Geoportti methodological storylines

A Landsat composite covering all Amazonia for applications in ecology and conservation.

AUTOR(S): Jasper Van doninck, University of Turku, Department of Geography and Geology

jasper.vandoninck@utu.fi

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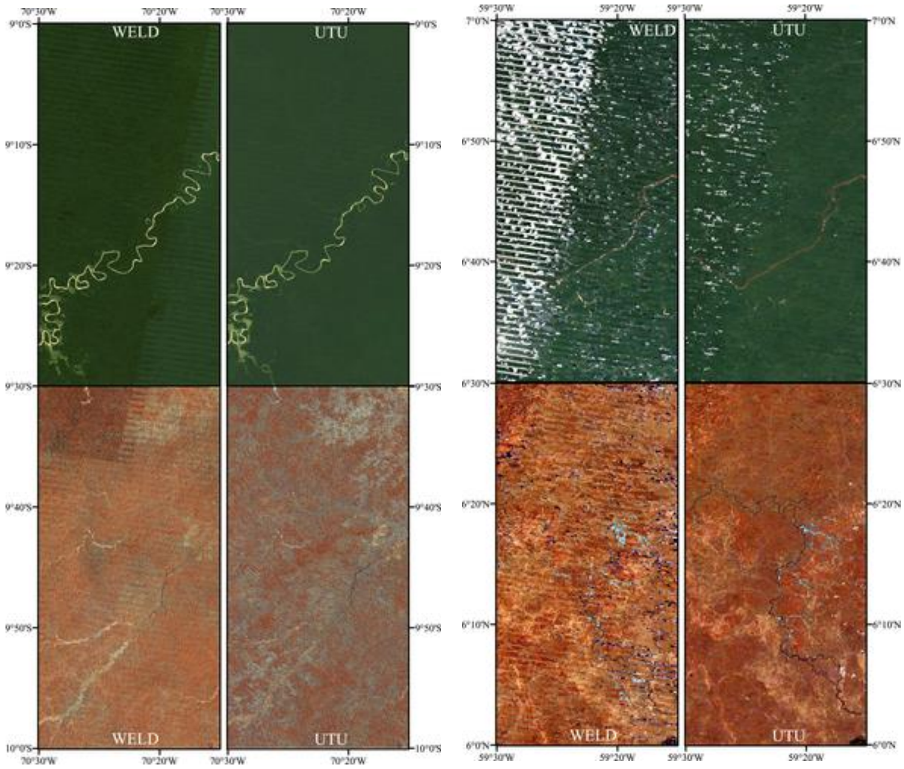
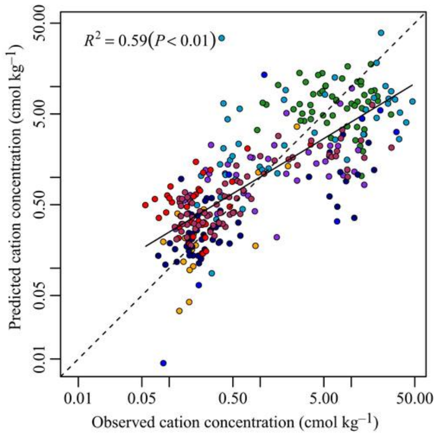
RATIONALE OF THE WORK: We wanted to combine Landsat imagery with datasets obtained from field inventories to identify different forest types across Amazonian. Unfortunately, there are some problems related to using Landsat data over tropical rainforests. The first issue is quite obvious: the rain feeding the forests comes from clouds, and multispectral satellites such as Landsat cannot look through clouds. The second issue is related to how sunlight scatters on forest canopies, which is non-lambertian, and causes an east-west reflectance gradient in Landsat images over Amazonian forests. Especially this second problem is often ignored, and existing high-level Landsat products over Amazonia, e.g., Web-Enabled Landsat Data (WELD), are too noisy to be useful in the type of analysis at high thematic resolution that we wanted to do. We therefore developed our own processing chain to download and process Landsat TM/ETM+ data in order to create a biome-wide, noise-free composite image.

KEY RESULTS: As can be seen in the two examples below, our processing and compositing chain (UTU) created composite images with much lower noise levels than the already available products (WELD) over Amazonia forests. Combining our composite image with field data, we showed that canopy reflectance is indicative of soil fertility.

The composite image we created can be a useful product for ecologists who work in Amazonia and want to integrate remote sensing data in their research, but lack the technical knowledge to undertake this type of image processing themselves.





RESEARCH DATA: We used free Landsat data for this study (available through USGS). Our Landsat TM/ETM+ image composite can be downloaded through Fairdata Etsin.

METHODOLOGY: We implemented our image processing chain in CSC Taito, using mostly R code. The chain consists of these steps:

Data downloading

We wanted to process several thousands of individual Landsat images, since the more data you can work with, the better you can filter noise effects. There are several interactive tools to browse and download Landsat data, e.g., USGS EarthExplorer (https://earthexplorer.usgs.gov/), but we chose to develop an R code using an application programming interface (API) so we could automate the process [link to code]. Using this code requires that you obtain basic HTTP authentication from USGS (for info: custserv@usgs.gov). One important problem is that only one download at a time is allowed, which makes this a bottleneck in the workflow, which is otherwise maximally parallelized.

Atmospheric correction and directional normalization

We used the ESPA software LEDAPS atmospheric correction to process Landsat images from Level-1 (at sensor radiance) to Level-2 (surface reflectance). ESPA software is unfortunately not (yet) installed in CSC Taito, so the users would have to install these codes themselves (see https://github.com/USGS-EROS/espa-surface-reflectance). An alternative is to download Level-2 products direct from USGS, which allows to skip this step at the cost of longer downloading times.

The directional normalization consists of two parts: a correction for terrain and a correction for illumination/viewing angle (BRDF). BRDF normalization requires a set of parameters that describe how light is scattered in the different directions by the earth surface. Directional scattering depends on the terrain: bare soil surfaces have different scattering properties than grasslands or forests. Some studies proposed BRDF parameters that are applicable globally, but we found that these were not appropriate for Amazonian forests and therefore developed our own set of parameters.

Reproject and composite

The final step consists of reprojecting all images to a common geographic reference system and spatial extent, and of assembling all individual images into one single composite. A critical user input here is which compositing criterion will be used. The “maximum NDVI” criterion is historically the most popular, but for Amazonian forests, we found that selecting the multidimensional median observation for each pixel resulted in the composite with the lowest noise.

TAKE HOME MESSAGE: Image processing techniques are often development and validation for specific regions on Earth, e.g., over Europe or North America. It is important to keep in mind that high-level products validated for these areas are not necessary of the same quality for other places on earth. Some initiatives have been taken to make Landsat or Sentinel-2 data available in a way that they are more accessible to researchers with limited knowledge in remote sensing, e.g., in Analysis Ready Data (ARD) formats or through the FORCE software (available in CSC Taito). However, developers of such data and software should keep in mind that a one-size-fits-all solution rarely exists. Depending on applications and/ or geographic location, studies will have different requirements or face specific problems. It is therefore important that enough versatility and possibility for user-interaction is provided in these products.