The CRU daily weather generator developed for the BKCC programme

Model Description

- Markov Chain Model
- First Order
- Continuous State
- Transfer Function : Gamma distribution

Model Operation

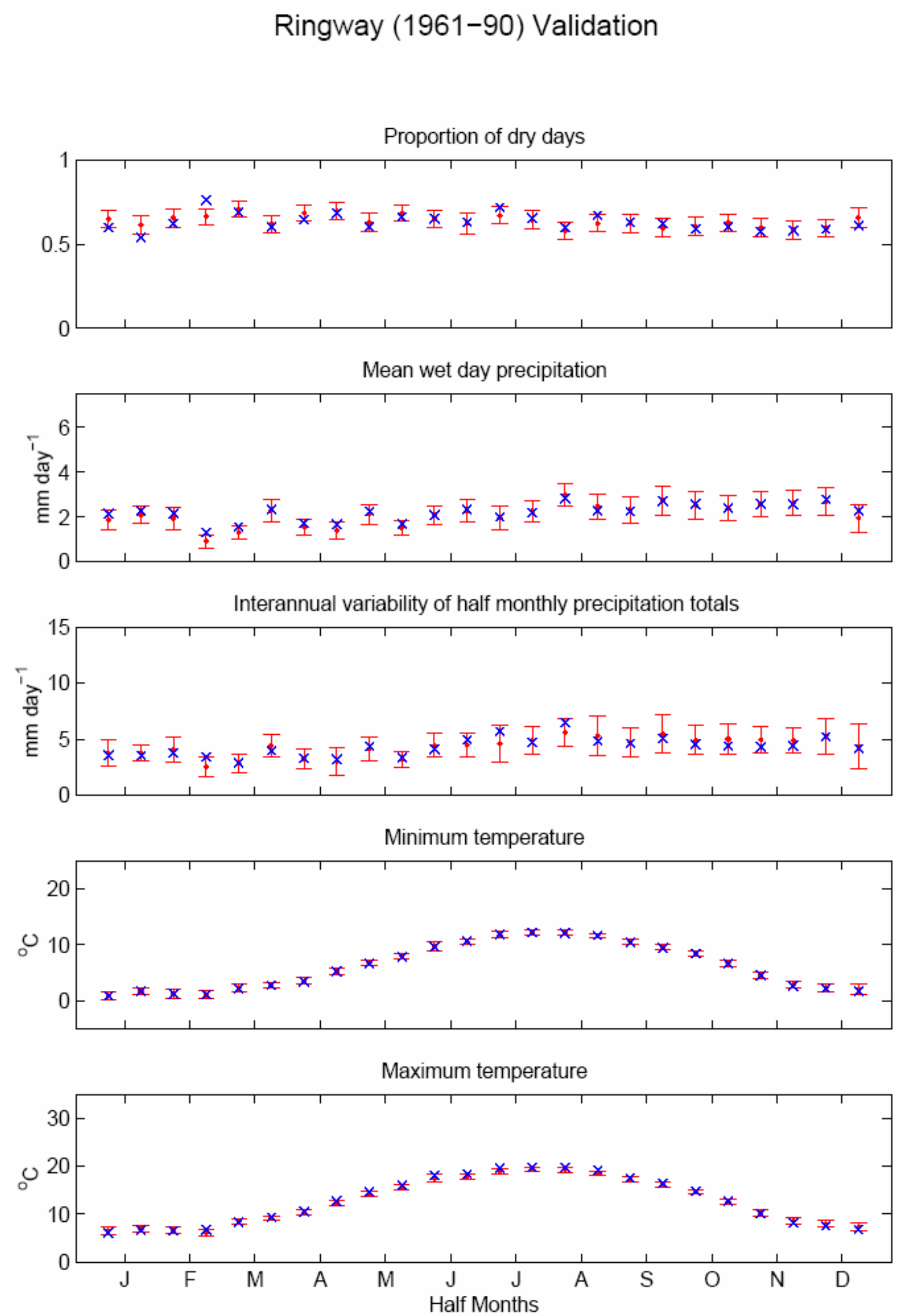
- Create transition matrix
- Calculate parameters for transfer function for each transition
- Derive general relationship for parameters based on precipitation amount
- Calculate today's precipitation from yesterdays by inverting the transfer function
- Use today's precipitation to derive other variables

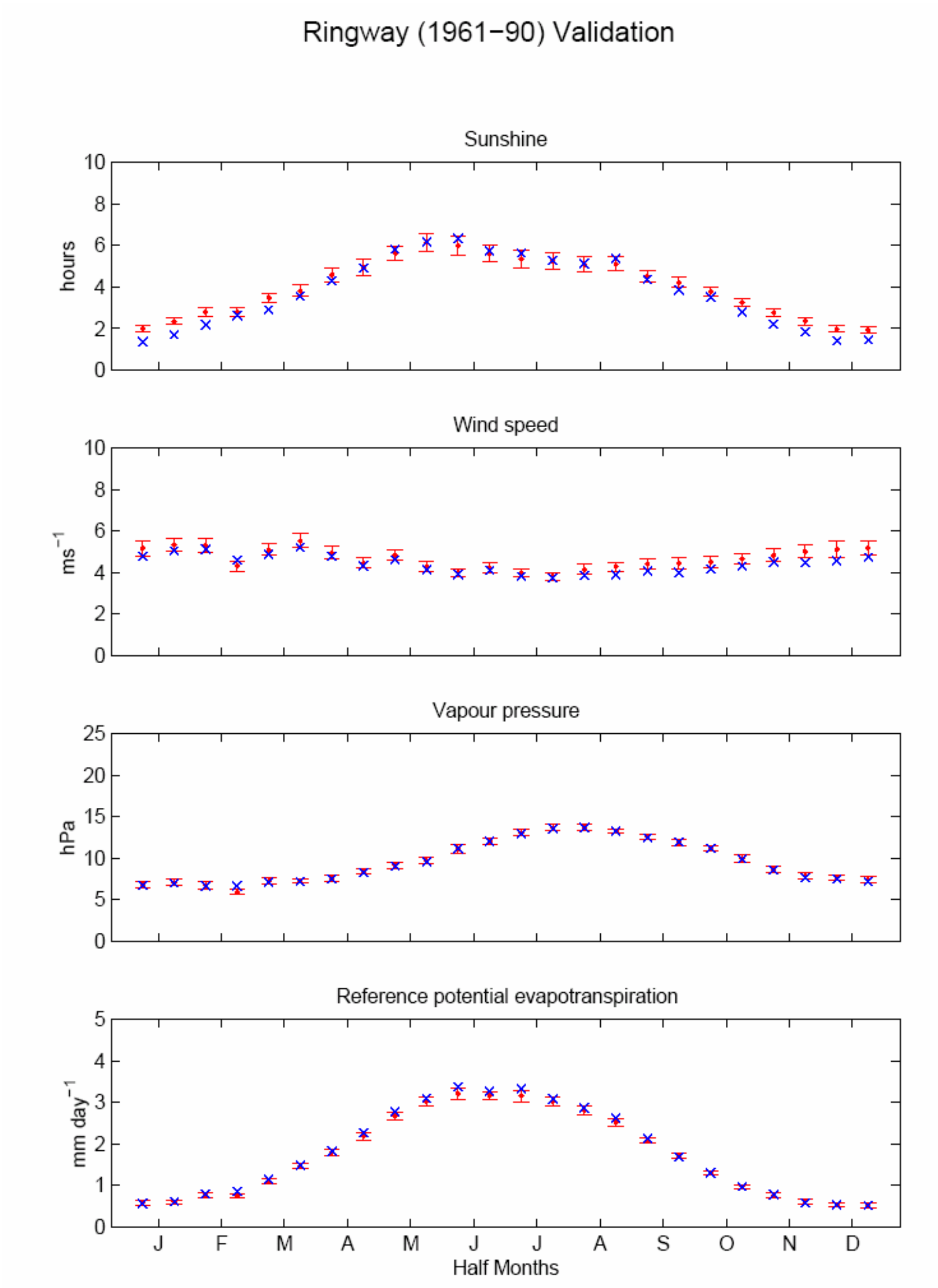
The CRU daily variables

Primary generated variable: Precipitation (mm)
Secondary generated variables: Minimum temperature (degrees C) Maximum temperature (degrees C) Vapour pressure (hPa) Wind speed (ms^{-1}) Sunshine duration (hours)
Calculated variables: Relative humidity (%) Reference potential evapotranspiration (mm day^{-1})

CRU weather generator is stochastic

- 100 simulations is optimal
- We present range across 100 simulations in figures (and we provide Excel files containing these numbers)
- For the time series, we provide a representative run (i.e., from middle of distribution) – but others can be provided on request


Ringway (1961−90) Validation
Proportion of dry days
Mean wet day precipitation
mm day−1
Interannual variability of half monthly precipitation totals
mm day−1
Minimum temperature
°C
Maximum temperature
°C
J F M A M J J A S O N D
Half Months

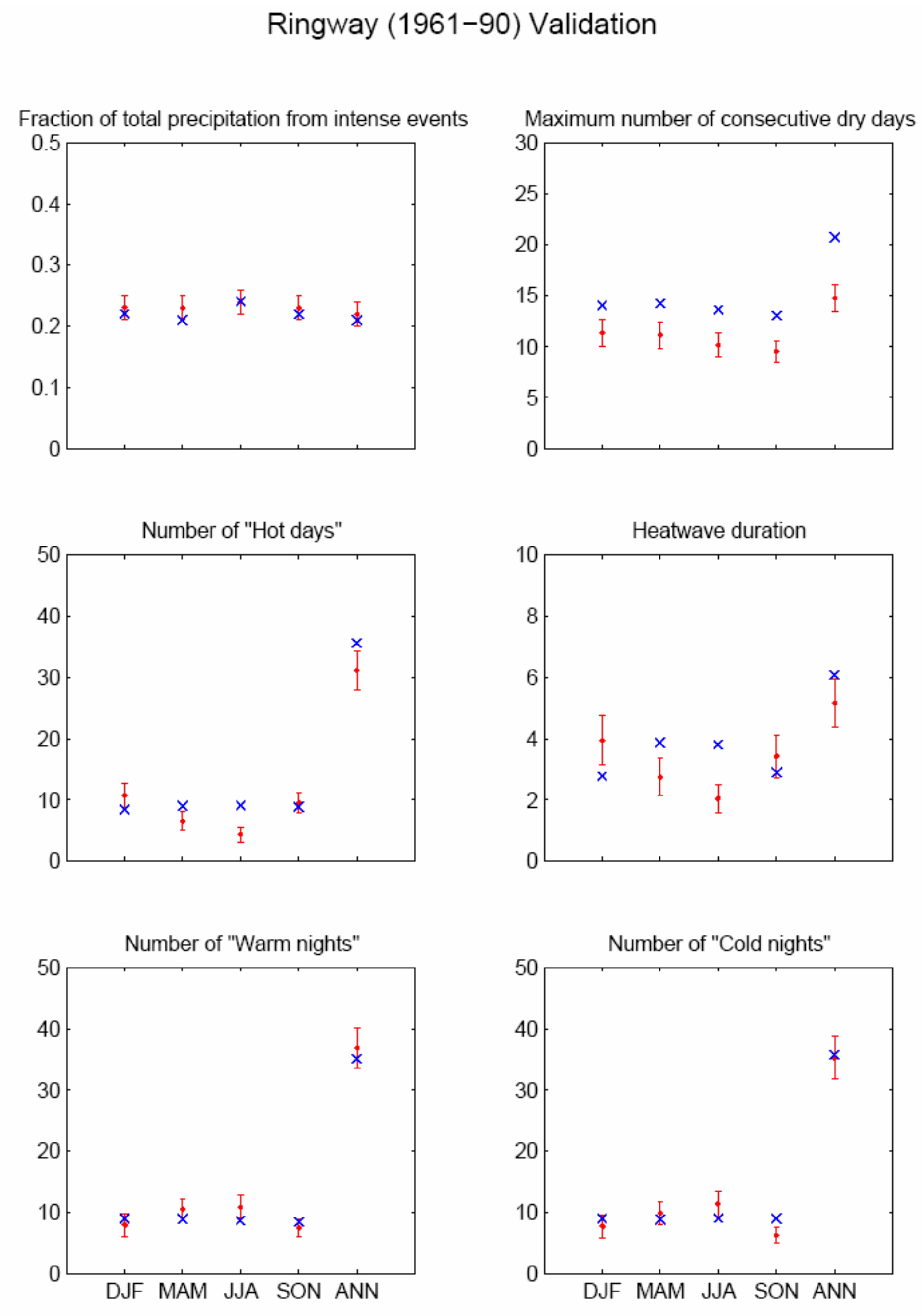


Ringway (1961−90) Validation
Sunshine
hours
Wind speed
ms−1
Vapour pressure
hPa
Reference potential evapotranspiration
mm day−1
J F M A M J J A S O N D
Half Months

BETWIXT description	*STARDEX name*	*Definition*
Fraction of total precipitation from intense events	pf95	Fraction of total precipitation above the annual 95th percentile value
Maximum number of consecutive dry days	pxcdd	Maximum number of consecutive dry days
Number of "Hot days"	txf90	Number of days when maximum temperature is greater than the 90th percentile value
Heatwave duration	txhwd	Cumulative count of number of consecutive days when maximum temperature exceeds the 90th percentile value for more than 5 days (NB the first 5 days are not counted in the index)
Number of "Warm nights"	tnf90	Number of days when minimum temperature is greater than the 90th percentile value
Number of "Cold nights"	tnf10	Number of days when minimum temperature is less than the 10th percentile value

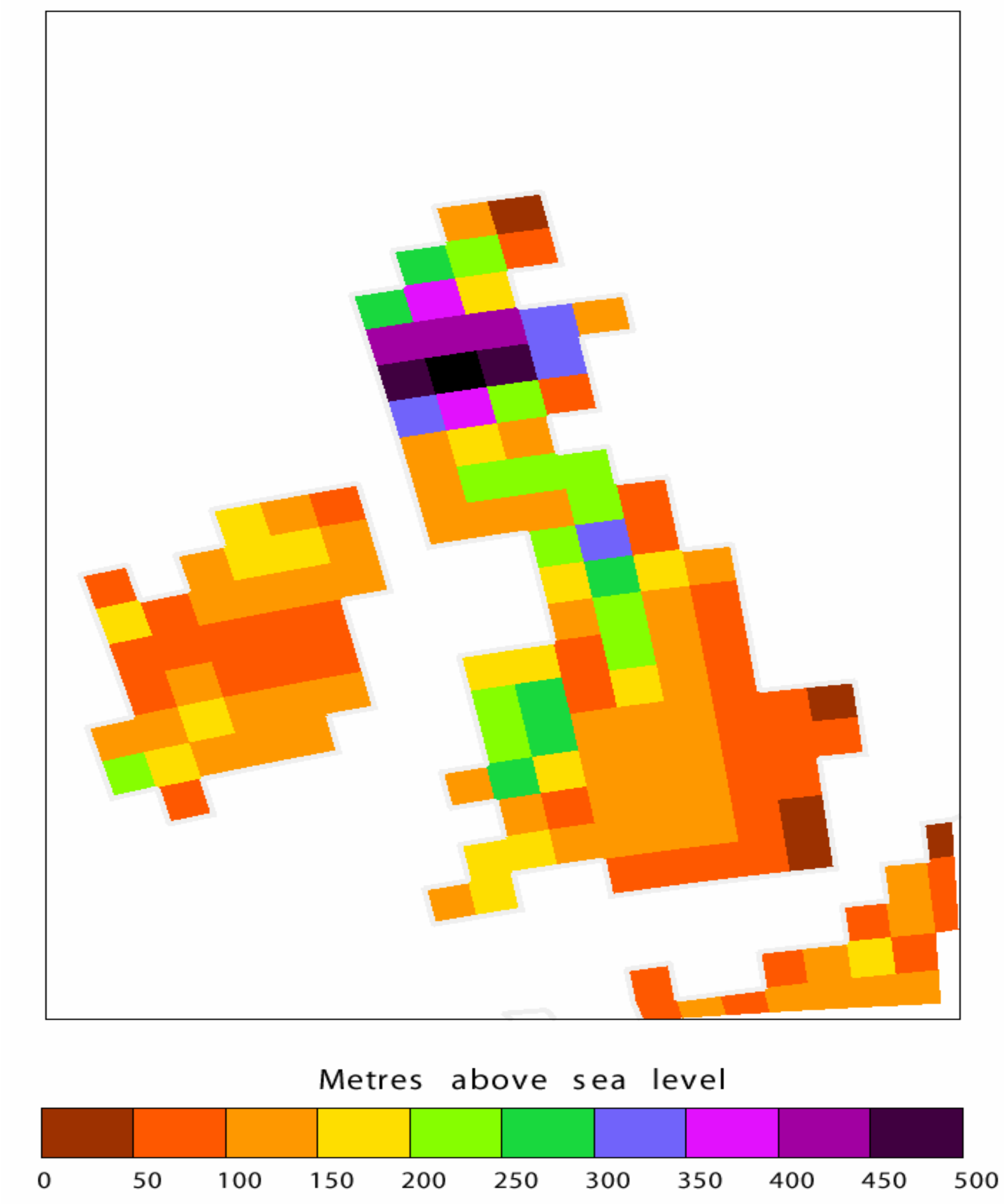
e.g., observed thresholds values tqx90

	DJF	MAM	JJA	SON	ANN
Bradford	10.6	17.0	23.0	17.8	19.7
Coltishall	10.7	17.2	23.7	19.9	21.1
Elmdon	10.8	17.6	24.3	19.3	21.3
Eskdalemuir	8.5	15.6	21.0	15.7	17.9
Gatwick	11.0	18.5	25.1	20.3	22.2
Hembsy	10.3	15.3	21.7	19.0	19.7
Heathrow	11.7	19.1	26.0	20.9	22.9
Paisley	9.9	17.0	22.6	17.0	19.4
Ringway	10.8	17.4	23.7	18.4	20.4
Yeovilton	12.1	18.1	24.7	19.7	21.8


Ringway (1961−90) Validation
Fraction of total precipitation from intense events
Maximum number of consecutive dry days
Number of "Hot days"
Heatwave duration
Number of "Warm nights"
Number of "Cold nights"
DJF
MAM
JJA
SON
ANN

BETWIXT scenarios

- Control period (1961-1990)
- For each emissions scenario (low, medium-low, medium-high, high), three future time periods: 2020s, 2050s, 2080s, i.e., 12 series per station
- Clickable tables on public web site for downloading station series and figures

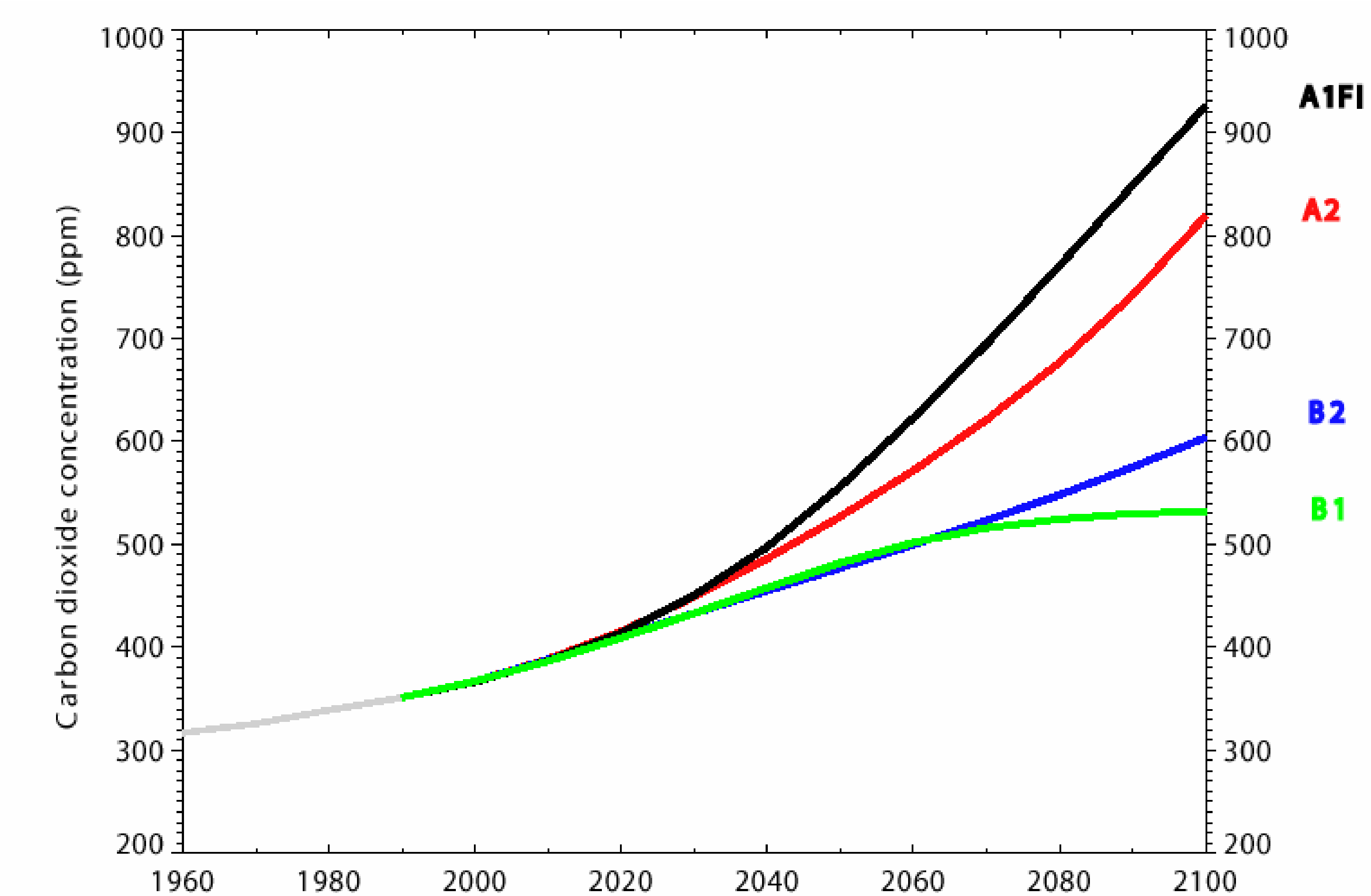


Hadley Centre Regional Climate Model (HadRM3)

50 km grid

Tyndall°Centre for Climate Change Research
Met Office Hadley Centre
UK Climate Impacts Programme
DEFRA Department for Environment, Food & Rural Affairs

Carbon dioxide concentrations: IPCC scenarios



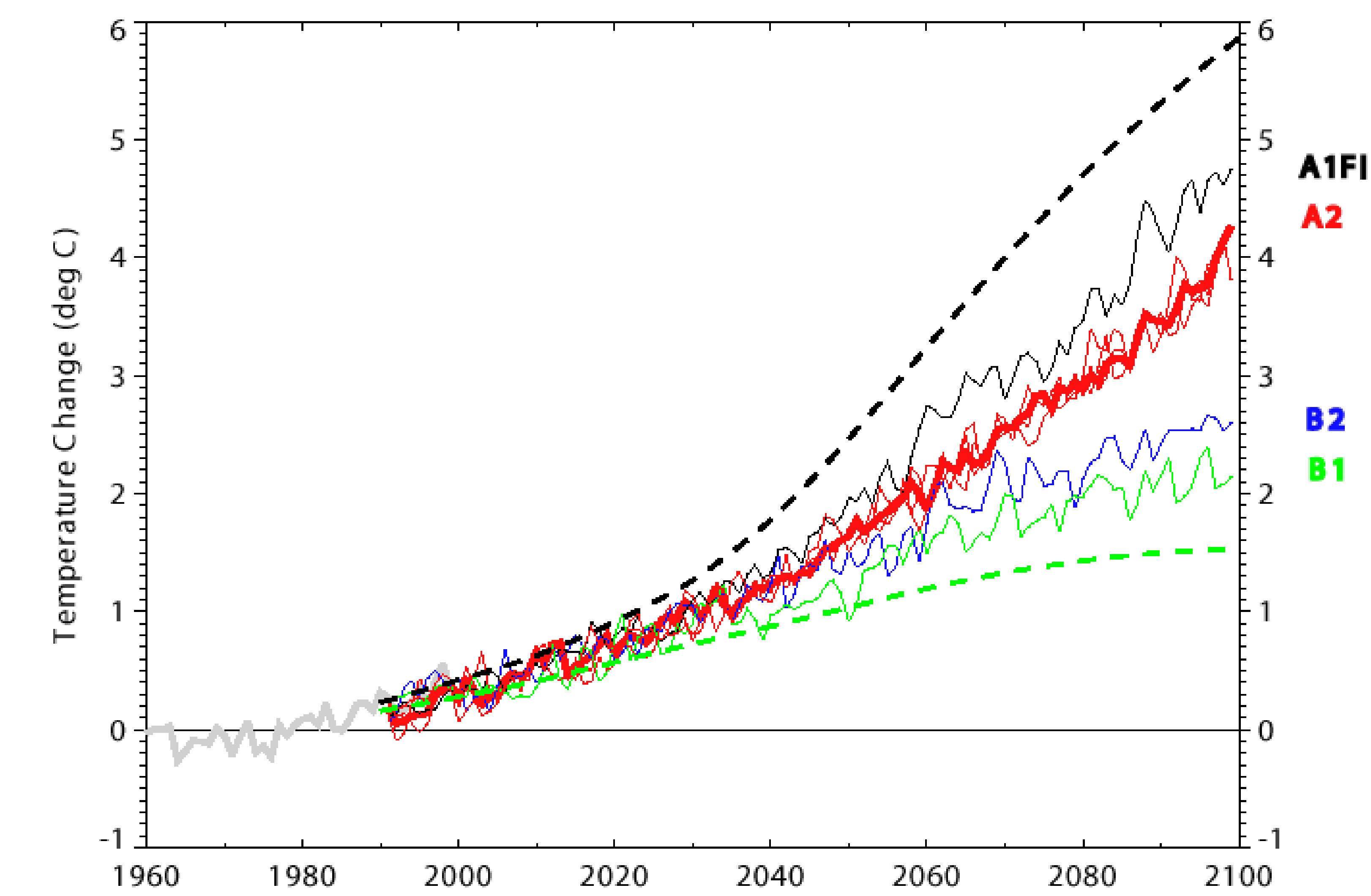
Tyndall°Centre for Climate Change Research

Met Office Hadley Centre

UK Climate Impacts Programme

DEFRA Department for Environment, Food & Rural Affairs

Global temperature (2000 - 2100)



Tyndall°Centre for Climate Change Research
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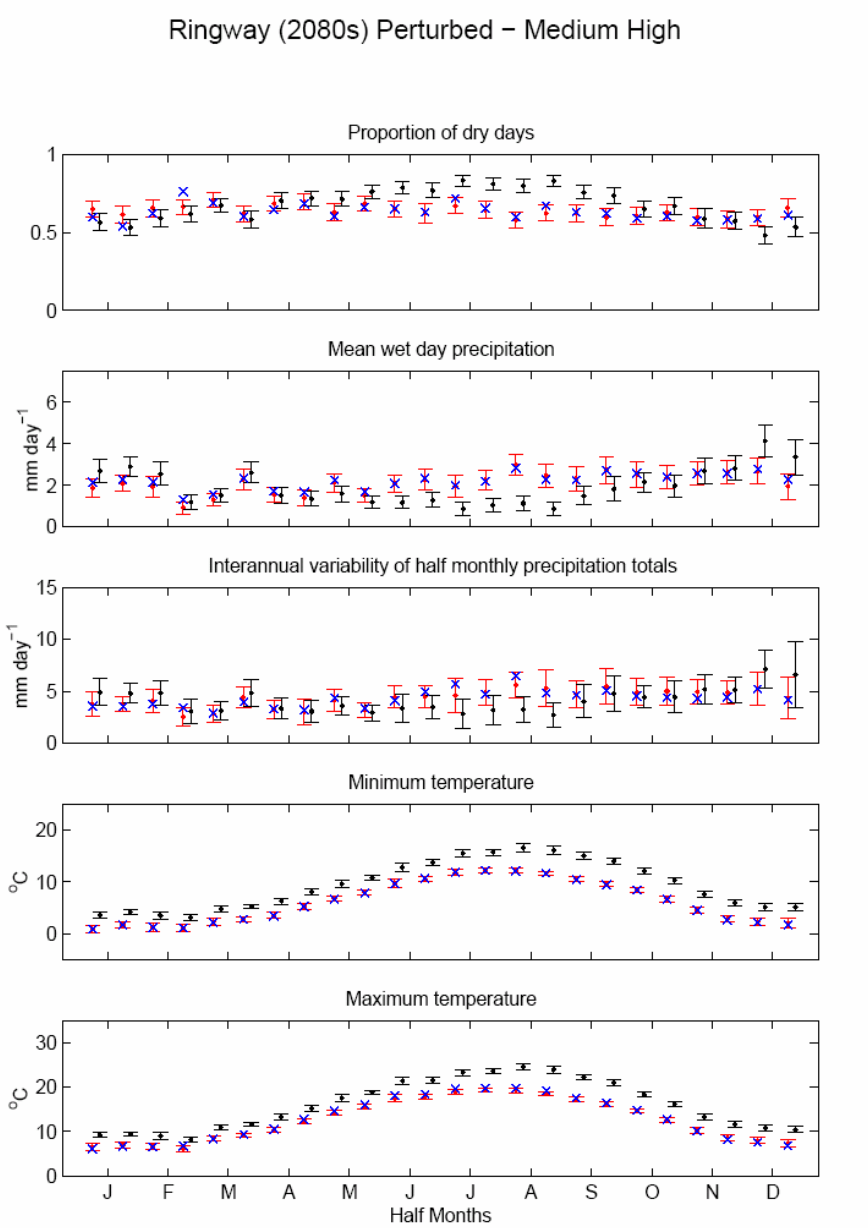
BETWIXT maintains consistency with UKCIP02

- By using 'change factors' calculated from the same HadRM3H simulations as used to produce the UKCIP02 spatial patterns
- By using UKCIP02 multiplying factors

Time-slice	Low Emissions	Medium-Low Emissions	Medium-High Emissions	High Emissions
2020s	0.24	0.27	0.27	0.29
2050s	0.43	0.50	0.57	0.68
2080s	0.61	0.71	1.00	1.18


Ringway (2080s) Perturbed − Medium High
Proportion of dry days
Mean wet day precipitation
mm day⁻¹
Interannual variability of half monthly precipitation totals
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Minimum temperature
°C
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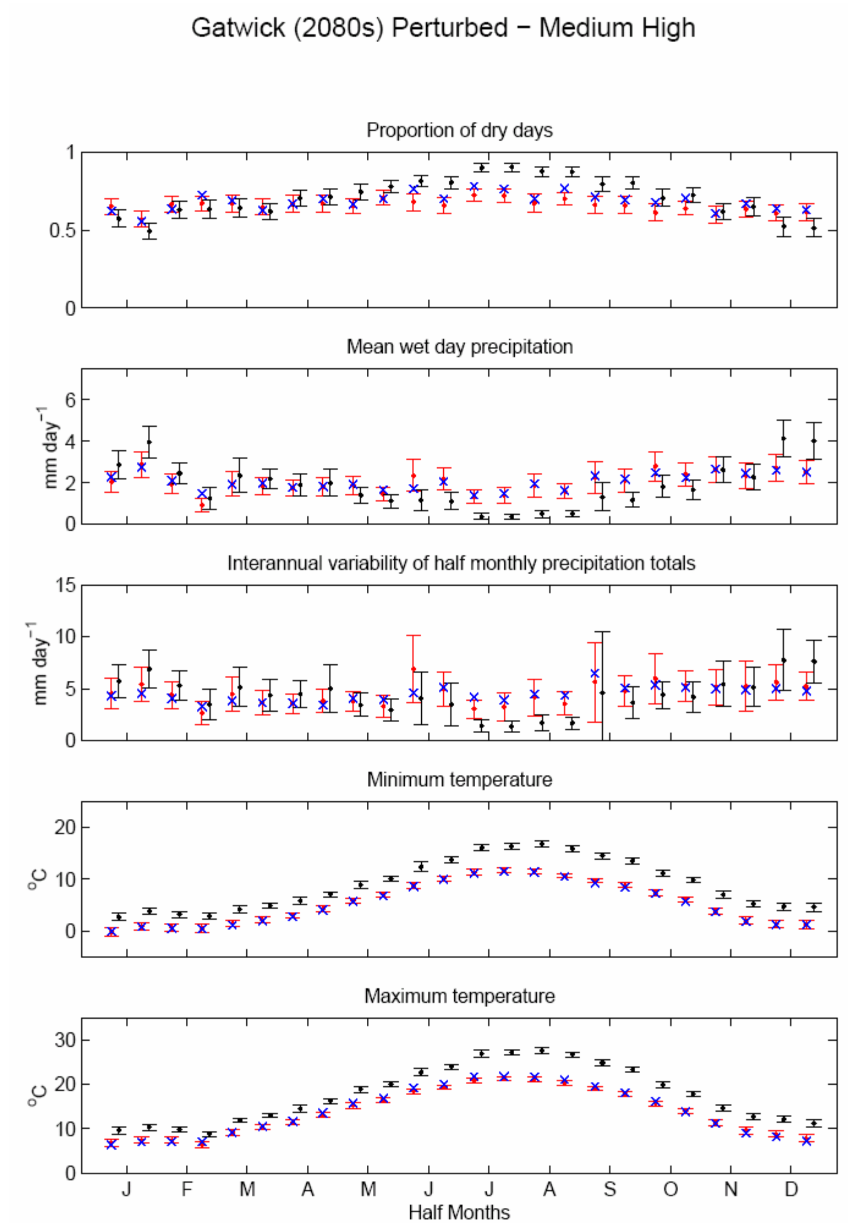
Half Months


Gatwick (2080s) Perturbed − Medium High
Proportion of dry days
Mean wet day precipitation
mm day⁻¹
Interannual variability of half monthly precipitation totals
mm day⁻¹
Minimum temperature
°C
Maximum temperature
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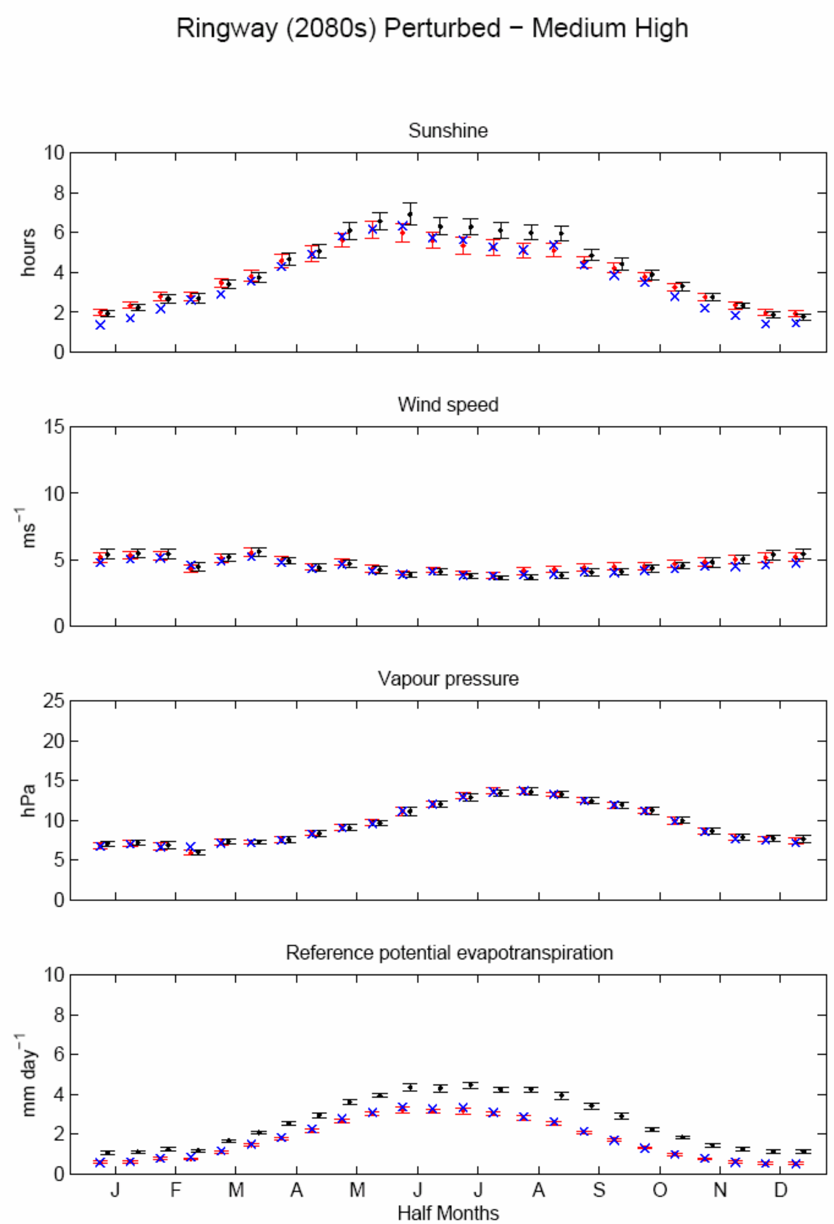
J F M A M J J A S O N D
Half Months


Ringway (2080s) Perturbed − Medium High
Sunshine
hours
Wind speed
ms −1
Vapour pressure
hPa
Reference potential evapotranspiration
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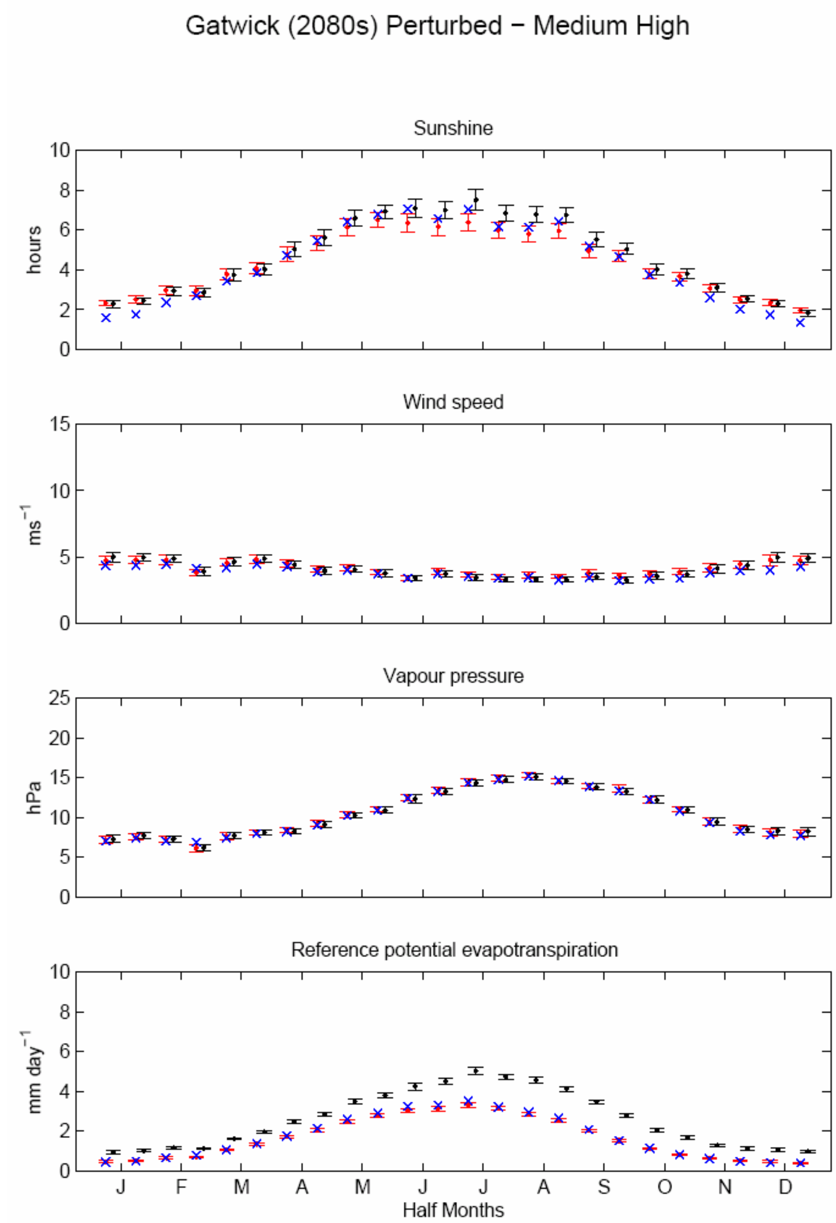
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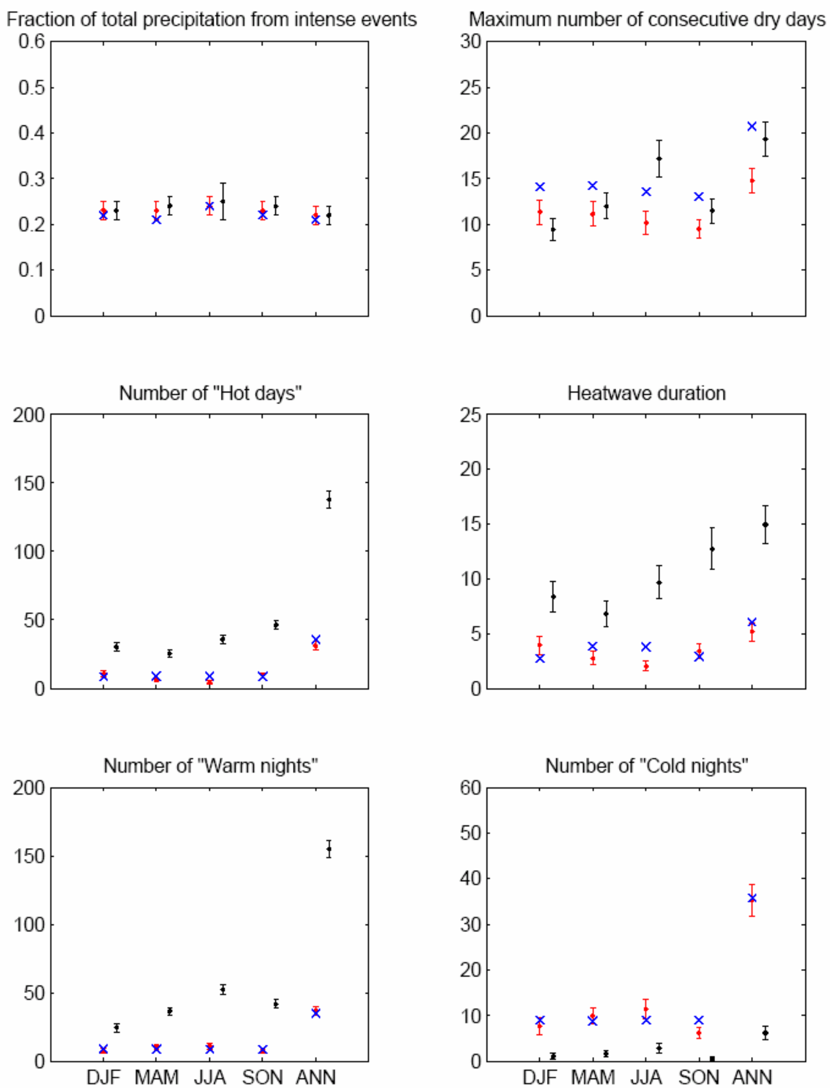
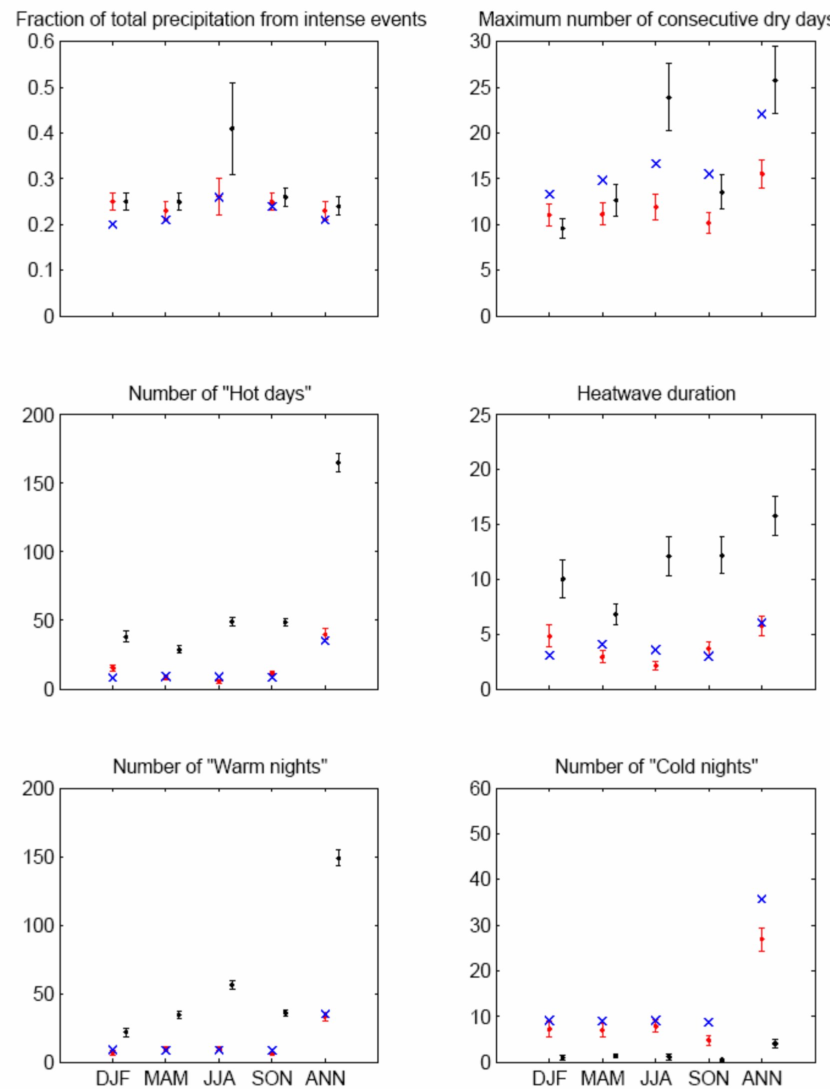


Gatwick (2080s) Perturbed − Medium High



Technical briefing notes

Available from the BETWIXT web site:

1. **The CRU daily weather generator**
2. **Neymann-Scott rectangular pulses rainfall simulation system**
3. **Simulating climate change in urban areas**
4. **Validation of the CRU daily weather generator**
5. **Predicting future changes in wind**
6. **Relative impact of radiative forcing, landscape effects and local heat sources on simulated climate change in urban areas**

More titles in preparation……….

Consistency of the CRU and Newcastle scenarios

- **We are using the same change fields and scaling factors (hence these will be described in a jointly-produced technical briefing note)**

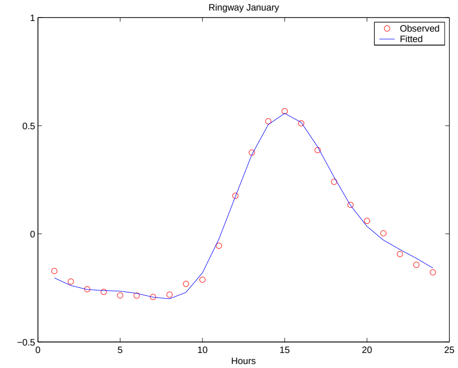
- **Scenarios for common stations could be compared, e.g., do different models produce different changes in extremes? (downscaling uncertainty)**

GNSRP hourly rainfall output are being used to drive the CRU hourly weather generator

- **Vapour pressure, wind speed and sunshine duration, are calculated from regression equations (for each hour/half month) with hourly temperature as the predictand**

- **Hence we need to calculate the diurnal temperature cycle for each day, so that it is consistent with the GNSRP hourly precipitation….**

- So we aggregate the hourly rainfall to give a daily total
- Which is used as the primary variable to run the CRU daily weather generator, to give consistent daily temperature
- From which we then calculate the diurnal temperature cycle using a fitted sine curve to give us the predictands for the other variables



Primary generated hourly variable:

From GNSRP -

Precipitation (mm)

Secondary generated hourly variables:

From generated daily temperature (fitted sine curve) -

Minimum temperature (degrees C)

Maximum temperature (degrees C)

From regression equations with hourly T as predictand -

Vapour pressure (hPa)

Wind speed (ms^{-1})

Sunshine duration (hours)

Calculated hourly variables:

Relative humidity (%)

Wind gust speed (mm day^{-1}) *from ratios of mean hourly/gust speeds calculated by Clair Hanson*

Representativenesss of station data

- **Manchester case study**
  - **transect:**

    Knutsford

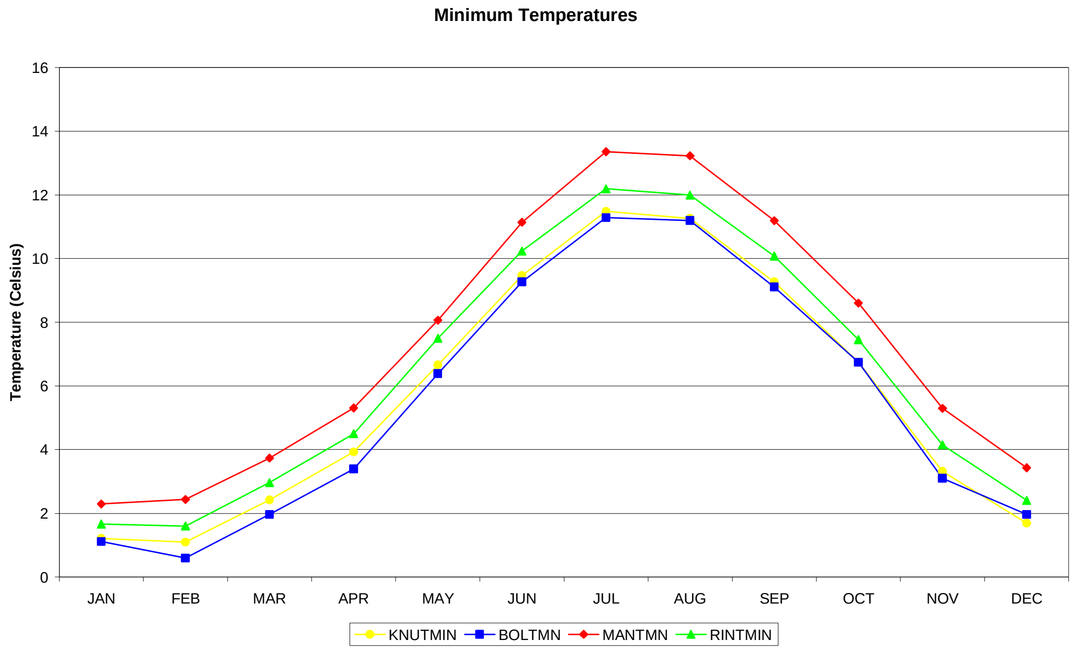
    Ringway

    Manchester weather centre

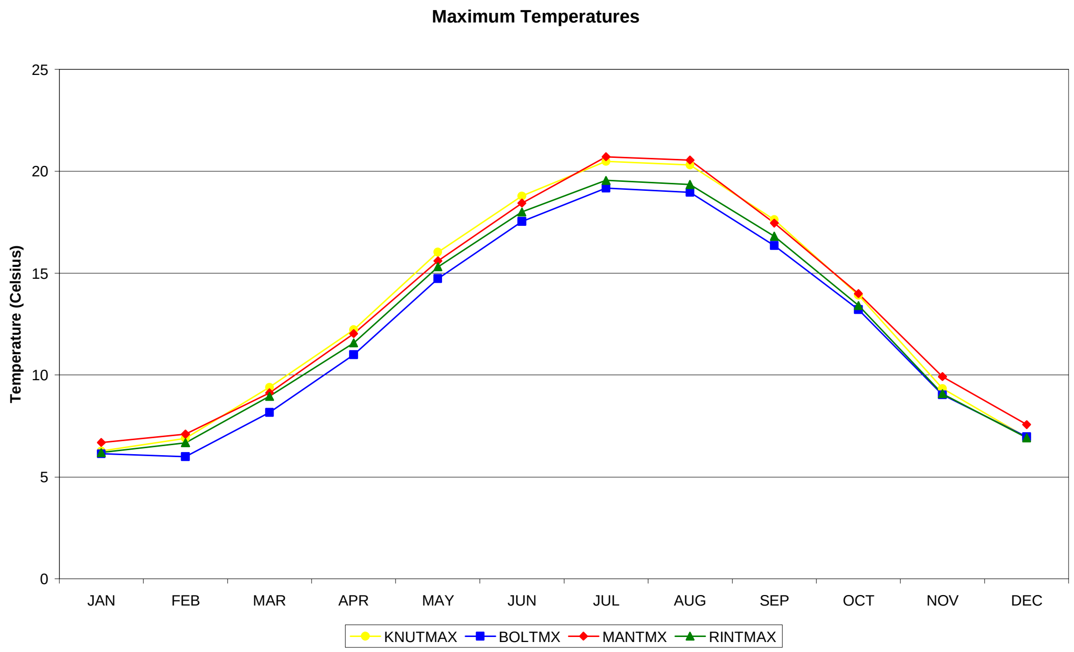
    Bolton
  - **repeat of Rob Wilby's London study**

Theo Chineke and Clare Goodess

Minimum temperature seasonal cycle

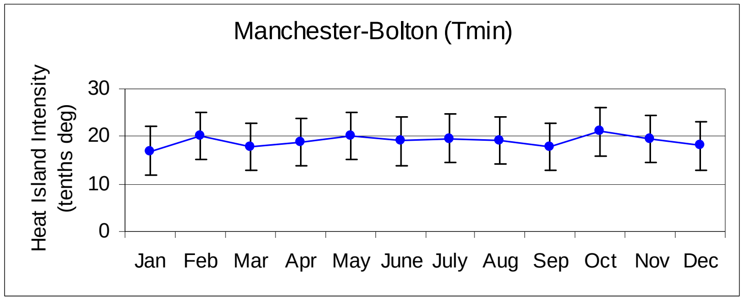


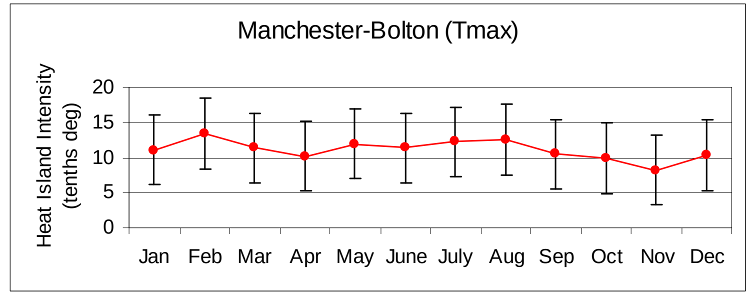
Knutsford – yellow
Ringway – green
Weather C. – red
Bolton - blue

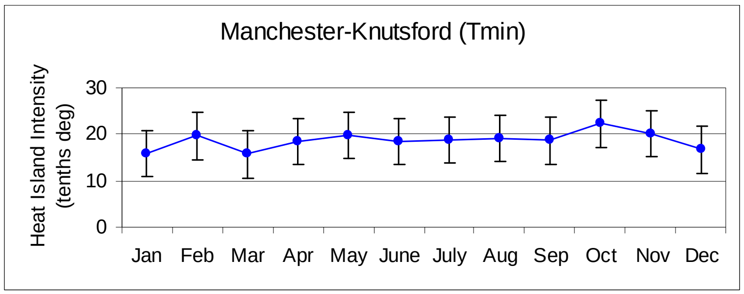


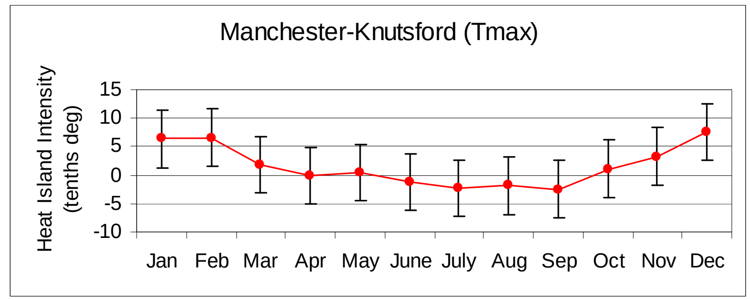
Maximum temperature seasonal cycle

‘Urban heat island’ seasonal cycle





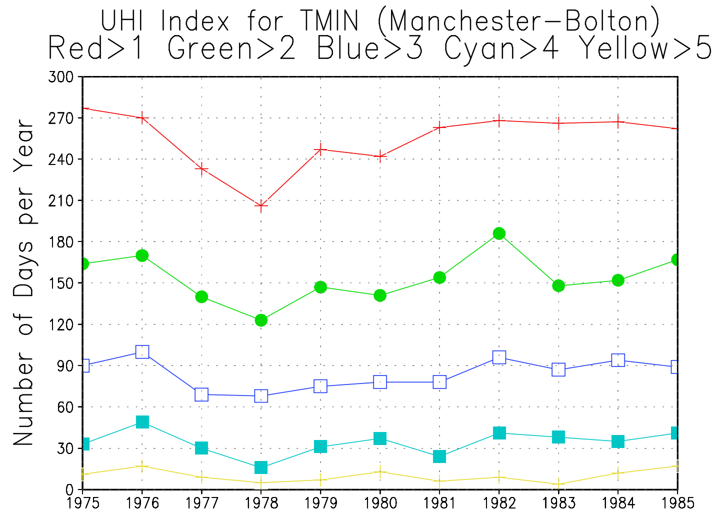




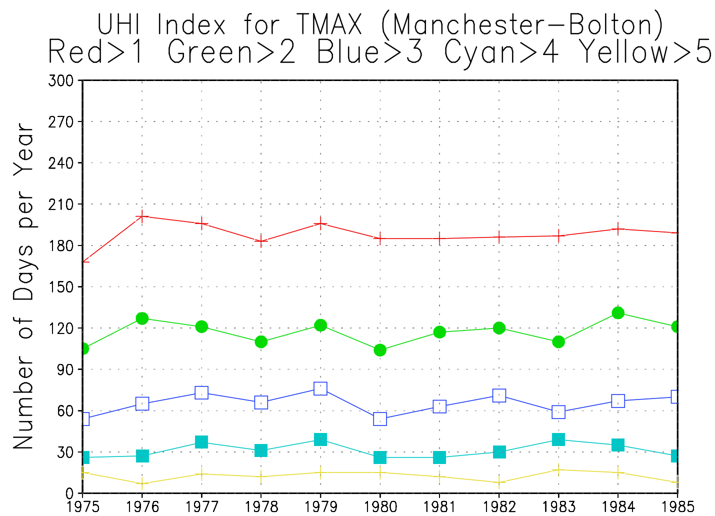
Station	txq90	txq90	txq90	txq90	txq90	tnq10	tnq10	tnq10	tnq10	tnq10	tnq90	tnq90	tnq90	tnq90	tnq90
	DJF	MAM	JJA	SON	ANN	DJF	MAM	JJA	SON	ANN	DJF	MAM	JJA	SON	ANN
Bolton	9.7	16.5	23.3	17.8	20.3	-3.9	-0.4	7.1	0.8	-1.0	5.1	8.2	14.0	11.6	12.1
Knutsford	10.6	17.7	25.0	19.3	21.8	-3.9	-0.5	7.2	0.5	-1.1	5.5	8.1	14.0	11.5	12.1
Manchester	10.9	17.9	24.9	18.9	21.4	-1.5	1.7	9.5	3.5	1.1	6.6	9.7	15.7	12.9	13.6
Ringway	10.7	17.3	24.5	18.5	21.1	-3.4	0.5	8.4	1.8	-0.4	5.8	8.8	14.9	12.4	12.9
M-B	1.2	1.4	1.6	1.1	1.1	2.5	2.1	2.3	2.6	2.1	1.5	1.5	1.6	1.2	1.5
M-K	0.3	0.2	-0.1	-0.4	-0.4	2.4	2.2	2.3	2.9	2.2	1.1	1.6	1.6	1.4	1.6

‘Urban heat island’ time series, 1975-1985

Minimum temperature
Manchester-Bolton

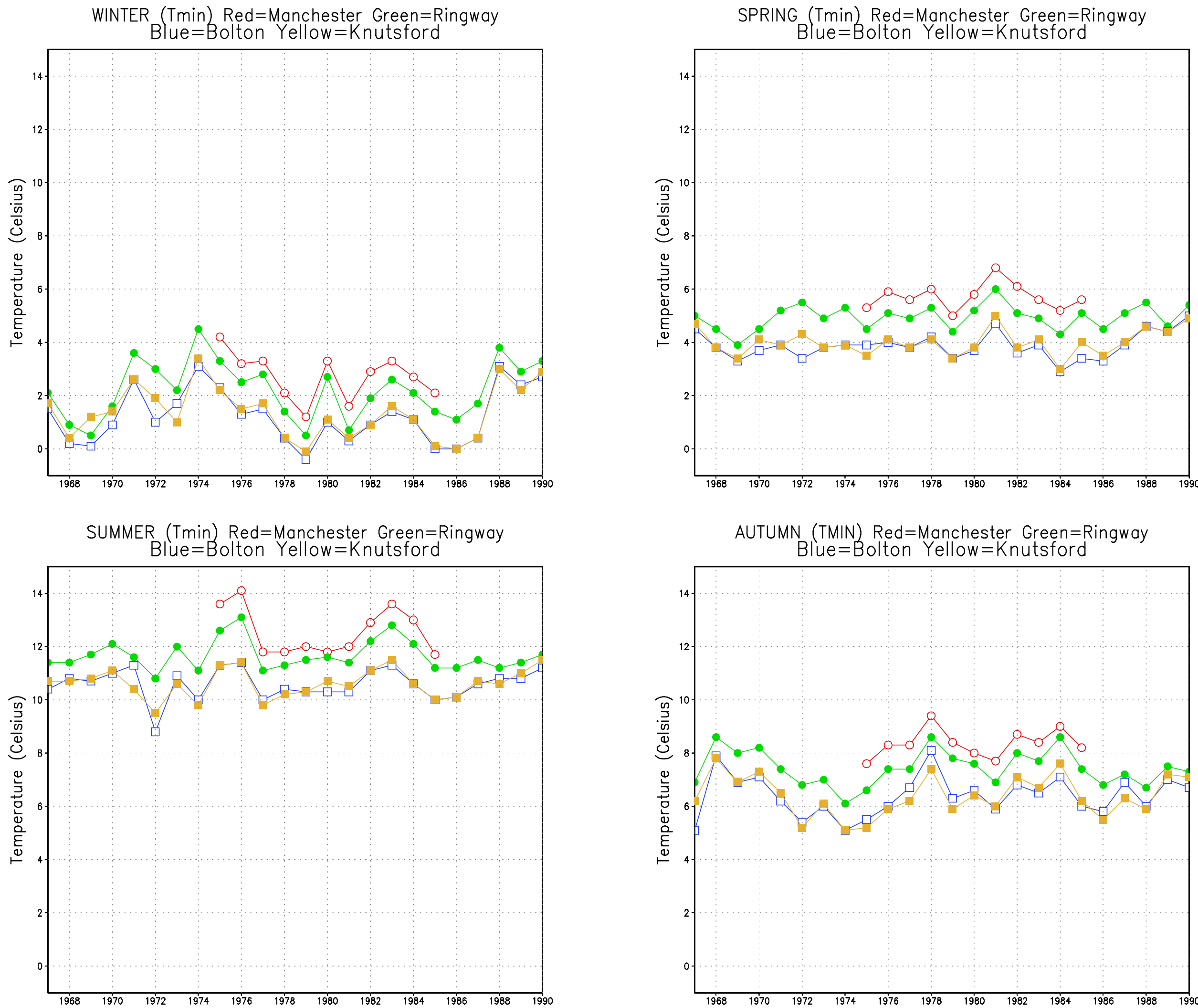


Maximum temperature
Manchester-Bolton



Minimum temperature time series, 1967-1990

Knutsford – yellow
Ringway – green
Weather C. – red
Bolton - blue



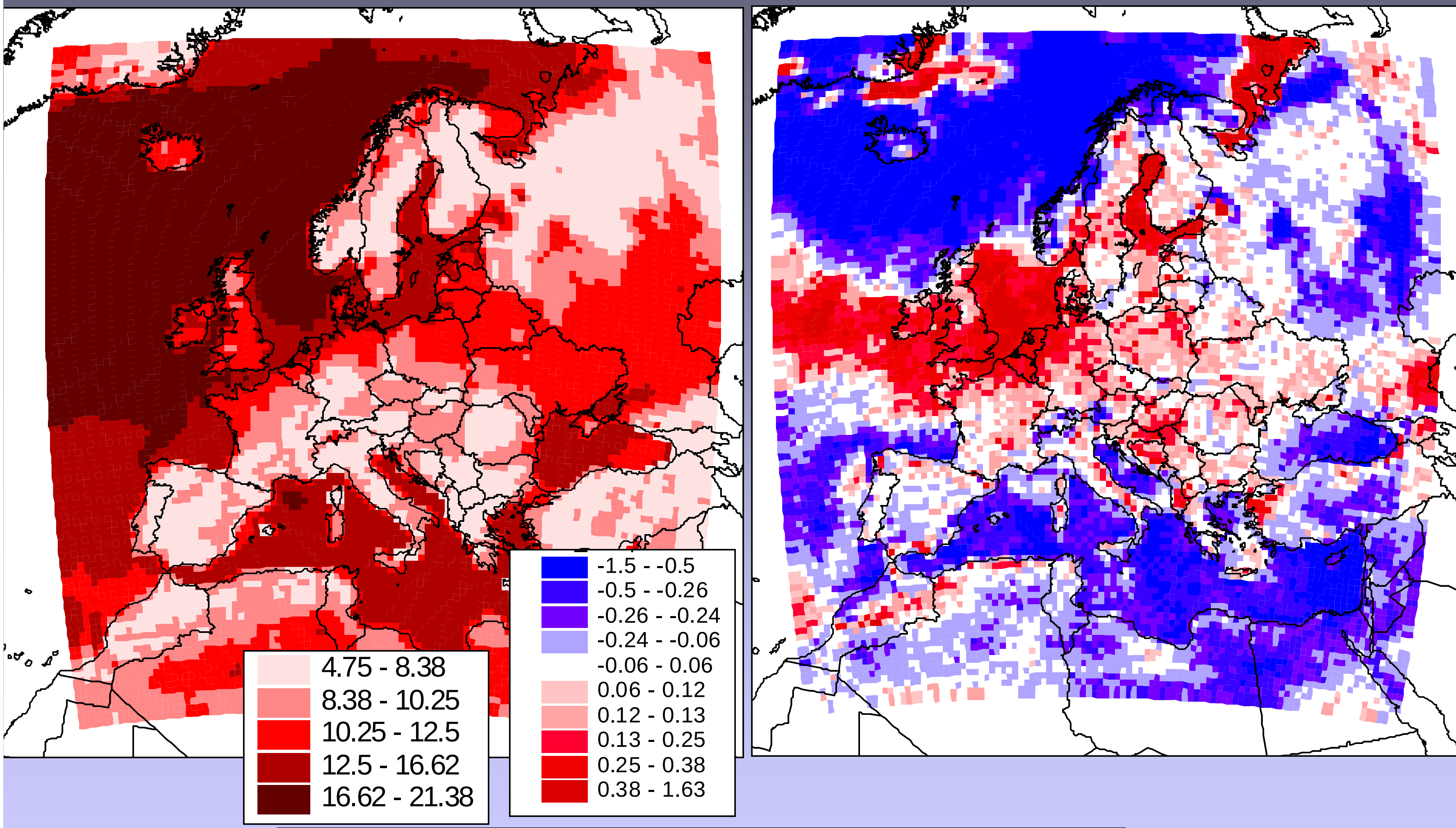
We had hoped to use SDSM to estimate future changes in the ‘urban heat island’ using Hadley Centre model output, but poor relationships and lack of time….

- Winter maximum temperature?
- Summer minimum temperature?

Wind Extremes

COM

A2a – COM



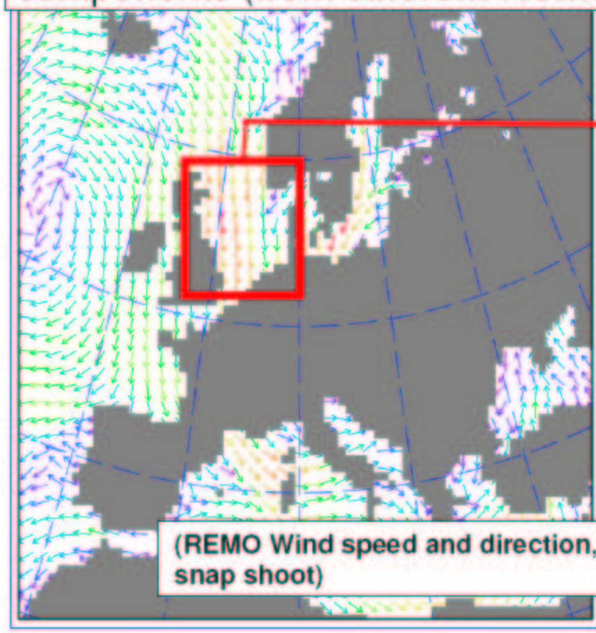
HadRM3H: A2a-CON, Climate Signal

Wmax, 95th percentile

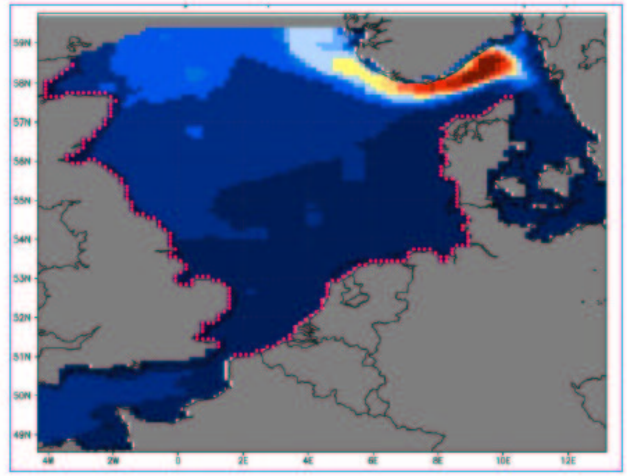
Methods: dynamical downscaling of surge

Forcing of the surge model (TRIM):

SLP and near surface wind components (from different RCMs)



(REMO Wind speed and direction, snap shoot)



Results of the dynamical downscaling:

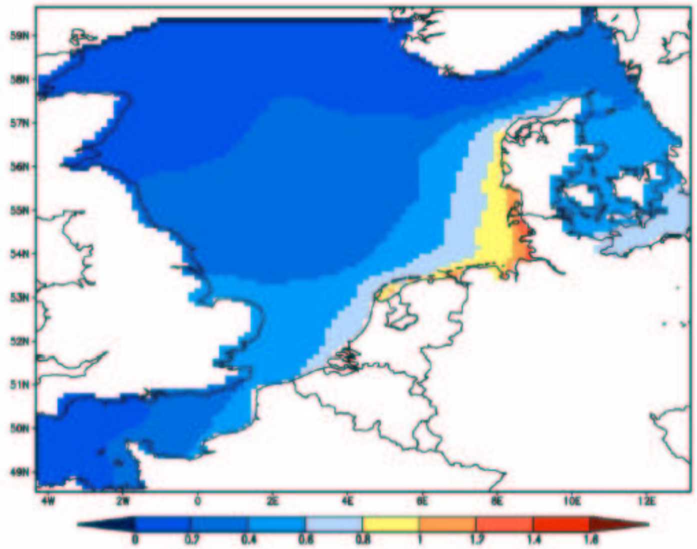
a high resolved data set in time and space of barotropic current velocity and water level for the integrated area

Without taking into account of increase in mean sea level

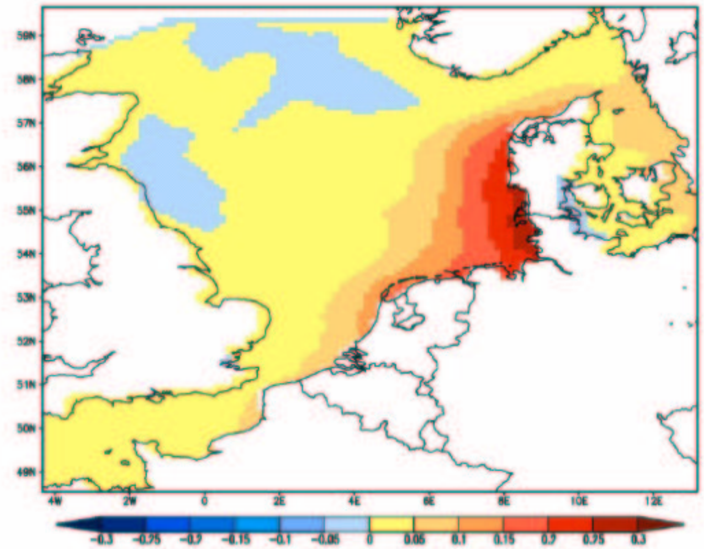
without taking into account of 'external surges' coming from Atlantic

TRIM tide surge model driven with HIRHAM: as one example

99.5 %-ile, surge (DJF) absolute:
CTL



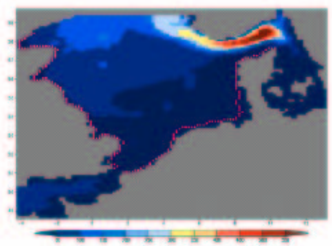
99.5 %-ile, surge (DJF)
Changes: A2 - CTL



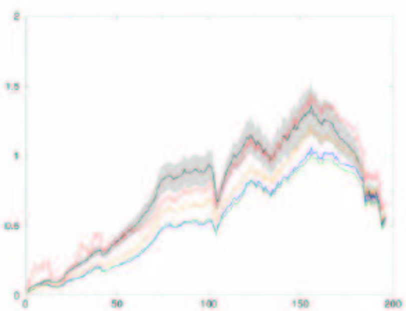
99.5%-ile during winter sampled every half an hour → thus the level is exceeded on average approximately 10 hours within a 3 month winter season

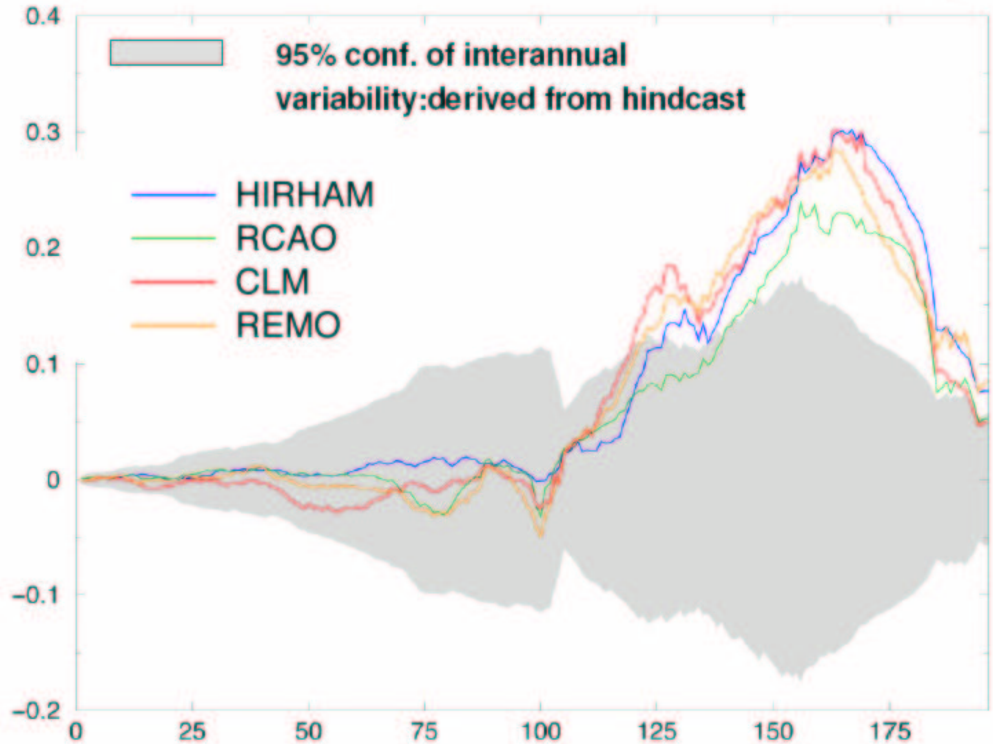
Projections for the future from RCM-ensemble: surge (changes in 99.5 % –ile)

Changes in 99.5 %-iles: A2 – CTL, four model forcings:



Ctl run, four model forcings:





grid cells: 10 m depth line along the coastline