Unexpected ice

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Paul Holland
British Antarctic Survey

by Natasha Vizcarra

On the prowl for food, Adelie penguins scan the ice ceiling. They peck at silverfish and hunt for polynyas, gaping holes in the sea ice where shoals of krill and bug-like copepods graze on clouds of algae. When spring comes, the huge plates of sea ice start to melt and later in the brief Antarctic summer all but disappear. Then, algae blooms unfurl: a bacchanalian feast for krill and critters all the way up the Antarctic food chain. Sea ice, sunlight, and food—they all come and go with the seasons in the Southern Ocean.

Paul Holland, a climate modeler with the British Antarctic Survey, has spent the last ten years studying Antarctica's sea ice and the Southern Ocean. Lately, he has been scrutinizing the seasons of Antarctica and how fast the ice comes and goes. Holland thinks these seasons may be a key to a conundrum: If Earth's temperatures are getting warmer and sea ice in the Arctic has been

A pressure ridge forms on the sea ice near Scott Base in Antarctica. These form when separate ice floes collide and pile up on each other. Lenticular clouds are seen above. (Courtesy M. Studinger/NASA) shrinking fast, why then is sea ice in the Antarctic slowly increasing?

Opposite poles

Sea ice is simply frozen seawater. Although found only in the Arctic and the Antarctic, it influences Earth's climate in big ways. Its bright surface reflects sunlight back into space. Icy areas absorb less solar energy and remain relatively cool. When temperatures warm over time and more sea ice melts, fewer bright surfaces reflect sunlight back into space. The ice and exposed seawater absorb more solar energy and this causes more melting and more warming.

Scientists have been watching this feedback loop of warming and melting in the Arctic. To them, Arctic sea ice is a reliable indicator of a changing global climate. They pay the most attention in September when Arctic sea ice shrinks to its smallest extent each year. Measured by satellites since 1979, this minimum extent has been decreasing by as much as 13.7 percent per decade. Antarctic sea ice, on the other hand, has not been considered a climate change indicator. Whereas Arctic sea ice mostly sits in the middle of land-locked ocean—which is more sensitive to sunlight and warming air—Antarctic sea ice surrounds land and is constantly exposed to high winds and waves.

According to climate models, rising global temperatures should cause sea ice in both regions to shrink. But observations show that ice extent in the Arctic has shrunk faster than models predicted, and in the Antarctic it has been growing slightly. Researchers are looking much closer at Antarctica, saying, "Wait, what is going on down there?" Holland is one of those intrigued.

"The Antarctic case is as interesting as the Arctic case," Holland said. "You can't understand one without understanding the other."

Minding the models

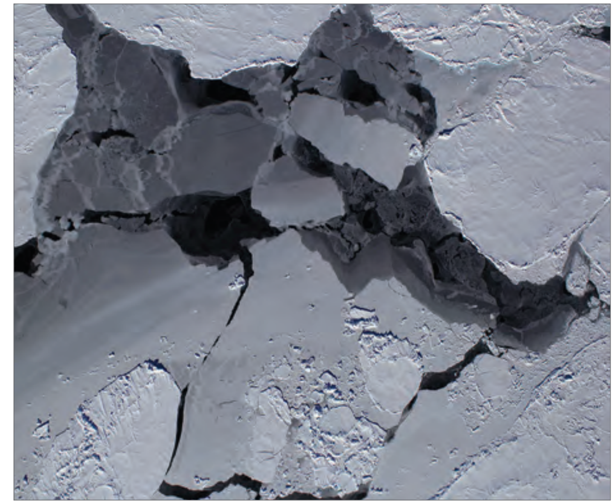
To Holland, the discrepancy calls parts of the climate models into question. Modeling groups from around the world collaborate on the Coupled Model Intercomparison Project Phase 5 (CMIP5), which simulates Earth's climate and predicts how it will change in the near future. World leaders and policy makers rely on it to decide how much countries should limit carbon emissions, known to cause some aspects of climate change.

"Almost all of the CMIP5 models produce a decrease in Antarctic sea ice," Holland said. "There is a problem in the bit that reproduces the last 30 years of sea ice variability." Holland was searching for data to improve and verify his own modeling of trends in Antarctic ice when he noticed that other researchers were finding that the trends varied in strength in the different seasons.

Most studies on Antarctic sea ice trends focus on changes in ice extent. For Holland, it was more important to look at how fast the ice was growing or shrinking from season to season. "Changes in climate forcing directly affect the rate of ice growth," he said, "not the amount of ice." Year to year cooling in autumn, for example, may cause faster ice growth during autumn, but not necessarily an increase in the amount of autumn ice.

Spring surprise

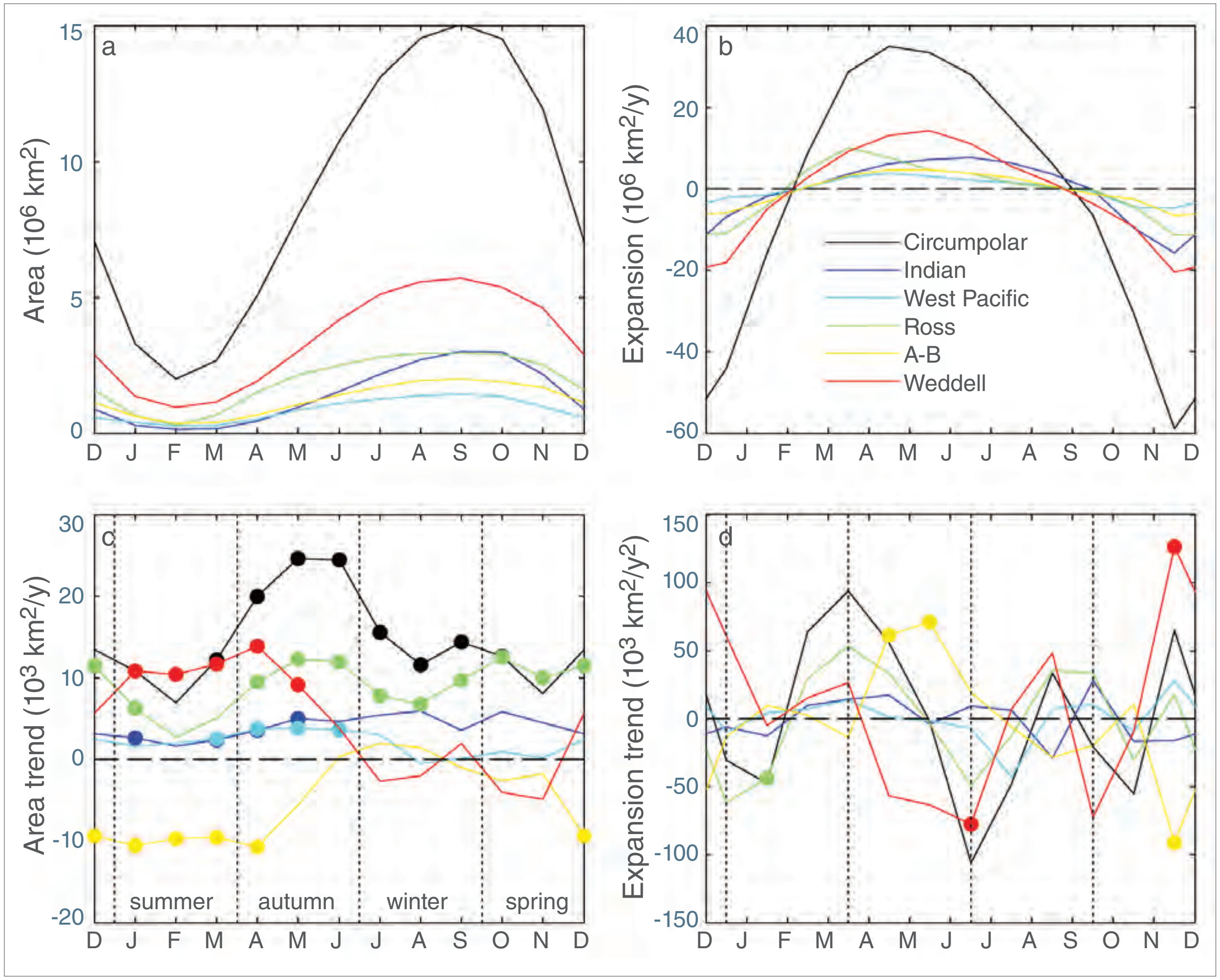
Holland used data from the NASA National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC) to calculate the ice concentration rate of growth for each single



This scene shows a mixture of sea ice types commonly seen in the Southern Ocean. The different thicknesses of sea ice form a spectrum of colors and shapes ranging from dark black open water, a thin grease-like covering called grease ice, and thicker grey ice. Older sea ice has a bright white covering of snow and many chaotic deformation features, visible as ridges and rubble fields and caused by the continuous motion of the ice pack. (Courtesy M. Studinger/ NASA)

day, which he called intensification; and the total ice area rate of growth, which he called expansion. "I did that for all thirty years of data and plotted the trends," he said. Holland's plots showed that the different regions in the Southern Ocean contributed to the overall increase, but they had very diverse trends in sea ice growth. This suggested that geography and different wind patterns played a role. So to gain more insight Holland looked at seasonal wind trends for the different regions.

Holland found that winds were spreading sea ice out in some regions and compressing or keeping it intact in others and that these effects began in the spring. It contradicted a previous study in which, using ice drift data, Holland and Ron Kwok from the NASA Jet Propulsion Laboratory



The panels above show seasonal variations of sea ice quantities for each region and the whole Southern Ocean. The mean monthly total ice expansion (b) peaks in autumn, and mean monthly total ice area (a) peaks in the winter. Interannual trends in monthly total ice area (c) show that for the last thirty years, Antarctic sea ice has tended to expand during the autumn. Interannual trends in monthly total ice expansion (d) show that changes in ice growth in the spring produced the change in the ice the following summer and autumn. (Courtesy P. R. Holland)

found that increasing northward winds during the autumn caused the variations.

"I always thought, and as far as I can tell everyone else thought, that the biggest changes must be in autumn," Holland said. "But the big result for me now is we need to look at spring. The trend is bigger in the autumn, but it seems to be created in spring."

"Paul has created two more sea ice metrics that we can use to assess how Antarctic sea ice is responding," said researcher Sharon Stammerjohn, referring to the measures of intensification and expansion. The new metrics help assess how the system is responding as opposed to simply monitoring the state of the system. "Say your temperature is at 99.2 degrees Fahrenheit," Stammerjohn said. "You don't have any insight to that temperature unless you take it again an hour later and you see that it changed to 101 degrees. Then you can say, okay, my system is responding to something."

Partial explanations

Holland continues to study the Antarctic spring to better understand why Antarctic sea ice is changing. While Holland's work helps researchers begin to see the problem in more detail, scientists continue to develop ideas about why the ice is expanding.

One study paradoxically suggests that ocean warming and enhanced melting of the Antarctic ice sheet is causing the small but statistically significant sea ice expansion in the region. Another study suggests that rain caused by a warmer climate has been causing an influx of fresh water into the Southern Ocean, making it less dense and inhibiting oceanic heat from reaching sea ice in the Antarctic. To date, there is no consensus on the reason for the expansion.

"Partial explanations have been offered, but we don't have the complete picture," said Ted Scambos, a scientist at the NSIDC DAAC. "This may just be a case of 'we don't know yet.'"

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For more information

NASA National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC)
http://nsidc.org

About the remote sensing data

Satellites	Nimbus 7 and Defense Meteorological Satellite Program (DMSP) F8, F11, F13, F17
Sensors	Scanning Multichannel Microwave Radiometer (SMMR), Special Sensor Microwave/Imager (SSM/I), Special Sensor Microwave Imager/Sounder (SSMIS)
Data set	Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS Passive Microwave Data
Resolution	25 kilometers
Parameters	Sea ice concentration
Data center	NASA National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC)

About the scientists

Paul R. Holland is an ocean modeler at the British Antarctic Survey in Cambridge, United Kingdom. His research focuses on ocean-ice shelf interaction, polar oceanography, sea ice, ice shelf glaciology, gravity currents, and lake hydrodynamics. NASA and the British Antarctic Survey supported his research. Read more at http://goo.gl/nAUwFQ. (Photograph courtesy P. R. Holland)

Ted Scambos is the lead scientist at the National Snow and Ice Data Center. His research focuses on glaciology, remote sensing of the poles, climate change effects on the cryosphere, Antarctic history, geochemistry, and planetary science. NASA supported his research. Read more at http://goo.gl/NZygTB. (Photograph courtesy P. Gibbons)

Sharon Stammerjohn is a senior research associate at the Institute of Arctic and Alpine Research at the Universtiy of Colorado Boulder and assistant adjunct professor at the University of California Santa Cruz. Her research focuses on polar oceanography and climate, and ecosystem response to climate variability. The National Oceanic and Atmospheric Administration supported her research. Read more at http://goo.gl/TxtnqI. (Photograph courtesy S. Stammerjohn)