Tullamore
6th November
2008

National REPS Conference 2008 **Farming for a Better Environment**

European Climate Change Policy – Impacts on Irish Agriculture

John Sweeney, ICARUS, NUI Maynooth

(with acknowledgements to R. Fealy, C. Murphy, N. Holden and A. Brereton)

NUI MAYNOOTH
Ollscoil na Éireann Má Nuad

epa

ICARUS
Irish Climate Analysis and Research Units

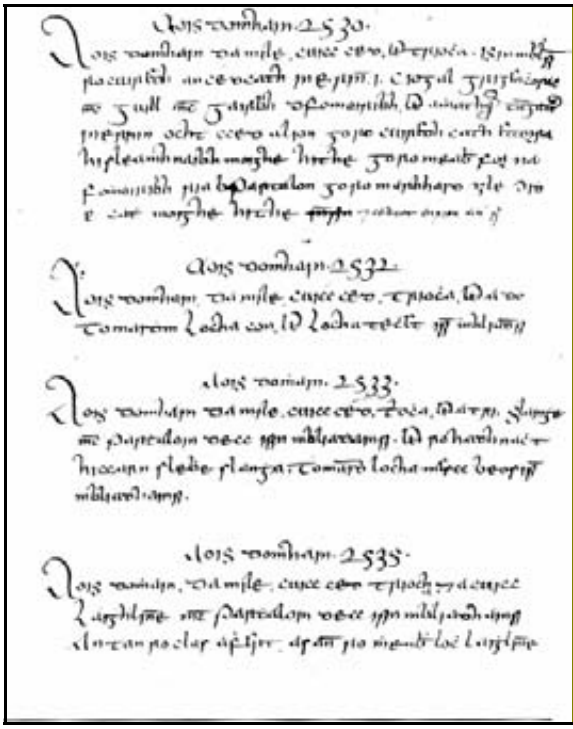
John Constable : The Haywain 1821

The Landscape of the Haywain 1821

The Landscape of the Haywain as it is today

Landscapes change as farmers exploit new opportunities or adapt to changed conditions

- Coping with, and sometimes causing, landscape change has always been a feature of farming
- Farmers have always been sensitive to the natural world and all its inhabitants. In the Celtic Ireland of the early medieval period a more harmonious and respectful relationship between people and nature was apparent than today. This is evident in some parts of the Brehon Laws e.g.
  'It is illegal to override a horse, force a weakened ox to do excessive work or threaten an animal with angry vehemence which breaks bones.'

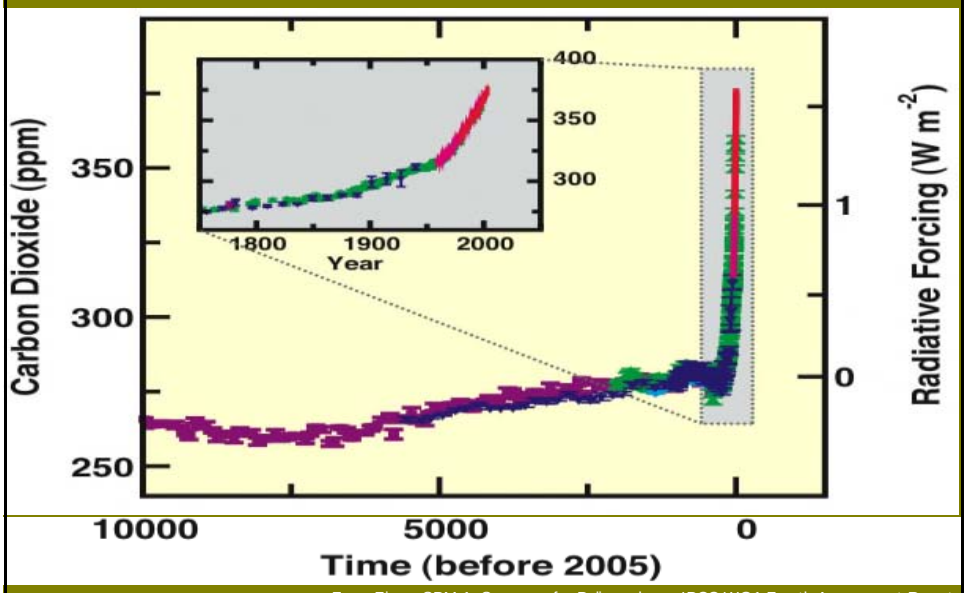


The first written account of a weather event in Ireland or Britain.

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

Changes in CO2 over 10,000 years

from ice-cores (colored symbols) and atmospheric samples (red line)



From Figure SPM-1, Summary for Policymakers, IPCC WG1 Fourth Assessment Report

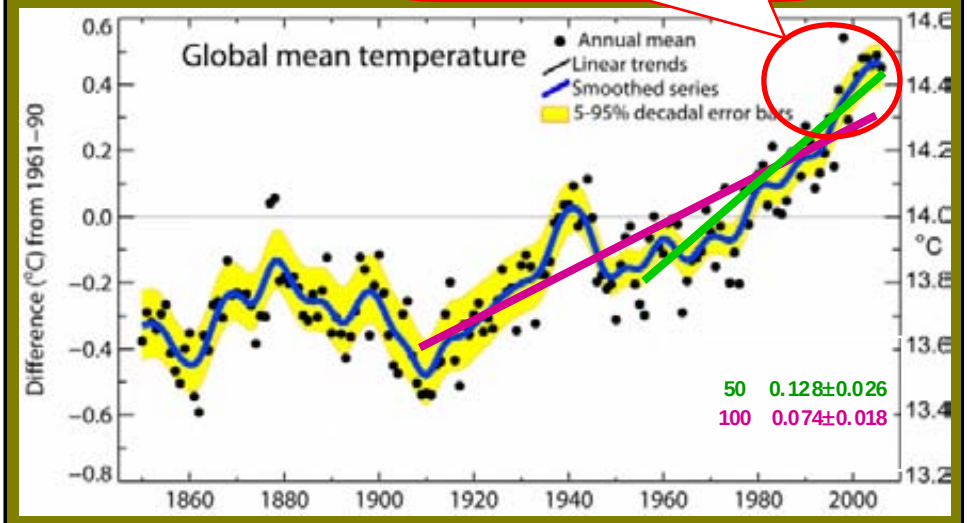
Direct Observations of Recent Climate Change

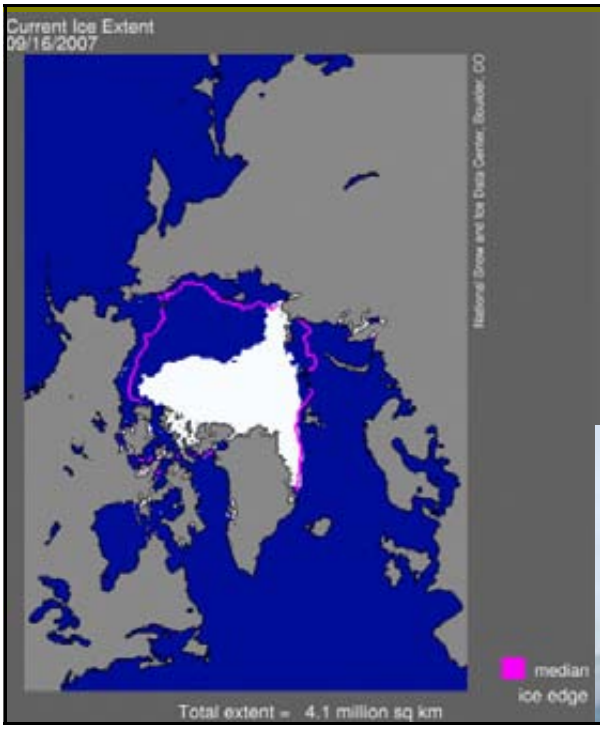
Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.

IPCC WG1 Fourth Assessment Report

Global mean temperatures are rising faster with time

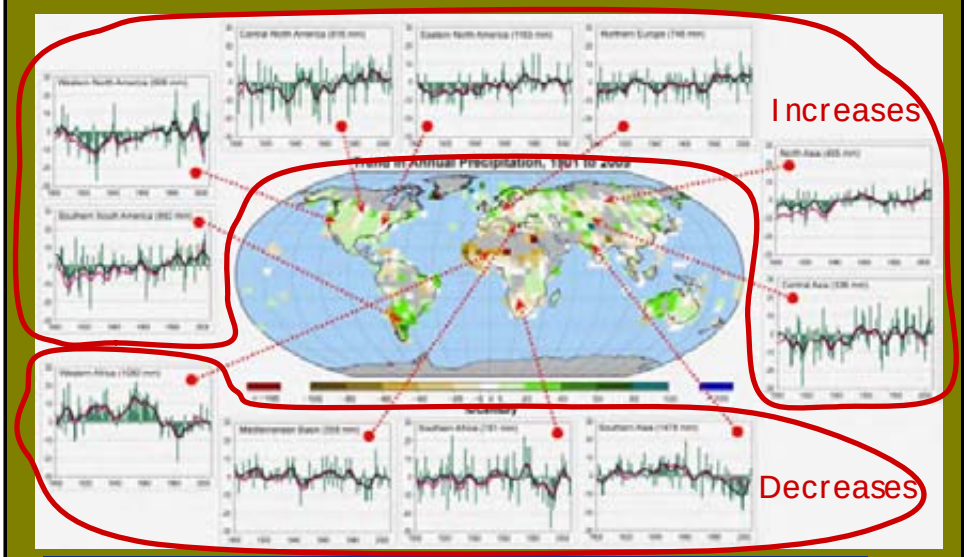
Warmest 12 years:
1998,2005,2003,2002,2004,2006,
2001,1997,1995,1999,1990,2000





Autumn 2007 saw the least Arctic sea ice on record

Land precipitation is changing significantly over broad areas

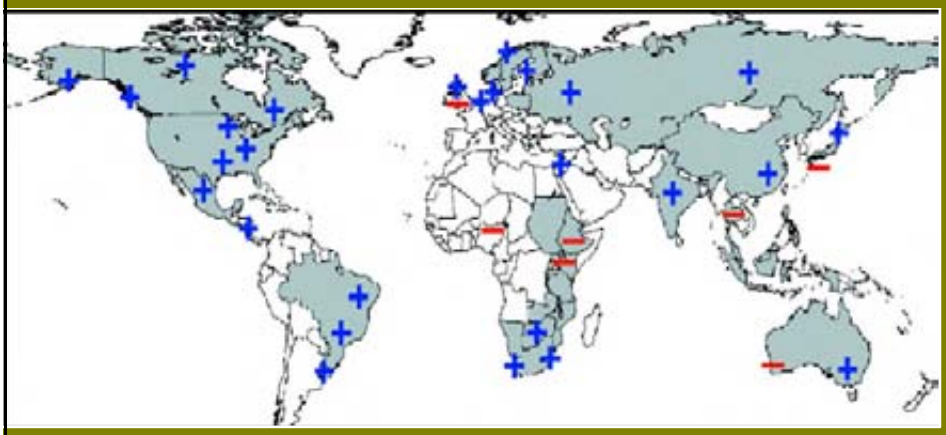


Smoothed annual anomalies for precipitation (%) over land from 1900 to 2005; other regions are dominated by variability.

Changes in Precipitation, Increased Drought

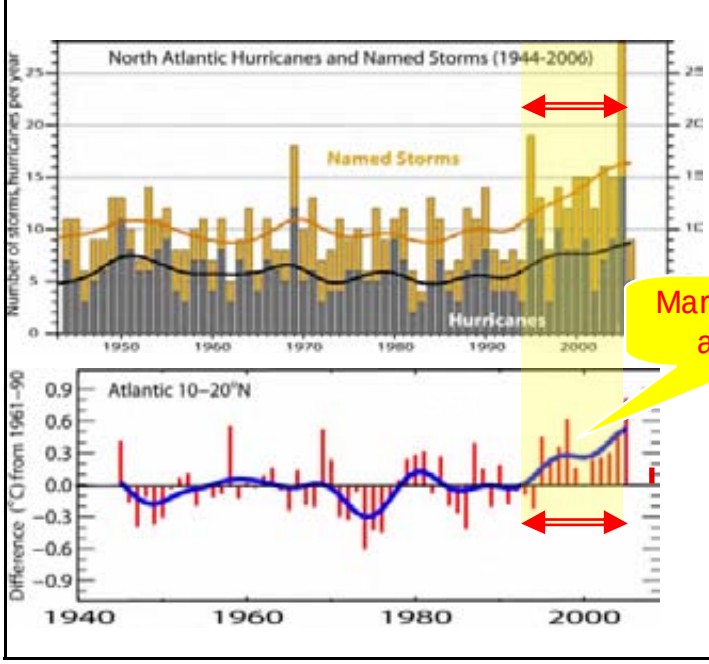
- Significantly increased precipitation in eastern parts of North and South America, northern Europe and northern and central Asia.
- The frequency of heavy precipitation events has increased over most land areas - consistent with warming and increases of atmospheric water vapour
- Drying in the Sahel, the Mediterranean, southern Africa and parts of southern Asia.
- More intense and longer droughts observed since the 1970s, particularly in the tropics and subtropics.

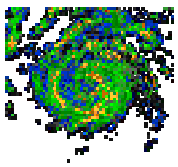
Proportion of heavy rainfalls: increasing in most land areas



Regions of disproportionate changes in heavy (95th) and very heavy (99th) precipitation

North Atlantic hurricanes have increased with SSTs

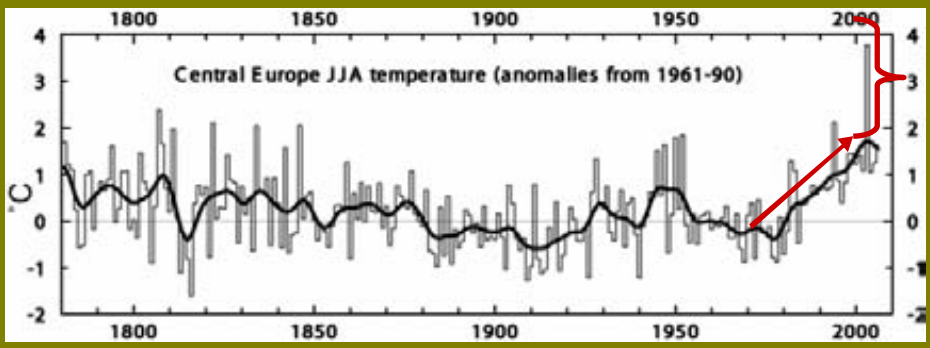




Marked increase after 1994

Global number and percentage of intense hurricanes is increasing

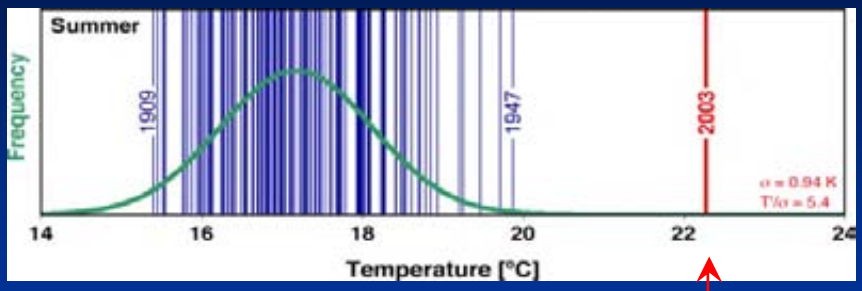
Heat waves are increasing: an example



Extreme Heat Wave
Summer 2003
Europe

European heat-wave 2003 - 20,000 died

Swiss Temperature Series for June-August 1864-2003



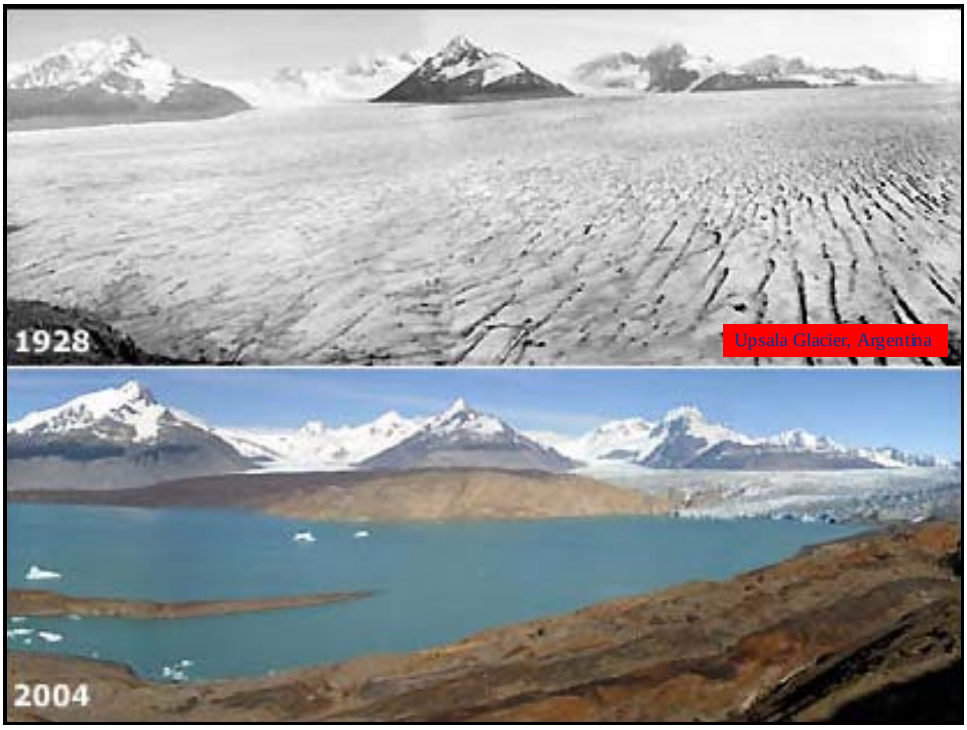
extremely rare event

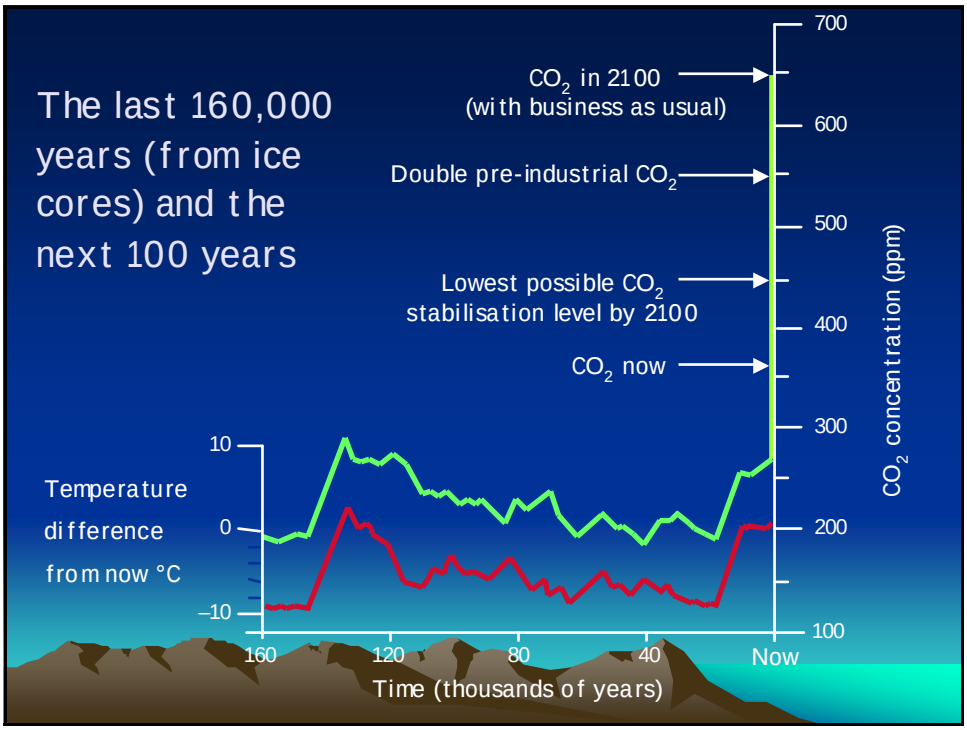
Analysis shows it likely that most of the risk of the event is due to increase in greenhouse gases - also

- by 2050, likely to be average event
- by 2100, likely to be a cool event

(*Schär et al. 2004, Nature, 427, 332-336, Stott et al 2004, Nature 432 610-614*)


1985
2002
Mount Hood


1928
Upsala Glacier, Argentina
2004

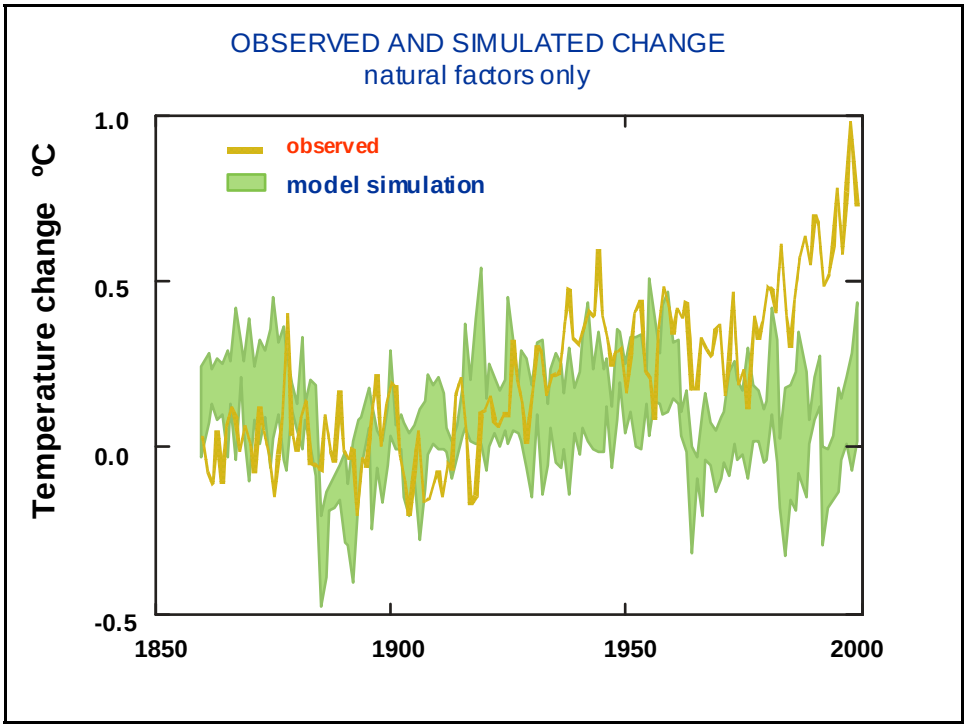


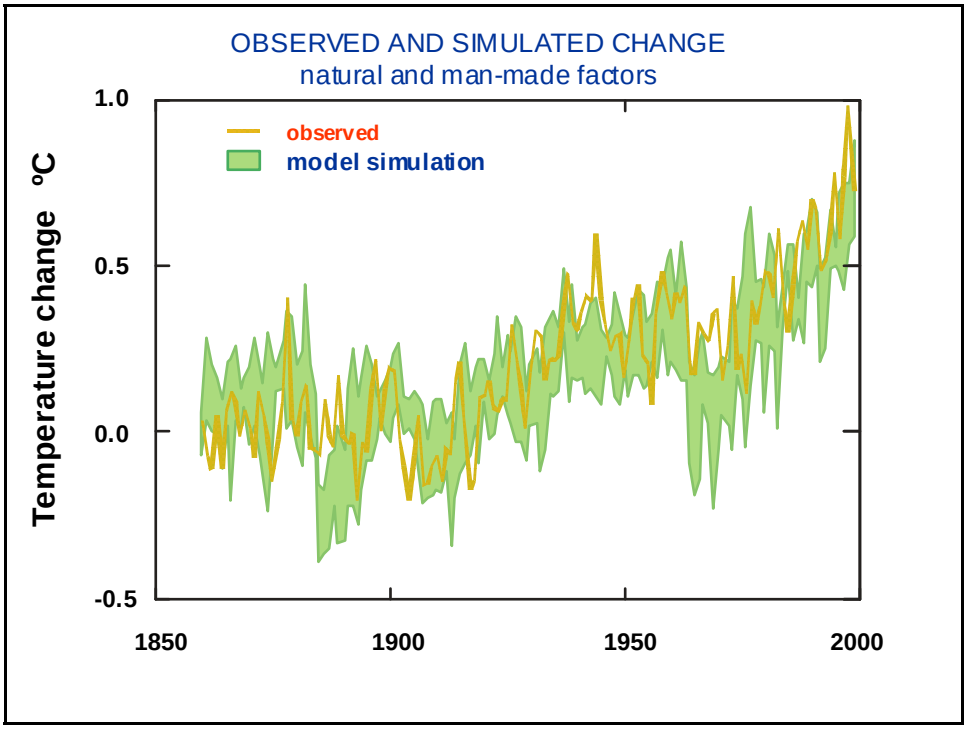
Attributing Climate Change to Human Factors

- 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)


OBSERVED AND SIMULATED CHANGE
natural factors only
Temperature change °C
1.0
0.5
0.0
-0.5
1850
1900
1950
2000
observed
model simulation


OBSERVED AND SIMULATED CHANGE
natural and man-made factors
Temperature change °C
1.0
0.5
0.0
-0.5
1850
1900
1950
2000
observed
model simulation

Working Group 2

Chapter 5: Food, Fibre and Forest Products

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General Conclusions relating to Agriculture from the 4th Assessment Report

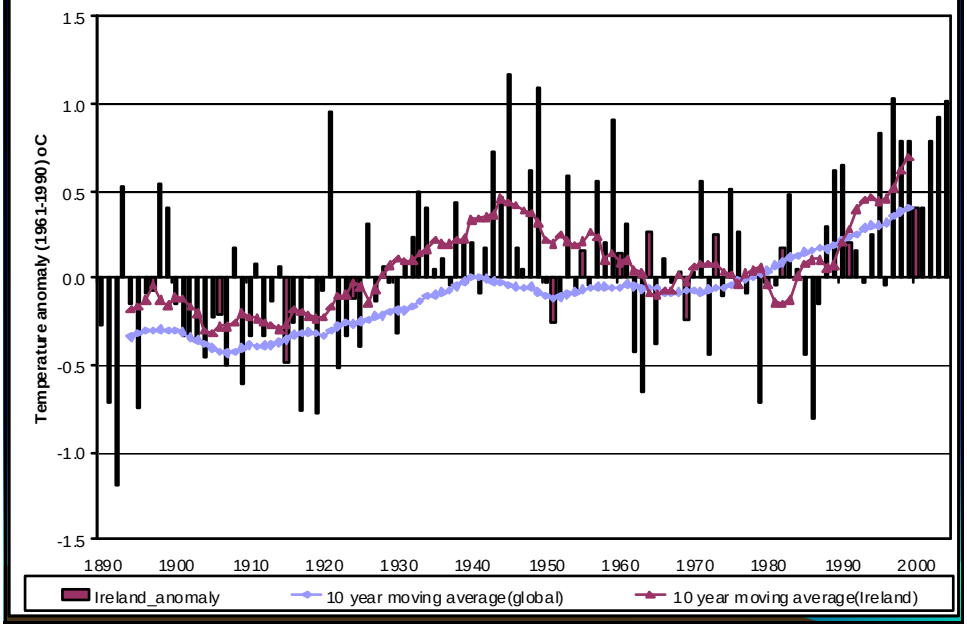
- Additional CO_2 in the atmosphere is likely to have a beneficial effect on crop yields, especially in the mid latitude regions where other factors such as water and pests/diseases are not limiting.
- In the tropics, reduced rainfall is likely to pose serious threats to agricultural productivity and even small temperature increases will increase vulnerability in these areas.
- Changes in agricultural crop productivity will be highly sensitive to changes in drought and floods frequencies. Livestock production in hotter areas is likely to suffer as a result of heat stress on cattle.

What does all this mean for Ireland?

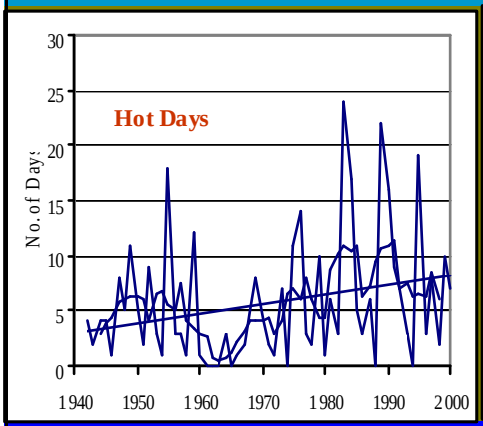
1. We need to establish a future climate scenario for Ireland which offers a confident projection of temperature and rainfall conditions exists.
2. We need to use these scenarios with best practice agricultural models to project how crop and livestock agriculture will perform under changed climate conditions.
3. We need to consider how Irish farmers can and will adapt to the changing environmental conditions in which they will work, and the changed policy environment at EU and global levels within which they must operate.

What are major indicators of climate change are currently observable in Ireland?

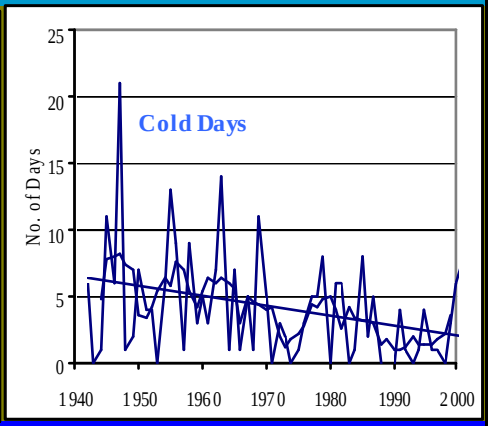
Global and Irish mean temperature



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



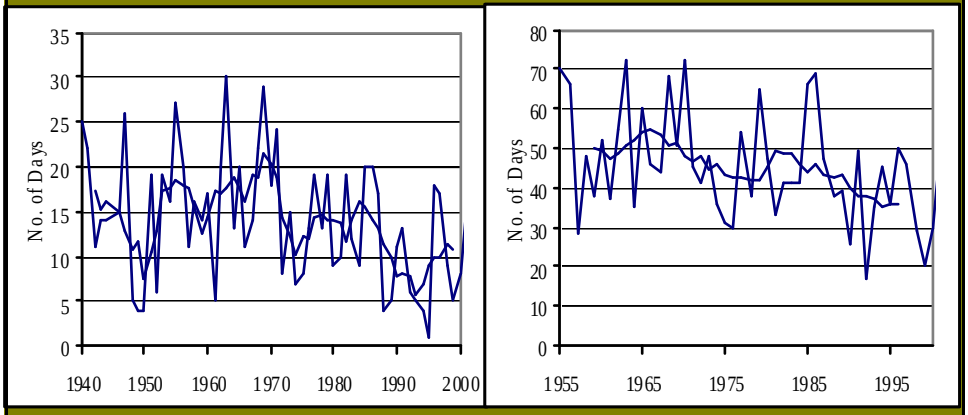
'Hot' day = mean temperature > 18ºC



'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

Frequency of 'frost' days
Valentia & Birr

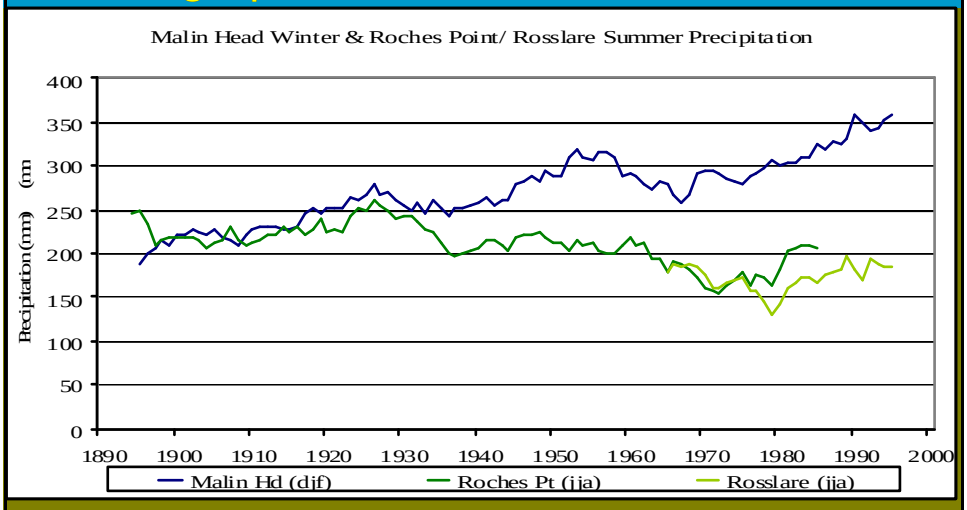


- Frost Day = minimum temperature < 0°C

A typical winter in the south west now has less than half the frosts of 20 years ago

Smaller reductions have occurred in the midlands

Geographical & Seasonal differences

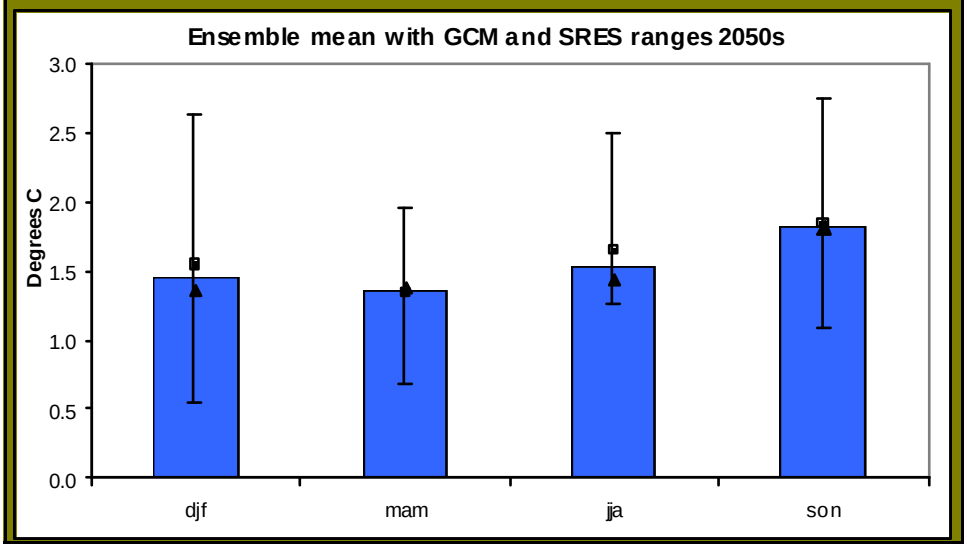


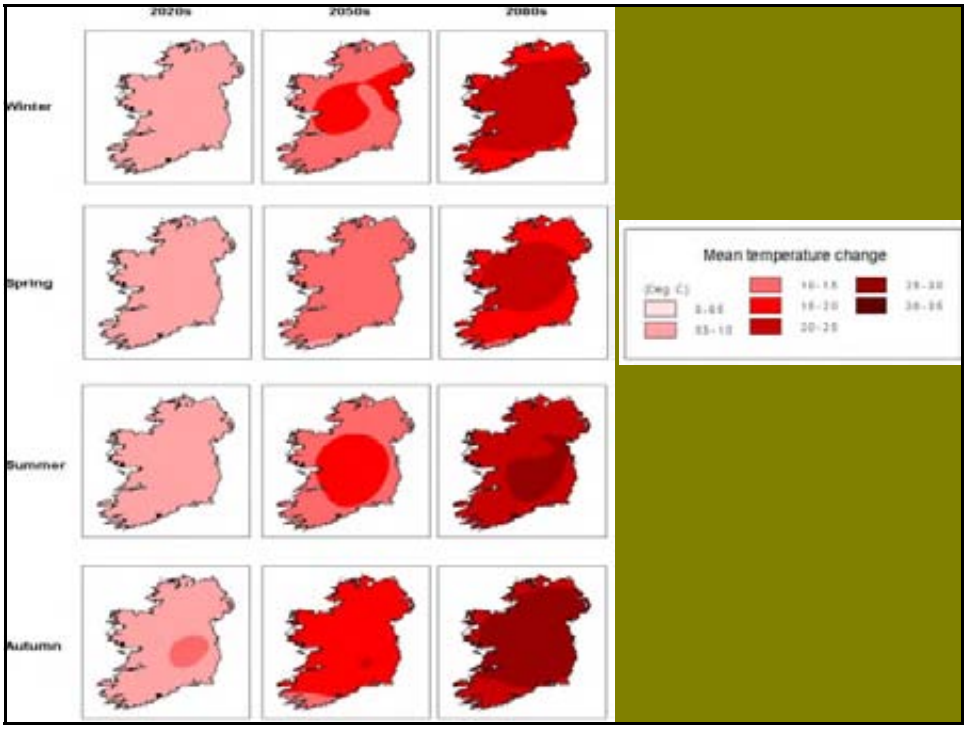
Winters in the north west are getting wetter

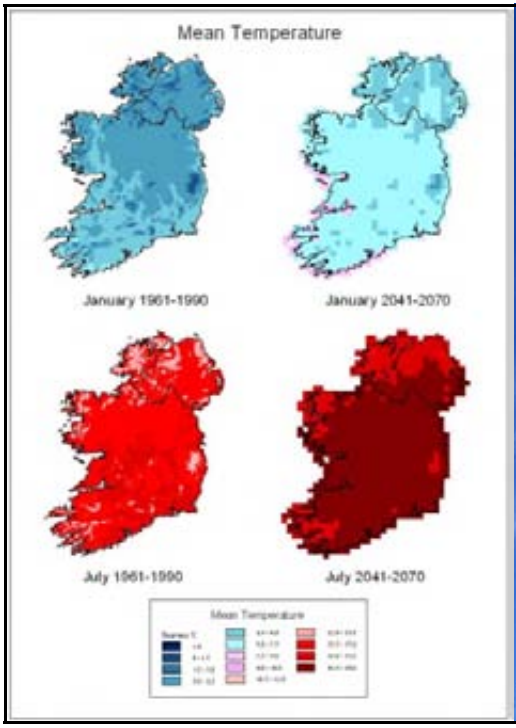
Summers in the south east are getting drier

Ensemble mean temperature for the 2050s produced from the weighted ensemble of all GCMs and emissions scenarios (bars). Upper and lower ranges (lines) are the results from the individual GCMs and emissions scenarios.

Ensemble A2 scenario (■) and B2 scenario (▲)







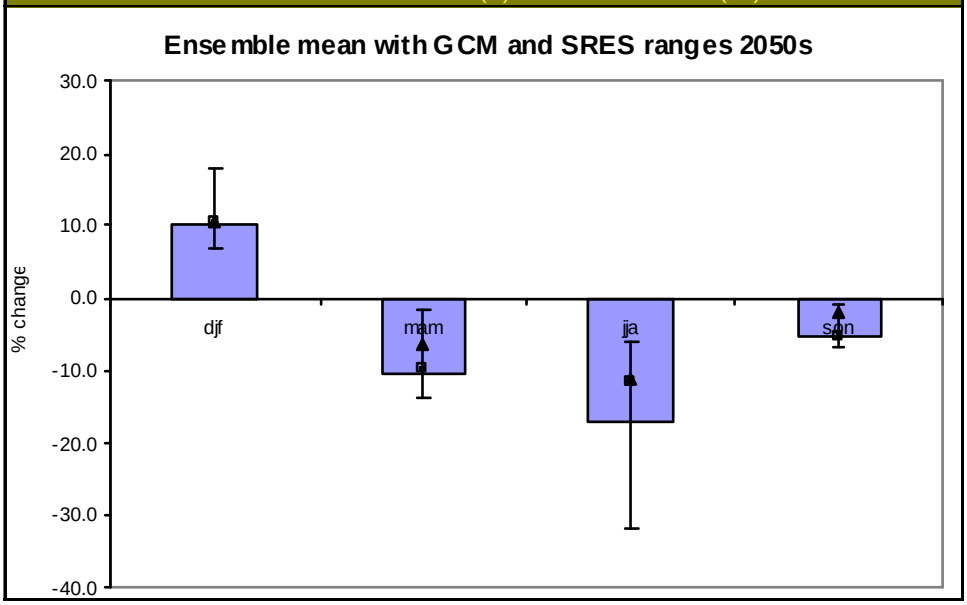
Warming relative to 1961-90

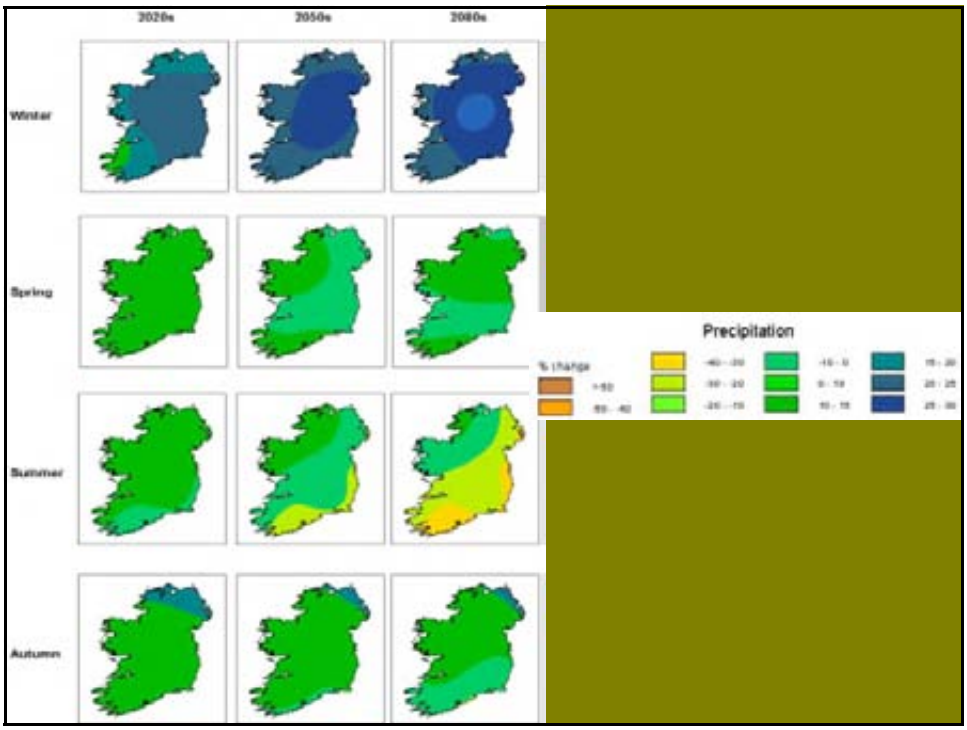
Mean January figures are predicted to increase by 1.5ºC by mid century with a further increase of 0.5ºC-1.0ºC by 2075.

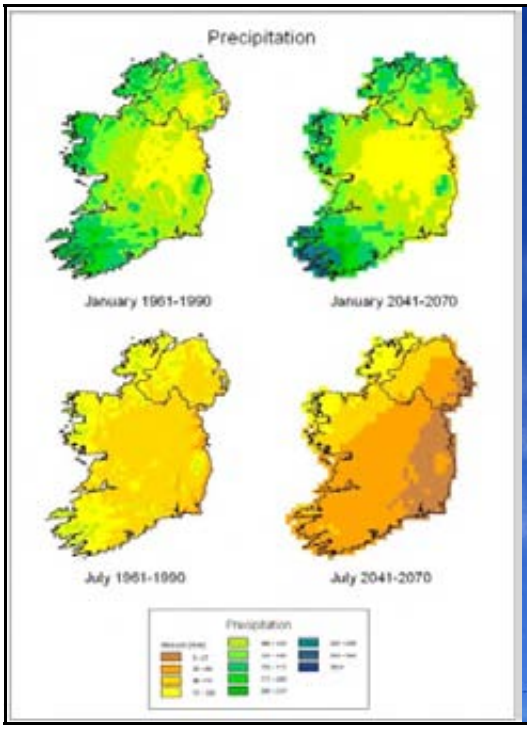
By 2050, the extreme south and south west coasts may have a mean January temperature of 8.0ºC. By then, winters in Northern Ireland and in the north Midlands will be similar to those presently experienced along the Cork/Kerry coast.

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

Ensemble mean precipitation for the 2050s produced from the weighted ensemble of all GCMs and emissions scenarios (bars). Upper and lower ranges (lines) are the results from the individual GCMs and emissions scenarios. Ensemble A2 scenario (■) and B2 scenario (▲).





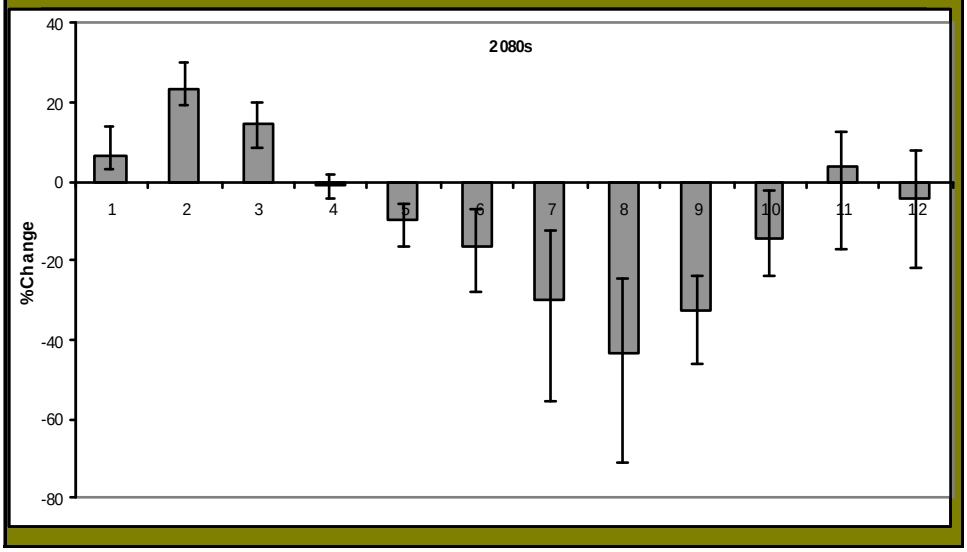


Rainfall relative to 1961-90

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.

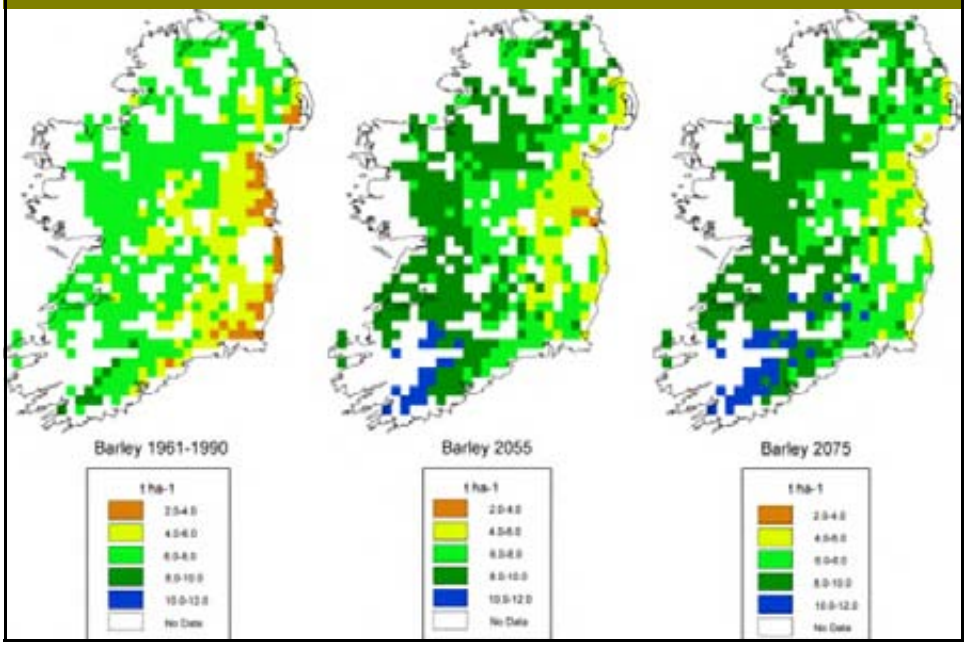
Percent change in simulated monthly **Streamflow**
Boyne Mean Ensemble



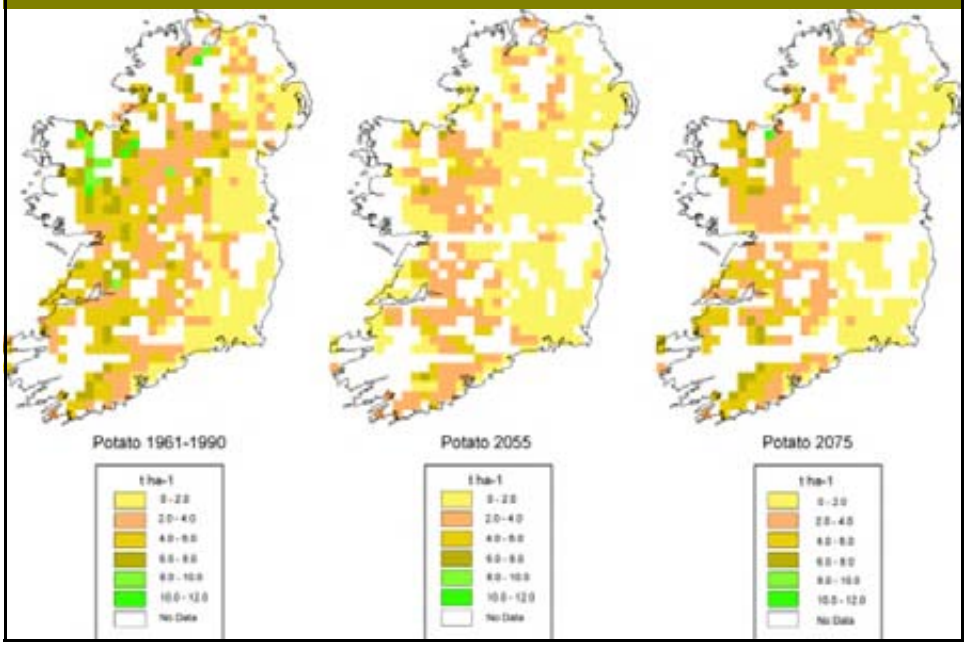
Impacts of Climate Change on Irish Agriculture

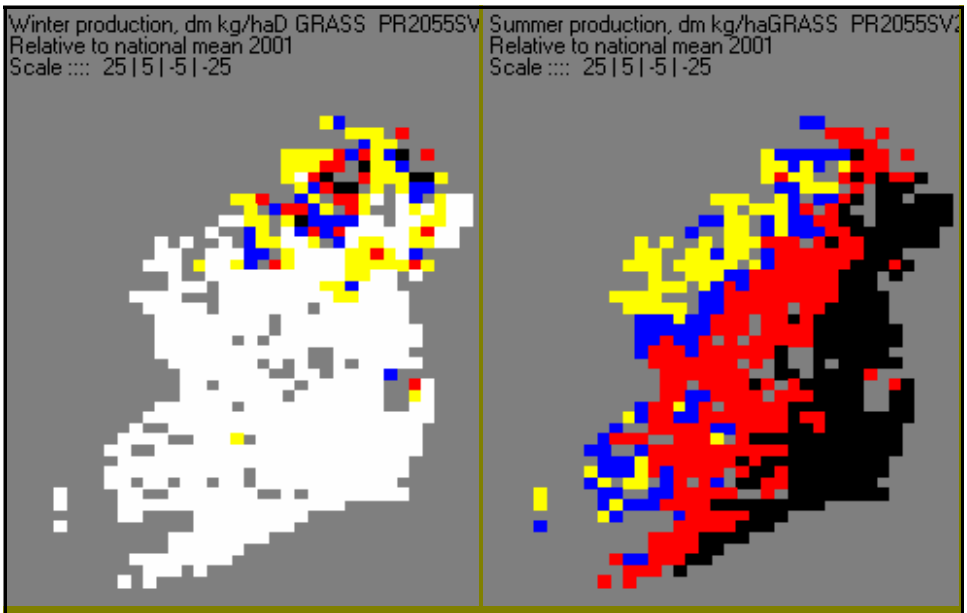
- Drive crop models with high spatial resolution monthly climate scenario data
- Drive farm management systems with low spatial resolution daily climate scenario data

Barley yield in Ireland under baseline (1961–1990) climate, and the change for the 2041–2070 and 2061–2090 scenarios

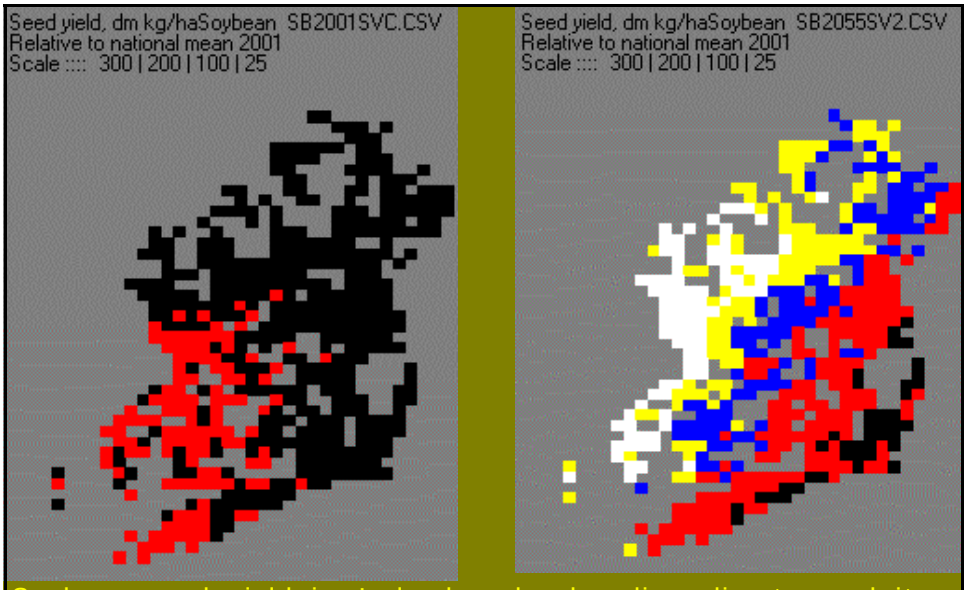


Potato yield in Ireland under baseline climate, and the change for the 2041–2070 and 2061–2090 scenarios



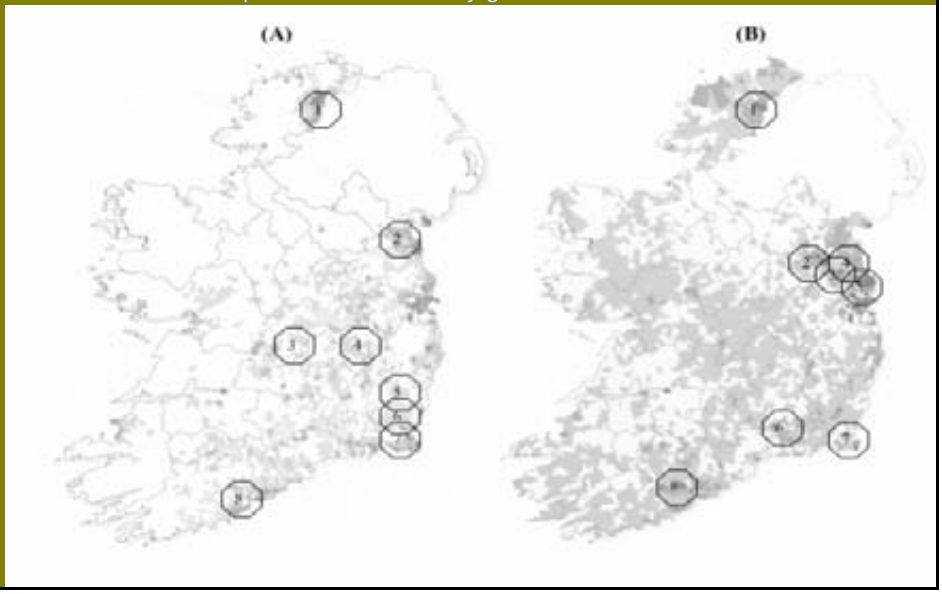


Grass yield in Ireland: winter and summer relative change with the 2055 scenario. Black: <25%; red: 25 to 100%; blue: 100 to 200%; yellow 200 – 300% and white >300%



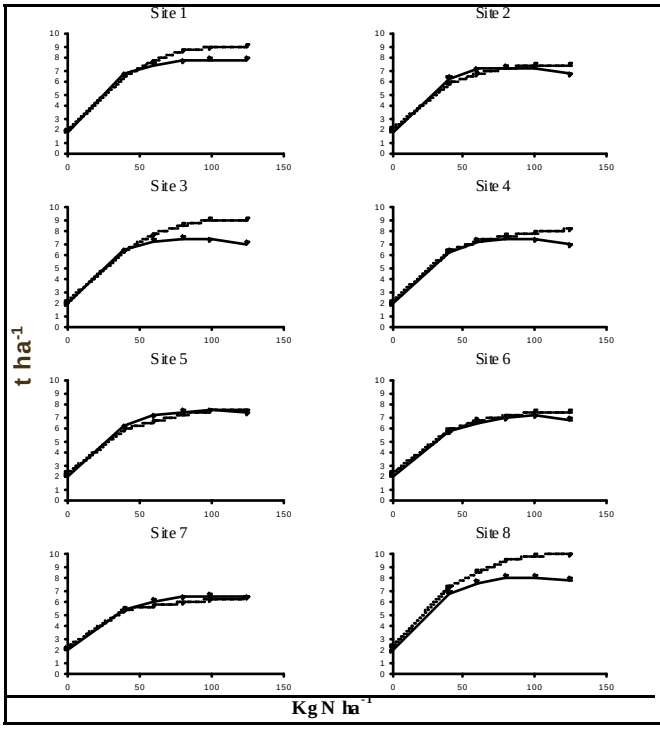
Soybean seed yield in Ireland under baseline climate, and its relative change with 2055 scenario. For the relative yield maps are compared to baseline national mean yield, black: <25%; red: 25 to 100%; blue: 100 to 200%; yellow 200–300% and white >300%

Main areas of barley (A) and potato (B) as a percentage of area farmed. (adapted from Lafferty et al., 1999). The eight sites where each crop is most commonly grown are labelled.



Modelling Assumptions

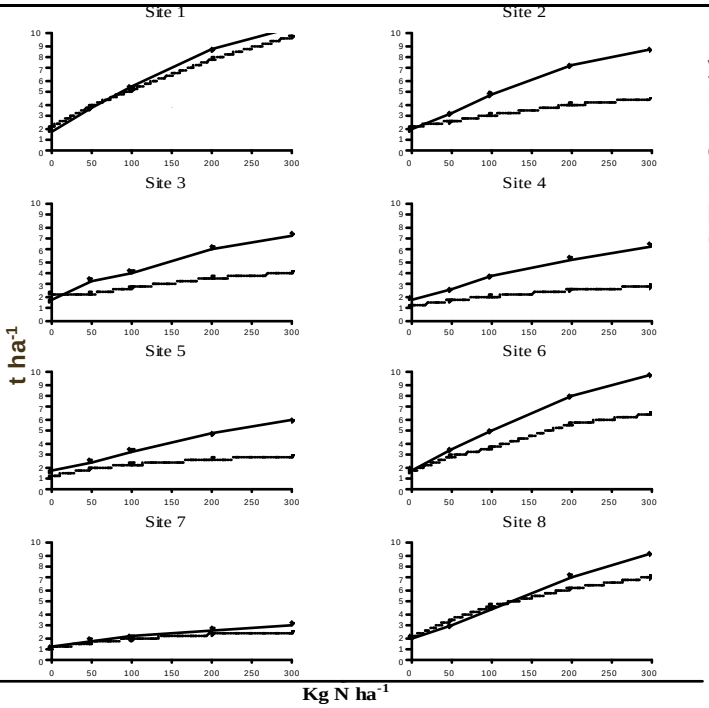
- Increase in CO2 to 581ppm by 2055
- Allowance for increased growth rates due to enhanced CO2 (1.05-1.2 for barley, 1.02-1.08 for potato)
- No pest/disease effects
- No limitations in field access or planting dates
- Dominant soil type at each location used
- Models: Decision Support System for Agricultural Technology Transfer (DSSAT)



Non-irrigated, barley yield (t ha-1) nitrogen (kg ha^{-1}) response curves for eight sites with high rates of spring barley production [baseline (●) and 2055 (❍)].

Similar yields for baseline and future climates irrespective of higher fertiliser inputs. Drier sites have the lowest yields.

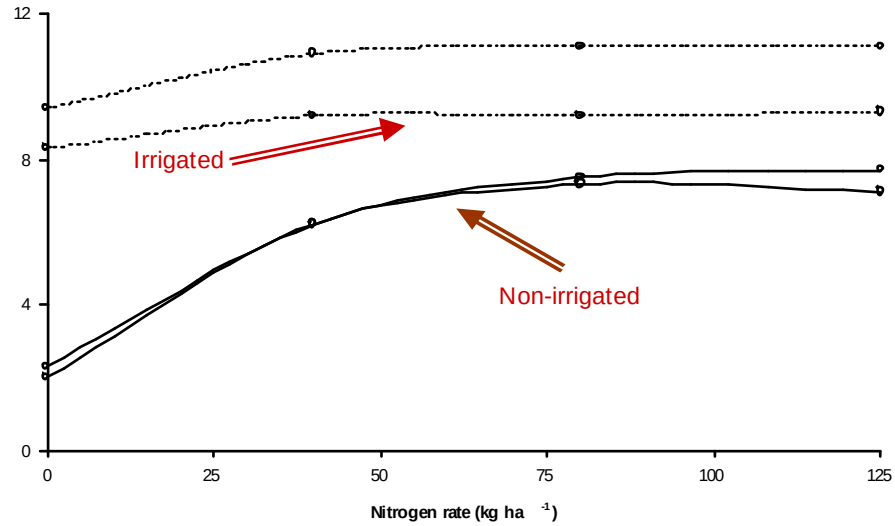
Conclusion: Fertiliser input reductions may not decrease yields as climate changes



Non-irrigated, potato yield (t ha-1) nitrogen (kg ha-1) response curves for eight sites with high rates of potato production [baseline (●) and 2055 (❍)].

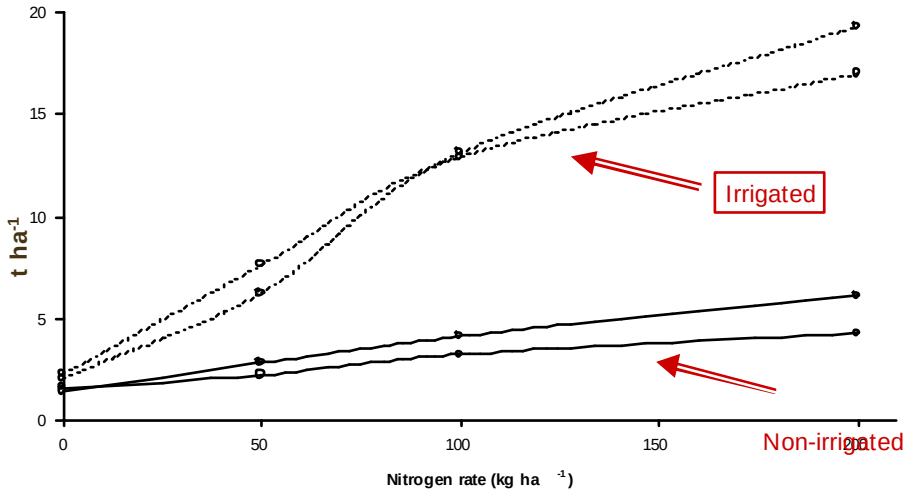
Little change at wetter western sites, marked decline at drier eastern sites.

Conclusion: Gains from extra CO2 are negated by drier conditions



The nitrogen response with and without irrigation for: barley averaged over the eight sites where the crops are most commonly grown. [Baseline = black. 2055 = grey.]

Yields insensitive to nitrogen application rates. Conclusion: With some irrigation, yields can be maintained with significantly lower fertiliser inputs.



The nitrogen response with and without irrigation for potato averaged over the eight sites where the crops are most commonly grown. [Baseline = black. 2055 = grey.]

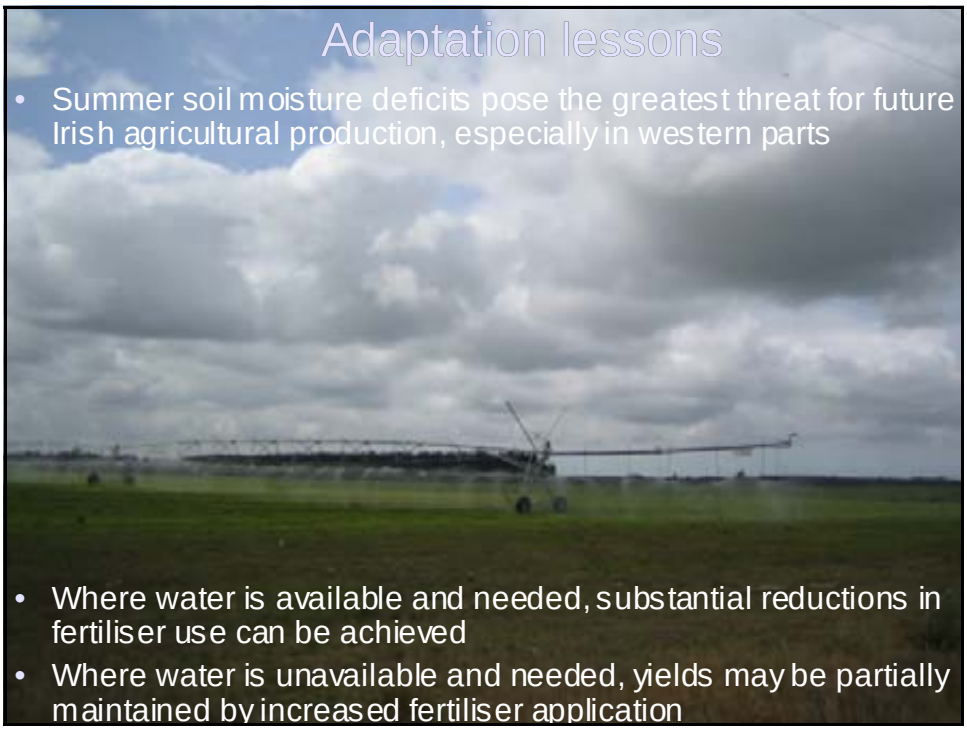
Marked response to irrigation. Some response also to increased Nitrogen input. Conclusion: Potato yields will fall as summers dry. Irrigation is the best option to redress this, though increased fertiliser inputs may also help.

Adaptation lessons

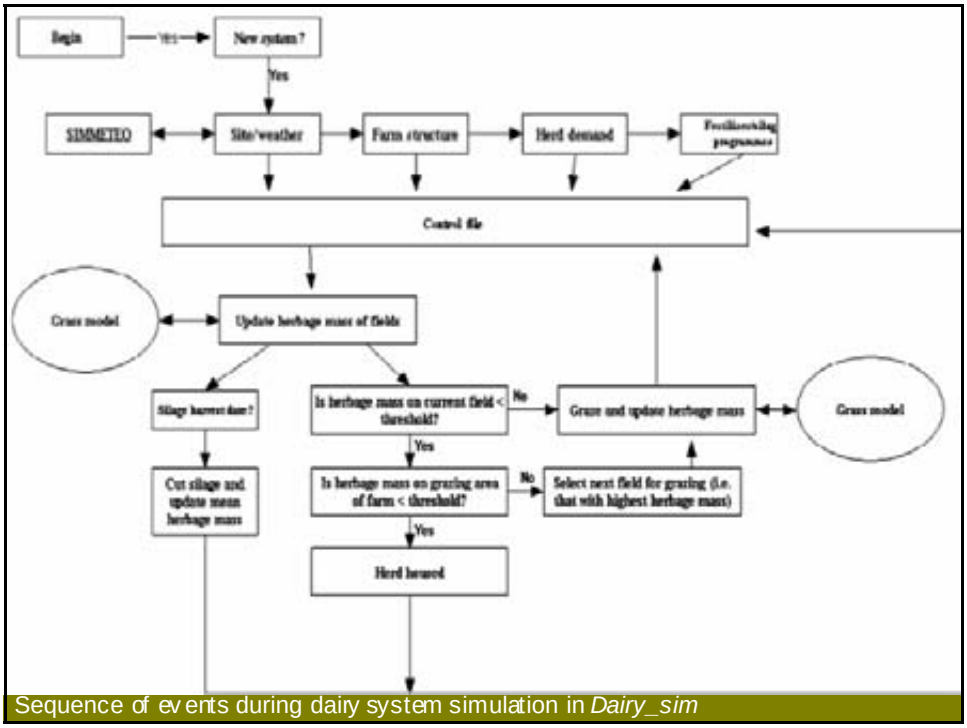
- Water stress avoidance will enable reductions in fertiliser use for key crops. Application rates could be halved by 2055. For most areas, barley yields will increase in the medium term, even without irrigation.
- Potato growing areas in Donegal and Cork will only be able to maintain yields in the absence of irrigation by increasing fertiliser inputs to high levels. Wexford and the drier SE appears increasingly unsuited to potato cultivation. Even with 310mm of irrigation in the north Co. Dublin area soil conditions will limit yields considerably.
- Infrastructure to store winter rainfall will be needed in areas of the SE where irrigation is profitable.

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



Sequence of events during dairy system simulation in *Dairy_sim*

Inputs to Dairy sim

- Farm location (climate: synoptic weather stations)
- Farm layout (sub divided into paddocks by the user)
- Herd data (stocking rate, lactation yield, live weight post calving, daily feed demand)
- Farm management (fertiliser, silage management)

Dairy sim was parameterised using the NDB system

Location:	Fermoy, Ireland	Total Nitrogen applied:	360 kg N ha^{-1}
Paddocks:	20	Area of farm used for 1st cut silage:	9 ha
Farm area:	20 ha	Area of farm used for 2nd cut silage:	7 ha
Closing Date:	26 November	Date of closing for 1st silage cut:	1 April
Stocking rate:	2.6 cow ha^{-1}	Date of closing for 2nd silage cut:	28 May
Milk yield:	6400 l cow^{-1} yr^{-1}	Date of cut 1:	27 May
Live weight:	610 kg	Date of cut 2:	15 July

The National Dairy Production Blueprint (NDB) as described by O'Donovan (2000) as the basis for dairy unit rotational grazing management in Ireland

Comparison of calibrated *Dairy_sim* system with NDB

	NDB	*Dairy_sim*
Number of paddocks	20	20
Turnout	Early March	29 February
Close	mid-late November	26 November
Winter	100 days	98 days
Close for first silage cut	1 April	1sApril
Date first-cut silage	28 May	28 May
Proportion of area for 1st cut silage	0.45 (variable)	0.45
Date Second-cut silage	15 July	15 July
Proportion of area for 2nd cut silage	0.35	0.35
Concentrate (kg cow^{-1})	500	543
Milk (l cow^{-1})	6359	6400
Silage (t DM cow^{-1})	1.4	1.53
Total Herbage production (DM t ha^{-1})	12-15	13 (non-irrigated) 15.8 (irrigated)
Silage yield (DM t ha^{-1})	5.4	4.8
Silage fed housed (kg DMcow^{-1})	----	1400
Silage supplement at pasture (kg DM cow^{-1})	----	205
Nitrogen (mineral+organic) (kg N ha^{-1})	360	360

Dairy sim

- Run for 5 locations (30 year simulation) representative of climate regions in Ireland
- Adjusted to obtain a neutral silage balance and minimum days of winter housing

	Baseline			2020			2050		
Drainage	Stress	Excess	Total	Stress	Excess	Total	Stress	Excess	Total
Well	97	0	**97**	100	0	**100**	123	0	**123**
Moderate	68	0	**68**	82	0	**82**	116	0	**116**
Poor	68	221	**289**	118	208	**290**	116	196	**312**

Soil limitation (in days per year) due to water stress, water excess and total on grass growth (80th percentile value shown)

	Baseline		2020		2050	
Drainage	Day	Duration	Day	Duration	Day	Duration
			Field access for grazing			
Well	1	365	1	365	1	365
Moderate	1	365	1	365	1	365
Poor	134	142	130	154	123	164
			Field access for machinery			
Well	148	109	140	133	130	149
Moderate	148	109	140	133	130	149
Poor	156	112	143	135	137	147

Day of year and days of available field access for grazing and machine access (80th percentile value shown)

Climate Change and Agriculture in Ireland

- In east Leinster and east Ulster water stress in grass, barley, potato and to a lesser extent maize will occur on a much increased frequency. Summer soil moisture deficits will be problematical for dairying, losses from which may be partially compensated by reductions in fertiliser inputs. Late summer feed deficits may require supplementation or the introduction of a mid season housing period.
- In the midlands less stresses are apparent in summer and good yields of grass, barley, maize, potato and, later in the century, soybean can be expected. Scope for reduced fertiliser inputs will be greater in areas of poorly drained soils.
- In the extreme northwest cool temperatures and relatively wet conditions will produce lower grass, maize and soybean yields, but good barley and potato yields. On poorly drained soils agriculture will be slightly more productive than at present. Dairying will not be heavily impacted.
- In south and south west Munster warm temperatures and relatively moist conditions will lead to good grass, barley and maize yields and provide potential for new crops such as soybean. Potato yield is limited. The relative advantages of this region for dairying will be maintained though summer droughts will become more common than at present.

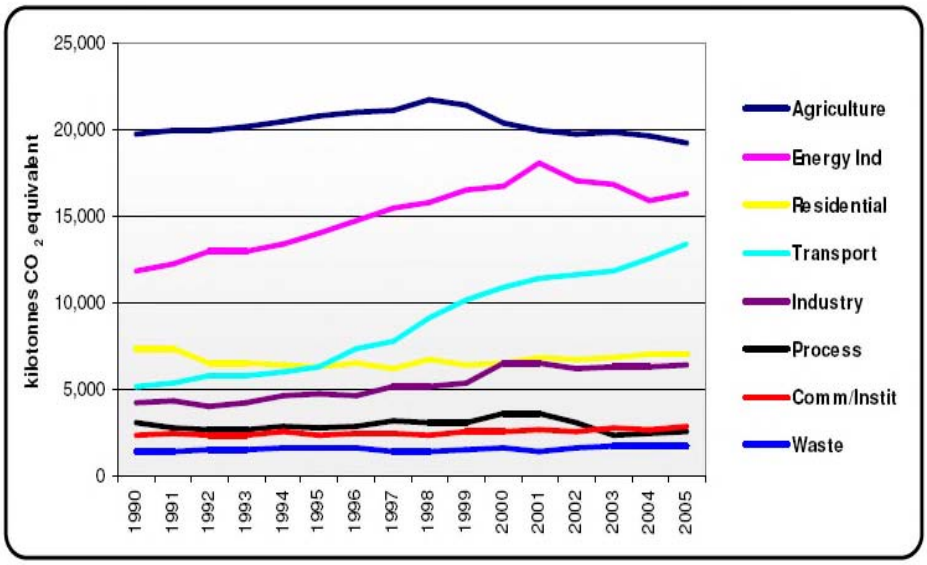
- Adaptation to climate change for Irish agriculture will centre either on maximising outputs or minimising inputs. Generally the potential for considerable reduction in nitrogen application rates will occur.
- For the key dairying sector, a range of response options exists which should mean the continuing viability and profitability of this sector.

Overall – from a climate change perspective…..

- Irish agriculture will be capable of adapting to climate change and most of the current crops will remain viable.
- Extensification will be facilitated by climate change in many areas.
- Summer water will become the determinant of productivity. But who else will be looking for water in the summers of mid century?
- Changed occurrences of pests/diseases may alter conclusions significantly

But what about the EU……..?

Irish Greenhouse Gas Emissions



EU Climate Change Policy

Overall EU Goal: Reducing its overall emissions to at least 20% below 1990 levels by 2020

- EU is using a portfolio of policies to meet goal across all sectors through the EU Climate Change Program (ECCP)
  - Cross-cutting cap and trade
  - Regulation
  - Incentives
  - Voluntary approaches
- Updated goals and binding measures for ECCP portfolio announced January 23, 2008:
  - **Energy supply measures**: increase share of renewable energy to 20% by 2020
  - **Energy demand measures**: 20% reduction in energy consumption through energy efficiency
  - **Transportation, buildings, agriculture: reduce emissions 10% below 2005 levels**
    - Commitments by car makers to reduce CO_2 emissions rate from new passenger cars by 25% below 1995 levels by 2008/2009
    - Increase share of sustainable biofuels to 10% of overall petrol and diesel consumption
  - **Improved EU ETS**

EU Climate Policy Looking Forward

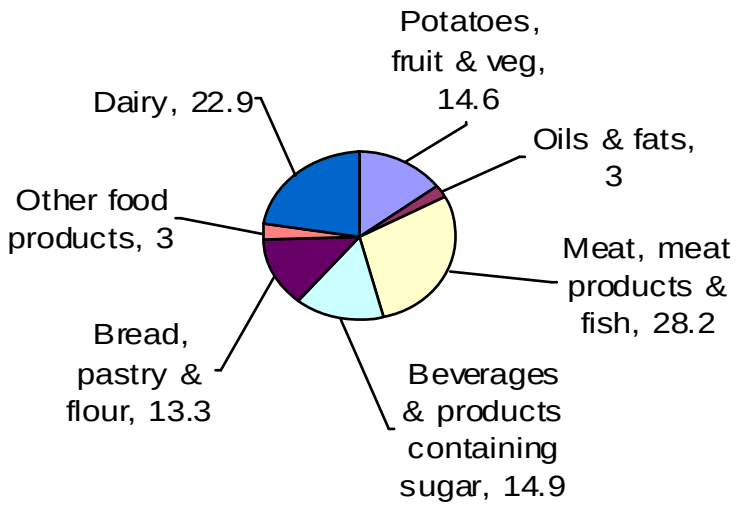
- Further improvements to EU ETS
  - Single EU-wide cap instead of 27 national caps
    - Average 1.846 billion metric tons CO_2/year
  - Increasing share of auctioning (full auctioning of power sector allowances in 2013)
  - Community-wide new entrant reserve (5% of cap)
  - Expanding to include other sectors and gases
    - Aviation
    - Aluminum (PFCs) and Chemicals (N_2O)
    - Recognize carbon capture and storage (CCS)
  - Linking
    - Phase 2: Norway, Iceland, and Liechtenstein
    - International Carbon Action Partnership (ICAP)
      - Discussions with the Northeast Regional Greenhouse Gas Initiative (RGGI), California, Australia, New Zealand and Canadian Provinces
- With global agreement, EU will commit to 30% below 1990 levels by 2020

Agriculture Emissions Projections

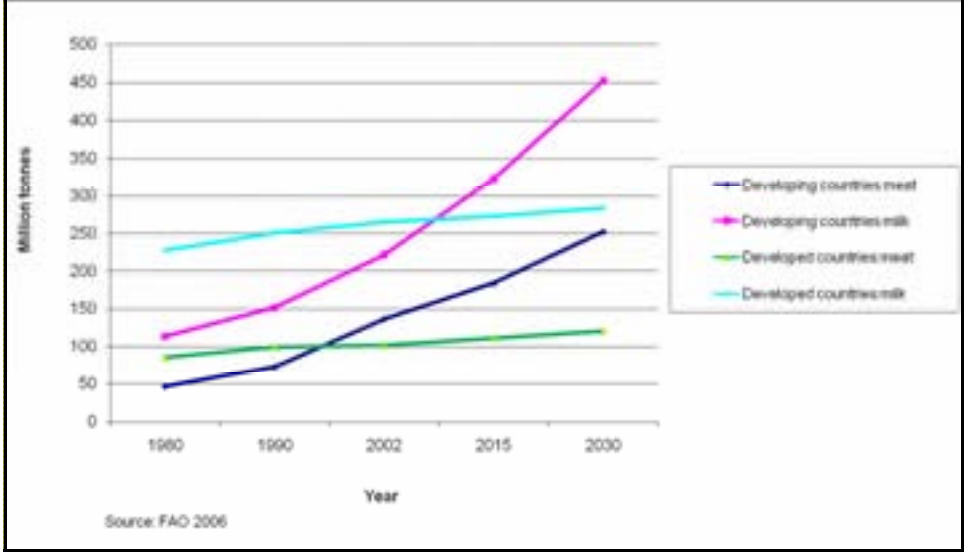
- Only one scenario based on forecast animal numbers supplied to the EPA in April 2008
- Incorporates recent changes in markets (increases in cereal, fertiliser and dairy prices, abolition of the milk quota by 2015, introduction of a new suckler cow premium in Ireland)

3% increase in agricultural emissions 2006-2020 to19.9Mt CO_2 equivalent

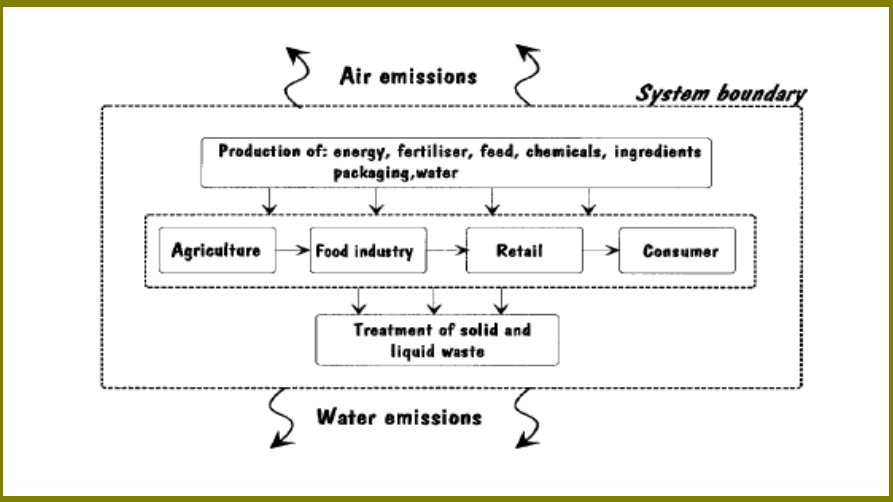
Contribution of food groups to Dutch GHG emissions KG/CO2e



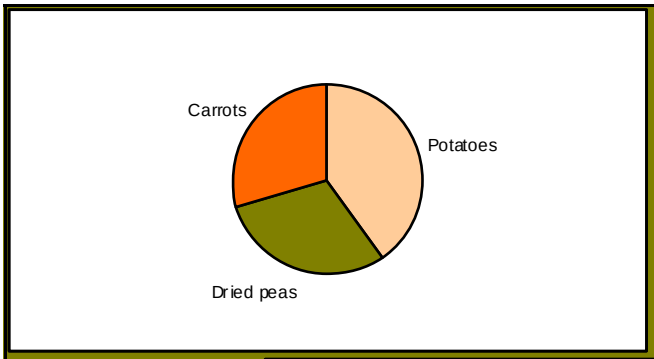
Projected global trends in meat & dairy demand

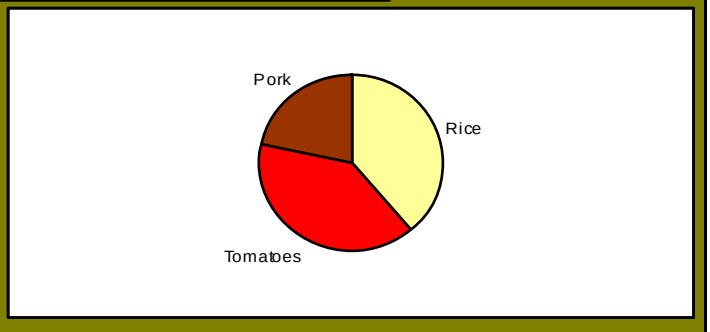


A typical food LCA diagram



Source: http://www-mat21.slu.se/publikation/pdf/Programplan2004.pdf





Production of meal on the left is nine times less GHG intensive than the one on the right

Food industry initiatives: retailers

- M & S:
- £200 million ‘Plan A’
- All operations carbon neutral by 2012
- 25% energy cut; power stores with green electricity
- Label and reduce air freighted produce
- Tesco:
  - Label and reduce air freighted produce
  - 50% energy cut in stores and DCs by 2020
  - £100 million renewables fund
  - Halve distribution emissions / case in 5 yrs

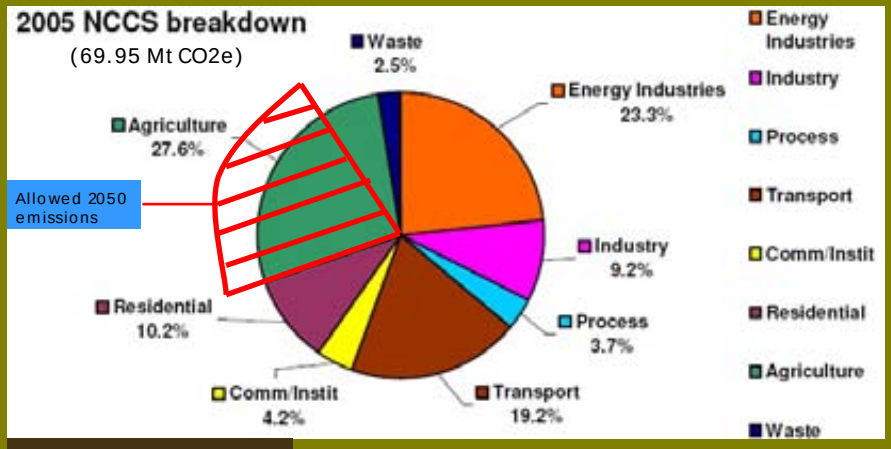
Food industry initiatives: manufacturers

- Tate & Lyle: biomass boiler to replace 70% fossil energy
- McCain's: up to 70% electricity needs from renewables including wind turbines and CHP plant running on biogas
- Cadbury’s: 50% absolute cut in carbon emissions by 2020
- Many others starting to carbon footprint their operations

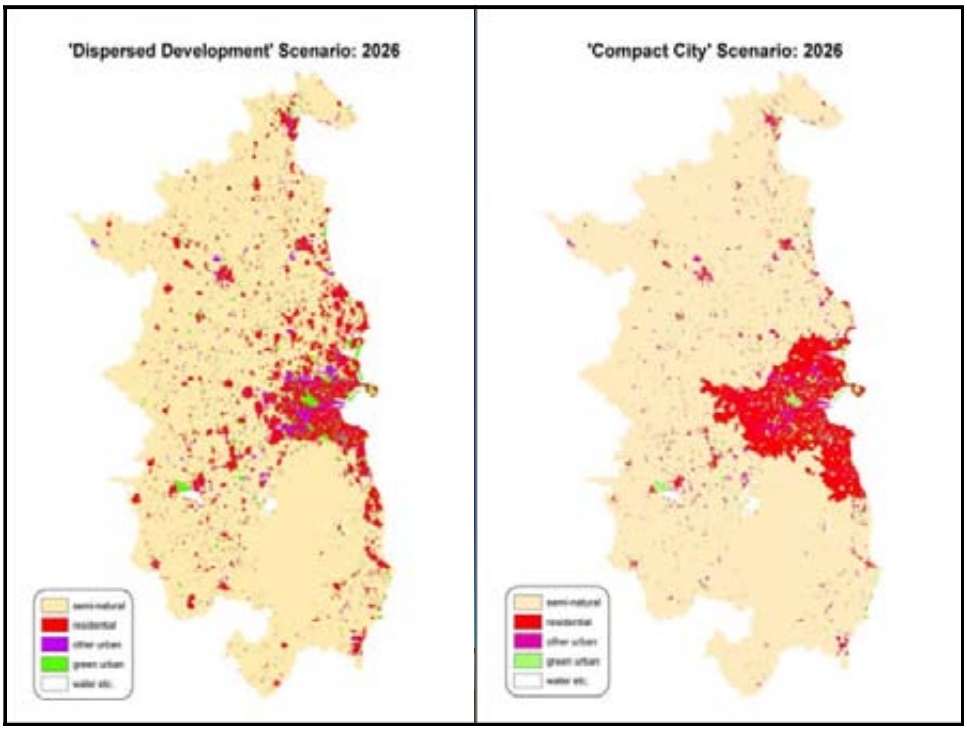
Mitigation Possibilities for Irish Agriculture

1. Animal husbandry (feedstocks, breeds etc)
2. Farm enterprise and management aspects (organic/non organic, intensification/ extensification)
3. Better management of outputs (manure)
4. Herd numbers
5. Buofuels/forestry

Implications of 80% reduction for Ireland??



1990	55.78 Mt
2020	54.81 Mt
2050	13.70 Mt


'Dispersed Development' Scenario: 2026
'Compact City' Scenario: 2026