Topographic Signatures of Permafrost Processes on the Seward Peninsula, Western Alaska, USA

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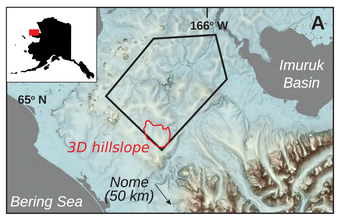
Problem: Do channel networks **expan**d or **contract** with permafrost thaw?

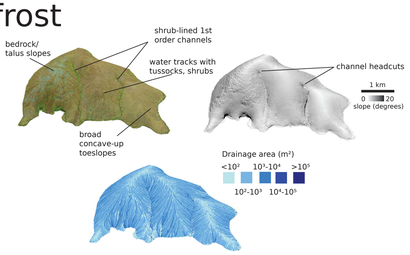
Expansion if
- Lower incision threshold (unfrozen soil during snowmelt/rain, removal of vegetation armor)
- Reduced infiltration capacity (removal of permeable vegetation)
- Less efficient concavity filling (slower solifluction/creep, or creation of concavities with slope failures)

Contraction if
- Higher incision threshold (new vegetation armor)
- Increased infiltration capacity (deeper unfrozen layer)
- More efficient concavity filling (faster solifluction/creep)

(green = hypothesized dynamic)

Seward Peninsula, AK: soil-mantled hillslopes in discontinuous permafrost

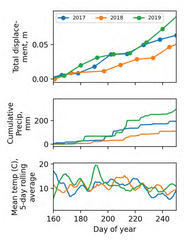




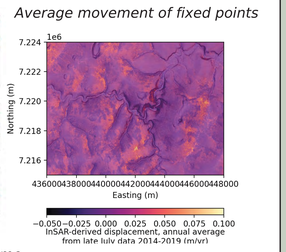
Repeat field and InSAR measurements show **surface displacements average 5 cm/yr** but can be **much higher**

(Del Vecchio et al., 2019; Rowland et al., 2020)

Is there a **spatial pattern** to InSAR-derived displacements, and if so what controls it?



Track fixed point over time

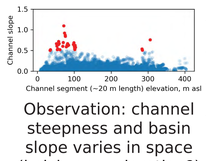


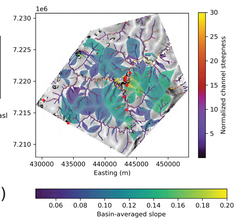
Average movement of fixed points

Could base-level fall and basin steepening control short-term displacements?

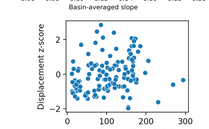
All topographic data for this study were processed via **LSDTopoTools** developed by the Land Surface Dynamics research group at the University of Edinburgh.

LSDTT GitHub ⟷ this project's repository

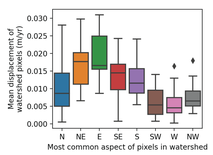


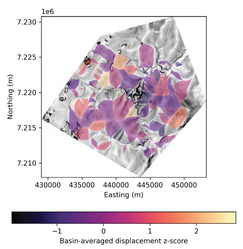


Observation: channel steepness and basin slope varies in space (knickzone migration?)



Since InSAR look direction biases measurements on different slope aspects...

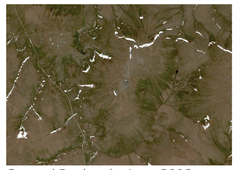




...we have to normalize by aspect (find z-scores of displacements grouped by aspect)

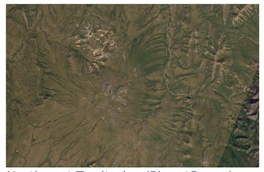
Conclusion: no clear pattern in basin-averaged displacements

On the Seward Peninsula and in other permafrost landscapes, **water tracks** are curvilinear surface and subsurface flowpaths that transport large volumes of water **without carving channels** and creating convergent topography



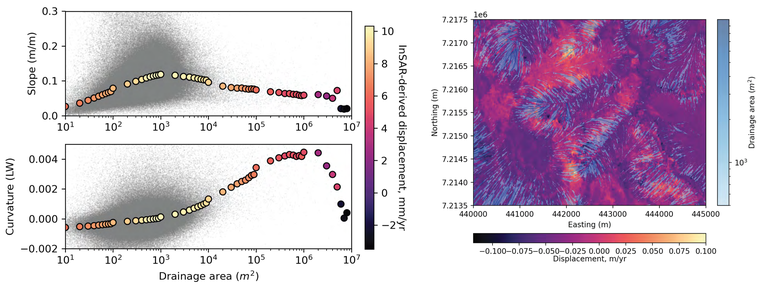
Seward Peninsula, June 2019 (PlanetScope)

Northern foothills of Brooks Range, AK, (McNamara et al., 1999)



Northwest Territories (PlanetScope)

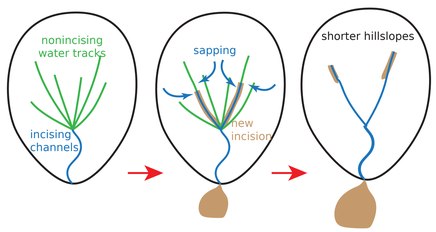
Across the study area, the landscape positions occupied by **water tracks** are also positions with the **highest summer displacements**.



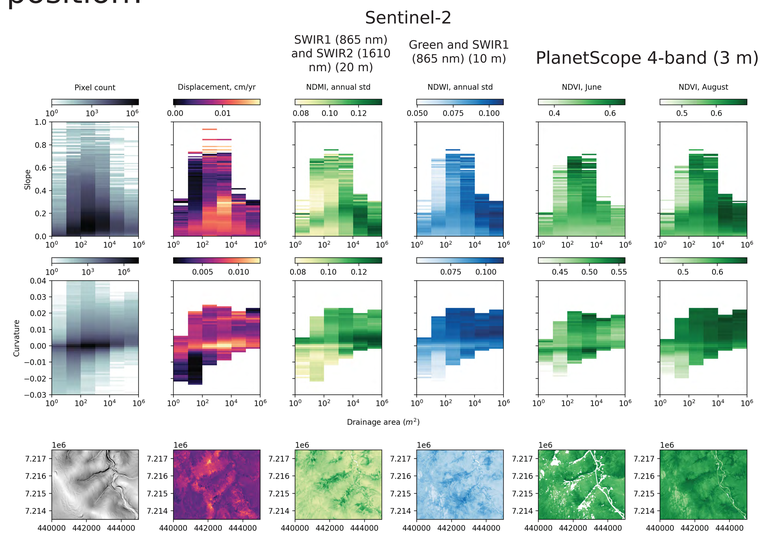
In the field, these disturbances look like **hillslope failure** at slope/area thresholds, new **incision into the tundra mat**, and deepening of existing channels.

drone imagery from Julian Dann

Because water tracks subside with warming and drain surrounding tracks, concavities are likely to grow and **the incised channel network will expand** with earlier ground thaw, later and heavier summer rainstorms, and vegetation change.



How do ecological factors vary by landscape position?

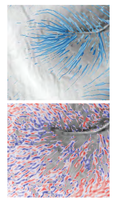


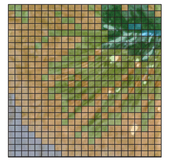
Landscape positions have characteristic vegetation and moisture patterns

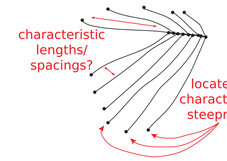
Next steps

Because water track evolution is key to predicting permafrost channel change with warming, we need to (1) efficiently map and characterize water tracks and (2) develop thermal and mechanical models to predict their dynamics

Geomorphic data + Spectrally derived land cover classfication = Network map of water pathways







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