Integrating Stream, River and Lake Components of CO_2 Fluxes into Boreal Landscape Perspective

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Introduction: The boreal ecosystem is the largest terrestrial and most extensive biome in the world. An impressive number of lakes, streams and rivers in those regions form a complex aquatic network. Supersaturated in CO_2 with respect to atmospheric equilibrium, C fluxes from boreal waters are likely to play a major role in regional carbon budgets. However, their overall contribution to the net C balance is still far from being well understood.




Goals

1. Examine the correlation between pCO_2 and physico-chemical parameters of boreal surface waters in Eastmain region, northern Quebec (data from 3-year monitoring program);
2. Estimate CO_2 fluxes from each major aquatic component: lakes, rivers and streams;
3. Develop useful tools (models) to predict regional C emissions from boreal aquatic.

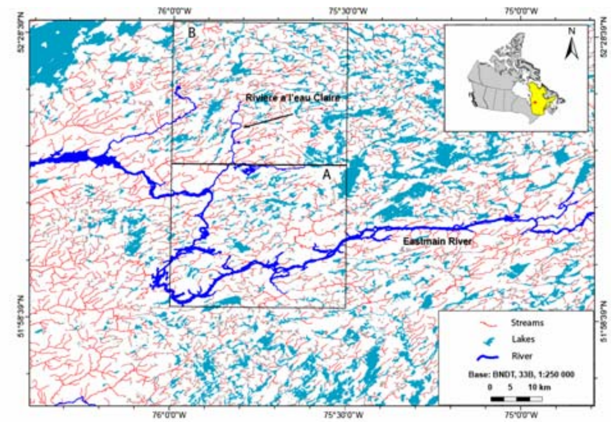

Figure 1. Hydrological network of the study area and the location of the two investigated blocks of landscape

Approach

- Establish empirical relationships between pCO_2 and easily measured characteristics of the water bodies.
- Scale up to the entire landscape using this relationship and the distribution of the predictor variables.

CO_2 flux calculations:

$$F = k \cdot K_h \cdot (pCO_{2\ water} - pCO_{2\ air})$$

k - gas exchange velocities ($m\ d^{-1}$);
K_h – Henry ct. corrected for temperature;
($pCO_{2\ water}$ - $pCO_{2\ air}$) – air/water gradient.

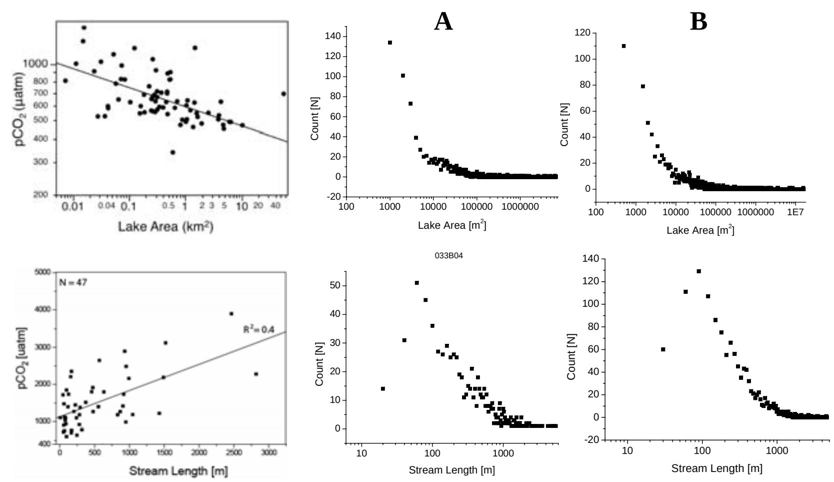

Figure 2. Left: linear relationship between pCO_2, lake area and stream length. Right: size distribution of lakes and streams contained within the two blocks of landscape (A and B)

No		Area [Km^2]	% AqSyst [%]	pCO_2 [ppm]	C flux [$mg\ C\ m^{2}\ d^{-1}$]	Total C [$t\ yr^{-1}$]	Total C [%]	
A		**967.7**						
Total aquatic system		**119.1**	**100**	**630**	**152**	**3257**	***100***	
2	River	37.2	*31.3*	616	**199**	1332	*40.9*	k=2
1030	Lakes	80.5	*67.6*	608	**77**	1110	*34.1*	k=0.8
790	Streams	1.4	*1.1*	2356	**3322**	815	*25.0*	k=4
B		**962.8**						
Total aquatic system		**138.8**	**100**	**602**	**94**	**2343**	***100***	
1	River	1.1	*0.8*	845	**391**	75	*3.2*	k=2
1455	Lakes	136.7	*98.5*	588	**70**	1724	*73.6*	k=0.8
1288	Streams	1.0	*0.7*	2136	**2953**	545	*23.2*	k=4

Table 1. Aquatic partition, weighted average pCO_2, C fluxes and annual C emissions from the aquatic system contained within the two blocks of landscape (A and B)

Conclusions

❑ **Lakes** are the dominant component of boreal surface waters (67 and 98% of total aquatic area). Generally characterized by lower fluxes, lakes play the major role in the annual C emissions (34 and 74% of total aquatic flux);

❑ Large **rivers** are not an omnipresent element of boreal landscape. With one order of magnitude higher fluxes that lakes, rivers can contribute substantially to the overall C emission;

❑ Despite their small contribution to the aquatic surface (about 1%) but with one to two orders of magnitude higher fluxes than lakes and rivers, boreal **streams** supply more than 20% of the annual C emissions. Yet ignored or mostly underestimated, integrating streams into catchment C budgets must be a common practice.