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Mesospheric odd hydrogen as an indicator of energetic particle precipitation

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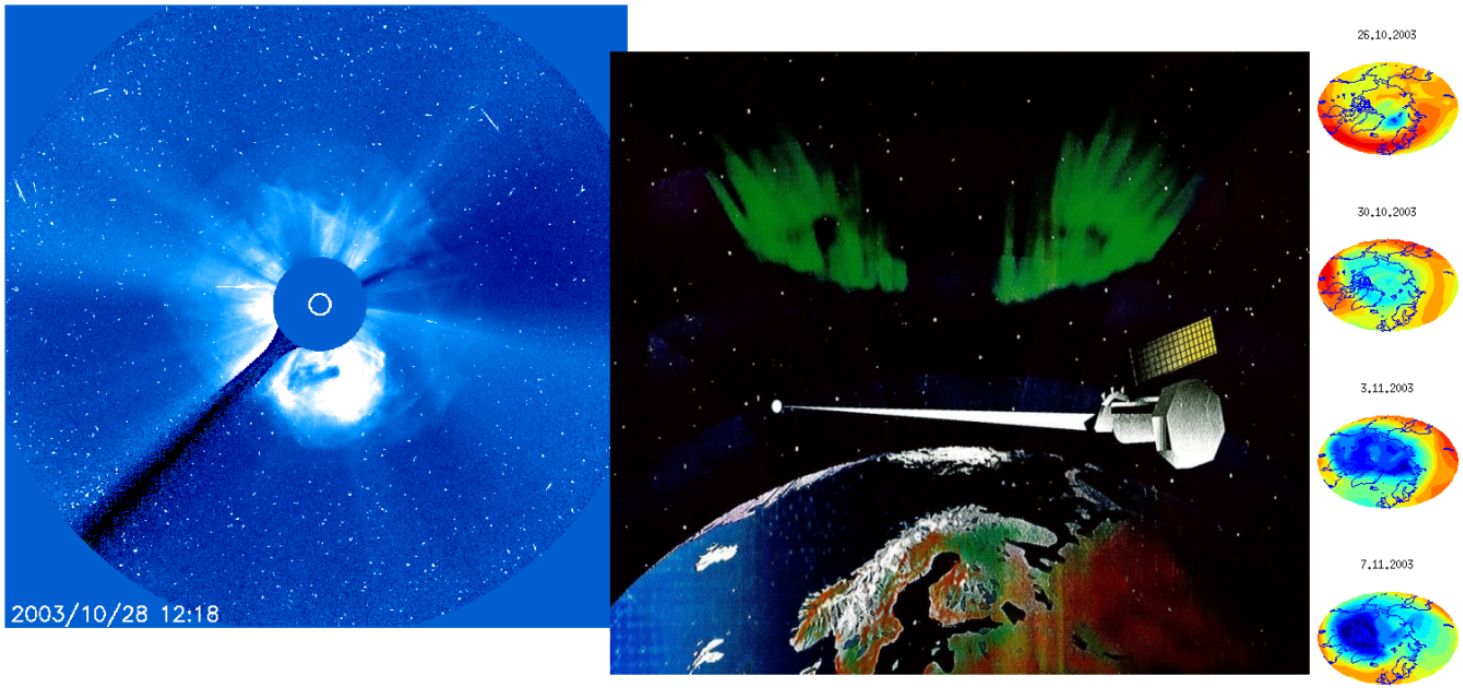
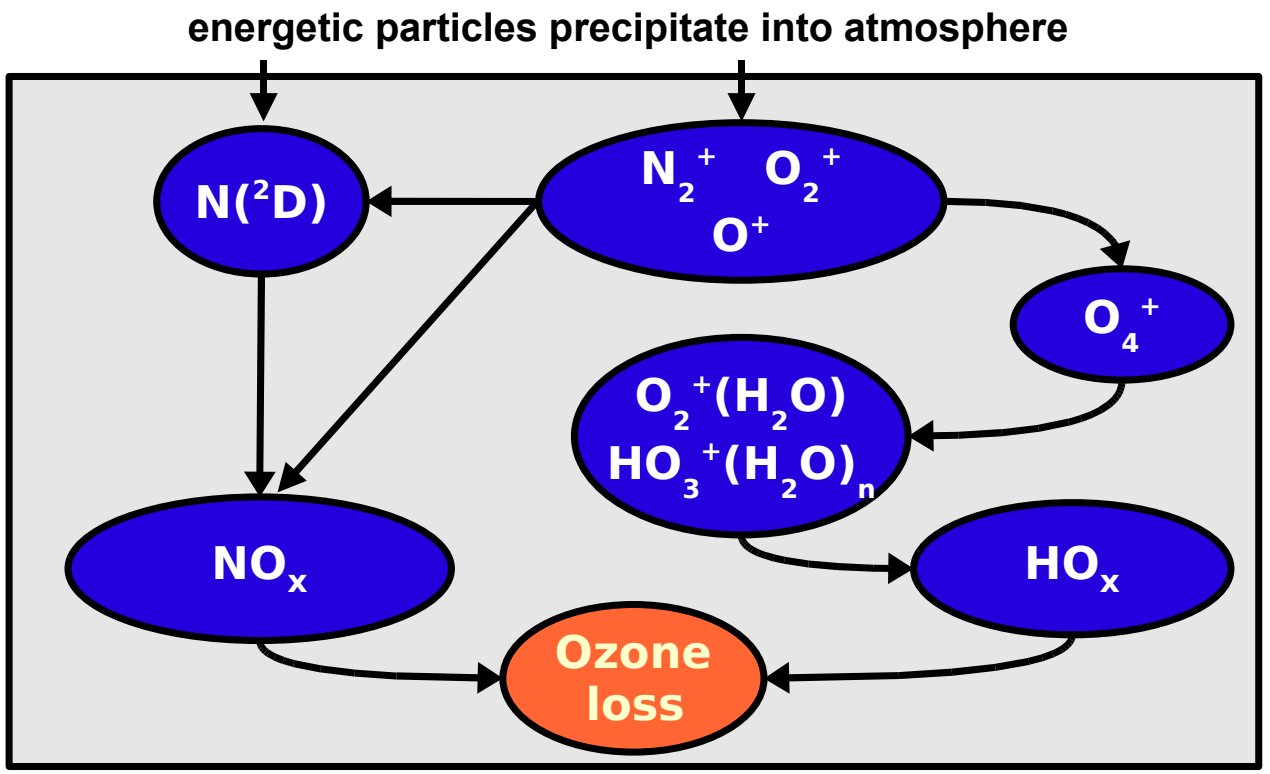
Energetic particle precipitation (EPP)



Earth's magnetic field directs charged particles into polar regions

EPP affects both ionosphere and middle atmosphere

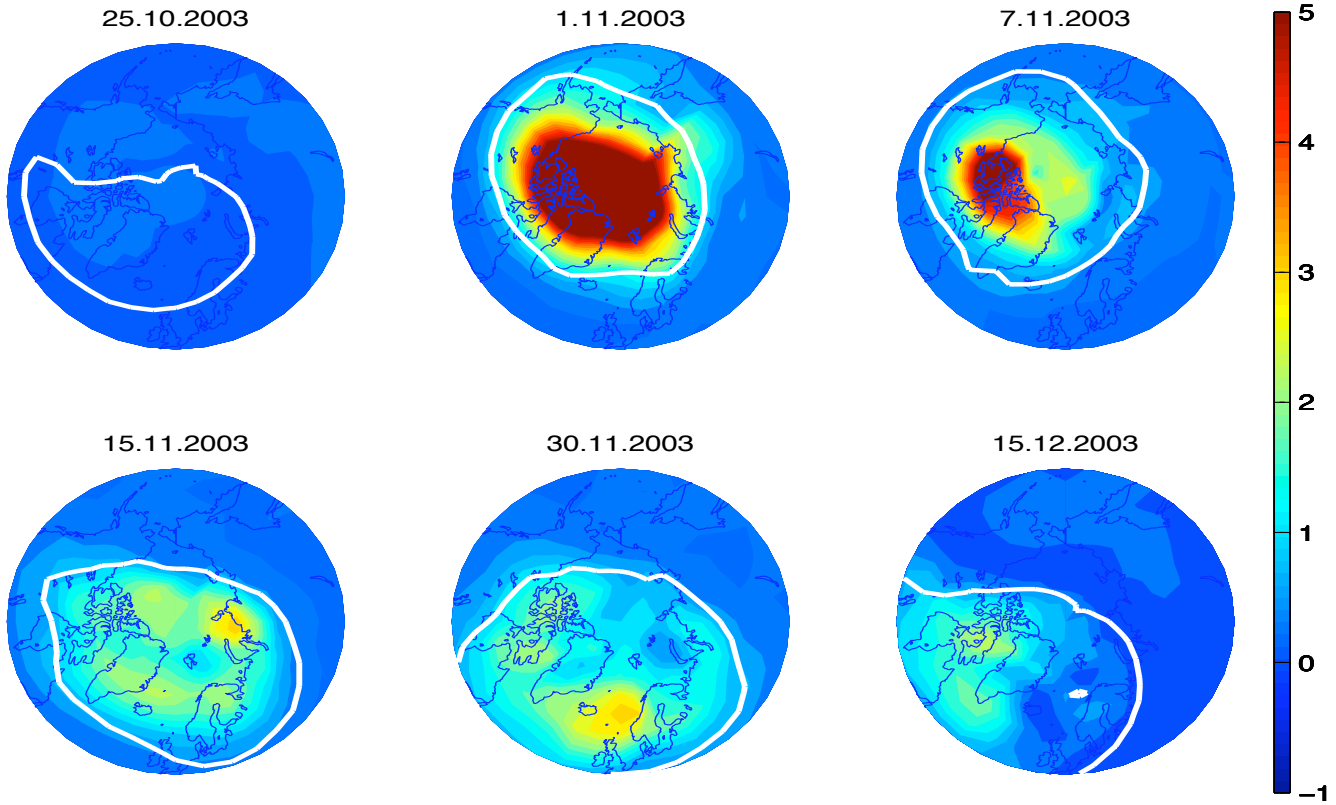
Atmospheric effects of EPP



Ozone connects to temperature and dynamics

Influence of polar vortex

HNO_3 (ppbv) at 45 km, Oct–Dec 2003



FinROSE chemistry-transport model

Mesospheric odd hydrogen: indicator of EPP

- Night-time HO_x ($= H + OH + HO_2$) concentration is relatively low.
  $\Longrightarrow$ It can be enhanced by moderate EPP forcing.

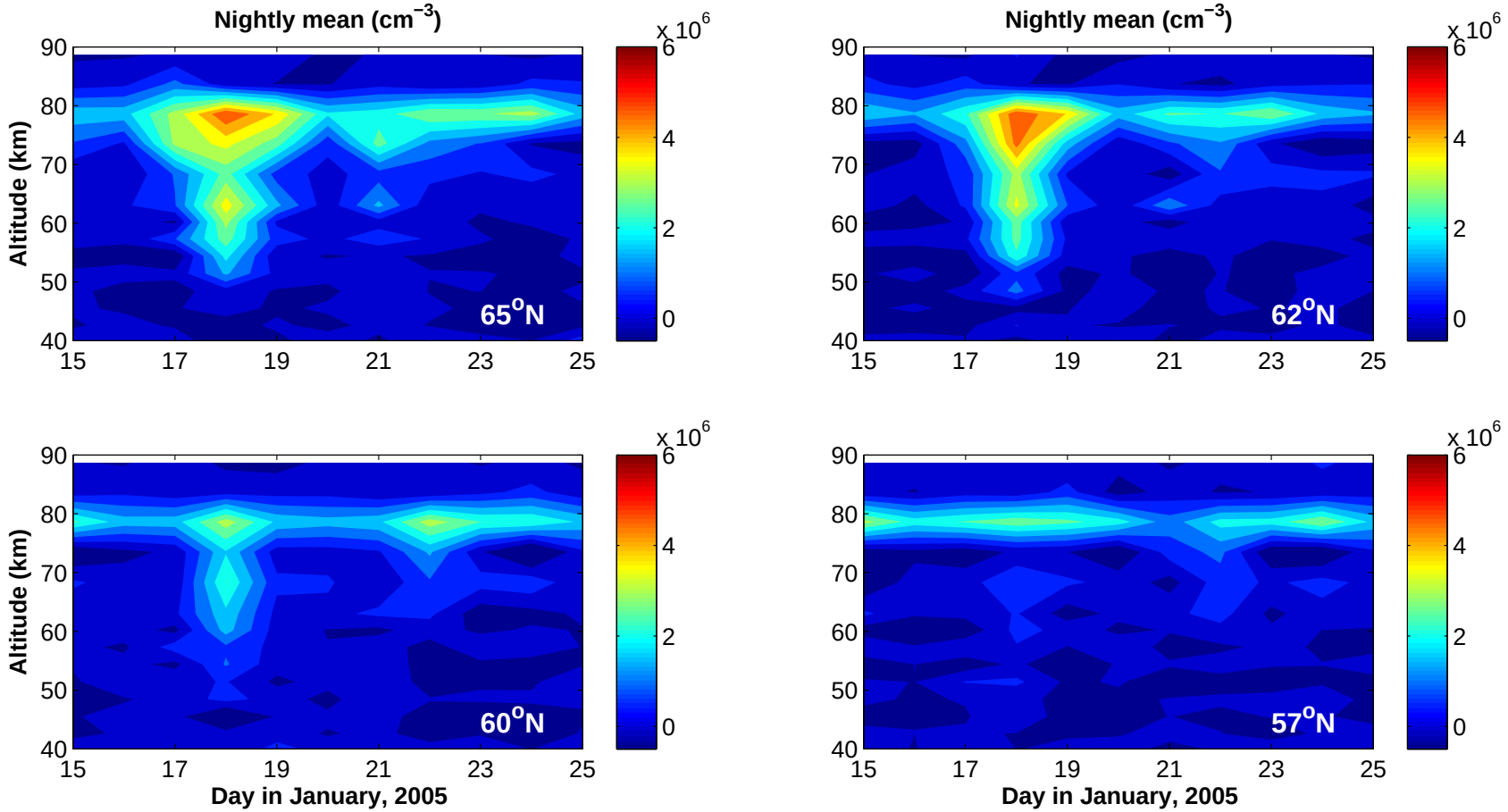
- HO_x has a relatively short chemical lifetime (hours).
  $\Longrightarrow$ Returns quickly to normal values after EPP forcing stops.

Odd hydrogen responds quickly
to increases and decreases of EPP forcing

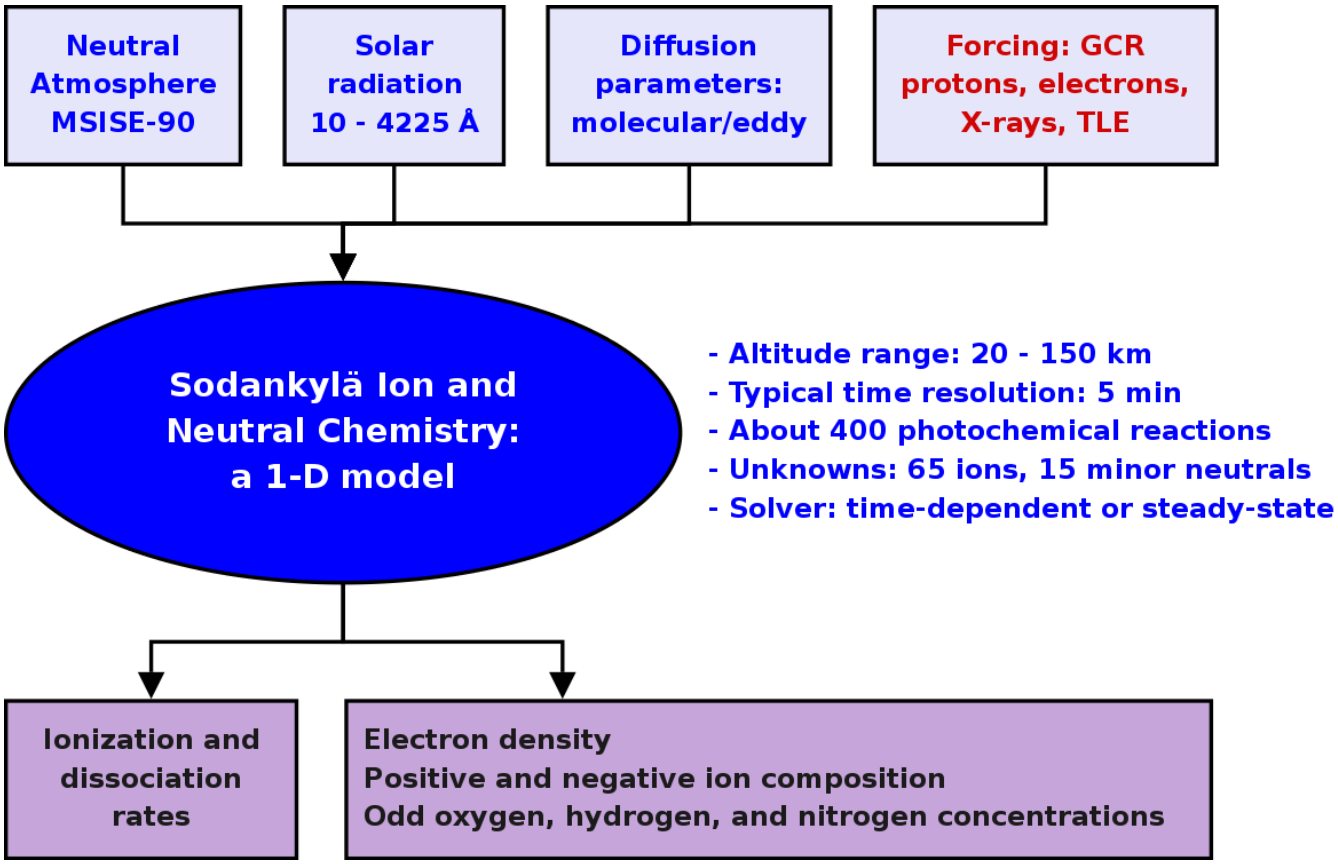
- HO_x data are available from the MLS/Aura instrument, providing observations of mesospheric changes during EPP.

MLS/Aura – mesospheric OH during EPP

Solar proton event of January 2005

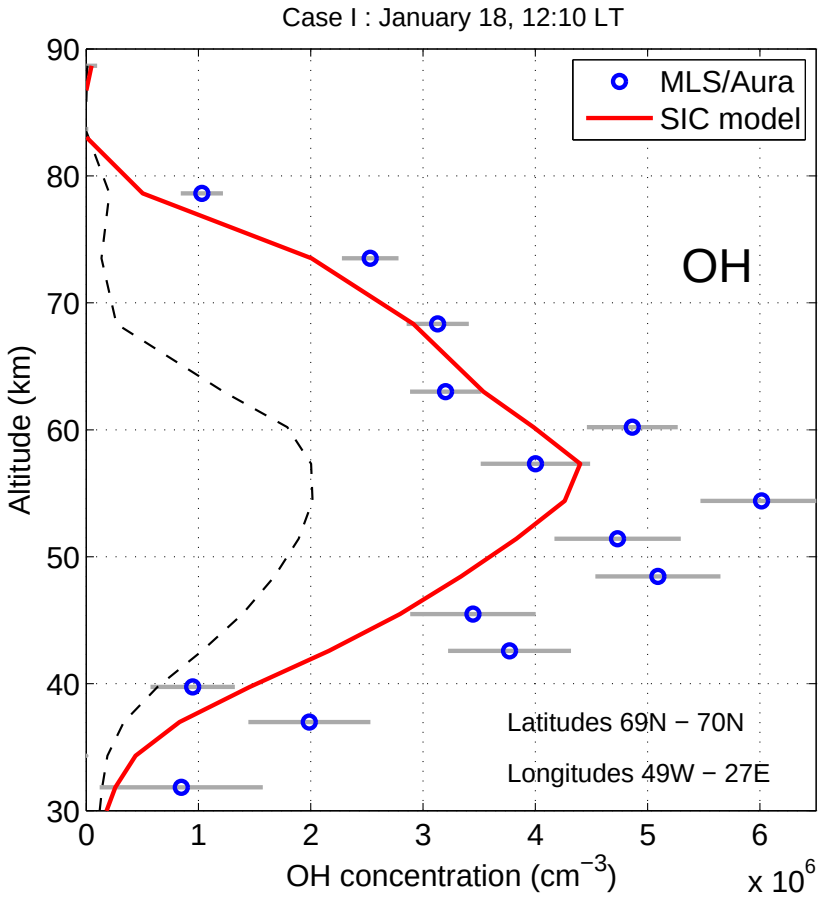


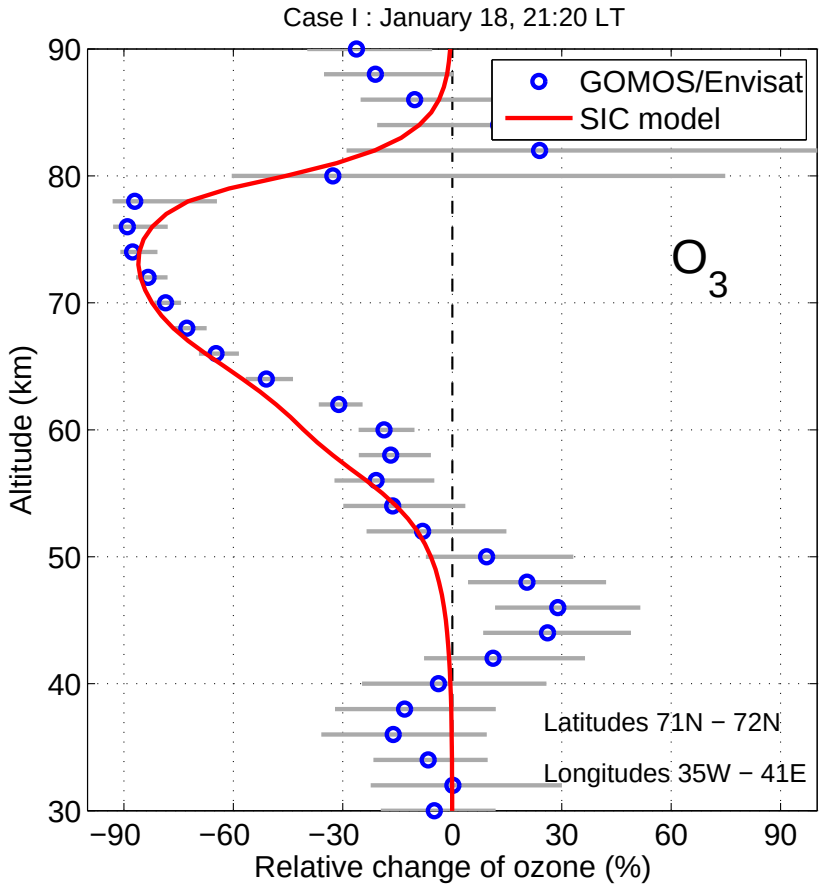
SIC model – Ion chemistry and odd hydrogen



OH production – SIC vs. MLS/Aura

Solar proton event of January 2005





OH observations: a feasible proxy for EPP?

- In case of strong solar proton events: YES
  - the effects cover the polar cap regions
  - high-flux events last for $\sim$10 days
  - protons come directly from Sun

  NOTE: direct proton flux observations are easy to make from satellites.

- In case of electron precipitation: MAYBE
  - effects cover only restricted latitudes/longitudes
  - magnitude and duration of the forcing are very variable
  - electrons come from radiation belts and magnetosphere

  $\Longrightarrow$ Electron flux observations are not telling the whole story.

OH proxy would have great value
in characterizing electron precipitation

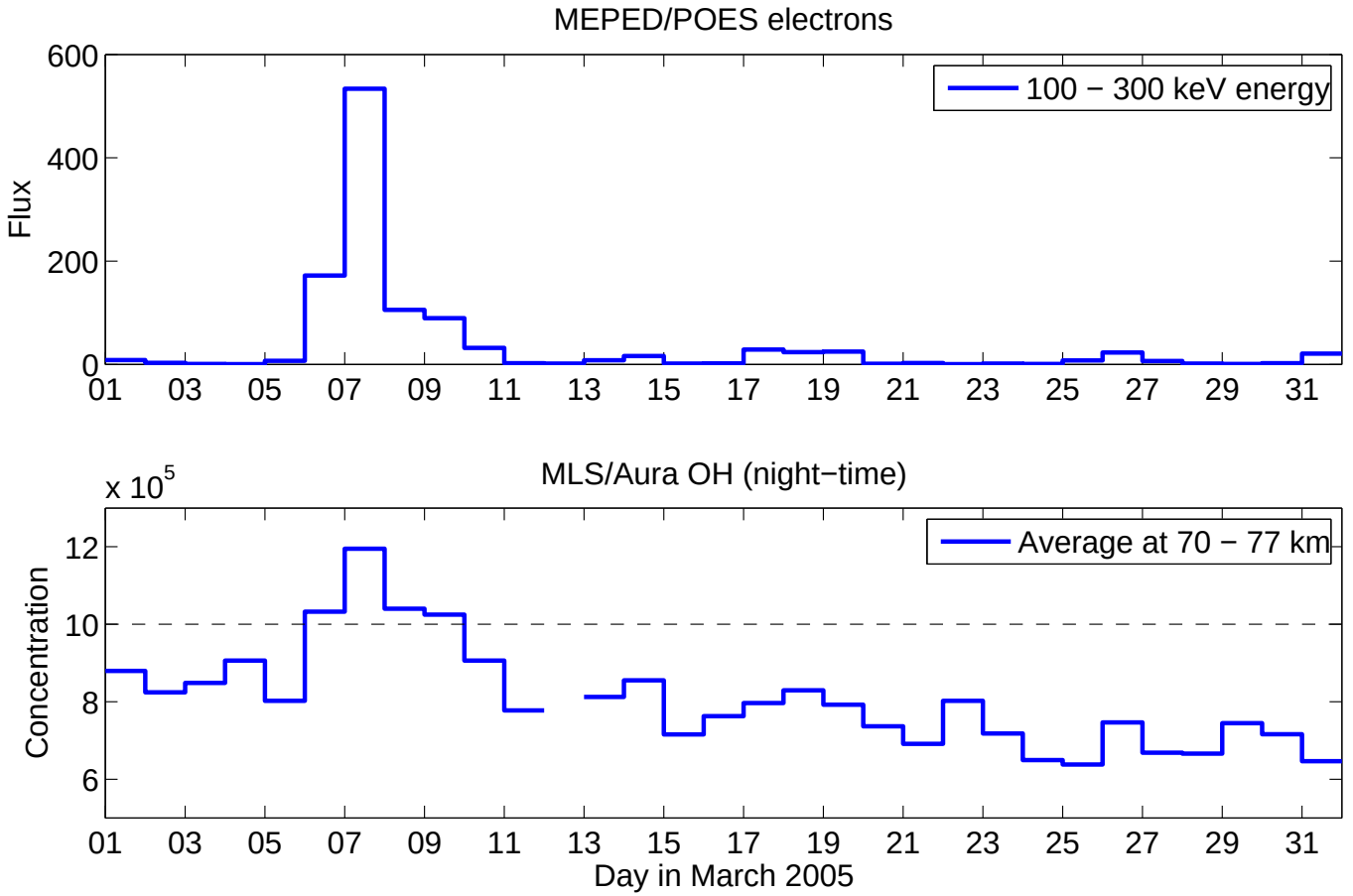
Medium Energy Proton and Electron Detector (MEPED)

- On board NOAA POES Satellite
- Measures in the radiation belts
- Electron channels >30, >100, and >300 keV
- The so-called zero-degree electron telescope observes precipitating flux but only sees a fraction of the whole loss cone area.

  $\Longrightarrow$ It does not measure "true" flux of EPP.
  However, it can be used to monitor changes in EPP.

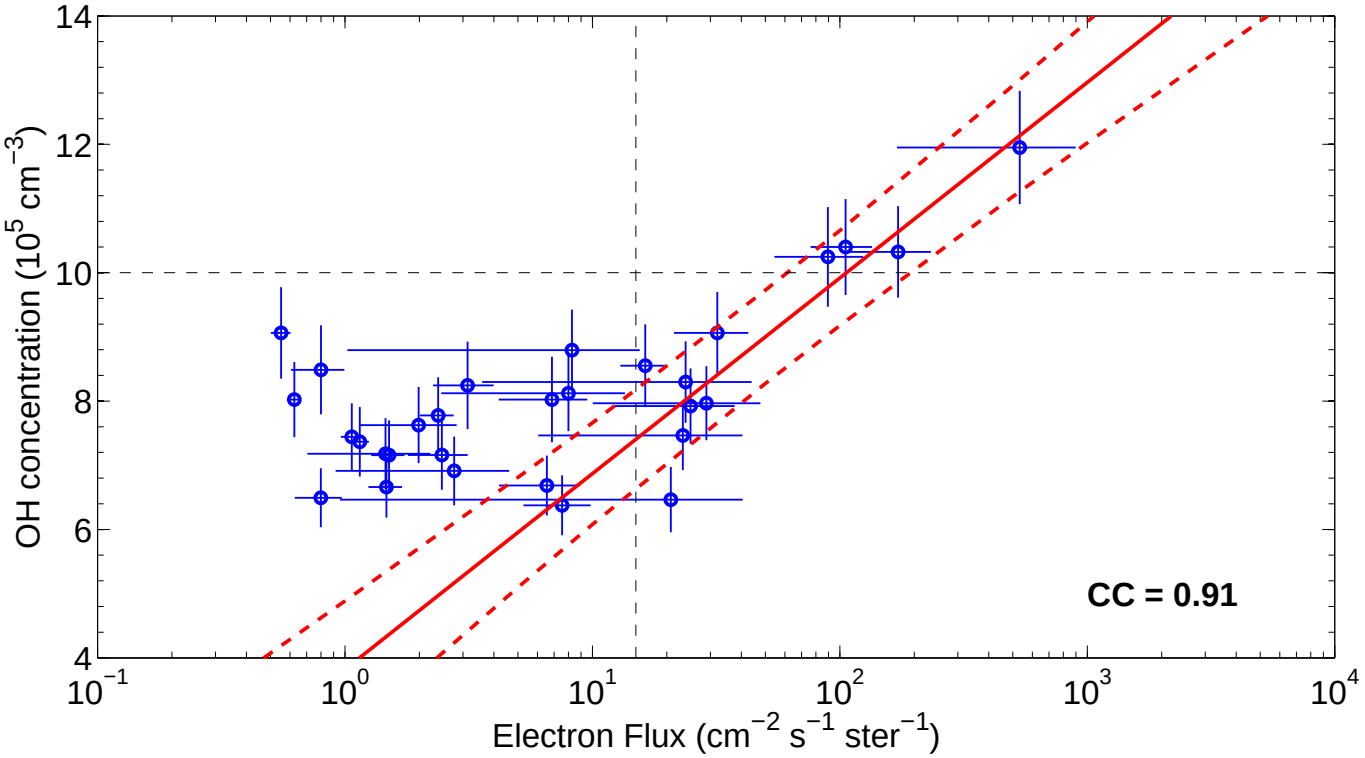
Observations in March 2005

Magnetic latitudes 55 – 65°S



Correlation: electron flux vs. OH concentration

March 2005, magnetic latitudes 55 – 65°S



High electron fluxes are seen in OH concentration

Summary

- Energetic particle precipitation (EPP) produces odd hydrogen in the mesosphere
- MLS/Aura can detect the changes in HO_x caused by EPP
- HO_x behaviour can be modelled if ion chemistry is taken into account
- MLS/Aura observations can help in characterisation of the magnitude and spatio-temporal extent of EPP
- For more details, see
  Verronen et al., *Geophys. Res. Lett.*, *33*, L24811, 2006
  Verronen et al., *Ann. Geophys.*, *25*, 2203–2215, 2007