RV *Investigator* Voyage Scientific Highlights and Summary

Voyage #:	IN2018_v01		
Voyage title:	Detecting Southern Ocean change from repeat hydrography, deep Argo and trace element biogeochemistry (PI Rintoul) & CAPRICORN (Clouds, Aerosols, Precipitation, Radiation, and atmospherIc Composition Over the southeRn ocean, PI Protat)		
Mobilisation:	Hobart, Tuesday, 9 January 2018		
Depart:	Hobart, 0900 Thursday, 11 January 2018		
Return:	Hobart, Wednesday, 21 February 2018		
Demobilisation:	Hobart, Thursday, 22 February 2018		
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Scientific Highlights

The Chief Scientist

Dr Steve Rintoul is a physical oceanographer and climate scientist at CSIRO Oceans & Atmosphere, the Antarctic Climate and Ecosystems Cooperative Research Centre and the Centre for Southern Hemisphere Oceans Research. His research over the past 30 years has focused on the role of the Southern Ocean in the Earth's climate system. He has led 14 expeditions to the Southern Ocean. His research and scientific leadership have been recognised by national and international awards, including the Tinker-Muse Prize for Science and Policy in Antarctica, the George Wüst Prize (Germany), and the Australian Antarctic Medal. He is a Fellow of the Australian Academy of Science.

Title

Detecting Southern Ocean change from repeat hydrography, deep Argo and trace element biogeochemistry & CAPRICORN (Clouds, Aerosols, Precipitation, Radiation, and atmospherIc Composition Over the southeRn oceaN)

Purpose

The voyage consisted of three main projects with the following objectives:

1. To quantify changes in water properties and circulation of the Southern Ocean between Australia and Antarctica.
2. To determine the distributions of trace metals and isotopes, their change with time, and the physical, chemical and biological processes controlling those evolving distributions.
3. To quantify cloud-aerosol-precipitation-radiation processes and interactions over the Southern Ocean and their variability as a function of latitude and large-scale context (CAPRICORN).

Contribution to the nation

The Southern Ocean plays a critical role in the Earth's climate system. The region takes up more of the extra heat and carbon dioxide added by human activities than any other latitude band of the ocean: more than 40% of the ocean inventory of anthropogenic carbon dioxide, and more than 75%

of the increase in ocean heat content, entered the ocean through the Southern Ocean. The circulation of the Southern Ocean carries nutrients northward that support 75% of primary productivity in the ocean north of 30S. Changes in the Southern Ocean would therefore have widespread consequences for climate. The measurements collected on this voyage will be used to discover how and why the Southern Ocean is changing and the implications for climate, sea level rise and biological productivity in the sea. Climate models used to project future climate change suffer from substantial biases related to poor representation of clouds and cloud / radiation interactions over the Southern Ocean. The CAPRICORN program will improve understanding of Southern Ocean clouds and resulting surface radiation and their representation in climate models, leading to improved projections of future climate. By improving our understanding of the role of the Southern Ocean in Earth's climate system, the voyage will help inform Australia's strategy for climate change mitigation and adaptation.

As a result of this voyage

1. We have a better understanding of how the Southern Ocean influences climate, ocean circulation and chemistry, sea level rise, biological productivity and the overlying atmosphere. These advances will underpin improvements in earth system models, resulting in better climate projections.
2. We have found evidence that the Southern Ocean is changing throughout the full ocean depth of change in the physical and biogeochemical state of the Southern Ocean from the sea surface to the sea floor.
3. We have mapped physical and biogeochemical characteristics of the Southern Ocean from the sea surface to the sea floor between Australia and Antarctica. We have collected the most complete set of oceanic and atmospheric measurements yet obtained from this region.
4. We have commenced a program of research that will lead to new insights into how and why the Southern Ocean is changing, the sources and sinks of carbon and other elements, and the causes of long-standing biases in representation of clouds in climate models.)
5. We have collected unprecedented cloud, precipitation and surface radiation dataset that will allow for a full understanding of cloud / radiation interactions and under which large-scale conditions do climate models struggle to represent them.
6. We have characterized Southern Ocean cloud properties from collocated ship and in-situ NCAR G-V aircraft data from the international SOCRATES field experiment, which will allow for an understanding of how oceanic production of aerosols transfer into the upper-troposphere and modulate cloud properties.
7. We have collected collocated ship and NASA Global Precipitation Mission (GPM) satellite precipitation observations (17 cases with rain, snow, and mixed-phase precipitation) that will allow us to improve notoriously deficient satellite precipitation retrievals south of 40° South.