COMMUNICATING FORECAST UNCERTAINTY

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A little test……

- What does “30% showers in an area” mean?
    1. 30% of the area will receive rain
    2. 30% of the time it will rain in the area
    3. 30% chance of rain <u>everywhere</u> in the area
- ➢ Number 3: it is the likelihood of rain “on your head” anywhere in that area

- How else can we describe “30% of showers”?

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What is Forecast Uncertainty?

Weather prediction is fundamentally uncertain

- Due to the chaotic nature of the atmosphere (Lorenz)
  - Small uncertainties in the initial conditions can result in large differences between different forecasts
- Uncertainty refers to:
  - The condition where the state of the atmosphere is not known exactly

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Weather prediction is fundamentally uncertain, continued……

- However, weather forecasting evolved into a deterministic approach
- Particularly rapid developments in NWP strengthened deterministic forecasts
- The implementation of Ensemble Prediction Systems (EPS) in the 1990’s introduced a practical approach to describe uncertainty through probabilities

- The danger is that forecasters still use EPS products to issue deterministic forecasts thereby keeping useful information from users

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Sources of Forecast Uncertainty?

- Atmospheric unpredictability
  - Observation error, NWP grid completely describe atmosphere
- Uncertainty in data interpretation
  - Forecaster interpretation of NWP and EPS, rain parameterization
- Uncertainty when composing the forecast
  - Appropriate terminology
- Forecast interpretation
  - Some of greatest uncertainty arises from user interpretation
  - Forecasters own understanding of terminology can differ

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Deterministic vs Uncertainty

- Deterministic forecasting is an exact specification of the weather in explicit terms without any description of associated uncertainty,
  - For example: thunderstorms will occur tomorrow in Pretoria with large hail
  - Or temperature will be 30C in five days over Pretoria

Deterministic vs Uncertainty

- Probability is only *one way* of expressing uncertainty
  - Objective interpretation:
    - Number of times an event occurs divided by the nr of opportunities for the event to occur, or 6 out of 10 models predicted rain = 60%
  - Subjective interpretation:
    - degree of belief that an event is going to occur (difficult to quantify)
- Probability of Precipitation is the most known example: 30% chance of showers

- All can be applied to give useful information to users to some extent

To summarize…

- *"Uncertainty is a fundamental characteristic of hydrometeorological prediction, and no forecast is complete without a description of its uncertainty"* (Completing the Forecast, NRF, USA 2006)

- The challenge is that forecast products *rarely contain sufficient information about uncertainty* in the forecast, and *few users understand properly* how to reap benefits from it in their decision making processes

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Why Communicate Forecast Uncertainty?

- To Improve decision making
  - Users tune their responses to different levels of forecast uncertainty according to their own particular needs – depending on costs and losses
- Manage user expectations that forecasters must always be correct
  - Retaining users are more likely if they understand forecasts have uncertainty and can tune their decision making accordingly
- Promotes user confidence
  - Reassures people that they are dealt with honestly, objectively and scientifically
- Reflects the state of the science
  - Otherwise we mislead the user

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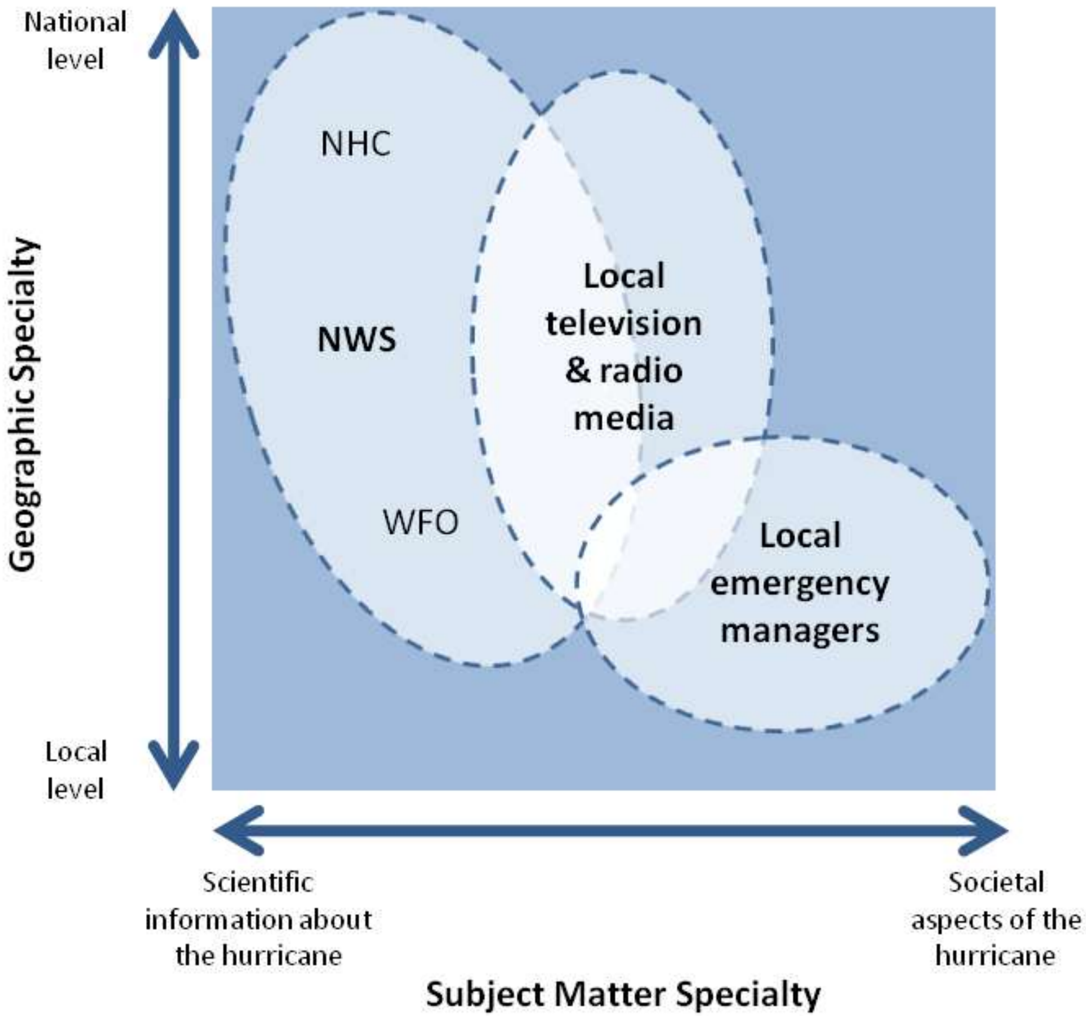
Communicating Hurricane Information (NSF/NOAA)

NCAR



Communicating Forecast Uncertainty

Human Perception & Use of Uncertainty Information

- For people to use uncertainty info in decision making, they must first interpret it

⇒ With time and education people's understanding will improve

- Different users require different forms of uncertainty info
  - Emergency managers: want to know when and if hazards is due (but can use uncertainty: evacuation plan activated if probability >20%)
  - Some users are quite sophisticated and may require complex graphs
  - Others may prefer simple messages and graphics
  - Some ask "is it going to rain, yes or no" but then actually want to hear how forecaster feel = this is uncertainty communication

⇒ "One size does not fit all" – tailor information according to needs

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Examples of Uncertainty Info: Terminology

- Language can be very complex or very simple
- Deliberately vague phrases (because forecaster is uncertain about time or location):
  - “chance of”, “possible”, “later”, “developing”, “in the area”
- When a pattern is really unpredictable:
  - A narrative description is useful, including alternative scenarios
  - Radio is an ideal way to communicate this info
- In many countries few users have access to internet or TV and rely on radio - Narrative description is then the only way
  - Uncertainty info must then be very clear and consistent
  - Language, cultural differences and levels of sophistication must be taken into account in defining standard terminology
  - Translation may cause problems in some instances

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Terminology continued……

Table: Example of a scale with common terms

Terminology	Likelihood of the occurrence/outcome
Extremely likely	Greater than 99% probability
Very likely	90% to 99% probability
Likely	70% to 89% probability
Probable - more likely than not	55% to 69% probability
Equally likely as not	45% to 54% probability
Possible - less likely than not	30% to 44% probability
Unlikely	10% to 29% probability
Very unlikely	1% to 9% probability
Extremely unlikely	Less than 1% probability

- NB: Interpretation of “possible” and “probable” vary widely

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Examples of Uncertainty Info: Graphs

Figure: Meteogram produced by an EPS – needs interpretation

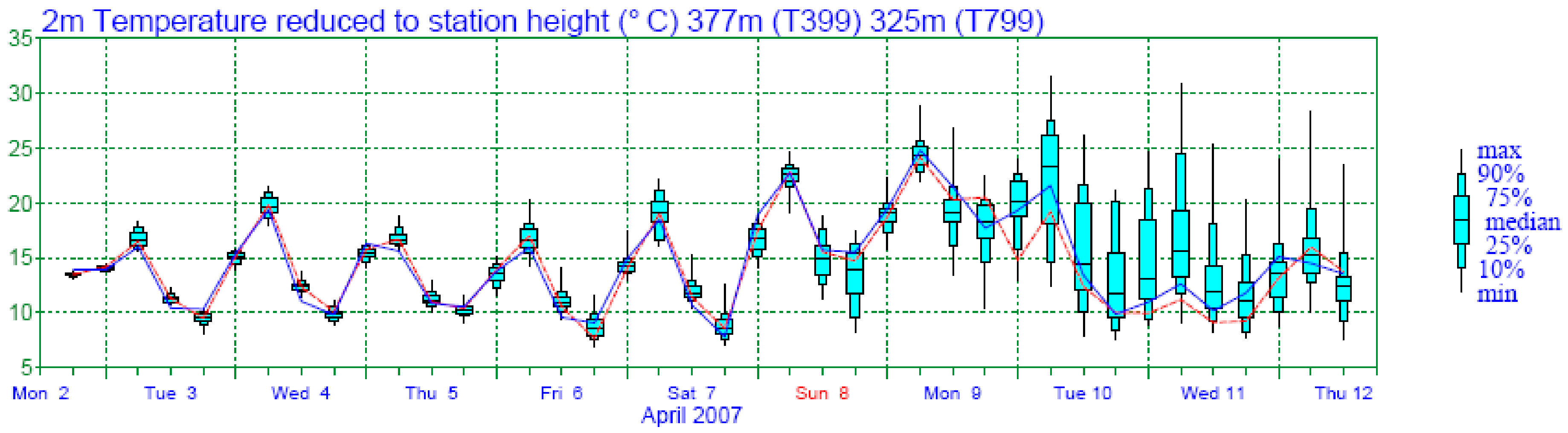
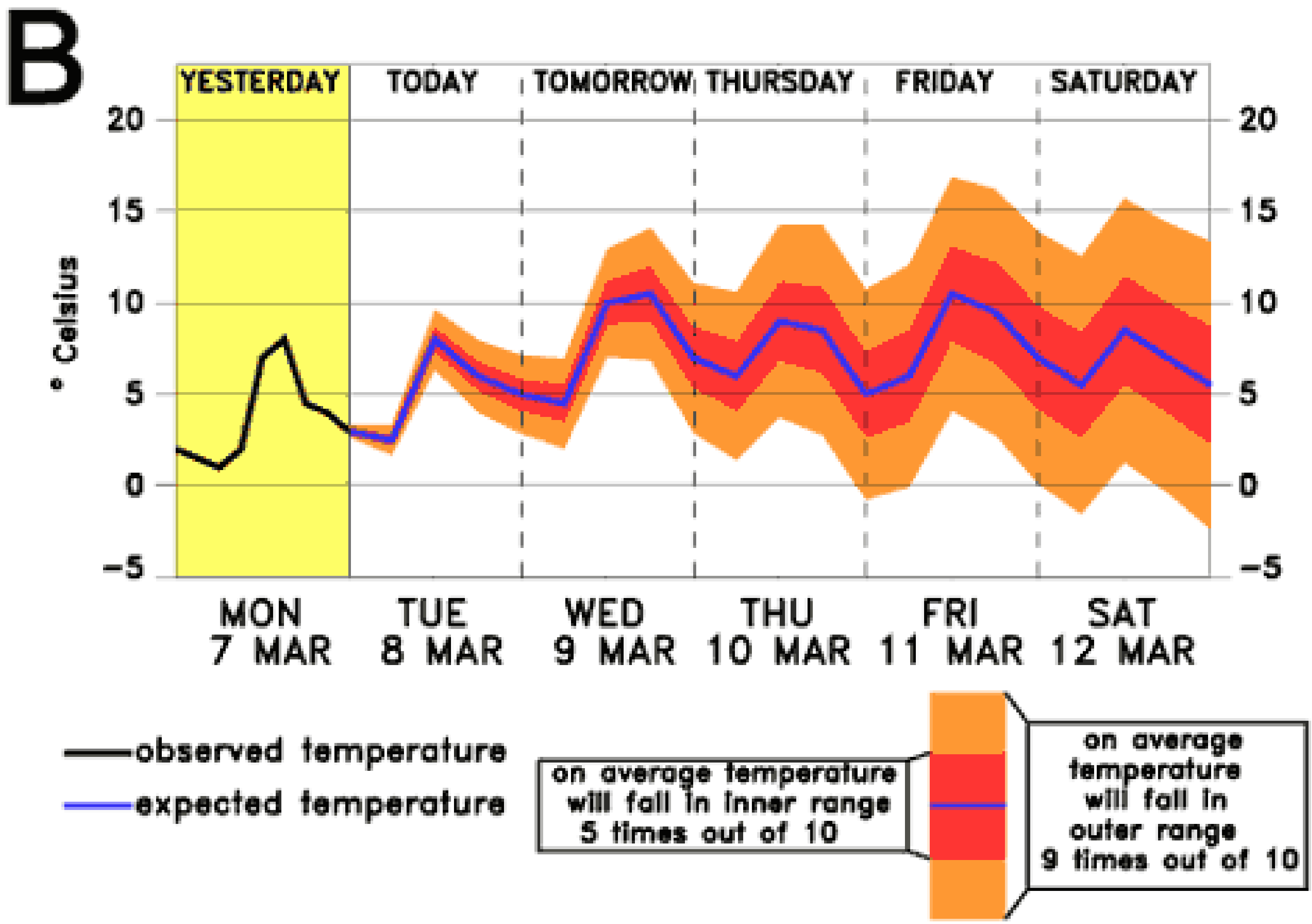
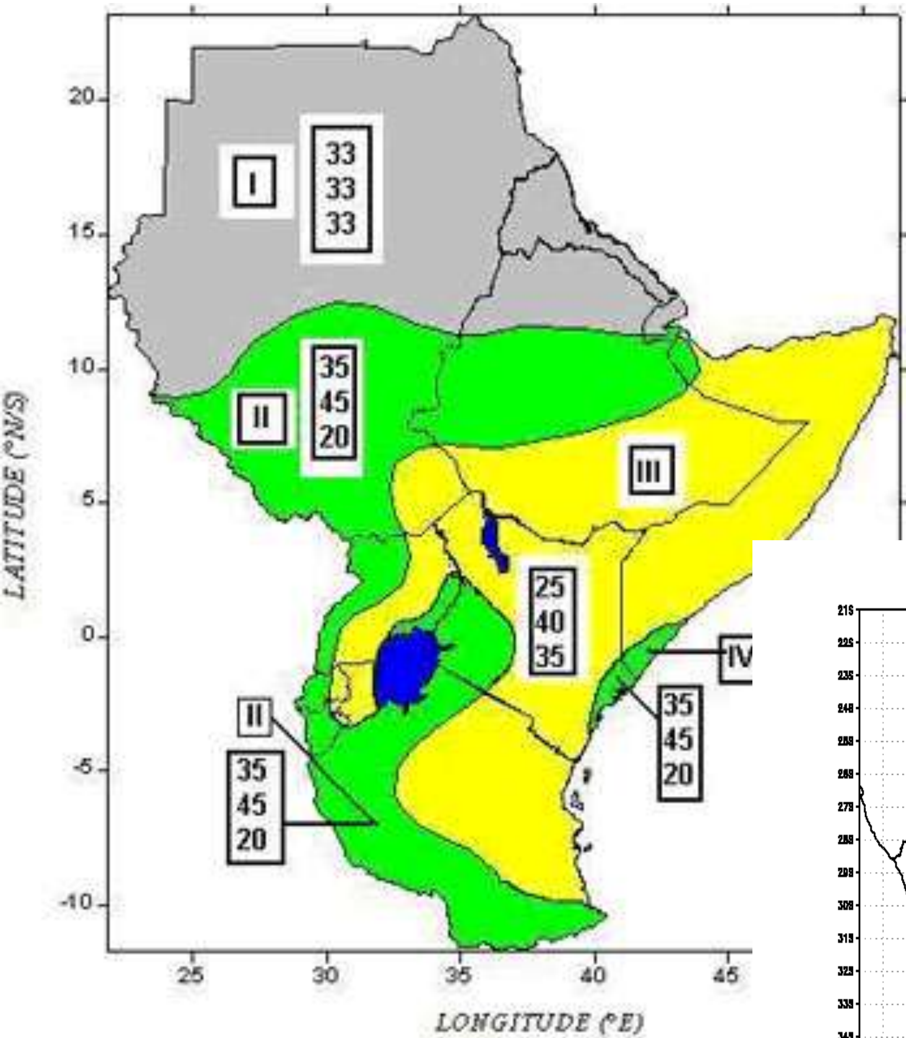


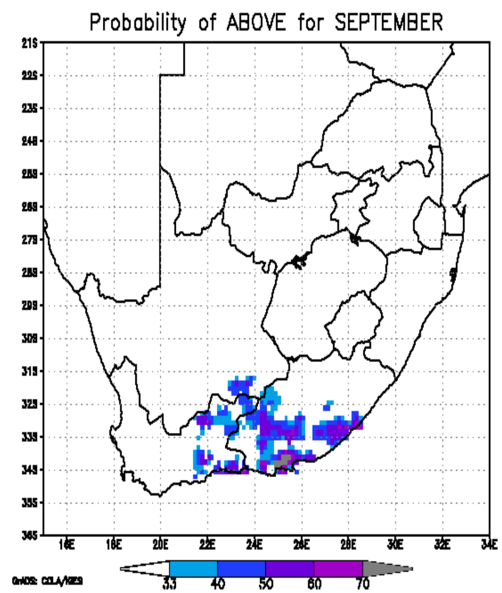
Figure: Fan chart using "natural frequencies"

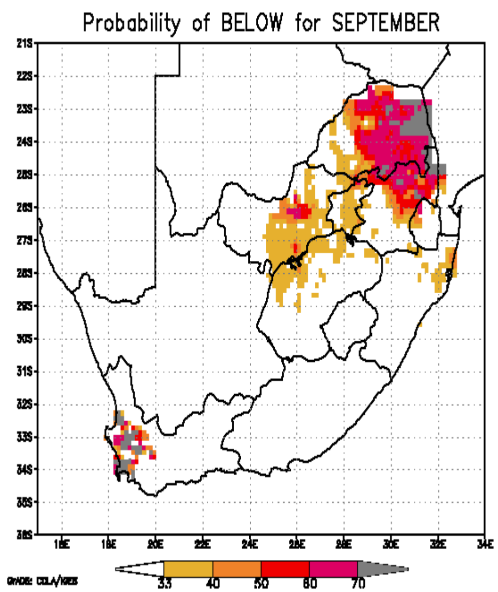


Examples of Uncertainty Info: Charts and maps

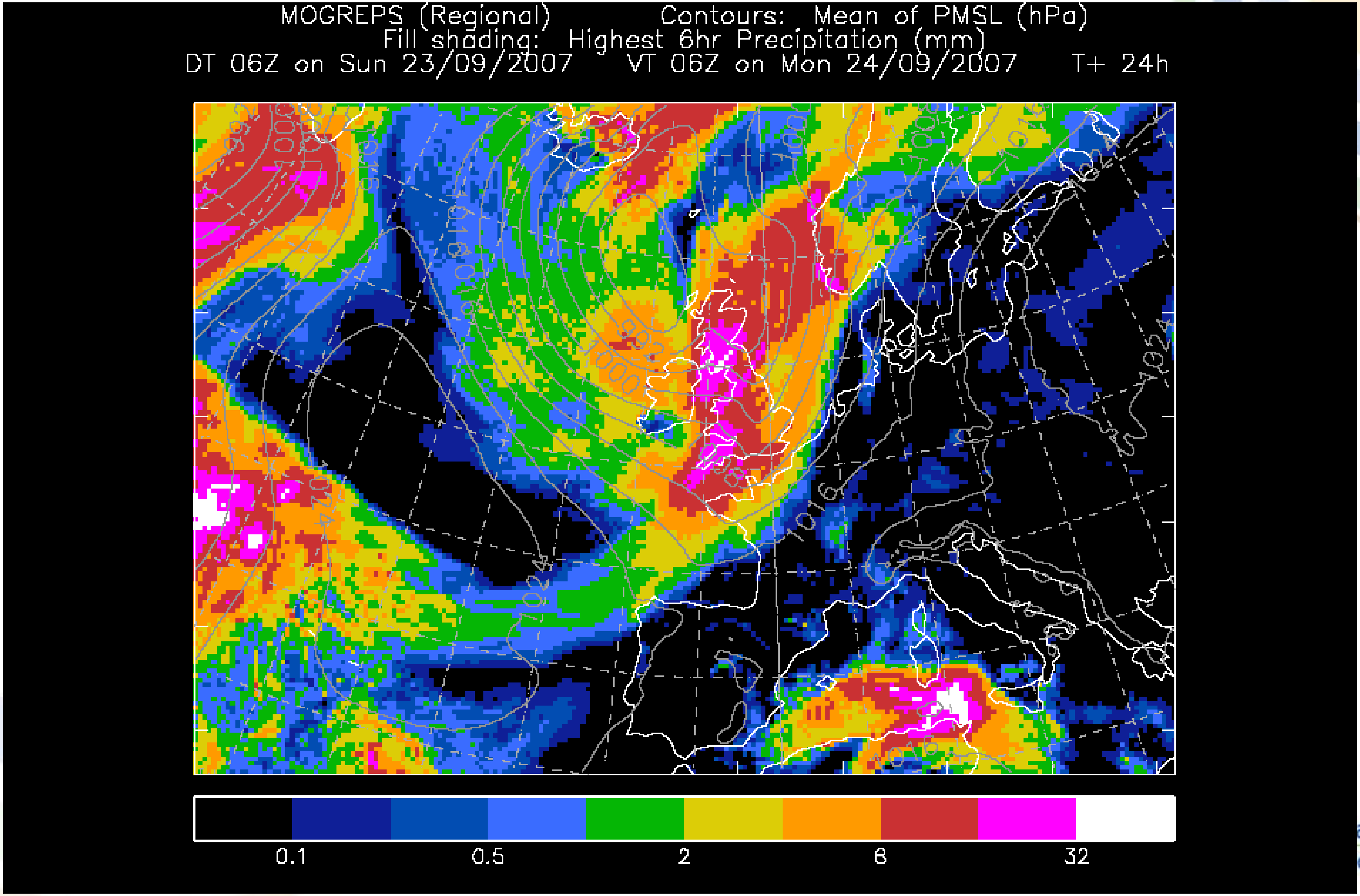


- Multi-category maps are difficult to interpret
- Additional narrative is needed to add additional information on skill and uncertainty of significant events



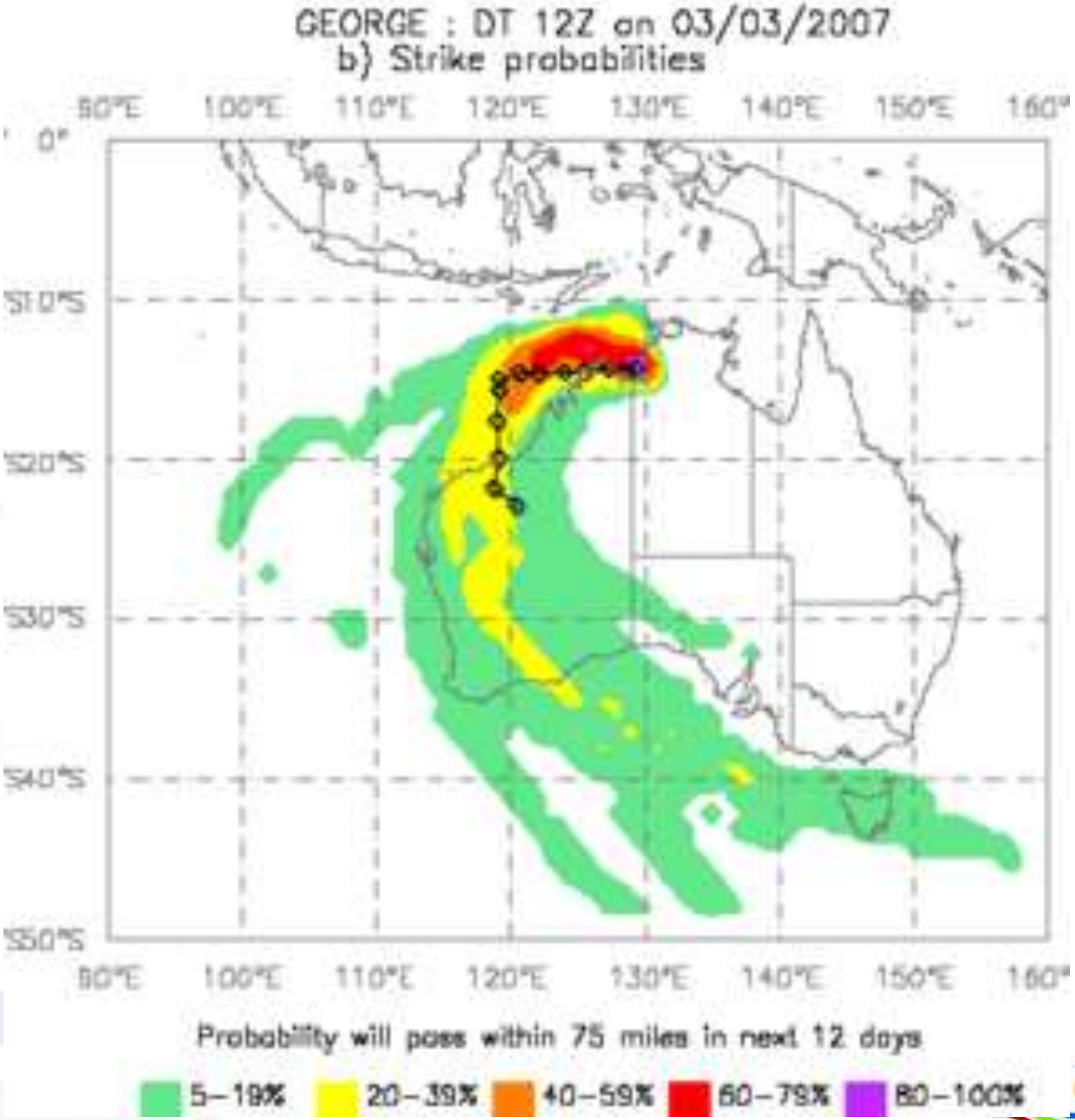


Maximum 6h-rainfall forecast – at each grid-point the highest rainfall predicted by any of the ensemble members is shown, giving the user a picture of the worst-case scenario.



CHARLEY #8 -Assuming AVERAGE FORECAST ERROR - the EYE should track in the white cone in next 72 hours
Miami
Key West
Bahamas
INSMET
National Forecast Center, Cuba
Instituto de Meteorología
Havana
Cuba
Agosto 12 / 8 PM
Camaguey
Agosto 12 / 8 AM
Agosto 11/ 8 PM
Kingston
Jamaica
80W
75W
25
20
Tropical Storm CHARLEY
Initial Pos. Aug 11 / 12 noon
16.5 N 76.1 W
175 km SE Kinsgton, JAM
860 km SE Isle of Youth
Max.Sust.Winds: 110 km/h

can
vice



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In Conclusion

- Different media – different methods:
  - Radio vs TV vs web vs printed media
- Optimization of user decision making requires a good understanding of the decision and its impact on users
  - Cost / loss scenarios can determine thresholds for action
- Tests has shown that users with uncertainty information makes significantly better decisions than users without
- Forecast verification is crucial to provide reliable information

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Questions?

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