IceTrendr - Pixel

A Landsat data visualization tool for monitoring glacier ecosystems

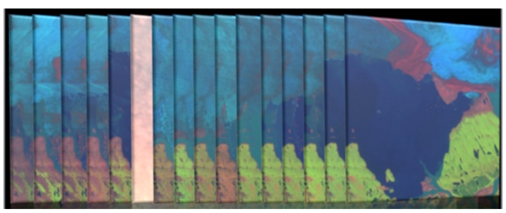
http://pixel.icetrendr.oregonstate.edu/

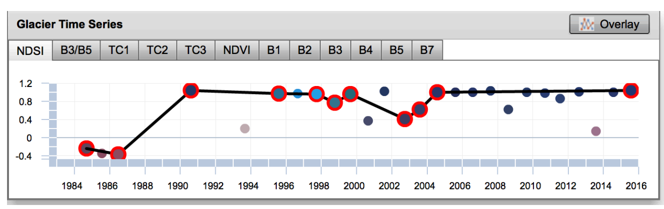
Pixel Segmentation and Vertices Instructions

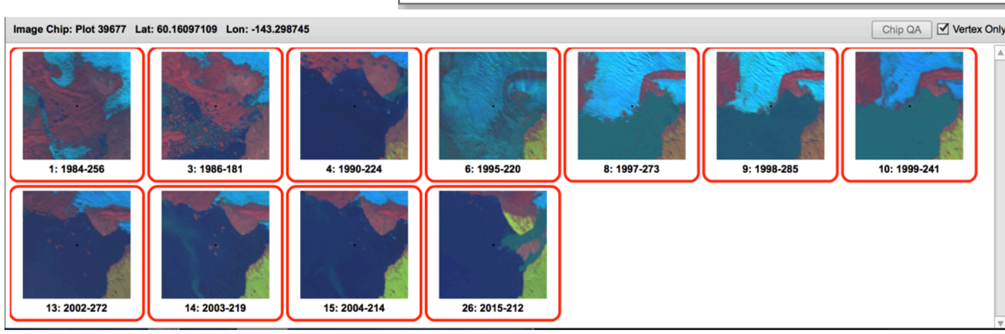
INTRODUCTION

Using the 1984-2015 Landsat satellite imagery as the primary information source, we want to observe and describe how the land cover changes through time. Using a pixel as the plot extent (30m x 30m), we want to identify important dates, label land cover at these times, and describe the land cover process between these important dates. We want to know what was there at the first satellite observation, the last satellite observation, what happened between these observations, how confidant you are in your determination, and why.

For each listed plot, the goal is to create a glacier time series that reflects the land cover process(es) expressed in the 1984-2015 Landsat image chips, glacier time series graph, high resolution imagery in Google Earth, and other ancillary data. This is done in a process called 'segmentation' which creates a series of approximately linear segments across the Landsat time series. A segment is composed of a 'start date' vertex and 'end date' vertex where a vertex is defined as an important Landsat image determined by the interpreter. Each date is given a land cover label and then the land cover process between these two points is described.







Additional background details can be found in Cohen et.al.(2010), Kennedy et.al.(2010), Kennedy et.al.(2015).

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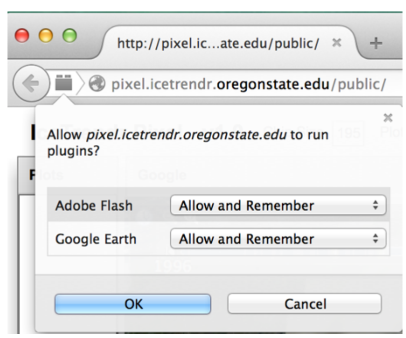
OVERVIEW

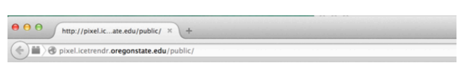
Prior to using IceTrendr, you will need to obtain a login and password by contacting Peder Nelson (peder.nelson@oregonstate.edu).

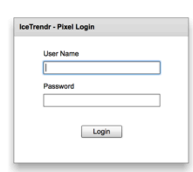
You may also use a guest login if you prefer but note that this profile is available to other users and therefore other users could overwrite any data:
Login: guest
Password: IsWelcome!

In your browser, navigate to: http://pixel.icetrendr.oregonstate.edu/. At present, Firefox browser is the preferred browser because Chrome is now blocking the required Google Earth plug-in. Make sure you have the Google Earth plug-in added to your browser (https://www.google.com/earth/explore/products/plugin.html). Note you may need to 'allow' the plug-in when you first visit the website.



a. Log in to website, using your assigned user name or 'guest'





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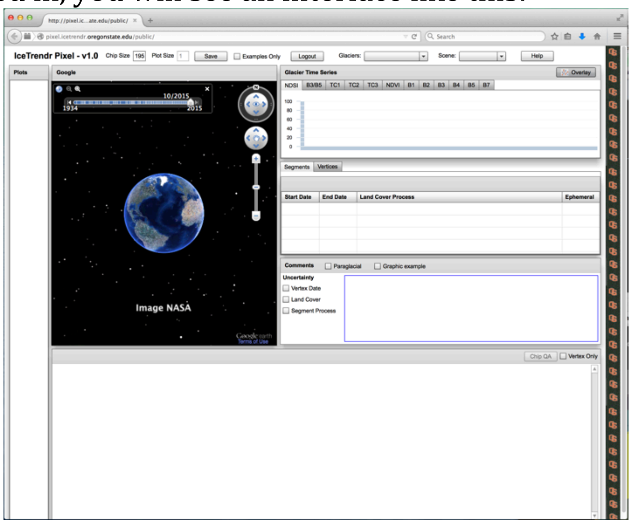
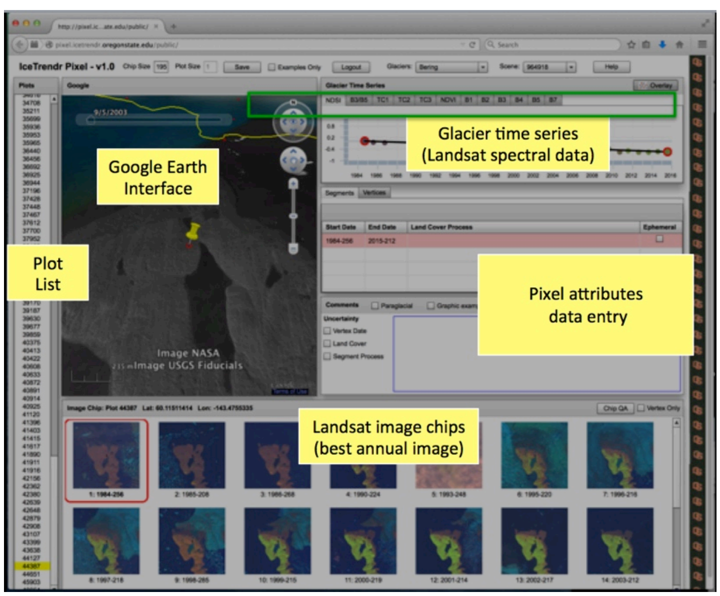
1. Once logged in, you will see an interface like this:



IceTrendr-Pixel interface components

There are four main components to the web interface, which will be discussed in sequence: The ***Google Earth interface*** (center), the **Landsat image chips** (bottom), the **pixel attributes data entry** (center right), and the **glacier time series graph** (upper right).



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Google Earth interface (center)

Key purpose is to assess the context of the Landsat pixel (or 3x3, 5x5 Landsat pixels) relative to the imagery in the Google Earth interface with the ability to navigate a virtual globe.

1. Here, you can see the pixel of interest overlaid on high spatial resolution satellite imagery or air photos.
2. Use the slider bar at the top to see historical imagery.
3. As with Google Earth, you can tilt, zoom, pan, etc. (see controls here).

Pixel attributes data entry (center right)

Key purpose is to guide interpretation and record attributes to a database

a. Using the drop-down menus, select from list of labels that describes the type of glacier changes observed in the image chips, Google Earth, and temporal trajectory.
b. Your selections are saved if you click "Save" or if you move on to a different plot.
c. Rules and guidance for assigning these labels on page 10.

Glacier time series graph (upper right)

Key purpose is to view the spectral data measured by the Landsat satellite. Using the location of the value on the y-axis and how that pixel moves along the x-axis is related to the land cover and the segment process. Since Landsat data is composed of 6 bands of information, use the different index values to create a multi-view understanding of how the polygon area graphs over time.

a. This shows the temporal trajectory of the pixel.
b. The spectral trajectory quantifies the story of the pixel from Landsat's perspective. Different indices can be selected using the tabs (i.e. NDSI, Band3/5, TC1, TC2, TC3, etc.). These may tell slightly different stories.
c. If you need to zoom into a particular Y-value range, either right-click or select "plot stretch" or "global stretch" and use the mouse left-click and drag a box to define the new bounds of Y values.

Landsat image chips (bottom)

Key purpose is to view a zoomable series of 1984-2015 Landsat images for the polygon location. These images are false color combinations, which highlight glacier features while keeping many features similar to a natural color image.

a. These are extractions of the Landsat data we have used in the automated segmentation.
b. Use the mouse wheel roller while hovering over an image chip to zoom in or out. (*note this only works on Windows OS)

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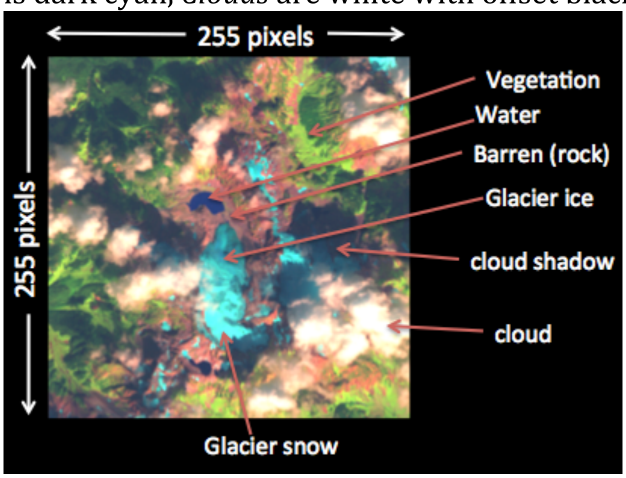
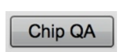
c. The dates of the image are in the format YYYY-DDD, where DDD is the calendar day of year (starts with 1 on January 1st). Here's a lookup table.

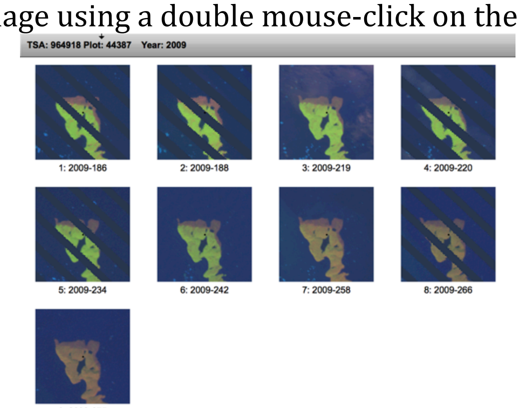
d. Color interpretation requires that you know how to interpret Landsat imagery in this false color band combination (red=band 5, green=band 4, blue=2).

e. As you zoom into the center of the image chip, you will need to use your understanding of color theory and your imagination to recognize true ecological changes that are visible in this view of the Landsat imagery because each pixel is 30m x 30m and comprised of multiple land cover types at certain resolutions.

f. The images are created to create false color images using Landsat bands 5, 4, 2. Generally speaking: *Vegetation* is green, *Water* is blue, *Rock/soil* is red, *Glacier ice* is dark cyan, *Clouds* are white with offset black shadows, and *Snow* is bright cyan.



g. Use the 'Chip QA' button  to view the imagery available for that particular year. This opens a window, allowing you to replace the default image using a double mouse-click on the image of your choice.



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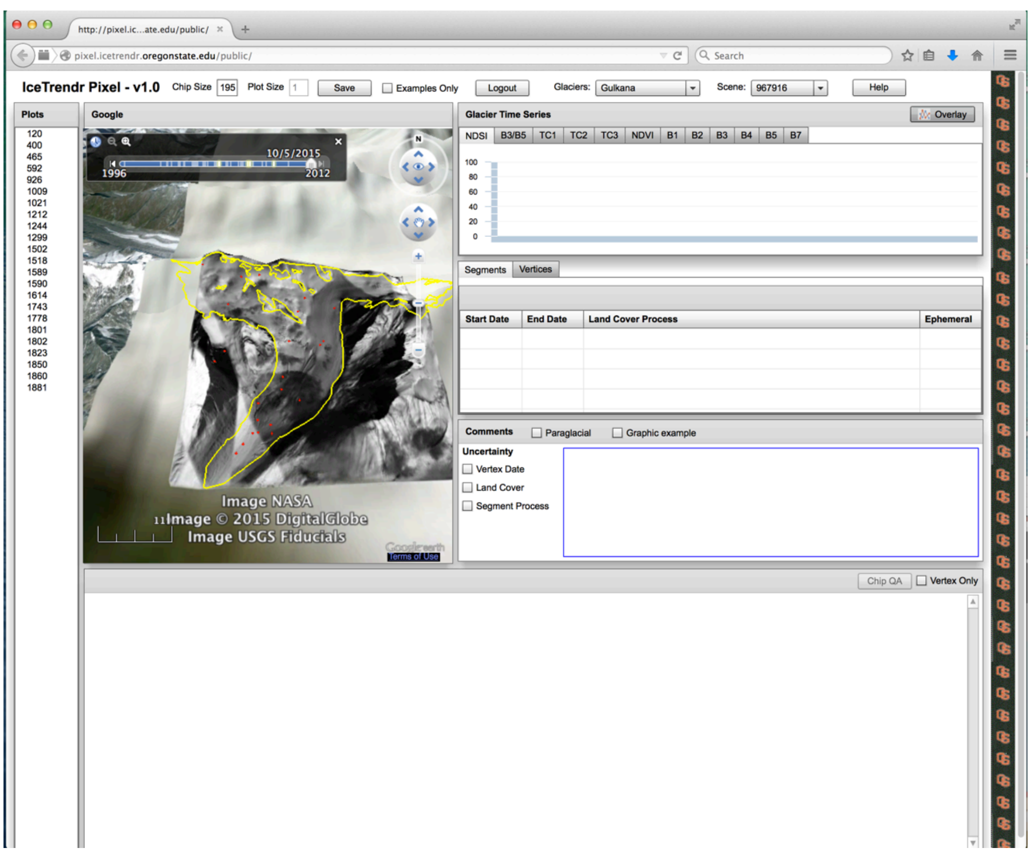
2. **Select a 'Glacier', and then select the 'Scene'.**
    a. Currently, we have five glaciers loaded: South Cascade (WA), Wolverine (AK), Gulkana (AK), White (Canada), and Bering (AK).

    b. 'Scene' is the WRS2 Landsat path/row. It is in the format of a 6-digit number where the first three digits are the path number and the second three digits are the row number (eg '046026 = path 46, row 26)). Some glaciers span multiple path/rows, so we need to specify which one is the focus. Note, that if there is a leading '9' value in the path/row it denotes a glacier that consists of overlapping path or rows (eg '946926') which maximizes Landsat observations.

    c. Once you have selected those values, the list of plot numbers will populate the 'Plots' column. Each plot, defined by the Landsat pixel neighborhood defined in the 'Plot Size' value, has a red outline. The yellow line indicates the GLIMS glacier outline.



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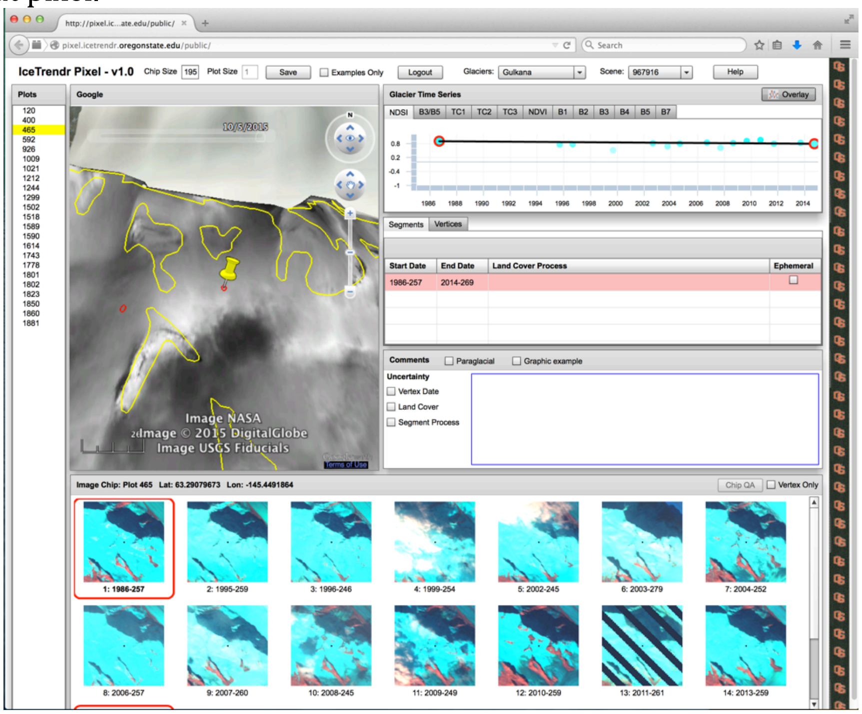
3. **Select a plot** by clicking a value with the mouse. The interface will become populated. In the Google Earth interface, you will notice a yellow pushpin representing the location of the data rendered in the Glacier time series graph. It is approximately the center of the Landsat pixel.



4. **Begin interpretation as follows.**
   a. Examine the Landsat image chips (zooming in & out for context).
   b. Examine the polygon and neighborhood in Google Earth using the available high resolution and historical imagery.
   c. Determine the conceptual land cover and processes for this plot.

>Task 1: select best images for glacier time series graph.

In this first task, you will review the image chips for each year to insure the best one is selected *cloud free, *fits best with other years in terms of phenology or overall land cover, *minimizes topographic shadow, and *is no longer glacier ice (if retreat is visible within a Chip QA window).

a. Go to **first** image: use ‘Chip QA’ to select best image for this year.
b. Go to **last** image: use ‘Chip QA’ to select best image for this year.
c. Review all intermediate images, replace default images to achieve the best annual images that are:

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>Task 2: create additional vertex points (as needed) to create linear segments.

Once the images are selected in Task 1, your next task is to review the Landsat image chips and glacier time series graph to determine if additional vertex points (important dates) need to be added to the default linear trajectory. Vertex dates are noted with red outlines in both the Landsat image chips and glacier time series graph.

a. Go to **first** image chip: if the image is 'bad data' (i.e. cloud, missing data), move the vertex to the next good sequential image. Otherwise, move to step (b).
b. Go to **last** image: if the image is 'bad data' (i.e. cloud, missing data, ETM+ scanline), move the vertex to the next good prior image.
c. View all intermediate image chips and glacier time series graph, add vertices at influential years.
d. Review added vertices to make sure you are comfortable with your determination.

>Task 3: Label the vertices 'land cover'

Your next task is to identify the land cover type that dominates the pixel in each vertex image you selected and enter into the data entry fields. Click the Vertices tab, if needed.

a. Go to the **first** date listed:
b. Iterate through step (a) for each date listed.
c. Review your decisions

>Task 4: Label the segments 'land cover process'

In this task you will label the intent or the reason for the land cover change in the 'Start Date' and 'End Date' vertices. If you are unsure of the reason for the land cover process, make note in the comments (task 5). If you use the 'Other' category, describe your rationale in the comments block.

a. Go to **first** Land Cover Process drop down menu:
b. Iterate through step a for each segment listed.
c. Review your decisions

>Task 5: add Comments, identify examples.

Your next task is to identify uncertainties associated with your decisions. Also, at this time, note whether this pixel is something that should be identified as a graphic example or is a paraglacial feature. Use the comment box to explain any nuances to this plot that will help others understand the landscape dynamics and land cover at this location.

>Task 6: Review your data entry save.

Your final task is to review that all your data entry for each vertex, and segment is complete. When satisfied, use the Save button to send to database.

5. **Select next plot in list, repeat interpretation process (steps 4 & 5) until all plots are complete.**

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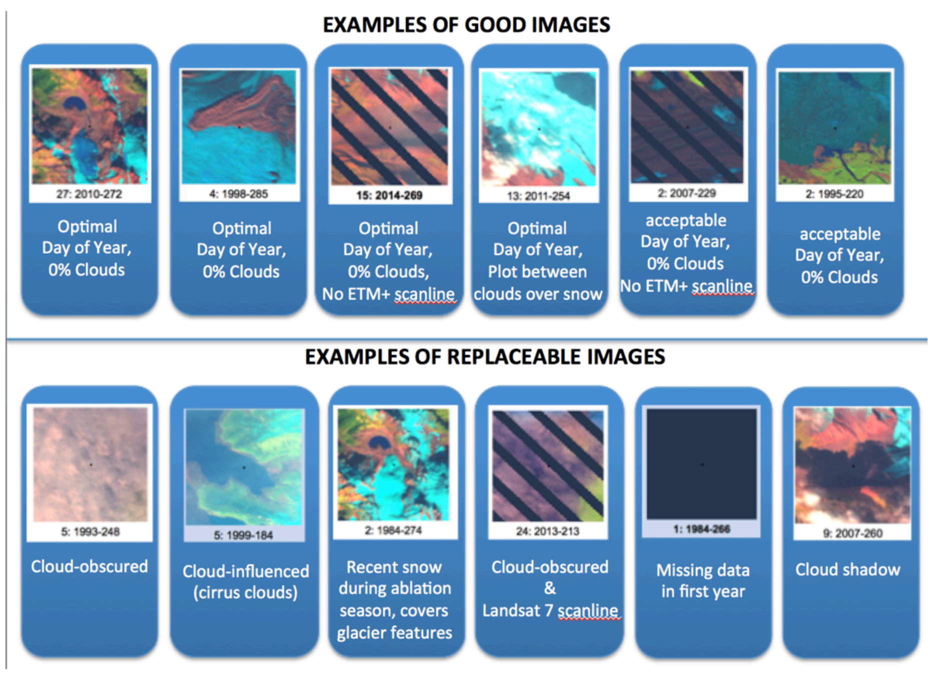
TASK 1: SELECT BEST IMAGES FOR GLACIER TIME SERIES GRAPH

Your task is to review the default image chips selected for each year. The default image selected is the Landsat image closest to the glacier's 'target date' (same day of year that is late in ablation season) that is cloud-free and is not within a Landsat 7 scanline. You need to review the default image chip selection in order to insure that the Landsat data selected *actually* *minimizes cloud obstruction of the pixel, *fits best with other years in terms of phenology or overall land cover, *minimizes topographic shadow, and *is no longer glacier ice (if retreat is visible within a Chip QA window). Be aware, that glacier environments, in particular, are susceptible to recent snow cover that obscures glacier features and therefore may require a different image chip selection from the default.



a. Go to **first** image: use Chip QA to select best image for this year.

b. Go to **last** image: use Chip QA to select best image for this year.

c. Review all intermediate images, use Chip QA to replace default images to achieve the best annual images that are:
   *Near the end of the ablation season
   *Cloud-free
   *Image is in same phenological period as adjacent images

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TASK 2: CREATE ADDITIONAL VERTEX POINTS (AS NEEDED) TO CREATE LINEAR SEGMENTS.

Once the images are selected in Task 1, your next task is to review the Landsat image chips and glacier time series graph to determine if additional vertex points need to be added to the default linear trajectory as you identify changes to the land cover. Vertex dates are noted with red outlines in both the Landsat image chips and glacier time series graph.

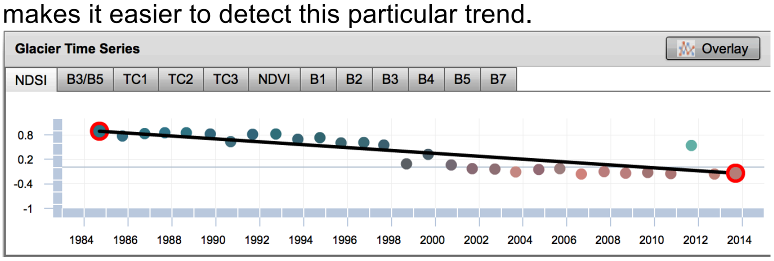
Add vertex by using a mouse double-click on the image chip. This will add a red outline indicating it is now a vertex. To remove an image chip as a vertex, use your mouse to double left-click on the image chip.

a. Go to **first** image chip: if the image is 'bad data' (i.e. cloud, missing data), move the vertex to the next good sequential image. Otherwise, move to step (b).

b. Go to **last** image: if the image is 'bad data' (i.e. cloud, missing data, ETM+ scanline), move the vertex to the next good prior image.

c. View all intermediate image chips and glacier time series graph, add vertices at influential years where:
   - land cover changes from one land cover value to anther. This is recognized primarily by color changes to graph data points and in the image chips.
     Examples include:
     - = Glacier ice, snow covered *or* Snow, seasonal
     - = Glacier ice, debris covered
     - = Rock *or* Moraine, terminal
   - the data is divided into approximately linear segments

     In this example, the Glacier Time Series graph displayed using NDSI shows a continuous downward trend of data points. The linear overlay between the start date and end date, makes it easier to detect this particular trend.



d. Review added vertices to make sure you are comfortable with your determination.

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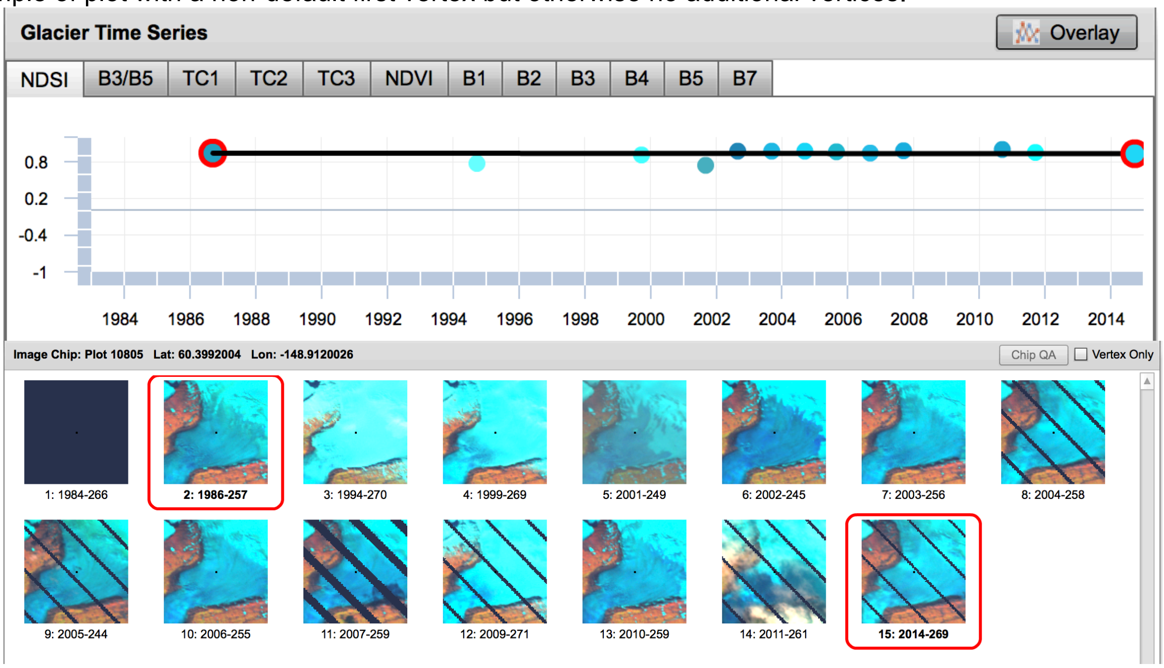
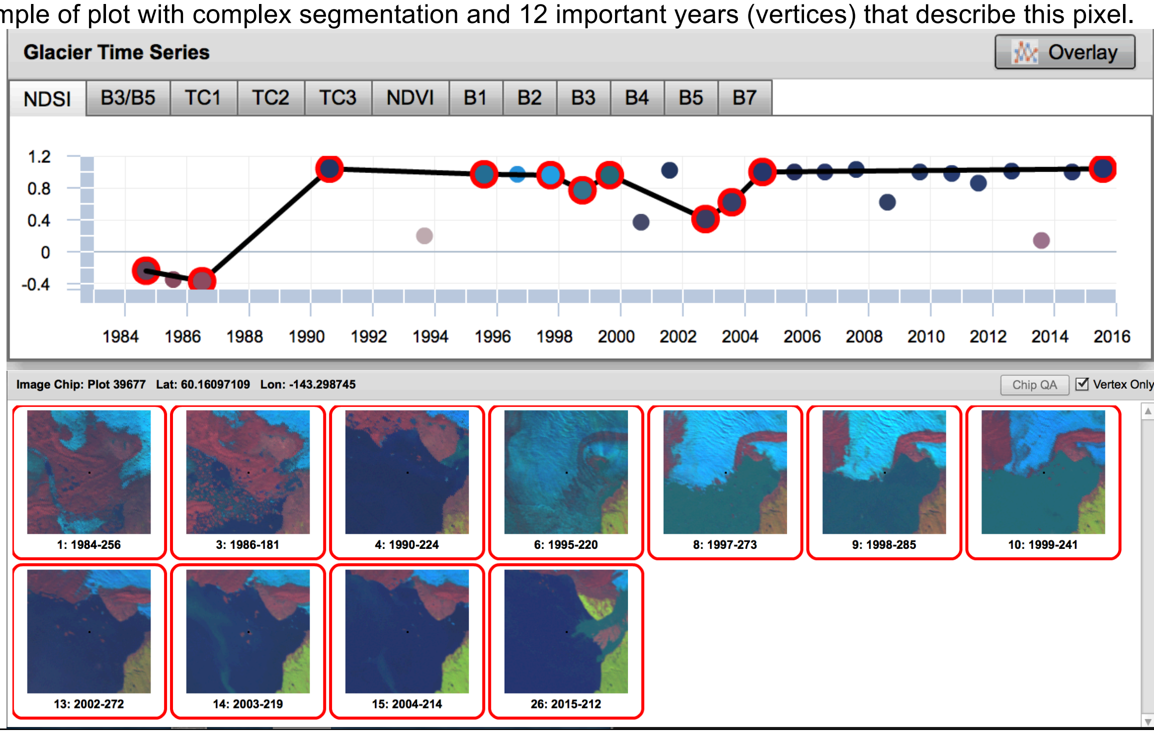
Example of plot with a non-default first vertex but otherwise no additional vertices.



Example of plot with complex segmentation and 12 important years (vertices) that describe this pixel.



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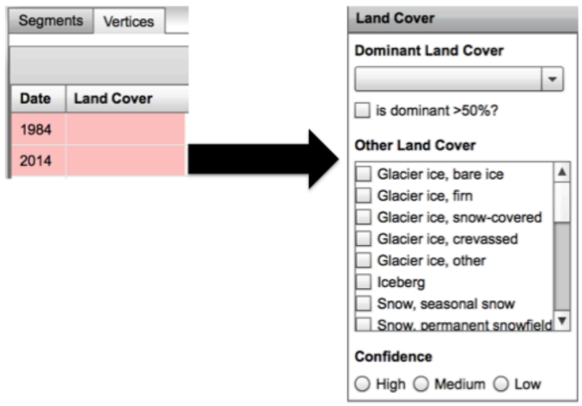
TASK 3: LABEL THE VERTICES 'LAND COVER'.

Your next task is to identify the land cover type that dominates the pixel in each vertex image you selected and enter into the data entry fields. Click the Vertices tab, if needed.



a. Go to **first** the first Date listed:
   - enter the dominant land cover type.
   - Check the 'Is dominant >50%' box (if appropriate),
   - select 'Other Land Cover' (as appropriate)
   - select your 'Confidence' level in determining these labels

b. Iterate through step a for each Date listed.

c. Review your decisions

For more information on Land cover definitions, see the document at [LandCover_IceTrendr_Pixel.pdf](http://pixel.icetrendr.oregonstate.edu/public/LandCover_IceTrendr_Pixel.pdf) (http://pixel.icetrendr.oregonstate.edu/public/LandCover_IceTrendr_Pixel.pdf).

Glacier ice, bare ice
Glacier ice, firn
Glacier ice, snow-covered
Glacier ice, debris-covered
Glacier ice, crevassed
Glacier ice, other

Iceberg

Snow, seasonal snow
Snow, permanent snowfield

Moraine, terminal
Moraine, lateral
Moraine, medial

Rock, nunatak
Rock, horn
Rock, other

Water, supraglacial melt pond or lake
Water, supraglacier stream
Water, proglacial lake, high turbidity
Water, proglacial lake, low turbidity
Water, proglacial braided channels
Water, other

Vegetation, shrub
Vegetation, trees
Vegetation, other

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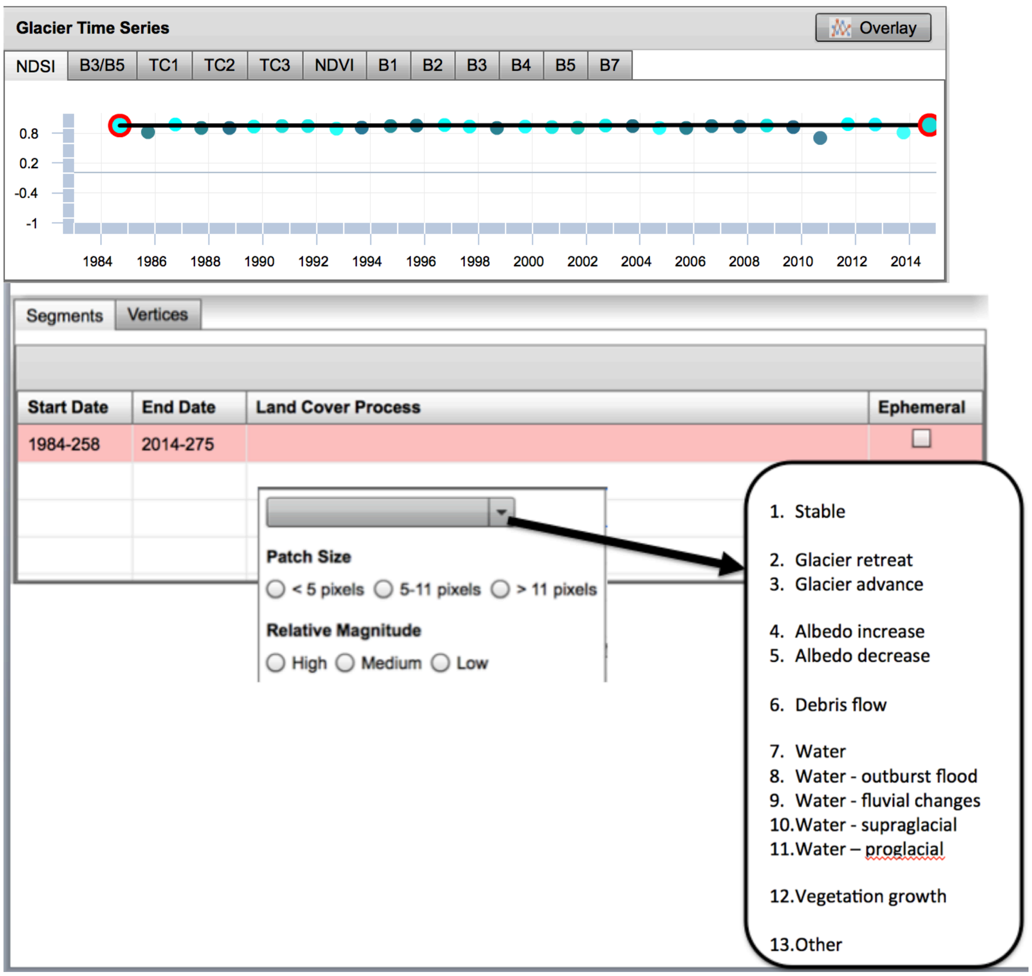
TASK 4: LABEL THE SEGMENTS 'LAND COVER PROCESS'.

In this task you will label the intent or the reason for the land cover change in the 'Start Date' and 'End Date' vertices. If you are unsure of the reason for the land cover process, make note in the comments (task 5). If you use the 'Other' category, describe your rationale in the comments block.



a. Go to **first** Land Cover Process drop down menu:
- Select a land cover process from the options available.
- Select the whether the pixel is within a larger patch area also undergoing the same land cover process, noting the size (<5, 5-11, >11 Lansdat pixels)
- select the Relative Magnitude of the land cover process, using the graph values as a guide.

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b. Iterate through step a for each segment listed.

c. Review your decisions

For more information on Land cover definitions, see the document at LandCover_IceTrendr_Pixel.pdf (http://pixel.icetrendr.oregonstate.edu/public/LandCover_IceTrendr_Pixel.pdf).

1. Stable

2. Glacier retreat
3. Glacier advance

4. Albedo increase
5. Albedo decrease

6. Debris flow

7. Water
8. Water - outburst flood
9. Water - fluvial changes
10. Water - supraglacial
11. Water – proglacial

12. Vegetation growth

13. Other

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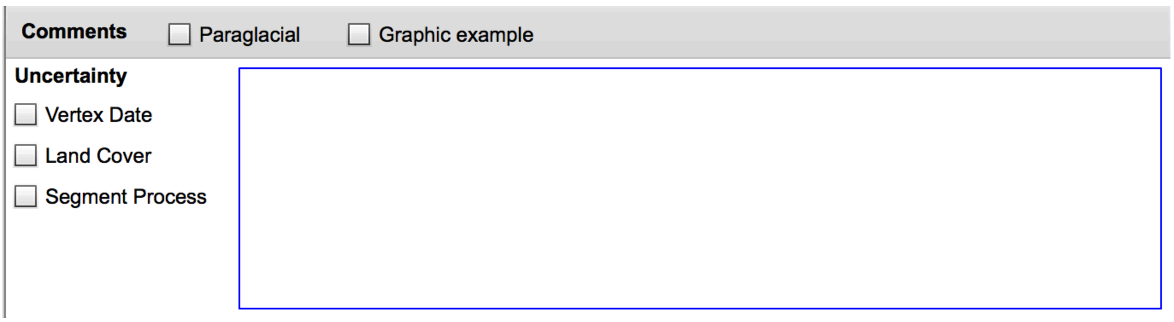
TASK 5: ADD COMMENTS, NOTE EXAMPLE.

Your next task is to identify uncertainties associated with your decisions. Also, at this time, note whether this pixel is something that should be identified as a graphic example or is a paraglacial feature. Use the comment box to explain any nuances to this plot that will help others understand the landscape dynamics and land cover at this location.



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TASK 6: REVIEW YOUR DATA ENTRY, SAVE

Your final task is to review that all your data entry for each vertex, and segment is complete. When satisfied, use the Save button to send to database.

As data is entered into the data entry fields, the plot number turns to *italics* noting that the values have changed but not yet saved to the database. After the 'save' button is pushed, if all data has been entered then the plot number is highlighted in green. If this does not occur, double-check all the data entry fields.

Quality Assurance check

- Did you include all the vertex points you intended?
- Did you describe any out of the ordinary events (such as day of year selection)?
- Did you describe any uncertainty of your interpretation?
- Did the plot number become highlighted in green after saving?

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Additional references

Cohen, W.B., Y. Zhiqiang, 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.

Griffiths, P, Kuemmerle T, Kennedy RE, Abrudan IV, Knorn J, and Hostert P. (2012). Using annual time-series of Landsat images to assess the effects of forest restitution in post-socialist Romania. *Remote Sensing of Environment* **118**: 199-214.

Kennedy, R.E., Z. Yang, Z., 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

Kennedy, R.E., Zhiqiang, Y., Cohen, W., Pfaff, E., Braaten, J., & Nelson, P. (2012). Spatial and temporal patterns of forest disturbance and regrowth within the area of the Northwest Forest Plan. *Remote Sensing of Environment* ***122****: 117-33.*

Powell, S.L., Cohen, W.B., Healey, S.P., Kennedy, R.E., Moisen, G.G., Pierce, K.B., & Ohman, J.L. (2010). Quantification of live aboveground forest biomass dynamics with Landsat time-series and field inventory data: A comparison of empirical modeling approaches. *Remote Sensing of Environment, 114*, 1053-1068.

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