Production of Evapotranspiration Maps for Years 2004 and 2006 for Landsat Path 44 Covering the Upper Sprague River area of Oregon using Landsat Images and Vegetation Indices

by
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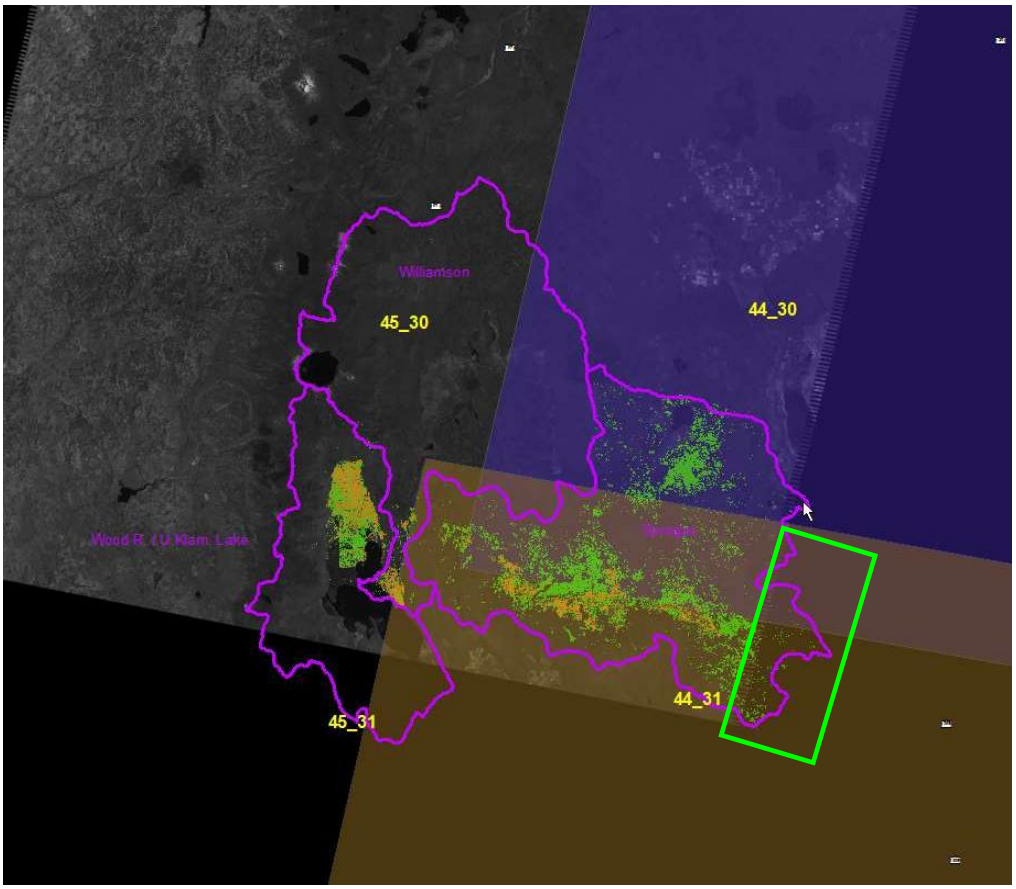

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Background

The area of interest to the Evapotranspiration (ET) study of the Klamath and Sprague River systems of Oregon is outlined in the figure on the cover of this report (courtesy of Dan Snyder, USGS). A general outline of two of the areas of interest is shown in Figure 1. Most of the areas of interest lie in path 45 of the Landsat WRS coverage, as shown in the cover figure. A very small portion of the upper Sprague River basin lies to the east of path 45 and is covered by path 44, only. Portions of the Sprague basin lie in an overlap of both paths 45 and 44.

The areas lying in path 45 were processed using the University of Idaho METRIC energy balance based procedure to produce actual ET. Parts of rows 30 and 31 were processed. Details for years 2004 and 2006 are provided in two other reports. Each Landsat path requires its own METRIC application and calibration because the images occur on different dates. Full METRIC applications for path 44 were not considered to be economical due to the small area. Instead, a relatively rapid, vegetation-index-based method for estimating fraction of reference ET, ETrF, was applied, where the coefficients for the method were based on data derived from the full METRIC application for path 45. Some adjustment to the general coefficients was made to account for background evaporation stemming from antecedent precipitation.

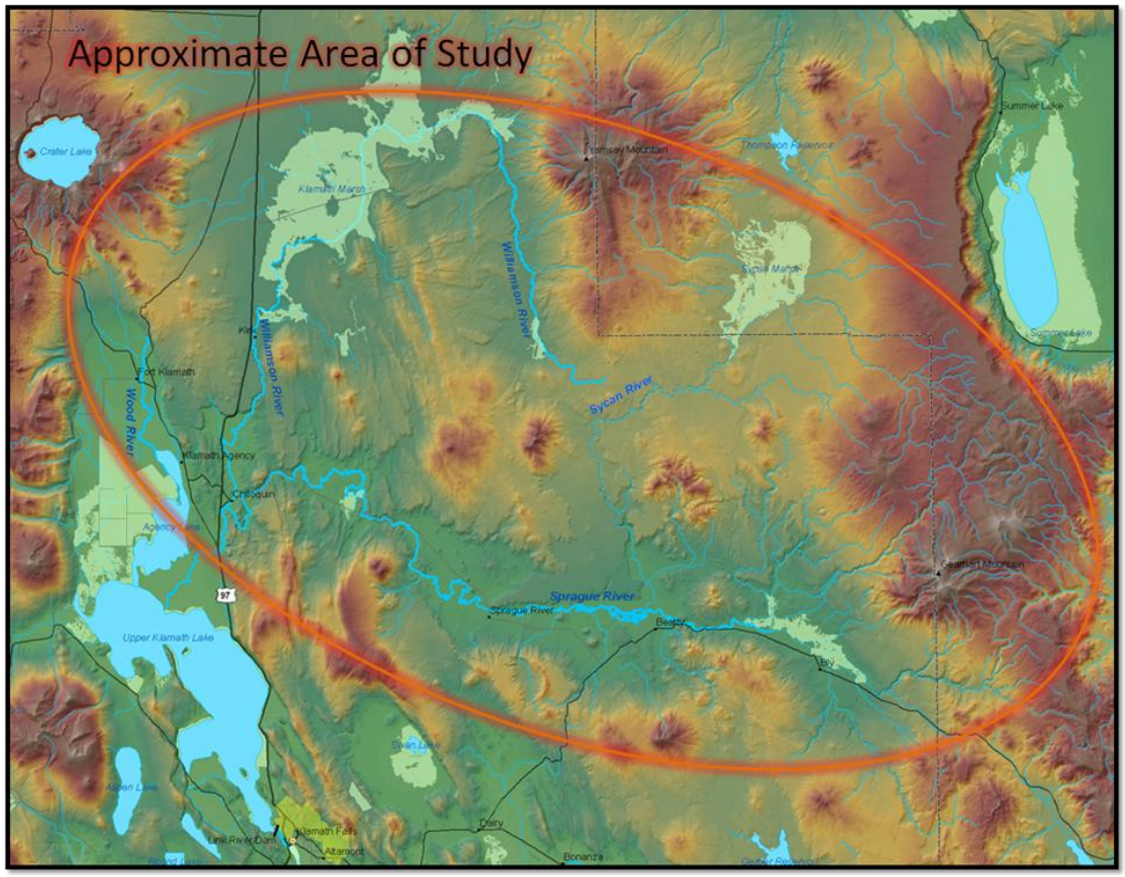

Figure 1: Approximate area of interest in Klamath and Sprague River basins of south-central Oregon.

Procedure

The normalized difference vegetation index, NDVI, is computed as:

$$NDVI = (\rho_{t,4} - \rho_{t,3}) / (\rho_{t,4} + \rho_{t,3}) \quad (1)$$

where: $\rho_{t,3}$ and $\rho_{t,4}$ are at-satellite reflectances for bands 3 (red) and 4 (near infrared) of Landsat 5 or 7. The NDVI is a sensitive indicator of the amount and condition of green vegetation. Theoretically, values for NDVI can range between -1 and +1. Green surfaces typically have NDVI values between about 0.2 and 0.85 for Landsat data, and water, snow and clouds usually have values less than zero. The NDVI determined from Eq. 1 used reflectance values that were based on 'top of atmosphere' radiance, for consistency with common practice.

The computational steps were as follow:

1. METRIC submodels m001 and m01 were used to generate top of the atmosphere NDVI

2. From NDVI, baseline estimates for ETrF were calculated as:

$$ETrF = 1.2 * NDVI \quad \text{when} \quad NDVI > 0 \quad (2a)$$

$$ETrF = 0.7 \quad \text{when} \quad NDVI < 0 \ \text{(representing water bodies)} \quad (2b)$$

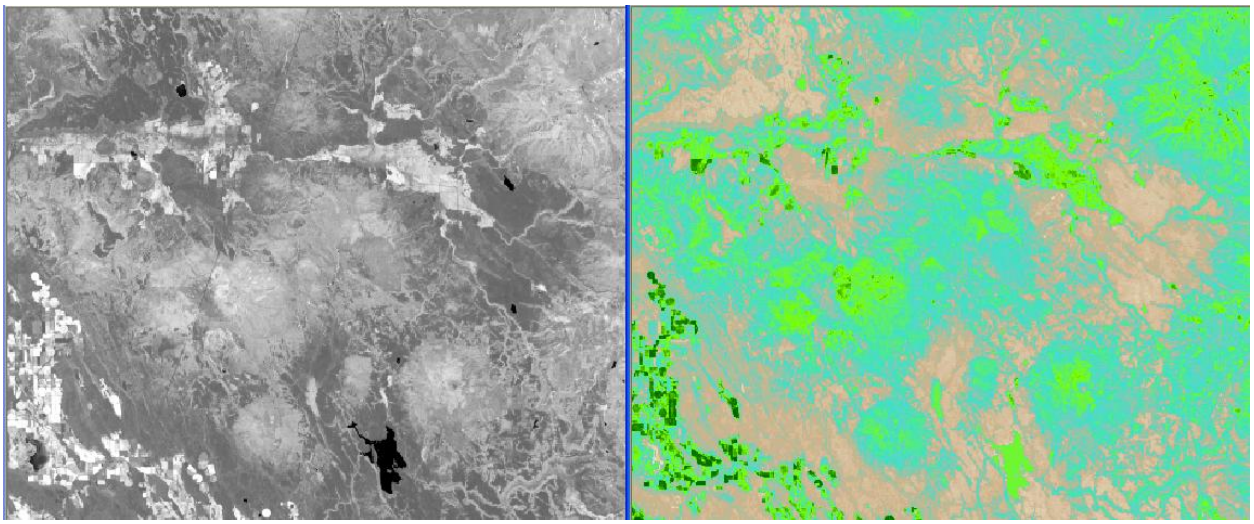

Figure 2. Left: NDVI image for 07/12/2004. Right: ETrF image estimated as ETrF=1.2*NDVI for the same date. Water bodies (black spots in the NDVI image) were assigned a fixed value of ETrF=0.7.

The 1.2 coefficient in Eq. 2a was based on ETrF vs. NDVI relationships observed from the path 45 images processed for years 2004 and 2006. The 1.2 multiplier, with 0.0 offset, represents ET conditions where the soil surface is relatively dry, so that the majority of ET is due to the presence of vegetation and transpiration.

3) ETrF images were cloudmasked. A value of -2 was assigned for clouds and Landsat 7 gaps.

4) ETrF images were cloudfilled.

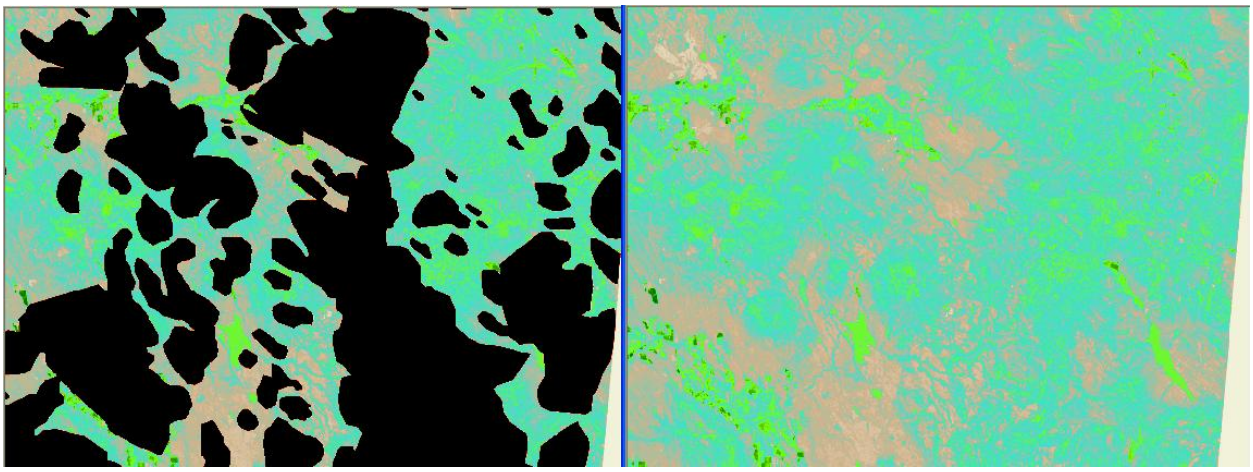

Figure 3. Left: masked ETrF image for 05/25/2004; black areas are clouds masked with a value of -2. Right image: The same image after ETrF in the cloudy areas was estimated using the METRIC cloud filling algorithm.

5). The METRIC splining model was used to generate monthly ETrF images for path 44.

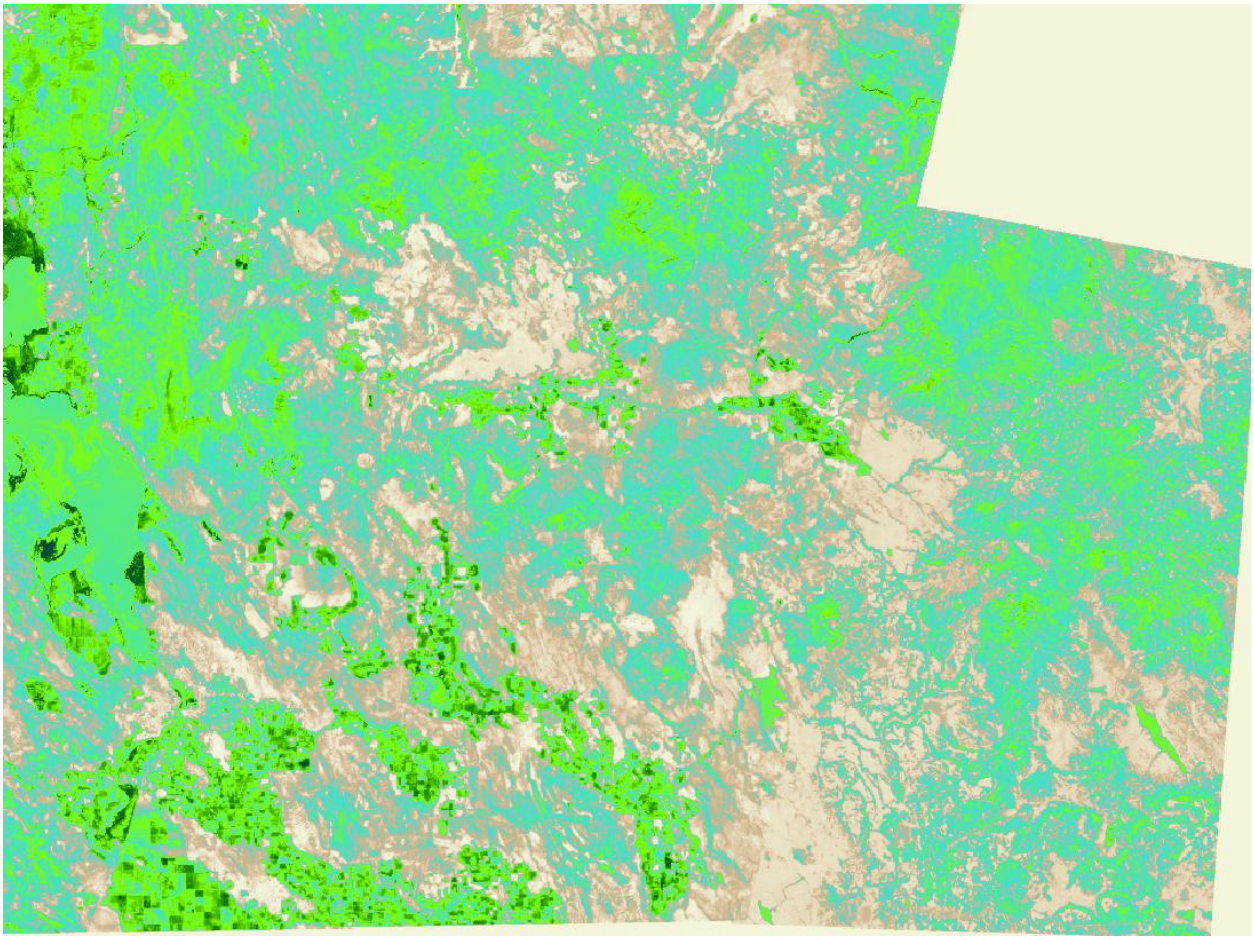

Figure 4. Mosaiced Image for August 2004.

6) Depending on the match of monthly ETrF for Path 44 that was derived from NDVI to monthly ETrF for path 45 that was derived from energy balance, ETrF for path 44 was adjusted to account for higher or lower background evaporation due to specific moisture conditions observed for the particular month and images on which the monthly ETrF were based. This was done as:

$$ETrF\_adjusted = a*(ETrF/1.2) + b \quad (3)$$

where a and b are coefficients determine by iterative, visual comparisons between the path 44 and path 45 products. Only classes 52 (shrub) and 71 (grassland) were adjusted, since these classes are the most subject to precipitation induced evaporation. The adjustment was most pronounced at pixels having low NDVI. A comparison between pre and post adjustment for monthly ET in April 2004 is shown in Figure 5, where the overlap between the two paths is quite pronounced before adjustment and less pronounced following adjustment.

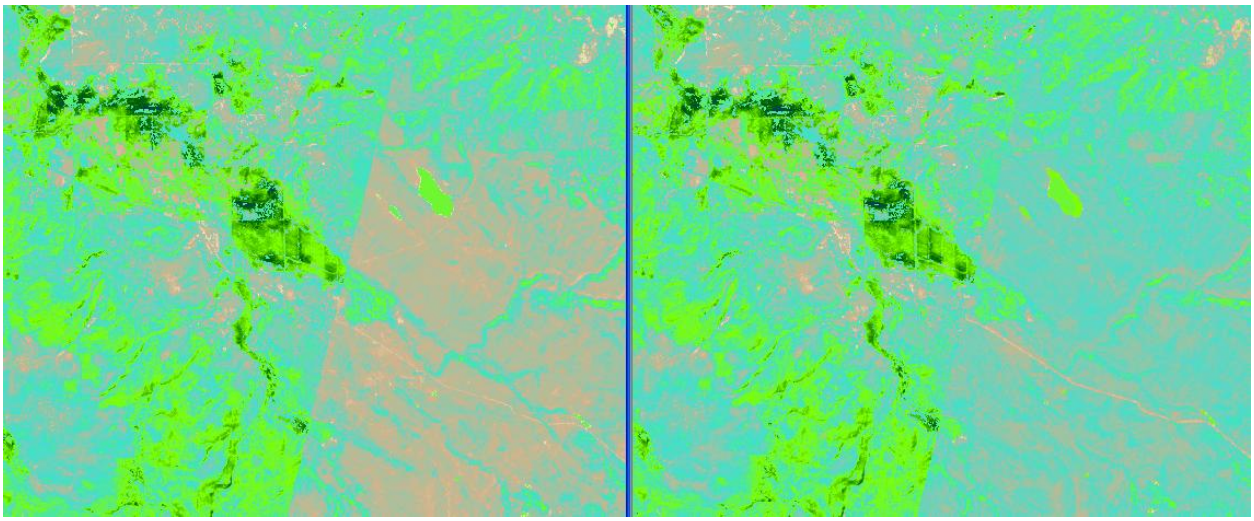

Figure 5 . Close-up of the mosaiced ETrF image for April 2004. Left: Before adjustment; Right: After adjustment.

7) Final Path 44 monthly and growing season ETrF and ET images were mosaiced with Path 45 images using Arc-GIS. Moasiced images can be considered to be the final products and used as inputs to water balances. These image files are housed in the folder named Klamath_2004_2006_paths_44_45_Final_Mosaiced_Products that was delivered to the USGS.

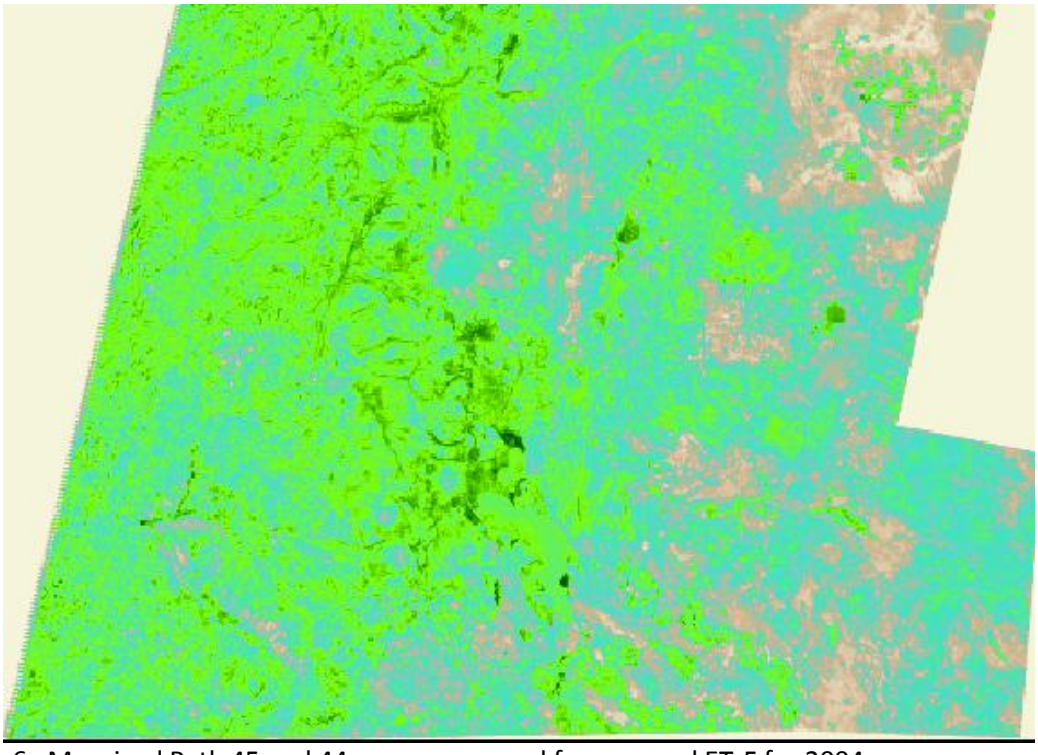

Figure 6. Mosaiced Path 45 and 44 areas processed for seasonal ETrF for 2004.

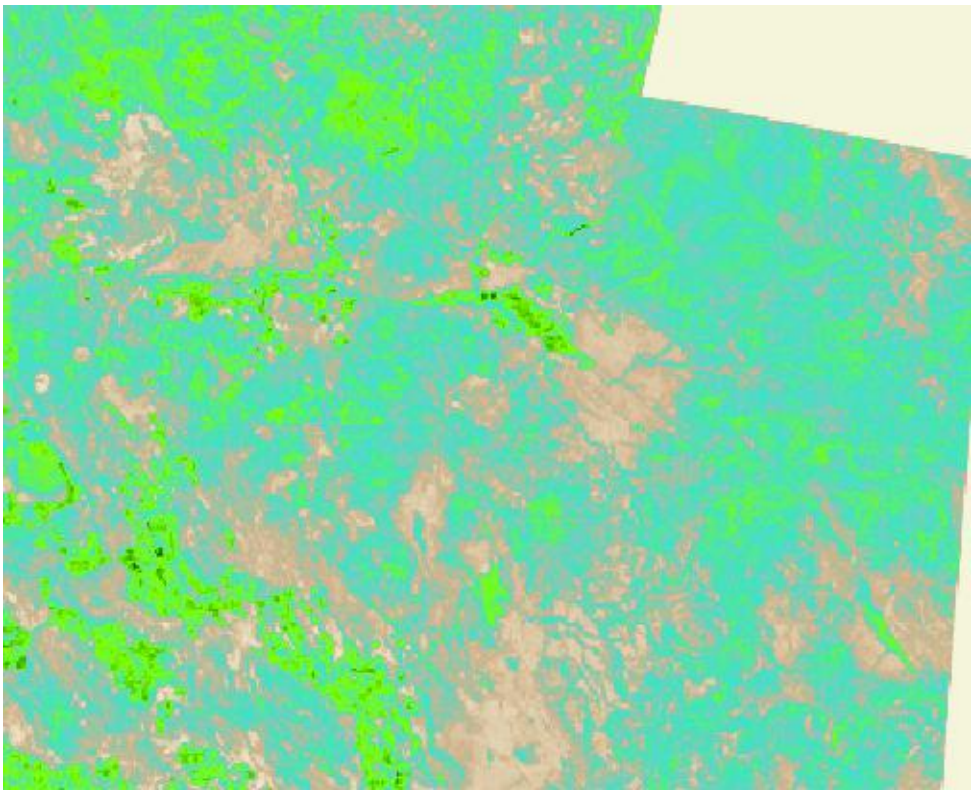

Figure 7. Close-up of the path overlap area for the seasonal ETrF map for 2004.