Characterization of elemental content & green house gases fluxes from different zones in the Lena Delta River

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Background

Permafrost science remains limited in data. Observations at isolated spaces and times are insufficient to evaluate the long term climatic and environmental responses over large regions. Permafrost models may be used to establish links between the geographical scales from local to large regional, continental, and hemispheric scales.

This poster aims to show some examples for measuring C/N quantities and CO_2/CH_4 fluxes and to offer comparison of their contribution in C-cycle in different areas of Lena Delta River (2-core comparison and a global one on 12 core samples from the KoPf Expedition in 2018).

Location

- ➢ Arctic coastal dynamics influence in Siberia.
- ➢ Arctic continental climate with low mean annual air temperatures of -13 °C, a mean temperature in January of -32 °C, and a mean temperature in July of 6.5 °C.
- ➢ Largest delta in the Arctic occupying an area of $3.2x10^4$ km^2, counting the second largest river discharge in the Arctic 525 km^3/yr).
- ➢ The collected cores (PX) are located on third terrace, which is an erosional remnant of a Late Pleistocene plain consisting of fine-grained, organic-rich and ice-rich sediments, characterized by polygonal ground and thermokarst processes.
- ➢ P13 (Elementary Analysis or EA):
  - close to an erosion feature
  - belongs to Yedoma upland
  - Vegetation inventory includes Salix, moos, sedges and few lichens species.
  - Active layer limit is at 21 cm depth.
- ➢ P14 (EA):
  - Thaw slump with a 15° slope.
  - Vegetation inventory includes high grass
  - Slope located between Yedoma and thermokarst lake.
  - Active layer limit at 67 cm depth.
- ➢ P17 (incubation setup):
  - Occasionally flooded area in the delta (mainly sandy)
  - The active layer limit at 36 cm depth.
  - This core will be used as example for measuring CO_2 and CH_4 fluxes in contribution to other master theses.

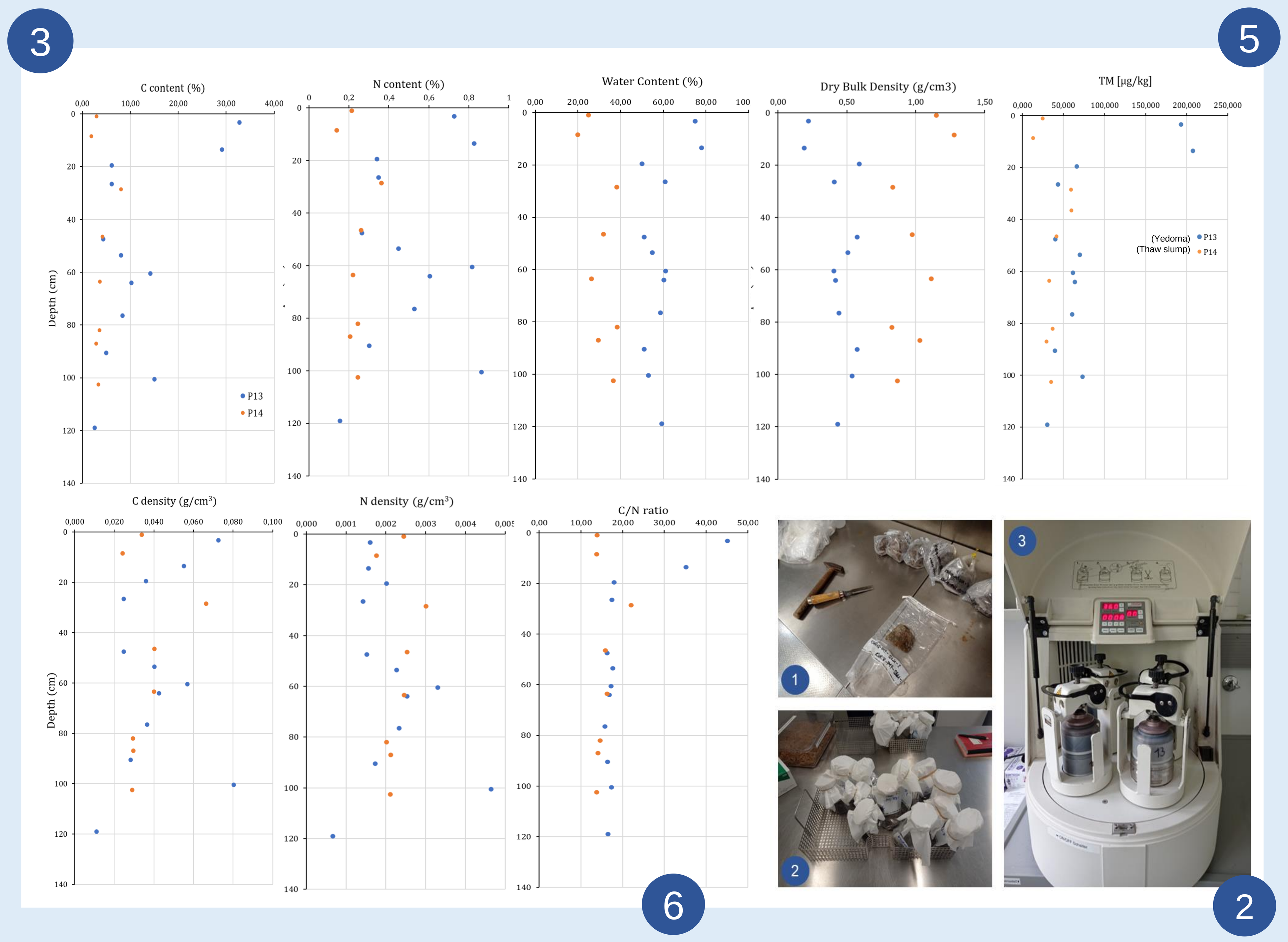
Methods

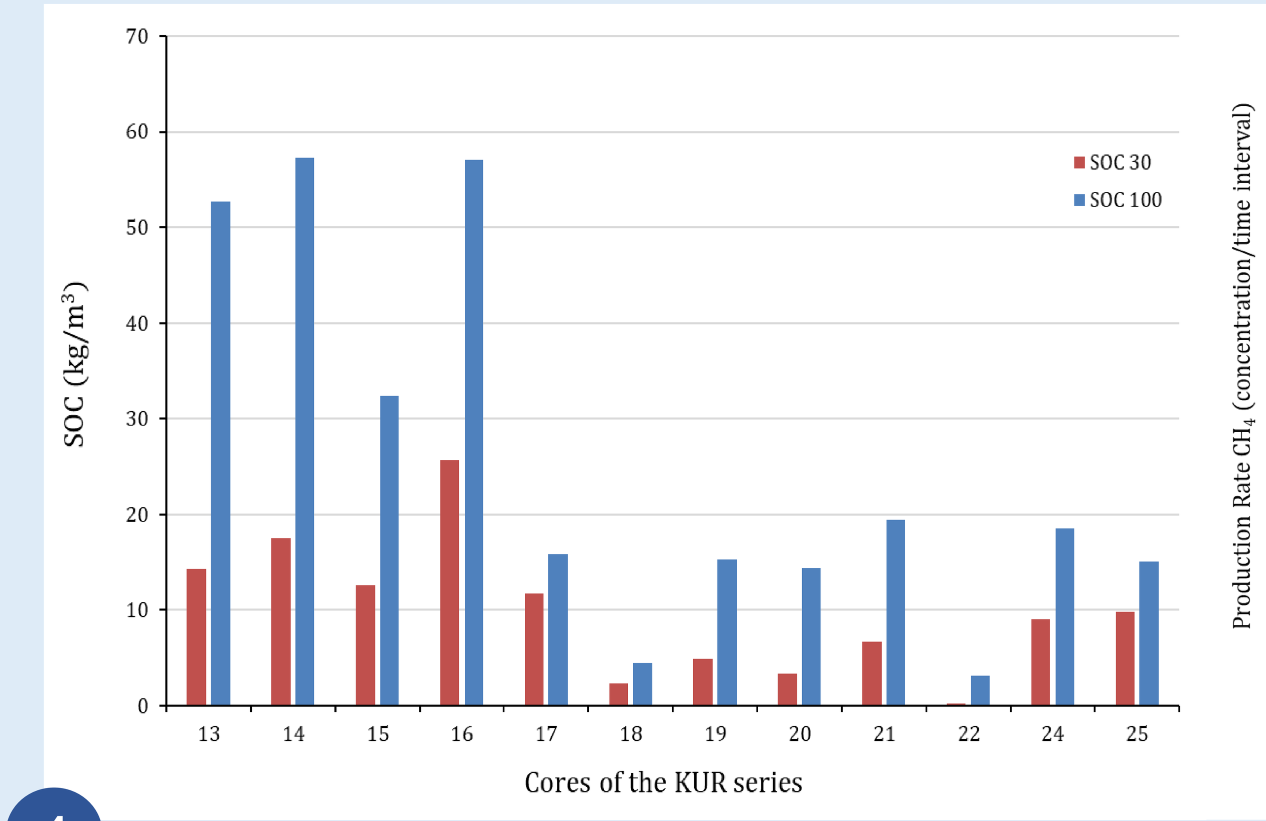
- ➢ Description of samples (field and climate chamber (1)) – Water Content calculation – Freeze-drying (2) – Dry Bulk Density calculus – Milling (3)
- ➢ C – N – Hg Elementary Analysis
- ➢ Incubation setup – Measurement on GC of CO_2 & CH_4 fluxes
- ➢ Gas Production Rate & Cumulative Gas Amount

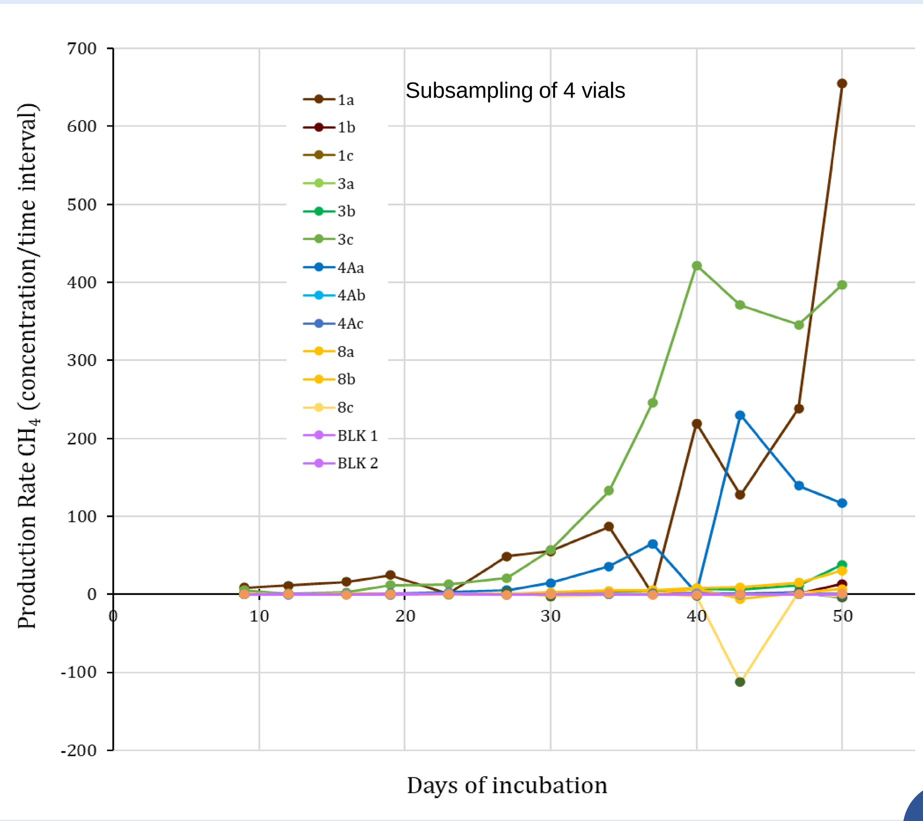
Results

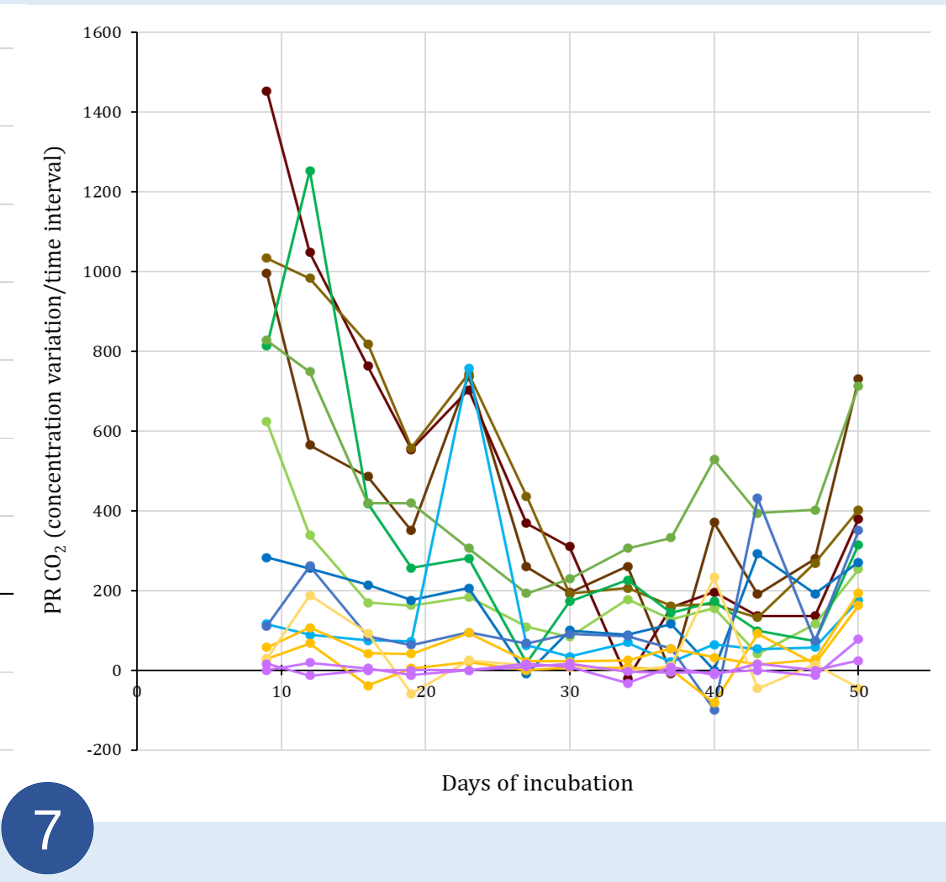
- ➢ Water content - Bulk density - C & N concentrations – SOC and C/N ratio
  - P13 holds more carbon than P14 (difference on the top of the core)
  - C content in P13 varied more than P14.
  - P13 stores more ice-water than P14.
  - Same variations are recorded for N.
  - The limit between active and permafrost layer is always deductible, according to field notes.
  - C storage is higher in P13 and presents more variations than in P14 (where C concentration remains stable in relation to depth.
- ➢ SOC and C storage are low for floodplain cores, whereas Yedoma is high
- ➢ Incubations – Potential carbon release – Production rate
  - Surface sets are decreasing exponentially, unlike deeper sets, for which we can observe softer variations.
  - Production rate of CH_4 increases slowly for the totality of the samples (exponential trend)
  - Production rate of CO_2 decreases for all samples.
  - The two blanks are not varying at all in terms of production of methane or carbon dioxide.

1. Localization of the Lena Delta River and of the KoPf project cores (Matthias FUCHS, AWI).
2. Examples of different methods used for this study (description in 'Methods' content).
3. Graphs showing water content, C content & N content relatively to depth.
4. SOC storage comparison between the twelve KUR cores. Blue histograms stand for the first 100 cm and red ones for the first 30 cm.
5. Hg content relatively to depth.
6. Graphs showing C & N density, C/N Ratio and dry bulk density relatively to depth. (blue = P13 ; orange = P14)
7. Production Rate of CH_4 and CO_2 for the first 40 days of incubation.









Discussion

- ➢ Relationship between Soil Characteristics and Gas Release
  - C content is constant in slump over the whole depth, partly because many layers were mixed up.
  - Floodplains are always active and sandy & have a smaller vegetation density than stabilized Yedoma.
  - C accumulation - while decomposition process - does not creates as much as organic matter than Yedoma upland.
  - Speaking of matter porosity, the question is, if it creates changes in thawing processes. It is still a factor to look at in the later studies.
- ➢ Freezing and thawing processes play a very important role in the CH_4 & CO_2 releases.
  - Some results could be affected differently : it is an explanation for lower results in the P17 to P25 cores because of few freezing but more thawing phenomenon in thaw slumps (intermediate values) and floodplains (low values).
  - For C and N calculations in depth variations, it could be explained by richness in organic matter. We should check other mineral components like Hg or whole molecules, markers for biological processes, that could lead to a better understanding of the soil system.
- ➢ Aerobic vs. Anaerobic Incubations
  - What happens with aerobically incubated samples?
  - Oxidation phenomenon is really enhancing sensitivity for green house gases releases.
  - We should pay attention for the reproducibility of the samples replicates.
- ➢ Active vs. Permafrost Layer Emissions
  - Topography, ecosystems and thermokarst or river proximity can not be left out, because they are a cause of the resp. formation/degradation of new flooding areas/uplands.
  - Flooding processes prevent water from freezing in the winter season.

Conclusion

- ➢ Active deltaic floodplains are significant permafrost carbon pools.
- ➢ They could become one of the first environments vulnerable to soil decomposition, leading to a sensitive release of CH_4 & CO_2.
- ➢ Elementary analyzes showed differences between Yedoma uplands and active floodplains.
- ➢ Thaw slump was not as organic rich as those from Yedoma uplands.
- ➢ Silt-sandy-rich cores from active floodplains were C-poor.
- ➢ Carbon stocks showed large differences between vegetated and non-vegetated sites. They showed content variability with depth, indicating that these soils were formed by deltaic and fluvial processes as well.
- ➢ A more detailed set could enhance knowledge for ages of formation (radiocarbon dating) and aerobic releases.
- ➢ Further investigations are requested in elementary analyses of other compounds and types of zones.
- ➢ We should add multiple factor scale and carry out more experiment in order to find more global explanations.

Summary diagram of the study

For any questions or comments, please contact the following adress : alice.vetier@ens-lyon.fr. (2022)