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Coupling WRF 3 & CLM 3.5 for Regional Climate Simulation & Understanding Land Cover Feedbacks to Climate

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Interactions between Land Cover and the Atmosphere

- Ecosystem forcing of climate: albedo, emissivity, evapotranspiration, & surface roughness
- Vegetation type change can cause 1-3ºC local temperature changes (Snyder et al 2004; Diffenbaugh 2005)
- Vegetation properties & distribution may be affected by changes in temperature and precipitation, or by policy responses to Climate Change

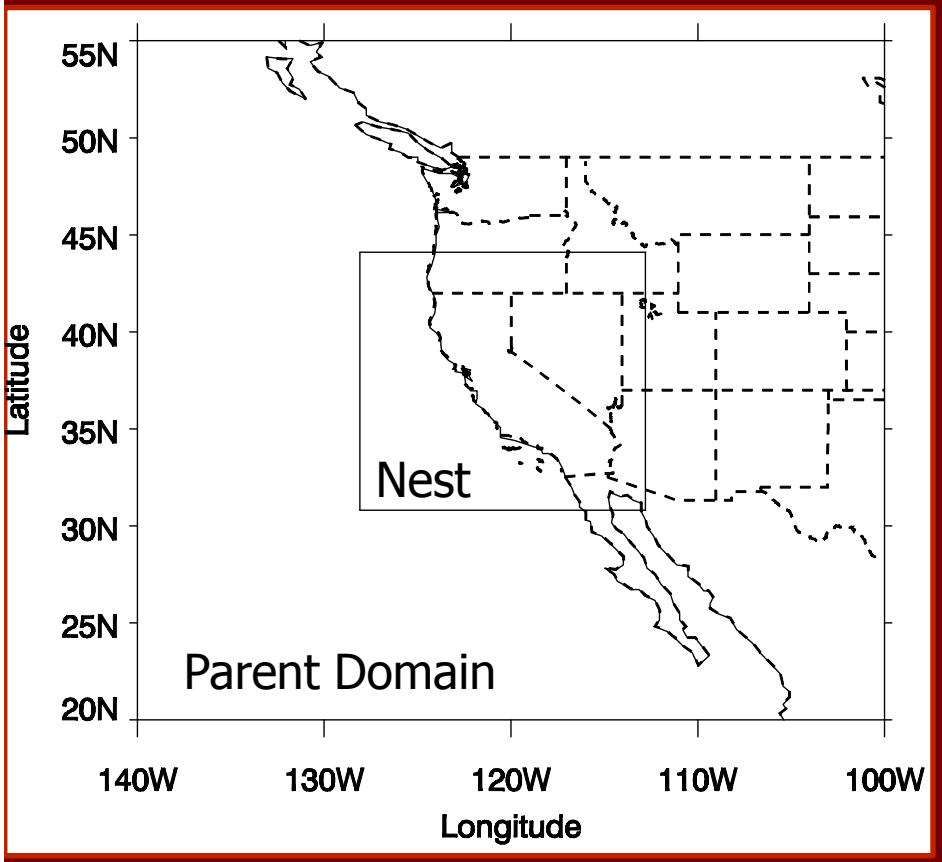
Land Models in RCMs

- RCMs, like WRF, have extensive atmospheric physics with fine grid spacing, but less land surface processes than some GCMs
- Including additional mechanisms allows more specific vegetation properties to be changed for vegetation change experiments
- WRF-CLM is analogous to previous community efforts: WRF-Noah, RegCM-CLM (Steiner et al 2005), MM5-LSM (Cooley et al 2005)

WRF3-CLM3.5 Software Approach

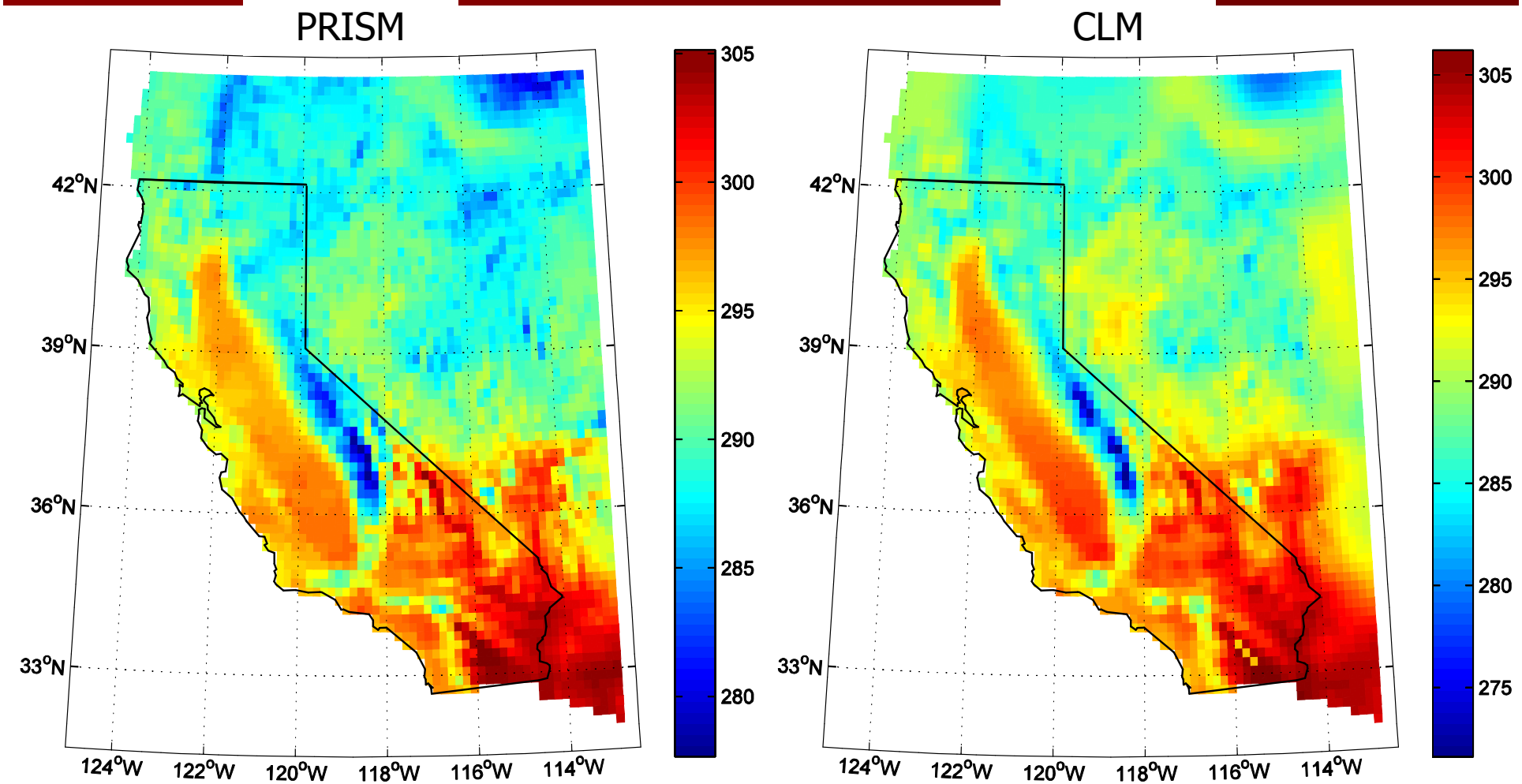
- WRF2-CLM3 coupled by Jiming Jin, Utah State University
- CLM biogeophysics runs as WRF's LSM
- CLM called independently at each timestep, preserving WRF's driver layer and compile / run procedures
- Can run using PFT & soil lookup table with WRF's land surface categories

WRF3-CLM3.5 Evaluation

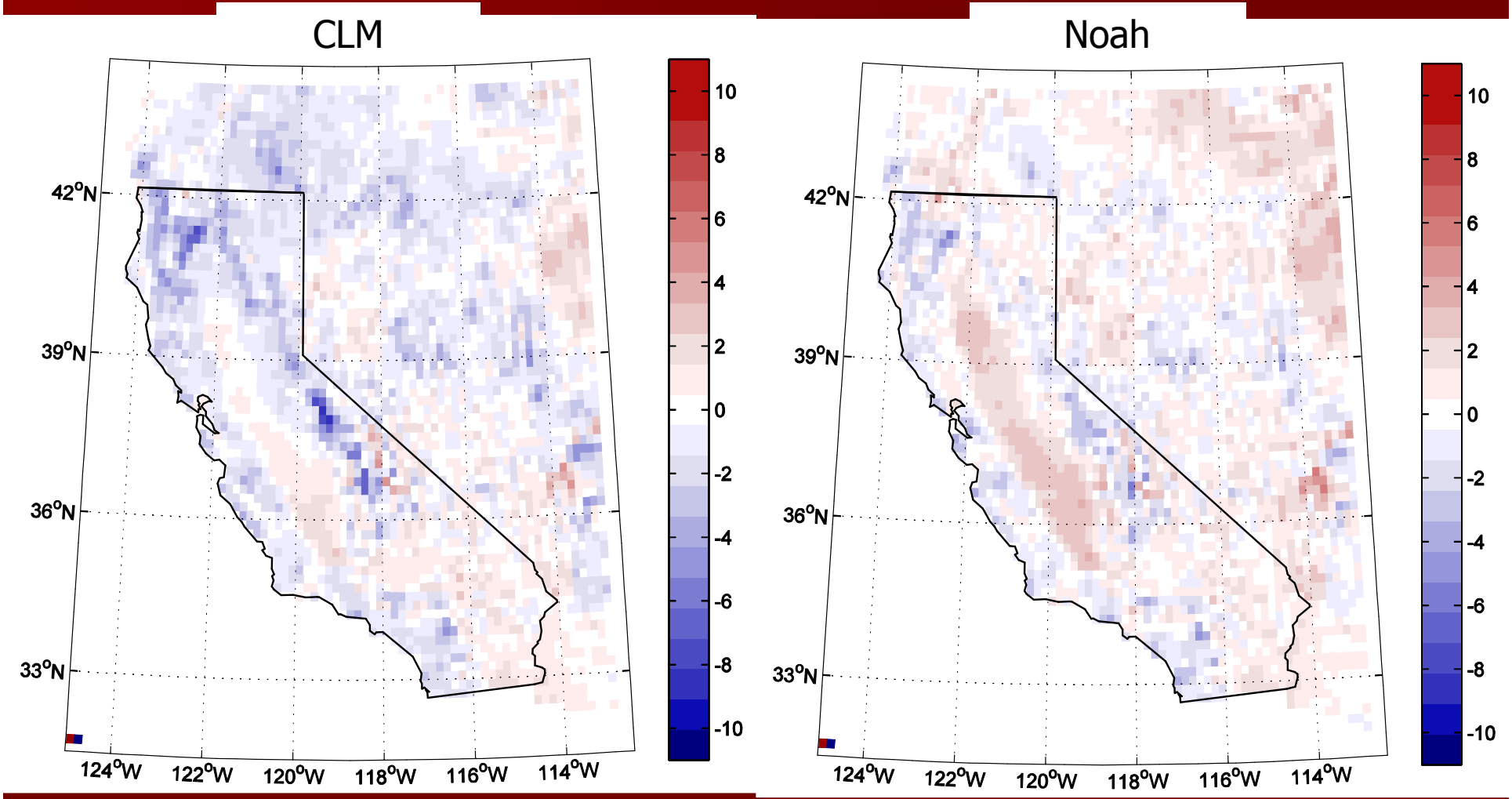


- 1981-1991, forced by NCEP-DOE RP2 (2º)
- Compared to PRISM data
- Identically configured WRF3-Noah run
- Parent: 1/2º (55 km), nest: 1/6º (18 km)

Annual 2m T_{max} (K)

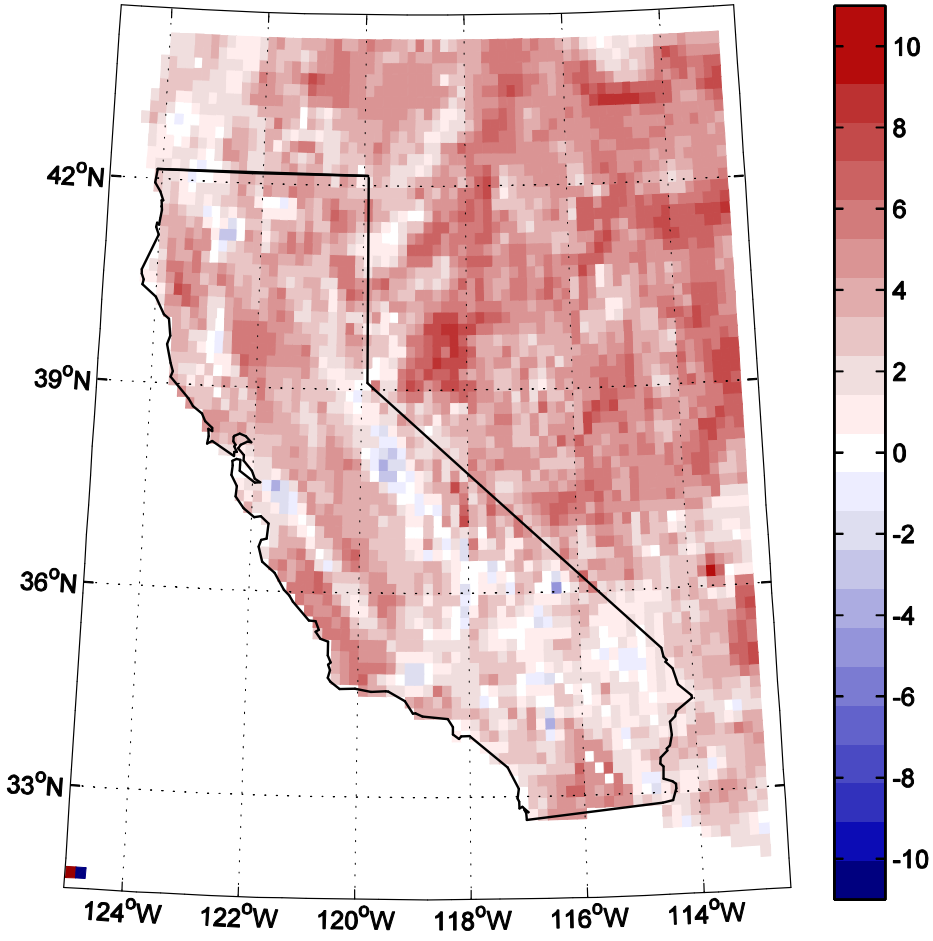


Annual 2m T_{max} Bias (K)

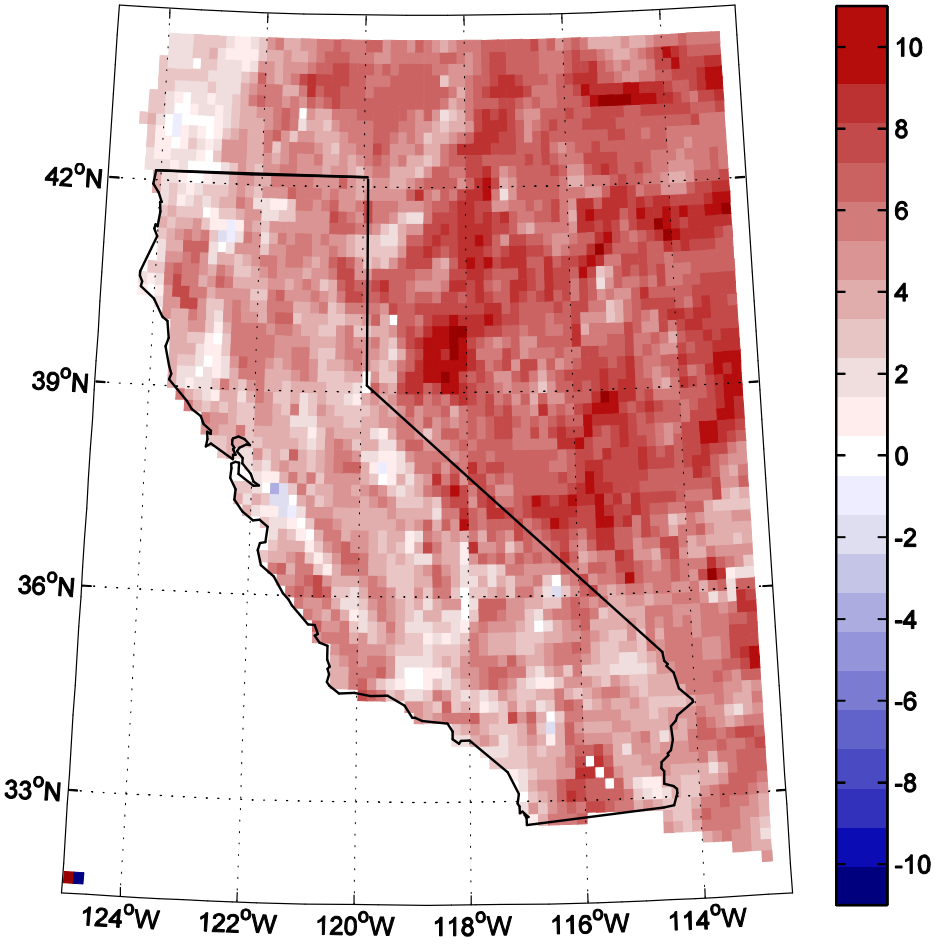


Annual 2m T_{min} Bias (K)

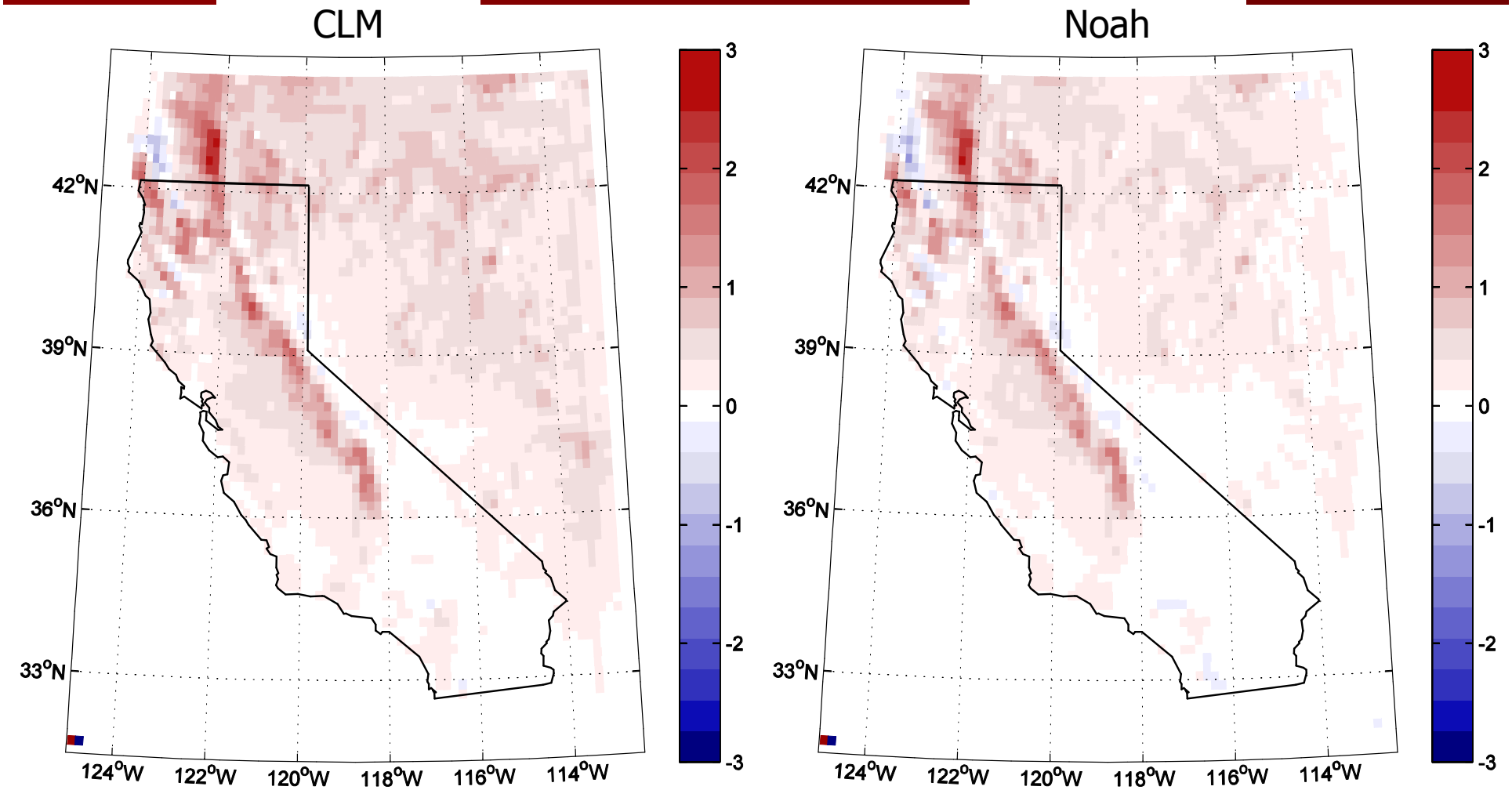
CLM



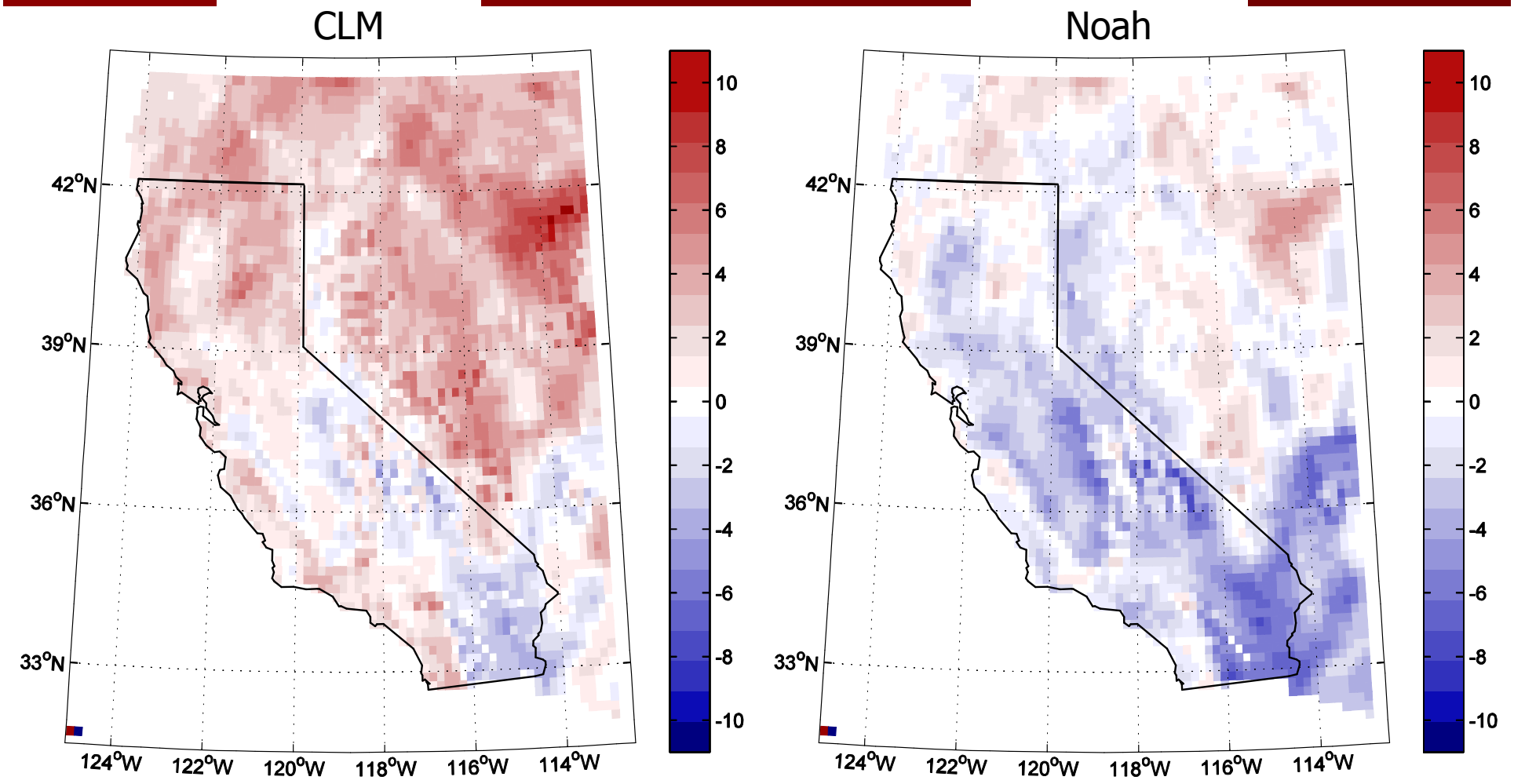
Noah



Annual Precip. Bias (m y^{-1})



Annual Dewpoint Bias (K)



Evaluation: Summary

- Overall statistics (not shown): WRF3-CLM3.5 outperforms WRF3-Noah for T_{min} and dewpoint, and is comparable for precip. and T_{max}.
- Both models reproduce absolute spatial patterns well but leave room for improvement in biases
- WRF3-CLM3.5's additional mechanisms and subgrid PFT patches offer advantages for land cover change experiments

Afforestation

- Strategy for CO_2 sequestration that may have effects on regional climate
- Contrasting results in previous studies for net surface temperature effect of mid-latitude / temperate forest cover
  - Albedo decrease → warming
  - LH increase → cooling
  - (sometimes cloudiness, winds) → ?

California's Diverse Ecosystems

Antelope Valley

Joshua Tree

San Bernardino

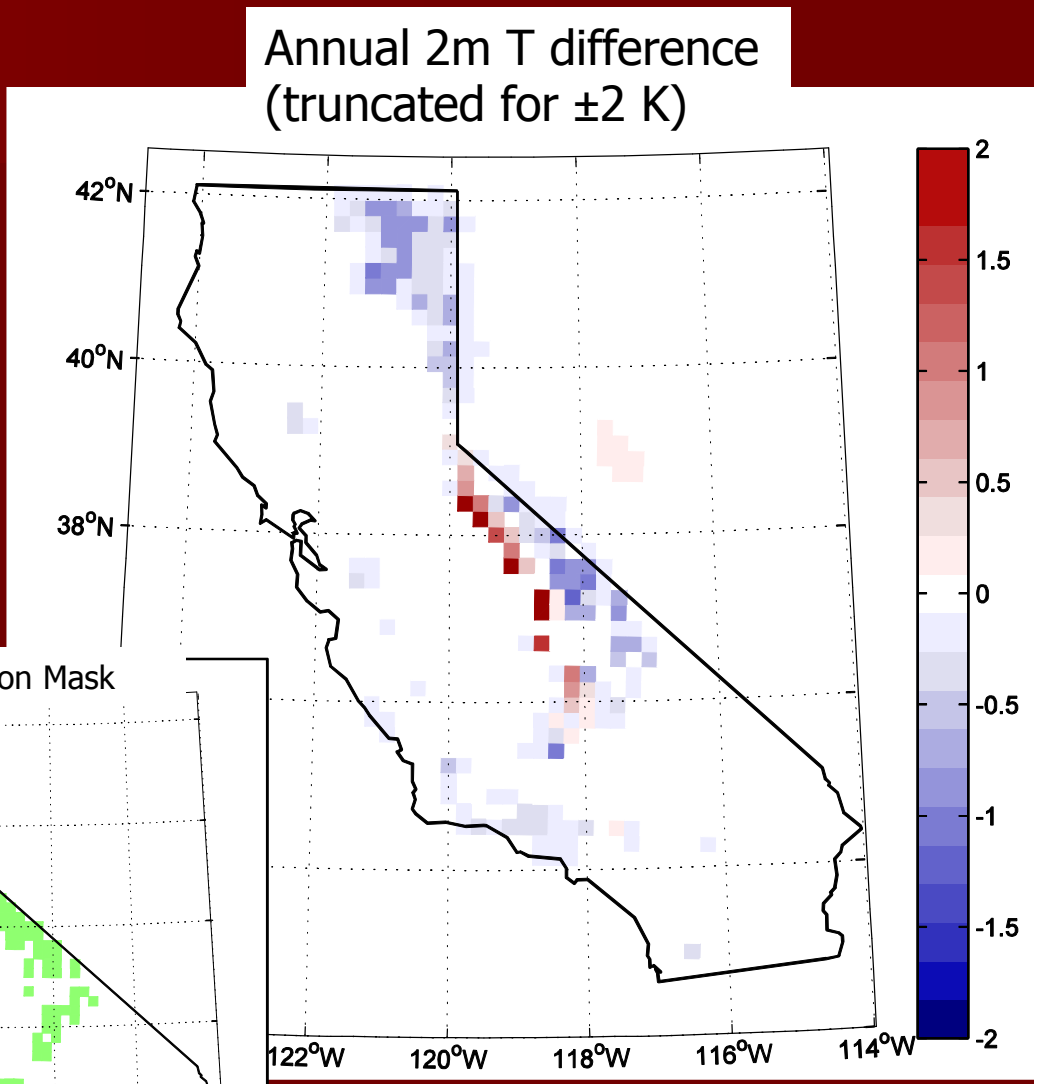
Big Basin

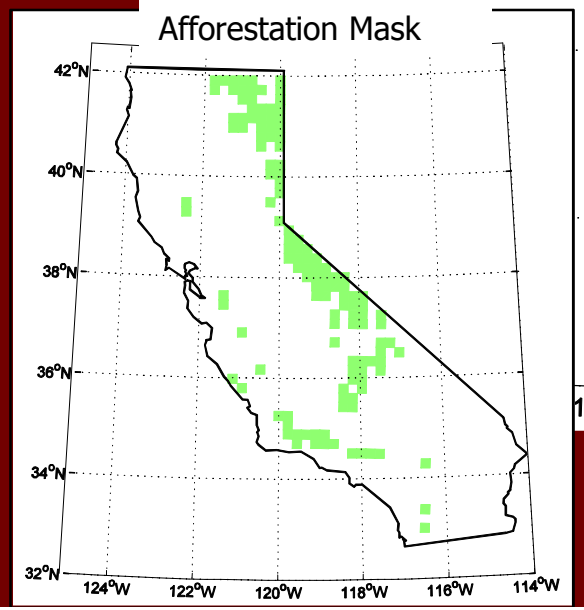
Regional Climate Model Experiment

- Kueppers et al (2008) CEC Report, Subin et al to be submitted to Earth Interactions
- 20 km resolution (75 x 80 gridcells)
- GFDL Boundary Conditions: Future A2 (2058-2070)
- Future Potential Vegetation (Lenihan et al 2006 – based on MC1 Model) + Afforestation Scenario (Brown et al 2004)
- 16 California-specific plant functional types combined into 14 ecosystem categories

Afforestation Experiment

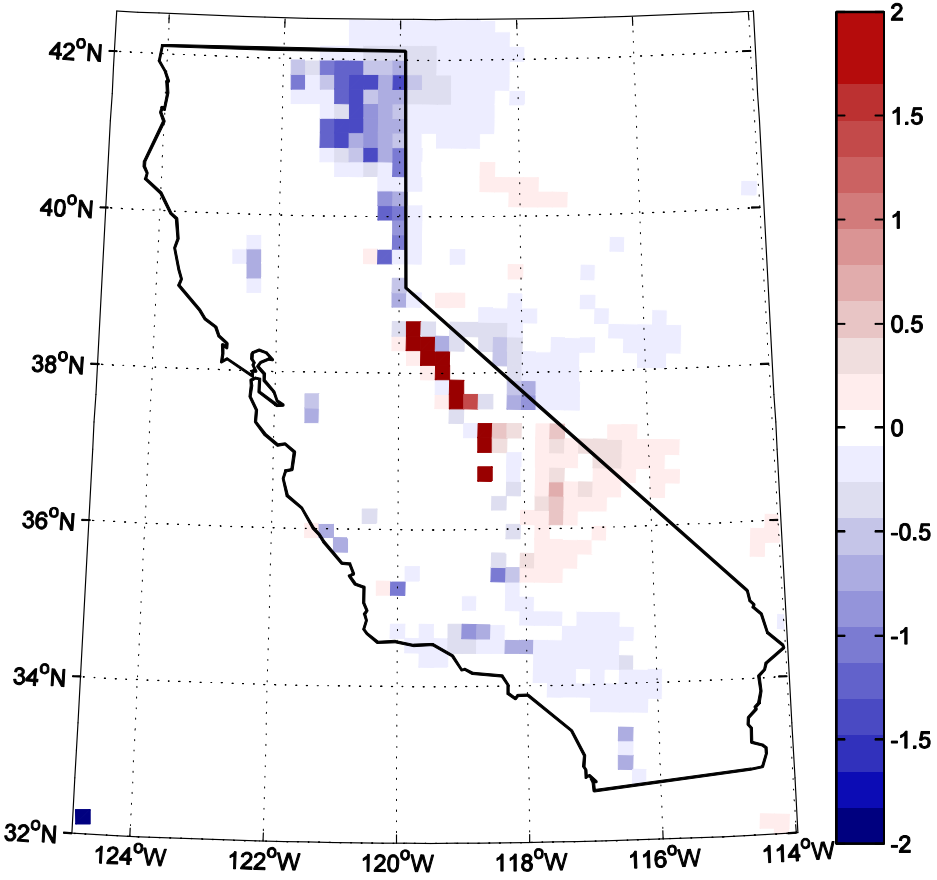
- Broad summer cooling
- Localized winter warming
- Same seasonal contrast found in previous studies: e.g. Snyder et al 2004



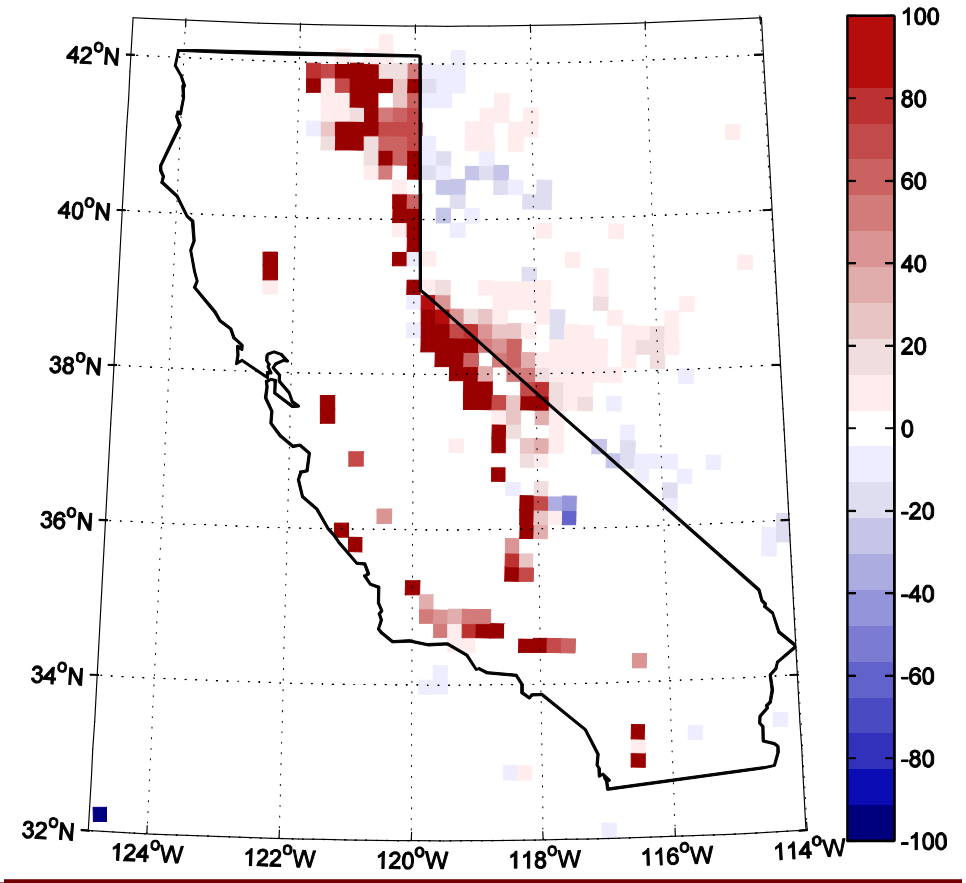


Summer 4pm Differences

2m T 4pm difference, JJA (truncated for ±2 K)



LH 4pm difference, JJA (truncated for ±100 W m^{-2})



Discussion

- Afforestation may cause significant cooling in snowfree regions
  - Albedo decrease is overwhelmed by ET increase
  - Statistically significant cooling downwind of added forest
  - More cooling than lower resolution studies
- More work needed to better parameterize ecosystems, test realism of afforestation scenario in future climate, & include effects of increased CO_2 over domain

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