Short-Term Climate Predictions for Water Management

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Abstract

Short-term climate predictions (two weeks to two years) have many applications in operation of water supply and flood control facilities. They can influence use of water for irrigation, hydroelectric power production, flood control operation, recreational use of reservoirs, and numerous related water operations. The climate predictions now available have limited usefulness. Their value will increase markedly as ongoing research improves their dependability.

1. Introduction

Forecasts of short-term climatic fluctuations (two weeks to two years) could be extremely useful in the management of water resources. Such forecasts could be used by those who manage reservoir releases for irrigated agriculture, schedule reservoir releases for hydroelectric generation and/or schedule winter and early spring releases to provide flood-control space. Short-term forecasts would also be helpful to operators of recreational facilities at reservoirs and in ski areas, construction contractors awaiting clear weather to begin work in the spring, schedule snow removal from highways, and who deploy men and equipment to fight forest fires.

The National Weather Service (NWS) established a Climate Analysis Center (CAC) in 1978 with a major purpose of improving projections of short-term climate fluctuations. This paper was prepared to assist the CAC in an examination of the needs and problems of users of the projections.

The background for this discussion is the Mediterranean-type climate of California, where almost all precipitation falls from November through March, and agriculture is almost entirely dependent on irrigation through the summer. The paper also reviews a seven-year experimental program in which short-term climate predictions were converted to forecasts of runoff, which were then used as the basis for water-management decisions.

2. Reservoir storage

Because substantial storage capacity is available in California's surface reservoirs and ground water basins, below-normal stream run off does not become critical until the annual deficiency approaches 40%. Actual deficiencies have reached 70% during some years, however, and from time to time, California has experienced dry periods of several years.

A recent example was the 1976–77 drought, the driest two-year period of record in California.

Many of the larger reservoirs have a flood control reservation, usually built by, or with funds provided in part by the U.S. Army Corps of Engineers (USACE). Following a good winter year, it is often necessary to draw down the reservoirs by the 1st or 15th of November to create the mandatory space in the reservoir to store potential flood inflows during the winter. Frequently this water generates electricity as it is released; it is usually an undesirable reduction in storage, however, because it depletes supplies that could be used for agriculture and other purposes during the following spring and summer months. Fall predictions of winter precipitation that would provide a basis to delay or decrease such release would be a welcome addition to our tools for water management.

Predictions covering two- and three-week periods during the winter could be used to schedule more flood water releases through hydroelectric plants and less through flood outlets. Such scheduling would be possible if there were reasonable assurance that no large storm was in the offing. (Other problems that accompany reservation of space for flood control are discussed in Section 5).

Late winter and early spring storm predictions would also complement the forecasts of water supplies to be expected from melting snow. All western states accumulate some snow during the winter, from which forecasts of spring and summer runoff are made. The Department of Water Resources (DWR) makes such forecasts in California; the U.S. Soil Conservation Service, in cooperation with NWS, makes these predictions for the other western states.

These runoff predictions are now based on the assumption that precipitation and temperature will be normal following the date of the forecasts. However, additional predictions of short-term climatic conditions would increase the value of the program.

Predictions covering two to twelve months, giving an expected precipitation value for each month, would also be helpful in forecasting water supplies. Such predictions need not be accurate to the day; the important consideration is the precipitation to be expected during a given month.

Class predictions (wet, near-normal, and dry) also have value, but as discussed under "Project Hydrospect", they must be converted to quantities if they are to be used to prepare forecasts of runoff.

3. Stored water and irrigated agriculture

Forecasts of runoff covering a full year could be very useful to operators of reservoirs storing irrigation water. An outstanding example of the problem reservoir operators face is provided by the 1976-77 California drought. As the 1976 irri-
gation season began, reservoir operators and agricultural interests had to decide whether the following water year would be dry or normal. In most instances, they assumed that 1977 would bring normal precipitation and runoff, that being the greatest probability. As a result, reservoirs were drawn down well below normal to provide near-normal irrigation supplies. Unfortunately, the even drier 1976-77 water year provided little inflow, and spring and summer releases for agriculture had to be severely curtailed.

Under similar circumstances reservoir operators would probably make the same assumption (of a normal water year following a dry year). Moreover, they will continue to do so until they can be supplied with annual predictions in which they can feel confident.

Farming in flood plains and in floor bypass channels does not usually involve crops that have to remain in the ground during the winter, but predictions of early spring precipitation would be valuable to farmers, who must assess the risk involved in early spring tillage of such areas. Some of the river channel lands are very good, and their use for long-growing-season crops is highly desirable. Tilling too early, however, involves the risk of overflow; should the land be flooded, it would have to be retilled at substantial cost.

Each winter and spring, DWR receives many inquiries from financial institutions concerning prospective water supplies for the coming agricultural season. Undoubtedly, these institutions would have increased confidence in our forecasts if their accuracy were enhanced by knowledge of near-future climate conditions.

4. Hydroelectric power generation

The Pacific Gas and Electric Company (PG&E), the utility serving most of northern California, has several staff meteorologists, who devote much effort to forecasts of temperature and its relationship to the amount of fuel that will be required for production of heat and energy. In addition, PG&E produces a great deal of energy in hydroelectric power plants. Forecasts of the supply of water available to produce hydroelectric energy are important elements in PG&E's operations. With more dependable short-term climate predictions, PG&E (and other utilities) could more accurately schedule operation of hydroelectric facilities. This would benefit the economics of energy production in California significantly.

Similarly, forecasts of temperatures at various elevations, and thus the elevations at which snow will occur during storm periods, along with temperatures between storms, would help answer such questions as how high the snow line will be and how long the snow will last at various elevations. Such predictions would be helpful to those who schedule reservoir flood operations, forecast future water supplies, schedule highway snow removal operations, and operate ski resorts, to name only a few.

5. Flood control

Early spring predictions of precipitation to be expected during the remainder of the rainy season would have numerous applications, particularly following a relatively dry winter. Such forecasts could be very useful to operators of reservoirs with flood-control reservations, in areas that do not accumulate substantial snow packs above the reservoirs. The 1958 experience of one central coastal county flood control district is a telling example. The district has constructed a reservoir, primarily to store water for summer release for ground water recharge. In constructing the reservoir, the district provided substantial space for winter flood control. (In this case, the county paid the cost of the flood-control reservation without relying on USCE).

In 1958, the flood-control space was held empty into March. During the latter part of the month, heavy rain fell, producing significant inflow to the reservoir, and the flood control engineer decided to store much of it in the flood-control reservation, since April runoff in the area is usually quite low. Then, during the first week of April, some of the heaviest storms in years occurred, filling the remaining flood-control space rapidly. The district had to make emergency water releases, undermining part of the spillway which required costly repair. The district has since been far more cautious about encroaching on the flood-control reservation during March.

Other agencies have experienced similar problems by encroaching on flood-control space during early spring. In such cases, forecasts covering April, May, and June would be of real value to reservoir operators.

The value of short-term climate predictions to those who farm in river channels and flood bypass channels was mentioned earlier. In addition, 15-30-day predictions of fall and spring precipitation would be helpful to construction contractors, who often have work underway in these channels at the beginning of the flood season in late fall, or want to begin work as early as possible in the spring. This involves construction of bridges, pipelines, roadways, and other large structures, some of which require many months for completion. Every spring and fall, DWR receives numerous requests from contractors for short-term climate predictions for these projects.

6. Water-related recreation

Short-term climate predictions would also be helpful to operators of water-related recreational facilities on inland waterways. This is a rapidly growing industry in California and in much of the nation, particularly the use of the flat water available in reservoirs. Even river rafting, which also is gaining popularity, depends in large part on reservoir releases to downstream channels. Recreational operators at such facilities must often rely on guess work to estimate future patronage.

For example, Collins Reservoir, about 85 km north of Sacramento, is a small irrigation and recreational reservoir with a more sophisticated recreational operation than most. Recreation use at the reservoir is influenced by its water levels during spring and mid-summer. During dry years, the levels will be low, and recreational use, along with the operator's gross revenues, falls off drastically.

Each fall, the operator of the recreational facilities at Collins Reservoir refurbishes the outboard motors used during the summer and sells them to fishermen. He then buys new
8. Project Hydrospect

From 1972-78, DWR sponsored a program called “Project Hydrospect” to apply “long-range weather forecasts” (short-term climate predictions) to the operation of irrigation projects. Also contributing to Project Hydrospect were the U.S. Bureau of Reclamation, the USCE, seven San Joaquin Valley water districts and associations, the University of California’s Scripps Institution of Oceanography, two private engineering firms, and two private meteorologists.

The group paid for the long-range weather forecasts, providing frequent updates during the winter of 1980-81 on the outlook for drought in the United States. These were appended to the long-term outlook discussions and received on Teletype Circuit “C”.

9. Qualification of short-term predictions

The DWR meteorologist and certain department engineers have stressed the importance of accompanying short-term predictions with confidence limits, so that the predictions can be used effectively.

They also suggested that CAC be complimented for providing frequent updates during the winter of 1980–81 on the outlook for drought in the United States. These were appended to the long-term outlook discussions and received on Teletype Circuit “C”.

10. Reduction of climate records

The reduction of NWS observation network over the past four years will lower the effectiveness of short-term climate predictions. Some of the 340 stations eliminated from the network had records dating from more than 100 years ago.

11. Application

Some decisions regarding operation of water projects are very nearly “toss-of-the-coin” affairs, therefore, predictions (even those with low confidence levels) can be helpful. Short-term climatic predictions will be particularly useful to operators of large water projects, who must often base decisions for reservoir releases on expected weather conditions over the next 15-30 days. In that regard, the chief operator of the California State Water Project has expressed appreciation to DWR meteorologist for keeping him informed of the short-term climate predictions made by various organizations, and for the levels of confidence that should be placed on them.

12. Conclusions

Most of the short-term climate predictions now available have some limited usefulness in water resources management. Those given an average skill factor of 65% can influence water management decisions. Their use will increase very rapidly as ongoing research increases their reliability.