

Evidence essay · Sea ice and ocean

Extent and volume tell different ice stories

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Fictional author and institute · Editorial demonstration, not peer reviewed

ABSTRACT

Extent, area, and volume are separated through a hypothetical sea-ice grid cell whose concentration and thickness can change independently. The worked arithmetic shows why an unchanged outline can conceal a loss of frozen material, while wind-driven spreading or compaction can alter extent without equivalent ice formation or melt. The essay explains the concentration threshold behind extent, surface-melt complications in remote sensing, and the sampling problem posed by thickness distributions. PIOMAS is described as a model-based reanalysis with validation and uncertainty, not a direct weighing of the pack. Published seasonal extent results provide an example of how rankings can be overextended. A fair comparison retains dates, domains, units, reference periods, and the meaning of uncertainty before deciding whether apparently conflicting graphs are physically consistent.

Keywords: sea-ice extent · sea-ice area · ice volume · PIOMAS · seasonal comparisons

Adapted from the Still North field journal. Original article. A source-based editorial text, not a report of original Still North research. Examples and imagery are illustrative.

Two sea-ice graphs can move in different directions without either being wrong. One may count the ocean surface containing ice; another may estimate how much frozen material remains. Before asking which graph to trust, ask which question each is answering. The distinction matters whenever a modest change in the ice edge is described as a recovery of the Arctic pack.

Start with one imaginary square

Consider an invented ocean grid cell covering 100 square kilometres. Ice occupies 60% of it. In a standard extent calculation using a 15% concentration threshold, the whole 100 square kilometres counts towards extent. A concentration-weighted area calculation counts 60 square kilometres of ice. Those are different summaries of the same scene, not rival observations.

The National Snow and Ice Data Center explains this threshold method, including why extent is often more robust than area during surface melt. Passive microwave sensors can confuse water on the ice with water between floes. Establishing whether a cell exceeds a threshold can be less demanding than estimating its precise ice fraction. The definition trades some detail for a consistent large-scale record.

Now give the ice in our imaginary cell an average thickness of two metres. Its volume is 60 square kilometres multiplied by 0.002 kilometres: 0.12 cubic kilometres. If thickness falls to one metre while concentration remains unchanged, extent and area stay the same, but volume halves. Nothing on an extent-only map reveals that loss.

Wind can change the outline without making ice

Ice is not fixed to the grid. Wind and currents spread floes apart, compact them, or push them into ridges. In the simplified example, spreading the same frozen material over a wider surface can increase the number of cells

above the extent threshold. Compaction can shrink that footprint. Neither rearrangement, on its own, says how much ice has formed or melted. Real events often combine movement and thermodynamic change.

Thickness also has a distribution. A region containing level ice and deep ridge keels cannot be represented adequately by measuring whichever surface is easiest to reach. Volume requires the area-weighted contribution of those different thicknesses. Our [sea-ice overview](#) explains why deformation and sampling belong alongside the satellite outline.

Volume is an estimate with a method

It would be convenient to weigh the whole pack. Instead, thickness information comes from instruments with different coverage: satellite altimeters, upward-looking sonar, and field measurements. Altimeters measure a surface elevation from which thickness is inferred, using assumptions about snow and densities. None supplies a complete, uninterrupted history of every part of the Arctic.

The University of Washington's PIOMAS volume reanalysis combines a sea-ice and ocean model with observations, including ice concentration, and evaluates the resulting thickness against independent measurements. Its volume series is therefore a model-based reconstruction, not a direct satellite weighing. That does not make it disposable. It makes the model version, validation, geographic domain, and uncertainty necessary parts of its interpretation.

An anomaly adds another distinction. It compares a value with a reference average for the same part of the seasonal cycle. The uncertainty in an anomaly need not equal the uncertainty in total volume, because persistent biases can cancel in a difference. A shaded band must be read from its caption: it might describe uncertainty,

variability, or spread around a trend. Those are not interchangeable.

A fair comparison keeps the season attached

Take the [NOAA 2025 assessment](#). The September daily minimum extent was 4.60 million square kilometres, ranked tenth lowest in its satellite record. That ranking concerns one measure at one seasonal limit. It cannot establish a tenth-lowest volume, nor describe winter thickness. A daily minimum also differs from a September monthly average, even when both appear in the same report.

When two graphics appear to disagree, align their dates, regions, units, definitions, and reference periods first. Then ask whether the remaining difference is physically plausible: a wider but thinner pack, for example. Keep the original captions available through the [observation record](#). The useful outcome is not one winning graph. It is a description that says how far the ice reaches and how much material that outline contains.

References

1. National Snow and Ice Data Center explains this threshold method (nsidc.org)
2. PIOMAS volume reanalysis (psc.apl.uw.edu)
3. NOAA 2025 assessment (arctic.noaa.gov)