ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Thawing Permafrost worldwide

A new app- & community-driven monitoring project

Julia Boike[1], Norbert Anselm[2], Sarah Chadburn[3], Julia Martin[2], Simon Zwieback[4] & T-MOSAiC Thaw Action Group

[1]AWI Geosciences – Permafrost Research, [2]AWI Computing & Data Centre – Data Logistics Support, [3]University of Exeter, [4]University of Alaska Fairbanks

November 9, 2021

Facts

Widespread warming of permafrost is observed (Biskaborn et al. 2019) → Warming leads to *permafrost thaw*



- Thaw monitored in isolated locations, but not systematically.
- Thaw can lead to major greenhouse gas emission, so we must include permafrost thaw in global climate models.
- Arctic landscape and thus thaw rate is highly heterogeneous: Factors vary on multiple spatial scales. We need to better understand this to make global assessments.

T-MOSAiC Permafrost thaw action group

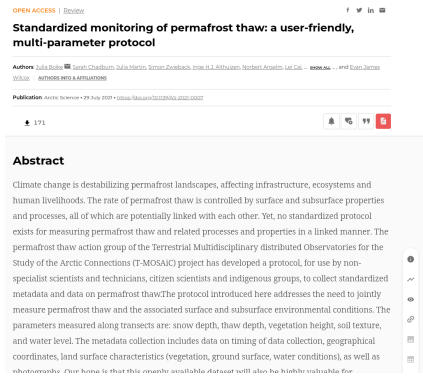
Coordinated by Julia Boike, Simon Zwieback, Sarah Chadburn, Julia Martin (2019-2021)
15 participants from 10 countries

Objectives

- Better monitor and understand permafrost thaw
- Establish a baseline of data from around the permafrost region

Method

- Develop a sampling protocol for standardized field measurements of processes related to permafrost thaw
- Establish cooperative work (e.g. INTERACT)
- Planned: Get everyone on board (citizen science)



OPEN ACCESS | Review

Standardized monitoring of permafrost thaw: a user-friendly, multi-parameter protocol

Authors: Julia Boike, Sarah Chadburn, Julia Martin, Simon Zwieback, Inge H.J. Althuizen, Norbert Anselm, Lei Cai, ... and Evan James Wilcox | AUTHORS INFO & AFFILIATIONS

Publication: Arctic Science • 29 July 2021 • https://doi.org/10.1139/AS-2021-0007

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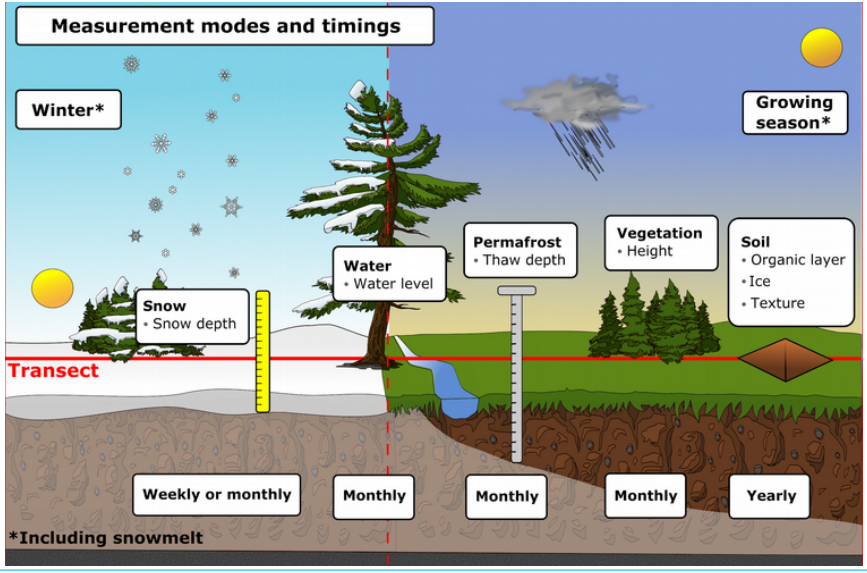
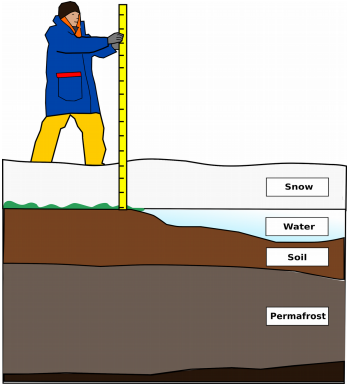
Abstract

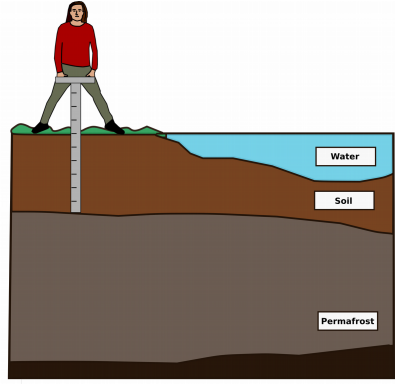
Climate change is destabilizing permafrost landscapes, affecting infrastructure, ecosystems and human livelihoods. The rate of permafrost thaw is controlled by surface and subsurface properties and processes, all of which are potentially linked with each other. Yet, no standardized protocol exists for measuring permafrost thaw and related processes and properties in a linked manner. The permafrost thaw action group of the Terrestrial Multidisciplinary distributed Observatories for the Study of the Arctic Connections (T-MOSAiC) project has developed a protocol, for use by non-specialist scientists and technicians, citizen scientists and indigenous groups, to collect standardized metadata and data on permafrost thaw.The protocol introduced here addresses the need to jointly measure permafrost thaw and the associated surface and subsurface environmental conditions. The parameters measured along transects are: snow depth, thaw depth, vegetation height, soil texture, and water level. The metadata collection includes data on timing of data collection, geographical coordinates, land surface characteristics (vegetation, ground surface, water conditions), as well as photographs. Our hope is that this openly available dataset will also be highly valuable for

doi.org/10.1038/s41467-018-08240-4


Measurement modes and timings
Winter*
Growing season*
Snow
• Snow depth
Water
• Water level
Permafrost
• Thaw depth
Vegetation
• Height
Soil
• Organic layer
• Ice
• Texture
Transect
Weekly or monthly
Monthly
Monthly
Monthly
Yearly
*Including snowmelt

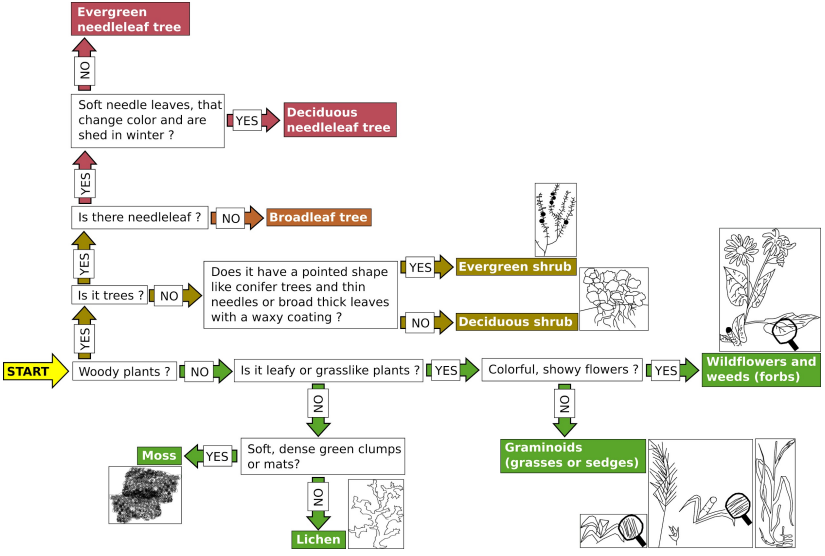


Snow depth

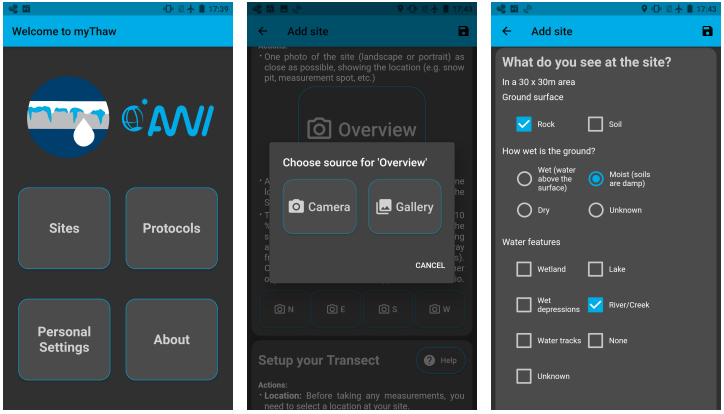


Thaw depth

Vegetation height


START
Woody plants ?
NO
Is it leafy or grasslike plants ?
YES
Colorful, showy flowers ?
YES
Wildflowers and weeds (forbs)
NO
Graminoids (grasses or sedges)
NO
Soft, dense green clumps or mats?
YES
Moss
NO
Lichen
YES
Is it trees ?
NO
Does it have a pointed shape like conifer trees and thin needles or broad thick leaves with a waxy coating ?
YES
Evergreen shrub
NO
Deciduous shrub
YES
Is there needleleaf ?
NO
Broadleaf tree
YES
Soft needle leaves, that change color and are shed in winter ?
YES
Deciduous needleleaf tree
NO
Evergreen needleleaf tree

myThaw mobile app to collect permafrost data

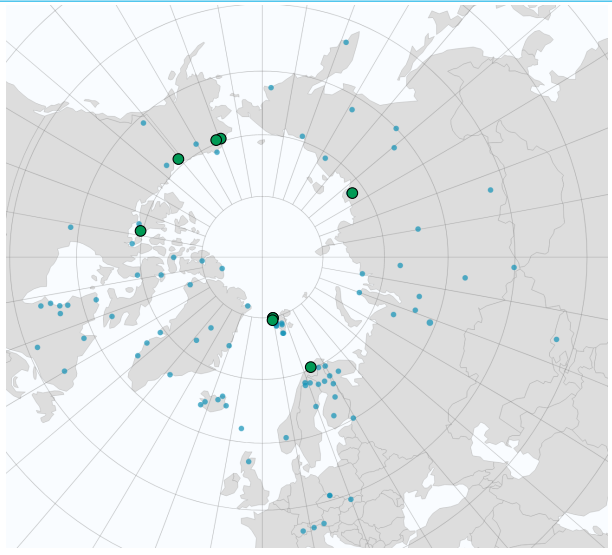


Please contact us if you would like to use it and contribute data!

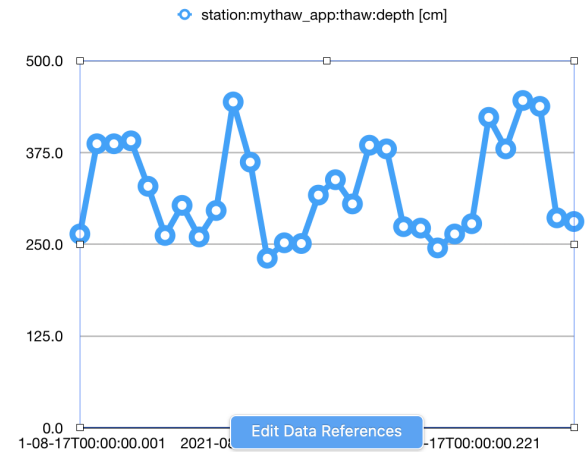
INTERACT

datasets until November 9, 2021

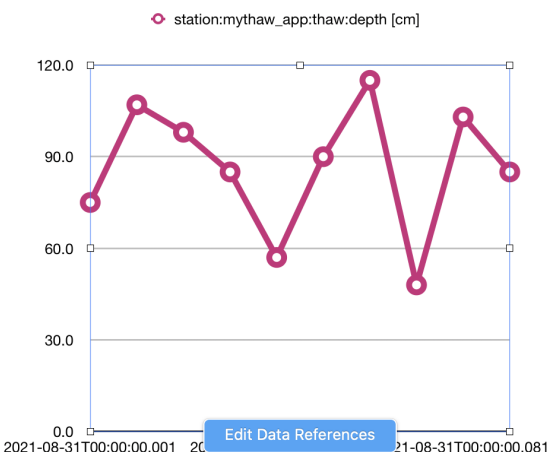
- Bayelva
- Bayelva March 2021
- Cambridge Bay
- Toolik Lake
- Siksik Creek (TVC)
- Kevo Vaisejaeggi
- CNR@Bayelva
- 01_Samoylov
- Toolik Field Station



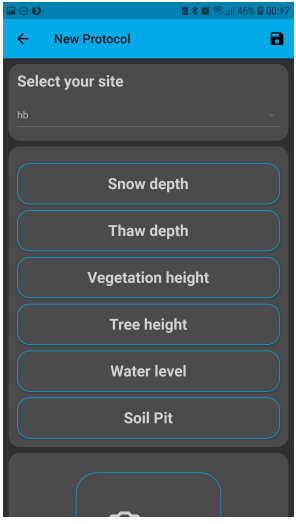
First data



Trail Valley Creek



Bayelva



myThaw Permafrost Observation App

Overview | Contacts | Actions | Parameters | Resources | Properties | Local Frame | Subdevices | Images | Ingest

Current Version

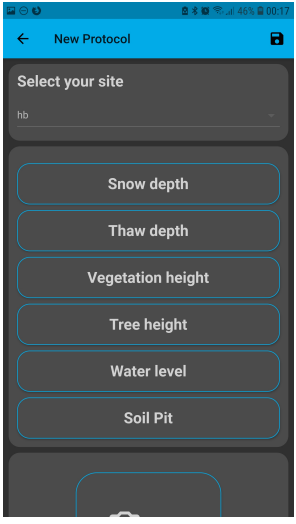
Reassign Edit

Sensor (2021). Metadata for station myThaw Permafrost Observation App at Current Version. https://hdl.handle.net/10013/sensor.9d5e7c8a-051b-4f74-89a4-127b9a9af655

State:	Construction | Public | Store
ID:	7938
Parent:	
Device URN:	station:mythaw_app
Short Name:	mythaw_app
Long Name:	myThaw Permafrost Observation App
Collections:	
Description:	This metadata description follows the protocol of the T-MOSAiC Thaw Action Group. Via App permafrost thaw and the associated surface and subsurface environmental conditions are measured. Each sub-protocol is defined in a sub-device here. The app can be found i) for Android OS https://play.google.com/store/apps/details?id=de.awi.permafrost, and ii) iOS https://apps.apple.com/us/app/mythaw/id1578278222?ign-mpt=uo%3D2.
Serial:	
Manufacturer:	
Model:	
Type:	station
Asset Number:	

Download sensor metadata as: Sensor ML | JSON

Close



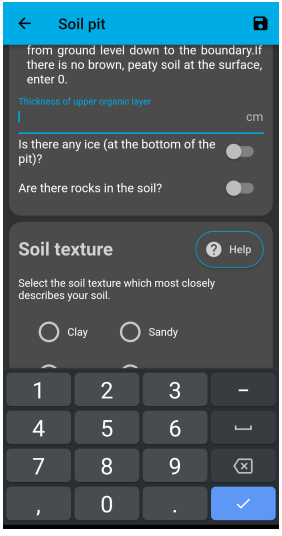
myThaw Permafrost Observation App

Overview | Contacts | Actions | Parameters | Resources | Properties | L

Current Version

Subdevices:

- myThaw App Hydrology section (hydrology)
- myThaw App Site Metainformation (meta)
- myThaw App Soil Pit section (pit)
- myThaw App Snow section (snow)
- myThaw App Permafrost Thaw section (thaw)
- myThaw App Tree section (trees)
- myThaw App Vegetation section (vegetation)



myThaw App Soil Pit section

Overview | Contacts | Actions | Parameters | Resources | Properties | Local Frame | Subdevices | Images | Ingest

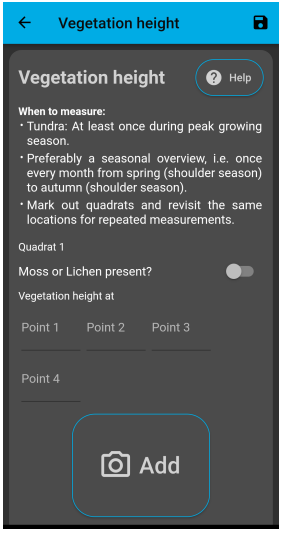
Current Version

Show 25 entries Search:

ID	Short Name	Name	Type	Unit	Tools
91989	ice	Soil pit ice presence at the bottom	text	text	
91990	ice_photo	Soil pit ice presence at the bottom photo	text	text	
91994	notes	Soil pit notes	text	text	
91988	organic_layer	Soil pit estimation of upper organic layer thickness (m)	height	cm	
91987	photo	Soil pit photo with scale	text	text	
91991	rock	Soil pit rock presence	text	text	
91992	rock_photo	Soil pit rock presence photo	text	text	
91993	soil_texture	Soil pit texture description	text	text	

Showing 1 to 8 of 8 entries Previous 1 Next

Close



myThaw App Vegetation section

Overview | Contacts | Actions | Parameters | Resources | Properties | Local Frame | Subdevices | Images | Ingest

Current Version

Show 25 entries Search:

ID	Short Name	Name	Type	Unit	Tools
91969	height_p1	Vegetation height point 1 in quadrant (m)	height	cm	
91970	height_p2	Vegetation height point 2 in quadrant (m)	height	cm	
91971	height_p3	Vegetation height point 3 in quadrant (m)	height	cm	
91972	height_p4	Vegetation height point 4 in quadrant (m)	height	cm	
91968	moss_lichen	Vegetation presence of moss lichen	text	text	
91974	notes	Vegetation notes	text	text	
91967	transect_point	Vegetation transect point ID	index	number	
91973	vegetation_photo	Vegetation photo	picture	text	

Showing 1 to 8 of 8 entries Previous 1 Next

Close

get a glimpse on what's coming in

deviceID	dom	siteID	idx	thawDepth	thawNotes	thawPhoto	thawDepthError
e5e0f050-1764-4c90-a514-07aecf0530ab	2021-08-31	CNR@Bayelva	0	75	the site has a rocky soil and so some measurements could be underestimated	20211103_e2801f9c-97c2-405e-9a89-a92d567dc2d3.jpg	10
e5e0f050-1764-4c90-a514-07aecf0530ab	2021-08-31	CNR@Bayelva	1	107	the site has a rocky soil and so some measurements could be underestimated	20211103_e2801f9c-97c2-405e-9a89-a92d567dc2d3.jpg	10
e5e0f050-1764-4c90-a514-07aecf0530ab	2021-08-31	CNR@Bayelva	2	98	the site has a rocky soil and so some measurements could be underestimated	20211103_e2801f9c-97c2-405e-9a89-a92d567dc2d3.jpg	10
e5e0f050-1764-4c90-a514-07aecf0530ab	2021-08-31	CNR@Bayelva	3	85	the site has a rocky soil and so some measurements could be underestimated	20211103_e2801f9c-97c2-405e-9a89-a92d567dc2d3.jpg	10
e5e0f050-1764-4c90-a514-07aecf0530ab	2021-08-31	CNR@Bayelva	4	57	the site has a rocky soil and so some measurements could be underestimated	20211103_e2801f9c-97c2-405e-9a89-a92d567dc2d3.jpg	10
e5e0f050-1764-4c90-a514-07aecf0530ab	2021-08-31	CNR@Bayelva	5	90	the site has a rocky soil and so some measurements could be underestimated	20211103_e2801f9c-97c2-405e-9a89-a92d567dc2d3.jpg	10

Tab. 1) excerpt from dataset 1264013 (originally 10 × 73 array)

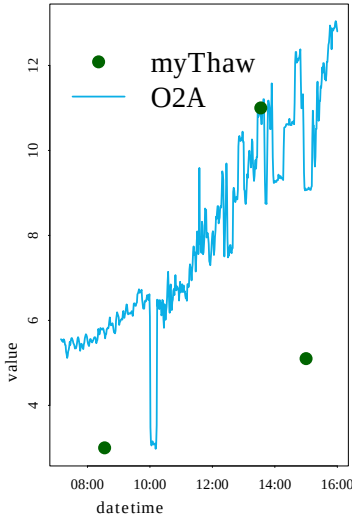
fitting a workflow

O2A

- steady stream of consecutive measurements
- datetime as central index

myThaw

- repetitive but rather sporadic measurements
- index? what is it and how much do we need? ← based on datasets



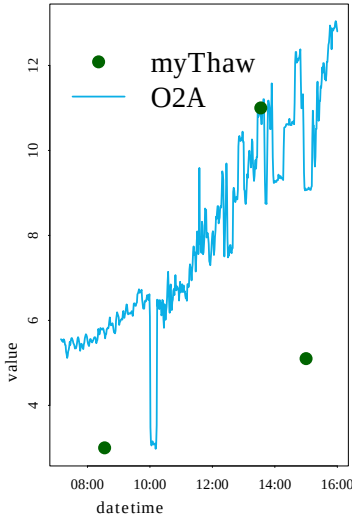
fitting a workflow

O2A

- steady stream of consecutive measurements
- datetime as central index
- simple aggregation possible on numeric data

myThaw

- repetitive but rather sporadic measurements
- index? what is it and how much do we need? ← based on datasets
- no aggregation possible



fitting a workflow

O2A

- steady stream of consecutive measurements
- datetime as central index
- simple aggregation possible on numeric data
- for near-real time data until 03/2020 focus on numeric data only
- „easy“ automation of data handling & analyses

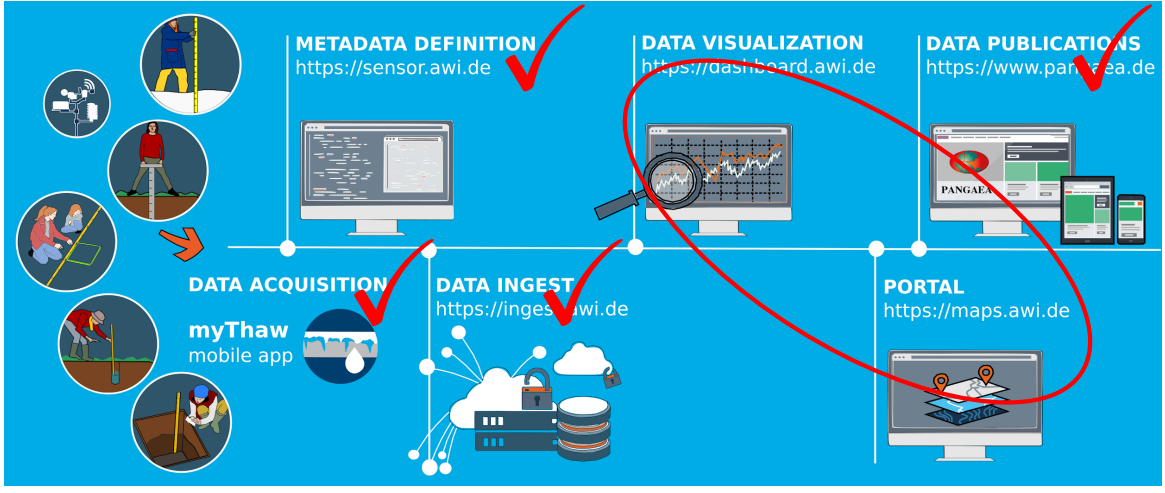
myThaw

- repetitive but rather sporadic measurements
- index? what is it and how much do we need? ← based on datasets
- no aggregation possible
- several flavors (metric vs. interval, strings vs. numerals)
- (expert) knowledge required for processing

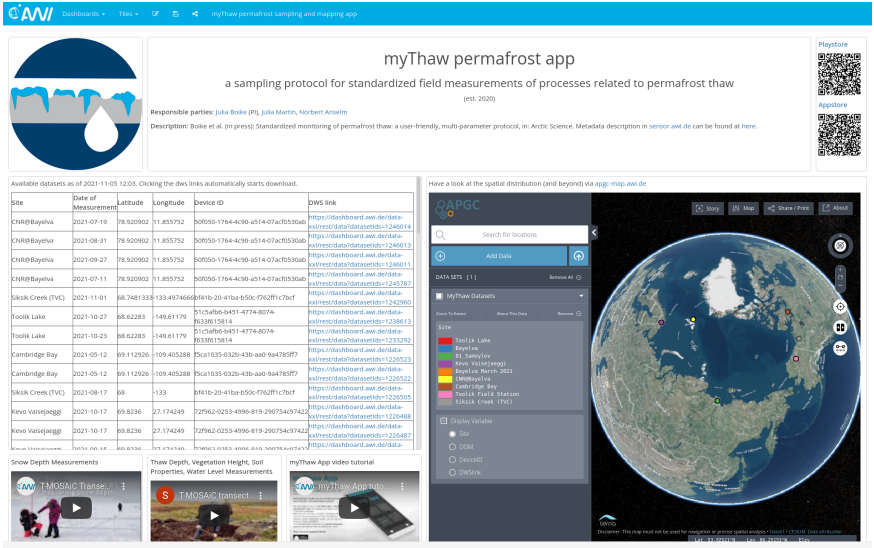
challenge to cover

- strings as in comments/notes → `Approximately 150m away from camp`
- strings as in Booleans → `True`
- strings as in filenames → `20211103_0cf62570-8f2d-4ce9-b844-cf316dd3da9d.jpg`
- strings as in categorial data → `Lichen`

we're doing pretty good – mostly



what we can do for now. . .



myThaw dashboard

what's the plan ...

- make use of existing infrastructure/know how
  - VMs → marketplace.awi.de/
  - make use of APIs
  - functions → (partly) existing

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- make use of existing infrastructure/know how
  - VMs → marketplace.awi.de/
  - make use of APIs
  - functions → (partly) existing
- Shiny application as a central place to go
  - avoid „coding" → click and go
  - „hide" complex procedures
  - per protocol type → specific topics, questions, plot types

what's the plan ...

Listing 1) 'harvest dataset IDs'

```
declare -a ids
for i in $len; do ids+=(`echo $tmp | jq .[$i].id`); done
idsSorted=` printf "%s\n" "${ids[@]}" | sort -n `
idsSortedTop=`printf '%s\n' "${idsSorted[@]}" | tac | tr '\n' ' ';
    echo`
table=''
for i in $idsSortedTop; do
    did=$i &&
  id=`curl --silent -X GET "$link$did" -H "accept:
      application/json;charset=UTF-8"` &&
  a=`echo $id | jq .data[0][3] | sed s/\"//g` &&
  b=`echo $id | jq .data[0][2] | cut -c2-11 | sed s/\"//g` &&
  c=`echo $id | jq .data[0][1] | tr -d 'null | sed s/\"//g'` &&
  d=`echo $id | jq .data[0][5] | sed s/\"//g` &&
  e=`echo $id | jq .data[0][6] | sed s/\"//g` &&
  hyper=`echo $link$did || sed s/\"//g` &&
  table=$table'<tr style=\"height: 18px;\">\n<td style=\"
      width: 16%; height: 18px;\">'$a'</td><td style=\"width:
       10%; height: 18px;\">'$b'</td><td style=\"width: 7%;
      height: 18px;\">'$d'</td><td style=\"width: 7%; height:
      18px;\">'$e'</td><td style=\"width: 27%; height: 18px;\
      ">'$c'</td><td style=\"width: 27%; height: 18px;\"><a
      href='$hyper'>'$hyper'</a></td></tr>'
        done
##
```

- make use of existing infrastructure/know how
  - VMs → marketplace.awi.de/
  - make use of APIs
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what's the plan ...

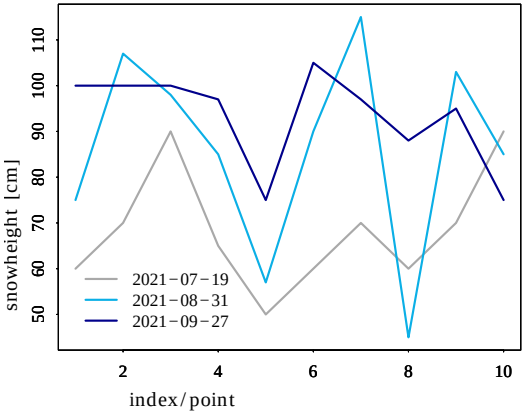

Fig. 1) snow height of CNR@Bayelva from 1246014, 1246013, 1246011

- make use of existing infrastructure/know how
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what's the plan ...

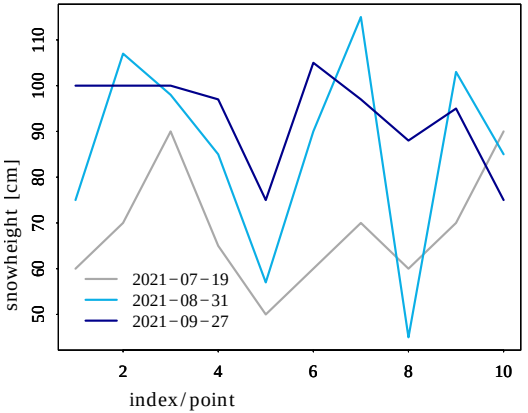

Fig. 1) snow height of CNR@Bayelva from 1246014, 1246013, 1246011

- make use of existing infrastructure/know how
  - VMs → marketplace.awi.de/
  - make use of APIs
  - functions → (partly) existing
- Shiny application as a central place to go
  - avoid „coding" → click and go
  - „hide" complex procedures
  - per protocol type → specific topics, questions, plot types
- can be adapted → extending user domain

conclusions

- novel approach to collect data on permafrost (thaw)
- we want to go big data
- easy to use tool needs easy to use exploration
- complex data needs complex treatment
- extending the field of application for O2A

Thank you

References I

Biskaborn, Boris K., Sharon L. Smith, Jeannette Noetzli, Heidrun Matthes, Gonçalo Vieira, Dmitry A. Streletskiy, Philippe Schoeneich, Vladimir E. Romanovsky, Antoni G. Lewkowicz, Andrey Abramov, Michel Allard, Julia Boike, William L. Cable, Hanne H. Christiansen, Reynald Delaloye, Bernhard Diekmann, Dmitry Drozdov, Bernd Etzelmüller, Guido Grosse, Mauro Guglielmin, Thomas Ingeman-Nielsen, Ketil Isaksen, Mamoru Ishikawa, Margareta Johansson, Halldor Johannsson, Anseok Joo, Dmitry Kaverin, Alexander Kholodov, Pavel Konstantinov, Tim Kröger, Christophe Lambiel, Jean-Pierre Lanckman, Dongliang Luo, Galina Malkova, Ian Meiklejohn, Natalia Moskalenko, Marc Oliva, Marcia Phillips, Miguel Ramos, A. Britta K. Sannel, Dmitrii Sergeev, Cathy Seybold, Pavel Skryabin, Alexander Vasiliev, Qingbai Wu, Kenji Yoshikawa, Mikhail Zheleznyak, and Hugues Lantuit (Jan. 2019). "Permafrost is warming at a global scale". en. In: *Nature Communications* 10.1, p. 264. DOI: 10.1038/s41467-018-08240-4. URL: https://www.nature.com/articles/s41467-018-08240-4 (visited on 11/01/2021).

Boike, Julia, Sarah Chadburn, Julia Martin, Simon Zwieback, Inge H.J. Althuizen, Norbert Anselm, Lei Cai, Stéphanie Coulombe, Hanna Lee, Anna K. Liljedahl, Martin Schneebeli, Ylva Sjöberg, Noah Smith, Sharon L Smith, Dmitry A. Streletskiy, Simone Maria Stuenzi, Sebastian Westermann, and Evan James Wilcox (July 2021). "Standardized monitoring of permafrost thaw: a user-friendly, multi-parameter protocol". In: *Arctic Science*. Publisher: NRC Research Press. DOI: 10.1139/AS-2021-0007. URL: https://cdnsciencepub.com/doi/10.1139/AS-2021-0007 (visited on 08/16/2021).

Koppe, Roland, Peter Gerchow, Ana Macario, Antonie Haas, Christian Schäfer-Neth, and Hans Pfeiffenberger (June 2015). "O2A: A Generic Framework for Enabling the Flow of Sensor Observations to Archives and Publications". In: *OCEANS 2015 Genova*. DOI: 10.1109/OCEANS-Genova.2015.7271657. URL: https://epic.awi.de/id/eprint/38295/.