Mathematics and the ocean: Movement, mixing and climate modeling

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Studying the dynamics of the ocean system can greatly improve our understanding of key processes of ocean circulations, which have implications for future climate. Can applying mathematics to the research help? Dr. Emily Shuckburgh of the British Antarctic Survey, speaking at the 2012 SIAM Annual Meeting, thinks the answer is an emphatic "yes."

Dr. Shuckburgh described mathematical ideas from dynamical systems used by her group, along with numerical modeling and experimental observations, to analyze circulation in the Southern Ocean. The Southern Ocean is unique in that it connects 3 major ocean basins—the Pacific, the Atlantic and the Indian oceans—with a powerful current that circulates all the way around Antarctica. This circumpolar current travels from the North Atlantic, sinking down to the bottom of the ocean and coming up to the surface around Antarctica, thus connecting the deep ocean with the atmosphere above. When water from the deep ocean comes up to the surface, it can exchange heat and carbon dioxide from the atmosphere, thus making it highly significant for climate change.

Shuckburgh and her team study circulation at Drake Passage, which separates South America from the Antarctic Peninsula, at the point where water in the Southern Ocean passes from the Pacific to the Atlantic oceans. Because of the differing properties of water from different regions—salty water from the Northern Atlantic and the extremely cold waters of Antarctic ice—this region is perfectly suited to study how water with different properties mixes together during circulation. Moreover, as water moves through Drake Passage, flowing over rock-bottom mountainous topography and then churning upward, it creates a great deal of mixing. Mixing is a key determinant in the uptake of heat and carbon by oceans.

Shuckburgh's team quantifies the amount of mixing by taking measurements of ocean properties and currents from the surface of the water down to the bottom of the ocean. In addition, dyes and tracers are tracked as they flow through Drake Passage in order to observe how mixing occurs. Diffusion of the tracer is a good qualitative indicator of transport and mixing properties, and can give an indication of how absorbed heat may be redistributed in the water.

Ocean mixing is currently not well simulated by climate models, even though it plays a major role in ocean heat uptake. Oceans are capable of absorbing, storing and slowly releasing large quantities of heat. As greenhouse gases trap heat from the sun, oceans absorb more heat, leading to increased sea surface temperatures, rising sea levels, and consequently, changing climate patterns around the world. In addition, oceans can diffuse the effects of changes in temperature over great distances due to mixing and movement, and potential alteration of ocean currents, which can result in a greater ability to absorb heat. Studying processes such as ocean mixing is thus essential to understanding the oceans' influence on future climate.

More information: You can view here entire presentation here: live.blueskybroadcast.com/bsb/ … 2&PCAT=4072&CAT=4708

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