TEN-YEAR forecasting of changes in weather patterns

At local level, ten-year forecasting will help farmers to plan for the necessary adaptation to climate change.

The various changes in weather patterns have an undeniable social, environmental and economic impact. The latest form of climatic modelling, ten-year forecasting, aims to bridge the gap between seasonal predictions and end of century climate forecasting.

Long term forecasts are typically used to describe future climate and its implications over a century. However, it remains crucial to characterise changes in weather patterns over a shorter time span. Ten-year forecasting (from 3 to 30 years) is seen as an intermediate range, useful to develop and implement solutions to adapt to climate change, particularly in the field of agriculture. It must predict how key variables, i.e. rainfall and temperatures, are going to evolve, and establish the way in which they will vary from one year to another.

Climatologists are increasingly aware of what naturally produces strong weather pattern changes over a period of ten years. They are mainly linked to oceans (see insert). The ten-year oscillation in the North Atlantic produces, among other effects, successive hot and cold phases. Persistent drought in the Sahel region in the 1970s and 80s, which caused famine and depopulation, was attributed to a cold phase in the North Atlantic's ten-year oscillation. Such internal changes are possible to predict, as are external changes (also known as "forcing") linked to human activity, such as (warming) greenhouse gas or (cooling) dust emissions. The main challenge of this forecasting exercise is that the impact of those internal changes is comparable to the impact of anthropic forcing. However, forcing originating from natural causes, such as volcanic eruptions or low solar activity periods, is unpredictable. Based on what we know of such mechanisms, climate modelling over a ten-year period involves solving the oceanic and atmospheric flow equations in three dimensions, for the entire planet, and in as detailed a way as possible. This forecast is created by a model based on the initial state of the climate. The greater the detail known about this state, the more reliable the result of the simulation will be. Uncertainty increases as the range of the forecast extends into the future.

In order to take into account the uncertainty linked to the initial state of the climate, several simulations are carried out, based on slightly different initial states. The closer the simulation results are, the greater the confidence in the accuracy of the forecast will be, without ever ensuring total reliability. This approach based on probability also helps explore various possible future scenarios.

Forecasting: what for?

In agriculture, ten-year forecasts can be used to guide the development of new varieties, build irrigation or water storage infrastructures, or adapt cropping systems. From tactical farm management as we know it, involving hourly to termly ranging forecasts, ten-year forecasting opens the door to strategic management.

"It now seems crucial to establish links between scientists, who develop ten-year forecasts and know their inherent limitations, and future users, who know the risks that weather vagaries present for their industry. That is the main challenge of those currently developing operational services across the world. The French Department of the Environment has therefore decided to fund a project run by the Institut des sciences des services climatiques, in partnership with CNRS and Météo-France and led by the Institut Pierre Simon Laplace", explained Éric Guilyardi. Those services aim to translate ten-year forecasts into risk factors for various sectors, including agriculture, and ultimately, into a decision support tool.

From "*Prévoir les changements climatiques à 10 ans, le nouveau défi des climatologues*", by Éric Guilyardi (CNRS), Juliette Mignot (IDR), Christophe Cassou (Cerfacs), published on theconversation.com/fr.

The Pinatubo eruption in 1991 had a global cooling effect of around 0.5°C for six months. Such external forcing cannot be predicted.

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Oceans store 93% of the additional heat produced by human activity. Their heat absorption capacity may temporarily mask climate change.

« THE TEN-YEAR RANGE: a combination of internal changes adjusted by external factors (volcanic eruptions, solar activity, greenhouse gas emissions due to human activity). »

Global warming may be "masked" in ten-year forecasts

Oceans get warmer less quickly and for longer than the atmosphere. Their gigantic heat absorption capacity, which allows them to store most of the heat related to climate changes, acts as a buffer against such changes.
This natural adjustment results in variations of just a few tenths of a degree in the overall Earth temperature. However, it is great enough to temporarily mask global warming caused by human emissions.

WHAT CAN WE EXPECT FROM ten-year forecasts?

Eric Guilyardi: "Ten-year weather forecasting services must be developed in partnership with scientists and potential end users in order to integrate everyone's knowledge and requirements."

The concept of ten-year forecasting only emerged a decade ago, and it represents a challenge for scientists. Éric Guilyardi, oceanographer and climatologist at the Institut Pierre Simon Laplace (IPSL), defines its merits, as well as its limitations.

Perspectives Agricoles: **What will determine the quality of ten-year forecasts?**

Eric Guilyardi: This forecasting range requires a detailed knowledge of all weather data, past and present. In order to be able to produce a forecast, we first need to be able to describe in as much detail as possible the initial state of the climate system (atmosphere, oceans, continents, sea ice…). Historical data is used to validate the relevance of climate models, by comparing their forecasts with actual weather. This central preliminary statistical work is hampered by the limited reliable historical data available. Having a clear understanding of the initial state of the climate is therefore crucial for accurate forecasting, but difficult to achieve. It requires a very dense observation network, including over oceans, which play a determining role in that range of forecasts. It is only in the past decade that such level of detail has been available. The 4000 buoys of the ARGO network continuously observe the first 2000 meters of the ocean, whereas satellites such as Jason monitor its height and surface temperature.

P. A.: **What progress has been made?**

E. G.: For just about a decade now, we've held the three prongs of ten-year forecasting: an observation network, a better understanding of climate variability patterns over a ten-year period, and better climate models. The buoys network established to monitor oceans is now going from an experimental phase to an operational stage, and ARGO buoys with a 4,500m range are also being developed. We have a better understanding of the interaction between the different components making up a climate system, but it is still "easier" to forecast the evolution for tropical areas than for our latitudes, because it is more chaotic. In Europe, the climate over several years is primarily determined by currents in the North Atlantic, and to a lesser extent by the snow cover in Siberia and the size of the arctic ice pack. If we manage to predict the way in which those ocean currents will vary, on the surface and at depth, over a ten-year period, we can hope to be able to establish reliable ten-year forecasts for mid-latitudes.

P. A.: **When can we hope to have an operational product?**

E. G.: As things stand, ten-year forecasting is still a long way from being operational. Climate services must be built by scientists in conjunction with future users, in order to integrate everyone's constraints, requirements, aims and challenges. In the meantime, we need to improve our climate models and validate the reliability of forecasts. To do that, we need to gather and digitize more historical data, in order to "reconstruct" the climate of the past. We must also expand the ocean observation network in certain key areas, in particular in the North Atlantic. Everything depends on the speed of progress made by research and of the forecast reliability assessment. However, we hope to be able to say one day that springs will tend to be wetter over the next ten years, or that extreme weather events will increase in numbers, but we will probably not be in a position to do that within the next 5 years. We will nevertheless soon be able to present to farmers the array of possible future climates we can expect within the next 20 years, with the level of probability for each of them.

Interview by Paloma Cabeza-Orcel and Olivier Deudon