

Methods note · Wildlife and ecology

How cloud screening changes a seasonal greenness comparison

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ABSTRACT

Seasonal vegetation composites summarise retained observations, not an equally observed season. This methods note synthesises MODIS compositing guidance, Landsat quality-band documentation, and NOAA tundra-greenness methods to examine the interaction between cloud screening and ecological comparison. A fictional pixel history shows how an unseen peak can lower both observed maximum and available-observation mean without any underlying vegetation change. The analysis distinguishes seasonal statistics, selected observation dates, quality thresholds, reconstruction, changing spatial footprints, and cross-sensor support. It proposes coverage diagnostics and sensitivity comparisons that remain tied to the chosen question. No imagery is reprocessed and no published Arctic trend is re-estimated. The conclusion is that greenness results become more interpretable when observation timing, masks, and fitted values accompany the statistic rather than disappearing inside a seamless map.

Keywords: seasonal greenness · cloud masking · NDVI composites · observation timing · tundra remote sensing

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

The season a satellite was able to see

A seasonal greenness composite is not simply the landscape viewed without clouds. It is a statistic calculated from the observations that survived cloud screening and other quality rules. In one year those observations may include the vegetation peak; in another they may fall mainly before and after it. An apparent difference can therefore combine ecological change with a change in which parts of the season were visible. The central question is how to distinguish these contributions without pretending that the missing observations exist.

This methods note draws on the MODIS vegetation-index user guide, USGS Landsat quality-band documentation, and the NOAA Arctic Report Card tundra-greenness chapter. It examines screening, compositing, and temporal support rather than attributing an Arctic greening trend. All numerical pixel histories below are fictional. The synthesis does not reprocess satellite imagery or challenge a published result through an unperformed analysis.

Define the seasonal statistic first

Maximum vegetation index, mean growing-season index, integrated seasonal greenness, and estimated timing of green-up answer different questions. A maximum attempts to describe the strongest observed vegetation signal. A mean depends on how observations are distributed through time. An integral requires a time axis and treatment of gaps. A phenological date depends on the shape and coverage of the seasonal curve. None should be labelled simply annual greenness without its definition.

The NOAA tundra chapter explicitly reports maximum NDVI and identifies its sensor records, spatial masks, and observational periods. That is a useful reporting model. A comparison of annual maxima should not quietly be

interpreted as a comparison of whole-season carbon uptake, species diversity, or vegetation health. Even a robust spectral trend requires additional evidence to explain its ecological causes and consequences.

NDVI contrasts red and near-infrared reflectance. Snow, water, soil background, atmospheric contamination, view geometry, and vegetation structure influence the observed signal. A cloud mask removes some contaminated observations, but the retained record is not free of all these influences. A valid analysis therefore needs a target statistic, product-specific quality handling, and an account of residual limitations rather than an assumption that screening has solved the measurement problem.

A composite is a selection procedure

The MODIS vegetation-index user guide describes quality filtering and a constrained view-angle maximum-value approach for the relevant 16-day products. Candidate observations with high NDVI are considered along with view geometry. The guide also describes backup methods and differences among product resolutions and temporal aggregations. A user should not assume that a 16-day value is the arithmetic mean of sixteen daily measurements.

Different pixels within a composite can originate from different days. Neighbouring pixels can therefore depict different seasonal stages or weather histories even though they appear in one seamless image. The selected observation date and quality fields help reveal this. A regional mean can mix an early-season view in one subregion with a late-season view elsewhere. Spatial continuity in the image does not guarantee temporal simultaneity.

Landsat quality fields use bit-packed indicators for conditions including clouds, shadows, snow, and radiometric saturation. The USGS documentation shows why

the complete product-specific definitions matter: a clear flag does not mean that every other potentially unsuitable condition has been excluded. Applying a rule copied from another sensor or collection can retain contaminated data or remove useful observations. Quality screening should be explicit and versioned.

Worked example: an unseen peak

Fictional worked example. Suppose the actual NDVI at a pixel is 0.30 in early July, 0.60 in late July, and 0.40 in late August. For simplicity, assume both years have exactly this underlying sequence. Year A has acceptable observations at all three times. Year B has acceptable observations only in early July and late August because cloud obscures the late-July view. The observed annual maximum falls from 0.60 to 0.40 despite no change in the constructed vegetation history.

The arithmetic mean of the three observations in Year A is approximately 0.433. The mean of the two available observations in Year B is 0.35. Neither the maximum nor the available-observation mean provides an unchanged sampling of the season. The mean difference is not a time-weighted seasonal integral either, because the observations have not been assigned appropriate temporal support. Calculating a statistic correctly does not ensure that its interpretation is correct.

A linear interpolation between the two Year B observations would miss the peak in this example. A fitted seasonal curve might estimate one, but its height would depend on model assumptions and external information. It should be labelled a reconstruction, with uncertainty, rather than presented as the missing observation. More flexible curves do not solve the absence of constraints automatically; they can simply offer more ways to draw an unseen peak.

Now add a thin-cloud-contaminated observation with an anomalous index. A permissive screen might select it as the maximum; a stricter screen might remove it but also leave a long gap. This creates a trade-off, not a reason to abandon screening. Compare credible quality rules and observation coverage. Do not select whichever rule produces the most appealing trend and then describe it as an objective standard.

Missingness can have a seasonal and spatial pattern

Cloud is not generally distributed at random across a growing season or landscape. Coastal fog, topography, storms, and changing weather can affect observation availability. Snow-screening rules can remove the very transitions needed for phenology. Excluding all snow observations may be appropriate for peak summer greenness, while complicating a question about the start of the snow-free season. The same mask can serve one question and undermine another.

Summarise acceptable observation counts and dates alongside the derived index. A count alone is insufficient: ten observations clustered in June may constrain an August peak poorly. Useful diagnostics include the longest gap, observations near the expected peak, selected composite dates, and the fraction of the region meeting the

coverage rule. Examine whether these diagnostics change systematically between years or among terrain types.

A minimum-count threshold changes the spatial population if poorly observed pixels drop out. An apparently stable regional average may then describe a shifting subset of the tundra. Report both a consistent-footprint analysis where defensible and the coverage excluded by that choice. A fixed footprint helps comparability but can omit systematically cloudy environments; it is not automatically more representative of the entire region.

Match the comparison to a defensible temporal support

For a seasonal mean, one approach is to summarise within fixed time bins and combine bins with specified weights, rather than weighting dates by the number of clear acquisitions. Missing bins still require an explicit decision. For a maximum, require adequate observations near plausible peak timing or show sensitivity to their absence. For a trend, examine whether observation density and product changes could themselves produce a directional sampling effect.

Comparing multiple sensors can strengthen interpretation when their limitations differ, but does not make the records interchangeable. Spatial resolution, spectral response, acquisition timing, atmospheric correction, and compositing differ. Agreement among products that share inputs or processing assumptions is not fully independent confirmation. Disagreement should prompt examination of support and method before being assigned to an ecological mechanism.

Snow, water, and land masks also deserve temporal scrutiny. A permanent-water mask can maintain a stable analysis boundary while missing newly formed ponds; an annually changing water mask can remove real landscape change from the index population. The correct choice depends on whether the question concerns surviving vegetation, all ice-free land, or a fixed set of terrestrial pixels. Publish that choice so the reader knows what can change in the result.

Limits and a more informative greenness map

This note simplifies both vegetation seasonality and satellite processing. Real products combine atmospheric correction, quality rankings, viewing geometry, and several temporal stages. The worked example demonstrates a possible sampling artefact, not its frequency or magnitude in any actual Arctic record. Broad, long-term greening evidence cannot be dismissed solely because clouds exist. The relevant test is whether the documented processing and sensitivity analyses adequately constrain their effects.

A useful output pairs the greenness statistic with observation dates, coverage, masks, and a short explanation of how gaps were handled. Label fitted values separately from retained observations. Identify which ecological interpretation would require field evidence or a different seasonal statistic. This changes the question from whether the map looks convincingly green to whether the same part of the season was compared. That is a small

change in presentation with a large effect on what the result can responsibly mean.

References

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