

Objective

Explain the polar sea ice paradox:
 Large decrease in Arctic sea ice vs
 slight increase in Antarctic sea ice

Issues to be addressed

1. Mechanisms for sea ice production
2. What protects the sea ice cover
3. What factors sustain Antarctic ice
4. What causes regional variability
5. Consistency among factors above
6. Same physics but opposite effects in Arctic versus Antarctic sea ice

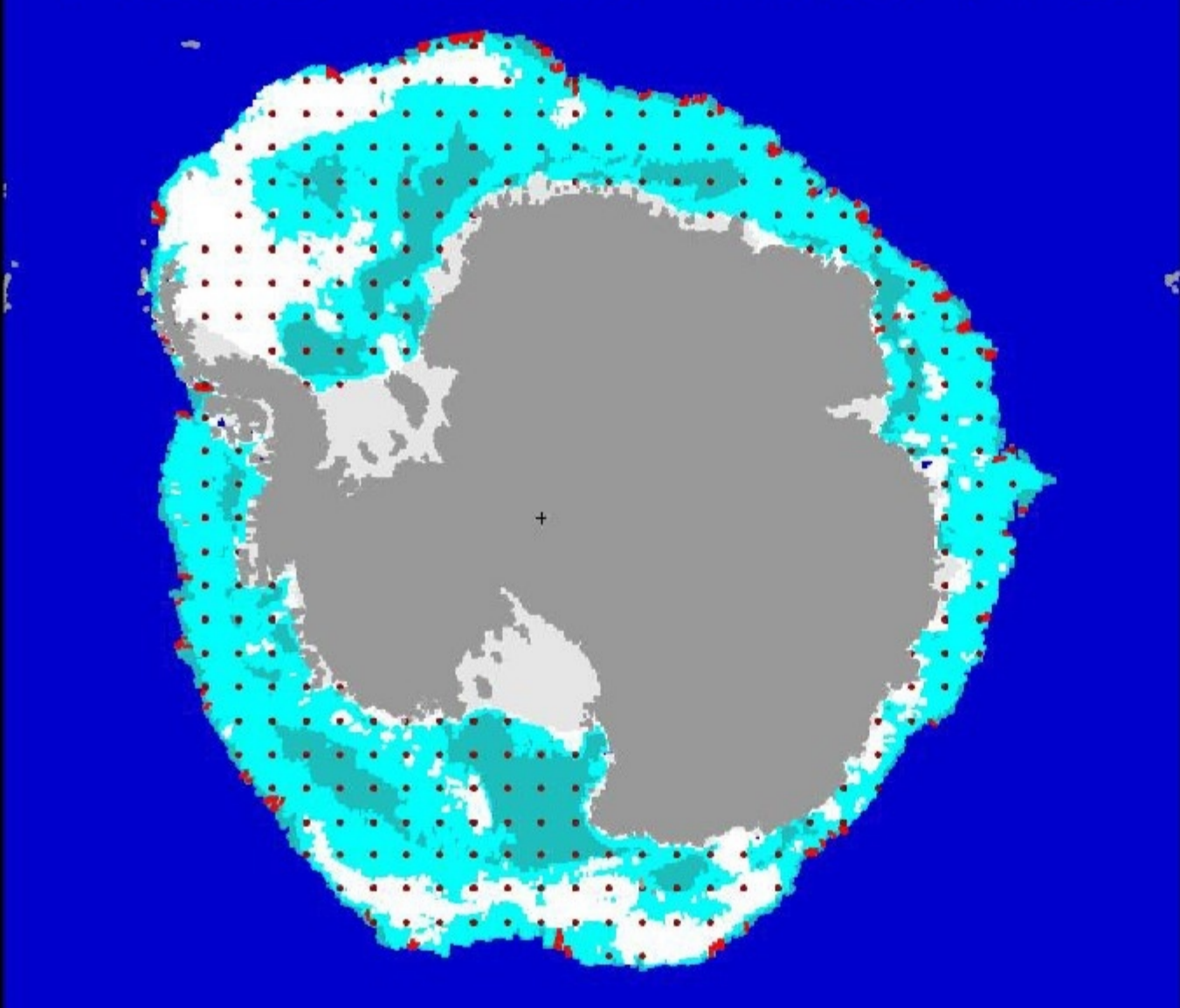
Antarctic Sea Ice Production

- Ozone change increasing sea ice (Marshall, 2003; Gillett & Thompson, 2003; Son et al. 2010) but not effective (Sigmond & Fyfe, 2010)
- Lower salinity/density in the near-surface layer weaken mixing (Manabe et al., 1991)
- Enhancement of thermohaline stratification (Zhang, 2007); Meltwater from ice shelves in cool layer (Bintanja et al., 2013)
- Wind intensifications for more ridging and thus thickening sea ice (Zhang, 2013)

Synoptic Sea Ice Classes

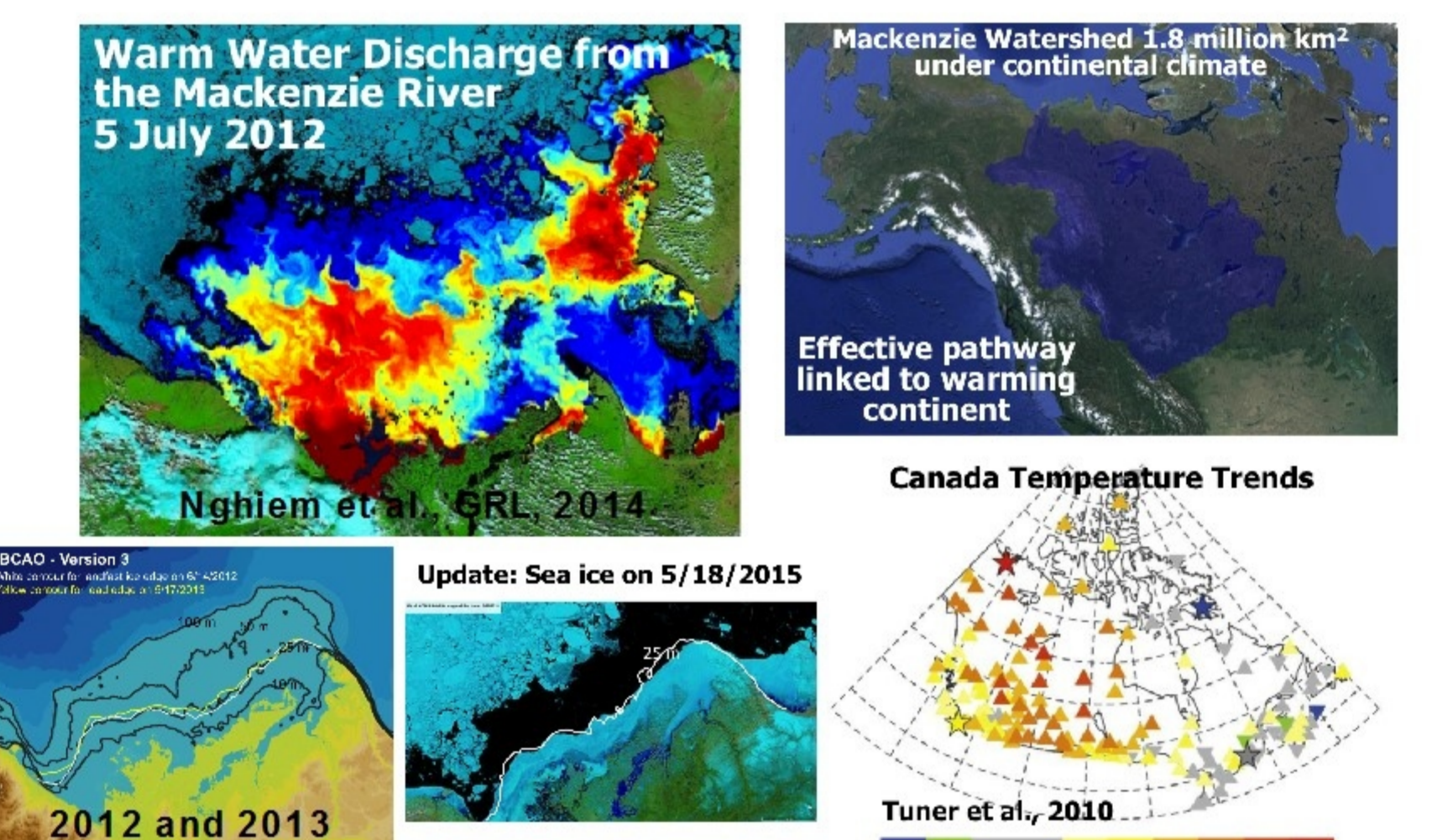
- Statistical analysis shows a Gaussian distribution of Antarctic sea ice backscatter signatures in contrast to the bimodal distribution for Arctic sea ice.
- Using the Gaussian mean and STD, we define 'YI Class' for younger ice, 'OI Class' for older ice, and 'RI Class' for rough older ice with highest backscatter.
- Use >10 years of backscatter data (1999-2009) to map synoptic sea ice classes over the Antarctic sea ice cover.

This is a movie



Arctic River Discharge

Effective pathway linked to warming continents



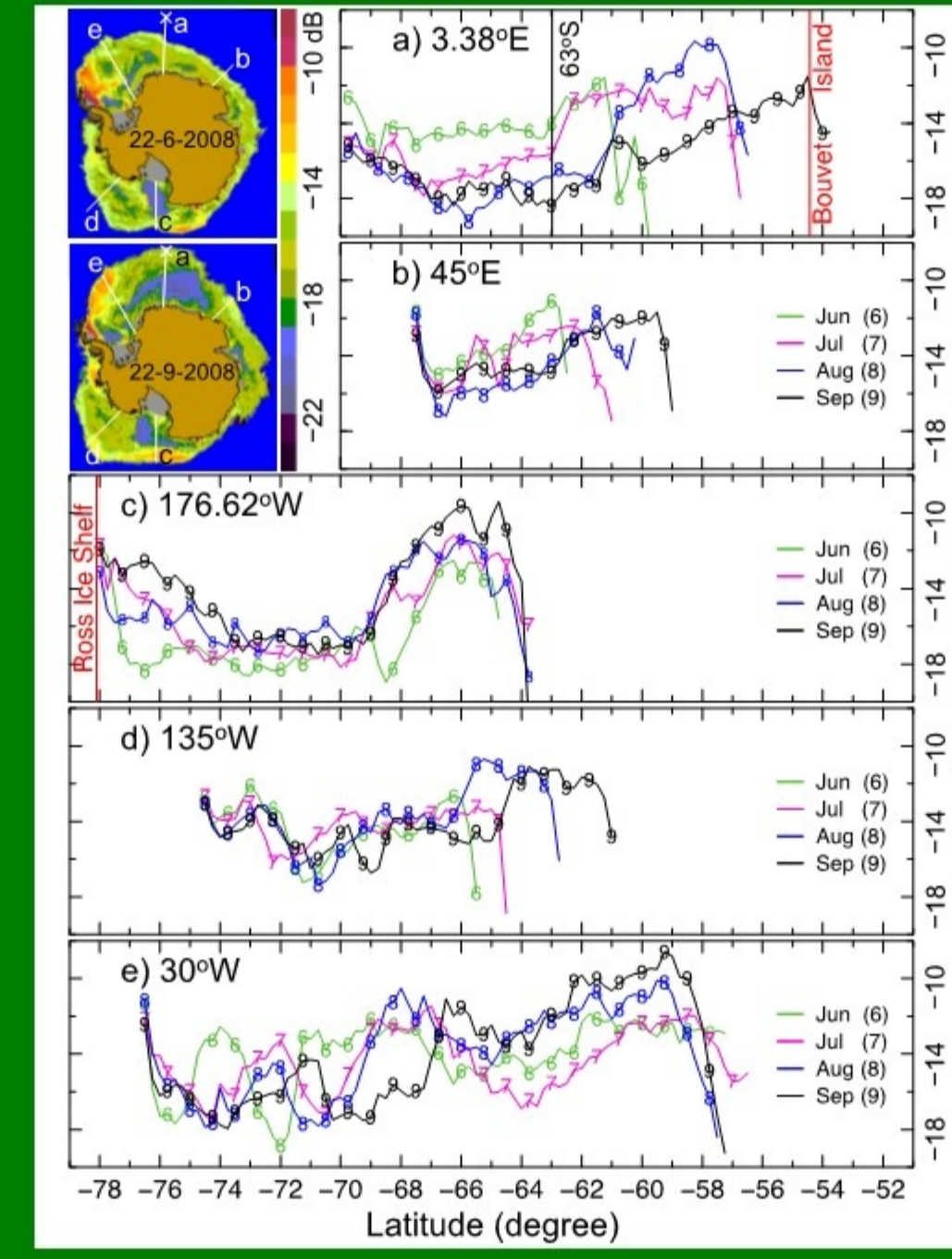
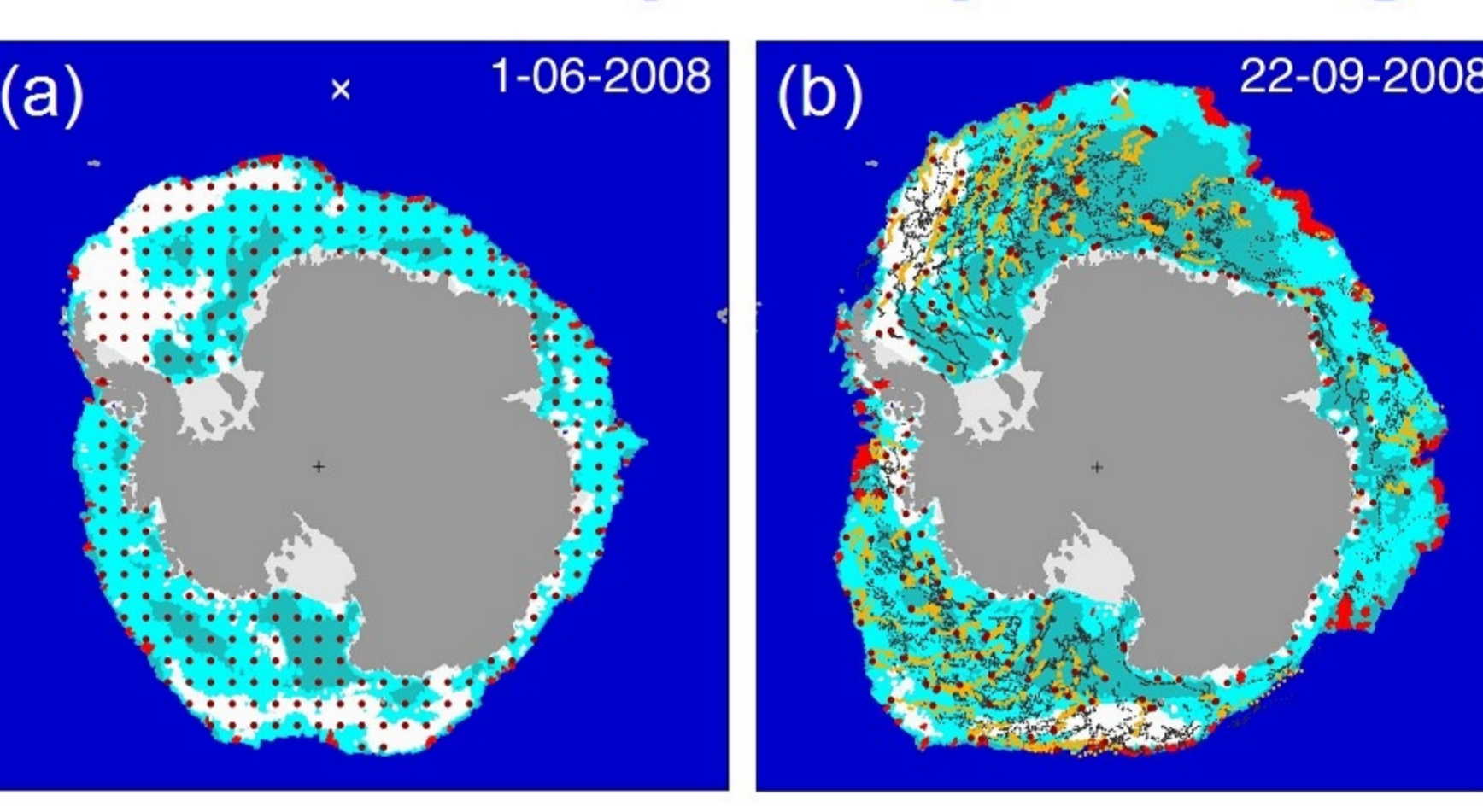
Heat Source from Rivers

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

A stark contrast between Arctic and Antarctic!

72 rivers: Blue = <6 km³/y; Yellow = 6 to <60 km³/y; Red = 60 to 600 km³/y. No such rivers!

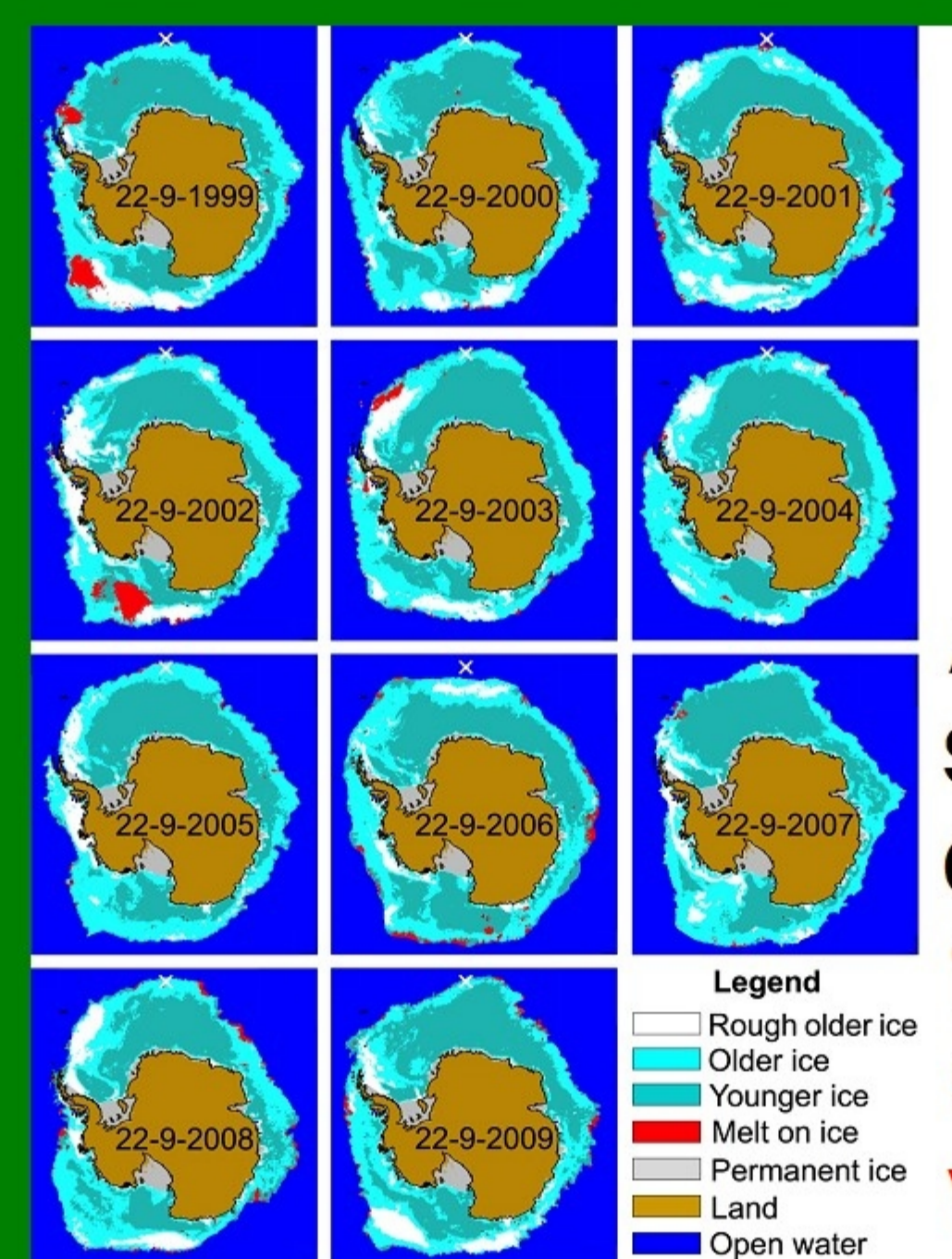
A Different Perspective from Sea Ice Trajectory Tracing



Synoptic patterns of Antarctic sea ice backscatter signatures

Formation of a Frontal Ice Zone (FIZ)

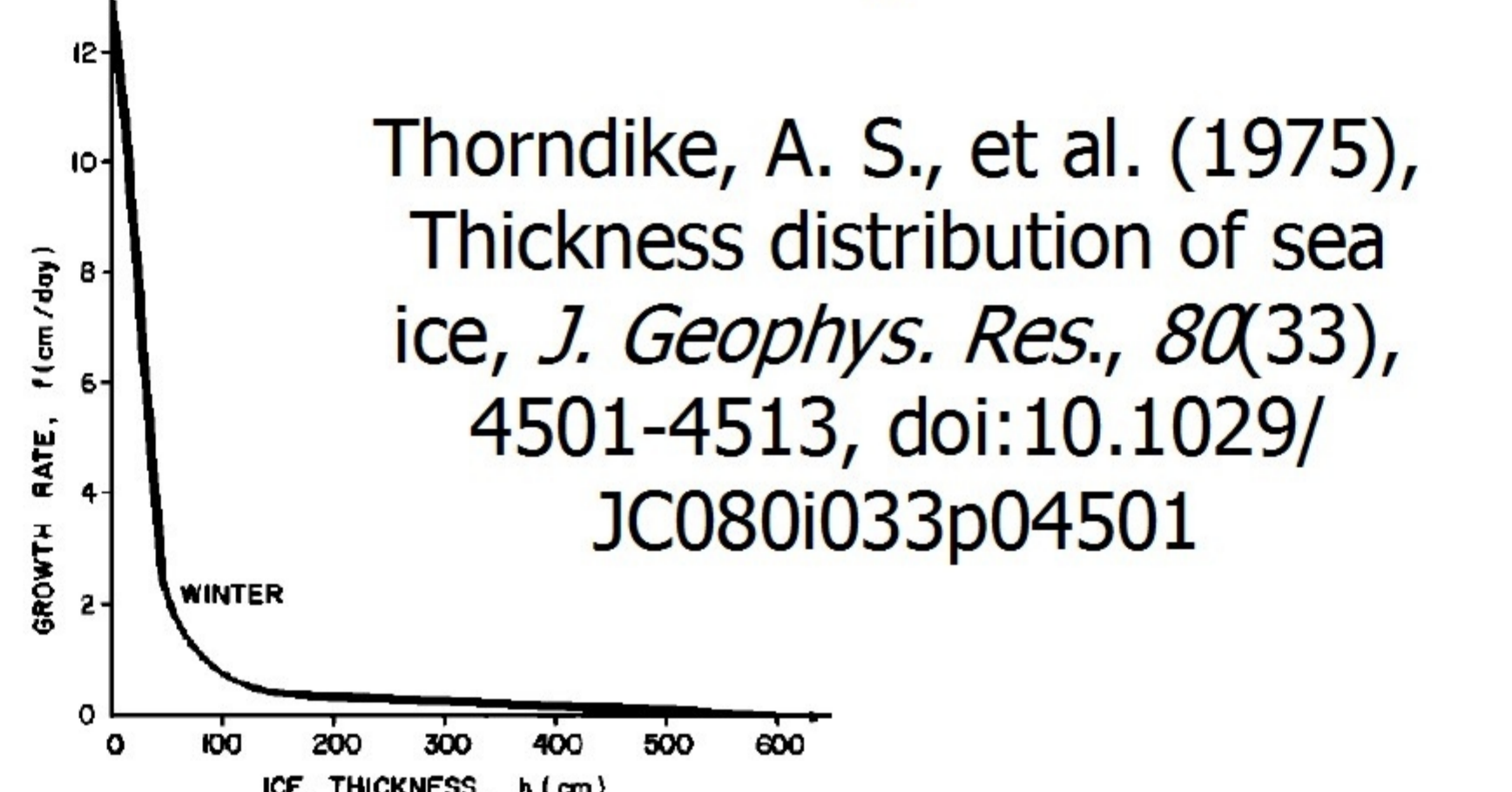
OI Class - Older, rougher, thicker



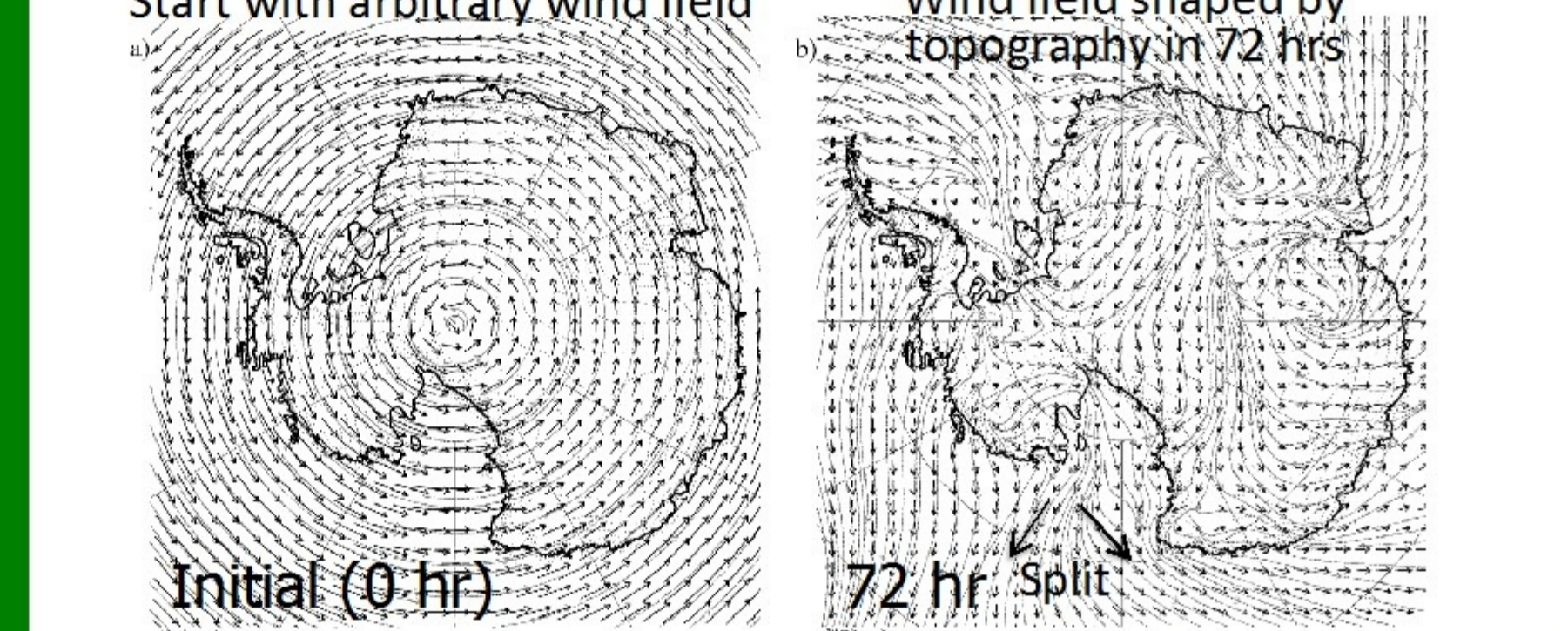
Decadal maps of synoptic sea ice classes

Antarctic FIZ surrounded & encapsulated the Antarctic sea ice cover vs Arctic MIZ

Effective Growth of Sea Ice in the Regions of Younger Sea Ice (YI) Class

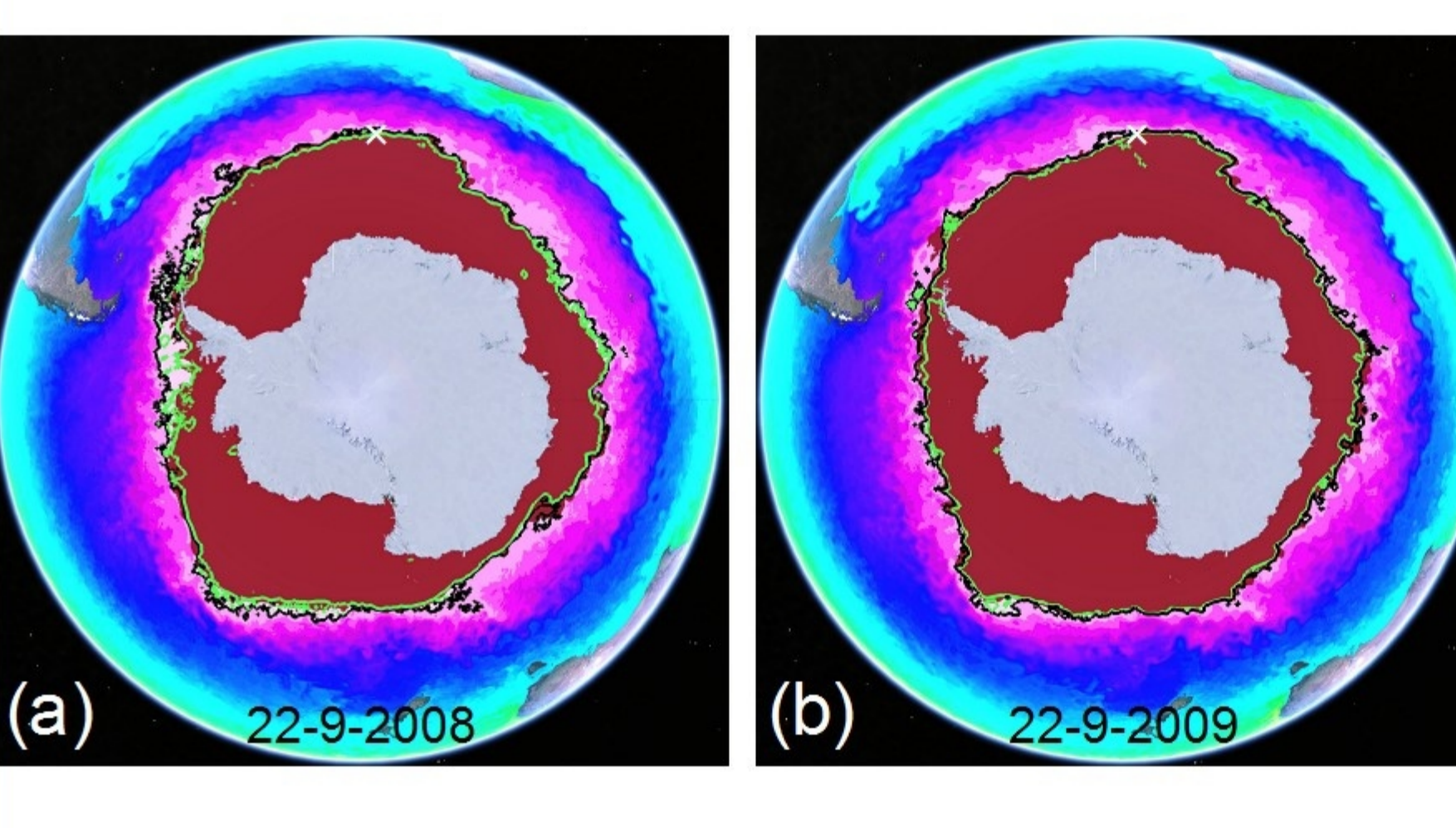


Wind Pattern Shaped by Continental Topography

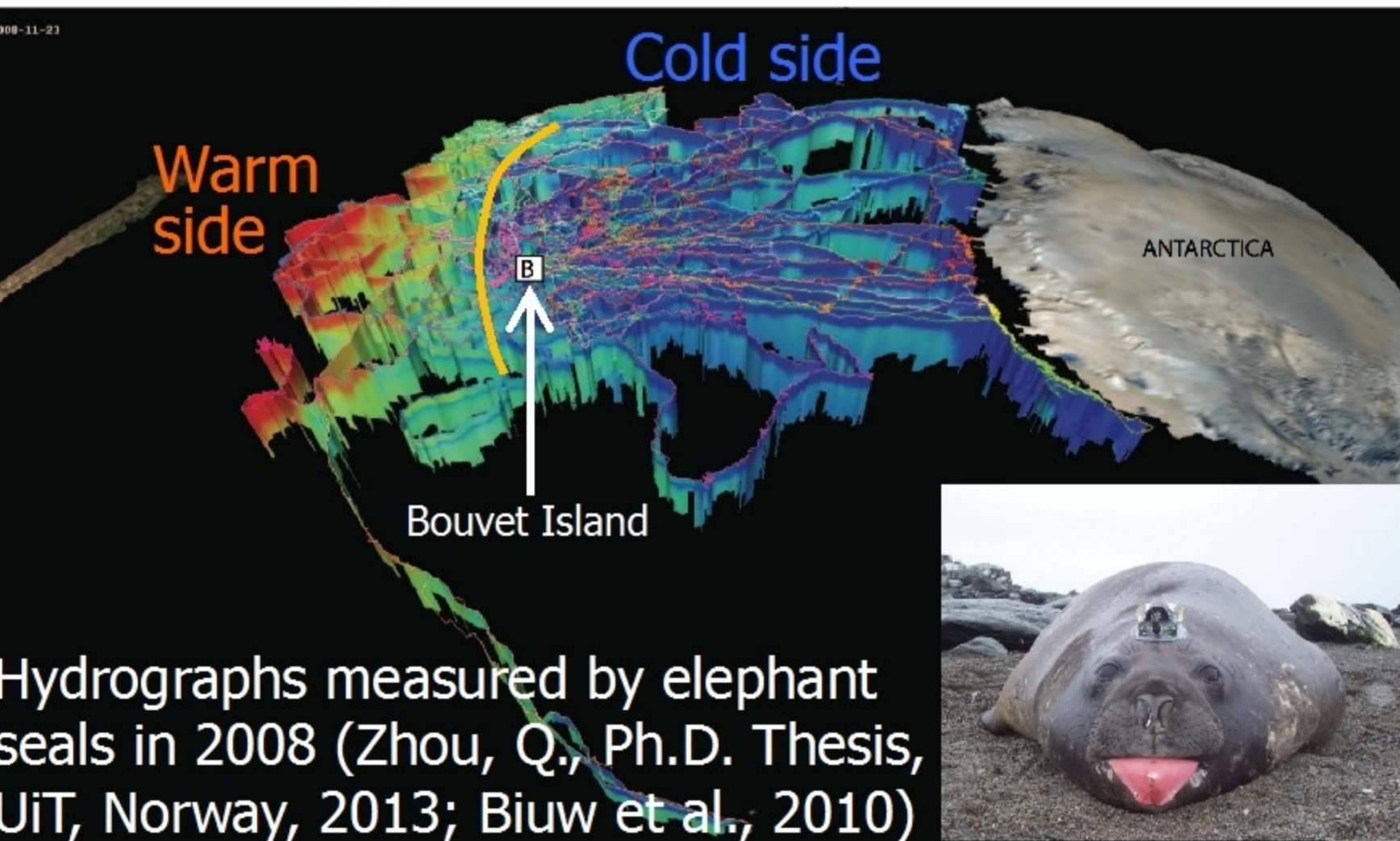


Parish, T. R., and J. J. Cassano, J. J. (2003). Diagnosis of the Katabatic Wind Influence on the Wintertime Antarctic Surface Wind Field from Numerical Simulations. *Monthly Weather Rev.*, 131, 1128-1139.

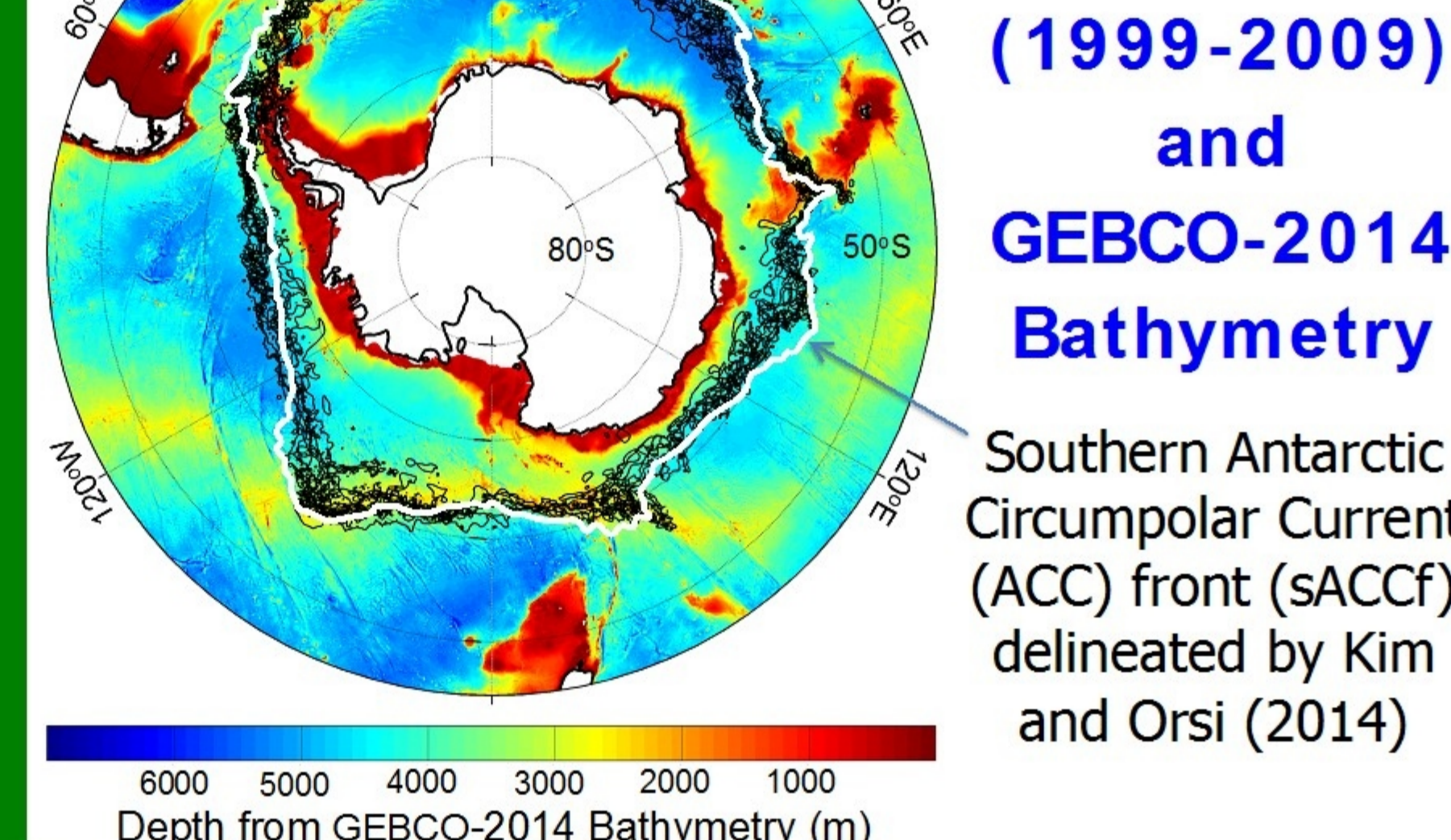
Sea Ice and Sea Surface Temperature (MUR Product)



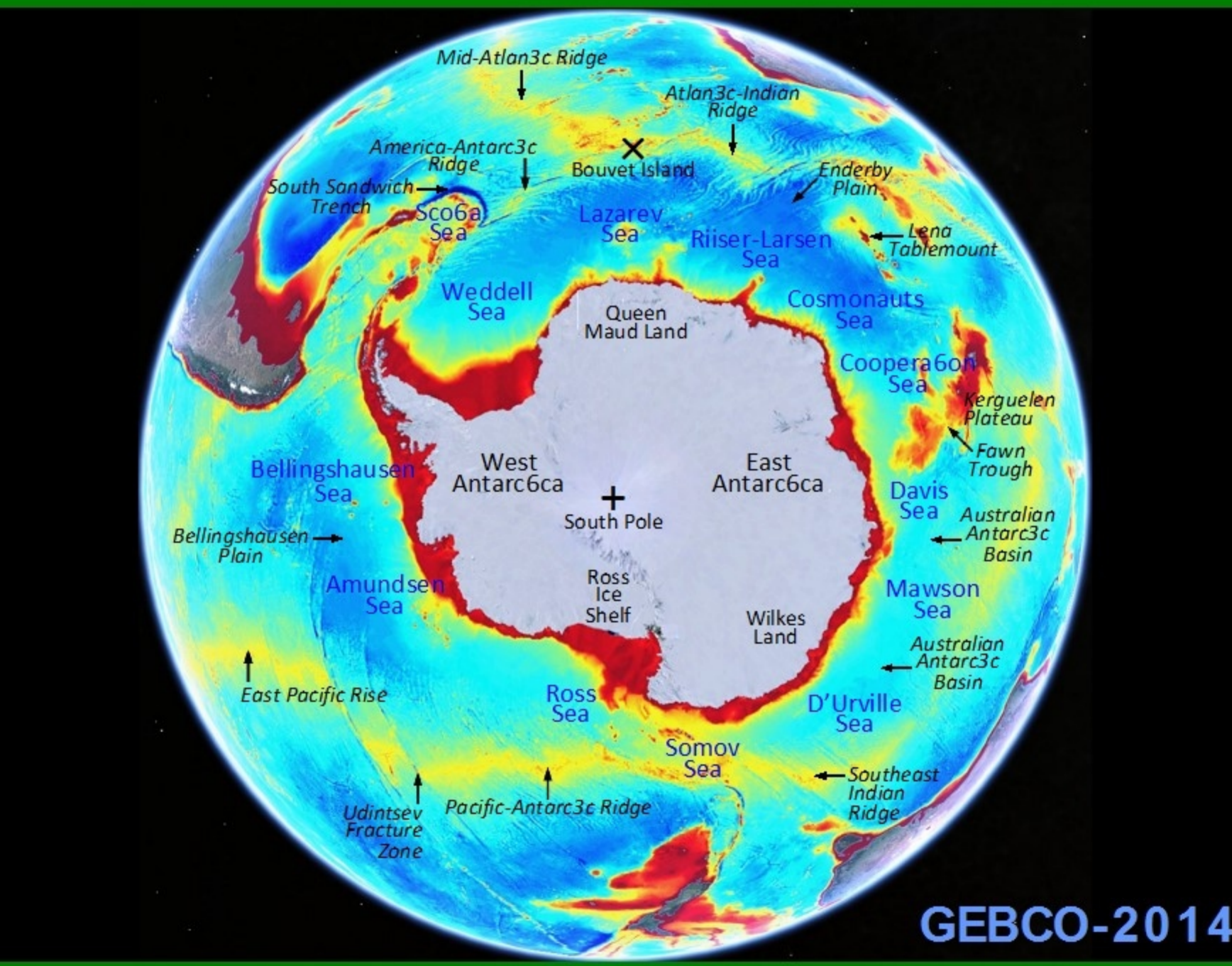
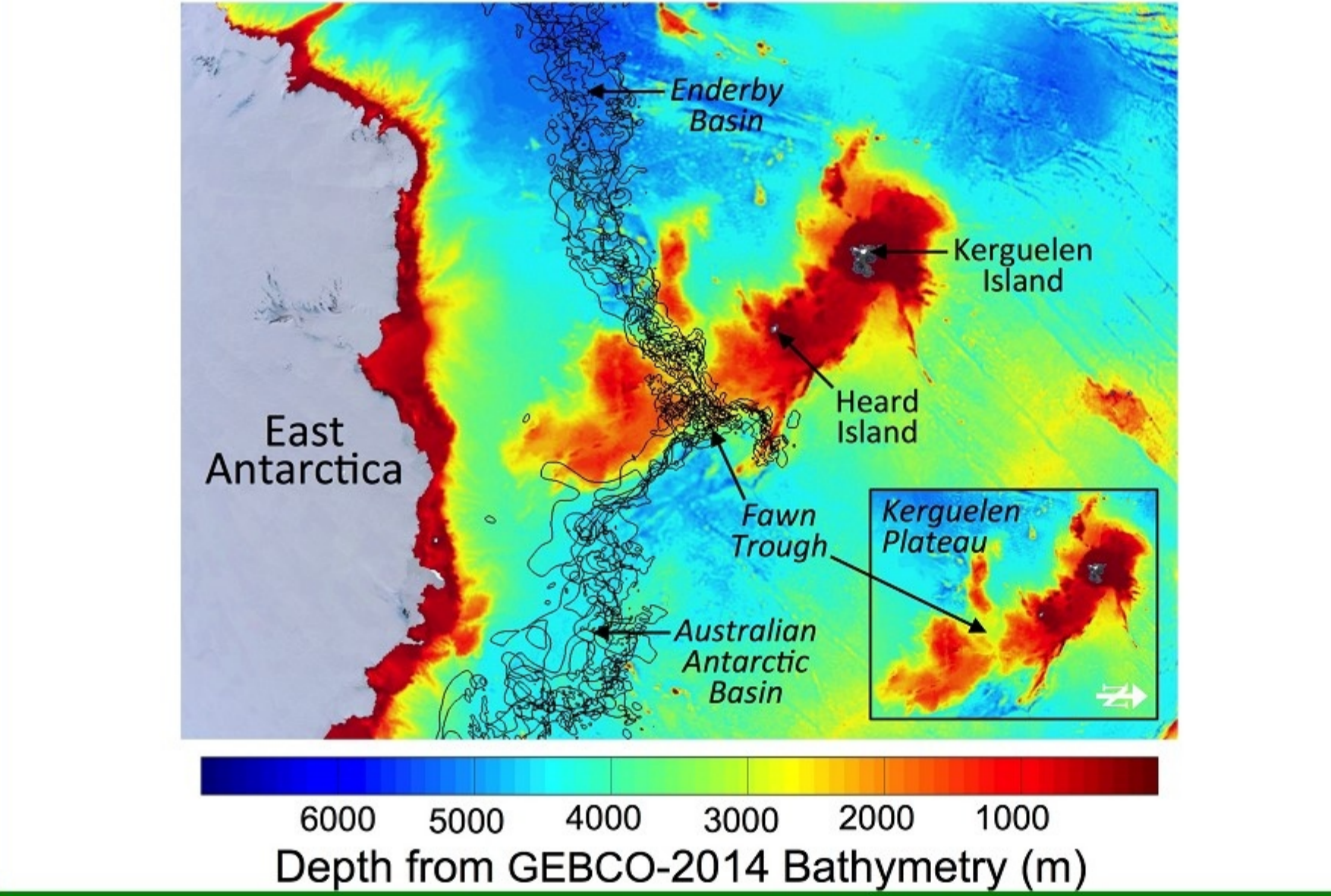
Cold and Warm Waters in the Region of Bouvet Island



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



SST over Kerguelen Plateau



Conclusions

- "Great Shield" zone of Antarctic Sea Ice: with OI and RI, encapsulating and protecting internal YI sea ice, bounded by the sACC front. FIZ recirculation by the persistent westerlies.
- Wind consistently opening internal sea ice for effective ice growth (ice factories in YI areas).
- 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.