PALEOZONE

Variation of ozone in the middle Atmosphere in the presence of a varying Earth Magnetic Field

• Will a magnetic polarity transition affect the chemical composition of the middle atmosphere?

• Is there an impact on the ground UV radiance?

M. von König, J. Burrows and K. Künzi
Magnetic field determines where charged particles penetrate the atmosphere

Charged particles: $e, p, \ldots$ from Galactic Cosmic Rays GCRs, Solar Proton Events SPEs and Energetic Electron Precipitation EEP

$N_2 + e \rightarrow N_2^+, N+N^+, N+N \ldots \rightarrow N, NO$

$O_2 + e \rightarrow O_2^+, O+O^+ \ldots \rightarrow O$

$O_2^+ + H_2O \rightarrow \ldots \rightarrow H, OH$
Production of NOx and HOx leads to ozone destruction:

**Ozone production:**

\[ O_2 + h \rightarrow O + O \]
\[ O + O_2 \rightarrow O_3 \]

**Ozone loss in catalytic cycles:**

**Odd hydrogen HOx=H+OH+HO2**

\[ OH + O \rightarrow H + O_2 \]
\[ H + O_3 \rightarrow OH + O_2 \]

**Odd nitrogen NOx=N+NO+NO2**

\[ NO + O_3 \rightarrow NO_2 + O_2 \]
\[ NO_2 + O \rightarrow NO + O_2 \]
2 D latitudinal x altitude model:
90° S to 90° N, 0 - 100 km

Dynamical module (THIN AIR):
J. Kinnersley, University of Edinburgh

T, p, horizontal and vertical transport
4 h timestep

Chemical module (SLIMCAT):
M. Chipperfield, University of Leeds

57 species, 181 chemical reactions, 37 photolysis reactions
HOx, NOx, Ox families in photoch. equilibrium
15 min. timestep on 0° longitude

N, NO, O, H, OH production as function of energy deposition (Jackman, 1990).
Solar Proton Event "worst case" scenarios:

Normal magnetic field: particle precipitation into polar cusps

No magnetic field: isotropic particle precipitation

3 large events during one year:

(1) October 1989; July 2000; November 2000

(2) 3 x October 1989
Model results: 3 x October 1989, 80 N, no magnetic field

SPEs

NOx [ppb]

HOx [ppb]

O$_3$ [ppm]
Model results: 3 x October 1989, O$_3$ column change, normal/no magnetic field
Model results: $O_3$ columns

$50 \ ^\circ N$

![Graph showing $O_3$ columns over time with magnetic field conditions.]

No SPEs

- October 89; July 00; November 00
- 3 times October 89
Model results: O$_3$ columns

80°N

No magnetic field

Normal magnetic field

No SPEs
October 89; July 00; November 00
3 times October 89

No SPEs
October 89; July 00; November 00
3 times October 89
Ozone and UV-B radiation

Radiative transfer model (SCIATRAN)
Vladimir Rozanov, University of Bremen

- multiple scattering / full spherical model
Conclusions

- NOx production and ozone loss due to SPEs are well reproduced by the model

- A change of magnetic field strengths has a potentially large impact on stratospheric ozone, BUT:
  - mainly restricted to polar regions
  - only when a period of small magnetic field strengths coincides with a large solar activity

- Potentially large impact on UV-B radiation (comparable to "ozone hole")
Model results: radiated power 280-315 nm
50 °N

No SPEs
October 89; July 00; November 00
3 times October 89

Normal magnetic field

No magnetic field
Model results: radiated power 280-315 nm
80 °N

No SPEs
October 89; July 00; November 00
3 times October 89