Responses of nitrogen oxide to high-speed solar wind stream in the polar middle atmosphere

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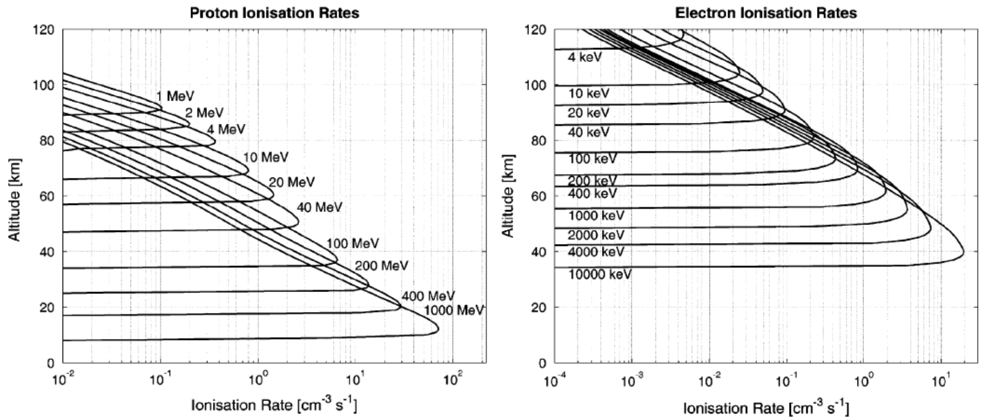
The impact of particle precipitation on neutral atmosphere

Energetic Particle precipitation

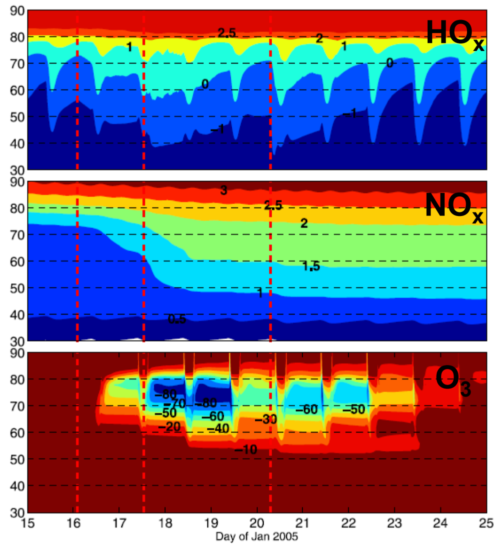
Production of NO_x and HO_x

Destruction of mesospheric and upper stratospheric O_3

Climate change?

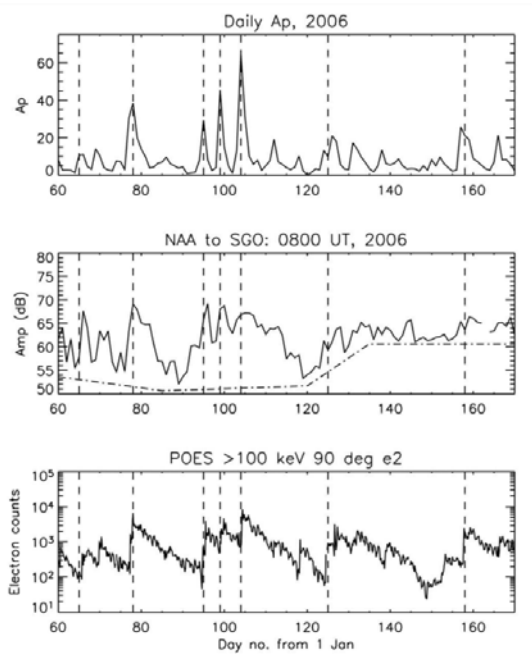


(from Turunen et al., 2009)

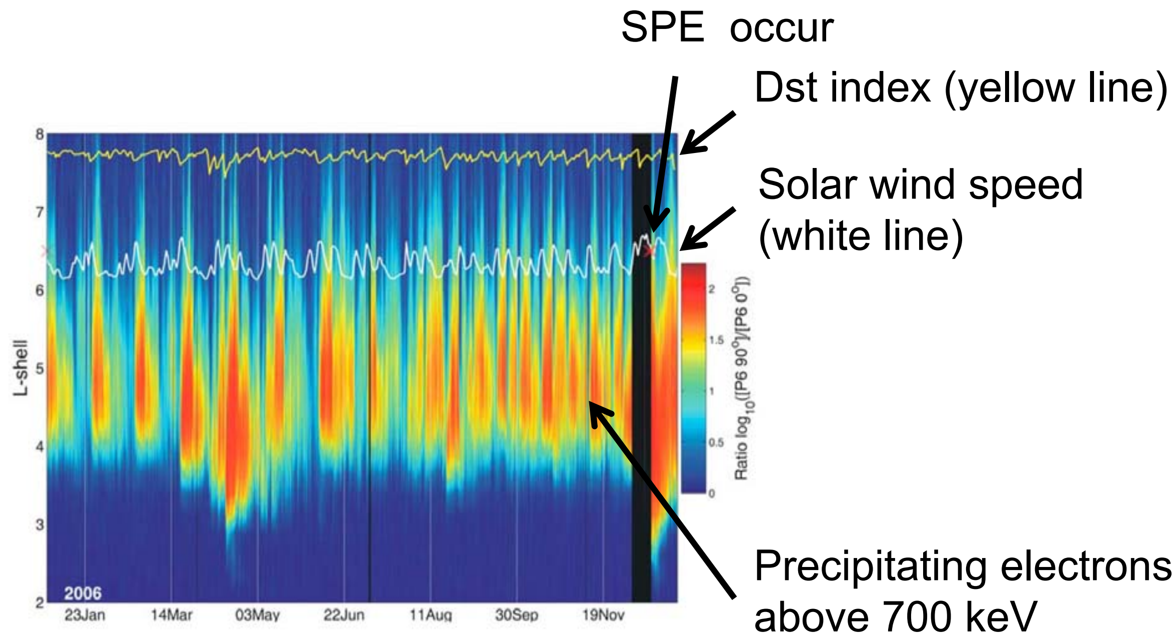


(from Seppälä et al., 2006)

Source of EPP



(from Clilverd et al., 2010)



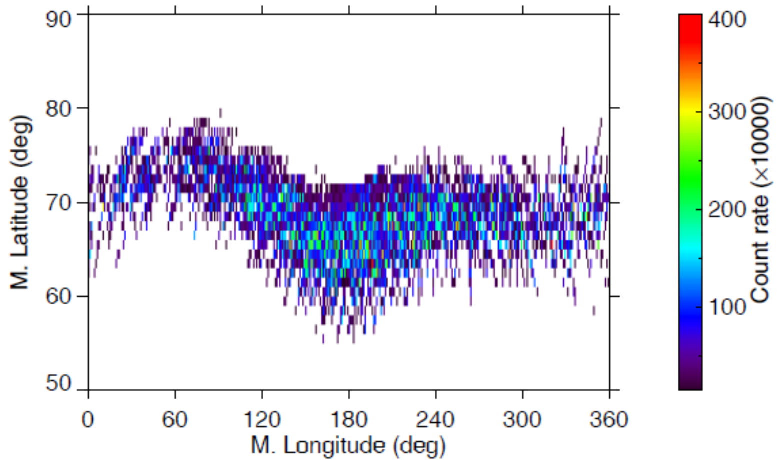
(from Rodger et al., 2010)

- SPEs largely increase the particle precipitation, but has low occurrence rate.
- EPPs occur more frequently and persistently during HSSs events.
- HSSs can be more important to chemical change in the polar atmosphere by EEP.

Goals

- Where is the depth associated with the direct production of NO_x by HSSs?
- How much the NO_x by the direct effect by HSSs?
- How much the O_3 destruction by NO_x associated with HSSs?

Used data



1. Selected HSS events

- 6 November, 2007 to 1 February, 2008

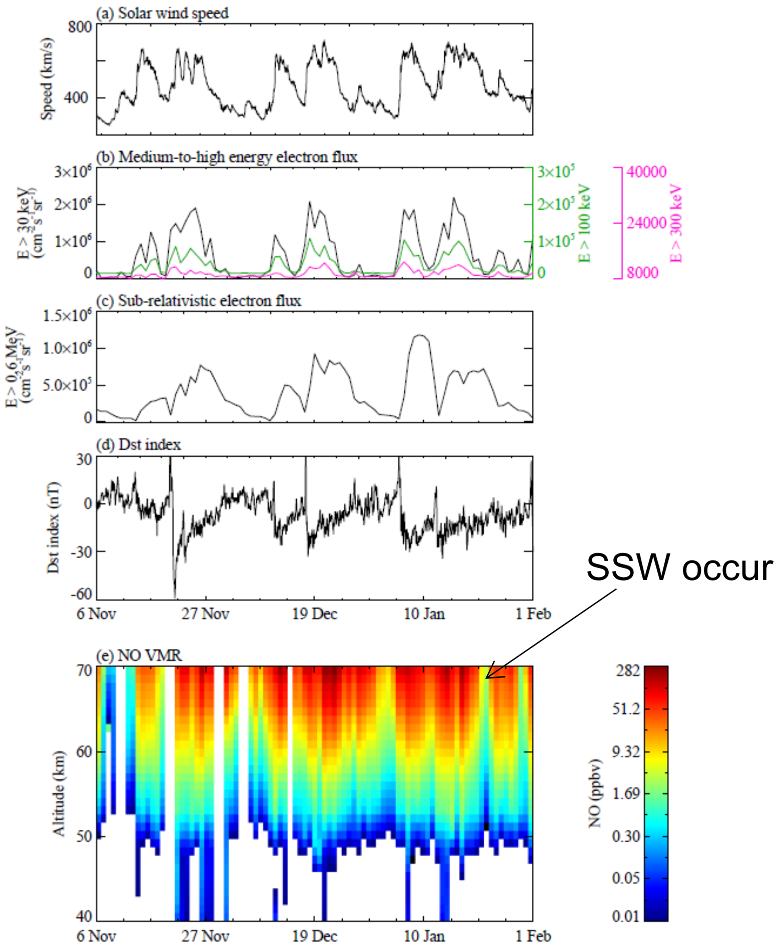
2. Space condition

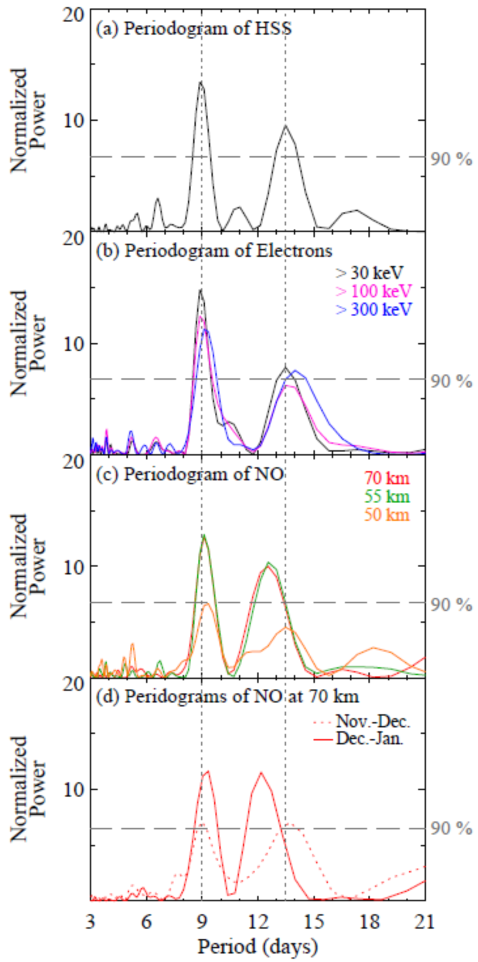
- Solar wind speed from SWEPAM/ACE
- Precipitating electron flux from MEPED/POES
- Geomagnetic latitude range : 60-77°N

3. Middle atmospheric condition

- NO_x and tracer gases (CO and CH_4) volume mixing ratio from MIPAS/Envisat
- O_3 VMR from MLS/Aura
- Vertical range : 20-70 km

Result 1 : Response of NO by HSSs

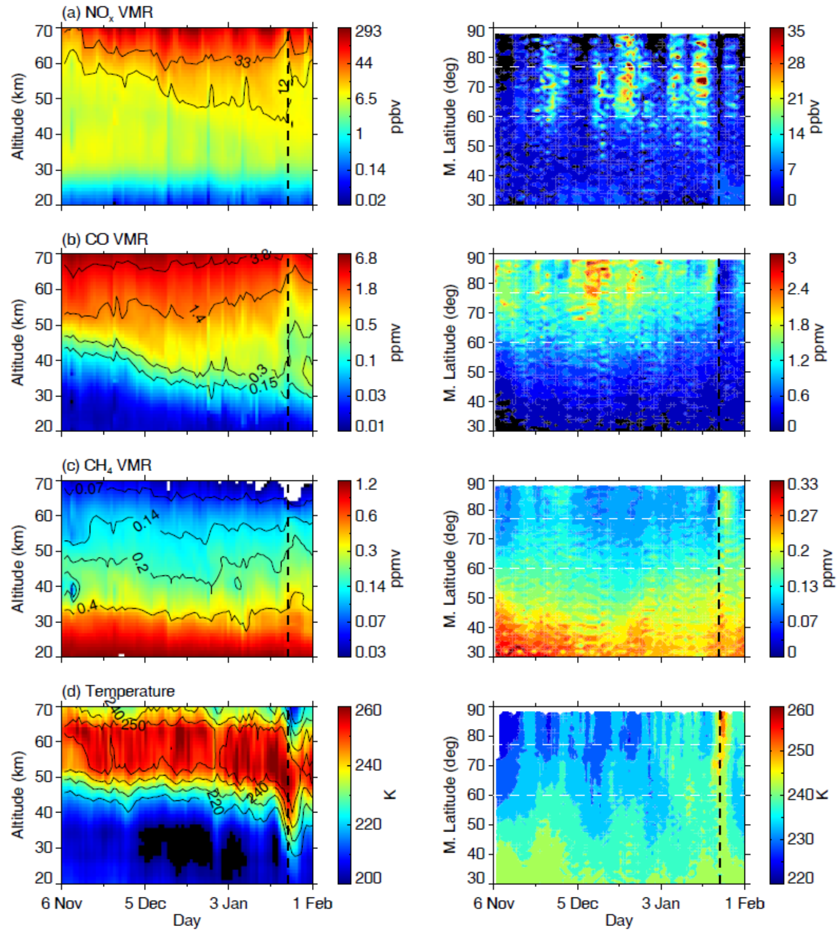




- Effect of the HSSs may be reached down to 55 km altitude.

Downward transport of NO_x and vortex dynamics

Daily zonal mean (60˚N-77˚N) VMRs and Temperature
vertical mean (40-70 km)



- Tracer is interrupted downward transport and temperature is disturbed in Nov and Jan.
- Strong horizontal mixing may occur in Nov and Jan.
- To estimated the amount of directly produced NO_x, have to remove the horizontal mixing effect.
- Remove the horizontal mixing effect using correlation with NO_x and tracer.

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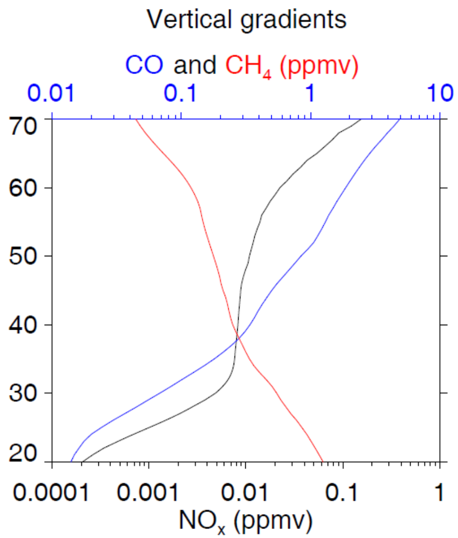
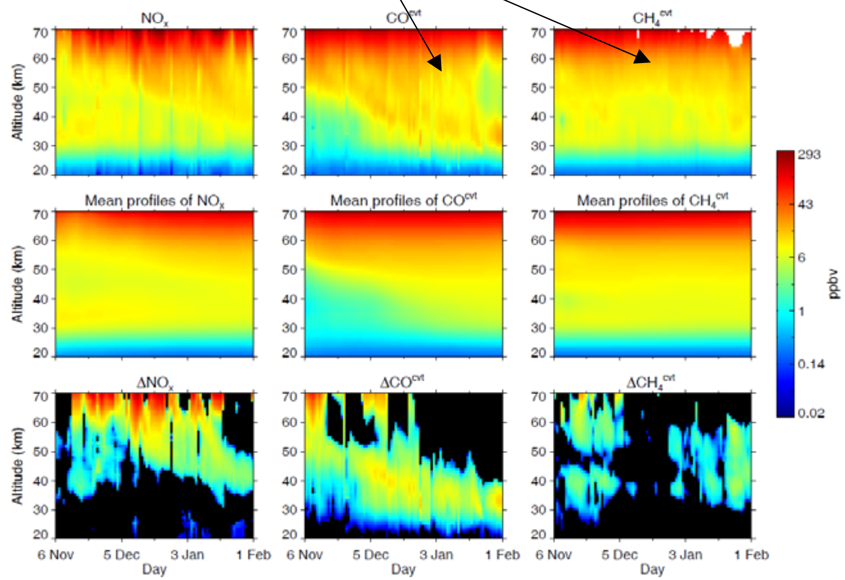
Estimation of amount directly produced NO_x

Converted CO and CH4 seems to similar to NO_x's vertical gradient





To directly compare the NO_x and tracer, we have to convert the vertical gradient of tracer.

$$NOx^{avg} \times \frac{tracer}{tracer^{avg}}$$

$$NO_x{}^{P} \approx \Delta NO_x - \Delta CO^{cvt} - \Delta CH_4{}^{cvt} - \overline{\Delta NO_x} - \overline{\Delta CO^{cvt}} - \overline{\Delta CH_4{}^{cvt}}$$

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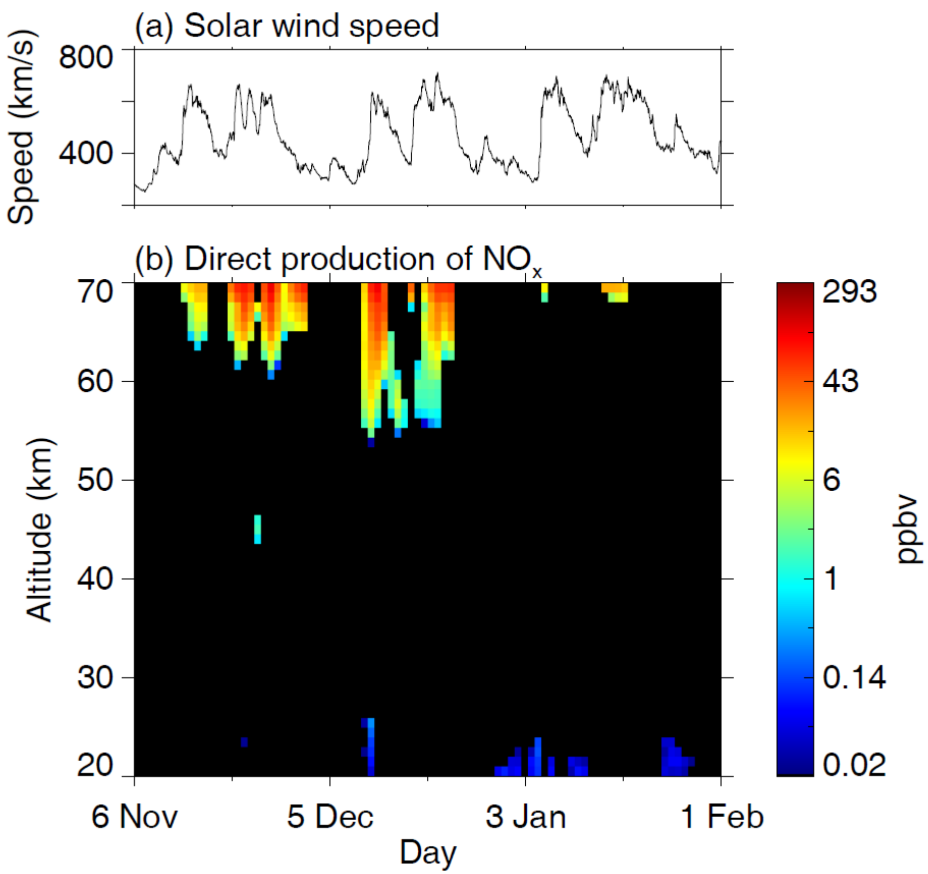
Result 2 : Amount of direct production of NO_x



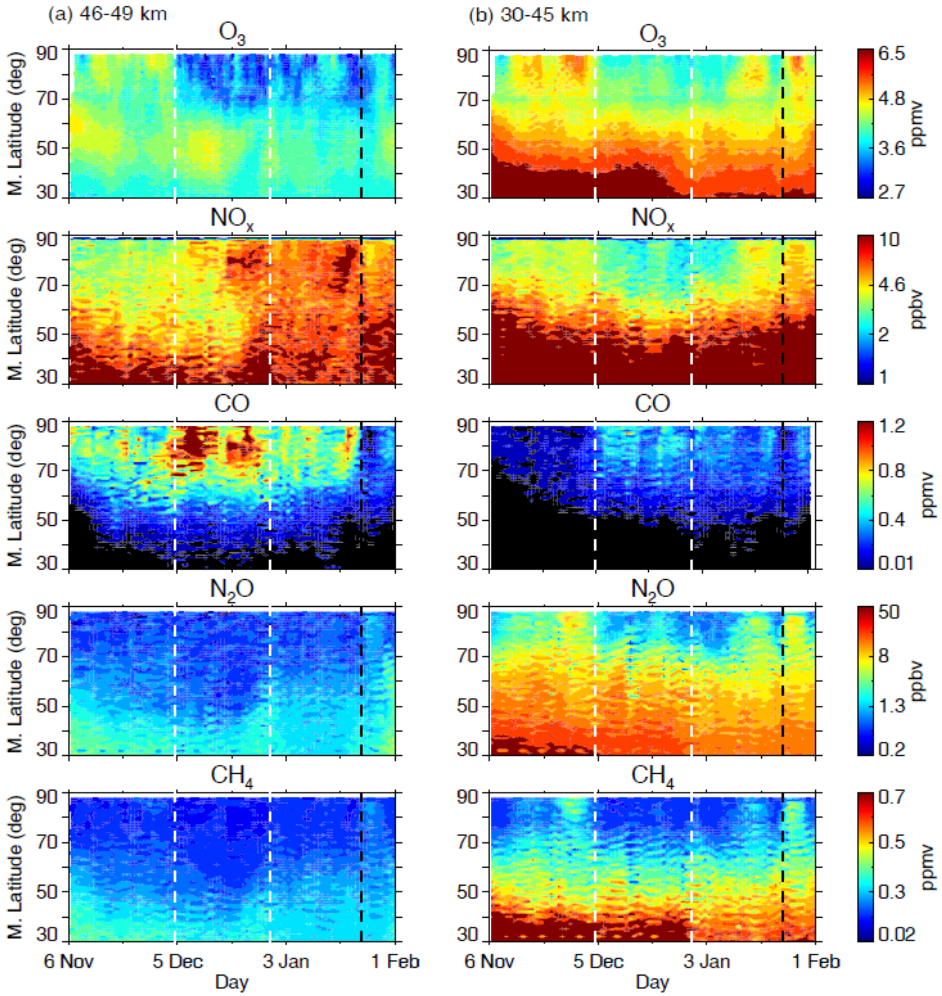
- Estimated that 2 ppbv of NO_x is produced directly at 55 km.

- Our result is largly consistent with the previous studies

  - Direct NO production was about 2 ppbv at 55 km altitude (Smith-Johnsen et al., 2017)

  - Direct production of NO_x was about 3-6 ppbv at the altitude of 40-64 km (Sinnhuber et al., 2014).

Result 3 : Ozone destruction by EEP induced-NO_x



- Strong downward transport appears in December.
- O_3 loss identifies in both altitude region.
- But, O_3 loss in lower altitude region is accompanied by low NO_x.
- O_3 loss by EEP during HSSs may occur in most upper stratosphere alone.

Summary

- Using satellite observations for NO_x, CO, CH_4, and O_3 VMRs during high–speed solar wind streams (HSSs) events from 6 November 2007 to 1 February 2008, we investigated the effects of HSSs on NO_x and O_3 in the polar middle atmosphere.

- The vertical impact range of the high–speed solar wind is estimated to be down to 55 km as a result of the periodical analysis.

- The amount of directly produced NO_x estimated about 2 ppbv at the altitude of 55 km.

- The O_3 may be destroyed by HSSs-induced NO_x in the most upper stratosphere.

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Thank you!

CHAMOS meeting 2018

8-12 October, 2018. University of Otago, Dunedin, New Zealand

Monday

Morning (start at 10am)

- Welcome
- CHAMOS updates
  - New people
  - Ongoing projects
  - New and upcoming publications

Afternoon

- Updates on simulation capability
  - SIC model
  - CESM/WACCM
  - EEP model for providing ionisation rates for climate models.

Evening: CHAMOS welcome dinner in town

Tuesday

Morning (start at 9am)

- Particle precipitation, atmospheric ionisation work, ionosphere
  - Update on EEP ionisation rate [MLT model] validation work
  - EMIC wave driven electron precipitation - energetic, relativistic, ultrarelativistic, or all of the above?
  - Intensity and properties of microbursts
  - High energy particles and X-rays in middle atmosphere, status of in-situ measurements and planned new observations
  - Proton precipitation with a global hybrid-Vlasov magnetospheric model: Vlasiator
  - Geoeffectiveness of solar wind high-speed streams during cycles 23 and 24
  - Early detection of solar flares using VLF observations

Afternoon

- Particle precipitation, atmospheric ionisation work, ionosphere - continued from morning

Evening optional program: Dinner at a restaurant in St Clair by the ocean

Wednesday

Morning (start at 9am)

- Updates on our polar observation networks
  - Particles
  - Ionisation
  - Ionosphere
- Distribution of our EEP ionisation rate datasets (Van de Kamp et al. work, including CMIP6 ionisation rates, etc)
- Funding for CHAMOS work
- Student opportunities

Afternoon - Local excursion

Thursday

Morning (start at 9am)

- Atmospheric chemistry, dynamics and climate change
  - Antarctic ozone and Solar Proton Events
  - Substorm impacts on the atmosphere - from short term toleejihee@kopri.re.kr solar cycle variability
  - Atmospheric impact of microbursts
  - EMIC impacts on atmosphere
  - Can changes on mesospheric ozone levels propagate to the surface?
  - Long term climate change in the D-region - modelling progress

Thursday

Afternoon

- Updates on our polar observation networks
  - Chemistry
    - Mesospheric ozone monitor MOSAIC instrument: development update, data analysis, future plan
  - Dynamics (winds, temperatures)

Evening: CHAMOS dinner in town

Friday

Morning (start at 9am)

- Meetings in the next 12-24 months
- Next CHAMOS meeting