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 necessarily 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 crosssection 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:
  - $P > \frac{C}{L}$ – take protective action
  - $P < \frac{C}{L}$ – take no protective action
  - $P = \frac{C}{L}$ – either course
  - $0 \leq \frac{C}{L} \leq 1$
Reference framework

- Climatological probability - the climatological relative frequency of the occurrence of a weather/climate event
- A forecast 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?)
  – relevance (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)**
<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>DEFINITION</th>
<th>RELATED MEASURES</th>
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</thead>
<tbody>
<tr>
<td>1. Bias</td>
<td>Correspondence between mean forecast and mean observation</td>
<td>bias (mean forecast probability-sample observed frequency)</td>
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<td>2. Association</td>
<td>Strength of linear relationship between pairs of forecasts and observations</td>
<td>covariance, correlation</td>
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<td>3. Accuracy</td>
<td>Average correspondence between individual pairs of observations and forecasts</td>
<td>mean absolute error (MAE), mean squared error (MSE), root mean squared error, Brier score (BS)</td>
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<td>4. Skill</td>
<td>Accuracy of forecasts relative to accuracy of forecasts produced by a standard method</td>
<td>Brier skill score, others in the usual format</td>
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<td>5. Reliability</td>
<td>Correspondence of conditional mean observation and conditioning forecast, averaged over all forecasts</td>
<td>Reliability component of BS, MAE, MSE of binned data from reliability table.</td>
</tr>
<tr>
<td>6. Resolution</td>
<td>Difference between conditional mean observation and unconditional mean observation, averaged over all forecasts.</td>
<td>Resolution component of BS</td>
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<td>7. Sharpness</td>
<td>Variability of forecasts as described by distribution of forecasts</td>
<td>Variance of forecasts</td>
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<tr>
<td>8. Discrimination</td>
<td>Difference between conditional mean forecast and unconditional mean forecast, averaged over all observations</td>
<td>Area under ROC, measures of separation of conditional distributions; MAE,MSE of scatter plot, binned by observation value</td>
</tr>
<tr>
<td>9. Uncertainty</td>
<td>Variability of observations as described by the distribution of observations</td>
<td>Variance of observations</td>
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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