CO_2 Flux at the Northern Old Black Spruce –

Changing the way we see the seasonal cycles and long term trends in boreal forests (…and later, in Arctic tundra)

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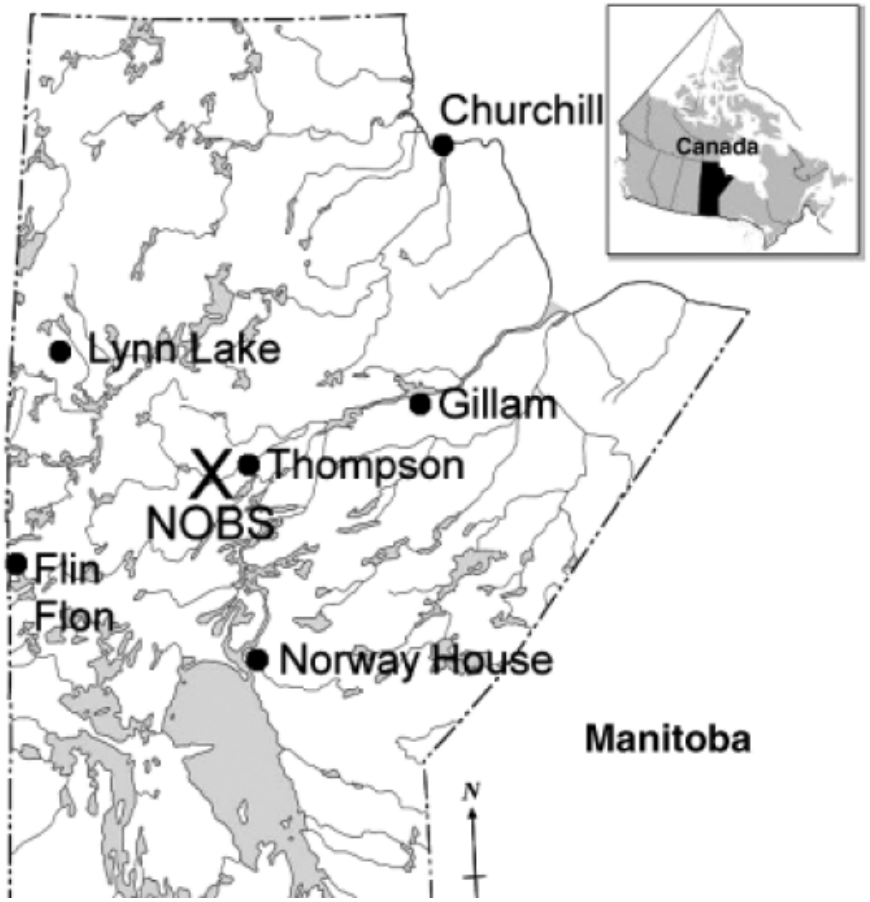
Brian Amiro -- U Manitoba

View from NOBS Eddy Flux Tower -- *Allison L. Dunn*



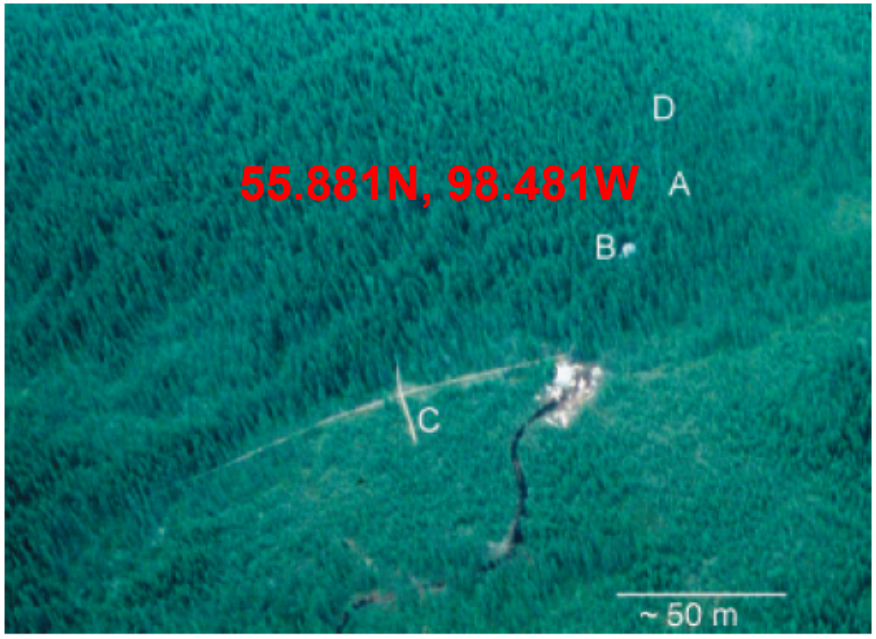
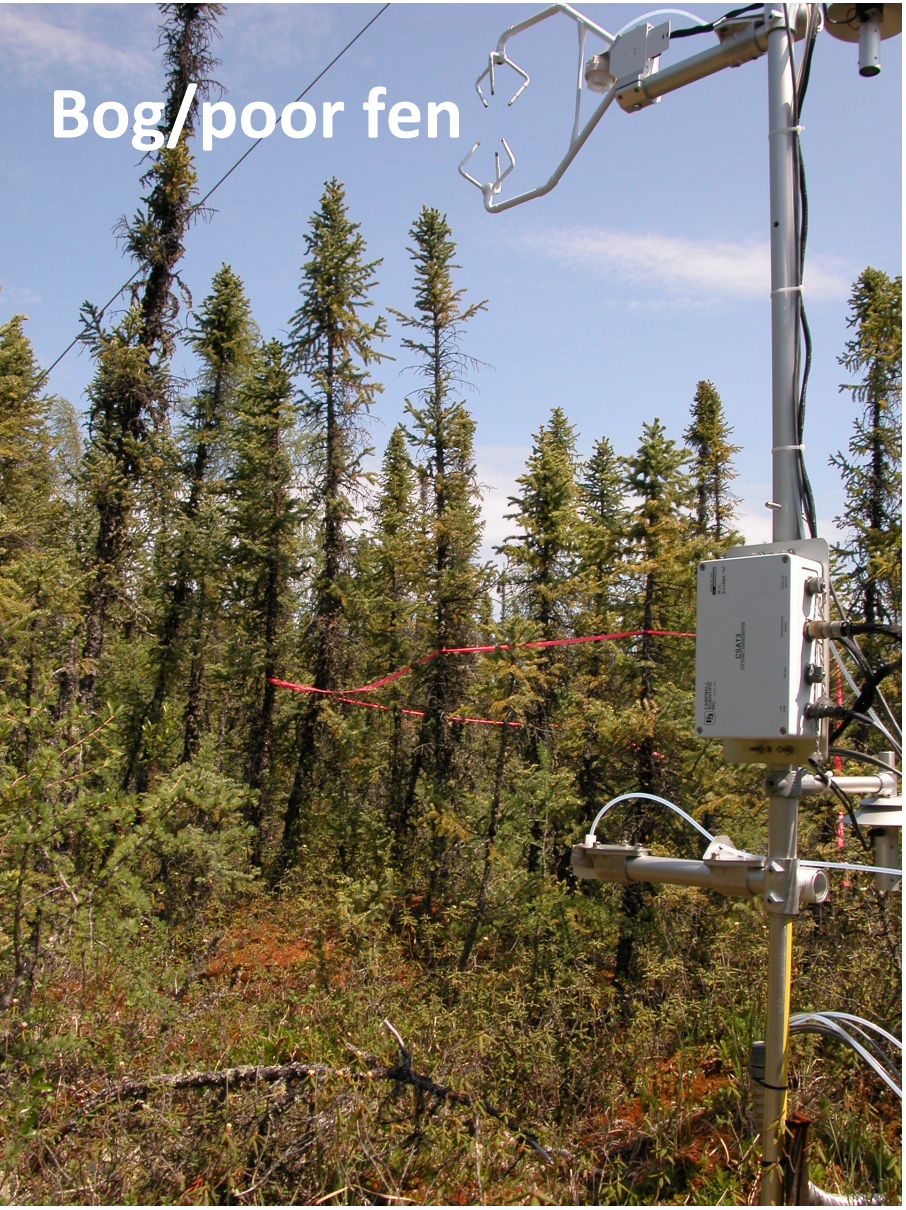


Plate 1 Northern Old Black Spruce site, including: (A) 30 m instrument tower, (B) instrument hut, (C) *Sphagnum* bog study area, (D) upland feathermoss study area. Note the heterogeneity in the tower's footprint; scale is approximate due to oblique angle of photo.

Dunn, A. L., C. C. Barford, S. C. Wofsy, M. L. Goulden, and B. C. Daube. 2007. The long-term carbon balance of a boreal black spruce forest: means, responses to interannual variability, and long-term trends. Global Change Biology 13: 577–590.


Bog/poor fen


Upland Black Spruce


Ali Dunn


Lucy
Hutyra


Carol
Barford

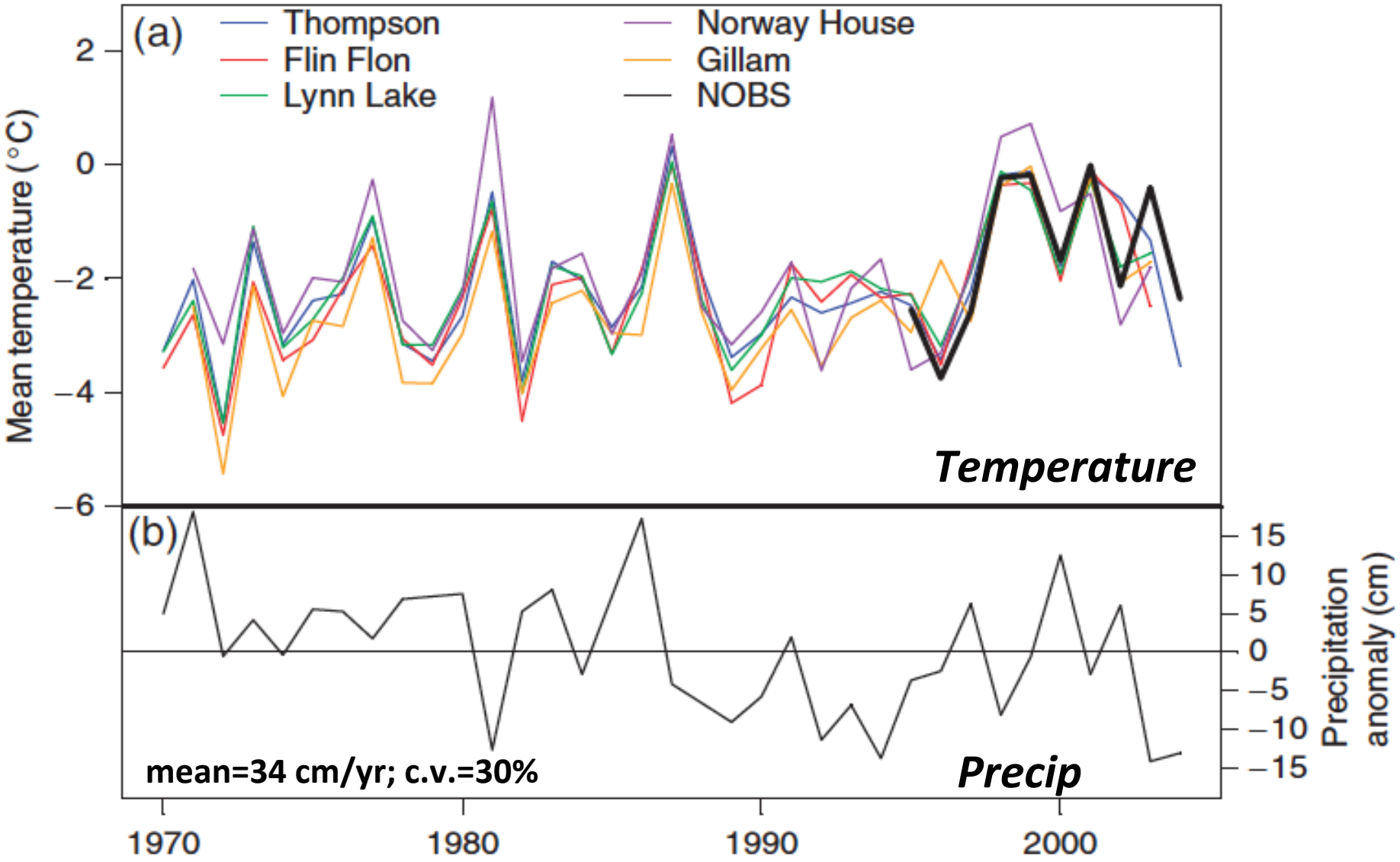

Alfram
Bright

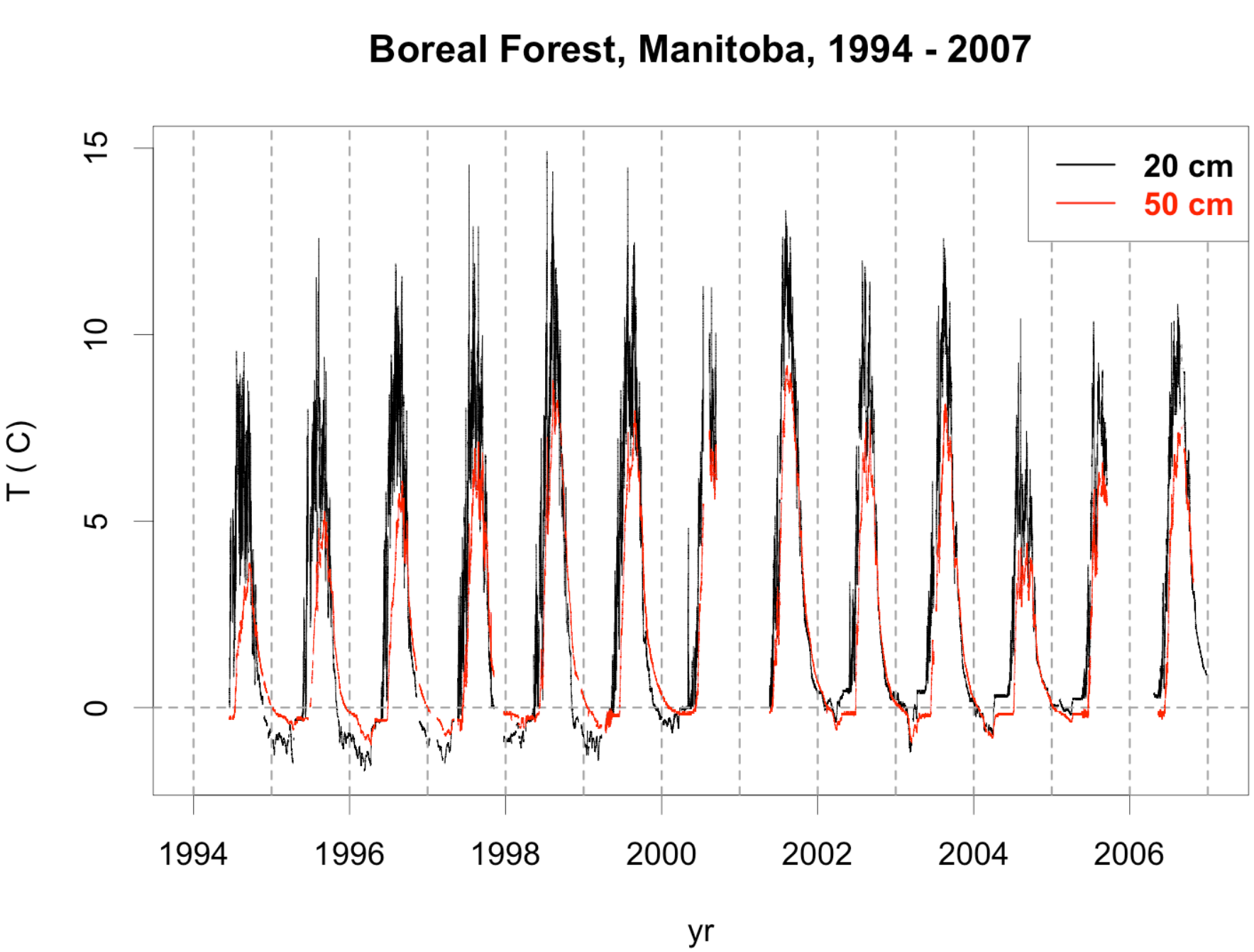

John
Budney

BOREAS NOBS: what did we observe, what did we learn?

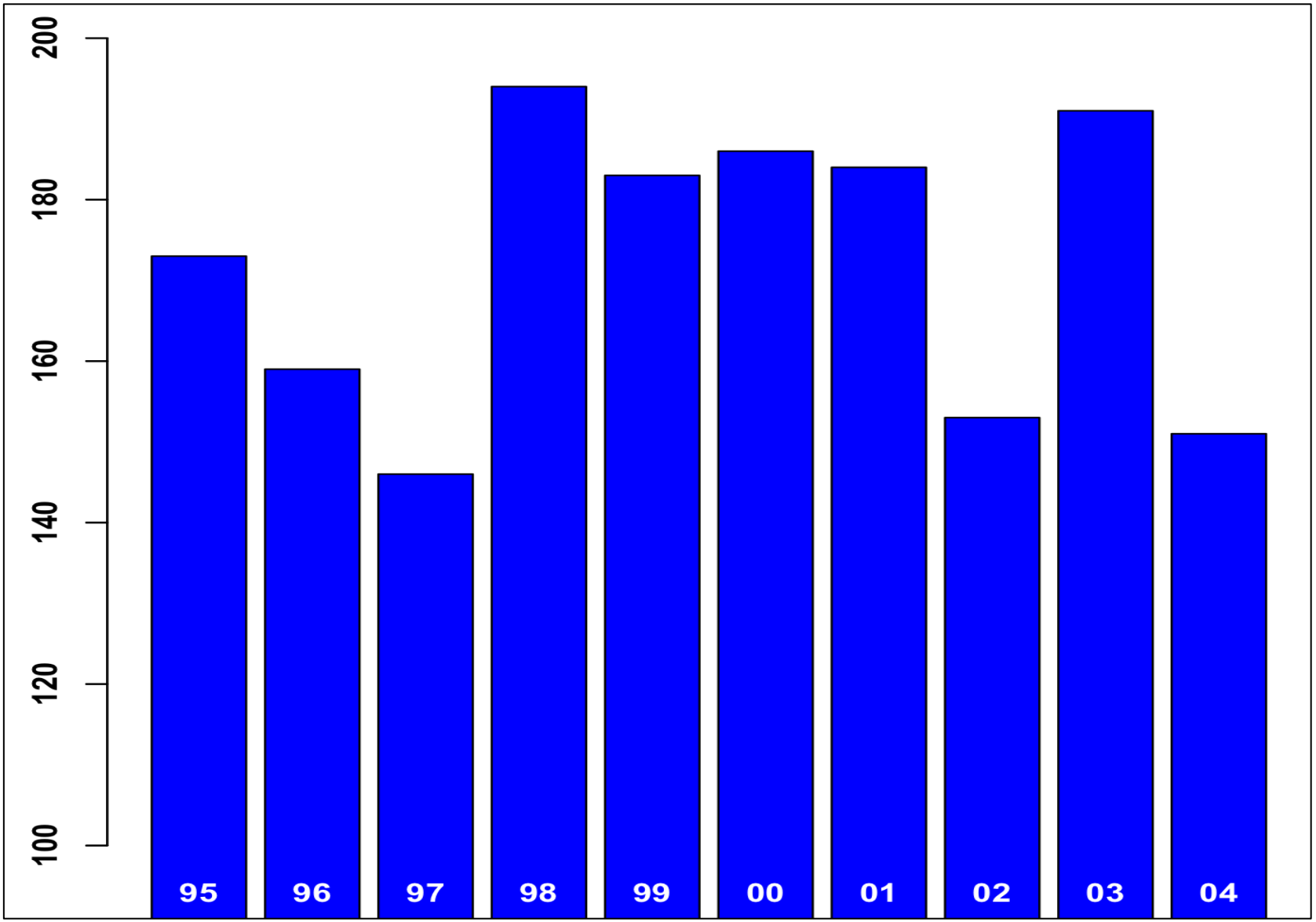
Temperature, precipitation very variable,

30 year trend not obvious

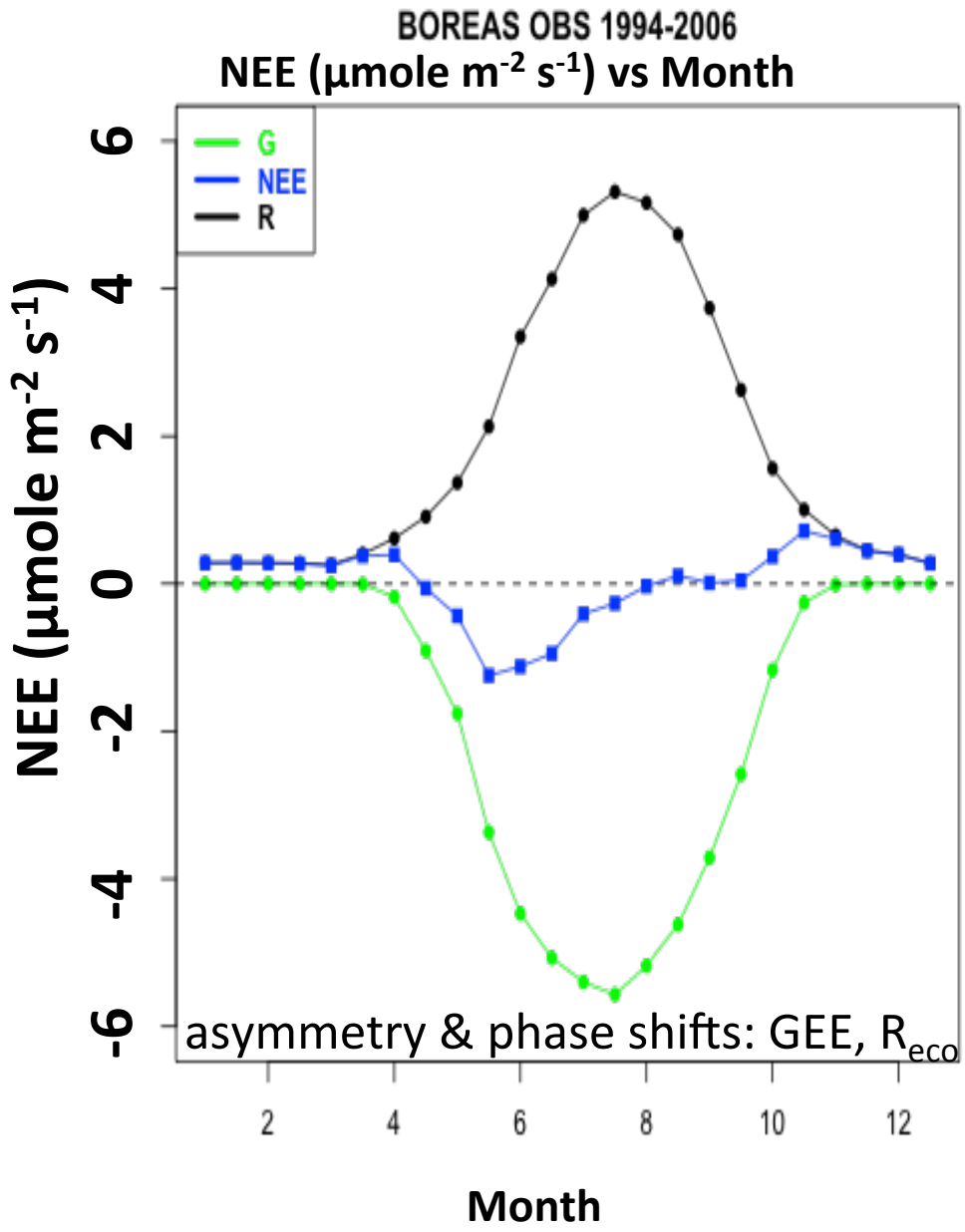


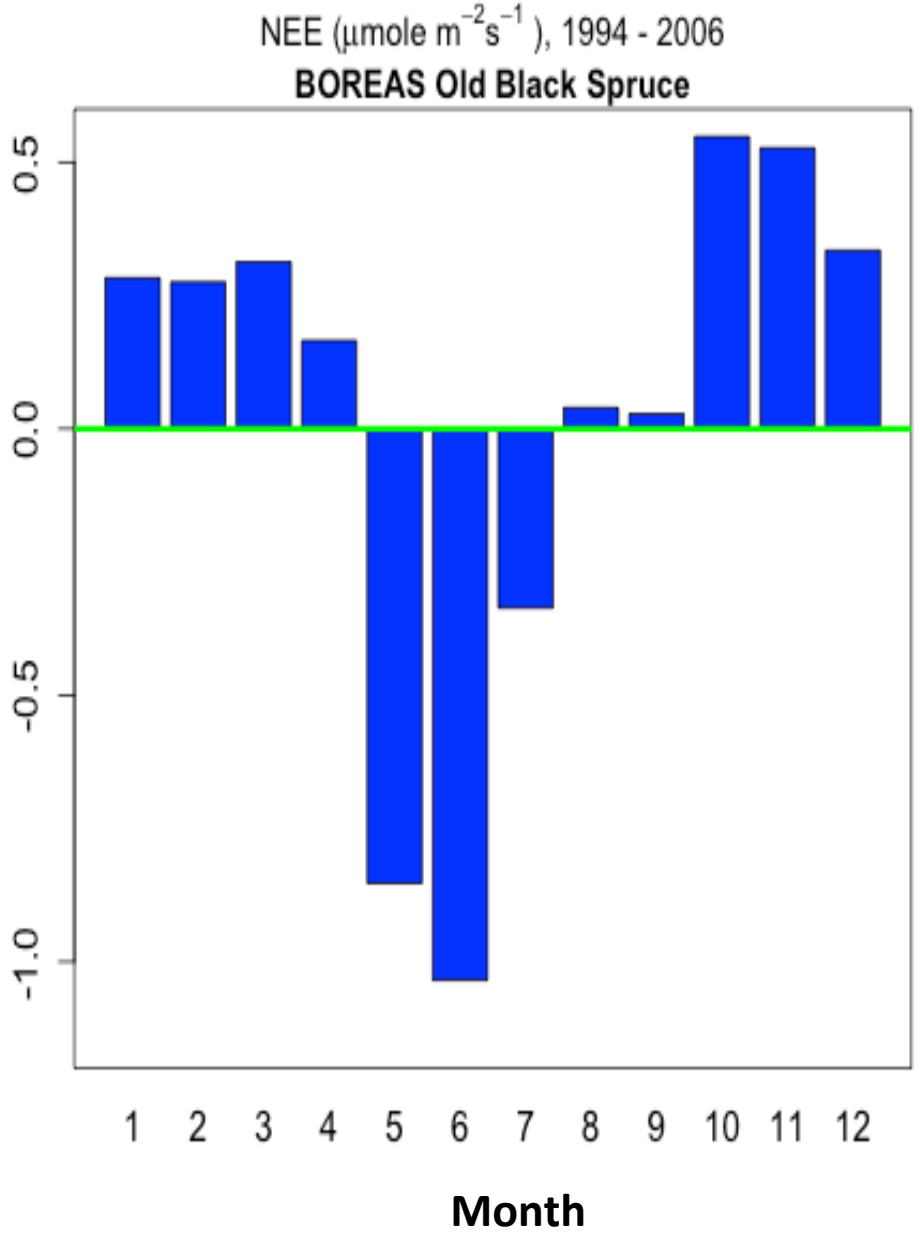

Boreal Forest, Manitoba, 1994 - 2007
20 cm
50 cm
T (C)
0
5
10
15
1994
1996
1998
2000
2002
2004
2006
yr

Length of the growing season (days) vs year



Early Uptake, Large Fall/Winter Resp., Aug-Sep "Shutdown"





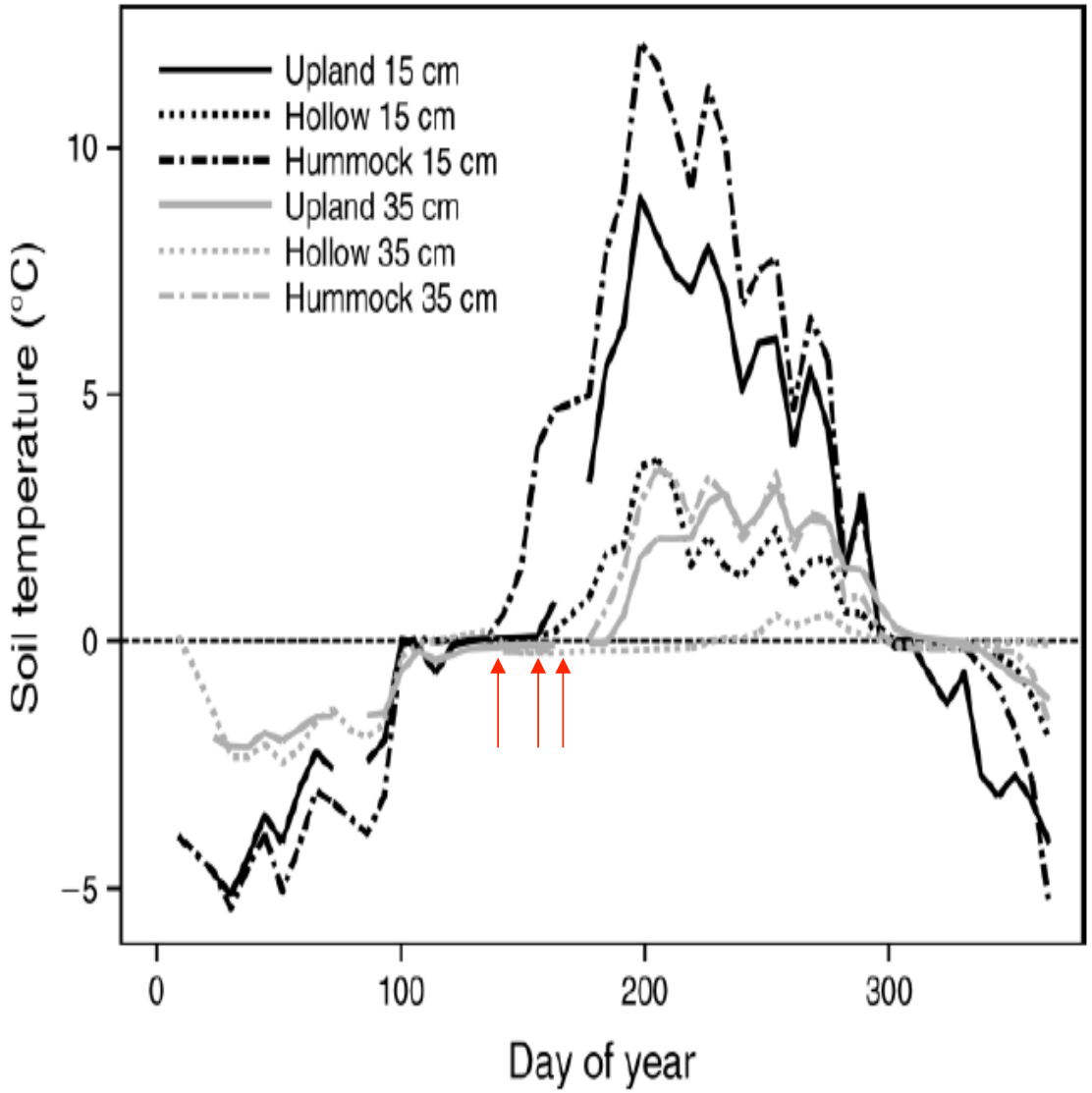
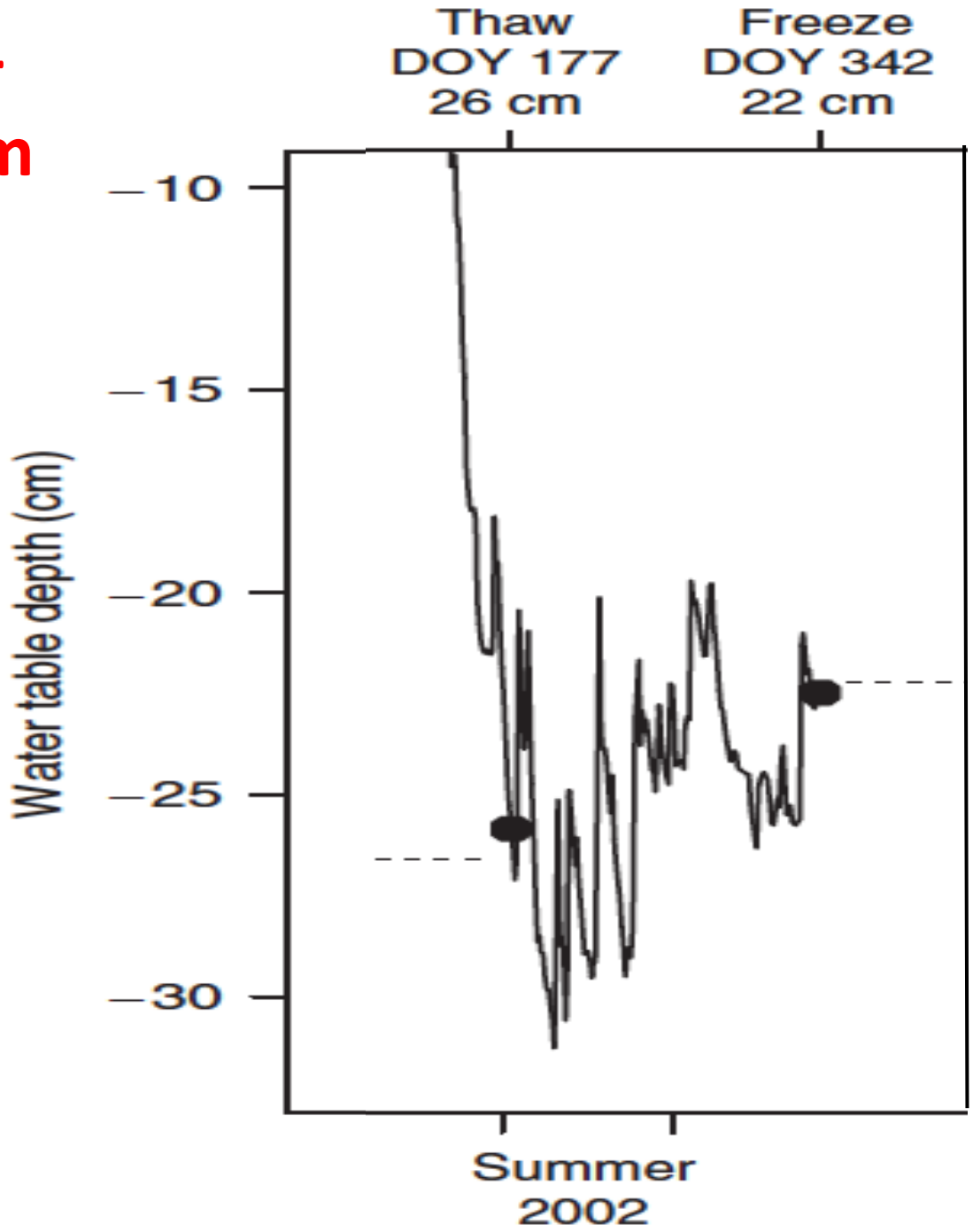


FIG. 1. Soil temperature during 2004 in three boreal land cover types: upland (well-drained soils, dense closed-canopy forest), hollow (microtopographic low point in a poorly drained wetland), and hummock (microtopographic high point in a poorly drained wetland).

Water table depth—a driver of ecosystem respiration

***Spring*: frost-perched water table suppresses R**

***Fall*: Zero curtain extends active R**



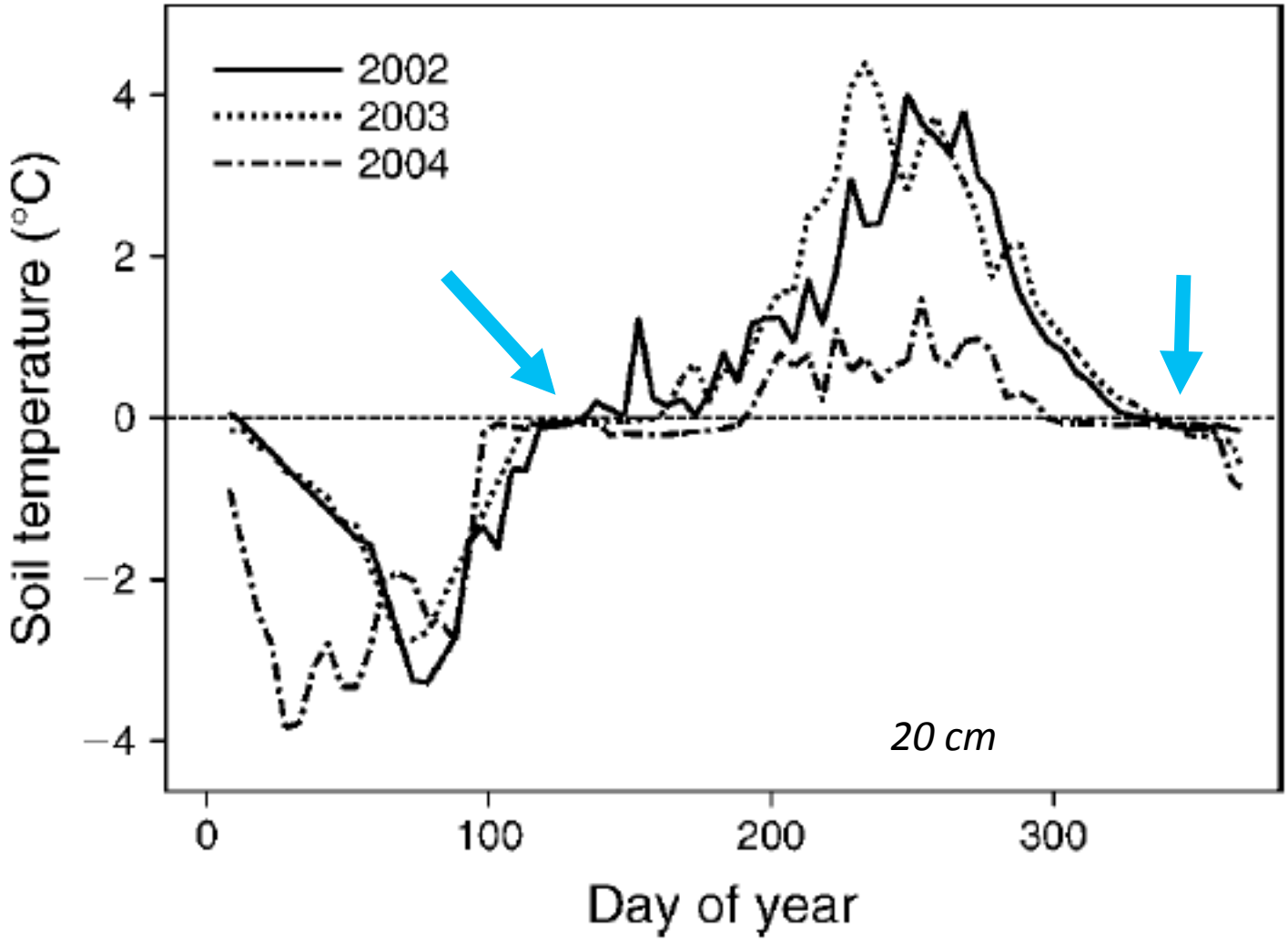


FIG. 2. Interannual variability in soil temperature in a microtopographic hollow at the wet site during the three years of this study.

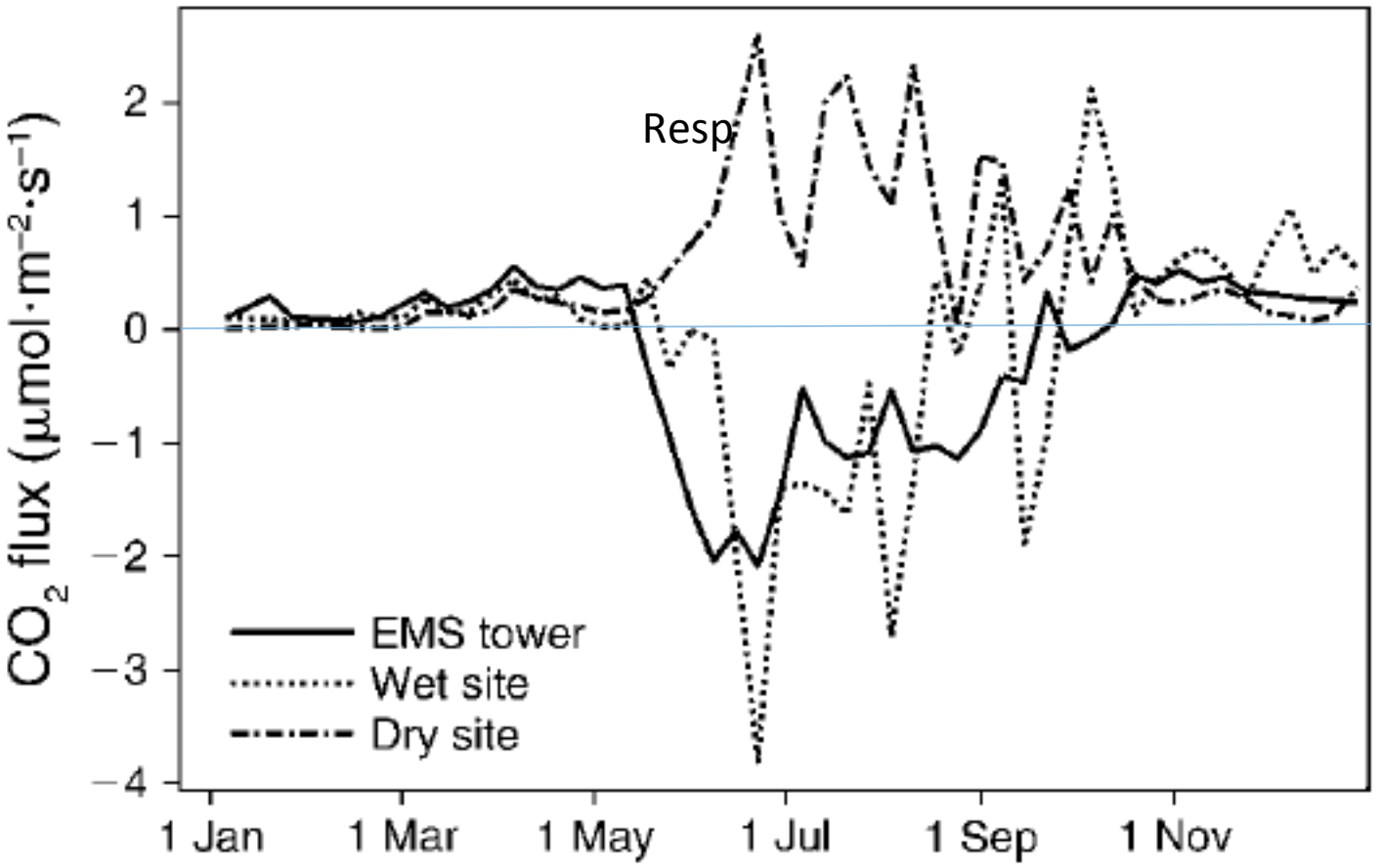
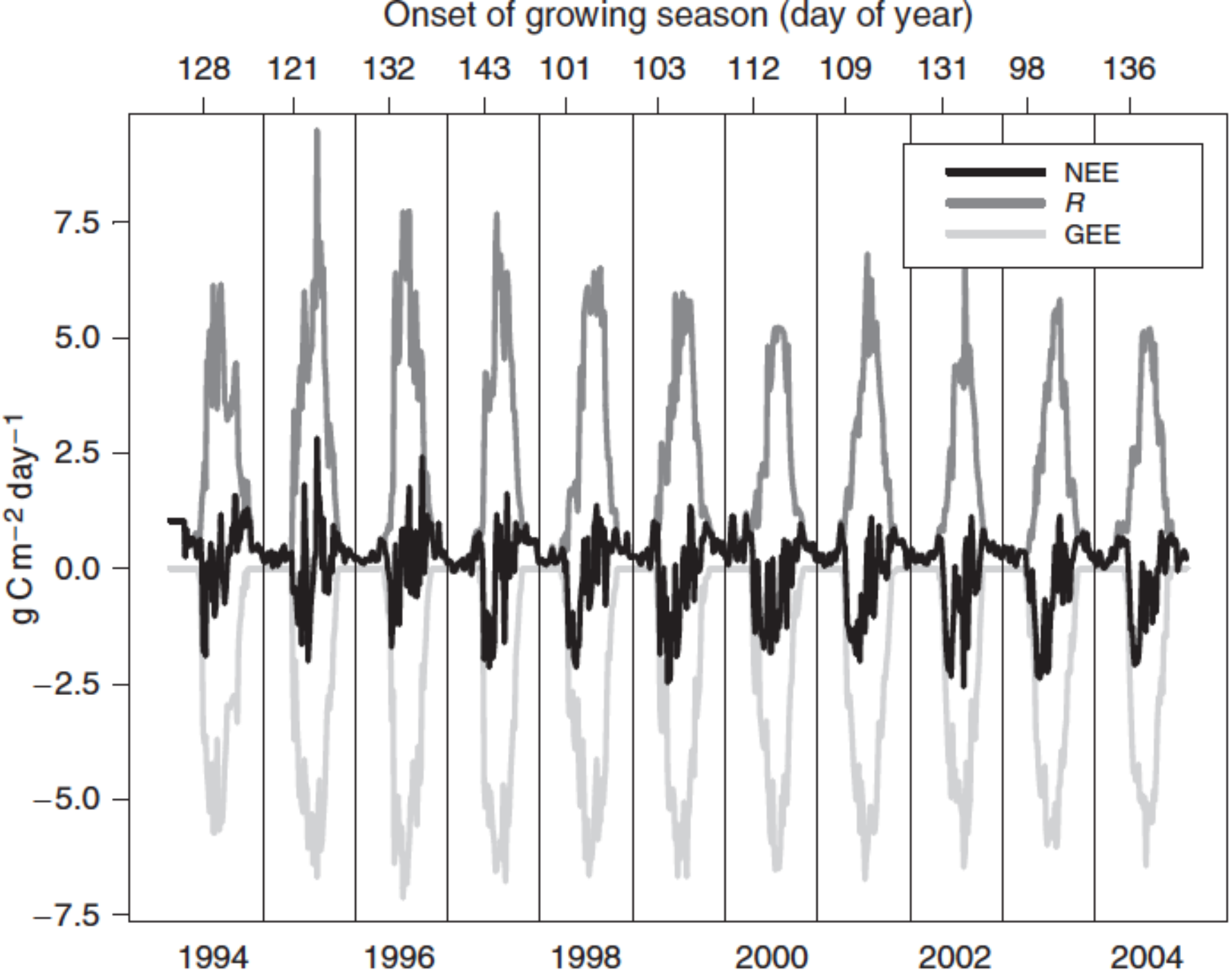
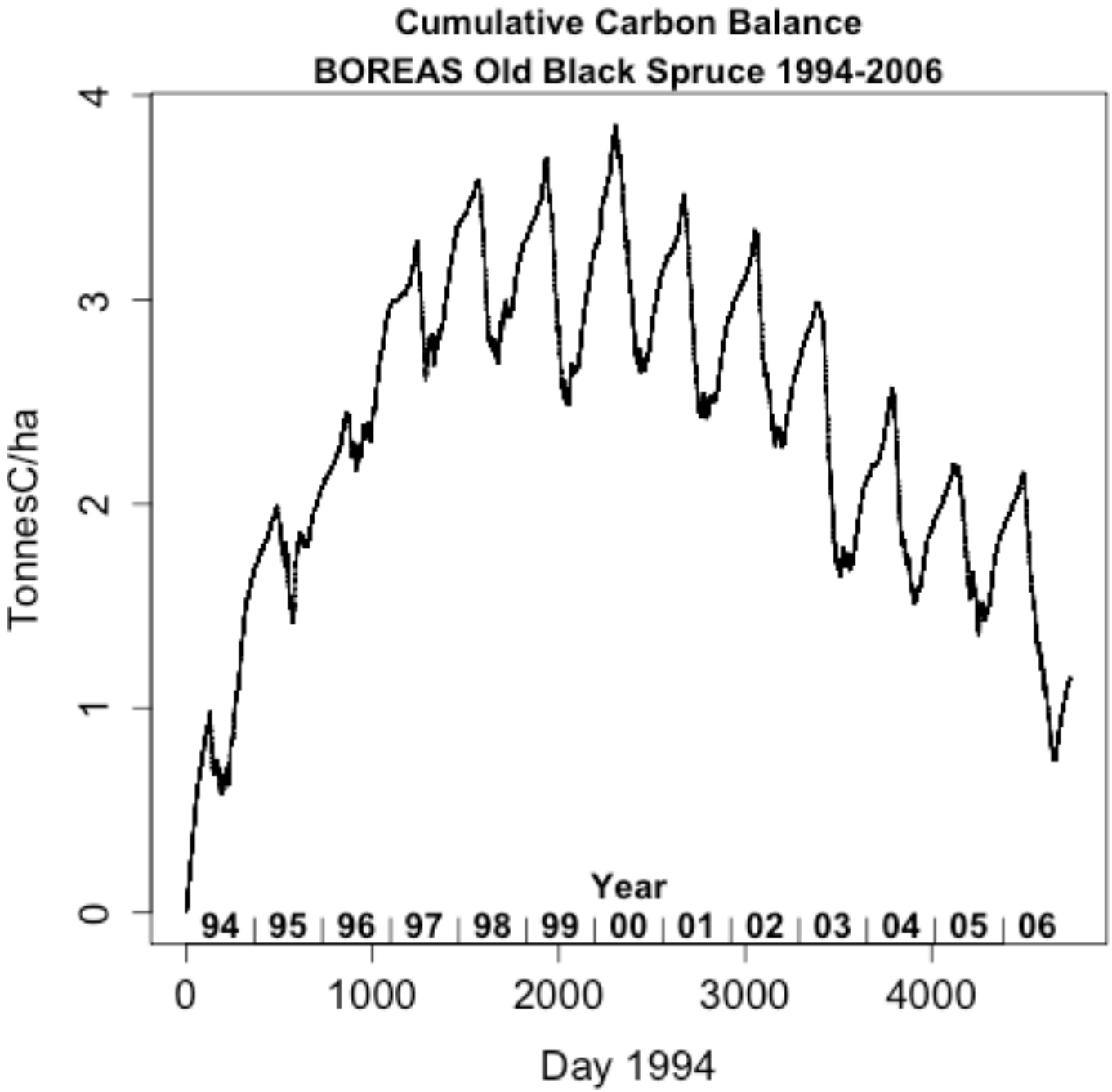
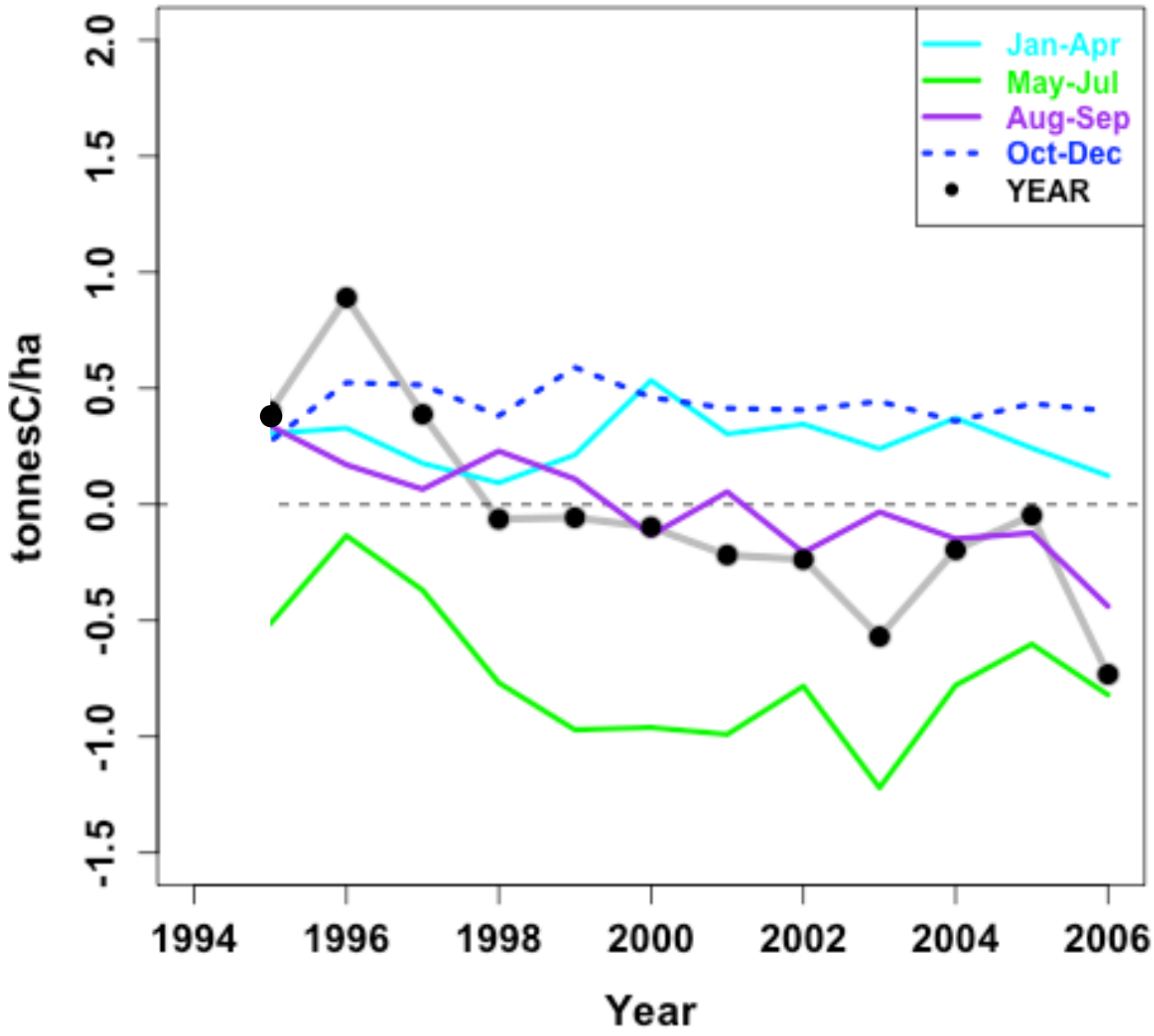


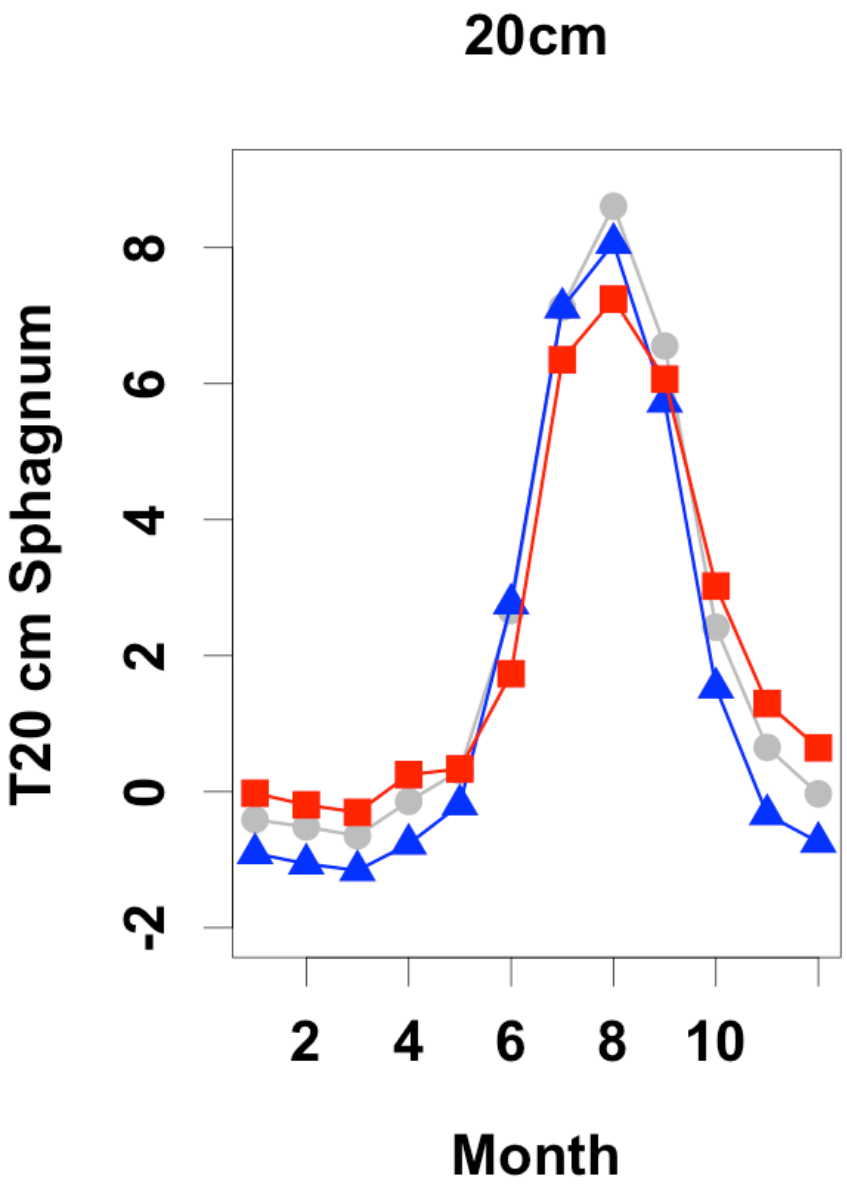
FIG. 6. Weekly average CO_2 flux during 2004 at the 30-m EMS tower and at the 2-m wet and dry sites.

Resp picks up more slowly


Onset of growing season (day of year)
128
121
132
143
101
103
112
109
131
98
136
NEE
R
GEE
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
g C m−2 day−1
1994
1996
1998
2000
2002
2004


Cumulative Carbon Balance
BOREAS Old Black Spruce 1994-2006
TonnesC/ha
0
1
2
3
4
Year
94
95
96
97
98
99
00
01
02
03
04
05
06
0
1000
2000
3000
4000
Day 1994


Jan-Apr
May-Jul
Aug-Sep
Oct-Dec
YEAR
tonnesC/ha
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
1994
1996
1998
2000
2002
2004
2006
Year


20cm
T20 cm Sphagnum
-2
0
2
4
6
8
2
4
6
8
10
Month

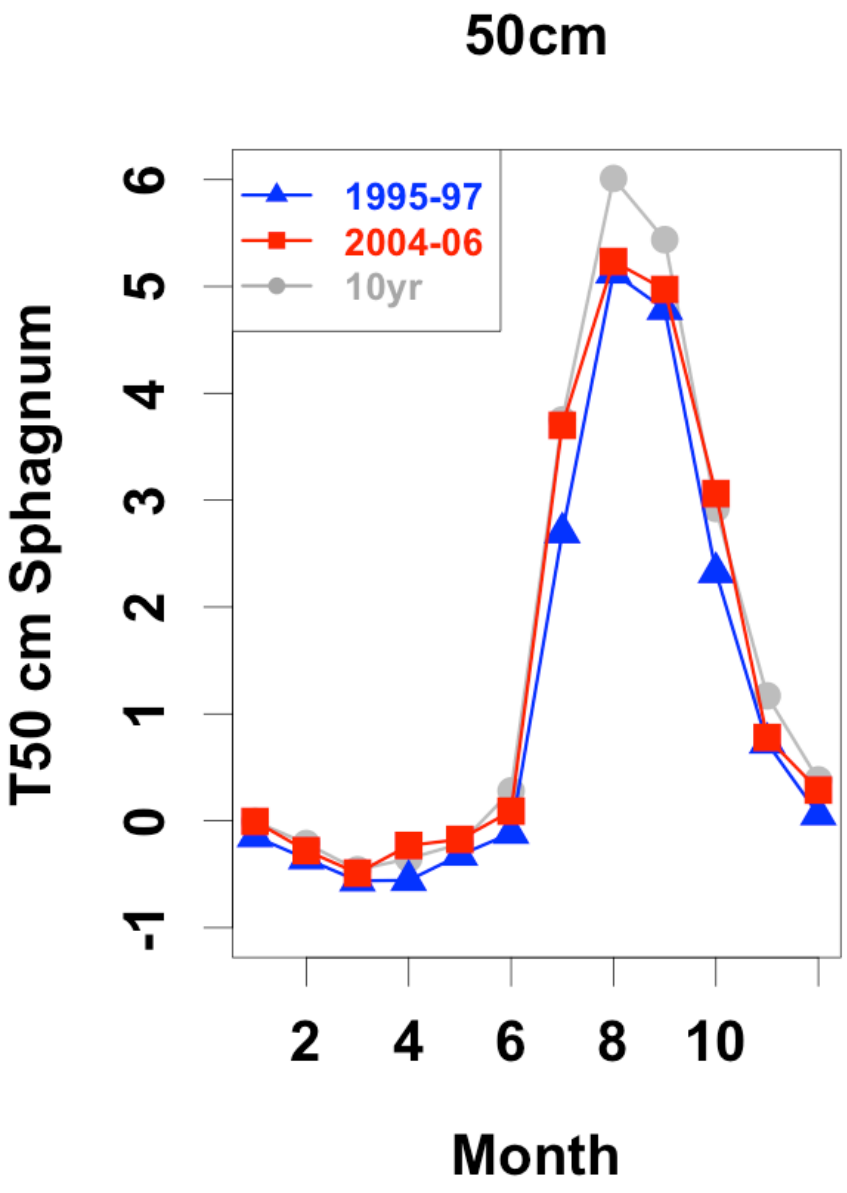

50cm
T50 cm Sphagnum
-1
0
1
2
3
4
5
6
1995-97
2004-06
10yr
2
4
6
8
10
Month

Table 2 Results of regressions between annual carbon exchange, 3-year lagged climate moisture index (CMI.3), and current year potential evapotranspiration (PET)

	CMI.3 coefficient	PET coefficient	R^2	P
NEE	−9.5	0.4	0.75	0.008
R	−18.4	2.0	0.87	0.0008
GEE	8.7	−1.6	0.77	0.006

CMI.3 = mean($[Precip - PET]_{-1} + [Precip - PET]_{-2} + [Precip - PET]_{-3}$)

After Hogg, 1997

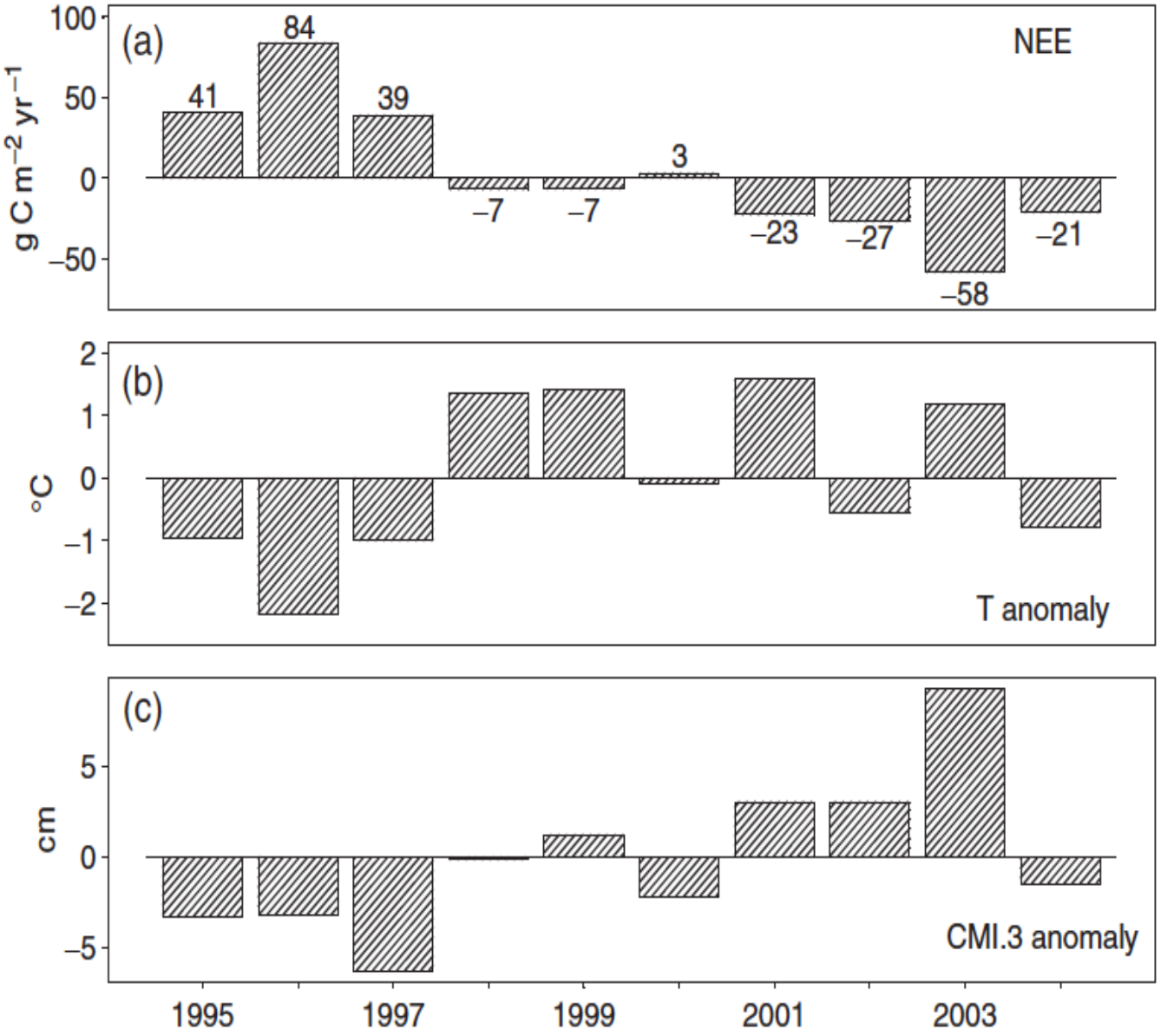
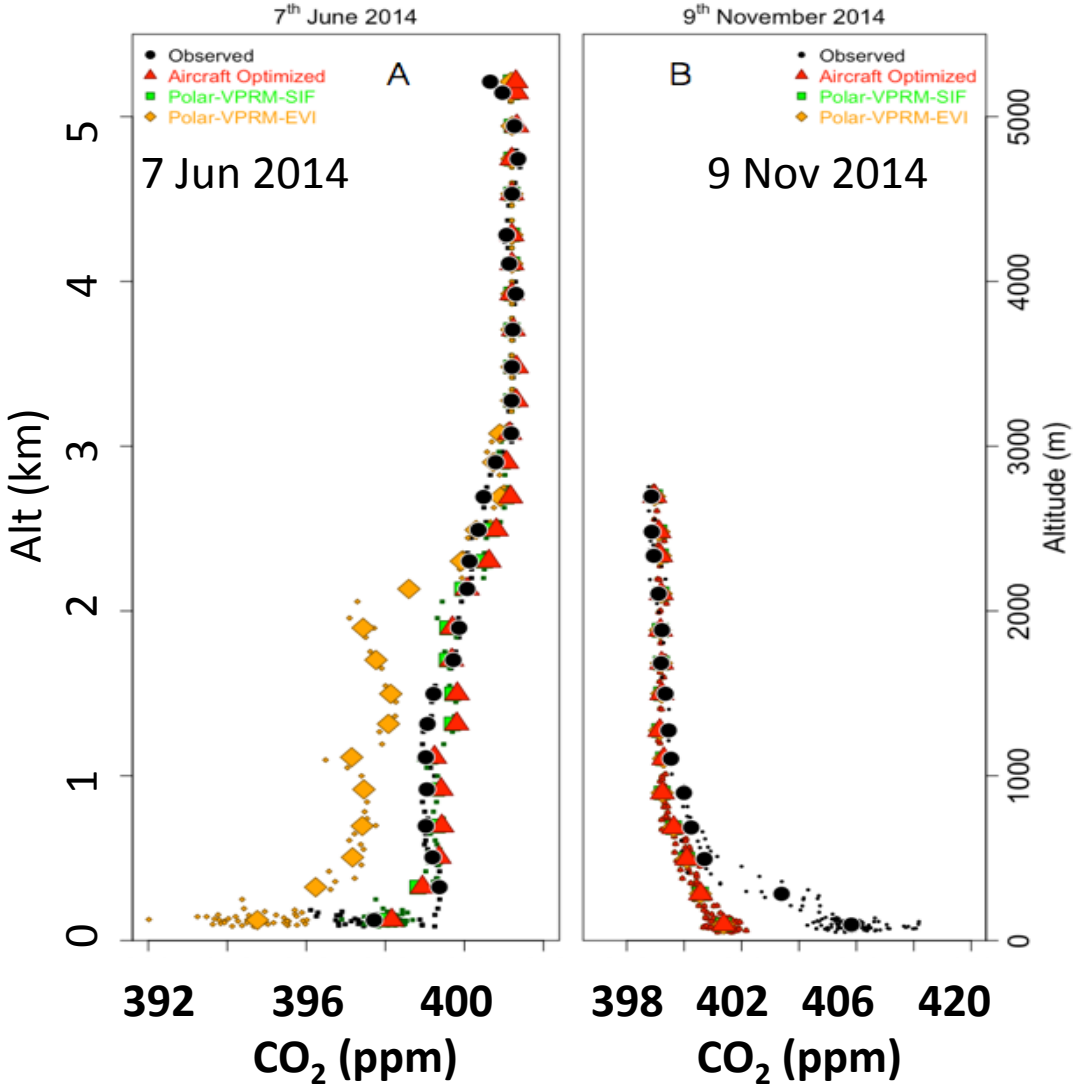


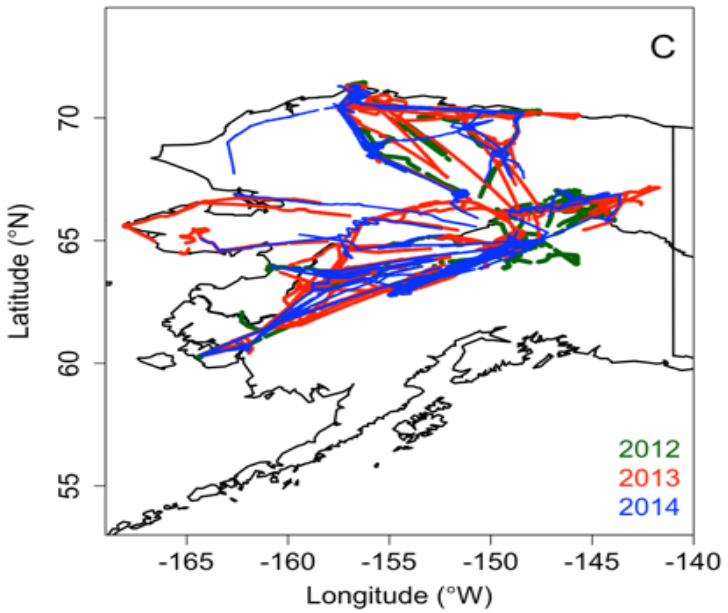
Fig. 7 Comparison with (a) net ecosystem exchange, (b) temperature anomaly, (c) 3-year lagged climate moisture index anomaly.

Carbon in the Arctic Reservoirs Vulnerability Experiment (CARVE) – EVS1 at JPL, C. E. Miller, PI;

Róisín Commane, Rachel Chang, Steve Wofsy, Harvard PIs

Colm Sweeney, NOAA; Jim Randerson, UCI

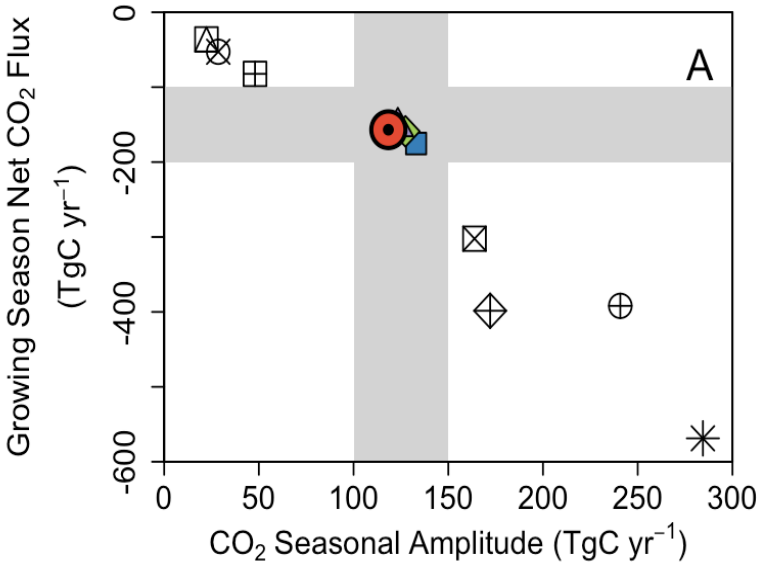


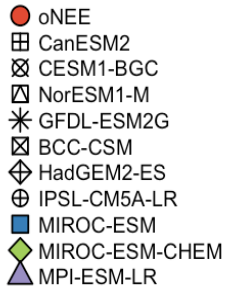


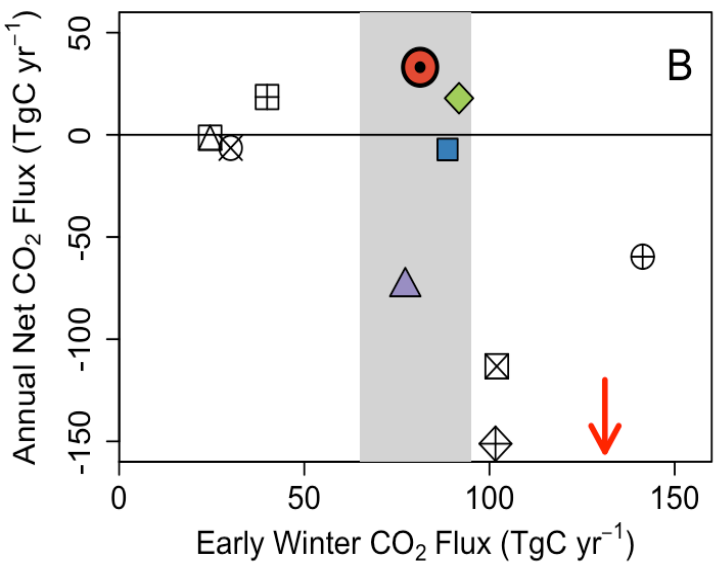
Three years of flights 2012-2014

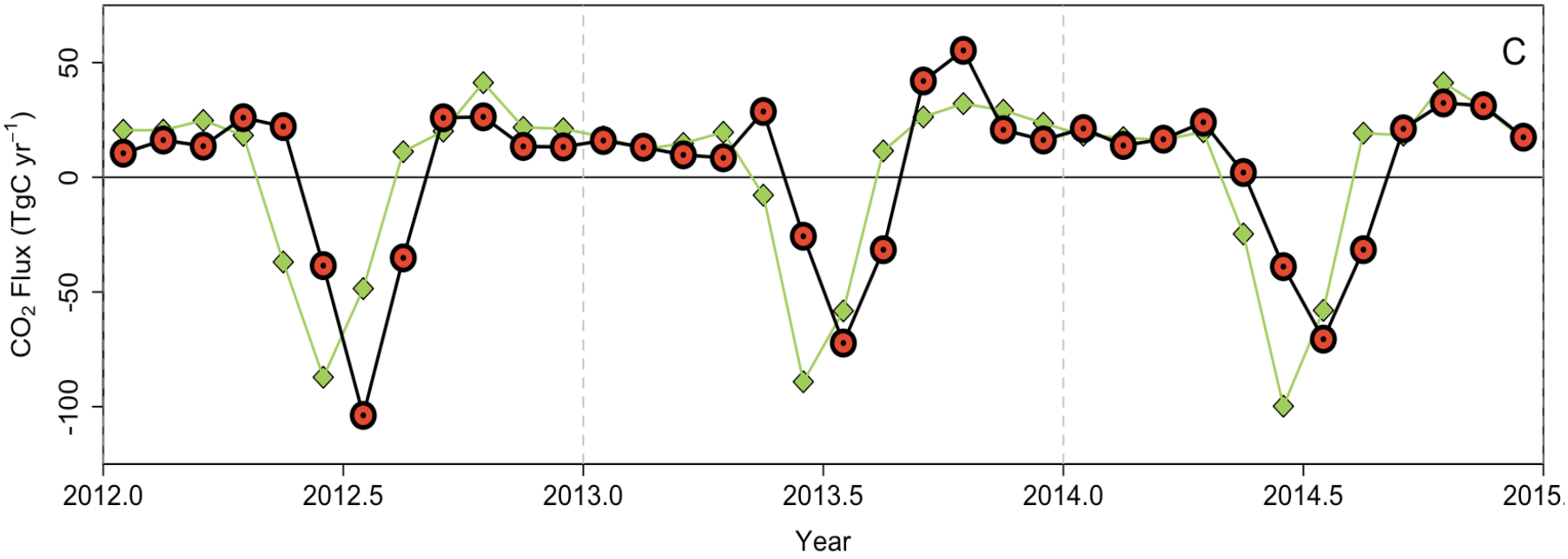
← Hundreds of vertical profiles

CARVE Regional Fluxes (Tundra + Forest) – similar seasonality to NOBS, *not simulated at all by IPCC (CMIP5) models*



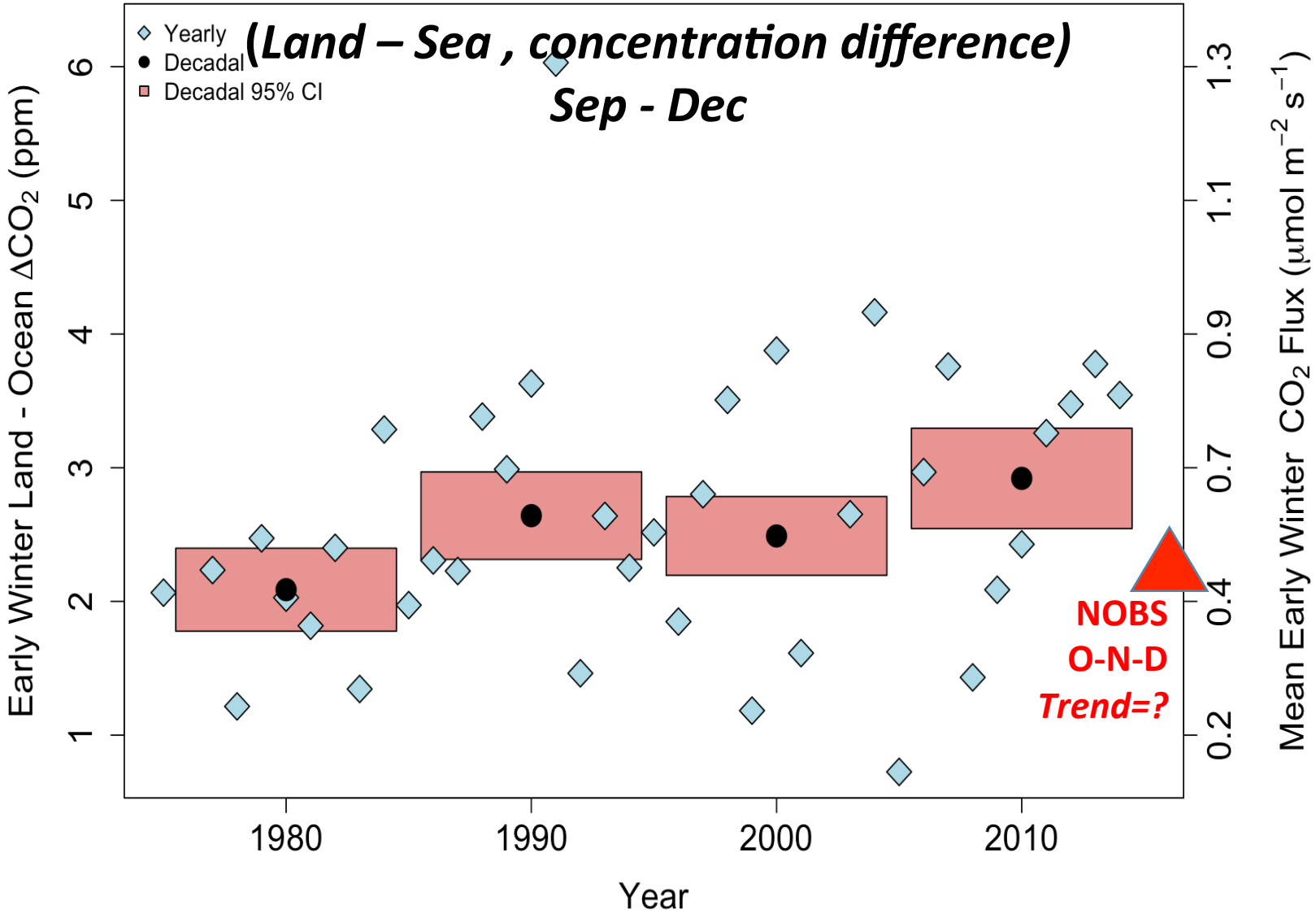




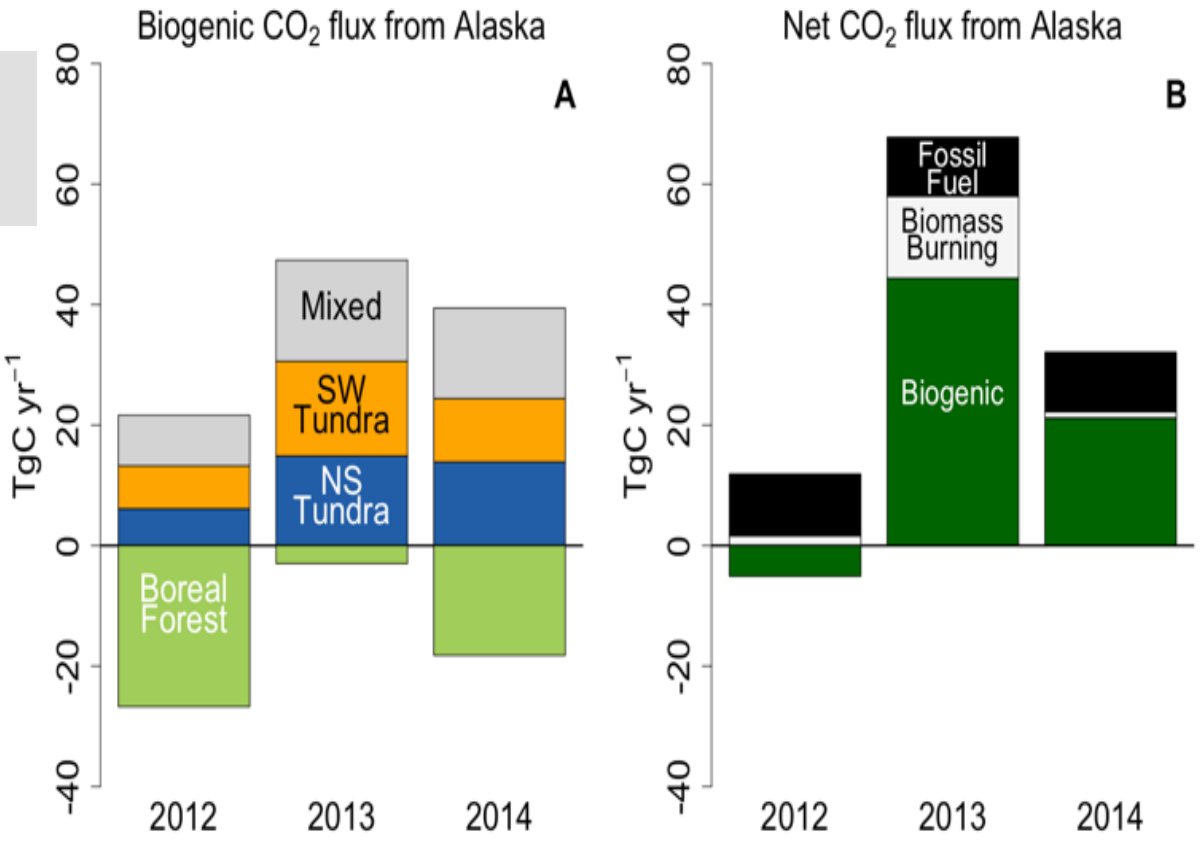


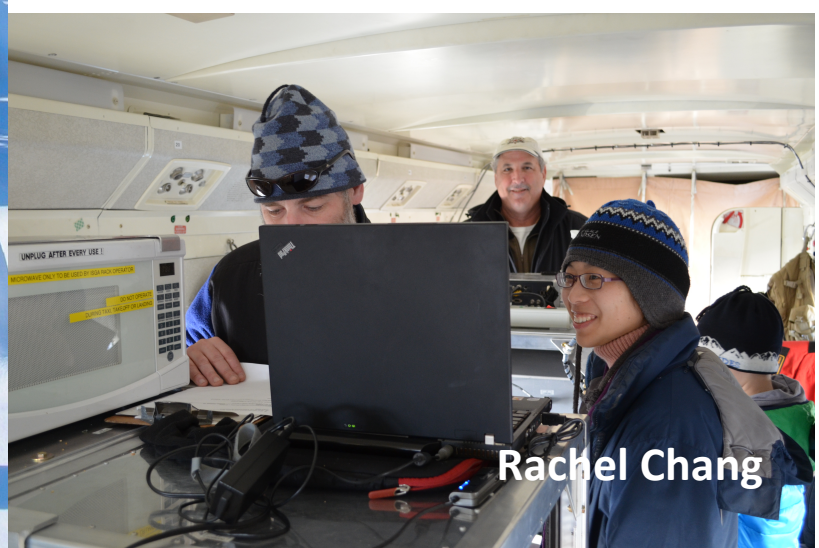
BRW Fall CO_2 efflux has increased 40-70% over 40 years

Fall R emissions inferred from 40 years of BRW data



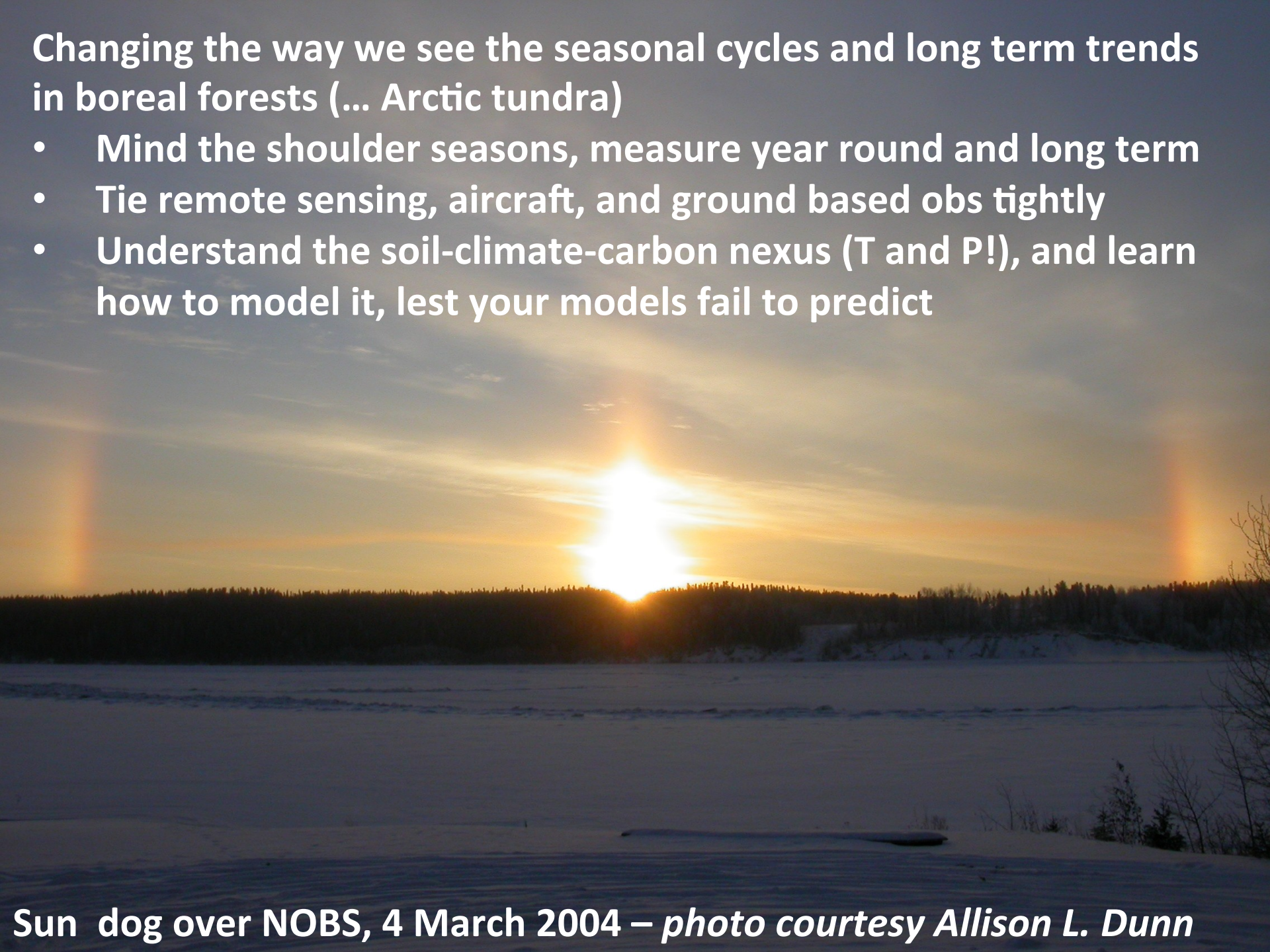
CARVE = BOREAS Grandchild…





Changing the way we see the seasonal cycles and long term trends in boreal forests (… Arctic tundra)

- **Mind the shoulder seasons, measure year round and long term**
- **Tie remote sensing, aircraft, and ground based obs tightly**
- **Understand the soil-climate-carbon nexus (T and P!), and learn how to model it, lest your models fail to predict**



Sun dog over NOBS, 4 March 2004 – *photo courtesy Allison L. Dunn*