GLOBAL ATMOSPHERIC CIRCULATION INFLUENCE ON MELTING MARITIME GLACIERS

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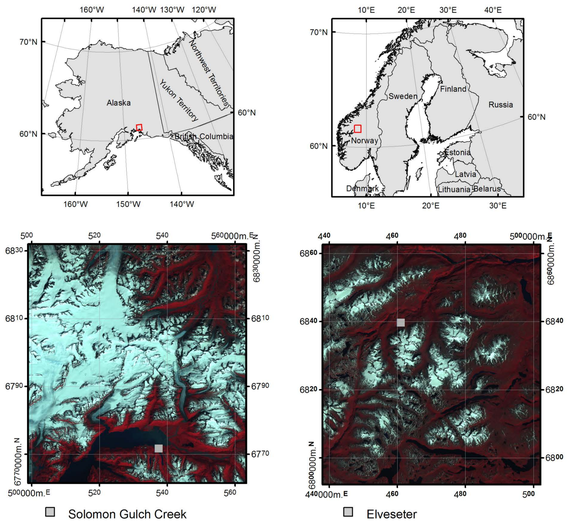
Abstract

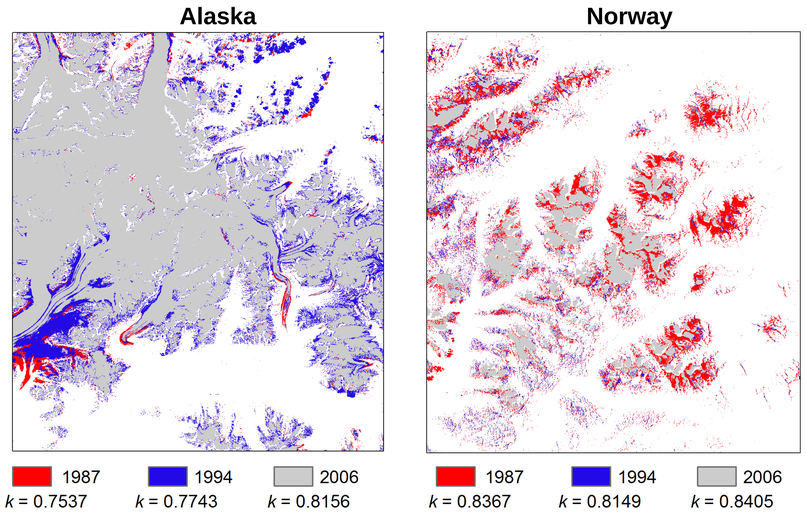
Understanding melting rates of maritime glaciers resulting from global and regional atmospheric circulation patterns requires cost-effective estimates of changes in glacier parameters over different spatio-temporal scales. In this research, we present the results that quantify glacier extents derived from Landsat (TM) imagery in two comparable study areas located in coastal Alaska and Norway over two time periods. The periods that we use are between 1987-1994 and 1994-2006, which are intended to quantify changes in glacier extents resulting from alterations in regional climate and larger-scale El Niño - Southern Oscillation (ENSO) or North Atlantic Oscillation (NAO) events. We analyze the Norway and Alaska glaciers using Landsat and in situ data, and then explore spatio-temporal correlations between these study areas and global data from the NCEP/NCAR Reanalysis, in order to assess the roles that teleconnections play in glacier melt rates in Alaska and Norway. Our analysis includes surface air temperatures, melting rates, and local streamflow rates from the Norway and Alaska study areas, along with global data on sea surface temperatures, sea level pressures, surface air temperatures, precipitation rates, winds, and geopotential heights at multiple pressure levels.

Study Area

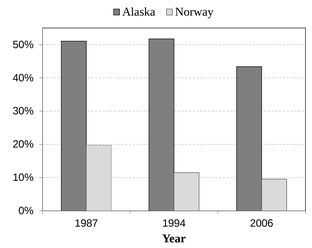
The Alaskan glaciers chosen for this study are in the Chugach Mountains while the Norway glaciers are located in the Jotunheimen high-mountain area in southern Norway.



Glacierized Area Changes



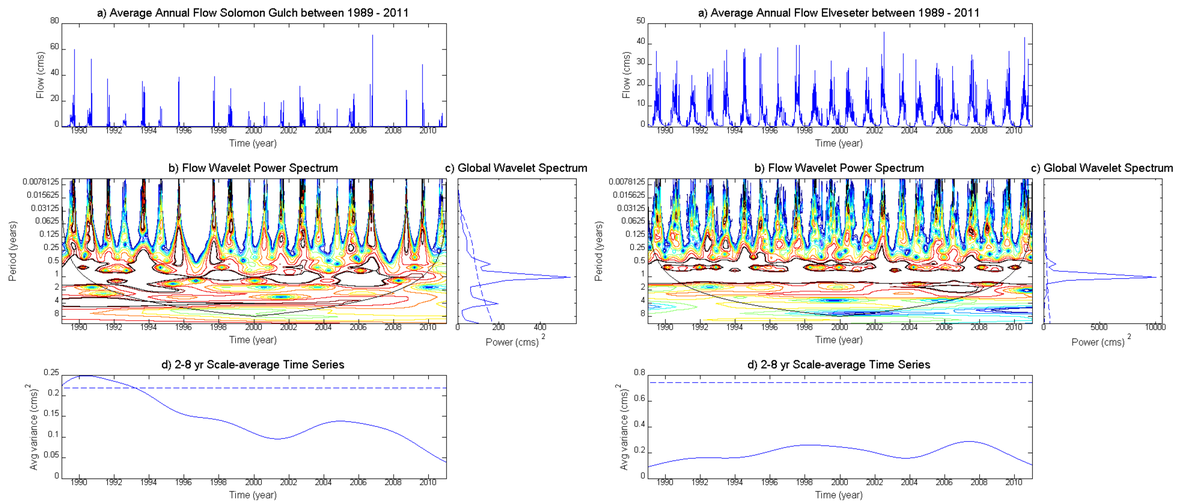
Estimates from Landsat TM imagery suggests that glaciers in Alaska and Norway have retreated with varying recession rates. The change of total glacierized area in Norway is higher which may result from the presence of smaller glaciers that shrank more rapidly while in Alaska the change is more pronounced during ENSO events.



Wavelet Analysis

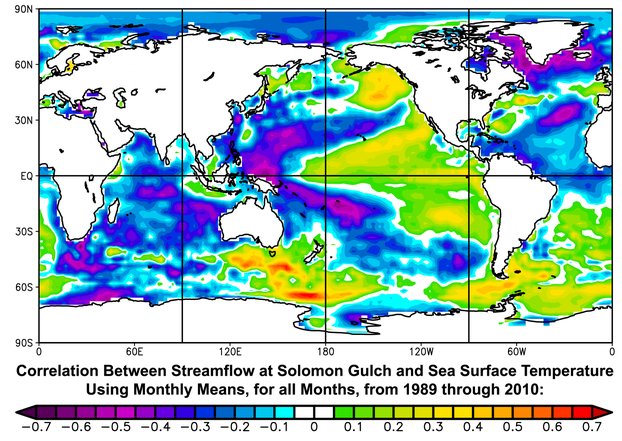
The aim of the wavelet analysis was to analyze a possible teleconnection of ENSO phenomena with long-term streamflow fluctuation measured at Solomon Gulch near Valdez (Alaska) and Elveseter (Norway). Periodic events such as ENSO have significant impacts on streamflows and weather patterns globally and regionally. To investigate such periodicities in river discharge data , continuous wavelet transform (CWT) analysis was used to transform the time series to a time-frequency space for detecting localized and quasi-periodic fluctuations.

The analysis shows that the variation in concentration of power (i.e., significant regions are in red/orange) and global wavelet power spectrum of the time series in Solomon Gulch is characterized by two main frequencies with dominant periods at 0.5 - 2 years and 3 - 7 years which coincided with expected ENSO periodicity. The average variance over all scales between 2 and 8 years shows that streamflow variance was high.

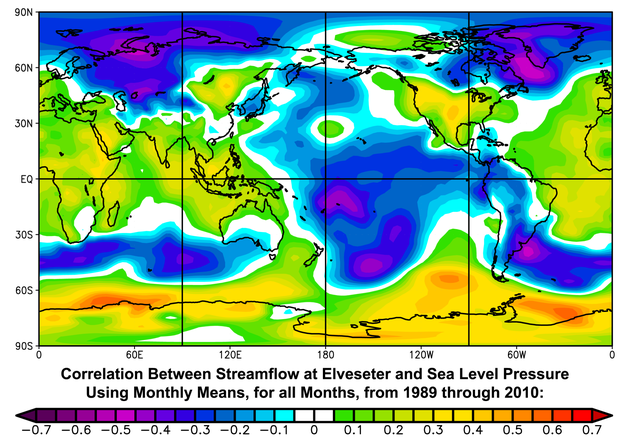


Global Teleconnections

Streamflow at the Solomon Gulch site in Alaska shows a noticeable correlation with the positive phase of ENSO, along with possible teleconnections to other ocean-atmosphere oscillations around the world:



Streamflow at the Elveseter site in Norway shows a noticeable correlation with the positive phase of the North Atlantic Oscillation, along with possible teleconnections to other oscillations around the world:



Results

Results indicate that maritime glacier melt rates in the Alaska study area exhibit a significant correlation with the positive phase of ENSO. The relationships between glaciers in the Norway study site and global patterns are more complex, though some linkages exist between the Norway glaciers and large-scale atmospheric patterns such as the NAO. These findings agree with some patterns explored by previous studies, while also highlighting some new relationships between maritime glacier melt rates and global processes that have important implications for future climate changes and their effects, and thus merit further investigation. Our study also demonstrates the cost-effectiveness of leveraging existing remotely sensed datasets such as from Landsat, in combination with local in situ data and global models, to provide new information about important relationships between the atmosphere and cryosphere.