

IceTrendr – Point

A web-enabled Landsat time series visualization and characterization tool

<http://icetrendr.oregonstate.edu/public/>

For more information contact:

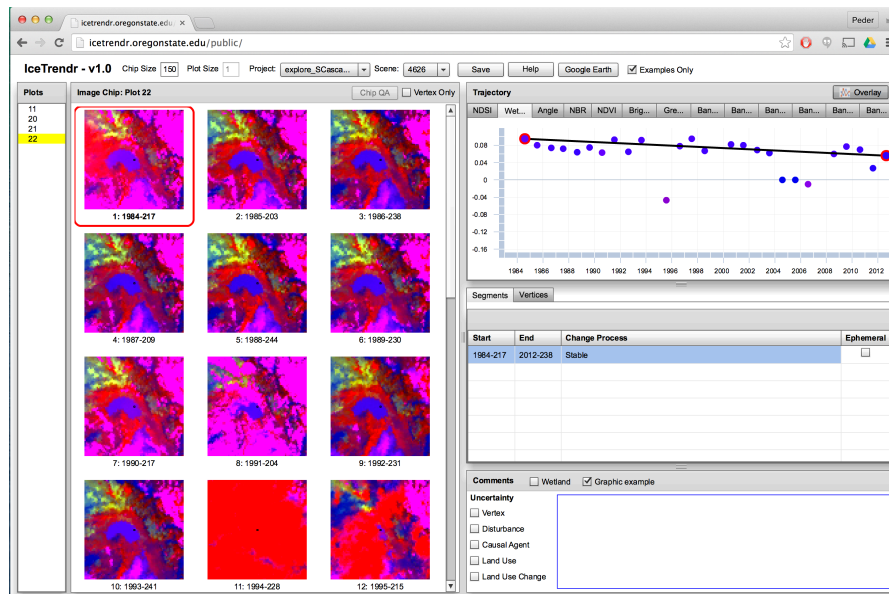
Peder Nelson

peder.nelson@oregonstate.edu

iceTrendr.peder@gmail.com

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IceTrendr is developed to help address the challenge of determining rates of change in paraglacial landscapes and characterize how far they have advanced along the trajectory from glacial to non-glacial landscapes.



This document describes the IceTrendr approach to label plot-level Landsat time series segmentations. For any given plot, the IceTrendr Web Attribution Tool is used to visualize and temporally segment the data series. Segmentation, in this context, is defined by vertices and segments. The segments are approximately linear spectral trends that comprise a full temporal spectral trajectory, and are associated with surface changes occurring throughout the time period of the series. Each segment is constrained by start and end vertices that identify the time stamp of the segment, and describe the land use and land cover of the plot at each vertex. For further descriptions of both the conceptual approach to and the application of temporal segmentation refer to Cohen et al. (2010) and Kennedy et al. (2010).

Land Function (Use)

- **Ice - Glacier**
- **Snow**
- **Tundra**
- **Barren land**
- **Water**
- **Vegetated**
- **Urban**

Definitions:

Described in <http://landcover.usgs.gov/pdf/anderson.pdf>

Ice – Glacier = Glacial ice originates from the compaction of snow into firn and finally to ice under the weight of several successive annual accumulations. Refrozen melt water usually contributes to the increasing density of the glacial ice mass. With sufficient thickness, weight, and bulk, flow begins, and all glaciers exhibit evidence of present or past motion in the form of moraines, crevasses, and so forth.

Where the snowline of adjacent ice-free areas extends across the glacier, it is known as the firn limit, which represents the dividing line between the glacier's two major zones, the zone of accumulation and the zone of ablation. While glaciers normally are recognized easily, certain glacial boundaries may be subject to misinterpretation, even by the experienced interpreter. Flow features upglacier from the firn limit typically are obscured by fresh snow, forcing the image interpreter to depend on secondary information such as valley shape or seek a more discriminating sensor. Similarly, morainal material may cover the terminus (or snout) of the glacier because of ablation, making boundary determination in that vicinity difficult. This latter problem occasionally is compounded by the presence of considerable vegetation rooted in the insulating blanket of ablation moraine.

Further subdivision of glacial occurrences, mainly on the basis of form and topographic position, would include: small drift glaciers (sometimes called Uralttype or cirque glaciers); valley glaciers (also called mountain or alpine glaciers); piedmont glaciers; and icecaps (or ice sheets).

Other features have somewhat the surface form of true glaciers, such as "rock glaciers." Since these are composed primarily of fragmented rock material together with interstitial ice, they are classified as Bare Exposed Rock.

Snow = Perennial Snowfields are accumulations of snow and firn that did not entirely melt during previous summers. Snowfields can be quite extensive and thus representative of a regional climate, or can be quite isolated and localized, when they are known by various terms, such as snowbanks.

The regional snowline is controlled by general climatic conditions and closely parallels the regional 32 degrees F (0oC) isotherm for the average

temperature of the warmest summer month. The use of the term "line" is somewhat misleading, because the "snowline" represents an irregular transitional boundary, which is determined at any single location by the combination of snowfall and ablation, variables which can change greatly within short distances because of changes in local topography and slope orientation. Small isolated snowfields occurring in protected locations can develop into incipient or nivation cirques, which become gradually hollowed by the annual patterns of freezing and thawing, aided by downslope movement of rock material. They are circular to semicircular and often develop ridges of mass-wasted materials called protalus ramparts at their downslope margins. As Flint (1957) has pointed out, "Such cirques, of course, are not in themselves indication of glaciation, they indicate merely a frost climate."

Snowfields can normally be distinguished from the following Glacier category by their relative lack of flow features.

Tundra = Tundra is the term applied to the treeless regions beyond the limit of the boreal forest and above the altitudinal limit of trees in high mountain ranges. In the United States, tundra occurs primarily in Alaska, in several areas of the western high mountain ranges, and in small isolated locations in the higher mountains of New England and northern New York. The timber line which separates forest and tundra in alpine regions corresponds to an arctic transition zone in which trees increasingly are restricted to the most favorable sites. The vegetative cover of the tundra is low, dwarfed, and often forms a complete mat. These plant characteristics are in large part the result of adaptation to the physical environment one of the most extreme on Earth, where temperatures may average above freezing only 1 or 2 months out of the year, where strong desiccating winds may occur, where great variation in solar energy received may exist, and where permafrost is encountered almost everywhere beneath the vegetative cover.

The number of species in the tundra flora is relatively small compared with typical middle- and low latitude flora, and this number of species decreases as the environment becomes increasingly severe with changes of latitude and altitude. The tundra vegetation consists primarily of grasses, sedges, small flowering herbs, low shrubs, lichens, and mosses. The vegetative cover is most luxuriant near the boreal forest, with the ground surface usually being completely covered. As the plant cover becomes sparse, shrubs become fewer and more bare areas occur. Species diversity is lowest near the boundaries of permanent ice and snow areas, where only isolated patches of vegetation occur on the bare ground surface.

The vegetation of the tundra is closely associated with other environmental factors. Minor manmade disturbances, as well as micro-environmental changes over short distances, can have significant effects. Minor changes in available moisture or wind protection, for example, can result in different plant associations. Similarly, man's activity in the tundra may engender new drainage patterns with resultant changes in plant community or erosion characteristics (Price, 1972).

The boundaries between Tundra, Perennial Snow or Ice, and Water are best determined by using images acquired in late summer. The Forest Land/Tundra

boundary in the Arctic tends to be transitional over a wide area and characterized by either incursion of forests where site improvement occurs, as along the flood plains or river valleys, or by increasing environmental severity, as on exposed dry uplands. This Forest Land-Tundra boundary is much easier to delineate in alpine areas. The Barren Land Tundra interface occurs where one or more of the environmental parameters necessary for vegetation growth is deficient and also would be determined best with late-summer imagers.

Using the results of various investigations, Level II categories of Tundra based primarily on what is interpretable from remote sensor image signatures are: Shrub and Brush Tundra, Herbaceous Tundra, Bare Ground Tundra, Wet Tundra, and Mixed Tundra.

Barren land = Barren Land is land of limited ability to support life and in which less than one-third of the area has vegetation or other cover. In general, it is an area of thin soil, sand, or rocks. Vegetation, if present, is more widely spaced and scrubby than that in the Shrub and Brush category of Rangeland. Unusual conditions, such as a heavy rainfall, occasionally result in growth of a short-lived, more luxuriant plant cover. Wet, nonvegetated barren lands are included in the Nonforested Wetland category.

Land may appear barren because of man's activities. When it may reasonably be inferred from the data source that the land will be returned to its former use, it is not included in the Barren category but classified on the basis of its site and situation. Agricultural land, for example, may be temporarily without vegetative cover because of cropping season or tillage practices. Similarly, industrial land may have waste and tailing dumps, and areas of intensively managed forest land may have clear cut blocks evident.

When neither the former nor the future use can be discerned and the area is obviously in a state of land use transition, it is considered to be Barren Land, in order to avoid inferential errors.

Level II categories of Barren Land are: Dry Salt Flats, Beaches, Sandy Areas other than Beaches; Bare Exposed Rock; Strip Mines, Quarries, and Gravel Pits; Transitional Areas; and Mixed Barren Land.

Water = The delineation of water areas depends on the scale of data presentation and the scale and resolution characteristics of the remote sensor data used for interpretation of land use and land cover. (Water as defined by the Bureau of the Census includes all areas within the land mass of the United States that persistently are water covered, provided that, if linear, they are at least 1/8 mile (200 m) wide and, if extended, cover at least 40 acres (16 hectares) .) For many purposes, agencies need information on the size and number of water bodies smaller than Bureau of the Census minimums. These frequently can be obtained from small-scale remote sensor data with considerable accuracy.

Vegetated = Lands where vegetation is growing.

Urban = For IceTrendr, these are areas that are human impacted including research facilities, buildings, or permanent camps. Urban or Built-up Land is comprised

of areas of intensive use with much of the land covered by structures. Included in this category are cities, towns, villages, strip developments along highways, transportation, power, and communications facilities, and areas such as those occupied by mills, shopping centers, industrial and commercial complexes, and institutions that may, in some instances, be isolated from urban areas.

As development progresses, land having less intensive or nonconforming use may be located in the midst of Urban or Built-up areas and will generally be included in this category. Agricultural land, forest, wetland, or water areas on the fringe of Urban or Built-up areas will not be included except where they are surrounded and dominated by urban development. The Urban or Builtup category takes precedence over others when the criteria for more than one category are met. For example, residential areas that have sufficient tree cover to meet Forest Land criteria will be placed in the Residential category.

Land Cover

- Ice – glacier debris covered
- Ice – glacier
- Ice – iceberg
- Ice – glacier crevasses
- Snow - glacier
- Snow - seasonal
- Rock moraine – terminal
- Rock moraine –lateral
- Rock moraine – medial
- Rock – nunatak or horn
- Rock
- Water – supraglacial lake
- Water - supraglacial river
- Water – proglacial lake (high turbidity)
- Water – proglacial lake(low turbidity)
- Water – proglacial braided channels
- Water
- Vegetated
- Vegetated - trees
- Urban

Definitions:

Ice – glacier debris covered = (aka Rock glacier) looks like a [mountain glacier](#) and has active flow; usually includes a poorly sorted mess of rocks and fine material; may include: (1) interstitial ice a meter or so below the surface (“ice-cemented”), (2) a buried core of ice (“ice-cored”), and/or (3) rock debris from avalanching snow and rock.



Frying Pan Glacier, Colorado, is almost entirely covered by rocks and debris in this photograph from 1966. (Photo courtesy of George L. Snyder, archived at the World Data Center for Glaciology, Boulder, CO.) <http://nsidc.org/cryosphere/glossary-terms/glaciers?page=15>

Ice – glacier

Ice – iceberg

Ice – glacier crevasses

Snow - glacier

Snow - seasonal

Rock moraine – terminal =

Including:

moraine – push = moraine built out ahead of an advancing glacier.
(<http://nsidc.org/cryosphere/glossary-terms/glaciers?page=14>)

Rock moraine – lateral = a ridge-shaped moraine deposited at the side of a glacier and composed of material eroded from the valley walls by the moving glacier.
(<http://nsidc.org/cryosphere/glossary-terms/glaciers?page=12>)

Rock moraine – medial = a ridge-shaped moraine in the middle of a glacier originating from a rock outcrop, [nunatak](#), or the converging lateral moraines of two or more ice streams. . (<http://nsidc.org/cryosphere/glossary-terms/glaciers?page=12>)

Rock – nunatak or horn = surrounded by glacier

Horn - a peak or pinnacle thinned and eroded by three or more glacial cirques.,

Nunatak - a rocky crag or small mountain projecting from and surrounded by a glacier or ice sheet.

Rock =

Water-supraglacial lake = standing water on surface of glacier ice

Water – supraglacial river =

Water-proglacial_highTurbidity =

Water-proglacial_lowTurbidity =

Water – proglacial braided channels = newly deglaciated areas comprised of rock till and outlet streams

Water =

Vegetated =

Vegetated – trees =

Urban = areas impacted by humans. Examples include research base camps, airport landing strips.

Change Process

Stable	Water - fluvial changes
Glacier retreat	Water - supraglacial
Glacier advance	Water - proglacial
Albedo increase	Water - glacier moulin
Albedo decrease	Water
Glacier - reconstituted	Vegetation growth
Debris flow	Other disturbance
Water - outburst flood	Other non-disturbance

Change Process Definitions:

Stable = where no ecological change is evident in the spectral segment

Glacier Retreat = when a mountain glacier's terminus doesn't extend as far downvalley as it previously did; occurs when ablation surpasses accumulation. <http://nsidc.org/cryosphere/glossary/R>

Glacier Advance = when a mountain glacier's [terminus](#) extends farther downvalley than before; glacial [advance](#) occurs when a glacier flows downvalley faster than the rate of ablation at its [terminus](#).
<http://nsidc.org/cryosphere/glossary/A>

****Glacial Surge** = event defined by 'glacier advance' and 'glacier retreat' segments. A glacier that experiences a dramatic increase in flow rate, 10 to 100 times faster than its normal rate; usually surge events last less than one year and occur periodically, between 15 and 100 years.
<http://nsidc.org/cryosphere/glossary-terms/glaciers?page=16>

Albedo increase = primarily due to new snow deposition.

Albedo decrease = There are many reasons why albedo of the Earth's surface may decrease, including

- Declining albedo (glacier debris covered)
- Declining albedo (wind transported dust)
- Declining albedo (supraglacial meltwater)
- Declining albedo (snow metamorphosis)

Glacier - reconstituted = glacier that is reconstructed or reconstituted out of other glacier material; usually formed by seracs falling from a [hanging glacier](http://nsidc.org/cryosphere/glossary-terms/glaciers?page=7), then re-adhering (<http://nsidc.org/cryosphere/glossary-terms/glaciers?page=7>)

Water - outburst flood (jökulhlaup) =

(1) a large [outburst flood](http://nsidc.org/cryosphere/glossary-terms/glaciers?page=11) that usually occurs when a glacially dammed lake drains catastrophically (2) any catastrophic release of water from a glacier.

<http://nsidc.org/cryosphere/glossary-terms/glaciers?page=11>

Outburst flood = any catastrophic flooding from a glacier; may originate from trapped water in cavities inside a glacier or at the margins of glaciers or from lakes that are dammed by flowing glaciers.

Water – fluvial changes = newly deglaciated areas with dynamic changes directly due to melt water from glacier

Water - glacier moulin = a nearly vertical channel in ice that is formed by flowing water; usually found after a relatively flat section of glacier in a region of transverse crevasses; also called a [pothole](http://nsidc.org/cryosphere/glossary-terms/glaciers?page=12).

<http://nsidc.org/cryosphere/glossary-terms/glaciers?page=12>

Water – supraglacial =

Water = water was the main process

Vegetation growth = process of vegetation growth of any type including herbaceous, shrub, and trees.

Other disturbance = any disturbance not listed above. There must be further description in the comment field

Other non-disturbance = any segment whose

References

Cohen, W.B., Z. Yang, and R.E. Kennedy. 2010. Detecting trends in forest disturbance and recovery using yearly Landsat time series: 2. TimeSync - Tools for calibration and validation, *Remote Sensing of Environment* 114:2911-2924.

Kennedy, R.E., Z. Yang, and W.B. Cohen. 2010. Detecting trends in forest disturbance and recovery using yearly Landsat time series: 1. LandTrendr - Temporal segmentation algorithms, *Remote Sensing of Environment* 114:2897-2910.