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Modeling the solar cycle effect of radiation belt electron precipitation on the atmosphere

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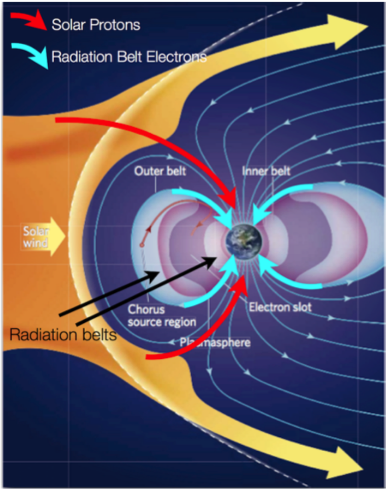
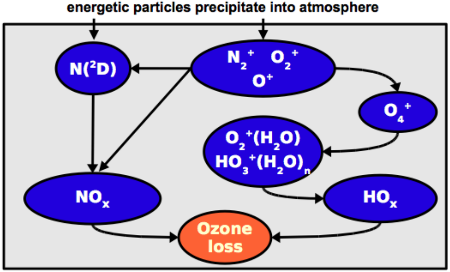
Energetic particle Precipitation (EPP) – Atmospheric Effects

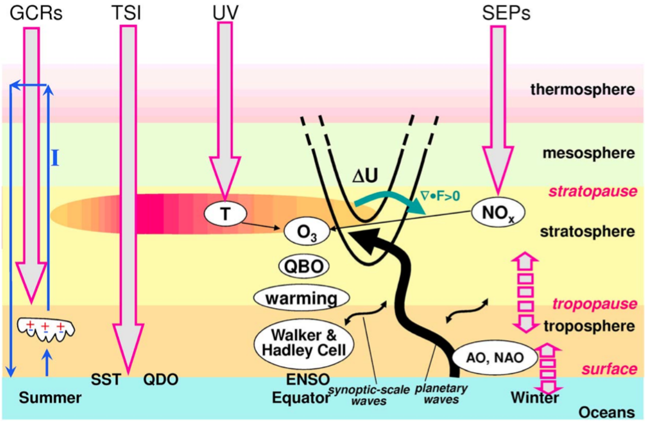


The concept: particles ionize middle atmosphere, leading to an ozone response.



Top-Down Atmospheric Coupling

From Gray et al., *Rev. Geophys.*, 2010

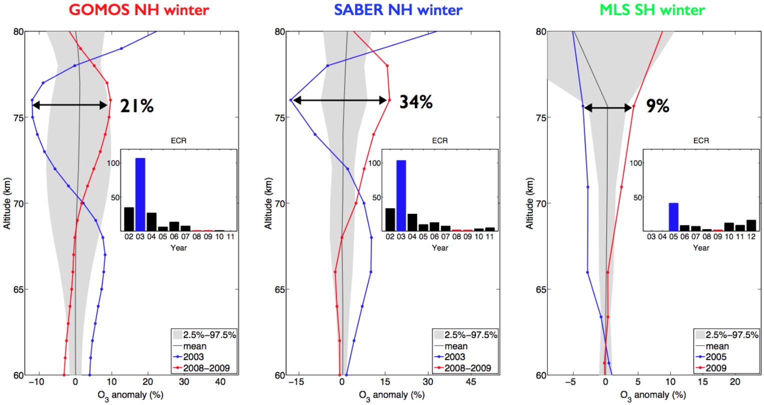


Stratospheric ozone connects to winds, waves, and NAO

Solar-cycle effect on mesospheric ozone

Andersson et al., *Nature Commun.*, 2014

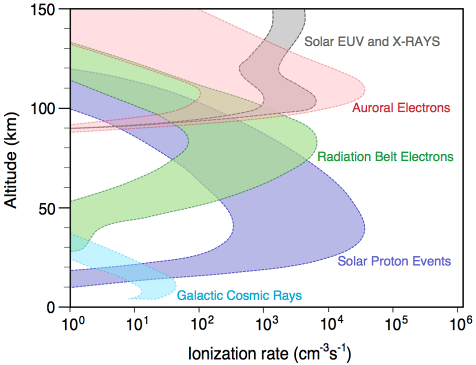
Yearly ozone anomaly for high and low electron forcing



– Results suggest that top-down mechanism (for EPP) could originate from mesosphere

Medium-energy electrons (MEE) of key importance?

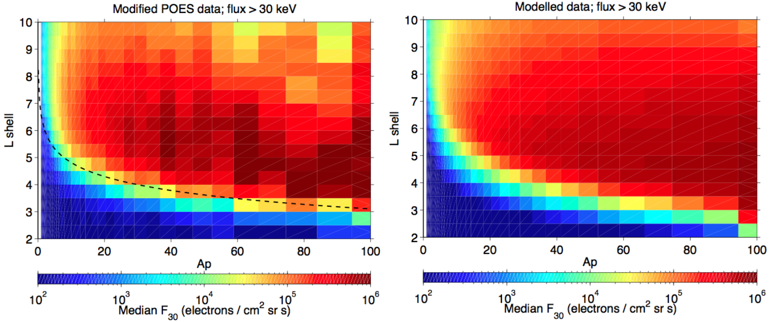
From Baker et al., EOS, 2012



– Contribution of all should included for the assessment of solar-cycle effects
– Long-term modeling of solar protons and auroral electrons has been done
– Radiation belt electrons (or medium energy-electrons, MEE) have been missing

MEE spectrum from Ap-driven model

Integrated flux (from van de Kamp et al., JGR, in review, 2016)

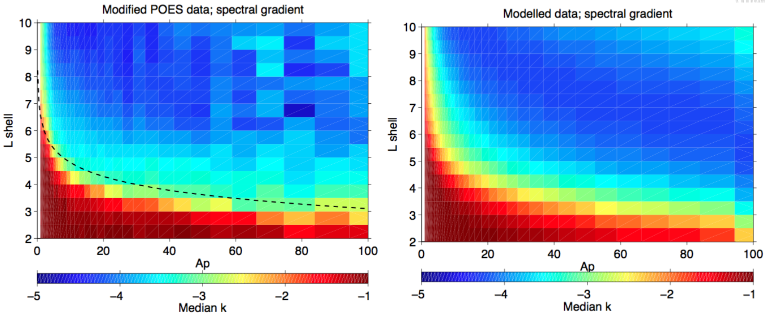


Model is based on MEE flux observations from MEPED/POES (years 2002-2012)

→ Proton contamination and noise floor corrections have been applied
→ Data is sorted in magnetic latitude bins
→ Power-law energy-flux spectrum fitted to daily zonal means
→ Spectral parameters are expressed as functions of magnetic Ap (or Dst) index

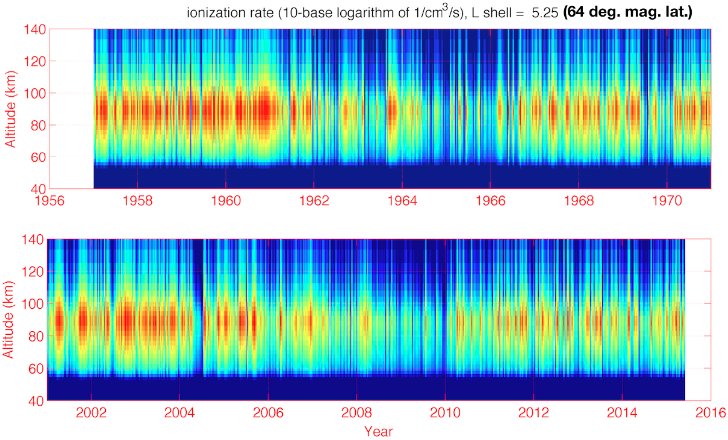
MEE spectrum from Ap-driven model

Spectral gradient (from van de Kamp et al., JGR, in review, 2016)



– Location of the plasmapause is important, we use Ap/Dst-based models to describe it
– Ap and Dst are long-term datasets, providing long-term MEE description

Overview of MEE ionization rates (10-day mean)



– Electron energies 30–1000 keV are considered.

– Largest rates at 70–110 km, no significant ionization below 55 km.

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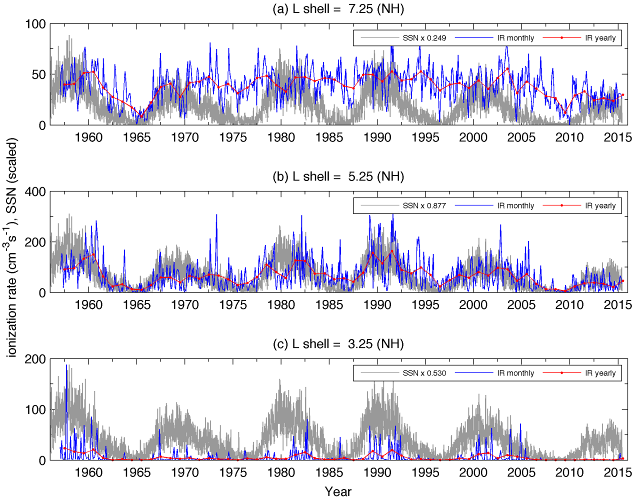
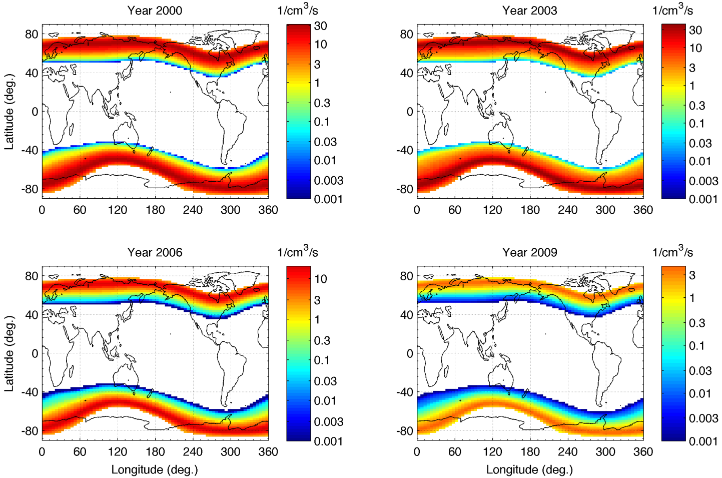
Solar-cycle variability of MEE ionization at 80 km



– Solar cycle more clear in the lower magnetic latitudes.

– Peak ionization occurs 1–2 years after the peak in sunspot number.

MEE ionization: Yearly maps at 66–83 km

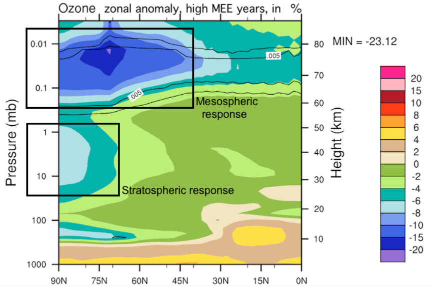


– Ionization at magnetic latitudes 44°–72°

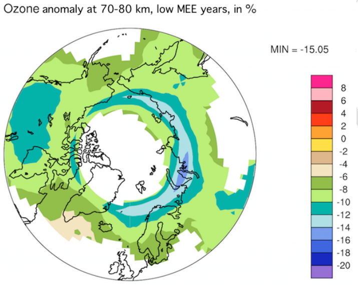
– NH/SH differences in geographic distribution

58-year climate simulation, effect on polar ozone

Wintertime (DJF) anomaly for high (left) and low (right) MEE years, preliminary results



Latitude



Even low MEE has an impact!

- Whole Atmosphere Community Climate Model (WACCM).
- Climate Model Intercomparison Project 5 (CMIP5) setup.
- Simulation with MEE compared to the reference simulation without MEE.

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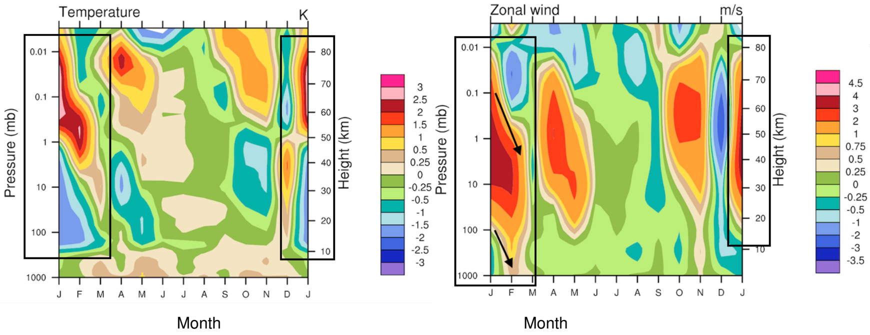
58-year simulation, effect on NH polar T and zonal wind

Anomaly for high MEE years, preliminary results



– Response in wintertime polar regions seems to be qualitatively as expected
– Ozone decreases, temperature increases/decreases in meso/stratosphere
– Zonal wind increases, and the perturbation descends to lower altitudes.

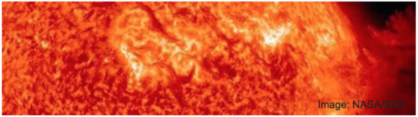
Summary

Ap-based ionization data set is freely available from the SOLARIS-HEPPA web site at http://solarisheppa.geomar.de/solarisheppa/cmip6

- We have created an atmospheric ionization data set for MEE ($E = 30 - 1000$ keV) precipitation, the data are daily zonal mean values.
- Using the magnetic Ap (or Dst) index as a proxy, we provide a timeseries from year 1850 (or 1957) to present at magnetic latitudes 44°–72° (L shells 2–10).
- The data set allows for studies of MEE climate impacts on solar cycle time scales.
- Preliminary results from model simulations seem to indicate a reasonable wintertime polar response in middle atmospheric ozone, temperature, and zonal winds.

6th international HEPPA-SOLARIS workshop

13-17 June, 2016, Helsinki, Finland



Welcome

heppa-solaris-2016.fmi.fi

Last modified: 02-Jun-2015

to the **6th International HEPPA-SOLARIS Workshop** which will be held on 13-17 June, 2016, at the Finnish Meteorological Institute (FMI) in Helsinki, Finland.

The workshop continues the series of meetings organized since 2008 and will focus on observational and modeling studies of the **influences of solar radiation (SR) and energetic particle precipitation (EPP) on the atmosphere and climate**. Broad topics to be covered include

- the causes and phenomenology of SR and EPP variability
- mechanisms by which SR and EPP forcing affect atmospheric chemistry and dynamics
- contributions of SR and EPP forcing to variations in space, atmosphere, and climate
- the current state of the art and outlook for relevant observations and models

Scientific committee: Scott Bailey, Bernd Funke, Kuni Kodera, Manuel López-Puertas, Katja Matthes, Jerry Meehl, Cora Randall, Aaron Ridley, Craig Rodger, Gabriele Stiller, Esa Turunen, and Pekka Verronen.

Meeting information

Welcome page
Twitter account (TBA)
Registration and abstracts (TBA)
Workshop program (TBA)
Accommodation (TBA)
Venue and traveling
Weather in Helsinki

External links

5th HEPPA-SOLARIS Workshop 2014
Solar influence for SPARC
HEPPA-MMI working group
EU COST Action ES1005 (TOSCA)
Scientific Committee on Solar Terrestrial Physics (SCOSTEP)