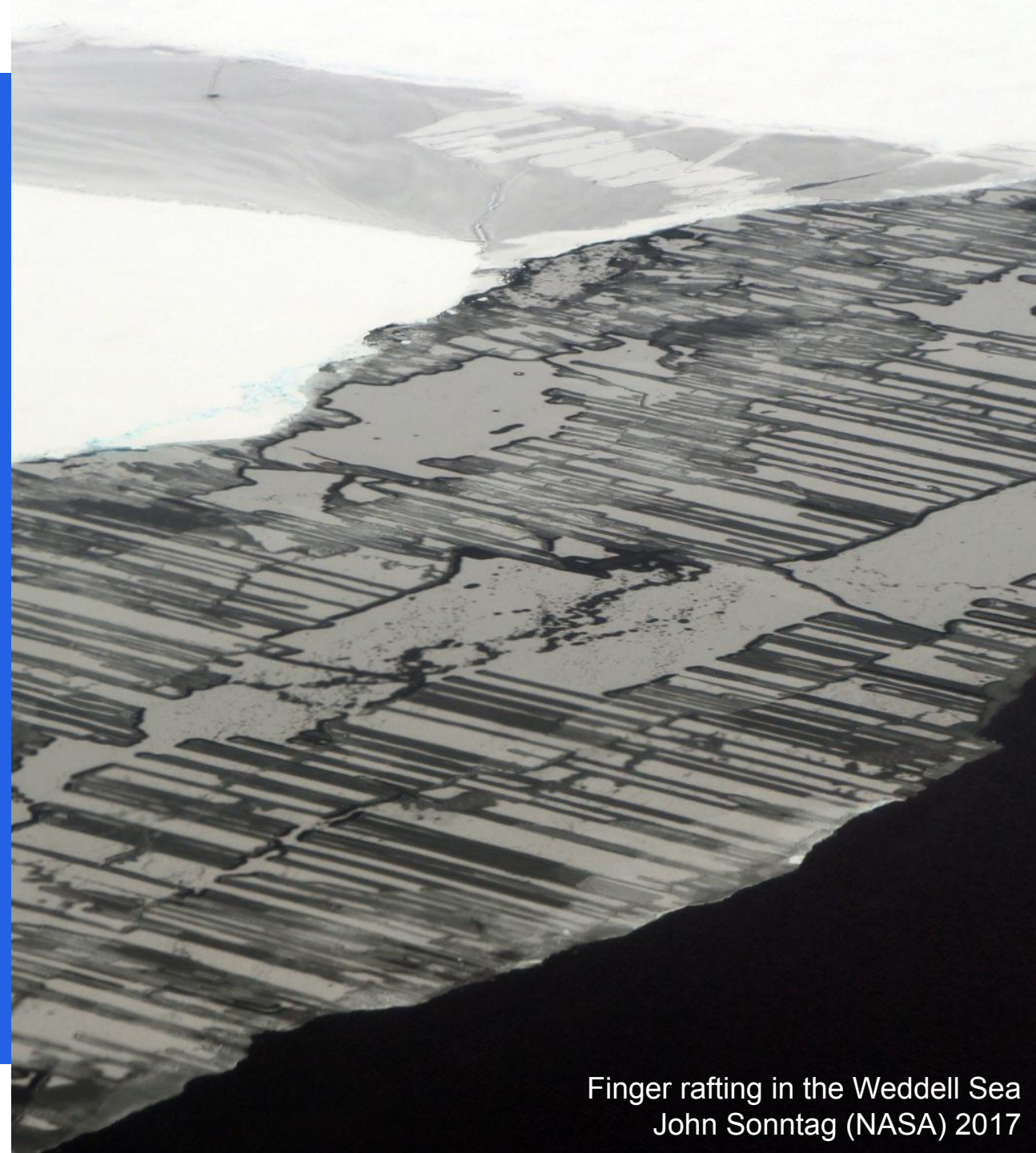




The Bureau
of Meteorology

The OceanMAPS v4.0 Sea-ice Forecast Demonstration Project mk 2 (Austral Summer 2022-23)

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Gary Brassington¹
Pavel Sakov¹
Jan Lieser¹
Helen Beggs¹
Mikhail Entel¹
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Duan Beckett¹



Overview

- Structure of OceanMAPS v4.0 system
- Demonstration project mk1 – analysis only
 - Analysis of ice concentration tendency and DA scheme behaviour
 - Simulation period spans full annual cycle
- Demonstration project mk2 – analysis + forecast
 - Case study: analysis of sea-ice extent



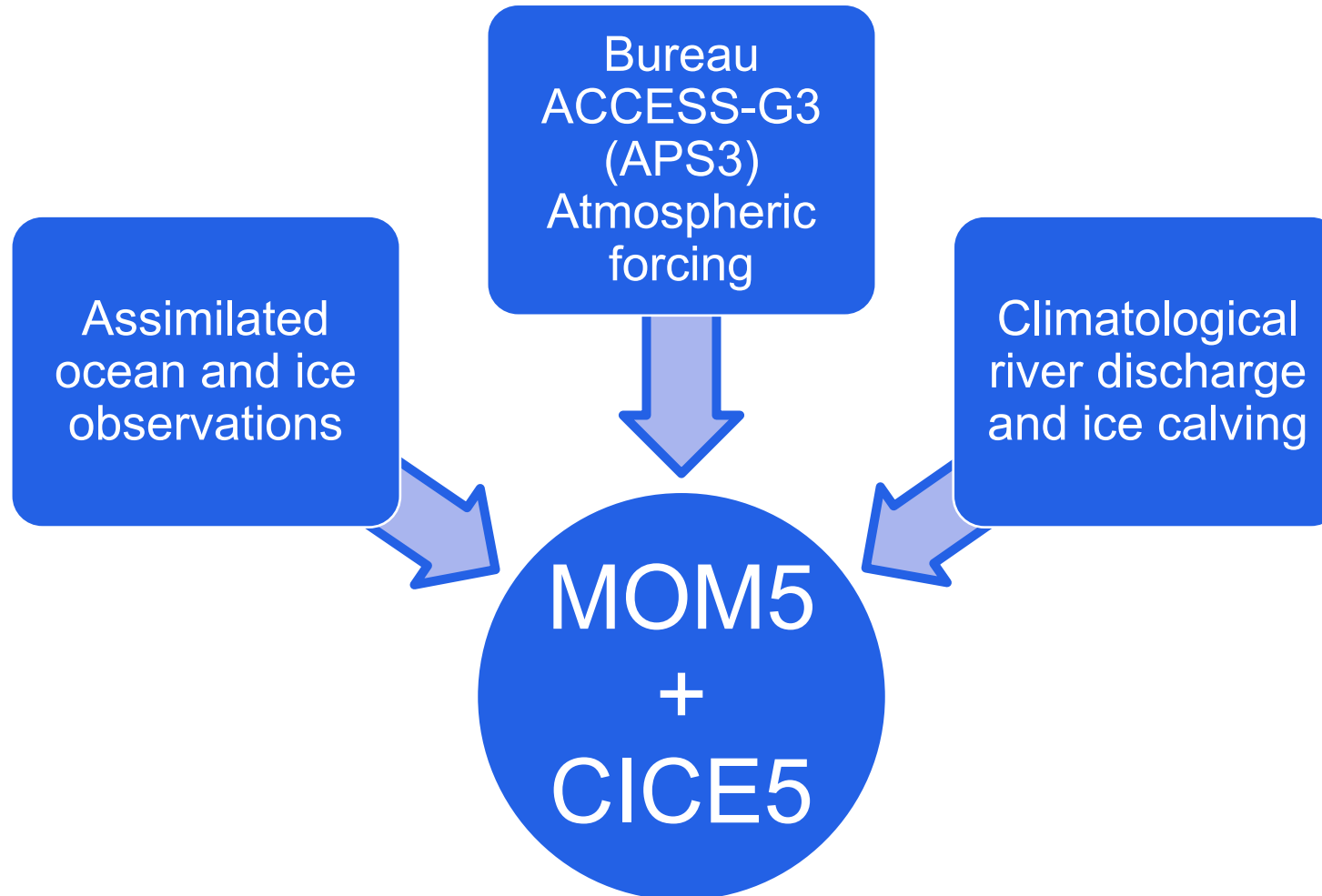
COSIMA

- The Bureau, CSIRO and AAD worked with the Australian National University and others to develop a linkage grant to:
 - merge of BlueLink ocean forecasting and climate modelling communities.
 - develop an eddy-resolving global ocean-sea-ice forecast model.
- The Consortium for Ocean Sea-Ice Modelling in Australia (COSIMA) began in 2017.
 - An earlier consortium COMA has started in 2012
- Developed ACCESS-OM2-01
 - For community use.
 - Growing community of users (annual workshops have grown from 6 participants to over 100)
 - Operationalization by the Bureau as OceanMAPS v4.0



OceanMAPS v4.0

The next generation of the Bureau's ocean analysis and forecast system.





OceanMAPS version 4.0

System

Model

- ACCESS-OM2-01 (MOM5-CICE5)
- $0.1^\circ \times 0.1^\circ$, 75 z*-levels (1.1m top cell)
- 4 ice layers + 1 snow
- 5 thickness categories
- Mushy ice thermodynamics

Atmospheric forcing

- ACCESS-G3 (APS3) Bulk formulae
- Climatological river discharge and ice calving

Data assimilation

- EnKF-C
- Hybrid-EnKF
- 48 dynamic members
- 144 low-mode members
- FGAT, Restart initialization

Observations

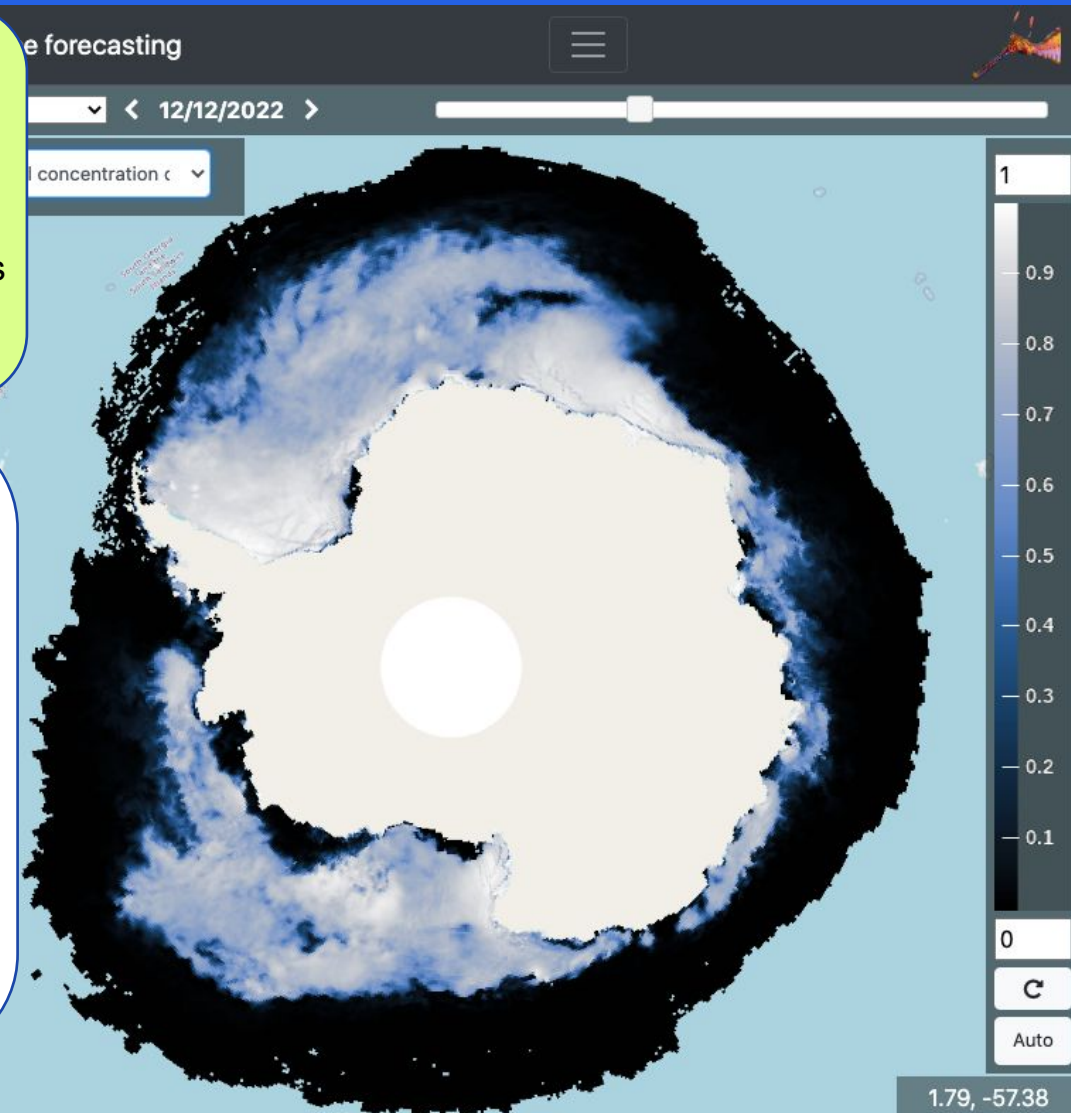
- In situ profiles (GTS, GDAC)
- Satellite altimetry (RADS, J3, SARAL, Sentinel-3A, Cryosat-2)
- Satellite SST (AMSR2, NAVOCEANO, NPP-VIIRS, NOAA20-VIIRS)
- SIC (AMSR2, SSMIS L2p)

Forecasts

- EnKF (-3 day analysis) + 3 day hindcast to real-time
- Daily 7 day forecasts every 3 days
- 4 synchronous ensemble forecasts
- 10 lagged ensemble forecasts

Web viewer

- [Seedragon.org](https://seedragon.org)



Assimilated Sea-Ice Concentration observations

EUMETSAT OSI-SAF Level 2 SIC products

- Resolution: DMSP/SSMIS: 25 km, GCOM-W1/AMSR-2: 10 km on Level 2 swath projection
- Longevity: 1/7/2021 to present (released 6 July 2021)
- Latency: 3 hour 40 min.
- Frequency: Available up to 15 times per day for each SSMIS satellite (DMSP-F16, F17, F18) and up to 30 times per day for AMSR-2
- Accuracy/Sensitivity: Target accuracy 10% for NH, 15% for SH.
- **Assimilation of AMSR-2 initially, addition of SSMIS from January 2023**



OceanMAPS 4.0 Sea-ice Demonstration Project mk1

Austral Summer 2021—2022 *and beyond*

- Demonstration sea-ice analysis service planned for Austral Summer 2021-2022.
 - Was planned to commence in mid-December 2021.
 - Development delays saw this system commence running in April 2022.



OceanMAPS 4.0 Sea-ice Demonstration Project mk1

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- Spin-up from mid-October 2021.
 - Initial ensemble derived from ACCESS-OM2 multi-decade runs.
- Analysis produced every 3 days initially behind real-time, catching up to near real-time.
 - Forecast mode from November 2022 (more details in subsequent slides)



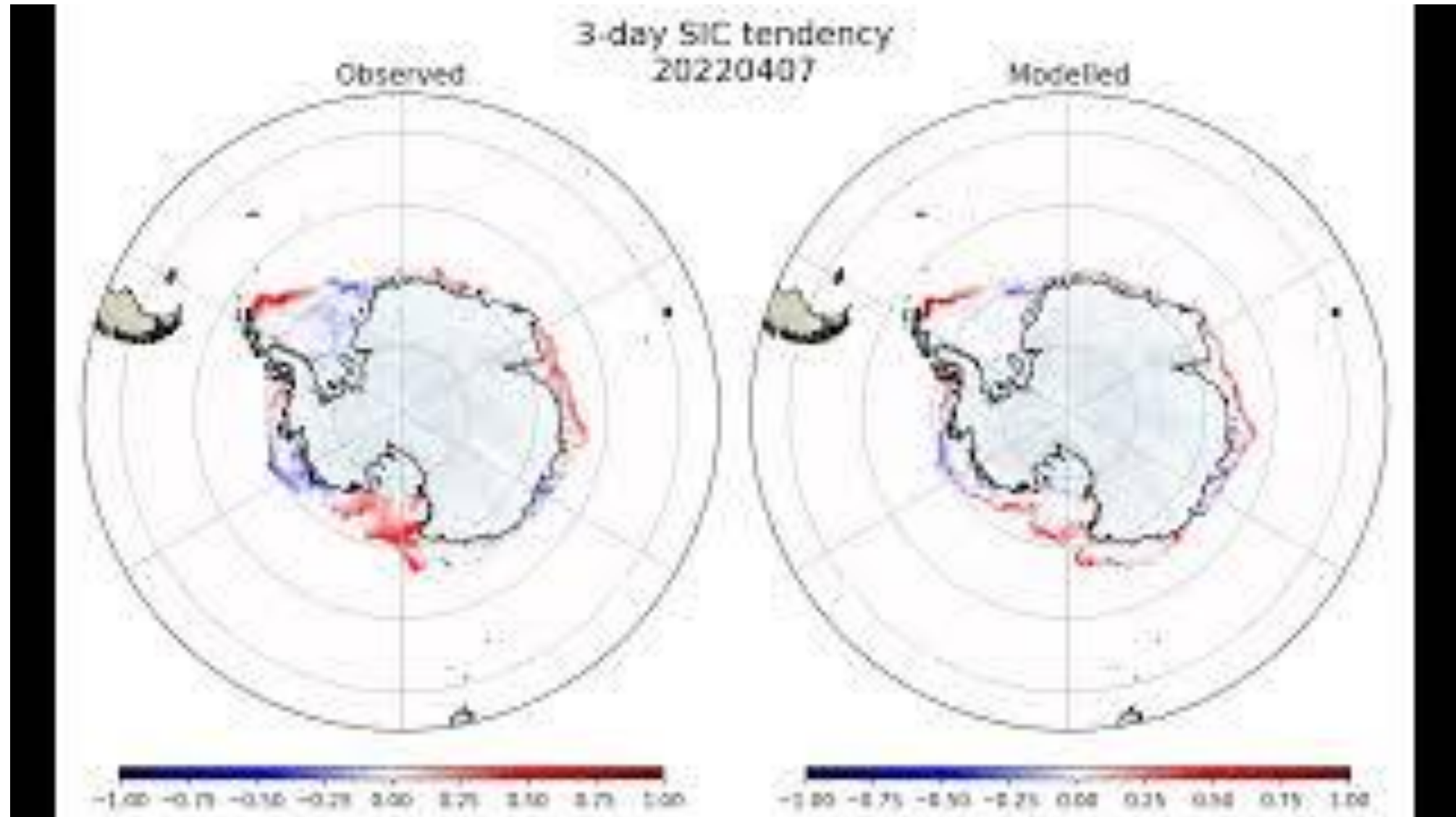
OceanMAPS 4.0 Sea-ice Demonstration Project mk1

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- Analysis produced every 3 days initially behind real-time, catching up to near real-time.
 - Forecast mode from November 2022 (more details in subsequent slides)
- Run on NCI research platform (non-operational).
- Focus is on Antarctic region.
- Output products support Bureau ice analysts.
 - Support to maritime operations – supply, research, fisheries.
 - Accurate and timely ice state information needed for guidance on navigable routes.
- Products delivered via interactive seedragon.org viewer.
 - Product list developed in consultation with ice analyst with feedback and review



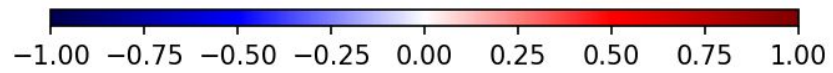
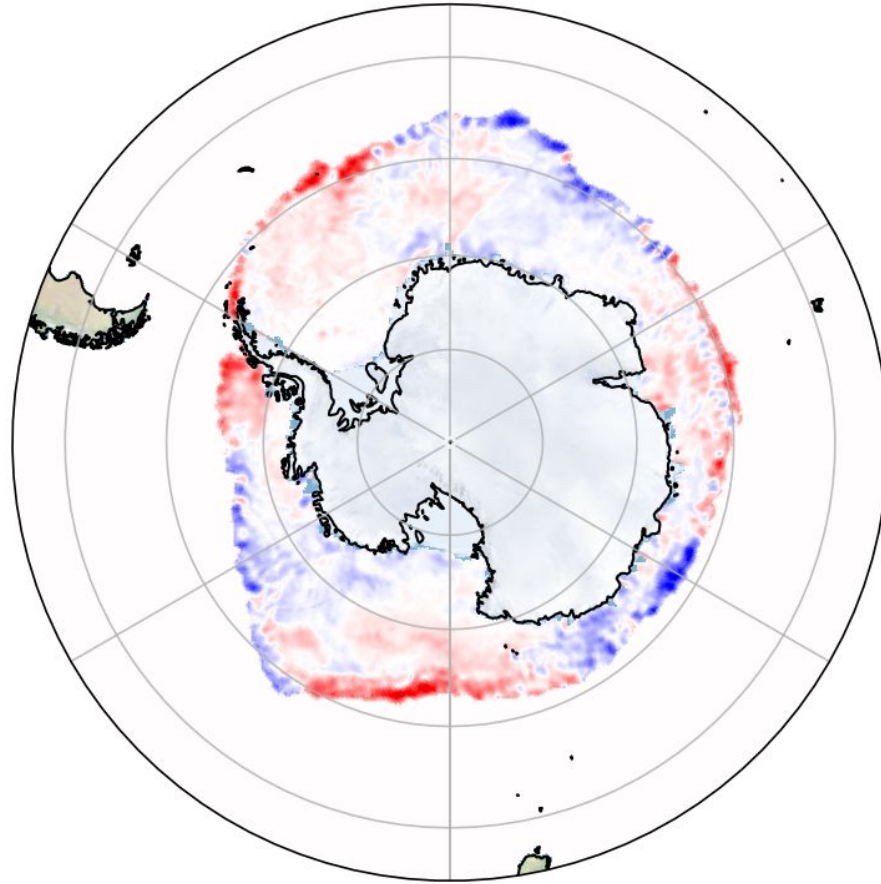
Tendency



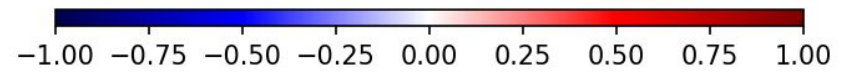
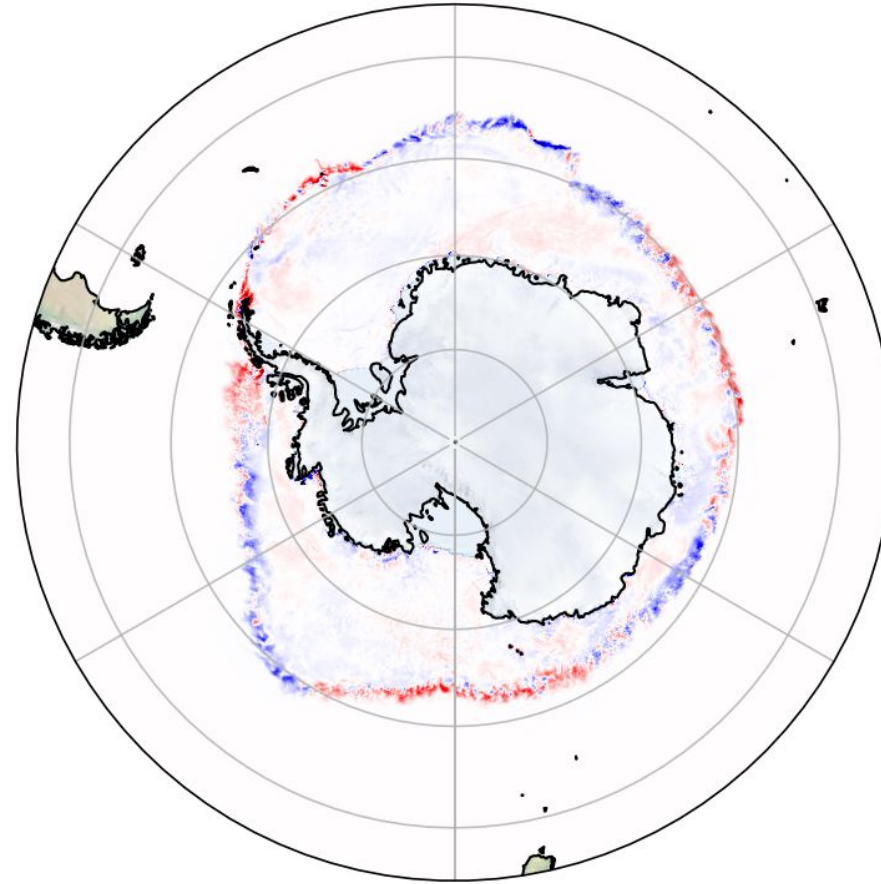
Tendency

3-day SIC tendency
20220907

Observed



Modelled

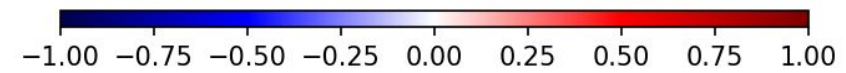
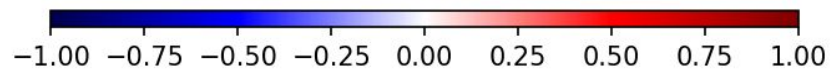
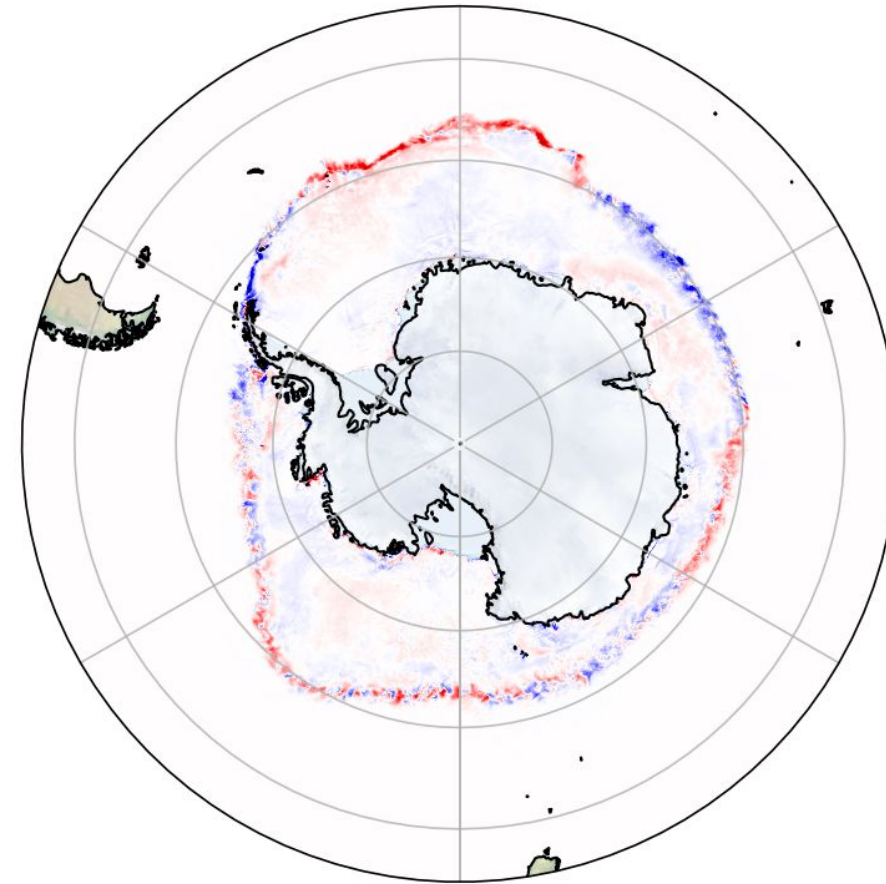
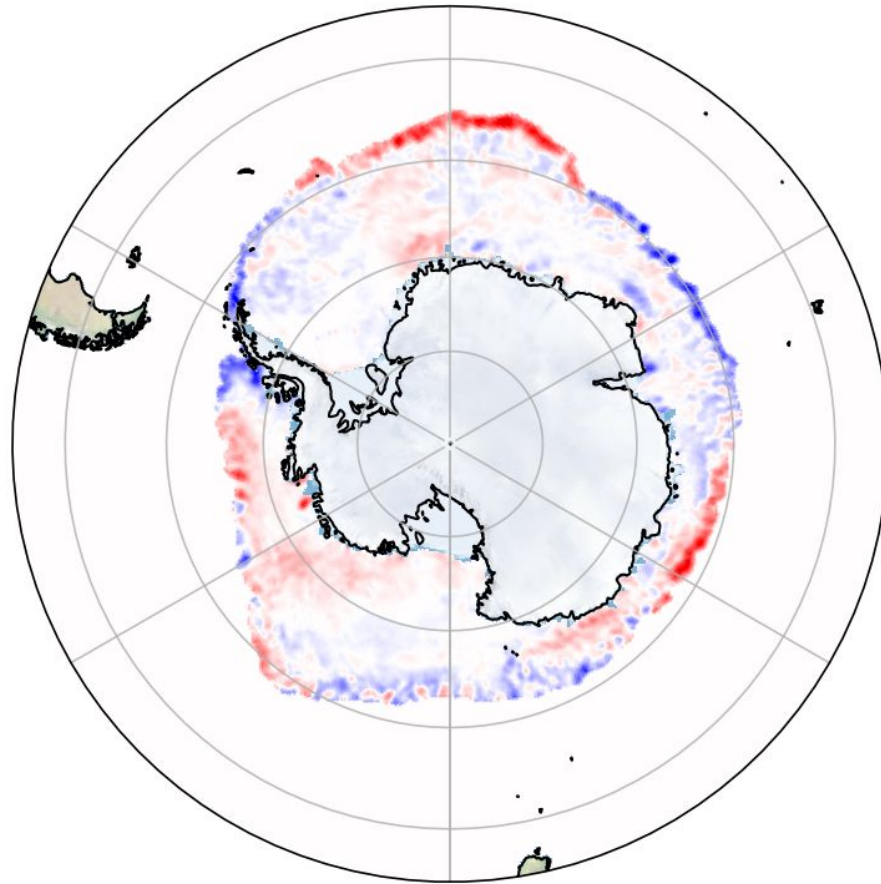


Tendency

3-day SIC tendency
20220910

Observed

Modelled



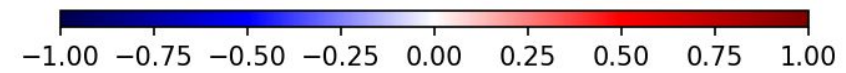
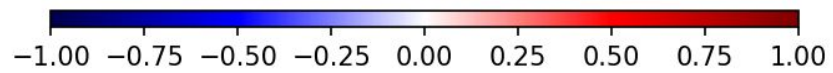
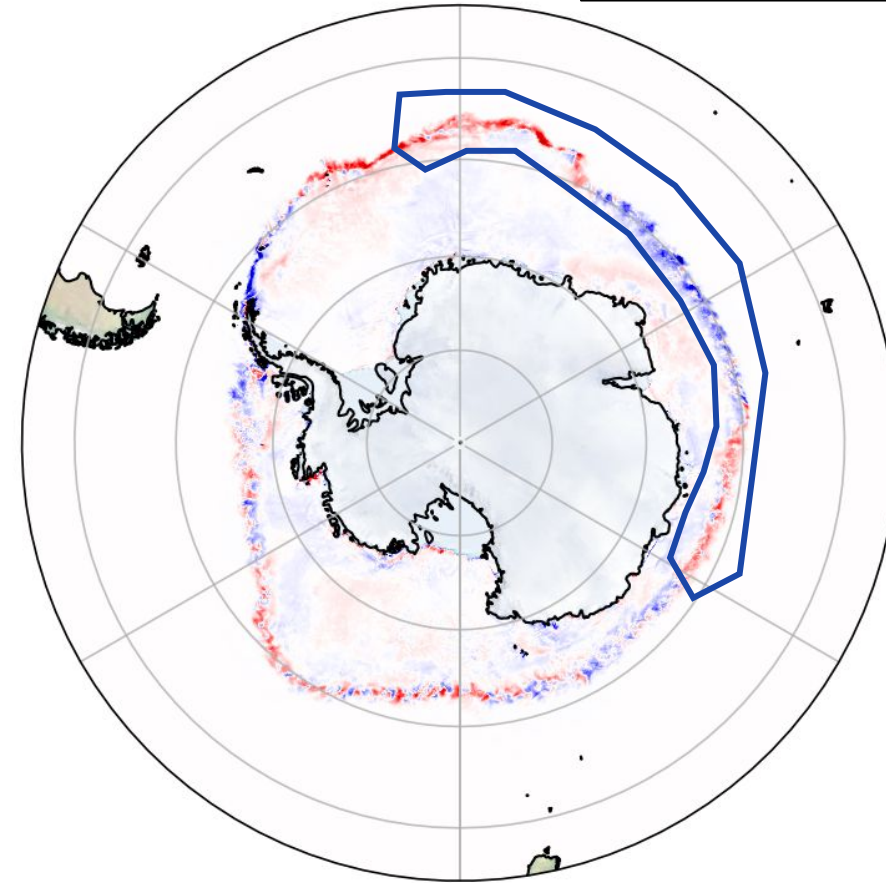
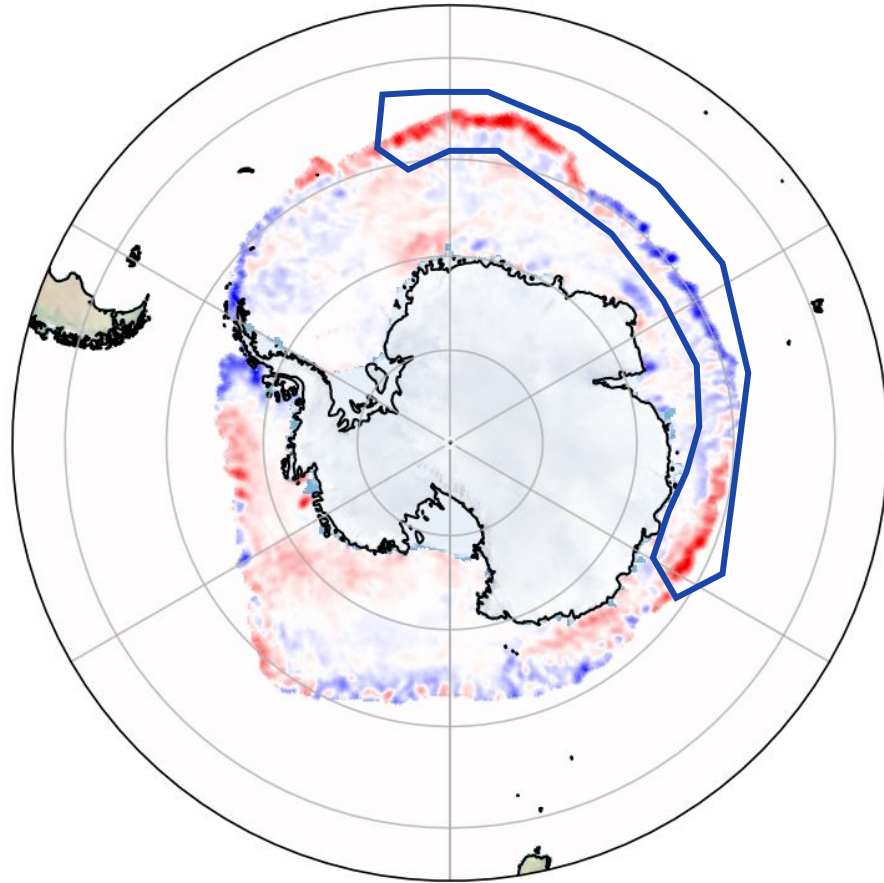
Tendency

- Growth/ablation of ice-edge well-simulated.

3-day SIC tendency
20220910

Observed

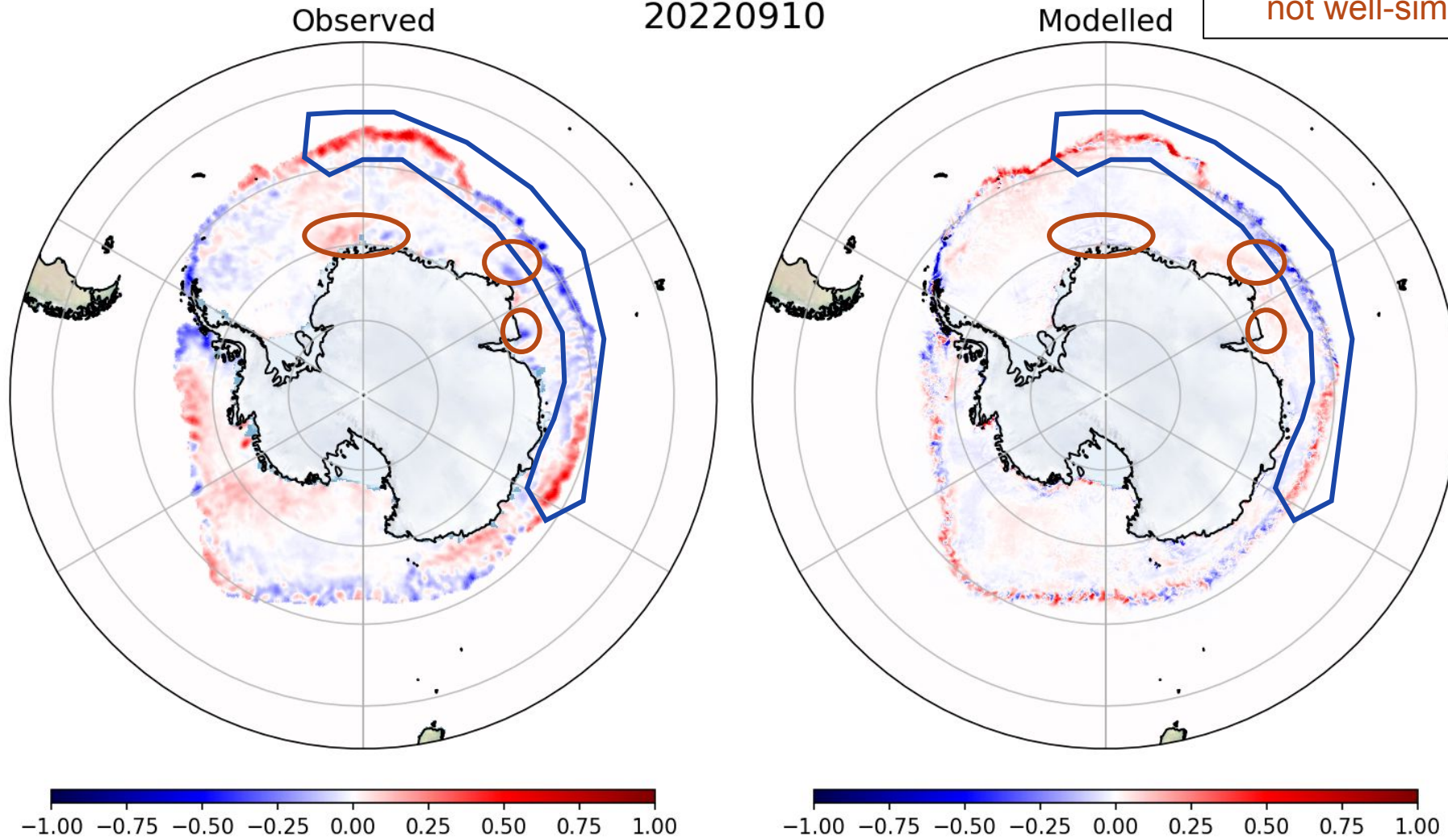
Modelled



Tendency

3-day SIC tendency
20220910

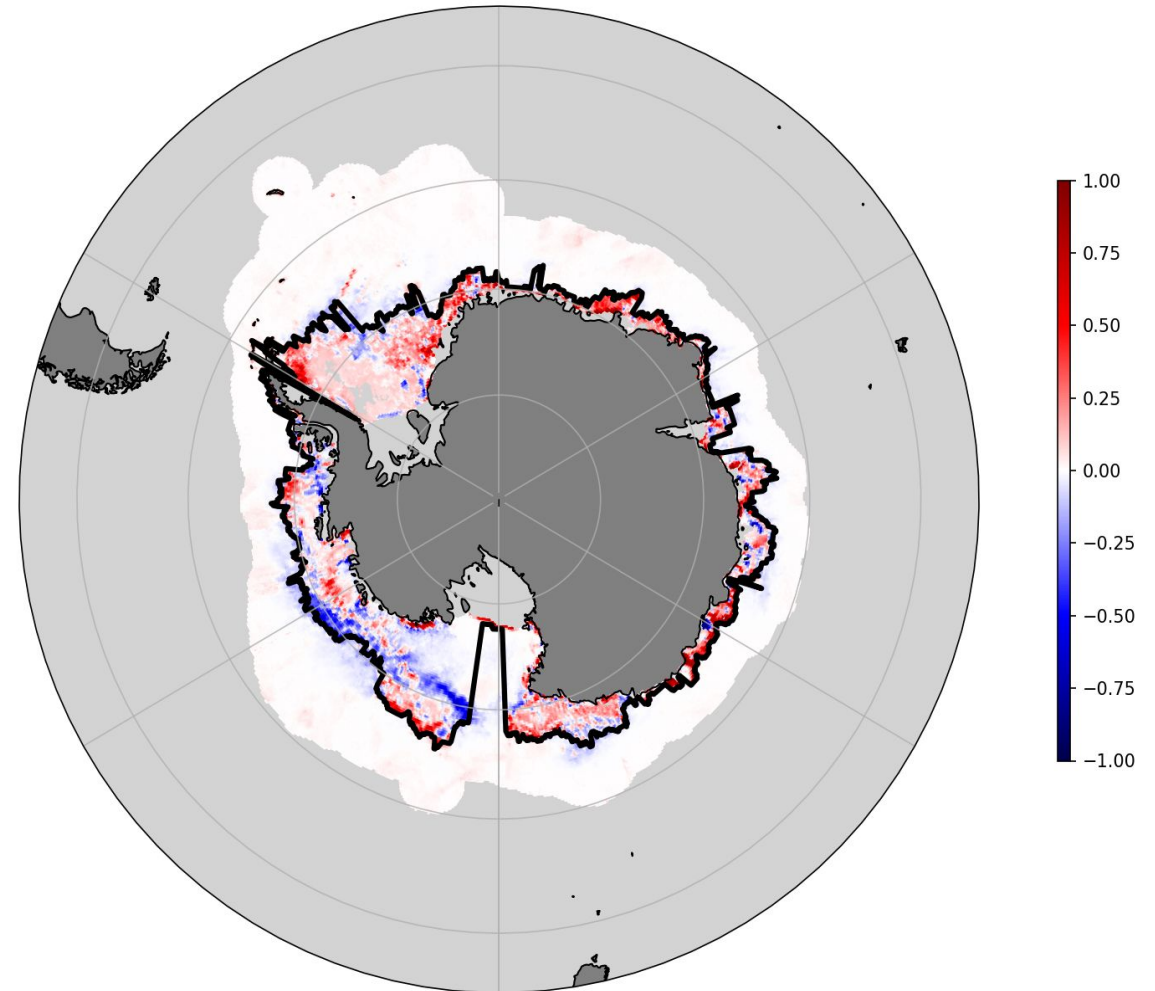
- Growth/ablation of ice-edge well-simulated.
- Important internal features not well-simulated.



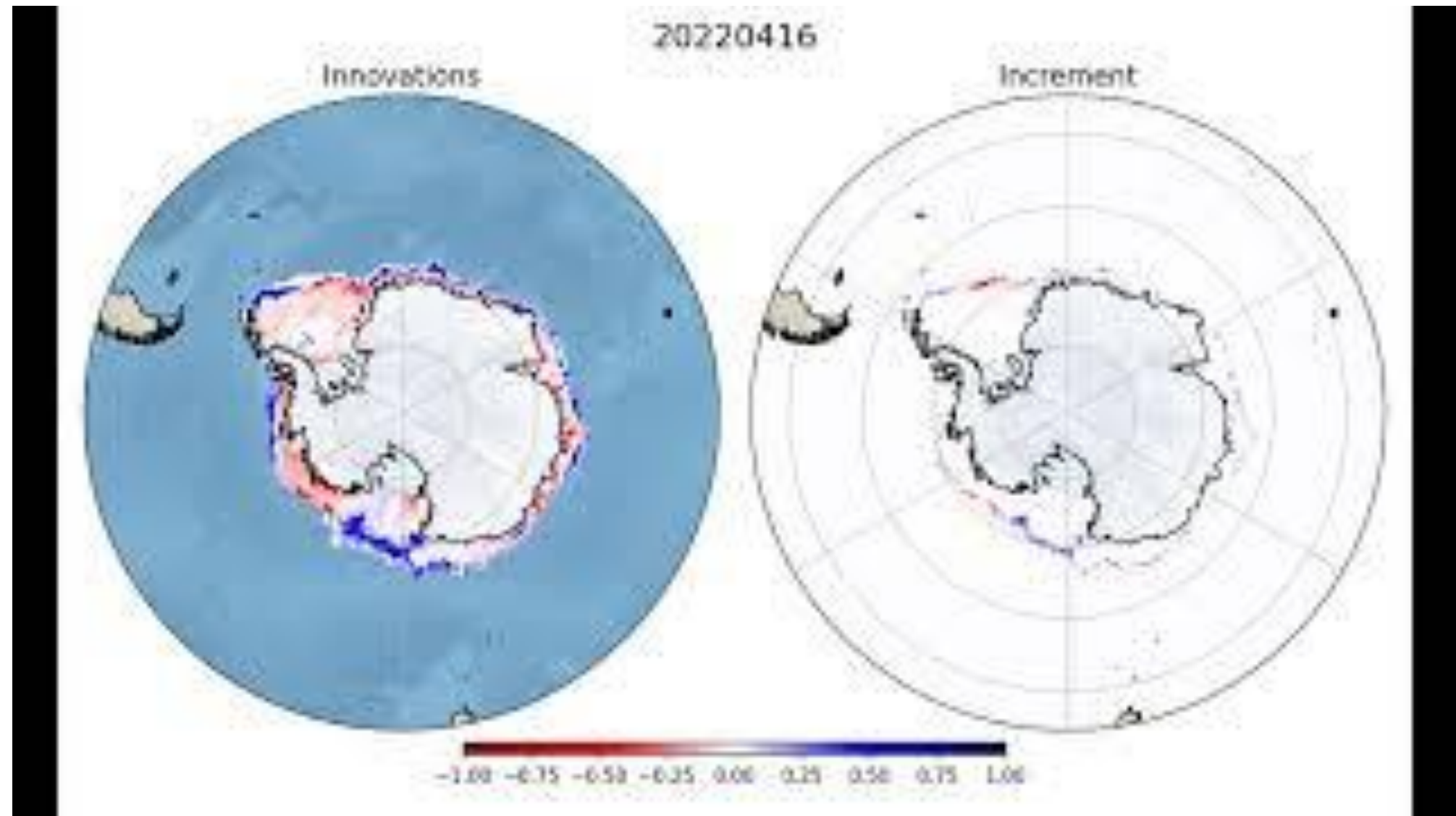
Determination of sea-ice region

- Applied an algorithm that allows estimation of actual sea-ice region (*contra* extent).
 - Reduces large bias towards open water equatorward of ice region.
- Semi-2D algorithm that find minimum latitude of either observation or analysis > 15% conc.
 - *Excludes* small, isolated and transient area of sea-ice (likely erroneous).
 - *Includes* internal areas of open water, such as polynyas.
- Averaged over 3 cycles.
- Resultant region is defined as a series of minimum latitudes for each longitude, a.k.a. a 'ribbon'.

Forecast Innovations
cycle: 20220116



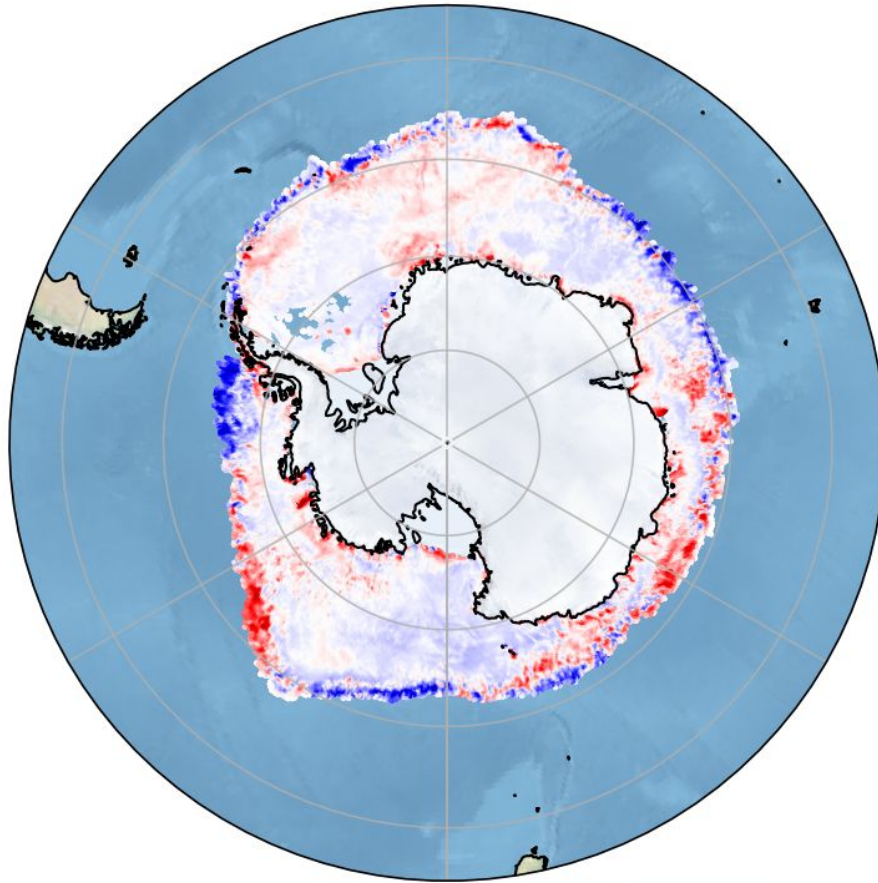
Increments and Innovations



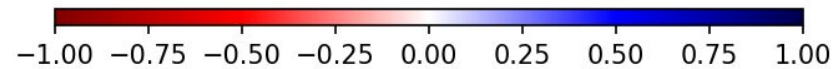
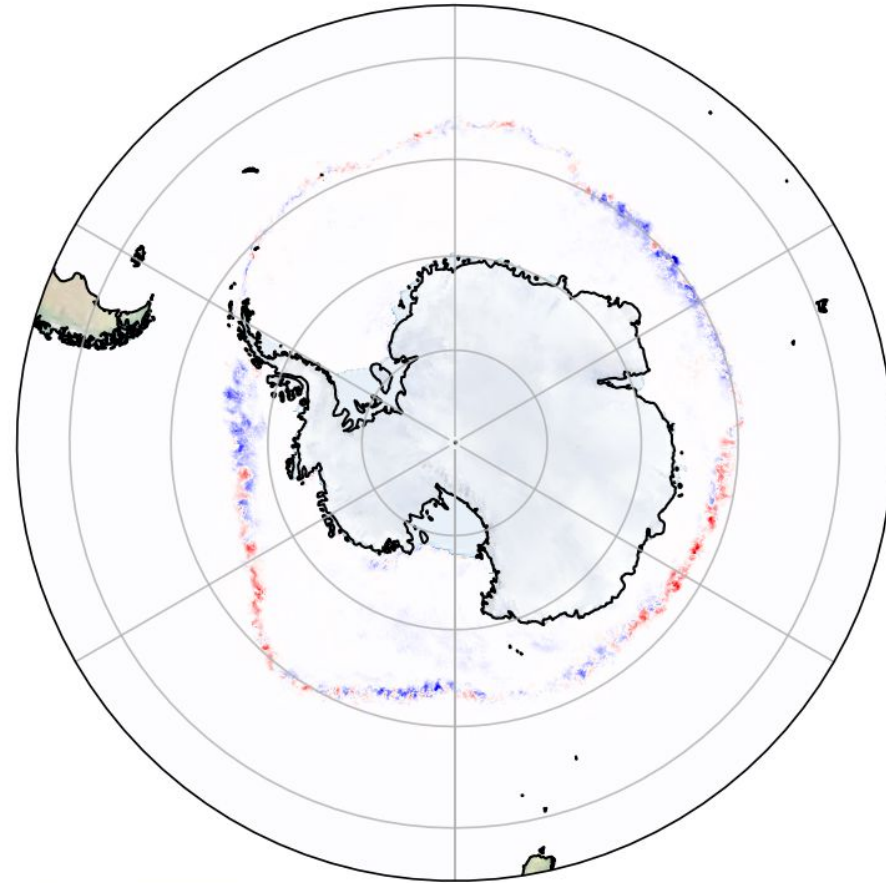
Increments and Innovations

20220907

Innovations



Increment



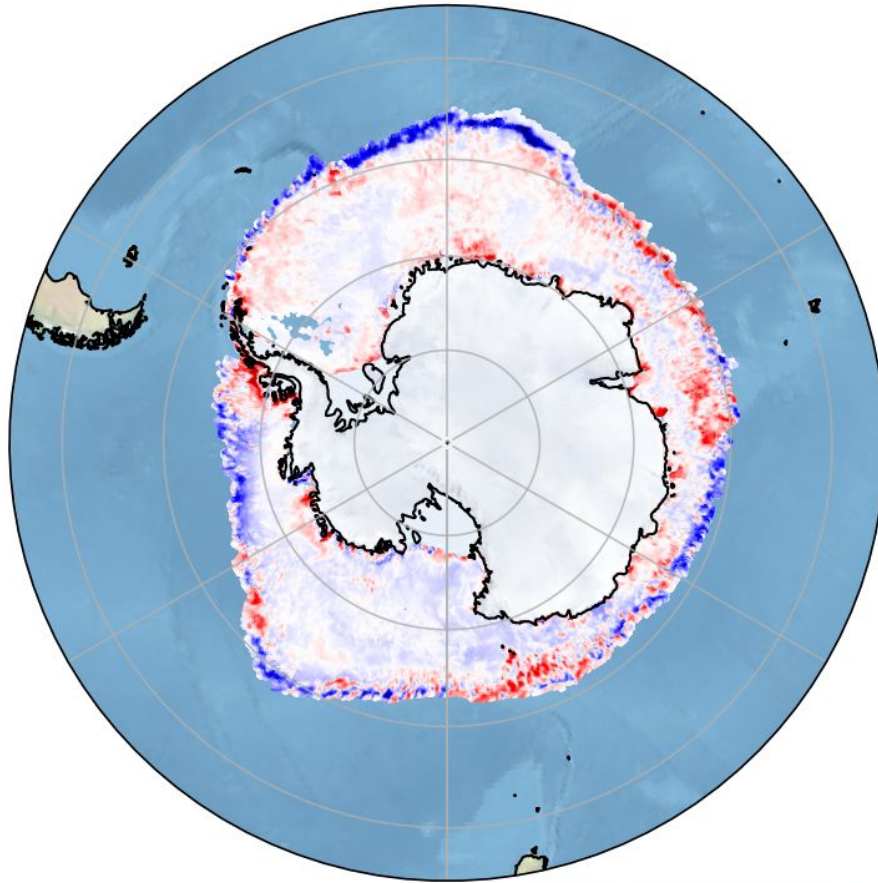
Innovations: blue = obs higher red = model higher
Increments: blue = ice added red = ice removed



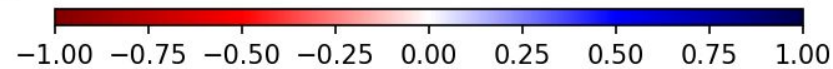
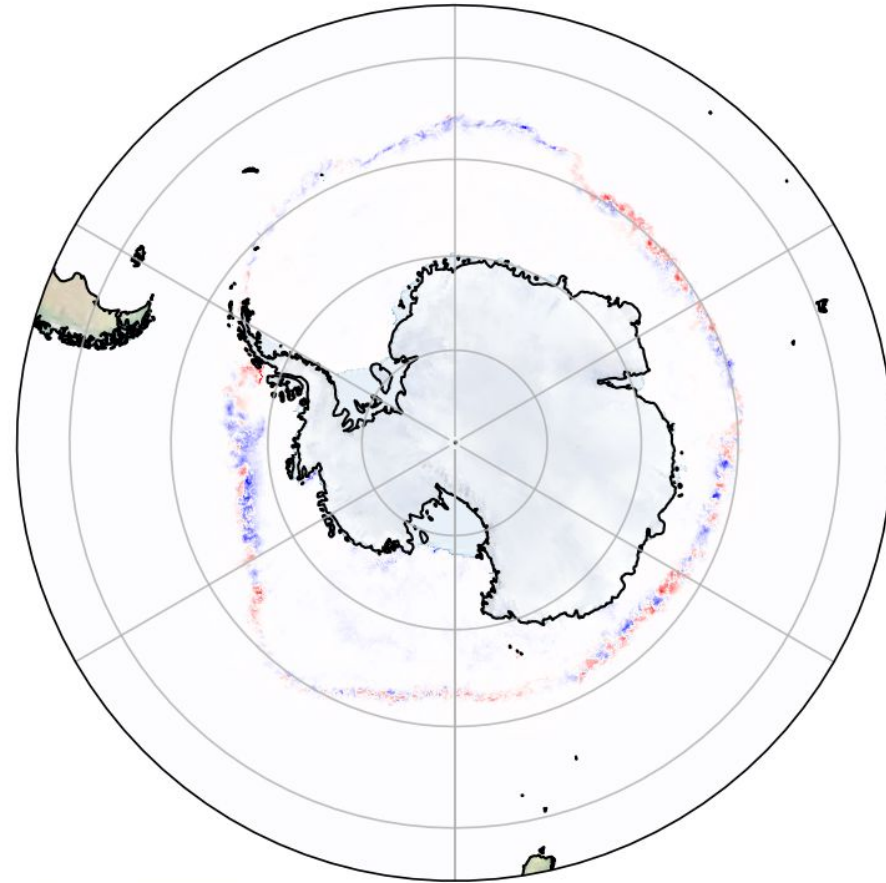
Increments and Innovations

20220910

Innovations



Increment

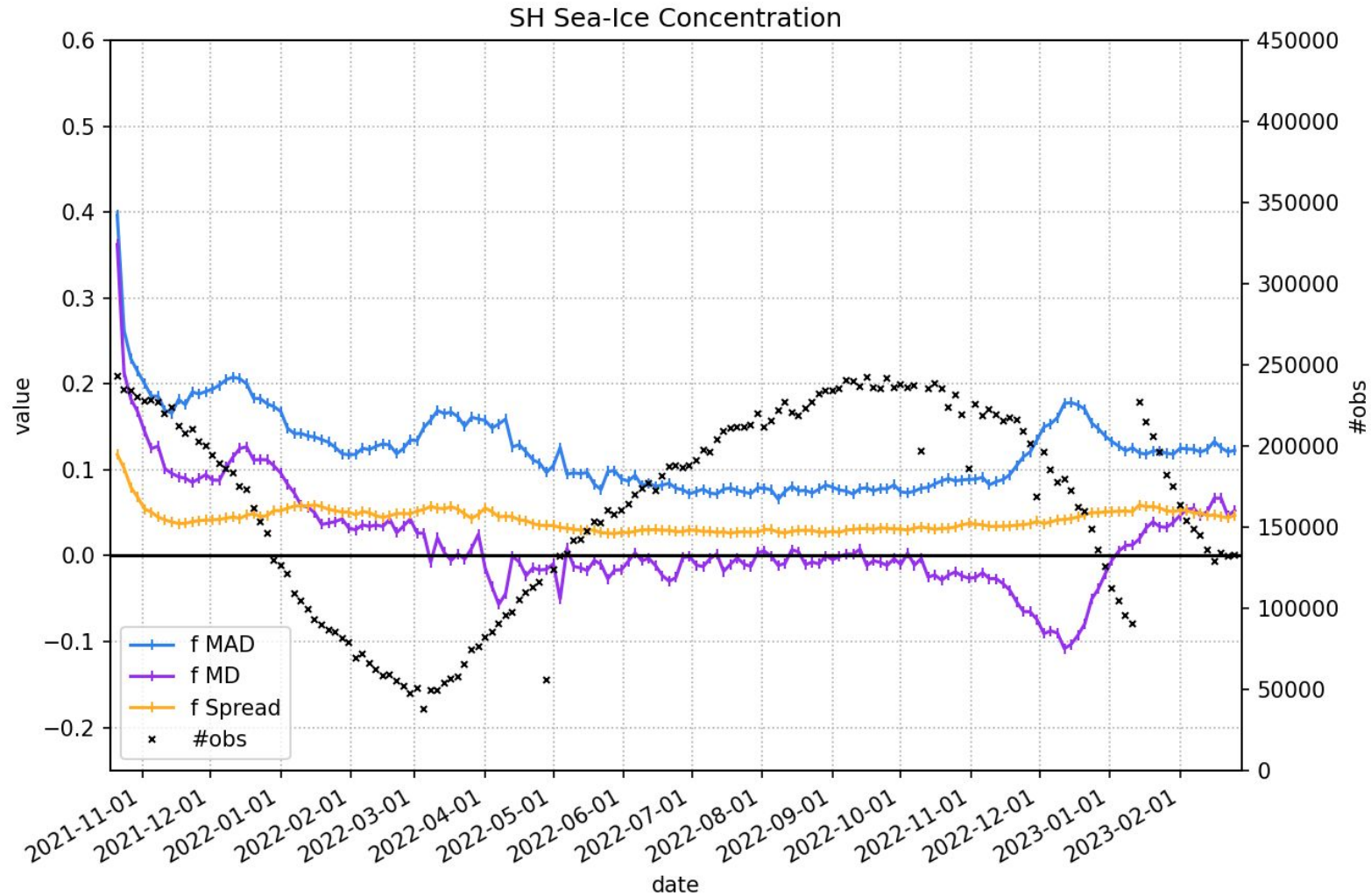


Innovations: blue = obs higher red = model higher
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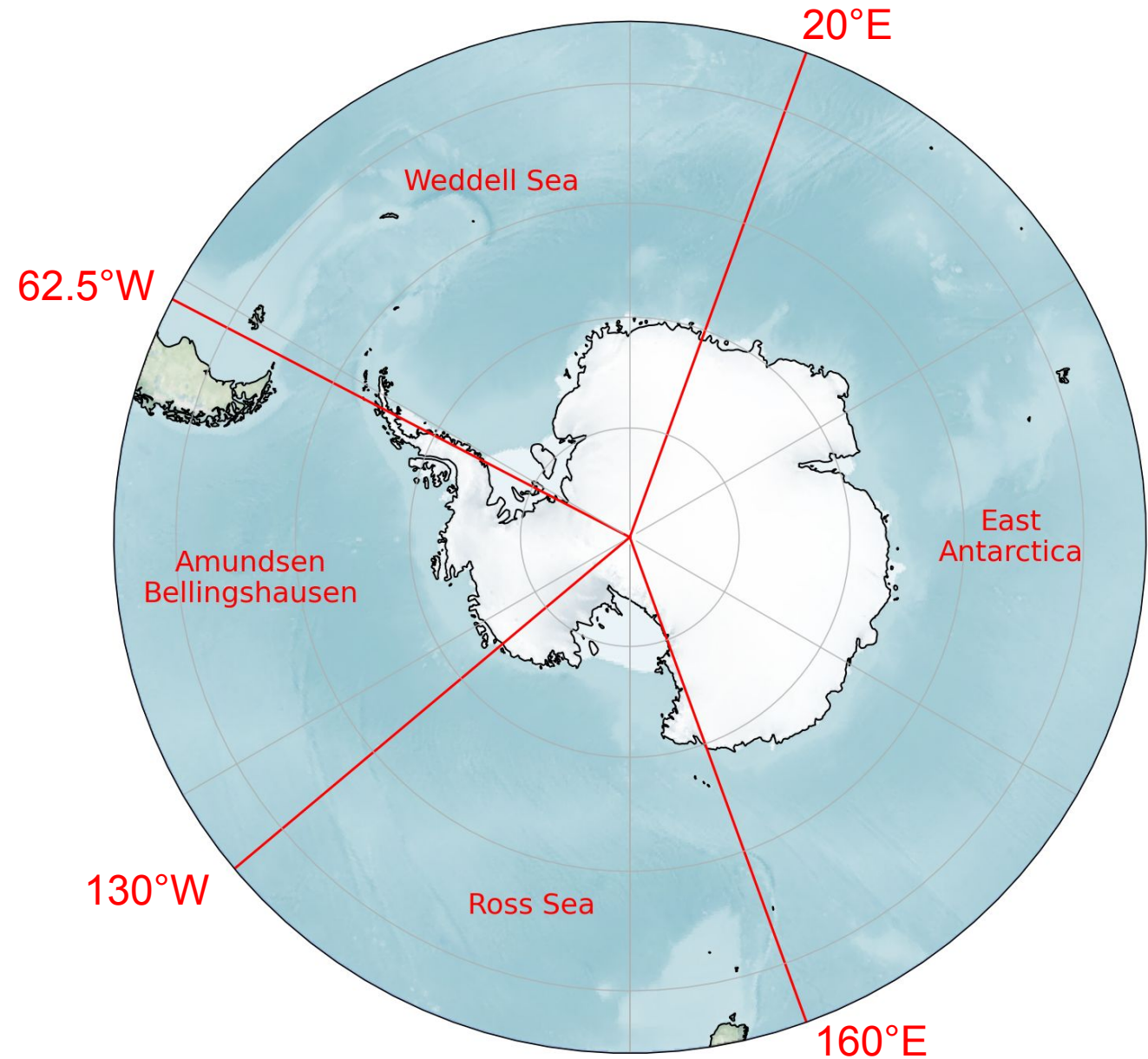
Innovation statistics – with ribbon filter applied

Differences are 'observations minus model'



Statistics in sectors

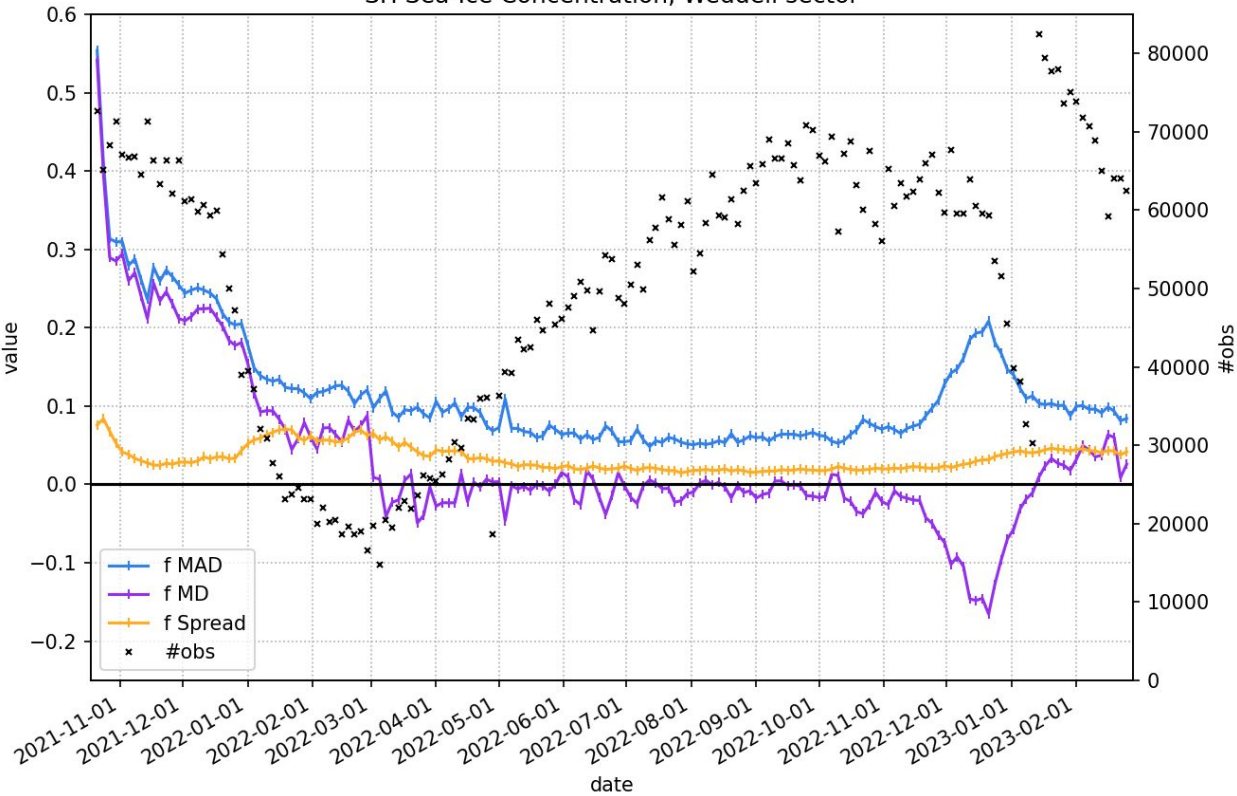
- Sector longitudinal width varies from 67.5° to 140°
 - Must be kept large to ensure sufficient observations are used for calculation of statistics.



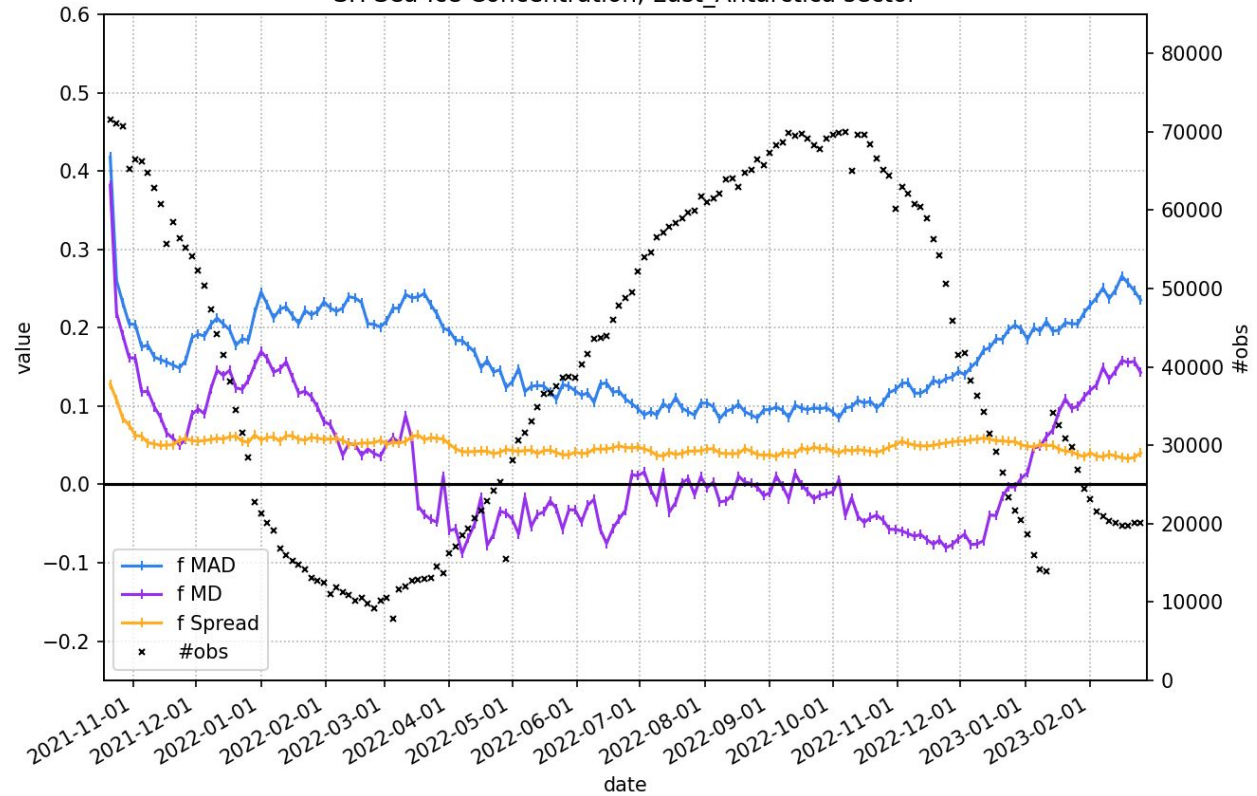
Innovation statistics in sectors

Differences are 'observations minus model'

SH Sea-Ice Concentration, Weddell sector



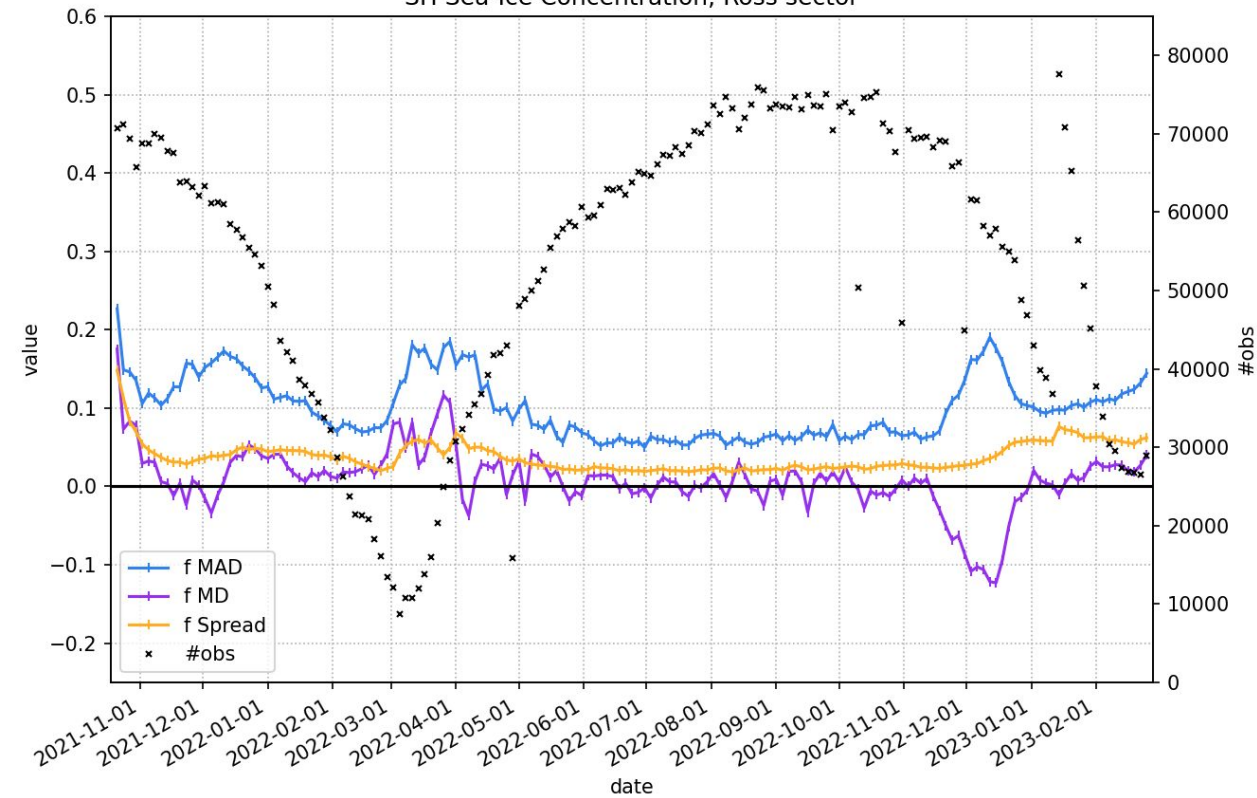
SH Sea-Ice Concentration, East_Antarctica sector



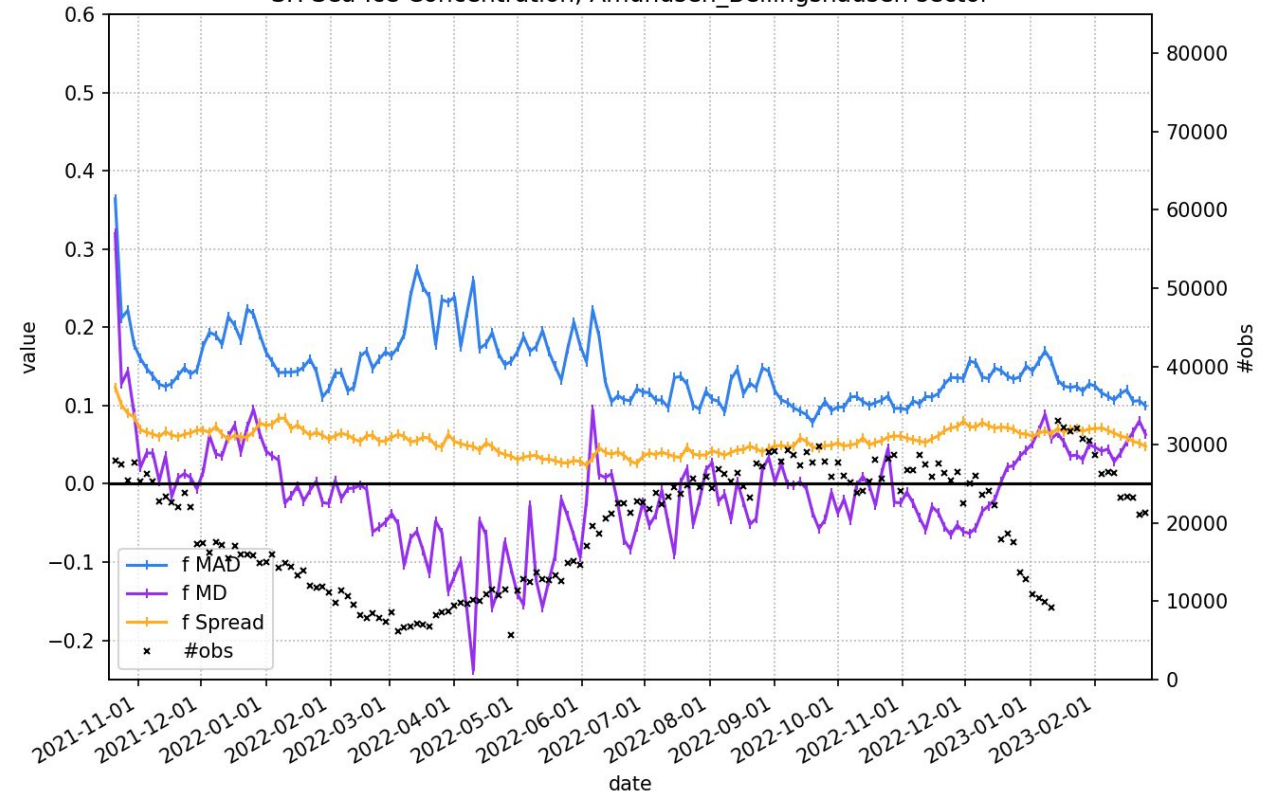
Innovation statistics in sectors

Differences are 'observations minus model'

SH Sea-Ice Concentration, Ross sector



SH Sea-Ice Concentration, Amundsen_Bellingshausen sector



Demonstration project mk2, Austral summer 2023: analysis + forecasts

Case study: analysis of sea-ice extent

- Atmospheric forecast fluxes added in November 2023.
 - 7-day forecasts produced.



Demonstration project mk2, Austral summer 2023: analysis + forecasts

Case study: analysis of sea-ice extent

- Atmospheric forecast fluxes added in November 2023.
 - 7-day forecasts produced.
- Lowest ever observed Antarctic sea-ice extent since satellite era.
 - NSIDC reported the annual minimum was reached on 21 Feb 2023.



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Antarctica
'Everyone should be concerned': Antarctic sea ice reaches lowest levels ever recorded

With the continent holding enough ice to raise sea levels by many metres if it was to melt, polar scientists are scrambling for

The Bureau of Meteorology



The Economist

Menu | Q

Graphic detail | Daily chart

Sea ice in Antarctica is at its lowest-ever level, again

A recent decline of ice around the South Pole worries climate scientists

Feb 20th 2023



European Commission | Copernicus | Climate Change Service

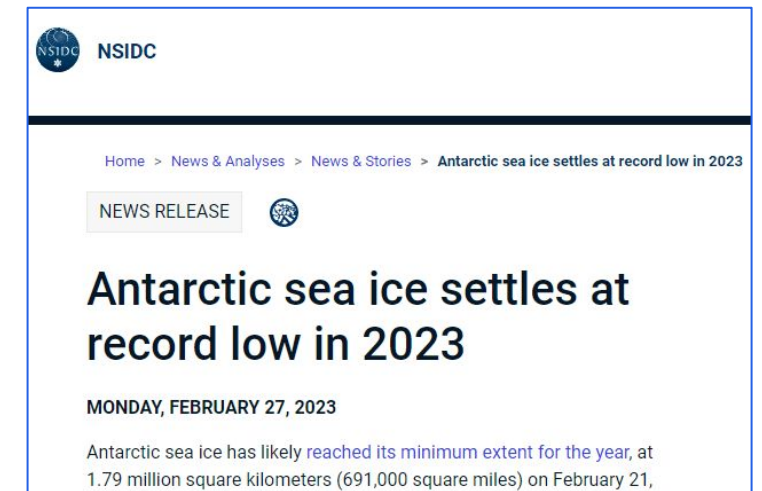
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FEBRUARY 2023 CLIMATE BULLETINS | NEWSFLASH

Copernicus: Antarctic sea ice extent reaches all-time minimum in February – Second warmest winter on record in Europe



NSIDC

Home > News & Analyses > News & Stories > Antarctic sea ice settles at record low in 2023

NEWS RELEASE

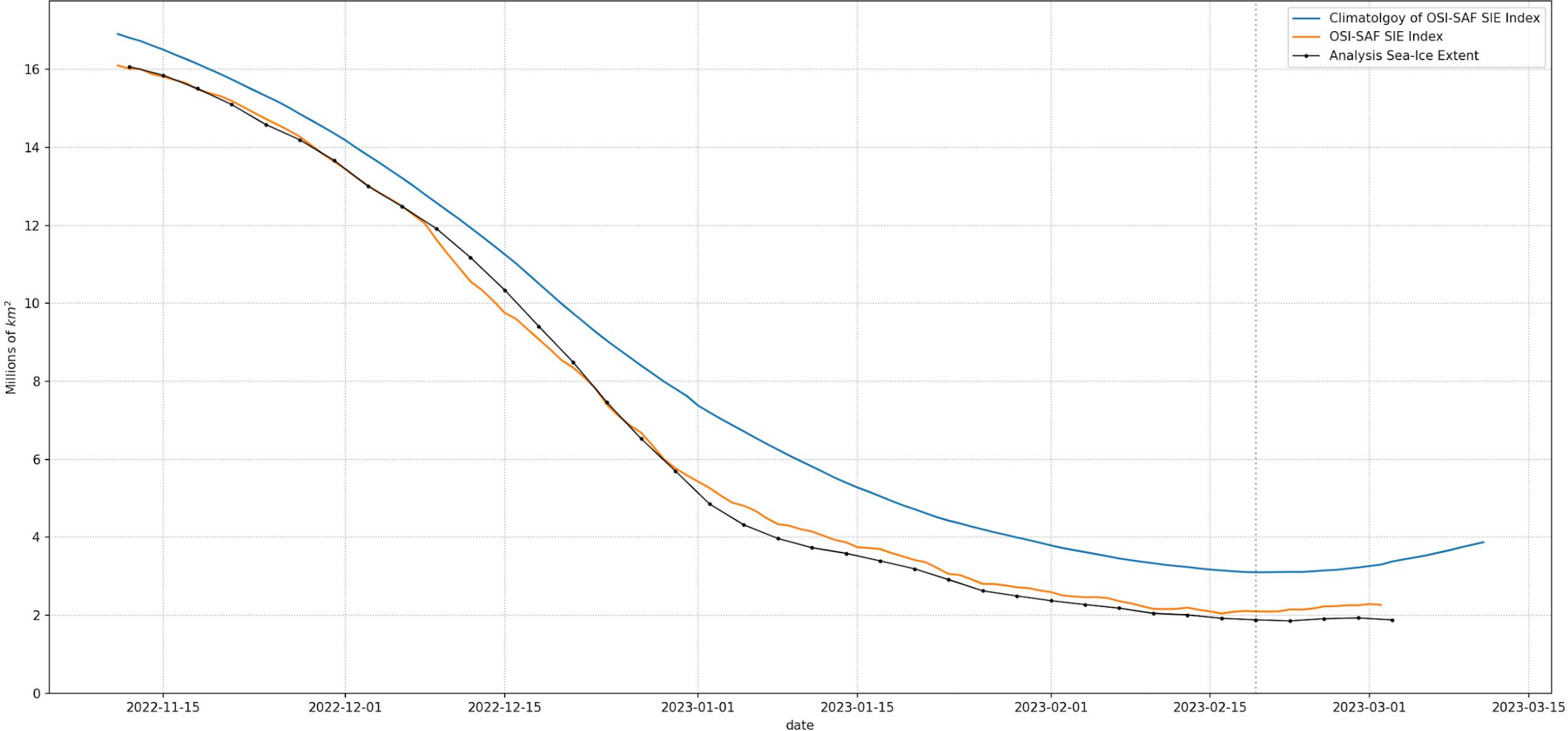
Antarctic sea ice settles at record low in 2023

MONDAY, FEBRUARY 27, 2023

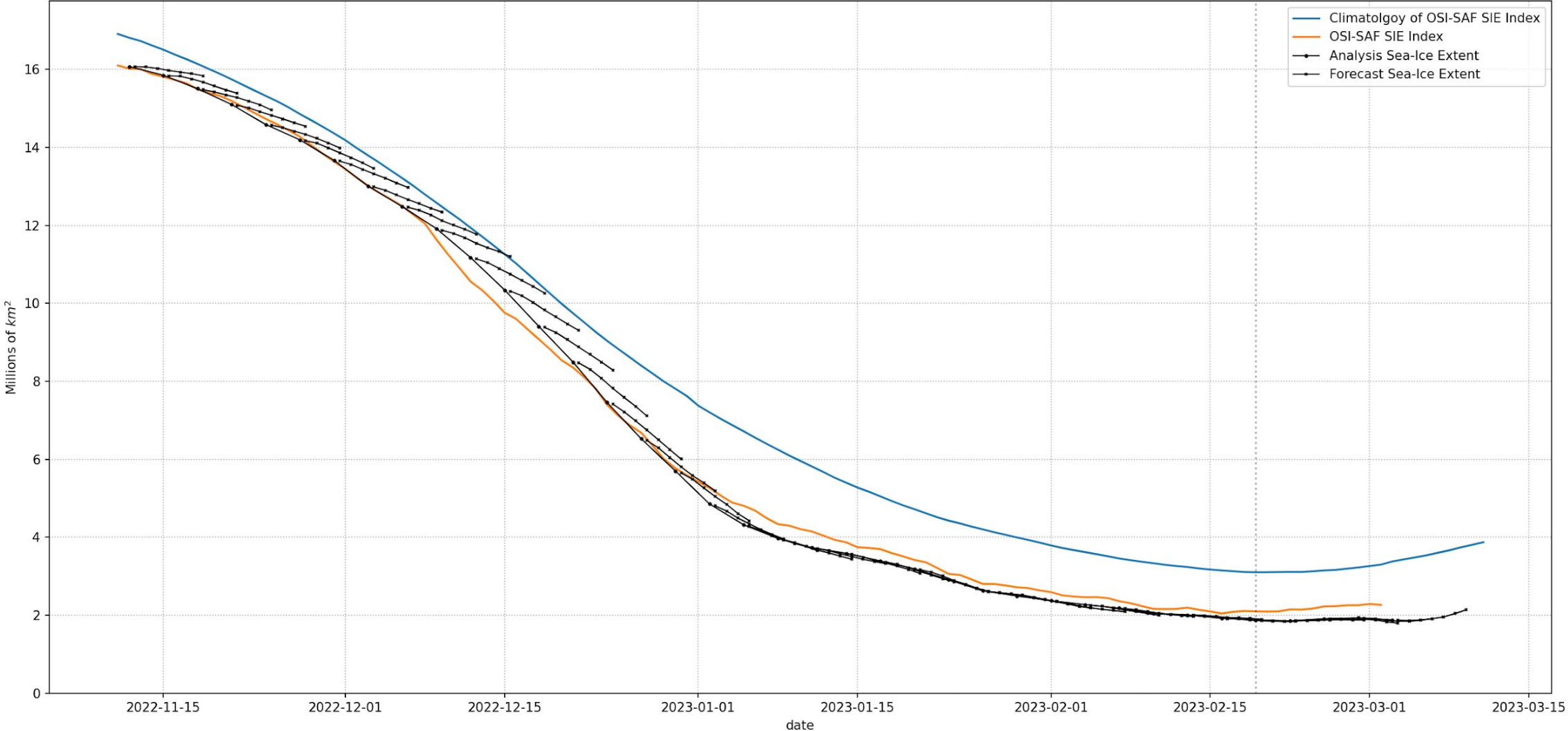
Antarctic sea ice has likely reached its minimum extent for the year, at 1.79 million square kilometers (691,000 square miles) on February 21,



Sea-ice extent

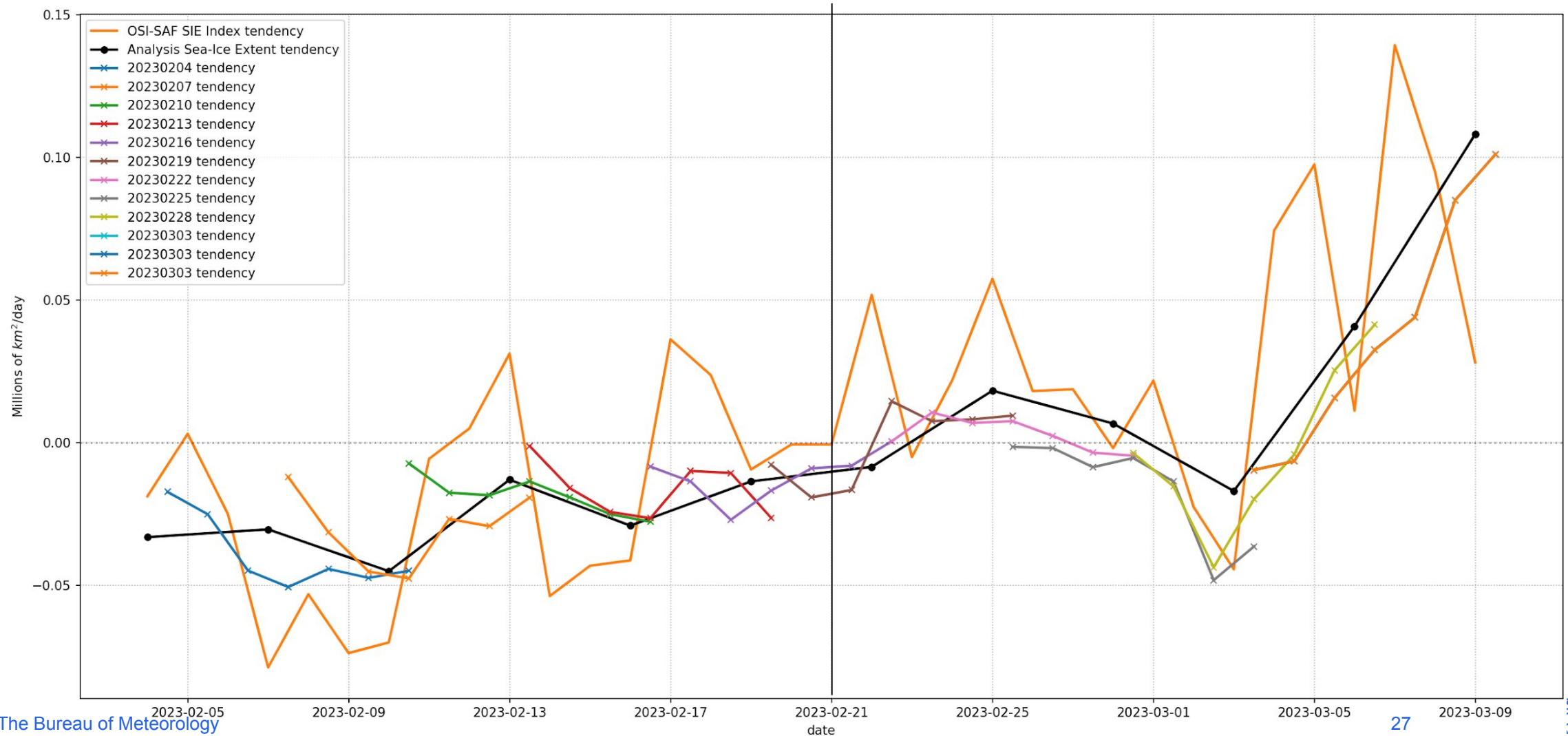


Sea-ice extent



Sea-ice extent – Annual minimum

- The model forecast this to occur on 22 Feb (1 day later than observed)
- Predicted with up to 7 days lead time



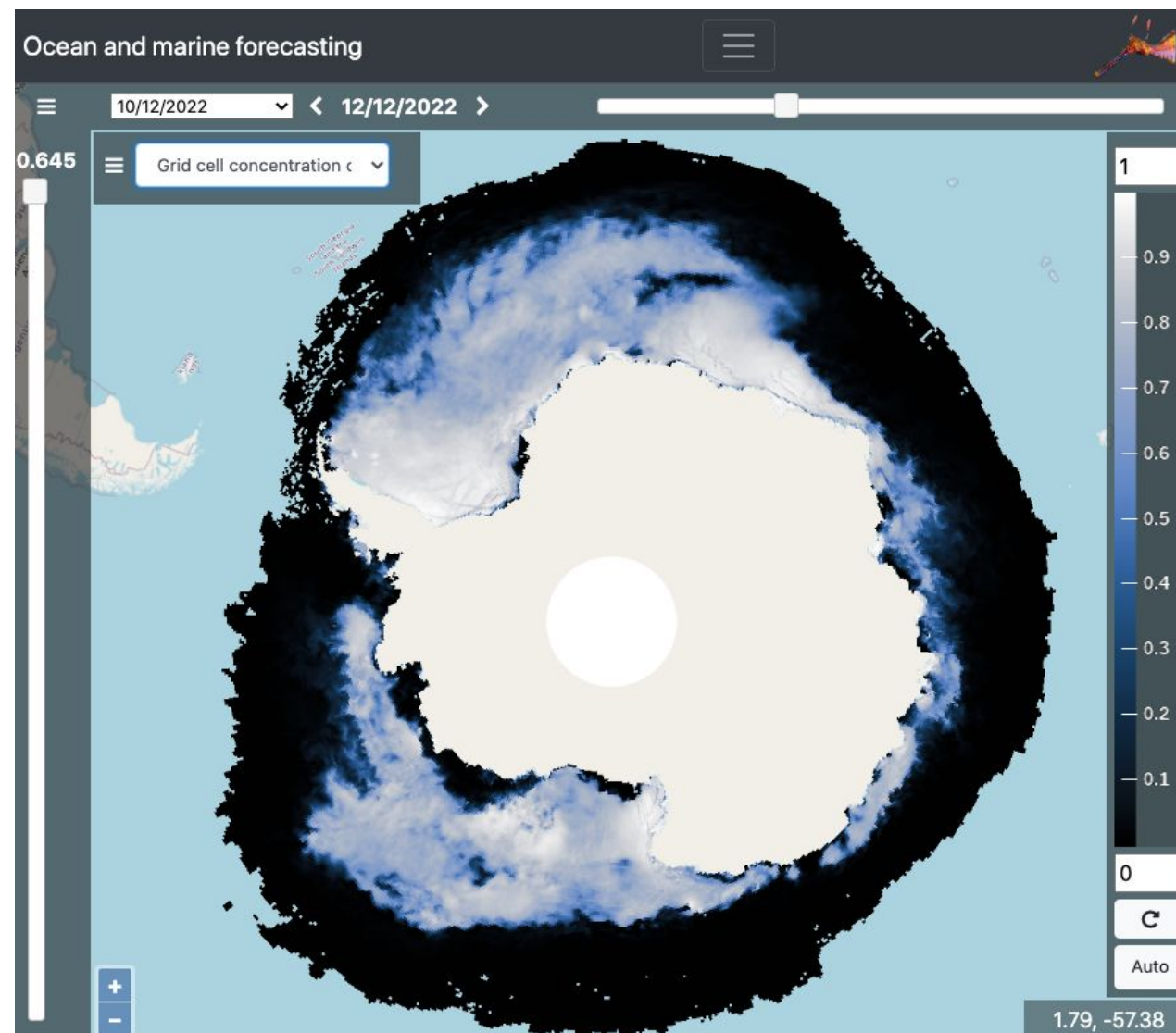
Further work

- More detailed analysis of forecast skill with comparison against L2 observations.
- Operationalise following MTU upgrade in ~~late 2023~~ early 2024
- Consider alternate Ice Thickness Distribution.
 - More thickness categories
 - Higher resolution of thinner ice



Summary

- OceanMAPS v4.0 run in analysis mode only since October 2021 and forecast mode since November 2022.
- Analysis displays:
 - accurate ice tendency at the ice-edge,
 - misses features in the interior of ice pack.
 - Poorer simulation of the rapid summer sea-ice retreat
- Model forecasts have the right tendency sign but not the correct magnitude during periods of rapid sea-ice retreat.
- Model did predict annual sea-ice minimum within a day or observed, with up to seven-days lead.
- Data available from seedragon.org:
- Forecasts
 - ↳ Sea ice South Pole Analysis
 - ↳ Sea ice South Pole Forecasts





The Bureau
of Meteorology

Seedragon.org



Thank you

Stewart Allen

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