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From a pair of scientists working at the Goddard Space Flight Center (NASA, Greenbelt, Maryland, USA), a novel way to measure heat content changes of the oceans using the data of magnetometers of orbiting satellites.

Climate science

How hot is the sea?

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A novel way to measure how much heat the oceans are hiding

"NOBODY really knows" was Donald Trump's assessment of man-made global warming, in an interview on December 11th. As far as the atmosphere is concerned, that puts him at odds with most scientists who have studied the matter. They do know that the atmosphere is warming, and they also know by how much. But turn to the sea and Mr Trump has a point. Though the oceans are warming too, climatologists readily admit that they have only a rough idea how much heat is going into them, and how much is already there.

Many suspect that the heat capacity of seawater explains the climate pause of recent years, in which the rate of atmospheric warming has slowed. But without decent data, it is hard to be sure to what extent the oceans are acting as a heat sink that damps the temperature rise humanity is visiting upon the planet—and, equally important, how long they can keep that up.

This state of affairs will change, though, if a project described by Robert Tyler and Terence Sabaka to a meeting of the American Geophysical Union, held in San Francisco this week, is successful. Dr Tyler and Dr Sabaka, who work at the Goddard Space Flight Centre, in Maryland, observe that satellites can detect small changes in Earth's magnetic field induced by the movement of water. They also observe that the magnitude of such changes depends on the water's temperature all the way down to the ocean floor. That, they think, opens a window into the oceans which has, until now, been lacking. To measure things in the deep sea almost always requires placing instruments there—either by lowering them from a ship or by putting them on board submarine devices. The supply of oceanographic research vessels, though, is limited, and even the addition in recent years of several thousand "Argo" probes (floating robots that roam the oceans and are capable of diving to a depth of 2,000 metres) still leaves ocean temperatures severely under-sampled.

presented at AGU (San Francisco, CA) December of 2016.

Satellites, however, can look at the whole ocean—and, if they are properly equipped, can plot ways in which Earth's magnetic field is deflected by seawater. This deflection happens because seawater is both electrically conductive and always on the move. Such a moving conductor will deflect any magnetic field that passes through it. Crucially, saltwater's conductivity increases with its temperature. This means the deflection increases, too. And since the magnetic field originates from within Earth, it penetrates the whole ocean, from bottom to top. So any heat, whether in the deepest troughs or near the surface, contributes to the deflection.

All this means that, if you know where and how ocean water is displaced, the changes in the magnetic field, as seen from a satellite, will tell you the heat content of that water. Dr Tyler and Dr Sabaka therefore built a computer model which tried this approach on one reasonably well-understood form of oceanic displacement, the twice-daily tidal movement caused by the gravitational attraction of the moon.

Sadly, when they had crunched all the numbers, they found that with the available magnetic data, understanding the tides alone is not enough to calculate the oceans' heat content. That requires one or both of two things to happen: adding the effects of other water movements, such as ocean currents and solar (as opposed to lunar) tides to the calculation, and collecting better magnetic data. The second approach, at least, is already in hand. Three recently launched European satellites, known collectively as *Swarm*, are busy gathering just the sort of data required. So if Dr Tyler and Dr Sabaka can upgrade their model of ocean movement appropriately to receive *Swarm*'s data, they may yet answer the questions of how much heat there is in the sea, and how much more it might reasonably be expected to absorb. ■