September 2020

LANDFIRE Remap: Improvements to Landsat Image Processing

LANDFIRE (LF) 2016 Remap is a comprehensive mapping effort with a new base map representing contemporary conditions using recent imagery and state of the art techniques. LF Remap offers new products and opportunities to LF users and represents circa 2016 ground conditions. LF Remap leverages improvements such as unlimited access to the Landsat archive, and increased computing capacity and automation to generate higher quality and more consistent products. LF National (the previous base map) products were collections of field reference data, Landsat 5/7 imagery, biophysical gradients, and other ancillary data. For LF National each image had to be individually examined and vetted for quality. Landsat imagery is the foundation for all LF products; therefore, the efficiency and reliability of image processing directly impacts the quality of all LF products.

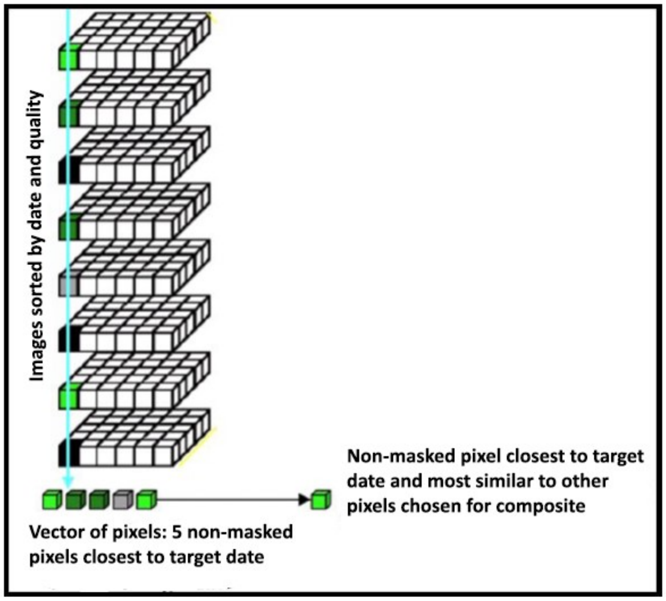

Figure 1. *A visualization of the image compositing best-pixel process. This process selects the pixel closest to the target date that is "most similar" to the other non-masked pixels in the stack.*

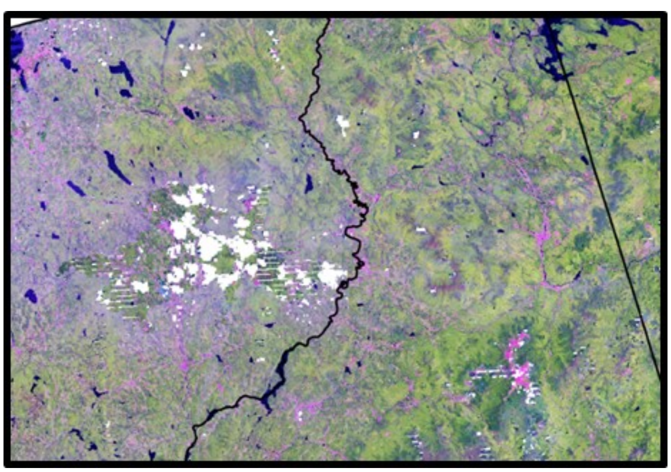

Figure 2. *An LF Remap best-pixel image composite of northern Vermont and New Hampshire. The white blotches represent data gaps showing areas where no clear pixels were available for the date ranges provided. Data gaps like these are repaired using the SSG process in LF Remap.*

Image Compositing

In its simplest form, image compositing uses statistics and algorithms from stacks of tens to thousands of individual images in hopes of producing a single cloud-free image (i.e. a composite). For LF Remap Conterminous United States (CONUS) the best-pixel compositing algorithm was employed (Nelson and Steinwand 2015). This best-pixel technique chooses the "most similar" pixel to the five non-masked pixels closest to the user-defined target date, from a stack of individual scenes (Figure 1). This process differs from methods for LF National that used hand selected single scenes picked from hundreds of individual path rows. The improved best-pixel compositing technique in LF Remap allows for automation and high-performance computing, which leads to increased efficiency and less time spent on the compositing process.

Why circa 2016?

To ensure that LF Remap image composites contain cloud-free pixels with no gaps, LF Remap extends the date range from 2016 to include 2013 through 2017. Through-out the compositing process, first priority is given to using

2016 pixels, second priority to 2015 or 2017 pixels, and third priority to 2013 and 2014 pixels. With this technique the majority of pixels in LF Remap composites are from 2016. Lastly, to ensure that conditions are current to 2016, disturbances dating back 5 years are also accounted for within LF Remap products .

Image Cleaning

Even with 5 years of image data, areas of persistent cloud or snow cover can cause gaps and other artifacts in image composites (Figure 2). To fix these areas LF uses a process called Spectral Similarity Grouping (SSG) developed by Jin et al. 2012. This concept replaces a no data pixel within a composite with a value from a "similar" pixel inside the same composite, using a target image to determine the location of the similar pixel.

The SSG technique keeps the data scaled appropriately and reduces seamlines. Unlike the LF National technique which utilized a clip and paste method from one composite to another, resulting in seamlines and artifacts. The SSG technique, combined with manual image cleaning by experts, results in less abrupt boundary landscape changes and a better representation of vegetation conditions throughout LF Remap products (Figure 3).

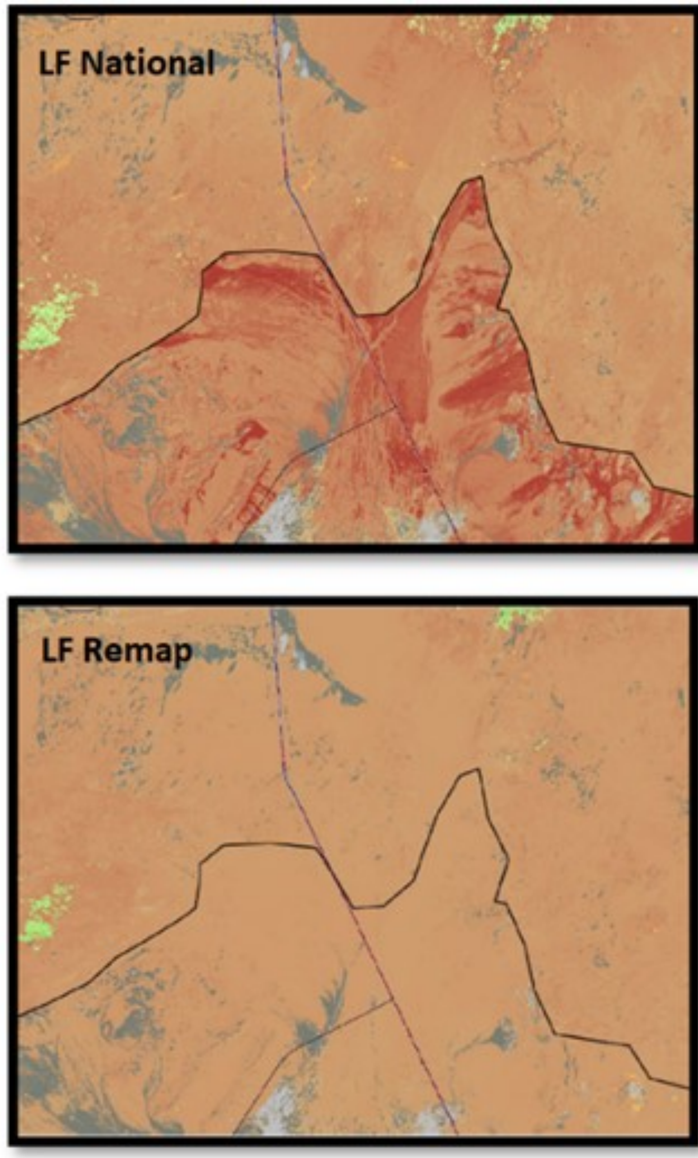

Figure 3. *Existing Vegetation Cover (EVC) in LF National 2014 (top) versus the improved EVC product in LF Remap (bottom). Zone boundaries are depicted in black. In the top image, there is a difference in land cover between the areas within the zone and outside of the zone, but in LF Remap this abrupt difference between the boundaries is resolved.*

Synthetic Imagery

As production progressed into the eastern United States, LF Remap shifted from using best-pixel compositing to using synthetic imagery produced from the Landcover Change Monitoring Assessment and Projection (LCMAP) program of the USGS (US Geological Survey). Synthetic imagery has advantages in areas where cloud cover is persistent, like in the eastern US, because it is derived from models that predict what a cloud-free pixel "should look like". This prediction is based on a user specified date and trends of all images available since the area's last disturbance or the year 1984 (whichever comes first). This results in cloud-free images that contain fewer artifacts, and thus, require significantly less post-processing image cleaning .

The use of synthetic imagery is relatively new and was not available at the start of the LF Remap effort. However, as LF Remap progresses the benefits of synthetic imagery are significant and warrant the use of this method. Synthetic imagery is consistent with mapping tiles and provides increased quality and time savings. Also, all imagery is based on more recent conditions (2016 conditions in the case of LF Remap) because the models producing the synthetic imagery can predict for any specified year and day dating back to 1984.

Summary

Overall, the use of best-pixel image composting and synthetic imagery in LF Remap provides many advantages, such as: the improved ability to produce data sets free of clouds, shadows, seamlines, boundary lines, and gaps, as well as increased automation, and added flexibility due to date range modifications. These improvements and innovations trickle down to other LF products, such as disturbance, surface fuels, and vegetation. The benefits of the LF Remap image composite process can be seen in Figure 4. This mosaic of CONUS represents the combined results of best-pixel compositing, LCMAP synthetic imagery, and many hours of manual image cleaning. It depicts the range of land cover across the nation, allowing for better representation of vegetation and disturbance conditions in LF Remap products. To learn more about LF Remap go to https://www.landfire.gov/lf_remap.php .

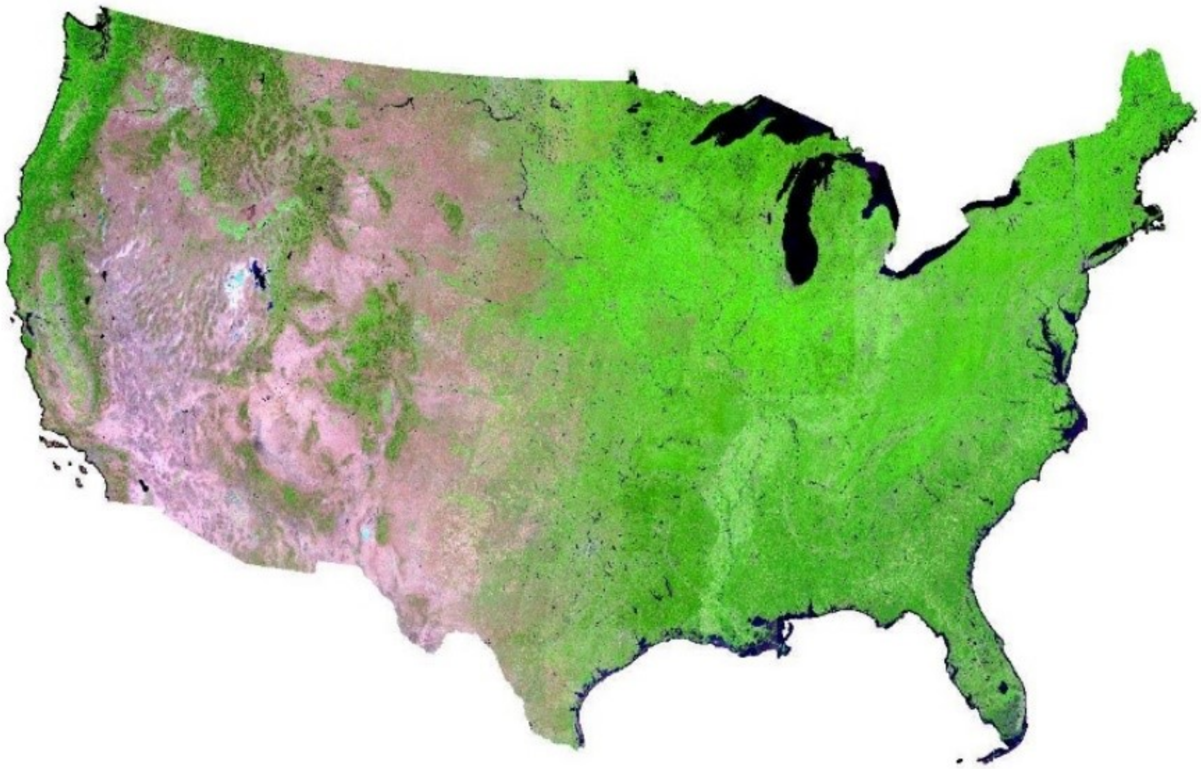

Figure 4. *A mosaic of CONUS Landsat imagery and LCMAP synthetic imagery used to create LF 2016 Remap existing vegetation products.*

Works Cited

Jin, S., Homer, C., Yang, L., Xian, G., Fry, J., Danielson P., and Townsend, P. (2012). Automated cloud and shadow detection and filling using two-date Landsat imagery in the USA. International Journal of Remote Sensing, 34:5, 1540-1560.

Nelson, K. and Steinwand, D. (2015). A Landsat data tiling and compositing approach optimized for change detection in the conterminous United States. Photogrammetric Engineering & Remote Sensing, 81:7, 573-586.