Constraints on temperature during the 2003 European Summer Heatwave

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Motivation

- To understand what causes European heatwaves
- Ascertain how much anthropogenic influence has a role
- Diagnose the mechanisms that allowed the 2003 event to be so severe.
- Improve prediction of heatwaves in future.

Background

Many regions experienced a large number of deaths due to the elevated temperatures; and attribution studies have determined that human activity has at least doubled the risk of such a heatwave, compared to a non-industrial scenario.

Stott, P., Stone, D., and Allen, M. (2004). Human contribution to the European heatwave of 2003. Nature, 432:610–613.

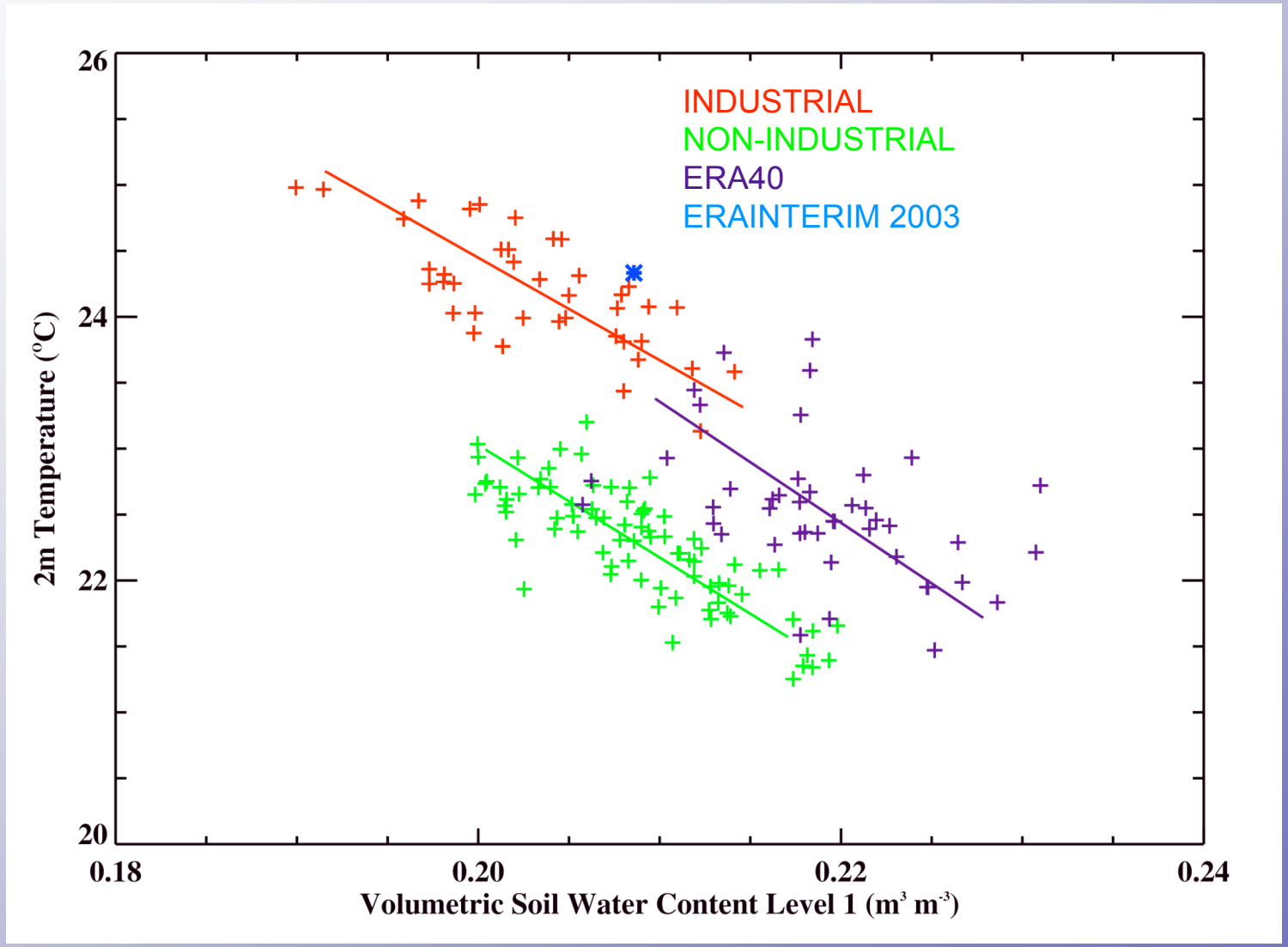
Modelling Experiment

- ERA40/ERAINTERIM

- 2 Large ensembles of simulations driven by summer-2003 boundary conditions are run with a variant of the ECMWF IFS as used for seasonal forecasting.
  - Industrial
  - Non-industrial

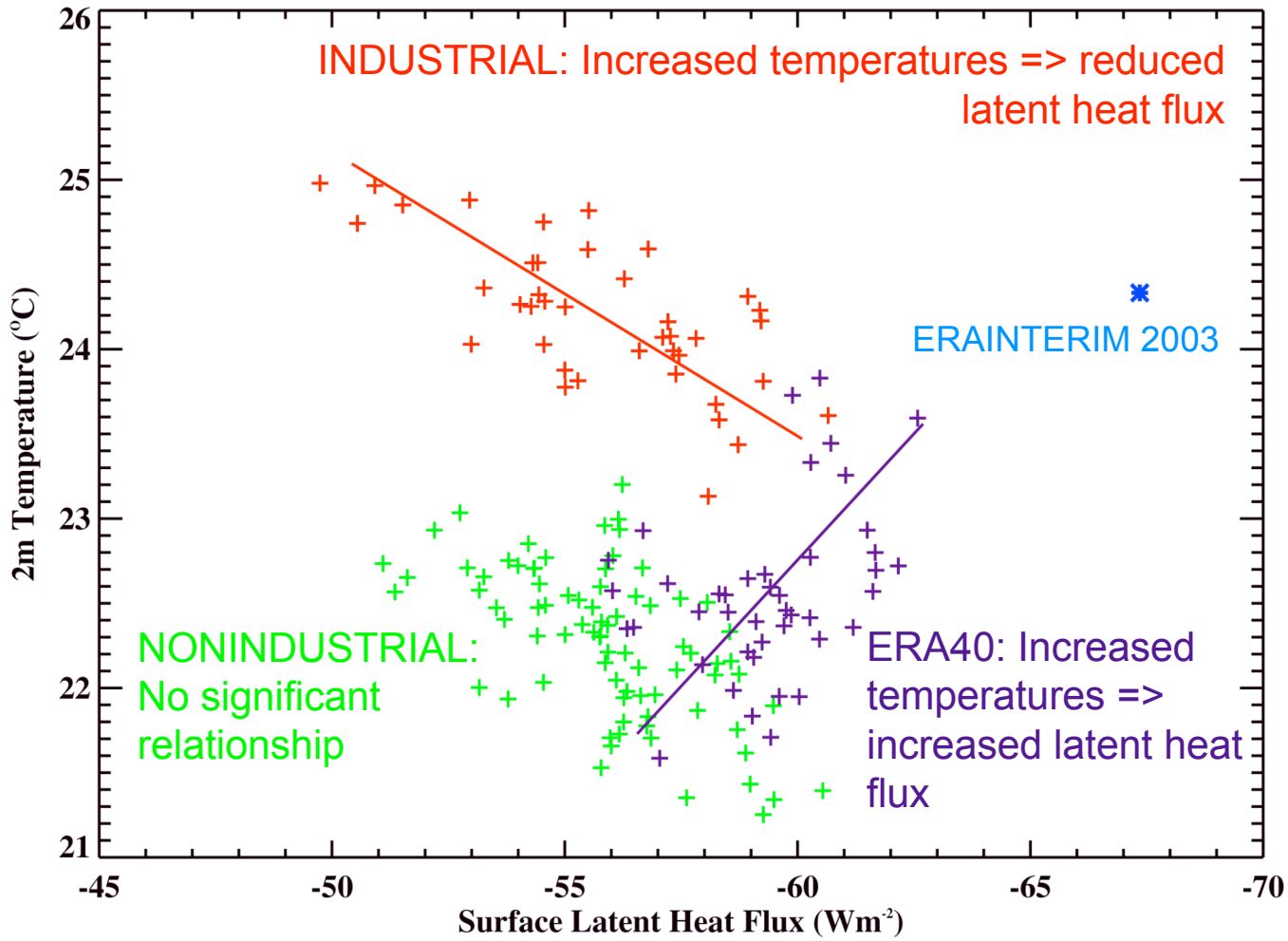
Correlations of Summer average temperature and soil moisture averaged over the Mediterranean region

Temperature and soil moisture highly correlated in IFS ensembles and ERA40



MED Region (10°W:40°E longitude and 30°:50°N latitude)

Correlations of Summer average temperature and latent heat flux averaged over the Mediterranean region



MED Region (10°W:40°E longitude and 30°:50°N latitude)

Results

$$T_{estimate} = \beta_1 F_{ASW} + \beta_2 F_{SLHF} + \beta_3 F_{SSHF} + \beta_4 F_{MSLPGRADIENT} + \beta_5 F_{SML1} + constant$$

- Analysis of principle components suggest soil moisture and surface fluxes are the largest contributors to the temperature anomaly in 2003

- Fluxes were acting together so could not be considered independent

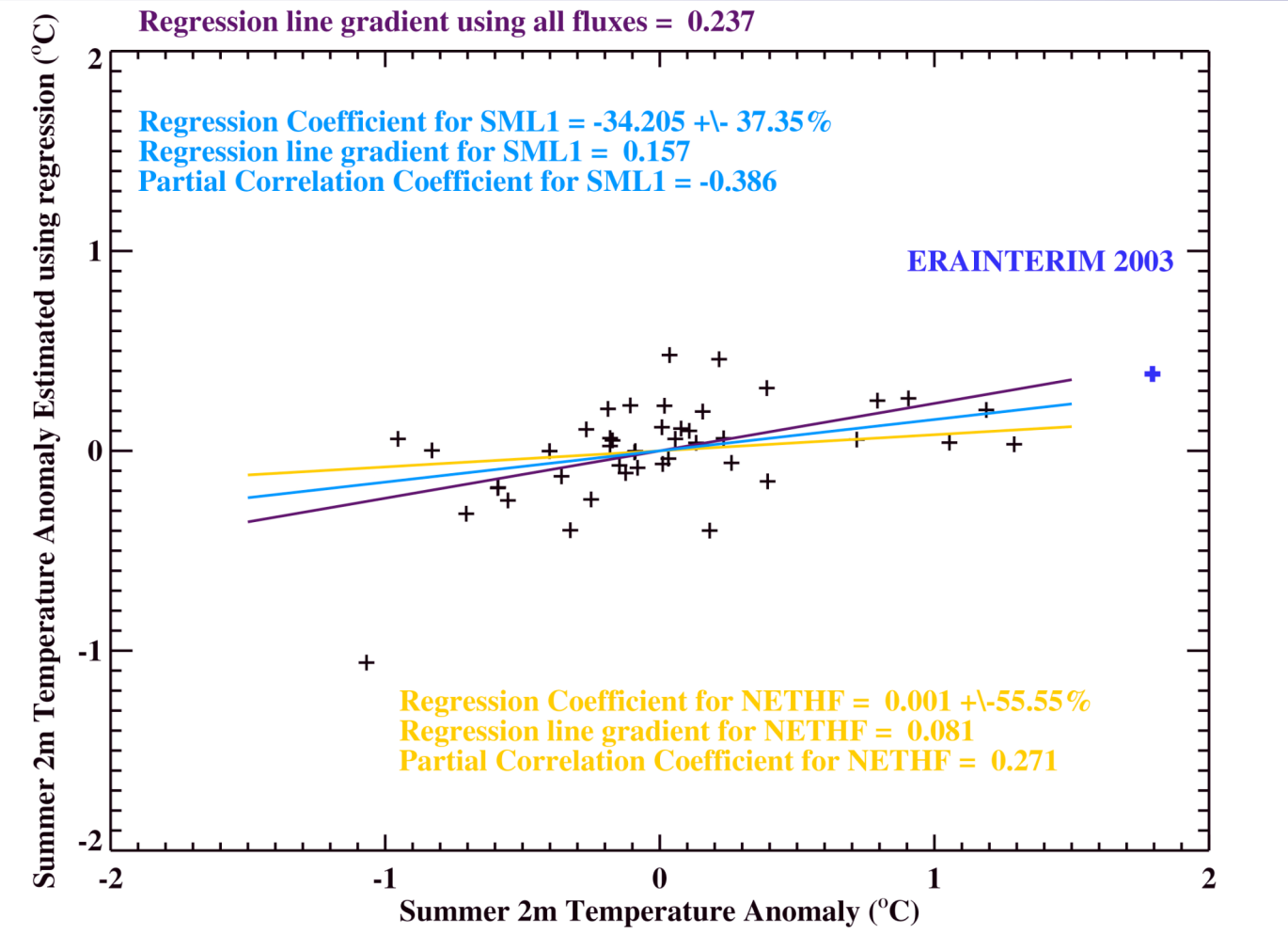
NetHF = Absorbed solar-latent heat - sensible heat

$$T_{estimate} = \beta_1 F_{NetHF} + \beta_2 F_{SML1} + constant$$

Results

$$T_{estimate} = \beta_1 F_{NetHF} + \beta_2 F_{SML1} + constant$$

ERA 40

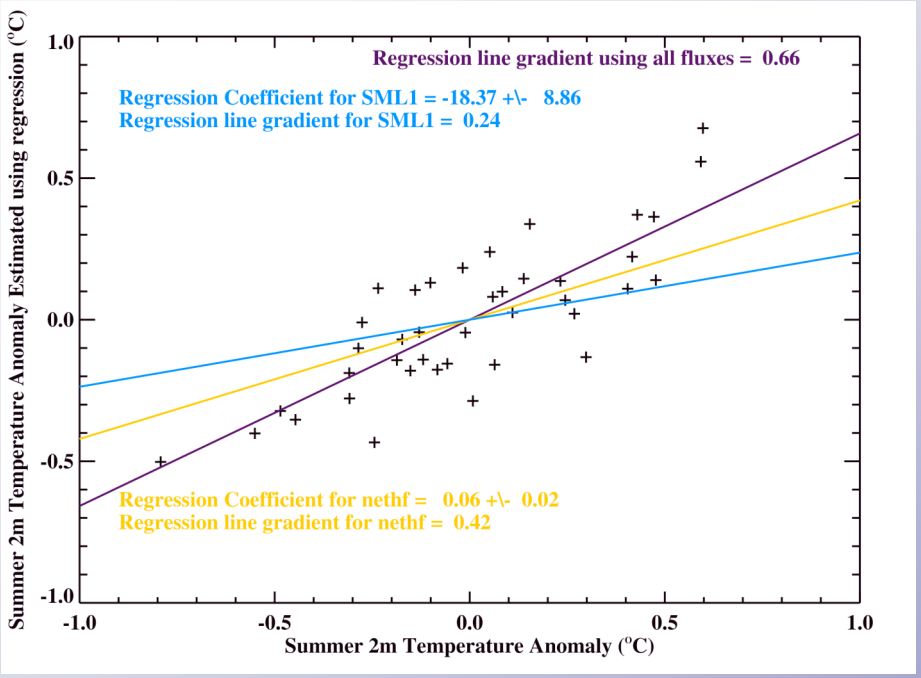


- Regression is performed across years of ERA40
- Anomalies compared to climatology of SML1 and NETHF regressed against anomalies of temp

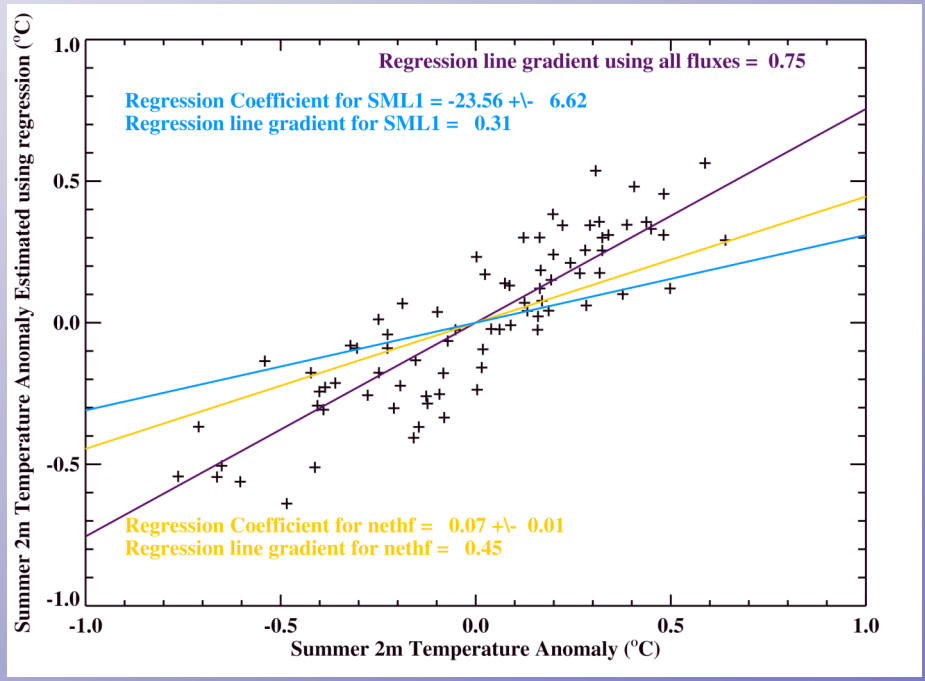
Results

$$T_{estimate} = \beta_1 F_{NetHF} + \beta_2 F_{SML1} + constant$$

Industrial

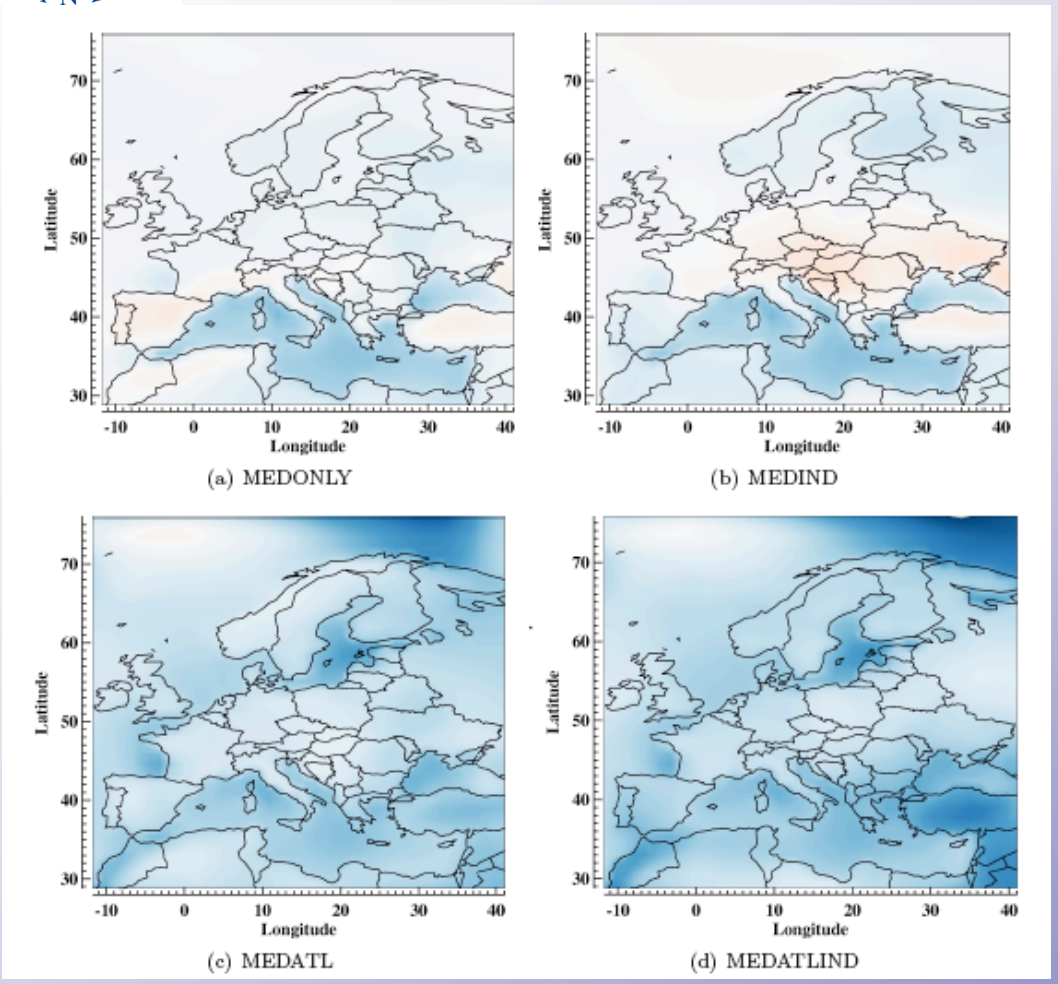


Non-industrial



Regression performed across all members of each ensemble

Sensitivity to SSTs



- Maps of the Summer average 2m temperature anomalies from the industrial ensemble Summer average for MEDONLY (a), MEDIND(b), MEDATL (c) and MEDATLIND (d). 4 Non-industrial type ensembles to assess sensitivity of 2003 European Temps to individual oceans

- Longitude 10◦W:40◦E Latitude 30:50◦N.

Conclusions

- The results support the theory that a feedback between soil moisture and temperature acted to amplify the already excessive temperatures in Summer 2003.
- The interaction of variables involved in this feedback are sensitive to certain land-surface properties, which implies that if the same factors that caused the 2003 event occurred in a different location the event could have been very different.
- 2003 temperatures were shown to be sensitive to Atlantic sea surface temperatures
- It is imperative to understand the factors leading to extreme heatwave events when attempting to predict changes in extreme events in the future and the impacts they will have.
- To aid more effective planning to minimise financial losses and loss of human lives associated with extreme climatic events

Future Work

Decadal prediction - Is there any skill in predicting the change in summer heatwave indices for near-term future?

Poster: Session C25, W74A, Wednesday 10:30-12:00

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References

1. *Hanlon, H. (2010). An investigation of causes of the 2003 heatwave in Europe using an atmospheric climate model. DPhil Thesis, University of Oxford.*
2. *H.Hanlon 2011 (in prep)*
3. *Stott, P., Stone, D., and Allen, M. (2004). Human contribution to the European heatwave of 2003. Nature, 432:610–613.*
4. *Black, E. and Sutton, R. (2007). The influence of oceanic conditions on the hot European summer of 2003. Climate Dynamics, 28:53–66*