tc-2020-218 Supplementary Materials

Permafrost thaw couples slopes with downstream systems and effects propagate through Arctic drainage networks.

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Supplementary Materials include:

Supplementary Methods 1-3 (Geoprocessing steps for hydrological network analysis of slump effects and flow accumulation analysis).

Supplementary Figures 1-3.

Supplementary Tables 1-4.

Supplementary Videos 1-3. (URL links provided to SV 1 and 2. Video 3 is attached).

Supplementary Methods 1-3

Supplementary Method 1. Workflow for Willow River downstream accumulation of effects.

To quantify the scar and debris tongue areas of slope thermokarst features (STKs) affecting streams in the Willow River catchment and the downstream accumulation of STK scar areas through the fluvial network as an index for sedimentary and geochemical impact (main text Sect. 2.5.), we used delineations of STK scar/debris areas (Rudy and Kokelj, 2020), hydrologic data (streams and lakes) from the 1:50,000 National Hydro Network (NHN) dataset (Natural Resources Canada, 2016), and RivEX 10.25 software (Hornby, 2017). Data were compiled in ArcMap 10.6 and projected in the Canada Lambert Conformal Conic (CLCC) projected coordinate system. The workflow is documented in the following steps:

1) Manually delineated the Willow River catchment, in ArcMap 10.6, using topographic data from the 1:50,000 Canadian Digital Elevation Model (CDED) dataset (Natural Resources Canada, 2015). In order to aid the interpretation of the watershed boundary, NHN Primary Directed Network Linear Flow (PDNLF) and Waterbody Shapefiles (10MC002) were added to represent streams and lakes, respectively.
2) Clipped PDNLF and Waterbody feature classes (10MC002) to the Willow River catchment delineation from step 1.
3) Manually adjusted the PDNLF features to accommodate a recent channel abandonment and alteration in the routing of stream flow in the lower part of the catchment (main text Sect. 2.5.). Adjustments included:
    a) Removed PDNLF polyline (nid: 186964fe0c0c425c82150c486f7cbb71).
    b) Split PDNLF polyline (nid: a44c53c852f14ff29561a048435aca29).
    c) Added PDNLF polylines and assigned nid's: a1, a2, and a3.
    d) Reversed the direction of PDNLF polylines with the following nids:
        i) 8e0462e45626485bb69e6a7932f30c32
        ii) 9cb7a1ca015543a5ab825684402188b0
        iii) 6897bbd8a58c468c8cd15caf0610f5c2
        iv) D94bcd35f20d46f39d9f920b5e4e5365
        v) 92b84230ed9a4f6e9a881a18effa8884
        vi) f53ff86131864f3ea2adcfc8dd34b780
4) Constructed a topological network and ran 'Quality Control' tools using RivEX. Adjusted PDNLF polylines as necessary to ensure network continuity (i.e. consistent from- and to-nodes).
5) NHN PDNLF features represent the primary or (main route) of a stream. However, the PDNLF features are segmented in sections of braided channels that result in pseudo-nodes. To remove pseudo-nodes in sections of braided channels, a pseudo-node free network was generated using the 'Create Network Free of Pseudo Nodes' tool in RivEX.
6) Generated points at the intersections of streams and lakes and split the streams at the intersection points using a search radius of 5m.

7) Using the pseudo-node free network from step 6, constructed a topological network, using RivEx, and ran 'Quality Control' tools (except monotonic trends). During construction of the topological network, RivEX assigned each PDNLF polyline (segment) a unique ID (RivID).

8) Added a field (RivID) to the STK scar and debris shapefiles, from Rudy and Kokelj (2020), with the field type assigned as 'short integer'.

9) Assessed STK affects to stream and lake features, using delineations of STK scar and debris areas derived from 2018 Landsat imagery. STK features were interpreted to affect streams or lakes based on direct contact with the hydrological feature or based on the direction of down-slope flow indicated by topographic data (i.e. CDED). PDNLF segments affected by STK were recorded by assigning the value of the ‘RivID’ field, from the PDNLF segment, to the corresponding STK polygon. Special considerations included:
    a) Where STK(s) affected a lake, the RivID that corresponded with the hydrological/stream segment, located within the lake and at the lake outflow, was assigned to the STK polygon.
    b) In cases where STK affected multiple stream segments, the RivID from the most upstream segment, was assigned to the STK polygon. Some exceptions included:
        i) Where STK affected both a main-stem and a tributary the RivID from the stream segment with the largest contact length, with the STK polygon, was assigned to the STK polygon.
        ii) Where STK affected multiple headwater streams, the RivID from the stream segment with the largest contact length, with the STK polygon, was assigned to the STK polygon.

10) In order to ensure the consistency of areal measurements from the research paper, the area of delineations for scar and debris areas, using 2018 Landsat, were computed using the Universal Transverse Mercator Zone 8, North American Datum 1983 (NAD 83) coordinate system.

11) Using ArcMap's 'Summary Statistics' tool, a summary table was generated for the STK scar area shapefile, where the areas of all disturbed features were summed for each RivID value.

12) Repeated step 9 for the STK debris area shapefile.

13) Joined the summary tables, from step 9 and 10, to the stream network based on the RivID field.

14) Using RivEX, assigned Strahler Order to stream segments and performed upstream accumulations for both the scar and debris areas. For the abandoned channel, accumulation values were manually re-set to 0.

15) Using the 'Feature to Point' tool in ArcMap, generated points for each stream segment affected by STK.

16) Scar and debris areas were summarized by Strahler Order (excluding hydrological/stream segments within lakes.)

Supplementary Method 2. Workflow for broad-scale downstream accumulation of effects.

To quantify the number of hydrologic features (streams, lakes, and coastlines) affected by slope thermokarst features (STKs) and to propagate the downstream effects of STK (main text Sect. 2.5), within Arctic drainage from continuous permafrost, we used an inventory of hydrologic features affected by STK (Kokoszka and Kokelj, 2020), hydrologic data (streams, lakes and coastlines) from the 1:50,000 National Hydro Network (NHN) dataset (Natural Resources Canada, 2016), and RivEX 10.25 Software (Hornby, 2017). Data were compiled in ArcMap 10.6.

Due to the significant amount of hydrologic data required to propagate STK affects throughout the entire study basin, geoprocessing was completed on the basis of Water Survey of Canada sub-sub-drainage areas (NHN Work Unit), for a total of 68 Work Units. A complete list of NHN Work Units is available from Kokoszka and Kokelj, 2020. Because the fluvial network was connected across NHN Work Units, accumulation analyses were first conducted for Work Units located in the headwaters of the study basin. Accumulation analyses were then conducted within downstream NHN Work Units to ensure propagation of STK effects throughout the entire study basin. The workflow involved the following steps:

1) For a specified Work Unit, NHN Primary Directed Network Linear Flow (PDNLF), Waterbody, and Littoral feature classes were imported to ArcMap to represent streams, lakes, and coastlines, respectively.
2) Re-projected the PDNLF, Waterbody, and Littoral feature classes to the Canada Lambert Conformal Conic projected coordinate system (CLCC).
3) Removed features from the Waterbody feature class that were attributed as watercourses or intermittent.
4) Modifications to hydrologic data were made for the specified NHN Work Units:
    a) NHN Work Unit 10TB002: Removed a littoral segment that extended beyond the coastline into the Arctic Ocean (nid = 4bcd3316c65c449a99f307803d0bddb3).
    b) NHN Work Unit 10MD002: Clipped hydrologic data to the reduced extent of the Work Unit delineation (Kokoszka and Kokelj, 2020).
    c) NHN Work unit 10MC002: Re-routed the Mackenzie River to propagate STK effects through the eastern portion of the Mackenzie Delta as opposed to the central region of the Mackenzie Delta by adding a PDNLF polyline (nid = 10mc002ADD01) and removing a PDNLF polyline (nid = 874e0d518ce34245a367869ddcbadeab).
5) Joined the attribute tables from the PDNLF feature class and STKI_Stream feature class (Kokoszka and Kokelj, 2020) based on the 'nid' fields.
6) Added an attribute field (ValDirect) to the PDNLF feature class with the field type assigned as 'short integer'.
7) Selected PDNLF features where the 'STK' field was equal to 1 (directly affected by STK) and from the selected PDNLF features, attributed the 'ValDirect' field with a value of 1.
8) Constructed a topological network and ran 'Quality Control' tools using RivEX. Error logs were generated by RivEX and were inspected for quality control. For this project, the error logs generated by RivEX included:

a) Small polylines composed of two vertices: Small polylines (< 1m) in length. Small polylines do not affect the integrity of the topological network. As such, for the purpose of this project, small polylines were not adjusted during the quality control process.

b) Polyline spikes: A digitization error where a single vertex is out of place that creates an acute angle along the length of the polyline. Spikes do not affect the integrity of the topological network, but can increase the length of a polyline segment. For the purpose of this project, polyline spikes were not adjusted because the increase in polyline length was deemed negligible compared to the overall length of polylines within the study basin.

9) Computed the upstream accumulation of direct STK affects, within the NHN Work Unit. In RivEX, selected 'attribute network' -> 'accumulate attribute in network' -> 'Run Tool' -> selected the variable to accumulate as 'ValDirect' -> specified the output field as 'AccDirect' -> selected 'OK'.

10) Identified indirectly affected PDNLF polylines (segments) (i.e. segments located upstream of directly affected segments). In ArcMap, started an edit session -> from the 'selection' tab, selected 'select by attribute' -> set selection method as 'create new selection' -> from the PDNLF layer, selected features where the 'AccDirect' field was > 0 -> selected 'OK' -> attributed the selected features 'STK' field with a value of 2 (indirect).

11) Identified PDNLF segments that were directly and indirectly affected by STK. In ArcMap, started an edit session -> from the 'selection' tab, selected 'select by attribute' -> set the selection method as 'create new selection' -> from the PDNLF layer, selected features where the 'AccDirect' field was > 0 -> selected 'OK' -> started a new selection from the 'selection' tab by selecting 'select by attribute' -> set selection method as 'from the current selection' -> from the PDNLF layer, selected features where the 'STK' field was not 0 -> selected 'OK' -> attributed the selected features 'STK' field with a value of 3 (both).

12) In ArcMap, visually inspected the attribution of the ''STK' field, for PDNLF segments, by adjusting the colour scheme of the 'STK' field as follows: 'STK' = 0 to Cretan Blue (no STK affect), 'STK' = 1 to Mars Red (direct STK affect), 'STK' = 2 to Electron Gold (indirect STK affect), and 'STK' = 3 to Tuscan Red (both).

13) Identified indirectly affected Waterbody features (i.e. located upstream of directly affected PDNLF segments). In ArcMap, started an edit session -> from the 'selection' tab, selected 'select by attribute' -> set the selection method as 'create new selection' -> from the PDNLF layer, selected features where the 'AccDirect' field was > 0 and the 'Pseudo' field was equal to 0 -> selected 'OK' -> started a new selection from the 'selection' tab by selecting 'select by location' -> set the selection method as 'select features from' -> set the target layer as the Waterbody layer -> set the source layer as the PDNLF layer and ensured the 'use selected features' radio button was checked -> set the selection method as 'contain the source layer' -> selected 'OK' -> attributed the selected features 'STK' field with a value of 2 (indirect).

14) Identified Waterbody features that were directly and indirectly affected by STK. In ArcMap, started an edit session -> from the 'selection' tab, selected 'select by attribute' -> set selection method as 'create new selection' -> from the

PDNLF layer, selected features where the 'AccDirect' field was > 0 and the 'Pseudo' field was equal to 1 -> started a new selection from the 'selection' tab by selecting 'select by location' -> set the selection method as 'select features from' -> set the target layer as the Waterbody layer -> set the source layer as the PDNLF layer and ensured the 'use selected features' radio button was checked -> set the selection method as 'contain the source layer' -> selected ‘OK’ -> attributed the selected features 'STK' field with a value of 3 (both).

15) In ArcMap, visually inspected the attribution of the "STK' field of Waterbody features by adjusting the colour scheme of the 'STK' field as follows: 'STK' = 0 to Cretan Blue (no STK affect), 'STK' = 1 to Mars Red (direct STK affect), 'STK' = 2 to Electron Gold (indirect STK affect), and 'STK' = 3 to Tuscan Red (both).
16) In ArcCatalog, generated a new point feature class (AccSink) and added an attribute field (ValDirect) with the field type assigned as 'short integer'.
17) Locations where stream and lake derived STK affects propagated to the coastline were identified by visually inspecting the downstream path of PDNLF segments based on the 'STK' field's colour scheme (i.e. PDNLF segments that were not Cretan Blue) and mapping AccSink points at the downstream end of PDNLF segments, that terminated at the coastline. In order to represent the number of upstream (accumulated) hydrologic features directly affected by STK at the coastline, the value of the 'AccDirect' field, from the PDNLF segment, was attributed to the 'AccDirect' field of the AccSink point.
18) Because PDNLF segments represent the main route of network flow, in some cases streams affected by STK did not propagate to the main stem of the Mackenzie River (NHN Work Unit: 10LC000). In such cases, the corresponding value of the 'AccDirect' field was added to the AccSink point at the outlet of the Mackenzie River main stem. Similarly, values of the 'AccDirect' fields, for streams located near the outer reach of the Mackenzie Delta, were consolidated to the AccSink point located at the outlet of the Mackenzie River main stem.
19) Generated a 500m buffer (AccSinkBuffer) around the AccSink points.
20) Identified indirectly affected Littoral features (i.e. features located downstream of directly and indirectly affected PDNLF segments). In ArcMap, started an edit session -> from the 'selection' tab, selected 'select by location' -> set the selection method as 'select features from' -> set the target layer as the Littoral layer -> set the source layer as the AccSinkBuffer layer -> set the selection method as 'intersect the source layer' -> selected ‘OK’ -> started a new selection from the 'selection' tab by selecting 'select by attribute' -> set the selection method as 'select from current selection' -> from the Littoral layer, selected features where the 'STK' field was equal to 0 -> selected ‘OK’ -> attributed the selected features 'STK' field with a value of 2 (indirect).
21) Identified Littoral features that were directly and indirectly affected by STK. In ArcMap, started an edit session -> from the 'selection' tab, selected 'select by location' -> set the selection method as 'select features from' -> set the target layer as the Littoral layer -> set the source layer as the AccSinkBuffer layer -> set the selection method as 'intersect the source layer' -> selected ‘OK’ -> started a new selection from the 'selection' tab by selecting 'select by attribute' -> set selection method as 'select from current selection' -> from the Littoral layer, selected features where

the 'STK' field was equal to 1 -> selected ‘OK’ -> attributed the selected features 'STK' field with a value of 3 (both).

22) Repeated steps 1 to 21 for each NHN Work Unit. Where STK affects propagated between NHN Work Units, prior to conducting the accumulation analysis the value of the 'AccDirect' field, for the upstream PDNLF segment (i.e. located in the upstream NHN Work Unit), was attributed to the 'AccDirect' field for the downstream PDNLF segment (i.e. located in the downstream NHN Work Unit).

23) For each NHN Work Unit, segments from the PDNLF feature class, where the 'STK' field was equal to 1 (i.e. directly affected by STK), were selected and exported as new feature classes. The feature classes were then merged to generate a downstream trace that represented the propagated and accumulated STK affects across the entire study basin.

24) The downstream trace was visually inspected to ensure continuity of STK affects between NHN Work Units.

Supplementary Method 3. RivEX Workflow to Assess Strahler Order

To derive the Strahler stream and lake orders within four watersheds (Keele/Redstone, Peel, Amundsen Gulf, and Banks Island) of the Arctic drainage area from continuous permafrost of northwestern Canada (main text Sect. 2.5), we used hydrologic data (streams and lakes) from the 1:50,000 National Hydro Network dataset (NHN) (Natural Resources Canada, 2016) and RivEX 10.25 Software (Hornby, 2017). Data were compiled in ArcMap 10.6. Steps in the workflow included:

1) In ArcMap, imported NHN Primary Directed Network Linear Flow (PDNLF), Waterbody, and NHN WorkUnit feature classes to represented streams, lakes, and hydrologic boundaries, respectively.
2) Generated watershed delineations by merging the following NHN Work Unit feature classes for each specified watershed:
    a) Keele/Redstone: 10HA000 and 10HB000
    b) Peel: 10MA000, 10MB000, and 10MC002
    c) Amundsen Gulf: 10OA001, 10OA002, 10OB000, 10OC001, and 10OC002
    d) Banks Island: 10TA001, 10TA002, 10TA003, 10TA004, 10TB001, and 10TB002
3) Modifications to hydrologic data were made for the specified NHN Work Units:
    a) NHN Work Unit 10TB002: Removed a littoral feature that extended beyond the coastline into the Arctic Ocean (nid = 4bcd3316c65c449a99f307803d0bddb3).
    b) NHN Work Unit 10MC002: Work Unit feature class was manually reduced to specify the drainage area from a specified segment of the Peel River (nid = f1d3cf54069c4e4f9f35ddef517e4b9d). The 10MC002 Work Unit area included PDNLF polylines within the Mackenzie Delta. Computing Strahler order for PDNLF polylines within the 10MC002 Work Unit would have required computing Strahler order for the entire Mackenzie River, which was not feasible given computational restraints.
4) Merged PDNLF and Waterbody feature classes for their respective watersheds (see step 2). The merged PDNLF and Waterbody feature classes, from the Peel watershed, were clipped to the reduced watershed delineation (see Step 3b).
5) Constructed a topological network for each watershed using the merged PDNLF feature classes (see Step 4), and ran ‘Quality Control’ tools, using RivEX. The quality control error logs included small polylines and spikes within the networks. However, the presence of small polylines and spikes do not affect the topology of the network and were disregarded in the quality control process.
6) Computed Strahler Order for PDNLF polylines by selecting 'Strahler' from the 'Network Attribution'' tool in RivEX.
7) Performed a spatial join between PDNLF polylines (join features) and Waterbody polygons (target features) to determine lake order. The spatial join matched PDNLF polylines that were located within Waterbody features based on the maximum Strahler Order of the PDNLF polylines, using a one-to-one join operation.
8) Visually inspected the Strahler stream and lake order outputs for quality assurance.

Supplementary Figures 1-3

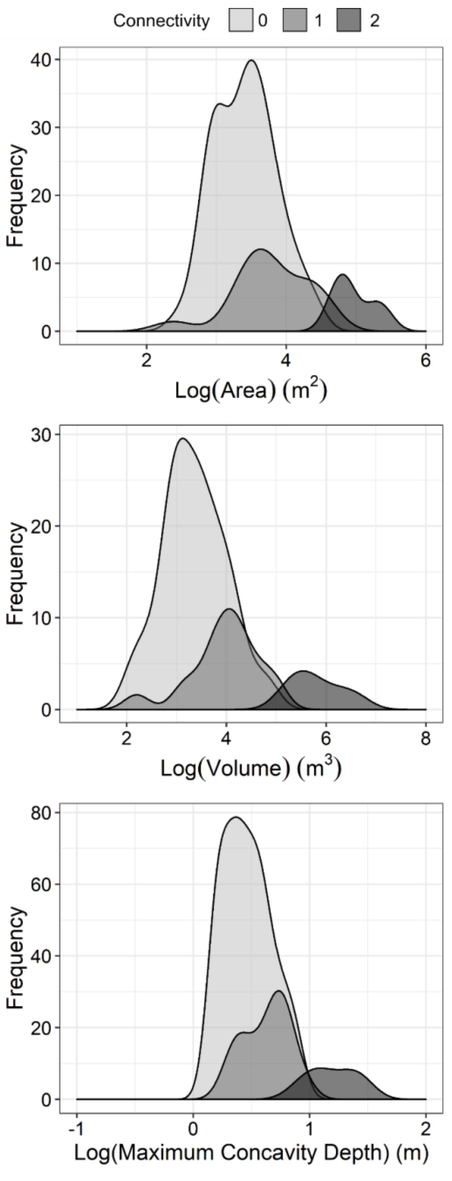
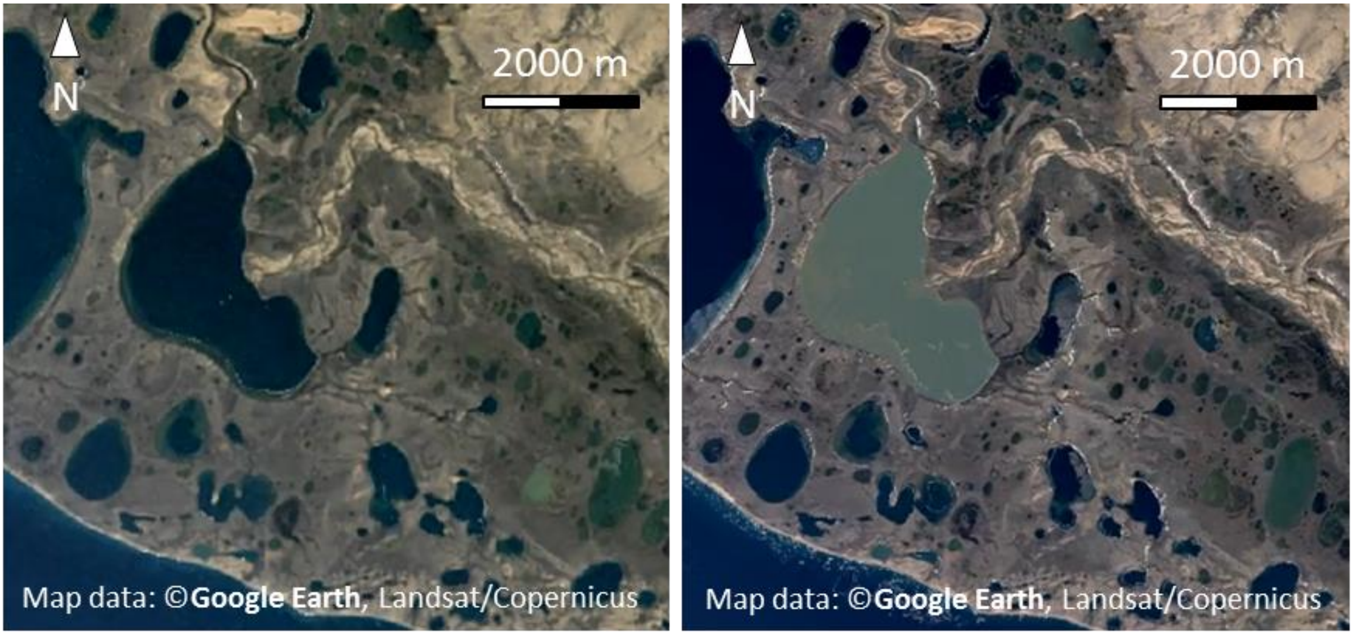


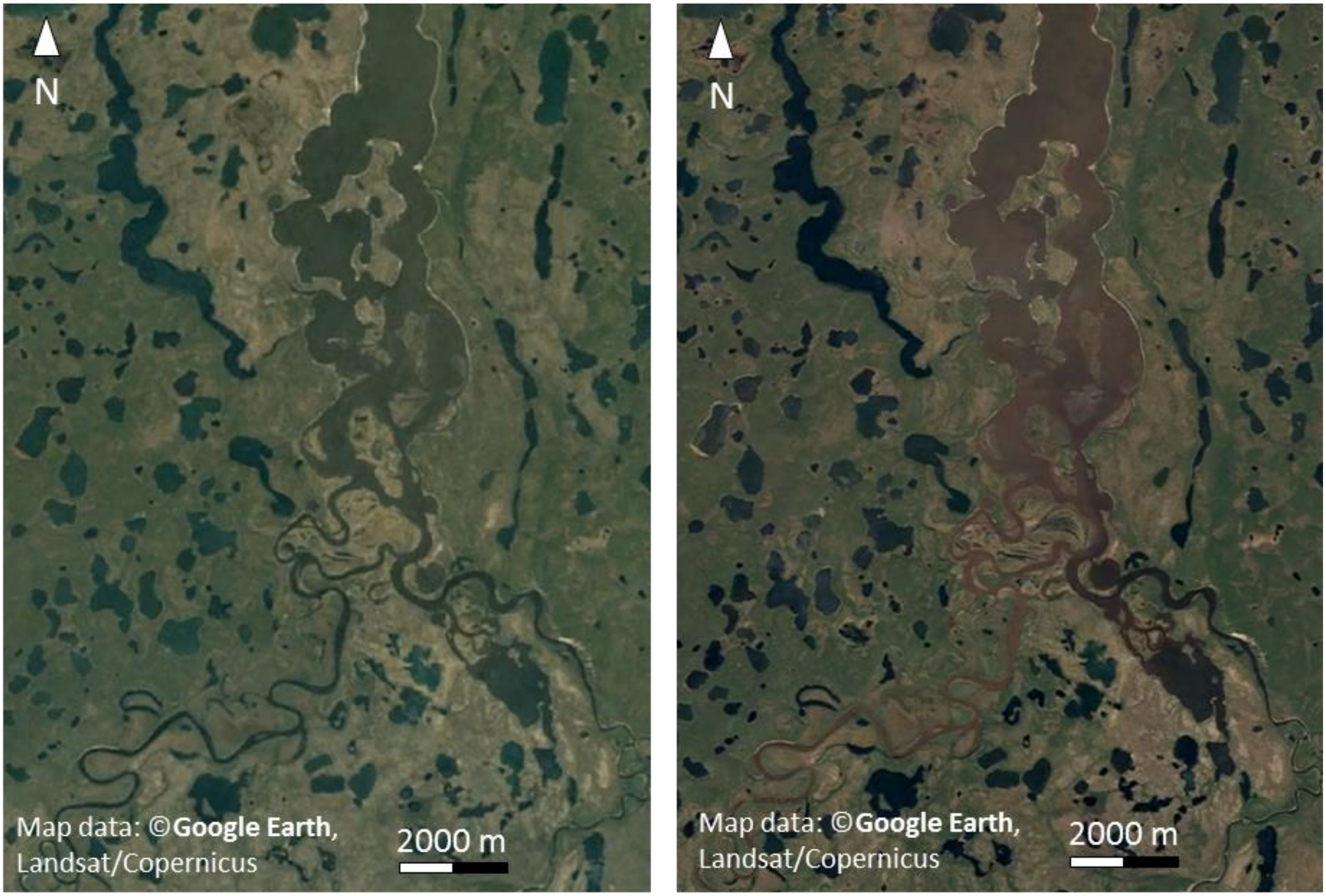
Figure S1. Frequency distributions for thaw slump size indices grouped by downstream connectivity. Class 0 indicates no physical connection between the slump and downstream environment; 1 is a physical connection between an active or bare scar and the downstream environment; and 2 is evidence of downstream deposition, including a debris tongue in a valley bottom, or a sediment lobe protruding into adjacent lake or coastline.

Figure S2. Willow River main stem view looking southwest. Photograph shows small shallow slides in foreground, and large deep-seated translational failures which have evolved into retrogressive thaw slumps. Slide materials have runout onto the braided floodplain. Numerous retrogressive thaw slumps are visible in background on slopes of incised tributary streams. Photograph is upstream view towards inset (b) on Figure 6.

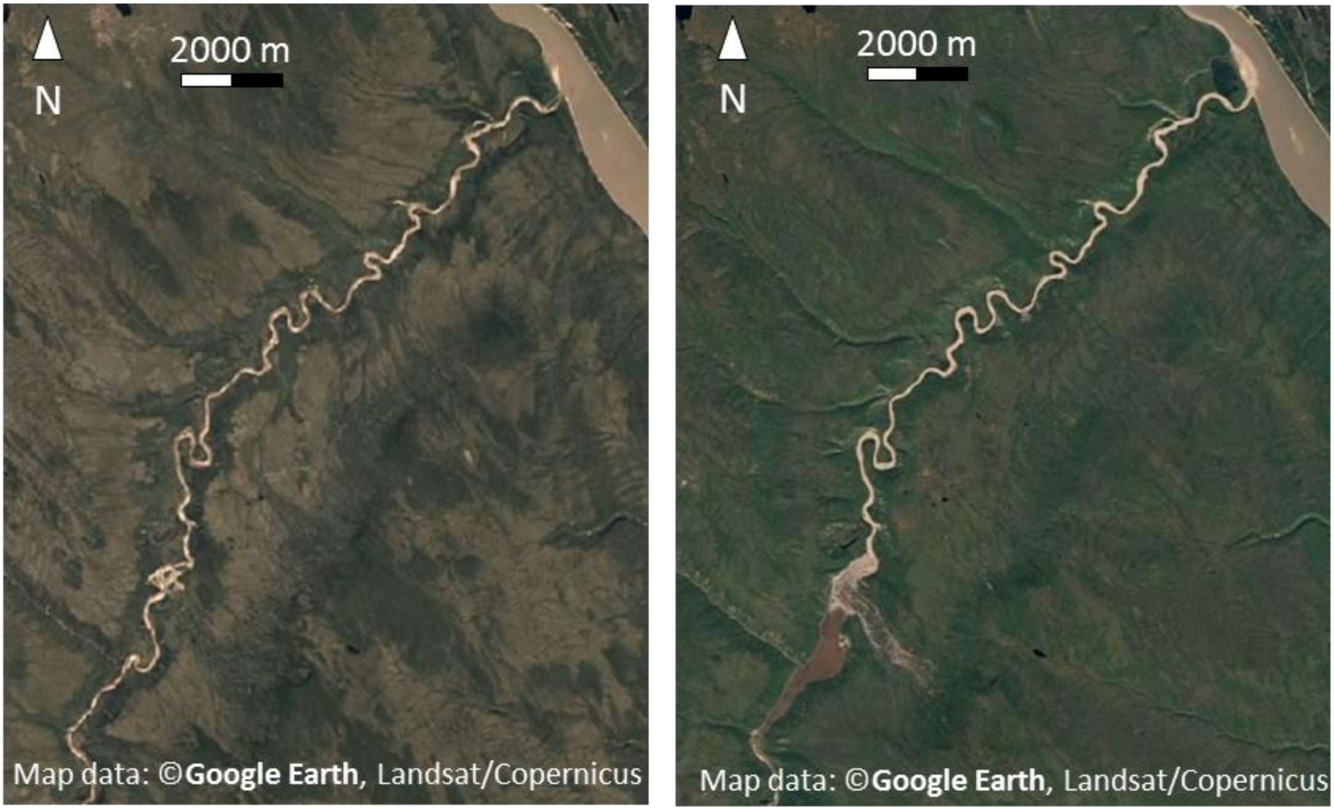
Figure S3. Panels show downstream effects of slope thermokarst affects. Examples of thaw-driven increases in downstream sedimentation include examples from: i. Sachs River inflow to Big Fish Lake, Banks Island; ii. Inflow of Miner and Kugalik Rivers to Husky Lake estuary, Mackenzie Delta region; iii. Development of massive, deep seated translational failure on Johnson River, central Mackenzie Valley. Locations are indicated on Figure 8.



i. Sachs River and Big Fish Lake, Banks Island 1985 and 2018 (Lat/long: 71.8237 N, -124.4983 W).



ii. Inflow of Miner River (lower left) and Kugalik River (lower right) into Husky Lake estuary 1991 and 2018. Note turbidity or Miner River in 2018 (Lat/long: 69.1617 N, -131.0135 W).



iii. Johnson River near the confluence with Mackenzie River showing changes caused by a major deep-seated translational failure that occurred in fall 2017. Images are 1991 and post slide development (2018) (Lat/long: 63.6587 N, -124.0530 W).

Supplementary Tables 1-4

Table S1. Summary of UAV surveys conducted over the four-year campaign to support Sections 3.1-3.3 (modified from Van der Sluijs et al., 2018).

Site	Date	UAV	Res (cm)	Area (ha)	Photos (no.)
D1 (67.1771° N -135.7555° W)	2015-07-28	PX8	1.5	4.3	295
	2015-07-29	PX8	1.5	3.8	291
	2016-08-03	Inspire	1.3	1.7	79
	2017-07-27	P4P	1.2	6.3	316
	2018-09-18	eBee	1.5	9.0	311
FM3 (67.2539° N -135.2732° W)	2015-07-29	PX8	1.9	28.3	658
	2016-08-02	Inspire	2.4	34.3	583
	2017-07-26/28	eBee	3.3	365.0	3,499
	2018-09-19	eBee	3.3	88	463
FM2 (67.2545° N -135.2286° W)	2016-08-02	Inspire	2.4	83.6	1516
	2017-07-26/28	eBee	3.3	365.0	3499
	2018-09-18	eBee	3.3	161	982
Husky (67.5207 ° N -135.3005 W)	2016-08-03	Inspire	1.7	36.8	773
	2017-07-28	eBee	3.4	100.5	723
	2018-09-19	eBee	3.2	90.0	510
CB (67.1814° N -135.7295° W)	2015-07-28	PX8	1.5	12.1	711
	2018-09-18	eBee	2.7	28.1	438
Mean			2.3	83	920
Stdev			0.8	115	1024
Sum				1,053	15,647

Note: Flights conducted for thermal mapping, oblique still photography and video purposes are not included. Table headings "Res" is resolution or pixel size. UAV platforms: Spyder PX8 Plus (PX8), Phantom 2 Vision Plus (P2), RX4-S Surveyor (RX4), Inspire 1 Pro (Inspire), eBee Plus RTK/PPK (eBee), and Phantom 4 Pro (P4P).

Table S2 Summary statistics of slump area, volume and scar concavity depth estimates, Peel Plateau, Anderson Plain and Tuktoyaktuk Coastlands derived from 2011 LiDAR (n=71).

		Area (m^2)	**Volume (m^3)**	**Concavity depth (m)**	
				Mean	**Maximum**
Mean		14,934	-106,003	-1.82	-4.76
Median		3,323	-3,860	-1.18	-3.36
Std. Deviation		38,056	480,480	2.27	4.73
Skewness		5	-6	-3.62	-3.34
Kurtosis		26	45	15.46	12.85
Minimum		242	-3,653,390	-14.39	-28.37
Maximum		253,937	-128	-0.11	-1.48
Sum		1,060,280	-7,526,216		
Percentiles	25	1,495	-13,982	-2.10	-5.47
	50	3,323	-3,860	-1.18	-3.36
	75	7,730	-995	-0.70	-2.22

Table S3. Size indices of active thaw-slumps in the Willow River catchment for 1986, 2002 and 2018. Area estimates were determined by digitizing orthorectified, color balanced, could free Landsat imagery (Rudy and Kokelj, 2002). Thaw slump volume and maximum concavity depth were estimated using relationships shown in Figure 4.

Parameter	**1986**	**2002**	**2018**
Scar area (m^2)			
Count	21	73	198
Cumulative area	105,081	669,249	3,545,445
Median	4,512	5,688	8,293
Mean (STdev)	5,004 (2,601)	9,768 (10,608)	17,906 (29,685)
Max	13,497	63,838	198,986
Min	1,649	766	1,073
Scar volume (m^3)			
Cumulative volume	144,868	1,437,340	11,688,197
Median	5,537	7,687	13,119
Mean (STdev)	6,898 (5,513)	19,690 (35,515)	59,031 (161,741)
Max	26,154	236,479	1,184,216
Min	1,330	449	723
Concavity depth (m)			
Median	3.6	3.9	4.5
Mean (STdev)	3.6 (0.67)	4.1 (1.5)	5.1 (2.1)
Max	5.3	9.3	14.1
Min	2.5	1.9	2.1
Debris tongue area (m^2)			
Count	6	31	67
Median	5,046	6,165	8,884
Mean (STdev)	18,655 (24,511)	9,681 (10,071)	15,394 (18,857)
Max	59,011	39,682	100,569
Min	1,631	1,250	1,087

* Landsat dates: 1986_07_07; 2002_07_20; 2018_07_22

Table S4. Results Dunn's post-hoc test for comparison of thaw slump scar area between 1986, 2002 and 2018 following a Kruskal-Wallis Rank Sum test (p>0.00001).

Comparison dates	**Z score**	**P. unadjusted**	**P. adjusted**
2002-2018	-3.4614	0.0005	0.0008
1986-2002	1.4714	0.1411	0.1411
1986-2018	3.6529	0.0002	0.0008

***Dunn's post-hoc results indicate significant differences between 1986 and 2018, and 2002 and 2018.

Supplementary Videos 1-3

Video S1.
Video shows truncation of a small tundra lake by thaw-slump growth causing rapid drainage on the Peel Plateau in 2015 (67.5207 ° N -135.3005° W).
https://www.nwtgeoscience.ca/services/permafrost-thaw-slumps/video-permafrost-thaw-causes-lake-drainage-peel-plateau-nwt

Video S2.
UAV fly through of a large active retrogressive thaw slump in Willow River catchment shown in Figure 6b (68.1119° N -135.6806° W).
https://www.nwtgeoscience.ca/services/permafrost-thaw-slumps/drone-survey-permafrost-mega-slump-willow-river-nwt

Video S3.
Animated GIF image generated using the "UI LandTrendr Time Series Animator" (1985-2019) for lower Willow River catchment on the eastern edge of the Mackenzie Delta showing evolution of major thaw slumps most notably in lower left corner of imagery (Fig. 6b). The time series shows acceleration of disturbance activity in the late 1990s and early 2000s, alluviation of the Willow River Channel and infilling of the large Mackenzie Delta lake from 2007 and 2019 with slump-derived sediment transported by the Willow River (Fig. 6c).

The Landsat time series has been smoothed by LandTrendr spectral-temporal segmentation on ©Google Earth Engine (Kennedy et al., 2018). URL: https://emapr.github.io/LT-GEE/ui-applications.html (Accessed 3 August 2020).

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