Soil Moisture and Extremes in European Climate

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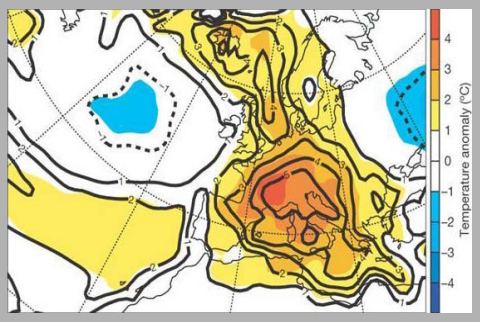
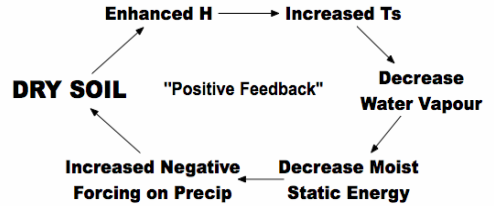
Key issues

- The summer of 2003 was an extreme climatic anomaly.
- It is possible that temperature extremes like those in the summer of 2003 will become closer to average summer temperatures.
- One possible cause of this are interactions between soil moisture and atmospheric physics



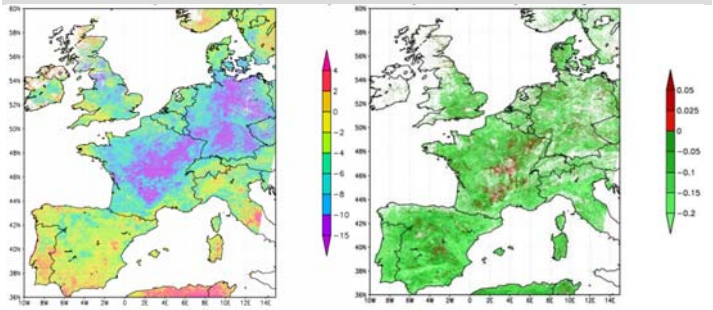
Background

- Soils have been shown to impact weather systems via changes in surface heating. In 2003 the precipitation deficit and prolonged hot conditions at the surface led to the drying of the soil. Reduction in soil moisture leads to strongly reduced latent heat flux, which increases the amount of sensible heat emitted from the surface and increases surface temperatures. This can then set up a positive soil moisture feedback:



- Soil moisture and surface fluxes are heterogeneous over the land surface, and observations are sparse and only representative at a local scale.
- How well can regional land surface models can simulate these feedback processes?

Use of Earth Observation

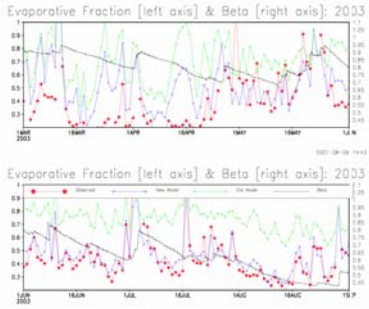


- Differences (2007 minus 2003) in MODIS/TERRA data: Left: Land surface temperatures daily averaged over 31/7-4/8 2003/07 and Right: 8-day averaged FPAR over the period 28/7-4/82003/07
- The differences in soil moisture between 2003 and 2007 lead to a contrast in surface temperatures within the UK, France and Germany showing a difference of up to 10°C. A weaker signal is seen in the FPAR with small increases of up to 5% during 2007, resulting from the increase in available soil moisture

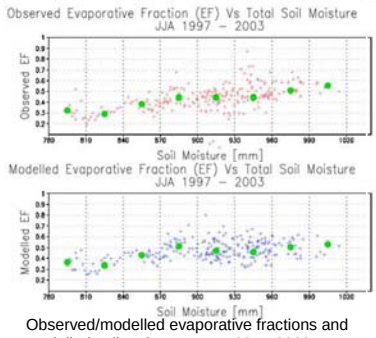
Land Surface Modelling

- Data from Netherlands FLUXNET observation site was used to drive a 2nd-generation land surface scheme: Joint UK Land Surface Simulator (JULES)
- Land surface models are a major cause of uncertainty in climate change predictions – it was important to compare JULES output to observations from the site it simulated, to verify it can simulate water stressed conditions
- JULES was run with a standard set up, driven by met data for Loobos 97-03, and output compared with observations taken during the same years
- Sensitivity analyses were carried to investigate effects of changing soil hydraulic parameters (critical soil moisture, θ_c and soil moisture availability factor, β), the surface conductance (g_s) and vegetation type (Leaf Area Index, LAI and Plant Functional type fractions).
- Satellite derived land surface temperatures from MODIS/TERRA were compared with modelled values over a range of soil moistures. Results will be used to improve modelled land surface temperature data at a point scale

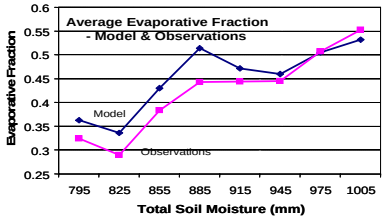
Model-Observations comparisons



Modelled and observed evaporative fraction for: old parameter setup (green), new parameter setup (blue), flux tower observations (red) and total soil moisture availability factor (beta) in a 3m column (black)



Observed/modelled evaporative fractions and modelled soil moisture: JJA 1997 - 2003.



Modelled and observed evaporative fractions averaged over soil moisture intervals

- Soil hydraulic parameters are used to define how soil moisture affects evapotranspiration. JULES uses 3 classes (fine, medium & coarse) – results illustrate how sensitive fluxes are to changes in soil parameters.
- By default JULES does not simulate the partition between latent heat (LE) and sensible heat fluxes (H). Evaporative fraction (LE/(LE+H)) is overestimated for most of the year - consequently an underestimation of the surface temperatures.
- Soil hydraulic parameters were reassessed, and a more realistic representation of vegetation fractions was implemented
- Model/observation comparisons were continued for more years data and compared with total modelled soil moisture. Below 900mm, modelled evaporative fraction is overestimated. Above 900mm it is underestimated compared to observations.
- We are currently exploring whether this behaviour can be observed in the modelled and satellite surface temperatures.
- This will give an idea of whether satellite data can be used to improve the specification of soil parameters and hence regional scale simulations.

Find out more…

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