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NCCR CLIMATE
Swiss Climate Research

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Soil moisture—atmosphere interactions during the 2003 European summer heatwave

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With Sonia Seneviratne, Pier-Luigi Vidale, Daniel Lüthi, and Christoph Schär

AMS Meeting
30 Jan 2006

Outline

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- Introduction
- Characteristics of the 2003 heatwave
- Soil moisture sensitivity experiment
- Conclusions

Summer 2003

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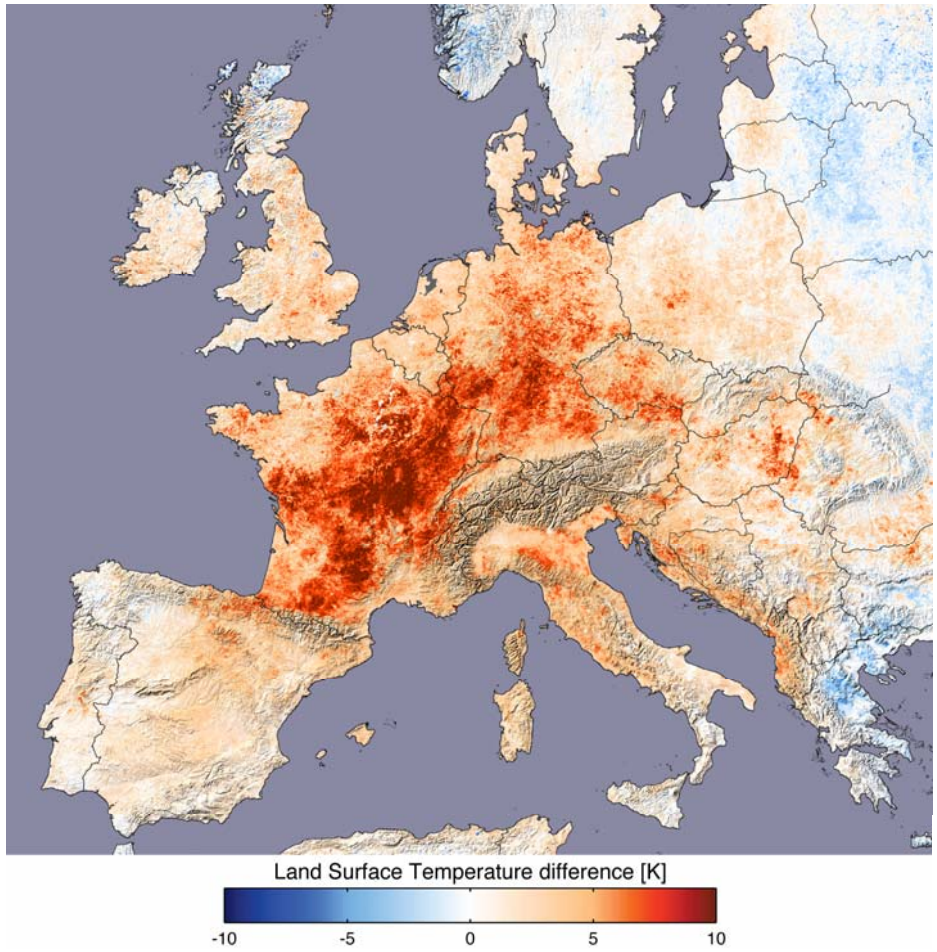

- Very likely the hottest European summer over the past 500 years
- About 35,000 heat-related deaths across Europe
- Crop losses of around US$ 12.3 billion and damage due to forest fires in Portugal of US$ 1.6 billion (Swiss RE)

Land surface radiative temperature anomaly July/Aug 2003 wrt the mean of 2000, 2001, 2002 and 2004 (NASA Earth Observatory, Reto Stöckli et al. 2004)

Model domain

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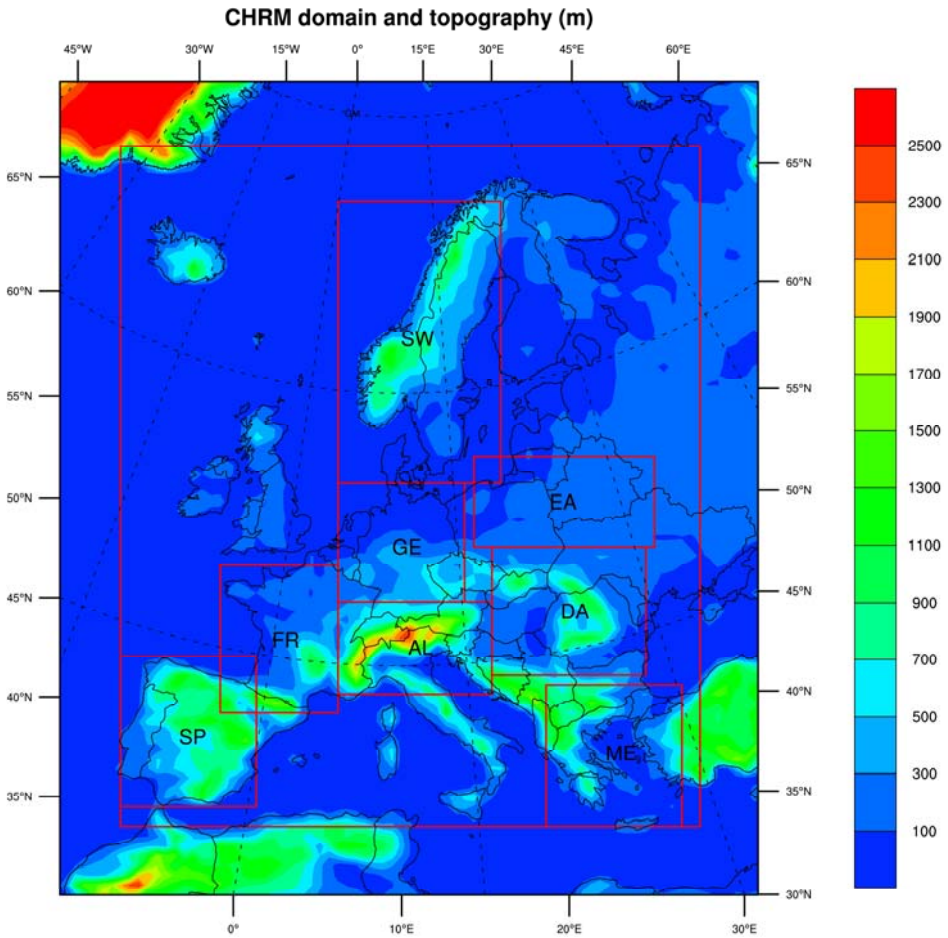

CHRM

- Version with spatial resolution Δx 56 km and temporal resolution Δt 300s
- Adapted for climate, tested for skill at interannual variability
- European domain
- Ensemble simulations

Lateral boundary conditions

- 2003: ECMWF analysis
- 1970-2000: ERA-40

Temperature anomaly

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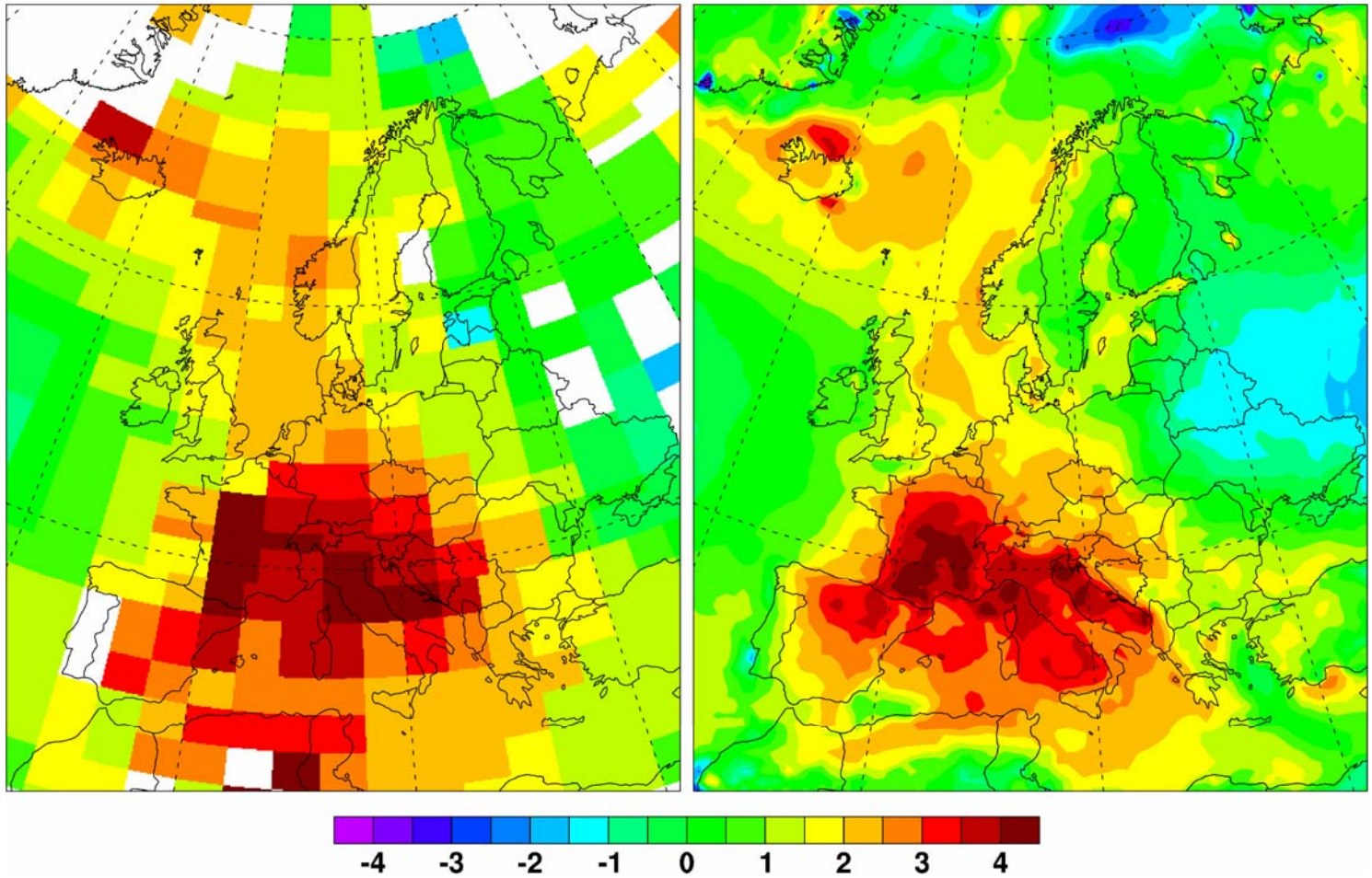
JJA 2003 wrt 1970-2000

GISTEMP

CHRM



Circulation anomaly

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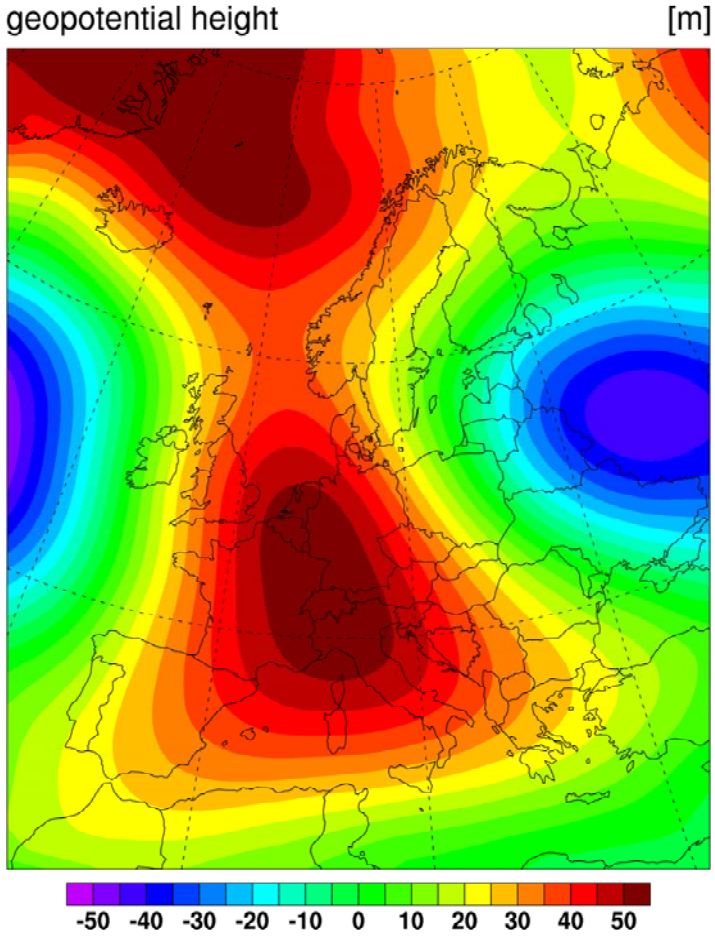
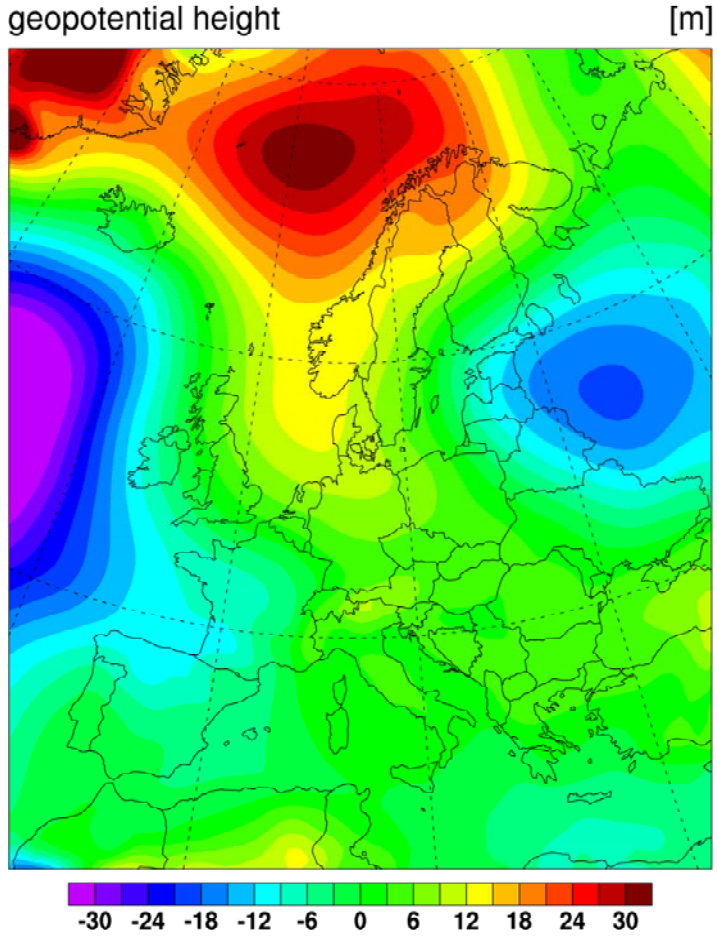
JJA 2003 wrt 1970-2000

500hPa



1000hPa



Precipitation anomaly

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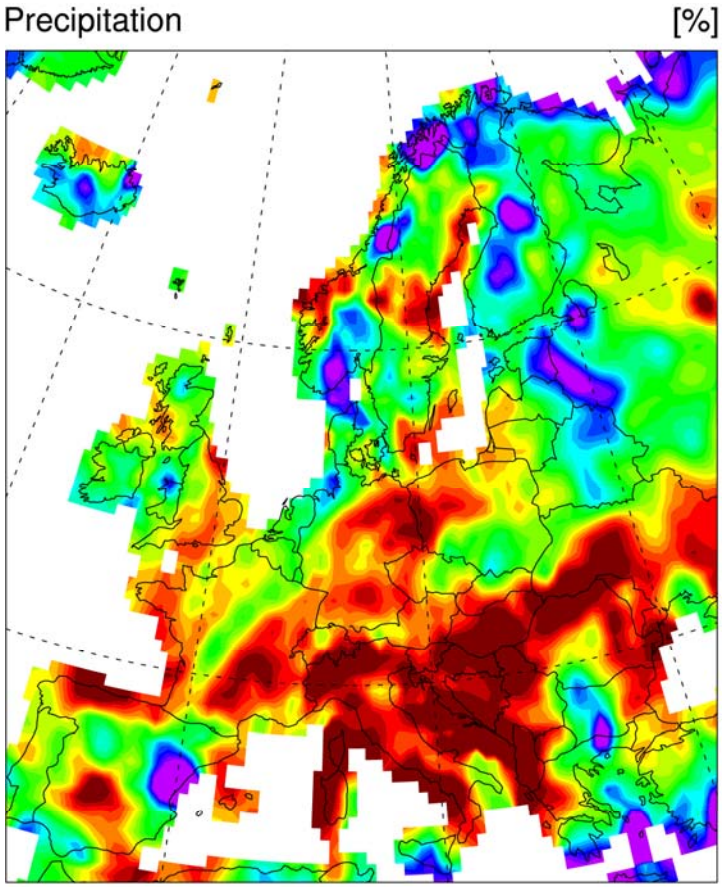
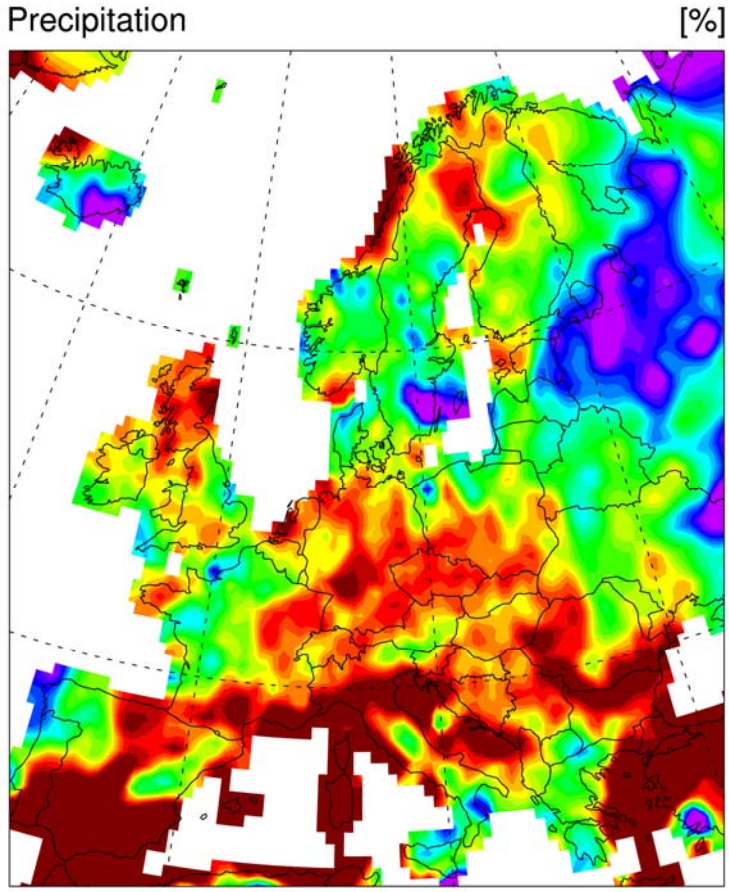
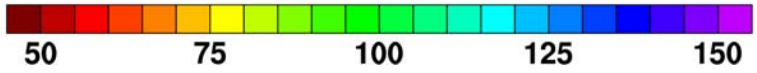
GPCC observational precipitation

Spring 2003



Summer 2003





Terrestrial water storage

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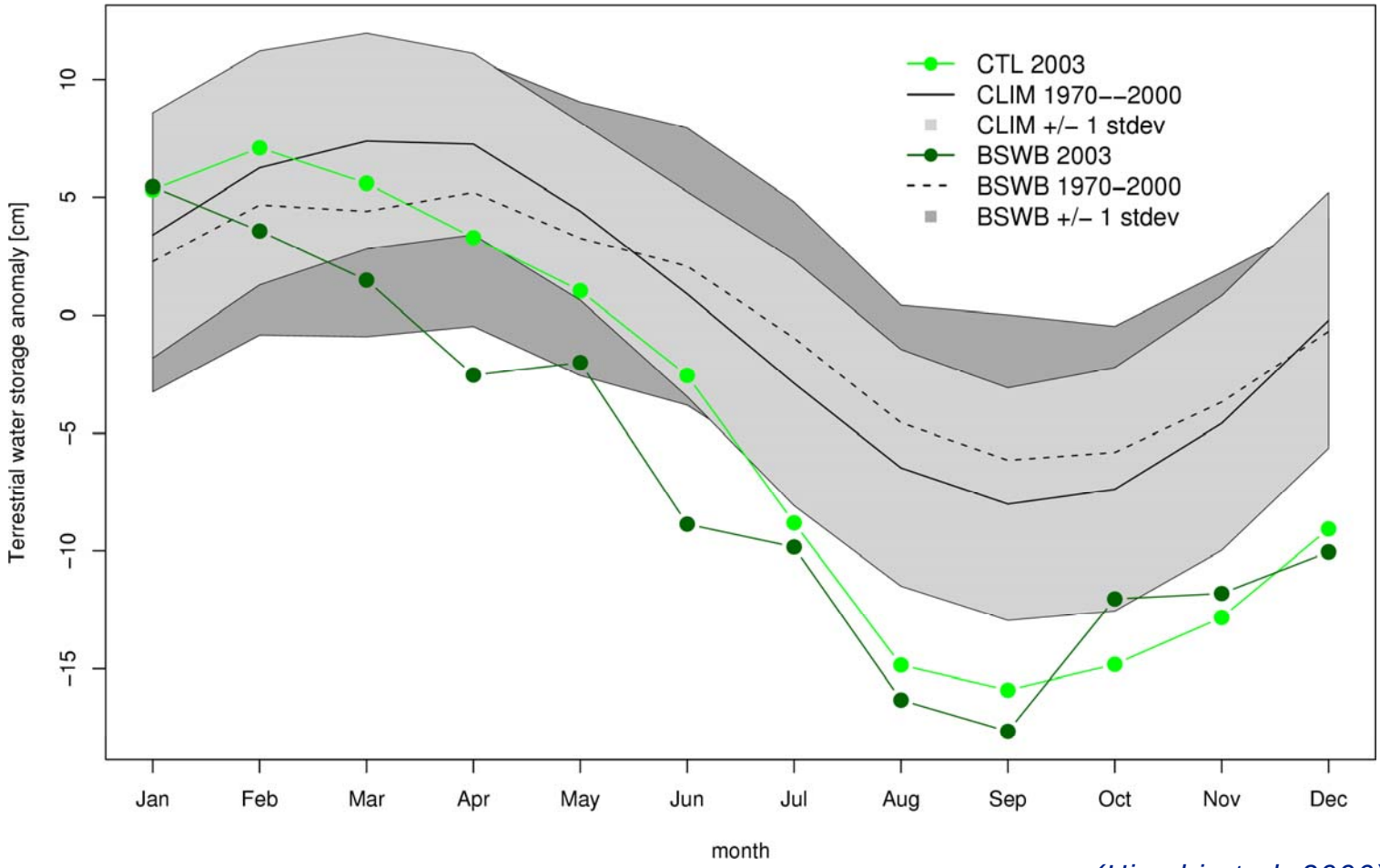
Rhine catchment



(Hirschi et al. 2006)

Surface energy budget

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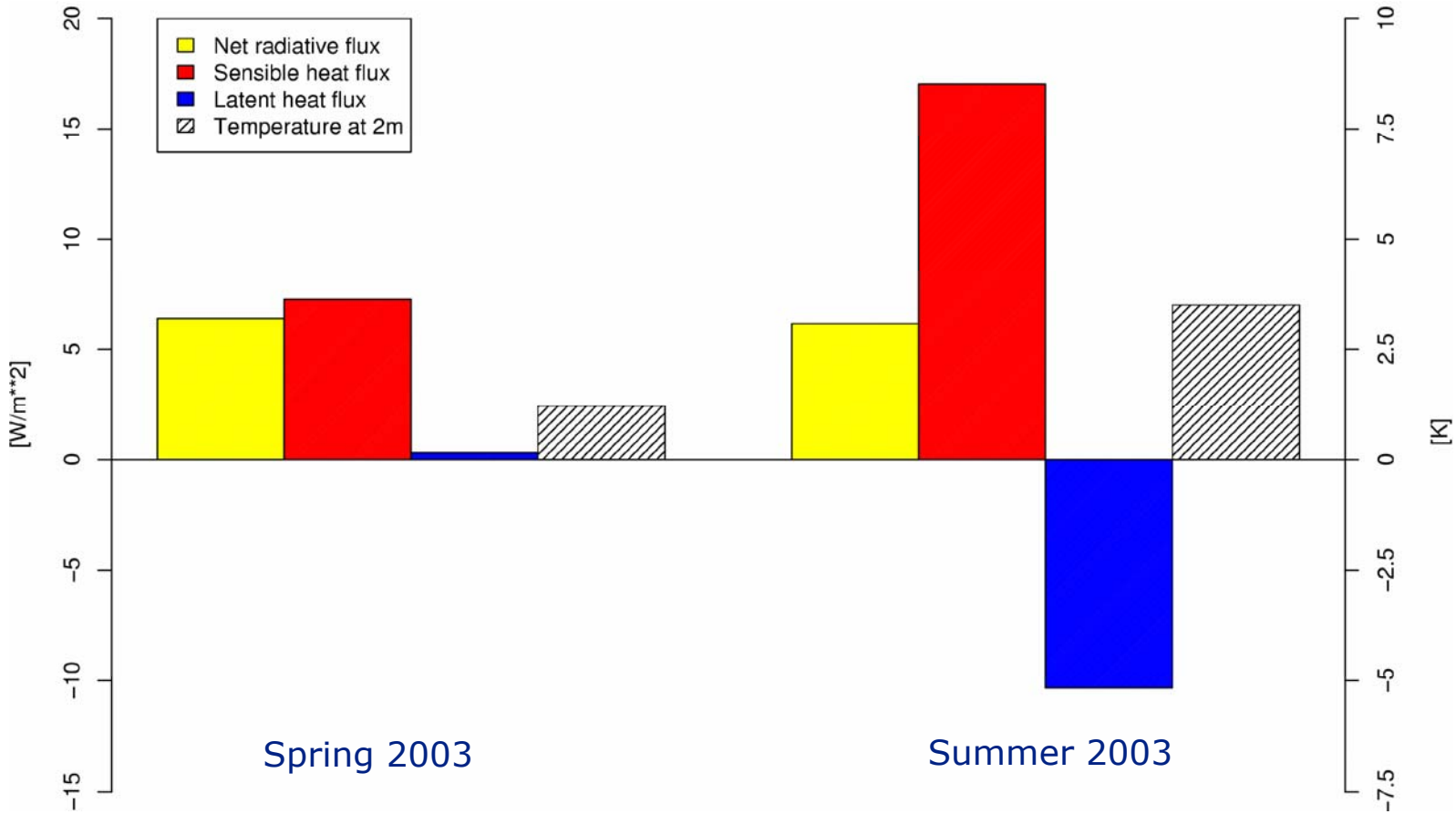
Radiative and turbulent flux anomalies 2003



Soil moisture experiment

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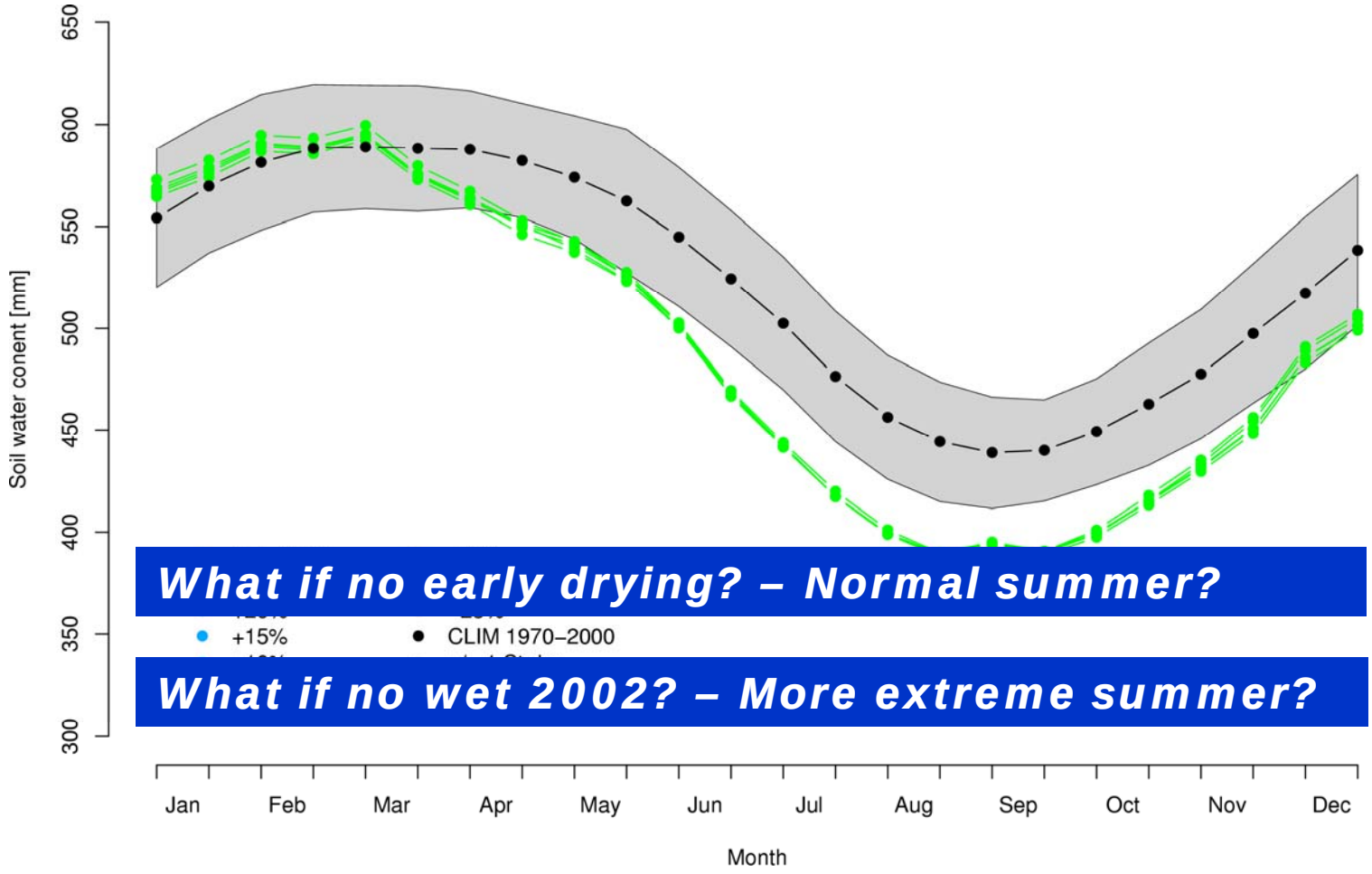
Soil moisture over France



What if no early drying? – Normal summer?

What if no wet 2002? – More extreme summer?

Soil moisture experiment

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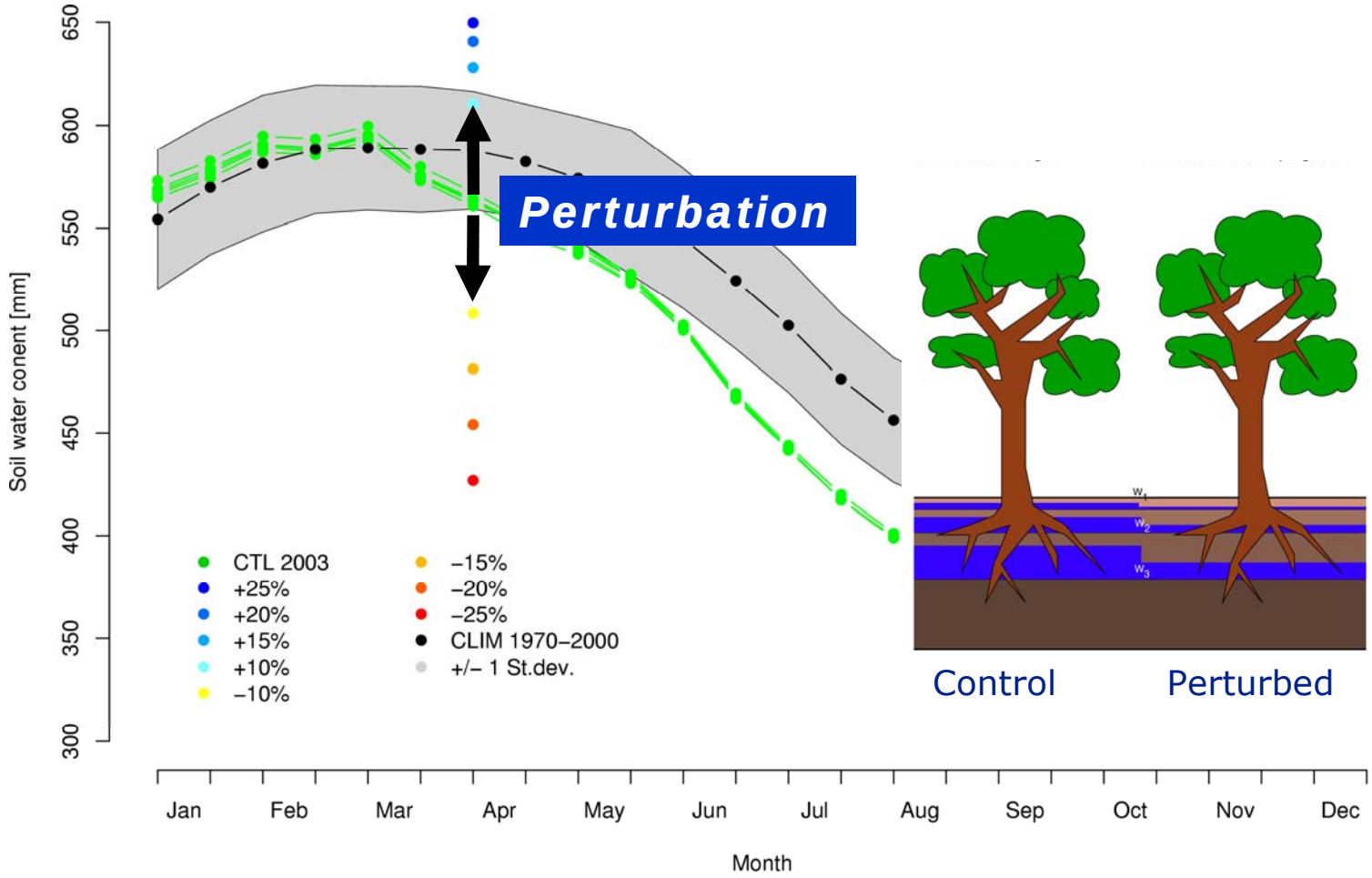

Soil moisture experiment

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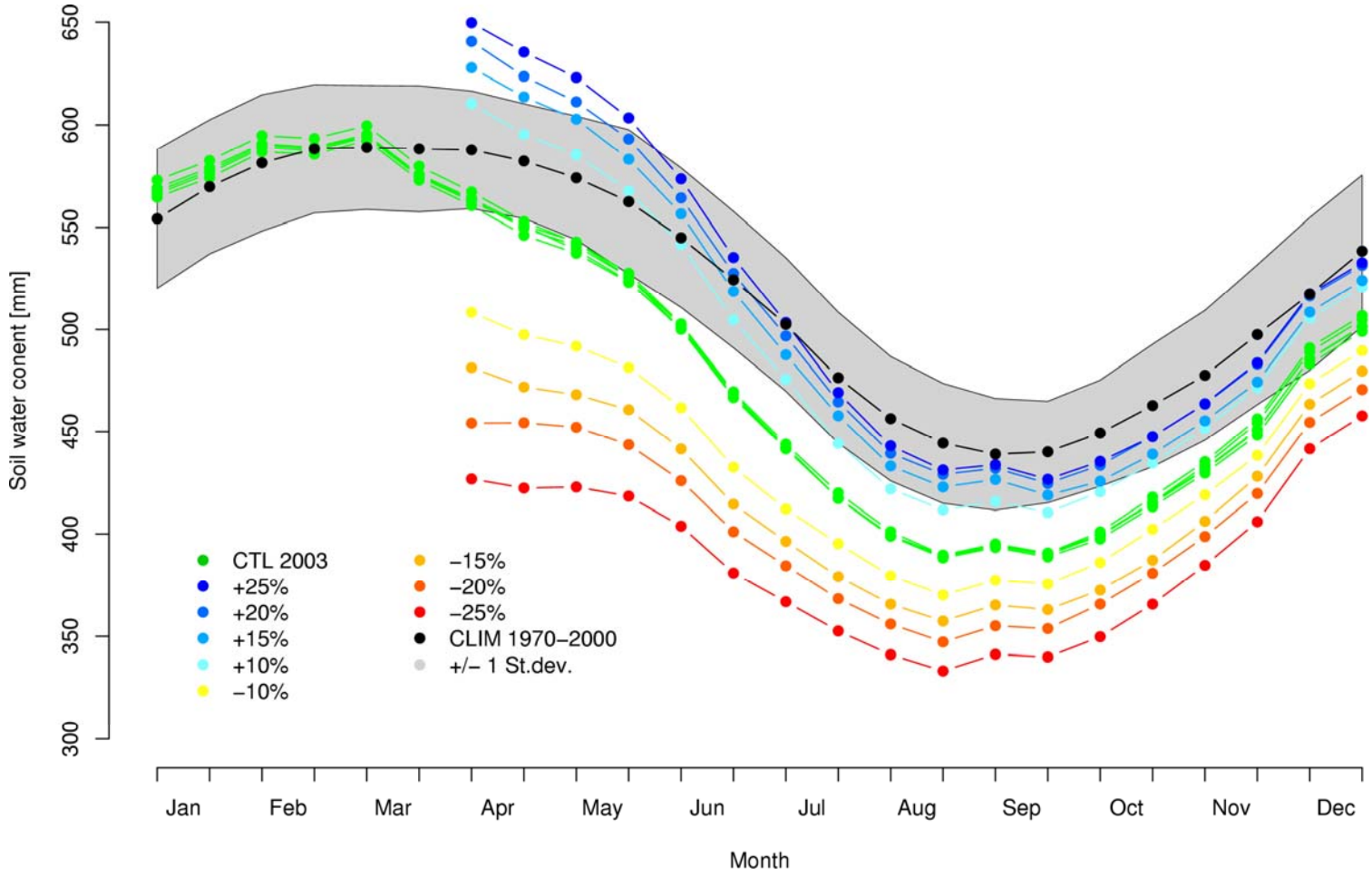

Temperature anomaly

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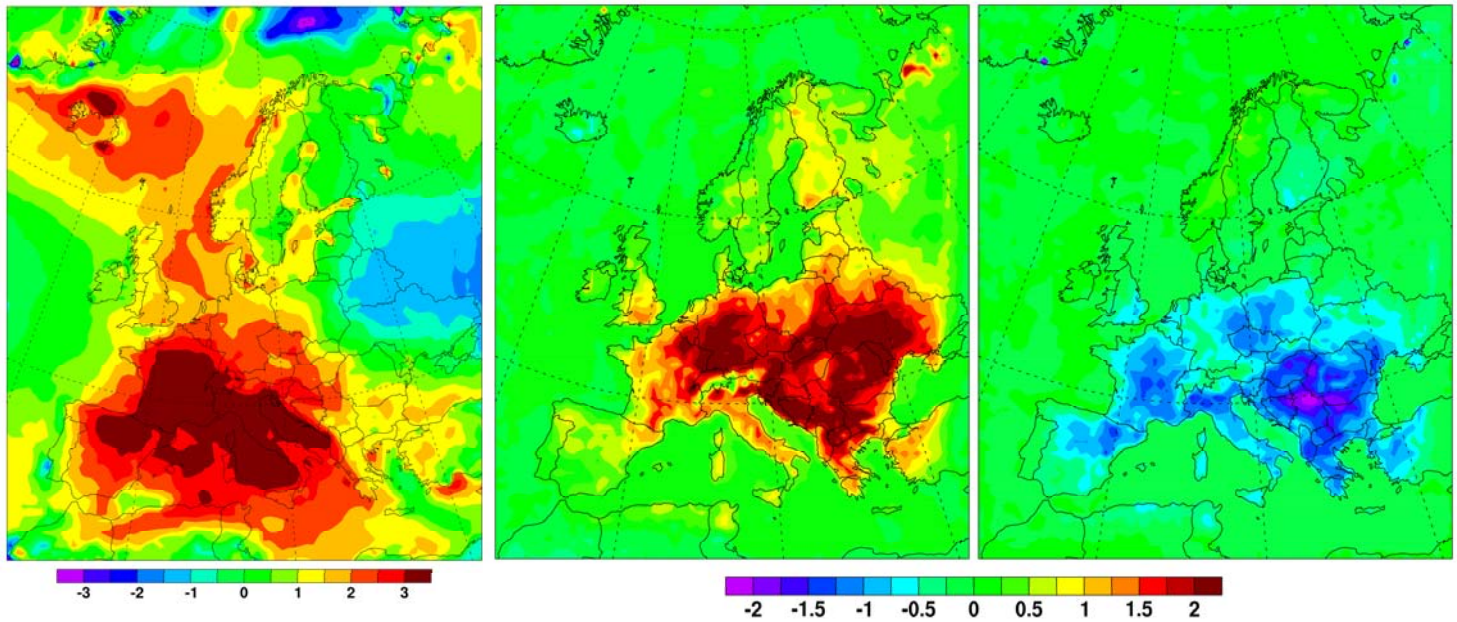
CTL-CLIM DRY25-CTL WET25-CTL



Dry run → larger (more than 2K) and spatially extended anomalies

1000hPa geopot. height

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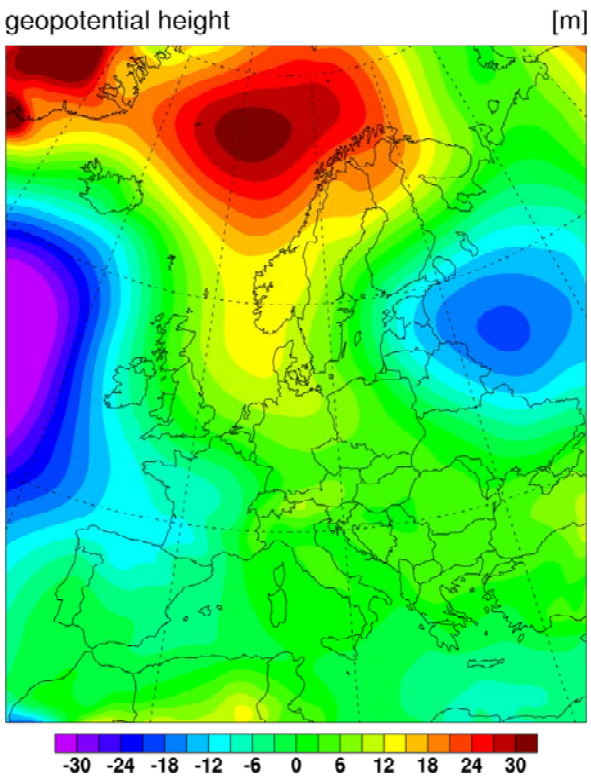

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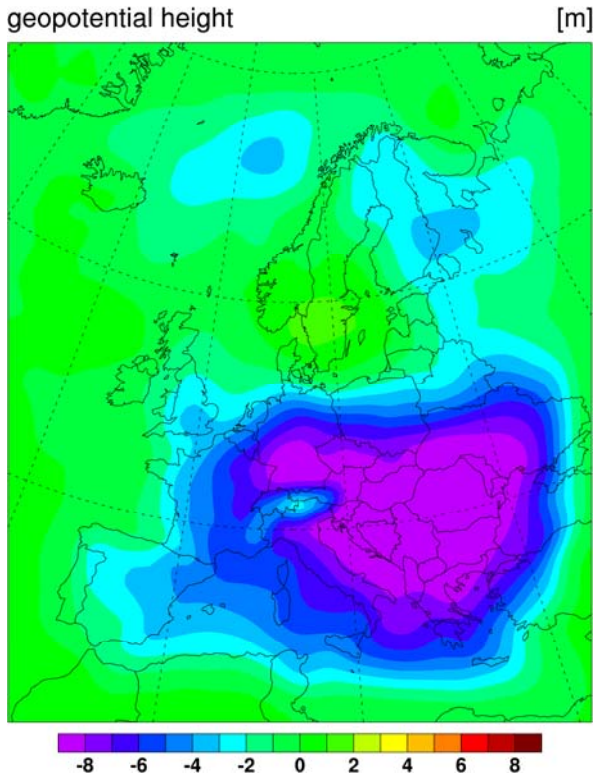

Dry soil → surface heat low

500hPa geopot. height

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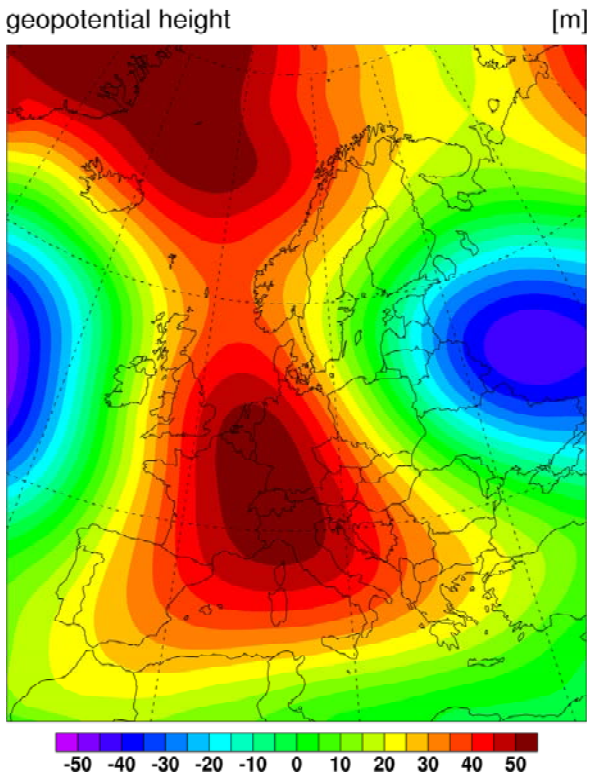

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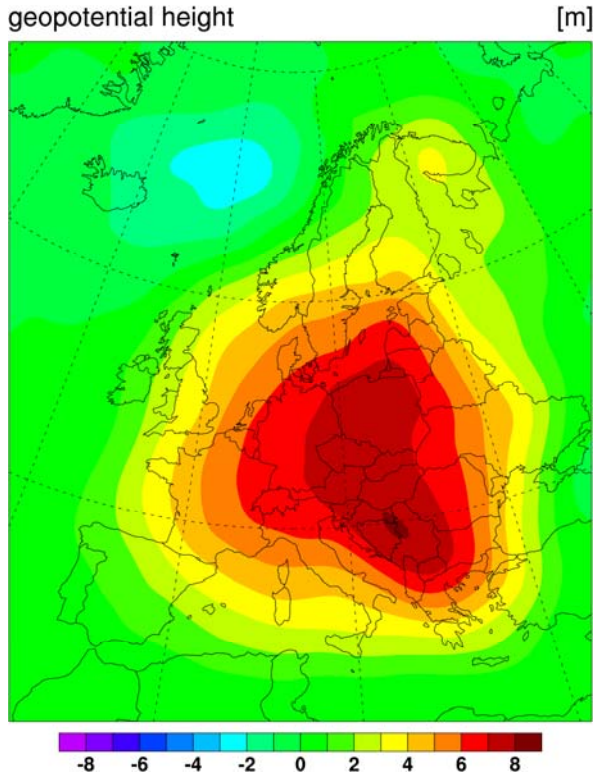

Dry soil → positive 500hPa height anomaly

POSITIVE FEEDBACK!

Conclusions

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- Anticyclonic forcing, strong radiative anomalies and the lack of precipitation in spring and early summer contributed to a rapid loss of soil moisture resulting in reduced latent cooling.
- Simulations show that soil moisture anomalies may account for more than 2K surface temperature difference over Central Europe during JJA 2003.
- Negative soil moisture anomalies result in the formation of a surface heat low and strengthen the positive height anomaly in the mid-troposphere -> positive feedback