PROJECT T-REX - Impact of Heavy Rainfall Events on Svalbard Permafrost and Tundra Ecosystems

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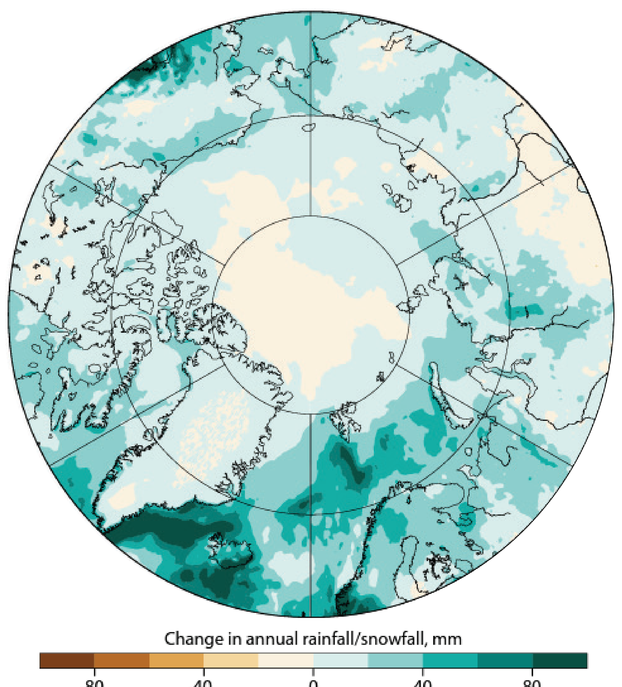


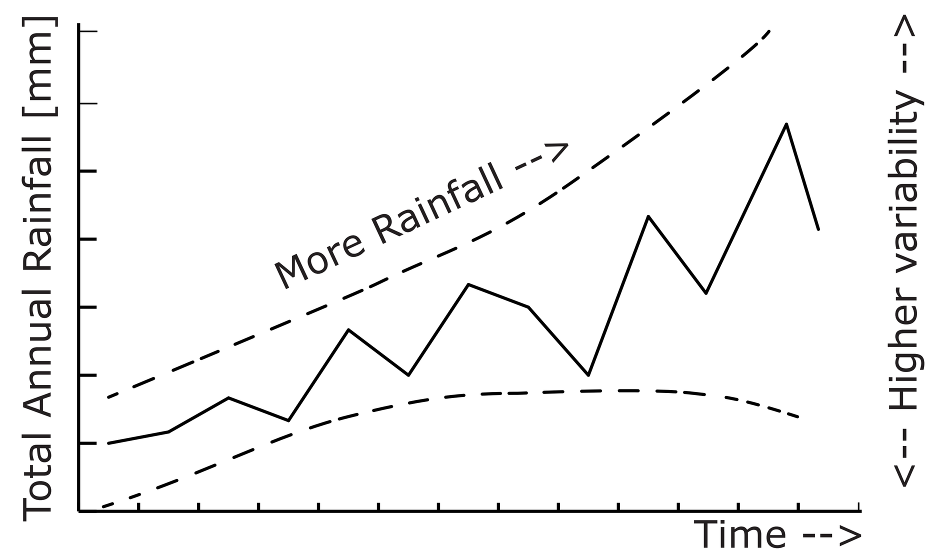
Fig 1) Rainfall trends *across the Arctic for 1979-2021. Data: ERA5. Source: amap.no*

Towards a rainier Arctic

Beside temperatures, **precipitation is increasing in the Arctic**. In a warmer Arctic, a larger proportion of precipitation will fall as **rain instead of snow**. Also the interannual variability in rainfall is expected to become larger, so that both **extreme rainfall events** and very dry summers will occur more often.

Studies of climate change impacts on Arctic ecosystems have so far focused more on warming than on rainfall, even though heavy rainfall may substantially affect **permafrost degradation**, **plant growth** and various other aspects of tundra **ecosystem functioning**. Time for a new series of experiments focusing on **T**undra **R**ainfall **EX**tremes - The **T-REX Project**!

Fig 2) Climate projections *indicate increases in rainfall and increased inter-annual variability*



Making it rain on Svalbard!

How do we know what the impacts of future heavy rainfall events may be? **By making it rain!** We have run irrigation experiments on Svalbard that **simulate future changes** across a range of ecosystems and monitored a wide range of ecosystem variables. Earlier work[1] in Alaska and Siberia showed **increased permafrost thaw** under heavy rainfall. Could this be different on Svalbard?

We have laid out control and treatment plots, of which treatment plots have received an approximate **doubling (+50mm) of average summer rainfall**. Different treatments received irrigation at different moments, to assess whether **timing of rainfall events** co-determines their impact.

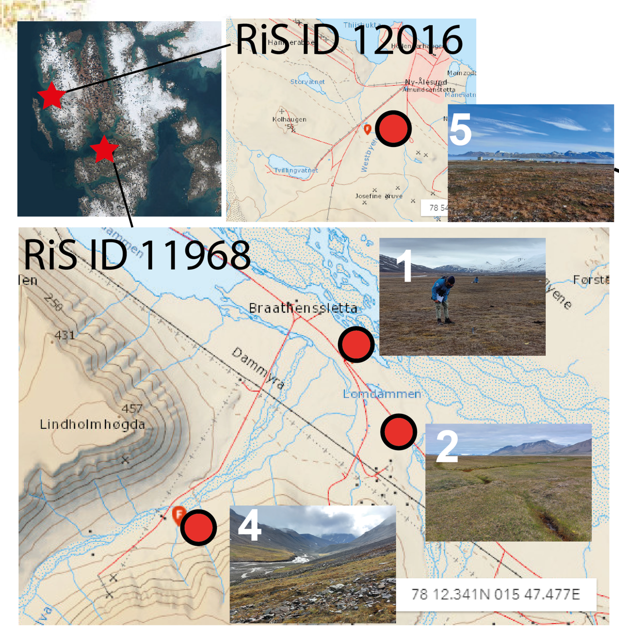
Our experimental sites represent a **variety of ecosystems** (soil type, terrain, plant community). We expect that impacts may differ across such gradients, for instance among wetter and drier sites.

We continue to **monitor a range of environmental variables** (see progress overview) for several years to assess whether impacts of a very wet summer may be felt for **multiple years** and across multiple levels of ecosystem functioning.

1) e.g. Magnússon et al. (2022) Extremely wet summer events enhance permafrost thaw for multiple years in Siberian tundra. *Nat. Comms.*

SPATIAL DESIGN

4 locations - variable conditions

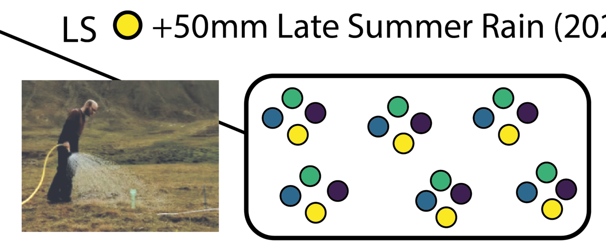


1 - Adventdalen (river terrace, silty sand)
2 - Adventdalen (polygonal tundra, organic soil)
4 - Endalen (slope, rocky soil)
5 - Ny-Alesund (esker, rocky soil)

EXPERIMENTAL DESIGN

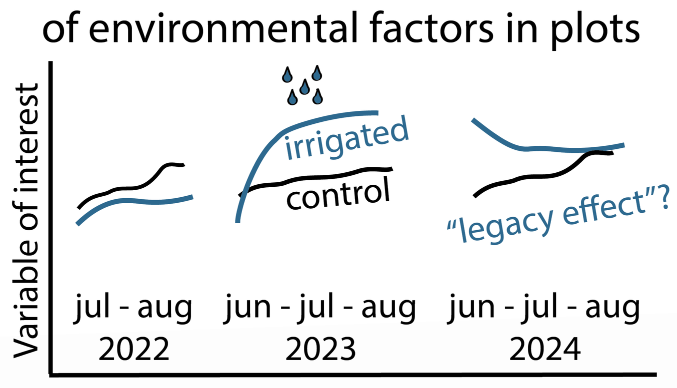
6-7 replicate sets of 4 treatments:

- C — Control (No Extra Rain)
- I — +50mm Late Summer Rain (2022)
- ES — +50mm Early Summer Rain (2023)
- LS — +50mm Late Summer Rain (2023)



MULTI-YEAR MONITORING

of environmental factors in plots



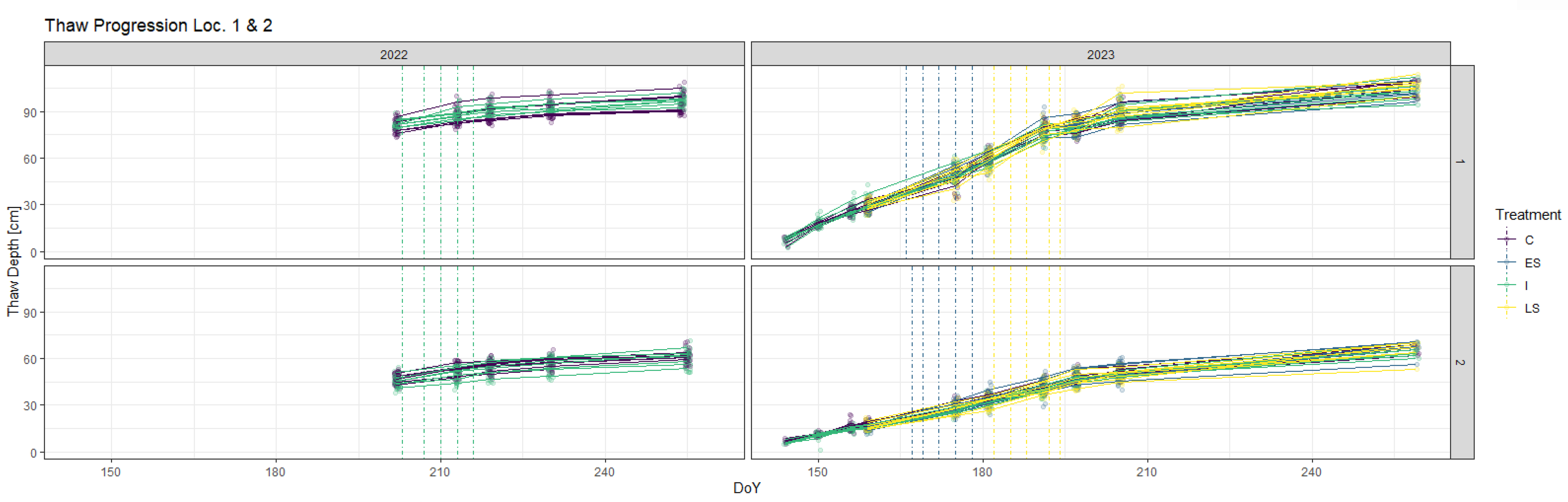


Fig 3) Thaw progression *for Locations 1 (Adventdalen, river terrace, mineral soil) and 2 (Adventdalen, polygonal tundra, wet organic soil). C = ‘control’, I = “late summer irrigation 2022”, ES = “early summer irrigation 2023” and LS = “late summer irrigation 2023”. Vertical coloured lines indicate irrigation timing.*

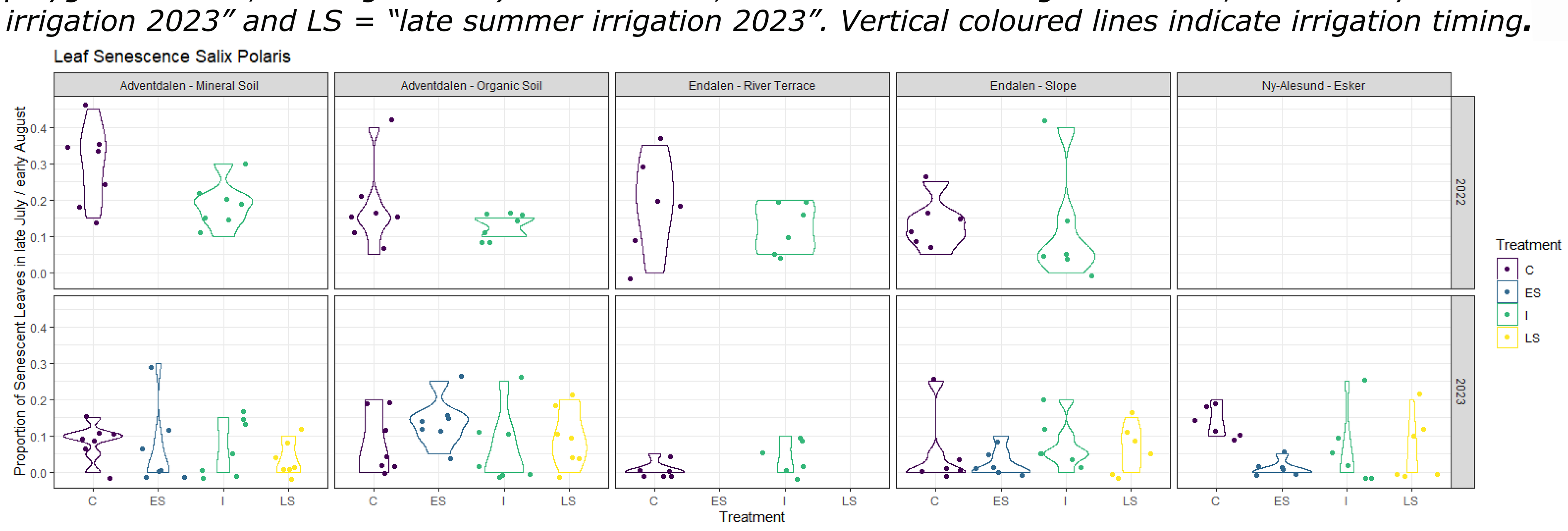


Fig 4) Proportion (0-1) of senescent leaves *from a random 10 leaf sample per plot in late summer 2022 (August 3rd) and 2022 (around July 20th), shown per location per year. C = ‘control’, I = “late summer irrigation 2022”, ES = “early summer irrigation 2023” and LS = “late summer irrigation 2023”.*

Selected Preliminary Findings

Permafrost dynamics under rainfall extremes

- **No significant contrasts in active layer thickness**, nor evidence of carry-over effects to the next summer season (**Fig. 3**).
- **Temporarily increased thaw rates** [mm/day] of permafrost under early and late summer irrigation in 2023, but only in dry mineral soils (Adventdalen, Location 1). This suggests that impacts of heavy rainfall events on permafrost thaw on Svalbard are comparatively **local, minor and of short duration** compared to other Arctic regions.

Vegetation dynamics under rainfall extremes

- **Significantly lower senescence of polar willow leaves in irrigated sites** in late summer in 2022. In 2023, irrigation effects were only significant in experimental plots in Ny-Alesund (Location 5) (**Fig. 4**).
- **Late-season photosynthetic activity** of polar willow leaves was significantly associated with plot level moisture in 2022.
- No significant effect of irrigation treatments on vegetation height, leaf size or N-content. Tendency ($p < 0.1$) for higher plot-level NDVI after early summer irrigation in 2023.
- This suggests a **potential minor “greening” under early summer rainfall**, and **potential alleviation of drought-induced growth limitations under late season rainfall**

Expected Data

- Lab & microscope analysis for plant root traits, litter decomposition rates, insect emergence and tree-ring width & wood vessel size of polar willow

Project Timeline

	Summer 2022 C & I Treatment		**Summer 2023** C, I (legacy effect), ES & LS Treatment		**Summer 2024** Final Sampling & Monitoring	
Permafrost & Soil Thermal Regime Monitoring	monitoring	data analysis	monitoring	data analysis	monitoring	data analysis
Arthropod Abundance & Emergence Monitoring			monitoring	lab & data analysis	.. + drone flights?	
Vegetation Productivity & Phenology Monitoring	monitoring	data analysis	monitoring	data analysis	monitoring	data analysis
Litter Decomposition & Root Trait Monitoring			sampling	lab & data analysis		
Tree Ring & Wood Anatomical Response (*Salix polaris*)			pilot sampling	lab & data analysis	sampling	lab & data analysis

Forskningsrådet
Arctic Field Grant 2023

KNAW
KNAW Fund Ecology 2023

INTER ⇌ ACT
EU INTERACT Transnational Access Grant 2023

.. looking for funds for summer 2024! ;)

Updates & Datasets

RiS ID: 11968 & 12016

Research in Svalbard

Blogs, Photos & Artwork

www.runamagnusson.com & LinkedIn