



# Occurrence of Ionospheric irregularities over Brazil and Africa during the 2019 Antarctic minor sudden stratospheric warming

Ebenezer Agyei-Yeboah<sup>a,\*</sup>, Paulo Roberto Fagundes<sup>a</sup>, Alexandre Tardelli<sup>a</sup>,  
Valdir Gil Pillat<sup>a</sup>, Francisco Vieira<sup>a,b</sup>, Mateus de Oliveira Arcanjo<sup>a</sup>

<sup>a</sup> *Laboratório de Física e Astronomia, Universidade do Vale do Paraíba (UNIVAP), Av Shishima Hifumi, 2911, Urbanova, 12244-000 Sao Jose dos Campos, SP, Brazil*

<sup>b</sup> *Observatório de Física Espacial, Instituto Federal de Tocantins-IFTO, Araguatins, Rua Castelo Branco, Povoado Santa Tereza-km 05, Brazil*

Received 31 January 2022; received in revised form 22 August 2022; accepted 24 August 2022

Available online 28 August 2022

## Abstract

The influence of sudden stratospheric warming (SSW) on the ionosphere and ionospheric irregularities has been studied extensively over the years. However, majority of these investigations have been conducted using warming events originating from the northern hemisphere. Only a few studies have been done on ionospheric variations due to the Antarctic SSW events and to the best of our knowledge, there have not been any studies on southern hemisphere SSW and the occurrence of ionospheric irregularities. In this study, the occurrence of ionospheric irregularities during the 2019 minor Southern hemisphere (SH)/Antarctic SSW is investigated. The event occurs in a relatively calm solar and geomagnetic activity period which makes it possible to identify the effects of SSW on the occurrence of irregularities. Three ionosondes located in different latitudinal regions in Brazil as well as a network of ground-based GPS receiver stations located in both Brazil and Africa were used for this undertaking. Complimentary data from the same ionosonde stations using the same months from 2017 and 2018 were also used. On average more Spread-F was observed in 2019 than in 2017 or 2018 at all stations. ROT observations showed more occurrence in the Brazil sectors followed by West Africa and then East Africa. It was observed that the occurrence frequency decreased between 8% and 46% from the pre-SSW phase to ascending/peak phases and from 2018 to 2019 for the peak phase.

© 2022 COSPAR. Published by Elsevier B.V. All rights reserved.

**Keywords:** Sudden stratospheric warming; Ionospheric irregularities; Antarctic; ROT; Spread-F

## 1. Introduction

Sudden stratospheric warming (SSW) is a large-scale meteorological phenomenon that occurs in the polar stratosphere during winter. The phenomenon is described as one of the most spectacular meteorological fluctuations in the polar stratosphere during the wintertime, acting as

one of the strongest manifestations of vertical coupling of the different regions of the atmosphere (Chau et al., 2012; Goncharenko et al., 2010b; Taroh Matsuno, 1971). The phenomenon is characterized by a sharp increase in stratospheric temperature at high latitudes occurring over several days. This temperature increase is caused by the interaction between upward propagating planetary waves (PWs) and the zonal wind. The eastward zonal wind sometimes decelerates (minor warming) and often completely reverses direction westward (major warming). The warming events are known to contribute to large-scale electrodynamic and morphological variations in the ionosphere and their

\* Corresponding author.

E-mail addresses: [ebenezer.agyeiyeboah@google.com](mailto:ebenezer.agyeiyeboah@google.com) (E. Agyei-Yeboah), [fagundes@univap.br](mailto:fagundes@univap.br) (P.R. Fagundes), [tardelli@univap.br](mailto:tardelli@univap.br) (A. Tardelli), [valdirgp@univap.br](mailto:valdirgp@univap.br) (V.G. Pillat).