

# Climate Change Indicators for Wales

Review of Options for Monitoring Changes in the Welsh Climate

This is the summary of a technical report produced for the National Assembly for Wales by a team co-ordinated by the Centre for Ecology and Hydrology Bangor.

Further information is available from:

Centre for Ecology and Hydrology  
Orton Building  
Deiniol Road  
Bangor  
Gwynedd  
LL57 2UP  
Tel: 01248 370045

Environment Division  
National Assembly for Wales  
Cathays Park  
Cardiff  
CF1 3NQ  
Tel: 02920 823178

October 2001

**Principal contributors:**

Dr A Buse, Centre for Ecology and Hydrology Bangor; Mr T H Sparks, Centre for Ecology and Hydrology Monks Wood; Dr J P Palutikof, Climatic Research Unit, University of East Anglia; Prof. J Farrar, Institute of Environmental Science, University of Wales Bangor; Prof. G Edwards-Jones, School of Agriculture and Forest Sciences, University of Wales Bangor; Dr G. Mitchelson-Jacob, Centre for Applied Oceanography, University of Wales Bangor; Dr J Corson, Institute of Medical and Social Care Research, University of Wales Bangor.

**Photos:** All CEH, except for: cover – Dr Jeremy Williams, University of Wales Bangor; Pied flycatcher – Duncan Brown, Countryside Council for Wales

## Introduction

This report summarises a study of possible indicators of changes in the climate of Wales.<sup>1</sup> Indicators are needed to improve our understanding of the impacts of climate change on the natural environment, the economy and public health, and to assist the National Assembly for Wales to fulfil its commitment to ‘set, monitor and evaluate targets for environmental performance improvements’, in support of its resolution to reduce greenhouse gases.<sup>2</sup> Wales will thereby play its part, with other areas of the UK and the UK Government, in meeting the emission reduction targets adopted in the Kyoto Protocol in December 1997.<sup>3</sup>



In 1999, the National Assembly commissioned a scoping study to review existing information and research studies relevant to climate change in Wales. One of the resulting recommendations was the need to consider the selection of indicators of climate change for Wales.<sup>4</sup> The present study was commissioned in response to this.



Climate change indicators are needed to make known that changes are occurring, at what rate they are happening and whether attempts at reducing the causes of change are working. In 1999, a list of 34 UK indicators was published<sup>5</sup>, but few of these indicators can be applied directly to Wales. The present study investigates a wide range of potential indicators for Wales, and the data sets on which they are based, before drawing up a short-list of recommended indicators.

## How the indicators were selected

The study was headed by a team of experts in the field of climate change, with specialisms in climate, economy, human health, environment, agriculture, forestry, and marine and freshwaters. In addition, more than fifty organisations and 50 individuals were consulted during the study. A wide range of potential indicators was considered, seventy-two in detail. They were tested against the criteria that climate change indicators should, as far as possible:

- *respond to changes in climate and show trends over time,*
- *provide an easily recognisable picture of the effects of climate change, e.g. increased river flow, based, where possible, on Welsh sites,*
- *be based on data that has been collected over many years and that is expected to continue to be collected,*
- *have a good scientific basis*
- *be useful in modelling and forecasting the effects of climate change,*
- *be available at a reasonable cost, and*
- *be well-documented and updated at regular intervals.*

<sup>1</sup> *Review of possible climate change indicators for Wales.* Buse *et al.* Report to NAW (2001)

<sup>2</sup> *Climate change Wales: Learning to live differently.* Available at [www.wales.gov.uk/climatechange](http://www.wales.gov.uk/climatechange)

<sup>3</sup> See Introduction in *Climate change Wales: Learning to live differently* (Footnote<sup>2</sup>) for details.

<sup>4</sup> *Wales: Changing climate, challenging choices.* Available at [www.wales.gov.uk/subienvironment/content/climatechange/cc-scopingstudy-e.htm](http://www.wales.gov.uk/subienvironment/content/climatechange/cc-scopingstudy-e.htm)

<sup>5</sup> *Indicators of climate change in the UK.* Available at [www.nbu.ac.uk/iccuk/](http://www.nbu.ac.uk/iccuk/)

Some good potential indicators had to be rejected because recording began too recently for there to be a long enough series against which to compare new data; these may become important indicators in future. Also, some features with a major influence on the Welsh climate, such as the Gulf Stream, were included: these are based on multi-national data sets.

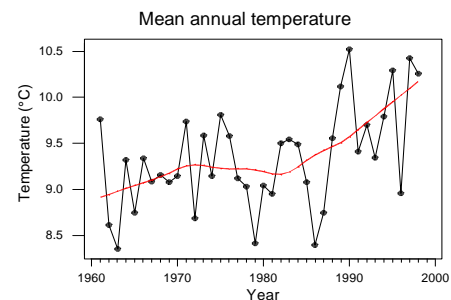
## Recommended indicators and why they were chosen

Twenty-two indicators are recommended. They are considered in three groups: indicators of changes in climate, indicators of the effects of these changes, and indicators of some major features that influence the climate.

### Indicators of changes in the Welsh climate:

#### 1. Air temperature

Air temperature is an important measure of global warming. Data are available from at least seven meteorological stations distributed throughout Wales. Indicators include the incidence of maximum/minimum temperatures and hot/cold days.



#### 2. Rainfall

As global warming is expected to result in drier summers and warmer winters, rainfall is an appropriate indicator; daily or annual means and extreme rainfall events are suitable. Data are available from the same sites as air temperature.

#### 3. Snow cover

Increased winter temperature will affect the duration of snow cover on the Welsh mountains.



Fluctuations in the snowline on the north face of Snowdonia have been measured daily for some years.

#### 4. Westerly winds

Wind direction is particularly important in winter, when westerly

winds cause a rise in temperature. Data on wind direction are available from coastal meteorological sites and marine buoys.

#### 5. Gale index

Global warming is expected to increase the number of extreme weather events, such as winter gales. Data on the frequency of gales are available from coastal meteorological sites, and can be calculated as a 'gale index' from data sets of air pressure at sea level.

### Indicators of the effects of changes in the Welsh climate:

#### 6. Outdoor fires

Outdoor fires may be linked with climatic conditions; more might occur during prolonged drought and fewer during wet weather. Official statistics show that the annual number of outdoor fires is linked with summer rainfall and summer temperature.

#### 7. Human mortality and morbidity

A greater than expected proportion of deaths and hospital admissions occurs during extreme

heat or cold. An increase in the number of extreme climatic events might increase this proportion. Official statistics can be used to monitor mortality and morbidity (i.e. disease).

### **8. Flowering of clover varieties in agriculture**

Many biological phenomena, including the date of flowering, are affected by light and by temperature. Long-term data show that the flowering dates of clover contain clear trends of earlier flowering with warmer spring temperatures in recent years.

### **9. Ear emergence**

Light and temperature also affect the appearance of the ears (i.e. the stems that will hold the grain) on ryegrass. Over the last thirty years, there has been a trend towards earlier earing.

### **10. Leafing dates**

The date at which the buds open in many plants is related to temperature; buds of beech, for example, open earlier at higher April temperatures. It is considered that many long-term data sets exist in Wales, perhaps recorded by private individuals

### **11. Greenness**

A measure of the 'greenness' of Wales at specific intervals could show how advanced spring is in a particular year. Such data, recorded by NASA, would represent the whole of Wales, rather than fixed points. However, data processing might be costly.



### **12. Insect timing**

The date when adult insects appear is related to temperature, particularly during an earlier part of the year. Welsh data on the meadow brown butterfly, for example, show a clear relationship between its peak week and temperature.

### **13. Insect abundance**

The abundance of insects is also related to climate and the abundance of the same species as in 12 above could be monitored.

### **14. Bird migration timing**

The arrival time in Wales of migrant birds is particularly dependent on climate; swallows, for example, appear when insects are plentiful. Data from the Welsh island observatories show that blackcap has had a dramatic trend towards earlier arrivals.

### **15. Egg laying timing**

Temperature influences the timing of egg laying. Data on the pied flycatcher from North and South Wales show a strong correlation with temperature and a trend towards earlier laying. Red kite data suggest that nesting success is related to spring rainfall, affected by climate change.

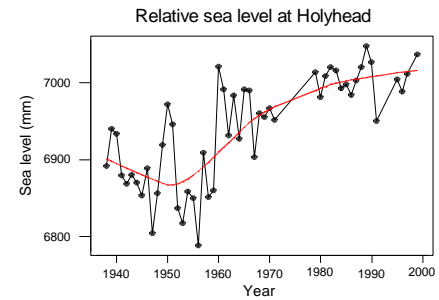


### **16. Flowering time of native flora**

The timing of flowering is particularly dependent on temperature; the mountain Purple Saxifrage is a good example, but has only a short series of data. It is considered that further investigation will reveal longer time series, from which suitable species can be selected.

## 17. Sea level

Sea level will rise as a result of warming oceans and melting ice caps. Holyhead is a good location for monitoring sea level because it is unaffected by land to the north rising and land to the south subsiding as it re-levels following the pressure of ice during the last ice age.



## 18. Sea temperature

Sea temperature is expected to rise with climate change.

Several long-term data sets exist for Wales that, after suitable analysis, will provide a sea temperature series, for example, for the Menai Strait and the Irish Sea.

## 19. River flows

High and low river flows are associated with the heavy rainfall and drought that might become more frequent if there are more extremes of climate. Data are available for both upland and lowland rivers.



## 20. The timing of frogspawn

The timing of the appearance of frogspawn is related to winter temperature and thus to changes in climate. Data from Pembrokeshire show correlation with December and January temperatures, and a tendency for spawning to become earlier.

### [Indicators of changes in major features influencing the Welsh climate:](#)

#### 21. North Atlantic Oscillation

NAO measures the difference in atmospheric pressure between the Azores (high) and Iceland (low). When the difference is great, Wales has mild conditions; when it is weak, conditions are generally dry and cold. Long-term NAO data indicate increasing mildness in recent years.

#### 22. Gulf stream

The Gulf Stream is a warm ocean current flowing from the Gulf of Mexico to the British Isles. It is responsible for Wales' relatively mild climate. Changes in sea temperature and salinity, by melting of the Arctic ice cap, would alter the flow of the current and thus the climate of Wales. A long series of data on the position of the Gulf Stream is available.

### [Other important data sets](#)

Several long-term, wide-ranging data sets, although not meeting our criteria, have the potential of detecting unforeseen changes in the state, or effects, of the climate:

- a) Sites monitoring many environmental factors (e.g. Environmental Change Network)
- b) Official statistics in general (e.g. Hospital Admission Data; Digest of Welsh Statistics)

## What is the next step?

It is recommended that the National Assembly for Wales should examine the long-term viability of each indicator in terms of funding, consistency in the quality standards of the observations, security of the recorded data, and certainty that recording will continue. The required procedures to secure long-term monitoring of climate change in Wales can then be established.