VARIABILITY OF TEMPERATURE AND OZONE IN THE TROPOPAUSE AND LOW-MIDDLE STRATOSPHERE DURING INTENSE GEOMAGNETIC STORMS IN THE ANTARCTIC PENINSULA

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RESUMEN

Las tormentas geomagnéticas (TGs) que se originan en eventos solares e interplanetarios generan perturbaciones en diversas regiones del entorno espacial terrestre. En algunas regiones estos efectos pueden ser severos y dominar las condiciones físicas del sistema. Sin embargo, los efectos eventuales en la tropopausa y la estratosfera baja y media son menos conocidos y son objeto de debate. Por otro lado, dada la configuración del campo geomagnético, las regiones polares del entorno espacial de la Tierra generalmente sufren los mayores efectos de estos fenómenos.

En este trabajo, presentamos una caracterización de las condiciones atmosféricas sobre la estación Marambio de Argentina, a través del uso de datos de ozono-sondeos (Servicio Meteorológico Nacional de Argentina e Instituto Meteorológico Finlandés). En particular, analizamos la variabilidad de la temperatura y el ozono, en la troposfera superior, y la baja-media estratosfera, durante tormentas geomagnéticas intensas y de larga duración.

Además de cuantificar el impacto sobre la atmósfera, los resultados de este estudio serán útiles para caracterizar perfiles atmosféricos durante eventos de Meteorología del Espacio, que permitirán realizar correcciones atmosféricas, para simular la cascada extendida de Rayos Cósmicos (RCs) y compararlas con observaciones a nivel del suelo, mediante un detector de partículas en la Antártida.

ABSTRACT

Geomagnetic storms (GSs) originated in solar and interplanetary events generate disturbances in various regions of the terrestrial space environment. In some regions these effects can be very severe and dominate the physical conditions of the system. However, eventual effects on the tropopause and the low and middle stratosphere are less known and are a subject in debate. On the other hand, given the configuration of the geomagnetic field, the polar regions of the Earth's space environment generally suffer the greatest effects of these phenomena.

In this work, we present a characterization of the atmospheric conditions at the Argentinean Marambio station, through the use of ozone sounding data (National Meteorological Service of Argentina and Finnish Meteorological Institute). In particular, we analyse the variability of temperature and ozone, at levels of the upper troposphere, and the low-mid stratosphere, during intense and long-duration geomagnetic storms.

The results of this study will be useful to better understand the possible impact of Space Weather events on the Antarctic atmosphere, and to make atmospheric corrections to improve numerical simulations of the extended shower, to determine the Cosmics Rays (RCs) fluxes at ground level, to compare them with observations from a particle detector in Antarctic.

Keywords: Space Weather, Geomagnetic Storm, Antarctica.

1) INTRODUCTION

There is a number of studies showing that ozone content variations are related to the effect of Solar Energetic Particles (SEPs) precipitating into the atmosphere of the polar or auroral latitudes during GSs (e.g., Laštovička et al., 1992; Andersson et al., 2014; Verkhoglyadova et al., 2014). Moreover, the stratospheric temperature and ozone content are interdependent (Mohanakumar, 2008). On the other hand, the growing importance of extreme space weather events underscores the need to develop the modeling and prediction capabilities for these low-probability but high-impact events (Sharma et al., 2017): a well-resolved stratosphere in seasonal prediction models helps to improve weather prediction (Gerber et al., 2012).
In this work, we present an analysis of the temporal scale variability of atmospheric parameters, such as temperature, and Space Weather parameters, such as the Kp planetary index that quantifies the level of geomagnetic perturbation and is related with the flux of particles from solar flares and Coronal Mass Ejection (CME) that can affect the Earth's magnetic field, and ozone partial pressure, which is measured in the Marambio station by ozone-sounding, between the tropopause and the low and middle stratosphere. In particular, we study seven intense geomagnetic storm events and of long duration that happened in the beginnings of the Solar Minimum of Cycle 23-24 (2005-2006) and during the Solar Maximum of Cycle 24 (2012-2015).

2) METHODOLOGY AND RESULTS

In a first analysis, we consider the 50 most intense GSs for the period 1998-2016, which have a major impact on the geo-space. We calculate the temperature difference between the 7 days before the events (Pre) and the 7 days after (Post1) and the next 7 days (Post2), in each of the seasons, such as in the Autumn, as shown in Figure 1. We observed a cooling tendency after the GSs, except for Spring.

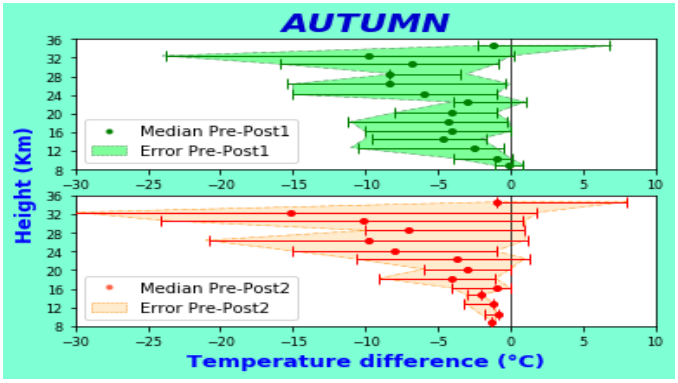

Figure 1: Temperature differences between days before the occurrence of intense GSs and the following days, considering 10 cases in Autumn.

Given the important role that the Polar Vortex plays in the destruction of ozone (its concentration varies fundamentally between the end of Winter and the beginning of Spring), we include in the analysis height profiles between 10 and 22 km of daily temporal variations of the partial pressure of ozone, during 7 GSs that occurred in the solar minimum of Cycle 23-24 and the solar maximum of Cycle 24, considering also a temporary window of one month around these events.
However, more work is needed to determine if the observed changes in temperature and ozone were an actual consequence of physical and chemical mechanisms during geomagnetic storms.

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