M196B

Updated Climate Divisions for Alaska

Peter A. Bieniek[1], Uma S. Bhatt[1], Richard L. Thoman[2], Heather Angeloff[1], James Partain[2], John Papineau[2], Frederick Fritsch[2], Eric Holloway[2], John E. Walsh[3], Chris Daly[4], Martha Shulski[5], Garry Hufford[2], David F. Hill[4], Stavros Calos[4], and Rudiger Gens[1]

[1]Geophysical Institute, UAF, [2]NWS Alaska, NOAA, [3]International Arctic Research Center, UAF, [4]Oregon State University, [5]High Plains Regional Climate Center, UNL

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Main Results

- 13 climate divisions in Alaska, difficult to draw the lines with sparse stations
- AO, NPI, PNA, PDO and EP/NP have seasonal links with divisional average temperatures
- Useful for seasonal forecasting and many other research applications

Motivation and Background

- Alaska climate regions first drawn by Fitton (1930) (Fitton)
- Divisions outlined by Searby (1968) are currently used by the National Climatic Data Center (NCDC)
- Climate regions updated by Shulski and Wendler (2007) (ACRC)
- None are based on primarily objective methods
- Useful for seasonal forecasting and many other research applications

Poster based on Bieniek et al. (2011)

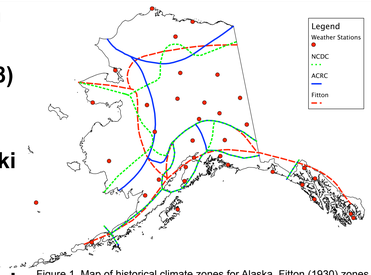

Figure 1. Map of historical climate zones for Alaska. Fitton (1930) zones outlined by red dashed, National Climate Data Center (NCDC) climate divisions green dashed, and the Alaska Climate Research Center (ACRC) climate regions solid blue lines, respectively. The stations used in the cluster analysis are shown by red dots. The climate zones have undergone only minor revisions since their inception, and are mainly drawn over major terrain features.

Data and Methodology

Station temperature and precipitation obtained from:

- National Climatic Data Center (NCDC)
- National Weather Service (NWS)
- Environment Canada
- Alaska Climate Research Center

Procedure

Data Processing

- Procedure follows Wolter and Allured (2007)
- 1977-2010 analyzed, had most complete data
- Missing months filled with mean adjusted AVHRR when possible
- 3-month smoothing applied
- Normalized by 3-month period

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Apply Clustering Methods

- Cluster Analysis is a method of grouping data with similar variability
- Three methods selected:
  - Wards
  - Average-Linkage
  - K-Means

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Determine number of clusters

- Check clustering metric for sudden increases in distance with a decreasing number of clusters
- Can be somewhat subjective

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Compare Results

- Compare results of the three clustering methods
- Identify uncertain areas for further consideration

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Evaluation and Validation

- Compare with clustering results of other data sets
  - AVHRR surface temperature
  - NARR surface temperature and precipitation
  - CRU surface temperature and precipitation
- Cross-correlation checks using division averages
- Check climographs of each division for consistent climate types

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Draw division lines

- Manually draw lines around the clustered stations
- Consider natural terrain boundaries and results of the alternate gridded data sets

Clustering identified 13 divisions in Alaska/Canada

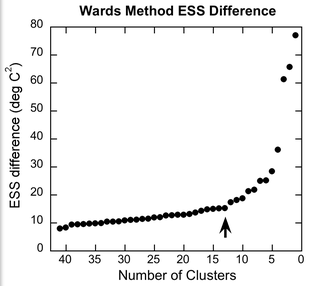


Figure 2. Error Sum of Squares (ESS) difference from step to step as shown in black dots for the Wards method cluster analysis of station temperature for 1977-2010. An arrow marks where the optimal number of clusters was selected for our data (13 clusters).

- **Precipitation found to be too localized/sparse for clustering; temperature used alone**
- The distance between clusters or error sum of squares (ESS) increases faster after 13 clusters are formed
- Stopped at 13 clusters: 11 Alaska, 2 entirely in Canada

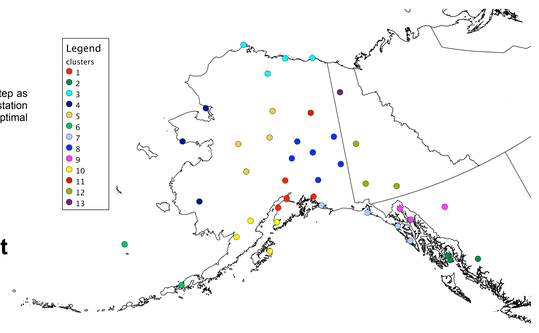


Figure 3. The 13-cluster solution from the Ward's method cluster analysis of station temperature. Dots are color-coded by their cluster membership. There are 11 clusters in Alaska with 2 entirely in Canada. The stations appear to group around major terrain features.

- Three methods had generally consistent results
- Stations appear somewhat clustered about terrain
- Most discrepancies in southeast and south-central coastal stations
- How to draw lines with such sparse data?

Where should the lines be drawn?

- Terrain features appear to have strong influence on the locations of the divisions
- Cross-correlation checks of the station data supported the divisions selected
- CRU, NARR and AVHRR gridded data had uncertainties in their clusterings such that they were of only limited use

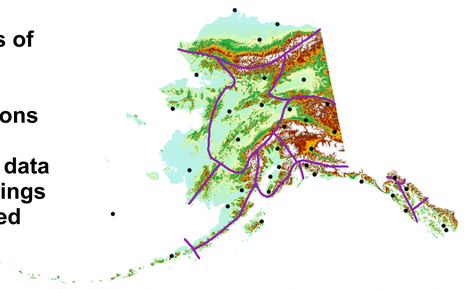


Figure 4. Climate division boundaries drawn over Alaska topography. Black dots show the locations of the Alaska stations used in the cluster analysis. Human expert analysis was necessary to draw these lines, as no effective objective method could be found due to the sparse station network available for clustering.

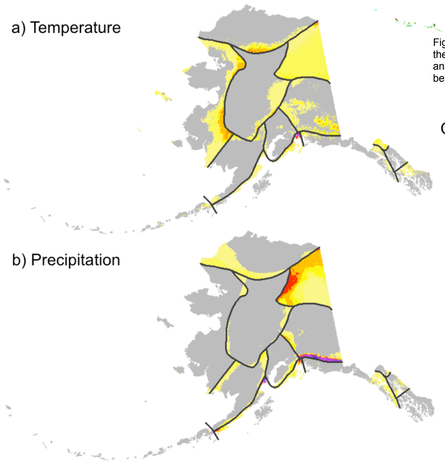
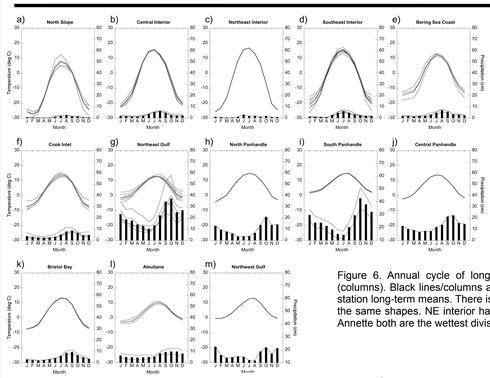


Figure 5. Counts of when a point was correlated higher with another division average than its own for (a) temperature and (b) precipitation. Higher counts indicate that multiple division averages had higher correlations than when the point was correlated with its own division average. Most areas correlate best with their own divisions.

- Boundaries tested using downscaled temperature and precipitation (Hill and Calos, 2011)
- Division average station temperature and precipitation correlated with each point
- Counts > 0 indicate pixels that correlated higher with divisions other than their own
- Most areas correlated best with their own division average temperature and precipitation

Climates of the divisions



- Stations within each division have similar climate characteristics
- Little spread in monthly mean temperature and precipitation

Figure 6. Annual cycle of long-term monthly mean temperature (lines) and precipitation (columns). Black lines/columns are the division average and the grey lines are the individual station long-term means. There is little spread within each division and the annual cycles have the same shapes. NE interior has the largest range in temperature and the Southeast coast/ Annette both are the wettest divisions in Alaska.

- Division average temperature have seasonal links with major teleconnections:
  - In the arctic:
    - AO
  - In the N. Pacific:
    - PDO
    - EP/NP
    - NPI
  - With ENSO:
    - PNA
- Links vary by division and season

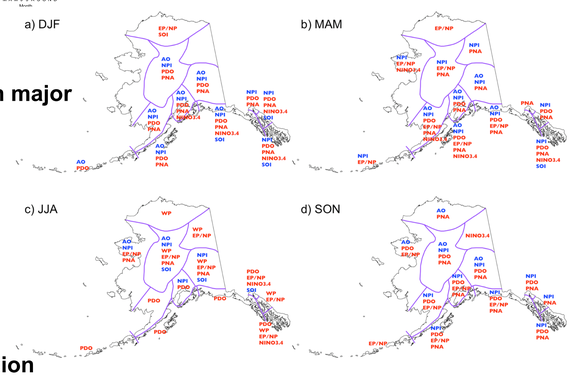


Figure 7. Teleconnection indices that were significantly (95% level or greater based on Student's t-test) correlated with (a) DJF, (b) MAM, (c) JJA, and (d) SON seasonal average temperatures for each division. Positive/negative correlations are shown as red/blue. The most common correlations occur with the AO, NPI, PNA, and PDO.

Summary and Conclusions

- 13 climate divisions in Alaska with terrain as the barriers
- For Alaska, a mix of objective and subjective methods are required to define climate divisions
- Stations within each division had similar climate types/regimes
- A diverse set of teleconnections impacts each division differently in each season
- Climate divisions are useful in many areas of research and forecasting

References

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