1. Title slide
   1. This project is funded by the NSF Navigating the new Arctic
   2. I want to thank all the work from our entire arctic rivers project team and special thanks to Dr. Keith Musselman, Dr. Michael Gooseff, and Dr. Josh Koch
2. Project goals
   1. Many studies focus on how river will change in the future, we wanted to look at how they have already changed in the observational record
   2. This is possible in AK because the observational record is just now long enough to start trend analysis but there is still inherent uncertainty with how long of a record is needed to average out the climate fluctuation
   3. Outside of natural variability, what are the drivers of discharge and how are these drivers changing
   4. We work with an indigenous advisory board on this work, and they are interested in this analysis because they rely on these rivers for subsistence fishing, transportation of goods on ice roads, drinking water, etc
3. Workflow
   1. All our data comes from the USGS stream gages in Alaska. Started with all of them. I removed years that were not 90% complete. Then I removed all gages that did not have 30 years of data that was at least 70% complete overall.
   2. Visualized the data to look at general trends of stations by plotting their average decadal hydrograph and calculated the trends for each year and each time and each record length from 30-60 years.
   3. Ran a plethora of tests on the data to see what change was occurring, testing both high and low flows, timing of discharge, flashiness, recession, etc
4. Data Availability
   1. There were very few stream gages in AK until the 1950s
   2. Many are in remote areas of AK so can go a long time with missing data before they are repaired
   3. But are located where they are still accessible to the USGS, so there is a bias in the location of these gages towards bigger rivers, lower elevations, and larger population centers.
   4. The 10 gages with 60 years of data are all in the southern half of the state because that is where most of the people live
5. Visualize the data
   1. Looking at the data, I plotted the average annual hydrograph for each decade of the station record.
   2. Some patterns start to emerge. Fall and Winter discharge seems to be increasing. Peak discharge may be decreasing but that is harder to tell.
6. Climate Variability Makes Trend Analysis Difficult
   1. To determine how long of a record we should use in our analysis, we took the 10 gages that have 60 years of record and calculated the trends in various metrics for all 30 – 60 year and above record lengths within that time period
   2. This plot shows the average z-score of all 10 gages for 10th percentile of discharge analyzed using the prewhitened mann-kendall trend test.
   3. The z-score can be positive or negative indicating a positive or negative trend. We have not ascribed a significance level yet but anything between -0.95 and 0.95 would not be significant depending on your choice of alpha
   4. Talk about the arrows and bullet points
7. Climate Variability Makes Trend Analysis Difficult (cont)
   1. We home to see a similar color in records above a certain threshold. It doesn’t matter what color we are just looking for stability in the trend.
   2. Here the 30-year record goes from dark blue to light red depending on your start and end years
   3. Above the 40-year threshold looks better with trends at various years being significant positive but there is still some fluctuations
   4. Above 50 years is best but there are only 50 data points here
   5. We did this on many different variables, and it looks like more than 40 years of data is better, but more than 50 years is best.
8. Low Flows Are Increasing Across the State
   1. 10, 25, and 50th percentile flows are increasing at 0.05 significant
   2. The data at which 25% of the flow for the water year is decreasing which means it is getting earlier in the year. This doesn’t usually occur until May but is starting to appear earlier.
   3. Geospatially stations in all areas that are represented are showing increases
   4. Now we began to investigate why these changes occurred.
      1. Low flows for the year occur during the winter period from roughly the start of the water year until spring melt
      2. Correlated with climate indexes from NOAA – no strong correlation
      3. This means that localized climate is more important for stream flow
9. Frozen Period Decreasing Due to Warming
   1. Built using ERA5 data from 1960 to present
      1. High resolution gridded dataset with hourly estimates of temp and precip on 30 km grid
      2. Built from satellite and in-situ data
      3. Each dataset was clipped to the contributing watershed to the gage and averaged the correlated to discharge
   2. Describe results.
      1. Show that mean temperature is increasing, and the date of thaw is getting earlier
      2. Starting to see later freeze-up too
      3. Less days of freezing because of variability in shoulder seasons and warmer winter temps
10. Winter Discharge is Highly Temperature Dependent
    1. Describe axis
    2. This shows that winter discharge is more dependent on temperature than precipitation while annual is dependent on both temp and precip.
       1. When temperatures are higher in the winter discharge is higher
    3. Thinking back to the last slide, warmer winter temps and shorter winter season will increase annual lows flows or winter discharge
11. Warm Winter Temperatures Increasing Days Above Freezing
    1. Winter temperatures has increased an average of 4.5C since 1950s
    2. Now there are 2 days above freezing during winter when historically there was on average none
    3. Losing over a day of frozen season per year
12. Conclusions
    1. Expand on what is on the slide
    2. Larger context: With increasing winter temperature and higher winter discharge. River ice becomes more unstable. This causes issues for the transportation of goods and services between areas of Alaska.