A Multiscale Analysis of an Ice Jam Flood on the Pemigewasset River in Central New Hampshire on 26 February 2017

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MOTIVATION

Ice jams and associated flooding occur regularly in midlatitude regions during the winter/spring season and can have locally high societal and economic impacts. A high-impact ice jam flood formed on the Pemigewasset River between Ashland and Plymouth, New Hampshire on 26 February 2017, and resulted in dozens of student losing their vehicles to high water (see Fig. 1 below). The purpose of this presentation is to provide a multi-scale ingredient-based overview of the conditions leading up to the ice jam flood.

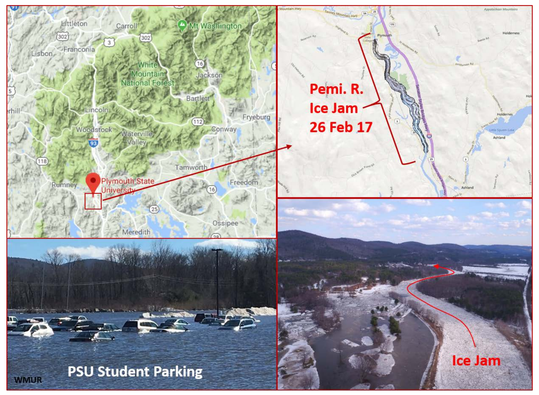

Figure 1: Top left) Google terrain map of White Mountain region/Pemigewasset River watershed. Top right) Close-up of Pemi. River with USGS aerial photo of ice jam. Bottom right)USGS Drone photo of ice jam and associated flooding in Ashland. Bottom right) Photo of PSU student parking lot, in Holderness, with submerged cars.

BACKGROUND

During the morning of 26 February 2017, a cold-frontal squall line moved through New Hampshire. Precipitation from the squall line fell on a deep, ripening snowpack and resulted in large amounts of rapid snow-water equivalent (SWE) losses across the Pemigewasset River watershed. Having already been swollen due to enhanced snowmelt during several days of abnormally warm temperatures (nearly 20˚C), the added snowmelt/loosened ice on the Pemi and resulted in an ice dam near Ashland NH with upstream flooding in Holderness.

DATA/METHODS

- Automated weather station reports
- Snow Data Assimilation System
- NCEP Climate Forecasting System Reanalysis
- USGS stream data: discharge and gage height
- PSU/NOAA–ESRL Snow-level radar
- KGYX radar and sounding profile

RESULTS

Antecedent conditions:

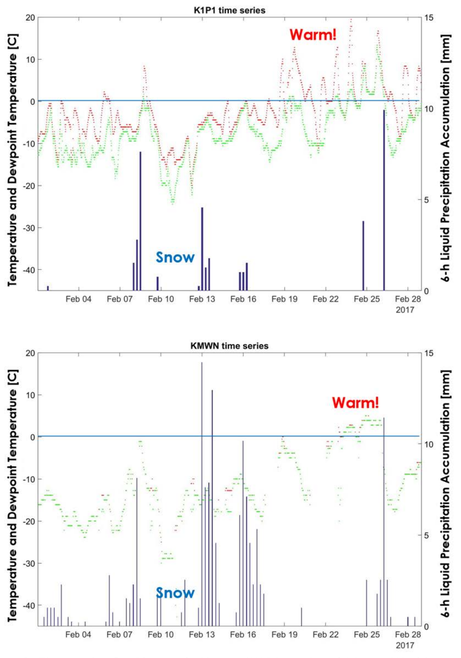

Figure 2: Time series for Plymouth Airport (K1P1, top) and Mount Washington Observatory (KMWN, bottom) for February 2017, showing temperature (red dots, ˚C), dewpoint temperature (green dots, ˚C), and 6-h precipitation totals (blue bars, mm).

- February 2017 featured early average below freezing with series of snowstorms that transitioned during 19–25 February to much above freezing, with temperatures reaching 20˚C
- Mount Washington summit (elev. 1916 m) experienced several days of dewpoint/air temperatures above 0˚C
- 26 Feb precipitation event produced 0.32-in of rain at Plymouth and snow melting level around 2.5 km

In-situ synoptic conditions:

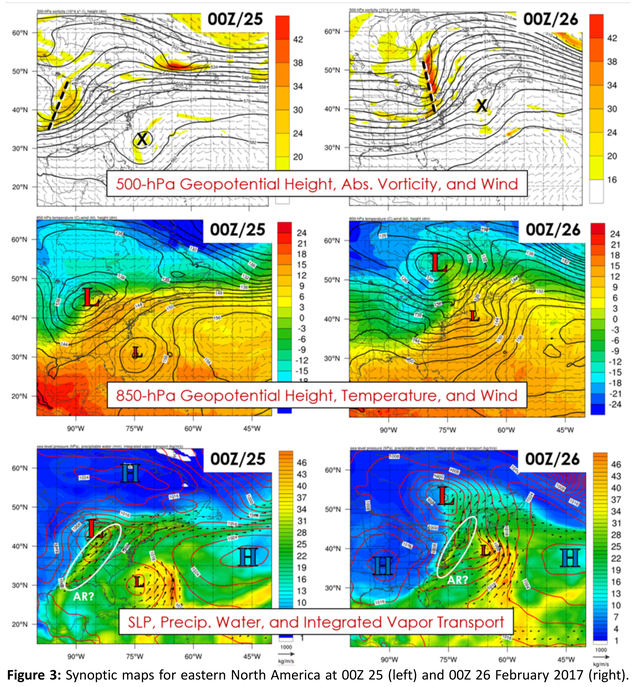

Figure 3: Synoptic maps for eastern North America at 00Z 25 (left) and 00Z 26 February 2017 (right). The top panels display 500-hPa geopotential heights (black lines, dm), absolute vorticity (color scale, 10^{-5} s^{-1}) and wind barbs (kts). The middle panels display 850-hPa geopotential heights (black lines, dm), temperature (color scale, ˚C), and wind barbs (kts). The bottom panels display sea-level pressure (red lines, hPa), precipitable water (color scale, mm), and integrated vapor transport (arrows, kg/m/s).

- 00Z/25: Region of low 850-hPa heights centered over Great Lakes downstream of negatively tilted trough at 500-hPa, with warm front extending eastward toward Maine and cold front to Texas
- 00Z/26: Region of low heights and warm front moved northeast, with 850-hPa temperatures over New England around 10˚C
- Corridor of enhanced moisture transport along surface cold front in warm sector of cyclone translates northeast into New England with orientation perpendicular to White Mountains – feature identified as a weak “atmospheric river”

Hydrologic response:

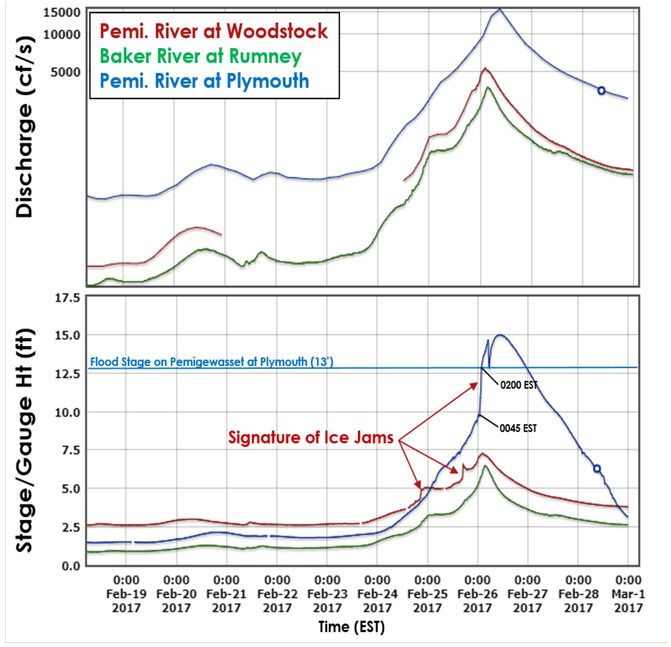

Figure 4: Time series during February 2017 for discharge (top, cf/s) and stage height (bottom, ft) for USGS stream gage sites at Woodstock NH (red line) and Plymouth NH (blue line) on the Pemigewasset River and at Rumney NH (green line) on the Baker River. The time is noted as being displayed in EST.

- Warm period during 19–25 February resulted in excessive snowmelt (basin–wide 3-day SWE loss exceeded 6-in, not shown) and elevated baseline flow in streams across the region
- Pemigewasset River at Plymouth reached flood stage around 0200 EST on the 26th (=07Z/26) after damming of ice downstream in Ashland (see Fig. 1) as indicated by periods of nearly vertical slope in gauge height trace

CONCLUSIONS/FUTURE WORK

- Climatological preconditioning of region for an ice jam flood occurred in 3 stages:
  1. Initial cold period with multiple snowstorms to develop ice in river beds and a deep snowpack
  2. Extended warm period which primes snowpack for release into streams
  3. Snow/ice break-up triggered by frontal passage and orographic enhanced precipitation
- Precipitation from a passing atmospheric river was orographic enhanced in the White Mountain region, and featured a melting level greater in elevation than all of the regional peaks – all rain, no snow
- Rainfall accumulations were not large, but sufficient given preconditions to cause flooding (it is possible that jam would have occurred without rain)
- Next step: Use a climatology of New England ice jams in order to identify synoptic-scale precursors and relationships to atmospheric rivers

ACKNOWLEDGEMENTS

- Funding for this project was provided by the Center for the Environment
- Model data was sourced from NCEP Climate Forecasting System Reanalysis and plotted in NCAR Command Language
- This ice jam initiated impact-based decision support services among Plymouth/ Holderness/NHHSEM/Plymouth State/National Weather Service
  - Collaboration led to positive outcomes during subsequent July 2017, October 2017, and January 2018 floods