Principles of Retrospective Decision Analysis

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Motivation

How do we evaluate management responses to forecast information?

What is the best response to a forecast?

How do we factor the inherent uncertainty of seasonal forecasts into recommendations?

How to we attribute value to a forecast system, or compare forecast systems?
Model-based vs. Descriptive Analysis

**Ex-ante**, model-based valuation

<Assess potential impacts before they are realized.

<Based on:

– models of what decision makers are expected to do
– elicited rules of what they think they would do

**Ex-post**, descriptive valuation

<Estimate observed impacts

<May require model-based analyses to supplement observation
Climate and impacts are probabilistic

Uncertainty is a characteristic of decisions
  <Does a good outcome = a good decision?  
  <Does a poor outcome = a poor decision?

Must understand uncertainty of forecast climate and agricultural impacts

Must understand decision outcomes over a range of variability
Optimal Climate Information Use

Some Notation

Utility function \( U(w) \)

Climate distributions \( f(2) \) (climatology \( C \)) & \( g(2|F_j) \)
(conditioned on forecast \( F_j \))
2 is a realization of weather or seasonal mean

Strategy, or vector of decisions \( \mathbf{x} \)
\( \mathbf{x}^* \) denotes the optimal strategy

Environment (everything else) \( \mathbf{e}_t \)

Returns \( w_i(\mathbf{x}, 2, \mathbf{e}_i) = w_{i-1} + A_i(\mathbf{x}, 2, \mathbf{e}_i) \),
a function of decisions, weather, environment
Optimal Climate Information Use

Decision Rule, Climatology

Maximize

\[
E\{U(w)\} = \int U(w(x, 2, e_{\text{now}})) f(2) \, d2
\]

...subject to constraints

Equivalently, maximize \( w_{CE} \)

Single (fixed) optimal strategy / \( x^*|C \)
For each $F_j$, maximize

$$E\{U(w|F_j)\} = \int U(w(x, 2, e_{\text{now}})) g(2|F_j) \, d2$$

$$n_j^{-1} \sum U(w_i(x_j, 2_i|F_j, e_{\text{now}}))$$

subject to constraints

Multiple (flexible) optimal strategies $x^*|F_j$

must evaluate for every $F$
“Climate forecasts have no intrinsic value” (Graeme Hammer).
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Outcomes of improved decisions do.
Economists define the value of information as the expected outcome of best decisions using the new information minus the expected outcome of best decisions in the absence of the new information.
**Objective**: difference in expected returns:

\[ V = E\{W(x^*|F)\} - E\{W(x^*|C)\} \]

\[ = n^{-1} \sum (W_i(x^*|F_i, 2_i) - W_i(x^*|C, 2_i)) \]

**Subjective**: difference in CE:

\[ V = W_{CE}(x^*|F) - W_{CE}(x^*|C) \]

\[ = U^{-1}(n^{-1} \sum U(W_i(x^*|F_i, 2_i))) - U^{-1}(n^{-1} \sum U(W_i(x^*|C, 2_i))) \]

**Can consider value realized in a particular season, can be positive or negative**
Value of Forecast Information

Assumptions

P“Value” assumes:

<Optimal use of forecast and climatology
<Utility function captures relevant goals
<Realistic constraints
<Ability to predict outcome distribution as a function of forecast or observed climatological distribution
<Subjective uncertainty = “objective” distribution

Potential value of optimal use of climate information in the model system
Applying Forecast Value

Basis for answering:

- What decisions are most sensitive to forecasts?
- Relative value of forecast systems or formats?
- Relative importance of various components of forecast quality, e.g., skill vs. lead time?

Optimal strategies an entry point for stakeholder discussion or further research

Only way to estimate potential benefit before asking stakeholders to risk livelihoods.
The formulation presented here is only a generic framework. Several methods are available for analyzing decisions. The method should be appropriate for the nature of the decision and the system being managed.
Nature of the Decision

- Discrete or continuous decision variables?
- Determined by continuous climatic states or thresholds?
- Static or dynamic?
- Profit maximizing or risk averse?
- Single or multiple objectives?
- Single or multiple decision makers?
- Are climate and outcomes closely linked?
System Levels

PField level, e.g., crop management
PFarm level, e.g., resource allocation
PHousehold level, e.g. livelihood decisions
PCommunity level, e.g. Florida potato farmers clearing drainage canals
PWatershed level, e.g., irrigation distribution
PSub-national level, e.g., food reserves
PNational level, e.g., requests for food aid
Use the simplest analytical framework that captures the important determinants of the decision problem.