**OBJECTIVE**

It is the purpose of this paper to outline the breadth

of the field of study which may be called "objective

weather forecasting," to describe in a general way some

of the recent developments in this field, and to indicate

the deficiencies and unanswered questions which have

arisen in such work.

**THE FORECASTING PROBLEM**

**Definition of Objective Weather Forecasting.** In the

history of weather forecasting, attempts have often

been made to devise numerical and objective methods

for producing the forecast. Thus Besson [2] in 1904 and

Taylor [24] and Rolf [20] in 1917 produced graphical

devices for representing lag relationships between selected

weather variables. These studies, in common with

others made in later years [4, 12, 14, 15, 27], have attempted

to provide an equation or a graphical device

of some form which would be useful in applying a particular

relationship or combination of relationships to

the problem of making a forecast. The distinction between

an objective forecasting procedure and a procedure

which depends on subjective judgments and

subjective experience has not been sharply defined, nor

is it intended in this paper to advocate a rigid definition.

The purpose of this review will be served by defining an

objective forecasting system as any method of deriving

a forecast which does not depend for its accuracy upon

the forecasting experience or the subjective judgment

of the meteorologist using it. Strictly speaking, an objective

system is one which can produce one and only

one forecast from a specific set of data. From the practica!

standpoint it appears reasonable to include as

objective, however, those forecasts which require meteorologica!

training insofar as such training is standardized

and is itself based upon a study of well-founded

physical principles and atmospheric models which are

commonly recognized from the facts of observation. It

would be throwing away information of demonstrated

value in forecasting if, for example, an objective forecasting

system were not permitted to make use of isobaric

patterns on analyzed maps because of the objection

that they are arrived at subjectively. The test of

whether a system is objective is whether different ·

meteorologists using the system independently arrive

at the same forecast from a given set of maps and data.

**Goals of Objective Forecasting Investigations.** The

obvious ultimate goal of forecasting investigations is to

enable the forecaster to increase the accuracy of forecasts

made routinely. Contributions toward this end

may be made in several ways. The forecaster may

study the physical characteristics of the atmosphere,

especially the dynamic relationships which have been

derived on the hasis of simplifying assumptions. Such

study may enable him, in the course of analyzing given

situations, to recognize processes in the real atmosphere

which have been described analytically, and in

such cases he will know better what to expect of the

atmosphere in the immediate future. The success of

this method of attack depends on the skill of the theoretical

meteorologist in describing the real atmosphere

when he sets up a model and makes simplifying assumptions,

and on the skill of the forecaster in diagnosing

the present sequence of events in the atmosphere, selecting

the theoretical processes which are most nearly

applicable, and judging what modifications are necessary

in individual instances.

On the other hand, the forecaster may search for empirica!

relationships between observable characteristics

of the atmosphere, and with little or no reference to the

physical validity of the relationships, make use of them

in forecasting. Many forecasters gain a high degree of

skill after many years of experience because of this

second factor, but skill obtained in this way is difficult

to transfer from place to place or from individual to

individual. It appears certain, furthermore, that some

forecasters base forecasts in large part on hypothetical

relationships that have neither a physical nor a statistica!

hasis and that cannot even be expressed in

objective or quantitative terms. In such a case, it is

impossible to discover from data whether or not these

relationships exist in the atmosphere.

Ideas for testing and possible incorporation into an

objective system can come from several sources: by

testing new theoretical concepts for their possible contribution

to forecasting practice and providing objective

ways to use the results; and by testing, combining,

and systematizing the use of rules and principles which

ha ve been discovered orare already used by experienced

forecasters.

The goal of objective forecasting is simply to eliminate

as many as possible of the subjective elements which

enter into the *application to forecasting* of the results of

such studies. Objective forecasting is not so much concerned

with the source of hypothetical relationships as

it is with the practica! value of the ideas and the extent

to which they contribute to the accuracy of forecasts.

Objective forecasting studies and research projects

which aim to develop objective methods or objective aids

to forecasting are characterized by the use of historical

data to demonstrate the reliability of forecasting rela-

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H. R. Byers et al., *Compendium of Meteorology*

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tionships, and by the expression of the forecast itself in

quantitative terms or at least in unequivocal terms.

Fear has sometimes been expressed by forecasters that

a result of the development of objective forecasting

methods will be to supplant experienced forecasters by

mechanical methods. It should be obvious, however,

that the greater the reduction in the number of subjective

and uncertain decisions required in the process of

preparing the forecast, the more time will be available

to the forecaster either for studying the effect of new

and untried variables and the value of new principles,

or for interpreting the forecast for the exceedingly diverse

uses to which it is applied by the public.

From the standpoint of discovering and understanding

relationships which hold in the atmosphere, forecasting

investigations have been relatively ineffective

because of their stress on lag relationships, and it seems

clear that only a complete physical explanation of the

atmosphere together with complete observational data

will make it possible to produce perfect weather forecasts.

Practically, however, uncertainties exist which

make the maximum attainable accuracy something less

than perfection [22]. The forecasting problem is thus,

in essence, one of estimating what is likely to occur with

any given state of the atmosphere and its environment.

More precisely, the problem is to state the probability

that any specified weather event will occur within any

specified time interval.

The statistica! or probability aspect of weather forecasting

was recognized as early as 1902 by Dines [7],

who pointed out the impossibiliţy of knowing exactly

what weather is going to occur and suggested that the

laws of chance should be applied. Hallenbeck [9] in

1920 found an encouraging response from the public

when he attempted the use of numerical probability

statements as part of his agricultura! forecasts. It seems

to ha ve been only recently, however, that this objective

has been recognized by a large group of meteorologists

and that attempts have been made to apply the methods

of mathematical statistics or to develop new methods

suitable for the estimation of forecast probabilities

[5, 25]. Since the public generally has demanded categorica!

forecasts, attempts to express the "chances"

of a weather event occurring ha ve usually been frowned

upon by forecasters. N early every decision the forecaster

is called upon to make, however, involves weighing

the chance as indicated by one set of factors against

the chance as indicated by one or more other sets.

Objective forecasting studies have not often provided

final, conclusive evidence of the chance of occurrence

of the weather event in question, but such studies have

reduced the uncertainty to quantitative and understandable

terms, and it is one purpose of such studies to

determine the actual frequency with which any sequence

of events which it may be desired to specify can

be expected to occur.

**Limitations of Objective Forecasting.** Some of the

objective forecastingmethods which ha ve been developed

[1, 8, 17] have demonstrated a rather clear superiority

to forecasts made by conventional methods under rautine

operational conditions. The question then arises,

why have forecasters generally not seized wholeheartedly

the opportunities offered by these methods of

investigation for improving their own forecasts? There

are a number of reasons, based partly upon misunderstanding

of the methods and accomplishments of objective

forecasting, but based more largely on the limitations

of objective forecasting under the present

organization of forecasting services.

One criticism often made is that objective methods do

not take account of all of the pertinent variables nor of

all the characteristics of the weather situation which

help in judging the weather to carne. This deficiency is

certainly true of most, if not all, of the systems which

have been published, but it is less a criticism of objective

forecasting as such than it is an admission that

items are used in forecasting which the forecaster cannot

express objectively or quantitatively. The extent

to which present forecasting knowledge is real knowledge

as distinct from lore may be judged in part by the

extent to which forecasters have been able to incorporate

it into objective systems or have been able to write

it down in a form which can readily be taught to

students of forecasting. It is one of the goals of objective

forecasting studies to collect and systematize this

knowledge so it will be available for study and subsequent

use by any forecaster, but major problems are

encountered at this point. Even a relatively inexperienced

forecaster has an ability to find in a given

weather situation features which appear to be significant

for the forecast, but which are extremely difficult

to express in any objective way. Methods must be

devised to take into account these more tenuous concepts

and features of the atmosphere and to separate

the real relationships from the fictitious.

The time required to work out a forecast by objective

techniques is a limitation on the use of such techniques

in many offices. The organization of forecasting services

is generally centralized to reduce the work of plotting

and analyzing the numerous maps and charts required

for forecasting and to make it possible to utilize the

best forecasters to cover the widest possible area. This

generally results in the forecaster's being faced with

tight schedules and gives him a totally inadequate

amount of time to spend in actual preparation of the

forecast. In spite of the success of simplified objective

methods in equalling the accuracy of conventional forecasting

procedures, it is suspected that forecasts which

are improved to any great extent over present levels of

accuracy will be produced, for the most part, only by

methods which require a longer time to apply and

which, therefore, cannot conveniently be used by forecasters

at present.

One characteristic requirement of present-day forecasts

which are issued to the public is that a definite

bias must frequently be introduced into the forecast,

or in other words, the forecaster must not state exactly

what he thinks is most likely to happen. For example,

the bare mention of rainfall in a public forecast will

often be construed by the public as a forecast of rain

no matter how the forecaster qualifies the statement.

If the occurrence or nonoccurrence of rain is an un