Robust influences of super-parameterization on land-surface fluxes and their response to climate change

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&
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Thank you to Cristiana Stan, Li Xu, Mark Branson,
Melissa Burt, David Randall for simulations

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Land-surface interactions investigated in two versions of SPCAM (SPCCSM and SPCESM)

	SP(CCSM)	SP(CESM)
Configuration:		
Model Versions	SP-CCSM4	SP-CESM1-CAM4
GCM Resolution	0.9° x 1.25°	1.9° x 2.5°
CRM Resolution	3 km	4 km
Experiments:		
Control	Present-day	Pre-Industrial
Climate Change	RCP8.5	4x CO_2
Time Analyzed	10 years	5 years

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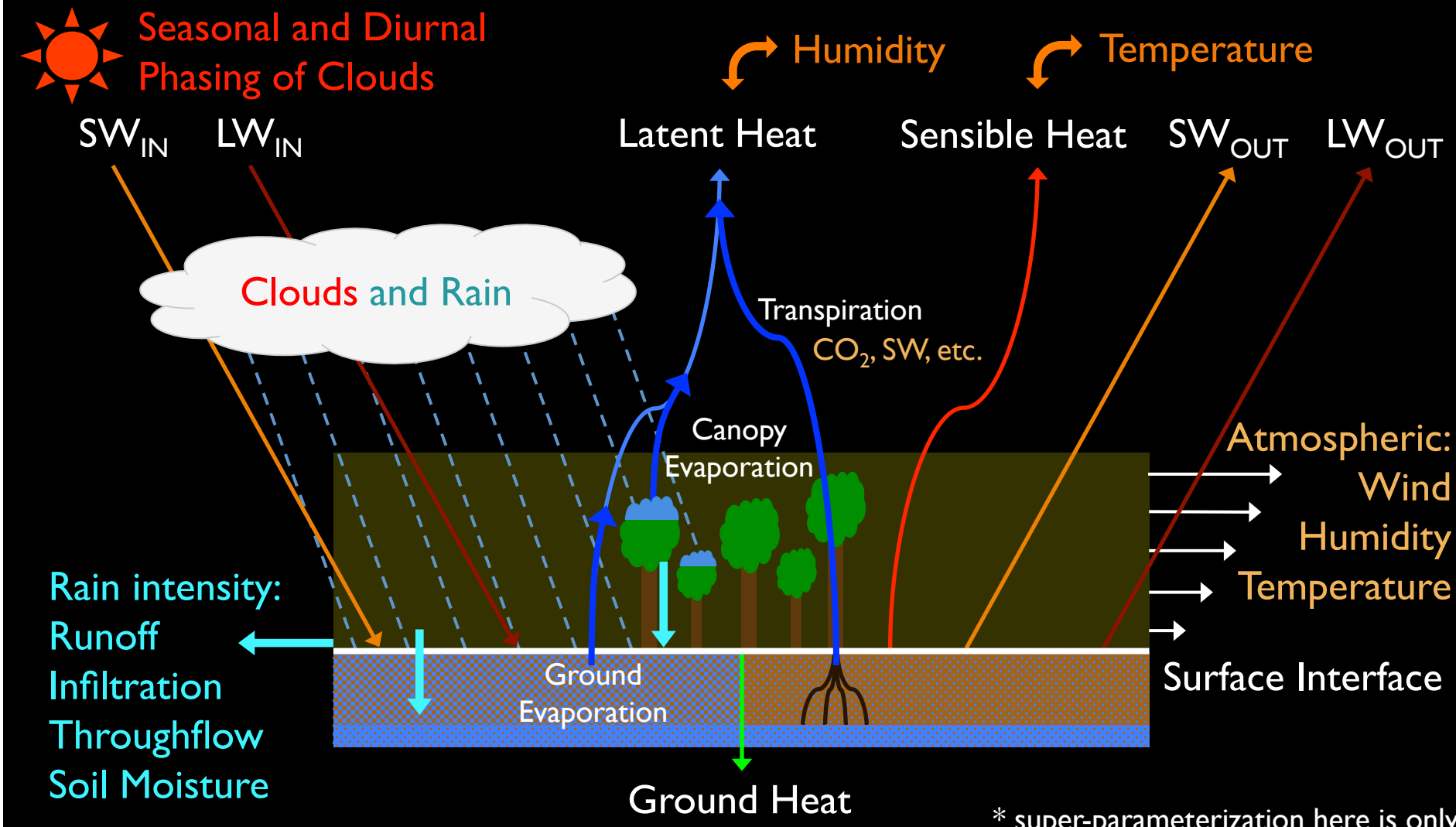
How can super-parameterization impact land-surface energy exchange?



* super-parameterization here is only represented in the atmosphere (MASL in Scott's definitions).

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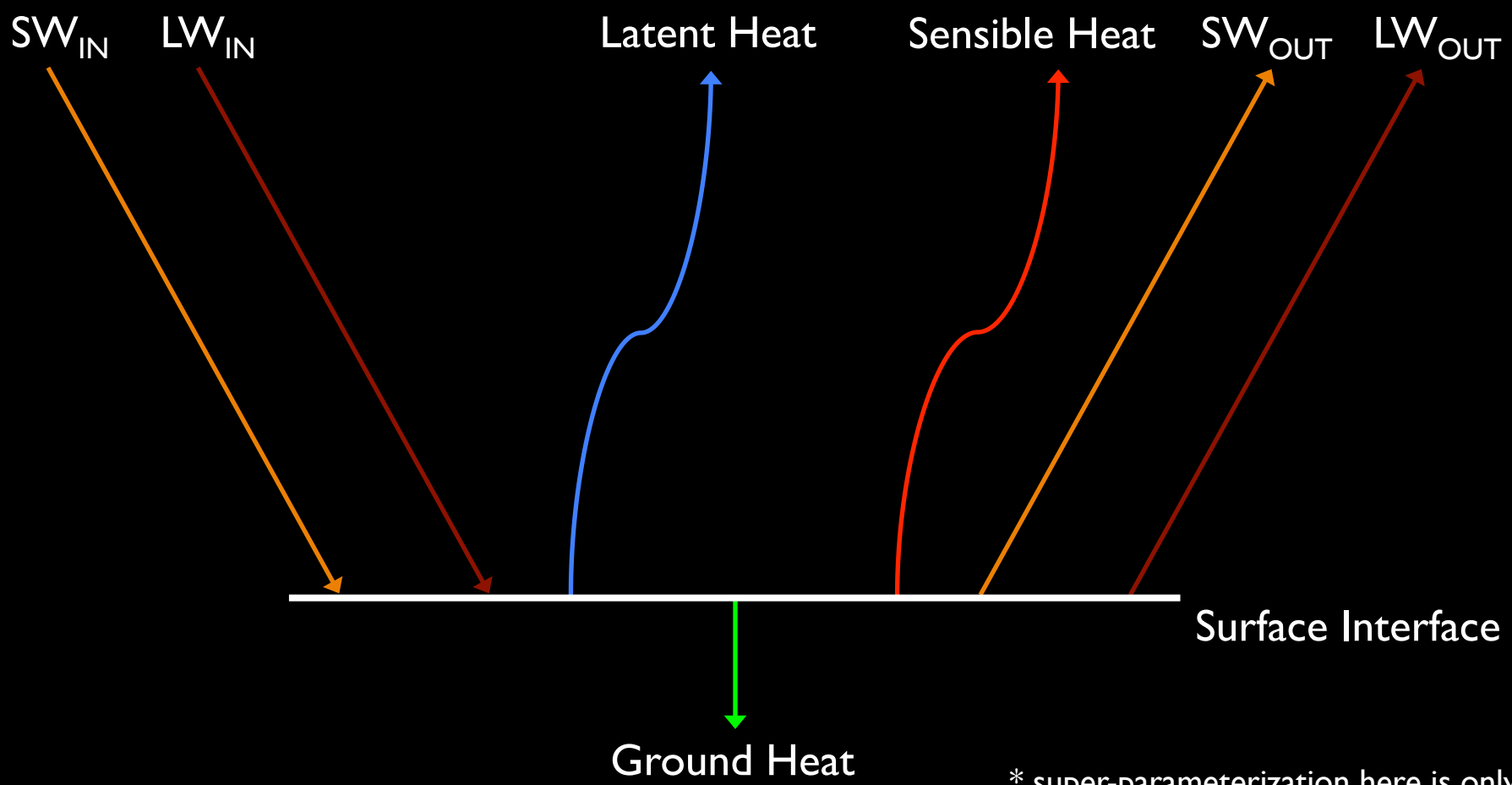

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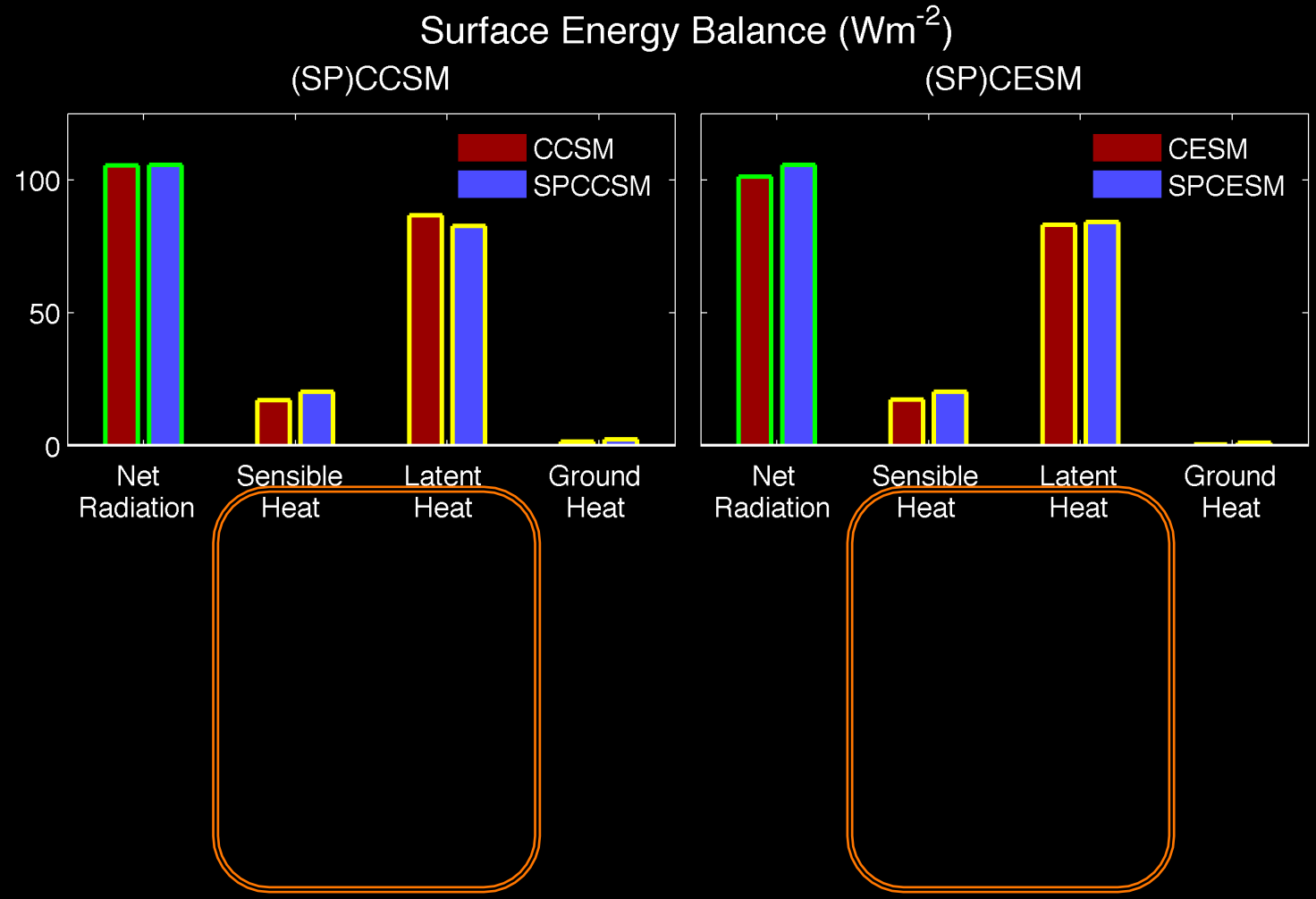
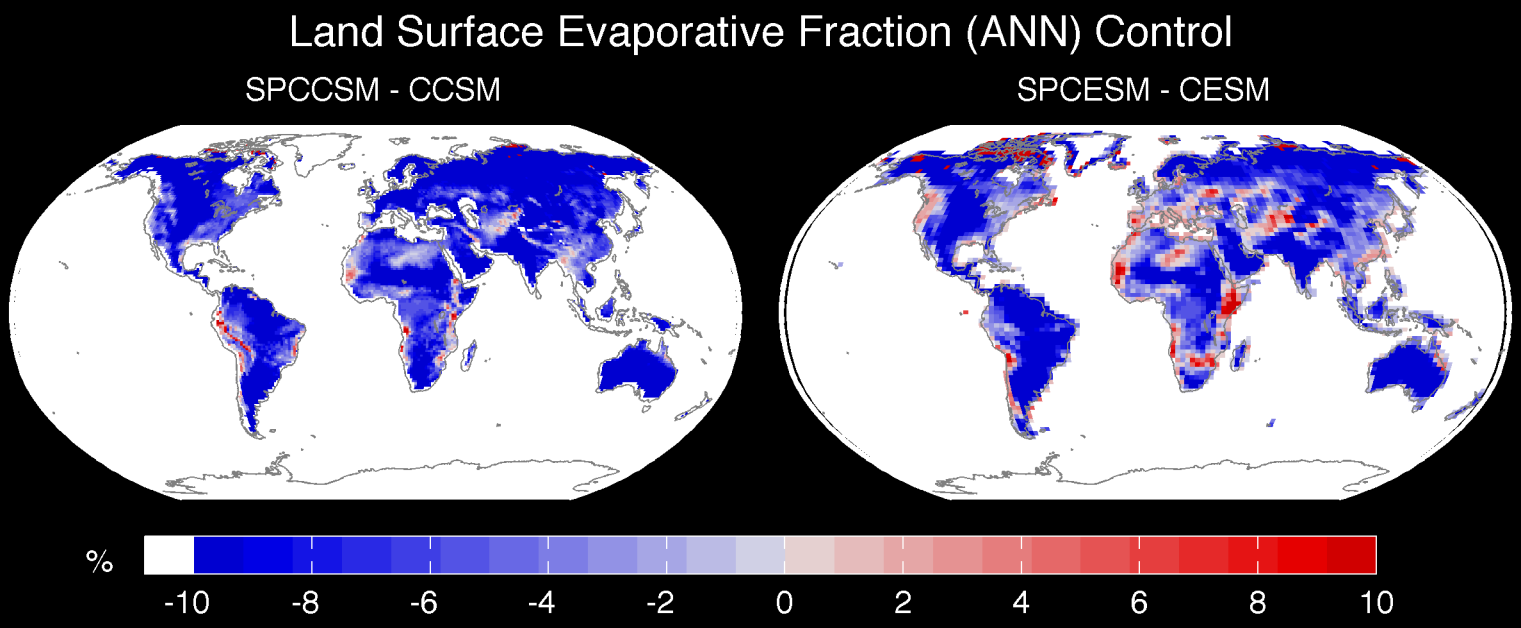
Super-parameterization consistently has less latent heat and more sensible heat over land

Annual Mean:



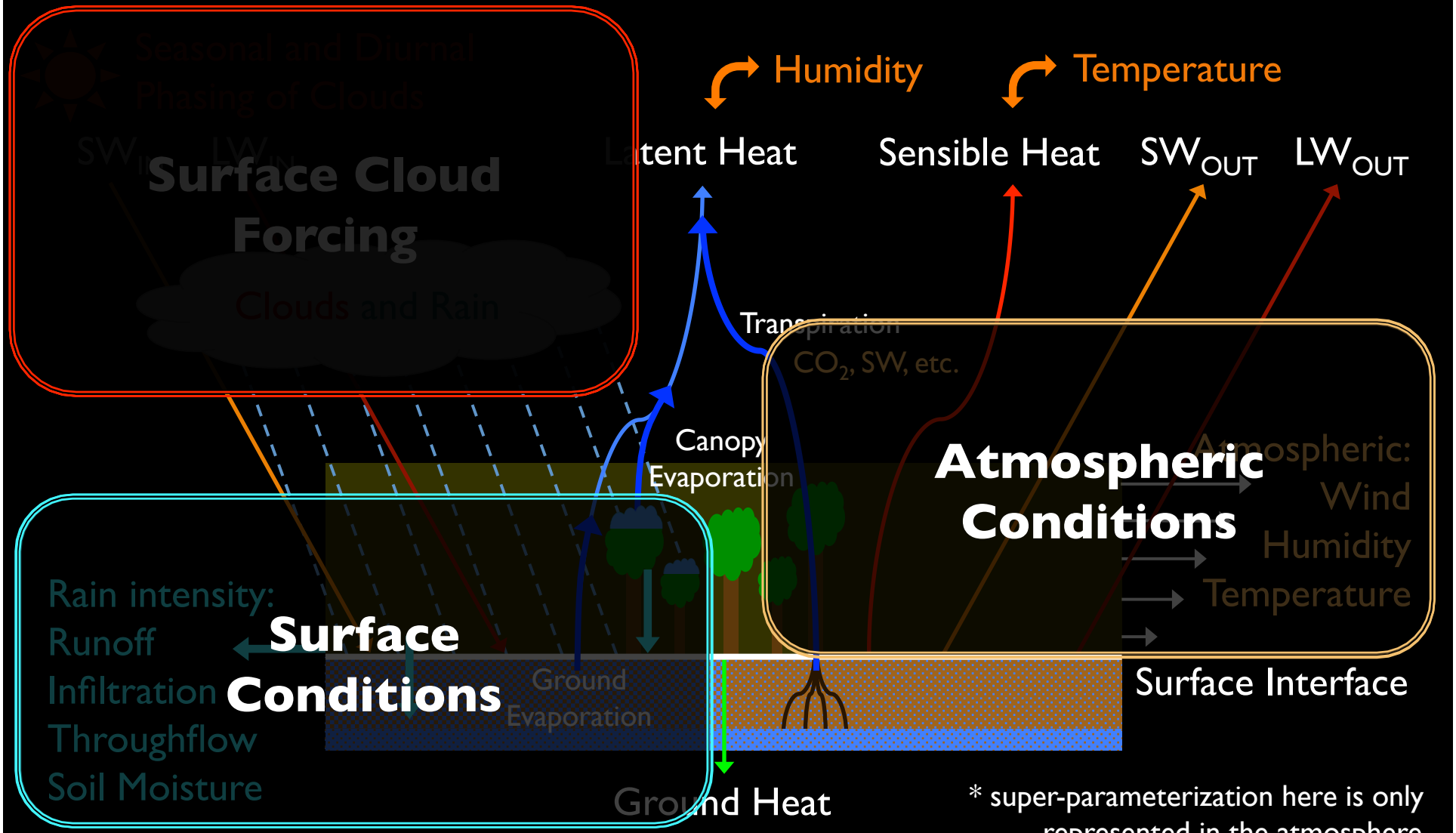
- Net Radiation = SW_{IN} + LW_{IN} + SW_{OUT} + LW_{OUT}

Robust regional and seasonal impact of super-parameterization on surface fluxes over land



- Latent heating is consistently lower over land in SPCAM than CAM, while sensible heating is consistently higher
- The difference between models is strongest during the summer growing season

How can super-parameterization impact sensible and latent heat partitioning?



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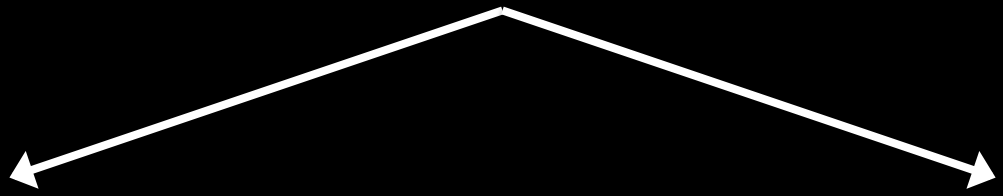


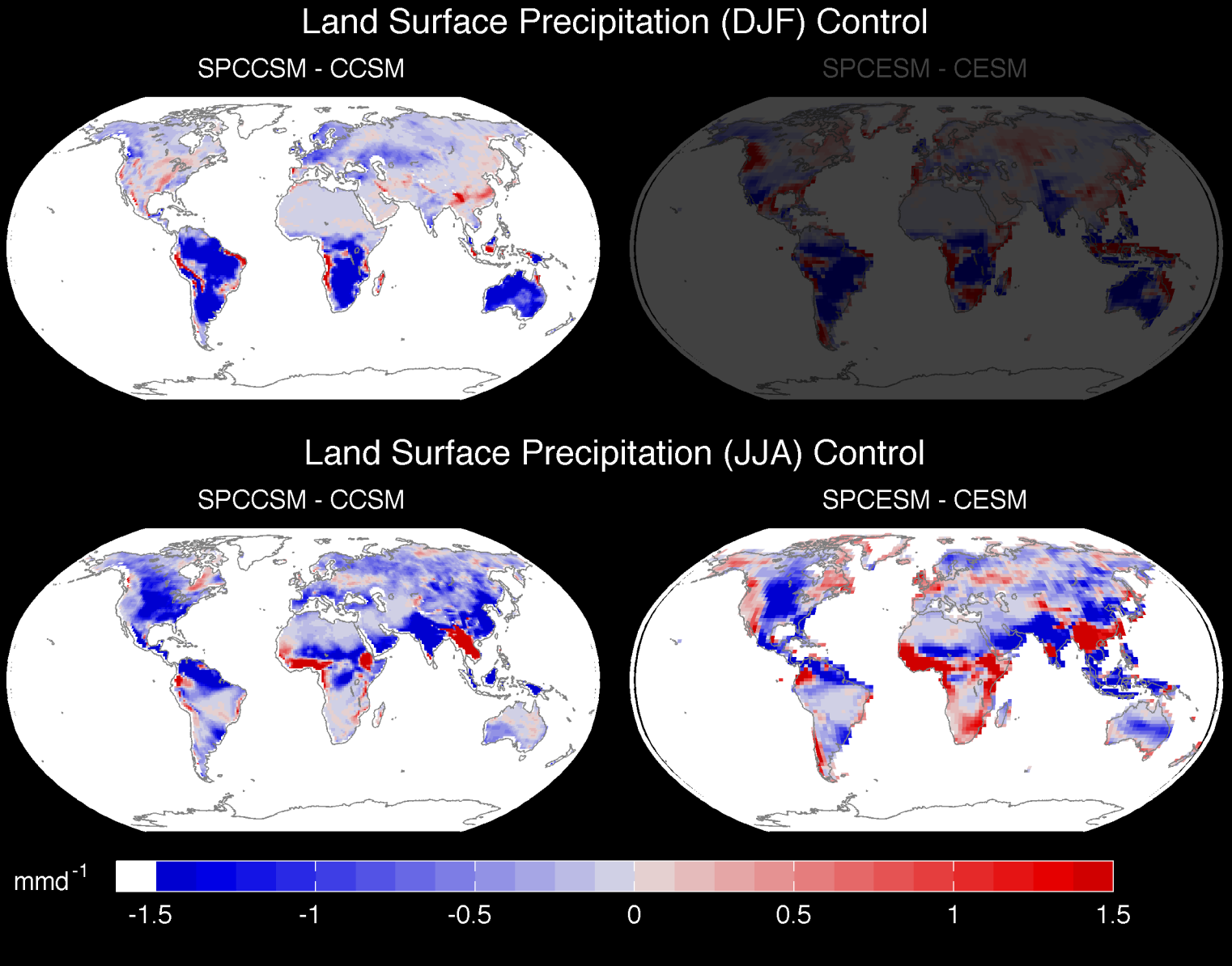
Surface Conditions

Rainfall, Soil Moisture, and Evapotranspiration

Atmospheric Conditions

Temperature and Humidity

Less rainfall over land in SPCAM reduces soil moisture, especially during summer



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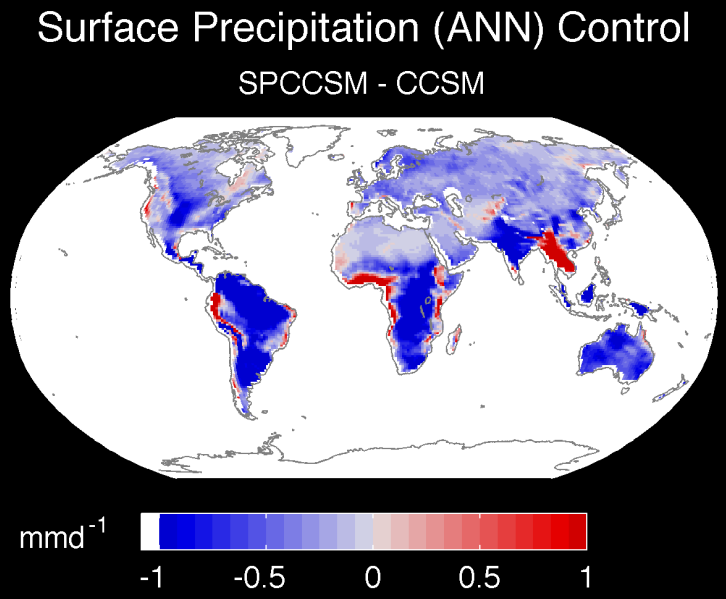
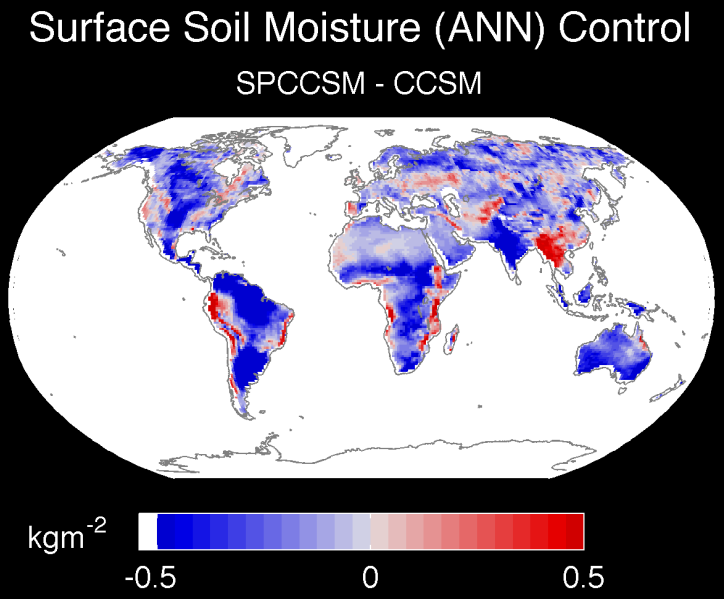
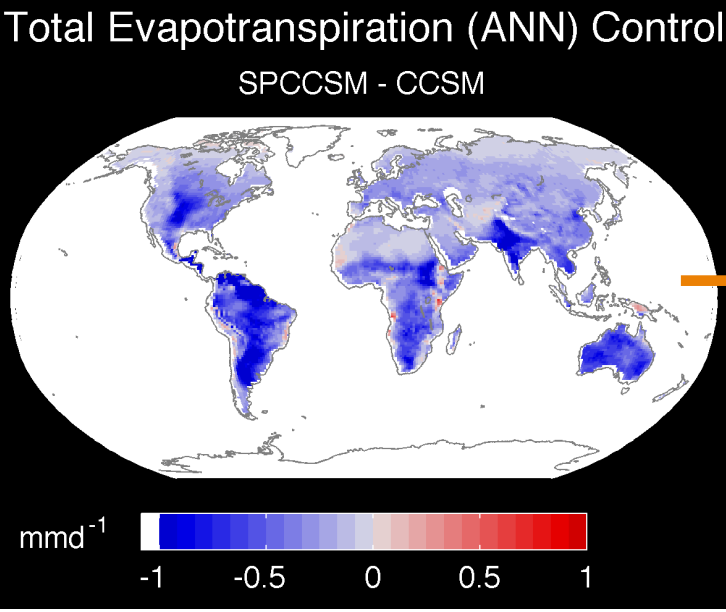
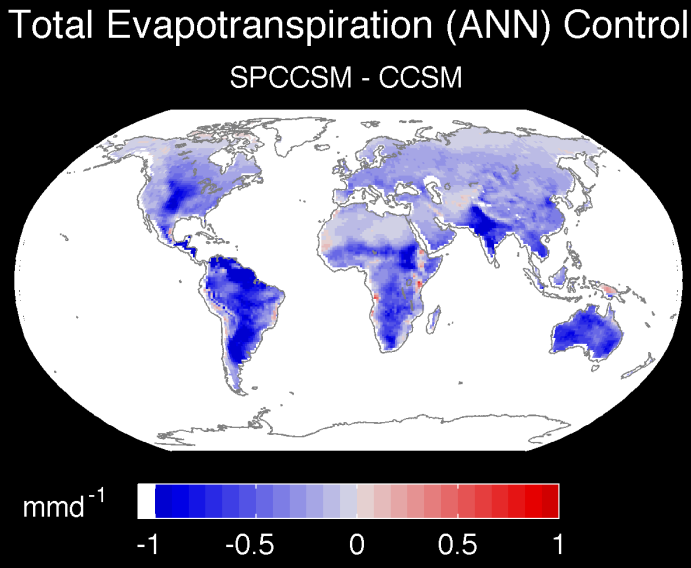


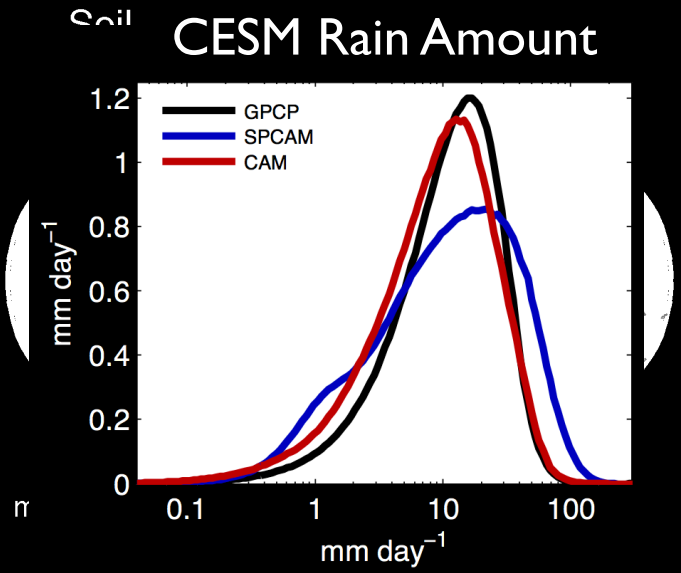


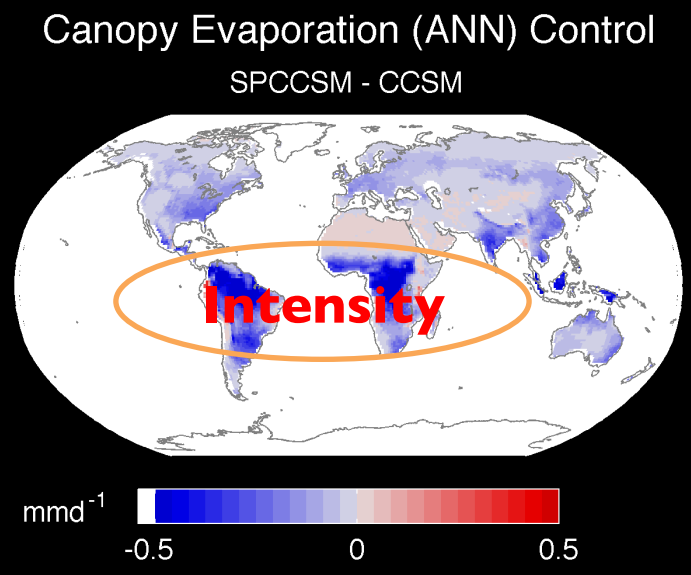


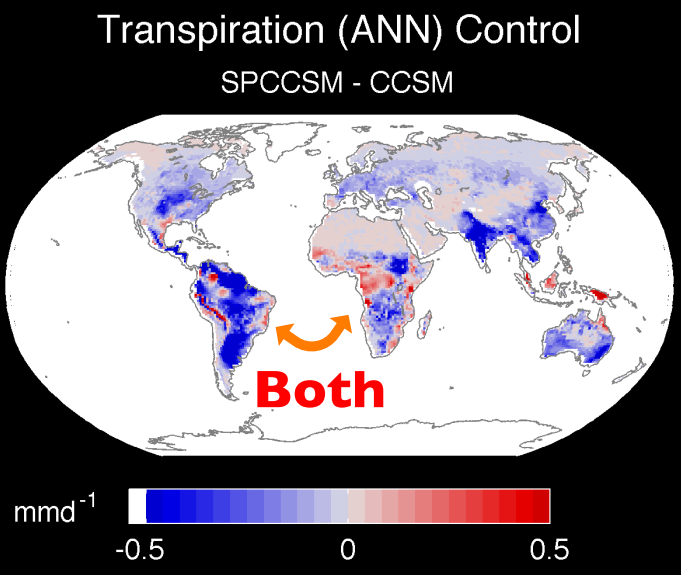
- Surface soil moisture does not completely explain evapotranspiration
- Something else limits evapotranspiration in regions with more rain

Reduction from all components of latent heat but regional influence from rain intensity









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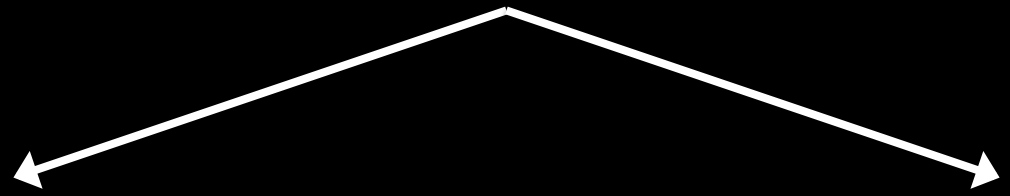


Surface Conditions

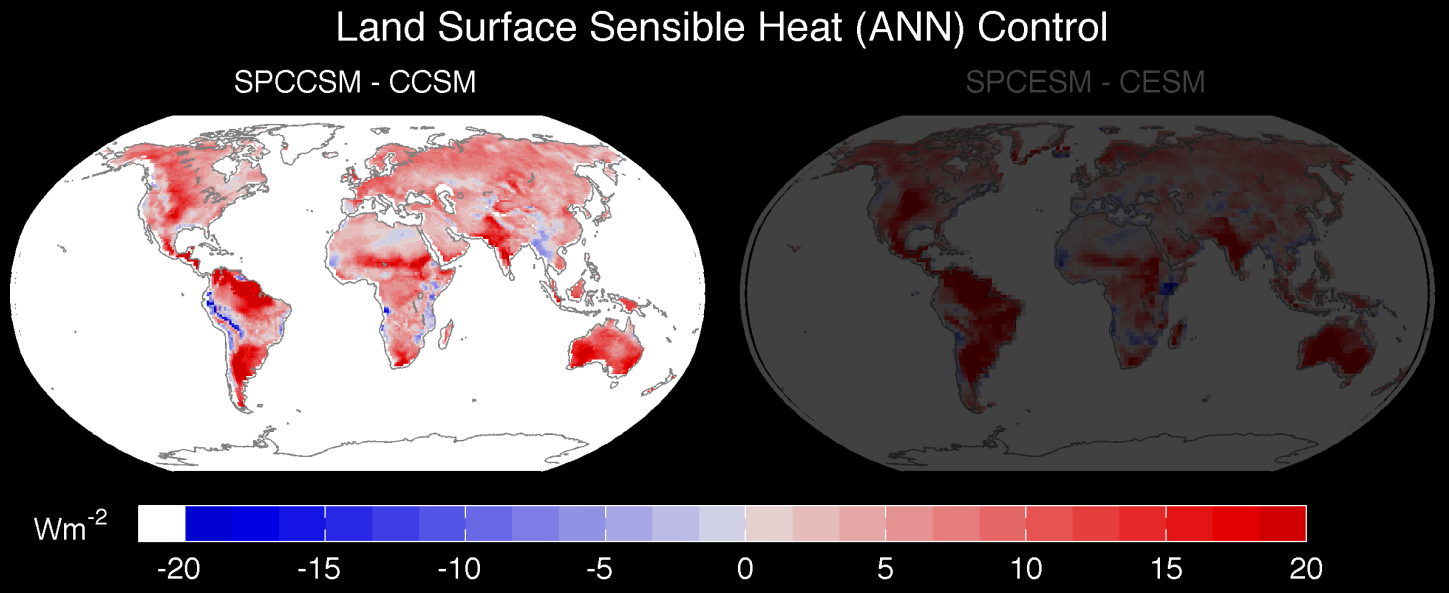
Rainfall, Soil Moisture, and Evapotranspiration

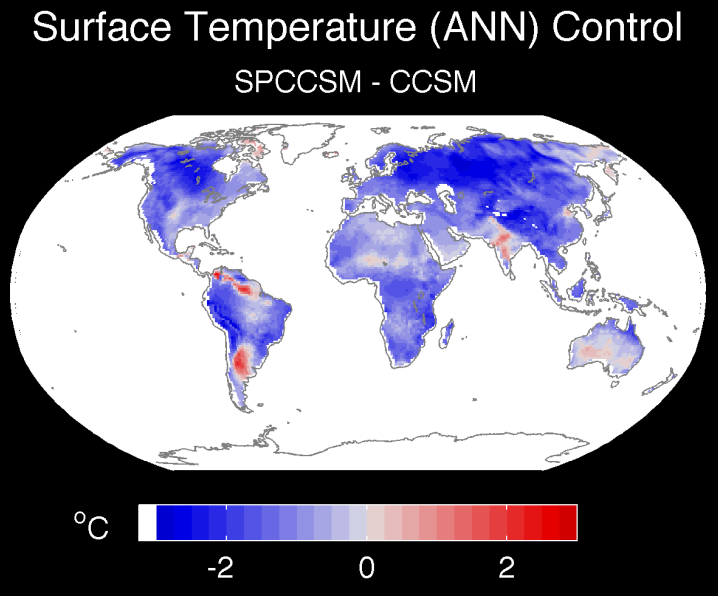
Promotes Less Latent Heating

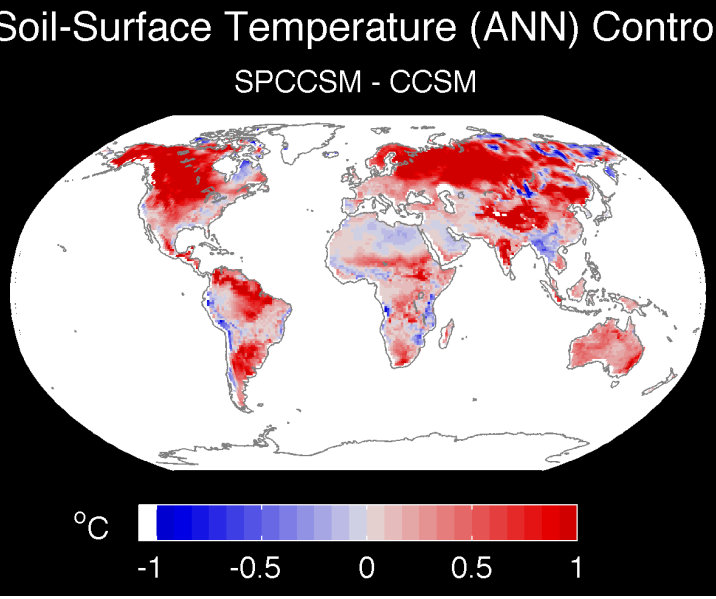
Atmospheric Conditions

Temperature and Humidity

Amplified land-atmosphere thermal contrast enhances sensible heating?







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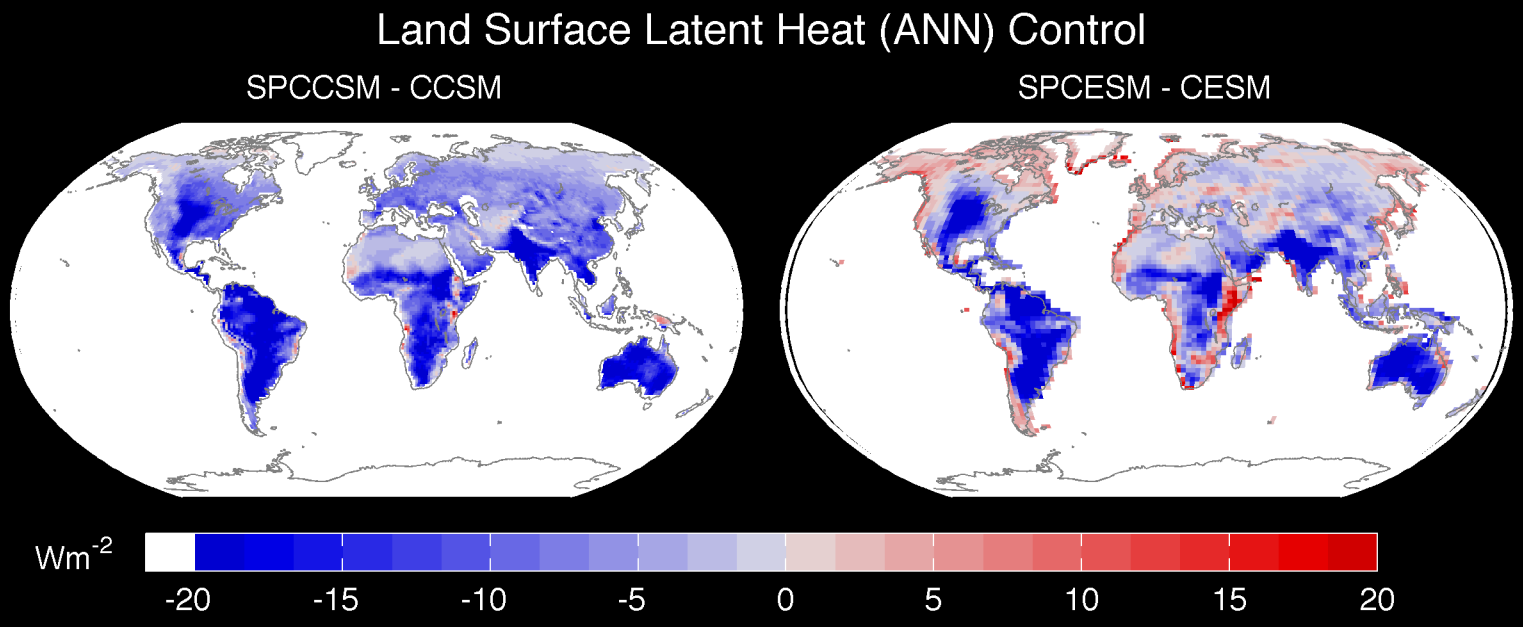
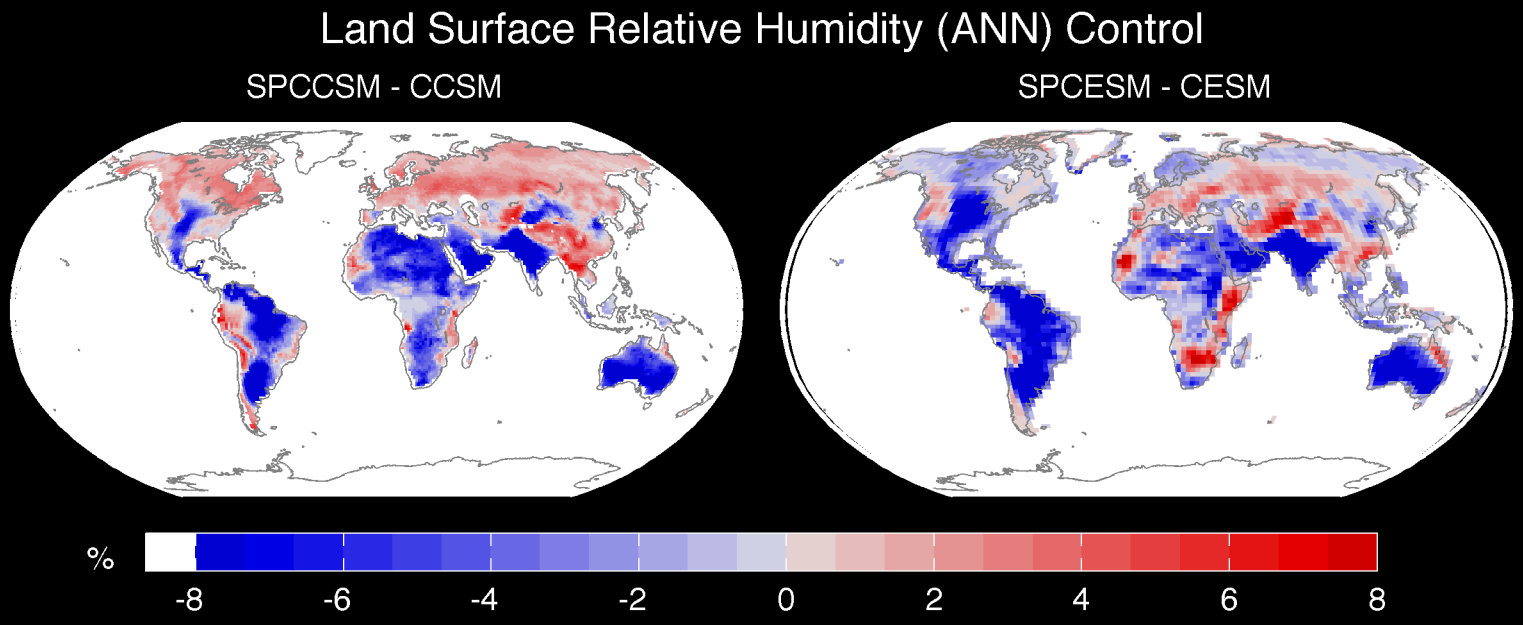
Lower soil moisture reduces surface humidity





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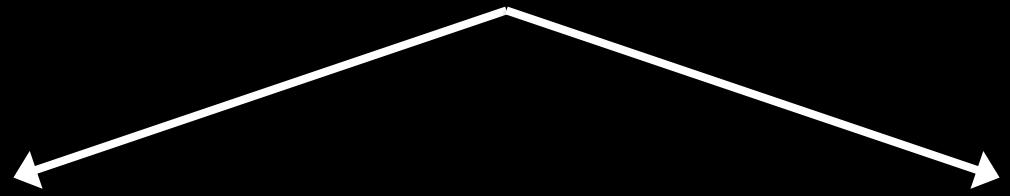


Surface Conditions

Rainfall, Soil Moisture, and Evapotranspiration

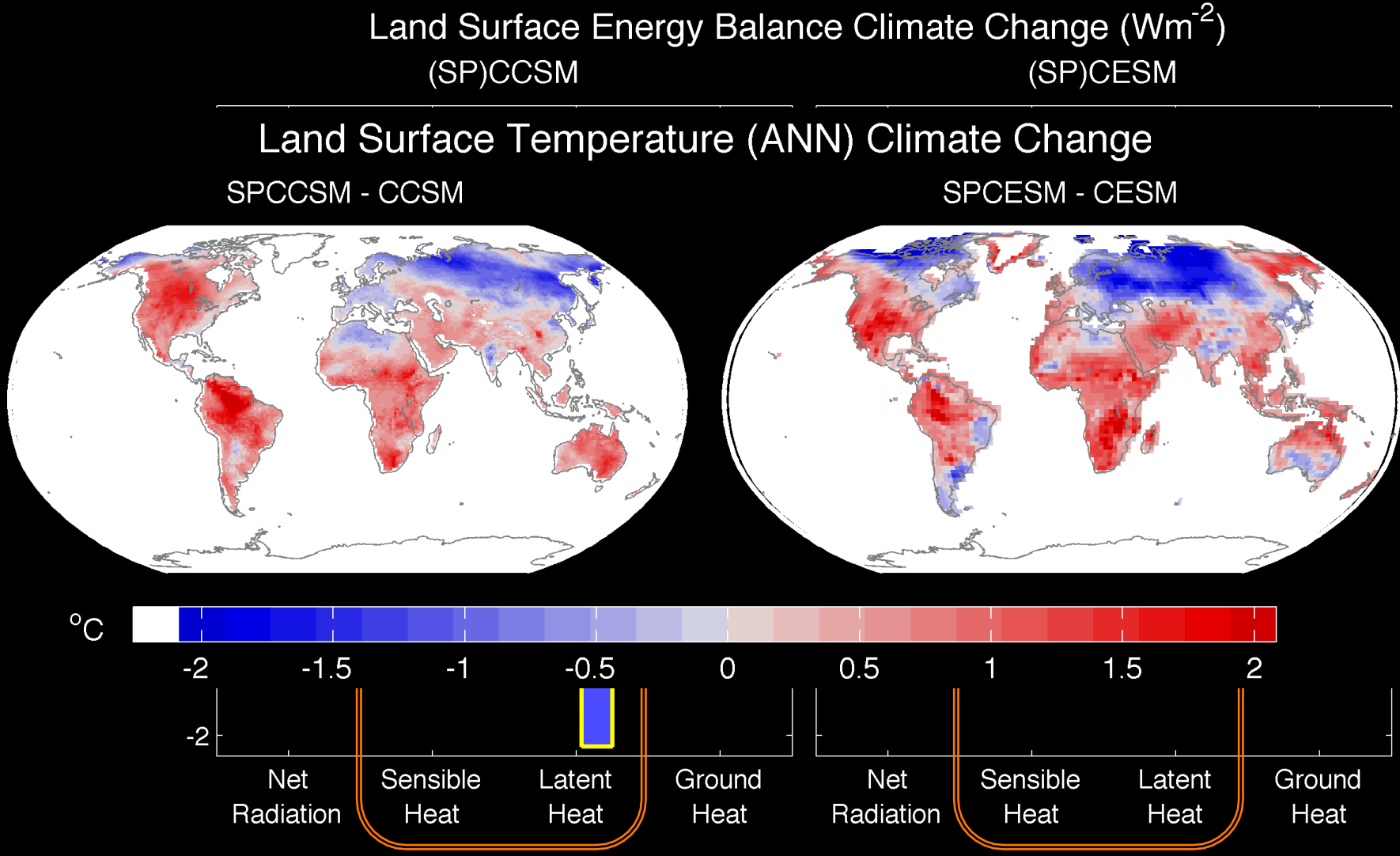
Promotes Less Latent Heating

Atmospheric Conditions

Temperature and Humidity

Promotes More Sensible Heating

SP-CAM further reduces evaporative fraction with climate change relative to CAM



- Climate Change = ($SPCAM_{Forcing}$ – $SPCAM_{Control}$) – ($CAM_{Forcing}$ – $CAM_{Control}$)

Conclusions:

- SP-CAM enhances sensible over latent heating
- SP-CAM has less rainfall over land and lower soil moisture, limiting latent heating
- A colder overlying atmosphere in SPCAM associates with more sensible heating
- Climate change amplifies Bowen ratio in both models, but more in SP-CAM

Questions:

- Does super-parameterization have a more/less realistic representation of land-surface fluxes?
- Why does SPCAM rain less over land (feedbacks)?
- Why does SPCAM cool the surface atmosphere?