

# Snow and Vegetation Yearly Variation of Altai Region

# SNOW Cover in Summer Observed from MODIS Images

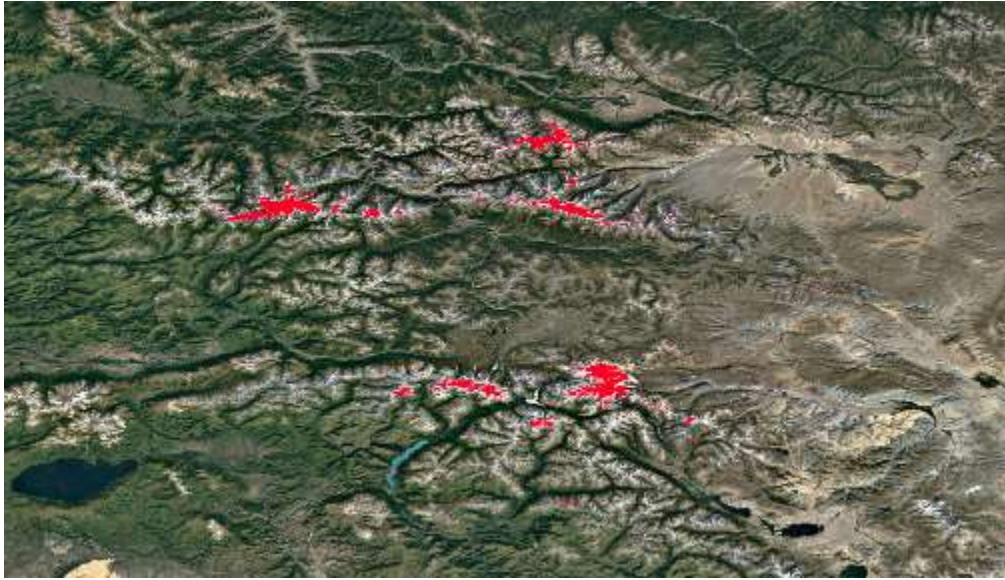
**Figure: Snow pixels (Red color), Google Satellite Basemap**

# Method

- Use MODIS Snow Cover Index (Value range: 0 – 100, indicates percentage of cloud cover for the pixel).
- Only MODIS images acquired in summer months (June – August) are used.
- Pixels having value  $\geq 90$  is considered to be snow.
- A location is observed multiple time during the months of the considering year, if it is snow-covered at least once then the location is classified as snow for the year.

# Summer, 2002 - 2005

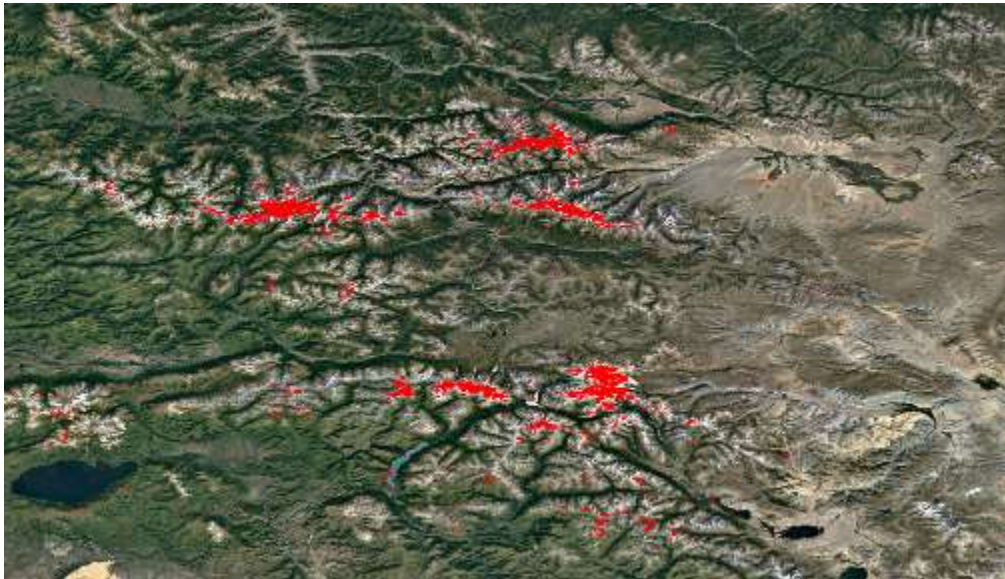
2002



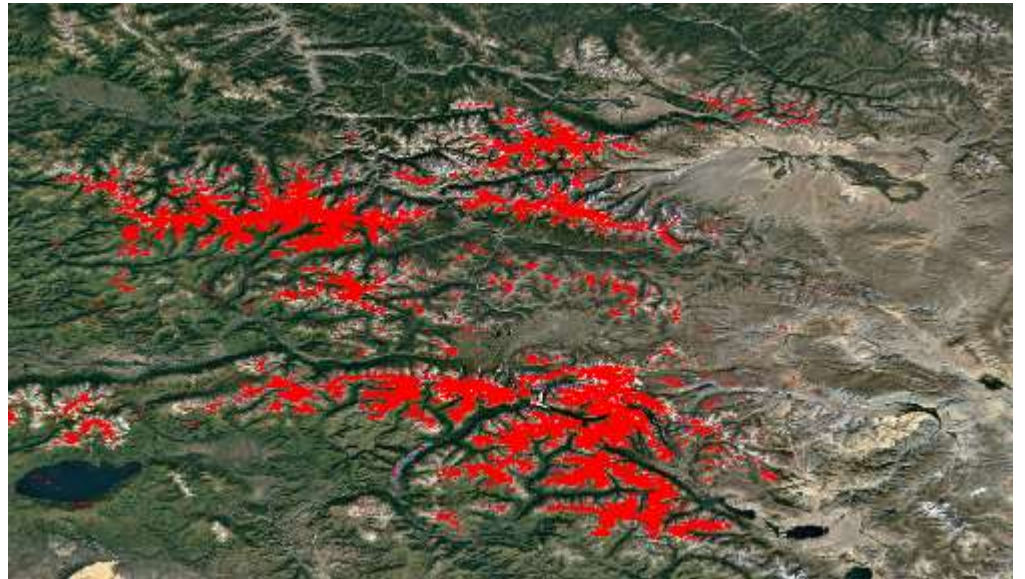
2003



2004



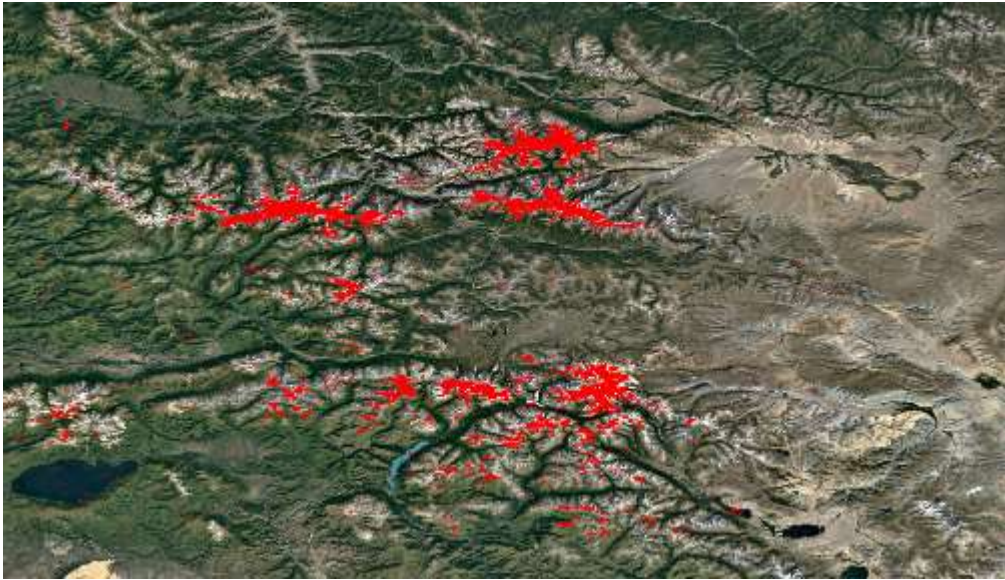
2005



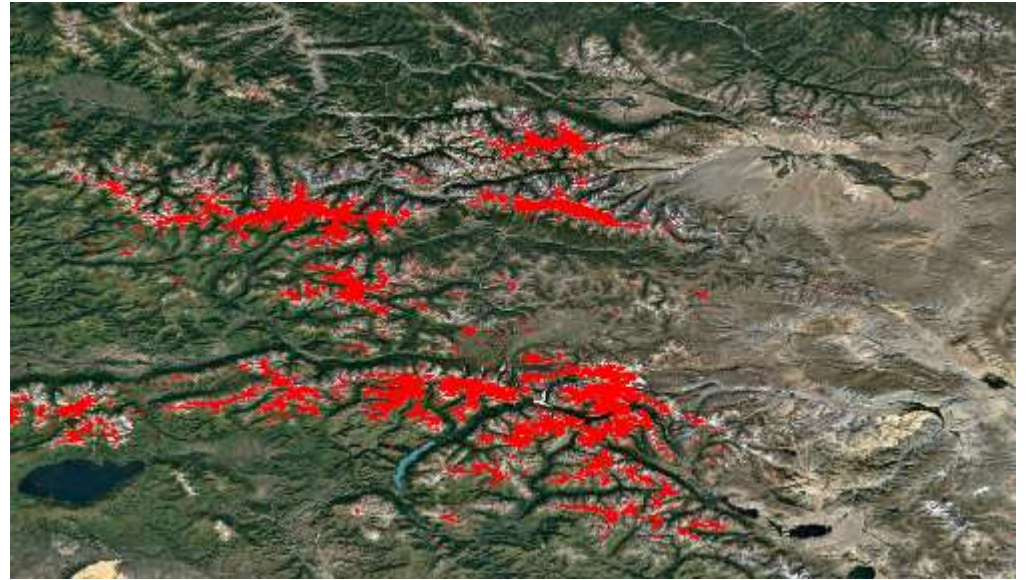


# Summer, 2006 - 2009

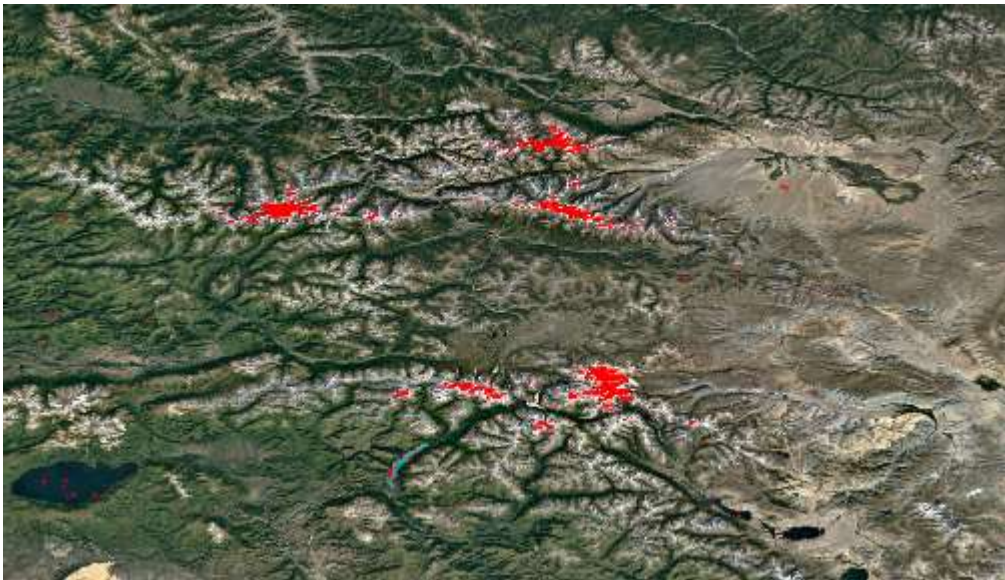
2006



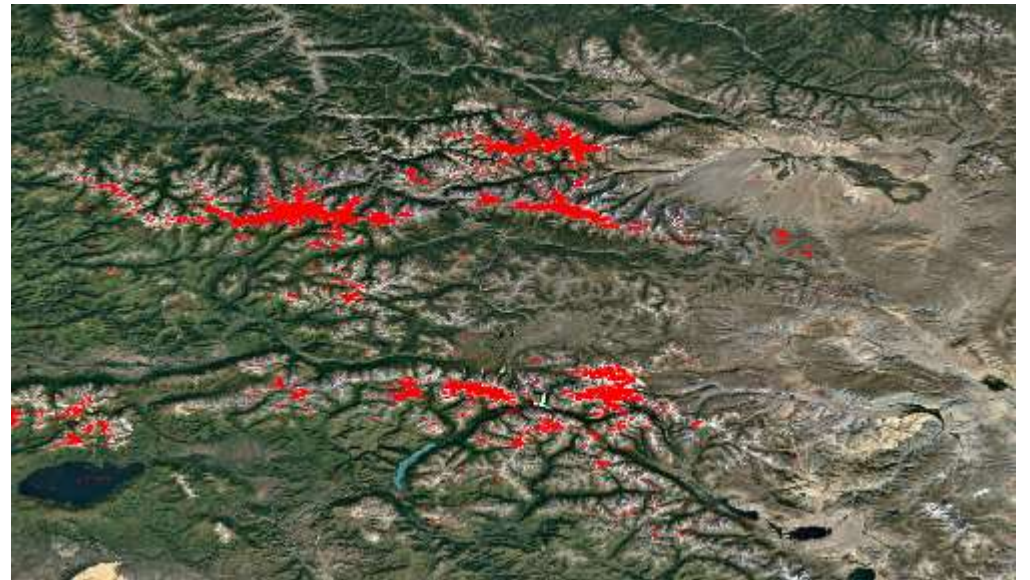
2007



2008



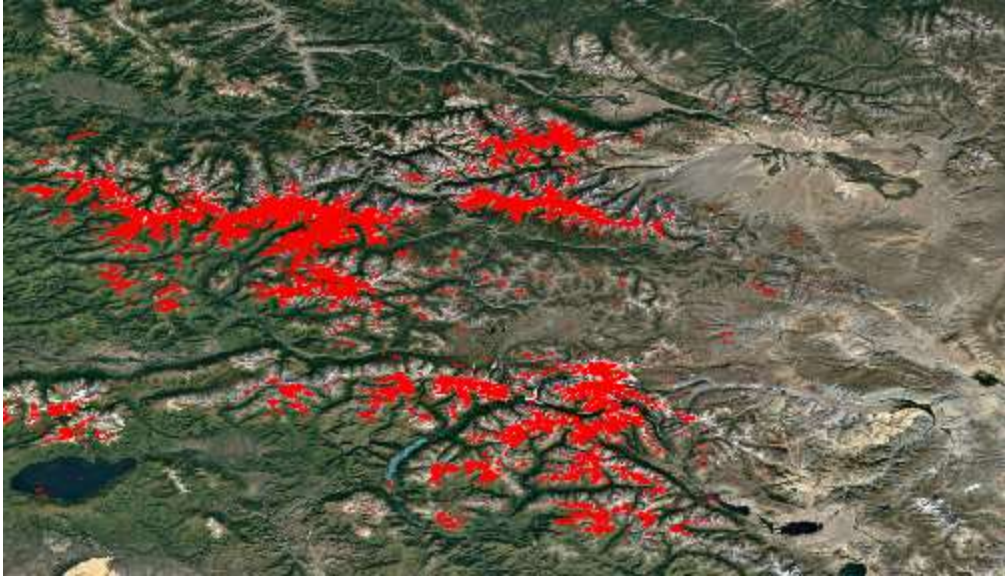
2009





# Summer, 2010 - 2013

2010



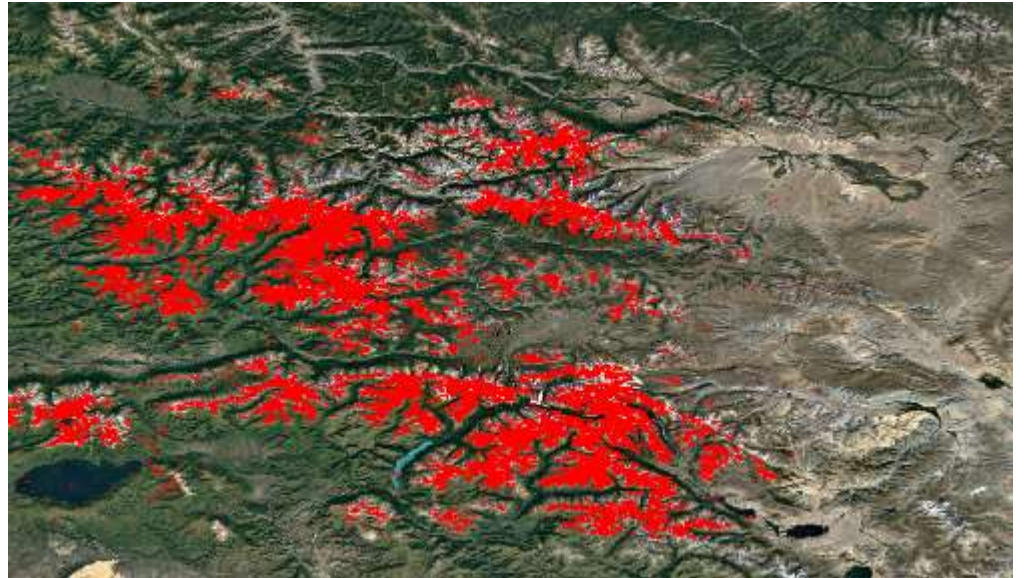
2011



2012



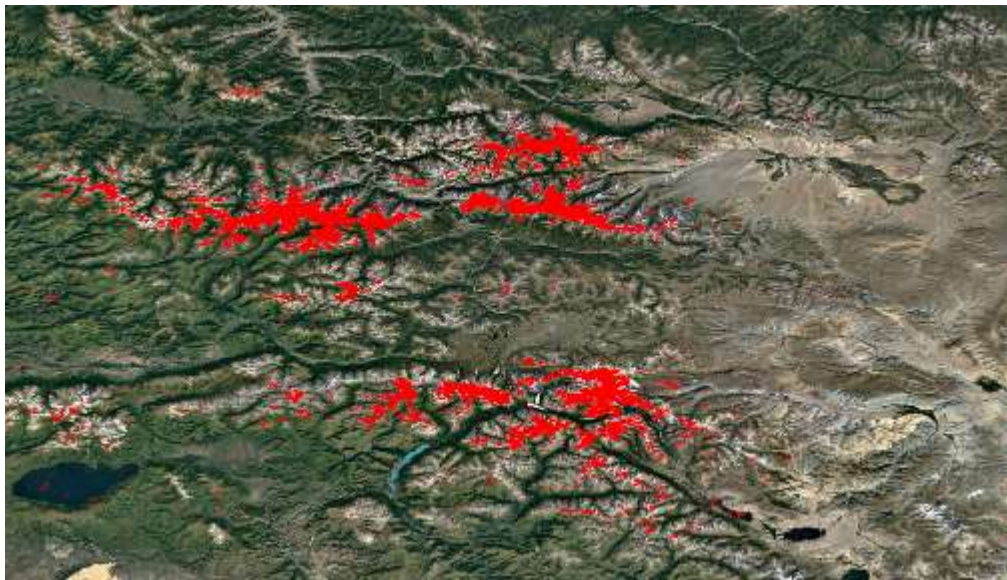
2013



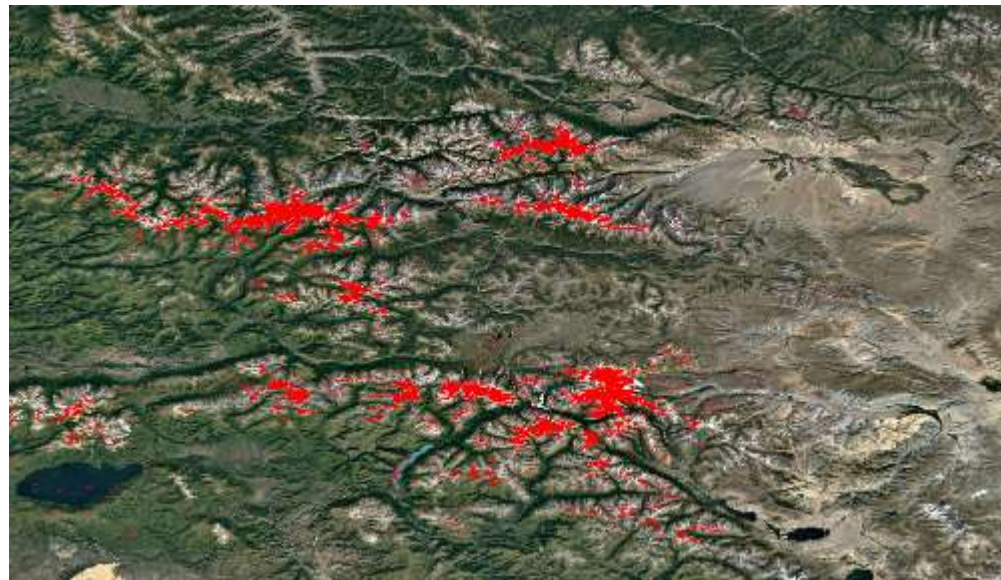


# Summer, 2014 - 2017

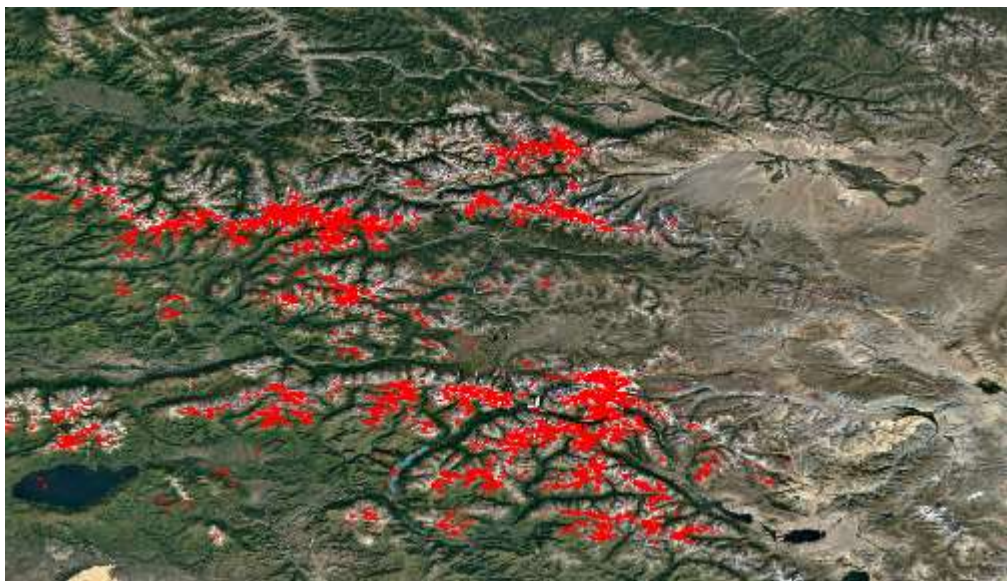
2014



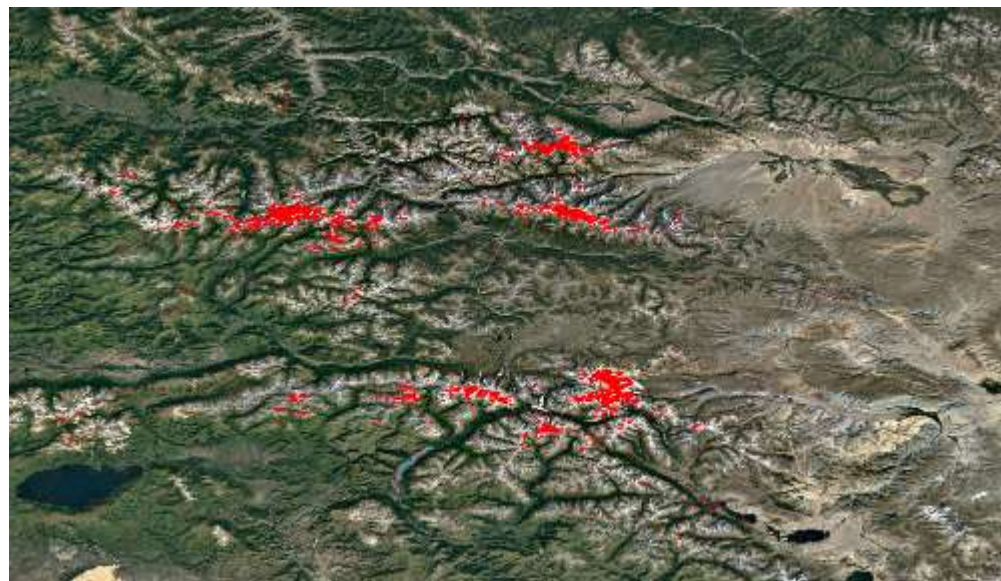
2015



2016



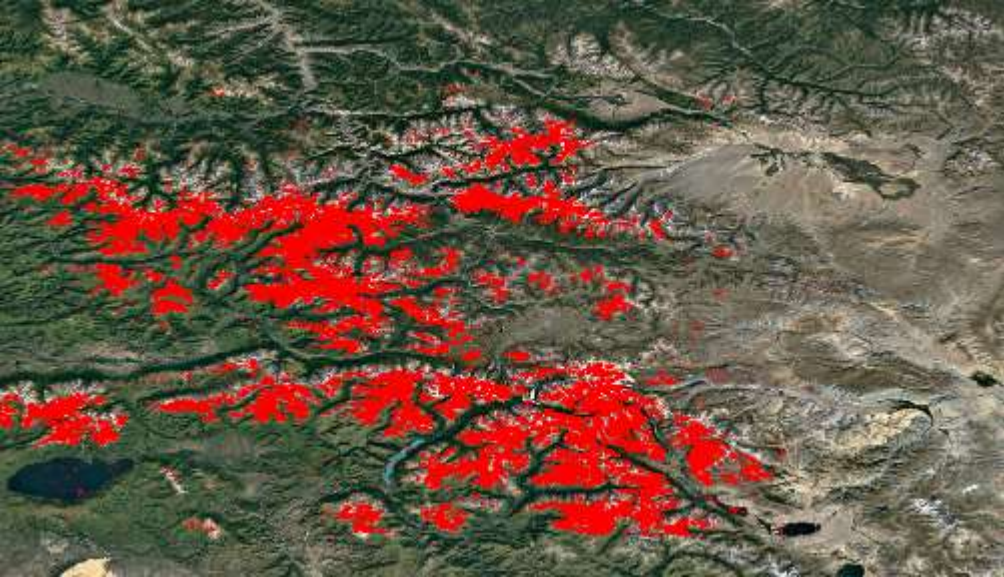
2017





# Summer, 2018 - 2019

2018



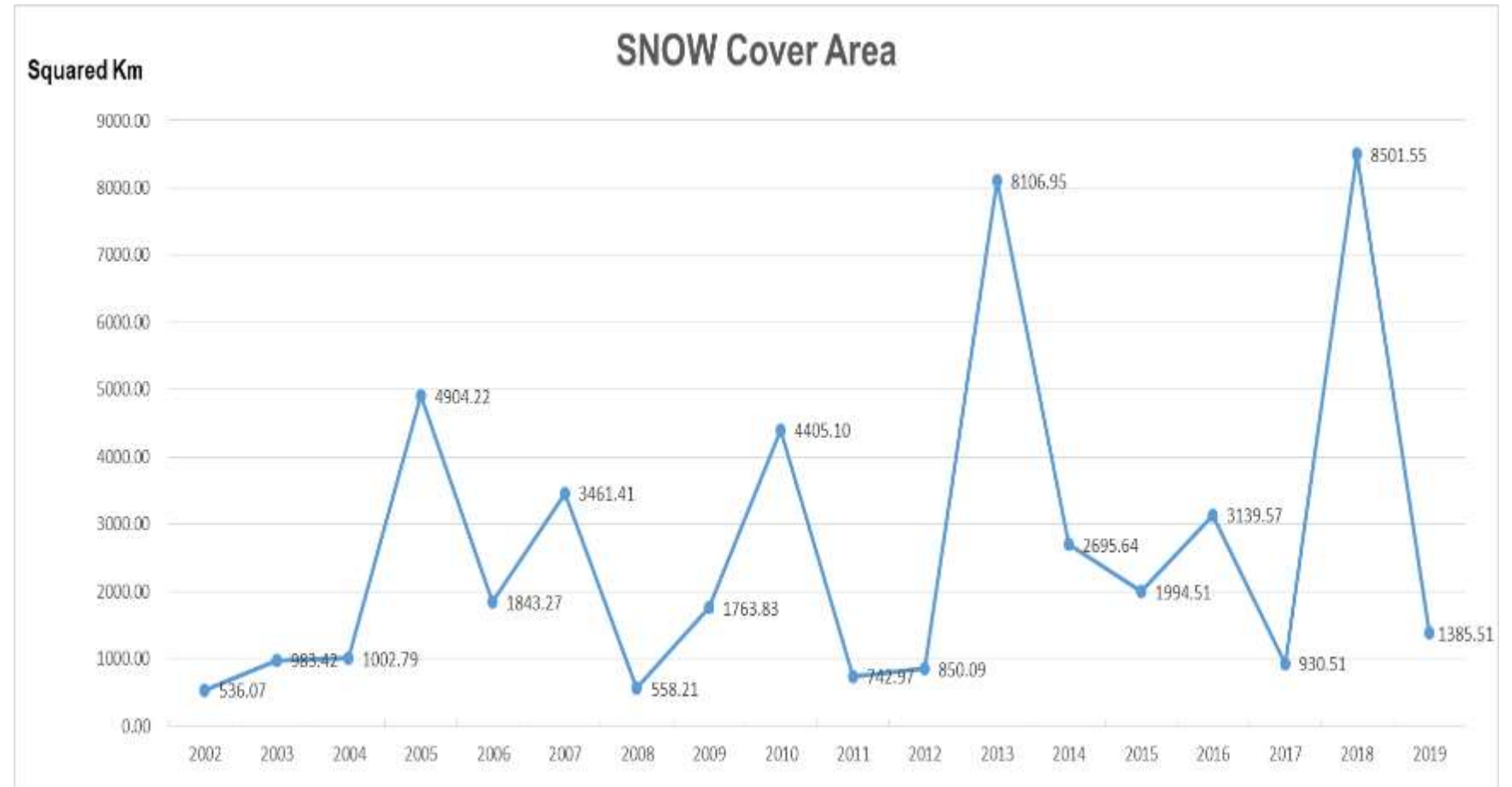
2019





# Quantitative assessment of SNOW Cover

Year	Area (squared km)
2002	536.068
2003	983.4154
2004	1002.787
2005	4904.216
2006	1843.273
2007	3461.407
2008	558.2075
2009	1763.831
2010	4405.102
2011	742.9743
2012	850.0902
2013	8106.95
2014	2695.642
2015	1994.505
2016	3139.571
2017	930.5086
2018	8501.553
2019	1385.507



# Analysis for SNOW with MODIS

- It is difficult to say if there is a retreating trend of glacier in the area for the period from 2002 – 2019.
- Snow cover is varying year by year.
- 2005, 2013, 2018 seem colder than the other years.



# SNOW Cover in Summer Observed from Landsat Images

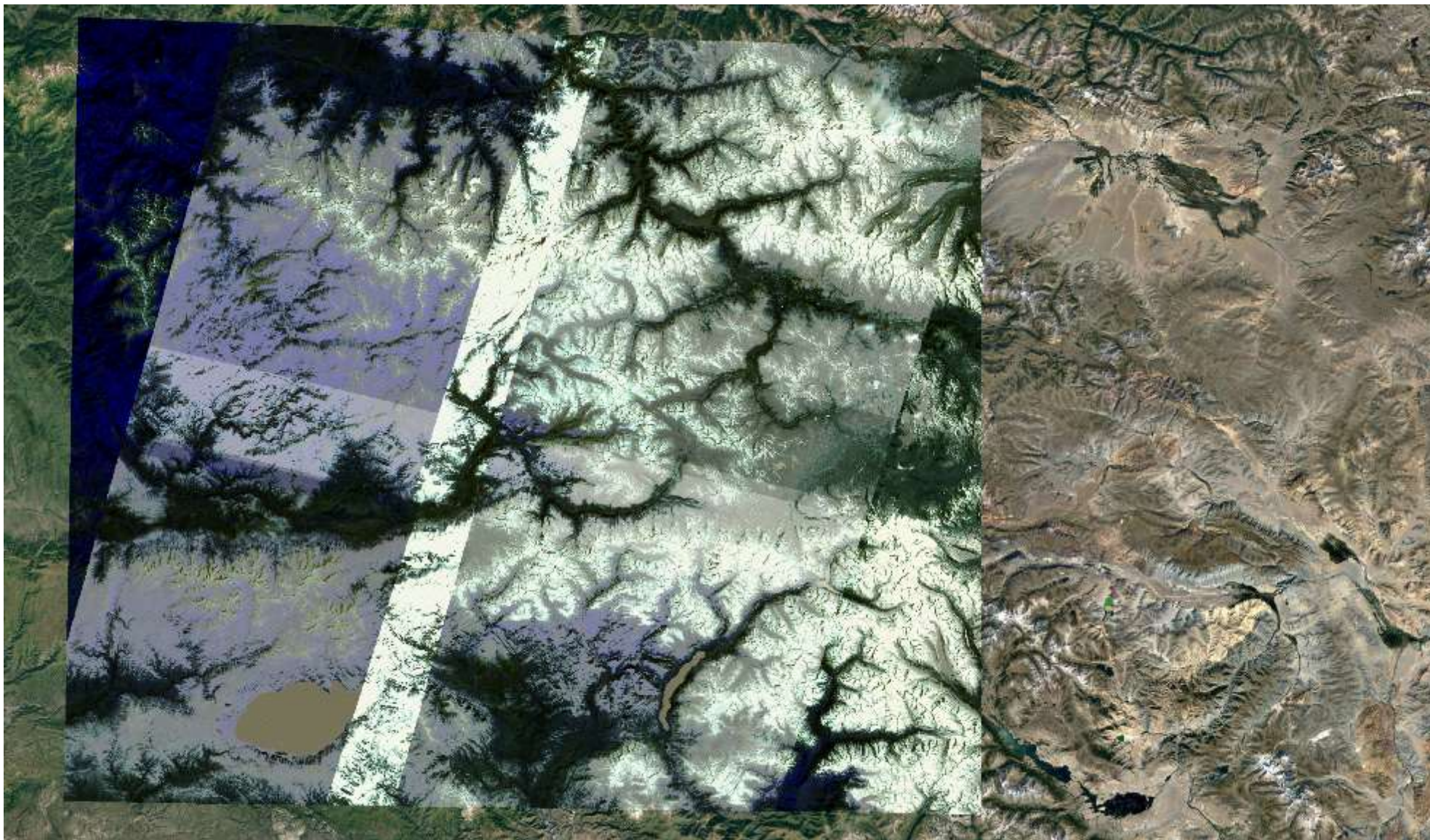
**Figure: Snow pixels (Red color), Google Satellite Basemap**

# Method

- Use Landsat *SNOW* cover mask from USGS (for 1997 – 2018).
- Only Landsat images acquired in summer months (June – August) are used.
- A location is observed multiple time during the months of the considering year, if it is snow-covered at least once then the location is classified as snow for the year.

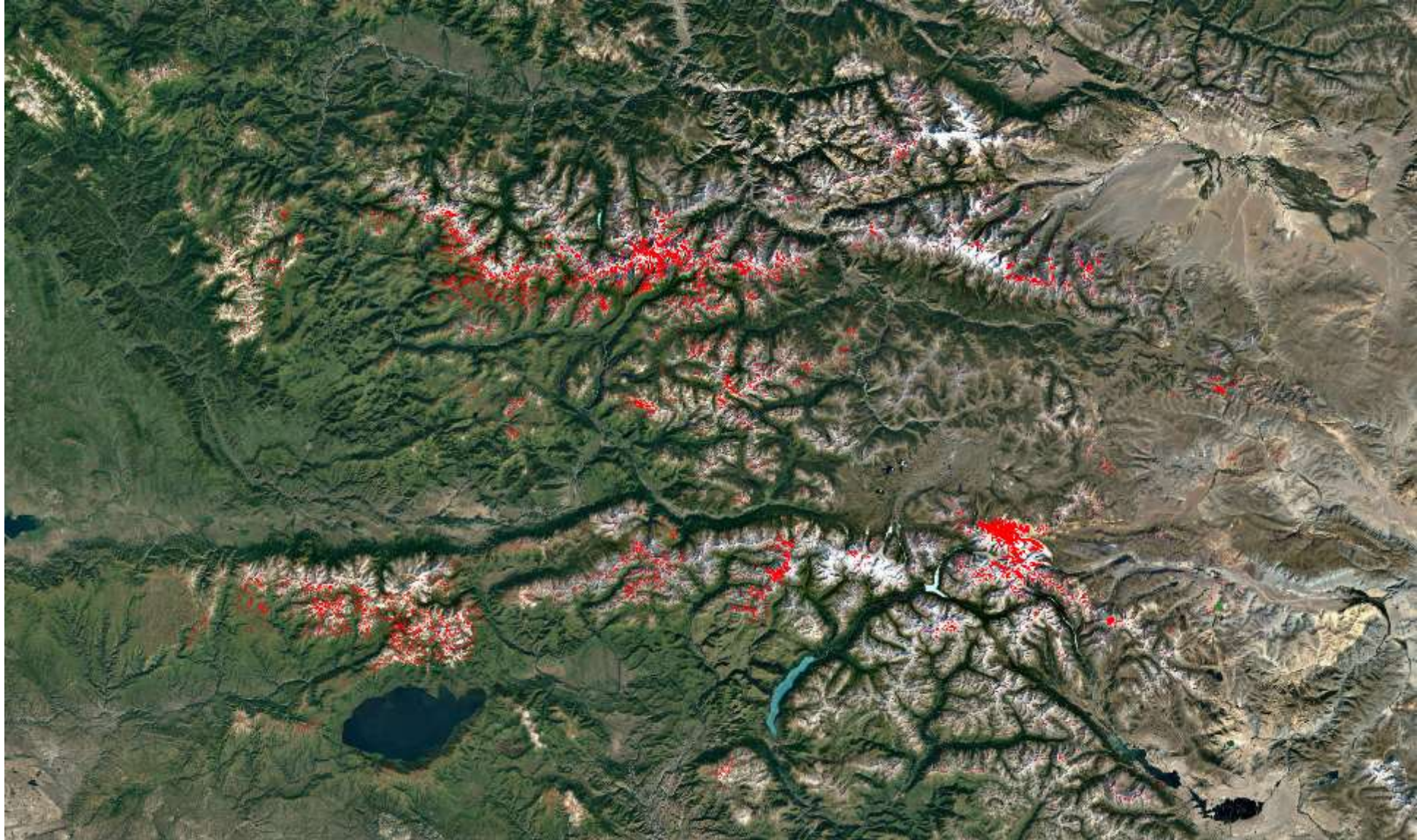


# Landsat Mosaic Images – June 1975



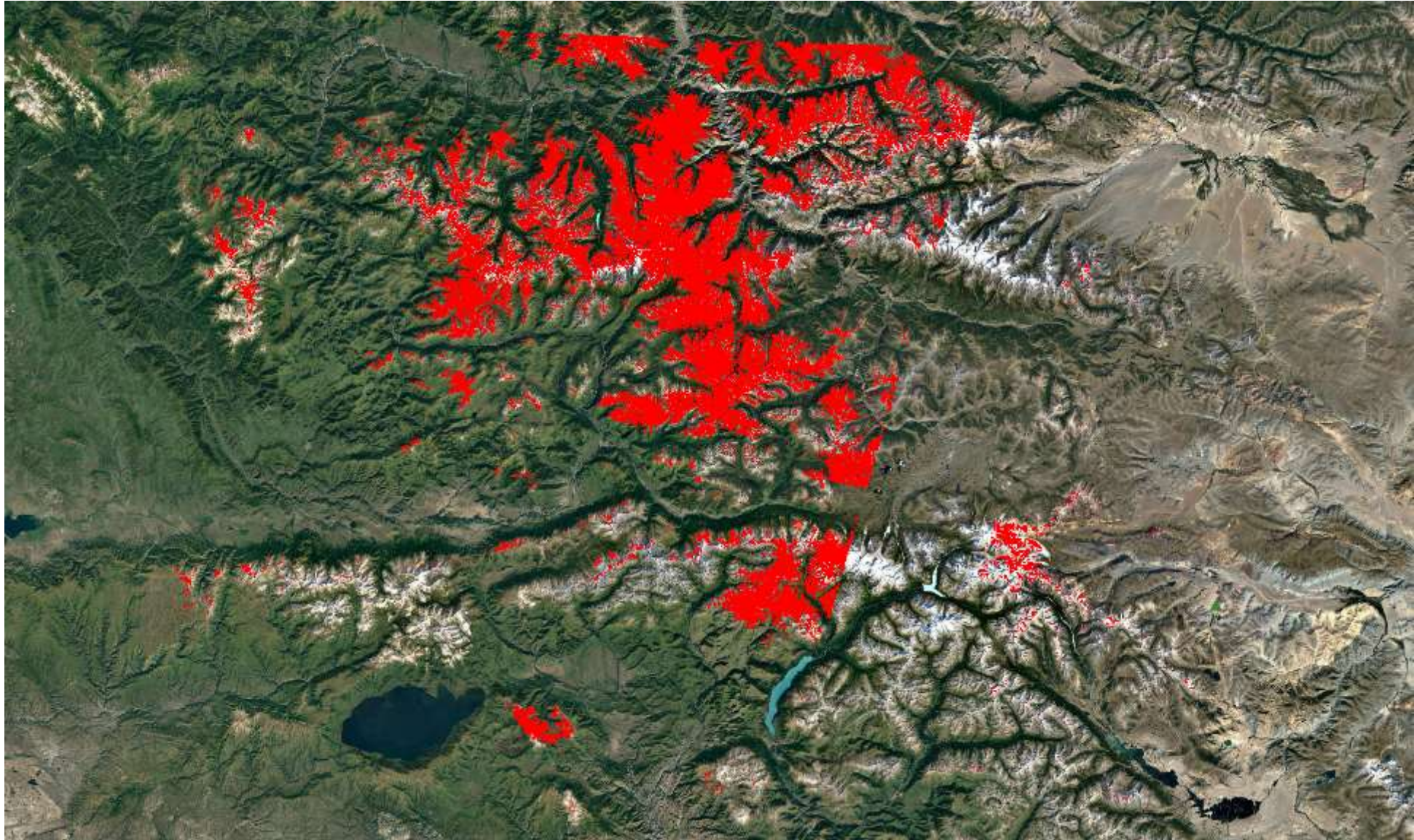


# Landsat SNOW cover map - 1994



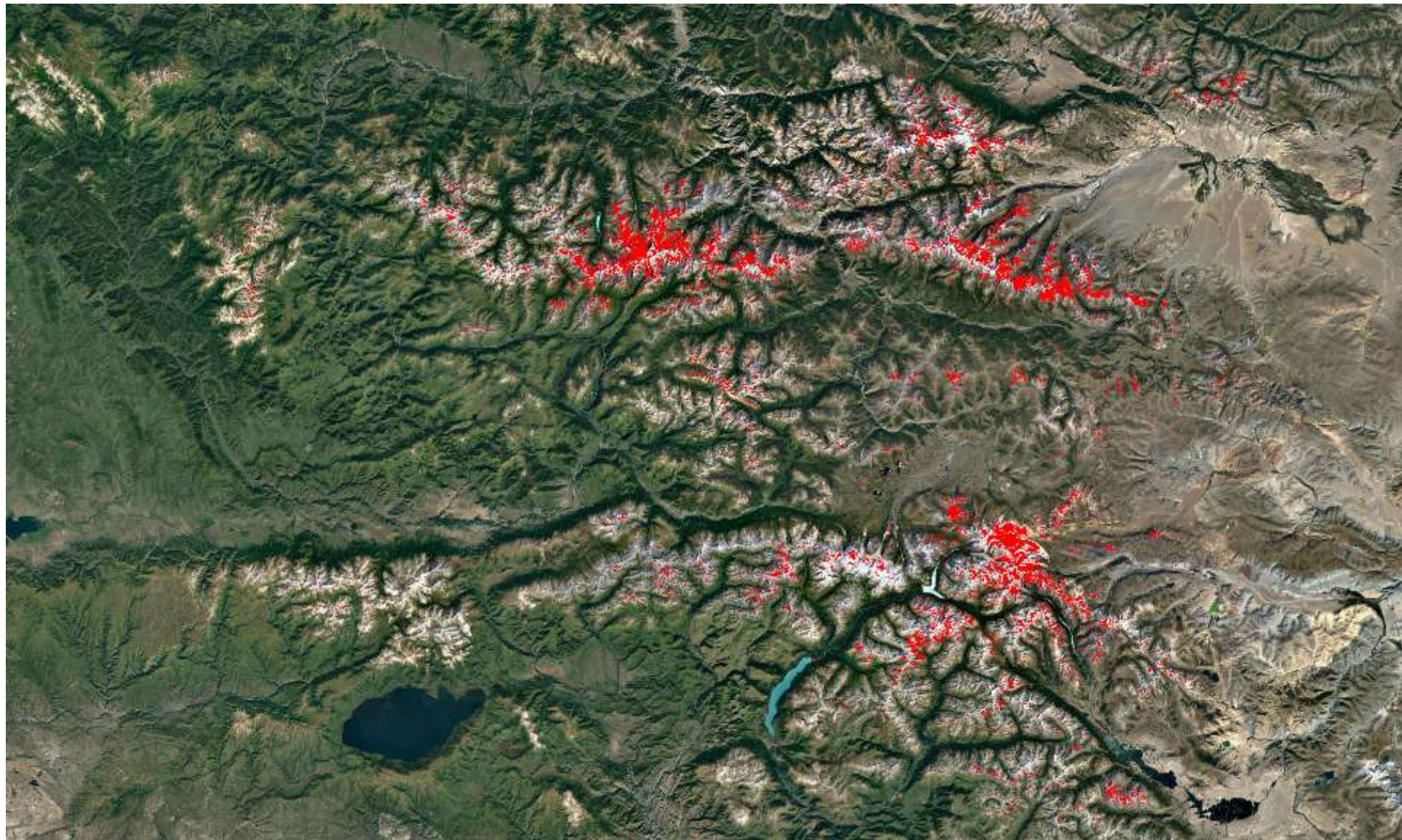


# Landsat SNOW cover map - 1997



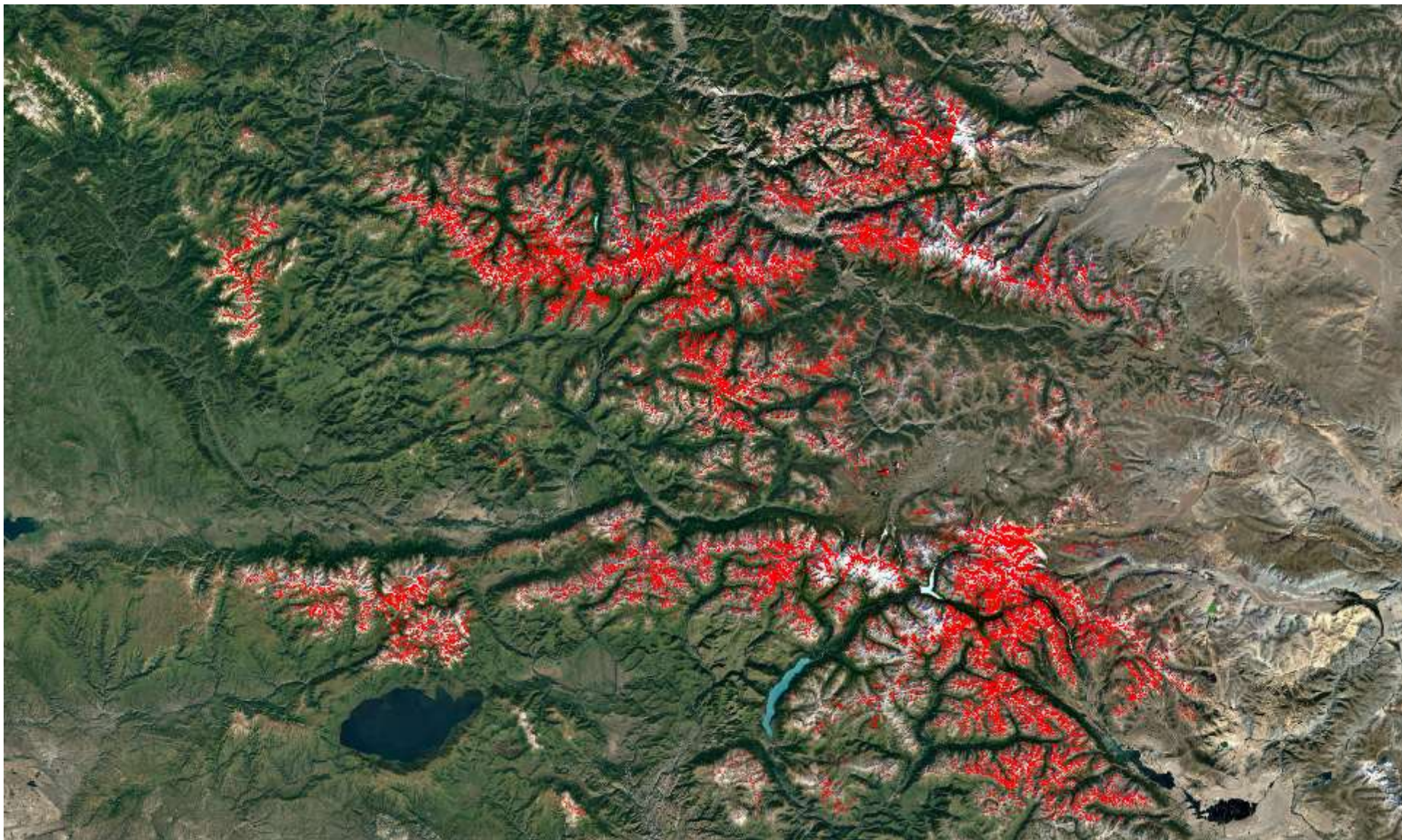


# Landsat SNOW cover map – 2007

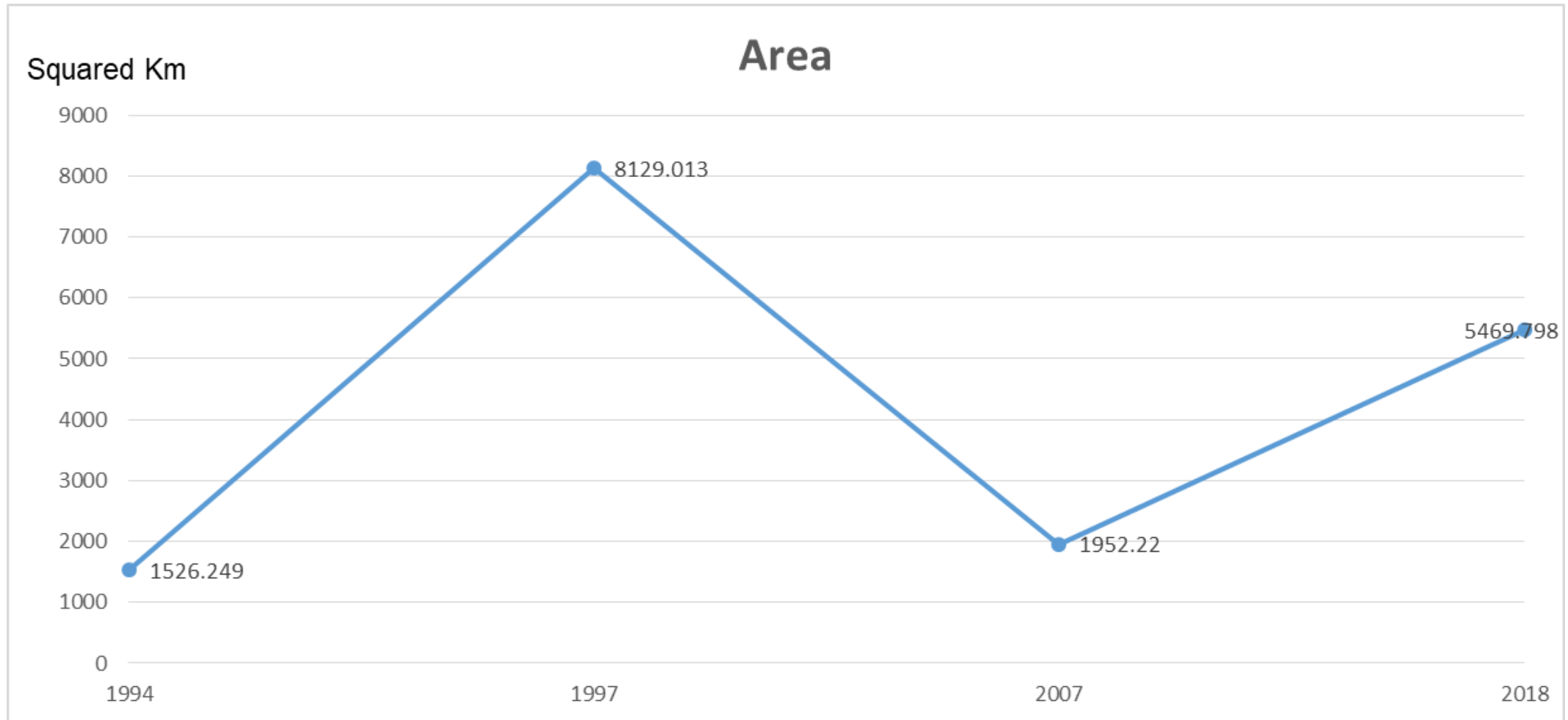




# Landsat SNOW cover map – 2018



# Quantitative assessment of SNOW Cover



# Analysis

- From 1997 – 2018, there is also not a clear trend of glacier retreat.
- But 1975 image seems to show that the area of snow of that time is much bigger than the 1997 – 2018 period. However, this image is still not fully cover the area.
- For Landsat's SNOW Cover, the snow cover areas for 2007, 2018 are smaller than MODIS's snow cover areas. This may be because of cloud problem, and MODIS is more frequent collected than Landsat. However, the trend is similar with 2007's snow cover is much smaller than 2018's snow cover.



# Vegetation Observed from MODIS Images

**Figure: Lower value (light orange) -> Higher value (Red)**

# Method

- Use MODIS NDVI index data from 2000 – 2019.
- Use all MODIS images acquired in a year.
- A location is observed multiple time during the years, then all are used to compute mean value of NDVI for that year.



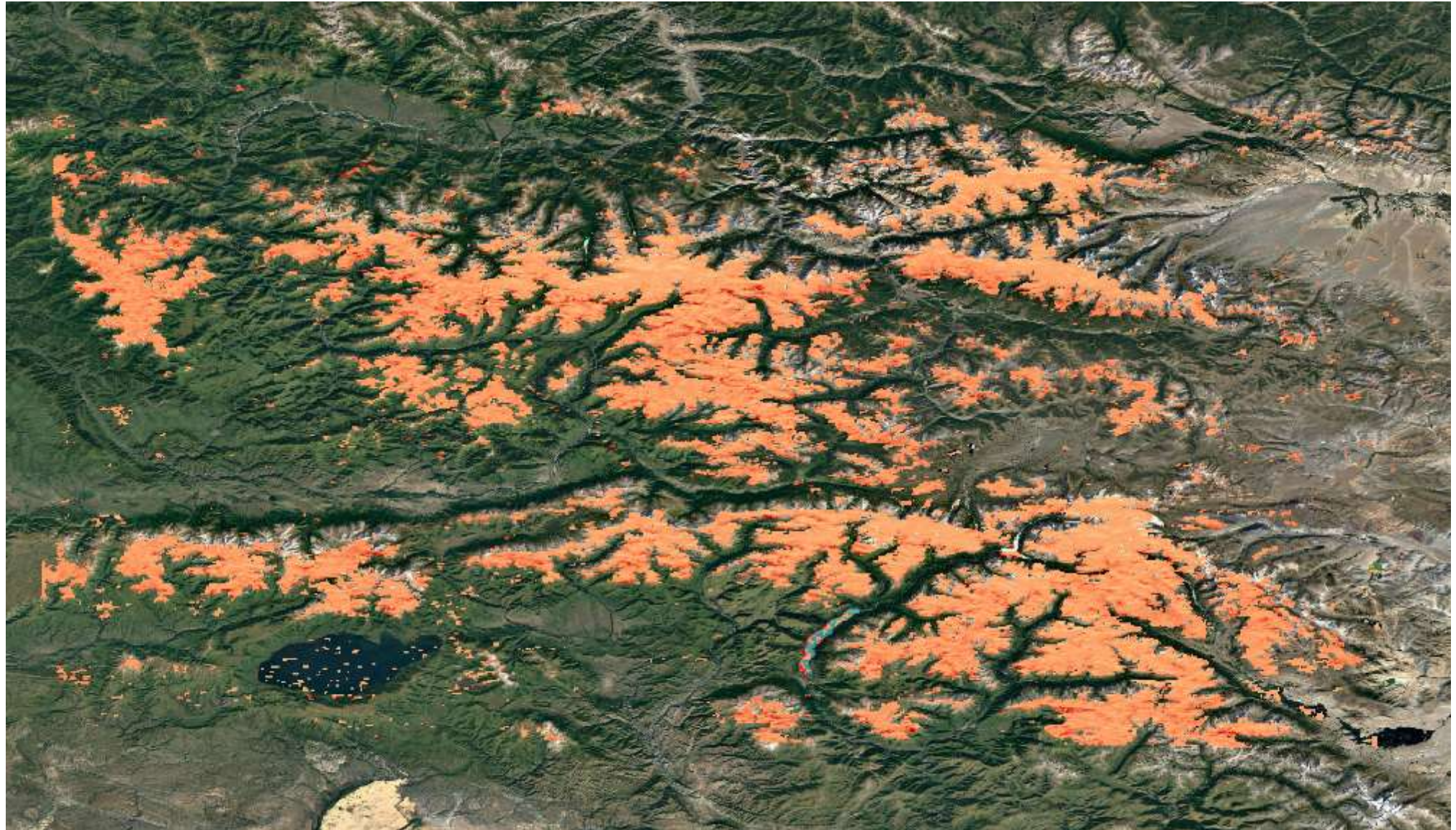
# NDVI Mean for 2000



Lower value (light orange) -> Higher value (Red)

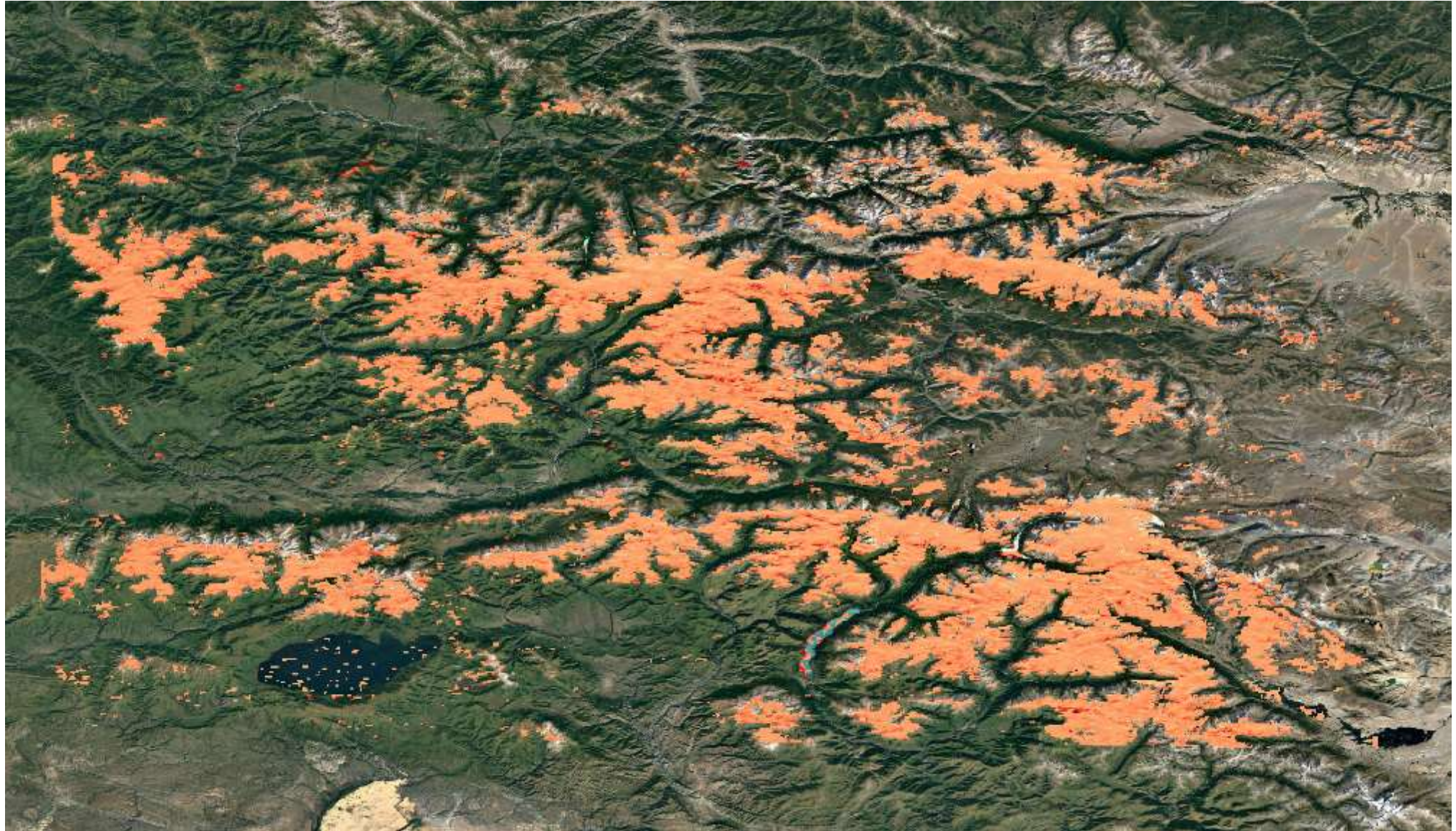


# NDVI Mean for 2001



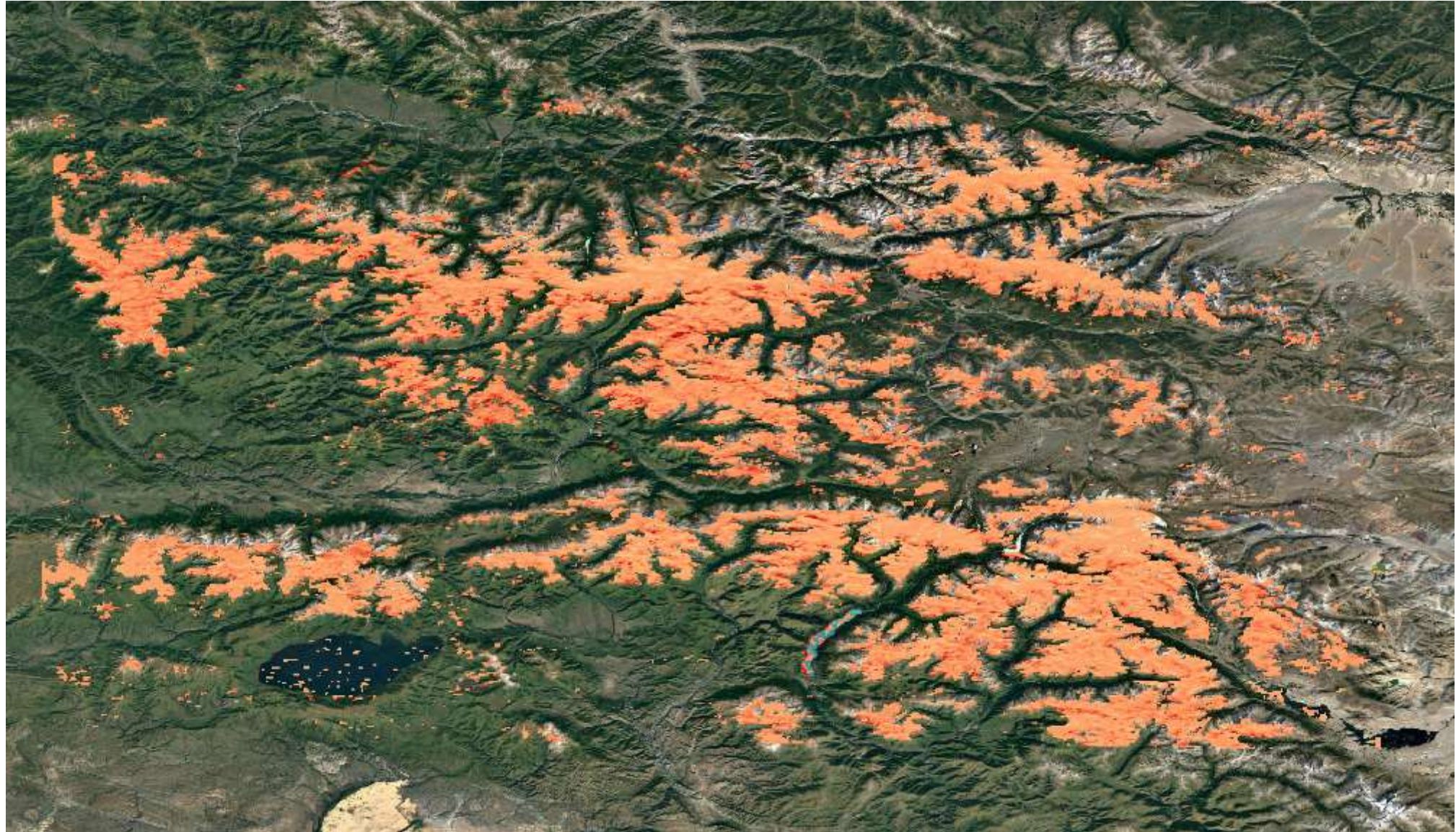


# NDVI Mean for 2002



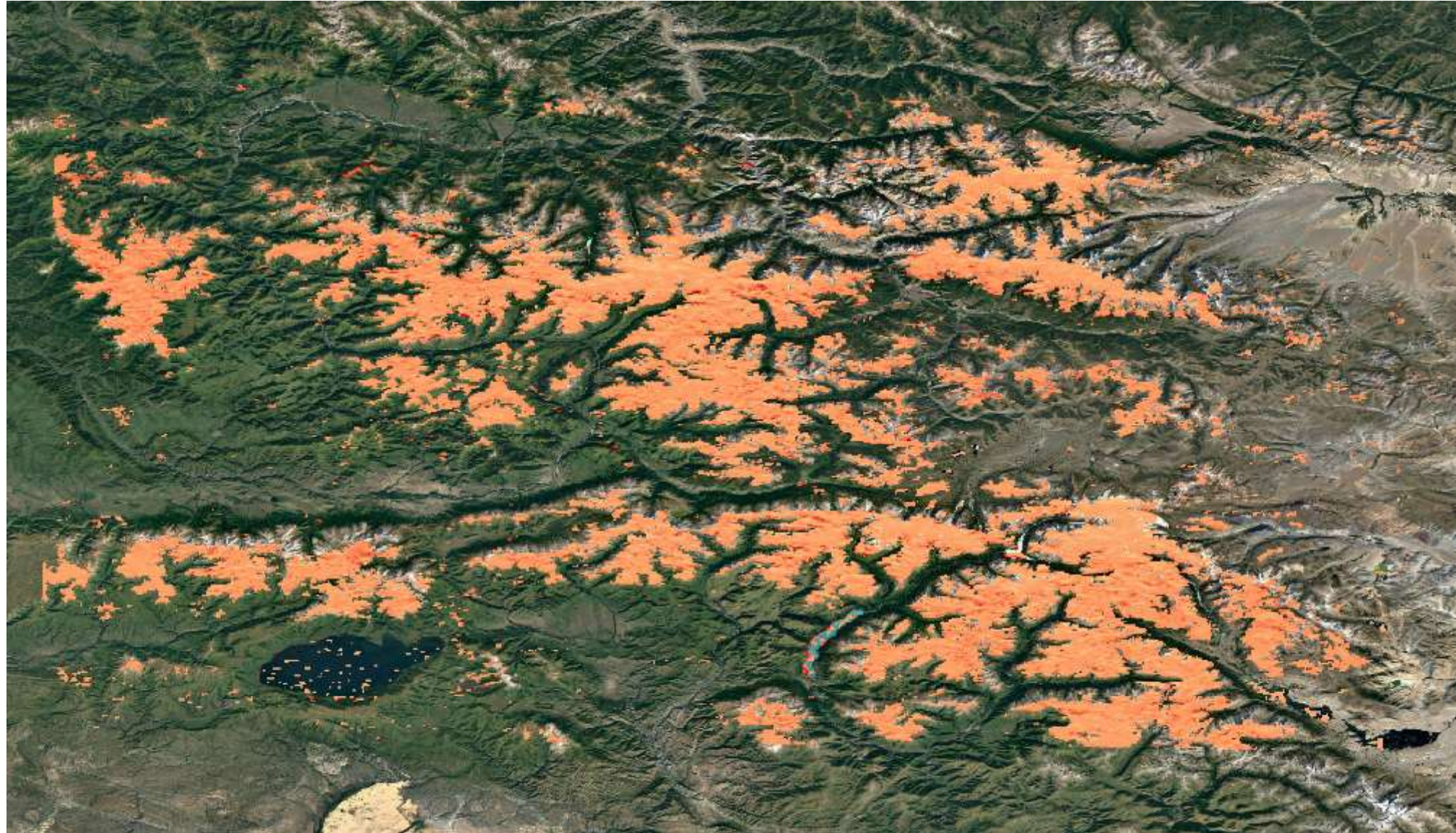


# NDVI Mean for 2003



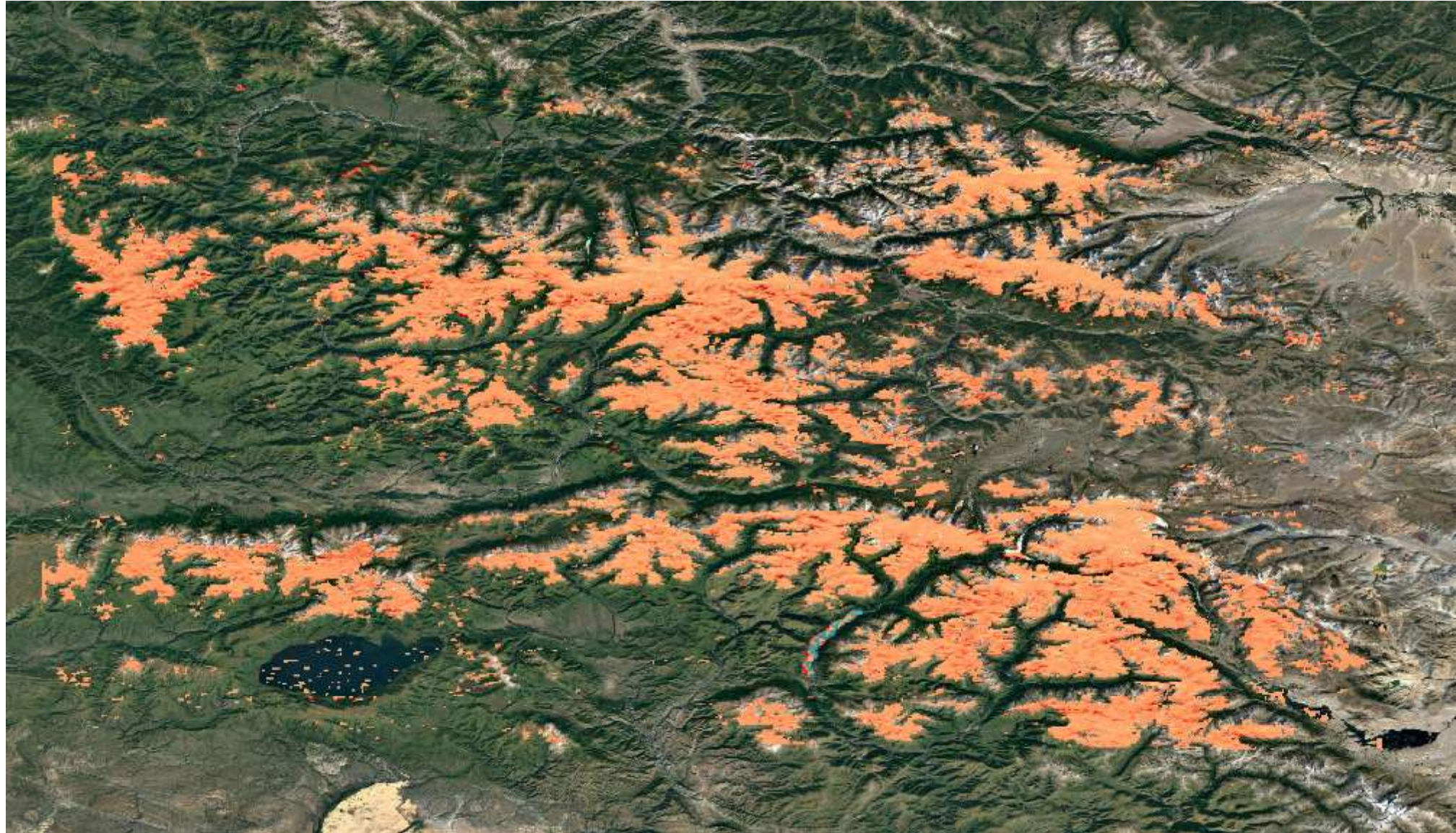


# NDVI Mean for 2004



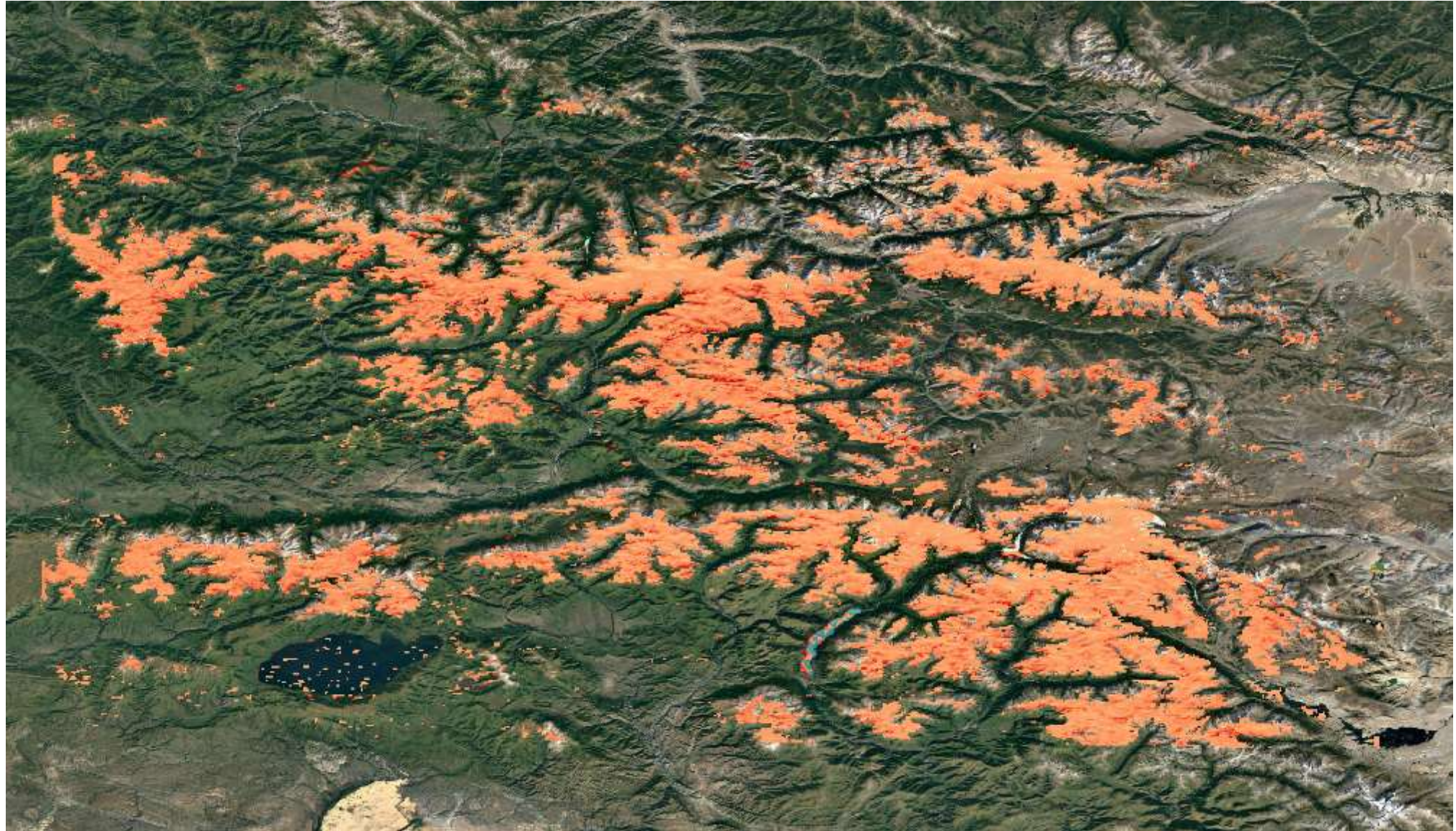


# NDVI Mean for 2005



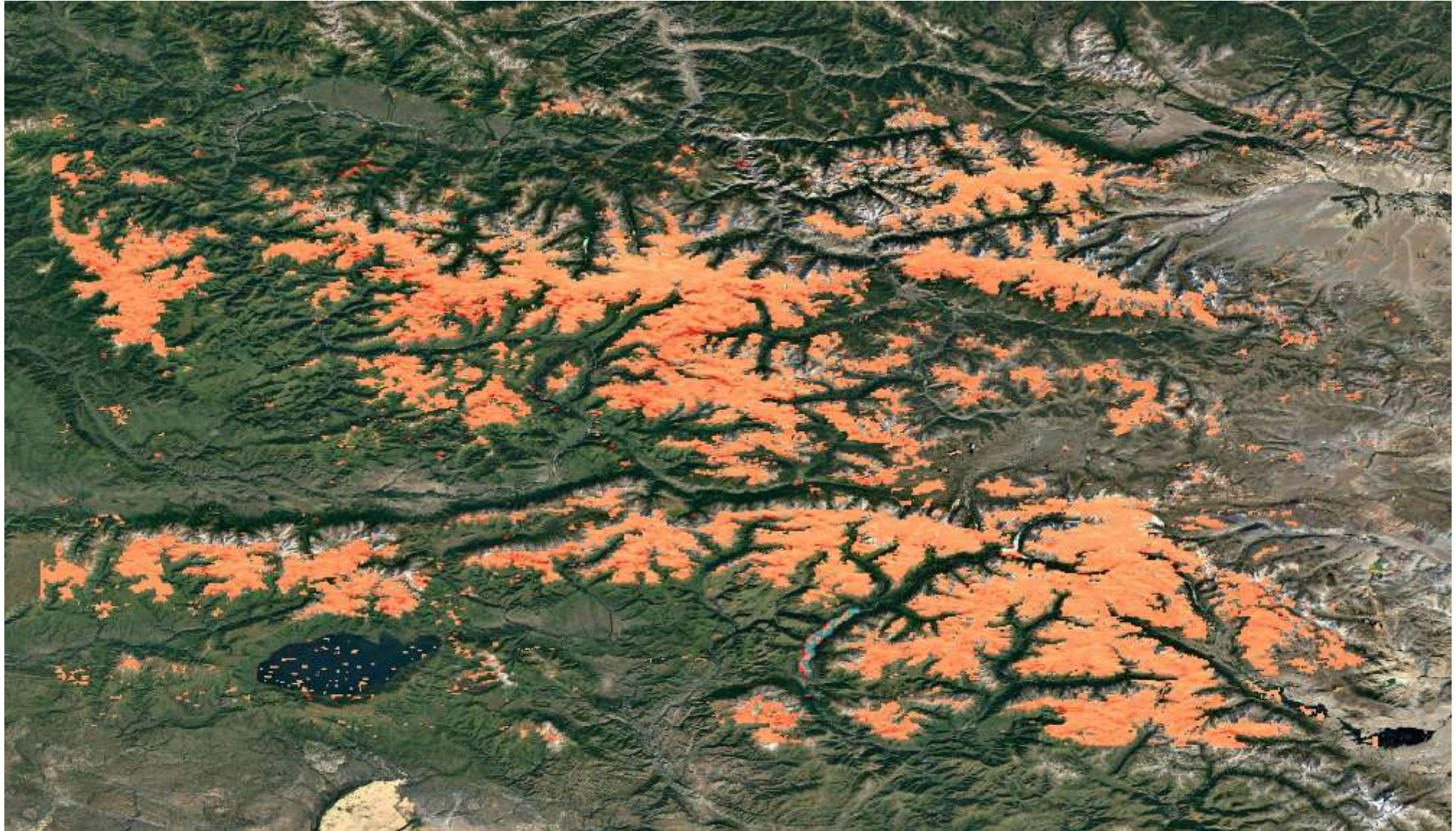


# NDVI Mean for 2006



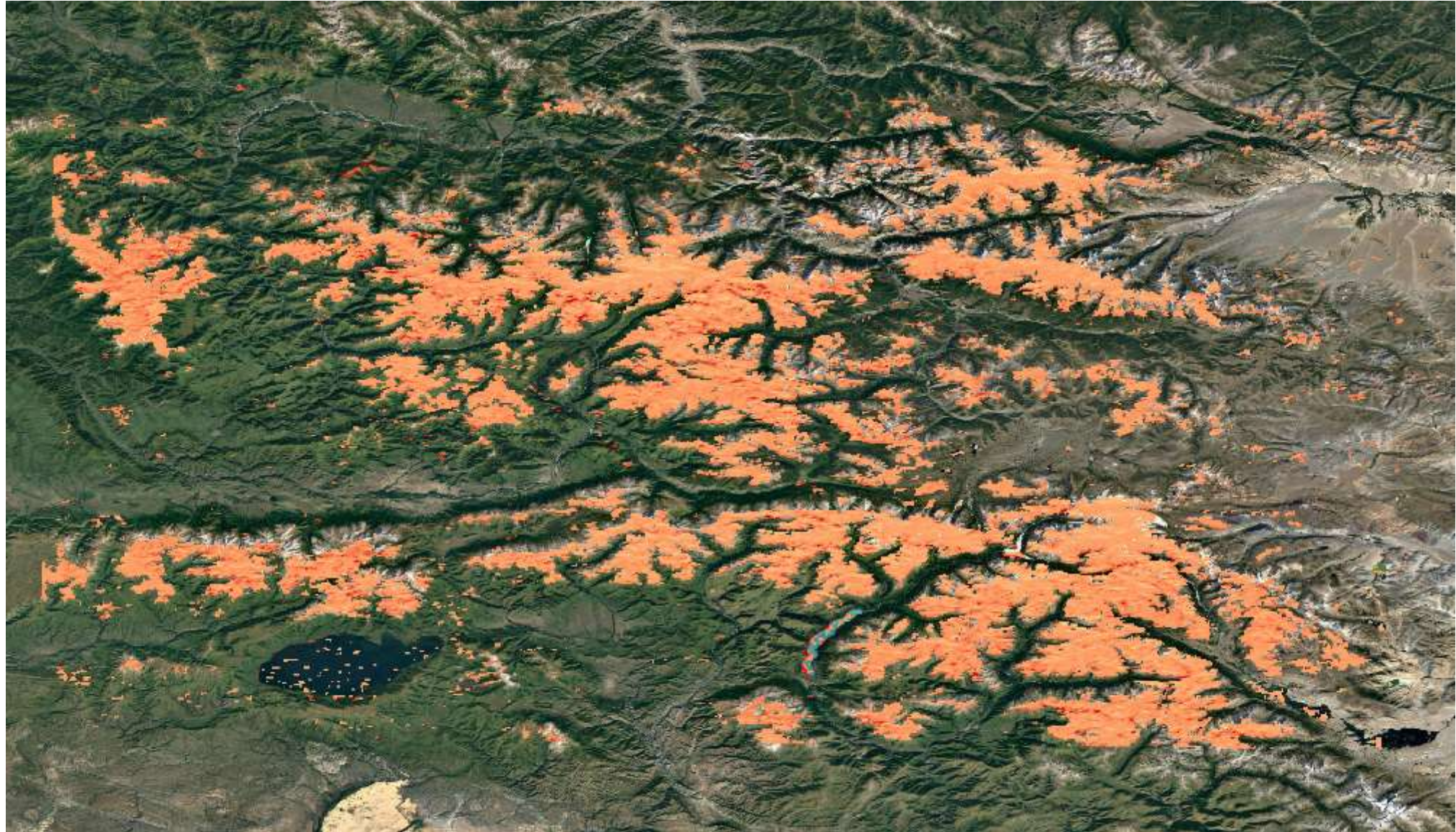


# NDVI Mean for 2007



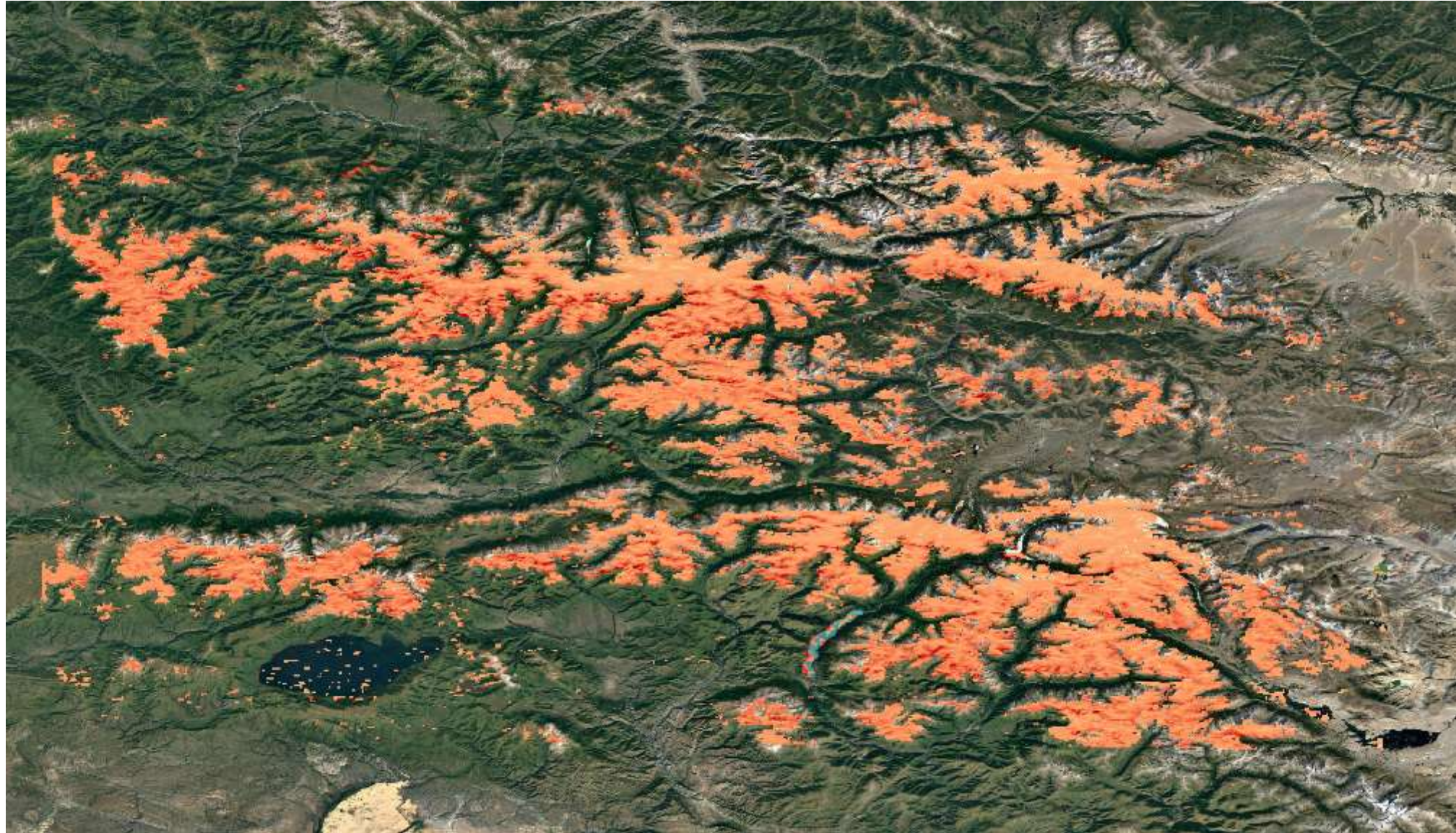


# NDVI Mean for 2008



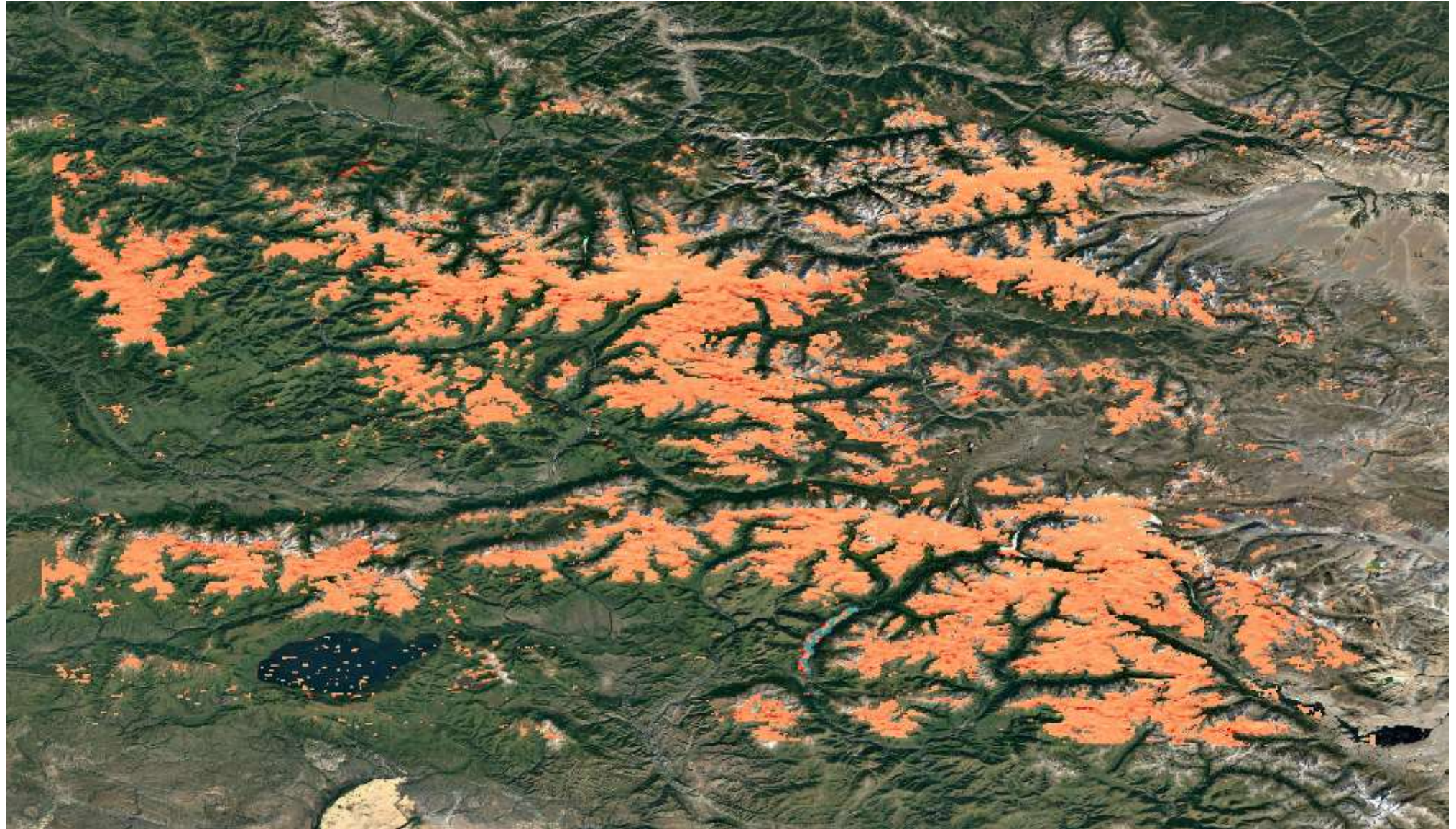


# NDVI Mean for 2009



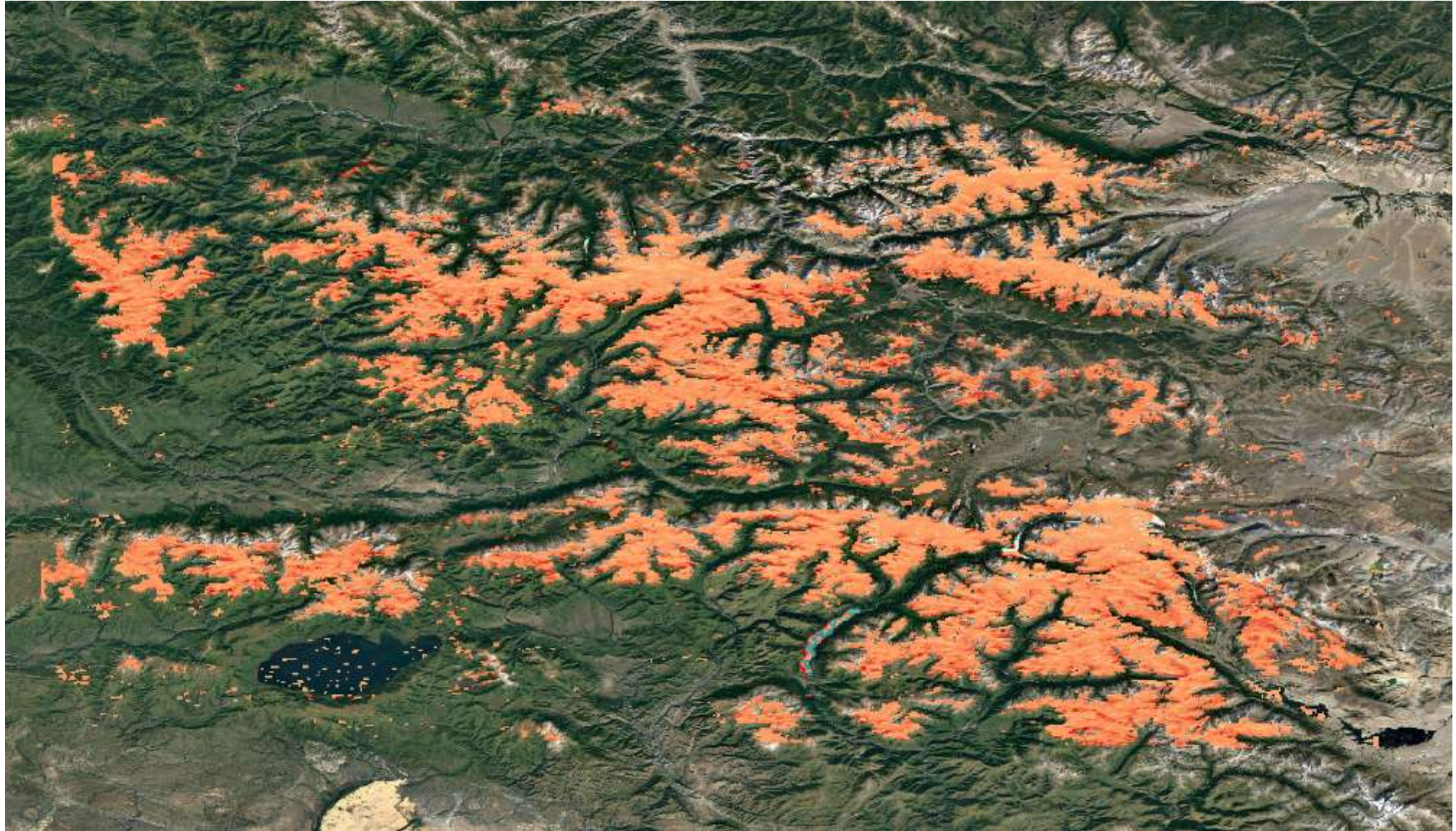


# NDVI Mean for 2010



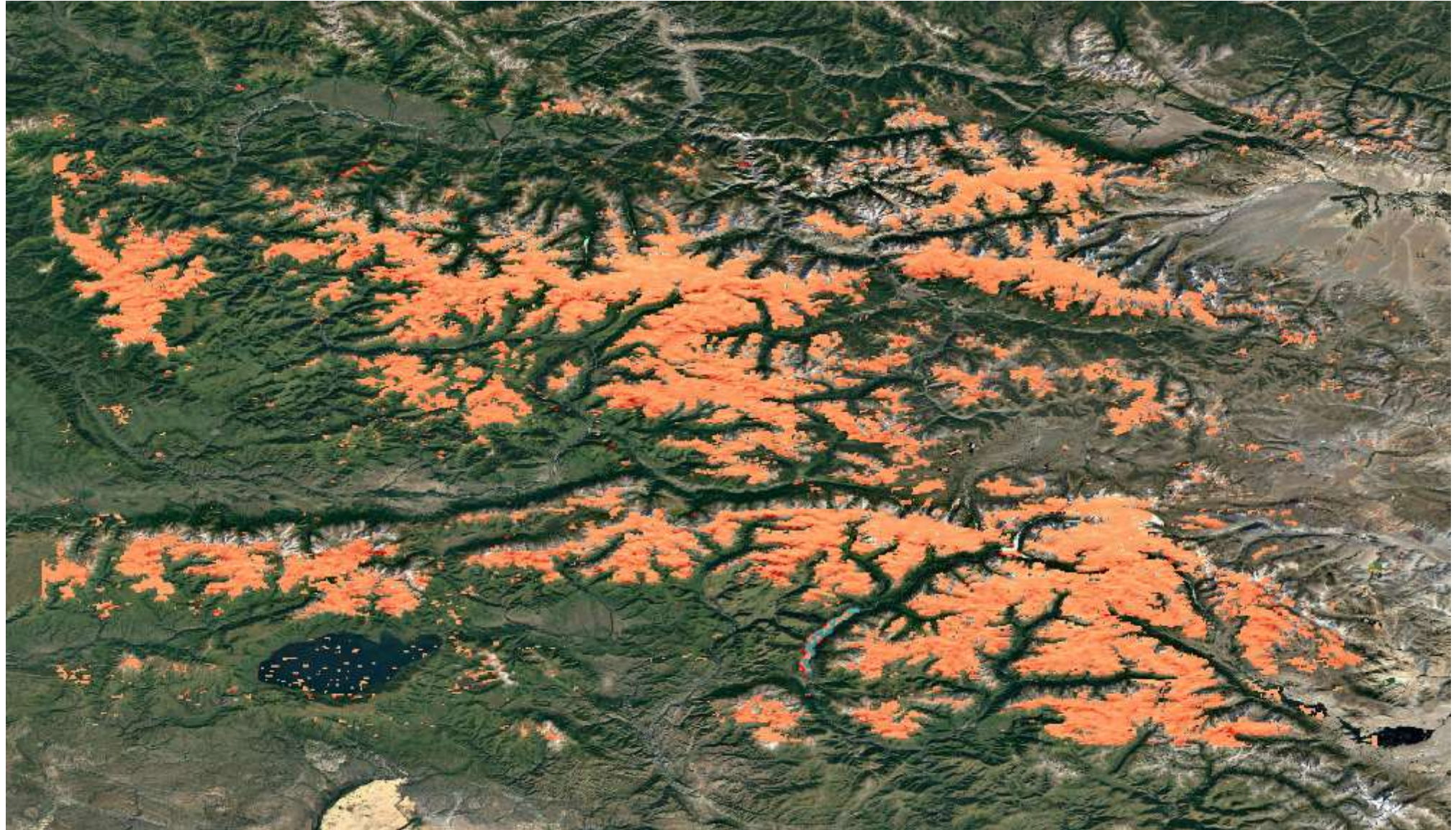


# NDVI Mean for 2011



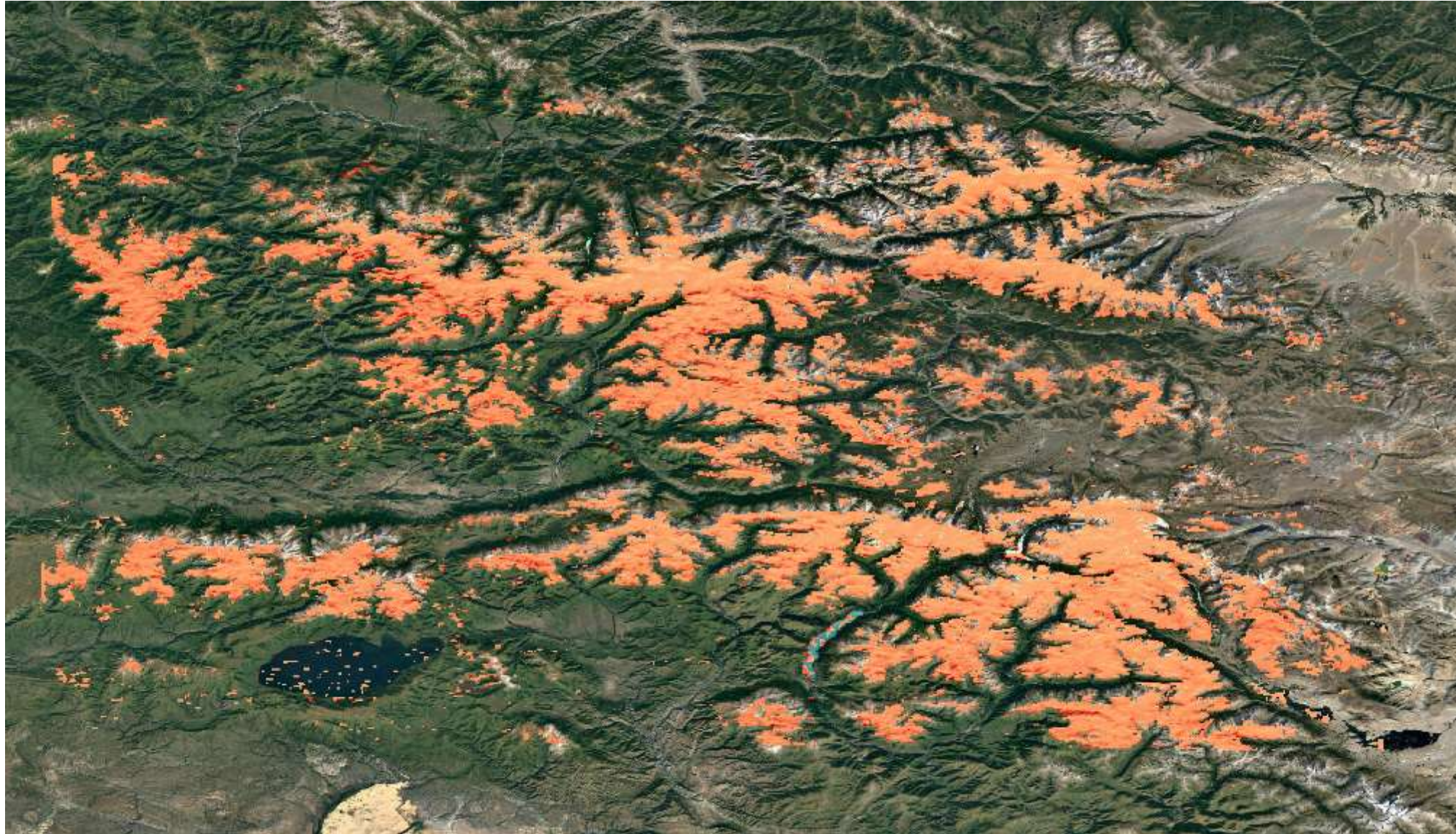


# NDVI Mean for 2012



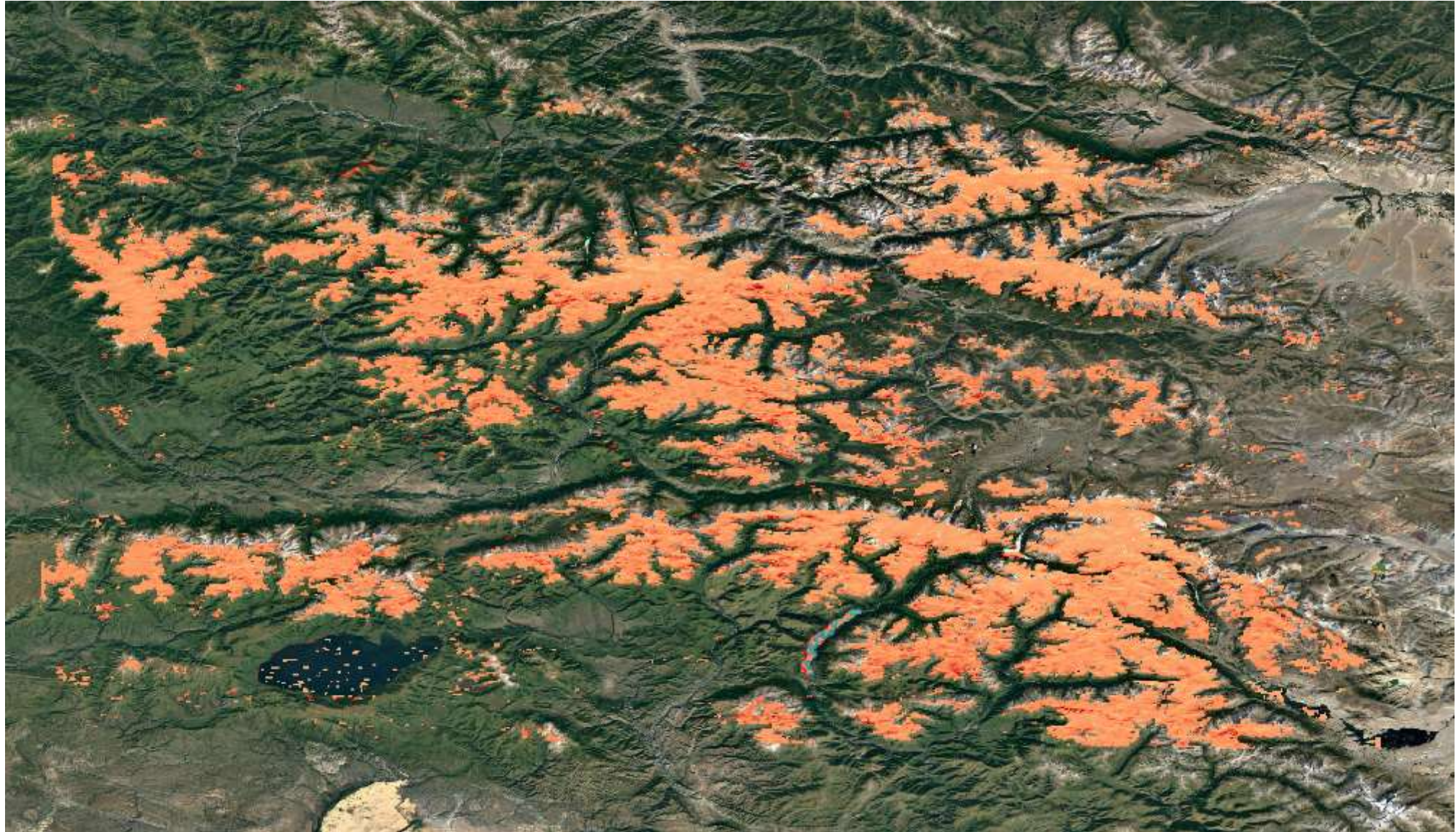


# NDVI Mean for 2013



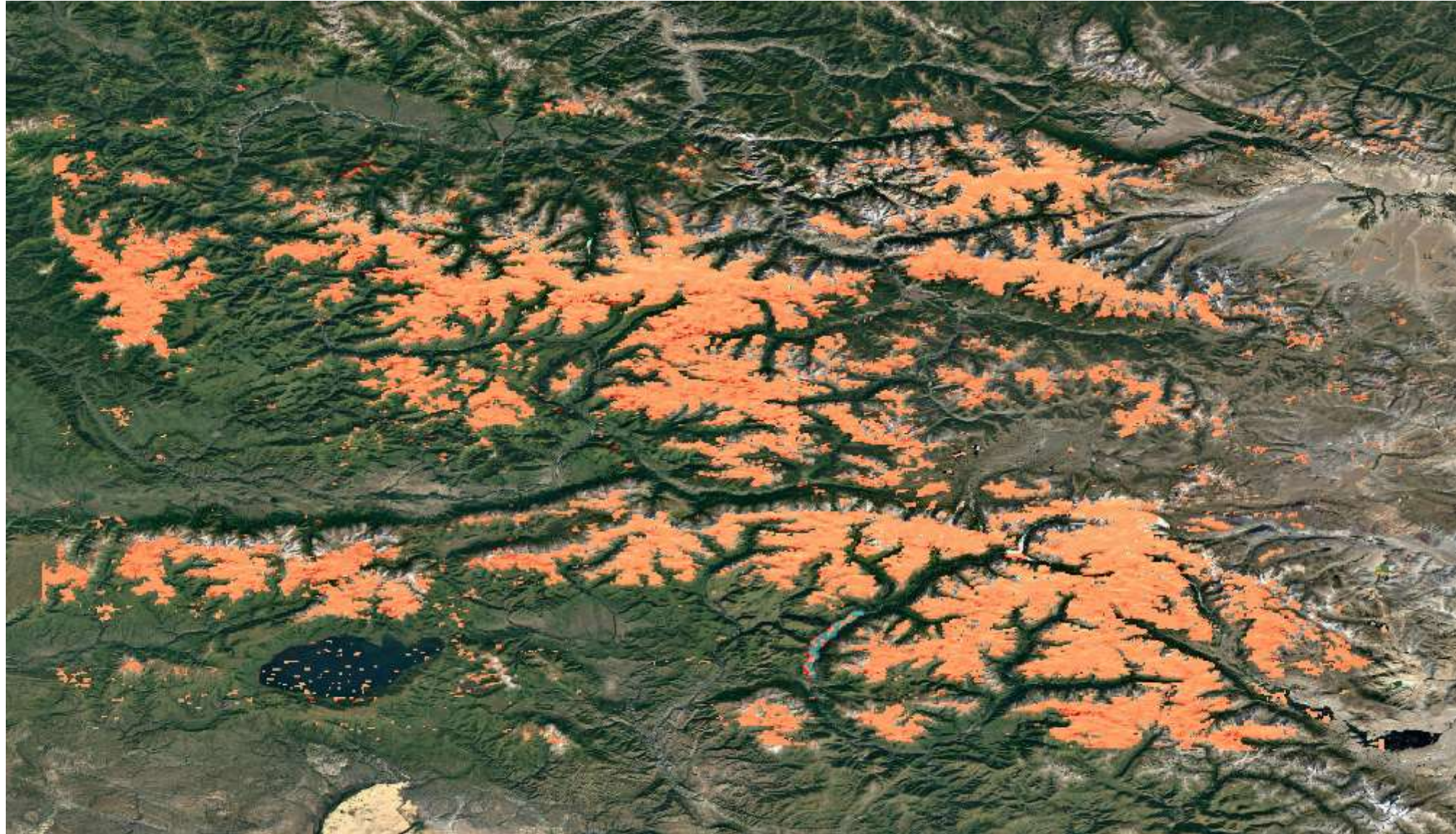


# NDVI Mean for 2014



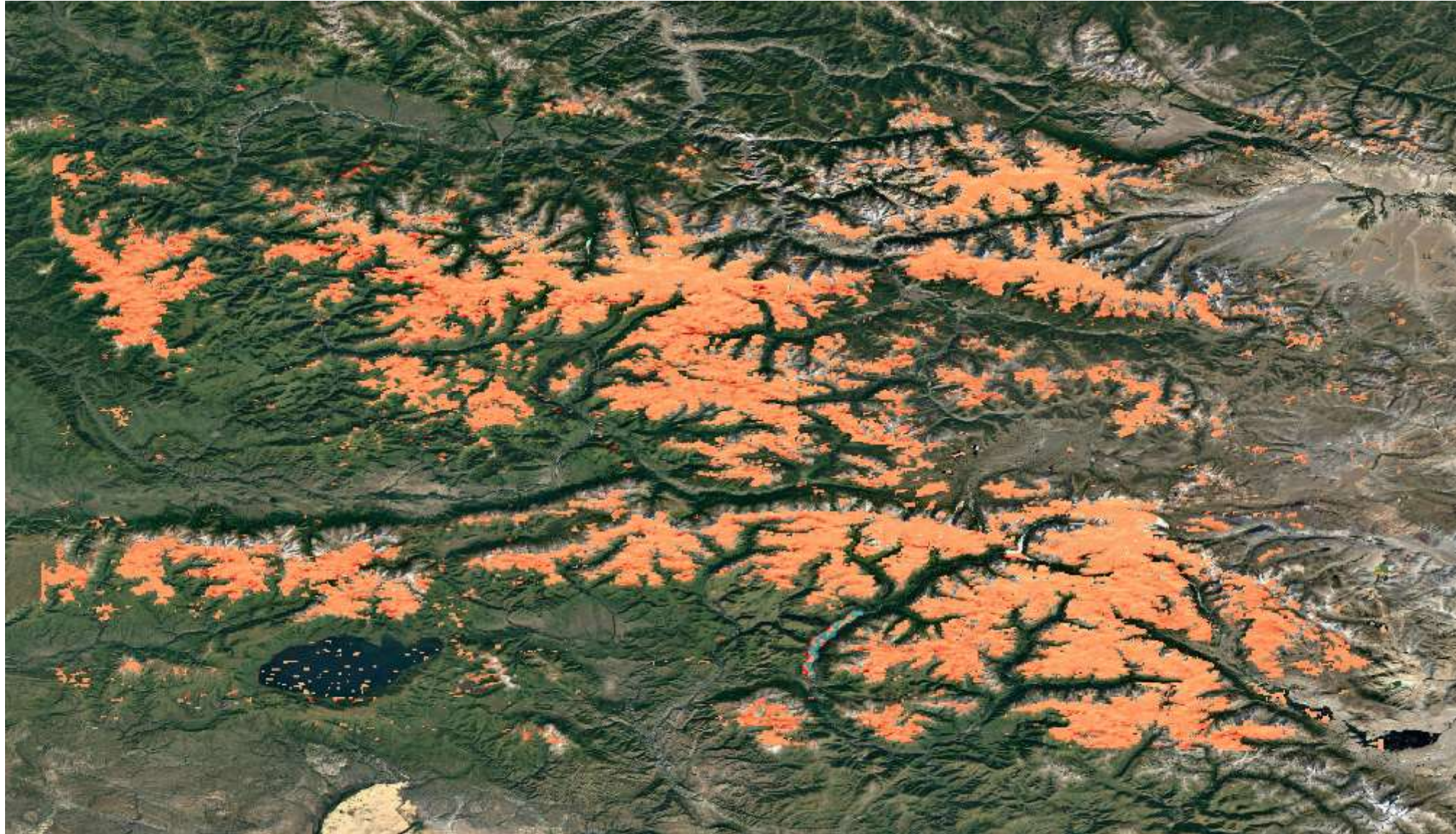


# NDVI Mean for 2015



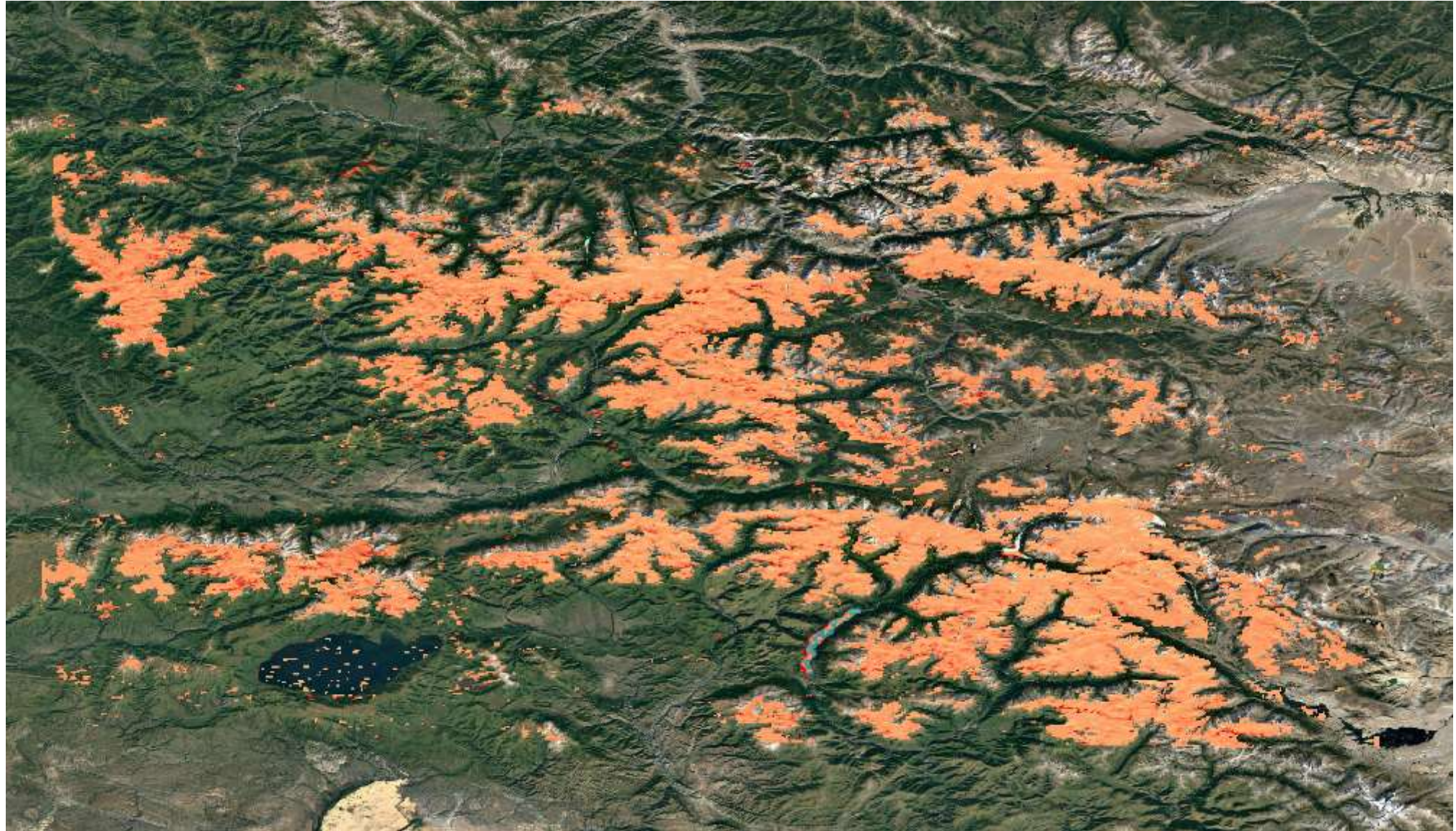


# NDVI Mean for 2016



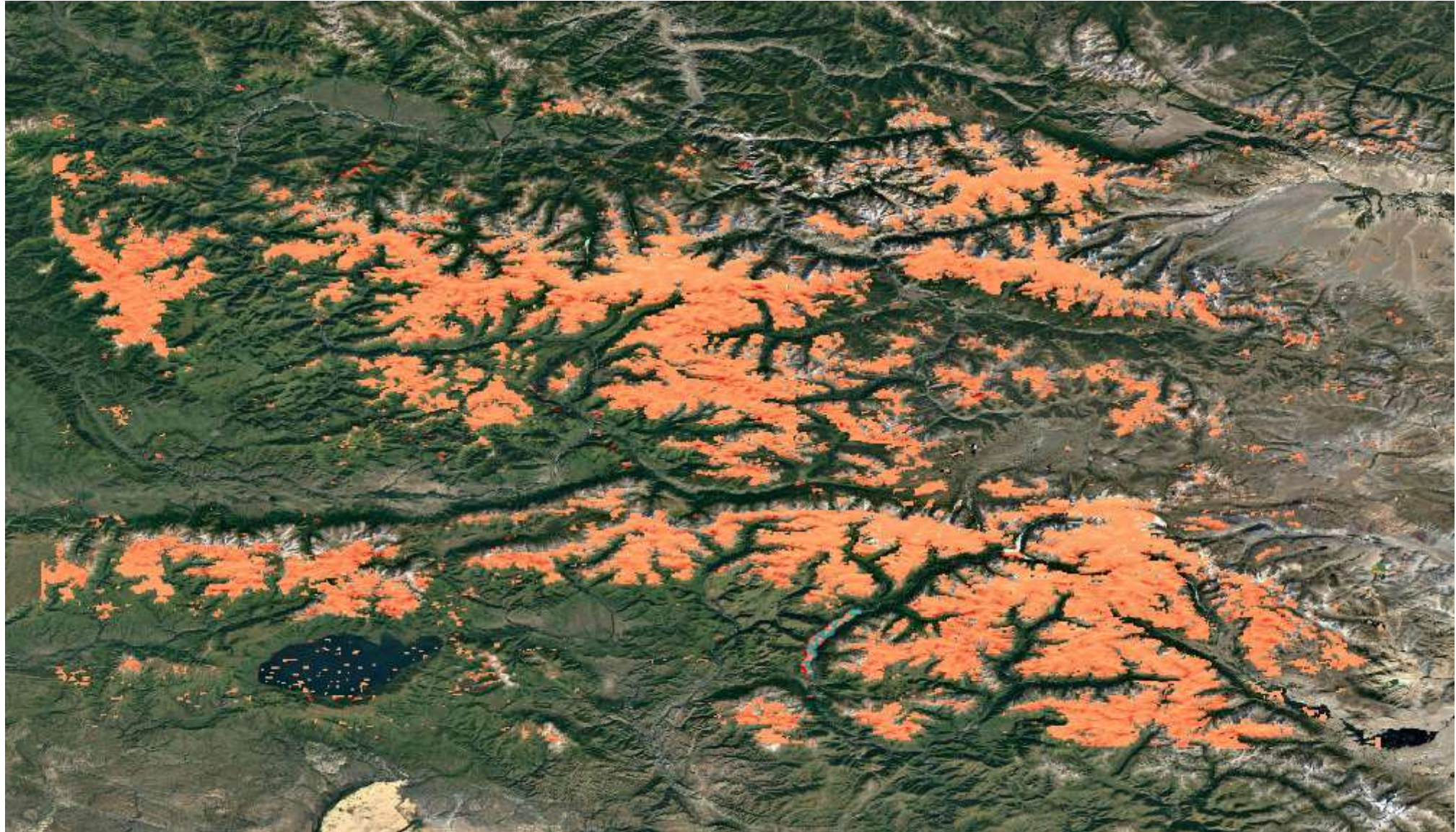


# NDVI Mean for 2017



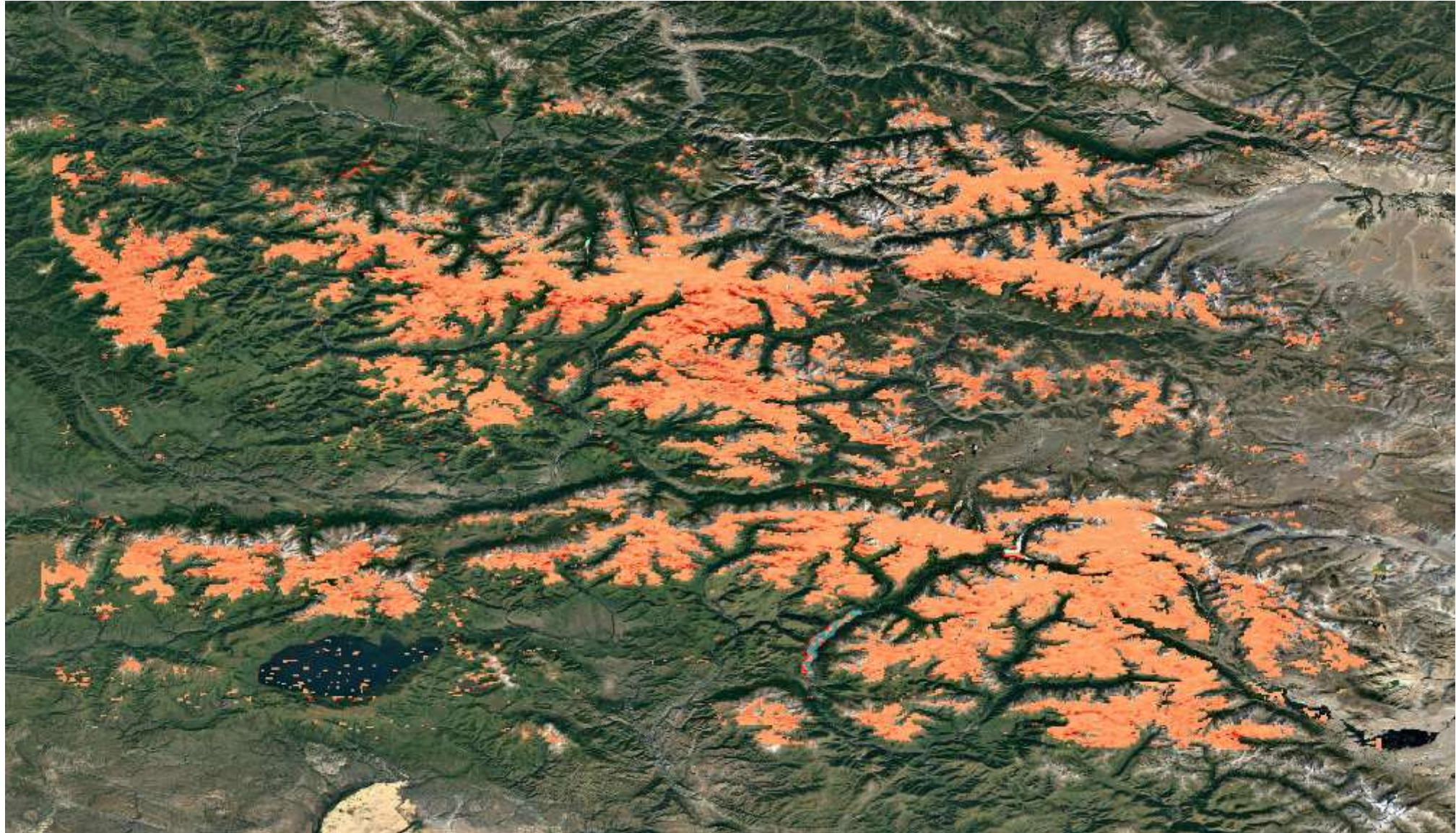


# NDVI Mean for 2018





# NDVI Mean for 2019





# Analysis

- NDVI seems to have correlation with SNOW.
- Years with high snow-cover area have lower NDVI magnitude (2005, 2013, 2018).