


Data-Model Intercomparison of ET Fluxes Across Amazonia: Hydrological Mechanisms

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Specific Questions

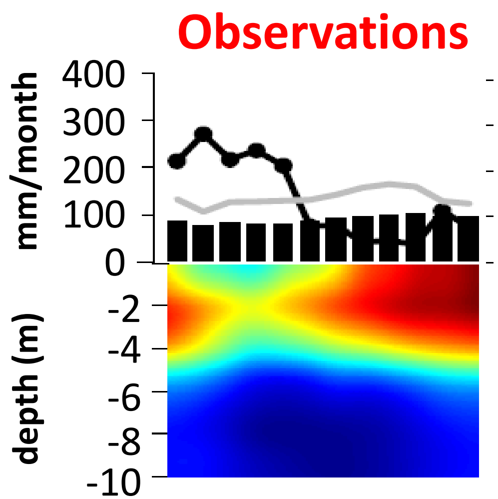
- What are the **seasonal** drivers of **evapotranspiration** (ET)?

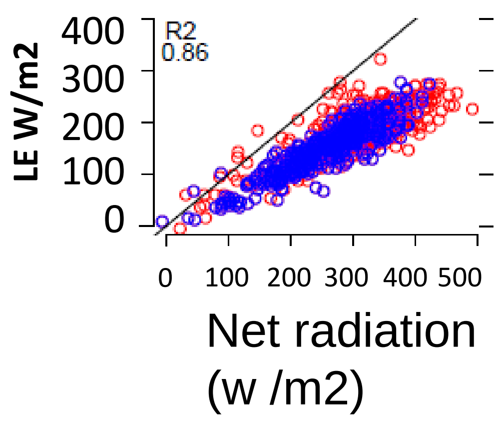
- Belowground mechanisms: How does **soil moisture storage capacity** and **representation of roots** influence model performance?

Drivers of ET Seasonality

ET Seasonality: K67 (Observations)

(seasonal moist tropical forest)





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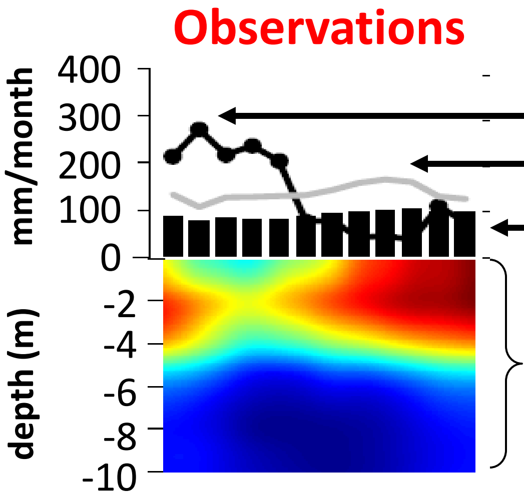
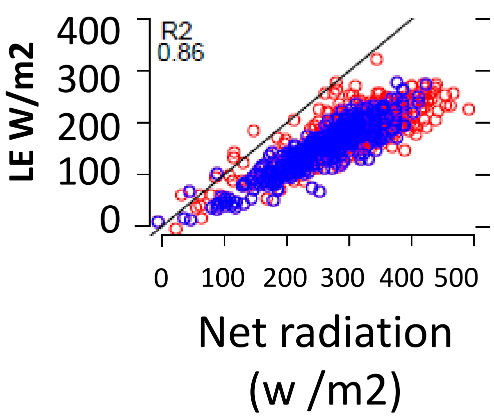


Precipitation (mm/month)

Net radiation (mm/month water equivalent)

ET (mm/month)

Soil moisture (normalized to maximum)

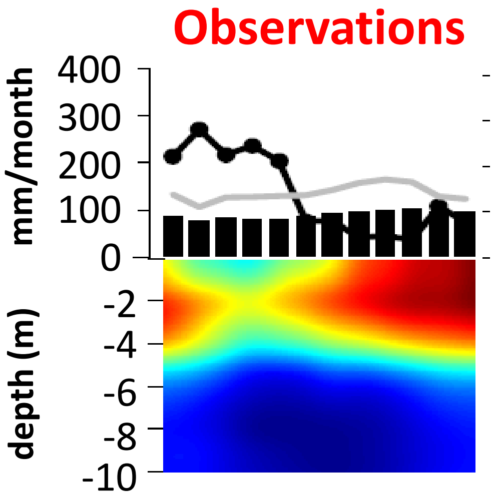


Red: Dry season ET

Blue: Wet season ET

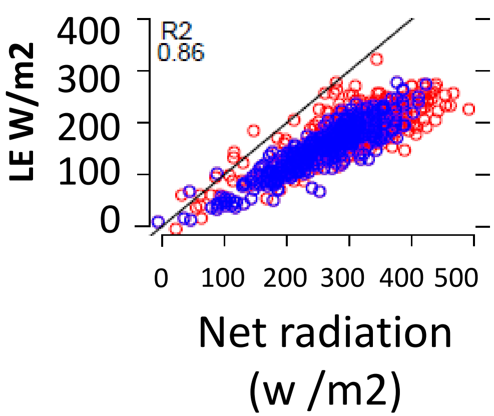
ET Seasonality: K67 (Observations)

(seasonal moist tropical forest)



ET peaks in the dry season

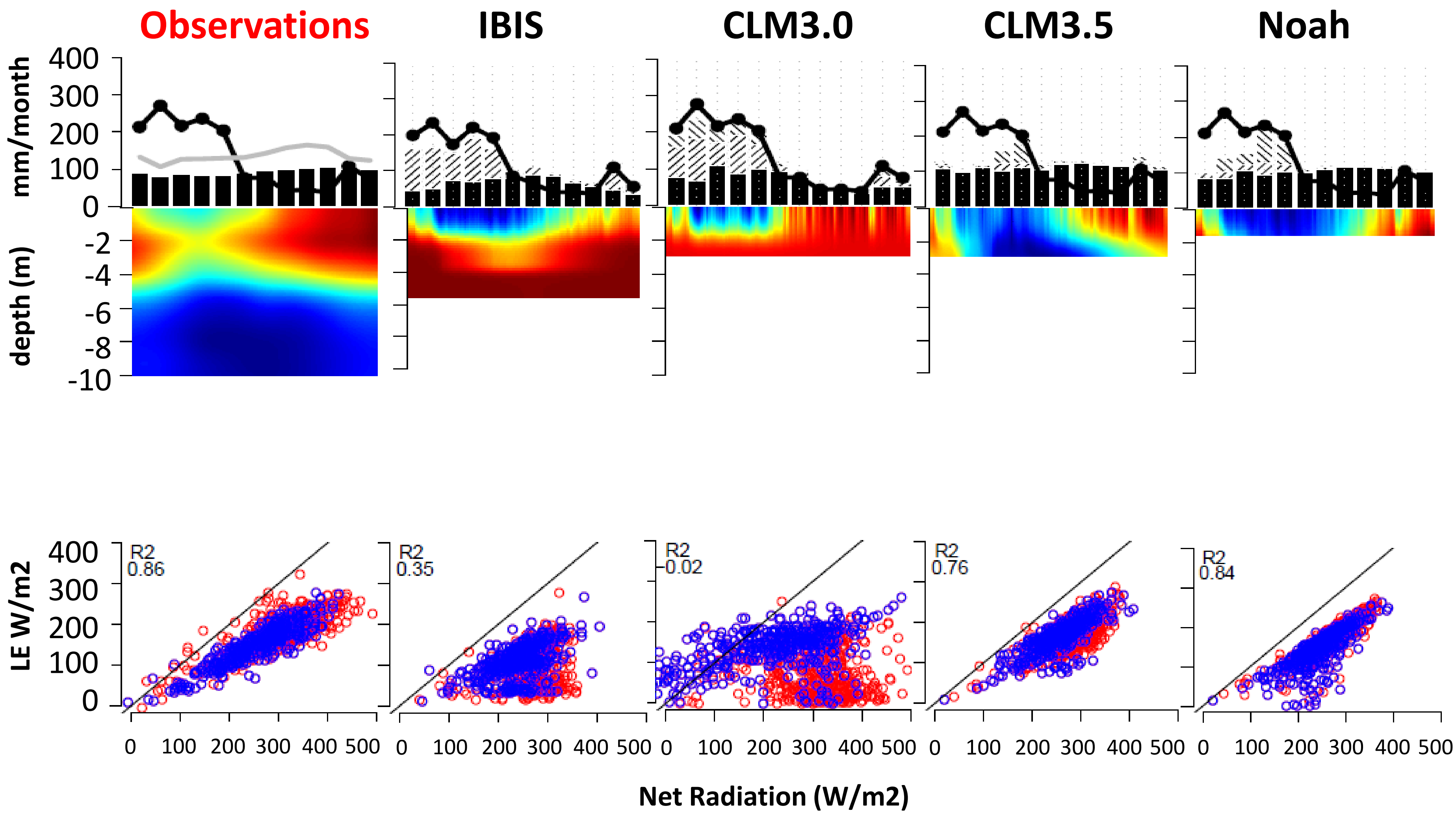
Deep drying & root water uptake



Available energy explains 86% of variation in ET

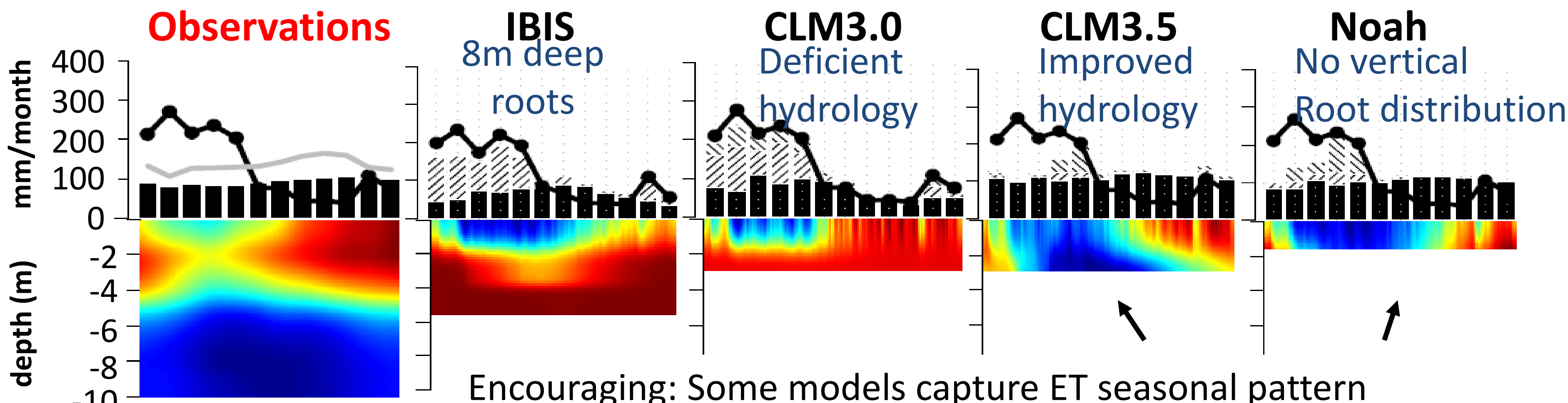
ET Seasonality: K67 (Intercomparison)

(seasonal moist tropical forest)



ET Seasonality: K67 (Intercomparison)

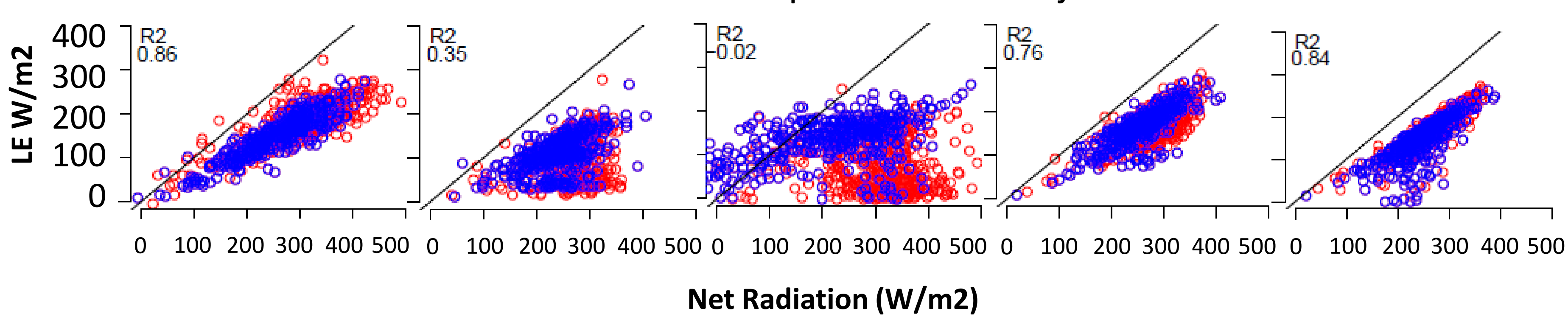
(seasonal moist tropical forest)



Encouraging: Some models capture ET seasonal pattern

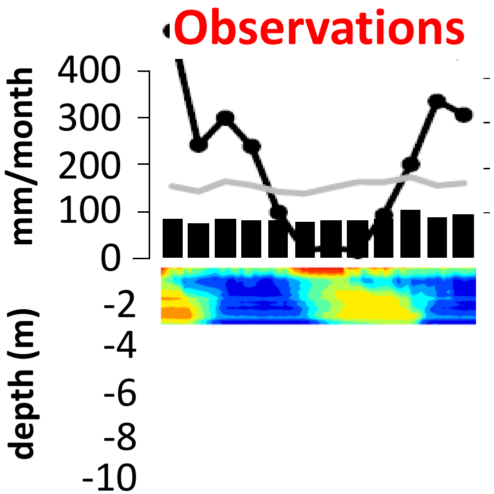
→ Release of moisture stress; available energy controls ET

→ Is aquifer in CLM3.5 justified?



ET seasonality: RJA (observations)

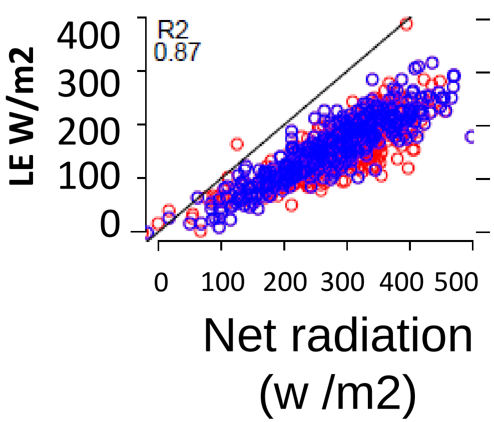
(seasonal transitional tropical forest)



ET constant throughout dry season

Soil moisture (Hodnett & Gash; ABRACOS Experiment)

→ Shallow soil but seasonal water table influence



Available energy explains 87% of variation in ET

ET seasonality: RJA (intercomparison)

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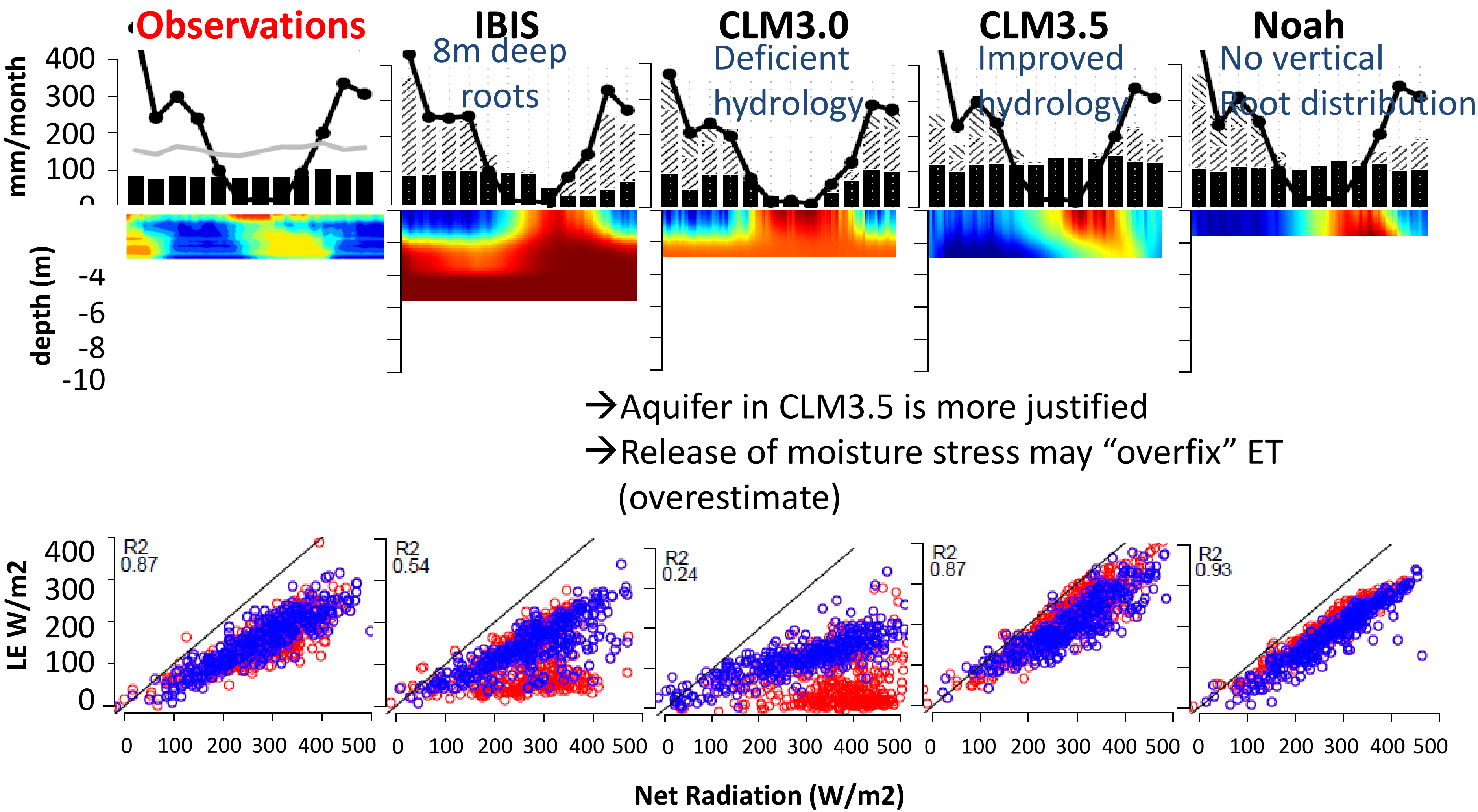
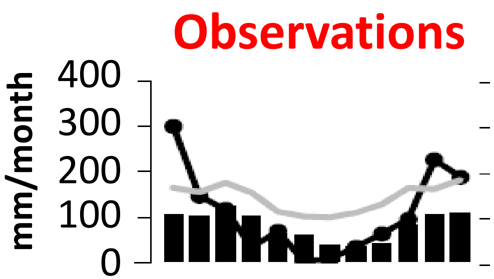


→Aquifer in CLM3.5 is more justified

→Release of moisture stress may "overfix" ET (overestimate)

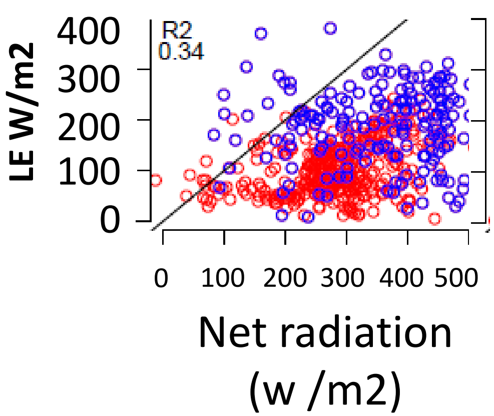
ET seasonality: PDG (observations)

(cerrado / savanna)



ET trough in the dry season

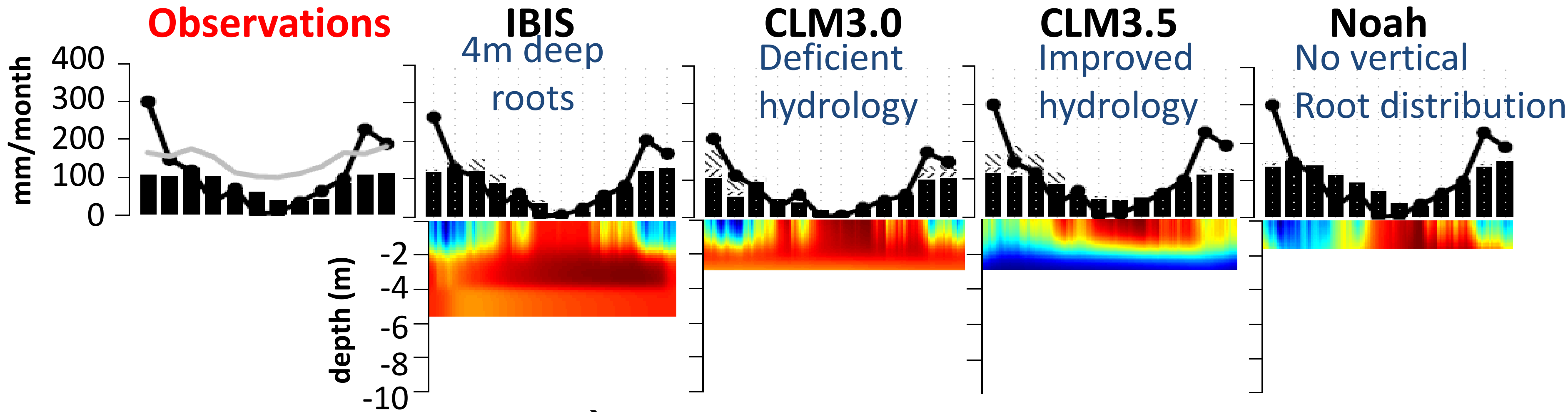
Soil moisture observations N/A



Available energy explains only 34% of variation in ET

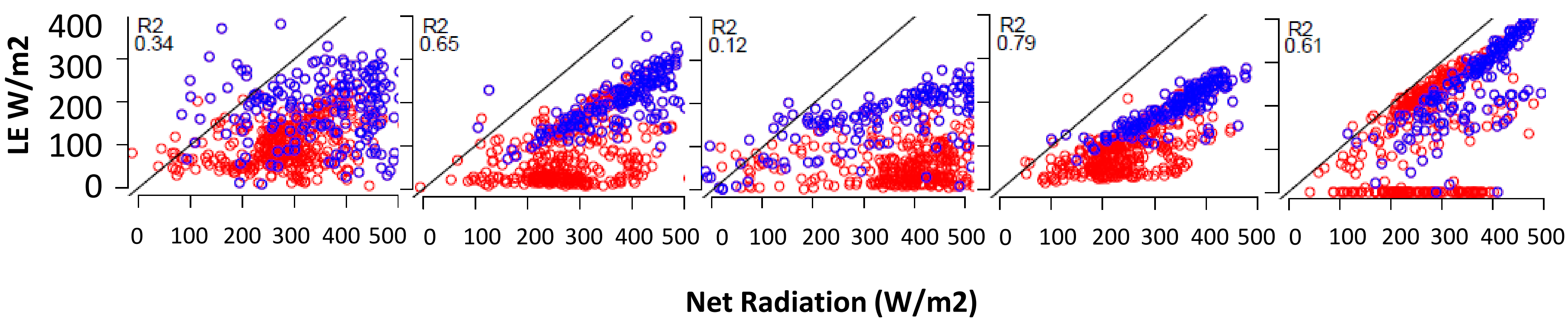
ET seasonality: PDG (intercomparison)

(cerrado / savanna)

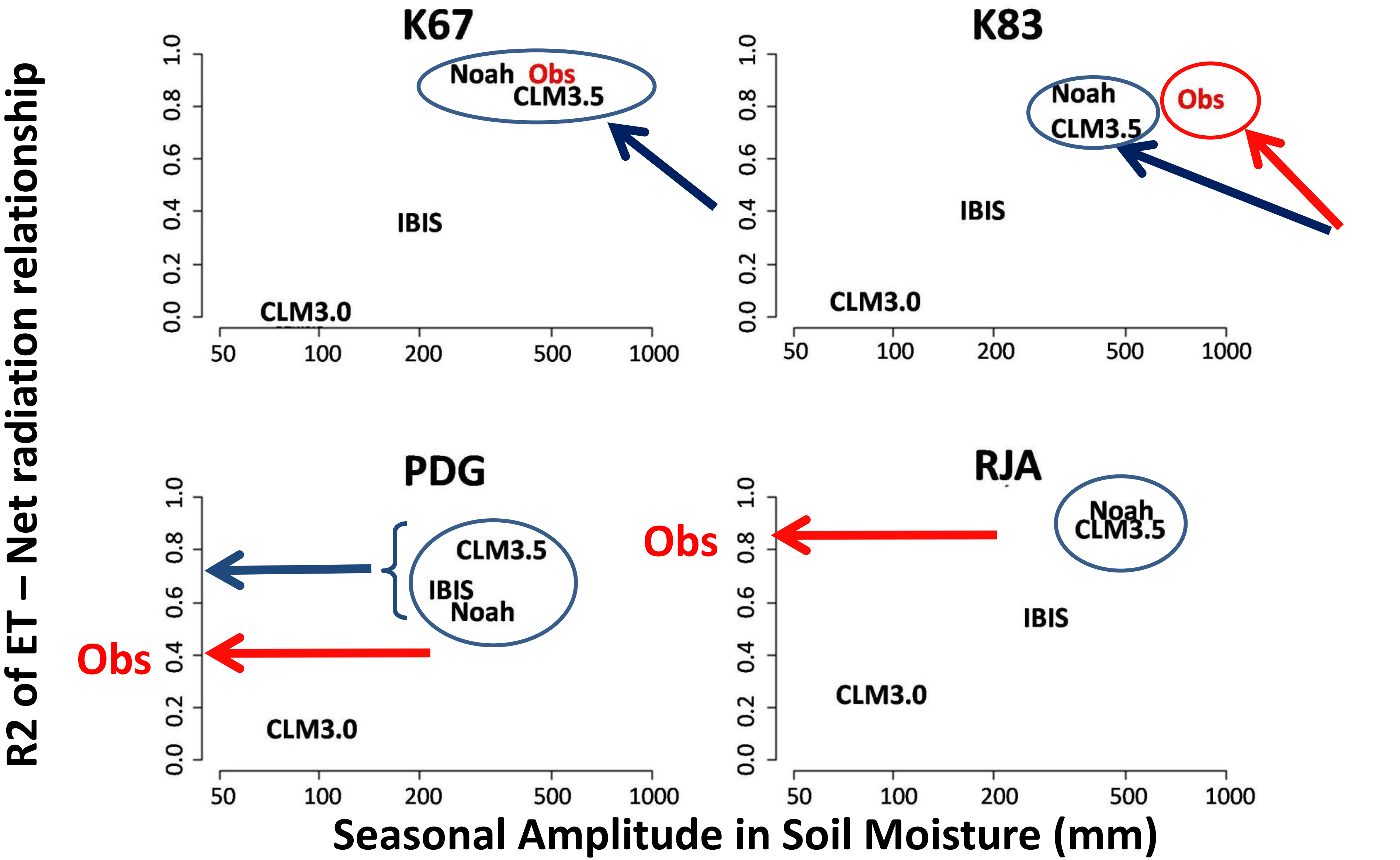


→ET seasonal pattern well captured by most models

→Some models still overestimate (soil too wet?)



Soil moisture storage capacity and net radiation control of ET

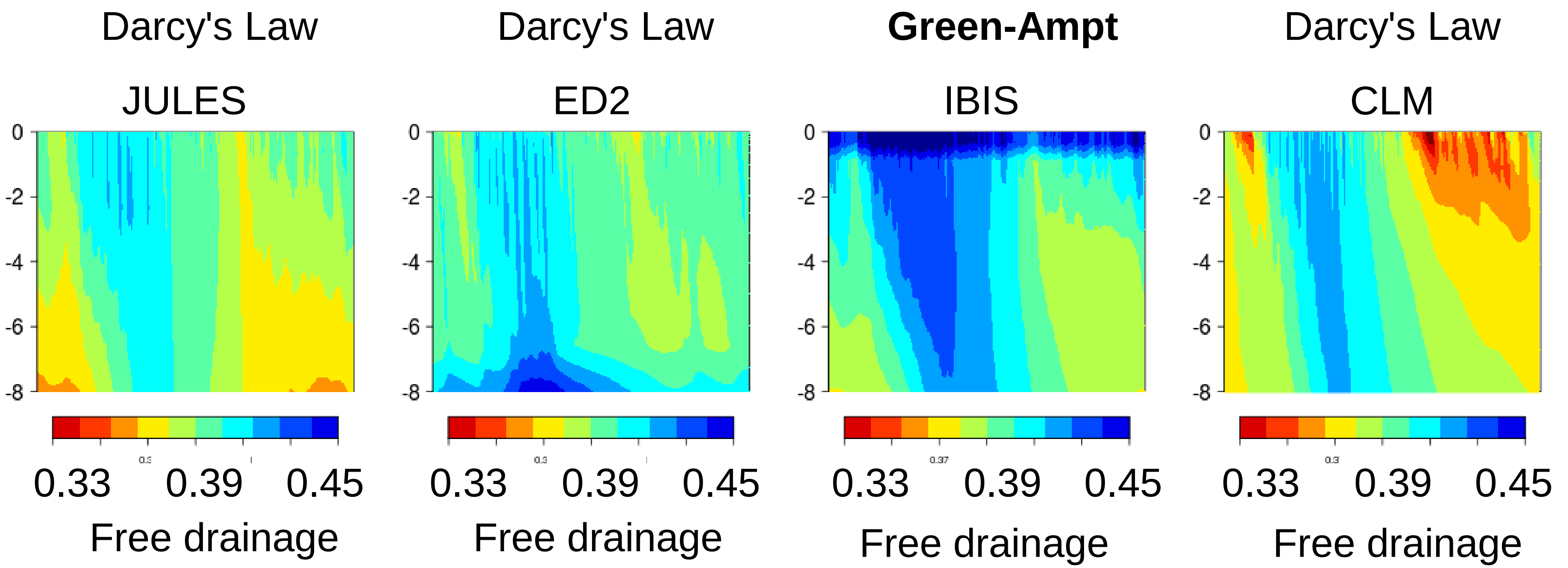


Ongoing & future work

Partitioning the biological from the physical: roles of root water uptake functions in explaining flux differences

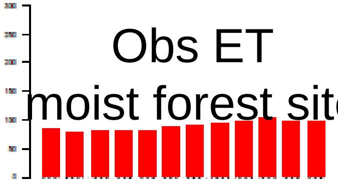
Differences in soil moisture across models w/ standardized hydrology

UPPER BOUNDARY CONDITION (INFILTRATION)



BOTTOM BOUNDARY CONDITION

Subsurface aquifer in CLM generates very wet soils and is unrealistic

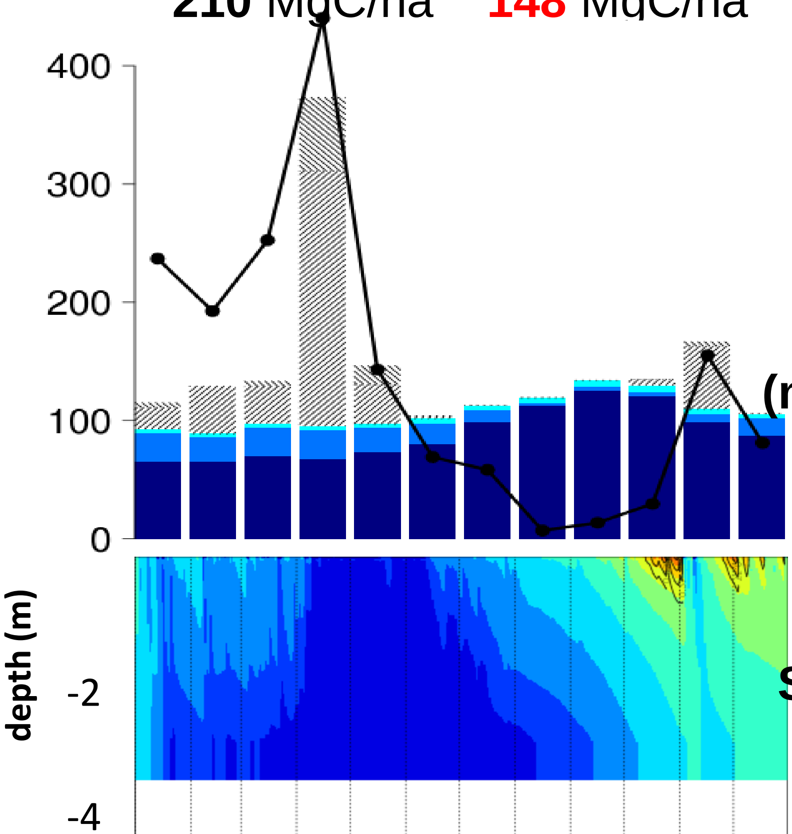


CLM-DGVM Default

Aboveground Biomass

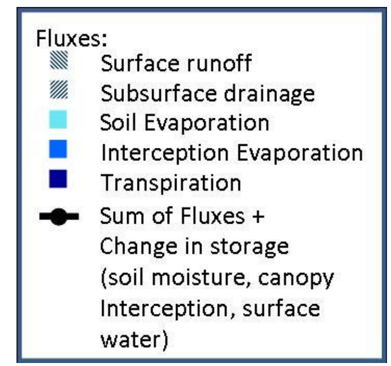
Simulated *Observed*

210 MgC/ha **148** MgC/ha



water flux (mm/month)

Soil moisture (m3/m3)



Subsurface aquifer in CLM generates very wet soils and is unrealistic …as are shallow soils!

CLM-DGVM Default

Aboveground Biomass

Simulated *Observed*

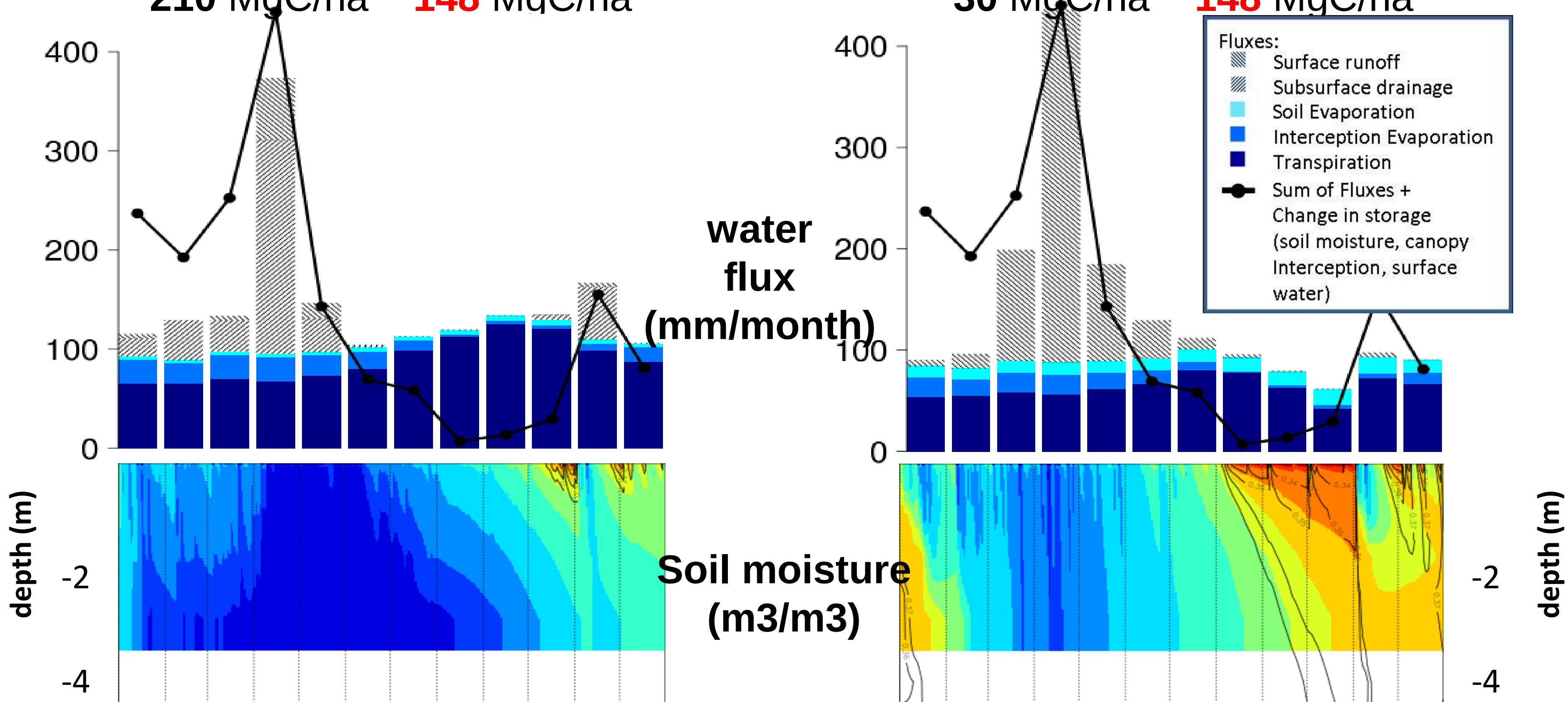
210 MgC/ha **148** MgC/ha

CLM-DGVM Free Drainage (no aquifer)

Aboveground Biomass

Simulated *Observed*

30 MgC/ha **148** MgC/ha



Removal / modification of unrealistic model components

- **Observed** characteristics of clay-rich Amazonian soils:
  - Highly weathered & deep (FAO 2008)
  - High infiltration rates and low surface runoff (Nepstad et al., 2002) (high surface root densities?)
  - Deep water tables on remnant plateaus (Nepstad et al., 2002)
- **Modifications**
  - Model a deep soil column (increase from 3.5 to 8 m)
  - Create small (10mm max) prognostic surface water store to allow higher infiltration rates during pulse rainfall events
  - Reinstate free drainage bottom boundary condition:

$$q_{bot} = k = f(ksat, \theta_{bot}) \qquad \textit{(mm/s)}$$

Proposed mechanism of drought tolerance

- Default case: Root density-dependent water uptake

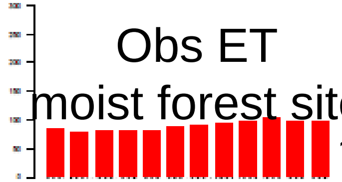
$$r_{e,t} = \frac{\sum_{j=1}^{npft} \left(r_{e,t}\right)_j \left(E_v^t\right)_j \left(w\,t\right)_j}{\sum_{j=1}^{npft} \left(E_v^t\right)_j \left(w\,t\right)_j}$$

Zeng et al., 2001, Jackson et al., 1996

- Alternative hypothesis: Relaxation of rooting density-dependent water uptake
  - Suggested by other models (Baker et al., 2008; Moorcroft et al., 2001)
- Neither hypothesis has been definitively rejected

Free Drainage
Deep soil (8m)

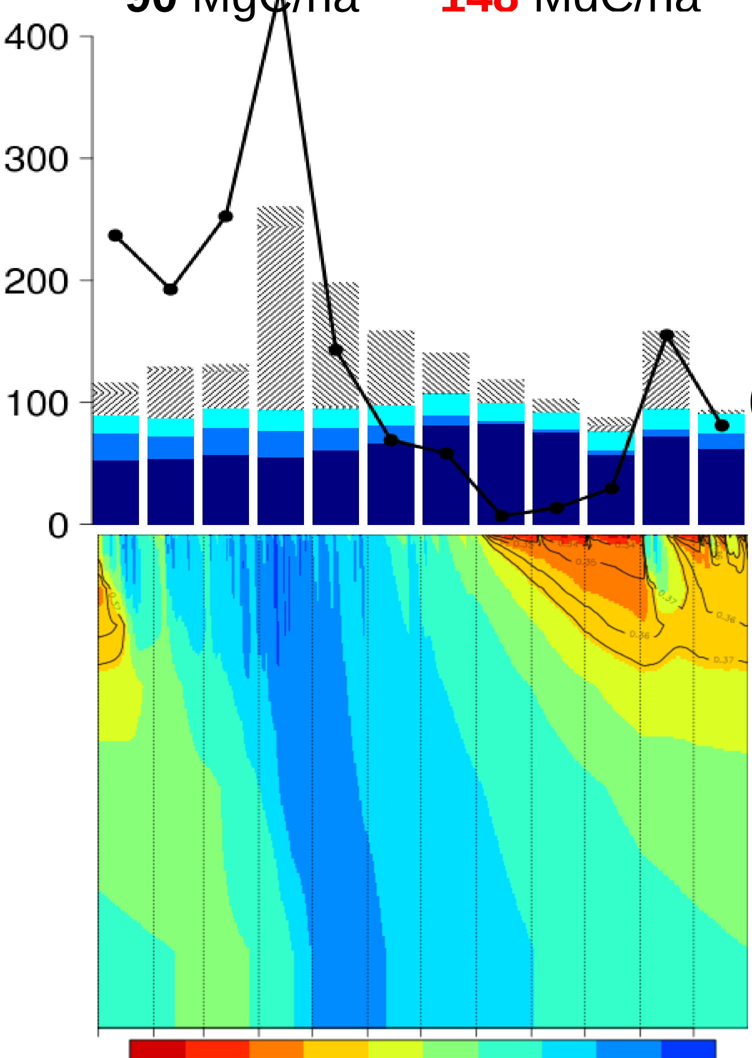
Obs ET
moist forest site



Free drainage
Deep soil (8m)
Increased infiltration, rooting depth uptake

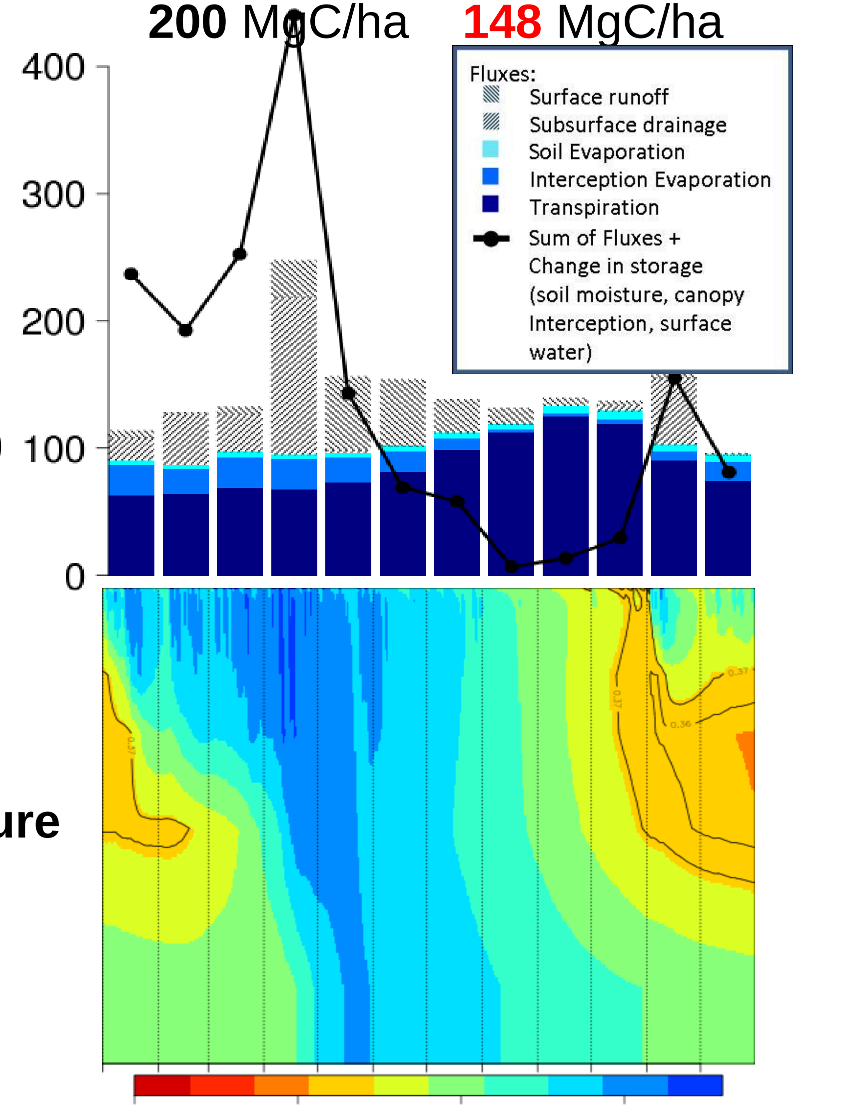
Aboveground biomass
Simulated *Observed*
90 MgC/ha **148** MgC/ha

Aboveground biomass:
Simulated Observed
200 MgC/ha **148** MgC/ha

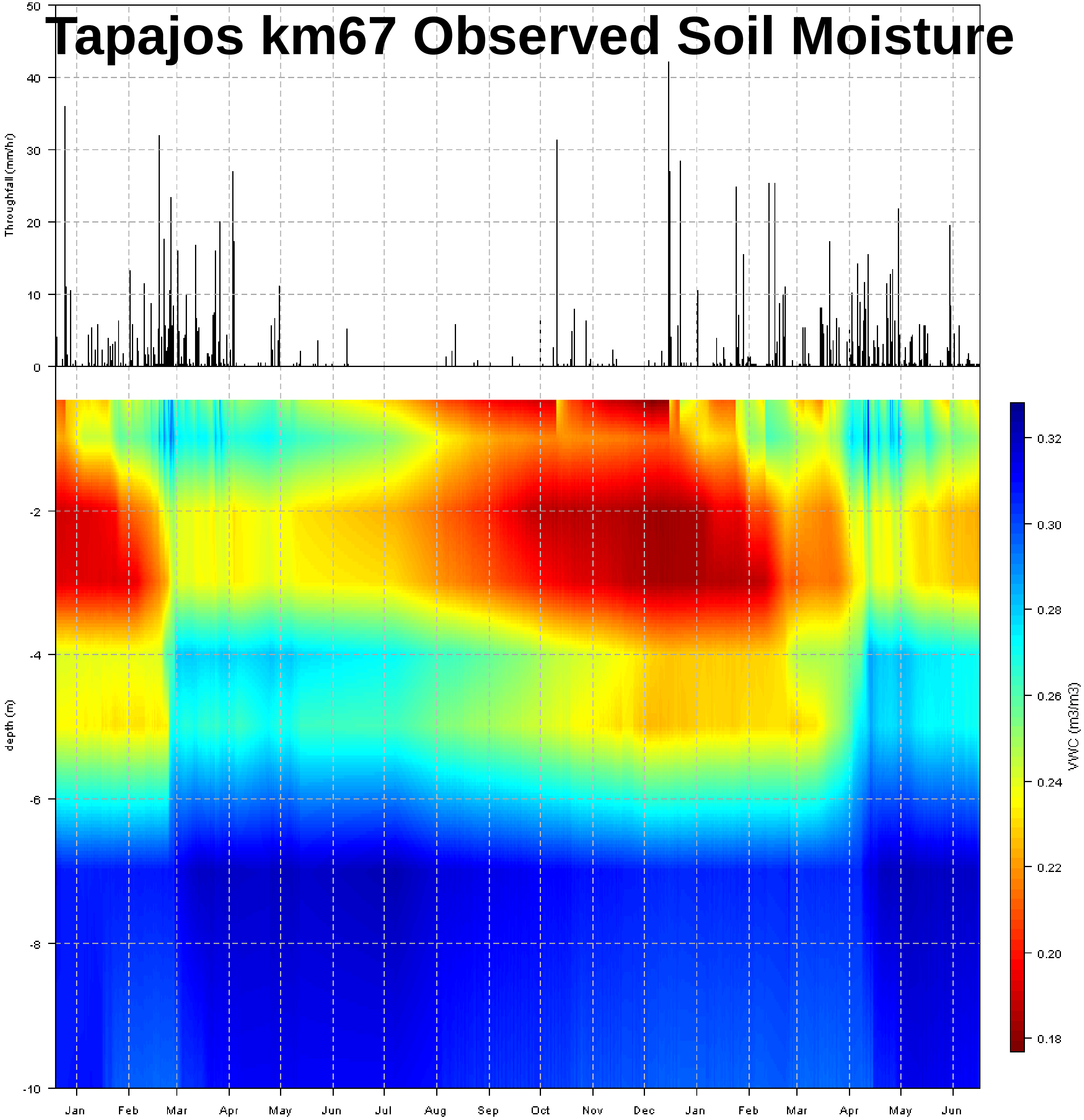


water flux (mm/month)

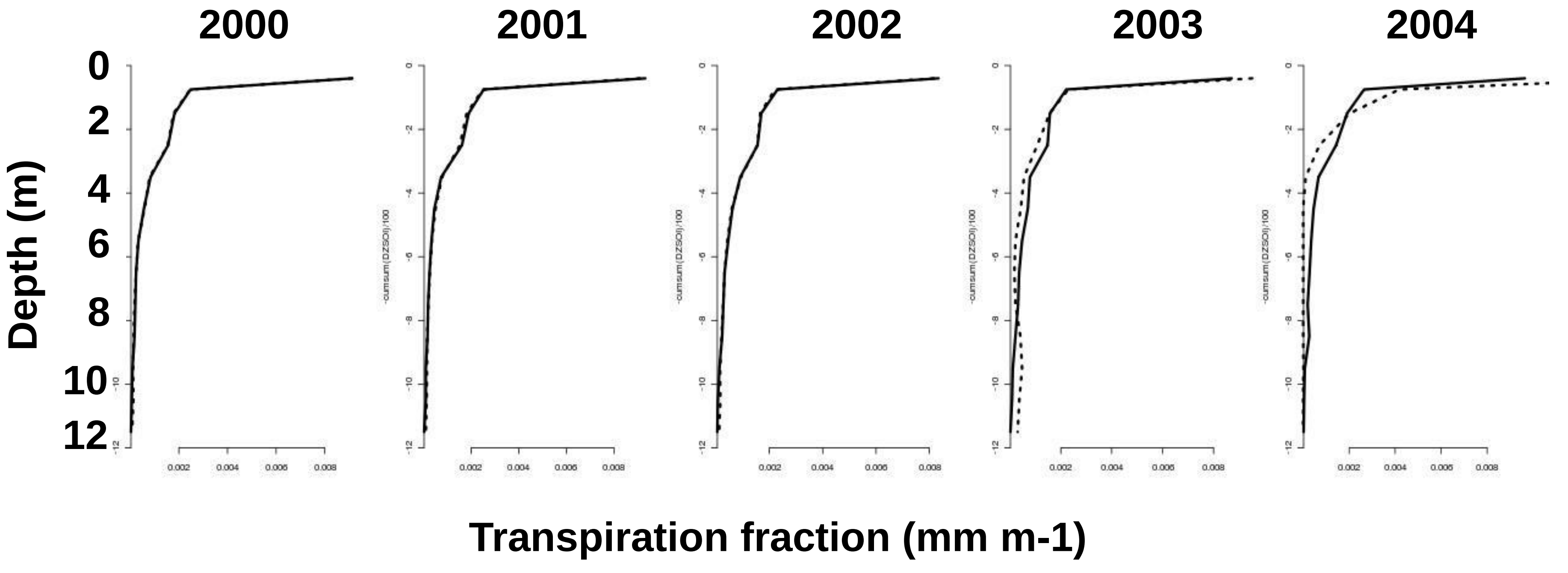
Soil moisture (m3/m3)



Tapajos km67 Observed Soil Moisture



Root water uptake estimates for model validation (Markewitz et al., 2010)



Summary & Conclusions

- Here, I explored: mechanisms leading to deficiencies, mechanisms necessary for good performance
  - Deep roots: provides a fix in the right direction, but points to need to further develop uptake functions
  - Aquifers: provides a needed moisture reserve, but recharge fluxes are questionable
  - Seasonal soil moisture dynamics: capturing observed variability important for "atmospheric control" on ET