New benchmarks for northern high latitudes

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Why the northern high latitudes?

- 1. Its where a large fraction of the carbon is.
- 2. The water-ice phase change is a critical nonlinearity in temperature that touches every aspect of northern ecosystems.
- 3. CMIP5 generation models largely neglected these ecosystems.

A note on where we are coming from...

Spatial maps of carbonclimate feedback





(kgC m⁻² K⁻¹)

IPCC-AR5-WG1-Ch6



Koven et al., 2013



Required benchmarks that are specific to high latitudes

- 1. Surface energy exchange as mediated by snow
- 2. Freeze-thaw dynamics in soils
- 3. Soil carbon stocks
- 4. Vegetation dynamics along boreal tundra ecotone
- 5. ... plus everything you'd want to benchmark anywhere else

1: Surface energy exchange as mediated by snow

- Snow exerts enormous control on surface energy exchange
 - Radiative (included in all models, but still high uncertainty)
 - Conductive (poorly or not included in many models)



Surface energy exchange as mediated by snow





National Snow and Ice Data Center Supporting Cryospheric Research Since 1976

Slater et al., in prep

Observational and theoretically-consistent benchmark





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Slater et al., in prep

Models Compared





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Climate controls on active layer thickness (ALT)





Developing a benchmark for this is key as it could be a powerful emergent constraint...



Zero Curtain Effect: Differences due to representation of freeze-thaw can be seen via histograms of soil temperatures across freezing point





Soil Carbon Stocks: Benchmarks for surface soils



Hugelius et al., 2014



Koven et al., Submitted

Soil Carbon Stocks Observations for deep soil carbon



Strauss et al., 2013

Wetlands and CH₄



Vegetation dynamics along boreal – tundra ecotone



Beck and Goetz, 2011

- Distributions of different vegetation from remote sensing at multiple spatial and temporal scales
- Forest inventory data in boreal forest
- Coupled dynamics of vegetation and organic soil layers over fire cycles

Plus everything you'd want to benchmark against anywhere else...

