

Evidence review · Observation and data

When a second sensor is not a second network

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Fictional author and institute · Editorial demonstration, not peer reviewed

ABSTRACT

Instrument counts alone do not establish observing-network resilience. This evidence review combines the Arctic observing-network assessment, GCOS monitoring principles, and measurement-uncertainty guidance to distinguish redundancy for availability, accuracy, coverage, and timely delivery. A fictional reliability calculation contrasts independent failures with two instruments sharing a vulnerable platform. Further analysis follows common dependencies through calibration, software, archives, funding, and specialist expertise, while distinguishing environmental correlation from correlated measurement error. The review considers removal experiments and irreversible gaps in long records without ranking actual investments or specifying operational safety coverage. It also rejects treating community-led observation as an interchangeable spare component. Redundancy is most defensible when it protects a named evidential function through an independent, authorised route whose limitations are documented.

Keywords: observing networks · redundancy · common-cause failures · record continuity

A source-based editorial text, not a report of original Still North research. Examples and imagery are illustrative.

Count the routes to evidence, not only the instruments

Two instruments can fail together because they share a power supply, a mounting platform, a communications service, or the same unsupported processing software. Conversely, two instruments at one site may be essential for diagnosing a subtle measurement fault even though they add little geographic coverage. Redundancy is therefore not a property that follows from counting hardware. It is a relationship between an observation requirement and the independent ways that requirement can still be met.

This evidence review examines that relationship through the 2025 Arctic observing-network assessment, the updated GCOS Climate Monitoring Principles, and the JCGM treatment of correlated measurement uncertainty. It uses a fictional reliability comparison to distinguish independent component failures from common causes. It does not estimate the reliability of any actual Arctic network, recommend operational safety coverage, or calculate the monetary value of real programmes.

Specify what must continue

A network can be required to preserve several different things: a long-term reference series, a regional mean, observations of an unusual event, or timely delivery of a product. These are not interchangeable. A nearby site may help estimate a regional temperature average while being a poor replacement for a particular valley's snow record. A satellite can provide broad coverage without measuring the subsurface quantity needed at a fixed station.

The 2024 GCOS principles accordingly begin with appropriate spatial and temporal sampling, precision, accuracy, and stability. They also distinguish sustaining

historically uninterrupted systems from incorporating new technologies. A redundancy argument should name the required variable, scale, interval, uncertainty, and acceptable gap. Without those definitions, both “duplicate” and “essential” are assertions without a test.

Continuity has at least two clocks. The first concerns whether an observation was made. The second concerns whether it reached a user. A communications outage may delay delivery while the instrument retains a recoverable local record. A power outage may destroy the observation opportunity itself. Buying a second modem addresses a different failure pathway from buying a second sensor or a more durable power system.

Fictional case: two routes through a shared platform

Imagine a purely educational requirement: obtain at least one valid daily value for a specified index. Suppose each of two completely independent instruments is unavailable on 10% of days. Under the deliberately strong assumption of independent daily failures, both are unavailable on 1% of days. At least one is available on 99% of days, compared with 90% for one instrument. This familiar multiplication is correct for the model, not proof that field failures are independent.

Now consider a different invented arrangement. Two instruments share a platform that is unavailable on 8% of days. When the platform is available, each instrument independently fails on 2% of those remaining days. The probability of losing both routes is 0.08 plus 0.92 multiplied by 0.02 squared, approximately 8.04%. The second instrument barely changes availability because the shared failure pathway dominates.

In the second arrangement, one instrument alone would be unavailable on 9.84% of days. Adding another

Invented arrangement	Both routes unavailable	What the comparison reveals
Two independent instruments, each 10% unavailable	1% of days in the model	Independent duplication can improve availability markedly
Shared platform unavailable 8%; conditional instrument failure 2%	About 8.04% of days in the model	A common cause can dominate otherwise reliable instruments

reduces that to about 8.04%, not to 1%. The numbers are chosen to make the mechanism visible. They are not measured failure rates, design targets, or a recommended allowance. Real outages have duration, seasonality, repair constraints, and dependencies that these daily probabilities omit.

Redundancy can protect accuracy as well as availability

An instrument may keep delivering values while its response drifts. Co-located comparison can reveal disagreement before the record becomes unusable. A second system based on a different measurement principle may be especially informative because it does not share every failure mode. Yet disagreement identifies a problem, not automatically which instrument is correct. A reference, deployment history, and uncertainty account remain necessary.

The JCGM Guide's discussion of correlation is relevant when measurements are combined. Shared references and common influences can correlate errors. Averaging several estimates does not remove a bias common to all of them. Nor does agreement prove independence. Two independently designed products may draw on the same observations and therefore carry some of the same limitations into their published values.

Environmental correlation and error correlation must also be separated. Nearby thermometers should respond similarly to the same weather. That useful agreement is not itself evidence of a shared calibration error. Conversely, two products may look different because they target different spatial footprints, not because one is faulty. The comparison needs a measurement model, not a rule that identical outputs are redundant and different outputs are independent.

Look downstream of the sensor

The 2025 Arctic observing-network assessment traces observations through processing and derived products into scientific assessments. It identifies reliance on specialist expertise and the work required to reconcile satellite transitions. That value-chain perspective matters because several apparently distinct datasets may depend on one calibration team, one algorithm, or one source archive.

A dependency account should therefore follow the observation through power, storage, transmission, quality control, processing, archiving, and publication. It should include people and institutions where they are genuinely critical. An undocumented correction performed by one experienced analyst can be a single point of failure even when every field instrument has a spare. The remedy might be retained expertise, shared procedures, or supported succession rather than more equipment.

Financial diversity also needs careful interpretation. Two projects with different names can depend on the

same annual funding decision. Two archives can be hosted by the same provider. Conversely, distinct funding routes may impose incompatible reporting burdens that weaken the underlying programme. Resilience is not maximised by multiplying contracts without examining whether maintenance, stewardship, and staff continuity are actually funded.

Evaluate a proposed removal against the requirement

One useful analytical exercise is to remove a candidate observing route from an historical reconstruction and examine what changes. Does regional uncertainty increase, does seasonal coverage collapse, or does a reference comparison disappear? Such an exercise can inform a choice, but it inherits the model's assumptions. If the reconstruction already interpolates confidently across an unobserved region, removing a station may appear harmless for the wrong reason.

The exercise should distinguish ordinary conditions from the conditions under which alternatives fail. A second route that adds little during routine operation may become valuable during cloud cover, a servicing gap, or a processing transition. The opportunity cost also matters: resources devoted to duplicating a well-observed site cannot simultaneously fill an unrelated gap. There is no universal answer, but there can be an explicit comparison.

Long records create another asymmetry. Closing a station may save an annual operating cost while permanently losing the chance to measure the transition into a new climate regime at that location. Restarting later cannot recreate the missing interval. This does not mean every historical site must be retained regardless of quality or purpose. It means the removal decision should account for irreversible information loss, not only next year's instrument inventory.

Authority is not a substitutable component

Network diagrams can become ethically misleading if they portray community-led observation or Indigenous knowledge as a spare sensor for an institutional gap. Different knowledge systems have their own purposes, governance, and responsibilities. The NOAA assessment recognises Indigenous-led monitoring alongside the need for meaningful investment and leadership. Technical complementarity does not confer permission to access knowledge or make one programme an interchangeable replacement for another.

A proposal relying on another organisation's observations must establish whether those observations are available for the intended use, maintained on an appropriate timescale, and shared under legitimate terms. A public catalogue entry is not a commitment to provide a fallback service. Resilience requires agreements that the

contributing parties can actually sustain, not assumptions quietly added to someone else's workload.

Limits and implication

The source assessment concerns a subset of indicators already supported well enough to appear in the Arctic Report Card. Its authors explicitly warn that this makes their assessed performance an upper estimate rather than a complete inventory of Arctic observing capacity. The fictional reliability model here is narrower still. It cannot rank actual investments or replace engineering, scientific, and governance review.

The central implication is to ask a more useful question than how many sensors exist: which required knowledge would disappear if this route failed, and what independent, authorised route could preserve it? Sometimes a second instrument is the answer. Sometimes the decisive investment is an overlap period, an analyst, a local archive, or a different site. Redundancy becomes defensible when it protects a named evidential function.

References

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