The contribution of electron precipitation to middle atmosphere composition

Direct production of NOx in the upper stratosphere / lower mesosphere ?

Results from the Bremen 3 D model, 2003-2004

Miriam Sinnhuber[1], M.-B. Kallenrode[2], S. Kazeminejad[1], B.-M. Sinnhuber[2], G.P. Stiller[3], N. Wieters[1], and J.-M. Wissing[2]

[1]University of Bremen, [2]University of Osnabrück, [3]Karlsruhe Institute of Technology

Why 2003 / 2004 ?

Large SPE in Oct/Nov 2003

Geomagnetic activity during SH winter 2003:

- High NOx values observed in SH winter middle atmosphere by HALOE (*Randall et al, 2007*)
- Downward propagation of NOx during SH winter observed by MIPAS (*Funke et al, 2005*)

Why 2003 / 2004 ?

Large SPE in Oct/Nov 2003

⇒ Stratospheric direct effects well documented

Geomagnetic activity during SH winter 2003:

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⇒ Downwelling from mesosphere / lower thermosphere, or direct effect ?

Experiments with the Bremen 3D CTM, 01/2003 – 08/2004

Ionisation driven by AIMOS ionisation rates:

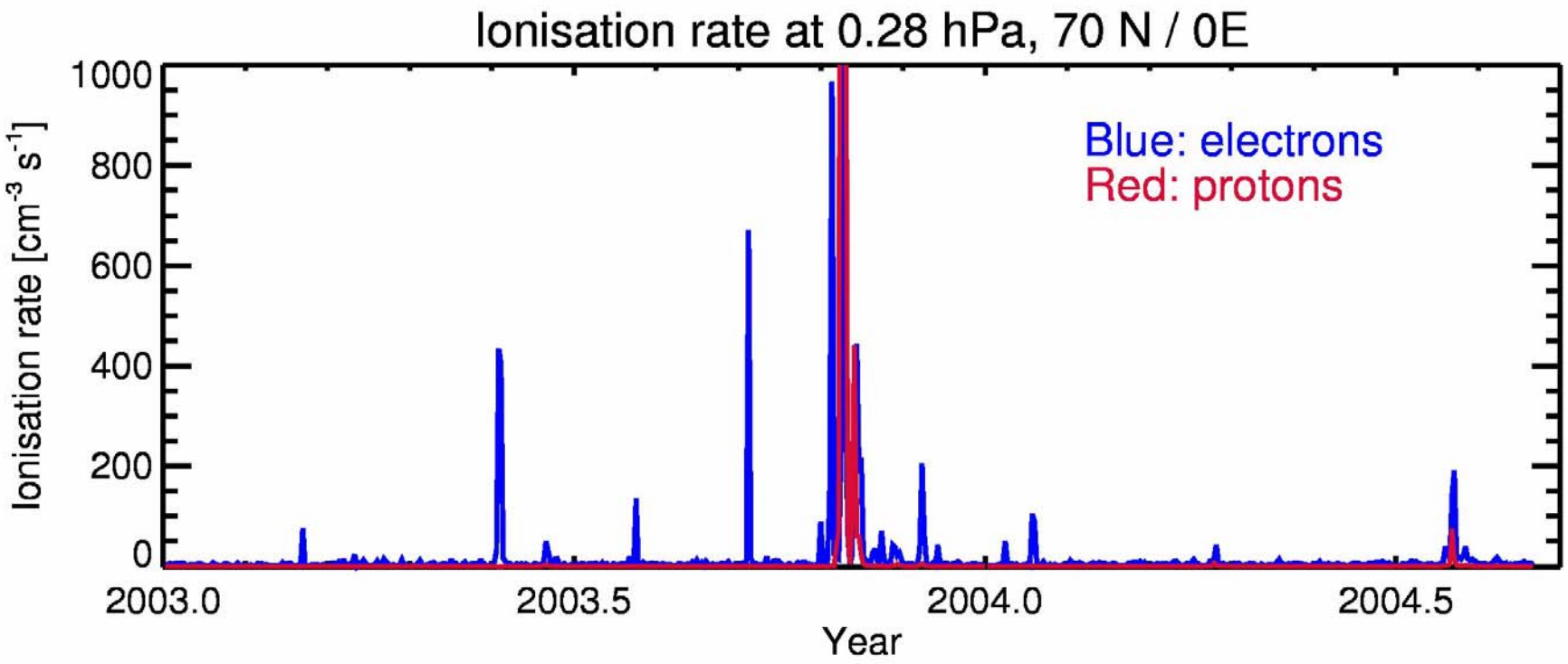
- A: no ionisation
- C: only electrons
- D: protons + electrons

Parameterisation of NOx and HOx increase due to atmospheric ionisation (*Jackman et al, 2005*)

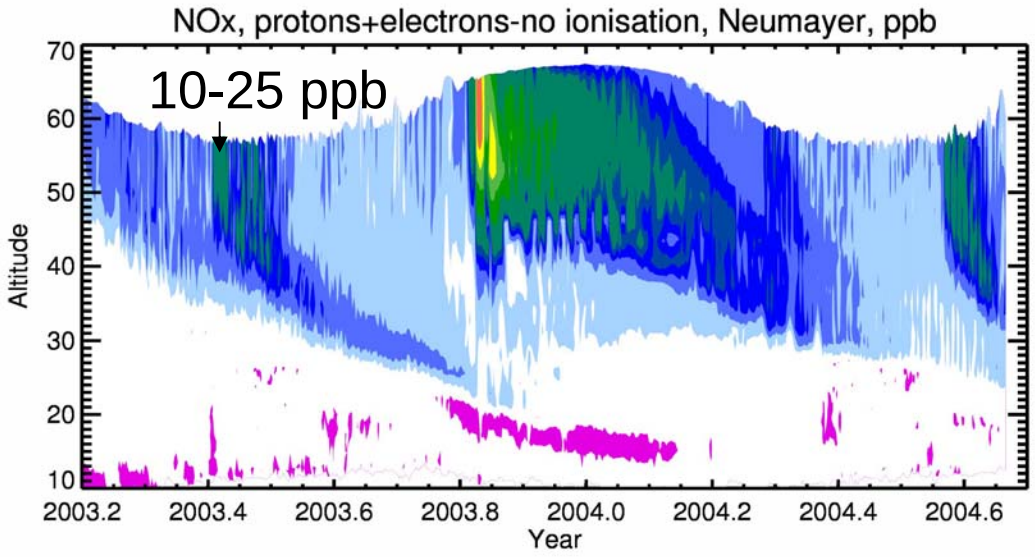
The Bremen 3 D Chemistry and Transport Model

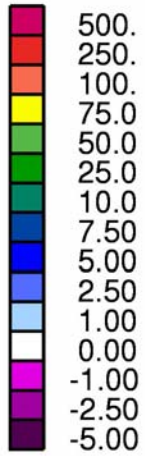
- driven by ECMWF (~10 - 60 km) analysis on isentropic surfaces
- vertical transport from radiative heating / cooling
- output at 12 UT or MIPAS overpass time

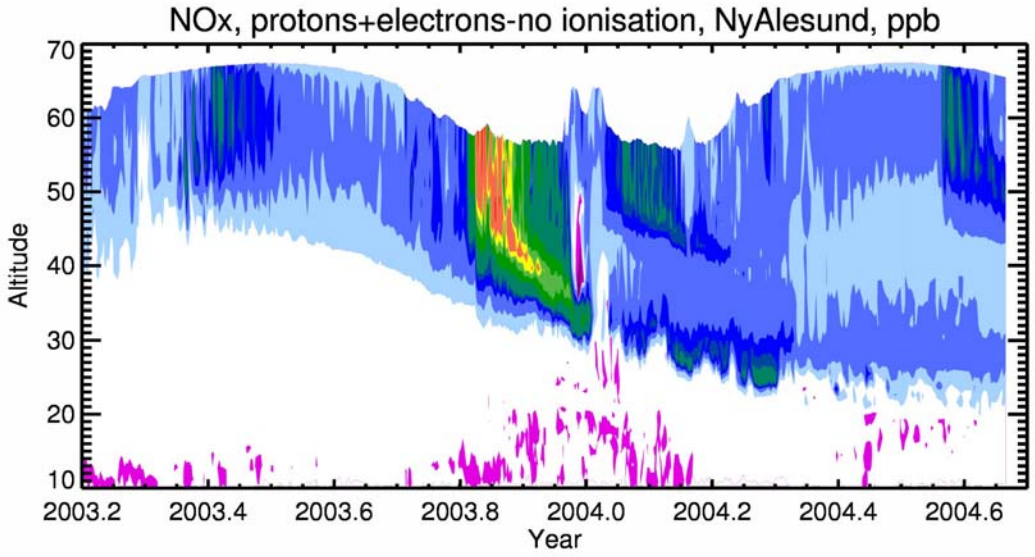
AIMOS ionisation rates in the upper stratosphere / lower mesosphere (~ 55 km), 01/2003 – 08/2004

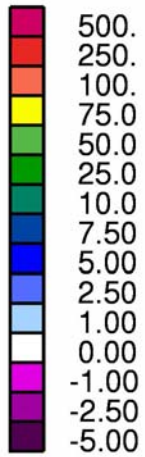


B3dCTM results: NOx production at high latitudes









ΔNOx due to particle precipitation:

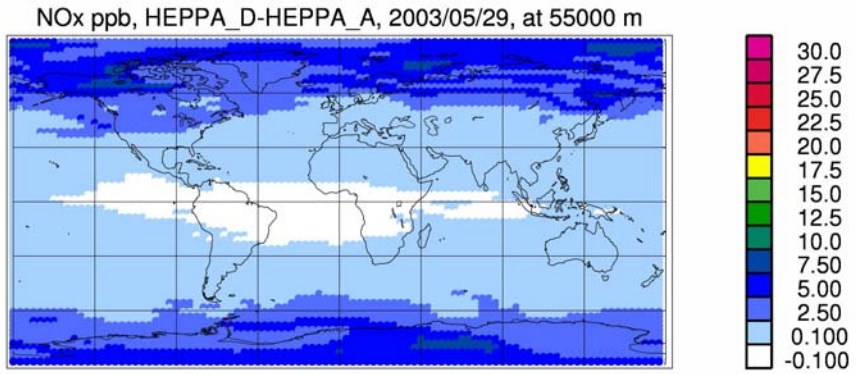
D - A

SH: **70°S, 8°W**

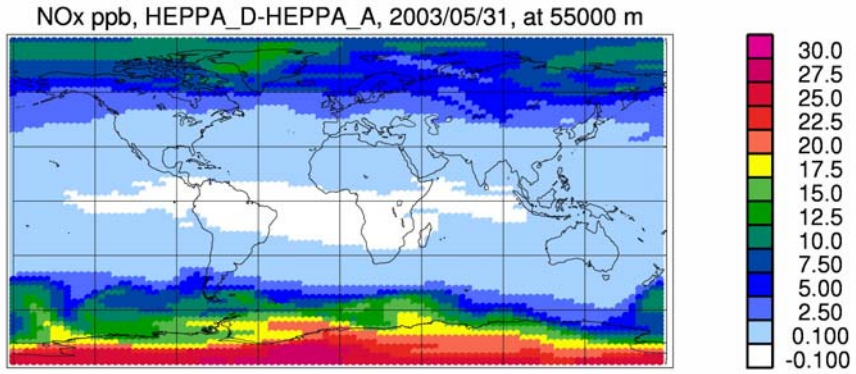
NH: **79°N, 12°E**

B3dCTM results: global NOx production

ΔNOx, 55 km, pre-event

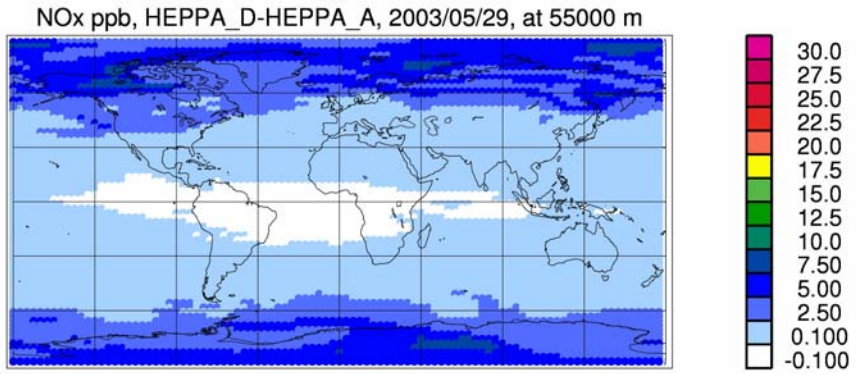


55 km, during event

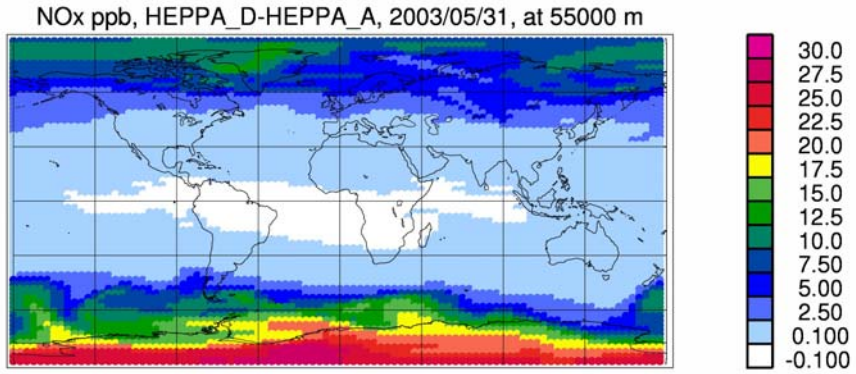


B3dCTM results: global NOx production … and downwelling

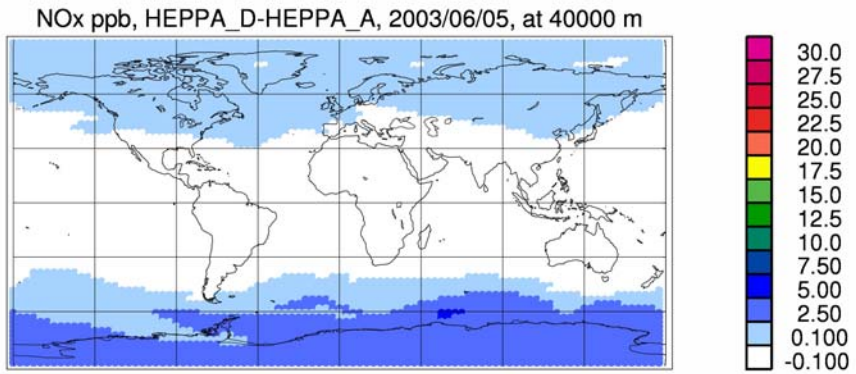
ΔNOx, 55 km, May 29



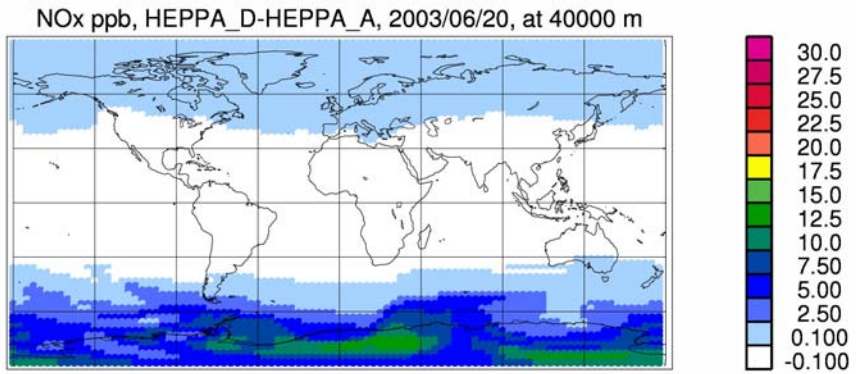
55 km, May 31



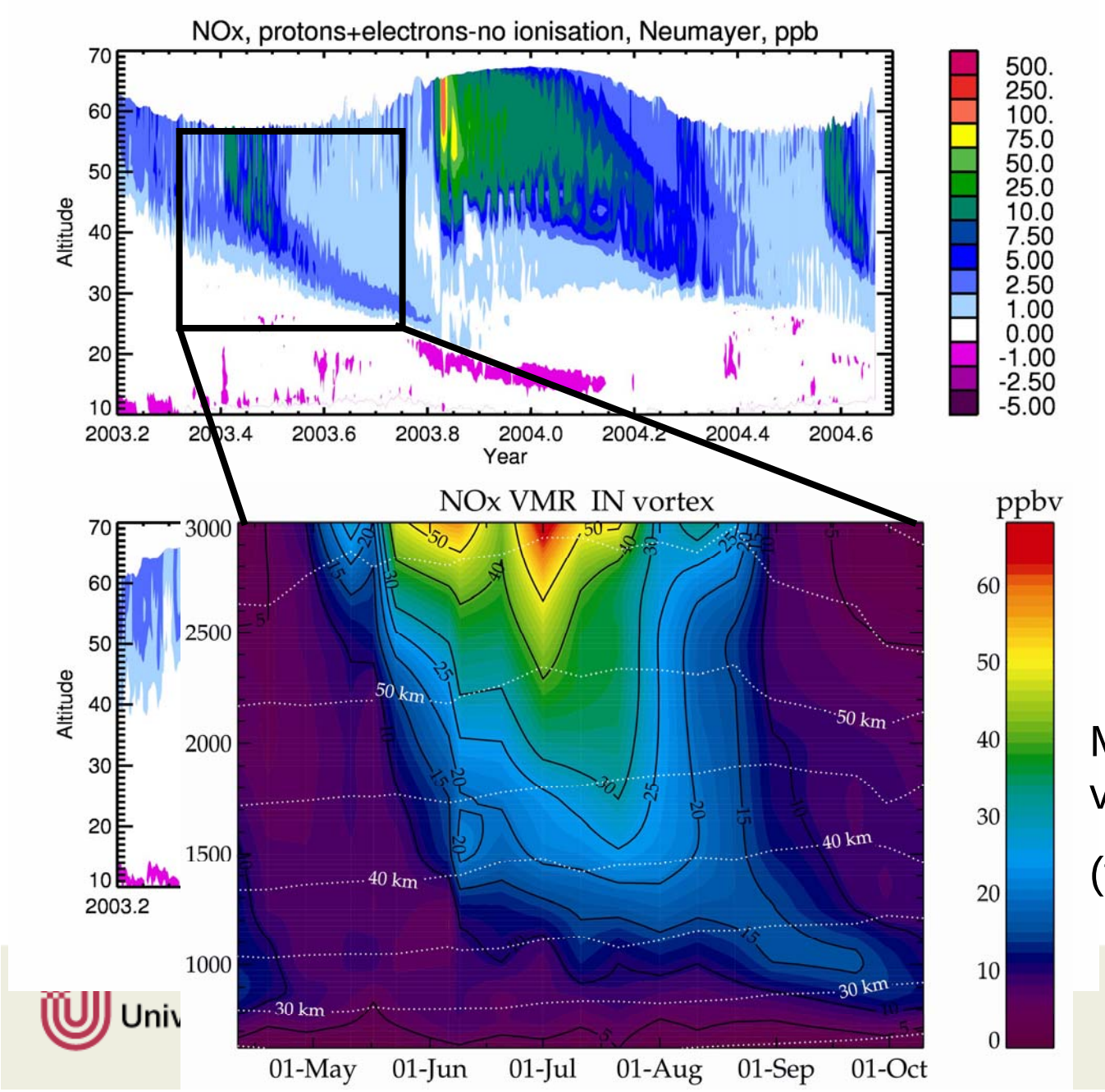
ΔNOx, 40 km, June 1



40 km, June 20



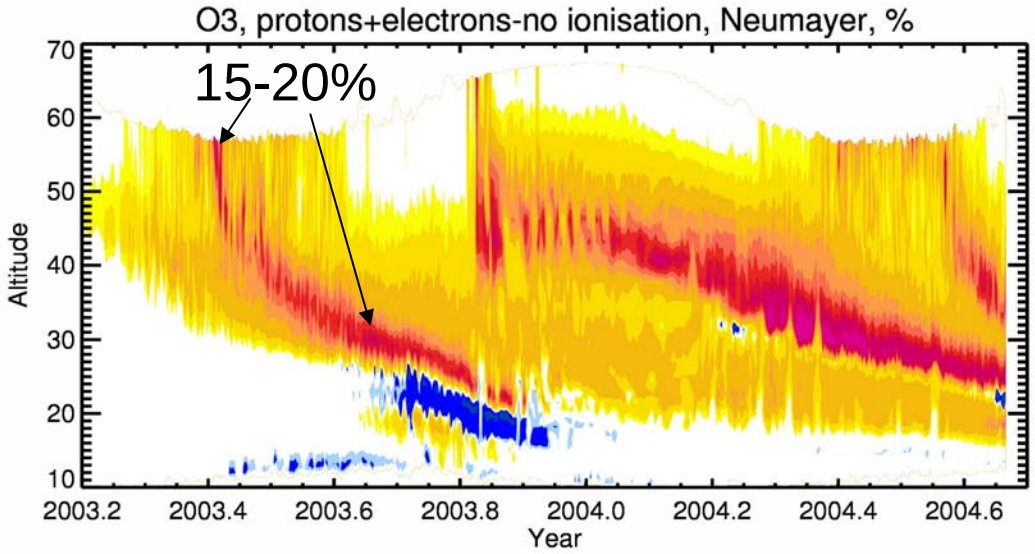
B3dCTM results: NOx production at high latitudes

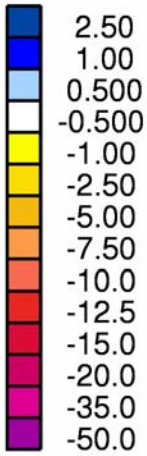


MIPAS NOx in 2003 SH vortex

(from *Funke et al, 2005*)

B3dCTM results: ozone loss at high latitudes

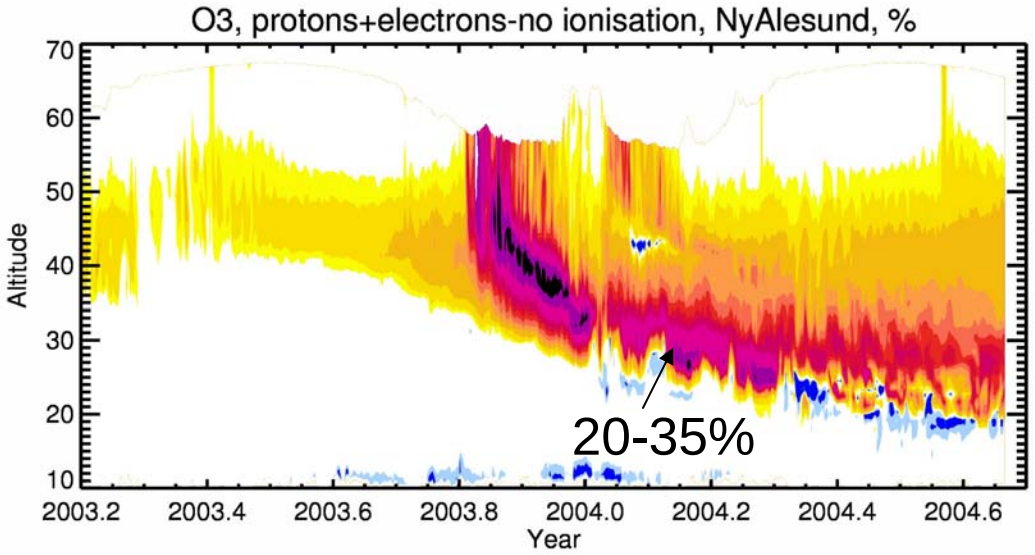


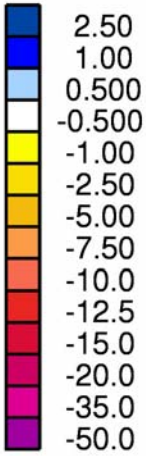


ΔO3 due to particle precipitation:

(D-A)/A

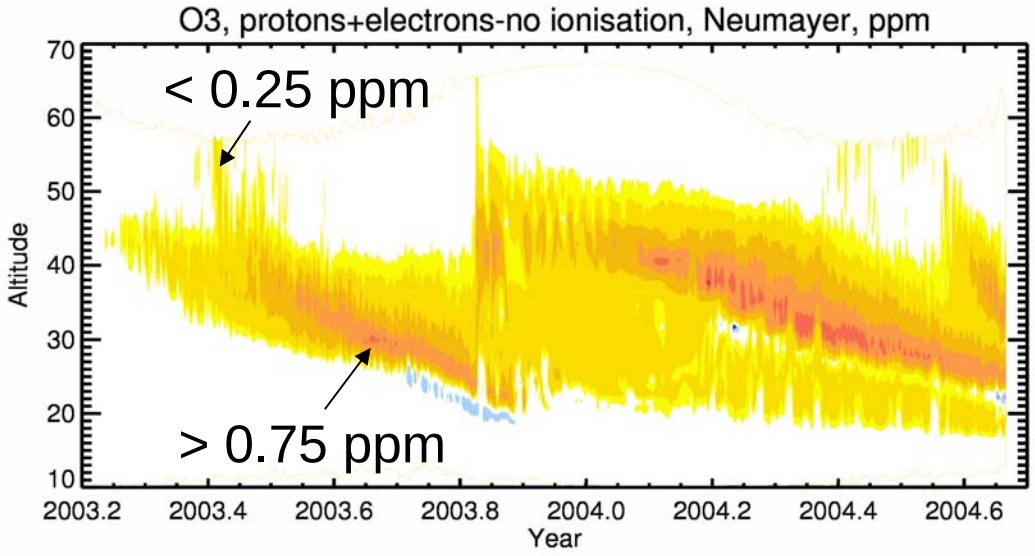
SH: **70°S, 8°W**

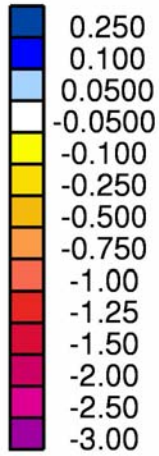




NH: **79°N, 12°E**

B3dCTM results: ozone loss at high latitudes





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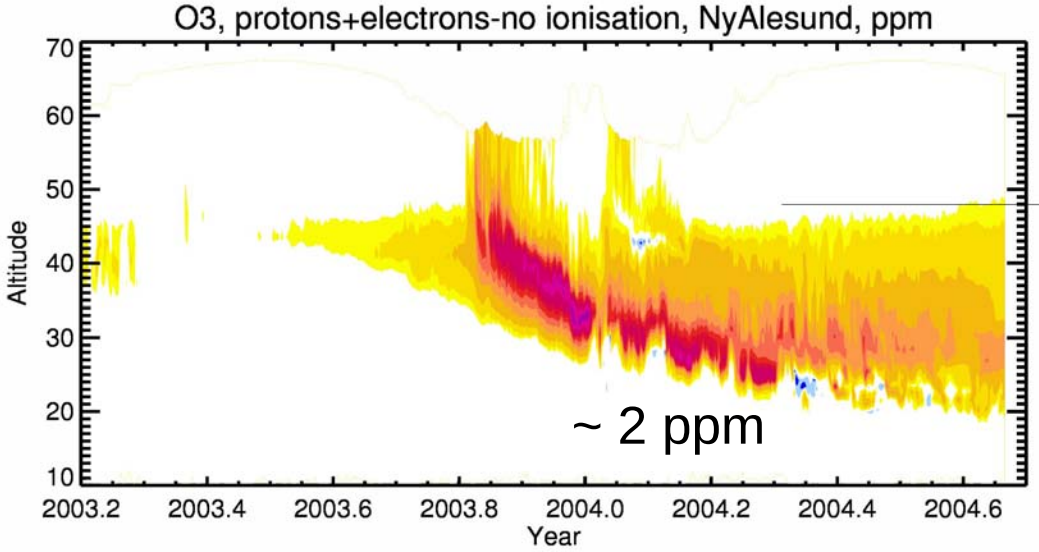

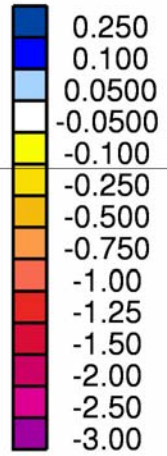

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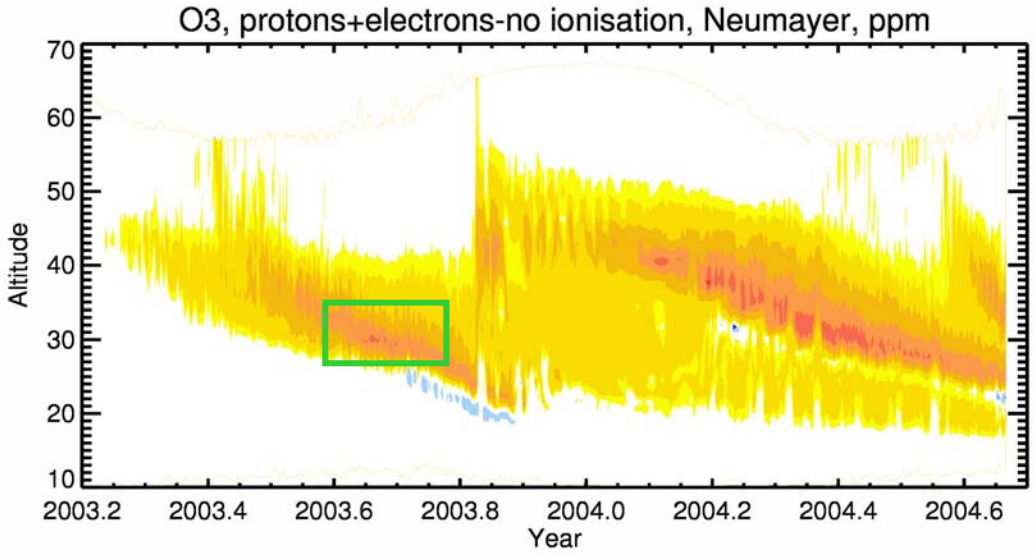

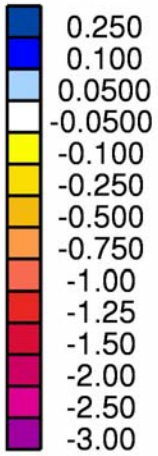

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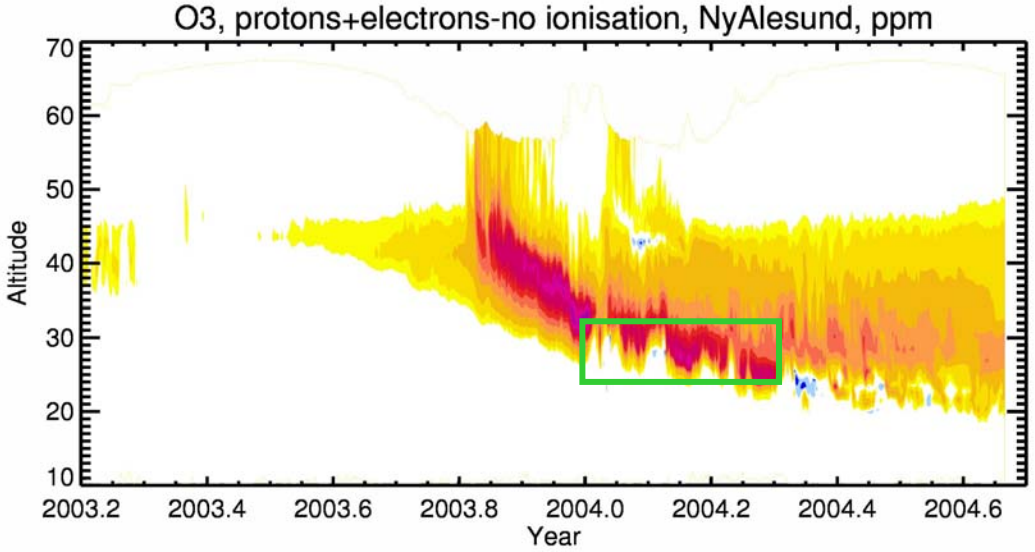

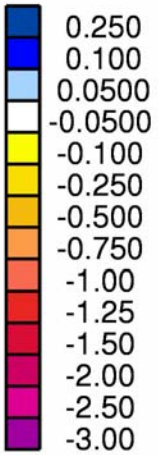

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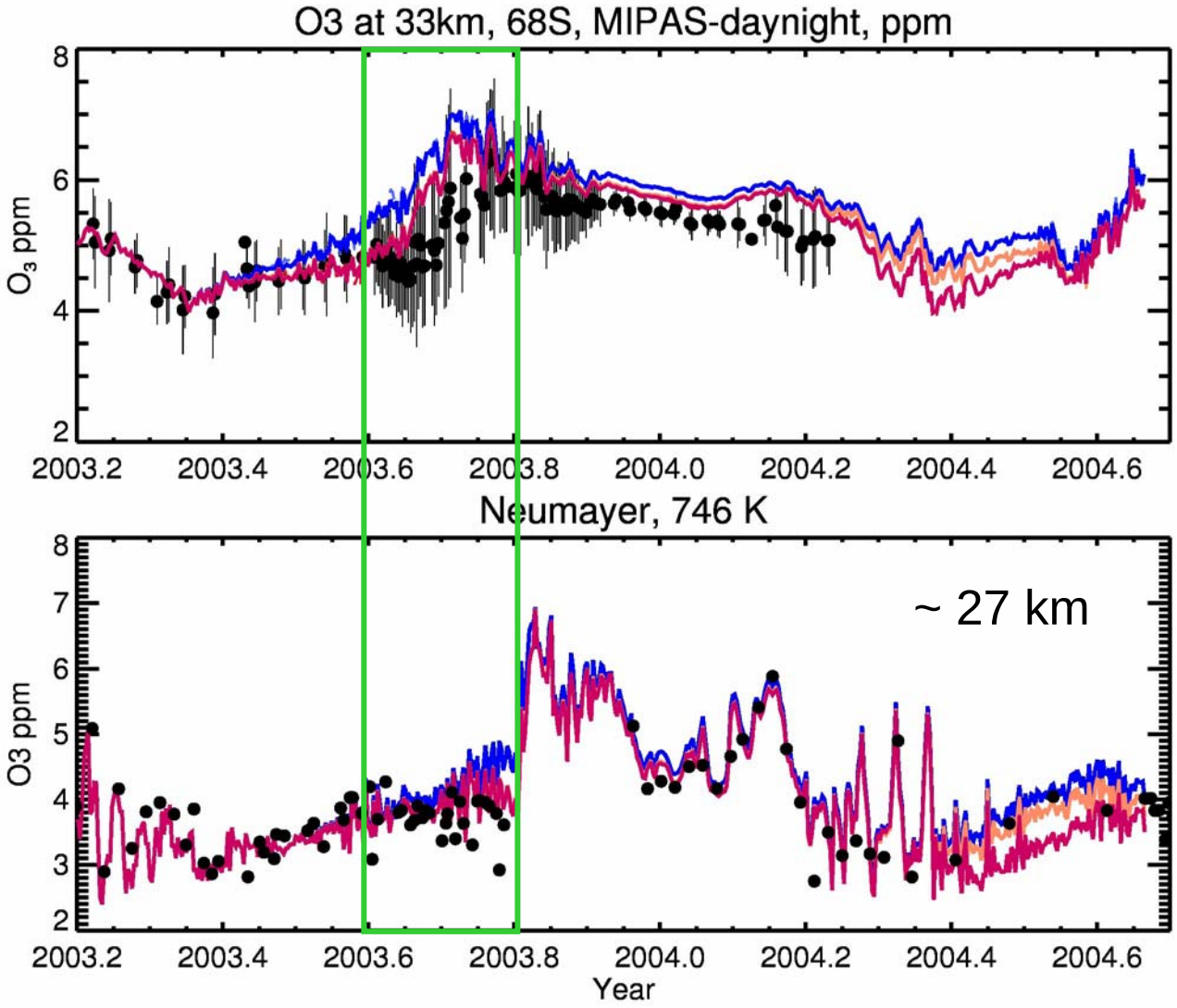
SH O_3 at ~ 30 km: comparison to measurements



Black: MIPAS

Blue: A

Orange: C

Red: D

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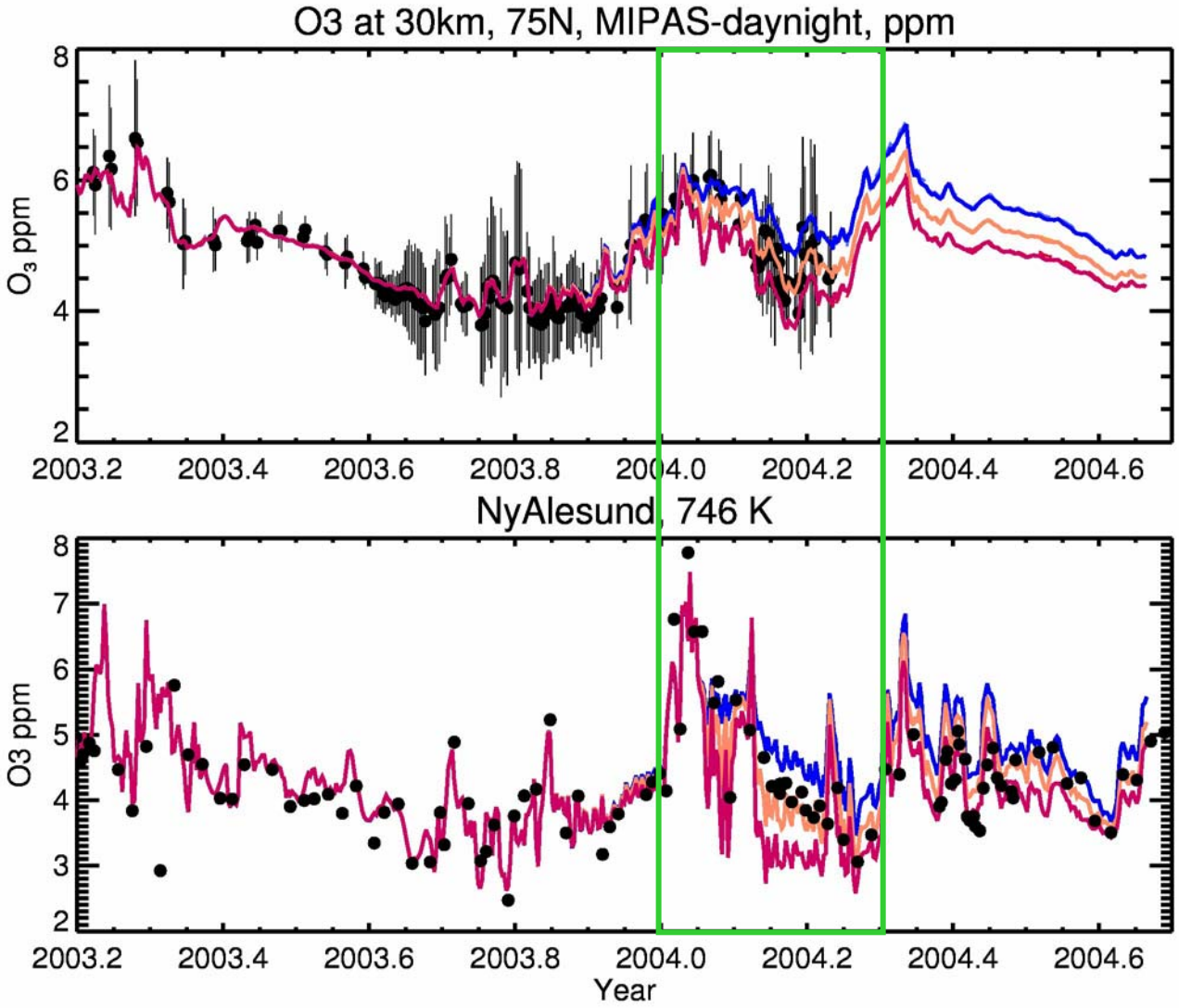
NH O_3 at ~ 30 km: comparison to measurements



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Conclusions

The electron events of 2003 and 2004 lead to significant changes in middle atmosphere NOx and ozone, both modelled and observed

Mid-stratosphere ozone loss due to the May 2003 EEP event is captured by the model quite well – consistent with direct EEP effect in the upper stratosphere

However, stratospheric ozone loss due to the large SPE seems to be overestimated by the model: due to overestimation of the proton ionisation rates ?