THE DIFFERENCE BETWEEN WEATHER FORECASTERS AND WEATHER ADVISORS

R. R. Rapp

May 1965

P-3145

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R. R. Rapp

The RAND Corporation,* Santa Monica, California

ABSTRACT

During the last half of the last century, those natural philosophers who had been attempting to understand weather phenomena were called upon to organize weather services. Knowledge of the atmospheric processes was meager, but the weather advisories issued by these services were considered to be sufficiently useful to warrant their expansion in most countries and the formation of international organizations to provide weather data.

While twentieth century science has improved our understanding of the atmosphere, it has not kept pace in its ability to provide advice to those who could benefit from this increased knowledge. It is apparently no longer possible for the meteorologist to communicate directly to the user. It is suggested that our improved, but still imperfect, knowledge of the atmosphere can best be transmitted by creating a link between the meteorologist and the user. This link, which has been personified by the term "weather advisor," would combine the operational requirements of the users with the weather information of the meteorologist to produce advisories with direct application to the problem. The application of decision theory to properly stated forecasts might well produce the best advisories.

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This paper was prepared for presentation at the 27th National Meeting of the Operations Research Society of America, Boston, Massachusetts, May 6--7, 1965.

THE BEGINNINGS

The last half of the eighteenth and the first half of the nineteenth century saw students of weather begin to make some advances in the scientific understanding of the phenomena. In 1735, Hadley analyzed wind reports from the tropics and proposed an explanation for the trade winds; later on Franklin made his famous observations on the movement of storms. By 1820 Brandes was drawing weather maps. Early in the nineteenth century a few people started what I would call weather advice. Mathew Maury's classical analysis of the winds over the ocean applied to sailing ship routes is a very good example. Maury used his mean wind charts to determine the least time tracks for vessels sailing between major ports of the world. Dove's statement of the law of storms was designed to advise seamen as to the nature of storms, and even more important, what to do about them. There is a distinct difference between Hadley's analysis of the trade wind zone and Maury's analysis of the sailing ship routes. One is purely scientific, the other is advisory in nature. Franklin's discovery that weather systems moved was followed by Dove's statements so that mariners could make use of this information. This is essentially a difference between a student of the weather and a weather advisor.

WEATHER BUREAU

By the time the telegraph was invented, there was quite a bit known about the weather. Storms were known to move, and they could be recognized on weather maps. The telegraph provided a way of quickly assembling data and making weather maps in time to be useful. It was a very short time after the first demonstration of a successful telegraph in 1844 that a weather service was organized. The first official bureau was set up by Napoleon III who instructed an astronomer, Leverrier, to prepare weather maps to advise the French fleet and the French government of critical weather conditions. This was apparently the result of a disastrous storm which struck the French and British fleets in the Black Sea during the Crimean War.

At about this same time, in the 1850's, the Smithsonian Institution in Washington, D. C. began producing telegraphic weather maps "for the benefit of the general public." A few years later the U.S. War Department was charged with the duty of making observations and preparing weather maps, again for the "public good" in the U.S.A.

The basis of these weather bureaus was service. They tried to apply what was known about the weather to practical problems. By our standards today, the information was meagre, but it was sufficient to be useful -- at least, everybody was convinced that it was useful -- so that weather bureaus expanded and grew in many countries. It was the growth of the service organizations which slowly provided the data for additional studies and improvements in our understanding of the weather. From the time the weather services started up until WWII, the studies and the services went hand in hand. The date when study and service began to diverge is hard to set, but WWII provides a convenient breaking point.

THEORY OF BUREAU OPERATIONS

The type of operation that I got into when I started as a meteorologist during WWII was a combination of forecaster and advisor, and indeed, this was the general plan with which the U.S. set up its military meteorology program for WWII. Large numbers of meteorologists were trained and attached to many units of the armed forces. It was assumed that these men would be able to observe, analyze, predict and advise on the weather problems that were confronting the unit to which they were attached.

At about this same time, the general idea of centralizing the main forecasting services was also suggested, but still during WWII the basic premise was that the meteorologist on the spot would give the advice as to the effects of weather on proposed operations. This approach also held, to a large extent in civilian life, during the 40's and 50's, particularly in the aviation services. Pilots would come to the meteorologist to get a briefing on the weather, reach a mutual understanding of the weather situation, and then would undertake whatever flights they had planned.

CENTRALIZATION AND TECHNOLOGY

The effect of centralizing forecasting services was to break the personal contact between the man who had analyzed the weather maps and made the forecast, and the man who was going to use the weather information. This centralization was necessary because meteorological technology was advancing rapidly. The advent of computers and numerical forecasting made it imperative that the predictions be made at central locations, and that information be sent out in a rather impersonal fashion.

At the same time that scientific meteorology was advancing by leaps and bounds, other technologies were also advancing by leaps and bounds, and with improvements in technologies came new and different weather problems. While meteorologists happily forged ahead with their understanding of atmospheric processes and their improvements in the techniques for understanding these processes, the service side received less and less attention. There has been very little research done over the past 20--30 years in how to best serve the people who can make use of weather information.

THE EVILS OF TECHNIQUE

I can remember a rather amusing example of the technology failing to take into account the user's problem. A very good, very enthusiastic, very far-sighted forecaster at one of the bases where I was stationed during the war had -- and this was a long time ago -- recently learned much from the then new technique of isentropic analysis. In his enthusiasm he wrote into a forecast that there would be upslope motion along the isentropic surface. The forecast was greeted by the pilots with howls of derision, and the poor man was practically hooted out of the officer's mess that night. It was a good forecast, and it turned out to be right, but it meant absolutely nothing to the people who read it. I am afraid that the science of meteorology as a whole is falling into this kind of trap. We have improved many of our forecasts. Our prognostic charts, those produced by the models in our national numerical

weather center, are vastly superior to what we had a few years ago. However, we are dispensing technical information that does not answer practical questions. I think we are in danger of being hooted down if we continue to hand out this kind of information.

THE PROBLEM OF COMMUNICATION

One of the attempts that has been made to simplify our communications problem with the users of weather information has gone along the route of transmission and display. The basic philosophy is that if you simply transmit a lot of weather information and find nice technical methods for displaying it, such as television tubes, light boards, and the like, you will have achieved your purpose of communicating with the public. I am afraid that this is not the answer.

Communication is much more than presenting information. A particularly enlightening article on the subject by Rogers and Roethlisberger appeared in 1952.(1) They presented the thought that until someone can tell you in his language what you have told him in yours, you have not really established communication. Using this criterion I would say that a room full of prognostic charts and current weather data does not really communicate with people who need the weather information.

A LOOK AT SOME USERS' PROBLEMS

Just about a year ago, Ralph Huschke and I completed a study entitled Weather Information: Its Uses, Actual and Potential.(2) What we were trying to do was to show how best use could be made of whatever weather information was available -- be it climatological or predictive. At the same time that we were making this study for the Weather Bureau, the Bureau was also engaged in a study to try to estimate the value of weather information. Both of the studies indicated that we were not very efficient in communicating weather information to users, and furthermore, that there was very little research being done to improve this phase of the weather service.

In our report we tried to make a distinction between the producers of weather information -- the forecasters -- and the interpreters of weather information, whom we called weather advisors.

The difference between the weather forecaster and the weather advisor was that the forecaster should be concerned with putting out the best technically phrased information as to the future state of the atmosphere, whereas the weather advisor should be concerned primarily with applying this information to the specific problem faced by an operator.

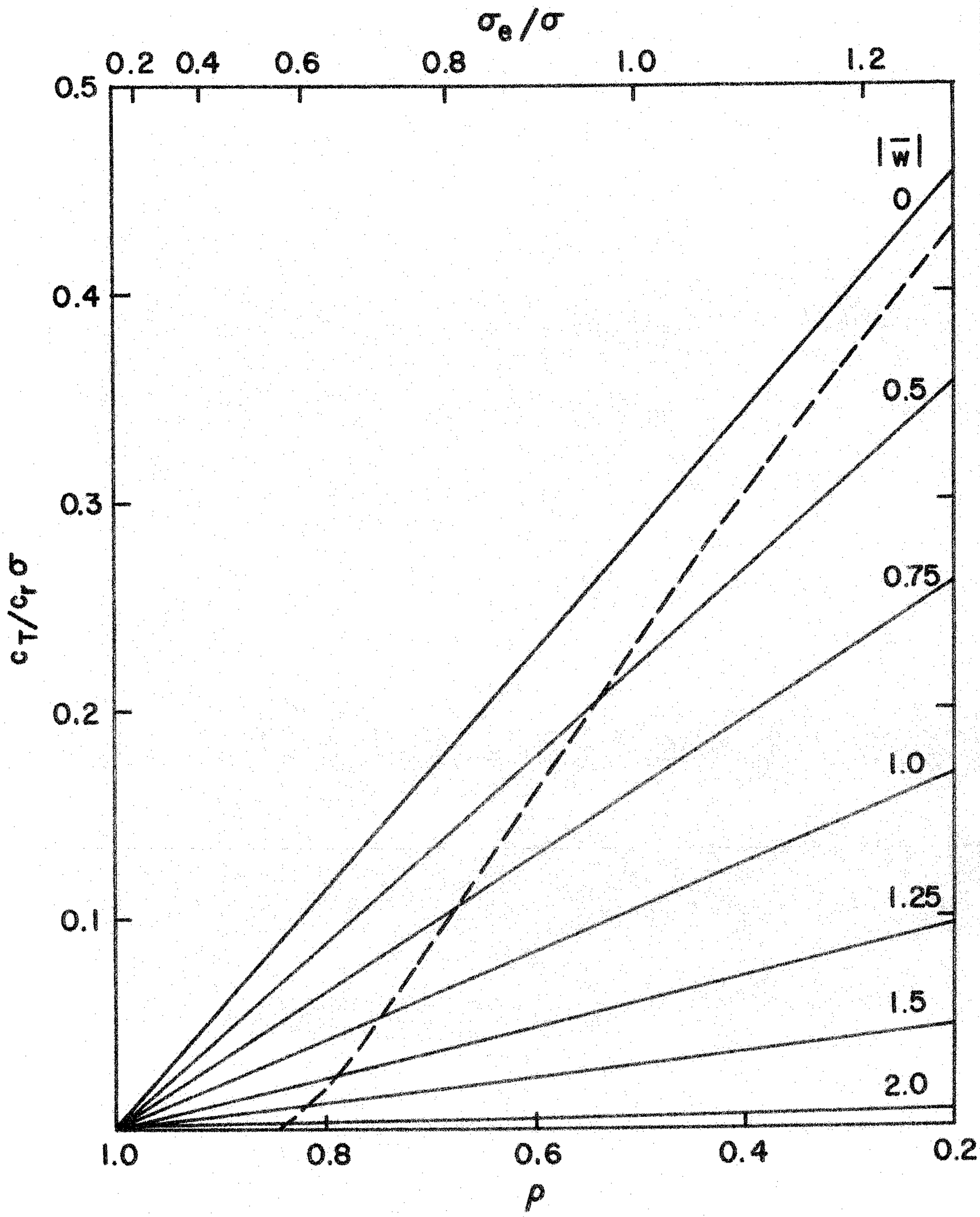
We presented two examples, and I would like to show how the forecast input led to an economic output. One was the choice of route for airlines, a technique worked out by Dr. Conway Leovy of The RAND Corporation, and the other a study of the problem of drying raisins which was worked out by Mr. L. L. Kolb and me. The key point in both these studies is that the information was used in an operational context, and the worth of the information was judged not on how often it was right or how often it was wrong, but on how it provided an economic payoff in the long run.

First let's look at the weather advisor's role in choosing between two alternate air routes. Slide (1) shows the cost due to imperfect knowledge of the wind as a function of the forecast accuracy.

The ordinate is a non-dimensional measure of the cost per trip over and above what it would cost if the winds were known precisely. The abscissa is the correlation between forecast wind and observed wind, with the values of the correlation indicated at the bottom of the diagram.

At the top of the diagram this measure of forecast accuracy has been converted to the ratio of the variance of the vector wind difference between forecast and observed winds, σ_e, to the <u>climatological</u> variance of the wind vector, σ.

The solid sloping lines give the cost versus these measures of forecast accuracy for the different values of a measure of climatological average time difference between the two routes. As



Slide 1 $(c_T/c_r\sigma)$ versus ρ or (σ_e/σ) for various values of $|\bar{u}|$. The heavy dashed line represents the relationship between $(c_T/c_r\sigma)$ for climatology and $|\bar{u}|$.

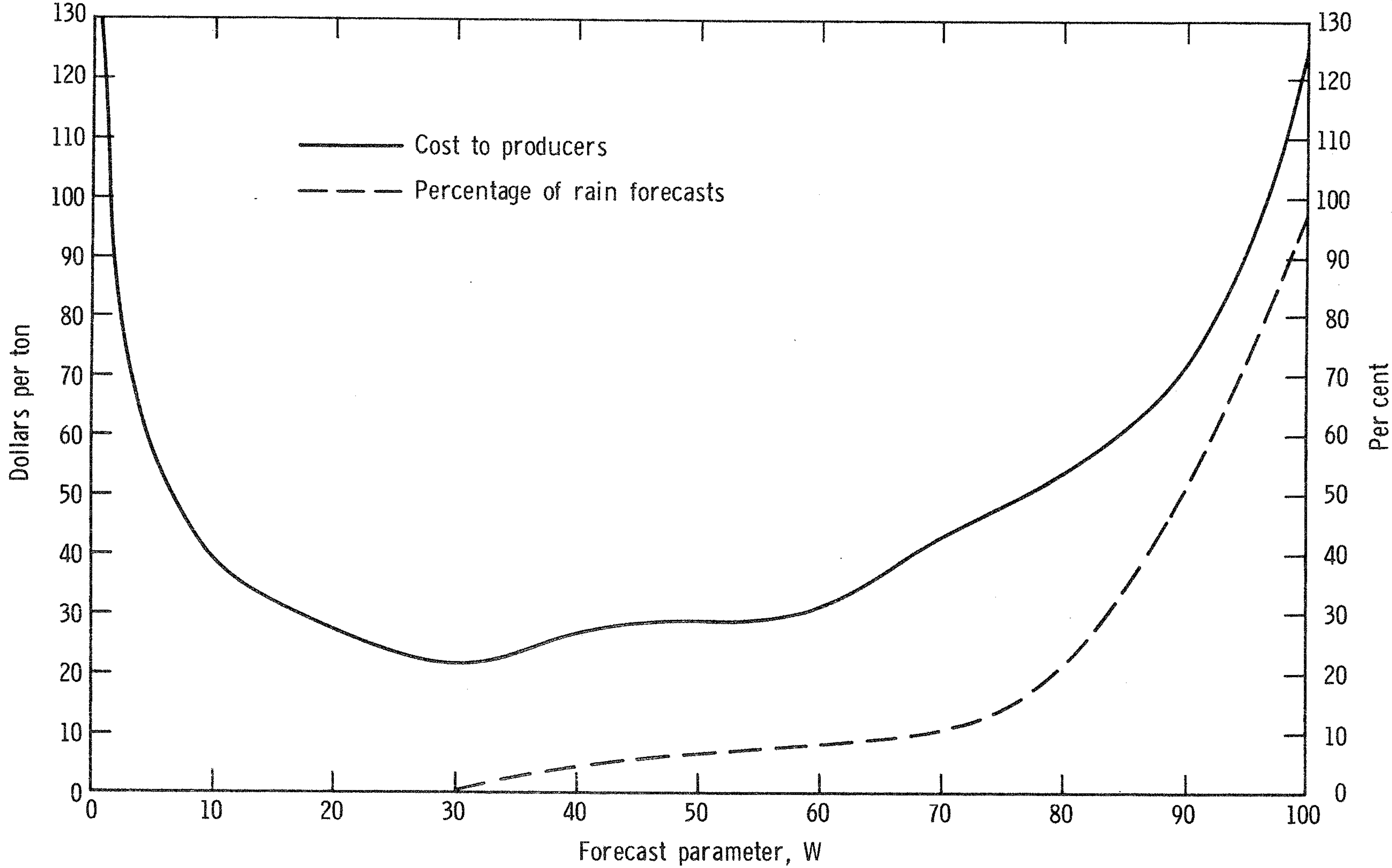
the forecast improves (toward the left), the costs go down. Also as the average time difference between routes increases, the costs go down. This is because, for large average time differences, we could always fly the same route, and be right most of the time.

The dashed line gives the cost versus average time difference, corresponding to the solid lines, between the routes if the route which was better on the average were always chosen. Its intersections with the solid lines are points where this choice of routes and the choice of the forecast fastest route have equal value.

Only forecast procedures which lie above and to the left of the dashed line have any value relative to always flying the route which is faster in the climatological average.

The raisin producer's problem is slightly different. If more than 0.04 inch of rain falls on the grapes which are spread in the sun to become raisins, the entire crop is lost. If the producer expects rain he can take steps to protect the crop. He must spread his grapes to make raisins but he dare not let them get wet -- he has a problem.

The forecasters have produced a statistical analysis of rain in the Fresno area during the drying period which produces a parameter W which is related to the probability of rain. In Slide (2), the dashed curve shows how this parameter is related to the probability of rain. Until W reaches a value of 30, the probability of rain is practically nil. When W has a value of 95, the probability of rain is 70%. If one were trying to make the best forecasts in the sense that one wanted the fewest wrong predictions, then one would not forecast rain unless W were greater than 90. But the economics of protection and crop losses need to be taken into account. The solid curve shows the expected losses to the producer if rain is predicted when W exceeds the value on the abscissa. Thus if rain is not predicted unless W is greater than 90, the producer's expected losses due to protection and to rain losses are about $70 per ton. If, however, rain is predicted whenever W exceeds 30, the expected combined losses are only $21. If rain is forecast whenever W exceeds 30, it will be forecast 6



Cost to producers
Percentage of rain forecasts
Dollars per ton
Per cent
Forecast parameter, W
0
10
20
30
40
50
60
70
80
90
100
110
120
130

Slide 2

times for each observed case of rain. But the well advised producer will be willing to spend the money for protection that is not needed in order to insure that he does not get caught.

There are many such studies that could be carried out; I believe that the Weather Bureau has contracted to have a study done of the construction industry to determine how weather information could be used to the economic advantage of this rather large segment of the economy. There are certainly many problems in agriculture. One large fertilizer company is making use of weather information to advise their clients about the optimum time for planting and the best mixes of fertilizer. All such examples involve the application of economic analysis and decision theory to a measure of the accuracy of the forecast. The analyses are simple in concept, but the basic economic and meteorological data are not easily obtained, and there are many pitfalls to be avoided. It takes a good operations research team to do the job.

SOME HARDER PROBLEMS

There is, however, a large segment of our population that needs weather information; people who should be getting the benefits of our advances in the science of meteorology, and who are not at present noticing the fact that our weather forecasting has improved over the last 20 years. I believe that meteorologists can put their information before the general public much more effectively than they do now. It will require a great deal of research. I think this is something that should perhaps be done, not by meteorologists, but by experts in operations research and communication. Certainly more information is available than the standard, "fair and warmer with scattered showers."

In addition to the general public and their use of weather information there are many small businesses which are vitally dependent on the weather but which are in no position to hire high powered operations research corporations to study their problems. There is much that can be done in the field of recreation. I am

acutely aware, due to my interest in sailing, of the deficiencies of the off-shore weather forecasts in southern California. The off-shore weather forecasts are usually right, but they do not convey to me, or to the general boating public some of the vagaries which are extremely important to a small boat owner. The off-shore weather forecasts generally cover several hundred miles of coastline, whereas the small boat owner is interested in only several tens of miles. I am convinced that a study of the operational problems of the sailor could produce the means of providing him with much better advice without any increase in forecasting skill.

I think it is incumbent upon the meteorological profession, together with operations research, to convey to the public usable information -- not just symbols of its technical proficiency.

REFERENCES

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2. Rapp, R. R., and R. E. Huschke, Weather Information: Its Uses, Actual and Potential, The RAND Corporation, RM-4083-USWB, May 1964.