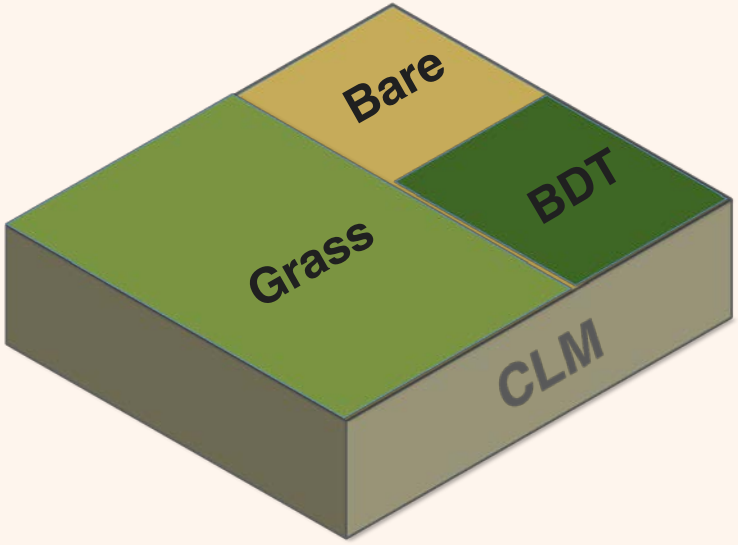
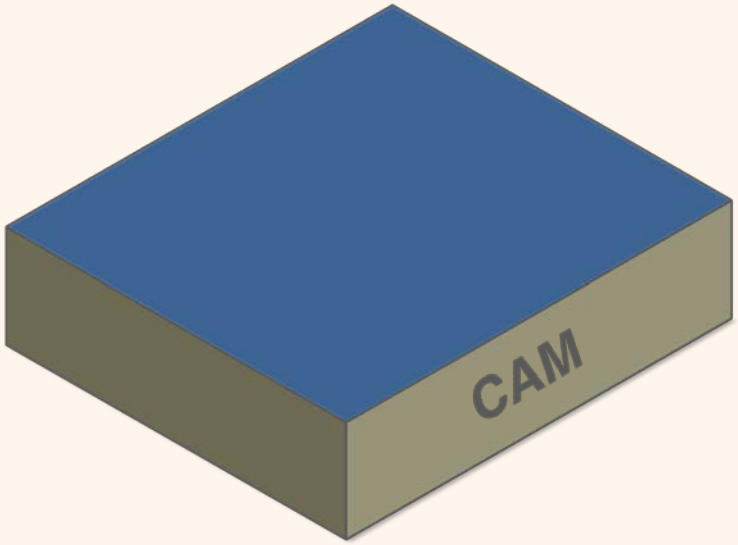
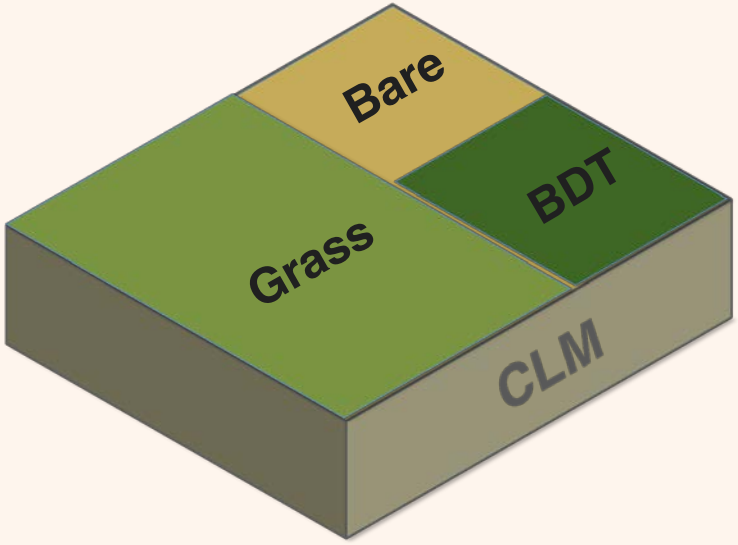
Tracking Land-Atmosphere Coupling in CESM

Ahmed Tawfik
NCAR CGD, TSS

Simulations Courtesy of:
Cecile Hannay!, Colin Zarzycki, Yu-heng Tseng


Bare
BDT
Grass
CLM


CAM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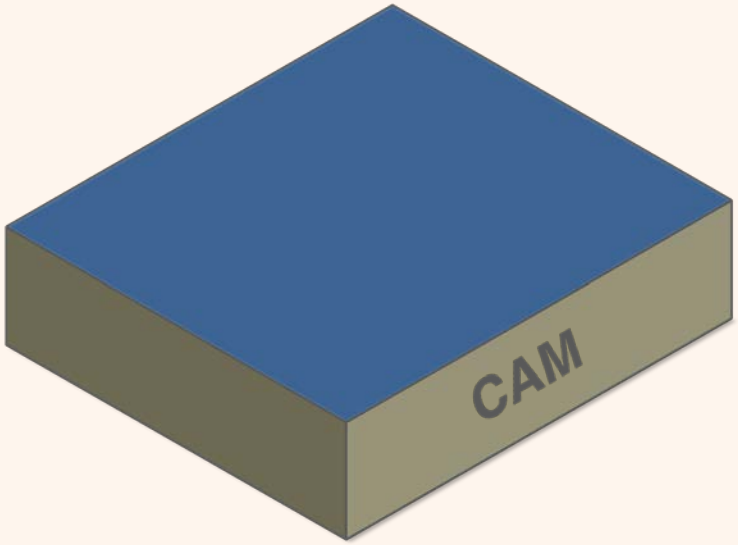
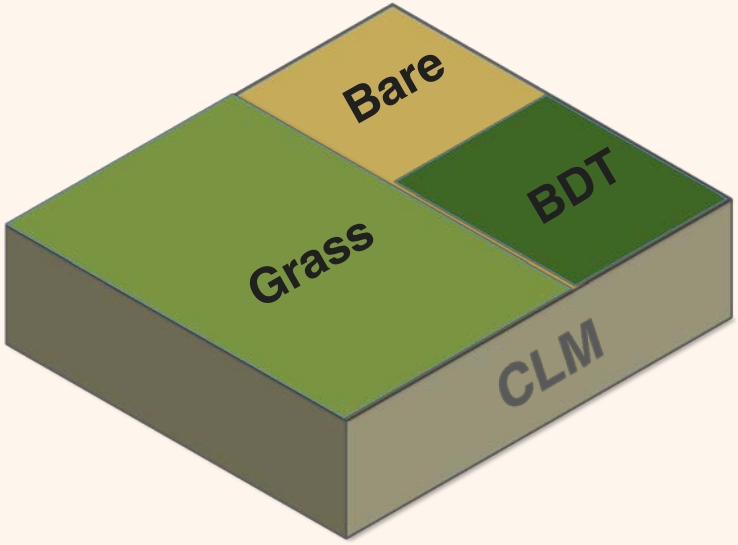
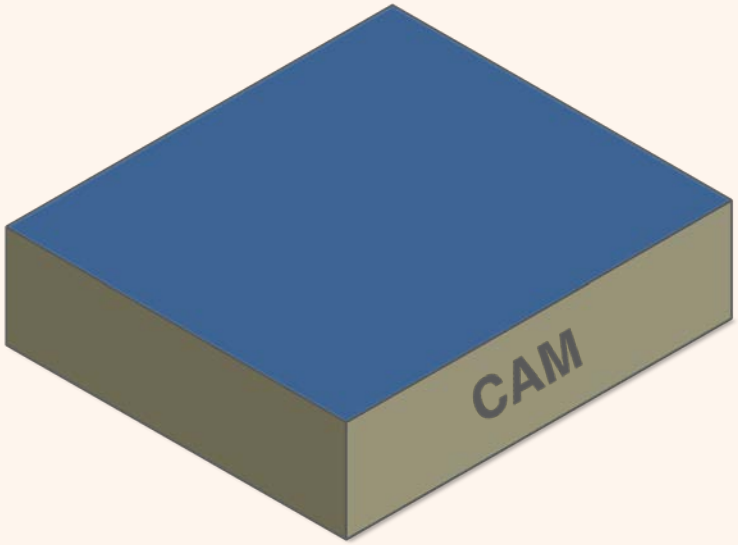


CLUBB | Updates to MAM | Consistent auto-conversion | Improved momentum and drag | Variable Mesh | CSLAM and dycore changes



Variable Soil Depth | Dry layer soil | More realistic Nitrogen cycle | Drought stress pheno correction | More crop types | Surface datasets | Multi-layer Canopy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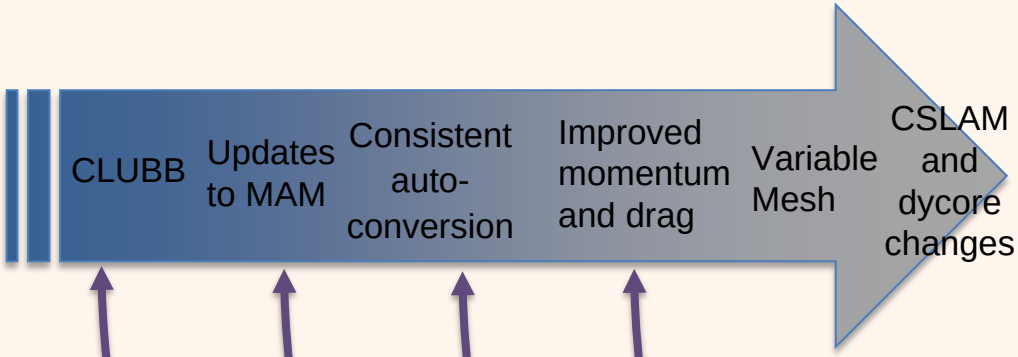
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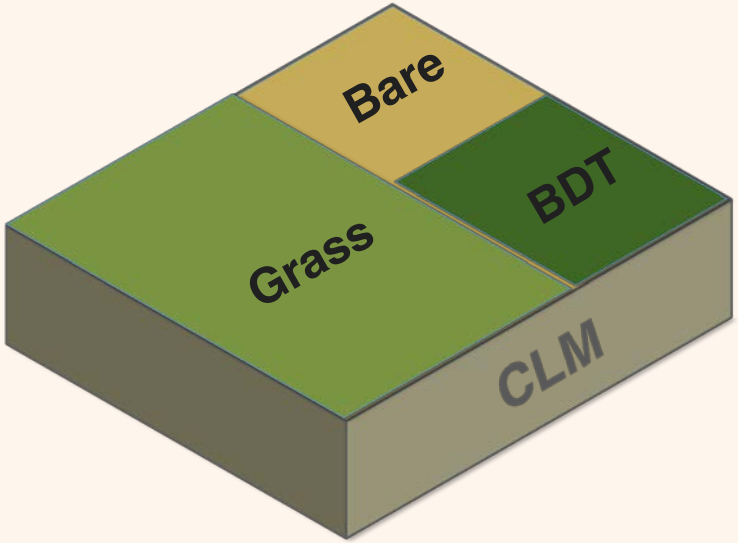
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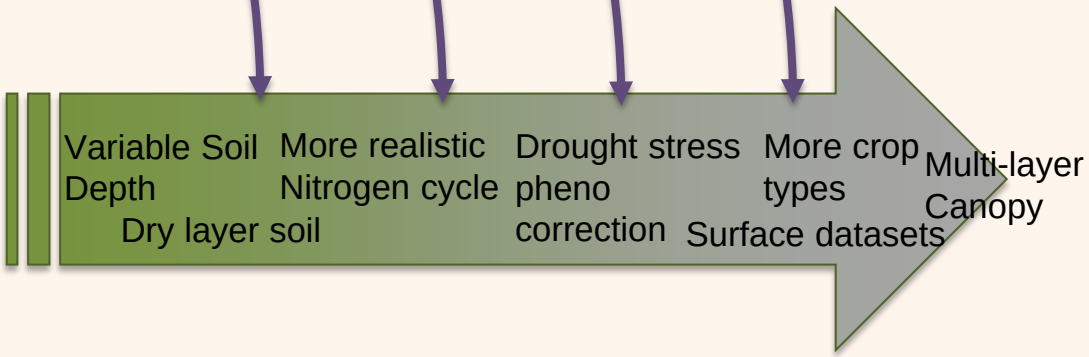
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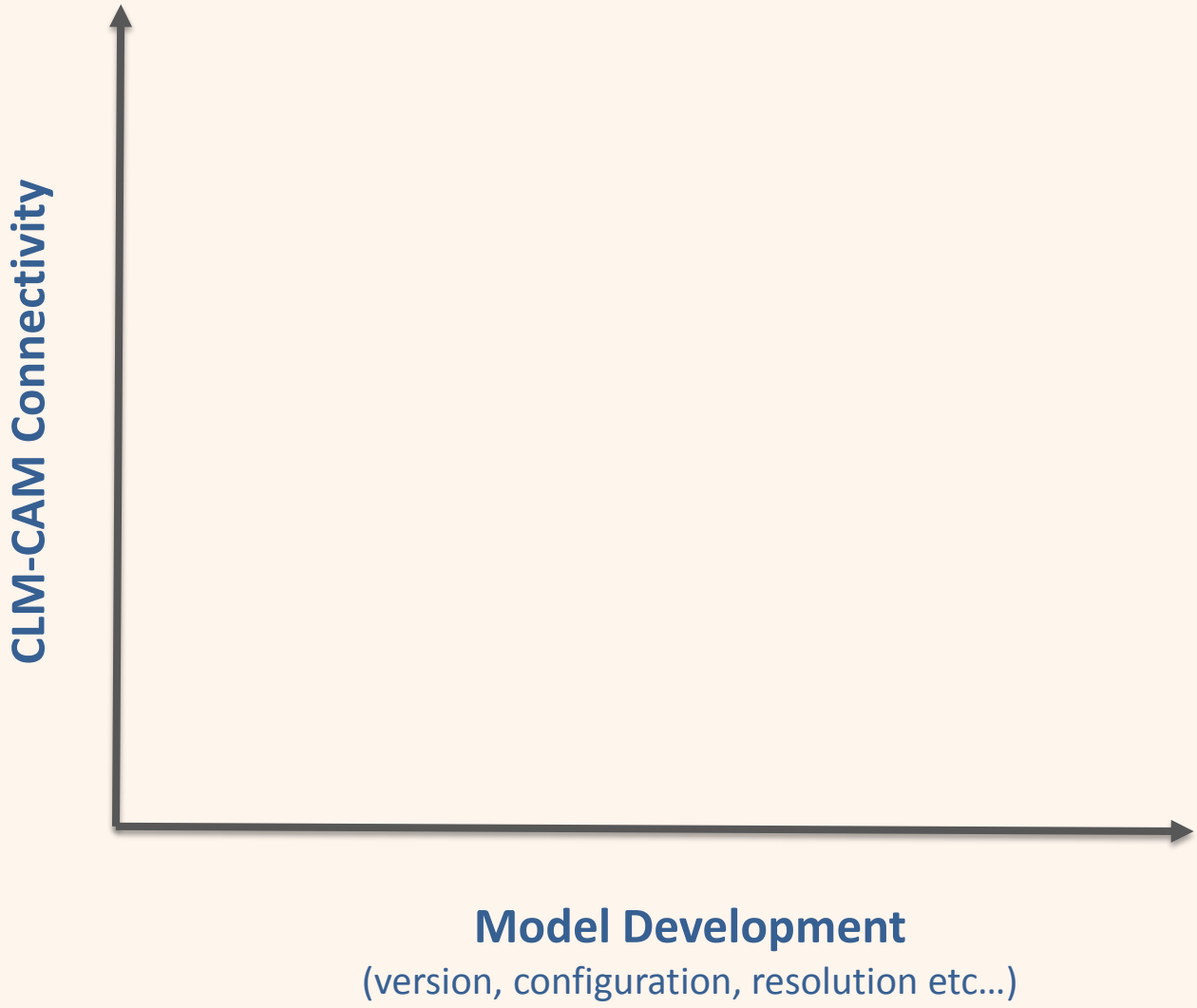
Surface datasets
Multi-layer Canopy

How sensitive is **CLM** to changes in **CAM** and visa-versa?



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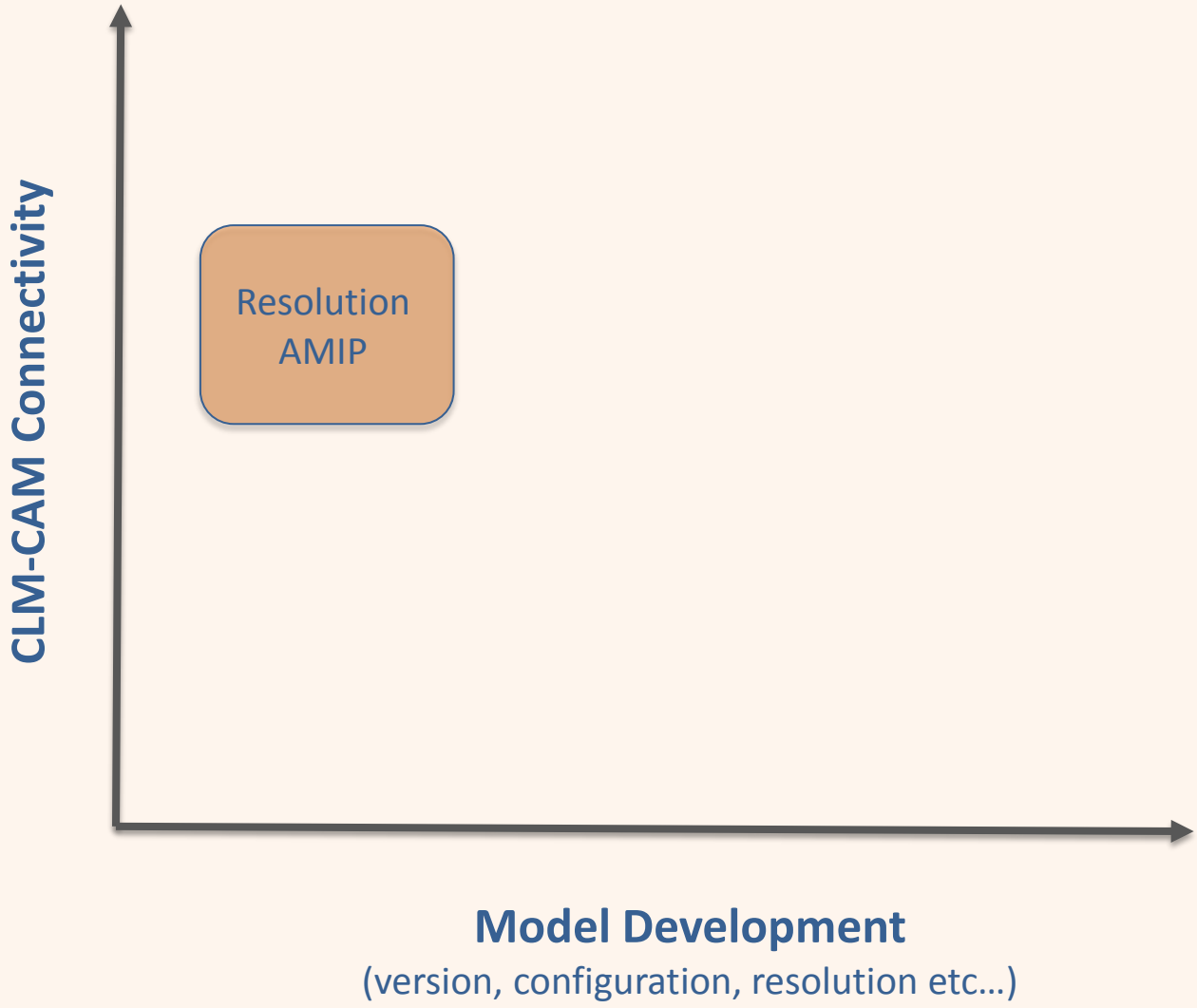

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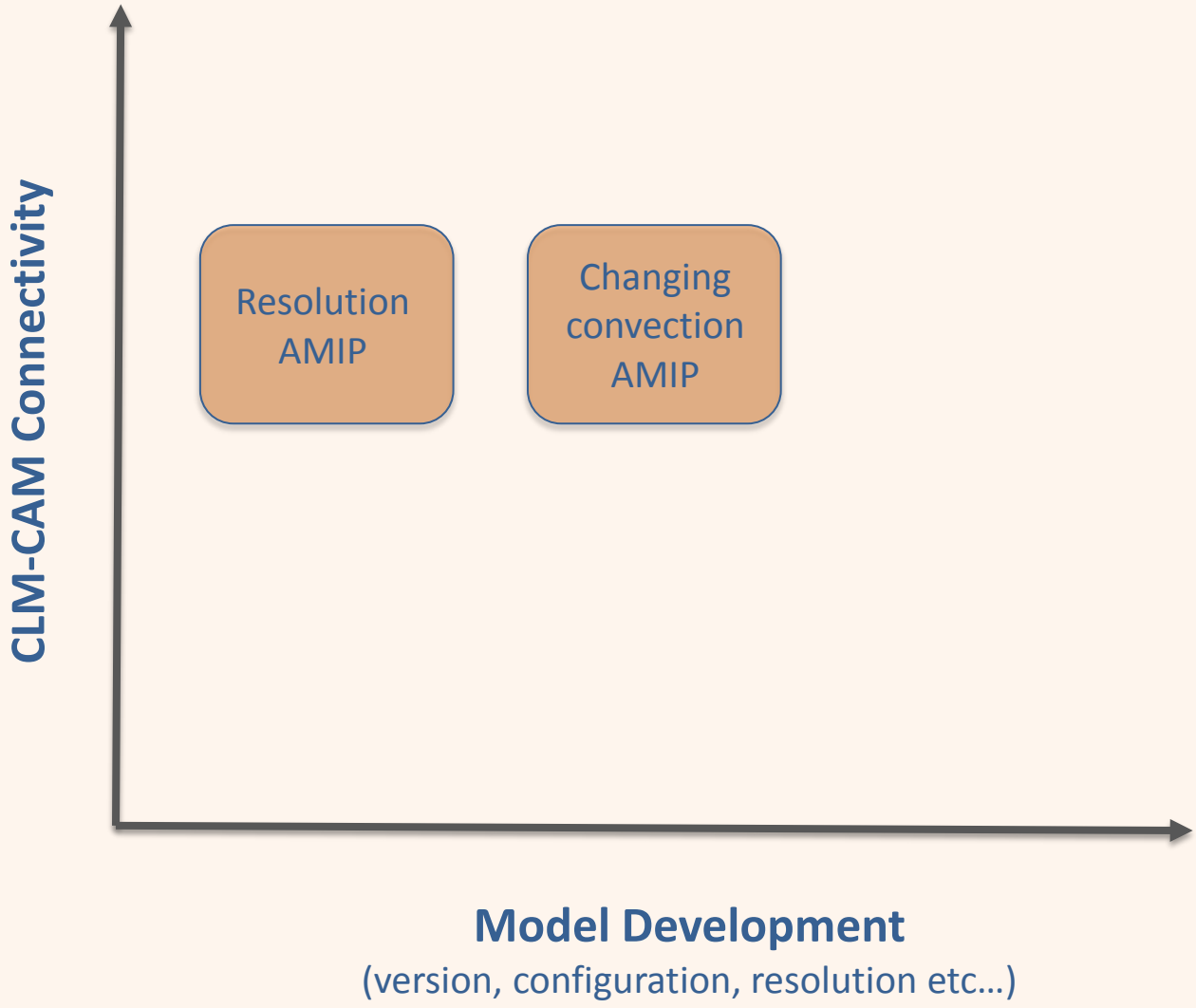

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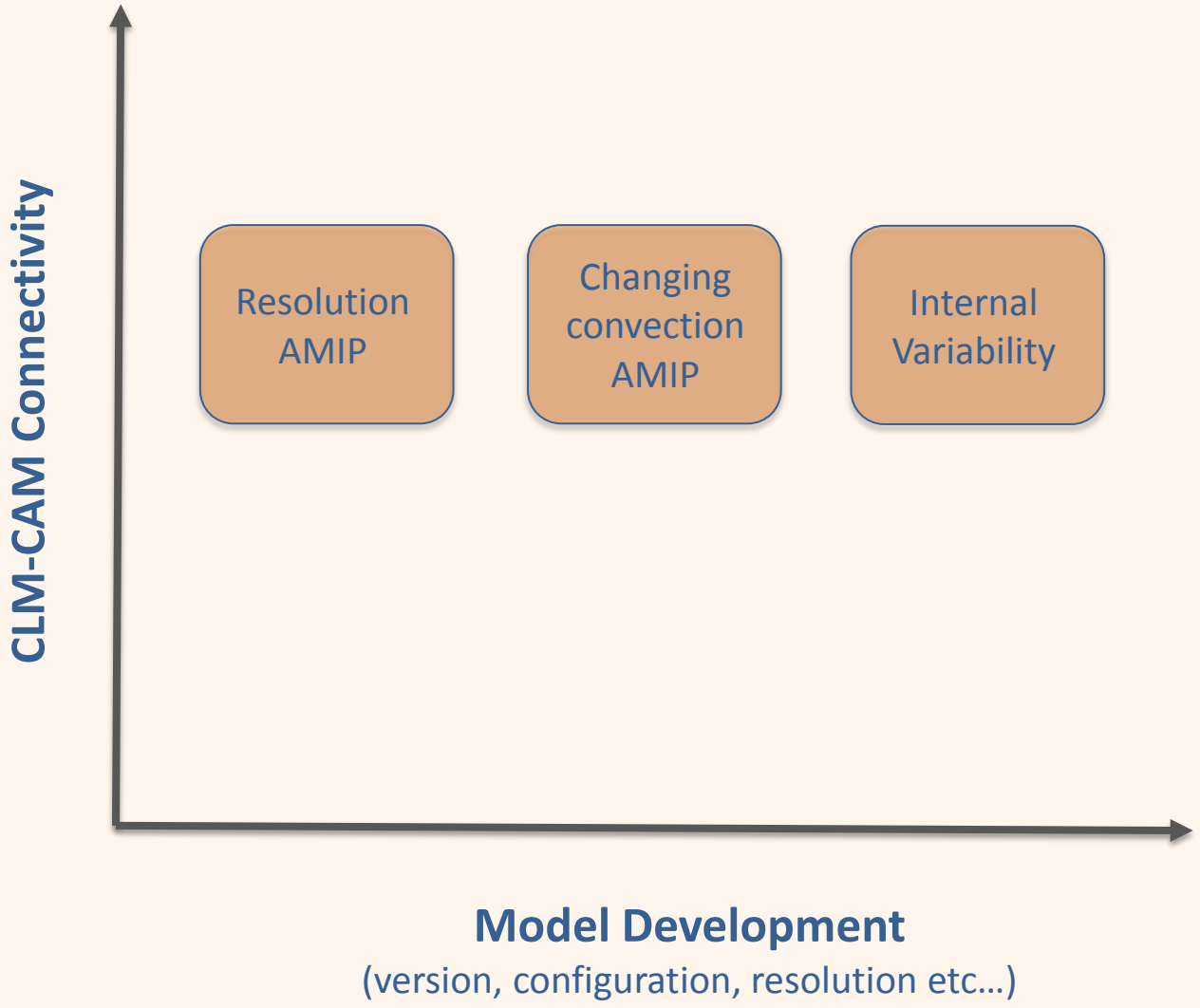

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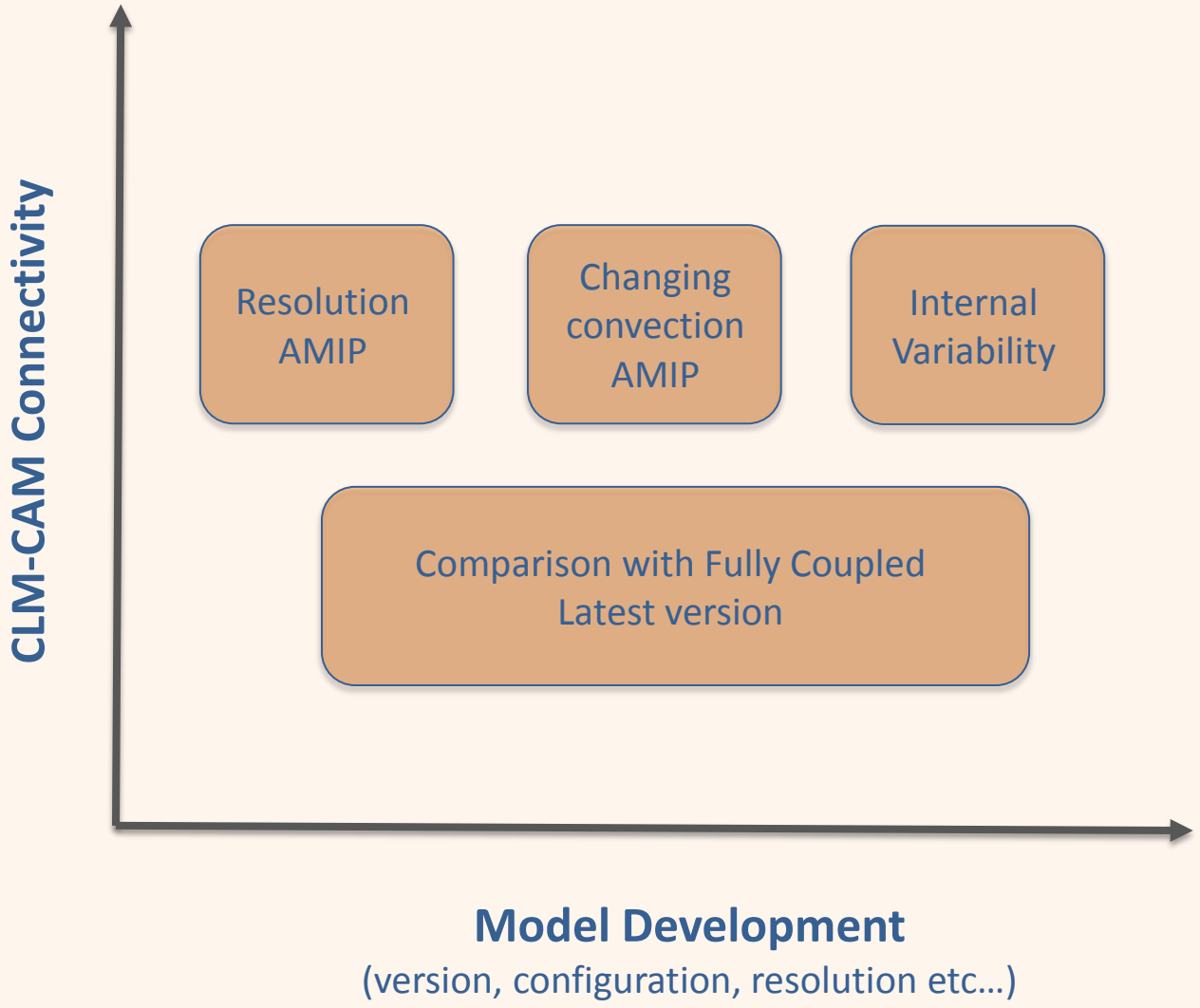

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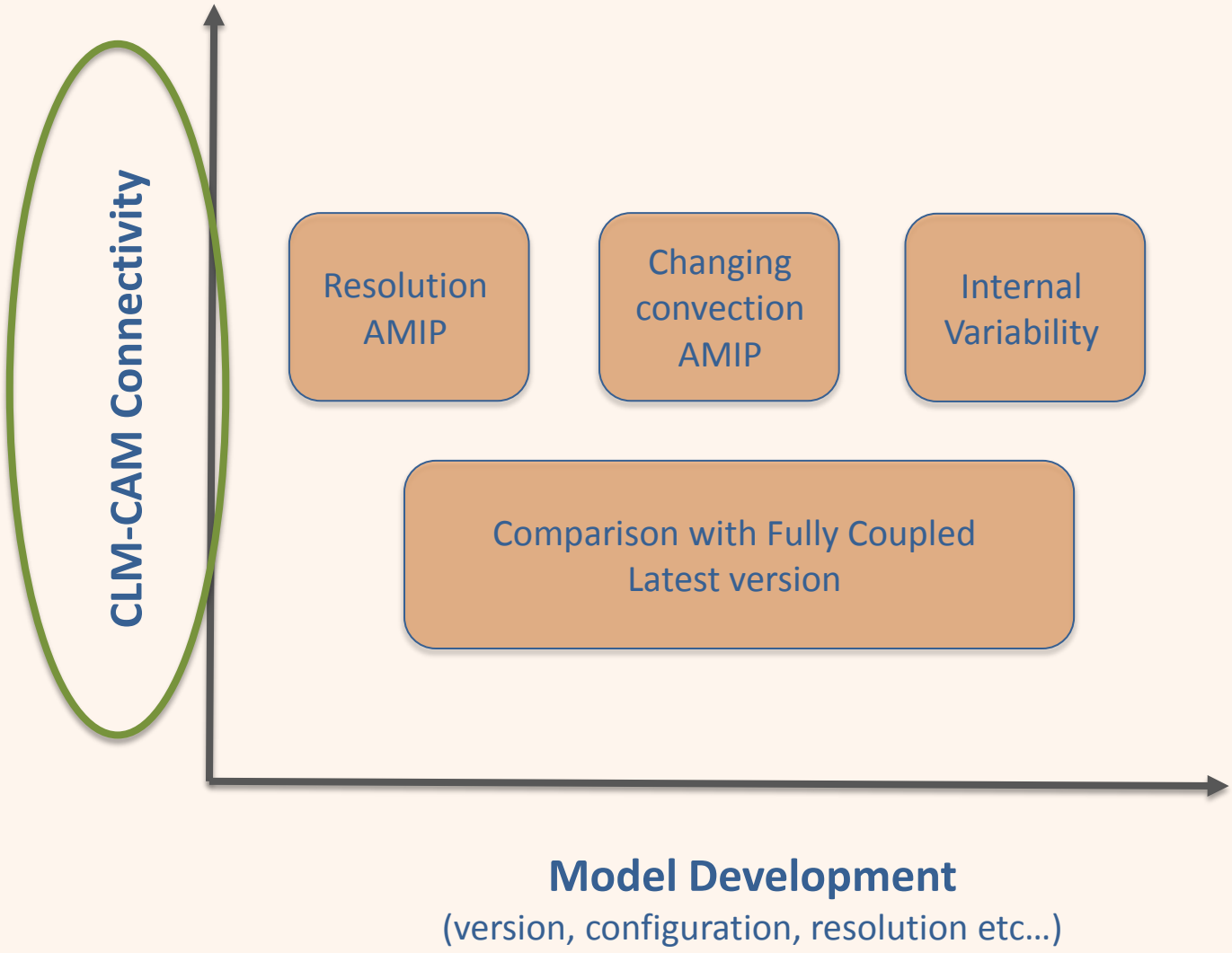
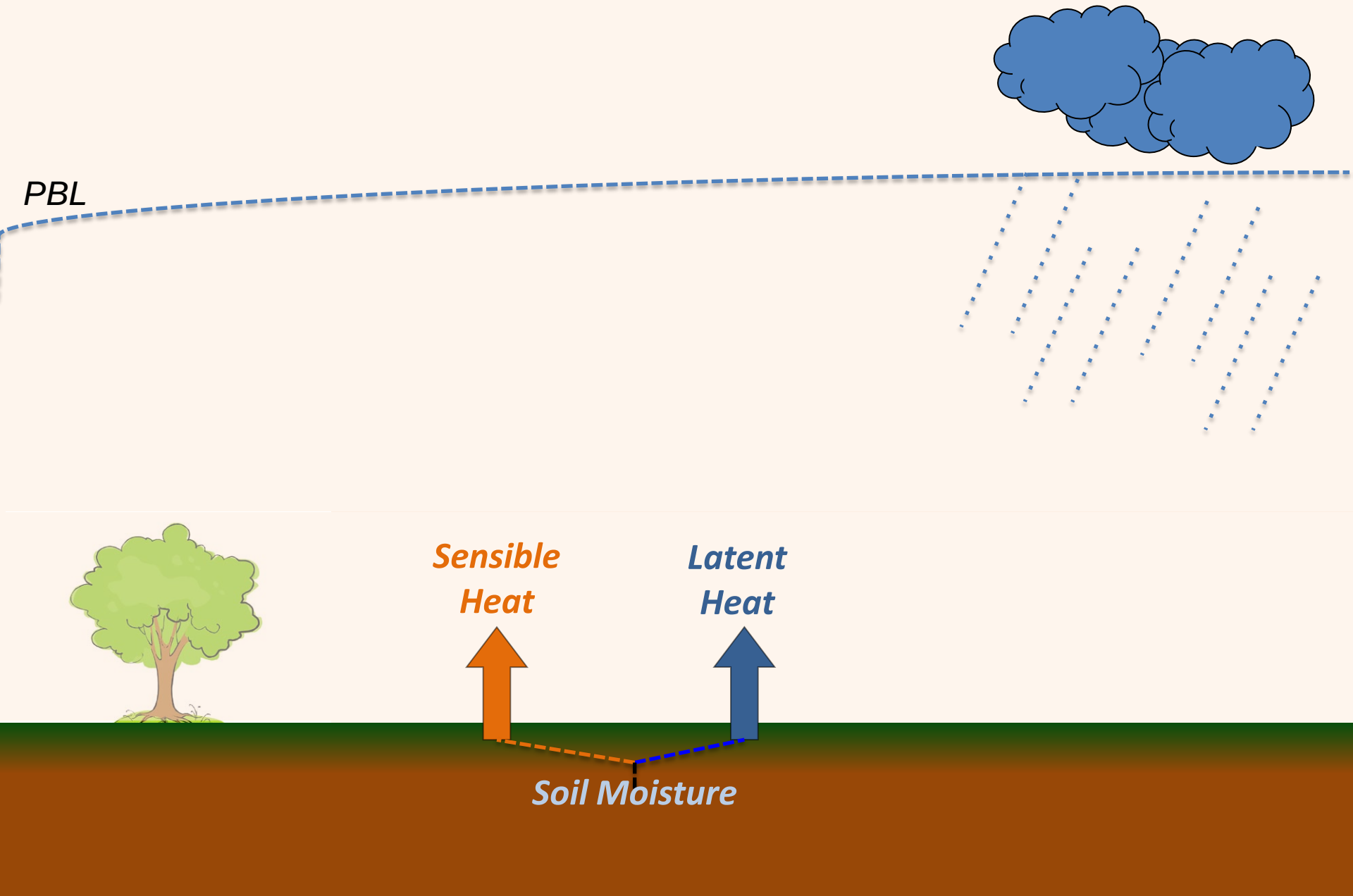


Quantifying CLM-CAM connectivity



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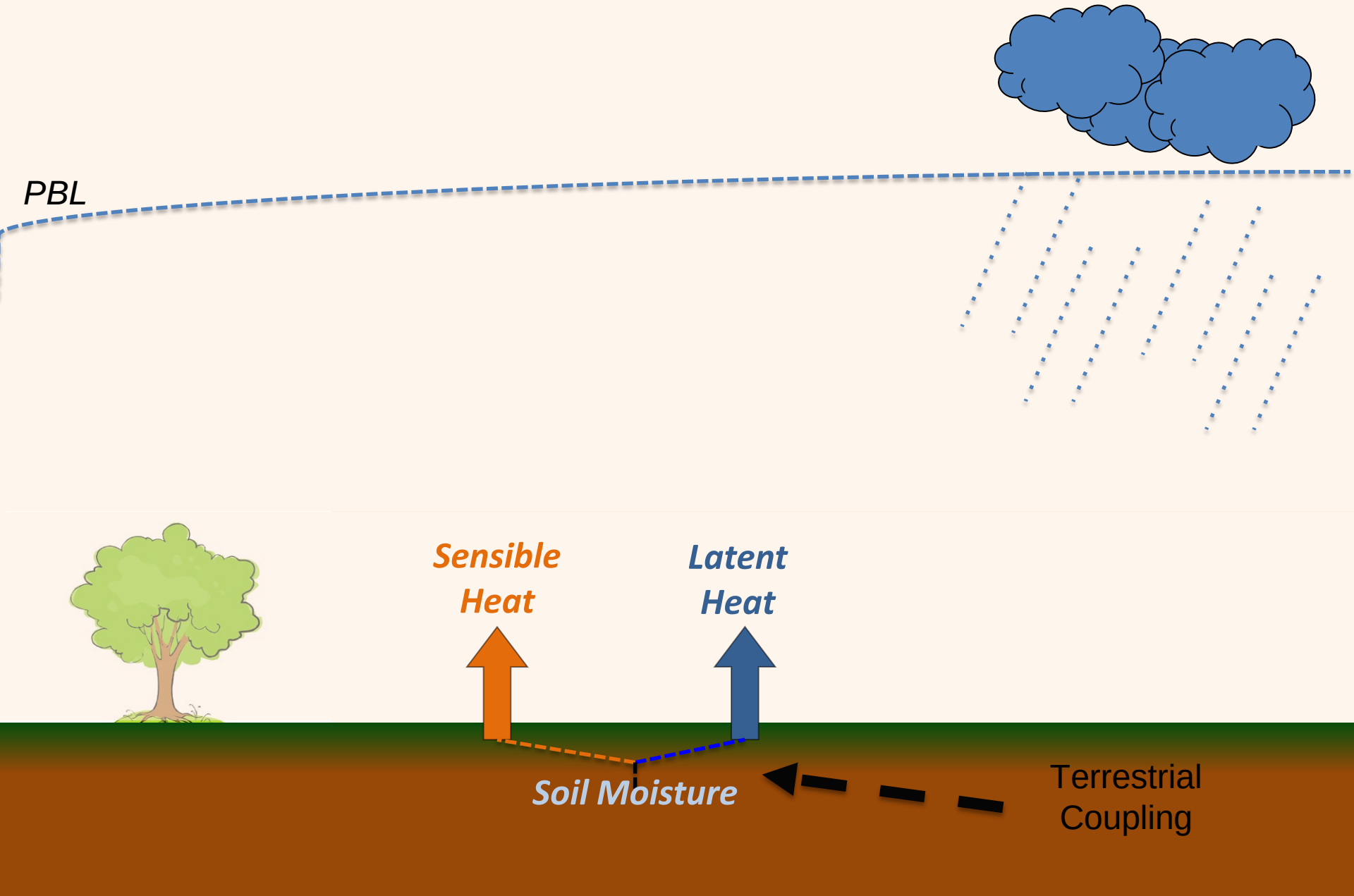

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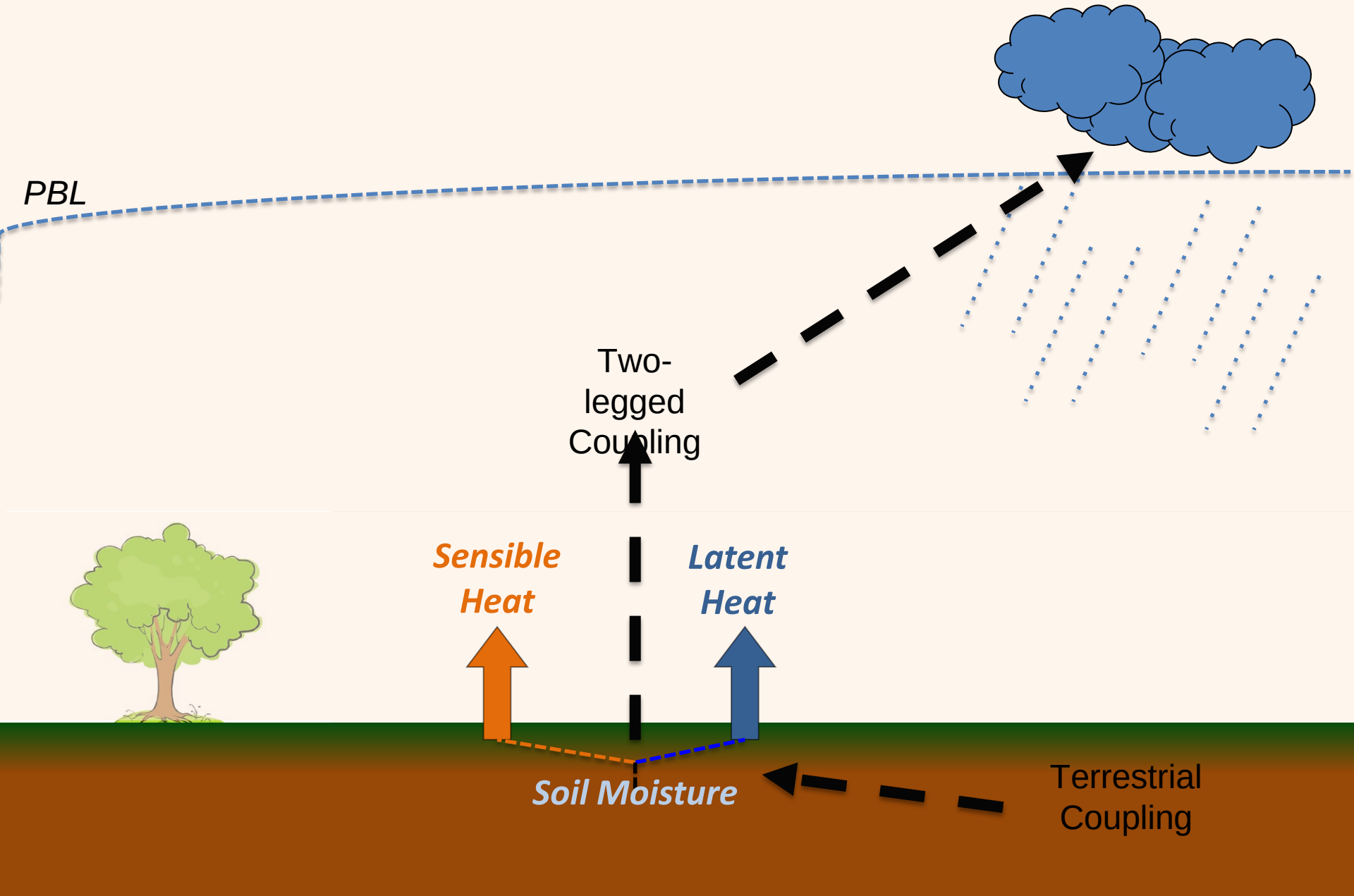

Quantifying CLM-CAM connectivity

Terrestrial Coupling =

Two-legged Coupling =

Quantifying CLM-CAM connectivity

Terrestrial Coupling = ***latent heat flux*** variability controlled by ***soil moisture*** variation

Two-legged Coupling = ***Some atmospheric variable*** variability controlled by ***soil moisture*** variations through latent heat flux

Quantifying CLM-CAM connectivity

Terrestrial Coupling $= \sigma_{SoilM} \frac{d(\text{Latent})}{d(\text{SoilM})}$

Two-legged Coupling $=$

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Terrestrial Coupling $= \sigma_{SoilM} \frac{d(\text{Latent})}{d(\text{SoilM})}$

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Quantifying CLM-CAM connectivity

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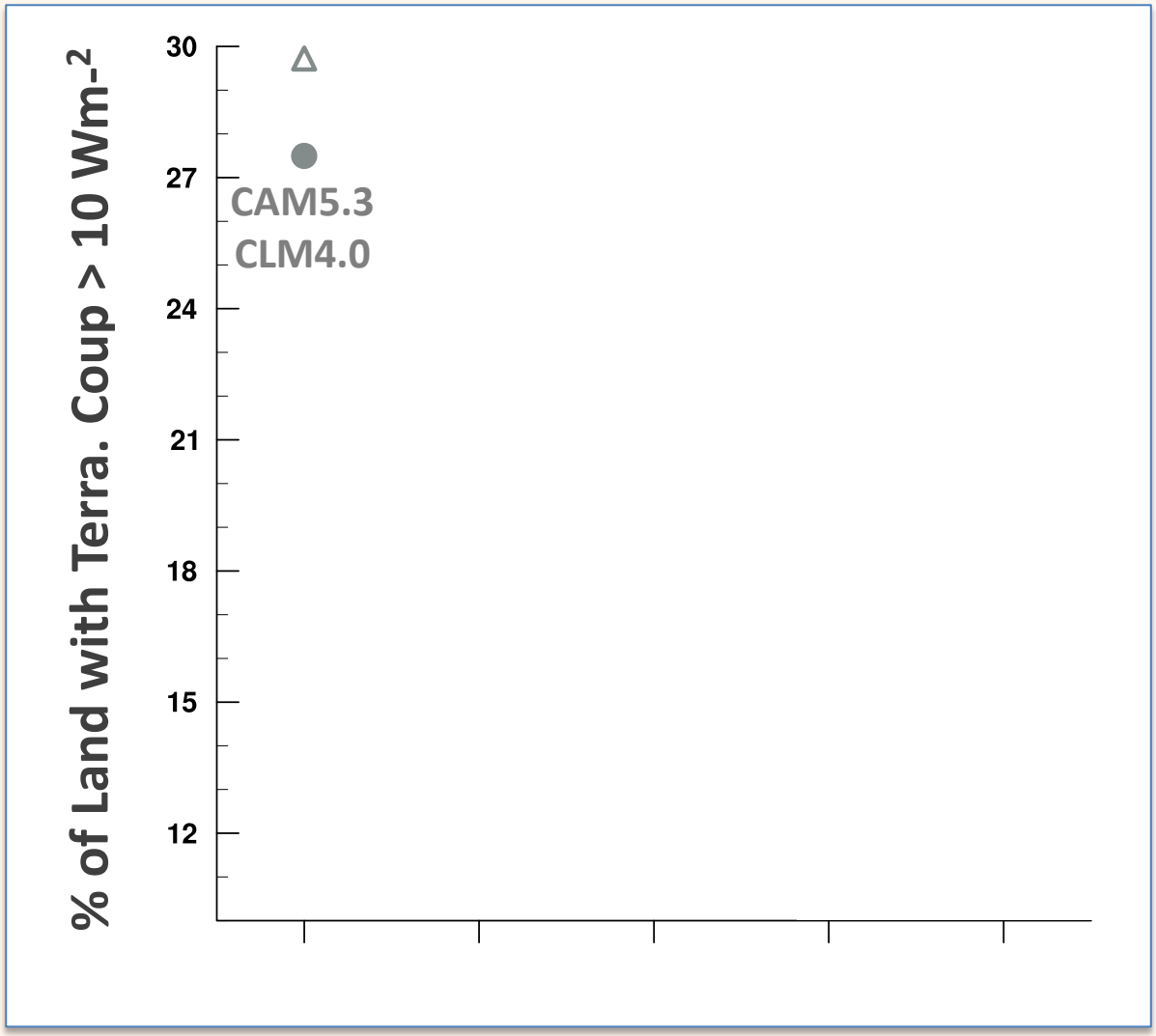
Two-legged Coupling $= \sigma_{SoilM} \frac{d(Latent)}{d(SoilM)} \frac{d(Precip\ or\ CAPE)}{d(Latent)}$

Applied to:

Daily data for a given month → July

Terrestrial Coupling Across Version and Set-up



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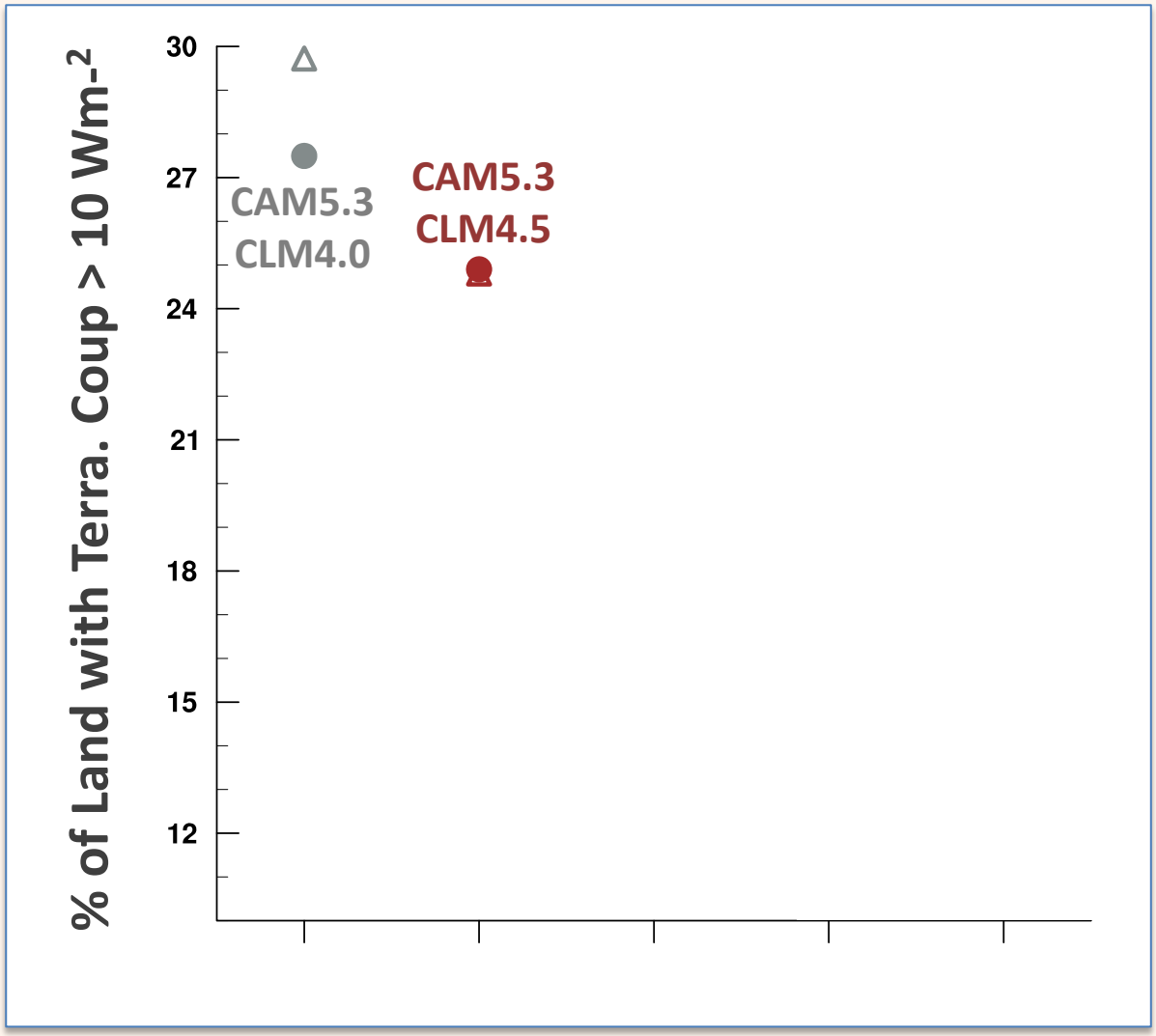

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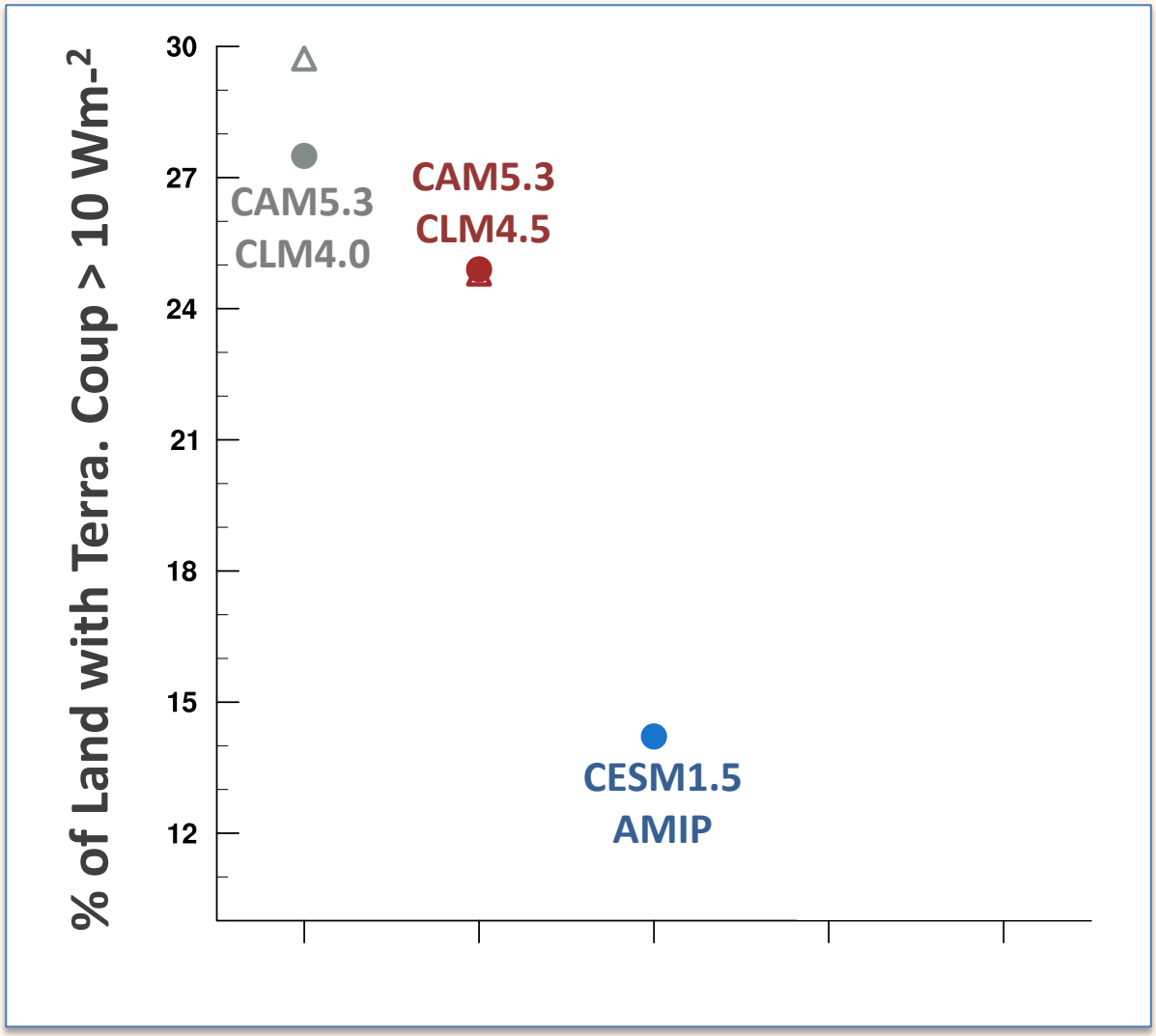

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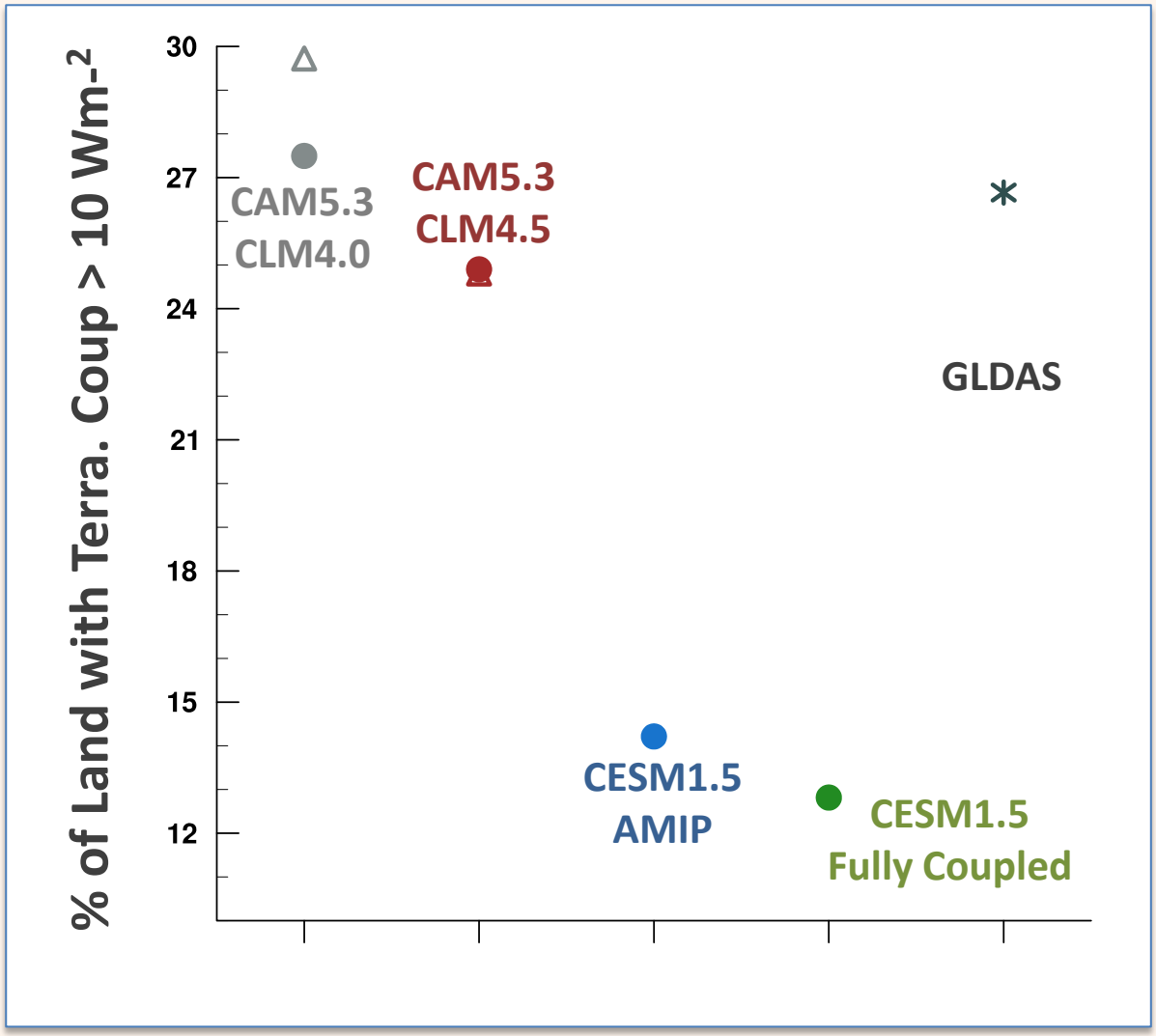

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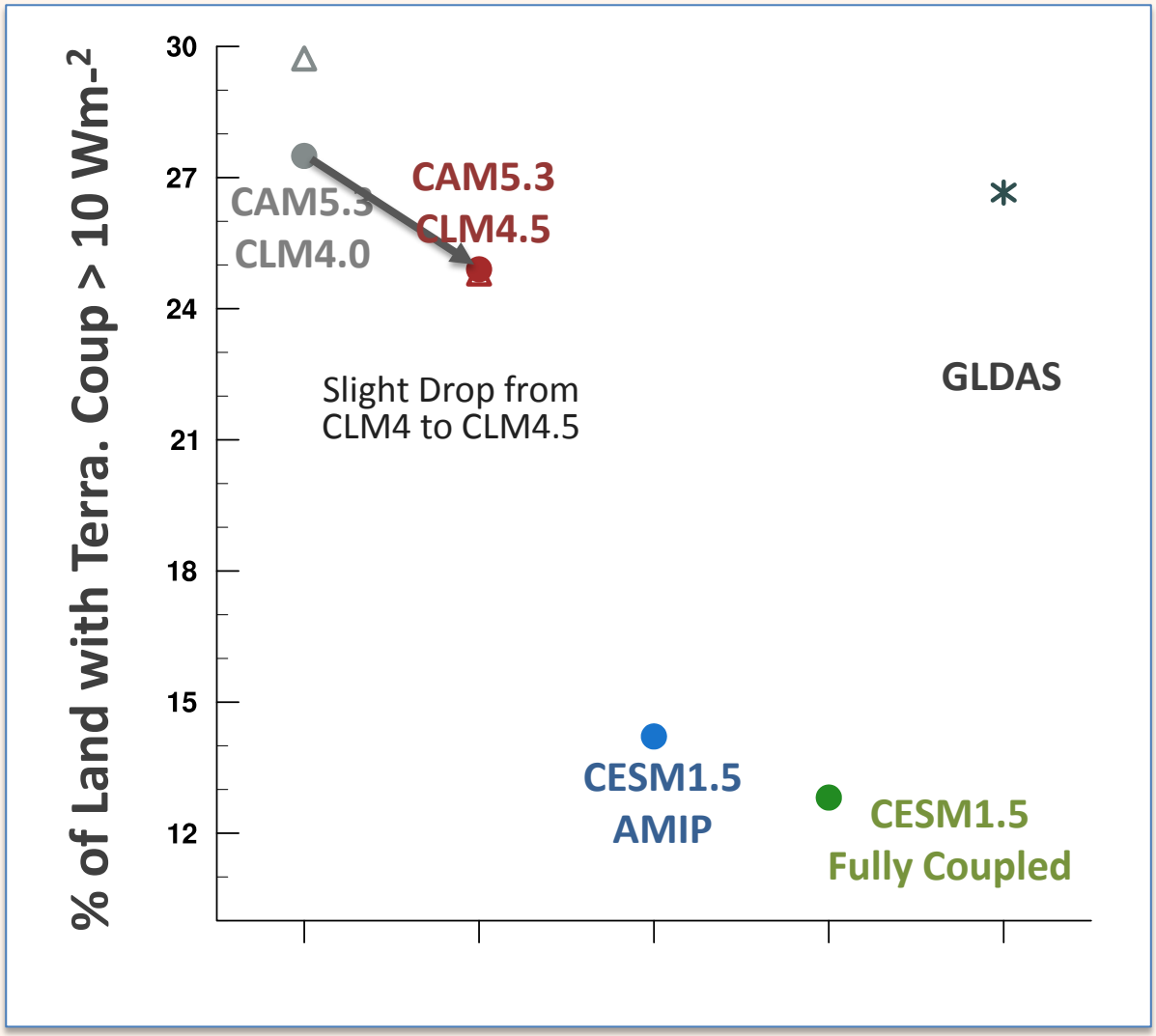

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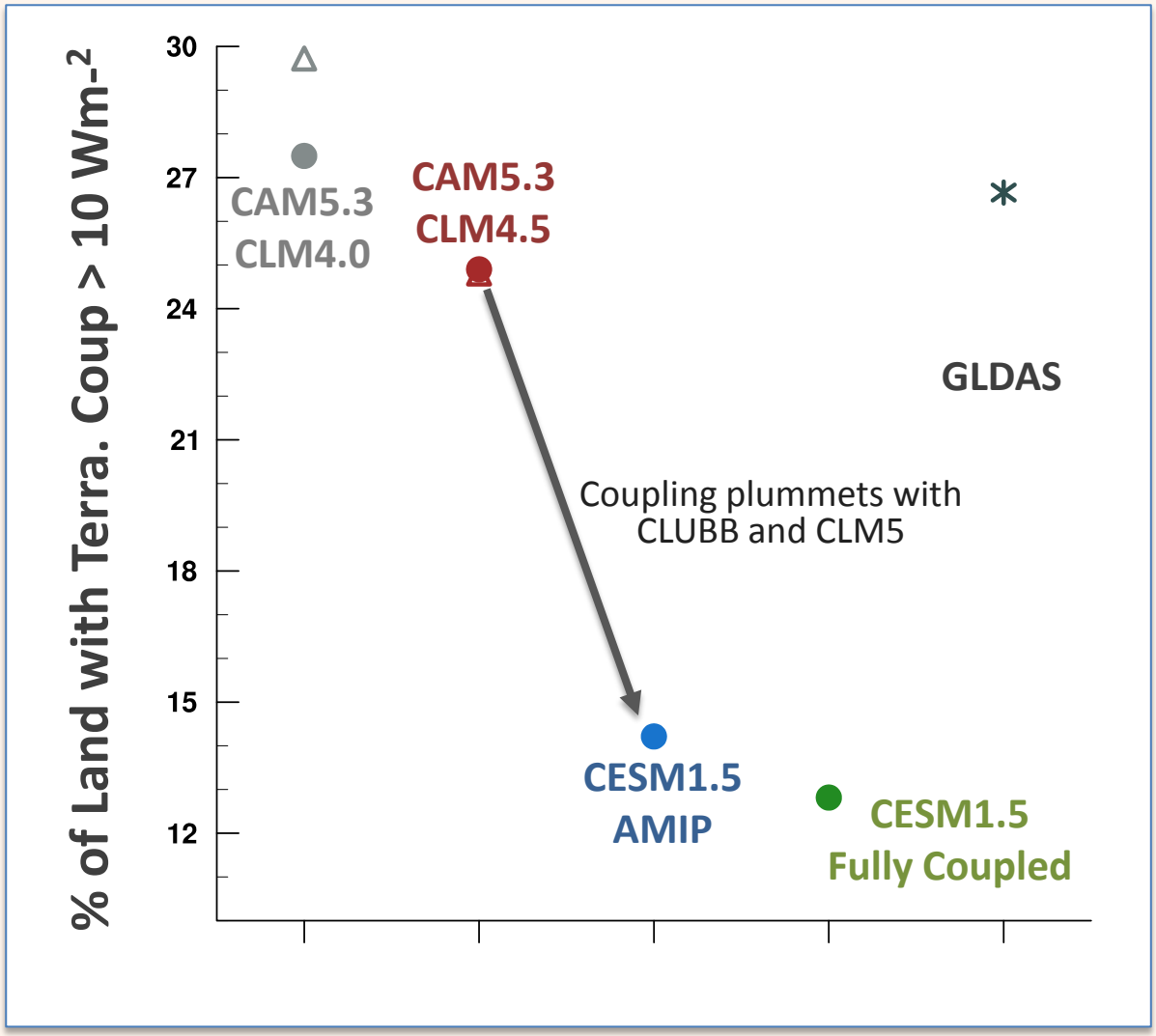

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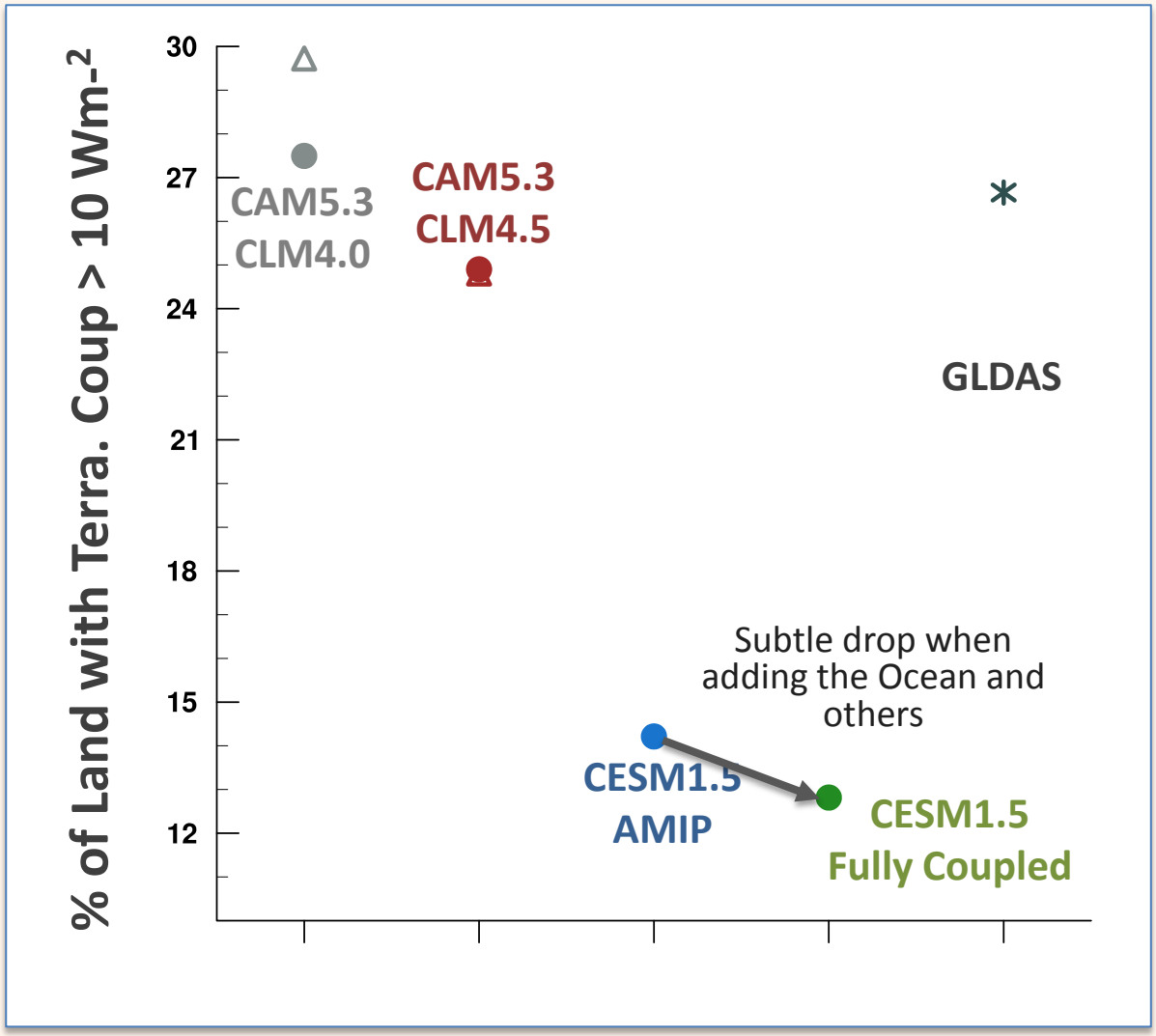

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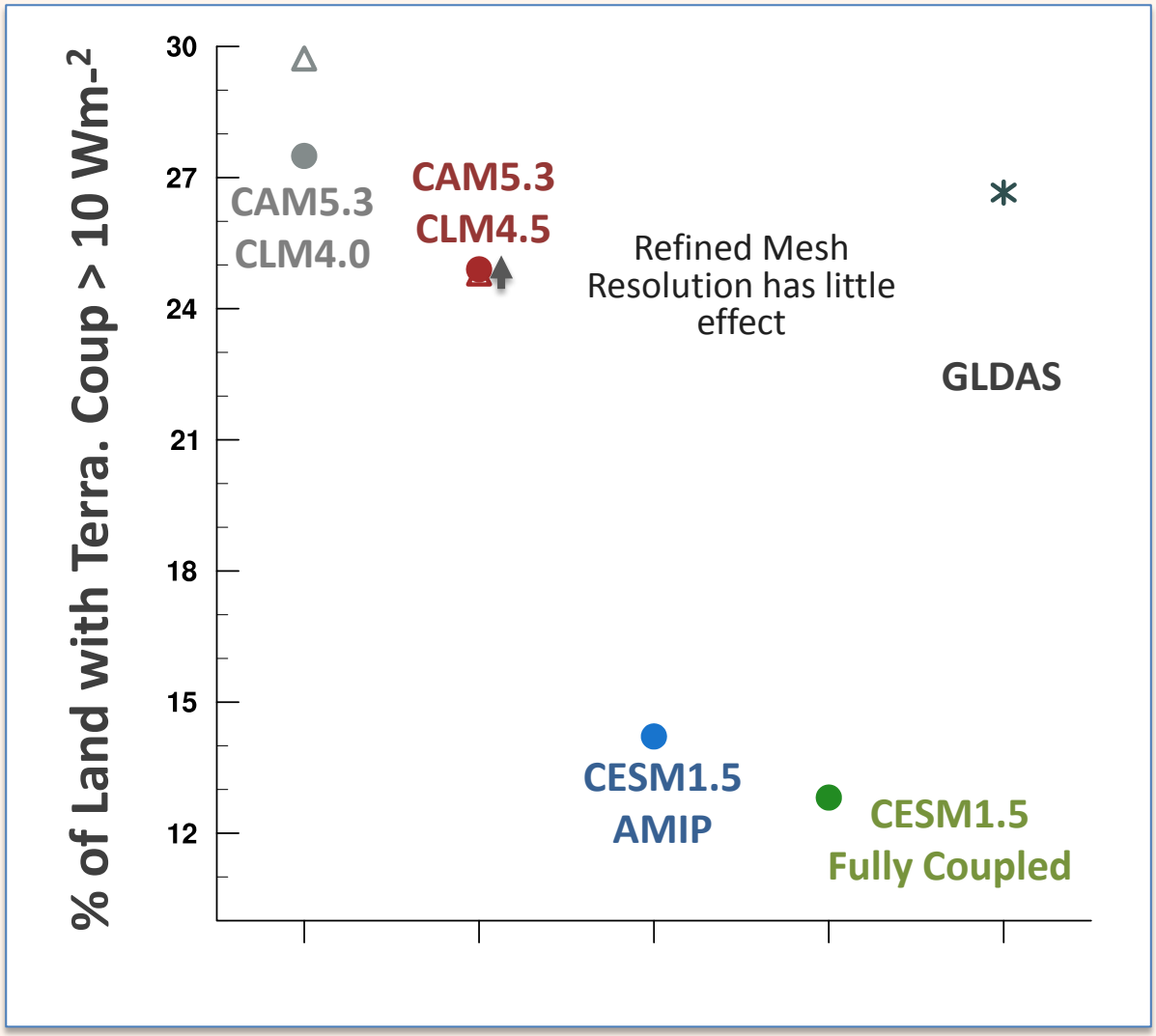

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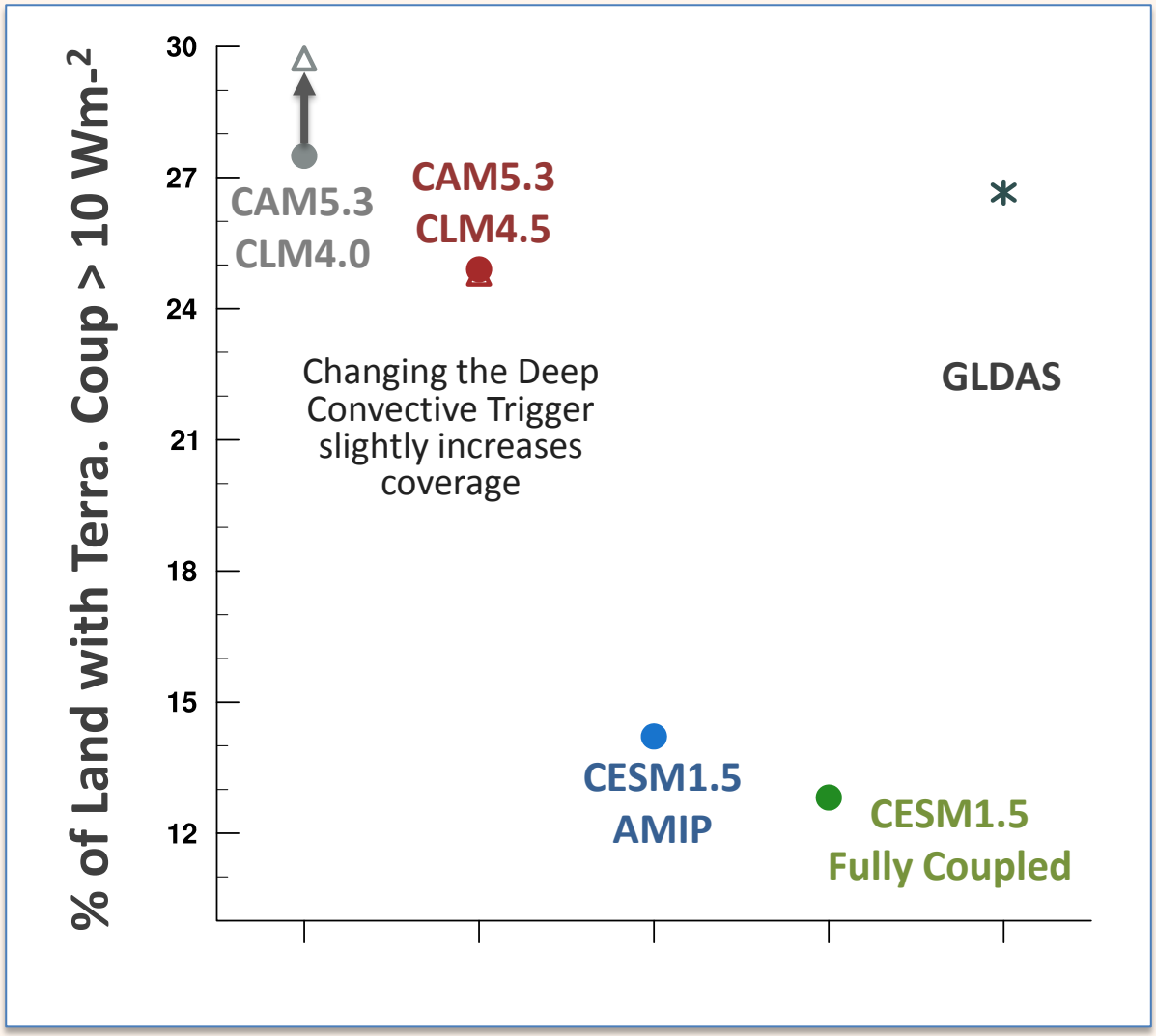

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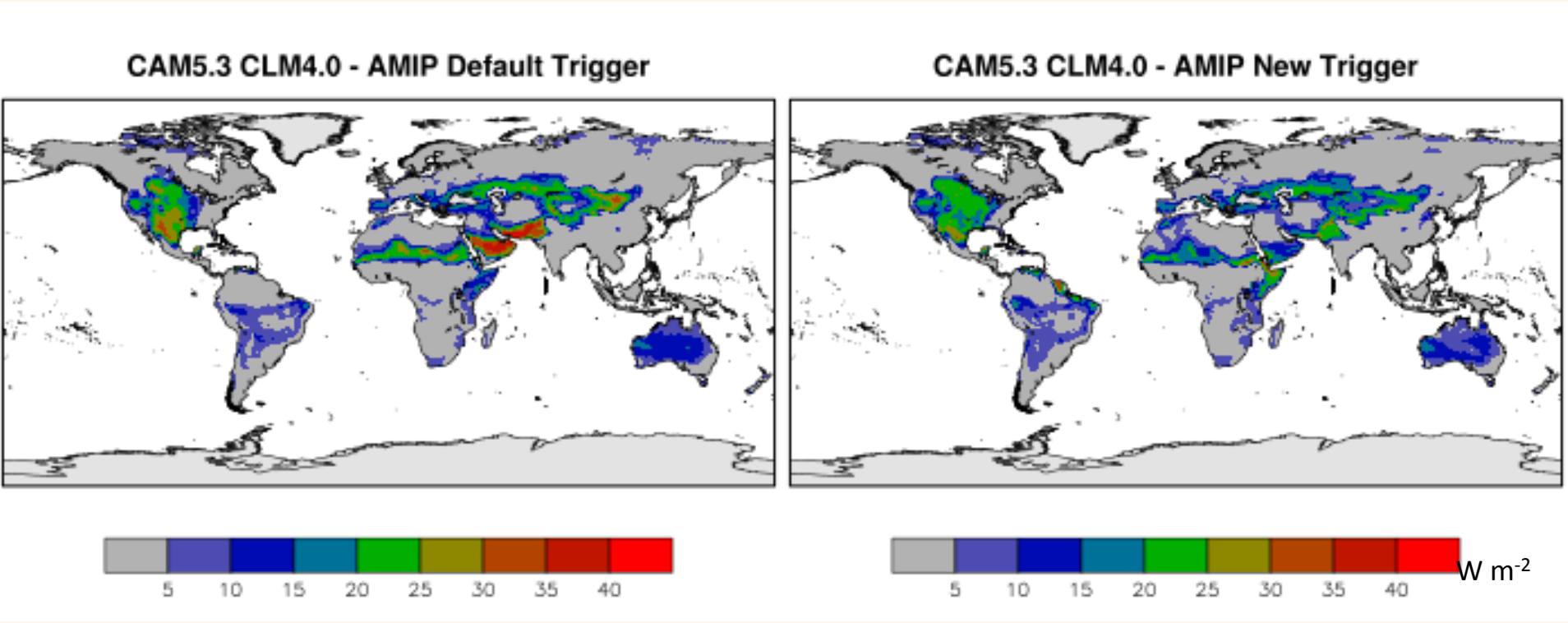

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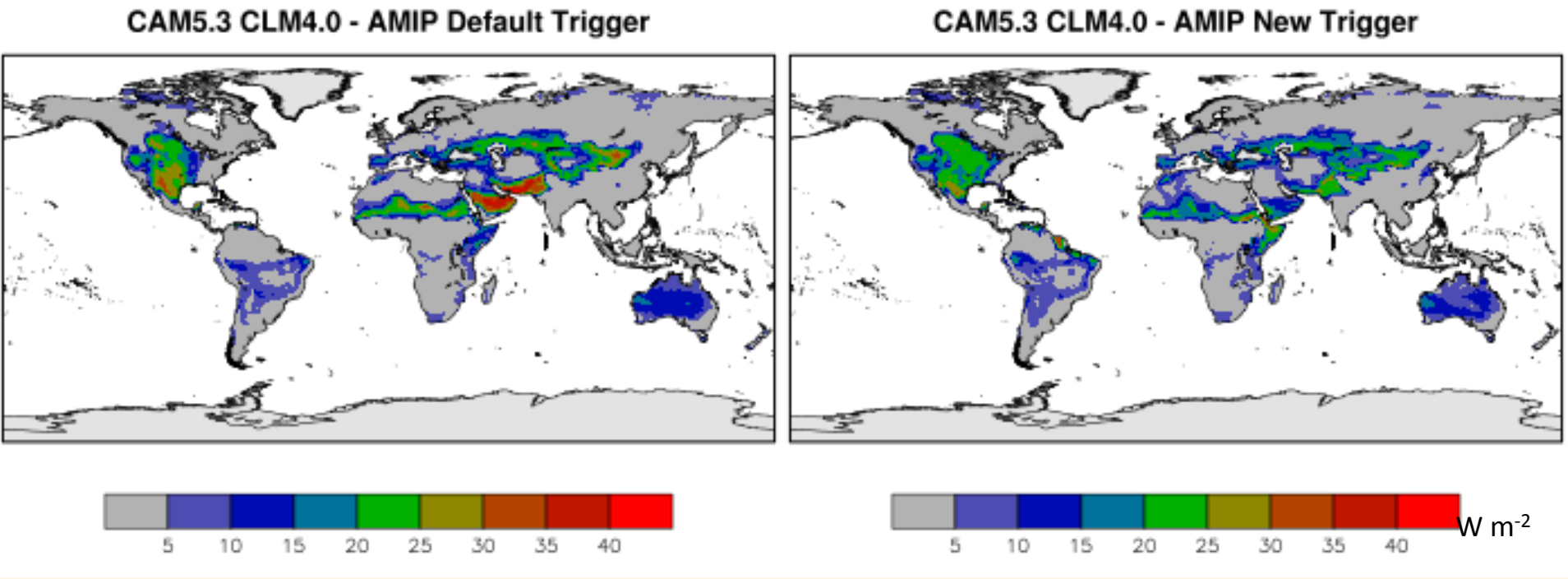
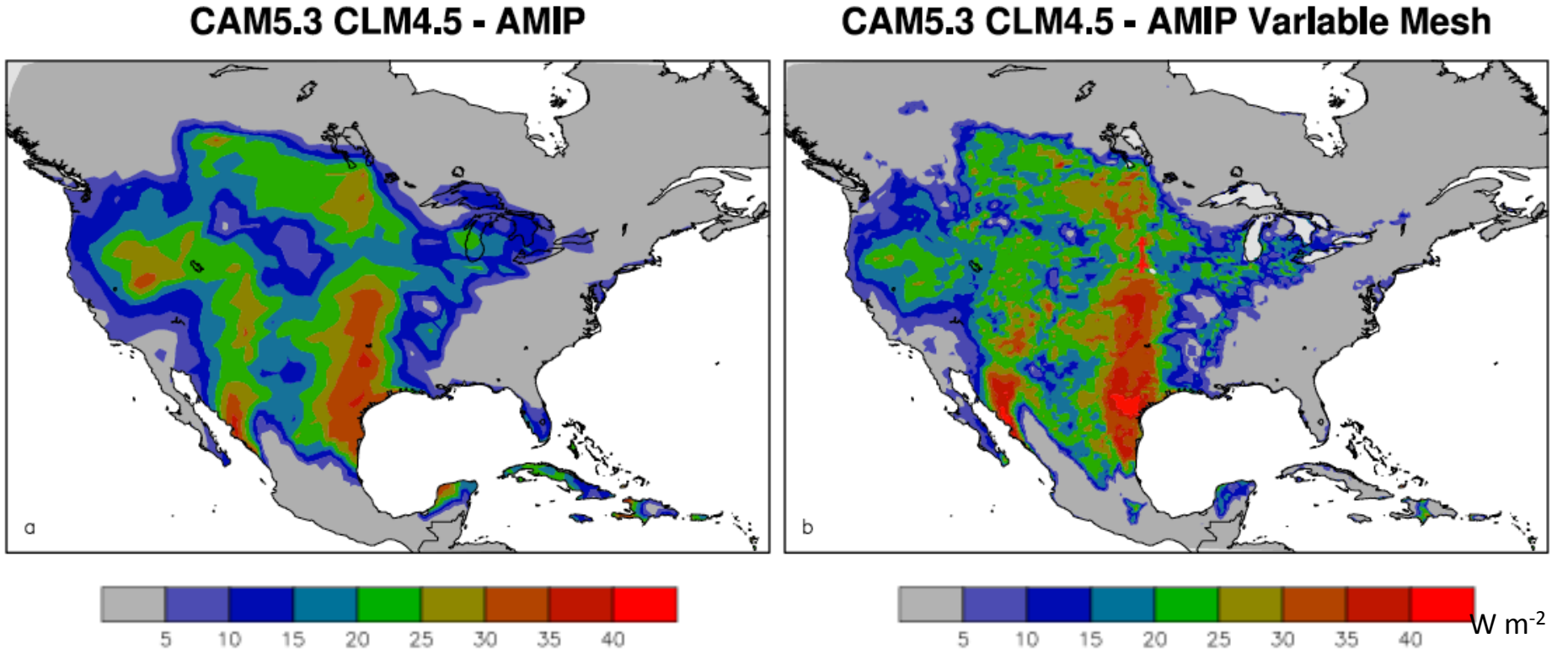


Changing Convective Trigger

Weaker Coupling with Convective Inhibition controlled but broader coverage

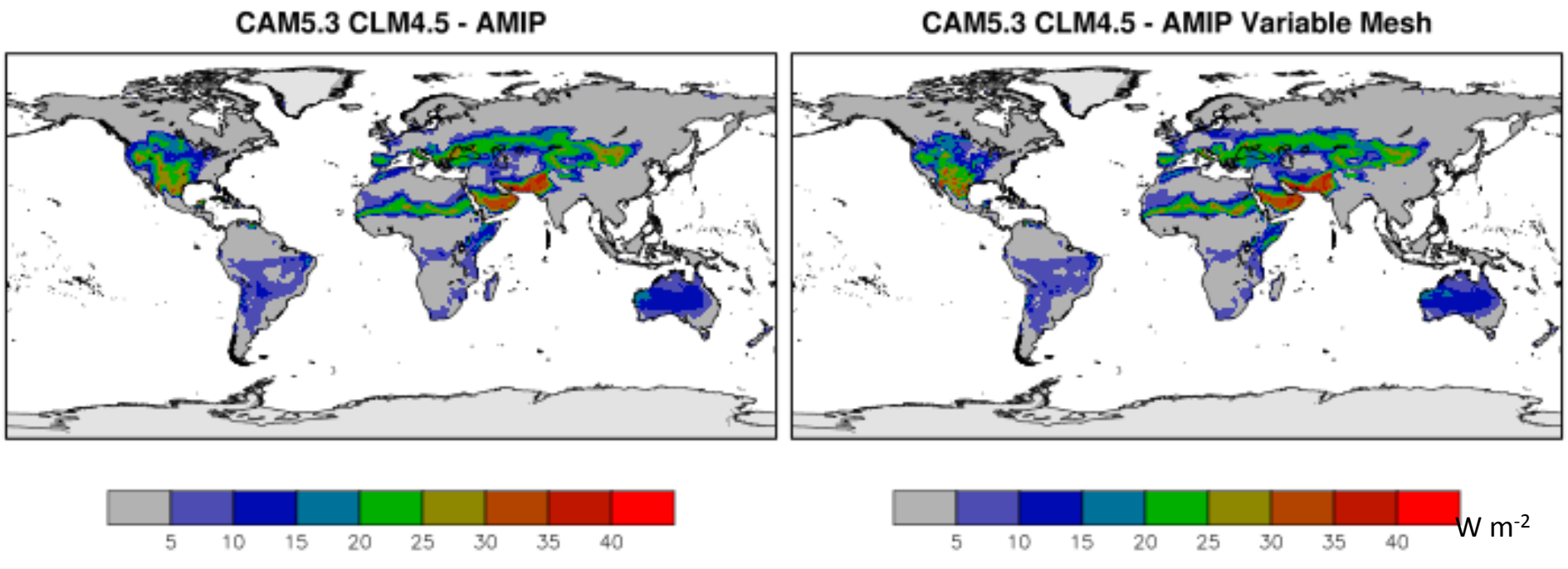
Terrestrial Coupling Across Version and Set-up



Changing Resolution:

More local maxima but structure is the same

Terrestrial Coupling Across Version and Set-up



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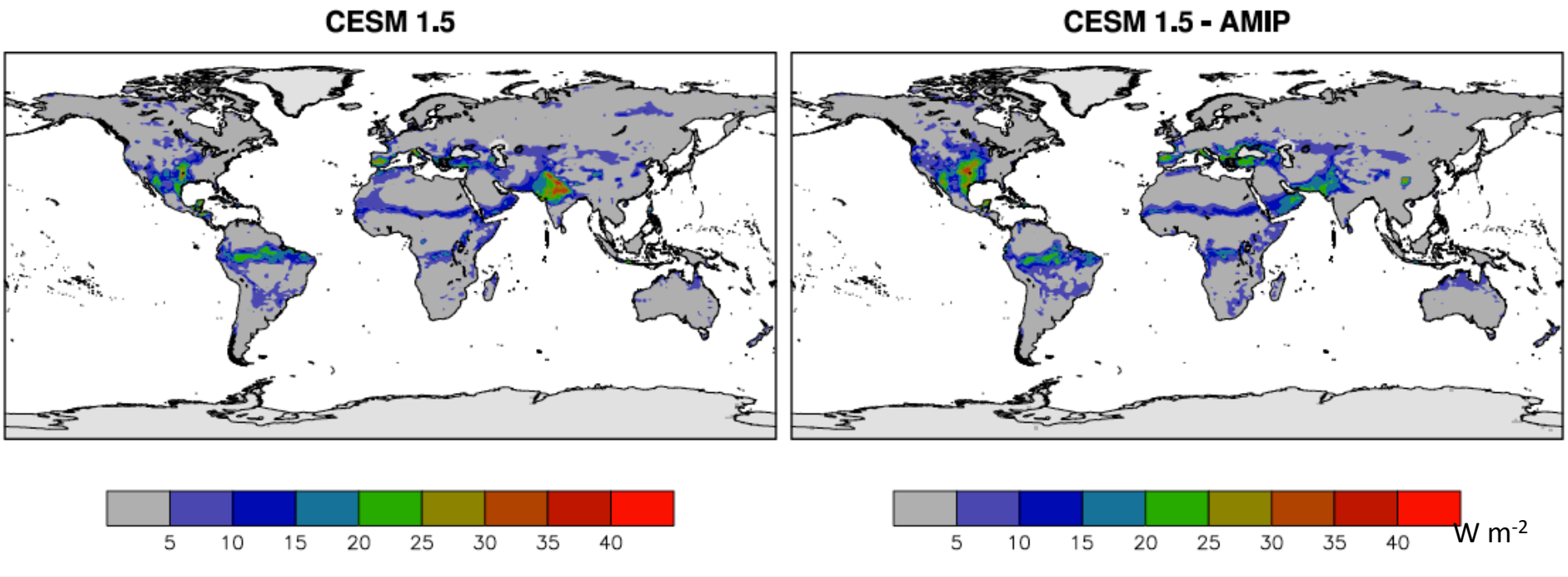

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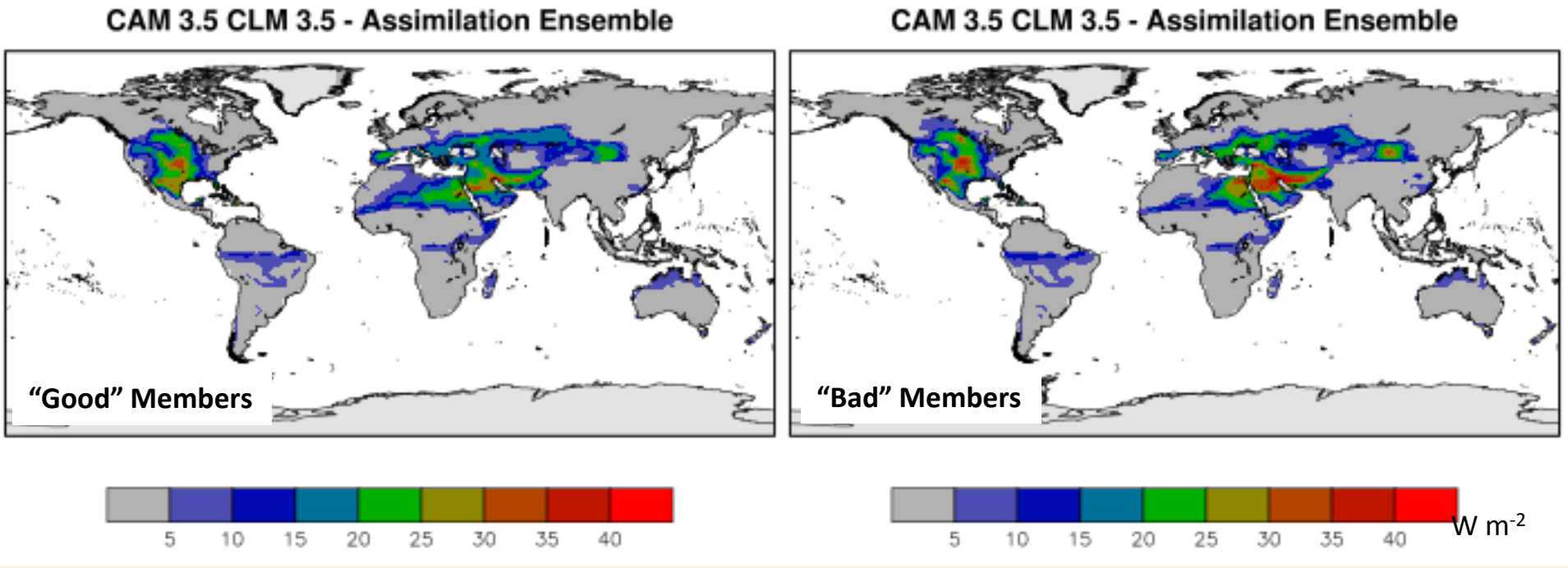

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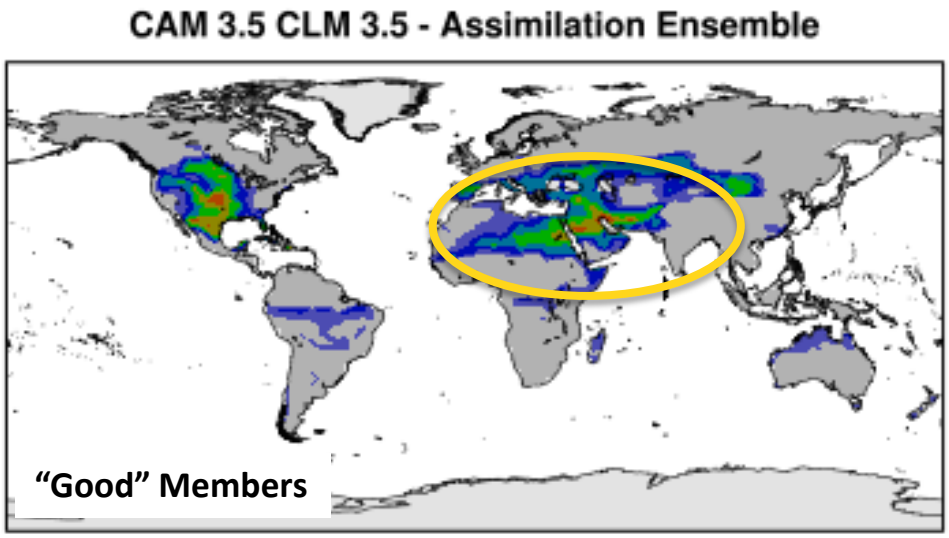

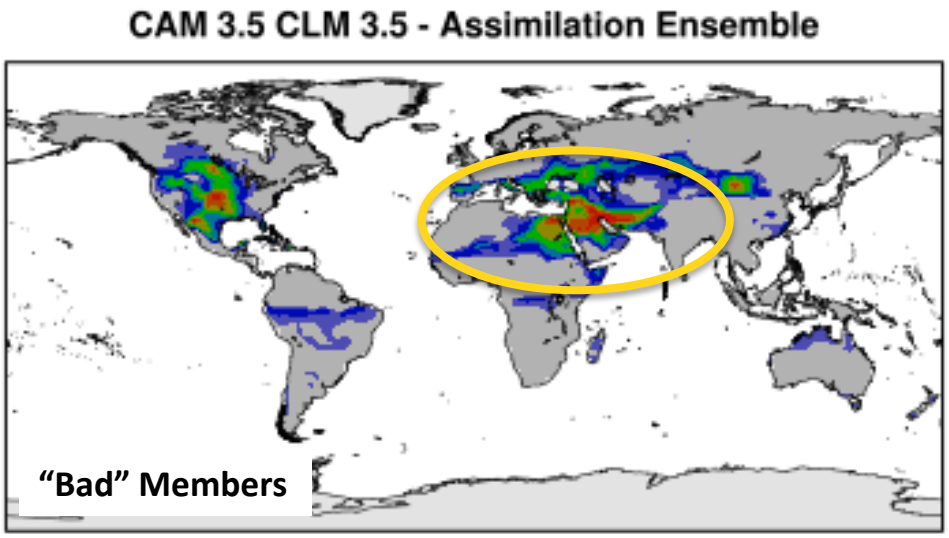

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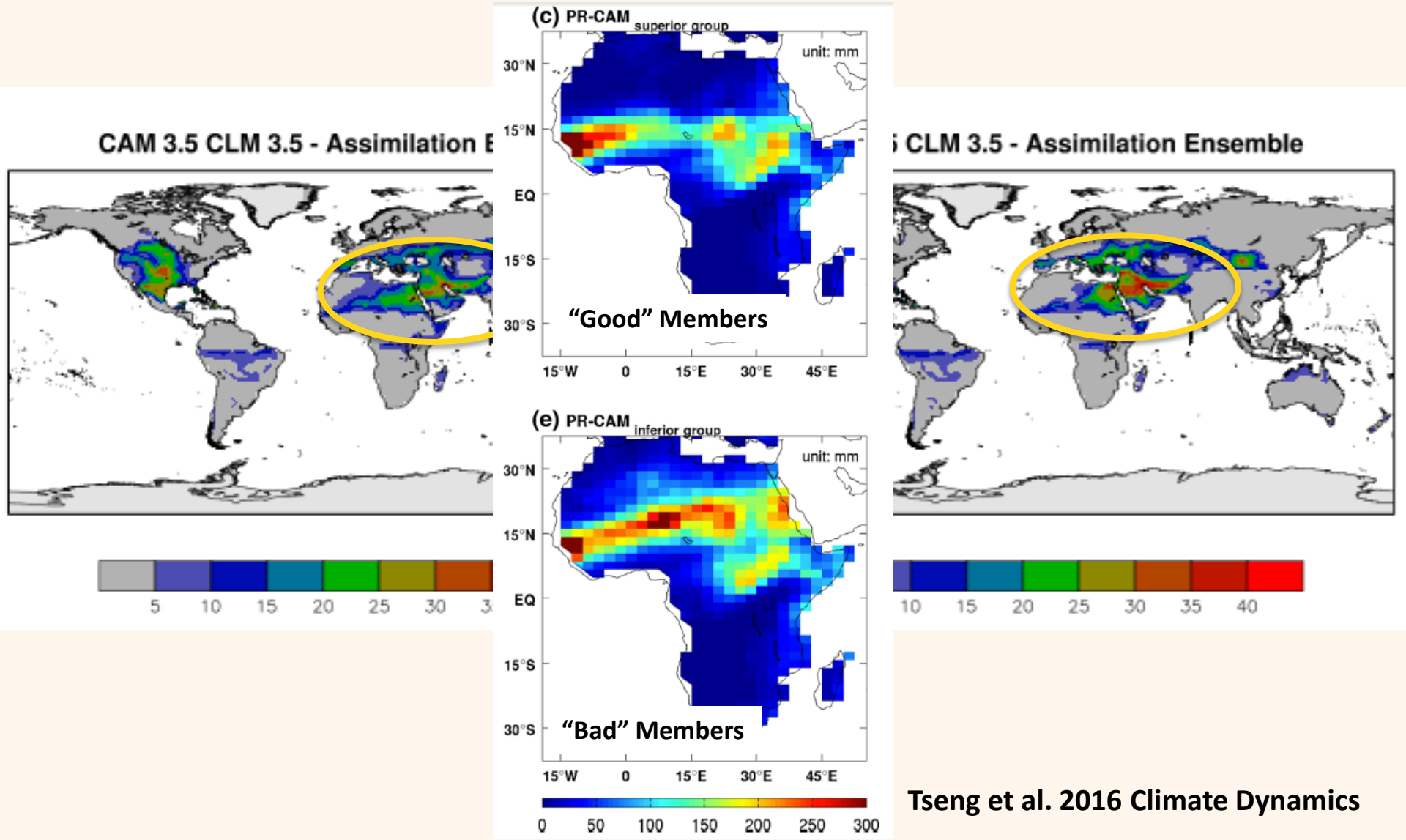

Tseng et al. 2016 Climate Dynamics

What Dominates the **Terrestrial** Coupling Signal?

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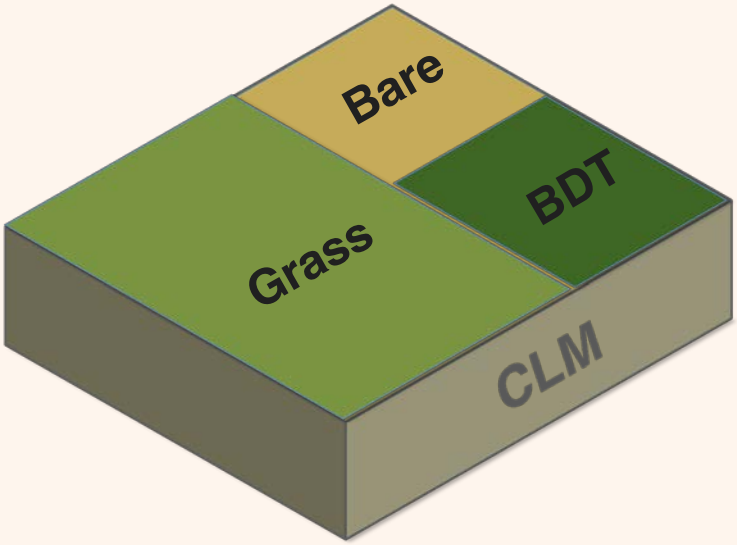

- CLM contains sub-grid plant functional types (PFTs)
- There are ~17 PFTs in CLM4.5
- CLM5 will have 6 new representative crop types
- Each PFT can contribute to terrestrial coupling

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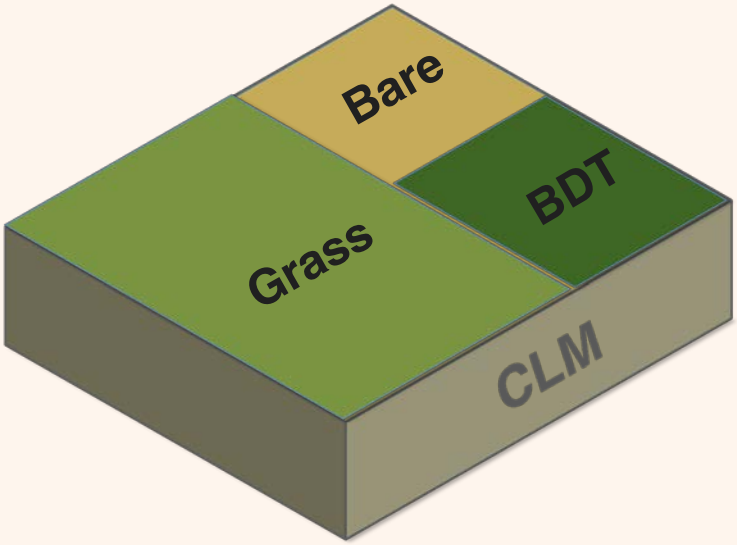

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PFT-level data are available from the CAM5.3 CLM4.5 simulation

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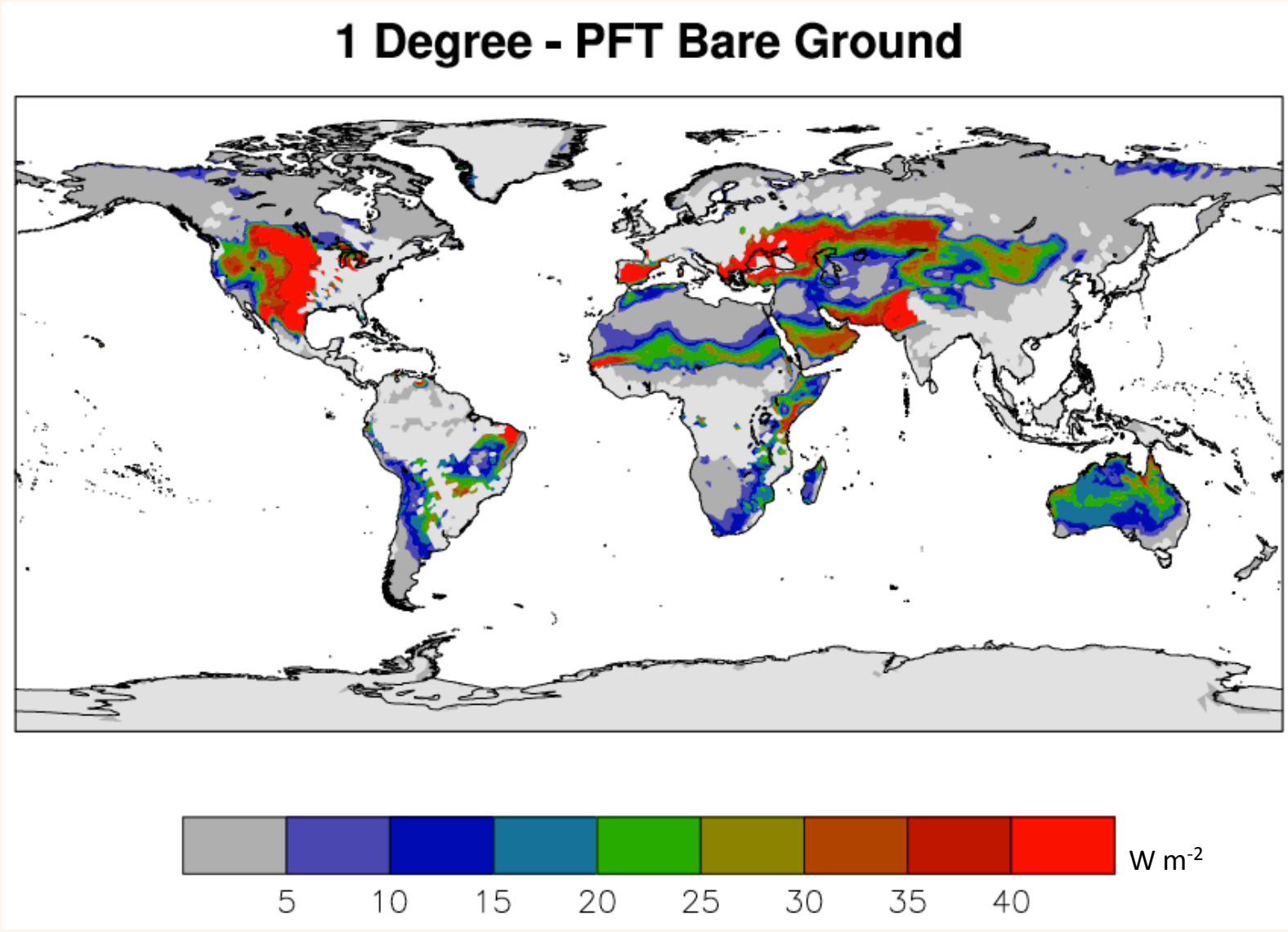

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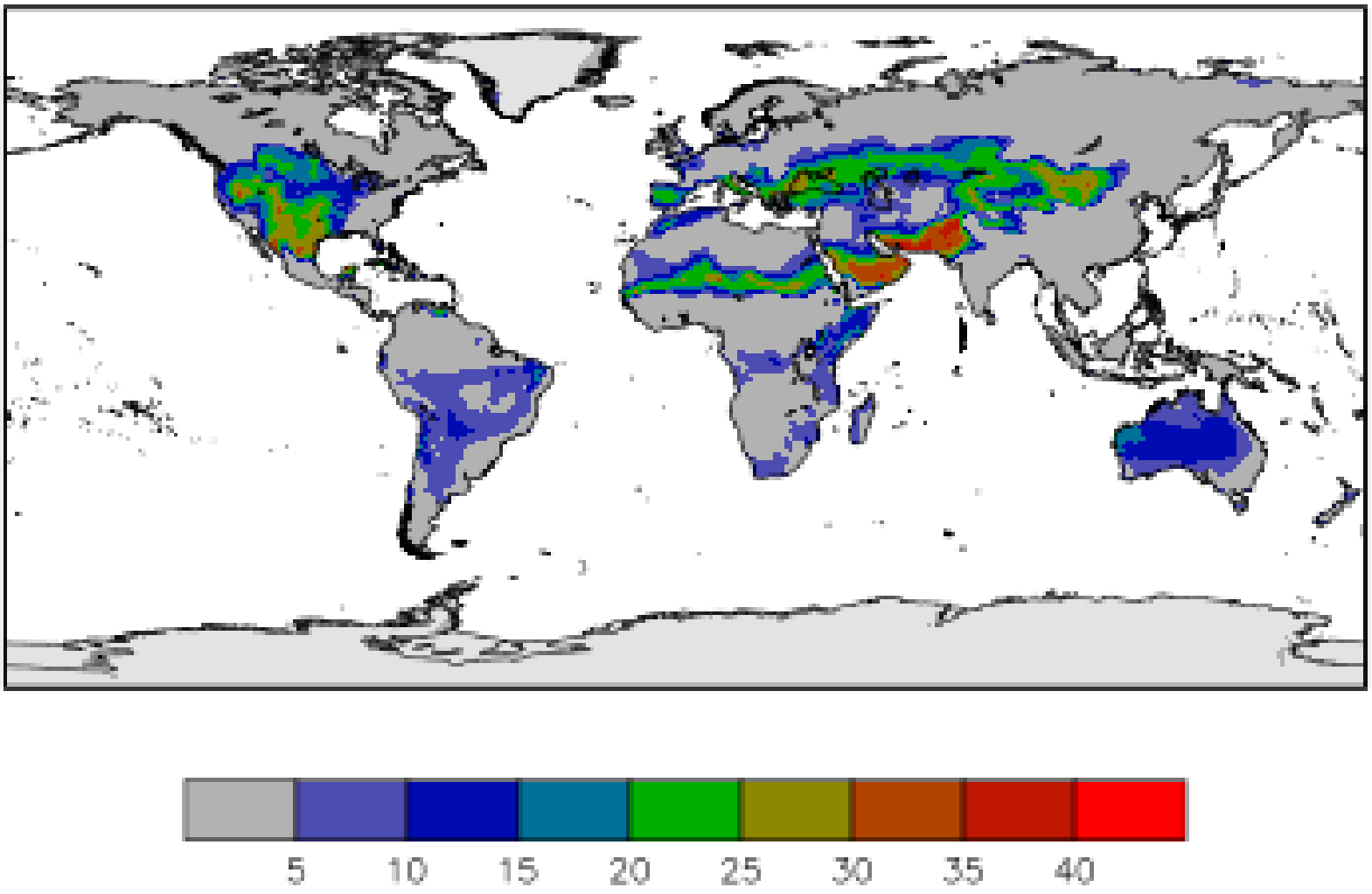
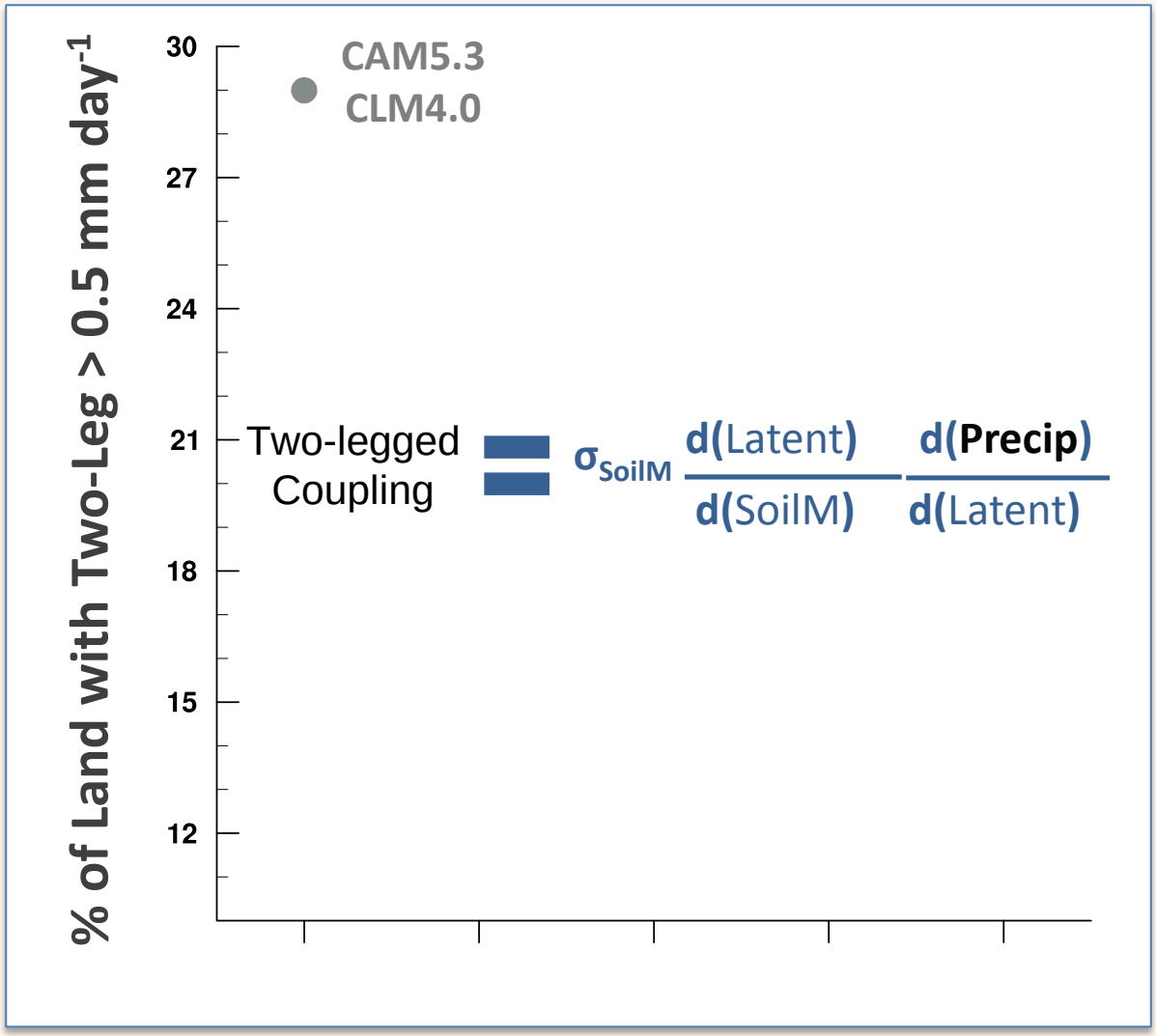


Two-Legged Coupling Across Version and Set-up



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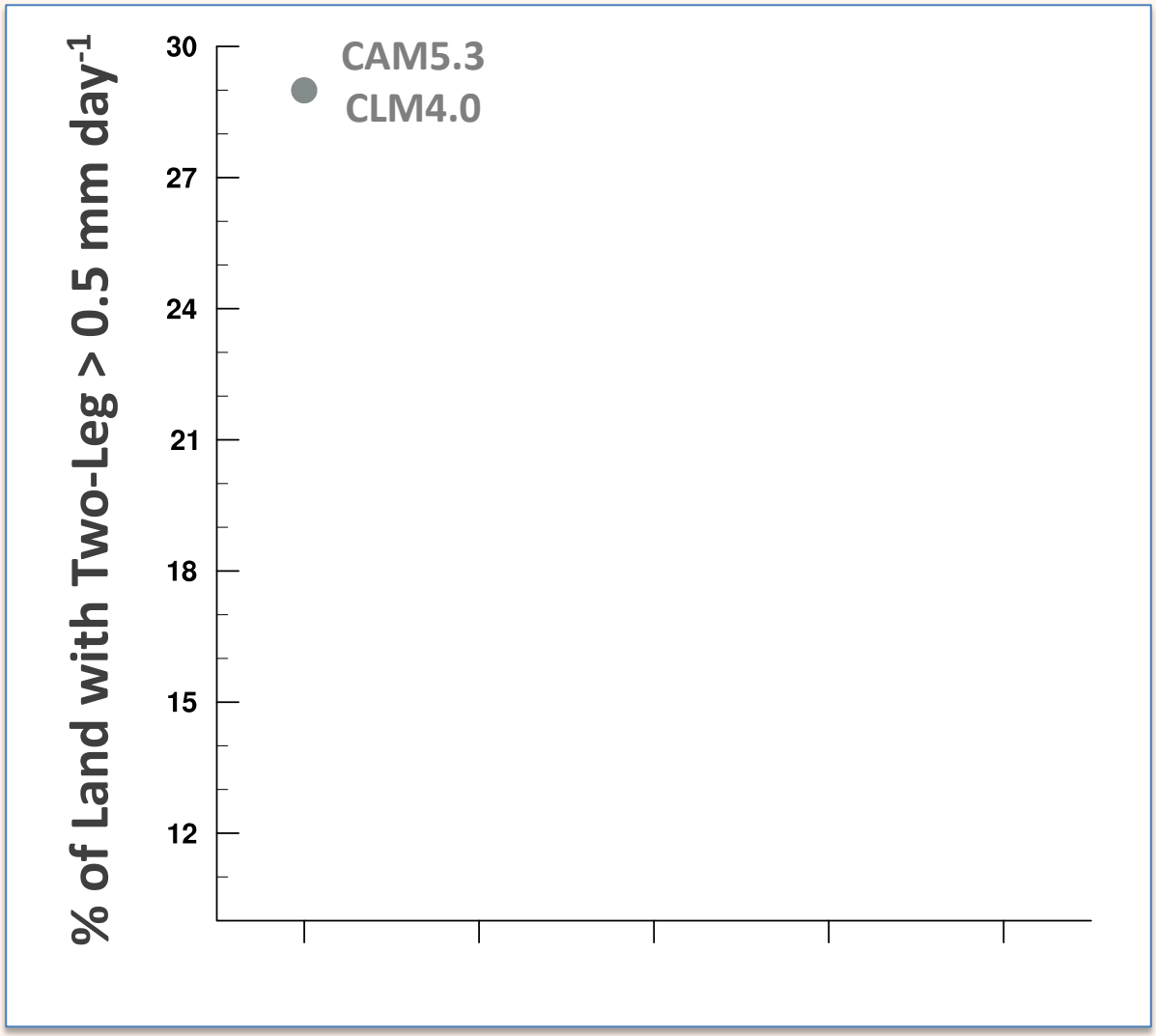

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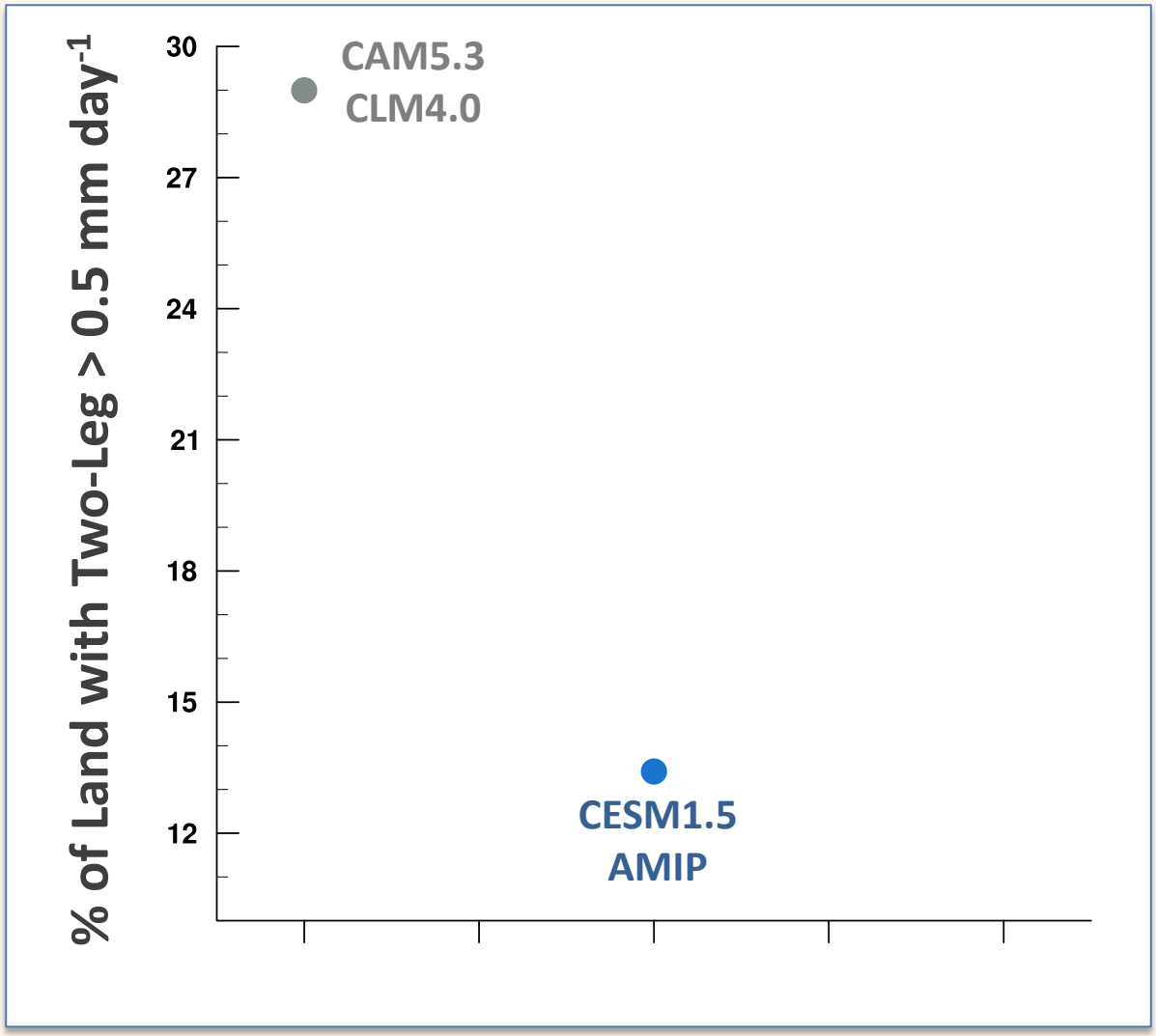

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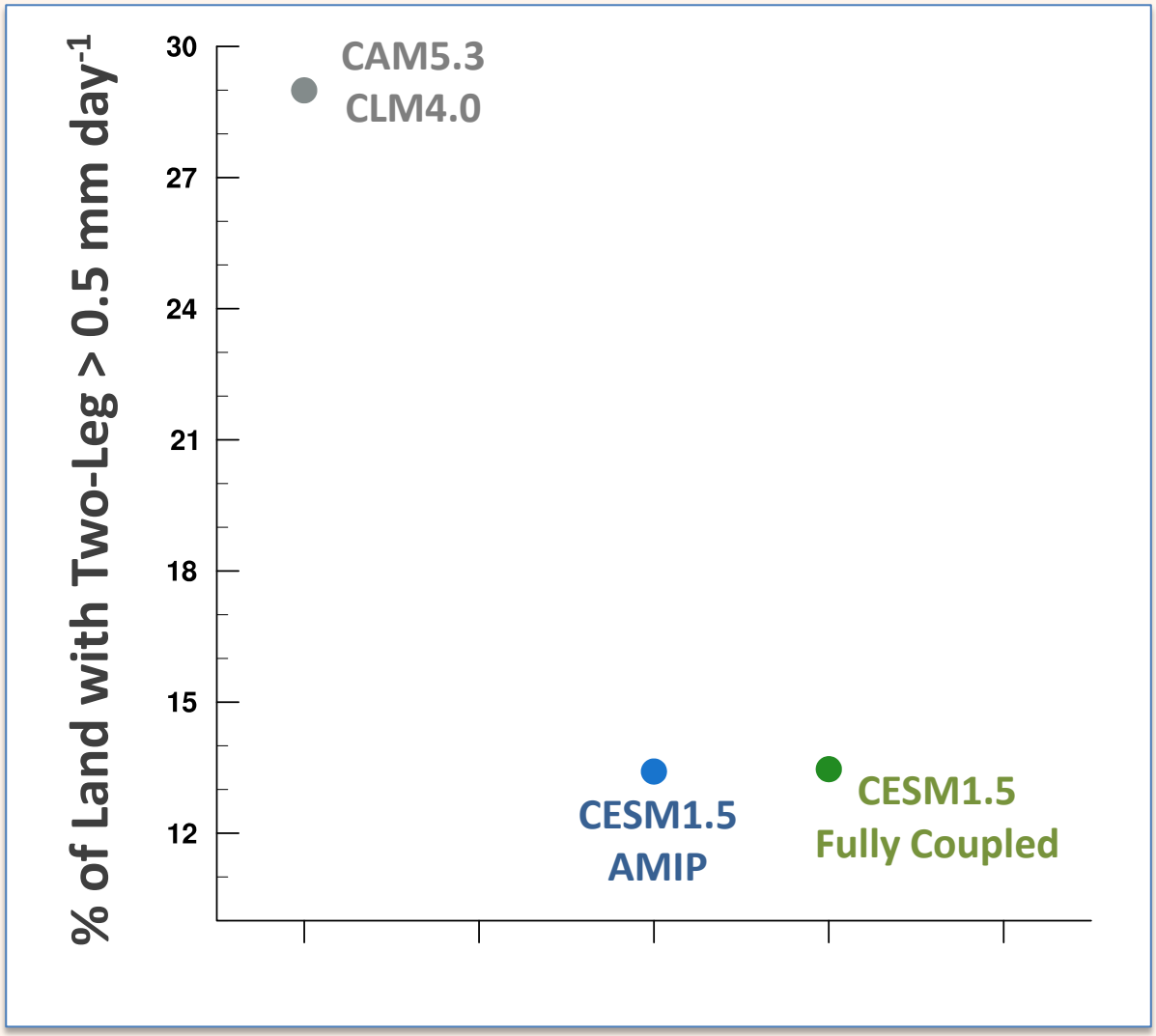

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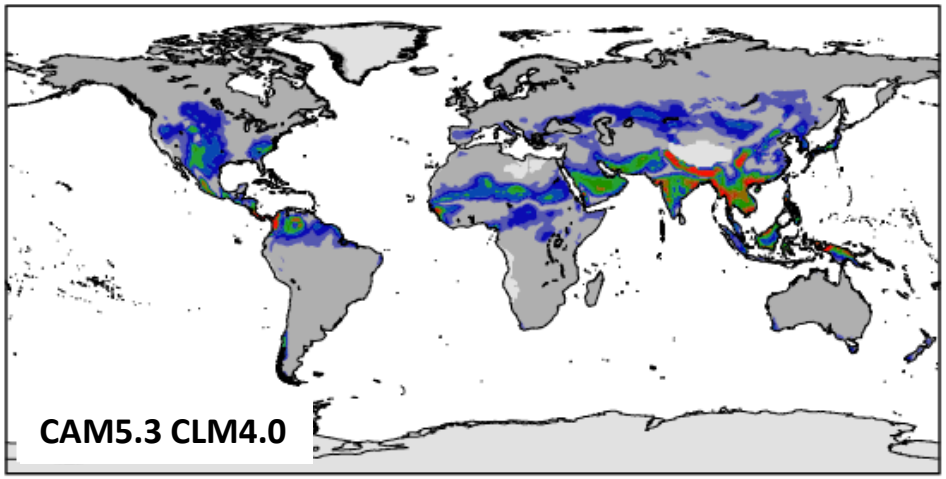

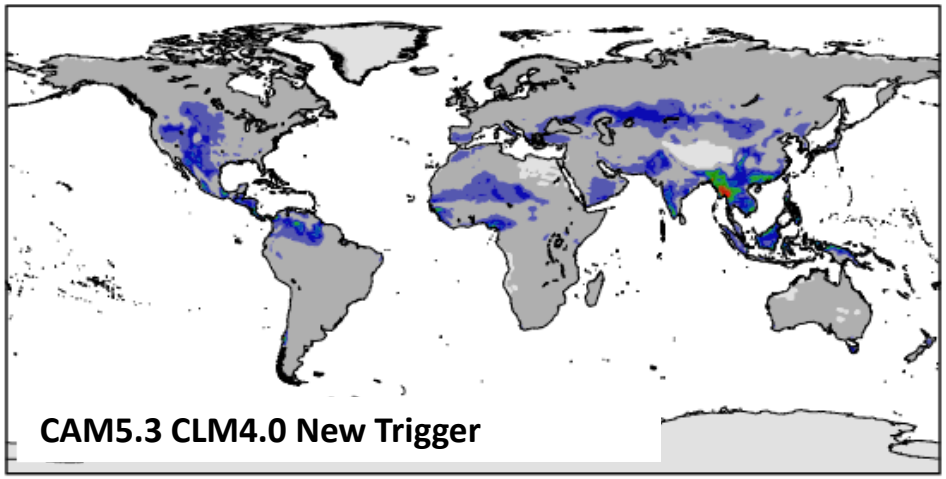

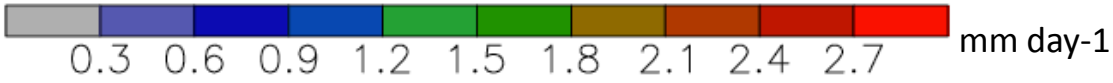

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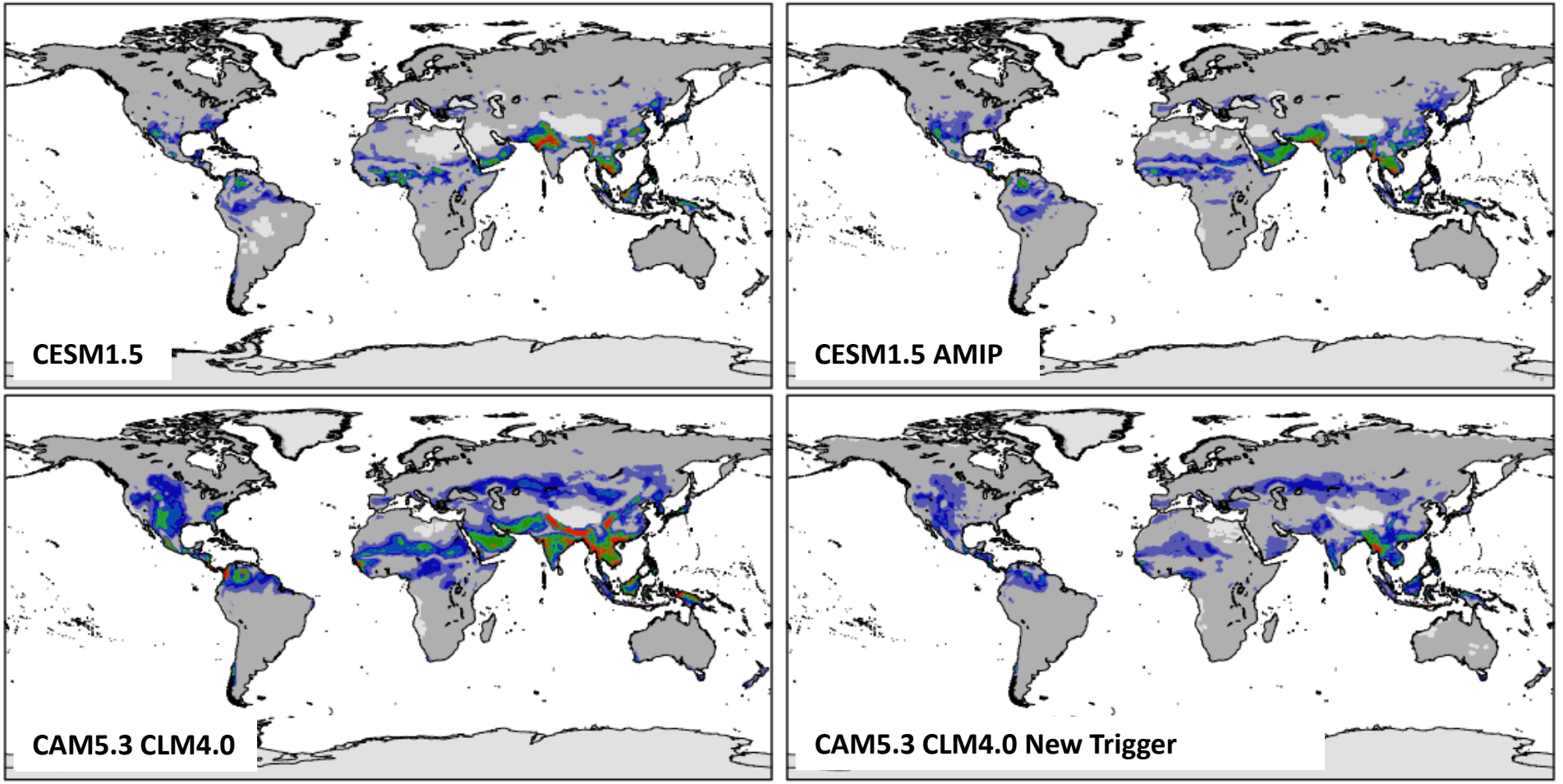
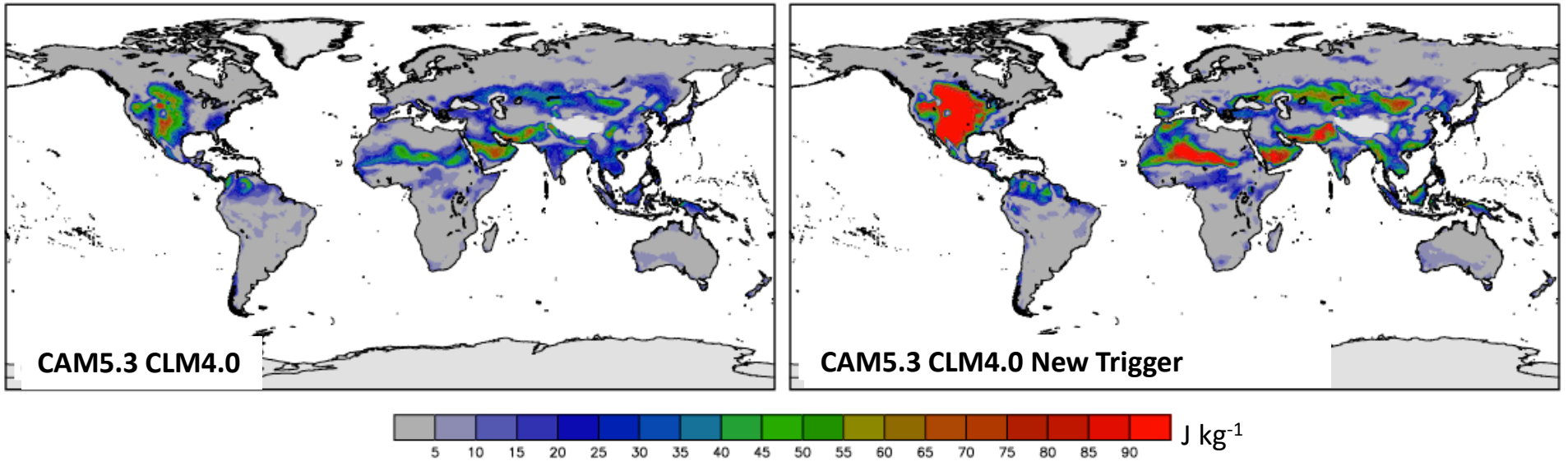


Two-Legged Coupling Across Version and Set-up

$$\text{Two-legged Coupling} = \sigma_{SoilM} \frac{d(\text{Latent})}{d(\text{SoilM})} \frac{d(\textbf{CAPE})}{d(\text{Latent})}$$



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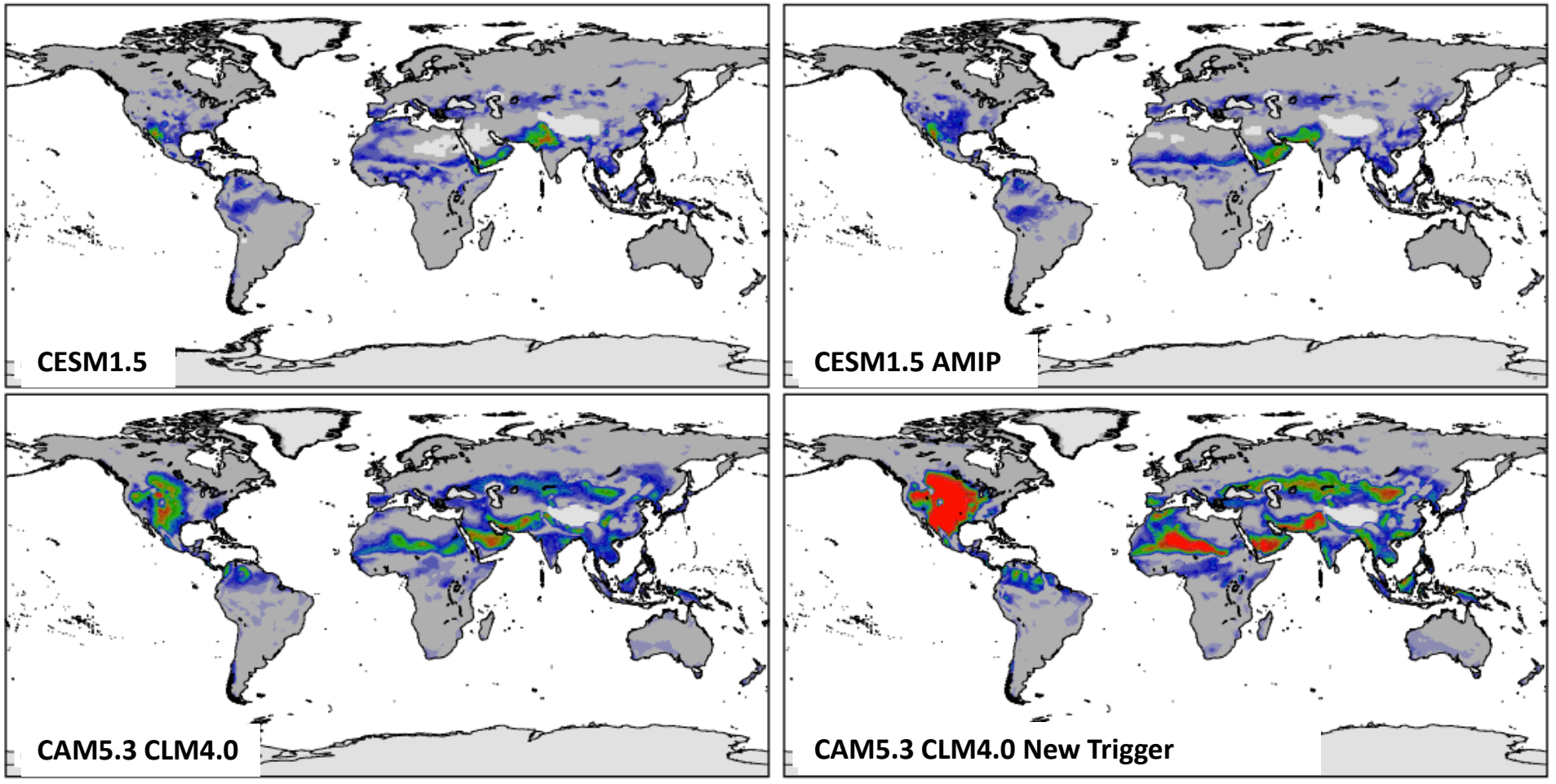
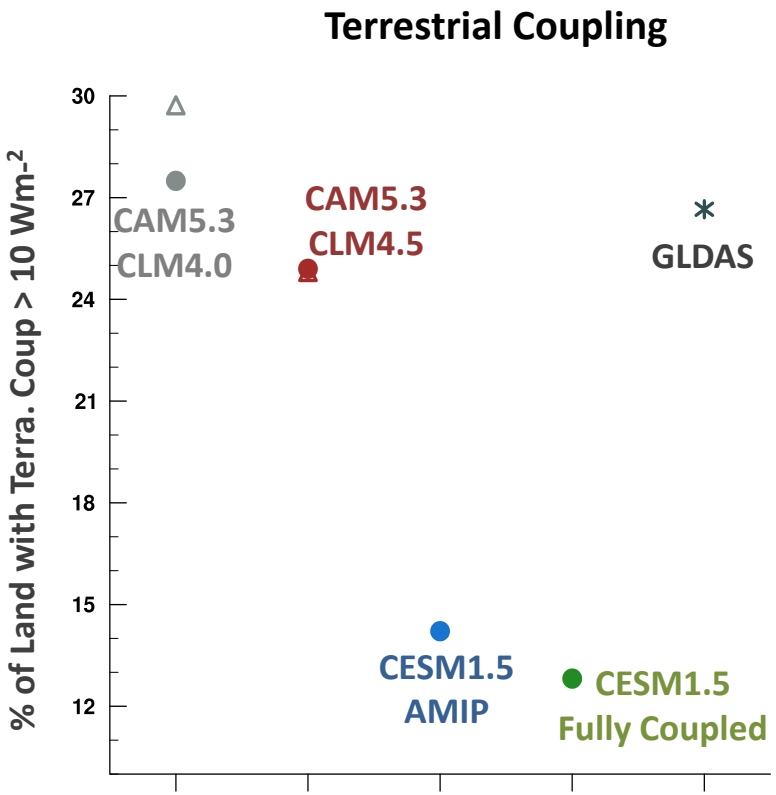
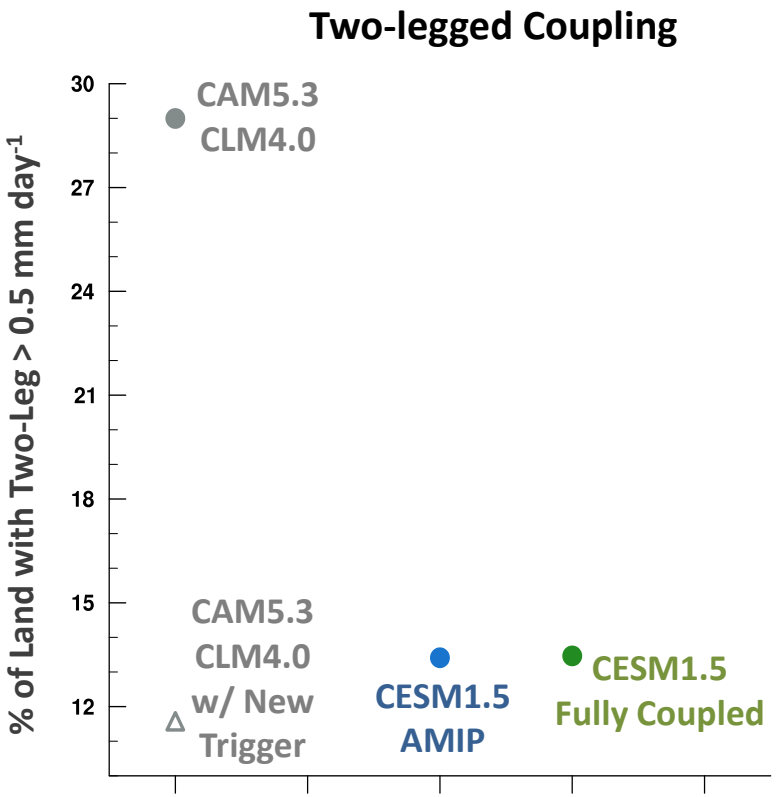


Summary


Terrestrial Coupling
% of Land with Terra. Coup > 10 Wm-2
30
27
24
21
18
15
12
CAM5.3
CLM4.0
CAM5.3
CLM4.5
GLDAS
CESM1.5
AMIP
CESM1.5
Fully Coupled


Two-legged Coupling
% of Land with Two-Leg > 0.5 mm day-1
30
27
24
21
18
15
12
CAM5.3
CLM4.0
CAM5.3
CLM4.0
w/ New
Trigger
CESM1.5
AMIP
CESM1.5
Fully Coupled