The Influence of Middle Range Energy Electrons on Chemistry and Regional Climate

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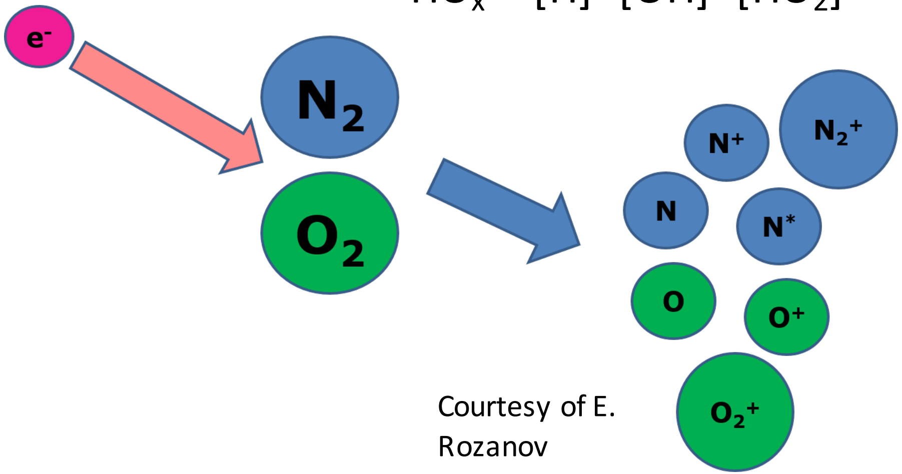
Energetic Particles

$NO_x = [N]+[NO]+[NO_2]$
$HO_x = [H]+[OH]+[HO_2]$

- Galactic cosmic rays (up to 5×10^{13} MeV)
- Solar protons (up to 500 MeV)
- Auroral low energy electrons (<30 keV)
- Radiation belt middle energy electrons (30 to 300 keV)
- Radiation belt high energy electrons (300 keV to 10 MeV)



Courtesy of E. Rozanov

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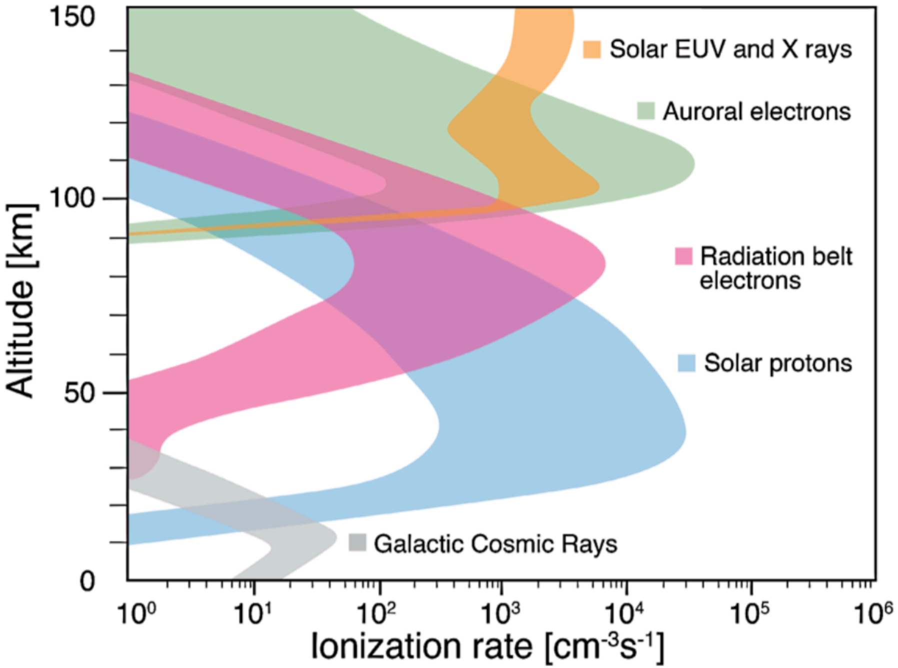
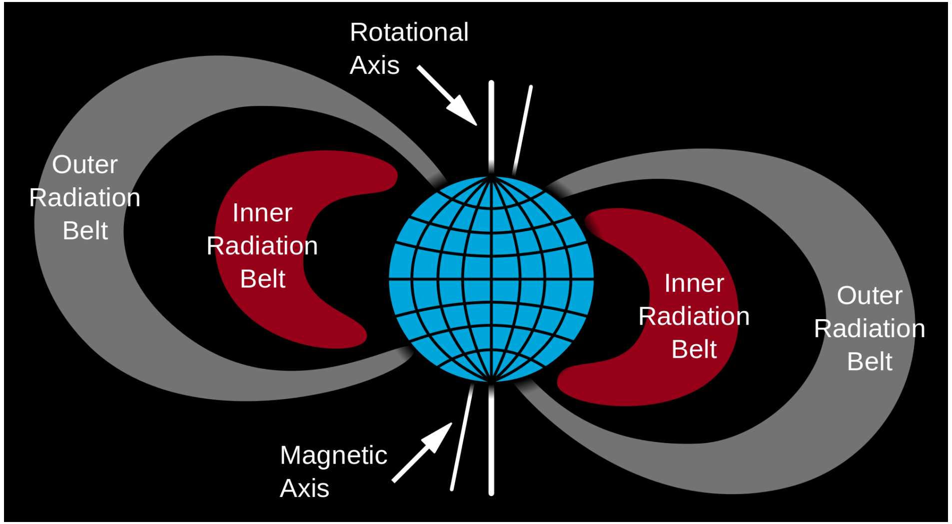


Mironova et al., 2015

Are MEE important for chemistry and climate?

- Originate from outer radiation belt
- Energy 30-300 keV
- Produce HO_x and NO_x below 80 km
- HO_x and NO_x induced ozone depletion
- Potentially important for chemistry and climate



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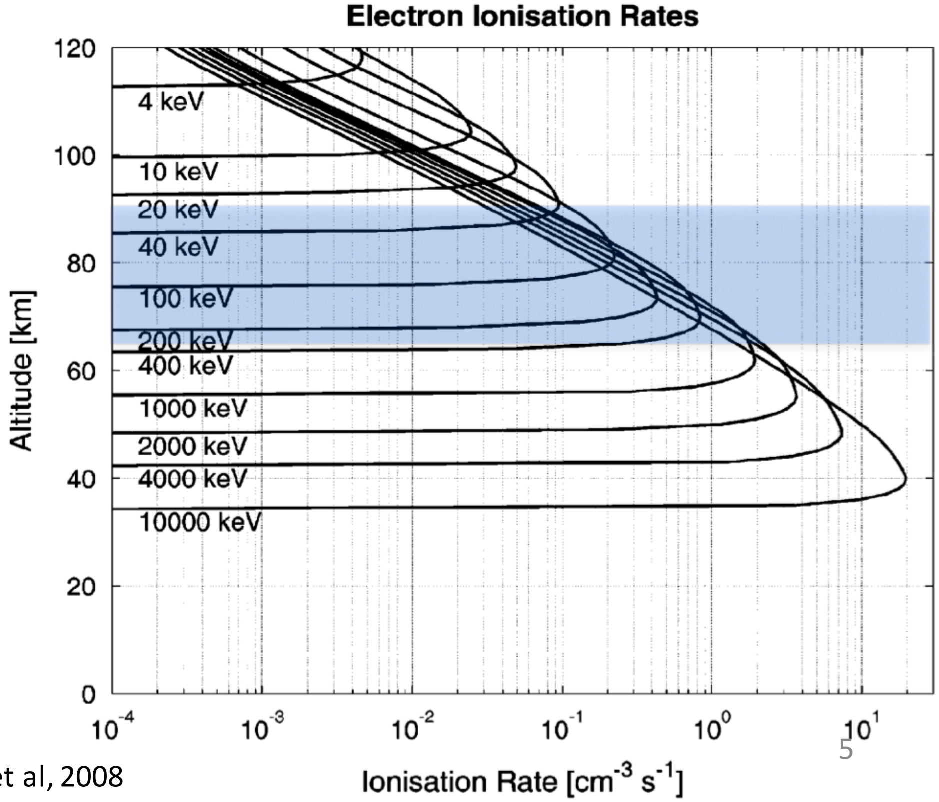
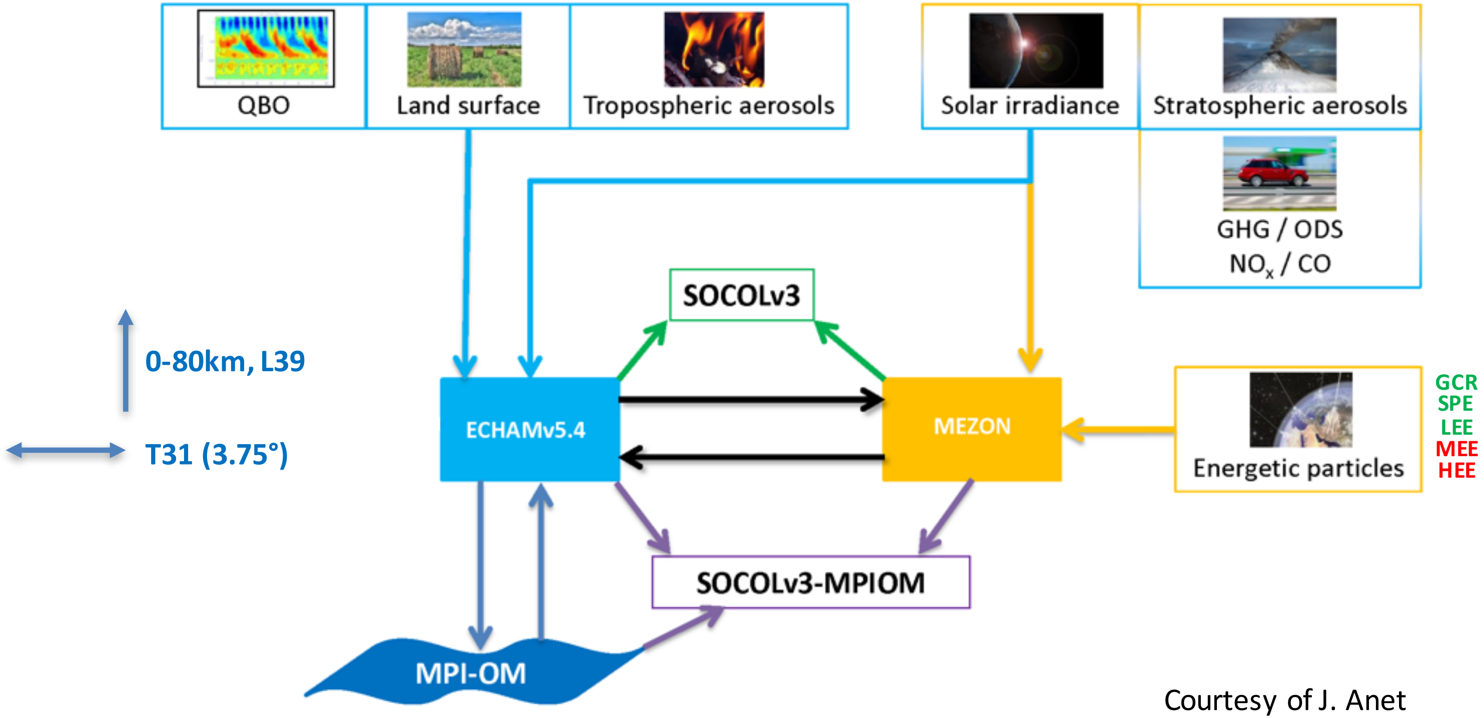


Turunen et al, 2008

SOCOLv3-MPIOM Model Framework

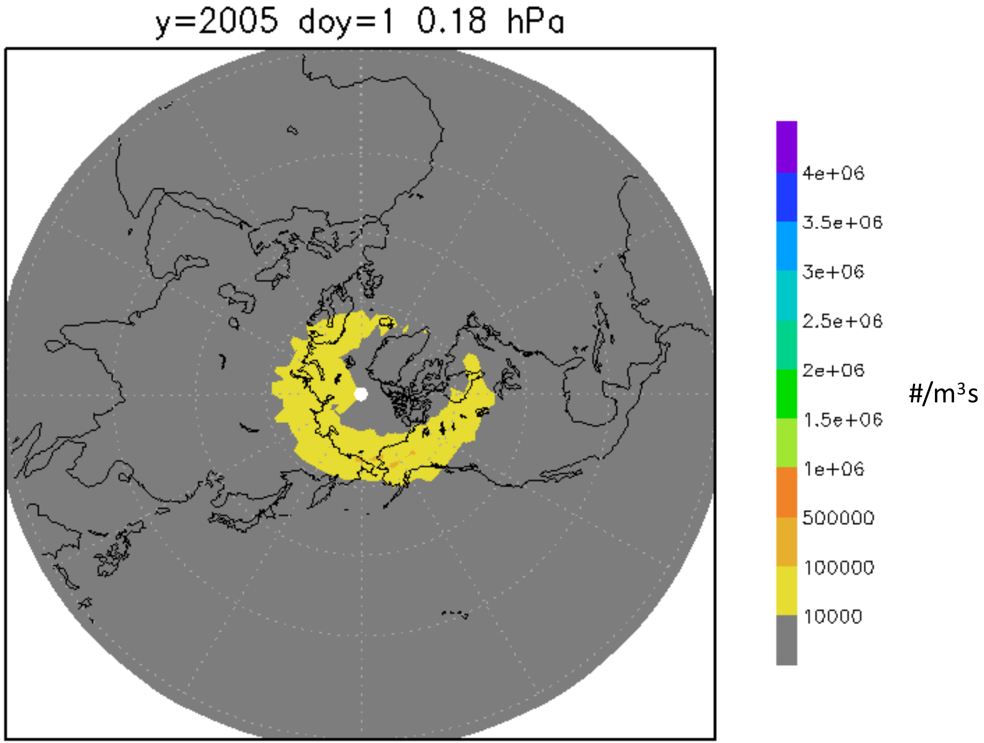


Courtesy of J. Anet

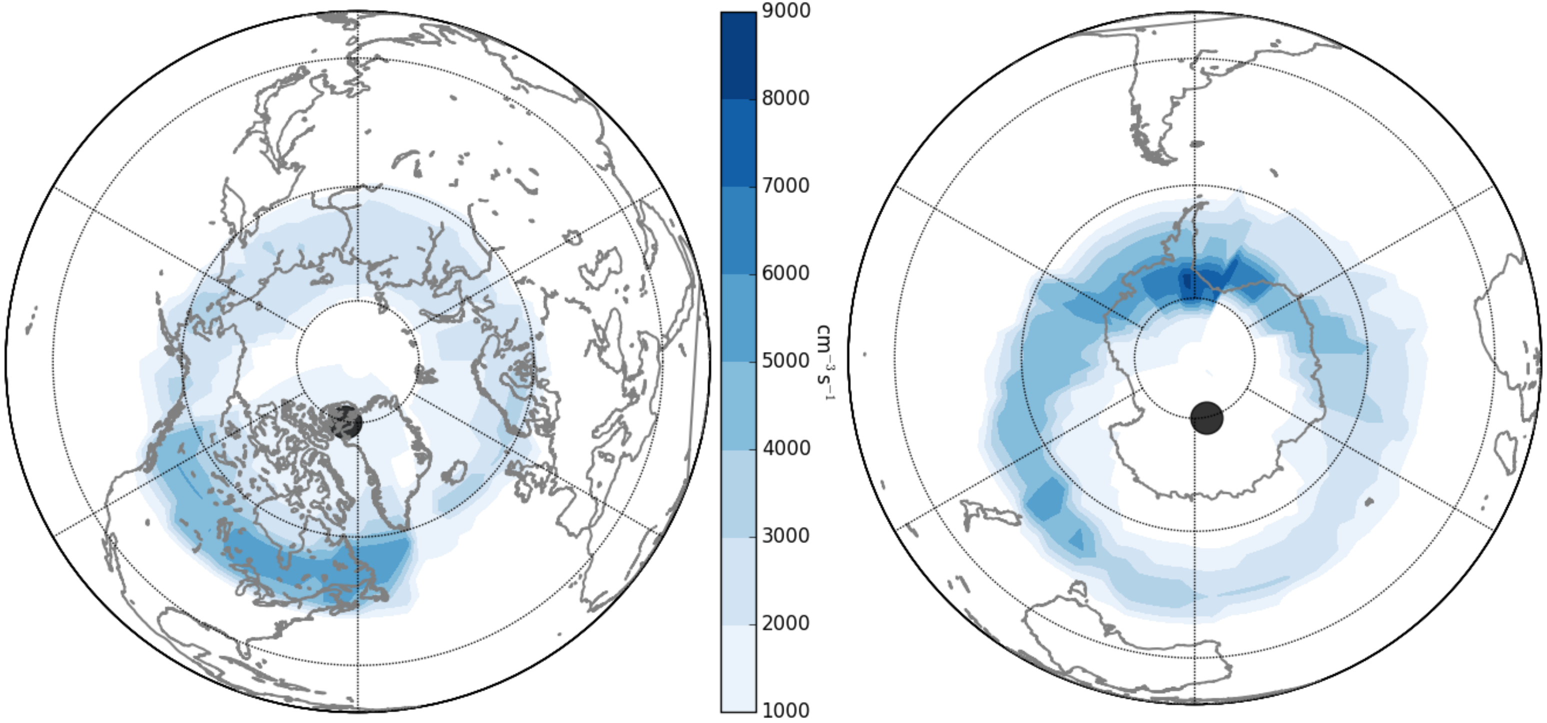
MEE Ionization Data

- Ionization rates from **Atmosphere Ionization Module Osnabrück (AIMOS)** by Wissing and Kallenrode (2009)
- Time period: 2002-2010
- Comparison between the simulation with MEE and reference simulation (NOMEE)

AIMOS Ionization Rates Data

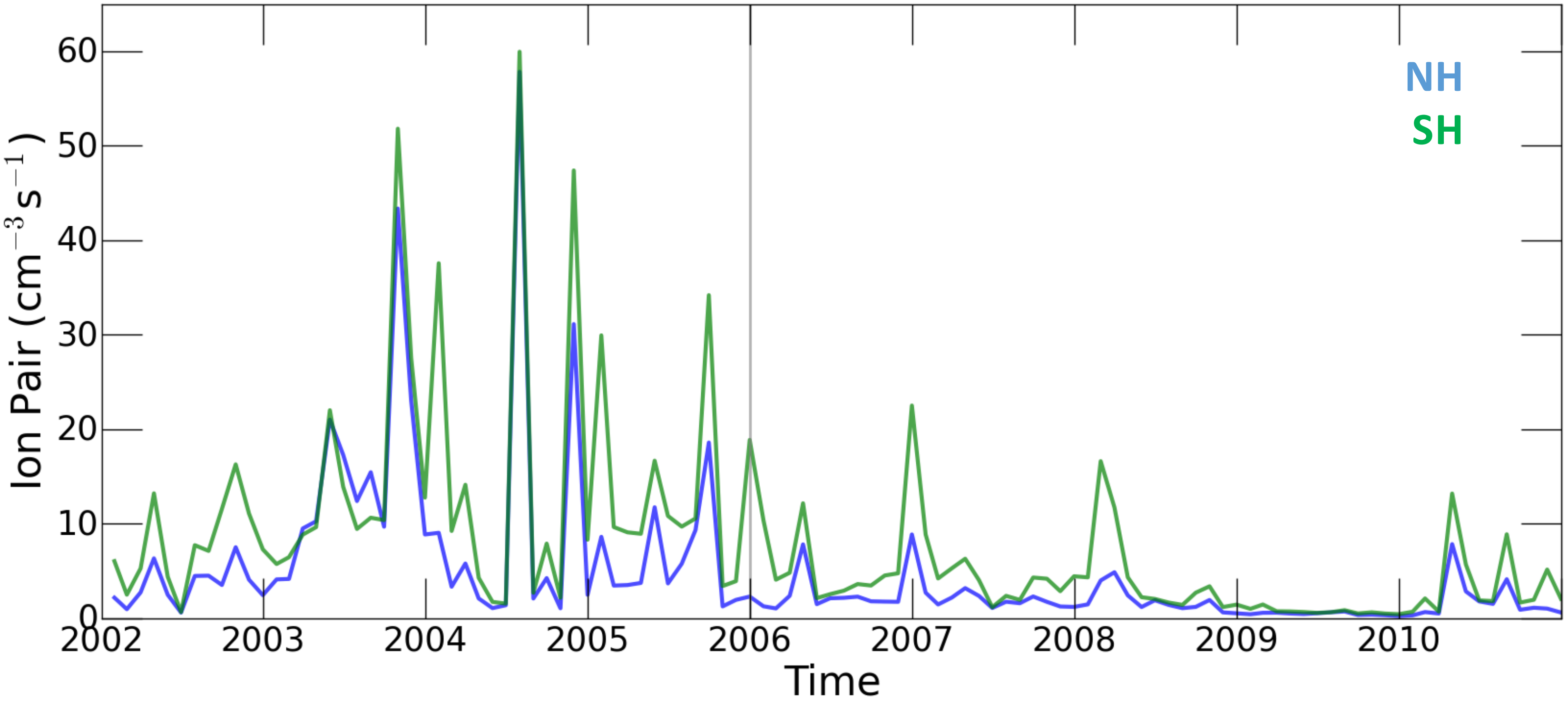


AIMOS Ionization Rates Data

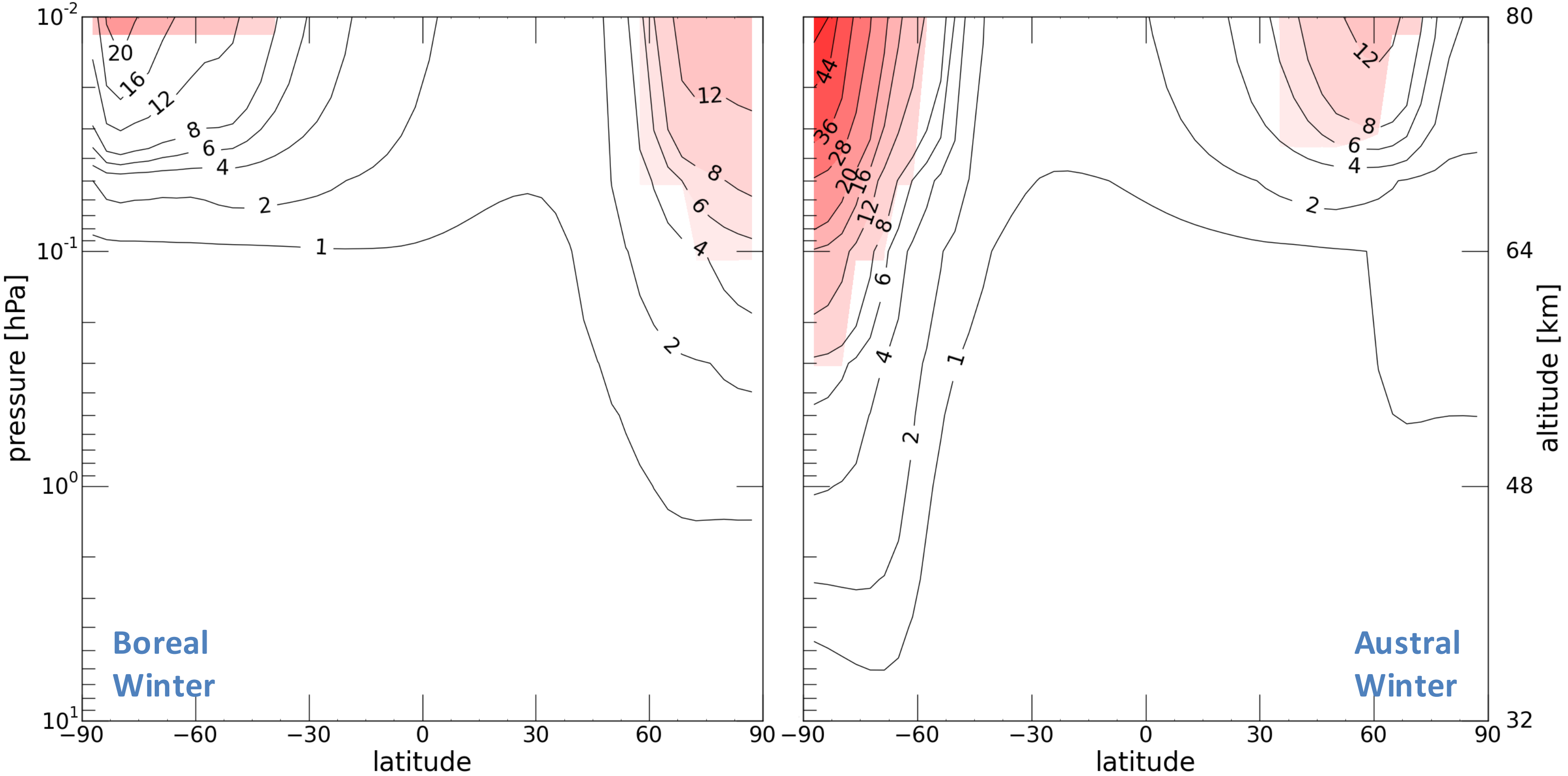


AIMOS Ionization Rates Data

p=0.01hPa, hemispheric mean

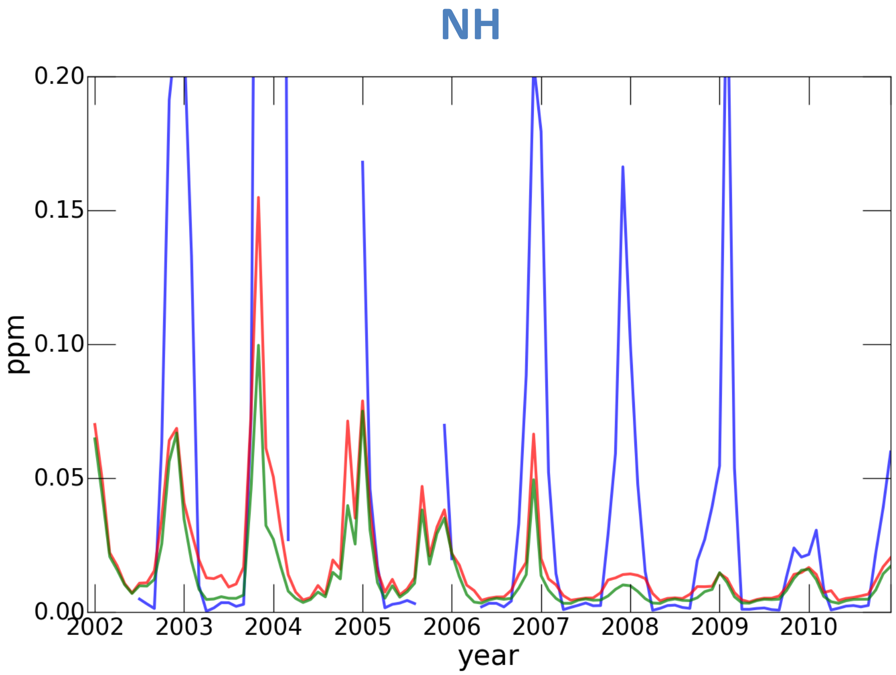


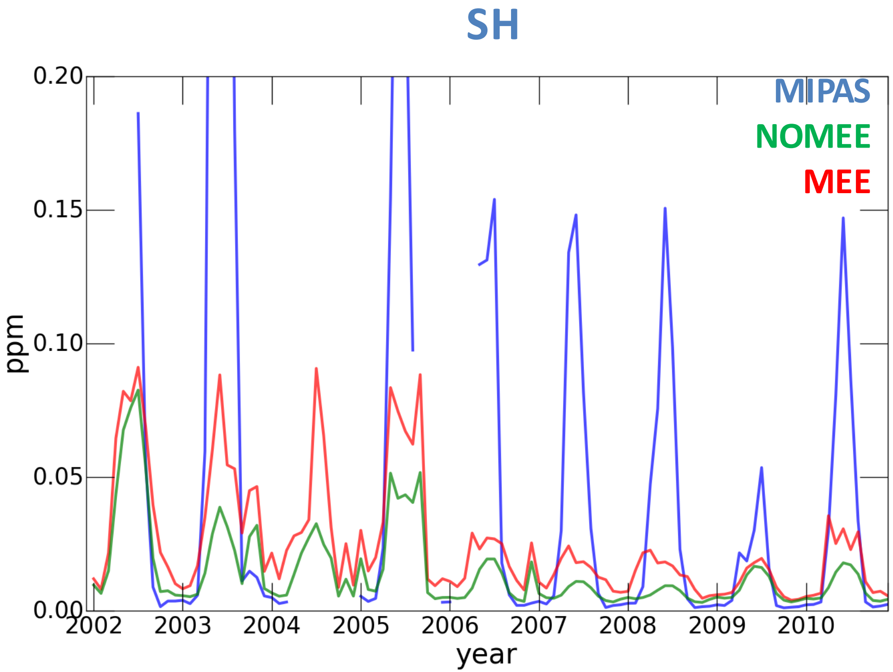
NO_x zonal mean difference [ppb] (MEE-NOMEE) 2002-2005



Comparison of modeled NO_y and observed NO_y* [ppm] for 70 km

70° to pole mean



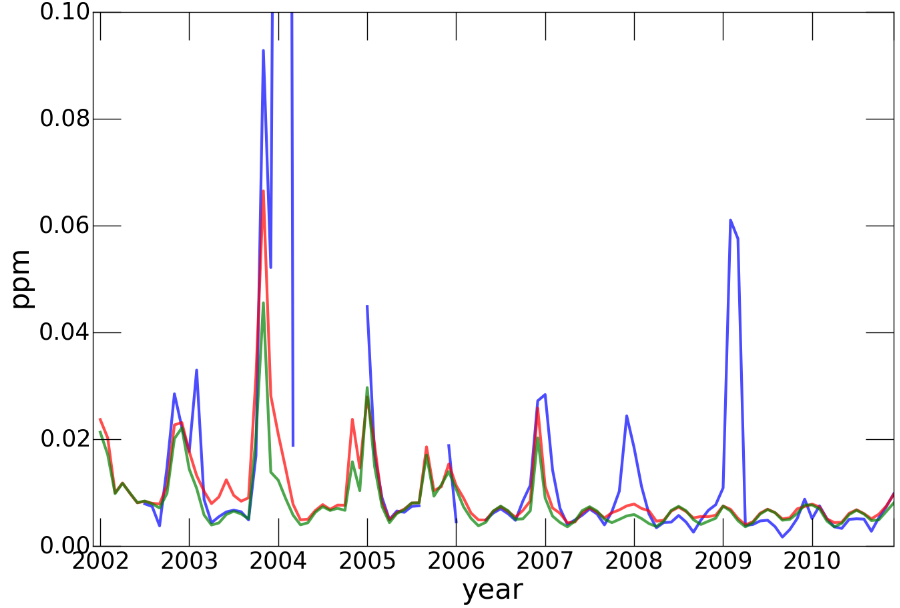


***MIPAS**, Funke et al, 2014

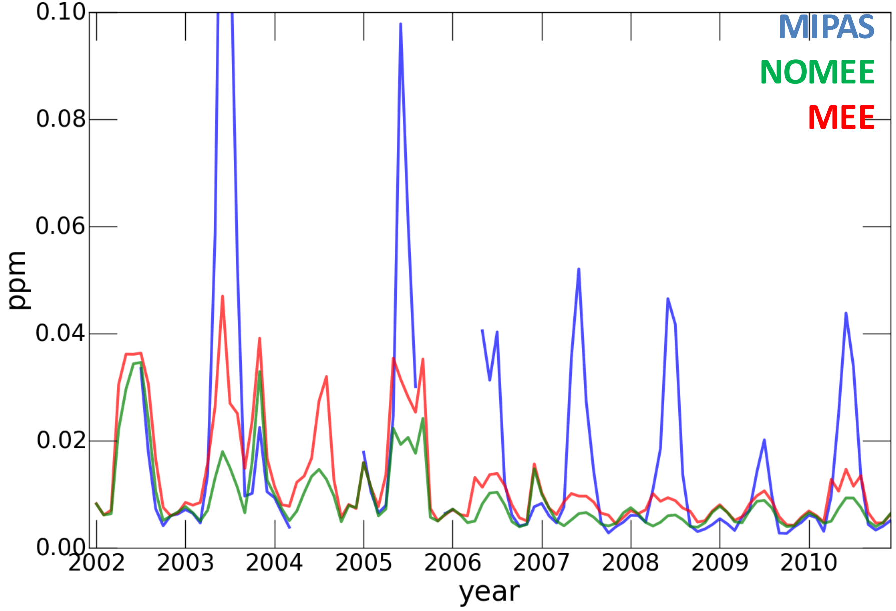
Comparison of modeled NO_y and observed NO_y [ppm] for 60 km

70° to pole mean

NH

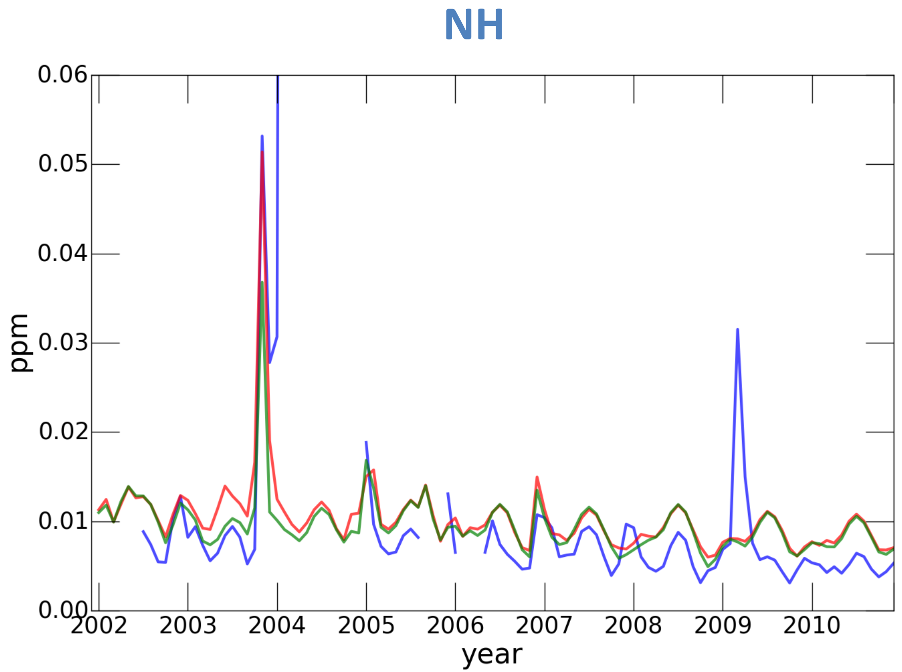


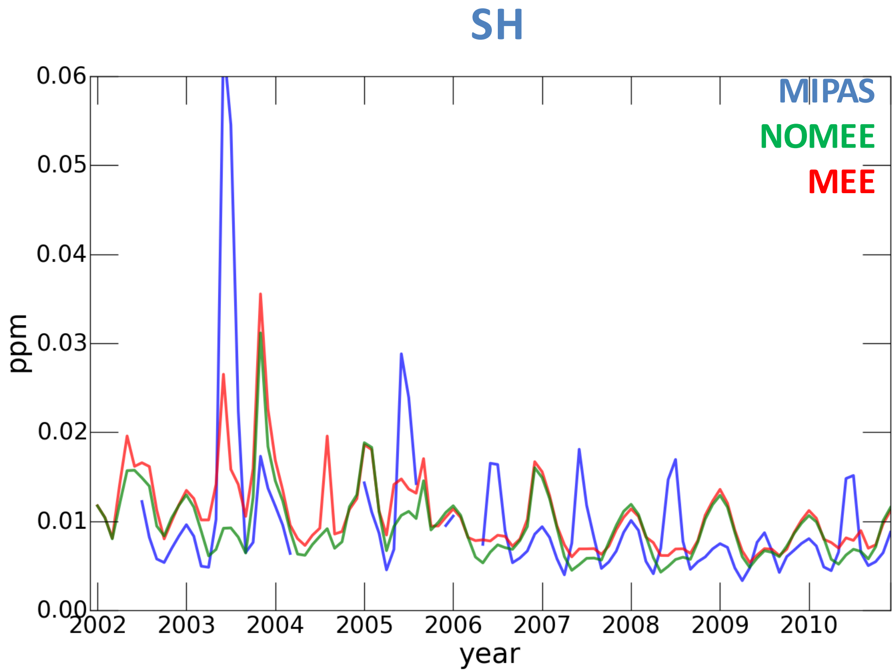
SH



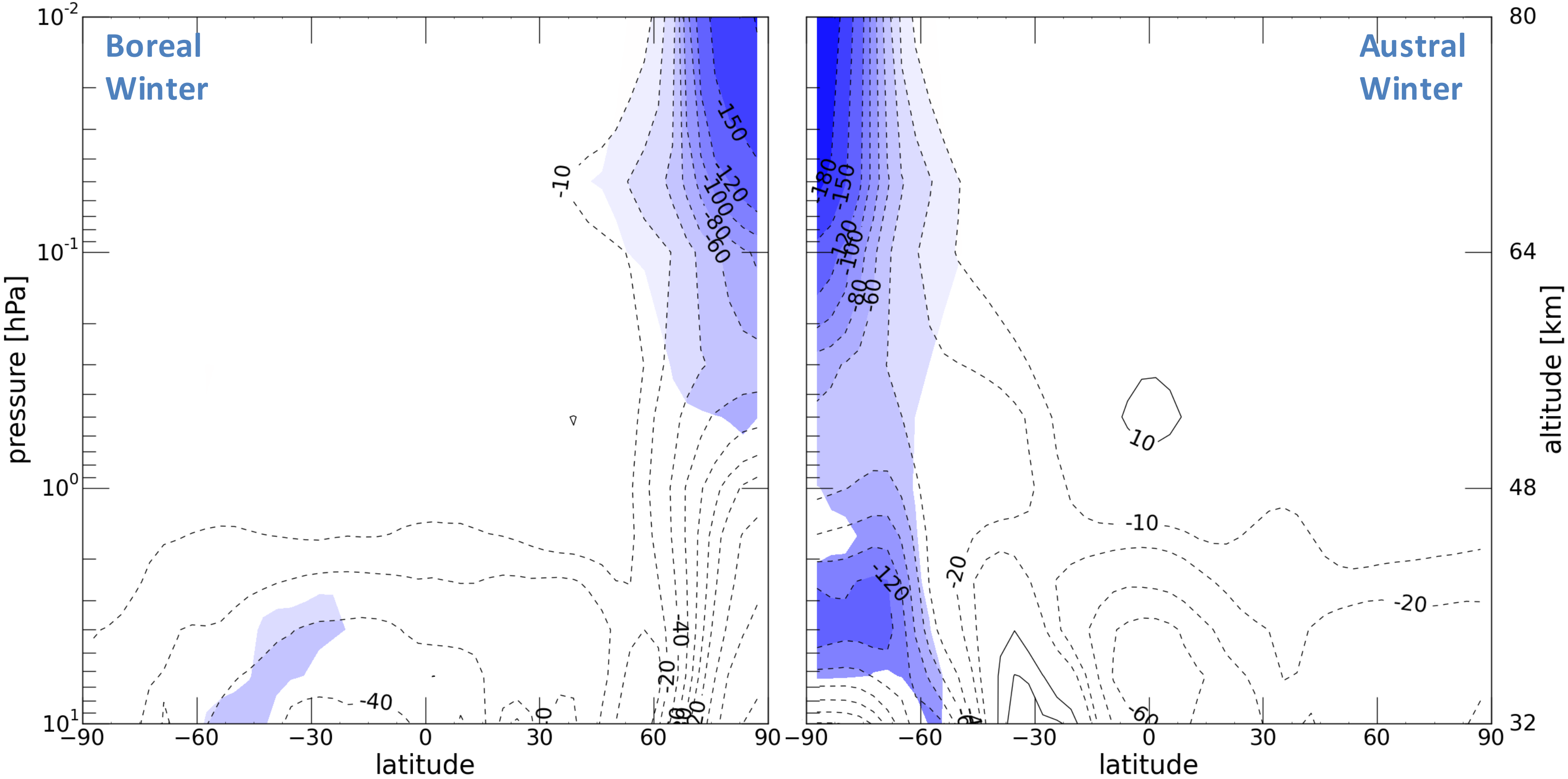
Comparison of modeled NO_y and observed NO_y [ppm] for 50 km

70° to pole mean



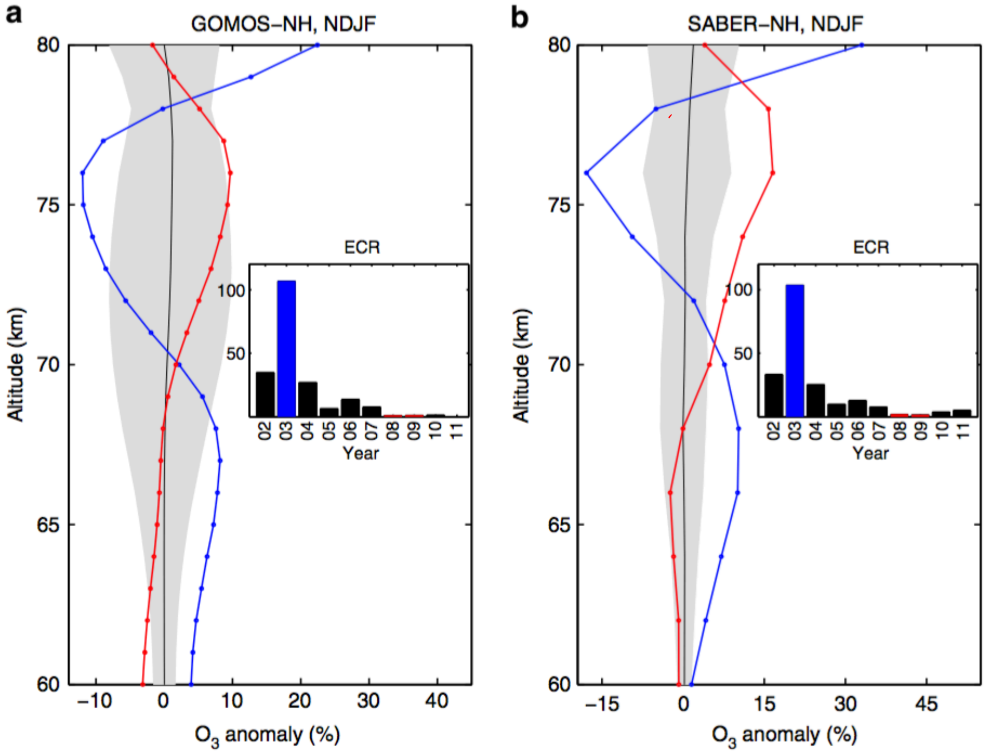


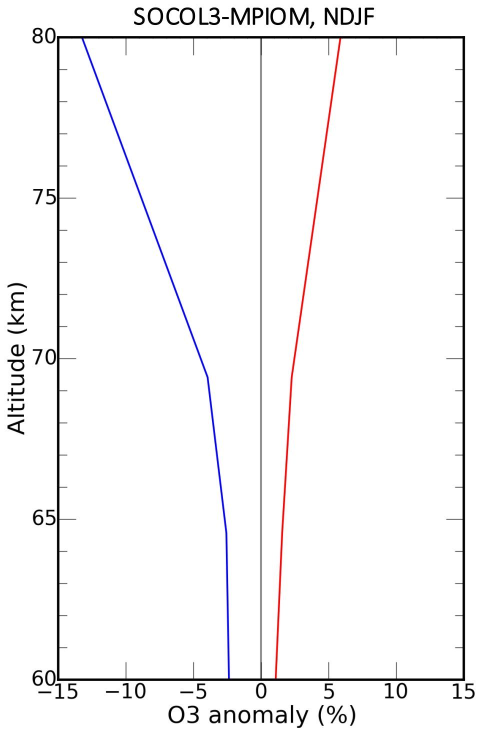
Ozone zonal mean difference [ppb] (MEE-NOMEE) 2002-2005



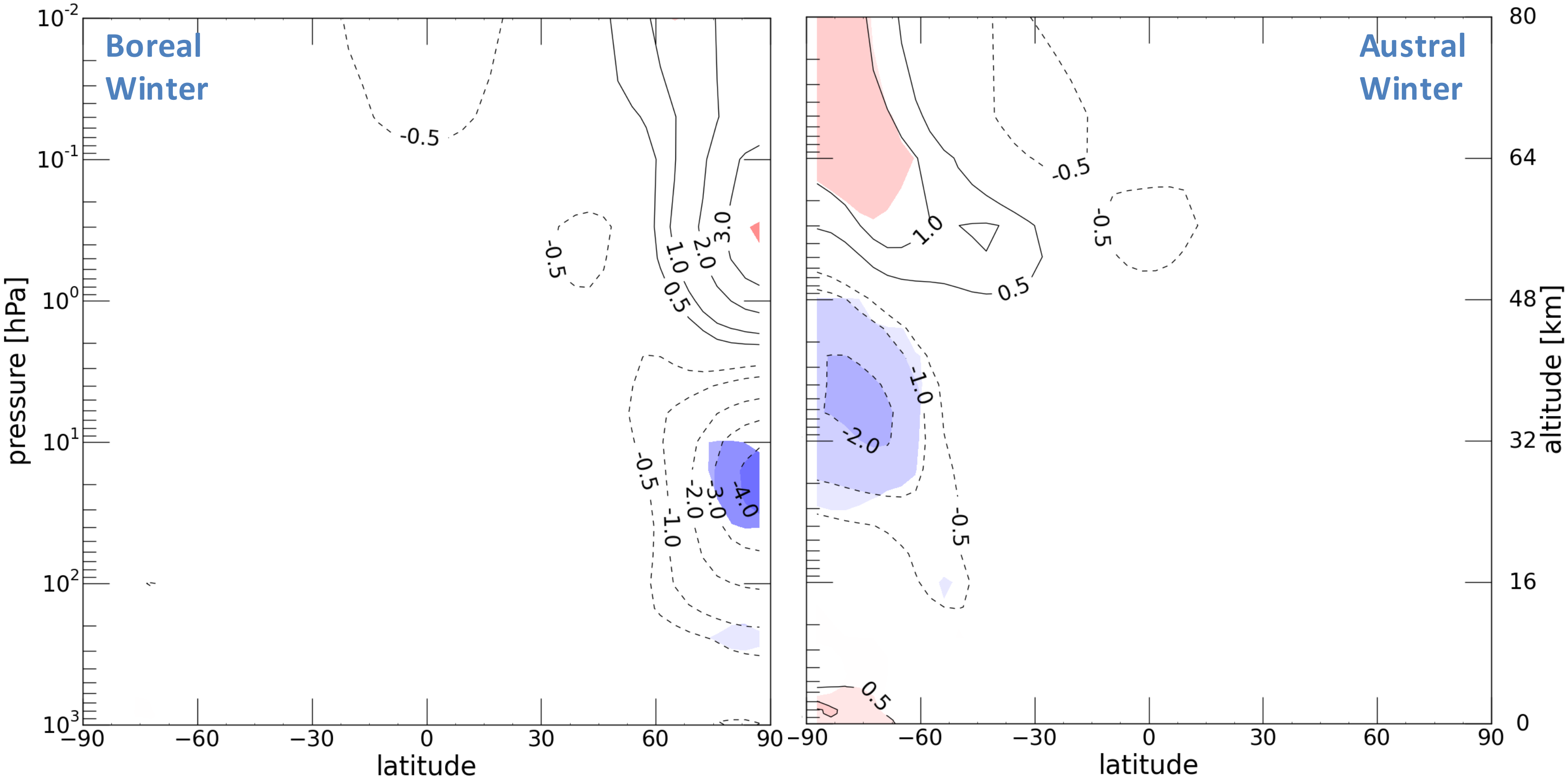
Ozone profile comparison with Andersson et al., 2014

55° - 65° geomagnetic mean

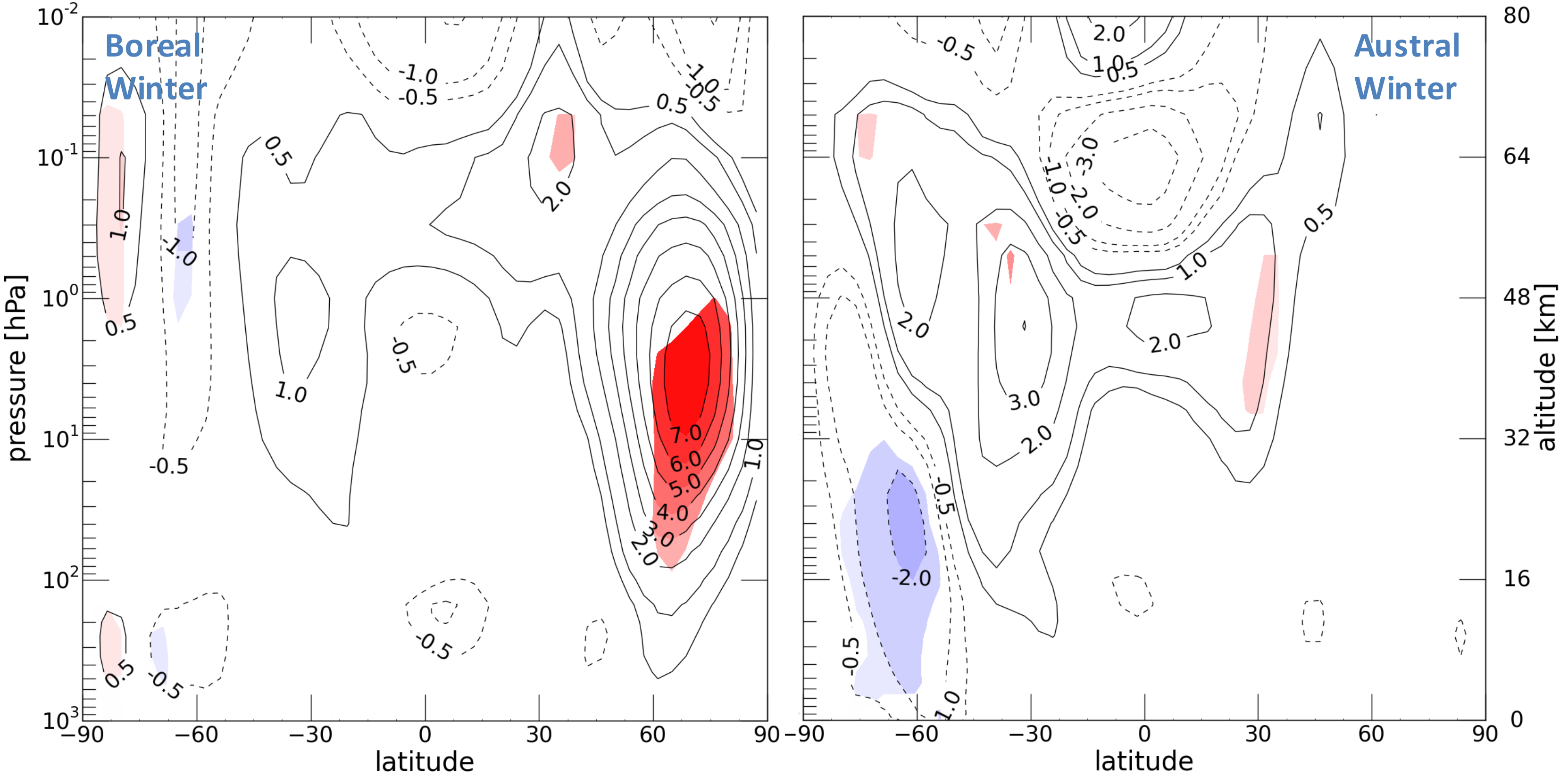




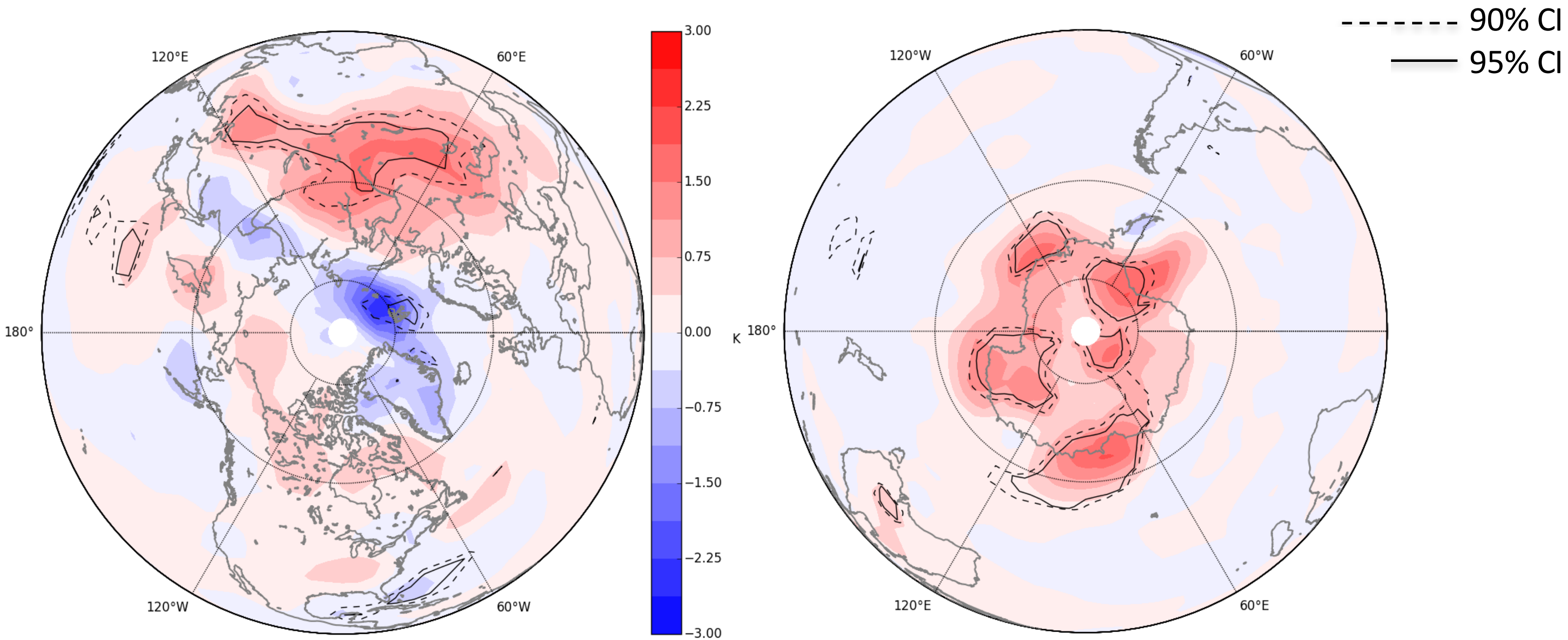
Temperature zonal mean difference [K] (MEE-NOMEE) 2002-2005



Zonal wind difference [m/s] (MEE-NOMEE) 2002-2005



2m temperature difference (MEE-NOMEE) 2002-2005



Conclusions

- MEE produce significant amount of NO_x for geomagnetically active period
- Total model NO_y follows the seasonal cycle, but underestimates NO_y above 50 km altitude
- Decrease of ozone in mesosphere (boreal – 25%, austral – 40%)
- Intensification of NH polar vortex and change in temperature
- Changes in surface temperature (Antarctica, continental Asia)

Arsenovic et al, JASTP, doi:10.1016/j.jastp.2016.04.008