

Topographic heterogeneity and aspect moderate exposure to climate change across an alpine tundra hillslope gradient

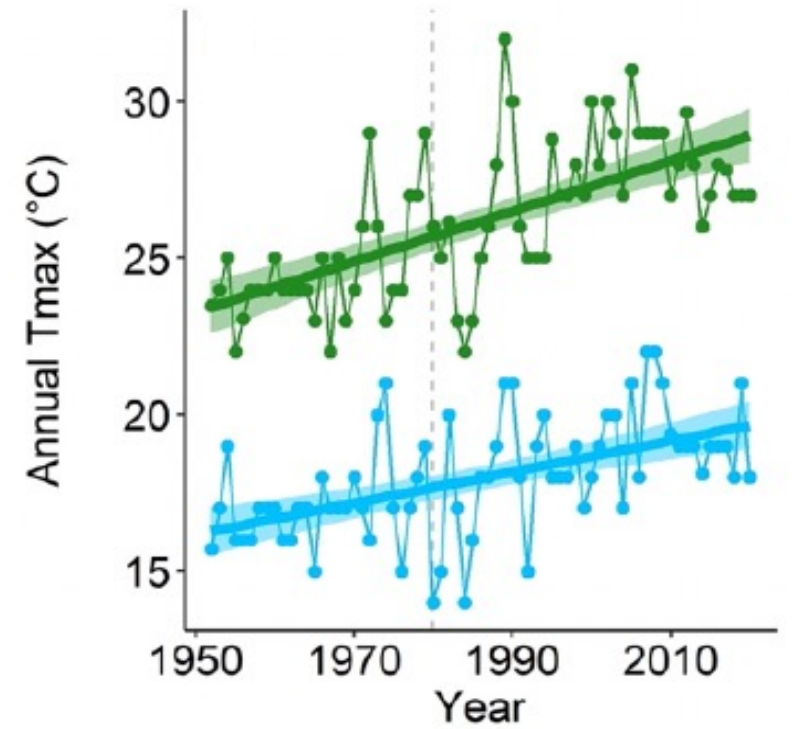
Katya Jay, Will Wieder, Sean Swenson,
John Knowles, Sarah Elmendorf, Hannah Holland-
Moritz, Katie Suding



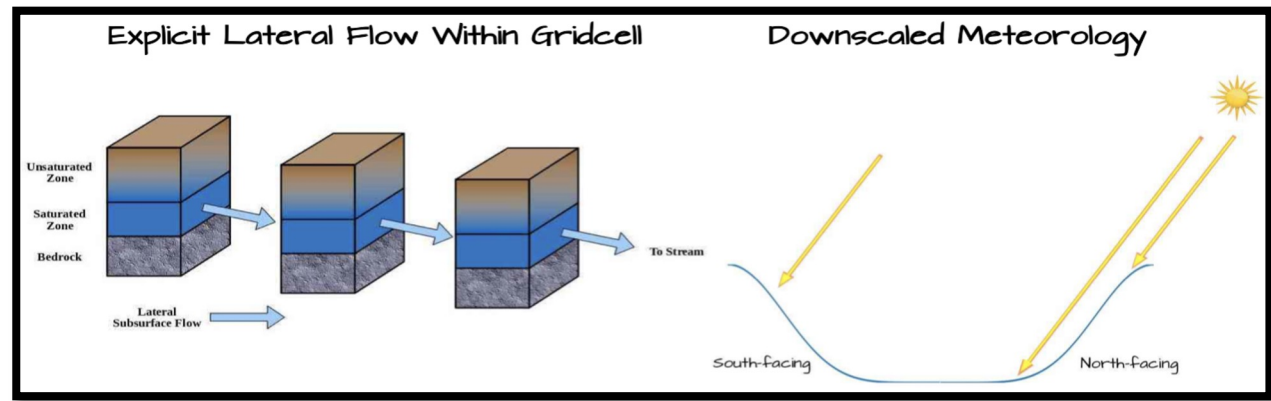
NATIONAL SCIENCE FOUNDATION
LTER NETWORK
LONG TERM ECOLOGICAL RESEARCH

Alpine ecosystems are changing rapidly

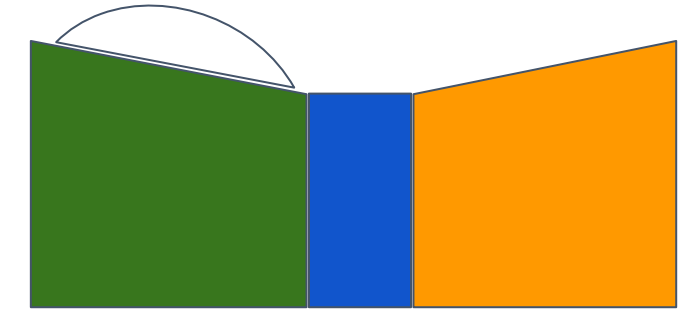
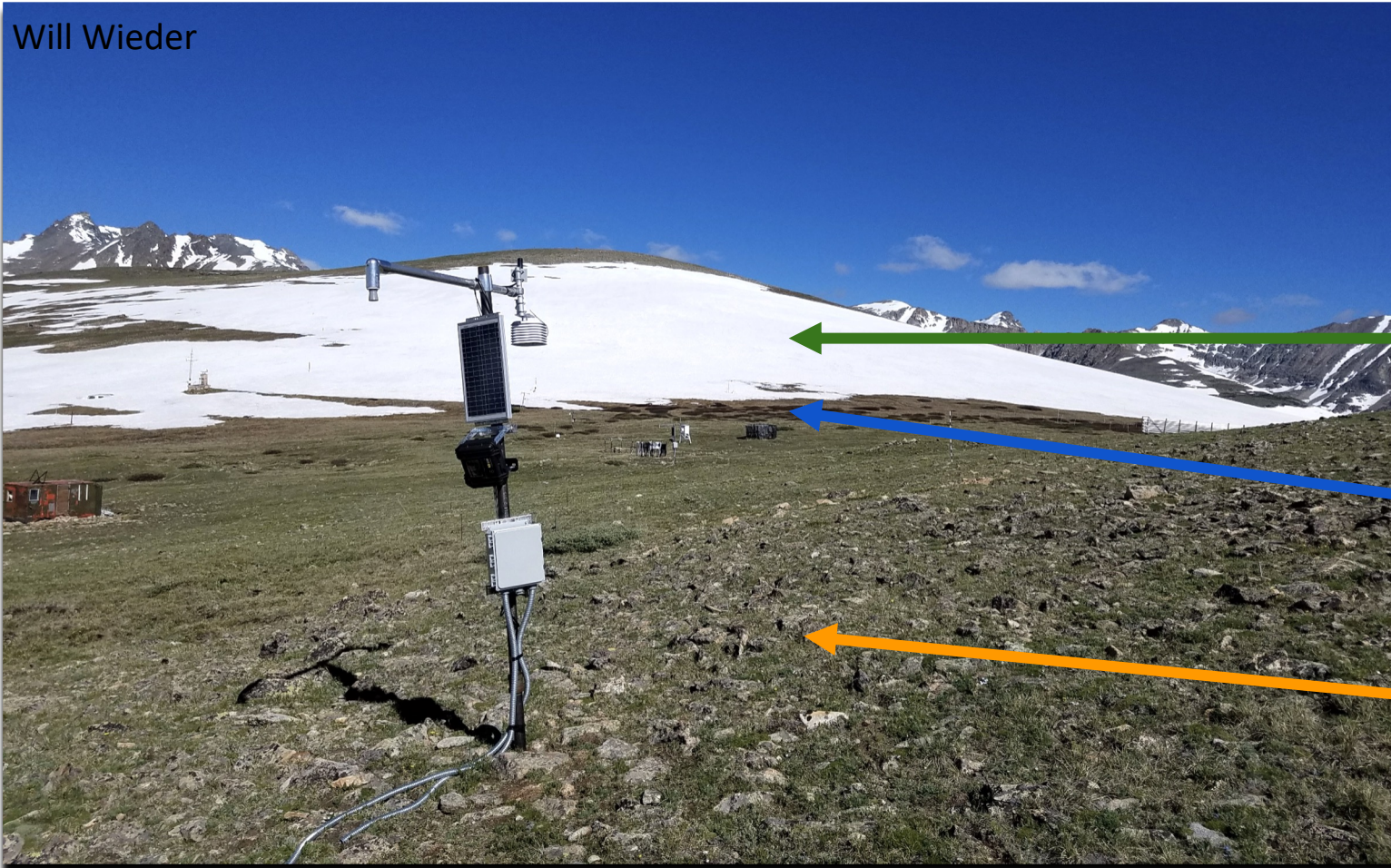
Niwot Ridge LTER: long-term measurements



Niwot Ridge Representative Hillslope "The Saddle"



Will Wieder



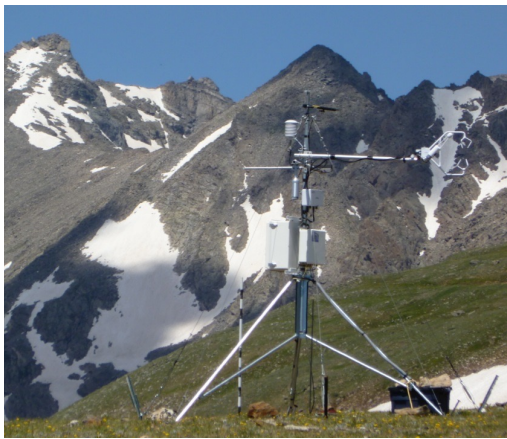
Moist Meadow
*Resource-acquisitive
plants*

Wet Meadow

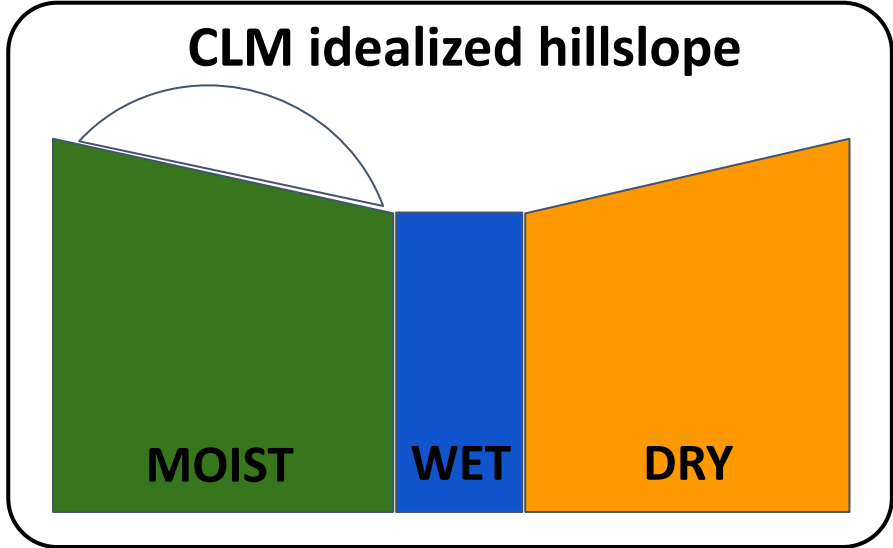
Dry Meadow
*Conservative growth
strategies*

1. Can CLM reproduce patterns in snow/hydrology, soils, and productivity across a topographically complex landscape?
2. How do aspect-driven differences in radiation alter these patterns?
3. Does landscape position (aspect and vegetation community) moderate exposure to future climate changes?





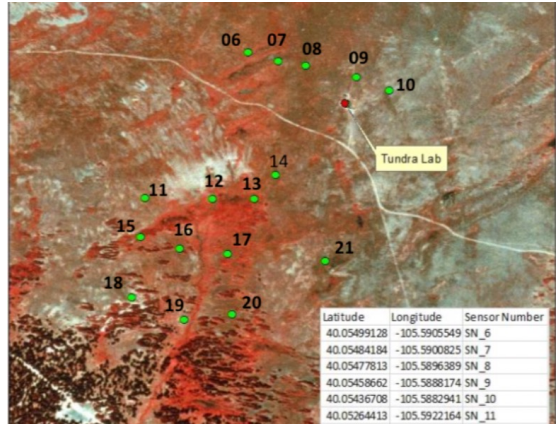
Site input data
 Saddle precipitation
 Tvan meteorology
 Ameriflux radiation
 Soil properties



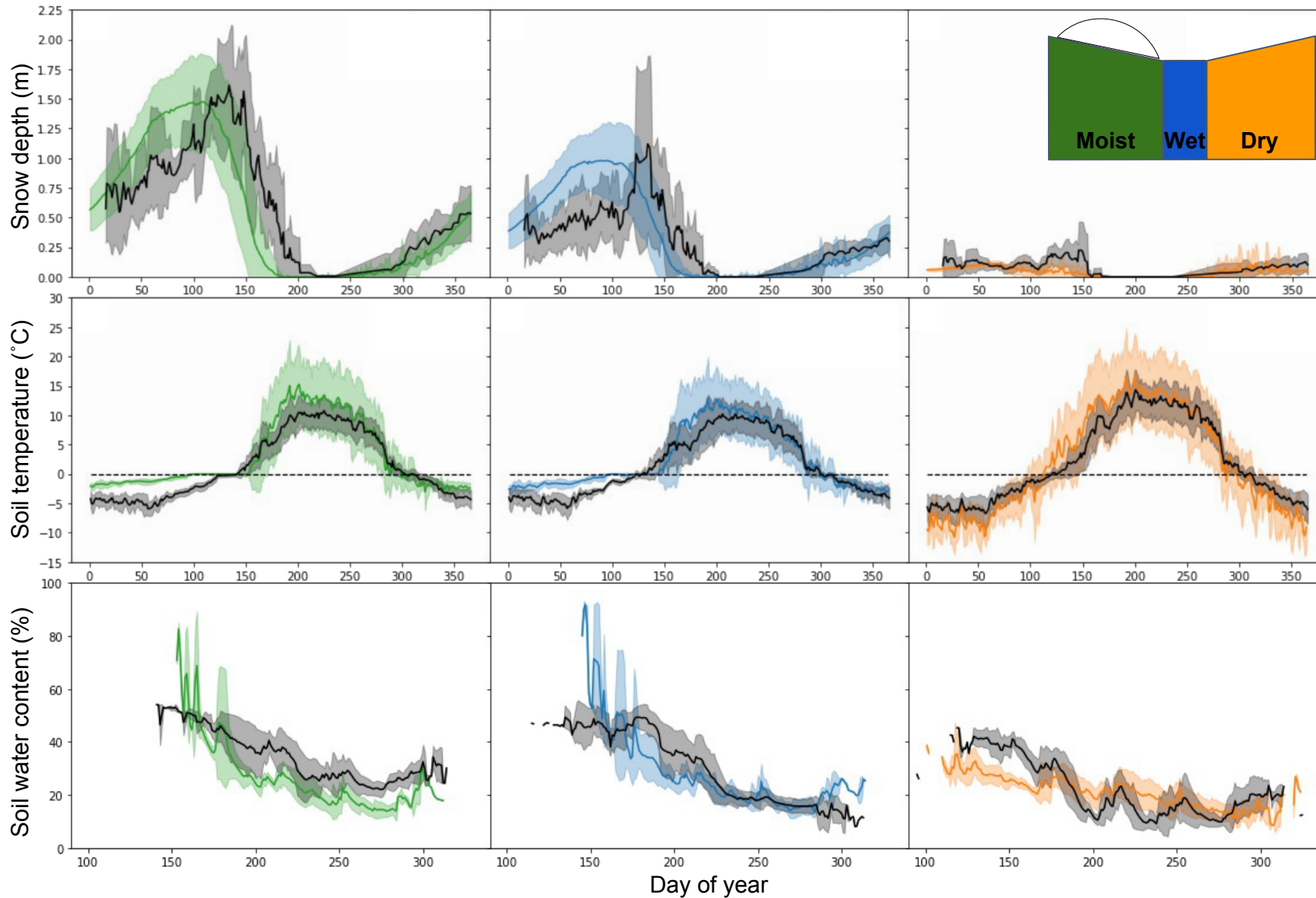
Model evaluation
 Snow depth
 Soil temperature
 Soil moisture
 Productivity
 Eddy covariance fluxes



Model parameterization
 Foliar traits
 Phenology traits
 Plant hydraulics

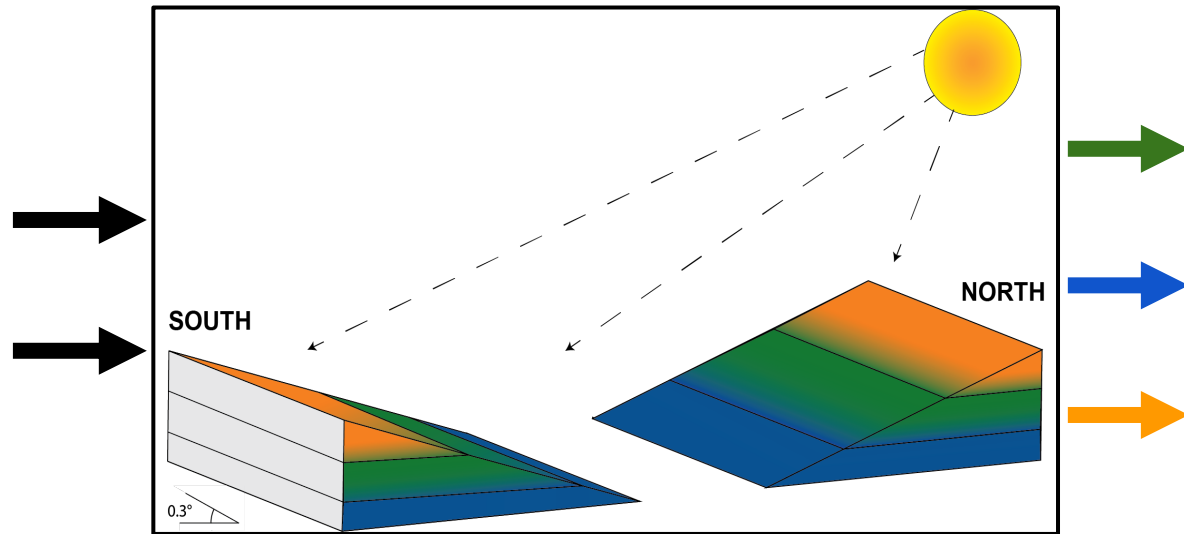


Model validation: Niwot Ridge LTER measurements





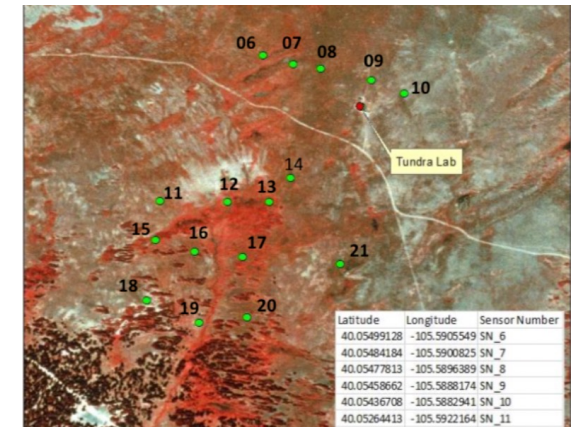
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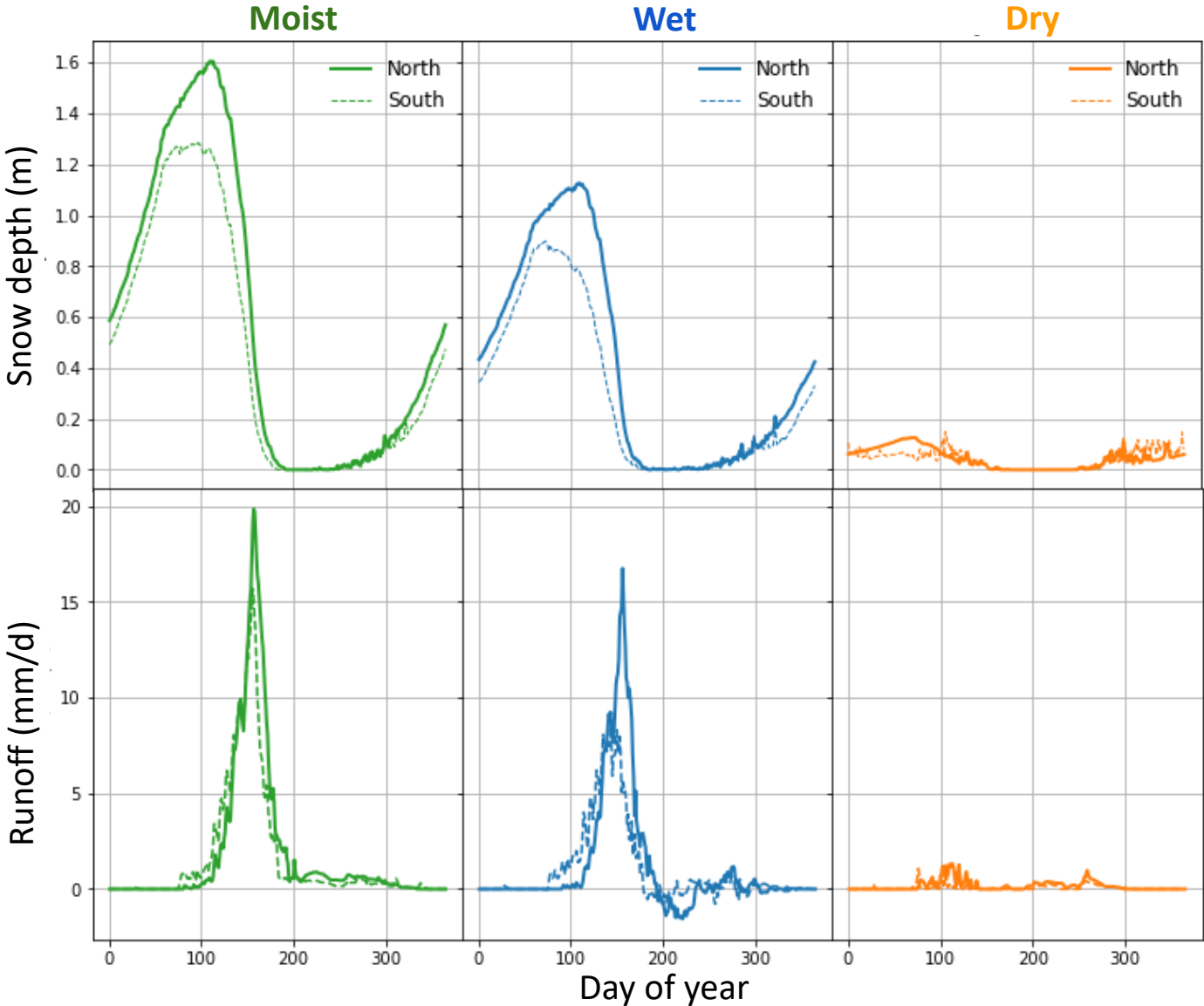
Model application
 Aspect simulations
 Anomaly forcing



Model parameterization
 Foliar traits
 Phenology traits
 Plant hydraulics



Decreased snowpack and altered timing of runoff in wet meadow

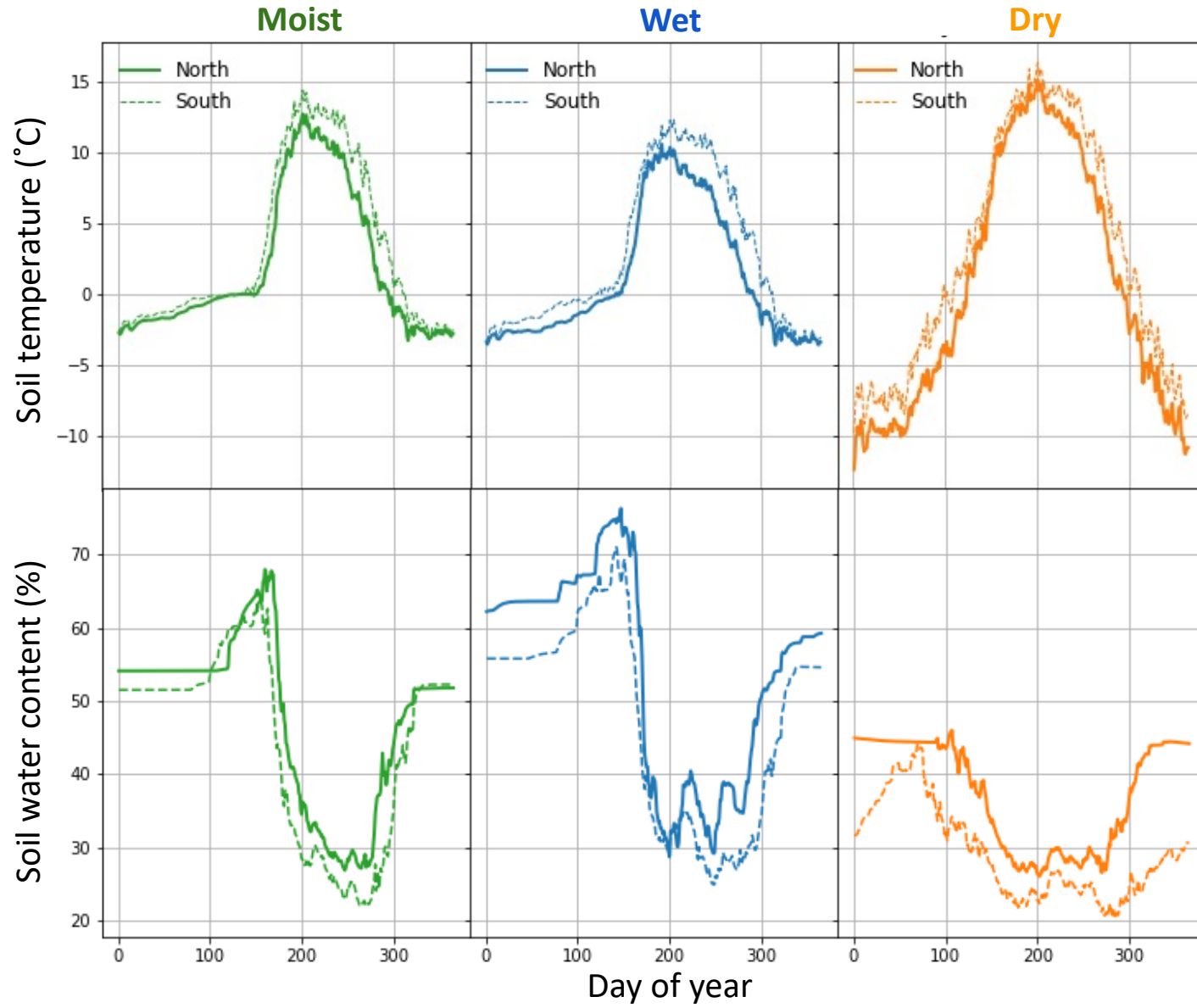


Δ growing season length (days):

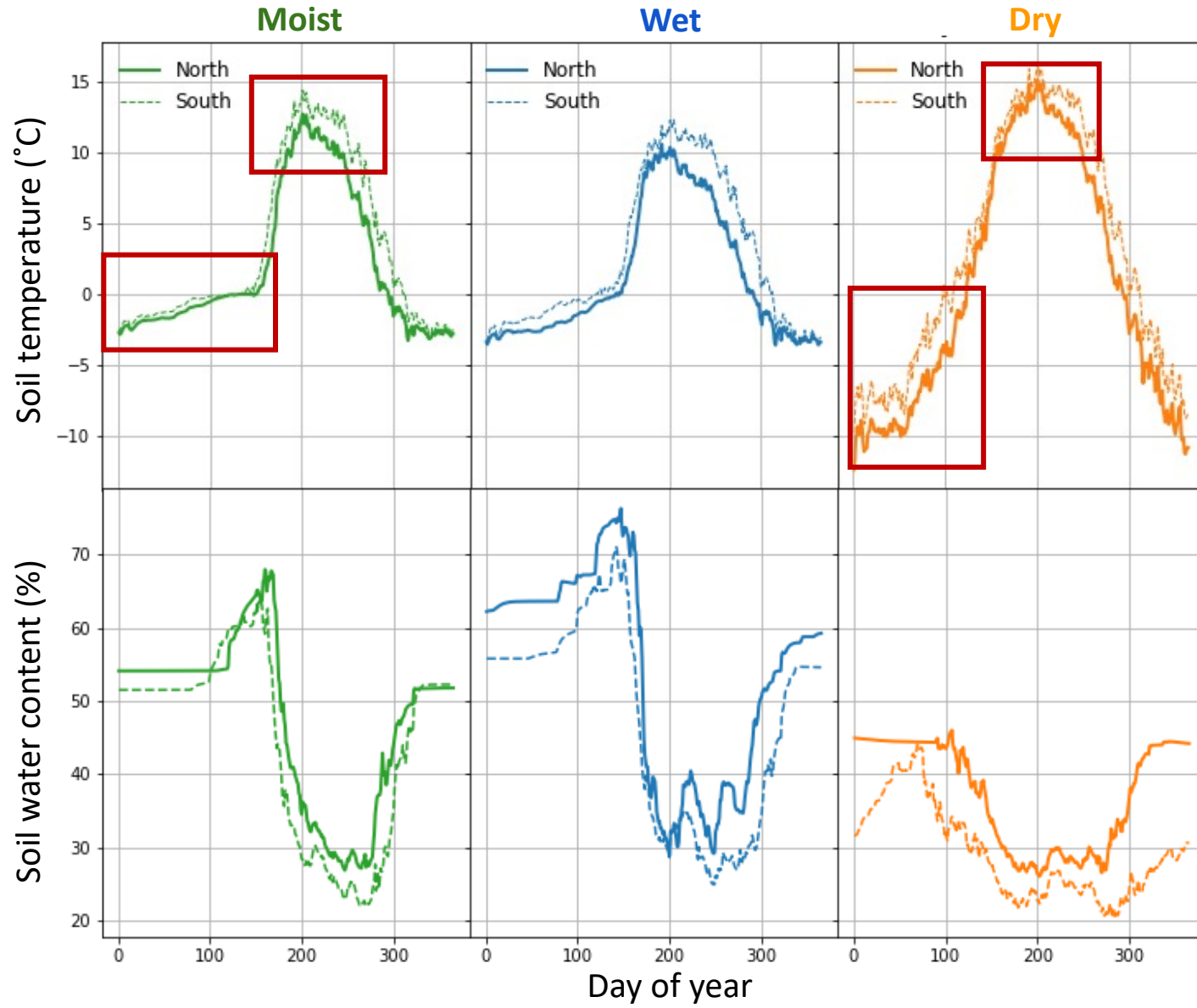
- Moist: +8 (south)
- Wet: +7 (south)
- Dry: +10 (south)



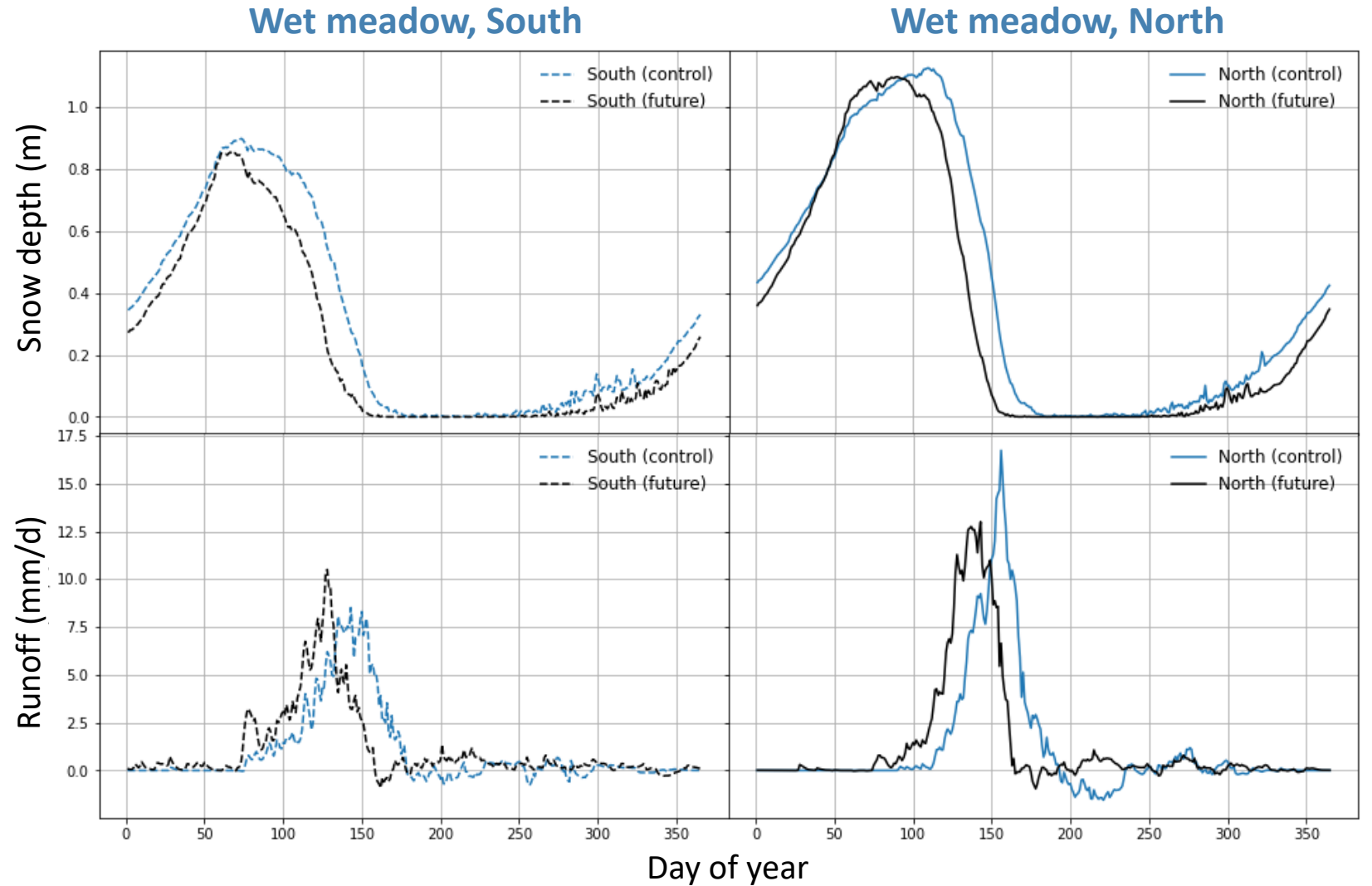
South aspects are drier + warmer, with seasonal variation across communities



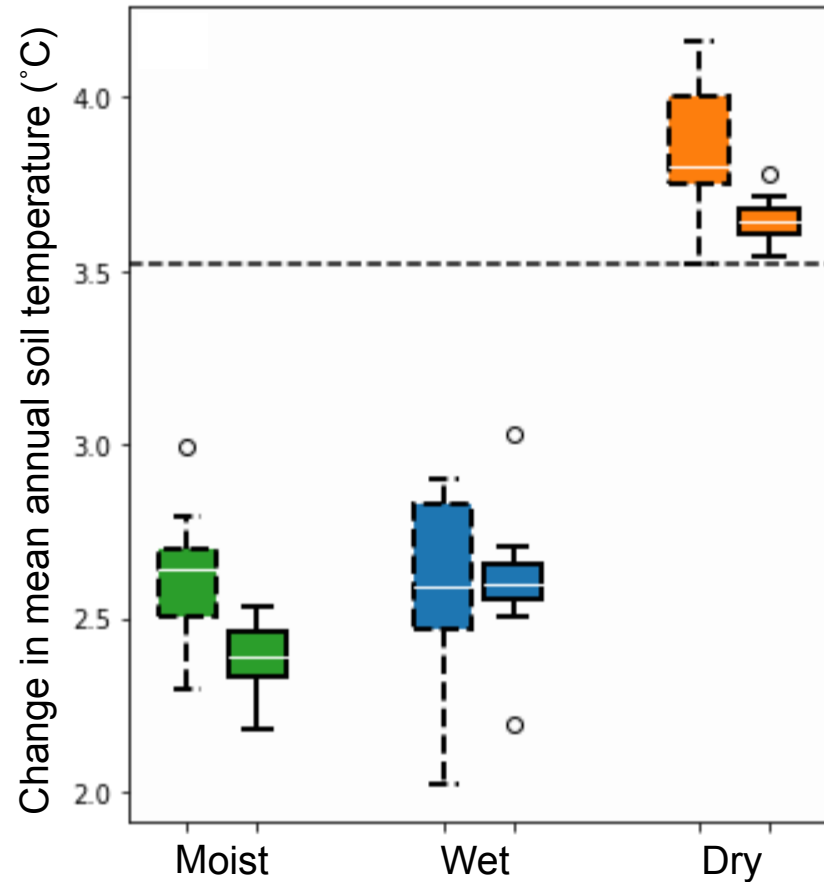
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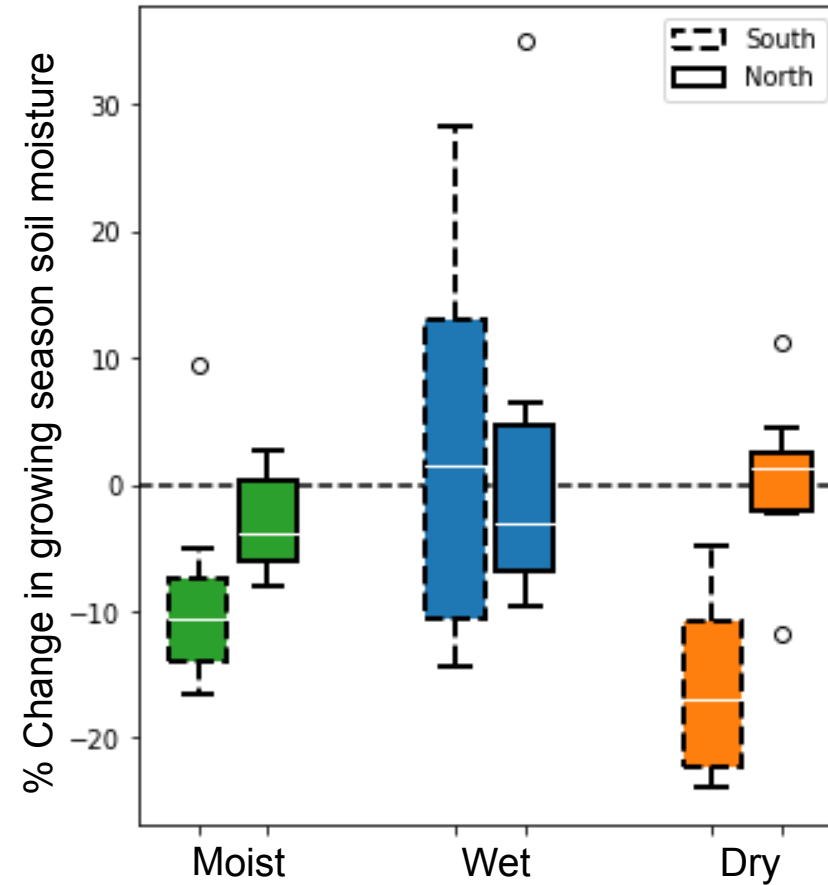
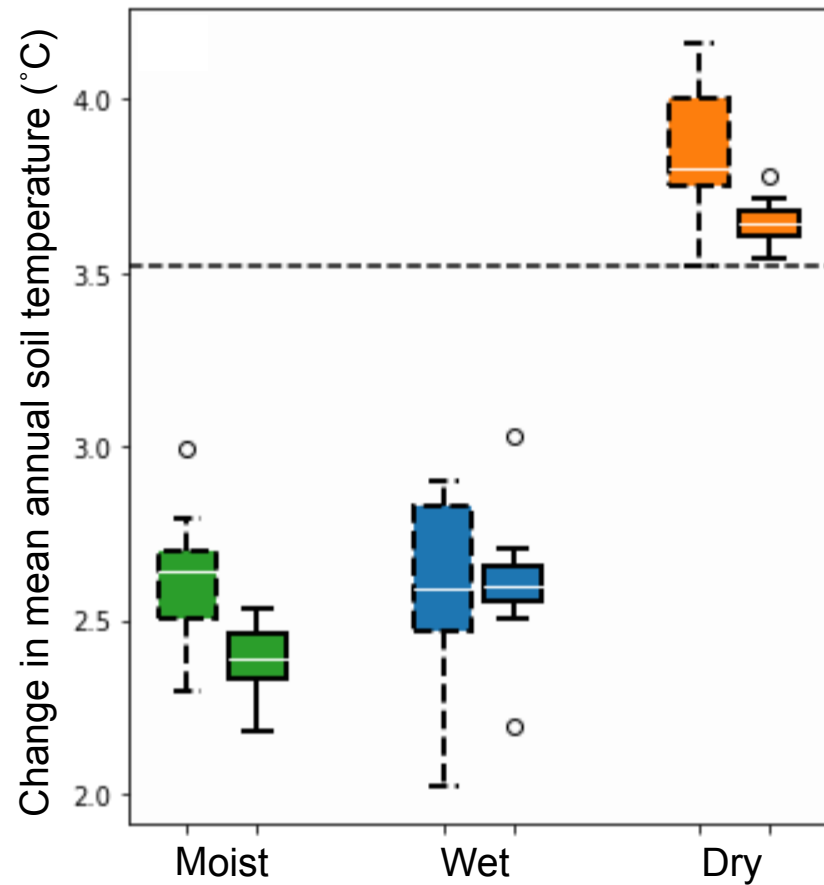
Altered timing of snowmelt and runoff in future scenario



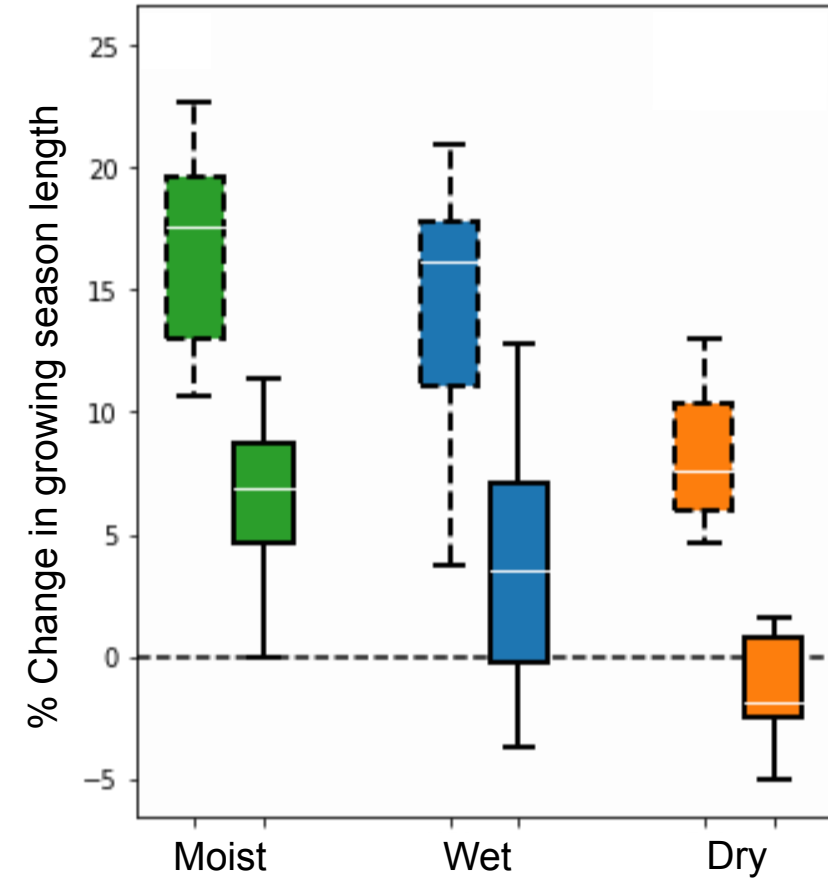
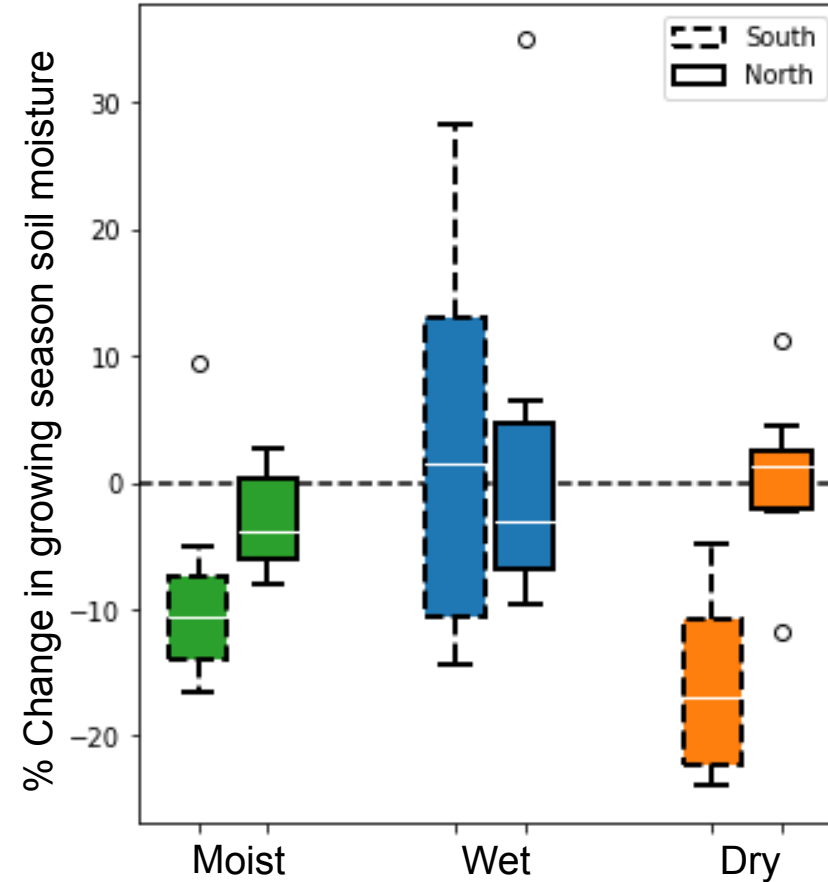
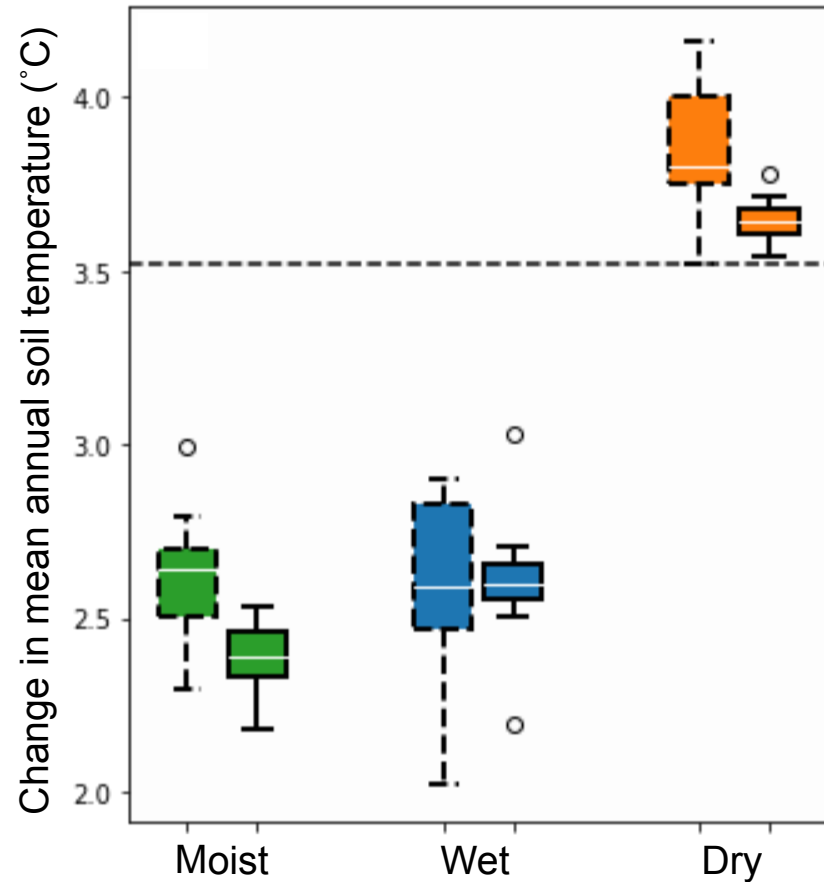
Dry meadow tracks air temperature change, while snow-covered areas are buffered



Changes in soil moisture driven by aspect and community

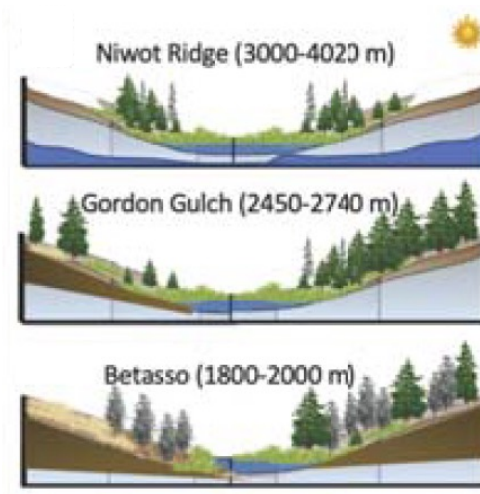


Increase in growing season length moderated by aspect



Takeaways and next steps

- CLM with hillslope hydrology can capture differences in soils, productivity, and snow across a topographically complex alpine landscape
- Altered timing of snowmelt and runoff could decouple resource availability from demand during growing season
- Exposure to future climate change is moderated by landscape position in alpine tundra
- Next steps:
 - Applying our modeling framework at lower elevation sites (Niwot forest site, Gordon Gulch, Betasso) to co-develop estimates of climate refugia, informed by stakeholders and public values



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