Effects of winter events on nutrient mobilization and loading across different land uses

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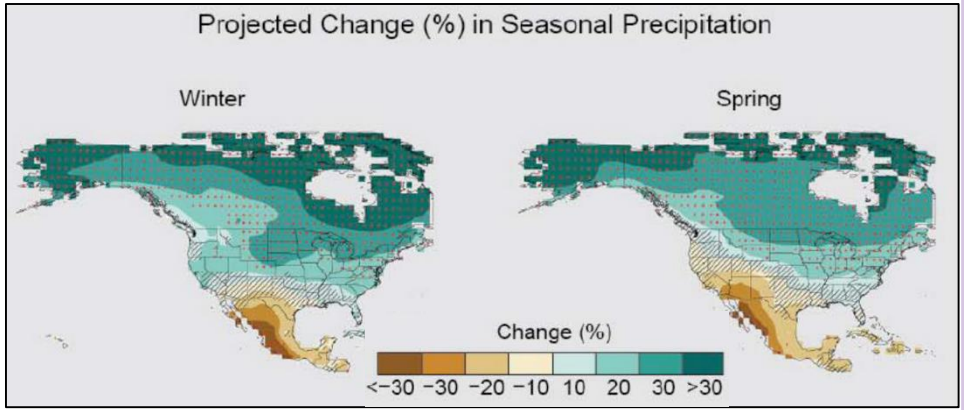
Background

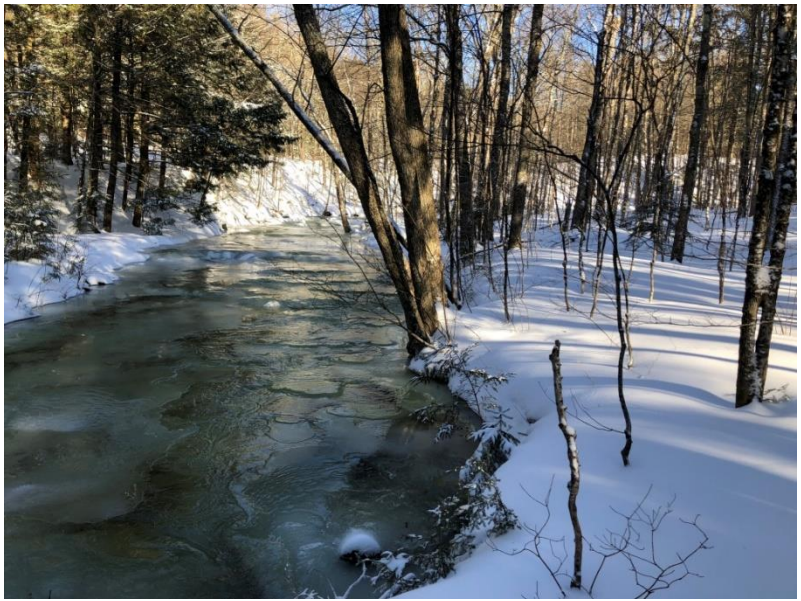


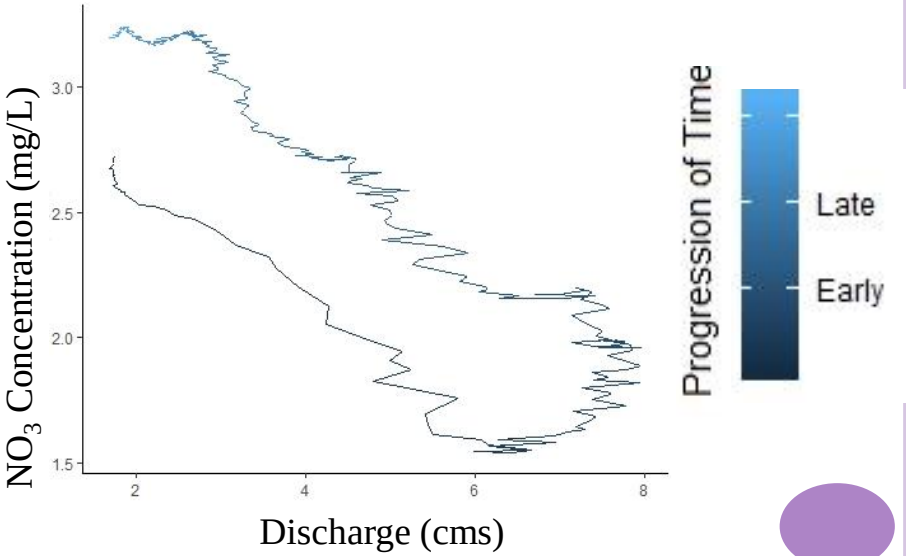
- Predicted increased temperatures for Northeastern US
  - Greatest warming in the winter
- Increased frequency of rain on snow (ROS) events, earlier snowmelt days and less snow accumulation
- ROS events contribute significantly to nutrient export (winter and annual)
  - Usually focused on NO_3 and sediment
- Nutrient flushing in a period that was characterized by low mobilization – but relatively little known about these type of events

Figure: World Climate Research Program CMIP

Objectives

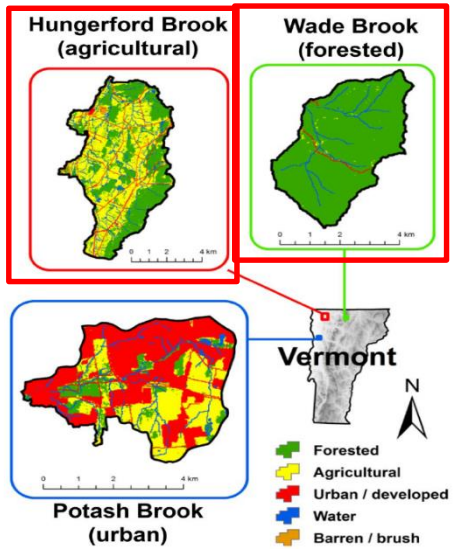
- Identify how much nitrate (NO_3^-) is exported during ROS vs snowmelt events
- Identify whether ROS events are characterized by distinct event-scale hysteresis patterns





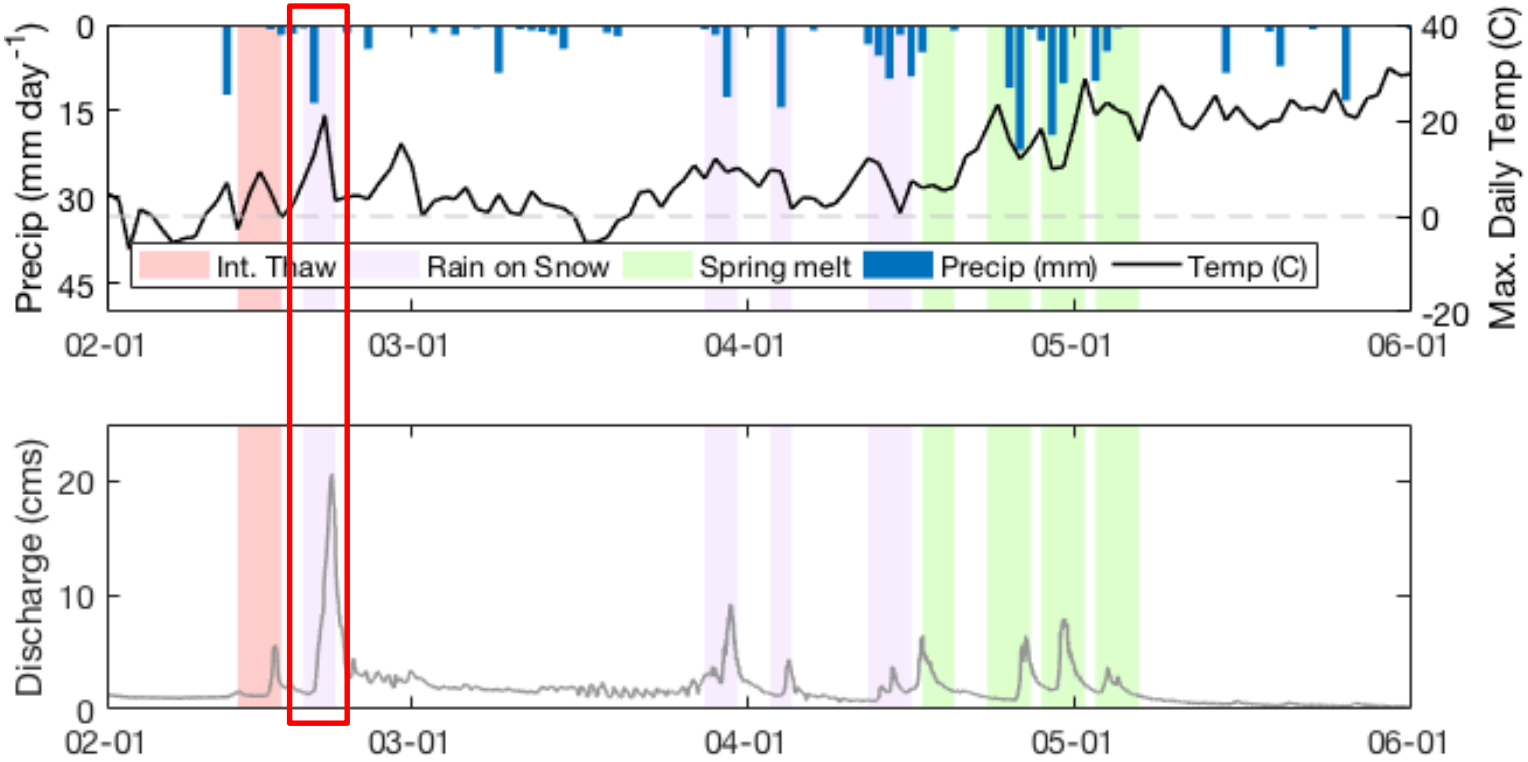
Methods

- Two watersheds in VT to study ROS and snowmelt events: Hungerford and Wade Brook
- Early season events (Feb-March) were monitored using Teledyne ISCO samplers
- s::can spectrolyser UV-Vis spectrophotometers were deployed in the streams from early-April to May 2018
- With concentration and discharge data, we calculated the cumulative NO_3^- yields for each event and determined the direction of hysteresis



Map of catchments from Vaughan et al. 2017

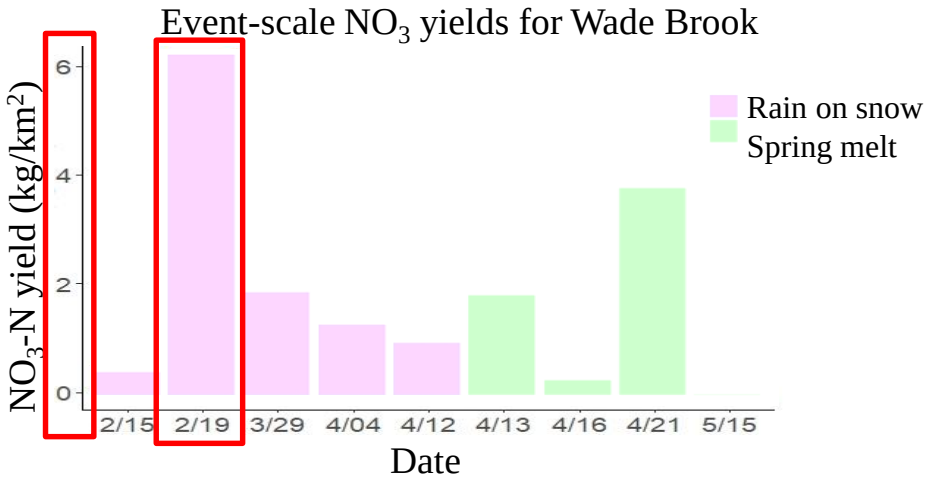
Results

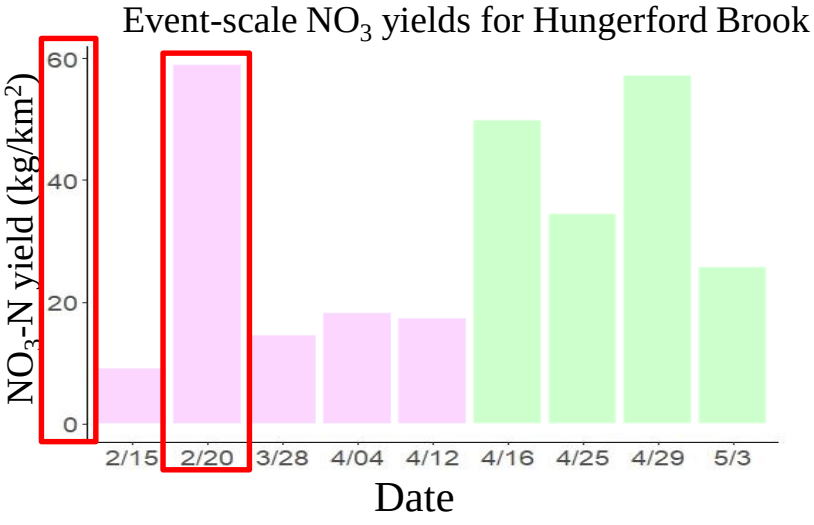


Precipitation, air temperature and discharge time series for spring events

Results

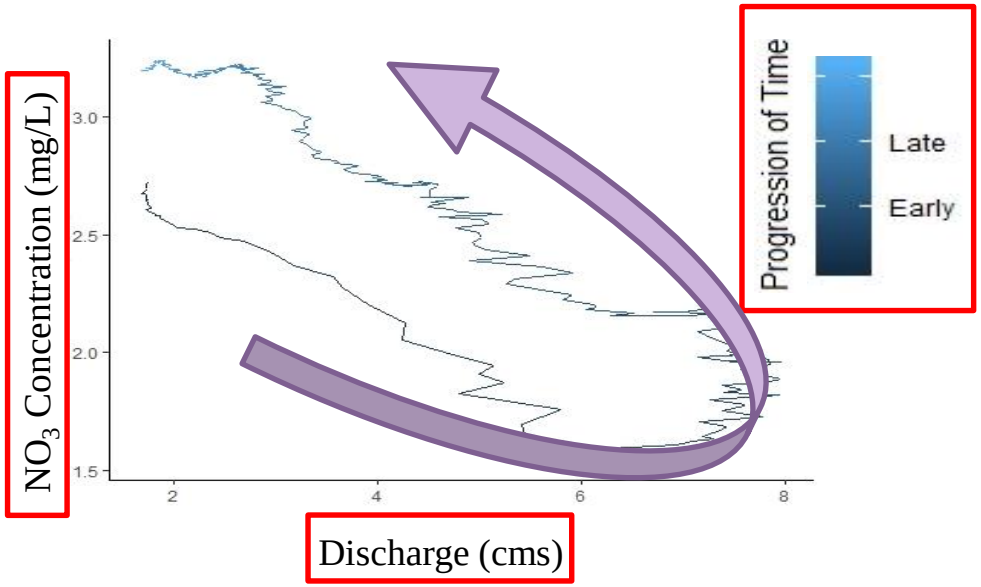
- Wade → forested site
  - Feb 19 largest single contribution to annual fluxes in 2018
  - Event contribution to annual yield: **30%** from ROS events vs **12%** from snowmelt
- Hungerford → agricultural site
  - Feb 20 largest single contribution to annual fluxes in 2018
  - Event contribution to annual yield: **22%** from ROS events vs **31%** from snowmelt
  - Higher yields at agricultural site than the forested site





Results

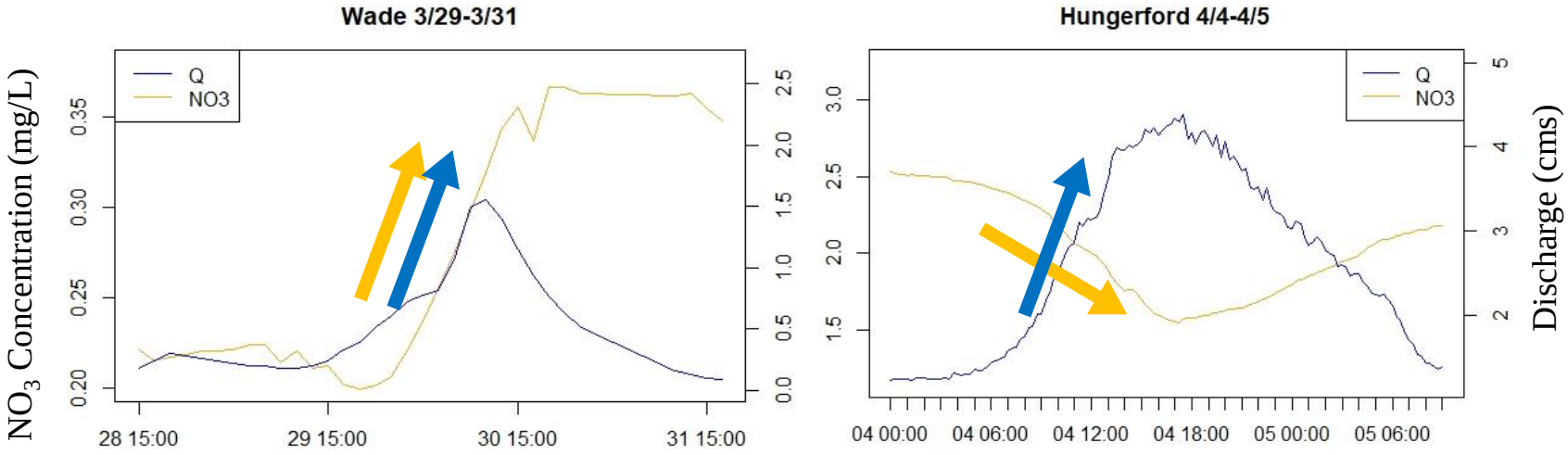
- Hysteresis plots were made for each event



- Clockwise loop could mean that concentration and discharge peak both coincide in the event
- Counterclockwise loop could mean that concentration peaks but there is a lag in discharge peak in the event
- Information on nutrient availability, storage and transport

Results

- Events were classified as having a flushing or diluting response



- Flushing → Q and C both increase at the beginning and then return to base lines
- Diluting → Q increases but C decreases at the beginning and then return to base lines

Results

- Wade Brook
  - Early events were flushing but behavior changed later to diluting response
  - Consistent pattern of hysteresis class during ROS events
  - `Mixed hysteresis class during snowmelt events
  - Change in hysteresis direction could mean change in nutrient source and availability
    - Snowpack nitrate being depleted and soil nitrate becoming more available

Event characteristics for Wade Brook

Event Date	Event Number	Type of Event	Hysteresis Class
Feb 15-16	1	Flushing	N/A
Feb 19-21	2	Flushing	N/A
Mar 29-31	3	Flushing	Anti-clockwise
Apr 4	4	Diluting	Anti-clockwise
Apr 12-13	5	Diluting	Anti-clockwise
Apr 13-14	6	Diluting	Anti-clockwise
Apr 16-18	7	Diluting	Clockwise
Apr 21-22	8	Diluting	Clockwise
Apr 22-23		Diluting	Figure 8
Apr 23-24		Diluting	Anti-clockwise
Apr 24-25		Diluting	Anti-clockwise
Apr 25		Diluting	N/A
May 15-16	9	Flushing	Clockwise

Results

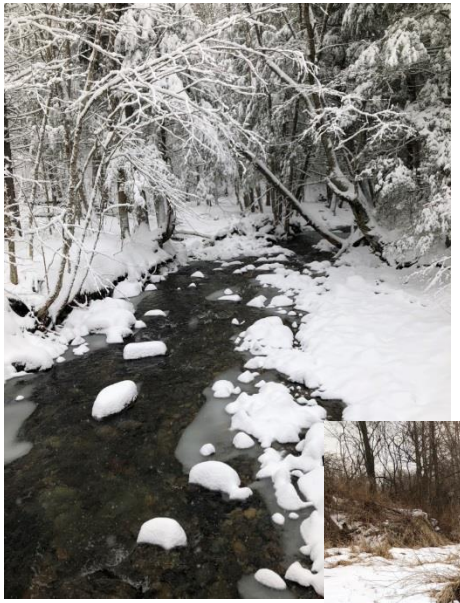
- Hungerford Brook
  - Events were mostly characterized by diluting response
  - Late March was only flushing event
  - Mixed hysteresis response for both ROS and snowmelt events
  - Change in hysteresis direction could mean change in nutrient source and availability
    - Flushing event in between hysteresis changes could mean soil nitrate was not available

Event characteristics for Hungerford Brook

Event Date	Event Number	Type of Event	Hysteresis Class
Feb 15-16	1	Diluting	N/A
Feb 20-22	2	Diluting	Anti-clockwise
Mar 28-31	3	Flushing	Clockwise
Apr 4-5	4	Diluting	Clockwise
Apr 5-6		Flushing	Anti-clockwise
Apr 12-13	5	Diluting	Clockwise
Apr 13-15		Diluting	Anti-clockwise
Apr 16-19	6	Diluting	Anti-clockwise
Apr 25-28	7	Diluting	Anti-clockwise
Apr 29- May 2	8	Diluting	Anti-clockwise
May 3-4	9	Diluting	Figure 8
May 4-6		Diluting	Clockwise

Discussion

- Early season ROS events mobilized a substantial amount of NO_3^- to downstream ecosystems in both watersheds
- NO_3^- yields from ROS were similar magnitude as snowmelt, suggesting that a large fraction of N is being exported earlier in the winter
  - Wade: **30%** vs **12%** for **42% total**
  - Hungerford: **22%** vs **31%** for **53% total**
- Hysteresis responses were variable, and no clear pattern was identified between ROS and snowmelt events
- Similar results in both land uses
- Future work will look at the effects of antecedent soil conditions on hysteresis response to help determine nutrient source



Thank you very much!

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