What is a decadal prediction?

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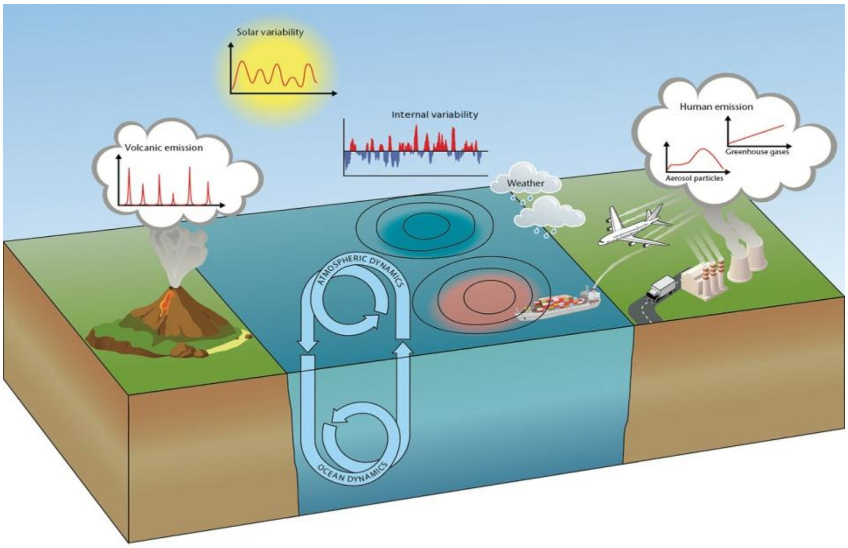
Weather is chaotic which limits its predictability to one or two weeks (link to seasonal fact sheet?). This means that it will never be possible to extend normal weather forecasts to seasonal time-scales and beyond.

For example, we will never be able to predict the weather on a specific date in a specific place years in advance. However, **changes in *prevailing* weather over the course of several months to years are potentially predictable**. For instance we may be able to say if a particular region might expect, on average, colder winters or drier summers. Such changes in weather patterns occur due to the interaction of the atmosphere with more slowly varying parts of the Earth system.

Weather is a result of energy moving through the Earth system. Energy is originally radiated to the Earth from the Sun, with most being re-emitted or reflected back to space. The amount that remains in the Earth system is modulated by many things: some emerge naturally within the system (*internal variability*), whilst others are controlled by external factors such as variations in solar output, greenhouse gases, and atmospheric particles (*aerosols*) from human emissions or volcanic eruptions.



This figure shows some of these factors along with representations of their variability on decadal time-scales.

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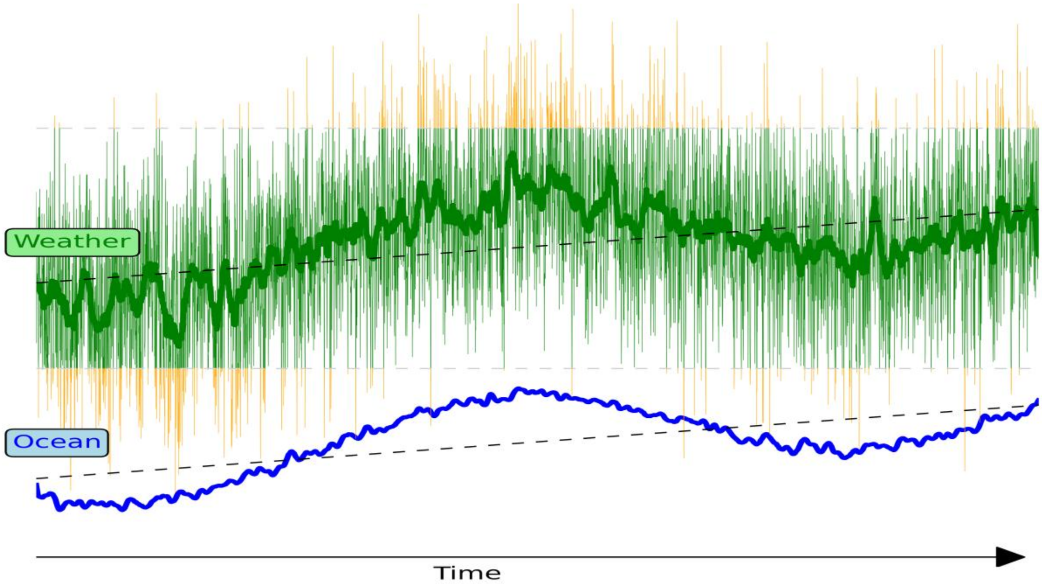
Energy that remains in the Earth system drives changes in the ocean, atmosphere, ice, land and biology. These changes are often complex, but some that affect weather patterns vary slowly and are potentially predictable. This is particularly true for the oceans where variations in El Niño and ocean currents in the North Atlantic can be predicted well beyond weather forecast time-scales.

An example of such ocean variability is shown by the red/blue trace above. Predicting coming changes in these, along with more direct impacts of external factors such as global warming, allows prediction of the associated changes in prevailing weather.

Decadal predictions are made using a computer model which combines our best estimate of the current state of the earth system with projections of external factors. Unlike century-scale climate change projections, decadal forecasts are *initialised*, meaning the oceans, ice and atmosphere in the model are matched to real world observations at the start of the forecast. This is necessary to predict the internal variability that is inherent in the Earth system (such as El Niño), in addition to variability driven by external factors (such as greenhouse gases and aerosols).

Uncertainties in forecasts are inevitable due to chaotic variability of the weather, and uncertain knowledge about future changes to external factors. To account for this, an *ensemble* of many forecasts is made. This ensemble approach allows us to quantify the uncertainties.



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The figure above shows idealised data representing a skilful decadal forecast. The actual day-to-day weather conditions (thin green/orange line) are highly changeable, however, when they are smoothed (thick green line) one can see multi-year variations in the prevailing weather. Such changes in prevailing weather might be predicted if they are driven by a component which itself can be predicted months or years in advance.

For instance, the periodic variations in the figure might be driven by predictable changes in El Niño or Atlantic Ocean currents. This is represented by the blue ocean observations line. Note that changes in the number of extreme values (highlighted in orange as they exceed the grey thresholds) are also predicted.

Decadal forecasts have already proven useful for predicting important phenomena like the severity of hurricane seasons, and changes to the number of daily temperature extremes. Ongoing research is attempting to identify and refine products such as these. They can then be used by planners and policy makers to make informed decision about future investment and resource allocation.

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