Global Water Futures 2021 Operations Team Meeting – Project Reporting Template

Instructions: All GWF projects are asked to provide a summary update on their activities and accomplishments in preparation for the upcoming Operations Team meeting. **Please submit these by email to chris.debeer@usask.ca by no later than December 2.** These will be used to help guide discussions and breakout synthesis activities and will be made generally accessible on our website in advance of the meeting.

Project Name:	Winter Soil Processes in Transition (December 2018- November 2021)

Our major accomplishments to date are:

Our project advanced the process-based understanding of the impacts of winter warming and freezing and thawing (FT) cycles on carbon (C) cycling, biogeochemical transformations of nutrients and contaminants, and microbial processes.

- We demonstrated that the recurrent FT of the soil surface layer causes variations in oxygen (O_2) availability in the vadose zone, which, in turn, affect soil microbial activity and the processes involved in organic matter decomposition, greenhouse gas (GHG) emissions, and nutrient cycling.
- We found that thawing of the surface soil layer is accompanied by pulses of carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions that are attributed to a combination of the release of trapped gas that accumulated under the ice layer during frozen condition and *de novo* microbial reactions (*e.g.,* fermentation and denitrification) due to the sudden increase in temperature and O_2 supply upon thaw.
- Our results suggest that the enhanced access to relatively labile organic matter mobilized during freezing may additionally contribute to the observed post-thaw CO_2 and N_2O pulses.
- We developed machine-learning model and synthesis data-driven approaches to determine that changes in soil moisture, temperature, and photosynthesis are the primary drivers of changes in net C flux during the non-growing season (NGS). We projected a 103 per cent increase in Mer Bleue peatland C loss by 2100 under a high radiative forcing scenario, highlighting that the peatland C loss will therefore constitute a strong positive climate feedback loop.
- Using CO_2 production rates measurements in laboratory incubations with soils from seven Canadian peatland sites in the boreal and temperate bioclimatic vegetation zones (or 'ecoclimates'), we found that the statistically significant variations in the temperature sensitivity of peat soil CO_2 production rates between the cold-temperate and boreal ecoclimate zones. The finding highlights that the variable temperature sensitivities under different climate conditions need to be accounted for when assessing future global trajectories of peatland carbon pool stability.
- We used climate-related parameters to define the start and end dates of the NGS and our results supported defining NGS based on readily available climatic parameters that account for the interannual variability of regional climate and ecosystem response.
- We also studied the impact of winter soil processes on nutrient leaching in cold region agroecosystems and the results indicated that fall-applied fertilizers are prone to loss under soil FTCs during NGS and fertilizer nitrogen is susceptible to nitrification and loss via leaching. The results also showed that nitrification inhibitors were effective at reducing nitrification under thaw conditions but were less effective under freeze-thaw conditions.
- Our research on microbial community compositional stability in agricultural soils during freeze-thaw and fertilizer stress determined the specific response of the soil microbiome through the

winter in terms of gene expression and metabolic capacity, and microbial impacts on biogeochemical cycling.
Our current activities are:
• This project is ended on November 30, 2021. We are now finalizing three more manuscripts on the results from FTC leaching experiments and will submit to international peer-reviewed journals.
The main accomplishments expected by the end of the project are:
• This project is ended on November 30, 2021 and the main accomplishments are described in above “Our major accomplishments to date”.
Here is a key visual from the project (figure, photo, table, graph, etc.)