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Press release

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Climate Clues in the Southern Ocean

- Ocean currents surprisingly resistant to intensifying winds -

The westerly winds over the Southern Ocean are intensifying due to global climate change. But what is the response of the Southern Ocean circulation and its ability to absorb carbon dioxide from the atmosphere? A study led by scientists from the Leibniz Institute of Marine Sciences (IFM-GEOMAR) in Kiel, Germany, provides new and partly surprising results using data from a worldwide network of profiling deep-ocean drifters. The observations confirm the deep-reaching warming and freshening of the Southern Ocean predicted by climate models. However, the Southern Ocean currents have not changed in recent decades: the results suggest that the intensified wind forcing is balanced by small-scale motions of ocean eddies, a process not realistically captured in present climate models. The study will be published in the December issue of Nature Geoscience.

The Antarctic Circumpolar Current is the current system with the largest volume transport in the world ocean. Between 40° and 60°S strong westerlies move about 140 million cubic meters of water per second around the Antarctic continent (this is about five times the transport of the Gulf Stream). Vertical motions associated with this current have been responsible for transporting a substantial fraction of the anthropogenic carbon dioxide emissions from the atmosphere to the deep ocean, thereby effectively damping the rate of global warming. Investigations in this key region of the world ocean have been hampered by a sparse database due to the logistical challenges for ship based expeditions in the high-latitude Southern Ocean.

“In our study we used data obtained by the international Argo Programme”, explains Prof. Claus Böning from the Leibniz Institute of Marine Sciences (IFM-GEOMAR) in Kiel, Germany. Argo is a system of currently 3000 autonomous free-floating robotic systems which are surveying the world ocean. Every 10 days these buoys measure temperature and salinity profiles over the upper 2000 meters. These measurements are transmitted to land stations via satellite. “For this study about 52,000 profiles of more than 600 Argo-drifters in the Southern Ocean were used and compared with historic ship measurements”, explains oceanographer Astrid Dispert from IFM-GEOMAR. For this analysis the extensive archives of the Australian marine research centre in Hobart, Tasmania were also used.

As expected, the observations in the subpolar ocean demonstrate an increase of water temperature and a decrease in salinity at the same time. Nevertheless, in contradiction to the simulations of various climate models the data show no significant changes in water transport. “Our results point to one important thing: Eddies which are currently not resolved in climate models might be the key process in controlling the transport of the ACC”, Prof. Böning explains. Hence, his conclusion is that investigations with high-resolution ocean models are required to test this hypothesis. “Of course, besides the simulations we also need further observations”, adds Prof. Martin Visbeck (IFM-GEOMAR). “Thanks to the international Argo observations programme we now have continuously access to data from a worldwide network of more than 3000 profiling-

drifters. This is a quantum leap in the field of ocean observations, which, together with high resolution modelling gives us new insights about long-term changes in the ocean."

Further investigations have to show whether the results are robust. If confirmed, this would in one way be good news: Until now the Southern Ocean is the biggest oceanic sink for anthropogenic carbon dioxide and therefore a crucial regulator for the atmospheric carbon dioxide concentration. Climate models predicted a severe reduction in the southern ocean carbon dioxide uptake due to wind-forced changes in the current fields. Now high-resolution models are needed to assess the role of the hitherto unresolved ocean eddies in the Southern Ocean's response to the progressive changes in the atmospheric conditions.

Scientific Paper:

Böning, C.W., A. Dispert, M. Visbeck, S. Rintoul and F.U. Schwarzkopf, 2008: The response of the Antarctic Circumpolar Current to recent climate change. *Nature Geoscience*, doi: 10.1038/ngeo362, advanced online publication.

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Figures

Under http://www.ifm-geomar.de/index.php?id=4627 figures are available for download.

Figure captions:

1) Current positions of Argo drifters in the Southern Ocean. At present about 3200 drifters are active globally, whereas about 900 of them in the Southern Ocean south 30°S. Coloured background are the meandering streamlines of the Antarctic Circumpolar Current of a high-resolution model simulation.
2) Rough conditions and icebergs are some of the challenging conditions in the Southern Ocean. The photo was taken on an expedition with the US icebreaker Nathaniel B. Palmer, that launched Argo drifters between New Zealand and Antarctic (Photo: M. Visbeck).

3) Launch of an Argo drifter. Photo: Archive IFM-GEOMAR

4) Schematic diagram of the circulation in the Antarctic Circumpolar Current (ACC). The ACC (red) is surrounding the Antarctic continent in eastern direction while the current shows intensive meanders and eddies (yellow). Crossways at the northern rim of the ACC large-scale downwelling of surface water to depth of app. 1000 meters takes place whereas at the south rim water is upwelled from greater depths.