Tropical forest allocations of productivity and biomass are not accurately predicted by CMIP5 models

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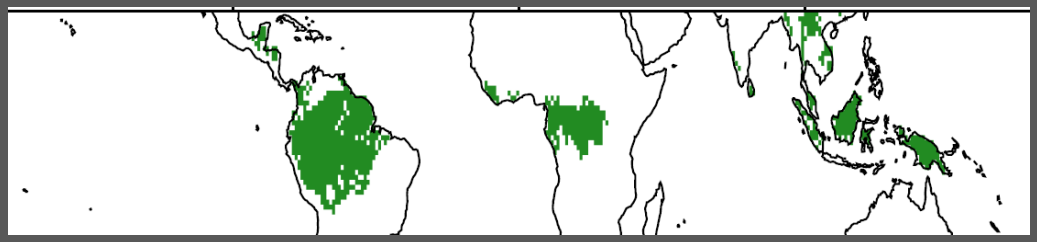

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Lawrence Berkeley National Laboratory

SFA BGC-Climate presentations
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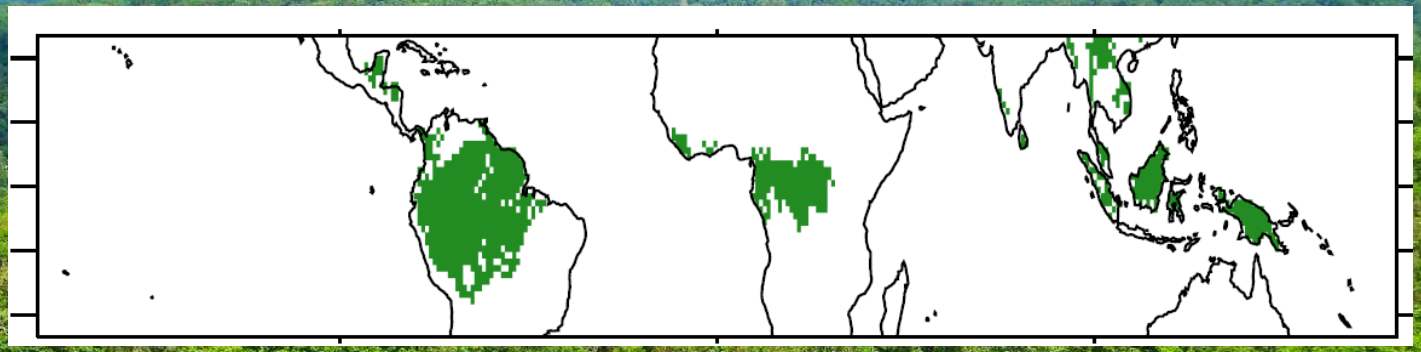
Why focus on tropical forests?



Tropical forests:

- account for ~34% (42 PgC yr^{-1}) of terrestrial GPP.
- account for ~35% (22 PgC year-1) of terrestrial NPP.
- contain ~66% (262 PgC) of terrestrial biomass.

The conversion of carbon uptake to biomass depends on carbon allocations and affect directly the carbon cycle and climate

Questions we will answer today:

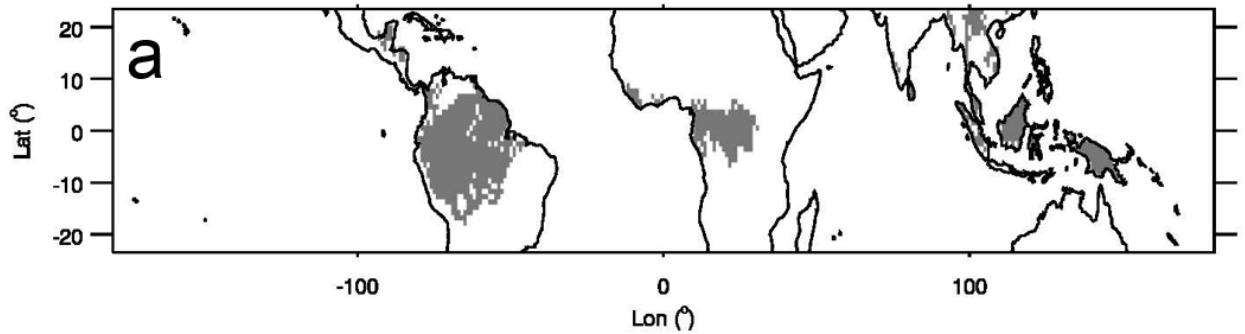
- **Do CMIP5 ESM's reproduce observed allocations (productivity and biomass) in the main tree compartments (leaves, wood, roots)?**
- **Do CMIP5 ESM's represent observed spatial patterns of productivity and biomass?**
- **Which observed-derived Benchmark metric could be used to assess model performance?**
- **Do models reproduce known ecological relationships and forest behaviors?**

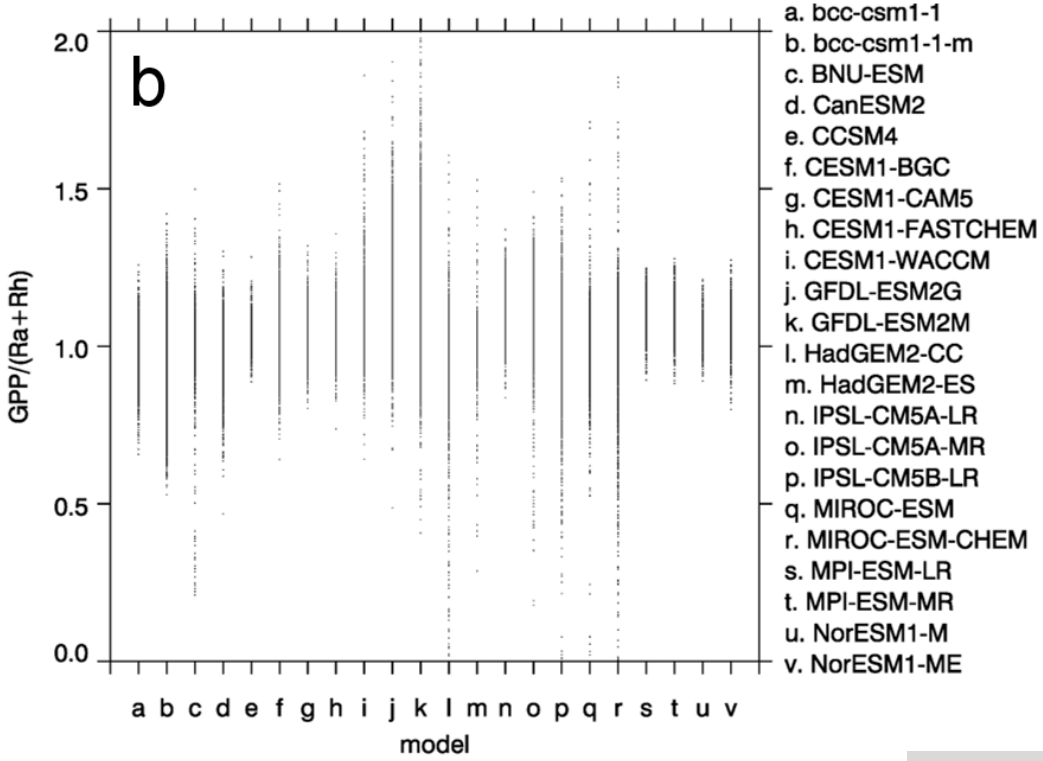
Steady-state conditions?

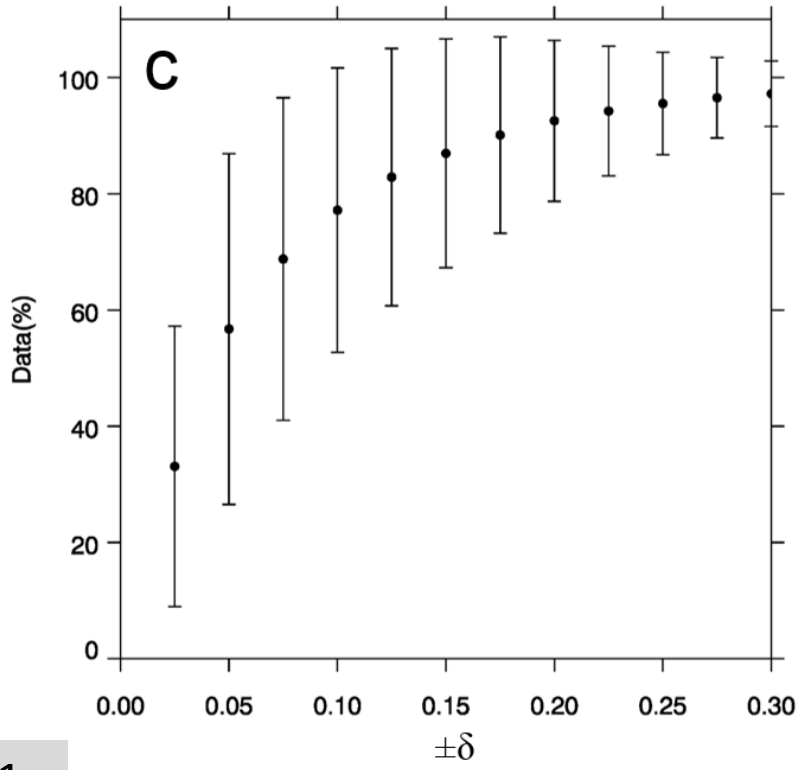
CO_2 inputs (GPP) ~ CO_2 outputs (Ra+Rh)

$$1 - \delta \leq \frac{GPP}{Ra+Rh} \leq 1 + \delta$$

CMIP5 Historical simulations: yearly data from 1971-2000



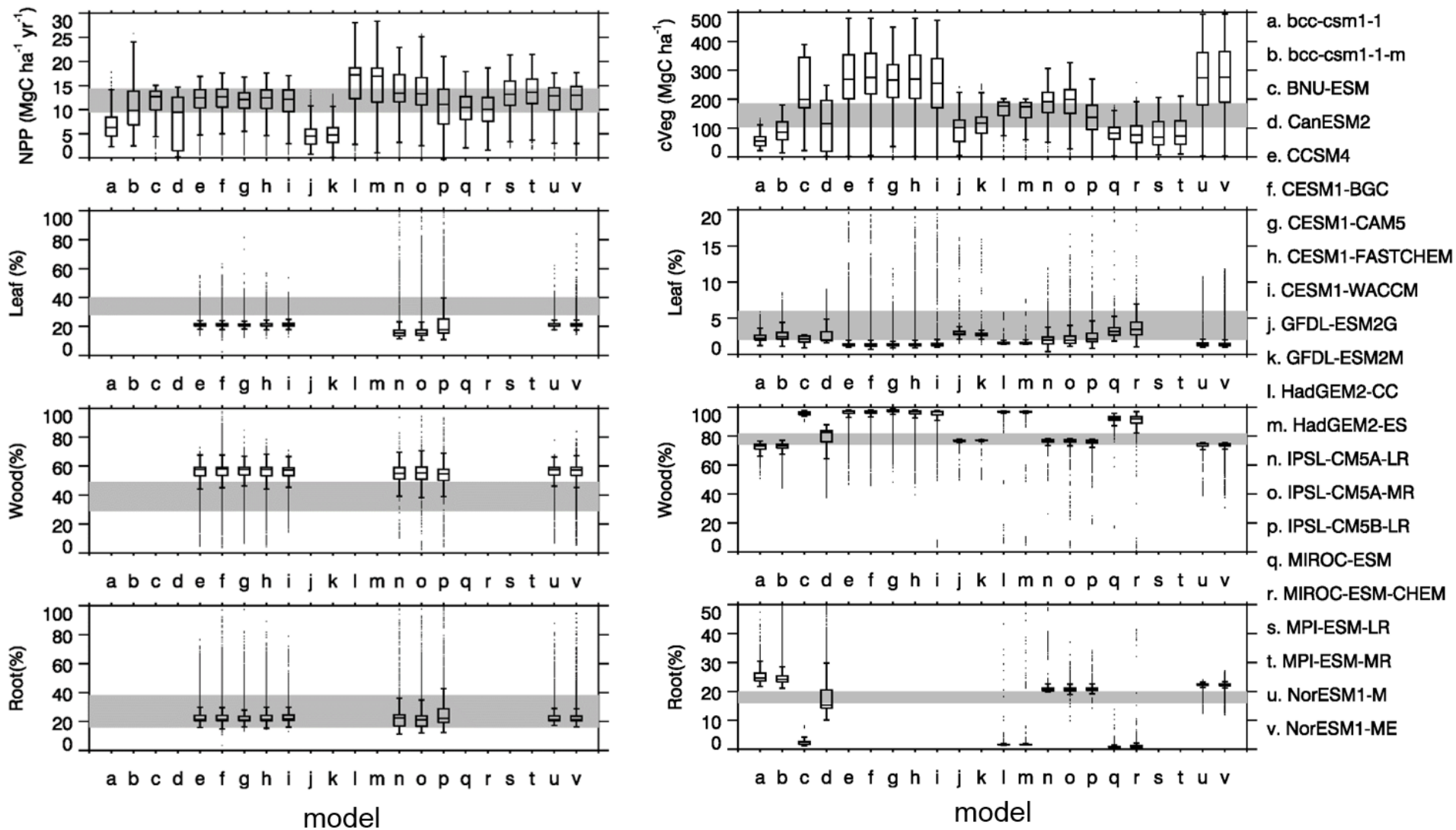




δ=±0.1

Do models reproduce the observed allocations?

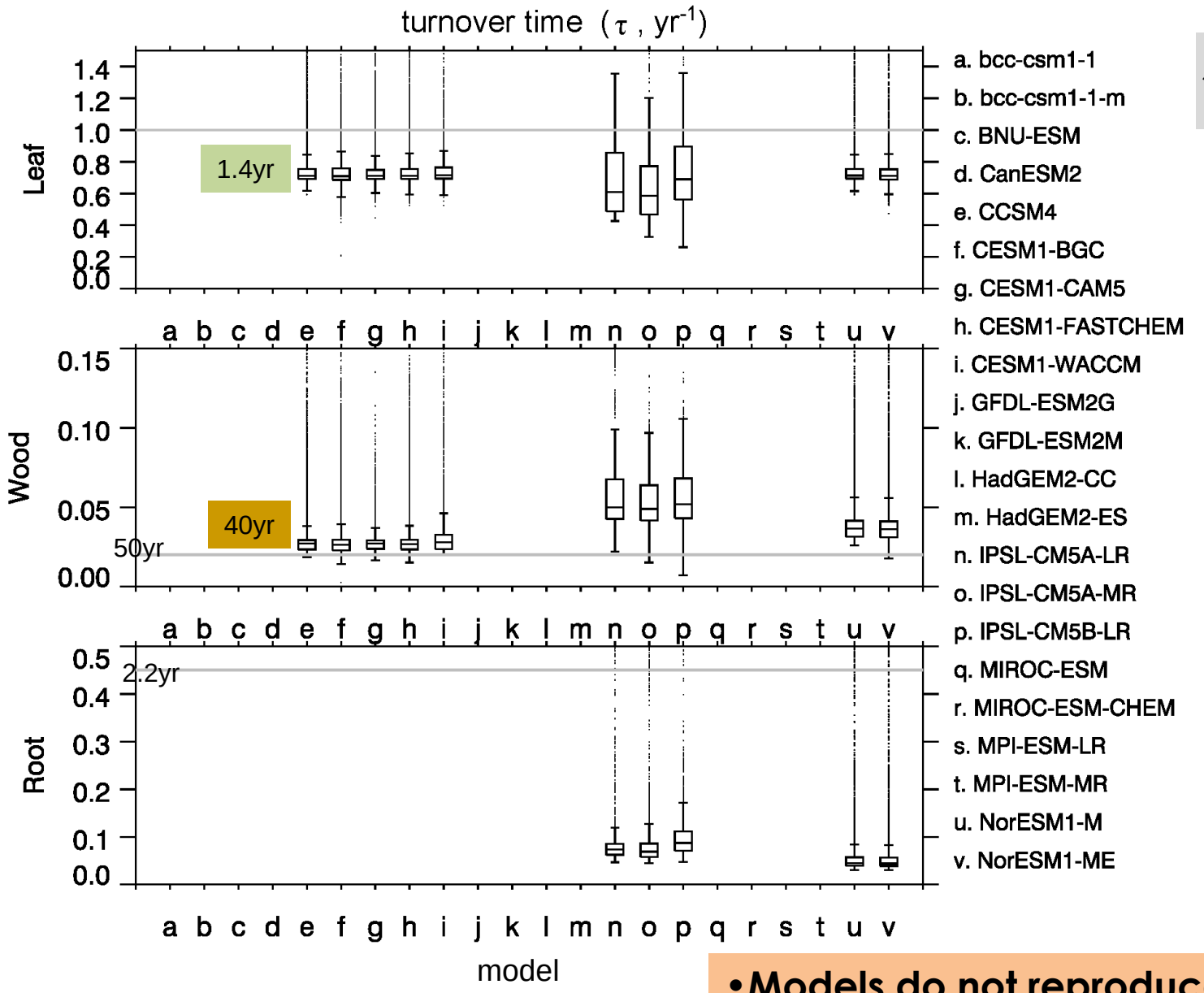
CMIP5 Historical simulations: yearly data from 1971-2000



- **Models do not reproduce observed allocations.**

Do models reproduce the observed turnover time?

CMIP5 Historical simulations: yearly data from 1971-2000

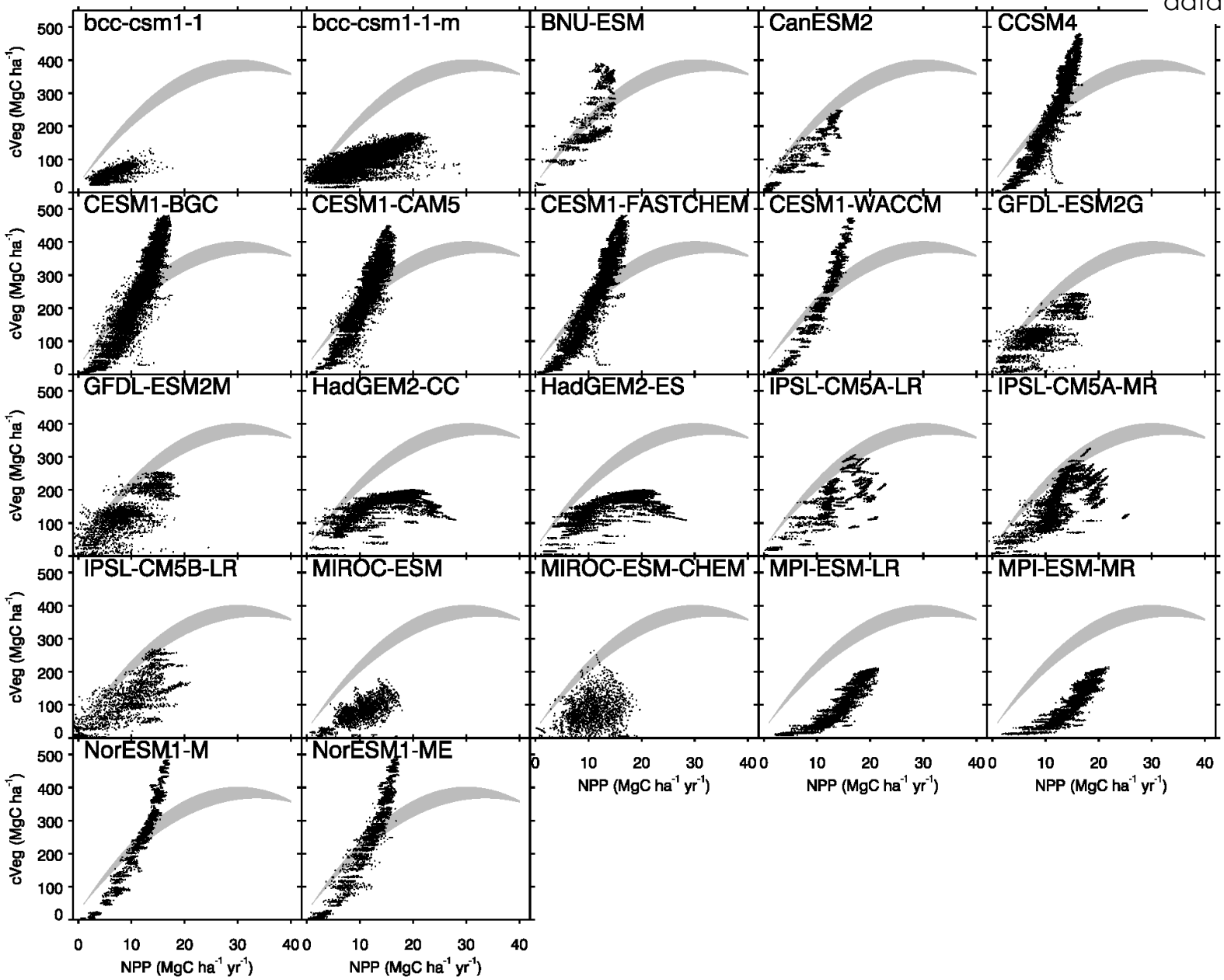


$$\tau_i = \frac{NPP_i}{biomass_i}$$

- **Models do not reproduce observed τ**

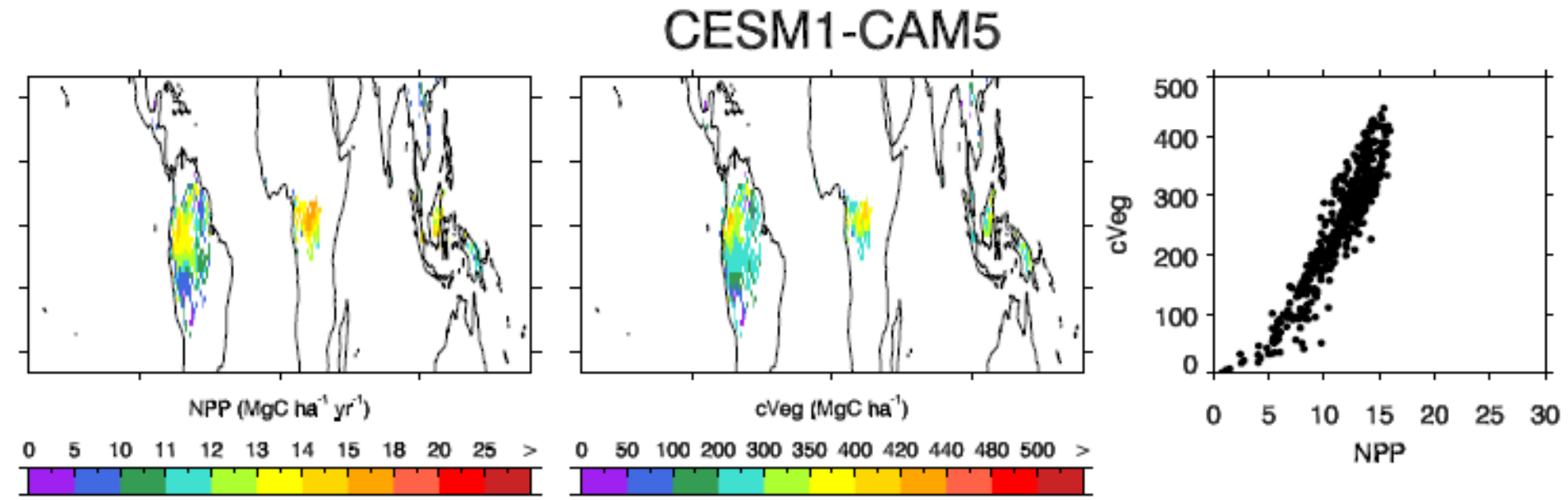
Do models reproduce the observed NPP – Biomass relationship?

CMIP5 Historical simulations: yearly data from 1971-2000



Do models reproduce the observed NPP – Biomass relationship?

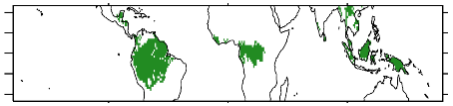
CMIP5 Historical simulations: mean 1971-2000

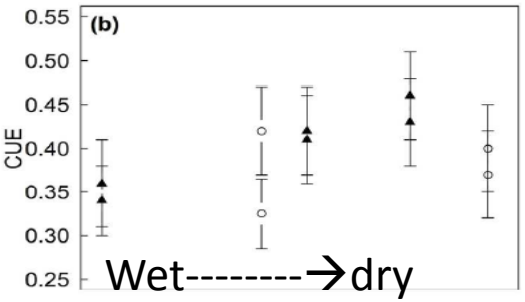


Which observed derived Benchmark metric can be used?

CMIP5 Historical simulations: yearly data from 1971-2000

$$CUE(carbon\ use\ efficiency) = \frac{NPP}{GPP}$$





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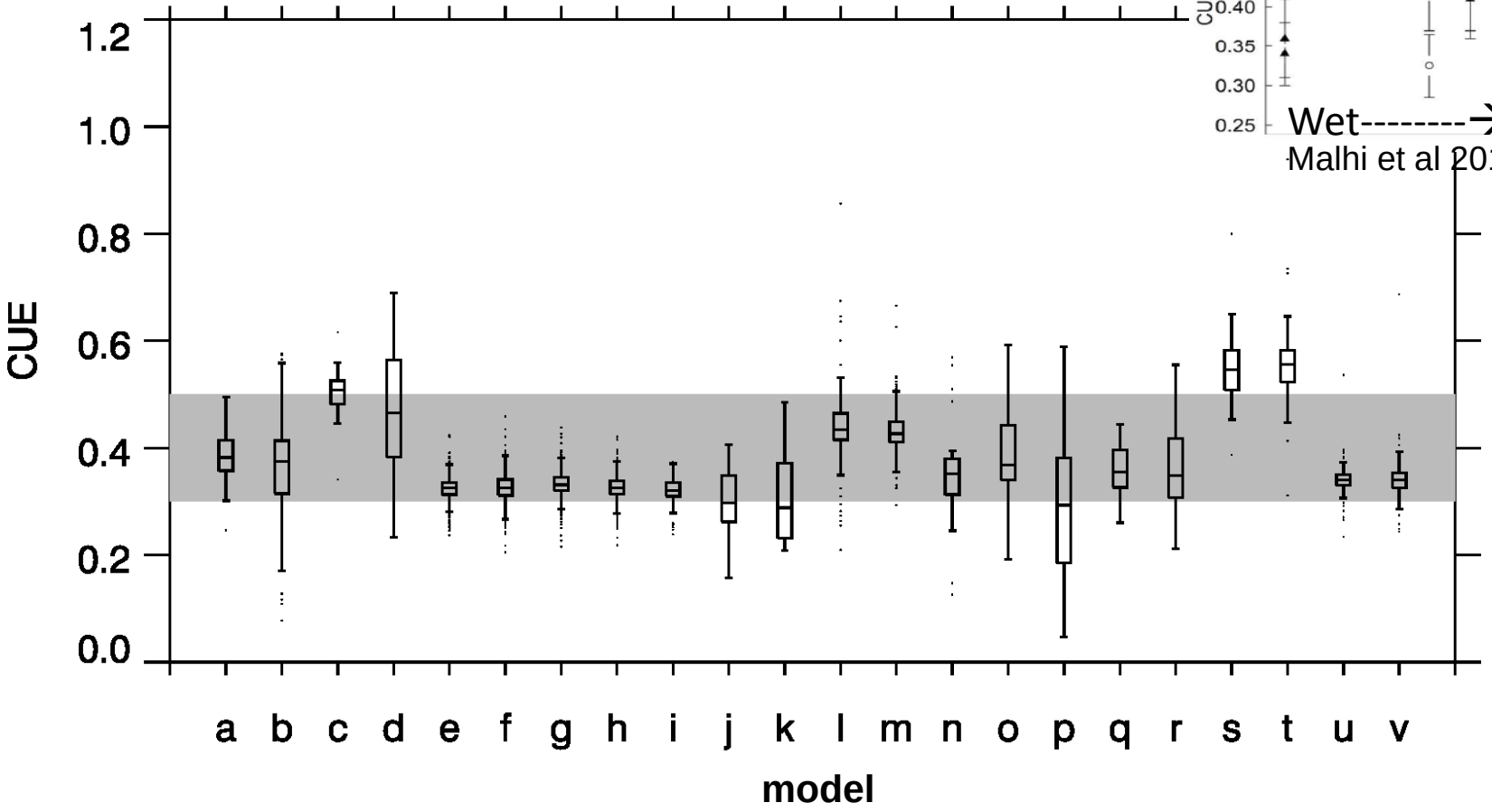
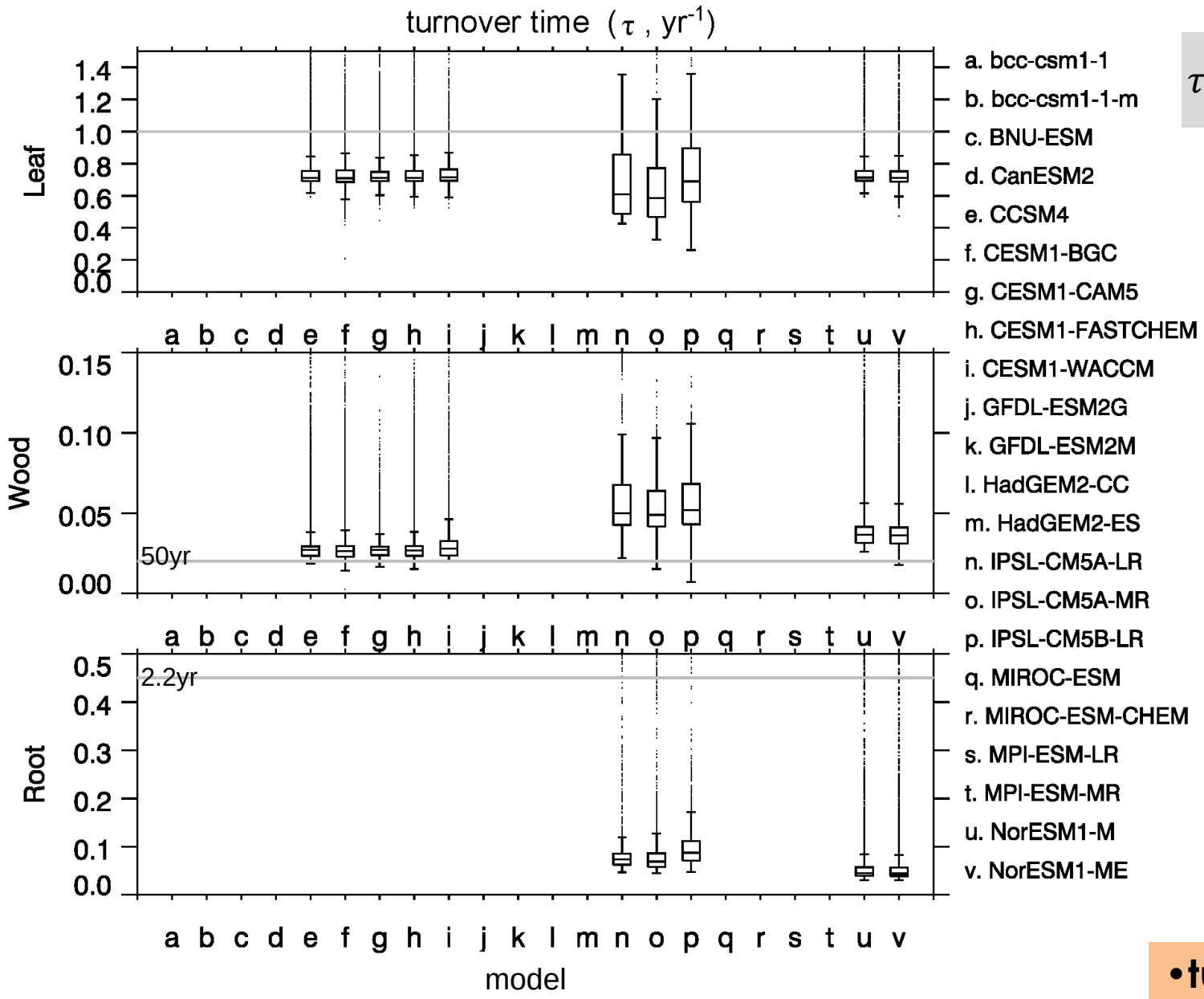


Carbon use efficiency

Which observed-derived Benchmark metric can be used?

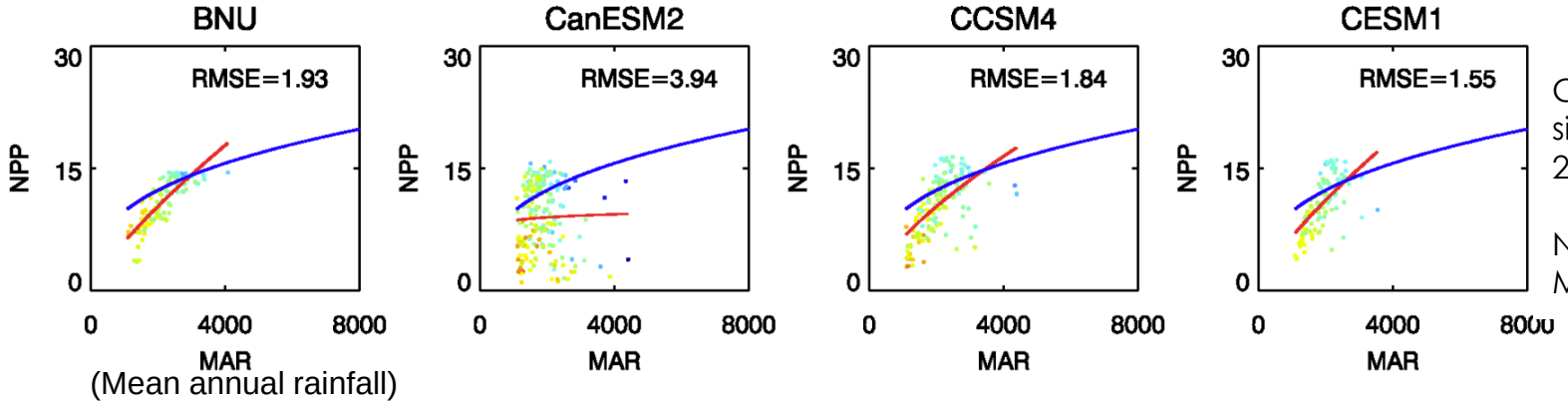
CMIP5 Historical simulations: yearly data from 1971-2000



$$\tau_i = \frac{NPP_i}{biomass_i}$$

- **turnover time**

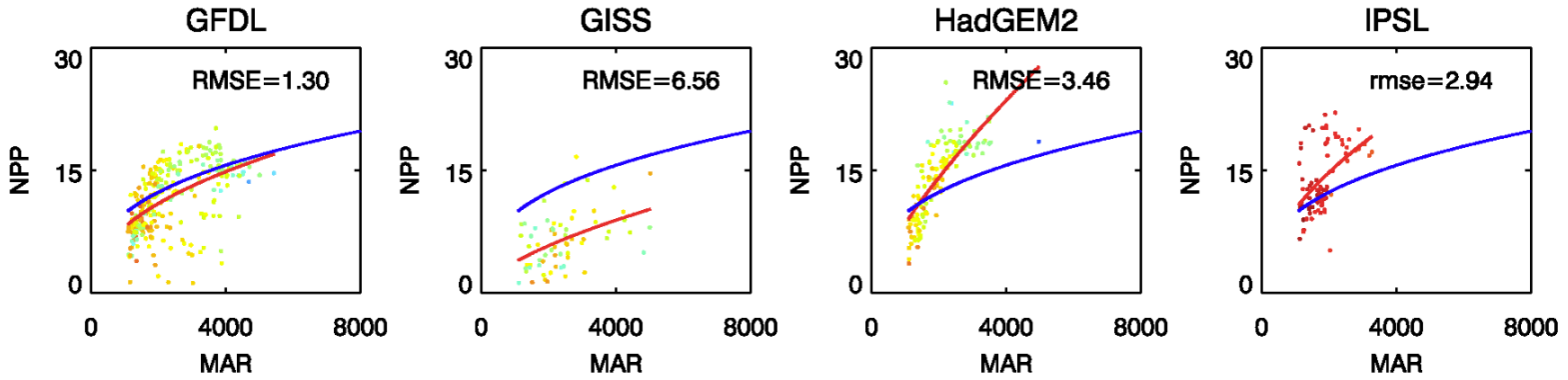
Which observed derived Benchmark metric can be used?

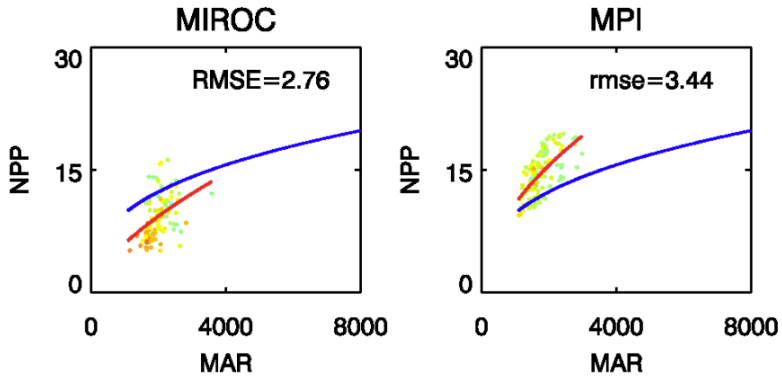


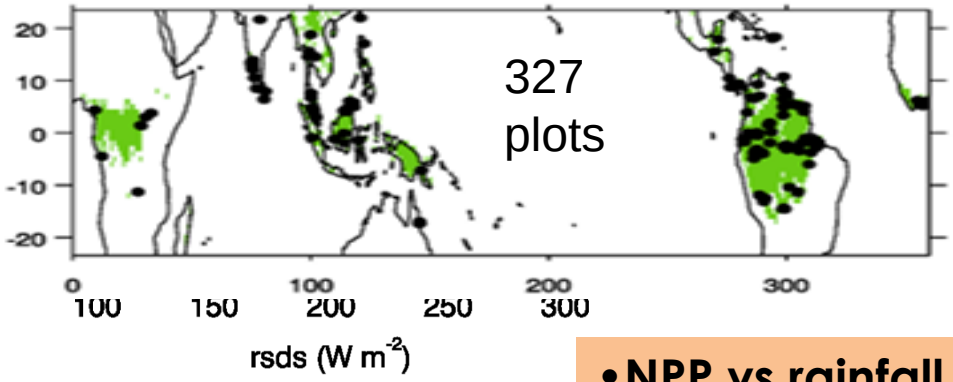
(Mean annual rainfall)

CMIP5 Historical simulations: 1971-2000

NPP: MgC ha^{-1} yr^{-1}
MAR: mm yr^{-1}



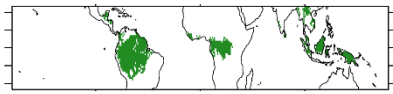




- **NPP vs rainfall.**

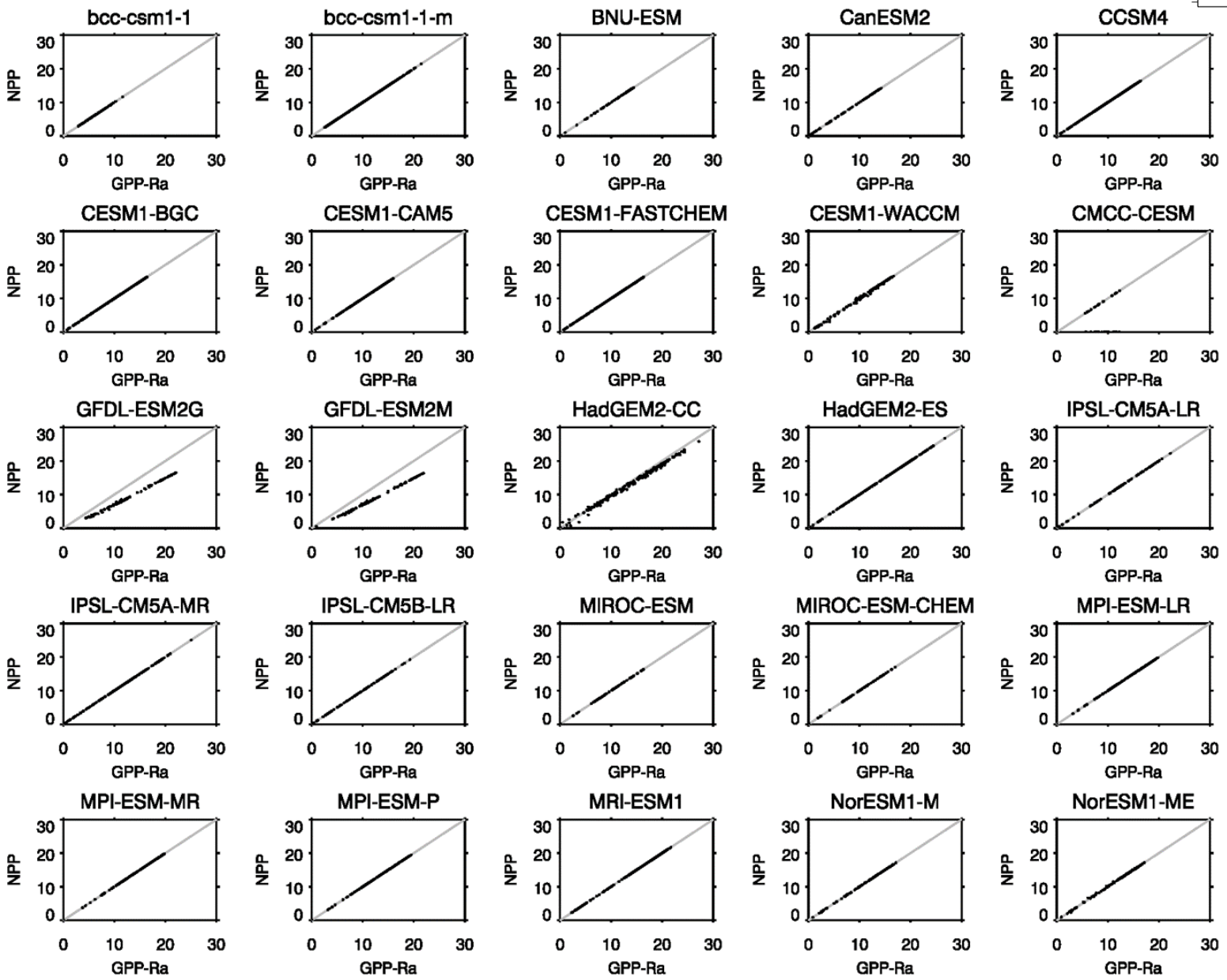
Do models show basic relationships?

NPP=GPP-Ra



CMIP5 Historical
1971-2000

MgC ha^{-1} yr^{-1}



Yes, Most of them

The conversion of carbon uptake to biomass depends on carbon allocations and affect directly the carbon cycle and climate

Questions we will answer today:

- **Do CMIP5 ESM's reproduce observed allocations (productivity and biomass) in the main tree compartments (leaves, wood, roots)?**
  Models do not reproduce observed allocations and turnover time in leaves, wood, and roots.

- **Do CMIP5 ESM's represent observed spatial patterns of productivity and biomass?**
  A decrease in biomass at high values of NPP was not reproduced by models

- **Which observed-derived Benchmark metric could be used to assess model performance?**
  Fraction of GPP to NPP: carbon use efficiency
  Allocations: turnover time
  Climate and NPP: NPP vs rainfall

- **Do models reproduce basic relationships?**
  NPP=GPP-Ra: Yes, most of them.