THE GLOBAL EFFECTS OF CLIMATE CHANGE

Thursday 16th October

Prof. John Sweeney,
National University of Ireland, Maynooth

Dublin City
Baile Átha Cliath

Change your world.
Change the world.

change | Ireland's plan of action on climate change

NUI MAYNOOTH
Ollscoil na Éireann Má Nuad

ICARUS
Irish Climate Analysis and Research Units

NDP
NATIONAL DEVELOPMENT PLAN

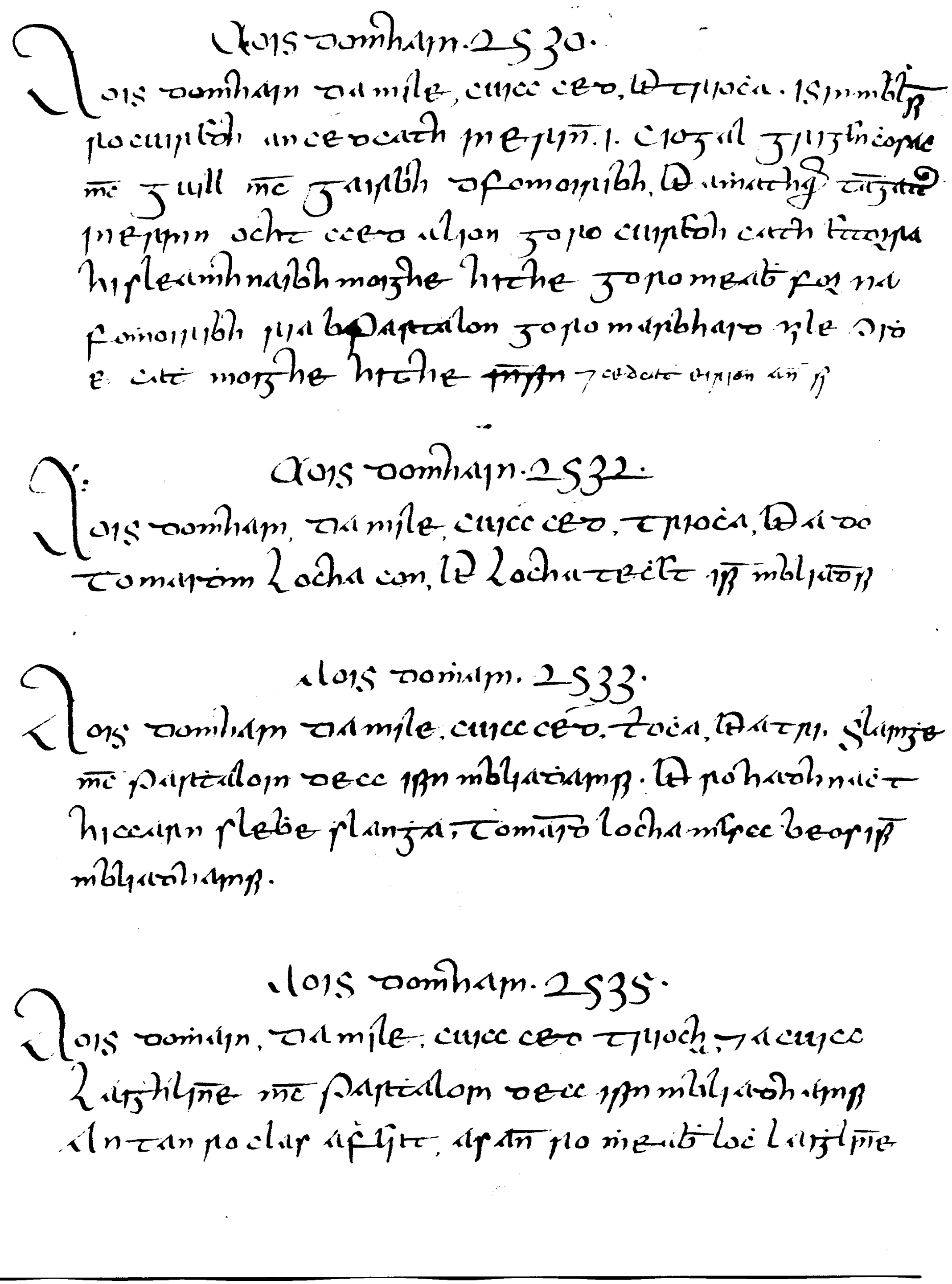
epa

John Constable : The Haywain 1821

The Landscape of the Haywain 1821

The Landscape of the Haywain as it is today





The first written account of a weather event in Ireland or Britain.

From the Annals of the Four Masters it tells of a flood on Lough Conn, allegedly in 2668 B.C.

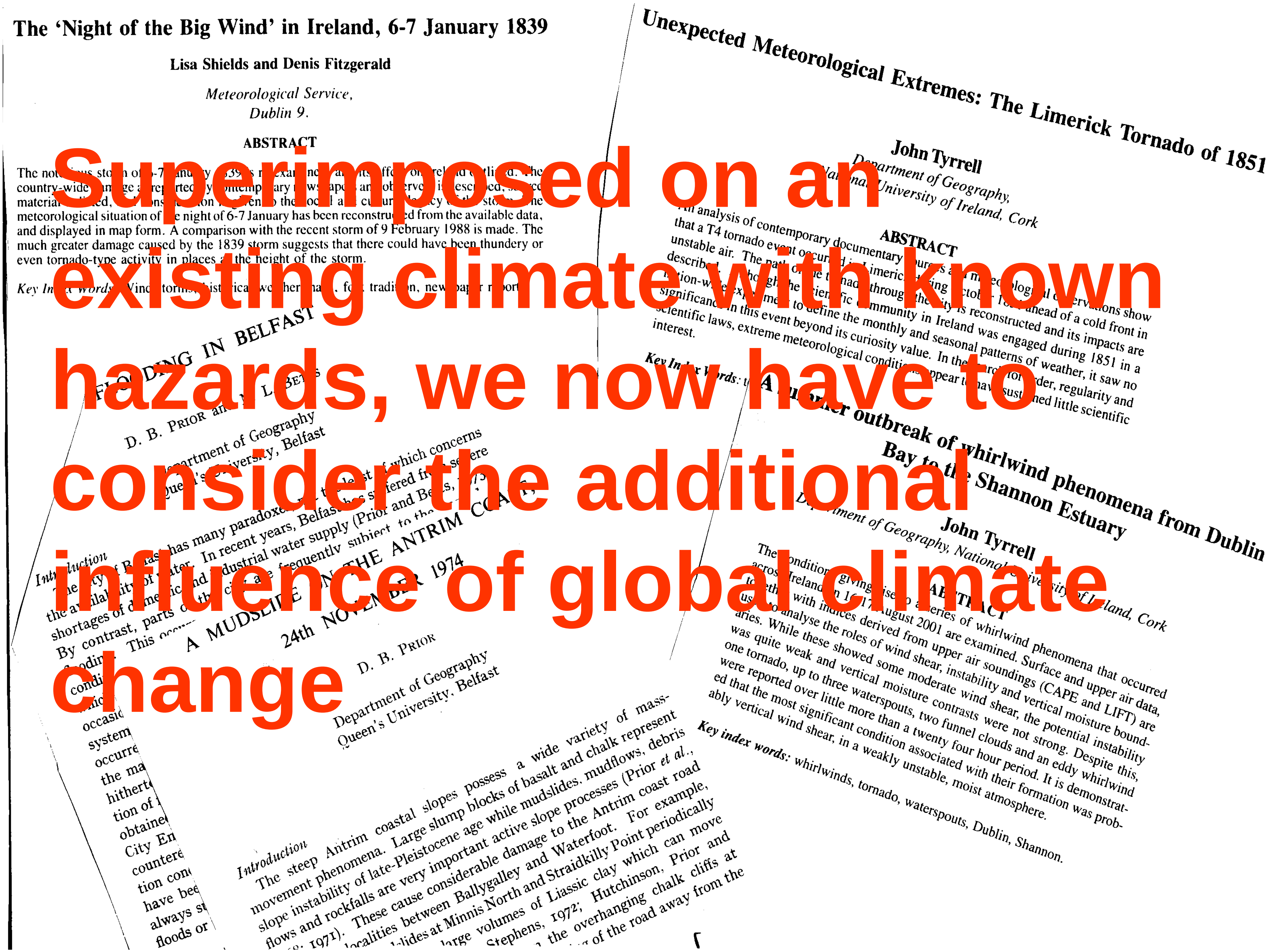
The River Dodder in Bushy Park after 'Hurricane' Charley

Though generally possessing one of the most equable climates in Europe, Ireland does have a record of extreme events

Pollathomas Landslide

Blanchardstown By Pass

Superimposed on an existing climate with known hazards, we now have to consider the additional influence of global climate change



The 'Night of the Big Wind' in Ireland, 6-7 January 1839

Lisa Shields and Denis Fitzgerald

Meteorological Service, Dublin 9.

ABSTRACT

[illegible] meteorological situation of [illegible] night of 6-7 January has been reconstructed from the available data, and displayed in map form. A comparison with the recent storm of 9 February 1988 is made. The much greater damage caused by the 1839 storm suggests that there could have been thundery or even tornado-type activity in places at the height of the storm.

Unexpected Meteorological Extremes: The Limerick Tornado of 1851

John Tyrrell

Department of Geography, National University of Ireland, Cork

ABSTRACT

An analysis of contemporary documentary sources [illegible] that a T4 tornado event occurred in Limerick [illegible] unstable air. [illegible] significance in this event beyond its curiosity value. In the [illegible] scientific laws, extreme meteorological conditions appear to have sustained little scientific interest.

FLOODING IN BELFAST

D. B. PRIOR and [illegible] BETTS

Department of Geography, Queen's University, Belfast

Introduction

[illegible] has many paradoxes [illegible] In recent years, Belfast has suffered from severe [illegible] industrial water supply (Prior and Betts, [illegible]

A MUDSLIDE ON THE ANTRIM COAST, 24th NOVEMBER 1974

D. B. PRIOR

Department of Geography, Queen's University, Belfast

Introduction

The steep Antrim coastal slopes possess a wide variety of mass-movement phenomena. Large slump blocks of basalt and chalk represent slope instability of late-Pleistocene age while mudslides, mudflows, debris flows and rockfalls are very important active slope processes (Prior et al., [illegible] 1971). These cause considerable damage to the Antrim coast road [illegible] localities between Ballygalley and Waterfoot. For example, [illegible] slides at Minnis North and Straidkilly Point periodically [illegible] large volumes of Liassic clay which can move [illegible] Stephens, 1972; Hutchinson, Prior and [illegible] the overhanging chalk cliffs at [illegible] of the road away from the

A [illegible] outbreak of whirlwind phenomena from Dublin Bay to the Shannon Estuary

John Tyrrell

Department of Geography, National University of Ireland, Cork

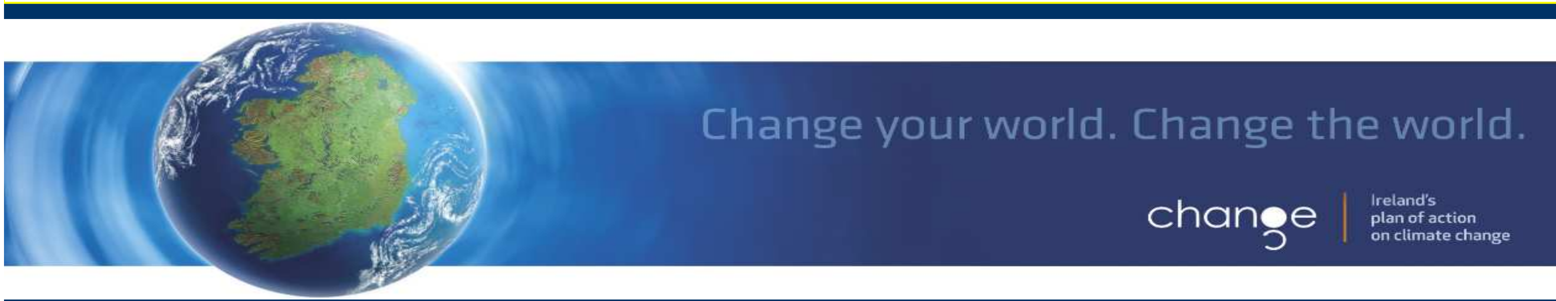
ABSTRACT

The conditions giving rise to a series of whirlwind phenomena that occurred across Ireland on 16-17 August 2001 are examined. Surface and upper air data, [illegible] with indices derived from upper air soundings (CAPE and LIFT) are used to analyse the roles of wind shear, instability and vertical moisture boundaries. While these showed some moderate wind shear, the potential instability was quite weak and vertical moisture contrasts were not strong. Despite this, one tornado, up to three waterspouts, two funnel clouds and an eddy whirlwind were reported over little more than a twenty four hour period. It is demonstrated that the most significant condition associated with their formation was probably vertical wind shear, in a weakly unstable, moist atmosphere.

Key index words: whirlwinds, tornado, waterspouts, Dublin, Shannon.

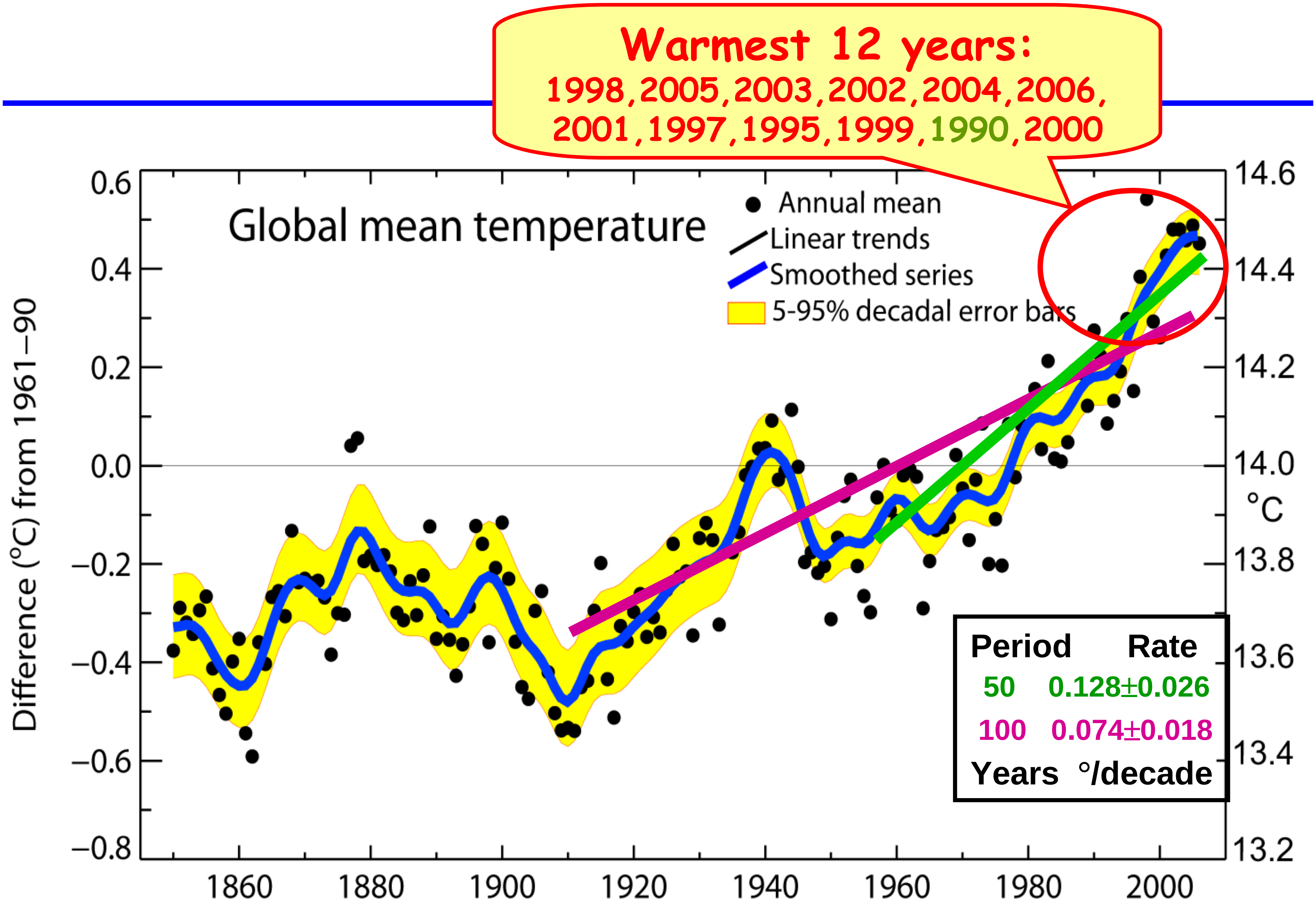
Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.

IPCC (2007)

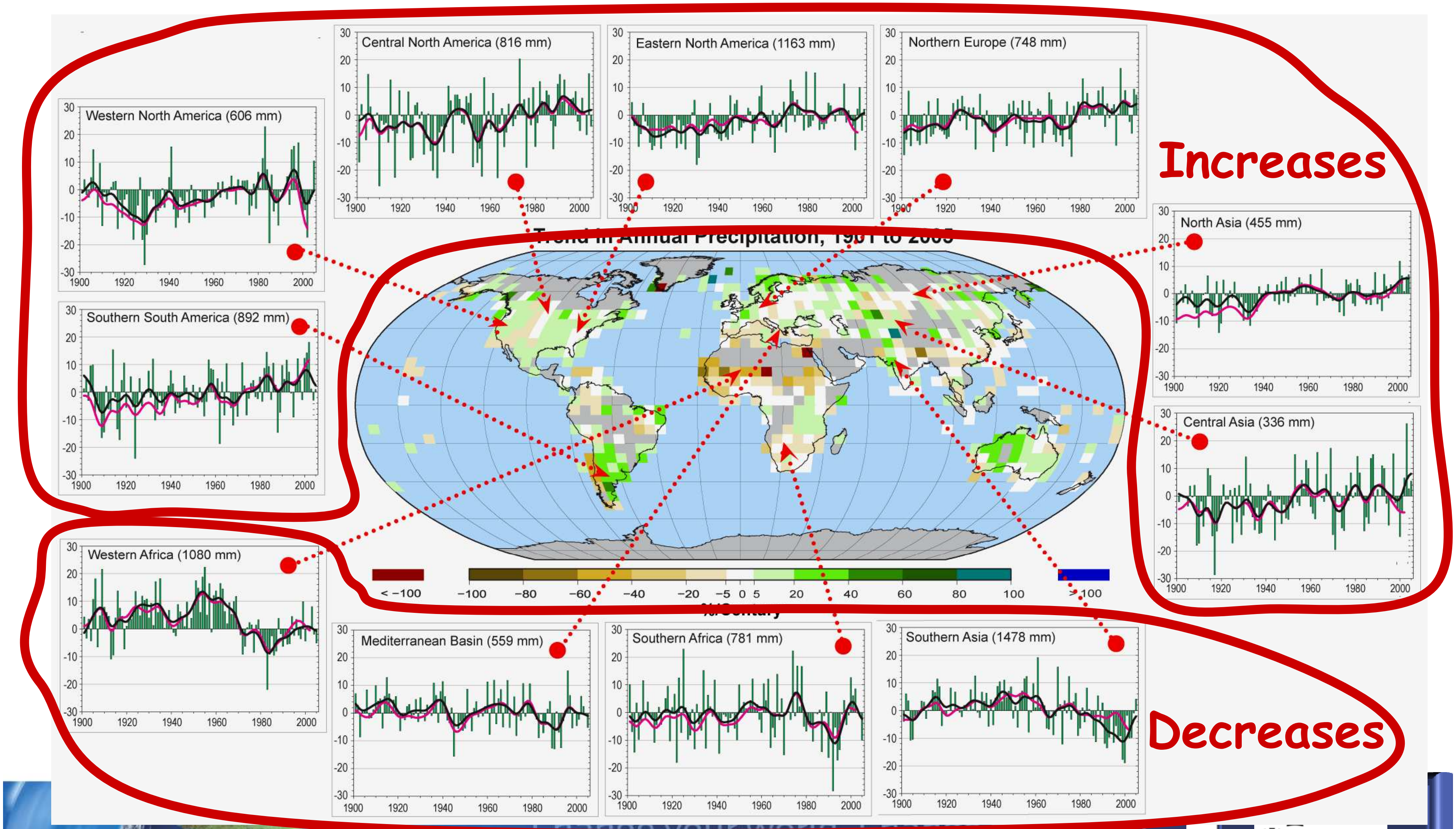


Dublin City
Baile Átha Cliath

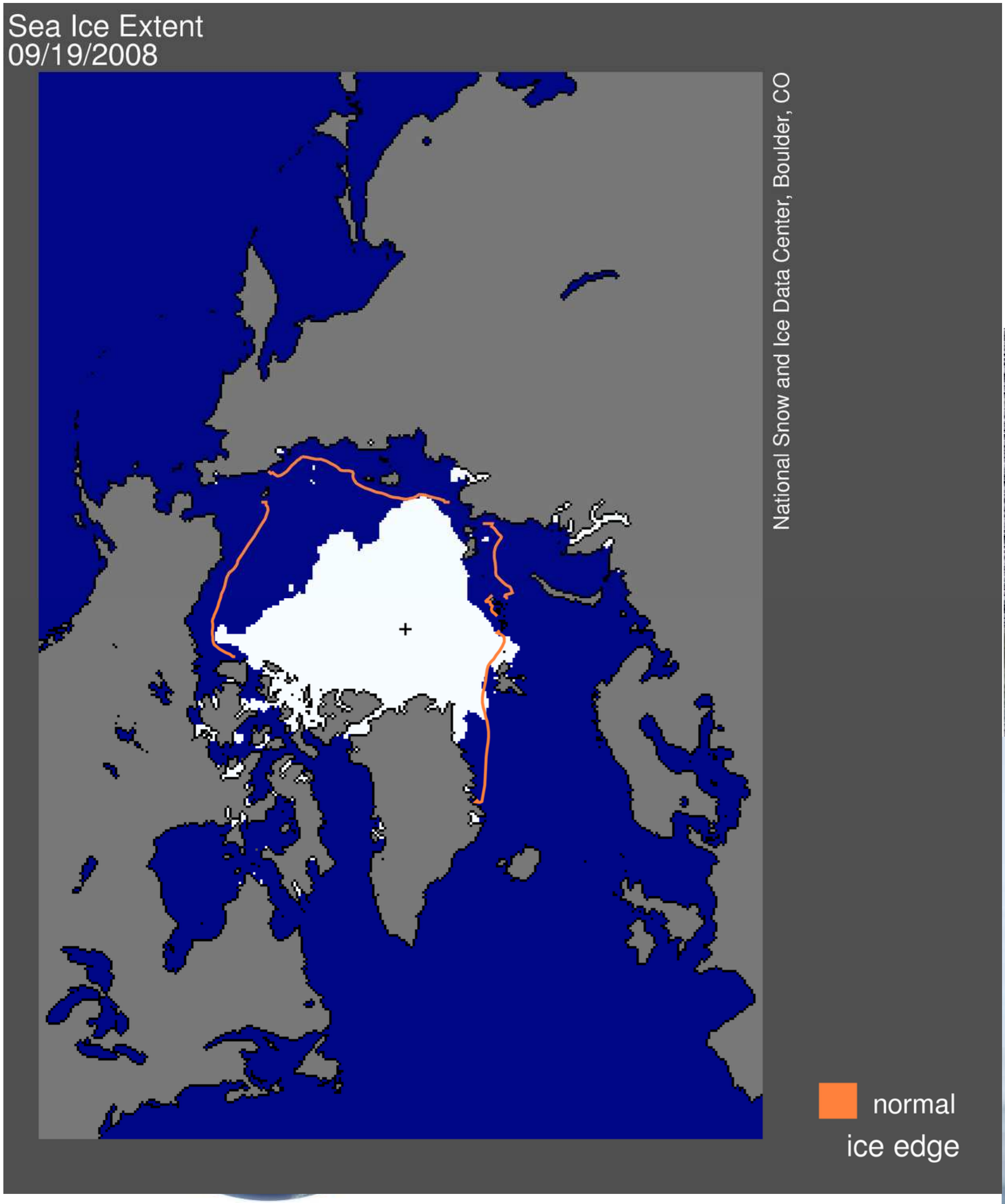
Global mean temperatures are rising faster with time



Land precipitation is changing significantly over broad areas



Smoothed annual anomalies for precipitation (%) over land from 1900 to 2005; other regions are dominated by variability.

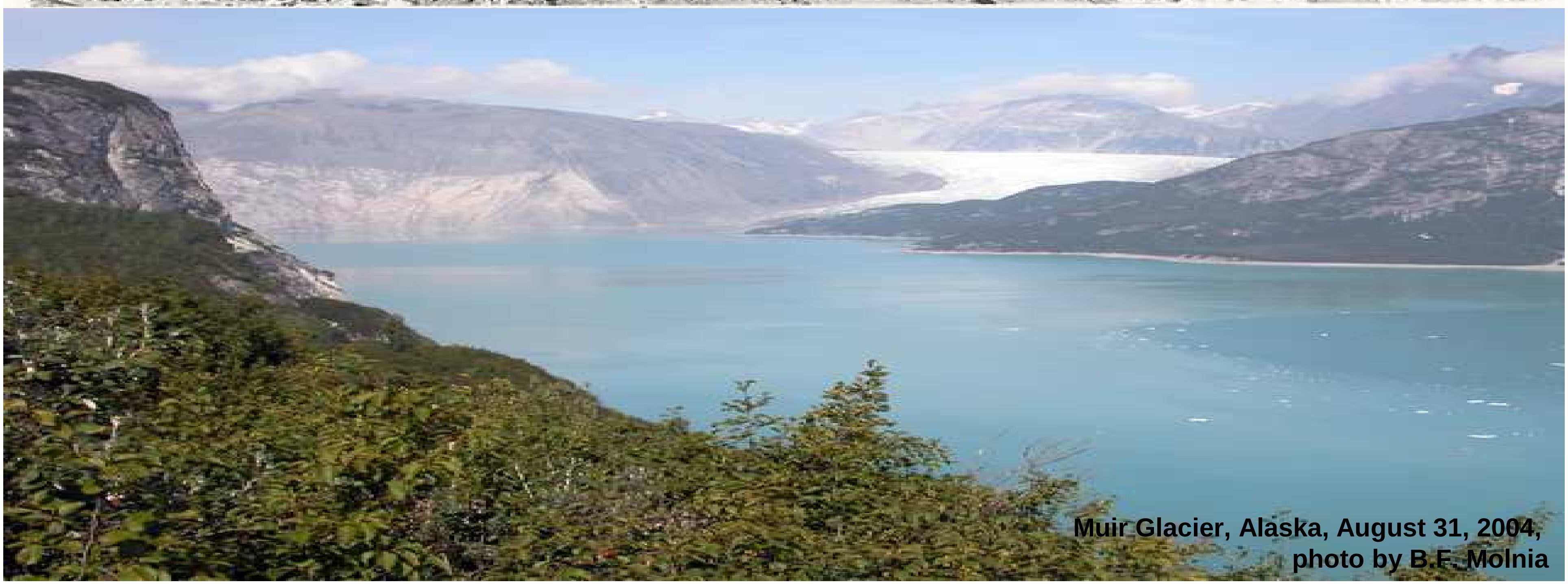


September 2008 saw the 2nd least Arctic sea ice on record (after 2007)


1985
2002
Mount Hood


1928
Upsala Glacier, Argentina
2004

Muir Glacier, Alaska, August 13, 1941,
photo by W.O. Field



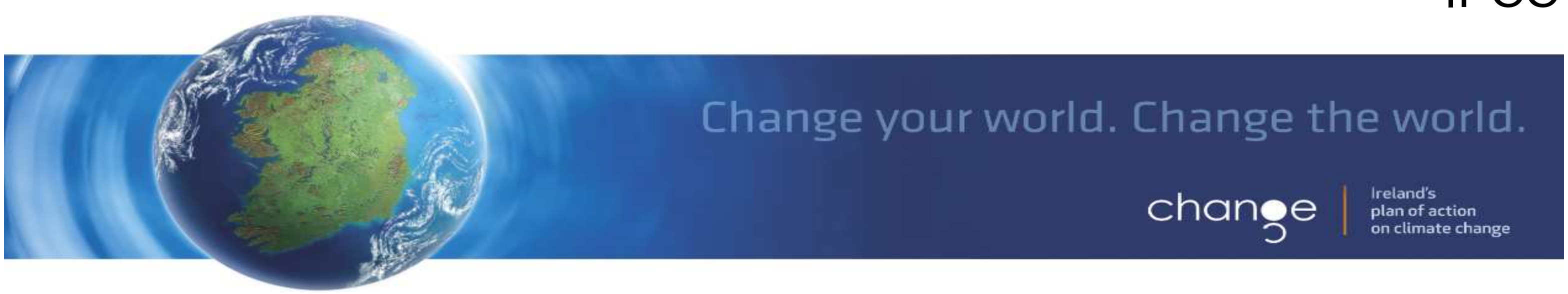
Muir Glacier, Alaska, August 31, 2004,
photo by B.F. Molnia

- Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.

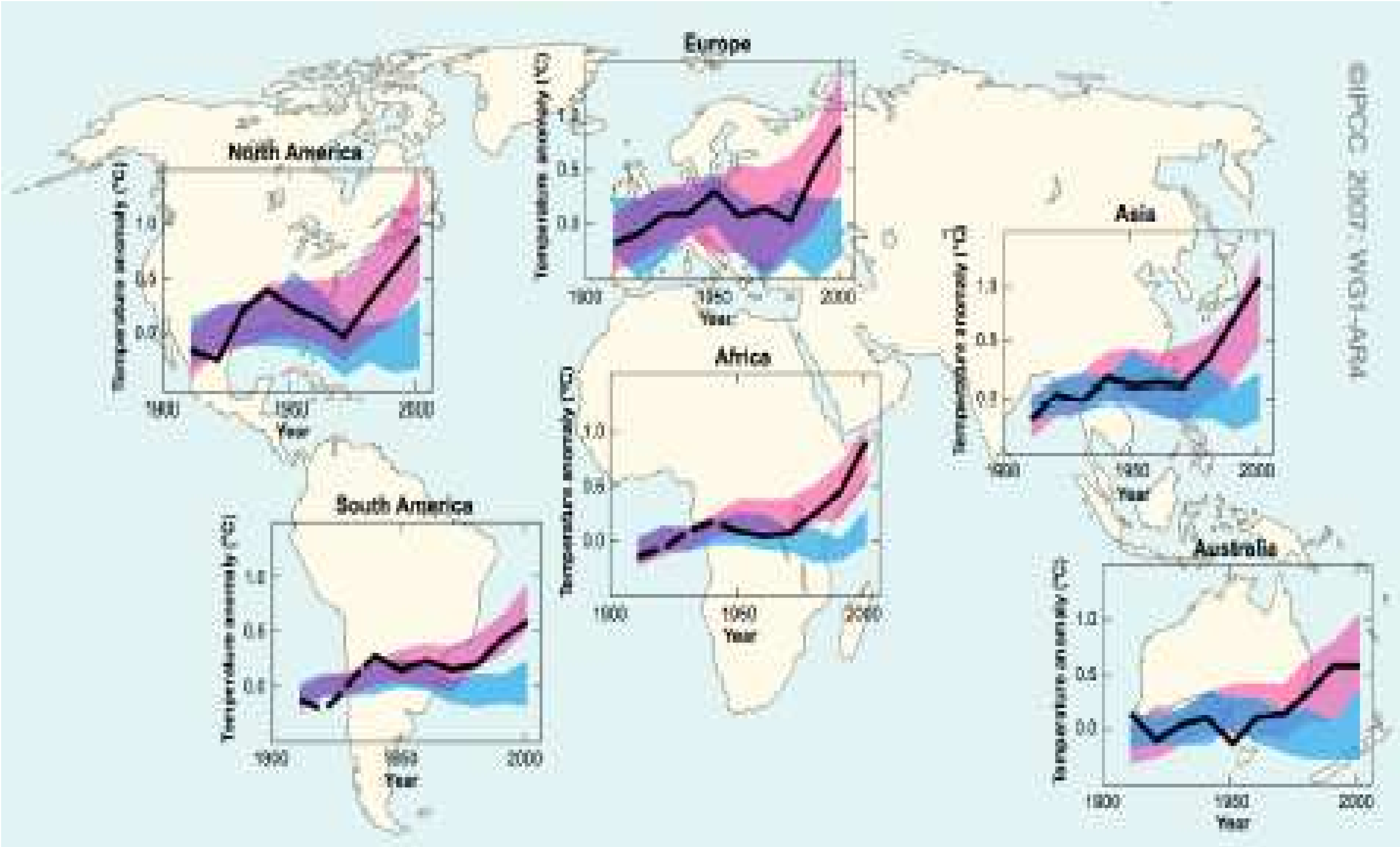
- Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns

*('very likely' = 90%)

IPCC (2007)



Dublin City
Baile Átha Cliath



Blue=Nature Only
Pink=Humans+Nature
Black=What Happened

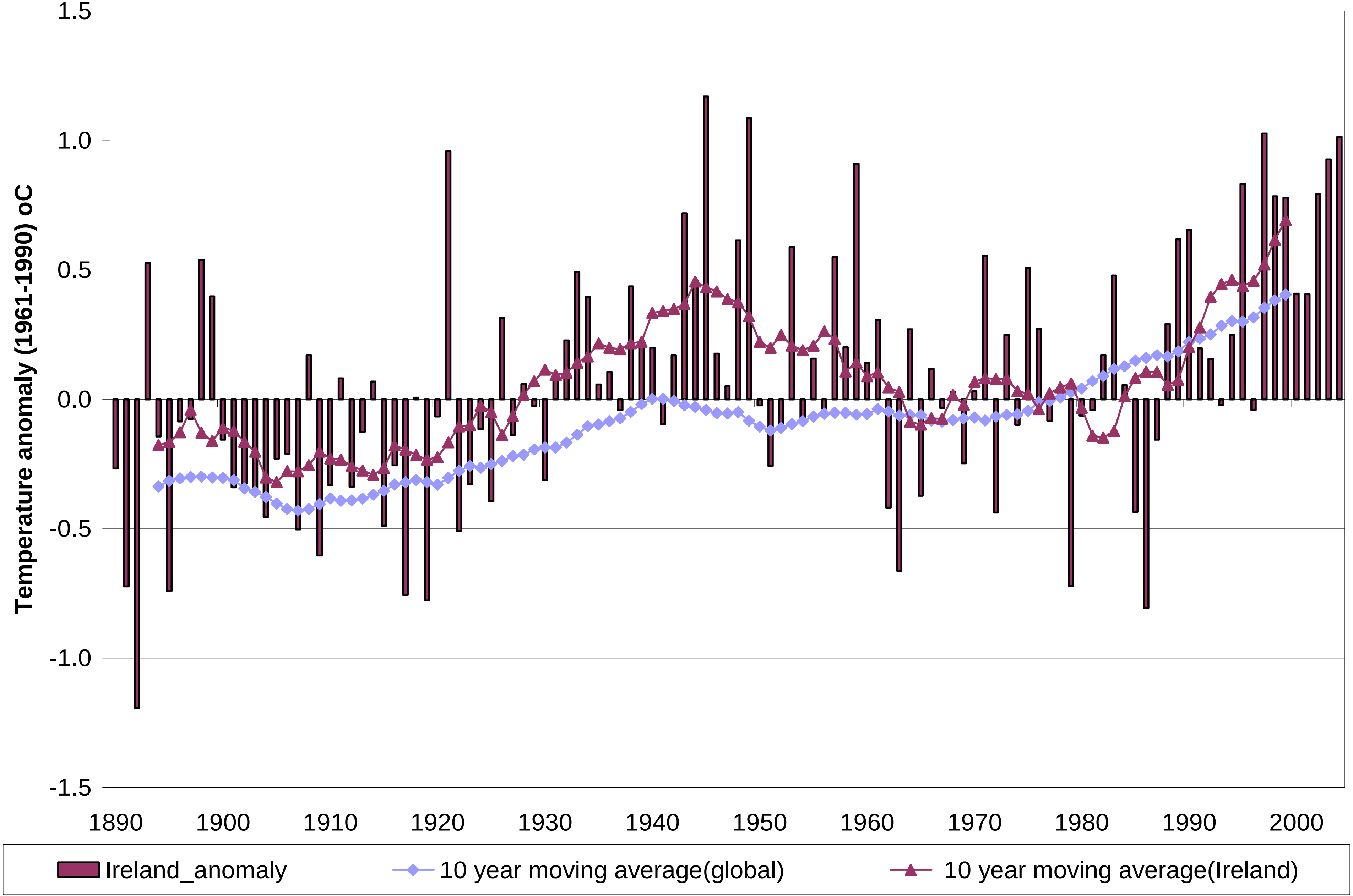
Warming is occurring because of us

What does all this mean for Ireland, and especially for Local Authorities?

1. We need to establish future climate scenarios for Ireland which offers a confident projection of future temperature and rainfall conditions.
2. We need to use these scenarios to project how the Irish environment and landscape will alter under changed climate conditions and what impacts this will have on how we manage society at a local and national level.
3. We need to consider how we can assist local authorities to plan for adaptation to the changing environmental conditions.

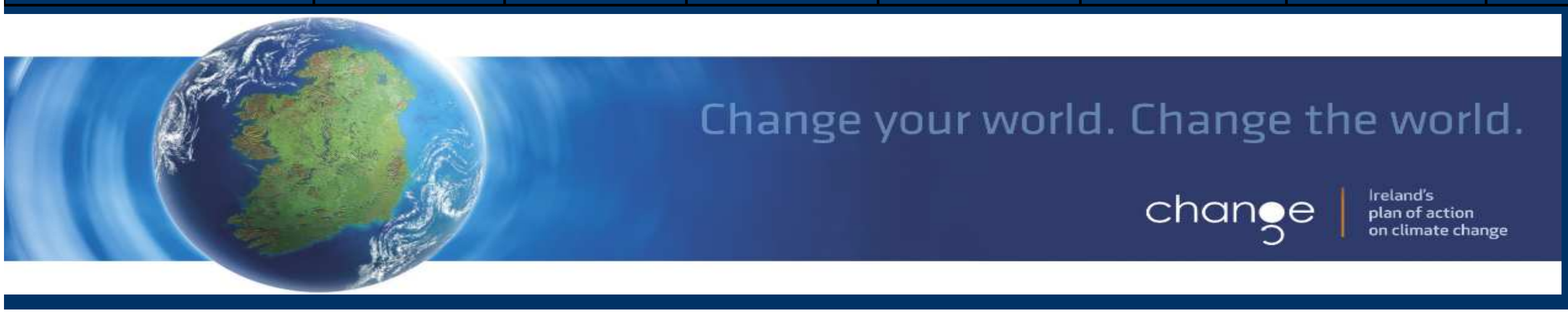
What evidence is there that climate change is currently occurring in Ireland?

Global and Irish mean temperature



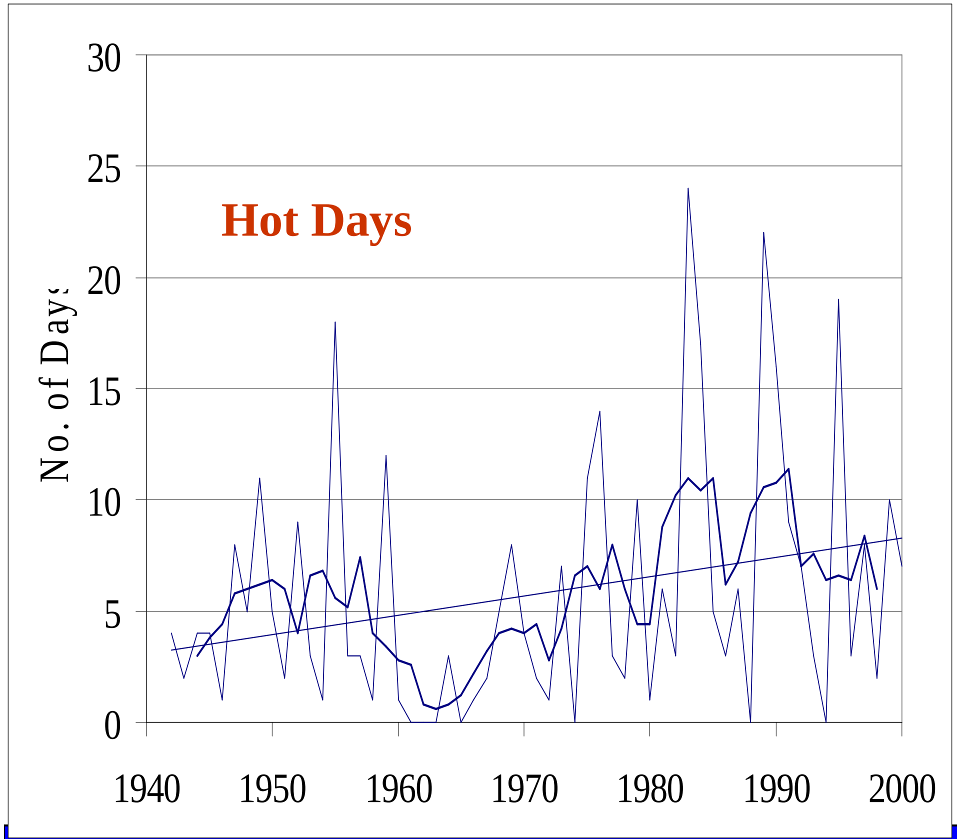
Differences in Seasonal Warming

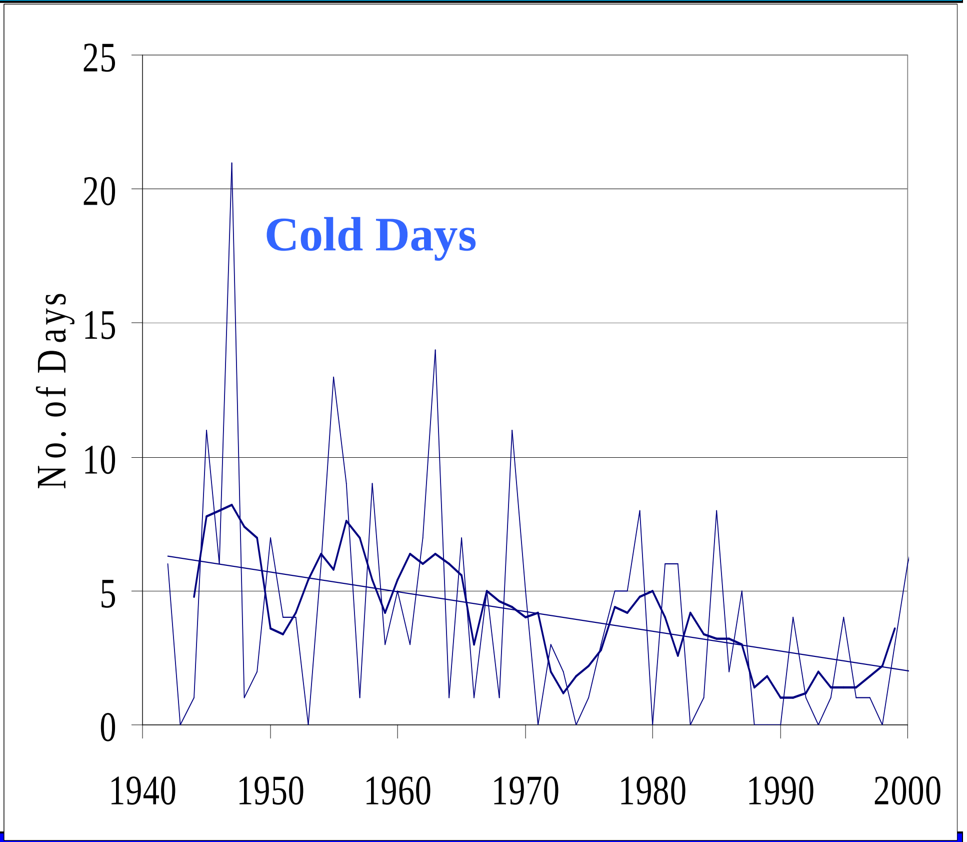
1961-2005	Spring Max	Spring Min	Summer Max	Summer Min	Autumn Max	Autumn Min	Winter Max	Winter Min
Valentia	0.68*	1.05*	0.43	1.20**	0.54	0.87*	1.17**	1.34*
Shannon	1.27**	1.58**	1.18*	1.70**	1.01*	1.28**	1.50**	1.83**
Malin	0.75*	1.18**	0.63	1.13**	0.47	0.84**	1.04*	1.20**
Belmullet	1.40**	1.21**	1.30**	1.39**	1.16**	0.80*	1.44**	1.23*
Phoenix Park	1.41**	0.88*	1.43**	0.92**	0.84*	0.41	2.52**	0.85
Clones	1.27**	1.33**	1.36**	1.63**	0.92**	1.04*	1.33**	1.41*
Rosslare	1.06**	1.28**	1.12**	1.19**	0.97**	1.02**	1.62**	1.32**
Claremorris	1.32**	1.19**	1.25**	1.49**	0.92*	0.84*	1.22**	1.32*
Kilkenny	1.40**	1.18**	1.22*	1.46**	0.95*	1.21**	1.52**	1.40**
Casement	1.05**	1.27**	0.83*	1.40**	0.55	1.15**	1.61**	1.36*
Birr	1.18**	0.95*	0.98*	1.21**	0.77*	0.77	1.44**	1.14*



Dublin City
Baile Átha Cliath

Frequency of 'hot' and 'cold' days at Dublin Airport



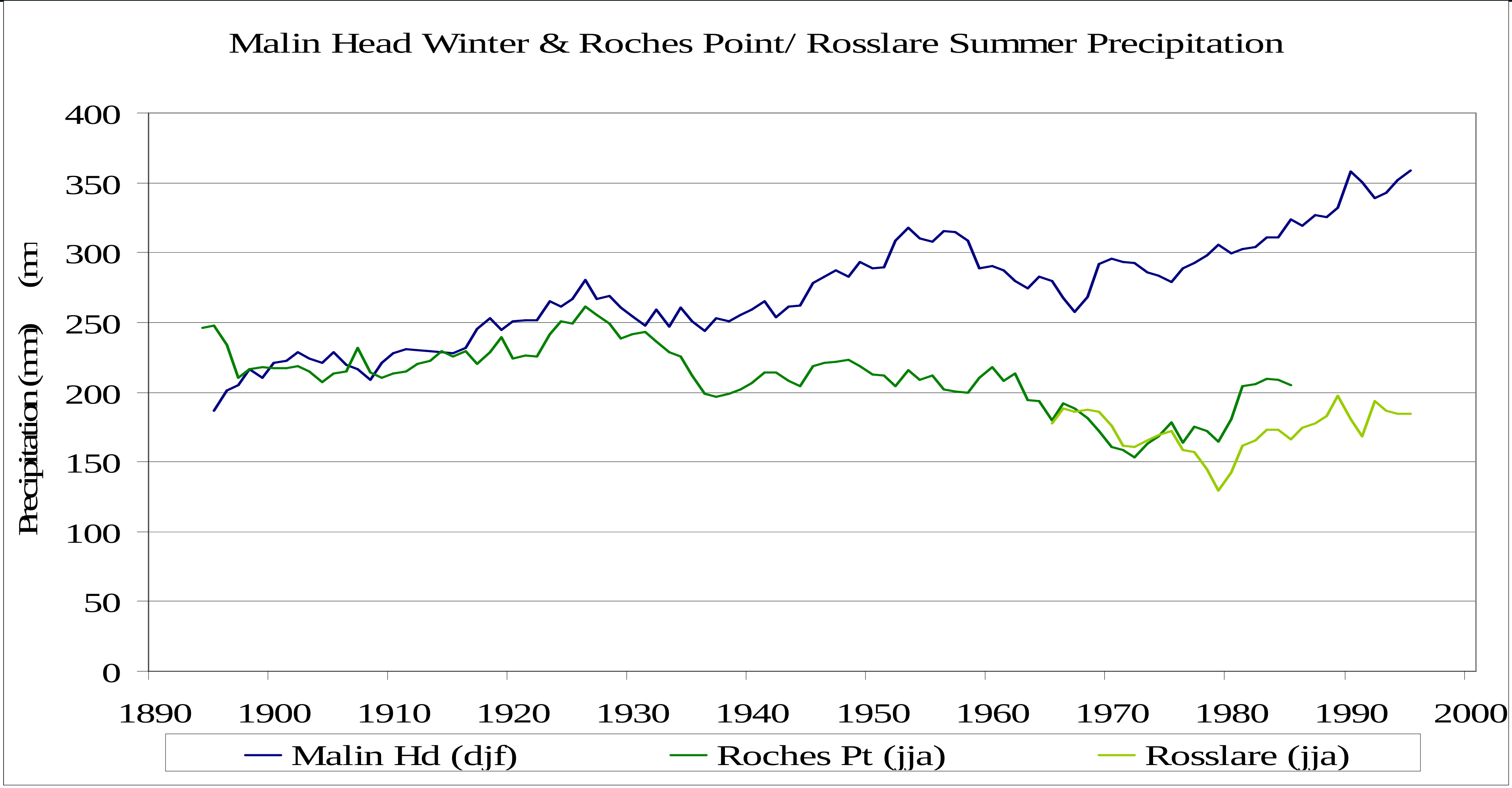


'Hot' day = mean temperature > 18ºC

'Cold' day = mean temperature < 0ºC

The average annual number of hot days in eastern Ireland has doubled, and cold days have halved over the past 40 years

Geographical & Seasonal differences



Winters in the north west are getting wetter

Summers in the south east are getting drier

What information do we need to project future climate?

- How much fossil fuel will we burn over the next few decades?

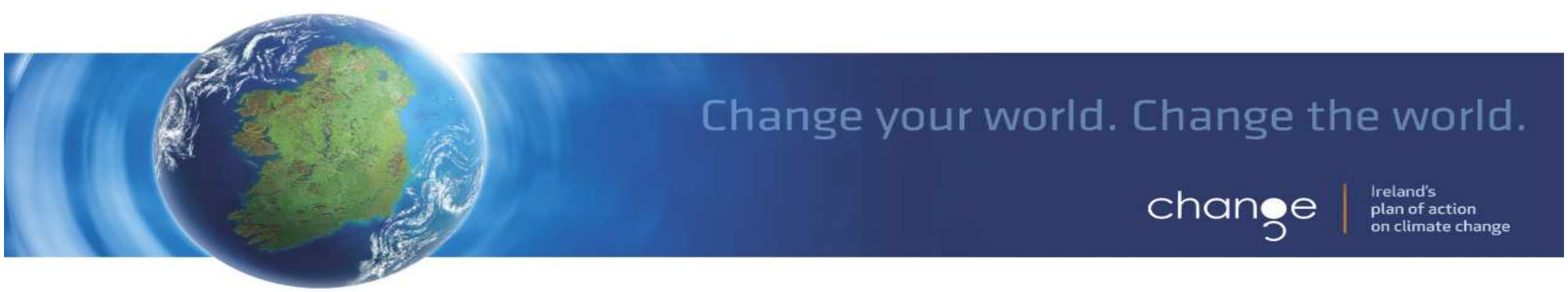
    Emissions Scenario

    Concentration Scenario

- How will the climate system respond to increased greenhouse gas concentrations?

    Modelling

- How can uncertainties in these aspects be handled?

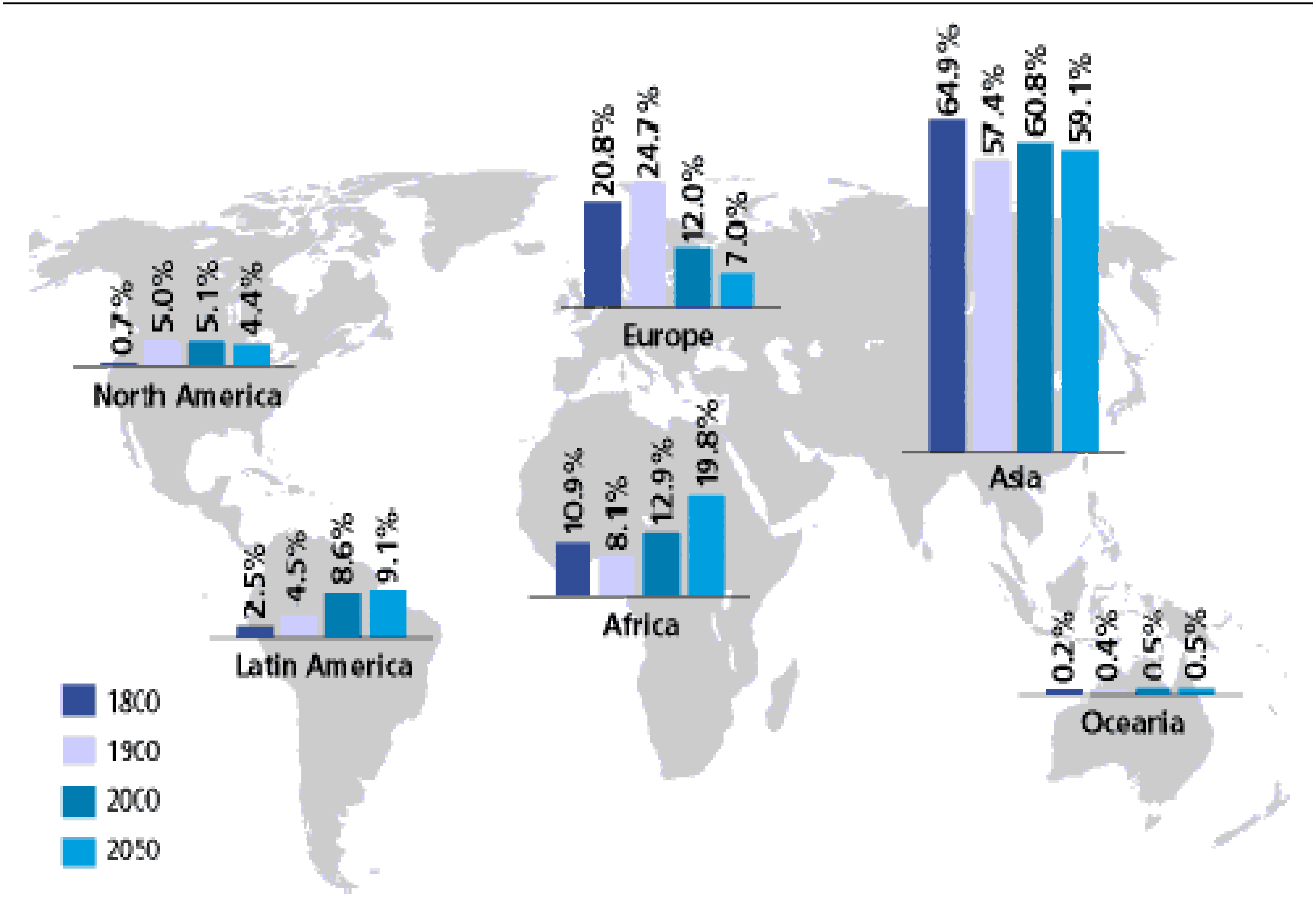


Emission Scenarios

- Based on assumptions regarding population, energy use, technological development

The Future: A more crowded world

Changing Distribution of the World's Population



How will these changes affect Food Production?

25,000 die daily from starvation

815m suffer from malnutrition

Freshwater resources are increasingly critical

By 2020, reserves of fresh water for drinking and irrigation will fall 30%.

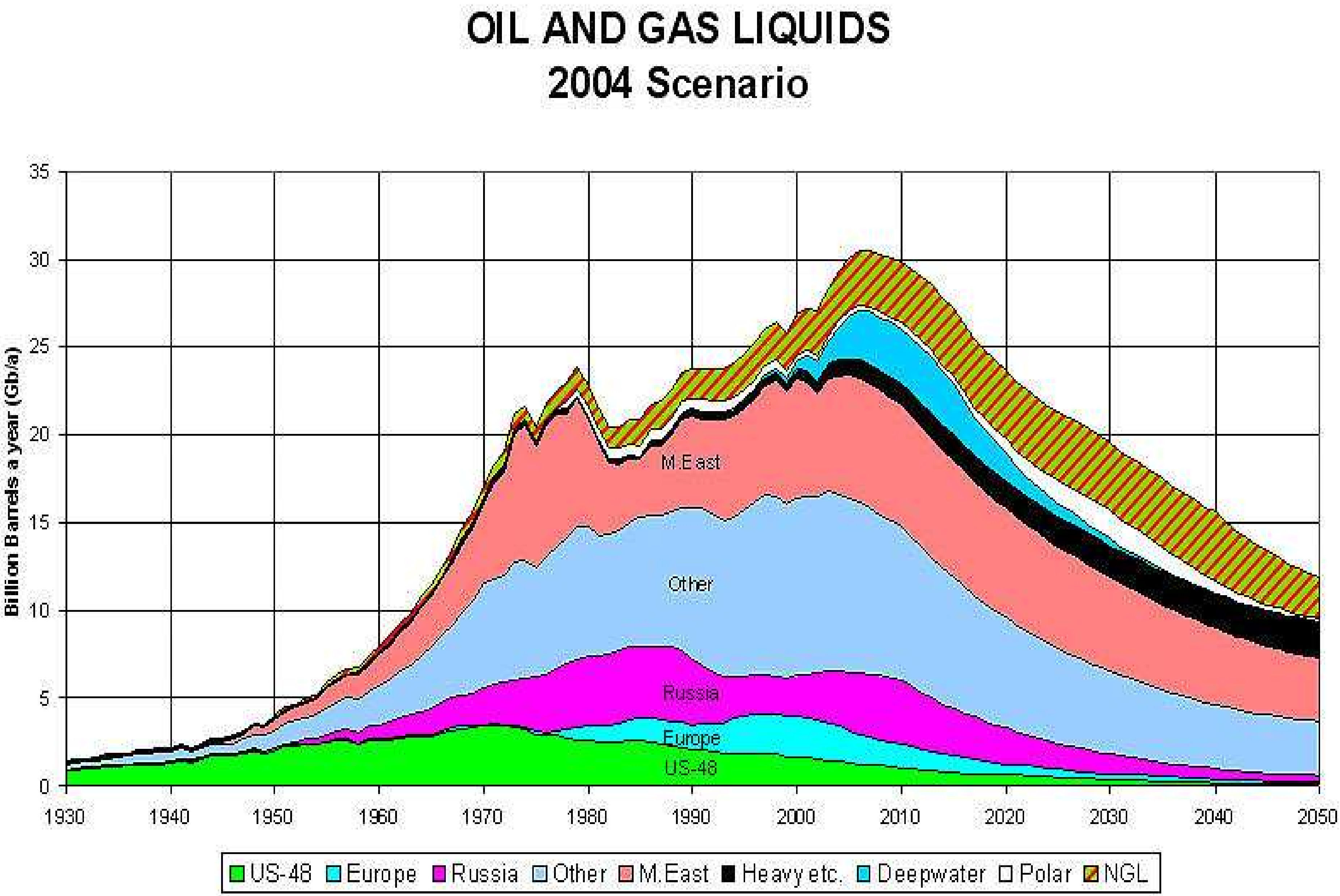
Consumption has doubled since 1950.

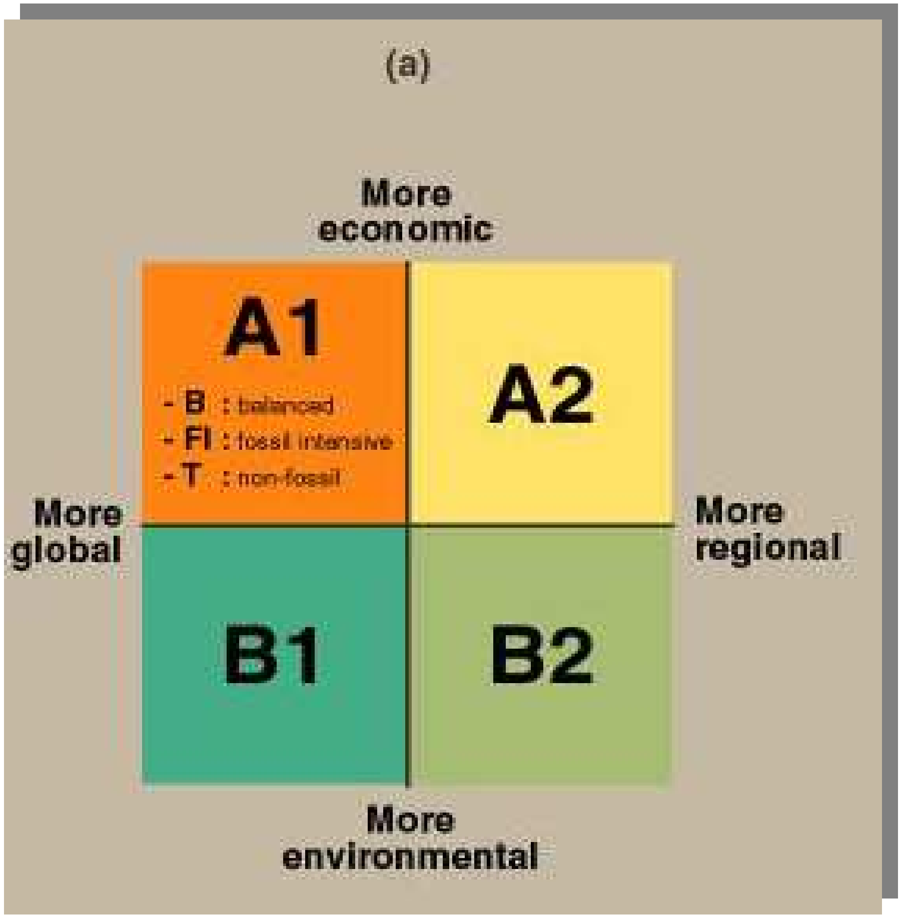
Much is polluted.

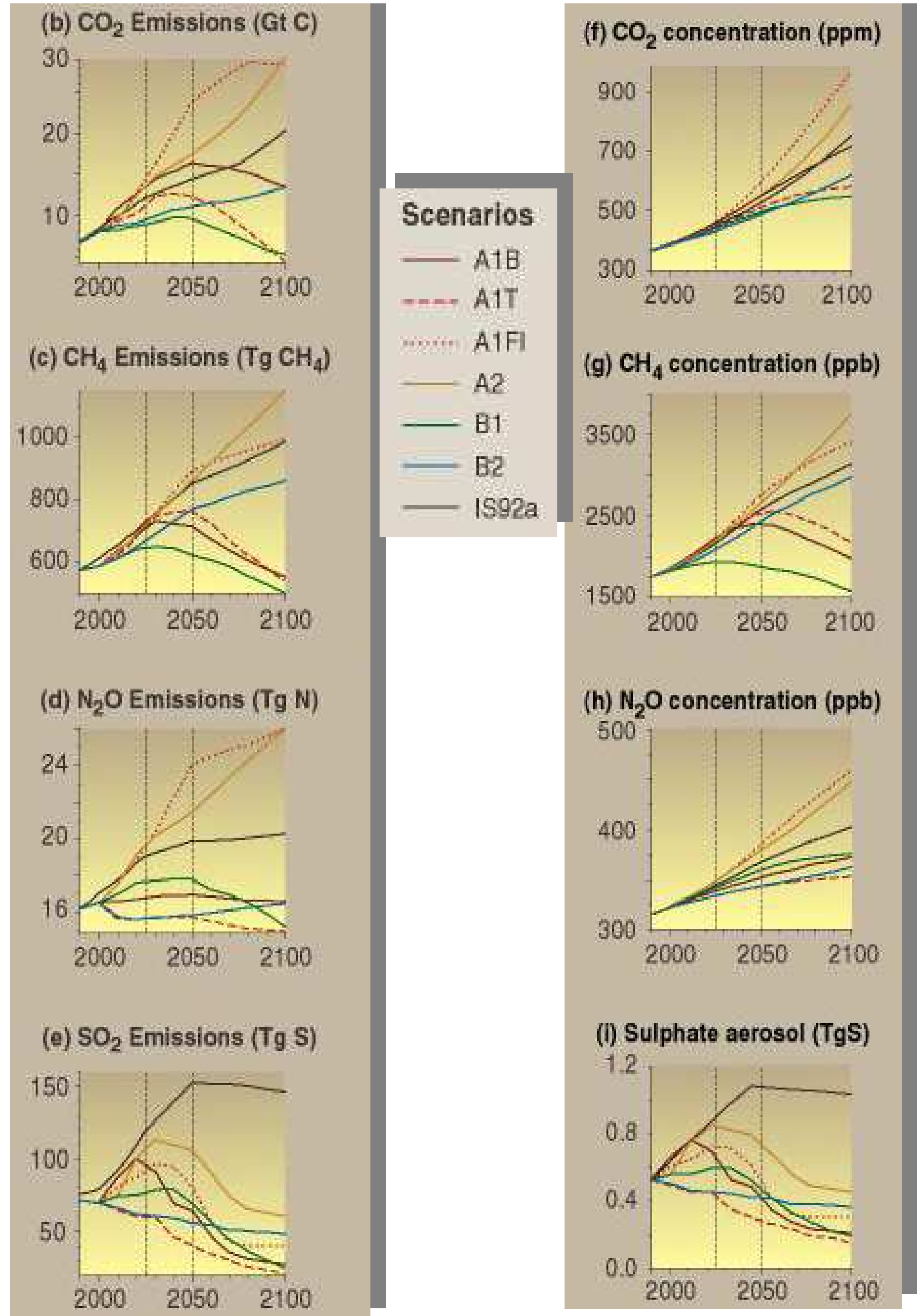
6,000 die daily from diarrhoea.

Will the world have enough energy?

Global oil production has peaked or is close to its peak

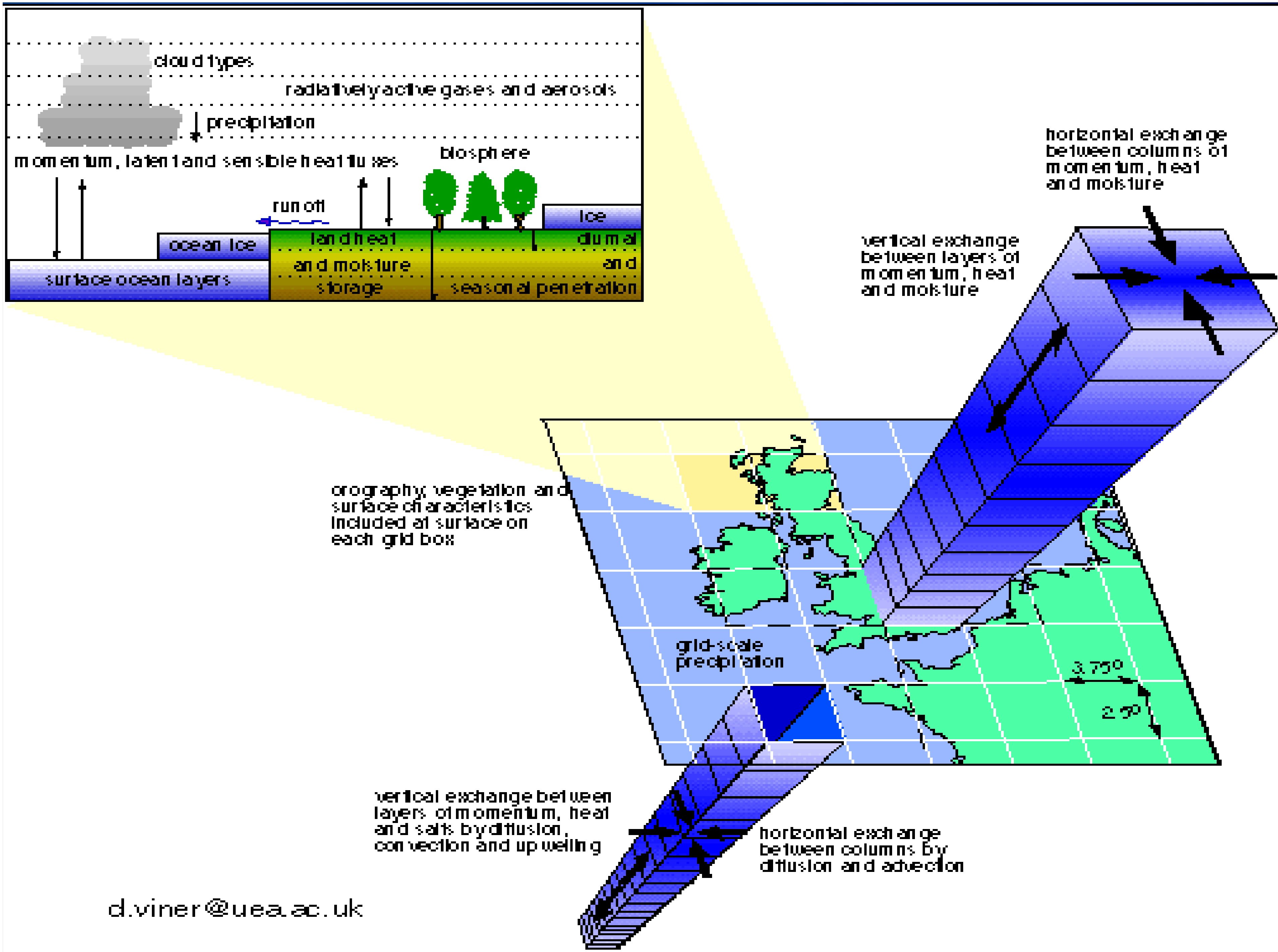




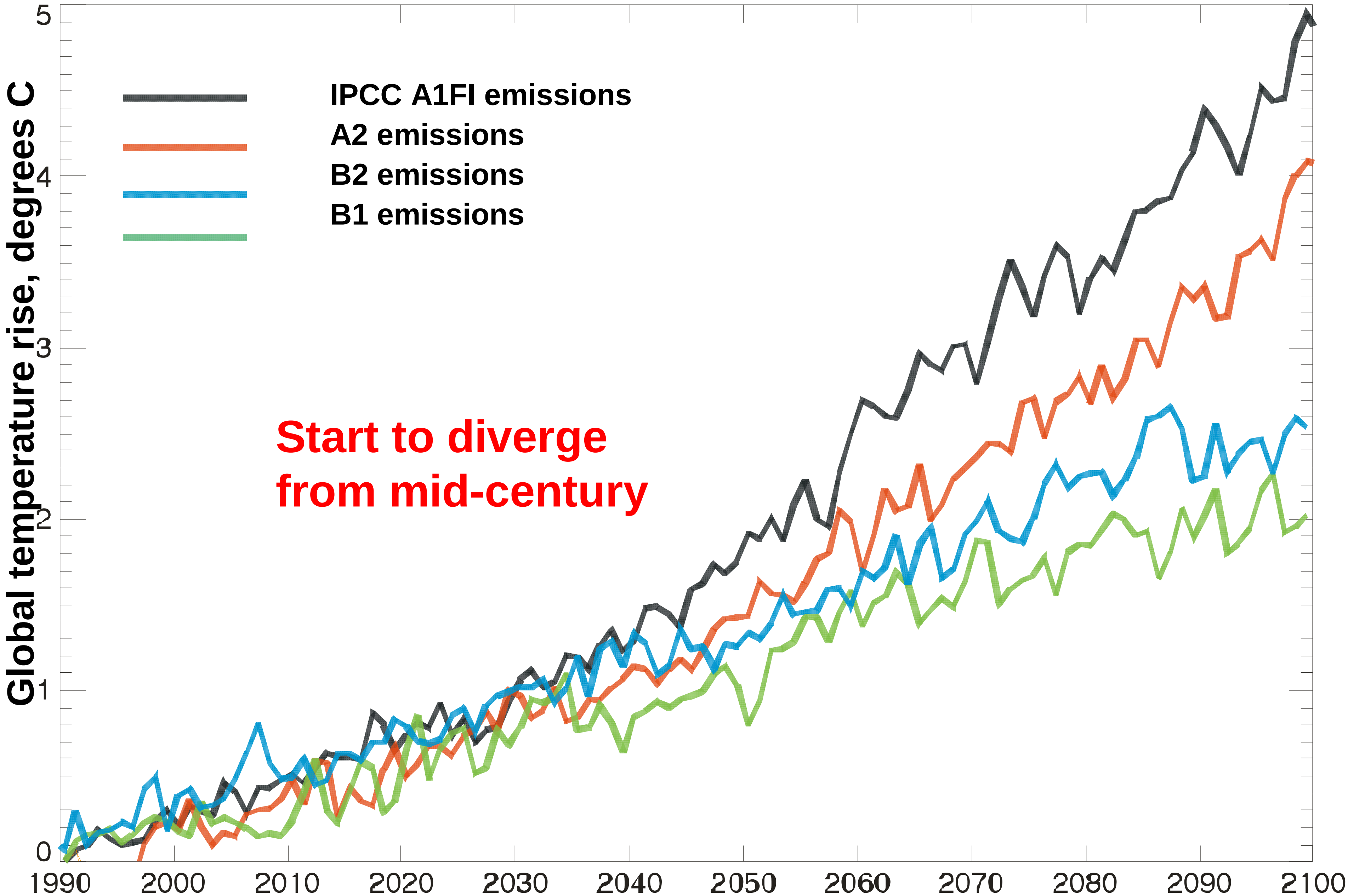


The SRES marker emission scenarios and the resulting change in concentration

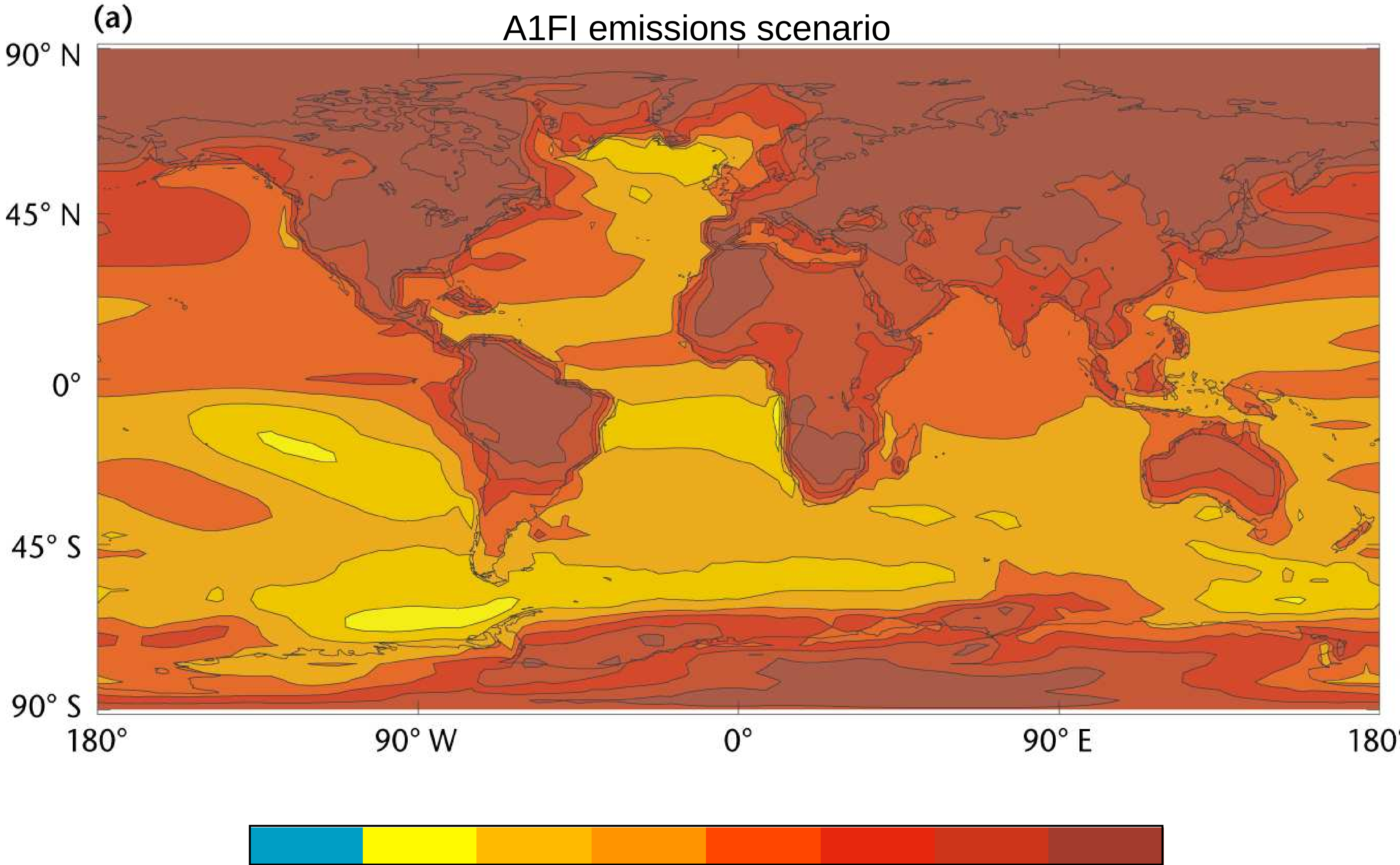
Emissions **Concentrations**


cloud types
radiatively active gases and aerosols
precipitation
momentum, latent and sensible heat fluxes
biosphere
run off
ice
ocean ice
land heat
and moisture
storage
diurnal
and
seasonal penetration
surface ocean layers
horizontal exchange between columns of momentum, heat and moisture
vertical exchange between layers of momentum, heat and moisture
orography, vegetation and surface characteristics included at surface on each grid box
grid-scale precipitation
3.75°
2.5°
vertical exchange between layers of momentum, heat and salts by diffusion, convection and upwelling
horizontal exchange between columns by diffusion and advection
d.viner@uea.ac.uk

GLOBAL TEMPERATURE RISE

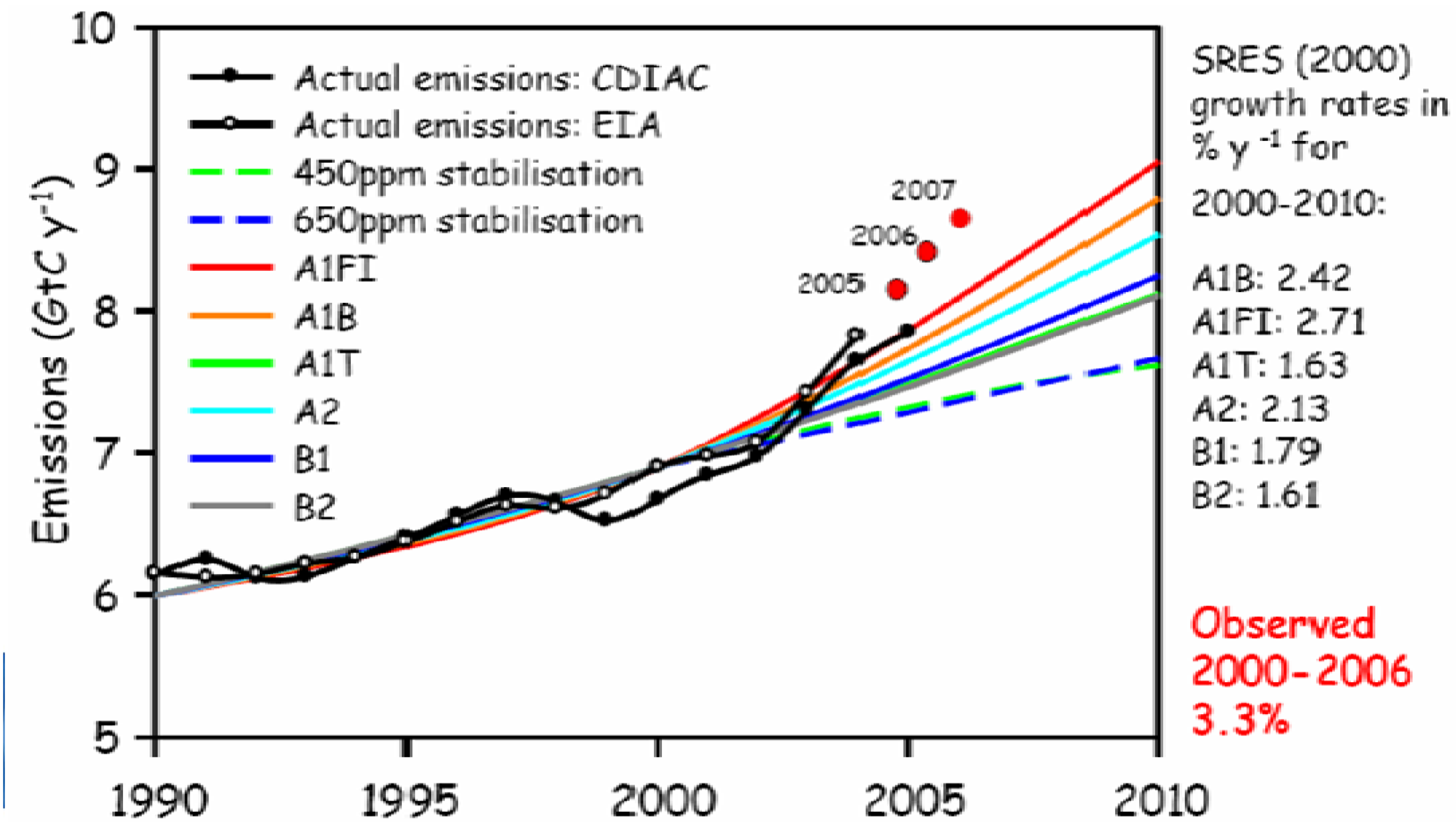


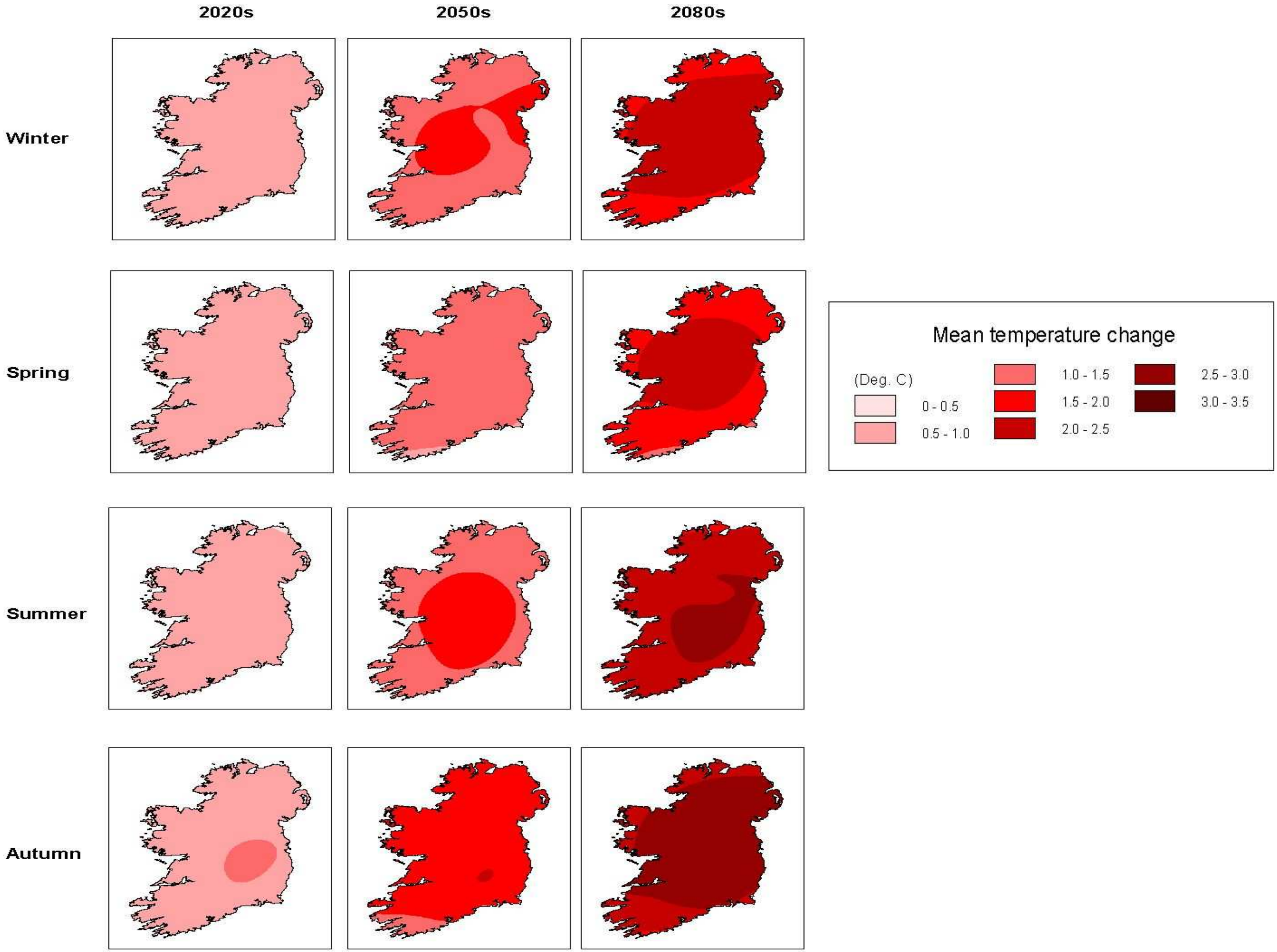
PATTERN OF ANNUAL TEMPERATURE CHANGES
2080s relative to present day



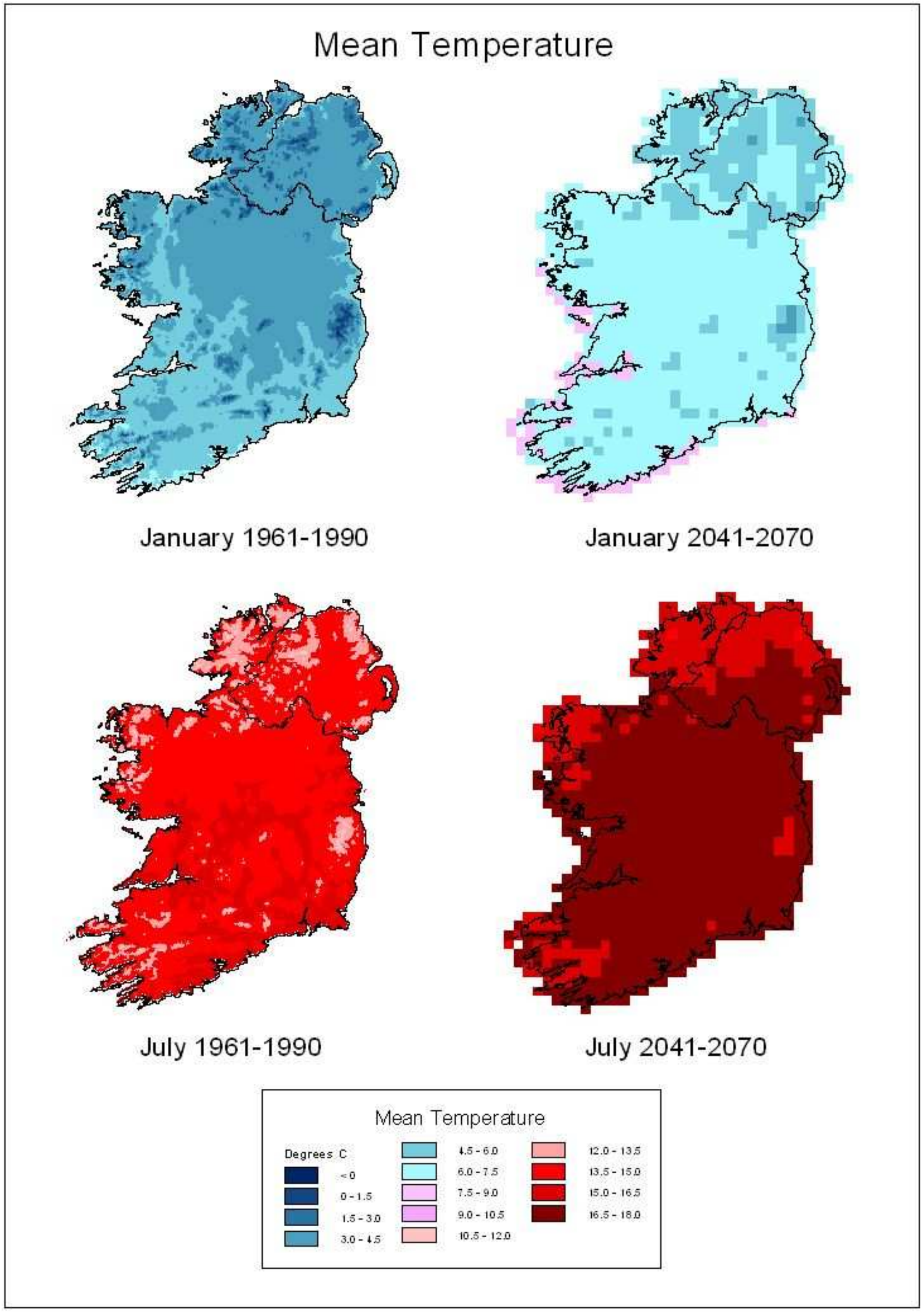
Met Office/Hadley Centre

Recent Global Emissions as Reported at Bonn UNFCCC Meeting (June 2008)





2020s
2050s
2080s
Winter
Spring
Summer
Autumn
Mean temperature change
(Deg. C)
0 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5

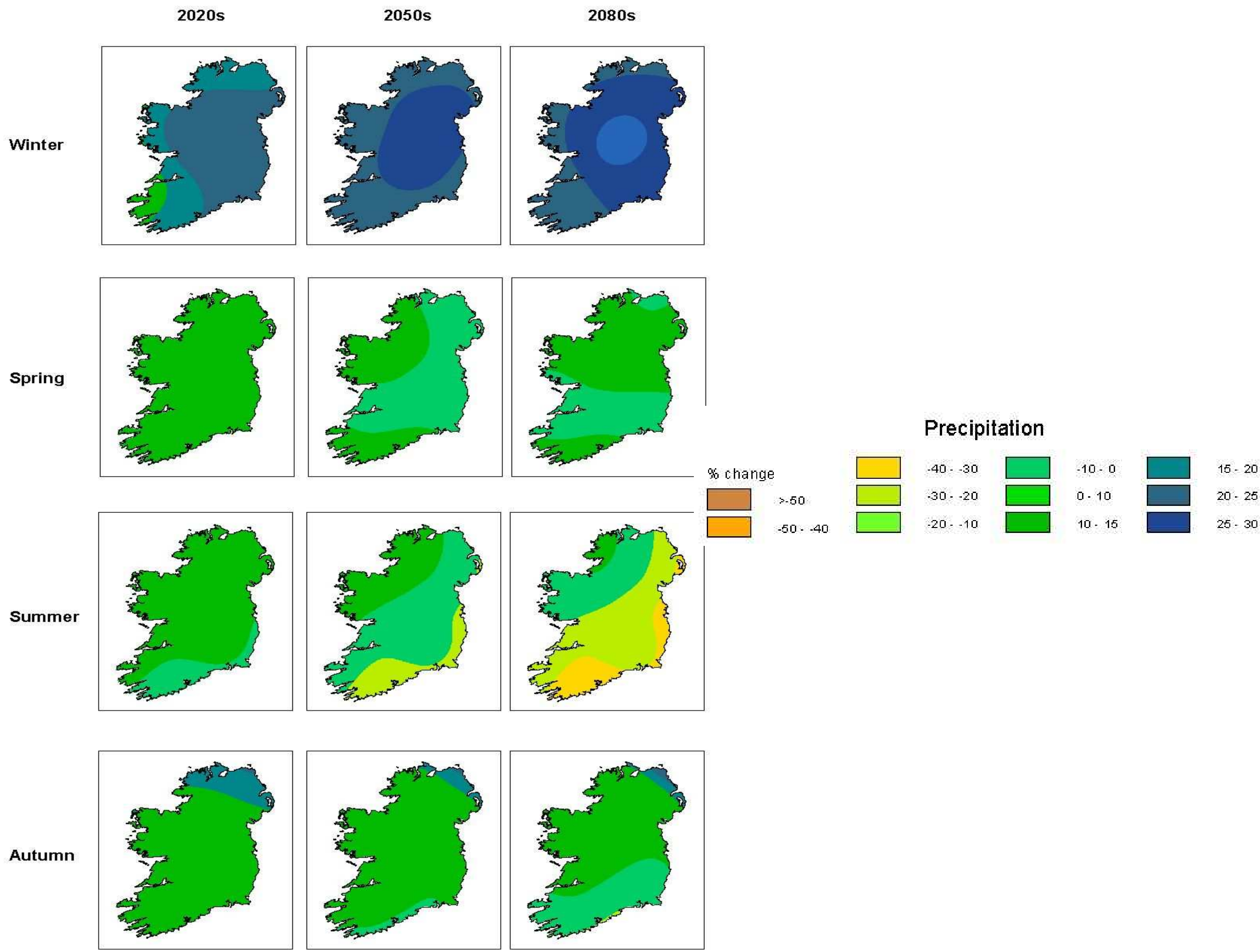


Warming relative to 1961-90

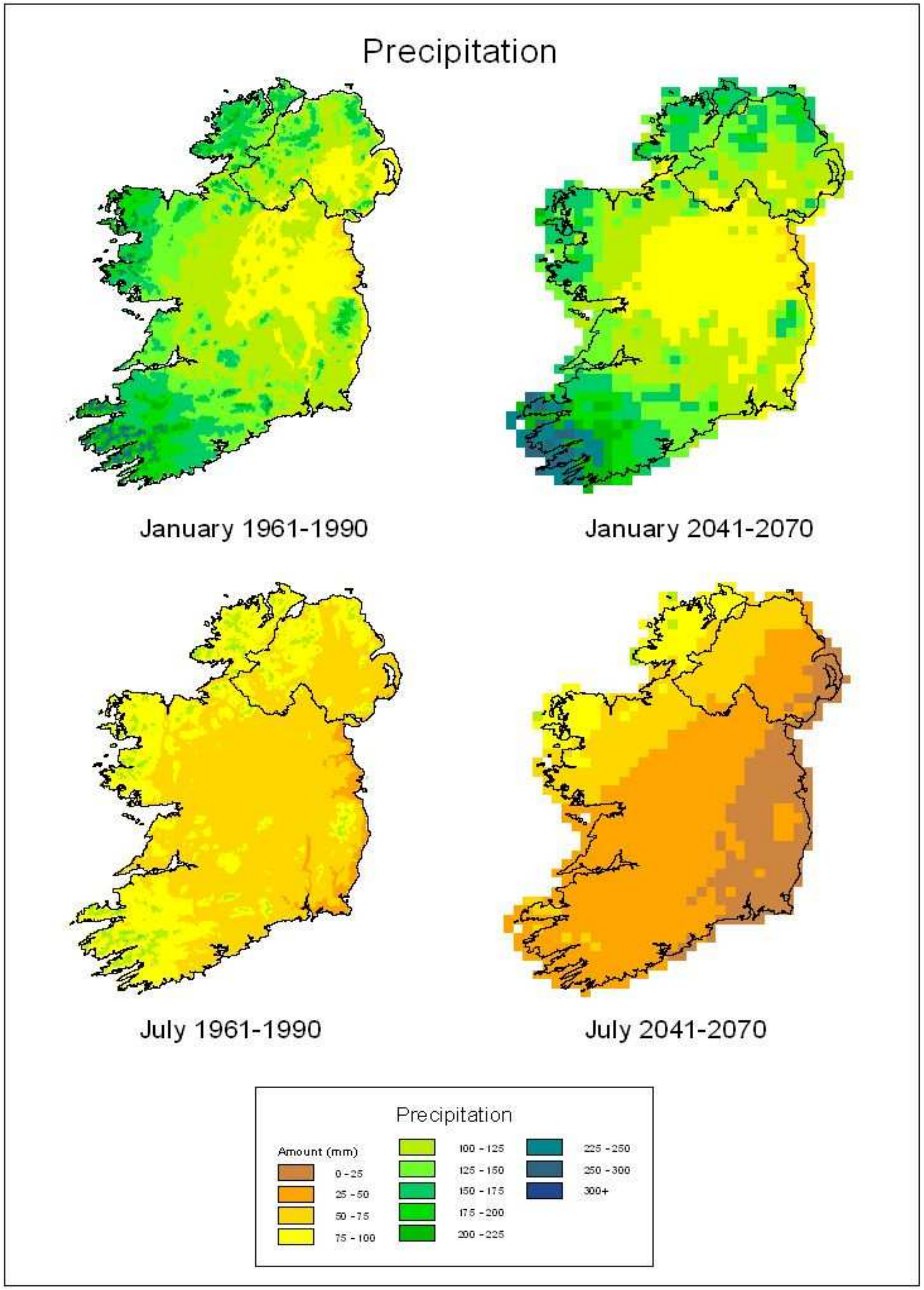
Mean January figures are predicted to increase by 1.5^{o}C by mid century with a further increase of 0.5^{o}C-1.0^{o}C by 2075.

By 2050, the extreme south and south west coasts may have a mean January temperature of 8.0^{o}C. By then, winters in Northern Ireland and in the north Midlands will be similar to those presently experienced along the Cork/Kerry coast.

July temperatures will increase by 2.5^{o}C by 2050 and a further increase of 1.0^{o}C by 2075 can be expected. Maximum July temperatures of the order of 22.5^{o}C will prevail generally with areas in the central Midlands experiencing maximum July temperatures of 24.5^{o}C.



2020s
2050s
2080s
Winter
Spring
Summer
Autumn
Precipitation
% change
>-50
-50 - -40
-40 - -30
-30 - -20
-20 - -10
-10 - 0
0 - 10
10 - 15
15 - 20
20 - 25
25 - 30



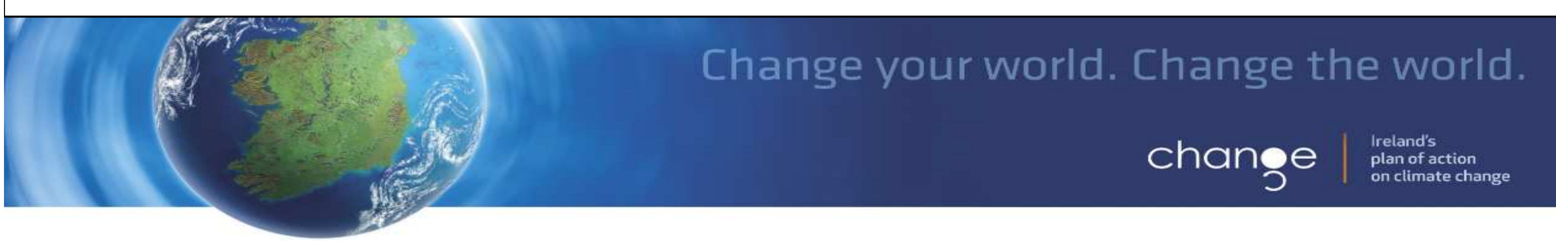
Rainfall relative to 1961-90

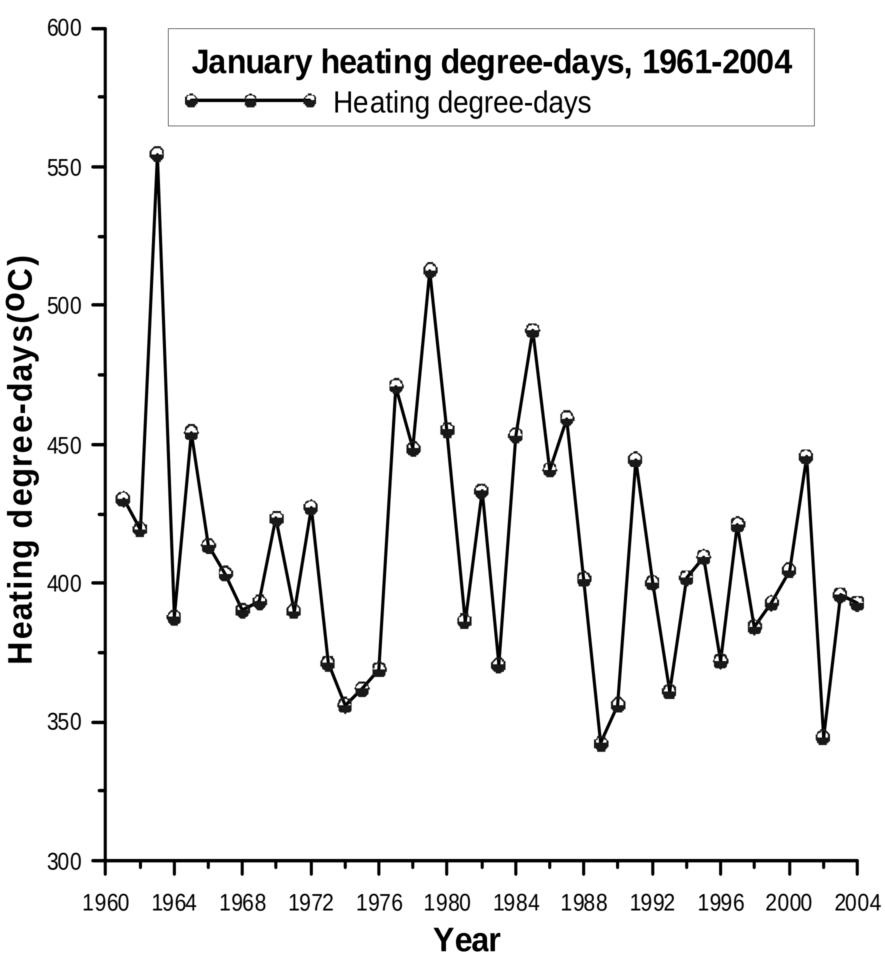
Overall increases in precipitation are predicted for the winter months of December- February. On average these amount to 11%. The greatest absolute increases are suggested for the north west.

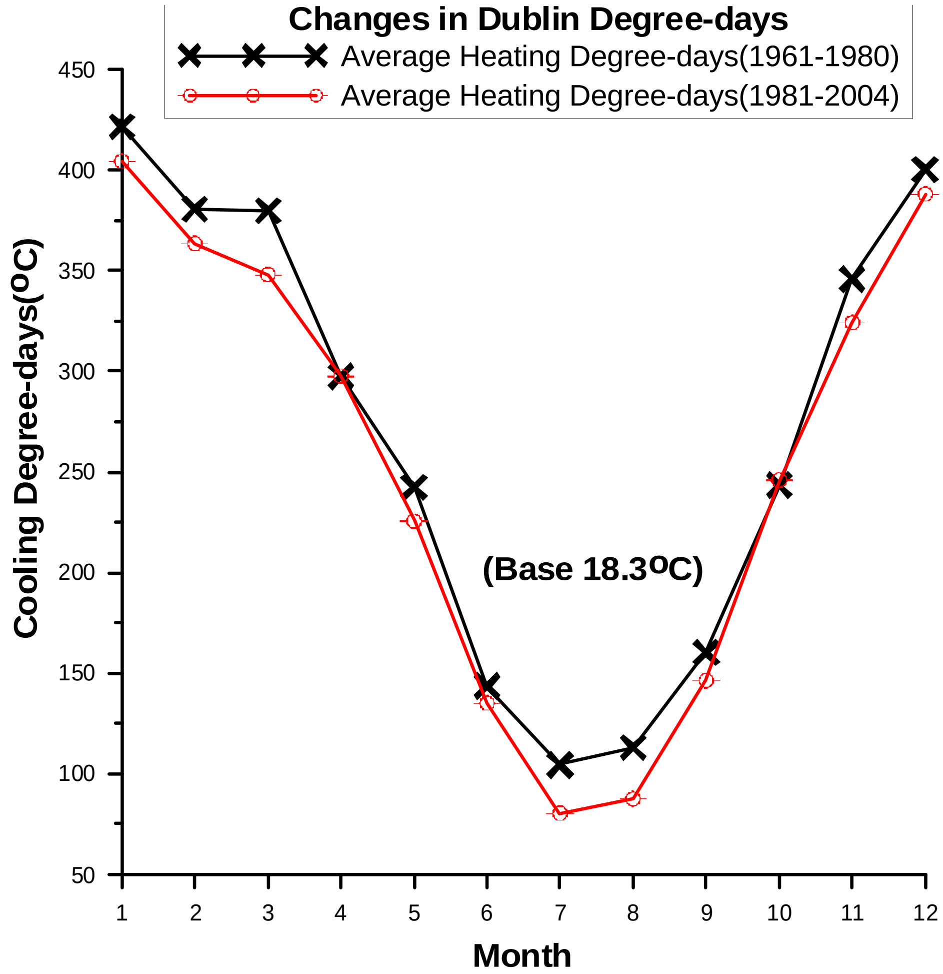
Marked decreases in rainfall during the summer and early autumn months across eastern and central Ireland are predicted. Nationally, these are of the order of 25% with decreases of over 40% in some parts of the south-east.

For local authorities we have to think especially about planning for sustainability in key sectors:

- Energy
- Water Resources, Flooding and waste water treatment
- Coastal Management/Sea-level rise
- Environmental Health
- Planning for infrastructure, housing, transport and other services





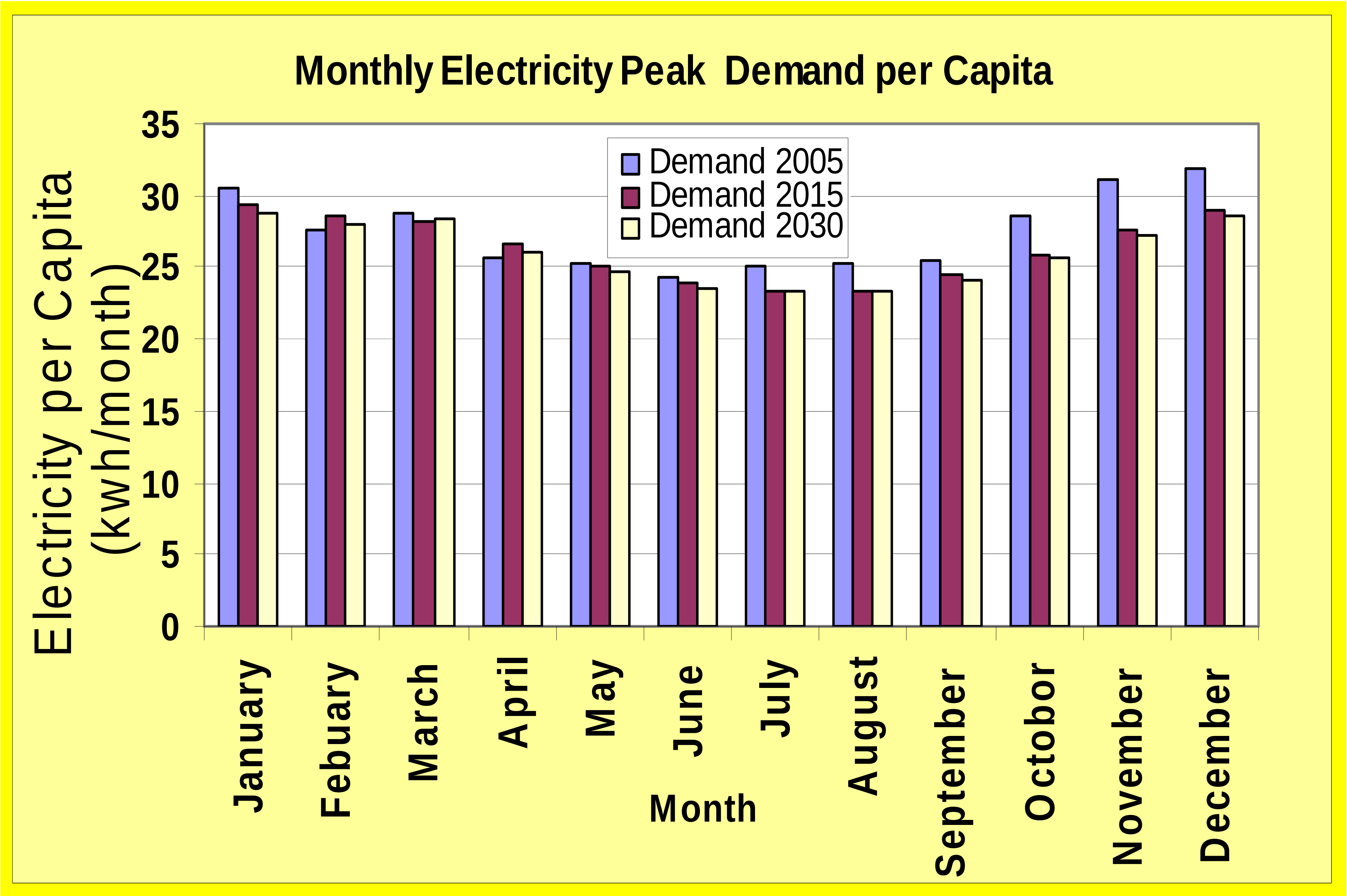


January Heating Degree-days Trend in Dublin, 1961-2004

Monthly Heating Degree-days Changes in Dublin, 1961-2004

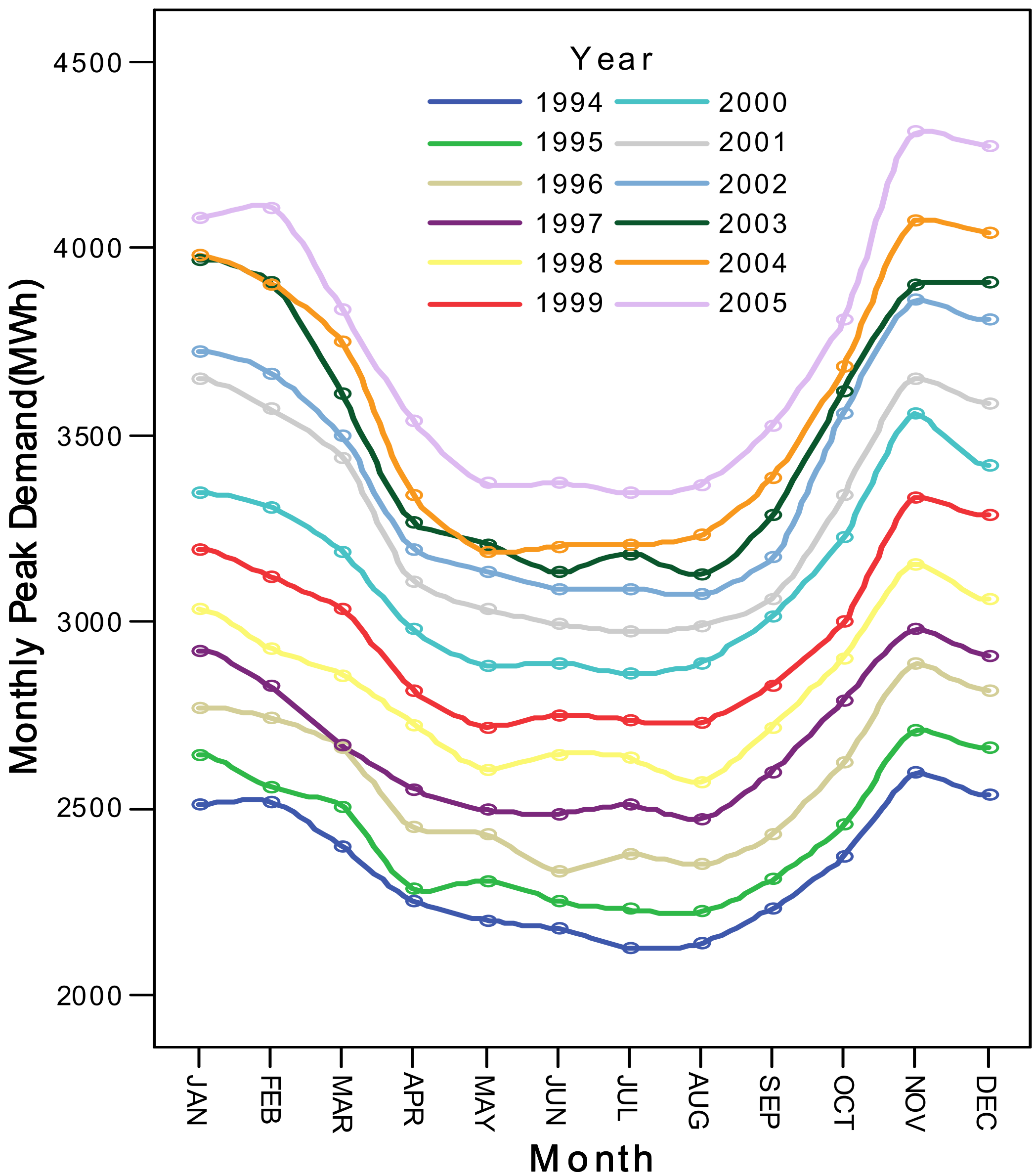
Mean temperature increasing

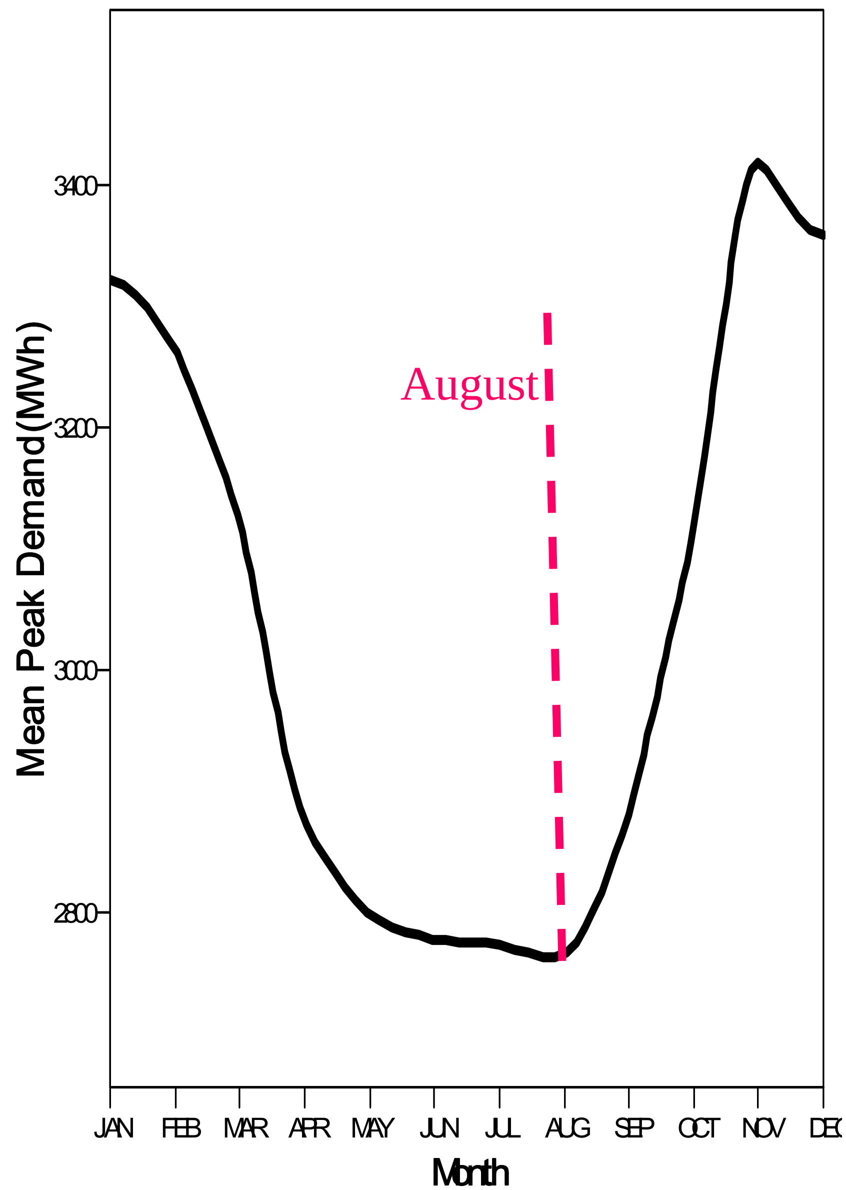
Projected Decrease in Winter Monthly Energy demand for the Greater Dublin region



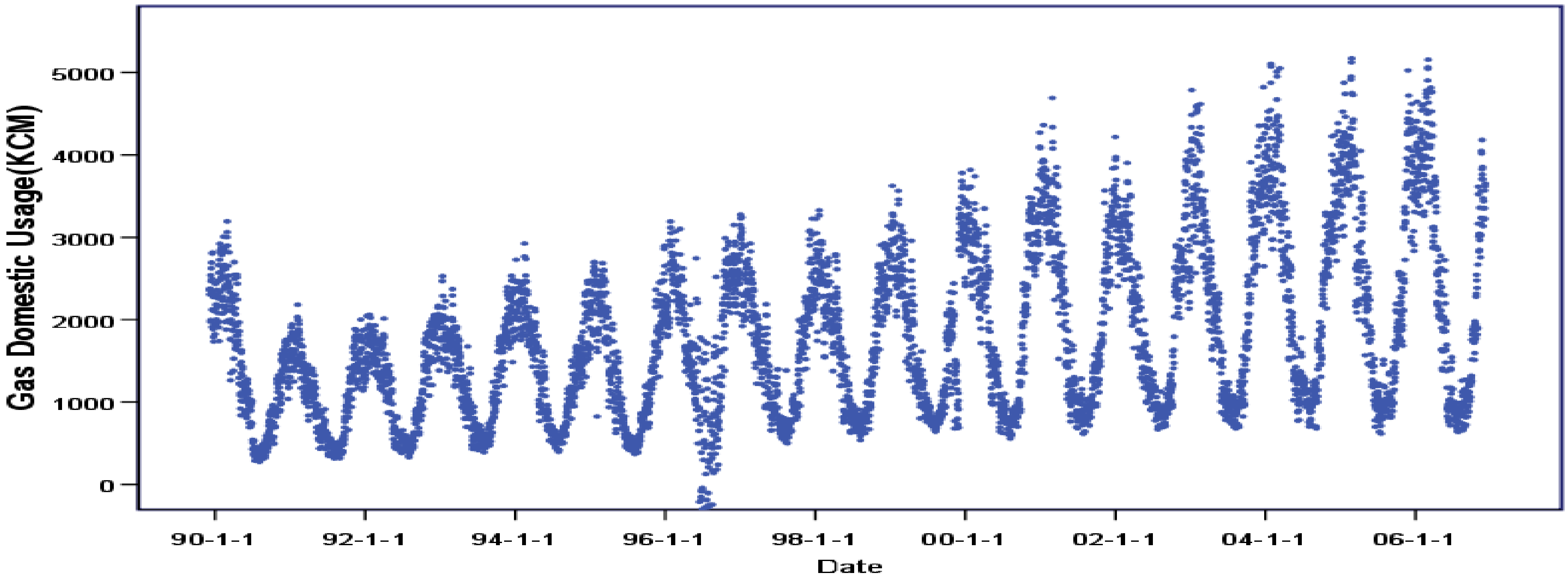
Seasonal Electricity Peak Demand - Republic of Ireland

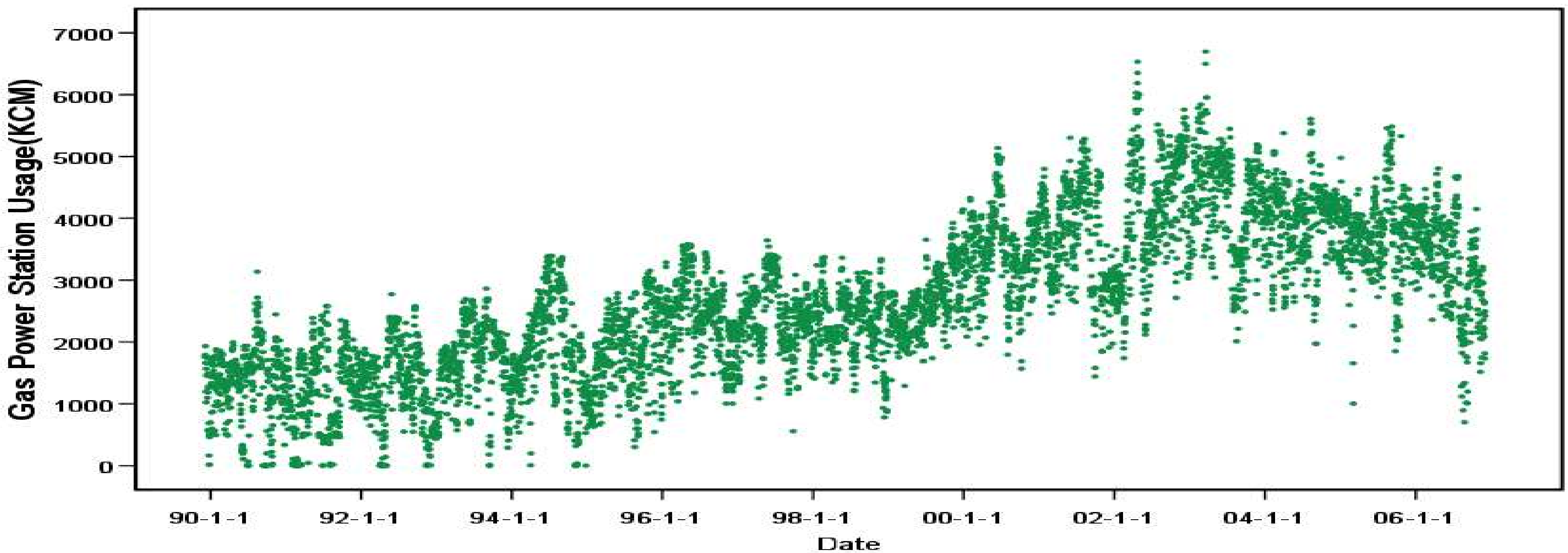
Monthly electricity peak demand, 1994-2005	**Mean monthly electricity peak demand, 1994-2005**





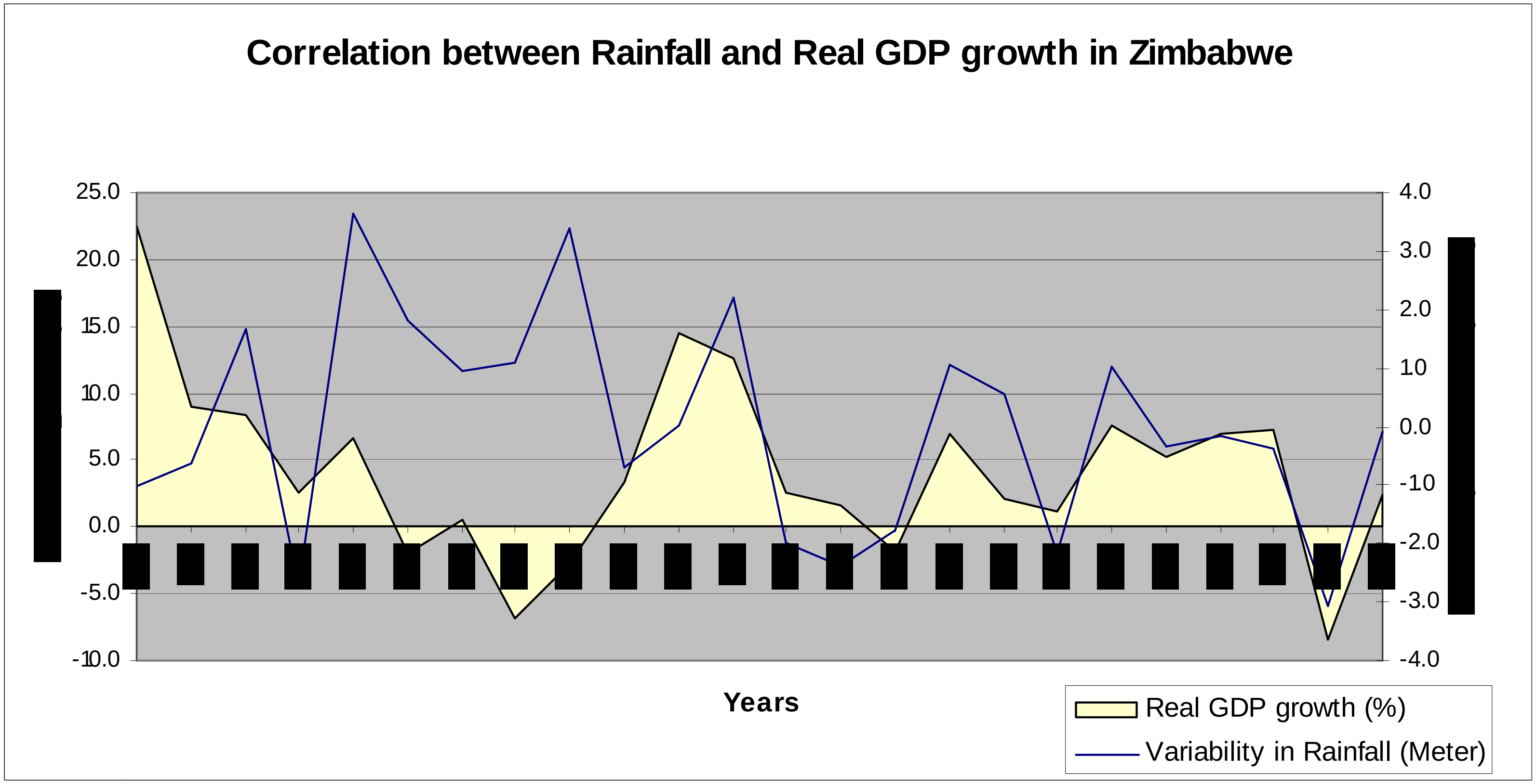
Dublin Domestic Daily Gas Use and Dublin Power station Daily Gas Use(1990-2006)



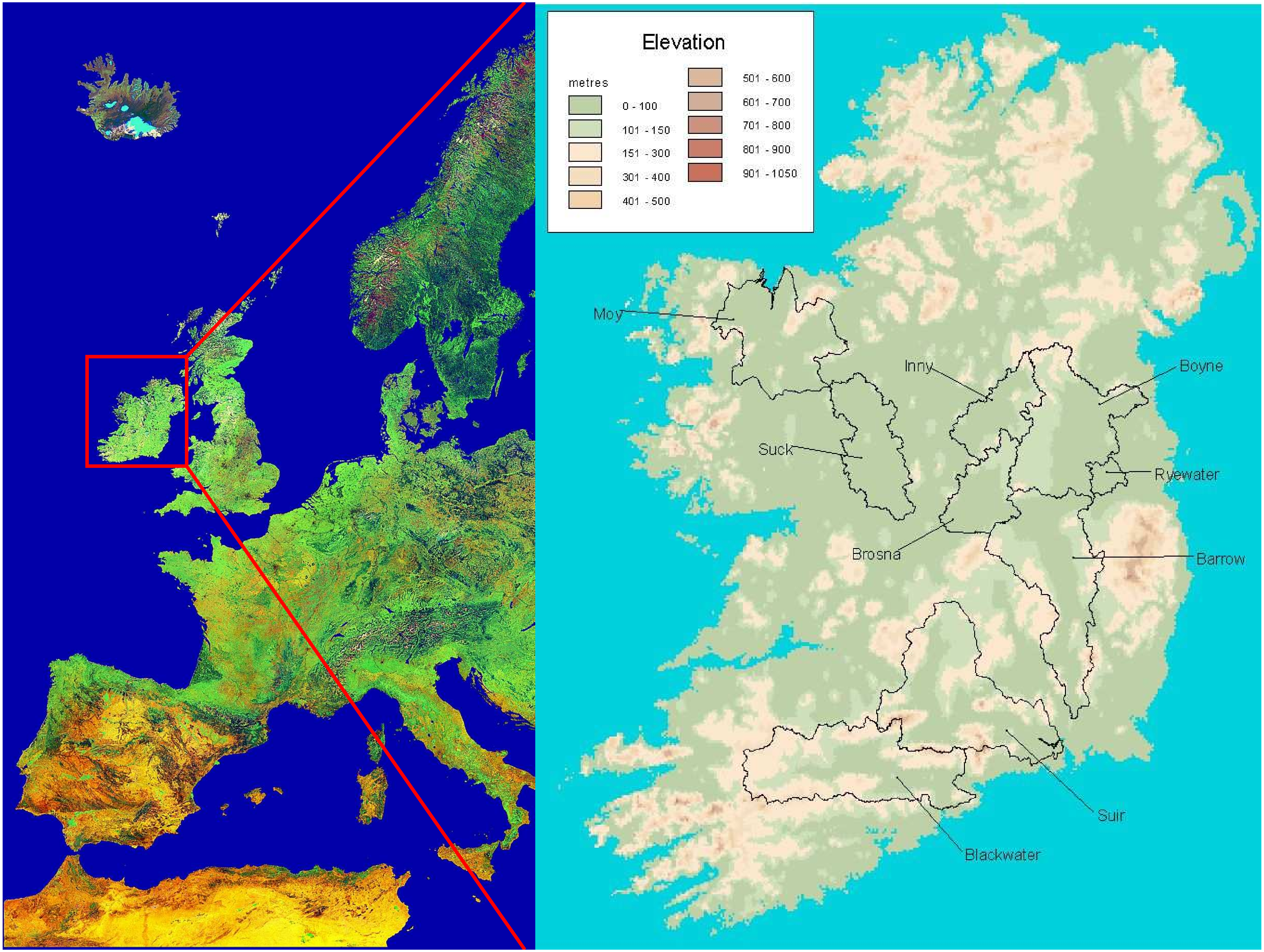


Water Resources, Flood Protection

Hydrological variability has huge impacts on poverty & livelihoods



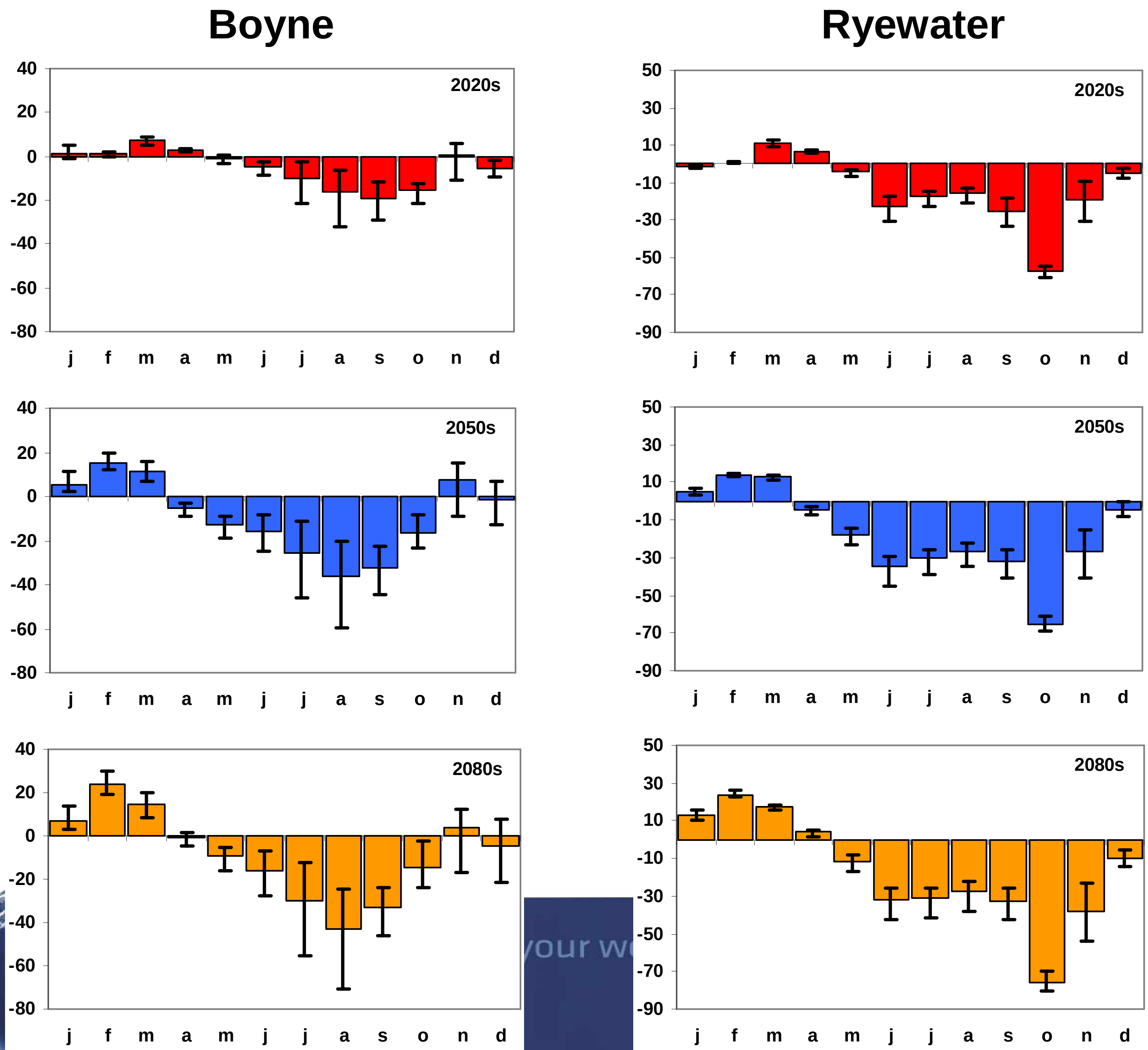
Relationship holds even in diverse middle income economies with substantial water storage infrastructure e.g. Morocco


Elevation
metres
0 - 100
101 - 150
151 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
901 - 1050
Moy
Inny
Boyne
Suck
Ryewater
Brosna
Barrow
Suir
Blackwater

			Barrow	B'water	Boyne	Brosna	Inny	Moy	R'water	Suck	Suir
T2	A_2	20s	1.8	1.8	1.9	2.1	2.5	1.6	1.6	1.5	1.8
		50s	1.6	1.5	1.4	1.5	1.4	1.5	1.4	1.4	1.7
		80s	1.3	1.4	1.2	1.3	1.2	1.3	1.5	1.2	1.5
	B_2	20s	1.8	1.5	1.4	1.8	1.6	1.4	1.4	1.4	1.8
		50s	1.6	1.5	1.4	1.4	1.3	1.4	1.7	1.4	1.8
		80s	1.5	1.5	1.3	1.3	1.3	1.4	1.6	1.4	1.6
T10	A_2	20s	4.8	3.6	7.1	13.9	12.7	4.2	3.4	4.4	4.4
		50s	4.8	4.2	3.4	3.4	4.5	4.4	3.3	4.5	6.9
		80s	3.4	3.4	1.8	2.0	2.0	2.2	4.1	2.1	3.2
	B_2	20s	3.7	2.6	2.3	4.0	4.1	2.2	3.5	2.4	4.1
		50s	4.0	2.6	3.5	3.0	3.5	4.6	5.5	5.5	4.1
		80s	2.9	3.8	2.2	2.1	2.3	3.9	5.4	4.6	2.8
T25	A_2	20s	8.3	5.1	15.1	39.3	26.4	7.7	5.3	8.8	6.5
		50s	10.1	7.3	5.6	4.9	7.5	8.5	5.5	9.7	16.9
		80s	6.7	5.3	2.3	2.8	2.7	3.1	6.9	3.0	4.7
	B_2	20s	5.5	3.2	3.0	5.6	6.6	3.0	6.4	3.5	5.8
		50s	7.7	3.4	6.9	4.5	6.1	10.3	11.0	14.2	5.8
		80s	4.6	6.6	3.2	2.6	3.2	8.2	12.8	13.8	3.7

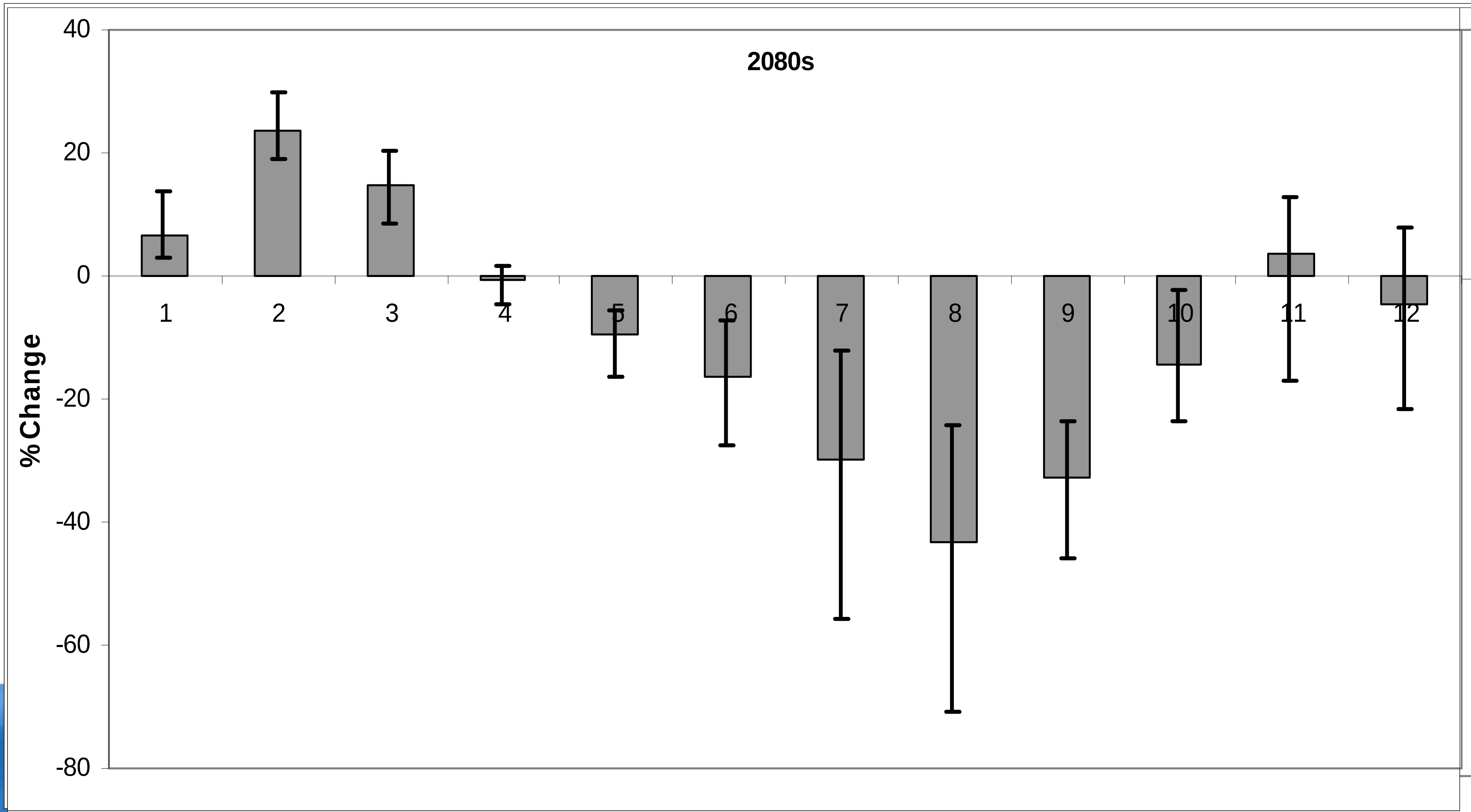
Changes in the frequency of floods of a given magnitude for each future time period. Results are based on the HADCM3 GCM using both A2 and B2 emissions scenarios.

% Change in monthly streamflow

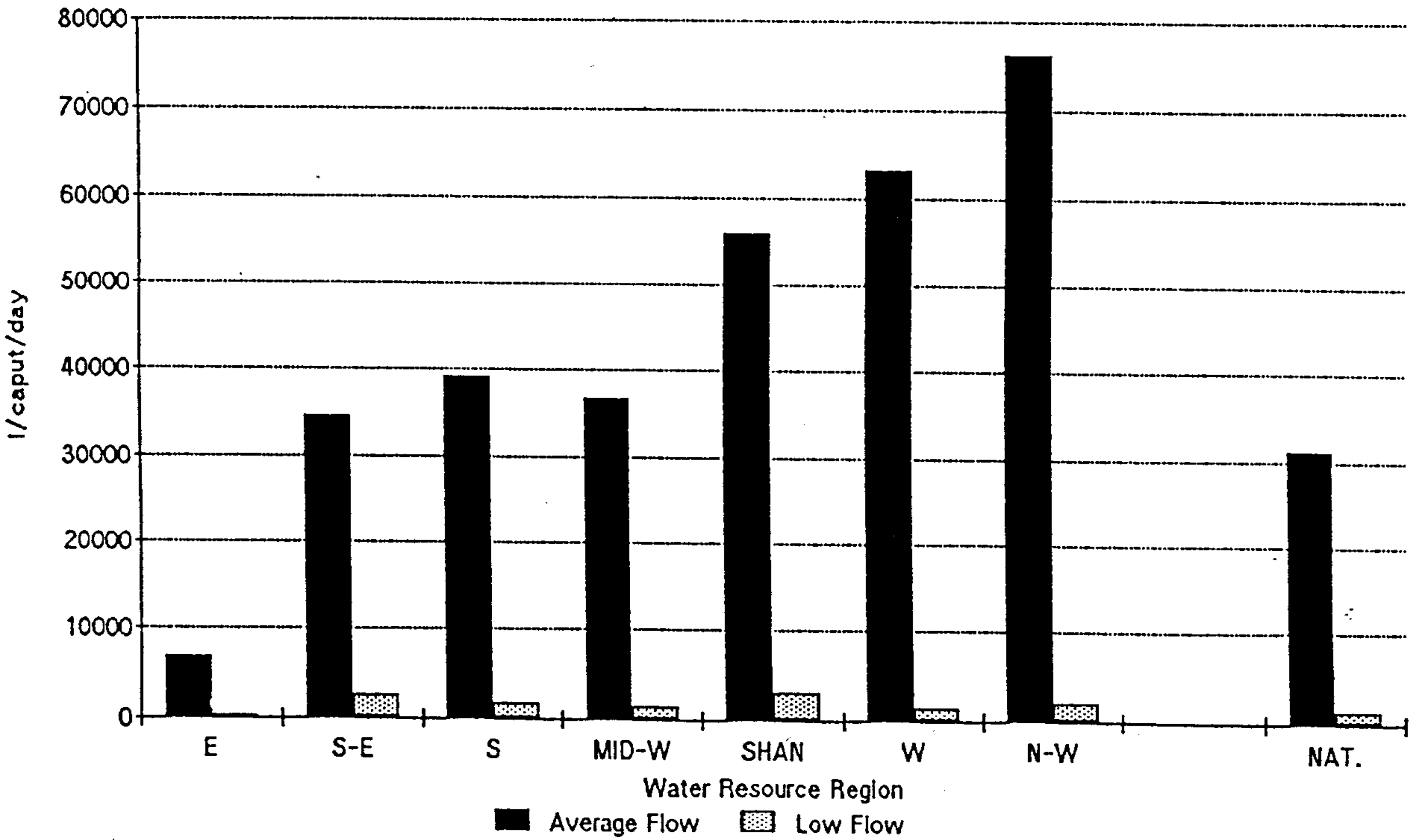


*I*rish *C*limate *A*nalysis and *R*esearch *U*nits

Percent change in simulated monthly **Streamflow** Boyne Mean Ensemble



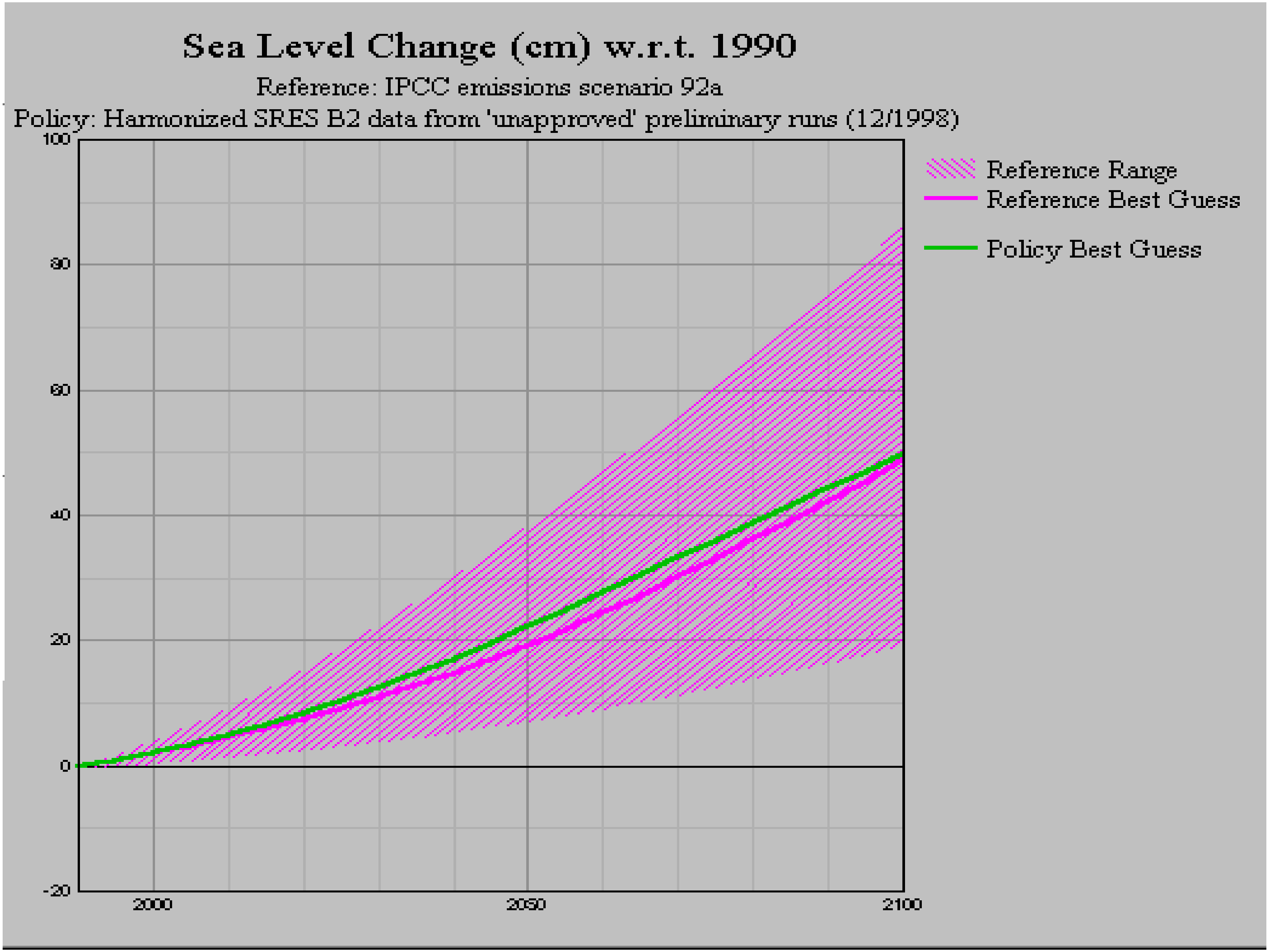
Regions with low per capita availability may experience the greatest reductions in water availability; especially during summer months



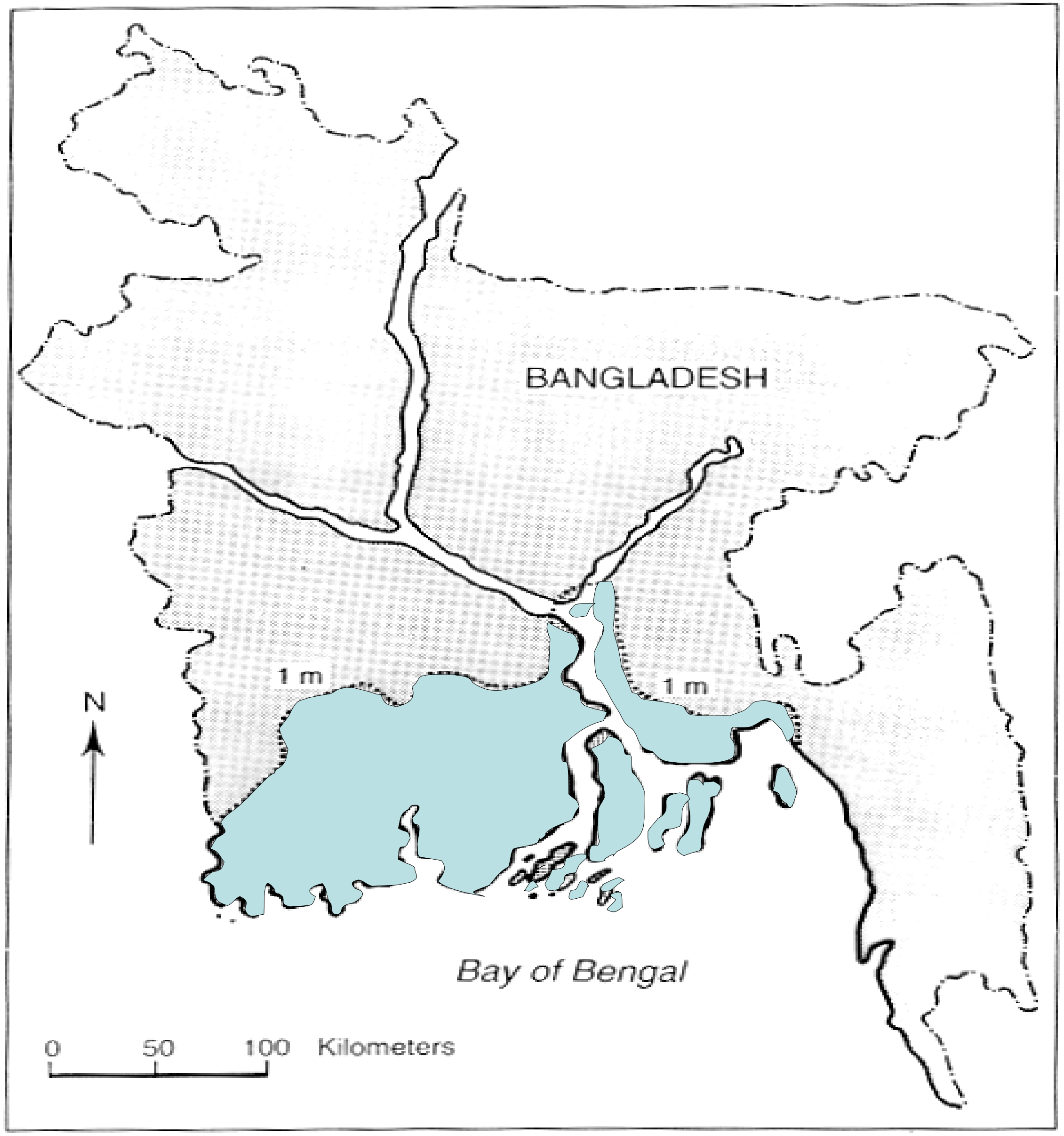
Adaptation lessons

- Summer soil moisture deficits pose the greatest threat for future Irish agricultural production, especially in western parts

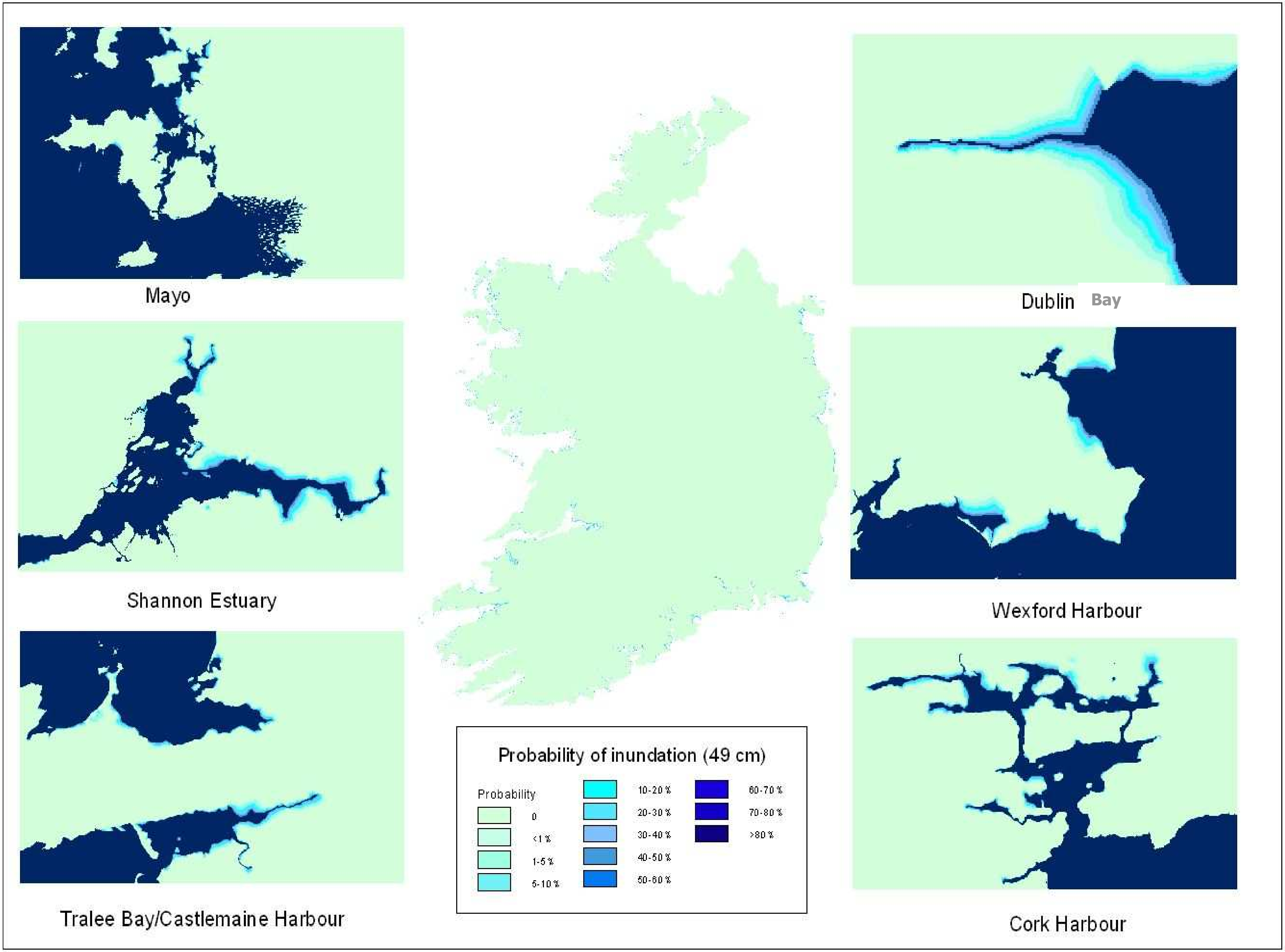
- Where water is available and needed, substantial reductions in fertiliser use can be achieved
- Where water is unavailable and needed, yields may be partially maintained by increased fertiliser application



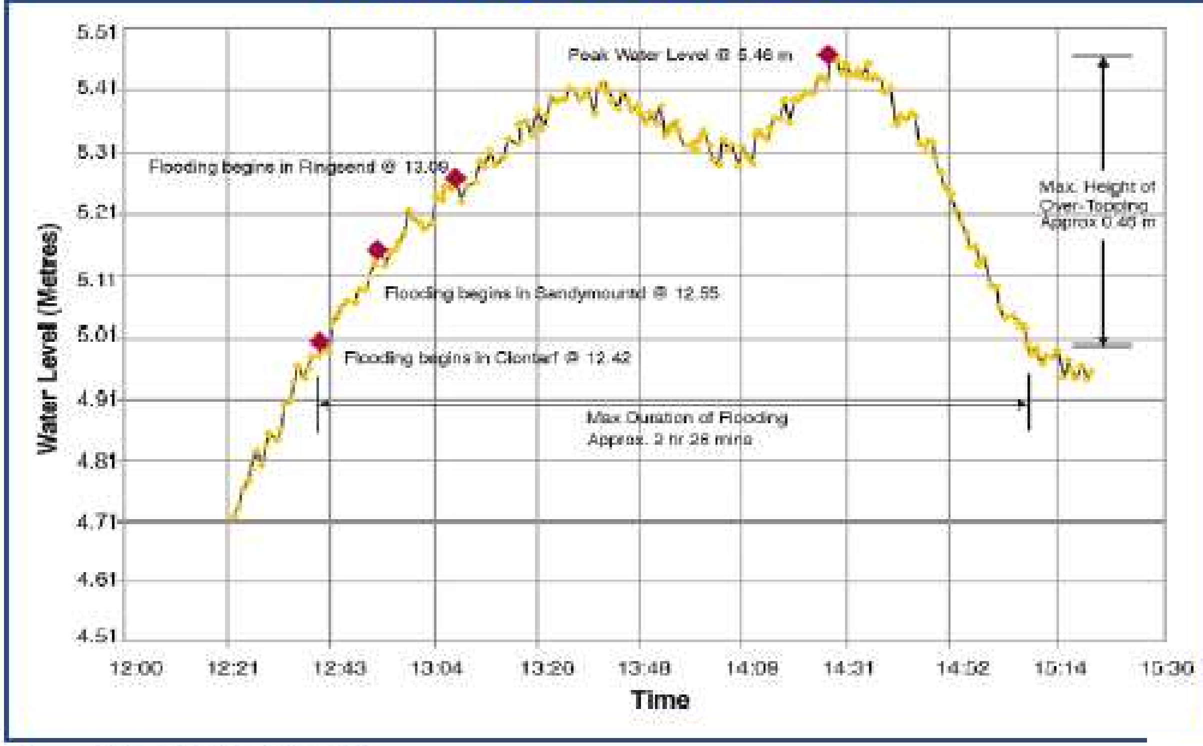
Sea Level Change (cm) w.r.t. 1990
Reference: IPCC emissions scenario 92a
Policy: Harmonized SRES B2 data from 'unapproved' preliminary runs (12/1998)
100
80
60
40
20
0
-20
2000
2050
2100
Reference Range
Reference Best Guess
Policy Best Guess



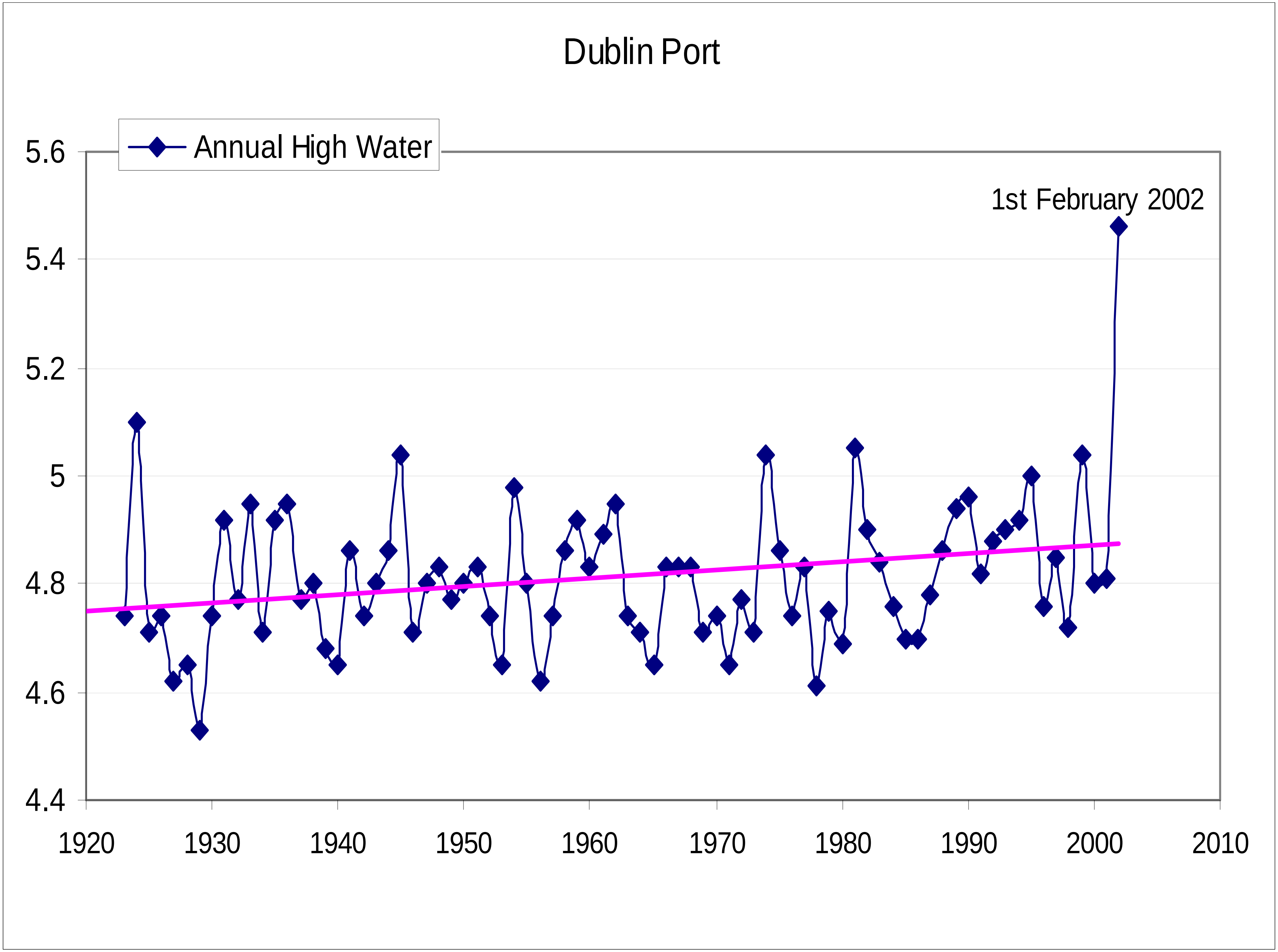
Land at risk in Bangladesh due to a 1m rise in sea level (after Huq *et al.* 1995).


Mayo
Dublin Bay
Shannon Estuary
Wexford Harbour
Tralee Bay/Castlemaine Harbour
Cork Harbour
Probability of inundation (49 cm)
Probability
0
<1 %
1-5 %
5-10 %
10-20 %
20-30 %
30-40 %
40-50 %
50-60 %
60-70 %
70-80 %
>80 %

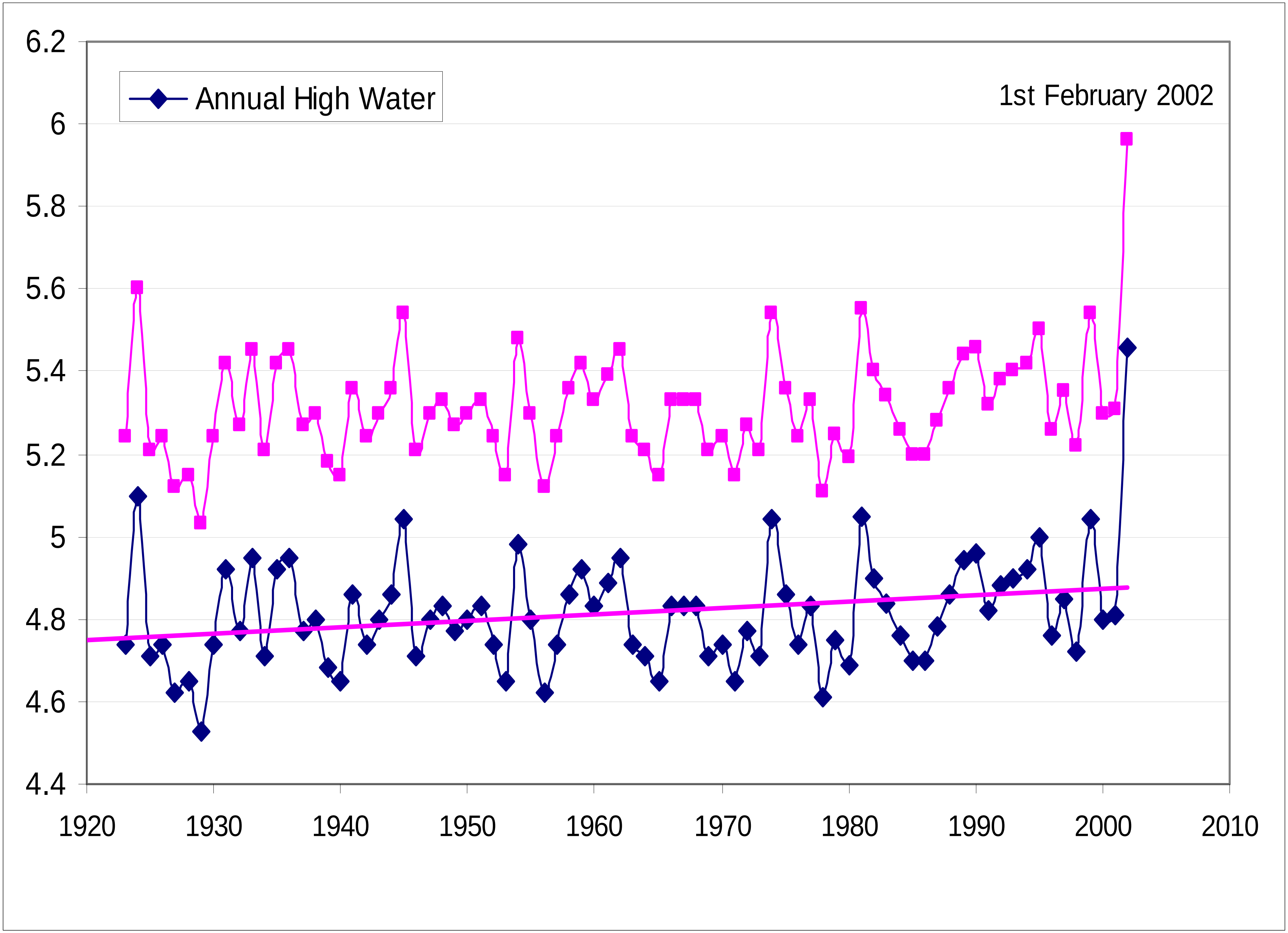
1 February 2002 - The Rising Tide



Source: M.C. O'Sullivan Ltd 2002



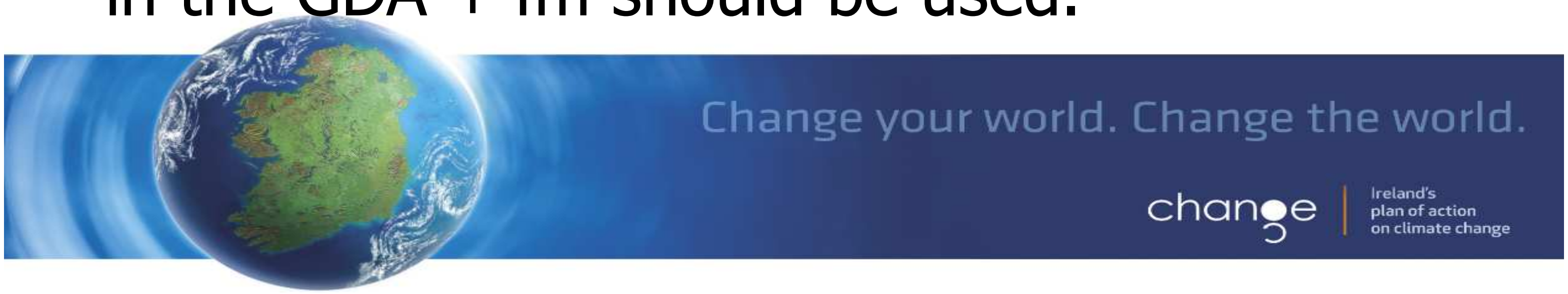
Dublin Port
Annual High Water
1st February 2002
5.6
5.4
5.2
5
4.8
4.6
4.4
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010



Annual High Water
1st February 2002
6.2
6
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

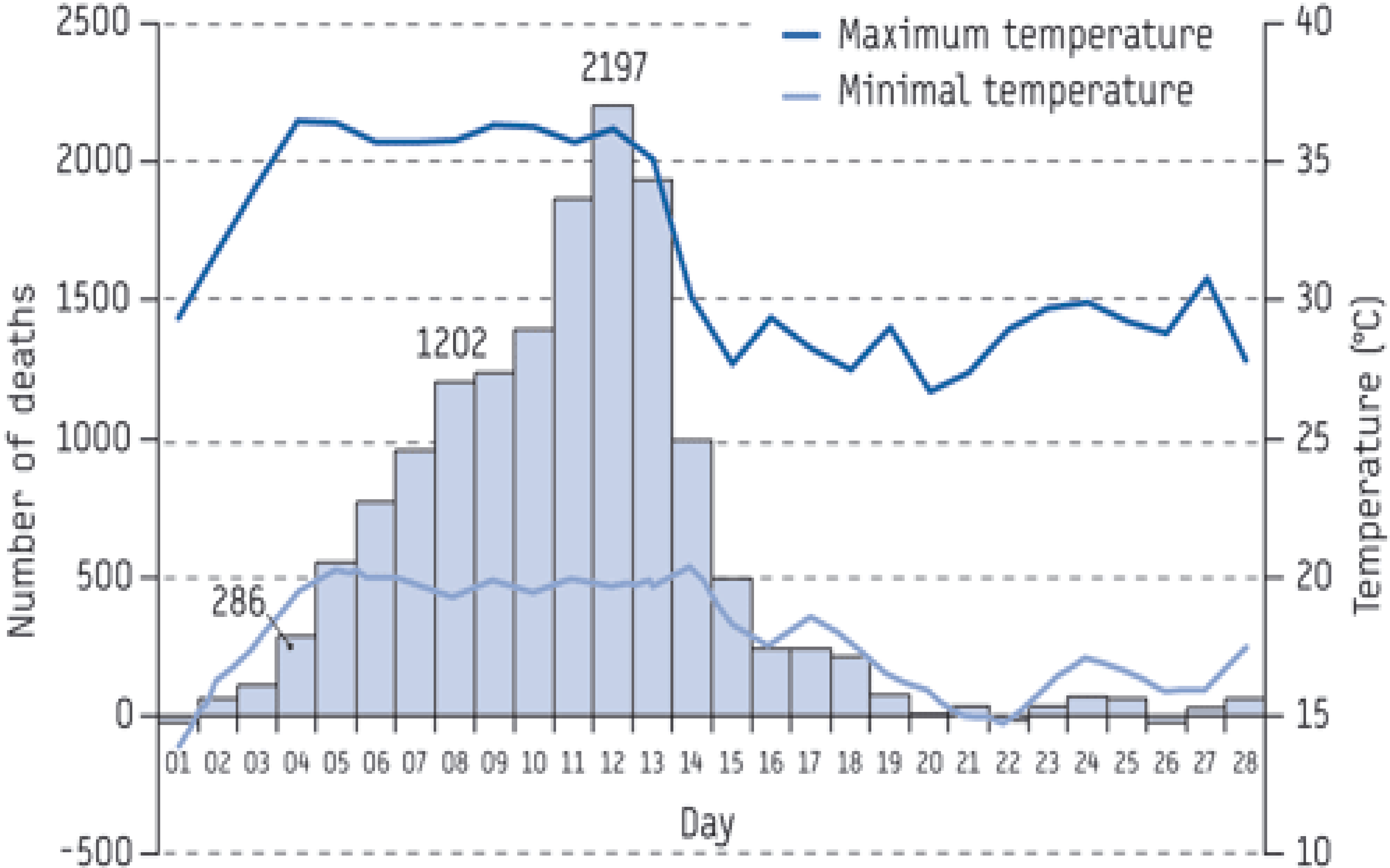
Some Recommendations for Coping with Sea-level Impacts in Ireland

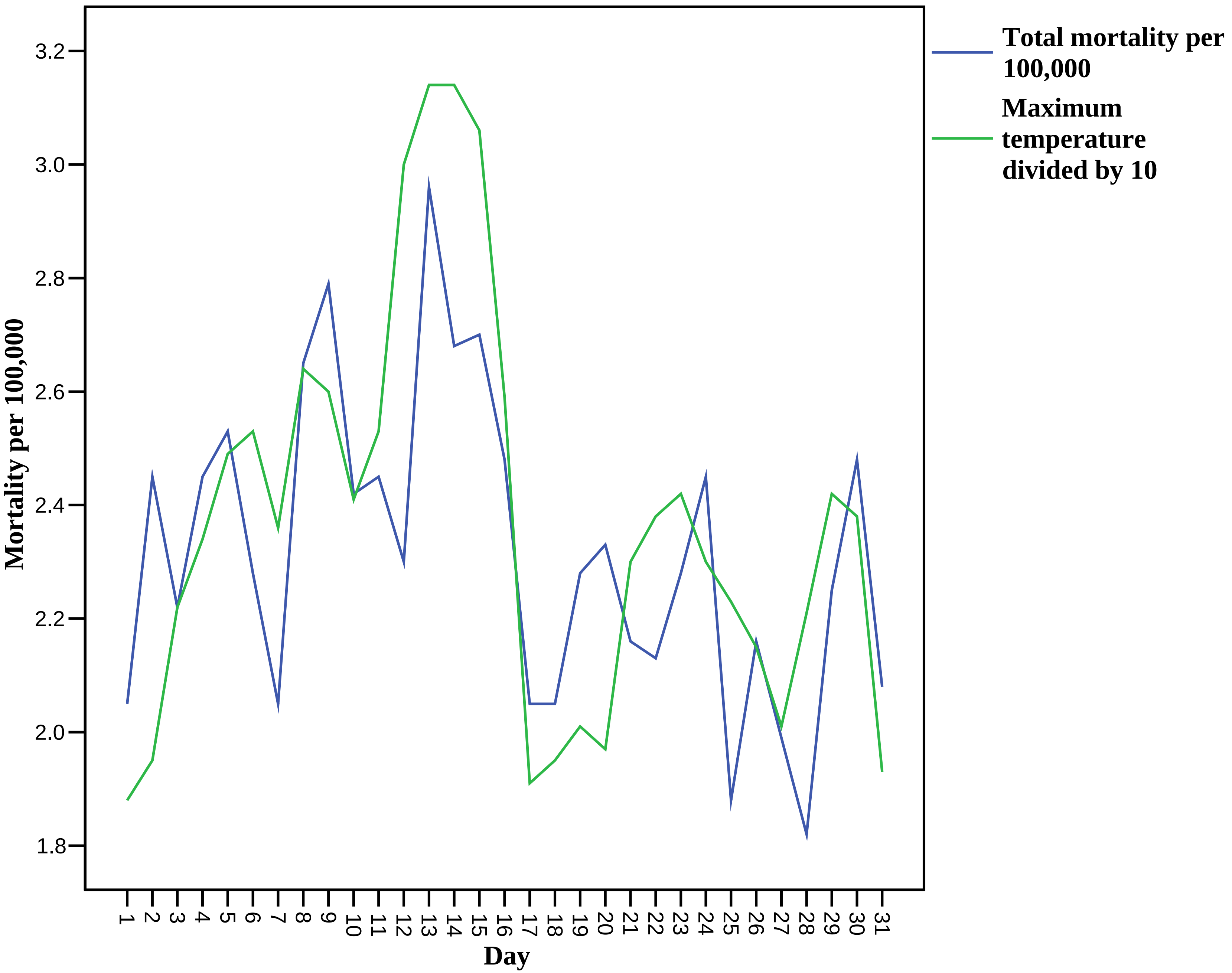
- No building or development within 100 metres of ‘soft’ shoreline
- No further reclamation of estuary land
- No removal of sand dunes, beach sand or gravel
- All new coastal defence measures to be assessed for environmental impact
- Sea level rise of 400-480mm for 2080 in eastern Ireland should be assumed.
- The 200-year return period should be used for coastal flooding design (+3.4m Malin OD). For major infrastructure in the GDA +4m should be used.



Dublin City
Baile Átha Cliath

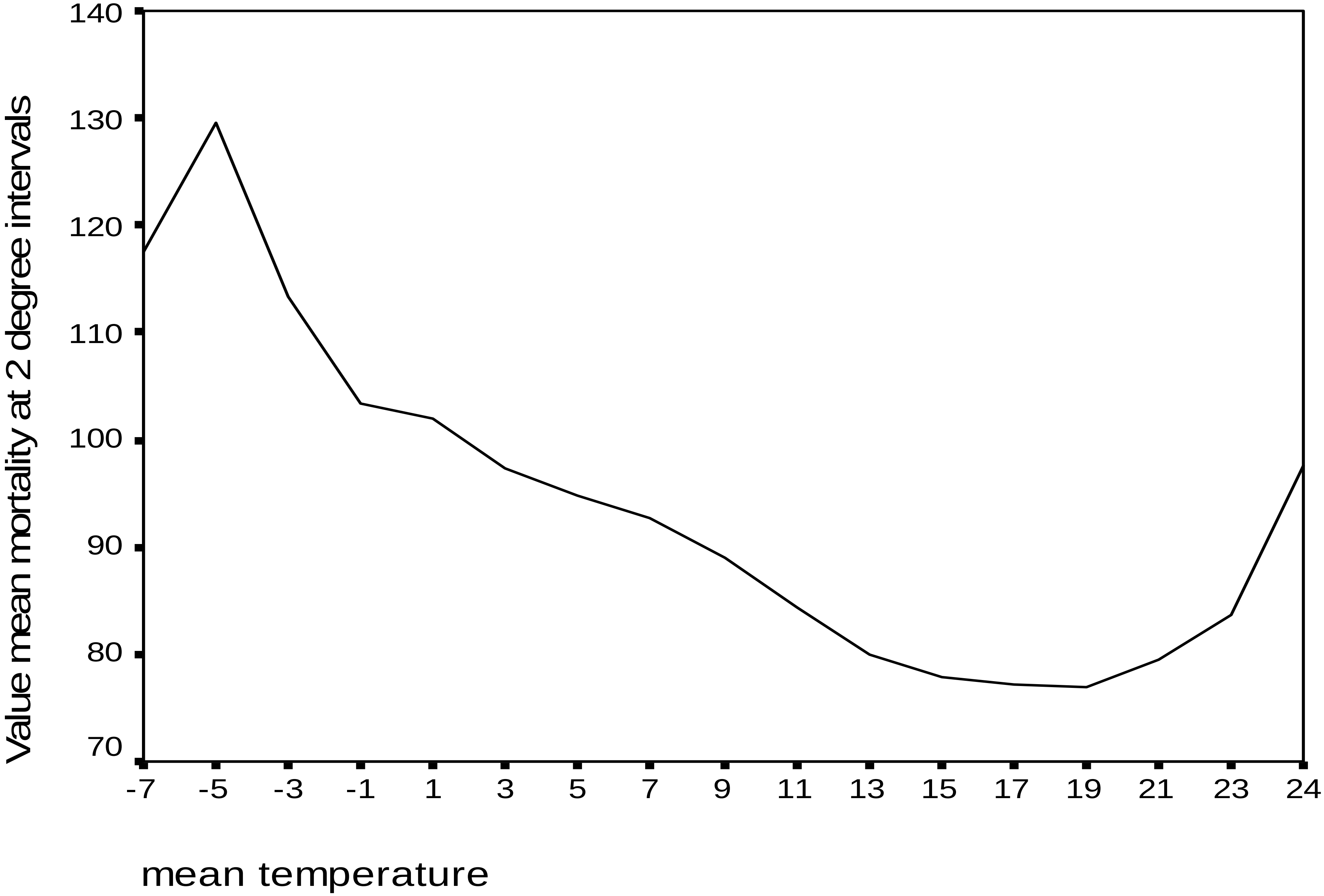
Daily excess of deaths during August 2003 and minimal and maximal daily temperatures, France





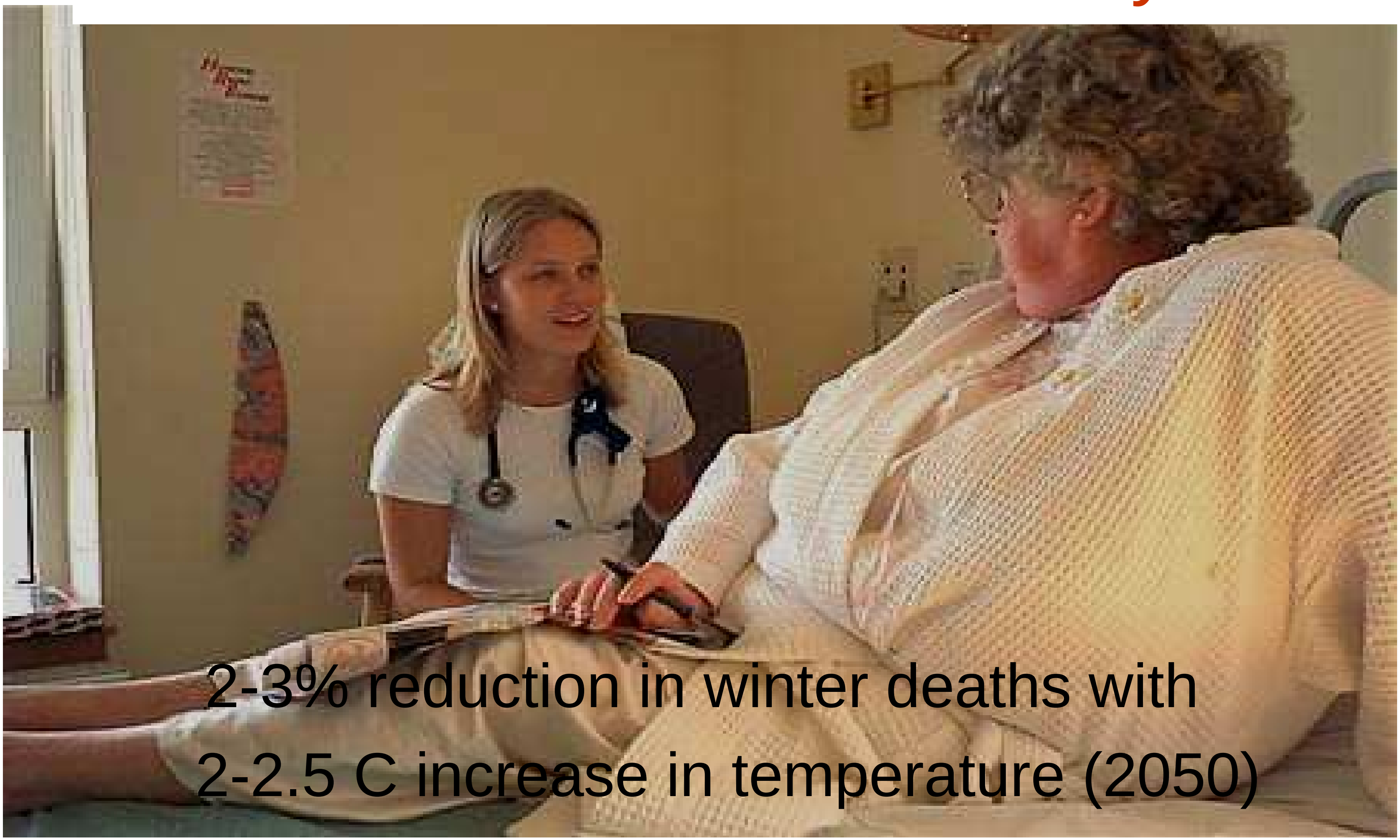
Total mortality per 100,000
Maximum temperature divided by 10
Mortality per 100,000
Day
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Temperature/Mortality in Ireland



Milder winters

Reduced Winter Mortality

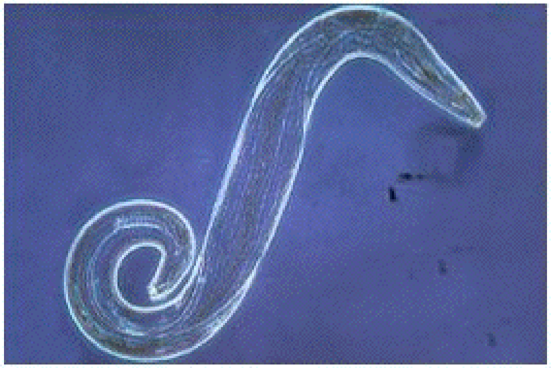


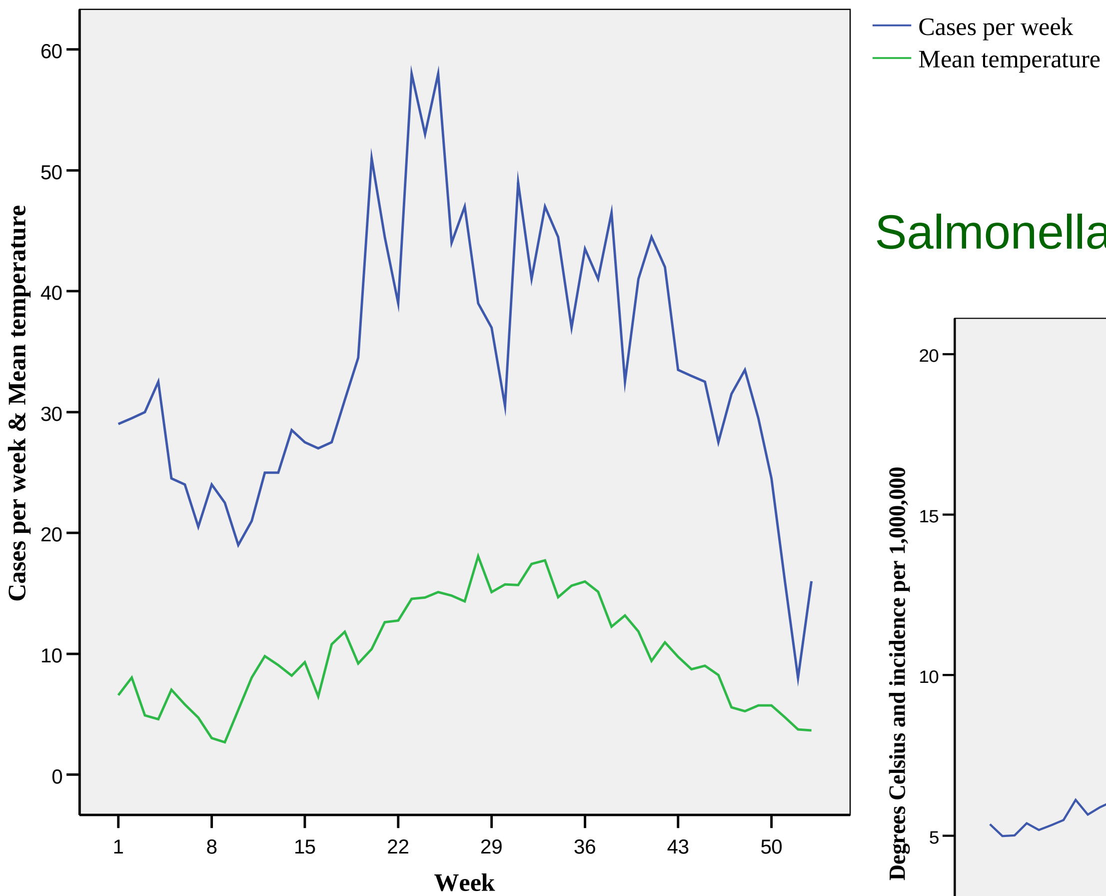
2-3% reduction in winter deaths with

2-2.5 C increase in temperature (2050)

Some infectious diseases are likely to increase in incidence

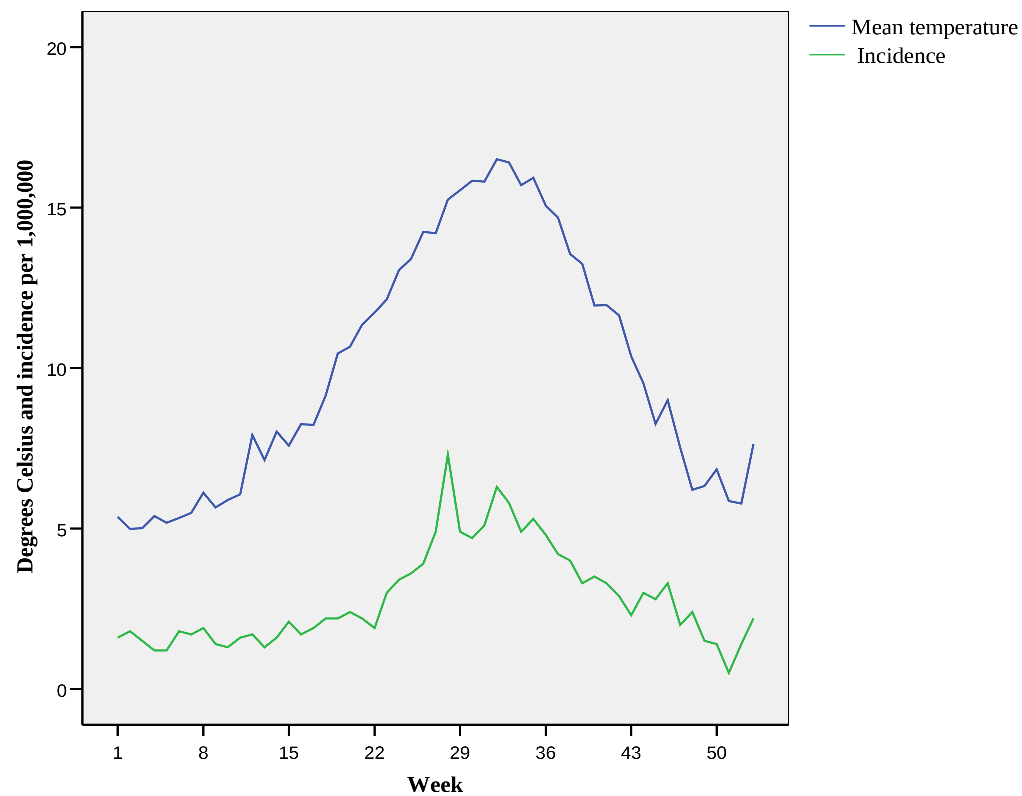
- Food poisoning
- Water borne disease
- Malaria?
- Tick borne disease?

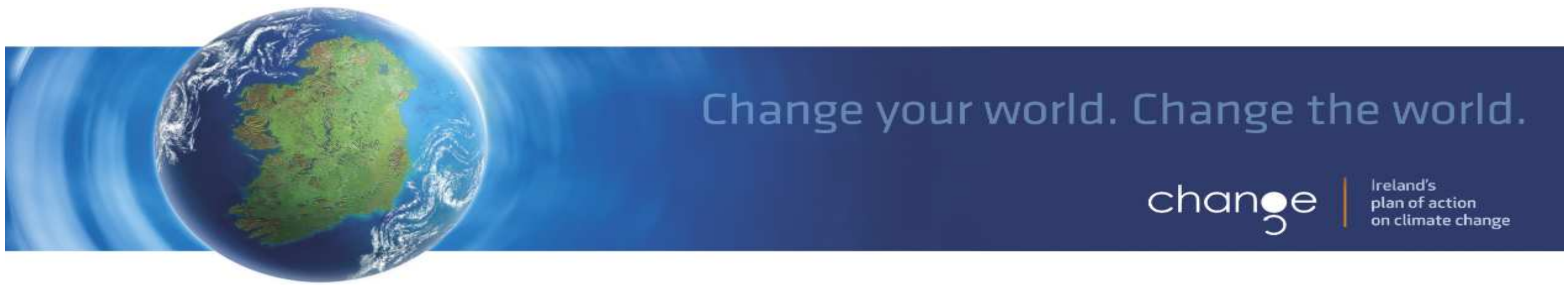




Campylobacter 2004-5

Salmonella 1988-2004 (per 100,000 population)





Dublin City
Baile Átha Cliath

External Uncertainties

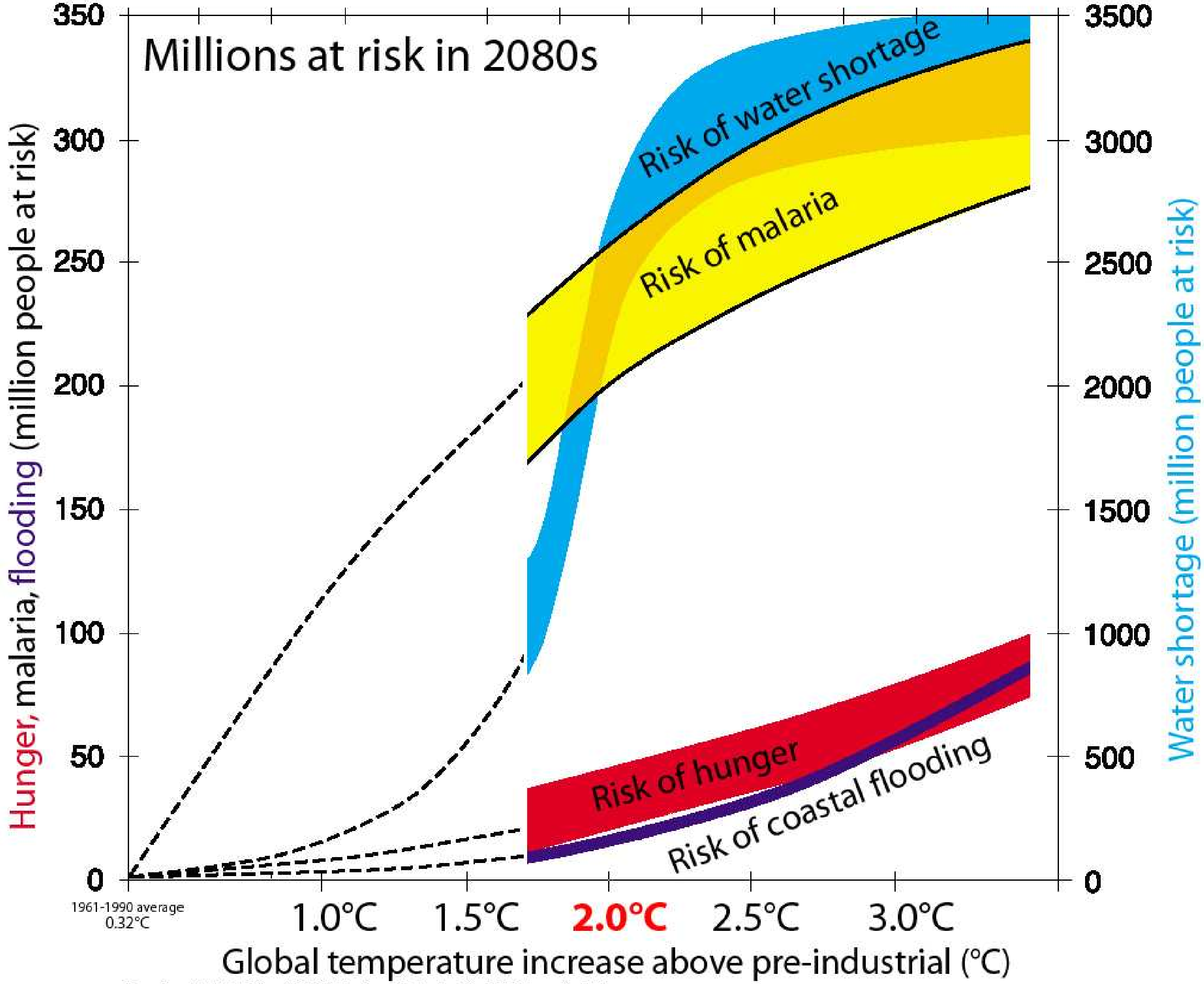
- Changes in the Thermohaline Circulation
- Changes in the biosphere's contribution to atmospheric carbon
- Changes in the ocean's ability to sequester carbon

EU's 2℃ target

"[...] the Council believes that global average temperatures ***should not exceed 2 degrees above pre-industrial level*** *[...]"* (1939th Council meeting, Luxembourg, 25 June 1996)

"REAFFIRMS that, with a view to meeting the ultimate objective of the United Nations Framework Convention on Climate Change [...] to prevent dangerous anthropogenic interference with the climate system, overall global annual mean surface temperature increase ***should not exceed 2°C above pre-industrial levels*** *in order to limit high risks, including irreversible impacts of climate change; RECOGNISES that 2°C would already imply significant impacts on ecosystems and water resources [...]"* (2610th Council Meeting, Luxembourg, 14 October 2004 Council 2004, 25-26 March 2004)

Millions at Risk (Parry et al., 2001)

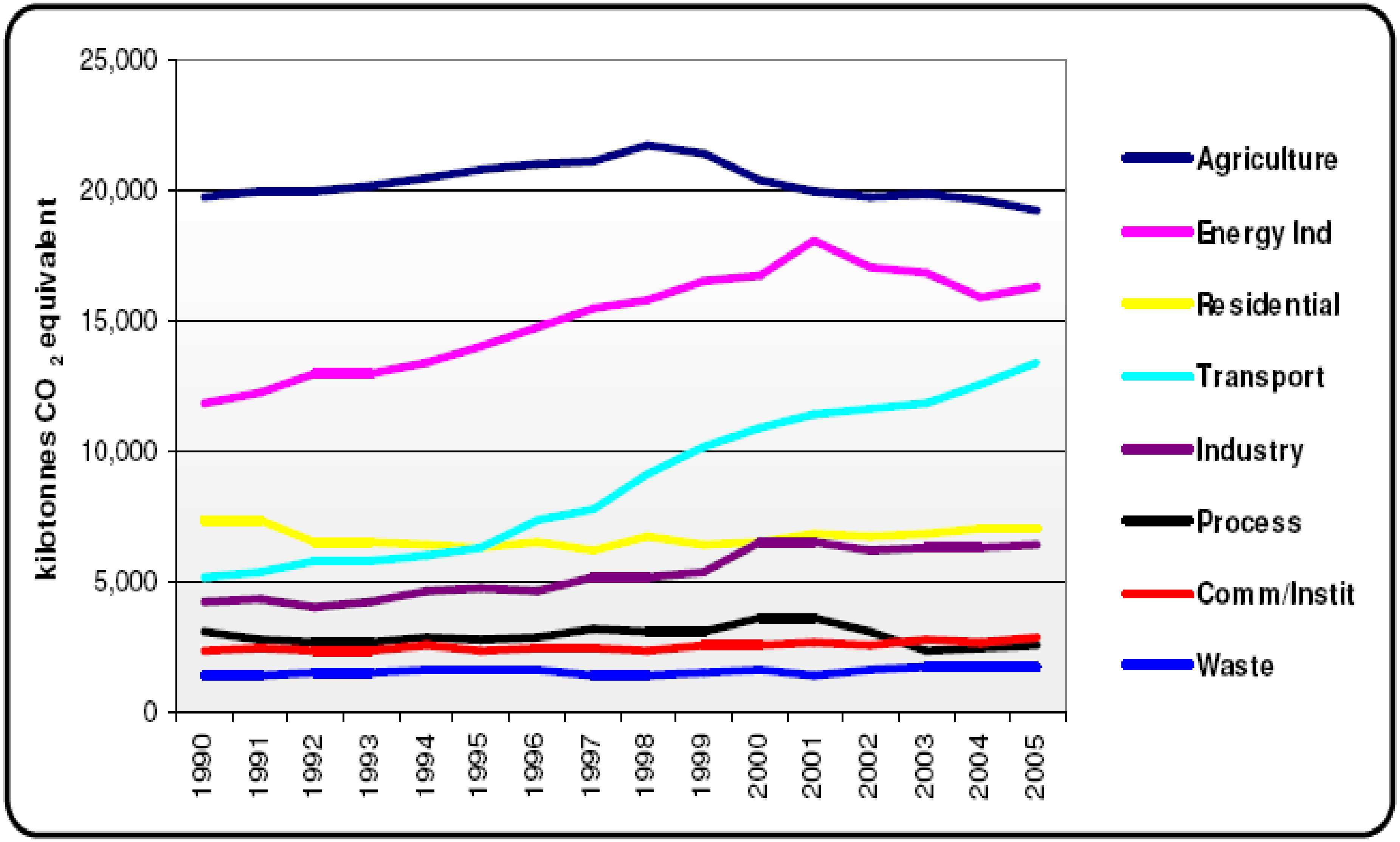


Source: Parry et al. (2001) "Millions at Risk" Glob. Env. Change. Graph adapted by M.Meinshausen, Nov. 2004
Note: The original graph presented temperature levels above 1961-1990 average (see Hulme, Mitchell et al. 1999), not above pre-industrial. The 1961-1990 average is 0.32°C above pre-industrial levels (1861-1890). Thus, a 0.32°C temperature difference has been added to the original scale. Furthermore, the original graph presented temperature levels in 2080 for different CO2 equivalance (!) stabilization scenarios. For a climate sensitivity of 2.5°C (as underlying the work of Parry et al.), the 2080 temperature level for the S550 CO2eq emission path has been about 1.4°C above 1990 (2°C above pre-industrial).

The EU on February 20th 2007 undertook unilaterally to cut greenhouse gas emissions by 20% on 1990 levels within 13 years

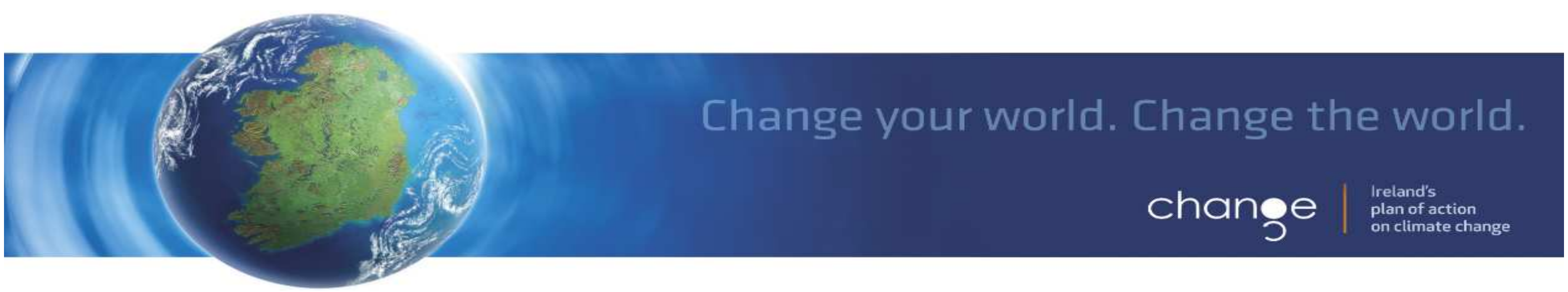
- Burden sharing proposals were announced on 23rd January 2008
- Ireland with the 2nd highest per capita gdp in the EU will be required to cut ghg emissions relative to 2005 by 20%
- This figure could increase to 30% should the incoming US administration return to the negotiating table

Irish Greenhouse Gas Emissions



Increasing Car Dependency

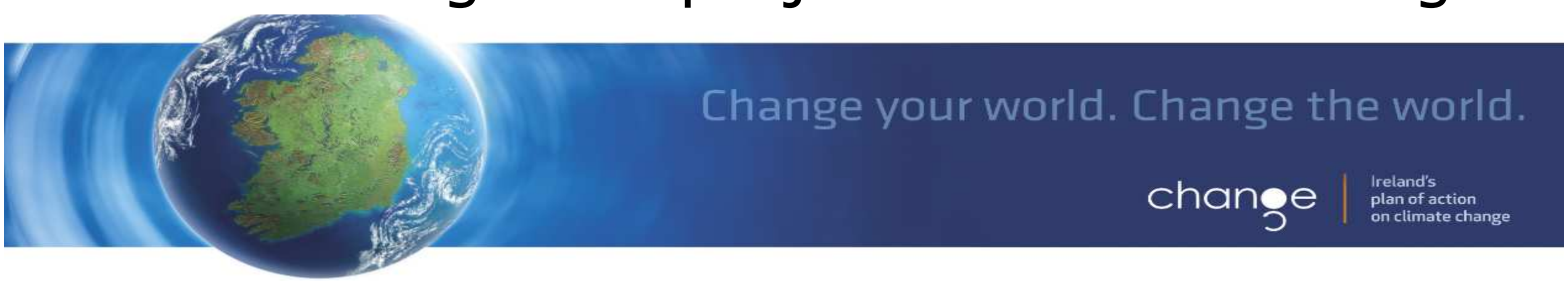
- 56% of Dublin commuters drive to work
- 80% less schoolchildren cycle to school in the Dublin area than in 1991
- One in three school pupils who live less than a mile from school travel by car each day
- Average bus speeds in Dublin have dropped below 13kph. Comparable figures for London are 26kph, Stockholm 28kph, Copenhagen 24kph.



Dublin City
Baile Átha Cliath

Planning Questions relating to Climate Change

- Are the potential impacts of projected climate change incorporated into EIA at individual project level?
- Do current County and Town Development Plans include strategic provision for the impacts of climate change?
- Are plans and programmes involving developments with a lifetime of more than 20 years factoring in climate change as part of assessment procedures?
- Does emergency planning take into account climate change?
- Have the elected members been acquainted with key risks arising from projected climate change?



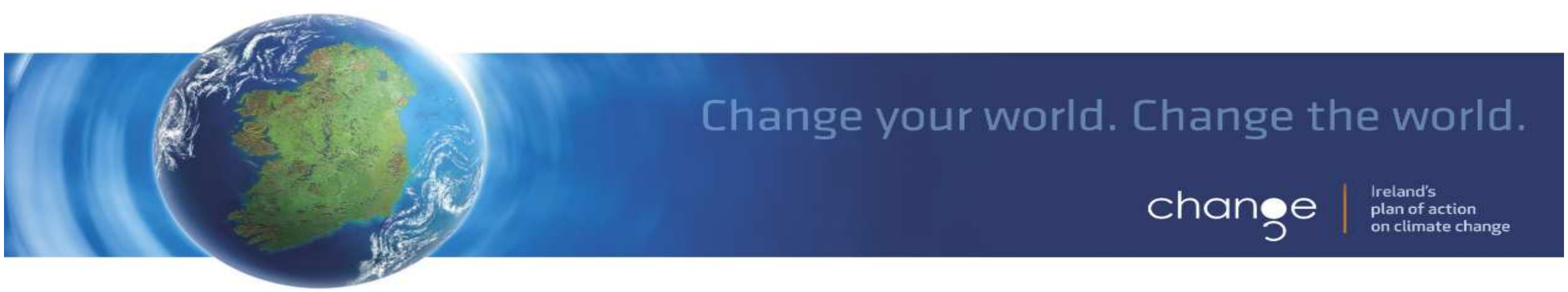
Dublin City
Baile Átha Cliath

Why local authority planners need to concern themselves with climate change in Ireland

- Typically, Irish cities such as Dublin have expanded into low-lying estuaries. As cities have grown by reclamation, they have exposed a growing population to coastal flood risk.
- Major investments in buildings and transport infrastructure frequently have taken place or are planned for coastal zones adjacent to urban centres.
- River regimes feeding into some major rivers have ‘flashy’ hydrological regimes with a history of flooding. E.g. for the Liffey, mountain rain fed rivers such as the Dodder, and heavily urbanised catchments such as the Tolka, deliver storm runoff into the urban drainage system rapidly.

- Projections for continuing rapid population growth as specified in the Regional Planning Guidelines raise serious and as yet unanswered questions regarding water supply and waste water treatment limits for the Greater Dublin Area should significant changes in rainfall occur.

- Engineering solutions to risk management based on e.g. the once in a century drought/flood/wind gust are now largely irrelevant since they are based on non representative thirty year records of past climate.

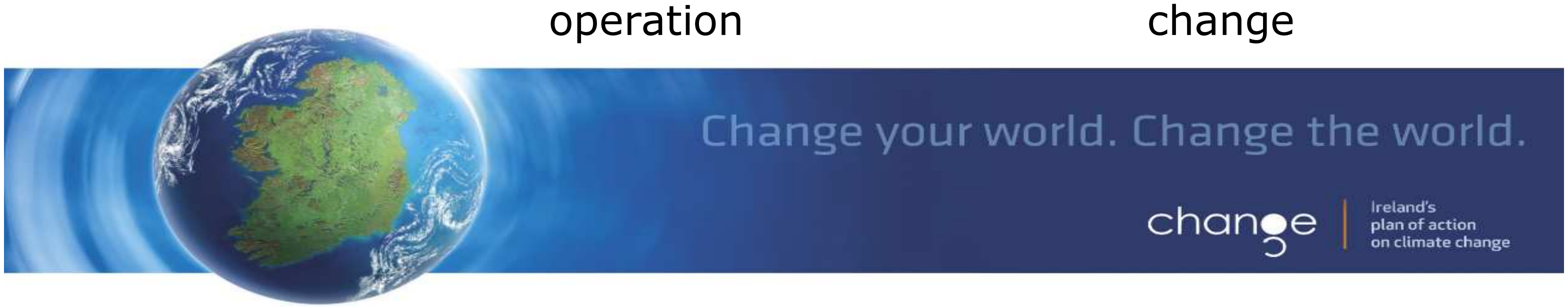


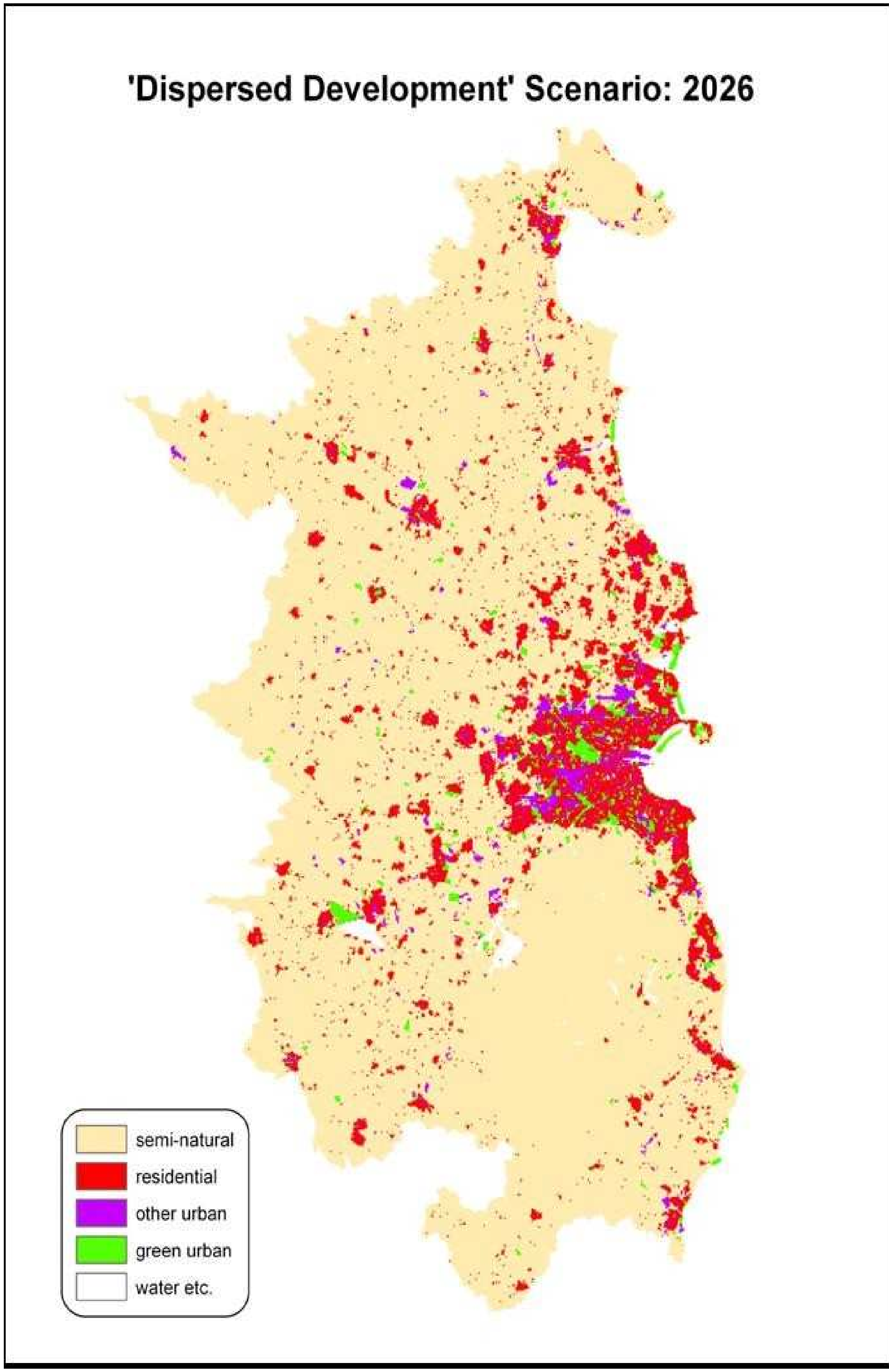
Strategic Planning

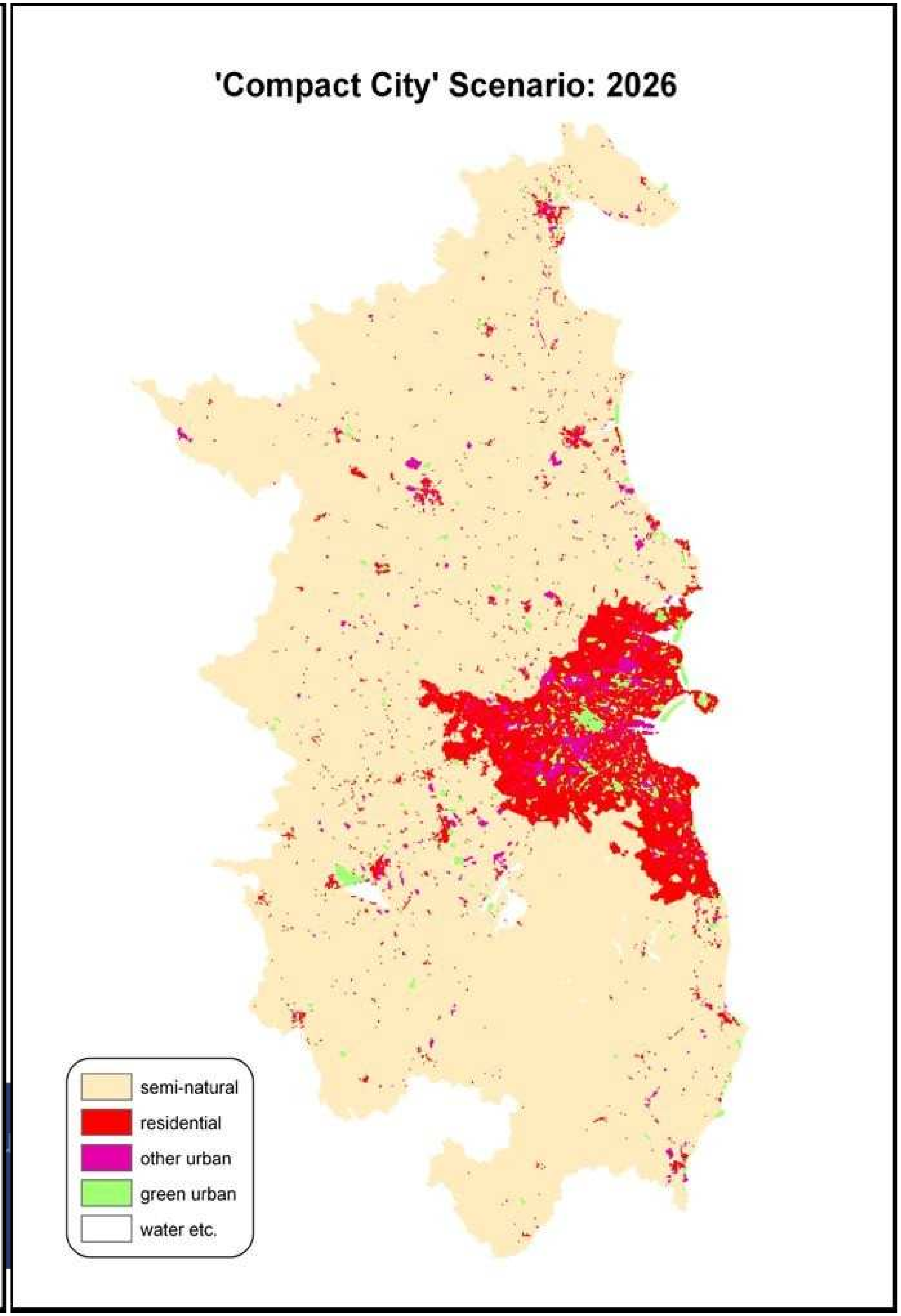
	Potential Impacts	Possible Adaptations
County Development Plans	Higher risk of winter flooding/erosion of unconsolidated sediments e.g. floodplains, coasts. Hotter, drier summers will increase demands on water infrastructure Effluent loadings will have increased risk factors due to reduced summer flows. Increased risk of extreme events	Overt applicationof the precautionary principle Incorporate landscape features to absorb water within developments. Reconsider safety margins for effluent dilution and groundwater protection
Emergency Planning	Increased risk of extreme weather events	Ensure emergency planning procedures and equipment are updated to accommodate changed risk factors

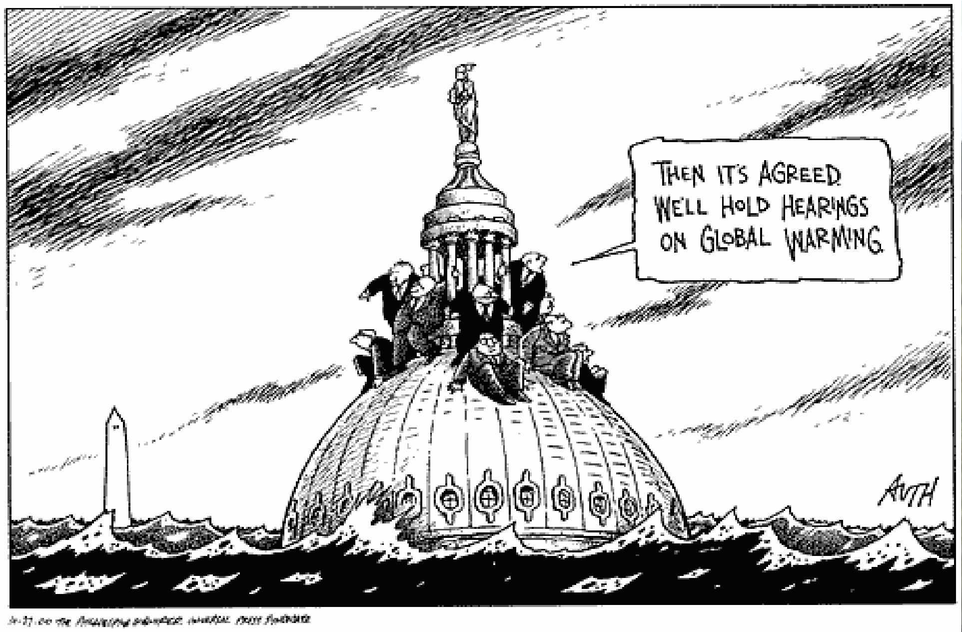
Planning for Housing, Transport and Environmental Services

	Potential Impacts	Possible Adaptation
Housing	Increased risk of subsidence as soils shrink in hotter drier summers	Plan for preventative and remedial maintenance.
	Higher risk to housing in floodplains or coastal margins	Restrict new zonings and new development in known risk areas
Transport	Increased rainfall intensities affecting embankments and bridge piers and washing more debris into gullies	Increase monitoring and maintenance. Increase gully emptying activities.
	Increased growth of roadside verges	Use slower growing plants. Revise mowing schedule.
Environmental Services	Year round grass maintenance	Adapt maintenance schedule and resources to meet change
	Precipitation and temperature changes may affect landfill design and operation	Monitor more closely. Check design and operation of future sites with regard to climate change




'Dispersed Development' Scenario: 2026
semi-natural
residential
other urban
green urban
water etc.

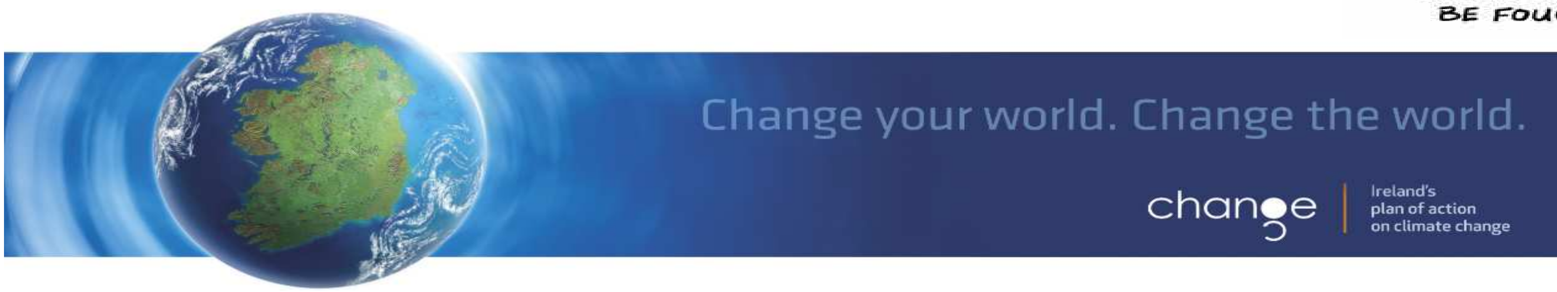

'Compact City' Scenario: 2026
semi-natural
residential
other urban
green urban
water etc.



"A day will come when our children and grandchildren will look back and they'll ask one of two questions: They will ask, 'What in God's name were they doing?' or they may look back and say, 'How did they find the uncommon moral courage to rise above politics and redeem the promise of American democracy?'"

Al Gore: 21st March 2007

IN THE FUTURE, WARS WILL BE FOUGHT OVER WATER



Dublin City
Baile Átha Cliath