Precipitating radiation belt electrons and enhancements of hydroxyl in the mesosphere during 2004-2009

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B3: Searching for mesospheric NO$_x$ production due to electron precipitation during 2008

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Time-series

Superposed Epoch Analysis

10/09/2012

4$^{th}$ international HEPPA workshop
Quantification of the stratospheric EPP-NOy deposition during 2002-2012 from MIPAS observations

- MIPAS NOy climatology 2002-2012
- Extraction of EPP-NOy using NOy-CH₄ and NOy-CO correlations
- Determination of total stratospheric EPP-NOy amount in polar winters 2002-2012
- Estimation of EPP-contribution to global NOy budget

[Images: MIPAS NOy observations 2002-2012, Global EPP-NOy at 20-70 km, Global EPP-NOy at 20-50 km]
Examining the Stratospheric Response to the Solar Cycle in coupled WACCM Simulations with an internally generated QBO

A. C. Kren, D. N. Marsh, A. Smith, and P. Pilewskie

- Examines stratospheric response as a function of the solar cycle and respective of the Quasi-Biennial Oscillation (QBO)
  - Specifically the response over the Polar regions to the Solar Cycle and respective of the QBO phase

- Results from two Whole Atmosphere Community Climate Model (WACCM)
  - Fully interactive ocean, chemistry, greenhouse gas and volcanic forcing, and an internally generated QBO.

- Both ensembles are transient simulations and free running.
  - Ensemble 1:1850-2005
  - Ensemble 2:1850-1943

- Internally Generated QBO agrees well with observations; solar response less significant than past observations and model simulations
On the Effects of Solar Protons Events on Thermospheric Temperature and Nitric Oxide

M. López-Puertas¹, B. Funke², M. García-Comas¹, F. Friederic³, G.P. Stiller², T. von Clarmann², M. Sinnhuber², U. Grabowski², N. Giatthor², and Gang Lu²

(1) IAA-CSIC, Granada, Spain; (2) KIT, IMK, Karlsruhe, Germany; (3) HAD, NCAR, Boulder, USA.
This study uses observations of Carbon monoxide (CO) from the EOS-MLS instrument to quantify horizontal and vertical transport in the polar region in winter.

In particular, we use the probability distribution function (PDF) of the CO data to identify CO concentrations characteristic of the interior of the vortex core as a function of space and time without any other information.

This is done by fitting two Gaussian distributions to the tracer PDF for a specific period and altitude.
Impact of solar spectral variability on middle atmospheric ozone

Aimee Merkel, Jerald Harder, Daniel Marsh, Anne Smith, Thomas Woods

Conclusions
1. Solar observations from the SORCE mission show enhanced variability in the UV and visible parts of the spectrum from solar active to quiet conditions.

2. Mesospheric out-of-phase SC response in ozone observed in three independent measurements: AURA-MLS, SABER, SME (SC 21)

3. An increase in UV variability helps to resolve differences between modeled ozone and observations in the mesosphere.

4. The SC response in mesospheric ozone is dependent on local time. Occultation ozone measurements should not be used for solar cycle analysis in the mesosphere.
Observations of nitric oxide in the Antarctic middle atmosphere during recurrent geomagnetic storms

David A. Newnham, Mark A. Clilverd, David J. Maxfield, & Richard B. Horne, UK
Patrick J. Espy, Craig Rodger, Annika Seppälä, Paul Hartogh, & Kim Holmén

Superposed epoch study

Microwave Radiometer at Troll, Antarctica

POES data
Studies of NOx production rates using UBIC

Holger Nieder, Miriam Sinnhuber
Studies of NOx production rates using UBIC

Holger Nieder, Miriam Sinnhuber
Studies of NOx production rates using UBIC

Holger Nieder, Miriam Sinnhuber
B12
Geomagnetic and Dynamical Effects on NO$_x$ and O$_3$ in 2005, 2009, and 2012 in the Northern Hemisphere

S.-M. Päivärinta, M. E. Andersson, A. Seppälä, P. T. Verronen, E. Kyrölä, and L. Thölix
Comparison using WACCM4/CESM1.0.3 to investigate the impacts of solar cycle variance on southern hemisphere polar lower stratospheric ozone.

Results show significant results when BOTH solar irradiance and auroral EPP are present in solar maximum conditions.

If either solar irradiance or auroral EPP are not in solar maximum conditions, the results lose statistical significance.

Comparisons to MERRA and MIPAS show similar results, though with different magnitudes and some interesting signals!

Drop by Poster B14 to learn more!
Transport of NOx from the lower Thermosphere into the middle Atmosphere in the KASIMA Model

T. Reddmann (1), B. Funke (2), G. Stiller (1), A. Gardini (2), S. Versick (1), J.M. Wissing (3), R. Ruhnke (1), W. Kouker (1), and A. Vlasov (1)

(1) Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, Karlsruhe, Germany, (2) Instituto de Astrofísica de Andalucía - CSIC, Granada, Spain, (3) FB Physik, University of Konstanz, Konstanz, Germany

Description of the KASIMA model

- Model description
- Atmospheric dynamics
- Chemistry
- Physical processes
- Boundary conditions

Realisation

- Model implementation
- Data assimilation
- Results validation

Motivation

- Observations during the last descending solar cycle have shown that the strength of NOx variations into the stratosphere in the course of solar activity is predominantly governed by specific atmospheric situations.
- The modelled variations range from 10% to 30% over 2000-2010.
- The model is able to reproduce the observed variations with a high degree of accuracy.

Effect from new GW drag setup

- Comparison with previous setup
- Improved agreement with observations

Arctic winter 2000-2010

- Modelling results
- Validation against observational data

Results from the HEPPA intercomp

- Comparison with other models
- Model performance

General transport characteristic of the model

- Model output
- Sensitivity studies

Reference:

Polar night NO in the MLT: Odin, ACE, and WACCM

Patrick Sheese et al.

![Graphs showing daily average NO, WACCM 2003-2010 composite, and 10-day mean NO peak altitudes, 2003-2010 average.](image)
Using the “function M” as a measure of horizontal transport in the southern polar vortex region
Middle stratospheric to lower mesospheric polar HNO₃ during and after SPEs compared to EEP production

G.P. Stiller, B. Funke*, T. von Clarmann, M. López-Puertas*, S. Kellmann, and A. Linden

* Instituto de Astrofísica de Andalucía, CSIC, Granada, Spain

Motivation: two (three) different processes contribute to HNO₃ build-up in the US/LM in polar winters. Which one dominates when?

MIPAS NOy observations from polar winters 2002 to 2012 are analyzed and the winters are inter-compared; SPE events are analyzed in detail.
Data sets for studying direct and indirect effects of high energetic particle precipitation on middle atmospheric composition by the Odin Sub-Millimetre Radiometer

J. Urban, S. Lossow, D.P. Murtagh, Y. Orsolini

Nitric oxide (NO) in the UM/LT region

![Diagram showing nitric oxide (NO) levels at 80km and 110km altitudes over time.](image)

- **110km**
- **80km**
Changes in H$_{O_x}$ and NO$_y$ Species during Solar Proton
Events: Analysis and Parameterization


**Ion Chemistry**

\[
\begin{align*}
N_2 + p^+(E) & \rightarrow N_2^+ + e^- + p^+(E - \Delta E) \\
O_2 + O_2 + e^- & \rightarrow O_2^- + O_2 \\
O_2^- + O_3 & \rightarrow O_3^- + O_2 \\
O_3^- + CO_2 & \rightarrow CO_3^- + O_2 \\
CO_3^- + NO_2 & \rightarrow NO_3^- + CO_2 \\
NO_3^- + H_2O + M & \rightarrow NO_3^-(H_2O) + M \\
NO_3^-(H_2O) + HNO_3 & \rightarrow NO_3^-(HNO_3) + H_2O \\
NO_3^-(HNO_3) + H^+(H_2O)_4 & \rightarrow HNO_3 + HNO_3 + 4H_2O \\
\text{Net} & : H_2O + O_3 + NO_2 \rightarrow OH + HNO_3 + O_2
\end{align*}
\]

- Negative ion chemistry changes NO$_y$ partitioning during SPEs
- The Sodankylä Ion and Neutral Chemistry (SIC) model can produce the observed changes in HNO$_3$
- A SIC-based, simple parameterization of ion chemistry is available

4th HEPPA Workshop, Boulder, October 8–11, 2012
The SPEs 2012 as seen by MIPAS (B21)

T. von Clarmann, B. Funke, S. Kellmann, A. Linden, M. López-Puertas and G. Stiller

During the SPEs MIPAS has monitored:

• Temperature: stratospheric warming; subsidence of mesospheric air
• CO: subsidence of mesospheric air; indication of HO\textsubscript{x} chemistry;
• NO\textsubscript{x}: local response superimposed by subsided mesospheric NO\textsubscript{x};
• HNO\textsubscript{3}: short-term responses;
• N\textsubscript{2}O\textsubscript{5}: long-term transformation of NO\textsubscript{x} to N\textsubscript{2}O\textsubscript{5};
• ClONO\textsubscript{2}: direct short-term effect;
• N\textsubscript{2}O: subsidence signal and SPE-induced formation;
• HNO\textsubscript{4}: indication of short-term NO\textsubscript{x} response;
• ClO: sign of response depends on illumination;
• O\textsubscript{3}: short-term response to HO\textsubscript{x}; long-term response to NO\textsubscript{x}
Title: Model Simulations of the Impact of Energetic Particle Precipitation on the Chemical Composition and Heating Rates in the Middle and Upper Atmosphere


- B3dCTM model simulations for 2002-2004 with KMCM meteorological data (annual cycle) and AIMOS ionisation rates
- calculating the impact on \( \text{NO}_x \), \( \text{O}_3 \), and \( \text{HO}_x \) species
- calculating the change in radiative heating due to a change in \( \text{O}_3 \) abundance
- calculating the change in chemical heating rates due to exothermic reactions involving odd hydrogen species