TimeSync V3 User Manual

January 2017

Introduction

TimeSync is an application that allows researchers and managers to characterize and quantify disturbance and landscape change by facilitating plot-level interpretation of Landsat time series stacks of imagery (a plot is commonly one Landsat pixel). TimeSync was created in response to research and management needs for time series visualization tools, fueled by rapid global change affecting ecosystems, major advances in remote sensing technologies and theory, and increased availability and use of remotely sensed imagery and data products.

TimeSync is a Landsat time series visualization tool (both as a web application and for desktops) that can be used to:

- Characterize the quality of land cover map products derived from Landsat time series.
- Derive independent plot-based estimates of change, including viewing change over time and estimating rates of change.
- Validate change maps.
- Explore the value of Landsat time series for understanding and visualizing change on the earth's surface.

TimeSync is a tool that researchers and managers can use to validate remotely sensed change data products and generate independent estimates of change and disturbance rates from remotely sensed imagery. TimeSync requires basic visual interpretation skills, such as aerial photo interpretation and Landsat satellite image interpretation.

While TimeSync can be used to generate data for a variety of change estimation and mapping objectives, it is up to the user to choose an appropriate sampling design and plot locations. Understanding principles of sample design and inference is important to ensure that output data can be used to answer the intended research question.

For more information on TimeSync, including an online tutorial (for version 2 of TimeSync), go to: timesync.forestry.oregonstate.edu/tutorial.html. There you can register for an account and work through an online tutorial with examples and watch a recorded TimeSync training session.

This document contains detailed information about using TimeSync Version 3.

TimeSync Interface (The material presented in this section is generic and not focused on East Africa**)**

The basic interface of TimeSync consists of three main windows: the chip window, the spectral trajectory window, and the data entry window (Figure 1). The basic idea is to use TimeSync for temporal segmentation of time series, identifying and documenting when changes happened and what caused the changes.

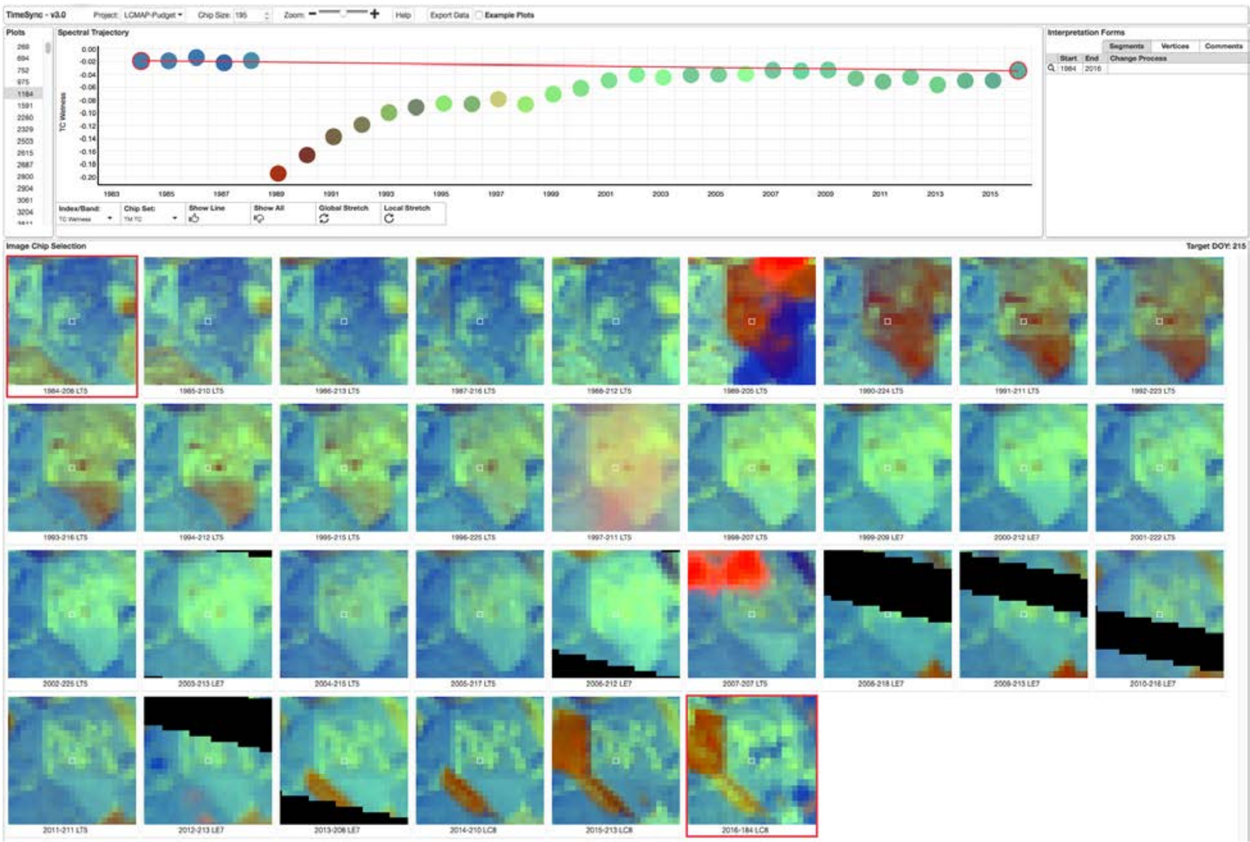

Figure 1

Temporal Segmentation

Within TimeSync, the spectral trajectory can be divided into multiple segments corresponding to changes in the trajectory due to disturbances such as harvest or fire, or spectral responses to growth or decline (Figure 2). New segments can be added to the spectral trajectory by double-clicking on a chip in the chip window, or a point in the spectral trajectory window. In the example below, we see several segments: stable, new road spur, stable, harvest, and a non-linear response to growth. Often, it may be difficult to determine exactly when a disturbance occurred, and a best guess will have to be made. For example, a disturbance may be clearly visible in supporting information (e.g., Google Earth), but not in the Landsat image chips.

Google Earth

Google Earth can be a valuable tool within the TimeSync environment, providing additional information that can be used to interpret various disturbances and changes land use/land cover. Google Earth imagery may not always exist for a plot, and the resolution and quality of the imagery can vary greatly. An additional caveat when using Google Earth is that the images do not always spatially align perfectly from year to year, so it is often best to go with the most likely reality based on Landsat images. Figure 3 shows a series of five Google Earth snapshots for the plot neighborhood, illustrating the pre- and post-conditions associated with the new road spur, and the harvest that followed the building of the new road spur.

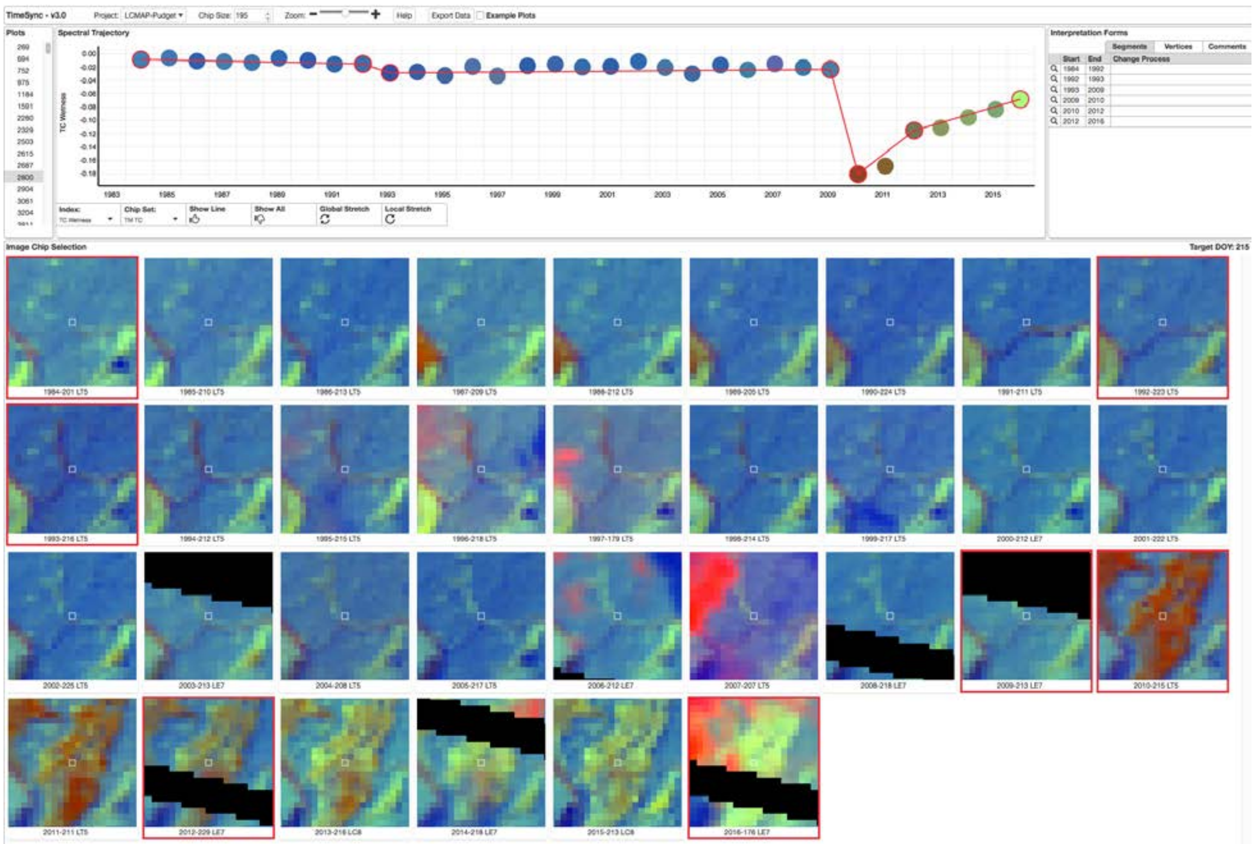

Figure 2

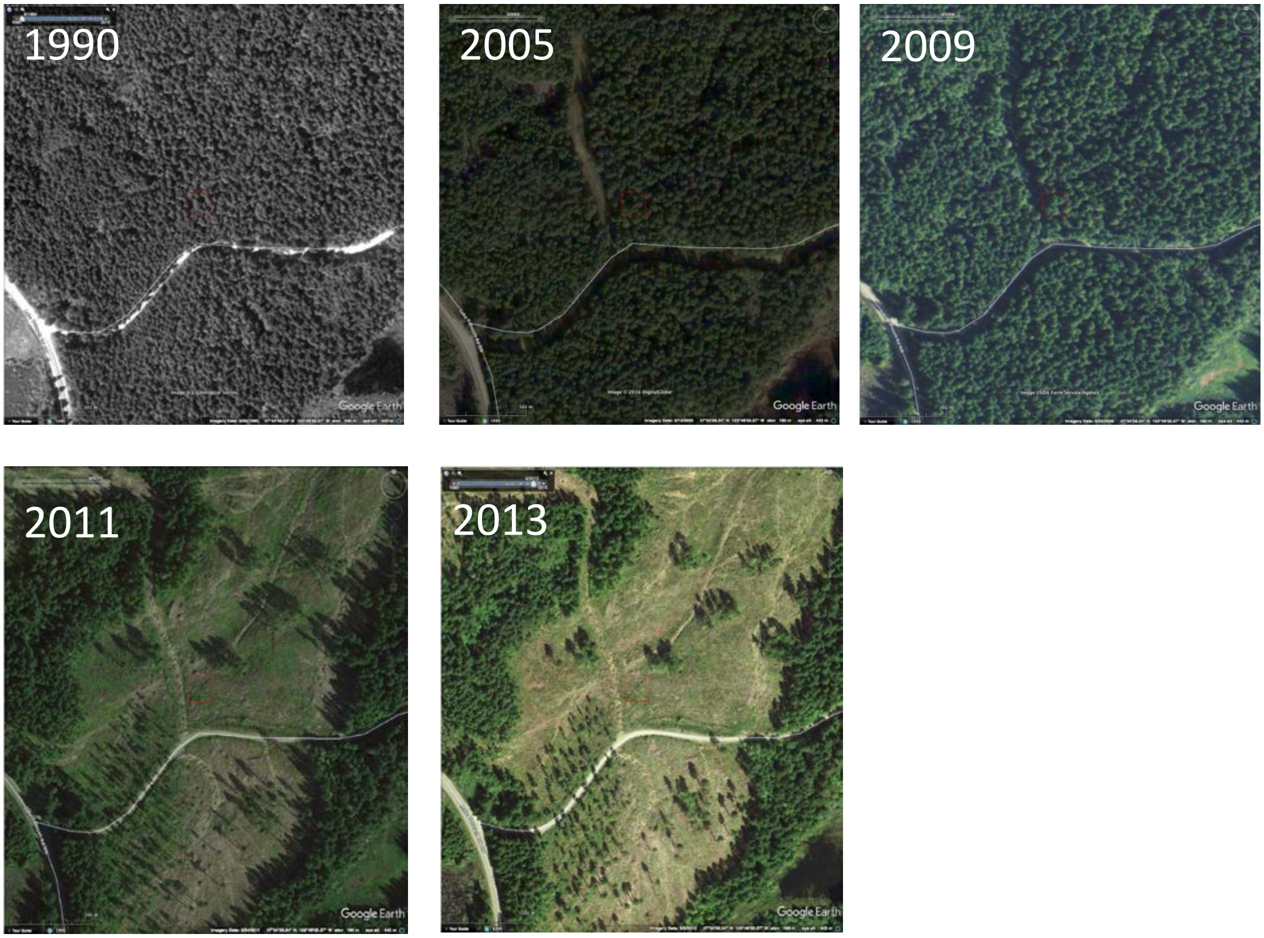

Figure 3

Chip Gallery

For each plot, the first step in the TimeSync interpretation is to perform a quality assessment (QA) of selected chips in the chip window. The chips show a single Landsat image for a given date for a given year in the time series. Multiple factors can affect image quality and determine whether a chip is suitable for interpretation. These factors include:

- Clouds or haze affecting the plot
- Misregistration
- Missing data at the plot location due to scanline errors
- Chip dates that are too far out of the desired date-range

TimeSync has an automated algorithm that selects a single “best” image chip for each year. However, this may not always be the best, and there may not always be a better choice. The chip gallery, which shows all of the available chips for a given year, can be accessed by hovering the mouse pointer over a chip, and clicking on the lower right corner (Figure 4). If a chip selected by the algorithm is not optimal, another chip may be selected. For example, in Figure 4 the chip selected for 1997 (DOY 179) has some haze, and a better chip may be available. In the chip gallery, the currently selected chip for a given year will be outline in red.

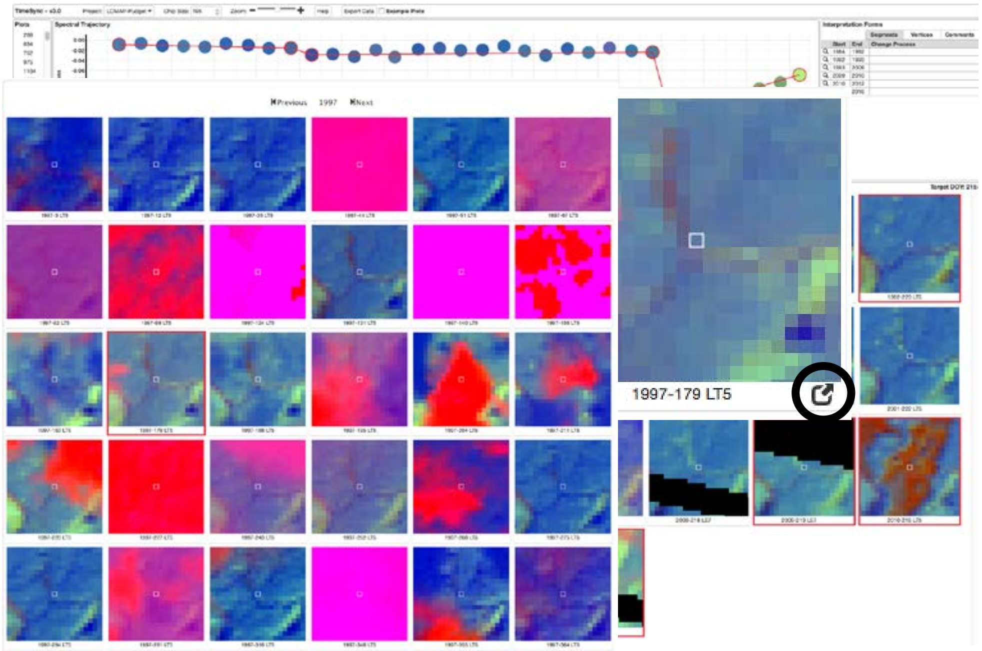

Figure 4

When selecting chips, the goal is to select a clear, high quality image chip for all years close to the target date (e.g. 215). In the same example shown in figure 4, the best choice is DOY 188, which is clear, and close enough to the target date. Also, note that in the 8 next dates after DOY 188, the plot is obscured by cloud cover or haze. The chip prior to DOY 179 could be used, but this is farther from the target date. Also note that the chips in 1995, 1996, 2006, 2007 and 2016 are cloudy or hazy and that there may be better chips for those years (Figure 5). The user may also remove “no data” strips from L7 SLC-off (2003, 2008, 2009, 2012, 2014, 2016), if desired. Sometimes this is essential if the plot falls within a strip.

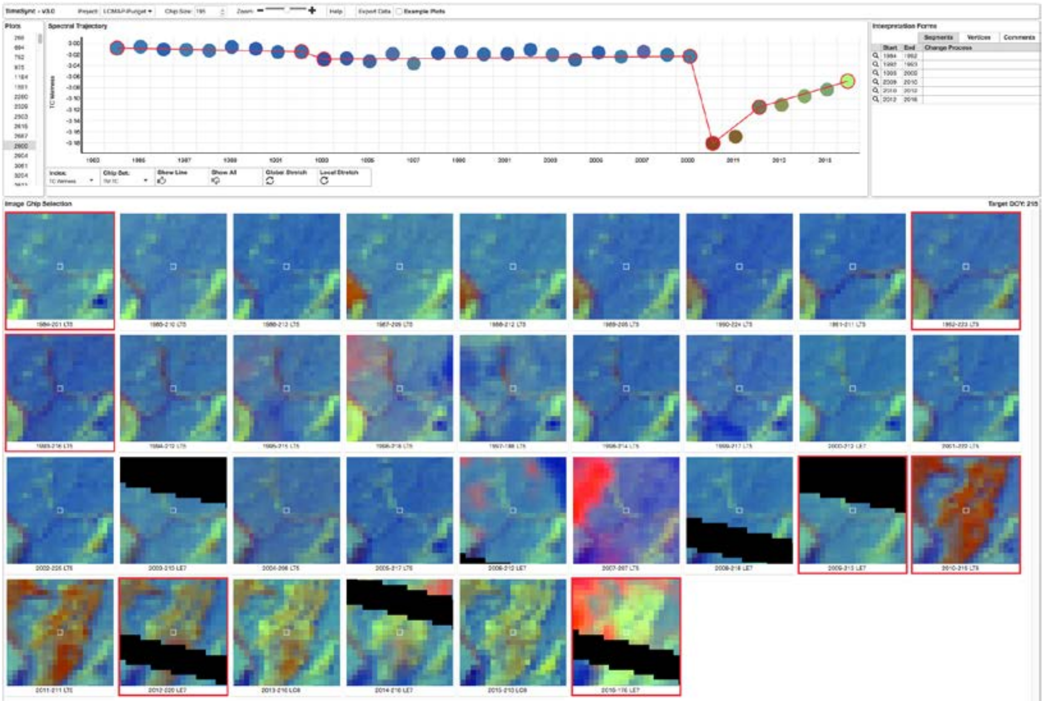

Figure 5

Figure 6 shows the final, best chip selection. Note that 2016 is DOY 168, but there was no better choice that was clear and closer to target date. Also note that the SLC-off strip is gone for 2016, but left in place for other years because it doesn't present a problem for the interpretation.

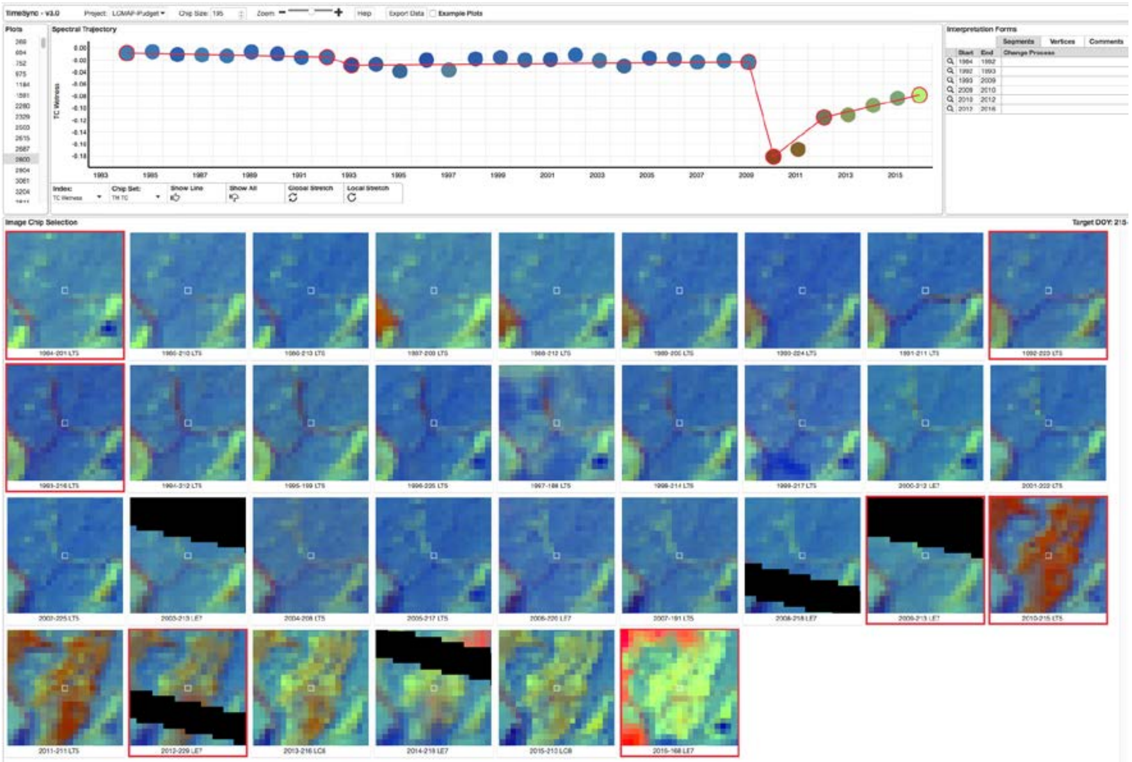

Figure 6

In another example below (Figure 7), the best available chip for 2016 from the image gallery is 253. The closest date to the target date of 215 is obscured by clouds. The date 197 could also be used, but a scanline error obscures half of the chip. Often it is necessary to try several different chips and assess how the spectral trajectory changes within a given index before making a decision on which chip to use. In some cases, no suitable chip may be available for a given year.

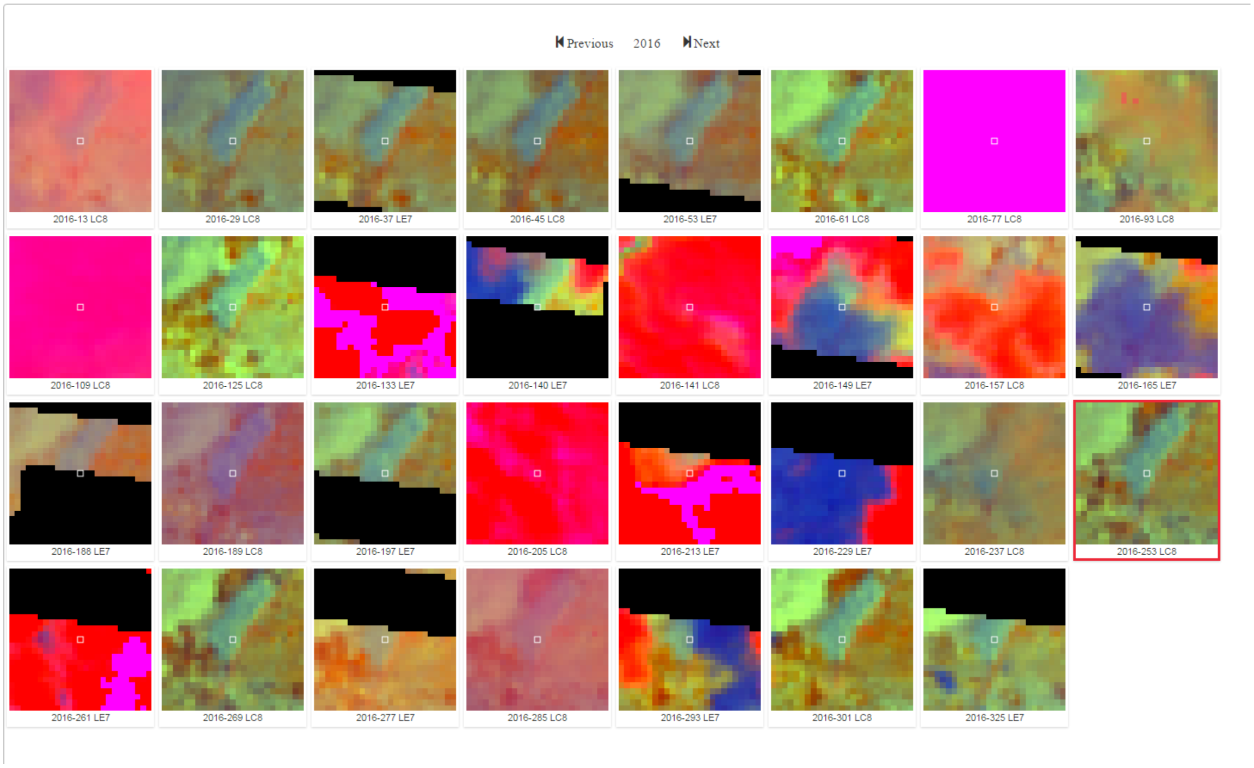

Figure 7

Chip Origin

Each chip comes from a given sensor and a given acquisition date. This information is shown under each chip: Year, DOY (Day of Year), Sensor (e.g. LT5 = Landsat 5 TM, LE7 = Landsat 7 ETM+, LC8 = Landsat 8 Continuity) (Figure 8)

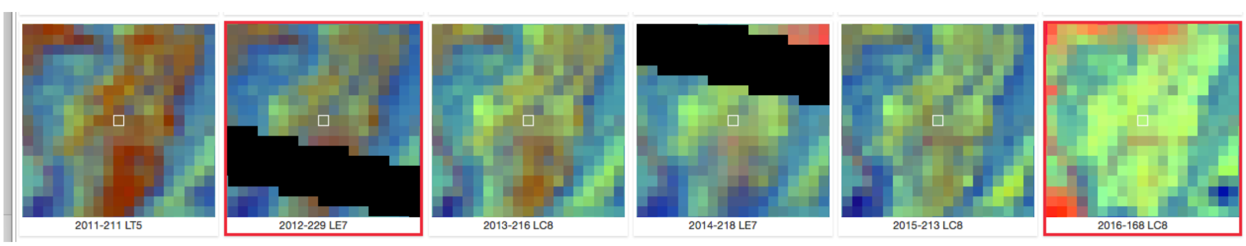

Figure 8

Chip Sets
For a given TimeSync project, different chip sets are generally available (figure 9): Three RGB sets (TM Tasseled Cap brightness (Red), greenness (Green) and wetness (Blue); NIR (R), Red (G), Green(B); SWIR2(R), NIR(G), Red(B). However, currently, the only chip set available for Uganda is the TM Tasseled Cap. (See C_TS_Response Design.pptx for details).

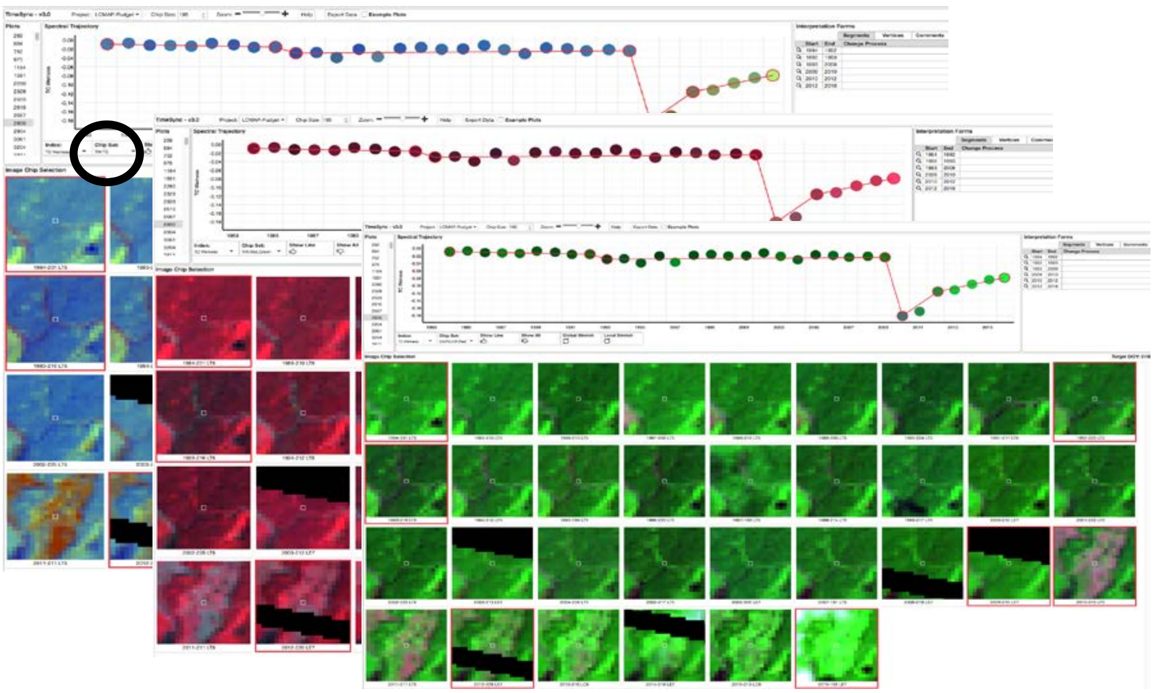

Figure 9

Band/Index
Within the TimeSync interface, the user can select any band or available spectral index (Figure 10). When a different index or band is chosen, the spectral trajectory will change to reflect the current index. Currently, the following bands and indices are available: Blue, Green, Red, NIR, SWIR1, SWIR2, TC Brightness, TC Greenness, TC Wetness, TC Angle, NDVI, and NBR. Generally, the bands/indices exhibit similar trajectories but often in the opposite direction (Figure 11). Sometimes they are different enough that the user must decide whether a different segmentation is more appropriate.

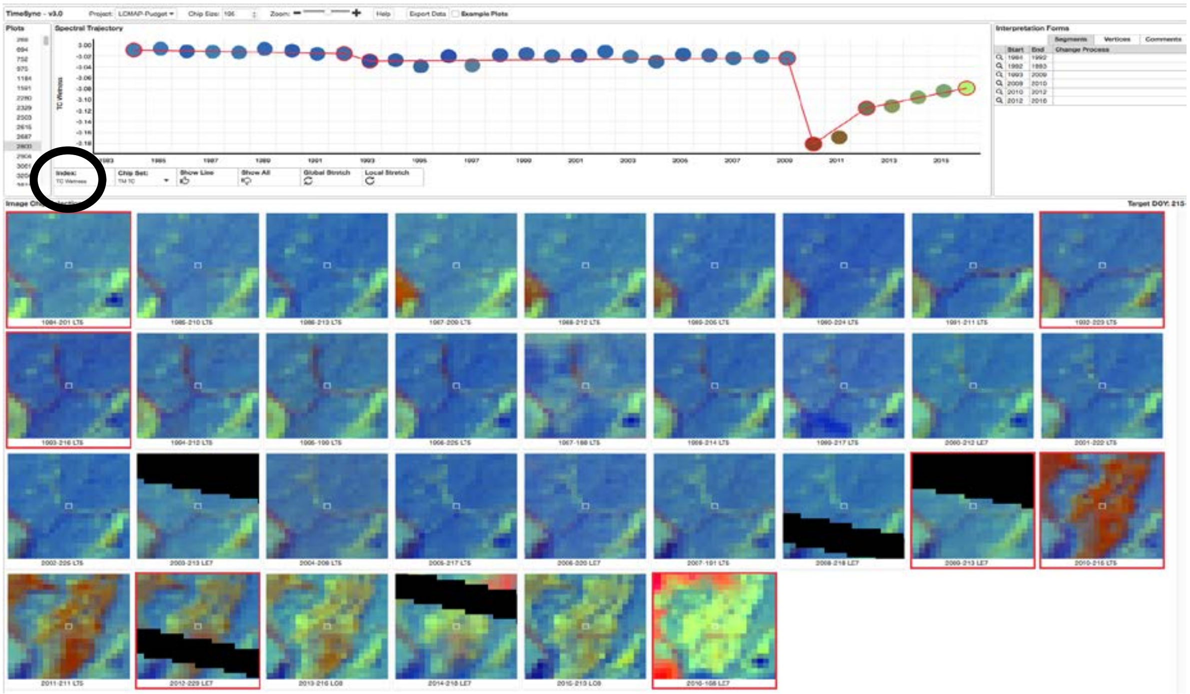
Figure 10

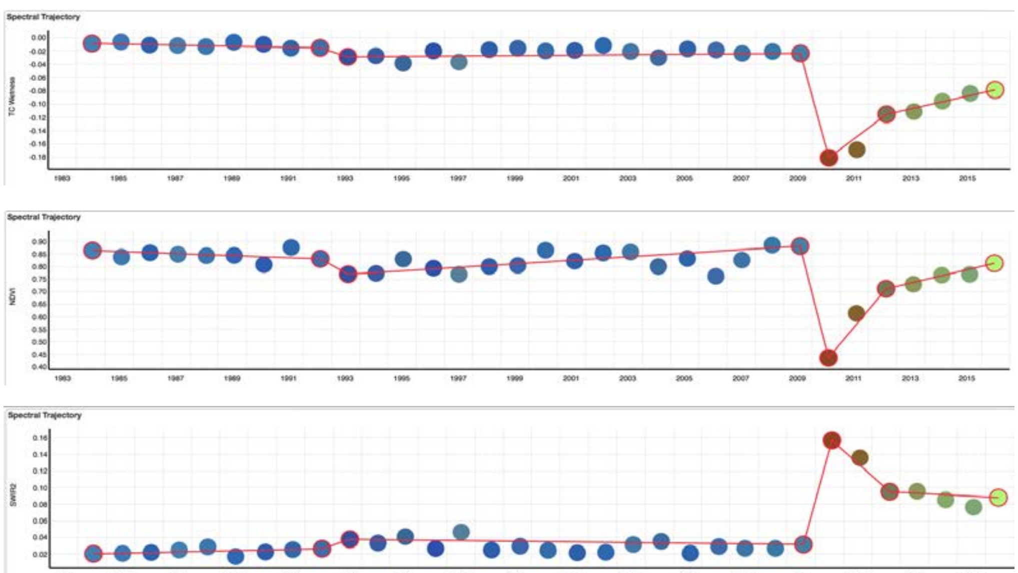

Figure 11

Displaying the Segmentation Line

The TimeSync interface allows the user to show the segmentation line or turn it off (without losing it, Figure 12). This can be a good reality check, as your eye can often be falsely guided by your previous decisions, and viewing the trajectory without the line can help to determine if a change is real or just noise (Figure 12, which shows the trajectory without the line in addition to the trajectory with the line).

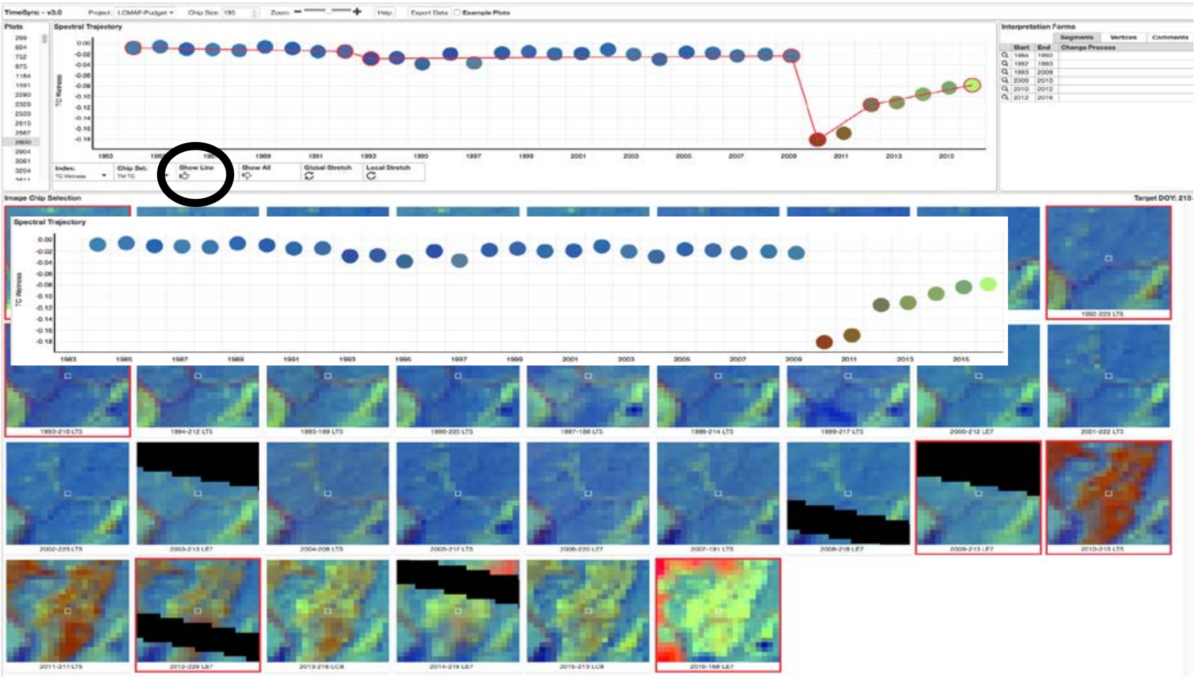

Figure 12

Show All

In the TimeSync interface, the default display is to show a single chip data point per year in the trajectory window, based on the final selection (either the default or adjusted using the chip gallery) (Figure 13).

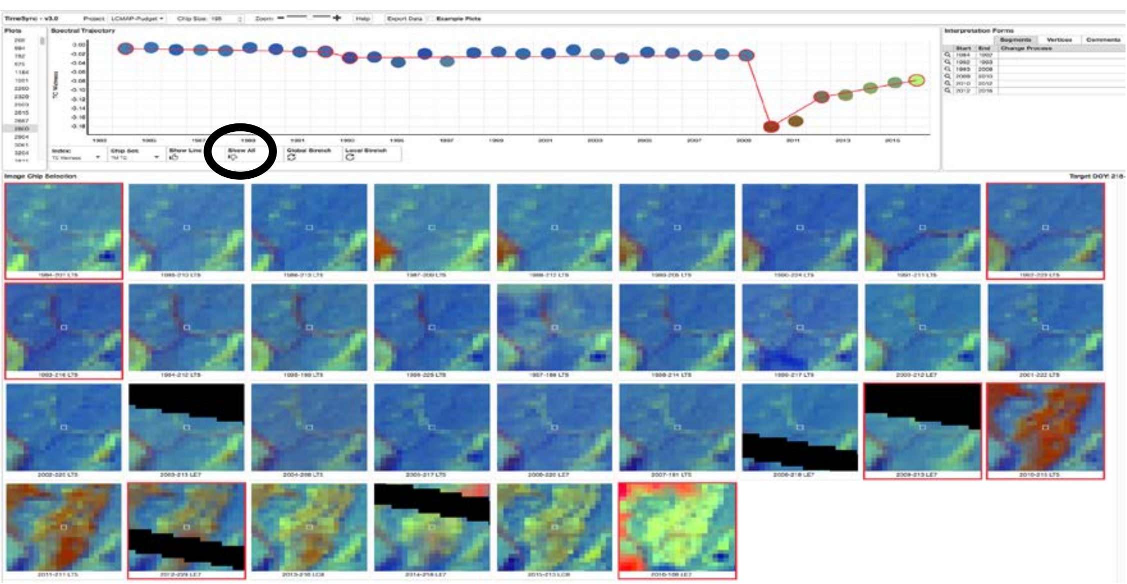

Figure 13

TimeSync also provides the option for displaying all points for all years (figure 14), as a guide to understanding how the selected annual chips fit in the phenological sequence across years. This can influence the decision about which chip to use for a given year, and the consequences for choosing a DOY not near the target date.

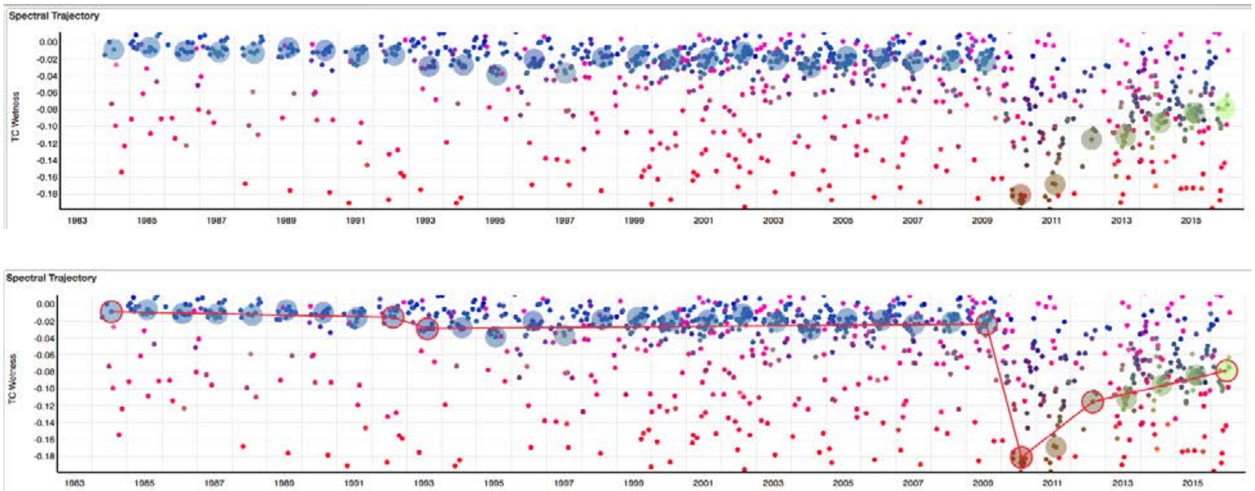

Figure 14

Local and Global Stretches

The default stretch for the spectral trajectory is a local, plot-based y-axis stretch (figure 15).

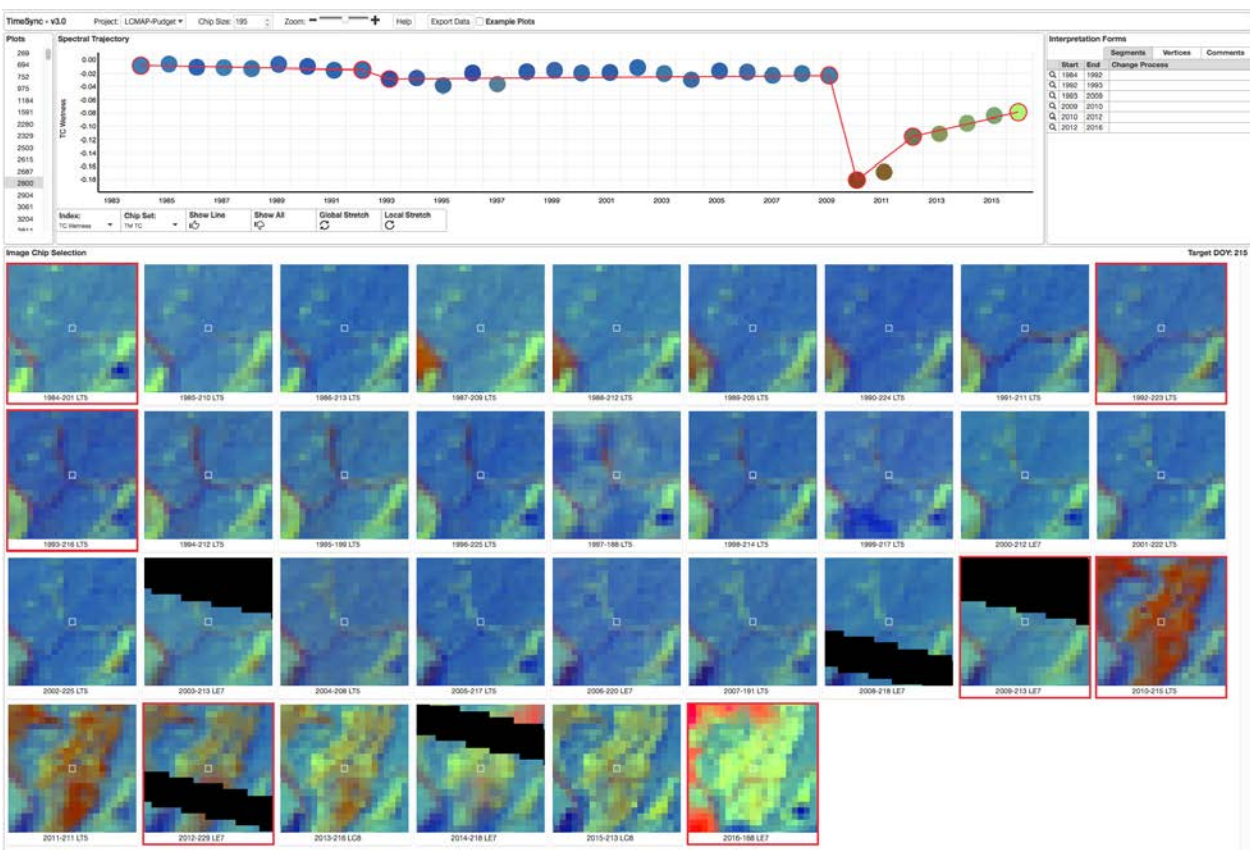

Figure 15

In figure 16 shown below, the local stretch (top) maximizes the y-axis stretch for the plot based on the selected annual chip set. The global stretch (bottom) uses a more generalized (across plot) stretch so that you can check whether you are zooming in too closely to the noise and thus over-interpreting the data.

Figure 16

Other stretch options allow the user to shrink the y-axis to show all points (including those outside of the local stretch) and to shift the y-axis up and down (figure 17).

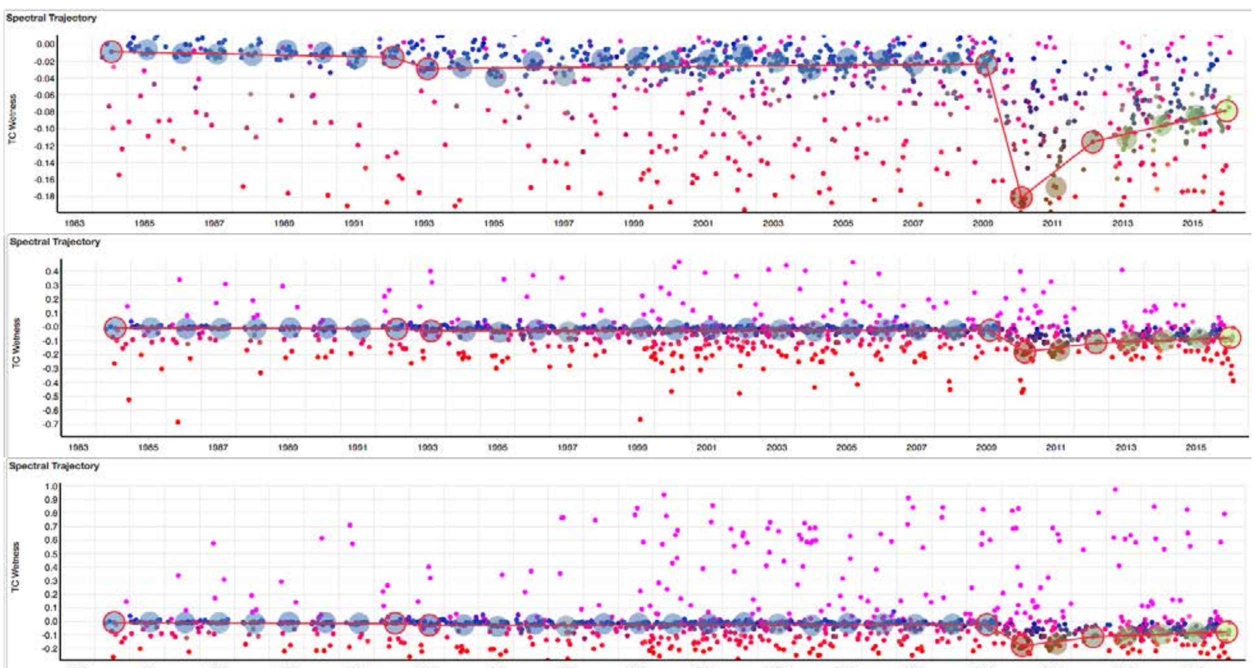

Figure 17

Finally, the user can also zoom and shift the x-axis (Figure 18). Shifting the x-axis is usually not helpful, but sometimes necessary.

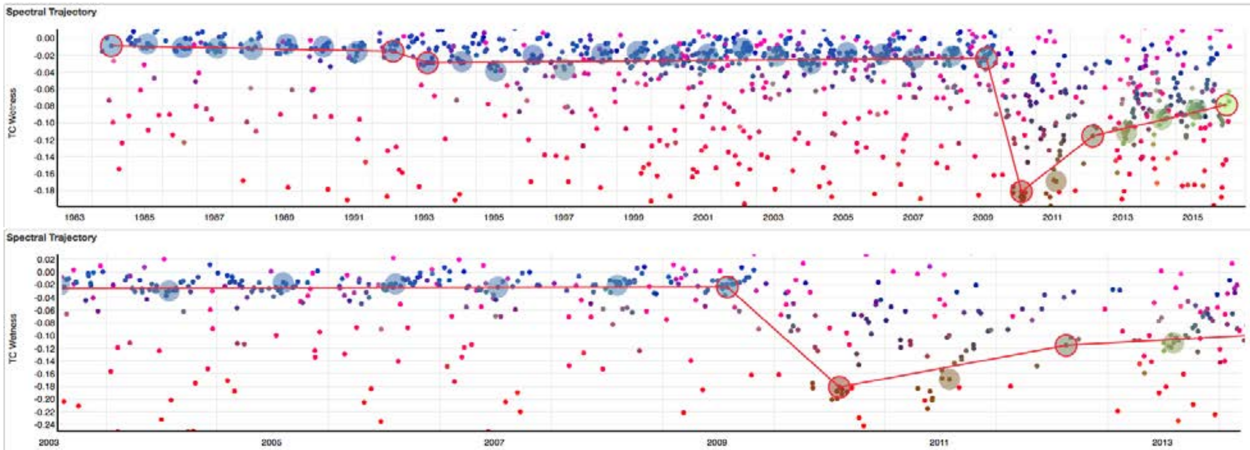

Figure 18

Projects

Within the TimeSync window, there may be many projects from which to choose (figure 19). These could be different geographic areas, or plot sets within an area for different interpreters, etc.

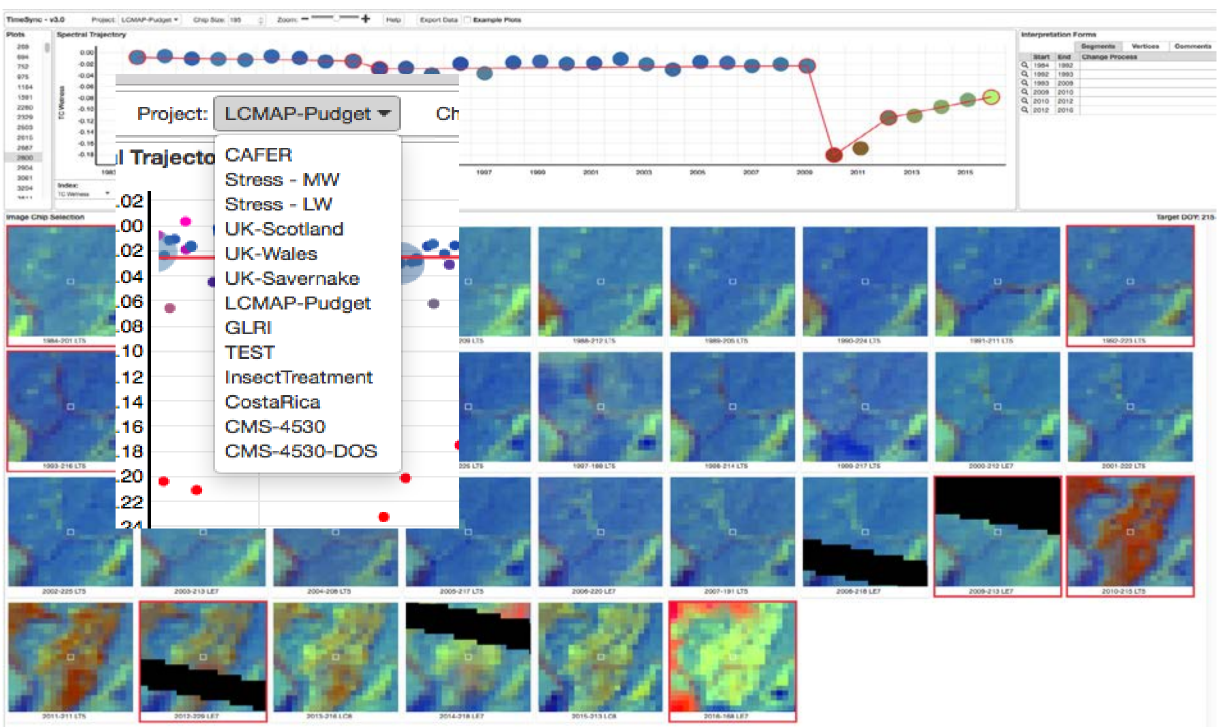

Figure 19

Chip Size

TimeSync works best with larger computer screen sizes. However for smaller screens the chip size can be changed (the default is 195x195 screen pixels) (Figure 20).

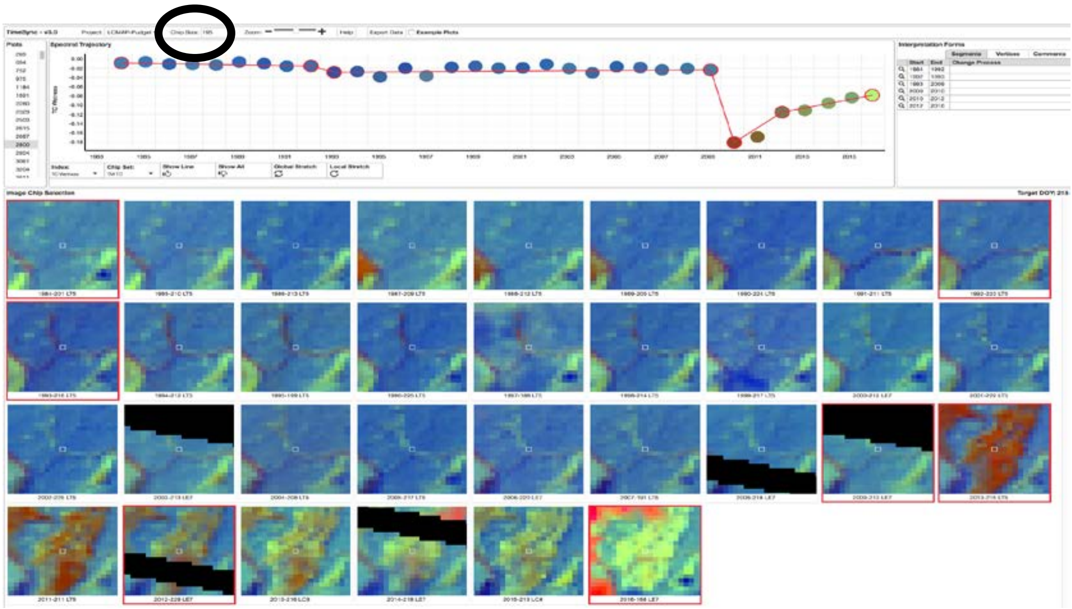

Figure 20

When the chip size is changed, the actual number of Landsat pixels shown does not change, but each chip takes up less space on the monitor (figure 21).

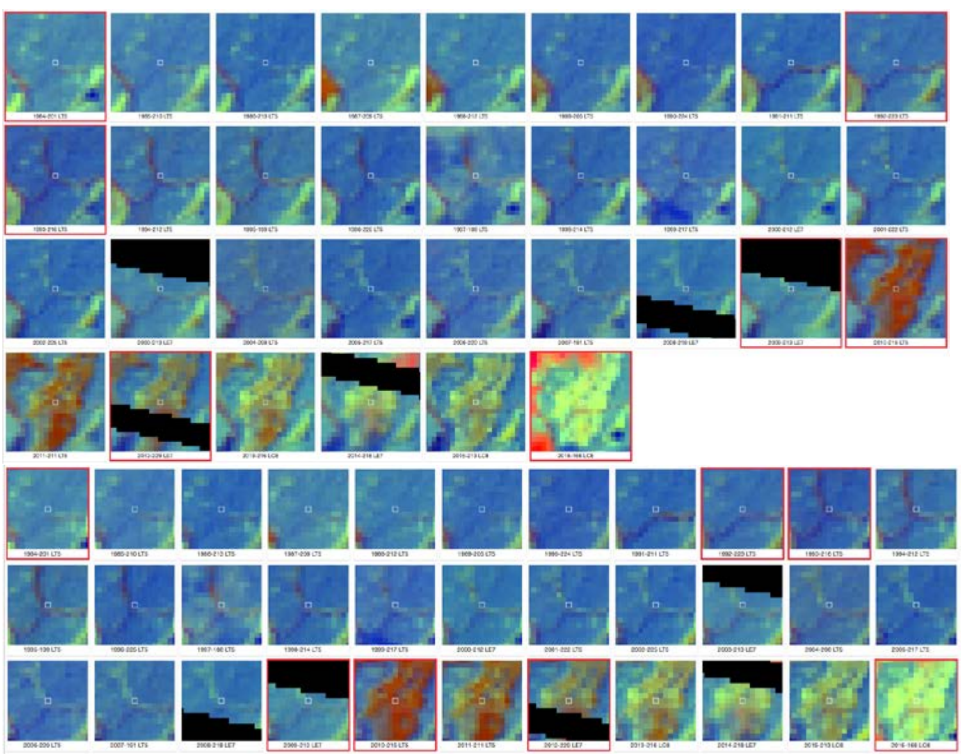

Figure 21

Scrolling
The other option is to keep the chip size larger, but use scrolling to scroll through the chips using the scroll bar. It is often advantageous to display all of the chips at once to help with assessing any trends in the time series. In Figure 22, the left side shows the first part of a series, while the right side shows the last part, illustrating where scrolling would be necessary to see the entire time series.

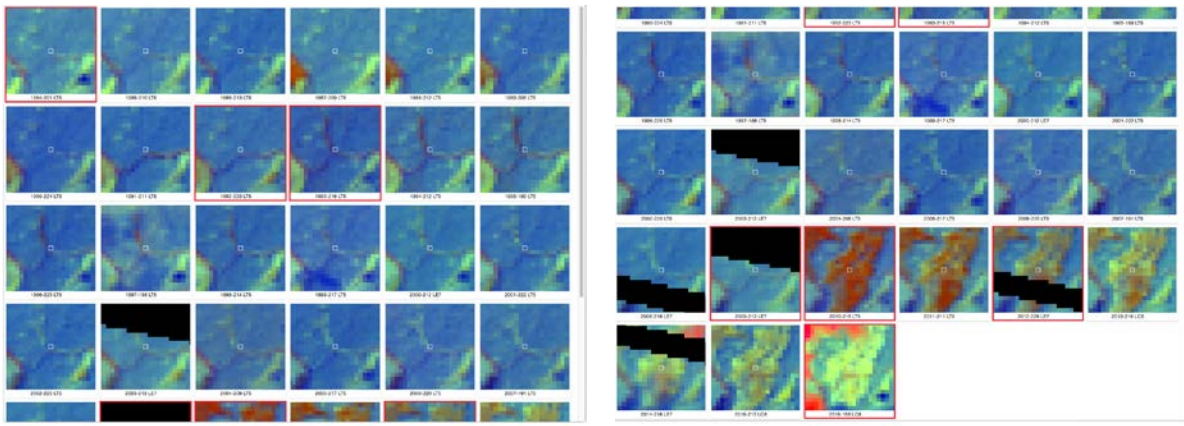

Figure 22

Zoom
Zooming in and out changes the number of Landsat pixels shown, independent of chip size (figure 23). It is a good way to get spatial context (zoom out) and spatial detail (zoom in) (figure 24).

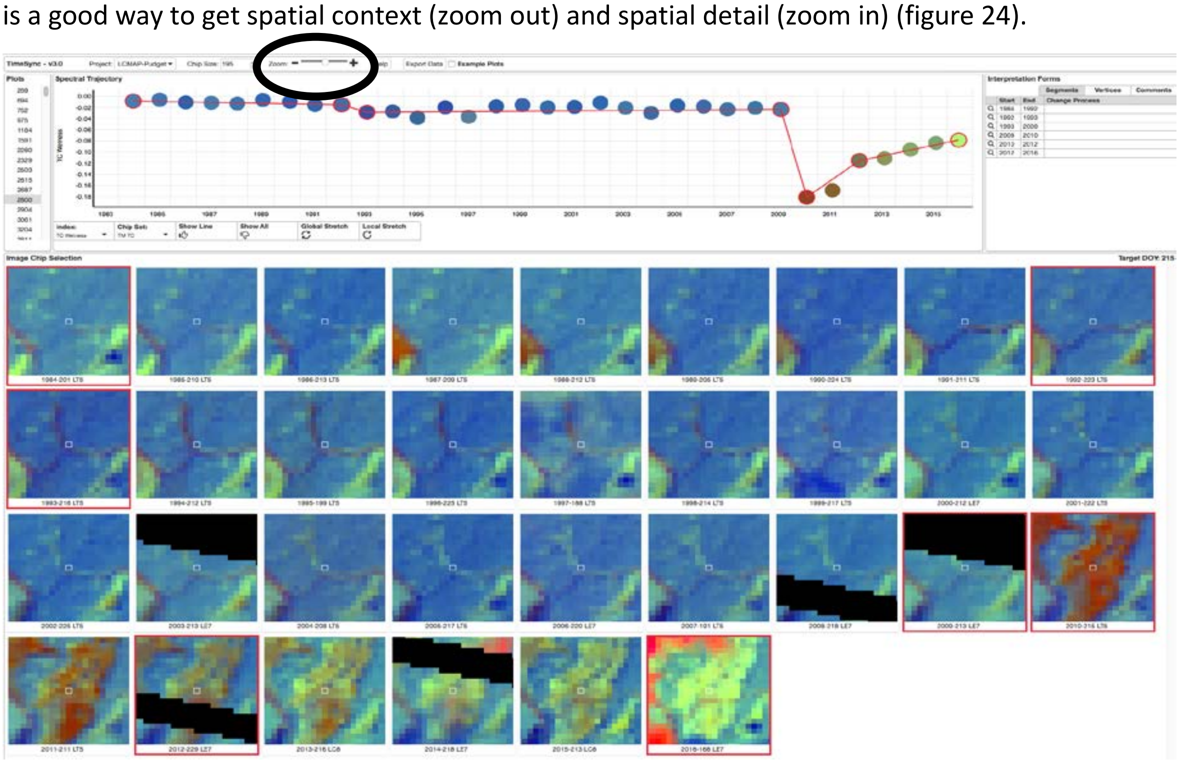

Figure 23

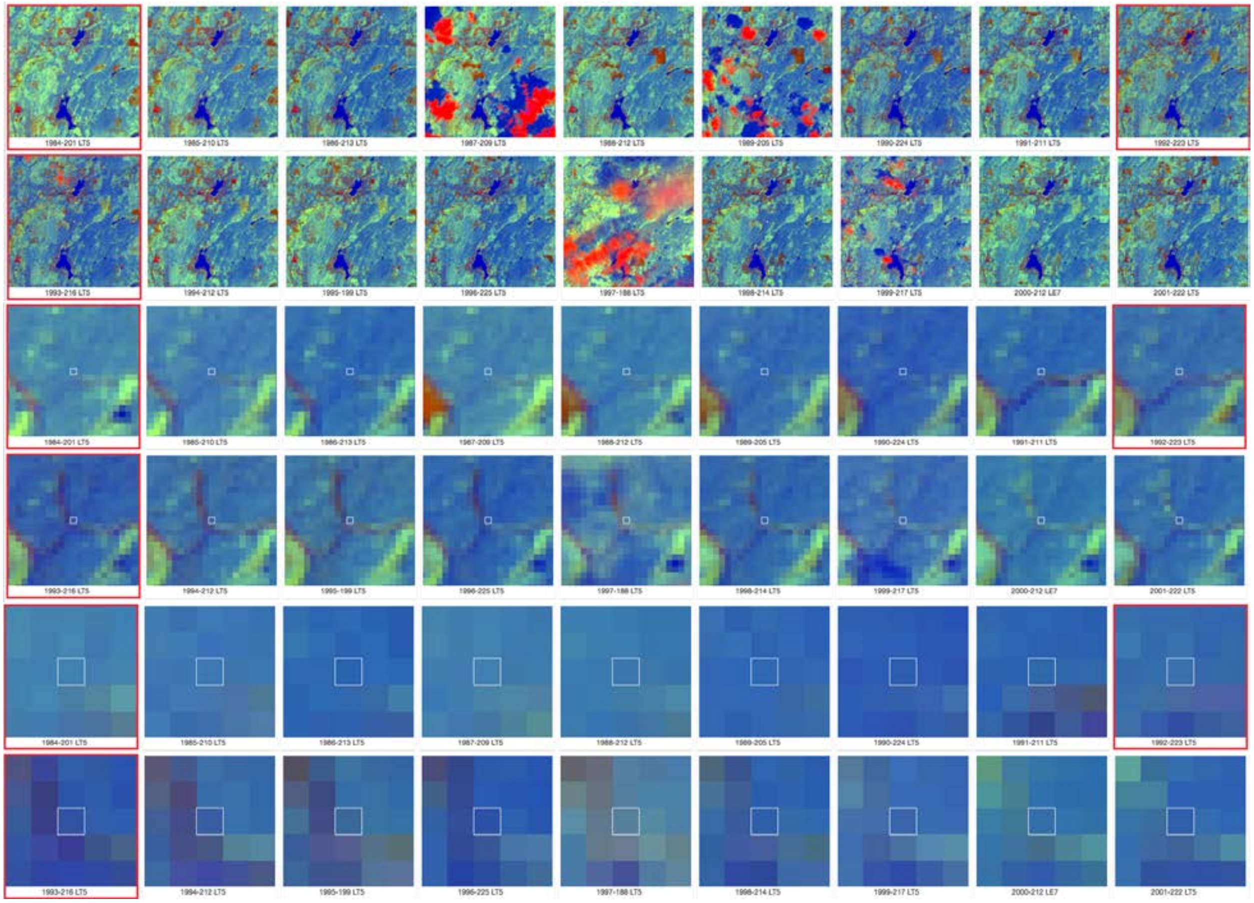

Figure 24

TimeSync Help

TimeSync provides a built-in help menu that can be accessed from the main window (figure 25).

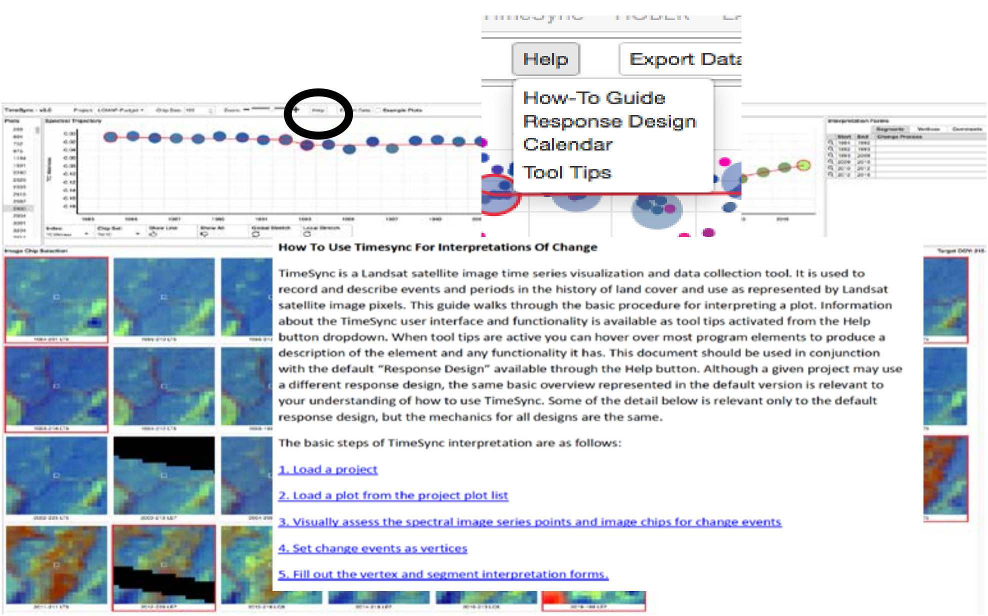

Figure 25

When clicking on the help button, a how-to guide, a response design document, calendar and tool tips can be accessed. The How-To guide opens a document that describes the functions described here and other important items. The response design labeling document should be used with the How-To guide, and may be specific to a given project. Clicking on the calendar drop down opens a DOY calendar for use with DOY chip considerations (figure 26).

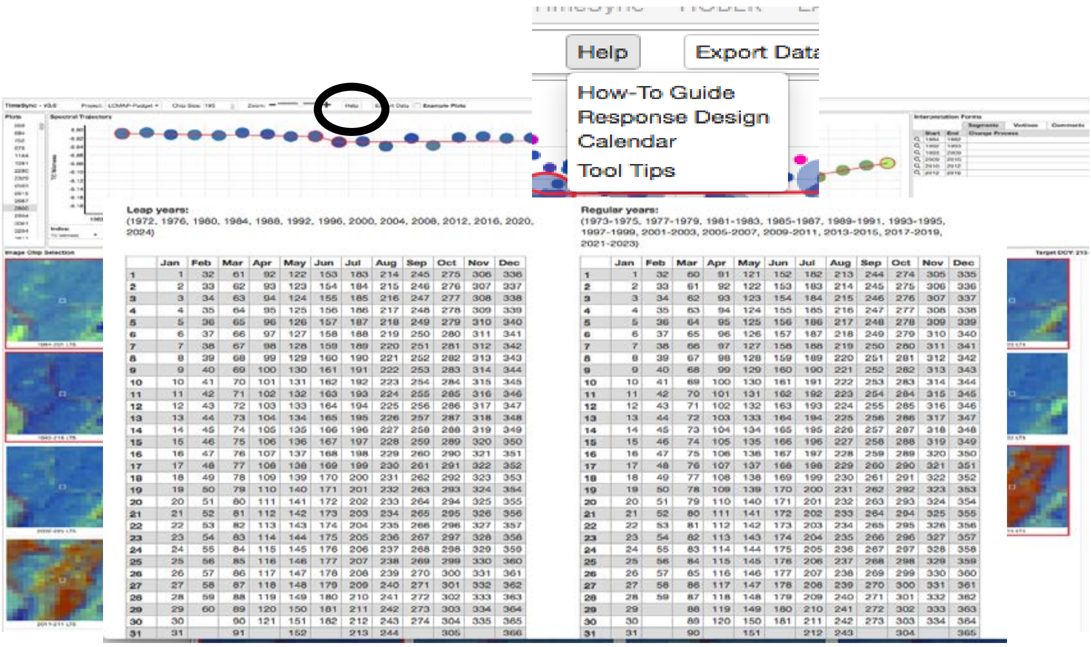

Figure 26

The Tool Tips drop down toggles tool-tips on and off. The tool tips describe context-specific functions. When the mouse pointer hovers over key areas of the interface, tool tips will pop up over key areas of the interface (figure 27).

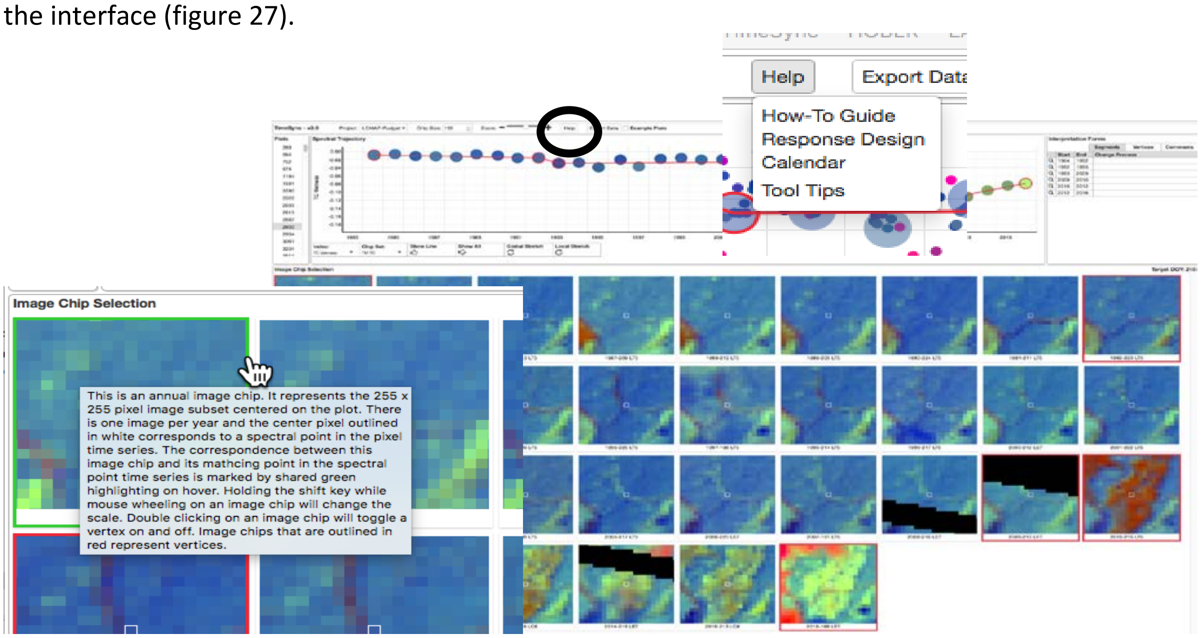

Figure 27

Export Data

The Export Data button on the TimeSync interface exports interpretations after data is collected (figure 28).

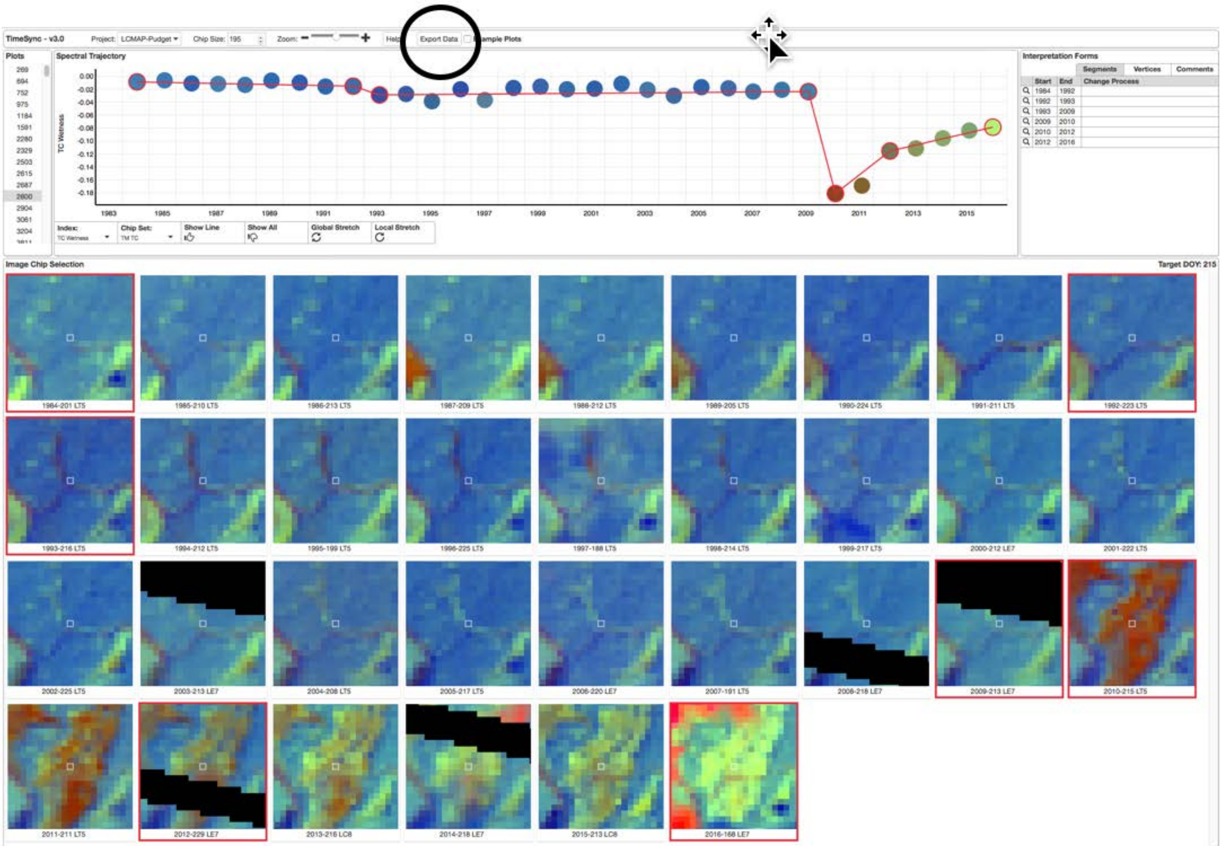

Figure 28

Example Plots

Example plots can be useful to easily recall special plots (examples for demonstration, ones that need to be looked at again, etc.). Checking the Example Plots box (top middle) shows from the full list of plots (top left), only those that were identified as examples in the Comments box (bottom) (Figure 29).

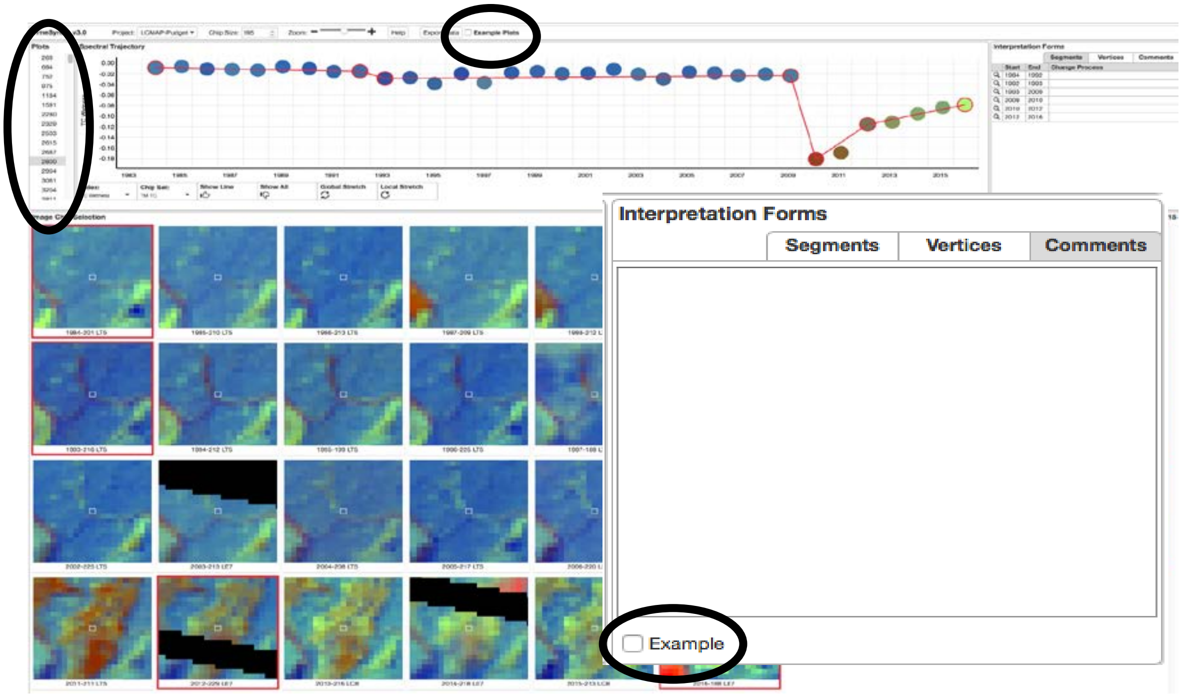

Figure 29

Plot List

Each project has a list of plots that can be interpreted (figure 30). Generally speaking a project will belong to only one person, and that person is responsible for all/most/some of the plots on the list. The number of plots in a given project is usually limited for practical reasons, but there are often extras to facilitate "bad" plots.

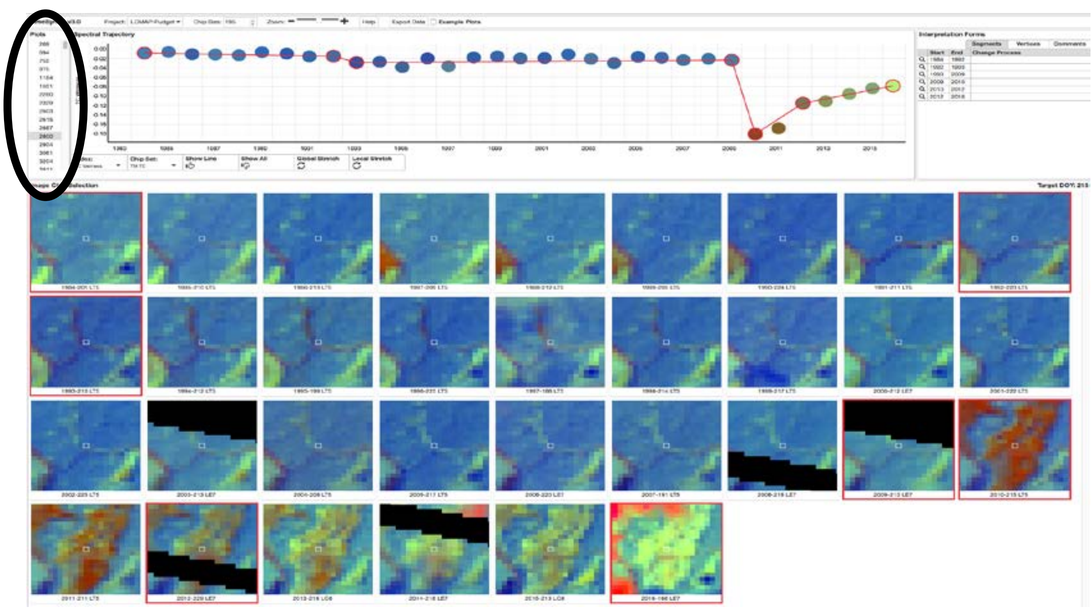

Figure 30

Interpretation Forms

For each plot, there are interpretation forms for labeling the segments and vertices, which are specific to a given project's response design. Shown below (figure 31) are the vertex labels chosen for this plot (use and cover), selected from a list that includes secondary use labels and a series of check boxes relevant to specific choices (notes, other). There is also an option for leaving comments regarding the plot interpretation.

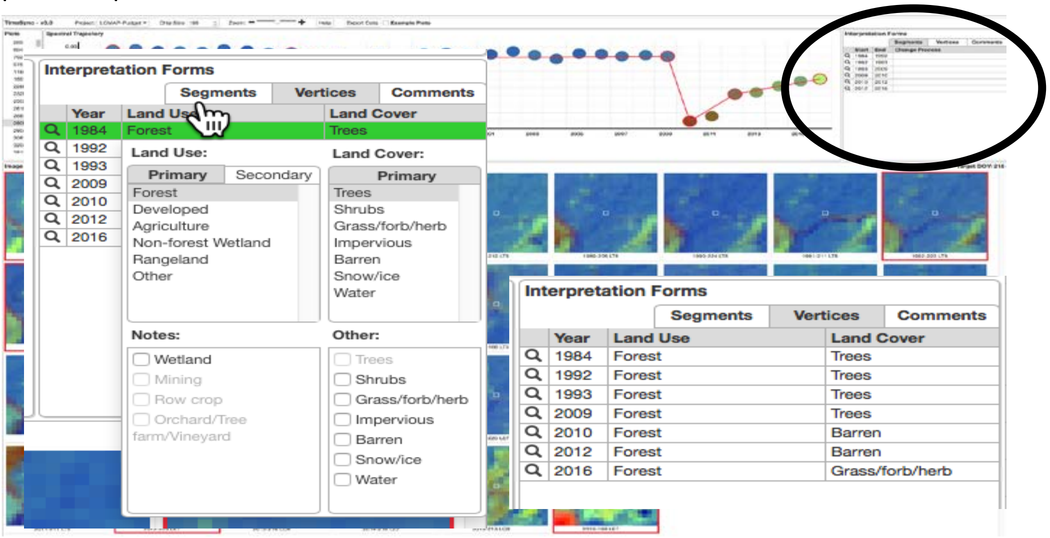

Figure 31

Shown in figure 32 are the segment labels chosen for this plot, selected from a list that includes secondary use labels as a series of check boxes relevant to specific choices.

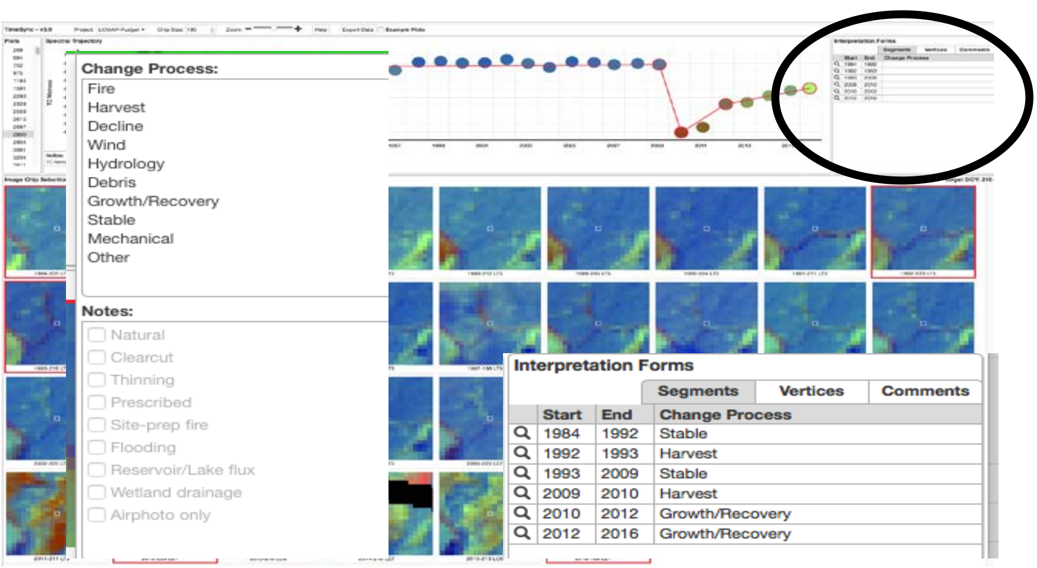

Figure 32

Query Button, and DOY "Tip"

Clicking on the query button associated with segments and vertices highlight the relevant vertices in the trajectory window (Figure 33). For segments there are two relevant vertices. Hovering over a data point in the trajectory window shows the DOY for that point (Figure 34).

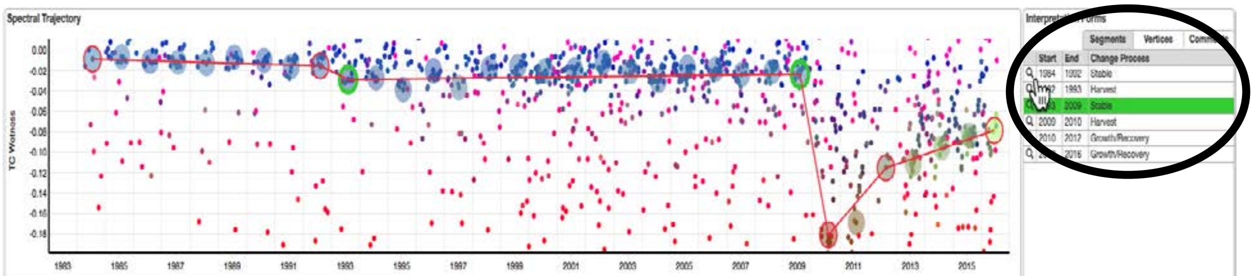

Figure 33

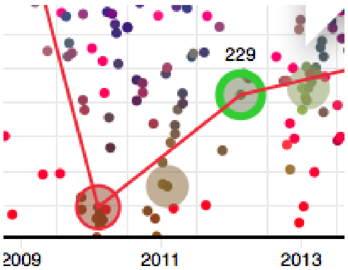

Figure 34

Data Set-up, Versions, Independence

There is a process for setting up a project in TimeSync, and while some people do it themselves, currently it is mostly done by the LARSE lab. There are two current versions of TimeSync:

- Online version (OLTS, v3.0)
- Stand alone version (SATS, v3.0)
- The versions are supposed to have identical functionality, but, currently, development occurs on OLTS, with SATS often lagging behind

Our goal is to have TimeSync software on GitHub (or similar), and let folks run with it. This will involve having the ability to design and load user-specified response design labels, load sample points, and download data.