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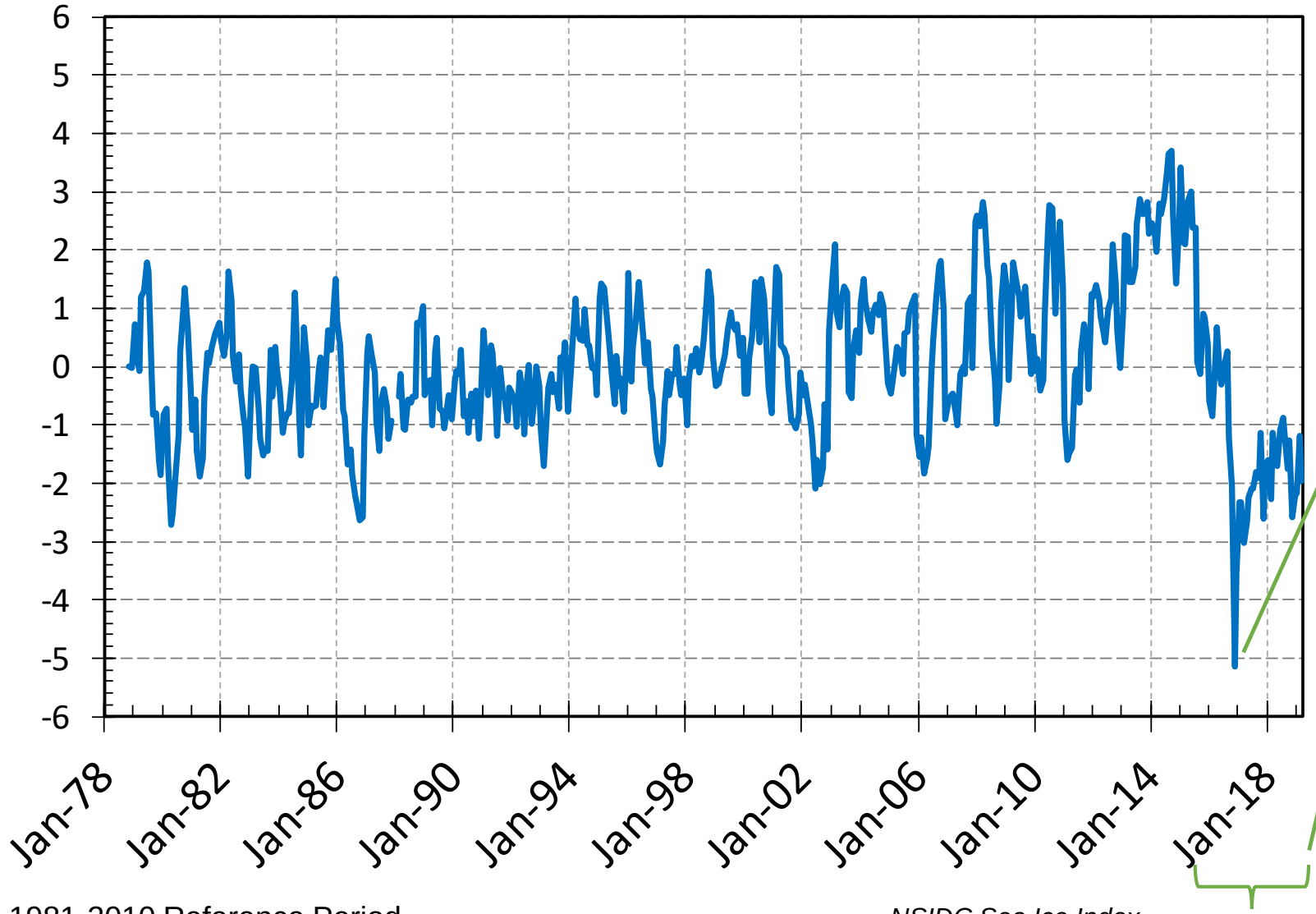
19-23 May 2019, Boulder, CO

Recent Antarctic Sea Ice Extent Variability

and Its Relation to Atmospheric Circulation in Reanalyses and Seasonal Forecasts

Richard Cullather, Bin Zhao, Andrea Molod, Feng Li

Monthly Antarctic Sea Ice Extent Anomaly [σ]



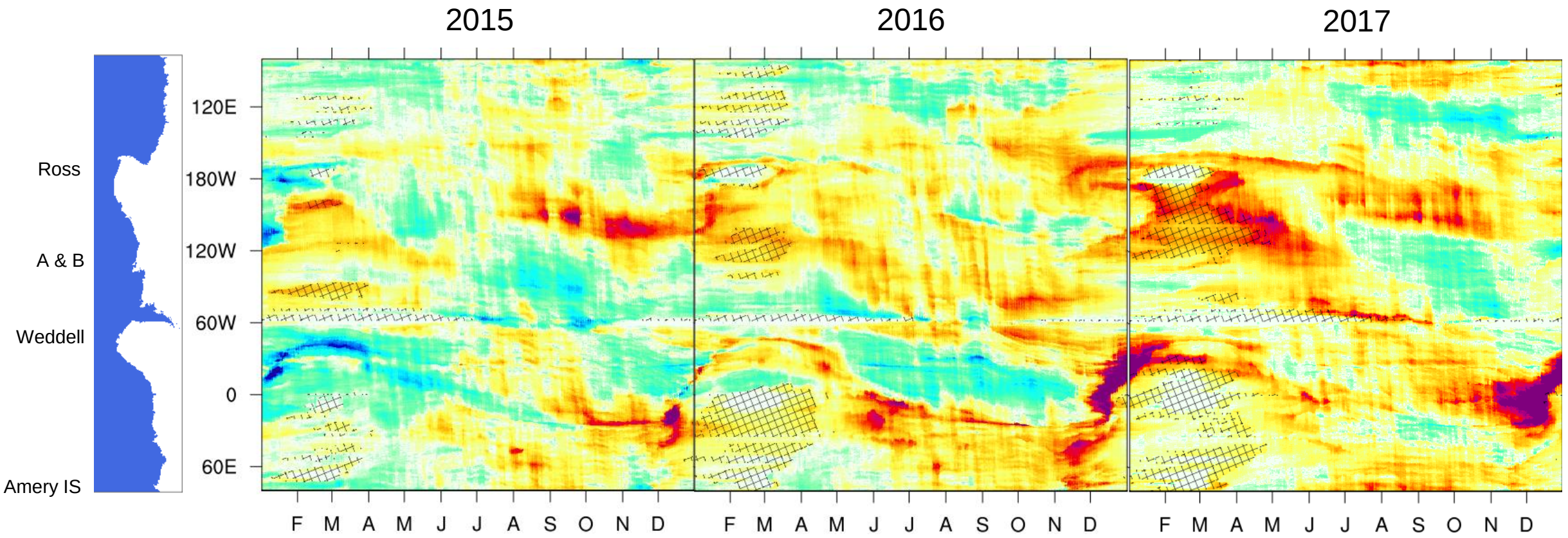
November 2016: −5.2 σ for monthly average.

September 2016 *to Present*: *Consistently* less than 1 σ.

1981-2010 Reference Period

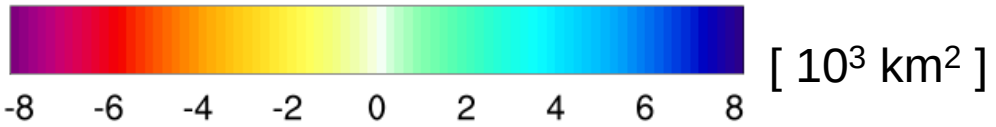
NSIDC Sea Ice Index

Daily Extent Anomaly



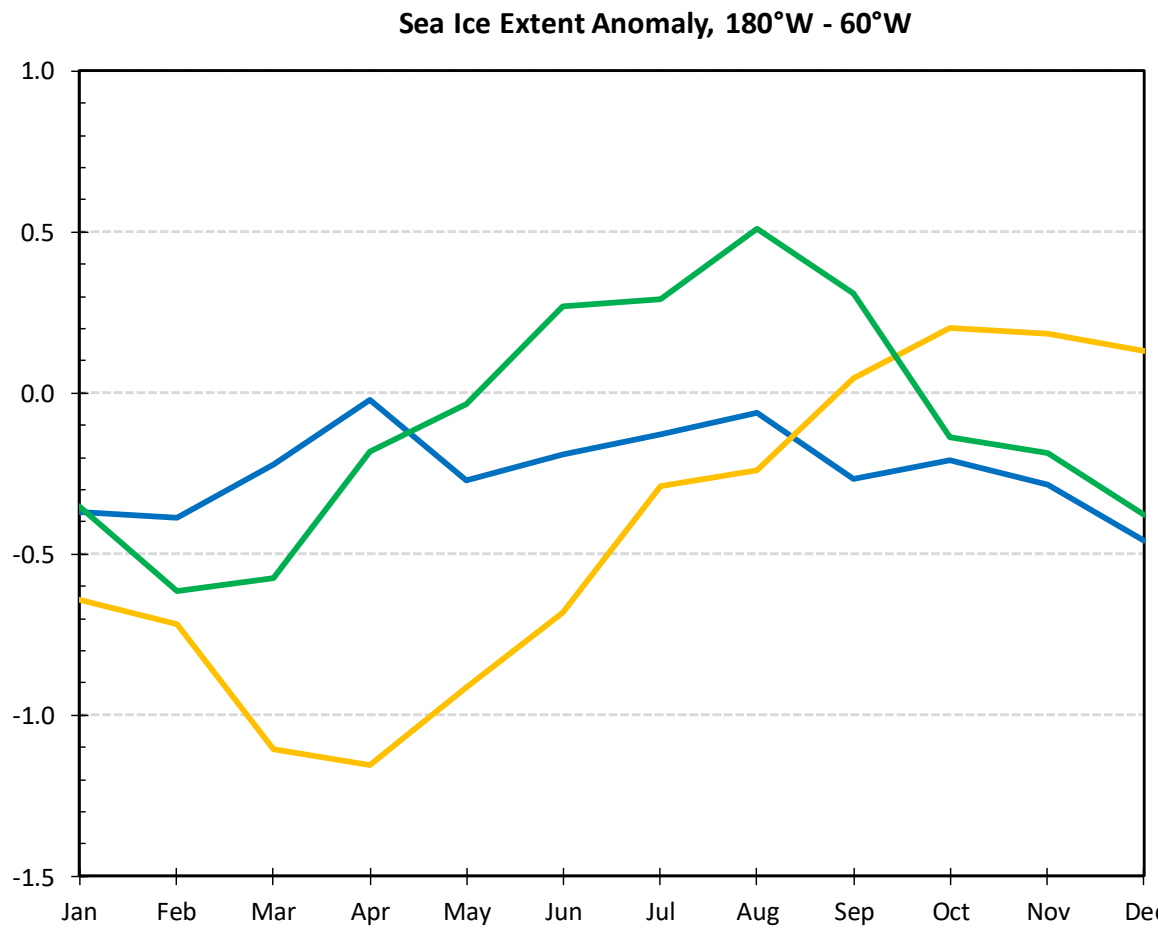
Hatched indicates Open Water

GSFC NASA Team

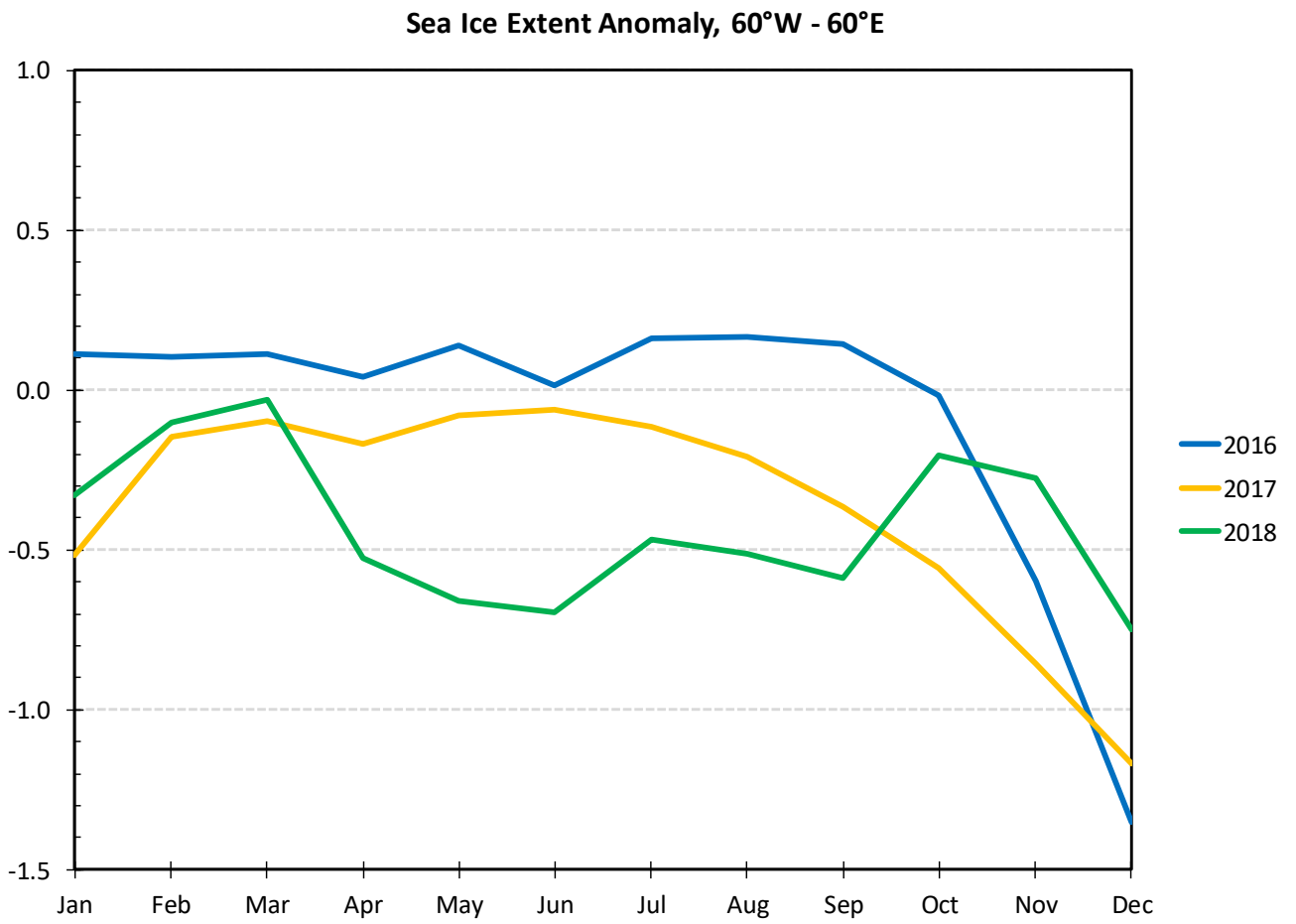


Extent Anomaly

Ross Gyre & Vicinity

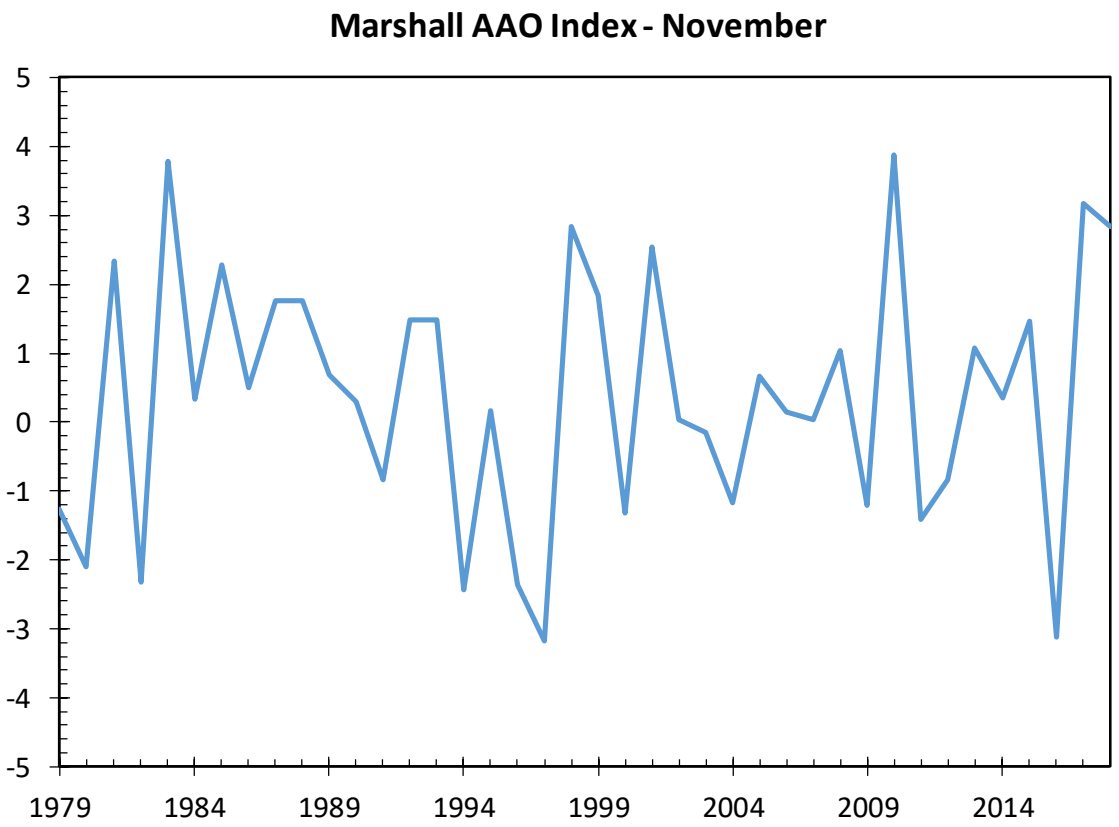


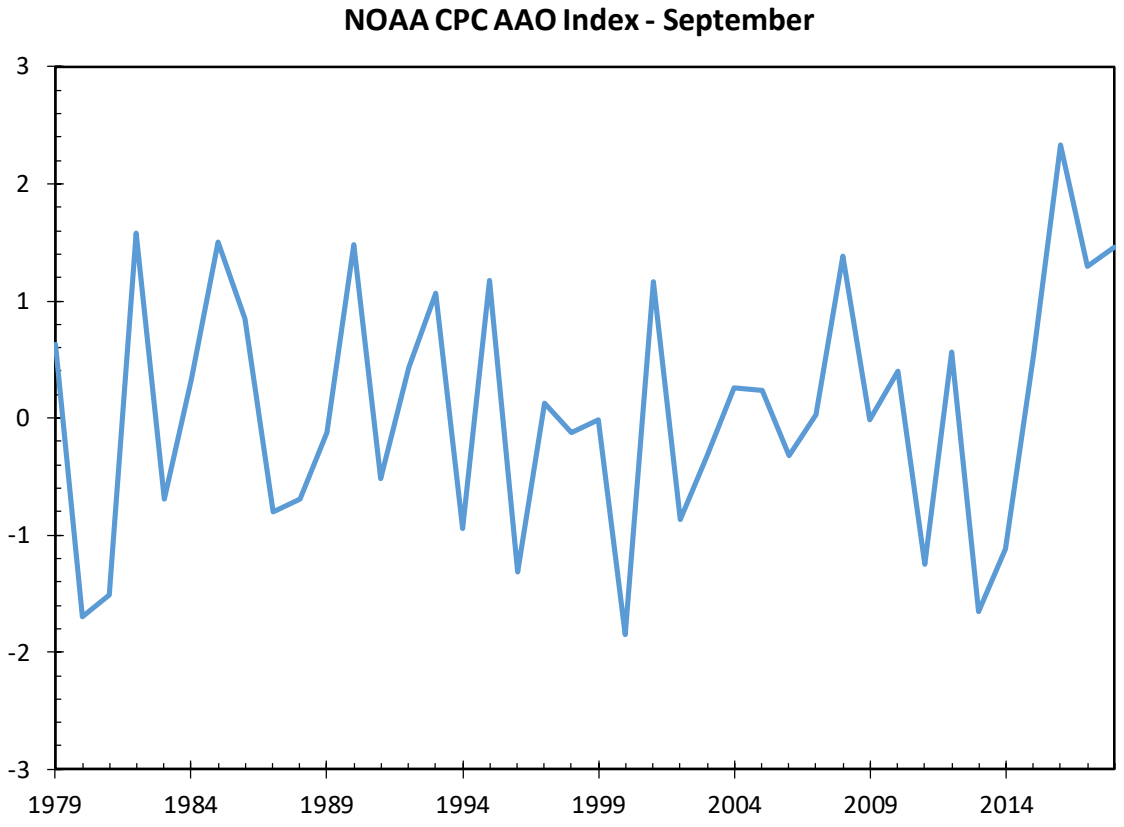
Weddell Gyre & Vicinity



GSFC NASA Team, 10^6 km^2

AAO Index


Marshall AAO Index - November
5
4
3
2
1
0
-1
-2
-3
-4
-5
1979
1984
1989
1994
1999
2004
2009
2014


NOAA CPC AAO Index - September
3
2
1
0
-1
-2
-3
1979
1984
1989
1994
1999
2004
2009
2014

Overview

ARTICLE

https://doi.org/10.1038/s41467-018-07865-9 OPEN

Sustained ocean changes contributed to sudden Antarctic sea ice retreat in late 2016

Gerald A. Meehl[1], Julie M. Arblaster[1,2], Christine T.Y. Chung[3], Marika M. Holland[1], Alice DuVivier[1], LuAnne Thompson[4], Dongxia Yang[2] & Cecilia M. Bitz[4]

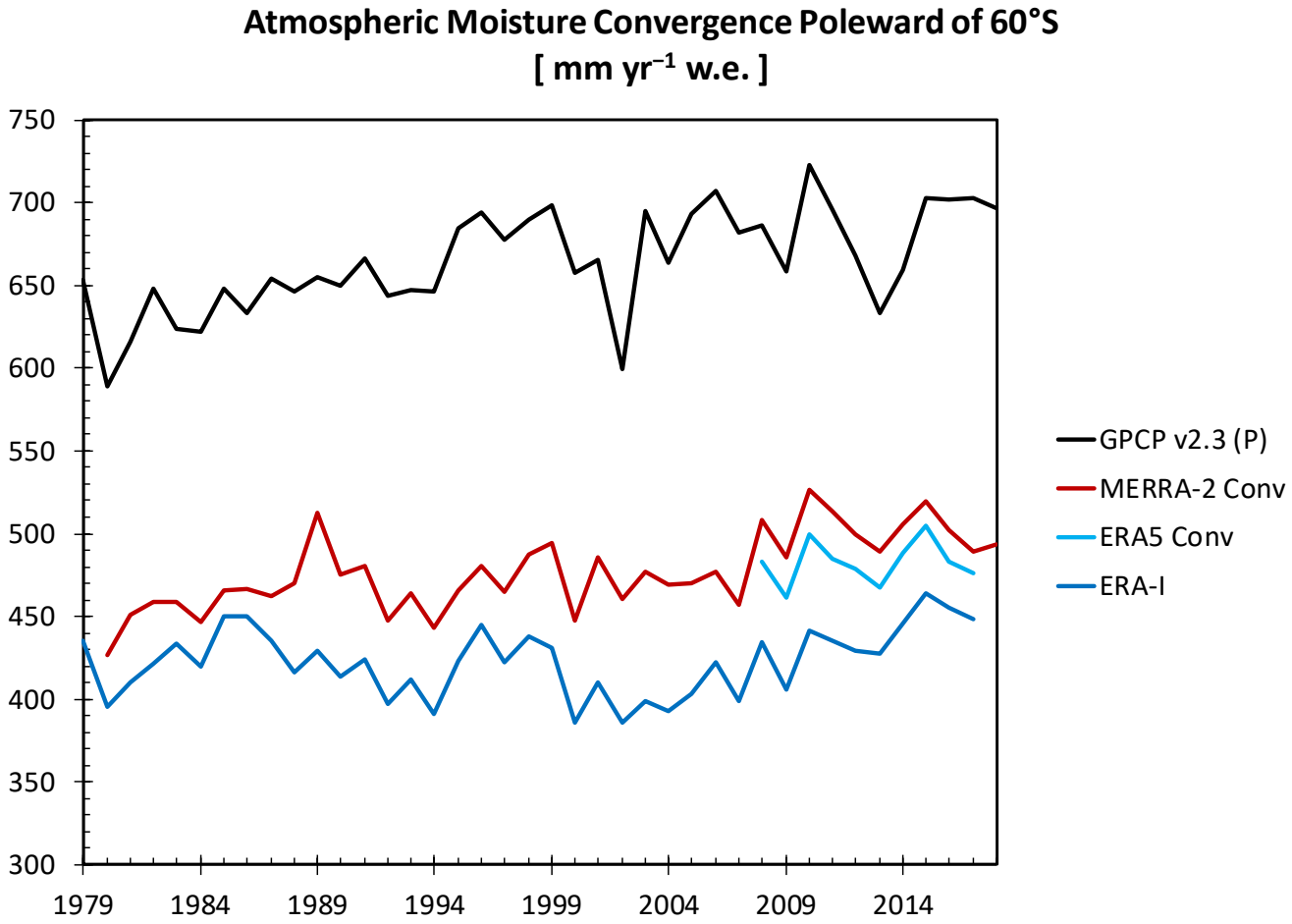
- Recent sea ice changes associated with the *Pacific Multi−Decadal Oscillation*.
- Increase in the surface wind stress curl.
- Enhanced warming of ocean mixed layer.

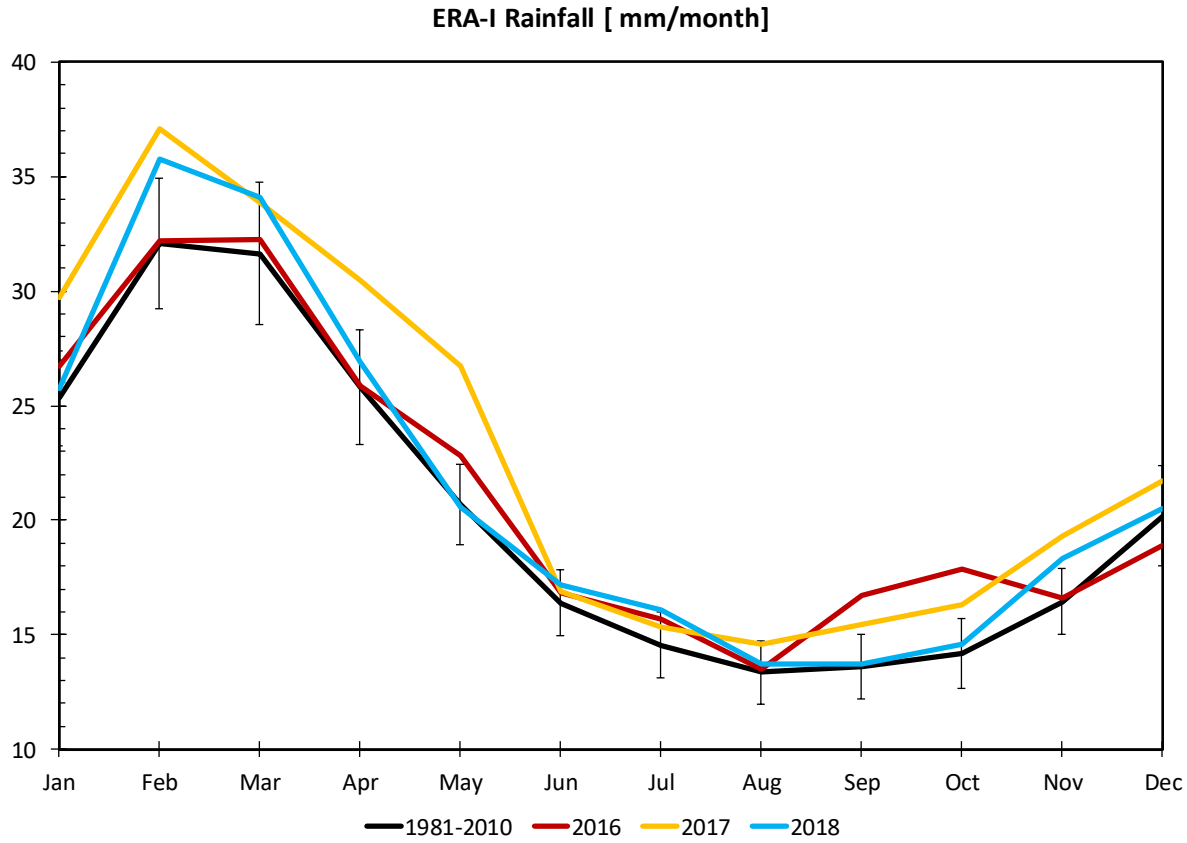
- Large-scale atmospheric changes are muted (perhaps threshold-related).
- Variables of interest: precipitation, storminess, wind stress.
- Hypothesis: Changes are associated with resulting changes to ocean mixed layer.

Objectives:

- Examine these issues over recent three year period & contrast with ice maxima period (MERRA-2).
- Examine changes in oceanic characteristics.
- GEOS S2S AO-CDAS: EnOI assimilation of major arrays, Argo, CTD, XBT, altimetry (GEOS/MOM5/CICE4.1).
- Keeping in mind that reanalysis trends are inherently dangerous..

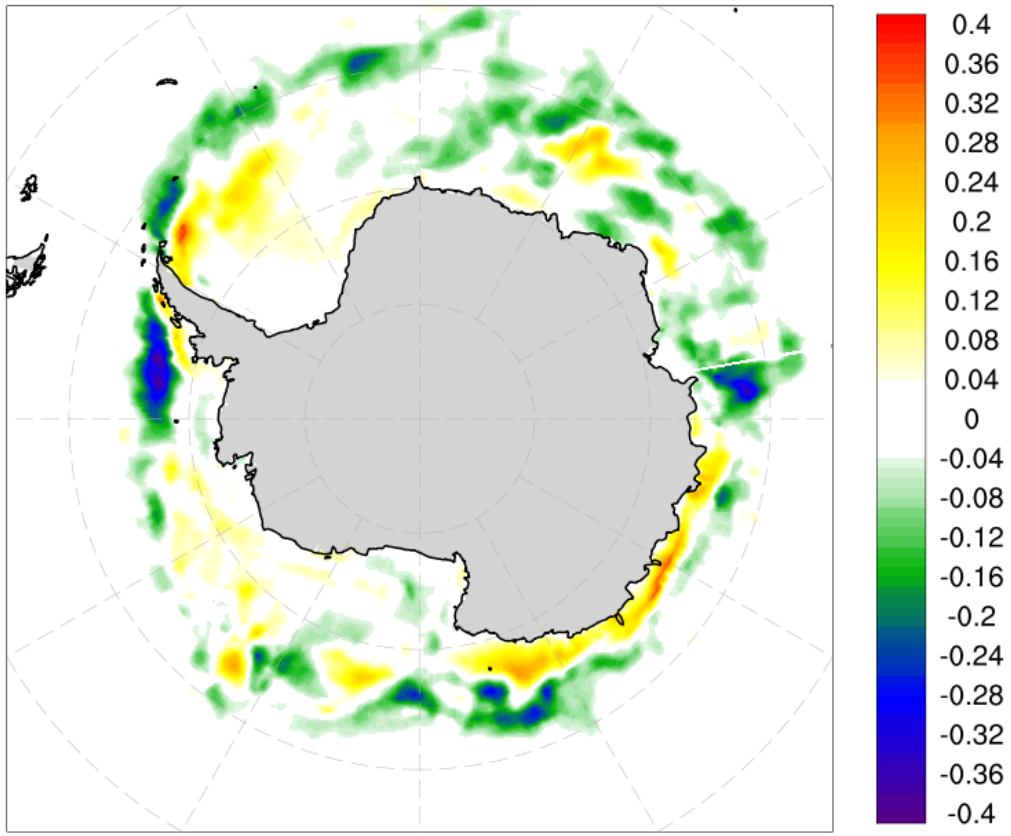
Ocean Precipitation Poleward of 60°S



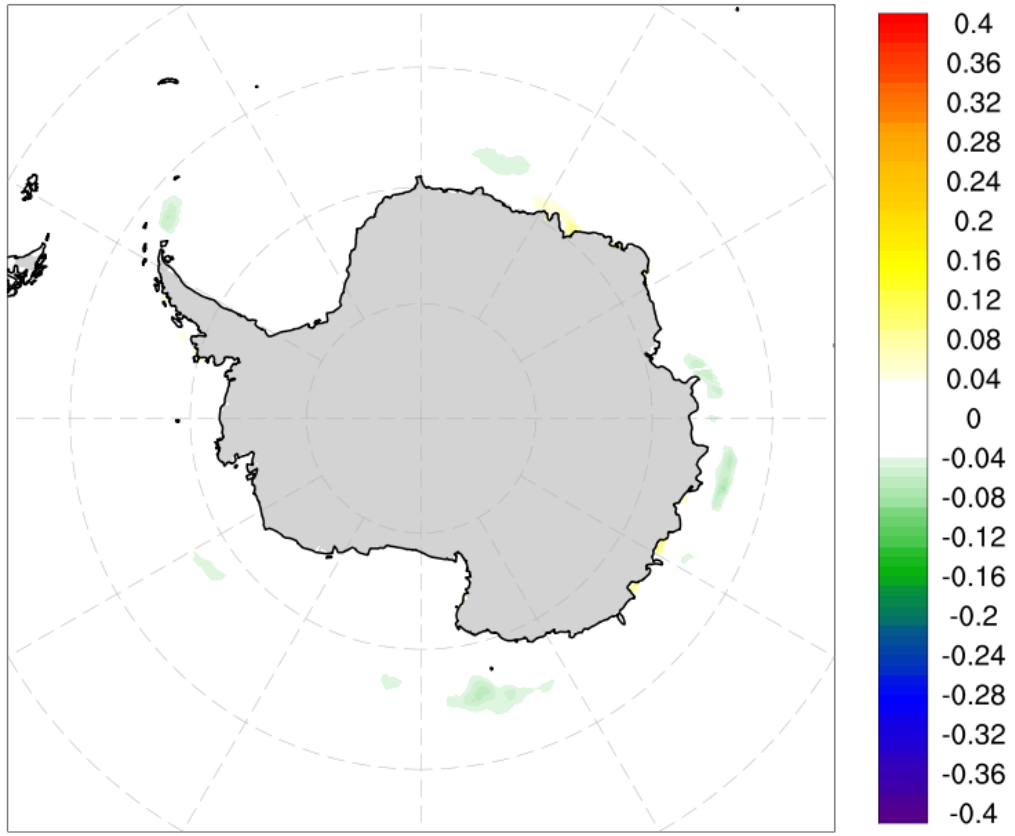


Sea Ice Melt, October-November-December

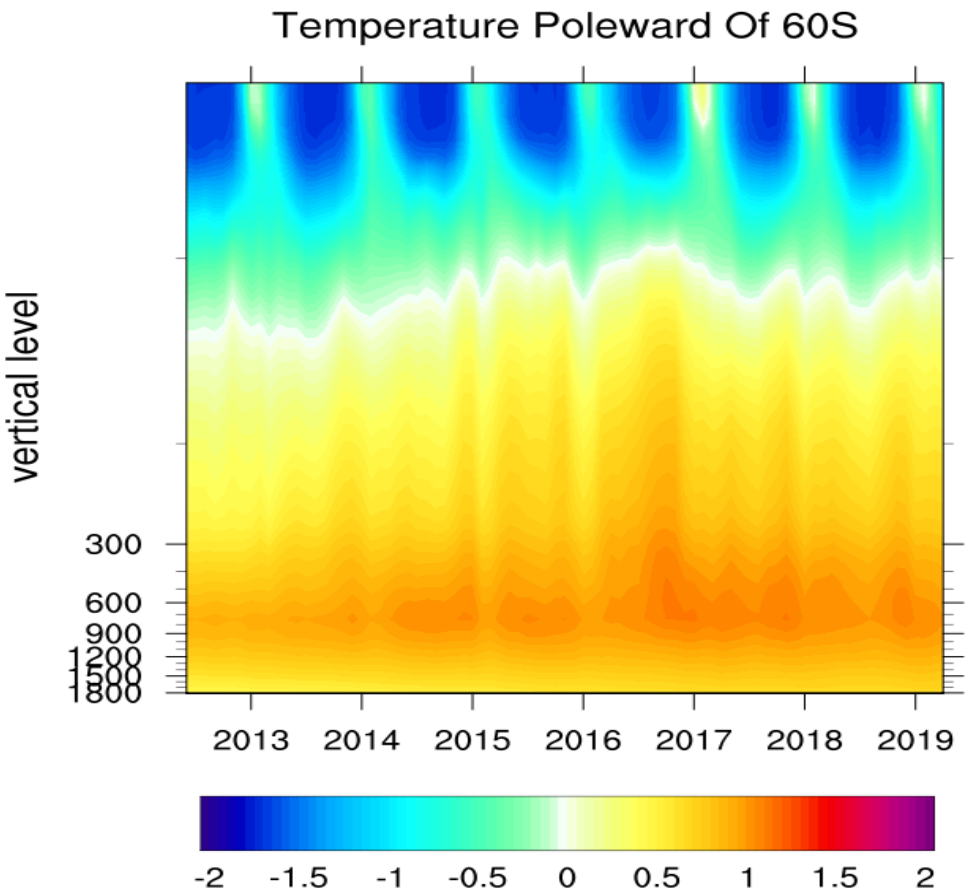
Basal Ice Melt, 2016-18 Minus 2012-14



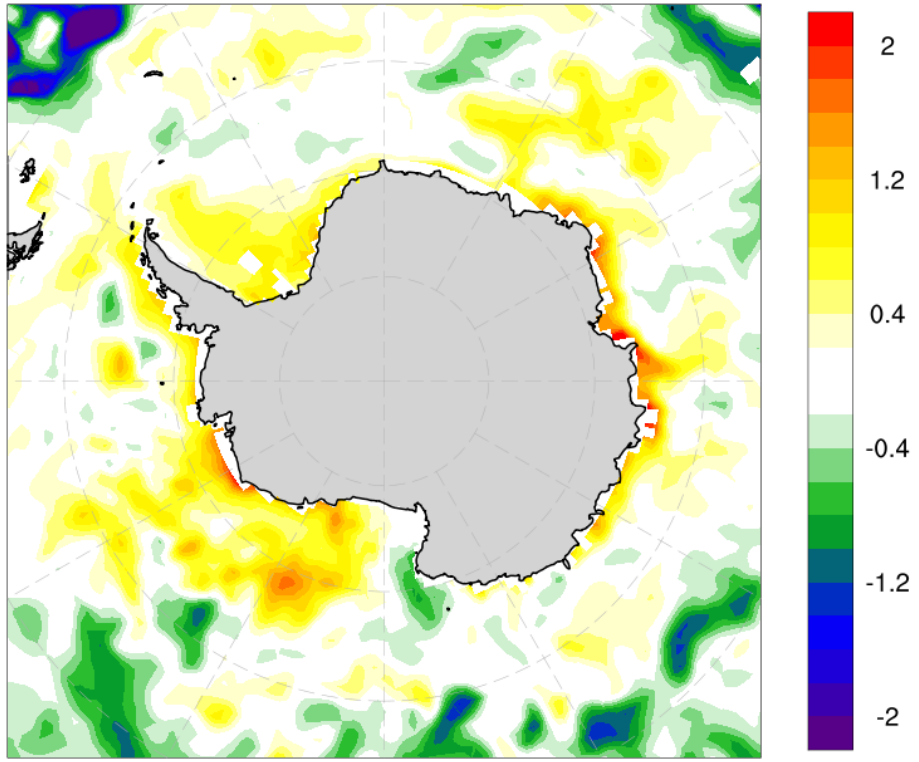
Top Ice Melt, 2016-18 Minus 2012-14



Ocean Temperature Profile



June-July-August 200m T
2016-2018 Minus 2012-2014



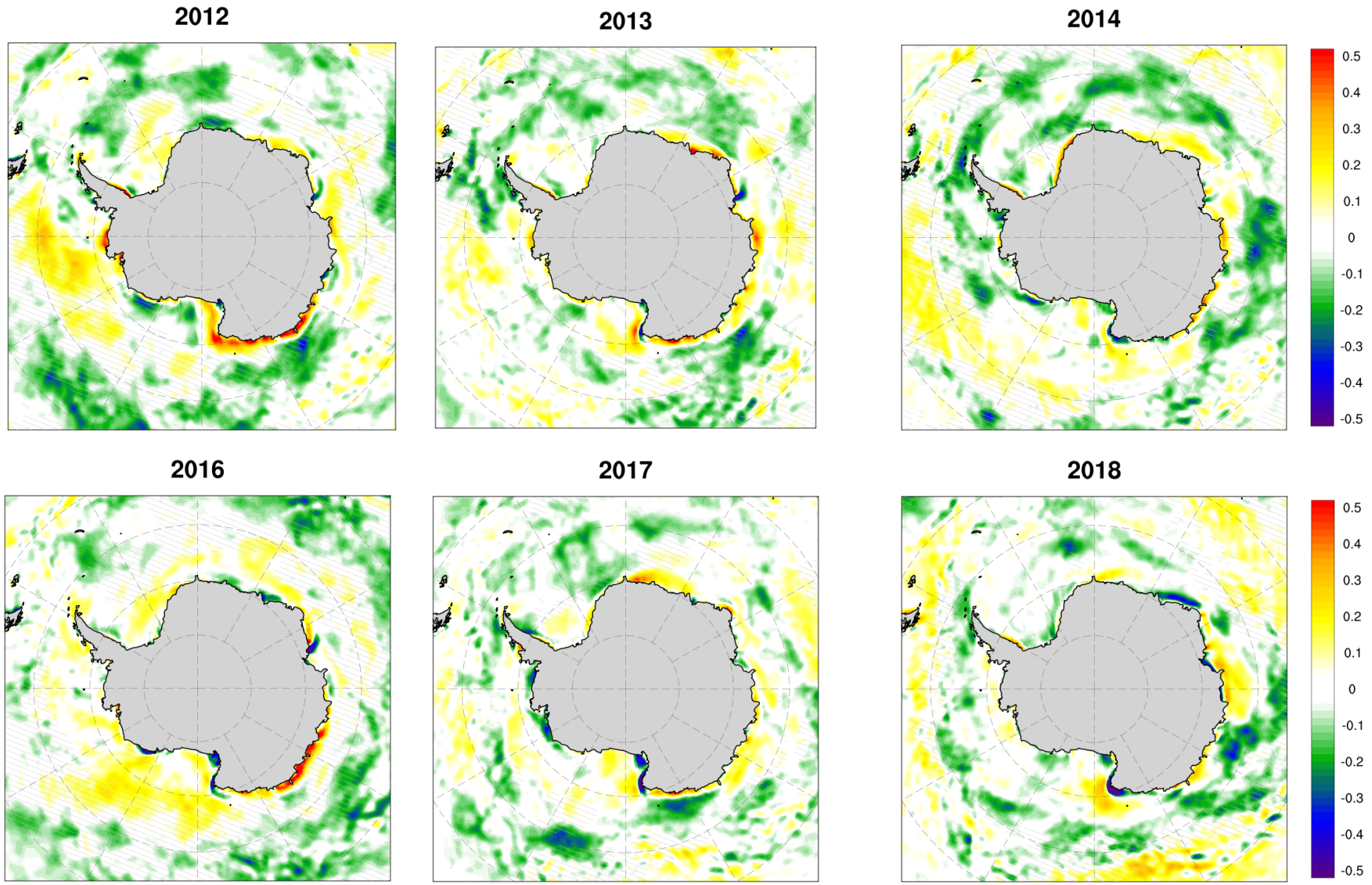
Ocean Mixed Layer Temperature Tendency

Neglecting diffusion,

$$\frac{\partial T_m}{\partial t} \approx \underbrace{\frac{Q_{NET}}{\rho_0 \, c_p \, h_m}}_{\text{Surface Heating}} \underbrace{- \vec{u}_m \cdot \nabla T_m}_{\text{Advection}} \underbrace{- \left(\frac{\partial h_m}{\partial t} + \nabla \times \frac{\vec{\tau}}{\rho_0 \, f} \right) \frac{\Delta T}{h_m}}_{\text{Entrainment}}$$

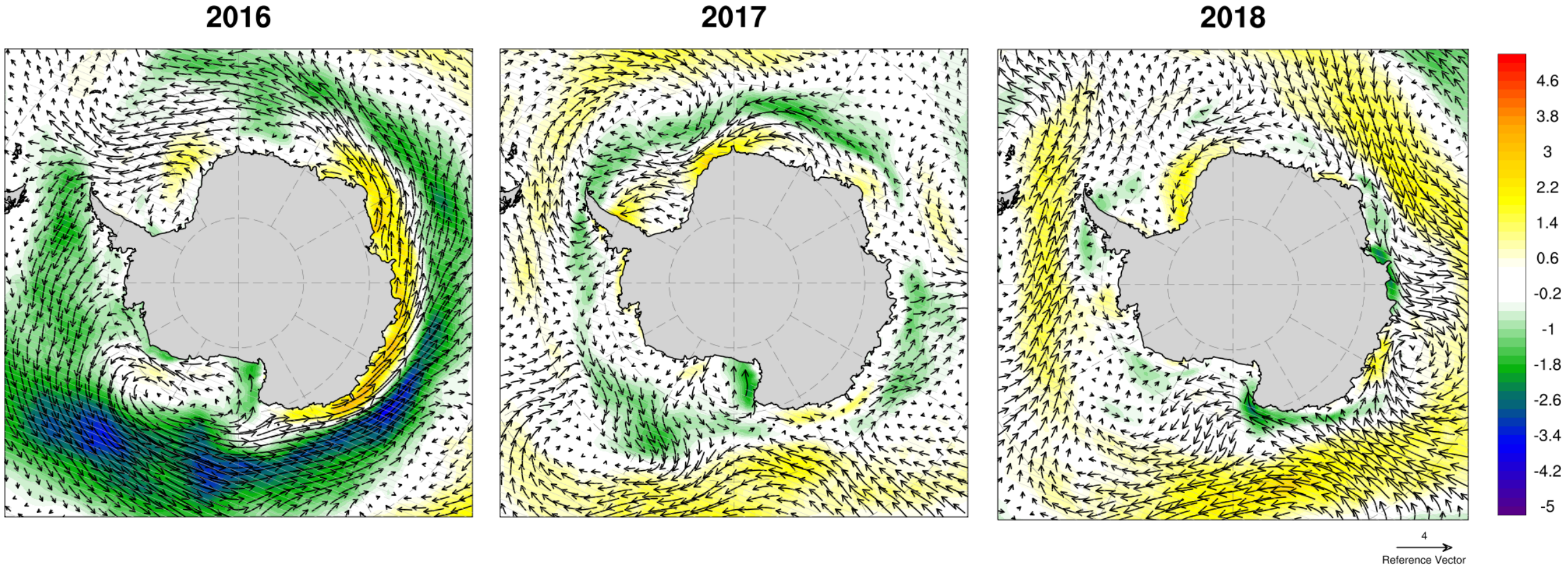
e.g., Dong et al. 2007; Santoso et al. 2010

Wind Stress Curl



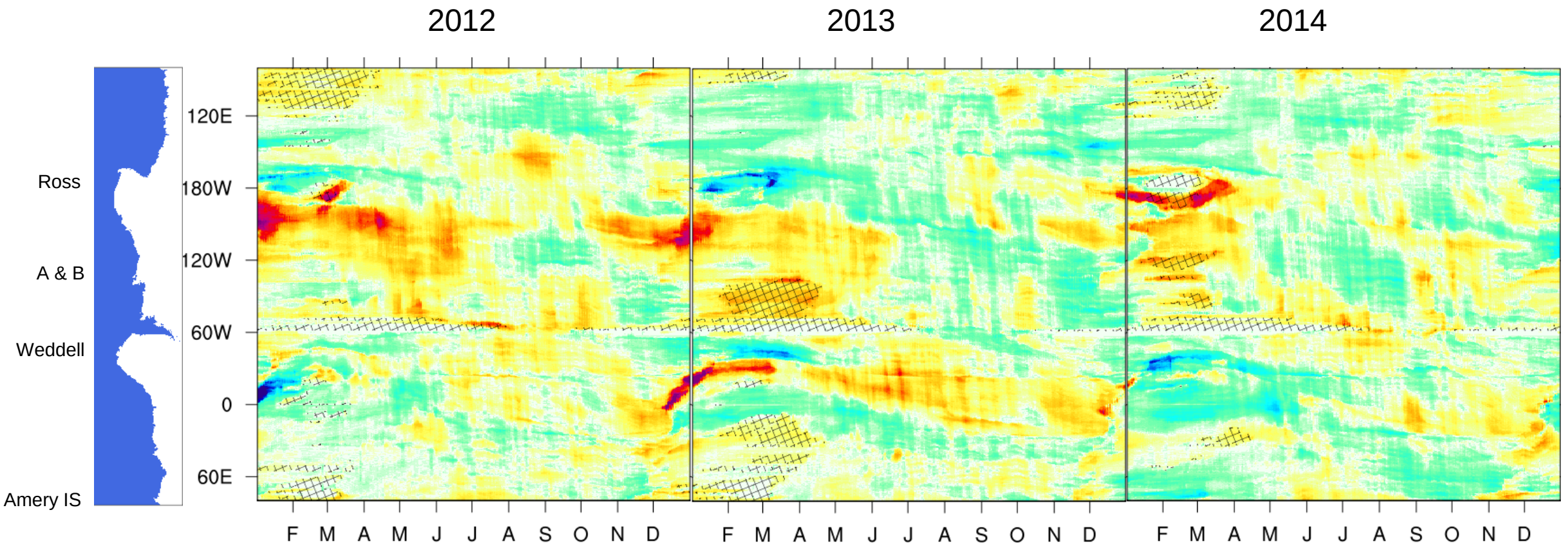
[10^6 N m^{-3}]

10 m Wind Anomaly, October-November-December



Summary

- Ongoing reduction of Antarctic sea ice beginning in 2016 appears to focus on subpolar gyre regions in Austral spring.
- The GSFC S2S ocean analysis indicates a mixed layer warming trend in recent years extending to the surface. There is enhanced basal melt of sea ice close in to the continent.
- Reanalyses suggest entrainment is a significant contributing factor to temperature changes in the ocean mixed layer, consistent with Meehl et al.
- Atmospheric reanalyses suggest increased rainfall over sea ice during the reduced sea ice period.



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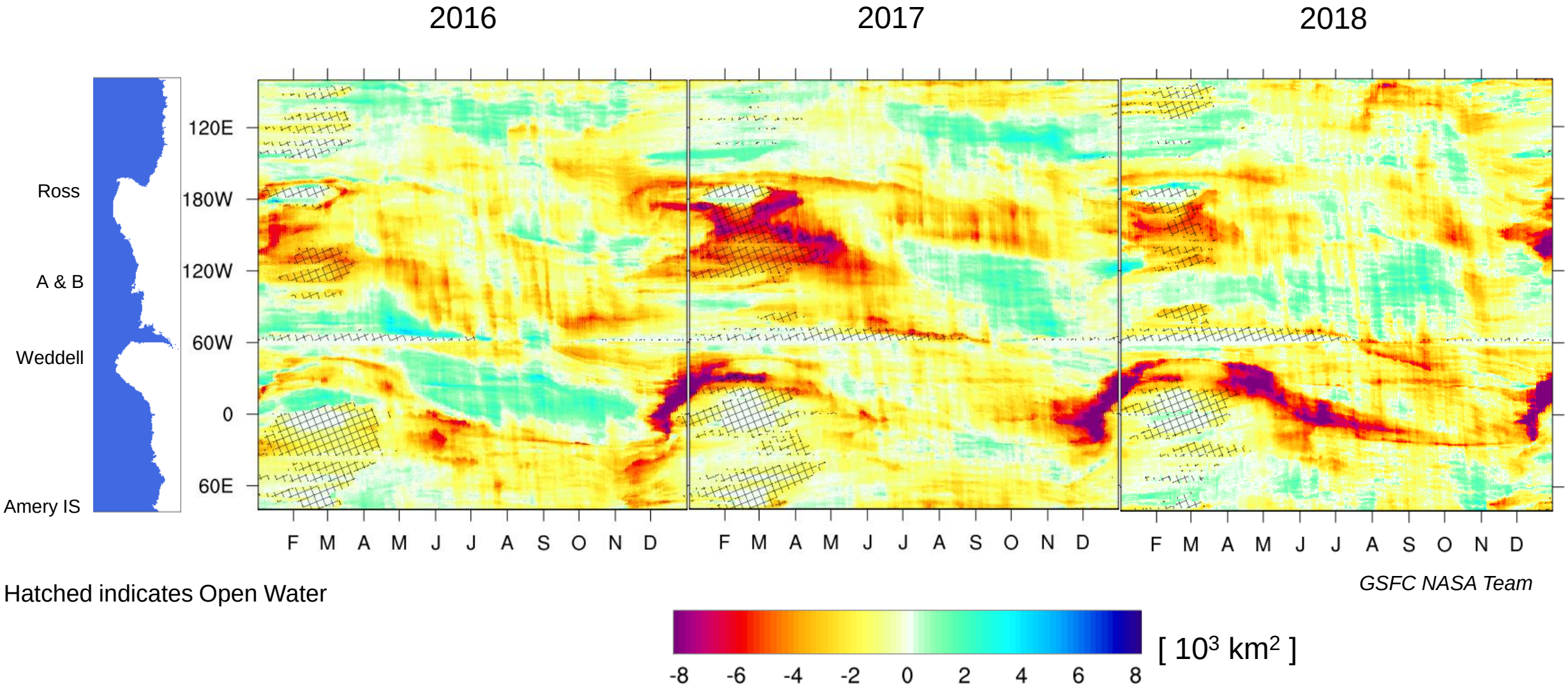

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