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WHICH CARBON SOURCES ARE RELEASED FROM THAWING PERMAFROST SOILS IN THE HIGH ARCTIC?

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INDRODUCTION & AIM

Global warming is most pronounced in Arctic regions, where temperatures have risen twice as quickly the last decades compared to the global average. About 25% of the northern circumarctic region is underlain by permafrost and this large area contains a vast carbon (C) pool that is about twofold of the C amount currently in the atmosphere. This frozen organic matter (OM), partly accumulated thousands of years ago, will become available for microbial turnover in a warmer world causing thawing of permafrost and enhancing microbial turnover of previously frozen OM resulting finally in its release to the atmosphere as climate-relevant greenhouse gases. Little information is so far available about which substrates aremicrobially degraded upon permafrost thaw.

AIM: In this study we used radiocarbon (^{14}C) dating of carbon dioxide (CO_2) reflecting carbon sources that are microbially degraded

STUDY AREA

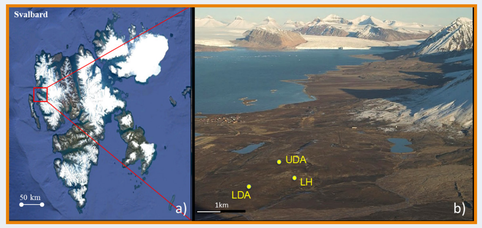


Fig. 1: Map of the study area. a) Satellite image of Svalbard, modified from (Luo, Y. et al. (2018); b) topographical map from Norwegian Polar Institute; c) three different study sites: LH = Leirhaugen Hill, LDA = lower drainage area, UDA = upper drainage area.

Field work was carried out in July 2017 close to Ny Ålesund, W-Svalbard. Three sites with different hydrology and vegetation cover, following the geomorphological gradient from glacier to fjord:

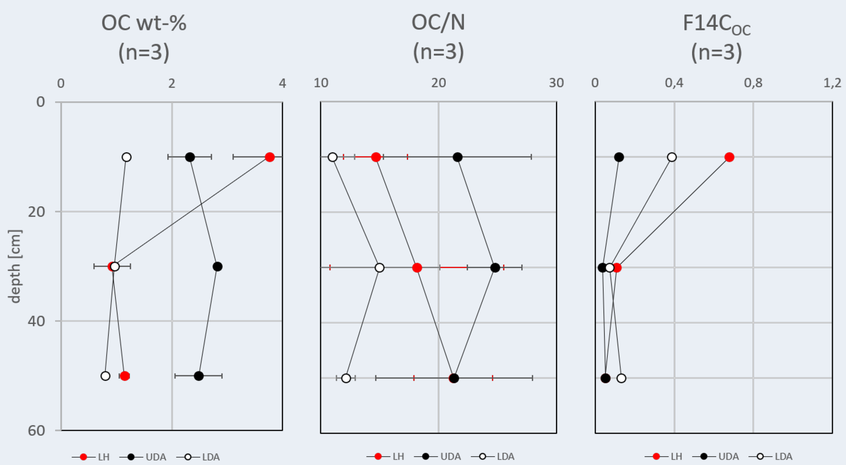
- ▷ UDA = upper drainage area (33 m a.s.l.)
- ▷ LH = top of Leirhaugen Hill (24 m a.s.l.)
- ▷ LDA = lower drainage area (12 m a.s.l.)

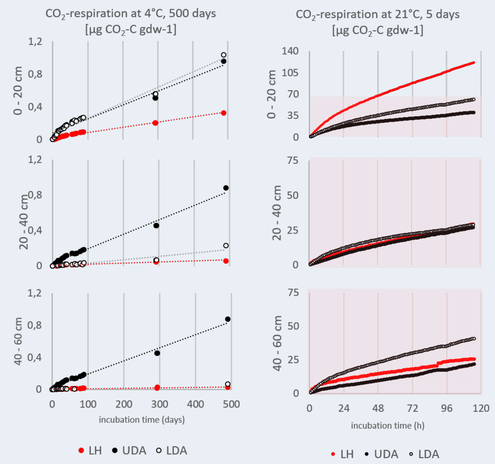
RESULTS

ORGANIC MATTER QUALITY AND DEGRADABILITY

OM Quality:

- Site closer to glacier (LH, UDA): less degraded OM (high OC/N), more OC
- Site closer to fjord (LDA): more degraded OM (lower OC/N), less OC
- Little change in OM quality with depth OM degradability:
- Bulk soil OC at all sites older than respired CO_2 → mainly fresh OM is decomposed upon long-term warming





SOURCES OF CO_2 RELEASE IN THE FIELD AND DURING INCUBATION

- CO_2 collected with respiration chambers in the field at all sites close to atmospheric $F^{14}C$-values
- Incubated surface layers (which contribute mostly to CO_2 efflux at the soil surface) are close to field measurements at the geomorphological elevated sites LH and UDA
- LDA only incubated profile with older $^{14}CO_2$ in the uppermost layer compared to field data → after thawing older, more recalcitrant OM is decomposed

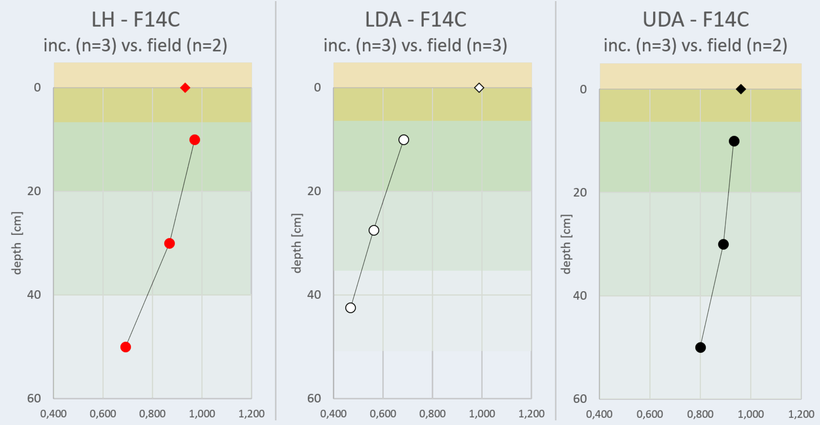
CO_2 PRODUCTION DURING INCUBATIONS

Long-term incubation:

- Surface soil: Long-term CO_2 production rates are higher at sites with less and older OC (UDA>LDA>LH)
- Deeper soil layers: high emissions from UDA related mainly to high OC and ^{14}C → mainly young, potentially labile fraction of the OM is decomposed

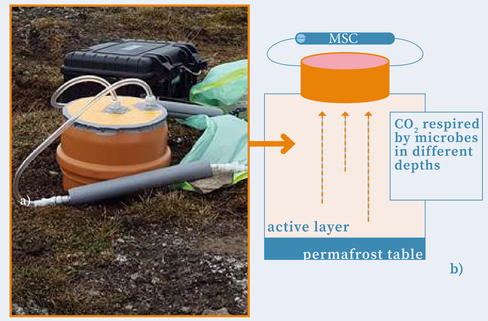
Short-term incubation, basal respiration:

- Respiration rates are related to bulk OC age and OC content in the surface soil: higher OC and lower age promotes OM degradation
- Up to 5 times higher respiration rates in surface soil at LH → driven by high OC content



METHODS

- Bulk sediment analysis: organic C (OC), OC/N-ratio, C isotopes
- CO_2 sampling in the field: with respiration chambers coupled to molecular sieve catridges
- Long-term incubation: 498 days in the dark at 4°C → headspace CO_2 sampled for C isotopic analysis
- Short-term incubation: 5 days at 21°C → O_2-consumption recorded hourly → after thawing peak, CO_2-emission leveled to a steady value: basal respiration



CONCLUSION

- Young OM sources are preferentially degraded if available presently (field analysis) and in the future (long-term incubation)
- If no young/labile material is available, ancient OC will be released as CO_2 upon warming (LDA)
- Respiration rates are controlled by OC content and 14C age: more OC and younger age promote CO_2 release

Outlook:

- Analysis of microbial lipids pre- and post-incubation to determine changes in microbial communities with ongoing warming.
- Ongoing δ13C analyses of the CO_2 will be used for differentiating organic and inorganic carbon sources.

ACKNOWLEDGEMENT

Field work took place in 2017, therefore a special thanks to the AWI team for supporting expedition planning and logistics as well as the AWIPEV research station for the possibility to carry out field work and on-site support. Last but not least I would like to thank Max Birkl for his help with the poster layout.

REFERENCES

Boike et al. (2018), Earth System Science Data 10 (1).
Gruber, S. (2012), The Cryosphere, 6.
Knoblauch et al. (2013), Global Change Biology, 19.
Luo, et al. (2018), Atmospheric Chemistry and Physics, 18.
Meredith et al. (2019), IPCC Special Reprot on the Ocean and the Cryosphere in a Changing Climate.
Schädel et al. (2014): Global change biology 20 (2).
Schuur et al. (2015), Nature 520 (7546).
Wischhöfer, P. (xxxx), unpublished manuscript.

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