T154B

Large-Scale Climate Controls of Interior Alaska River Ice Breakup

Peter A. Bieniek[1], Uma S. Bhatt[1], Larry A. Rundquist[2], Scott D. Lindsey[2], Xiangdong Zhang[3] and Richard L. Thoman[4]

[1]Geophysical Institute, University of Alaska Fairbanks, [2]Alaska-Pacific River Forecast Center, NOAA, [3]International Arctic Research Center, University of Alaska Fairbanks, [4]National Weather Service Fairbanks, NOAA

WCRP Open Science Conference, Denver, CO, October 24-28, 2011

C17. Hydrological Cycle in Cold Regions, Including Permafrost, Ice Sheets and Glaciers, 10:30am, Oct. 25

Main Results

- April-May temperature is the key control of Alaska breakup
- Breakup is related to December-January and April-May Pacific ENSO-like pattern
- Breakup occurs earlier when April-May is warm, a consequence of less clouds due to less Gulf of Alaska storms

Motivation and Background

- Due to lack of roads transportation depends on rivers in many areas of Alaska
- During breakup travel on rivers becomes impossible
- How is Alaska breakup influenced by the climate?

- *Poster based on Bieniek et al. (2011)*

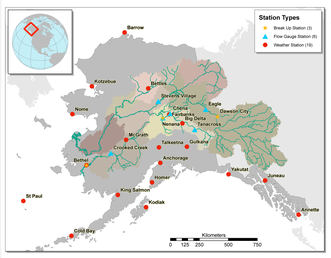
Methods and Climate Data

- NCEP/NCAR Reanalysis I gridded sea level pressure (SLP) and 500-hPa Height http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.html
- NOAA Extended sea surface temperature (SST) http://www.esrl.noaa.gov/psd/data/gridded/data.noaa.ersst.html
- CRU TS3.0 gridded surface air temperature (SAT) http://www.cru.uea.ac.uk/cru/data/hrg.htm
- Station Observation Data http://www.ncdc.noaa.gov/oa/ncdc.html
- Storm track data (Zhang et. al. 2004)
- Regression analysis using seasonal average: December-March (DJFM) April-May (AM) gridded and station data.
- Regression plots: 95% or greater significance shaded.
- Results scaled by -1 to reflect early breakup anomalies

Key:
NCAR: National Center for Atmospheric Research
NCEP: National Centers for Environmental Prediction
ENSO: El Niño Southern Oscillation
PNA: Pacific North American Pattern

AM: April-May seasonal average
DJFM: December-March seasonal average
GOA: Gulf of Alaska

Interior Alaska Breakup is Happening Earlier



- Breakup date and river ice thickness obtained from the Alaska Pacific River Forecast Center website: http://aprfc.arh.noaa.gov/data/breakup.php
- Discharge data obtained from the U.S. Geological Survey website: http://waterdata.usgs.gov/nwis/sw

Figure 1. Map of Alaska identifying locations of river breakup (gold stars), river discharge (blue triangles), and first order climate station (red circles) data.

- Breakup is the time when ice has been broken apart and begins flowing
- Tends to occur in April/ May
- Trend of 1.3 days per decade to earlier breakup
- Breakup displays low frequency variability
- The breakup stations display similar variability
  - Averaged together

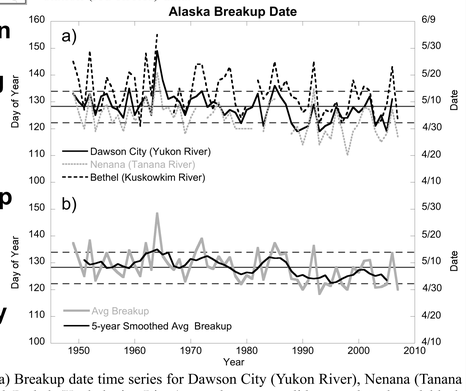


Figure 2. (a) Breakup date time series for Dawson City (Yukon River), Nenana (Tanana River), and Bethel (Kuskokwim River) are shown as solid, gray dotted, and black dashed lines respectively. (b) The gray line shows the 3-station average, while the 5-year running mean of the station average is shown in black. The horizontal solid and dashed lines show the mean and standard deviation of the average breakup respectively.

Local AM Temperature is Key Control of Breakup

- Significant relationship between AM temperature and breakup
  - Increased spring temperature results in earlier breakup
- Winter conditions not directly correlated with breakup
- Breakup is related to AM discharge
  - Discharge is related to both AM temperature and DJFM precipitation
- AM temperature is the key control of breakup

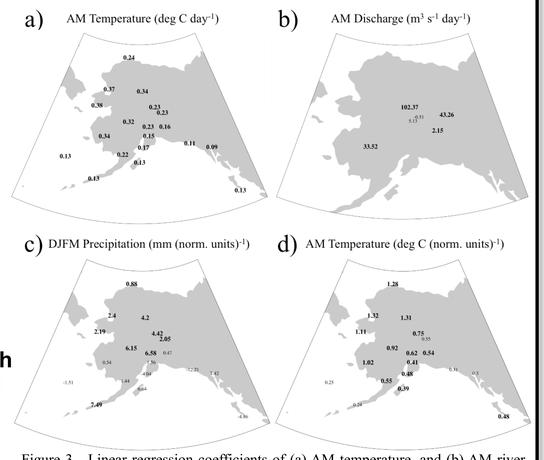
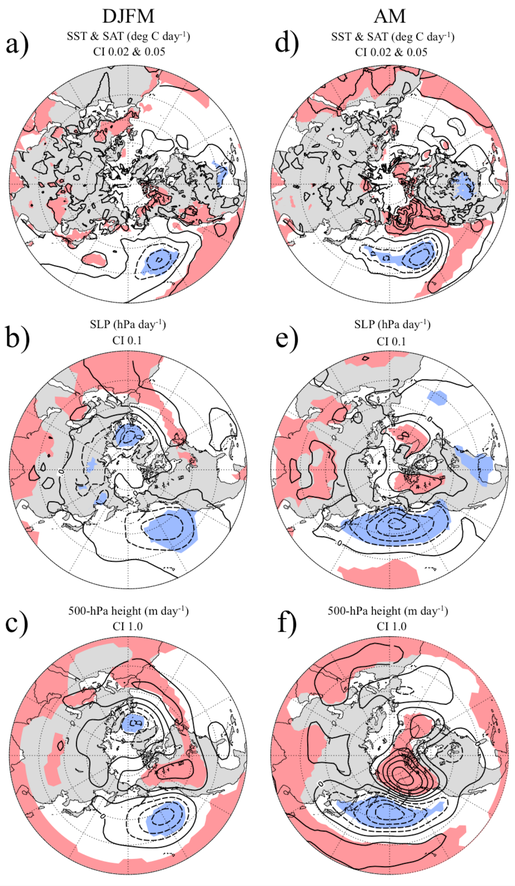


Figure 3. Linear regression coefficients of (a) AM temperature, and (b) AM river discharge on breakup date, and (c) DJFM precipitation and (d) AM temperature on AM river discharge. Regressions significant at the 95% level are shown in bold. Note that (a) and (b) have been scaled by -1.

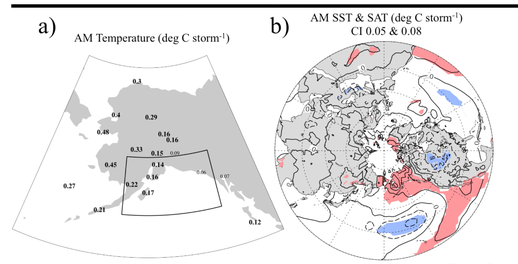
Breakup Related to DJFM/AM Pacific ENSO-like Pattern



- Breakup is related to Pacific ENSO-like SST pattern
  - Occurs in DJFM and AM displaying persistence
- Breakup is also related to a corresponding PNA-like pattern in 500-hPa height (and SLP)
  - Occurs in DJFM and AM
  - Farther west in AM
- No local relationship with SAT in DJFM in agreement with station results
- Strong relationship with AM SAT over Alaska also agreeing with the station results

Figure 4. Linear regression coefficients of DJFM (a) SST/SAT, (b) SLP, (c) 500-hPa Height, and AM (d) SST/SAT, (e) SLP, (f) 500-hPa Height on breakup. Contour intervals (CI) are shown under the titles. Positive (negative) regressions significant greater than the 95% level shaded dark grey (light grey). Note that (a)-(f) have been scaled by -1.

Breakup Linked to AM Gulf of Alaska Storms



- Decreased AM Gulf of Alaska (GOA) storm counts related to increased AM temperature

Figure 5. Linear regression coefficients of AM (a) station temperature, (b) SST/SAT on the AM Gulf of Alaska storm count. Contour intervals shown above plot. Note that (a)-(b) have been scaled by -1.

- AM GOA storms related to Pacific ENSO-like pattern
- AM GOA storms influence AM temperature.
  - Fewer storms during early breakup decrease cloud cover and precipitation
  - Reduced cloud cover increases solar insulation and temperature

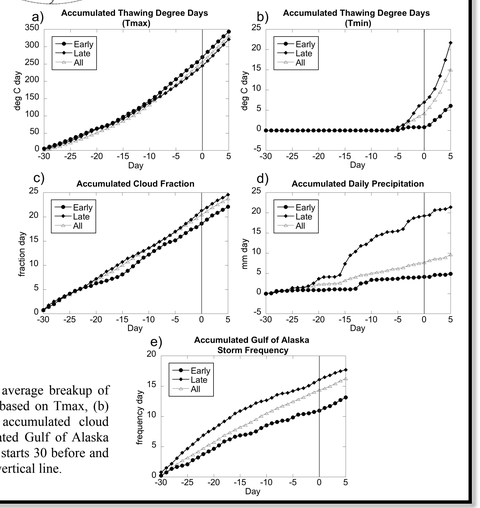


Figure 6. Daily average composites for late, early, and average breakup of Fairbanks observed (a) accumulated thawing degree-day based on Tmax, (b) accumulated thawing degree-day based on Tmin, (c) accumulated cloud fraction, (d) accumulated precipitation, and (e) accumulated Gulf of Alaska daily storm frequency in a moving window. The window starts 30 before and ends 5 days after breakup date. Breakup is marked with a vertical line.

Conclusions

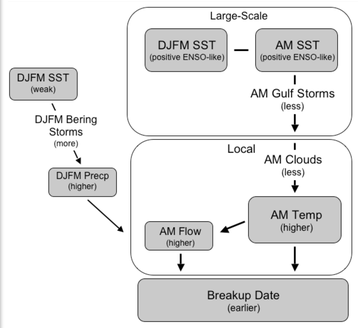


Figure 7. Summary of the breakup-climate mechanism highlighted for early breakup. The primary mechanism is outlined within the boxes, with the secondary weaker mechanism outside. Later breakup can be described by opposite sign anomalies.

- Breakup is related to DJFM/AM Pacific ENSO-like SST pattern at the large scale
- Related strongly to local AM temperature
- Positive ENSO results in decreased storms in the Gulf of Alaska
- Less storms result in less cloudiness, warmer temperatures and earlier breakup
- DJFM Precipitation related to discharge but has smaller influence on breakup

References

- Zhang, X. D., J. E. Walsh, J. Zhang, U. S. Bhatt, and M. Ikeda, 2004: Climatology and interannual variability of arctic cyclone activity: 1948-2002. *J. Climate*, **17,** 2300-2317.
- Bieniek P. A., U. S. Bhatt, L. A. Rundquist, S. D. Lindsey, X. Zhang, and R. L. Thoman, 2011: Large-scale climate controls of Interior Alaska river ice breakup. *J. Climate*, **24**, 286-297.

Acknowledgements

The authors would like to thank B. Moore for providing Figure 1. This research was funded by a University of Alaska Fairbanks graduate fellowship, the Geophysical Institute, and funds from National Science Foundation grant ARC-0652838, and NOAA grant NA06OAR4600179