Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

NFS NCCR climate

Simulation of physical processes and feedbacks active within the 2003 European summer heatwave

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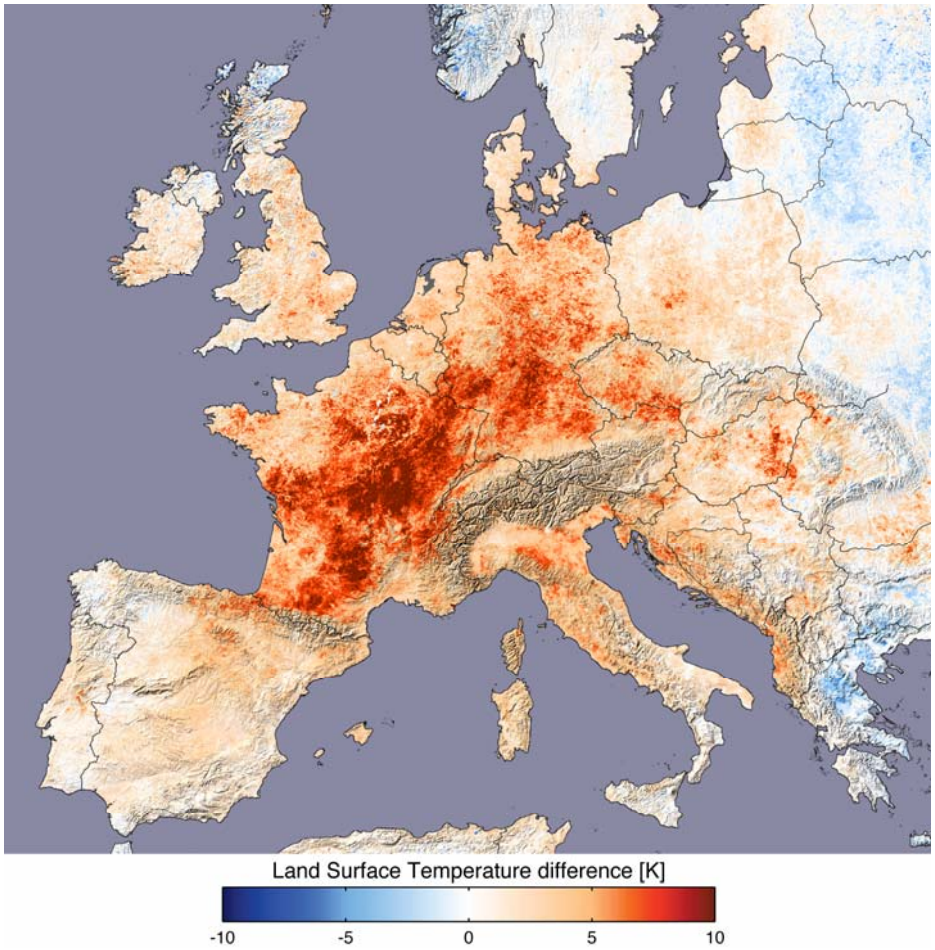
Summer 2003



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)

Dried-up River Töss (Central Switzerland,

- Very likely the hottest European summer over the past 500 years
- 22,000-35,000 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).
- *Synoptic patterns that lead to the heatwave are consistent with climate-change scenarios*

Objectives and project overview

Objectives

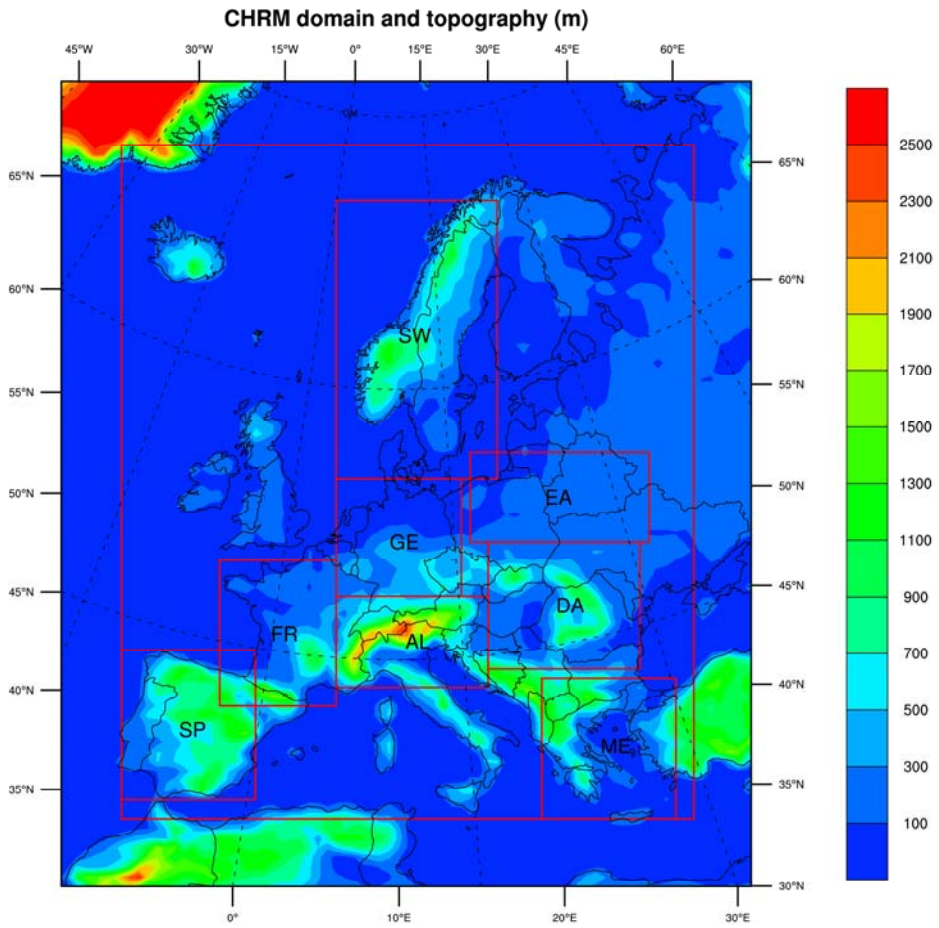
- Improve the physical understanding of the processes involved in the formation and persistence of the summer heatwave 2003

- Special focus on the role of soil moisture and land surface processes in the evolution of the heatwave

Approach

- Regional climate simulations including sensitivity experiments with perturbed spring soil moisture

Simulations' set-up

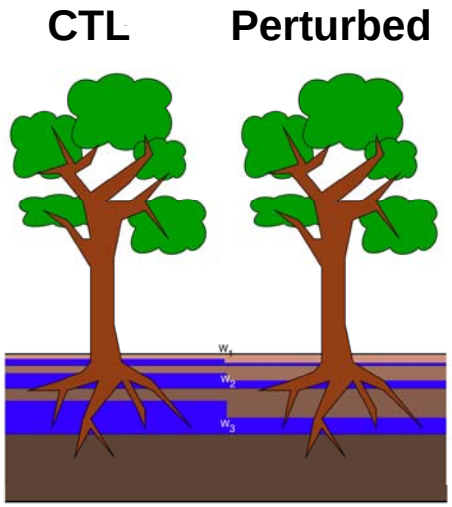


Model domain, topography [m.a.s.l.] and subregions.

CHRM simulations

- regional climate model based on DWD HRM, climate modifications by Lüthi et al. (1996); Vidale et al. (2003)
- spatial resolution: 56 km
- boundary conditions: ECMWF analyses (2003) and ERA-40 (1970-2000)
- 12-month simulations
- 5 control members (ensemble simulations) and 10 sensitivity experiments

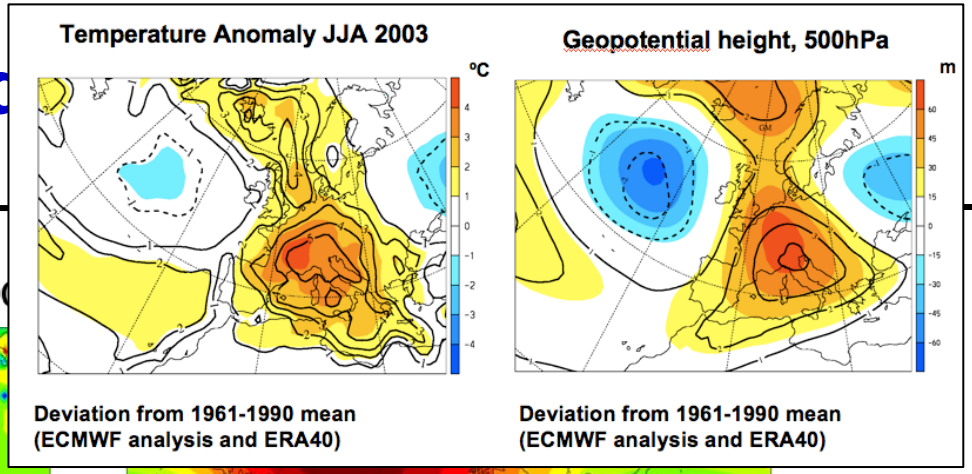
Soil water experiments



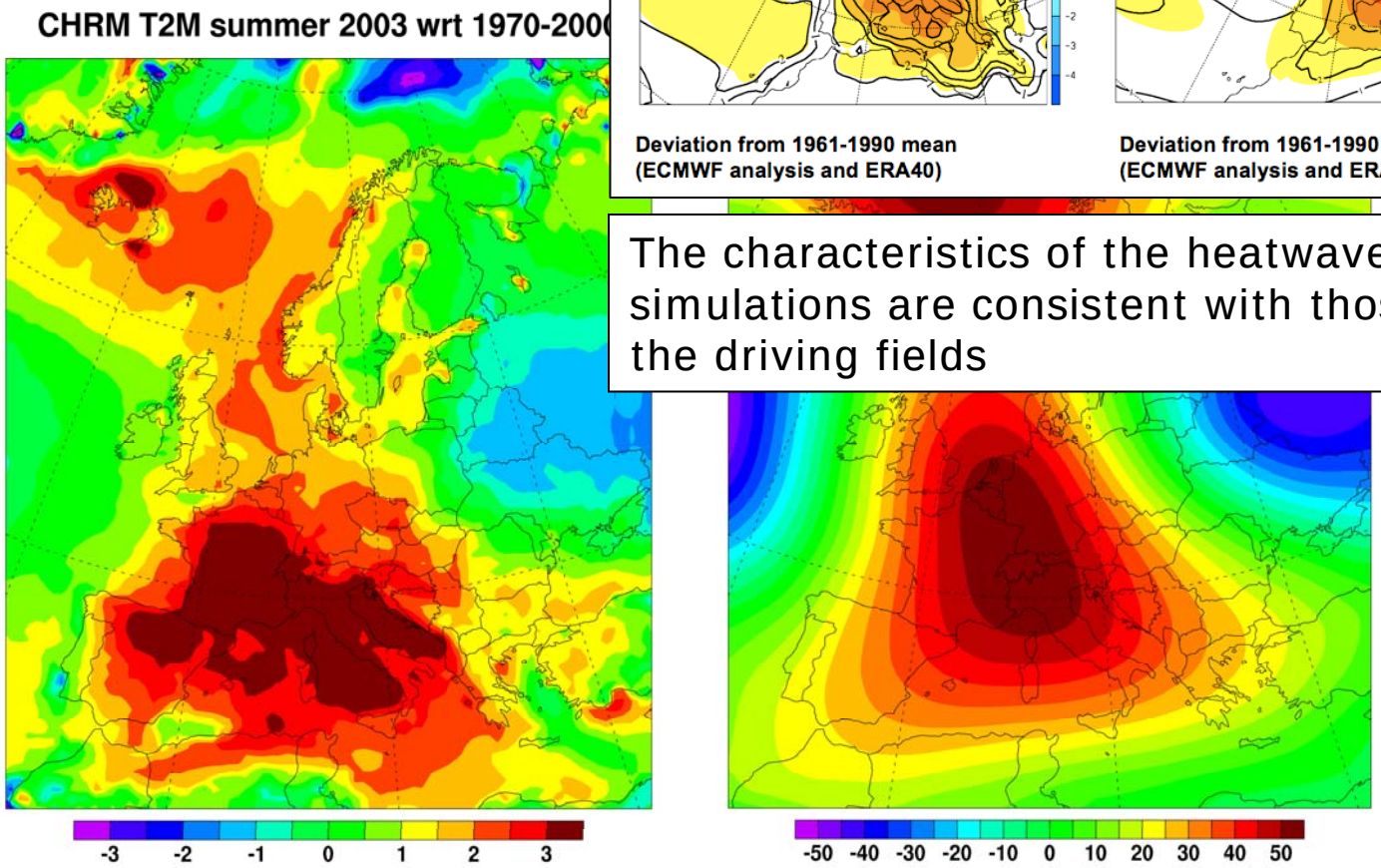
- *Control ensemble: 5 members*
- *10 runs with perturbed soil water initialization*

	Initialization date	Perturbation
CONTROL RUNS 1/2/3/4/5	Jan 1/2/3/4/5 2002	unchanged
SOILW - 50%	Jan 2002	- 50% Apr 03
SOILW - 25%	Jan 2002	- 25% Apr 03
SOILW - 20%	Jan 2002	- 20% Apr 03
SOILW - 15%	Jan 2002	- 15% Apr 03
SOILW - 10%	Jan 2002	- 10% Apr 03
SOILW +10%	Jan 2002	+15% Apr 03
SOILW +15%	Jan 2002	+25% Apr 03
SOILW +20%	Jan 2002	+25% Apr 03
SOILW +25%	Jan 2002	+25% Apr 03
SOILW +50%	Jan 2002	+50% Apr 03

Validation: Simulated

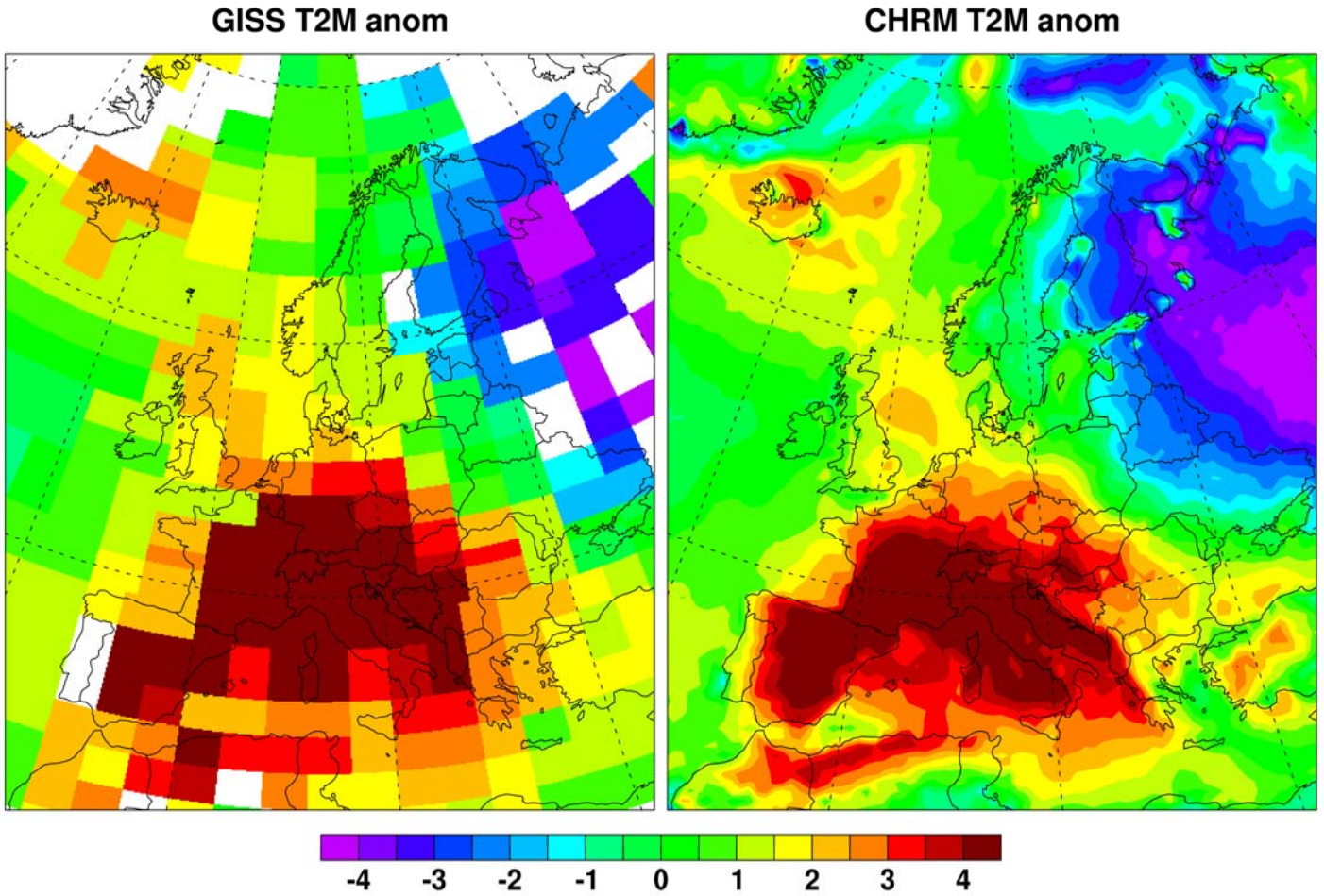


The characteristics of the heatwave in the simulations are consistent with those of the driving fields



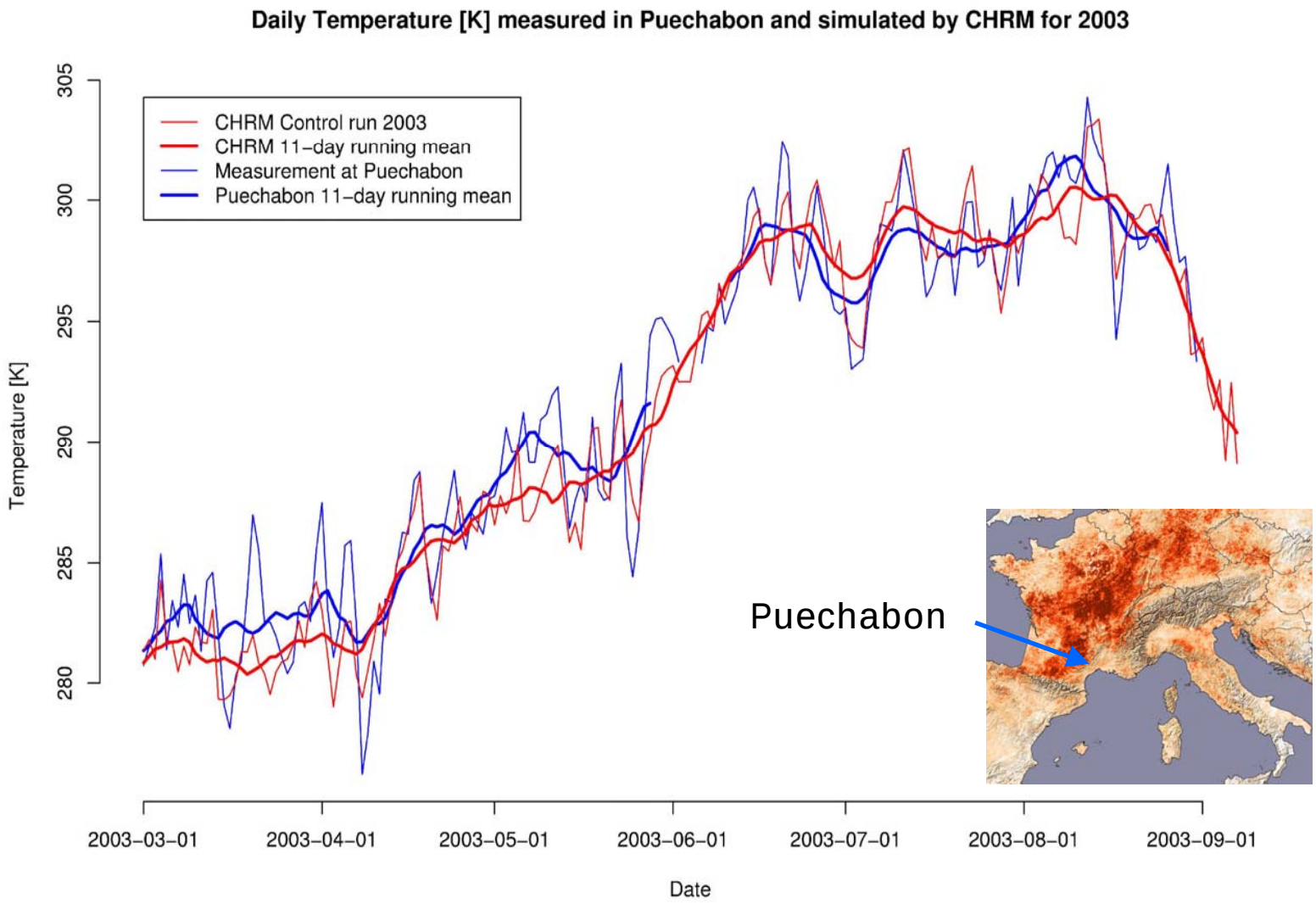
Temperature (2m) and geopotential height anomaly (500hPa) during summer 2003 wrt CHRM run 1970-2000.

Validation: Temperature anomaly 2003



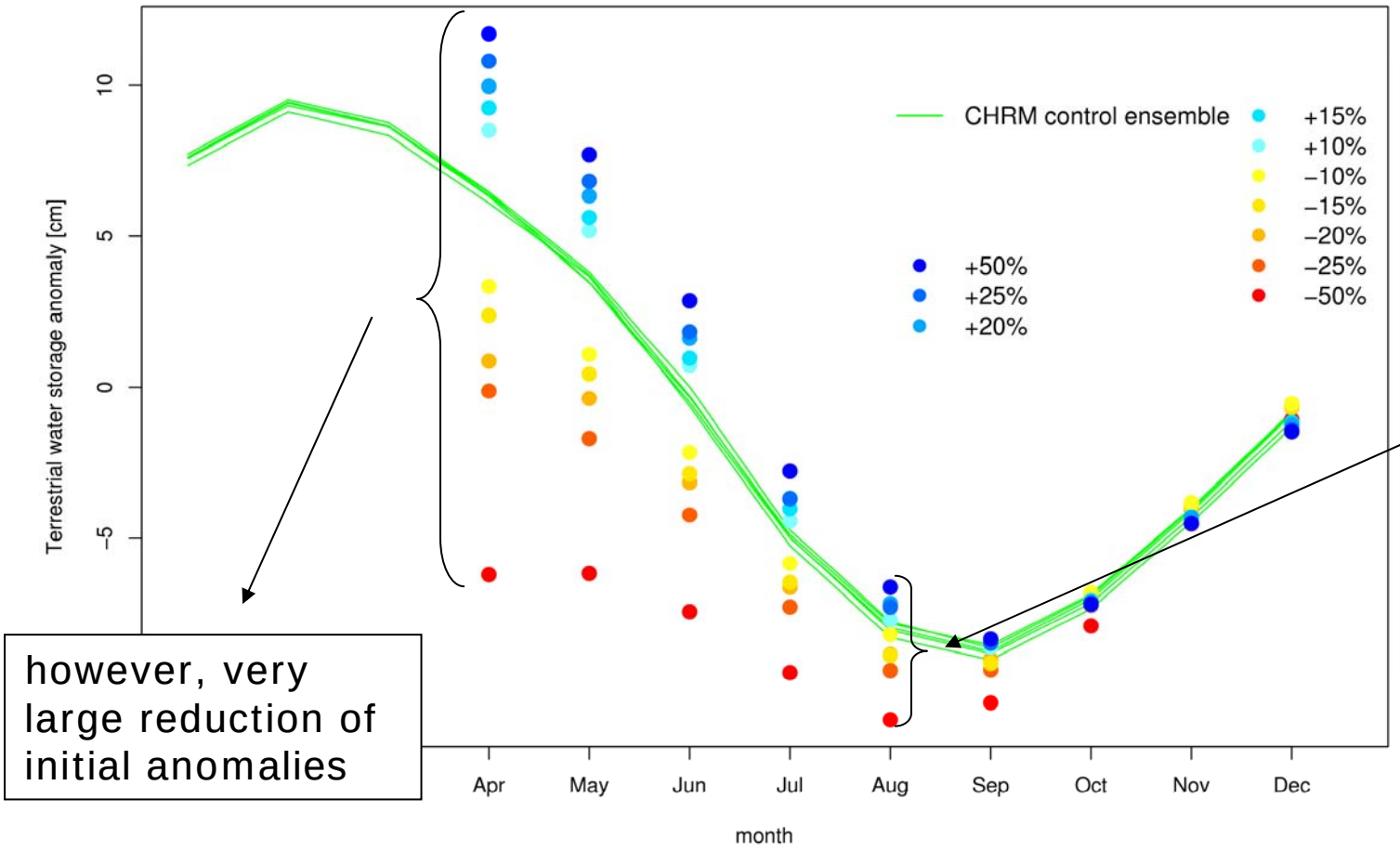
Temperature (2m) anomaly in June 2003 wrt 1970-2000.

Validation: Daily local temperature



Daily temperature (2m) in spring and summer 2003 in Southern France.

Sensitivity experiments: Soil water

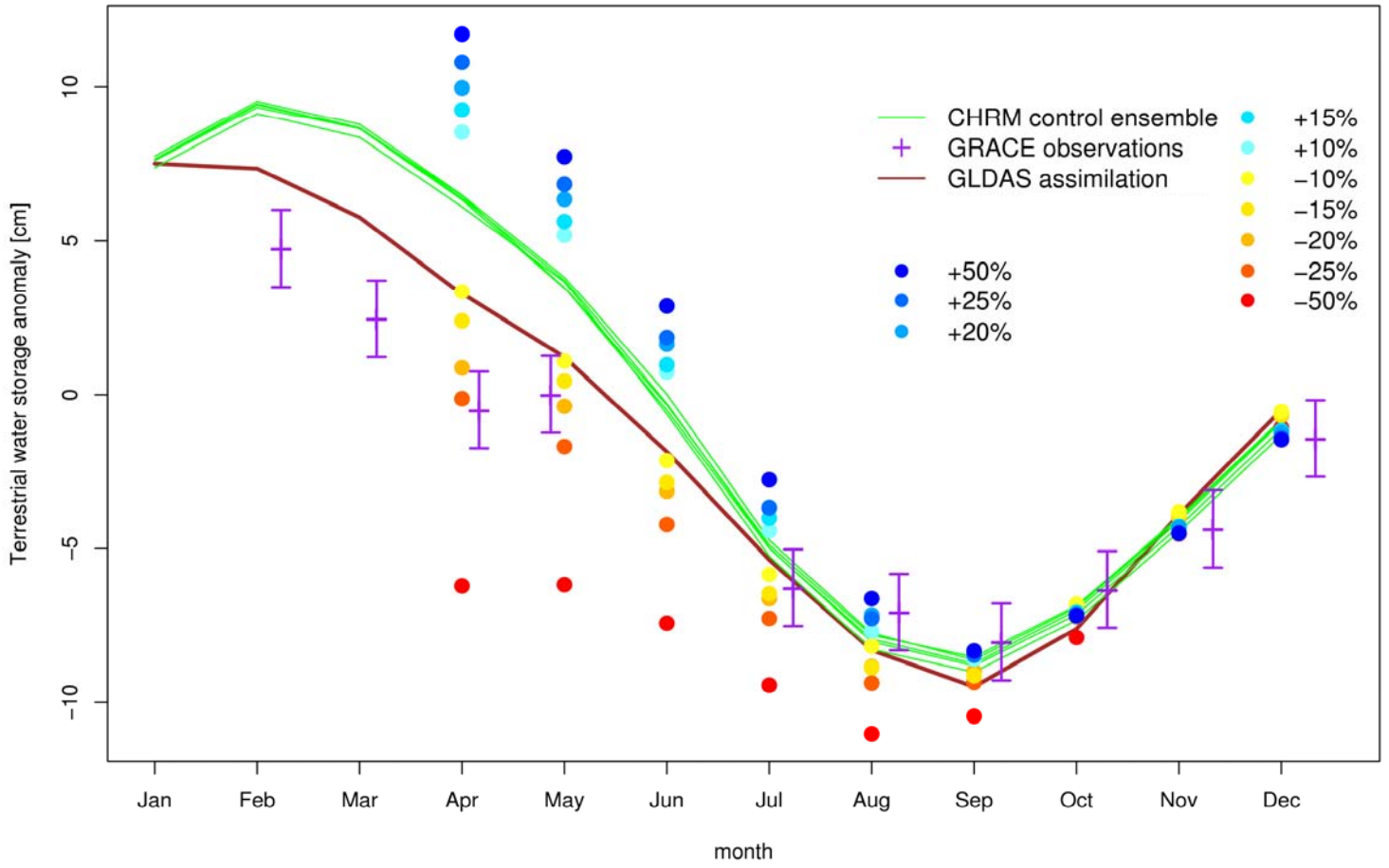


however, very large reduction of initial anomalies

anomalies persist until August

Monthly soil water anomaly 2003 over Europe.

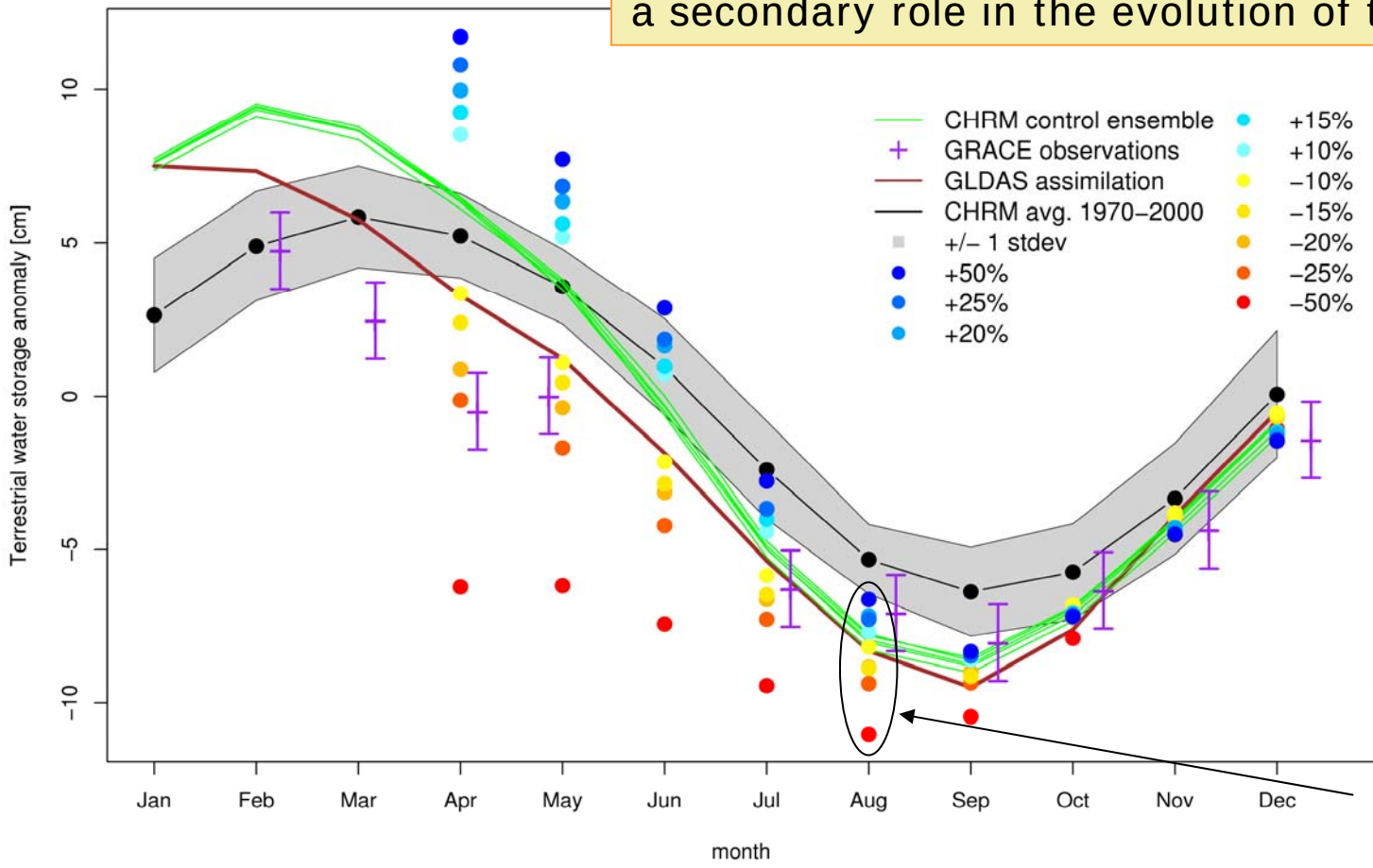
Comparison with GRACE and GLDAS



Dry runs more realistic ?

Comparison to climatology

Early-spring soil moisture conditions only played a secondary role in the evolution of the heatwave

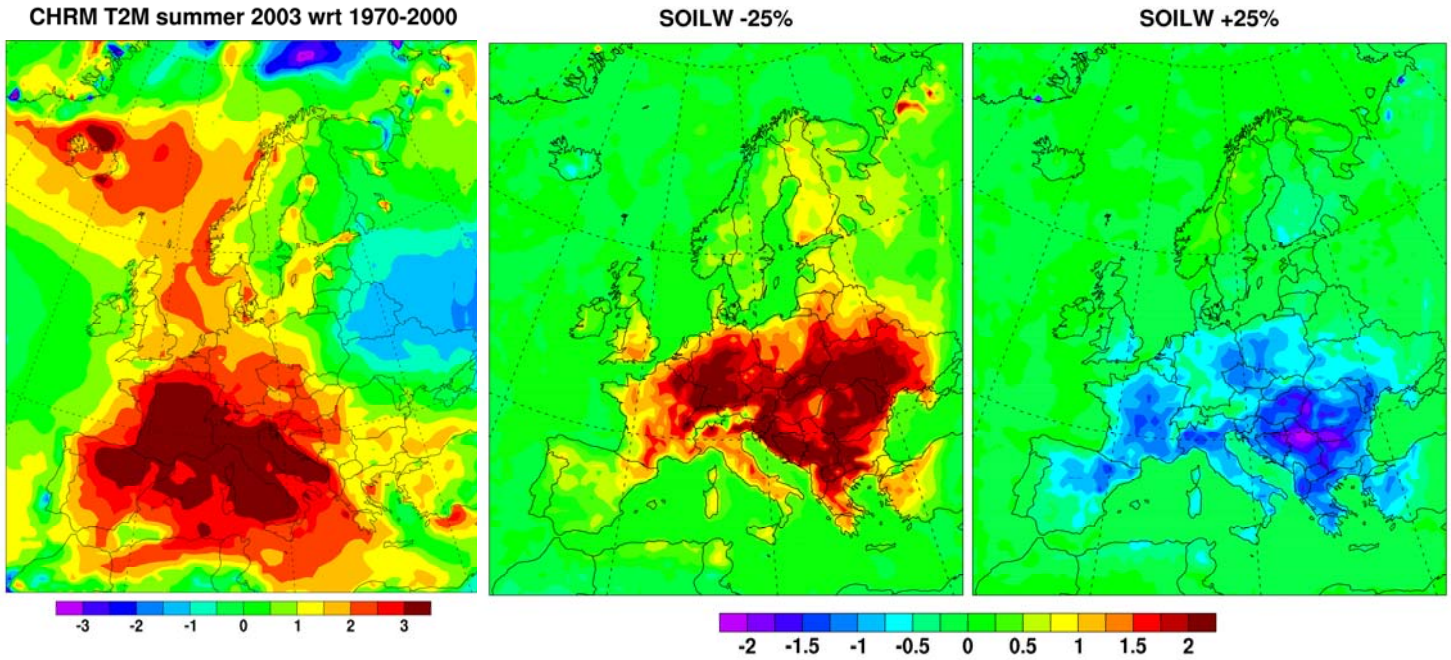


Monthly soil water anomaly 2003 over Europe.

even the wet runs are below the climatology in August

Temperature anomaly

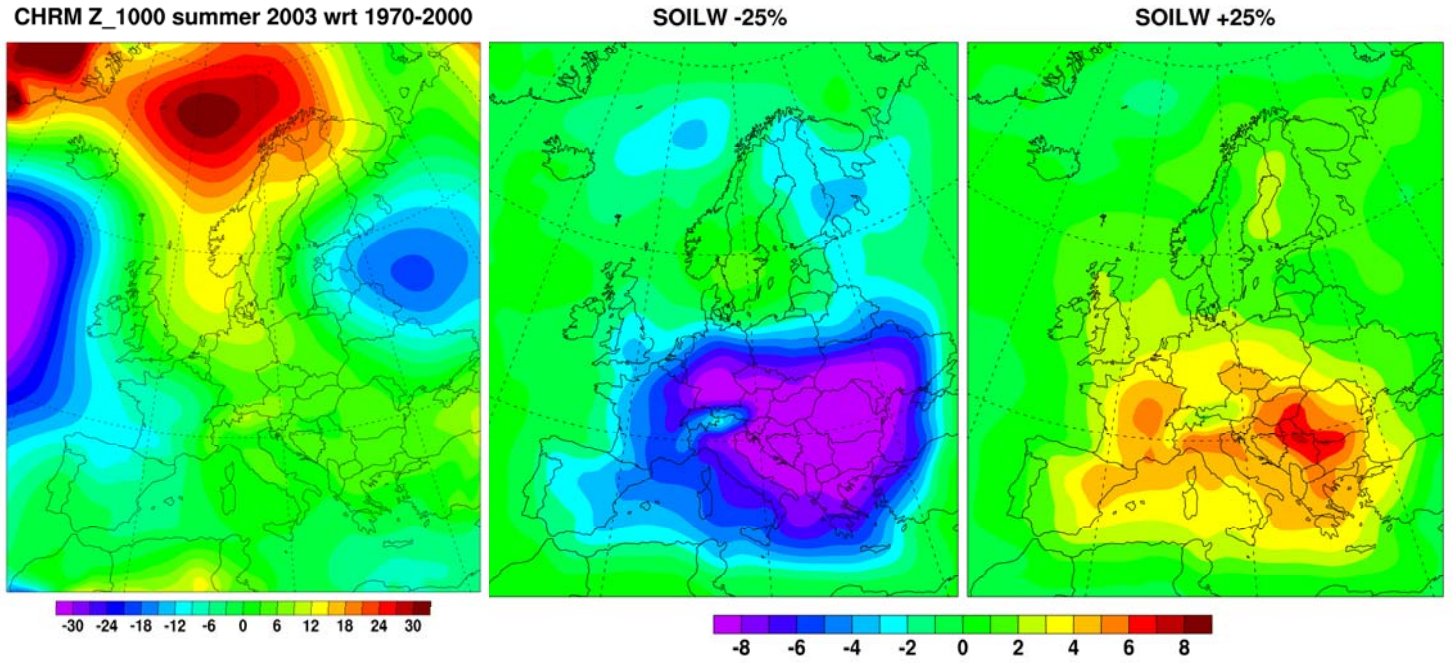
CTL – climat. **Dry run – CTL** **Wet run – CTL**



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

Z 1000 anomaly

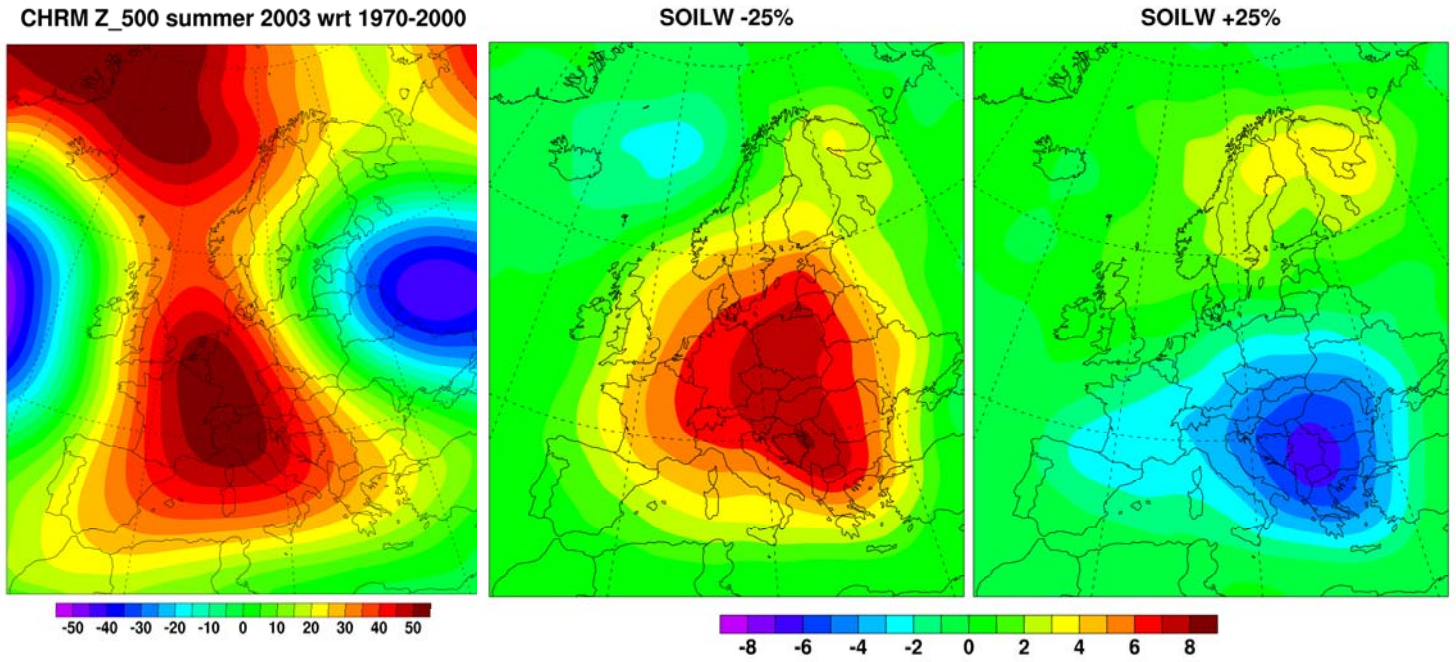
CTL – climat. **Dry run – CTL** **Wet run – CTL**



Dry run → surface heat low

Z 500 anomaly

CTL – climat. **Dry run – CTL** **Wet run – CTL**



Dry run → positive 500hPa height anomaly

POSITIVE FEEDBACK?

Conclusions

- The control experiments represent well the main characteristics of the summer 2003
- Anticyclonic forcing, strong radiative anomalies and the lack of precipitation in spring and early summer contributed to a rapid loss of soil water resulting in reduced latent cooling
- The loss of soil water likely contributed to a large part of the summer temperature anomaly (possibly up to 2K)
- Negative soil water anomalies result in the formation of a surface heat low and strengthen the positive height anomaly in the upper troposphere
  -> positive feedback?
- The initial anomalies do not have a direct impact on the evolution of the heatwave but rather on its strength

Next steps / Outlook

- Compare evolution of turbulent fluxes and precipitation anomalies with observational data
- Investigate the surface energy balance anomalies
- Conduct simulations without land-atmosphere coupling (soil moisture prescribed to climatological value)

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