



A Lengthening Vernal Window: Asynchronies in energy, water, and carbon balance



Elizabeth Burakowski, Alix Contosta, and Danielle Grogan,
Institute for the Study of Earth, Oceans, and Space, University of New Hampshire

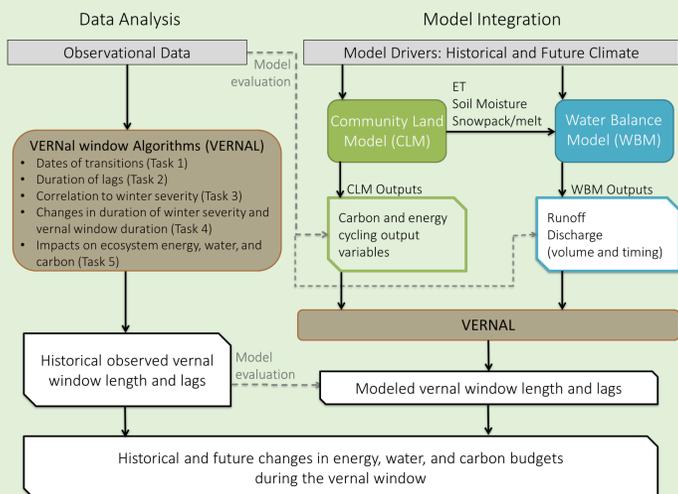
The vernal window^{1,2} is a key period for the functioning of seasonally snow-covered, forested ecosystems encompassing a time when neither a snowpack nor a closed forest canopy is present, allowing for direct inputs of solar radiation to soils and water bodies^{3,4}.



Hypotheses:

1. The vernal window will lengthen in a warming climate.
2. Lags between important thermodynamic and biogeochemical transitions will become longer, leading to asynchronies in ecosystem energy, water, & carbon cycles.
3. Extreme shift into a snow-free regime will replace vernal window with a prolonged period of increased net radiation into terrestrial and aquatic ecosystems between senescence and leaf out that may fundamentally alter ecosystem function.

Integrated Data-Model Approach:



References:
¹Contosta et al. 2017, *Global Change Biology*
²Creed et al. 2015, *Hydrological Processes*
³Tockner et al. 2010, *Freshwater Biology*
⁴Grime, 1994, *Ecophysiological Processes Above- and Belowground*

⁵Pierce et al. 2014, *J Hydrometeorology*
⁶Wisser et al. 2010, *Hydro. and Earth System Sci.*
⁷Grogan, D. *Doctoral Dissertation*
⁸Hufkens et al. 2018, *Methods in Ecol. and Evol.*

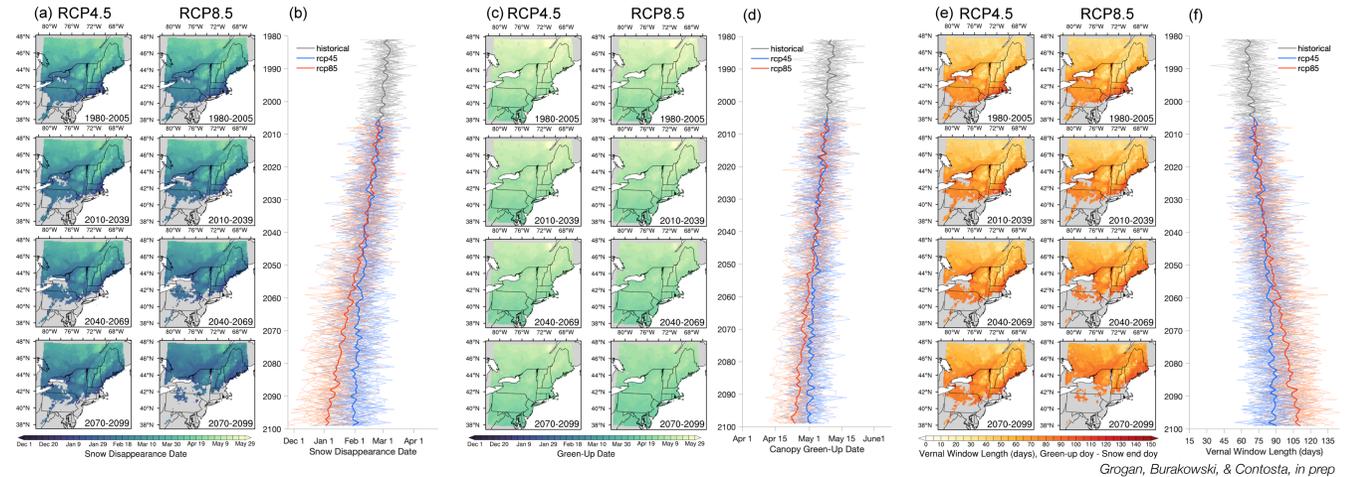
The vernal window lengthens 2-3 weeks in a warming climate by 2100.

Approach: Use daily Localized Constructed Analogs (LOCA) 29-member ensemble⁵:

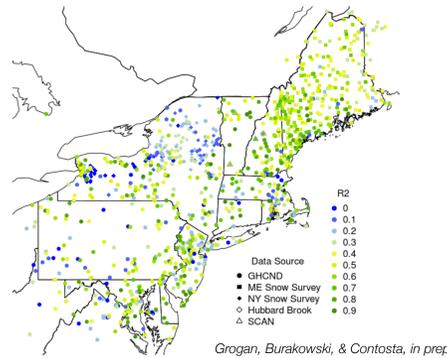
- Minimum air temperature
- Maximum air temperature
- Precipitation

to force the Water Balance Model (WBM)^{6,7} and Phenor⁸ thermal time phenology model. Calculate vernal window metrics:

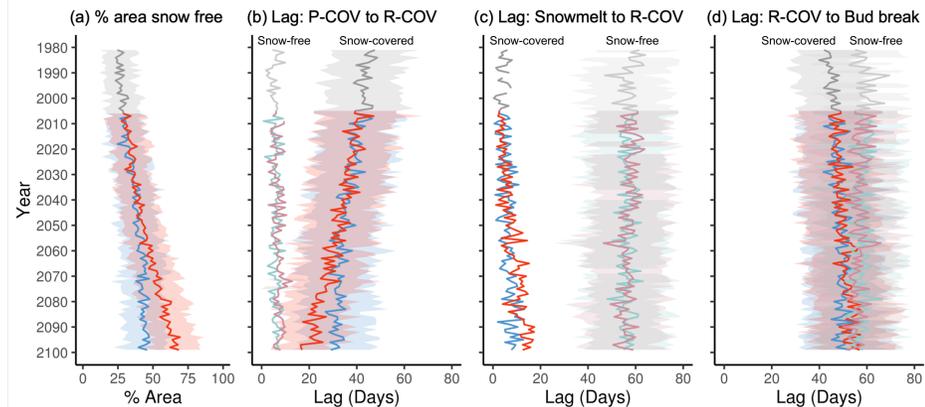
- Snow disappearance date
- Canopy bud break date
- Vernal window length
- Runoff Center of Volume (R-COV)
- Precipitation Center of Volume (P-COV)



WBM simulates snow water equivalent moderately well:



Snow free-region in Northeast increases from 27% to 43- 59% by 2100

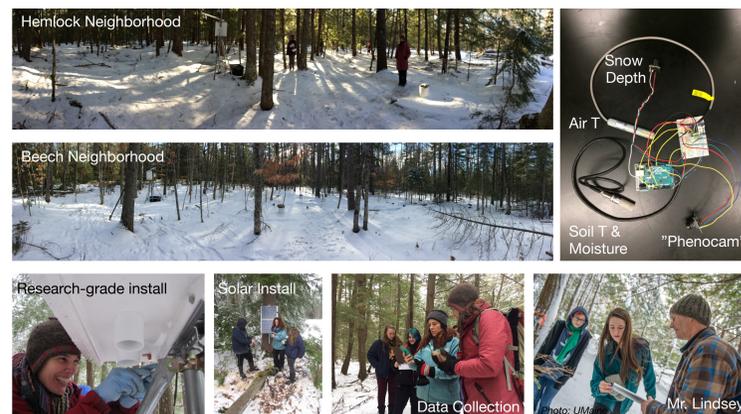


Asynchronous hydrologic transitions:

- Historically, R-COV occurred about one month after P-COV because snow stores winter precipitation.
- Under high emissions, R-COV and P-COV lag reduced to two weeks.
- Lag from R-COV to budburst remains constant.

Outreach: Arduino, ShinyR and GLOBE protocols in science education

Old Town High School Arduino low-cost (\$250) instrument suite will be deployed alongside research-grade equipment to track snow depth, soil temperature and moisture, air temperature, and phenology in the U-Maine Forest.



Shiny R

https://ot-vernal-windows.shinyapps.io/OT_Shiny_App/

Select Data
 Visualize and download data and graphs from the Old Town Ecological Observatory, Old Town, Maine. The observatory continuously monitors near-surface climate conditions in two neighboring forest stands, beech and hemlock.

Choose Date Range and Variables
 Select the date range and the variables you would like to plot and download. You have the option to view all of the data ever collected at each site or to view a shorter period. You can choose to view the beech and hemlock neighborhoods separately or at the same time. For variables measured at different depths in the soil profile, you can also select to view them singly, between sites, or all together.

Select Date Range to Plot
 Date Range: 2018-11-26 to 2019-05-13

Select Variables to Plot
 Both Neighborhoods

Relative Humidity
 Beech Neighborhood

Snow Depth
 Both Neighborhoods

Snow Temperature at 5 and 25 cm
 Beech Neighborhood 5 cm

Bundled GLOBE Protocols to track the vernal window, including snow depth, soil frost depth, and canopy green-up and a prototype soda lime base trap protocol to track soil CO₂ efflux.

Soil frost & snow depth

Soil CO₂

Data Stewardship

Canopy Green-up

Vernal Window Timeline Activity to hone hypothesis generation and testing skills. Evaluated at five schools, including Old Town High in Maine.

Students to present at the 2019 Northeast GLOBE Student Research Symposium.