New study finds variations in global warming trend are caused by oceans

May 15 2018

When the atmosphere gets extra warm it receives more heat from the ocean. Credit: University of Southampton

New research has shown that natural variations in global mean temperature are always forced by changes in heat release and heat uptake by the oceans, in particular the heat release associated with evaporation.

Analysing data from six climate models that simulated future climate change scenarios for the last International Panel for Climate Change (IPCC) Report, which appeared in 2014, University of

Southampton Professor Sybren Drijfhout has shown that in all cases variations in global mean temperature were correlated with variations in heat release by sensible and latent heat. Writing in the journal *Nature Scientific Reports*, Professor Drijfhout says these variations are associated with heat transfer due to temperature differences between the surface ocean and the overlying air, and heat transfer associated with evaporation. The heat fluxes are also called the turbulent heat fluxes.

"The relation holds in all models and is independent of the time-scale of the variation in temperature", says Professor Drijfhout, Chair in Physical Oceanography and Climate Physics at Southampton. "When the atmosphere gets extra warm it receives more heat from the ocean, when it is extra cool it receives less heat from the ocean, making it clear that the ocean is the driving force behind these variations."

"The same relation can be observed in the observations, but because the data on surface heat fluxes is characterised by large uncertainties, reviewers urged me to drop the part associated with analysis of these data," he adds.

Professor Drijfhout also explains he could only analyse six climate models because he needed to split natural temperature variations from the forced trend due to increased greenhouse gas concentrations. "You need the same model to repeat the same emission scenario a few times with slightly different initial conditions", he argues. "In that case the natural variations will run out of phase, while the forced response is the same in each model run. This allows for a clear separation of the two."

The relation between global mean temperature variations and total heat uptake appears to be more complex due to changes in absorbed solar radiation which are out of phase with the turbulent fluxes and the temperature response.

Before the ocean releases extra amounts of heat to the atmosphere, it is warmed by increased absorption of solar radiation. For a hiatus in global warming, or relatively cool period, the opposite occurs and more sunlight is reflected, cooling the ocean after which the atmosphere on its turn is cooled by less heat release from the ocean.

"The changes in solar radiation received at the Earth's surface are clearly a trigger for these variations in global mean temperature," says Professor Drijfhout, "but the mechanisms by which these changes occur are a bit more complex and depend on the time-scale of the changes.

"When the temperature variations only last a few years," he continues. "The changes in absorbed solar radiation occur in the tropics, preferably the Pacific, and are associated with moving patterns of more or less clouds that are characteristic with El Nino, or its counterpart, La Nina."

If the variations take longer, ten years or so, sea-ice becomes the dominant trigger, with more sea-ice reflecting more solar radiation and less sea-ice allowing for more absorption. These variations always peak over areas where surface water sinks to great depth and deep and bottom waters are formed which are transported by the global overturning circulation, or more popularly dubbed, Great Conveyor Belt.

"This is a bit strange," Professor Drijfhout concludes, "because the temperature signal of these global variations peaks over the tropical Pacific, while the trigger peaks over the subpolar oceans. We do not yet understand how the linkage is established in the models, but it appears very robust. Also, if you replace global mean temperature with an average over the tropical belt, this linkage still exists."

It should be noted that the models seem to underestimate triggers in the tropical Pacific on these long timescales. "Already with El Nino we know that the energy exchange between ocean and atmosphere is not

correctly captured in the models," he says. "But despite these model errors the linkages in the models should be qualitatively correct. Understanding how these links are established and analysing the observations more closely whether the same links can be found there is clearly the way the research of my group will follow in the coming years."

More information: Sybren Drijfhout. The relation between natural variations in ocean heat uptake and global mean surface temperature anomalies in CMIP5, *Scientific Reports* (2018). DOI: 10.1038/s41598-018-25342-7

Provided by University of Southampton