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NOAA's Climate Analysis Center (CAC) is one of the major elements of the National Climate Program. CAC was established in 1979 with resources (personnel and funds) from three major components of NOAA, the National Weather Service, the Environmental Data and Information Service, and the National Earth Satellite Service. Congress provided additional funding for CAC in FY 1978-80. CAC is an organization that combines research and development with the provision of products and services on an operational basis. CAC has roles in three of the six principal thrusts of the National Climate Program. It has a lead role in Climate Prediction. It is also involved in Generation and Dissemination of Climate Information, and Solar and Earth Radiation Budget.

CAC concentrates its attention on short-term climate variations from a few weeks to a few years. One of its principal concerns is to provide real-time information on the weather and climate in any part of the world to users concerned with climatic impacts in such climate-sensitive fields as agriculture, energy, and water resources. The organization of CAC is shown in Fig. 1. The Analysis and Information Branch is largely involved in providing real-time information to the user community. Its Agricultural Weather Section provides much of the direct contact with the USDA as part of the NOAA/USDA Joint Agricultural Weather Facility (JAWF). JAWF produces the venerable Weekly Weather and Crop Bulletin and provides expert advice to the World Agricultural Outlook Board and other USDA groups.

My presentation today is concerned with the work in climate diagnosis and prediction carried out mainly by the other two branches of CAC. This work is outlined in Fig. 2 where the functions of CAC are listed. Note that most of these functions involve diagnosis and/or prediction.

Diagnostics Branch Activities

- Current awareness

A watch is maintained on the major elements involved in short-term climate variations. These are:

- o Atmospheric wind, pressure, temperature, and moisture from near the surface into the stratosphere.
- o Sea surface temperature.
- o Snow and ice cover.
- o Precipitation and the accompanying heating of the atmosphere through condensation.

- o Components of the earth radiation budget (heating absorbed from the sun and cooling emitted from the earth-atmosphere system).

- o Cloudiness

- o Transports of heat, moisture, and momentum within the atmosphere and ocean.

Several of these elements cannot be observed in many parts of the globe, or at best can be estimated only crudely. Weather satellite data are helping to provide vital information on many of them. Although desired accuracies and space and time coverage may still be insufficient in many cases, it is now possible at least to construct indices that represent the principal trends and variations.

Some examples of such indices for snow cover and sea surface temperature anomaly are shown in Figs. 3 and 4, respectively.

- <u>Analysis of recent climate fluctuations</u>

Recent major climatic events are diagnosed carefully to determine the dimensions and probable causes of the events and their influences on ensuing changes in climate. Examples of recent events of major importance in the United States and vicinity are the heat wave and drought of the summer of 1980 and the very dry winter of 1980-81 (note the minimum amount of snow cover in North America in 1981 in Fig. 3). The heat wave of summer 1980 was associated with a very large scale, quasi-stationary flow pattern from the mid-Pacific eastward to Europe that resembled the circulation patterns during simliar major heat waves in the 1950's. Another interesting preliminary finding of this investigation is that summer temperatures in the United States show some relationship to the strength of the subtropical high pressure belts around the globe in several preceding seasons (Fig. 5).

- <u>Investigation of broad scale interactions of the global climate system</u>

Variations in the climate in one part of the world are generally interrelated with events over distant portions of the globe and sometimes over periods of a year or more. Many of these interrelations are being discovered and documented in current studies, particularly as extensive collections of data can be examined more systematically and rapidly with advanced electronic computers, innovative analysis methods, and improved theory.

One such major climate interaction system involves the equatorial Pacific where very substantial variations in sea surface temperatures, winds near the surface and aloft, and cloudiness and precipitation occur at irregular intervals of 3 to 10 years. These fluctuations, which last a year or more, can have profound effects on extratropical circulations at great distances, particularly in the cold season of the year. This phenomenon, the "Southern Oscillation", is also associated with the occurrence of warm water along the coasts of Ecuador and Peru (the so-called "El Niño).

The contrast in tropical sea surface temperature anomaly patterns over the Pacific during the onset of such a Southern Oscillation-El Niño event is illustrated in Figs. 6 and 7. The shift from below to above normal sea surface temperatures over vast regions of the tropical Pacific between July 1971 and July 1972 is especially striking. These changes were accompanied by major changes in winds, pressures, temperatures, and precipitation in many parts of the world in 1971-72. The differences in Northern Hemisphere mid-tropospheric circulation patterns associated with opposing stages of the Southern Oscillation are illustrated in Fig. 8. The chart on the left is a composite of the winter 700 mb height anomalies (equivalent to pressure anomalies near 10,000 ft) in years when the Southern Oscillation index is high (sea surface temperature below normal in the equatorial Pacific); the chart on the right is the composite for the reverse situation. Over much of the Pacific, North America, and the Atlantic, the anomaly patterns are also practically reversed. The pattern on the right shows extensive negative (cyclonic) anomalies in the Pacific and eastern United States and a positive (anticyclonic) anomaly over western North America. This pattern is associated with generally cold weather in the eastern half of the United States and warm weather in the western half. The pattern on the left is generally associated with warm weather in the East and cold weather in the West. Thus, the events over the tropical Pacific appear to be strongly connected to the climate anomalies over the United States and many other middle and high latitude regions of the Northern Hemisphere. It must be emphasized, however, that these particular interrelations explain only a relatively small proportion of the entire climate variations over the United States and the rest of the Northern Hemisphere.

Prediction Branch Activities

- Current prediction program

The Prediction Branch prepares the official NWS monthly and seasonal predictions. Monthly forecasts are issued twice monthly a few days prior to the 30 day period to which they apply. Seasonal (3 month) forecasts are now issued once each month a few days prior to the beginning of the ensuing three months. The latest seasonal temperature forecast, issued last week, for November 1981-January 1982 is shown in Fig. 9. On a two class basis (below or above normal), these predictions have a 60% chance of being correct, based on past verification, as compared with 50% chance climatologically. (Forecasts for December-February have been 65% correct on the average.) Monthly predictions have a similar 60% skill for temperature and 55% for precipitation. Seasonal precipitation outlooks have a very low level of skill and are only issued in winter and summer, when their probabilities approach 55%.

- Goals for prediction research and development

Much of the diagnostic type of research referred to above, as well as research within and sponsored by the Prediction Branch, are directed toward finding improved statistical methods for preparing long range forecasts. It is also likely that diagnostic research will lead to the use of simplified physical models to aid in making the predictions in the next few years. Large-scale numerical general circulation models appear to be developing some skill in the medium range out to about two weeks. These advances should help in the improvement of the monthly forecasts in the next few years, but it is doubtful that such models can aid the seasonal forecasts in the next decade or longer.

The goals for climate prediction in the next 5 to 10 years are listed in Fig. 10. The near-term goal of an improved probability format of the monthly and seasonal forecasts is expected to be reached in about a year. The general plan is to draw additional contour lines on the forecast charts depicting a continuously varying estimate of the probabilities of warm or cold, wet or dry. Verification scores and the forecasters' judgment will be combined in the placing of these contours.

Some of the longer term improvements may be achieved in a few years. Top priority is being given to longer lead times for seasonal forecasts. We would like to be able to issue seasonal temperature forecasts as early as 3 to 9 months before the start of a season (e.g., a winter forecast issued at the beginning of September or as early as the beginning of March). We know that many of the users of climate predictions would find such longer lead time forecasts to be of considerable value.

Generally, of course, we wish to improve the accuracy of our current monthly and seasonal forecasts. We hope to do this through improved statistical methods derived from the new findings of diagnostic and prediction research and improved statistical techniques, the application of simplified climate models, and the improved skill in medium range forecasting being achieved by numerical general circulation models.

Expanded areal coverage of forecasts to include much of the globe should be of special interest to agriculture and water resource interests. Additional forecast elements such as cloudiness, solar radiation, and surface wind also need attention, but as yet we are not sure of the user demand for such predictions. As user demand is defined, it is likely that some effort will go into development of forecasts of these additional elements. We are optimistic that some useful skill could be achieved in predicting a few of them.

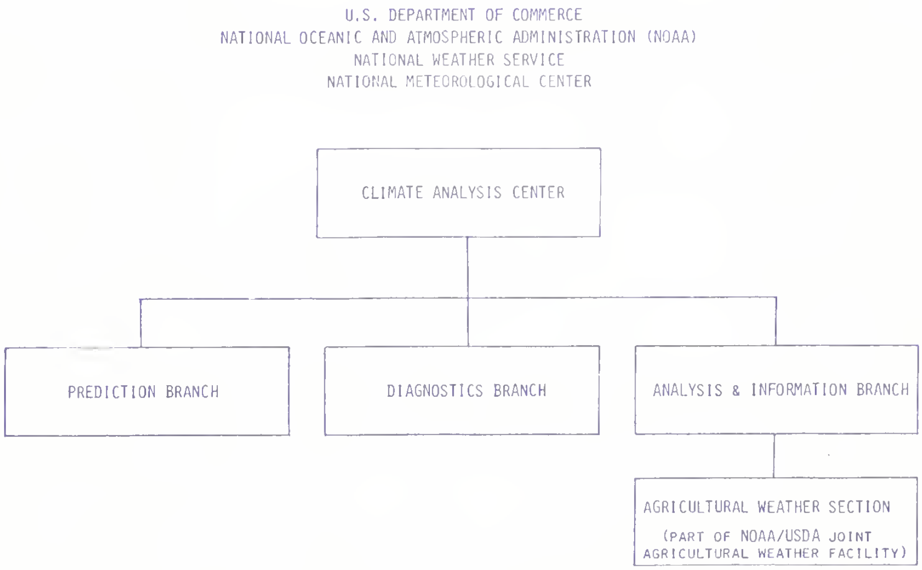


Figure 1

FUNCTIONS OF CLIMATE ANALYSIS CENTER

- O MAKES OFFICIAL U.S. PREDICTIONS FOR MONTHS AND SEASONS.
- O MAINTAINS CURRENT AWARENESS OF GLOBAL AND REGIONAL CLIMATE FLUCTUATIONS.
- O PROVIDES ANALYSES AND INFORMATION ON CURRENT AND PREDICTED WEATHER AND CLIMATE TO USER GROUPS (E.G. AGRICULTURE, ENERGY, WATER RESOURCES).
- O CONDUCTS AND SUPPORTS:
  - — NEW CLIMATE DIAGNOSTIC STUDIES.
  - — DEVELOPMENT OF IMPROVED STATISTICAL PREDICTION TECHNIQUES.
  - — COMPARATIVE TESTING OF PREDICTION TECHNIQUES.
- O MAINTAINS COGNIZANCE OF INTERNATIONAL AND NATIONAL PREDICTION RESEARCH AND DEVELOPMENT.
- O IDENTIFIES PROMISING NEW PREDICTION APPROACHES FOR TESTING AND POSSIBLE OPERATIONAL APPLICATION.
- O IDENTIFIES AND DEFINES USER NEEDS TO PROVIDE BETTER INFORMATION ON CURRENT AND PREDICTED CLIMATE FLUCTUATIONS.

Figure 2

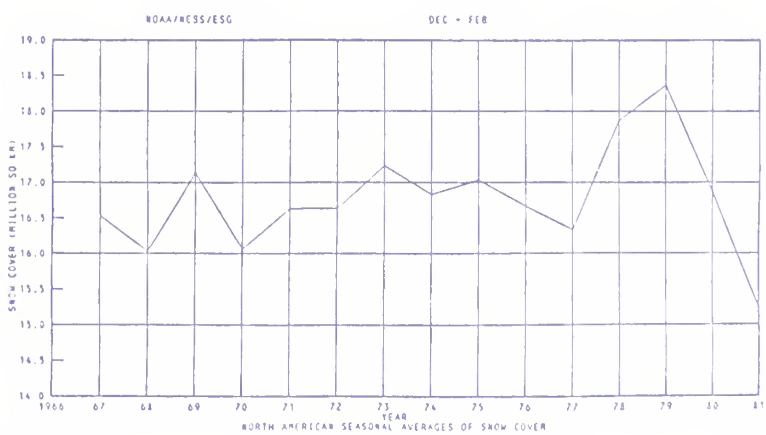


Figure 3

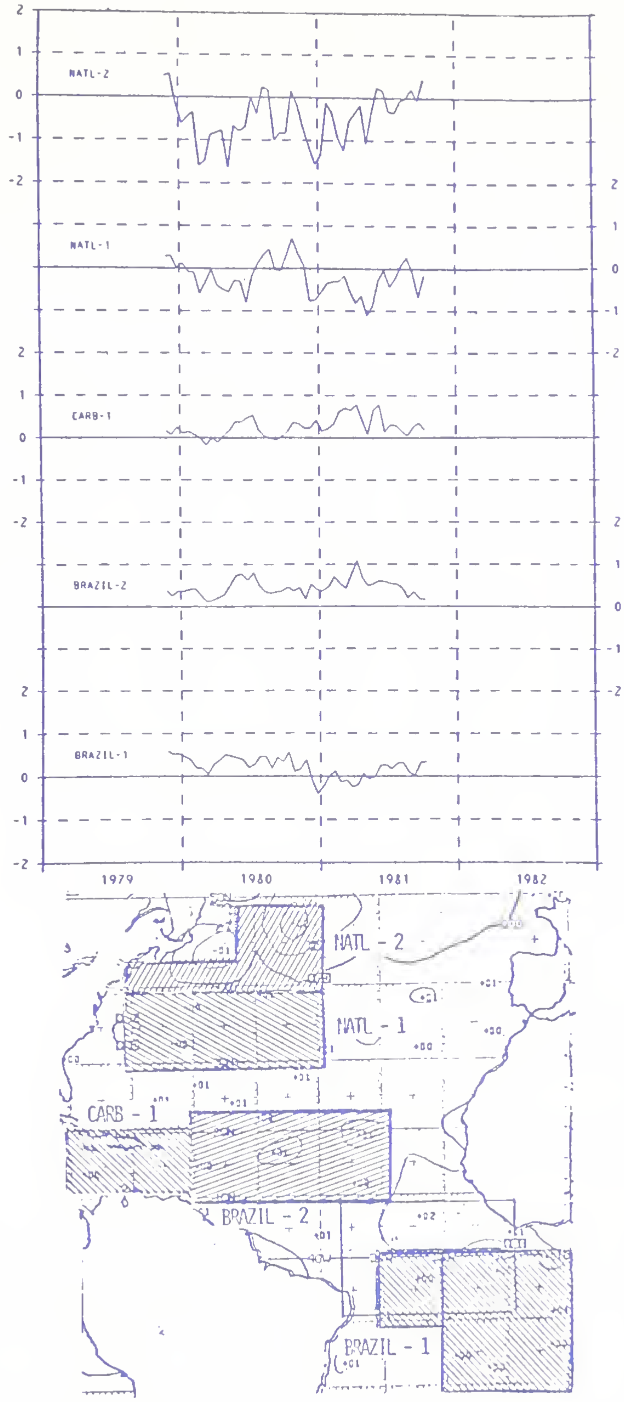


Figure 4. Plots of 15-day mean sea surface temperature anomalies (°C) for five areas in the Atlantic region.

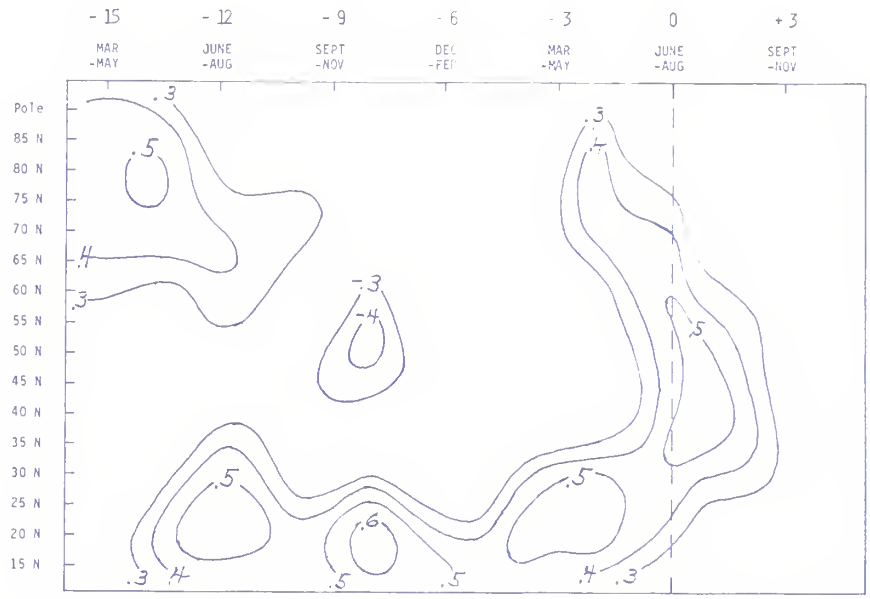
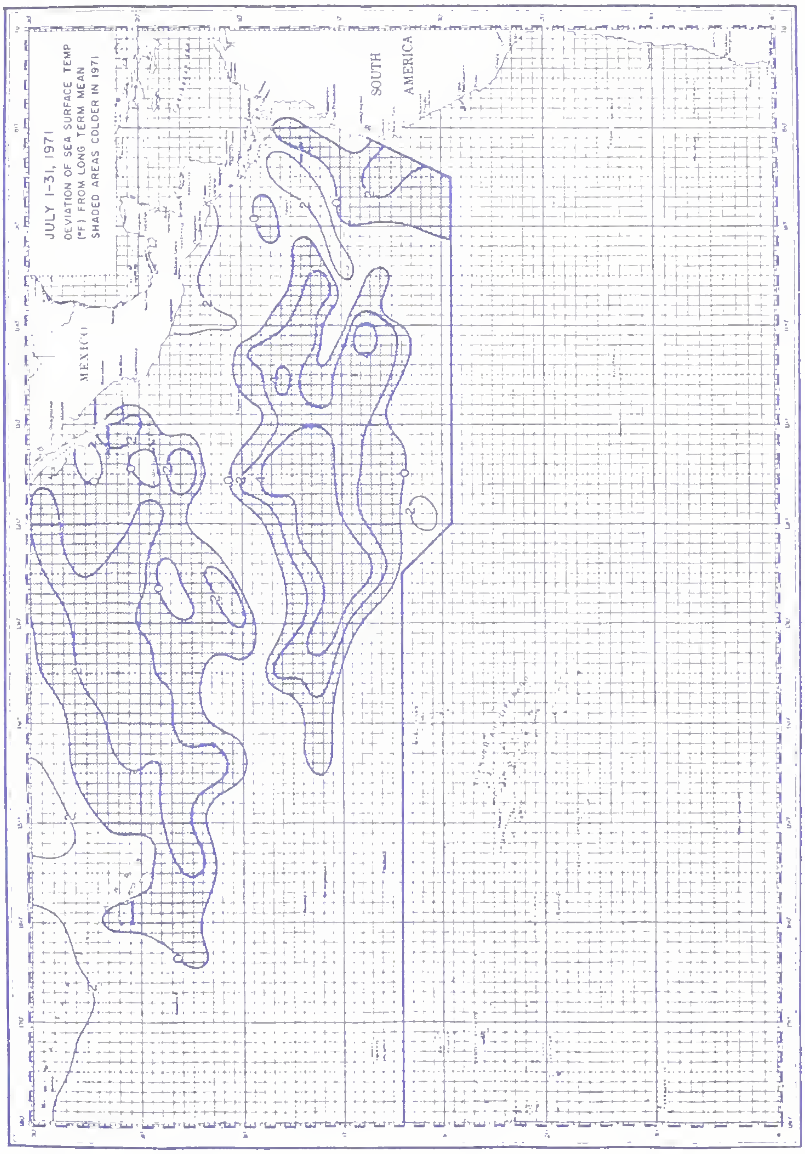


Figure 5. Isopleths of lag correlation coefficients (annual cycles removed) between seasonal mean 700-mb height anomalies for latitude belts around the globe and summer U.S. surface temperature anomaly. Period of record is 1948-1980. Negative lags signify height anomaly leading U.S. temperature anomaly



JULY 1-31, 1971
DEVIATION OF SEA SURFACE TEMP
(°F) FROM LONG TERM MEAN
SHADED AREAS COLDER IN 1971
MEXICO
SOUTH
AMERICA

Figure 6

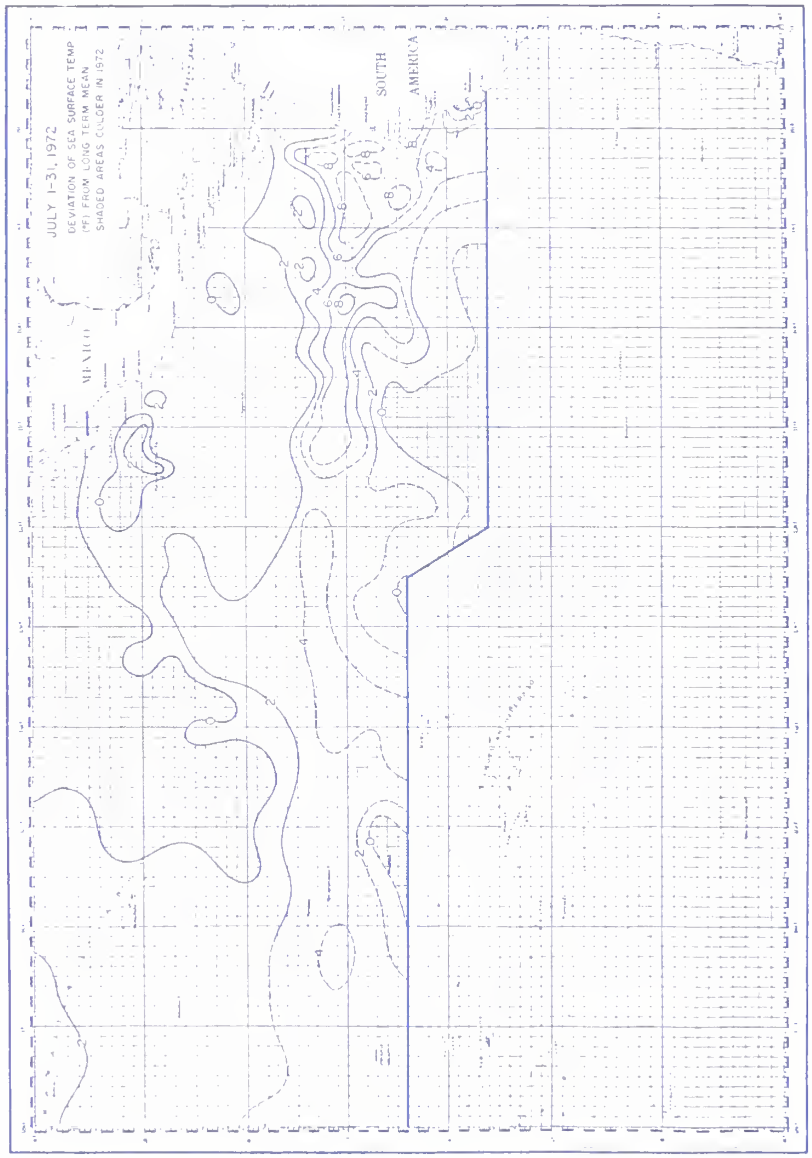
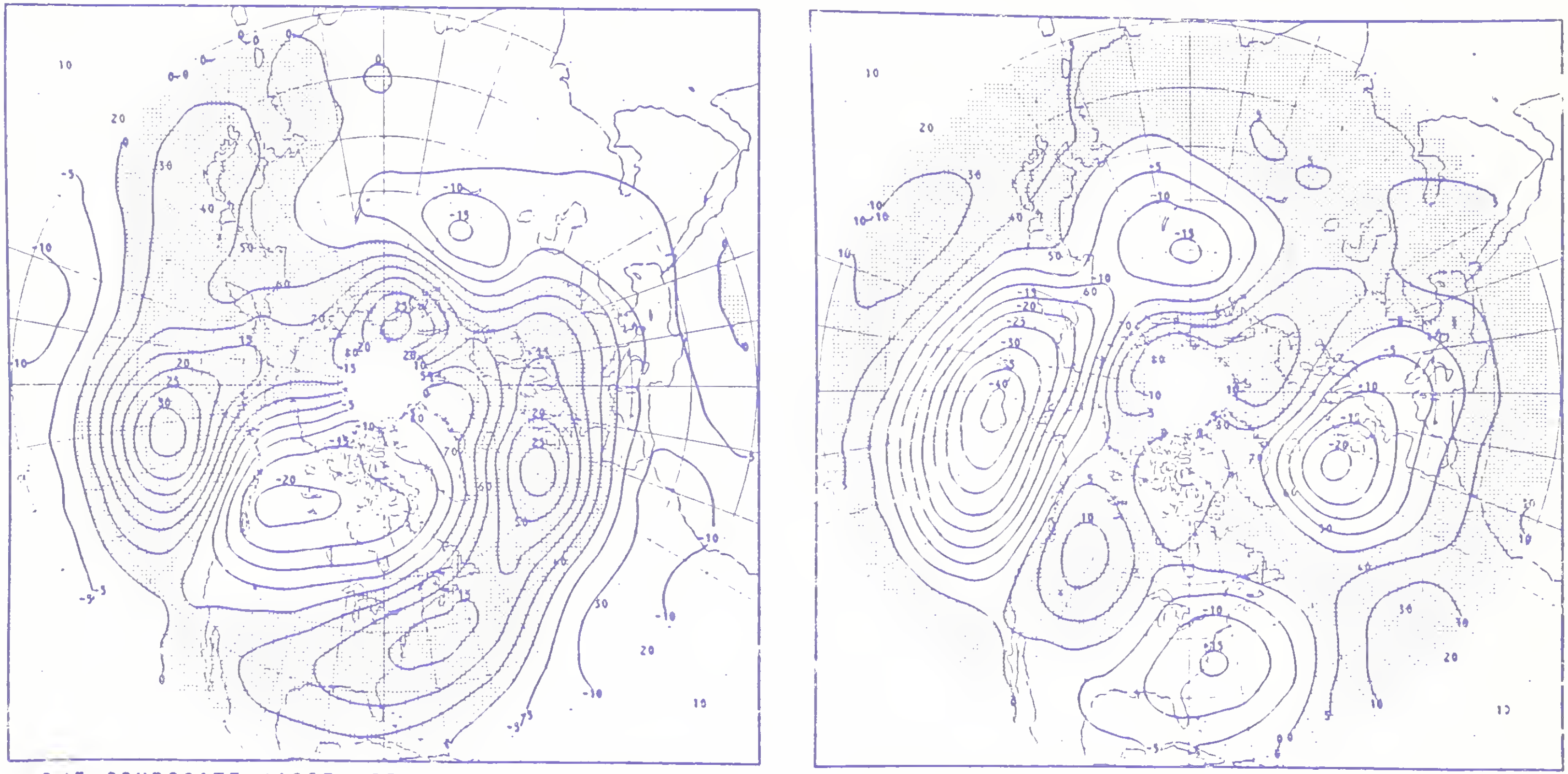

JULY 1-31, 1972
DEVIATION OF SEA SURFACE TEMP
(°F) FROM LONG TERM MEAN
SHADED AREAS COLDER IN 1972
MEXICO
SOUTH
AMERICA

Figure 7



DJF COMPOSITE (1953, 57, 65, 69, 72, AND 76)

DJF COMPOSITE (1954, 58, 66, 70, 73, AND 77)

Figure 8. Composite winter 700-mb height anomaly patterns for years when the Southern Oscillation index is high and equatorial Pacific sea surface temperatures are below normal (left) and for years of low Southern Oscillation index and above normal equatorial Pacific sea surface temperatures (right). Positive values are shaded.

OUTLOOK FOR 90 DAY AVERAGE TEMPERATURES
NOVEMBER 1981 THROUGH JANUARY 1982

A	ABOVE NORMAL, 60% CHANCE OF OCCURRENCE
B	BELOW NORMAL, 60% CHANCE OF OCCURRENCE
I	INDETERMINATE, 50% CHANCE OF ABOVE NORMAL 50% CHANCE OF BELOW NORMAL

The two categories Above and Below are to be compared to the long-term average or "normal" temperatures of the years 1941-70. Each category has a natural climatic frequency or probability of 50%. Each carries a 60% probability of occurring where forecast (shaded area) based on the verification scores of twenty-two years of experimental seasonal forecasting.

NOAA, National Weather Service
Climate Analysis Center

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Figure 9

MAJOR CLIMATE ANALYSIS CENTER GOALS FOR CLIMATE PREDICTION

NEAR TERM

- o INSTITUTE A NEW PROBABILITY FORMAT FOR MONTHLY AND SEASONAL FORECASTS.

LONGER TERM

- o INCREASE THE LEAD TIME OF SEASONAL FORECASTS UP TO SEVERAL MONTHS BEFORE SEASON BEGINS

- o IMPROVE THE ACCURACY OF MONTHLY AND SEASONAL FORECASTS THROUGH

  - — IMPROVED STATISTICAL METHODS

  - — APPLICATION OF SIMPLIFIED CLIMATE MODELS

  - — APPLICATION OF IMPROVED SKILL OF 10-15 DAY FORECASTS TO MONTHLY PREDICTIONS

- o EXPAND GEOGRAPHICAL EXTENT OF FORECASTS TO COVER ALL OF THE NORTHERN HEMISPHERE, INCLUDING THE TROPICS, AND LATER THE SOUTHERN HEMISPHERE AS WELL.

- o PREDICT ADDITIONAL ELEMENTS SUCH AS CLOUDINESS, SOLAR RADIATION, AND SURFACE WIND

Figure 10