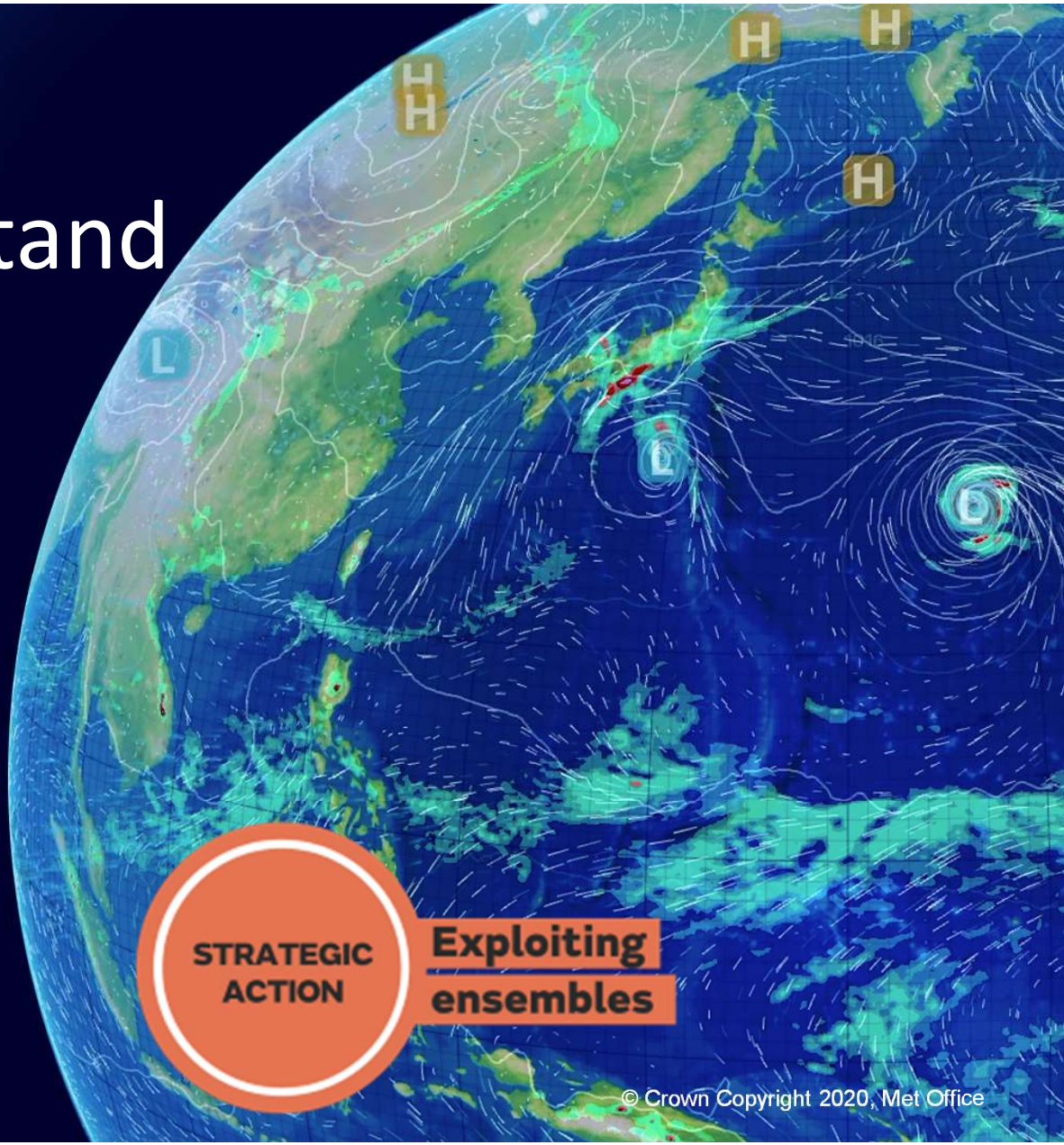
“People don’t understand probabilities” – or do they?

Ken Mylne[1] and Helen Roberts[2]

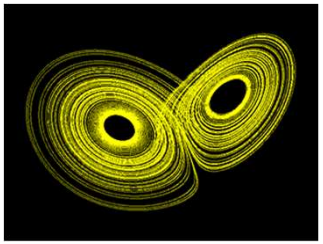
1. Science Fellow in Ensemble Exploitation
2. Socio-Meteorologist

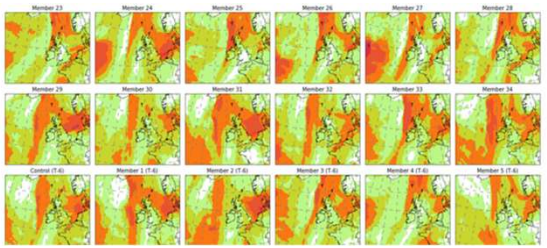
AMS Annual Meeting 2025
New Orleans

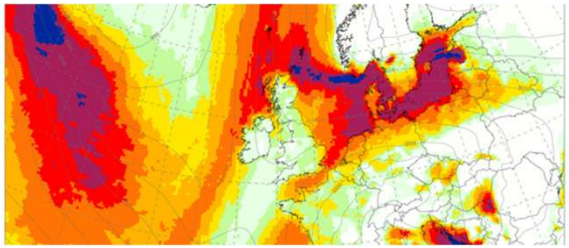


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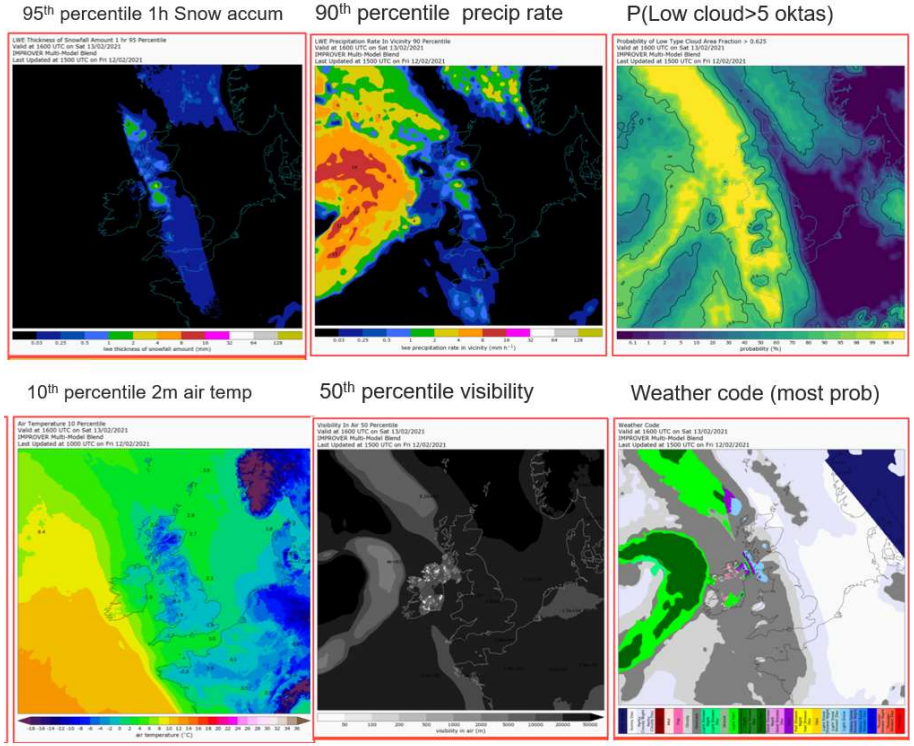


30+ years of ensemble forecasting

- ECMWF and NCEP both started medium-range EPS in 1992
- COSMO-LEPS regional started c. 1999
- Met Office MOGREPS-Regional 2005
- MOGREPS-UK convective-scale 2012
- IMPROVER blended post-processing



- …***so why aren't we using them more?***



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Assumption:

The Public don't understand probabilities

- Many conversations about how to make use of ensemble forecasts start with a statement of "People don't understand probabilities"
  - Established fact?
  - Evidence?
  - or assumption?

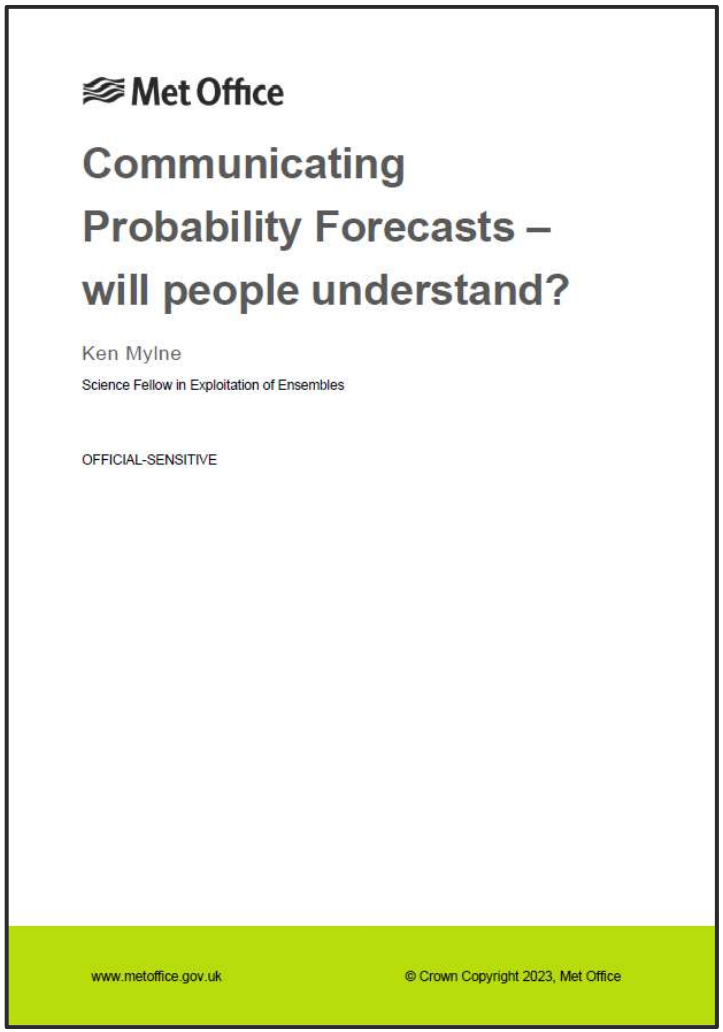


The standard response to this question is that, before we can develop or publish any probabilistic forecasts, we need more research – *but do we?*

Literature Review

- Not a new topic …

- Review the research literature to help guide the future communication of forecasts


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Communicating Probability Forecasts – will people understand?

Ken Mylne

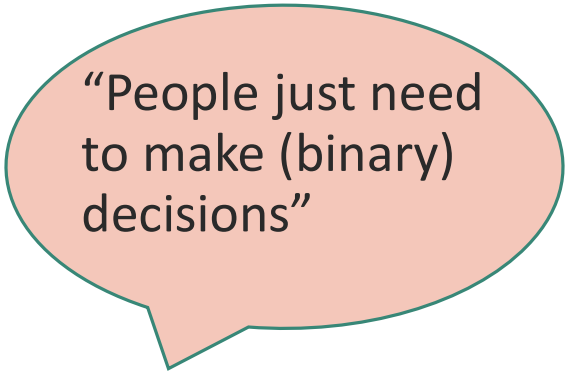
Science Fellow in Exploitation of Ensembles

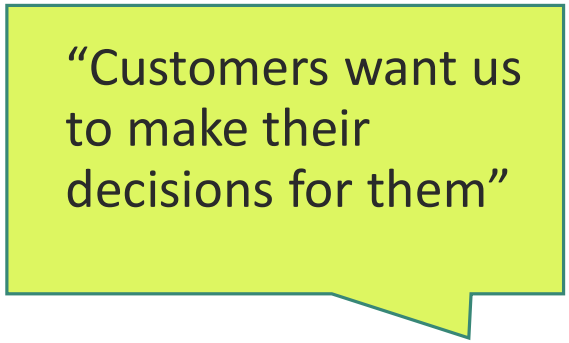
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Decision Making – a forecast is useless without a decision





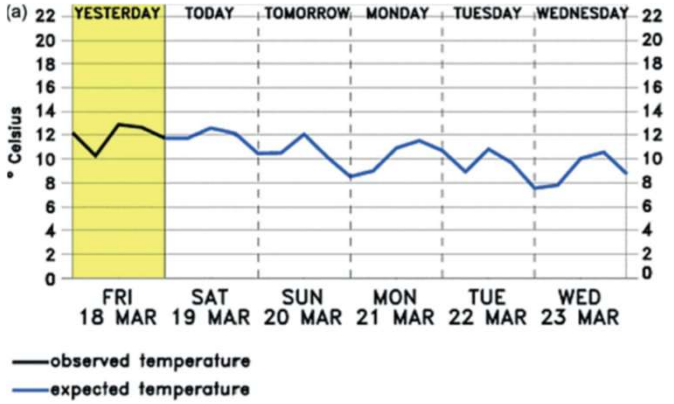
- Much research focuses not on whether people think they understand, but on whether they make good decisions

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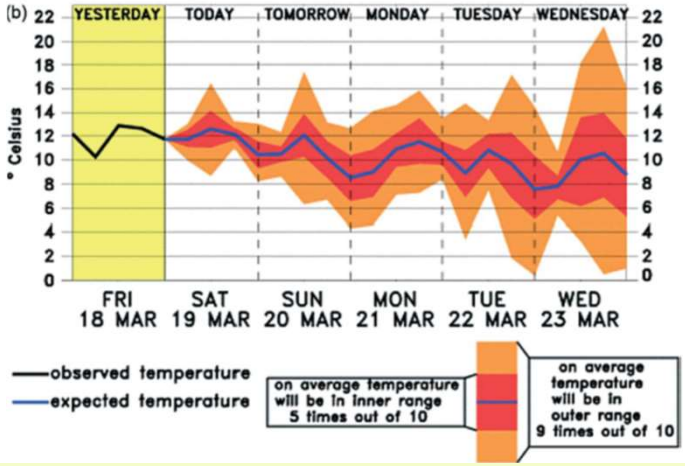
Roulston and Kaplan (2009) Marimo *et al* (2015) similar

- Experimental economics set-up – participants paid according to quality of choices
- Group **A** deterministic, Group **B** probabilistic
- Few "Swing Questions" where extra info really matters
- **A** picked most probable 69%, **B** 85%
- Results independent of gender or academic discipline

A



B



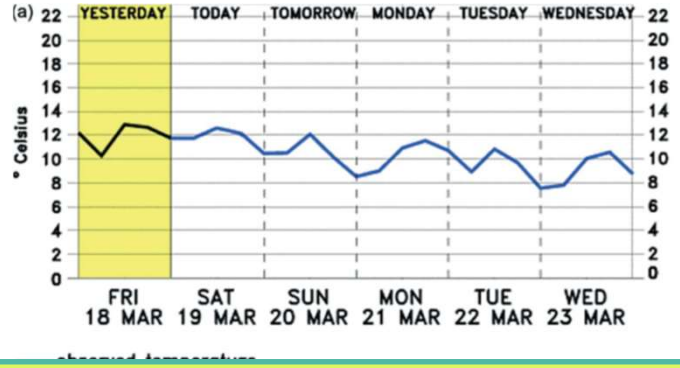
Two groups receive either presentation **A** or **B**
Options to receive £.50 if:
1. The temperature at midday on Monday is below 7 °C or if
2. The temperature at midday on Wednesday is below 6 °C.

Roulston, M.S. and T.R. Kaplan (2009) *Meteorol. Appl*. **16**: 237–244
Marimo P, Kaplan TR, Mylne K, Sharpe M (2015). *Weather and Forecasting*, **30**(1), 5-22.

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Roulston and Kaplan (2009) Marimo *et al* (2015) similar

A



Conclude that *"there exist contexts and formats for which the decision-making of non-specialists is improved by providing information about forecast uncertainty. Providing information about forecast uncertainty, therefore, can be a means to improve the value of forecasts to users."*

Marimo *et al*

- *The Met Office should engage users throughout the product development process in order to ensure information is communicated effectively and to minimize misinterpretations.*

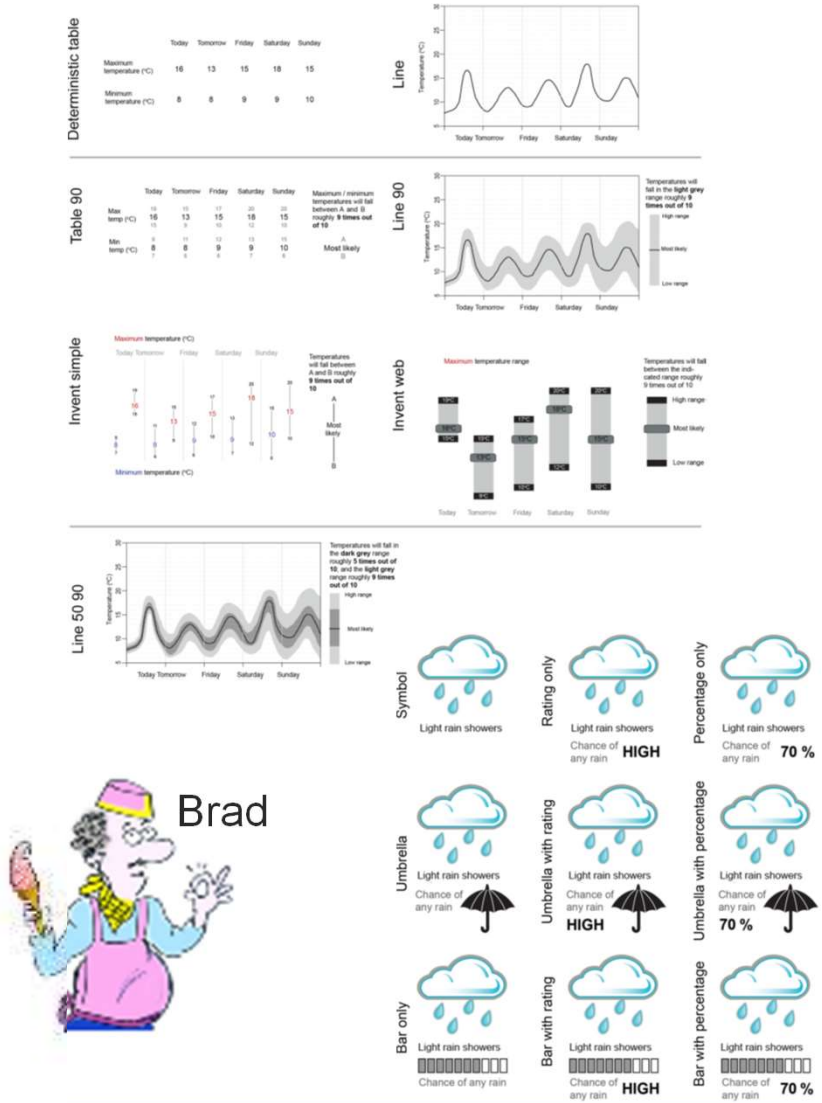
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The Weather Game

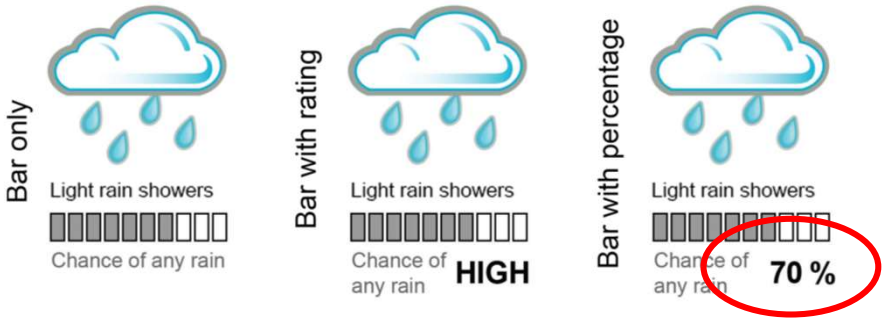
- Online game – more participants – wider demographic
- Players asked to interpret temperature and rainfall forecasts to help Brad sell ice cream
- Over 8000 participants
- Tested what decisions people made – did Brad make more money?
- Multiple presentations tested, of varying complexity…

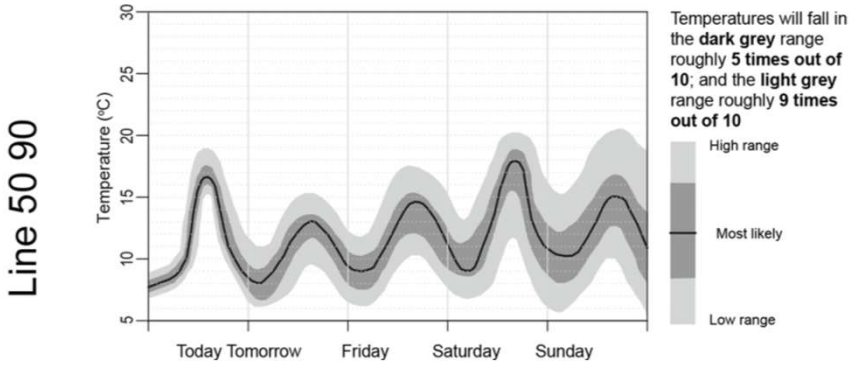


Elisabeth M. Stephens, David J. Spiegelhalter, Ken Mylne, and Mark Harrison
The Met Office Weather Game *Geosci. Commun.*, **2**, 101–116, 2019

The Weather Game - Conclusions

- Easy question – people not confused by more uncertainty information
- Confidence – with clear deterministic forecasts, people inferred a level of uncertainty – confidence <100% (consistent with other studies)
- Rainfall probability – people answered better when a numerical value given – even if same info available graphically





- Temperature – most correct decisions by participants with the most complex presentation

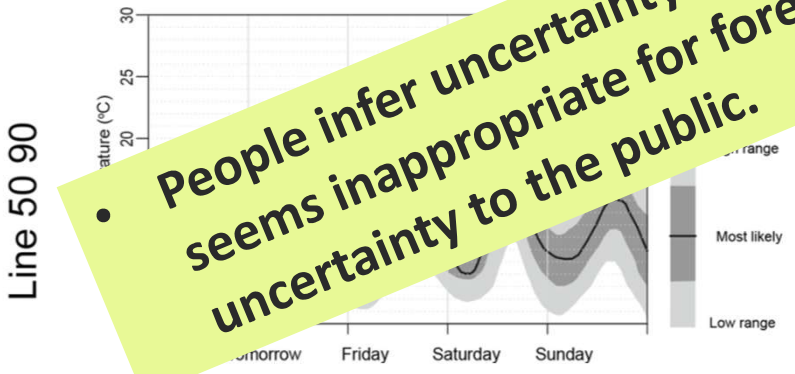
Elisabeth M. Stephens, David J. Spiegelhalter, Ken Mylne, and Mark Harrison
The Met Office Weather Game *Geosci. Commun.*, **2**, 101–116, 2019

The Weather Game - Conclusions

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People infer uncertainty in a deterministic weather forecast, and it therefore seems inappropriate for forecasters not to provide quantified information on uncertainty to the public.

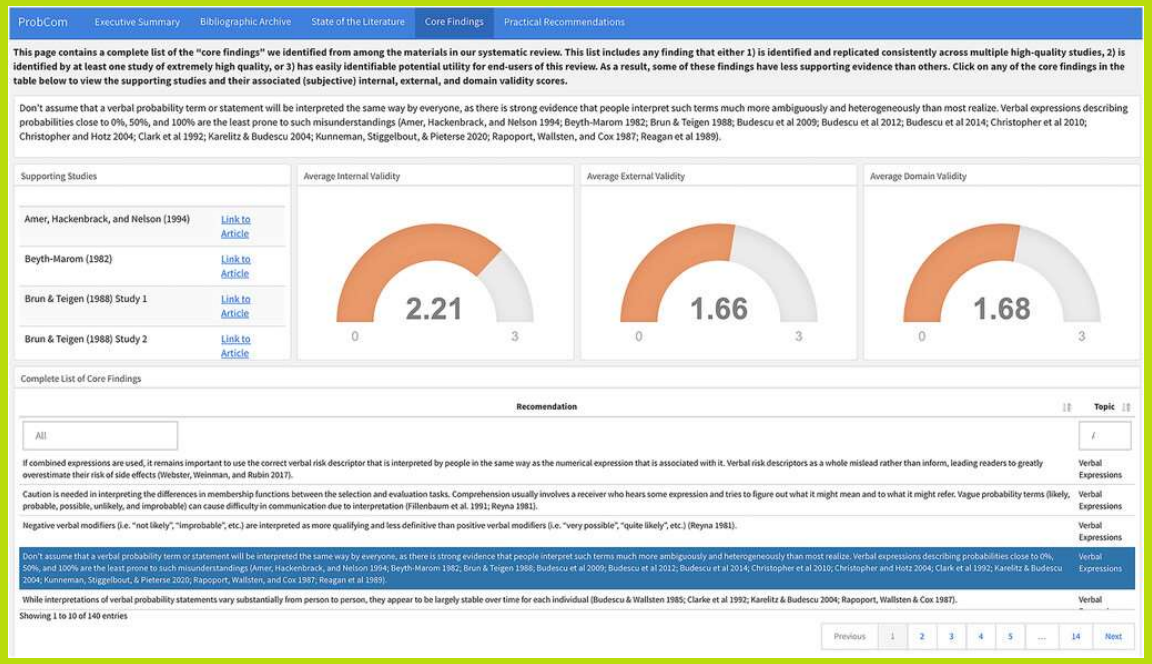




- Temperature – most correct decisions by participants with the most complex presentation

Elisabeth M. Stephens, David J. Spiegelhalter, Ken Mylne, and Mark Harrison
The Met Office Weather Game *Geosci. Commun.*, **2**, 101–116, 2019

Wider literature review - Ripberger et al (2022)



Systematic approach – electronic search, previous reviews and citation chains

Identified **327** unique studies

Saved us a LOT of work! ☺

Probability and uncertainty



Overview

Most people **intuitively infer uncertainty** even when given a deterministic forecast

Most **people can make sense of and use probability information** if consideration is given to information presentation

Assuming appropriate presentation, **probability information generally improves decision quality**

People make **better decisions**, have **more trust** in information, and/or display **more understanding** of forecast information when probabilistic information is used in place of deterministic statements

Importance of making probabilistic forecasts as **straightforward and easy to understand** as possible in order to avoid ‘information overload’



Weather, Climate and Society, American Meteorological Society **14**, 481-498.

Language – Probability and uncertainty

30% Probability

Mathematical, off-putting for some

30% Chance

Less scary

Confidence or Range may instil more trust than *Uncertainty*

Terms that have different meanings for scientists and the public		
Scientific term	**Public meaning**	**Better choice**
enhance	improve	intensify, increase
aerosol	spray can	tiny atmospheric particle
positive trend	good trend	upward trend
positive feedback	good response, praise	vicious cycle, self-reinforcing cycle
theory	hunch, speculation	scientific understanding
uncertainty	ignorance	range
error	mistake, wrong, incorrect	difference from exact true number
bias	distortion, political motive	offset from an observation
sign	indication, astrological sign	plus or minus sign
values	ethics, monetary value	numbers, quantity
manipulation	illicit tampering	scientific data processing
scheme	devious plot	systematic plan
anomaly	abnormal occurrence	change from long-term average

Weather, Climate and Society, American Meteorological Society **14**, 481-498.

Probability and uncertainty

Communication – words and phrases



Always include a numeric 'translation' for any verbal probability expressions used

~~*'Thunderstorms are possible this evening'*~~

'Thunderstorms are possible (30% chance) this evening'

'There is a 30% chance of thunderstorms this evening'



Probability and uncertainty

Biases



Directionality
'It is possible that the hurricane will affect town *x*' → overestimate risk
'It is likely that the hurricane will miss town *x*' → underestimate risk



Trend Effect
upgraded from a '*low*' risk ⇧ '*moderate*' risk ⇩ downgraded from a '*high*' risk

Magnitude
Higher probabilities perceived as more accurate
~~30% chance of rain~~
70% chance of dry weather



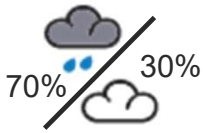
Severity effect
'Slight chance' of showers ~ 1%–5% chance
'Slight chance' of a hurricane ~ 10%–15% chance

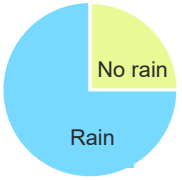
Probability and uncertainty

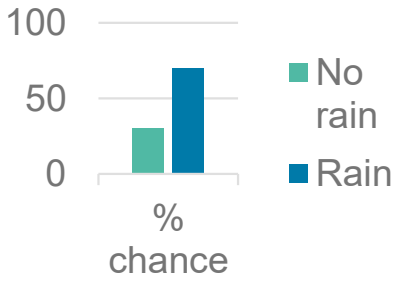
Communication – visualisation

Gist information









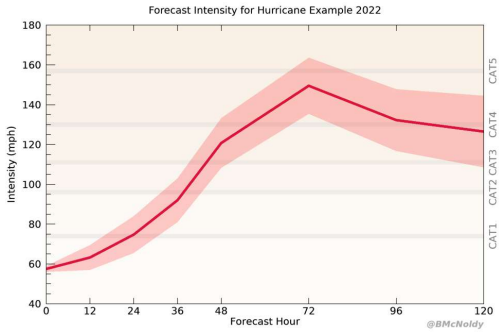
Ensemble/simulation representations promote risk comprehension

Importance of **explanatory labels**, numbers, explanation and description

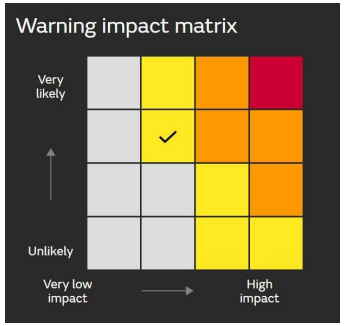
Including **probability information** in forecast graphics improves risk comprehension and increases protective action in high-risk areas

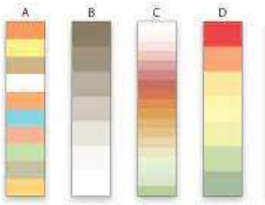
Polychromatic may be preferable to monochromatic schemes
Warm colours may indicate more risk than cool colours

No single ‘best way’ to visually communicate risk







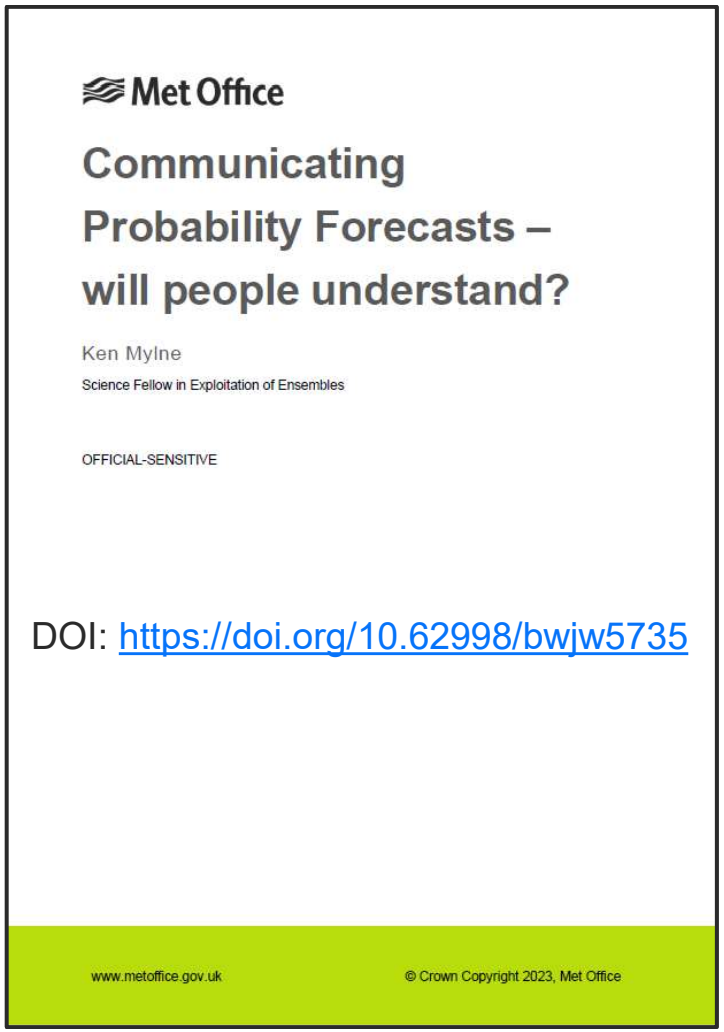


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Literature Review Summary

Overall:

- Literature review provides **strong support for communicating probabilistic information** to forecast users, including the general public.
- Does **not** support the idea that people's understanding should be a barrier to communicating such information.
- While not every single person will understand or take full advantage of the additional information**, most people will benefit and make better decisions** as a result.



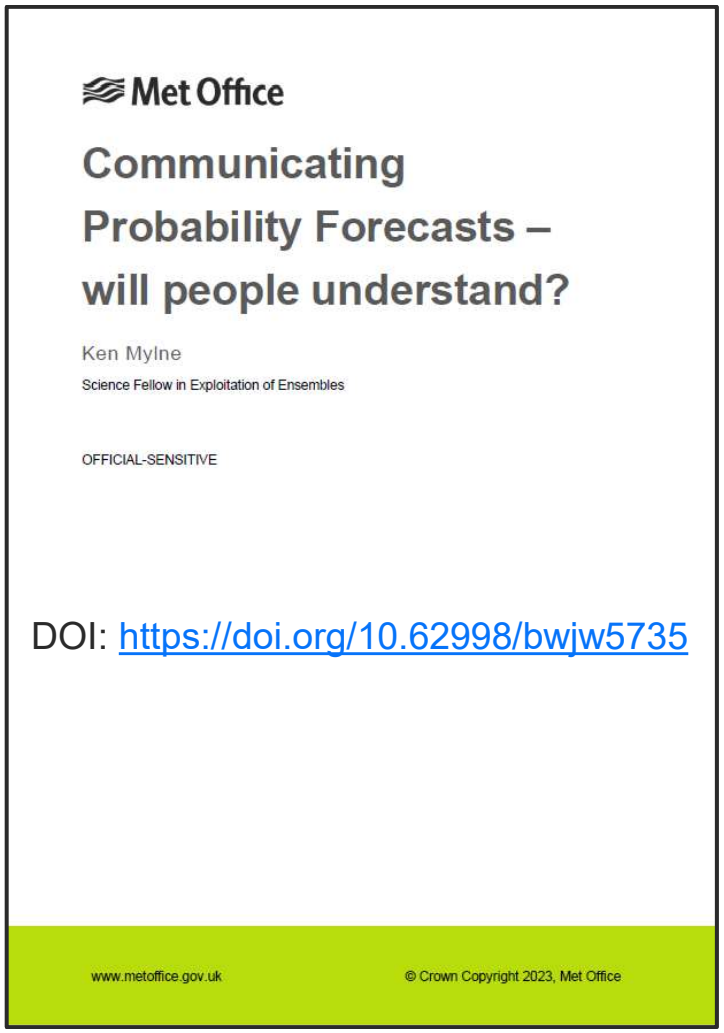
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Literature Review Summary

- Review the research literature to help guide the future communication of forecasts

Headline summary: ***The overwhelming and consistent conclusion found in the literature is that people do understand the probabilistic information and make better decisions when presented with it, provided that the information is presented appropriately.***

Questions?


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Communicating Probability Forecasts – will people understand?

Ken Mylne

Science Fellow in Exploitation of Ensembles

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Literature Review Summary

Key conclusions include:

- People make **better decisions**, have **more trust**, and/or display **more understanding** of probabilistic forecast information
- Providing additional information on uncertainty **does not lead to confusion** and misinterpretation
- The inclusion of a **numerical probability (e.g. 30%) alongside a visual or worded description** helps correct interpretation
- **Careful choice of language** helps promote understanding
- It is important to clearly **define the events** to which probabilities apply; **framing** can influence interpretation

