Soil moisture—atmosphere interactions during the 2003 European summer heatwave

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Outline

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

- 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)

**Model domain**

**Introduction**
- **2003 heatwave**
- **Experiment**
- **Results**
- **Conclusions**

**CHRM**
- Version with spatial resolution $\Delta x$ 56 km and temporal resolution $\Delta t$ 300s
- Adapted for climate, tested for skill at interannual variability
- European domain
- Ensemble simulations

**Lateral boundary conditions**
- 2003: ECMWF analysis
Temperature anomaly


GISTEMP

CHRM

AMS Meeting
30 Jan 2006
Circulation anomaly


500hPa

1000hPa

geopotential height [m]

-50 -40 -30 -20 -10 0 10 20 30 40 50

-30 -24 -18 -12 -6 0 6 12 18 24 30
Precipitation anomaly

GPCC observational precipitation

Spring 2003
Summer 2003
Terrestrial water storage

Introduction
2003 heatwave
Experiment
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Rhine catchment

(Hirschi et al. 2006)
Surface energy budget

Radiative and turbulent flux anomalies 2003

Spring 2003  Summer 2003

-15 -10 -5 0 5 10 15

Net radiative flux
Sensible heat flux
Latent heat flux
Temperature at 2m

AMS Meeting
30 Jan 2006
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

Introduction

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Perturbation

Control    Perturbed

Soil water content [mm]

Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec

CTL 2003  +25%  +20%  +15%  +10%  -10%

-15%  -20%  -25%  CLIM 1970–2000  +/- 1 St.dev.
Soil moisture experiment

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Temperature anomaly

Introduction
2003 heatwave

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ECT-CLIM

DRY25-CTL

WET25-CTL

Dry run \(\rightarrow\) larger (more than 2K) and spatially extended anomalies
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1000hPa geopot. height

CTL-CLIM

Dry soil → surface heat low

DRY25-CTL
Dry soil $\rightarrow$ positive 500hPa height anomaly

POSITIVE FEEDBACK!
Conclusions

- 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