Evaluating the contribution of land-atmosphere feedbacks to heat extremes in CMIP5 models

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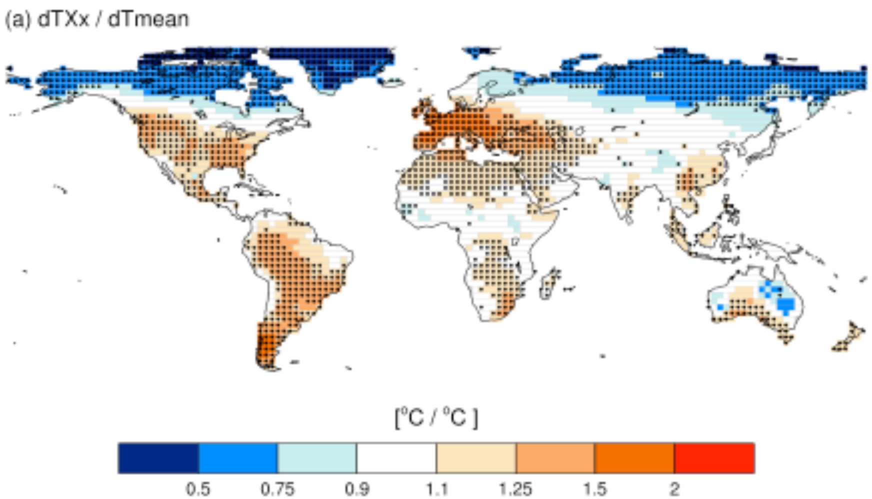
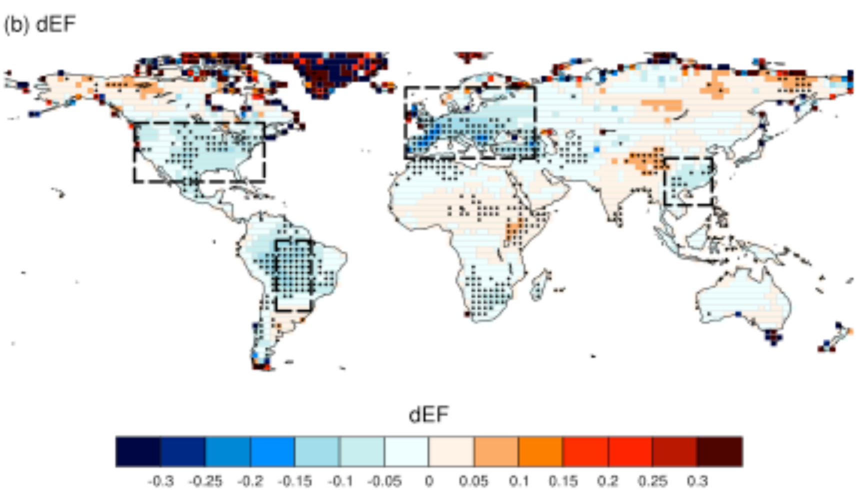
Motivation





- Hot extremes increase faster than the mean
- Land surface drying in hotspot regions

Donat et al. GRL (2017)

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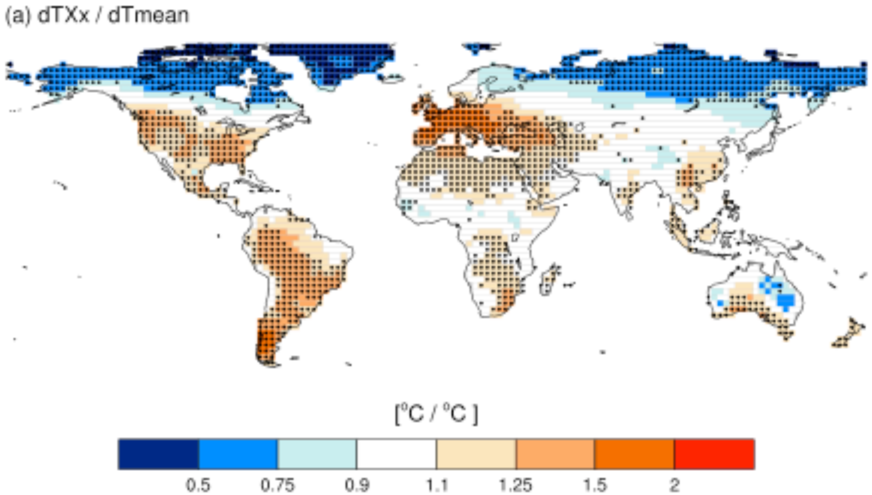
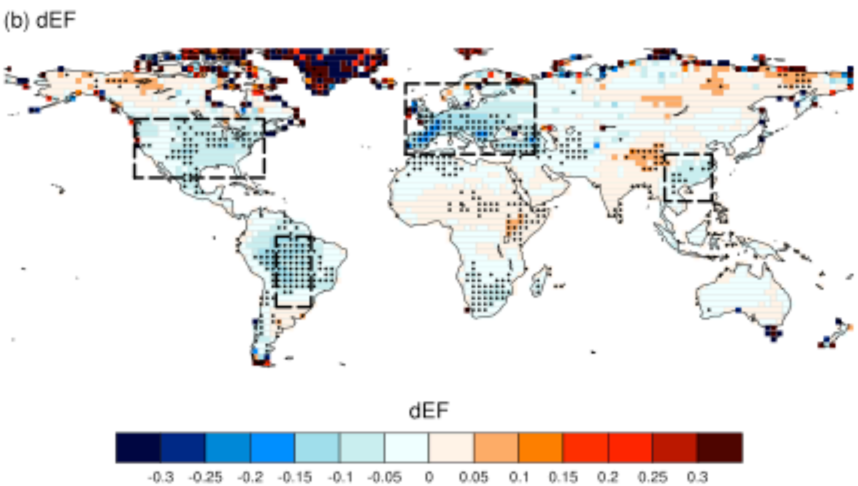


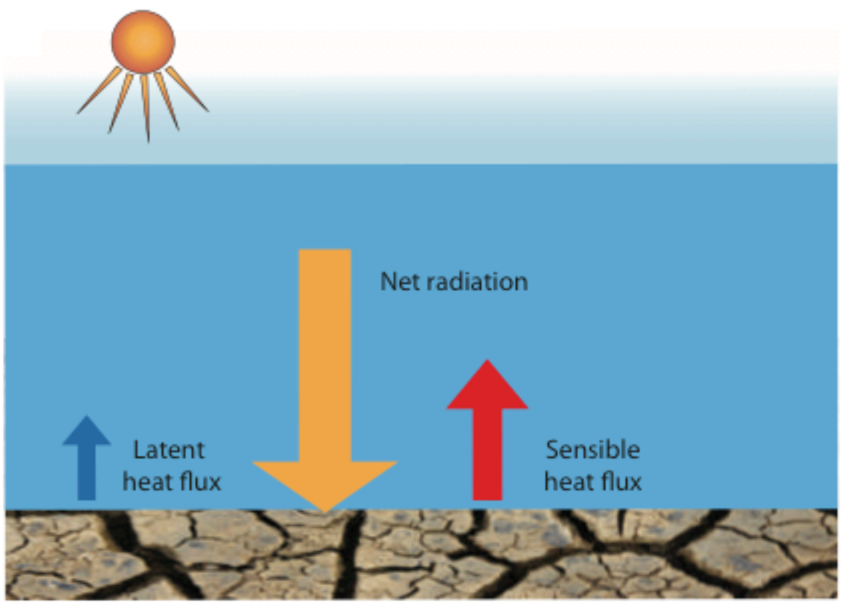


- Hot extremes increase faster than the mean
- Land surface drying in hotspot regions
- **How well do models capture these processes?**

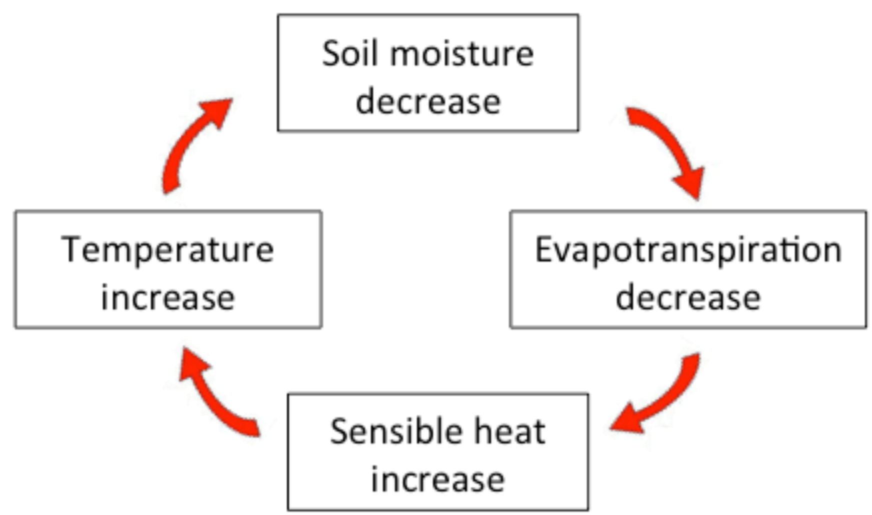
Donat et al. GRL (2017)

Co-variation of hot and dry extremes

- Land-atmosphere feedbacks can amplify heat extremes
- e.g. Europe 2003

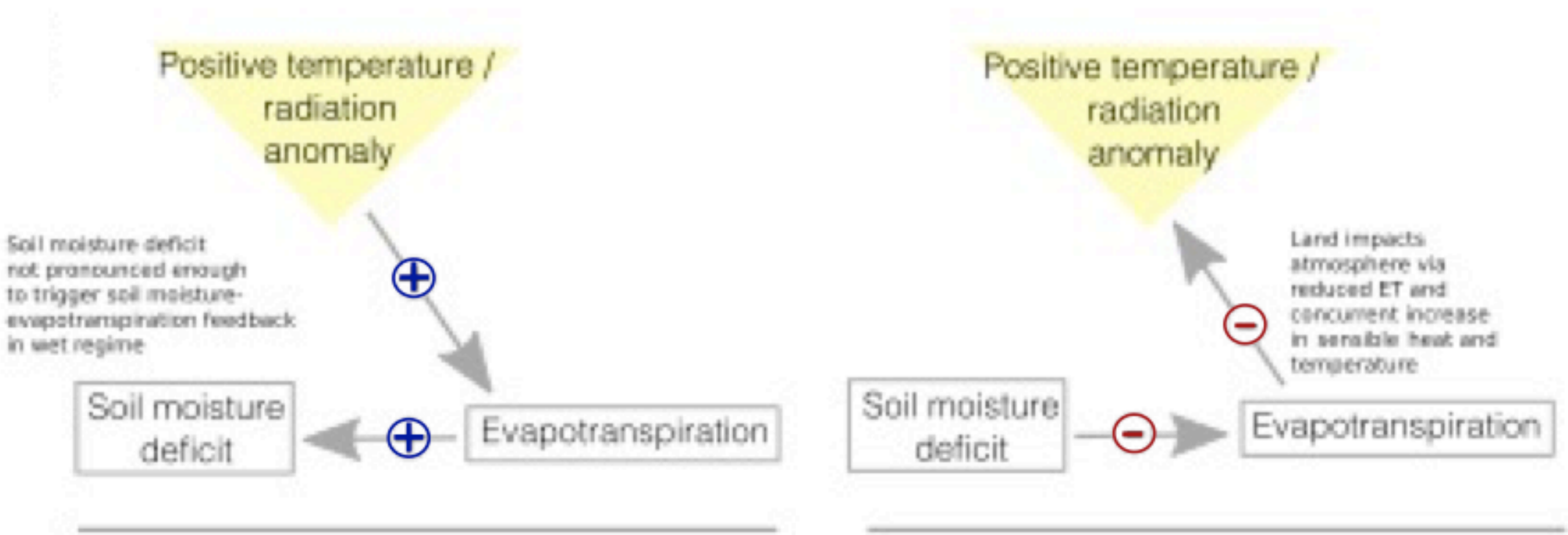


Dry soils



Alexander, 2010

Role of aridity



Wet regime

Dry & transitional regime

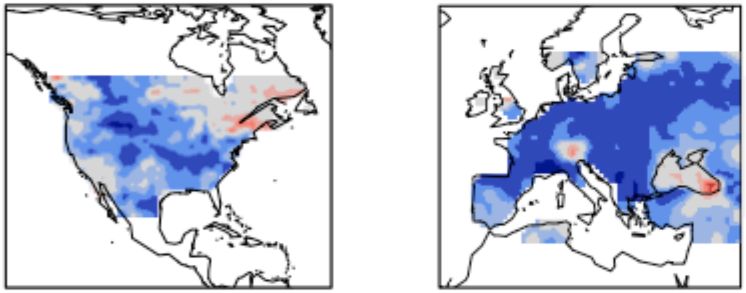
Sippel et al. ESD (2017)

Methods

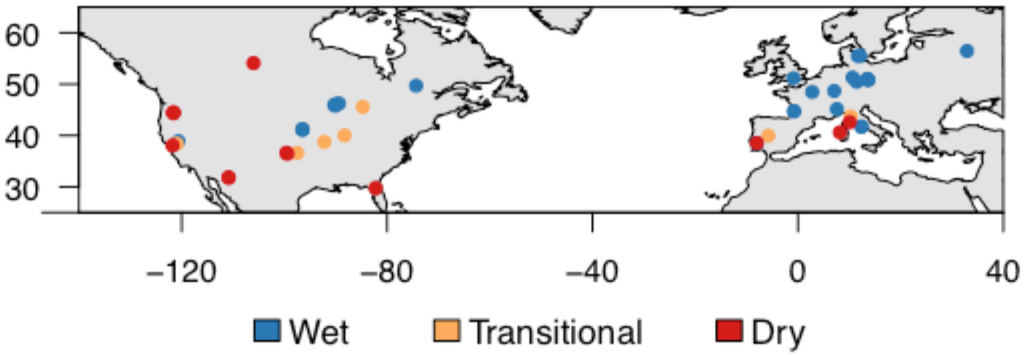
- 2.5% hottest days of year
- Evaporative fraction on the day

$$EF = \frac{latent}{latent + sensible}$$

25 CMIP5 models



Flux tower observations



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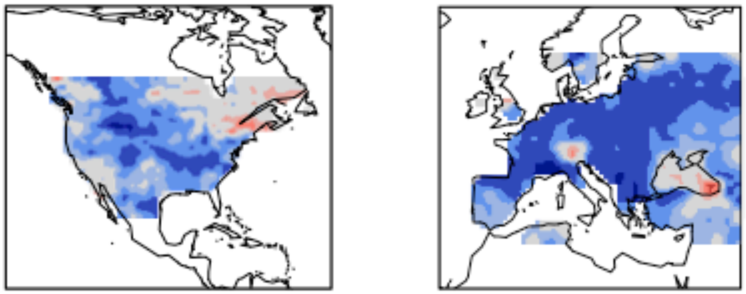

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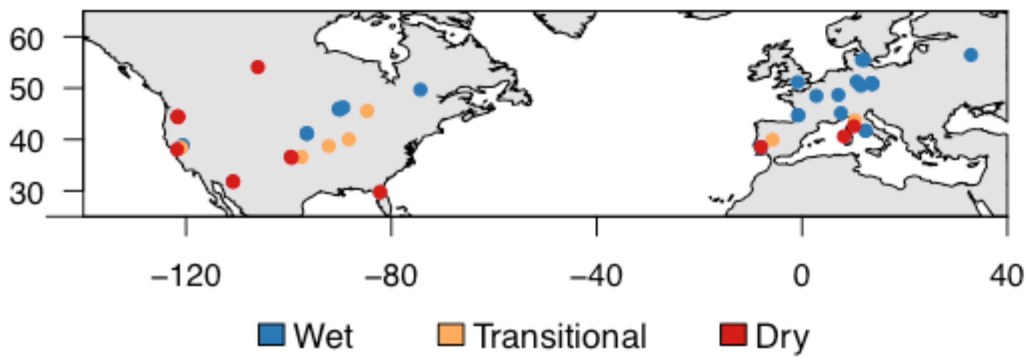


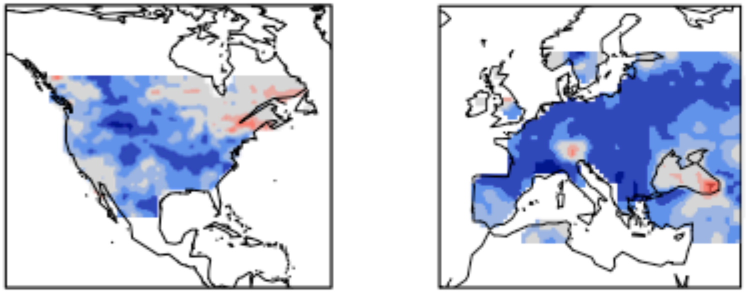
Methods

- 2.5% hottest days of year
- Evaporative fraction on the day

$$EF = \frac{latent}{latent + sensible}$$

- Group by aridity (wet, transitional, dry)
- **Can models capture the rel. ship between T_{max} and EF?**

25 CMIP5 models



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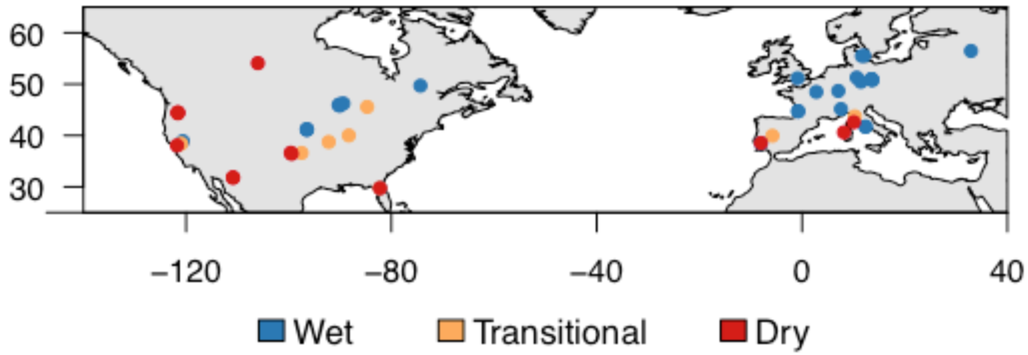
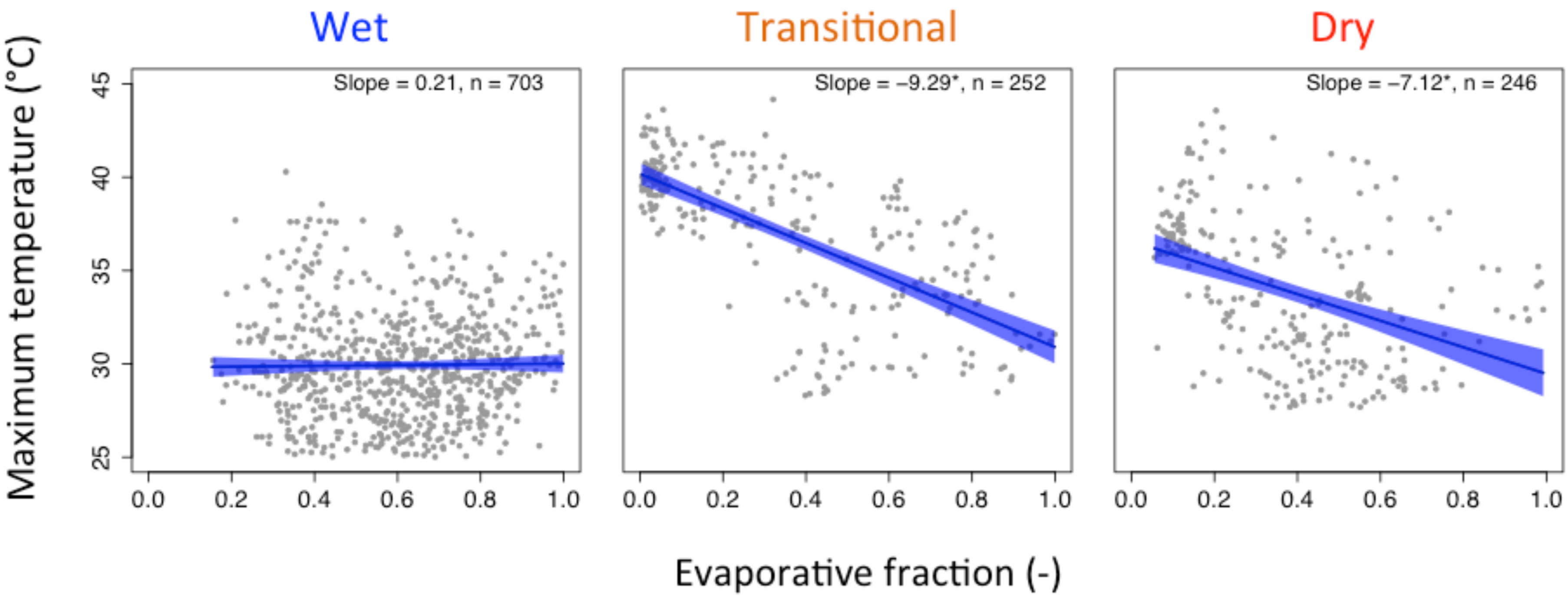
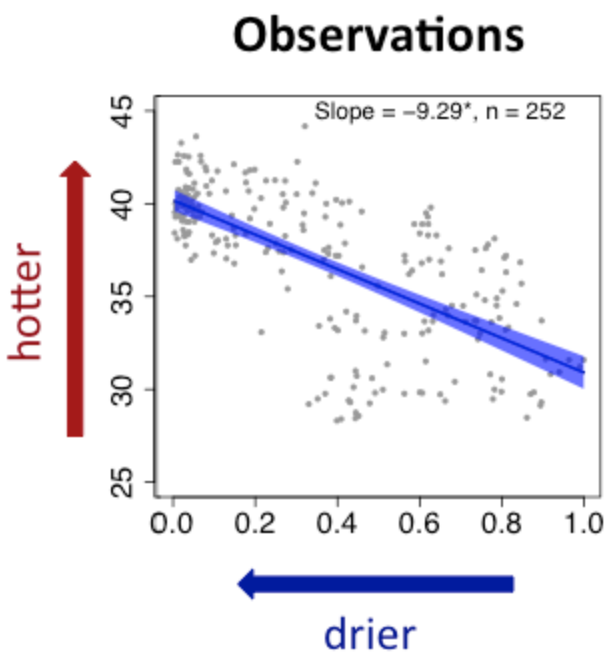
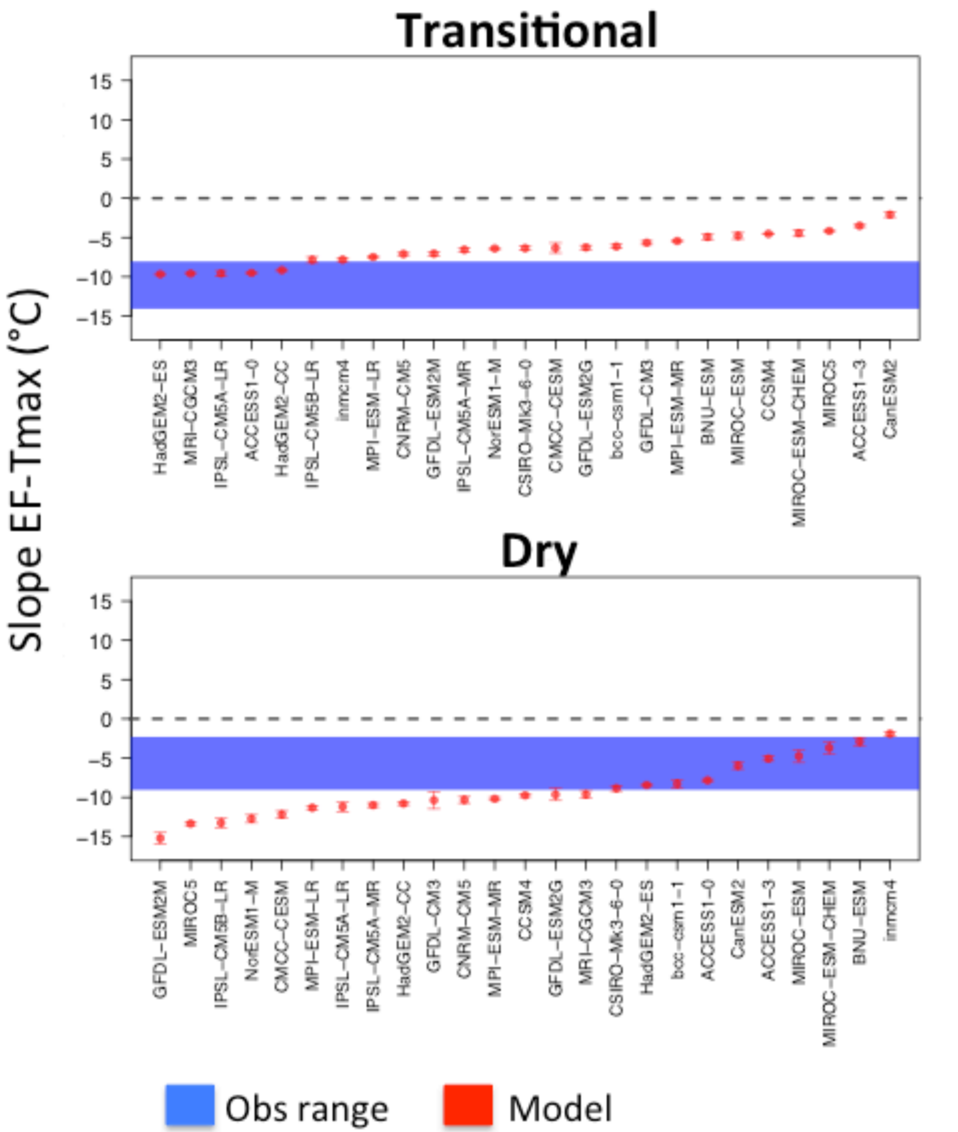


Observed relationship



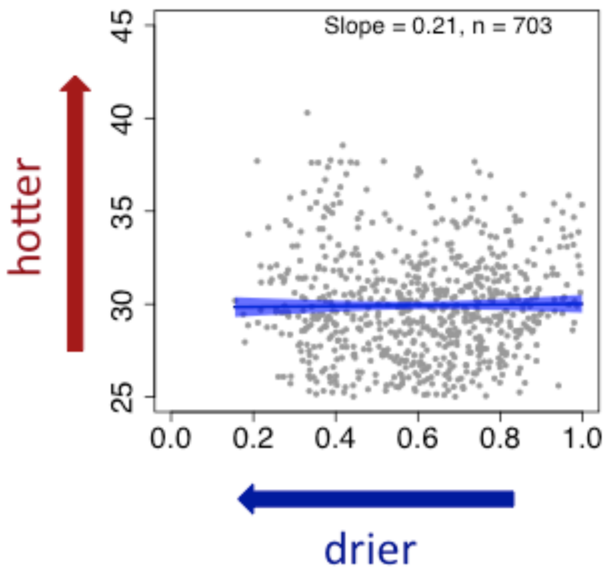
Transitional and dry environments



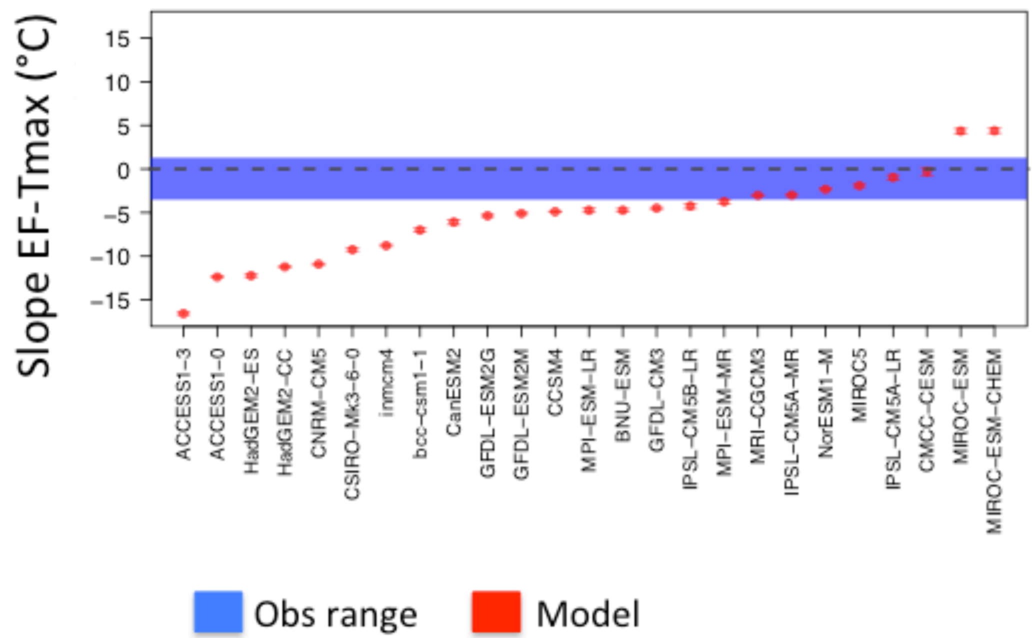


Wet environments

Observations



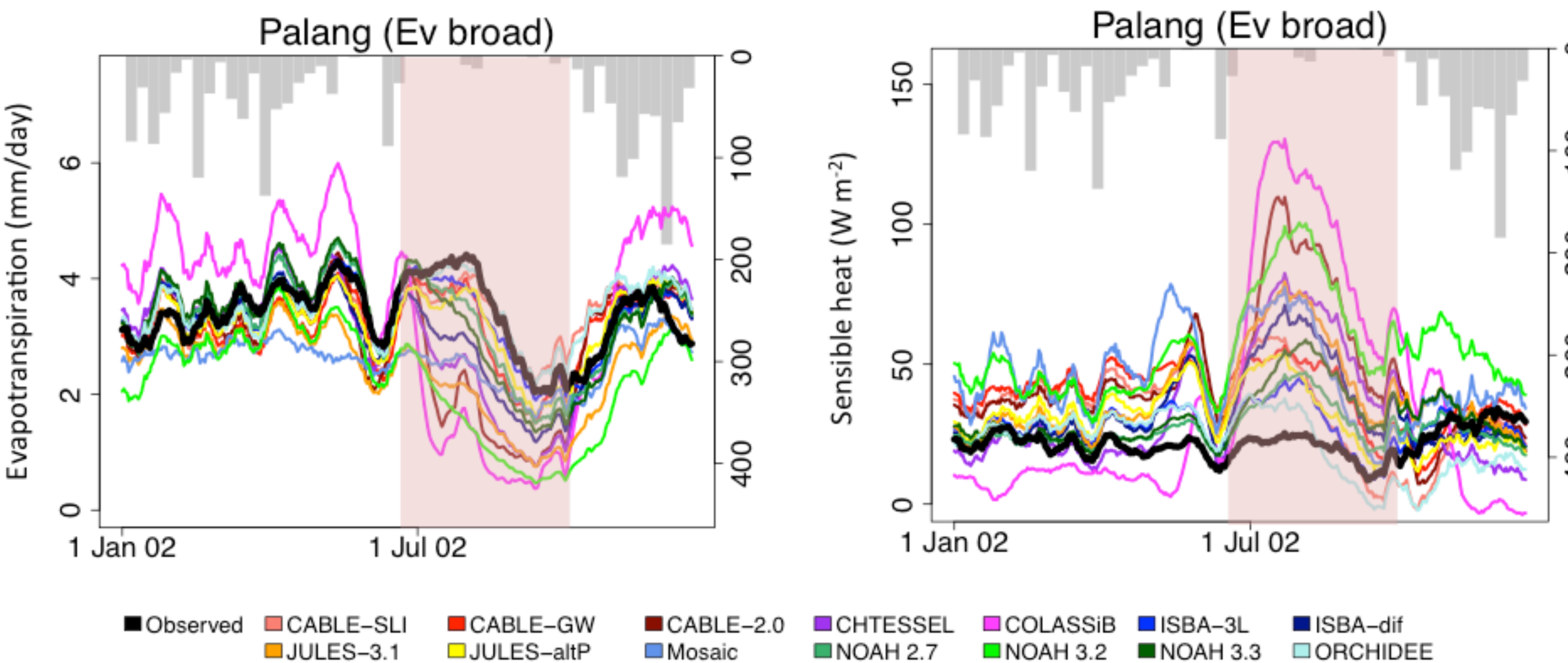
Wet



Biases in land surface models

Latent heat

Sensible heat



Ukkola et al. ERL (2016)

Why some models over-amplify T_{max}?

Strong amplification due to?

1. Low latent heat (on the day / during warm season) ✗

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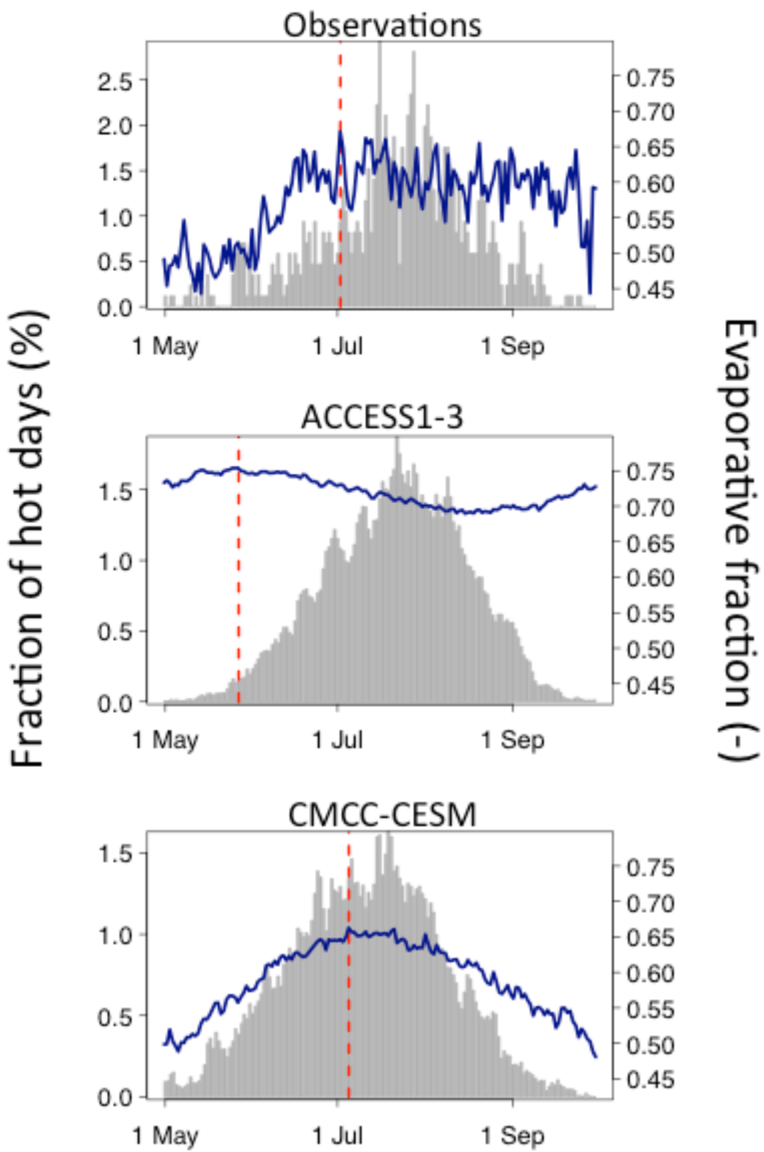
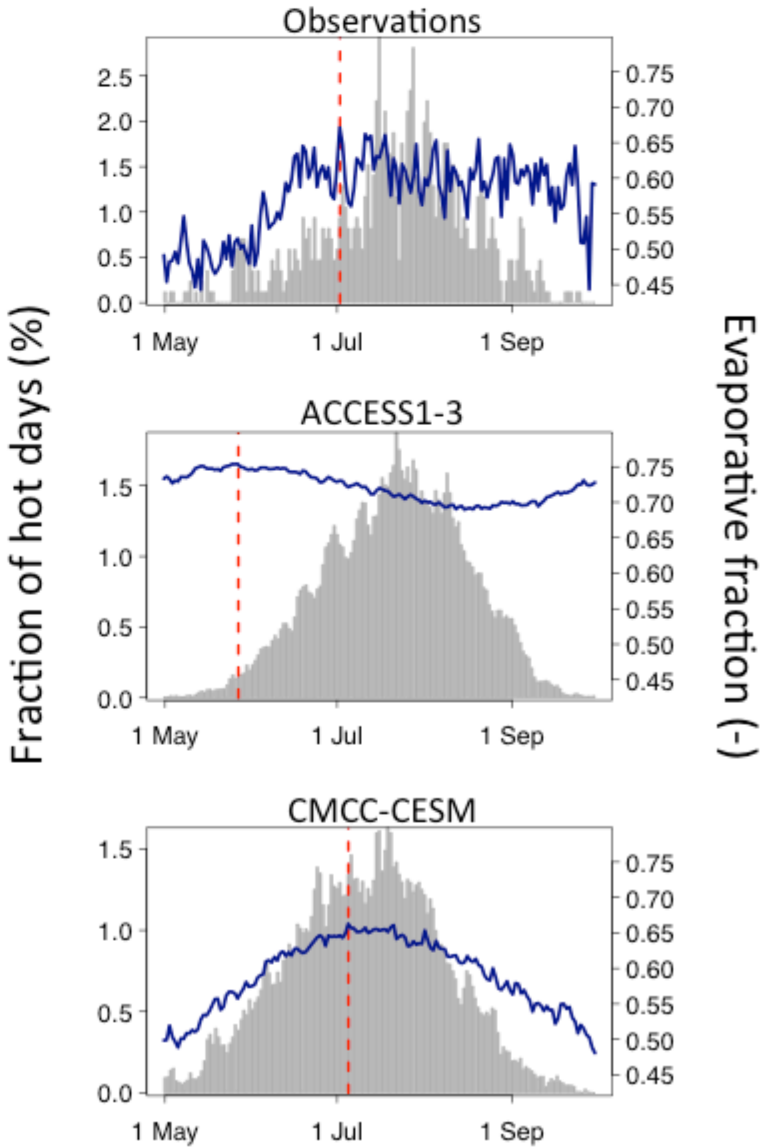


Why some models over-amplify T_{max}?

Strong amplification due to?

1. Low latent heat (on the day / during warm season) ✗
2. Different seasonality ✓
3. High spring LAI ✗



Conclusions

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Conclusions

- Most models capture obs in dry & transitional zones
- But many overestimate land surface feedbacks in wet regions
- Consistent with offline LSM biases
- What does this mean for projections of heat extremes?

Thank you

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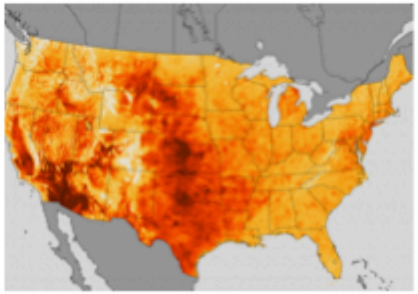

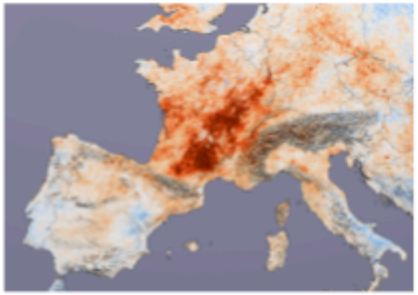

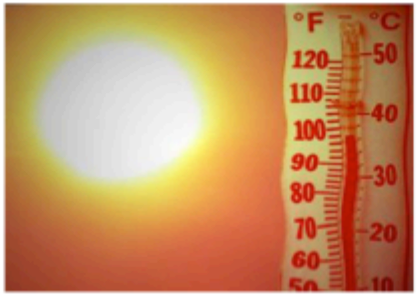

Observations by site