Where's The Heat? Think 'Deep Blue'

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"It's a match!" For detectives in a crime story, identical fingerprints or cloth fibers might solve the case. For scientists, it could be something equally dramatic. It might be real-life observations that match the simulations of their computer models.

Such a match would provide evidence that they understand enough about a complex system to be able to understand its past behavior and perhaps anticipate its future behavior. For researchers studying climate change, the proof they've been looking for is in the ocean.

A group of scientists led by Dr. James Hansen of NASA's Goddard Institute for Space Studies recently published their findings that Earth is absorbing more energy from the Sun than it is emitting back to space.

Their climate model predicted that growing amounts of human-produced greenhouse gases would trap solar radiation and lead to a warming planet. If the model were correct, it should be possible to find all that excess heat somewhere -- and they did.

New measurements show that, over the past ten years, the heat content of the ocean has grown dramatically. It's grown by so much that it can finally account for the excess energy that the climate model calculated should exist. It is, in fact, a match.

Figuring out the ocean's heat content and measuring it over time isn't easy. "It's a very noisy ocean. You need to see lots of data to get the big picture of what's going on," says JPL researcher Dr. Josh Willis, a co-

author with Hansen of the paper on Earth's energy imbalance published in the journal Science. Willis' study of warming in the upper ocean, published last year, provided some of the key measurements used to compare with the climate model.

"We looked at about a million temperature profiles from floats, buoys and other sources and combined those with altimetry data to put together a good estimate of ocean heat content," says Willis. The satellite data from Topex/Poseidon, Jason and other ocean altimeters provided a global picture of rising sea level.

The temperature profiles allowed the researchers to calculate just how much of the change was the result of thermal expansion. The analysis showed a fairly steady, measurable warming over the past decade. "The average ocean temperature is warmer," says Willis, "Some places are getting cooler and others warmer as the heat moves around, but the total amount of heat is growing."

The ocean was the logical place to look for any extra heat the Earth is collecting. "It's the biggest bucket to hold heat," says Willis.

"It has the largest heat capacity of any single component of the climate system." A high heat capacity means that it takes a lot of energy to raise the temperature. "You know it takes a lot of energy to boil a pot of water, so imagine how much you'd need to increase the ocean's temperature," adds Willis.

"It takes at least a 1000 times more energy to raise the temperature of the ocean than it does the atmosphere."

"We know that if the ocean temperature is rising," says Willis, "there is a lot of energy that is causing it. The only way we have to explain that much heating is by greenhouse gases."

Even with its great storage ability, some of the heat will go toward warming the atmosphere. Hansen, Willis and their colleagues conclude that even with no further increase in greenhouse gases, the temperature of Earth will rise about 0.6 degrees centigrade (1.1 degrees Fahrenheit).

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