Geophysical Constraints on Antarctic Sea Ice Cover

5th International Ice Analyst Workshop (IAW5)

U.S. National Ice Center (NIC)
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Geophysical Constraints on Antarctic Sea Ice Cover

Paradox

The Arctic sea ice cover has been retreating during the last three decades while the Antarctic sea ice cover appears stable with if anything a slight increasing trend

Conclusion

Antarctic sea ice behavior is consistent with Antarctic geophysics and thus not pose a paradox

Outline

Geographical contrast between Arctic and Antarctic Regions

Regional Forcing Factors

Ice Extent and Location of Thermal Fronts

Tracking of Sea Ice and Distribution of “New” Ice Classes

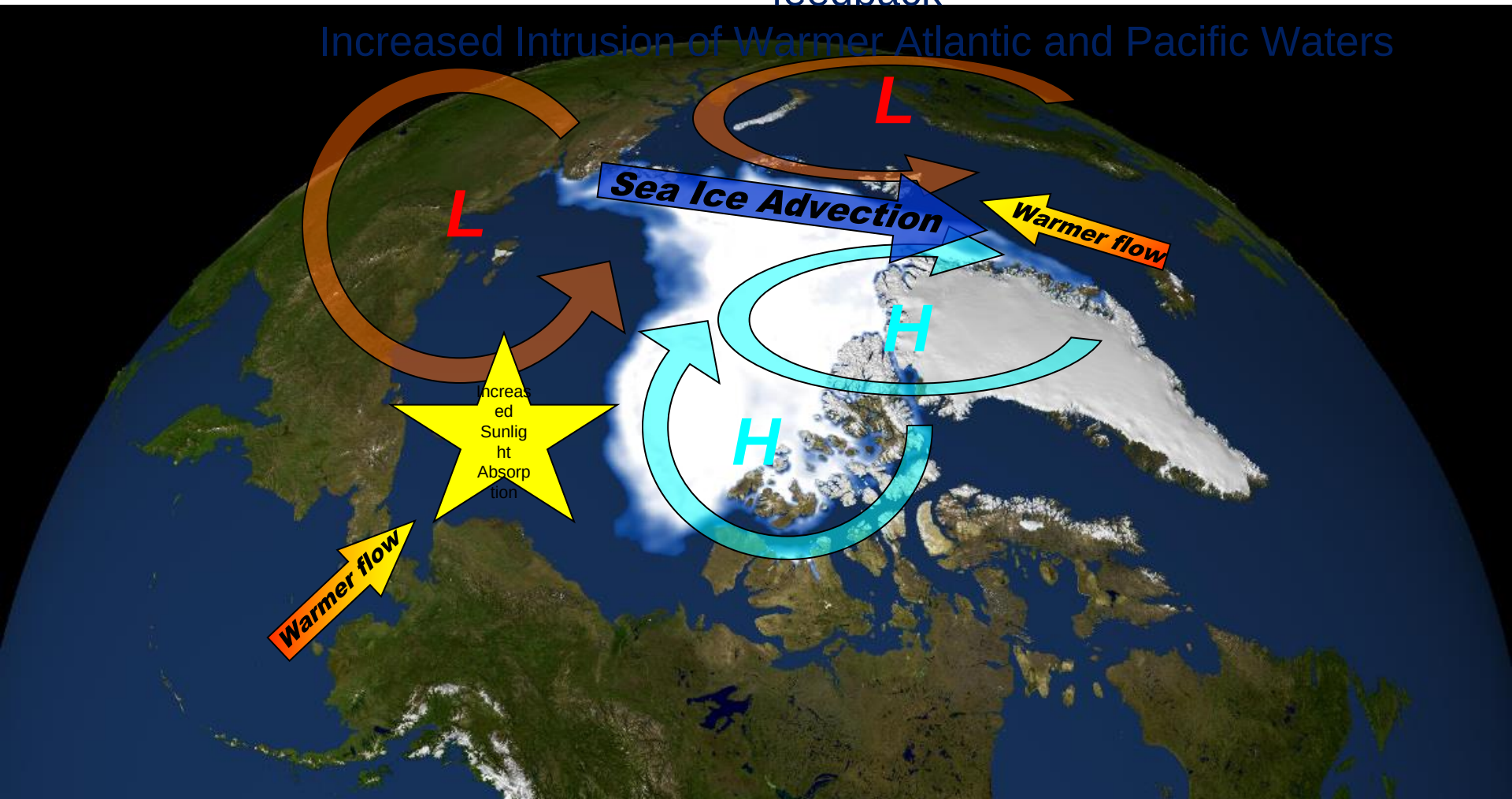
Arctic Sea Ice Loss Dominant Forcing:

Overall Increase in Arctic Temperature

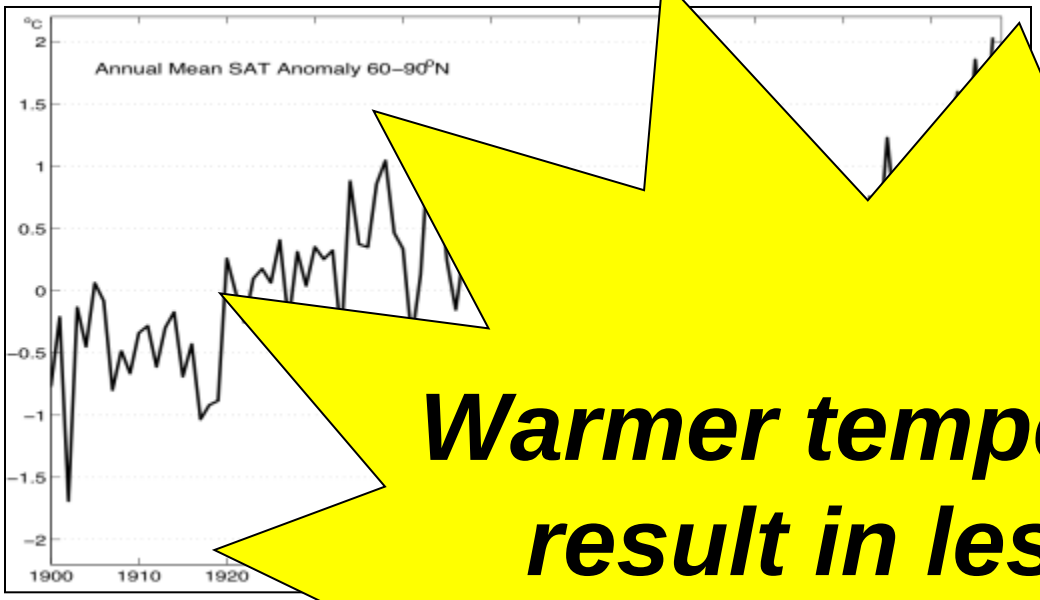
Advection by Anomalous Atmospheric Forcing

Increased Ocean Insolation (solar energy input) - positive feedback

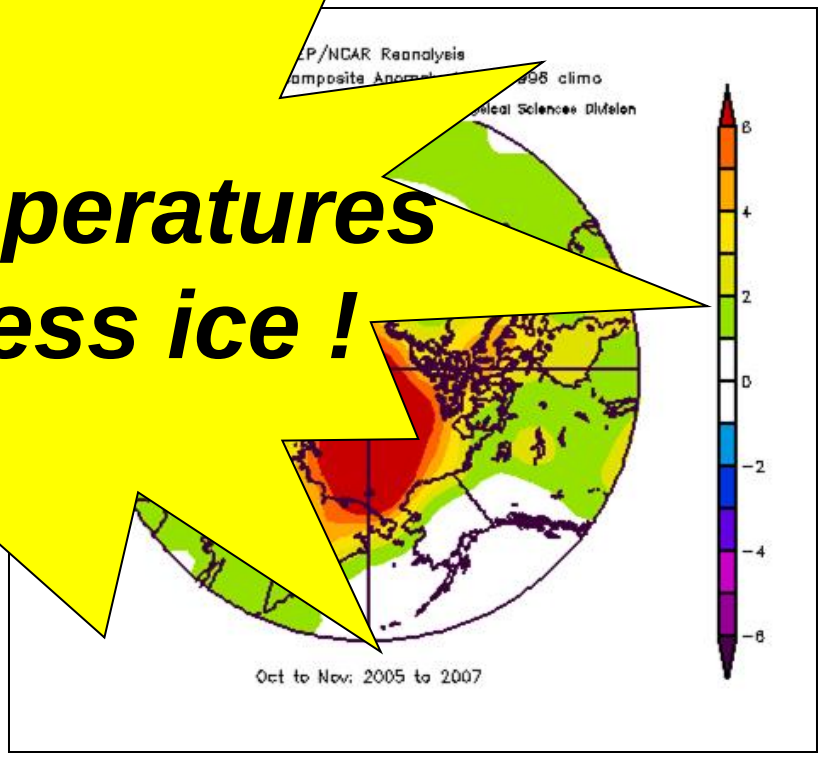
Increased Intrusion of Warmer Atlantic and Pacific Waters



Arctic Surface Air Temperature



Warmer temperatures result in less ice !

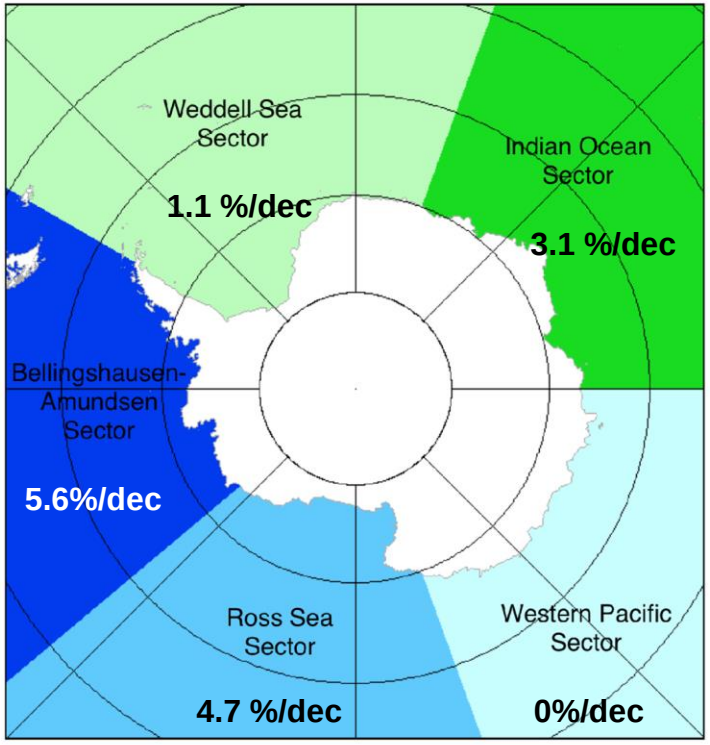


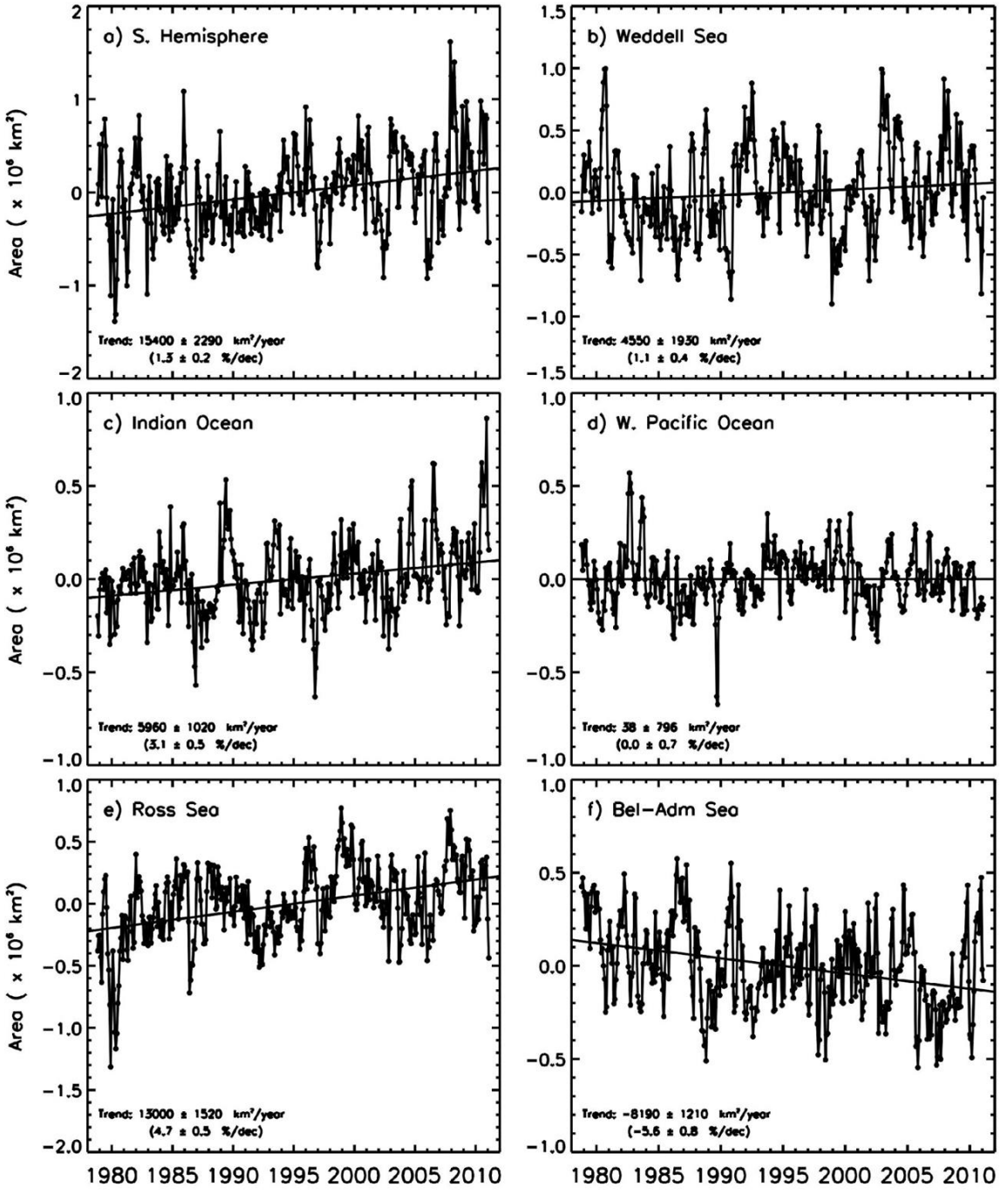
Arctic warming exceeds global mean warming
by roughly a factor of two

Antarctic Sea Ice

Monthly Anomalies and Trends

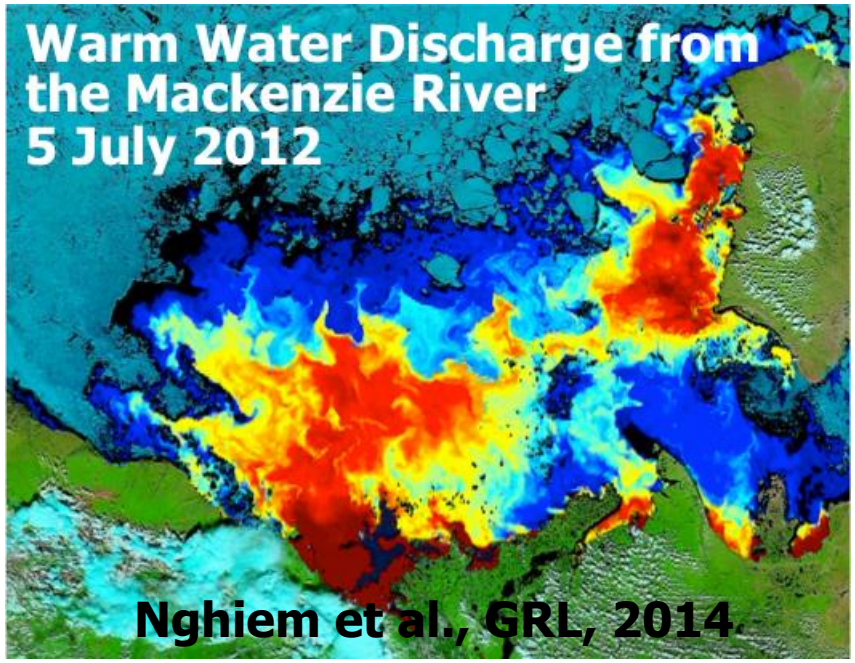
(After J. C. Comiso, NASA/GSFC 2011)

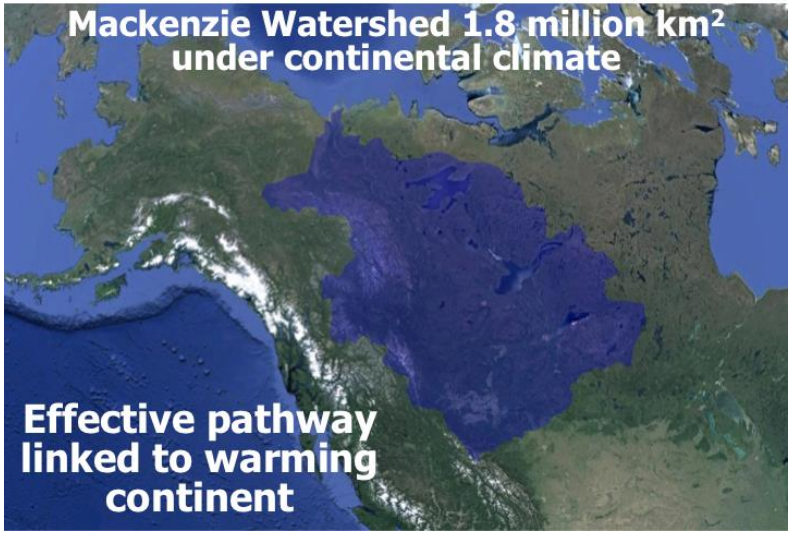


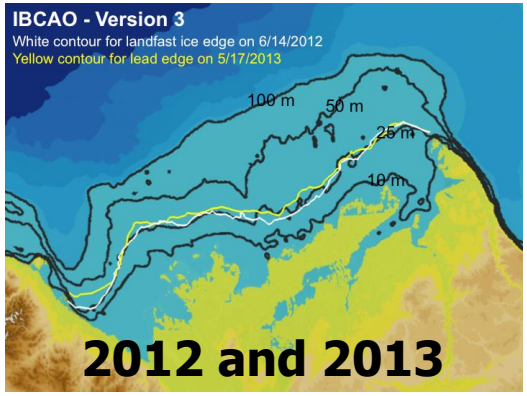


And One More Player: Arctic River Discharge

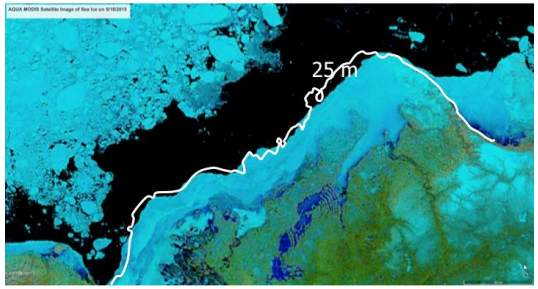
Effective Heath Pathway Linked To Warming Continents

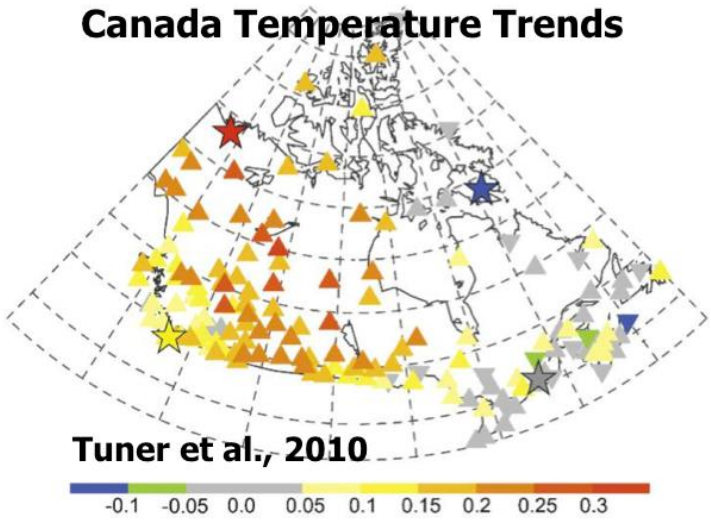






Update: Sea ice on 5/18/2015

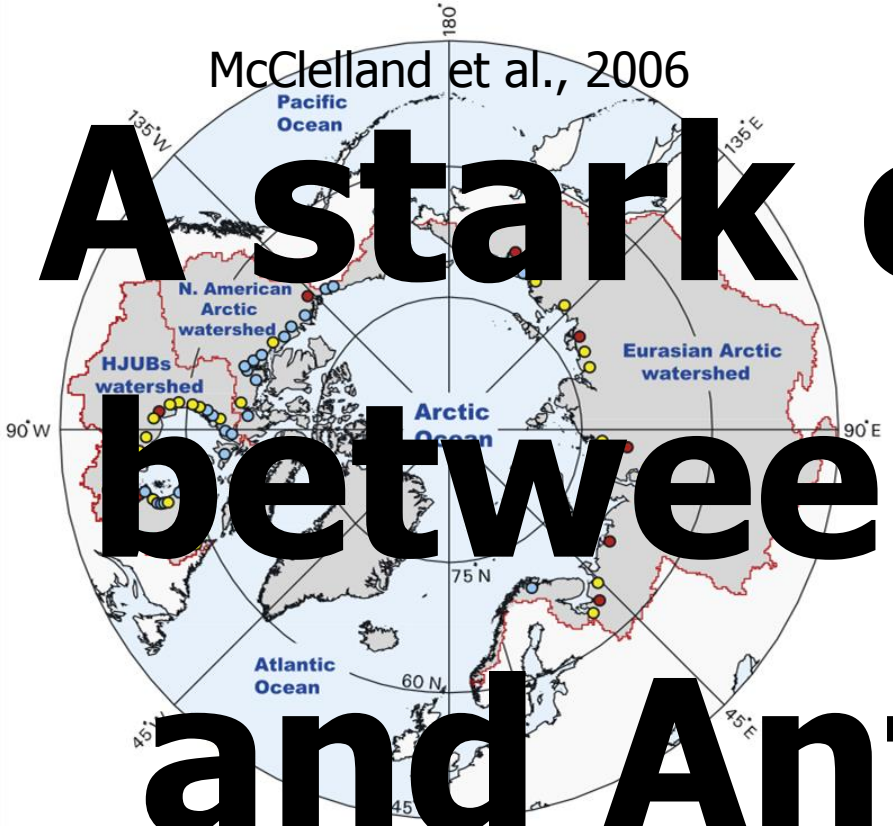




Heat Source from Rivers

- **Arctic sea ice: Warm river water discharge**
- **Antarctic sea ice: Frozen continent**

McClelland et al., 2006

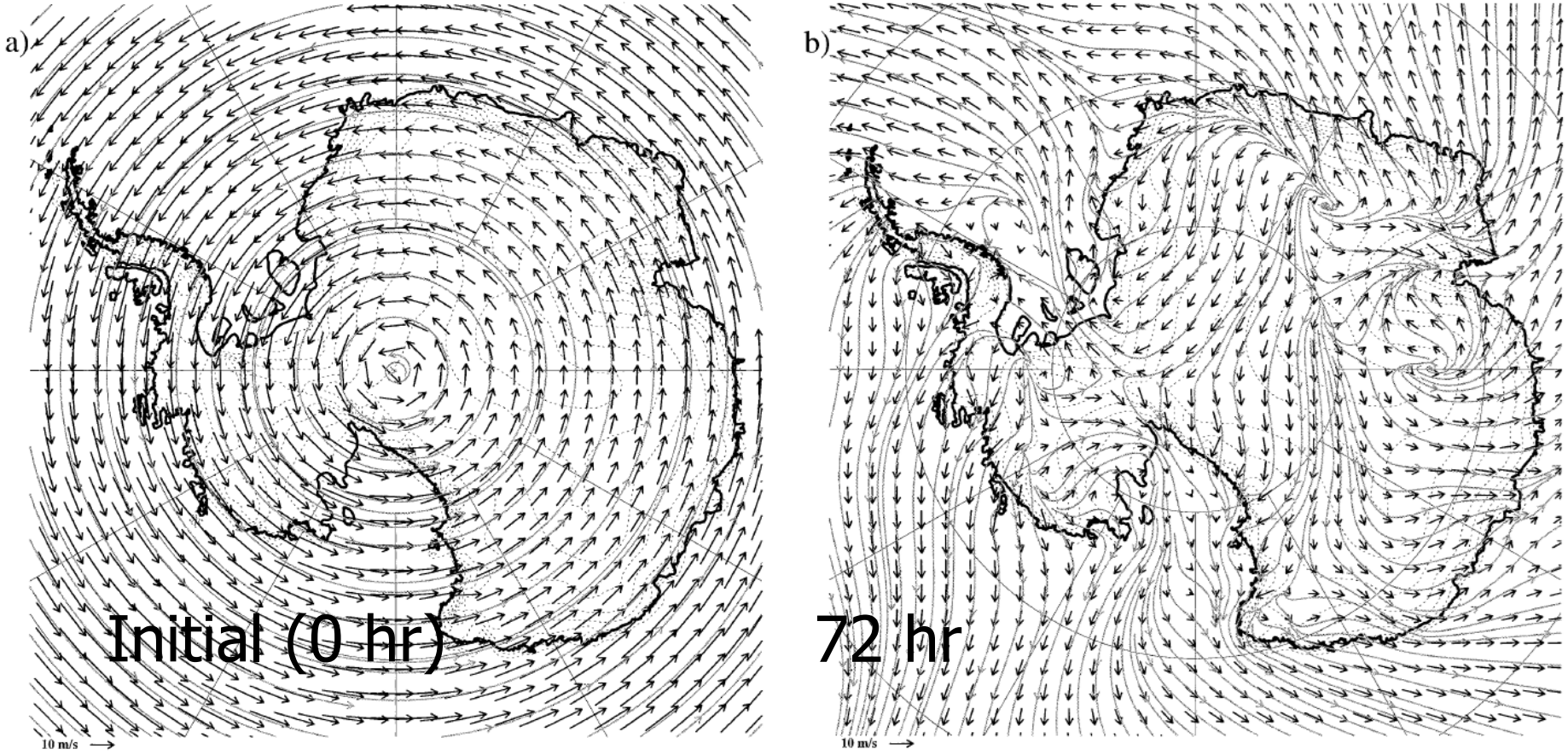


A stark contrast between Arctic and Antarctic!

72 rivers: Blue = <6 km^3/y; Yellow = 6 to <60 km^3/y; Red = 60 to 600 km^3/y.

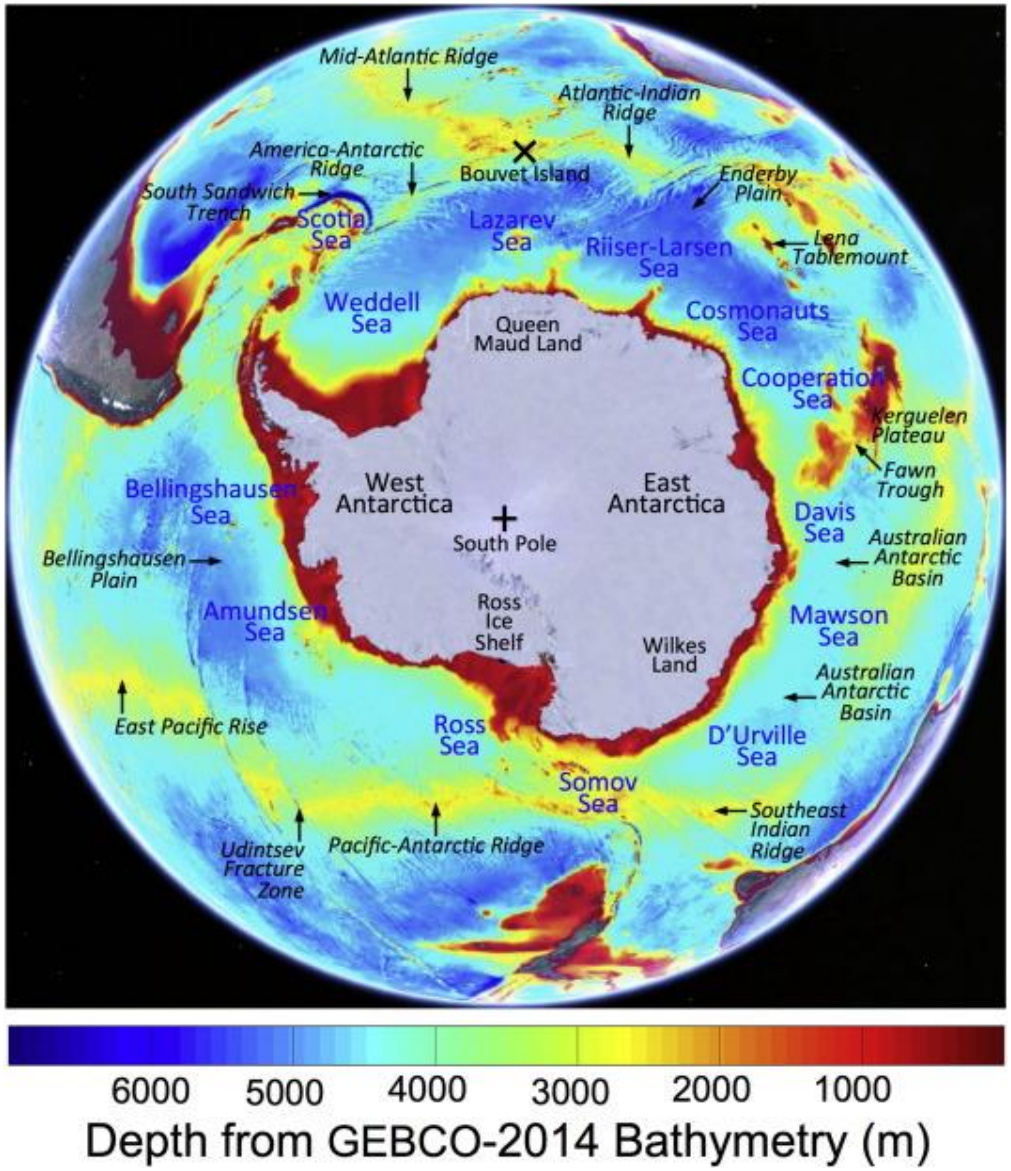
No such rivers, except for ice streams!

Wind Pattern Shaped by Continental Topography



Parish, T. R., and J. J. Cassano, J. J. (2003). Diagnosis of the Katabatic Wind Influence on the Wintertime Antarc-tic Surface Wind Field from Numerical Simulations. *Monthly Weather Rev.*, *131*, 1128-1139.

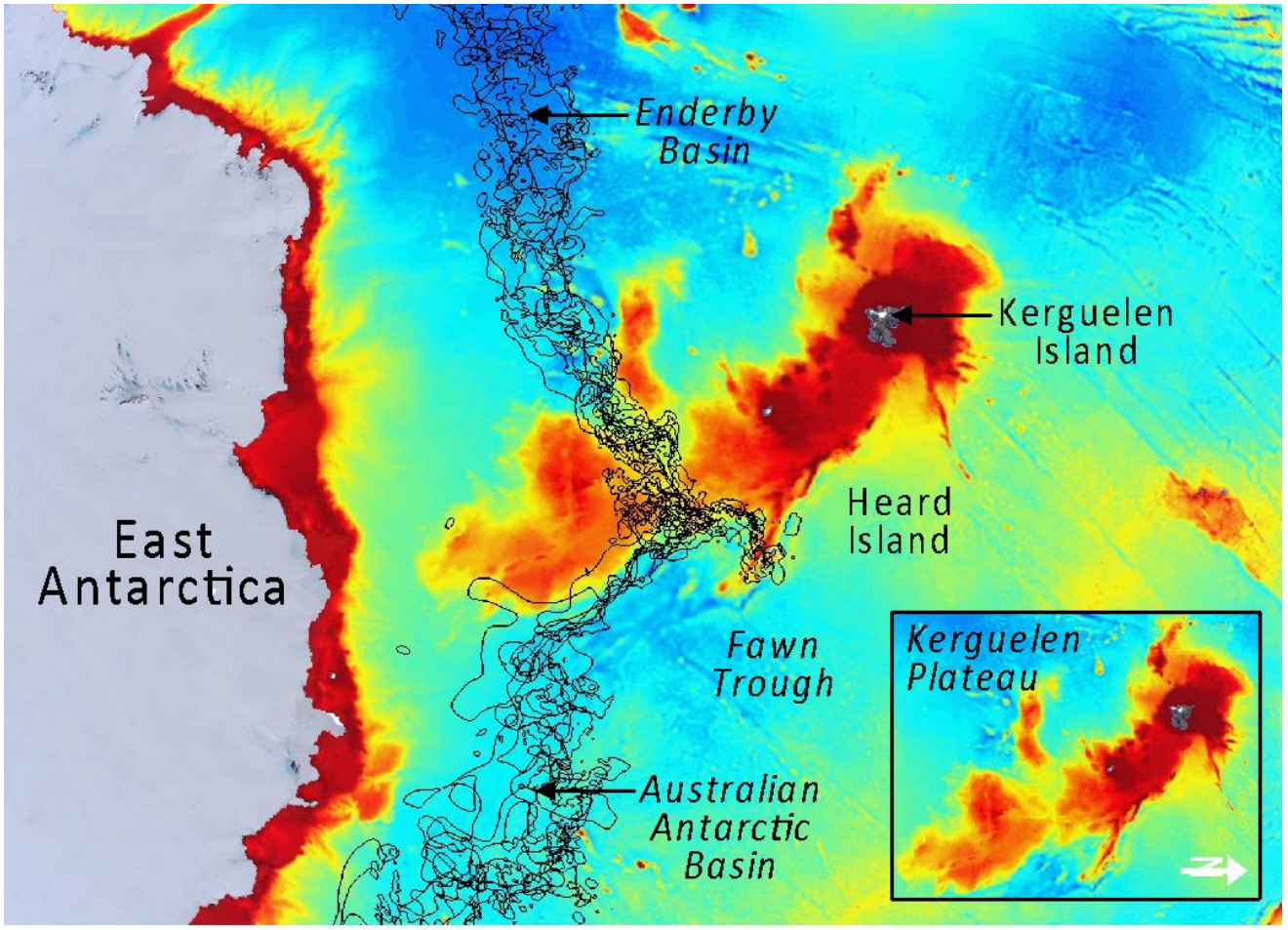
Southern Ocean Bathymetry



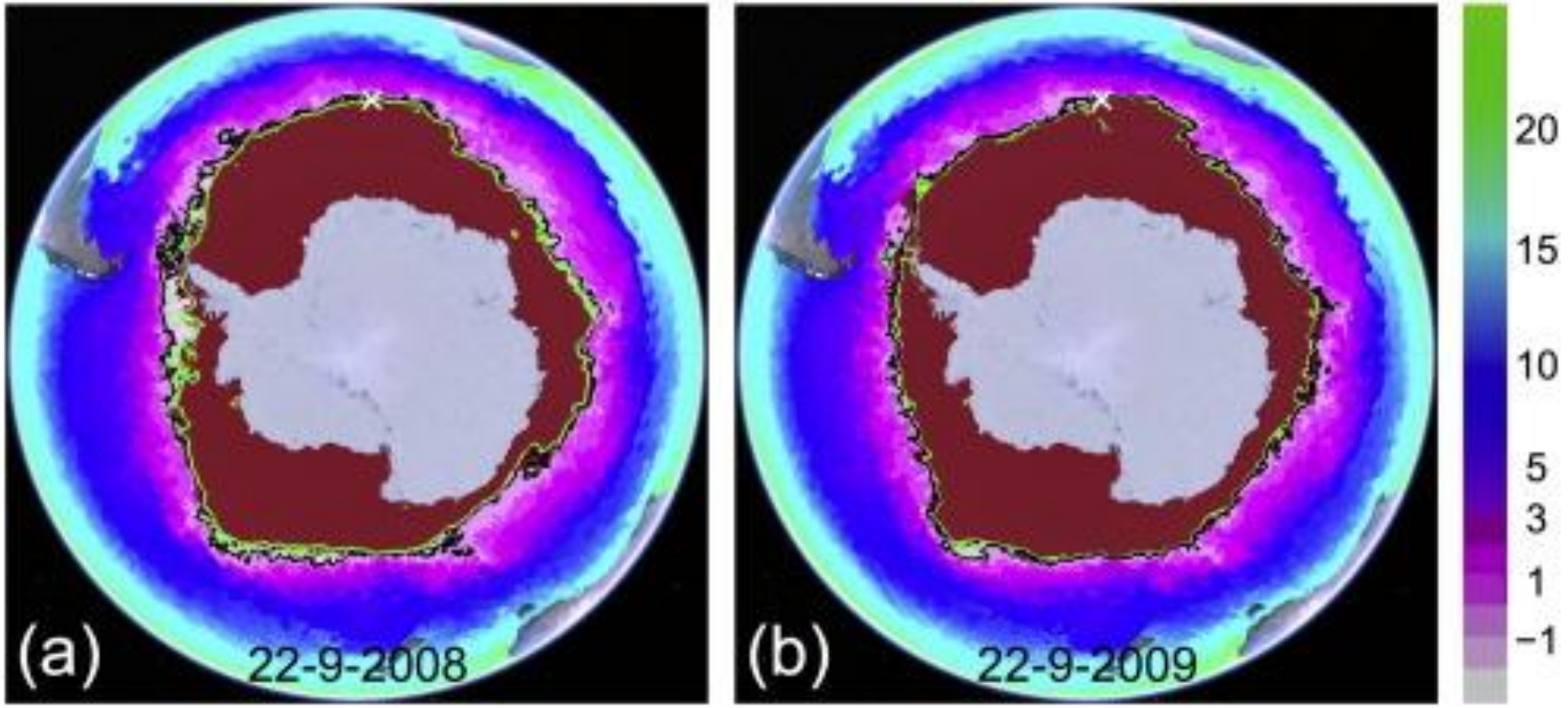
SST Isotherms (1999-2009) and GEBCO-2014 Bathymetry

Southern Antarctic Circumpolar Current (ACC) front (sACCf) delineated by Kim and Orsi (2014)

SST over Kerguelen Plateau

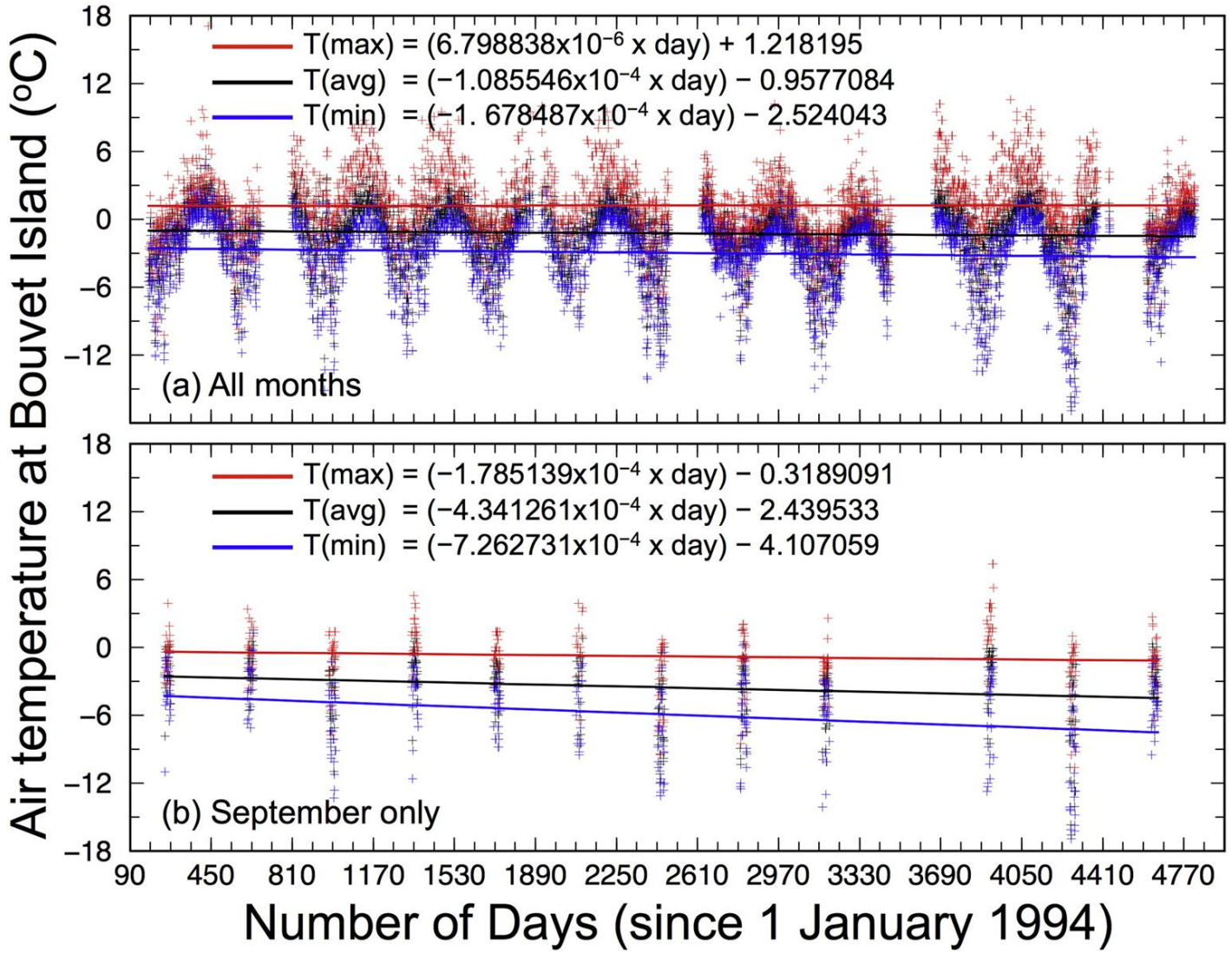


Satellite Sea Surface Temperature



Maps of Multi-sensor Ultra-high Resolution (MUR) Sea Surface Temperature (SST) represented by the color bar in degrees Celsius on the right with isotherms at − 1.0 °C (black contour) and − 1.4 °C (green contour) on National Ice Center (NIC) Sea Ice Extent.

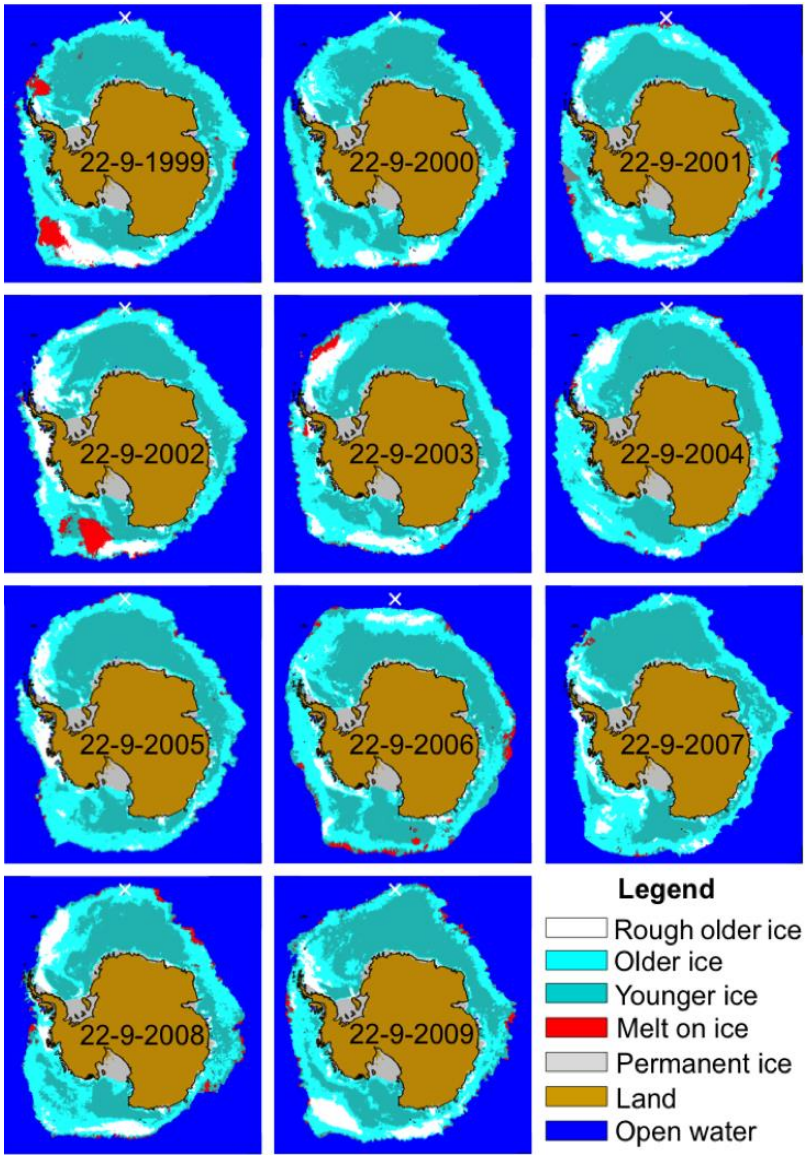
Stability of Air Temperature at Bouvet Is.

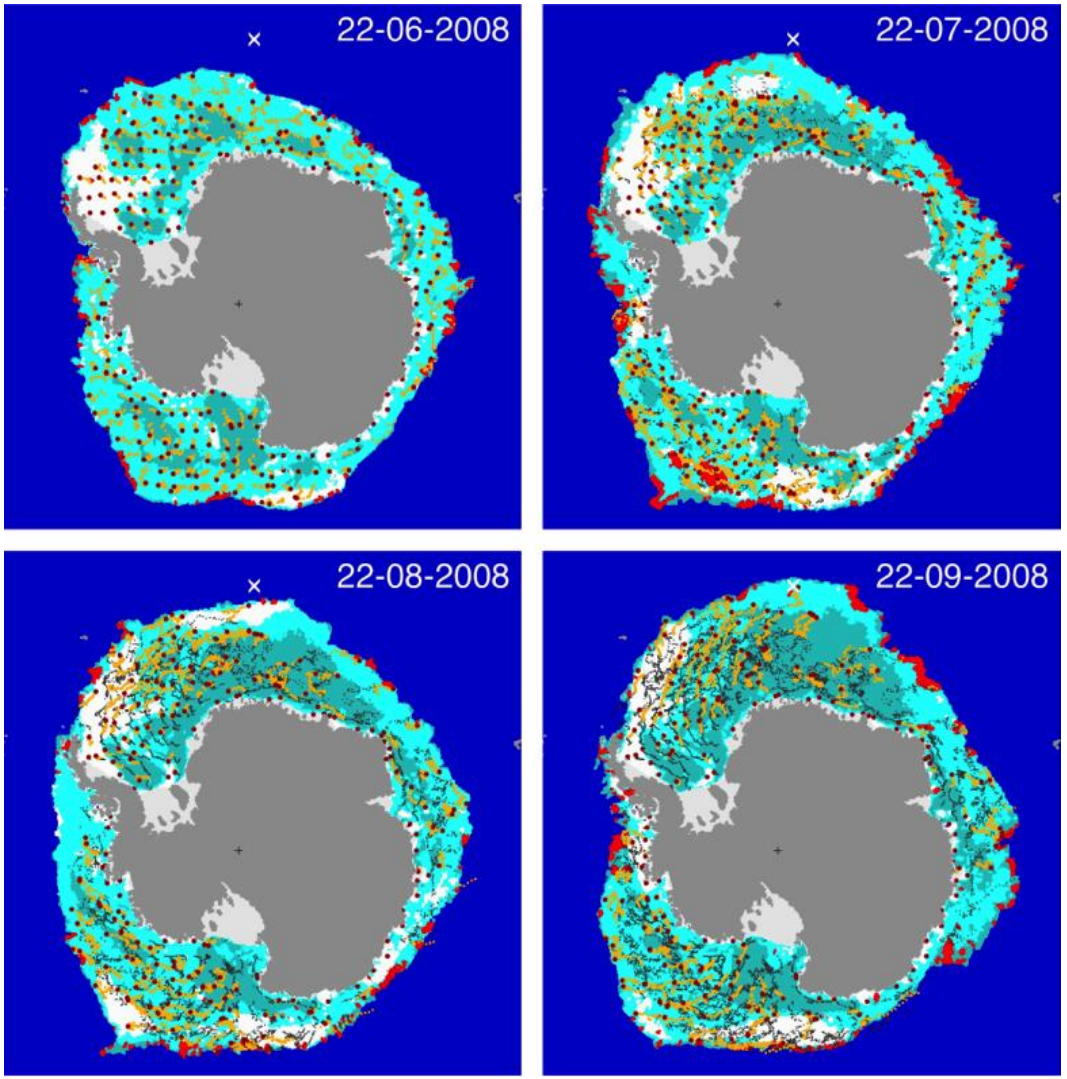


Backscatter Synoptic Sea Ice Classes

- Statistical analysis of QuikSCAT scatterometer backscatter data shows a Gaussian-like distribution of Antarctic sea ice signature in contrast to the bimodal distribution found for Arctic sea ice.
- Using the Gaussian mean and STD, we define ‘YI Class’ for younger ice, ‘OI Class’ for older ice, and ‘RI Class’ for rough older ice with highest backscatter.
- We then use 10 years of backscatter data (1999- 2009) to map synoptic sea ice classes over the Antarctic sea ice cover.

QuikSCAT Ku Backscatter Classification and Tracking of Antarctic Sea Ice

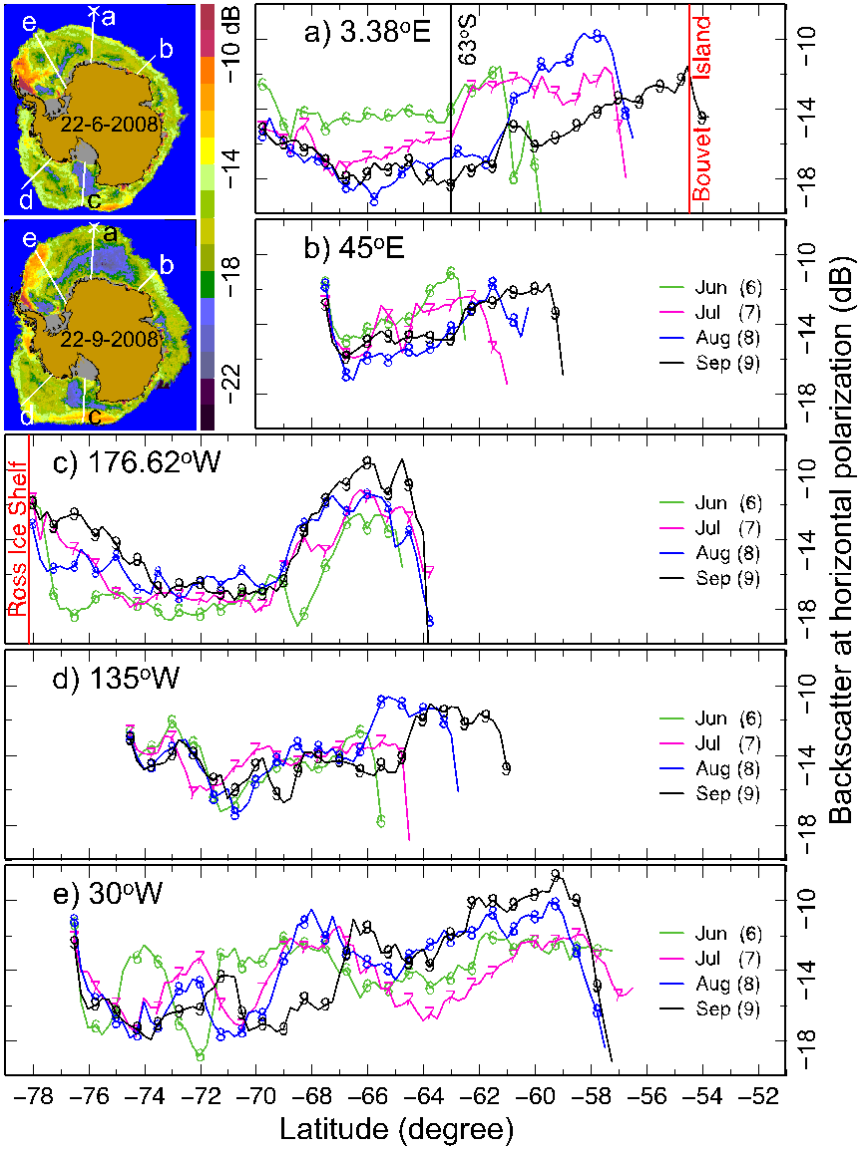




PSC backscatter tracks validated against buoy drifts

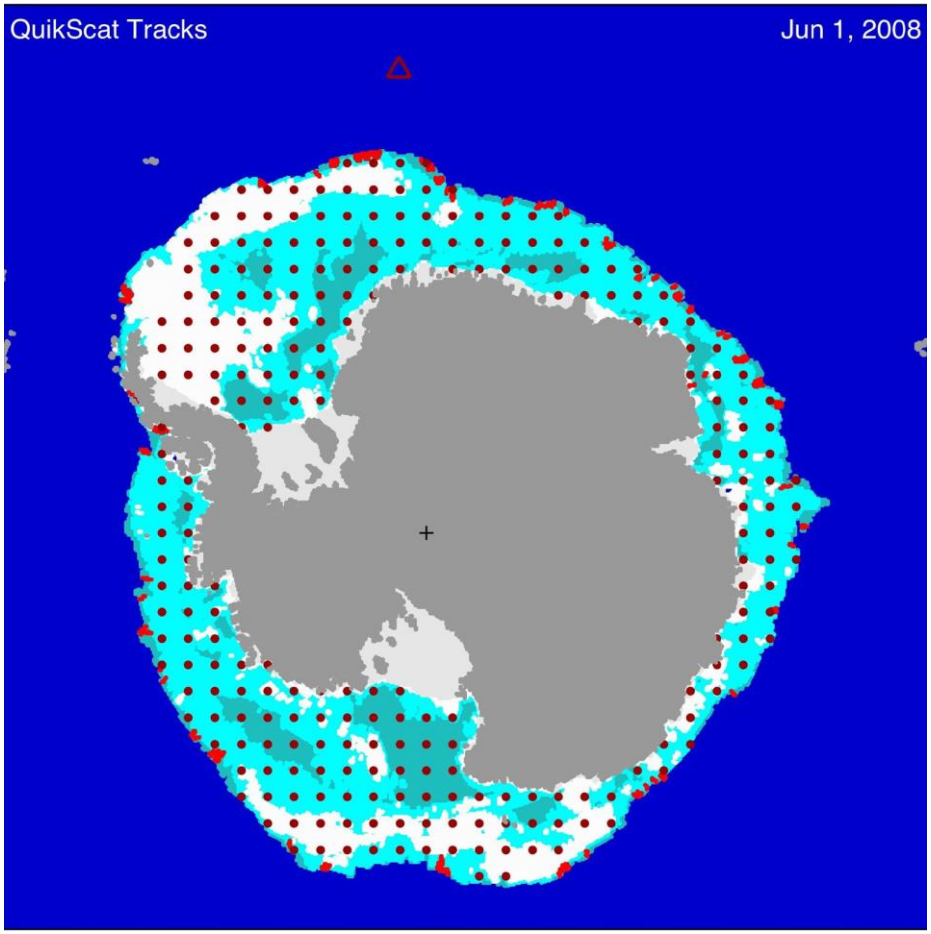
Nghiem et al. *Rem. Sens. Env.*, 2016

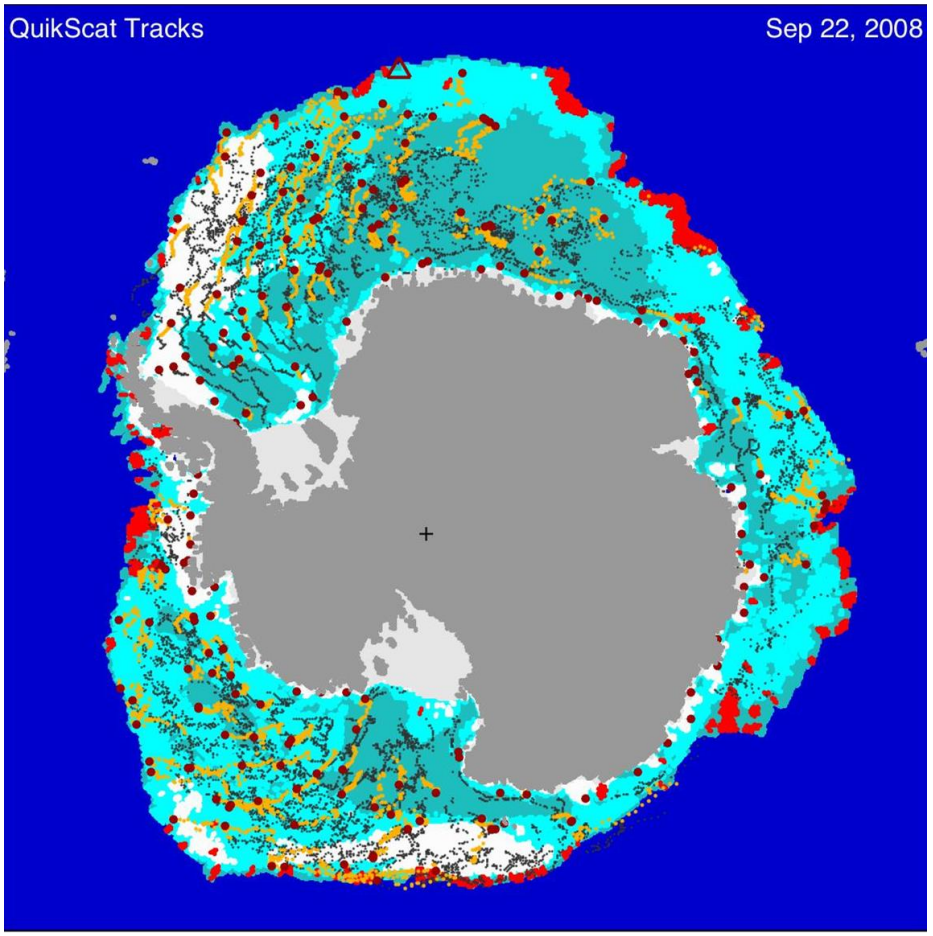
Tracks of Antarctic Sea Ice Backscatter Signatures



Indicate the Circumpolar Presence of the Frontal Ice Zone (FIZ)

A Complementary Observation From Sea Ice Trajectory Tracking





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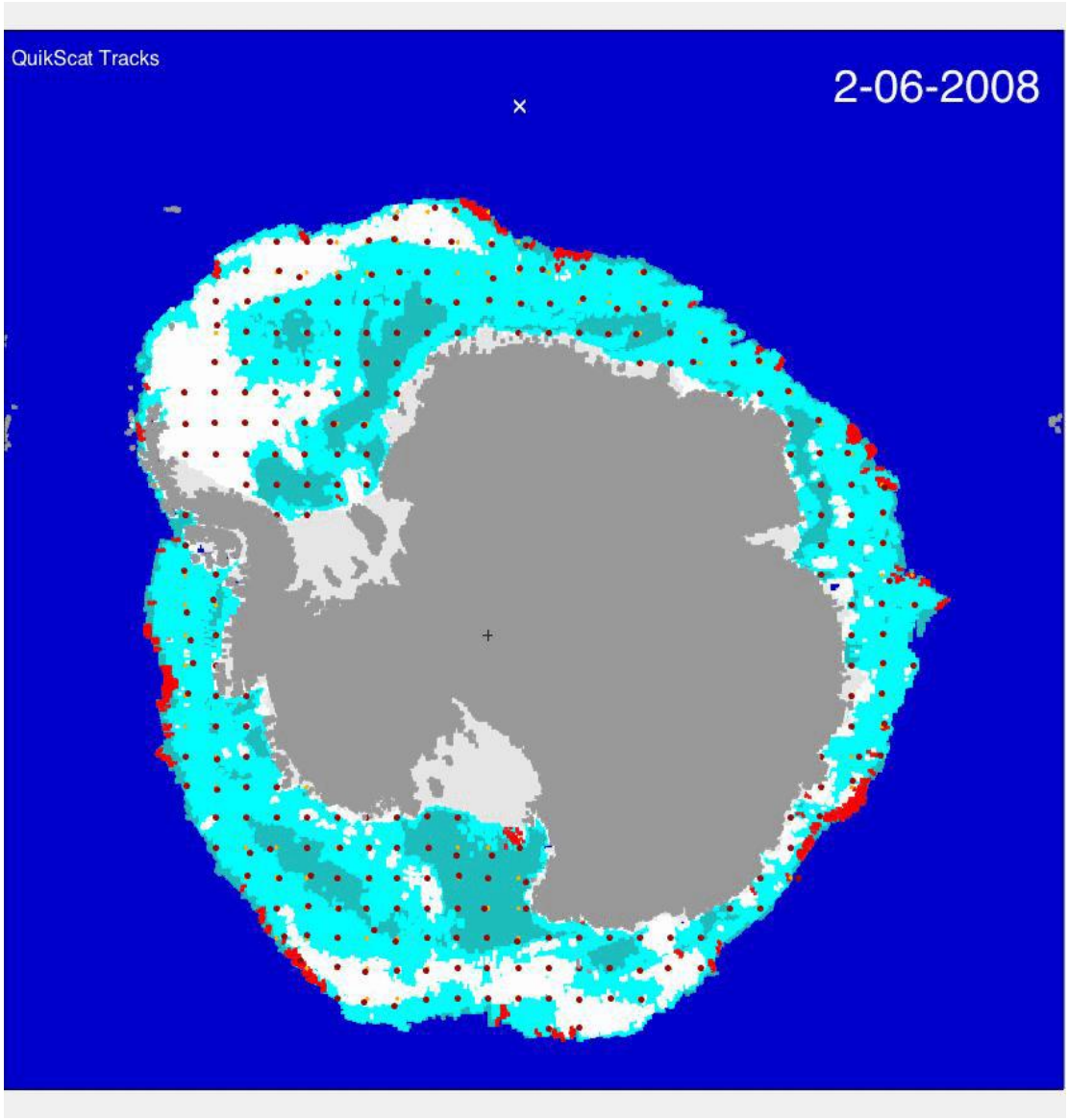


Conditions Observed Over Older Ice Class Region in the Bellingshausen Sea During SIMBA on October 2007

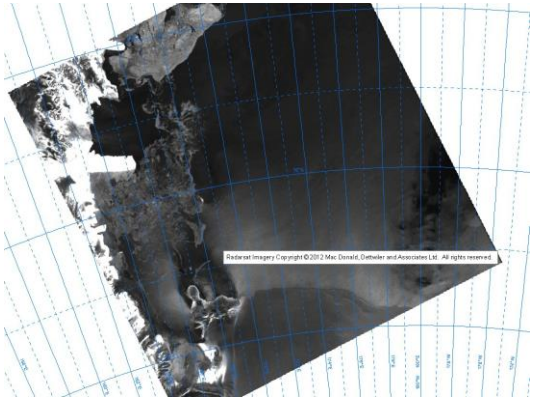
Photo courtesy of M. Lewis

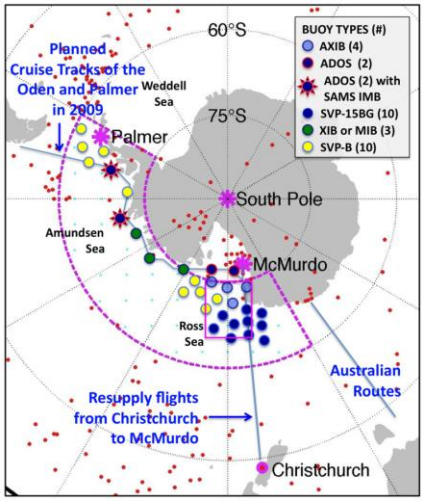
International Programme for Antarctic Buoys

Global participants working together to maintain a network of drifting buoys around the Antarctic continent to provide real-time operational requirements and research purposes.

SHARED RESOURCES
Science and Research
Manpower
Platforms of Opportunity
Financial Cost Sharing
Imagery Savings

Australia
Finland
France
Germany
Italy
Japan
New Zealand
Norway
South Africa
UK
United States





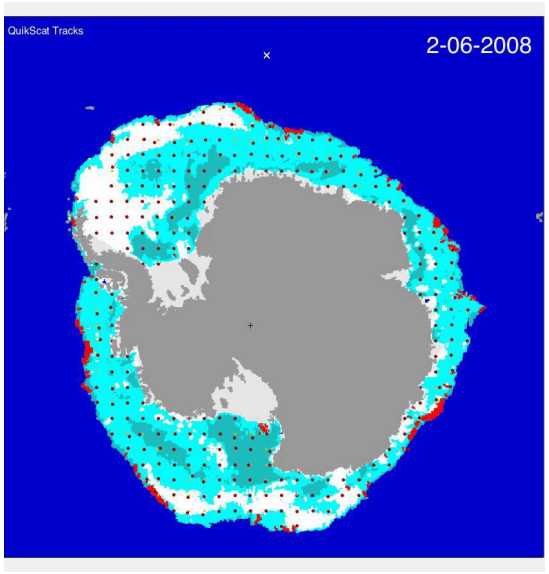
The U.S. IPAB contributions are coordinated through the U.S. Interagency Program for Antarctic Buoys (USIPAB), which is also managed by the U.S. National Ice Center and the Polar Science Center at University of Washington. To date the main effort has been funded by NSF with additional support from NOAA and limited leveraging of other USIABP resources. The goal is to establish and maintain an array of meteorological and ocean buoys on sea ice, primarily in the U.S. operational region of interest, i.e. Amundsen /Bellingshausen and Ross Seas.

Proposed 2017 IABP/IPAB Meeting in Hobart

Conclusions

- Wind consistently opens internal sea ice for effective growth (ice factories in YI areas).
- Formation of a FIZ with OI and RI encapsulating and thus protecting internal sea ice, bounded by the sACC front.
- FIZ recirculating around by the persistent westerlies.
- Geological factors, topography for winds and bathymetry for waters, persistently maintain the stability of Antarctic sea ice.
- Antarctic sea ice behavior is consistent with Antarctic geophysics and thus not a paradox.

Geophysical Constraints on Antarctic Sea Ice Cover

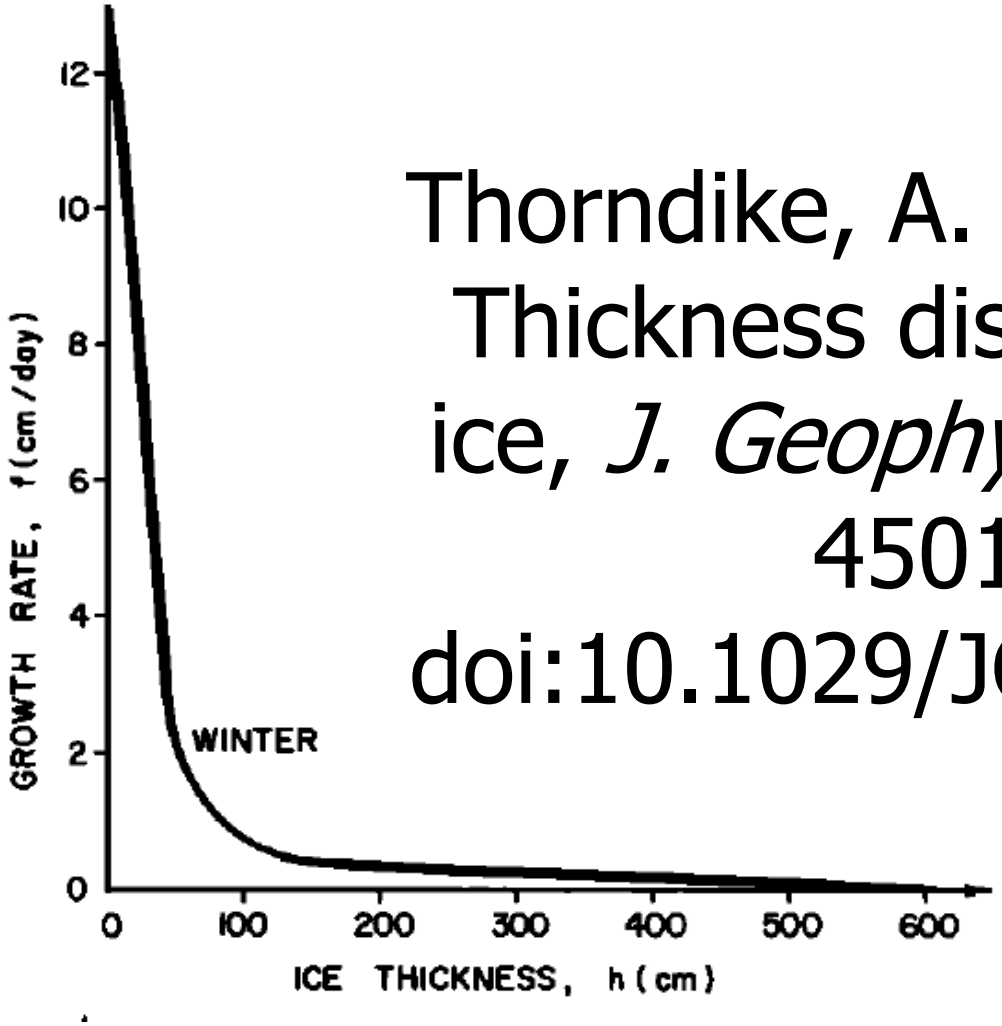


http://www.sciencedirect.com/science/article/pii/S0034425716301481

S.V. Nghiem, I.G. Rigor, P. Clemente-Colón, G. Neumann, and P.P. Li. Geophysical constraints on the Antarctic sea ice cover. *Remote Sensing of Environment*, Volume 181, 2016, 281–292. http://dx.doi.org/10.1016/j.rse.2016.04.005

Back-up Slides

Effective Sea Ice Growth in the Regions of YI Class behind the FIZ



Thorndike, A. S., et al. (1975), Thickness distribution of sea ice, *J. Geophys. Res.*, *80*(33), 4501-4513, doi:10.1029/JC080i033p04501