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ABNORMAL CIRCULATION CHANGES IN THE WINTER STRATOSPHERE,  
DETECTED THROUGH VARIATIONS OF D REGION IONOSPHERIC ABSORPTION

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ABSTRACT

This paper intends to introduce a method to detect stratospheric warmings using ionospheric absorption records obtained by an Absorption Meter (Method A3). The activity of the stratospheric circulation and the D region ionospheric absorption as well as other atmospheric parameters during the winter anomaly experience an abnormal variation. We have found in our observations a simultaneity in the beginning of abnormal variation in the mentioned parameters, using the absorption records for detecting the initiation of the stratospheric warming. Results of this scientific experience of "forecasting" in the "El Arenosillo" Range, are presented in this communication.

INTRODUCTION

For the last ten years, "El Arenosillo" Range has been participating in international programmes dedicated to the study of winter stratospheric sudden warmings with the launching of meteorological rockets, and with the analysis and distribution of the wind and temperature data recorded, following the rules given by the international scientific community.

The exceptional advantage of a station for the study of the atmosphere with ground-based equipment combined with a rocket launching range, has allowed the simultaneous analysis of the behavior of different parameters of the middle atmosphere during the periods considered as winter anomalies. It confirms that, for the latitude of "El Arenosillo", the abnormal variations of the absorption parameter in the ionospheric D region appear simultaneously with circulation changes (i.e., rotation of direction) of the stratospheric wind that accompany the sudden warmings (MORENA, 1981) as well as a lack of variation of the parameter temperature in the mentioned period of winter anomaly.

Analysing Figure 1a, it can be observed that in the winter period 1975/76 the zonal circulation in the upper stratosphere which presents west component coincides with normal values of absorption for that winter period (from 20th Dec. to 5th Jan., 9th to 18th Jan., and 27th Jan. to 5th Feb.), and on the contrary, the abnormal changes of the zonal circulation to winds of East component correspond to variations of the absorption which are higher than their mean value. On the other hand, the period of winter 1976/77 which was characterized by the absence of circulation changes in the upper stratosphere, showed a normal behavior of the parameter absorption in the ionospheric D region.

Figure 1b is a clear example that the temperature in the stratosphere virtually shows the same variations during unstable periods (as in winter 1975/76) and in periods of circulation stability (as in winter 1976/77).

Based on this, the present experimental study, whose finality is to detect the appearance of winter stratospheric circulation changes in middle latitudes and to follow its development through the observation of the abnormal variations of the ionospheric absorption parameter in D-region, was started. The practical check-up of the mentioned prediction system has been carried out for the last two periods of winter anomaly (1981/82 and (1982/83), using fourteen meteorological rockets Super-Loki, the stratospheric balloons and continuous

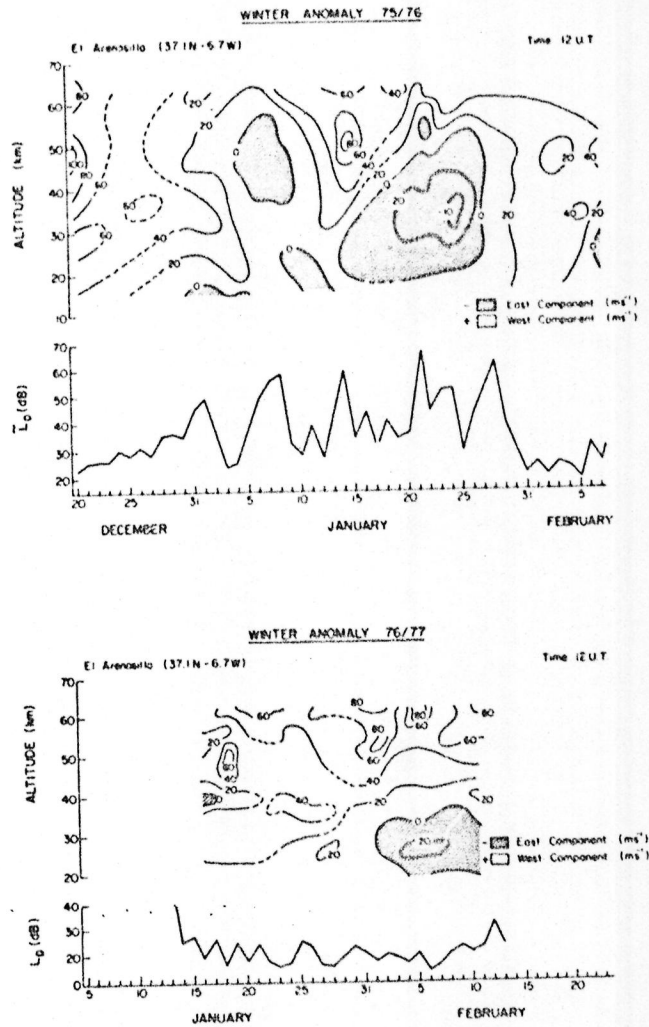


Figure 1a.

records of the A3-Absorption Meter, showing the results given in the following. This study is part of a wide investigation program being developed in "El Arenosillo" that pretends to develop a simple prediction system of the abnormal variations of the parameters characterizing the middle atmosphere through the use of ground-based equipment.

#### ANALYSIS OF THE DATA

The records of wind, temperature, and absorption obtained during the two winter anomaly periods 1981/82 and 1982/83, once again confirm the simultaneous

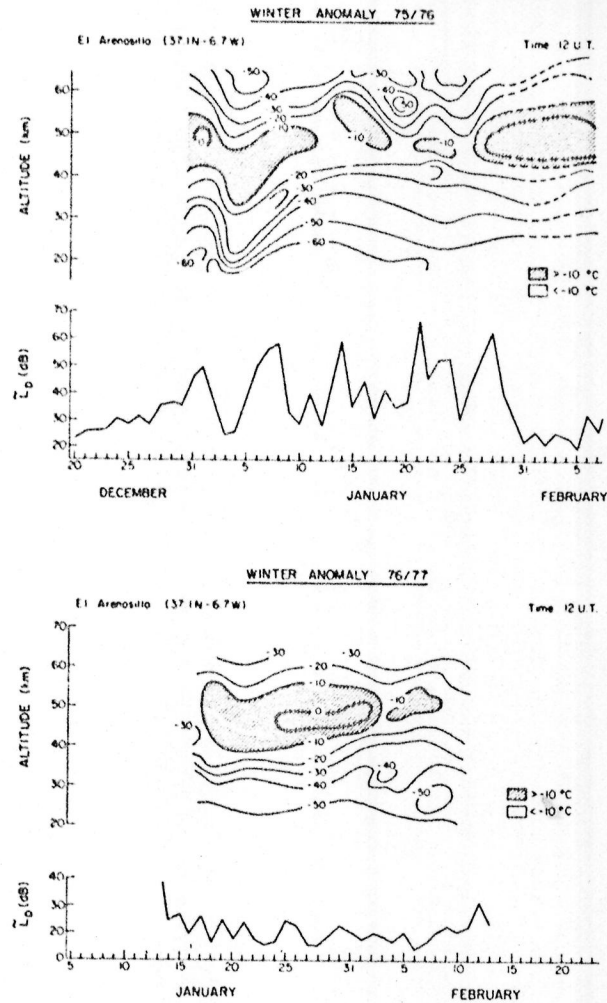


Figure 1b.

appearance of disturbances in the normal behaviour of these atmospheric parameters (Figures 2 and 3). Figure 2 presents a typical winter anomaly with two notable stratospheric changes represented in their meridional and zonal components, being evident in the irregular behavior of the ionospheric absorption in the D-region, with values which are higher than the mean value registered from 1976 to 1982. (We consider the mean value of absorption obtained during the solar cycle, represented by the continuous line, as more significant.)

The periods of maximum absorption coincide with a meridional circulation of North component in the whole stratosphere, while the normal values of absorption

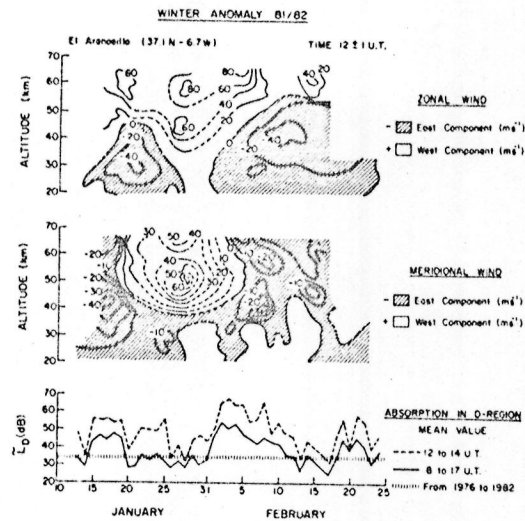


Figure 2

correspond with a wind circulation of East and West component in the upper stratosphere. In this diagram, it is easily seen that the meridional circulation precedes the change of zonal direction to winds of East component. The stratospheric temperature could not be measured during the winter period 1981/82 due to technical problems of the reception system.

Figure 3 analyzes the winter anomaly 1982/83. This was characterized by a period of circulation stability and of absorption, only altered by two weak beginnings of meridional circulation changes in the upper stratosphere, which coincided with sudden increases of ionospheric absorption that were easing off as the zonal circulation was being re-established. Similar as in the winter period of 1981/82, meridional winds of North component preceded the changes of zonal circulation in the upper stratosphere. As expected, the temperature did not experience any notable changes and its behavior was similar to that observed during the winter periods of 1975/76 and 1976/77.

Figure 4 gives a synoptic representation of the direction and intensity of the stratospheric wind during the analyzed periods of winter anomaly 1981/82 and 1982/83, offering a more intuitive image of the base used in this possible prediction system.

It can be observed that when the absorption is higher than the established mean value, a change of meridional direction in the wind circulation of the upper stratosphere begins simultaneously (15th to 19th January 1982, 1st to 7th February 1982, 28th of January to 1st February 1983 and 15th to 17th February 1983). On the contrary, periods of normal absorption indicate that the circulation has been established dominantly in East or West zonal components.

It is important to bring out the processes initiating the circulation change observed during the 28th and 30th of January and 1st of February 1983 by its possible application to the formation theory of the "warmings" through geopotential fluxes, as well as the sudden and big increase of the ionospheric absorption in these days, which reached the highest values recorded in El Arenosillo for the last ten years.

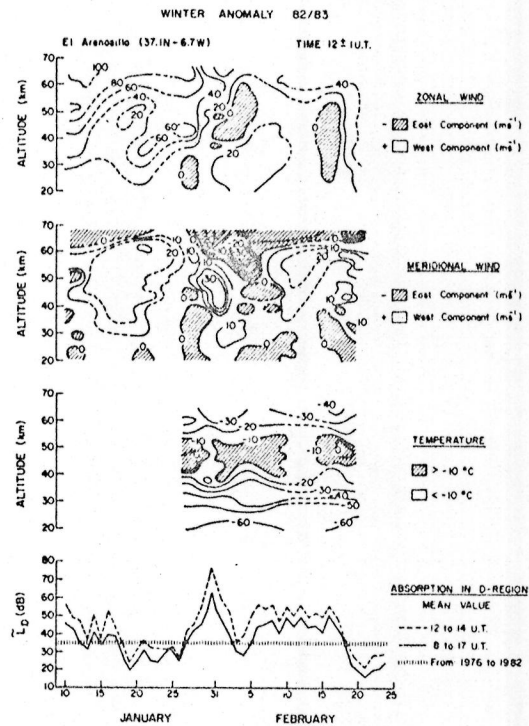


Figure 3.

CONCLUSIONS

- An evident correlation between the behaviour of the absorption parameter in the D-region, and the wind circulation in the upper stratosphere during the periods of winter anomaly is observed.
- Significant increases of absorption indicate the beginning of a circulation instability (turn-round of the wind direction) and the establishment of a meridional component of the wind in the upper stratosphere.
- Normal values of absorption indicate that the circulation is established dominantly in zonal components.
- The mean value of the absorption increases during those winter periods which are characterized by circulation instability.
- Winds of meridional component precede the abnormal change of the zonal circulation.
- Since the stratospheric temperature does not experience any notable variations during the periods of winter anomaly, the system of alert and prediction of sudden warmings (stratalert parts) has great limitations to be used in the middle latitude of El Arenosillo.

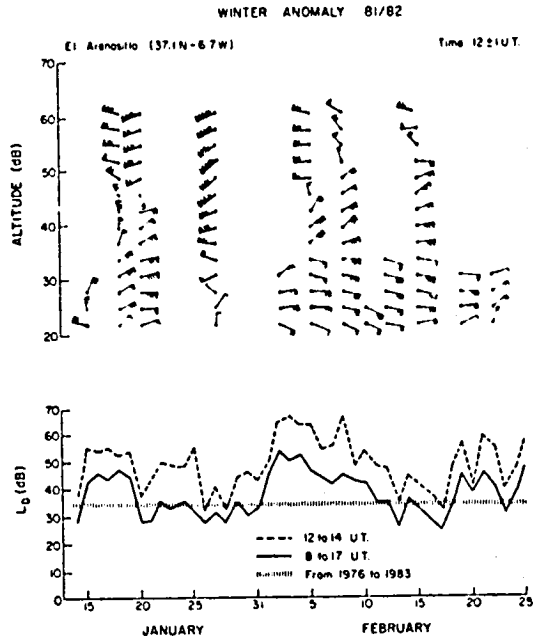


Figure 4a.

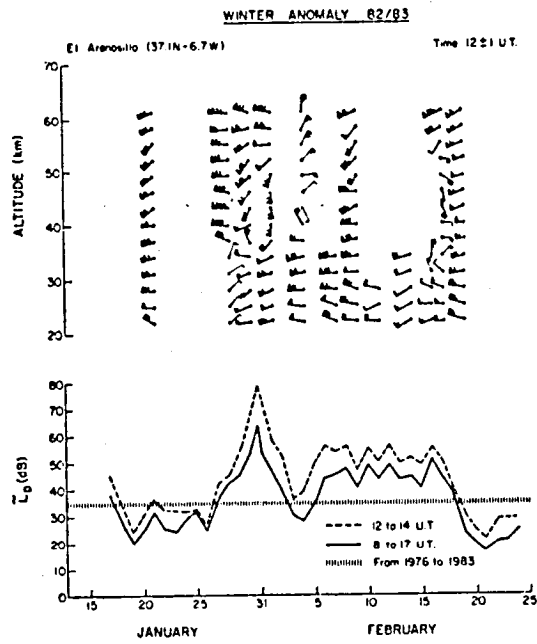


Figure 4b.

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