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# Water Demand Estimation using UKCP09

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# Overview

1. Rationale for estimating demand from meteorological variables
2. Possible drivers from UKCP09

# Aspects of demand dependent on meteorological variables

**Starting point:**

- **Impact of climate variables is confounded by consumer preference, willingness to pay, resilience, price elasticity, *etc*.**
- **Regression relationships with climate variables therefore not strong;**
- **Some sectors stronger: irrigation, power stations, industrial air con, golf courses....**
- **Will review methods anyway....**

# Previous work 1/3

## Protopapas 2000: New York

## linear increase in demand with daily temperature above 25 deg C

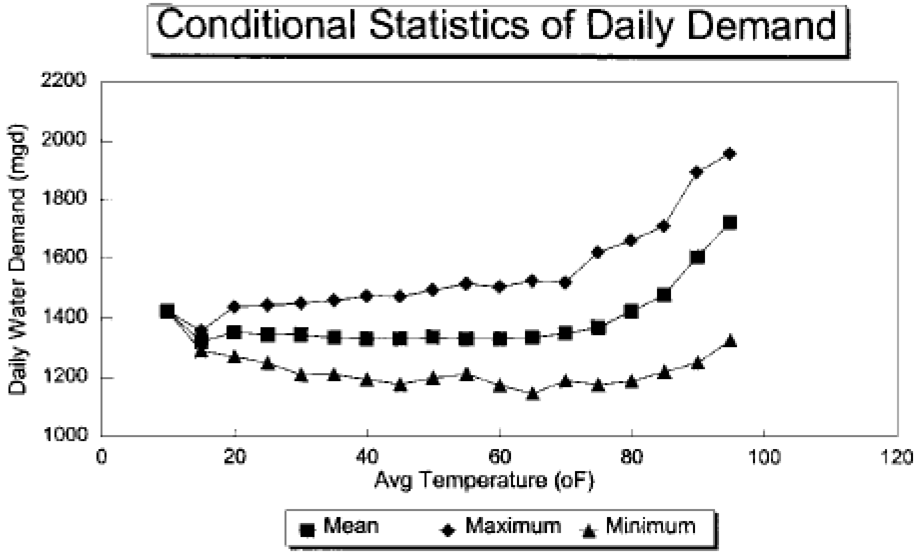



FIG. 5. Conditional Statistics for Daily Water Use at Given Average Daily Temperature

# Previous work 2/3

## Goodchild 2003: Essex and Suffolk

## Multiple regression on

- Tmax
- T > 25 deg C
- PET
- No of days since 2mm rainfall

Table 1. Correlation between individual weather variables and DWD for 1999, ranked by linear $R^2$

| Factor | Key | $R^2$ |
|---|---|---|
| Evapotranspiration (mm)[6] | $X_1$ | 0.63 |
| Water content in top 0.15m of soil (mm)[7] | $X_2$ | 0.63 |
| Sunshine hours | $X_3$ | 0.53 |
| Solar radiation (J/cm²) | $X_4$ | 0.49 |
| Is maximum temperature greater than 25°C (1/0) | $X_5$ | 0.44 |
| Rain minus evapotranspiration (mm) | $X_6$ | 0.38 |
| Maximum temp (°C) | $X_7$ | 0.29 |
| Dry bulb temp (°C) | $X_8$ | 0.26 |
| Days since 2 mm of rainfall | $X_9$ | 0.26 |
| Rain (mm) | $X_{10}$ | 0.19 |

# Previous work 3/3

## Hall 2003: London

## Weighted summer index

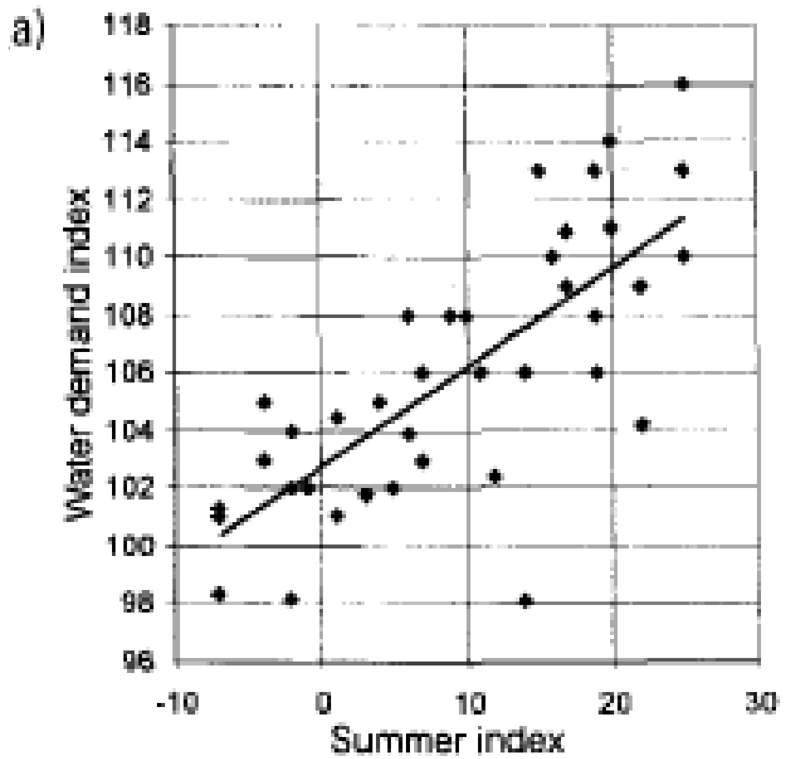
$$S_i = 3\sum_m T + 5\sum_m S - 5\sum_m R - 9m \qquad (2)$$

nere $m$ is the number of months to which the index applies,

$\sum_m T$ is the sum over the m months of the quintiles of monthly mean temperature;

$\sum_m S$ is the sum over m months of the terciles of monthly sunshine hours; and

$\sum_m R$ is the sum over m months of the terciles of monthly rainfall totals.



# UKCP09

UK CLIMATE PROJECTIONS

- **Latest probabilistic UK national future climate projections**
  - launched in June 2009
  - See
- **Not just single projections as previously, but**

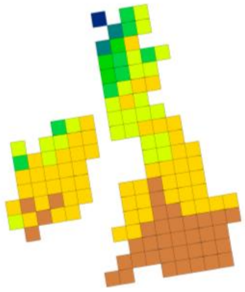
  **probabilistic range of projections**
  - for each of 3 emissions scenarios : low - medium - high
  - 30 year windows in decades: 2020s 2030s 2040s etc.

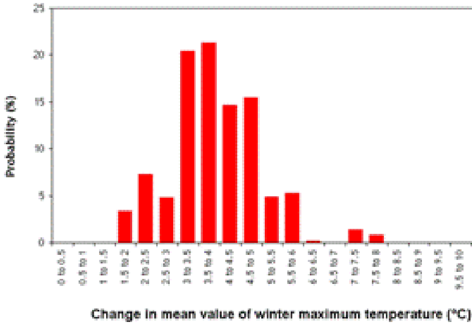
Met Office - Hadley Centre ran a large *Perturbed Physics Ensemble* (PPE) of climate models (GCMS) accounting for uncertainty in parameters:

These large scale results are downscaled using RCMS to 25km resolution

The outputs are pdfs (actually sample vectors of weather variables, and [redacted] actual data time series BUT

Weather Generator can [redacted] used to provide time series





# Useful weather variables

- The WG generates daily and/or hourly rainfall series, and then meteorological data for the following five variables:-
  - Daily mean temperature T (deg C)
  - Daily temperature range R (deg C)
  - Vapour Pressure VP (Pa)
  - Sunshine duration S (hrs)

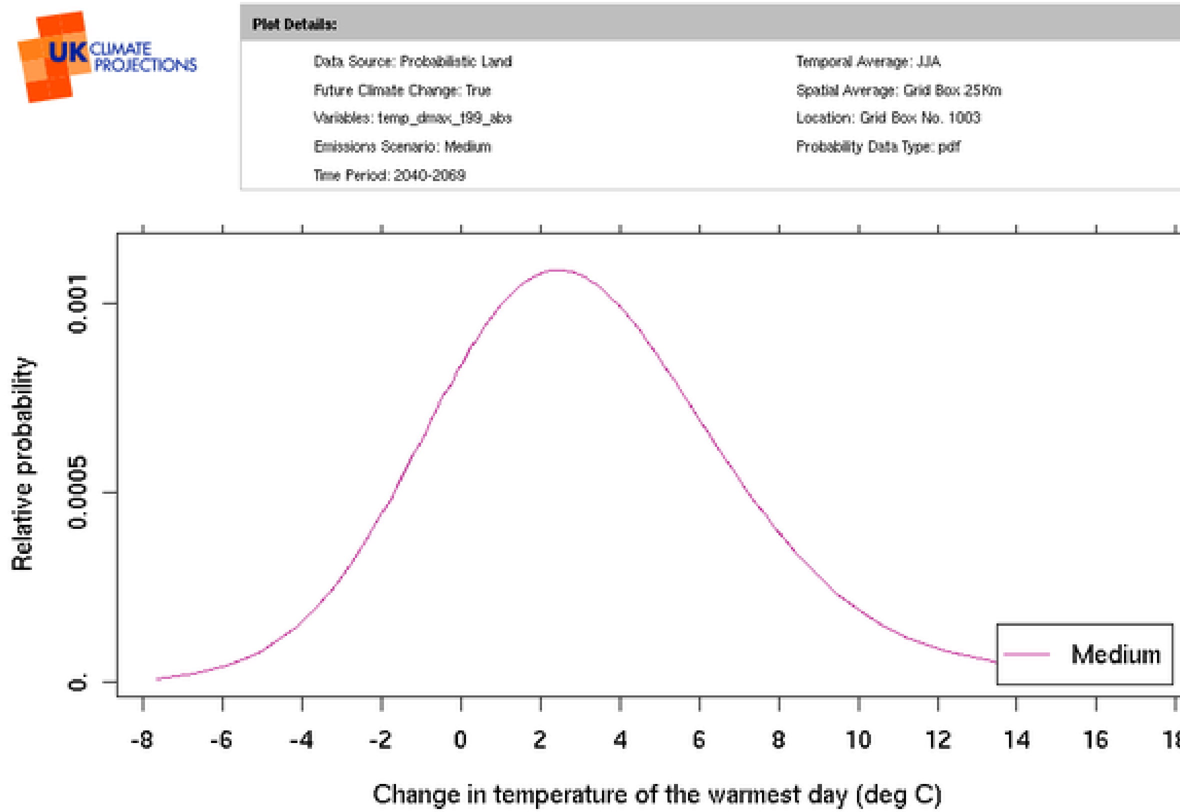
Additionally direct and diffuse radiation are calculated using a formula based on sunshine duration

These are then also used to calculate potential evapotranspiration (PET) using the Penman-Monteith method.

# UKCP09 - pdf

UK CLIMATE PROJECTIONS

Warmest day




Can also derive immediately for
- Tmax, Tmean, rainfall

From WG can derive:
- PET, days since rainfall, cumulative temperature, HDD etc.

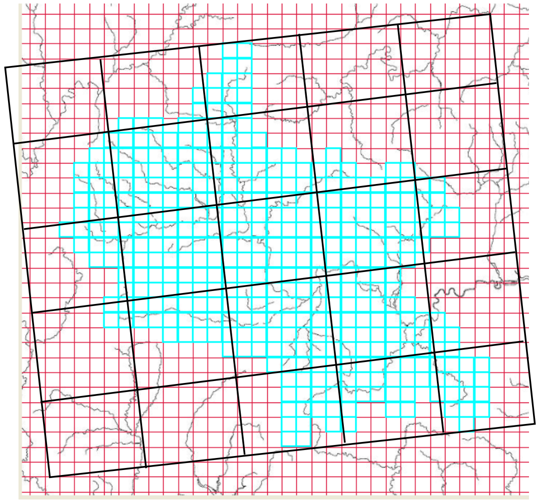
# Drought and heatwave

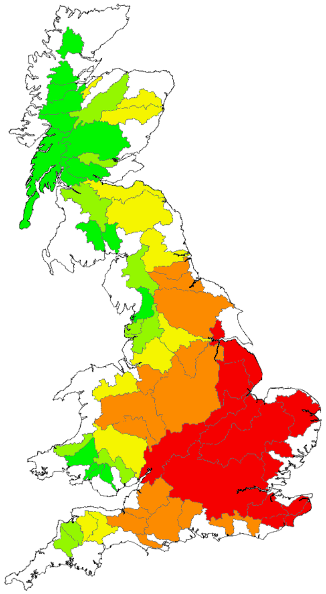
**Other developments**

1. **Spatial weather generator**

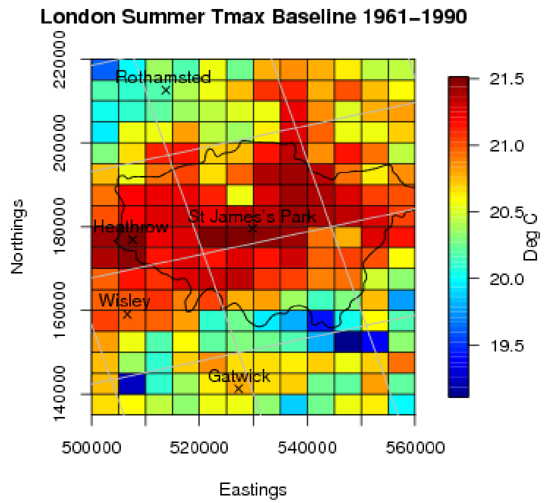
   **EPSRC ARCADIA project of spatial fields of rainfall and temperature under climate change**
   - National coverage, spatially correlated
   - For UKCP09 future projections
   - Simulating 100 year events for drought/heatwave
   - 5km daily gridded rainfall simulated fields
   - Probabilistic future changes
   - Medium sized regions : SWERVE project for Thames
2. **National rainfall model**

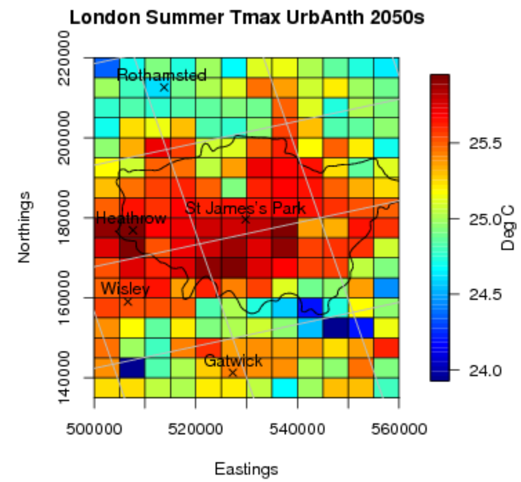
   **PhD project addressing water resource under future climates**

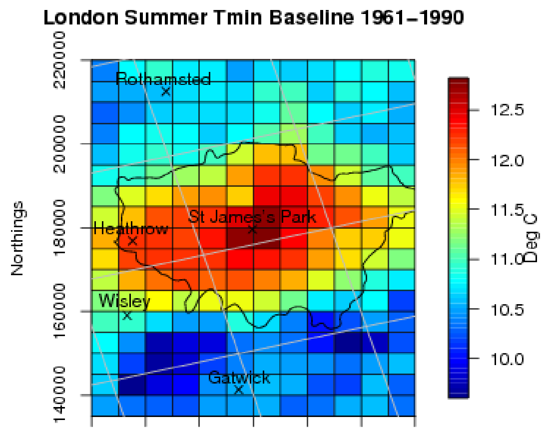


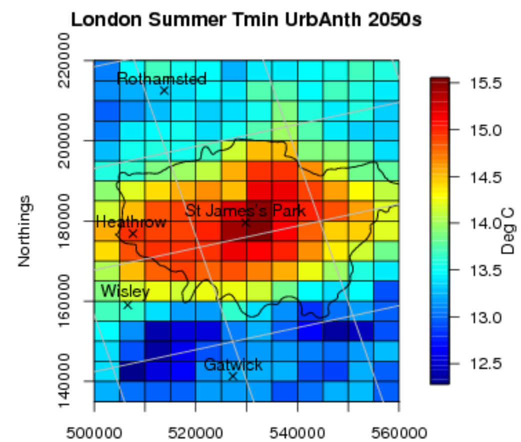


# Spatial implementation – future scenarios




Spatial WG outputs at 5km for baseline (left panel) and future scenarios (right panel). Tmax is shown in the top row and Tmin on the bottom.

# Conclusions and limitations

- **Limited power of explanation**
- **May be useful for some components of demand**

- **UKCP09 provides**
  - Consistent inter-variable relationships
  - Realistic frequencies of extreme events/droughts
- **Spatial WG provides**
  - Spatially correlated variables over a region
- **Now deriving transient scenarios**

# References

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