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[Quality of Weather Forecasts and Opportunity for Improvements]. CED-78-33; B-133202. January 24, 1978. 2 pp. + 1 enclosure (16 pp.).

Report to Rep. Louis Stokes, Chairman, Task Force on Community and Physical Resources, House Committee on Budget; by Elmer B. Staats, Comptroller General.

Contact: Community and Economic Development Div.
Budget Function: Natural Resources, Environment, and Energy: Other Natural Resources (306).
Organization Concerned: Department of Commerce; National Weather Service.
Authority: H.R. 6669 (95th Cong.).

Information was compiled on the quality of weather forecasts and options which may be available to improve weather predictions for both short-term and long-term forecasts. Brief descriptions are provided of the organizational structure and the current method used by the National Weather Service to predict weather. The amount of appropriated funds devoted by the National Weather Service to forecast preparation in fiscal year 1978 was $96.3 million. For short-range forecasts, the Weather Service appeared to have attained an acceptable level of accuracy for precipitation and temperature in terms of national averages. The level of accuracy, however, varied for specific sections of the country. For long-range predictions, the Weather Service's present ability falls far short of being useful to planners and policymakers. Alternate methods of weather prediction, including the analog technique and the Krick method, are briefly described. Areas where additional funding could be used to improve forecasting accuracy are outlined. (SW)

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

5135

B-133202 JAN 24 1978

The Honorable Louis Stokes
Chairman, Task Force on Community
and Physical Resources
Committee on the Budget
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

In your November 19, 1977, letter, you asked us to compile information on the quality of weather forecasts and to comment on options which may be available to improve weather predictions for both short- and long-term forecasts. Specifically, you were interested in:

--A brief description of the National Weather Service's organizational structure.

--A brief description of the current method used by the National Weather Service to predict weather.

--An assessment of the accuracy of the National Weather Service forecasts, both short and long term, in terms of temperature and precipitation.

--A brief description of alternate methods of prediction.

--Where additional funding could be used to improve the accuracy of weather forecasts.

Enclosed is our report on these matters. Forty copies are being provided directly to your task force office.

We did not obtain agency comments on the matters discussed in the report. However, the report contents were discussed informally with an official of the National Weather Service.

CED-78-33
(08201)

Your office requested that we make no further distribution of the report prior to hearings at which the report will be used. These hearings are now scheduled to be held in February.

Sincerely yours

Elmer B. Staats

Comptroller General
of the United States

Enclosure

ENCLOSURE I

QUALITY OF WEATHER FORECASTS

AND OPPORTUNITY FOR IMPROVEMENTS

NATIONAL WEATHER SERVICE

NATIONAL WEATHER SERVICE ORGANIZATION

The National Weather Service (NWS)--a major operating component of the National Oceanic and Atmospheric Administration--is responsible for

--insuring the safety and welfare of the general public with respect to weather conditions, including conditions involving natural disasters, and

--furthering the conduct of municipal, commercial, industrial, and other activities which are affected by weather, such as agriculture, aviation, transportation, construction, and energy transfer.

To accomplish these purposes, NWS

--observes and reports the weather, river, and ocean conditions of the United States and its possessions;

--issues forecasts and warnings of weather, flood, and ocean conditions;

--develops national meteorological, hydrological, and oceanic service systems;

--develops community preparedness programs; and

--participates in international meteorological, hydrological, oceanic, and climatological activities, including exchange of data and forecasts.

Weather reports, describing current weather conditions and predicting future weather events and conditions, are NWS' major product. To develop and disseminate weather reports to the general public and special user groups, NWS carries out the three broad functions of data acquisition, forecast preparation, and communications.

Fiscal year 1978 resources, excluding reimbursements and overhead of the National Oceanic and Atmospheric Administration, devoted by NWS to these functions is shown on the following page.

	Appropriated funds	Staff-years
	(millions)	
Data acquisition	$ 53.2	2,900
Forecast preparation	96.3	1,225
Communications	9.7	350
Total	$159.2	4,475

The $159.2 million in appropriated funds and 4,475 staff-years constitute about 86 percent of NWS resources.

Types of forecasts made by NWS

As noted above, $96.3 million in appropriated funds is devoted by NWS to forecast preparation. Shown below is a breakdown of this amount by type of forecast.

Large-scale forecasts		$ 7.9
Other forecasts:		
Public	$50.1	
Aviation	20.6	
River and flood	5.5	
Marine	3.5	
Forestry and rangeland fire weather and air pollution	3.1	
Agriculture	2.9	
Hurricane and tornadoes	2.6	88.4
		$96.3

Forecast preparation includes data processing and analysis, as well as the development of forecasts and other material. Forecast preparation includes:

1. Large-scale forecasting--focuses on national, hemispheric, and global weather conditions and largely produces guidance material for other forecasting.

2. Specialized forecasting--focuses on areas determined by the nature of the specific conditions and events being predicted and produces both guidance material and products intended for the user.

3. Medium-scale forecasting--focuses on weather conditions over State and multistate areas, as well as zones within a State. Most of the prepared products are issued to users.

4. Small-scale forecasting--involves adapations of medium-scale products to individual localities and communities.

NWS organizational elements making forecasts

Following is a table showing the various NWS organizational elements involved in producing the types of forecasts discussed above.

	Large scale	Special-ized	Medium scale	Small scale
National Meteorological Center	X			
National Hurricane Center		X		
National Severe Storms Forecast Center		X		
River Forecast Centers		X		
Weather Service Forecast Offices			X	X
Weather Service Offices				X

METHOD USED BY NWS TO MAKE FORECASTS

National Meteorological Center

The National Meteorological Center is the key to NWS' analysis and forecast function. It is responsible for developing coordinated large-scale forecasts and associated guidance material for the United States and much of the rest of the Northern Hemisphere, plus portions of the Southern Hemisphere. It produces a large number and variety of graphic products describing both current and forecast conditions throughout these areas.

The graphic products provide forecasters throughout the Nation with a generalized three-dimensional concept of the current weather situation. These products include periodic atmospheric pressure analyses at the surface and at preselected altitudes; analysis of cloud cover, thunderstorm, and related phenomena; and nationwide temperature and precipitation distribution, etc.

Using information on current conditions as a starting point, the National Meteorological Center then employs a combination of manual and automated numerical means (based principally on models of atmospheric dynamics) to predict future conditions on the Nation's weather for periods up to 5 days. Output is in the form of depictions, similar to those of current conditions, at the surface and at about 18,000 feet above the surface.

The National Meteorological Center transmits this body of information to forecasters throughout the Nation as guidance material for the preparation of specialized, medium-scale, and small-scale forecasts which become the final products issued to the using community. It makes 785 facsimile and 819 teletypewriter transmissions daily to field forecasters.

National Meteorological Center products are supplemented by information derived from data received from environmental satellites of the National Environmental Satellite Service, a part of the National Oceanic and Atmospheric Administration. The information is communicated to the National Meteorological Center and to the NWS organizations responsible for specialized and medium-scale forecasts.

NWS issues public forecasts twice daily for periods up to 48 hours. An extended outlook is issued once a day for periods 3 to 5 days ahead. NWS began issuing in December 1977 outlooks for the period 6 through 10 days ahead. The outlooks will be issued three times a week in both map and narrative form and will contain predictions of average temperature and precipitation for the period but not for expected conditions on each individual day.

<u>Long Range Prediction Group</u>

The National Meteorological Center's Long Range Prediction Group routinely puts out two major products.

One of the products is the Average Monthly Weather Outlook depicted in map form. It is issued shortly before the first and middle of each month and predicts whether the 30-day period ahead will be colder or warmer than normal and wetter or dryer than usual. In addition, some information is provided on the range of normal temperatures and median amount of precipitation in more than 100 cities.

Another product is a seasonal, or 90-day, average temperature outlook also depicted in map form, issued at the end of each November, February, May, and August. It provides an indication whether temperatures will be above normal, below normal, or indeterminate, the latter meaning no forecasts or there is equal probability that the temperature could go either way. For the winter and summer seasons, predictions are made as to whether precipitation will be more or less than normal.

A number of elements are considered in developing these long-range outlooks. The principal one is the upper level wind pattern at the 700-millibar level of atmospheric pressure; that is, about 10,000 feet above sea level. At that altitude, upper air pressure patterns are roughly equivalent to wind patterns of the high-level steering currents which are important to basic changes in the weather. The Long Range Prediction Group also monitors the behavior of the upper level wind patterns on several different time scales--5 day, 15 day, 30 day, and 90 day--and, at the time the prediction is made, determines how the patterns will deviate from normal patterns.

Another important element considered is to what extent the pressure pattern that is present will remain present; that is, which abnormal features are the ones most likely to persist for the coming month or season, which are not, and which are likely to reverse.

In addition, a set of conditional probability charts is used for identifying key abnormalities in the upper air at any particular location in the Northern Hemisphere and for determining the probabilities of various classes of temperature and precipitation that will result from those abnormalities.

Once the forecast for the upper airflow is made, determinations are made as to the weather features that will occur at the surface. Several methods are used in making these determinations. One method (analog technique) is to check back through charts for the last 30 years for the same time of year as the period in the outlook to find cases where the upper air circulation resembles the one being predicted.

In another method, a set of equations is used to make a temperature estimate. This estimate is then compared with the results obtained under the analog method.

Another tool used is probability tables for each of the lower 48 States, based on the years 1900 to 1960, which provide information on what the chance is for a particular State being warmer or cooler than normal, depending on the weather experienced in previous months. Also used are tables for a 10-year sample based on the joint consideration of the 5-day forecast and the previous month's temperature.

National Hurricane Center

The National Hurricane Center is responsible for developing specialized forecasts and associated guidance materials relating to hurricanes and similar weather phenomena.

Specifically, it is concerned with the current and future location, intensity, and movement of these storms. Its activities are supported by the Central Pacific Hurricane Center, the Eastern Pacific Hurricane Center, and three Hurricane Warning Offices.

During summer and autumn, the National Hurricane Center maintains a constant watch for tropical disturbances which could develop into destructive storms. The center monitors disturbances through hemispheric weather summaries from the National Meteorological Center, data from satellites, ship and aircraft reports, and measurements from a network of island weather stations. When it appears that a storm is developing, reconnaissance aircraft are sent to the area to make a thorough investigation. Temperatures, pressure, and wind readings are taken; cloud structure is observed; and the extent, movement, and position of the storm are noted. Radar is used to monitor the storm's movement as it approaches coastal areas. Information on the movement and intensity of the storm is then issued to NWS offices and the public based on the above data.

National Severe Storms Forecast Center

The National Severe Storms Forecast Center prepares and issues tornado and severe thunderstorm "watches," which are then disseminated to the public located in the affected areas. A watch is a public-oriented statement which indicates that meteorological conditions are favorable for the development of severe thunderstorms or tornadoes for the affected area.

The National Severe Storms Forecast Center monitors conditions in the North American atmosphere using data from hundreds of points and radar summaries, satellite photographs, meteorological upper-air profiles (obtained by balloons), and reports from aircraft. From these thousands of pieces of information, the center determines the areas most likely to experience severe thunderstorms or tornadoes. Information on these areas is then issued to NWS offices and the public in the form of a watch bulletin.

As opposed to a watch, a warning of severe thunderstorms or tornadoes can be issued by any NWS field facility once that facility receives information that severe thunderstorms or tornadoes have been sighted.

River Forecast Centers

The 12 River Forecast Centers cover major national watersheds or portions thereof. They develop specialized analyses and forecasts of river levels and flood stages to be expected in the major national watersheds and prepare runoff and snowmelt forecasts.

These centers monitor the meteorological and hydrological conditions affecting river and water supply. From the centers, water level predictions are provided for more than 2,500 points on the Nation's rivers. Center hydrologists design individual procedures for each of the Nation's river systems. Forecast procedures are designed by studying the past history of each stream and the relationships between precipitation, melting snow, soil conditions, and streamflow. Through these analyses, hydrologists develop river forecasting procedures for predicting the amount of water that will find its way into rivers and streams--and the time it will take to reach them--under different conditions.

Weather Service Forecast Offices

The 52 Weather Service Forecast Offices, generally one for each State, are the backbone of the field forecasting operation. Building primarily on the material provided by the National Meteorological Center and the National Environmental Satellite Service, the Weather Service Forecast Offices develop a large number of forecast products.

A representative list of these medium-scale forecast products follows.

1. State forecasts--cover general weather conditions up to 5 days for a State or, for areas like New England where the States are small, a grouping of States. Information issued to the public includes expected amount of sunshine or cloudiness, precipitation, temperature variations, and wind conditions.

2. Zone forecasts--similar in content to State forecasts but relate to a substate area generally comprising several counties and covering between 5,000 and 15,000 square miles.

3. Recreational forecasts--similar to State forecasts but limited to recreational zones, beaches, pleasure boating areas, and skiing areas.

4. Agricultural forecasts--represent a further particularization of weather elements included in a State forecast to allow decisionmaking by farmers in terms of spraying crops, irrigating, harvesting, etc.

5. Aviation forecasts--represent a further particularization of weather elements so that the information applies to aerodrome conditions and inflight weather.

6. Marine forecasts--similar in content to State forecasts except that they focus on coastal and high seas weather.

7. Air stagnation and fire weather forecasts--express either the atmosphere's ability to dilute and disperse pollutants or the impact of weather elements on wildfires.

Forecasts made by these offices start with the guidance and material furnished by the National Meteorological Center and the National Environmental Satellite Service. Meteorologists modify this material by considering current weather observations not included in the material furnished by the National Meteorological Center. The meteorologists also consider the regional topography, climatology, and special user needs, as well as their own experience, when they modify the material.

They also provide watches and/or warnings for certain meteorological hazards, such as winter storms and flash floods. In some instances, the Weather Service Forecast Offices will also make small-scale forecasts, which are discussed in the following section.

Weather Service Offices

One responsibility of the 243 Weather Service Offices is to make small-scale forecasts. Small-scale forecasting involves the modification of medium-scale products so that they are descriptive of a specific locality, such as a city and its suburbs, an airport terminal, a national forest, a farming community, a local recreational area, a point-source polluting area, and space launch and recovery areas.

This process considers two different sets of variables: (1) topographic and climatological peculiarities, in the case of local public weather-type forecasts, and (2) unique parameterization of basic weather elements that make them more useful for specialized activities.

FORECAST ACCURACY

Regarding short-range forecasts, NWS appears to have attained an acceptable level of accuracy for precipitation and temperature in terms of national averages. The level of accuracy, however, varies for specific sections of the country.

In the area of long-range predictions, NWS' present ability falls far short of being useful to planners and policymakers for operational purposes because they are general in nature, they cover broad geograpical areas, and they extend to only 90 days.

Today and tomorrow forecasts

The following table shows what NWS reports as its yearly average accuracy levels for precipitation and temperature forecasts issued to the general public for about 50 cities for the years 1966 through 1976.

Year (note a)	Precipitation (note b)	Temperature (note b)
	(percent)	(plus or minus error in degrees Fahrenheit)
1966	84.3	4.9
1967	83.1	4.6
1968	83.7	3.8
1969	83.6	3.9
1970	83.9	3.8
1971	82.6	4.0
1972	82.4	3.8
1973	82.7	3.8
1974	82.6	3.8
1975	83.6	3.7
1976	85.6	3.6

a/Generally from April 1 of stated year to March 31 of the following year.

b/Average of forecasts issued twice a day predicting conditions up to 36 hours in advance.

NWS determines the accuracy of forecasts issued to the general public on a national basis by comparing predicted weather conditions with what actually occurred. It verifies forecasts of probability of precipitation and maximum and minimum temperatures for about 50 cities geographically distributed across the United States.

For precipitation forecasts, NWS considers predictions of 40 percent or less as forecasts of no precipitation and predictions of 50 percent or more as forecasts of precipitation. Measurable precipitation for verification purposes is defined as 0.01 inches or greater in a 24-hour period. Precipitation is measured only at a single point within the forecast area.

Therefore, if NWS predicts that there is a 30-percent chance of precipitation and 0.02 inches of precipitation actually occurs at the measuring point, for verification purposes an inaccurate forecast was made. Conversely, if NWS predicts that there is a 70-percent chance of precipitation and less than 0.01 inches of precipitation is recorded at the measuring point, regardless of the amount of precipitation that might fall in the surrounding area, the forecast is considered to be in error. Generally the quantity of rain expected to fall is not predicted, but the quantity of snowfall is generally forecast.

For temperature, accuracy is determined by measuring the number of degrees in Fahrenheit the observed maximum and minimum temperatures vary from that predicted. For example, if the forecast maximum temperature is 50 degrees and the observed value is either 53 degrees or 47 degrees, the absolute error is 3 degrees. The same evaluation is made for minimum temperatures.

With respect to 1976, we analyzed the available statistics on precipitation to ascertain the average rate of accuracy for the individual NWS regions, as well as the range of accuracy for the participating offices within those regions. The table below presents the results of our analysis.

NWS region	Average rate of accuracy	Range of accuracy
	(percent)	(percent)
Alaska	77.0	68.0 to 82.8
Eastern	83.2	77.6 to 87.3
Southern	85.0	65.4 to 91.8
Pacific	85.6	(a)
Central	86.7	83.9 to 90.1
Western	89.9	81.5 to 95.2

a/Only one office within the region.

Our analysis of the accuracy of temperature forecasts for 1976 shows that, nationwide, 79 percent of the forecasts averaged errors of 5 degrees or less. In 17 percent of the forecasts, the errors ranged from 6 to 10 degrees, and in only 4 percent of the forecasts were the errors greater than 10 degrees.

In terms of the NWS regions, the Southern Region showed the lowest yearly average error--3.2 degrees--while the Central Region showed the highest--4.0 degrees.

Three- to five-day forecasts

As it issues its today and tomorrow forecasts, NWS issues forecasts for a period of 3 to 5 days ahead. These forecasts are the result of a combination of numerical models and manual techniques employed to produce weather analyses and prognoses.

An inherent characteristic of numerical models of atmospheric dynamics is that they become less useful as a forecasting tool as time increases. The reason is that it is not possible to exactly describe the initial state of the atmosphere because of the many variables involved and the exact solutions to the mathematical equations are not possible.

This degeneration of accuracy of forecasts is shown in the following table for the years 1975 and 1976.

	Precipitation (estimated percent)	Temperature (plus or minus error in degrees Fahrenheit)
Day 3	75	5.7
Day 4	70	6.3
Day 5	65	6.8

Thirty-day outlooks

Thirty day outlooks consist of maps which indicate by broad geographical areas whether the expected temperature pattern will be above or below normal and whether the expected precipitation will be more or less than the usual amount.

NWS determines the accuracy of its 30-day outlooks by comparing predicted precipitation and temperature data with observed data for a sample of 100 cities. For the period January 1974 through November 1977, 30-day predictions for more or less precipitation were correct about 52 percent of the time. Predictions of above or below normal temperatures for the same period were correct about 58 percent of the time.

These statistics support the NWS view that its skill relative to precipitation forecasting is only marginally better than predicting on the basis of chance (50/50) and that it has some skill relative to temperature forecasting.

As noted above, 30-day outlooks are made for broad geographical areas. NWS does not make specific predictions for counties or cities. Although precipitation and temperature predictions for broad geographical areas may be correct, specific localities within those areas might experience opposite weather conditions than those predicted for the total area.

Seasonal outlooks

Seasonal outlooks are also presented in a map-type format.

NWS has some skill in predicting whether the average seasonal temperature will be above or below the average temperature experienced for major geographical areas of the country. Seasonal temperature outlooks over a period of 19 years were correct 65 percent of the time when measured in above or below normal terms. NWS' average temperature projection for the 1976-77 winter season was highly accurate (85 percent correct) while its projection for the summer of 1977 was only 30 percent correct.

The skill for predicting whether certain areas of the country will have more or less than the usual amount of precipitation is not as developed as the skill for predicting average seasonal temperatures. A contributing reason is that precipitation occurs in more complex and broken spatial patterns than temperature; that is, local precipitation totals over a period are sensitive to the paths of individual storms to a far greater degree than are average temperatures. When made, seasonal precipitation outlooks are right about 55 percent of the time when measured in terms of more or less than the usual amount of precipitation.

The data and method used by NWS to determine average seasonal temperature and precipitation are such that NWS is not able to determine this information for certain areas of the country. The size and locations of these indeterminate areas vary both seasonally and yearly.

Although NWS has some skill in foretelling what the average seasonal temperature and precipitation for major geographical areas will be, NWS does not have the skill to make similar predictions for smaller geographical segments, such as a city or county. Similarly, NWS does not possess the skill to determine the extent of variance from the norm for either temperature or precipitation. NWS cannot predict how much colder or warmer or how much wetter or drier the weather will be. According to NWS officials, no one has this capability, and, until a major technological breakthrough in long-range meteorological forecasting is made, no one will have this ability.

ALTERNATE METHODS OF PREDICTION

The method used by NWS to make long-range weather predictions (see p. 5) is also used by other countries. The only difference appears to be the emphasis given to the various elements considered.

The Russians and the British place more emphasis on the analog technique than NWS does. The Japanese method of predicting long-range weather is similar to the NWS approach. According to NWS officials, predictions made by these countries are no better than those made by NWS.

Research is currently being conducted which, if proven to be scientifically valid, should add to the various elements considered by NWS. One area being researched involves the relationship between surface sea temperature and long-range weather forecasting. Another area involves the relationship of the wobble of the earth's axis and long-range weather forecasting. The National Oceanic and Atmospheric Administration is also attempting to improve long-range forecasts with more sophisticated mathematical computer models.

As far as we could determine, only one other method--known as the Krick method--is in current use in the United States.

The Krick method developed in the late 1930s by the California Polytechnic State University under the guidance of Dr. Irving Krick has been used since that time. Under this method predictions are made by advancing into the future a set of regular cycles of atmospheric behavior. The cycles are described as being based on the examination of past records and are expected to be accurate for many years into the future. The Krick method also considers the influence of forces from outside the atmosphere on the weather, whereas the NWS method does not.

The most significant distinction between the two methods relates to the preciseness of the predictions. As previously discussed, NWS predictions are for periods up to only 90 days, cover broad geographical areas, and only indicate above or below normal weather conditions.

Those who espouse the Krick method claim that predictions can be made (1) for periods up to 10 years, (2) for a specified geographical area, and (3) with details as to the specifics of the weather event that will occur; for example, the amount of precipitation.

There is considerable controversy and dispute regarding the Krick method. NWS officials and the American Meteorological Society maintain there is no scientific basic for this method. The Krick method also has never been objectively evaluated by a panel of meteorological experts even though efforts to make such an evaluation have been made.

On the other hand, predictions developed through use of the Krick method have been bought by various local, State, and Federal governmental activities, as well as the private sector.

FUNDING NEEDS

In short-term forecasting of heavy precipitation and radical temperature changes, the degree of accuracy becomes much more significant than when normal weather conditions prevail. In the case of the severe weather phenomena--tornadoes, hurricanes, hail storms, etc.--where life and property are threatened, the adequacy and reliability of the NWS forecasting and dissemination system become paramount.

According to NWS, more observation stations, more sophisticated equipment, more forecasters, etc., would contribute to improving short-term forecast accuracy. However, the essential question is whether additional improvement in forecast accuracy is worth the additional costs that would be incurred.

NWS believes the following are examples where additional resources could be applied to improve the quality of forecasts and their dissemination to the public.

--A denser network of observations in the Northeast Pacific Ocean to provide information on the development of storm systems. Funding needs are not available.

--A denser network of remote sensing devices, particularly for those areas that are flash-flood prone, since response time is extremely short--perhaps only a few minutes. Funding needs are not available.

--Installation of local warning radars where gaps in coverage exist. Estimated resources required include seven positions and $1,362,000 one-time costs and $1,282,000 recurring costs.

--Development of electronic detectors of severe local storms/tornadoes to provide increased lead time for warnings. Funding needs are not available.

--Add automatic telephone recording devices to avoid busy telephone lines. Estimated resources required are $665,000 initial costs and $633,000 recurring costs.

--Increase the coverage and signal strength of the National Oceanic and Atmospheric Administration Weather Radio system to reach fringe population areas. Estimated resources required include four positions and $2,250,000 initial costs and $750,000 recurring costs.

--Increase the number of NWS field offices on National Warning System circuits. About $96,000 is required for this item.

The Congress has recognized the need for improving long-range forecasting. Legislation (H.R. 6669-95th Cong.) to establish a national climate program has been introduced but has not yet been enacted. The purpose of this proposed legislation is to enable the Nation to respond more effectively to climate-induced problems by (1) improving climate monitoring (2) augmenting basic and applied research in climatology, (3) improving dissemination of climate-related data and, (4) identifying the impacts of climatic changes and fluctuations.

The National Oceanic and Atmospheric Administration has recently established the National Climate Program Coordinating Office. According to an official of this Office, the funding level of $50 million proposed in the legislation to establish a national climate program will be generally adequate.

CONCLUSION

NWS appears to have attained an acceptable level of accuracy for short-range precipitation and temperature forecasts in terms of national averages; however, the level of accuracy varies for specific sections of the country and, according to NWS, can be improved with additional resources.

On the other hand, NWS' present ability to make long-range predictions falls far short of being useful to planners and policymakers for operational purposes because the predictions

--are general in nature,

--cover broad geographical areas, and

--extend up to only 90 days.

AREAS TO BE PURSUED BY THE COMMITTEE

Short-range forecasts

Although we did not evaluate the need for any of the items previously shown under "funding needs," the provision of additional resources to NWS would, in our view, be warranted if the forecasting and dissemination of severe weather information could be improved to the point where lives are saved or damage to property is reduced. The Committee may want to inquire further into this matter with NWS officials during the hearings scheduled for February 1978.

Long-range forecasts

Some forecasters who use the Krick method of long-range forecasting claim that they can make predictions (1) that are precise in nature, (2) that relate to specific localities, and (3) for periods beyond 90 days. NWS officials maintain that this cannot be done.

We have not evaluated the validity of the Krick method nor, to the best of our knowledge, has anyone else. Because of the significant impact of weather on food production, transportation, energy consumption, water resources, etc., and the fact that public funds, especially at the State and local level, are being used to buy long-range predictions from forecasters who employ the Krick method, we believe that an independent and objective evaluation of the efficacy of this method should be made by a panel of experts drawn from either the academic community or one of the nonprofit foundations. The Committee may want to pursue this matter during the hearings.