Probability Forecasting

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Outline

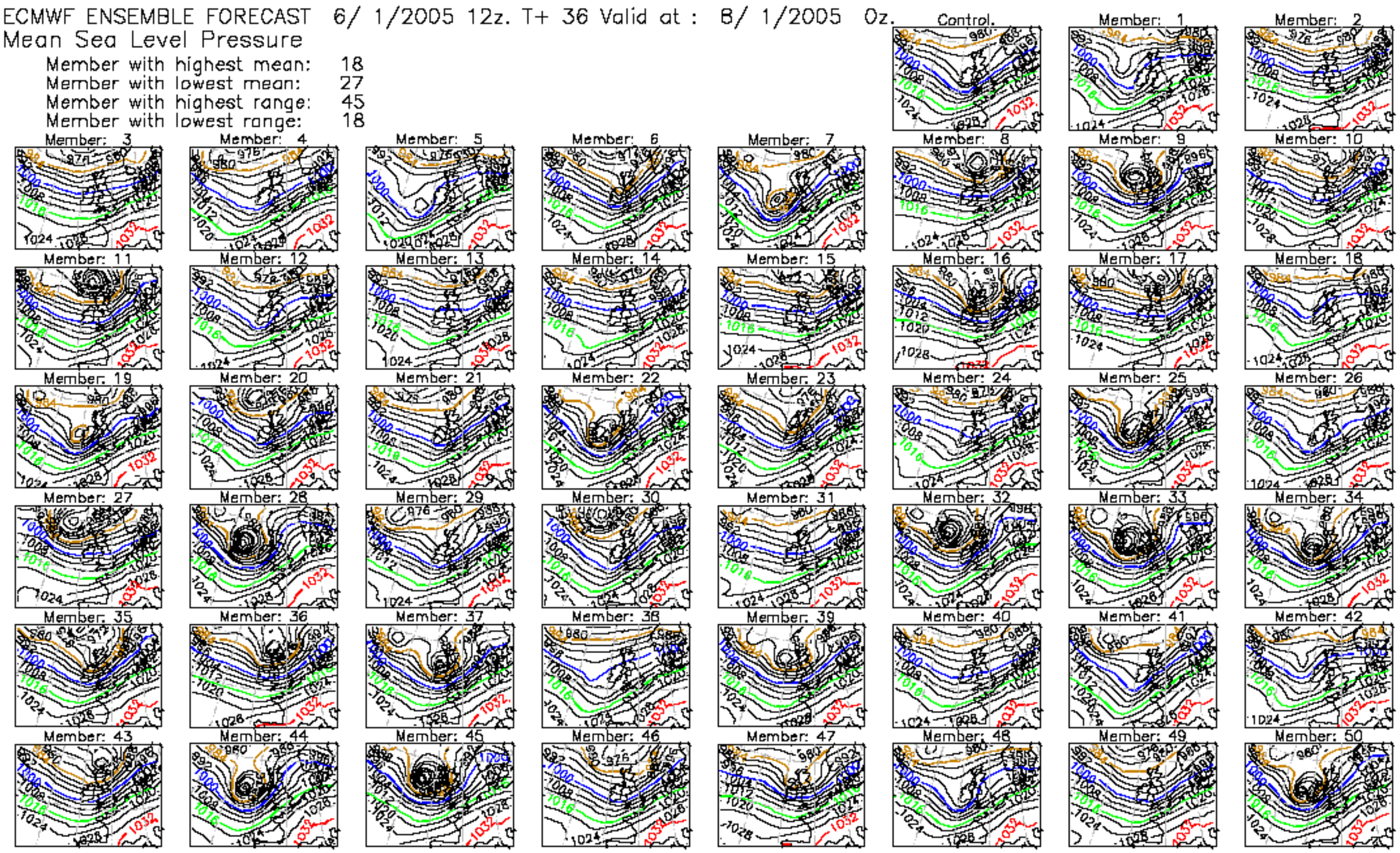
Risk Estimation using Ensemble Prediction

Probability Forecasting for Extreme Events

Decision-making with Low Probability

Questions and answers

Ensemble prediction System (EPS)

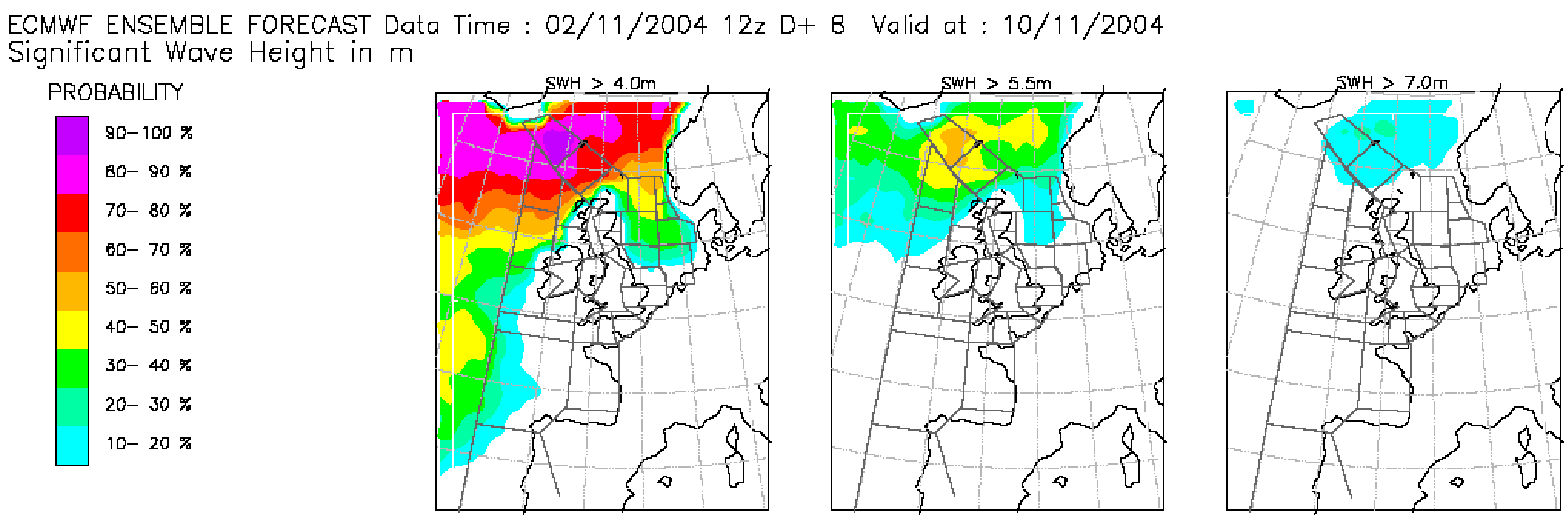


- Example from ECMWF 51-member medium-range ensemble
- Several global ensembles around the world
  - Combined to form multi-model ensembles - tool for global disaster prediction (eg. WMO THORPEX Programme)

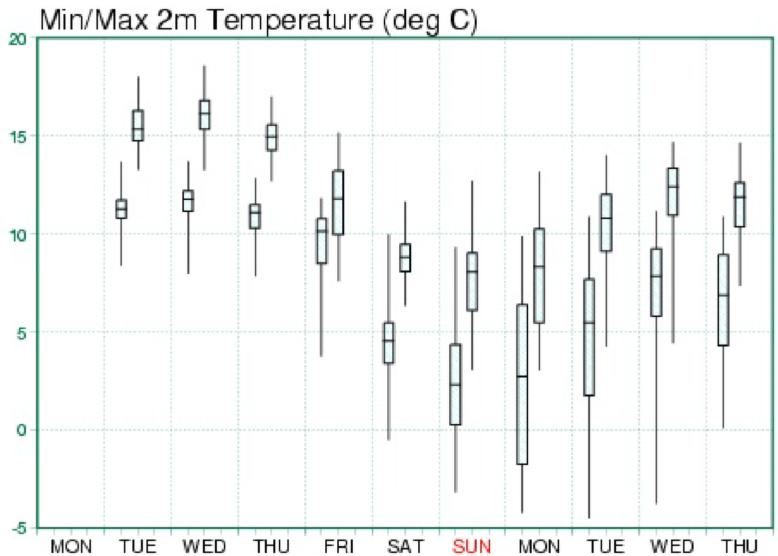
Ensembles – estimating risk

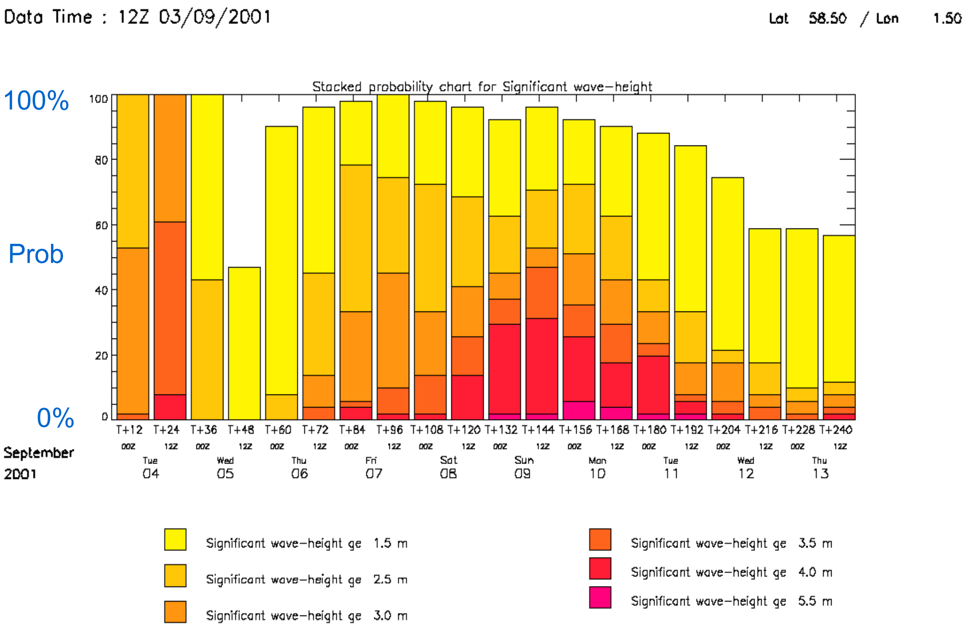
By running model(s) many times with small differences in initial conditions (and model formulation) we can:

- take account of uncertainty
- estimate probabilities and risks
    - eg. 10 members out of 50 = 20%



Products for the Risk Manager

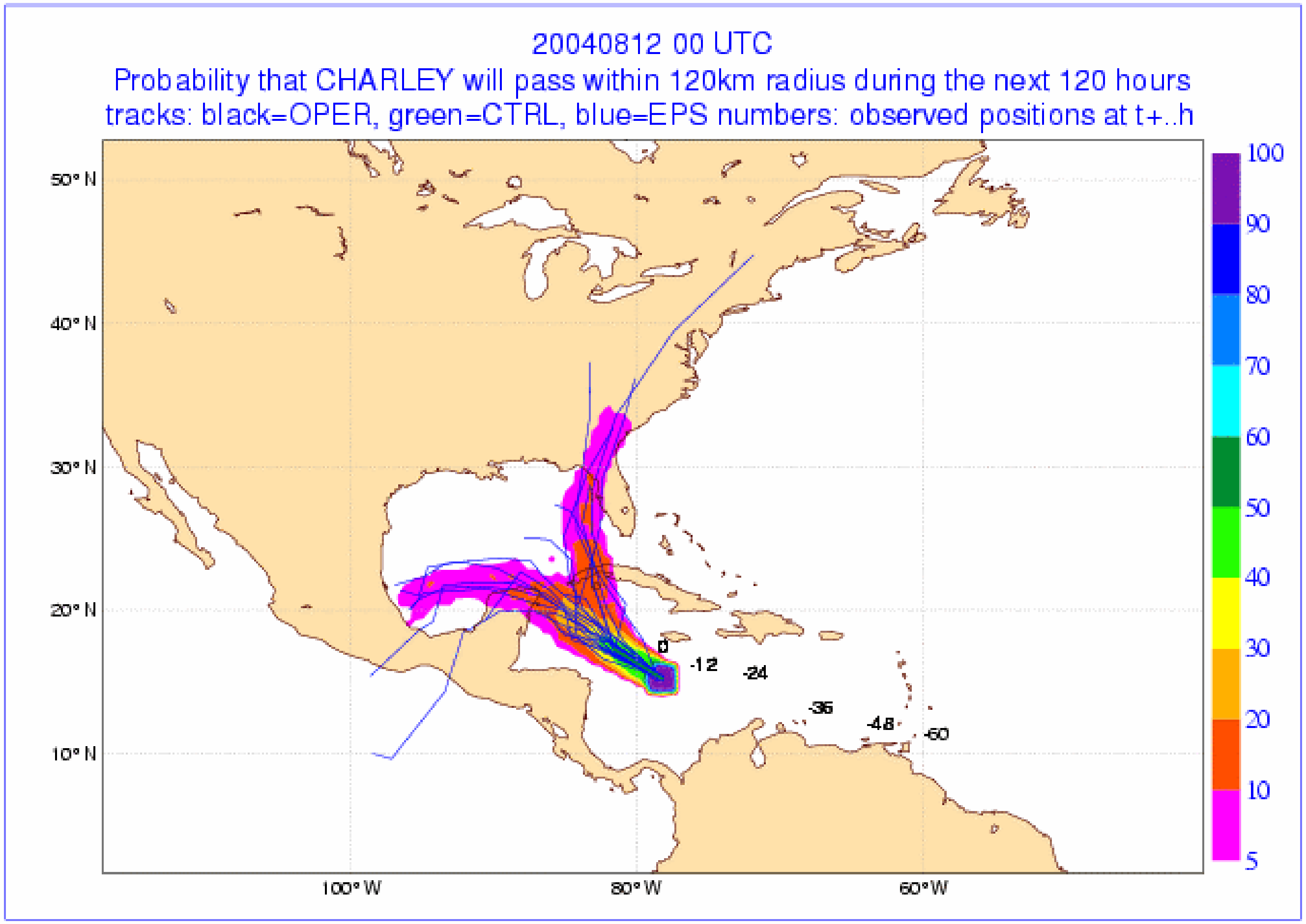




- Plot of ensemble spread
- Probability graph for multiple severity thresholds

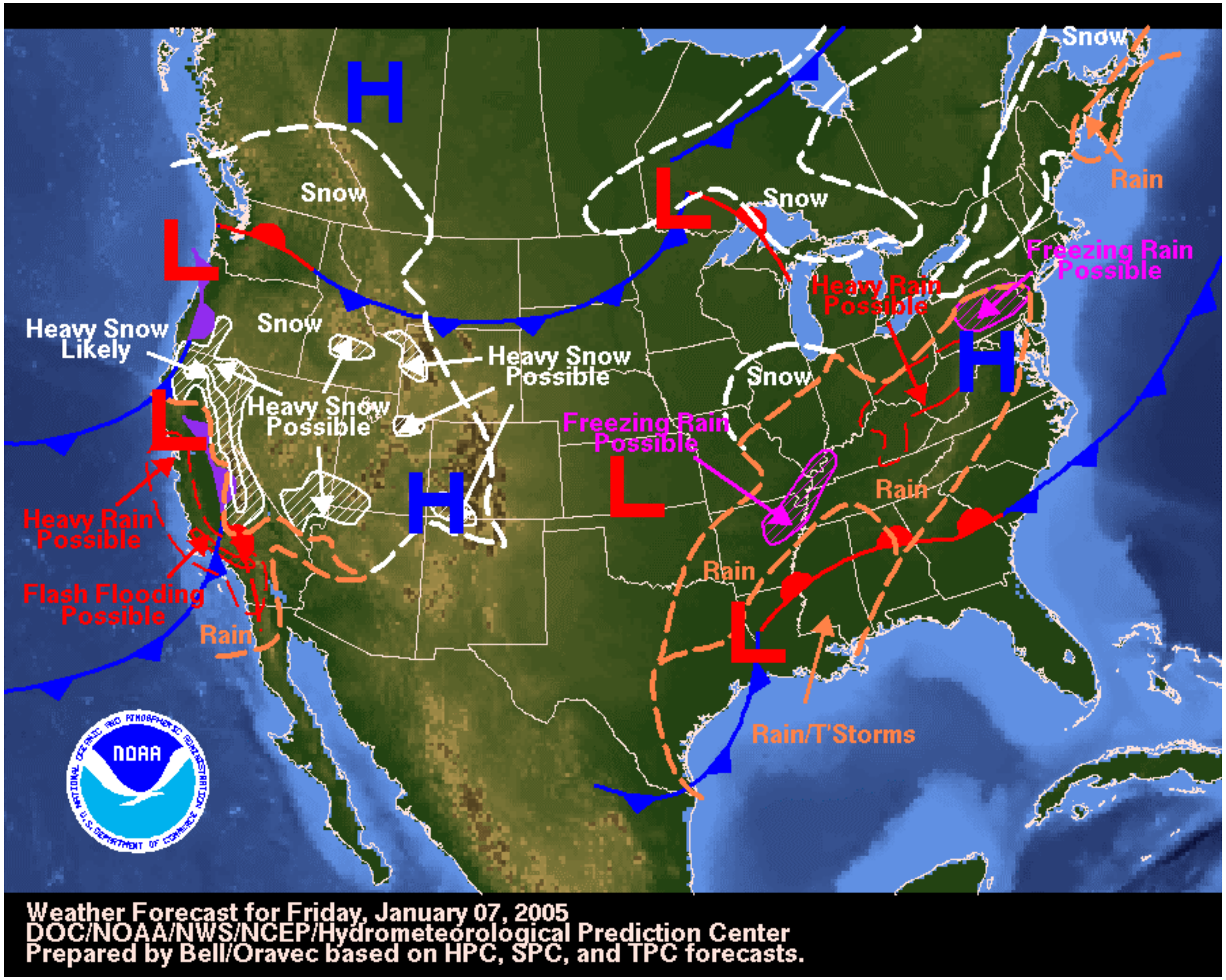
Tropical Cyclones

- Graphics of:
  - tracks
  - strike probabilities



Example Summary of Ensemble Risks

- Threats assessment produced by forecasters in US



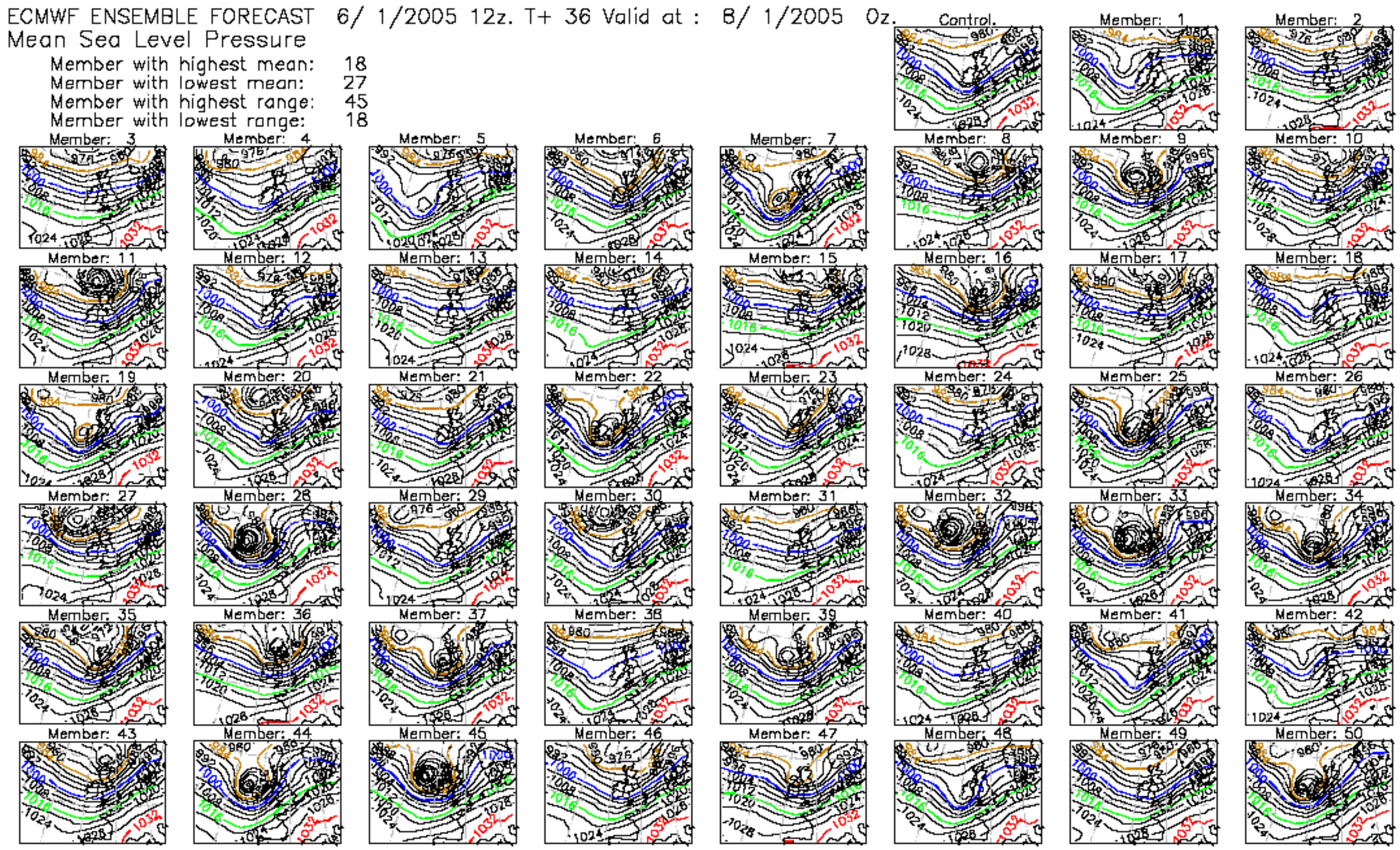
The Challenge of Extreme Weather

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

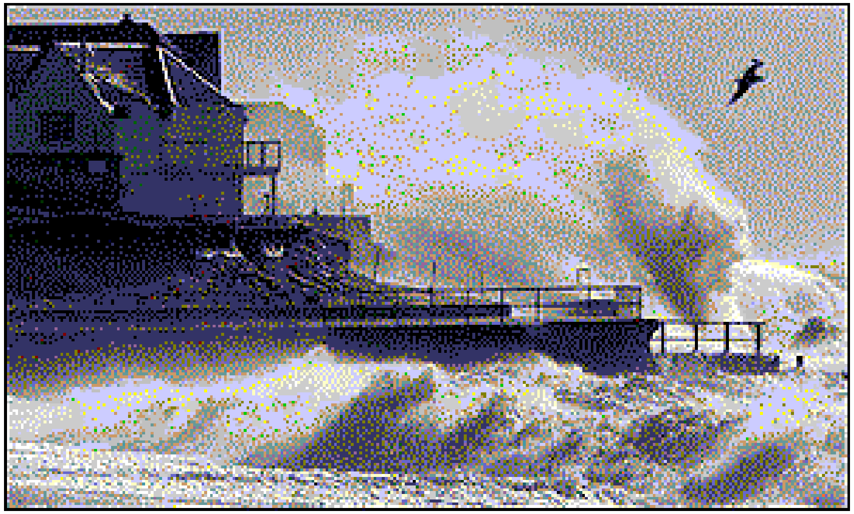


- This example was for a recent storm over the UK (8 Jan 2005)
- Large uncertainty in details for a 36 hour forecast

Early Warnings of Severe Weather (UK)

Met Office issues Early Warnings up to 5 days ahead - when probability ≥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

Early Warning outputs

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%

N. Scotland	33%
E. Scotland	49%
S.W. Scotland	51%
N. Ireland	37%
N.W. England	55%
N.E. England	59%
Midlands	45%
Wales	33%
S.W. England	41%
Cen. S. England	51%
S.E. England	33%
E.Anglia/Lincs	39%

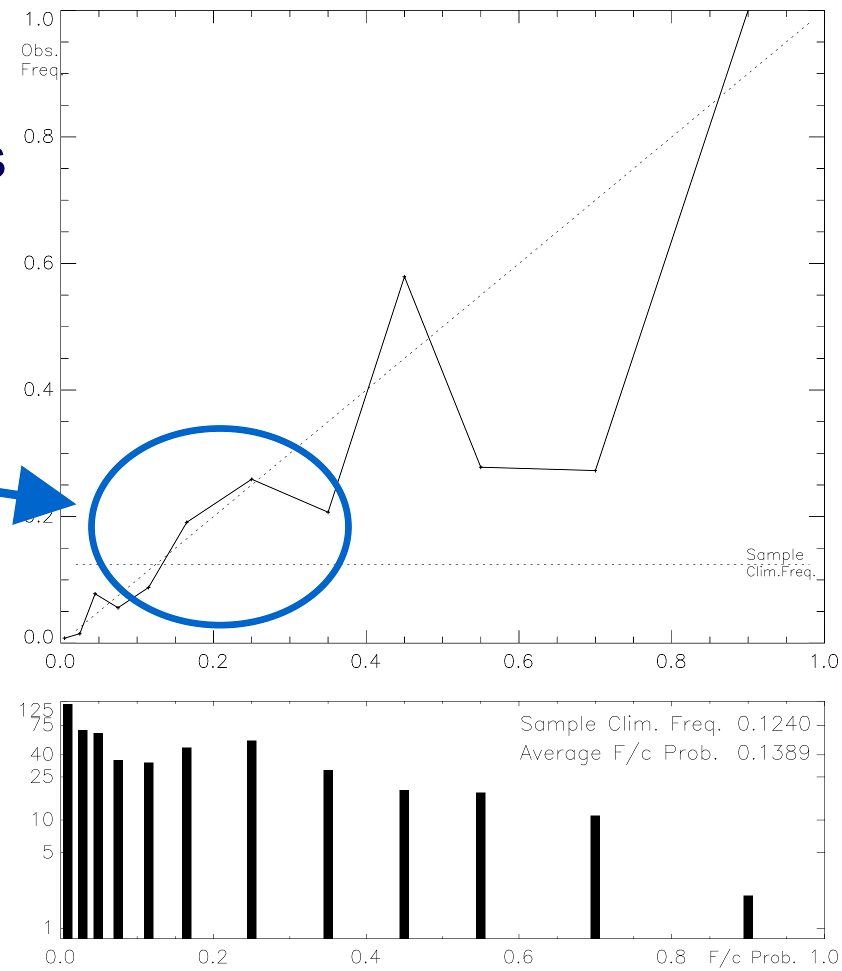
Event: SEVERE GALES - gusts of at least 70mph

T+ 18	36	12	10	11	47	30	24	34	1	18%																				
T+ 24	13	2%																												
T+ 30	16	2%																												
T+ 36	16	8	34	6	36	50	37	35	47	21	29	11	22	12	23	30	13	49	43	14	32	0	43%							
T+ 42	34	45	50	44	28	33	25	9	39	47	19	32	7	48	37	5	27	21	22	29	26	18	12	0	42	16	38	36	40	57%
T+ 48	28	32	20	9	44	33	7	42	22	45	1	25	5	50	27	30%														
T+ 54	5	34	37	32	8%																									
T+ 60	32	2%																												
T+ 66	16	2%																												
T+ 72	27	2%																												
T+ 78	27	50	4%																											
T+ 84	50	13	2	47	6	10%																								
T+ 90	50	13	48	28	8%																									
T+ 96	33	25	5	6%																										
T+102	8	25	4%																											
T+108	3	2%																												
T+114	--																													
T+120	--																													
T+126	--																													
T+132	--																													
T+138	4	2%																												
T+144	41	21	4%																											
T+150	--																													
T+156	--																													
T+162	26	2%																												
T+168	26	2%																												

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

Obs freq



f/c prob

Decision-making with probabilities – Extreme events

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 = 500/1,000,000 = 0.0005

Averaged over many occasions, the user's best strategy is to:
protect when ***p(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

C/L
small

Issue warning

No tsunami?

Explain C/L

Manage future expectations

Earthquake detected

Tsunami risk high

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

Accreditation

Met Office

POSITIVE ABOUT DISABLED PEOPLE

INVESTOR IN PEOPLE

ISO 9001 IT

BSI REGISTERED

WMO

WAFC

World Area Forecast Centre

Questions & Answers