REGIONAL CLIMATE MODELLING OF THE EUROPEAN SUMMER HEATWAVE 2003

Erich Fischer[1,2], Pier-Luigi Vidale[1,2], Daniel Lüthi[1], and Christoph Schär[1,2]

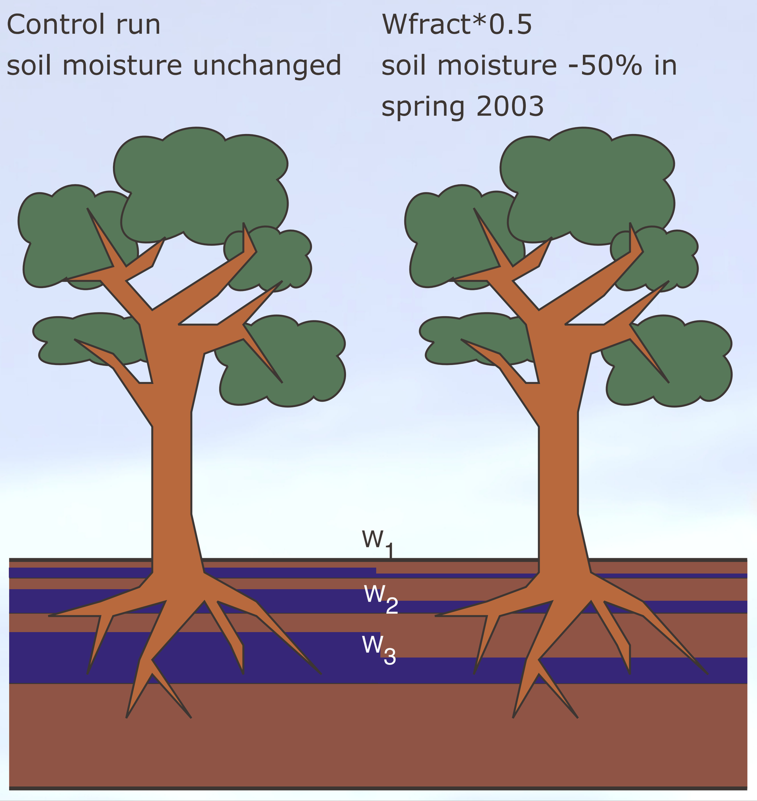
[1] *Institute for Atmospheric and Climate Science, ETH Zürich, Switzerland, e-mail: fischer@env.ethz.ch*
[2] *National Center of Competence in Research (NCCR) in Climate, Switzerland*

Introduction

A record-breaking heatwave affected Europe in summer 2003. With temperatures exceeding the 1961–90 mean by about 3°C *(1)* it was very likely the hottest European summer over the past 500 years *(2)*.
Estimations by the World Health Organization (WHO) indicate an excess mortality of 22000 persons *(3)* and the financial loss due to crop shortfall is estimated to 12.3 billion US$ by the reinsurance Swiss RE *(1)*.
We use the regional climate model CHRM (Climate High-Resolution Model) (4, 5, 6) to simulate the European summer 2003 in order to identify the influence of soil moisture on an evolving heatwave.

Table 1: *8 simulations (3 control simulations and 5 runs with manipulated soil moisture) were performed. The initialisation date is given in column 2, date and extent of total soil moisture manipulation (all 3 layers) is indicated in column 3. Column 4 shows the simulated summer mean temperature wrt the ERA40 run.*

	Init. date	Soil moisture	JJA Anom
CONTROL RUN	1. Sep 02	unchanged	1.16°C
CONTROL RUN 2	2. Sep 02	unchanged	1.14°C
CONTROL RUN 3	3. Sep 02	unchanged	1.16°C
Wfract*0.5	1. Sep 02	-50% Apr 03	2.25°C
Wfract*0.75	1. Sep 02	-25% Apr 03	1.69°C
Wfract*0.9	1. Sep 02	-10% Apr 03	1.35°C
Wfract*1.25	1. Sep 02	+25% Apr 03	0.87°C
Wfract*1.5	1. Sep 02	+50% Apr 03	0.84°C



Data and Methods

- We performe sensitivity experiments driven by assimilated lateral boundary conditions and SSTs from the ECMWF operational analysis.
- 8 simulations are conducted, a control ensemble of 3 members to determine the model's internal variability, and 5 runs with manipulated soil moisture.
- The simulated temperatures are expressed as departures from a 40 year CHRM run (1958-97) driven by ERA40 boundary conditions.

- Good agreement is revealed between summer 2003 temperature anomaly simulated by the CHRM (fig 1b), and that derived from ECMWF analysis - ERA40 reanalysis (fig 1a).
- The positve summer temperature anomalies are substantially enhanced (doubled in Wfract*0.5) and extend further east in simulations with decreased spring soil moisture.

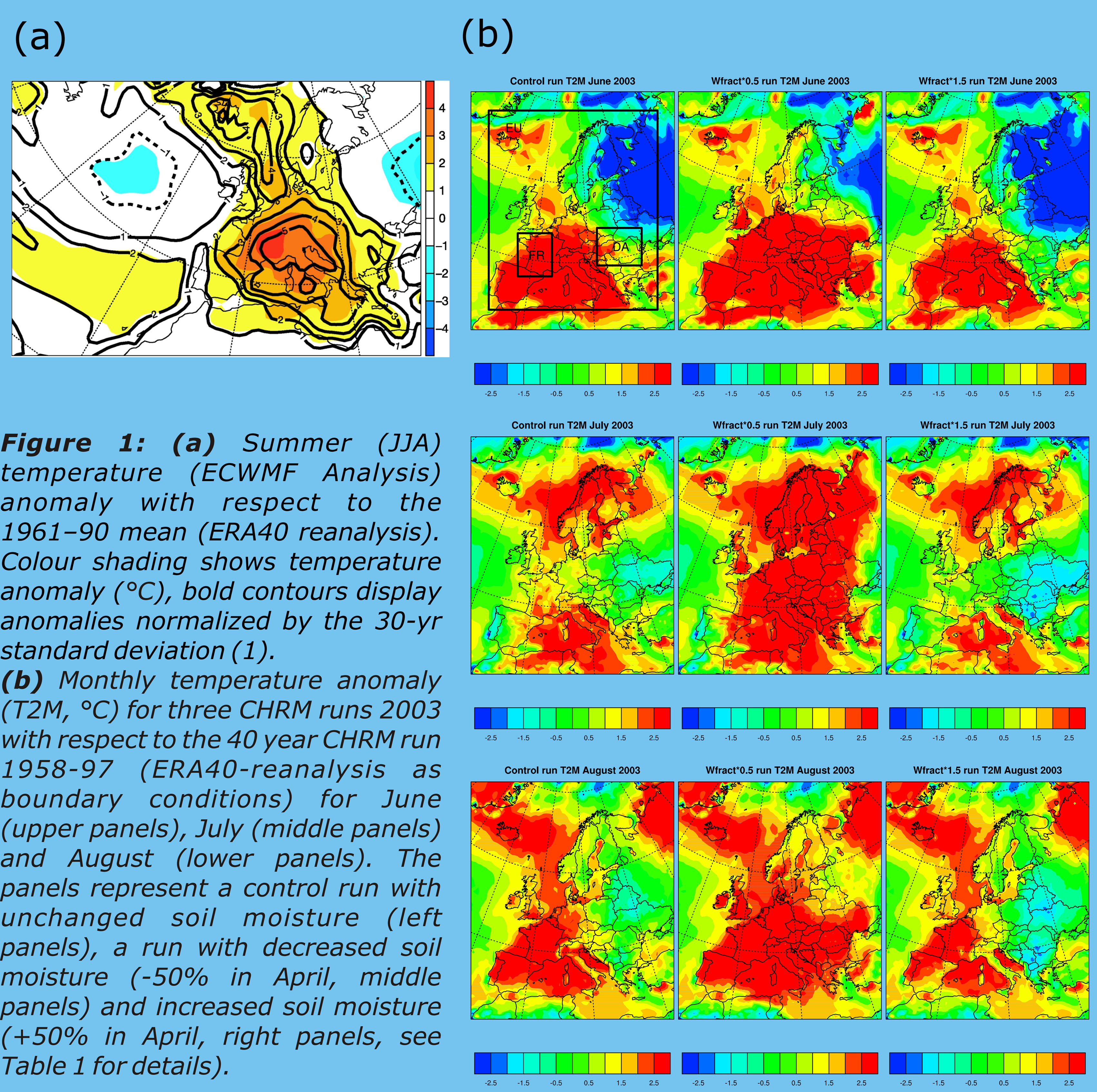


Figure 1: ***(a)*** *Summer (JJA) temperature (ECWMF Analysis) anomaly with respect to the 1961–90 mean (ERA40 reanalysis). Colour shading shows temperature anomaly (°C), bold contours display anomalies normalized by the 30-yr standard deviation (1).* ***(b)*** *Monthly temperature anomaly (T2M, °C) for three CHRM runs 2003 with respect to the 40 year CHRM run 1958-97 (ERA40-reanalysis as boundary conditions) for June (upper panels), July (middle panels) and August (lower panels). The panels represent a control run with unchanged soil moisture (left panels), a run with decreased soil moisture (-50% in April, middle panels) and increased soil moisture (+50% in April, right panels, see Table 1 for details).*

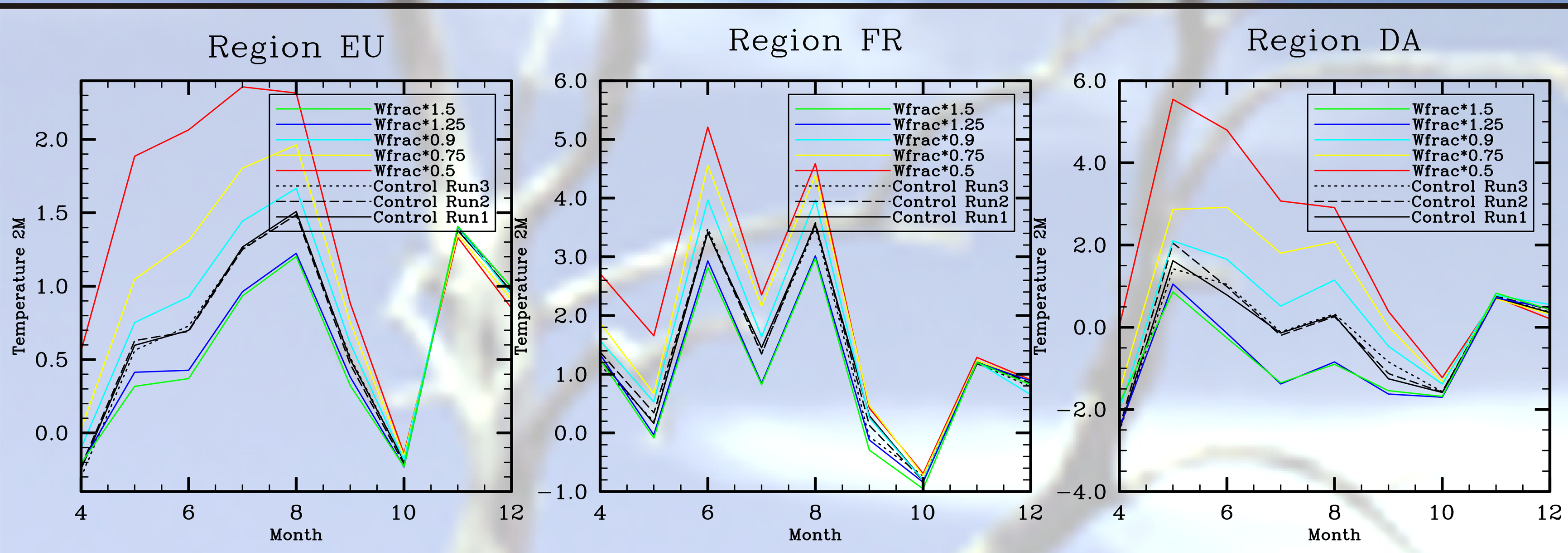


Figure 2: *Monthly temperature anomaly (T2M, °C) of 3 CHRM control simulations and 5 runs with manipulated soil moisture (see table 1) with respect to the CHRM run 1958-97 (ERA40-Reanalysis as boundary conditions) for Europe (EU), France (FR) and the Danube catchment (DA). The lower axis marks the month of the year (month 4 corresponds to April).*

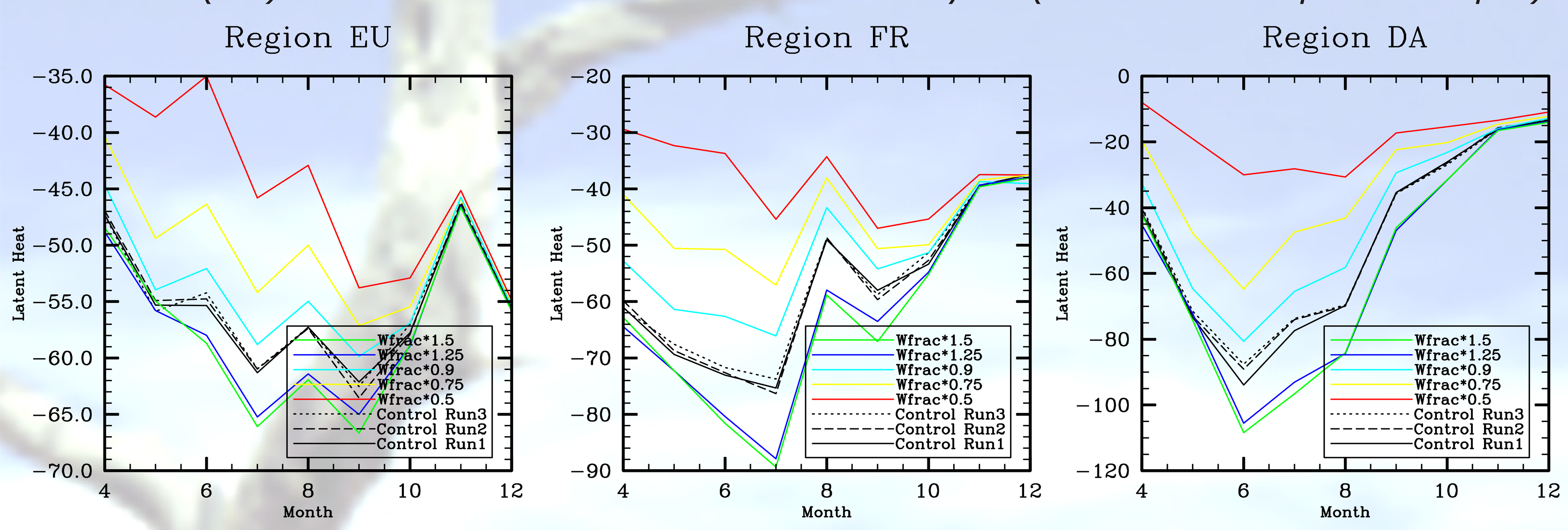


Figure 3: *Monthly mean latent heat flux (W/m^2) of 3 CHRM control simulations and 5 runs with manipulated soil moisture (see table 1 for details) . The lower axis marks the month of the year (month 4 corresponds to April).*

- Temperature difference between the simulations with manipulated soil moisture content exceeds the model's internal variability, as represented by the control simulations (fig 2).
- Spread between different simulations is larger over the Danube catchment (continental region) than over the France (maritime region) (fig 2) -> more important role of the soil moisture over continental regions.
- The heatwave 2003 reached its maximum over France in June and August, whereas July was little warmer than the 40 year average.
- The latent heat flux in simulations is substantially reduced with decreased soil moisture especially over the Danube catchment (fig 3).

Preliminary results

- Together with the positive geopotential height anomalies (7) **soil moisture** played an important role in the formation of the 2003 heatwave, especially in the late summer.
- The influence of soil moisture content on temperature is larger over **continental regions**.
- The temperature difference due to manipulated soil moisture substantially **exceeds** the model's internal variability.
- The **latent heat flux is reduced** in simulations with decreased soil moisture.

References

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