

Climate Influence on Breakup in Alaska

Presented by

Larry Rundquist

Alaska-Pacific River Forecast Center

Anchorage, Alaska

April 14, 2009

Presentation Outline

- **Who we are**
- **Breakup characteristics**
- **Climate and weather influences**
- **2009 breakup outlook**
- **Discussion and questions**

NWS Alaska-Pacific River Forecast Center (APRFC)

- **Operational office of NOAA's National Weather Service in Anchorage**
- **Responsible for monitoring river conditions throughout Alaska**
- **Generate routine and flood forecasts for many gauged locations through the open water season**
- **Have figuratively and literally watched breakup process for several decades**

Nenana Ice Classic Forecast



$$V_P = V_M + \beta_M B_M (H_M - H_P) + \frac{1}{2} \left\{ \left[\frac{V_L^2 - V_M^2}{2} + g(H_L - H_M) + \beta_M (Q_L - Q_M) \right] \cdot \frac{\Delta t}{\Delta x} - \frac{2 \Delta t g V_M |V_M|}{(1.49/n)^2 R^{4/3}} + q_{LM} \left(\beta_M - \frac{V_M}{A_M} \right) \right\}$$

where $\beta_M = \sqrt{g/A_M B_M}$.

Breakup Process Terms

- Breakup front is the term that is used for the location where moving ice impacts stationary ice
- Breakup process generally moves from upstream to downstream
- The threat of ice jam flooding is greatest during and after passage of the breakup front
- Tributaries can initiate secondary breakup front
- Process can have different characteristics in different parts of the state due to local conditions and weather variability

Breakup Process

Most Breakups are a Blend

Dynamic breakup

- Ice remains hard and resistant to breaking up
- Ice moves when pushed by ice from upstream
- Many ice jams form that cause upstream flooding
- Extreme cases are Kenai River in January 1969 and January 2007

Thermal breakup

- Ice becomes very rotten (candled) before ice from upstream arrives
- Rotten ice is weak and has less resistance to breaking into very small pieces
- No ice jams form
- Extreme case would occur with very little snow melt inflow and warm sunny weather to rot the ice

Breakup Characteristics

Timing



- Have historic quantitative breakup dates
- Breakup date is when breakup front passes village (dynamic breakup)
- Subjective assessment by an observer in village
- Very difficult to assess for thermal breakup
- Ice classic events precise but may not correspond with passage of breakup front

Severity

- Do not have historic quantitative data
- Subjective assessment
- Can be assessed for each village, each river, or entire state
- Dynamic breakups more severe than thermal
- Difficult to quantify
- Lacks historical documentation (e.g. number of ice jams)

Components of Breakup

- **Ice thickness and extent (vehicle)**

- *Vary due to freeze-up timing, temperatures, snow cover*
- *Always sufficient winter ice to cause jams and flooding*

- **Snow cover and water equivalent (engine)**

- *Vary annually & spatially in response to weather patterns*
- *Snow melt runoff increases flow and initiates breakup*
- *Can have big influence on breakup timing and severity*

- **April and May weather pattern (fuel)**

- *Dominates breakup timing and severity by controlling...*
 - *Snowmelt rates*
 - *Thermal conditioning and strength of ice*
 - *Type of breakup (Dynamic vs. Thermal)*

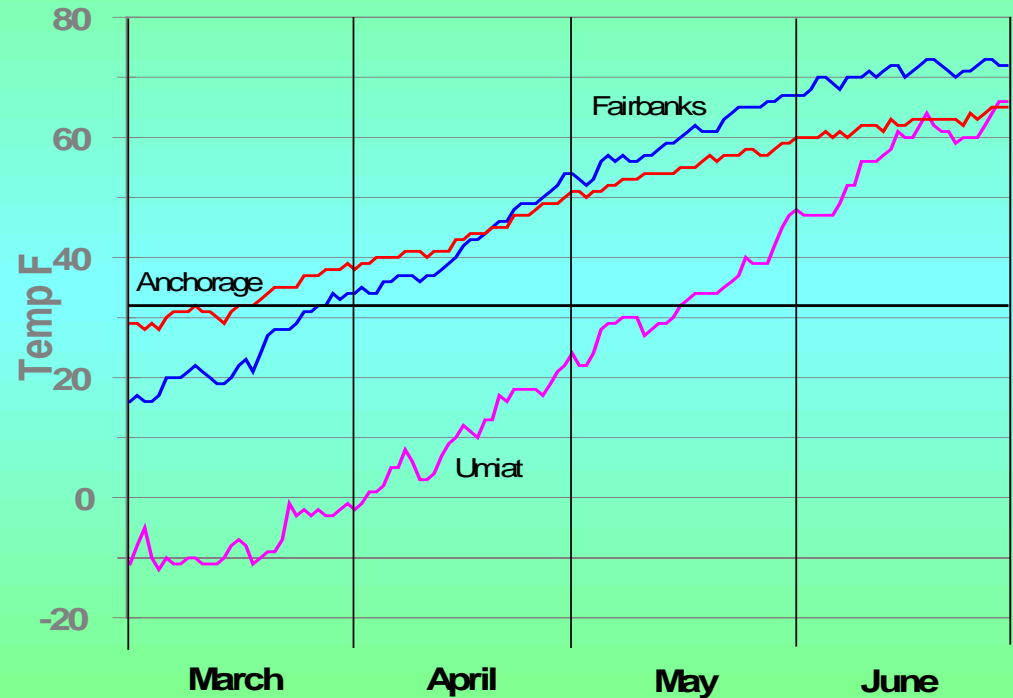
Weather vs Climate

- **According to Rick Thoman in January ACCAP presentation (see presentation for more details):**
 - *Weather – short term state of the atmosphere*
 - *Climate – statistics of weather over periods of decades*
- **Weather variability during the spring season influences the breakup characteristics for that season**
- **Climate variability influences the average characteristics of the breakup process**

Climate Influence on Breakup

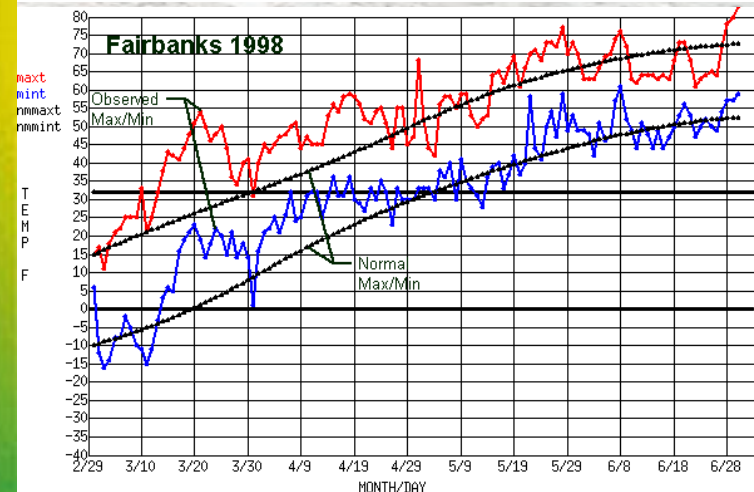
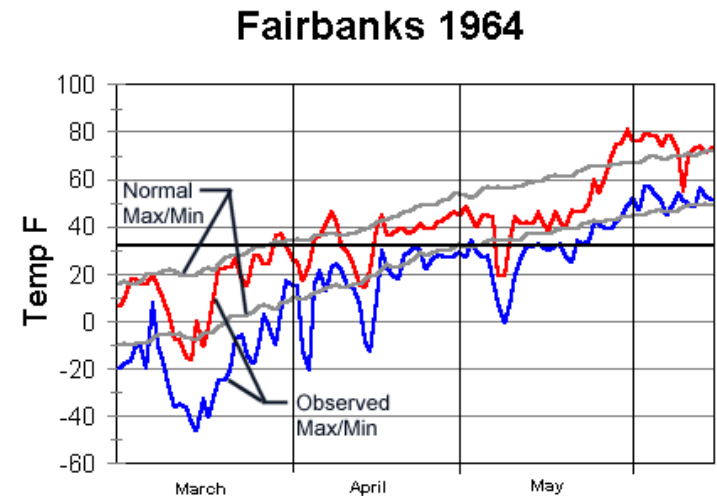
- Climate normals are indicative of average snow melt timing and flood potential
- Steeper temperature increases cause more rapid snow melt
- Rapid melt more likely to cause dynamic breakup

Normal Max Temperature Patterns
As Function of Latitude



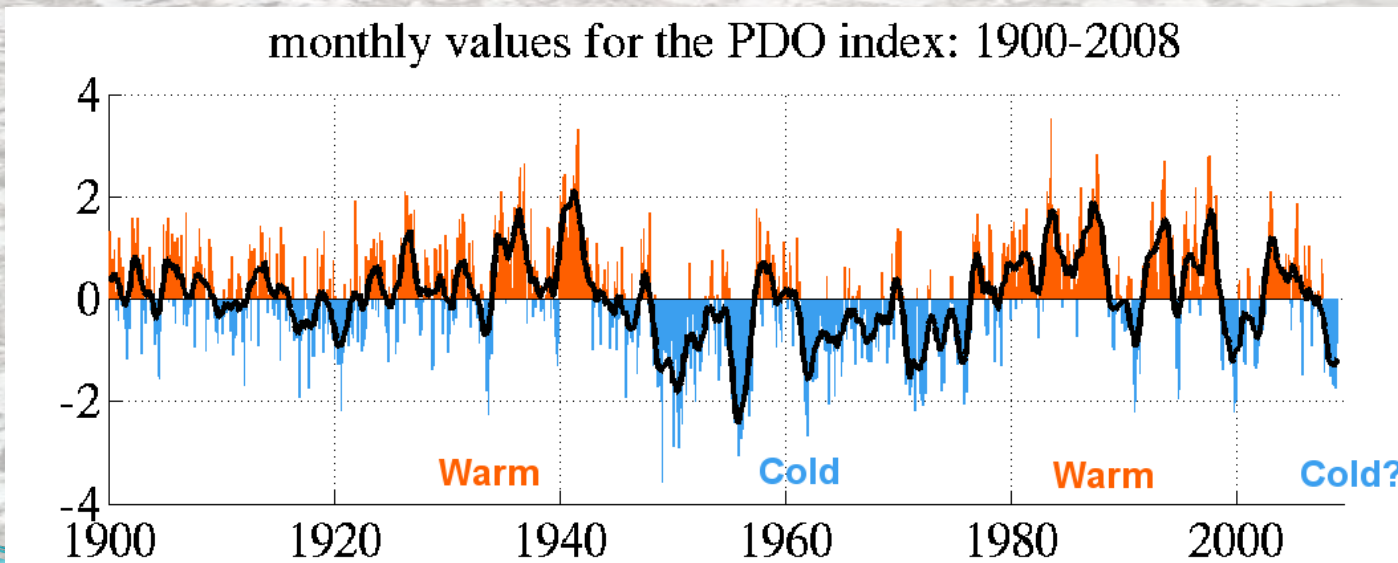
Weather Influence on Breakup

- Weather seldom follows normals
- Weather dictates breakup process
- Cold spring pattern
 - Late warm-up
 - Delayed ice degradation
 - Delayed snow melt
 - Rapid warm-up common
 - Dynamic breakup
- Warm spring pattern
 - Low elevation snow melt
 - Early exposure of ice
 - Less likely for rapid warm-up
 - Thermal breakup



ENSO and PDO Influence

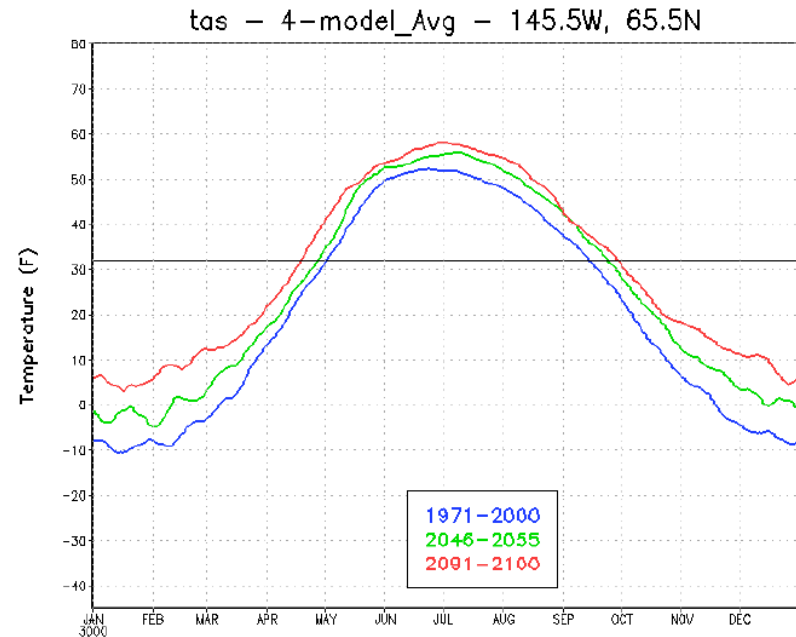
- Subjective assessment indicates possible correlation between PDO and breakup severity
- Limited NWS studies have not found strong correlation between either ENSO or PDO and breakup severity – further research is needed
- A quantitative breakup severity index is needed



Climate Change Influence

- This graphic from the February ACCAP presentation shows modeling results for projected temperatures at Fairbanks
- The shift to an earlier date for the average daily temperature going above freezing supports a February ACCAP result of an earlier average breakup date

Mean seasonal cycle of surface air temperature (Fairbanks grid cell)



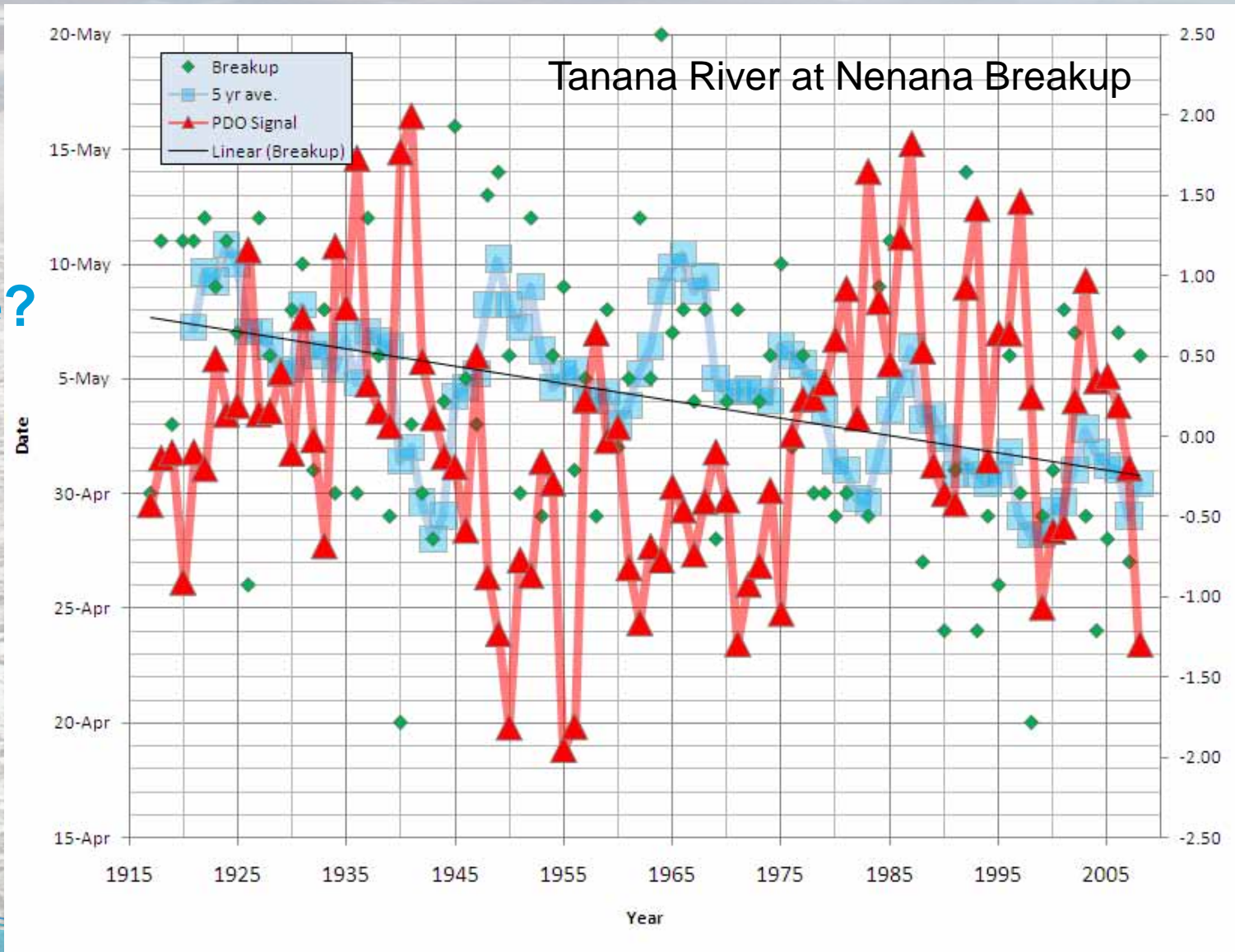
John Walsh¹, Sarah Trainor¹, Gongmei Yu²

¹Alaska Center for Climate Assessment and Policy
University of Alaska, Fairbanks

²Department of Sports, Recreation and Tourism
University of Illinois at Urbana Champaign

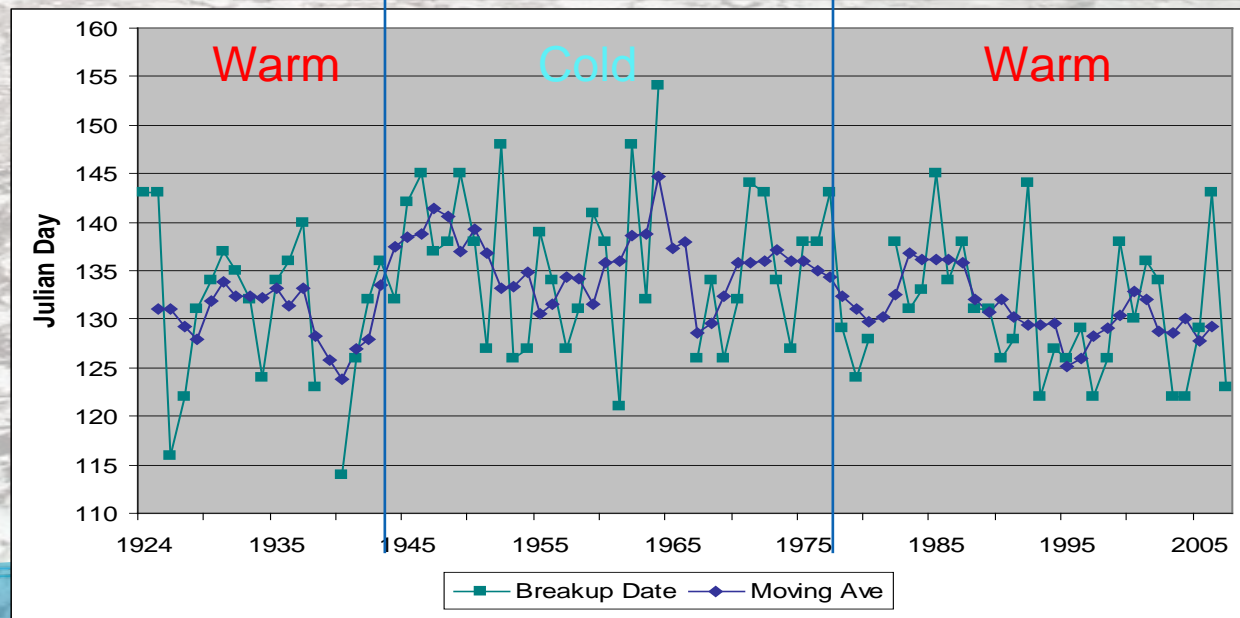
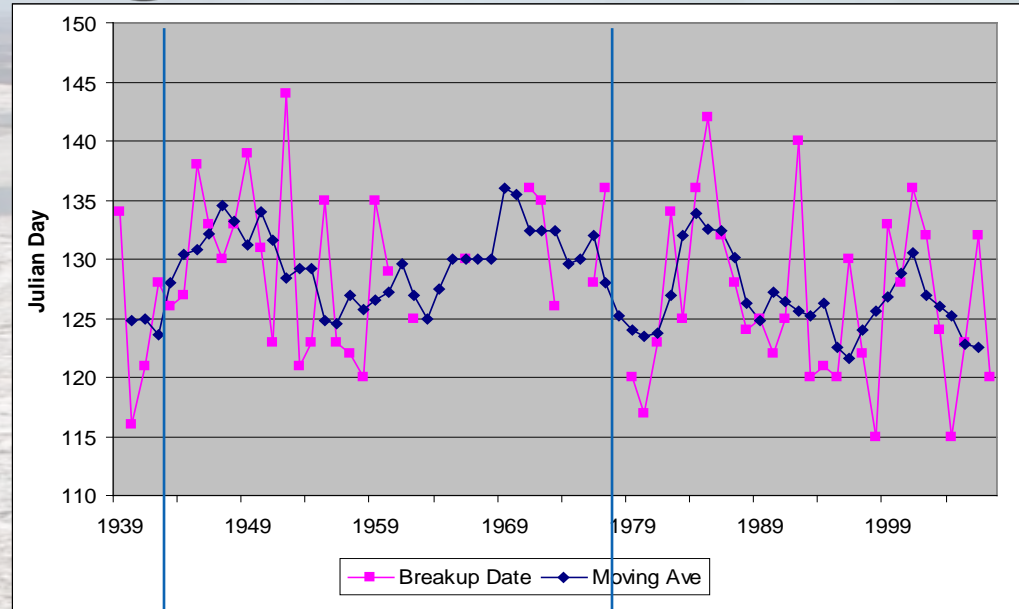
Climate Change Influence

- Climate change?
- PDO influence?
- Both?



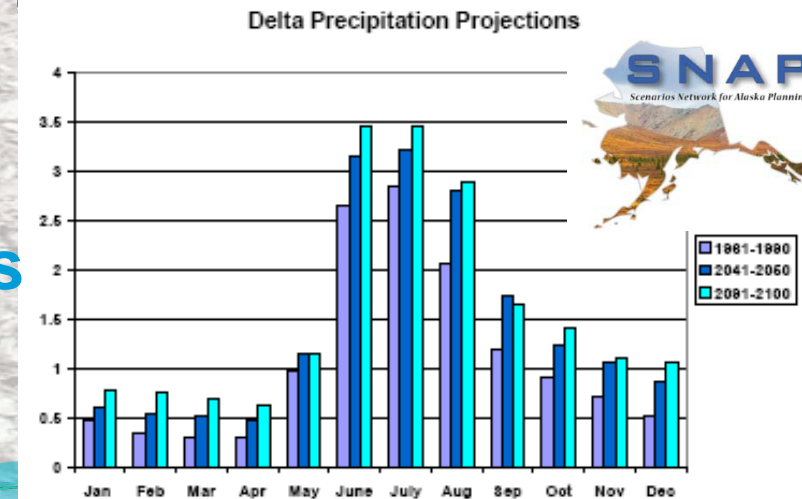
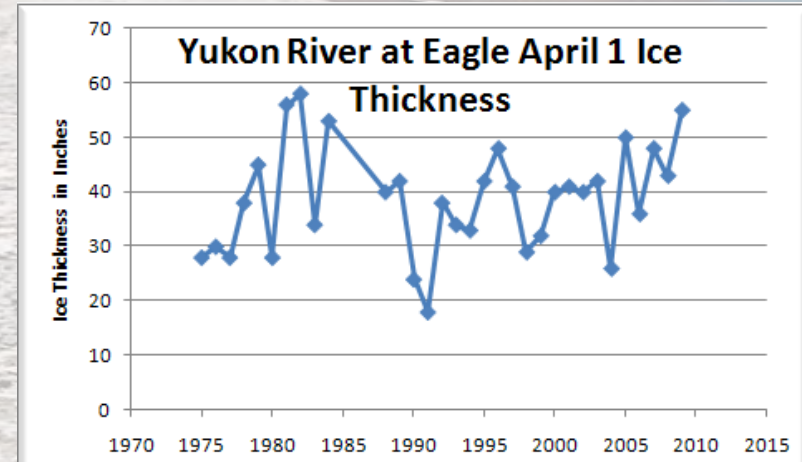
Climate Change Influence

- Breakup date trends
- Kuskokwim at McGrath
- Kuskokwim at Bethel



Climate Change Influence

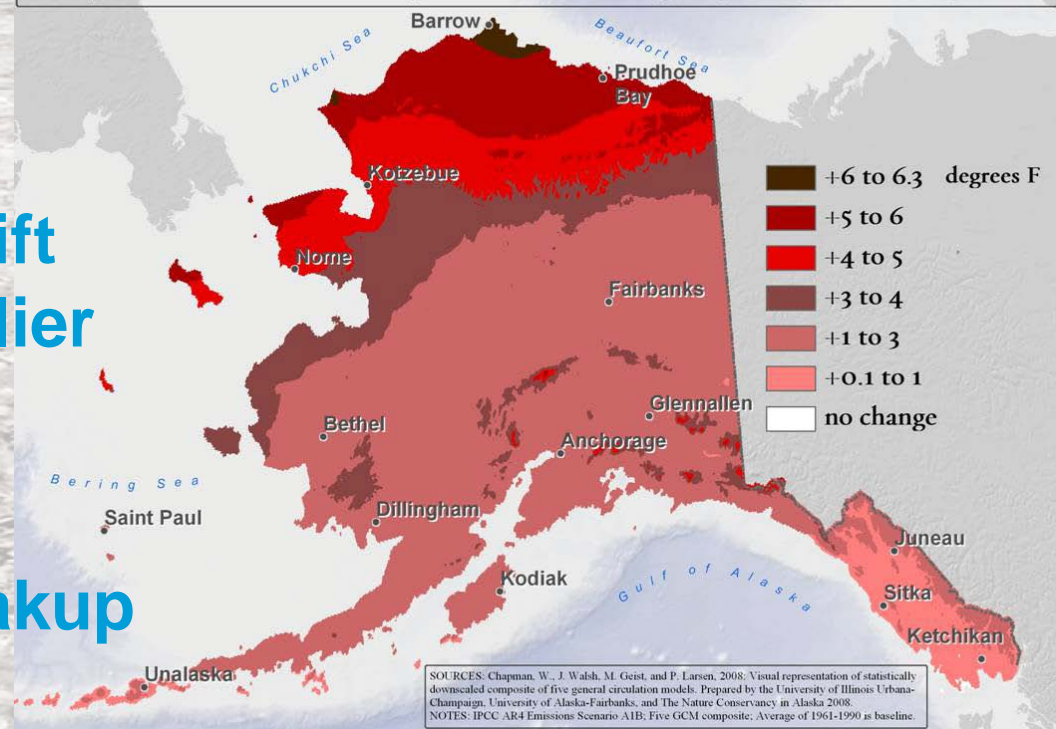
- What impact would a shorter and warmer winter have on the severity of breakup?
- Later freeze up and earlier breakup and warmer winter temperatures should lead to thinner average ice thickness
- Even with a projected increase in precipitation, warmer fall, winter, and spring temperatures should lead to lighter snow pack on average



Climate Change Influence

- Map shows spatial warming pattern
- Larger projected temperature increase in Brooks Range could shift mountain snowmelt earlier
- Larger snowmelt peaks could result
- Possible increased breakup severity for south slope rivers

Projected Annual Temperature Change 1961-90 to 2051-60

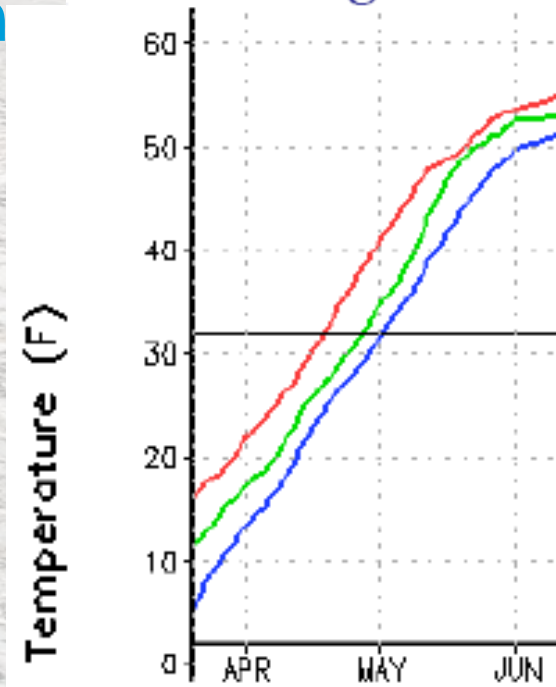


SOURCES: Chapman, W., J. Walsh, M. Geist, and P. Larsen, 2008: Visual representation of statistically downscaled composite of five general circulation models. Prepared by the University of Illinois Urbana-Champaign, University of Alaska-Fairbanks, and The Nature Conservancy in Alaska 2008.
NOTES: IPCC AR4 Emissions Scenario A1B; Five GCM composite; Average of 1961-1990 is baseline.

Climate Change Influence Summary

- Expect a slow trend to thinner ice and less snow
- Even thin ice and light snow pack can cause severe breakups with cold spring weather pattern
- With the average rate of temperature rise in the spring projected to remain the same, the current potential for cold or warm spring weather patterns should continue into the future
- Current range of breakup severity could result

Fairbanks grid cell

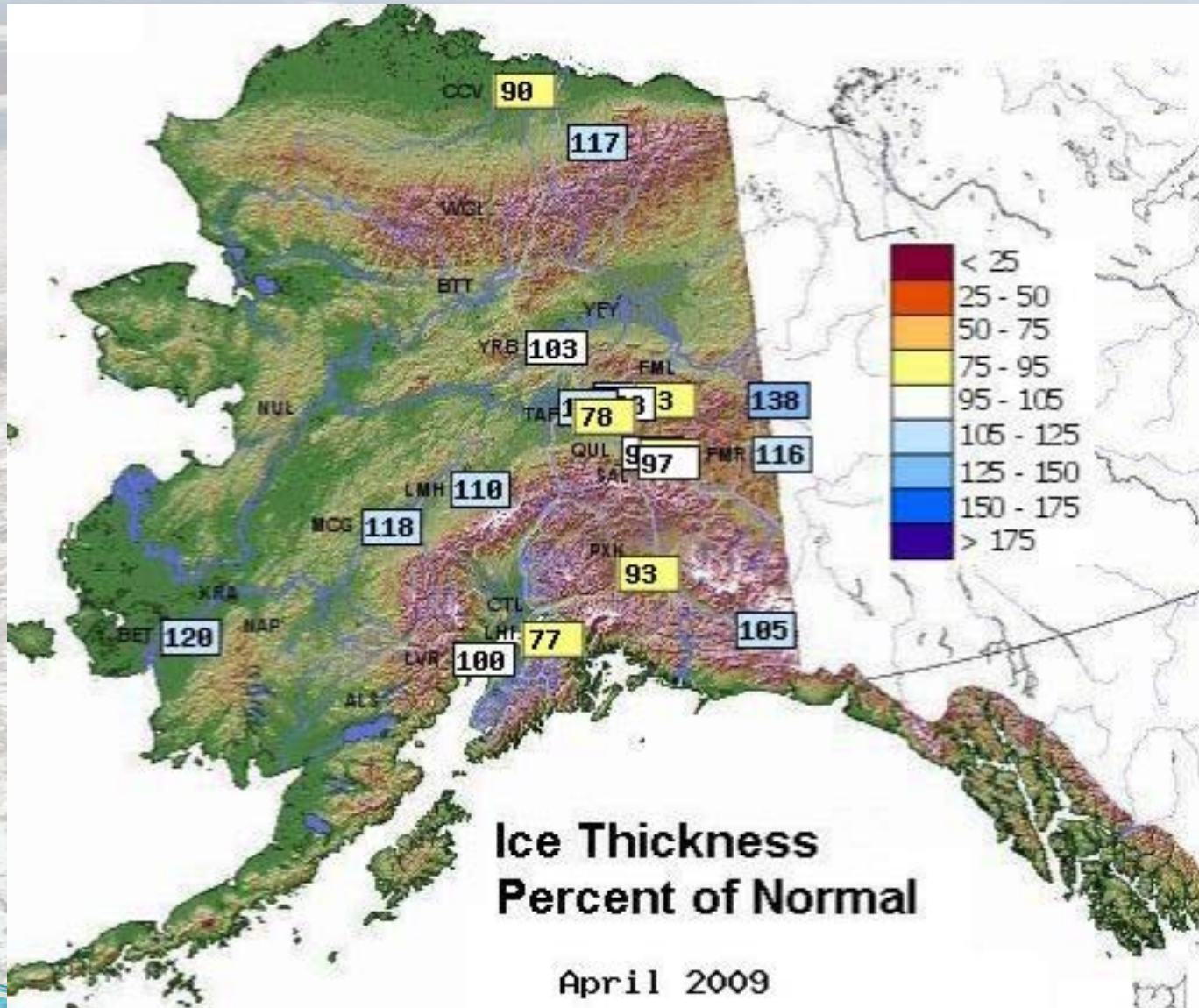


John Walsh¹, Sarah Trainor¹, Gongmei Yu²

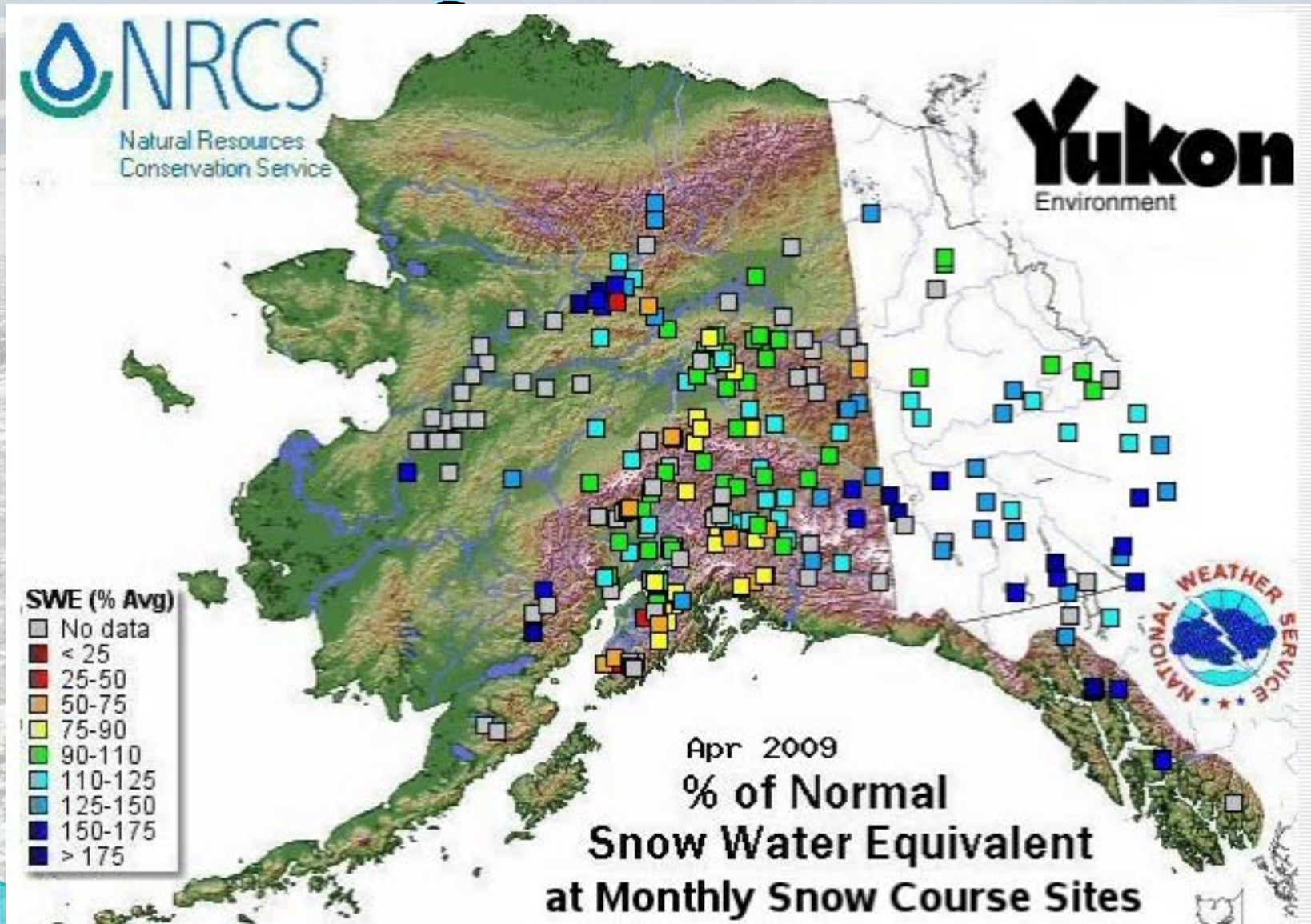
¹Alaska Center for Climate Assessment and Policy
University of Alaska, Fairbanks

²Department of Sports, Recreation and Tourism
University of Illinois at Urbana Champaign

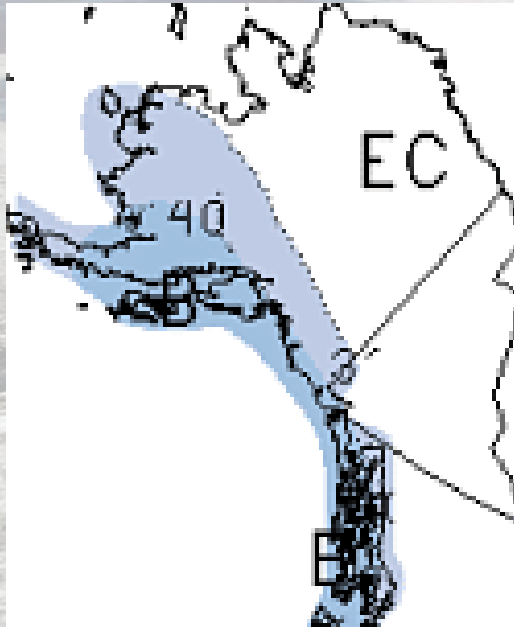
Breakup 2009 Ice Thickness



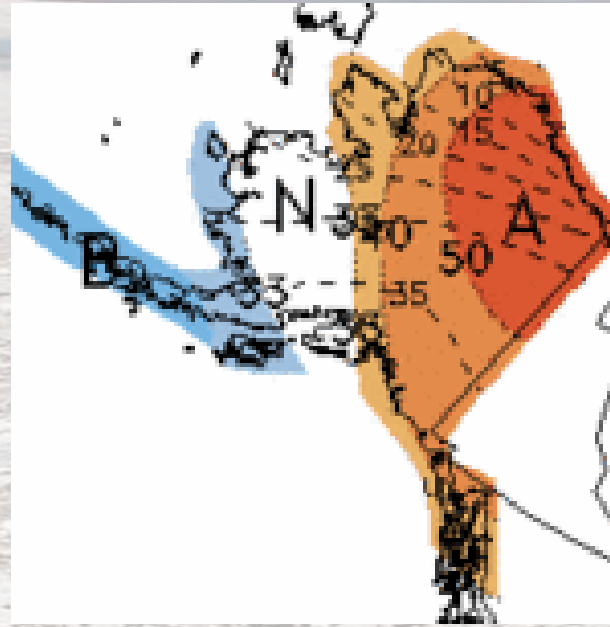
Breakup 2009 Snow Pack



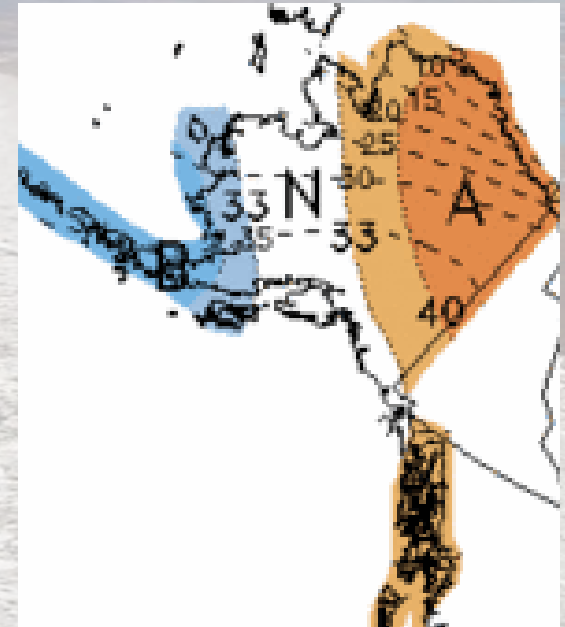
Breakup 2009 Outlook



**One-Month Outlook
Temperature Probability
Made 31 March 2009
Valid April 2009**



**6-10 Day Outlook
Temperature Probability
Made 13 April 2009
Valid April 19 – 23, 2009**



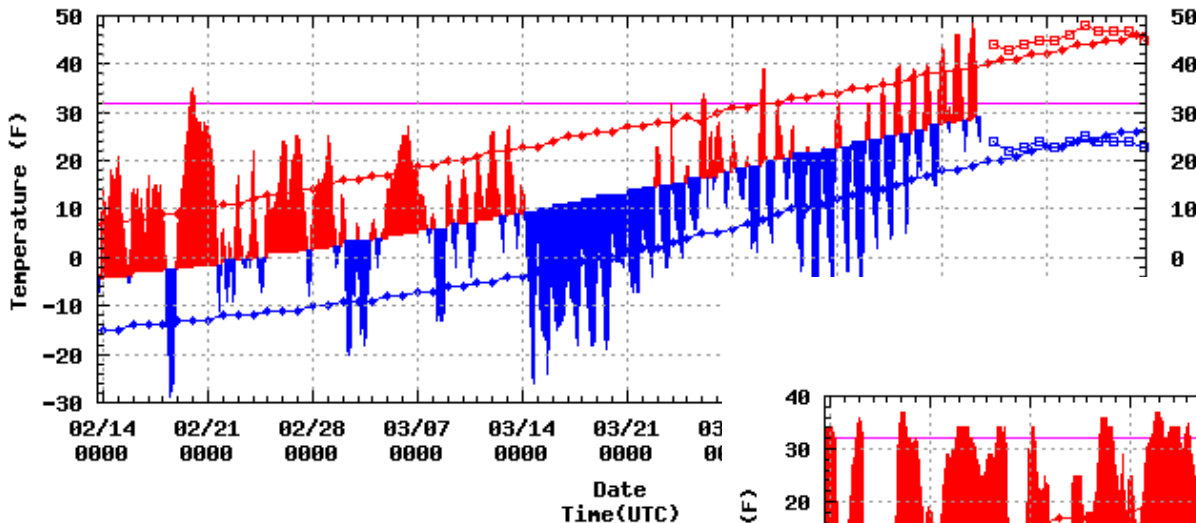
**8-14 Day Outlook
Temperature Probability
Made 13 April 2009
Valid April 21 – 27, 2009**

EC Means Equal Chances for A, N, B
A Means Above
N Means Normal
B Means Below

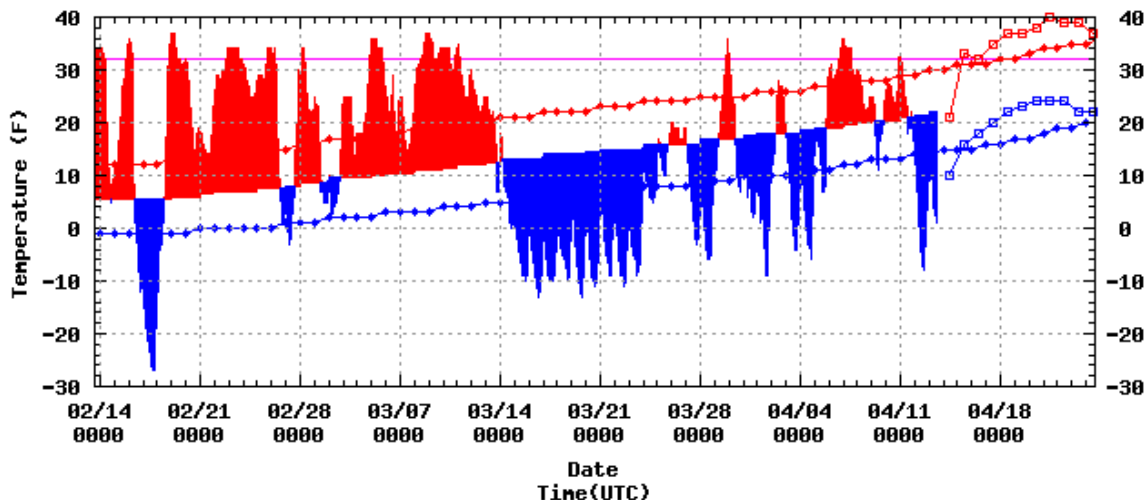
Dashed black lines are climatology (Deg F)
Shaded areas are forecast values Above (A) or Below (B) Normal
Un-shaded areas are near-normal

Breakup 2009 Weather

Station Name
FAIRBANKS



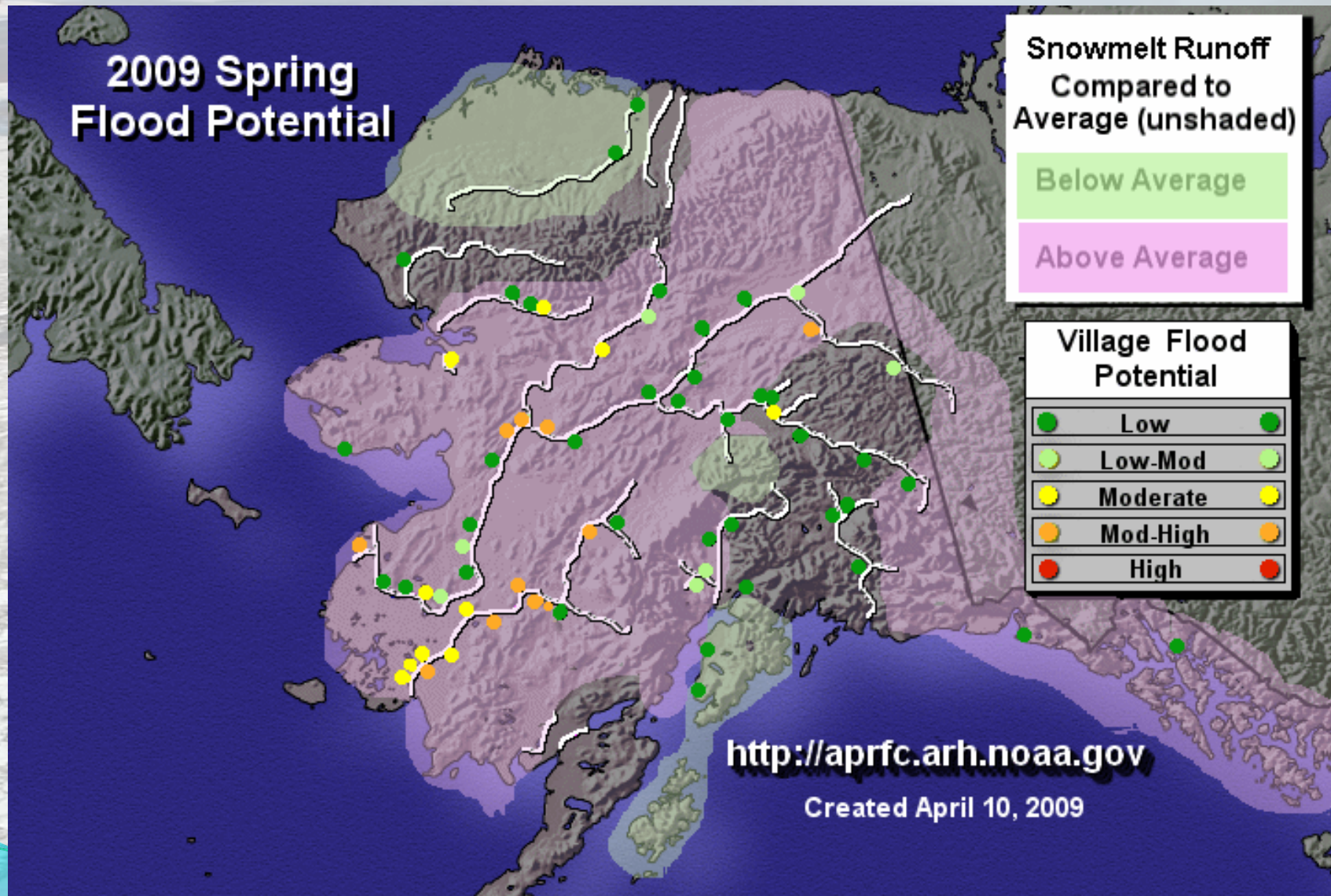
Station Name
BETHEL

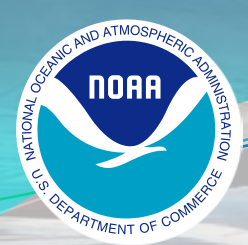


Graphs show hourly temperature departures from normal for the day and normal and forecast maximum and minimum temperatures

<http://aprfc.arh.noaa.gov/data/maps/TEMPS.all.png>

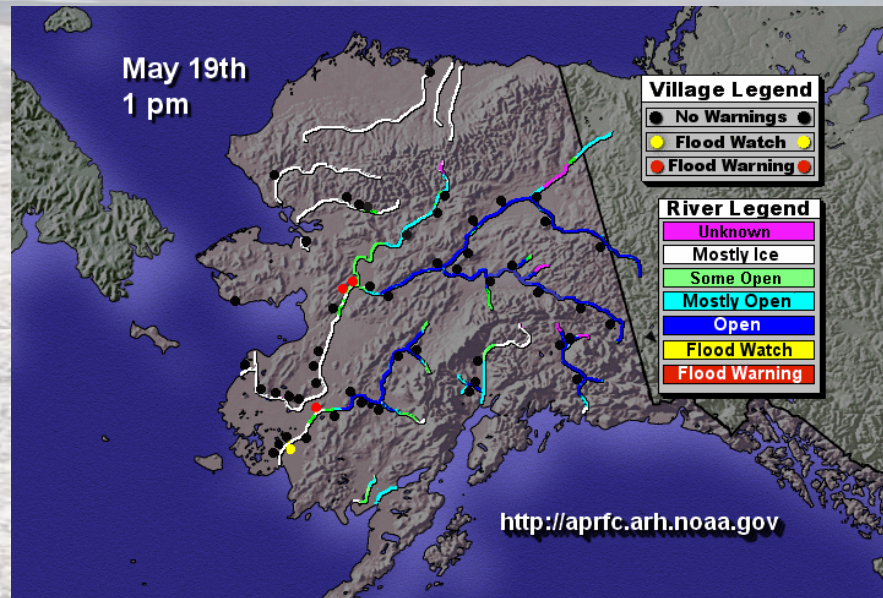
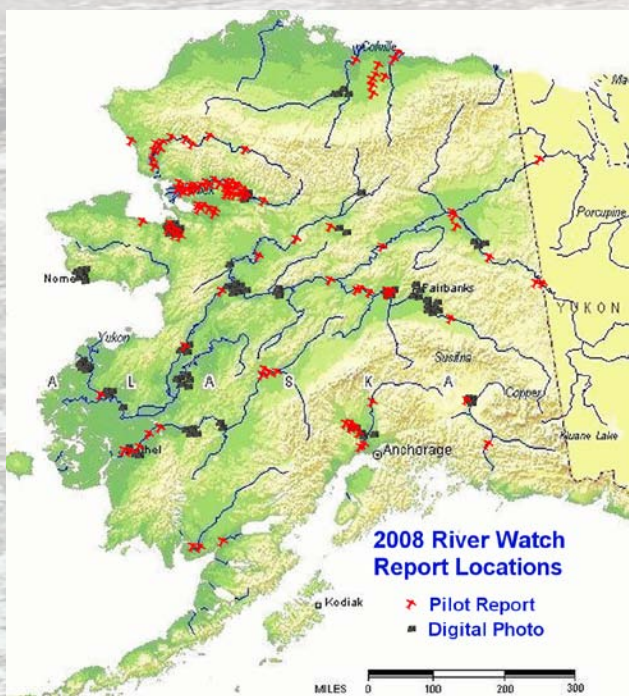
2009 Breakup Flood Potential





Thank You

Follow the breakup process on our web site in graphical and text formats:
<http://aprfc.arh.noaa.gov>



Questions and Discussion

Pilots can learn more about providing ice breakup pilot reports at:
<http://aprfc.arh.noaa.gov/resources/rivwatch/rwpindex.php>