Summary factsheet: Understanding forecast uncertainty

Piotr Wolski, Hydro-climatologist, CSAG, University of Cape Town

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What is forecast uncertainty?

Forecast uncertainty refers to the degree of doubt about how accurate a forecast is. While *forecast skill* measures how good a forecast is, all forecasts are limited by how well we can observe and model the climate system. Uncertainty is an unavoidable part of forecasting, even with sophisticated models, because of the complexity and chaotic nature of our climate system.

The chaotic nature of the climate system

It is impossible to predict weather and climate with complete certainty. The climate system is neither fully random nor entirely predictable – it is *chaotic*. Small differences in the initial conditions of the atmosphere in a model can lead to large variations in forecast outcomes, for example, making long-term forecasts increasingly uncertain. Non-chaotic systems such as river basins can stabilise over time, but atmospheric systems remain highly sensitive, requiring multiple simulations to capture a realistic range of outcomes.

Ensemble and probabilistic forecasts

Modern forecasting techniques address uncertainty by using ensembles – running many simulations with slightly different initial conditions. This approach captures a range of possible outcomes and is the basis for probabilistic forecasts, which express the likelihood of different scenarios rather than a single, deterministic result. This allows users to understand a broader range of potential weather or climate outcomes.

Limits of predictability

While some processes offer predictability, gaps remain due to limits of current models and imperfect observations. Sub-seasonal timescales are particularly challenging, sitting between more reliable weather forecasts and broader, long-term climate projections. Improving models and data assimilation is key to closing these gaps, but we can never achieve perfect predictability – uncertainty will always be a part of any forecast.

Why forecasts matter

Two forecasting centres might predict different rainfall amounts for the same region. One might show a 60% chance of above-average rainfall, while another shows 40%.

Which model is more believable can only be evaluated by looking at skill – i.e. a consistent evaluation of how well a particular forecast performed in the past.

Despite difficulty in interpretation of probabilistic forecasts, skilful forecasts are valuable – they help us understand the *range* of possible outcomes rather than one 'right' answer.

Image source: Creativity Vectors by Vecteezy

Communicating probabilistic forecasts

Forecasts are increasingly expressed in **probabilistic** terms. Forecasts should be made understandable and actionable for different users. Education, clear communication, and framing forecasts in terms of real-world impacts are essential for helping users apply forecast information effectively.

Collaboration and trust

Building trust in forecasts requires collaboration between scientists and users. Involving users in the forecasting process, for example, makes scientific reasoning transparent and invites questions, demystifying uncertainty and leading to more confident, informed decision-making.