

Communicating Climate Change Consequences for Land Use

Site: Lairg. Event: Golspie, 6th March 2008

Further information: http://www.macaulay.ac.uk/LADSS/comm_cc_consequences.html

Who Are We?

We are a research team from The Macaulay Institute in Aberdeen. Our work focuses on the impact that changes in policy and climate have on agricultural systems.

Agro-meteorological Indicators

Indicators are pieces of information that can be used by managers to make decisions about the system (e.g. farm, estate, water-catchment, etc) that they manage.

Our agro-meteorological indicators are derived from weather and soils data and are intended to be useful for the agricultural industry. We produce two sets of indicators – one using observed climate data and one using future climate data. By comparing the outputs we illustrate how things may change in the future.

Observed Climate Data

The Met Office provides us with daily weather data for sites across the UK. The examples in this document use the observation period **1971-1998**.

Future Climate Data

In order to make predictions of future patterns of weather we use the results from the Hadley Centre Regional Climate Model (HadRM3) using the medium-high CO₂ emissions scenario (known as A2) for the period **2070-2100**. There are other scenarios (low, medium-low and high emissions) but we consider the medium-high to be the most likely.

Locally Customised Indicators

The examples in this document are for **Lairg** but we can customise them for a particular area of interest. To illustrate this we have also included a summary table showing a selection of other Scottish sites.

Rate of Change

There is a lot of uncertainty surrounding future climate predictions. Our assumption of medium-high emissions gives results for the period 2070-2100 but it is important to note that if emissions were to be higher then changes in climate could occur more rapidly.

Decision Making in an Uncertain World

Decisions need to be taken despite the uncertainty surrounding climate change otherwise it may be too late to reduce the emission of greenhouse gases or adapt existing land management systems.

Location of Sites

Figure 1 shows the location of the sites that are discussed in this document.

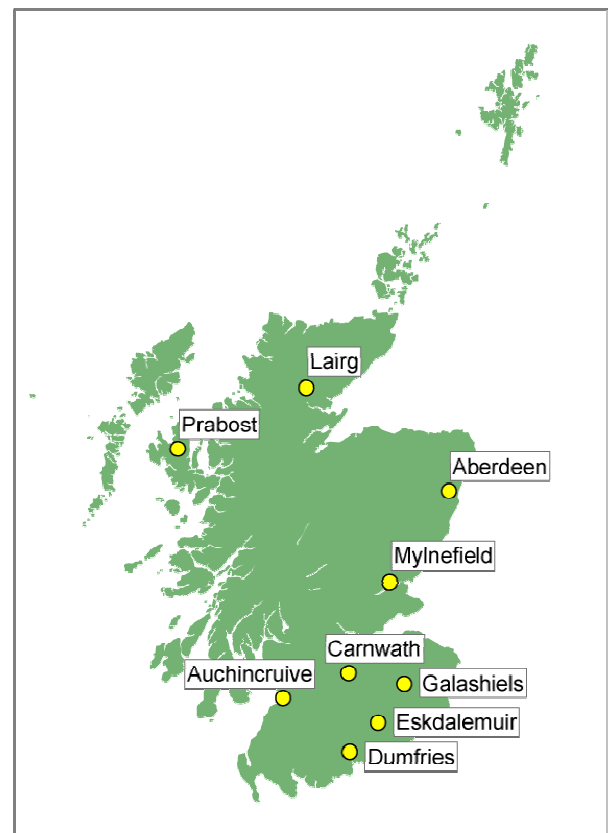


Figure 1: Map of Sites

Average Daily Temperature

It is widely accepted that temperature will increase with climate change. Figure 2 shows this change in a format that you will probably be familiar with. Note that our charts show observed data in blue while the future data is shown in red.

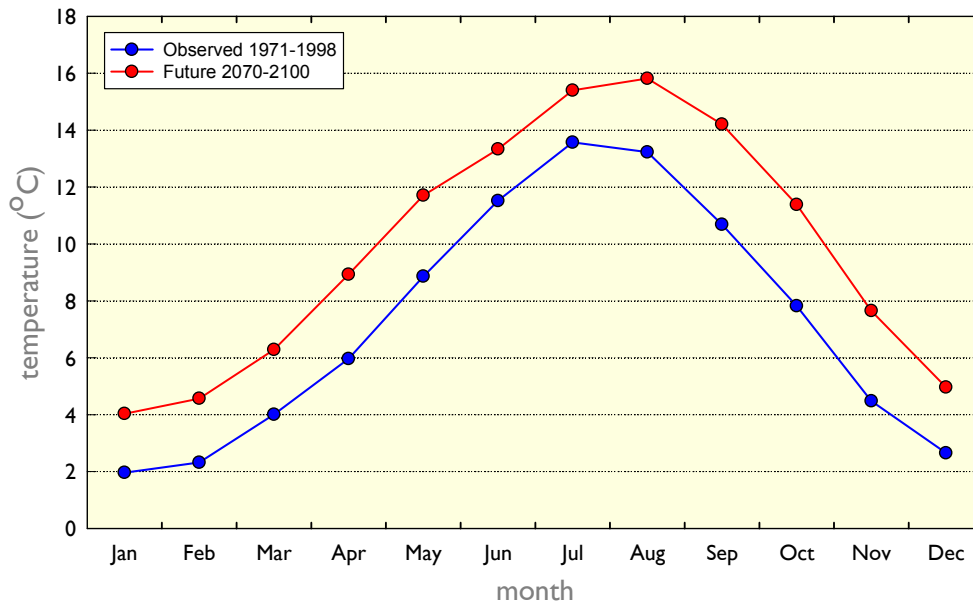


Figure 2: Average Daily Temperature by Month for Lairg

This chart shows a rise in average temperature of around 2 degrees. For Scottish farming this may be viewed as a positive impact since it may improve yields or even allow for the introduction of new crops or varieties further north than is possible at the moment.

Next consider rainfall...

Average Monthly Rainfall

Our research shows that some sites will have more rain, some less and some will remain about the same. Perhaps more importantly we have discovered that there may be a seasonal shift in the rain pattern for some sites. For instance, in the future Lairg might expect an increase in rainfall during the summer and a decrease in the winter with April in particular seeing much more rain (Figure 3).

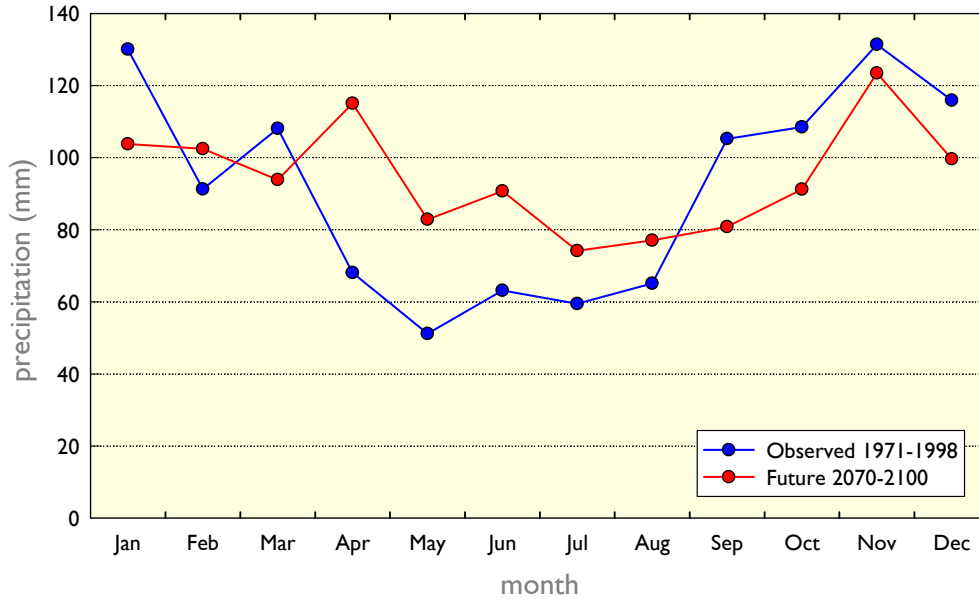


Figure 3: Average Monthly Rainfall for Lairg

Large amounts of rain falling in April will clearly have implications for lambing and spring field operations etc.

If we consider only temperature and rainfall charts it can be difficult to establish the extent to which these changes will affect agricultural systems at different times during the year. For this reason we have developed a set of more specialised indicators that show information that we hope is more relevant to the decision making process.

Growing Season

Our definition of a *growing day* is any day where the average temperature is above the base temperature (5.5 °C). The *start of the growing season* is the first date at which five growing days occur in a row. Similarly the *end of the growing season* is the last date at which five growing days occur in a row. Figure 4 is a yearly chart that shows the start and end dates of the growing season.

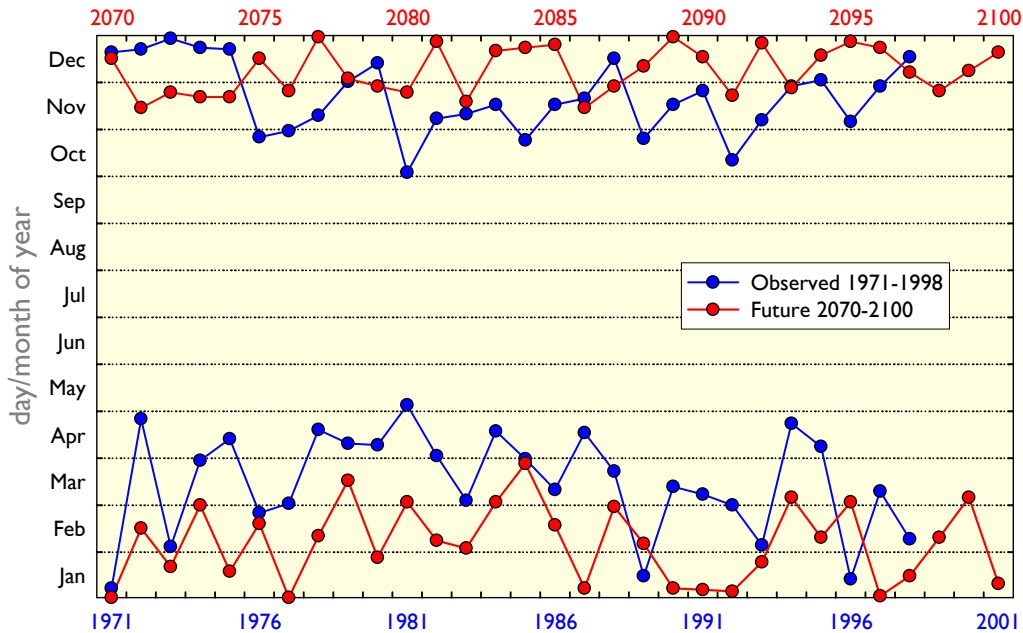


Figure 4: Start and End of the Growing Season for Lairg

On average the start of the growing season is 39 days earlier while the end of the growing season is around 17 days later. Figure 5 shows the average number of days that the temperature is above the growing base temperature. Considering temperature only for the moment, this chart shows that there will be the potential for significantly more growth in spring and winter.

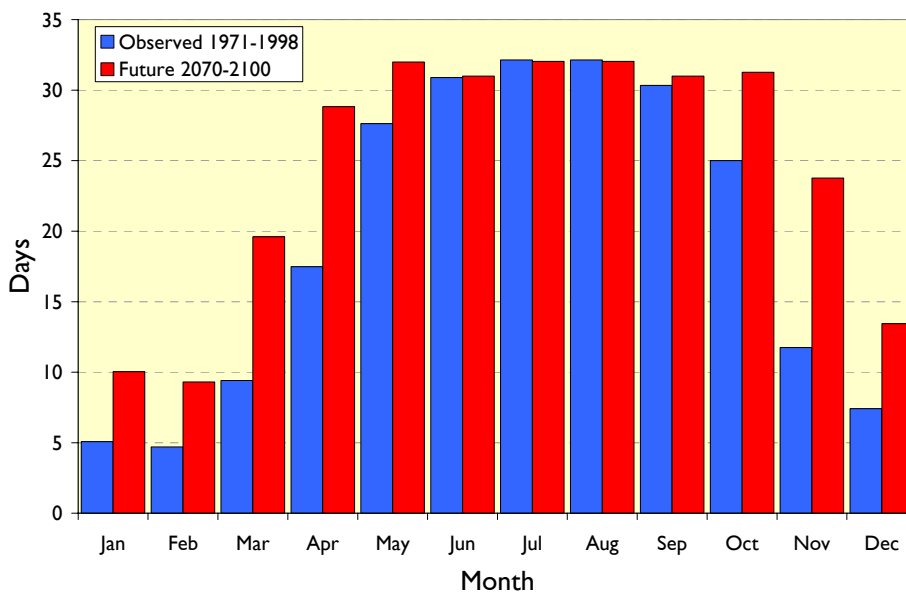


Figure 5: Growth Days by Month for Lairg

Start of Field Operations

The $T_{sum}200$ indicator is commonly used to determine the start of field operations (e.g. the date of the first fertiliser application). It is calculated as the date (starting January 1st) at which the accumulated positive average temperature reaches 200 °C.

Figure 6 shows that on average the $T_{sum}200$ date will occur 21 days earlier in the future.

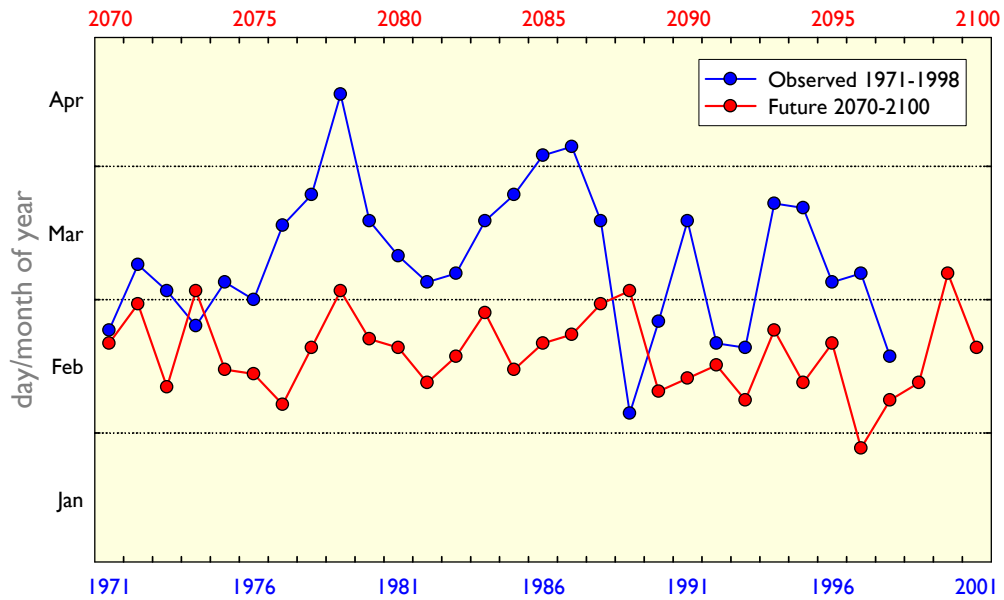


Figure 6: $T_{sum}200$ for Lairg

Frost

Figure 7 shows the dates of the last spring air frost. The observed data-set shows that a late frost in May or June is commonplace while the future data-set shows that the last air frost will occur between March and May – on average 47 days earlier.

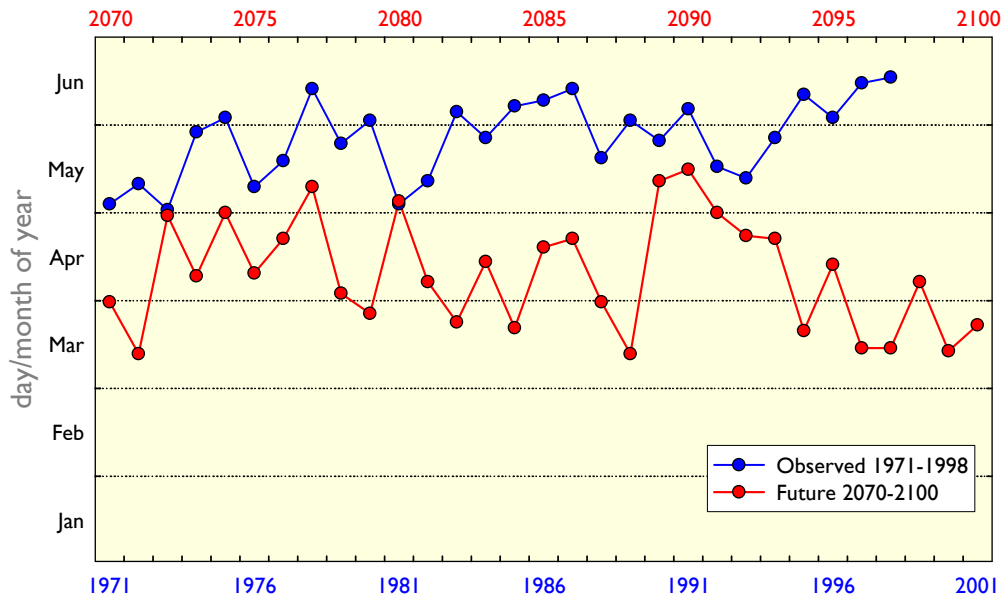


Figure 7: Last Spring Air Frost for Lairg

It is thought that a “good hard frost” is a farmers ally in protecting against pests and diseases; however Figure 8 shows that the average number of frost days is in decline. We define a frost day when the minimum daily air temperature drops to or below 0°C.

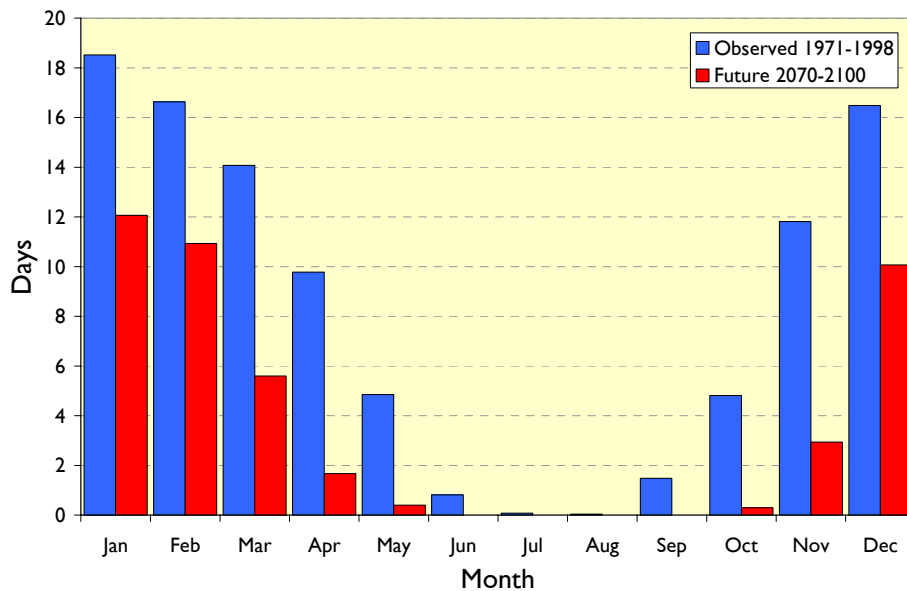


Figure 8: Average Frost Days by Month for Lairg

Field Access Period

Field capacity is defined as the amount of water that a soil can hold against gravity. Soil at field capacity is unable to bear cattle or machinery. This measure is affected by the texture and depth of the soil therefore we can customise these types of charts for specific soils. We define the end of field capacity as the first date at which the moisture in the soil drops 5mm below field capacity. Conversely, the return to field capacity is the date at which the soil refills back above this point (Figure 9).

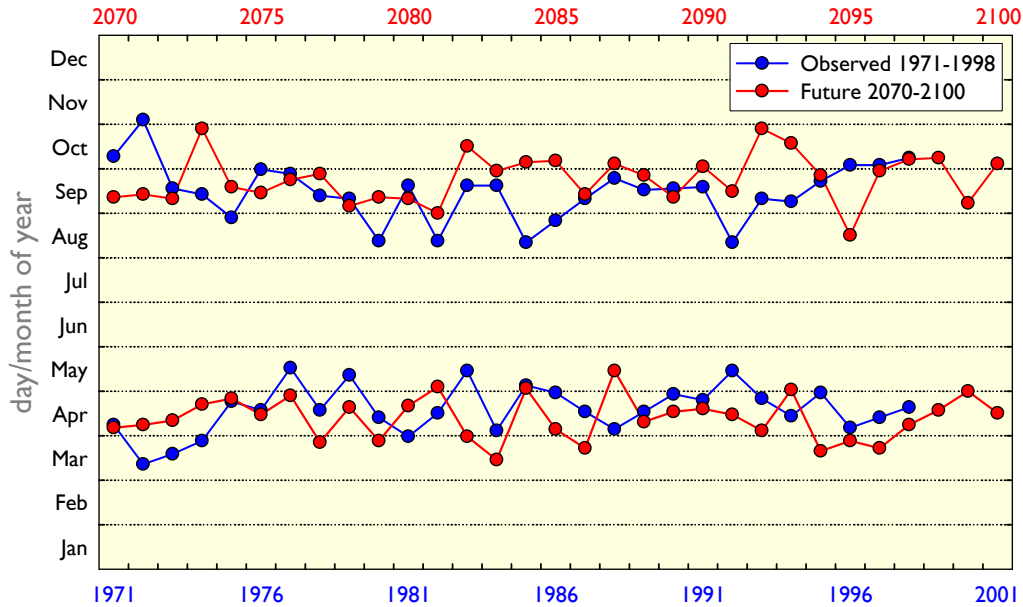


Figure 9: End and Return to Field Capacity for Lairg

The end of field capacity in spring is expected to occur around 6 days earlier in the future and the return to field capacity is expected to occur 9 days later. Figure 10 shows the average number of days of field access by month. It shows an increase in trafficability during September and October but a decrease in access during the period from April to August due to the extra summer rainfall.

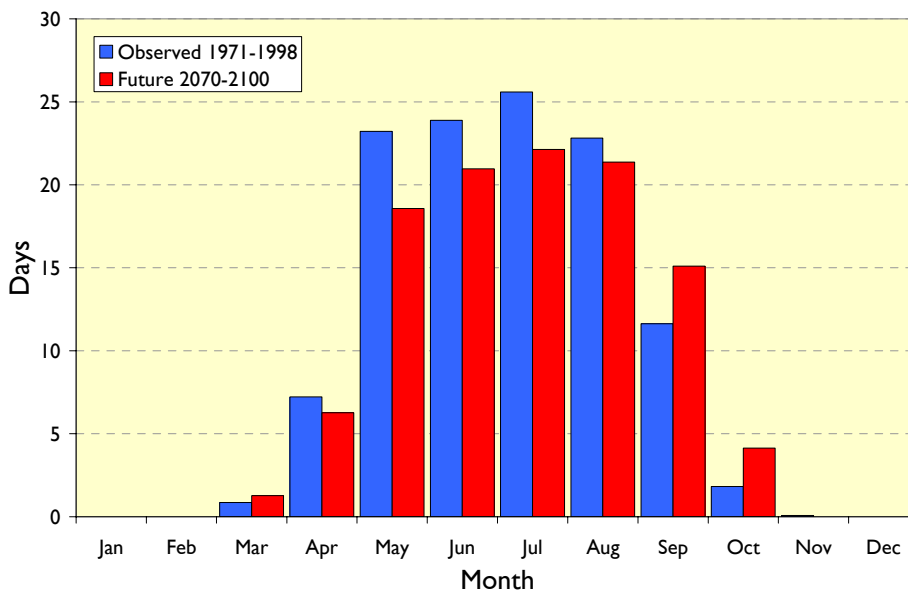


Figure 10: Days of Field Access by Month for Lairg

Field Access during the Growing Season

An increased growing season is all very well but with the reduction in access period it might not be possible to carry out field operations during the extended growing season. Figure 11 shows the average number of days per month that the temperature is above the growing base temperature and it is possible to access the field.

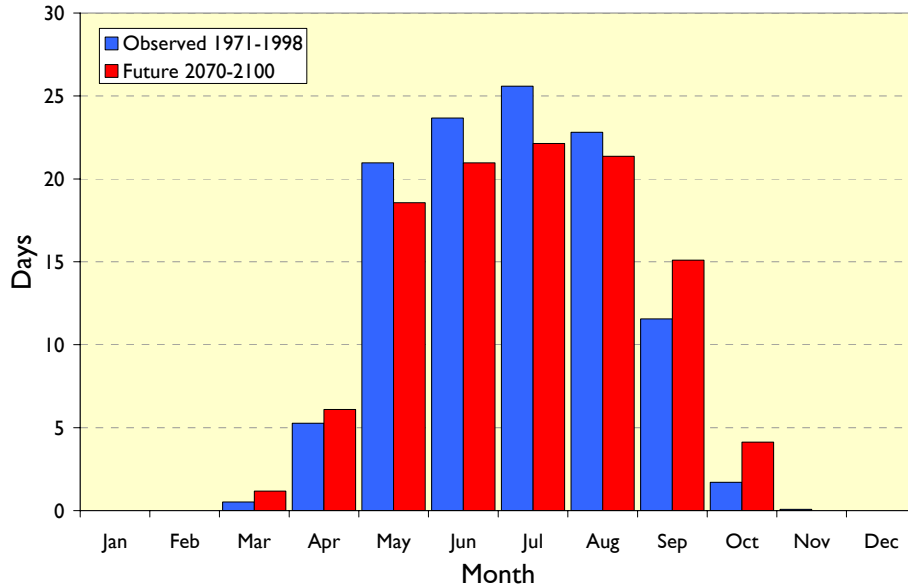


Figure 11: Average Number of Accessible & Growing Days by Month for Lairg

This chart shows that the number of accessible and growing days will increase during late spring and early autumn but decrease during in the summer.

Soil Moisture

An understanding of the water in the soil will be more important than ever with a changing climate. If climate change brings bigger rain events then we could be faced with an increased risk of saturated soils and erosion. Increased temperatures could mean that the soil dries out more often. We can, therefore, expect the soil to be pushed harder in the years ahead. The examples in this section use a 40cm sandy loam soil profile. For Lairg '79, '85 and '93 were amongst the wettest on record while '76, '84 and '95 were amongst the driest. Figure 12 and Table 1 show a comparison of the driest years for the observed and future periods.

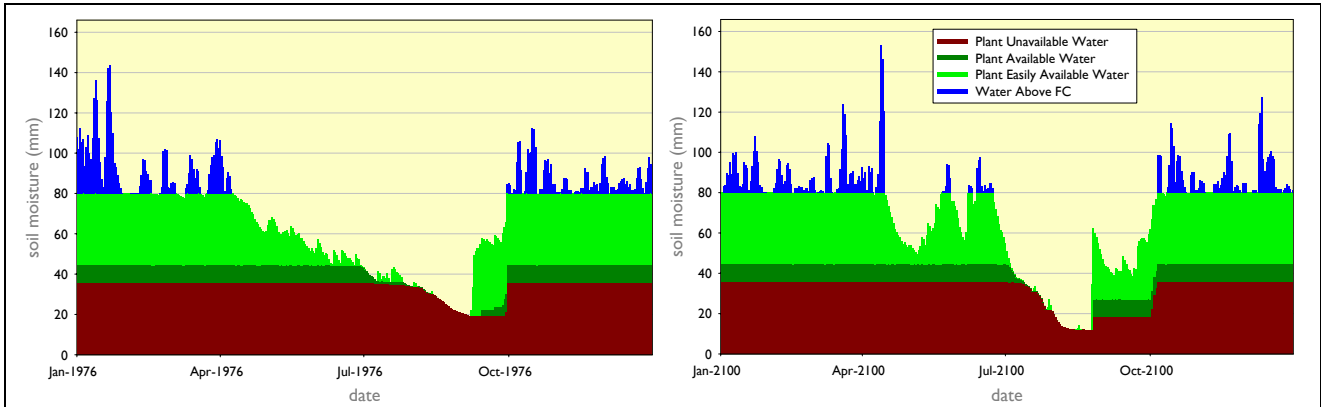


Figure 12: Dry year for the observed period (left) and future period (right)

The light green portion of the chart represents water which is easily available to crops. The dark green portion represents water that is available to crops but is difficult to extract and will impair growth. The dark red portion represents soil water that cannot be extracted by the crop. Blue is water above field capacity which is retained in the soil for a few days before running off.

Table 1: Comparison of water availability for driest years in observed and future datasets

	Observed	Future
Days at Saturation Point	0	0
Days at or above Field Capacity	202	221
Days of Plant Easily Available Water	321	331
Days of Plant Available Water	347	350
Days of Plant Unavailable Water	19	15

Figure 13 and Table 2 show a comparison of the wettest years.

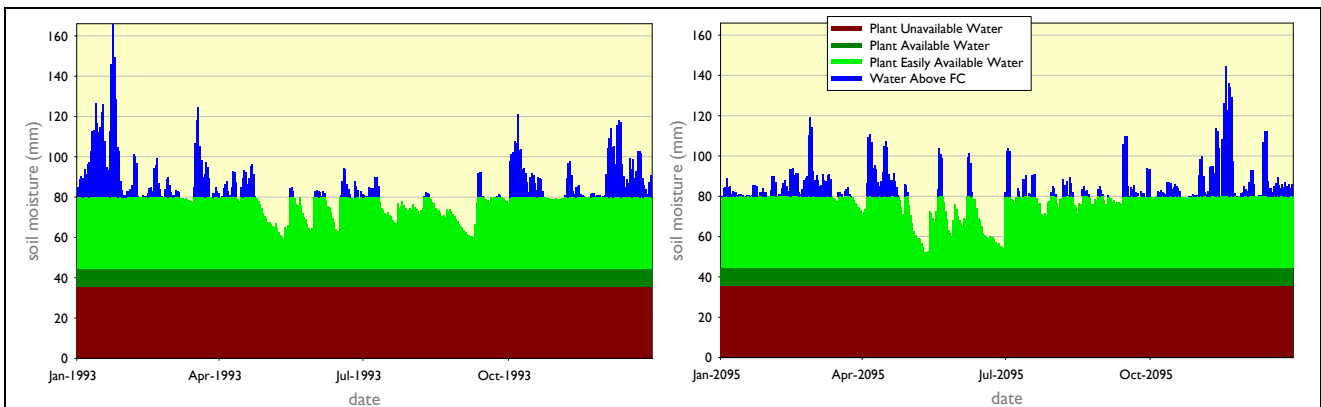


Figure 13: Wet year for the observed period (left) and future period (right)

- Communicating Climate Change Consequences for Land Use -

Table 2: Comparison of water availability for wettest years in observed and future datasets

	Observed	Future
Days at Saturation Point	1	0
Days at or above Field Capacity	285	303
Days of Plant Easily Available Water	365	365
Days of Plant Available Water	365	365
Days of Plant Unavailable Water	0	0

Compared with the wettest year in the observed dataset, the wettest year in the future will still have water available for the entire year but there will be more days where water is at or above field capacity causing a reduction in field access days.

Figure 14 shows a typical observed and future year.

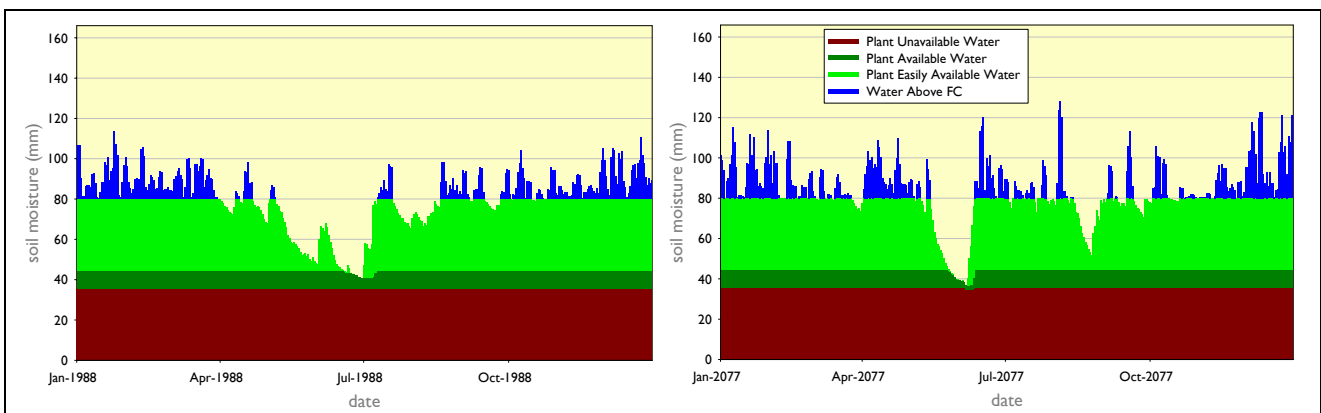


Figure 14: Typical year for the observed period (left) and future period (right)

Figure 15 shows that the average number of days per month where water is expected to be either unavailable or difficult for the plant to extract from the soil is in decline over the summer with an increase in September.

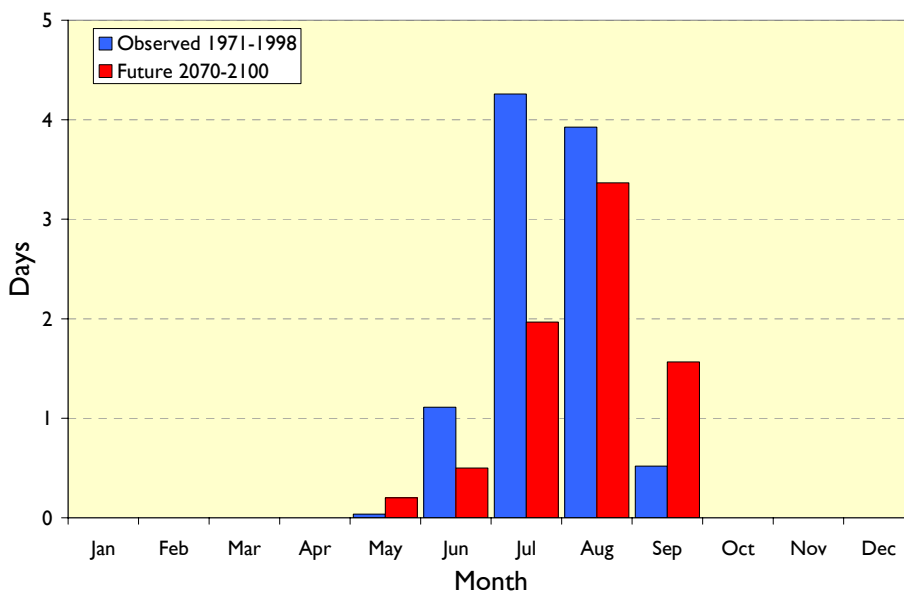


Figure 15: Average Days by Month where water is not easily available to plant

In order to gain an understanding of how a typical sequence of years would look we have shown the soil moisture profiles for 10-year periods in the observed and future datasets (Figure 16).

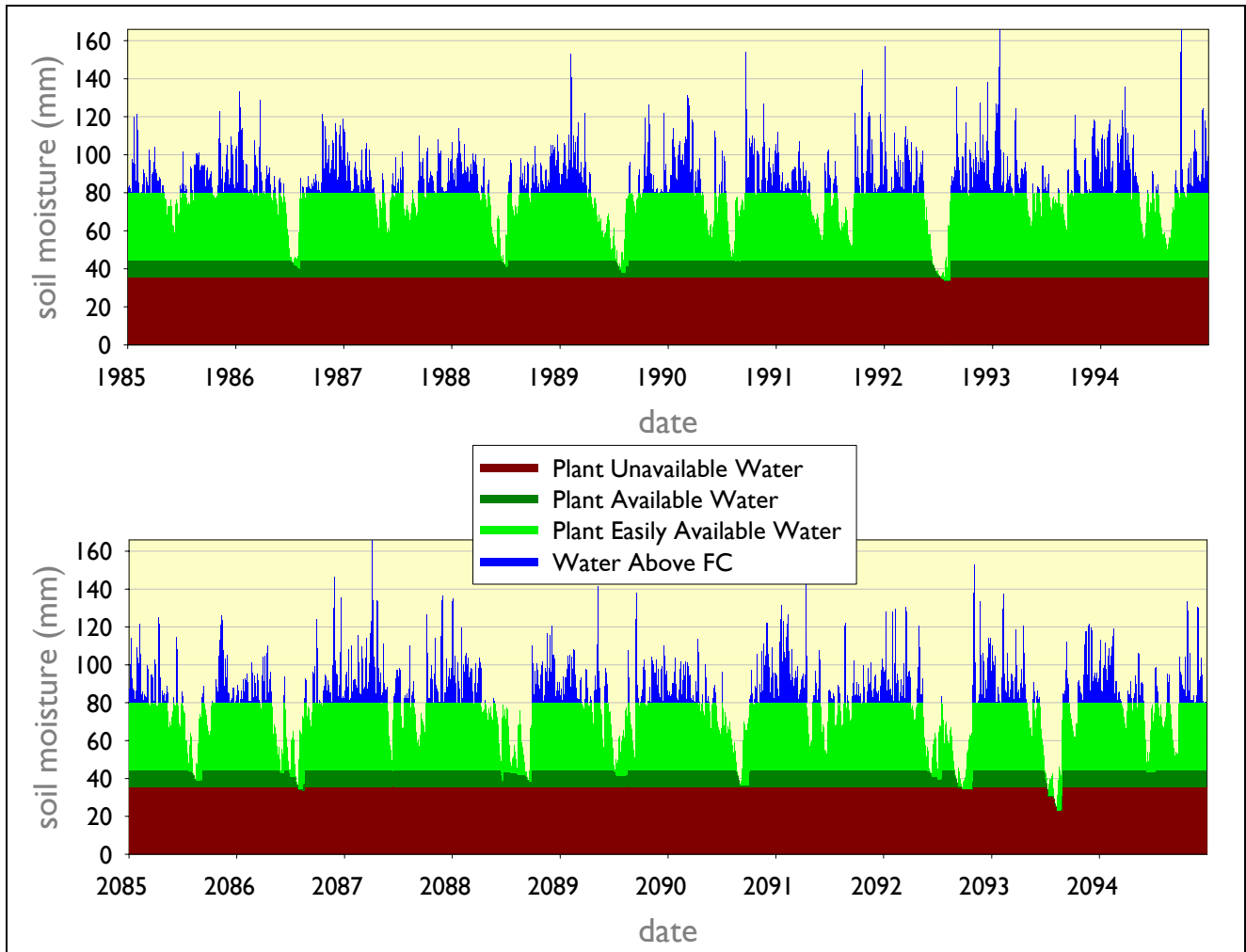


Figure 16: 10-year sample soil moisture profiles for Lairg: observed (top) and future (bottom)

Communicating Climate Change Consequences for Land Use -

Summary of Agro-meteorological Indicators

Table 3 shows a summary of the key indicators discussed in this document for a selection of Scottish sites. Blue arrows to the left denote less or earlier while orange arrows to the right denote more or later.

Table 3: Indicators showing the average change between observed and future datasets

Indicator	Aberdeen	Mylnfield	Carnwath	Galashiels	Eskd'muir	Dumfries	Auc'cruive	Prabost	Lairg
Soil Type	50cm SZL	50cm SZL	50cm L	50cm CL	50cm L	50cm CL	50cm L	40cm SL	40cm SL
Observed Period	1961-1990	1961-1990	1970-2000	1967-1997	1970-2000	1961-1990	1970-2000	1960-1990	1971-1998
Average Daily Temp. (°C)	➤ 2.8	➤ 3.1	➤ 2.8	➤ 3.0	➤ 3.0	➤ 3.3	➤ 2.8	➤ 1.2	➤ 2.6
Average Annual Rainfall (mm)	➤ 36	➤ 26	➤ 35	◀ 16	➤ 20	➤ 100	➤ 70	➤ 310	➤ 36
Start of the Growing Season (day)	◀ 48	◀ 35	◀ 37	◀ 36	◀ 50	◀ 27	◀ 14	◀ 30	◀ 39
Tsum200 (day)	◀ 22	◀ 22	◀ 21	◀ 25	◀ 26	◀ 22	◀ 16	◀ 16	◀ 21
End of Field Capacity (day)	◀ 3	◀ 2	n/a	◀ 4	◀ 7	➤ 2	◀ 3	◀ 6	◀ 6
Last Air Frost in Spring (day)	◀ 42	◀ 41	◀ 52	◀ 32	◀ 49	◀ 36	◀ 37	◀ 63	◀ 47
Return to Field Capacity (day)	➤ 14	➤ 18	n/a	➤ 26	➤ 11	➤ 23	➤ 18	➤ 10	➤ 9
End of Growing Season (day)	➤ 17	➤ 17	➤ 16	➤ 20	➤ 23	➤ 19	➤ 20	➤ 16	➤ 17
Dry Soil (days)	➤ 3	➤ 11	n/a	➤ 12	➤ 1	➤ 13	0	0	◀ 1
Growing Season Length (days)	➤ 64	➤ 63	➤ 58	➤ 62	➤ 66	➤ 60	➤ 55	➤ 58	➤ 59
Access Period Length (days)	➤ 11	➤ 19	n/a	➤ 36	➤ 22	➤ 47	➤ 30	➤ 3	◀ 7
Access during Growing Season (days)	➤ 20	➤ 26	n/a	➤ 42	➤ 30	➤ 51	➤ 33	➤ 3	◀ 2