CalCAST Updates

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Modeling Workgroup Quarterly Review

04/04/2023

What is CalCAST?

- Relatively parsimonious, spatially explicit, largely data-driven watershed modeling tool calibrated in a statistical framework

- Represents > 80,000 National Hydrography Dataset Plus (NHDPlus) catchments within the Bay watershed and leverages data from > 400 USGS monitoring stations for calibration

- Predicts long-term average and annual streamflow, %stormflow, sediment, and nutrients at NHDPlus catchments

Why CalCAST?

- Primarily used as spatial calibration tool
- Main purpose: probabilistically test hypotheses on factors related to spatial variation in contaminant loads and quantify parameters that describe such relationships
- Spatial parameters estimated by CalCAST will inform CAST and the dynamic model
- Incorporate data-driven line of evidence into modeling approach

Today's updates

1. Testing different meteorological datasets in CalCAST

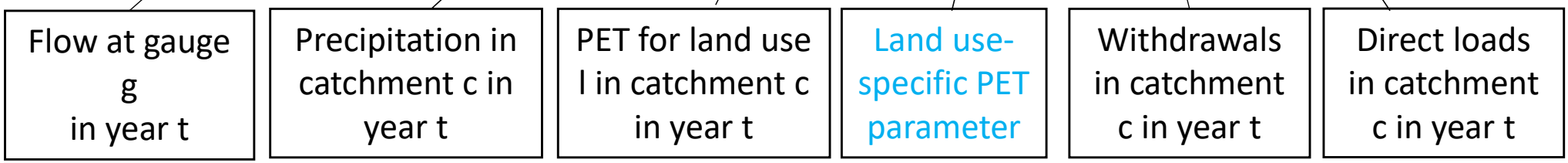
2. Testing different PET formulations in CalCAST

3. Downscaling MD water withdrawals to NHD catchments

Testing different meteorological datasets

The main equation that predicts total flow in CalCAST is a mass balance between precipitation and evapotranspiration at upstream NHD catchments

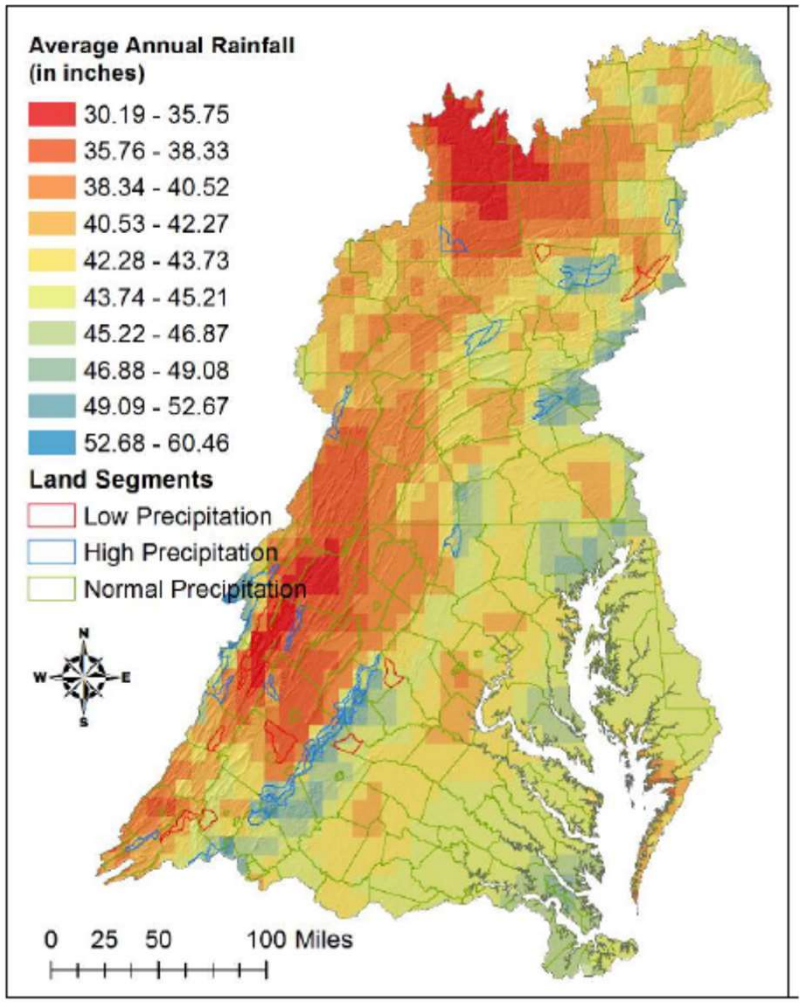
$$\sum_{t} Q_{g,t} = \sum_{t} \sum_{c} \left(P_{c,t} - \sum_{l} \left(PET_{l,c,t} \times LUP_{l} \right) - W_{c,t} + I_{c,t} \right)$$

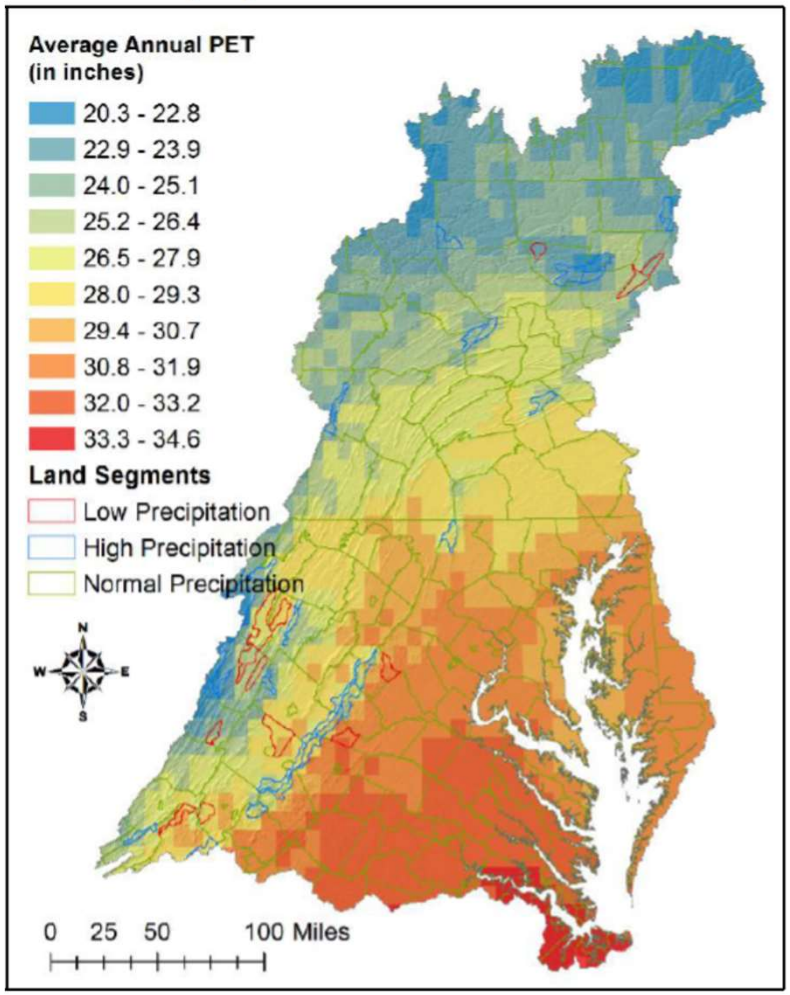


Testing different meteorological datasets

P6 and CalCAST so far:

- Precipitation: NLDAS[1] dataset aggregated at land-segment scale
- PET: Hamon[2] formulation based on NLDAS temperature and daylight hours





[1]NLDAS: North American Land Data Assimilation System (spatial resolution ~ 14x14 km)

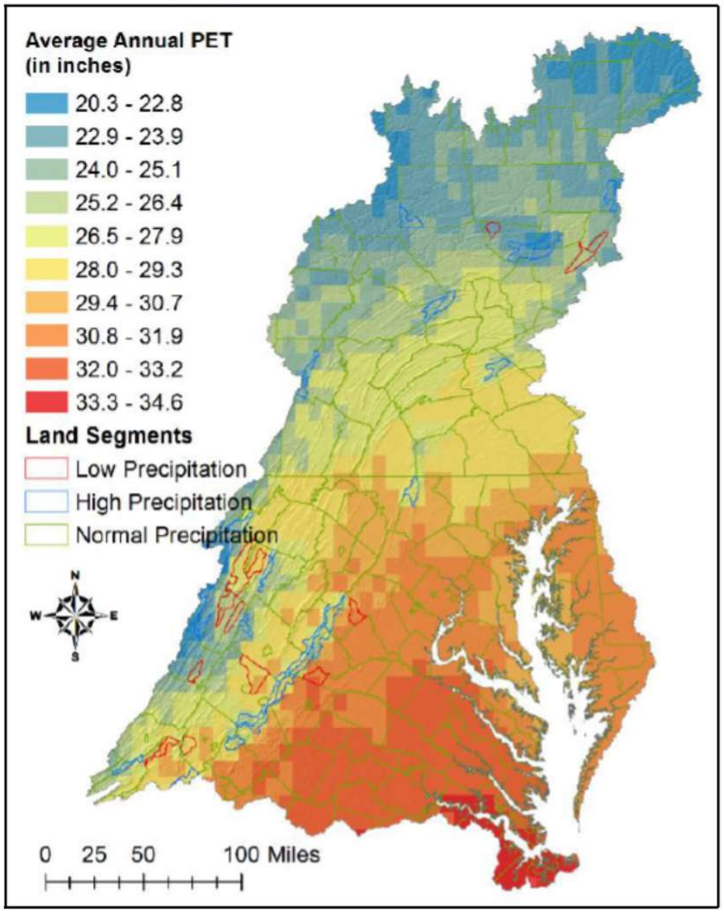
[2]Hamon, W.R., 1961. Estimating potential evaporation. Proceedings of the American Society of Civil Engineers

Testing different meteorological datasets

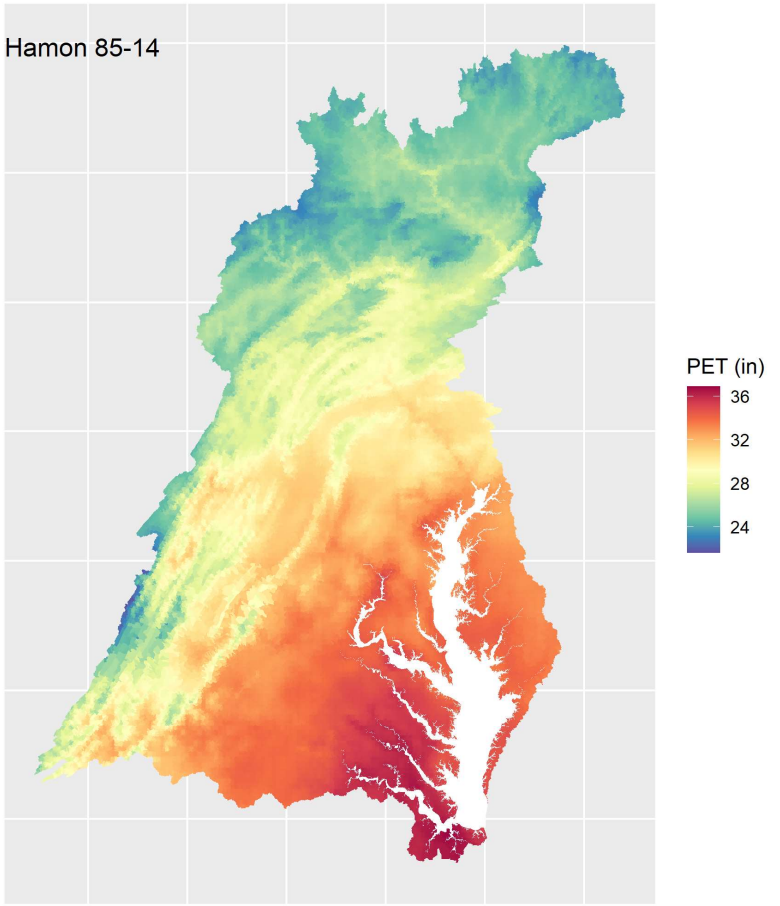
Does CalCAST model performance change when using metereological datasets with higher spatial resolution?

Replaced lang-segment NLDAS Hamon PET with PRISM[1] Hamon PET <u>downscaled to NHD catchments</u>

P6 (based on NLDAS)



Based on PRISM

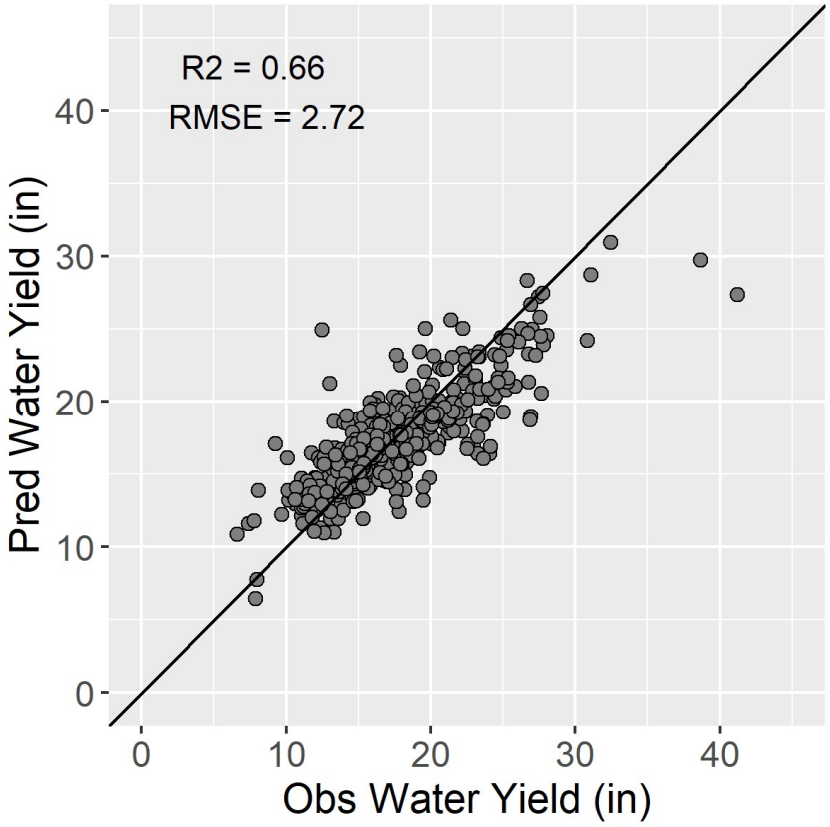


[1]PRISM: Parameter-elevation Regressions on Independent Slopes Model (spatial resolution ~ 4x4 km)

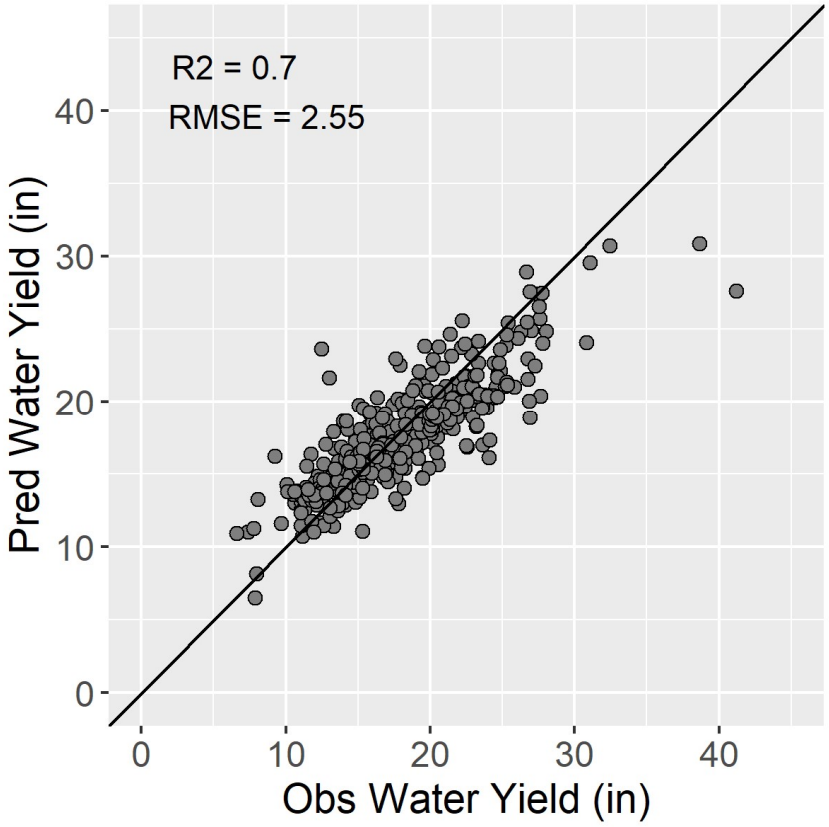
Testing different meteorological datasets

Average Annual Water Yield – Observed vs. Predicted

P6 Hamon PET (based on NLDAS)



Hamon PET based on PRISM

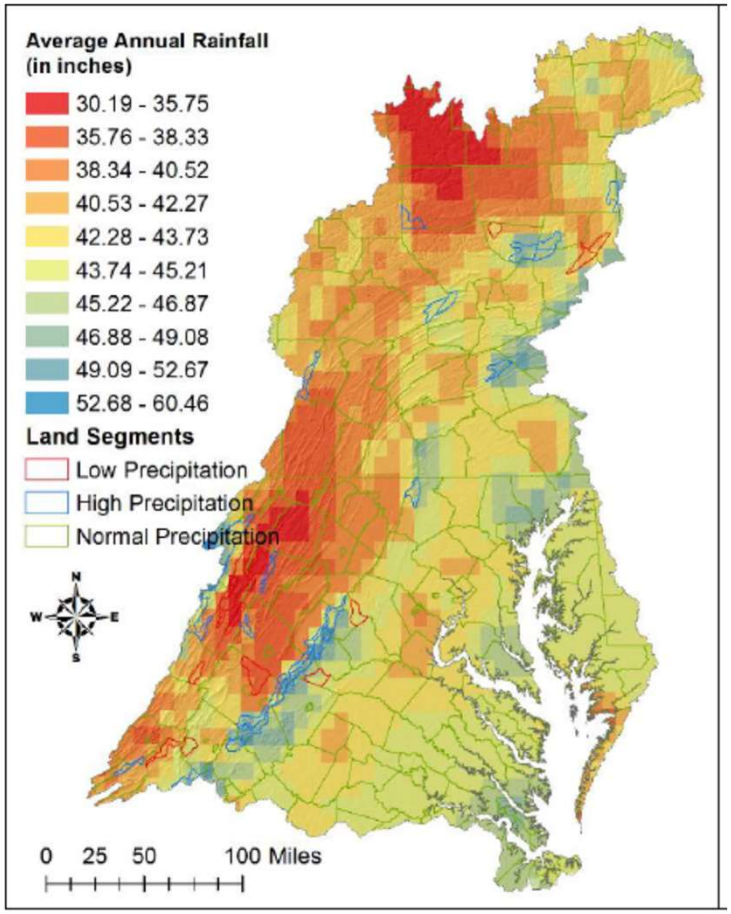


Testing different meteorological datasets

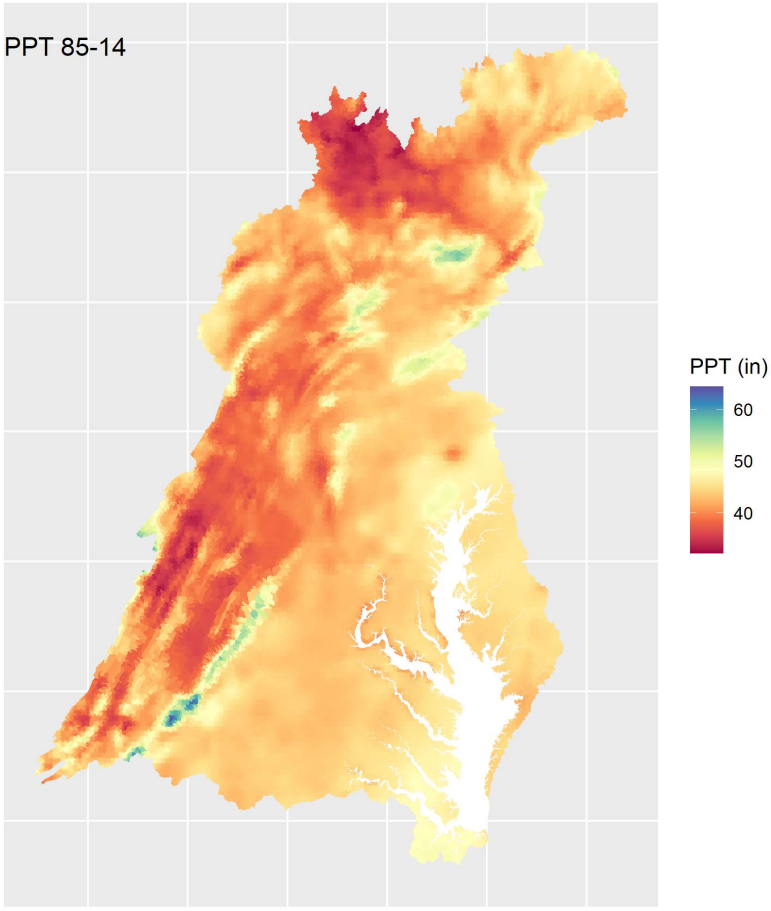
Does CalCAST model performance change when using metereological datasets with higher spatial resolution?

Replaced lang-segment NLDAS precipitation with PRISM[1] precipitation <u>downscaled to NHD catchments</u>

P6 (based on NLDAS)



Based on PRISM

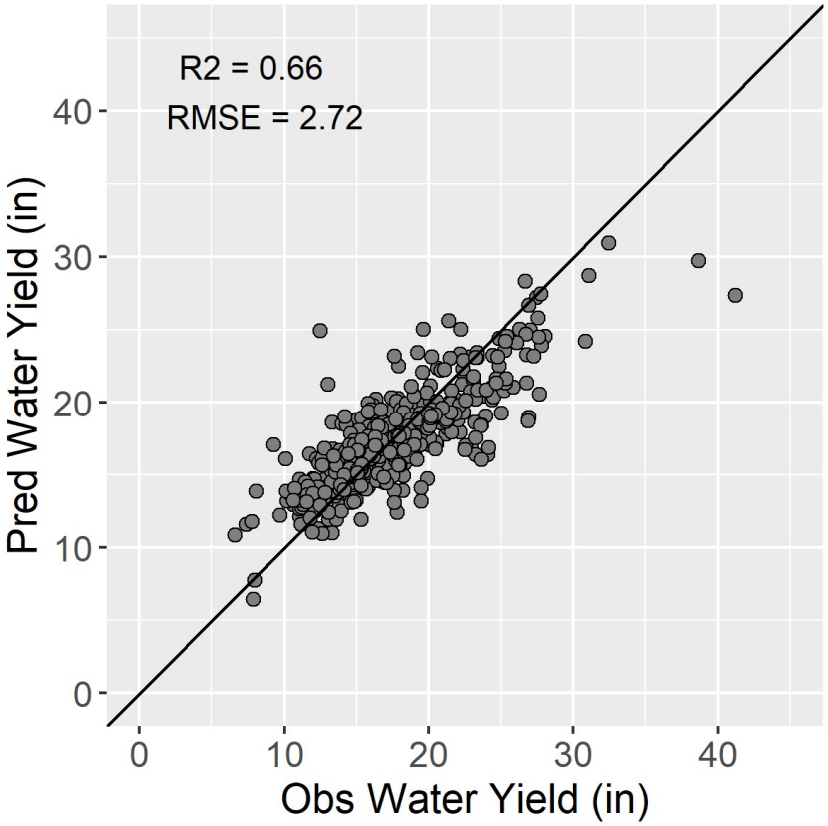


[1]PRISM: Parameter-elevation Regressions on Independent Slopes Model (spatial resolution ~ 4x4 km)

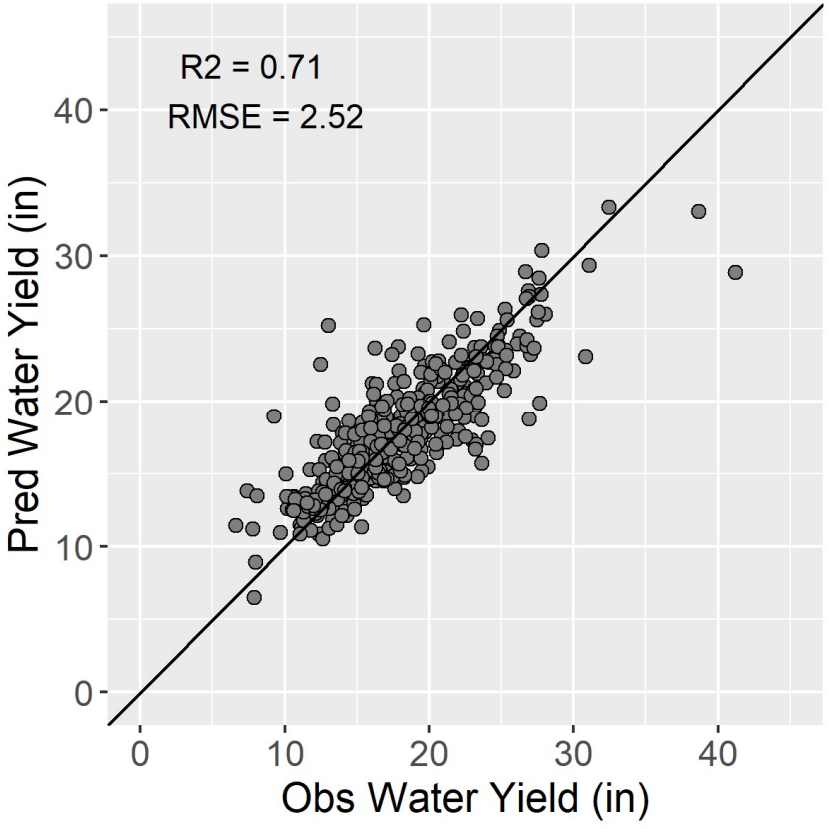
Testing different meteorological datasets

Average Annual Water Yield – Observed vs. Predicted

P6 PPT (based on NLDAS)



PRISM PPT



Testing different meteorological datasets

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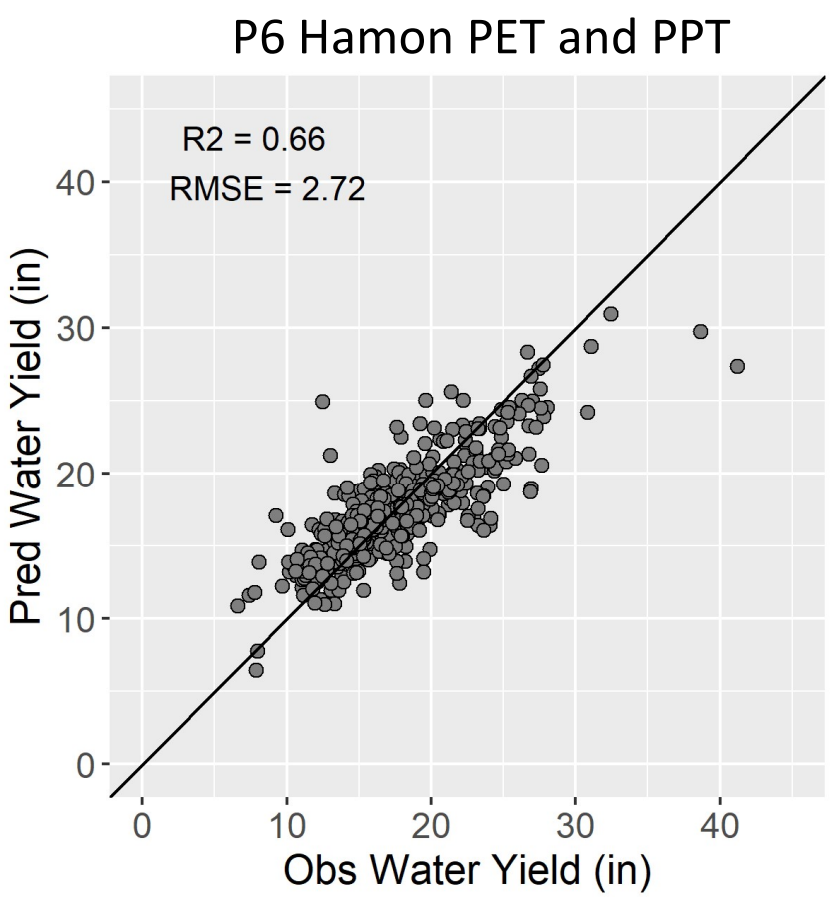

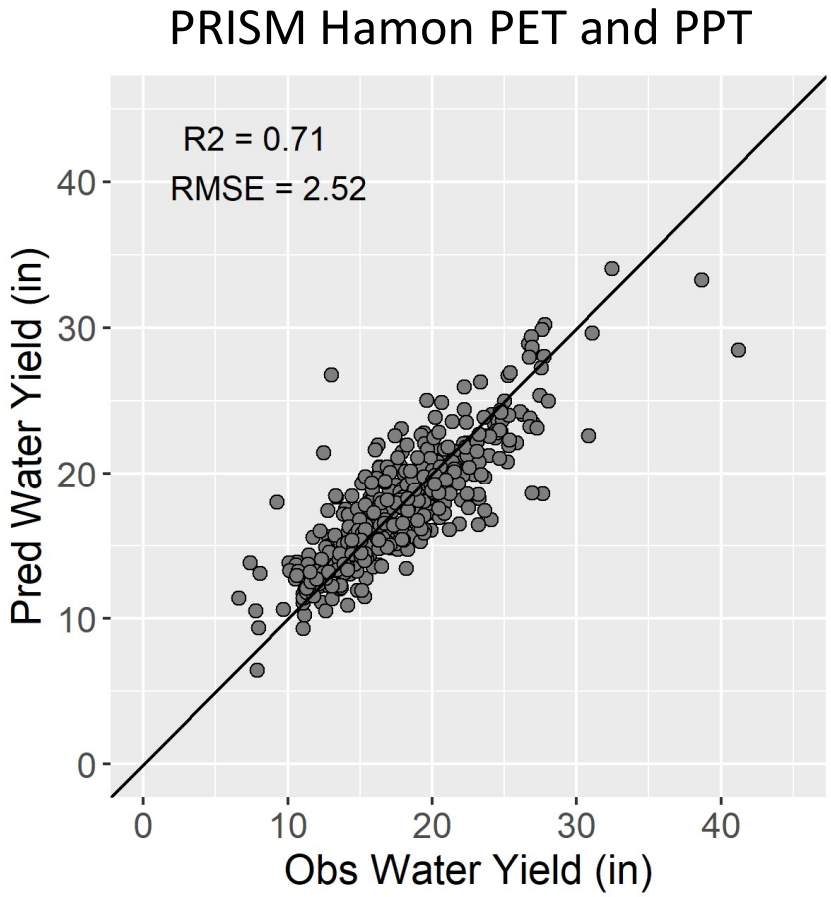

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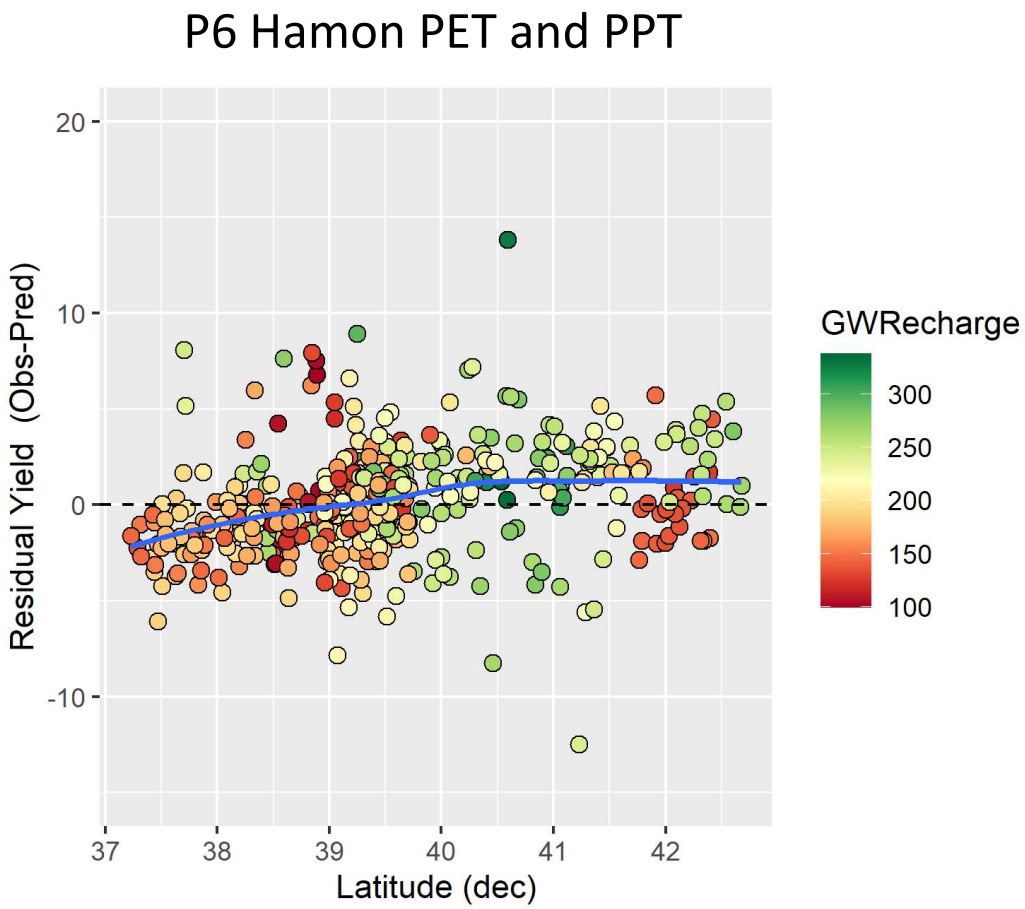

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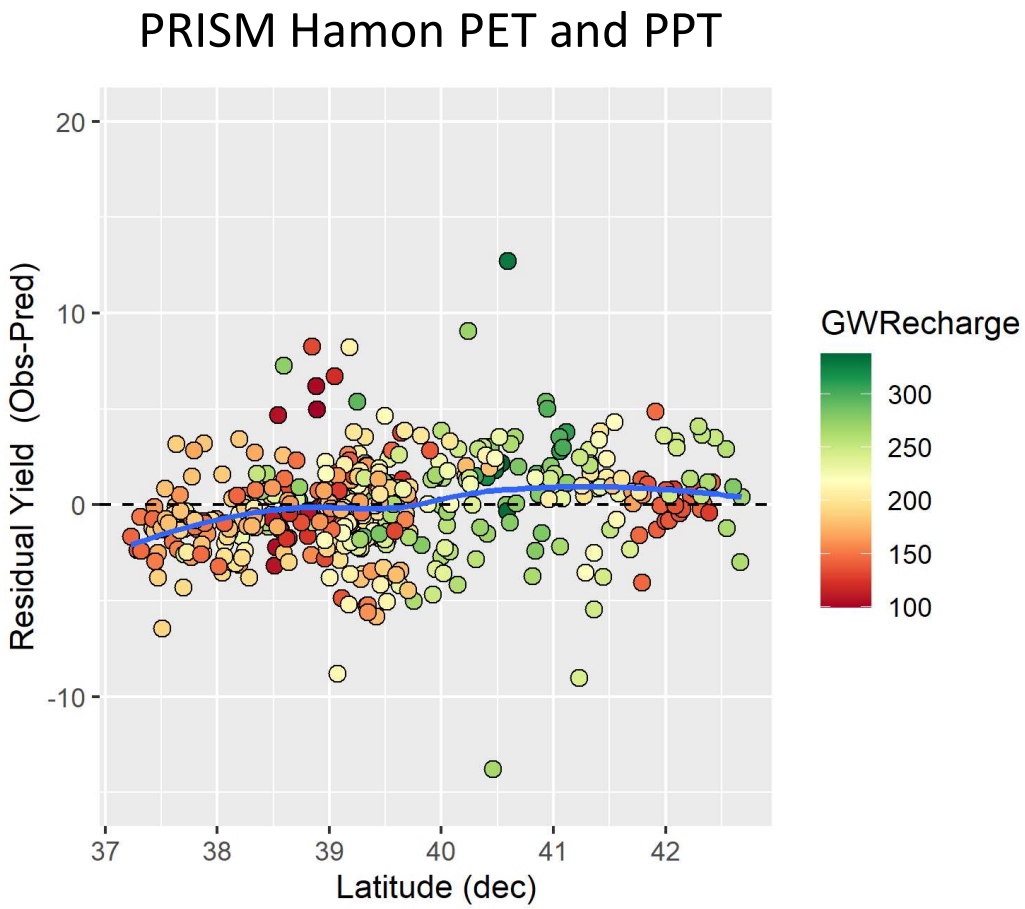

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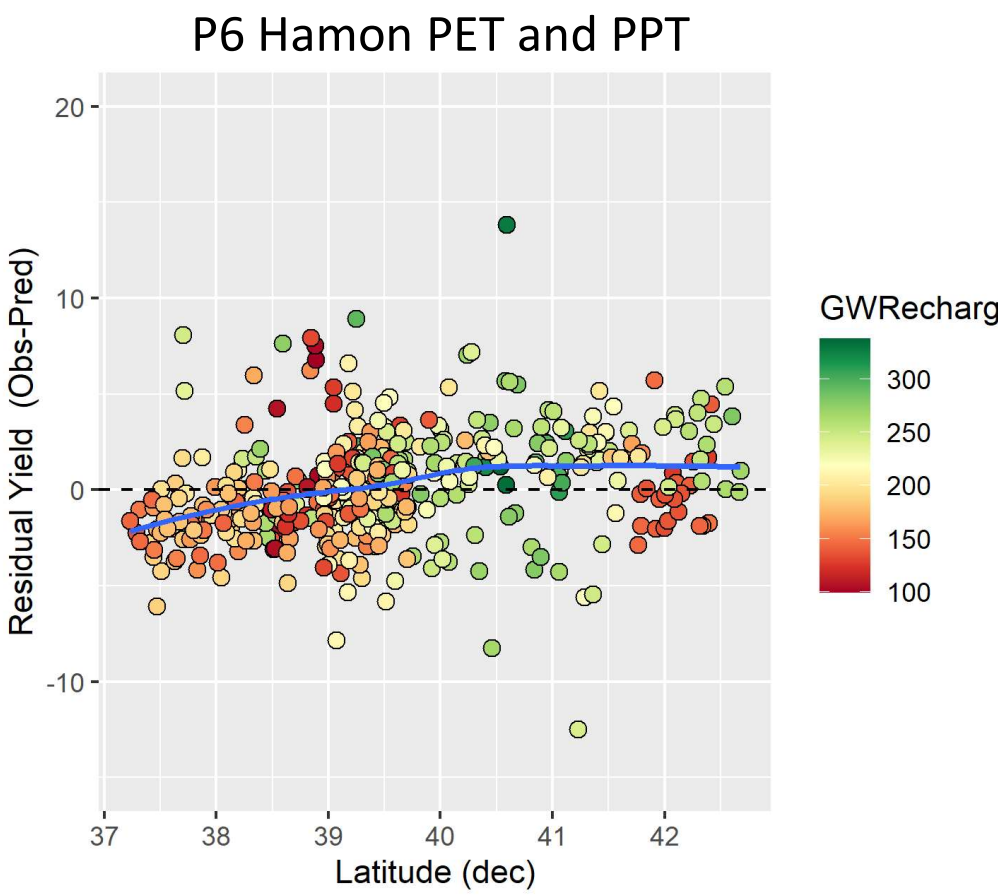
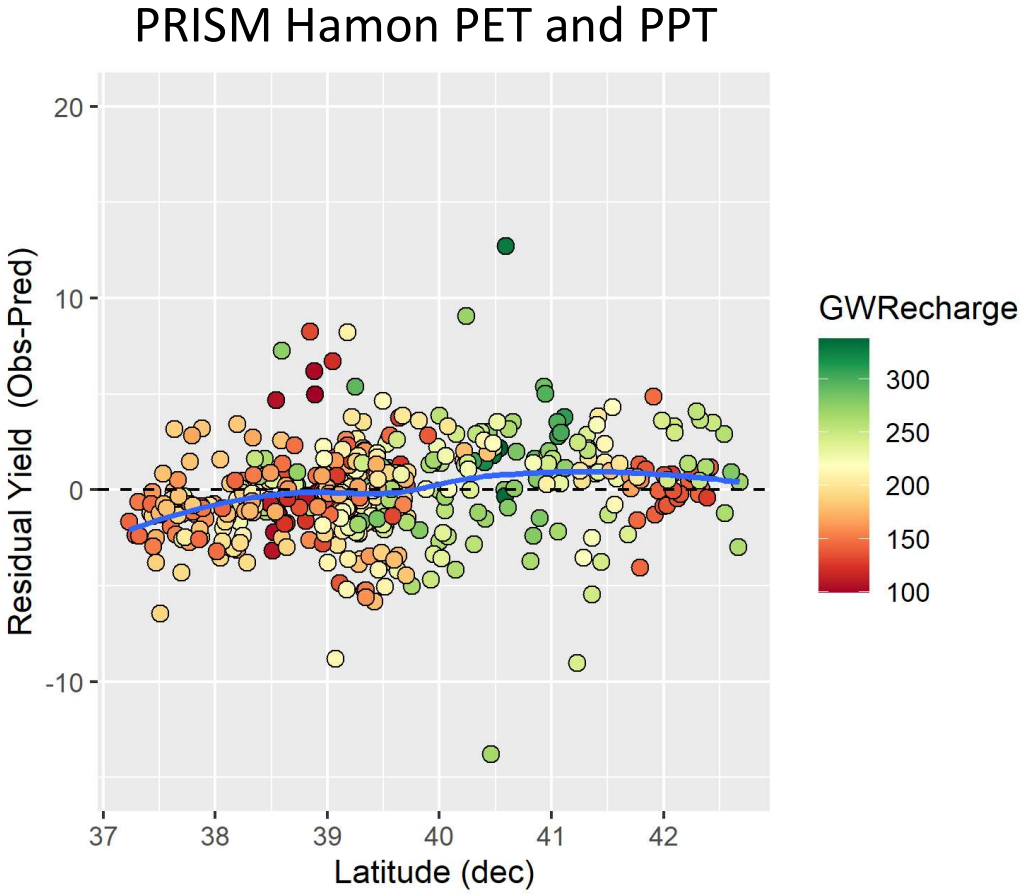




Today's updates

1. Testing different meteorological datasets in CalCAST

2. **Testing different PET formulations in CalCAST**

3. Downscaling MD water withdrawals to NHD catchments

Testing different PET formulations

In P6 and CalCAST we have used the Hamon formula to estimate PET so far

$$PET = 0.55 \times \left(\frac{DH}{12}\right)^2 \times \frac{\left(\frac{216.7 \times va_s * 10}{Tavg + 273.3}\right)}{100}$$

where:

$$Tavg = \left(\frac{Tmax + Tmin}{2}\right)$$

$$vs_{Tmax} = 0.6108 \times e^{\frac{17.27 \times Tmax}{Tmax + 237.3}}$$

$$vs_{Tmin} = 0.6108 \times e^{\frac{17.27 \times Tmin}{Tmin + 237.3}}$$

$$va_s = \frac{vs_{Tmax} + vs_{Tmin}}{2}$$

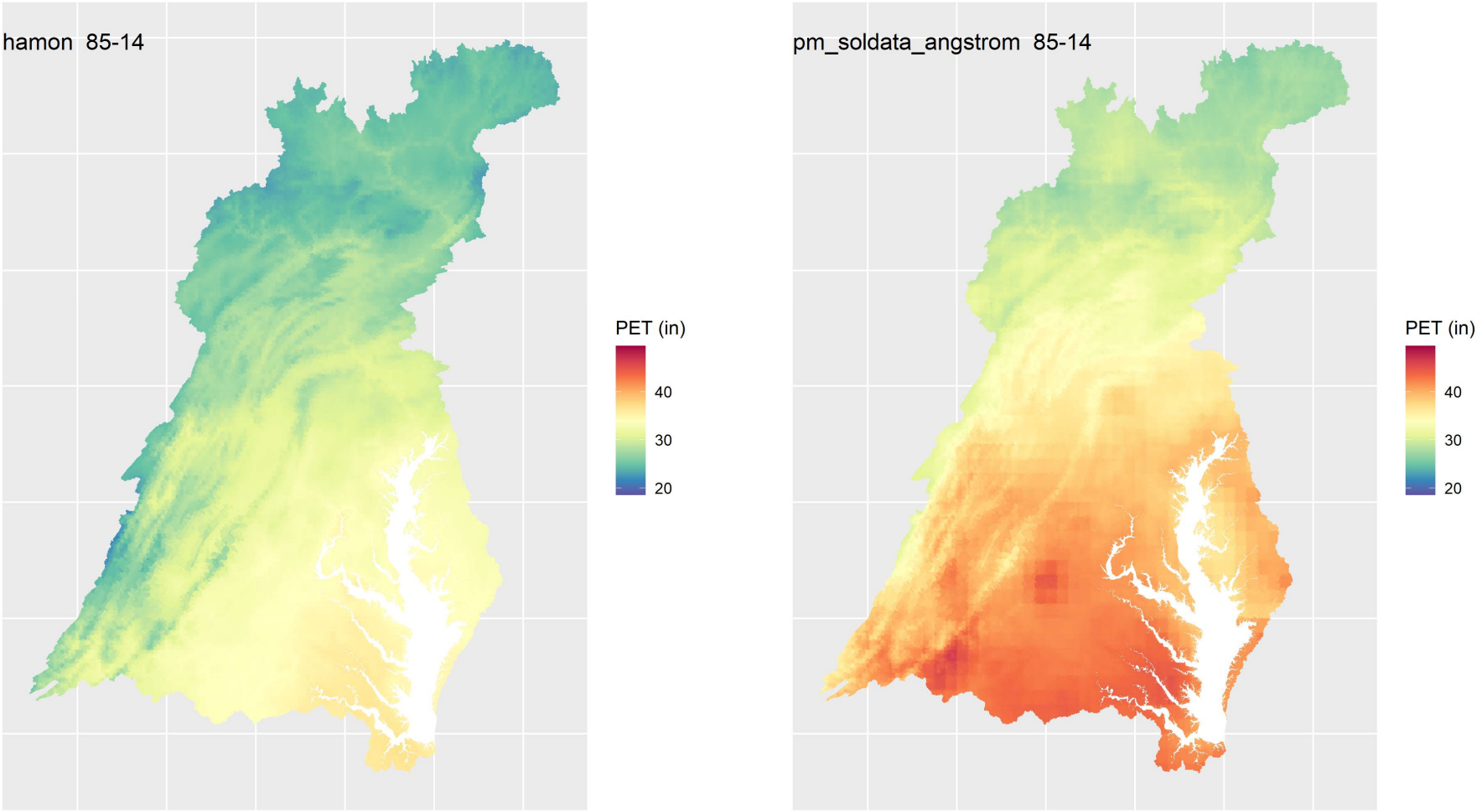
Tmax, Tmin: PRISM daily temperature downscaled to NHDPlus catchments

DH: daily number of sunshine hours (number of hours where NLDAS solar radiation is > 0)

Testing different PET formulations

Does CalCAST model performance change when using different PET formulations?

Replaced PRISM-based Hamon PET with **Penman-Monteith PET**

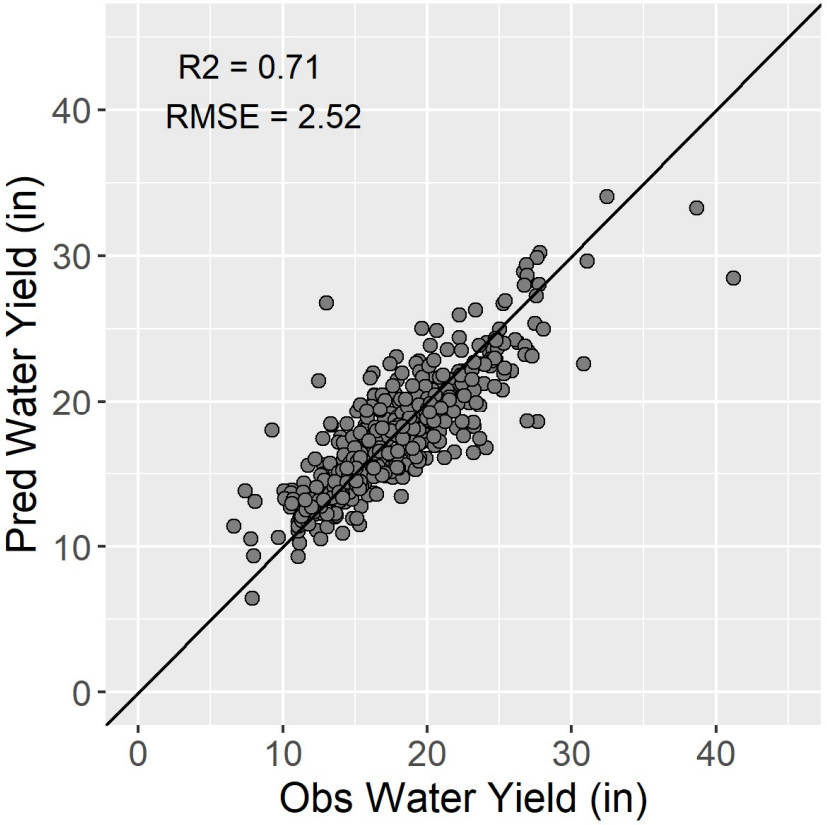


Penman-Monteith = f(Temperature, Wind Speed, Relative Humidity, Altitude, Latitude, Solar Radiation, day of year)

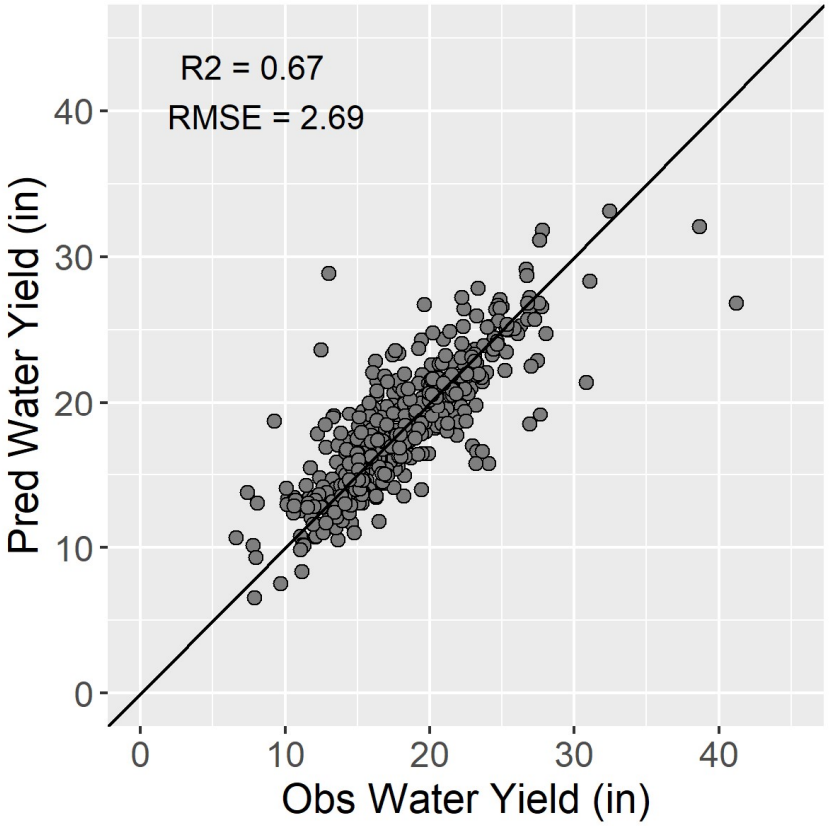
Testing different PET formulations

Average Annual Water Yield – Observed vs. Predicted

PRISM PPT and PRISM Hamon PET



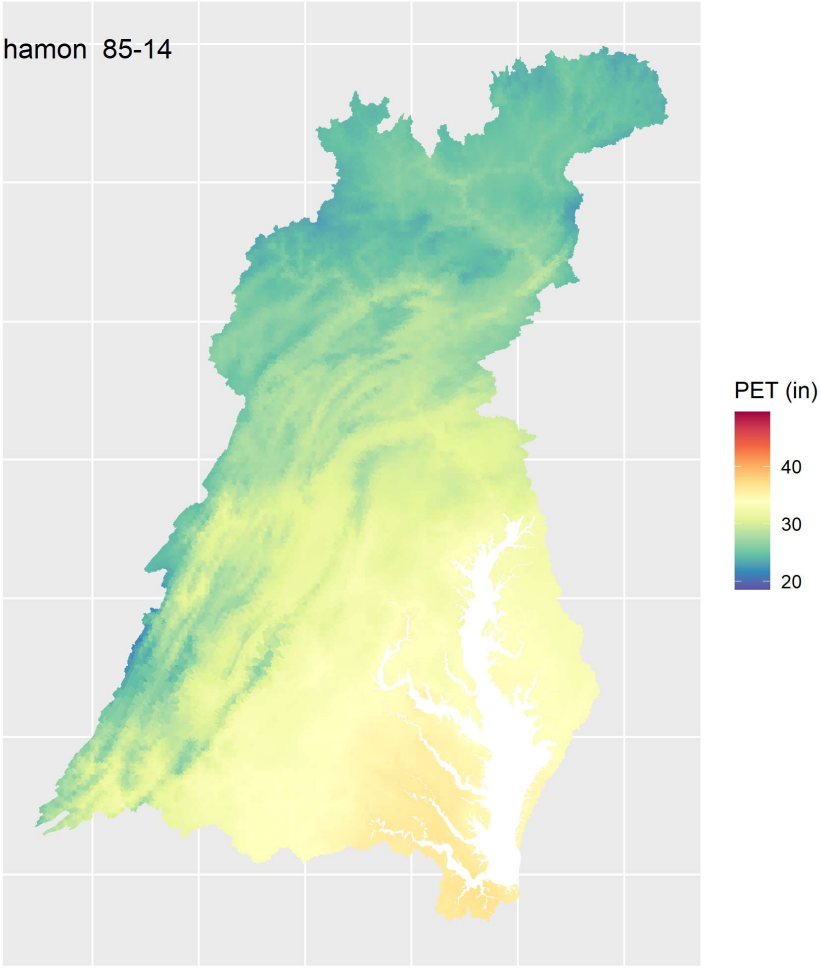
PRISM PPT and PRISM Penman-Monteith PET

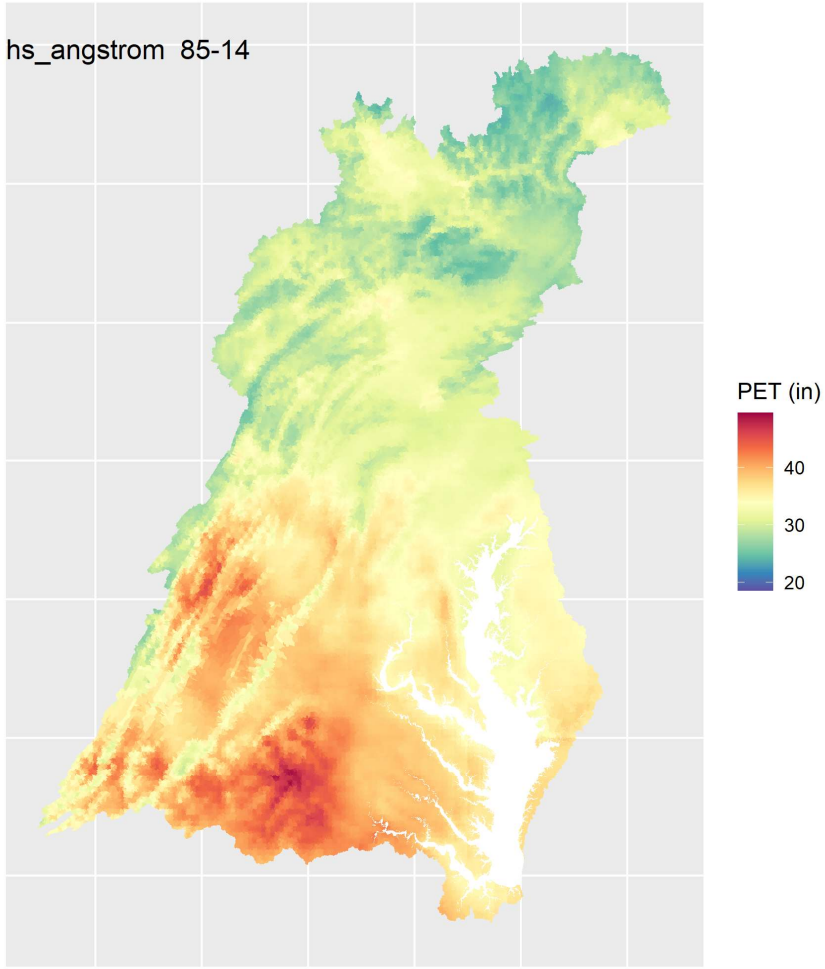


Testing different PET formulations

Does CalCAST model performance change when using different PET formulations?

Replaced PRISM-based Hamon PET with **Hargreaves-Samani PET**



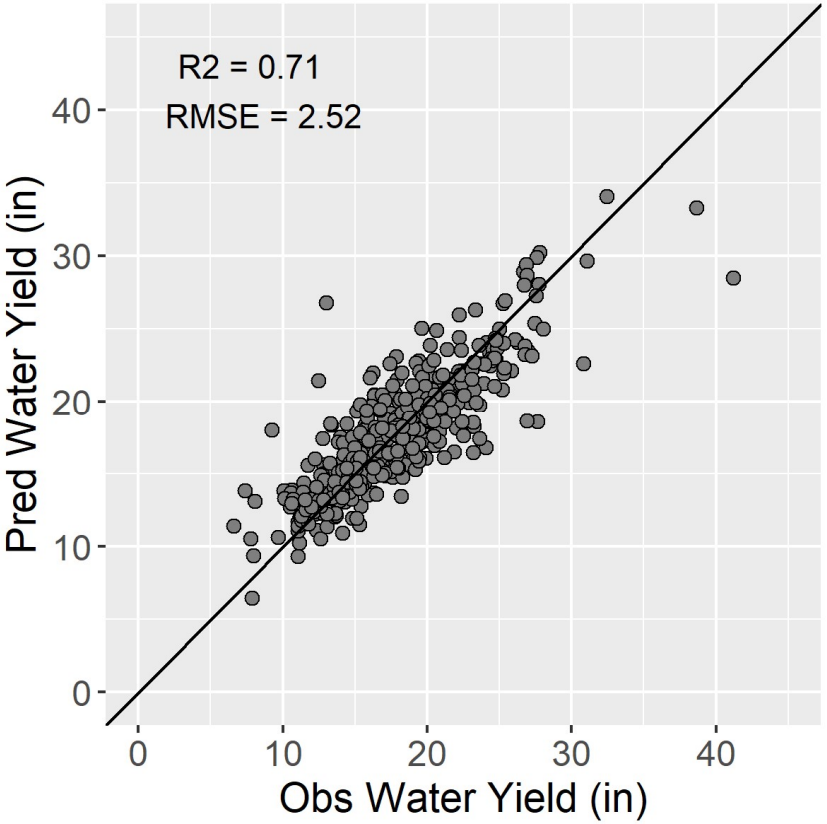


Hargreaves-Samani = f(Temperature, Latitude, Solar Radiation, day of year)

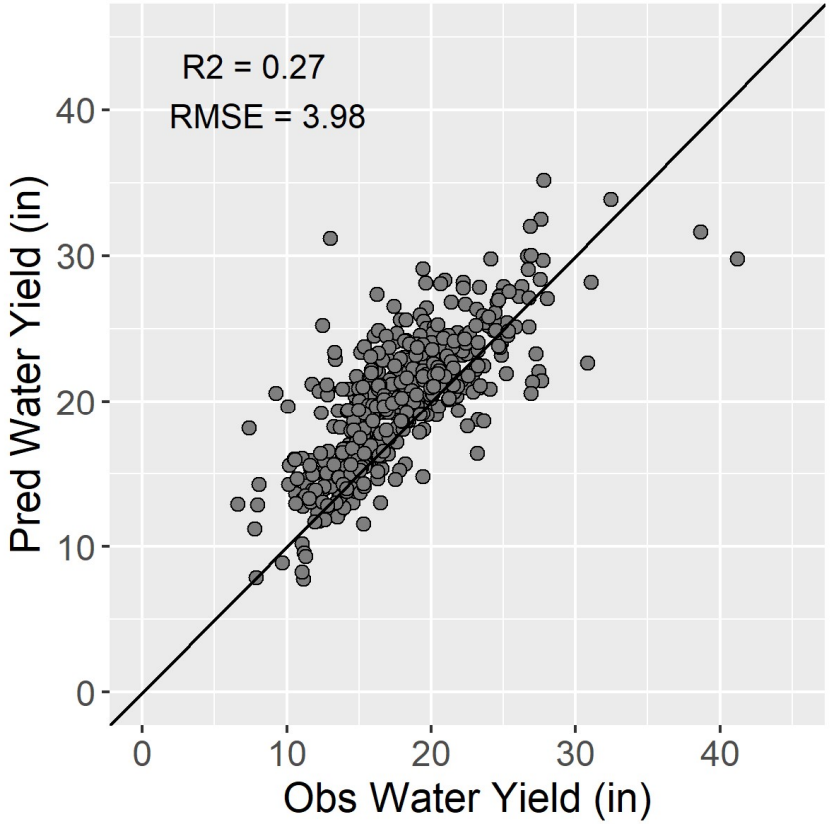
Testing different PET formulations

Average Annual Water Yield – Observed vs. Predicted

PRISM PPT and PRISM Hamon PET



PRISM PPT and PRISM Hargreaves-Samani PET



Constraint on PET parameters to avoid negative flow:

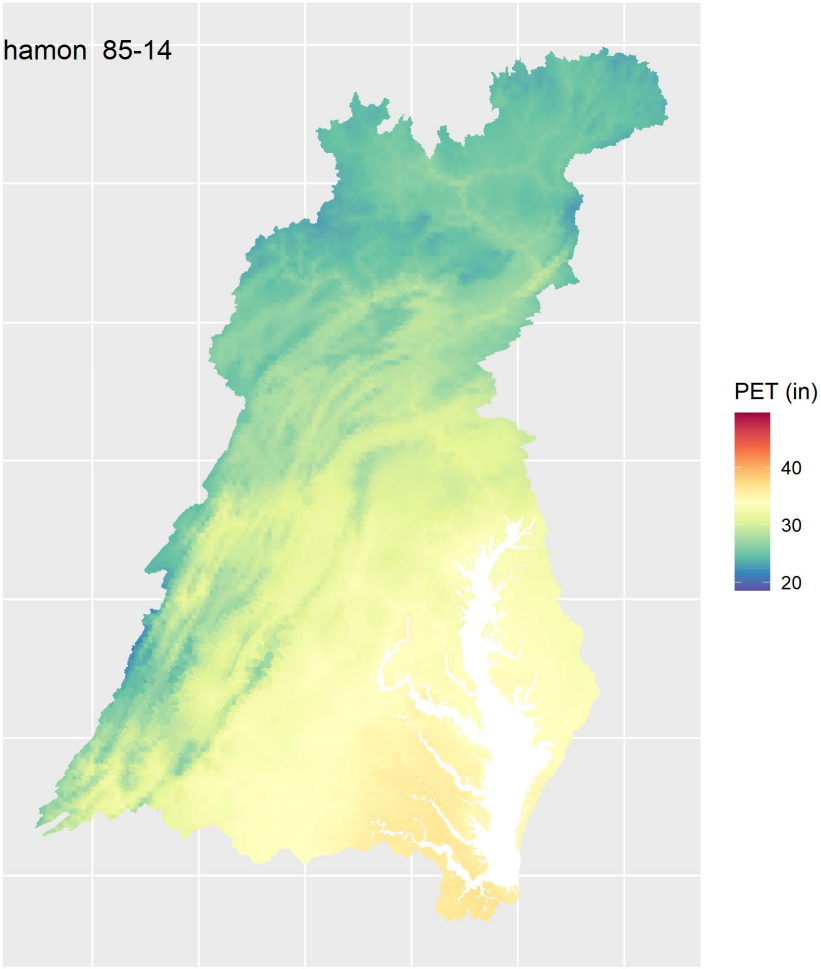
$pcp_c - pet_c * beta_{lu} > 0$

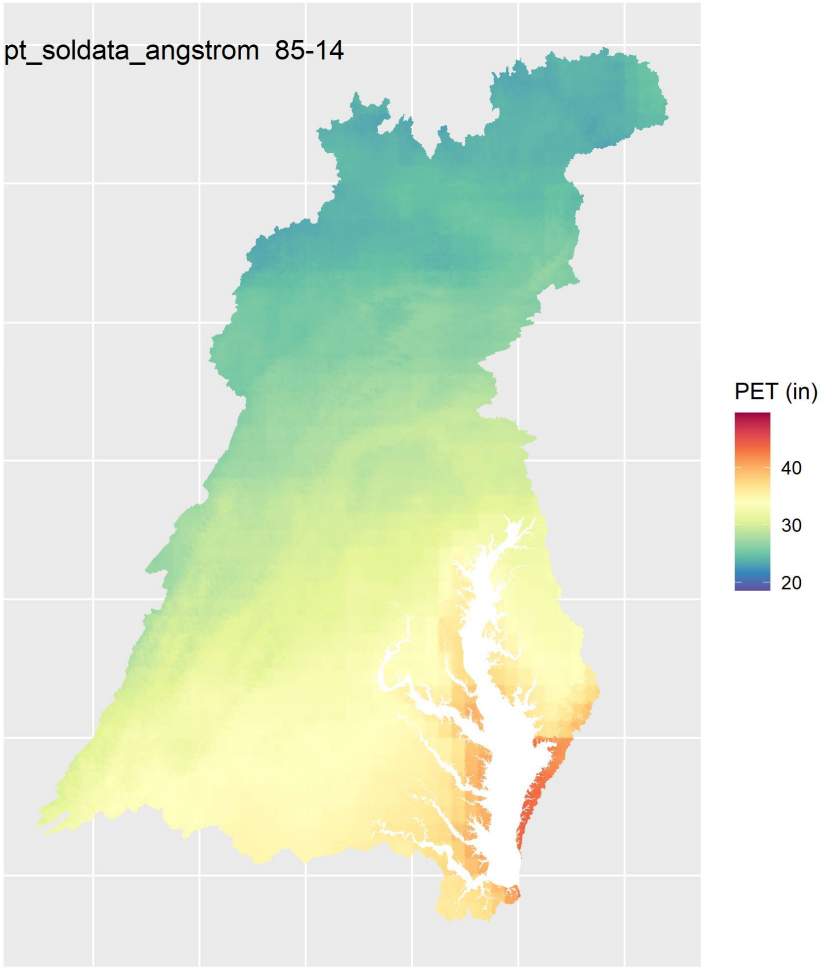
$beta_{lu} < \min(pcp_c / pet_c)$

Testing different PET formulations

Does CalCAST model performance change when using different PET formulations?

Replaced PRISM-based Hamon PET with **Priestley-Taylor PET**



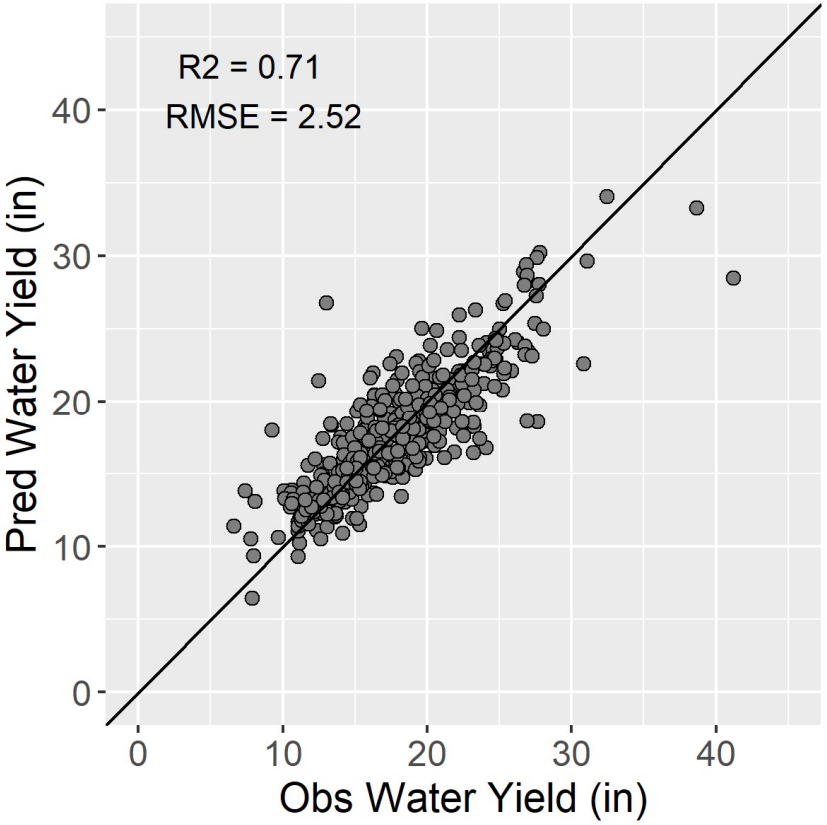


Priestley-Taylor = f(Temperature, Relative Humidity, Altitude, Latitude, Solar Radiation, day of year)

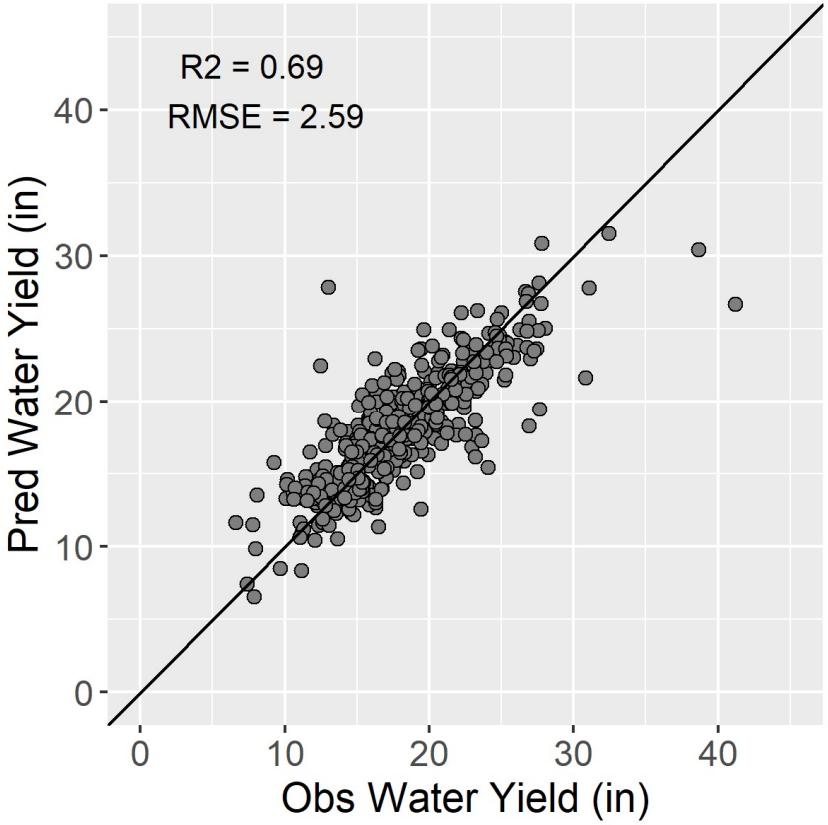
Testing different PET formulations

Average Annual Water Yield – Observed vs. Predicted

PRISM PPT and PRISM Hamon PET



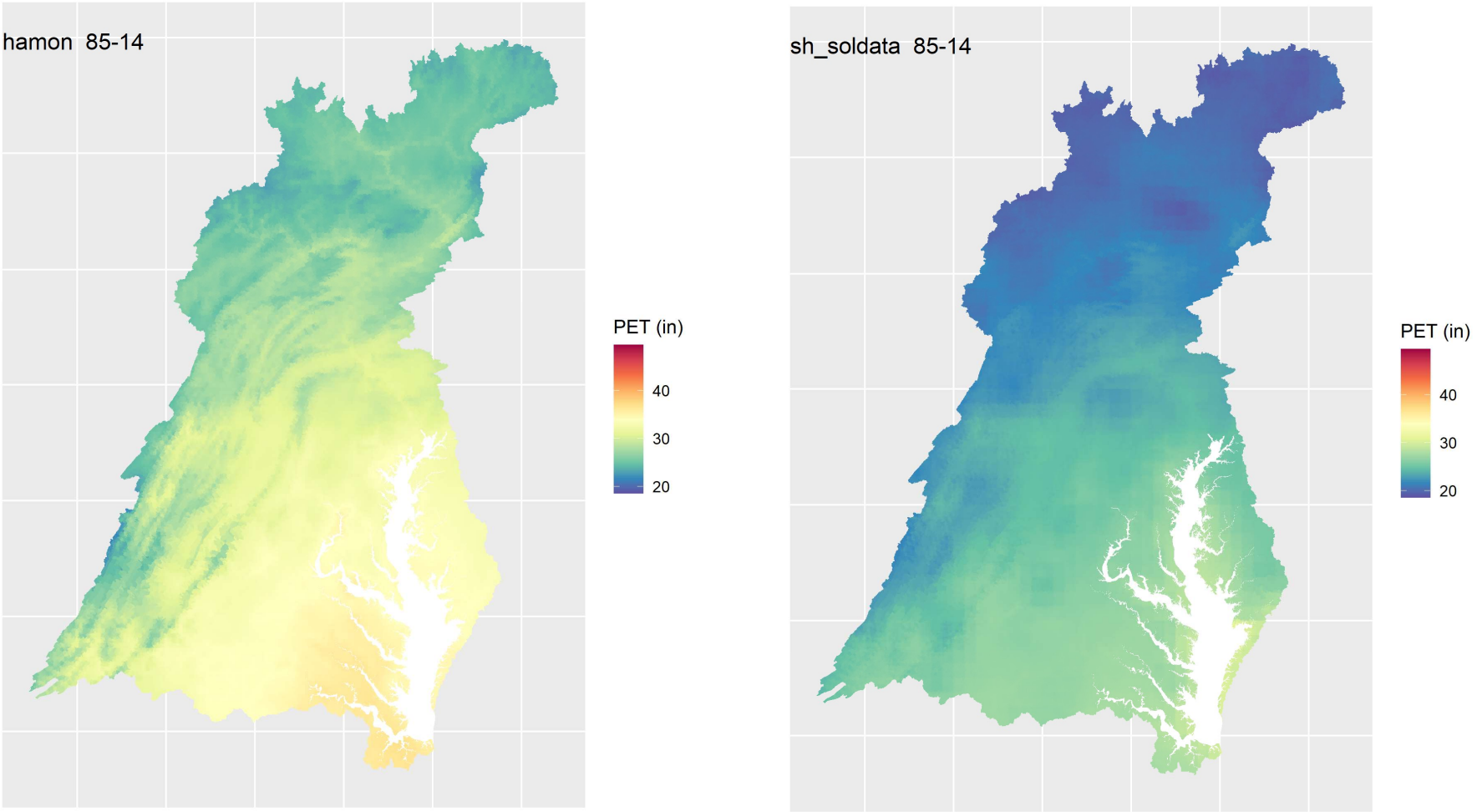
PRISM PPT and PRISM Priestley-Taylor PET



Testing different PET formulations

Does CalCAST model performance change when using different PET formulations?

Replaced PRISM-based Hamon PET with **Matt-Shuttleworth PET**

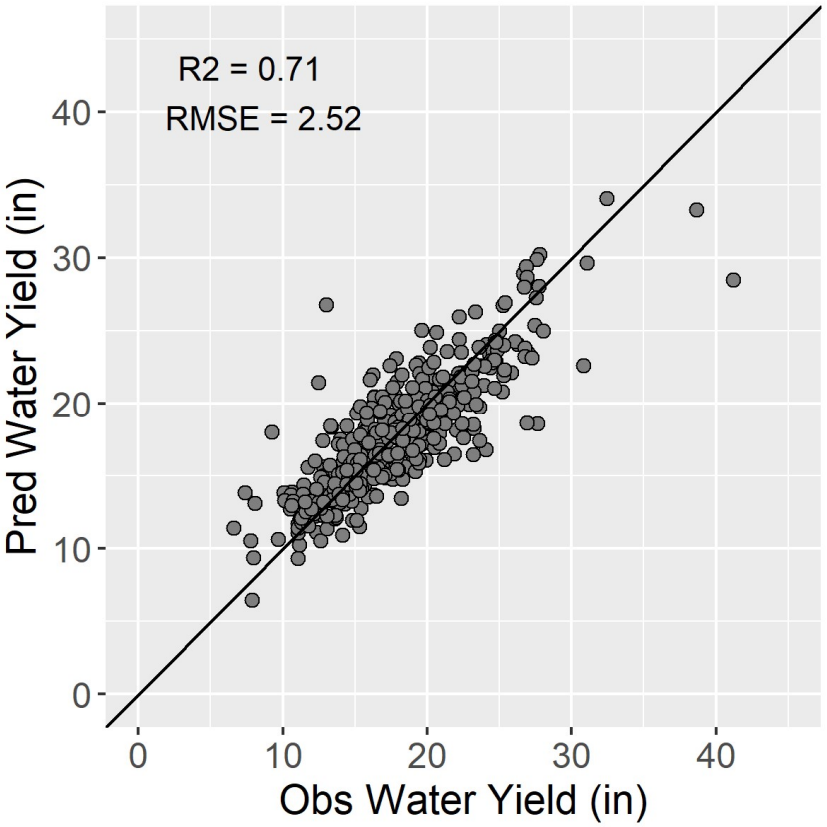


Matt-Shuttleworth = f(Temperature, Relative Humidity, Altitude, Latitude, Solar Radiation, day of year)

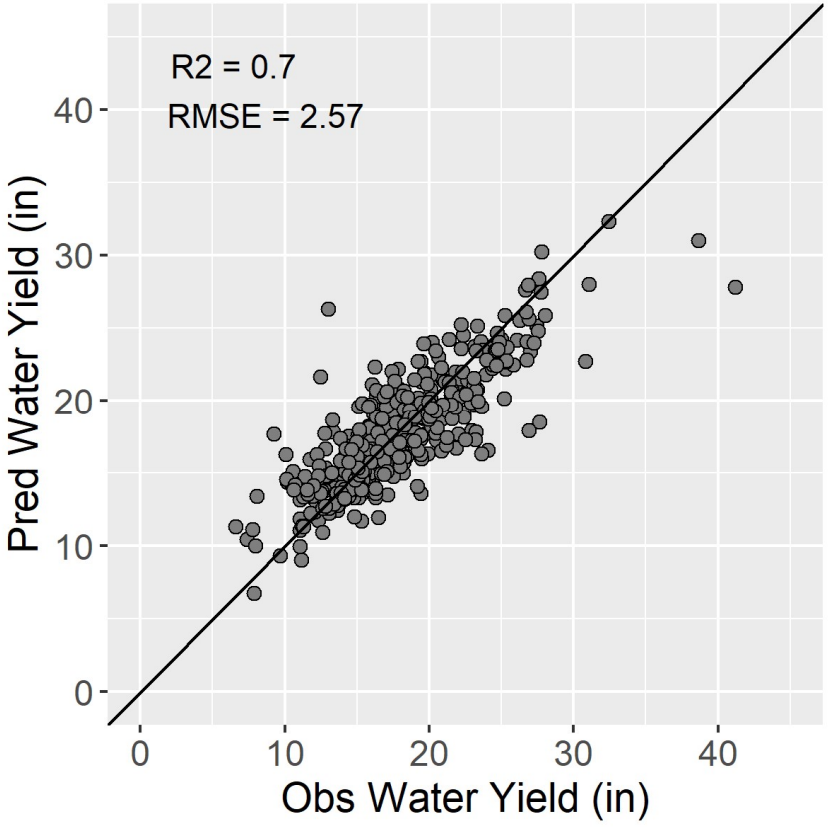
Testing different PET formulations

Average Annual Water Yield – Observed vs. Predicted

PRISM PPT and PRISM Hamon PET



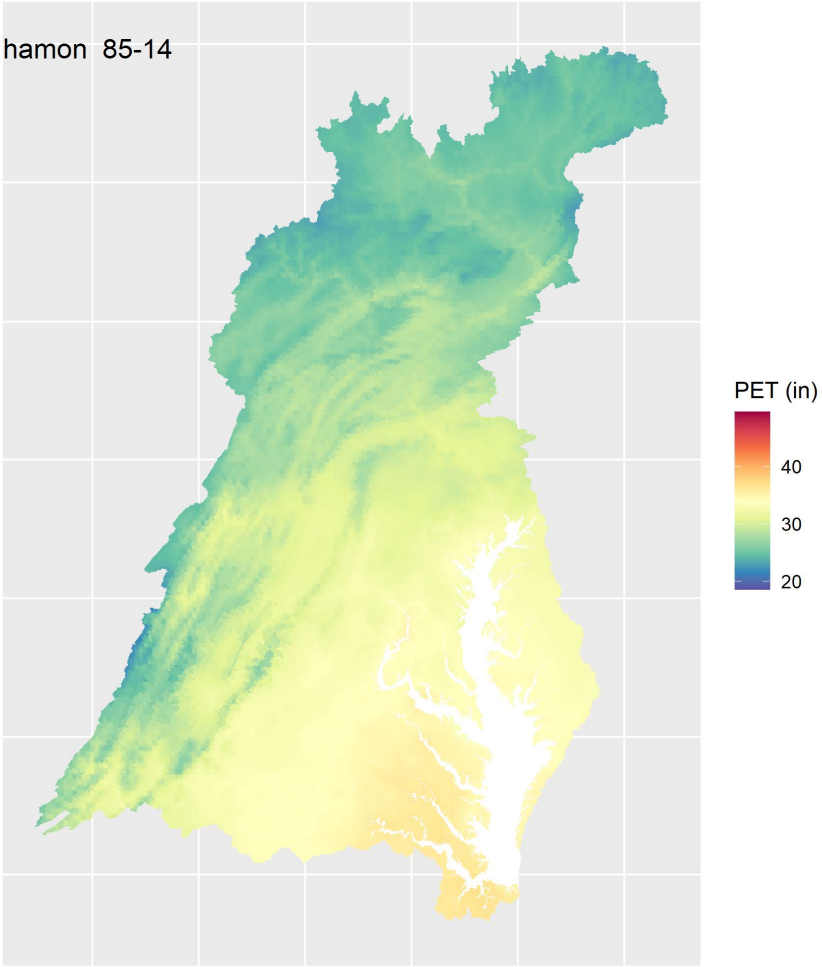
PRISM PPT and PRISM Matt-Shuttleworth PET

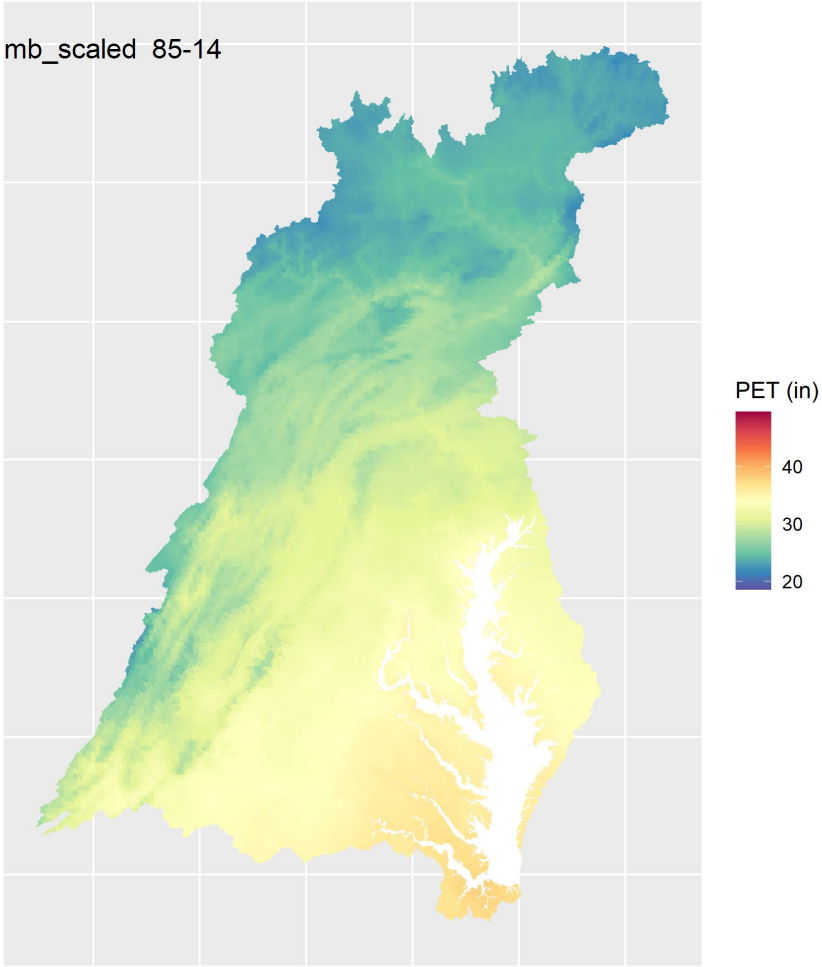


Testing different PET formulations

Does CalCAST model performance change when using different PET formulations?

Replaced PRISM-based Hamon PET with **McGuinness-Bordne PET scaled to Hamon**





McGuinness-Bordne = f(Temperature, Latitude, Solar Radiation, day of year)

Testing different PET formulations

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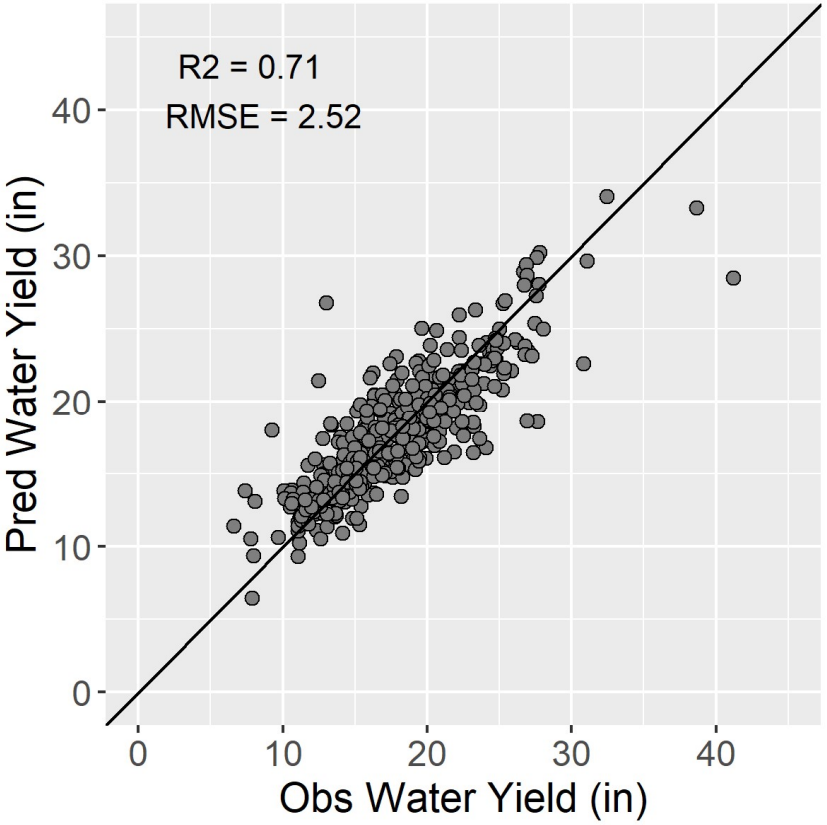
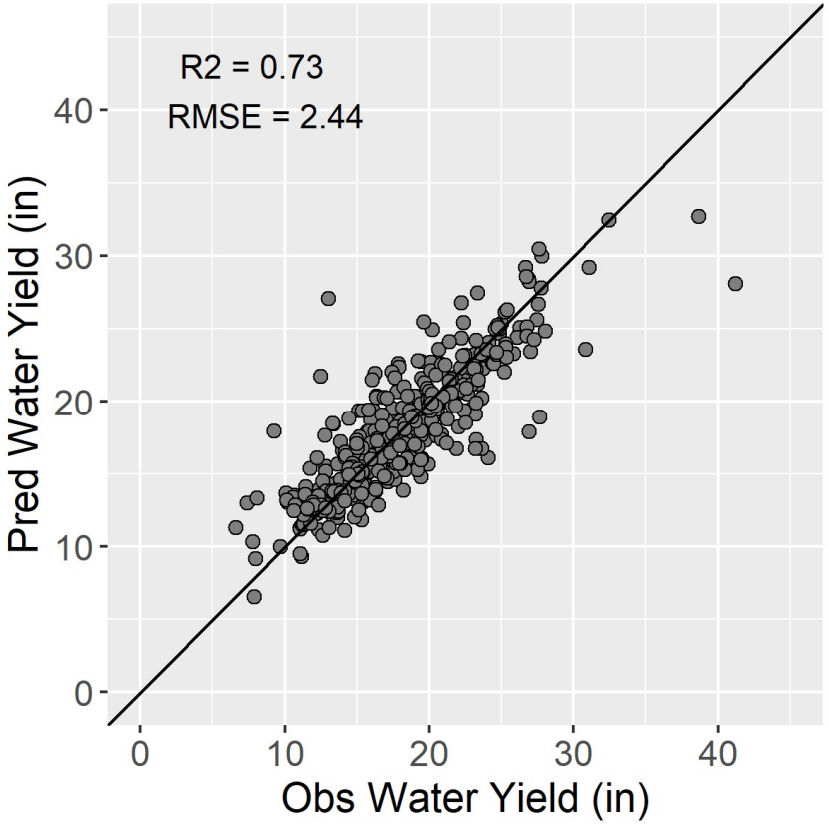


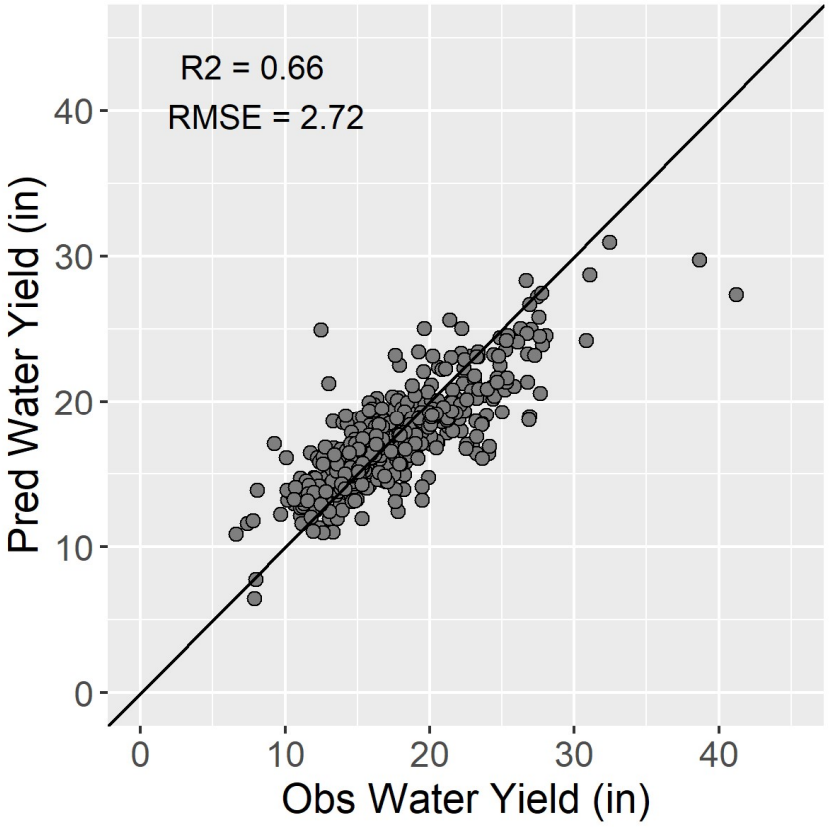
PRISM PPT and PRISM McGuinness-Bordne PET



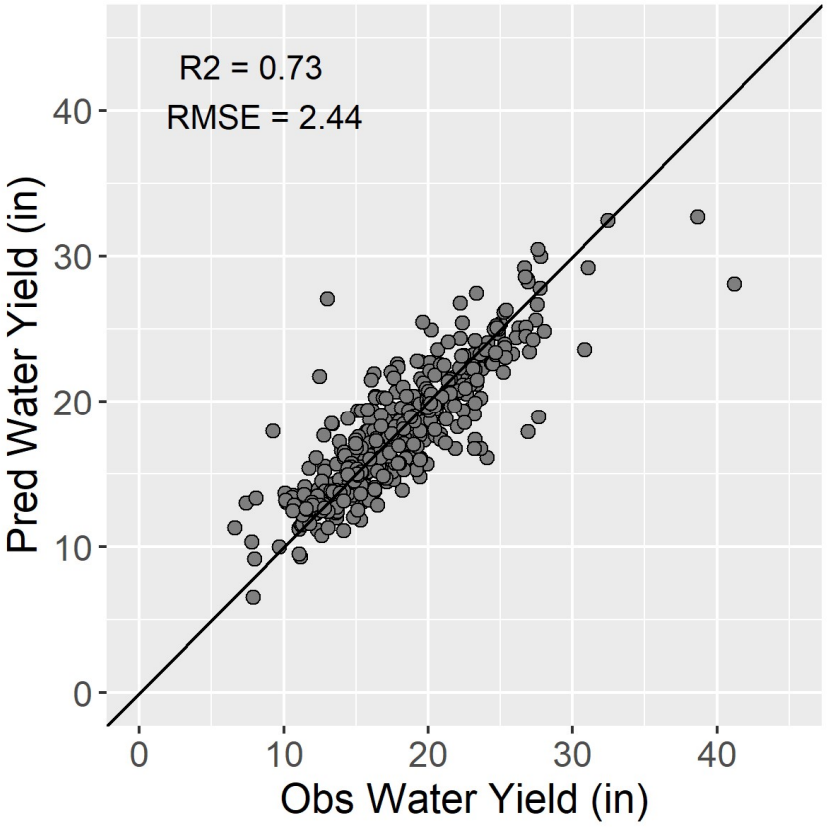
Overall improvement so far (preliminary)

Average Annual Water Yield – Observed vs. Predicted

P6 NLDAS PPT and Hamon PET



PRISM PPT and McGuinness-Bordne PET



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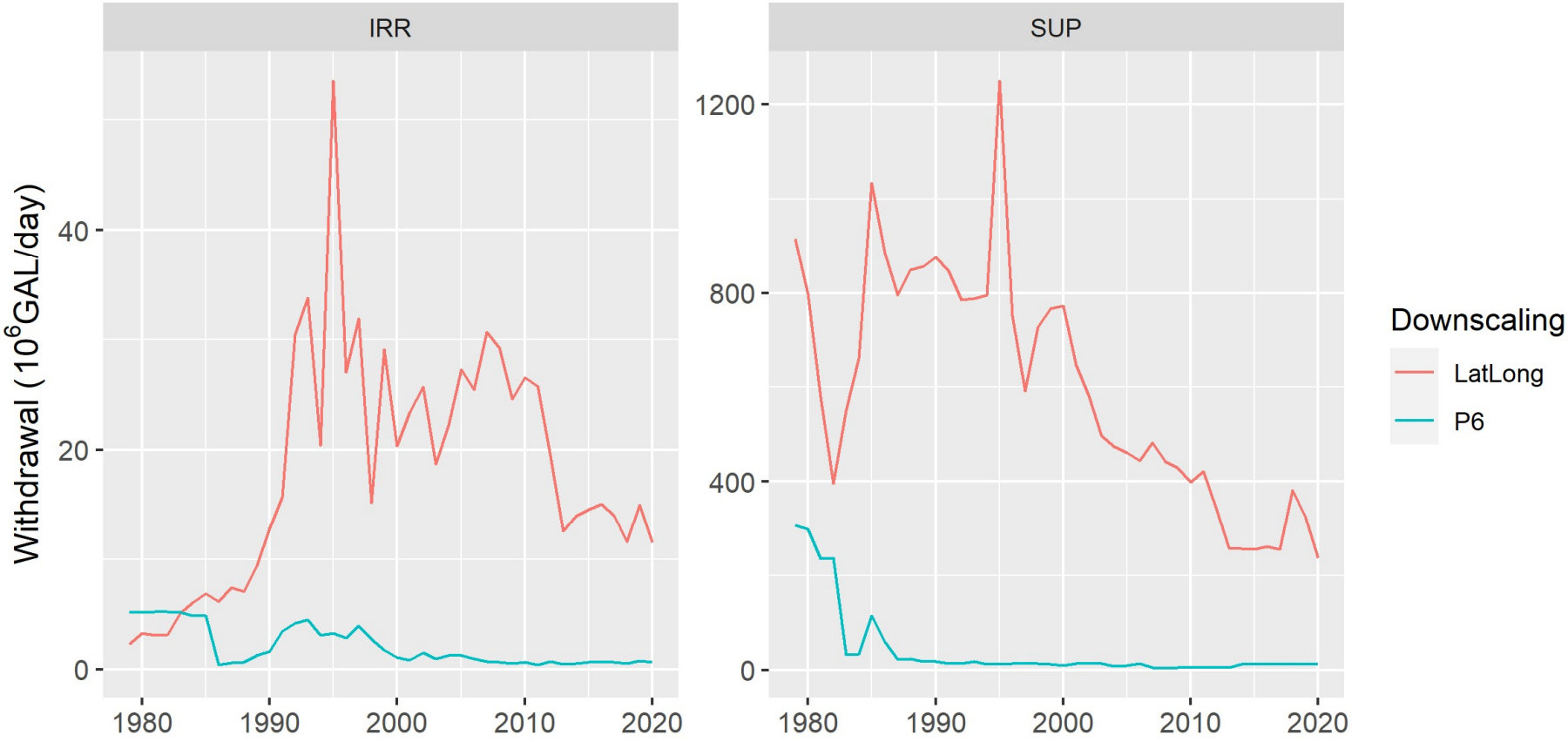
2. Testing different PET formulations in CalCAST

3. **Downscaling MD water withdrawals to NHD catchments**

Update on downscaling water withdrawals - MD

- MD water withdrawals available at county scale
- P6 approach: downscale county-level Irrigation and Public Supply withdrawals to river segments based on fraction of Ag and Urban land use in each river segment within a county
- Although the MD withdrawal dataset does not have Lat/Long information, it does have either an address or an approximate location for most withdrawals
- Performed geocoding (convert address to Lat/Long) on MD withdrawals with address information using R package
- Used P6 downscaling approach on withdrawals with no location information

Update on downscaling water withdrawals - MD

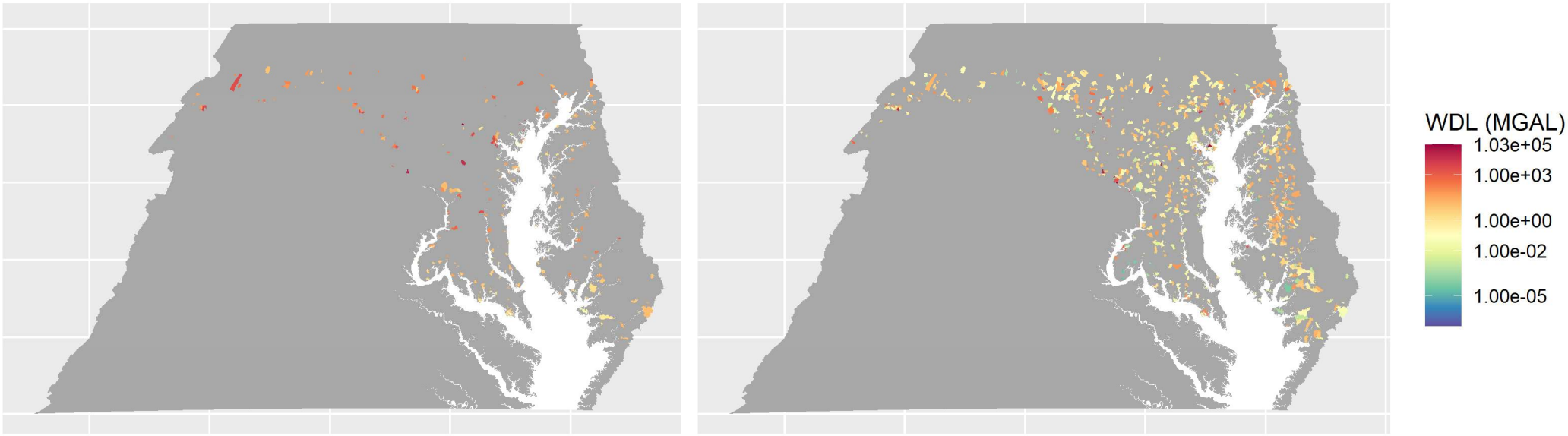


Note different y axis scale

Update on downscaling water withdrawals - MD

Old withdrawal locations

New withdrawal locations



Next steps

- Continue exploring PET formulations (including considerations for climate change applications)
- Use CalCAST to test predictors that can help explain spatial variability in flow and load observations and develop parameters for CAST/DM
- Continue updating/improving P6 datasets (e.g., cso, withdrawals, point sources)