

Soil moisture, soil temperature and air temperature measurements

Motivation

Soil moisture, soil temperature and air temperature are central abiotic variables in several COAT modules.

State variables:

Temperature data is used to calculate the following state variables:

- Ground temperature (C12)
- Timing of snowmelt (C1)
- Soil moisture (C19)

Reference to method:

Soil moisture and temperature are measured using TMS-4 data loggers (TOMST, Prague, Czech Republic). The loggers are recording soil moisture and soil temperature at - 6 cm (below ground) and air temperature at +2 cm and +15 cm with a logging interval of 15 minutes (Wild et al. 2019).

Spatial study design

Temperature and soil moisture is measured within the COAT Varanger intensive study design in Vestre Jakobselv and Komagdalen. Loggers are placed in heath, meadow and snowbed sites which are included in an herbivore enclosure experiment.

Meadow and heath sites are included at Vestre Jakobselv, where they are nested in two river valley sections, each section having 4 or 5 sites in meadow habitat and 4 or 5 sites in heath habitat near to productive areas (river valleys).

Snowbed sites are included at Vestre Jakobselv and Komagdalen. At Vestre Jakobselv, they are grouped to two altitudinal transects (sections Torvhaugdalen and Tranemyra forming one transect, whereas Bearalveaijohka and Gåsevannan form another transect). Majority of the sites are in the sections Torvhaugdalen and Bearalveaijohka, and the additional sites were added partly to logistic reason (i.e. large enough vegetated patches where enclosures could be established) and partly to extend the altitudinal transect. At Komagdalen, they are grouped in two altitudinal transects (sections Ruossachokka and Kjøltindan).

At each site, there is one TMS-4 logger which is placed in one corner of the small herbivore enclosure.

The complete list of siteIDs included in the current data collection is:

Heath and meadow sites:

Locality	Section	Site ID meadow (m)	Site ID heath_near (hn)
Vestre Jakobselv (vj)	Torvhaugdalen (to)	vj_to_m_a vj_to_m_b vj_to_m_c vj_to_m_d	vj_to_hn_a2 vj_to_hn_b2 vj_to_hn_c vj_to_hn_d
Vestre Jakobselv (vj)	Bearaveaijohka (be)	vj_be_m_a vj_be_m_b vj_be_m_c vj_be_m_d vj_be_m_e	vj_be_hn_a vj_be_hn_b vj_be_hn_c2 vj_be_hn_d2 vj_be_hn_e2

These sites are in the GPS-file "intensive sites meadow heath Varanger 2020.gpx".

<https://uitno.app.box.com/file/655735580225>

Snowbed sites:

Locality	Section	Site_ID snowbed (sn)
Vestre Jakobselv (vj)	Torvhaugdalen (to)	vj_to_sn_3, vj_to_sn_6, vj_to_sn_13, vj_to_sn_14, vj_to_sn_20, vj_to_sn_22, vj_to_sn_25
Vestre Jakobselv (vj)	Tranemyra (tr)	vj_tr_sn_2
Vestre Jakobselv (vj)	Bearaveaijohka (be)	vj_be_sn_1, vj_be_sn_8, vj_be_sn_12, vj_be_sn_13, vj_be_sn_14, vj_be_sn_17, vj_be_sn_22
Vestre Jakobselv (vj)	Gåsevannan (ga)	vj_ga_sn_2
Komagdalen (ko)	Ruossachokka (ru)	ko_ru_sn_1, ko_ru_sn_5, ko_ru_sn_8, ko_ru_sn_13, ko_ru_sn_14, ko_ru_sn_16, ko_ru_sn_19
Komagdalen (ko)	Kjøltindan (kj)	ko_kj_sn_2, ko_kj_sn_5, ko_kj_sn_7, ko_kj_sn_10, ko_kj_sn_13, ko_kj_sn_14, ko_kj_sn_17, ko_kj_sn_18

These sites are in the GPS-files "snowbeds lemming transect 2019.gpx" and "small mammal cameras 2019.gpx"

<https://uitno.app.box.com/file/354916477175> and

<https://uitno.app.box.com/file/356643069925>

Temporal study design

First loggers were established in 2020 at Vestre Jakobselv, but most loggers were established, at both localities, in 2021. Soil moisture and temperature is recorded the whole year with a logging interval of 15 minutes. Loggers are downloaded once a year in late July or beginning of August.

Procedure

Deploying the loggers – done only once

The loggers are placed in one of the corners inside the small herbivore enclosure (enclosure number 1 in heath and meadow sites). Preferably, loggers are placed in the upper left corner when facing towards the thicket/river in heath and meadow sites or in the upper left corner when facing uphill in snowbed sites. However, the position might need to be adjusted in order to find a position where the

soil is deep enough that entire belowground part of the logger (green part) is in contact with the soil. Use the metal blade to find a suitable position and then insert the logger carefully in the ground. The logger has to be at least 10 cm away from the vegetation plot (Figure 1)! If no appropriate spots are found in the small herbivore enclosure, the second small herbivore enclosure or the large herbivore enclosure can be used. In such case, loggers are also placed in the upper left corner when facing towards the thicket. If it is not possible to place the logger in this corner, find another spot not more than 30 cm away from the border of the large herbivore enclosure.

After deploying the logger, characterize the vegetation and soil around the logger:

Vegetation: Measure the vegetation height and the depth of the moss layer where you placed the logger.

Soil: Use a soil corer to take a soil sample next to the logger, but outside the plot. Measure the depth of the organic layer and write down whether the main soil type (more than 50 % of the soil core) is organic (mix of dark brown soil and litter), mineral (lighter brown, no litter) or peat. We want to know what kind of soil is in the 10cm layer that the logger is measuring. For mineral soils, estimate the percentage of sand, silt and clay. Also do this for organic soils if they have some mineral content.

Particle sizes:

Sand: 0.063-2 mm

Silt: 0.002-0.063 mm

Clay: <0.002

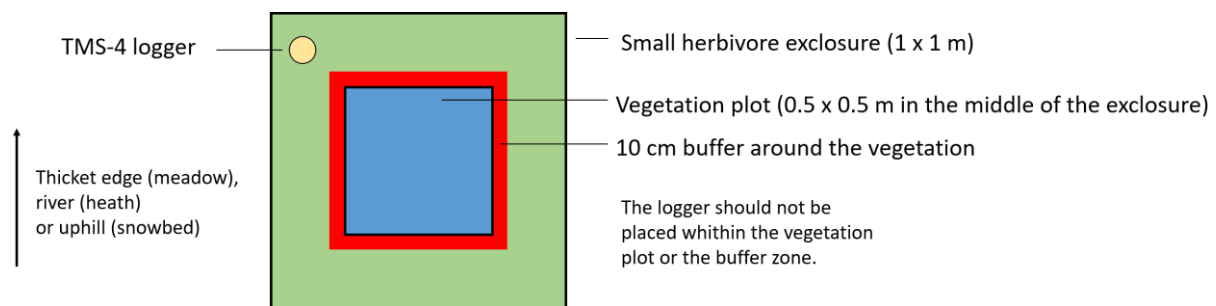


Figure 1: Position of a TMS-4 logger within a small herbivore enclosure. If necessary, the position of the logger can be moved within the green area.

Downloading data from the loggers – done annually

The program Lolly is used to download data from the loggers and can be downloaded from <https://tomst.com/web/en/systems/tms/software/>. Install the program before fieldwork!

It is recommended to download the loggers directly in the field. If that is not possible, for example if no field-computer is available, the loggers can be collected, downloaded in the cabin and deployed again. Label the loggers with the site ID if the loggers are collected!

1. Open the Lolly program
2. Go to the 'Options' tab and make sure that 'Read data' is ticked.

3. Select either 'Read all' for downloading all data or 'Read from date' and specify a date for downloading data from a specific date onwards (should be before the logger has been downloaded previously).
4. Select the folder where you want to save the data ('Save folder')
5. Go back to the 'Info' tab
6. Connect the TMS adapter to the computer
7. Remove the white plastic lid on top of the logger and connect the adapter to the top of the logger. Hold the adapter on top of the logger until downloading the data has finished. A window that shows the data will open.
8. Remove the adapter and put the plastic lid back on the logger
9. Go to the folder where the data was saved and check that the download was successful. There should be three new files, starting with binary_, command_ and data_.
10. Rename the data file with site id and year (e.g. vj_to_m_a_2021.csv).

Equipment needed

- TMS-4 loggers (when deploying new loggers)
- Metal blade to find a position for the logger (when deploying new loggers)
- Soil corer (when deploying new loggers)
- TMS adapter and cable (when downloading loggers)
- Computer with Lolly installed (when downloading loggers)
- Fieldbook and pencil
- Knife/scissors to open the exclosures
- Tie wraps to close the exclosures

Information recorded in the field

For each logger you deploy or download, write down in your notebook the site id, the serial number of the logger (written on the side) and at what date and time the logger is deployed or downloaded.

When deploying new loggers, record vegetation and soil classification as described in Appendix 3.

If collecting loggers without downloading them directly, make sure to mark the logger with the correct site ID and write down at what date and time the logger is collected and deployed again.

Data processing

Data from each downloaded logger is stored as a separate .csv file. These should be named with the site ID, treatment and year (for example 'vj_to_m_a_all_herbivore_exclosure_2021.csv' for file from vestre_jakobselv_torvhaugdalen_meadow_a).

Metadata (i.e. dates when loggers were deployed and downloaded, additional comments) should be entered in a metadata sheet (file "template_tomst_loggers_Varanger_metadata_version2021" in the Box folder "COAT/protocol/data typing templates" link:

<https://uitno.app.box.com/file/819366008688>). Save metadata file as txt-file with the name soil_moisture_temperature_metadata_VJ_2021.txt'.

Send all data files and metadata files to Eeva Soininen (eeva.soininen@uit.no).

Training requirements and specialized skills

No specialized skills are needed. New field observers should be trained by experienced field observers and read the protocol carefully.

References

Wild J., Kopecký M., Macek M., Šanda M., Jankovec J., & Haase T. (2019) Climate at ecologically relevant scales: A new temperature and soil moisture logger for long-term microclimate measurement. *Agricultural and Forest Meteorology*, 268, 40–47.

Appendices

1 Link to the TMS-4 Handbook

https://tomst.com/web/wp-content/uploads/2019/08/TMS_manual_english_ver-3.pdf

2 Preparation of new loggers

New loggers come basically ready to be deployed. They are started and set to a logging interval of 15 minutes. However, they should be tested to make sure that all loggers work properly.

1. Put the loggers for a few days in a place with known temperature, for example a cold room. Write down the date and time when you put in and when you take out the loggers as well as the temperature.
2. Repeat step 1 if another place with known temperature is available.
3. Download the data from the logger as described in '*Downloading data from the loggers*' but rename the csv-files to logger-id_test.csv (e.g. tms_94213448_test.csv). The logger-id is written on the side of the logger.
4. Check the graph that pops up when the download finished looks fine (temperature change when you put the logger in the cold room).
5. Check that the logging interval is set to 15 minutes (Basic mode). Change the logging interval is necessary