WaSSI MACA Modeling Updates

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Hypotheses

- A warming climate and increased precipitation in the south will ***increase*** southern forest ecosystem productivity.
- A warming climate will ***decrease*** water yield from forests and aggravate water supply stress for people.
- CO_2 fertilization alone will increase GPP, but NOT ET or water yield.
- Tradeoffs (carbon gain and water loss) will ***increase*** under future climate change and forest management that maximizes productivity and water use efficiency.

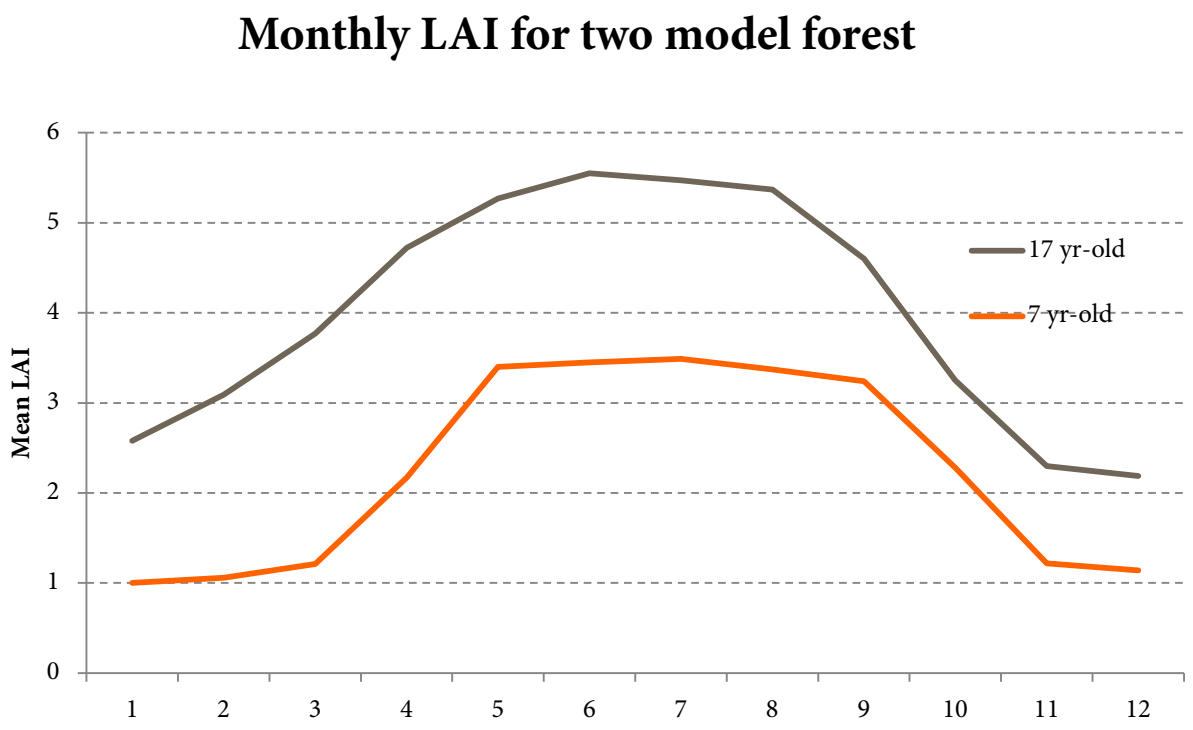
Modeling Schemes

- Model Forests: Two ages
  - 17 yrs old; WUE= 2.54 g C/m2/kg H2O mean LAI=4.0
  - 7 yrs old WUE =1.9 g C/m2/kg H2O; LAI = 2.3
- CO2 Scenarios
  - CO2 fertilization will not affect ET, but will increase 30% GPP based on Duke FACE data
- Climate change: for 20 MACA GCMs and two different scenarios (RCP4.5 and RCP8.5)

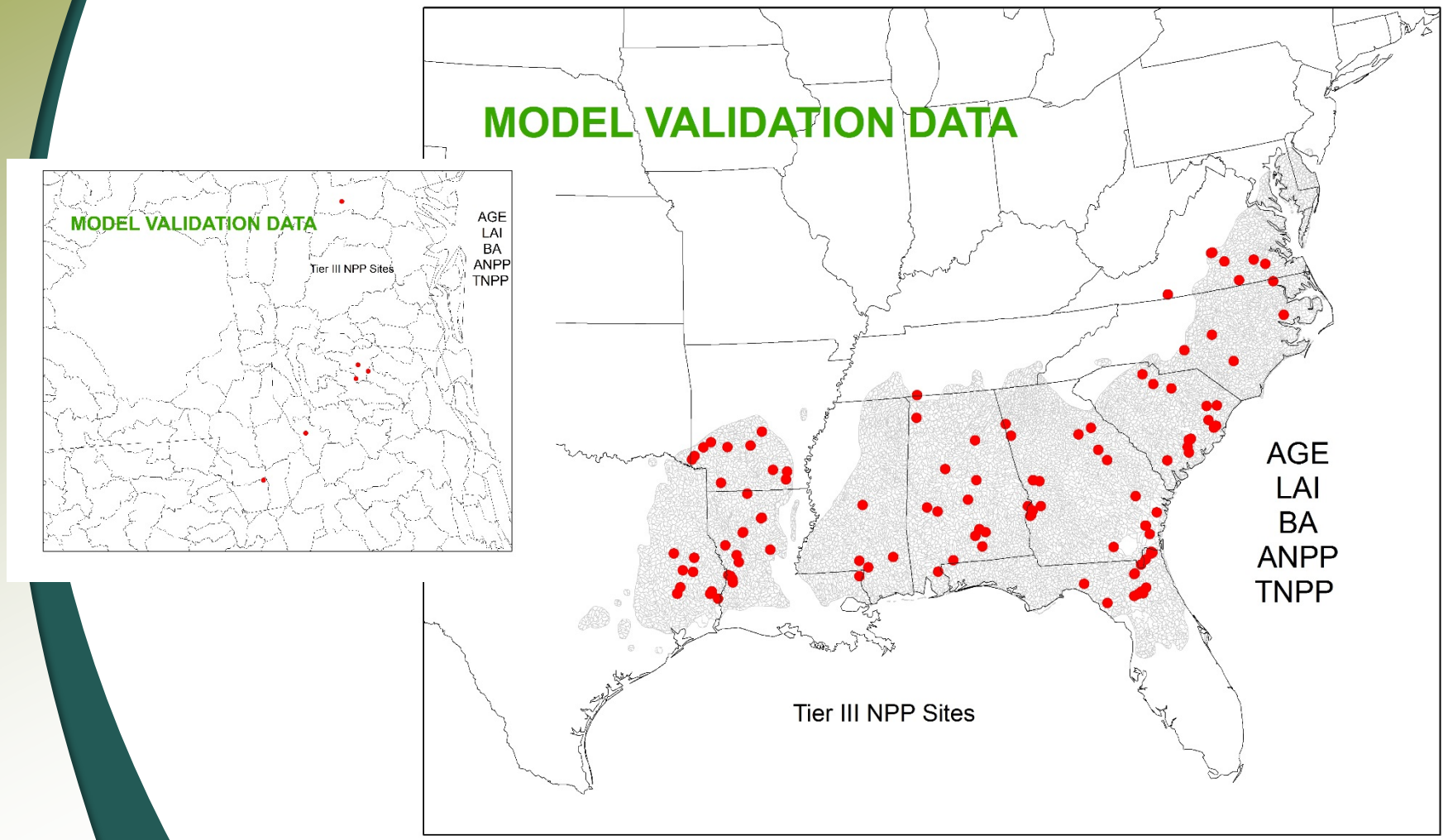
Model Forest

$$ET = 0.725*PET + 5.0*LAI$$

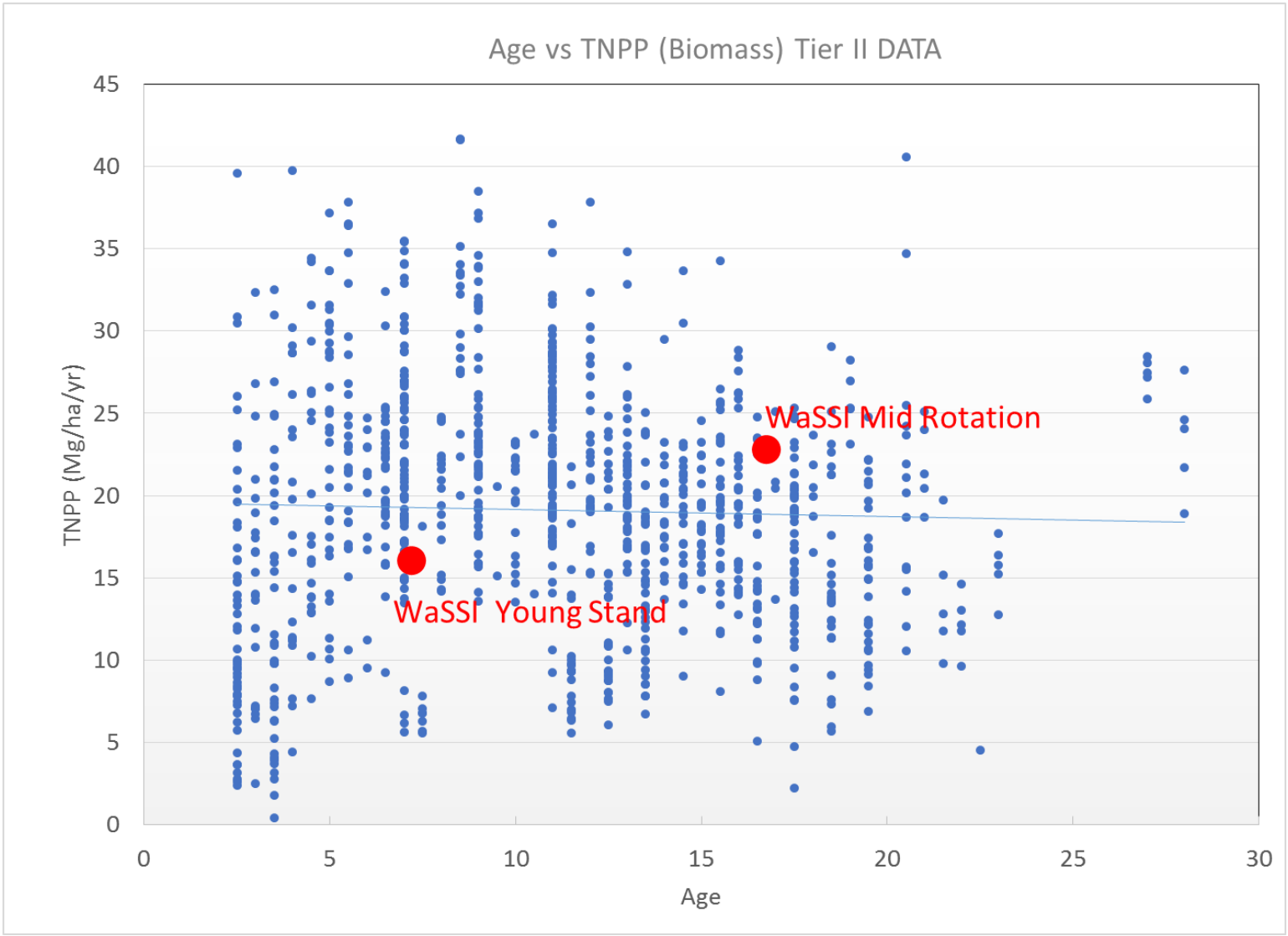
R^2=0.86, RMSE = 14, n =120



Model Validation (TierII NPP)



Model Validation (Tier II NPP)



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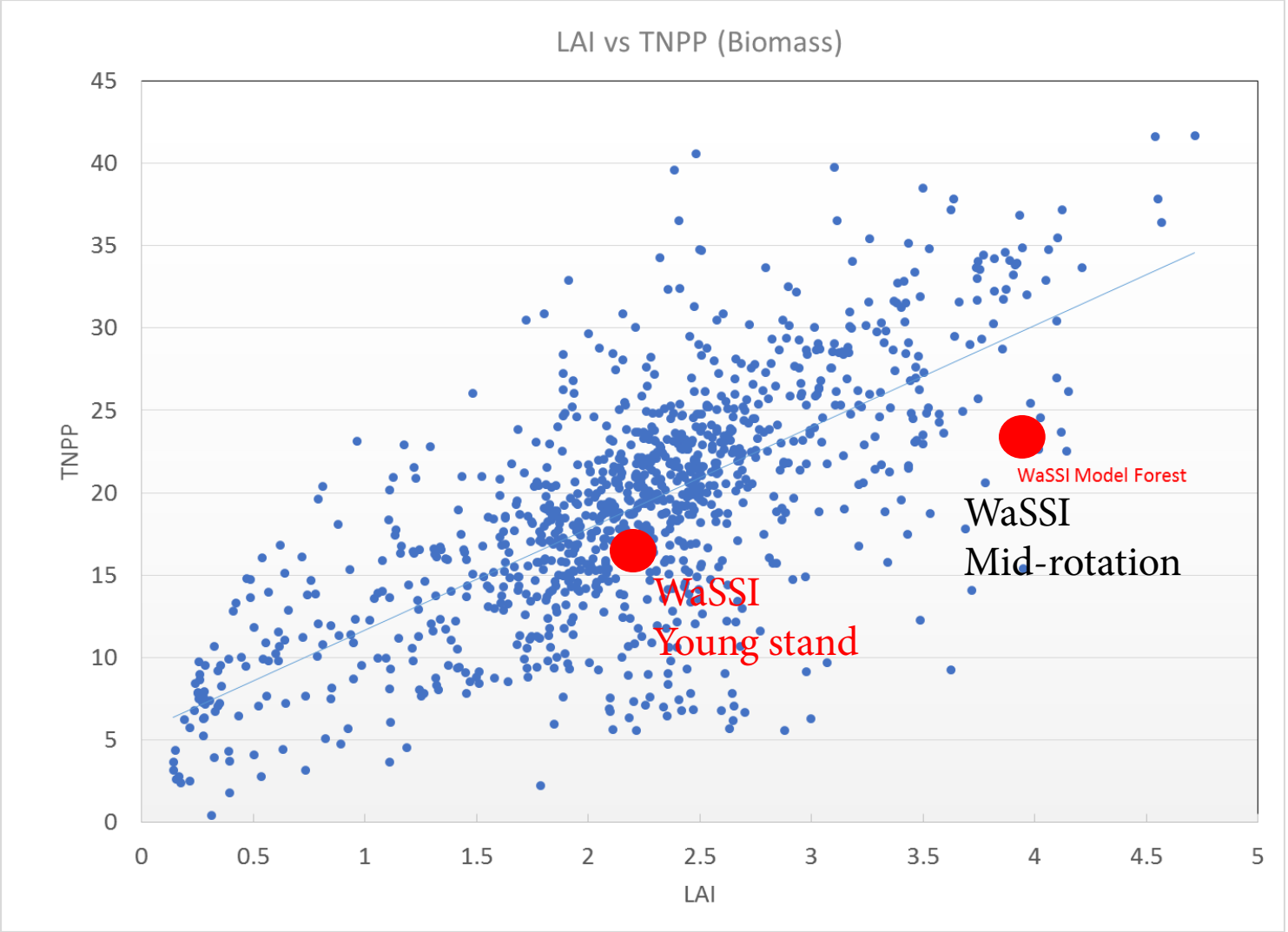

Definitions: Time Periods Used

- Historical data (1986-2005):
  - Based on gridded observations
- Model baseline (1950-2005):
  - reference period for calculating future changes
  - same statistics as actual years (1979-2009) from training data
- Model future periods (2020-2039, 2040-2059, 2060-2079, 2080-2099):
  - To assess climate, take averages over at least 20 yrs

Modeling Water and Productivity using 20 GCMs

- Step 1: run with a historical dataset (Training data)

- Step 2: run with baseline dataset. Compare model baseline output to historical output (Step 1) to generate error statistics.
- Step 3: run with projections data per model, per RCP, and per 20 yr time slice for future periods
- Step 4: compute difference between step 3 and step 2
- Step 5: calculate mean of these differences across all models per rcp and per 20 yr future time slice
- Step 6: add mean of the differences back to the historical map of GEP or Q (from Step 1)
- Step 7: repeat steps 5 and 6 except with std. deviation

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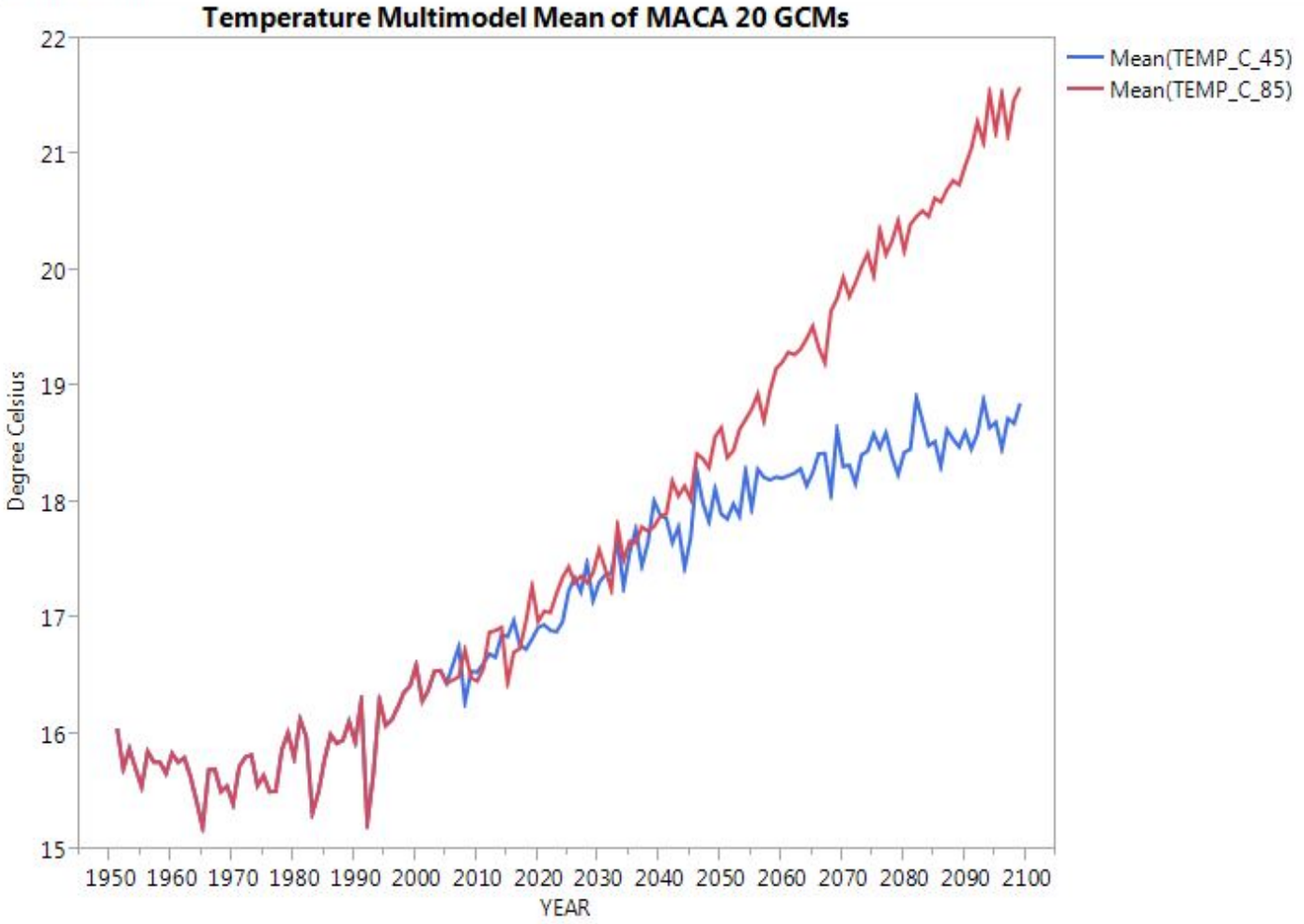
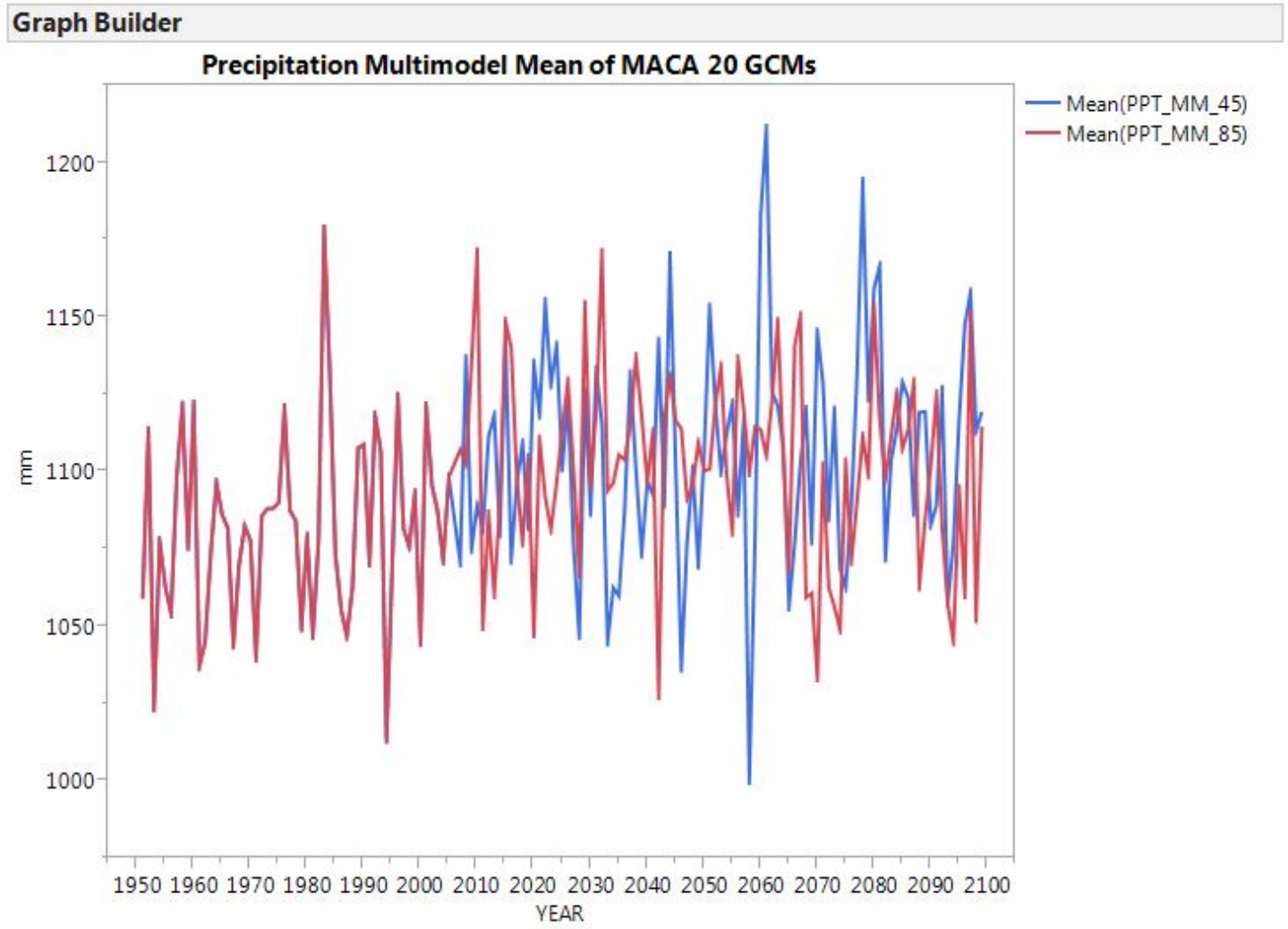
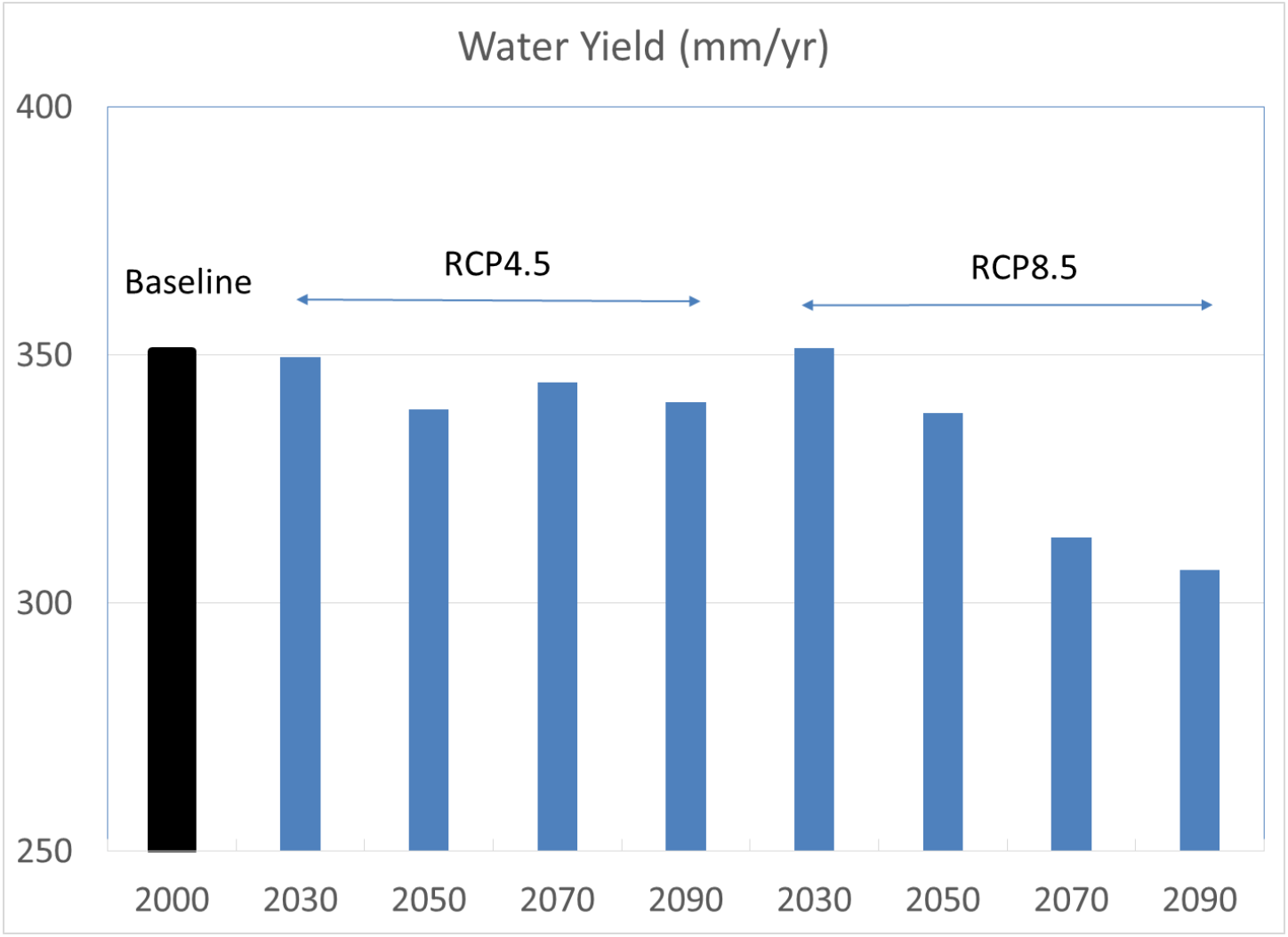
Graph Builder




Graph Builder
Precipitation Multimodel Mean of MACA 20 GCMs
Mean(PPT_MM_45)
Mean(PPT_MM_85)
mm
1200
1150
1100
1050
1000
1950 1960 1970 1980 1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
YEAR

WaSSI Modeled Mean Changes (all GCMs)



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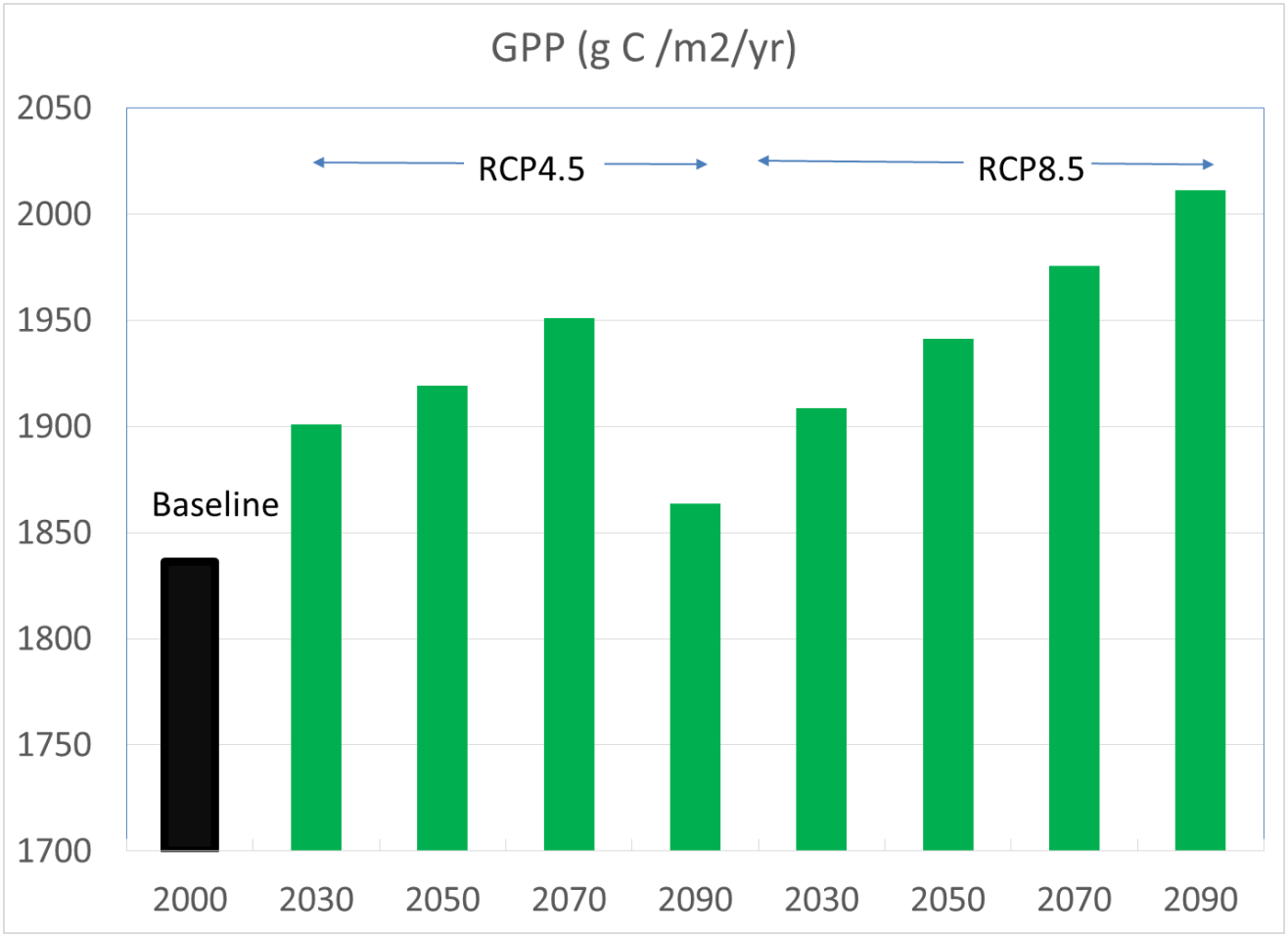
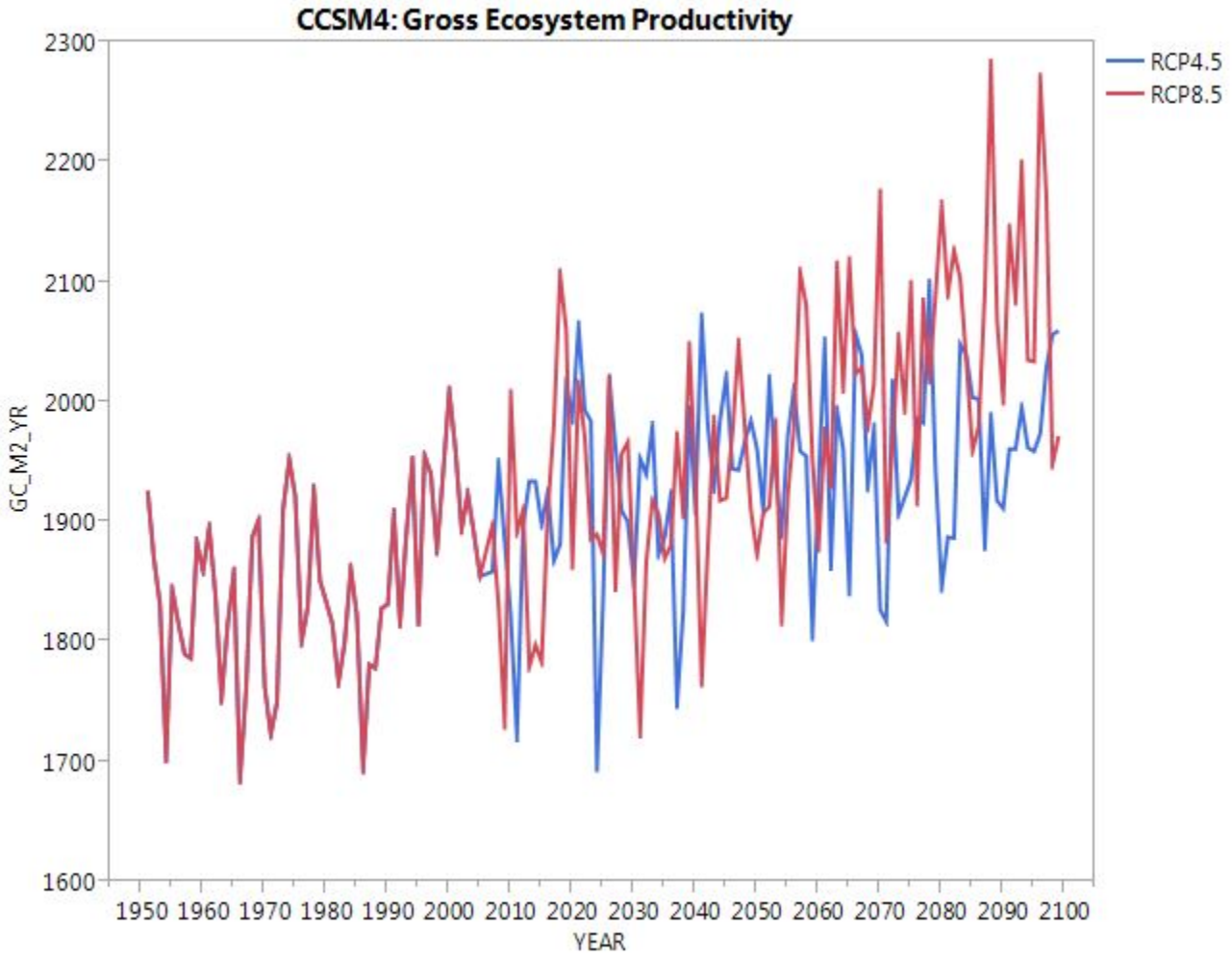
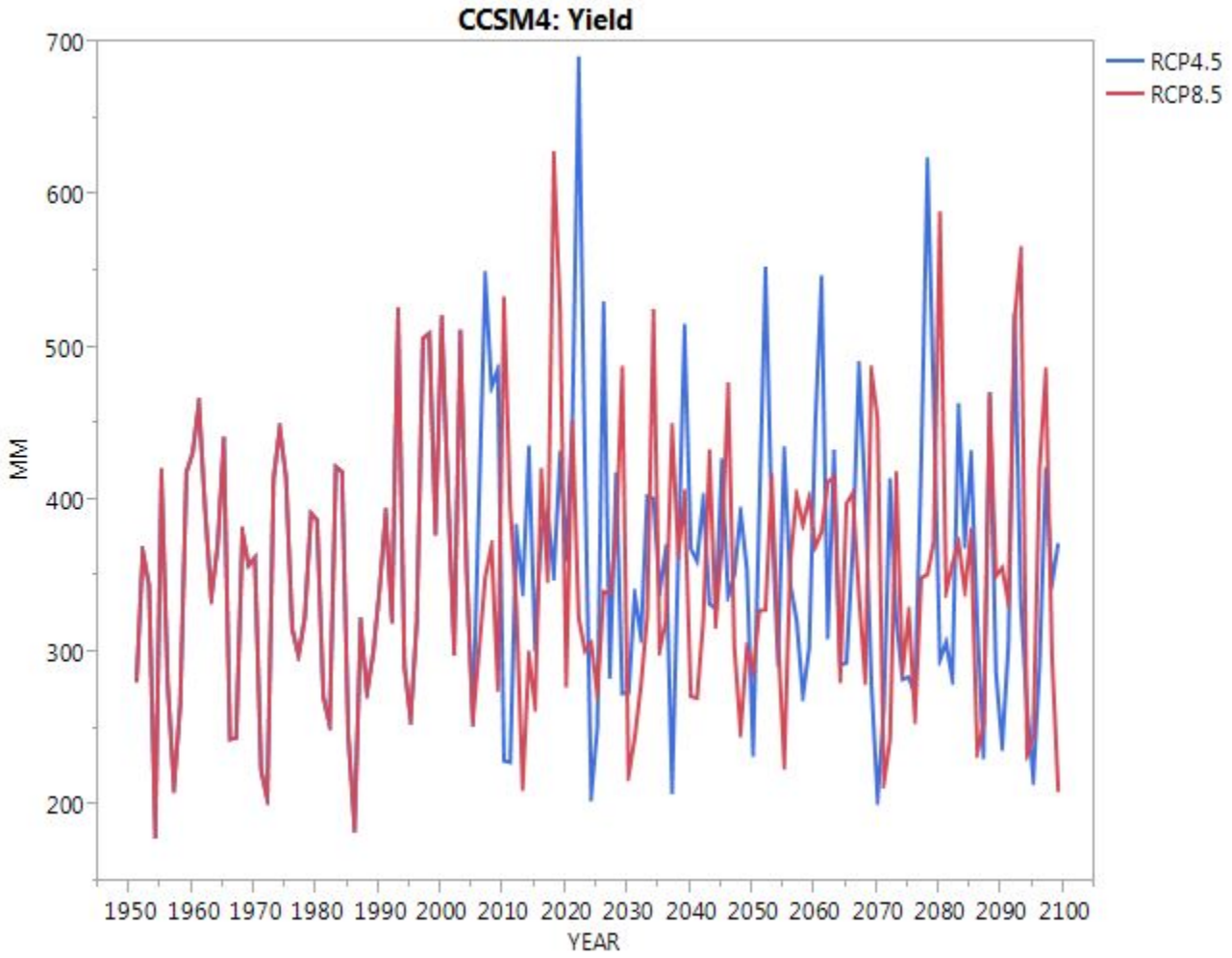


Modeled GEP


CCSM4: Gross Ecosystem Productivity
RCP4.5
RCP8.5
GC_M2_YR
2300
2200
2100
2000
1900
1800
1700
1600
1950 1960 1970 1980 1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
YEAR

Modeled Water Yield



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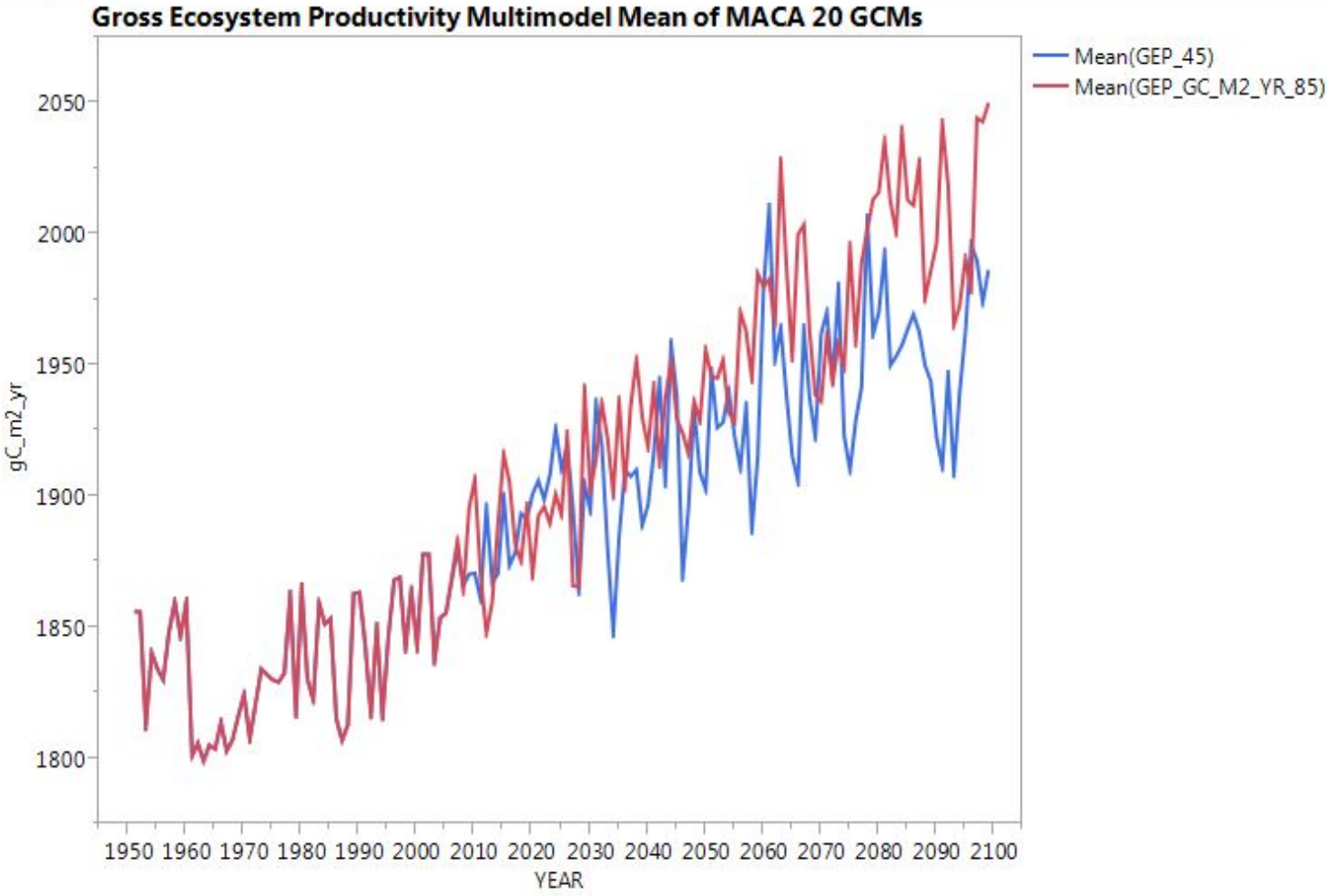
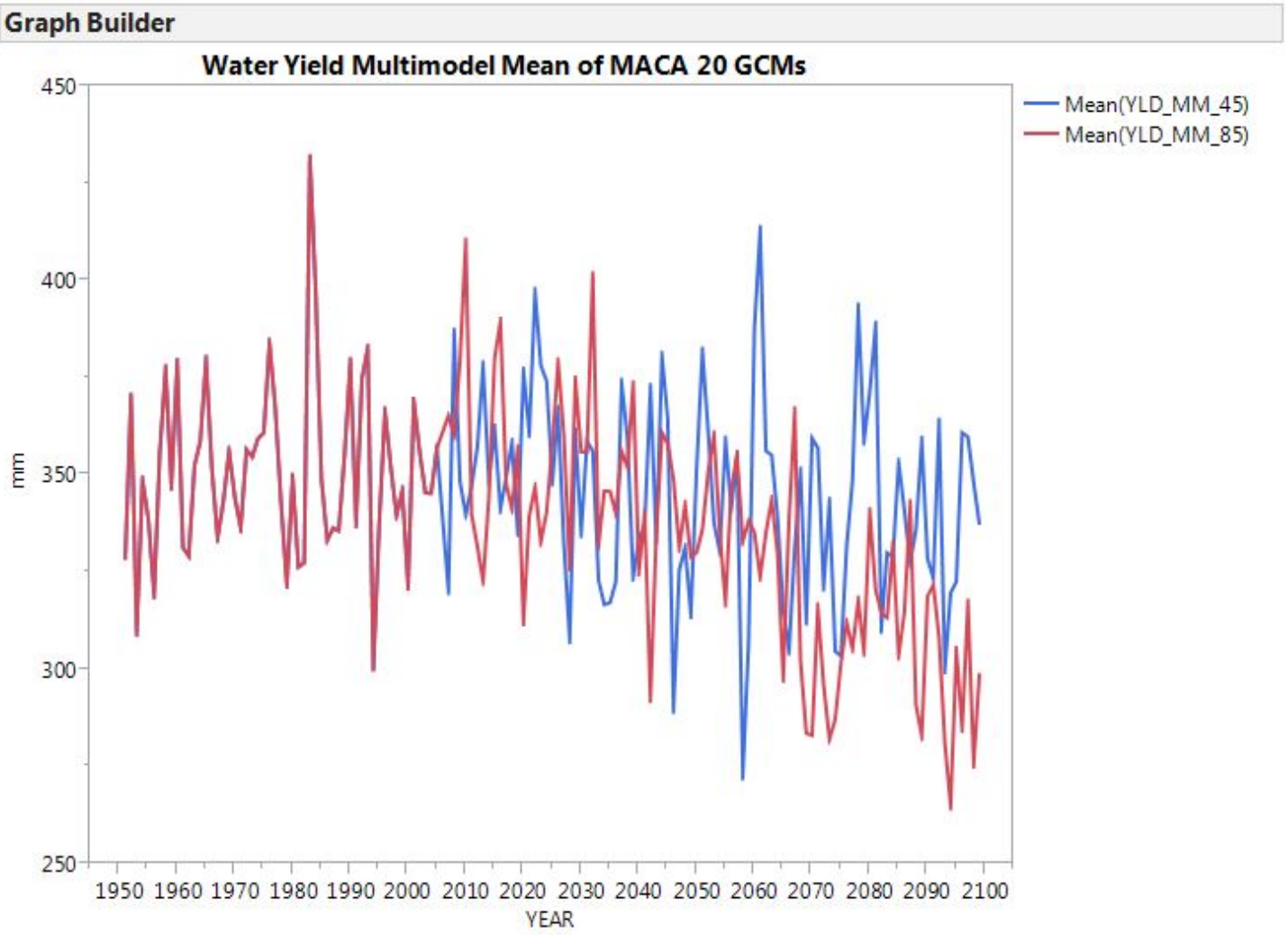
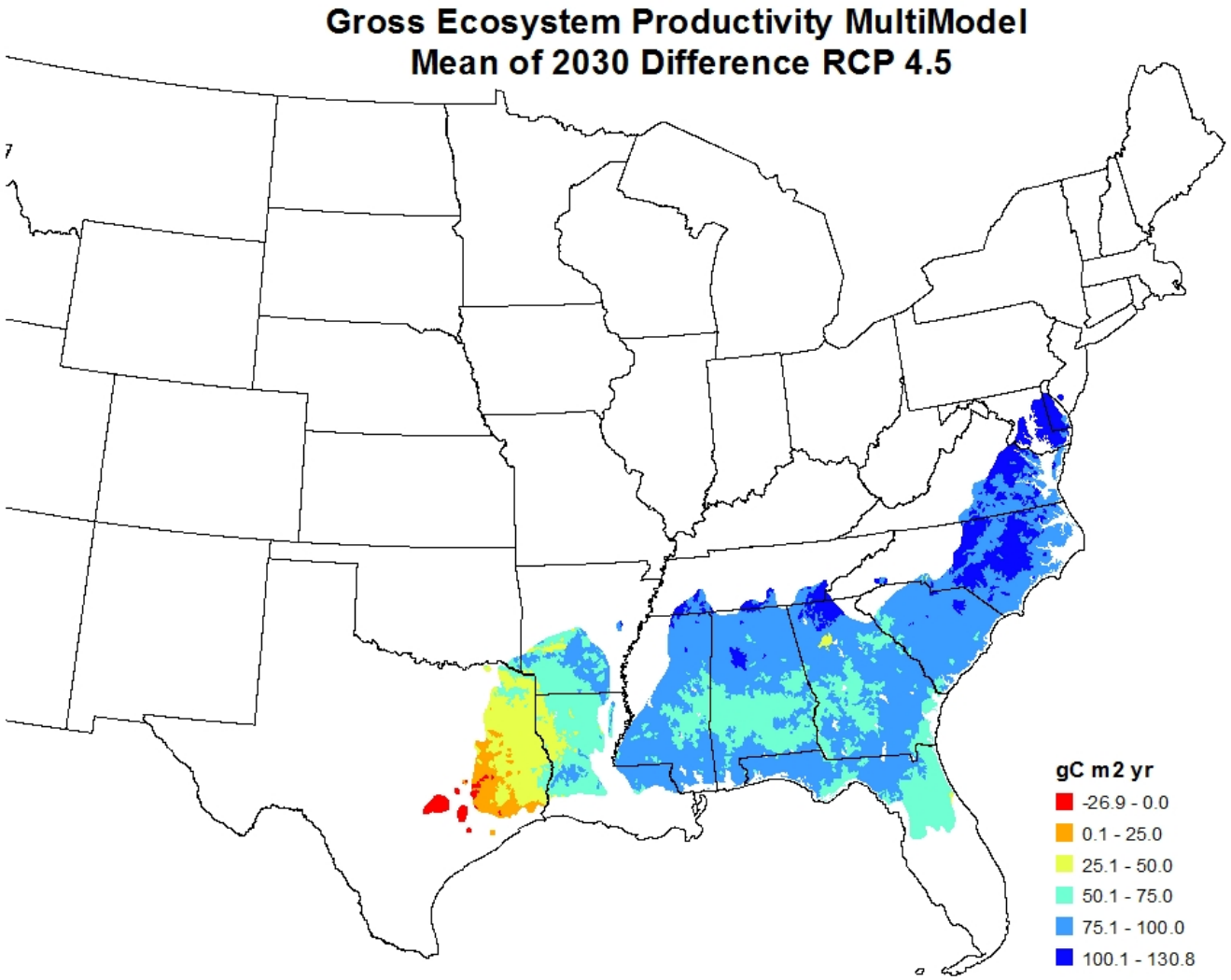
Graph Builder




Graph Builder
Water Yield Multimodel Mean of MACA 20 GCMs
Mean(YLD_MM_45)
Mean(YLD_MM_85)
mm
450
400
350
300
250
1950 1960 1970 1980 1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
YEAR

WaSSI Modeled Mean Changes by 2030 (all GCMs)



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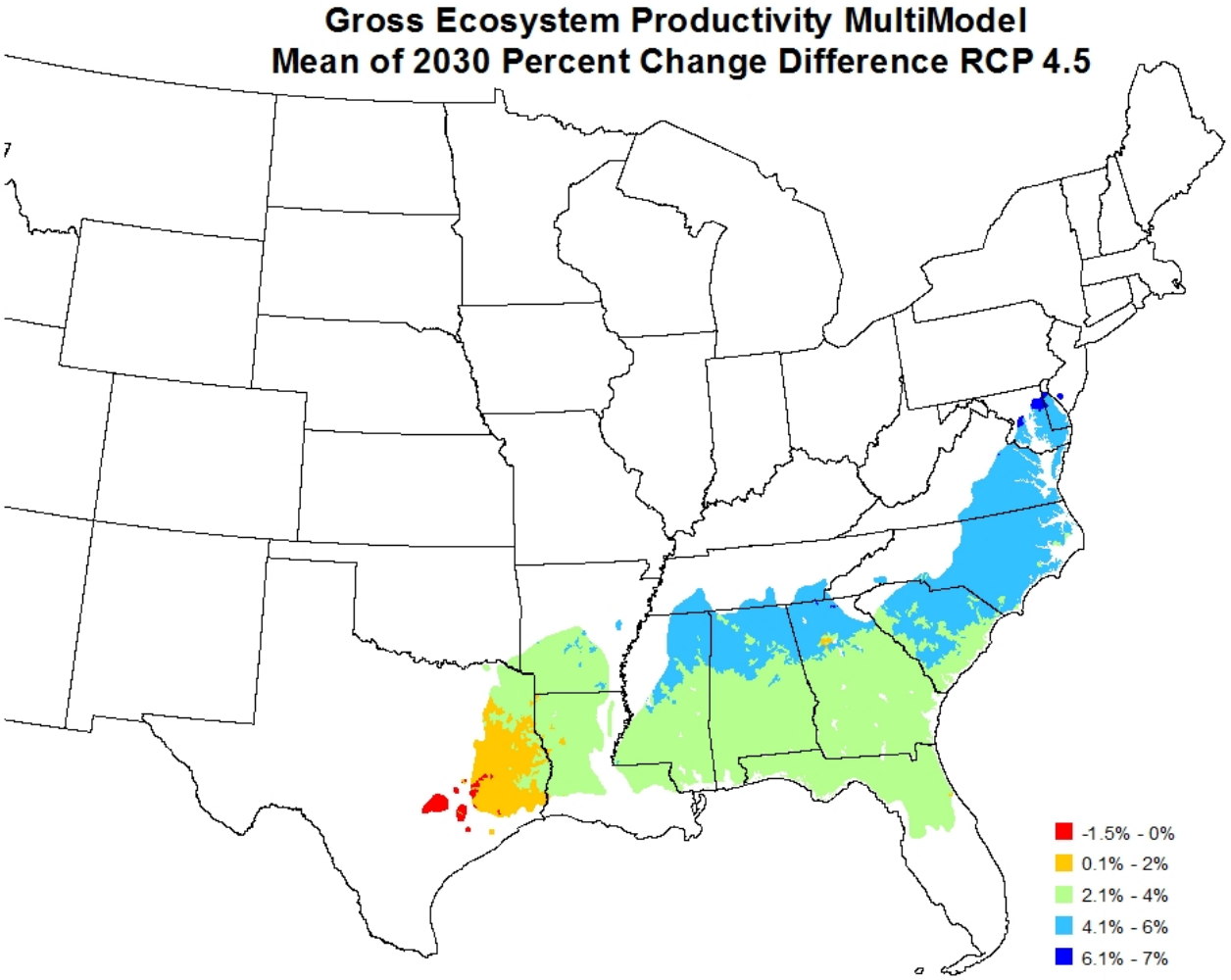
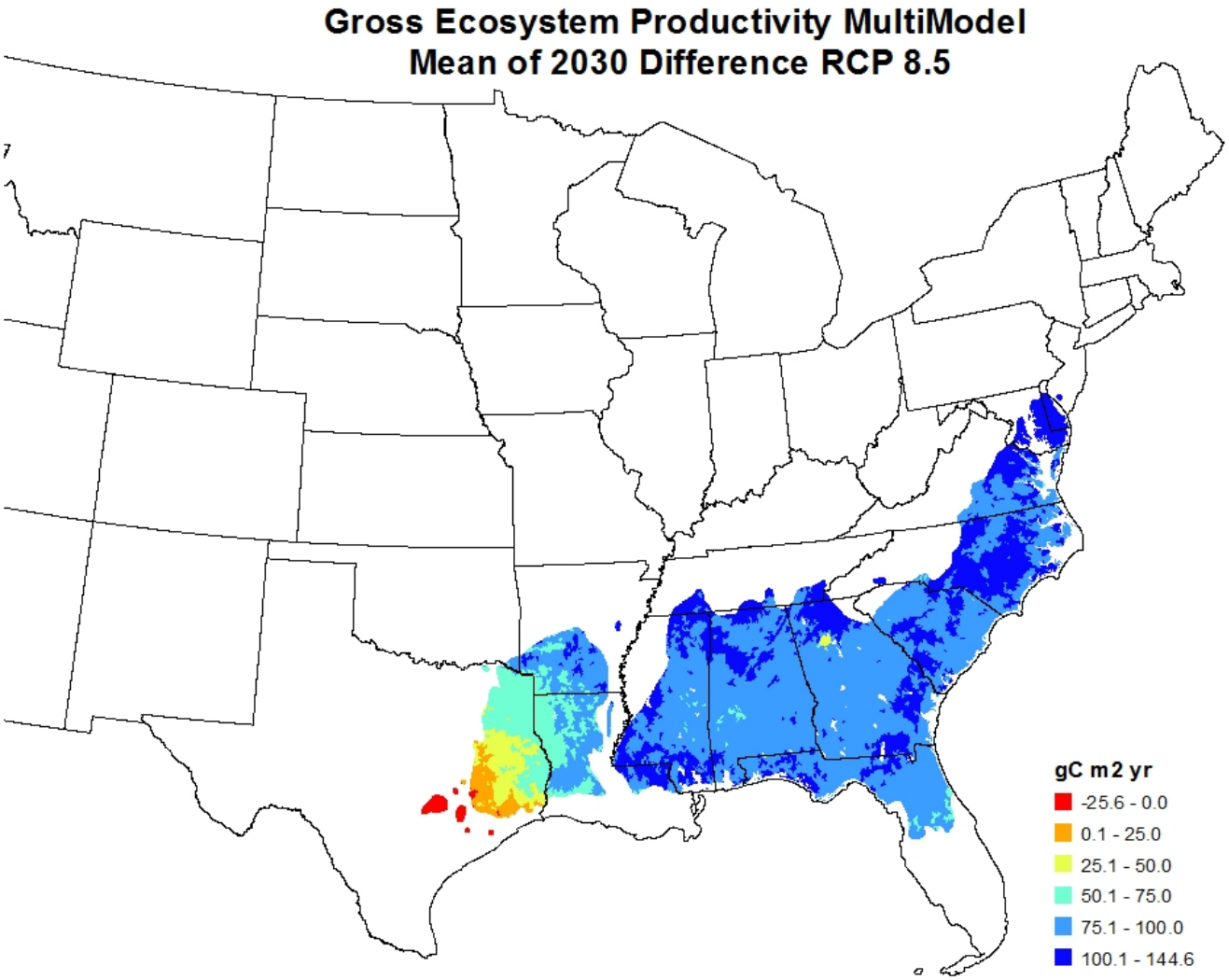
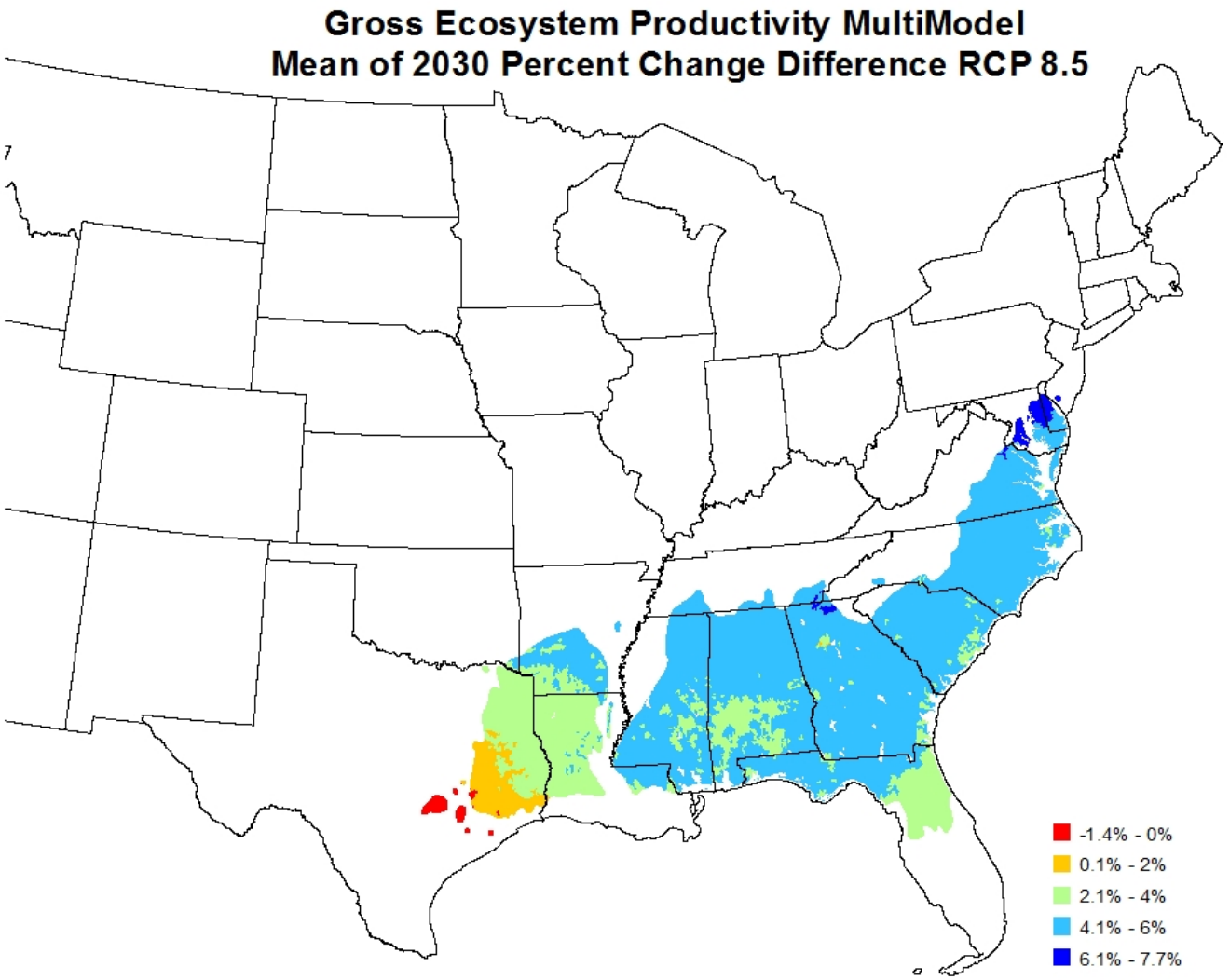


WaSSI Modeled Mean Changes by 2030 (all GCMs)



WaSSI Modeled Mean Changes by 2030 (all GCMs)



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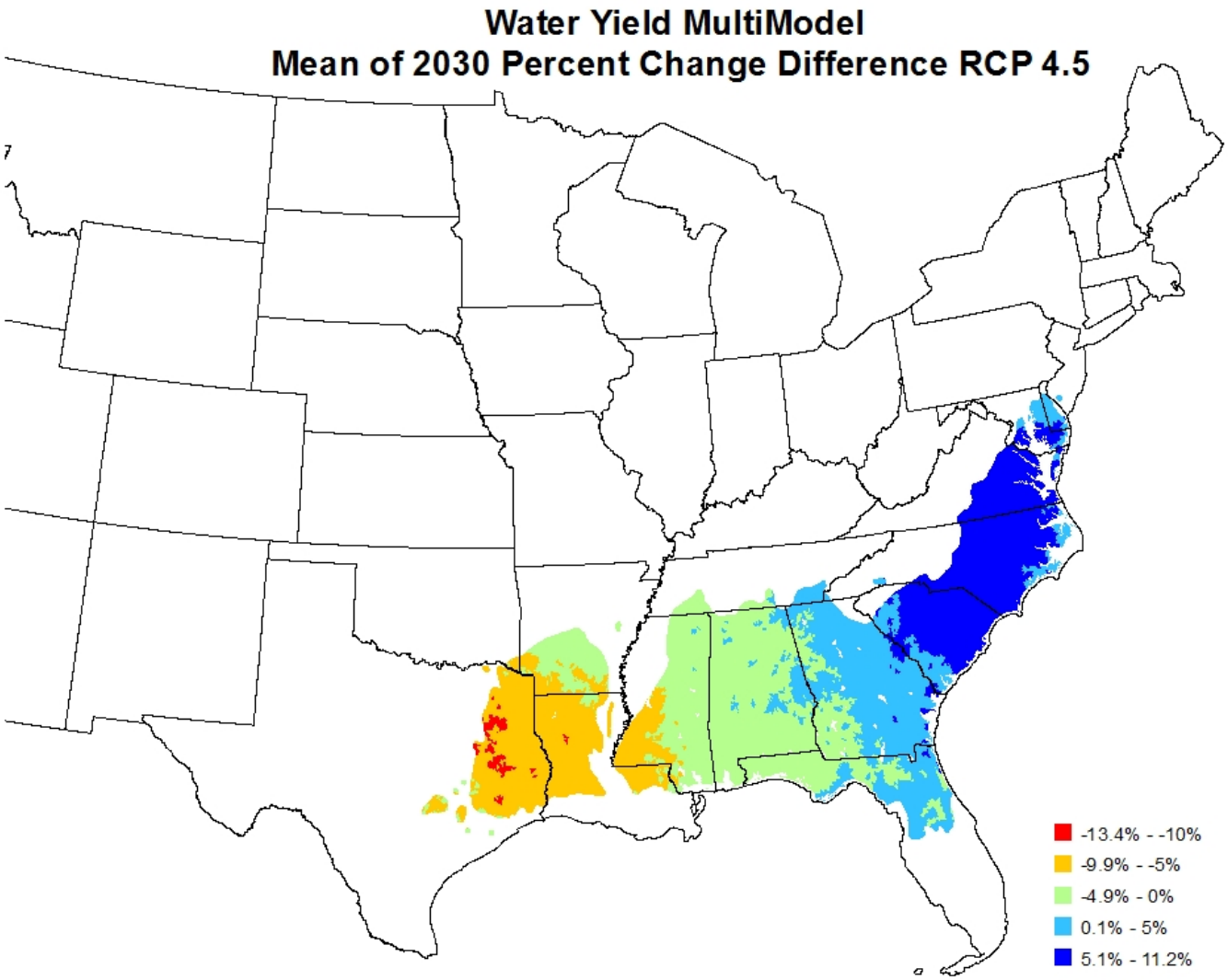

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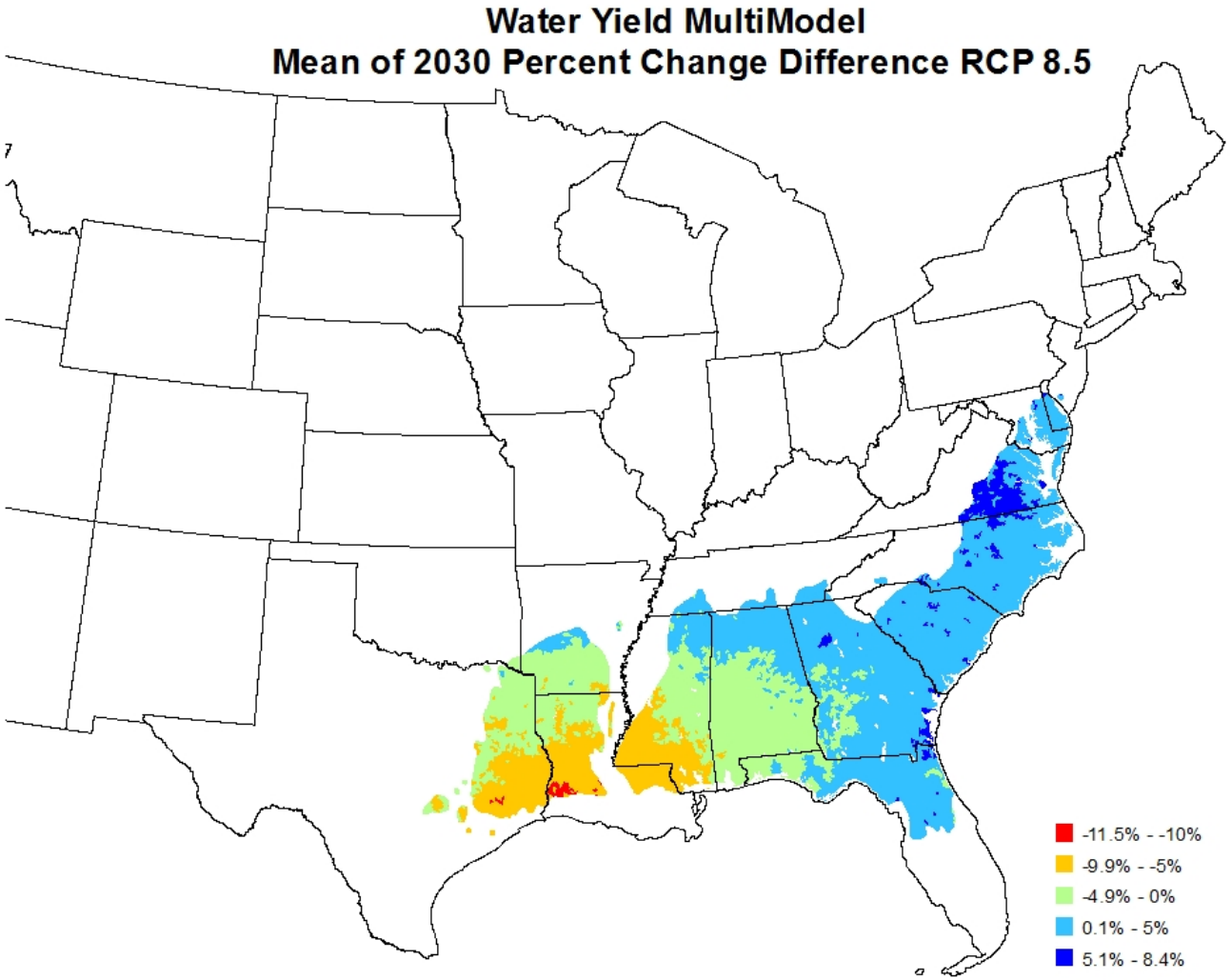

Summary and Next steps

- Divergent response? Productivity increases but water supply decreases at the regional scale.

- Will work on other scenarios: CO2 fertilization with altered WUE
  - Young stands (LAI-2.3)
  - Mature stands (LAI=4)

- Provide DSS required datasets
  - Young stands (LAI=2.3)
  - Mature stands (LAI=4)

Take Home Points

- Increases in atmospheric CO_2 and air temperature are predicted to ***increase*** loblolly productivity across the region
- Increases in atmospheric CO_2 will ***not change*** total annual ET because
  - Leaf Area increases cancel out decrease in per unit leaf water transpiration.
- A warming climate will ***decrease*** water yield from forests and aggravate water supply stress for people.
- Tradeoffs (carbon gain and water loss) will ***increase*** under future climate change and forest management that maximizes productivity and water use efficiency.