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Soil carbon and nitrogen stocks in Arctic river deltas: New data for three Northwest Alaskan deltas

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Abstract

Arctic river deltas are dynamic and rapidly changing permafrost environments in a warming Arctic. Our study presents new data on permafrost carbon and nitrogen stocks from 26 soil permafrost cores collected from the Noatak, Kobuk and Selawik river deltas in Western Alaska. We analyzed 318 samples for total carbon (TC) and total nitrogen (TN). Average landscape-scale carbon storage is 50.1 ± 7.8 kg C (both organic and inorganic) and 2.4 ± 0.3 kg N m^{-2} (0-200 cm). This totals 67 ± 11 Mt C and 3.3 ± 0.6 Mt N in the first two meters of soil in the Noatak, Kobuk and Selawik deltas combined. Our findings demonstrate that Arctic river deltas are important regions of permafrost soil carbon storage and need to be considered in panarctic permafrost carbon estimations.

Keywords: Permafrost carbon, upscaling, deep deposits

Introduction

Arctic river deltas are dynamic and rapidly changing permafrost environments. In addition, they are long-term depositional environments that formed over the Holocene and therefore may contain a significant carbon and nitrogen pool in the circum-arctic permafrost region. So far, only limited data are available for the major arctic river deltas in the latest carbon estimation (91 +/- 52 Pg) for the permafrost region (Hugelius *et al.*, 2014). Small arctic river deltas are largely overlooked but likely contribute substantially to soil and nitrogen storage in arctic river deltas (e.g. Ping *et al.*, 2011; Fuchs *et al.*, in prep.).

This study aims to enlarge the carbon and nitrogen data from Arctic river deltas and enhance the understanding of the size of the carbon pool stored in deltaic deposits in permafrost regions. Here we present soil C and N data for the Noatak, Kobuk and Selawik river deltas in northwest Alaska.

Study sites and methods

The Noatak (67.04°N; 162.45°W), Kobuk (66.75° N; 161.29°W) and Selawik (66.58°N; 160.05°W) river deltas are located in Northwest Alaska close to the town of Kotzebue. The three deltas are characterized by continuous (Noatak and Kobuk) and discontinuous (Selawik) permafrost (Jorgenson *et al.*, 2008). Their surface areas are 190, 410, and 1260 km^2 for the Noatak, Selawik, and Kobuk river delta, respectively.

We collected 26 soil permafrost cores to a depth of 2 m in August 2016. The active layer was excavated, measured and sampled with a fixed volume cylinder prior to drilling the permafrost deposits with a SIPRE auger of 2 inch (5.08 cm) diameter. Soil cores were described, subsampled in the field, and transported cool to the laboratory.

In total, 318 individual soil samples were analyzed for total carbon and total nitrogen in the laboratory. Mean soil carbon (SC) and soil nitrogen (SN) stores were calculated for each permafrost core for the reference depths 0-30 cm, 0-100 cm, and 0-200 cm. Mean values for the different deltas were then calculated and later used to upscale SC and SN stocks for the three river deltas.

Results and discussion

Mean active layer depth, mean TC and TN, as well as mean volumetric ice content are presented in Table 1 for the three different Arctic river deltas. The high standard deviations indicate the wide spread of the data, especially in TC content which ranges from 0.6 to 55%.

Mean total soil carbon and soil nitrogen data indicate higher SC and SN values for the Noatak river delta compared with the two other deltas for all reference depths (Table 2 and 3).

Based on average carbon and nitrogen contents from each core and on the spatial extent of the river deltas, total study area stocks are 67 ± 11 Mt C and 3.3 ± 0.6 Mt N excluding water body areas from the analysis. This results in a landscape mean of 50.1 ± 7.8 kg C m^{-2} and of 2.4 ± 0.3 kg N m^{-2} for these small, but prominent northwest Alaska river deltas in the first two meter of soil.

Our study shows the importance of including small Arctic river deltas in future permafrost carbon and nitrogen estimations. The dynamic nature of river deltas and the high C and N values for 0-200 cm present a significant carbon and nitrogen pool, especially considering that Arctic deltaic deposits are significantly deeper than only two meters (Hugelius *et al.*, 2014). Therefore, besides additional soil cores, information on the depth of deltaic deposits would strongly enhance the carbon pool estimations for Arctic river deltas in future.

Table 1: Mean active layer (AL), total carbon (TC), total nitrogen (TN) and volumetric ice content (± standard deviation) for the three deltas

River delta	Mean AL depth [cm]	Mean TC [%]	Mean TN [%]	Vol. ice content [%]
Noatak	34 ± 2	11 ± 14	0.5 ± 0.6	55 ± 13
Kobuk	47 ± 16	11 ± 15	0.6 ± 0.9	56 ± 14
Selawik	47 ± 5	17 ± 17	0.6 ± 0.5	60 ± 12
Average	44 ± 13	12 ± 15	0.5 ± 0.6	56 ± 14

Table 2: Mean profile soil carbon in kg C m^{-2} (± standard deviation) for the reference depths 0-30 cm, 0-100 cm, 0-150 cm and 0-200 cm

River delta	0-30 cm	0-100 cm	0-150 cm	0-200 cm
Noatak	19 ± 5	41 ± 12	52 ± 14	63 ± 15
Kobuk	16 ± 3	34 ± 8	40 ± 8	49 ± 8
Selawik	12 ± 4	35 ± 7	40 ± 6	48 ± 5
Average	16 ± 4	36 ± 10	44 ± 11	54 ± 12

Table 3: Mean profile soil nitrogen in kg N m^{-2} (± standard deviation) for the reference depths 0-30 cm, 0-100 cm, 0-150 cm and 0-200 cm

River delta	0-30 cm	0-100 cm	0-150 cm	0-200 cm
Noatak	0.9 ± 0.3	2.1 ± 0.8	2.6 ± 0.9	3.0 ± 0.9
Kobuk	0.8 ± 0.2	1.8 ± 0.4	2.1 ± 0.4	2.5 ± 0.3
Selawik	0.3 ± 0.2	1.3 ± 0.4	1.6 ± 0.3	2.1 ± 0.3
Average	0.7 ± 0.3	1.8 ± 0.6	2.2 ± 0.7	2.6 ± 0.6

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