MONSOONS OVER IDEALIZED CONTINENTS

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with Anne Laraia

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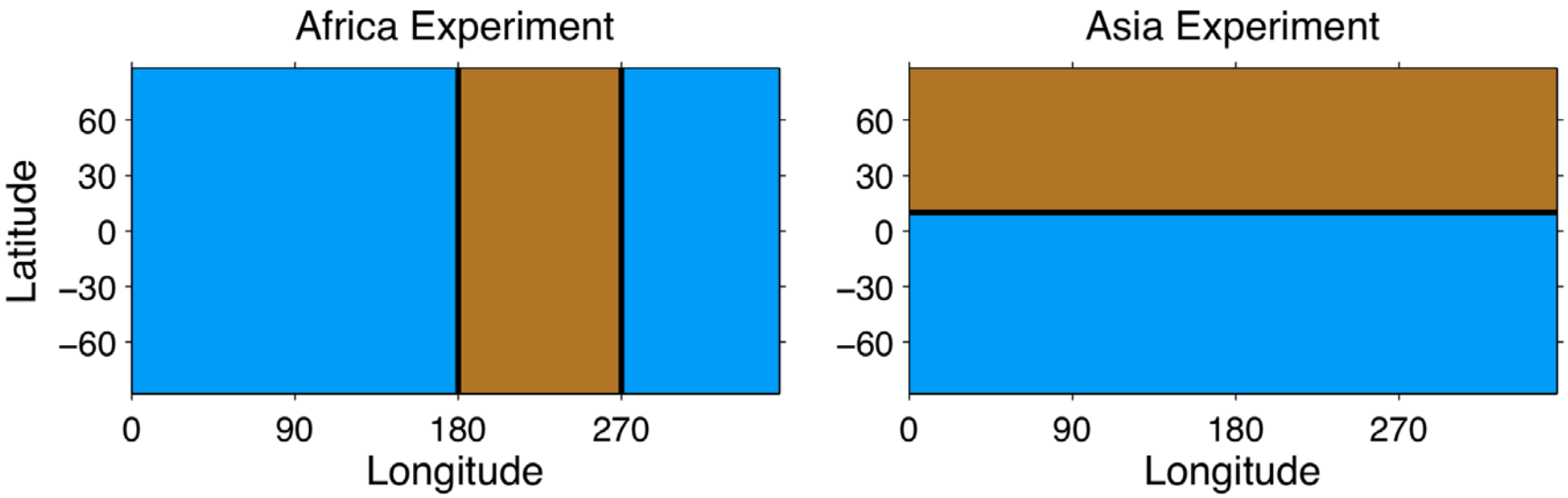
Lessons from aquaplanet experiments

- Land-sea contrast might not be necessary per se for the existence of monsoons;
- Land might be necessary only insofar as it provides a lower boundary with low enough thermal inertia to allow for rapid adjustments of lower level temperature and MSE, and for rain belts to migrate into the subtropics;
- Monsoon transitions are transitions in the leading momentum budget in the Hadley cell, from a regime in which the circulation is constrained by large-scale extratropical eddies to a regime in which the circulation more closely conserves angular momentum.

Bordoni and Schneider (2008)

But land-sea contrast still plays a role

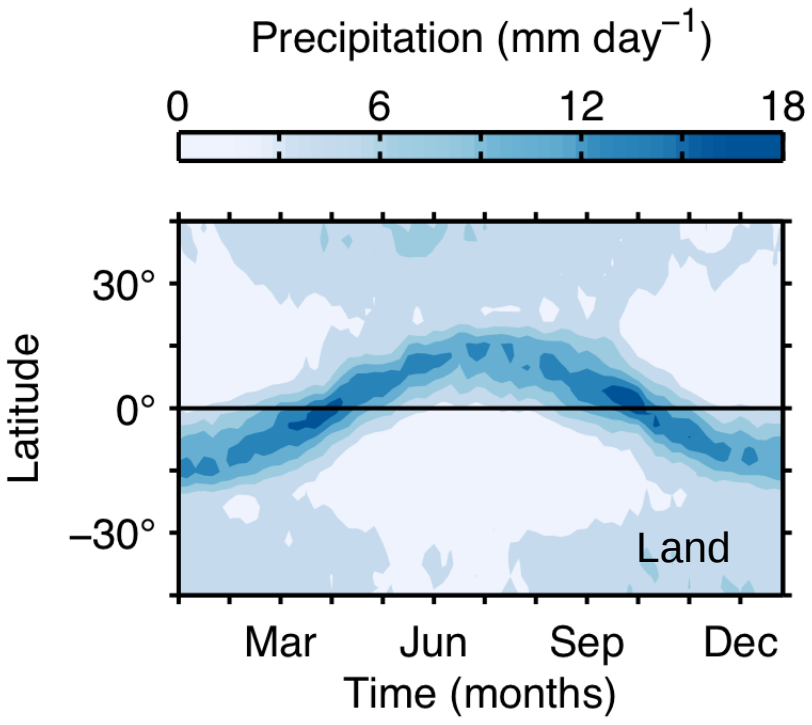


“Land”: 0.2 m mixed layer depth
“Ocean”: 20 m mixed layer depth
} Infinite reservoir of evaporation

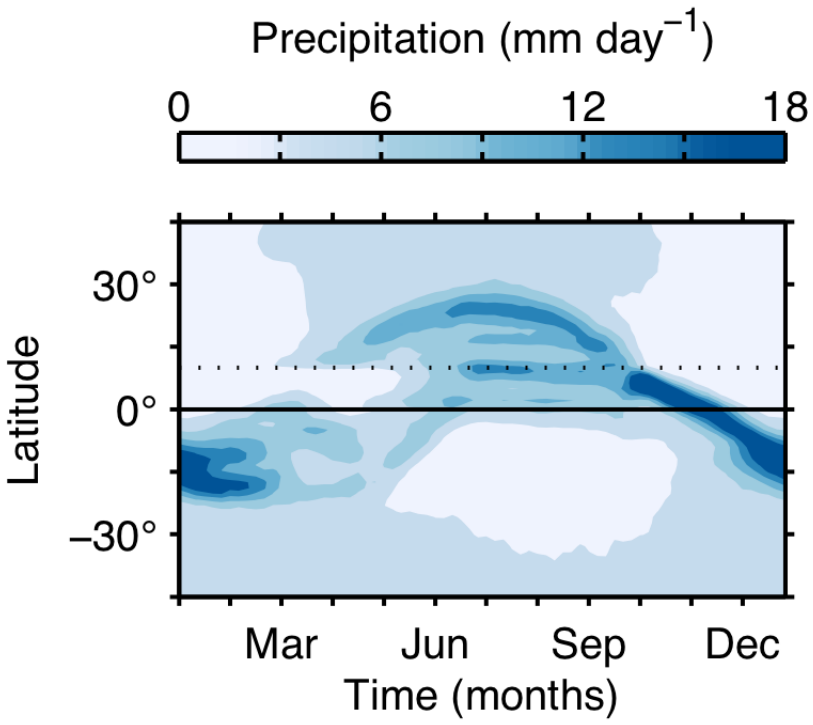
Also “Ocean” transports heat through a prescribed q-flux

Simulated precipitation in the two experiments

Africa



Asia



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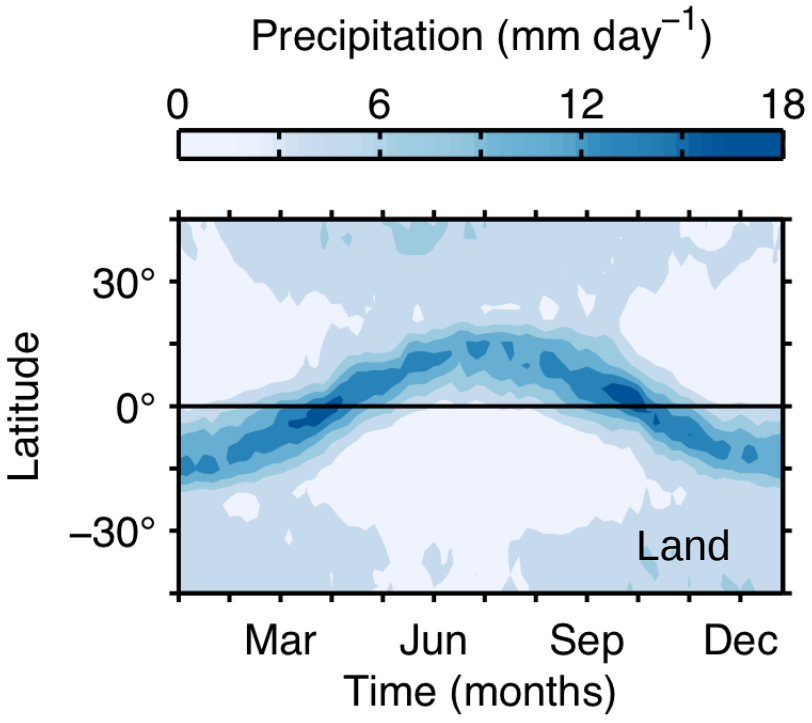
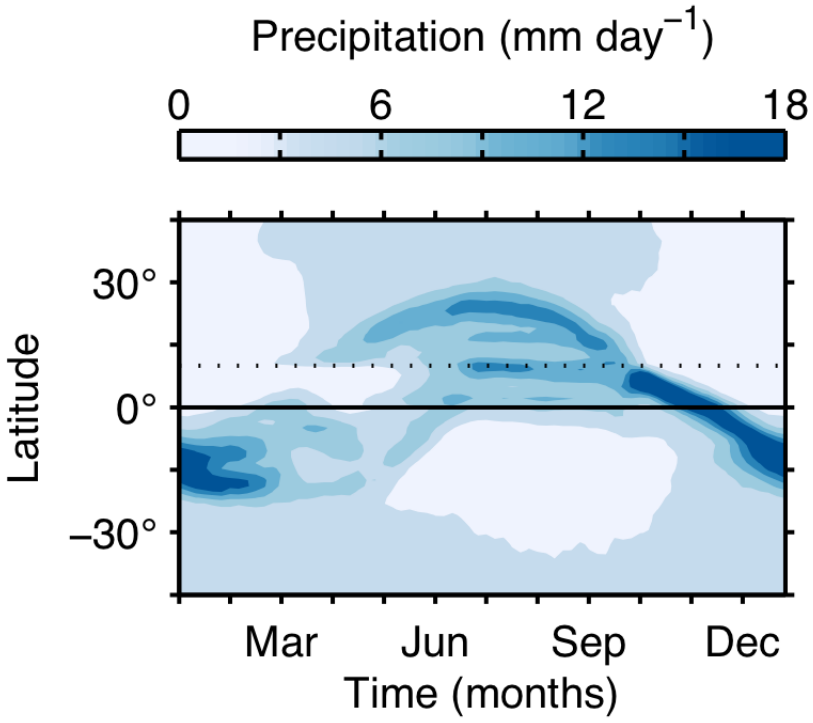
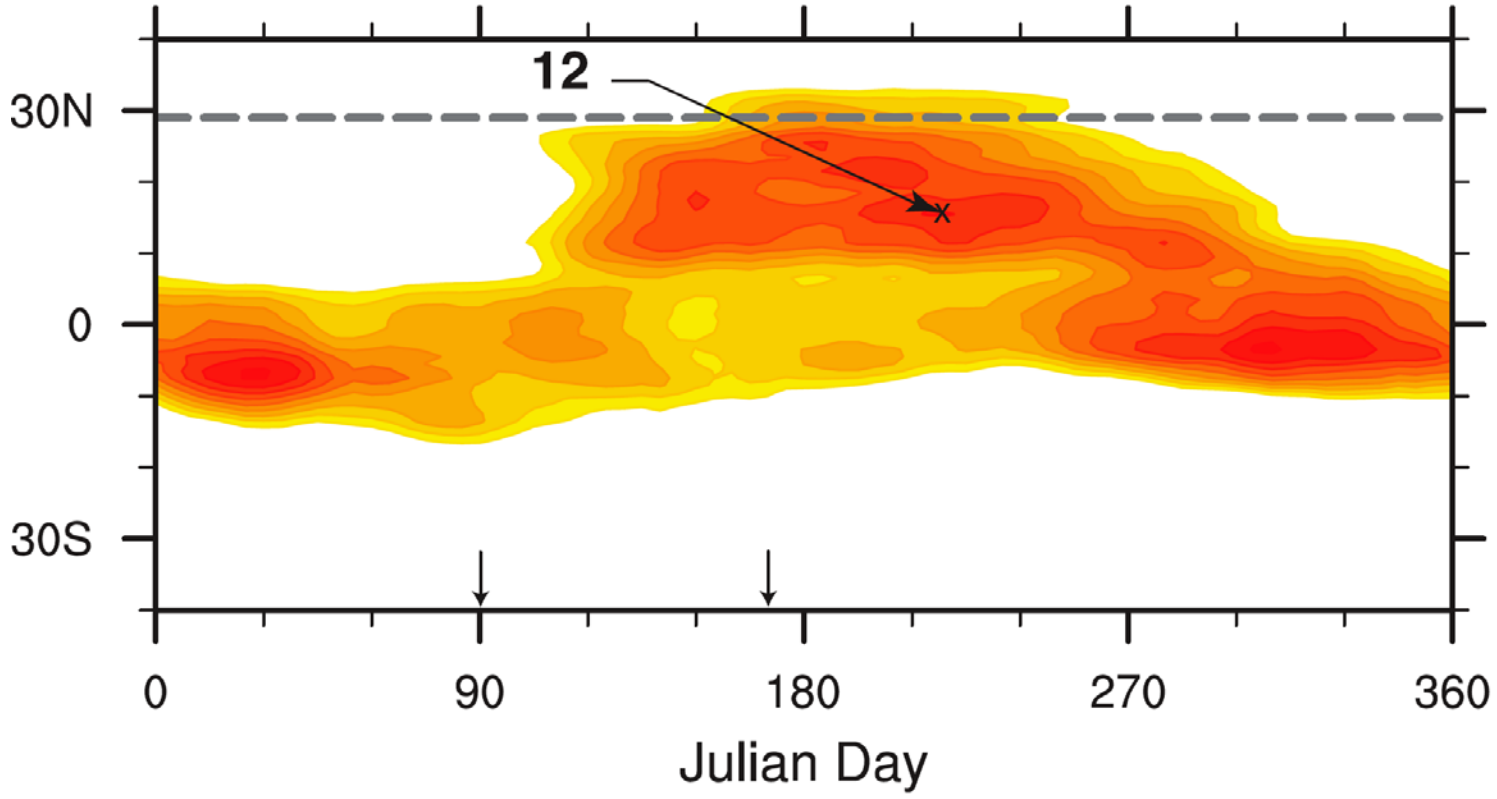


Asia



- Ventilation limits the poleward extension of the African monsoon
- Onset is rapid only in the Asia experiment
- But the retreat is not!

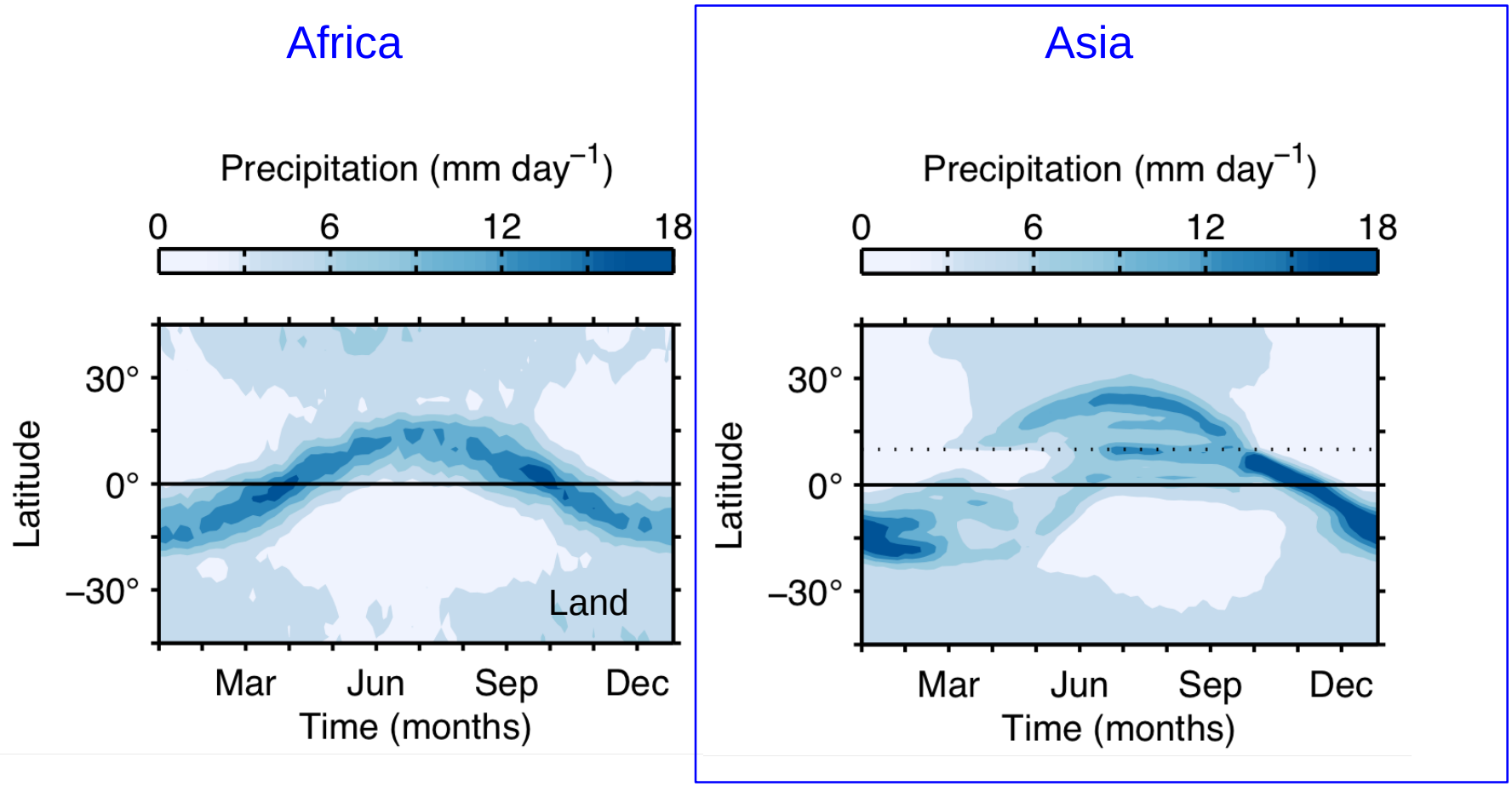
Seasonal cycle of P in Asian monsoon



Data source: GPCP 1DD

adapted from Bordoni and Schneider (2008)

Simulated precipitation in the two experiments



- Ventilation limits the poleward extension of the African monsoon
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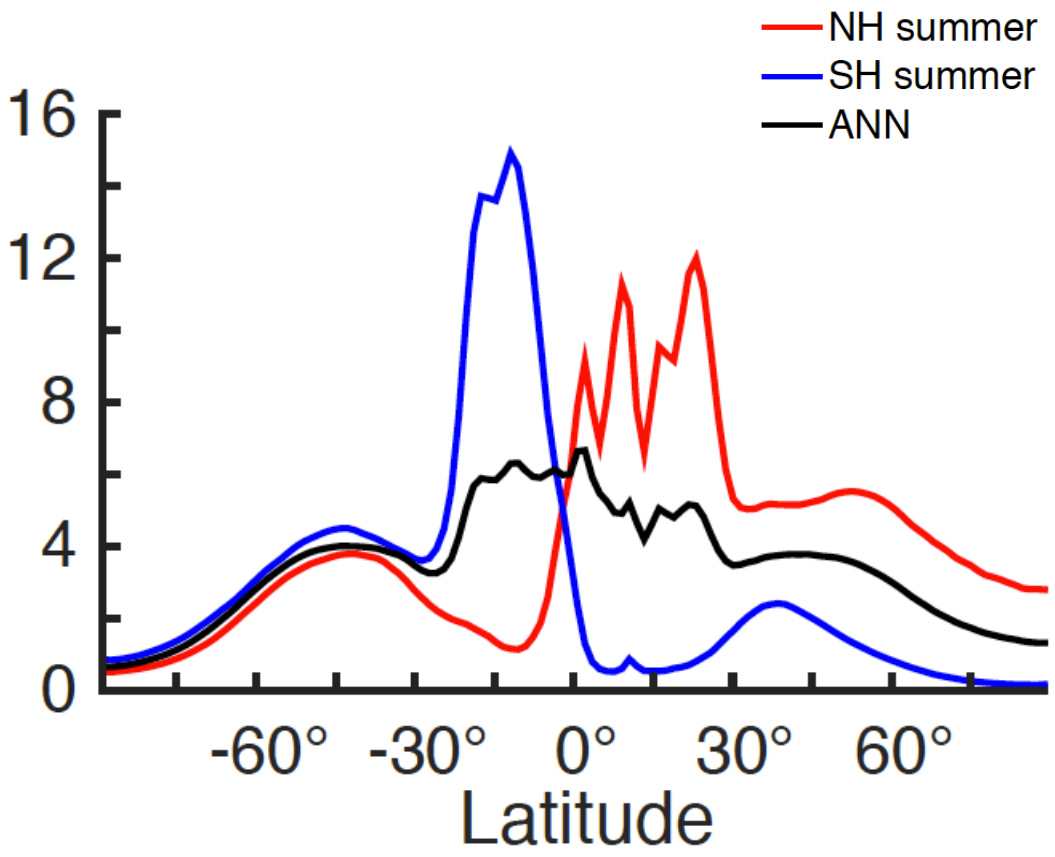
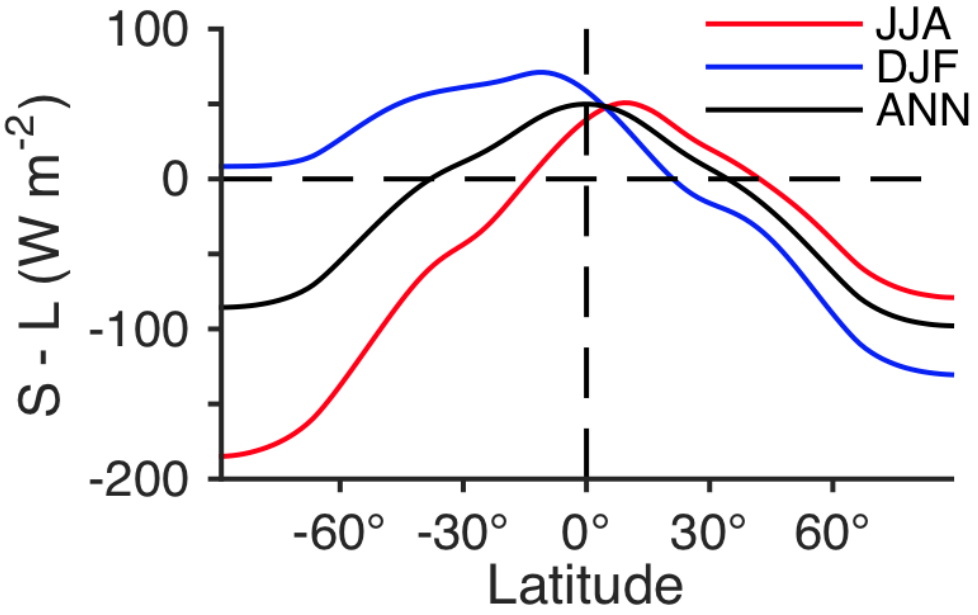
On the annual mean the ITCZ is in the SH!



TOA radiative imbalance

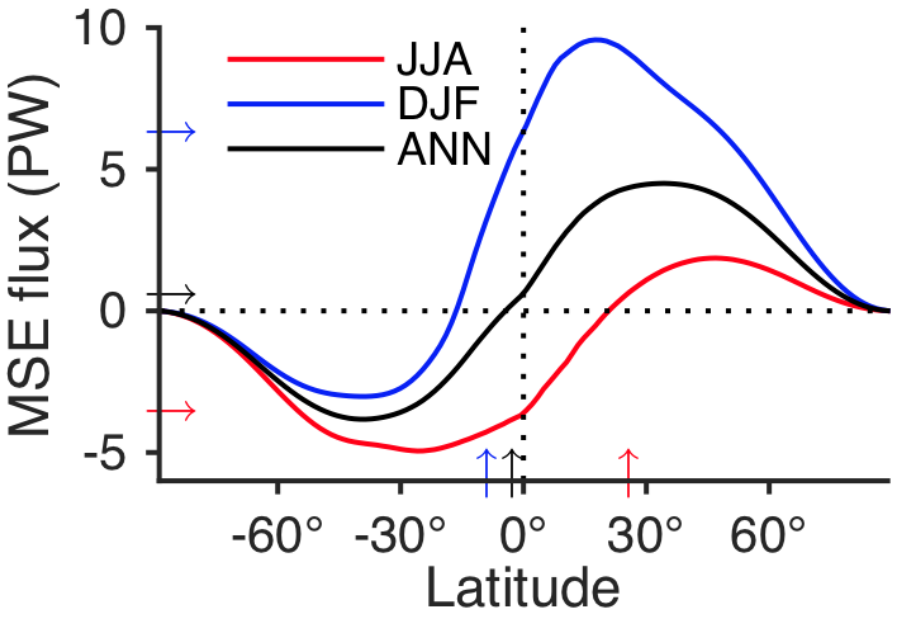


Warm continent in the summer radiates back to space

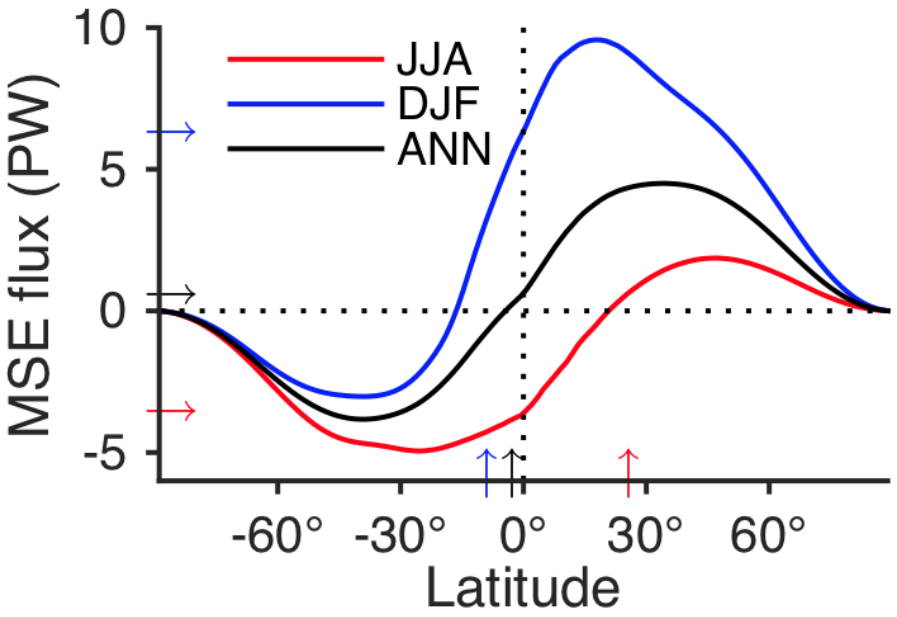
Questions

- What sets the position of the convergence zones?
- Why is the onset rapid, while the retreat is gradual?

Energetic constraints

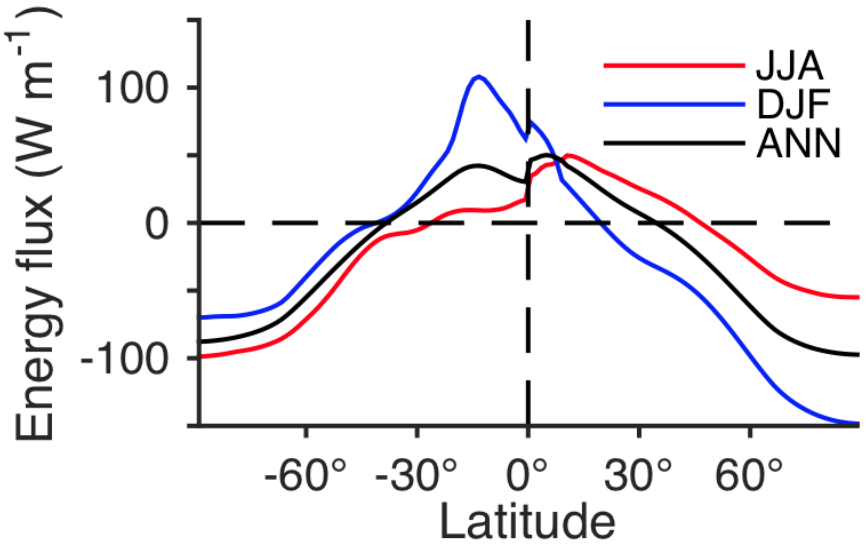


Energetic constraints



The convergence zone migrates further poleward in the NH, but the cross-equatorial energy transport is smaller!

Energetic constraints



Fnet at equator is approximately twice as large in DJF than in JJA.
Storage terms (or surface fluxes) play a role!

Questions

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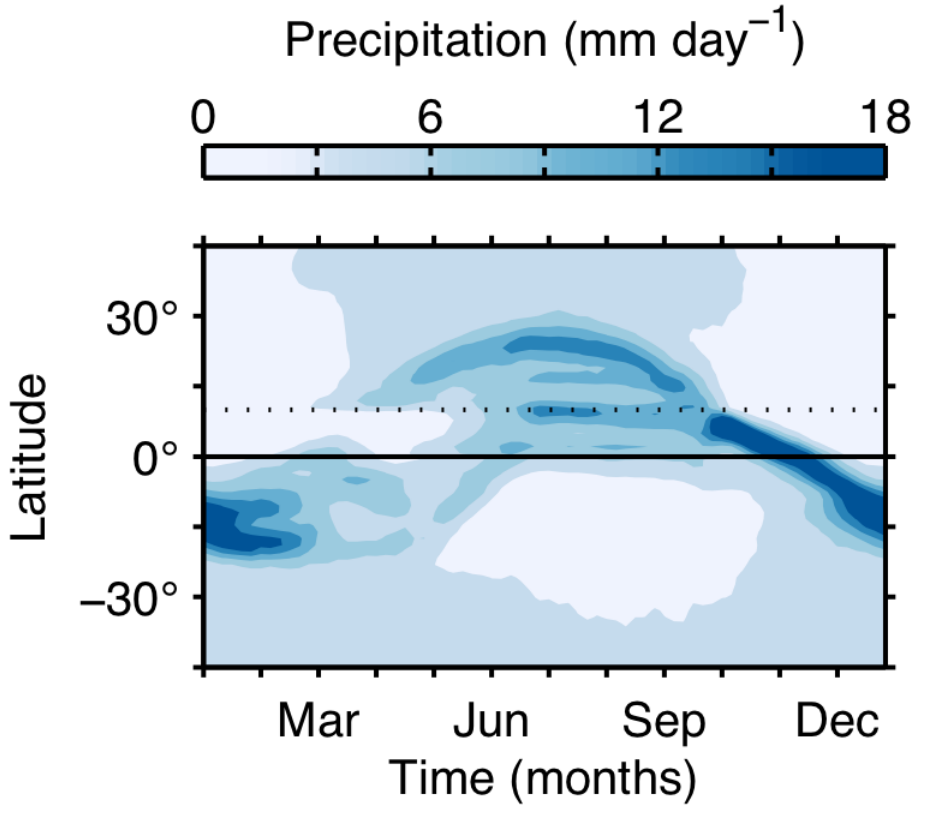
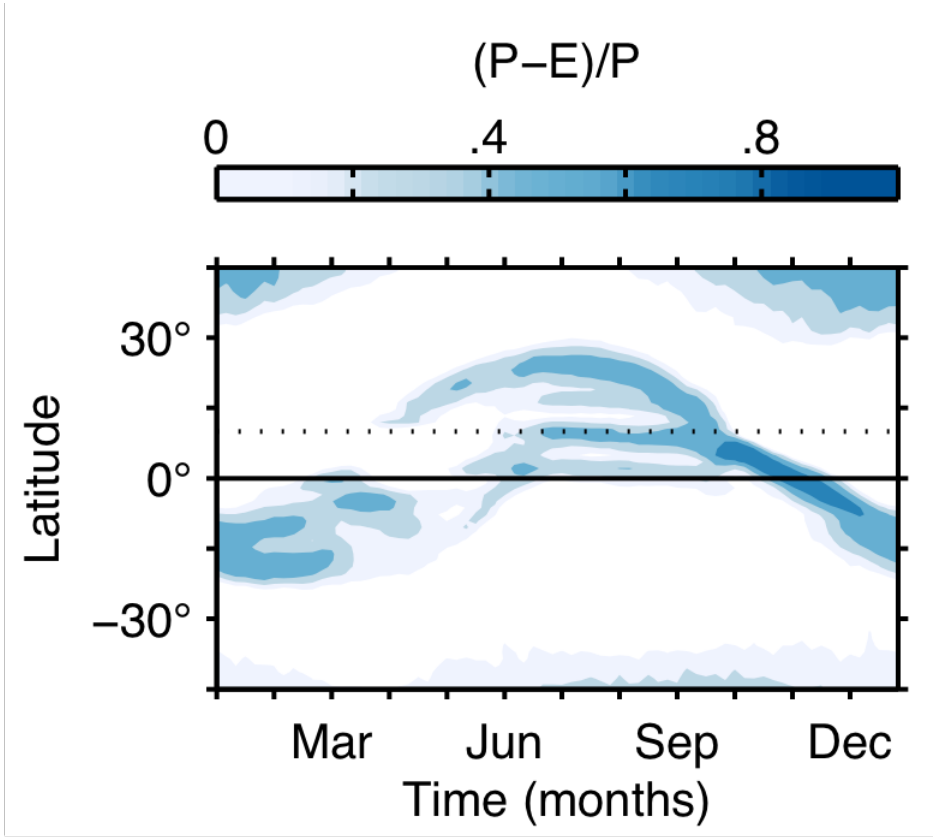
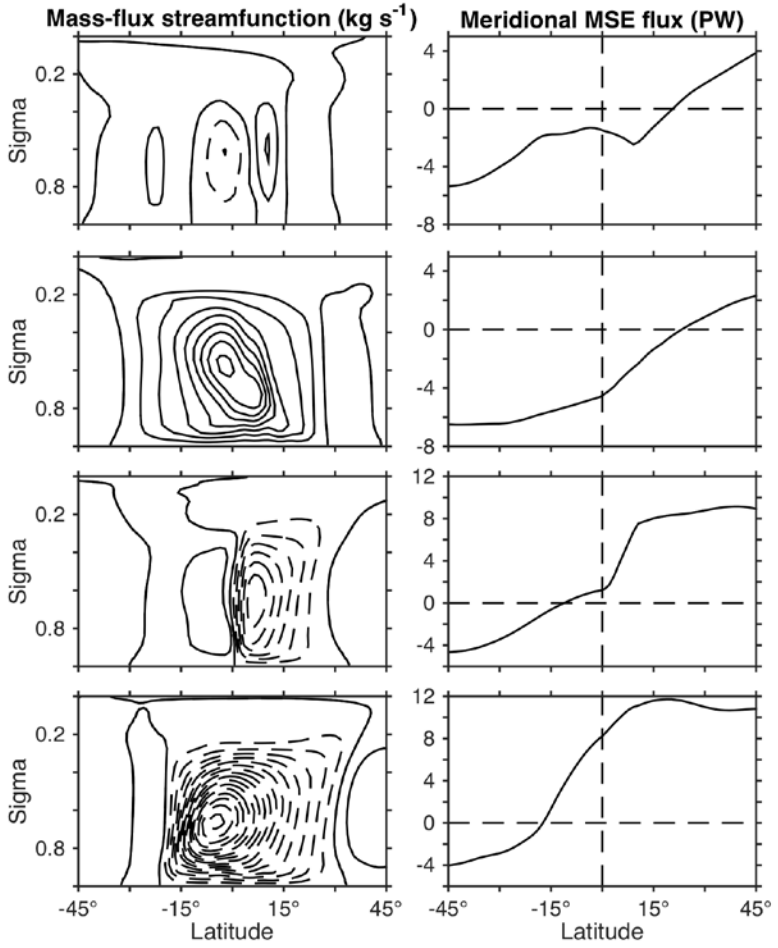
Seasonal cycle of precipitation



Seasonal cycle of P - E



Seasonal cycle of circulation



Maybe it’s the dynamics!

Conclusions

- Despite gross idealizations, rich phenomenology in monsoons over idealized continents;
- Energetic constraints provide useful diagnostics for rain belt positions, but energy storage plays a role (at least in these simulations);
- Dynamics might be important in onset/retreat asymmetry.