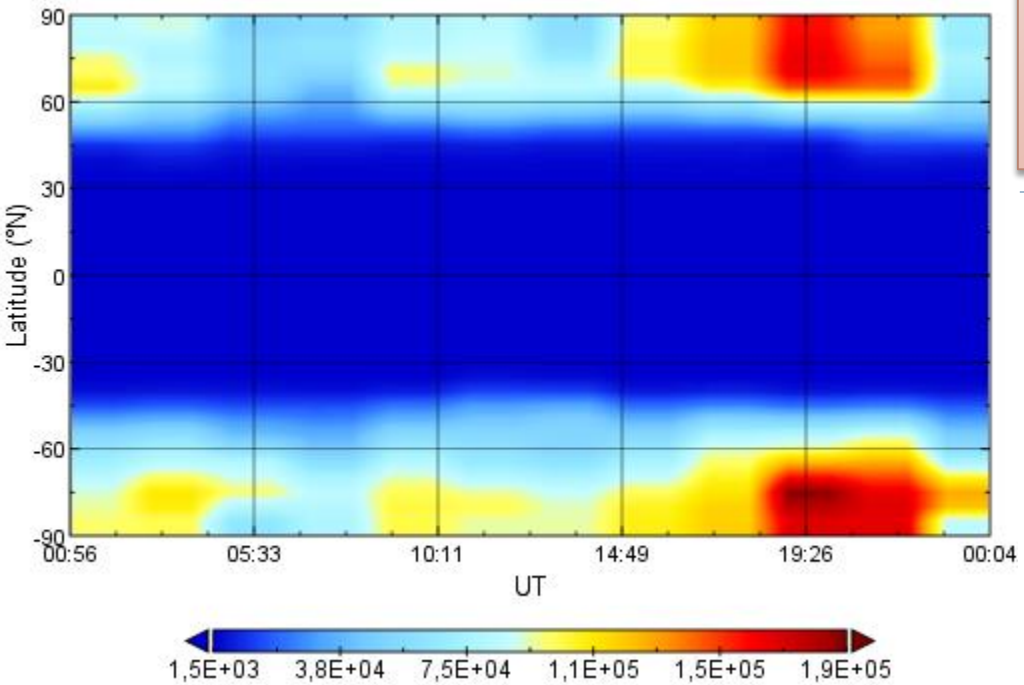


EAGLE log-ionization rates by protons (AIMOS)

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

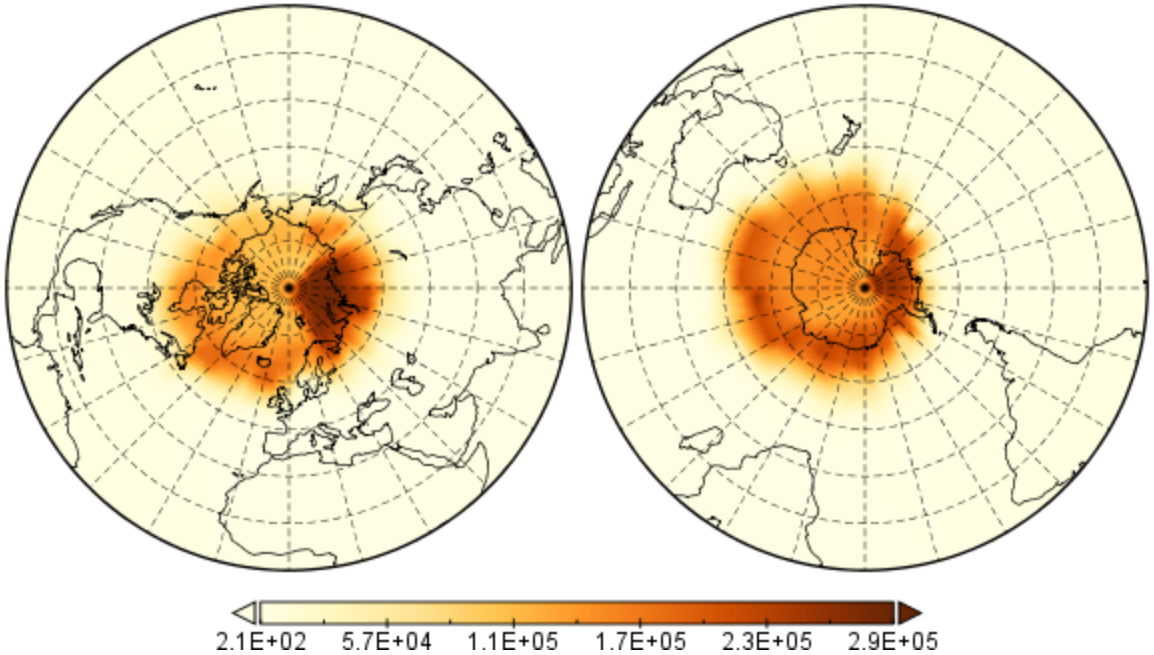


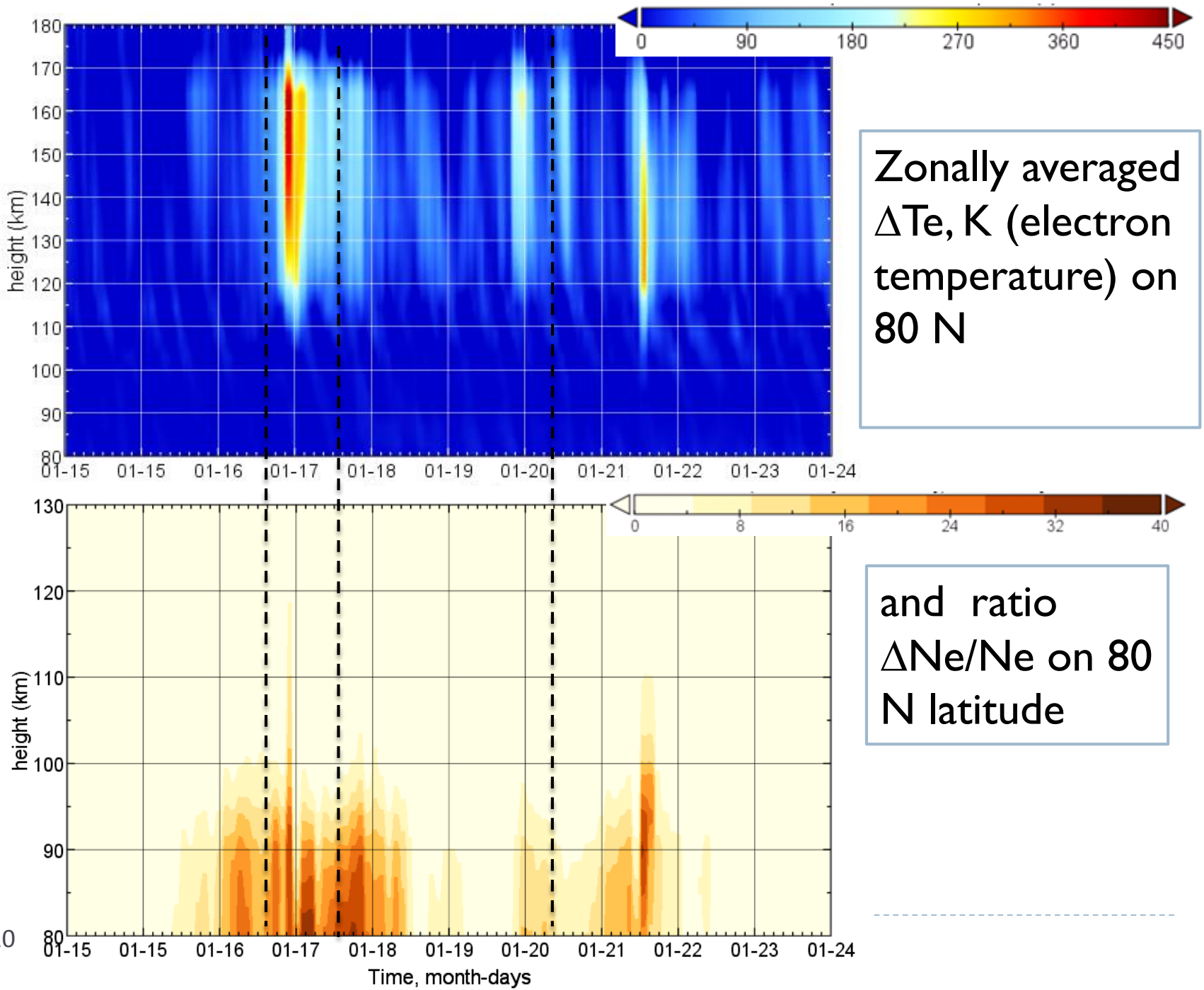
SOLAR PROTON EVENT, EAGLE model simulation



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

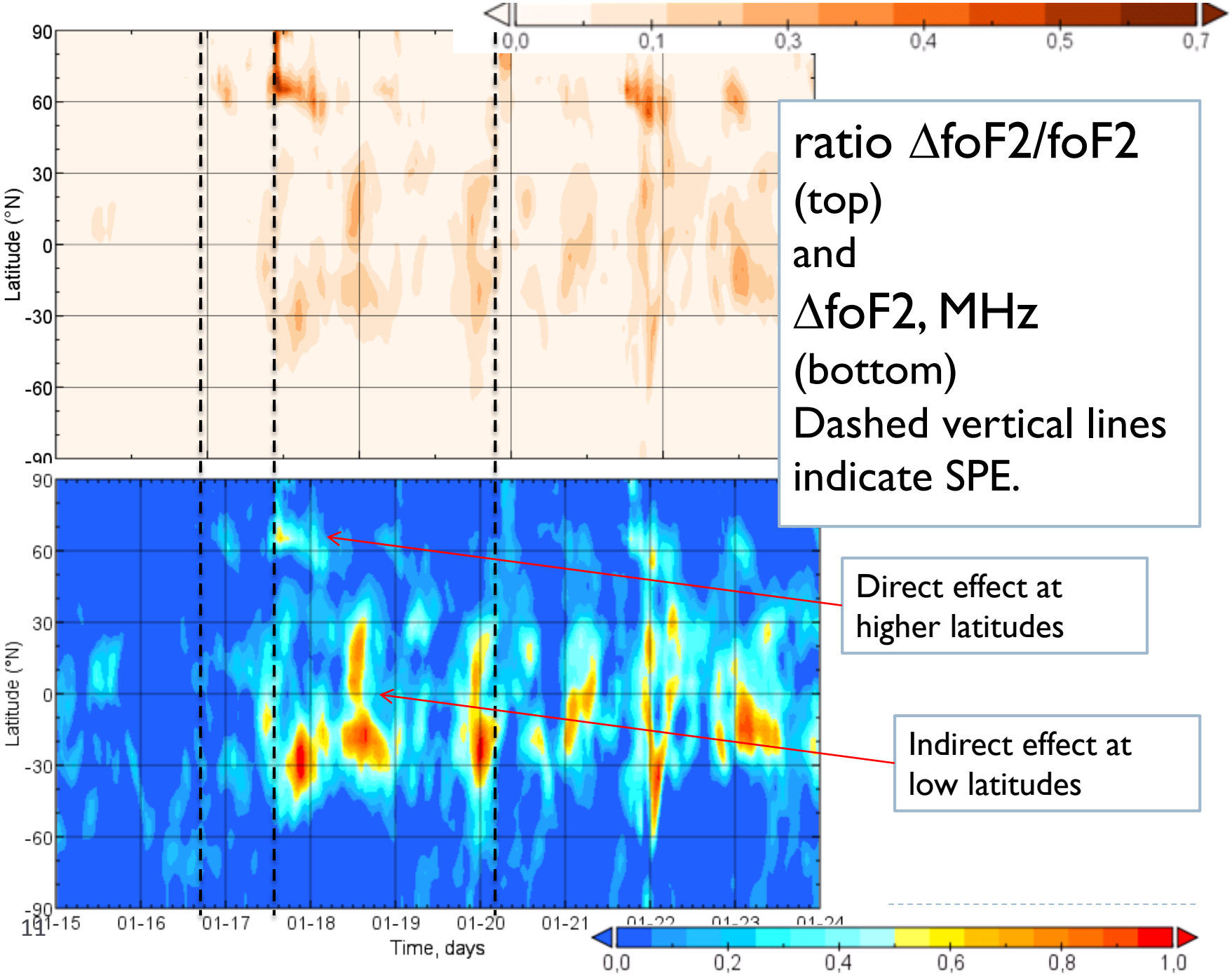
Ne,cm-3 at 83 km, 17 of January, 19 UT





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

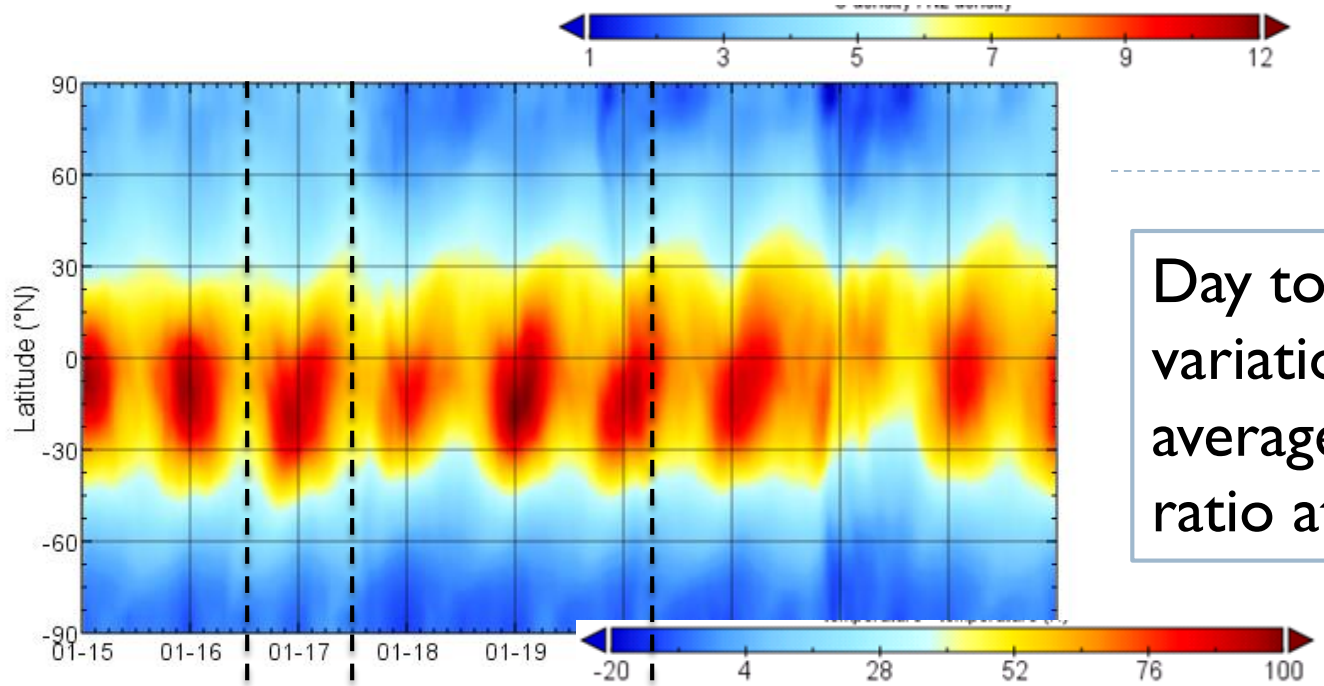
and ratio ΔNe/Ne on 80 N latitude



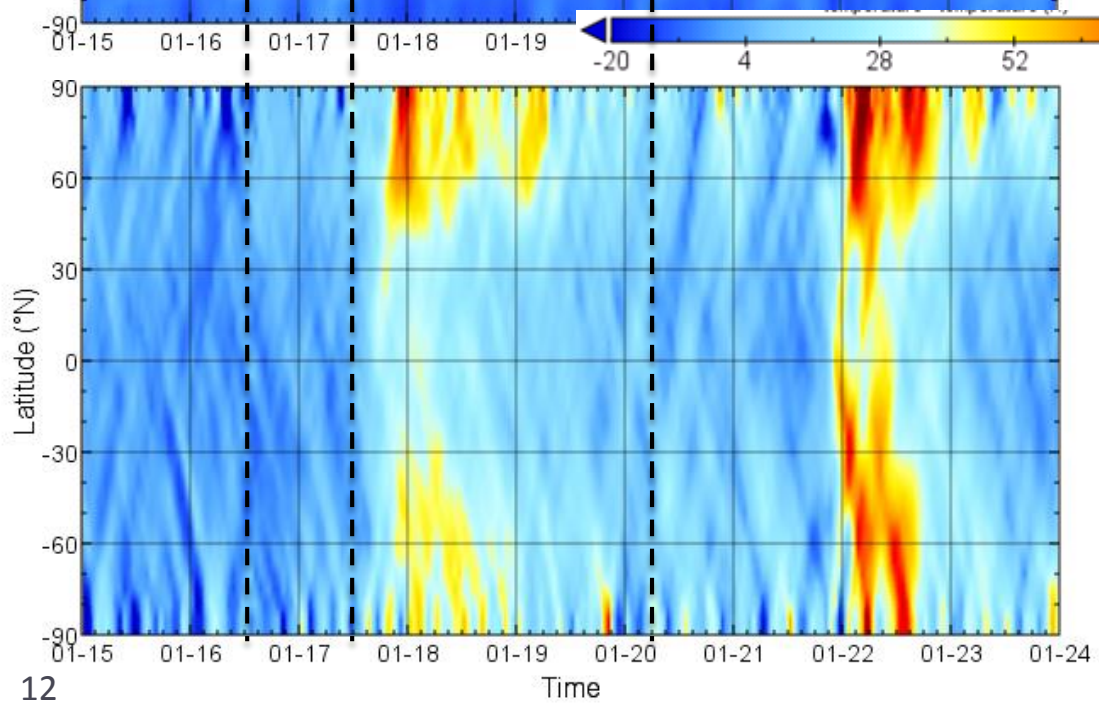
ratio ΔfoF2/foF2 (top) and ΔfoF2, MHz (bottom) Dashed vertical lines indicate SPE.

Direct effect at higher latitudes

Indirect effect at low latitudes

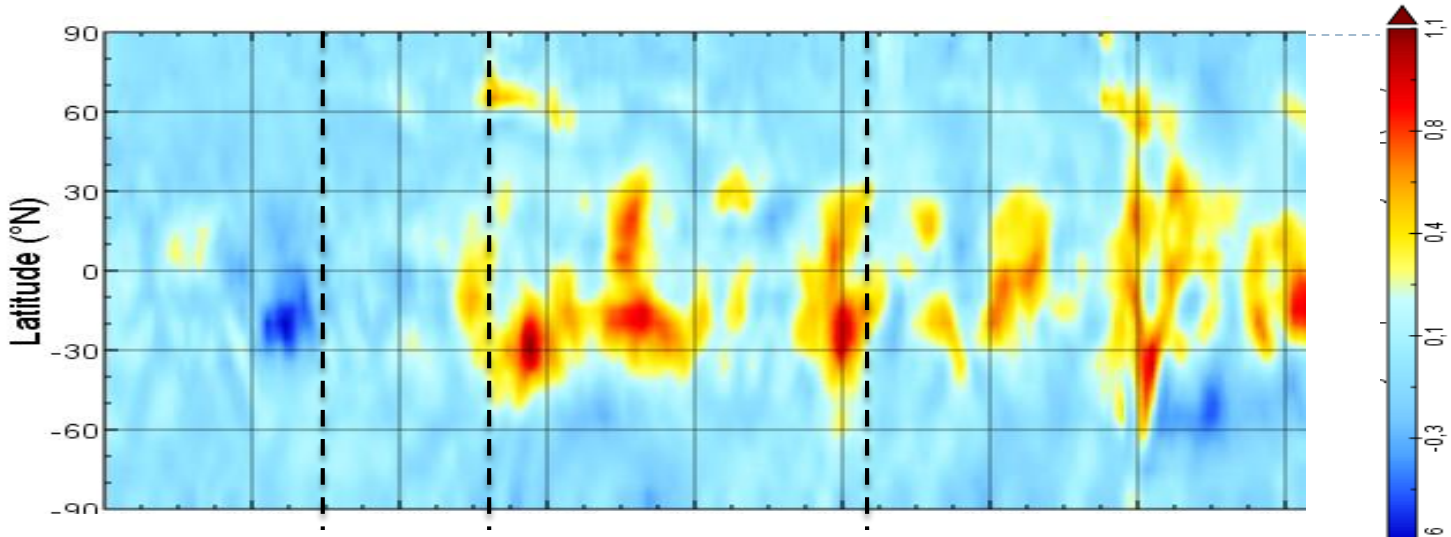


Day to day variation zonally averaged O/N2 ratio at 300 km

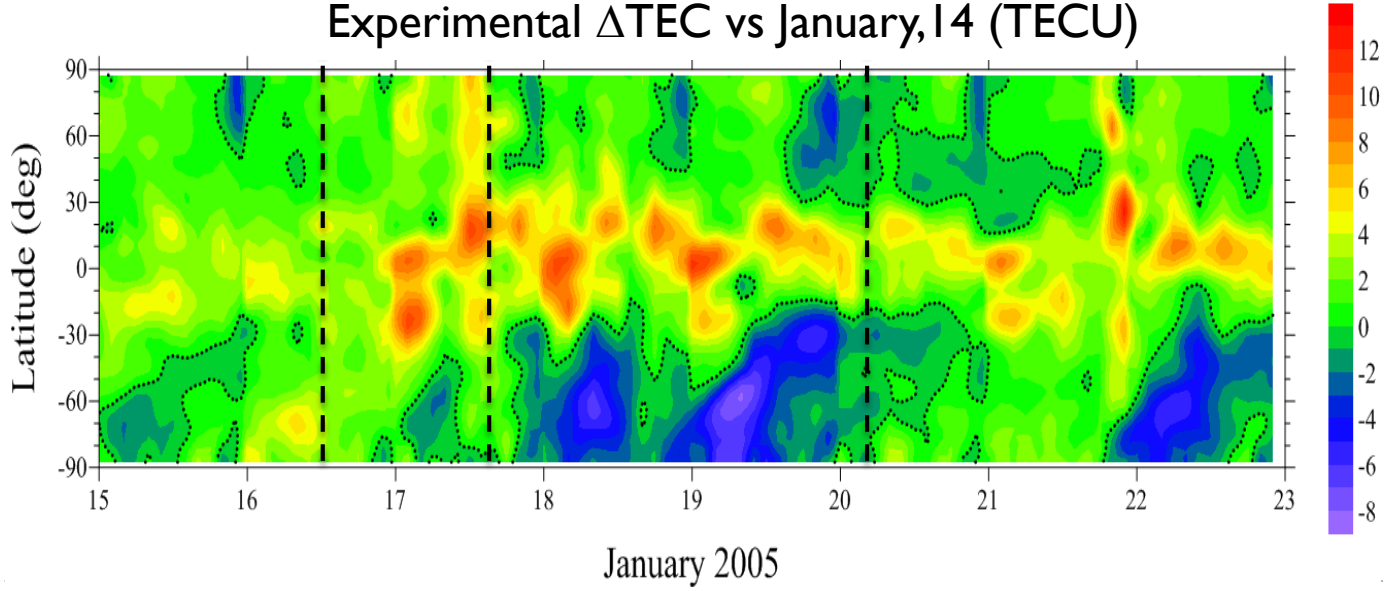


Zonally averaged ΔTn at 300 km

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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