Modeled impact of atmospheric ionisation by solar protons and magnetospheric electrons on upper stratospheric constituents compared with MIPAS measurements

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October 7, 2009
2nd International High Energy Particle Precipitation in the Atmosphere (HEPPA) Workshop

Outline

Motivation

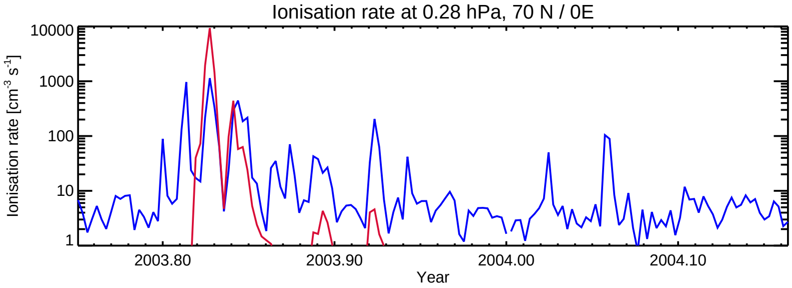

Figure: Daily mean AIMOS ionisation rates for protons (red) and electrons (blue) for October 1, 2003 - February 29, 2004

Motivation

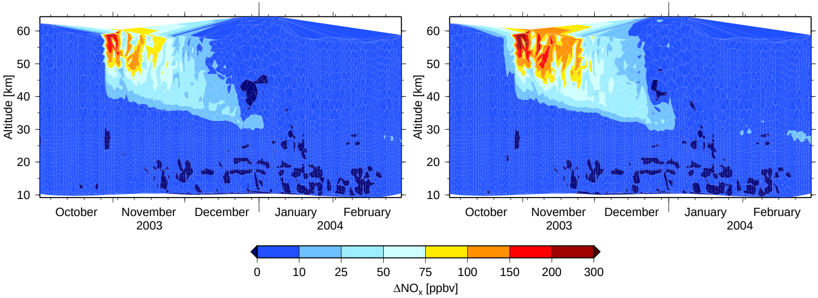

Figure: ΔNO_x near NyÅlesund, Svalbart

Motivation

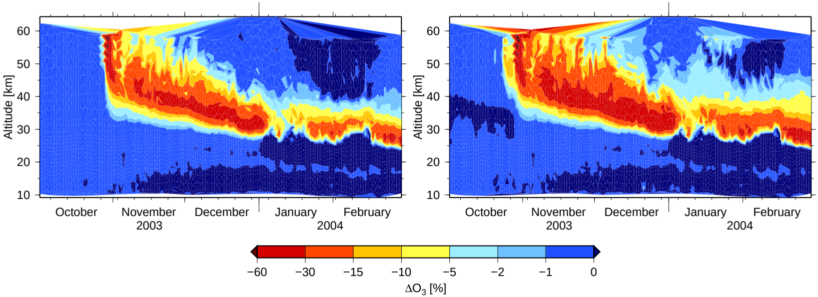

Figure: ΔO_3 near NyÅlesund, Svalbart

The Bremen 3d CTM

- global 3d Chemistry and Transport Model (CTM)
- driven by meteorological data (temperature, pressure, wind fileds): ECMWF operational
- horizontal transport along isentropes calculated from analysed wind fields
- vertical transport across isentropes calculated from diabatic heating rates
- neutral chemistry model, 57 tracer, families (O_x, NO_x, HO_x, ClO_x, BrO_x)
- JPL 2006
- ionisation rates from AIMOS model [Wissing et al., 2008]
- parameterised NO_x and HO_x production:
    - 1.25 NO_x (55% NO, 45% N) [Porter et al., 1976]
    - ≤ 2 HO_x [Solomon et al., 1981]

The Bremen 3d CTM

- horizontal resolution
  - 96 longitudes
  - 72 latitudes
  - $3.75^\circ \times 2.5^\circ$
- vertical resolution
  - 28 isentropes
  - 10 - 65 km
  - 1 - 4 km

adapted from Jan Aschmann

Bremen 3d CTM simulations

Met.data: ECMWF operational

AIMOS Ionisation rates

Scenario A	Scenario B	Scenario C
no ionisation rates	protons	protons + electrons
	parameterised production rates for NO_x and HO_x	

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NO_x response to different ionisation forcing

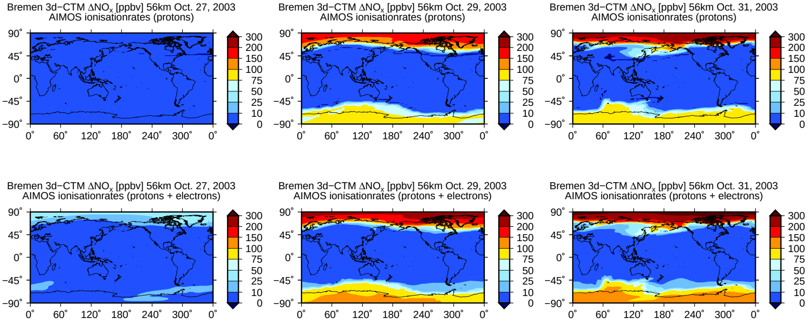

Figure: ΔNO_x [ppbv] at 56km altitude. Absolute differences for scenarios B and C to scenario A [Wissing et al., 2009]

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O_3 response to different ionisation forcing

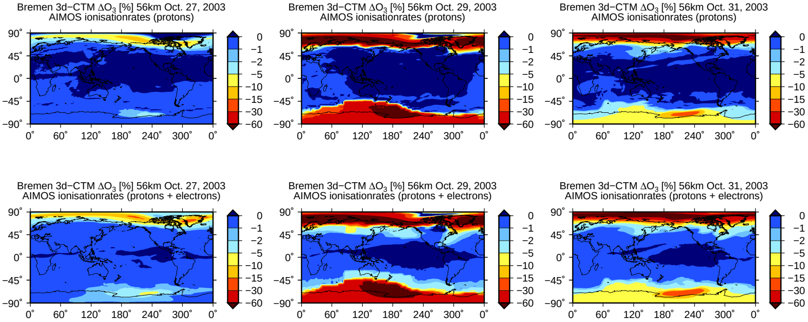


Figure: ΔO_3 [%] at 56km altitude. Percentage difference for scenarios B and C to scenario A [Wissing et al., 2009]

Ozone

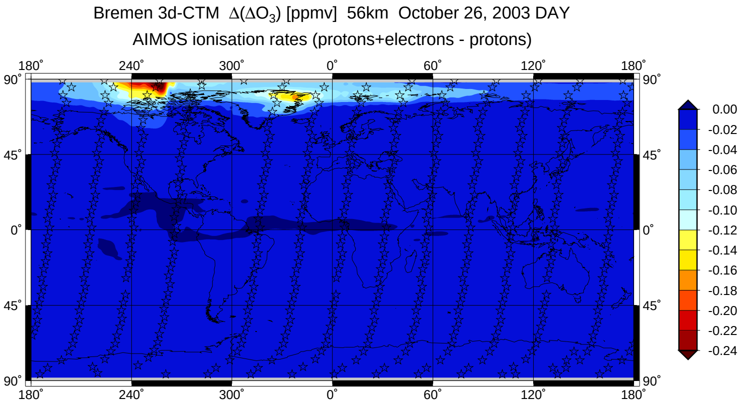
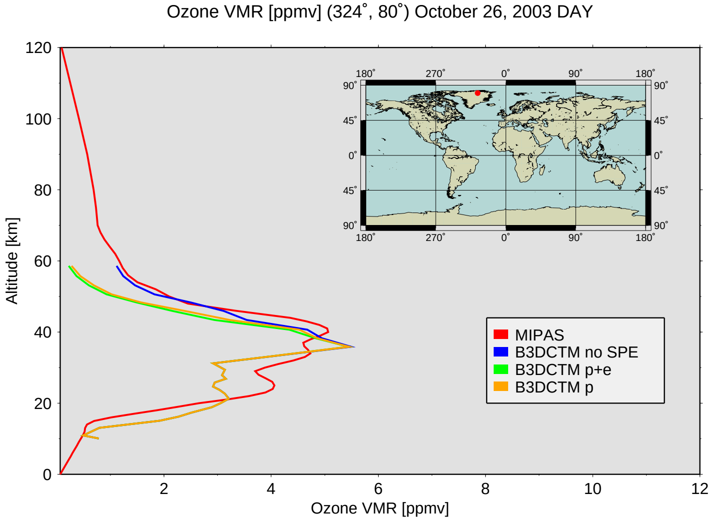


Figure: ΔO_3(scenario C - scenario B)

Ozone



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Ozone

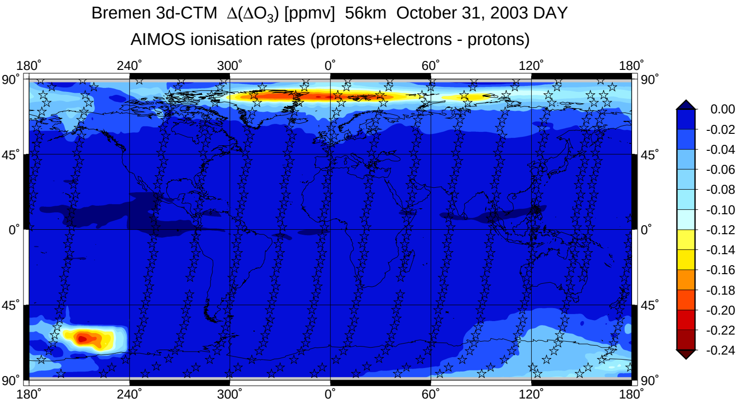
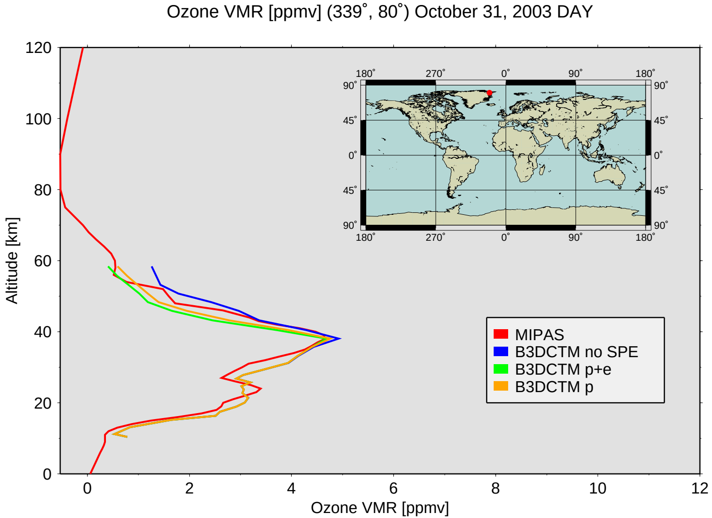


Figure: ΔO_3(scenario C - scenario B)

Ozone


Ozone VMR [ppmv] (339˚, 80˚) October 31, 2003 DAY
Altitude [km]
Ozone VMR [ppmv]
MIPAS
B3DCTM no SPE
B3DCTM p+e
B3DCTM p

NO

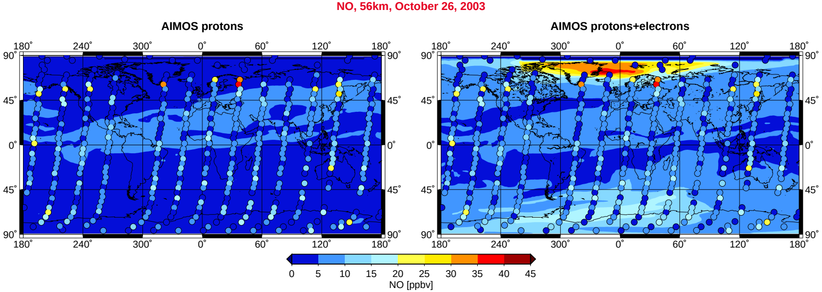


Figure: NO at 56km altitude, October 26, 2003 for scenario B (left) and C (right)

NO

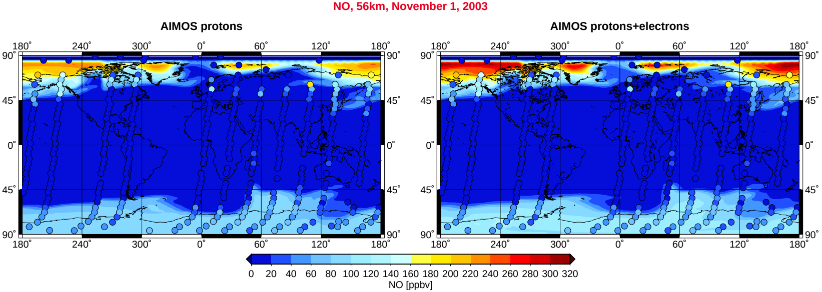


Figure: NO at 56km altitude, November 1, 2003 for scenario B (left) and C (right)

HNO_3 & NO_2

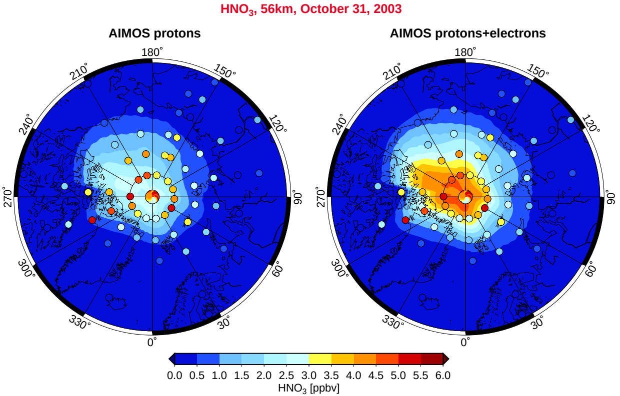


Figure: HNO_3 at 56km altitude for scenario B (left) and C (right), model results underlying, circles: MIPAS

HNO_3 & NO_2

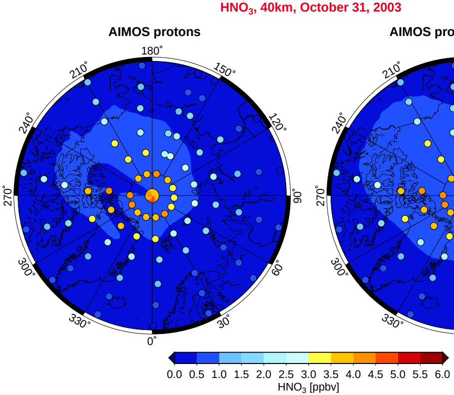


Figure: HNO_3 at 40km altitude for scenario B (left) and C (right), model results underlying, circles: MIPAS

HNO_3 & NO_2

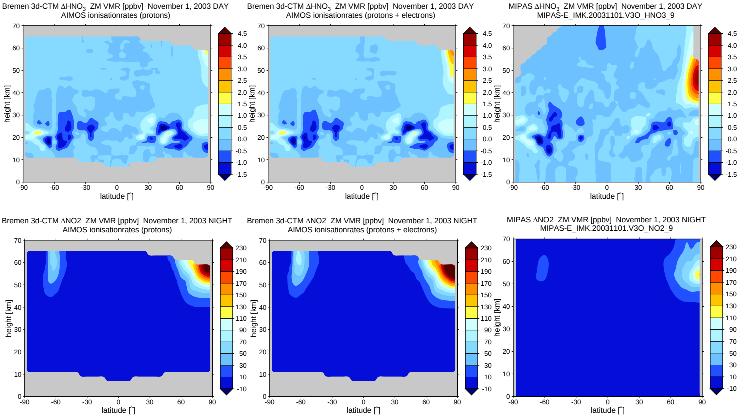


Figure: ΔHNO_3 and ΔNO_2 (Difference to October 26, 2003)

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Conclusion

- NO_x increase due to ionisation by electrons before the SPE
- enhanced NO_x production during SPE
- a larger decrease of ozone
- larger ozone depletion in mid latitudes
- enhanced HNO_3 production in high altitudes due too high amounts of NO_2

Thank You!

Porter, H., Jackman, C., and Green, A. (1976).
Efficiencies for Production of atomic Nitrogen and Oxygen by relativistic Proton Impact in Air.
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