Probabilistic Forecasts in Practice

Weather forecasts that are provided in the form of probabilities are much more useful for practical decision-making than single-valued ("deterministic") forecasts, because probabilistic forecasts supply information about the likelihood of potential outcomes. When the probability of different outcomes is combined with the financial or cost implications of those outcomes, the result is a powerful tool for risk management through informed decision-making. This document explains the simple process of using a probabilistic forecast to make day-to-day decisions about weather-sensitive operations.

Consider a small business whose primary activity is dependent on having dry weather in order to operate profitably. A company that pours concrete will serve as a good example. Each day, the business owner uses a weather forecast to decide whether or not to proceed with normal operations for the day. If the forecast suggests wet weather, the owner may decide to postpone concrete-pouring until the next day, but if the forecast suggests fine weather, normal operations will proceed. Either decision carries some risk, because the weather may turn out differently from the owner's expectation. In this example, a significant financial loss may be incurred if unexpected rain occurs during or after a concrete pour. On the other hand, the decision to sit idle will create an unnecessary loss if the weather turns out fine.

How is the business owner to make this decision? In many instances, the business owner will know from experience when it is safe to proceed with a pour, and when to postpone. However, ***a probabilistic forecast provides the necessary information to make the precisely correct decision.*** A simple calculation using the profit and loss information from the business, together with the probabilistic forecast, provides the exact answer.

Three pieces of financial data are needed from the business, as follows:

- L is the loss that occurs when operations proceed but rain occurs
- P is the profit that occurs when operations proceed and rain does not occur
- C is the cost of postponing operations (e.g. overhead expenses, salaries)

A probabilistic weather forecast is also needed:

- R is the forecast probability of rain occurring

The expected profit if the business owner proceeds with operations is:

$$P_{proceed} = (1 - R)P - RL$$

The expected profit if the business owner postpones operations is:

$$P_{postpone} = -C$$

Therefore the business owner should proceed if, and only if,

$$P_{proceed} > P_{postpone}, \text{ or}$$
$$(1 - R)P - RL > -C$$
$$-R(P + L) > -(C + P)$$

Condition to proceed: $\boxed{R < \frac{(C+P)}{(L+P)}}$ (1)

Conversely, the business owner should postpone operations if

Condition to postpone: $R > \frac{(C+P)}{(L+P)}$

Consider two examples of specific profit-loss scenarios. In the first, a “high-risk” scenario, the loss from unexpected rain is severe: L=$3000, P=$1000, C=$500.

In this case, the owner should proceed if R<0.375 (37.5%), and postpone if R>0.375 (37.5%). Note that if this business operates in a rainy area, where rain is likely on many days, business will often be postponed.

In the second example, a “low-risk” scenario, the loss from unexpected rain is not severe, but the cost of postponing operations is relatively large: L=$1500, P=$1000, C=$1000.

In this case, the owner should proceed if R<0.8, and postpone if R>0.8. This business scenario is quite tolerant of high rainfall probabilities; rainfall is not a major risk.

Note that if C>L, operations should always proceed regardless of the forecast, because it costs more to postpone than would be lost in an unexpected rain event.

The very same calculation can be performed for any business decision in which the possibility of a weather-related loss is associated with one decision, and the loss can be avoided by making the alternative decision. For example, a lemonade stand may find that the daily high temperature is the key weather variable that affects profitability. If the stand opens and the high temperature exceeds 70 °F, a profit P is obtained. If the stand opens and the high temperature does not exceed 70 °F, a loss L is incurred from wasted lemonade and other expenses. If the stand does not open, a cost C may be incurred. In this example, a probabilistic temperature forecast is used to decide whether or not to open the stand; the forecast must provide the probability of the temperature exceeding (or, in this case, failing to exceed) 70 °F. As before, equation (1) is used to compute the threshold probability for making the decision.

Note that the same equation (1) can be used if the cost C is zero.

In summary, the following steps describe the process that is needed to profitably use probabilistic weather forecasts.

1. Identify a weather event that adversely affects the financial outcome of your business activity. This must be a discrete "yes/no" event that may or may not occur in a specified time period. As described in this document, the "yes" outcome is unfavorable and the "no" outcome is favorable. A reliable[1] probabilistic weather forecast must also be available for this particular event.

2. Compute L, P, and C from the financial history of your business. In the generic case, these metrics are identified as follows:
   - L is the loss that will occur if business proceeds as normal, but the unfavorable weather event occurs.
   - P is the profit that will occur if business proceeds as normal, and favorable weather occurs.
   - C is the cost of disrupting or postponing business in anticipation of unfavorable weather.

3. Use equation (1) to compute the probability threshold to use in making the "go/no-go" decision. When the forecast probability of the unfavorable weather event occurring is less than R, proceed with business as normal. When the forecast probability of the unfavorable weather event occurring is greater than R, take alternative action to avoid the potential loss.

[1] A probabilistic forecast is "reliable" if the stated probability corresponds to the true likelihood of the event occurring. For example, if a reliable forecast states that the probability of rain is 50%, then rain will actually occur on half (50%) of all days having such a forecast. If a reliable forecast provides a probability of 90%, then rain will actually occur on 9 out of 10 such days. Not all forecast providers ensure that their probabilities are reliable.

To assist in using this information, Next Generation Weather provides an online calculator to compute the threshold probability for your business scenario at:

www.nextgenerationweather.com/calculator

To discuss in detail the use of probabilistic weather forecasts for your business environment, or to investigate customized solutions, contact Dr. Richard James at:

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