

## **Please tell me the weather**

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Much of the northeast is experiencing drought this summer. It is patchy because a lot of summer rain comes from scattered thunderstorms. Despite periods of drought and heavy rain, our garden here in Vermont is growing well this summer. In part this is because I have watered the whole vegetable garden twice, and a few crops more frequently. There has been one unexpected but delightful change in our local ecosystem, perhaps because of the warm winter. This spring and summer there have been so few mosquitos that weeding is a delight, and it is pleasure to eat dinner on the lawn in the evening. It is such a contrast from some recent years, when I wore a net over my head in the garden.

Last month I visited the European Weather Centre in England, which provides the best 10-day forecasts for the planet. For 30 years I have worked with scientists there to improve the modeling of the transfer of heat and water from land to atmosphere, since this affects the weather. Computers have improved so much that these forecast models can calculate changes in pressure, temperature, wind and precipitation every hour everywhere on the globe for points that are only 5-10 miles apart for one to two weeks ahead.

So now I am asked: "Weather forecasts have become pretty good for even next week, but what I really want is a forecast for the next two months, so I can make plans for my work, my crops and my vacation." This is much more difficult modeling challenge. Every day, we measure the state of the atmosphere with surface weather stations, weather balloons and instruments on perhaps a hundred satellites, and all this data goes into models for the global weather, running continuously on some of the largest computers available. One hundred forecasts may be run out for the next 2 weeks. For the first few days, they are very similar, because they remember the measurements they started from, so we know with some certainty what the weather will be. But as complex jet-streams and storms develop, the hundred forecasts spread apart, and after 2 weeks we cannot be sure what will happen.

When we run fifty forecasts for the coming season, these too spread out a lot within a month. The Earth does have some long term memory, the energy stored in the oceans, and the moisture in the soil that came from last month's rain, the snow cover in winter and ice in the Arctic that keeps temperatures below freezing by reflecting sunlight. These do influence the weather patterns for months. But the global jet stream patterns that strongly influence weather can change every week, so it is harder to predict their pattern a month ahead.

Seasonal forecasting still needs improvements in our models. The official 3-month outlook for August-September-October from NOAA is that the northeast will be warmer, but precipitation will be average. The corresponding seasonal forecast from the European Weather Centre is that the northeast will be both warmer and drier than average. If this happens, the drought will continue.

On the political front, some Vermont candidates for governor support a carbon tax on fossil fuels to nudge the energy system to become more efficient, and accelerate the development of renewable energy resources. In Canada, this helped the economy of British Columbia, and Alberta is now following the

same strategy. On the national front, one party drifts still further into a fantasy world, where devastating the planet's climate and ecosystems to satisfy its financial sponsors will somehow save America's ego.

Yet despite establishment resistance, the stunning speed of renewable energy development with the rapid fall of the price of solar panels and lithium batteries is accelerating change. Global carbon emissions could peak as early as 2020, so keep pushing for values that will bring us a sustainable future.