Five years of winter climate change-related research in the Canadian low Arctic: What have we learned?

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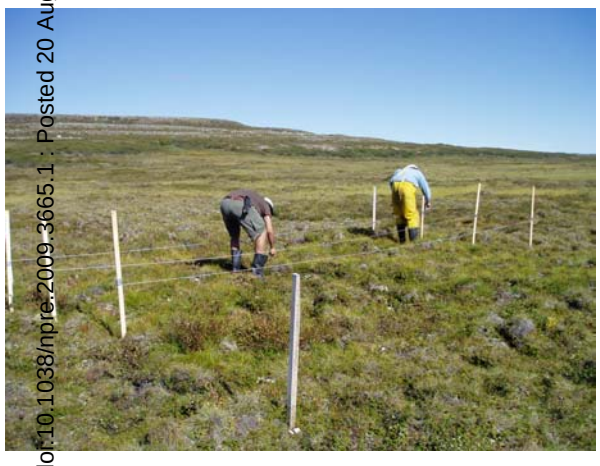
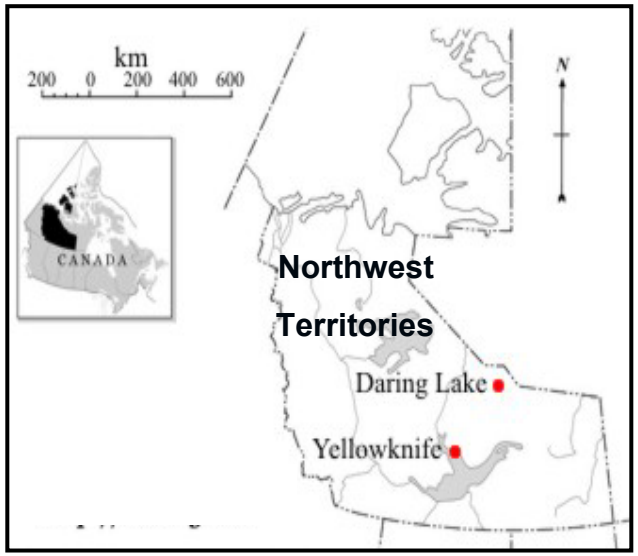
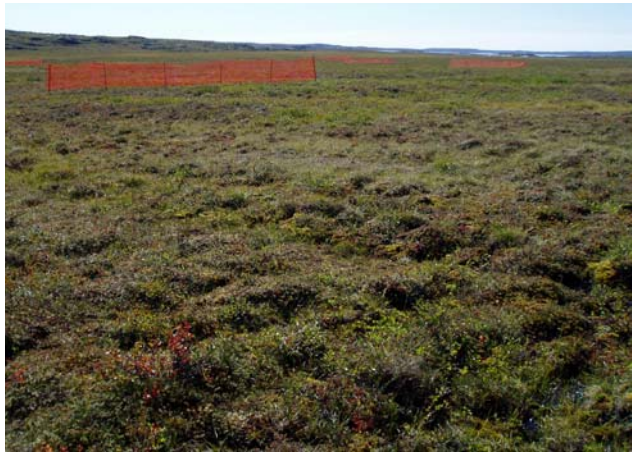
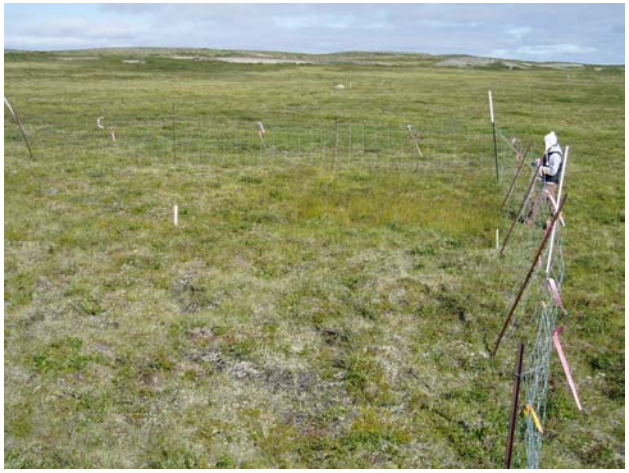
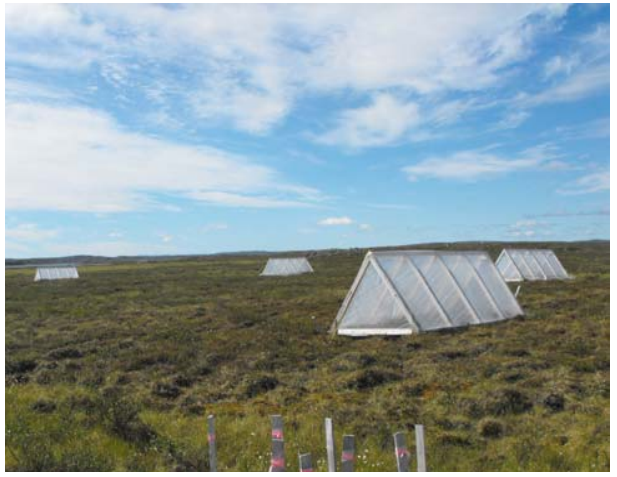
Daring Lake, NWT. Experimental manipulations to investigate ecosystem functioning…





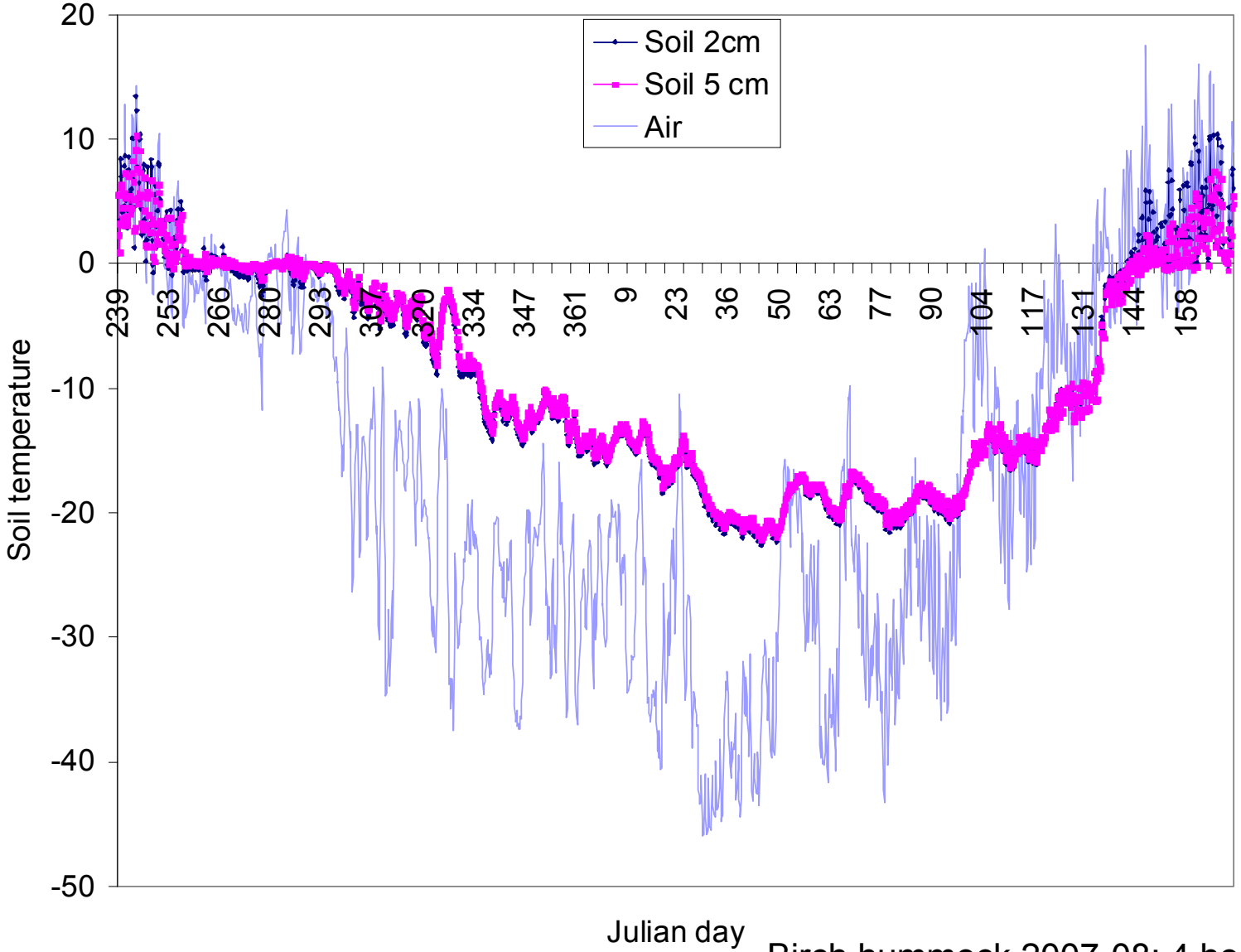






Do biogeochemical processes in the cold season significantly affect ecosystem functioning during the growing season?

What does a typical low arctic cold season soil temperature pattern look like?



Birch hummock 2007-08; 4 hourly data; n=2

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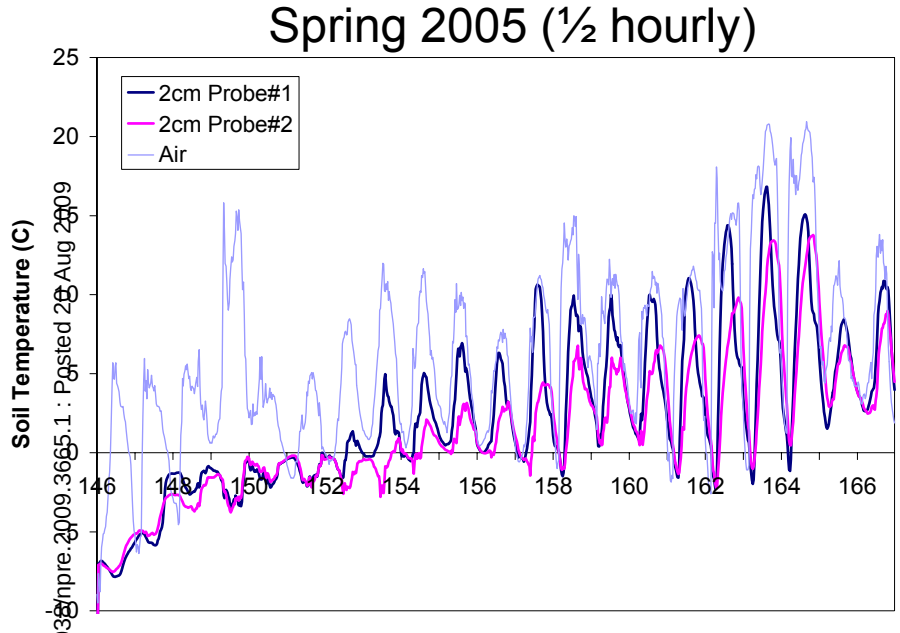
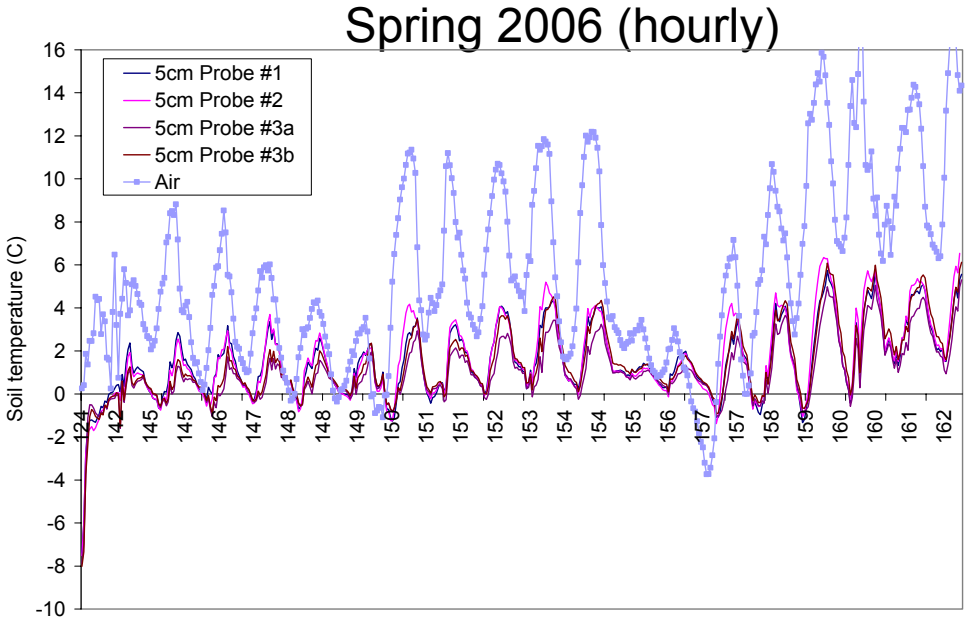
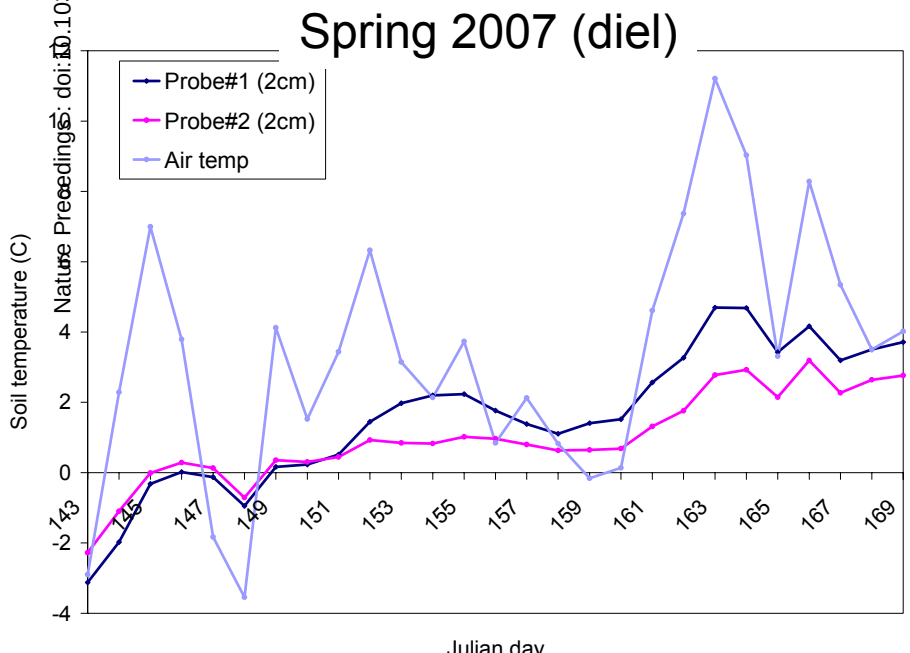
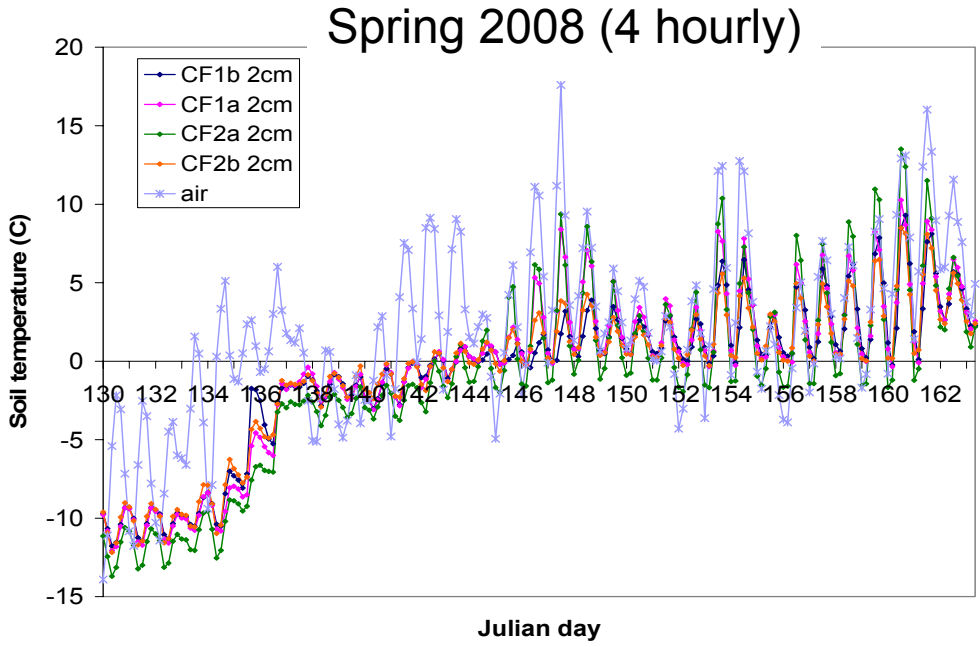
Soil temperature fluctuations around 0 ºC...







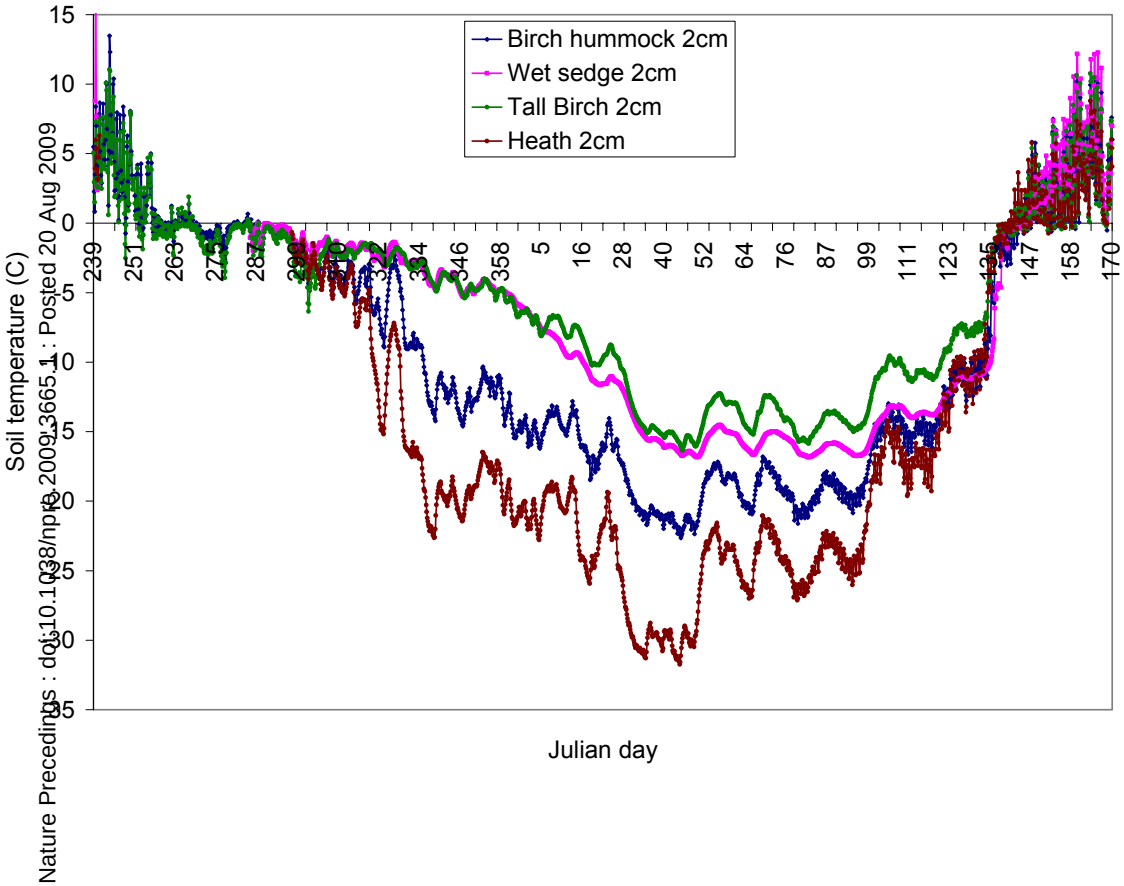


What factors determine the potential for soil freeze-thaw fluctuations?

- Insulation from severe air temperatures
  - Snowpack
  - Vegetation
- Soil moisture
  - Specific heat capacities
    - Water 4.1 J/C.g
    - Ice 2.1 J/C.g
    - Organic matter 1.8 J/C.g
  - Latent heat of freezing: 334 J/C.g
- *Winter-Spring? –Patchy in low arctic….but do occur elsewhere*
- *Fall?*

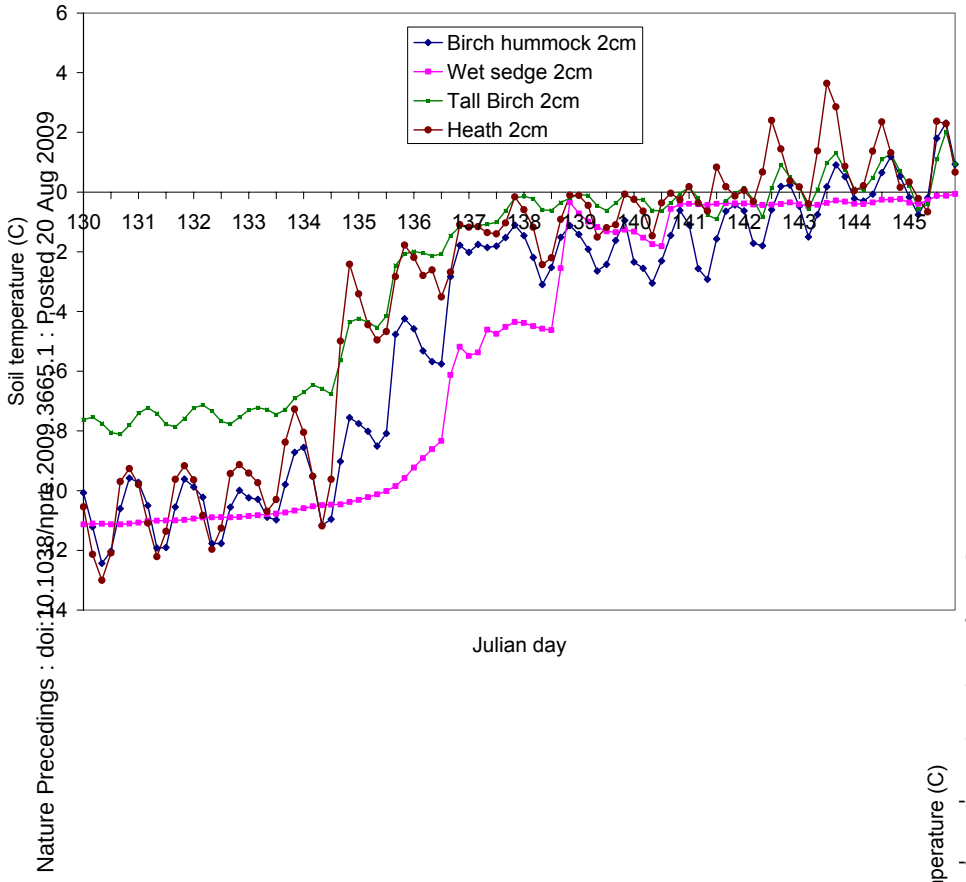
Energy released on cooling				
Temp.	Phase			
			Saturated (10 gH_2O/g)	Mesic (3 gH_2O/g)
5 C	Liquid	↓		
0 C	Liquid	↓	200	60
0 C	Solid	↓	3340	1113
-5 C	Solid		100	30

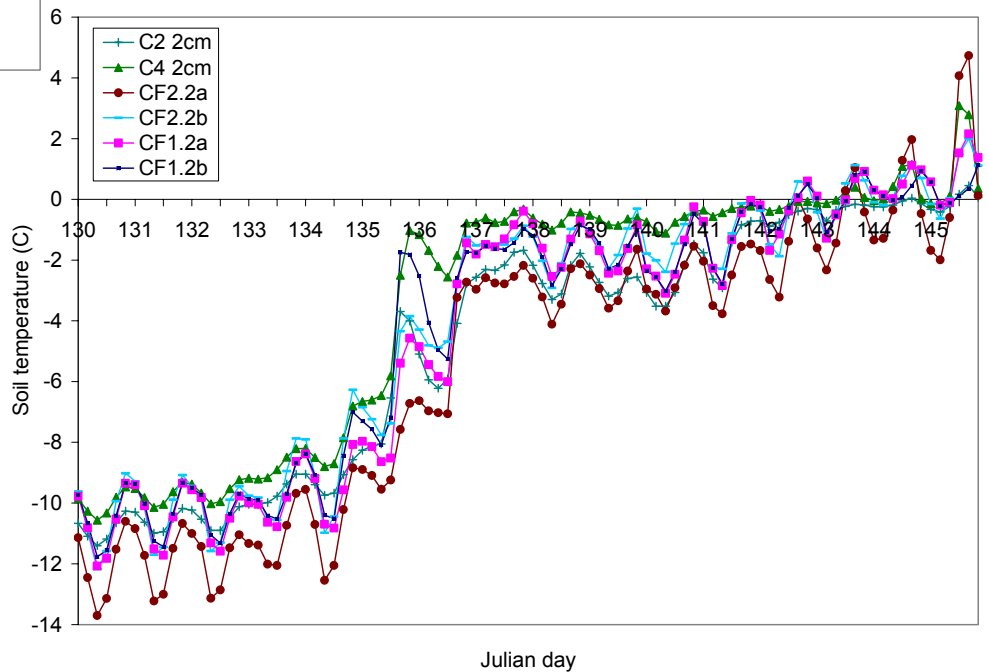
Spatial variation: among vegetation types…



2008; 4 hourly data; n=2-4; 2 cm depth

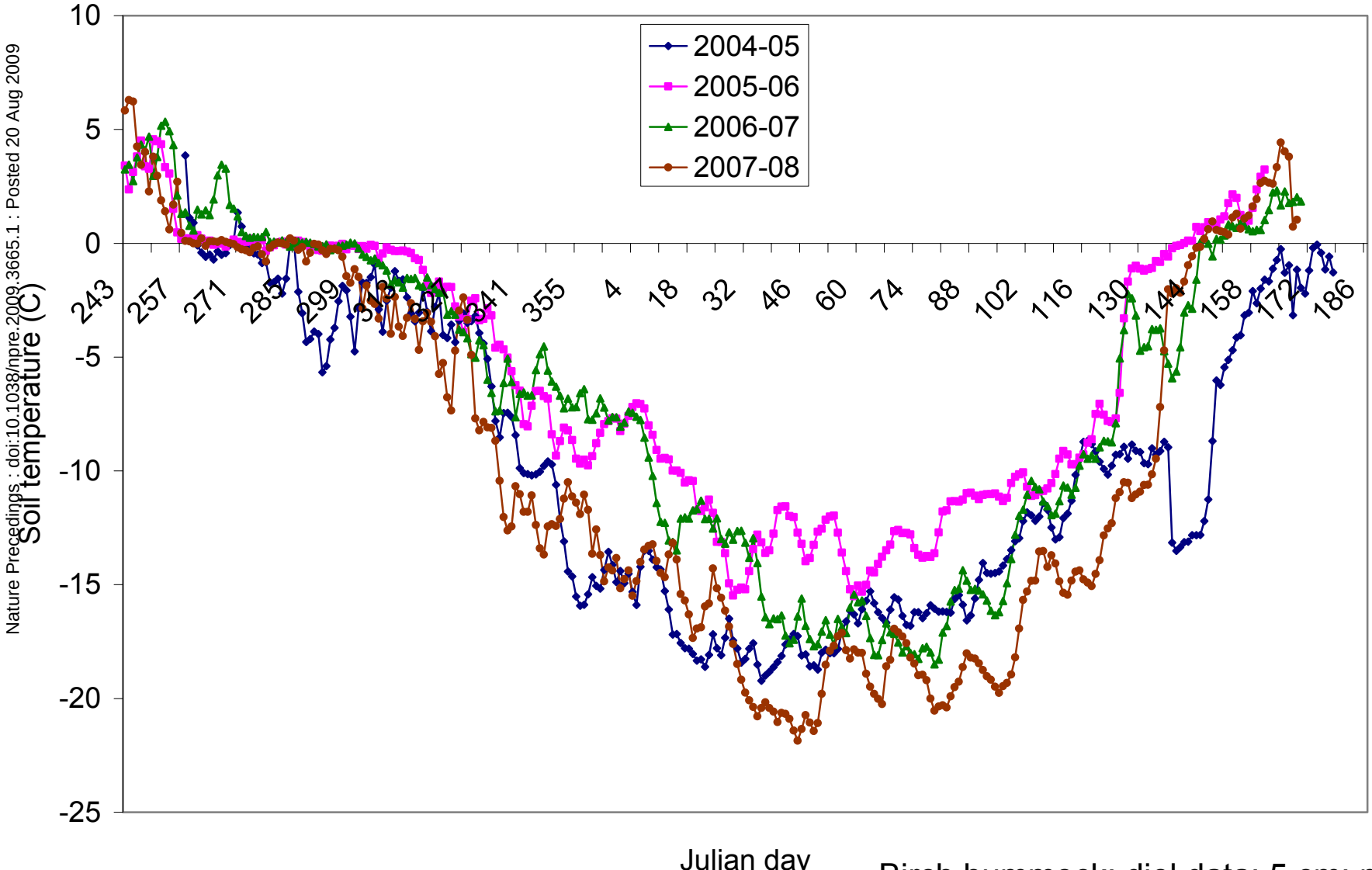
Spatial variation: among and within vegetation types





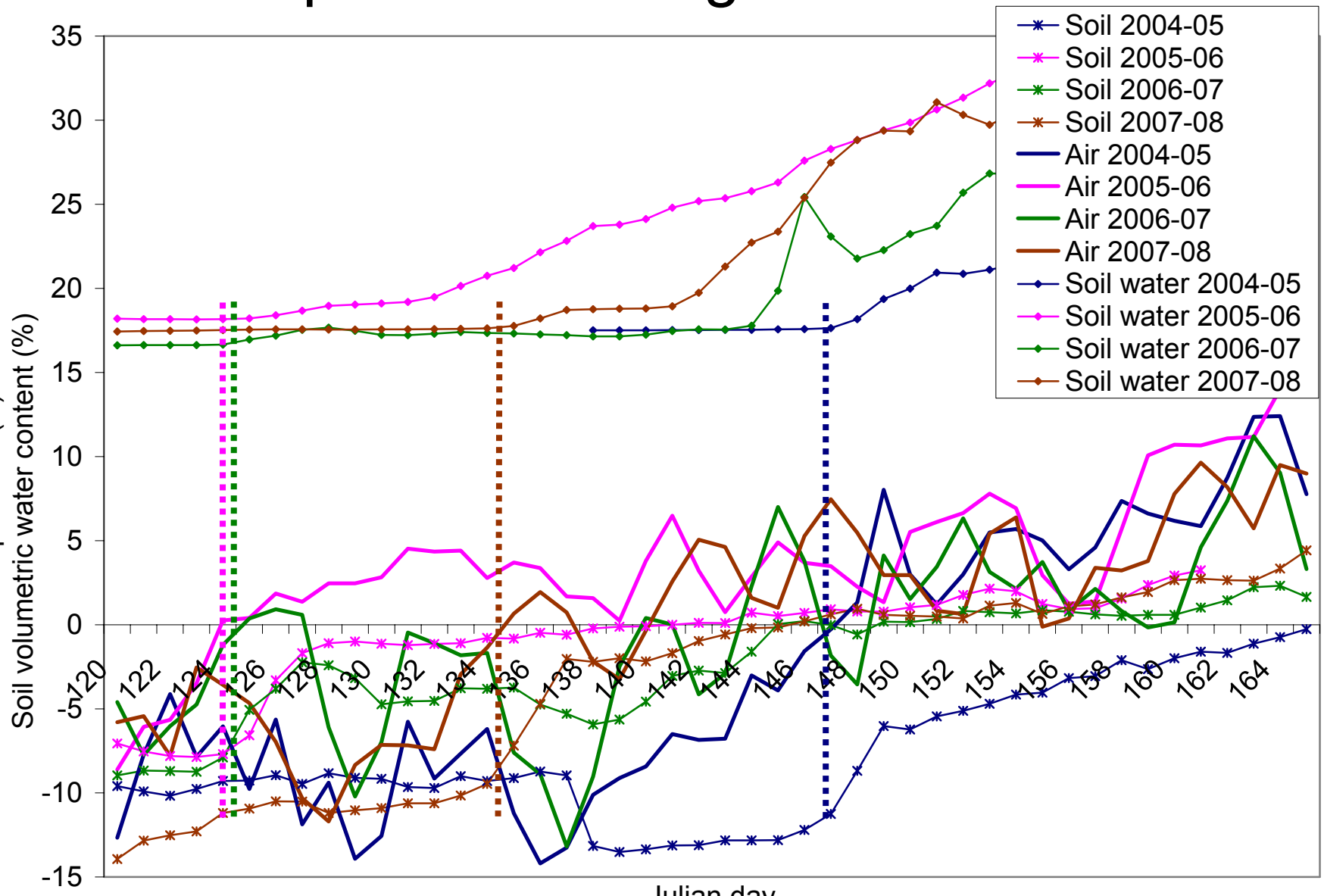
2008; 4 hourly data; n=2-4; 2 cm depth

Inter-annual variation in soil temperature



Birch hummock; diel data; 5 cm; n=2-4

What causes the rapid rise in soil temperature during late winter?



Birch hummock; diel data; 5 cm; n=2-4

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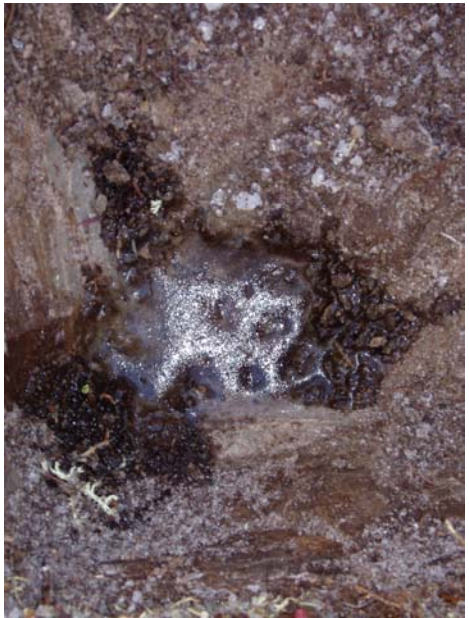
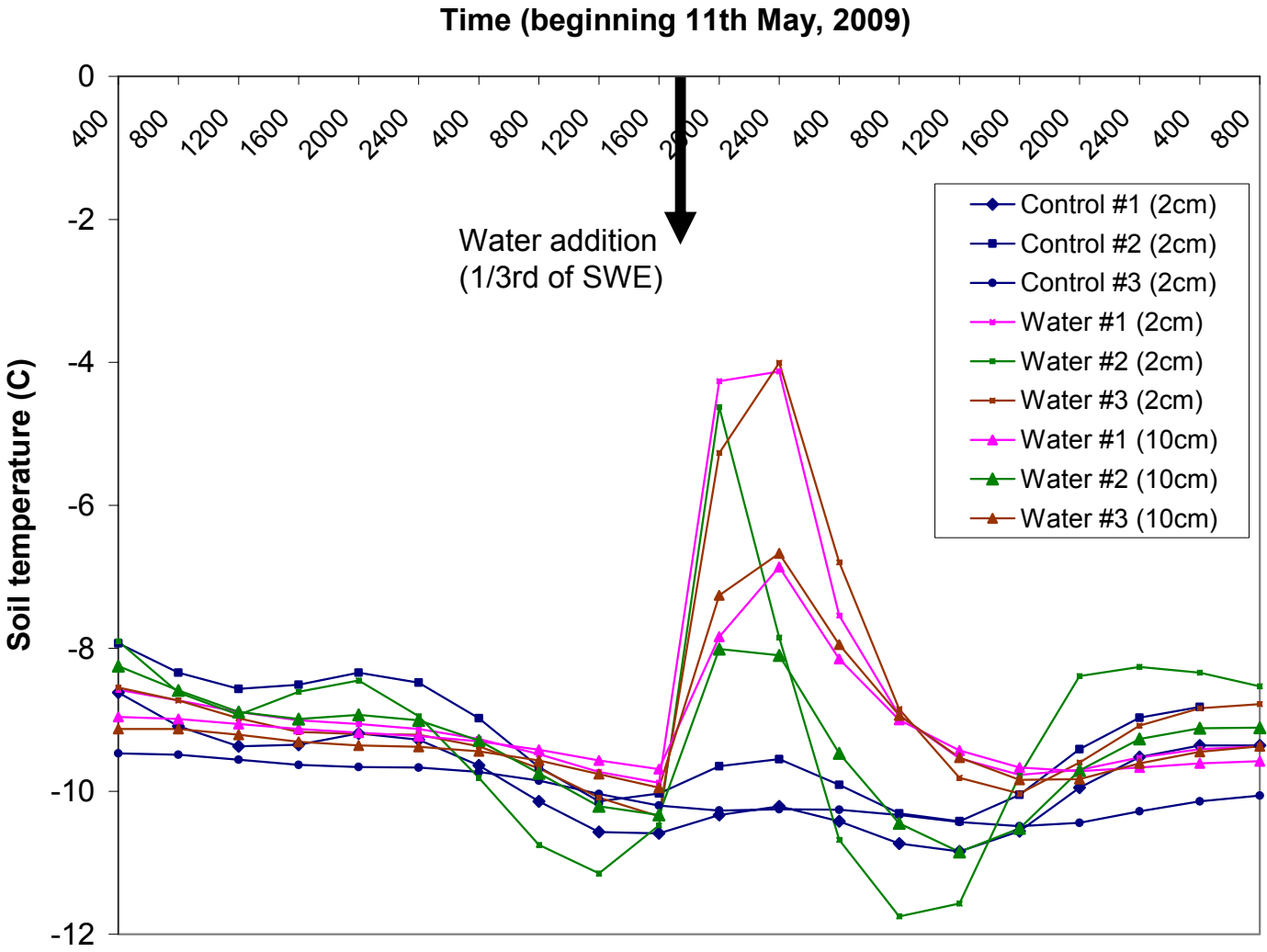
Some observations…



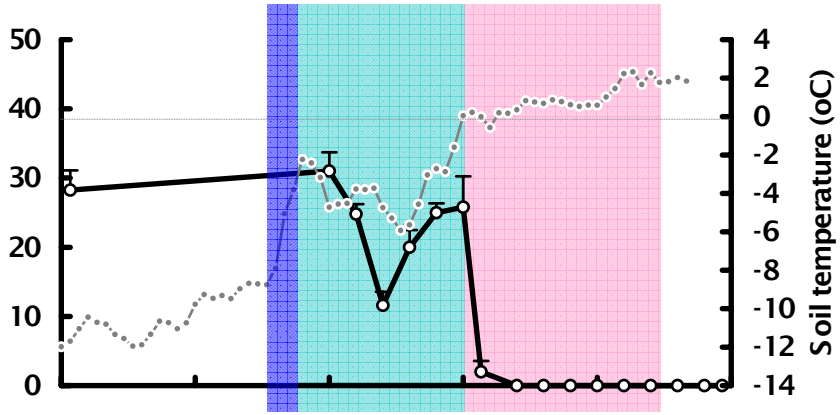
A water addition experiment to test the snow water percolation hypothesis…

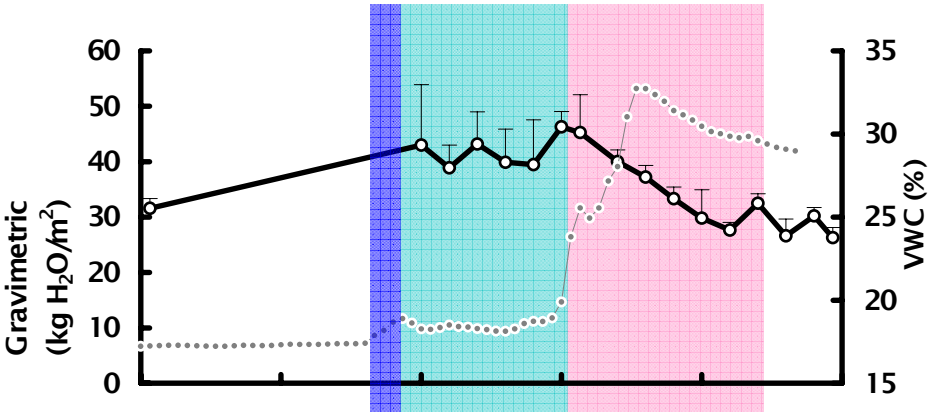


Air temp. -10^{0}C; Water temp. ~3^{0}C

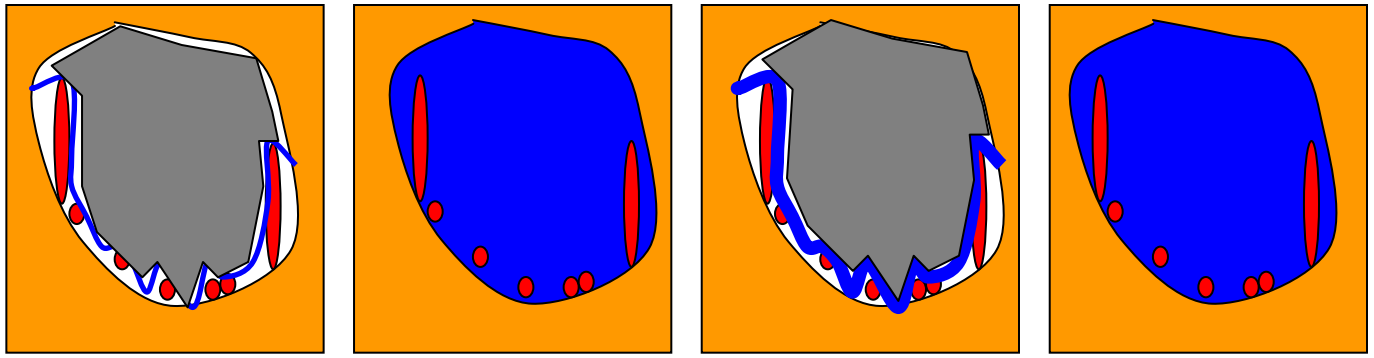
Birch hummock; 4 hourly data

Environmental phases during winter-spring transition



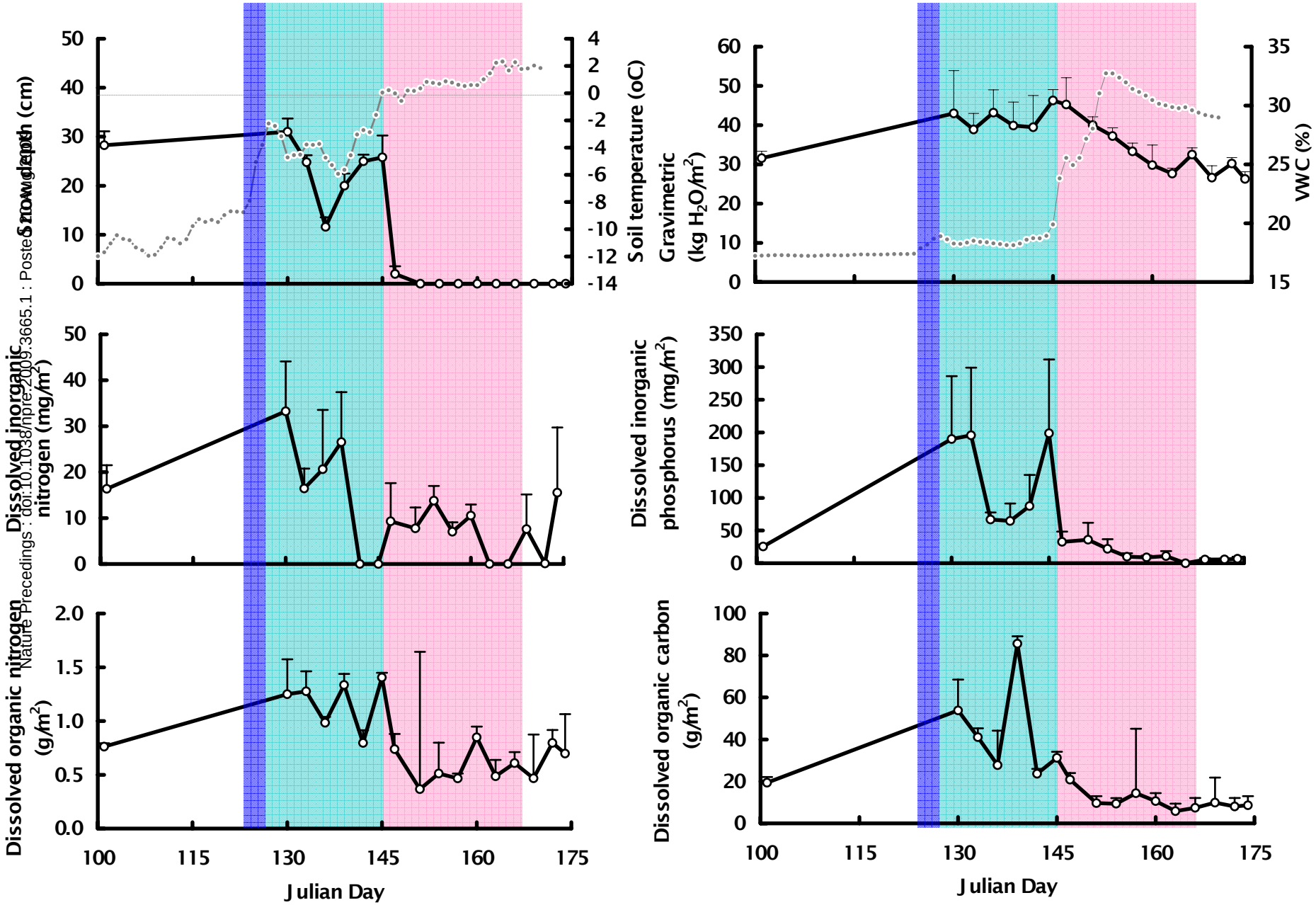


Winter-spring transition phases from a microbial perspective…

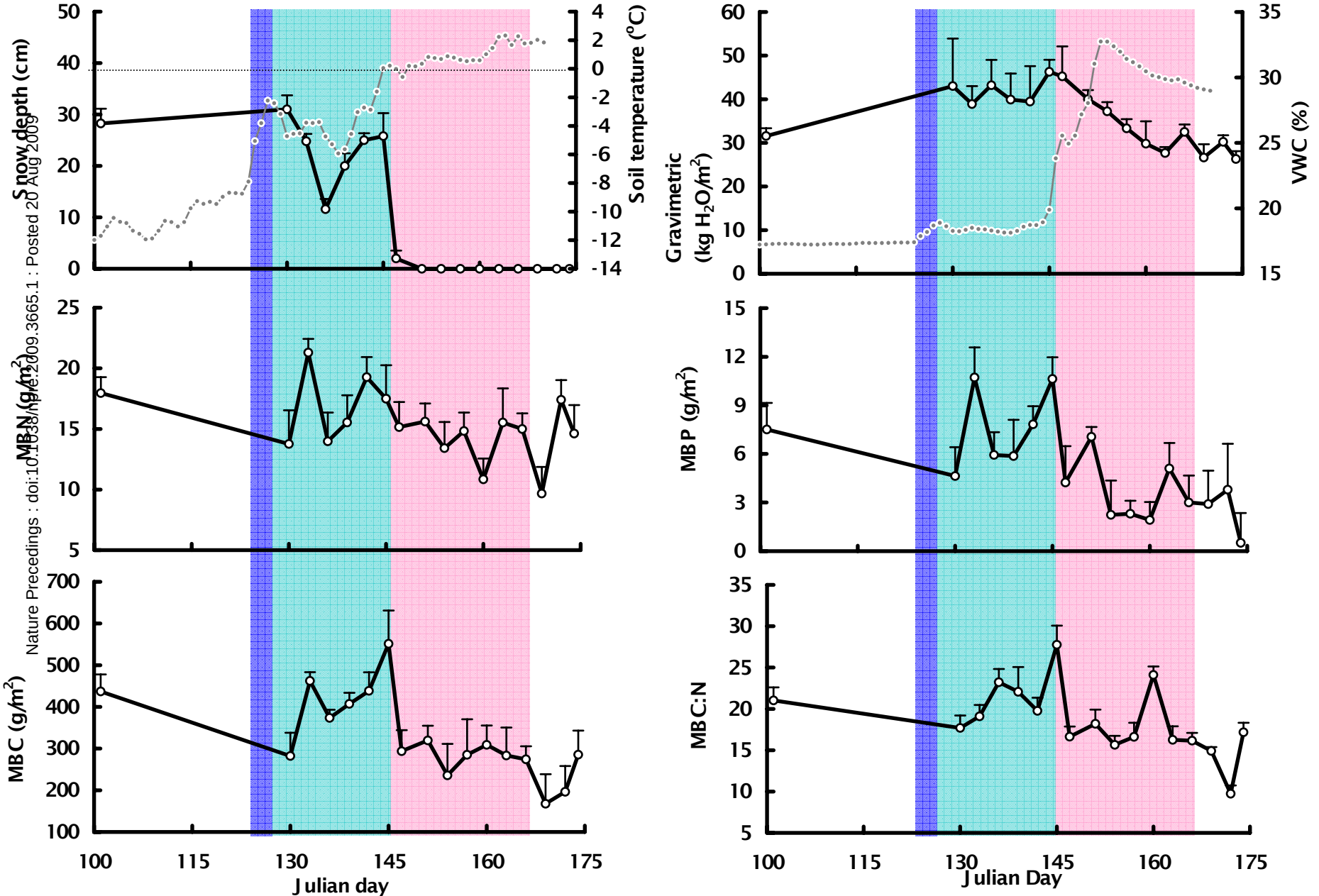


	Winter	Late winter	Early thaw Frozen/dryish	Late thaw Thawed/wet
Predominant H_2O form:	Ice	Water	Water/Ice	Water
Temperature:	-10C	Rapid rise	-3C	~0C
Duration:	Months	Hours	Days/Weeks	Weeks

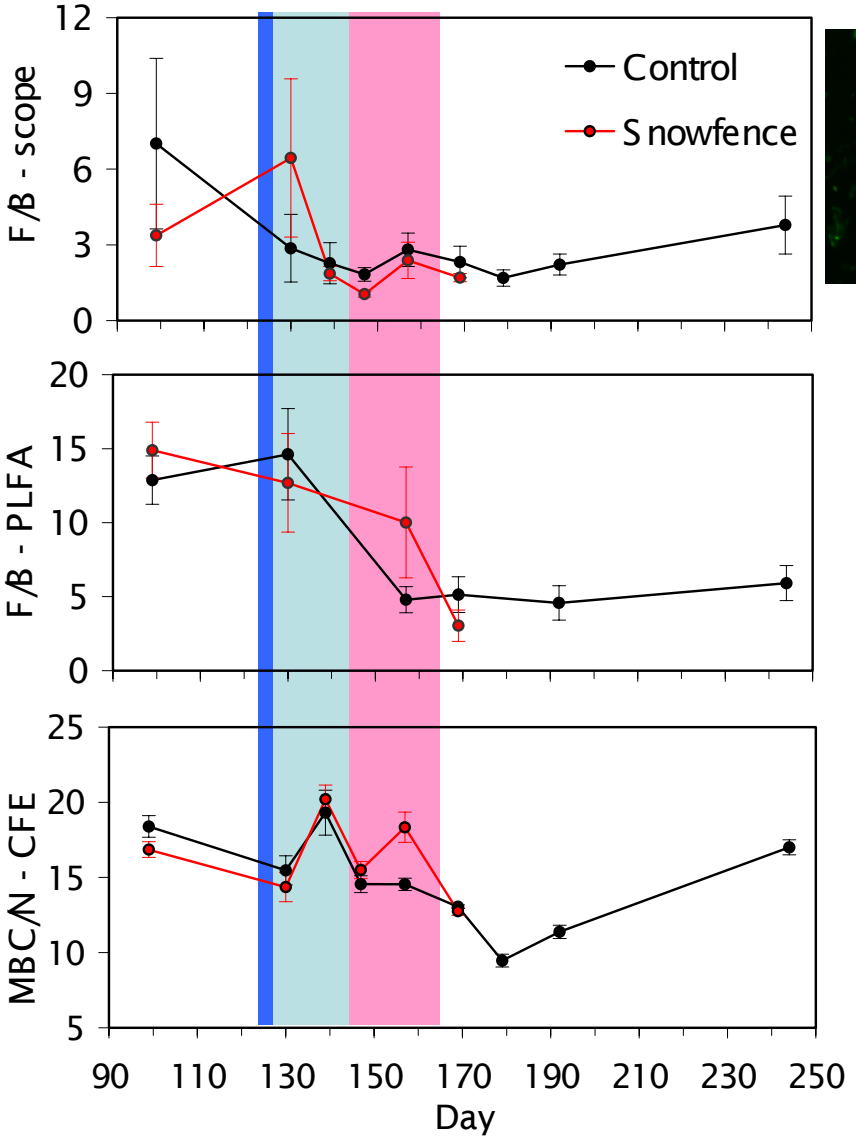
Do soil solution dynamics relate to environmental phases?

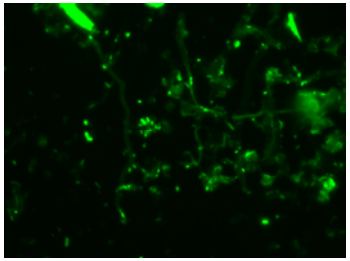


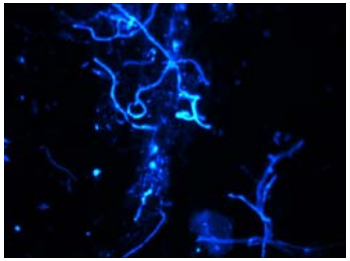
Do microbial pool dynamics relate to environmental phases?



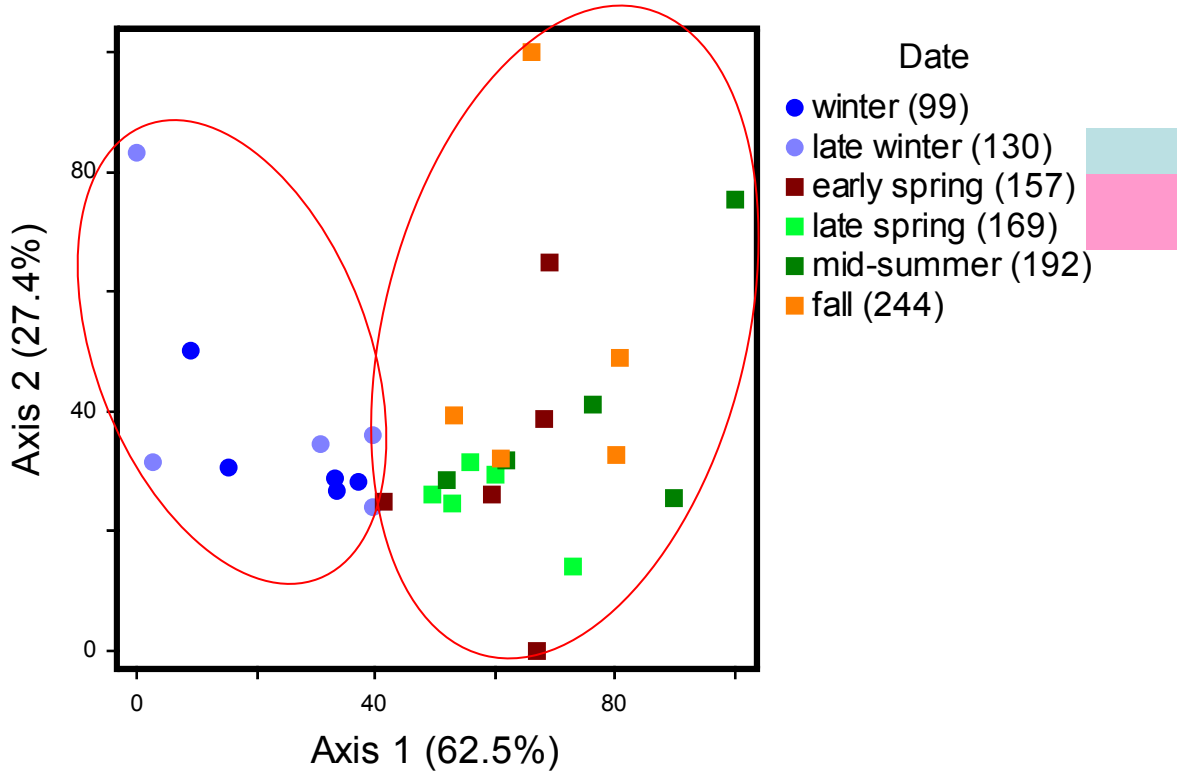
Fungal dominance of the soil microbial community is reduced during winter-spring transition







The relative abundances of bacterial groups (PLFA) changes during winter-spring transition



What have we learnt?

- **Three distinct** environmental phases during winter-spring transition
  - Late winter snowmelt percolation
  - Early (frozen/dryish) and late (thawed/wet) phases:
    - Microbial and soil solution nutrient pools are enlarged, and then generally decline
    - "Freeze-thaw" temperature fluctuations are generally small (rarely <-2C)
  - Fungal dominance declines as certain groups of bacteria flourish

- **Soil temperatures**:
  - *Similar* levels of variation among *and* within vegetation-types, as well as strong inter-annual variation
  - Interaction with H_2O at several scales

A little more about the environmental and bioogeochemical patterns, but the significance…

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