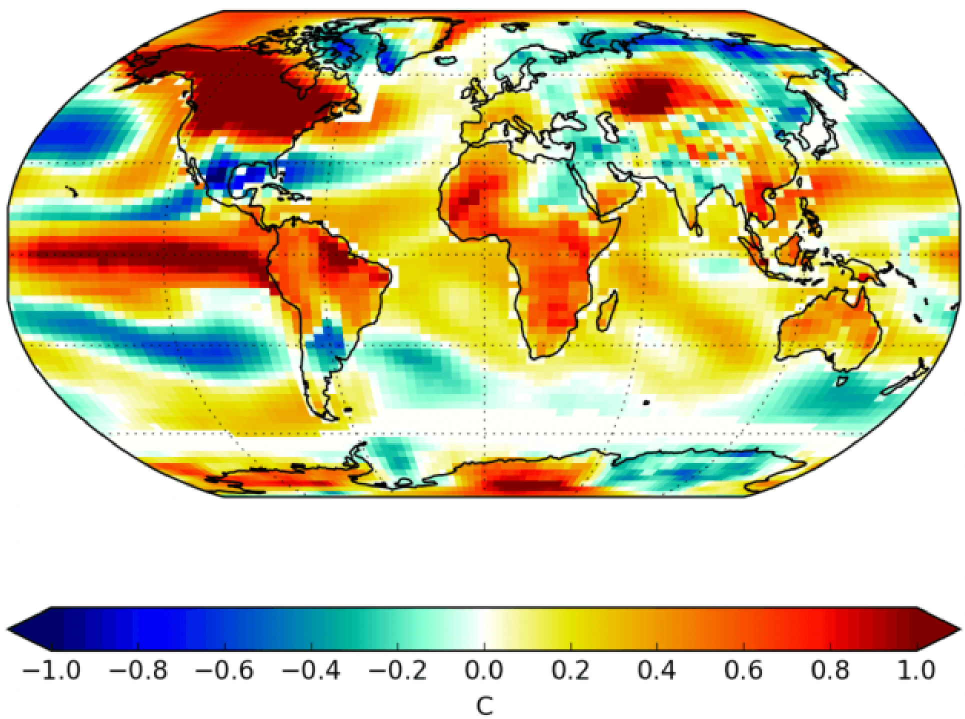
How does El Nino warm the entire globe?

October 6 2015, by Dietmar Dommenget And Nicholas Tyrrell



Surface temperature response to an El Nino forcing, using the ACCESS climate model.

We regularly hear about how El Niño events raise the temperature across much of the planet, contributing to spikes in global average temperature such as the one witnessed in 1998, with severe bush fires, droughts and floods.

Indeed, the extra warmth is typically much more apparent over land than in the oceans, despite El Niño being chiefly thought of as an ocean temperature phenomenon.

How is it that an event predominantly characterised by a warm blob of water in the tropical eastern Pacific can have such a pervasive effect on global land temperatures?

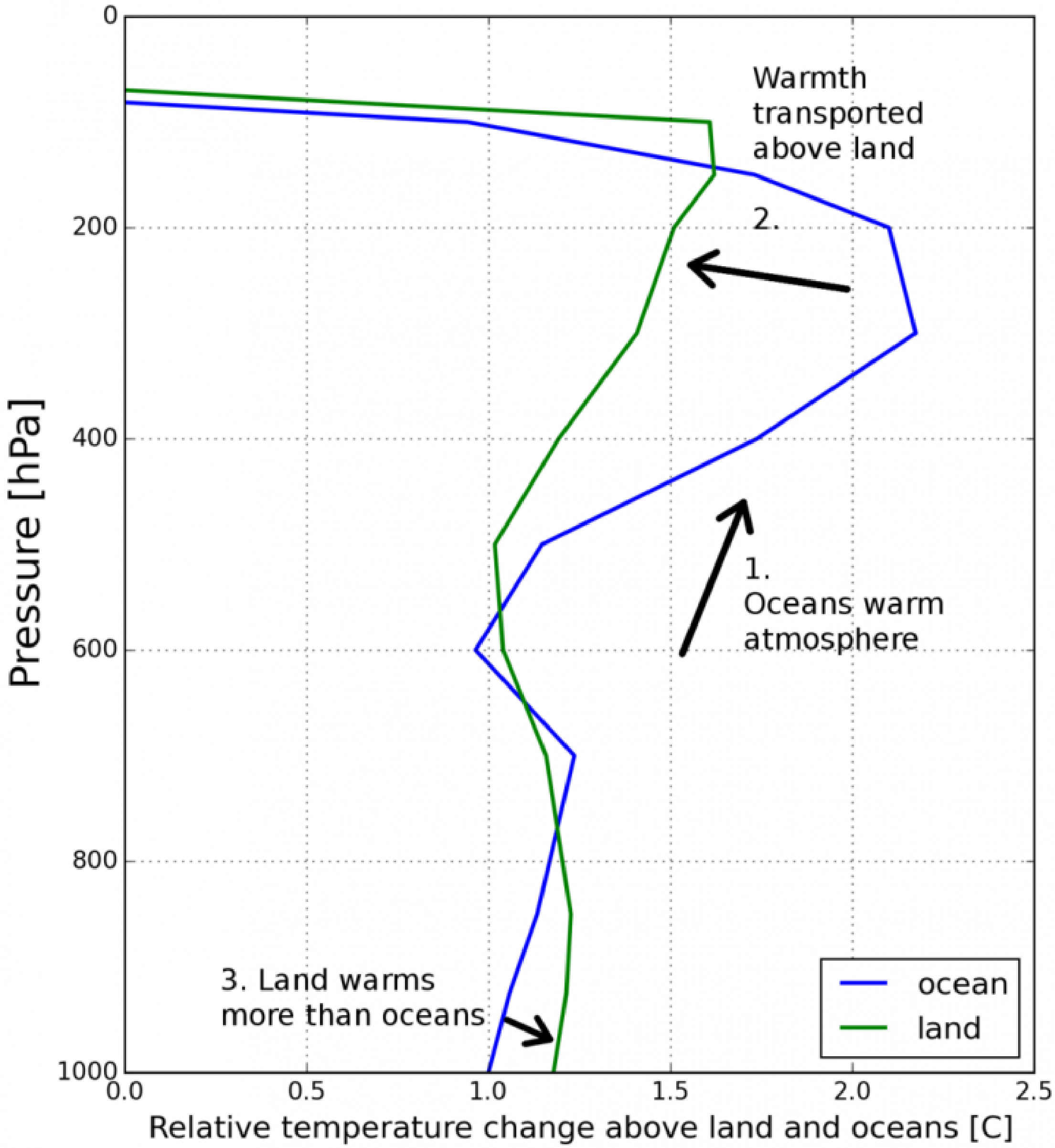
Consider the following: in your home you have a heater that warms all of the rooms. If you increase the heater's temperature by one degree you would expect that the rest of your home also warms a bit, but probably less than one degree, and that the most remote rooms would warm least of all. Surprisingly, this is not what happens when you warm the tropical oceans in our climate system. This heater heats up all the "rooms" by more than itself.

It turns out that if we were to warm all of the oceans on Earth by 1C, the land would, as a direct result, warm by 1.5C. On average, the land always warms more than the ocean. The key difference here is that when you warm the tropical oceans you also release additional water vapour into the atmosphere by evaporation from the oceans' surface.

When the warm air over the oceans rises to higher levels in the atmosphere, the moisture in the air rains out, releasing extra heat – called "latent heating of condensation". This leads to extra warming of the air.

The temperature above the land comes into balance with the warmer higher-level temperatures above it and, because the land surface is much drier it warms right away without surface evaporation cooling it.

Where El Niño comes in



The atmospheric temperature above land and ocean in the tropics (relative to changes in ocean temperature). The pressure on the y-axis indicates the altitude;

1000hPa is the surface and 200hPa is 10-15km high.

In a study we published last year, we used climate models to perform simulations in which we raised and lowered the temperature of the oceans to see how the land would respond. As expected, we found that land temperatures varied more than ocean temperatures, and changes in ocean temperature were amplified over the land.

To explore how an El Niño or La Niña event would affect this land/ocean contrast, we then introduced the El Niño Southern Oscillation (ENSO) into our model as the main source of temperature variability in the oceans.

This time, instead of assigning the whole ocean a uniform temperature, we simulated El-Niño/La-Niña conditions. We made the tropical Pacific Ocean warm and then cool over a period of four years (in the real world, ENSO is much less regular than this but the oscillation typically lasts about that long). We then watched to see how the rest of the ocean and land would respond.

Remarkably, the global land surface temperature still responded with increased variability, relative to the ocean. If the ocean surface temperature increased or decreased by 1C, the land temperature increased or decreased by almost 1.5C. Essentially, we found that the global land temperature can be altered simply by changing the temperature of the tropical Pacific Ocean.

You might ask: what if you changed the temperature of the Southern Ocean, or the North Atlantic, or some other bit of ocean instead? Would you get the same result? The answer is no.

Why is the tropical Pacific so influential?

The answer is because of tropical convection – the tendency for warm air and moisture to rise high into the atmosphere.

Atmospheric convection in the tropics reaches up to about 5-10km above the ocean, taking the warmth into the mid-to-upper troposphere. This is fuelled by the heat release from the condensing moisture in the tropical air. The colder oceans do not have the capacity to evaporate that much water vapour and therefore to generate the kind of convection that reaches this high.

Warm air penetrates the troposphere's upper levels (as opposed to the lower troposphere immediately above the surface) and in the tropical upper atmosphere air can flow freely and easily distribute heat, so regional differences in temperature are evened out. The warm temperatures above the Pacific Ocean spread out and encircle the tropics. The warmth from tropical ocean convection can also spread out of the tropics and influence atmospheric temperatures in the mid-latitudes.

What does this mean for the years ahead?

We know that land and ocean temperatures fluctuate around an average value. However, that average value is increasing as a result of global warming resulting from human carbon dioxide emissions.

At the same time, we currently have a large, potentially record-breakingly hot El Niño brewing in the Pacific Ocean, which is expected to keep growing at least through to January.

As the current El Niño combines with the background warming of climate change, we can expect land temperatures to continue to spike, potentially surpassing last year's global record average. This warmth is likely to persist through and slightly beyond the period of the El Niño, increasing the likelihood that 2015 and 2016 will be very warm years indeed for the planet.

Source: The Conversation