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Decadal climate predictions, impacts of Arctic sea ice loss, and the signal-to-noise paradox

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Many sectors of society are vulnerable to decadal changes in climate, which impact food security, freshwater availability, spread of pests and diseases, heat waves, droughts, floods, cyclones, wildfires, energy supply and demand, transport, migration, and conflict. On decadal timescales climate is influenced by both internal variability and changes in radiative forcing. Climate predictions that are initialised with observations are needed to account for all of these factors and will be reviewed in this talk.

Understanding the drivers of decadal climate is crucial for gaining confidence in forecasts. One hypothesis, namely that Arctic sea ice loss weakens mid-latitude westerly winds, promoting more severe cold winters, has sparked more than a decade of scientific debate. The Polar Amplification Model Intercomparison Project was developed to address this issue and results from coordinated multi-model experiments will be presented that support the above hypothesis and suggest that this effect is underestimated by current models. However, even when accounting for this underestimation, the response to Arctic sea ice is small compared to yearly variations in mid-latitude winters.

For predictions to be useful they must be skilful and reliable. There is mounting evidence that models may underestimate the strength of predictable signals, especially for atmospheric circulation in the North Atlantic. This error has been termed the “signal-to-noise paradox” since it leads to the unexpected situation that models can predict the real world better than one of their own ensemble members. Skilful predictions can be achieved using a very large ensemble, but the model output cannot be taken at face value and needs calibrating to obtain skilful and reliable forecasts. Given the potential impacts of changes in atmospheric circulation, understanding why the signal-to-noise ratio is too small in current climate models, and assessing the extent to which correcting this model error would reduce uncertainties in regional climate change projections of the coming decades, are high priority areas for future research.