Variability in the Timing of Advance and Retreat of Antarctic Sea Ice

Marilyn Raphael, Sarah Villhauer, Mark Handcock

University of California, Los Angeles

Contact Info:
Raphael@geog.ucla.edu
svillhauer@g.ucla.edu

Abstract

Sea ice is a key component of the complex Antarctic climate system. While the annual cycle is the dominant feature, an important contributor to the temporal variability in Antarctic sea ice extent is the timing of advance and retreat of the ice. Early advance can lead to greater extent at winter maximum while early retreat leads to lesser extent at summer minimum. Using satellite-observed sea ice for the period 1979-2021, we analyze the time of advance and time of retreat for sea ice extent of the five Antarctic sectors, as well as for the total.

Annual Cycle of Antarctic Sea Ice

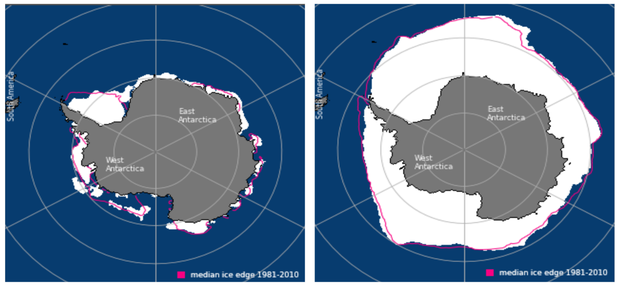
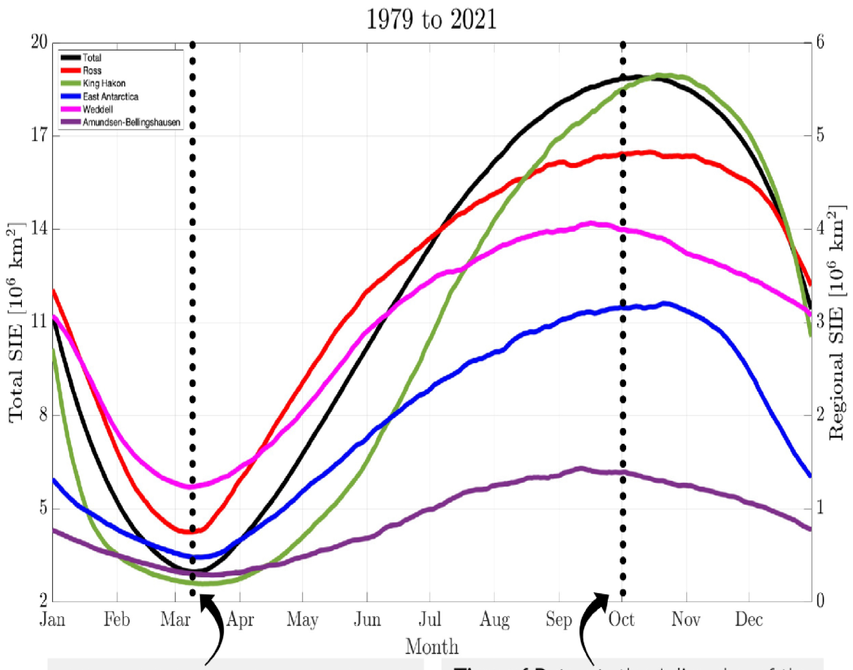


Figure 1. Spatial distribution of Antarctic sea ice at minimum (end of February) and maximum (September) (Source: NSIDC).



Time of Advance: the Julian day of the year at which sea ice extent starts increasing (when sea ice extent reaches its annual minimum)

Time of Retreat: the Julian day of the year at which sea ice extent starts decreasing (when sea ice extent reaches its annual maximum)

Figure 2. Antarctic sea ice spatially and temporally varies across five sectors. Time of advance and retreat are crucial contributors to temporal variation.

Time of Advance and Retreat

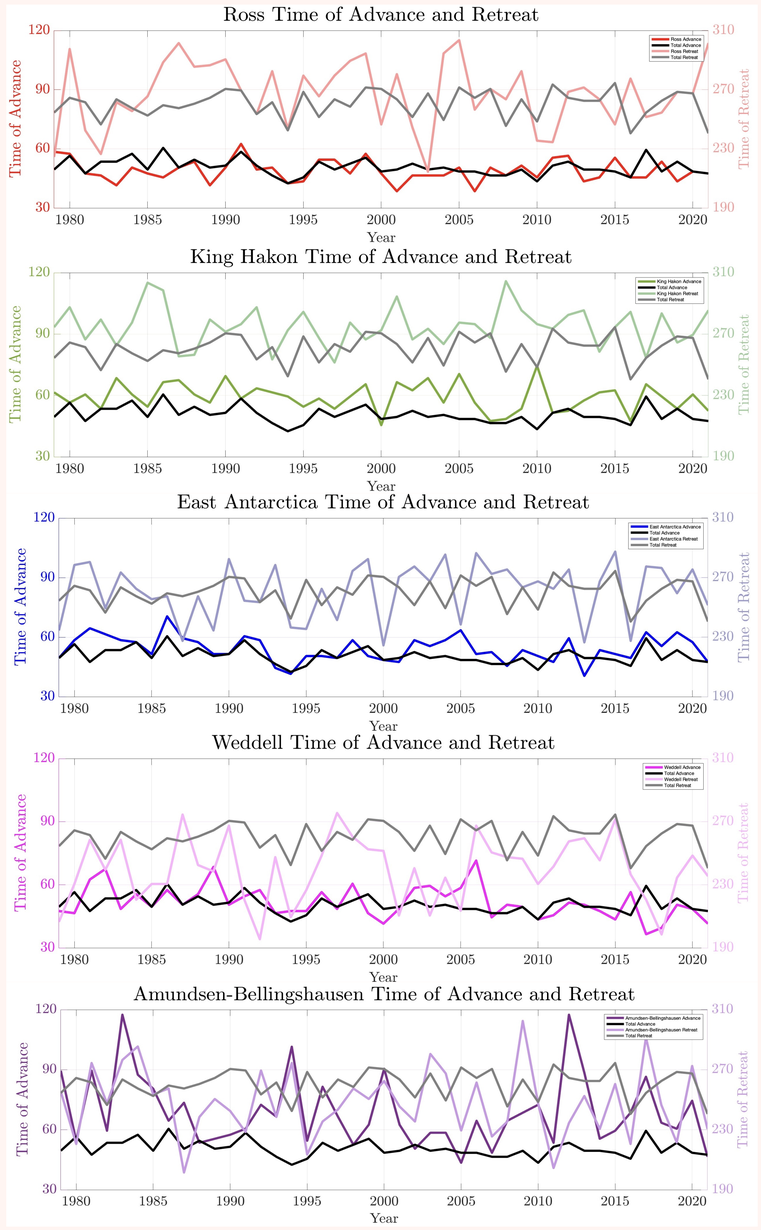


Figure 3. Julian day of advance and retreat of sea ice extent for the total Antarctic continent and the five Antarctic sectors.

- All regions show strong inter-annual variation in timing of advance and retreat.
- There are no significant trends in time of advance or retreat, except for the Weddell Sea sector, which shows a trend of earlier advance.
- Time of advance and retreat vary across sectors, a fact that is masked when only total sea ice extent is used.
  - The Amundsen-Bellingshausen Sea sector has the latest time of advance.
  - The King Hakon Sea sector has the second latest time of advance.
  - The Ross and Weddell Sea sectors have the earliest times of advance.
  - The Weddell and Amundsen-Bellingshausen Sea sectors have the earliest times of retreat.

Regional Relationships

- Despite strong regional variation, there are multiple inter-regional relationships.

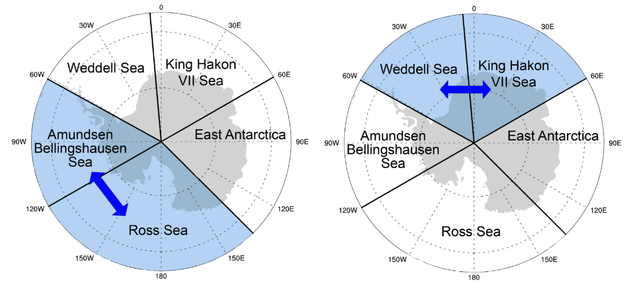


Figure 4. Time of retreat between [1] the Ross and Amundsen-Bellingshausen Sea sectors and [2] the King Hakon and Weddell Sea sectors is negatively correlated.

- Since these regions are adjacent to one another, the negative correlation is probably driven by a local-scale mechanism.

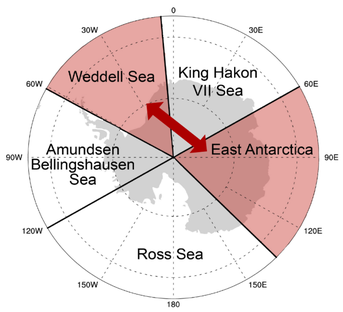


Figure 5. Time of advance between the Weddell Sea and East Antarctic sectors is positively correlated.

- Since the Weddell Sea and East Antarctica are not adjacent to one another, this correlation must be due to larger-scale atmospheric and/or oceanic effects, rather than local-scale effects.

Key Takeaways

- There is strong temporal and spatial variation in Antarctic sea ice that is not captured by annual and spatial means.
- Times of advance and retreat are not uniform around the continent, they vary by sector.
- Times of advance and retreat may influence Antarctic sea ice extent at maximum and minimum.
- Times of advance and retreat of some sectors are correlated:
  - Time of retreat inversely varies between the Ross and Amundsen-Bellingshausen Sea sectors, and between the King Hakon and Weddell Sea sectors.
  - Time of advance varies directly between the Weddell Sea and East Antarctic sectors.
- Factors that influence the timing of advance and retreat are atmosphere and the ocean. The correlation between the sectors may be due to mesoscale atmospheric circulation patterns including the Amundsen Sea Low and Zonal Wave Three.