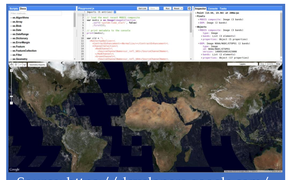
Utilizing Google Earth Engine to Retrieve the Devon Ice Cap's Equilibrium Line Altitude

Introduction

- Growing concern over climate change's potential negative environmental consequences
  - E.g. Abnormally high amounts of glacial melt
- Equilibrium line altitude (ELA), the elevation at which snow accumulation = loss, tracks glacial mass balance
  - Limitations in prior methods of ELA retrieval
    - Insufficient geospatial data to observe changes in glacial mass balance over time
    - Time-consuming data processing on the user end
- **We propose using Google Earth Engine to accurately determine the ELA and extent of melt of the Devon Ice Cap with minimal user burden.**

Google Earth Engine (GEE)

- A geospatial platform capable of fast, large-scale analysis and classification of satellite imagery
- Stores petabytes of satellite data in a public archive (updated daily)
  - Includes Sentinel-1, Landsat 8, etc.



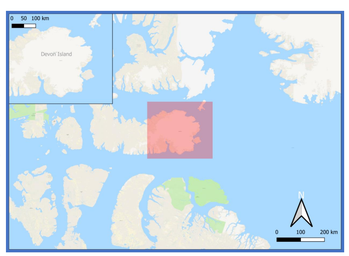
Source: https://developers.google.com/earth-engine/getstarted

Data Processing

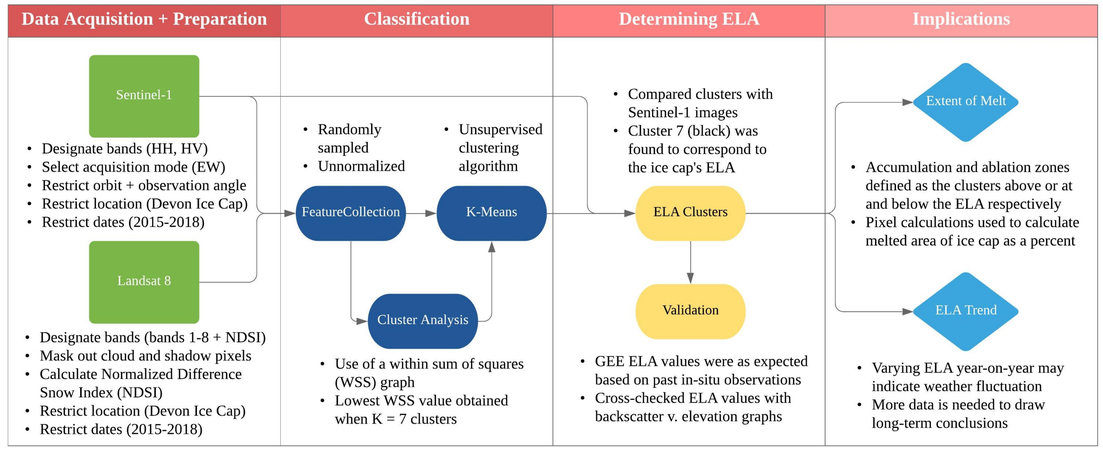
- Processing satellite data on a personal computer is typically very resource intensive
  - Data preparation of unprocessed satellite images dramatically increases file size – Time-consuming
- GEE pre-processes data with their supercomputers
  - No need for data to be downloaded locally
  - Further data restriction (location, orbit path, etc.) can be done through its API

Devon Ice Cap

- Nunavut, Canada
  - High melt levels since the 1960s
- Devon Ice Cap is ideal for case study
  - Location near the poles results in frequent satellite observation
  - Strong negative correlation between ELA and mass balance (r = -0.91)

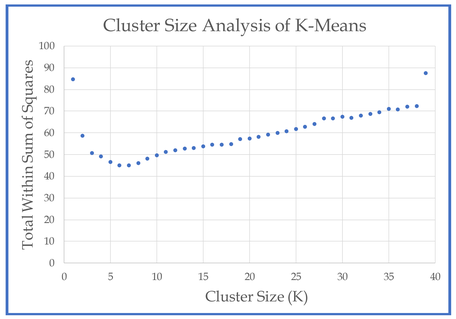


Research Process

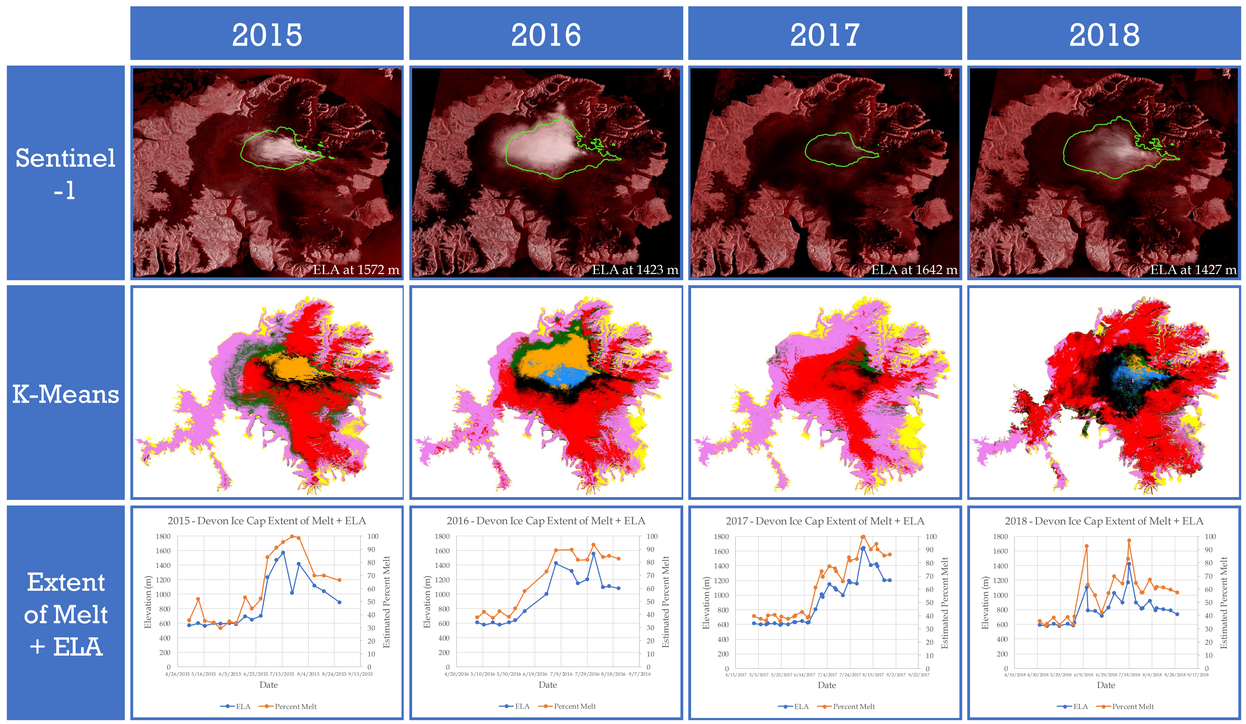


Classification: K-means Clustering

- K-means selects K arbitrary centroids in data
  - Calculates distance between each data point and the nearest centroid
  - Adjusts centroids iteratively until the distance from the points is minimized
  - Clusters defined as the data points nearest to each centroid
- Number of clusters (K) in our data is optimized when the within sum of squares (WSS) value is minimized
- K = 7 clusters when WSS is lowest



Clusters: 1 2 3 4 5 6 7



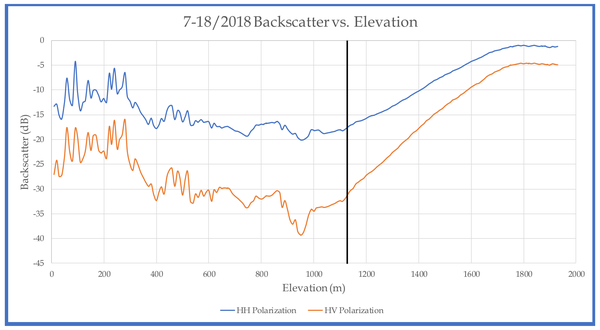
Validation

- ELA values of the ice cap obtained from GEE were compared to on-site ELA values in a previous study
  - GEE ELA values are higher than past annual ELA values (2003-2006)
    - Higher ELA is expected due to summertime vs. annual ELA measurements, climate change, etc.

Mass Balance Year	In-situ ELA (m)
2003	1229
2004	1090
2005	1328
2006	1417

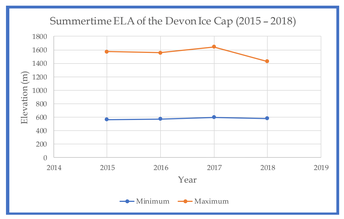
Source: Estimating the equilibrium line of Devon Ice Cap, Nunavut, from RADARSAT-1 ScanSAR wide imagery

- ELA cluster was compared to backscatter v. elevation graphs of the ice cap
  - Backscatter drop approximates ELA elevation
  - Cluster ELAs aligned with the backscatter drops



Conclusion

- GEE, with its access to pre-processed satellite datasets and classification tools, effectively monitors glacial melt
  - Capable of processing terabytes of data in minutes
- ELA + Extent of Melt
  - More data is needed to note long-term trends
  - Extent of melt (%) correlates with ELA



Future Research

- Experimentation with code to improve accuracy
  - Satellite datasets, classification techniques, etc.
  - Account for long-term changing shape of glacier
- Expanding the use of the code to glaciers globally
  - Potential for longitudinal study monitoring glacial change worldwide as more satellite data is acquired
  - Fast processing time makes this more feasible
- Integration with outside products to create a 3D glacial modeling application