9.3 AN ANTARCTIC CLOUD MASS TRANSPORT CLIMATOLOGY OVERVIEW

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1. INTRODUCTION

Antarctica is the coldest and driest continent on the planet. It consists of over 90 percent of the planet's ice, making it one of the most uninhabitable places. Brutal storms and harsh winds are common for those who travel to the continent for research and exploration. For many years, researchers have been attempting to understand the weather and climate of this harsh continent. Since the climate is so brutal, the collection of weather observations has occurred at only sparsely scattered locations, mostly on the coast of the continent. Satellites have added a whole new set of observations that fill in the gaps between the surface stations. Satellites have proven extremely useful in understanding the causes and effects of the Antarctic climate (Key et al., 2001; Wang and Key 2002; Lazzara et al., 2003a).

Using images made from satellite instruments, Antarctic Composite Satellite Images have been created from October 31, 1992 to August 18, 2001 (Lazzara et al., 2003b). Twenty different geostationary and polar orbiting satellites were used in constructing a full image of Antarctica and the surrounding area. In viewing these composite images evidence of Cloud Mass Transport has been found. This paper covers the methods used to view, obtain, and analyze the satellite data for those nine years, as well as a brief discussion on the initial results of the analysis.

2. ADDITIONAL ASPECTS

Cloud Mass Transport is defined as an event in which a cloud mass travels from an oceanic region perpendicularly onto the continent, particularly in the areas of Marie Byrd Land and Ellsworth in Western Antarctica, along with Enderby Land and Queen Mary Coast (Stearns, Lazzara, per comm., 2001). – See Figure 1. A connection has been made between Cloud Mass Transport and several other well-known events, such as El Niño – Southern Oscillation (ENSO). El Niño is an extensive warming of the equatorial Pacific Ocean between South America and the International Date Line. Atmospheric scientists have discovered that El Niño is associated with a seesaw of atmospheric pressure between the eastern equatorial Pacific and Indo-Australian area. This seesaw in pressure is referred to as the Southern Oscillation (Walker and Bliss, 1932, 1937). Scientists have been studying this oscillation since the 1890s.

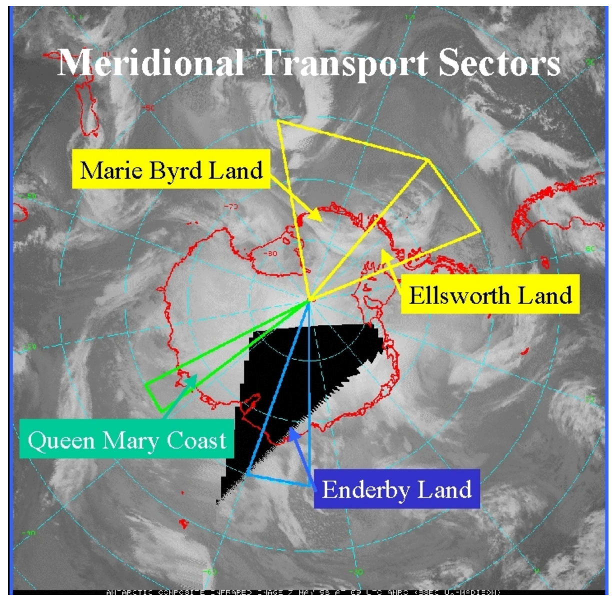

Figure 1. Satellite composite of the meridional transport sectors studied.

3. PREQUISITES FOR COLLECTION

A Cloud Mass transport event was defined as cloud transport onto the continent of Antarctica in a pre-defined region for a period of at least two days. Events less than two days, or a period of 48 consecutive hours were not considered and not counted as relevant to this research. Transport events that carried over to a new month or year were considered one event, and the number of days per each month was recorded in the respective months, allowing some months to obtain a 1 for the final number of occurrences per a month. Since data from October 31, 1992 did not consist of an entire day, it was not considered for this research. The time

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period covered in this initial study was between November 1, 1992 and August 17, 2003.

4. COLLECTION METHOD

The Cloud Mass Transport was obtained by first viewing the Antarctic Composite video at several different animation speeds. This allowed attention to be focused on any specific areas or sectors for collection and analysis. The viewing of the tape brought primary attention to the four sectors currently focused on in this research. Next, the tape was reviewed several more times, focusing on a different sector of Antarctica each time to identify any cloud transport present in the specific sector or area. Once a transport event was identified, the section of the tape was reviewed several times to obtain the correct length of time of the event- See Figure 2. The data was tallied according to each month within the four different sectors. A record of the specific days per month was also recorded.

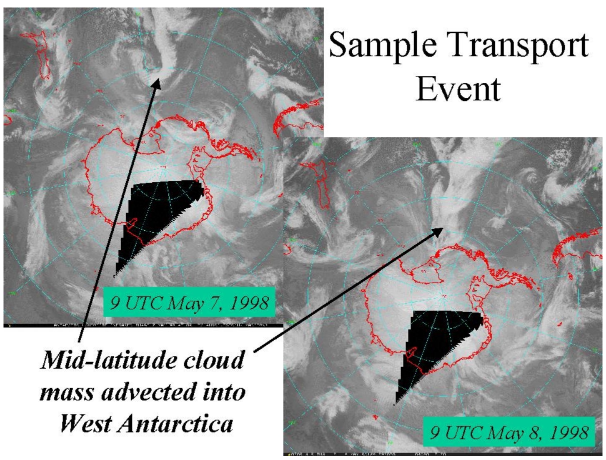

Figure 2. A satellite composite of a cloud mass transport event.

5. DATA ANALYSIS

Once this data was recorded, the results were tabulated and used to calculate a correlation coefficient dependent on the type of lag to be depicted. The equation used is as follows:

Correlation Coefficient Equation:

$$\frac{\sum((X_n - X_0)(Y_0 - Y_n))}{\sqrt{(\sum(X_n - X_0)^2 \sum(Y_0 - Y_n)^2)}}$$

where X_n is a specific data value from data set #1, X_0 is the average of data set #1, Y_n is a specific data value from data set #2, and Y_0 is the average of data set #2.

Two different lags were calculated with a lag span of one to thirteen months. From these lags, two main plots resulted from the data. The first graph examined the 'Number of Occurrences' per month for all years versus the cumulative Southern Oscillation Index (SOI) to determine if any visible connection could be found between the two. The connection was dependent on the lag month of the current 'Number of Occurrences' plot. The second graph looked at the data after the annual cycle was removed.

6. INITIAL RESULTS

Results of this previous research indicate a relationship between the Cloud Mass Transport (or CMT) and ENSO. It was found that there is a change in pattern in the relationship between CMT and ENSO. When CMT is high, ENSO is also high, but only until a certain peak. After reaching this peak, the relationship will shift and transform into a negative correlation in which it varies between a low ENSO and low amount of CMT. Figure 3 shows an example of a plot between Cloud Mass Transport and the SOI for the 5 month lag at Ellsworth Land.

The initial review of this correlation shows there is some representation of a connection between Cloud Mass Transport and the SOI in Ellsworth Land. A brief overlook of the plot shows there are times where the Cloud Mass Transport and the SOI are directly related, such as months 8 through 11. Similarily, there are also times when they are indirectly related, such as months 47 through 53.

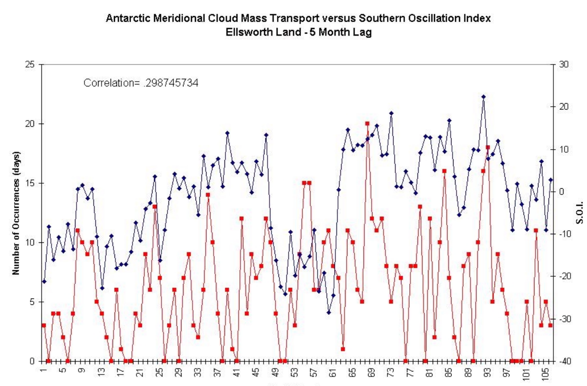

Figure 3. The 5 month lag plot at Ellsworth Land.

7. FUTURE WORK

The proposed research consists of three related elements. The first aim will be the addition of the latest Antarctic composites to the database. The new images would be analyzed and the database would be updated. The addition of this new data would significantly enhance the climatology focus of the research by allowing a ten year trend to be considered. Additionally, 2003 is a year in which a moderate El Niño year is occurring, which would sufficiently add to the dataset.

The second aim is to find other possible trends. The relationship between the semi-annual oscillation, the Southern Hemisphere annular mode, or the Antarctic Oscillation, and the monthly climatological occurrence have been considered for further research. This new research would consist of looking for further evidence of patterns between cloud mass transport and other atmospheric phenomena important for improving seasonal forecasts. The final aim is specific case driven research. There are many transport events that carry over a period between ten and twelve consecutive days. A further investigation of those days might lead to an explanation of the cause of other weather-related events over Antarctica. Forecasting is extremely difficult in Antarctica. This research hopes to produce the ability to a more accurate seasonal forecast, allowing easier access to the continent and safer travel.

Antarctic Cloud Mass Transport examines an important aspect of the Antarctic climate – the interaction between weather events and seasonal/annual signals. Evidence of a correlation will lead to an improved understanding of Antarctic weather that can help improve weather forecasting.

8. REFERENCES

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