An integrated multiscale (spatial and temporal) approach for carbon dynamics comprehension of boreal peatlands, Québec, Canada

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INTRODUCTION

In boreal regions of the northern hemisphere, peatlands cover up to 20% of the Canadian territory, and between 9 to 12% of the Quebec province. Considering that peat accumulation is thought to be largely a function of moisture and temperature, we developed a multidisciplinary approach in order to improve the understanding of peatland carbon dynamics in the northwest boreal region of Quebec (51-54°N; 73-78° W).

Between 2003 and 2006, we investigated from a local to a regional scale, different peatlands types representative of the climatic and ecogeomorphic areas from which they belong. The approach has been defined following three major axis of research and presents data from paleoecology, biogeochemistry, surface vegetation ecology, surface hydrology, geomorphology and remote sensing, integrated into a geographic information system (GIS).

- **AXIS 1 :** Regional characterization and classification of present-day surface peatland vegetation types using a combination of RADARSAT and LANDSAT satellite images and aerial photos.

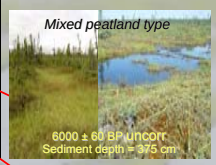
- **AXIS 2 :** Local and regional variability of CO_2 and CH_4 exchanges linked with the surface vegetation patterns to determine the relative sensitivity of different carbon fluxes in relation with current climate conditions and predicted global warming scenarios.

- **AXIS 3 :** Holocene and recent paleoenvironmental conditions of peatland dynamics and related carbon accumulation linked to peat inception and development in the *James bay region (Québec).*

For each peatland type, the PCARS model (Frolking *et al.*, 2001, 2002) is run to assess the relative sensitivity of CO_2 and CH_4 exchanges under future climate conditions using CGCM3 simulations. The integration of these data allow a comprehensive spatial and temporal understanding of boreal peatlands dynamics from the time they first began accumulating carbon to their present day patterns and processes.

STUDY AREA

The study region is located into the James Bay Lowlands drainage basin (73 - 78° W, 51 - 54° N), comprises from low boreal to sub boreal ecoregion where different types of peatlands ranging from rich minerotrophic to poor ombrotrophic and representative of distinct climatological, ecological and geomorphic gradients are investigated. Peatlands cover between 30 to 50% of the land area (Tarnocai *et al.*, 2000).



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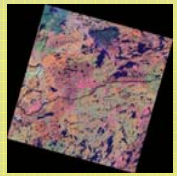
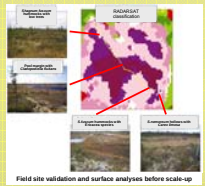
AXIS 1
Remote sensing

Regional characterization, classification and mapping of present-day surface peatland types and associated vegetation covers are realized with:

- Combination of RADARSAT-1 and LANDSAT satellite images and aerial photos for best characterization and classification of peatland and non-peatland environments;
- Over 200 field sites validation;
- Surface hydrology monitoring;
- Correlation between field data and satellites images;
- Extrapolation to assume regional fluxes related to the linear combination of the spatial extent of the different types of peatlands





AXIS 2
Peatland surface dynamics

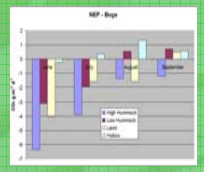
FLUXES

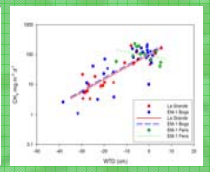
The local and regional variability of carbon (CO_2) and methane (CH_4) exchanges are assessed with :

- Periodic measurements of CO_2 and CH_4 fluxes realized with climate-controlled chambers on different vegetation types and pools in the different peatlands;
- Resulting measurements of CO_2 and CH_4 fluxes in order to determine the relative sensibility of different types of peatlands and integrate these inputs into the PCARS model.

ISOTOPIC FRACTIONATION

Analyses from sub-surface *Sphagnum* samples (< 20cm)

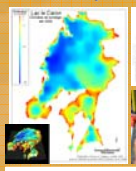


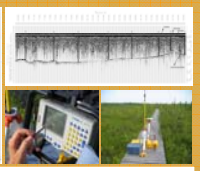


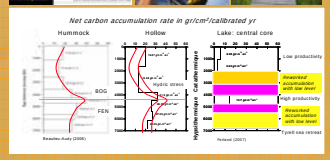
AXIS 3
Holocene paleoenvironmental conditions of peat and carbon accumulation

Paleoecology of peatlands and past carbon accumulation are reconstructed through the analysis of several cores taken from central and lateral locations in the different peatlands for :

- Stratigraphy, rates of decomposition, macrofossil, pollen and *Testate amoebae* analyses;
- Peatland carbon content estimated with Carbon to Nitrogen ratios (C/N) and high-resolution loss-on-ignition (LOI) analysis;
- Detailed geochronological controls by several ^{210}Pb and ^{14}C dates used for the reconstruction of short-term and long-term tendencies in peat sequences and carbon dynamics over the last 7000 years;

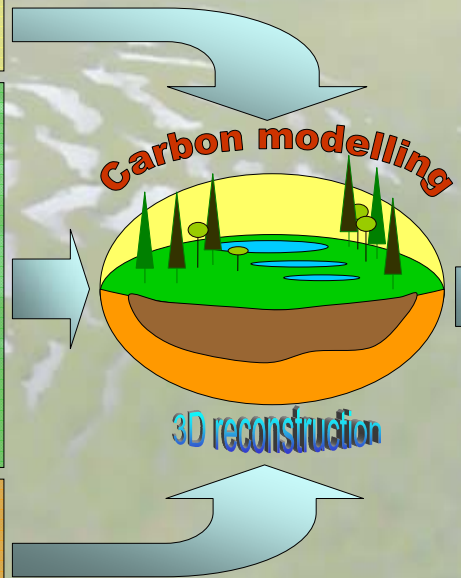




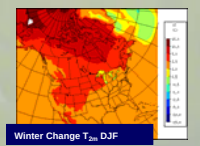


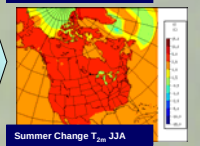
CARBON AND 3-DIMENSIONAL MODELLING

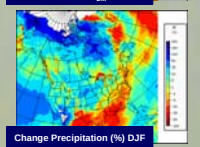
- Resulting multi-sources data from the three axis of this project are integrated into an ecosystem based carbon model for peatland (PCARS; Frolking *et al.*, 2001, 2002) and a GIS model.
- PCARS model is run to assess the CO_2 and CH_4 exchanges over the period of record, to simulate NEE and CH_4 emissions over several years and to determine the relative sensitivity of the gas exchanges under future climate scenarios.
- GIS model is used for a 3-dimensional reconstruction of the studied sites to allow a better understanding of processes influencing peatlands development and accumulation since peat inception to their present-day patterns and processes.
- Modelling results provide a spatial and temporal reconstruction of boreal peatlands dynamics influenced by climate variabilities and autogenic processes and contribute to the development of projected scenarios to estimate the potential impacts of future climate change on these ecosystems.

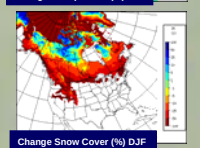


Climate change projections from CRCM (Ouranos, Québec) driven by CGCM3 (2050s, 45km)









CONCLUSION

This multidisciplinary project contributes to a global understanding of boreal peatland ecosystems under predicted changing climate :

- Development of a methodology to classify and map peatlands ecosystems;
- Acquisition of data on quantitative carbon storage and accumulation conditions over the past 7000 years coupled to greenhouse gas exchanges;
- Comprehensive spatial and temporal understanding of past, present and projected future peatland dynamics;
- Estimation of rates of peat decomposition and CO_2 and CH_4 budget in boreal peatlands under increasing evaporative losses and water-table lowering (Roulet, 2000).

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