

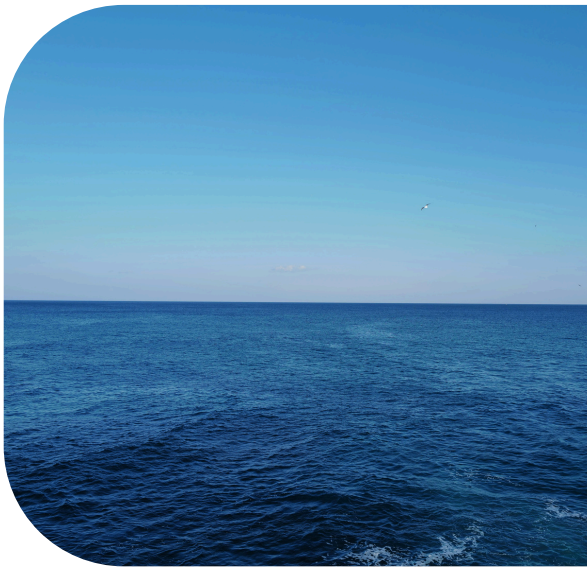
Climate modelling, predictability and forecast skill

This infosheet explores how climate predictions are produced, exploring concepts such as predictability and forecast skill, and how ASPECT is working to improve these.

How are climate predictions produced?

Climate predictions are produced by climate models, which mathematically simulate how the climate evolves over time.

In a process known as initialisation, the models start with observations of the climate system, such as ocean temperatures and atmospheric conditions, which helps improve the skill of the prediction. The models then simulate how the climate system may change over the coming months to years, accounting for both the initial starting climate conditions and external factors such as changing greenhouse gas concentrations.



Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement no. 101081460.

Climate predictions and ensembles

Climate predictions are produced using ensembles, where the same model is run multiple times with slightly different initial conditions. This is because we can't perfectly know the current conditions of the atmosphere and oceans, and even small differences can result in very different forecasts. For each ensemble member, the starting state of the climate system is altered slightly, creating a range of possible future outcomes rather than a single forecast. This helps forecasters assess the probabilities of different outcomes, e.g. how likely it is going to be wetter than usual in a particular region.

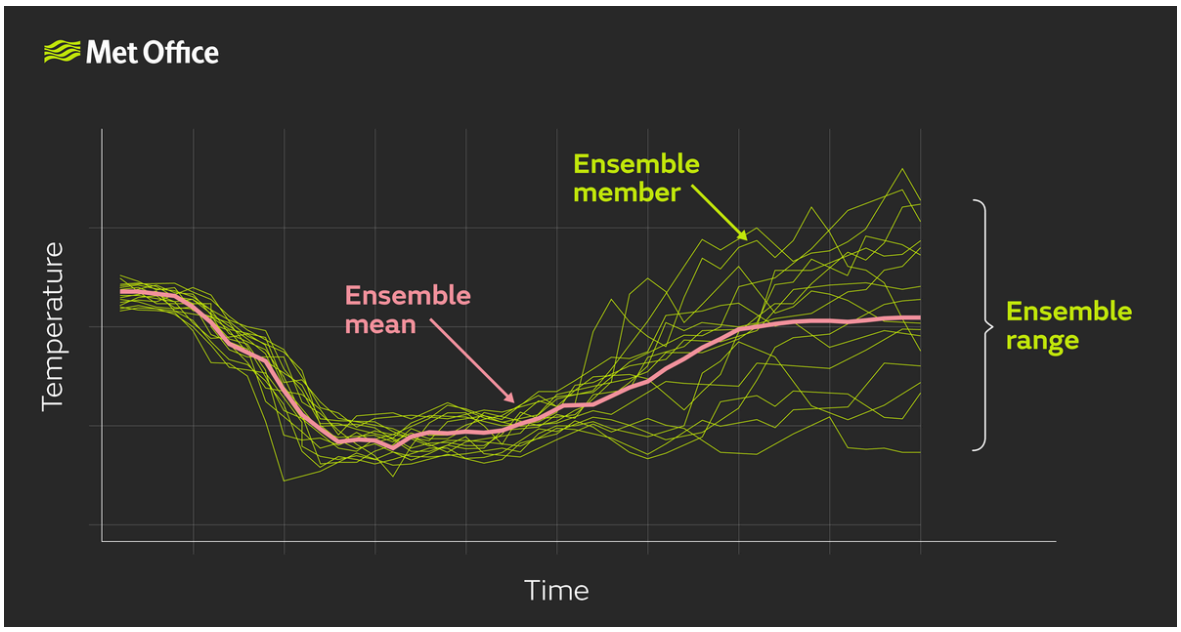


Figure 1: An illustration of a climate model ensemble. Each line represents an individual ensemble member, while the ensemble range shows the spread of possible outcomes for future temperature over time. Source: Met Office.

How is ASPECT improving climate predictions and projections?

Ensemble based predictions are used in ASPECT's seasonal to multi-decadal modelling experiments. A key part of the project has been the creation of new model simulations for multi-annual and multi-decadal timescales, in addition to increasing ensemble size for current modelling systems. Larger ensembles help to better constrain the range of possible future climate outcomes and increase confidence in our climate predictions. Large ensembles also give us the ability to better assess present-day and changing risk, particularly for extreme events. By increasing ensemble size, ASPECT is able to better identify predictable climate signals and provide more reliable information on future climate risks.

ASPECT is pioneering research to explore and assess these new prediction ensembles. It is also exploring methods for enhancing predictions, and ways to provide more local information using a group of techniques called downscaling.

The ASPECT project has created and improved a range of seasonal, multi-annual, decadal and multi-decadal prediction datasets, designed to support research into seamless climate information. These can be found on the ASPECT website.

What is model skill?

Skill refers to how well a prediction performs - by comparing it to the changes that actually happened. This can be assessed using hindcasts or reforecasts, which are retrospective forecasts for past periods where we have observations to compare with. For example, we could run a climate prediction for the last year using only information available up to one year ago, then compare this prediction to observations. This retrospective skill assessment informs our confidence in that model's real-time forecasts. In near-term climate predictions the forecast skill can vary depending on the timescale, season, variable, region and other factors.

Some regions and variables show consistently high skill, meaning they are well-simulated in models. For example, decadal prediction models have high skill for average European summer temperatures, particularly for the average of the next five years. However, when we look at more local regions, we may have lower skill and less reliability in our forecast - as it is harder for the models to capture signals of change over smaller areas.

Understanding climate variability

An important part of the ASPECT project, is better understanding the processes that drive climate variability; the season-to-season and year-to-year changes in the climate system which occur on top of the long-term warming trend. Better understanding of these processes can lead to improvements in prediction skill.

Recurrent, large-scale drivers of climate variability are referred to as 'modes of variability', examples include the El Niño Southern Oscillation (ENSO) and the North Atlantic Oscillation (NAO). Understanding these can make the climate more predictable on seasonal to decadal timescales. The ASPECT project is investigating how improved representation of different modes of variability in climate models can help improve forecast skill and provide more reliable climate information.



Windows of opportunity

Some regions and variables only show skill when certain modes of variability align, creating a ‘window of opportunity’ when predictions are particularly reliable. For example, strong ENSO events can provide important windows of opportunity on the seasonal prediction timescale in many regions, whilst decadal variability in the Atlantic Meridional Overturning Circulation (AMOC) has the potential to provide a window of opportunity for skilful European climate predictions.

ASPECT research is looking at the climate processes which create windows of opportunity and studying how they can be identified in advance. This could help provide more confidence in climate information when conditions favour more skilful predictions.



How is ASPECT improving future forecasts?

ASPECT is improving climate predictions by:

- Developing new multi-annual and multi-decadal prediction datasets.
- Increasing ensemble sizes to better capture uncertainty and improve forecast reliability.
- Improving understanding of key drivers of predictability such as ENSO and the NAO.
- Producing longer hindcast datasets to evaluate forecast performance.
- Post-processing methods e.g. ensemble pooling, ensemble selection and sub-sampling.
- Testing approaches to create higher-resolution information.
- Combining information from seasonal forecasts, observations and decadal predictions.



Find out more

To find out more, see our other infosheets on the ASPECT website.

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This document was prepared by the Met Office. October 2026