Evaluating Snow Cover Change in New Zealand with respect to Elevation, Slope, Latitude and Distance from Coast

Kyle McCarthy : Homework 5

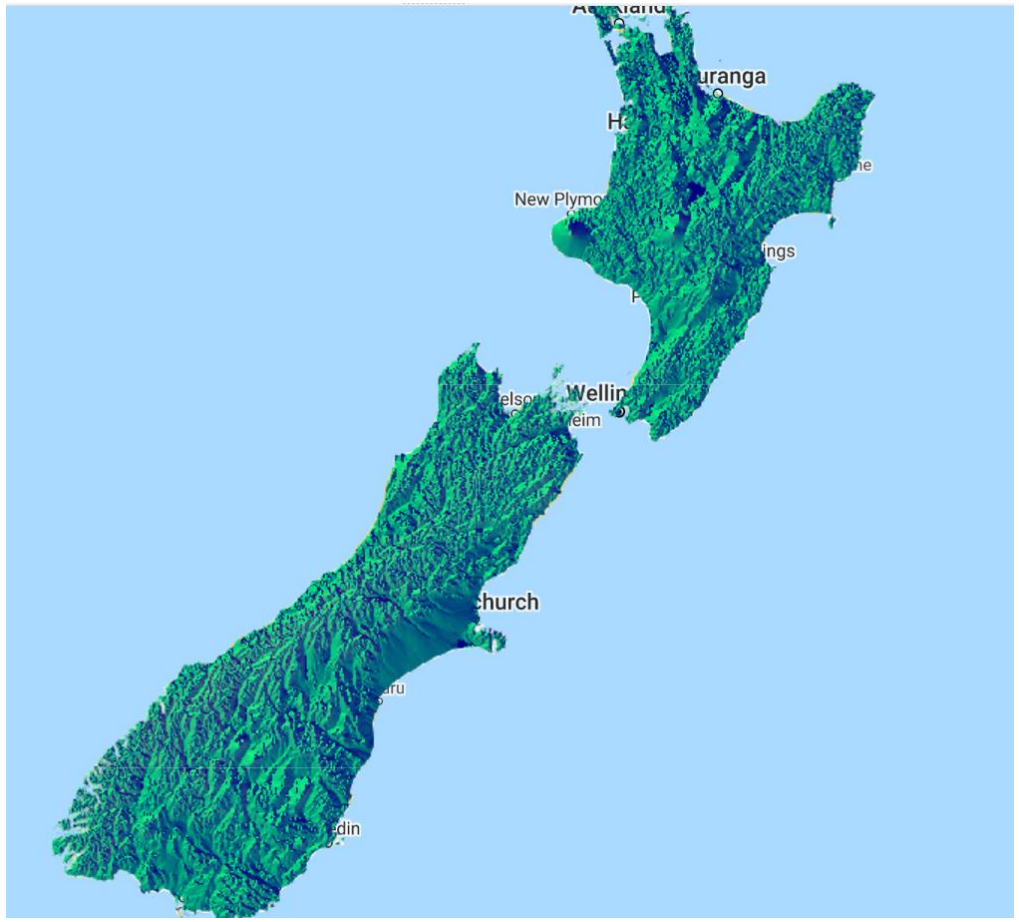
Link to code:
https://code.earthengine.google.com/324f89e13d92f12ddaf2cdd1e0454573

Step 1

- Import the datasets used and palettes
- Clip to study region (rectangle was drawn)
- Create an image that combines elevation, aspect and slope to understand the region

```
Imports (2 entries)
  var NewZealand: Polygon, 4 vertices
  var LatLine: LineString, 2 vertices
    type: LineString
    coordinates: List (2 elements)

// Import datasets and palettes
var dataset = ee.ImageCollection('MODIS/006/MOD10A1')
                  .filter(ee.Filter.date('2016-06-22', '2016-09-22'));
var snowCover = dataset.select('NDSI_Snow_Cover');
var snowCoverVis = {
  min: 0.0,
  max: 100.0,
  palette: ['black', '0dffff', '0524ff', 'ffffff'],
};

var snowCoverVis2 = {
  min: 0.0,
  max: 100.0,
  palette: ['yellow', 'red'],
};

var dataset2= ee.ImageCollection('MODIS/006/MOD10A1')
                  .filter(ee.Filter.date('2004-06-22', '2004-09-22'));
var snowCover2 = dataset2.select('NDSI_Snow_Cover');

var dataset = ee.Image('CGIAR/SRTM90_V4');
var elevation = dataset.select('elevation');
var elevationClip = elevation.clip(NewZealand);
var slope = ee.Terrain.slope(elevationClip);
var aspect = ee.Terrain.aspect(elevationClip);
//Map.addLayer(slope)
//Map.addLayer(aspect)
var SlopeAspectElevation = slope.addBands(aspect).addBands(elevation);
Map.addLayer(SlopeAspectElevation);
```

Image depicting slope, aspect, elevation

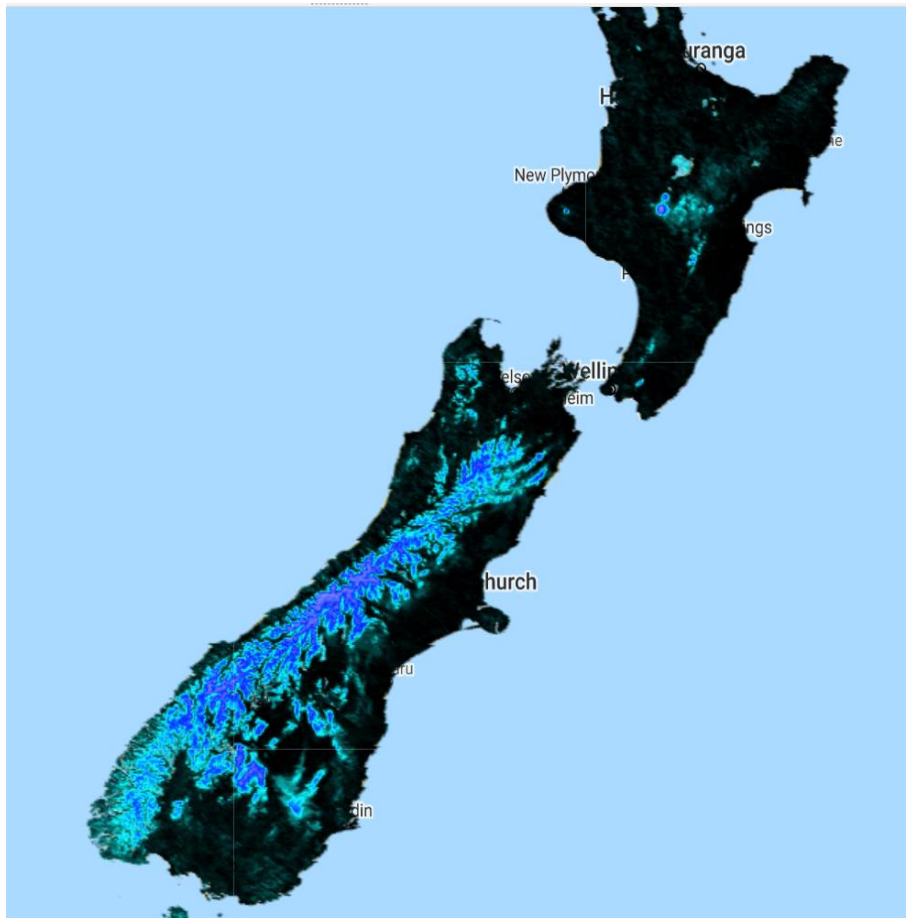


Step 2

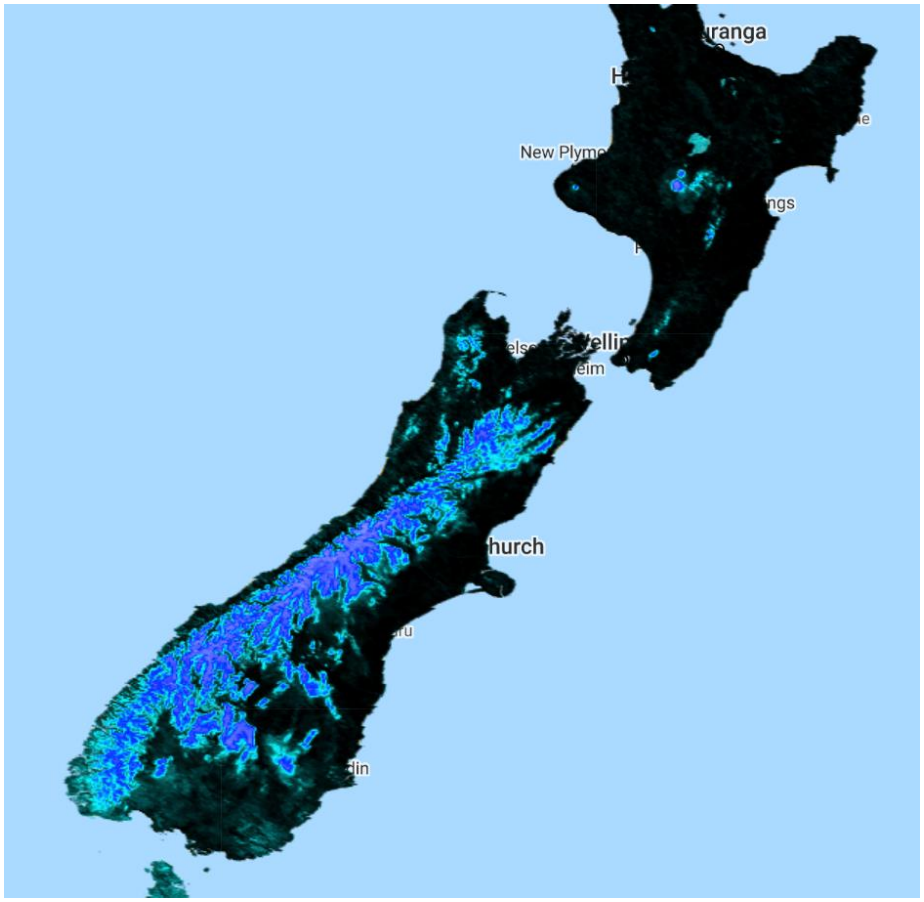
- Clip Snow Datasets to study region
- Apply kernel
- Add bands to create one image
- Difference bands (2016 – 2004)

```
//reduce both snow cover images
var SnowReduce = snowCover.reduce(ee.Reducer.mean());
var SnowReduce2 = snowCover2.reduce(ee.Reducer.mean());
// clip to study ares
var SnowClip = SnowReduce.clip(NewZealand);
var SnowClip2 = SnowReduce2.clip(NewZealand);
Map.addLayer(SnowClip, snowCoverVis, 'snowclip');
Map.addLayer(SnowClip2, snowCoverVis, 'snowclip2');
//set kernel circle kernel for the image
var TheKERNEL = ee.Kernel.circle( 2, 'pixels', true );
var SnowKernell = SnowClip.convolve( TheKERNEL );
var SnowKernel2 = SnowClip2.convolve( TheKERNEL );
Map.addLayer(SnowKernell, snowCoverVis, 'kernelImage1');
Map.addLayer(SnowKernel2, snowCoverVis, 'kernelImage2');
//Add Bands to combine the image
var CombinedSnow = SnowKernell.addBands(SnowKernel2);
//subtract 2016 from 2004
var differencedSnow = CombinedSnow.expression('b(1) - b(0)');
//mask those to get images that yielded a value less than -1
differencedSnow = differencedSnow.mask(differencedSnow.lt(-1));
Map.addLayer(differencedSnow, snowCoverVis, "differencedSnow");
```

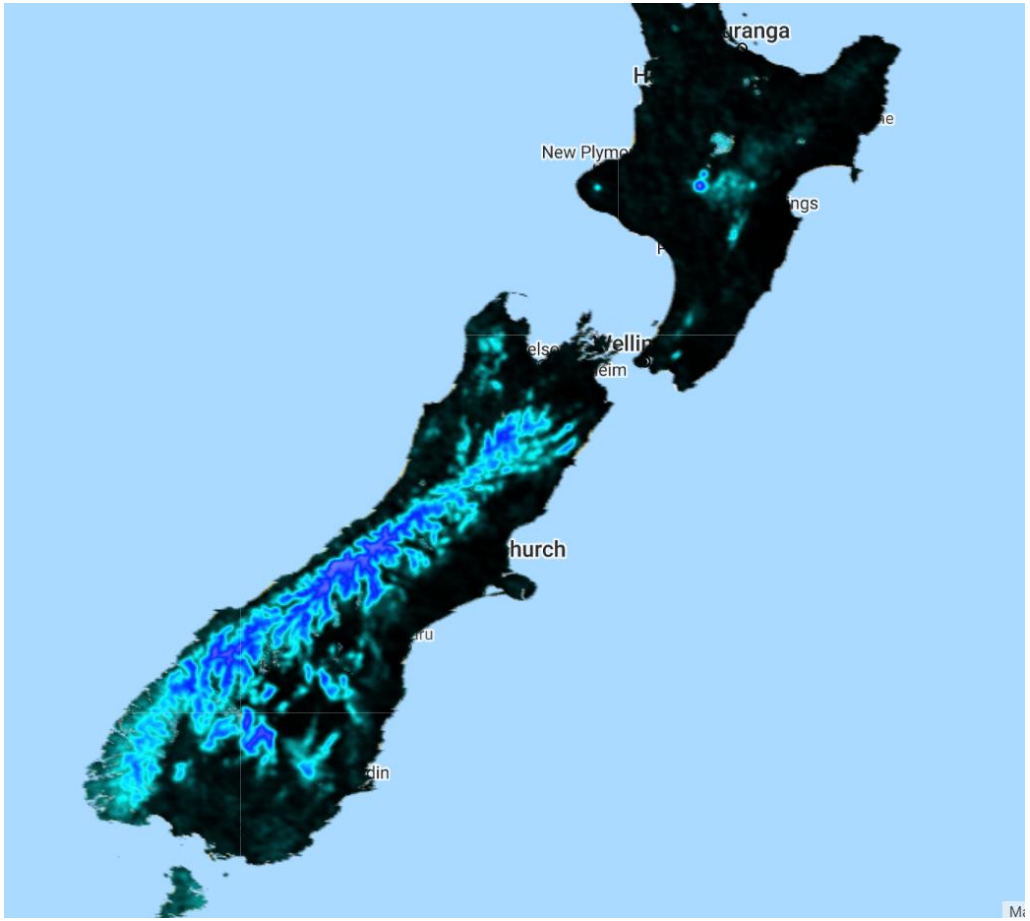
Snow Cover 2016



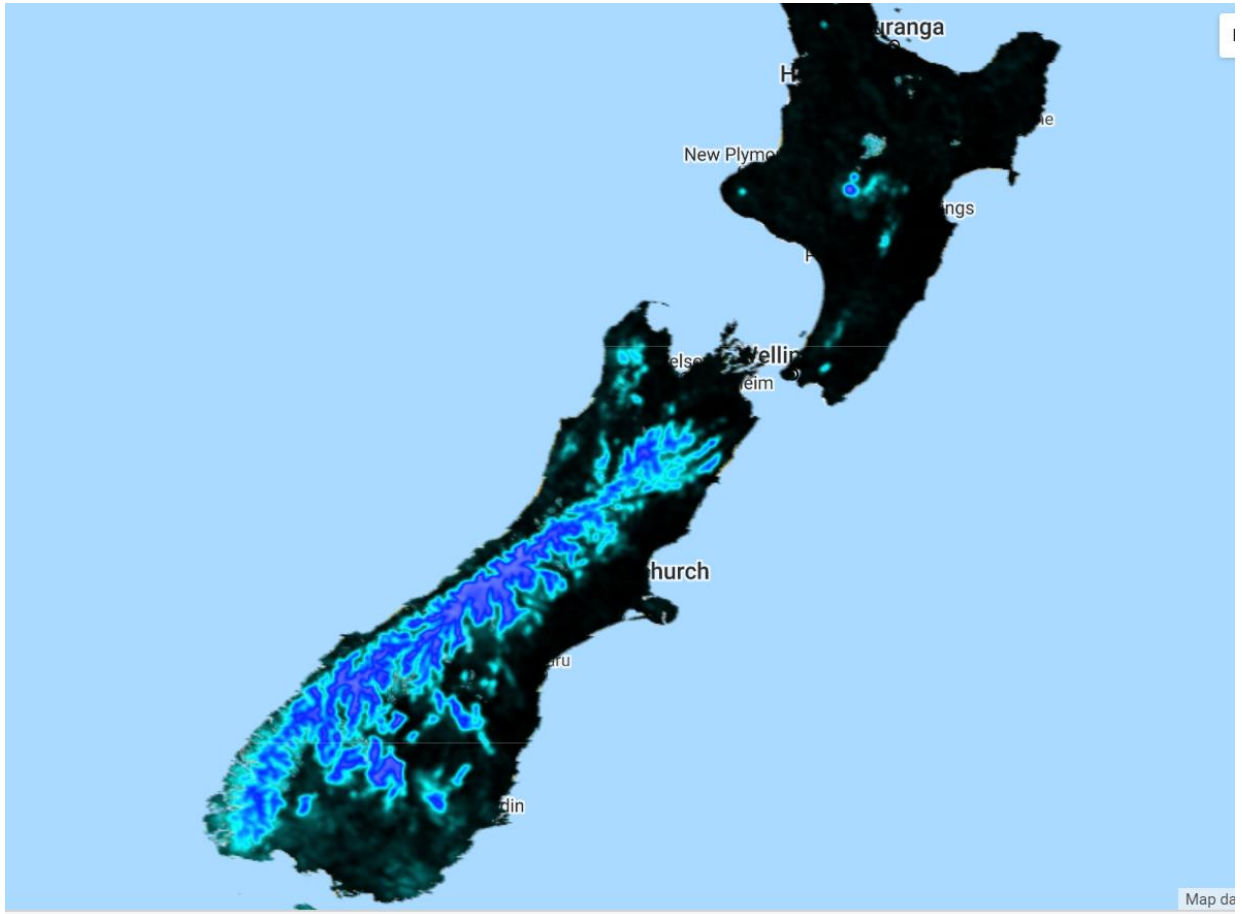
Snow Cover 2004



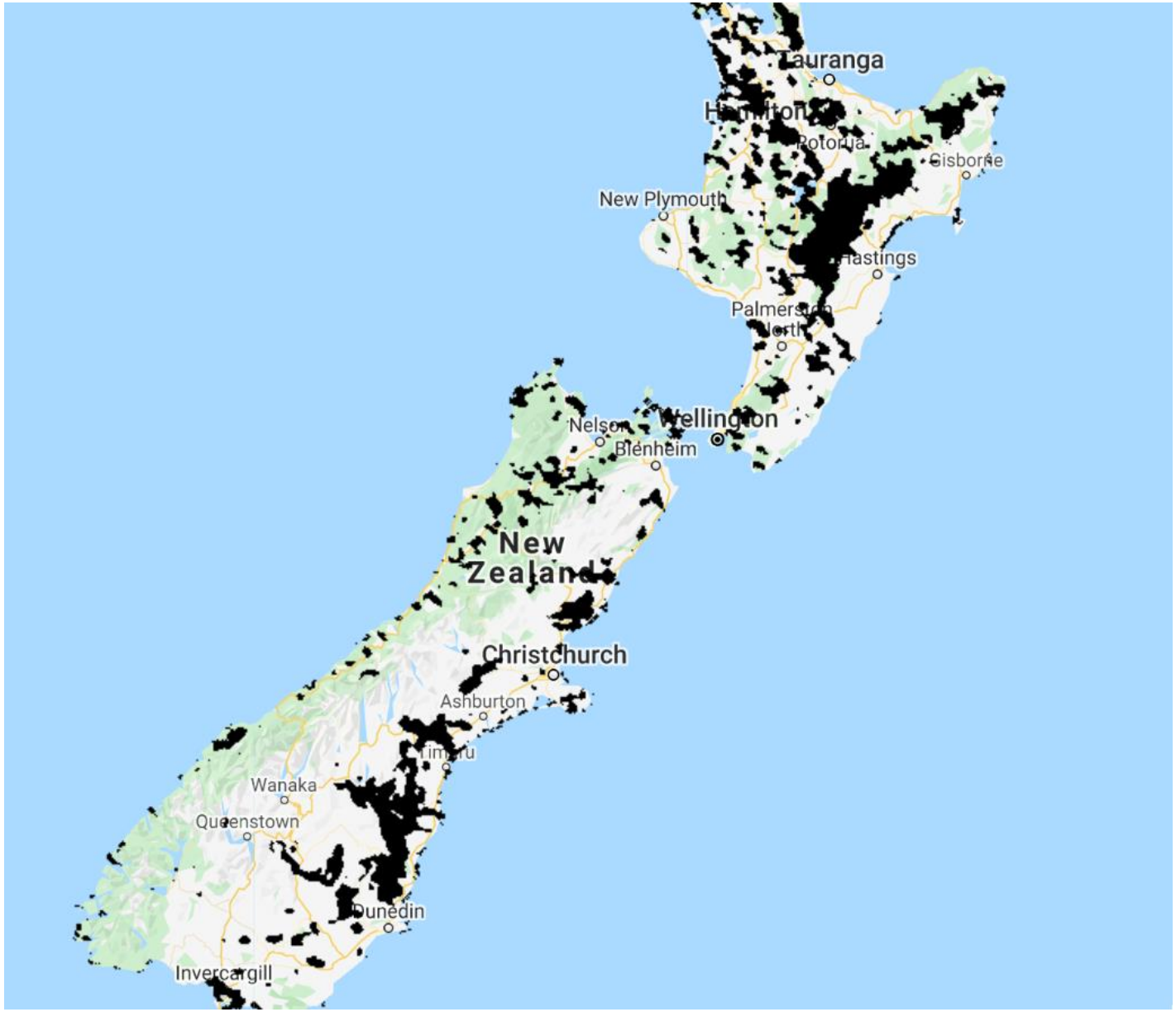
Snow Cover 2016 with Kernel



Snow Cover 2004 with Kernel



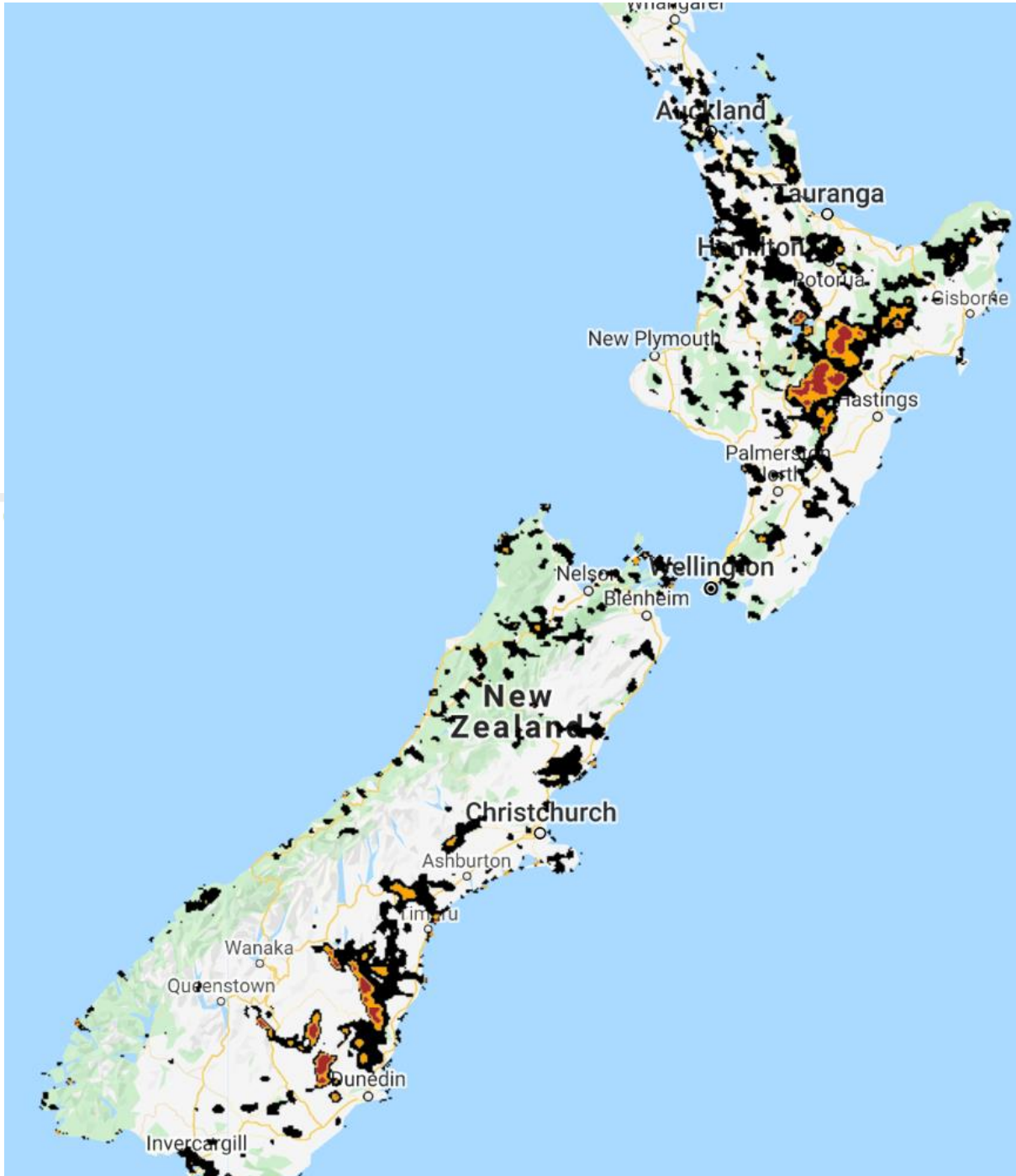
Regions where there was a decrese in snow Cover



Step 3: Separate into categories representing snow loss values

Black: low loss, orange: moderate loss, red: high Loss

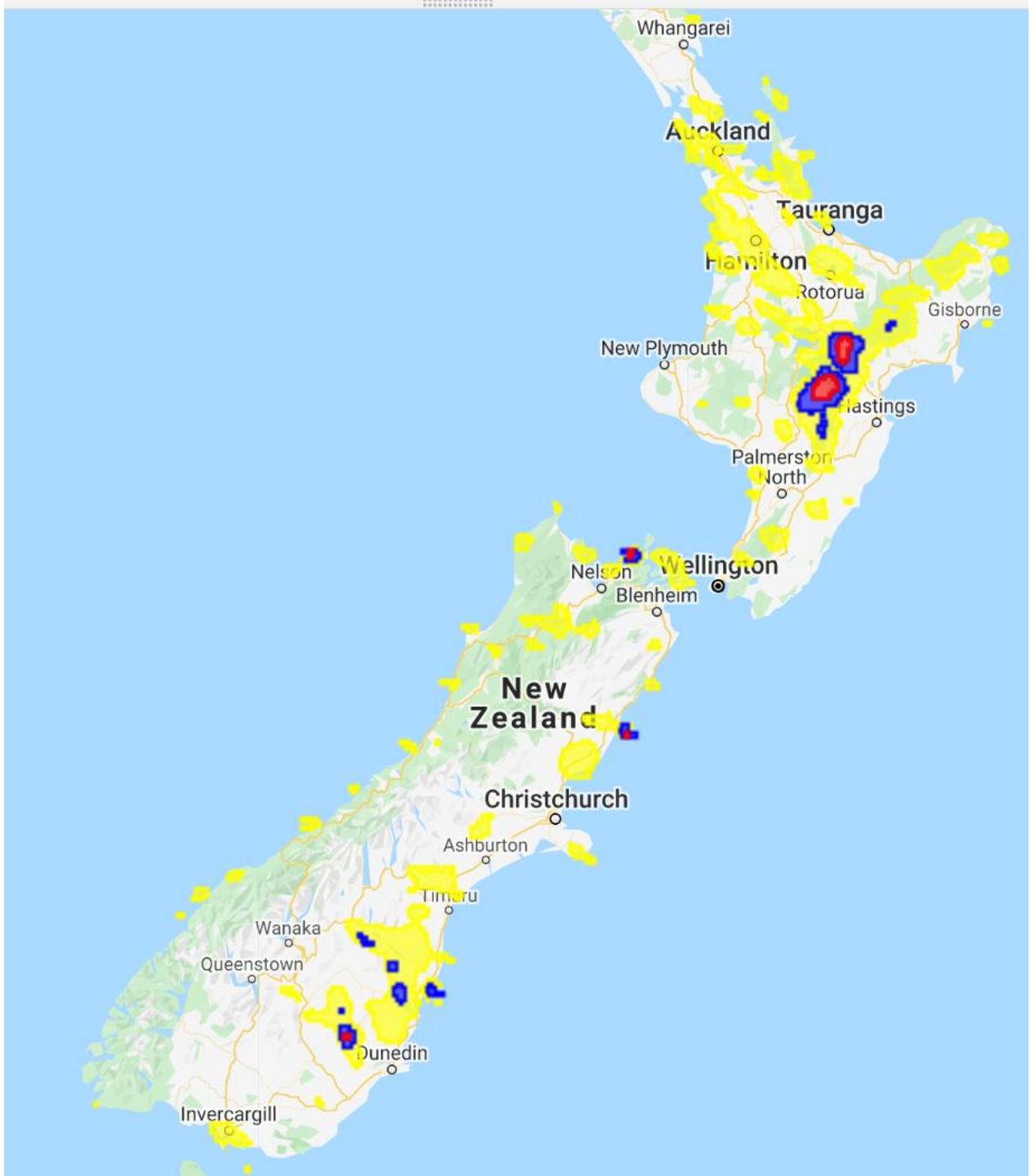
```
//Mask that image by seperating the image into categories of High Change, Moderate
//Creates three seperate images, one for each category
var significantDifference = differencedSnow.mask(differencedSnow.lte(-7));
var ModerateDifference = differencedSnow.mask(differencedSnow.gt(-7));
ModerateDifference = ModerateDifference.mask(ModerateDifference.lte(-4));
var LowDifference = differencedSnow.mask(differencedSnow.gt(-4))
Map.addLayer(ModerateDifference, {palette : 'orange'}, 'ModerateImage')
Map.addLayer(significantDifference, {palette : 'brown'}, 'HighImage')
Map.addLayer(LowDifference, {palette : 'black'}, 'LowImage')
```



Step 4: Convert raster values to integer and then reduce to vectors to create polygons representing each category

```
// Convert Values for each image to iteger
var LowDifferencePoly = LowDifference.toInt();
var ModDifferencePoly = ModerateDifference.toInt();
var HighDifferencePoly = significantDifference.toInt();

//Reduce the created images for each category to vectors. The created polygons will represent our Regions of interests
var TheEXTENT = ee.Geometry.Polygon([[165.12, -47.604],[179.5496,-47.60423],[179.53964,-33.8315],[165.125,-33.8315]]);
var TheREDUCER       = ee.Reducer.countEvery();
var LowDifferencePoly    = LowDifferencePoly.reduceToVectors( TheREDUCER, TheEXTENT,  4326, 'polygon',  false  );
var LowDifferencePoly = LowDifferencePoly.union(100000);
print(LowDifferencePoly);
Map.addLayer(LowDifferencePoly,{color : 'yellow'}, 'LowPoly');

var ModDifferencePoly    = ModDifferencePoly.reduceToVectors( TheREDUCER, TheEXTENT,  4326, 'polygon',  false  );
var ModDifferencePoly = ModDifferencePoly.union(100000);
Map.addLayer(ModDifferencePoly, {color : 'blue'}, 'ModeratePoly');

var HighDifferencePoly    = HighDifferencePoly.reduceToVectors( TheREDUCER, TheEXTENT,  4326, 'polygon',  false  );
var HighDifferencePoly = HighDifferencePoly.union(100000);
Map.addLayer(HighDifferencePoly, {color : 'red'}, 'HighPoly');
```

Regions of Interests representing different magnitude of snow cover change as polygons



Elevation Histogram Code

```
//Clip elevation to each created polygon

var LowDifElevation = elevationClip.clip(LowDifferencePoly);
var ModDifElevation = elevationClip.clip(ModDifferencePoly);
var HighDifElevation = elevationClip.clip(HighDifferencePoly);

Map.addLayer(LowDifElevation, {palette: 'pink'}, 'LowDifElevation');
Map.addLayer(ModDifElevation, {palette: 'teal'}), 'ModDifElevation';
Map.addLayer(HighDifElevation,  {palette: 'lime'}, 'HighDifElevation');

//Create Histograms to represent elevation in each polygon

var ElevationvsLowDif    = Chart.image.histogram(elevationClip, LowDifferencePoly, 100);
var ElevationvsModDif     = Chart.image.histogram(elevationClip, ModDifferencePoly, 100);
var ElevationvsHighDif    = Chart.image.histogram(elevationClip, HighDifferencePoly, 100);
var ElevationvsLowDif    = ElevationvsLowDif.setOptions( { title:'Elevation in Meters where there were Low Changes in Snow (
                                hAxis:{ title: 'Elevation in Meters' },
                                vAxis:{ title: 'Number of Pixels'} } );
var ElevationvsModDif    = ElevationvsModDif.setOptions( { title:'Elevation in Meters where there were Moderate Changes in S
                                hAxis:{ title: 'Elevation in Meters' },
                                vAxis:{ title: 'Number of Pixels'} } );
var ElevationvsHighDif    = ElevationvsHighDif.setOptions( { title:'Elevation in Meters where there were Signficant Changes
                                hAxis:{ title: 'Elevation in Meters' },
                                vAxis:{ title: 'Number of Pixels'} } );


print(ElevationvsLowDif)
print(ElevationvsModDif)
print(ElevationvsHighDif)
```

Slope Histogram Code

```
var SlopevsLowDif     = Chart.image.histogram(slope, LowDifferencePoly, 100);
var SlopevsModDif    = Chart.image.histogram(slope, ModDifferencePoly, 100);
var SlopevsHighDif    = Chart.image.histogram(slope, HighDifferencePoly, 100);
var SlopevsHighDif    = Chart.image.histogram(slope, HighDifferencePoly, 100);
var SlopevsLowdDif    = SlopevsLowDif.setOptions( { title:'Slope where there were Low Changes in Snow Cover 2004 vs 2016',
                                                    hAxis:{ title: 'Slope' },
                                                    vAxis:{ title: 'Number of Pixels'} } );
var SlopevsModDif    = SlopevsModDif.setOptions( { title:'Slope where there were Moderate Changes in Snow Cover 2004 vs 201
                                                    hAxis:{ title: 'Slope' },
                                                    vAxis:{ title: 'Number of Pixels'} } );
var SlopevsHighDif    = SlopevsHighDif.setOptions( { title:'Slope where there were High Changes in Snow Cover 2004 vs 2016'
                                                    hAxis:{ title: 'Slope' },
                                                    vAxis:{ title: 'Number of Pixels'} } );

print(SlopevsLowDif)
print(SlopevsModDif)
print(SlopevsHighDif)
```

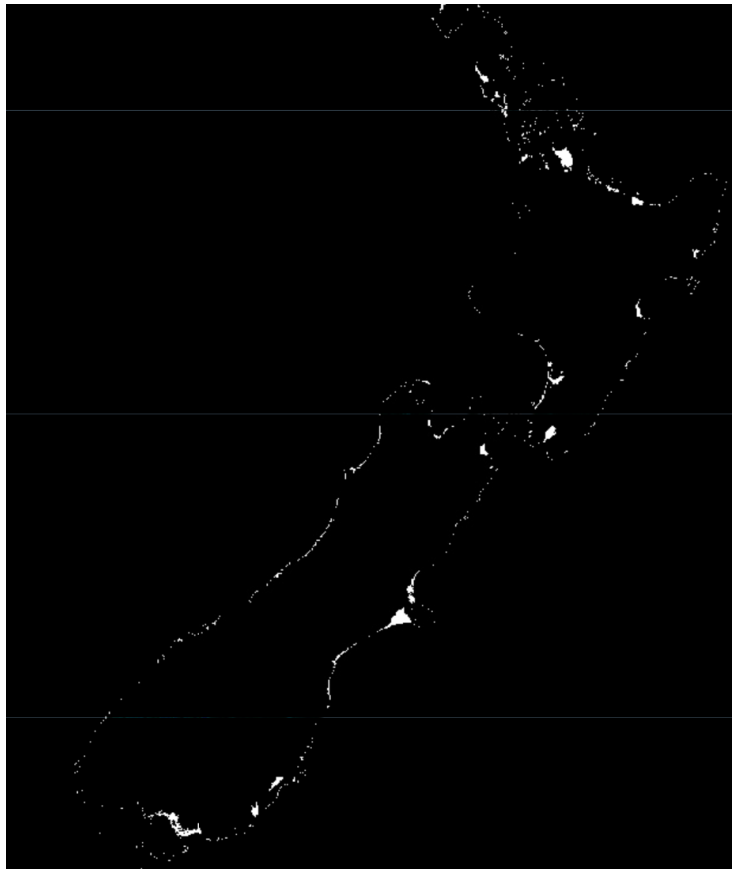
Latitude Histogram Code

```
//Create Latitude image of the study region

var LonLat = ee.Image.pixelLonLat( ).clip(NewZealand);
var Latitude = LonLat.select("latitude");
print(Latitude)

//Create histograms for categories, comparing change in snow to latitude
var LatvsLowDif     = Chart.image.histogram(Latitude, LowDifferencePoly, 100);
var LatvsLowDif    = LatvsLowDif.setOptions( { title:'Latitude where there were Low Changes in Snow Cover 2004 vs 2016',
                                               hAxis:{ title: 'Latitude' },
                                               vAxis:{ title: 'Number of Pixels'} } );
print(LatvsLowDif)
var LatvsModDif     = Chart.image.histogram(Latitude, ModDifferencePoly, 100);
var LatvsModDif    = LatvsModDif.setOptions( { title:'Latitude where there were Moderate Changes in Snow Cover 2004 vs 2016
                                               hAxis:{ title: 'Latitude' },
                                               vAxis:{ title: 'Number of Pixels'} } );
print(LatvsModDif)
var LatvsHighDif     = Chart.image.histogram(Latitude, HighDifferencePoly, 100);
var LatvsHighDif    = LatvsHighDif.setOptions( { title:'Latitude where there were Significant Changes in Snow Cover 2004 vs
                                               hAxis:{ title: 'Latitude' },
                                               vAxis:{ title: 'Number of Pixels'} } );
print(LatvsHighDif)
```

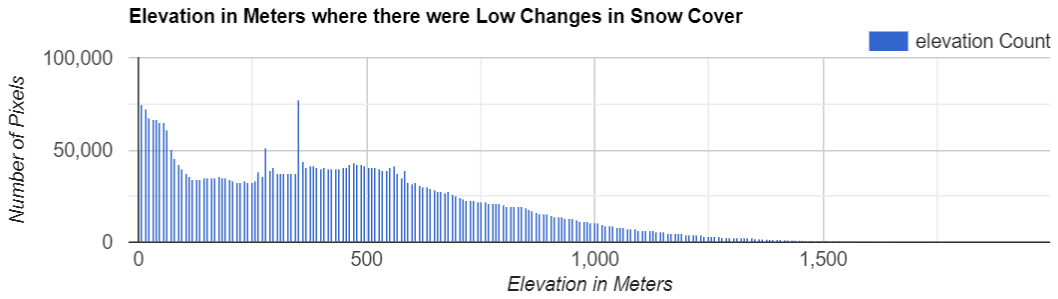
Distance From Coast Histogram Code – looking for distance away from regions with less than 10 meters in elevation

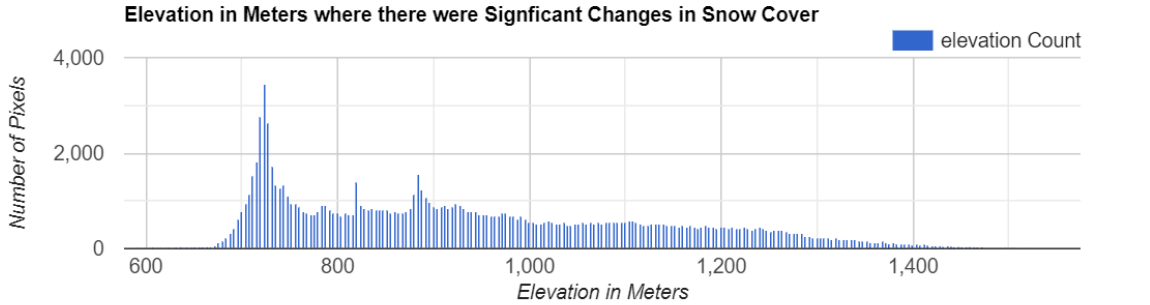
```
// Distance From Coast. Evaluate how the distance from coast relates to snow cover change

var ZeroIMAGE     = ee.Image(0).clip(NewZealand);
var TargetIMAGE   = ZeroIMAGE.where( elevationClip.lt(10), 1 );
Map.addLayer(TargetIMAGE);
var DistanceCoast = TargetIMAGE.distance( ee.Kernel.euclidean(150, 'pixels'));
Map.addLayer(DistanceCoast);
//Create Histograms comparing snow cover change to Distance from Coast
var CoastvsLowDif     = Chart.image.histogram(DistanceCoast, LowDifferencePoly, 100);
var CoastvsLowDif   = CoastvsLowDif.setOptions( { title:'Distance from Coast where there were Low Changes in Snow Cover 2004 vs 2016',
                                  hAxis:{ title: 'Distance From Coast in Pixels' },
                                  vAxis:{ title: 'Number of Pixels'} } );
print(CoastvsLowDif)
var CoastvsModDif     = Chart.image.histogram(DistanceCoast, ModDifferencePoly, 100);
var CoastvsModDif   = CoastvsModDif.setOptions( { title:'Distance from Coast where there were Moderate Changes in Snow Cover 2004 vs 2016',
                                  hAxis:{ title: 'Distance From Coast in Pixels' },
                                  vAxis:{ title: 'Number of Pixels'} } );
print(CoastvsModDif)
var CoastvsHighDif    = Chart.image.histogram(DistanceCoast, HighDifferencePoly, 100);
var CoastvsHighDif   = CoastvsHighDif.setOptions( { title:'Distance from Coast where there were Significant Changes in Snow Cover 2004 vs 2016',
                                  hAxis:{ title: 'Distance From Coast in Pixels' },
                                  vAxis:{ title: 'Number of Pixels'} } );
print(CoastvsHighDif)
```

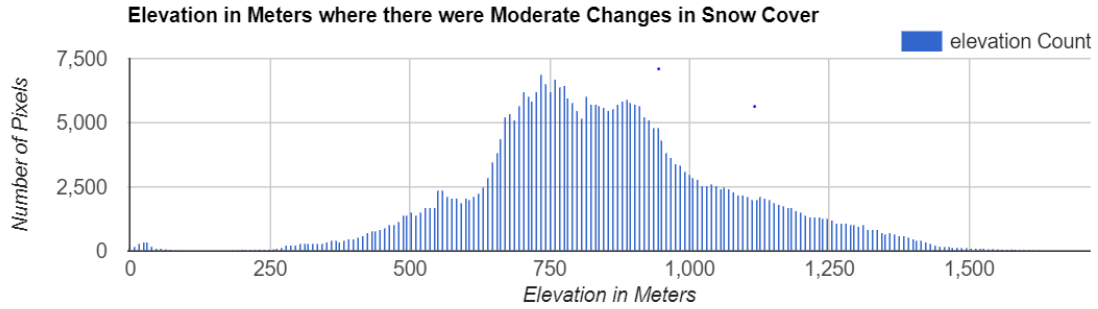
Image depicting New Zealand COastLine



Elevation Histograms

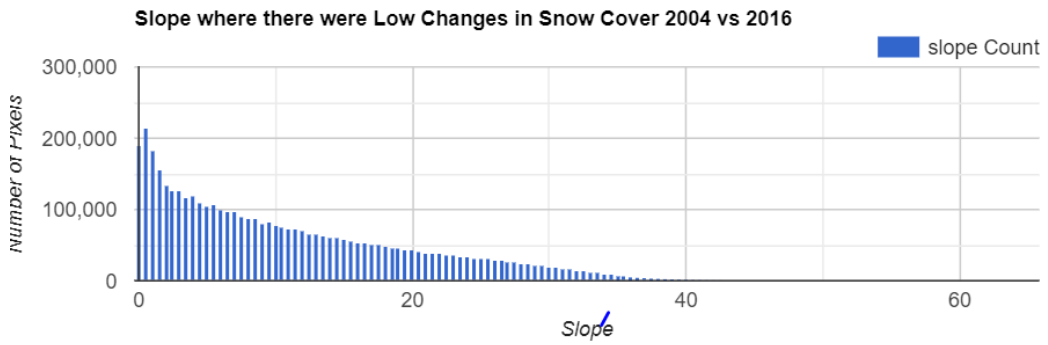


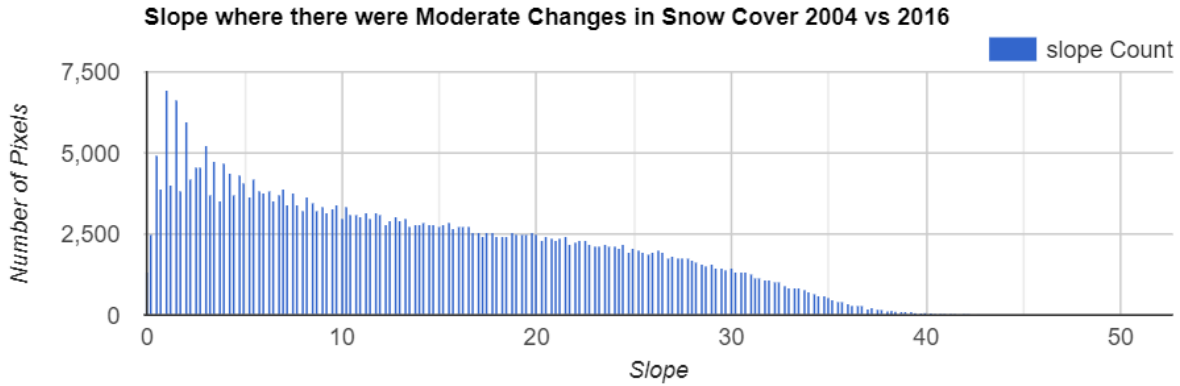


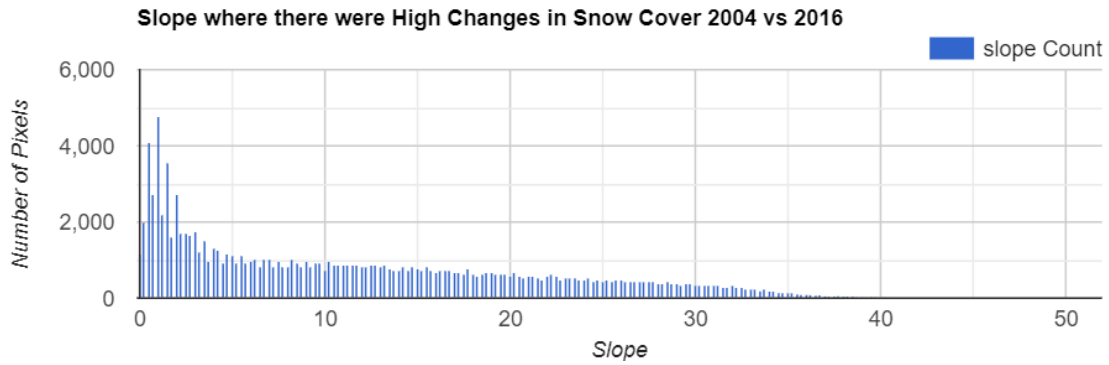


Note that the region where moderate and high changes occurred were generally at higher elevations than where low changes occurred

Slope Histograms



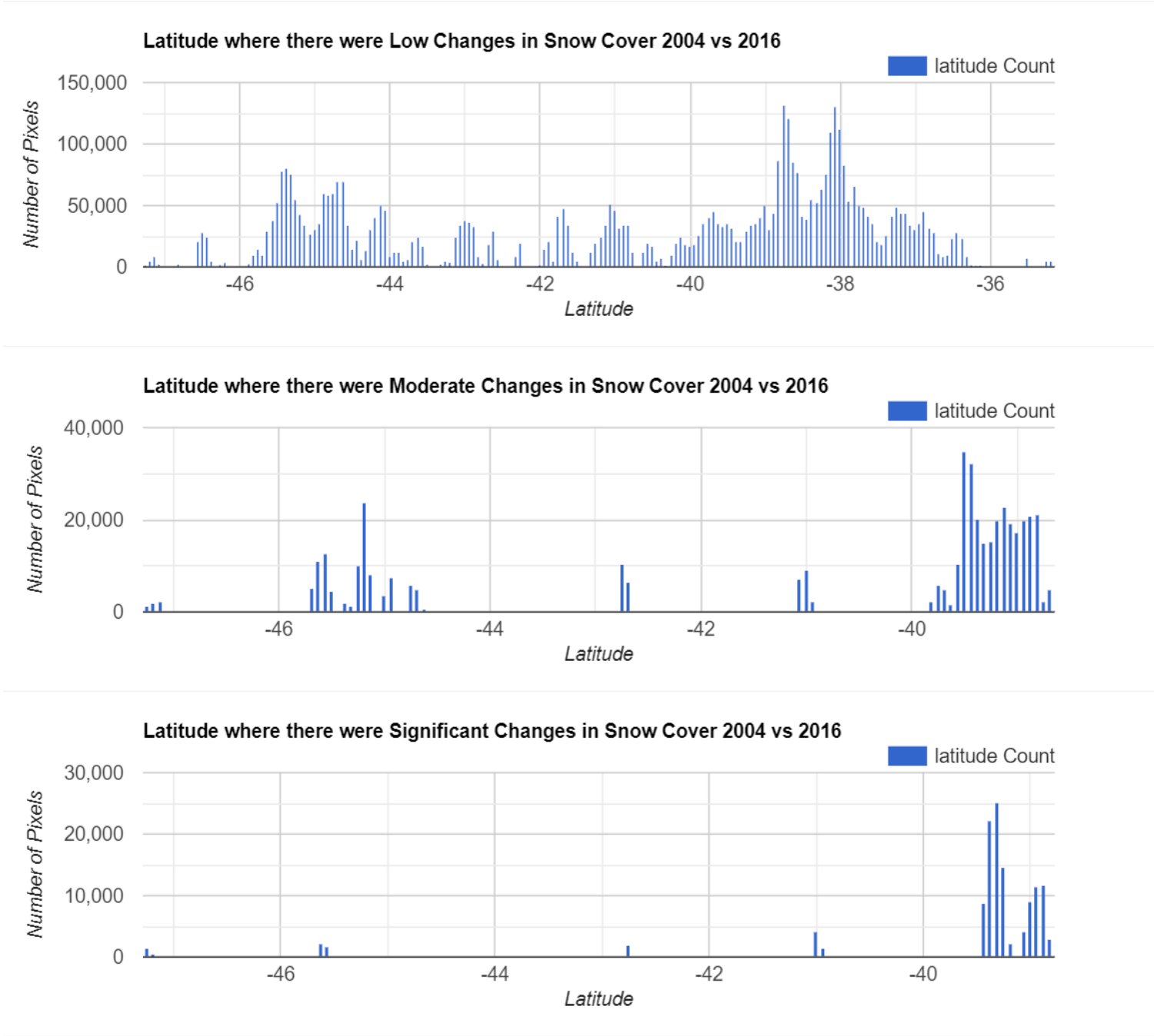




Note that slope does not have much of an impact

Latitude Histograms

- Note High and moderate changes most commonly occurred at higher latitudes, closer to the equater



Distance From Coast Histograms

Note that where significant changes occurred, they were typically farther away from the coast. However, there was a much smaller sample size regions where there was significant variation between 2004 and 2016, so not much can be concluded.