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14. Abstract/Notes

The important precursors of three Brazilian freezes that affected world coffee markets were found to be: (a) A slowly moving long wave pattern in the central south Pacific Ocean amplified abnormally four to five days before the freezes; (b) the long wave ridge was located in the southern Andes, while the troughs were located near 120ºW and 50ºW in the Pacific and Atlantic Oceans respectively. Two factors contributed to unusual amplification of cold troughs in Brazil: the oportune superposition of short and long wave troughs, and propagation of wave energy from the mid-Pacific at group velocity.

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SYNOPTIC PRECURSORS OF THREE SEVERE BRAZILIAN FREEZES IN THE PACIFIC OCEAN AND SOUTH AMERICA

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1. INTRODUCTION

Freezing temperatures occasionally destroy a large part of the harvest of coffee, sugar, wheat, and forage in southern Brazil. It is clearly of economic interest to search for any signs that might provide an early warning of a killing frost. Owing to the effect that a Brazilian freeze has on world coffee prices, a number of studies have focused on the synoptic conditions prior to and during freeze events. The analyses in such studies have been limited to the continent of South America, and even over land have been limited by scanty observations west of 60°W and north of 20°S, and everywhere above 400 mb. In this paper we present more extensive analyses of the synoptic conditions prior to and during the three most recent Brazilian freezes that had repercussions on world markets. Data from multiple sources including satellites and drifting buoys were combined with NMC analyses in a search for early warning signs of the freezes in 1975, 1979 and 1981. The 1979 case received special attention because it occurred during the second special observing period of the Global Weather Experiment (FGGE), when data from the Southern Hemisphere were unusually abundant.

2. SYNOPTIC CHARACTERISTICS

The synoptic history of the 1979 freeze may exemplify the processes preceding cold air outbreaks in the subtropics. Frontogenesis was seen on satellite imagery to be occuring in the central south Pacific between 20°S and 30°S latitude. The frontal cloud band then lengthened until it spanned the latitude range from 15°S to 65°S, while a high pressure ridge built off the coast of Chile. Next, a cold front formed in northern Argentina and advanced rapidly into Brazil, ahead of a short wave trough that had just entered from the Pacific. To the south, the surface anticyclone crossed the Andes, then immediately moved northward. For three days the upper level flow steered lower level polar air along the eastern flank of the Andes into low latitudes, even as far as the equator. Just after the Atlantic trough reached maximum development and was leaving Brazil, the skies cleared in the coffee-growing areas and a hard freeze was felt as far north as 20°S, east of the polar anticyclone.

A similar long wave amplification with the correct phase relationship occurred in the Pacific some 4-5 days before the Brazilian freeze of 1975. This event has been considered the most severe freeze of the century.

In 1981, the amplification of the troughs and ridges occurred somewhat farther west. Freezing temperatures were observed only in western subtropical areas of the continent, until the Atlantic trough amplified to the point that part of it was left behind as a cutoff cyclone. Propagating slowly equatorward, this cold-core system caused a severe freeze 2 days later in a swath of land recently opened to coffee cultivation, lying north of the Tropic of Capricorn in eastern Brazil.

Thus, observations of long wave and frontal development in the central South Pacific Ocean may furnish early warning of destructive frosts in Brazil. In 1975 and 1979, an amplification of a trough and ridge pattern between 150°W and 90°W, and a development of a frontal cloud band that extended unusually far from low to high latitudes, preceded a similar but more pronounced frontal development in South America by two days, and preceded a freeze in Brazil by five days. In 1981, amplification of a trough at 120°W, a ridge at 80°W, and an existing front between the two, preceded the formation of a cutoff cyclone in South America by three days, and preceded two nights of freezing temperatures in Brazil by 4-5 days. Equally important, the phase relationship of the long waves with respect to the geography of South America was favorable for the entry of cold air into southern Argentina, from where it was advected over land into subtropical latitudes. The presence of a ridge in southern Chile and a trough at the longitude of southern Brazil, at the time when both were highly amplified, favored this northward channeling of cold air.

3. DISCUSSION

In all years, the opportune arrival of a short wave trough, when the long wave trough in Brazil neared its peak development, was an important factor in introducing abnormally cold air into the subtropics. The amplification of the mid-latitude circulation first over the Pacific Ocean and then over South America suggests that eastward propagation of wave energy was another important factor. In a case study of a record breaking cold wave in the USA, Parry and Roe (1952) traced the propagation of wave energy as far back as Siberia. We employed the trough-ridge diagram introduced by Hovmoller (1949) to trace wave phase and energy propagation in two cases of Southern Hemisphere freezes. A plot of the v-component wind at 37°S in the

week before the 1975 freeze shows sucessive intensifications of long wave troughs and ridges in the Pacific prior to the intensification of features over South America. The phenomenon was noticeable as for west as 140°W some 48 hours before the time of the freeze in Brazil. A plot of 1000-500 mb thickness for the week of the 1979 freeze (Fig. 1) has the greatest thickness anomalies in two long wave troughs and ridges falling on a straight line. This suggests that energy was propagated along this line at a group velocity of 35 to 40 degrees per day, through more than 140 degrees of longitude. This exceeded both the observed velocity of the phases of the long waves and also the velocities of all identifiable short waves. Thus, propagation of wave energy appears to contribute to abnormally intense cold troughs in Brazil.

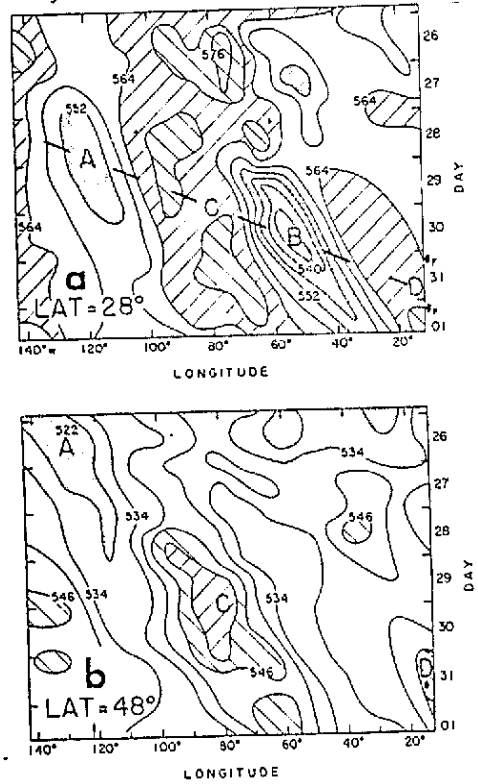

Fig. 1. *Hovmoller diagrams of 1000-500 mb thickness values as a function of longitude (right to left) and day (from top to bottom), at two selected latitudes: (a) 28°S and (b) 48°S. Plotted values are in decameters. Shaded areas represent negative anomalies; diagonally hatched areas, positive anomalies. The heavy dashed line represents energy propagation from one phase to another. The hours when frost occurred in Brazil are indicated by "F" at the lower right in (a).*

4. CONCLUSION

Although the synoptic evolution of the frontogenesis and the cold air advance differed in each of the three years studied, the developments in the Pacific Ocean appear remarkably similiar. Timely observation of a rapid intensification of long waves in the south Pacific Ocean might give 3 to 5 days advance warning of abnormal cold in Brazil, if and when the phase relationship of the waves with the continent is correct.

5. REFERENCES

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