Communicating Climate Change Consequences for Land Use

Site: Dunstaffnage. Event: Oban, 13th 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 **1971-1994**.

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 CO_2 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 **Dunstaffnage** 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.

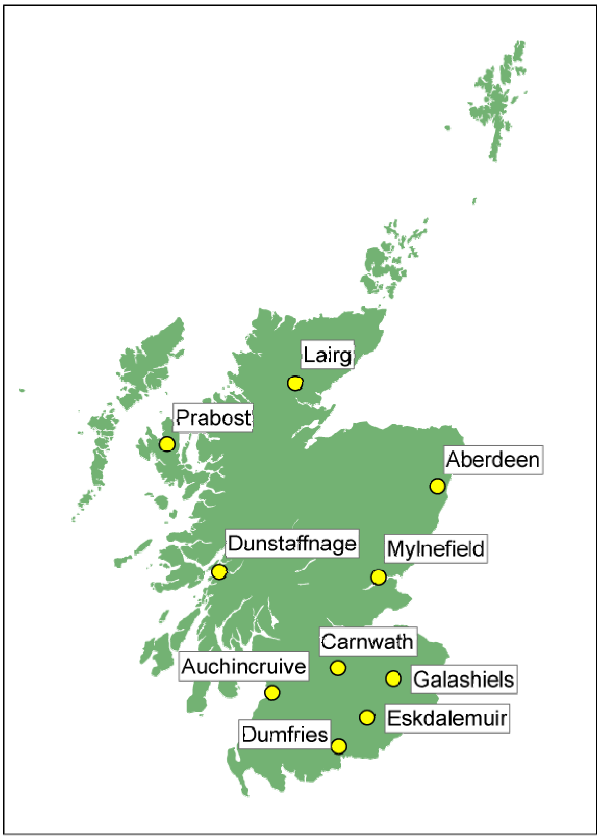

Figure 1: Map of Sites

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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.

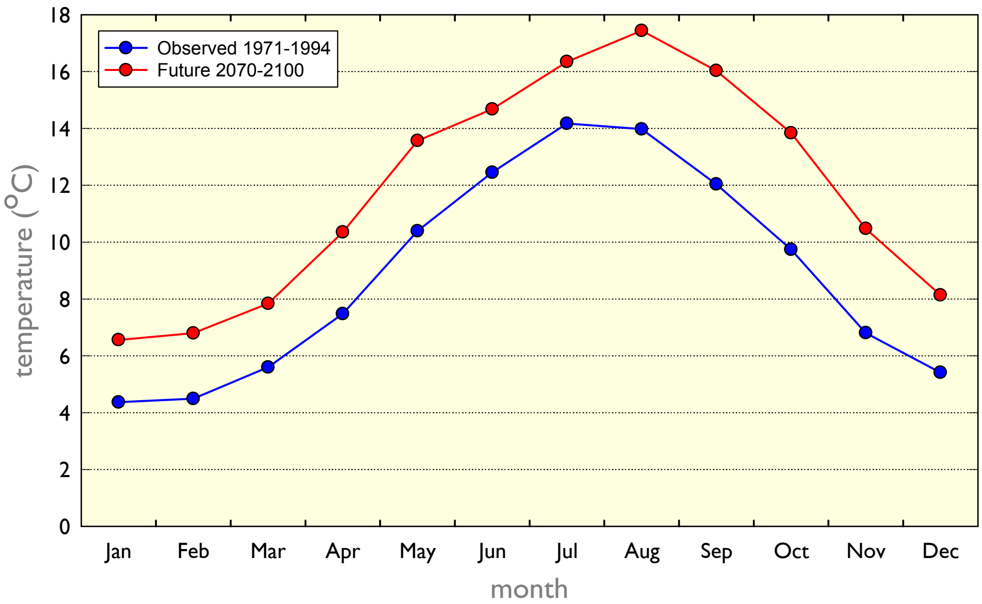

Figure 2: Average Daily Temperature by Month for Dunstaffnage

This chart shows a rise in average temperature of 2-3 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 Dunstaffnage might expect an increase in rainfall during the winter and a decrease in late summer/early autumn (Figure 3).

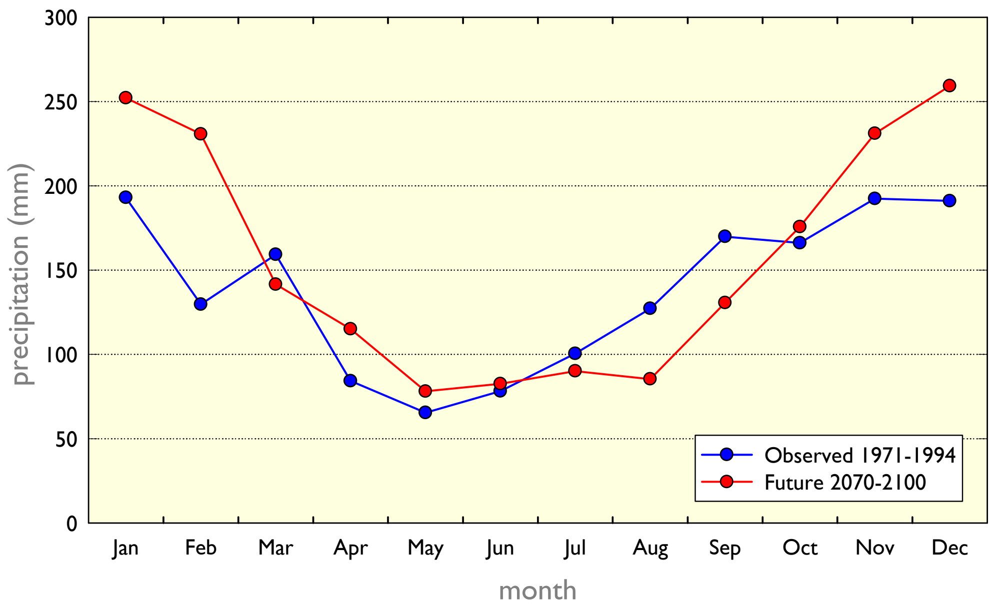

Figure 3: Average Monthly Rainfall for Dunstaffnage

Large amounts of rain falling at certain times of year will clearly have implications for some livestock and field operations.

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.

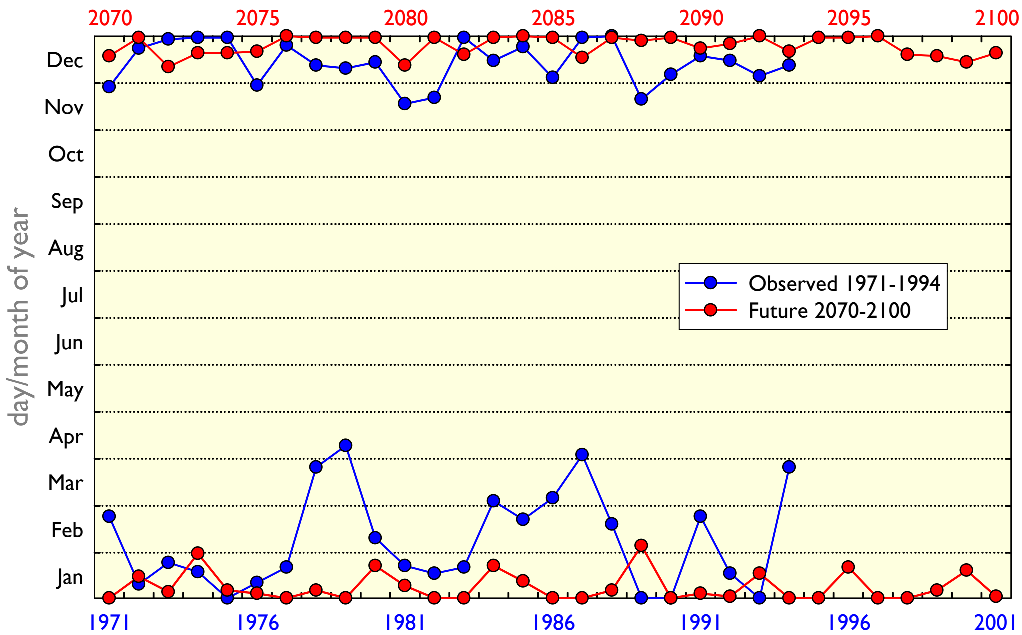

Figure 4: Start and End of the Growing Season for Dunstaffnage

On average the start of the growing season is 30 days earlier while the end of the growing season is around 11 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.

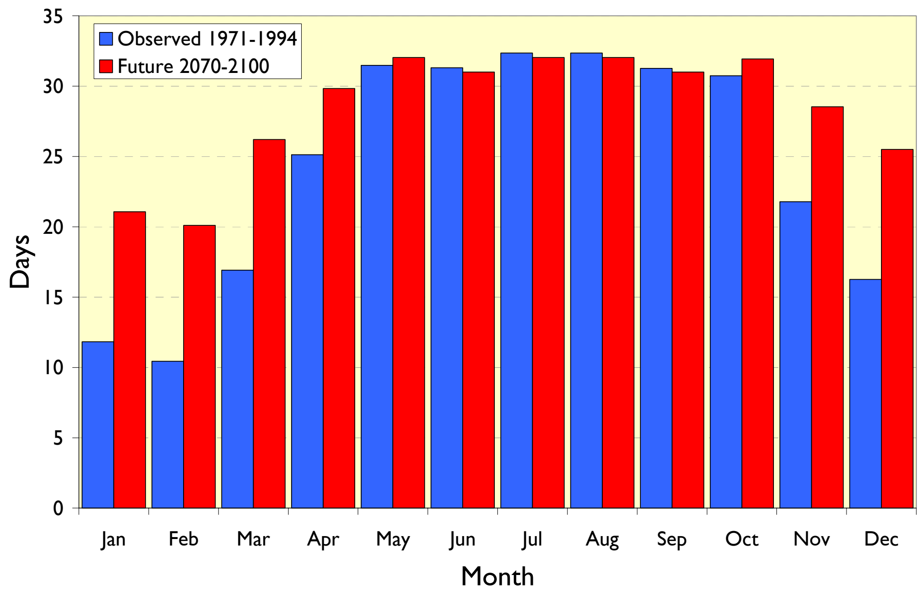

Figure 5: Growth Days by Month for Dunstaffnage

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 15 days earlier in the future.

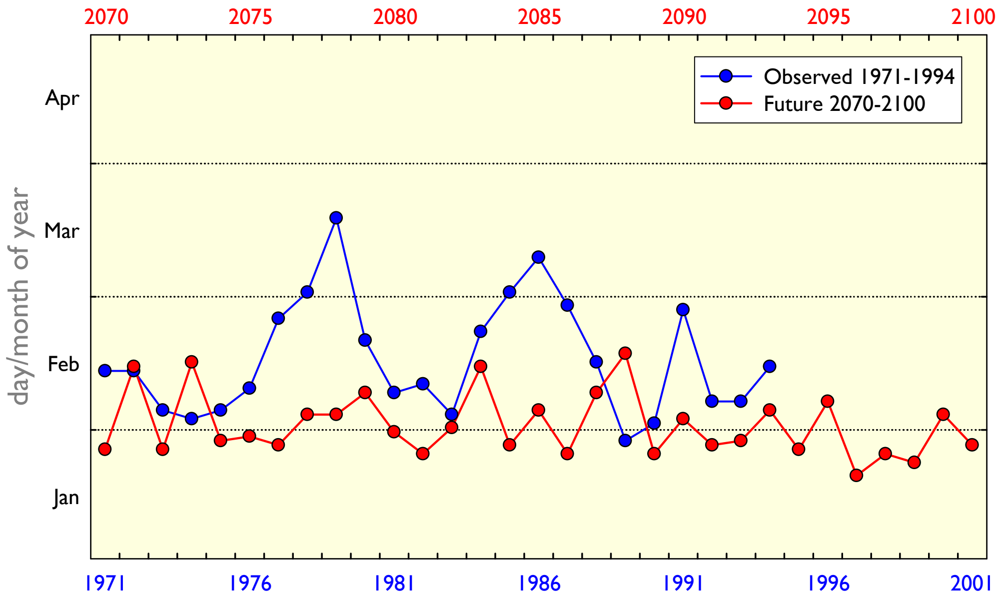

Figure 6: Tsum200 for Dunstaffnage

Frost

Figure 7 shows the dates of the last spring air frost. The observed data-set shows that a late frost in April or May is commonplace while the future data-set shows that the last air frost will occur between February and May – on average 35 days earlier.

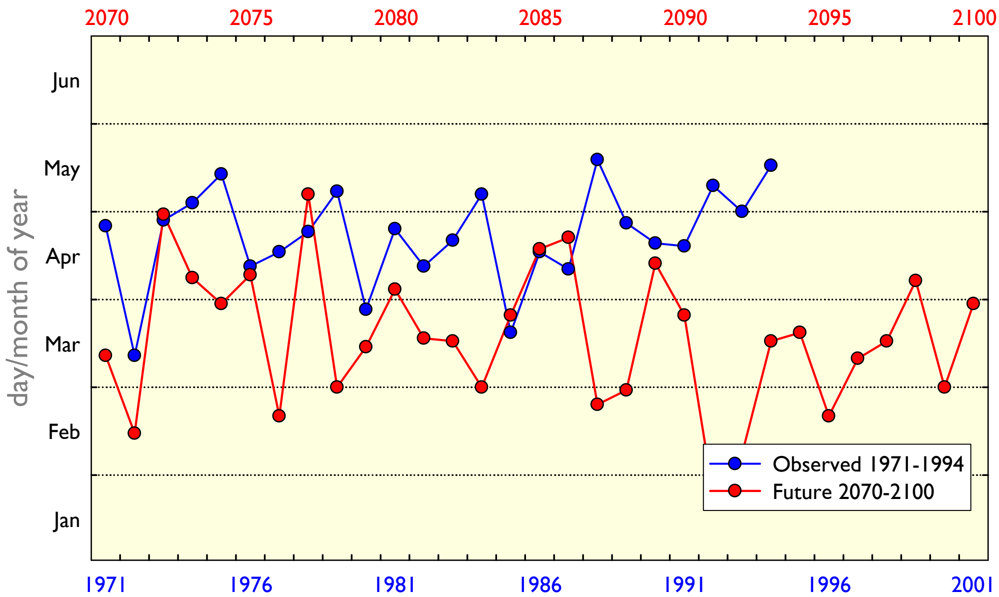

Figure 7: Last Spring Air Frost for Dunstaffnage

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.

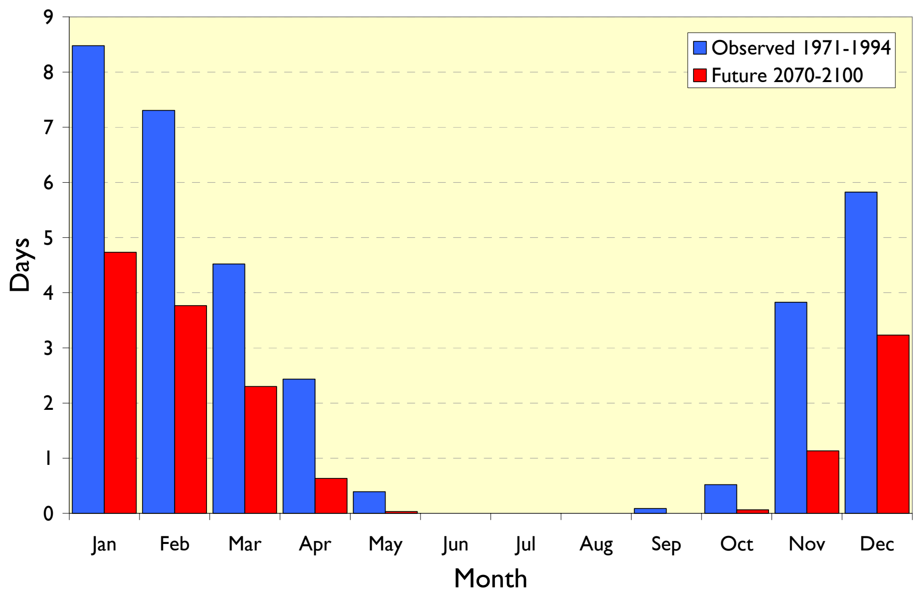

Figure 8: Average Frost Days by Month for Dunstaffnage

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).

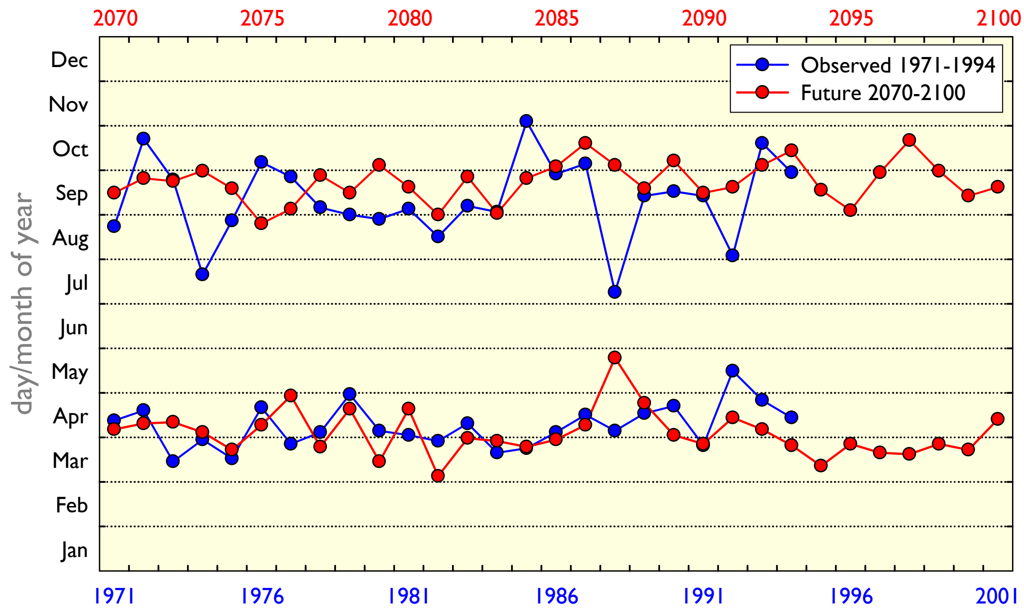

Figure 9: End and Return to Field Capacity for Dunstaffnage

The end of field capacity in spring is expected to occur around 5 days earlier in the future and the return to field capacity is expected to occur 12 days later. Figure 10 shows the average number of days of field access by month. It shows an increase in trafficability during August and September but a decrease in access during the period from April to June.

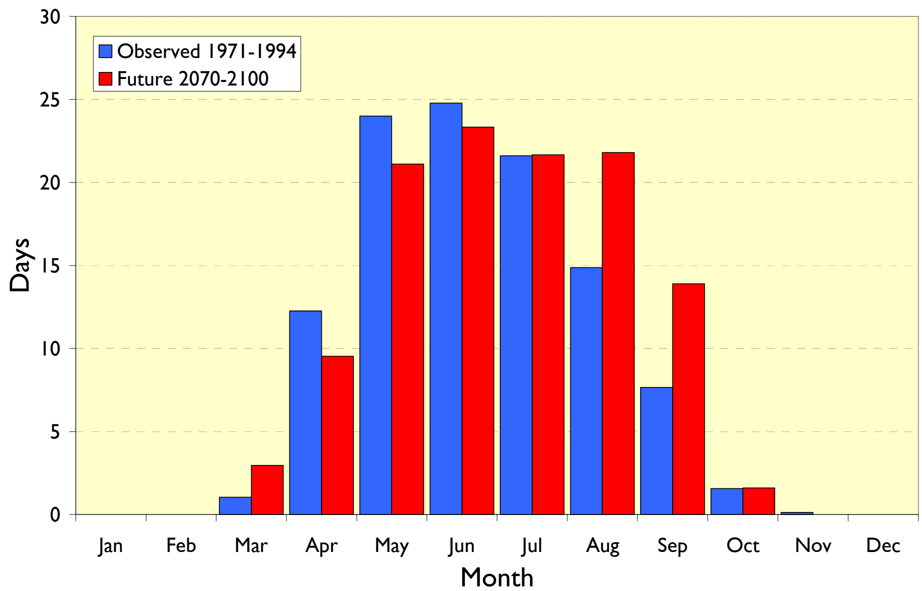

Figure 10: Days of Field Access by Month for Dunstaffnage

Field Access during the Growing Season

An increased growing season is all very well but with the smaller increase 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.

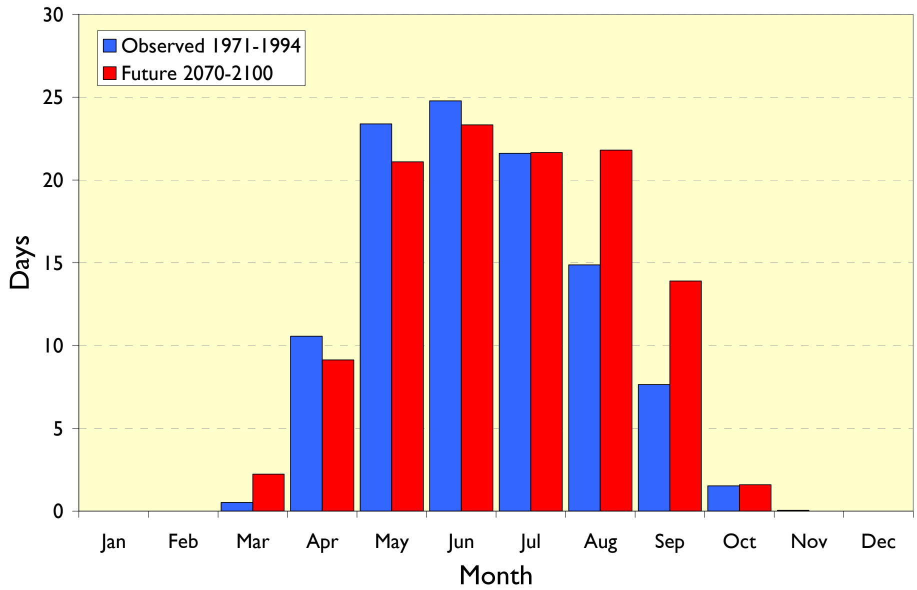

Figure 11: Average Number of Accessible & Growing Days by Month for Dunstaffnage

This chart shows that the number of accessible and growing days will increase in September and October.

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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 Dunstaffnage '72, '79 and '93 were amongst the wettest on record while '77, '78 and '84 were amongst the driest. Figure 12 and Table 1 show a comparison of the driest years for the observed and future periods.

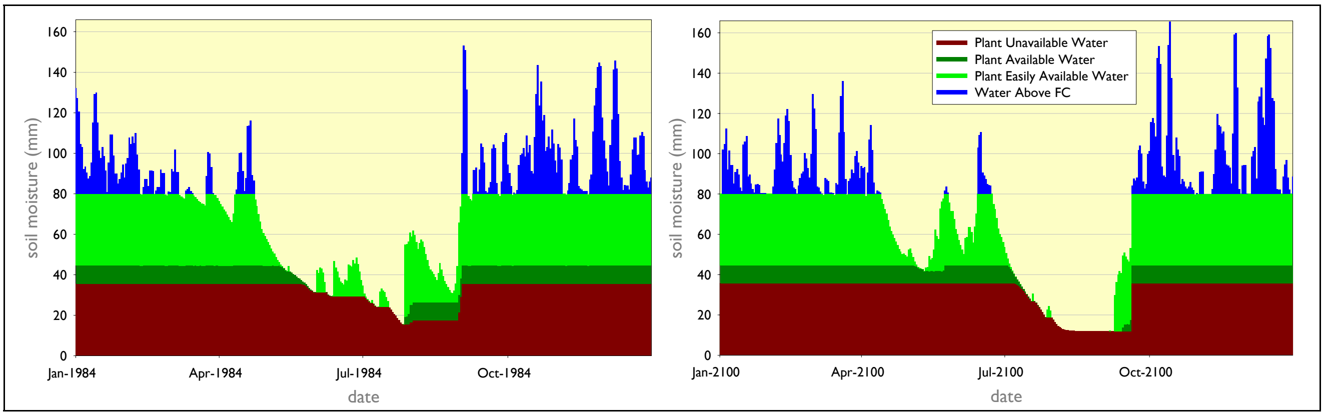

Figure 12: Dry year for the observed period (left) and future period (right)

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	1
Days at or above Field Capacity	226	224
Days of Plant Easily Available Water	339	312
Days of Plant Available Water	357	330
Days of Plant Unavailable Water	9	35

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

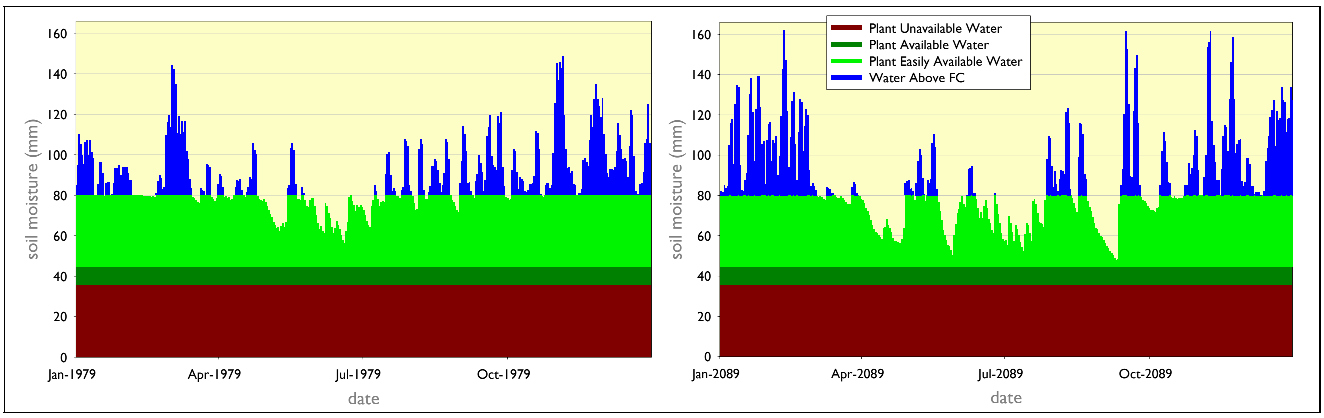

Figure 13: Wet year for the observed period (left) and future period (right)

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

	Observed	Future
Days at Saturation Point	0	0
Days at or above Field Capacity	313	260
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 have less days where water is at or above field capacity thus giving an increase in field access days.

Figure 14 shows a typical observed and future year.

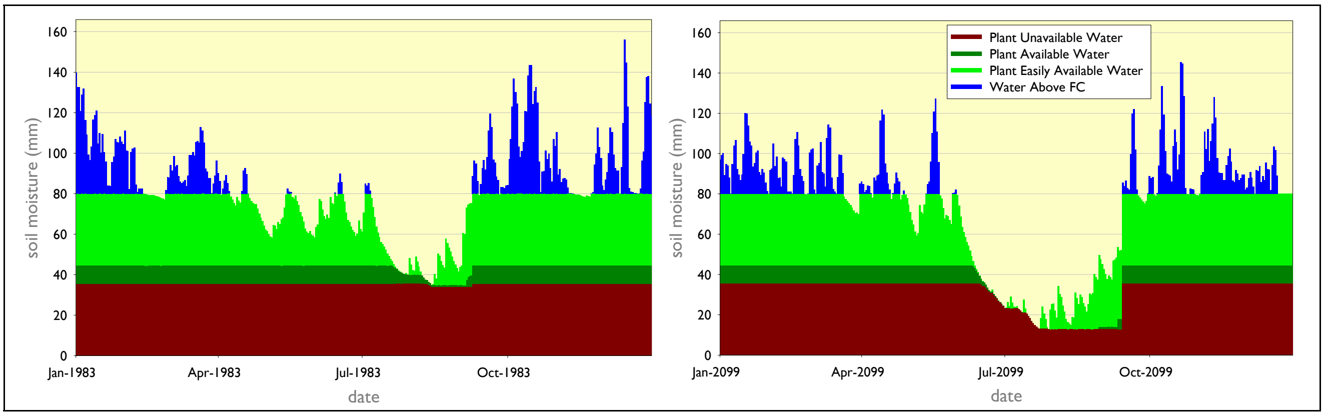

Figure 14: Typical year for the observed period (left) and future period (right)

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 during May with an increase in July, August and September.

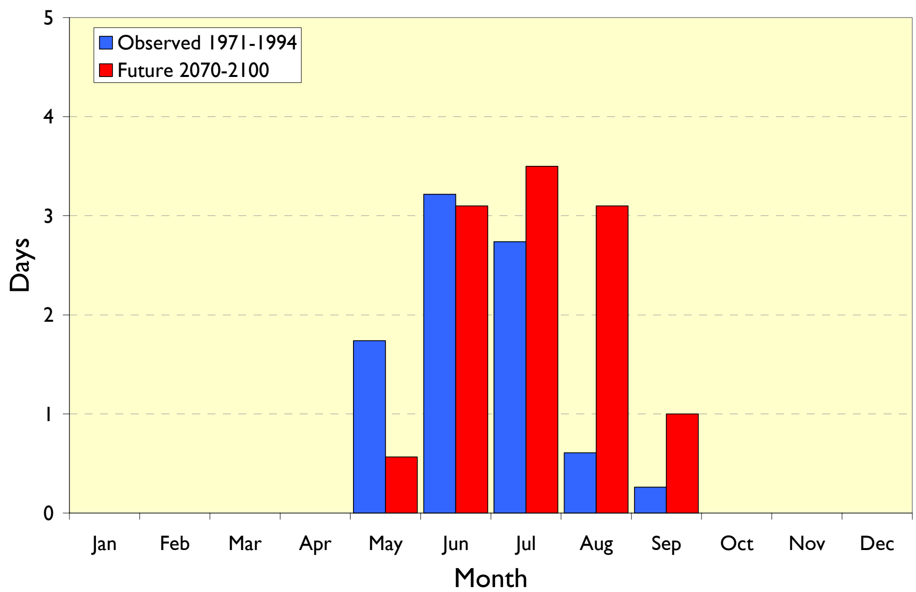

Figure 15: Average Days by Month where water is not easily available to plant

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).

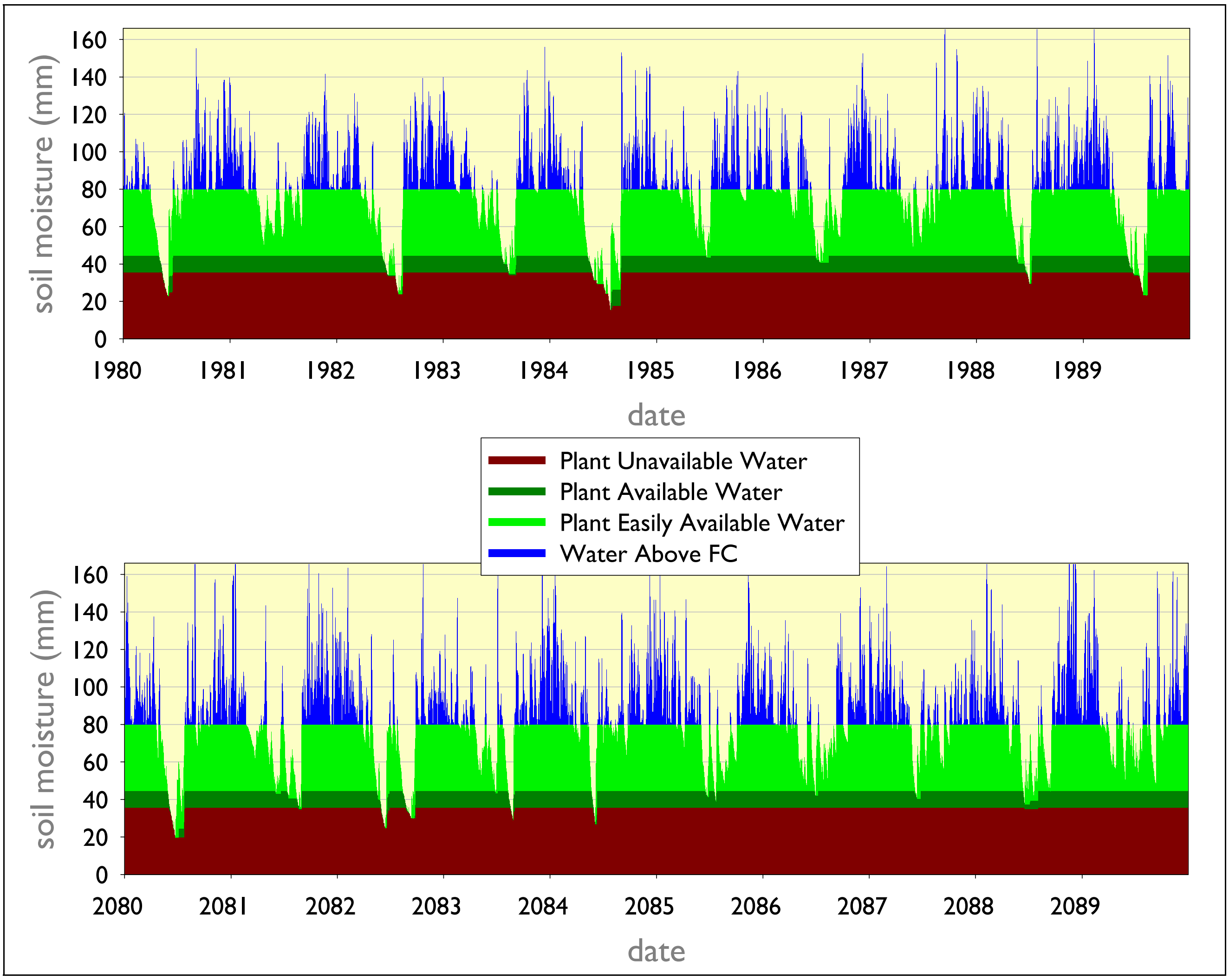

Figure 16: 10-year sample soil moisture profiles for Dunstaffnage: observed (top) and future (bottom)

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	Mylnefield	Carnwath	Galashiels	Eskd'muir	Dumfries	Auc'cruive	Prabost	Lairg	Dunst'nage
Soil Depth (cm) & Type	50 SZL	50 SZL	50 L	50 CL	50 L	50 CL	50 L	40 SL	40 SL	40 SL
Observed Period	1961-1990	1961-1990	1970-2000	1967-1997	1970-2000	1961-1990	1970-2000	1960-1990	1971-1998	1971-1994
Average Daily Temp. (°C)	▶ 2.8	▶ 3.1	▶ 2.8	▶ 3.0	▶ 3.0	▶ 3.3	▶ 2.8	▶ 1.2	▶ 2.6	▶ 2.9
Average Annual Rainfall (mm)	▶ 36	▶ 26	▶ 35	◀ 16	▶ 20	▶ 100	▶ 70	▶ 310	▶ 36	▶ 209
Start of the Growing Season (day)	◀ 48	◀ 35	◀ 37	◀ 36	◀ 50	◀ 27	◀ 14	◀ 30	◀ 39	◀ 30
Tsum200 (day)	◀ 22	◀ 22	◀ 21	◀ 25	◀ 26	◀ 22	◀ 16	◀ 16	◀ 21	◀ 15
End of Field Capacity (day)	◀ 3	◀ 2	n/a	◀ 4	◀ 7	▶ 2	◀ 3	◀ 6	◀ 6	◀ 5
Last Air Frost in Spring (day)	◀ 42	◀ 41	◀ 52	◀ 32	◀ 49	◀ 36	◀ 37	◀ 63	◀ 47	◀ 35
Return to Field Capacity (day)	▶ 14	▶ 18	n/a	▶ 26	▶ 11	▶ 23	▶ 18	▶ 10	▶ 9	▶ 12
End of Growing Season (day)	▶ 17	▶ 17	▶ 16	▶ 20	▶ 23	▶ 19	▶ 20	▶ 16	▶ 17	▶ 11
Dry Soil (days)	▶ 3	▶ 11	n/a	▶ 12	▶ 1	▶ 13	0	0	◀ 1	▶ 2
Growing Season Length (days)	▶ 64	▶ 63	▶ 58	▶ 62	▶ 66	▶ 60	▶ 55	▶ 58	▶ 59	▶ 51
Access Period Length (days)	▶ 11	▶ 19	n/a	▶ 36	▶ 22	▶ 47	▶ 30	▶ 3	◀ 7	▶ 9
Access during Growing Season (days)	▶ 20	▶ 26	n/a	▶ 42	▶ 30	▶ 51	▶ 33	▶ 3	◀ 2	▶ 10