An extreme-ensemble approach for evaluating regional responses to land cover change in the Northeastern United States using WRF

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Background

Changes in forest cover affect climate by altering biogeophysical surface properties that include both radiative (e.g., albedo) and non-radiative (e.g., surface roughness and evapotranspiration) forcings (Davin and de Noblet-Ducoudré, 2010). Wintertime responses are of particular interest in the mid- and high-latitudes due to the high albedo of snow cover (0.7-0.8) over deforested lands in comparison to the low albedo of forests (0.2-0.3)(Betts and Ball, 1997).

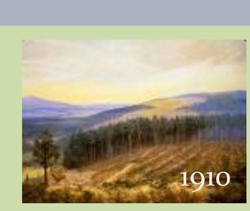
While much of the northern hemisphere mid-latitudes has remained deforested since 1850, the New England region of the Northeastern United States is dominated by extensive regrowth of mixed hardwood and softwood forest.

Here, we simulate New England climate using twelve configurations of WRF in an ensemble approach that provide a range of uncertainty for regional responses to historical deforestation.

New England Forest History

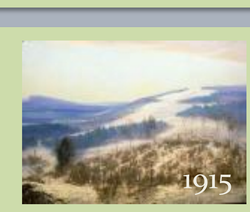
Pre-Settlement Forest

White Pine Harvest

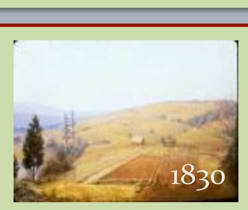


Homestead Clearing, 1740

Hardwood Succession

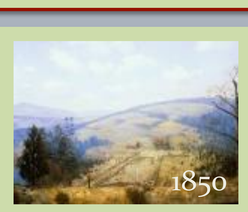


Peak Deforestation

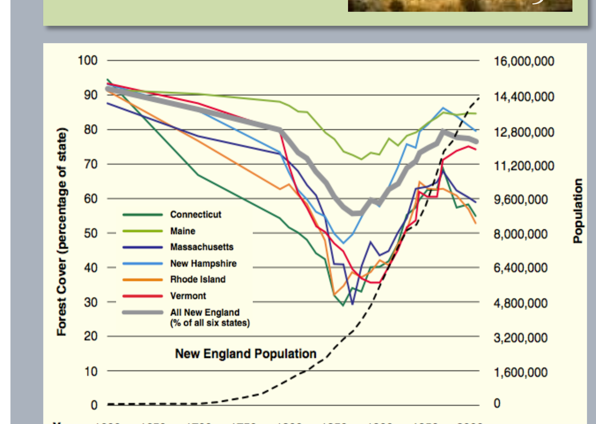


Hardwood Establishment

Farm Abandonment



Modern Forest



The land cover scenarios used include peak deforestation (~1830) and the modern forest (2010) from USGS 30" land cover. To develop the 1830 scenario, we deforested modern urban and forested land cover types at the lowest elevations until the minimum forest area % (left) was reached for each New England state.

Foster et al. 2008

Objectives

- Compare twelve different configurations of WRF to gridded observations of temperature, precipitation and physical snow depth during a cold, snowy winter and a warm, less snowy winter
- Evaluate the range of climate responses to a historical deforestation scenario for two climatic extremes

Ensemble-Extreme Approach

Ensembles (12)

Microphysics (2)
- WSM6
- Thompson New

Longwave/Shortwave (2)
- RRTM/Goddard
- CAM3/CAM3

Land Surface Model
- NoahMP1 (opt_alb=1)
- NoahMP2 (opt_alb=2)
- CLM4.0 (SP)

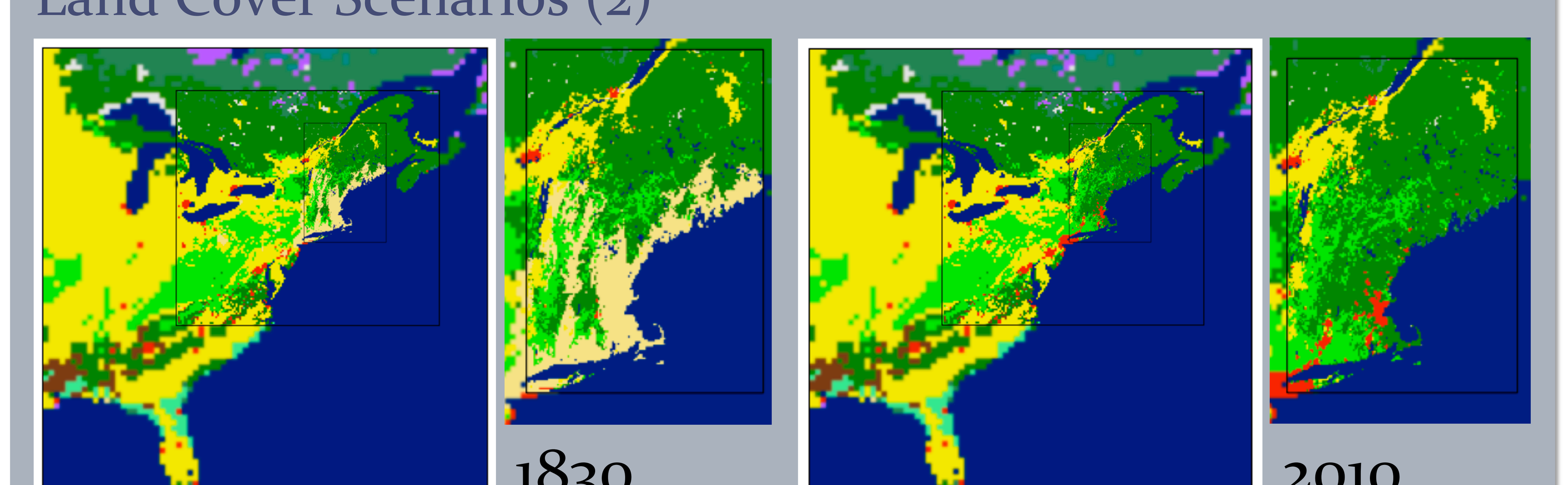
Extremes (2)

Nov 2008 – Apr 2009
- -0.5°C to -1.4°C below normal
- 106% to 123% of normal precipitation

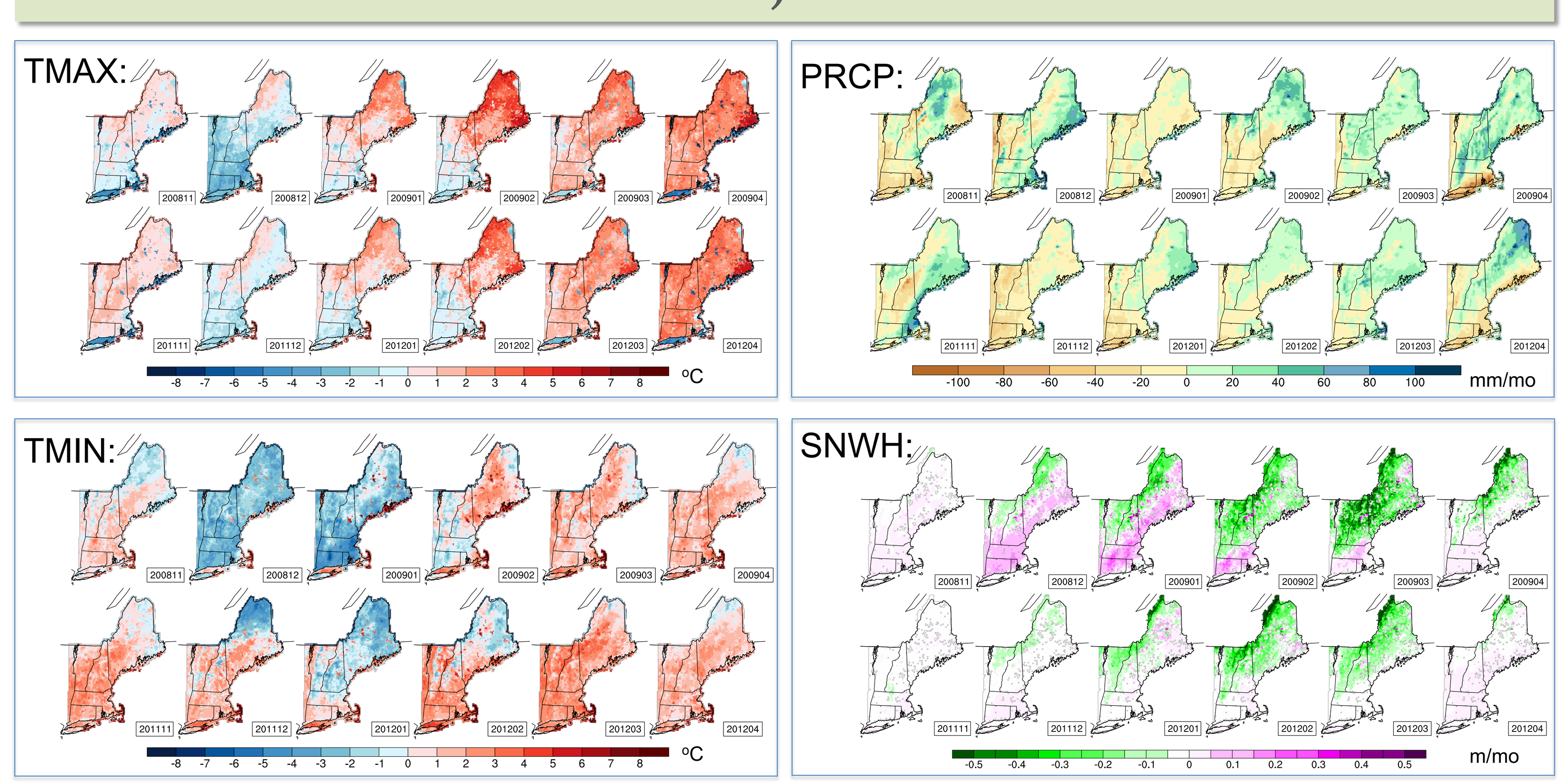
Nov 2011 – Apr 2012
- +2.2°C to +2.9°C above normal
- 75% to 88% of normal precipitation

48 simulations total

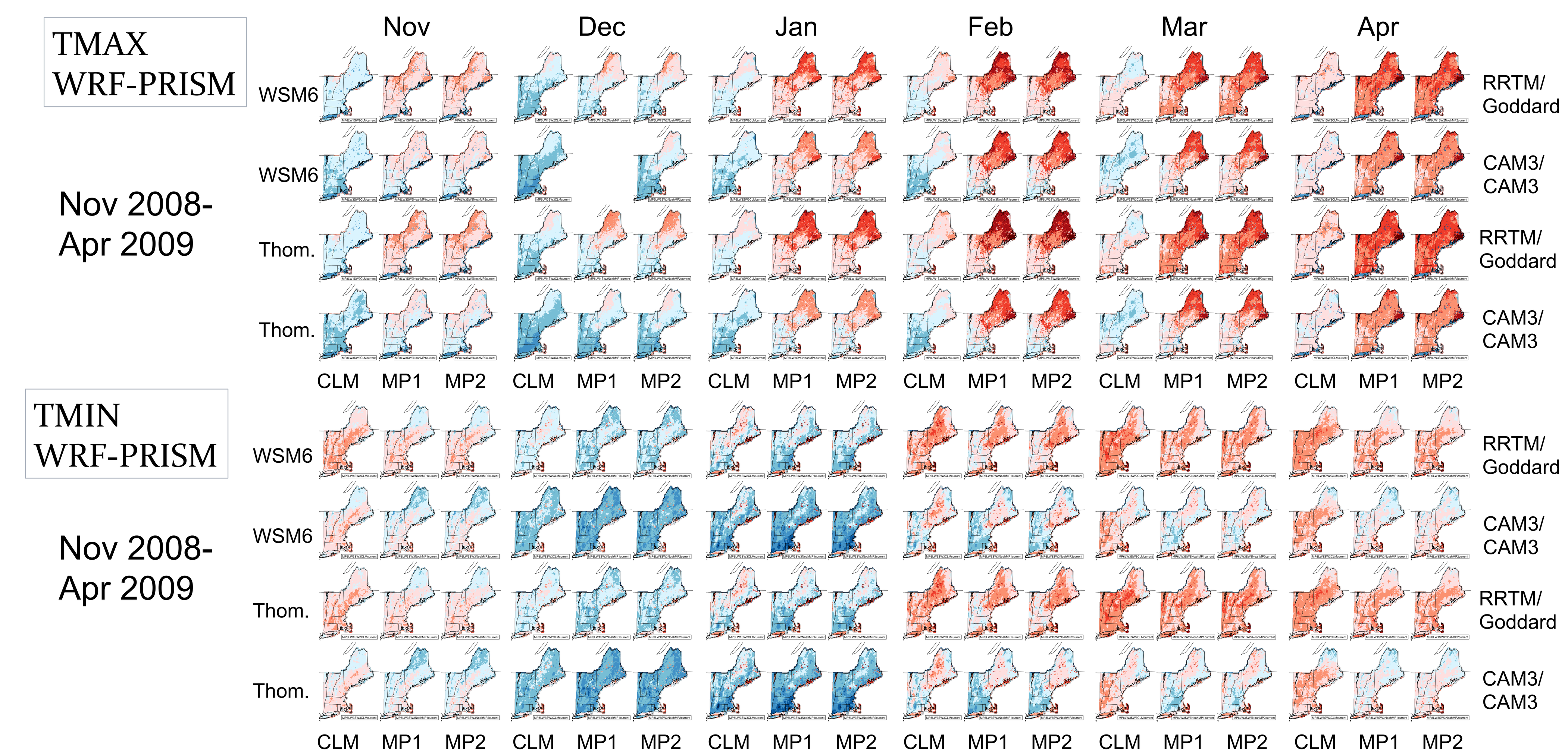
Land Cover Scenarios (2)



Results: WRF - Obs, Mean Ensemble



Results: WRF – PRISM, Individual Ensembles

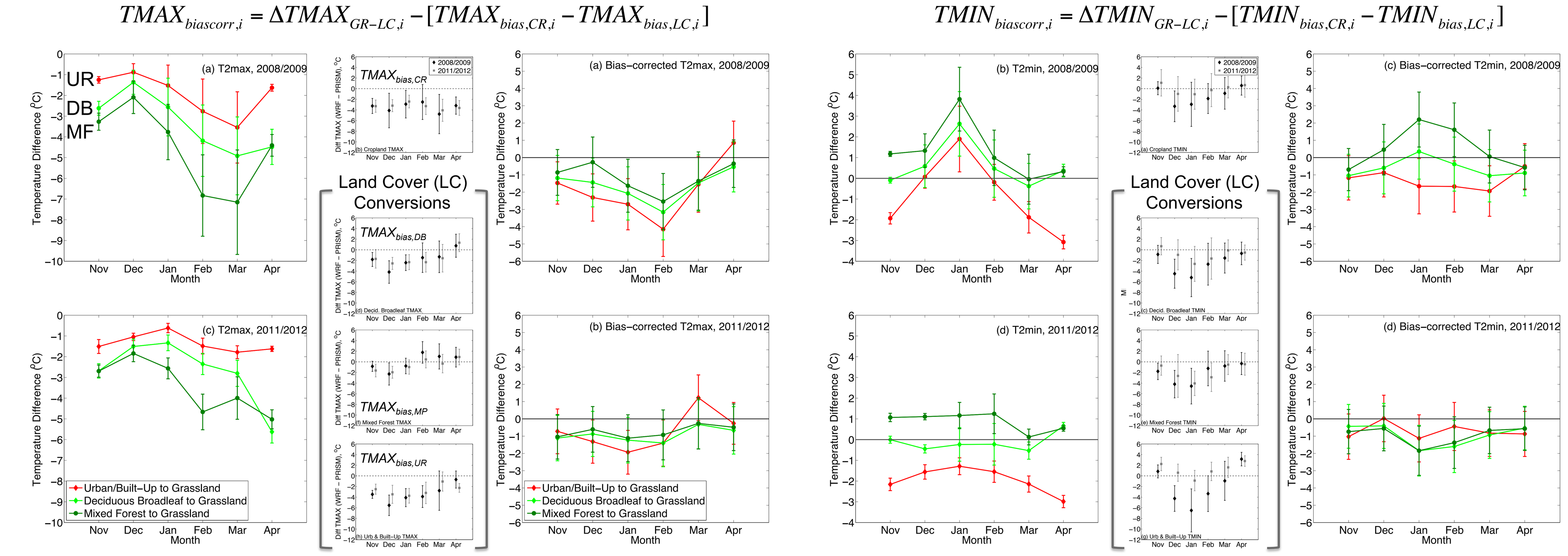


Results: Deforested – Present Day Land Cover

Bias-corrections:

$$TMAX_{biascorr,i} = \Delta TMAX_{GR-LC,i} - [TMAX_{bias,CR,i} - TMAX_{bias,LC,i}]$$

$$TMIN_{biascorr,i} = \Delta TMIN_{GR-LC,i} - [TMIN_{bias,CR,i} - TMIN_{bias,LC,i}]$$



Conclusions and Future Work

- Land surface model choice strongly influences mid-winter TMAX biases
- Longwave/shortwave scheme selection affects TMIN biases throughout 6-month cold season simulation
- Initial deforestation experiments during cold, snowy winters produce stronger cooling than warm, low snowfall winters
- Ensemble-extreme approach will provide a range of uncertainty in regional climate responses to historical deforestation in New England

References:

Betts, AK and JH Ball. 1997, Albedo over the boreal forest. *Journal of Geophysical Research 10*: 28901-28909.

Davin, EL and N de Noblet-Ducoudré. 2010. Climatic Impact of Global Scale Deforestation: Radiative versus Nonradiative processes. *Journal of Climate 23*: 97-112.

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