Stem Respiration of Black Spruce (*Picea mariana*), Interior Alaska

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ABSTRACT

This stem respiration, that is equipped with a control system that consists of data-logger (CR10X), NDIR CO_2 analyzer, and pump, a compressor, and seven stem chambers, was conducted in parallel with the flux-measurement of soil respiration in different-sized black spruce of 4.3 cm to 13.5 cm in DBH (diameter at breast height), interior Alaska during the growing season of 2007 to 2009. The average stem respirations were 0.011±0.005 $mgCO_2/m^3/s$ (range 0.005±0.002 to 0.015±0.008 $mgCO_2/m^3/s$, CV 45%) in black spruce forests, which the DBH (Diameter at Breast Height) of black spruce ranges from 4.3 to 13.5 cm. The stem respiration in different-sized black spruce forest soils has temporally varied during the growing season of 2007-9. This suggests that the young black spruce has 3-fold higher metabolism than the old. Temperature is one of critical roles in determining stem respiration rate. Q_{10} values on air temperature and average stem respiration rates are 2.02 in 2007, 2.00 in 2008, and 2.37 in 2009 during the growing season, respectively. However, during the dormant season, measurement of stem respiration was failed and especially the diaphragm pump was damaged by input of the extremely cold air of 35 °C below the zero. Interestingly, the lagging effect of stem respiration on temperature and PAR (photosynthetically active radiation) was found during the clear sky, indicating lagging time of 1-2 hours on temperature and of 4-5 hours on PAR, respectively. Based on the Q_{10} equation on air temperature, annual variation of stem respiration rate was estimated, suggesting that the relationship between measured and simulated daily stem respiration was a good linear for the better understanding of interannual variation of stem respiration rates during 2007-9. The contribution of simulated monthly stem respiration to the ecosystem respiration (Re) by the eddy covariance method was 4.2±2.1 % in 2007, 2.5±0.9 % in 2008, and 5.7±4.3 % in 2009, respectively. The suggests that the higher contribution during 2009 may be due to much higher

Methodology

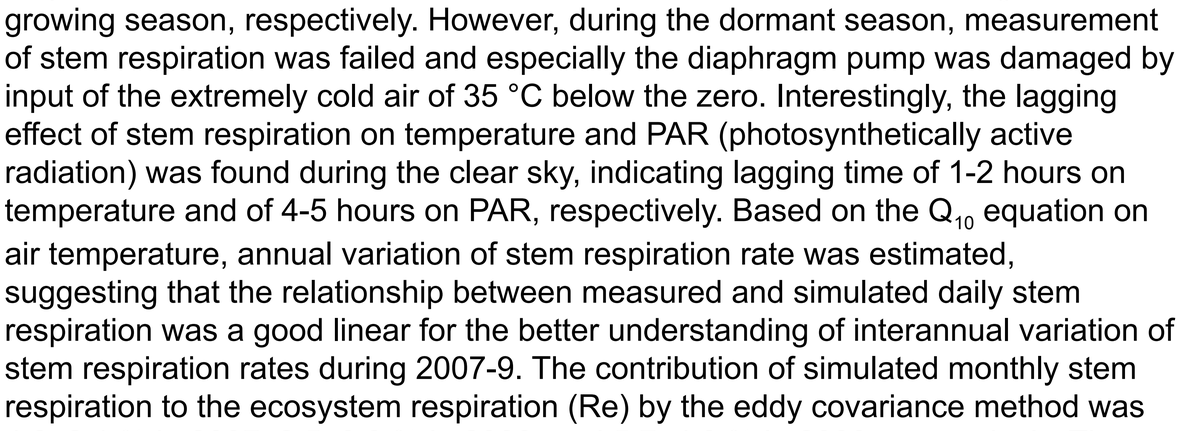

Fig. 1. Systematic scheme of stem respiration.

Black spruce (Picea mariana): DBH 4.3 (50 yr) to 13.5 (130 yr) cm
Observation period: growing seasons of 2007 to 2009

Results and Discussion

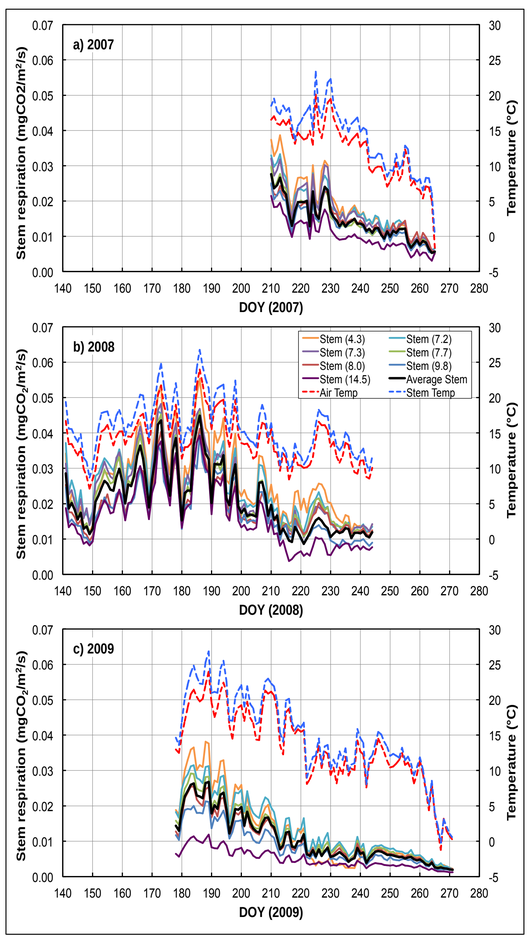

Fig. 2. Annual variations of stem respiration and temperature.

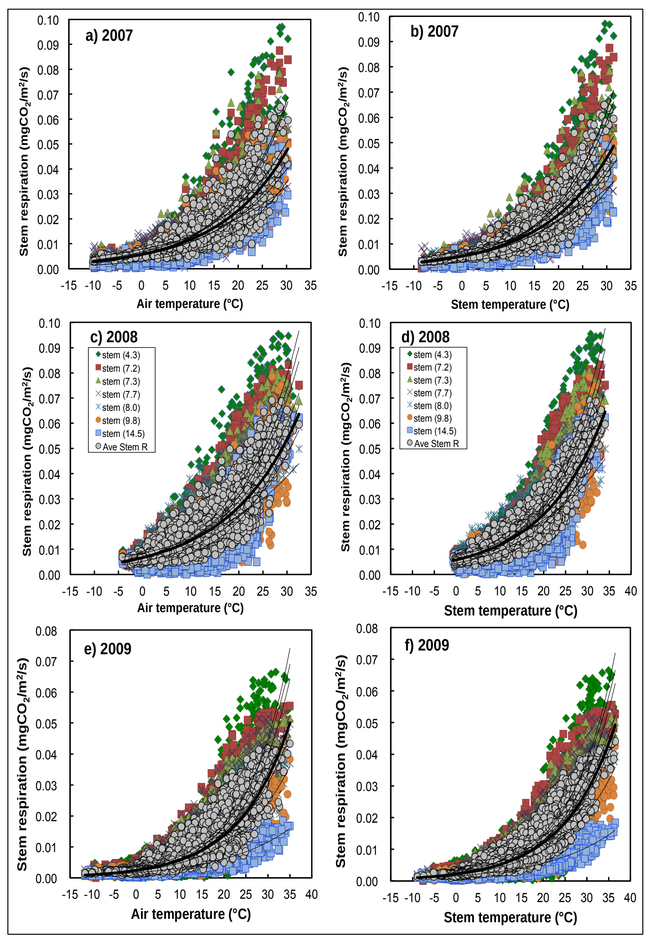

Fig. 3. Response of stem respiration on temperatures of air and stem.

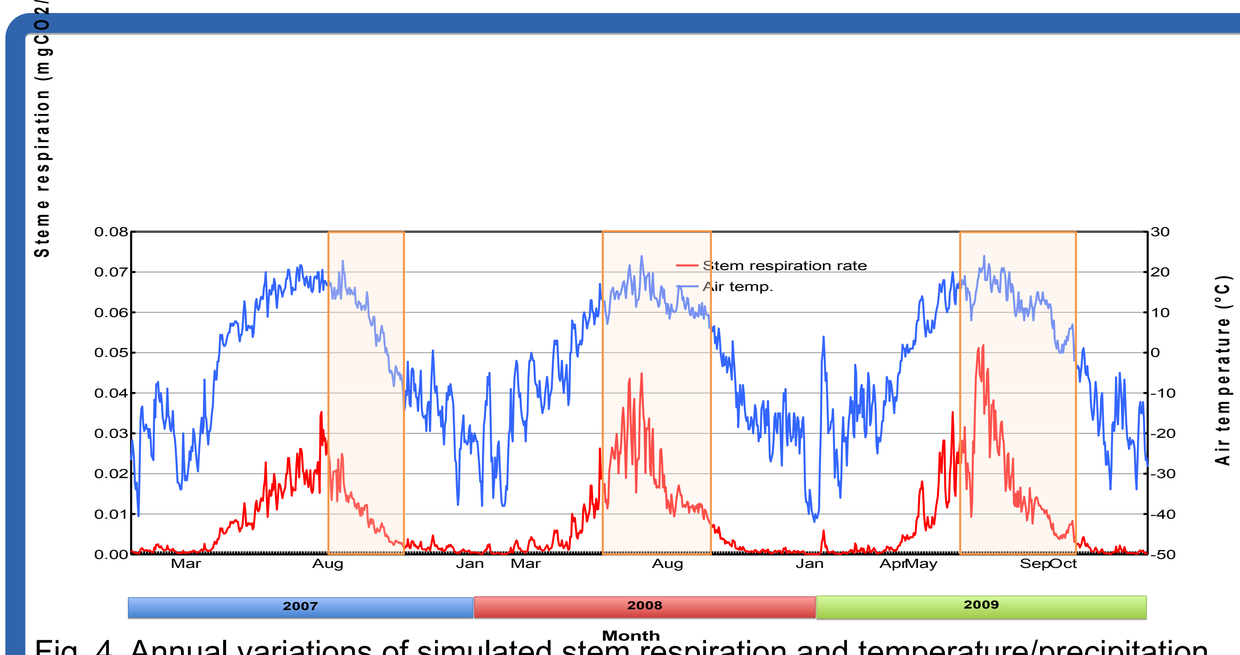

Fig. 4. Annual variations of simulated stem respiration and temperature/precipitation.

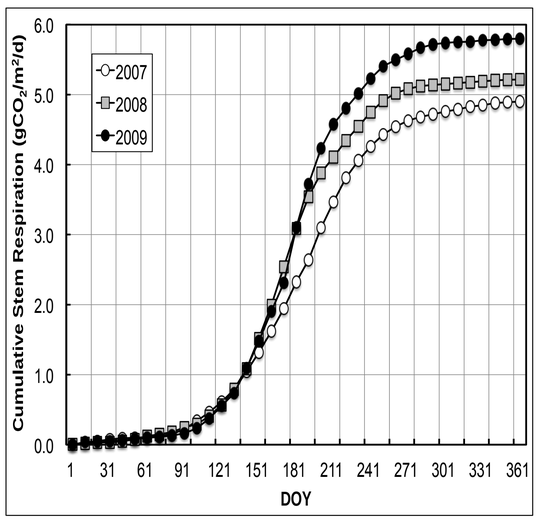

Fig. 5. Cumulated simulated stem respiration.

Table 1 Contribution (%) of monthly stem respiration to ecosystem respirtaion rate (Re) of black spruce, interior Alaska during 2007 to 2009

Month	2007	2008	2009
1	10.0	2.6	7.2
2	4.5	3.1	12.7
3	2.4	3.0	13.2
4	6.5	2.9	10.5
5	4.6	2.8	4.6
6	3.3	3.9	4.9
7	3.2	2.4	4.8
8	3.2	1.8	2.8
9	2.5	1.7	2.0
10	3.2	1.6	2.3
11	3.9	0.7	1.4
12	2.9	3.5	1.5
Average	4.2	2.5	5.7
Stdev	2.1	0.9	4.3
CV (%)	51	36	76

Table 2. Lagging times of stem respiration rates on temperatures of air and stem, and PAR under clear sky of 2007, 2008, and 2009

Year	Lagging time (hr)	Temperature	Q_{10}	R^2	Lagging time (hr)	R^2
2007	0	Air	1.67	0.60	0	0.10
Aug 27-30		Stem	1.75	0.84	1	0.31
	1	Air	1.81	0.79	2	0.56
		Stem	1.85	0.84*	3	0.75
	2	Air	1.88	0.87*	4	0.84*
		Stem	1.86	0.81	5	0.79
	3	Air	1.84	0.81	6	0.62
		Stem	1.79	0.67	7	0.42
2008	0	Air	1.72	0.70	0	0.04
Aug 27-30		Stem	1.91	0.88	1	0.19
	1	Air	1.86	0.90	2	0.38
		Stem	1.91	0.96*	3	0.57
	2	Air	1.91	0.96*	4	0.69
		Stem	1.89	0.89	5	0.70*
	3	Air	1.86	0.86	6	0.60
		Stem	1.79	0.70	7	0.43
2009	0	Air	1.86	0.78	0	0.02
Aug 01-04		Stem	1.91	0.90	1	0.13
	1	Air	1.86	0.92	2	0.28
		Stem	1.91	0.96*	3	0.45
	2	Air	1.91	0.94*	4	0.60
		Stem	1.89	0.91	5	0.68*
	3	Air	1.86	0.85	6	0.67
		Stem	2.07	0.75	7	0.58

* denotes the best fit on stem respiration rate.

CONCLUSIONS

1. **The younger stem of black spruce is much higher stem respiration than the old,**
2. **Stem respiration depends on temperature in air and stem,**
3. **The respiration shows the lagging time on temperature in air (2-hour), stem (1-hour), and PAR (4 to 5-hour),**
4. **Simulate stem respiration, based on the Q_{10} relationship, contributes to 4.2% in 2007, 2.5% in 2008, and 5.7% in 2009, respectively, depending on the winter period.**

ACKNOWLEDGEMENTS

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