5.8 EXTENDING ATMOSPHERIC FORECASTS BEYOND WEATHER: THE HISTORY OF CLIMATE PREDICTION

Robert W. Reeves*
Daphne Gemmill
Robert E. Livezey
Jim Laver
NOAA, National Weather Service, Washington, DC

1. INTRODUCTION

The increased attention climate topics have received over the past decade has also meant a greater interest on the climate prediction problem over the shorter time scales, e.g. monthly and seasonal. Responding to a greater community awareness of climate and the demand for climate products by many sectors of the nation's economy, the NWS established a climate service focus at its Headquarters in Silver Spring, MD. The Climate Services Division (CSD) provides the strategic vision for climate services at NWS and oversees the NWS climate prediction program. It also develops policy and requirements for climate prediction products and other services out to one year in advance and beyond. On the technical side, the CSD works closely with the NWS Office of Science and Technology to develop a plan for infusion of scientific and technological advances. That plan will include a discussion of promising avenues of research in climate prediction.

In order to place today's prediction problem in perspective and provide a meaningful context for serious consideration of future directions, the CSD has embarked on a project to document the modern (20th century) history of short-range climate (two-week to seasonal) prediction. The results of the study will help promote CSD's program to provide training for NWS operations personnel on climate, and contribute supporting historical and technical background material for the training modules. Another objective is to focus particularly on the events that led to the formation of the Climate Analysis Center (now Climate Prediction Center) and the subsequent expansion of its climate service capability. An up-to-date look at the history of climate prediction would also fill a gap in a discipline for which historical documentation has been encouraged by the International Commission on the History of Meteorology.

The project is in its early stages. Our goal at this point is to identify some of the major themes, technological advances and important policies or events (political and climatic), that shaped the development of long-range prediction. In the course of our study, we plan to research some of the events that influenced policy shifts, such as the change in emphasis for long -range prediction in the early 1940's from understanding the causes of the wide-spread drought of the 1930's to its application in military conflict.

**Corresponding author address:* Robert W. Reeves, National Weather Service, 1325 East-West Highway, SSMC2, RM 13370 Silver Spring, MD 20910; e-mail: robert.reeves@noaa.gov

2. CLIMATE AND WEATHER

In terms of atmospheric predictability a simple distinction often used is that climate is a boundary value problem and weather is an initial value problem. Two weeks is considered the point beyond which the employment of the numerical prediction problem and its initial conditions ceases to provide any measurable skill. For our purposes, we will extend the climate definition back to one week (beyond 7 days) in order that it coincide with the forecast responsibilities of the NWS Climate Prediction Center. This is about the lead time that boundary conditions become more important than initial conditions. While this study will include some aspects of the much longer range problem (multi-decades to centuries) our focus will be primarily on the 20th century attempts to extend the forecast capability beyond two or three days.

That part of the atmospheric sciences we refer to as climate may be considered as several themes or topics. In terms of its predictability, we usually think of this in terms of time scale. The subject of long-term climate change is largely viewed as a research topic and addresses issues such as global warming. On shorter time scales, we typically try to forecast the departure of monthly or seasonal temperature and precipitation from the long-term average. A separate stream of study, climatology, was largely treated as a descriptive activity related to establishing the long-term climate locally and regionally, and the compiling of related statistics. We will track these streams or topics as they have evolved, and where they have overlapped in their evolution.

3. MAJOR SOCIETAL/POLICY/CLIMATE EVENTS

Tracing the evolution of long-range prediction in the 20th century takes us back to one of the catastrophic events of the late 19th century, the disastrous Indian drought and famine of the 1870's. India undertook the task to determine the meteorological causes of the disaster. They were aided in their investigation by the spread of the telegraph to other parts of the globe which led to a sharing of weather observations and the possibility of interpreting significant local atmospheric events in terms of larger scale phenomena. The head of the Indian Meteorological Department, Henry Blanford, received pressure data from Australia and began to piece together a picture of a larger scale phenomenon. A later drought and famine led the successors of Blanford to renew the search for answers. Sir Gilbert Walker (1923, 1924) examined northern hemispheric pressure patterns and found 3 large scale horizontal see-saw oscillations. He called the pressure oscillations the Southern, the North Pacific, and the North Atlantic Oscillations.

In the U.S. some time later, the devastating Dust

Bowl years of the 1930's led the Congress to pass the Bankhead-Jones Act of 1935 "To provide for research into basic laws and principles relating to agriculture . . .". C-G Rossby was developing his long-wave theory of the Westerlies at M.I.T. in the 1930's, and applied for Bankhead-Jones funding to research the long-range prediction problem. Jerome Namias, in later years a prominent force in long-range prediction, joined Rossby's project at M.I.T.. The work at M.I.T. was also attracting attention of the military folks in Washington because of the escalating tensions in Europe in the late '30's and the prospect of war. Experimental long-range forecasts were being made at M.I.T., but the operation was transferred to Washington in May '41. Perhaps the memories of the drought years of the '30s were fading in the face of a new priority, possible military conflict and the challenge of predicting weather for defense operations.

In the late 1940's, the Institute for Advanced Study in Princeton was the setting for one of the major technological advances in atmospheric science with the advent of numerical prediction on the Eniac, the first high-speed computer. The development of the barotropic model opened a new era in atmospheric prediction.

The International Geophysical Year, 1957-58, allowed scientists to participate in a program of coordinated global observations, fortuitously during a major El Niño year. Sea surface temperature readings from commercial ships showed the extensive warming of the eastern Pacific. A major die off of seabirds off Peru and the appearance of tropical fish off California were for the first time connected to a much larger climate phenomenon.

The California Cooperative Oceanic Fisheries Investigations held a Symposium on "The Changing Pacific Ocean in 1957 and 1958" in Rio Rancho, CA, Sette and Isaacs (1960) which brought together meteorologists, oceanographers, and fisheries biologists. The informal tone of the meeting permitted unfettered speculation on the causes for the unusual conditions.

The Cold War had its influence on the national fortunes of climate, and led to the passage of the National Climate Program Act (1976) and its subsequent implementation. Bryson and Murray (1977) had noted a decrease of the global temperatures from the 40's to the early 70's and were concerned that those recent temperature trends indicated a possible ice age. Concern in the U.S. over how the Soviet Union might use this led to the NCP Act. *"The purpose of this Act is to establish a National Climate Program which will enable the Nation to respond more effectively to climate-induced problems (1) by improving climate monitoring in order to make the Government and the private sector aware of, and to enable the Government and the private sector to anticipate, fluctuations and anomalies in climate; (2) by augmenting basic and applied climate research, including research on the potential influence of human activities on regional and global climate; (3) by improving services relating to the climate, particularly the dissemination of climate-related data and information; and (4) by identifying the domestic and international impacts of changes and fluctuations in the climate, in particular on the allocations and use of energy resources, on the management of land and other natural resources , and on the planning of food supplies."* The implementation of the Act included the establishment of the National Climate Program Office to manage the interagency climate effort and the initiation of an experimental climate forecast center activity. The first Climate Diagnostics and Prediction Workshop was convened in 1976. The formation of the Climate Analysis Center (now the Climate Prediction Center) in the NWS followed a few years later. The elements of the Center were the Analysis and Prediction Branches formed from existing NWS units, and a Diagnostics Branch composed of individuals transferred from NESDIS' Center for Experiment Design and Data Analysis.

At the same time there were concerns over possible inadvertent anthropogenic climate change, particularly global warming. An international Study of Man's Impact on Climate (SMIC) was held in the summer of 1971 near Stockholm, Kellogg (1972). "Though we may have influenced the climate already, it has so far probably been in a small way." Kellogg briefly presented the main influences on climate, and in order of importance (at least in 1972) were:

Carbon dioxide -heating
Atmospheric particulate matter - probably a cooling (uncertain)
Albedo - heating
Farmland irrigation and evaporation of water - warming ultimately, since more sunlight is absorbed and the heat is released back into the atmosphere when the water condenses as rain or snow at some other place.

Kellogg stated that "From the above one can, and probably should, conclude that man can influence the climate of his planet Earth. The direction that this influence will take in the decades to come, if man continues to demand more energy to satisfy his craving for an ever improving standard of living, coupled with his increasing population, must be that of a warming, especially in the Northern Hemisphere."

The 3 to 7 year return period for El Niño meant that its appearance would continually refocus attention on it as a possible influence on regional climate. The 1972-73 El Niño had global economic implications starting with the collapse of the Peruvian anchovy fishery, to guano production, to grain-growing farmers worldwide. Predicting El Niño took on new significance. The failure of the Russian grain harvest in 1972 and the severe British drought of 1976 helped rivet attention on climate prediction.

Ten years later, the biggest El Niño of the century at that time (1982-83) peaked before the scientific community knew it was happening. The National Geographic magazine published an article on event, and this contributed to the world-wide attention to this El Niño. This event opened the eyes of the scientific community to the shortcomings of the observing system.

4. MAJOR TECHNICAL DEVELOPMENTS

We have used three sources primarily as we begin the process of identifying and documenting the technical developments of long-range prediction. Rather than attempt a partial accounting at this time, and running the risk of inadvertently neglecting one or more key researchers, we refer the reader to Namias (1968), Nicholls (1984), & Barnston et al (1994), and briefly mention some of the techniques. Much of the early work proceeded from the synoptic charts that were made possible by the telegraphic transmission of data. That led to the discovery of the existence of macro scale pressure patterns, the "Centers of Action", relating prevailing weather conditions over long periods to their strength and position. The use of correlations and regression techniques followed, the identification of teleconnections by Sir Gilbert Walker, and the use of analogues as soon as a sufficient archive of synoptic charts became available. Others searched for cycles and harmonics until power spectra failed to show significant cyclical phenomena in the troposphere other than the diurnal and annual cycles. The concept of Key Periods implies that the dominant character of the weather of the forthcoming season is indicated by the character of some shorter period in the preceding season - perhaps a pentad. Some investigators began looking at irregular variations of solar activity. Success in the Kinematics and Synoptics method depended upon the long-period continuity which shows up in anomalies of the "Centers of Action". Feed-back studies or surface influences came into prominence in the 60's. Charney, Phillips, Smagorinsky and many others contributed to the early development of dynamic numerical modeling. Research on univariate time-series methods and multi-variate statistical and physical methods followed later. In the 70's and 80's research on dynamical and probabilistic methods continued, and the Monte Carlo Method was developed in the 70's. Key developments in the 80's included the construction of the composite Pacific Basin-wide model of El Niño, the identification of low frequency modes of variability and detailed documentation of their teleconnected structure, clarification of the regional impacts on precipitation and temperature from the composite El Niño, the global circulation signature of El Niño, and new methodological standards.

An important focus of research in the 90's was the tropical Pacific sea surface temperatures as an important parameter for seasonal prediction. Several studies have attempted long-lead forecasts of the tropical sea surface temperatures (central and eastern Pacific).

5. SUMMARY

The NWS CSD and CPC are collaborating in a project to document the development of climate prediction during the 20th century, including the relevant roles of national policies and actions. The impetus for the study grew from the need to promote CSD's program to provide training for NWS operations personnel on climate and a desire by the Directors of the CSD and the CPC to (1) Trace the technical developments in extended prediction from about the time of Hurd Willett; and (2) Recount the recent legislative and policy history in climate services from the National Climate Program Act, particularly as it was related to activities at the CPC . Special emphasis will be placed on developments within the Federal weather entities (Weather Bureau, ESSA, NOAA), and their responsibilities in the time scales from extended prediction (weeks to seasons) to long-term climate change.

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