Skyline Extraction

Not Finished… in progress

Skylines are being extracted separately to help create “points of interest” useful as additional points for correspondence (point matching between images). The skylines have other uses such as gps markers (see the Yosemite half dome and peak finder notes).

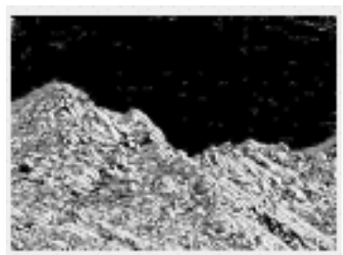
The intermediate image product while creating Canny Edge filters is a theta image created from the x and y gradients of the main color image. The theta image’s largest contiguous zero value pixels appears to be a good way to locate the sky. Those sky points can then be used with the color image to further grow the region to the apparent skyline.

These are notes while implementing the skyline extraction.

The contiguous zero values are found with a depth first traversal of image pixels. With the default stack size of the java jvm (the architecture is my laptop) the stack is small for the method frame of the dfs method when the number of pixels in the image is larger than about 870,000. Beyond that number of pixels, the runtime of the method dramatically increases. Image binning is performed to reduce the number of pixels to make a reasonable runtime. The image is down sized to a factor of a factor of 2 to result in nPixels < 870,000. Then the largest group of contiguous zero value pixels is found. The zero value points’ coordinates are then transformed back to the reference of the full size theta image and corrections for lower resolution are made.

This appears to result in a stable location of the sky.

scaled theta



zero points from down scaled image upscaled in blue

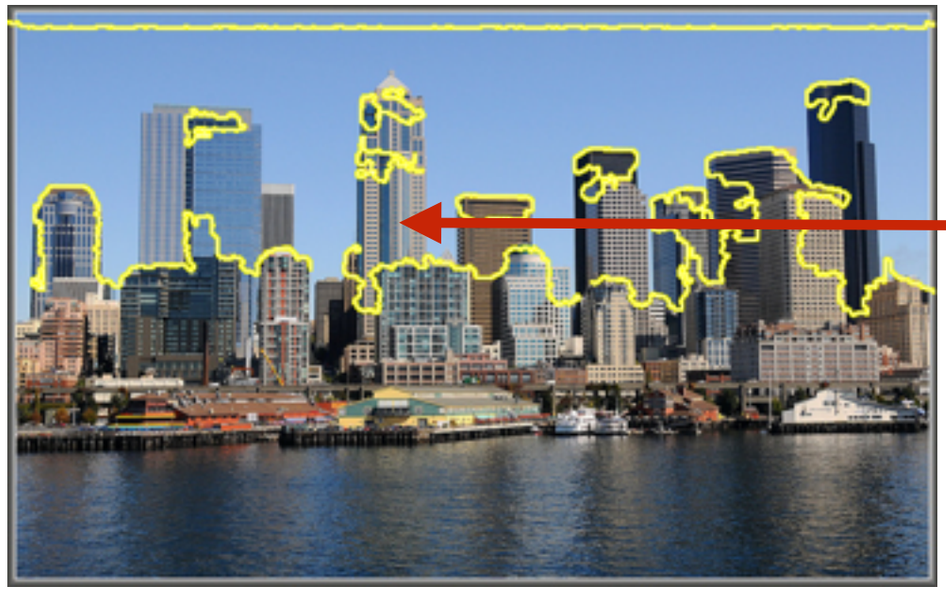
For clear skies and foreground objects with patterns and contrast, those sky points are the total sky. For other images, the sky has to be grown to larger boundaries using hue or contrast in the color image.

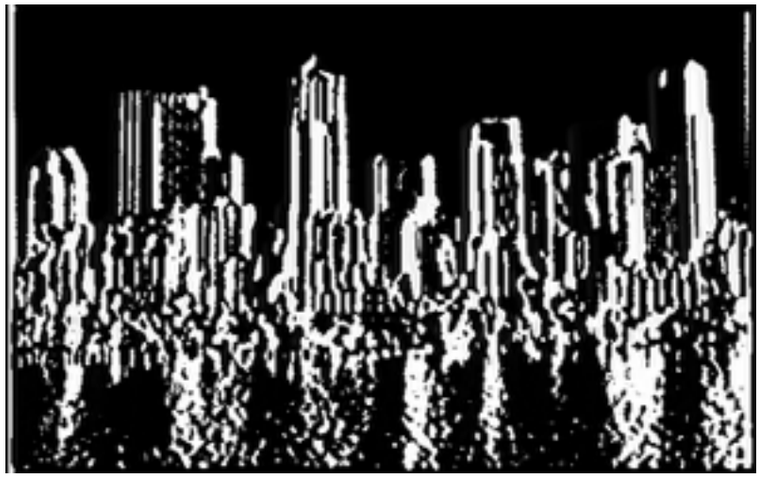
Note that skyscrapers with repetitive structure on the scale of combined convolution (approx the FWHM = 2.355 * sqrt(2*2 + 0.5*0.5) = 6 pixels) or any object w/such repetition can result in “blind spots” in the theta image and so they need to be removed from the sky points set using the color image before the sky point set is grown to larger boundaries.

Skyline Extraction

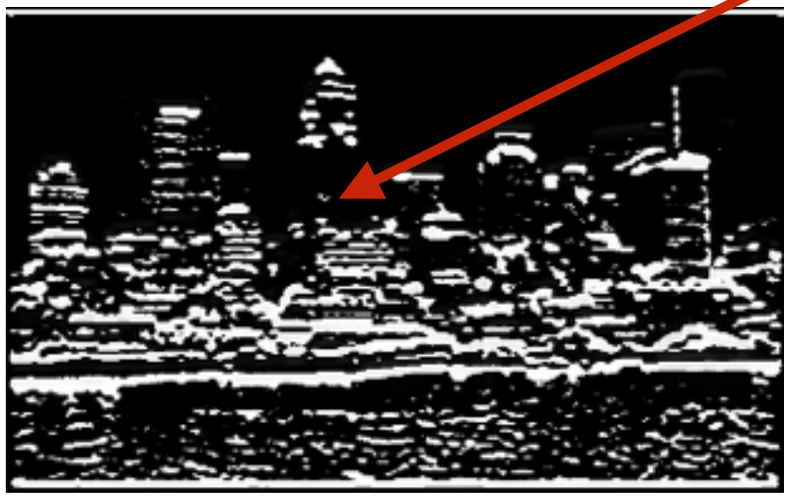
Here is an example of repetitive structure on the scale of combined convolution (approx the FWHM = 2.355 * sqrt(2*2 + 0.5*0.5) = 6 pixels in a skyscraper that results in a gap in the y gradient image where there is an object in the color image.

first gathering of sky pixels from theta before removing non-sky pixels and growing the set





gradient X



gradient Y

theta

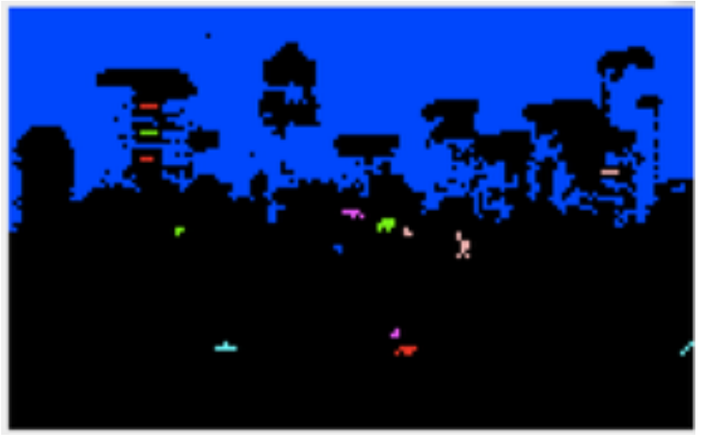
Skyline Extraction

Not Finished… in progress

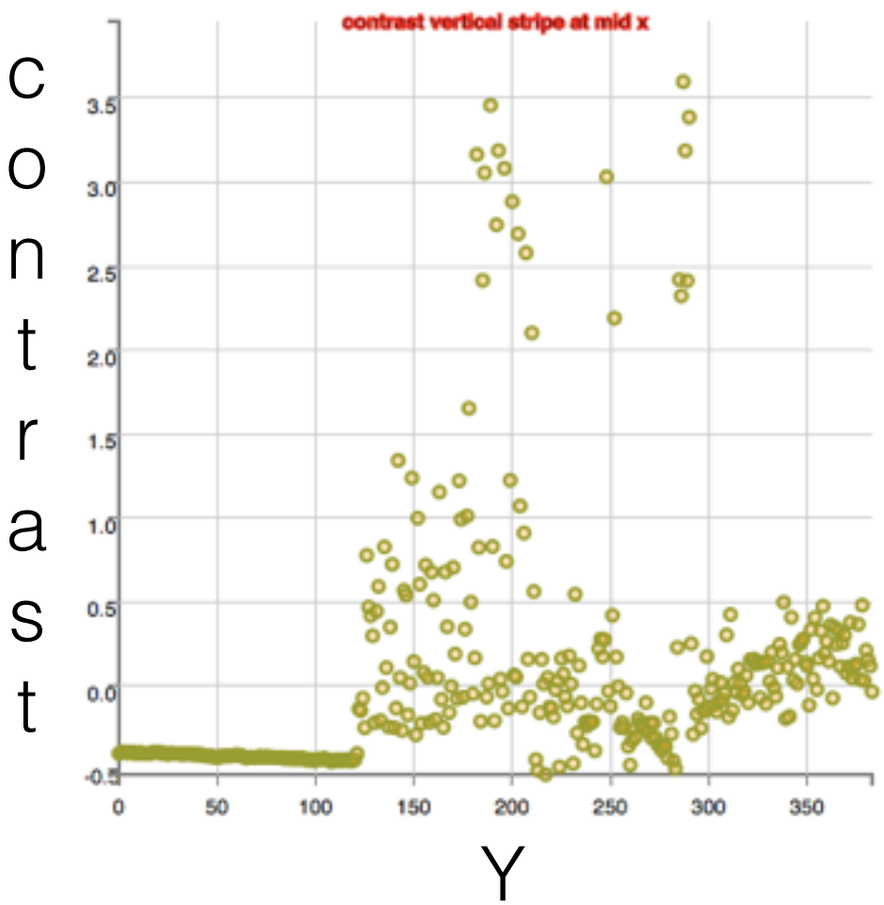
Seattle image:.vertical stripes through the middle of the image show contrast and blue are good indicators for skyline boundary.

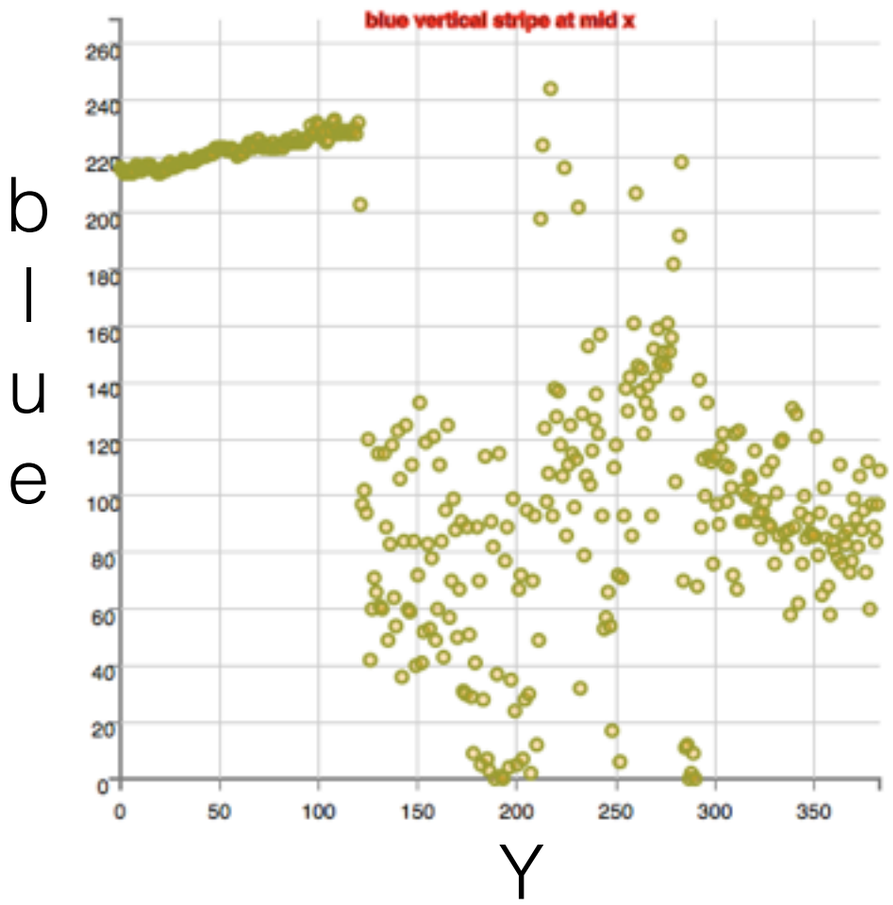
`https://www.flickr.com/photos/tdlucas5000/14177059903`

Y



blue sky:
skyline is where contrast decr, blue decr.





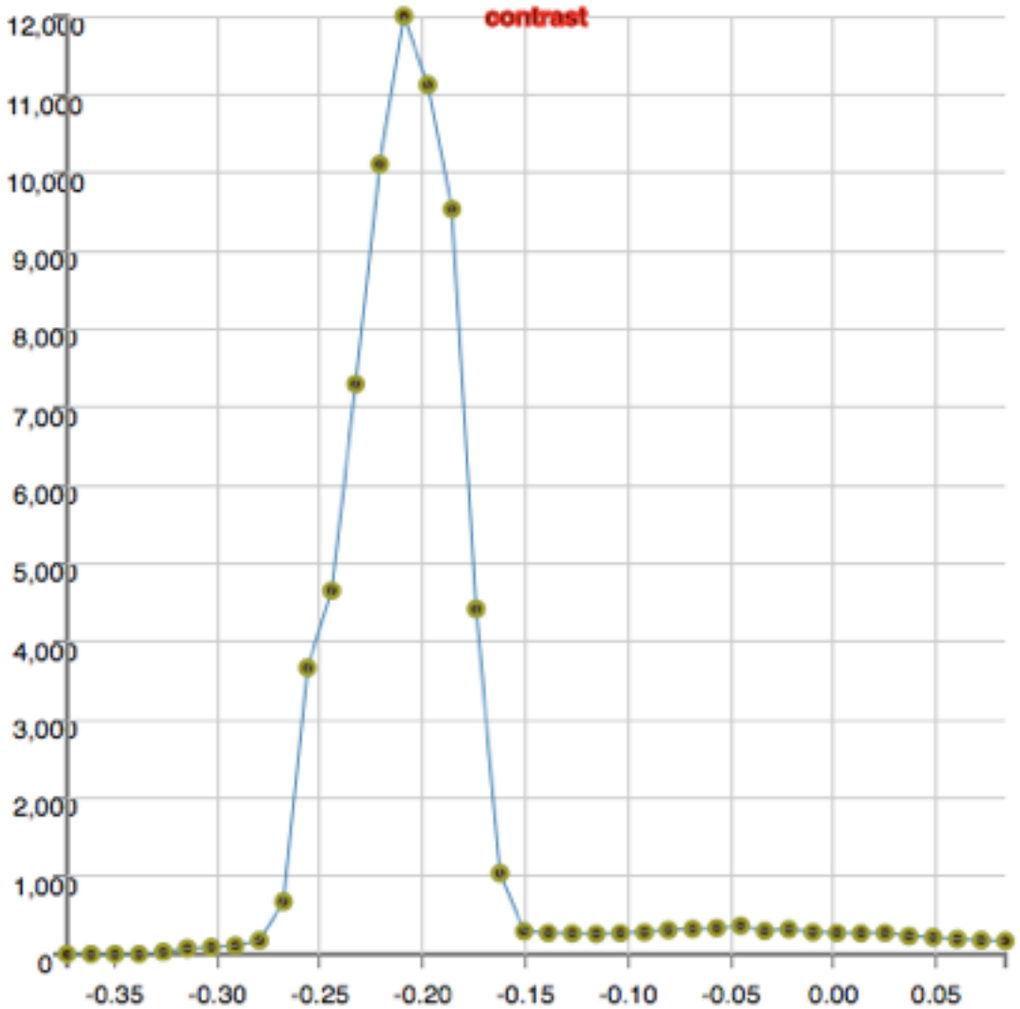
Skyline Extraction

Not Finished… in progress

Removing silhouette regions and keeping only the largest contiguous sky pixels.

histogram of contrast of sky pixels thus far.

Looks like can remove pixels w/ contrast > -0.15 to remove the building pixels from sky.



Skyline Extraction

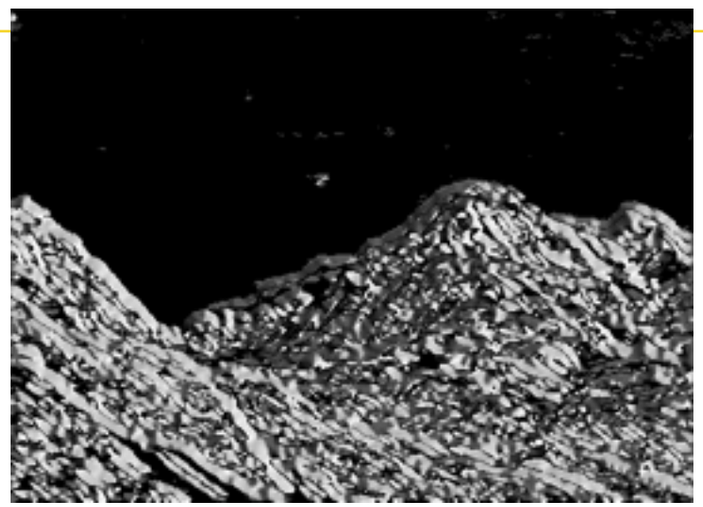
Not Finished… in progress

Growing the sky region to the skyline.

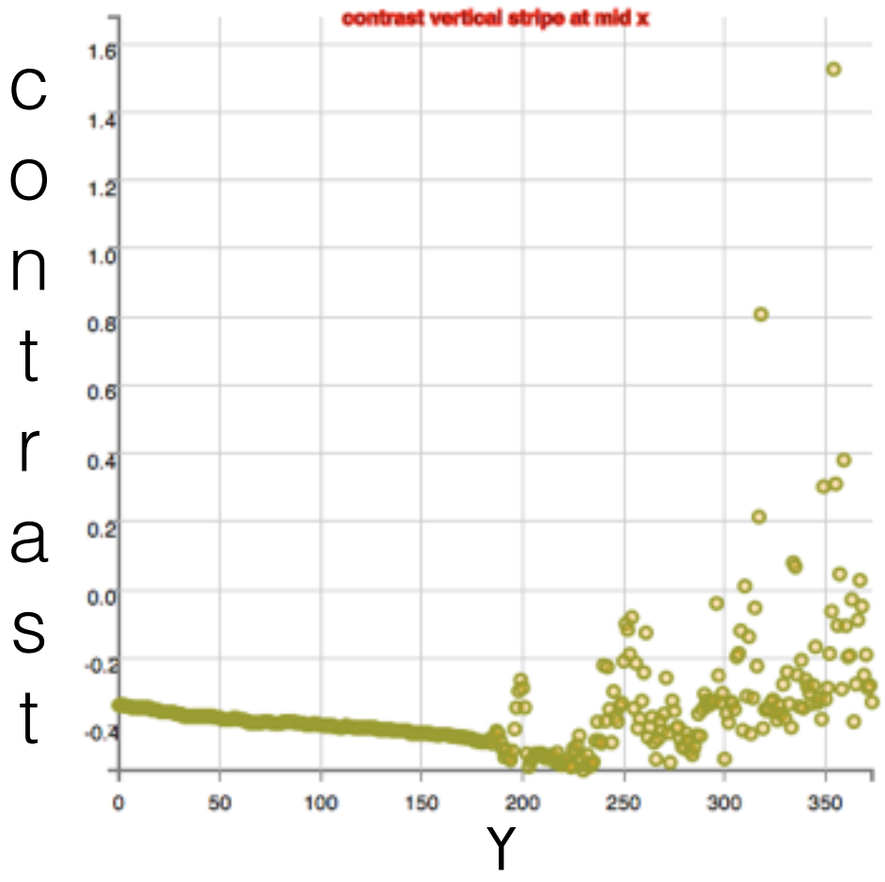
Skyline Extraction

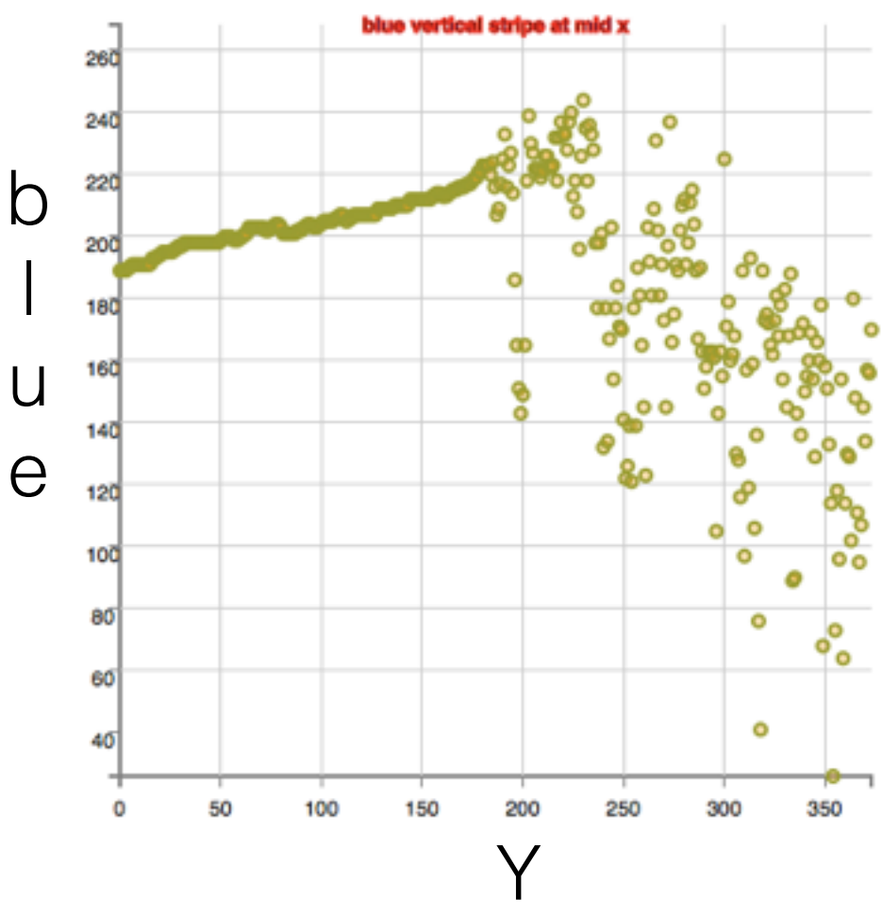
Brown & Lowe 2003 image:.vertical stripes through the middle of the image shows contrast and blue are good indicators for skyline boundary

Y



blue sky:
skyline is where contrast decr, blue decr.



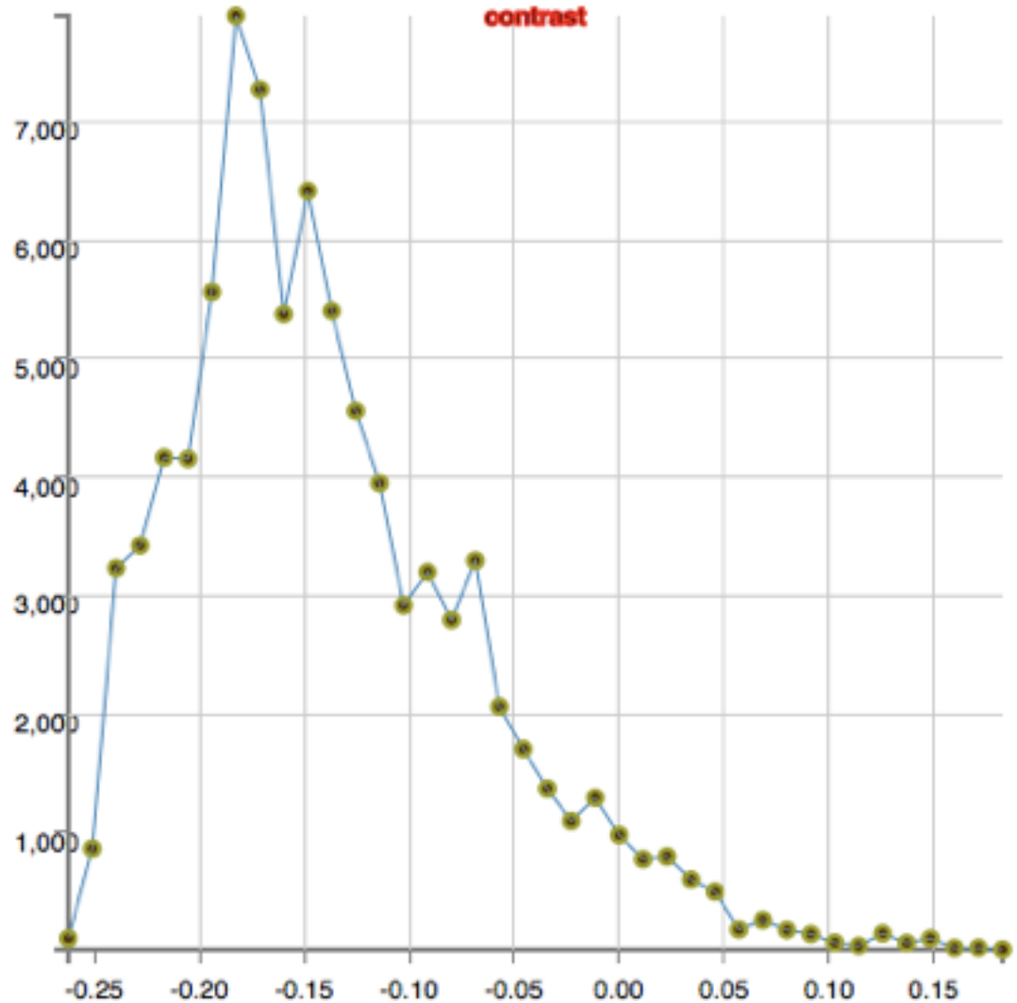


Skyline Extraction

Not Finished… in progress

Removing silhouette regions and keeping only the largest contiguous sky pixels.

histogram of contrast of sky pixels thus far.



pixels w/ contrast above limit removed

Skyline Extraction

Not Finished… in progress

Growing the sky region to the skyline.

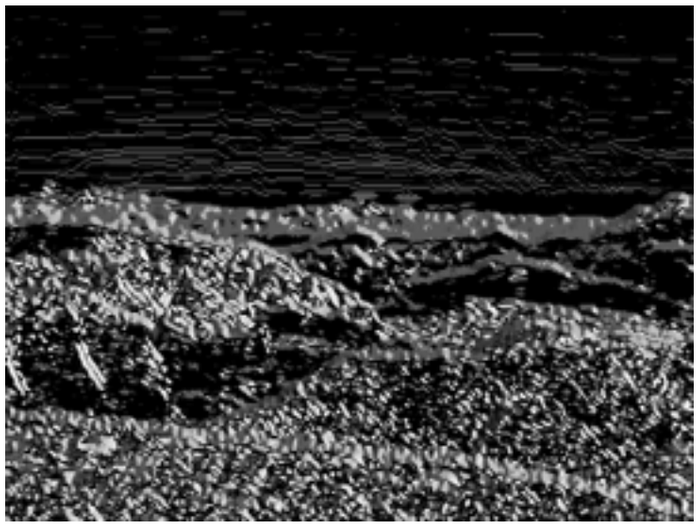
Skyline Extraction

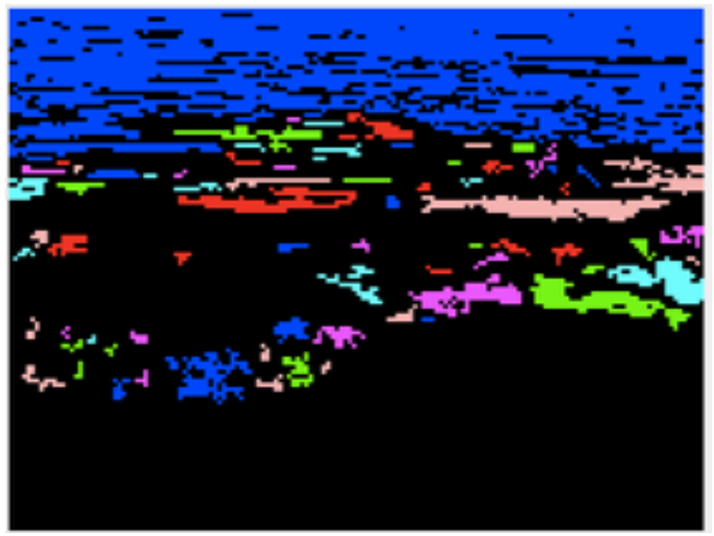
Not Finished… in progress

Venturi mountain image:.vertical stripes through the middle of the image shows contrast and blue are good skyline indicators

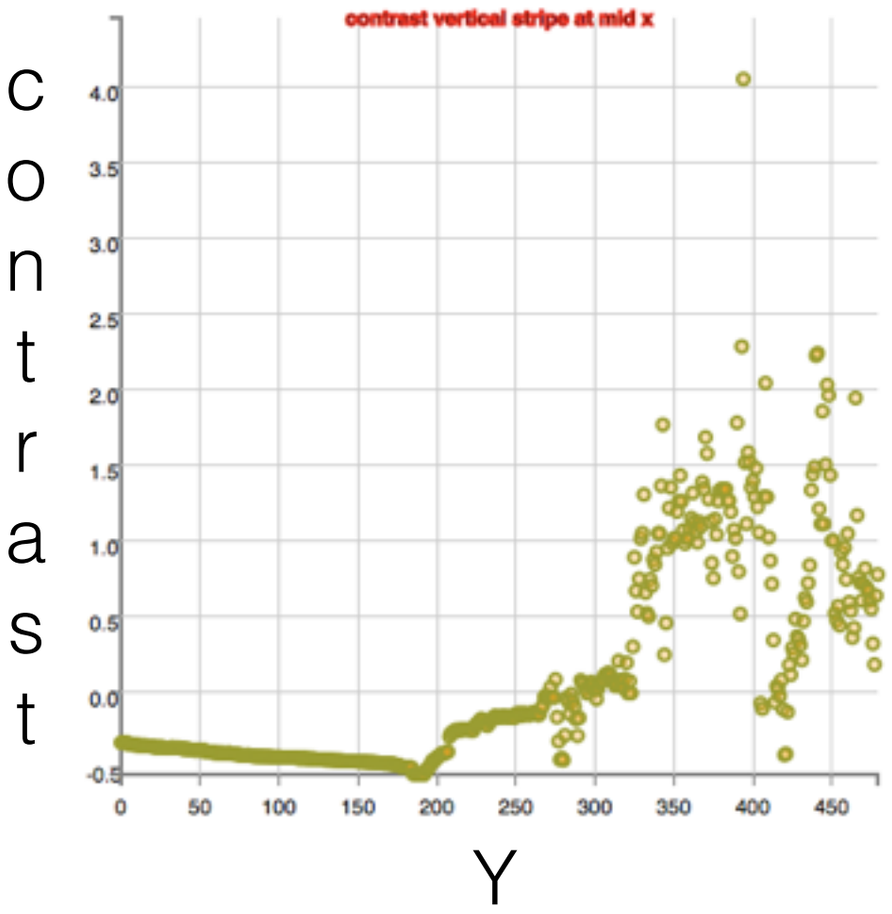
`https://venturi.fbk.eu/results/public-datasets/mountain-dataset/`

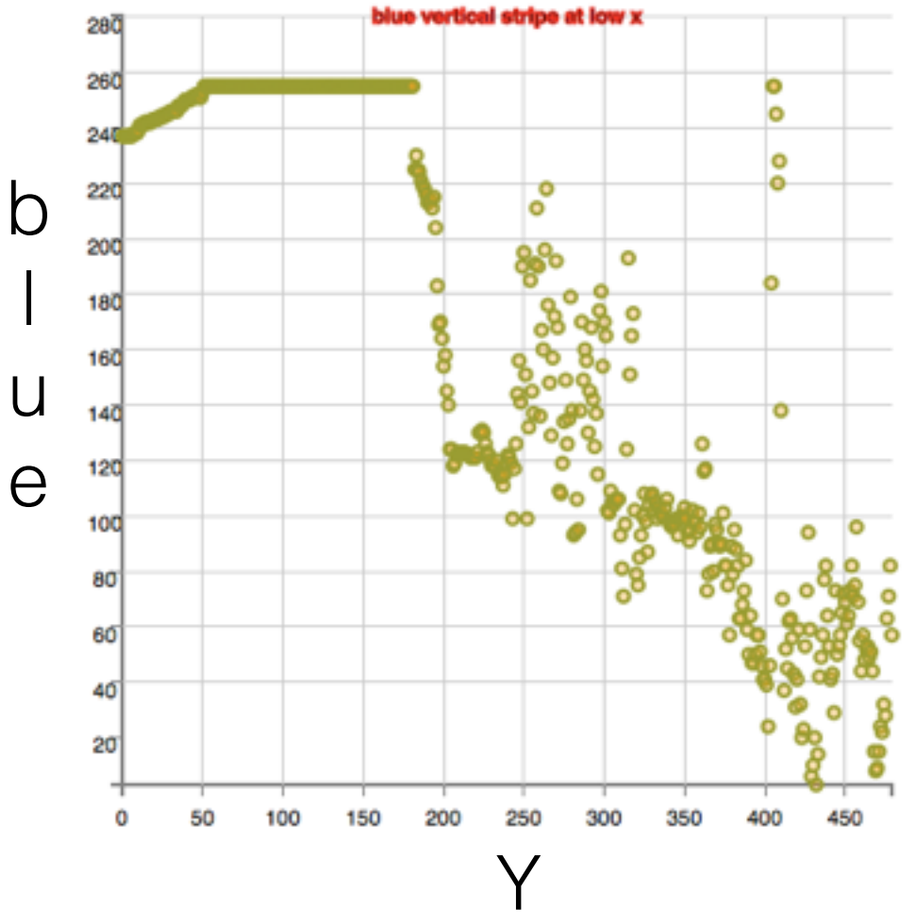
Y





blue sky:
skyline is where contrast decr, blue decr.

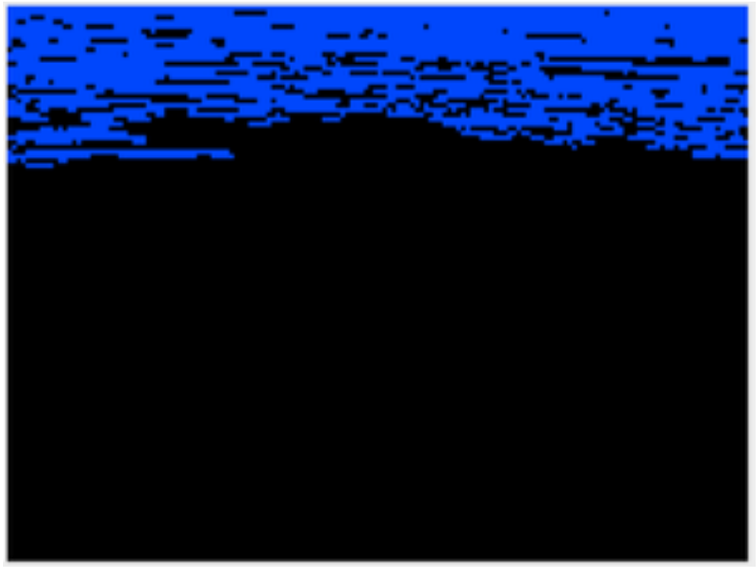




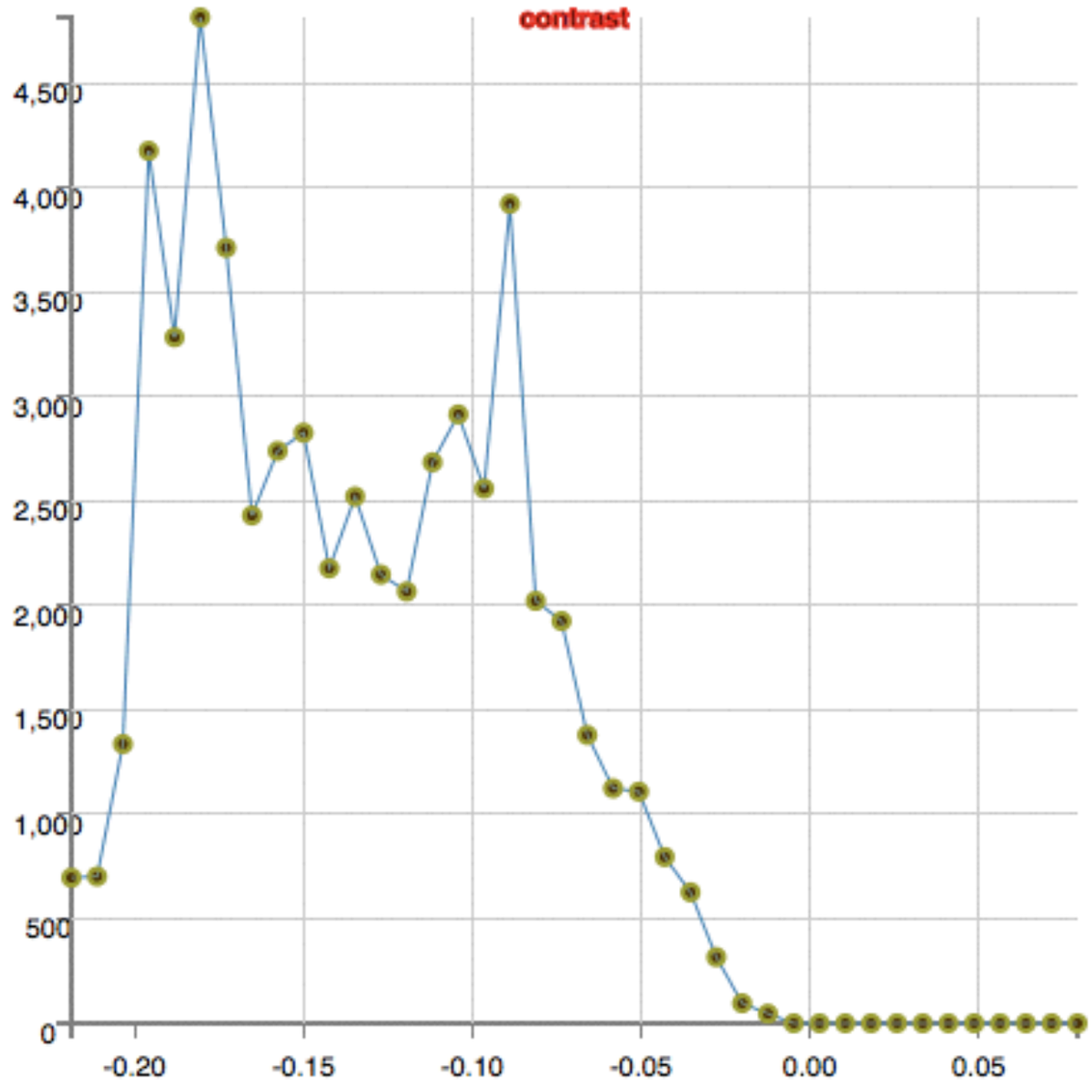
Skyline Extraction

Not Finished… in progress

Removing silhouette regions and keeping only the largest contiguous sky pixels.



histogram of contrast for sky pixels.



Skyline Extraction

Not Finished… in progress

Growing the sky region to the skyline.

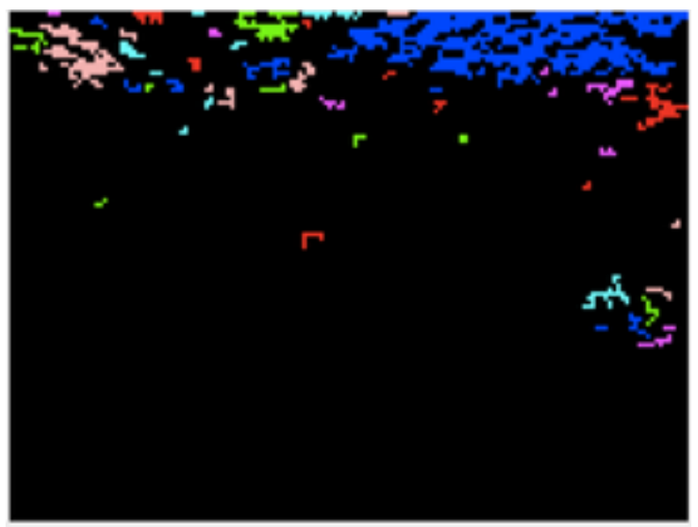
Skyline Extraction

Not Finished… in progress

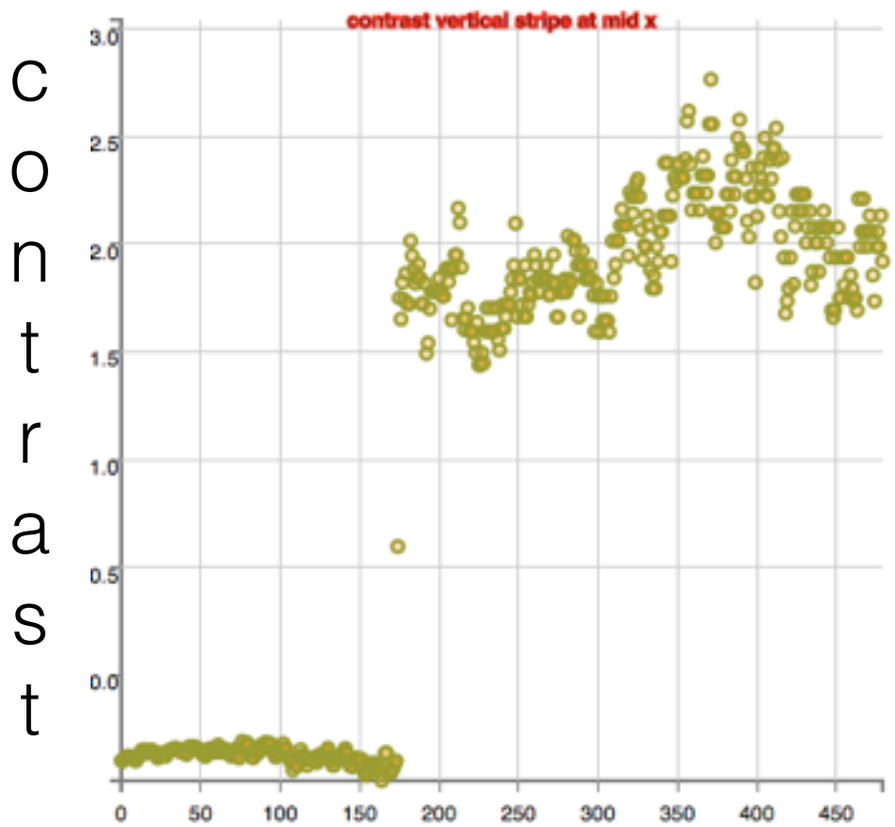
image:.vertical stripes through the middle of the image shows contrast and red are good indicators here for skyline boundary.

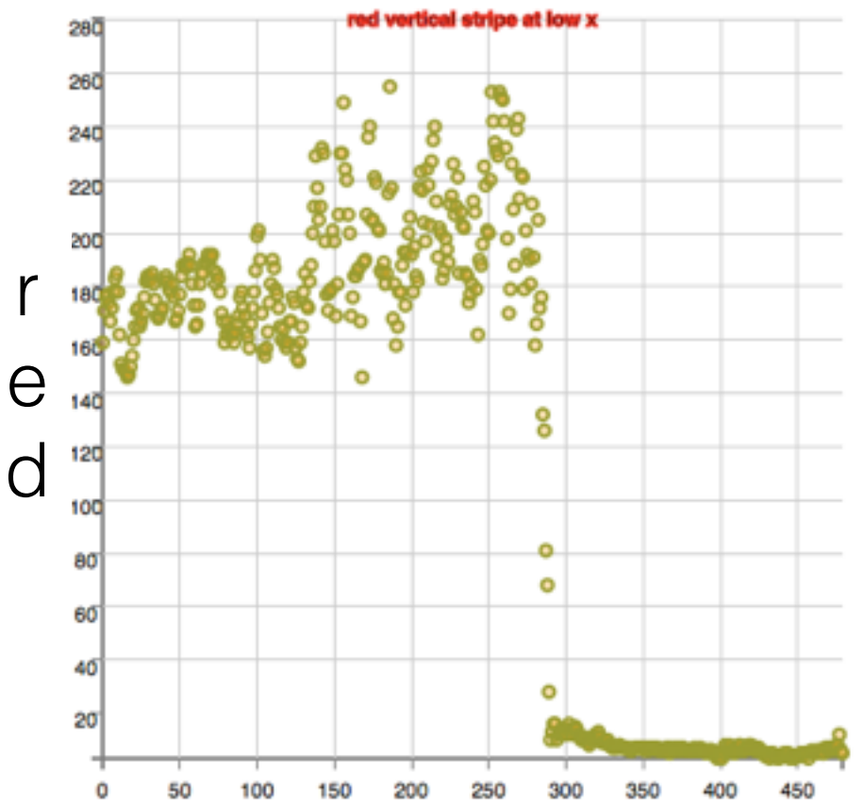
https://www.flickr.com/photos/stonehenge-stone-circle/11774684414/

Y



red sky + dark foreground:
skyline is where contrast incr, red decr. and reverses slope (plunges)

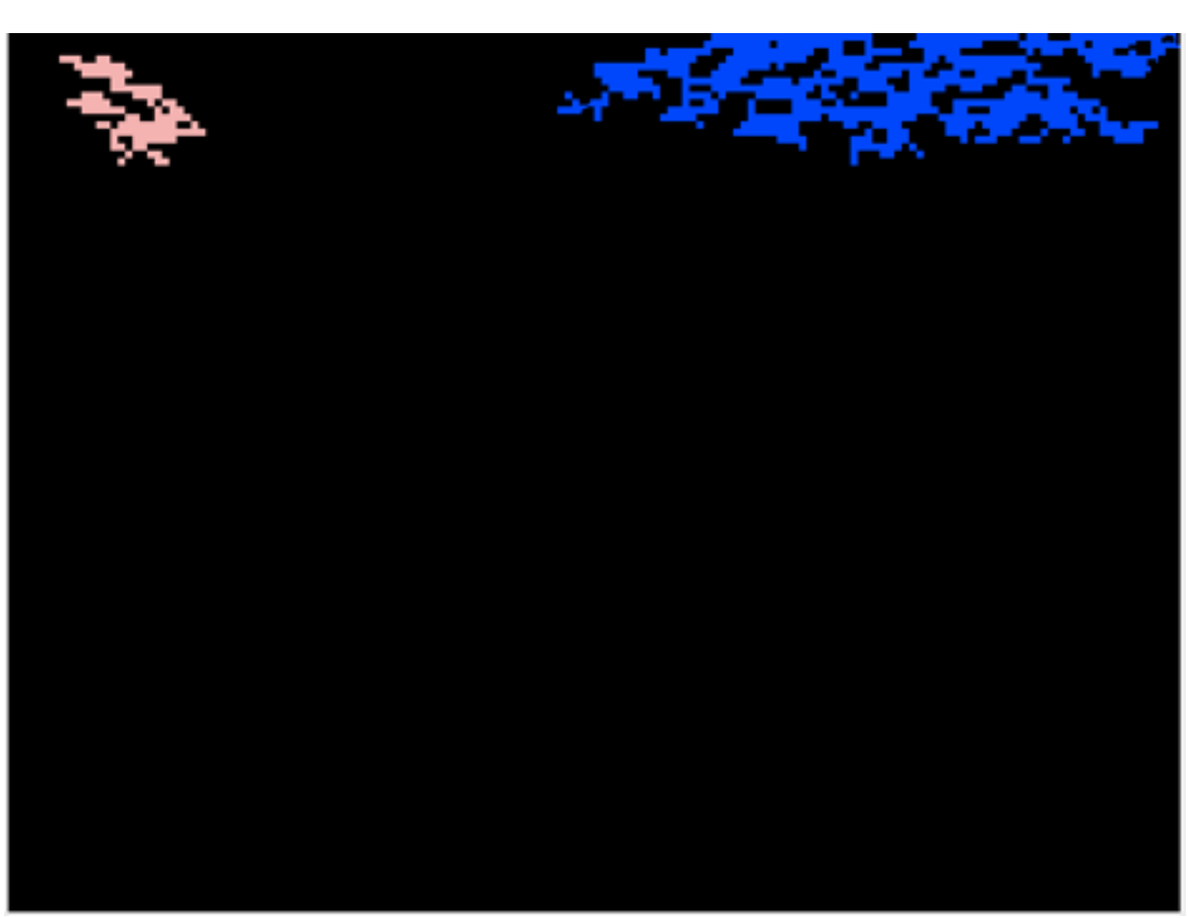




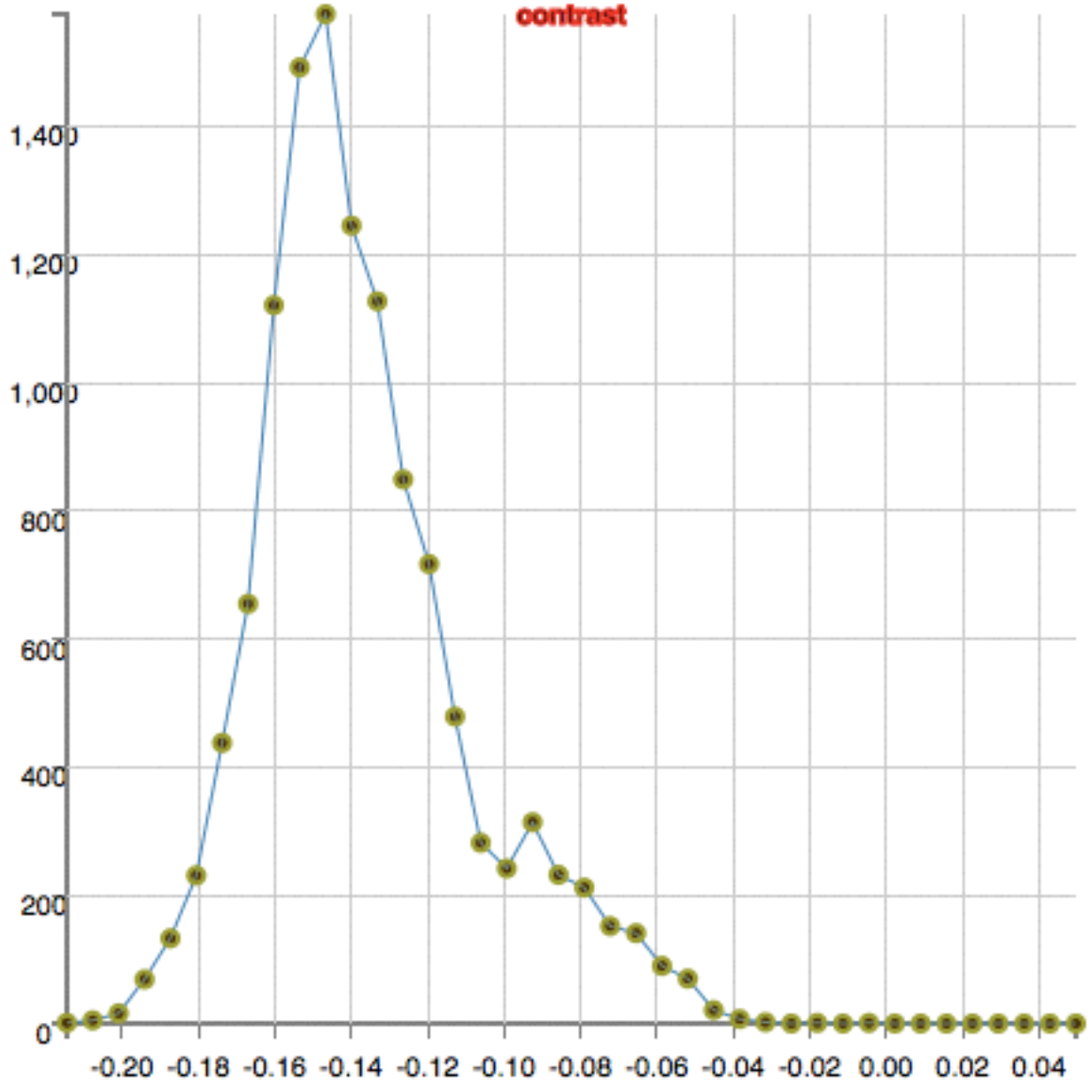
Skyline Extraction

Not Finished… in progress

Removing silhouette regions and keeping only the largest contiguous sky pixels.



histogram of contrast for sky pixels.



Skyline Extraction

Not Finished… in progress

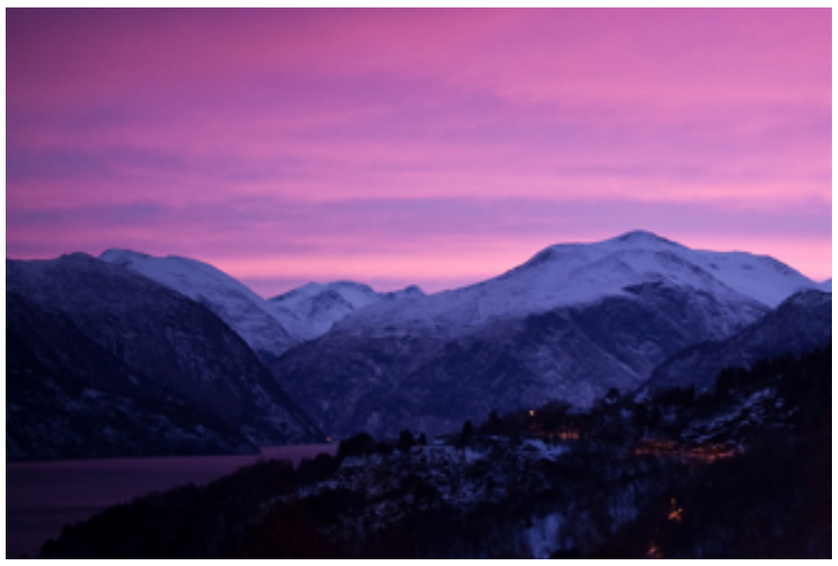
Growing the sky region to the skyline.

Skyline Extraction

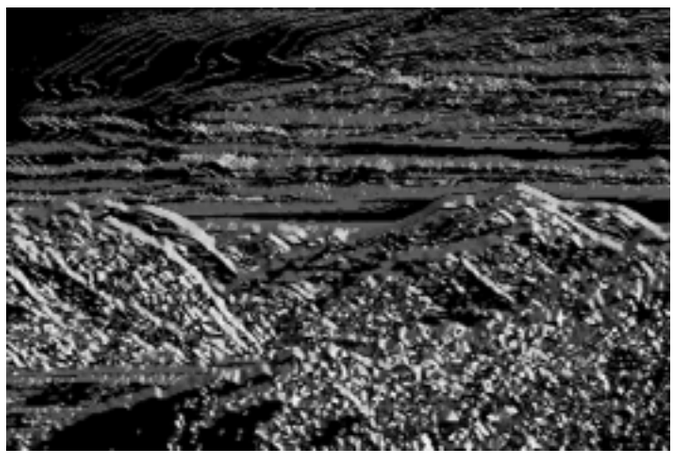
Not Finished… in progress

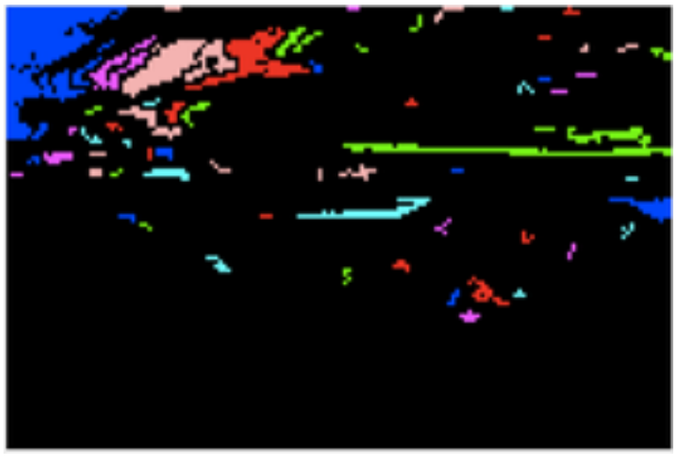
image:.vertical stripes through the middle of the image shows contrast and red are good indicators here for skyline boundary.

https://www.flickr.com/photos/jvikphoto/4305855415

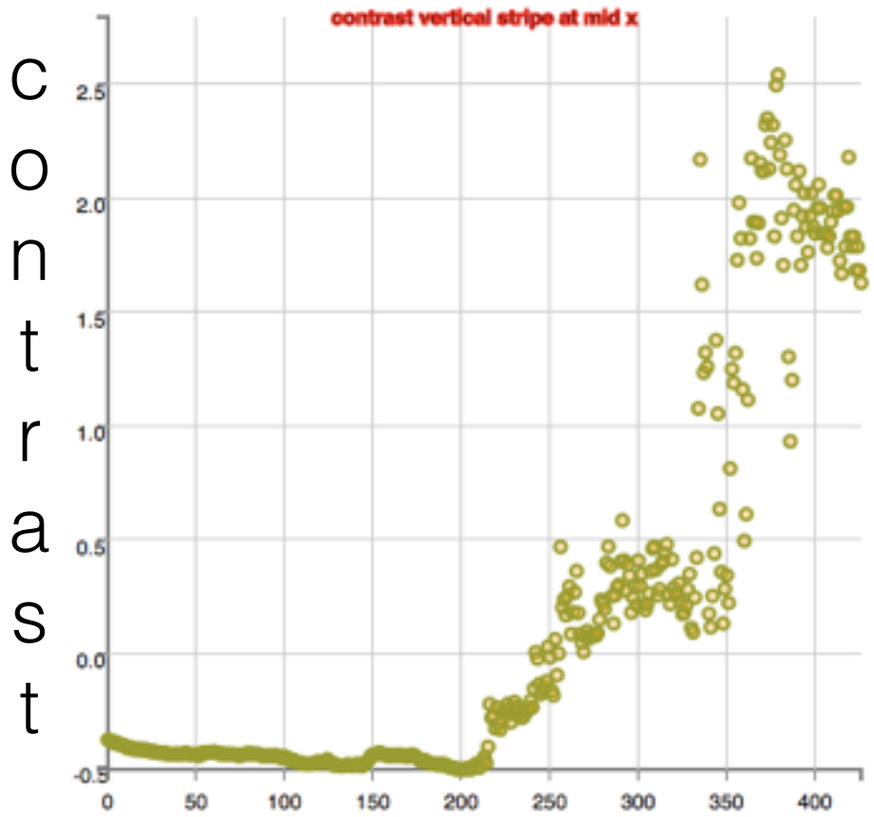


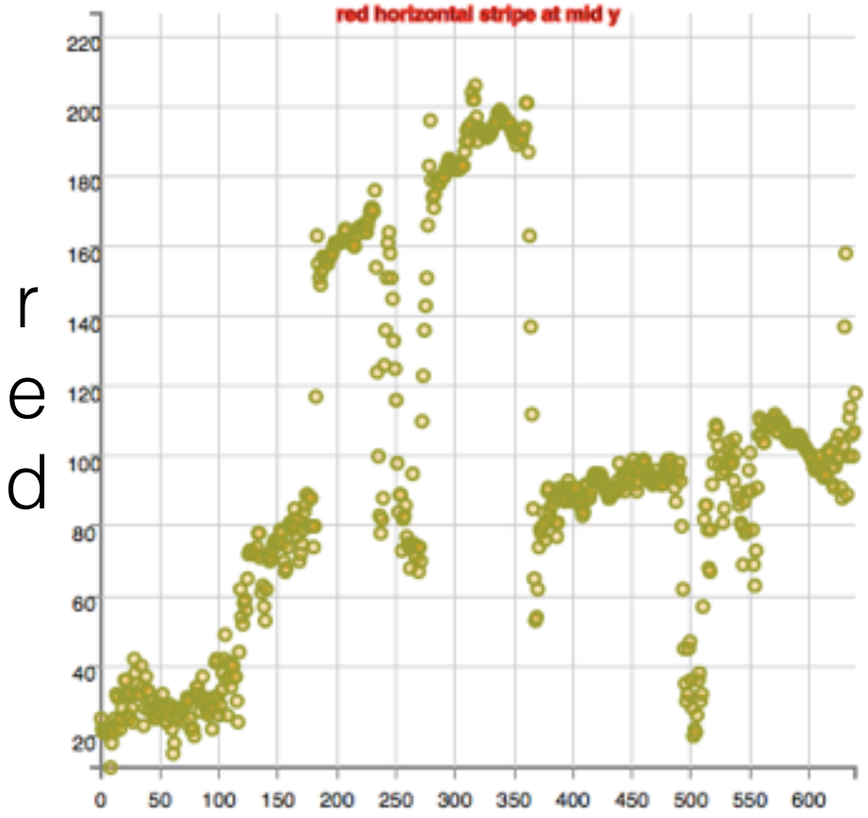
Y





purple sky + dark foreground:
skyline is where contrast incr, hue decr. and reverses slope (plunges) and so does red

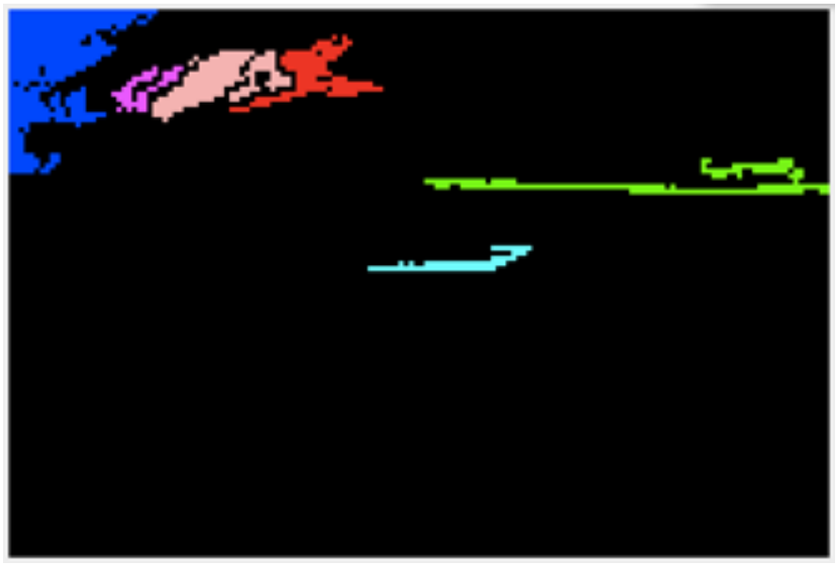


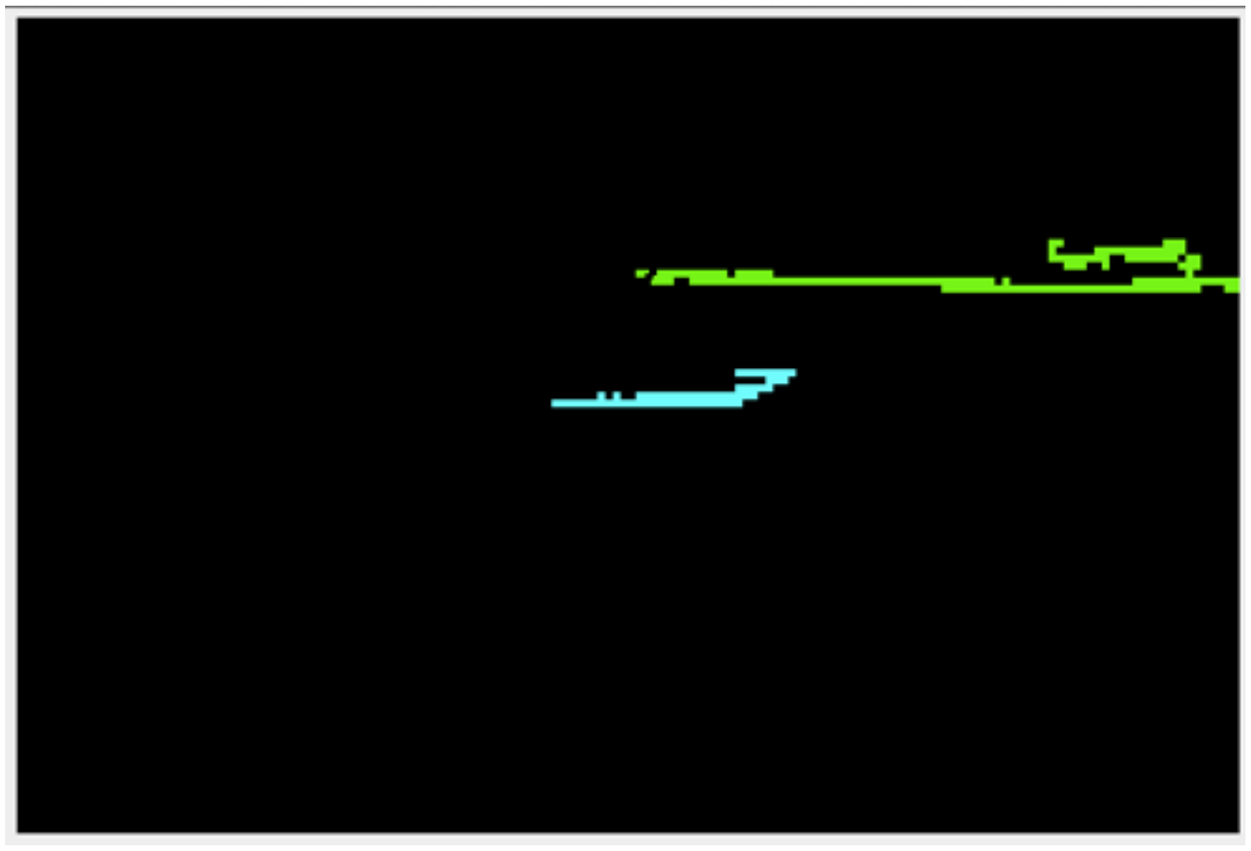


Skyline Extraction

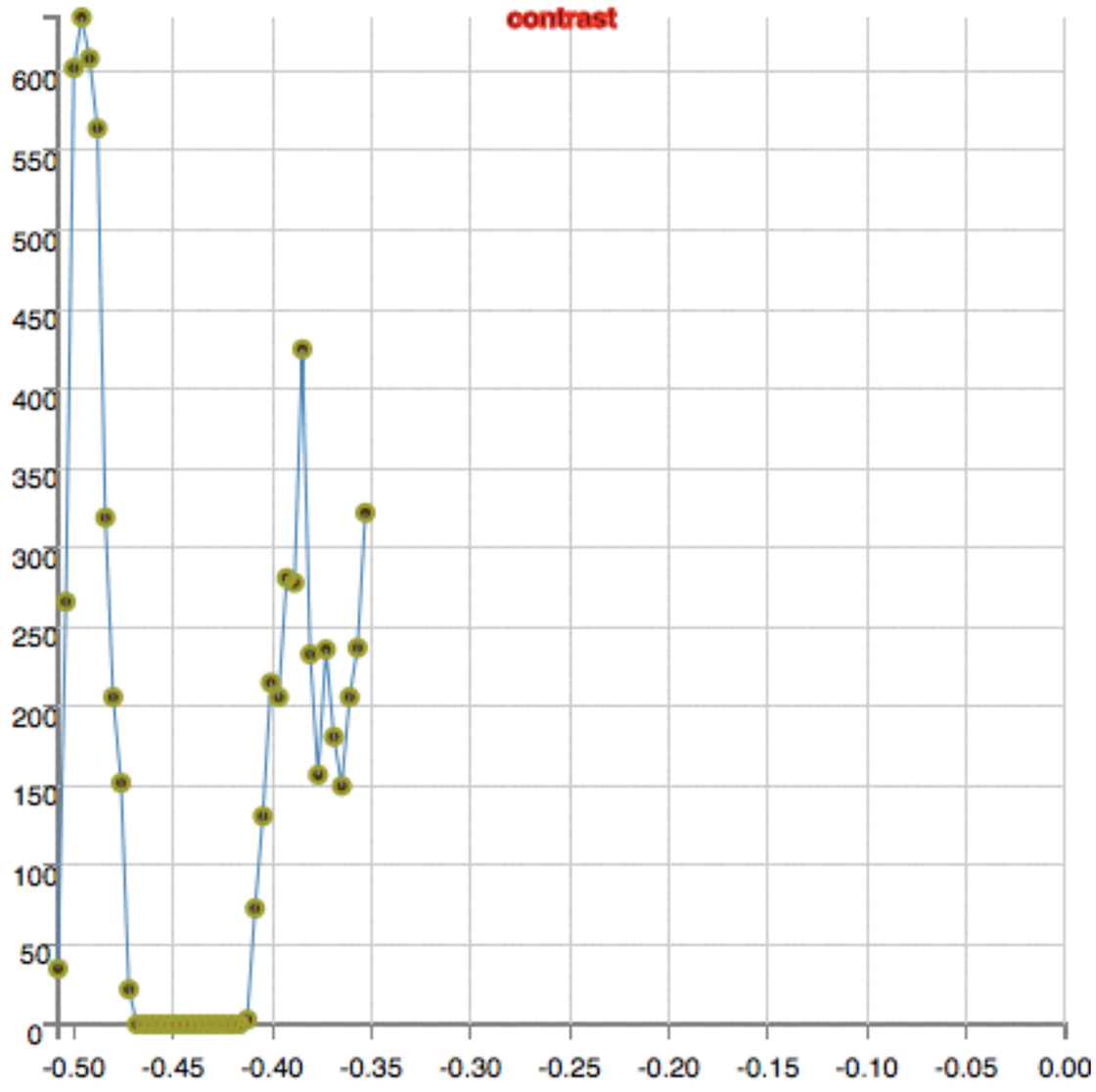
Not Finished… in progress

Removing silhouette regions and keeping only the largest contiguous sky pixels.





histogram of contrast for sky pixels.



Skyline Extraction

Not Finished… in progress

Growing the sky region to the skyline.

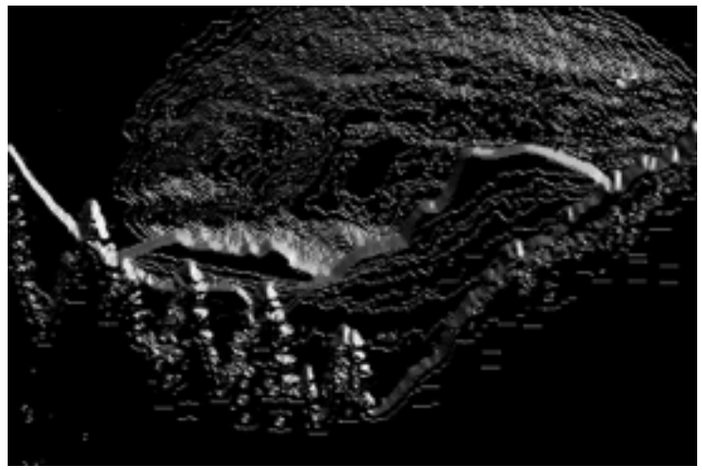
Skyline Extraction

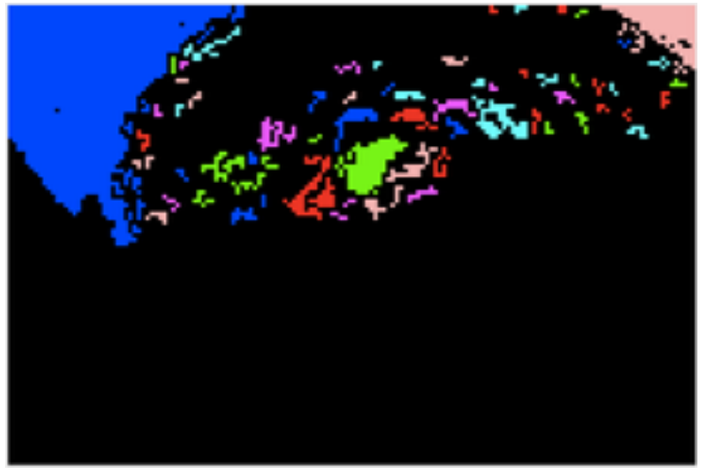
Not Finished… in progress

image:.vertical stripes through the middle of the image shows contrast and red are good indicators here for skyline boundary.

https://www.flickr.com/photos/7147684@N03/919374354

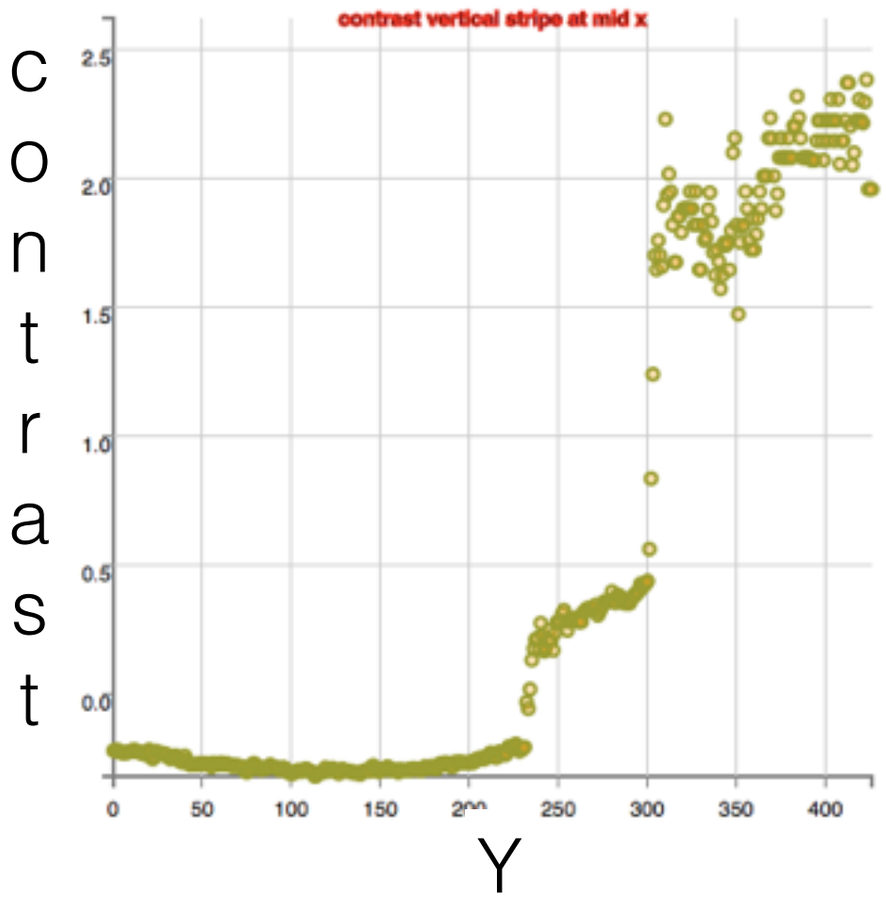
Y

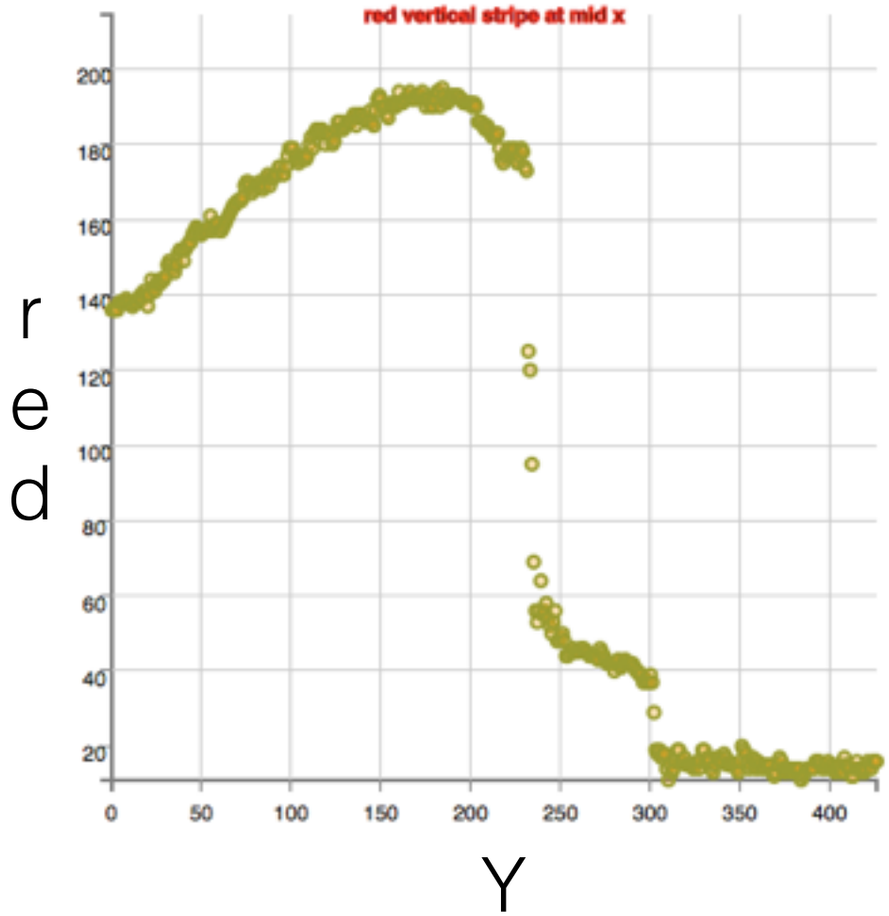




also, see PeakFinder http://www.peakfinder.org/?lat=37.7511&lng=-119.5215&ele=2365&name=37°45'N%20119°32'W

purple sky + dark foreground:
skyline is where contrast incr, hue decr. and reverses slope (plunges) and so does red



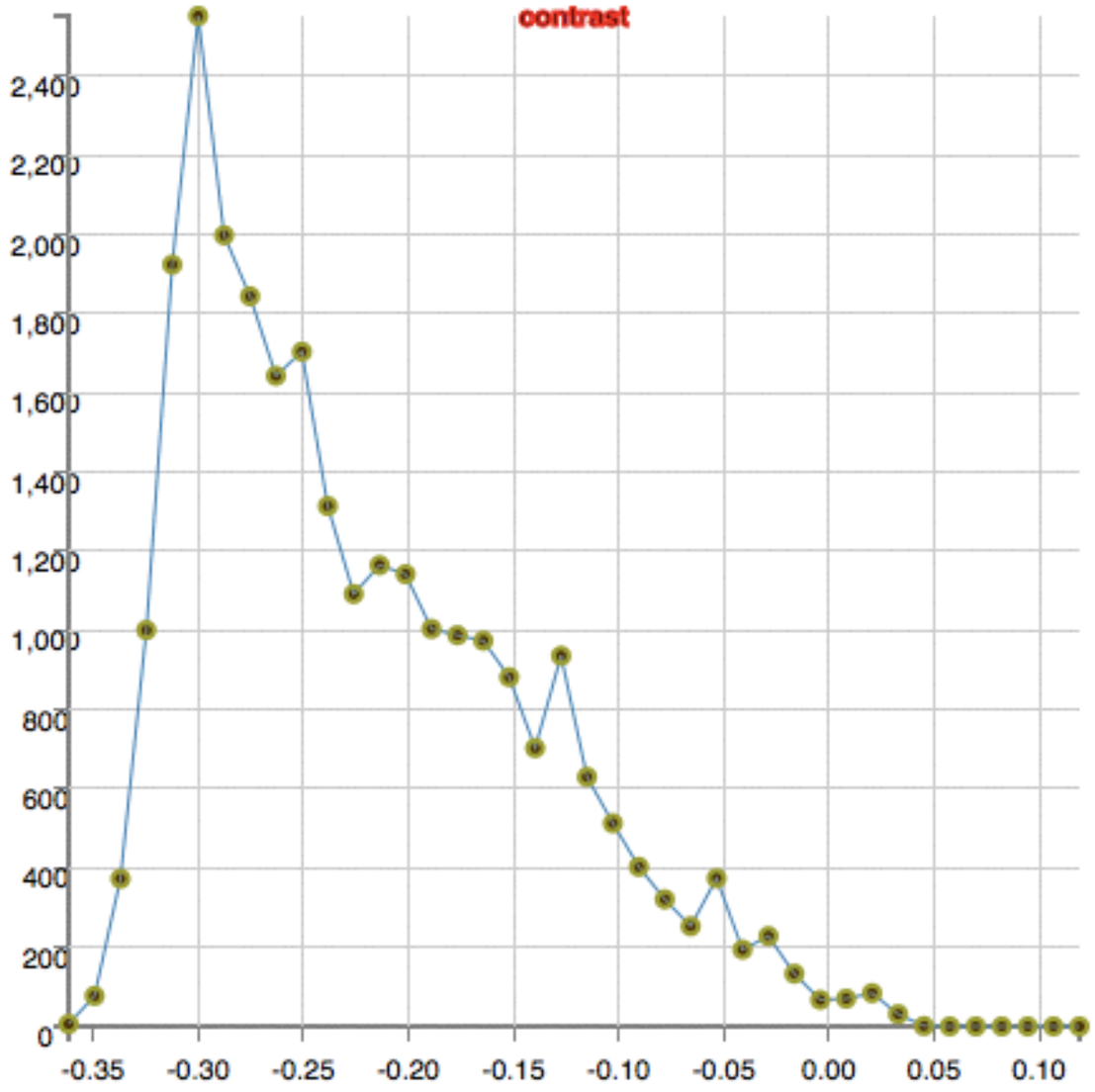


Skyline Extraction

Not Finished… in progress

Removing silhouette regions and keeping only the largest contiguous sky pixels.

histogram of contrast for sky pixels.



Skyline Extraction

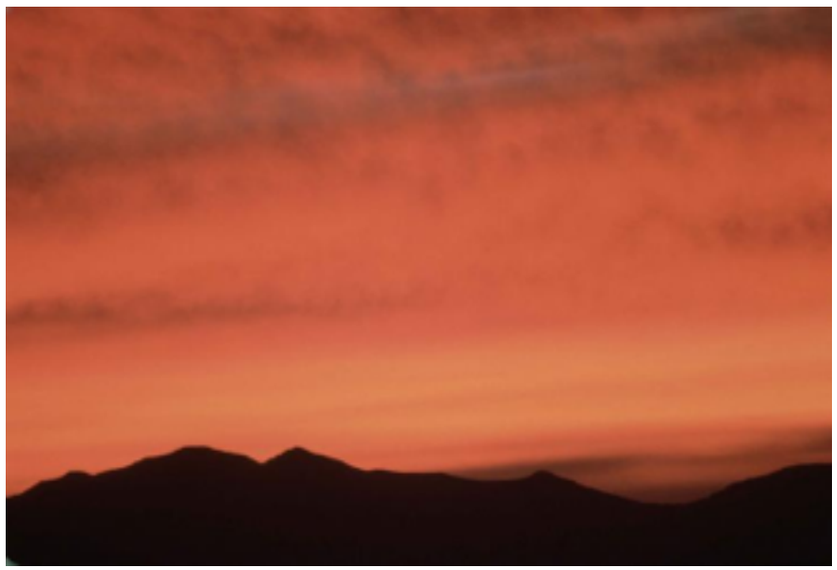
Not Finished… in progress

Growing the sky region to the skyline.

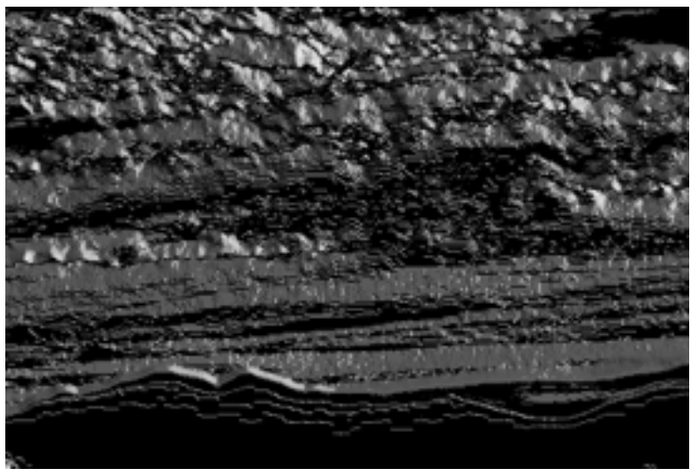
Skyline Extraction

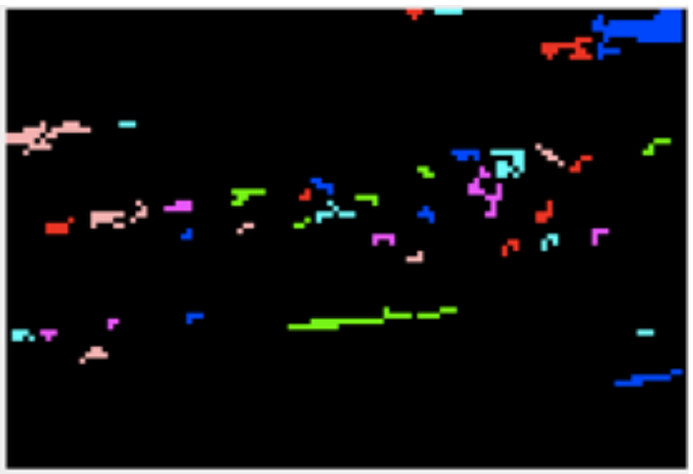
Not Finished… in progress

image:.vertical stripes through the middle of the image shows contrast and red are good indicators here for skyline boundary.



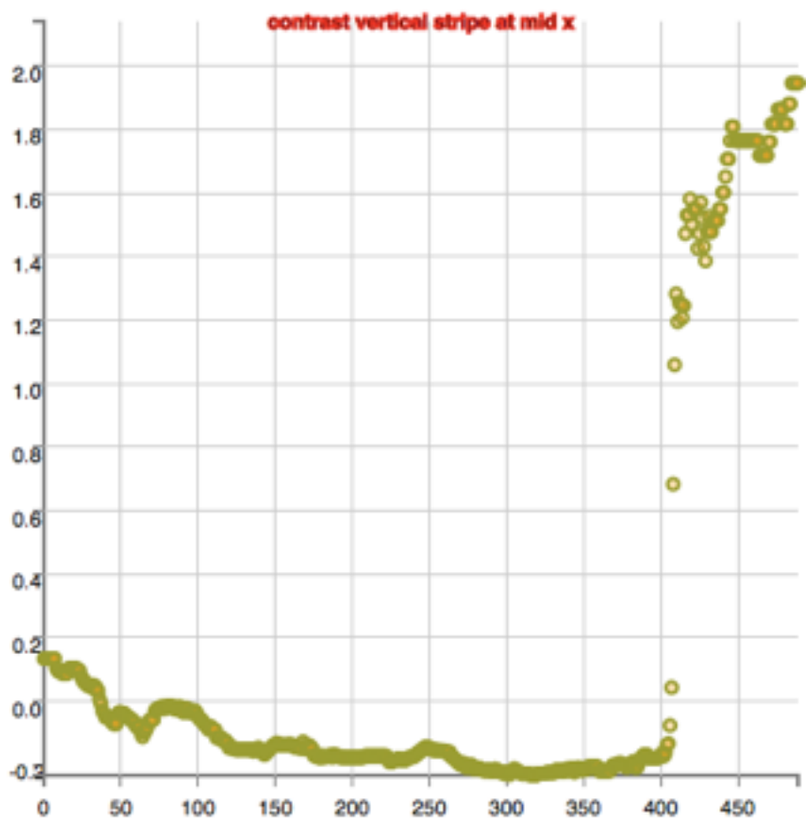
Y





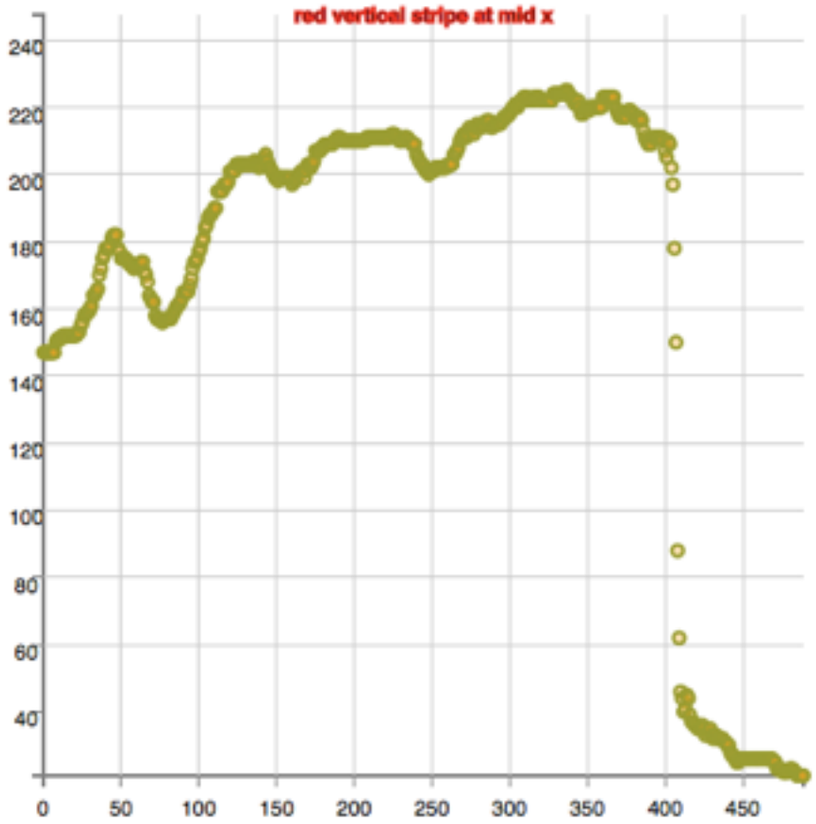
red sky + dark foreground:
skyline is where contrast incr, hue decr. and reverses slope (plunges) and so does red

contrast



Y

red



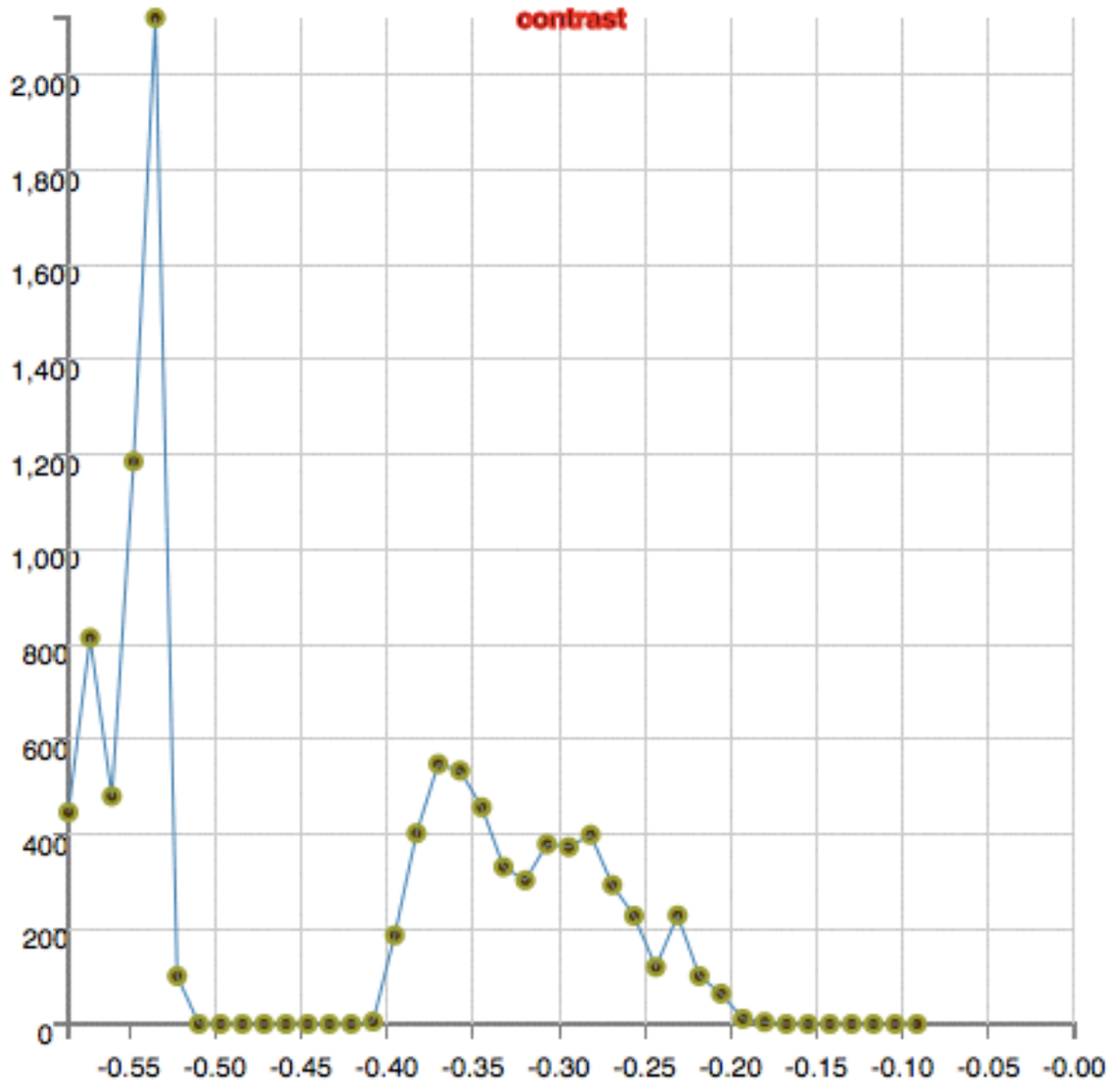
Y

Skyline Extraction

Not Finished… in progress

Removing silhouette regions and keeping only the largest contiguous sky pixels.

histogram of contrast for sky pixels.



Skyline Extraction

Not Finished… in progress

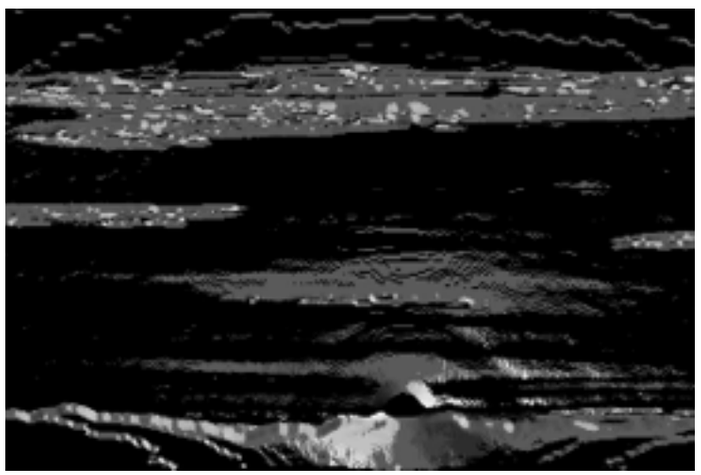
Growing the sky region to the skyline.

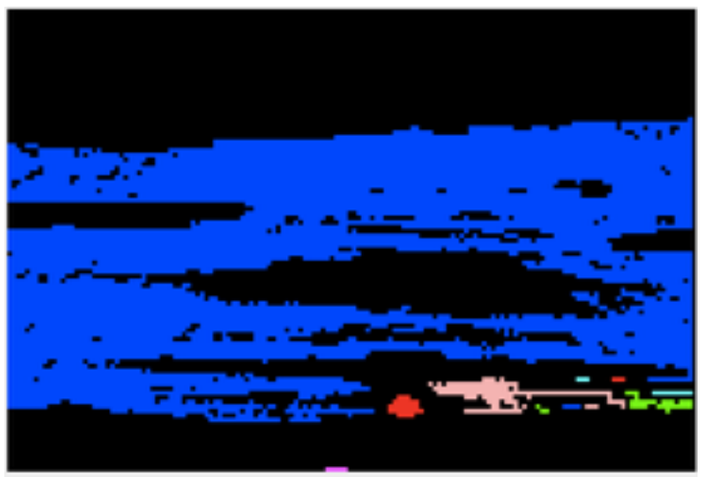
Skyline Extraction

Not Finished… in progress

image:.vertical stripes through the middle of the image shows contrast and red are good indicators here for skyline boundary.

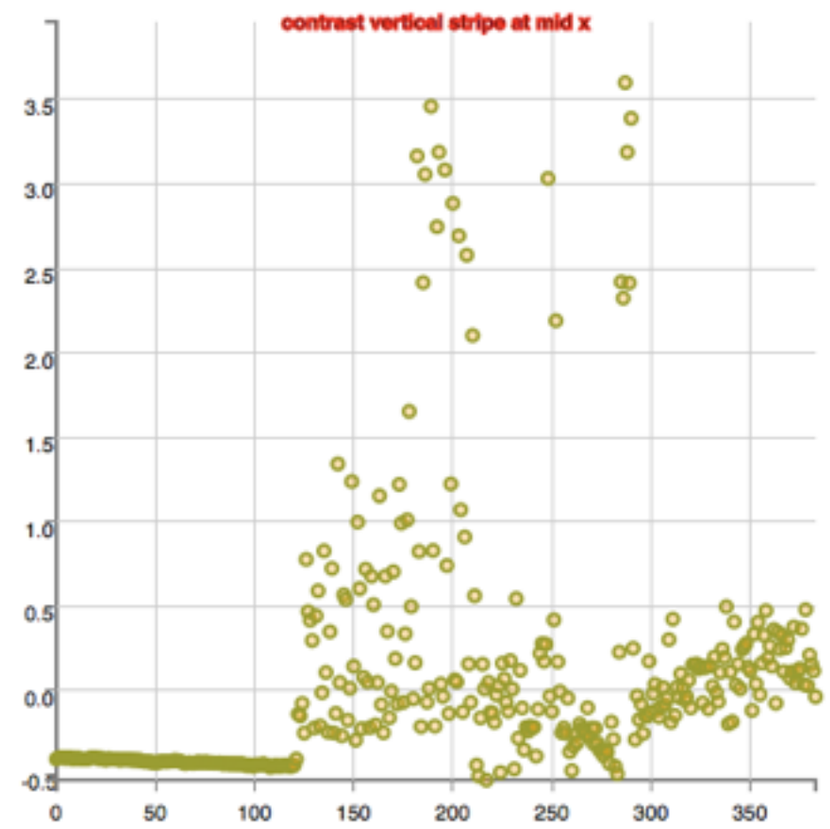
Y





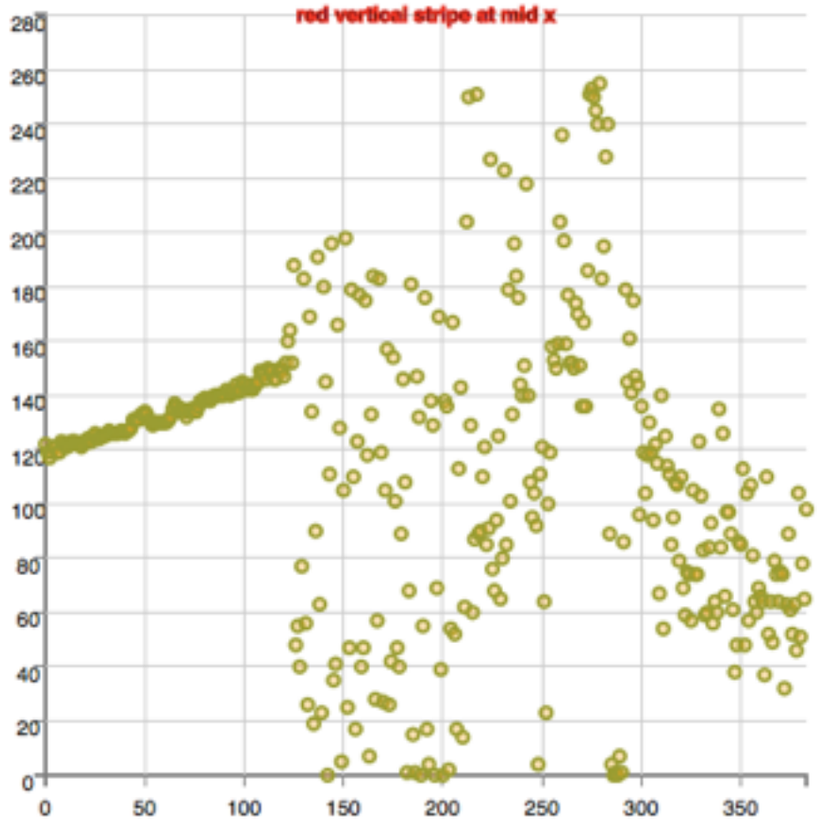
red sky + dark foreground:
skyline is where contrast incr, hue decr, and reverses slope (plunges) and so does red

contrast



Y

red



Y

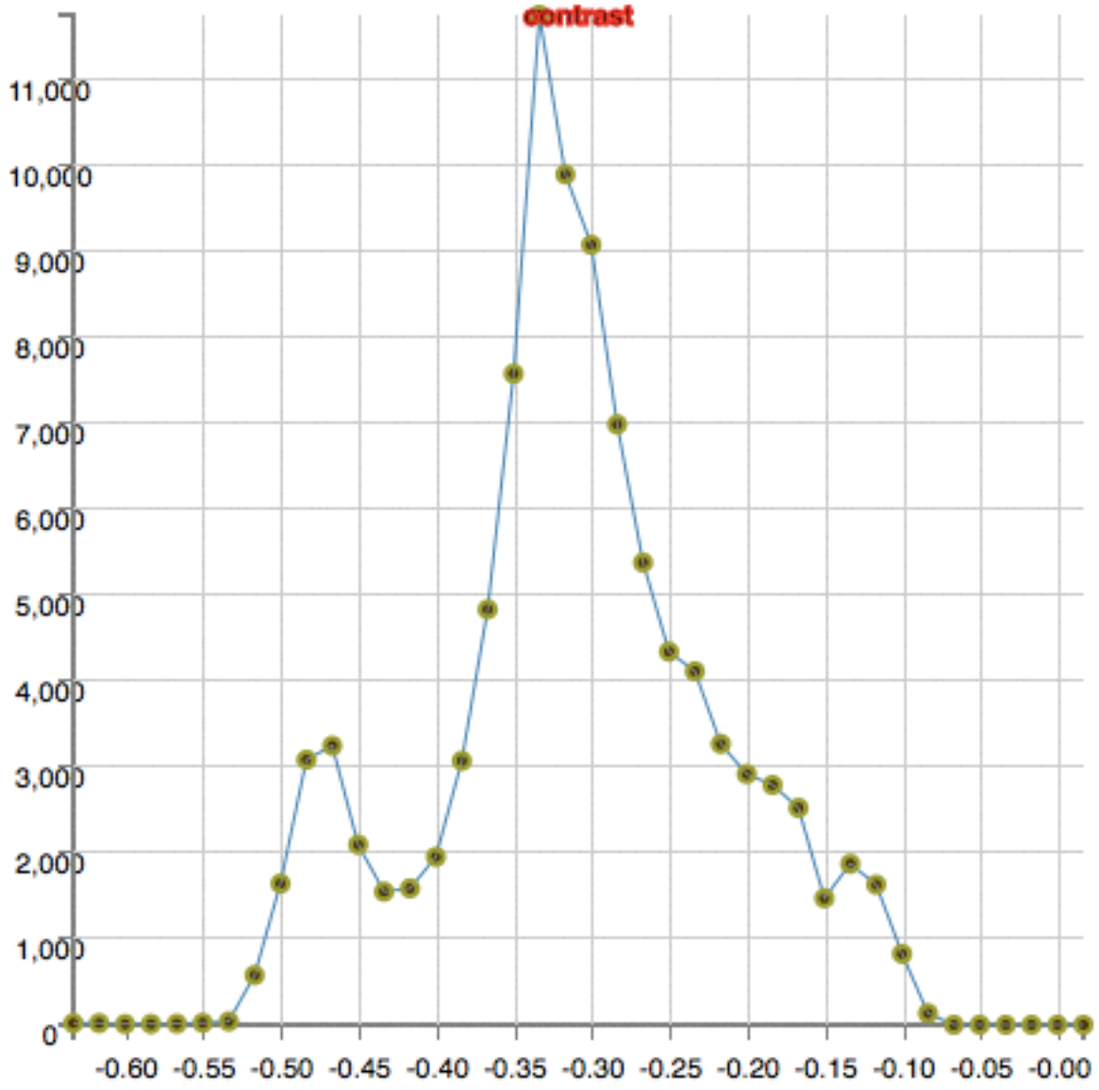
Skyline Extraction

Not Finished… in progress

Removing silhouette regions and keeping only the largest contiguous sky pixels.

the largest groups are kept:

histogram of contrast for sky pixels.



Skyline Extraction

Not Finished… in progress

Growing the sky region to the skyline.