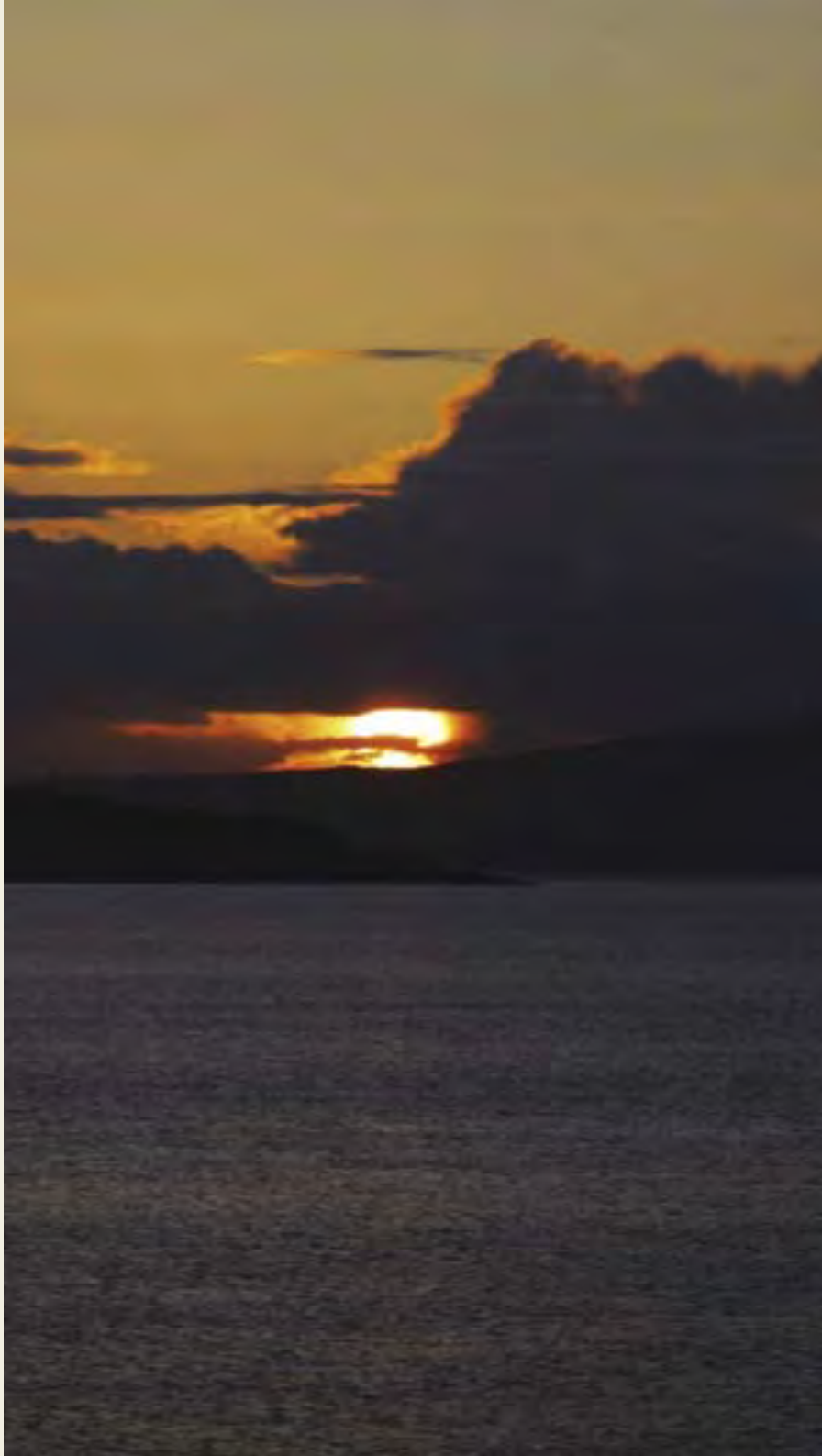
contents



Introduction

"Climate change is the most severe problem we are facing today" - this was the message from the UK Government's chief scientific adviser Sir David King in January 2004.

Since the 1970s, the world has warmed by about 0.15˚C per decade. In Northern Ireland, four out of ten of the warmest years on record occurred in the last decade. These are startling statistics. The clear message from the scientific community is that warming is due, at least in part, to the increasing concentrations of greenhouse gases in the atmosphere.

To assist in responding to the threat of climate change, and identifying its effects, the UK commissioned a report in 1999 entitled 'Indicators of Climate Change in the UK'. The original report recommended 34 indicators in the areas of: Climate, Hydrology, Sea Level and Air Pollution; Insurance, Energy, Tourism and Fire; Health; Agriculture and Forestry; Insects and Birds; Marine and Freshwaters.

The report was updated in 2003/2004 and 2 of the original indicators have now been discontinued. This report can be viewed on the web at:

http://www.nbu.ac.uk/iccuk/

The report is based on data obtained primarily for Great Britain, and so it was felt that a similar report focussing specifically on Northern Ireland would be extremely beneficial. 'Climate Change Indicators for Northern Ireland' identifies a set of indicators which could be used to monitor how the climate of Northern Ireland is changing, and how it may be affecting aspects of our lives and natural environment.

In the long-term, climate change may have large impacts on our economy and daily lives. Within the next decade or so, the first things to change may be subtle aspects of the behaviour of plants, animals and people where we already know them to be sensitive to climate change from past records. This type of indicator has been included, as well as the more obvious ones, such as temperature and rainfall.

This report takes account of previous studies of climate change impact. The Scotland and Northern Ireland Forum For Environmental Research (SNIFFER) published a scoping study entitled 'Implications of Climate Change for Northern Ireland: Informing Strategy Development' in 2002. This details the likely changes in climate and the responses of

16 sectors ranging from Water Resources, Agriculture, Horticulture and Forestry to Coastal and Flood Defence Tourism.

The indicators in this report have been chosen bearing in mind the following factors:

- A great deal of research has already been carried out in compiling the UK report, and so this research has been used as a basis for the Northern Ireland report. Proposals for indicators from other countries (Republic of Ireland, Wales) have also been considered;

- Anecdotal evidence was not seen as sufficient proof of a climate indicator;

- Availability of data has been a significant factor. Some potentially very useful indicators have not been included because they have not been systematically monitored or recorded in Northern Ireland;

- Only indicators which show a reasonable relationship with climate variables have been chosen.

It is vital that we monitor how our climate is changing, and how our environment is responding to these changes. As greenhouse gas concentrations in the atmosphere continue to rise, climate change effects may increase.

Evidence of climate change, provided by indicators, helps to strengthen the argument for the reduction in greenhouse gas emissions. We also need to turn our attention to adapting to the likely impacts of climate change – this set of indicators will help us to identify these.

This report has been prepared by the Environment and Heritage Service (EHS), an Executive Agency within the Department of the Environment. EHS provides technical and policy advice to the Department on climate change.
Future reviews and updates will provide an ongoing picture of climate change in Northern Ireland.

For further information on this report
contact:

Dr Barry McAuley
Air & Environmental Quality,
Environment and Heritage Service,
Commonwealth House,
35, Castle Street,
Belfast BT1 1GU.

Tel: (028) 9054 6434
e-mail: barry.mcauley@doeni.gov.uk

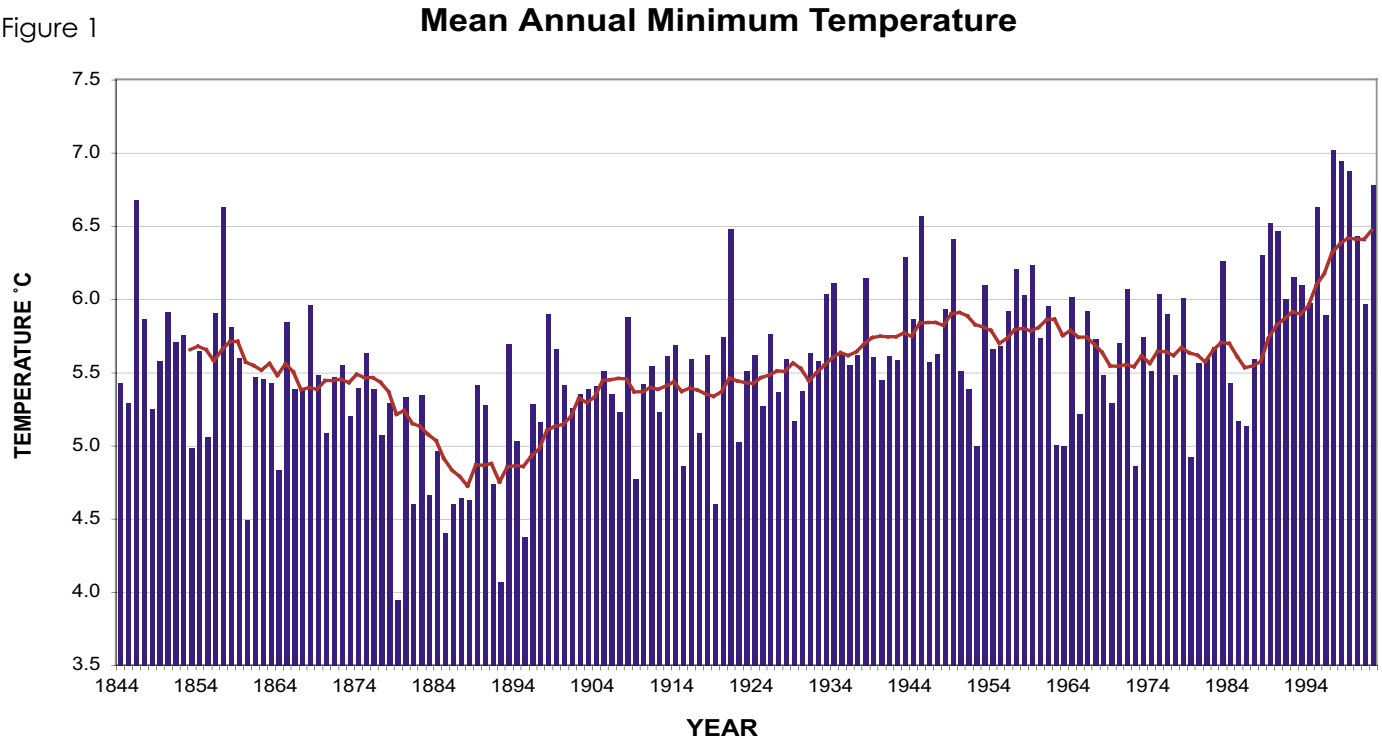
Further copies of this report are available online in pdf format: www.ehsni.gov.uk.

Air temperature in Northern Ireland

Air temperature in Northern Ireland

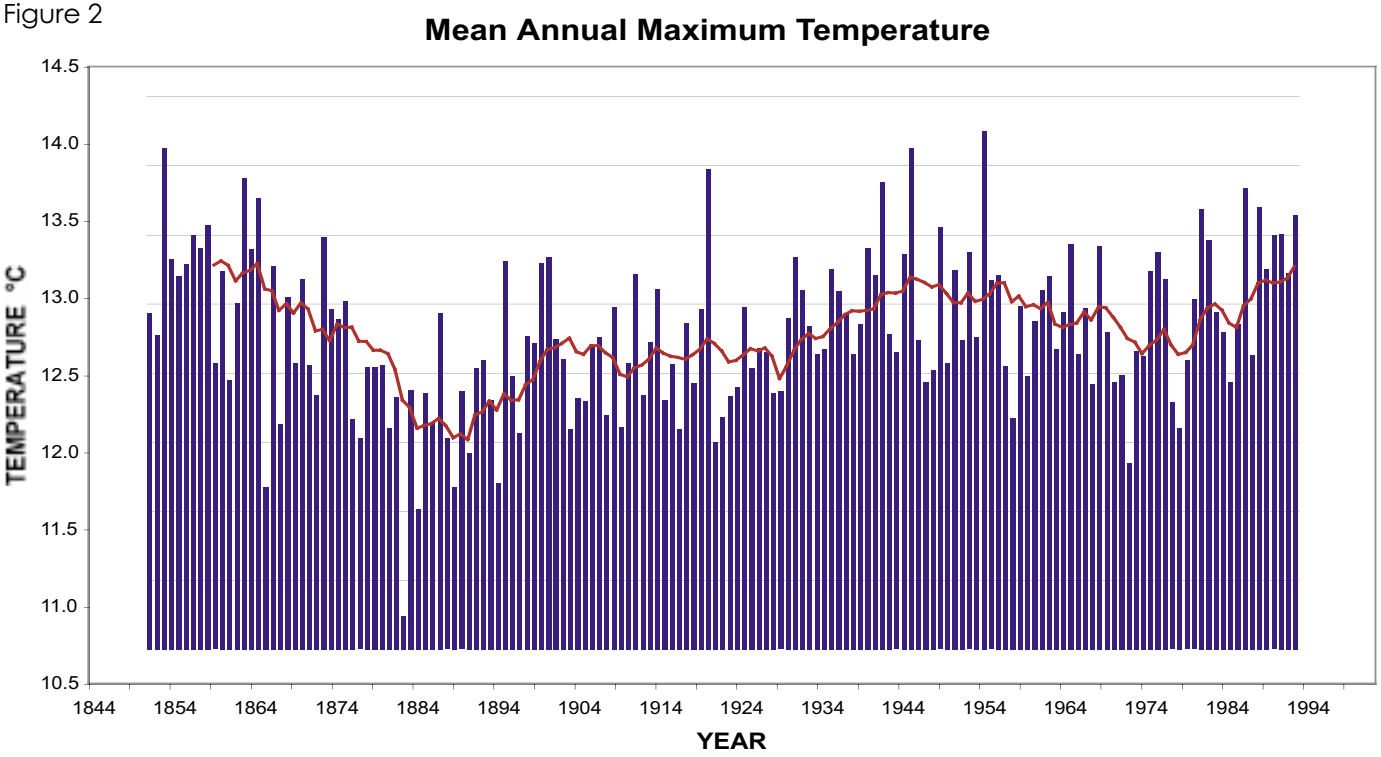
Background - A continuous temperature record has been maintained at Armagh Observatory since the 1840s. The air temperature measured in Northern Ireland is the most obvious example of a climate indicator.

Figure 1



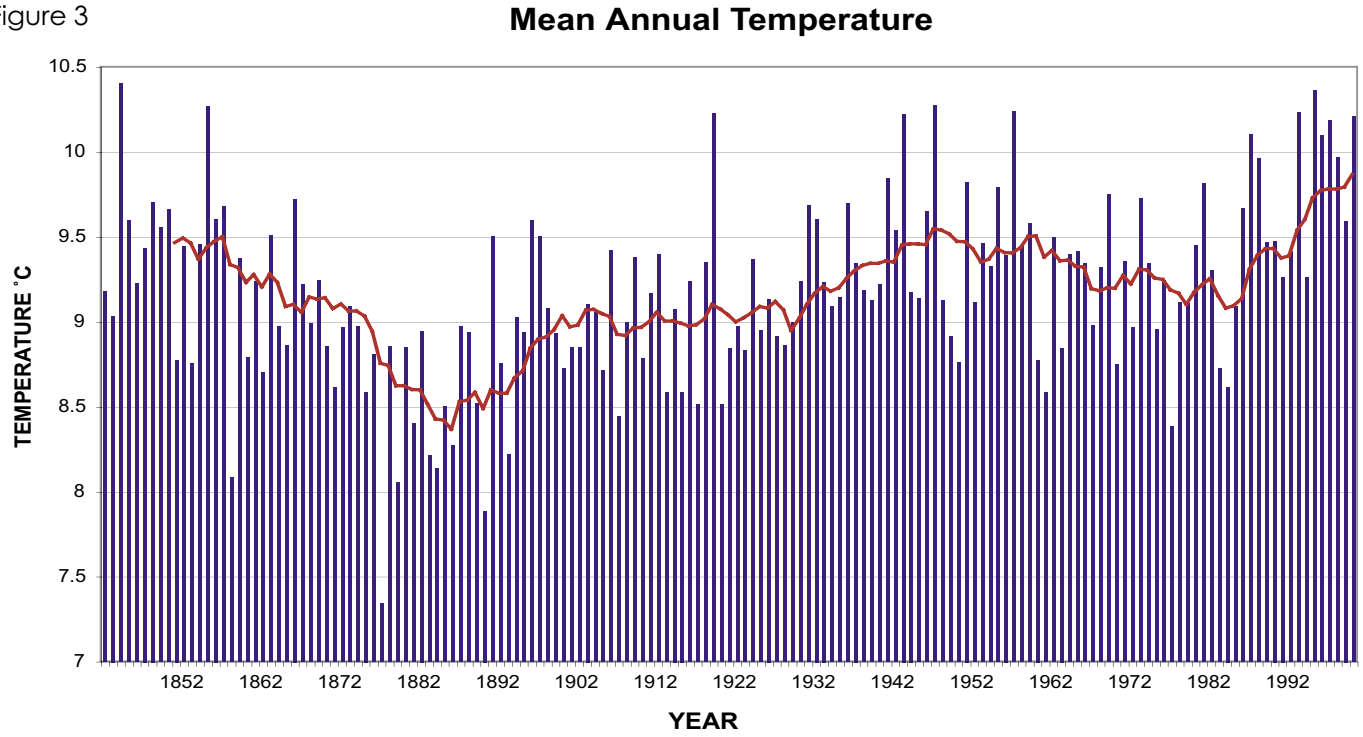
The mean annual minimum temperature has been calculated from Armagh temperature records for all years from 1841 to the present (figure 1). The trend line in red shows that the annual minimum temperature reached a low towards the end of the 19th century, and has been steadily increasing since. The 1990s have seen the mean annual minimum temperature rise to its highest levels since temperature records began. 1997 had the highest annual minimum temperature yet recorded.

Figure 2



The mean annual maximum temperature has been calculated from Armagh temperature records for all years from 1841 to present (figure 2). The trend line in red shows that the annual maximum temperature reached a low towards the end of the 19th century, and has been steadily increasing since. Since the late 1990s the average maximum temperature has been relatively high, but is not at the highest level recorded.

Figure 3



The mean annual temperature has been calculated from records (figure 3). This incorporates both the annual minimum and maximum temperatures. The trend line is currently at its highest level since records began.

Mean Annual Temperatures in Northern Ireland have been rising steadily since the early 1980s. This trend is particularly evident with Minimum Temperatures.

"Temperatures in Northern Ireland are predicted to rise."

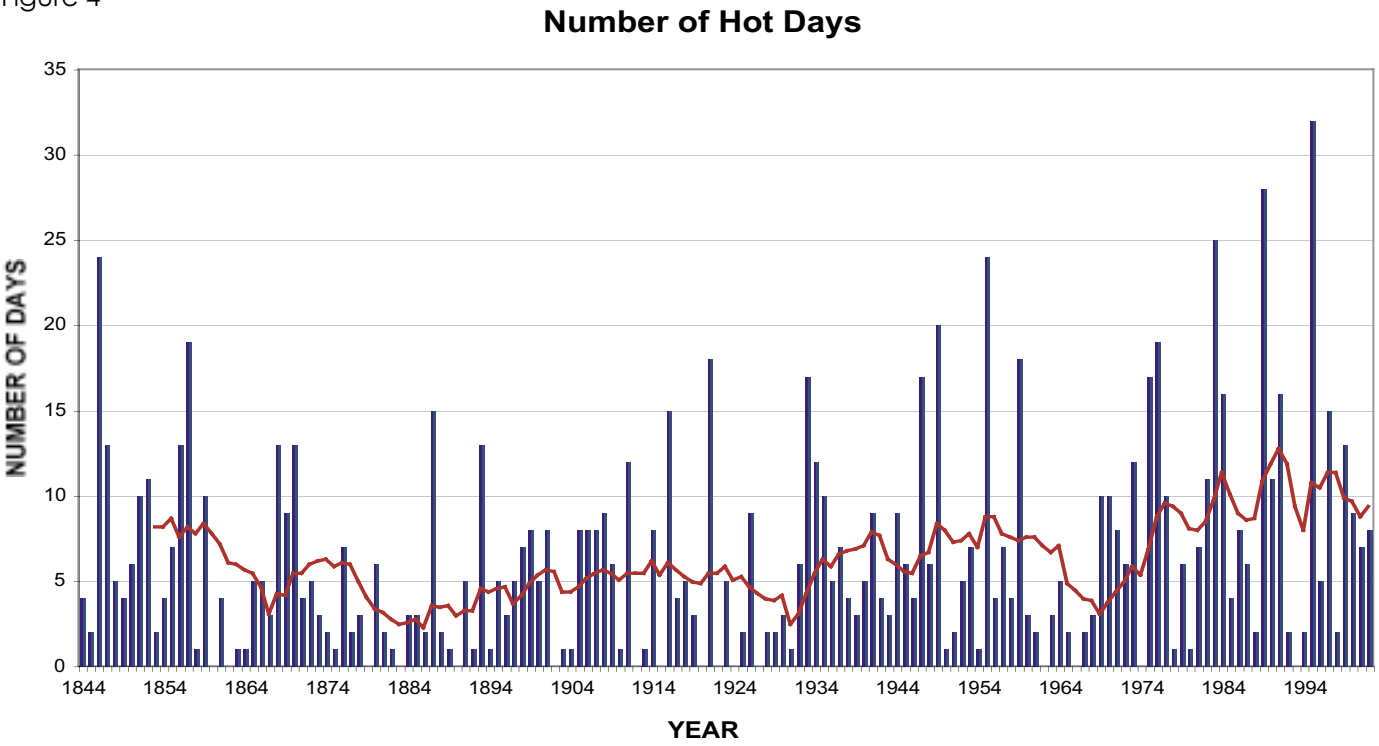
Number of hot and cold days per year

Number of hot and cold days per year

Background - A continuous temperature record has been maintained at Armagh Observatory since the 1840s. From this, the number of hot and cold days has been calculated.

Relevance - The number of 'hot' and 'cold' days in any particular year is a good indicator of climate change in general - it can be taken as an indication of how extreme weather events vary from one year to the next – in this case extremes of temperature.

Figure 4

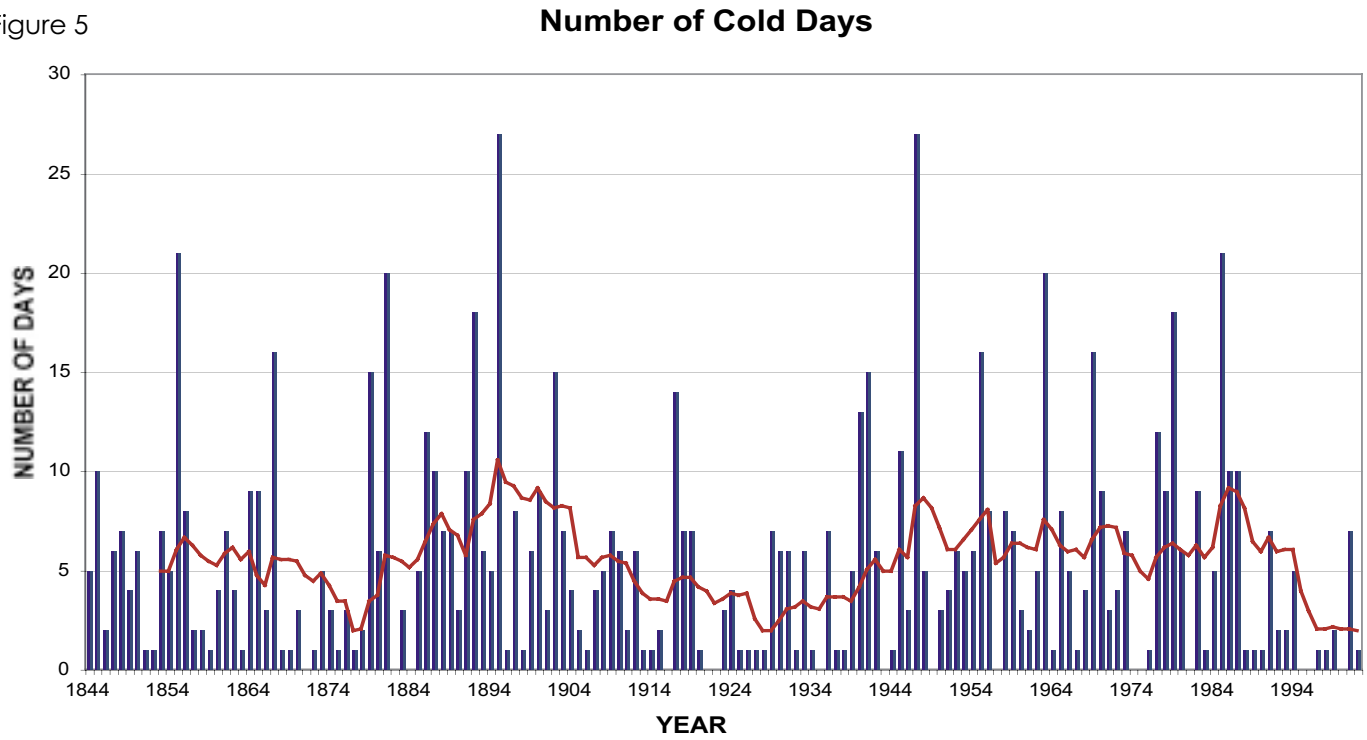


Hot days

A 'hot' day is taken to be a day where the mean daily temperature is greater than 18°C. Figure 4 shows the number of hot days each year from the 1840s to the present day. The trend line in red shows that the number of hot days each year is increasing, and has shown highest levels since the late 1980s. 1995 had the highest number of hot days on record.

"The number of hot days each year is predicted to increase"

Figure 5



Cold Days

A 'cold' day is taken to be a day where the mean daily temperature is less than 0°C. Figure 5 shows the annual number of cold days dating from the 1840s until the present. The trend line in red shows that the number of cold days is currently decreasing, and the trend line is presently at its lowest level.

The number of hot days recorded has shown high levels from 1980 to 2002 with some of the highest numbers recorded in this period.

The number of colds days has varied widely, although during the 1990s, recorded numbers have been low.

Number of hot and cold days per year

Temperature extremes have implications for various sectors - notably agriculture and health.

With more hot days, we could see changes in crop yields, adverse effects due to higher UV exposure, and potentially a greater number of photochemical pollution episodes.

With a decreasing number of cold days, we could expect to see effects which correlate to milder winters – decreased cold-related mortality rates and decreased frequency or severity of frosts (implications for roads, agriculture and horticulture).

"The number of cold days each year is predicted to decrease"

Seasonality of rainfall

Seasonality of rainfall

Background- Rainfall records have been kept at Armagh Observatory since 1930. The amount of rainfall observed in winter or summer (as a percentage of annual rainfall) was calculated.

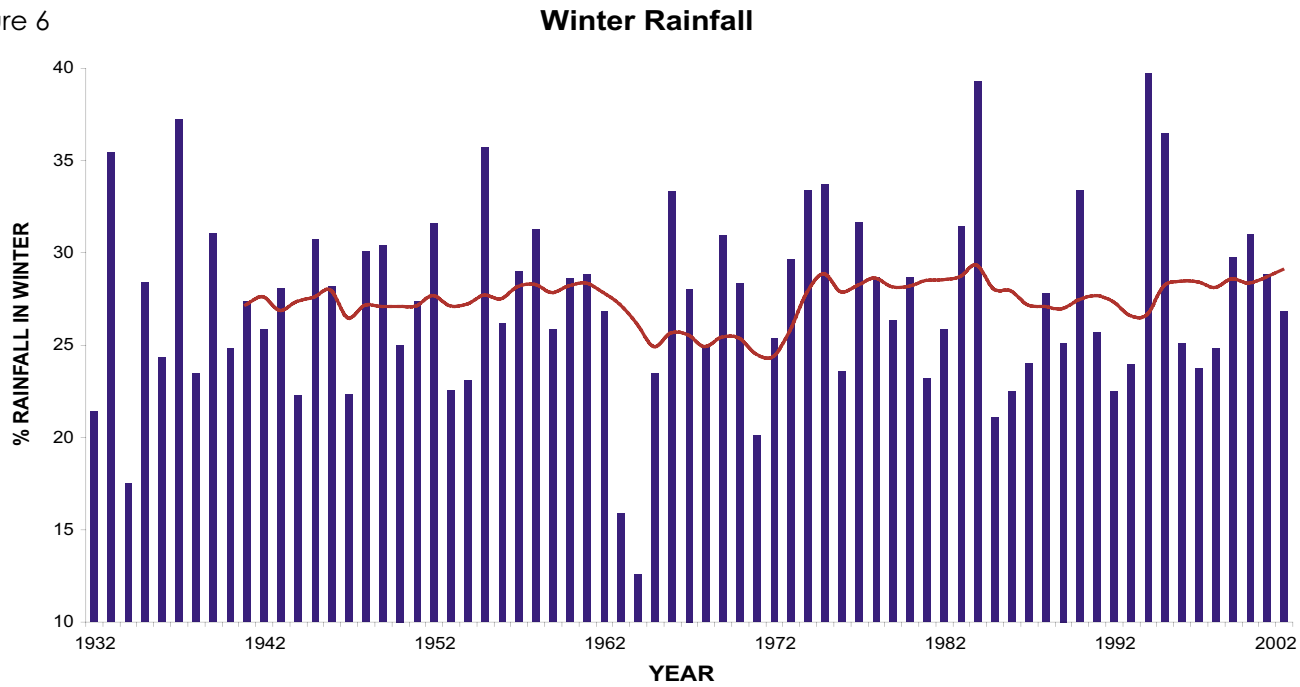
Relevance- Changing weather patterns are predicted as a consequence of climate change. This indicator focuses on changes in the annual distribution of rainfall. Long-term changes or noticeable trends in rainfall distribution provide us with evidence of how climate change is altering our seasons.

Climate models predict that Northern Ireland will see increasingly wet winters, with drier summers.

Knowledge of seasonal rainfall is of particular importance to agriculture. Farming methods in Northern Ireland have evolved to work with our current rainfall regime. River levels, flooding and water quality are also areas which may be affected by changes in seasonal rainfall.

"Seasonality of rainfall tells us if winters are becoming wetter, and summers drier."

Figure 6



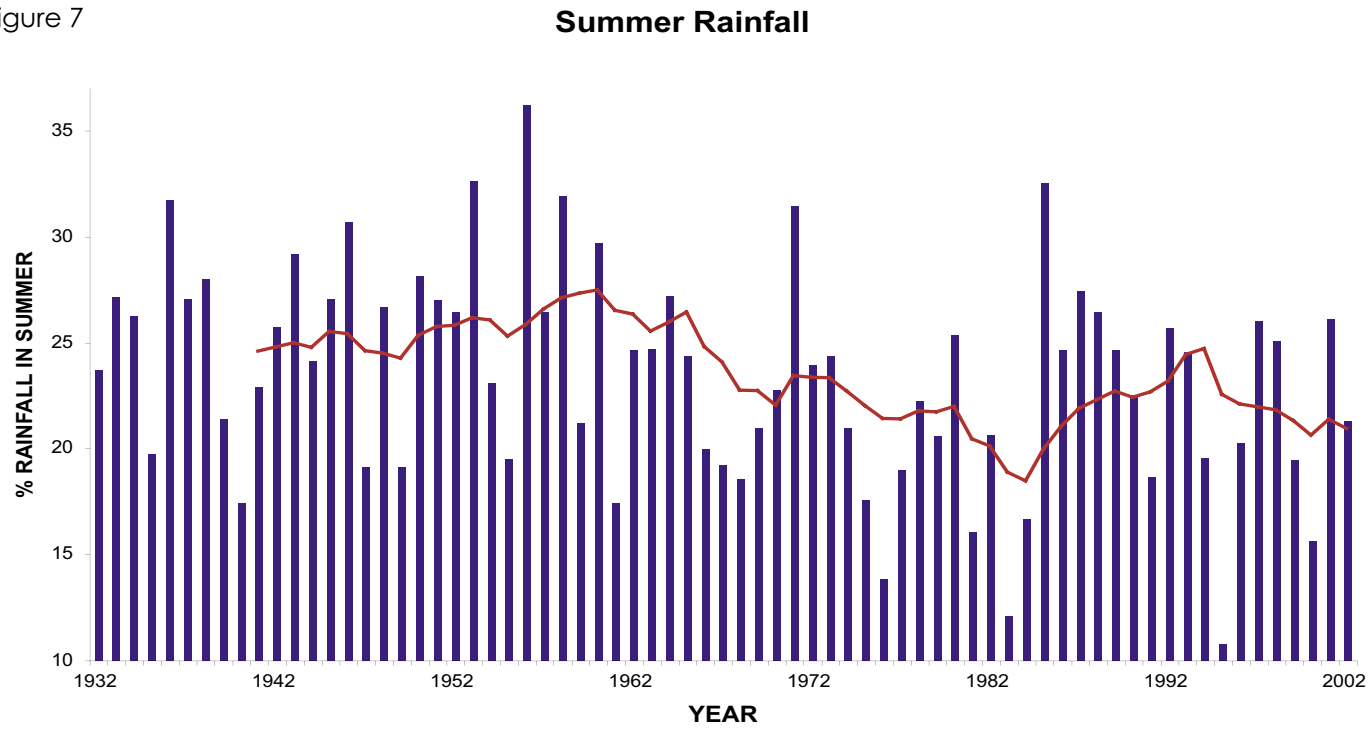
Winter rainfall

Figure 6shows the annual rainfall observed in the winter months (Dec, Jan, Feb) expressed as a percentage of the total annual rainfall. **Note** that the winter season runs from December of the previous year to February of the following year, and the total annual rainfall therefore runs from December of the previous year, to November of the following year. This method was chosen to keep the seasons intact.

The 1960s saw two years when the percentage of annual precipitation falling in winter was very low - this helps explain the dip in the trend line around this period. (1994 had the highest value recorded).

The graph shows that there is only a slightly evident trend (see red line) toward a higher percentage of mean annual rainfall falling in the winter months (Dec, Jan, Feb).

Figure 7



Summer rainfall

Figure 7 shows the annual rainfall occurring in summer (June, July and August) as a percentage of total annual rainfall (from December of the previous year to November of the following).

The graph shows that there is a trend towards less rain falling in the summer months. The three driest summers were recorded in 1976, 1983 and 1995. (1995 had the lowest percentage).

"Climate models predict drier summers and wetter winters."

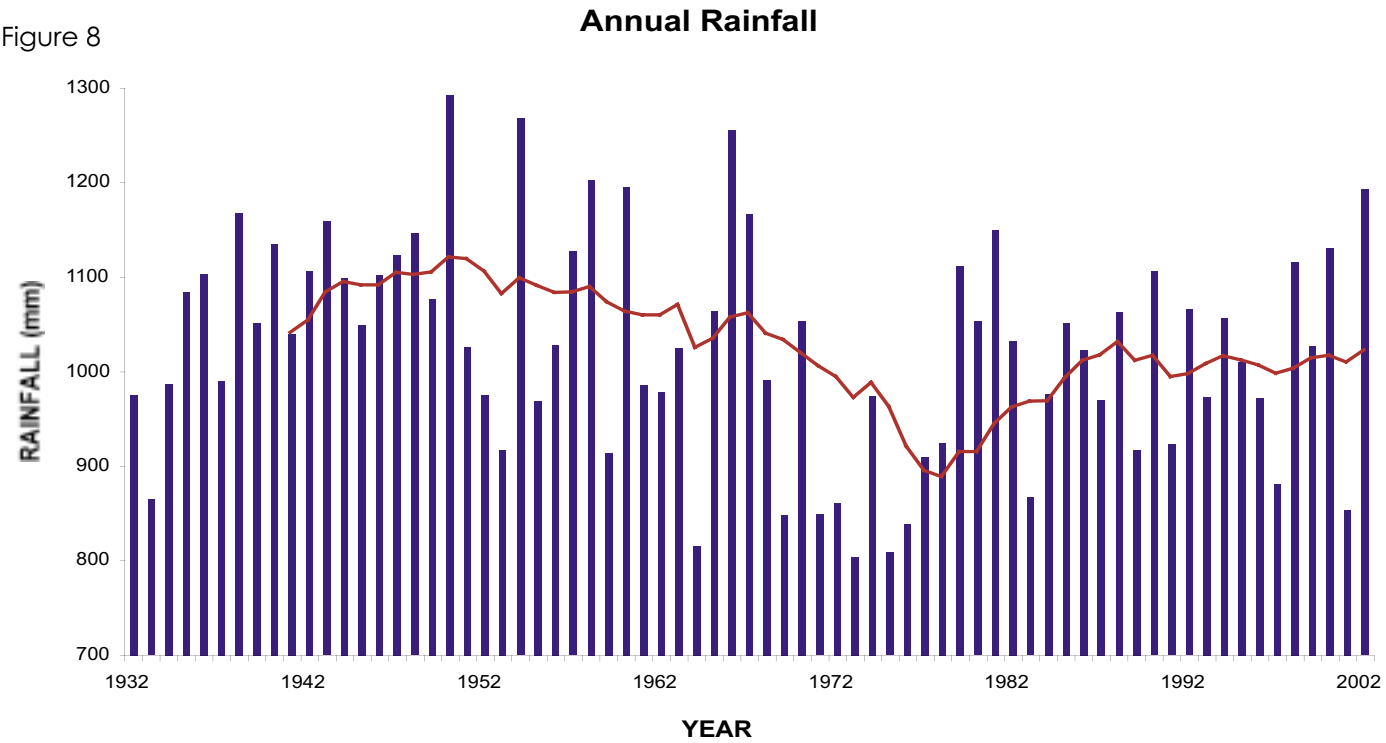
Annual rainfall

Annual rainfall

Background- A continuous record of rainfall in Northern Ireland has been maintained by the Armagh Observatory since the 1930s.

Relevance- Rainfall is important for Northern Ireland - it affects everyday life. Key impacts are felt in many sectors including: forestry; tourism; agriculture and water quality.

Figure 8



The frequency of 'extreme' events, e.g. flooding or droughts may also change. Given our reliance on rainwater, it is vitally important to monitor any changes in rainfall. Annual rainfall data is shown in Figure 8. Lower levels were seen in the 1970s. In recent years the levels have not shown any strong trend.

"Climate models predict changing rainfall in Northern Ireland"

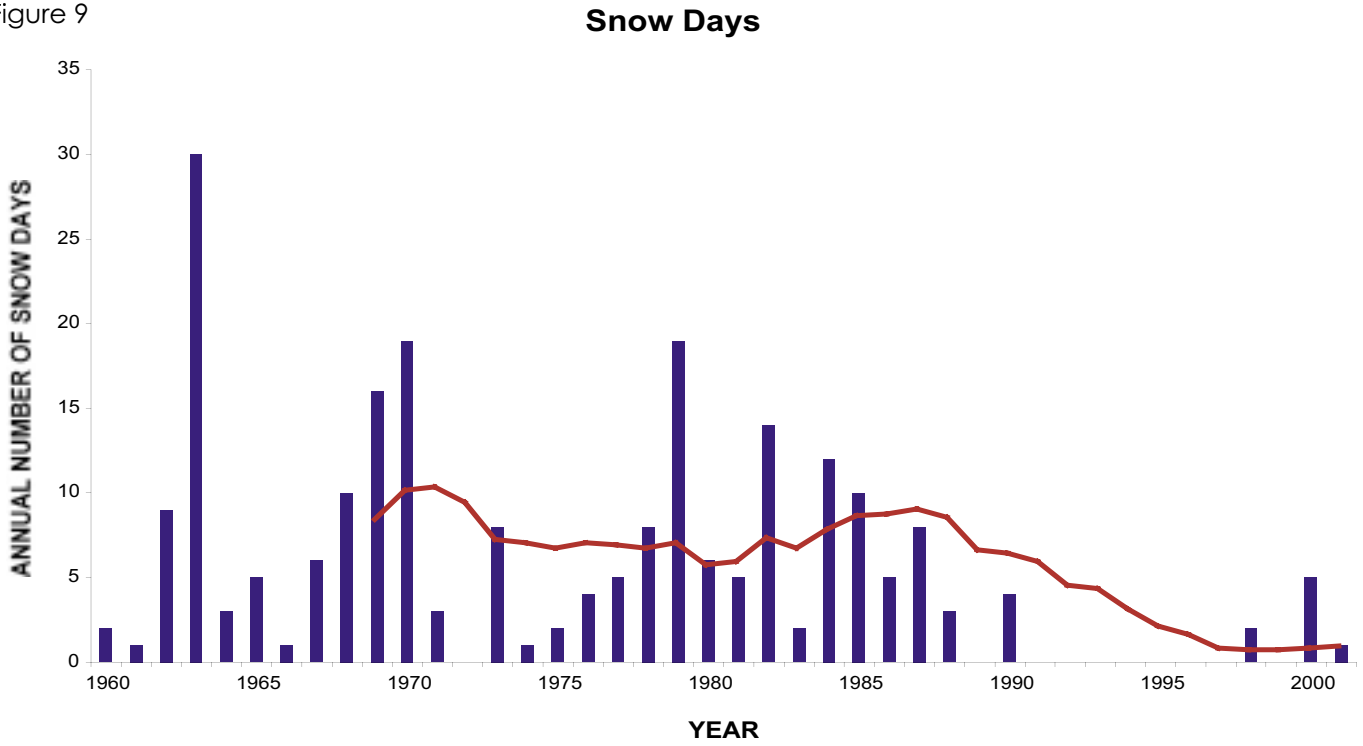
Number of snow days

Number of snow days

Background- A continuous record of the number of snow days each month has been kept at Armagh Observatory since 1960.

Relevance- The number of snow days each year is a good indicator of our climate, and the severity of winters are popularly based on this. Snowfalls can impact on many aspects of our lives: transport; communications; road safety; accidents and insurance claims.

Figure 9



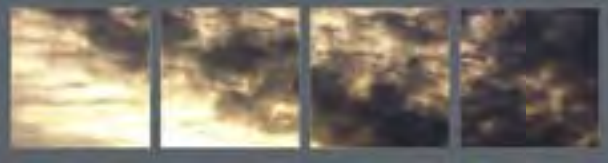
The number of snow days each year was calculated from records in Armagh (1960 onwards). This is shown in Figure 9.Given that a typical winter season runs from Dec-Feb, the data was analysed taking a year as running from March to February of the following year.

Since 1990, 8 years were recorded in which there was no significant snowfall in Armagh. Snowfall has clearly decreased in recent years.

"The number of snow days each year is decreasing"

Position of the Gulf Stream

Position of the Gulf Stream



Background- An index of the relative position of the Gulf Stream has been compiled by Professor Arnold Taylor of Plymouth Marine Laboratory. The data series runs from 1966 to 2000.

Relevance- The Gulf Stream is the name given to a series of important large scale ocean currents operating in the North Atlantic.

The Gulf Stream originates around the Straits of Florida, near the Caribbean, and the warm water found here makes its way northwards along the Eastern seaboard of the United States, before diverting eastwards across the Atlantic Ocean. An offshoot of the Gulf Stream, the North Atlantic Drift, continues eastwards to reach the British Isles.

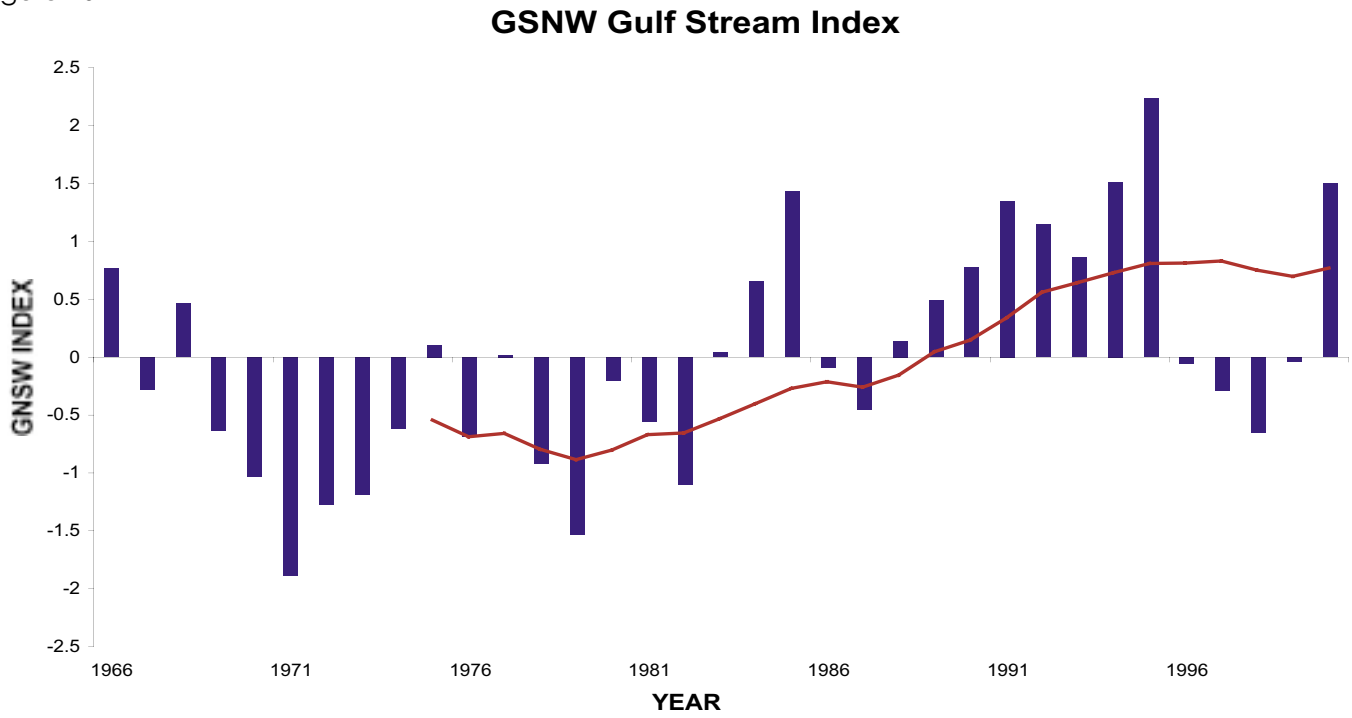
These ocean currents allow the British Isles to enjoy a temperate climate, with no extremes of summer or winter temperature – the average winter temperatures in Northern Ireland are approximately 10°C higher than those in coastal Newfoundland, lying at the same latitude on the other side of the Atlantic. Without the moderating influence of the Gulf Stream, we could expect winters to be severe, with prolonged periods of ice, snow and sub-zero temperatures.

An index of the relative position of the North Wall of the Gulf Stream (GSNW) is available on the website of the Plymouth Marine Laboratory. The index is dimensionless. Higher positive values indicate a relative shift northwards in the position, with negative values indicating a southwards shift.

We cannot say for certain if any changes in the position or activity of the Gulf Stream are caused by Climate Change, but it is important to measure any changes because of the potential effect on Northern Ireland's climate.

"The Gulf Stream gives Northern Ireland a mild climate, considering its northerly latitude".

Figure 10



Taylor, A.H. and J.A. Stephens, 1980. Latitudinal displacements of the Gulf Stream (1966 to1977) and their relation to changes in temperature and zooplankton abundance in the NE Atlantic. Oceanologica Acta, 3(2), 145-149

Figure 10 shows how the average annual GSNW has varied from 1966 to 2000.

The time series shows that the index is somewhat erratic, and that it reverses polarity frequently, although there is not necessarily a regular repeating pattern in this behaviour.

We can see from the trend line in red, that the index has become more positive, suggesting that there has been a tendency for the north wall of the Gulf Stream to move northwards over this period.

Position of the Gulf Stream

Alteration of the Gulf Stream could affect the climate of the British Isles.

Climate change is believed to have the potential to disturb the thermohaline circulation patterns, which the Gulf Stream is part of.

The full role of the Gulf Stream in climate change is unclear, however in future reports the G.S.N.W index will provide more specific information as understanding of its causes and effects improves.

"Changes to the Gulf Stream could potentially have severe impacts on Northern Ireland's climate."

Length of growing season

Length of growing season

Background- Climate data has been measured at the Armagh Observatory since the mid-nineteenth century. A continuous temperature record is available, and from this, the length of the growing season in Northern Ireland has been calculated from the 1840s to the present day.

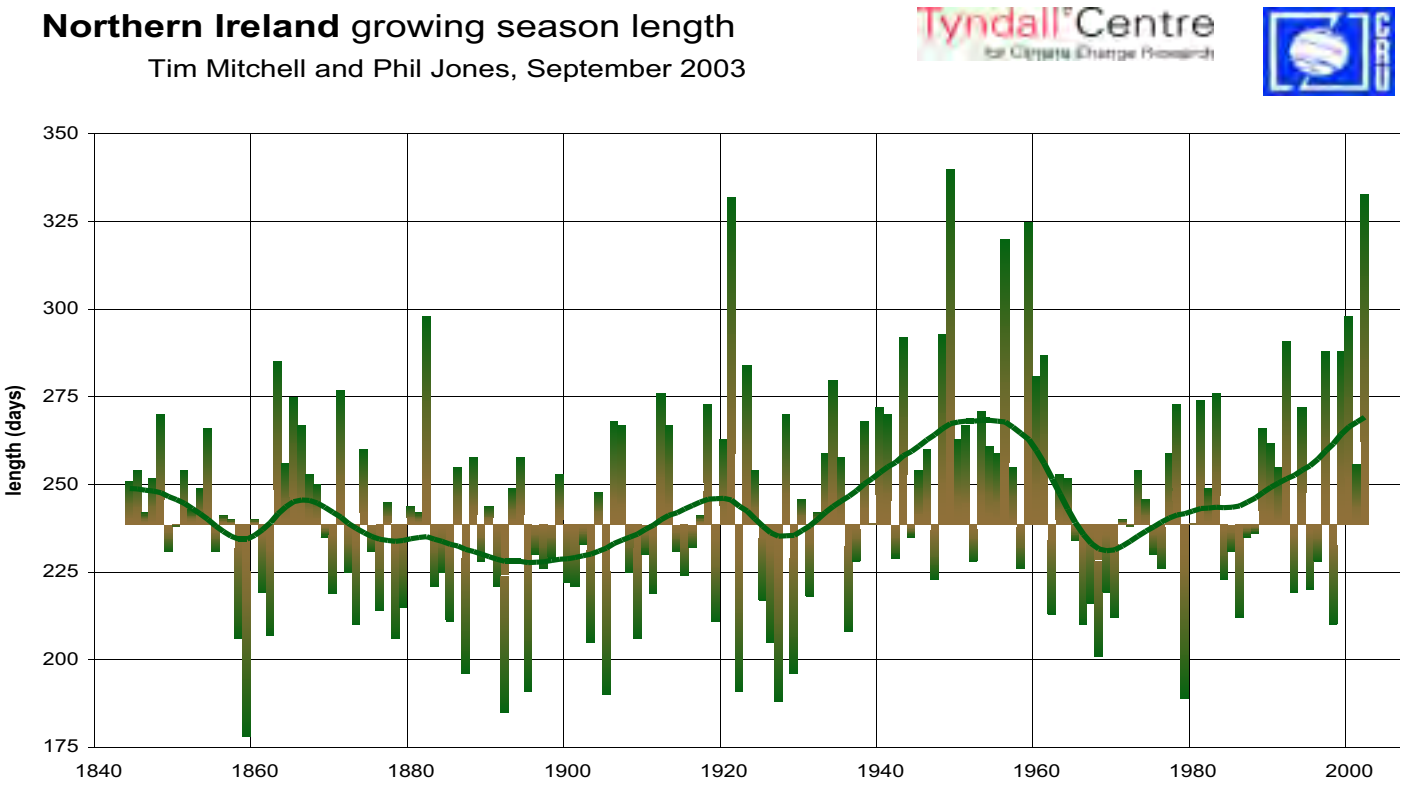
Relevance- The thermal growing season is taken to be that part of the year where the minimum temperature, averaged over 5 days, is above a threshold sufficient to allow for plant growth.

Change in the length of the thermal growing season has implications for a number of sectors – a longer growing season could alter crop yields, farming practices, the maintenance of greenfield local amenities. This indicator focuses only on temperature, however the actual growth of plants will be dependent on other factors, for example, sunlight levels and availability of water.

Nevertheless, analysis of the year on year thermal growing season length gives us a good indication of how climate change may be affecting plant life in Northern Ireland. This indicator tells us how we might expect phenological trends to behave. A year with a long growing season will see many events taking place perhaps later than usual: leaf-shed of trees; date of last grass mowing; in more general terms, the 'onset' of autumn.

"Length of the thermal growing season can tell us if the 'onset of autumn' is appearing to occur later in the year."

Figure 11



i. Length of growing season data was kindly obtained and compiled by SNIFFER, the Climatic Research Unit of the University of East Anglia, and Armagh Observatory.

ii. Graph kindly compiled by Phil Joes (UEA).

The onset of the thermal growing season is taken to be the first inclusive day on which the minimum temperature averaged over 5 days is at least 5ºC or over. For some years this may occur for example in January, but any dates before March 1st are excluded, since light levels would be too low to stimulate plant growth.

Length of growing season

Conversely, the end of the thermal growing season is taken as the first inclusive date when the minimum temperature averaged over 5 days drops below 5°C. The graph shows the length of growing season plotted by the year. Bar lines are either above or below the 1961-1990 average length.

The green line running through the graph is the trend line, which smoothes out any extreme results.

The 1940s and 50s saw growing season lengths increasing, however the 1960s saw this trend reversed. Since the 1980s there has been a tendency for longer growing seasons - in 2002 one of the longest on record was observed.

"Climate models predict that the length of growing season in Northern Ireland is set to increase in the future."

Potato yields

Potato yields

Background- The Department of Agriculture and Rural Development (DARD) in Northern Ireland publishes agricultural statistics – among these are annual crop yields. A record for potato yields in Northern Ireland since 1981 has been used here.

Relevance- According to DARD statistics, potatoes account for the largest crop yield in Northern Ireland, in terms of tonnage, with an output of approximately a quarter of a million tonnes in 2002 (provisional figure).

Potato crop output should be a good potential indicator of climate change, since yields will be linked to climatic variables. Figures obtained from the DARD statistics database show the relative success of potato production each year (tonnes per hectare).

Other factors affecting potato crop yield include water availability, pests and diseases and changes in farming methods. Examining the response of a crop yield to climatic conditions can show how climate affects agriculture. This indicator is of great significance in planning ahead for anticipated impacts of climate change on Northern Ireland's agricultural sector.

"Climate change can have a direct effect on crop yields."

Potato yields

Figure 12

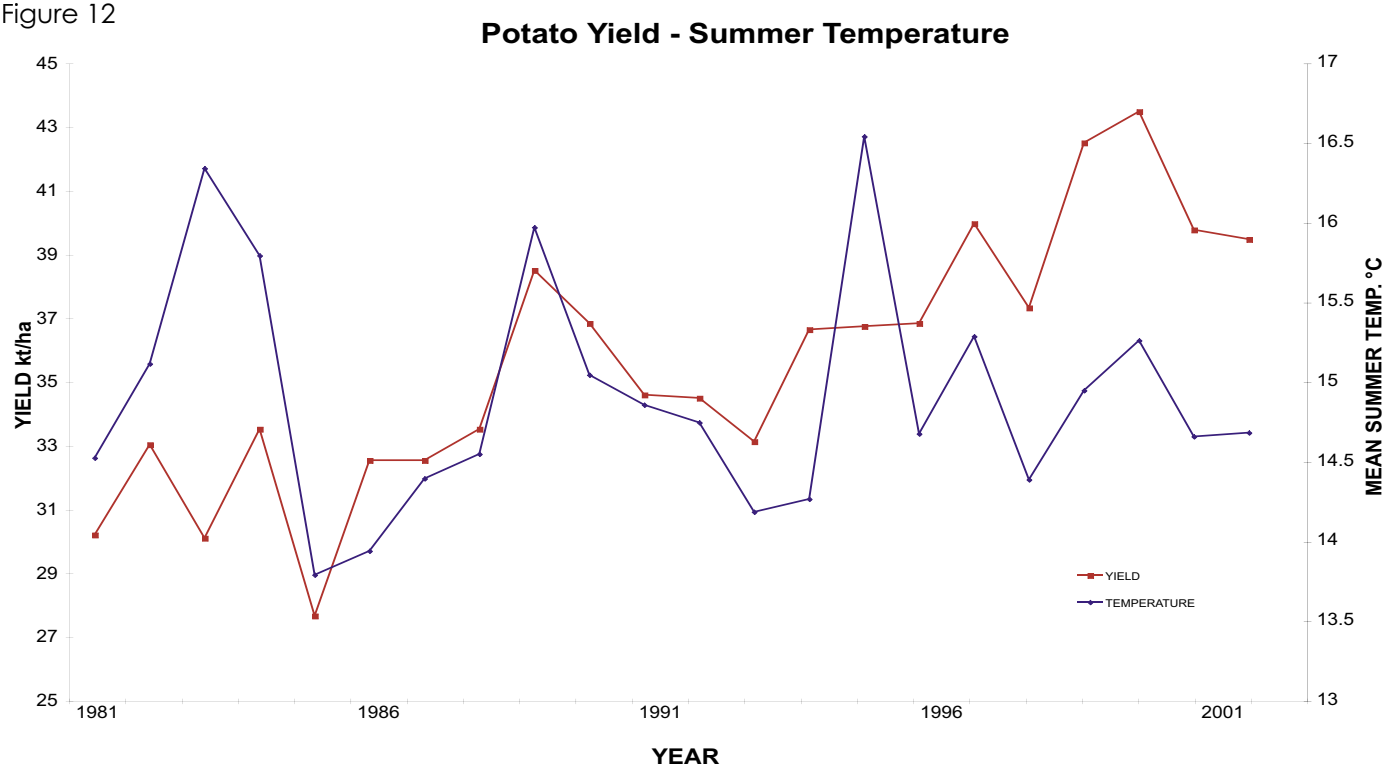


Figure 12 shows how the yield of potatoes in Northern Ireland (kilotonnes per hectare) has varied each year from 1981 until 2002. This has been plotted against the mean maximum summer (June, July, August) temperature for the corresponding years.

Mean maximum summer temperatures range from ca. 17.5 ˚C to 21 ˚C. The graph shows a good correlation between the two variables, suggesting that years with higher summer maximum temperatures tend to produce greater potato yields.

Correlation is not seen in 1995 and 1983. This was due to extremely low summer rainfall (see figure 7) impeding crop output, despite the high temperatures recorded in these years.

Potato Yields

In England, potato production was assessed against summer rainfall as a climate indicator, however no significant correlation was found when this was studied for Northern Ireland. This suggests that rainfall is not such a limiting factor for potato yields here, and demonstrates the regional nature of climate change impacts.

It is difficult to predict how long-term changes in Northern Ireland will affect potato production: on the one hand, higher summer temperatures encourage greater yields, but predicted changes in rainfall will offset this effect.

"Potato yields could be affected by climate change."

Arrival date of the first swallow

Arrival date of the first swallow

Background- Arrival dates for the swallow in Northern Ireland have been measured since the 1950s by the Copelands Bird Observatory, although data has not been available for a small number of years.

Relevance- The arrival of the swallow has traditionally been seen as one of the signs which herald the changing seasons. Swallows migrate south during our Winter months, and can be seen returning here in Spring. The arrival date of the swallow in this case is the first day on which a swallow has been observed from the Copelands RSPB Bird Observatory, Cross Island. The island lies approximately a mile offshore from the Northeast County Down coast.

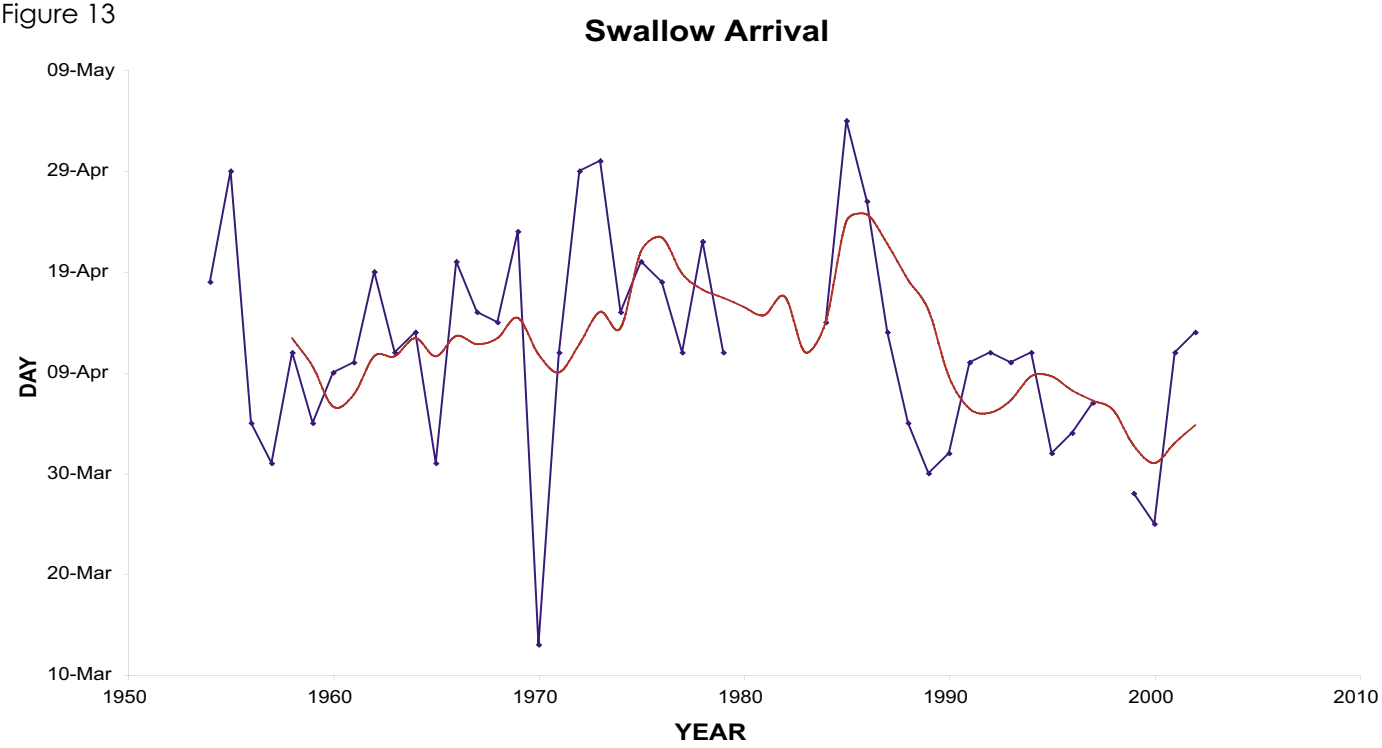
The presence of migratory birds in a given location in their migratory route is dependent on a number of factors – for example, availability of suitable sites and climate. Insects, which birds feed on, are also sensitive to these factors.

Human influences, which could influence bird habitats, for example changes in land use or farming methods must be considered when using this indicator in the long term.

"Migratory birds, including swallows, are expected to arrive earlier in years where temperatures are milder than usual."

Arrival date of the first swallow

Figure 13

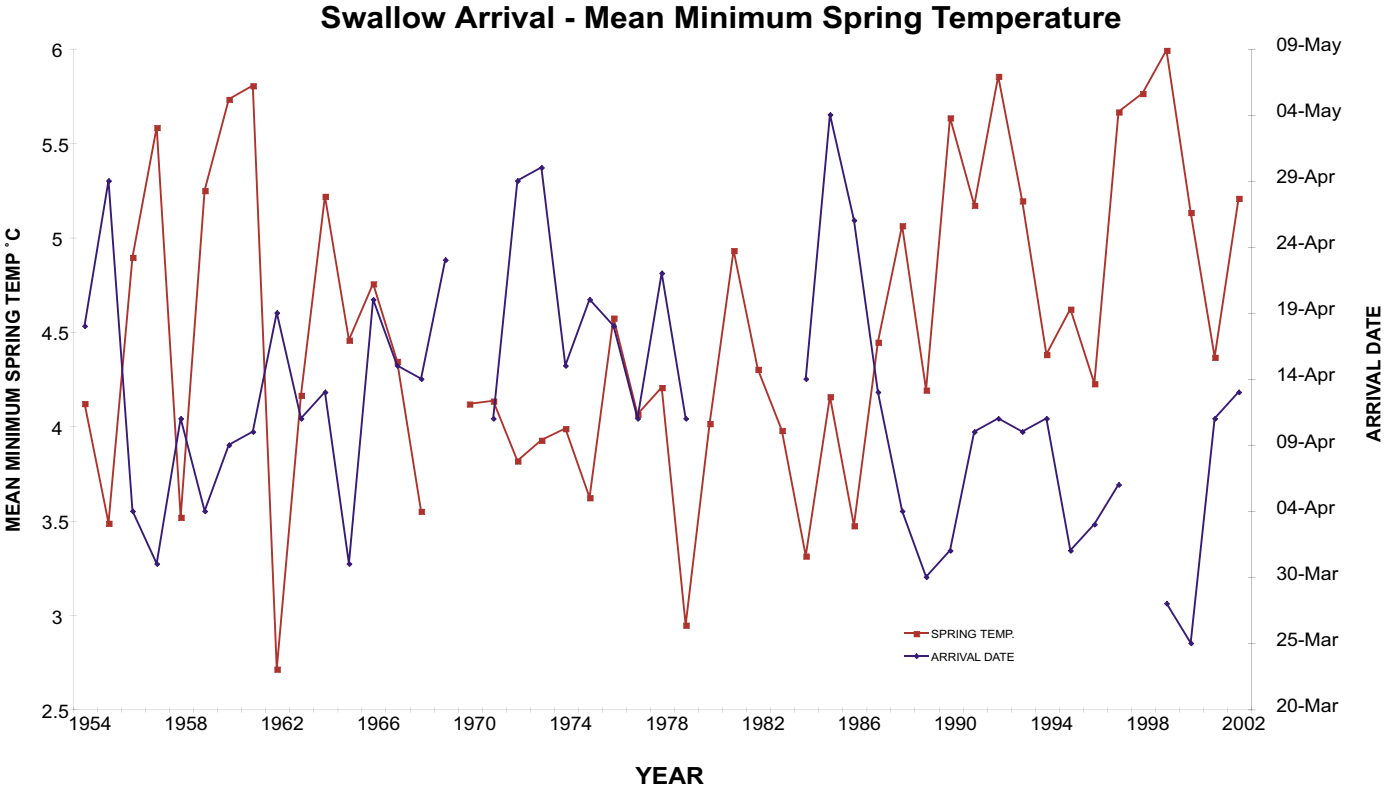


Data kindly provided by the Copelands Bird Observatory. Figure 13 shows how swallow arrival has varied over the years since 1954. The trend line shown in red indicates that swallow arrival is getting earlier each year, particularly since the 1980s.

The mean day over the time series for swallow arrival is the 11th of April.

Arrival date of the first swallow

Figure 14



Data kindly provided by the Copelands Bird Observatory. Figure 14 shows that there is a good inverse correlation between swallow arrival dates and average spring temperatures (March-May).

We can conclude that Swallow Arrival Date is a good indicator of climate. It shows the importance of climate in the natural world.

"Swallows have been observed arriving earlier than usual in recent years"

First sighting of large white butterfly

First sighting of large white butterfly

Background- The date of the first observed annual sighting of the Large White Butterfly in Northern Ireland has been recorded since 1978 by members of the Butterfly Conservation Society. This is defined as the first date on which a Great White Butterfly is seen on the wing.

Relevance- The date of emergence of butterflies is related to a number of factors – spring precipitation and temperature (especially minimum temperature), as well as climatic characteristics of the preceding winter. Researchers have found that butterfly species in Europe and the UK appear to be moving northwards, as well as to higher altitudes – this is presumed to be a response to climate change. Information about this trend can be found at:

http://www.butterfly-conservation.org/

In years with milder temperatures, butterflies are expected to emerge earlier than usual, so the date of emergence may be a climate change indicator. Computer models predict increasing air temperatures, so butterflies could emerge increasingly early in future years. If this happens, it will provide an indication of how the natural world is responding to changes in climate. Looking at trends in past emergence dates can enable assessment of this effect up until now.

"Butterflies are seen to emerge earlier in years with milder temperatures."

Figure 15

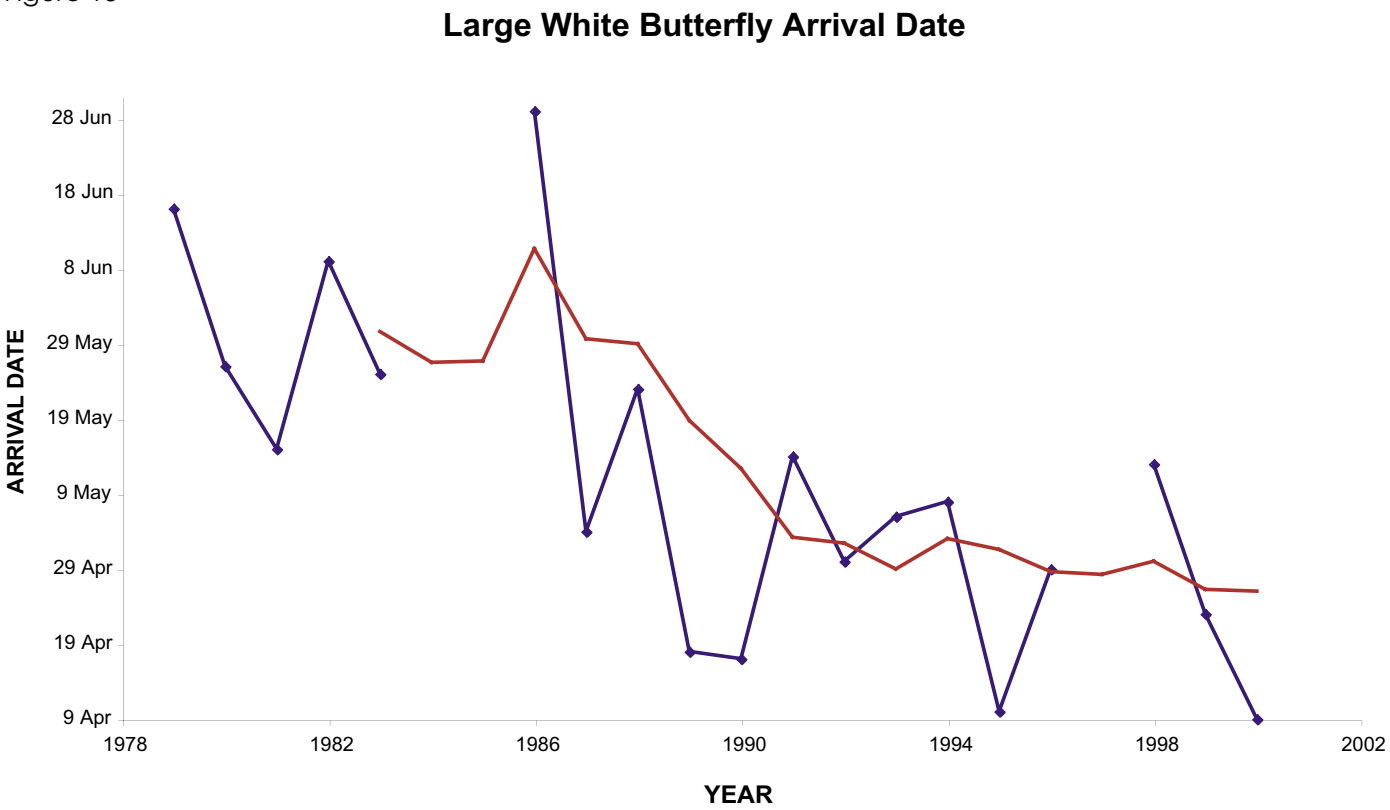


Figure 15-Data kindly analysed by T. Sparks, Centre for Ecology and Hydrology, Monkswood.

Figure 15 shows the dates of the first recorded sightings of the Large White butterfly from 1978 onwards. The red line running through the graph is a trend line, which smoothes out any extreme results. The trend line shows us clearly, that based on observations from 1978 to the present day, the date of the first observation of the Large White Butterfly in Northern Ireland is becoming earlier. The earliest observation was recorded in 2000.

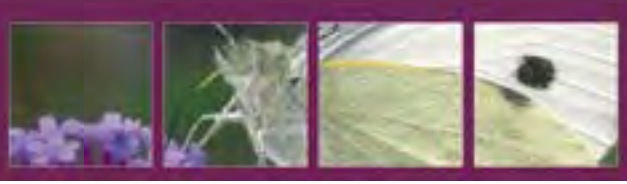
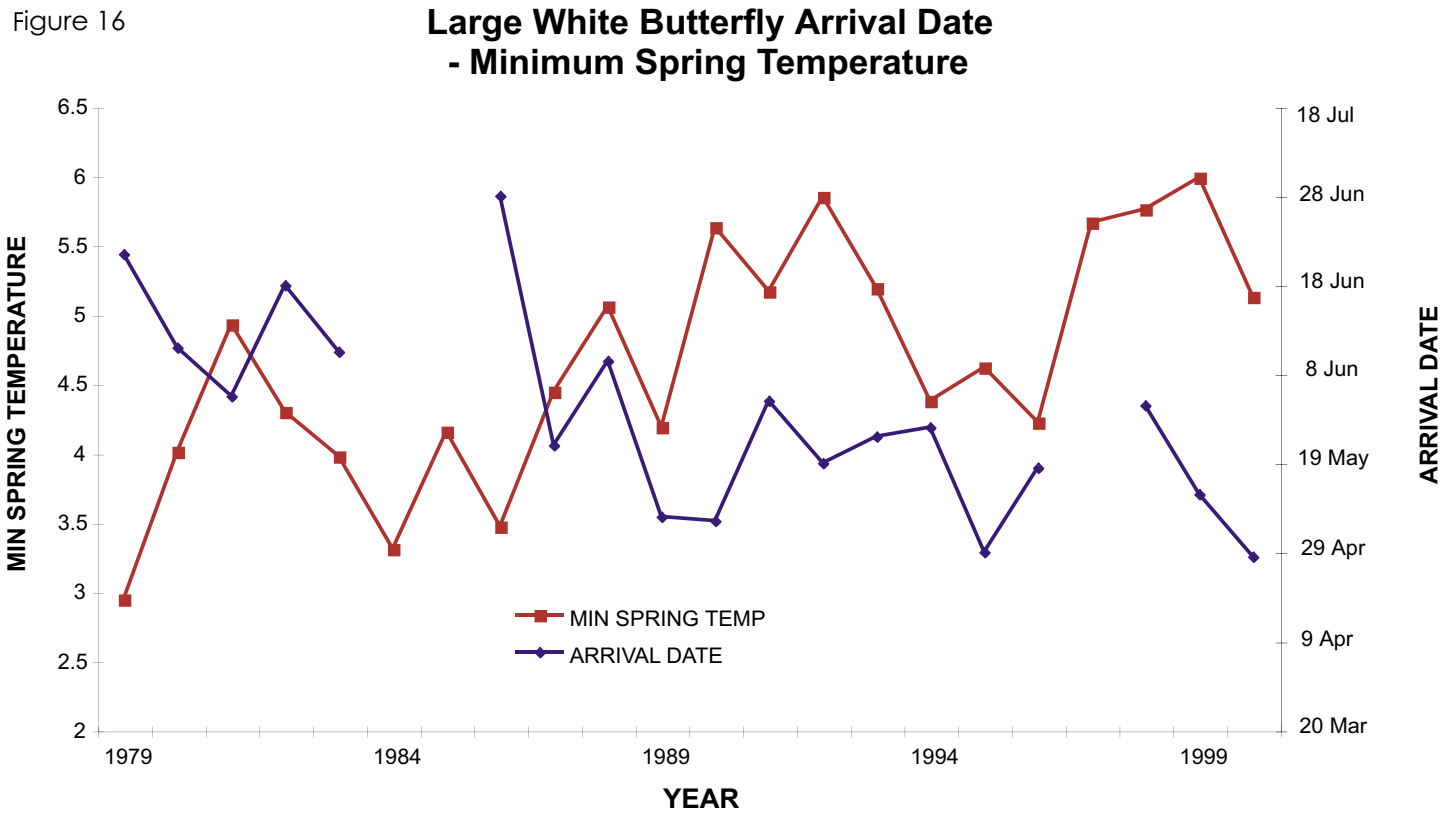


Figure 16

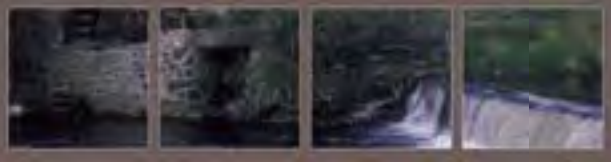


Although other factors may influence the date of emergence of butterflies, there is a strong negative correlation between mean winter temperature (over Dec, Jan and Feb) and emergence date (figure 16). This suggests that the date of emergence of the Large White Butterfly is a good indicator of Climate Change in Northern Ireland.

"We can expect to see butterflies emerge increasingly early in future years as the climate warms."

Mean river flow in the River Bush

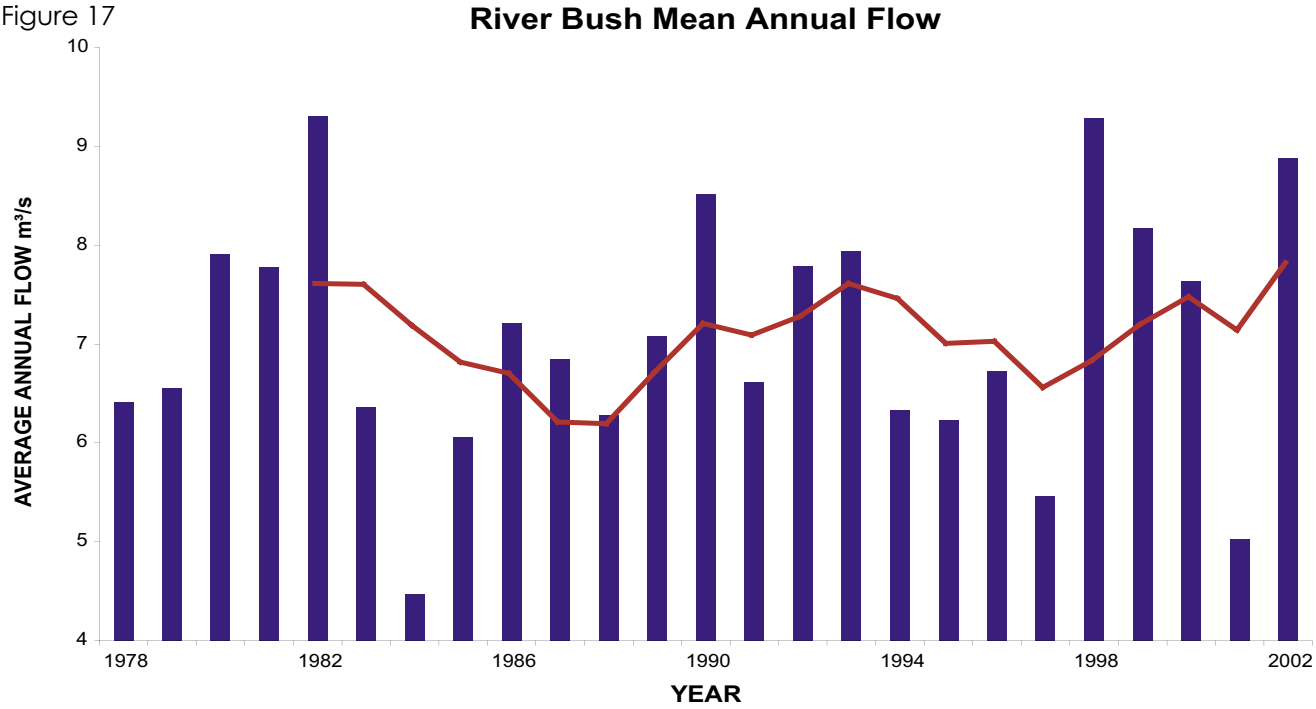
Mean river flow in the River Bush



Background- The River Bush enters the Atlantic Ocean near the Giants Causeway in County Antrim. A continuous record of measurements such as flow rates has been maintained since the 1970s. Flow rates for the River Bush were provided by the Rivers Agency.

Relevance- Climate models predict a change in Northern Ireland's rainfall patterns - river flows may change accordingly. River flows are of vital importance – areas affected include flooding, water quality, fishing and tourism.

Figure 17



Data obtained from the Rivers Agency shows that the mean annual flow rates for the River Bush have not shown any significant trends since the 1970s (figure 17). Mean river flow could also be linked to human influences, for example changes in watercourse management, so it is important to try and establish a link between river flow and climatic factors i.e. rainfall. Mean annual river flow was plotted along with mean annual rainfall data obtained from Armagh Observatory.

"Climate change models predict that precipitation patterns are likely to change."

Figure 18

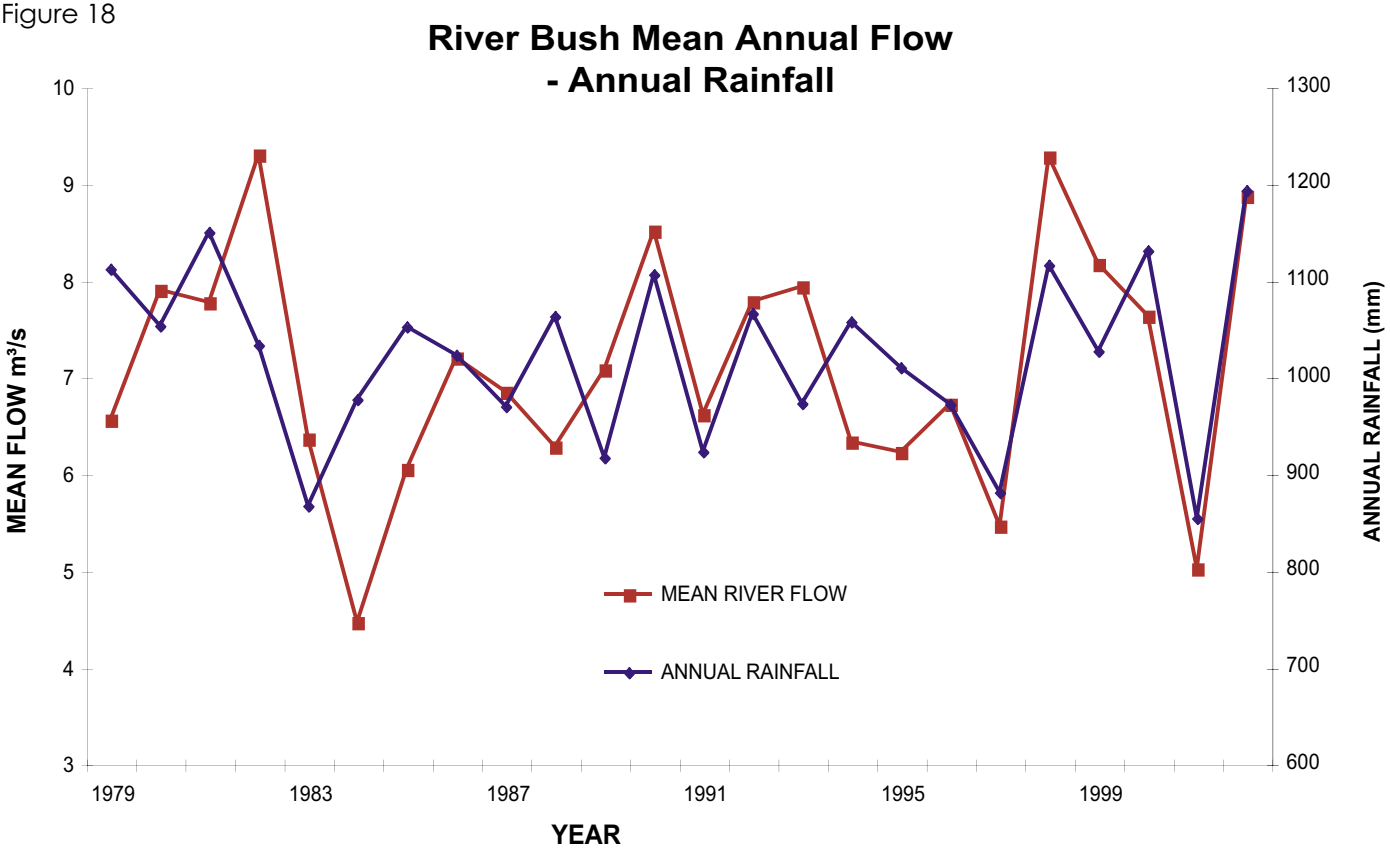
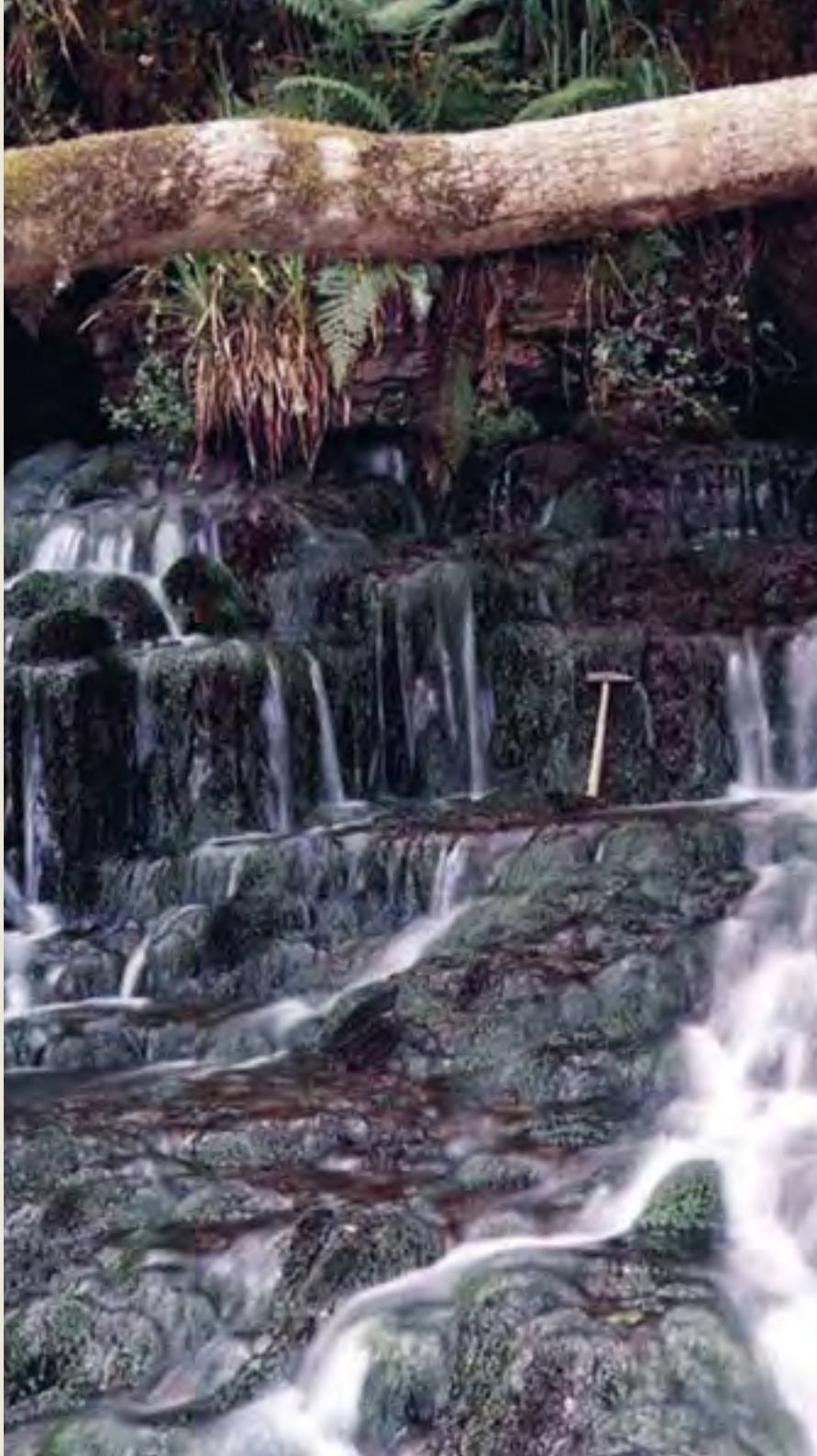


Figure 18 clearly shows that there is a strong correlation between annual rainfall and mean river flow in the River Bush. For example, in 1997 and 2001 when low rainfall levels were seen, mean flow rates were similarly low. Conversely in 1990 and 2002 when high rainfall levels were seen, mean flow rates were comparatively high.

"River flow levels are a good indicator of rainfall."

Groundwater levels in Dunmurry and Killylglen



Groundwater levels in Dunmurry and Killylglen

Background- The Water Management Unit of EHS maintains daily records of groundwater levels at various sites in Northern Ireland. These records have been linked with rainfall in Northern Ireland.

Relevance- Approximately 6% of the public water supply in Northern Ireland is sourced from aquifers, mainly in the Lagan and Enler valleys (sandstone aquifers). In addition, thousands of boreholes across the province are used for domestic, agricultural and industrial supplies.

Groundwater resources are considered to be under-utilised, and are being further evaluated as part of implementation of the EC Water Framework Directive. Killyglen and Dunmurry boreholes form part of the Northern Ireland Groundwater Level Monitoring Network in Northern Ireland. Monthly values have been averaged from hourly monitoring data.

Killyglen borehole is drilled into the Ulster white limestone (Cretaceous chalk), and Dunmurry into the Sherwood sandstone part of the Lagan aquifer. They react differently to rainfall events, with the Cretaceous chalk aquifer at Killyglen responding more quickly to runoff due to high permeability through fissures and cracks. The Dunmurry aquifer does not respond as quickly to rainfall, as slower rates of infiltration tend to dampen the effects of runoff.

"Groundwater levels in aquifers respond to rainfall events."

Figure 19

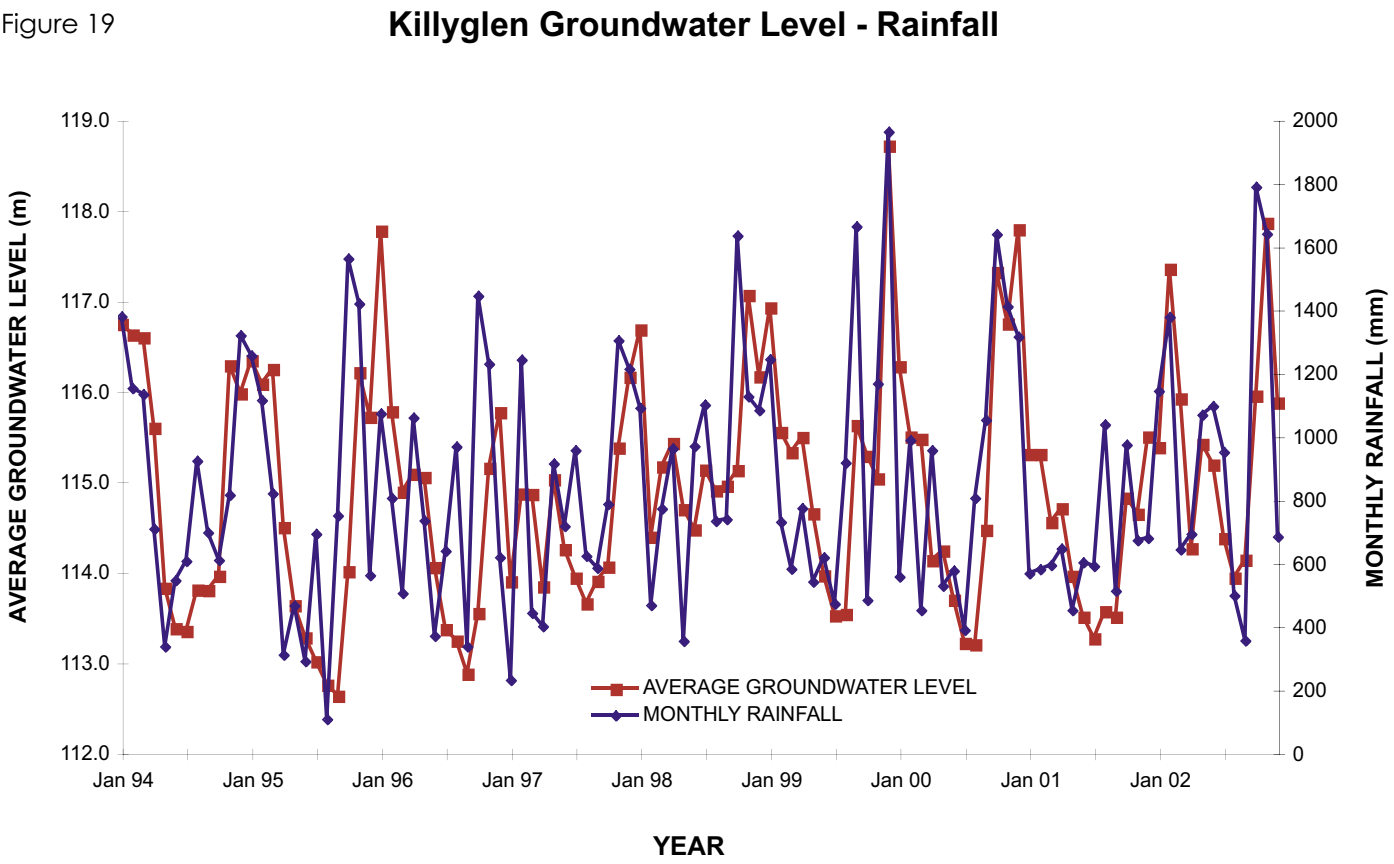


Figure 19 shows the average monthly groundwater levels (metres above sea level) for Killyglen aquifer, along with monthly rainfall totals. A good link can be seen between rainfall and groundwater levels.

Figure 20

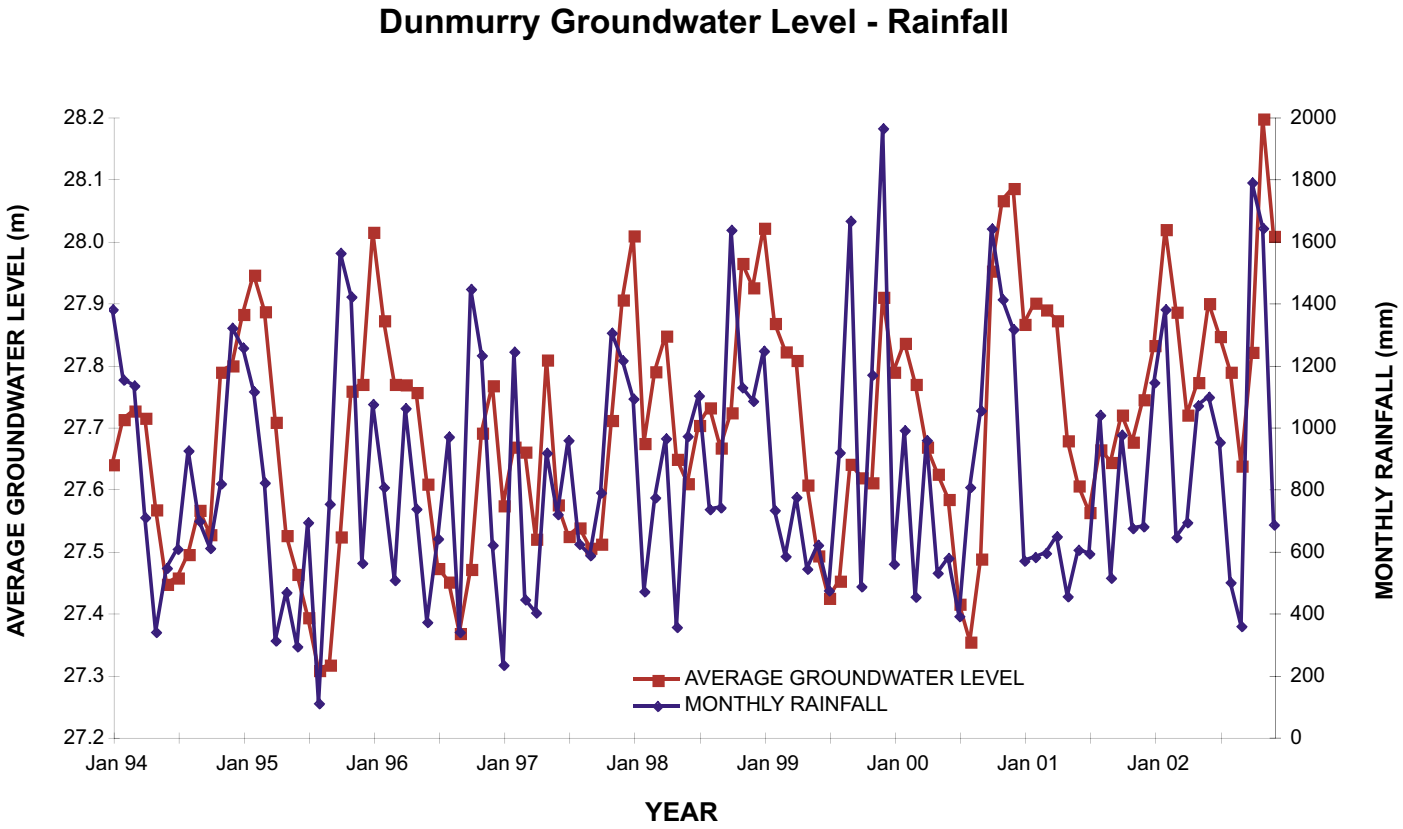


Figure 20 shows average monthly groundwater levels for Dunmurry along with monthly rainfall totals. Again, a good link is seen between groundwater levels and rainfall, however in this case a lag is seen – groundwater levels tend to peak after high rainfall levels. This is because Dunmurry is a sandstone aquifer, which is less responsive to rainfall than the fractured limestone aquifer, at Killyglen.

"Groundwater levels could be affected if climate change alters rainfall patterns."

Sea level in Northern Ireland

Sea level in Northern Ireland

Background- Sea levels in Belfast Lough have been measured by Belfast harbour Commissioners since 1918. This data has been analysed and adjusted to maintain an accurate record.

Relevance- Sea levels are predicted to rise globally as a result of the increased global temperatures associated with climate change. The most important cause of this is the thermal expansion of seawater, with another significant cause being the melting of glaciers which currently act as vast freshwater reservoirs.

Hadley Centre Models predict that global sea levels could rise by up to 36cm by the 2080s, although some models have put this figure as high as 50cm.

Heightened sea levels are expected to impact on storm surges and on coastal erosion. Storm surges are temporary increases in tidal height caused by particular weather conditions. In future the frequency or severity of storm surges may increase as climate change affects weather and sea levels.

Coastal erosion is a potential impact of rising sea levels with existing beaches and dunes being put under increased pressure. This will have implications for wildlife and habitat protection, as well as for coastal planning policy.

"Global sea levels are predicted to rise by up to 50cm."

Figure 21

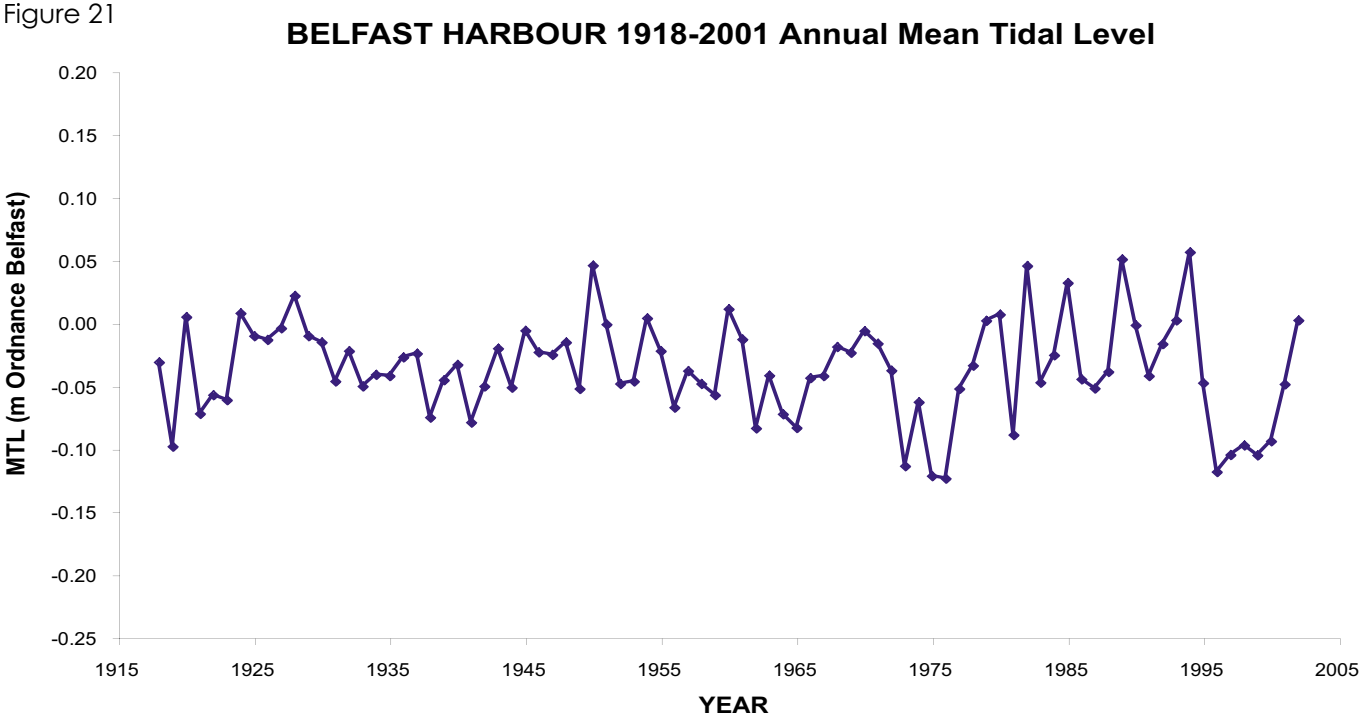


Figure 21. Mean Tidal Level (MTL) from Belfast Harbour tide-gauge based on adjusted data. Data kindly provided by Prof J. Orford, Queens University Belfast.

Figure 21 shows the adjusted mean tidal level (MTL) at Belfast Port. Problems have arisen with the data because the tidal gauge has been moved several times, and also because of various problems with the monitoring equipment. The raw data has therefore had to be adjusted, to produce a long term series of sea level values.

Sea level in Northern Ireland

Over the period of recording, the long term trend has been for sea levels in Northern Ireland to have fallen very slightly. In other parts of the British Isles, particularly in Southern Ireland and England, a rise in mean sea level has been observed. However, Northern Ireland has experienced isostatic uplift: during the last ice-age, glaciers covered much of the Northern British Isles, pushing down the land beneath. Since the retreat of the glaciers, the land has been slowly rising towards its pre-glacial position.

So, although global sea levels have been rising, the landmass here has also risen, and the observed mean sea-level has not changed as may have been expected. This land rise may become less significant in future, and sea levels may effectively rise.

Continued monitoring will help identify the impact of climate change on Northern Ireland's sea levels.

"Landmass movements in Northern Ireland may have compensated for some past sea level rises."

Trevor Boyd, Butterfly Conservation Society, Northern Ireland.

Dr John Butler, Armagh Observatory, Northern Ireland.

Richard Cole, Rivers Agency, Hydebank, Department of Agriculture and Rural Development Northern Ireland.

Colin Gibney, Environment and Heritage Service, Department of Environment Northern Ireland.

Colin Guy, Copelands Bird Observatory, Cross Island, County Down, Northern Ireland.

Mike Hartwell, Environment & Heritage Service, Department of Environment Northern Ireland.

David Jones, Central Statistics and Research, Department for Regional Development Northern Ireland.

Prof. Phil Jones, Climatic Research Unit, University of East Anglia.

Neville McKee, Copelands Bird Observatory, Cross Island, Co. Down, Northern Ireland.

Dr Tim Mitchell, Tyndall Centre, School of Environmental Sciences, University of East Anglia.

Prof. Julian Orford, School of Geography, Queen's University Belfast, N.Ireland.

Ian Rippey, Butterfly Conservation Society, Northern Ireland.

Dr Tim H. Sparks, Centre for Ecology and Hydrology, Monkswood, England.

Prof. Arnold Taylor, Plymouth Marine Laboratory.

Temperature Data- Development of Temperature Indices for Scotland and Northern Ireland", SNIFFER SR99(07)F: Centre for the Study of Environmental Change and Sustainability (CEPS) University of Edinburgh; Environmental Science Department University of Stirling; the Meteorological Office; Marine Laboratory of the Fisheries Research Services.

Precipitation Data- 1. Monthly Northern Ireland Precipitation (mm): Wigley et al; Wigley and Jones (J.Climatol.1987); Gregory et al. (Int.J.Climatol.1991); Jones & Conway (Int. J. Climatol. 1997). 2. Met Office; Armagh Observatory: **http://www.metoffice.gov.uk/climate/uk/stationdata/armaghdata.txt**

Potato Crop Data- Department of Agriculture and Rural Development Northern Ireland (DARDNI). Available on DARDNI website: **http://www.dardni.gov.uk/econs/stats.htm**

Swallow Data- Copelands Bird Observatory, Northern Ireland.

Butterfly Data- Butterfly Conservation Scheme, Northern Ireland.

River Bush Data- Rivers Agency, Department of Agriculture and Rural Development Northern Ireland. Available on CEH Wallingford website: **http://www.nwl.ac.uk/ih/nrfa/webdata/204001/g204001.csv**

Gulf Stream Data- Taylor, A.H. and J.A. Stephens, 1980. Latitudinal displacements of the Gulf Stream (1966 to1977) and their relation to changes in temperature and zooplankton abundance in the NE Atlantic. Oceanologica Acta, 3(2), 145-149. Available on Plymouth Marine Laboratory website: **http://www.pml.ac.uk/gulfstream/inetdat.htm**

Sea Level Data- Julian Orford, Joanne Murdy, Robert Friel. 20th Century sea level changes around the North of Ireland. Research Contract: GPA 308-CON 466, Environment and Heritage Service and Queens University Belfast, Jul 2003.

Groundwater data - Water Management Unit, Environment and Heritage Service.

Book design - David Walsh, EHS Corporate Communications.

Our aim is to protect and conserve the natural and built environment and to promote its appreciation for the benefit ofpresent and future generations.

Printed and Published by
Environment & Heritage Service
Publishing Unit 2004
ISBN 1-905127-07-3