Radiative effects of clouds and water vapour on an axisymmetric monsoon

Michael Byrne & Laure Zanna

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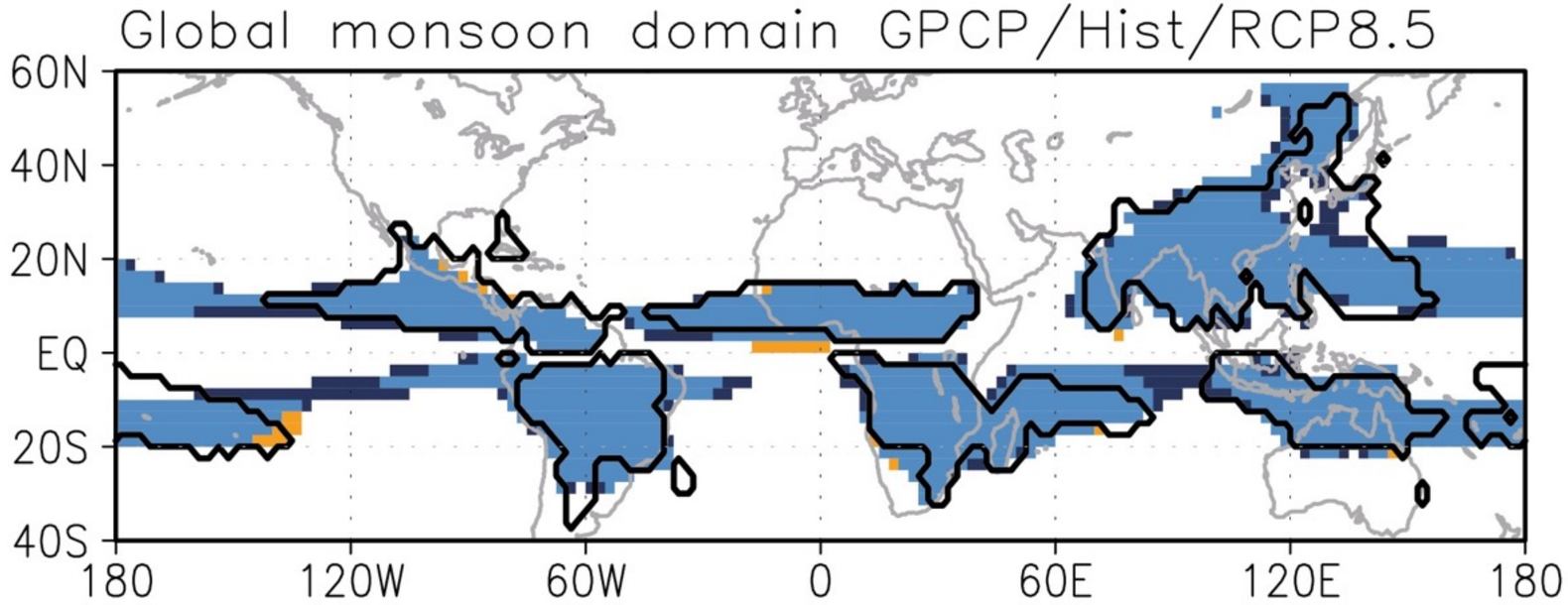
Monsoons: Summertime (sub)tropical atmospheric circulations delivering water to >50% of the global population



Kitoh et al (2013)

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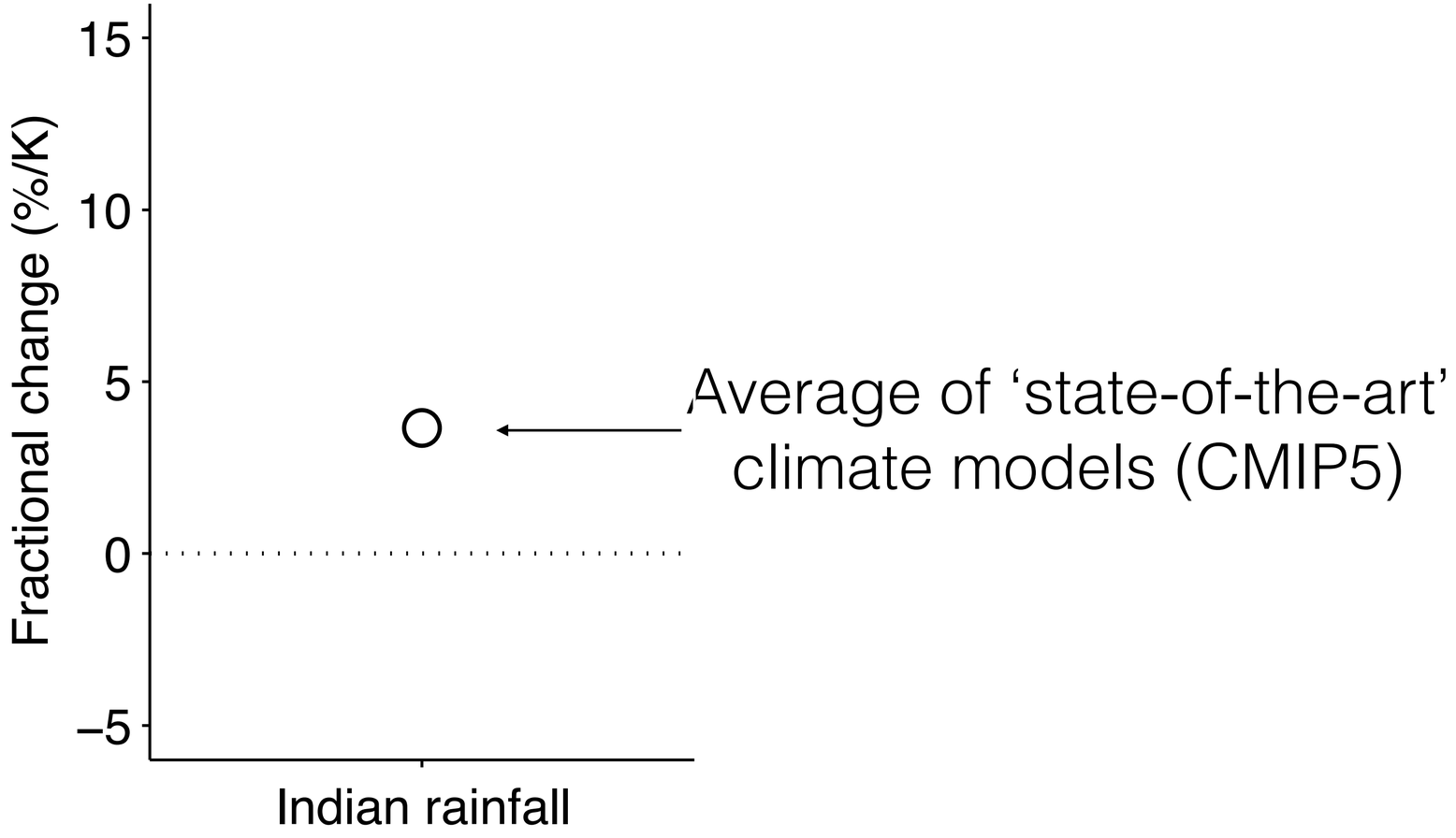
Monsoons expected to respond strongly to future climate change



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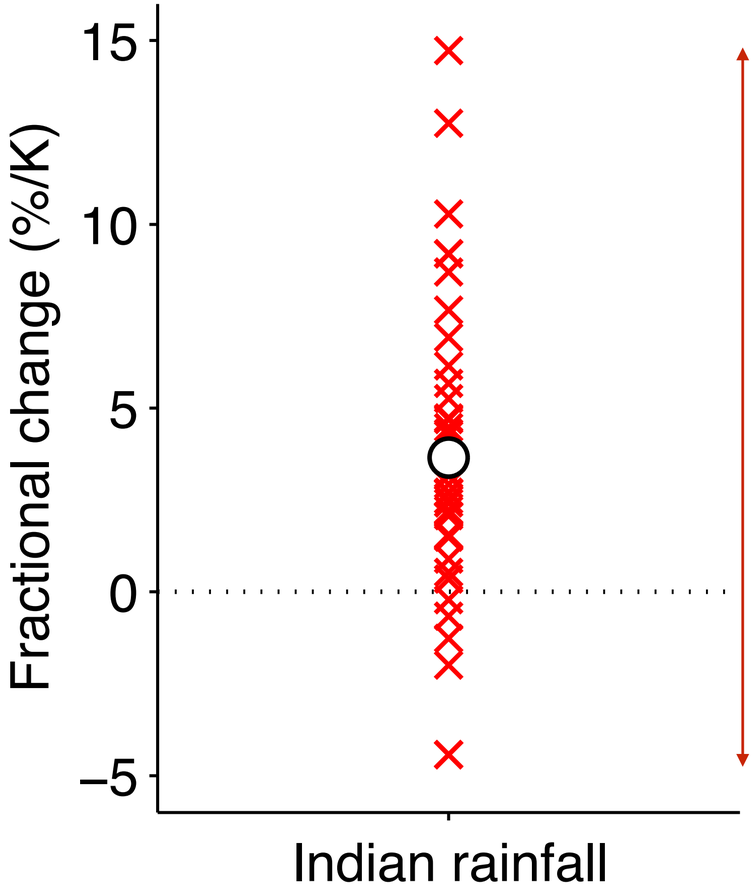
But… monsoon projections from climate models are highly uncertain



CMIP5: full model range

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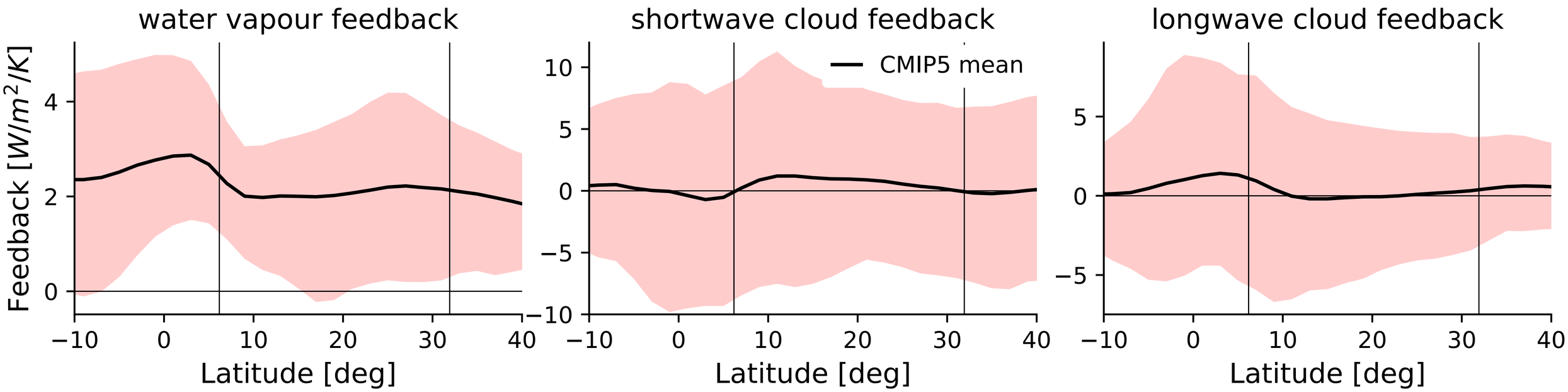
Cloud & water vapor feedbacks also very uncertain. Are radiative feedbacks driving monsoon uncertainty??



Radiative kernels provided by Mark Zelinka

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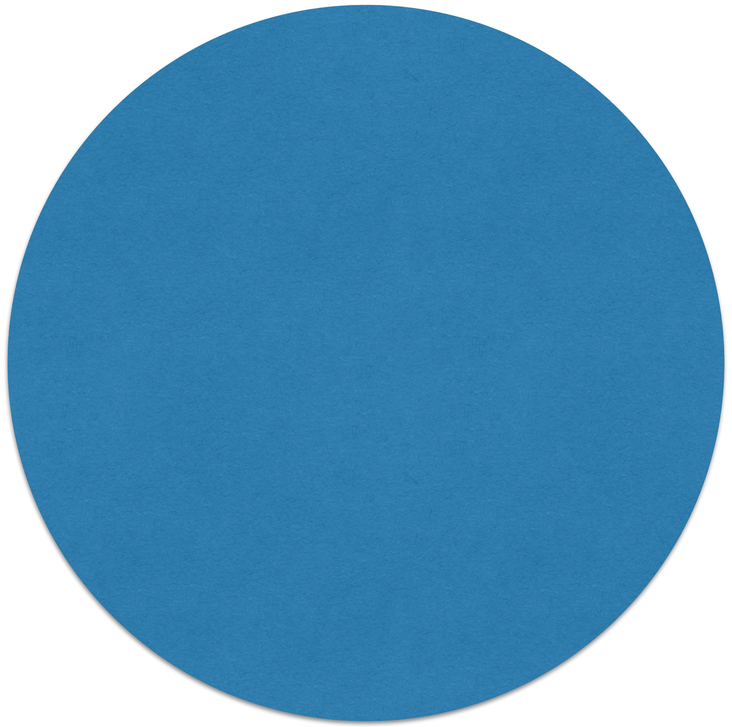
Start simple: aquaplanet simulations to investigate potential of clouds and water vapour to influence monsoons

model setup



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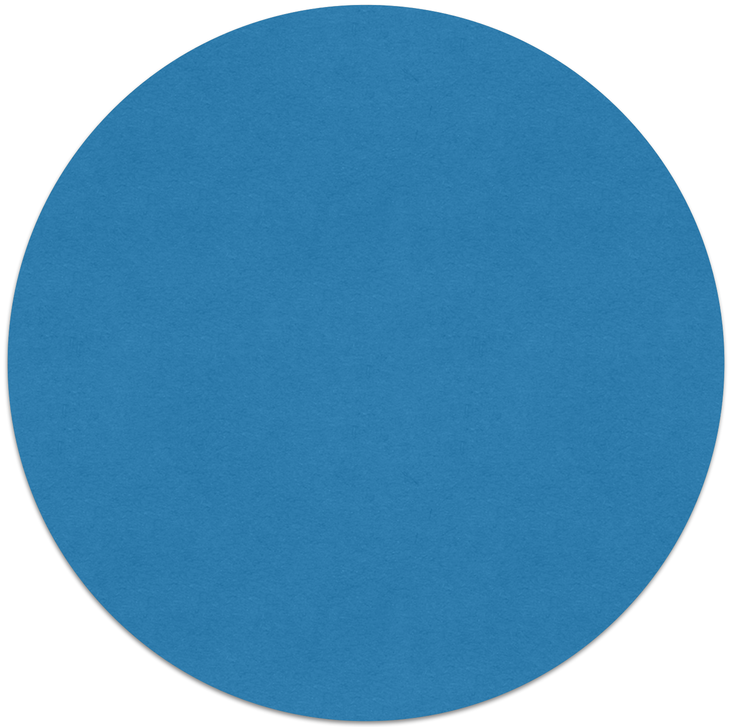

Using aquaplanets to learn about monsoons is not new *(e.g. Yano & McBride 1998; Privé & Plumb 2007; Bordoni & Schneider 2008)*

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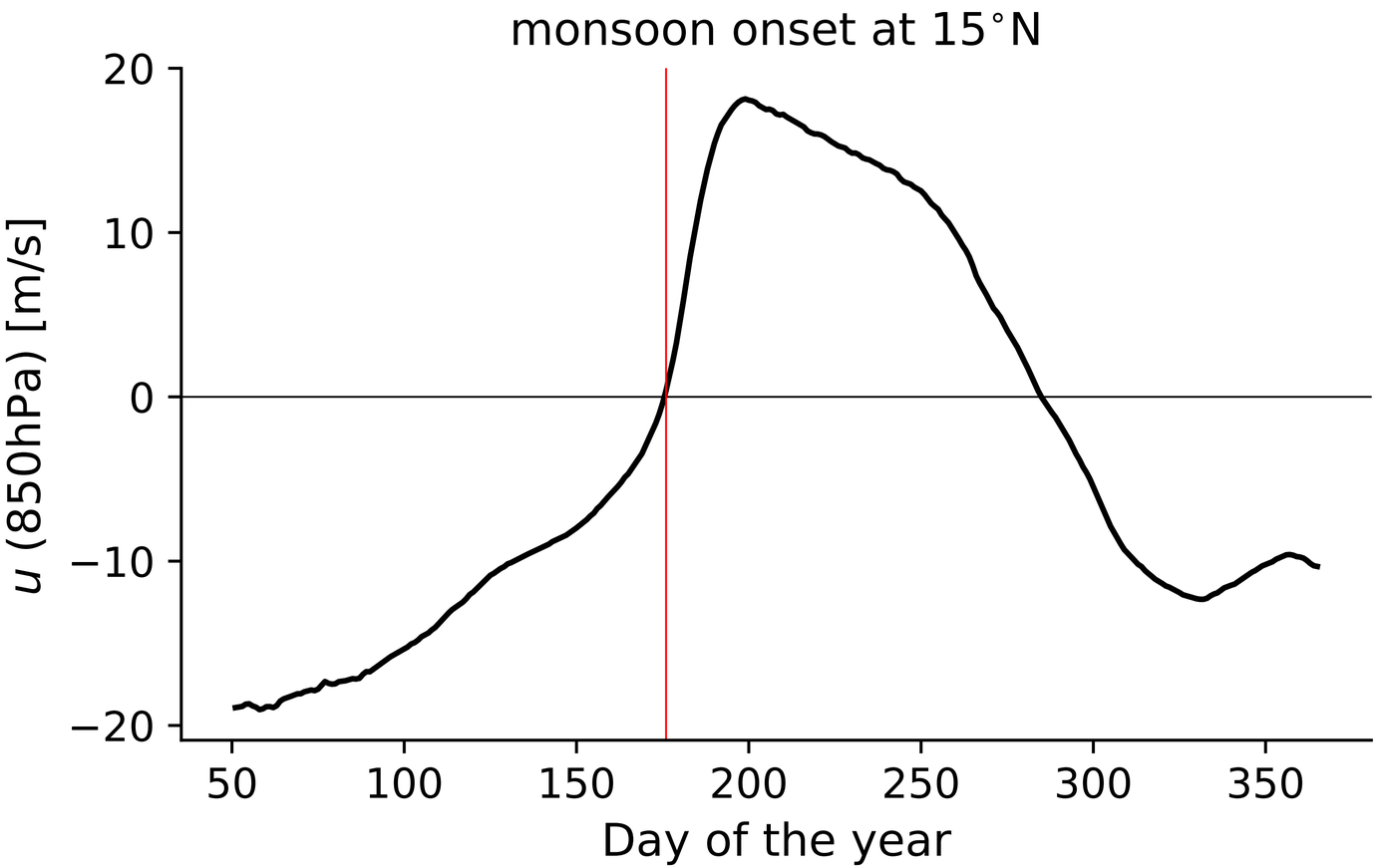
Aquaplanets simulate large-scale solstitial circulations with key monsoon features, including abrupt onset



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Two questions to tackle using our aquaplanet simulations

1. **Present day:** How is the monsoon shaped by seasonal cloud and water vapor feedbacks?

2. **4xCO_2:** Do cloud and water vapor feedbacks exert strong influences on the monsoon response?

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Two questions to tackle using our aquaplanet simulations

1. **Present day:** How is the monsoon shaped by seasonal cloud and water vapor feedbacks?

2. **4xCO_2:** Do cloud and water vapor feedbacks exert strong influences on the monsoon response?

Use radiation-locking method to isolate individual radiative effects on monsoon

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Radiation-locking method ‘locks’ clouds and water vapor to prescribed profiles *in the radiation code only*

regular, interactive simulation:
insolation maximum moves off the equator, clouds and water vapor migrate with Sun

-30 **0** **30**

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Radiation-locking method ‘locks’ clouds and water vapor to prescribed profiles *in the radiation code only*

isolate effect of insolation on monsoon:
cloud and WV locked to annual-mean profiles

-30 **0** **30**

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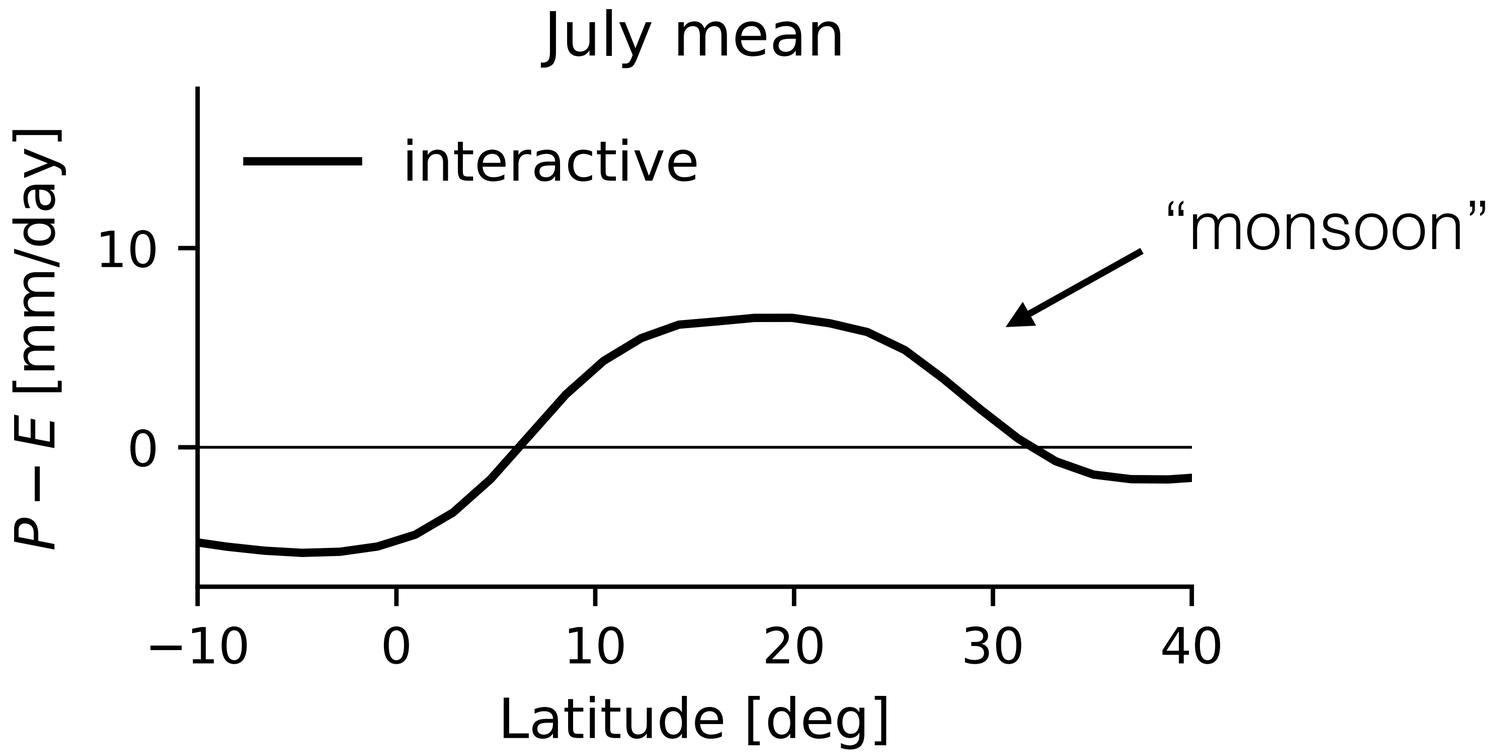
Seasonal cloud and water vapor feedbacks substantially weaken the monsoon (insolation alone produces a stronger monsoon)



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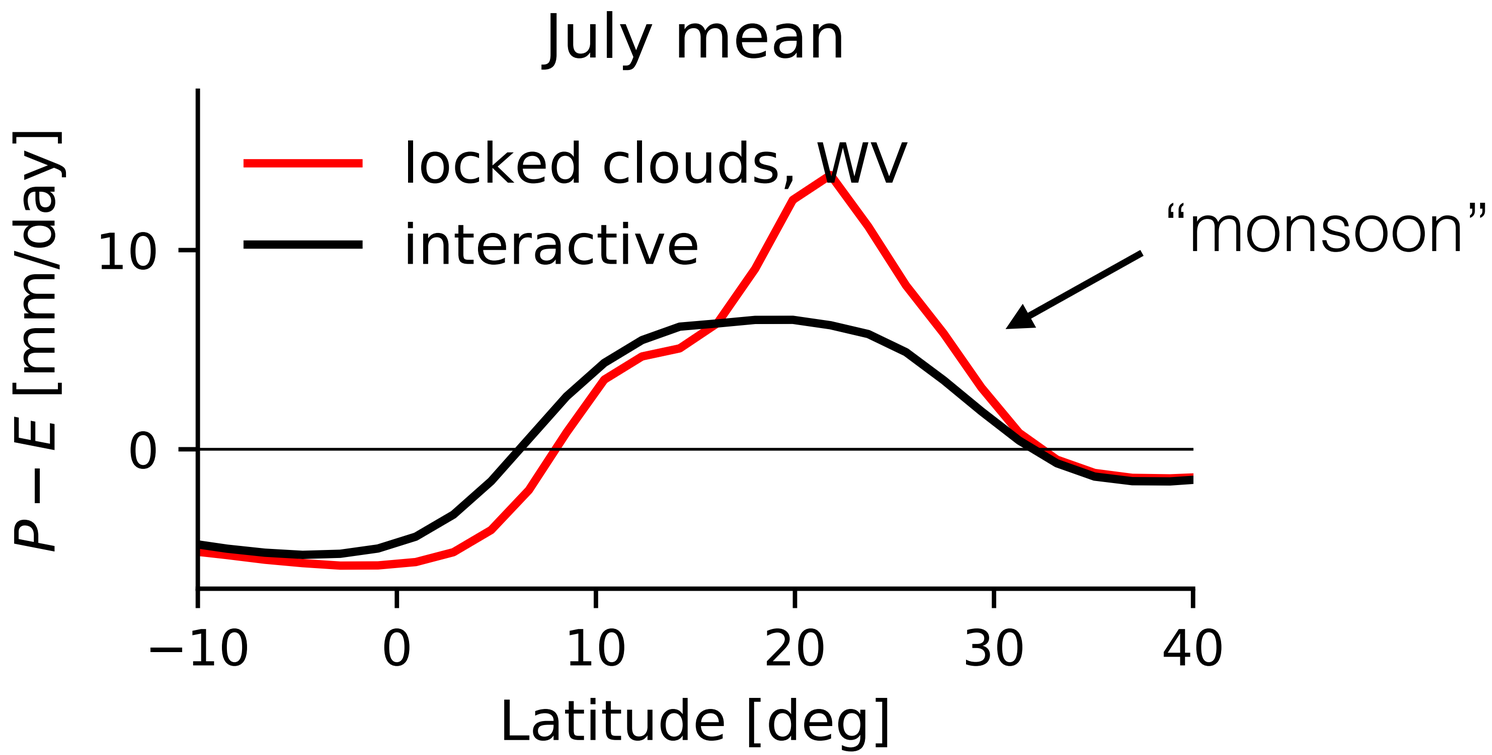

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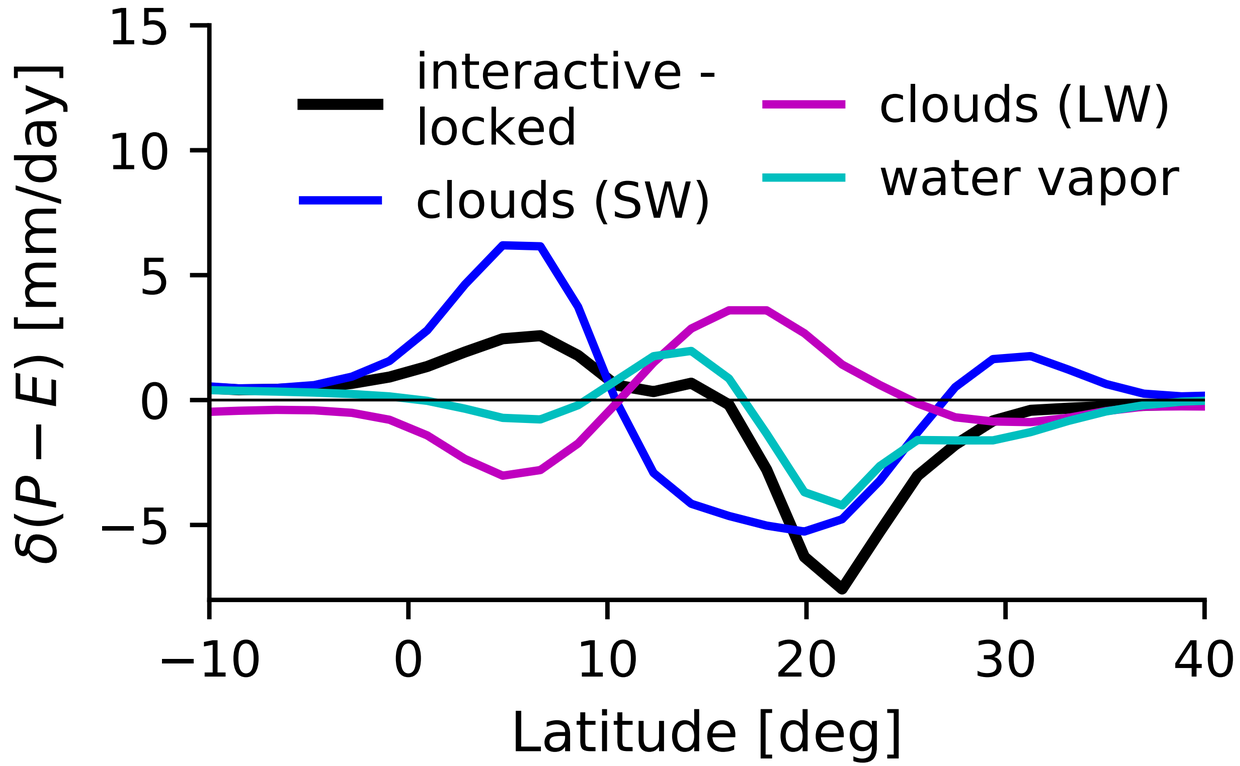
Seasonal cloud feedbacks essential to monsoon: LW strengthens it, SW weakens it



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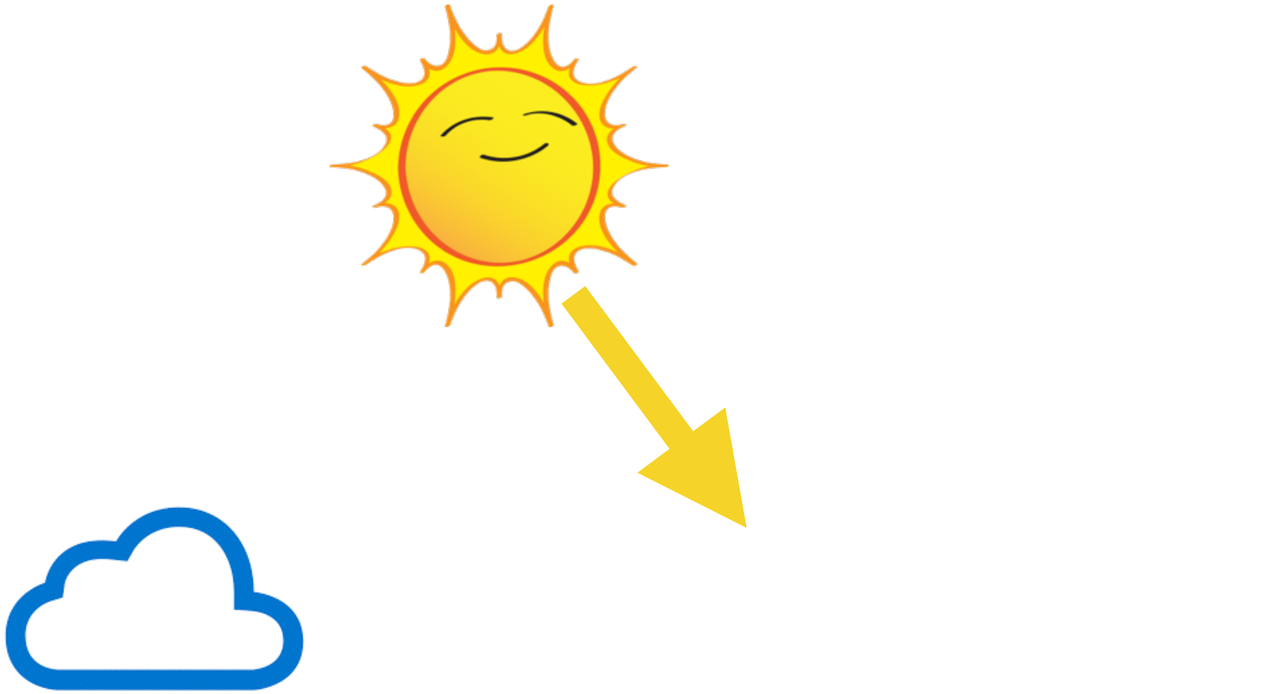
What's going on physically? A shortwave cartoon



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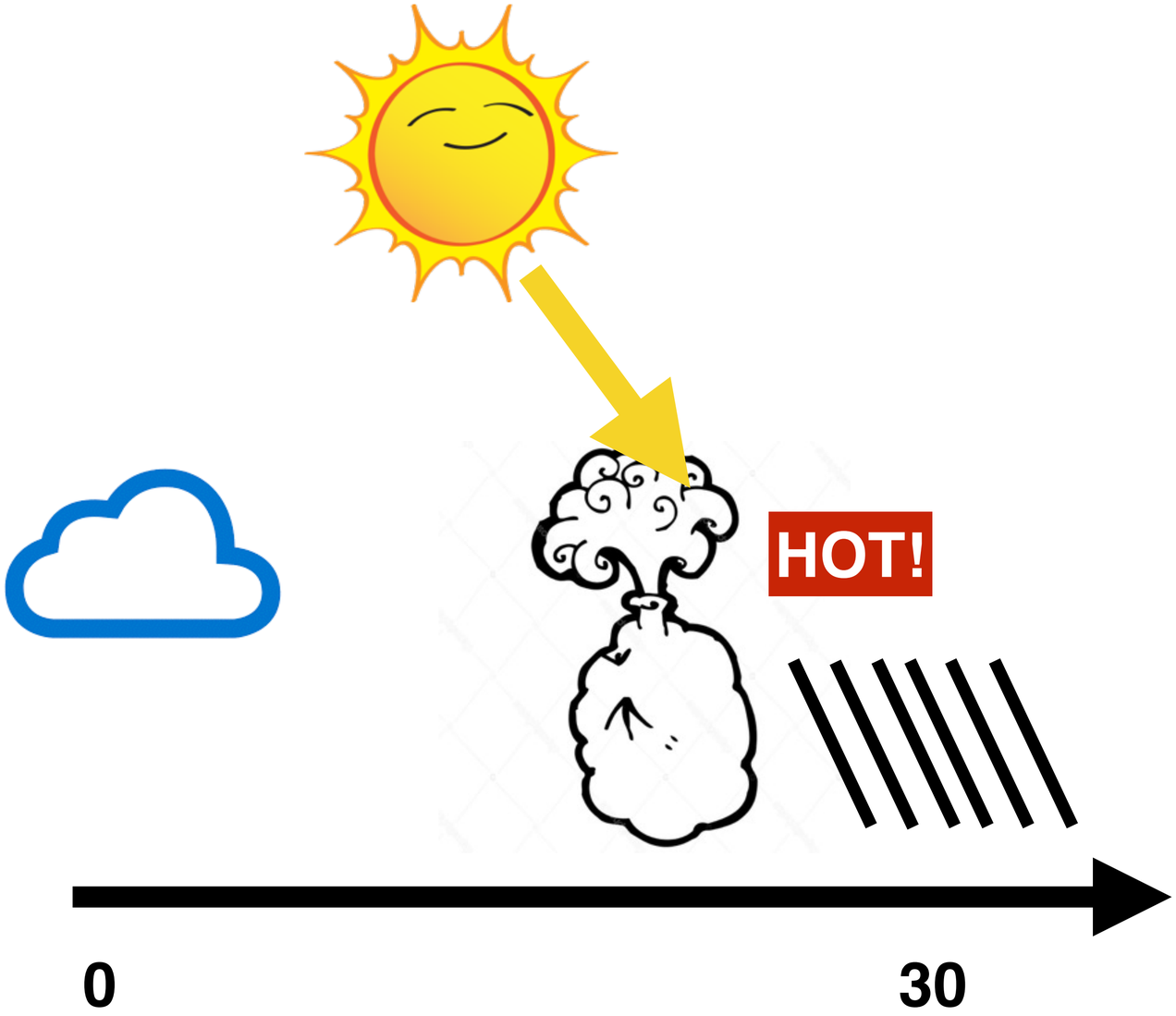

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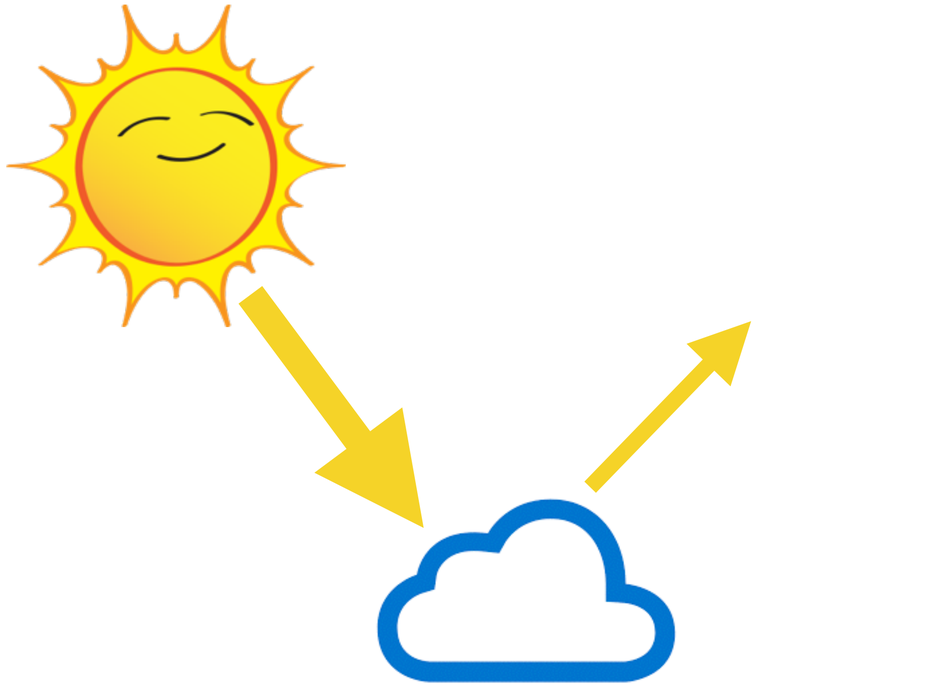

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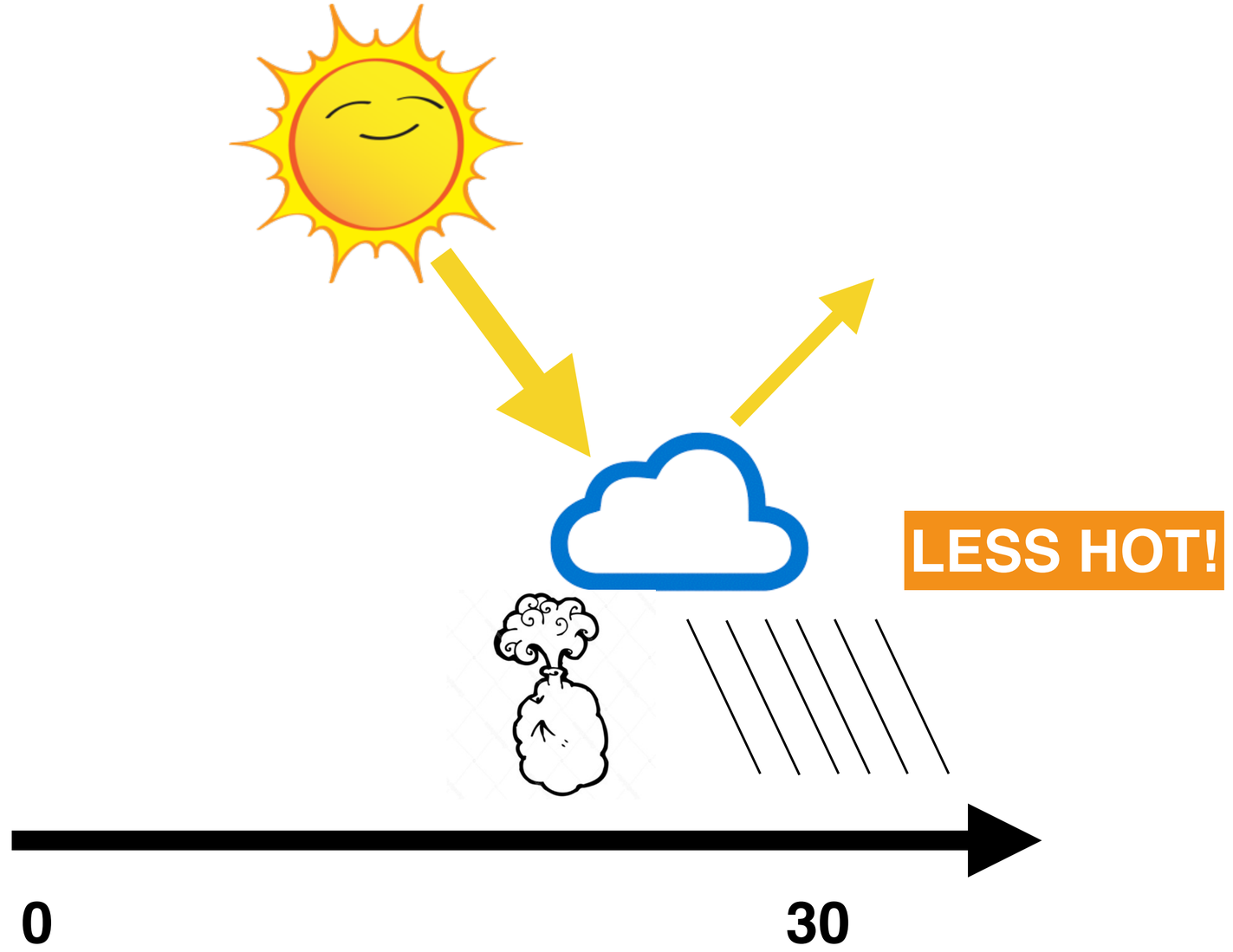

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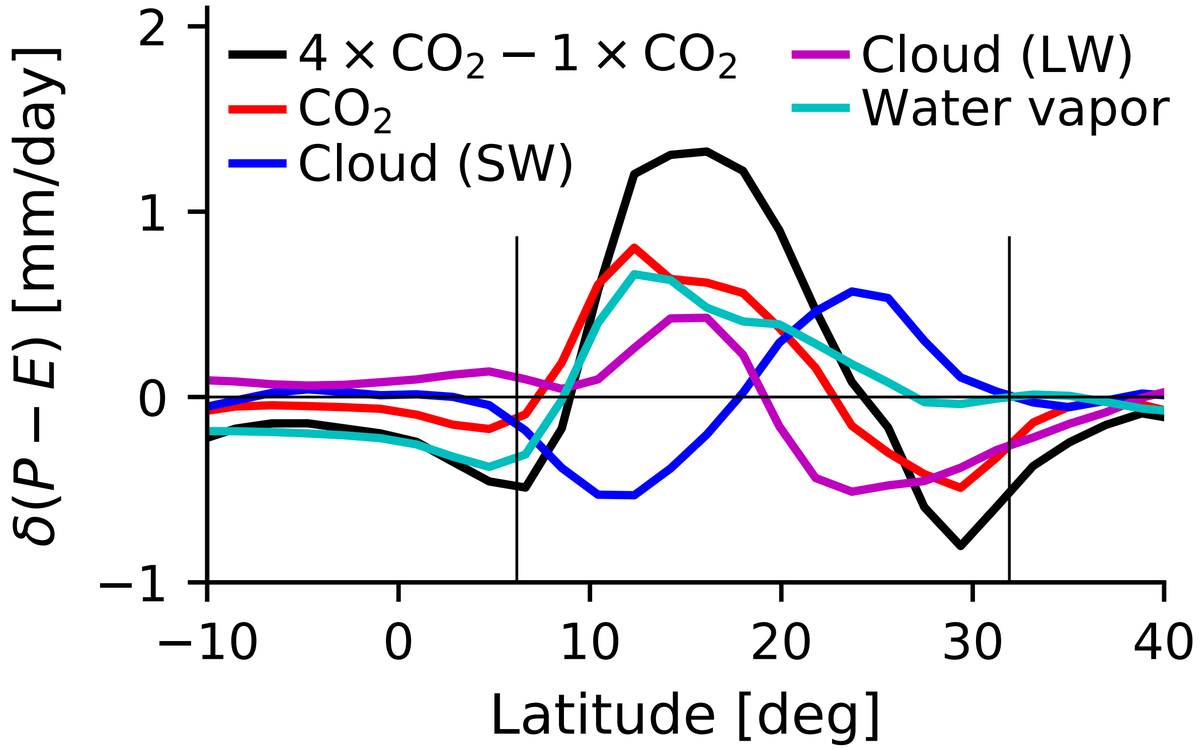
Cloud and water vapor feedbacks also strongly shape monsoon response to CO_2 forcing



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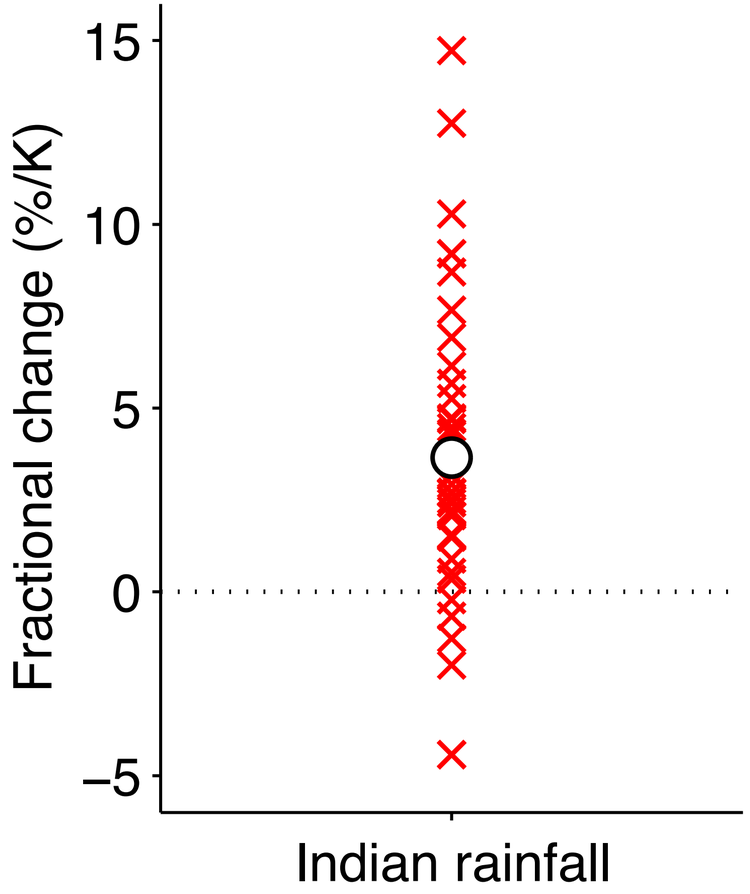
Next step: Can radiative feedbacks explain some faction of the huge diversity in CMIP monsoon projections?



planning radiation-locking simulations with a range of full-complexity models…

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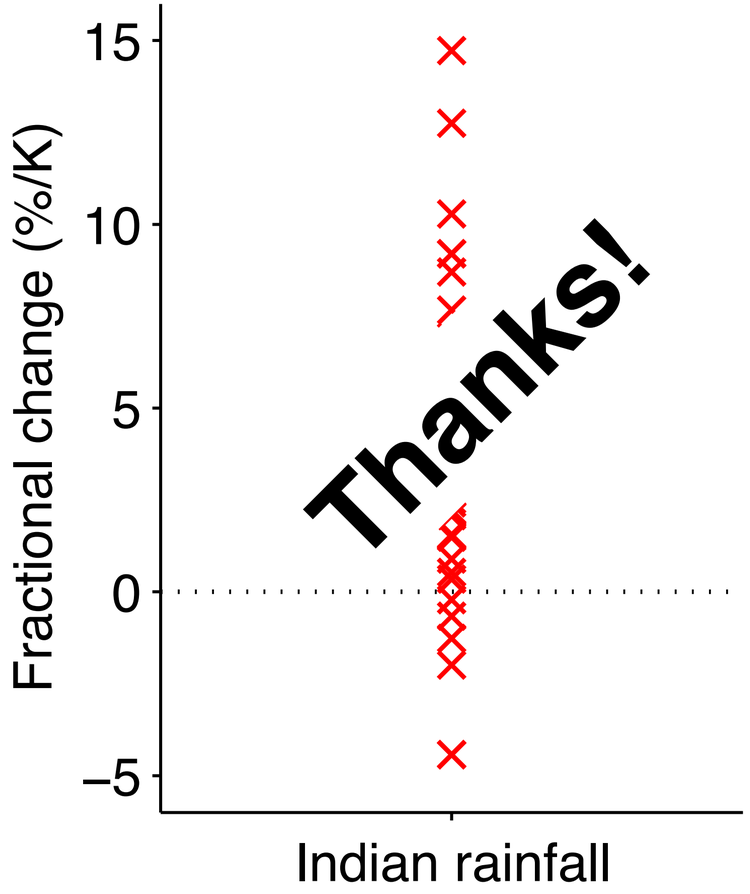

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