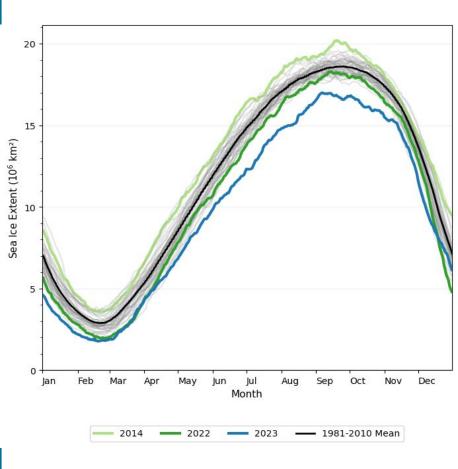


Antarctic Sea-Ice Report Card – 2023 (Annual summary)



Commentary on Antarctic sea ice

- Antarctic Sea-Ice Extent [SIE] during 2023 was at record minima, both in summer and winter. From May SIE remained at record low level for six consecutive months. The 2023 winter maximum SIE was 16.99 Mio km².
- In late 2023, near-coastal fast ice was at record low including off East Antarctica.
- Above average SIE in the Bellingshausen/Amundsen seas was due to cooler than normal atmospheric outflow from the continent, funneled via West Antarctica.

Relevant events

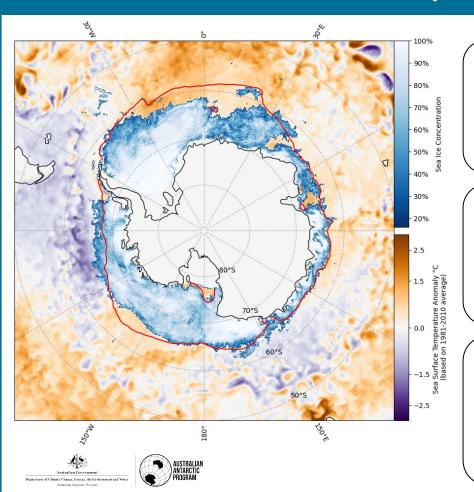
- 2023 was the warmest calendar year on record with a global-average temperature of 14.98°C, being 1.48°C warmer than the 1850-1900 pre-industrial level (@ERA5). While 2023 was the record warmest, or close to, over much of the oceans and most continents, Australia was an exception.
- Global-average SSTs [3] were persistently and unusually high, with record highs from April through December 2023, associated with marine heatwaves.
- 2023 saw a transition to El Niño, its onset declared in early July by WMO.
- Warming for September 2023 stands out, as its deviations is largest of any month in any year of ERA5 (0.93°C higher than the 1991-2020 average).

Update for stakeholders

- Low SIE will in general shorten nautical travel to coastal Antarctic locations.
- Intermittent fast ice and low fast-ice extent will present early summer challenges for over-ice logistics (aviation, sea-ice travel, cargo operations).
- Loss of older fast ice will lead to longer term impacts, including near-coastal station operations, accelerated loss of glacial ice around the coastal fringe, thawing of underwater permafrost, and difficulties for species that rely on persistent sea ice well into the Antarctic summer.
- Reversal of the recent Antarctic cooling may amplify the reduction in Antarctic SIE and its impacts.

Data sources and citations available on request.

Antarctic Sea-Ice Report Card – December 2023



Commentary on Antarctic sea ice

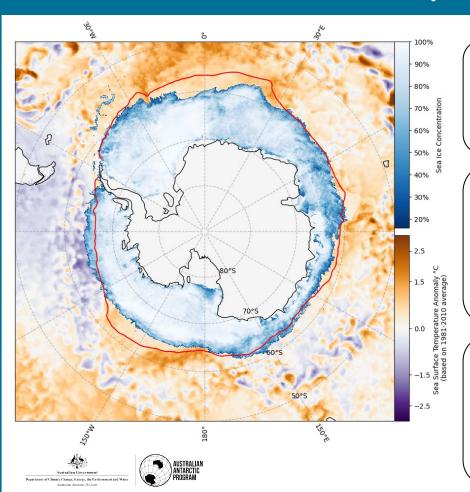
- Antarctic sea-ice extent remained at record low for first half of month, but since then has been closer to the lower end of the long-term mean (1981 2010).
- Sea-ice extent remained persistently low in the Weddell and Ross seas and off East Antarctica. As in previous months, sea ice in the Bellingshausen and Amundsen seas exceeded the long-term mean.
- Warmer than usual conditions over the wider eastern Weddell Sea plus offshore winds off East Antarctica resulted in large-scale sea-ice retreat along that coast.

Relevant events

- El Niño strengthened further during December 2023. It is coupled with a positive SAM.
- West Antarctic air temperature remains cool, extending across much of the Antarctic continent in 2nd half of December 2023.
- Global ocean SST experienced 9th consecutive monthly record high.
- Momentum energy globally higher, especially over oceans.
- Precipitation changed to strong high rainfall events with early wet season onset.

- Large swathes of fast ice off East Antarctica broke out late November and early December 2023, exposing much of the coastline by end December 2023.
- Due to stronger El Niño, westerly winds contracted to Antarctica resulting in dryer western Tasmania but excessive precipitation for eastern (especially NE) Australia incl. severe weather from strong onshore flow of moist air masses.
- Some big icebergs moving in near coastal waters. No reports of impact on high-level predators, i.e., fledging Emperor penguins, or maritime operations.

Antarctic Sea-Ice Report Card – November 2023



Commentary on Antarctic sea ice

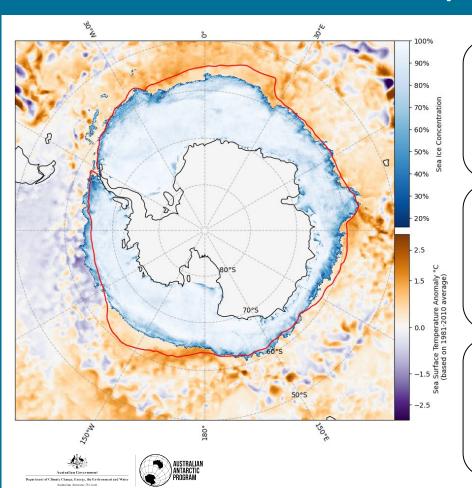
- Overall Antarctic sea-ice extent recovered slightly during November after six consecutive months of record low extent (~-14% to 1981-2010 mean). The 2023 Antarctic sea-ice extent was the 2nd lowest November in the record (-9%, 2016).
- Fast ice in Nov 2023 at record low around most of continent incl East Antarctica.
- Small bulge of excess pack ice remains in the Bellingshausen/Amundsen seas.

Relevant events

- Surface temperatures over Antarctic continent in November were 2nd coldest on record.
- Warmer temperatures for most of southern hemisphere including Australia.
- Global ocean exhibit 8th consecutive month of record maximum surface temperature.
- Damaging precipitation events encountered in both hemispheres.
- El Niño conditions prevail. NCEP expecting likelihood for El Niño to persist into mid 2024 is as high as 60%, likely leading to warm southern autumn.

- Low sea-ice extent will shorten nautical travel to coastal Antarctic locations.
- Intermittent fast ice and low fast-ice extent will present early summer challenges for over-ice logistics (aviation, sea-ice travel, cargo operations).
- Early regional sea-ice demise and fast-ice breakout to directly impact atmospheric circulation and precipitation locally and far field (mid latitudes).
- Very low fast ice and cool offshore winds promote iceberg calving and transport with poorly impacting associated ecosystems incl. high-level predators, such as fledging Emperor penguins.

Antarctic Sea-Ice Report Card – October 2023



Commentary on Antarctic sea ice

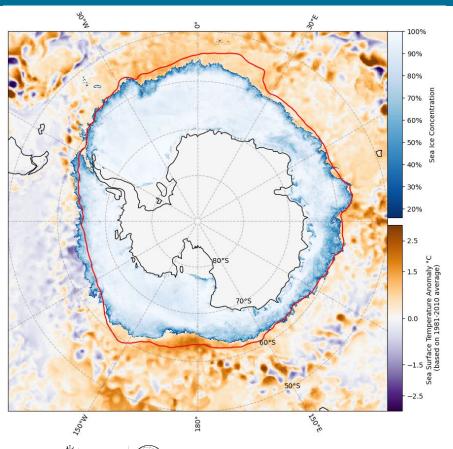
- Seasonal (spring) sharp decline in Antarctic sea ice.
- Antarctic sea-ice extent [SIE] is on record low for 6th consecutive month.
- SIE off East Antarctica only slightly below the long-term mean (1981 2000), with region from 30° 75°E nearly at long-term mean.
- Significant pack-ice deficit in NE rims (outflow) of Weddell & Ross gyres.
- Heavily eroded Marginal Ice Zone [MIZ], with deep MIZ from 82° 155°E.
- Low fast-ice extent for much from 37° 119°E and western side of peninsula.

Relevant events

- Surface temperatures over Antarctic continent were cold leading to 6th coldest October on record.
- Cooler temperatures for most of southern hemisphere but not for Australia.
- Global ocean exhibit 7th consecutive month of record maximum surface temperature.
- El Niño conditions prevail. NCEP expecting likelihood for El Niño to persist into early 2024 is as high as 80%.

- Low sea-ice extent may shorten nautical travel to coastal Antarctic locations.
- Intermittent fast ice and low fast-ice extent may present challenges in the next months for over-ice logistics (aviation, sea-ice travel, cargo operations).
- Low fast ice and (cold) offshore winds may promote iceberg movements with negative impact on associated ecosystems incl high-level predators.
- Patchy sea-ice cover combined with El Niño conditions may directly affect atmospheric circulation patterns from the high- to mid-latitudes.

Antarctic Sea-Ice Report Card – September 2023



Commentary on Antarctic sea ice

- The annual maximum Antarctic sea-ice extent (on 10 Sep 2023) of 16.96 10⁶ km² marks the absolut record low in the record (1979 now). The deficit to the long-term mean (1981 2010) is a staggering 1.5 10⁶ km², or about twice the size of NSW. The previous record low occurred in Sep 1986 (17.99 10⁶ km²).
- Sea-ice concentration within the pack was eroded compared to other years.
- Fast-ice margins varied throughout the year with a large number of open water near the coast, i.e., wide cracks and polynyas.

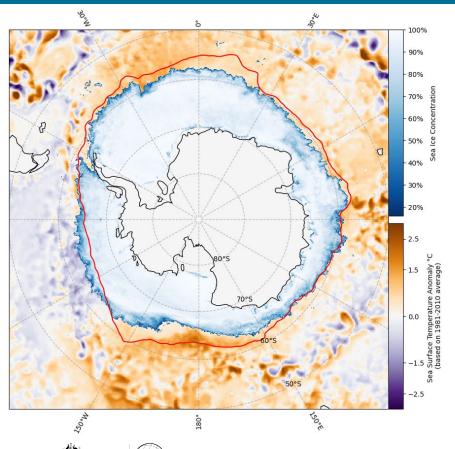
Relevant events

- Sep 2023 average global temperature highest September on record (1850-now).
- Oceania experienced its 3rd warmest September.
- Arctic sea-ice extent is 5th lowest on record (1979-now).
- Global ocean exhibit 6th consecutive month of record maximum surface temperature.
- Antarctica has warmed from cooler July & Aug, to record wam September.

- Antarctic sea ice exhibits a circumpolar deficit for Sep 2023 with exception of the Bellingshausen/Amundsen seas region, which coincides with outflow of cold Antarctic air.
- Near coastal fast ice is significantly less than previous records with implications for over-ice access off Eastern Antarctica (78° - 132° E)



Antarctic Sea-Ice Report Card – August 2023



Commentary on Antarctic sea ice

- Sea-ice concentrations well below-average in the northern Weddell, eastern Bellingshausen, and northern Ross seas but remaining above average in Amundsen Sea sector.
- Winter sea-ice thickness increased in the East Antarctic, reduced off West Antarctic Peninsula.
- Winter fast-ice extent low from 43° to 148° E.; lack of fast ice west of peninsula.

Relevant events

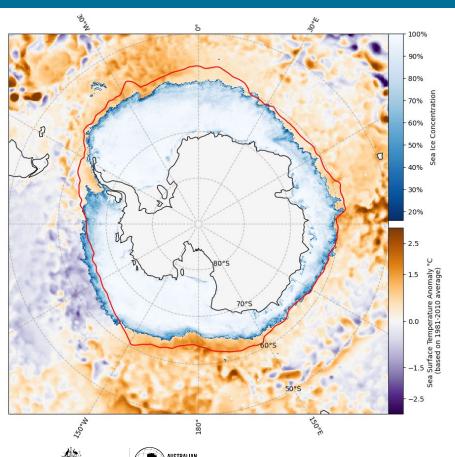
- Warmest August on record. +0.71°C above 1991-2020 average; +0.31°C above previous record (08/2016); warming records set in both, ocean & atmosphere.
- Heatwaves observed across the northern hemisphere and equatorial regions...
- Well above average temperatures over Australia, parts of South America and around much of Antarctica. However, unseasonably cool conditions over parts of Antarctica → West Antarctic cooling.
- Global atmospheric circulation patterns perturbed, including deep cyclonic activity (incl atmospheric rivers)

- Far field forcing dominated by El Niño as it strengthened over the equatorial eastern Pacific.
- Increased freshwater entry into global oceans due to glacial melt
- Shipping: reduced navigation trajectory in Eastern Antarctica (78° 132° E)





Antarctic Sea-Ice Report Card – July 2023



Commentary on Antarctic sea ice

- Sea-ice concentrations well below-average in the northern Weddell, eastern Bellingshausen, and northern Ross seas while above average in Amundsen Sea sector.
- Winter sea-ice thickness increased in the East Antarctic, reduced off West Antarctic Peninsula.
- Fast-ice stability for 2023 reduced between 65° 150° E.

Relevant events

- Hottest July on record. +0.72°C above 1991-2020 average; +0.33°C above previous record (07/2019).
- Global atmospheric circulation patterns perturbed. E.g., storminess, precipitation.
- Heatwaves occurred in southern Europe, Asia and North America.

 Unseasonably warm over parts of South America and around Antarctica.
- Global average sea-surface temperatures continued to rise.

- During July 2023 El Niño conditions strengthened; to continue into 2024.
- Amundsen Low driving cold air off the West Antarctic, and subsequent increased sea-ice formation as well as northward sea-ice export.
- Shipping: Reduced navigation trajectory in EA (78° 132° E).

