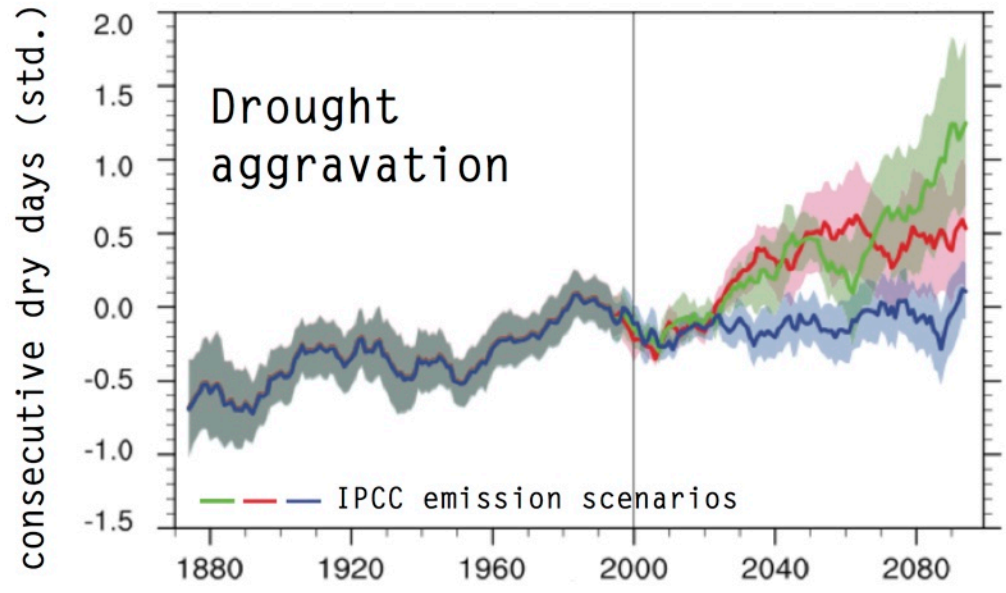
Diego G. Miralles

10/1516 – Ourense
EGU Leonardo

On the role of evaporation during droughts and heatwaves

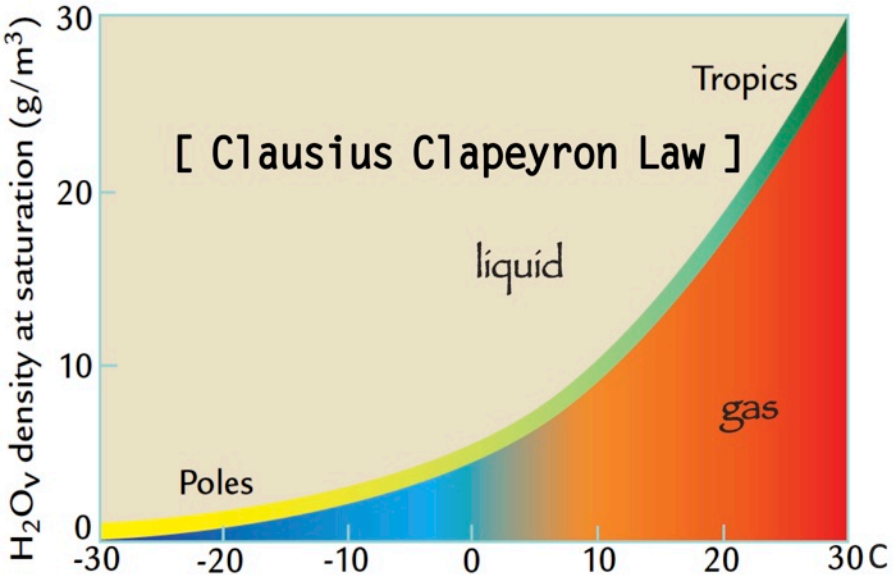
1 - evaporation and climate



Societal impacts: food and drinking water security, ecosystem services, adaptation to extremes, etc.

- **Global water cycle acceleration**: increase in evaporation, precipitation (?), runoff and groundwater recharge
- **Dry getting drier & wet getting wetter**: depending on water availability over land
- **Redistribution of global water cycle**: widening of tropics, intensified El Niño (?), stronger monsoons, runoff seasonality changes, societal stress

① Propagating global warming to the water cycle



$$P = E + R + dS/dt$$

[Water Balance Equation]

1 - evaporation and climate

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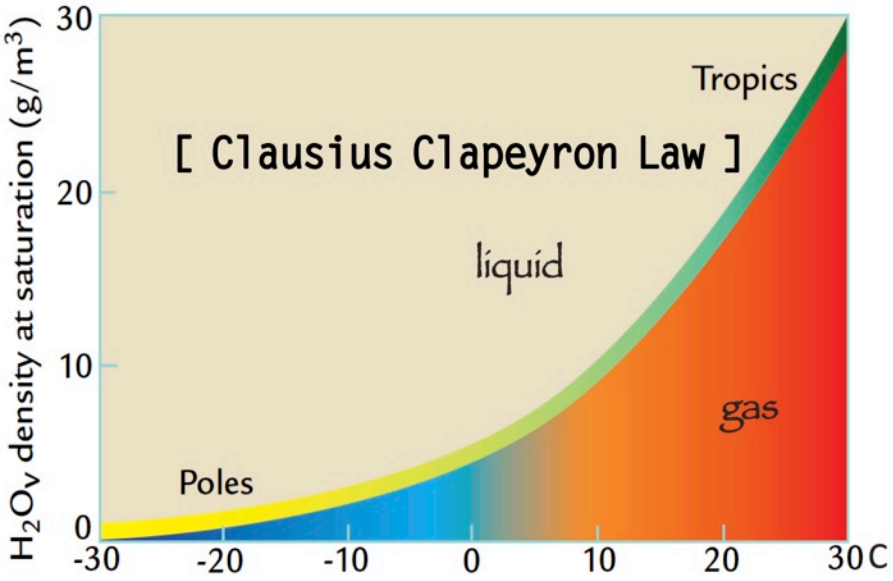


$$P = E + R + dS/dt$$

[Water Balance Equation]

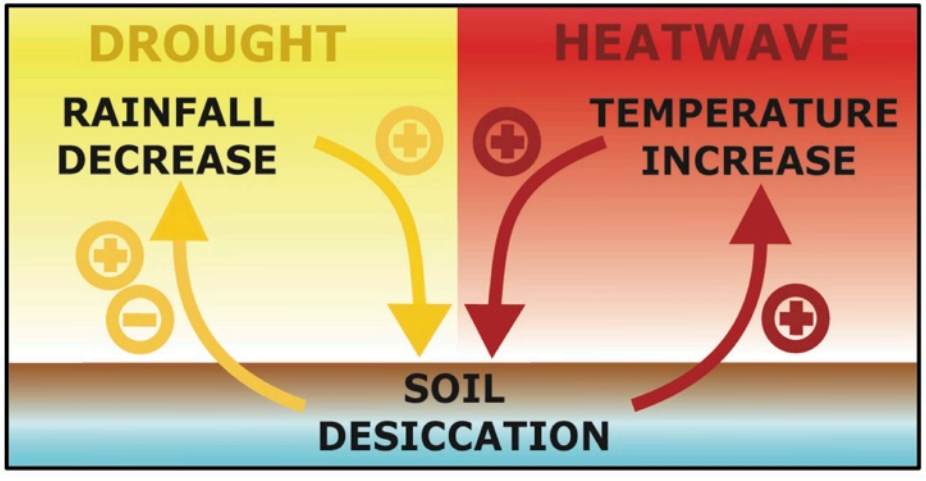
② Regulates climate and climate extremes

$$R_n = \lambda E + H + G$$

[Energy Balance Equation]

① the evaporation response

② the feedback on the event

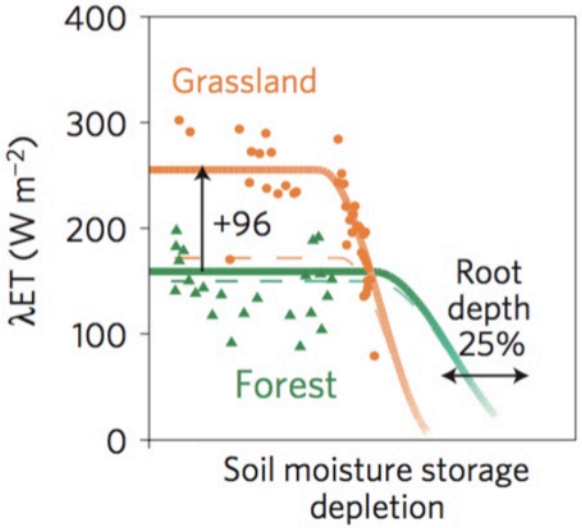


2 - the evaporation response

① **Eventual decay** due to soil water limitations

② **Initial increase** due to high atmospheric demand

③ Both with **implications for the development** of the extreme event



Teuling *et al.* (2010), *Nat. Geosc.*

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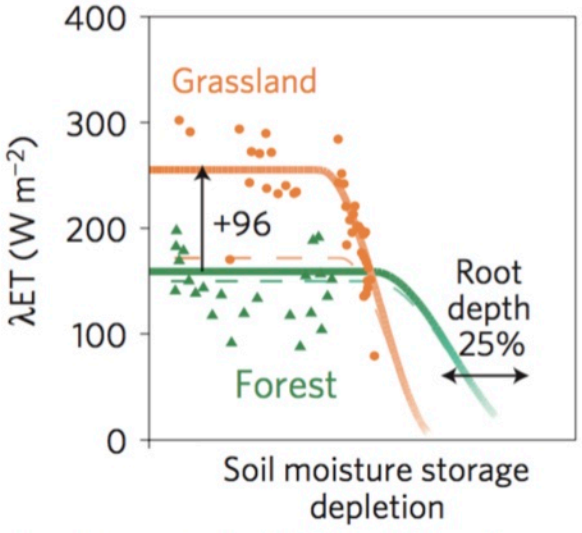

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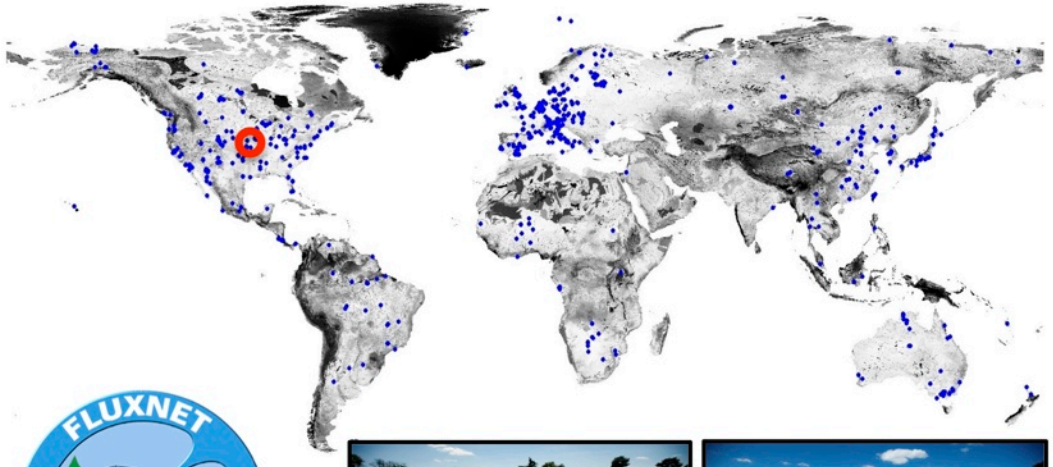
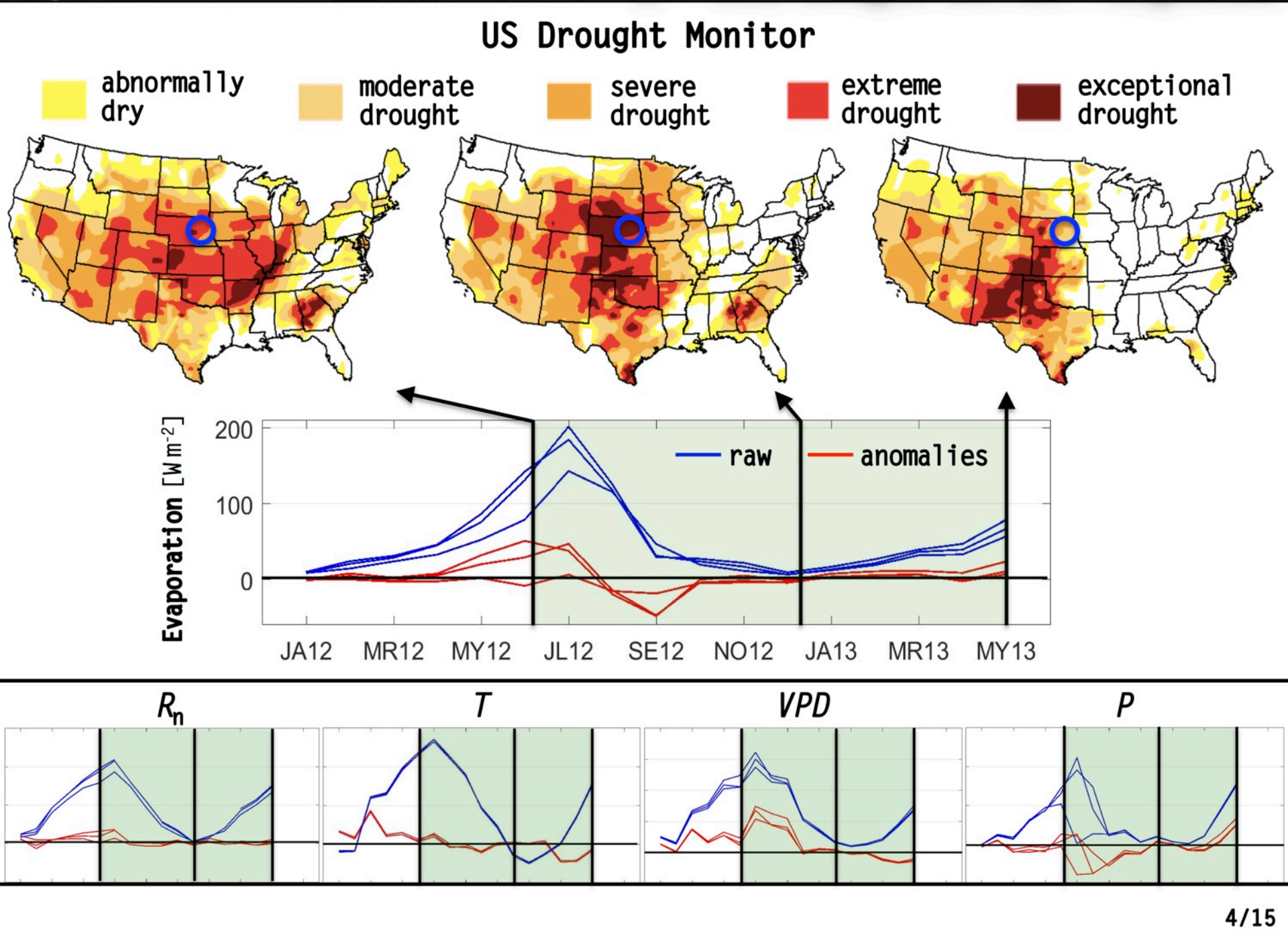


Pioneers Park, 2012 (Nebraska)

- **Three sites** in Nebraska - US-Ne1, US-Ne2, US-Ne3 - located within 1.6 km of each other
- **2001-2013** continuous dataset
- **Croplands**: maize, soybean, occasional irrigation and other agricultural practices

2 - the evaporation response



2 - the evaporation response

Potential Evaporation Module
Priestley and Taylor equation driven by observed surface meteorology

Rainfall Interception Model
Gash analytical model driven by observed precipitation

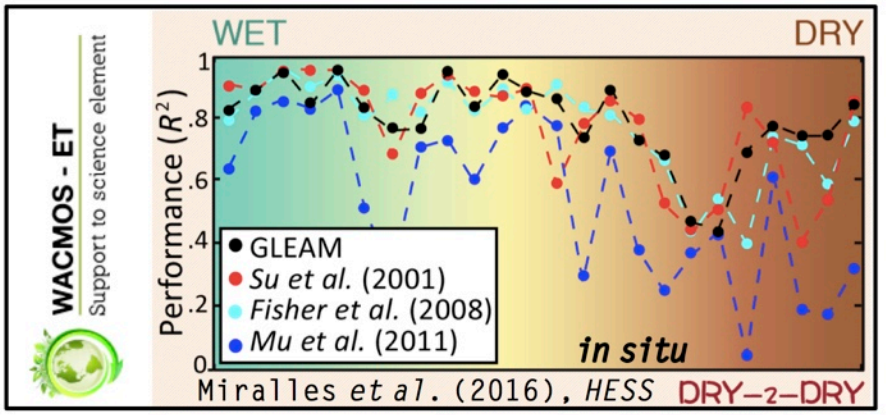
$$E = E_p \times S + E_i$$

Soil Module
Multi-layer soil model driven by observed precipitation

Stress Module
Semi-empirical relationship to root-zone soil moisture and vegetation optical depth

Data assimilation of satellite surface soil moisture

Miralles *et al.* (2011a), *HESS*



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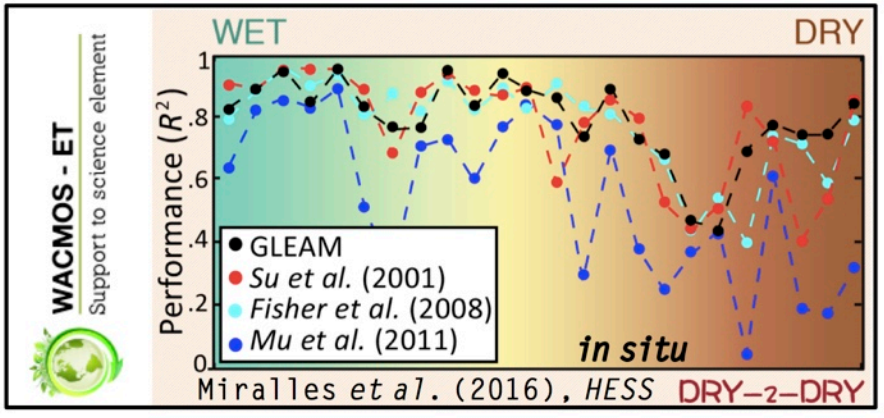
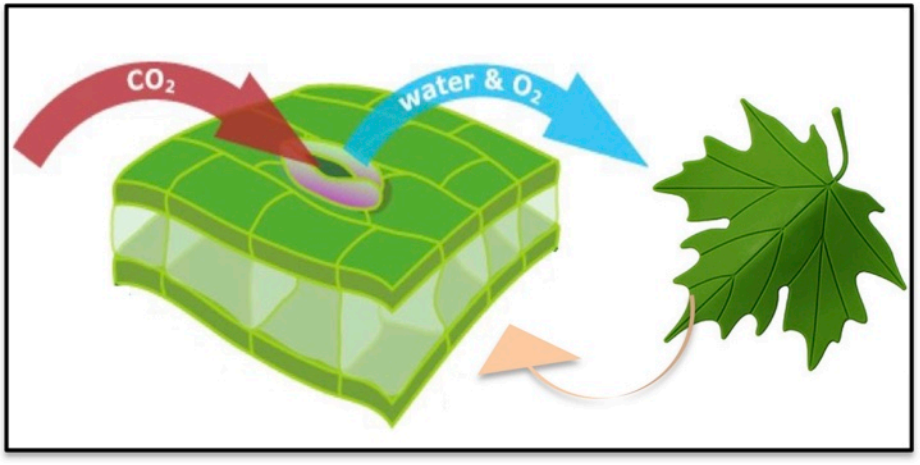


yet transpiration and photosynthesis are intrinsically connected...



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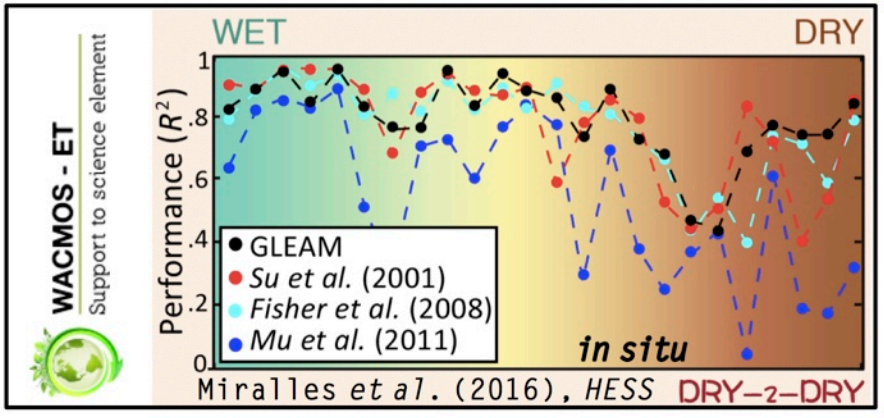
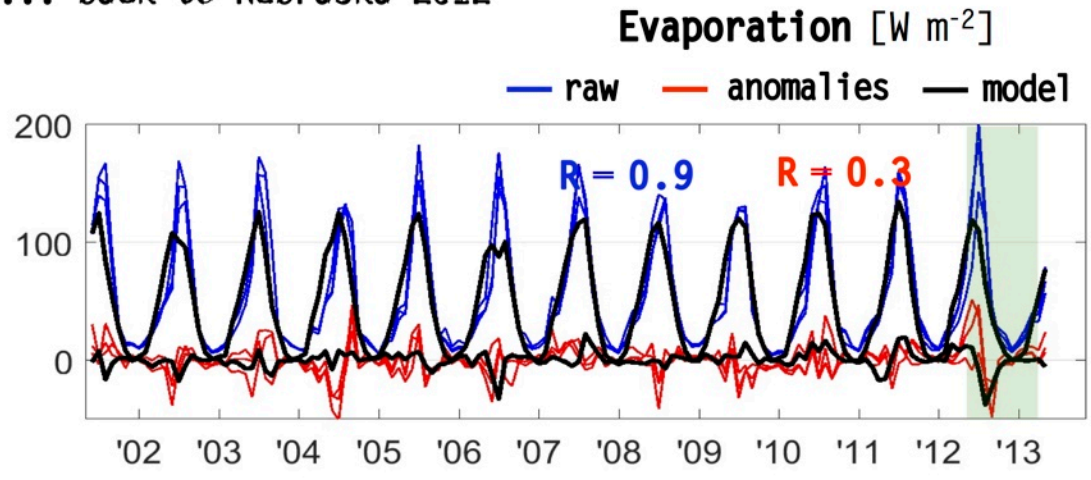


... back to Nebraska 2012



LETTERS
PUBLISHED ONLINE: 8 DECEMBER 2013 | DOI: 10.1038/NCLIMATE2068
nature climate change

El Niño–La Niña cycle and recent trends in continental evaporation

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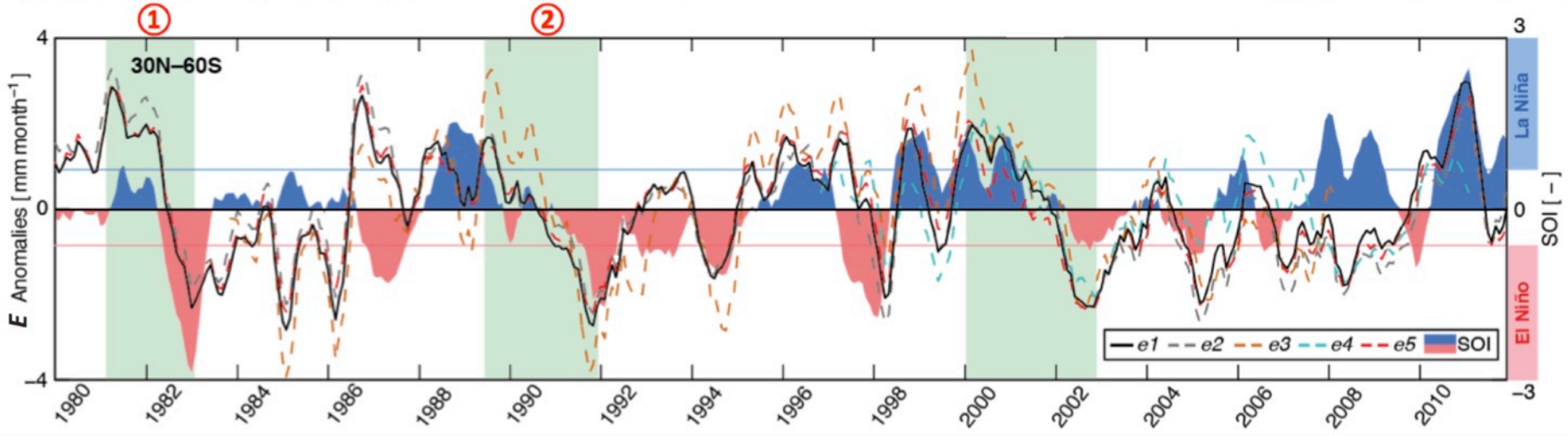

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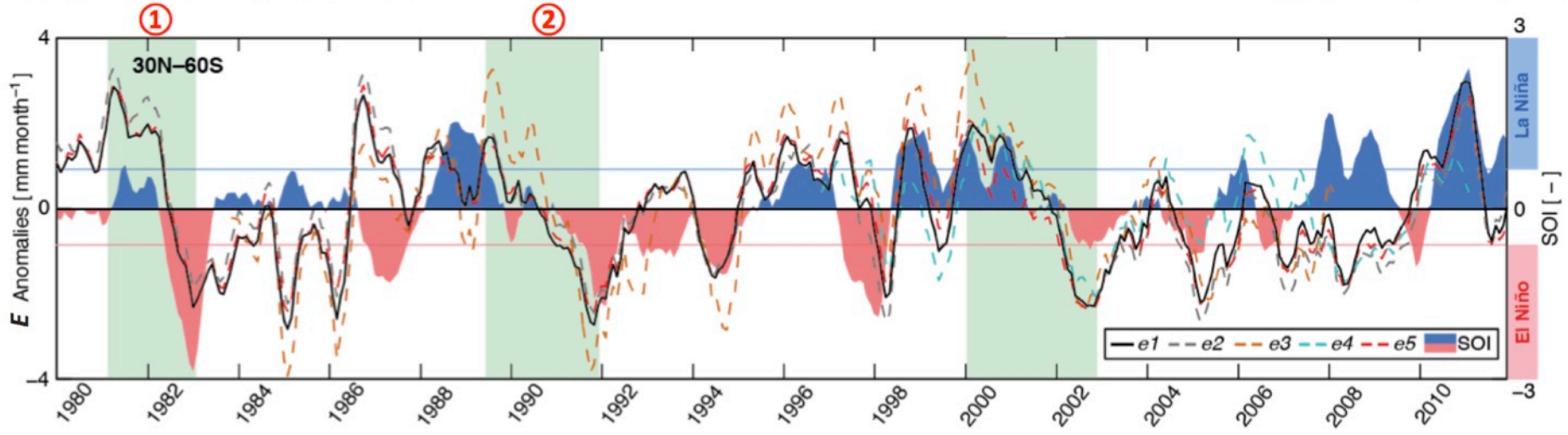
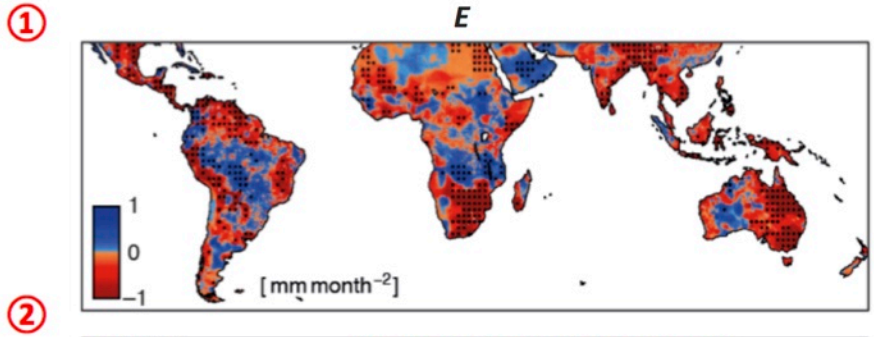
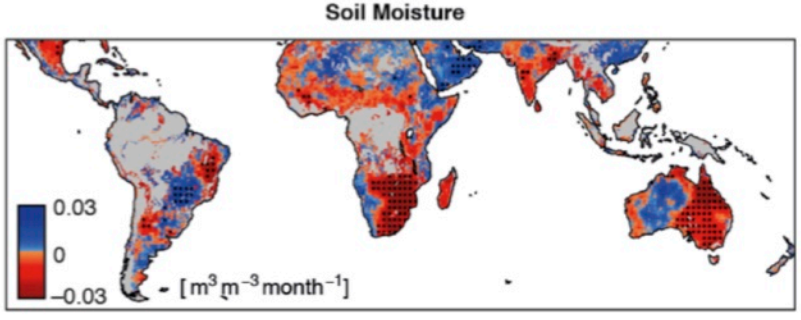
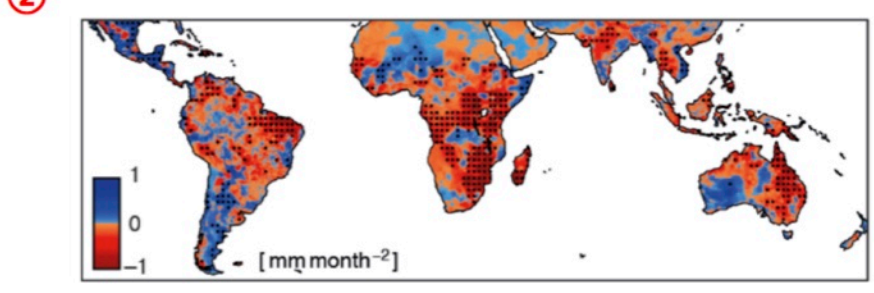
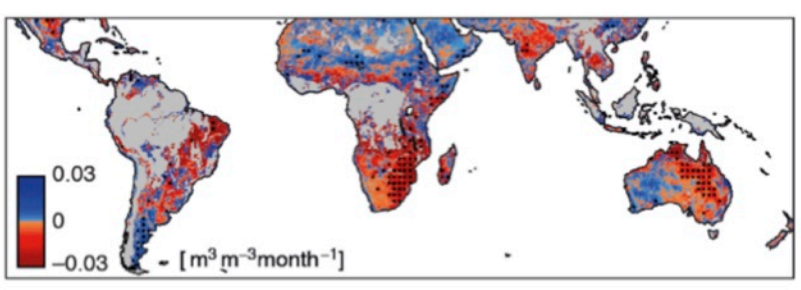




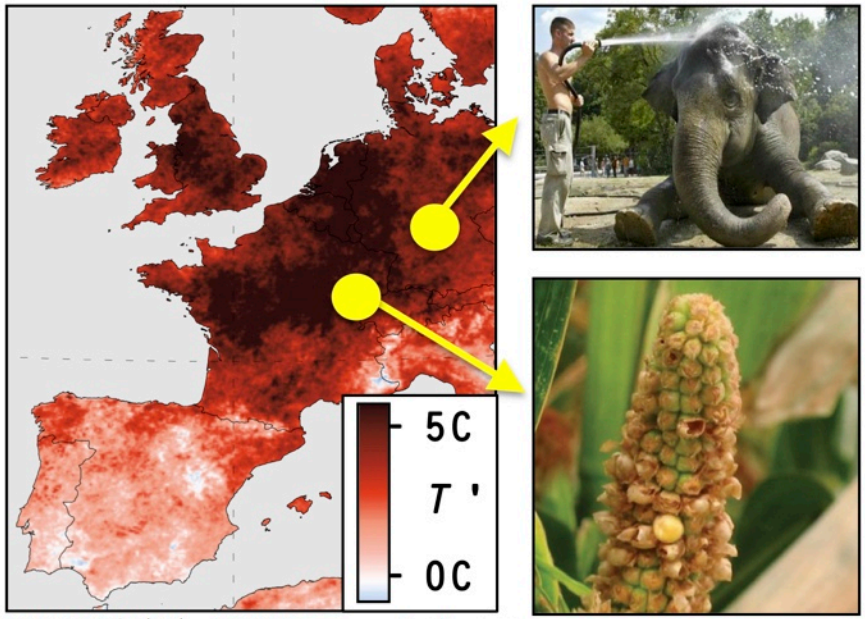






3 - the feedback on heatwaves

Western Europe 2003



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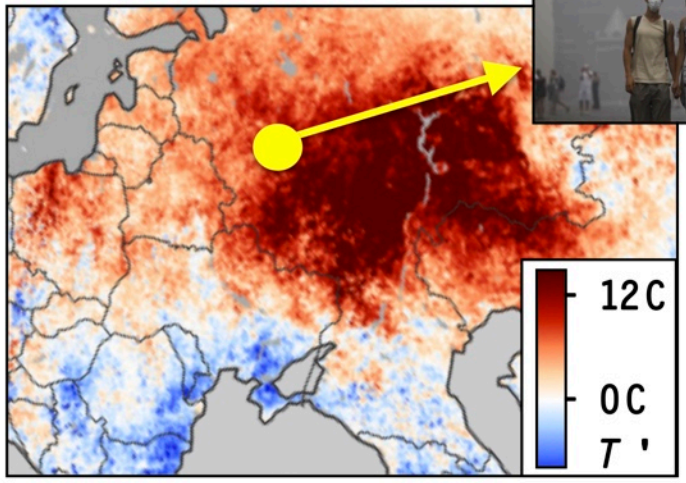
Russia 2010



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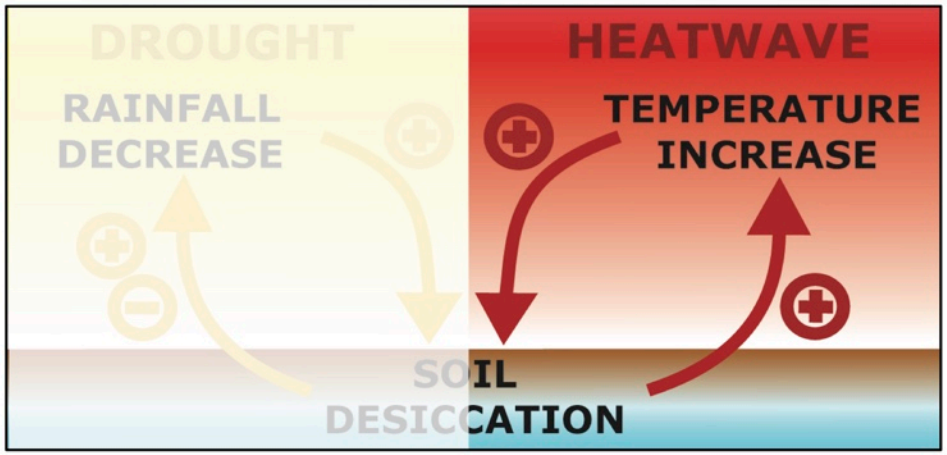
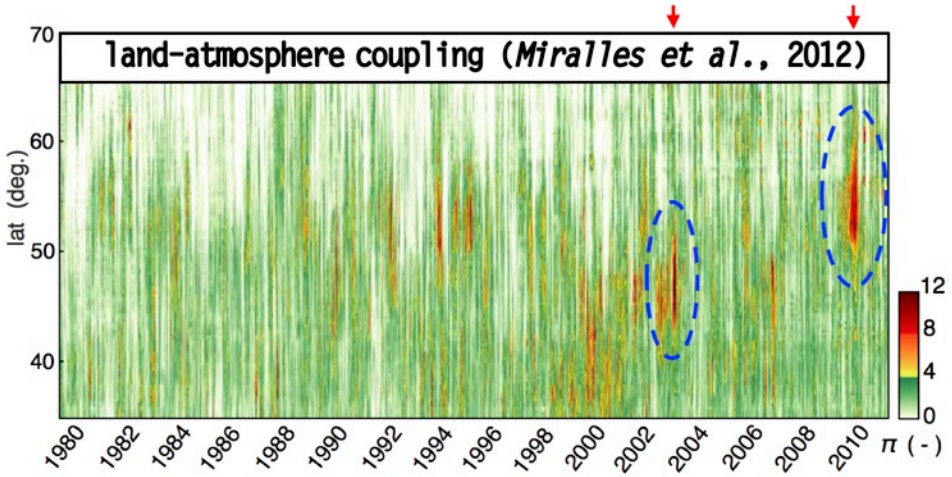


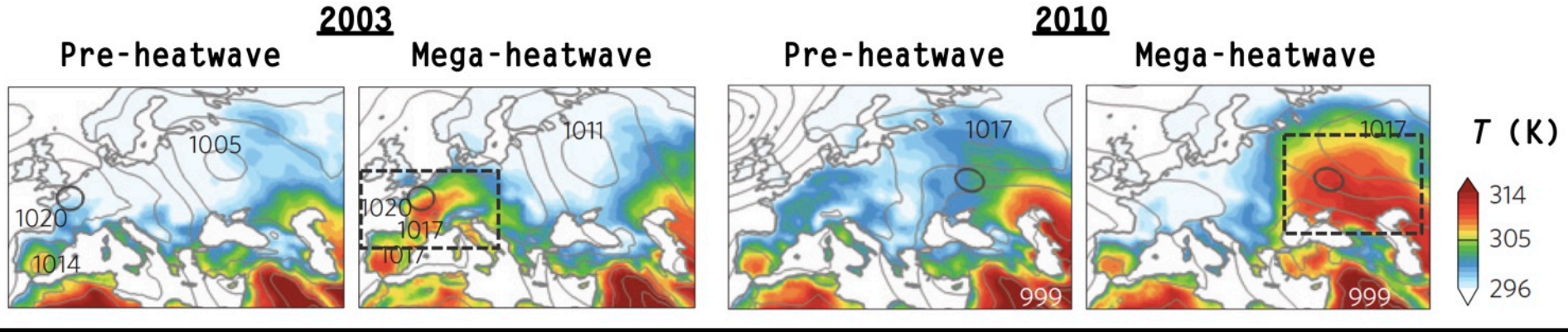


nature geoscience
LETTERS
PUBLISHED ONLINE: 20 APRIL 2014 | DOI: 10.1038/NGEO2141

Mega-heatwave temperatures due to combined soil desiccation and atmospheric heat accumulation

Diego G. Miralles[1,2*], Adriaan J. Teuling[3], Chiel C. van Heerwaarden[4] and Jordi Vilà-Guerau de Arellano[5]

3 - the feedback on heatwaves



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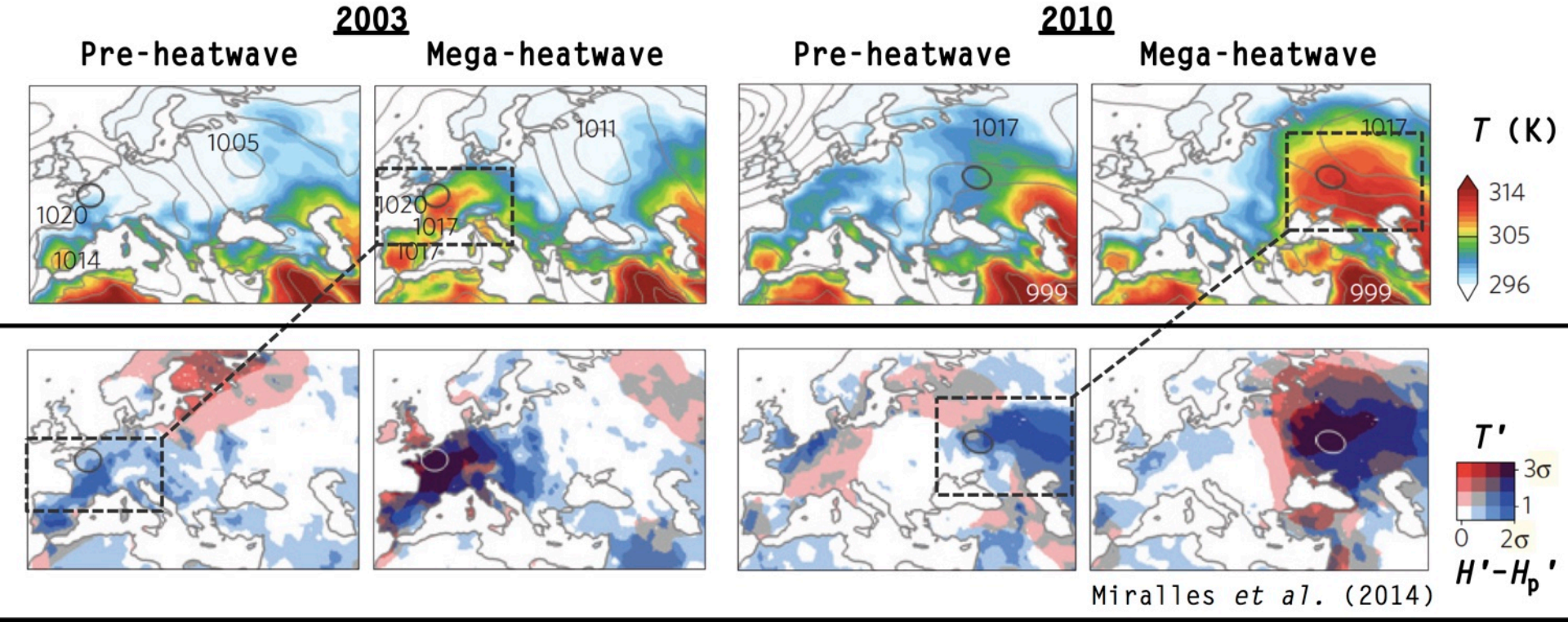

Miralles *et al.* (2014)

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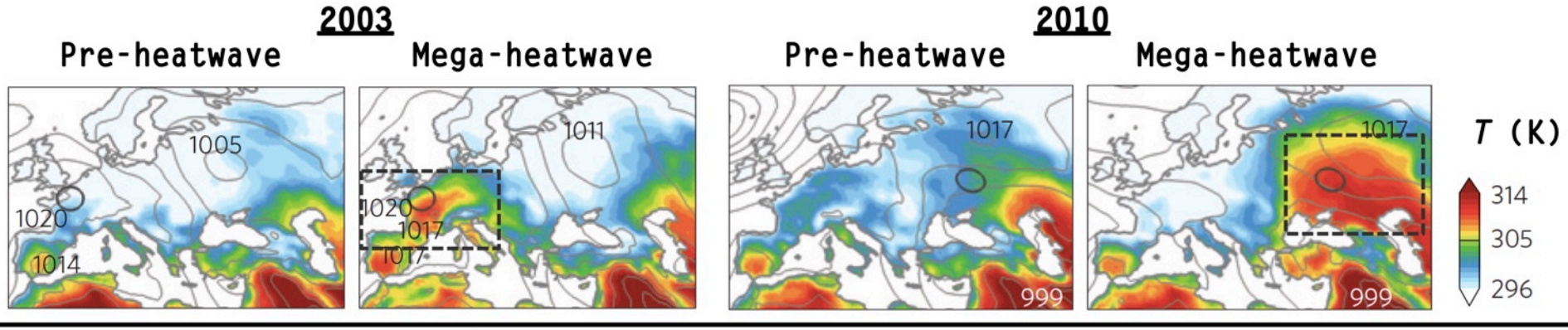

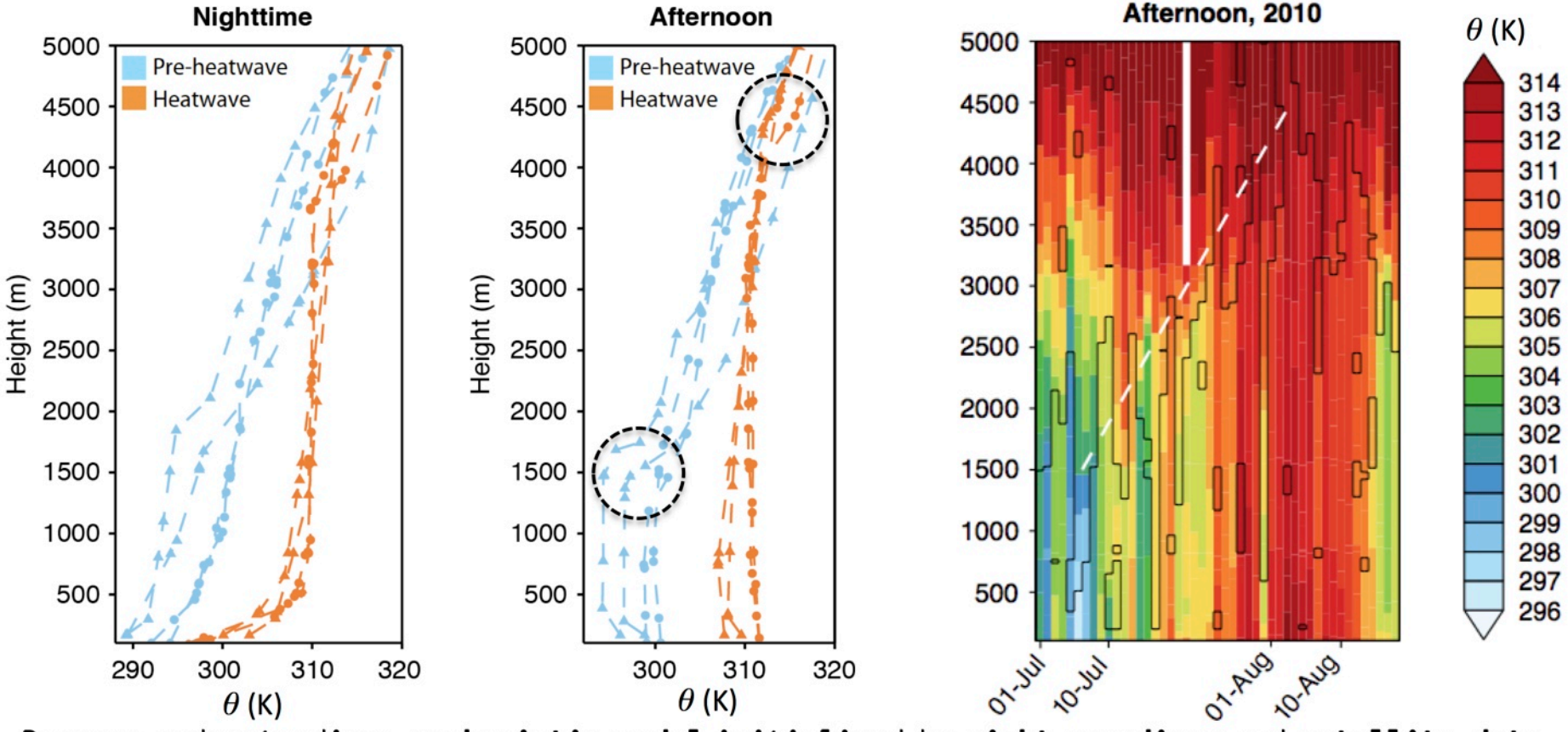

Process understanding: **mechanistic model** initialized by **night soundings** and **satellite data**

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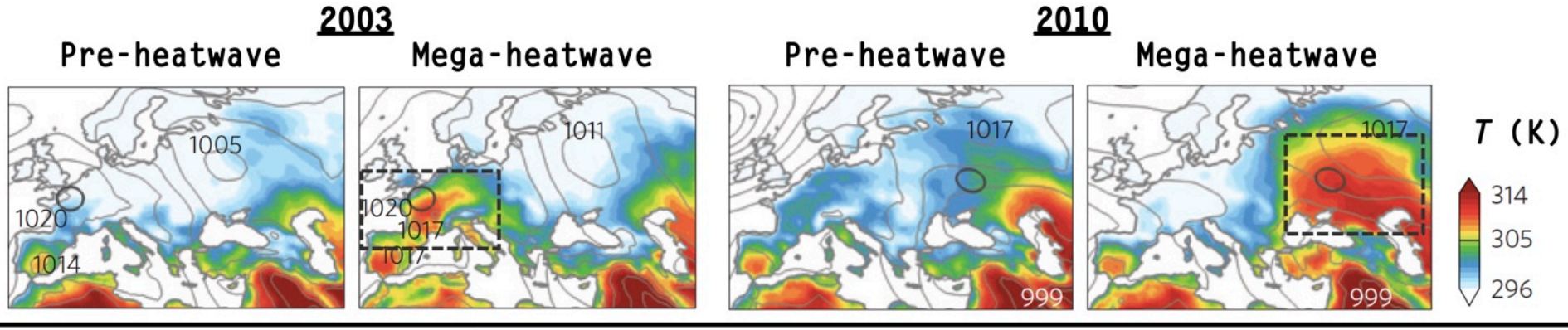

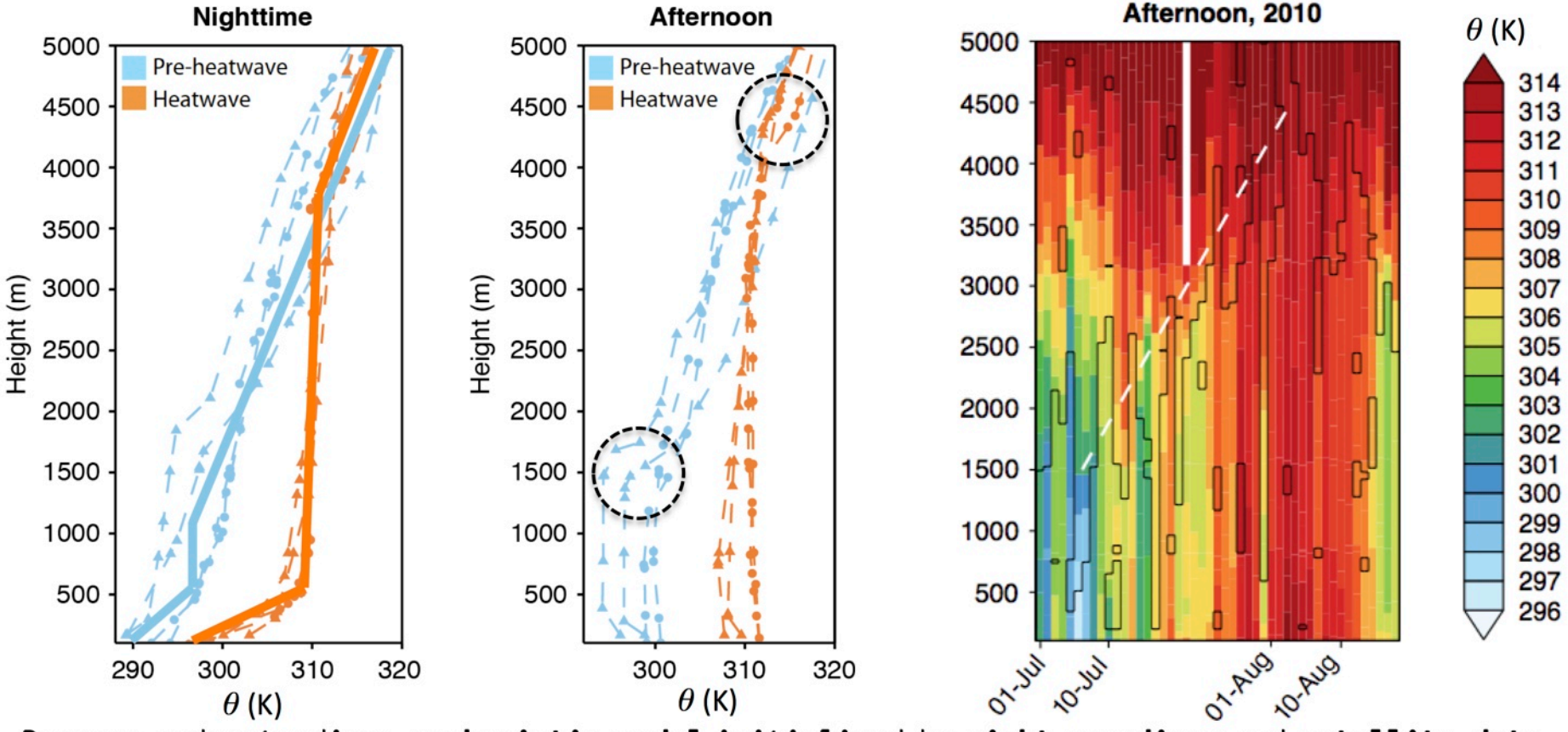

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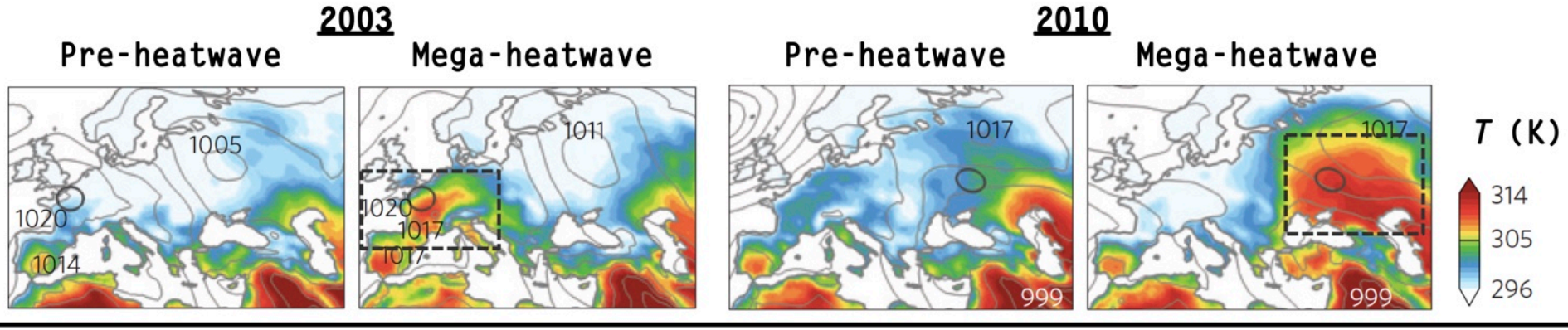

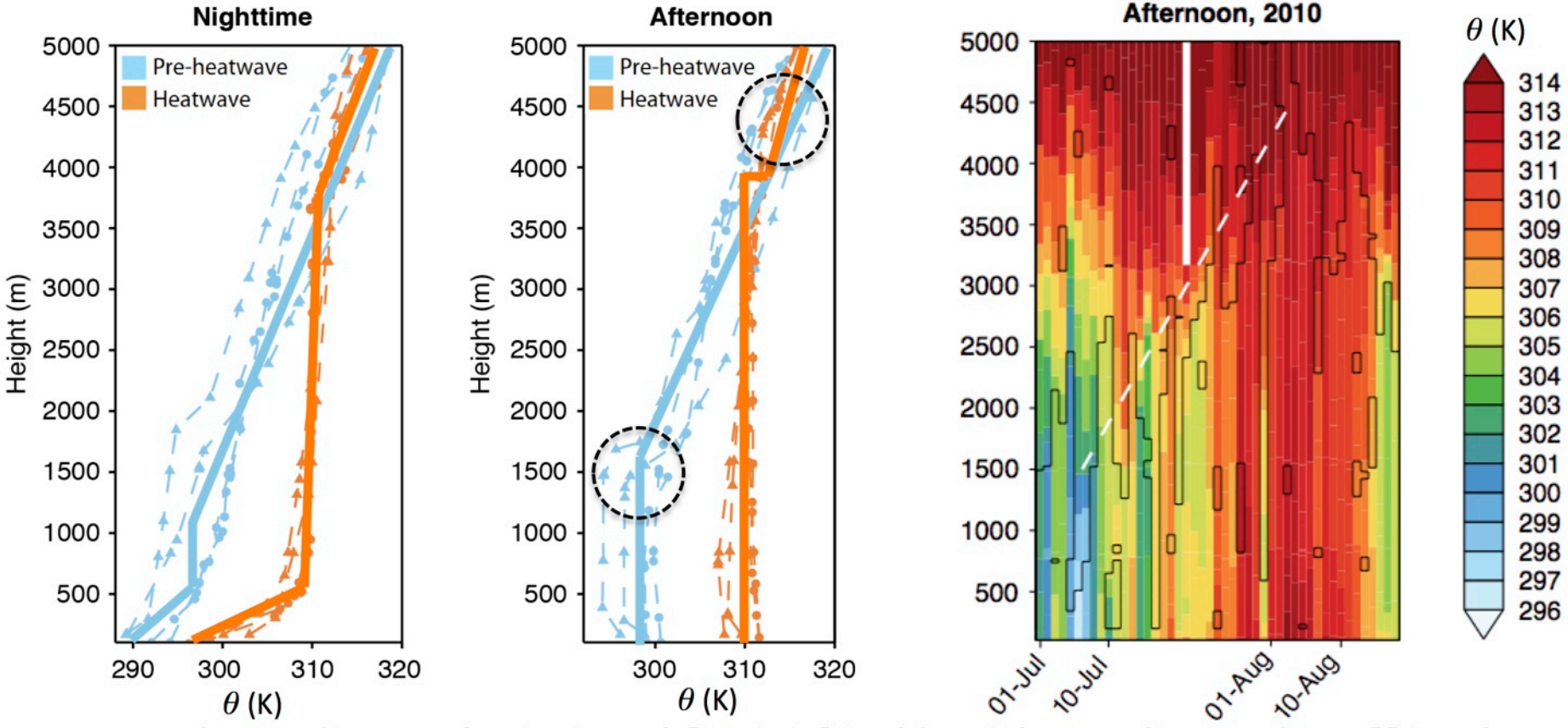

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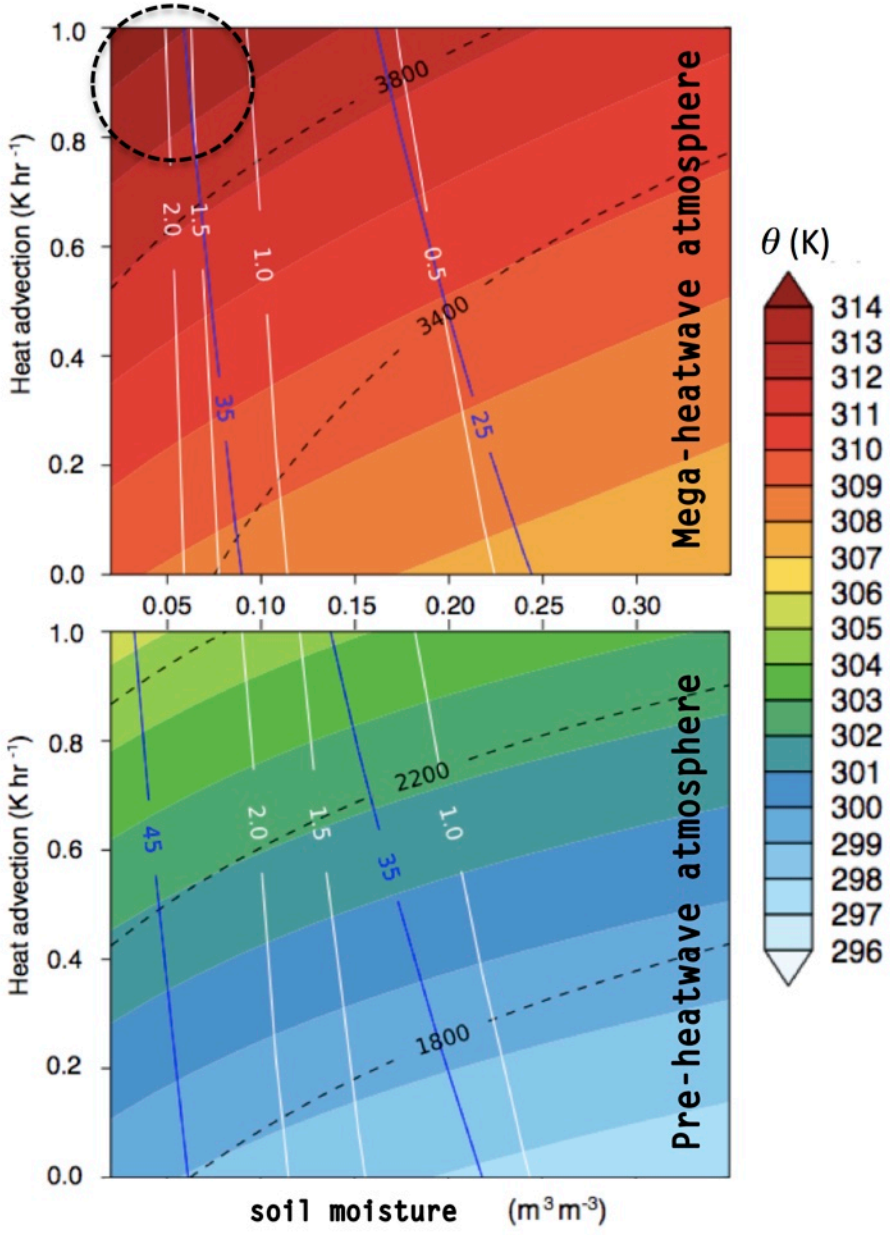
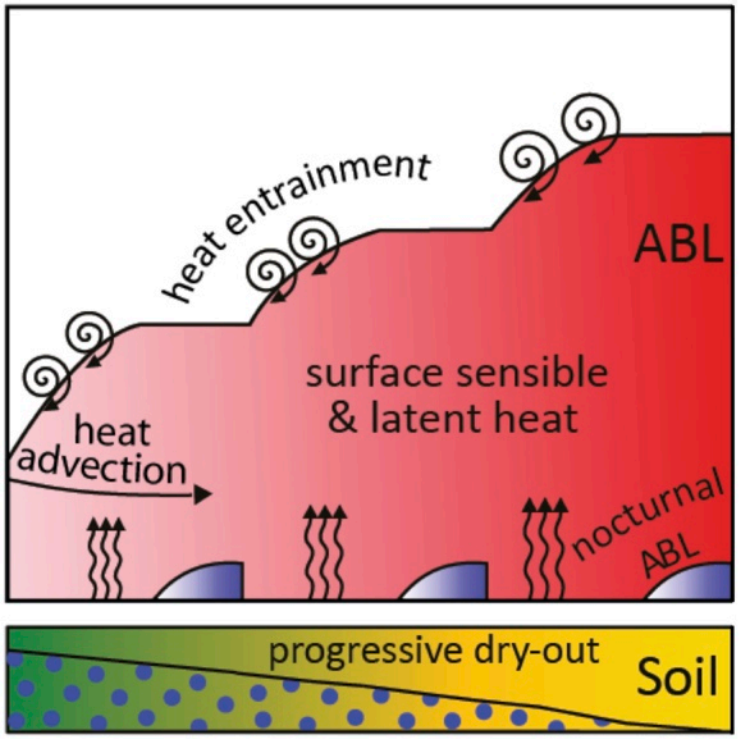




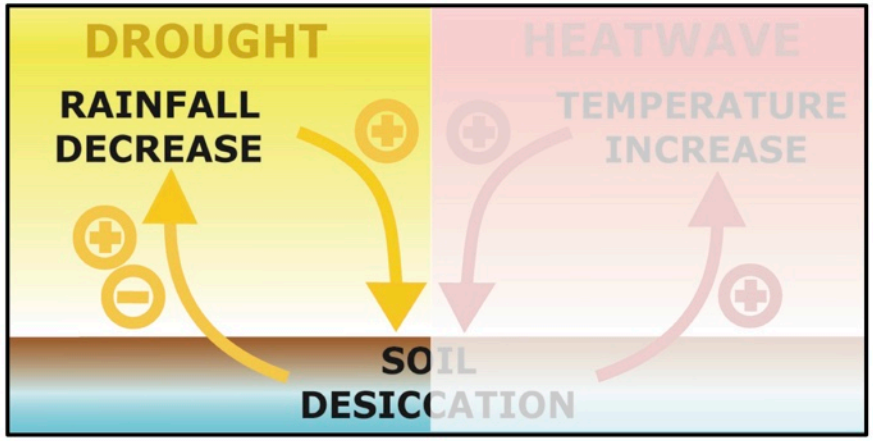
Miralles *et al.* (2014b), *Nature Geosc.*

① Only combined conditions of **low *E* + high heat advection** yield observed *T*

② **Multi-day accumulation** of heat in residual layer is essential

③ **~50% from sensible heat**, ~40% advection, ~10% entrainment

4 - the feedback on droughts

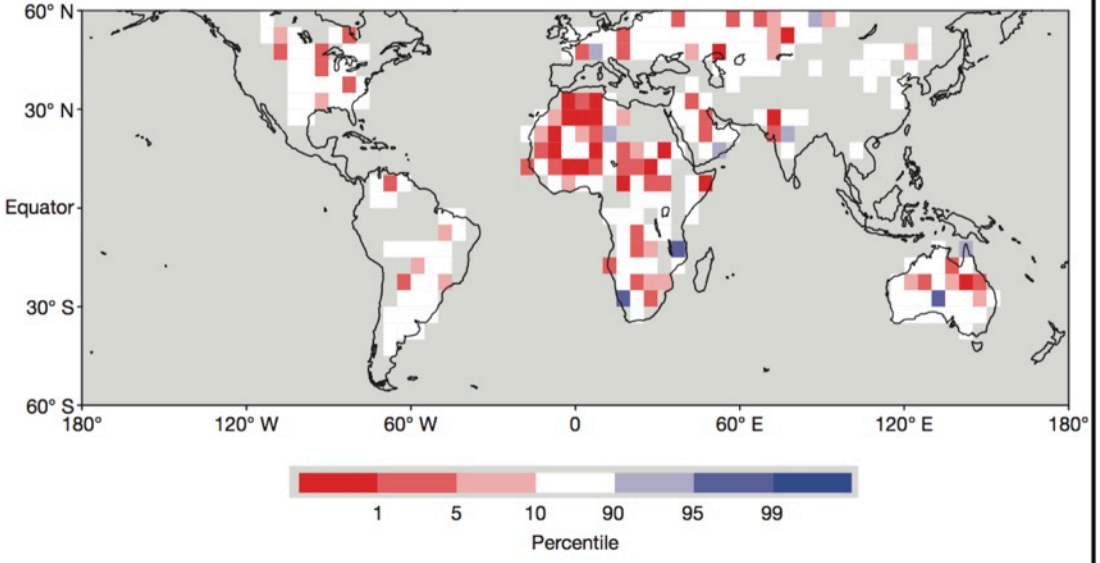


LETTER

doi:10.1038/nature11377

Afternoon rain more likely over drier soils

Christopher M. Taylor[1], Richard A. M. de Jeu[2], Françoise Guichard[3], Phil P. Harris[1] & Wouter A. Dorigo[4]



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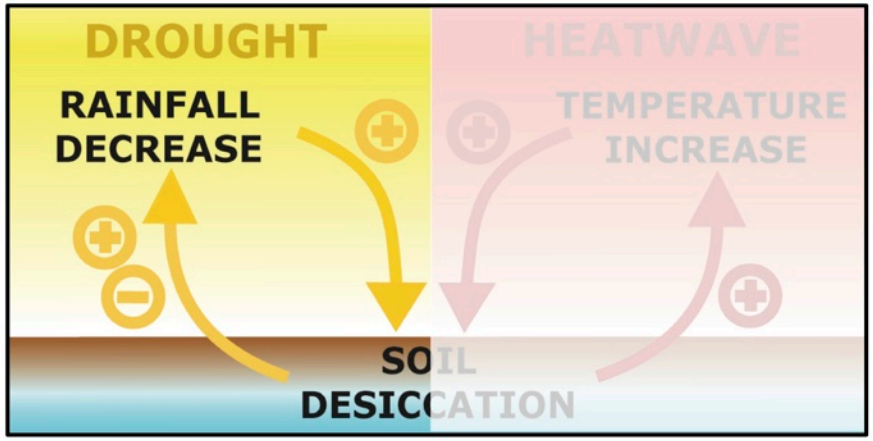

nature COMMUNICATIONS
ARTICLE
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Reconciling spatial and temporal soil moisture effects on afternoon rainfall

B.P. Guillod[1,†], Orlowsky[1], D.G. Miralles[2,3], A.J. Teuling[4] & S.I. Seneviratne[1]

LETTER
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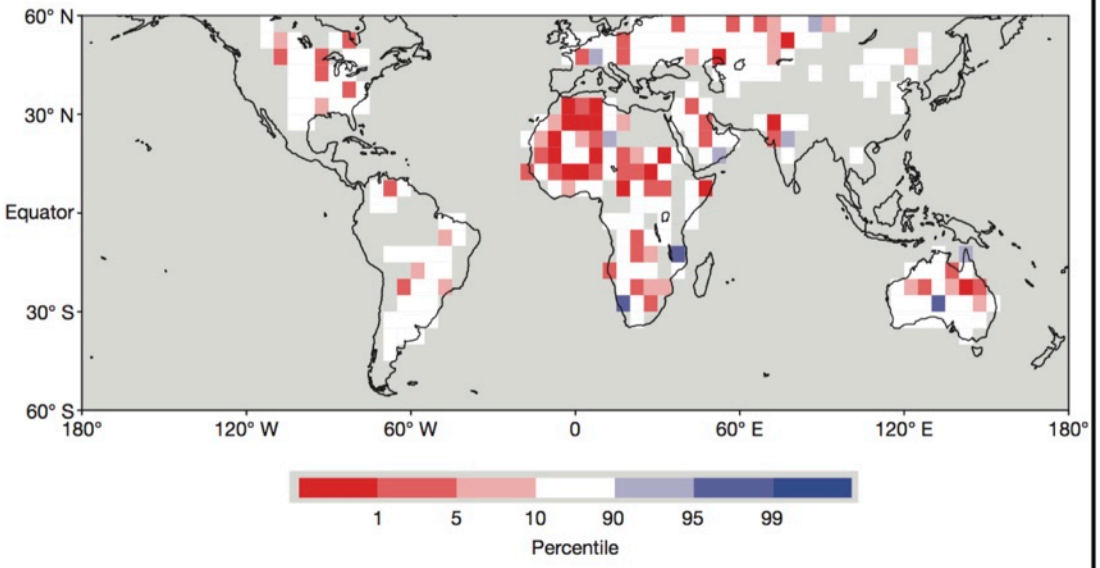
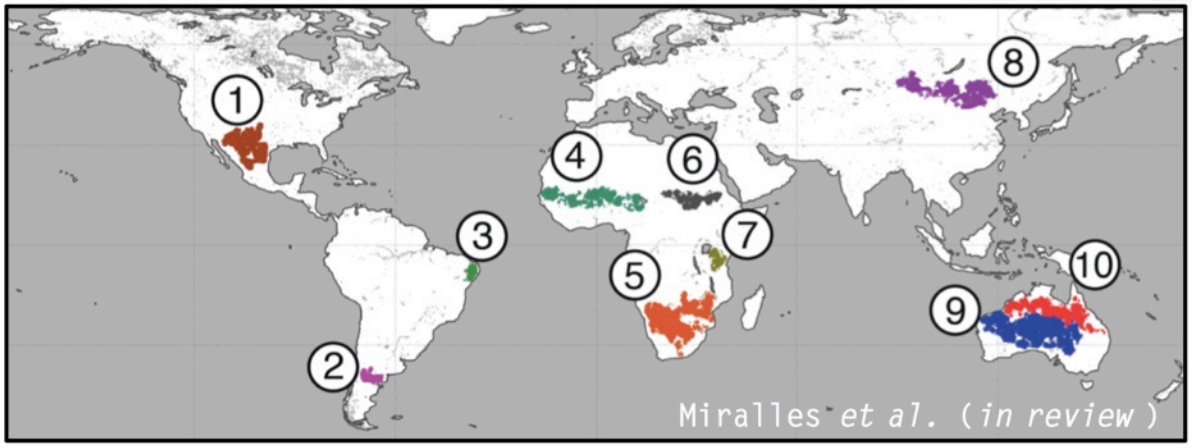
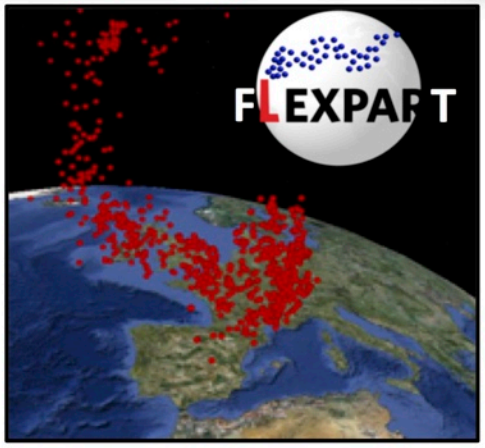


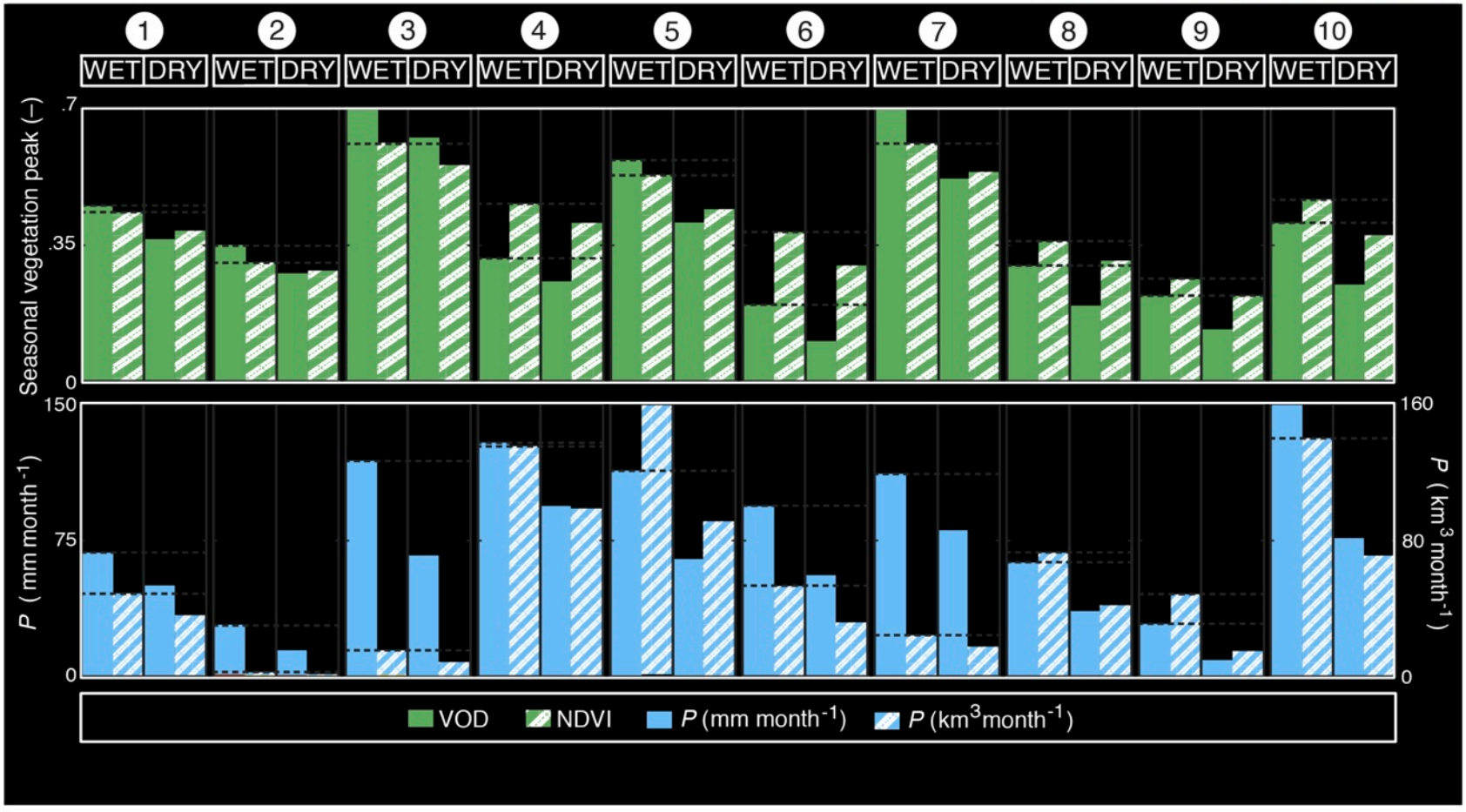
Perspective	Typical rainy cases
Temporal coupling: Rains when conditions are wetter	
Spatial coupling: Rains where conditions are drier	
Joint perspective: Rains when conditions are wetter and heterogeneous, in locations where conditions are drier	

Soils
Dry — Wet

4 - the feedback on droughts







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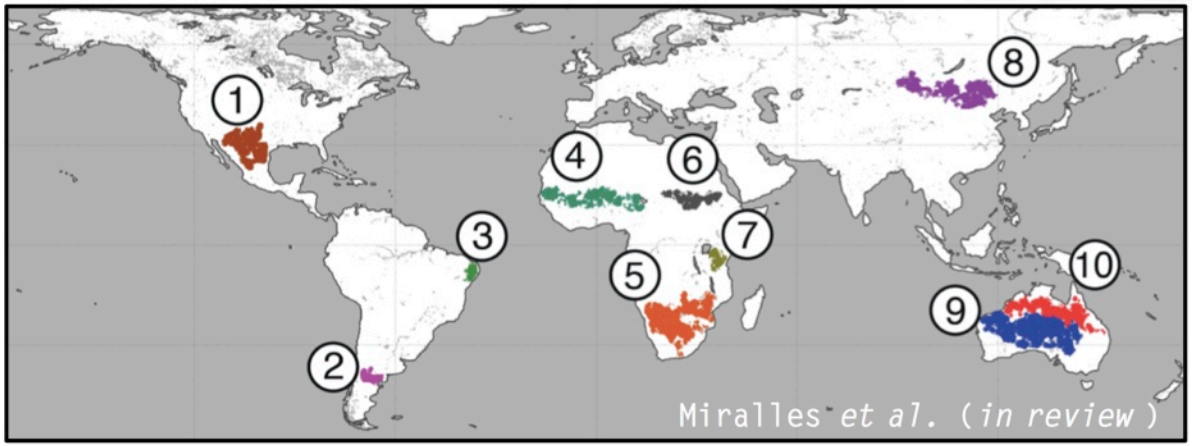

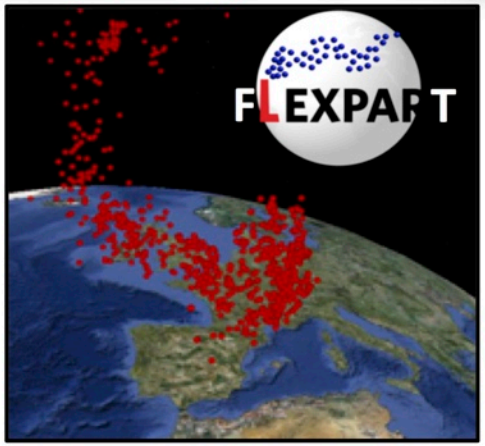

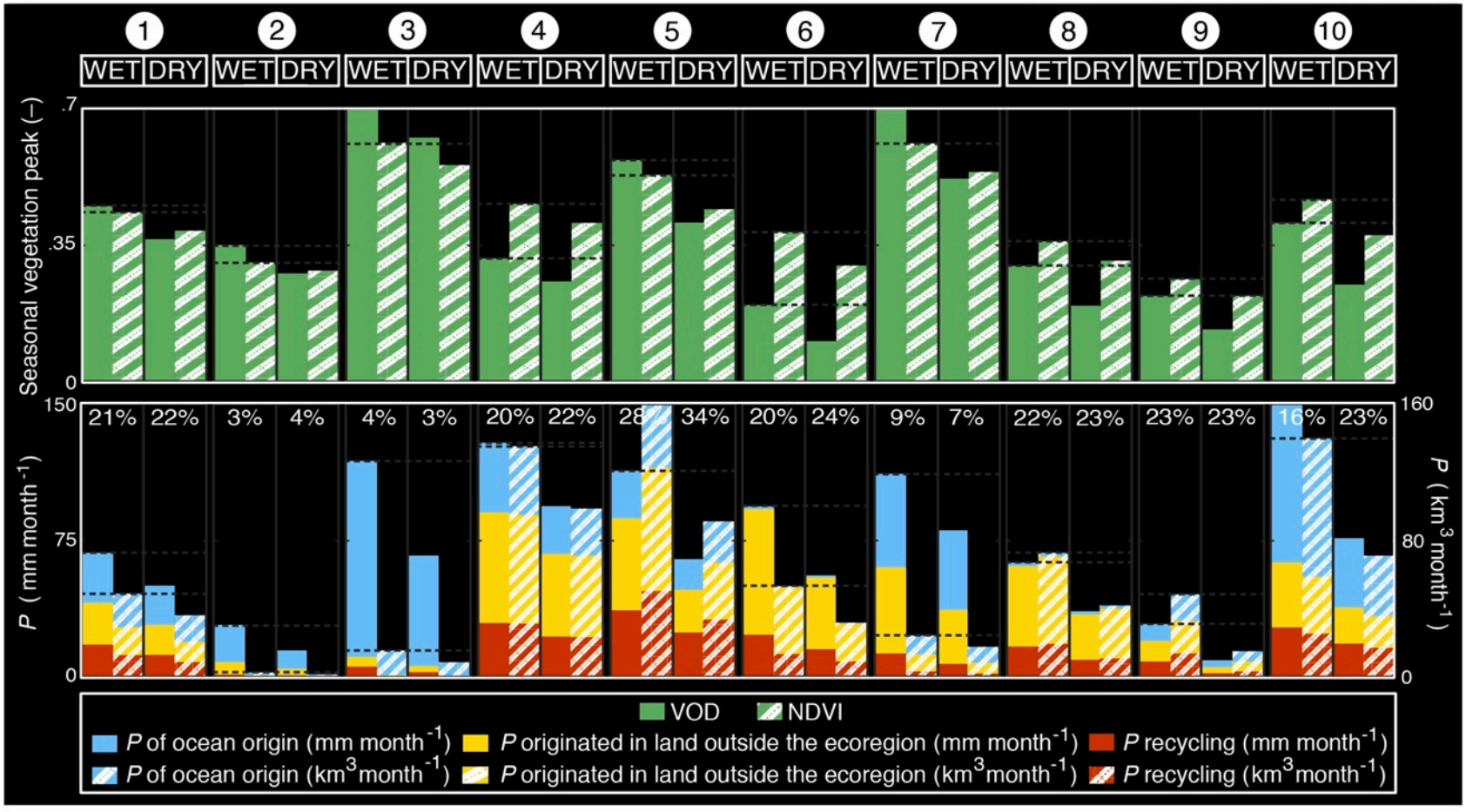

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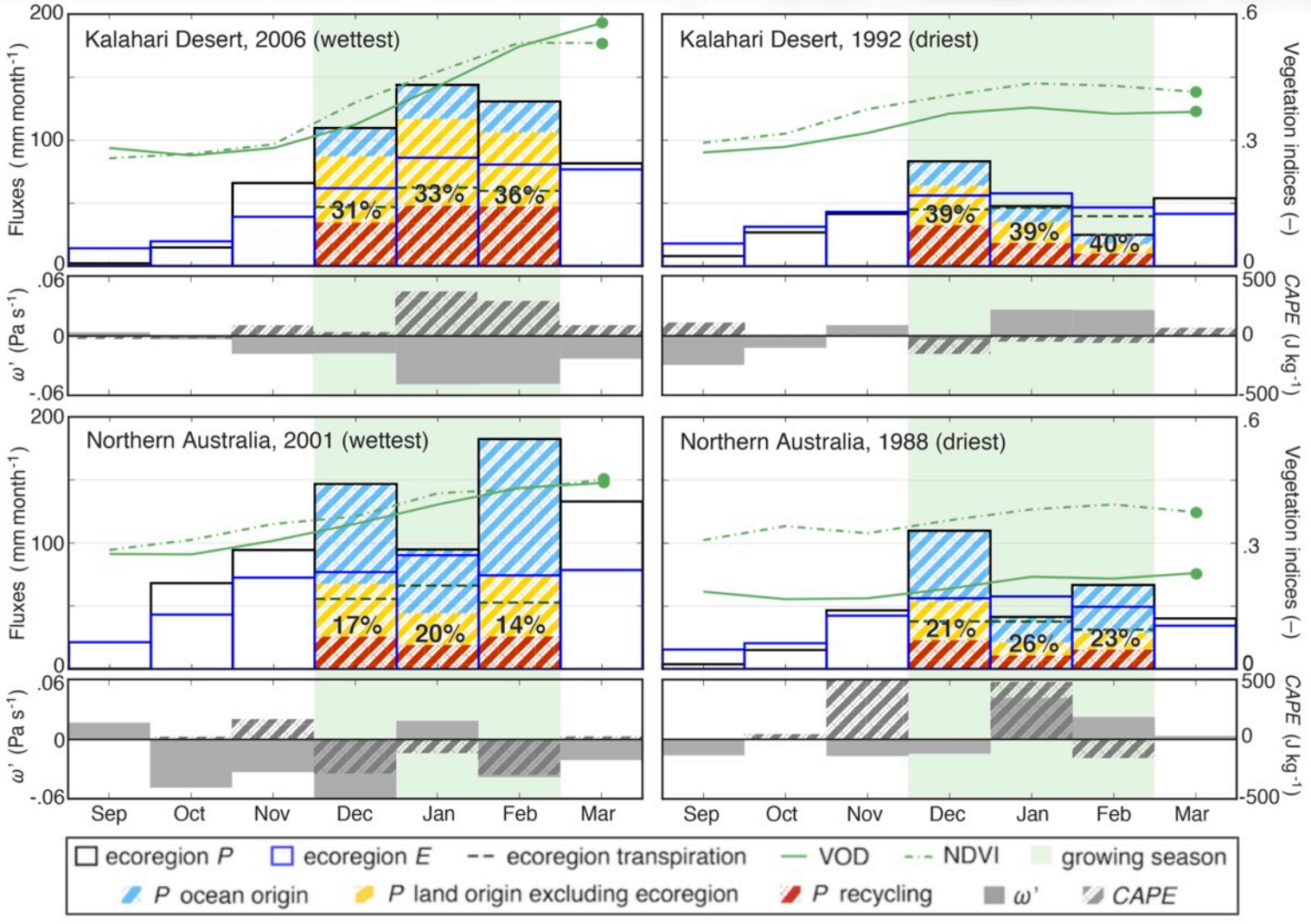
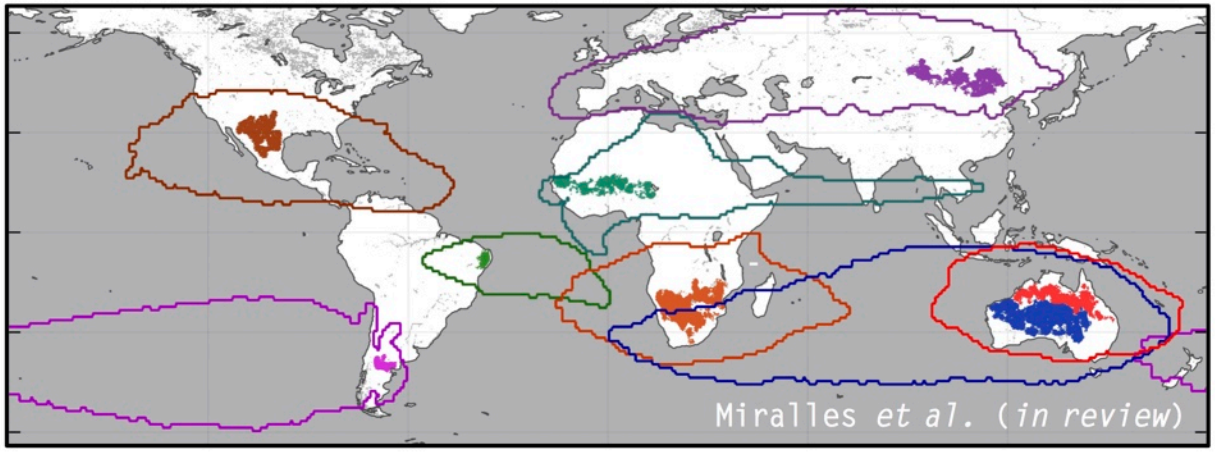


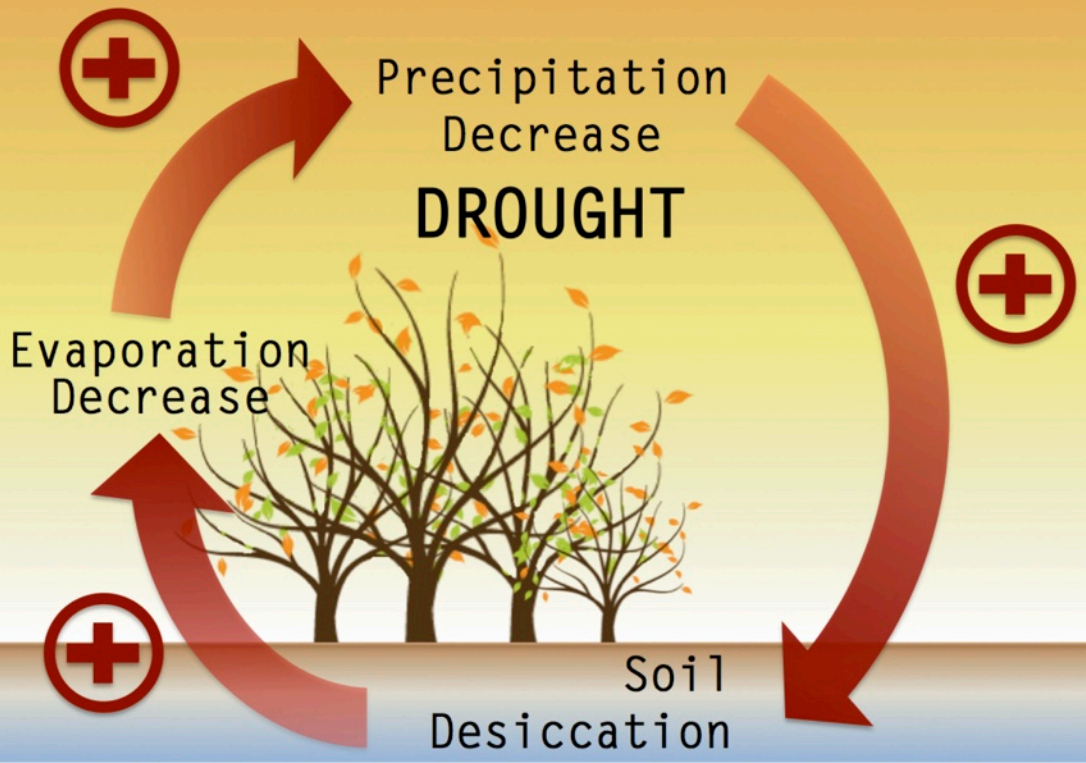
- **Recycling volumes are lower during droughts:** feedback is positive
- **Recycling ratios higher during droughts:** trigger coming from outside
- **High importance of transpiration** to sustain rainfall during dry times

4 - the feedback on droughts

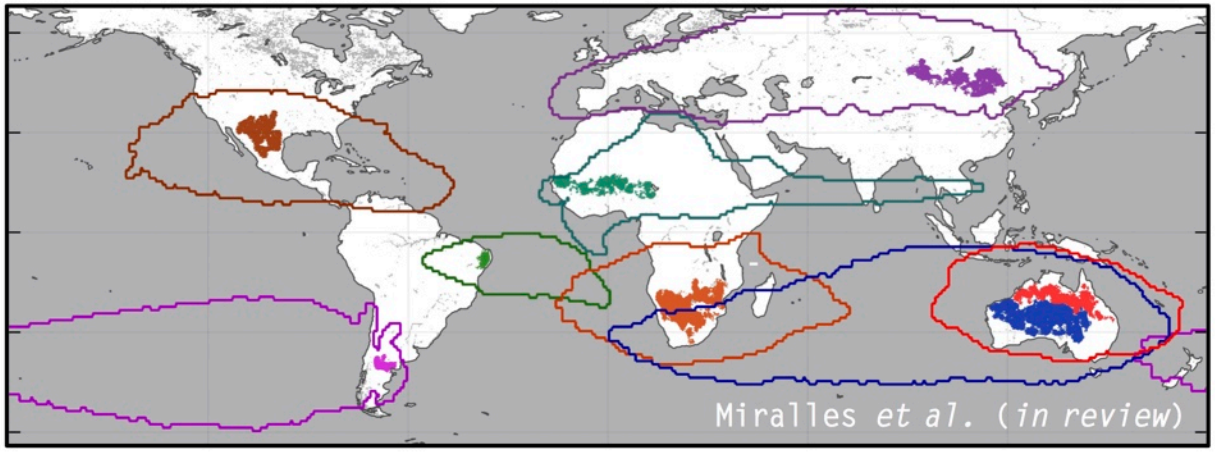


but also
teleconnected effects

self-intensification



4 - the feedback on droughts



but also
teleconnected effects

self-intensification

wind

self-propagation

Precipitation Decrease

DROUGHT

Precipitation Decrease

DROUGHT 2

Evaporation Decrease

Soil Desiccation

erc

Diego G. Miralles

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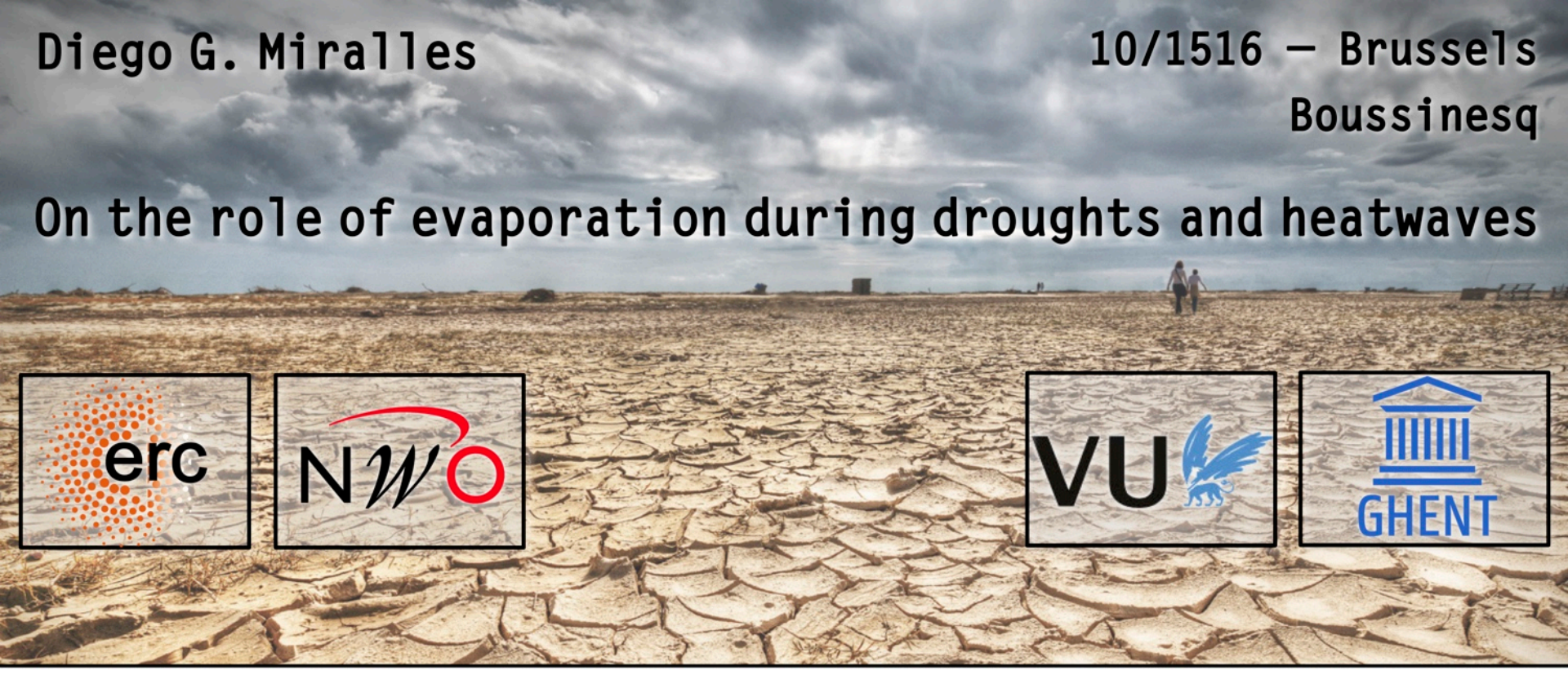
Boussinesq

On the role of evaporation during droughts and heatwaves



- Evaporation regulates land-atmospheric feedbacks, crucial at intensifying events
- Temperatures during heatwaves shown to be affected by evaporation declines
- Dry periods triggered from outside but intensified by local evaporation declines
- Important to consider teleconnected land-atmospheric feedbacks