Climate Information Quality Assurance and SEB

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Outline

- Perspective - Principles, conceptual framing, goals of verification and SEB Assessment
- General framework for verification (Quality assessment for valuing forecasts)
- Summary and Conclusion

Perspective - Principles, conceptual framing, goals of verification and SEB Assessment

Conceptual Framing

- Challenge to demonstrate value through ability to accurately forecast weather parameters
- Focus on devising "verification systems" aimed at assessing accuracy of forecast
- High verification score does not necessary imply economically useful forecasts
- Method of analysis to measure the economic utility of the forecast should consist of a verification procedure based on the operational risks involved in taking protective measures against' adverse weather.
- Forecasting accuracy linked synonymously with economic usefulness provides a framework for assessing SEB of forecasts

The meaning of ‘Value’

- “Weather forecasts possess no intrinsic value in an economic sense. They acquire value by influencing the behaviour of individuals or organizations (“users”) whose activities are sensitive to weather.”
  - Allan Murphy, Conference on economic benefits of Meteorological and Hydrological services (Geneva, 1994)

Types of "Value"

- Social value - Minimization of Hazards to human life and health
  - Value to individual users
- Economic value of forecasts
  - Value to a specific business
  - Value to a weather-sensitive industry
  - Value to a weather-sensitive sector
  - Value to the economy of a country
  - Market value (e.g. futures)
- Environmental value
  - minimizing risk to the environment
  - optimal use of resources

Value vs. Quality

- Quality refers only to forecast verification; Value implicates a user
- A perfect forecast may have no value if no one cares about it
- An imperfect forecast will have less value than a perfect forecast

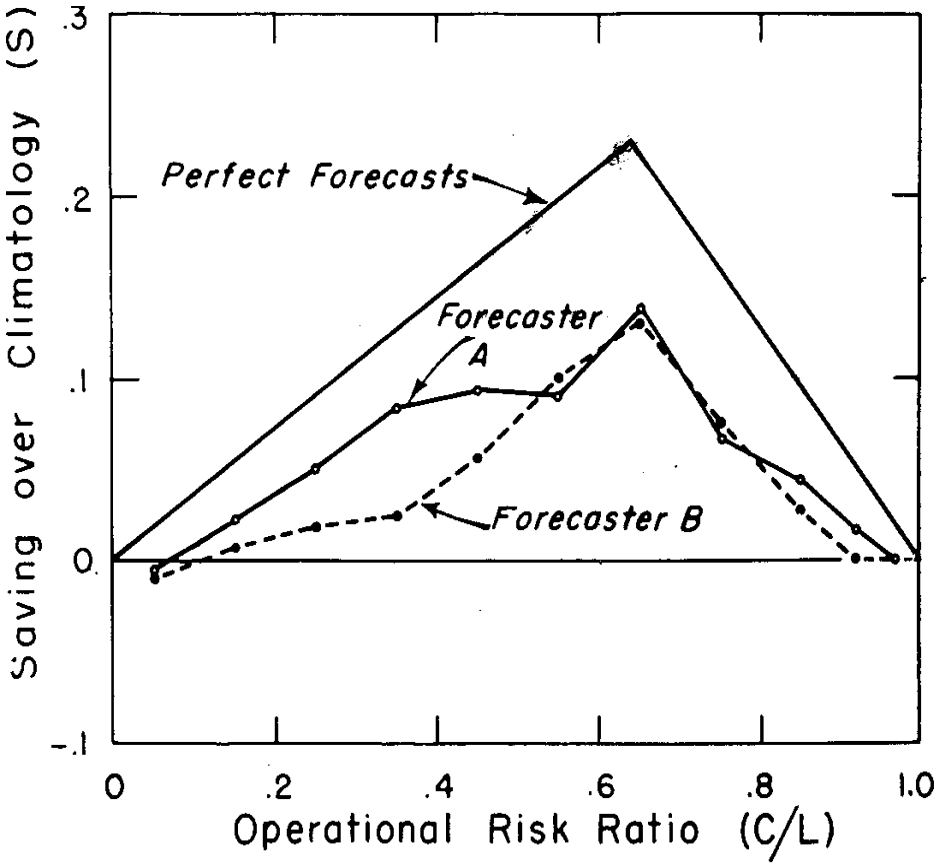
Measuring value

- The cost-loss decision model
  - focus on maximizing gain or loss-avoidance
  - requires objective cost information from user
  - user specific, difficult to generalize
  - economic value to weather-sensitive operation only
  - easy to evaluate relative value
- Contingent-valuation method
  - focuses on demand for service and “willingness to pay”
  - requires surveys of users to determine variations in demand as function of variations in price and/or quality of service
  - less user-specific; a larger crossection of users/industries can be evaluated in one study
  - measures in terms of perception rather than actual accuracy.
  - e.g. evaluation of ATADs, Rollins and Shaykewich, Met Apps Mar. 03

Cost-Loss Framework
Economic Decision Criterion

- Problem of deciding whether or not to take protective measures against a certain adverse weather element
- Forecasts probability (P) is linked to cost of taking a protective action (C) and Loss due to inaction (L)
- Take protective measures if some economic gain will be realized:
  - $P > C/L$ – *take protective action*
  - $P < C/L$ – *take no protective action*
  - $P = C/L$ – *either course*
  - $O \leq C/L \leq 1$

Reference framework



- Climatological probability - the climatological relative frequency of the occurrence of a weather/climate event
- A forecasts has value over climatology when its value is greater than zero

Figure 1. Saving over climatology for a series of experimental probability predictions made by two different forecasters, **A** and B.

General framework for verification - Quality assessment for valuing forecasts

Goals of Verification

- Administrative
  - Justify cost of provision of weather services
  - Justify additional or new equipment
  - Monitor the quality of forecasts and track changes
- Scientific
  - To identify the strengths and weaknesses of a forecast product in sufficient detail that actions can be specified that will lead to improvements in the product, ie to provide information to direct R&D.

Evaluation of forecasts

- Murphy's "goodness"
  - CONSISTENCY: forecasts agree with forecaster's true belief about the future weather [*strictly proper*]
  - QUALITY: correspondence between observations and forecasts [*verification*]
  - VALUE: increase or decrease in economic or other kind of value to someone as a result of using the forecast [*decision theory*]

Evaluation of forecast system

- Evaluation of forecast “goodness”
- Evaluation of delivery system
  - timeliness (are forecasts issued in time to be useful?)
  - relevence (are forecasts delivered to intended users in a form they can understand and use?)
  - robustness (level of errors or failures in the delivery of forecasts)

Principles of (Objective) Verification

- Verification activity has value only if the information generated leads to a decision about the forecast or system being verified
  - User of the information must be identified
  - Purpose of the verification must be known in advance
- No single verification measure provides complete information about the quality of a forecast product.
- Forecast must be stated in such a way that it can be verified
  - “chance” of showers
  - What does that gridpoint value really mean?
- Except for specific validation studies, verification should be carried out independently of the issuer of the product.

Verification Model

- Predictand Types
  - Continuous: Forecast is a specific value of the variable
    - wind
    - temperature
    - upper air variables
  - Categorical/probabilistic: Forecast is the probability of occurrence of ranges of values of the variable (categories)
    - Precipitation type
    - cloud amount
    - precipitation amount
  - Probability distributions (ensembles)

ATTRIBUTE	DEFINITION	RELATED MEASURES
1. Bias	Correspondence between mean forecast and mean observation	bias (mean forecast probability-sample observed frequency)
2. Association	Strength of linear relationship between pairs of forecasts and observations	covariance, correlation
3. Accuracy	Average correspondence between individual pairs of observations and forecasts	mean absolute error (MAE), mean squared error (MSE), root mean squared error, Brier score (BS)
4. Skill	Accuracy of forecasts relative to accuracy of forecasts produced by a standard method	Brier skill score, others in the usual format

ATTRIBUTE	DEFINITION	RELATED MEASURES
5. Reliability	Correspondence of conditional mean observation and conditioning forecast, averaged over all forecasts	Reliability component of BS, MAE, MSE of binned data from reliability table.
6. Resolution	Difference between conditional mean observation and unconditional mean observation, averaged over all forecasts.	Resolution component of BS
7. Sharpness	Variability of forecasts as described by distribution of forecasts	Variance of forecasts
8. Discrimination	Difference between conditional mean forecast and unconditional mean forecast, averaged over all observations	Area under ROC, measures of separation of conditional distributions; MAE,MSE of scatter plot, binned by observation value
9. Uncertainty	Variability of observations as described by the distribution of observations	Variance of observations

Summary and Conclusion

Issues on Value of Forecasts and Decisions

- The economic advantages inherent in the use of forecasts are undeniable
- Challenges with issuance of forecasts for general public use:
  - lack of experience on the part of forecasters in issuing probability forecast
  - need for public education regarding their use
  - technical difficulties arising from the necessity for simplifying a somewhat complex concept without invalidating certain basic principles.
  - reliance on forecasters to make operational decisions