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Response of nitric oxide(NO) to high-speed solar wind stream in high-latitude lower thermosphere and mesosphere

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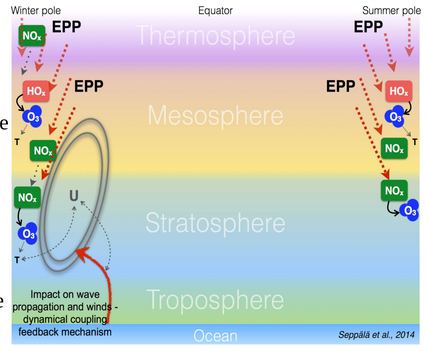
Abstract

Electron precipitation from the Earth's inner magnetosphere transfers solar wind energy to the upper atmosphere and at last may affect climate change. Here we conduct an analyze on NO production at high-latitude upper atmosphere due to precipitating electrons during high-speed solar wind stream (HSS) for northern wintertime of 2007-2008. Fluxes of precipitating E > 30 keV and E> 300keV electrons increase immediately in association with HSS onset and remains elevated during the passage of the HSS. Response of NO concentration to HSS is seen to down 50km altitude at nighttime but 80km altitude at daytime. The difference in the penetration depth of HSS effect may be attributed to the longer lifetime of NO at nighttime in no presence of sunlight until its reaching 50 km. The results of this study can contribute to a better understanding of the direct/indirect effects of HSS on the NO chemistry change in the upper atmosphere.

Introduction

Nitrogen oxides (NO_X : NO, NO_2) in the mesosphere and lower thermosphere are produced by energetic electron precipitation through interactions with the background atmosphere. The increased NOx owing to energetic particle precipitation are the major drivers of catalytic ozone loss. The chemical lifetime of NO in the lower thermosphere is approximately 0.8 day (19 h) in sunlit Condition [*Barth*, 1992; *Barth et al*., 2001]. Especially, it has a quite long lifetime in darkness and can be transported downward by polar vortex at high latitudes. In the thermosphere and upper mesosphere NO_X exists mainly in the form of NO, but below 70 km it is converted to NO_2 [*Solomon et al*., 1982]. The major source of producing NO in lower thermosphere(> 90km) is auroral electron(100eV < E < 30keV) precipitation. In the meanwhile electrons in capable of penetrating into the mesosphere(75-90km) to product NO is required for as high as 30-300keV [*Meredith et al*., 2011; *Lam et al., 2010*].



Motivation(or Purpose)

➢ **It is a study to determine (or investigate)**

1. How the NO chemistry change occurs by electron precipitation as linked to high speed solar wind streams (HSS)
2. The effect of HSS on NO production as appearing in periodicities of 7, 9, and 13.5 days
3. As far as which altitude the effect may penetrate into atmosphere

Data and Analysis

- For the analysis, the data as below selected for the Arctic winter from October 27 (day=300), 2007 to February 4 (day=35), 2008 at magnetic latitudes of 65°-75°N
- NO concentration: MIPAS/ENVISAT satellite (http://share.lsdf.kit.edu/imk/asf/sat/mipas-export/)
- Electrons (30-300 keV) : MEPED/POES satellite (ftp://satdat.ngdc.noaa.gov/sem/poes/data/)
- Solar wind data : OMNIWeb (http://omniweb.gsfc.nasa.gov/)

Result 1 : Variation of NO in upper atmosphere by HSS

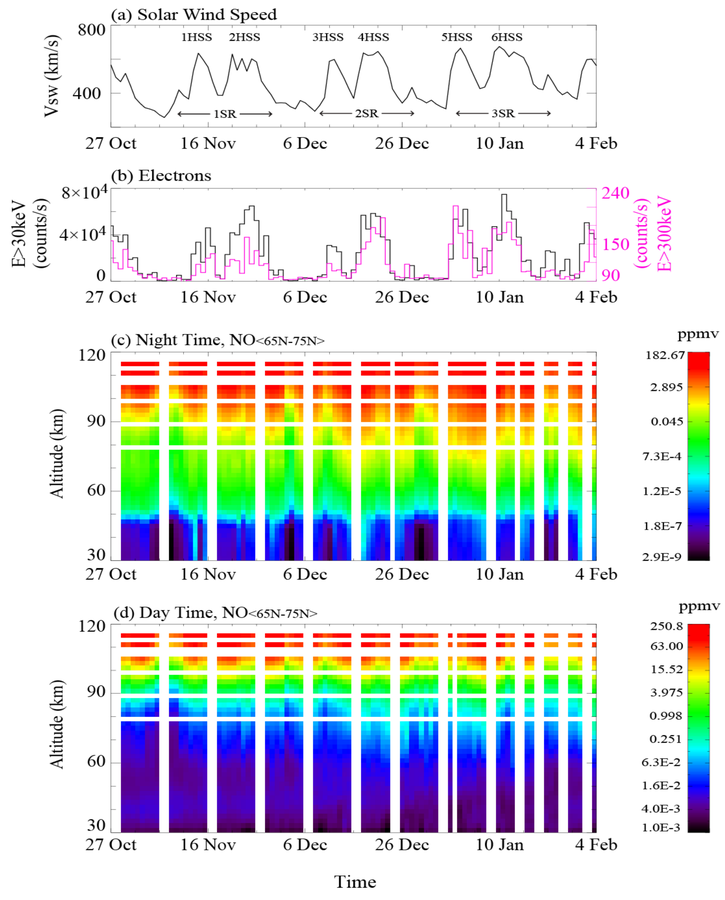


Fig. 1. Day-to-day variations of (a)solar wind speed, (b) electron count rate for >30keV and >300keV and (c), (d) NO profiles at altitudes of 30-120km during Arctic winter from October 27, 2007 to February 4,2008.

- Fluxes of precipitating E>30 keV and E>300 keV electrons significantly increase immediately likely in association with HSS onset.
- Electron flux and NO concentration remain elevated during the passage of the HSS.

Result 2 : Periodic analysis of NO response to HSS

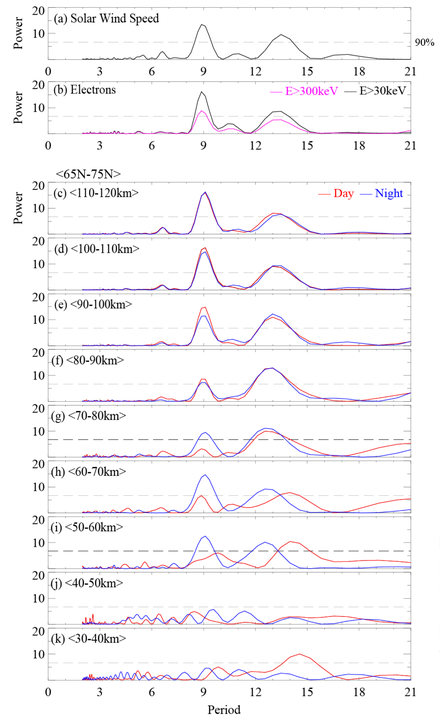


Fig. 2. Periodic analysis of (a) solar wind, (b) electron precipitation and (c) - (k) NO concentration at altitudes of 30-120km using Lomb-Scargle periodogram. Horizontal dashed lines (gray) represent the 90% significance level.

- This study finds that high-energy (30-300 keV) electron precipitations in a link to HSS possibly have effect on NO increase as low as 50 km. Above 50 km periodicities of 7, 9, and 13.5 days in NO concentration well correspond to those of HSS and electrons precipitation.
- An increase of NO concentration occurs down to 50 km at nighttime but is retained as far as 80 km at daytime as linked to the effect of HSS.
- The HSS effect of NO production penetrating as low as 50 km at nighttime likely include both direct and indirect effects. The latter is likely relevant to the NO propagating downward with time delay (see Fig. 1 c) from the upper altitudes through the polar vortex.

References

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