ASK DR SOO

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Q.: Hey, Dr. SOO, I've heard tell that butterflies are the real cause of weather, not cold fronts and upper-level storm systems and all that. Why don't you forecasters talk about butterflies in your forecasts? --Wobbly in Wibaux

Can butterflies control the weather?

A.: Hello Wobbly. What you are referring to is sometimes called "the butterfly effect", but it goes by other names, such as "sensitive dependence on initial conditions", "non-linearity", or "Chaos". It is also the reason we can't forecast next month's weather.

The idea behind Chaos is that small things, like the flapping of a butterfly's wings, can have big effects on the future. An extreme example might be a butterfly in Brazil causing a tornado in Texas a month later.

This may sound ridiculous at first glance, but it is actually true. In part. Think about the weather as a giant asteroid the size of Rhode Island a billion miles from Earth. Let's say it is lumbering directly towards Earth at 400 mph. At that rate it collides with the Earth in about 300 years. Now let's say there is a tiny grain of sand--this is the butterfly in our analogy--and that this grain collides with the asteroid out in space when it's a billion miles from Earth. This collision will be scarcely noticeable. That grain of sand might deflect that big, bad asteroid a mere millimeter per mile of travel. That's practically nothing. However, if the asteroid's path is changed by one millimeter per mile of travel, after 1 billion miles, its trajectory will differ by 1 billion millimeters, or over 600 miles. This is no longer small and could make the difference between the asteroid striking the Earth, devastating civilization and interrupting reruns of *Lost*, or missing the Earth altogether. Tiny events can have big effects, in the world of Chaos.

Weather is like that. Ridiculously tiny events, like the flapping of a butterfly's wings can have big effects on the future weather. The capricious actions of a butterfly probably do not really begin to affect the weather for at least a couple months, if not longer, but eventually they do.

If a butterfly matters, then so do other bugs, animals, plants, people, the shape of every grain of sand, in fact, every quantum-mechanical fluctuation of every particle in the universe matters, and will affect the weather at some, distant future time. To get back to our asteroid analogy, the weather is like that asteroid, but it is passing through space that is loaded with grains of sand. It is getting pelted by millions of sand grains every second. To predict the precise location of the asteroid in the future, you would need to account for the effect of each collision. This is too difficult.

Because there are so many butterflies and other small things, and because we have no way of knowing what they are doing, predicting the weather a long time into the future is not practical. Short-term forecasts of a couple days or so are often pretty good because these forecasts depend on big things like fronts and the jet stream. Further into the future, though, and the forecast begins to depend on smaller and smaller things; things which are too small to measure, and too numerous to keep track of. Consequently, forecasts get worse the further out you go in time.

Meteorologists have made great strides in forecasting in recent years, largely due to the development of computer models and new observing systems. Forecasts are now generally useful out 3 or 4 days into the future. Forecasts out as far as 7 days, while not very good, have some value. Because of inherent Chaos, it is believed that there is an upper limit to how far we can forecast the weather into the future, no matter how good our observations of the atmosphere and computer models get. This limit is probably about 2 weeks.

Since you sound like a curious and imaginative sort, I'll leave you with the following thought: It may actually be possible to forecast the weather for next year, or any distance into the future. In light of all the butterflies in the world, the only way to do this is to control the weather. Clearly, if you cause the weather, then you can schedule the weather any distance into the future. Forecasting becomes a matter of looking it up in the schedule. "And how, pray tell, can we control the weather?" you may ask. Well, the atmosphere is very large and controlling it directly with, say, giant fans, heating and cooling devices, and so forth, would require vast amounts of resources and energy. That is not going to work. What might work, though, is to take a lesson from all those butterflies. If you have enough knowledge about the atmosphere, then maybe you could figure out how to perturb it in just the right way such that you get the weather you want a month or so later. Using the asteroid analogy, the idea is to bump that asteroid when it is still a billion miles from Earth in just the right way so that it is where you want it to be 400 years later. Perturbing the atmosphere might involve such things as wind baffles or sunlight reflectors to cool the surface over some small area. Irrigation of farms has been shown to affect local weather, and this could be controlled. It is a big planet, and you would probably need to have a network of weather perturbation stations around the globe. The perturbations you add to the weather would still have to be pretty big in order to overwhelm the effect of all the smaller things you don't know about, like all those butterflies.

We can't do this now, and may never be able to, but it is something to think about.