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Global Sources of Extreme Precipitation over Antarctica

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ASK ME ABOUT THE FIRN SYMPOSIUM !

BACKGROUND.

Snowfall over Antarctica has mitigated sea level rise, and both the absolute value and interannual variability of snow are dominated by **extreme events,** sometimes the product of atmospheric rivers (ARs), bringing heat and moisture to Antarctica from as far as the tropical oceans. This can impact both surface mass balance and firn structure. The link between ocean sources and ice sheet impacts will change with increasing air and ocean warming, as well as in response to climate patterns (e.g. El Niño and La Niña).

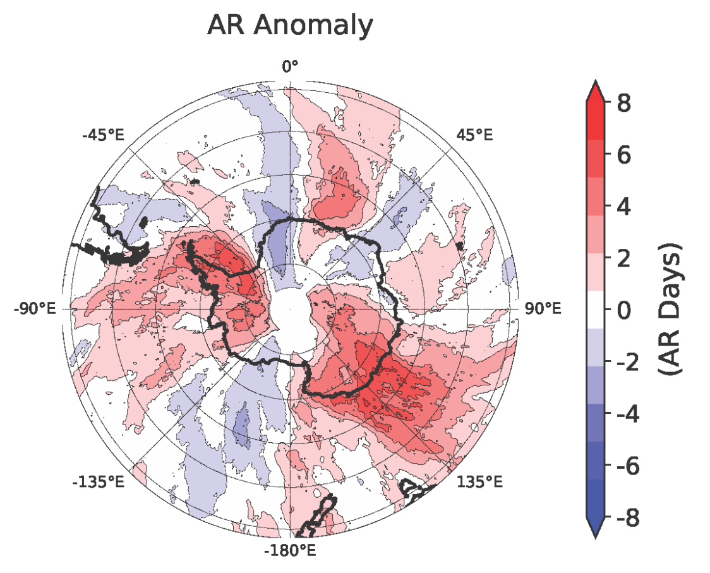


Fig. 6.5d: AR days anomaly compared to 1991-2020 mean,

From: BAMS State of the Climate, Antarctica and the Southern Ocean (Ref: 1)

CONTEXT

2022:

an extraordinary heatwave/AR over East Antarctica,

highest surface mass balance in 40 years.

2023:

Increasing ocean temps. declining sea ice continues

strong El Niño event

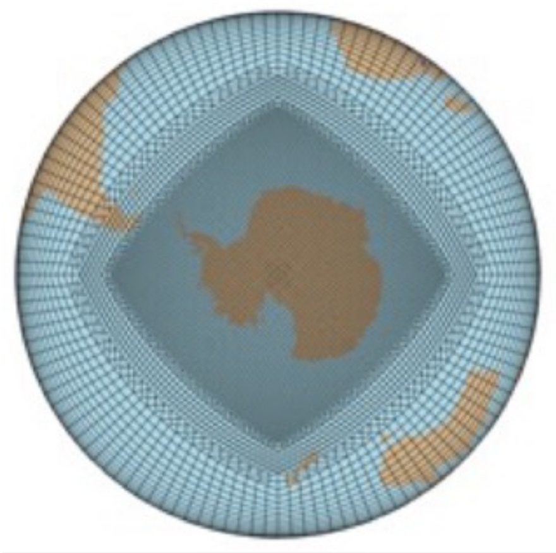
A comprehensive discussion on the Extraordinary Antarctic Heatwave:
(Ref: 2,3)

TOOLS

To detect extremes resulting from observed ocean/sea ice conditions, and quantify the sources of this moisture:

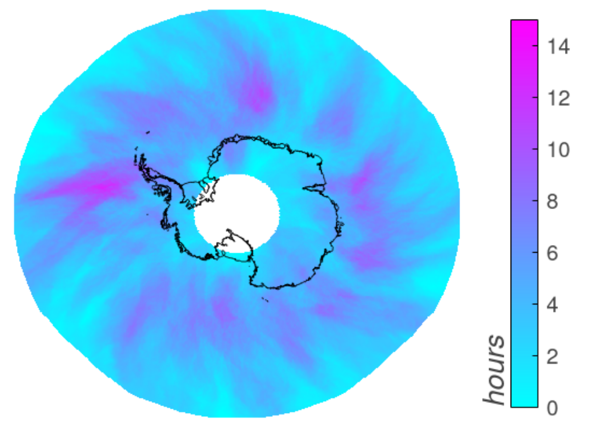
We use a variable-resolution version of the Community Earth Systems Model 2 (VR-CESM2, in an atmosphere-only configuration (sea surface temperatures & sea ice concentration are forced by data), with 3-hourly outputs.

Time period: 1990-2015, 2015-2020



The "ANTSI" variable-resolution grid (0.25° in the interior, 1° globally)

Evaluation of the atmosphere and SMB over Antarctica is discussed in in Datta et al., 2023 (Ref, 4)

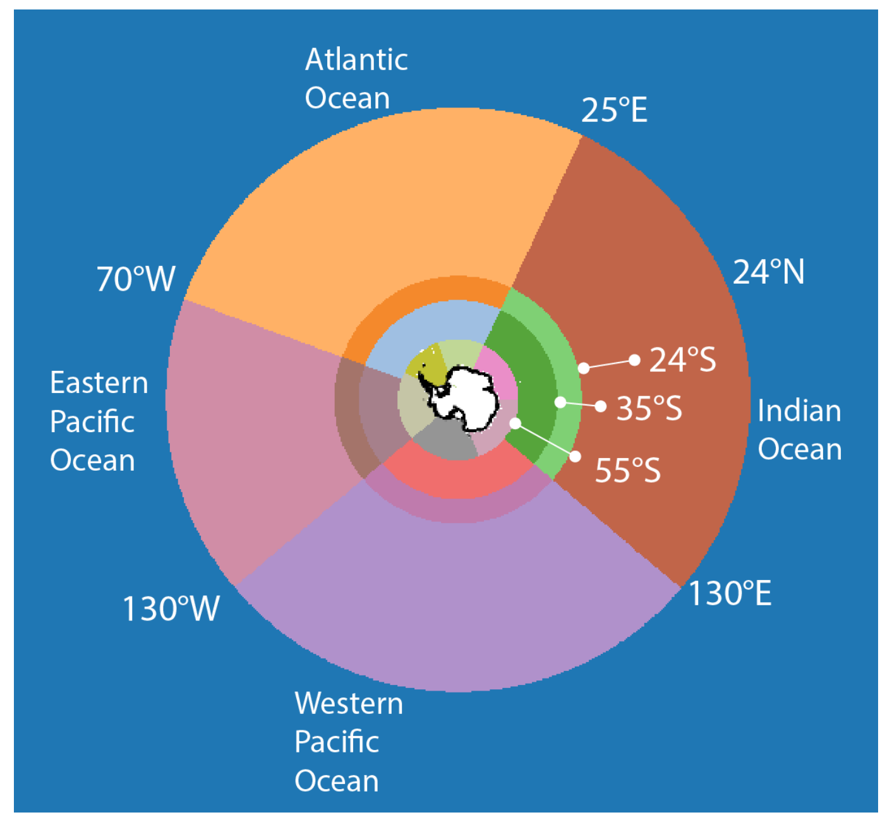


Average Hours / month experiencing an AR over the Antarctic domain south of 45°S, 1979-2015., ANTSI grid

To calculate ARs, we adapt an original algorithm by Wille et al., 2019

for use in an unstructured grid

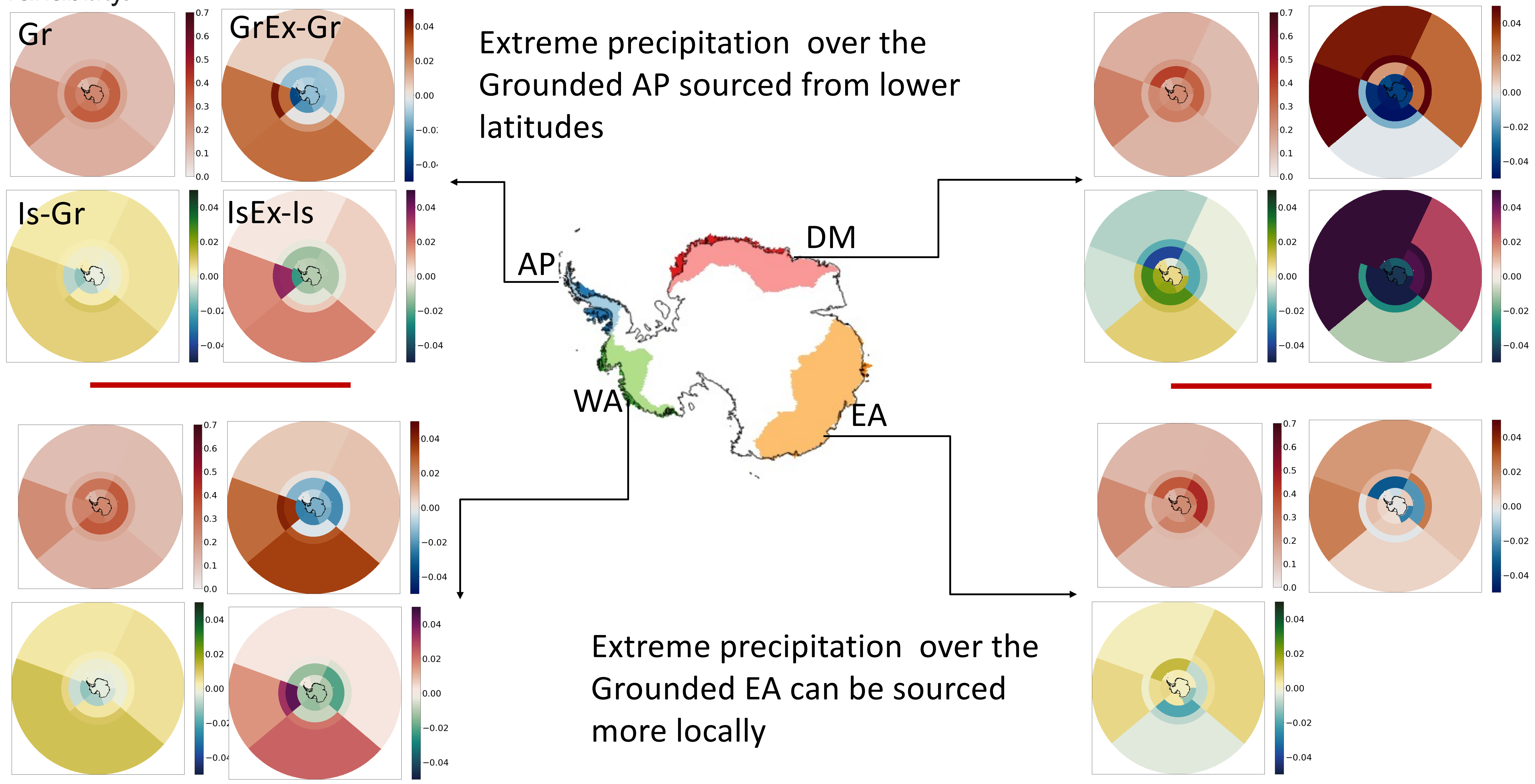
To link moisture **sources** to precipitation **sinks**, we implement moisture-tagging code. Precipitation on the globe is linked to 20 tagged regions at a daily timescale



MOISTURE SOURCE PATTERNS FOR PRECIPITATION

Total precipitation is measured at the basin scale, and can impact the grounded ice sheet and ice shelves differently and be the product of different dynamics during extreme precipitation.

We show the first EOF for the moisture sources for total precipitation for each region for grounded ice sheet (**Gr**). For moisture sources ice shelves (Is) and the 90th percentile of precipitation on the grounded ice sheet (**GrEx**), we show a difference between the first EOF (**Is/GrEx)-(Gr**). For the 90th percentile of precipitation on ice shelves (**IsEx**) we show the difference with the 1st EOF for ice shelves only(**IsEx-Is**). All EOFs are for the 1st EOF which explain >90% of variability.



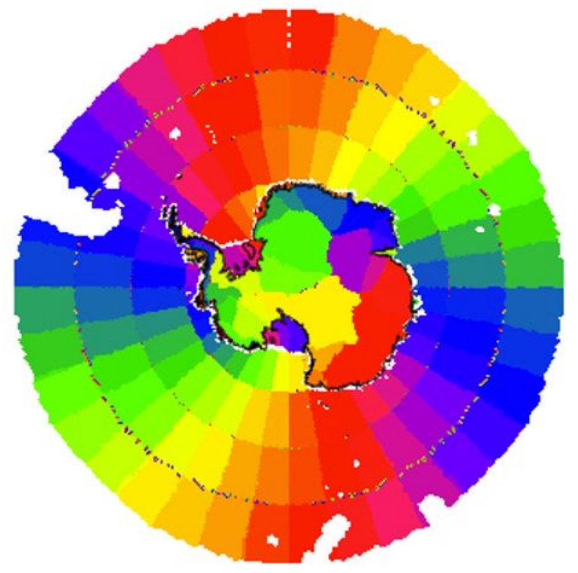
Extreme precipitation over the Grounded AP sourced from lower latitudes

Extreme precipitation over the Grounded EA can be sourced more locally

LEVERAGING ML

Linking Sources to Sinks using Machine Learning

Causal discover methods, e.g. PCMCI+, can uncover physical mechanisms governing source->sink relationships.



TELECONNECTIONS

What are the sources of moisture when an extreme is not atmospheric river?

How do El Niño and La Niña impact the dynamics of extremes?

We have performed additional experiments using the same setup, with 9-year ensembles of idealized El Niño and La Niña conditions extracted from the historical record.

REFERENCES

Ref 1: R. Tri Datta, Baiman, R., Yin, Z., Wille, J.D., Dunmire, D., Maclennan, M.L., Trusel, L.D. and Bozkurt, D. Ice Sheet Surface Mass Balance ["in "State of the Climate in 2022"]. Bull. Amer. Meteror.Soc, 104(8), "c. Ice-sheet surface mass balance" on page S15-S18, https://doi.org/10.1175/BAMS-D-23-0077.1.
R. Tri Datta, Wille, J.D., Bozkurt, D., Mikolajczyk, D.E., Clem, K.R., Yin, Z., and MacFerrin, M., The Antarctic heatwave of March 2022 ["in "State of the Climate in 2022"]. Bull. Amer. Meteror.Soc, 104(8), "Sidebar 6.1 The Antarctic heatwave of March 2022" on page S12-S14, https://doi.org/10.1175/BAMS-D-23-0077.1

Ref2: Wille, J. D., and Coauthors, 2023: The extraordinary March 2022 East Antarctica "heat" wave. Part I: observations and meteorological drivers. *J. Climate*, https://doi.org/10.1175/JCLI-D-23-0175.1, in press.

Ref 3: Wille, J. D., and Coauthors, 2023: The extraordinary March 2022 East Antarctica "heat" wave. Part II: impacts on the Antarctic ice sheet. *J. Climate*, https://doi.org/10.1175/JCLI-D-23-0176.1, in press.

Ref 4: R. Tri Datta, Herrington, A., Lenaerts, J. T. M., Schneider, D., Yin, Z., & Dunmire, D. Evaluating the Impact of Enhanced Horizontal Resolution over the Antarctic Domain Using a Variable-Resolution Earth Systems Model, *EGUsphere*, 1–34. https://doi.org/10.5194/egusphere-2022-1311(2022)