



What is the difference between a major SSW and a geomagnetic storm impact on the Earth's upper atmosphere?

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Both Sudden Stratospheric Warmings (SSW) and geomagnetic storms affect the thermospheric state however the impact is difference in two cases. Therefore it is interesting to specify which particular thermospheric parameters are changed and to which extent. Two ionosonde stations Rome and Millstone Hill located in European and American longitudinal sector has been analyzed for a major Arctic SSW in January 2009 and for two moderate geomagnetic storms occurred in February 2022 that caused the loss of 38 of 49 Starlink satellites due to enhanced neutral density. An original method, THERION (THERmospheric parameters from IONosonde and satellite observations), was used to retrieve aeronomic parameters from observed electron concentration in the ionospheric F region and Swarm satellite.neutral density observations for the periods in question. The main effect of SSW 2009 event is a decrease of the atomic oxygen [O] abundance in the thermosphere which is confirmed by satellite neutral gas density observations. Along with this no thermosphere cooling and correspondingly [N₂] effects were revealed [1]. Atomic oxygen rather than neutral temperature mainly controled the decrease of thermospheric neutral gas density in the course of the SSW event. Day-to-day variations of thermospheric circulation and an intensification of eddy diffusion during SSW are suggested to be the processes changing the atomic oxygen abundance in the upper atmosphere during SSW. Recent Global-Scale Observations of the Limb and Disk (GOLD) observations of O/N₂ column density confirm the depletion of the atomic oxygen abundance not related to geomagnetic activity during SSWs.

The main effect of the two geomagnetic storms occurred on 3 and 4 February 2022 was in neutral composition and temperature changes. In particular an increase of [N₂] and Tex, are shown to be the main reason for the observed increase of neutral density at the analyzed locations. The effect of the two geomagnetic storms have a moderate impact on the Ionosphere-thermosphere system but it was sufficient to determine the loss of satellites highlighting the importance of the Thermosphere monitoring.

1. Mikhailov, A. V., & Perrone, L. (2023). Whether sudden stratospheric warming effects are seen in the midlatitude thermosphere of the opposite hemisphere? *Journal of Geophysical Research: Space Physics*, 128, e2023JA031285. <https://doi.org/10.1029/2023JA031285>. S. Cannon, "Extreme Space Weather – A Report Published by the UK Royal Academy of Engineering," *Space Weather*, **11**, 4, April 2013, pp. 138-139, doi:10.1002/swe.20032.