Meteorology 454 Rossby Wave Theory Project

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ABSTRACT

This study looked at the Northern and Southern hemisphere waves in the 500 hPa flow, it also looked at the zonal winds at 500 hPa and at the upper levels. The temporal domain for this study was from 24 September 2006 to 8 November 2006. The data collected over this period included wave number, wave speed, amplitude, zonal winds at 500 hPa and the zonal winds at upper levels. In most instances Rossby wave theory held true showing that waves moved slower than the zonal winds. In cases where the theory didn’t hold it is speculated that the cause was a barotropic atmosphere and not baroclinic.

Introduction

This project will analyze the wave motions at the 500 hPa level and the zonal winds at the 500 hPa level and Upper level winds. Our study will look to show real life examples of Rossby waves and Rossby wave theory. Rossby waves are planetary waves which usually follow a trough-ridge pattern. In this project both the Northern and Southern hemisphere waves and zonal winds are analyzed from 24 September 2006 to 8 November 2006.
1.) In general waves tend to move at about $12.8^\circ$/day in the Southern Hemisphere and at about $9.1^\circ$/day in the Northern Hemisphere. This is only an average so waves can move slightly faster or slower in both hemispheres.

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b.) In the Northern hemisphere the waves tend to last for around 4 days. In the Southern hemisphere waves appeared to last for about 5 days. These are typical lengths of time for synoptic scale motions.
b.) In the Northern hemisphere the larger the amplitude the smaller the wave number. However, in the Southern hemisphere with larger amplitudes there is a trend toward larger wave numbers. In the Northern hemisphere this agrees with what is expected due to wave amplitude and wave number having an inverse relationship in Rossby wave theory. However, in the Southern hemisphere this relationship does not hold, in part this could be because of the lower percentage of land surface than ocean surface.
3.) The length of time to reach the maximum amplitude was about 3 days in the Northern hemisphere and 4 days in the Southern hemisphere. In the Northern hemisphere periods of growth seem to be fairly consistent with growth followed by decay and then followed by growth again. In the Southern Hemisphere there appears to be more of a general growth trend and not many periods of decay. In general for the Northern hemisphere the growth generally occurs by an increase of around 21% on average at the beginning of the period and increase toward the end of the period. In the Southern hemisphere near the beginning of the period the growth is on the order of 70% and tends to die down at the end of the period.
4.) Throughout the period in both hemispheres the wind speeds tend to go through periods of increasing and decreasing patterns. However, over the entire period the speeds remain relatively consistent. The oscillation time was about 5 days from minimum to minimum speed.

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a.) Waves in the Northern hemisphere move at 9.1º/day in the counterclockwise direction, but in the Southern hemisphere waves move at 12.8º /day in the clockwise direction. On average it would take 39.56 days to travel around the 50ºN latitude line in the Northern Hemisphere and 28.13 days to travel around the 50ºS latitude line in the Southern hemisphere.
b.) 500 hPa level:
With small increases in the wind at 500 hPa you would expect a large increase in the wave speed. This pattern is seen in both the Northern and Southern hemispheres. The winds at 500 hPa are 3.51 times greater than the wave speed, showing that Rossby wave theory holds true. In this case the winds would have to be greater than the wave speed, otherwise a westward propagation of waves in the Northern hemisphere would result. This also holds true for the Southern hemisphere winds in the 500 hPa level, which are 4.38 times greater than the wave speed.
c.) 300-150 hPa level:
A similar pattern in the upper winds is seen and is even more pronounced. This level also holds for Rossby wave theory. In this level the winds are 5.6 times greater than the wave speed in the Northern hemisphere and 6.94 times greater than the wave speed in the Southern hemisphere. These values indicate westward propagation of waves in the Northern hemisphere as expected.
d.) In the Northern hemisphere the trend indicates that as wave number increases the wave speed becomes increasingly negative. The opposite seems to be true for the Southern hemisphere, with the wave speed becoming less negative as the wave number increases. In Rossby wave theory there should be an increasingly negative wave speed with increasing wave number. Our Northern hemisphere tends to agree with Rossby wave theory, however our Southern hemisphere does not agree. This disagreement could result from assumptions in the Rossby wave theory.
6.) As the wind speed decreases the amplitude shows a general trend of increasing. This trend is shown in both hemispheres over the time period. YAY!

Conclusion

In this project, Rossby wave theory holds relatively true. It tells us how the wave speed is related to both the zonal winds and amplitude of the wave. In general Rossby waves are long waves and their travel is dependent on both amplitude and zonal wind flow. Any discretions to Rossby wave theory could have occurred due to data collection errors as well as modeling errors.