# Soil Carbon modeling in CLM4CN

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Sean Swenson

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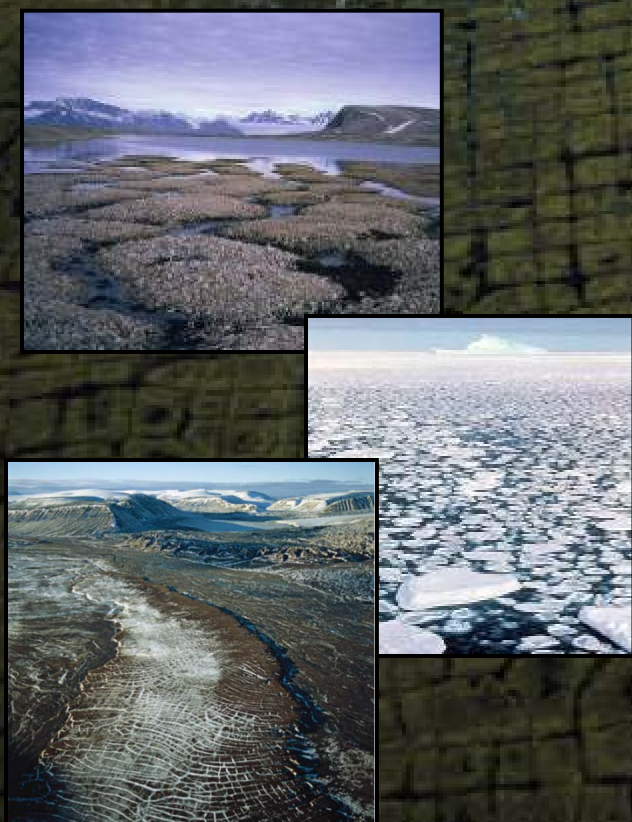
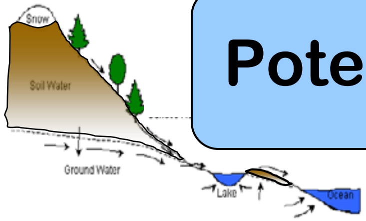
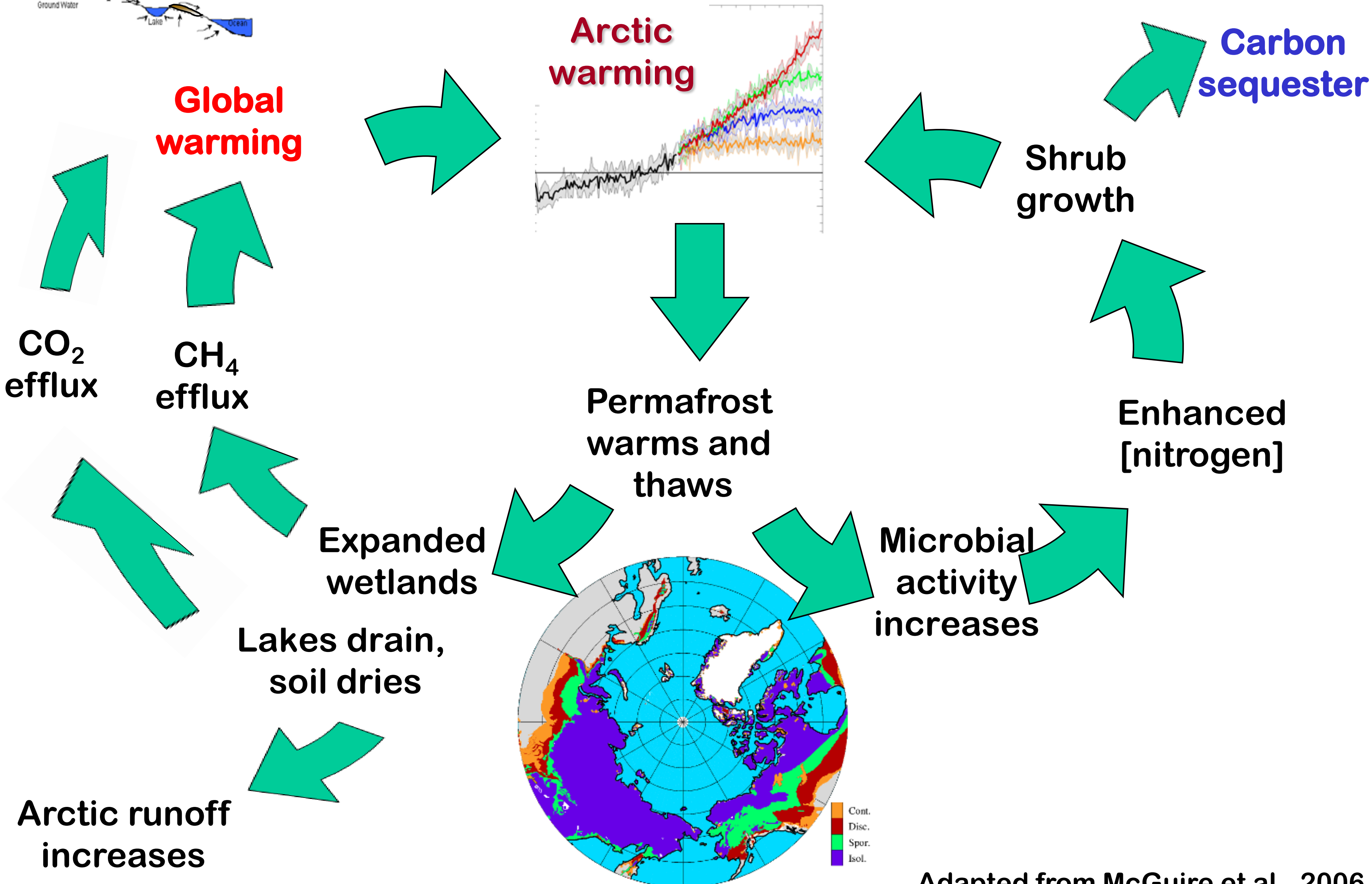
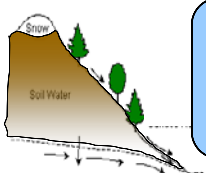


# Potential Arctic terrestrial climate-change feedbacks

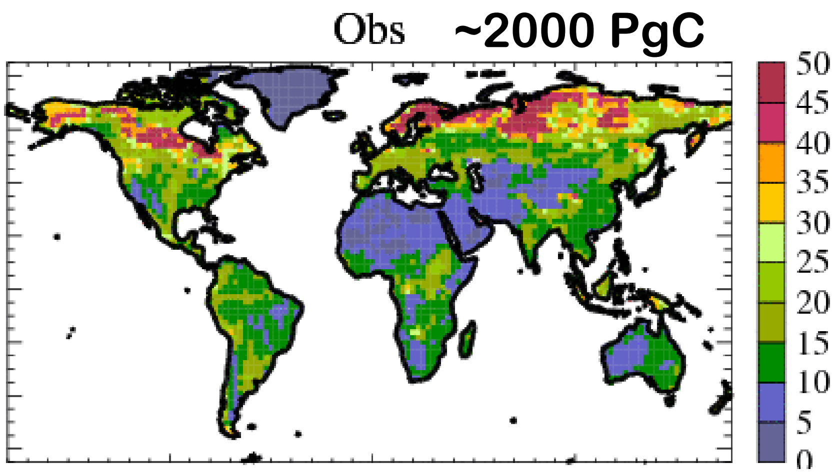


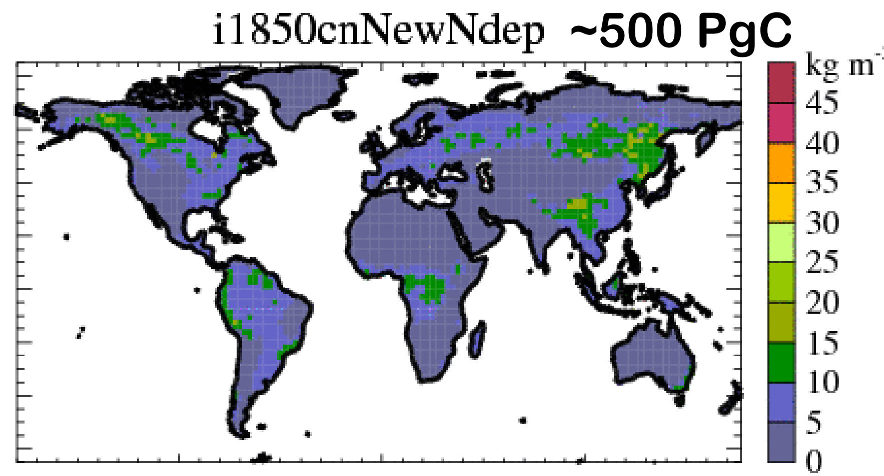



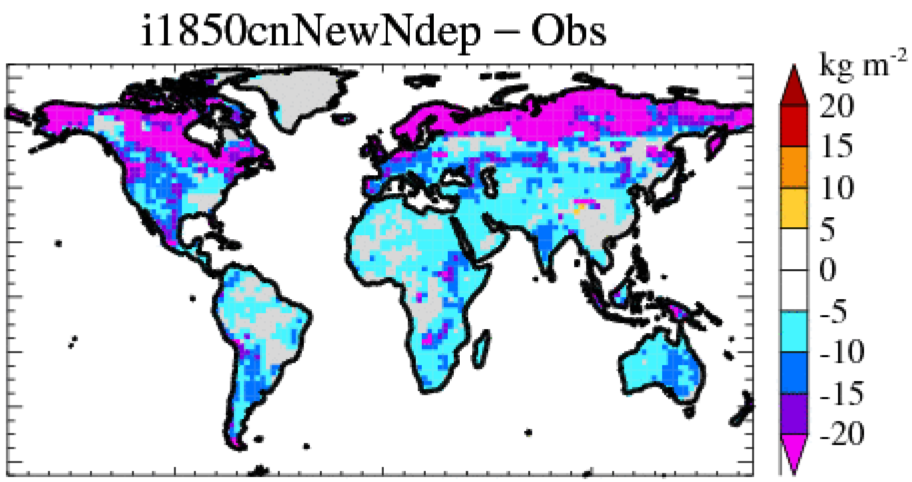

Adapted from McGuire et al., 2006

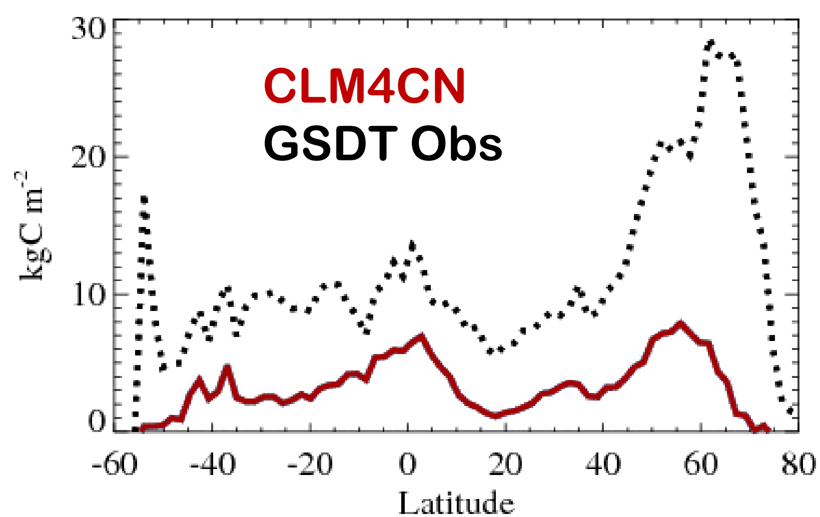



# CN Soil carbon compared to Global Soil Data Task obs

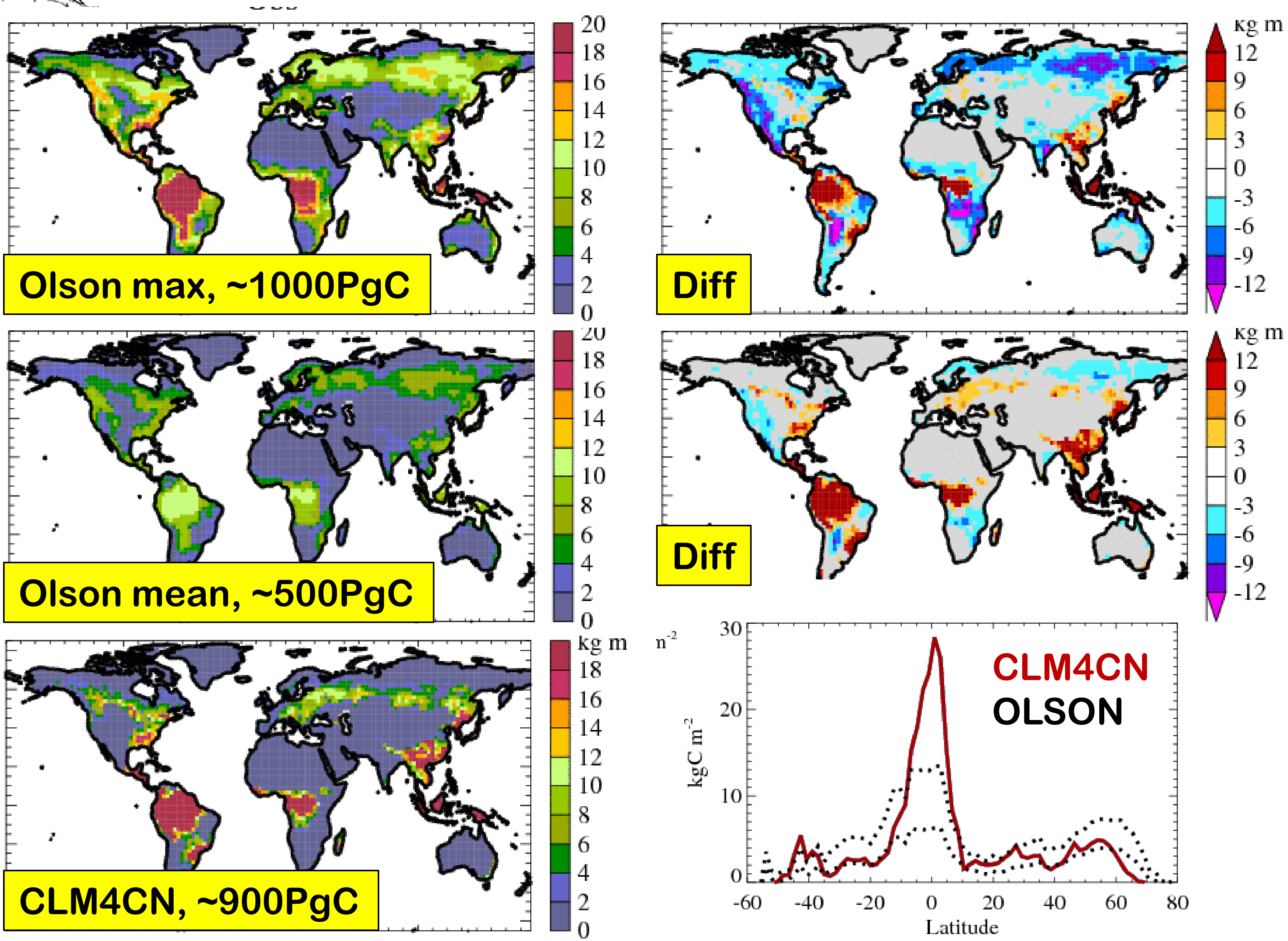


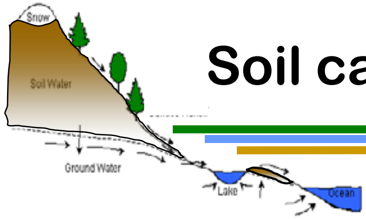



# Vegetation carbon compared to Olson et al. (1985) (updated by Gibbs et al. 2007)

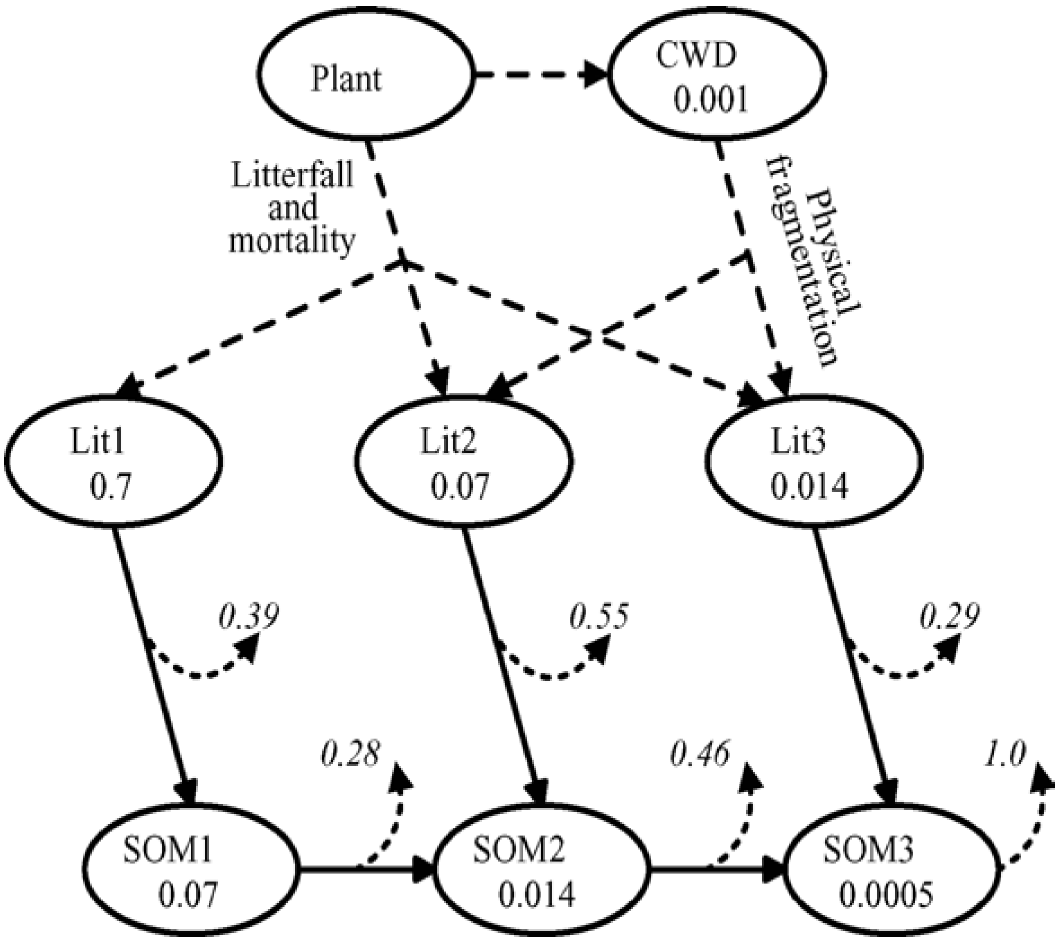





# Soil carbon: Issues from perspective of northern high latitudes

- In tundra zones, very low vegetation growth CLM4CN (at least partly due to hydrology problem)
- Soil decomposition rates
  - No limits due to anoxia at high water levels
  - Location of soil carbon is ‘virtual’ within top 5 model levels
- Large carbon stores result of thousands of years of accumulation (with differing initiation dates) in peatlands or similar systems
- Not representing unique biogeochemistry of peatlands

# Heterotrophic soil respiration in CLM-CN



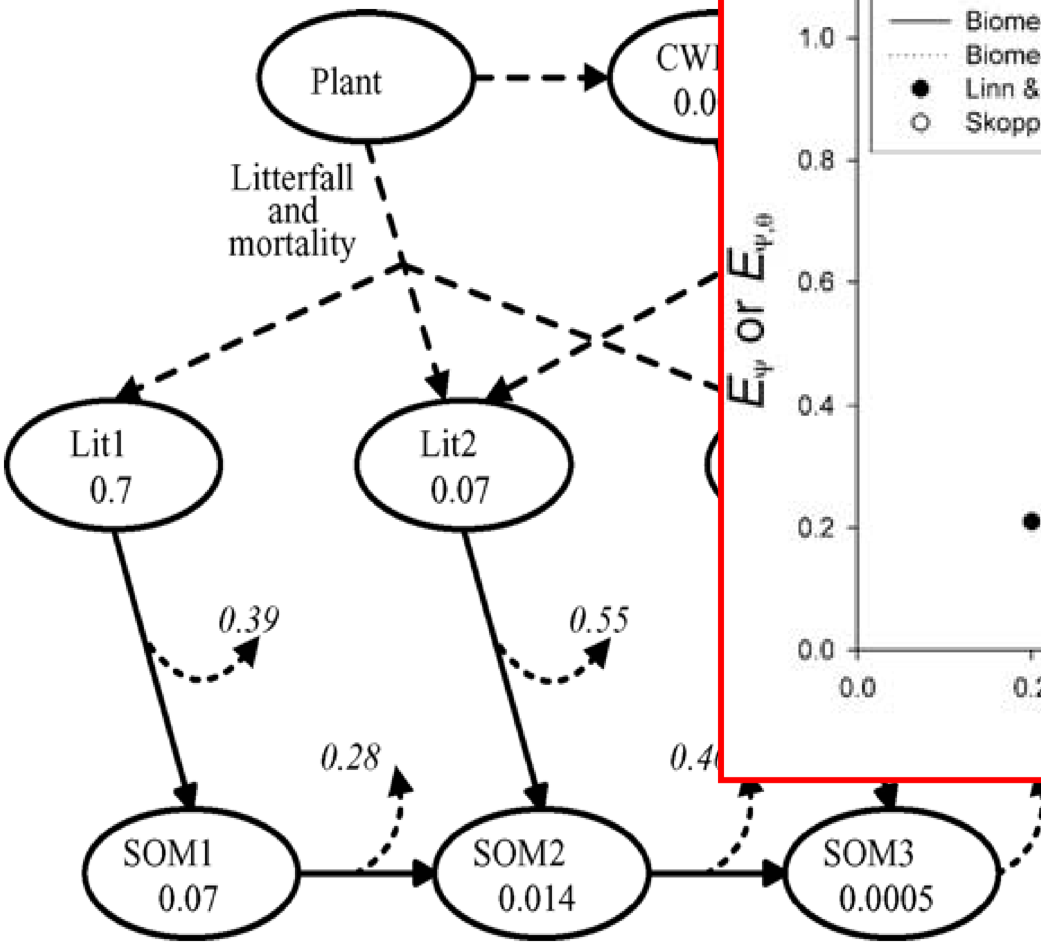

**Base decomposition rates for each SOM pool are modified by functions of water and temperature**

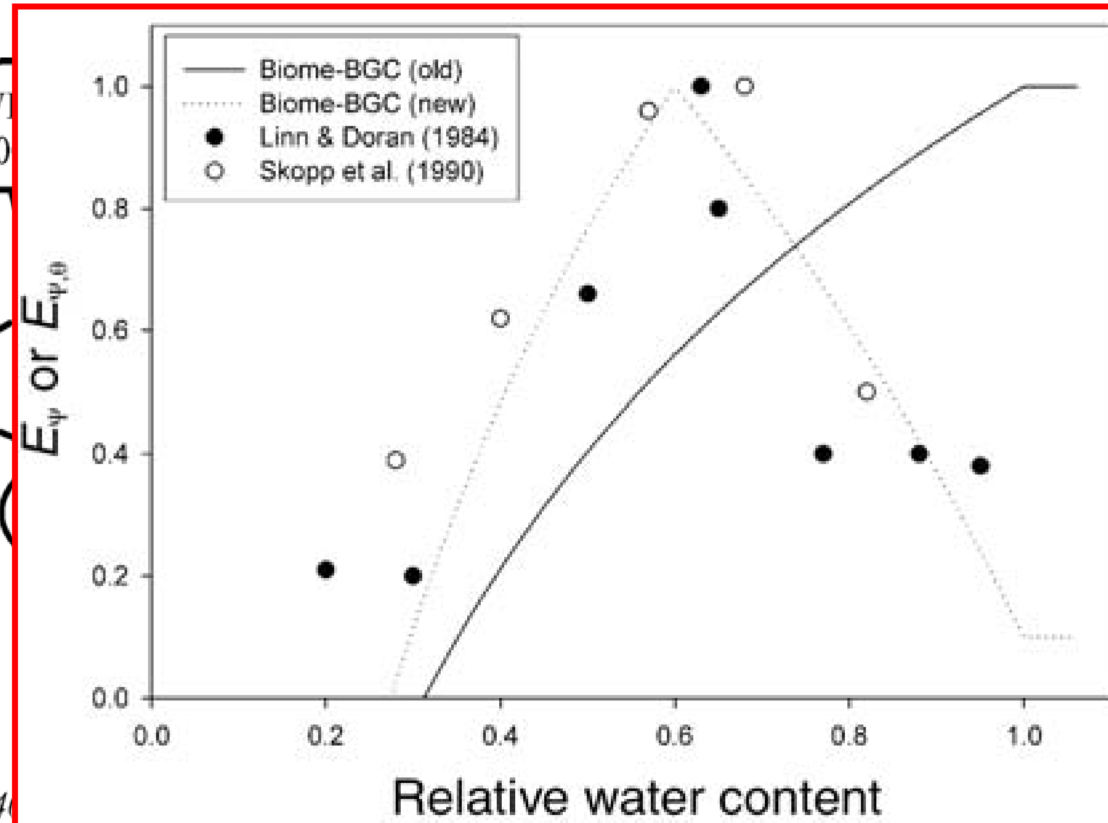
Thornton and Zimmerman, 2005

# Proposed modifications

- Cold region hydrology modifications from Sean
- Connect organic soil thermal and hydrologic properties (Lawrence and Slater, 2008) with prognostic CN soil carbon
  - Represent vertical decrease in hyd. conductivity from fabric to sapric peat - wetter soil in organic rich regions
- Incorporate anoxia limitation on decomposition rates
  - Sync up CLM soil suction with CN soil suction
- Account for impact of vertical distribution of soil carbon on decomposition rates
- Change Q10 from 1.5 to 2 or ???
- Assume that Arctic C3 grass more like moss – grows in nutrient-limited environs
- Initialize model with 'observed' soil carbon and slowly turn on carbon pool transfers

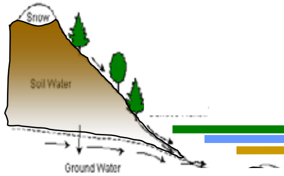
# Anoxia limitation on soil carbon decomposition




Bond-Lamberty et al., 2007

Thornton and Zimmerman, 2005




# Proposed modifications

- Cold region hydrology modifications from Sean
- Shallower rooting profile for Arctic C3 grass and boreal shrubs
- Connect organic soil thermal and hydrologic properties (Lawrence and Slater, 2008) with prognostic CN soil carbon
  - Represent vertical decrease in hyd. conductivity from fabric to sapric peat - wetter soil in organic rich regions
- Incorporate anoxia limitation on decomposition rates
  - Sync up CLM soil suction with CN soil suction
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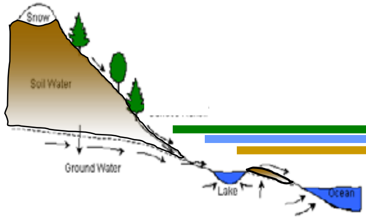
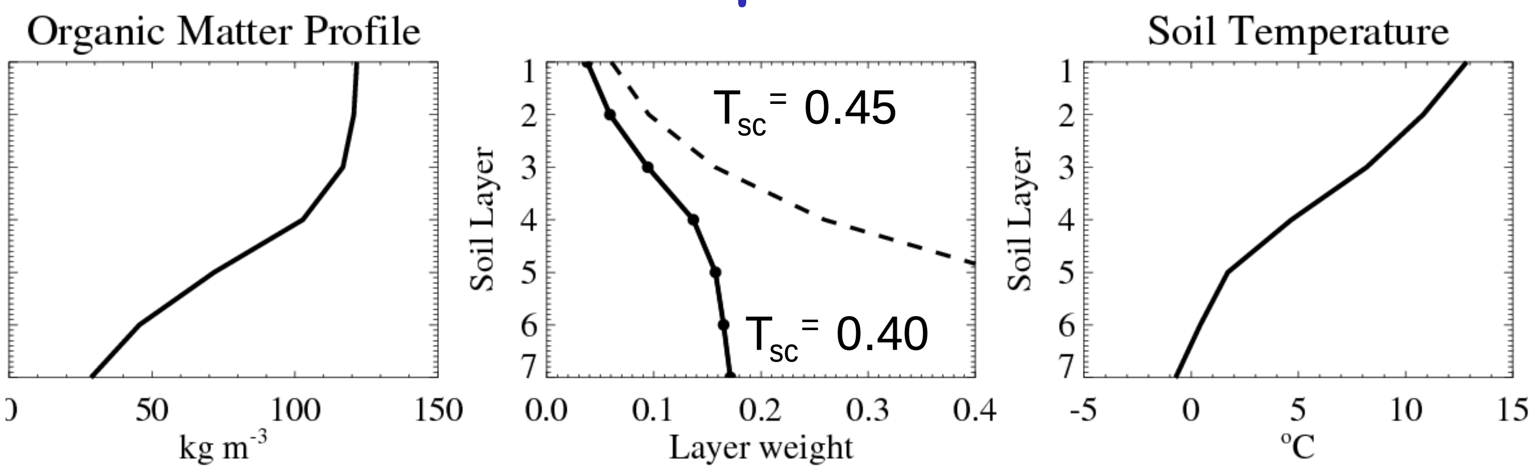
- Change Q10 from 1.5 to 2 or ???
- Assume that Arctic C3 grass more like moss – grows in nutrient-limited environs, leaf litter C:N ratio
- Initialize model with ‘observed’ soil carbon and slowly turn on carbon pool transfers

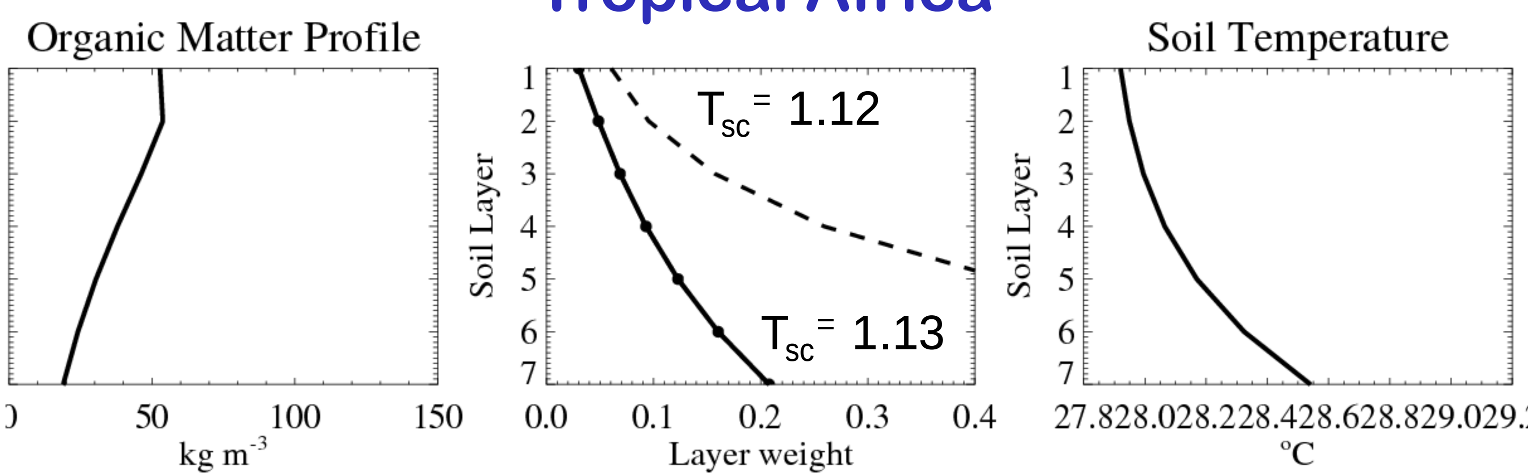


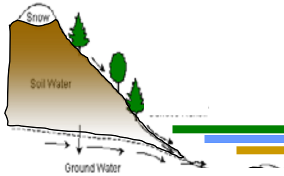

# Vertical distribution of carbon and impact on decomposition rates

## Siberia peatland




## Tropical Africa



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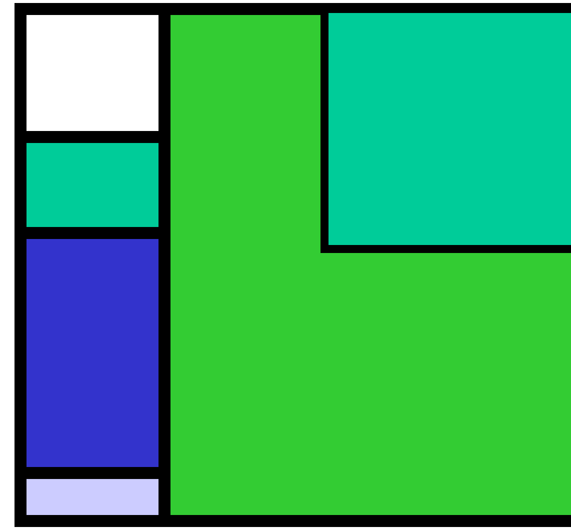
# Additional proposed revisions – wetland carbon cycling



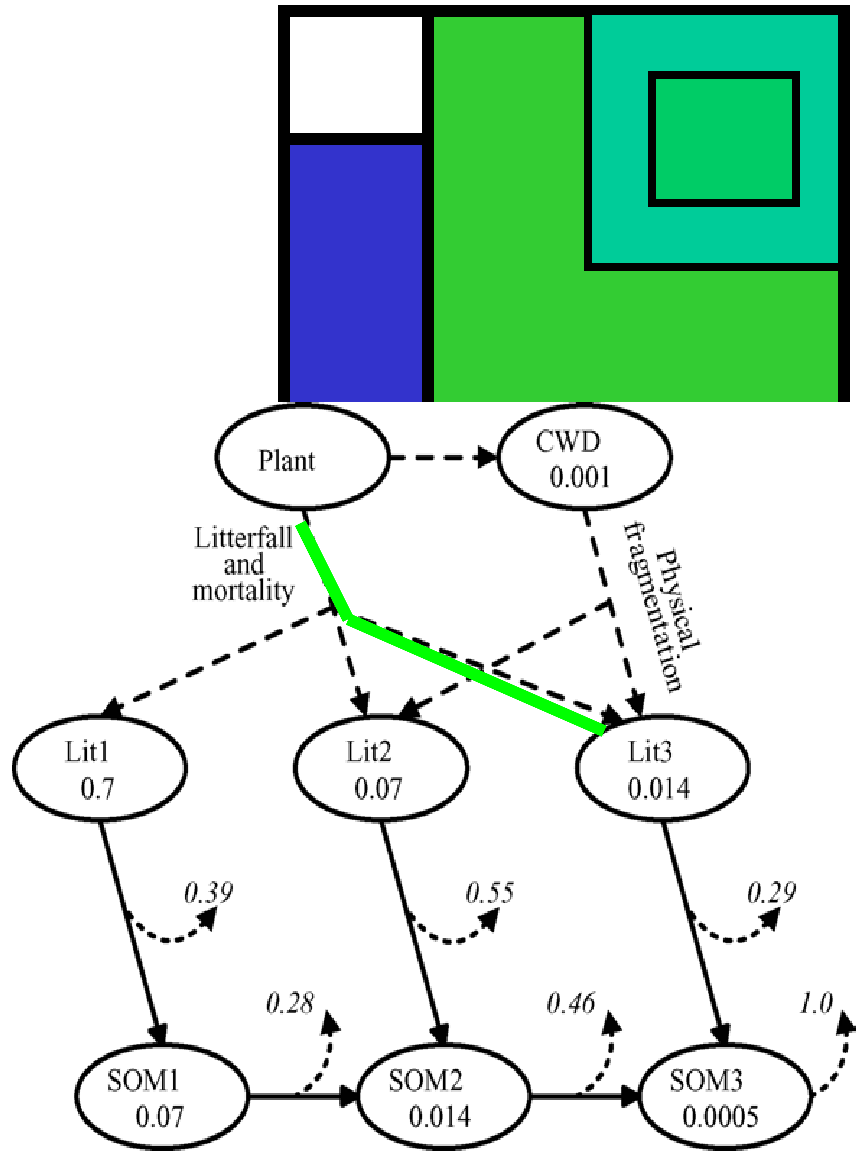
**At each time step:**

- **Calculate saturated fraction of vegetated portion of grid cell (Sean's work)**
- **For unsaturated fraction of grid cell, soil respiration calculated as above**
- **For saturated fraction of grid cell, soil respiration at 10% of temperature regulated base rate**

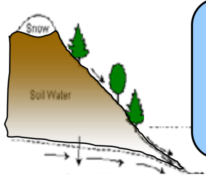
# What about wetland vegetation?

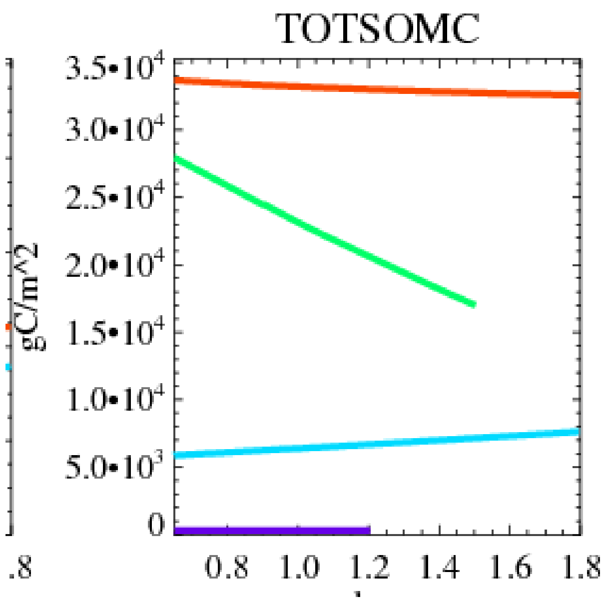
Ideally, need a new ‘moss-like’ PFT

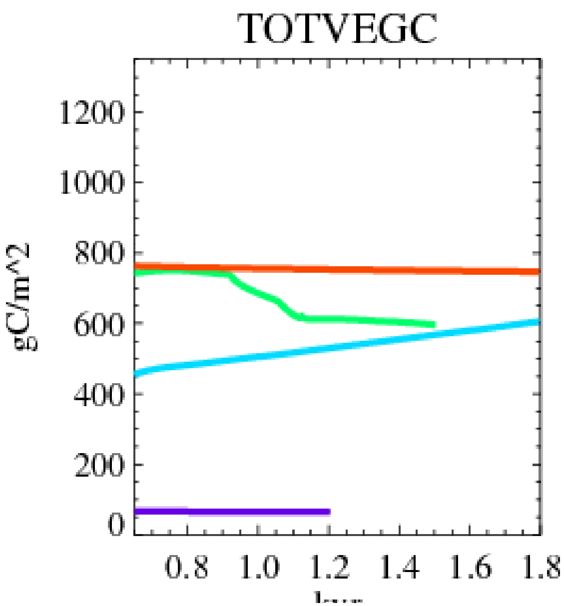
- Assume that moss preferentially inhabits the saturated fraction of grid cell
- Dead moss goes to recalcitrant litter pool
- Short cut: skip moss PFT and simply assume that litter from grass growing in saturated zone goes to recalcitrant litter pool

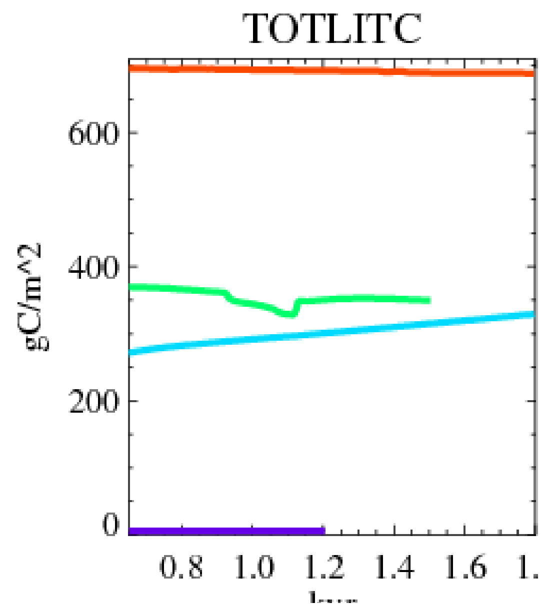


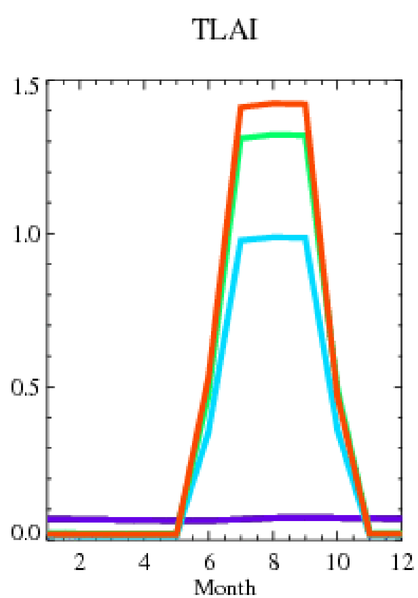
# Arbitrary point in Alaska Arctic

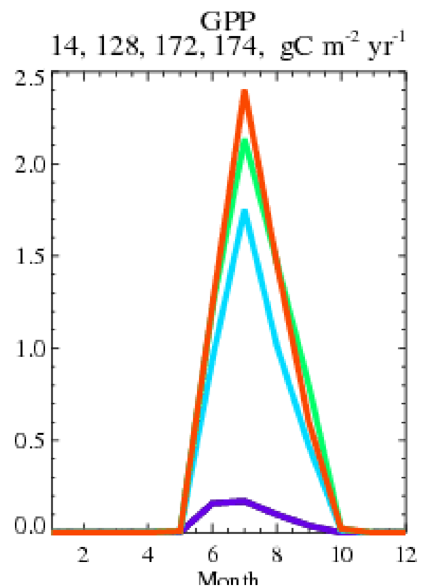


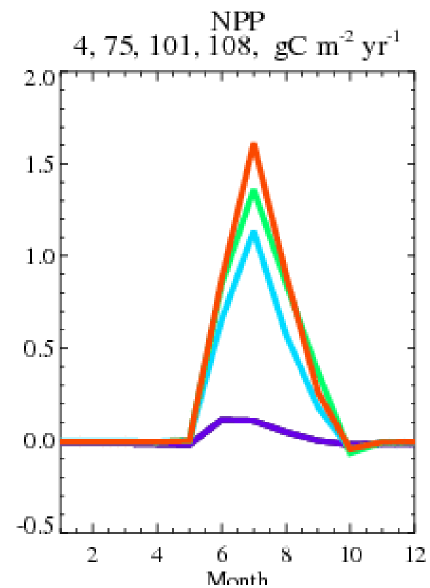



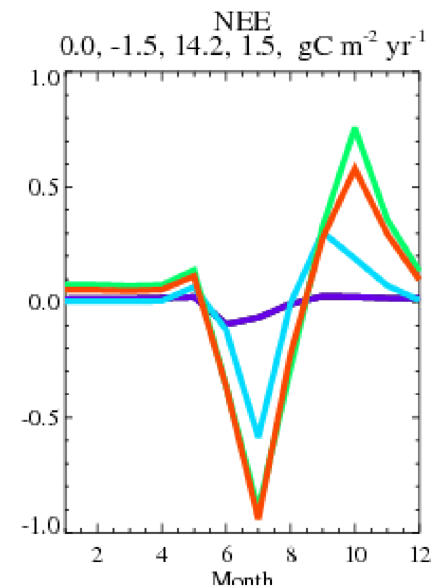



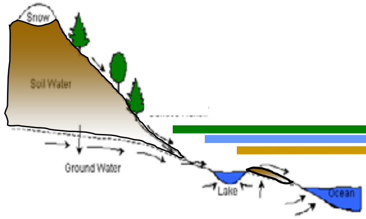



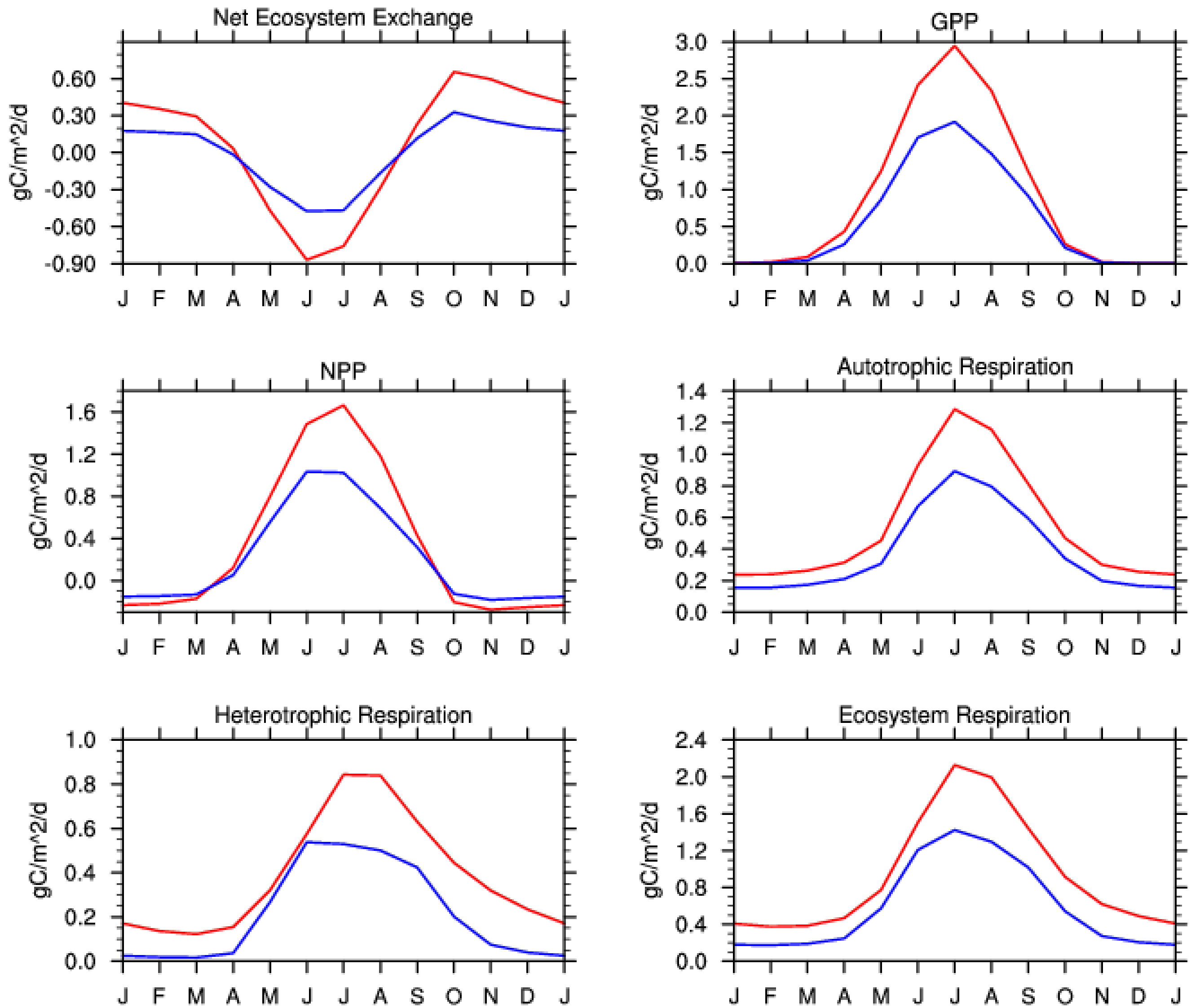



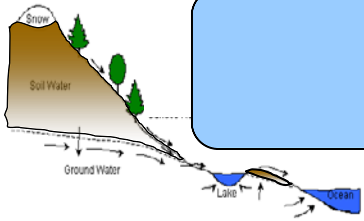



# Some results from global tests

## Polar(60-90N,-180W-180E)

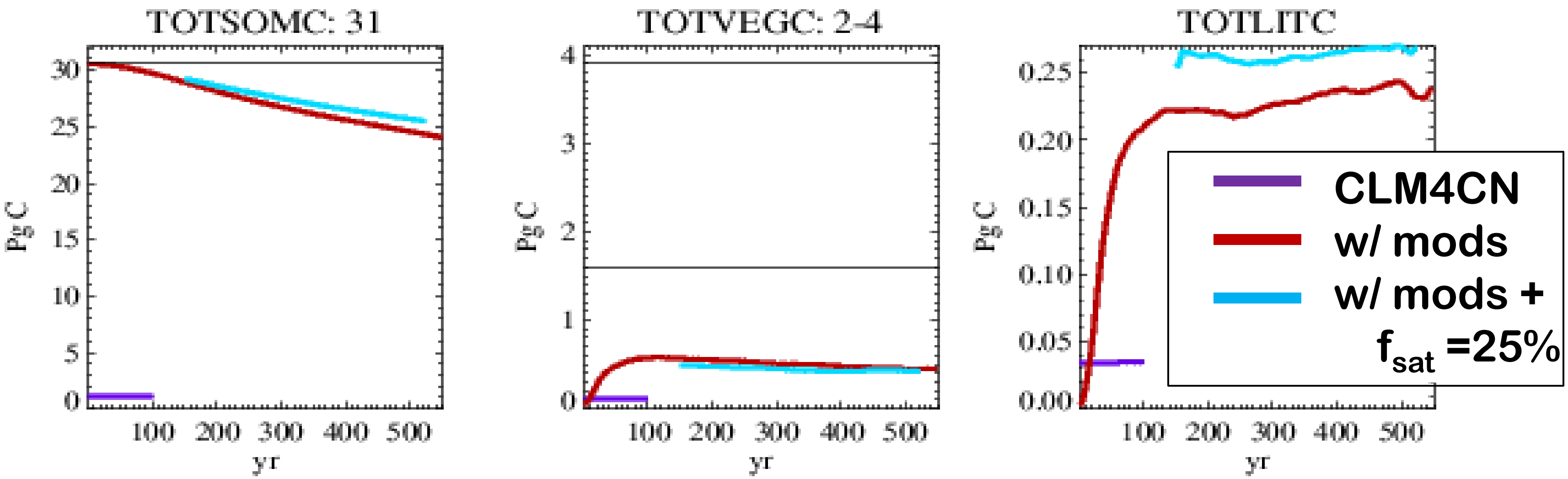
- CLM4CN (blue)
- w/ mods (red)



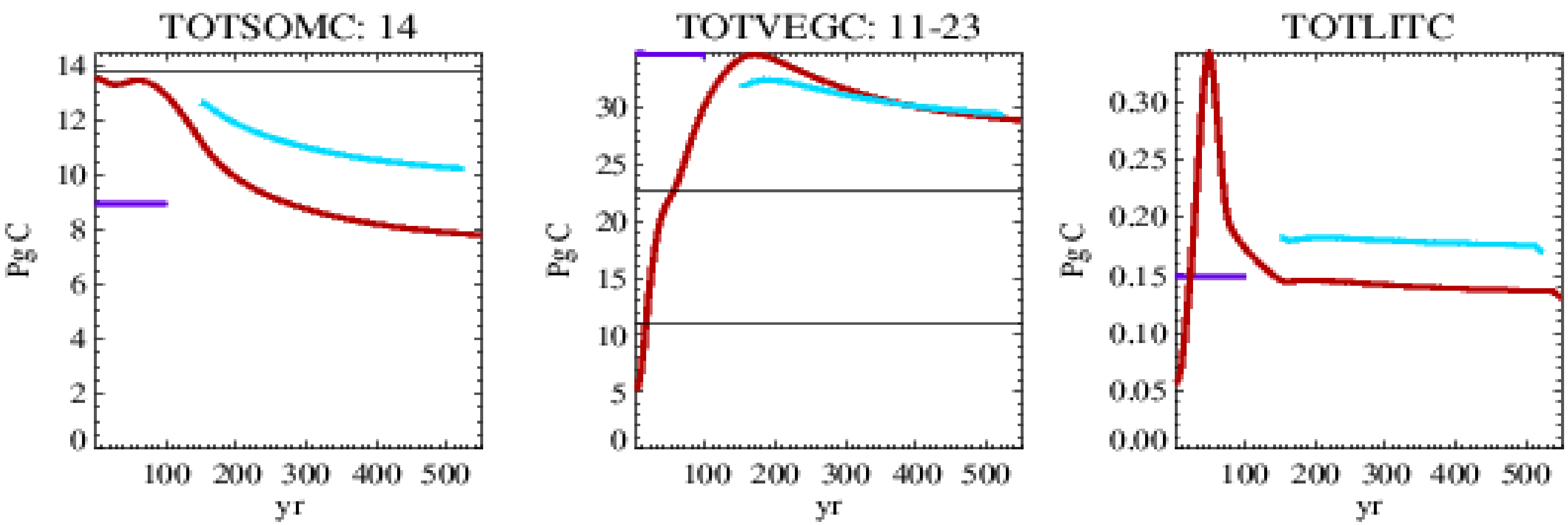


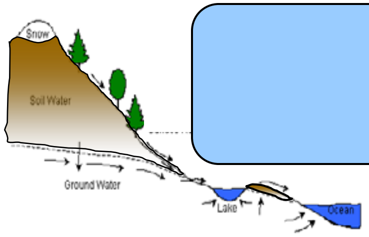

# Results from global runs

## Alaska Arctic



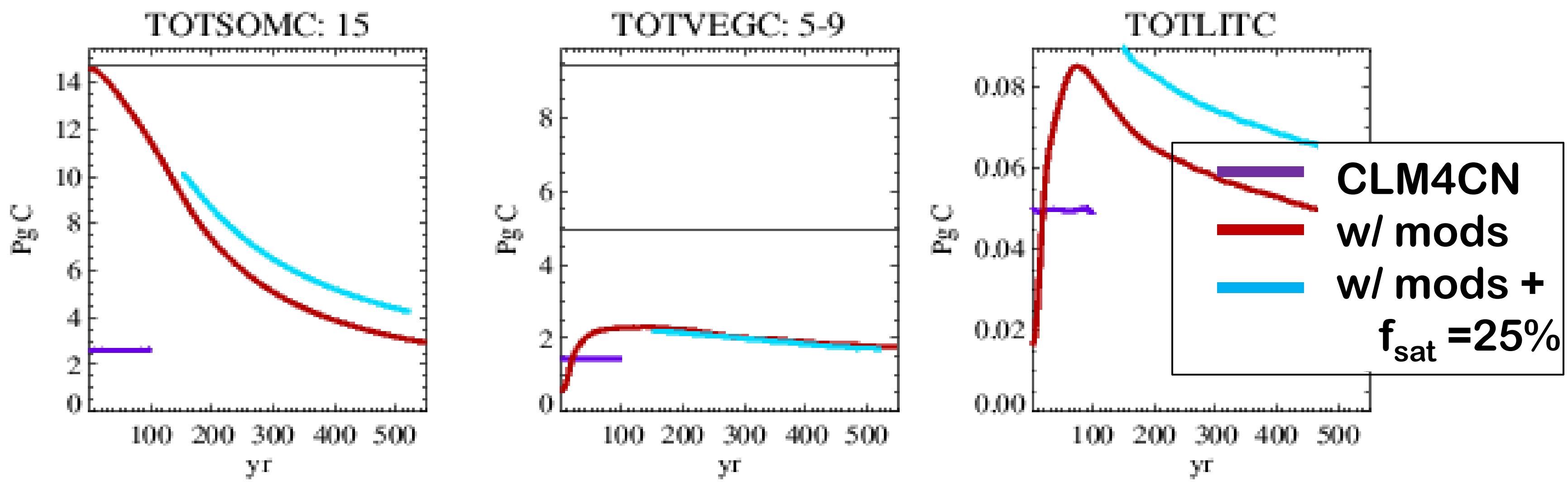

## Amazonia



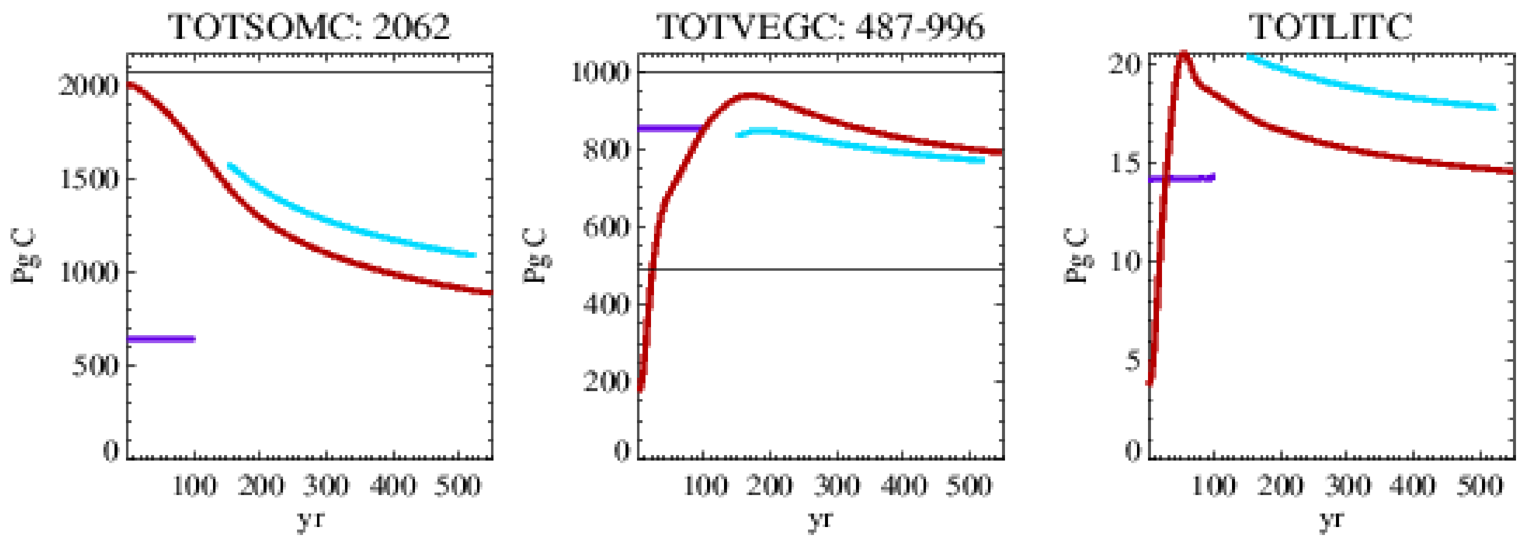


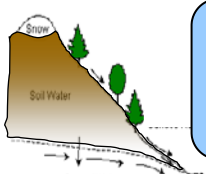

# Results from global runs

## Western US




## Global



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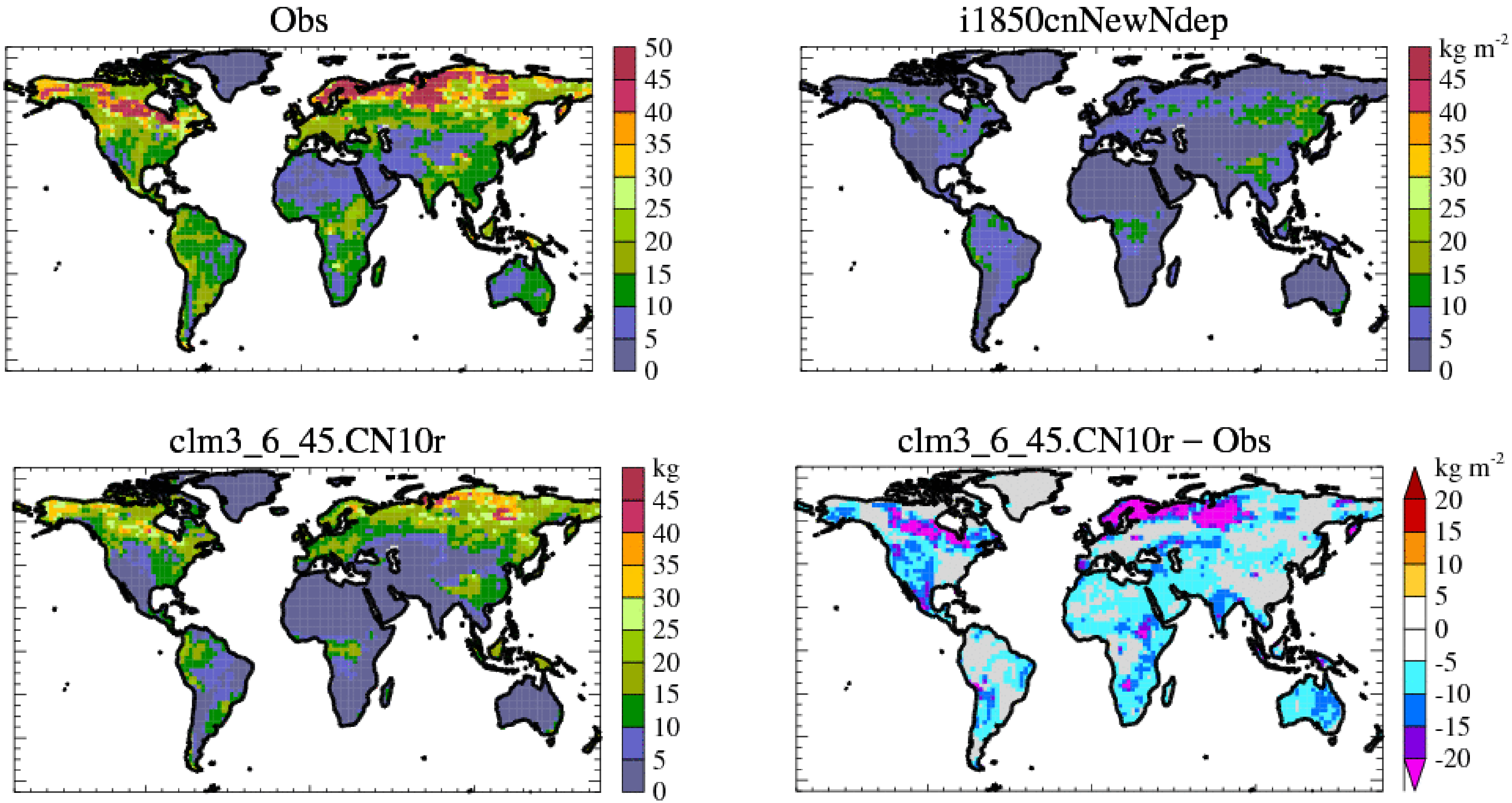
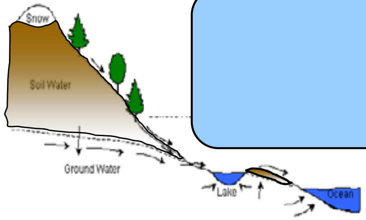
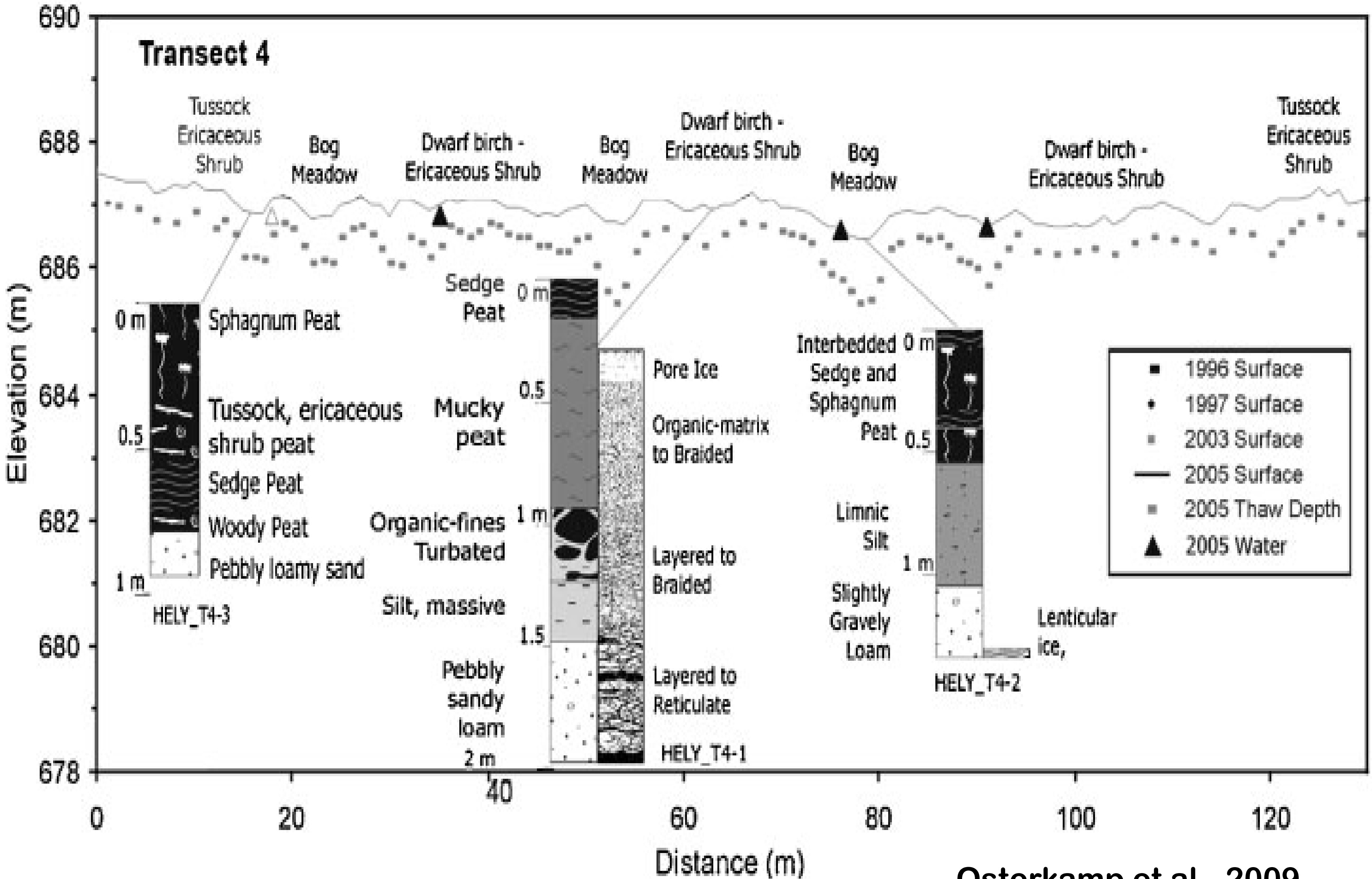




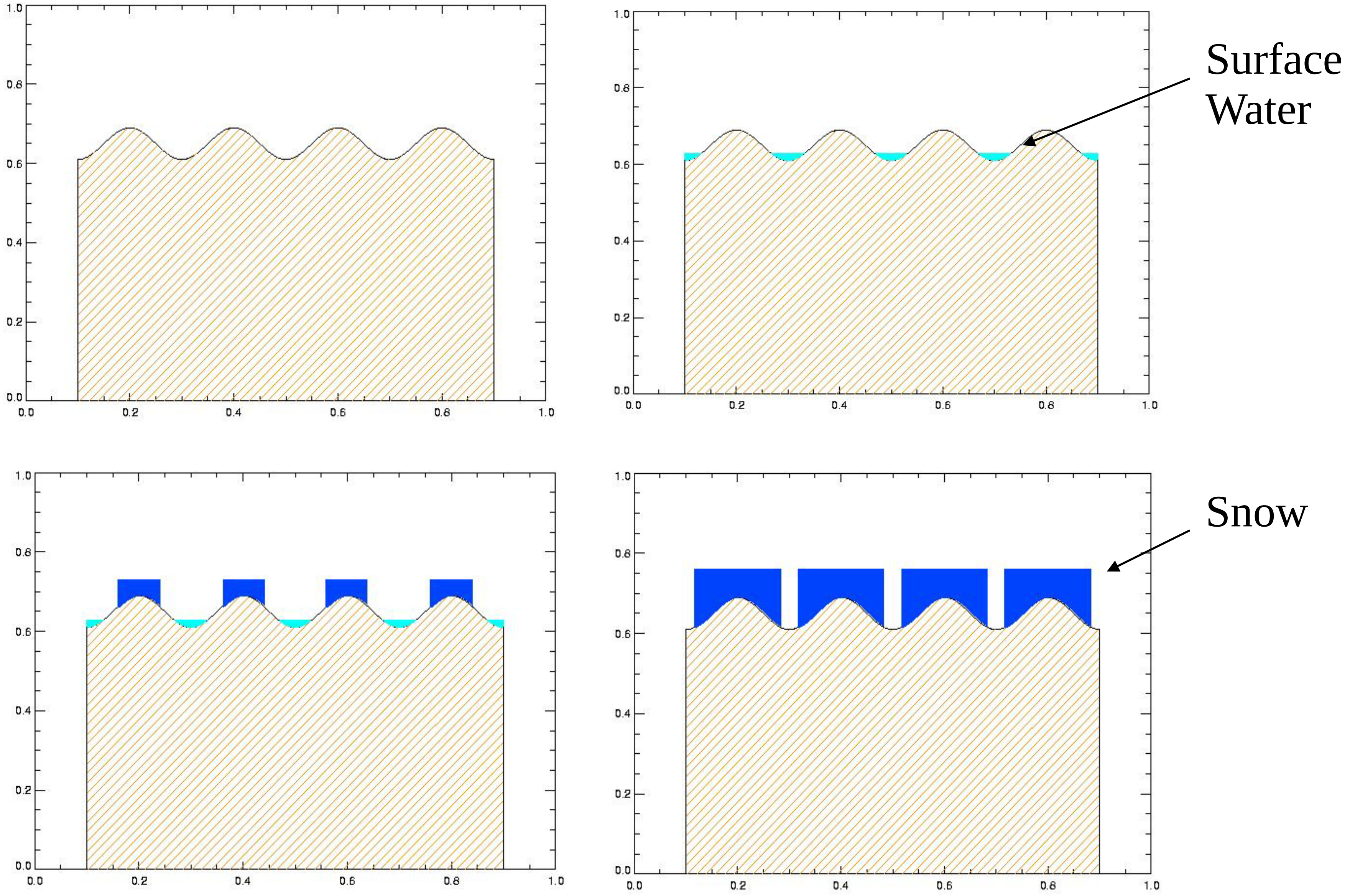

# Summary

# Microtopography




**Osterkamp et al., 2009**

# Surface Water Component Concept



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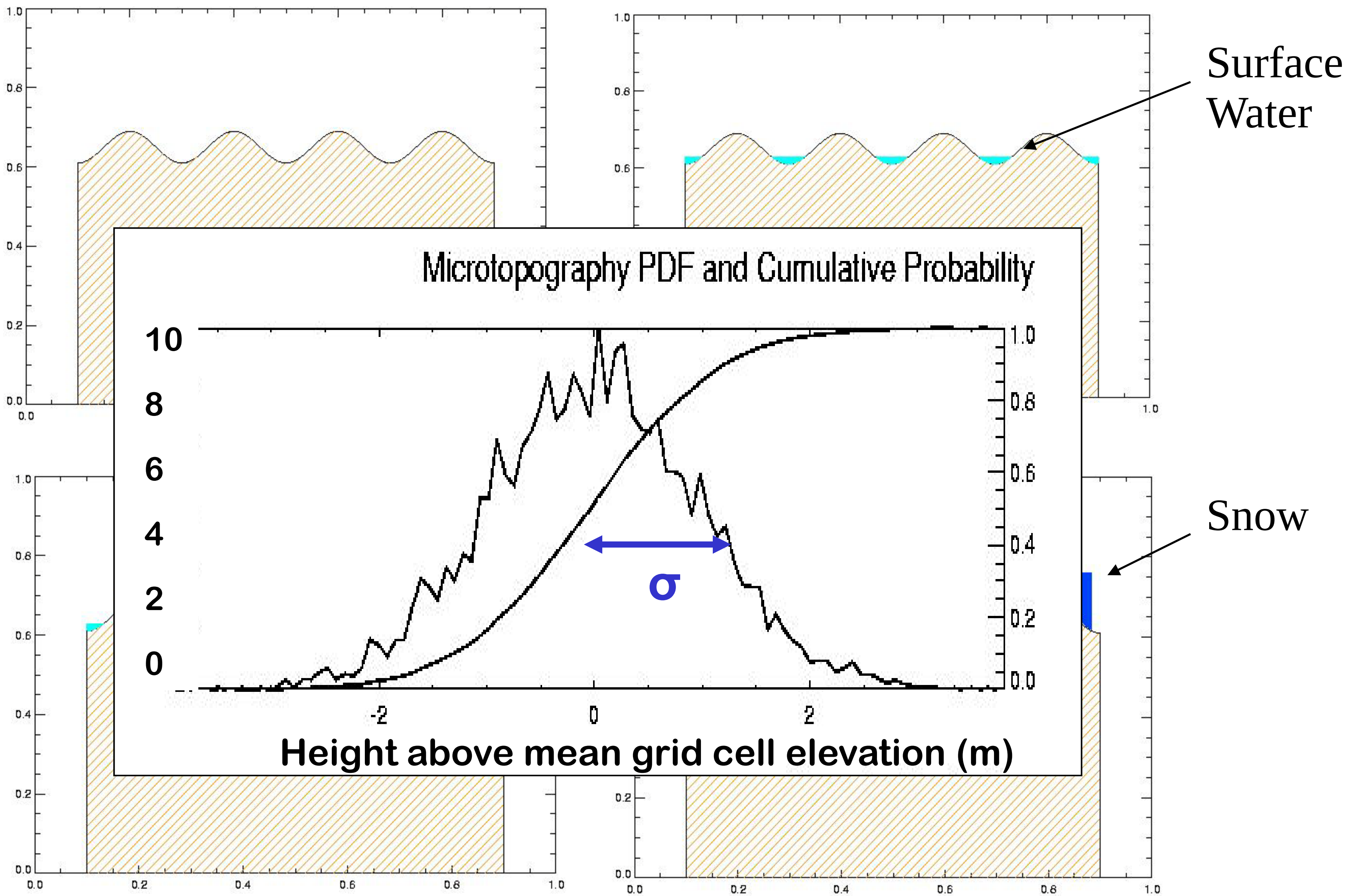
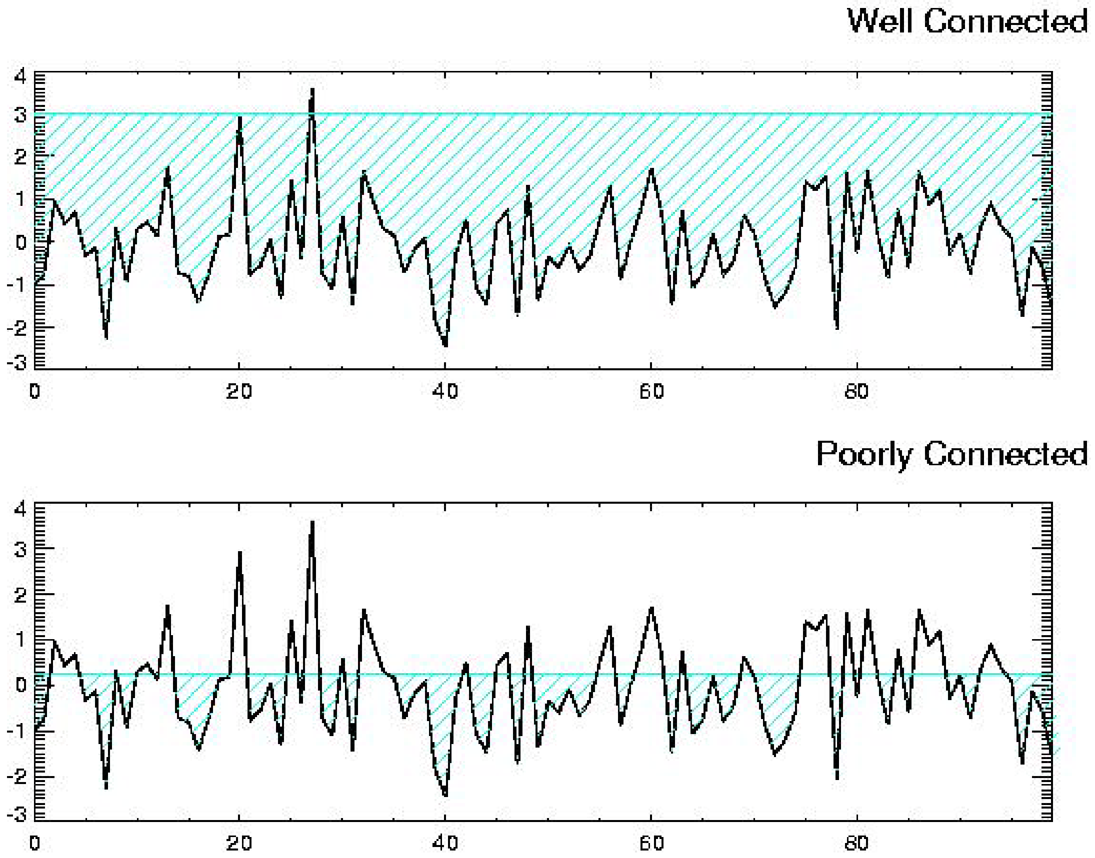


• When storage is large compared to microtopography, "wet" areas are well connected, and surface runoff is high.

• When storage is small compared to microtopography, "wet" areas are generally not connected, and surface runoff is low.



# Parameterizing Thermokarst

Low relief: e.g. Arctic coastal plains