1.9 AN ANALYSIS OF SOLAR DRIVEN CIRCULATION CHANGES IN THE EARTH'S UPPER TROPOSPHERE AND LOWER STRATOSPHERE USING THE INTEGRATED GLOBAL REANALYSIS DATA

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ABSTRACT

The National Oceanic and Atmospheric Administration's (NOAA) Global Reanalysis Data (GRD) with integrated worldwide observations is basis of this analysis which searches for solar driven circulations. The search is predicated on a previously described solar mechanism (Powell, et al 2000). The mechanism presumes the solar UV flux, which varies with the 28-day solar rotation, generates changes in the growth and decay of synoptic scale pressure systems through the UV heating process. The 200 mb surface was chosen for this initial analysis since it is near the region of UV heating by ozone absorption. A discussion of the temperature and temperature gradient analyses as they relate to the proposed solar mechanism will be discussed.

1. INTRODUCTION

In previous articles (Powell, Zuzolo, and Zuzolo 2000, 2001, 2002) hypothesized that solar UV heating through ozone absorption causes the energy in synoptic scale systems to cascade into a different spectrum of synoptic atmospheric waves via a change in the static stability of the troposphere. This analysis will use the 200 mb temperatures and gradients from NOAA's Global Reanalysis Data to determine whether any correlation with the temperatures and gradients in the GRD may be associated with the proposed mechanism. This preliminary analysis will take a simplistic approach in searching for a relationship by trying to find temperatures and temperature gradients that correlate well with the solar UV flux. The solar 10.7 cm flux is used as proxy for the solar UV flux.

2. RELATED WORK

In Powell, Zuzolo and Zuzolo 2001, several depictions of the change in the 200 mb temperature field showed increasing and relaxing temperature gradients across the northern hemisphere in phase with the solar 10.7 cm flux. This cycle was repetitive for the months of Jan, Feb, and Mar of 1989, a solar maximum year. In the solar minimum year of 1986, this trend was not clearly observable in the data. The depictions in the 2001 paper of the 200 mb temperature field changes were based on data from NOAA's Global Reanalysis Data (GRD). It is the intent of this analysis to look closely at the 1989 GRD data in an attempt to quantify the gradient change shown visually in the previous work. Based on the previous analysis, Powell et al indicated that the mechanism is strongest in the winter months and weak in the summer months.

3. THE ANALYSIS

To test the findings, four latitude bands were used for the analysis: (1) zero to 90 degrees, (2) zero to 30 degrees, (3) 30 to 60 degrees, and (4) 60 to 90 degrees. The mean temperatures and mean gradients for these latitude bands were computed. The mean gradient values for the positive gradients only, the negative gradients only and the combined gradients were also computed to test whether a relationship may be seen in the either subset or the combined gradient data. Each day, the 00Z GRD field was used to compute a daily number for each of the calculated temperature and gradient categories. The daily values of these quantities was then reviewed to determine whether any association with the solar flux could be discerned.

3.1 Expectations and Issues

The purpose of this study is to determine whether a worldwide solar terrestrial relationship can be observed based on the changes predicted by the proposed mechanism.

The use of the Global Reanalysis Data may cause difficulties in finding the any relationships due to the data assimilation techniques used to create the data set. However, the presumption has been made that the basic characteristics of the data have been retained in the data set.

The temperatures and gradients for the 200 mb pressure level will be analyzed for four latitude bands. The latitude bands roughly correspond to the three vertical circulation zones set up by the Hadley circulation and the earth's rotation plus a fourth quantity, the global average. The atmospheric dynamics in each of these zones has distinctly different characteristics that may obscure any solar terrestrial connection beneath the typical 'system noise' of the appropriate zones. Also, the different dynamic characteristics may produce different trends in each region making it hard to discern the relationship without special analyses. This preliminary study does not attempt to filter other factors from the analysis and this may obscure any solar terrestrial effects even if present. However, it provides an opportunity to determine whether a solar effect is observable without elaborate data reduction procedures. Also, checking each latitudinal zone independently provides the opportunity to better understand and quantify whether any observed effects vary by latitude.

Several predominant features may overwhelm the results of this preliminary study. These are the seasonal

changes in the temperatures, gradients and synoptic pressure systems. No accounting for dynamic features of any kind has been accomplished for this analysis. These characteristics make the analysis susceptible to missing the solar terrestrial coupling.

3.2 Temperatures

The proposed solar mechanism's effects imply changes to the size and intensity of the synoptic systems. For every change in gradient and temperature on the leading edge of a synoptic system, the reverse will likely be true on the trailing side of the system and be of the opposite sign and magnitude. The nature of the mechanism suggests the temperatures around a latitude circle may average to approximately the same value before and after any solar effects. As a result, it may be difficult to detect any changes in the averaged temperatures by latitude band. No impact was expected in the averaged temperatures as a result.

3.3 Temperature Gradients

The temperature gradients of the synoptic systems should reflect the solar effects if they are present. However, the size of the solar effects may be limited by the averaging by latitude band as used in this study. Also, the natural variability of the growth and decay of synoptic systems may generate enough system noise to make any effect unobservable without detailed accounting of the other ongoing physical processes. To provide a plausible opportunity to observe solar related changes, the temperature gradients were averaged in aggregate, by positive gradients, and by negative gradients in both the north-south and east-west directions for the specified latitude bands.

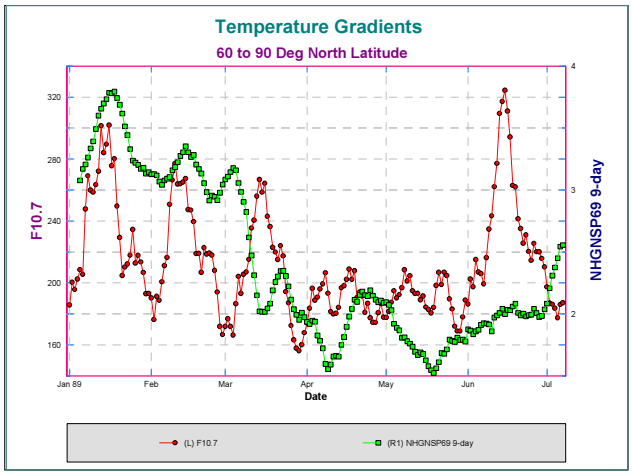
The north-south gradients were calculated by taking the poleward point and subtracting the more equatorial point from it. The east-west gradient took the eastern point and subtracted the western point from it. The resulting sign of the gradient was then used to classify the gradient as positive or negative for categorization.

3.4 Results

As expected, the mean temperatures showed reasonably large variations day-today and the data tended to be dominated by apparent seasonal or other trends. There was no apparent association between the temperatures and the solar flux in any of the four accumulated latitude bands, and none was expected.

For the temperature gradients, only the latitude band representing the 60 to 90 degrees north latitude band had any obvious possibility of being related to the solar flux. The solar flux appeared closely associated with the temperature gradients in the months of December, January, and February with a lag time of 3 to 5 days as suggested by the proposed mechanism. The remainder of the year showed little direct correlation. If a running mean of 14 days was applied to the solar flux, a much closer match between the peaks in the temperature gradients and the solar flux was achieved. However, some temperature gradients were still out of phase with the solar flux at various points throughout the year.

The following graph shows a portion of 1989 (January through July). The left vertical graph axis is the 10.7 cm solar flux and the right vertical graph axis is the positive north-south temperature gradient in degrees Kelvin. The red line is the solar flux and the green line with the box points is the calculated positive temperature gradient mean for the 60 to 90 degree latitude band.



3.5 Suggestions

Since some evidence appears to corroborate the suggested mechanism during the winter months, it is recommended that a more detailed analysis be accomplished that accounts for seasonal and known dynamic trends in order to make a definitive statement about the mechanism. It is possible the mechanism is valid and not clearly observable in this simple, preliminary analysis.

It is likely that a detailed analysis of the atmospheric waves and their corresponding energies will be required to determine whether the mechanism is valid. The variations in the temperatures and the temperature gradients are sufficiently large, prior to filtering using a running mean, to make it uncertain whether a solar effect can be observed. Also, this simple analysis did not account for other factors, such as seasonal trends, that may obscure or make the solar terrestrial analysis incomplete. The inclusion of such a normalization may have produced different results.

4. CONCLUSION

This analysis did not conclusively prove or disprove the proposed solar terrestrial mechanism.

a) ***Temperatures***: The mean temperatures had too much variability to isolate a solar component given the simple analysis performed and the dominate trends in the data tended to look like seasonal phenomena. In addition, no direct

impact was expected to be observed in the temperature data and none was seen.

b) ***Temperature gradients***: The temperature gradients in the 60 to 90 degree latitude band showed a possible agreement with the proposed mechanism in winter months but not the rest of the year. The other latitude bands showed no distinctive characteristics similar to those expected if the mechanism were valid.

To determine whether the solar terrestrial mechanism is valid, it appears that the data will need to be isolated from known features by filtering or otherwise normalizing the data. Any verification techniques applied to determine the validity of a proposed mechanism should clearly account for known factors and the method by which they were removed.

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