A Complete Picture of Southern Ocean Surface Circulation

For the first time, researchers combine estimates of sea surface height and circulation patterns in both ice-covered and ice-free regions of the Southern Ocean.

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Researchers combine estimates of sea surface height in both ice-covered and ice-free regions of the Southern Ocean, pictured here. Credit: Andrew Shiva/Wikipedia, CC BY-SA 4.0

By Kate Wheeling 30 April 2018

The Atlantic, Pacific, and Indian oceans meet in the Southern Ocean (https://eos.org/articles/icebergs-fertilize-southern-ocean-sequester-carbon), an uninterrupted body of water that encircles the continent of Antarctica. It's one of the most climatically critical regions in the world. With no landmasses in the way, powerful westerly winds whip up the Antarctic Circumpolar Current (ACC (http://oceancurrents.rsmas.miami.edu/southern/antarctic-cp.html)), the strongest current system (https://eos.org/research-spotlights/notorious-ocean-current-is-far-stronger-than-previously-thought) on the planet. Farther south, easterly coastal winds drive the Antarctic Slope Current (ASC), which flows along regions at the interface of the vast Antarctic ice sheet and the open ocean. Researchers rely on measures of the height of the ocean surface for

insights (https://science.nasa.gov/earth-science/oceanography/physical-ocean/ocean-surface-topography) into its currents and how those currents relate to weather and climate (https://eos.org/articles/deja-vu-ocean-warmth-melted-ancient-west-antarctic-ice-shelf). But the remoteness of the Southern Ocean and its harsh climate have long limited researchers' ability to study the region.

Since the 1990s, radar altimeter measurements from instruments aboard satellites have provided scientists with an incomplete picture of sea levels and surface circulation in the open ocean around Antarctica. Space-based measures of the sea surface are often obscured by the presence of sea ice, which can cover up to 19 million square kilometers in the Southern Ocean in winter. However, novel methods (http://onlinelibrary.wiley.com/doi/10.1002/2015JC011579/full) recently have been developed to estimate sea surface heights in ice-covered regions from radar altimeter data by picking out openings in the pack ice.

In a new paper, *Armitage et al. (http://onlinelibrary.wiley.com/doi/10.1002/2017JC013534/abstract)* combine conventional radar altimeter estimates of sea surface height in open regions with height estimates in ice-covered regions to create the first complete picture of sea levels and circulation (https://eos.org/research-spotlights/swirling-eddies-in-the-antarctic-may-have-global-impacts) across the entire Southern Ocean between 2011 and 2016. The study is the first to examine circumpolar sea surface height variability along the Antarctic margins.

The authors found that sea level changes are linked to two climate indices: the Southern Oscillation Index, which gives researchers some insight into the development and intensity of El Niño and La Niña events in the Pacific Ocean, and the Southern Annular Mode (http://www.bom.gov.au/climate/enso/history/ln-2010-12/SAM-what.shtml), which tracks the north or south migration of the westerly wind belt that blows around Antarctica. The strong 2014–2016 El Niño event, for example, was associated with drops in sea level around coastal West Antarctica and a weakened ASC in the Ross, Amundsen, and Bellingshausen seas.

The combined data set was based on monthly measures, which allowed the scientists to investigate seasonal sea surface height changes as well. The data set showed that along the Antarctic coast, sea levels were highest in the fall and lowest in the spring, with the pattern reversed out in the deeper ocean. The seasonal height variability kicked the nearly circumpolar ASC into high gear; the current moved regionally up to twice as fast in the autumn months, according to the study.

The study, a first look at sea surface height and circulation across the entire Southern Ocean, provides researchers with new insights into the Antarctic continental shelves and the Ross and Weddell gyres, regions that drive important ocean overturning and affect ocean heat delivery to the Antarctic ice sheet. (*Journal of Geophysical Research: Oceans,* https://doi.org/10.1002/2017JC013534 (https://doi.org/10.1002/2017JC013534), 2018)

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