Technology Strategy Board
Driving Innovation

Design for future climate

Opportunities for adaptation in the built environment

Bill Gething: Sustainability + Architecture

June 2010

Thanks:

Technology Strategy Board	Fionnuala Costello
UKCIP	Gerry Metcalf
	Roger Street
	Stephanie Ferguson
NERC	Simon Jackman
	Tessa Edgecombe
Arup	Chris Twinn
CIBSE	Anastasia Mylona
Kier	Chris Doran
AECOM	Ant Wilson
University of Southampton	Professor Bakr Bahaj
Land Securities	Dave Farebrother
CLG	Emily Hay
DEFRA	Will Lockhead
British Standards Institution	Alan Hall
Editor	Lindsey Coles.

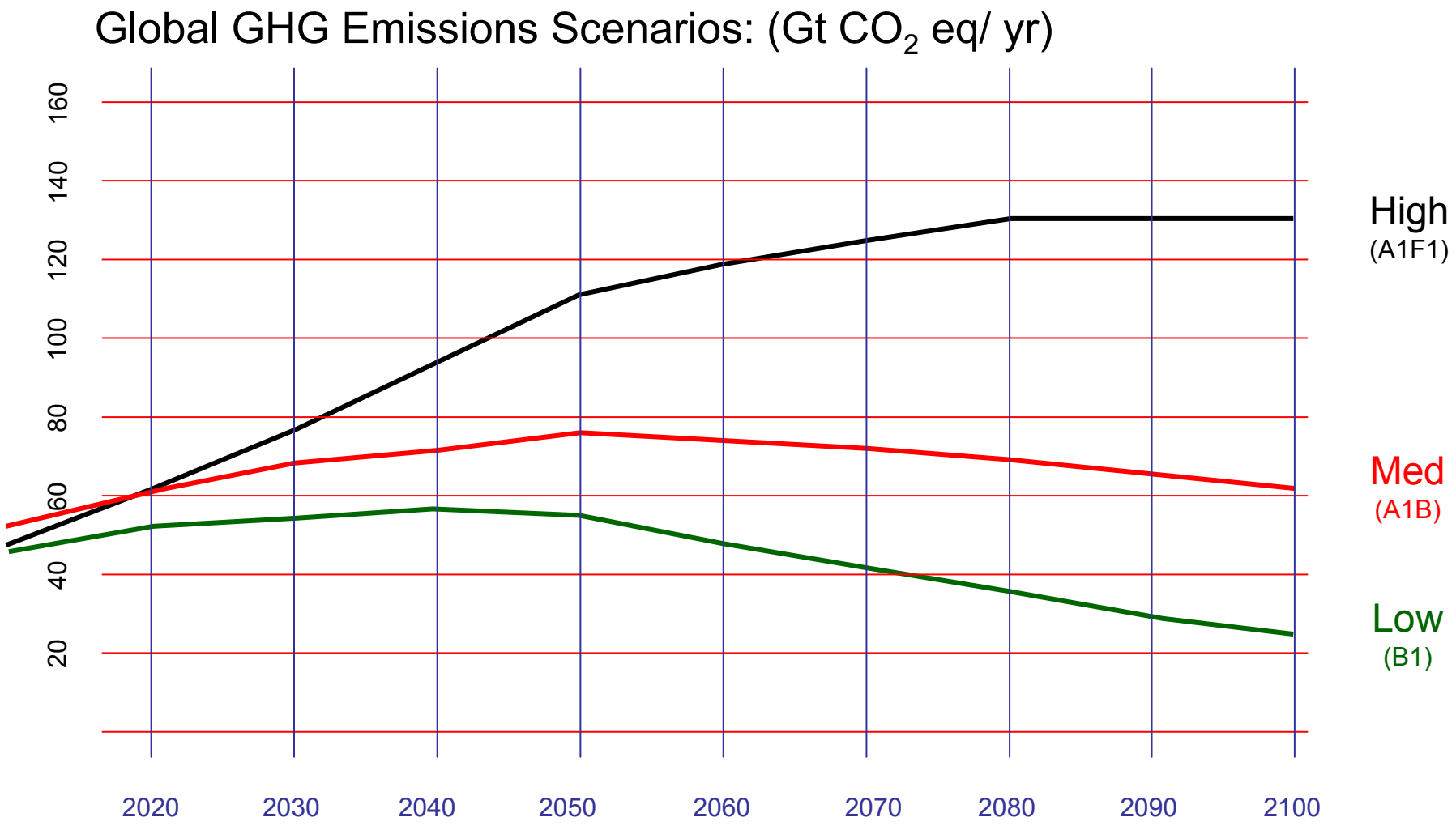
Stakeholder Panel

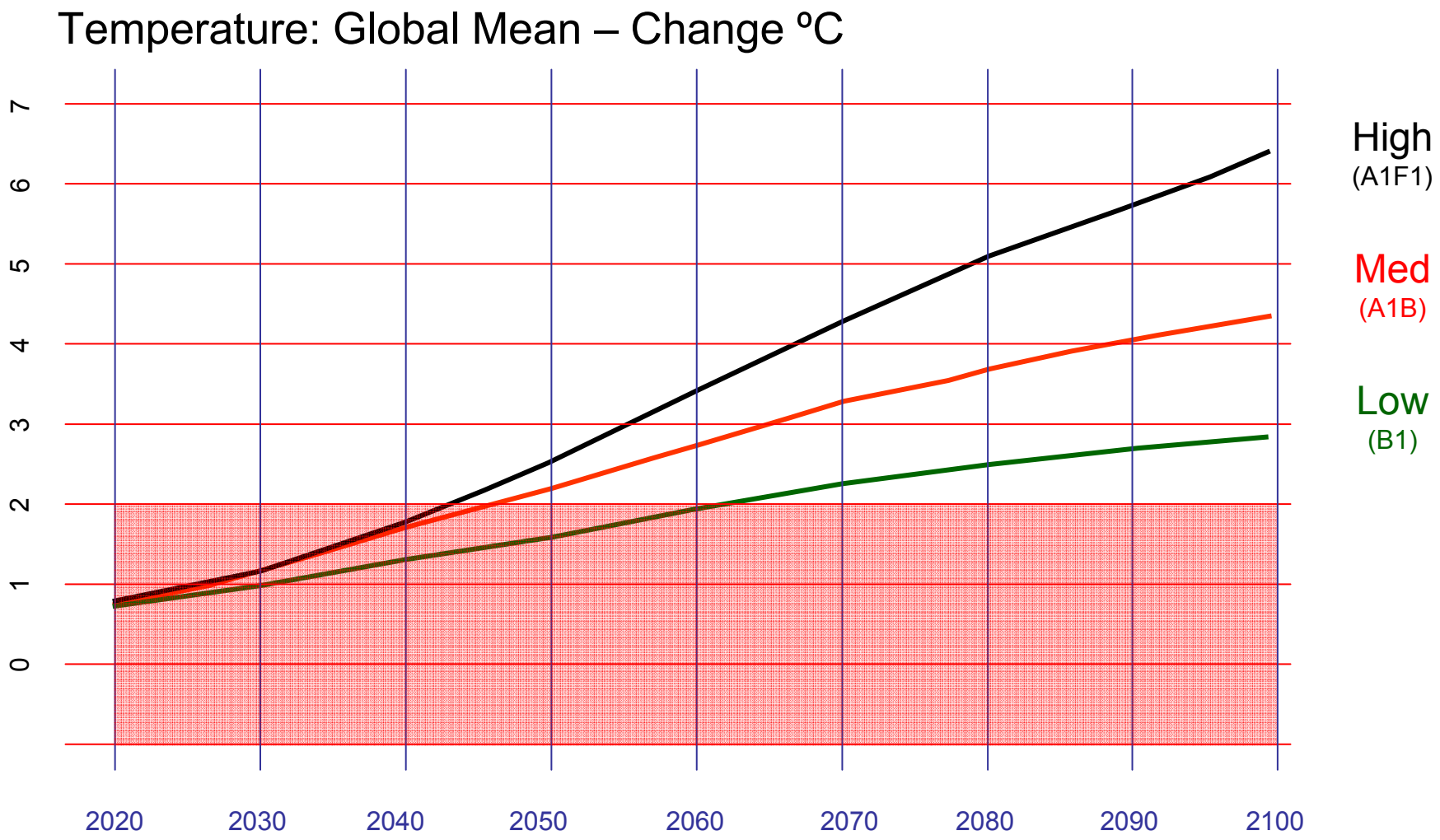
Report Outline

Outline of information available

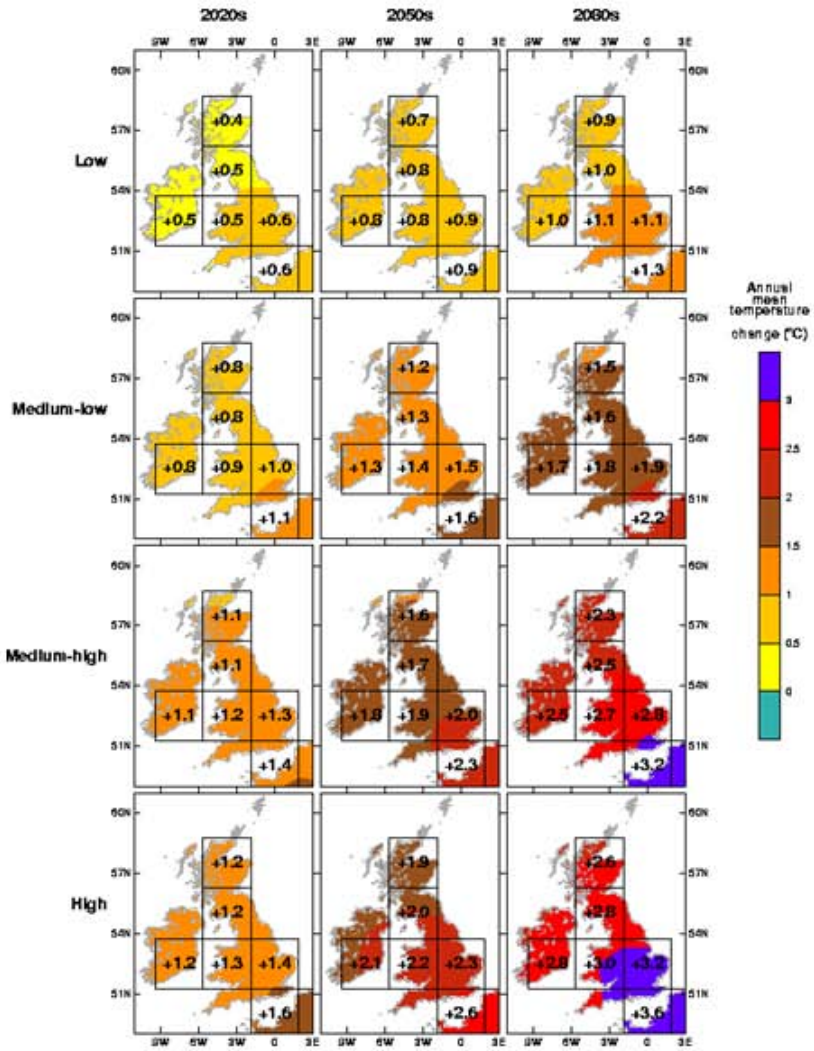
Context for adaptation

Impacts on the industry.


Global GHG Emissions Scenarios: (Gt CO_2 eq/ yr)
160
140
120
100
80
60
40
20
2020
2030
2040
2050
2060
2070
2080
2090
2100
High
(A1F1)
Med
(A1B)
Low
(B1)


Temperature: Global Mean – Change ºC
0
1
2
3
4
5
6
7
2020
2030
2040
2050
2060
2070
2080
2090
2100
High
(A1F1)
Med
(A1B)
Low
(B1)

Facing up to a changing climate



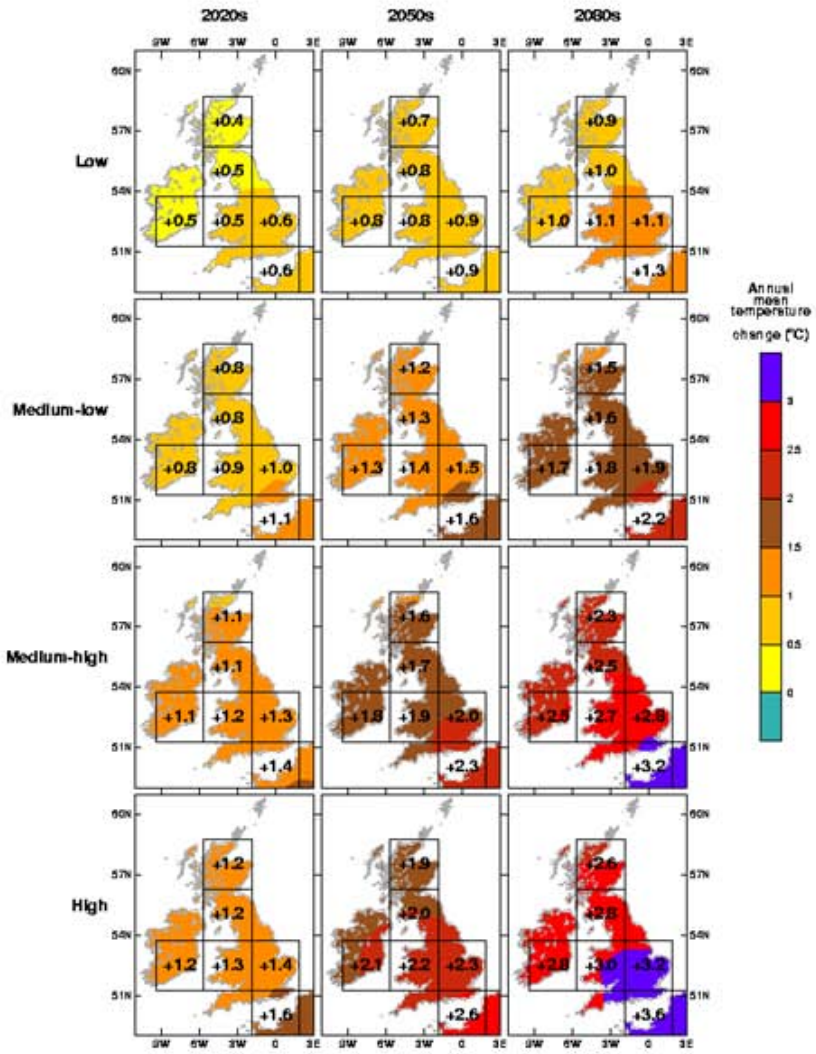
Hotter drier summers

Wetter warmer winters

Extreme events more likely

Sea level rise

Facing up to a changing climate



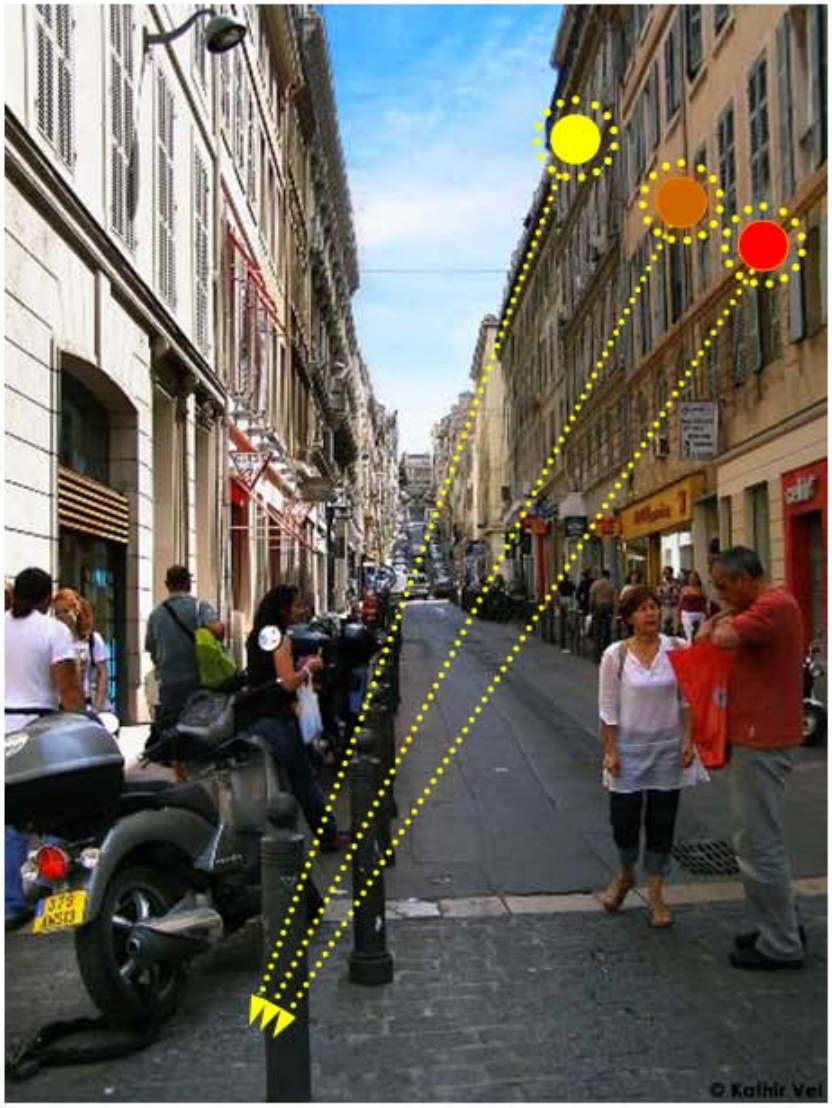
Hotter drier summers

Wetter warmer winters

Extreme events more likely

Sea level rise

Facing up to a changing climate

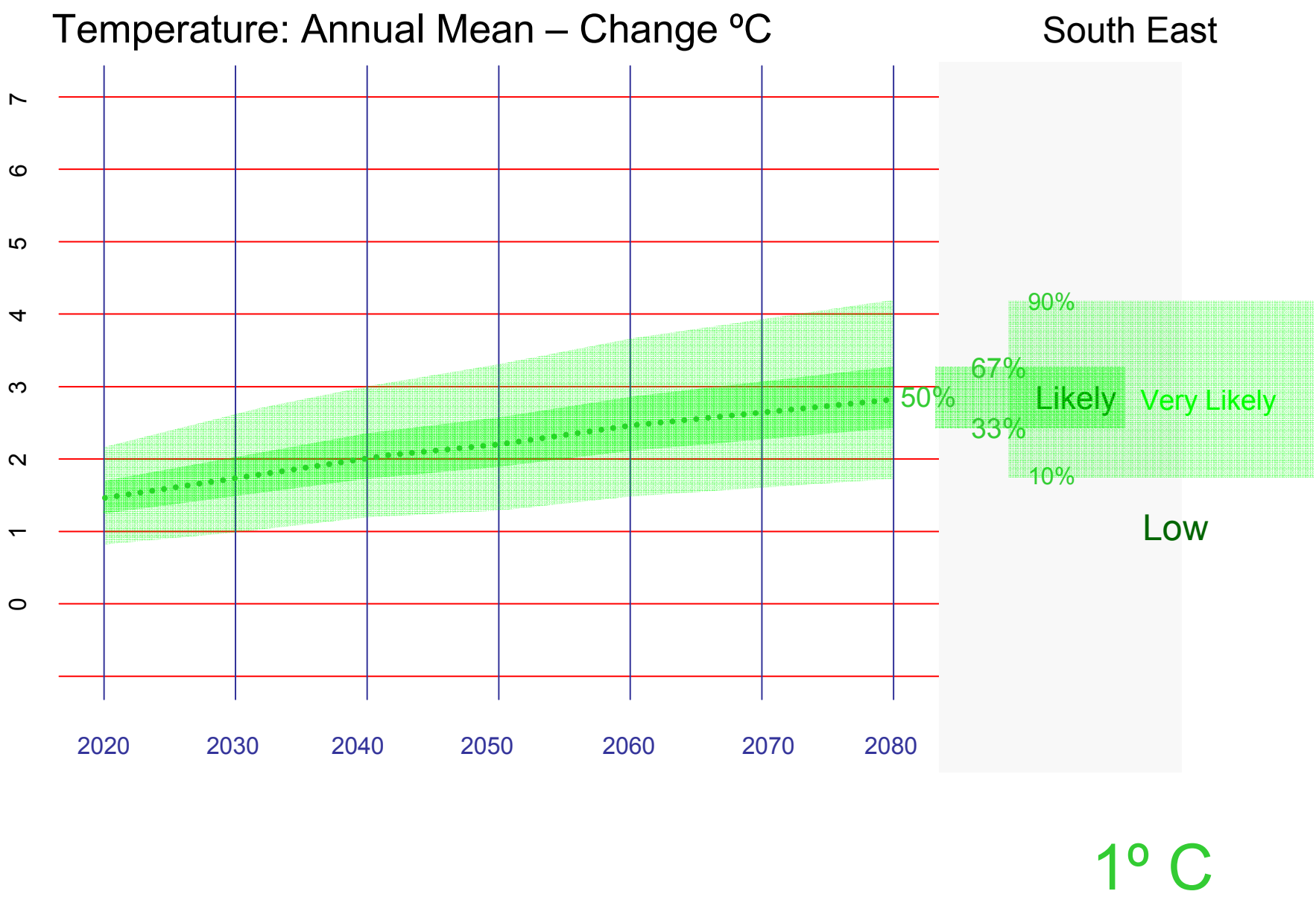


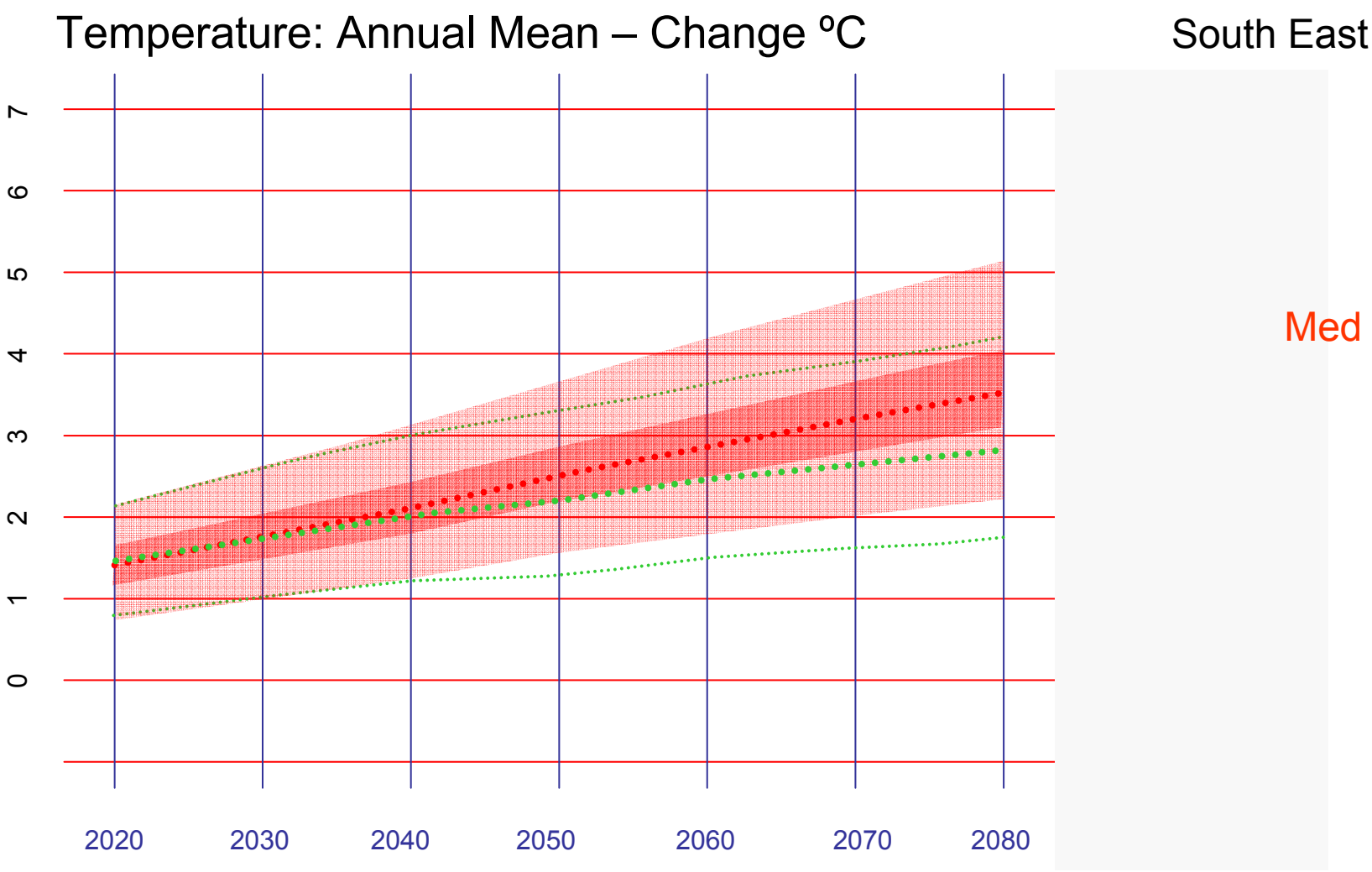
Hotter drier summers

Wetter warmer winters

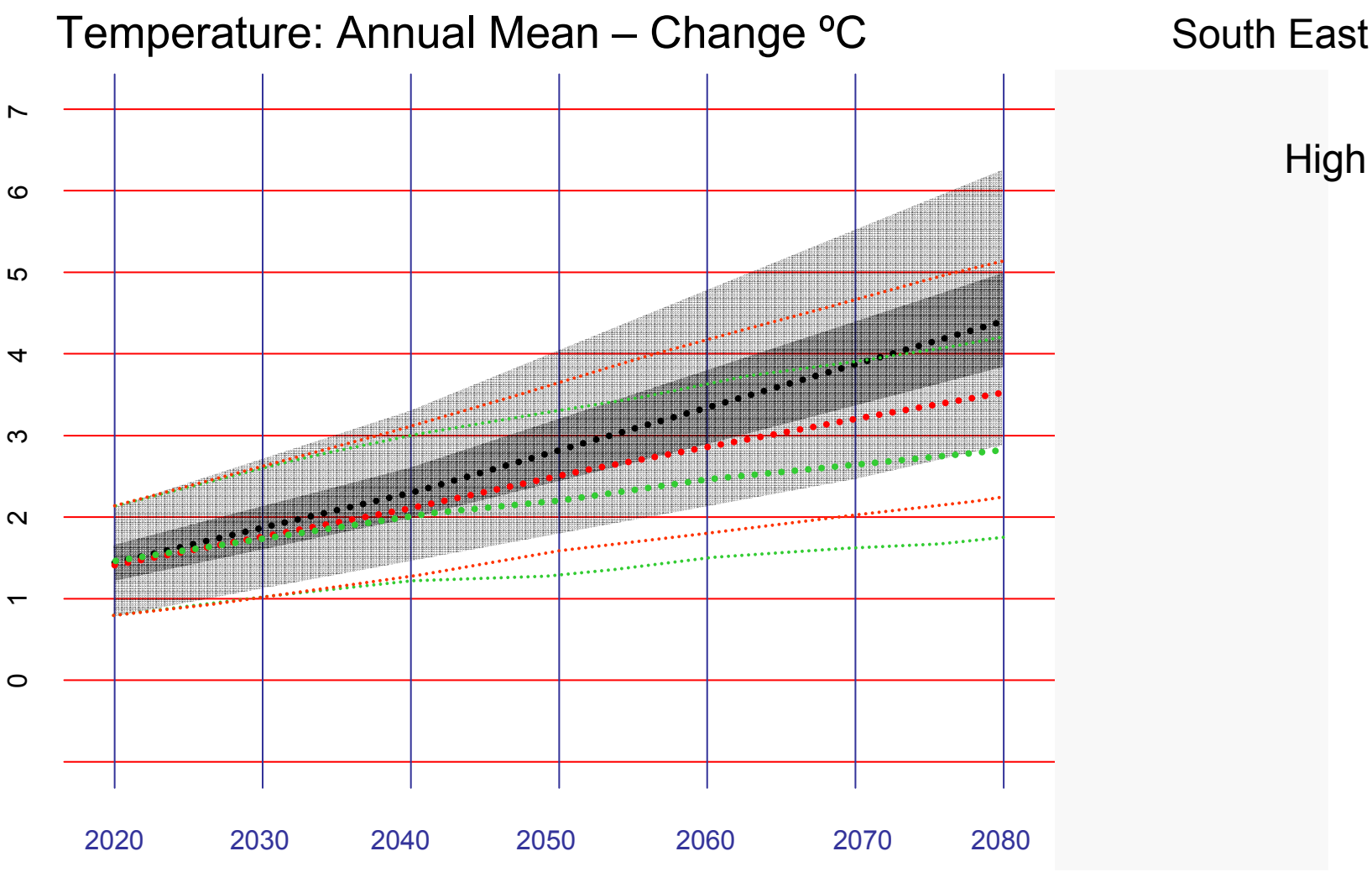
Extreme events more likely

Sea level rise

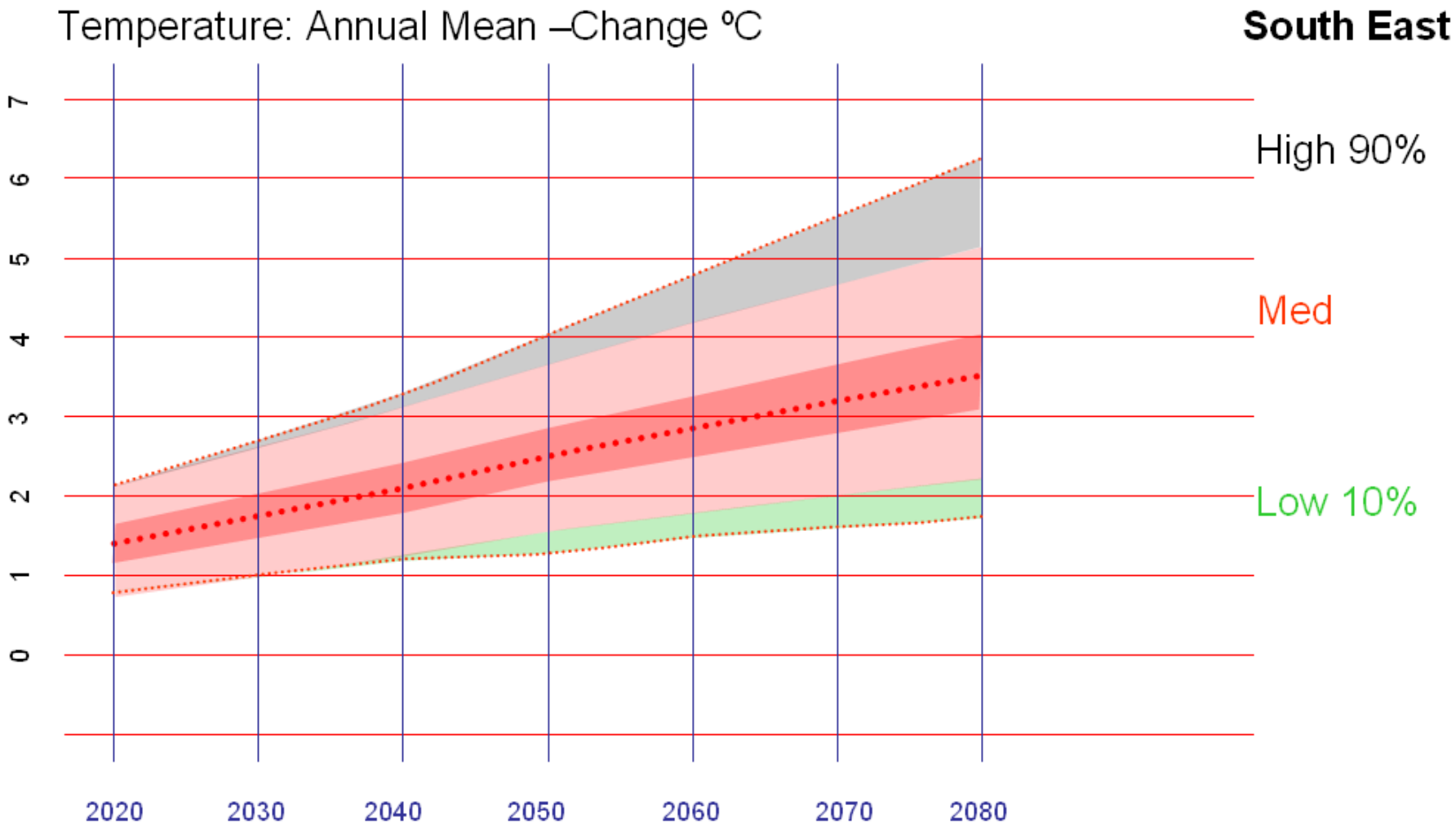

Temperature: Annual Mean – Change ºC
South East
7
6
5
4
3
2
1
0
2020
2030
2040
2050
2060
2070
2080
90%
67%
50%
33%
10%
Likely
Very Likely
Low
1º C

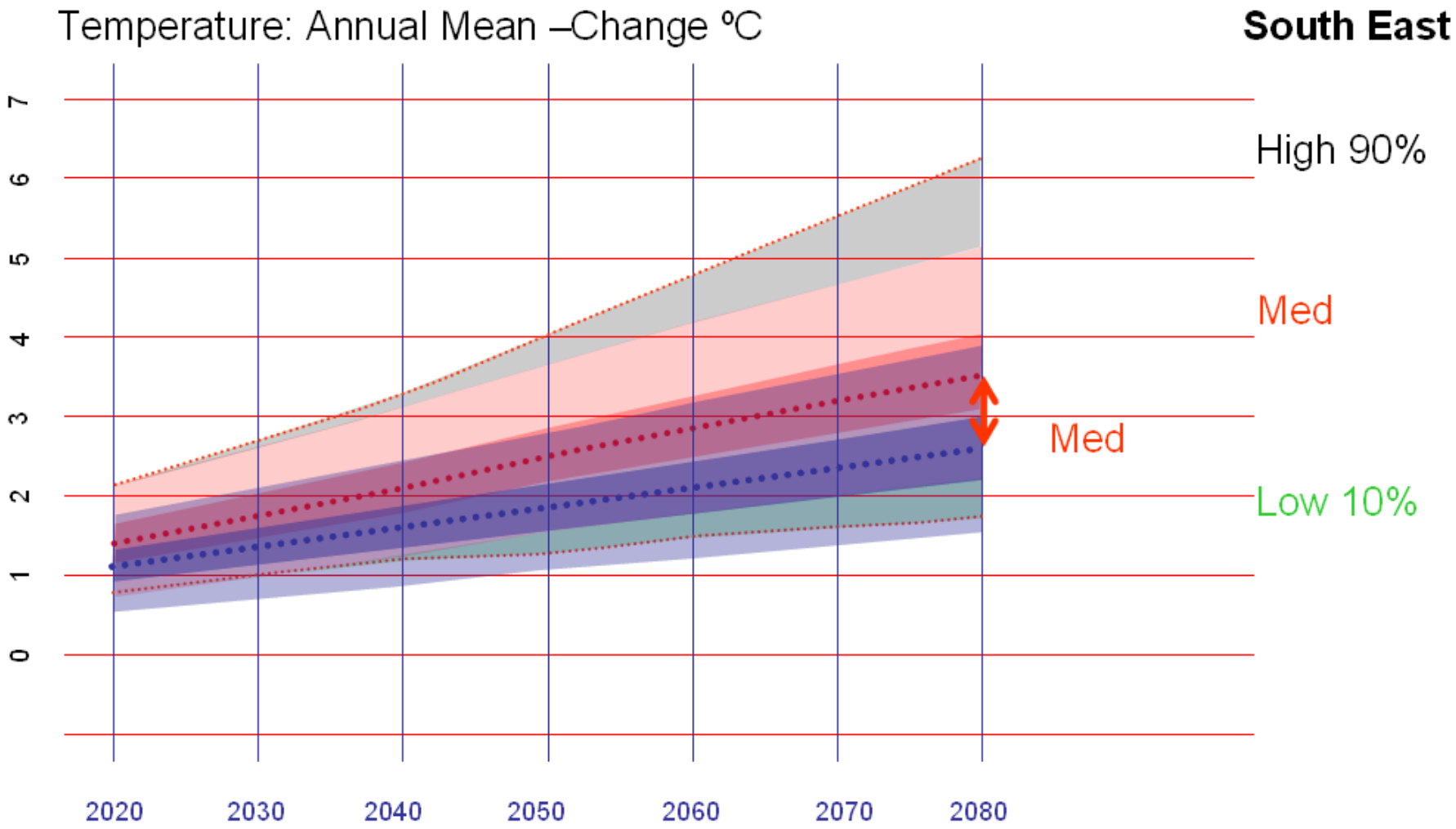

Temperature: Annual Mean – Change ºC
South East
Med
0
1
2
3
4
5
6
7
2020
2030
2040
2050
2060
2070
2080

2º C

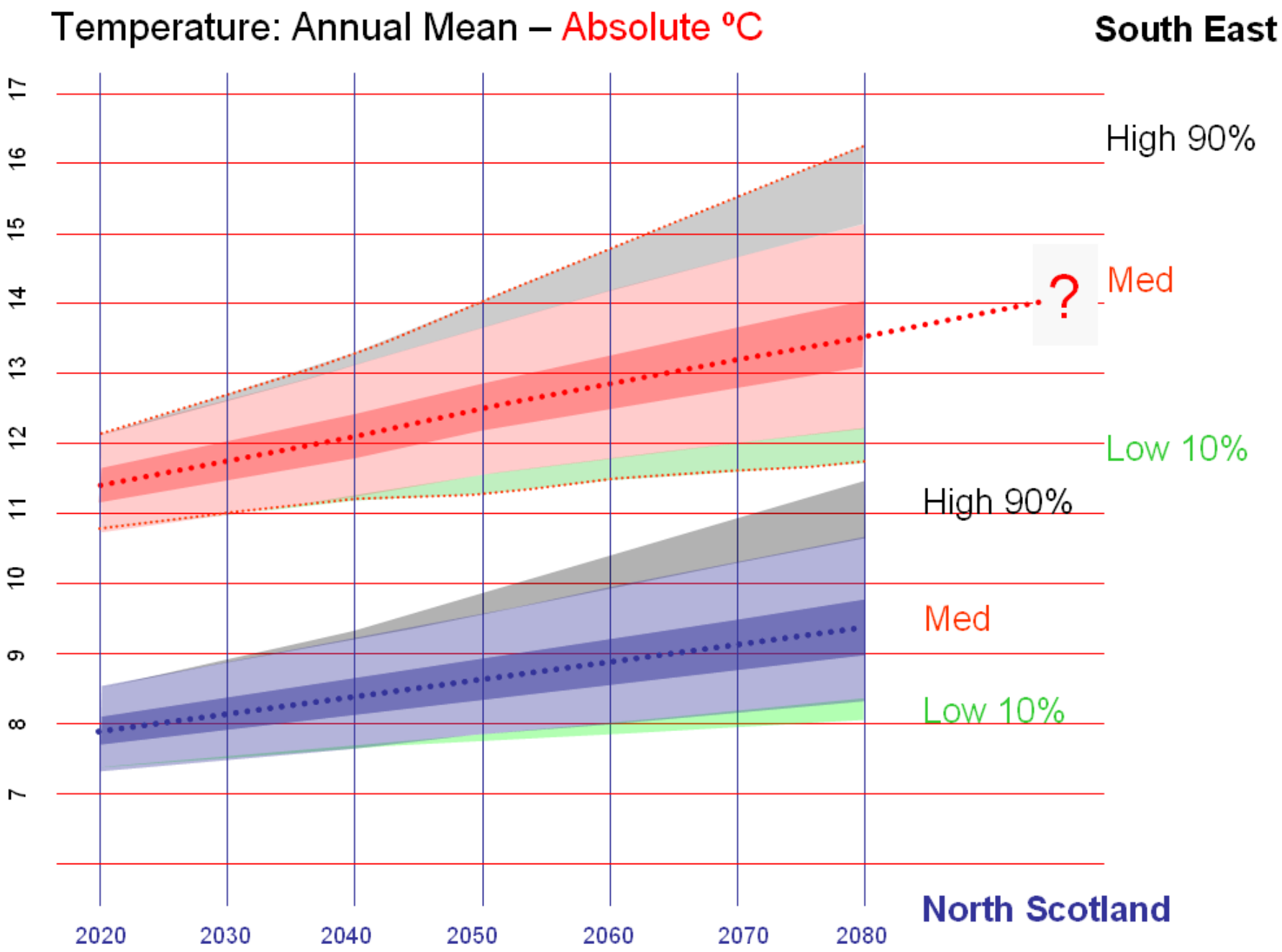

Temperature: Annual Mean – Change ºC
South East
High
0
1
2
3
4
5
6
7
2020
2030
2040
2050
2060
2070
2080

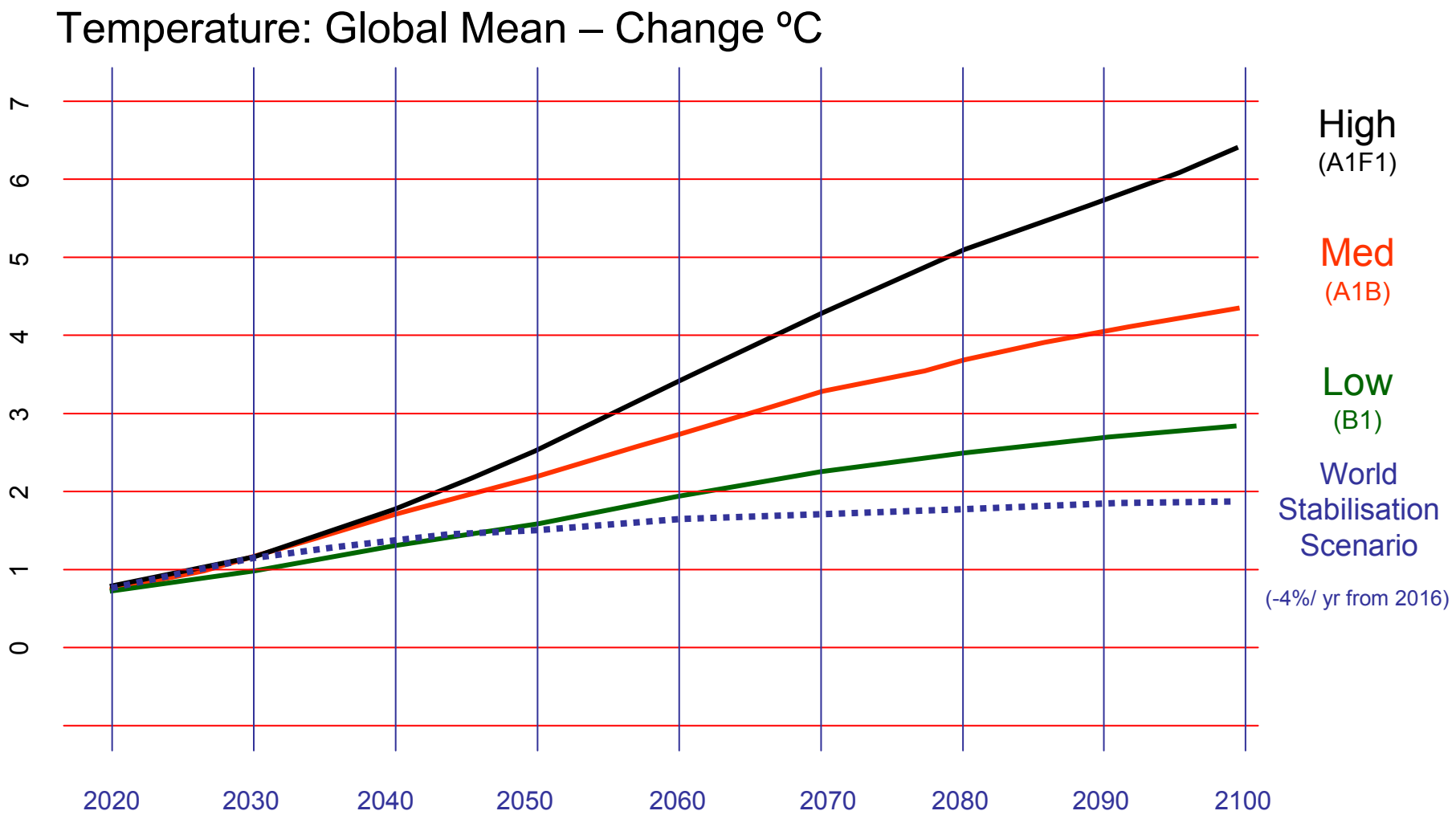
3º C

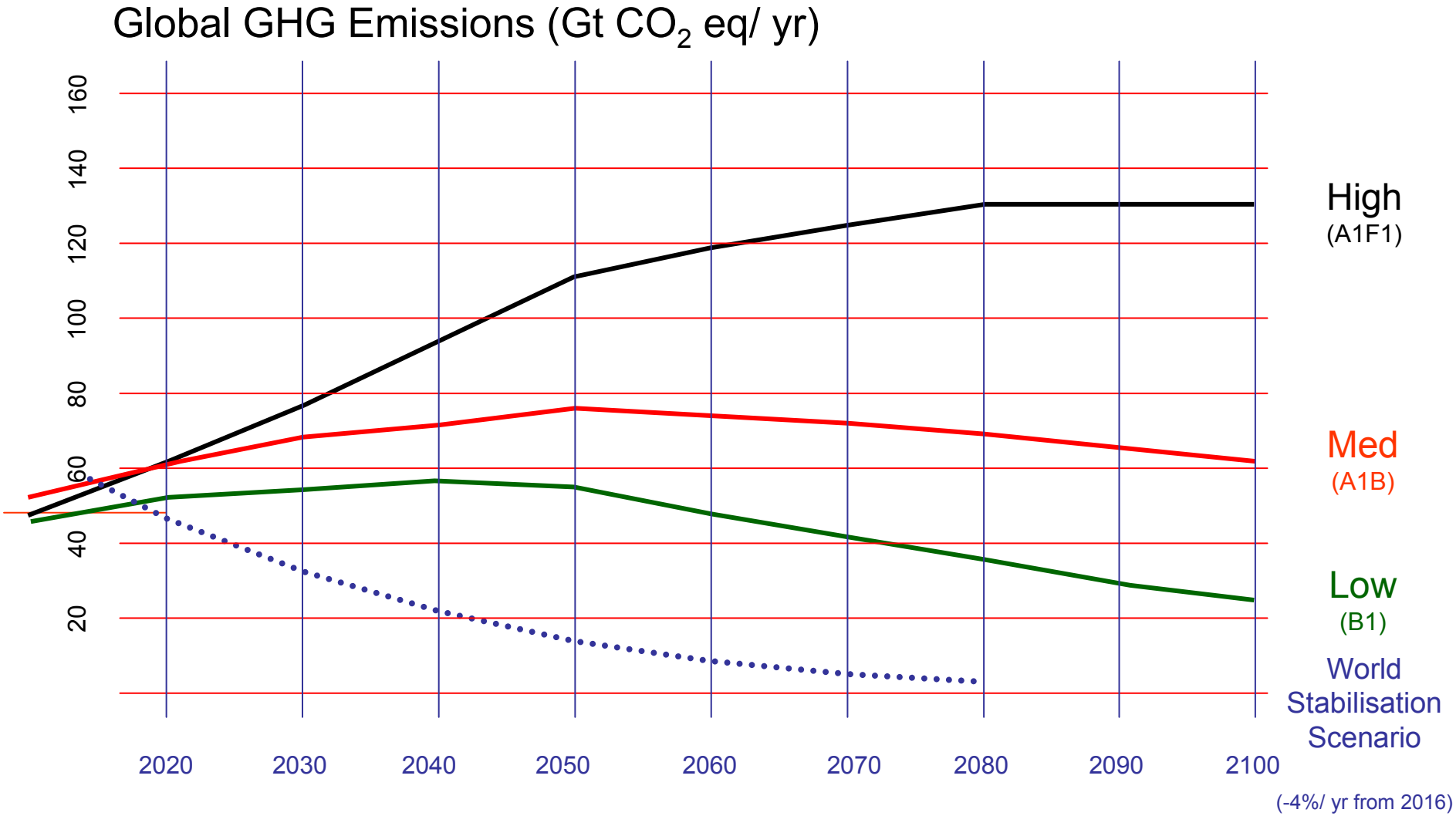

Temperature: Annual Mean –Change ºC
South East
High 90%
Med
Low 10%
0
1
2
3
4
5
6
7
2020
2030
2040
2050
2060
2070
2080

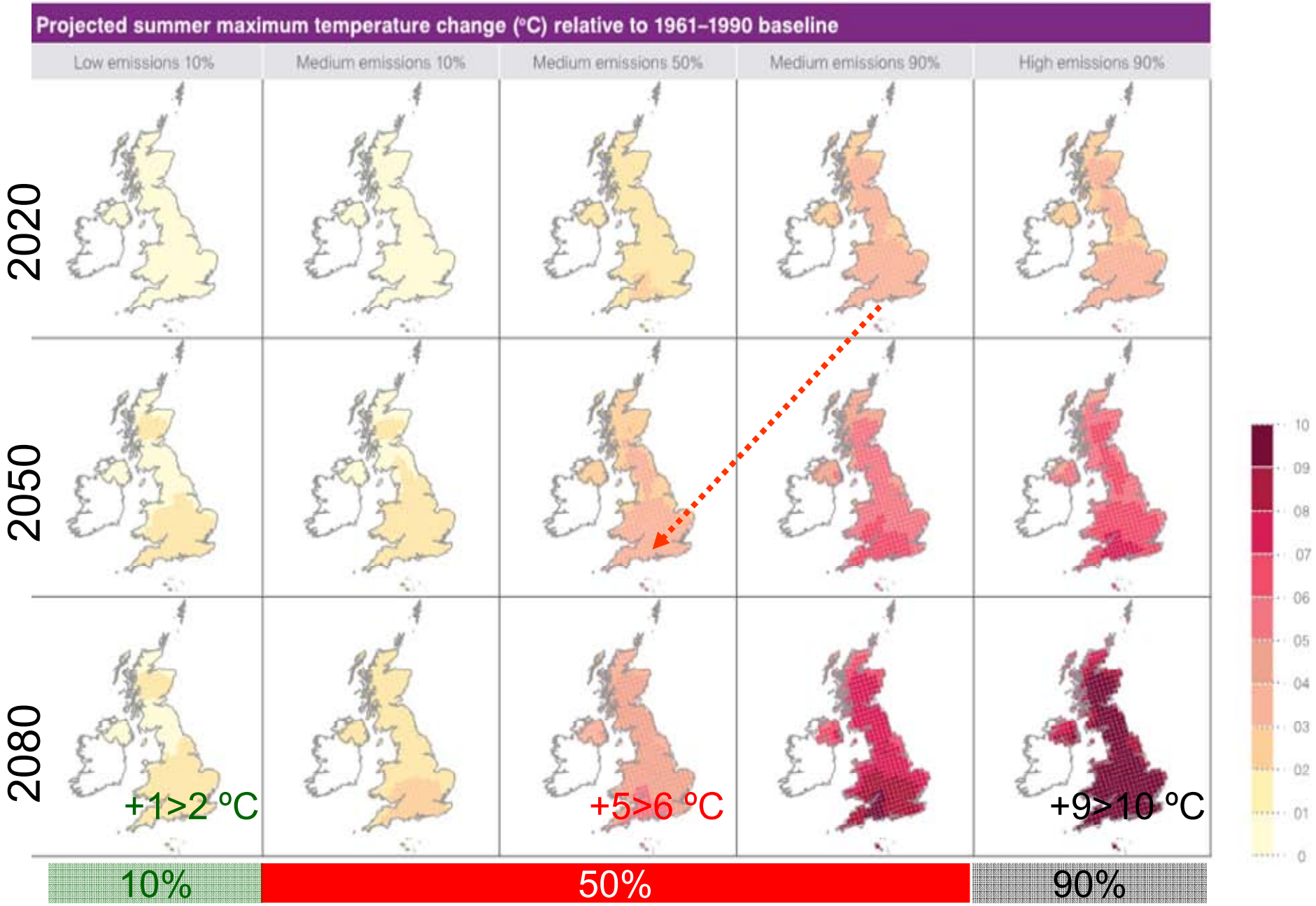


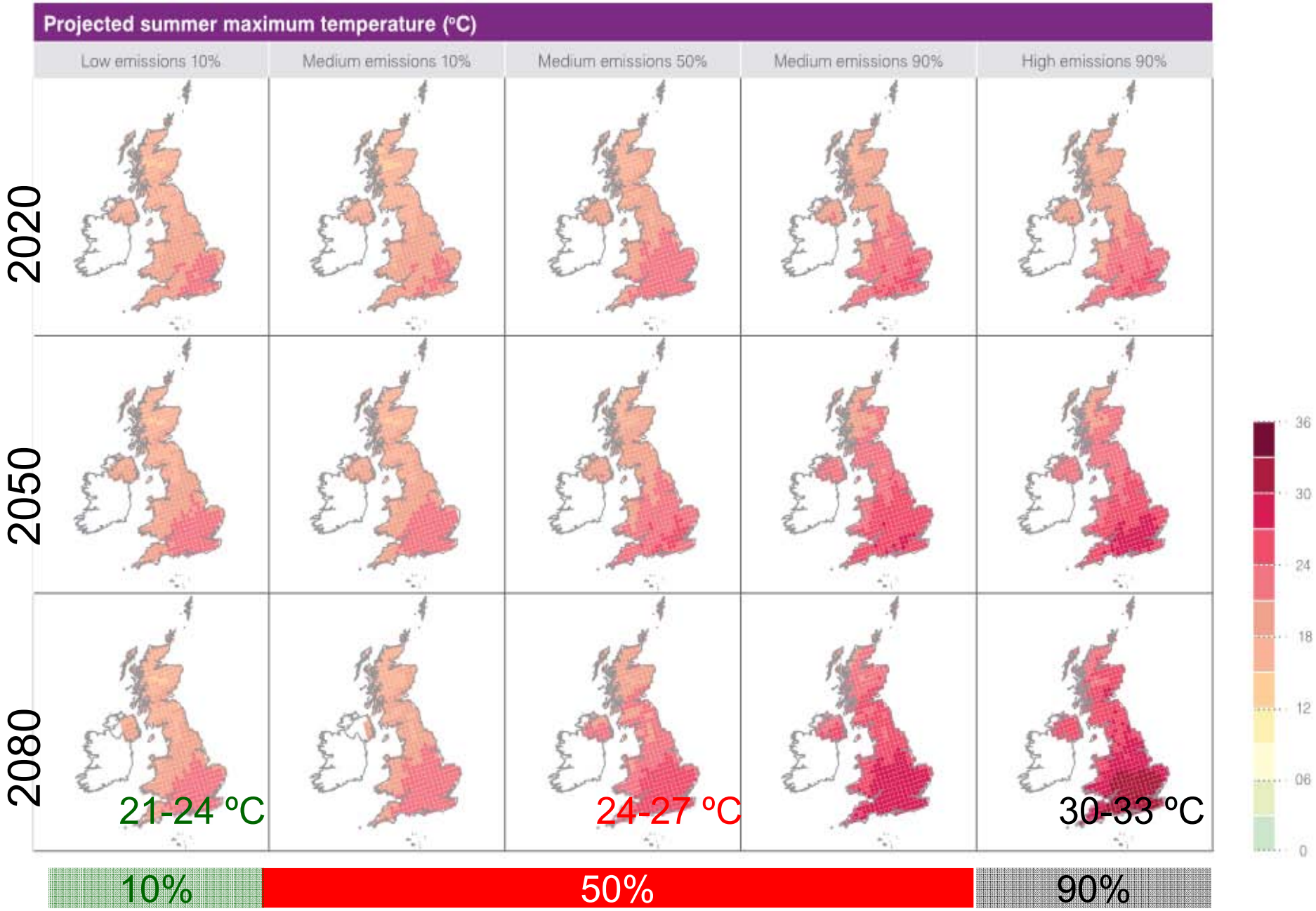
North Scotland

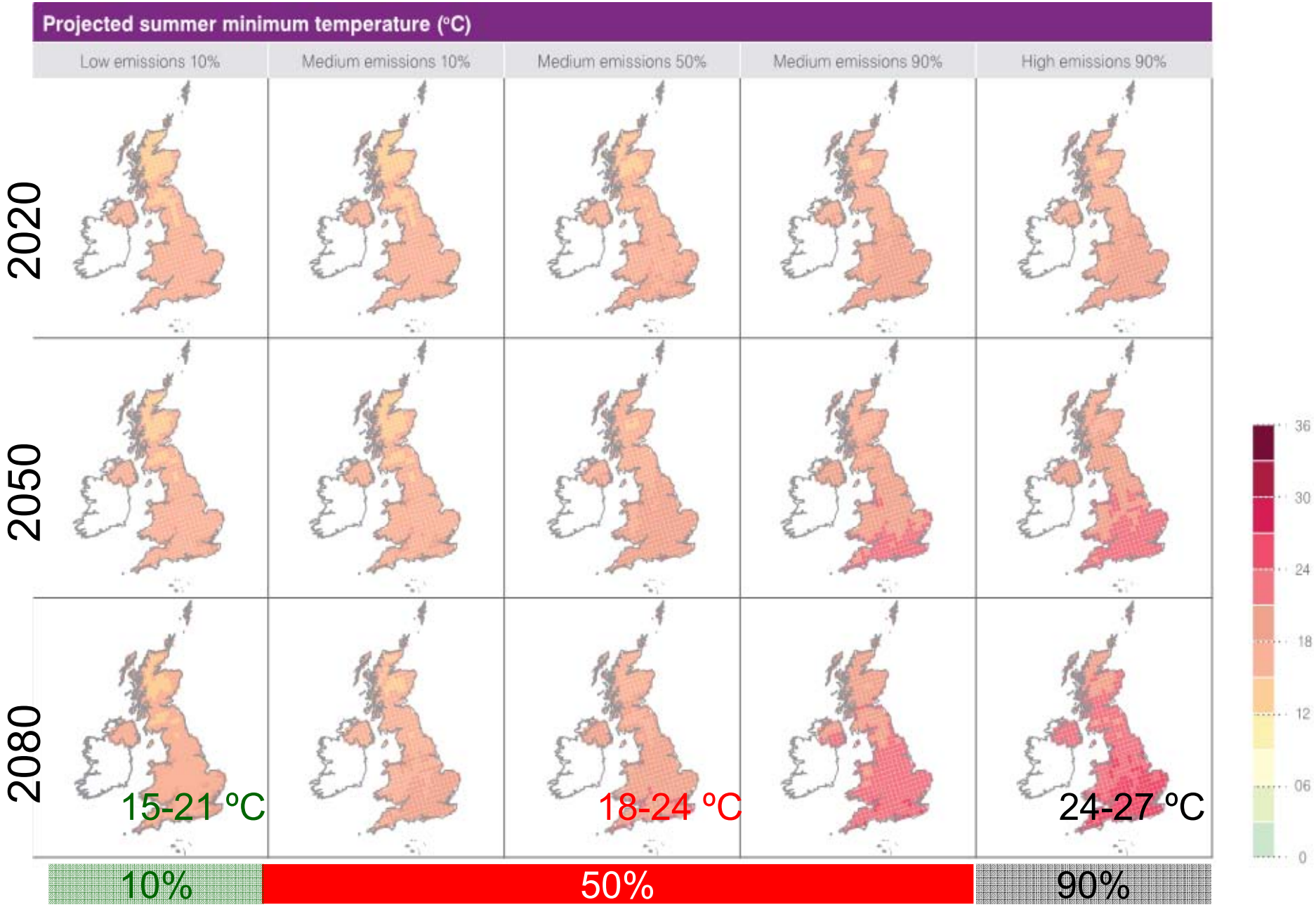

Temperature: Annual Mean – Absolute ºC
South East
17
16
15
14
13
12
11
10
9
8
7
High 90%
Med
?
Low 10%
High 90%
Med
Low 10%
North Scotland
2020
2030
2040
2050
2060
2070
2080


Temperature: Global Mean – Change ºC
0
1
2
3
4
5
6
7
2020
2030
2040
2050
2060
2070
2080
2090
2100
High
(A1F1)
Med
(A1B)
Low
(B1)
World
Stabilisation
Scenario
(-4%/ yr from 2016)


Global GHG Emissions (Gt CO_2 eq/ yr)
160
140
120
100
80
60
40
20
2020
2030
2040
2050
2060
2070
2080
2090
2100
High
(A1F1)
Med
(A1B)
Low
(B1)
World
Stabilisation
Scenario
(-4%/ yr from 2016)


Projected summer maximum temperature change (°C) relative to 1961–1990 baseline
Low emissions 10%
Medium emissions 10%
Medium emissions 50%
Medium emissions 90%
High emissions 90%
2020
2050
2080
+1>2 °C
+5>6 °C
+9>10 °C
10%
50%
90%
10
09
08
07
06
05
04
03
02
01
0


Projected summer maximum temperature (°C)
Low emissions 10%
Medium emissions 10%
Medium emissions 50%
Medium emissions 90%
High emissions 90%
2020
2050
2080
21-24 °C
24-27 °C
30-33 °C
36
30
24
18
12
06
0
10%
50%
90%


Projected summer minimum temperature (°C)
Low emissions 10%
Medium emissions 10%
Medium emissions 50%
Medium emissions 90%
High emissions 90%
2020
2050
2080
15-21 °C
18-24 °C
24-27 °C
10%
50%
90%
36
30
24
18
12
06
0

Precipitation

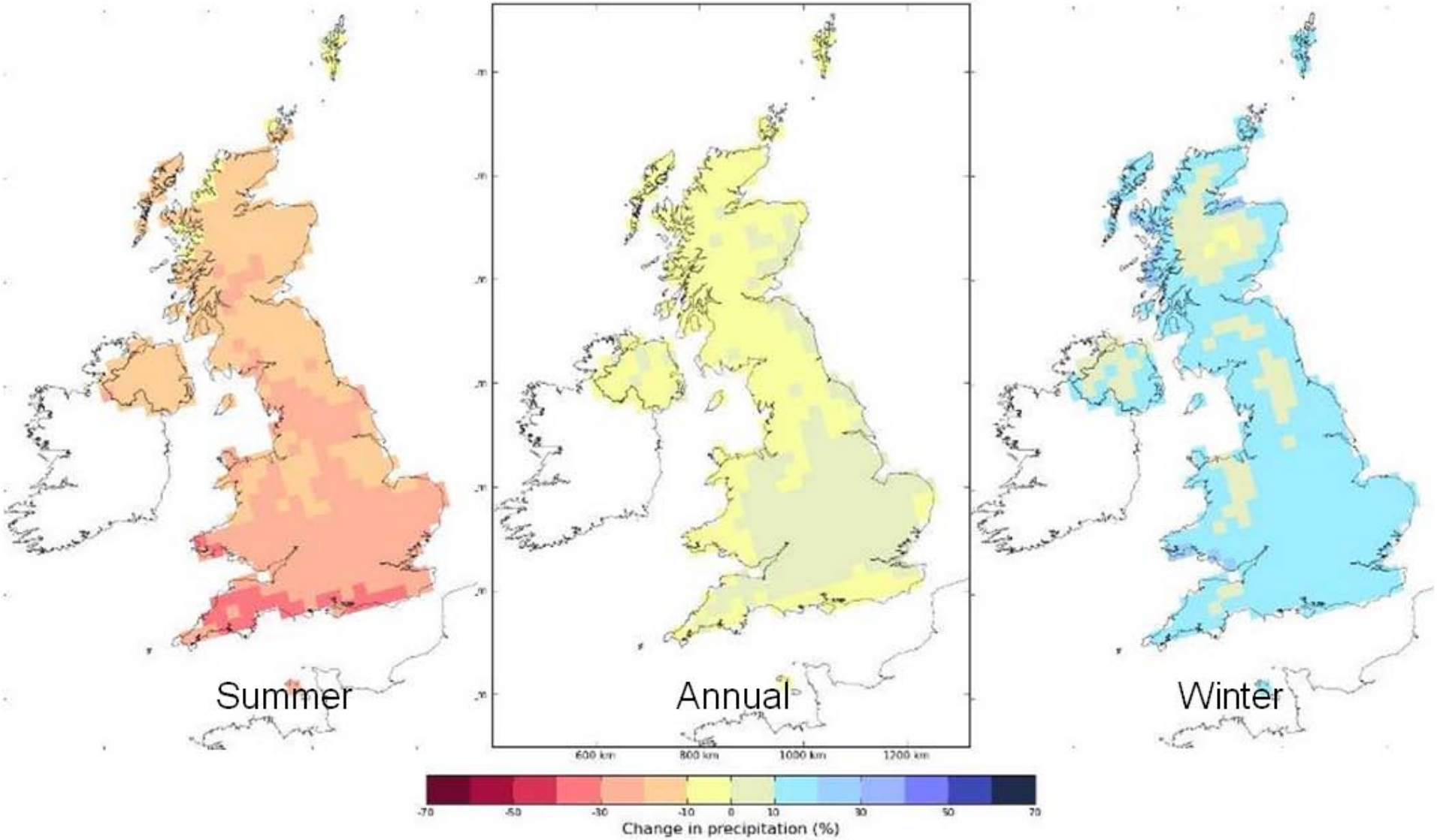
UK CLIMATE PROJECTIONS

Plot Details:

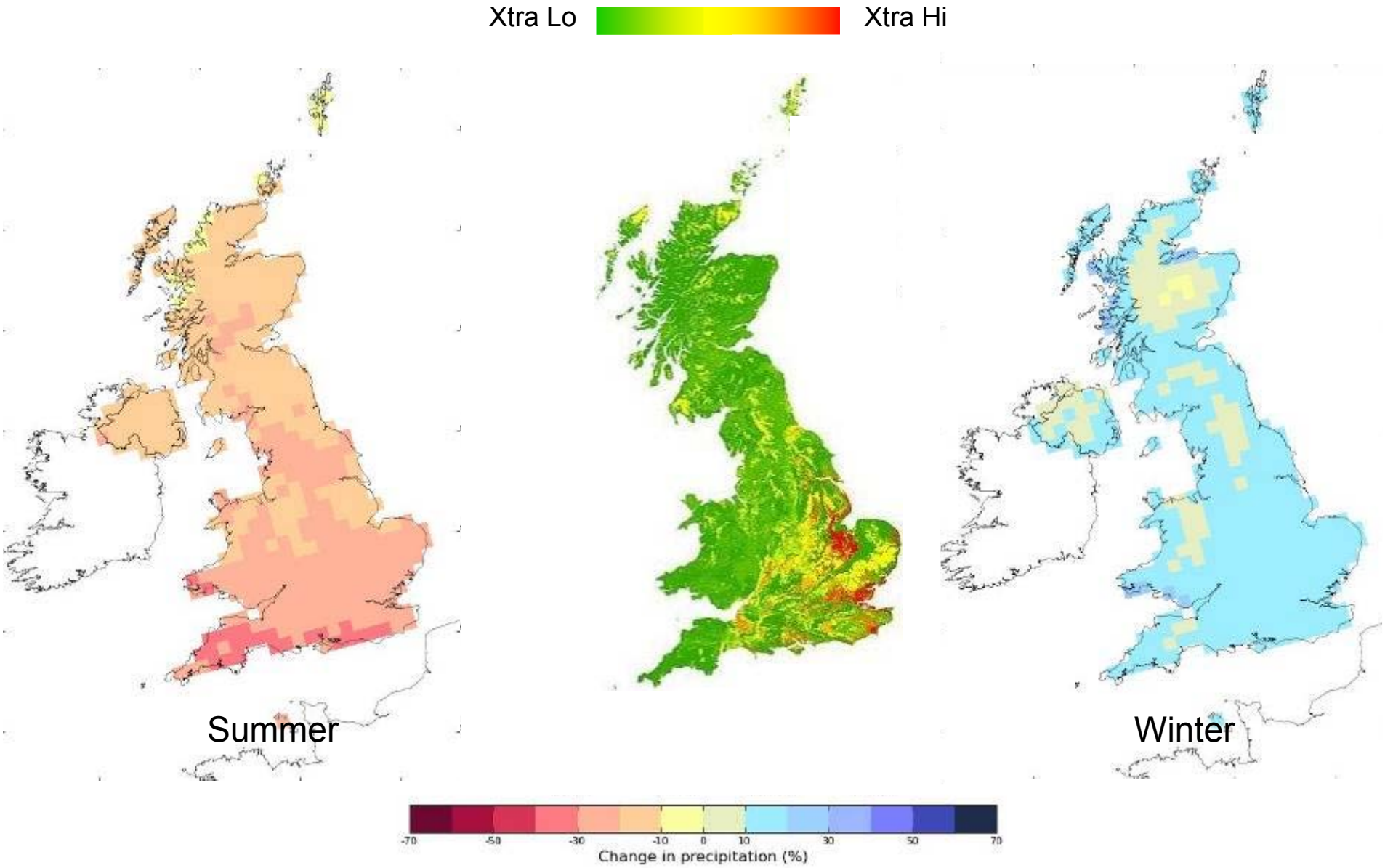
Data Source: Probabilistic Land
Future Climate Change: True
Variables: precip_dmean_tmean_perc
Emissions Scenario: Medium
Time Period: 2040-2069

Temporal Average: ANN
Spatial Average: Grid Box 25Km
Location: -10.00, 48.00, 4.00, 61.00
Percentiles: 50.0
Probability Data Type: cdf

2050s Med 50%



Precipitation + Soil shrinkage



Design agenda:	Comfort Construction Water
Context:	Regional variation + geographic specifics Existing stock Low carbon imperative + infrastructure resilience Robustness/ maintenance Delight.
Tactics:	Behavioural adaptation Timing Scale Competition, consensus and regulation.

Comfort

Designing for comfort

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategies.[1]

Key

Climate trend	Climate information	Time
Hotter, drier summers	P Primary issue	Short – 10 years
Warmer, wetter winters	S Secondary issue	Medium – 25 years
More extreme events		Long – 50 years

Climate	Design opportunities: Keeping cool – building design	Temp – summer mean*	Temp – summer mean max*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean min (night)*	Temp – warmest night of the season*	Temp – winter mean*	Temp – winter extreme, min and max*	Wind – summer mean**	Wind – summer still periods**	Wind – direction**	Wind – summer extreme**	Wind – winter average**	Wind – winter extreme**	Sunshine – average (Weather Generator)**	Rainfall – summer average	Rainfall – summer droughts (Weather Generator)**	Rainfall – summer extreme*	Rainfall – winter average*	Rainfall – winter dry periods (Weather Generator)**	Rainfall – winter extreme*	Time
	Keeping cool - internal																					
	Shading – manufactured	P	P	S	S	S				P	S	S		S	P		S					Short, Medium
	Shading – building form	P	P	S	S	S				P	S	S		S	P		S					Long
	Glass technologies	P	P	S	S	S				P	S	S			P		S					Medium
	Film technologies	P	P	S	S	S				P	S	S			P		S					Short
	Green roofs / transpiration cooling	P	P	S	S	S				P	S	S			P		S					Medium, Long
	Shading – planting	P	P	S	S	S				P	S	S			P		S					Short, Medium, Long
	Reflective materials	P	P	S	S	S				P	S	S			P		S					Short, Medium
	Conflict between maximising daylight and overheating (mitigation vs adaptation)	P	P	S	S	S				P	S	S			P		S					Short, Medium, Long
	Secure and bug free night ventilation	P	P	P	P	P				P	S	S			P		S					Short, Medium
	Interrelationship with noise and air pollution	P	P	P	P	P				P	S	S			P		S					Medium, Long
	Interrelationship with ceiling height	P	P	P	P	P				P	S	S			P		S					Medium, Long
	Role of thermal mass in significantly warmer climate	P	P	P	P	P				P	S	S			P		S					Long
	Enhancing thermal mass in lightweight construction	P	P	P	P	P				P	S	S			P		S					Medium, Long
	Energy efficient / renewable powered cooling systems	P	P	P	P	P				P	S	S			P		S					Medium
	Groundwater cooling	P	P	S	S	S				P	S	S			P	S	S		P			Medium
	Enhanced control systems – peak lopping	P	P	S	S	S				P	S	S			P		S					Short, Medium
	Maximum temperature legislation	P	P	P	P	P				P	S	S			P		S					Medium, Long

Climate	Design opportunities: Keeping cool – external spaces	Temp – summer mean*	Temp – summer mean max*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean min (night)*	Temp – warmest night of the season*	Temp – winter mean*	Temp – winter extreme, min and max*	Wind – summer mean**	Wind – summer still periods**	Wind – direction**	Wind – summer extreme**	Wind – winter average**	Wind – winter extreme**	Sunshine – average (Weather Generator)**	Rainfall – summer average	Rainfall – summer droughts (Weather Generator)**	Rainfall – summer extreme*	Rainfall – winter average*	Rainfall – winter dry periods (Weather Generator)**	Rainfall – winter extreme*	Time
	Keeping cool - external																					
	Built form – building to building shading	P	P	S	S	S				P	S	S			P		P					Long
	Access to external spaces	P	P	S	S	S				P	S	S			P		P					Long
	Shade from planting	P	P	S	S	S				P	S	S			P		P					Short, Medium, Long
	Manufactured shading	P	P	S	S	S				P	S	S		S	P		P					Short, Medium
	Interrelationship with renewables	P	P	S	S	S				P	S	S			P		P					Medium
	Shading parking / transport infrastructure	P	P	S	S	S				P	S	S			P		P					Short, Medium
	Role of water – landscape / swimming pools	P	P	S	S	S				P	S	S			P		P				S	Medium, Long

Climate	Design issue and opportunities: Keeping warm	Temp – summer mean*	Temp – summer mean max*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean min (night)*	Temp – warmest night of the season*	Temp – winter mean*	Temp – winter extreme, min and max*	Wind – summer mean**	Wind – summer still periods**	Wind – direction**	Wind – summer extreme**	Wind – winter average**	Wind – winter extreme**	Sunshine – average (Weather Generator)**	Rainfall – summer average	Rainfall – summer droughts (Weather Generator)**	Rainfall – summer extreme*	Rainfall – winter average*	Rainfall – winter dry periods (Weather Generator)**	Rainfall – winter extreme*	Time
	Keeping warm																					
	Building fabric insulation standards						P	P					S	S	P							Medium, Long
	Relevance of heat recovery systems						P	P					S	S	P							Medium
	Heating appliance design						P	P					S	S	P							Short, Medium

Comfort

Designing for comfort

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategies.

Key

Climate trend	Climate information	Time
Hotter, drier summers	P Primary issue	Short – 10 years
Warmer, wetter winters	S Secondary issue	Medium – 25 years
More extreme events		Long – 50 years

Climate	Design opportunities: Keeping cool – building design	Climate information	Time
	Shading – manufactured		
	Shading – building fo		
	Glass technologies		
	Film technologies		
	Green roofs / transpiration cooling		
	Shading – planting		
	Reflective materials		
	Conflict between maximising daylight and overheating (mitigation vs adaptation)		
	Secure and bug free night ventilation		
	Interrelationship with noise and air pollution		
	Interrelationship with ceiling height		
	Role of thermal mass in significantly warmer climate		
	Enhancing thermal mass in lightweight construction		
	Energy efficient / renewable powered cooling systems		
	Groundwater cooling		
	Enhanced control systems – peak lopping		
	Maximum temperature legislation		
Cli	**Design opportunities: Keeping cool – external spaces**	Climate information	Time
	Built form – building to building shading		
	Access to external s		
	Shade from planting		
	Manufactured shading		
	Interrelationship with renewables		
	Shading parking / transport infrastructure		
	Role of water – landscape / swimming pools		
Clim	**Design issue and opportunities: Keeping warm**	Climate information	Tim
	Building fabric insulation standards		
	Relevance of heat re		
	Heating appliance de		

Keeping cool - internal

Keeping cool - external

Keeping warm

Climate headlines

Climate issues & information

Timescale

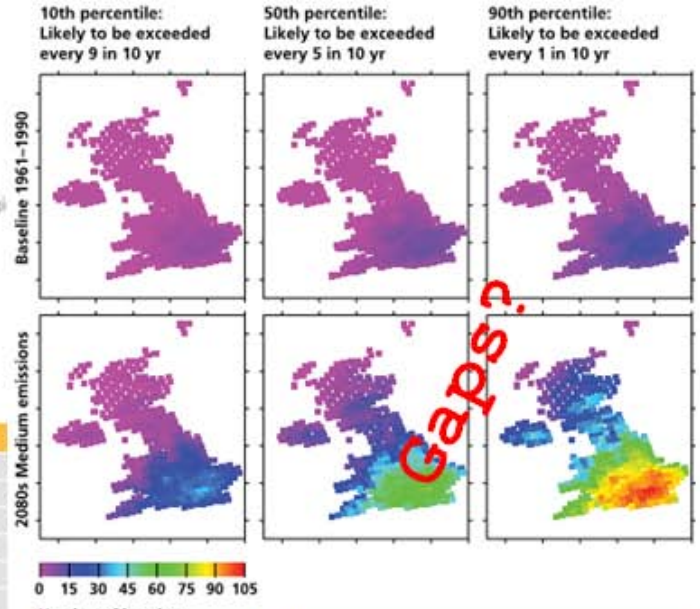
Comfort

Designing for comfort

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategi

Key

Climate trend	Climate information	Time
Hotter, drier summers	P Primary issue	Short – 10 years
Warmer, wetter winters	S Secondary issue	Medium – 25 years
More extreme events		Long – 50 years



Gaps?

Climate headlines

Climate issues & informati

Timescale

Climate	Design opportunities: Keeping cool – building design	Climate information	Time
	Shading – manufactured		
	Shading – building fa		
	Glass technologies		
	Film technologies		
	Green roofs / transpiration cooling		
	Shading – planting		
	Reflective materials		
	Conflict between maximising daylight and overheating (mitigation vs adaptation)		
	Secure and bug free night ventilation		
	Interrelationship with noise and air pollution		
	Interrelationship with ceiling height		
	Role of thermal mass in significantly warmer climate		
	Enhancing thermal mass in lightweight construction		
	Energy efficient / renewable powered cooling systems		
	Groundwater cooling		
	Enhanced control systems – peak lopping		
	Maximum temperature legislation		
Cli	**Design opportunities: Keeping cool – external spaces**	Climate information	Time
	Built form – building to building shading		
	Access to external sp		
	Shade from planting		
	Manufactured shading		
	Interrelationship with renewables		
	Shading parking / transport infrastructure		
	Role of water – landscape / swimming pools		
Clim	**Design issue and opportunities: Keeping warm**	Climate information	Tim
	Building fabric insulation standards		
	Relevance of heat re		
	Heating appliance de		

Keeping cool - internal

Keeping cool - external

Keeping warm

Comfort

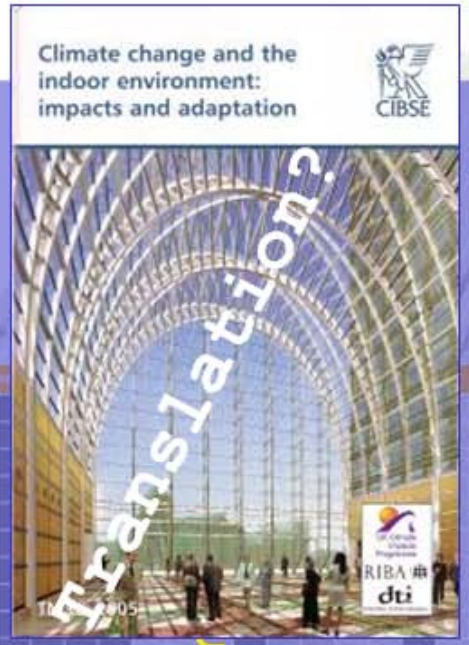
Designing for comfort

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategies.

Key

Climate trend	Climate information	Time
Hotter, drier summers	P Primary issue	Short – 10 years
Warmer, wetter winters	S Secondary issue	Medium – 25 years
More extreme events		Long – 50 years

Climate	Design opportunities: Keeping cool – building design	Climate information	Time
	Shading – manufactured		
	Shading – building form		
	Glass technologies		
	Film technologies		
	Green roofs / transpiration cooling		
	Shading – planting		
	Reflective materials		
	Conflict between maximising daylight and overheating (mitigation vs adaptation)		
	Secure and bug free night ventilation		
	Interrelationship with noise and air pollution		
	Interrelationship with ceiling height		
	Role of thermal mass in significantly warmer climate		
	Enhancing thermal mass in lightweight construction		
	Energy efficient / renewable powered cooling systems		
	Groundwater cooling		
	Enhanced control systems – peak lopping		
	Maximum temperature legislation		
	Design opportunities: Keeping cool – external spaces	**Climate information**	**Time**
	Built form – building to building shading		
	Access to external spaces		
	Shade from planting		
	Manufactured shading		
	Interrelationship with renewables		
	Shading parking / transport infrastructure		
	Role of water – landscape / swimming pools		
	Design issue and opportunities: Keeping warm	**Climate information**	**Time**
	Building fabric insulation standards		
	Relevance of heat recovery ventilation		
	Heating appliance design		



Keeping cool - internal

Keeping cool - external

Keeping warm

Climate headlines

Climate issues & inform

Timescale

Construction

Designing for construction

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategies.[1]

Key

Climate trend	Climate information	Time
Hotter, drier summers	P Primary issue	Short – 10 years
Warmer, wetter winters	S Secondary issue	Medium – 25 years
More extreme events		Long – 50 years

Temp – summer mean* | Temp – summer mean max* | Temp – duration of hot periods (Weather Generator)** | Temp – summer mean min (night)* | Temp – warmest night of the season* | Temp – winter mean* | Temp – winter extremes, min and max* | Wind – summer mean** | Wind – summer still periods** | Wind – direction** | Wind – summer extremes** | Wind – winter average** | Wind – winter extremes** | Sunshine – average (Weather Generator)** | Rainfall – summer average* | Rainfall – summer droughts (Weather Generator)** | Rainfall – summer extremes* | Rainfall – winter average* | Rainfall – winter wet periods (Weather Generator)** | Rainfall – winter extremes*

Climate	Structural stability – below ground	Climate information																									Time
	Foundation design – subsidence / heave / soils / regions													S		P	P	S	S	S	S						
	Underpinning													S		P	P	S	S	S	S						
	Retaining wall and slope stability															P	P	S	P	P	P						

Stability –above ground

Climate	Structural stability – above ground	Climate information																									Time
	Lateral stability – wind / [illegible]													P													
	Loading from ponding													S					S	P	P						

Stability –below ground

Climate	Fixings and weatherproofing	Climate information																									Time
	Fixing standards – walls, roofs													P												P	
	Detail designs for extremes – [illegible] approach													P												P	
	Lightning strikes (storms [illegible])												P	P				P								P	
	Tanking / underground tanks in relation to water table – contamination, buoyancy, pressure																		P	P	P						
	Detail design for extremes – rain – thresholds / joints													P							S	P					

Fixings and weatherproofing

Climate	Materials behaviour	Climate information																									Time
	Effect of extended wetting – permeability, rotting, weight														S				P	P	P						
	Effect of extended heat – [illegible]	S	P	P	S										P												
	Performance in extremes – [illegible]																	S	S	S	P						
	Performance in extremes – rain																		S	P	P						

Materials behaviour

Climate	Work on site	Climate information																									Time
	Temperature limitations for building processes		P	P	S	S									P												
	Stability during construction													P								S					
	Inclement winter weather [illegible]																		P	P	P						
	Working conditions – site accommodation	S	P	P	S	S				S				S	P							S					
	Working conditions – informal conditions in incomplete / unserviced buildings (overlap with robustness in use)	S	P	P	S	S				S					P												

Work on site

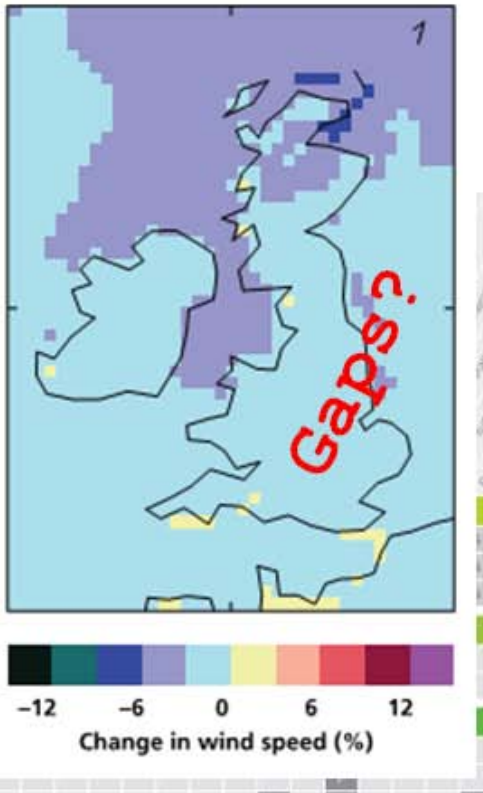
Construction

Designing for construction

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategies.[1]

Key

Climate trend	Climate information	Time
Hotter, drier summers	P Primary issue	Short – 10 years
Warmer, wetter winters	S Secondary issue	Medium – 25 years
More extreme events		Long – 50 years



Stability –above ground

Stability –below ground

Fixings and weatherproofing

Materials behaviour

Work on site

Construction

Designing for construction

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategies.[1]

Key

Climate trend	Climate information	Time
Hotter, drier summers	P Primary issue	Short - 10 years
Warmer, wetter winters	S Secondary issue	Medium - 25 years
More extreme events		Long - 50 years

Stability –above ground

Stability –below ground

Fixings and weatherproofing

Materials behaviour

Work on site

BSi

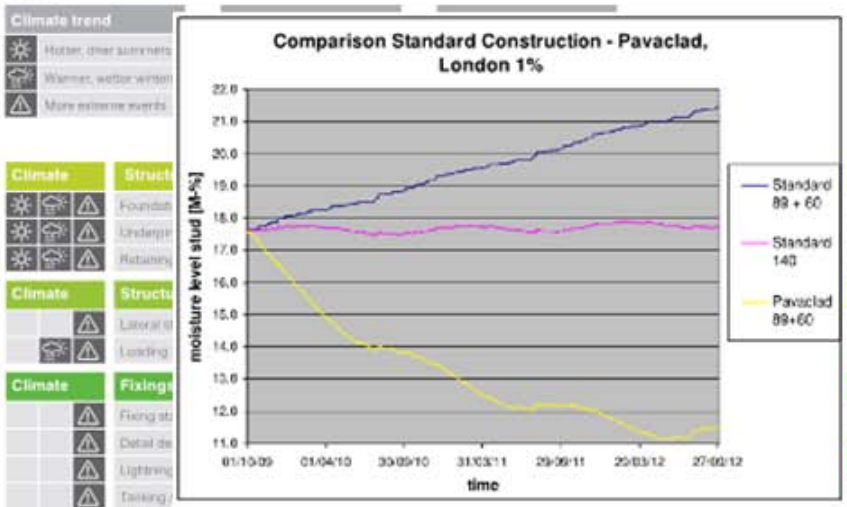
ABI Association of British Insurers

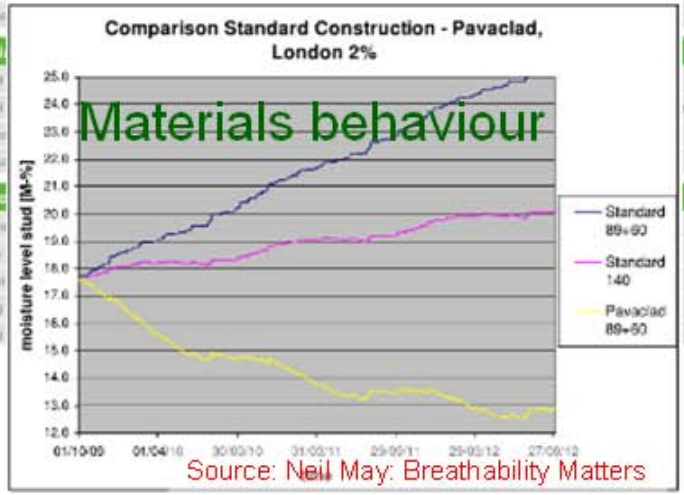
Construction

Designing for construction

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategies.[1]

Key





Materials behaviour

Source: Neil May: Breathability Matters

Gaps?

ing

BSi

ABI Association of British Insurers

Water

Designing to manage water

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategies.*

Key

Climate trend	Climate information	Time
Hotter, drier summers	P – Primary issue	Short – 10 years
Warmer, wetter winters	S – Secondary issue	Medium – 25 years
More extreme events		Long – 50 years

Climate	Water conservation	Temp – summer mean*	Temp – summer max mean*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean, min (night)*	Temp – winter mean*	Temp – winter extremes, min and max*	Wind – summer mean**	Wind – summer gust periods**	Wind – direction**	Wind – summer extremes**	Wind – winter average**	Wind – winter extremes**	Sunshine – average (Weather Generator)**	Rainfall – summer average*	Rainfall – summer drought (Weather Generator)**	Rainfall – summer extremes*	Rainfall – winter average*	Rainfall – winter wet periods (Weather Generator)**	Rainfall – winter extremes*	Time
	Low water use fittings													P	P		S				
	Grey water storage													S	S		S				
	Rain water storage													P	P		S				
	Alternatives to water-based drainage													P	P		S				
	Pools as irrigation water storage	S	S	S									S	P	P						
	Limits to development													P	P		S				
	Water intensive construction processes													P	P						

Climate	Drainage – external / building related	Temp – summer mean*	Temp – summer max mean*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean, min (night)*	Temp – winter mean*	Temp – winter extremes, min and max*	Wind – summer mean**	Wind – summer gust periods**	Wind – direction**	Wind – summer extremes**	Wind – winter average**	Wind – winter extremes**	Sunshine – average (Weather Generator)**	Rainfall – summer average*	Rainfall – summer drought (Weather Generator)**	Rainfall – summer extremes*	Rainfall – winter average*	Rainfall – winter wet periods (Weather Generator)**	Rainfall – winter extremes*	Time
	Drain design															S	S	P	P		
	SUDS and soakaway															S	S	P	P		
	Gutter / roof / upstand design																		P		

Climate	Flooding – avoidance / resistance / resilience	Temp – summer mean*	Temp – summer max mean*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean, min (night)*	Temp – winter mean*	Temp – winter extremes, min and max*	Wind – summer mean**	Wind – summer gust periods**	Wind – direction**	Wind – summer extremes**	Wind – winter average**	Wind – winter extremes**	Sunshine – average (Weather Generator)**	Rainfall – summer average*	Rainfall – summer drought (Weather Generator)**	Rainfall – summer extremes*	Rainfall – winter average*	Rainfall – winter wet periods (Weather Generator)**	Rainfall – winter extremes*	Time
	Environment Agency guidance – location, infrastructure															P	S	P	P		
	Condensation effects									P		P				P	S	P	P		
	Flood defence – permanent														S	S	S	P	P		
	Flood defence – temporary – products etc															S	S	P	P		
	Evacuation / self sufficiency															S		P	P		
	Flood tolerant construction															S	S	P	P		
	Flood tolerant products and materials															S	S	P	P		
	Post-flood recovery measures															S		P	P		

Climate	Landscape	Temp – summer mean*	Temp – summer max mean*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean, min (night)*	Temp – winter mean*	Temp – winter extremes, min and max*	Wind – summer mean**	Wind – summer gust periods**	Wind – direction**	Wind – summer extremes**	Wind – winter average**	Wind – winter extremes**	Sunshine – average (Weather Generator)**	Rainfall – summer average*	Rainfall – summer drought (Weather Generator)**	Rainfall – summer extremes*	Rainfall – winter average*	Rainfall – winter wet periods (Weather Generator)**	Rainfall – winter extremes*	Time
	Plant selection – drought resistance vs cooling effect of transpiration	P	P	P								S	P	P	P	S		P	S		
	Materials behaviour in high temperatures	S	P	S																	
	Changes to ecology	P	P	P								S	P	P	P	S		P	S		
	Irrigation techniques	P	P	P								S	P	P	P	S		P	S		
	Limitations on use of water features – mosquitoes etc	P	P	P								S	P	P	P	S		P	S		
	Role of planting and paving in modifying micro climate and heat island effect	P	P	P								S	P	P	P	S		P	S		
	Fire/safe design for extremes – water																		P		
	Firebreaks	P		P					S	S	S	S		P	P	P		S			

Water conservation

Drainage

Flooding

Landscape

Water

Designing to manage water

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategies.†

Key

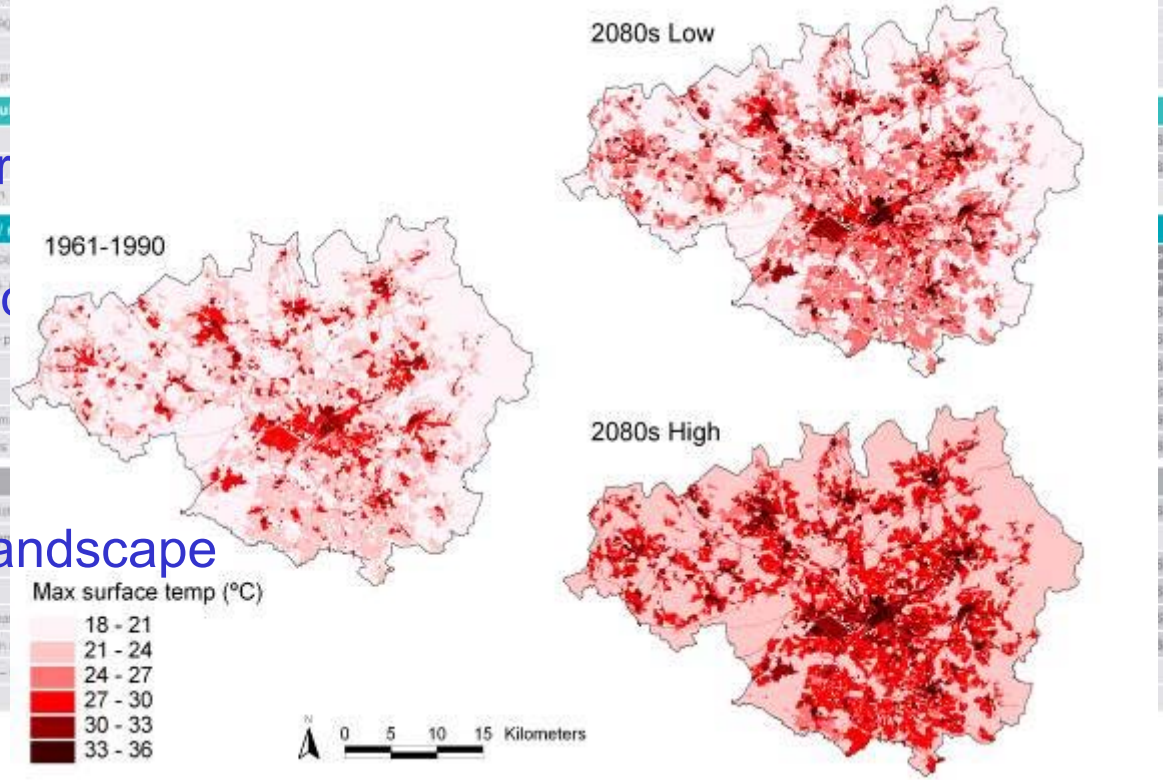
Climate trend	Climate information	Time
Hotter, drier summers	P Primary issue	Short – 10 years
Warmer, wetter winters	S Secondary issue	Medium – 25 years
More extreme events		Long – 50 years

Water conservation

Drainage

Flooding

Landscape



Concluding thoughts

Time to start work

Design opportunities

Managing uncertainty and building consensus

Role of regulation

Technology Strategy Board
Driving Innovation

Design for future climate

Opportunities for adaptation in the built environment

Bill Gething: Sustainability + Architecture bill@billgething.co.uk