Probability Forecasting

Ken Mylne
Risk Estimation using Ensemble Prediction
Probability Forecasting for Extreme Events
Decision-making with Low Probability
Questions and answers
Ensemble prediction System (EPS)

- Example from ECMWF 51-member medium-range ensemble
- Several global ensembles around the world
  - Combined to form multi-model ensembles - tool for global disaster prediction (eg. WMO THORPEX Programme)
Ensembles – estimating risk

By running model(s) many times with small differences in initial conditions (and model formulation) we can:

- take account of uncertainty
- estimate probabilities and risks
  - eg. 10 members out of 50 = 20%
Products for the Risk Manager

- Plot of ensemble spread
- Probability graph for multiple severity thresholds
Tropical Cyclones

- Graphics of:
  - tracks
  - strike probabilities

20040812 00 UTC
Probability that CHARLEY will pass within 120km radius during the next 120 hours
tracks: black=OPER, green=CTRL, blue=EPS numbers: observed positions at t+..h
Example Summary of Ensemble Risks

- Threats assessment produced by forecasters in US
Severe weather prediction difficult because:

- Model may not resolve severity of event
- Development often involves complex interaction of several elements
- Need to get all these elements right in combination
  - chance of categorical success is low
  - Ensemble *should* offer a solution

- Rare events mean few test cases, so difficult to
  - Verify (assess) quality of forecasts
  - Calibrate – correct for systematic errors
Increased uncertainty in extreme events

- This example was for a recent storm over the UK (8 Jan 2005)
- Large uncertainty in details for a 36 hour forecast
Early Warnings of Severe Weather (UK)

Met Office issues Early Warnings up to 5 days ahead - when probability $\geq 60\%$ of disruption due to:

- **Severe Gales**
- **Heavy rain**
- **Heavy Snow**

- Forecasters Provided with alerts and guidance from EPS

- Events NOT on disaster scale but this is a first attempt to estimate probabilities for real warnings
RECOMMEND ISSUE OF A WARNING

Probability % of event by region between 1800 07 JAN 2005 and 1200 08 JAN 2005
Prob. of event occurring anywhere in the UK is 80%

<table>
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<tr>
<th>Region</th>
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Event: SEVERE GALES - gusts of at least 70mph

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Verification

- Good relationship between forecast probability and frequency of occurrence
  - Most severe events can be forecast, but at low probabilities
- False alarms
  - For each correct low probability warning, several false alarms are also issued
1% risk that a plane will crash - *would you board it?*

Compared with climatology: **HIGH RISK**  
1 in 100 >> 1 in 7,000,000

Cost / Loss: Possible loss is much higher than the cost of protective action

Cost protective action = *plane ticket:* ~ $500  
Possible loss = *life!* ~ $1,000,000+  
\[ C/L = \frac{500}{1,000,000} = 0.0005 \]

Averaged over many occasions, the user’s best strategy is to:  
protect when \[ p(\text{event}) > C/L \]
In this case \[ p=0.01 >> C/L=0.0005 \]

We have to be prepared to take action even at low probabilities!!
False alarms

- Using low probabilities means we *will* be subject to False Alarms
  - 99% chance it will not happen in plane crash example

- If the user is liable to suffer a large loss, they may accept false alarms for the large benefit of being prepared when the event does occur.
  - Public education required
Example – Indian Ocean Tsunamis

Cost of False Alarm:
- Damage to tourism industry
- Possible loss of confidence
  - Requires public education
Loss of Missed Event:
- Many thousands of lives
- Many more injured

Earthquake detected

Tsunami risk high

Issue warning

No tsunami?

Explain C/L

Manage future expectations

C/L small
Conclusions

- Weather prediction difficult for extreme events
  - Ensemble prediction offers risk assessment
- Capability to forecast probabilities of severe events has been demonstrated
- Most events predicted at *low probabilities*
- Need to develop decision-strategies to make effective use of low probability warnings
  - Levels of preparedness
  - Cost/loss risk assessment
- Effective planning requires close collaboration between:
  - Forecasters to interpret ensembles and estimate risks
  - Emergency planners to develop responses
  - Meteorological community can offer effective 24/7 communications to disseminate warnings
Questions & Answers