Communicating Climate Change Consequences for Land Use

Site: Prabost, Skye. Event: Kyle of Lochalsh, 28th February 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 **1960-1990**.

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 **Prabost** 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.

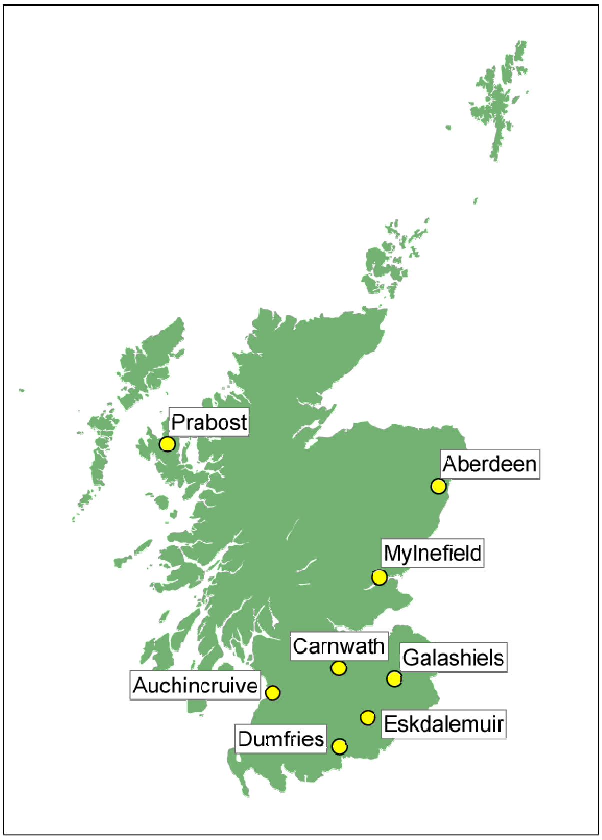

Figure 1: Map of Sites

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.

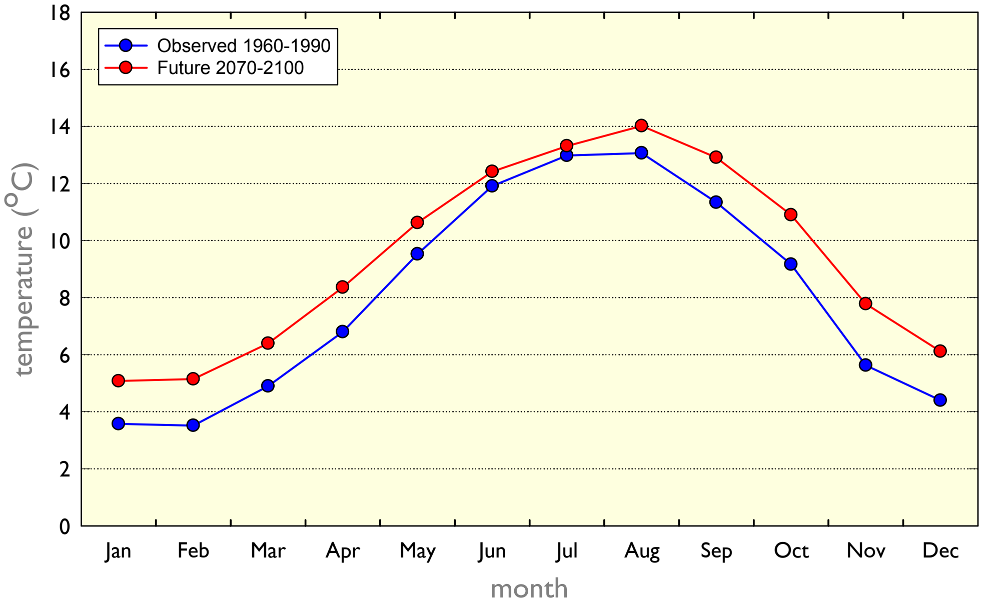

Figure 2: Average Daily Temperature by Month for Prabost

This chart shows a rise in average temperature of up to 2 degrees depending on the time of year. 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…

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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, Prabost might expect an increase in winter rainfall in the future with the summer remaining about the same. (Figure 3).

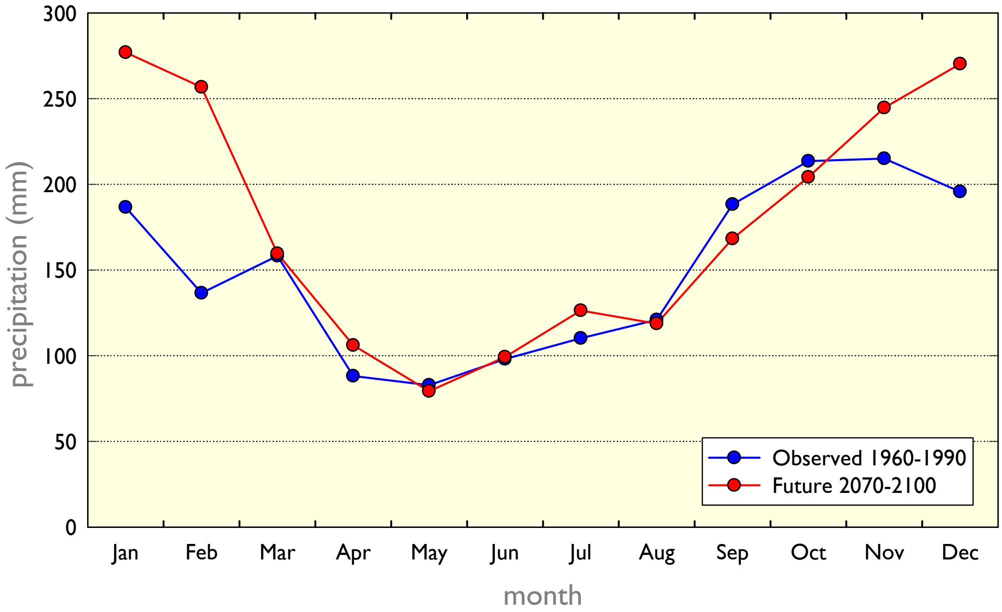

Figure 3: Average Monthly Rainfall for Prabost

Large amounts of rain falling in winter may have implications for some field operations or the out-wintering of livestock but, like the temperature chart earlier, it is difficult to establish just what kind of effect these changes will have on agricultural systems.

For this reason we have taken these climate statistics and 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.

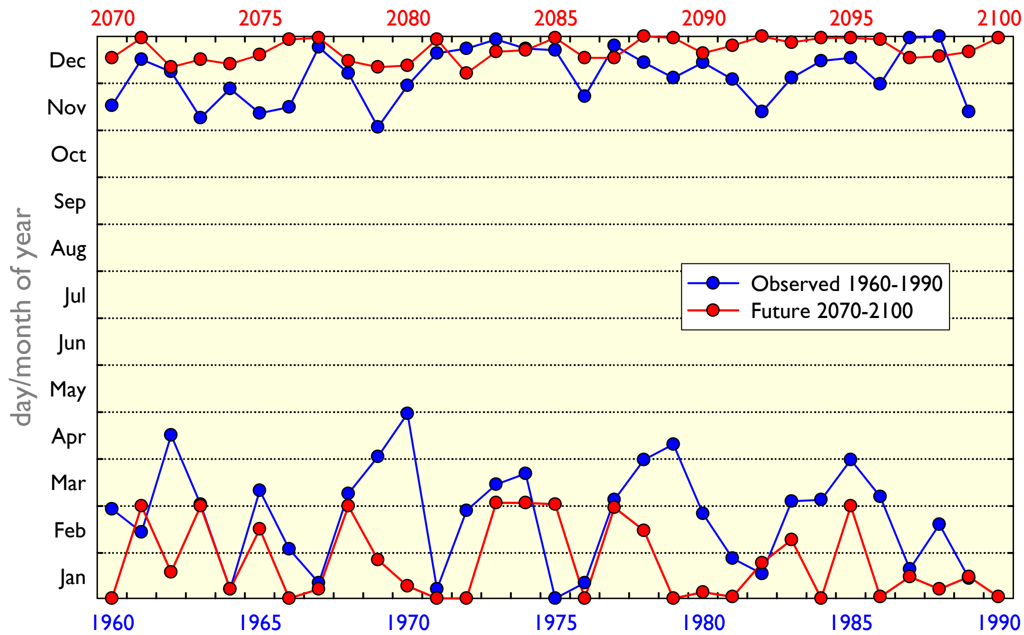

Figure 4: Start and End of the Growing Season for Prabost

On average the end of the growing season is 16 days later while the start of the growing season is around 30 days earlier. Figure 5 shows the average number of days that the temperature is above the growing base temperature. This chart shows that there will be the potential for significantly more growth in spring and winter.

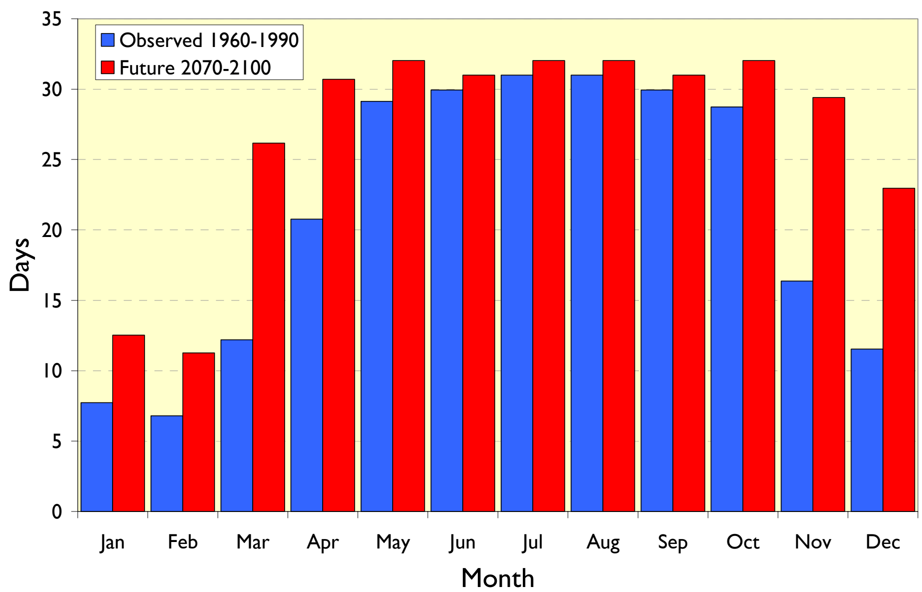

Figure 5: Growth Days by Month for Prabost

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 16 days earlier in the future.

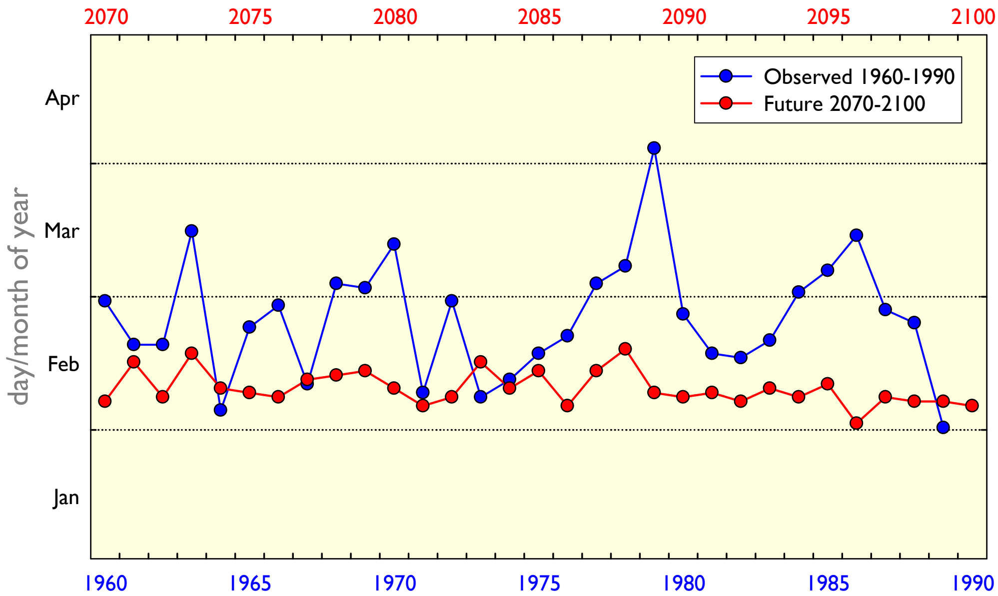

Figure 6: Tsum200 for Prabost

Frost

Figure 7 shows the dates of the last spring air frost. It shows that a late frost in April or May could be unheard of in the future with a last frost in February or March becoming more customary.

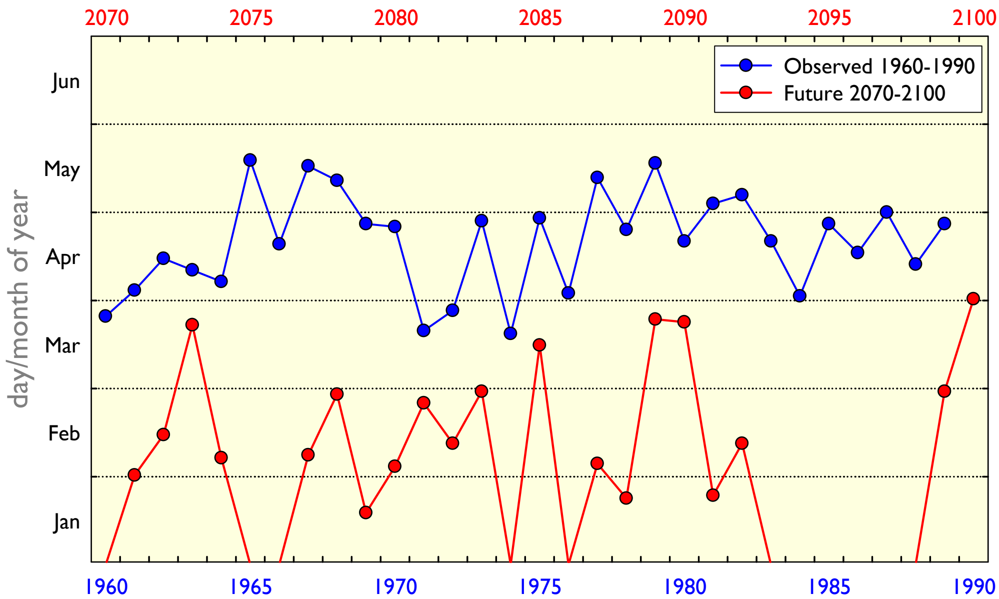

Figure 7: Last Spring Air Frost for Prabost

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 with only a day or two expected in early spring-time. We define a frost day when the minimum daily air temperature drops to or below 0°C.

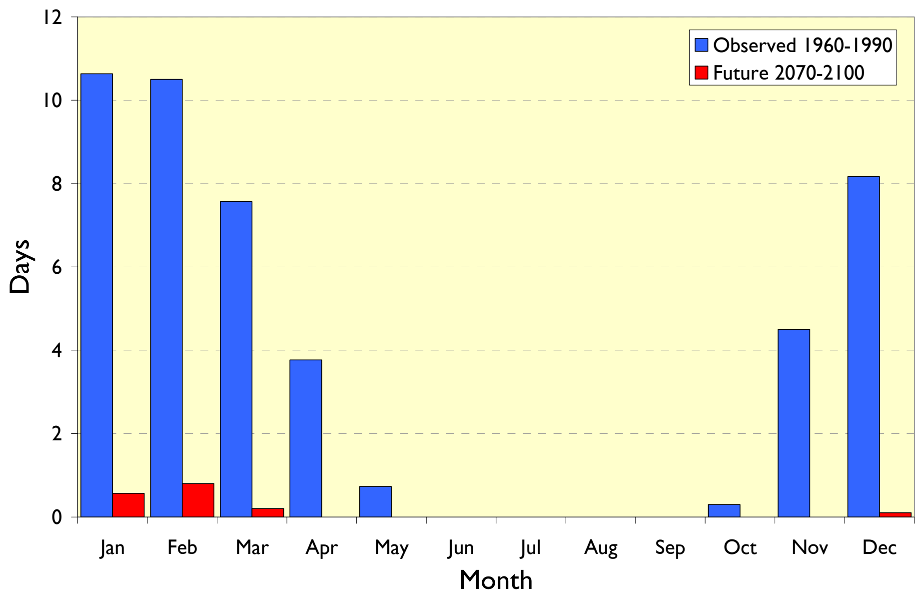

Figure 8: Average Frost Days by Month

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).

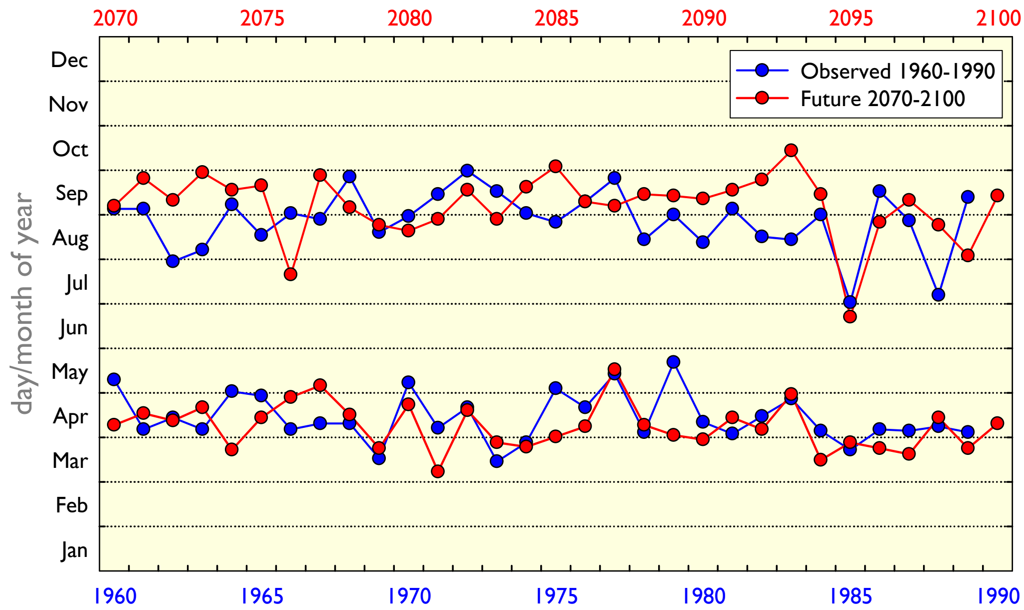

Figure 9: End and Return to Field Capacity for Prabost

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 10 days later. Figure 10 shows the average number of days of field access by month. It shows an increase in trafficability during September. There will be a slight reduction in access during June and July.

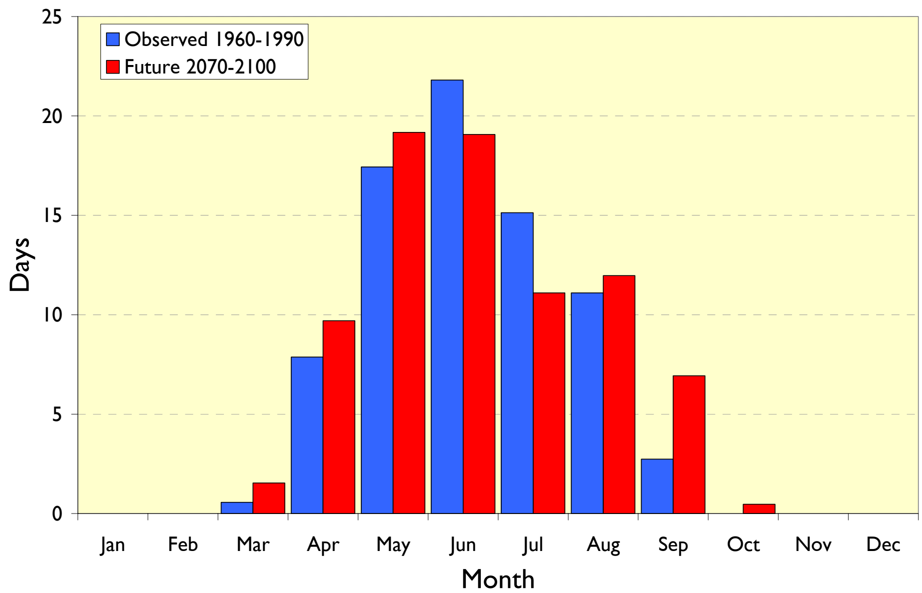

Figure 10: Days of Field Access by Month for Prabost

Field Access during the Growing Season

An increased access period and growing season is all very well but if the two do not overlap it may not benefit some enterprises. Figure 11 shows how many days that the temperature is above the growing base temperature <u>and</u> it is possible to access the field. These figures are monthly averages.

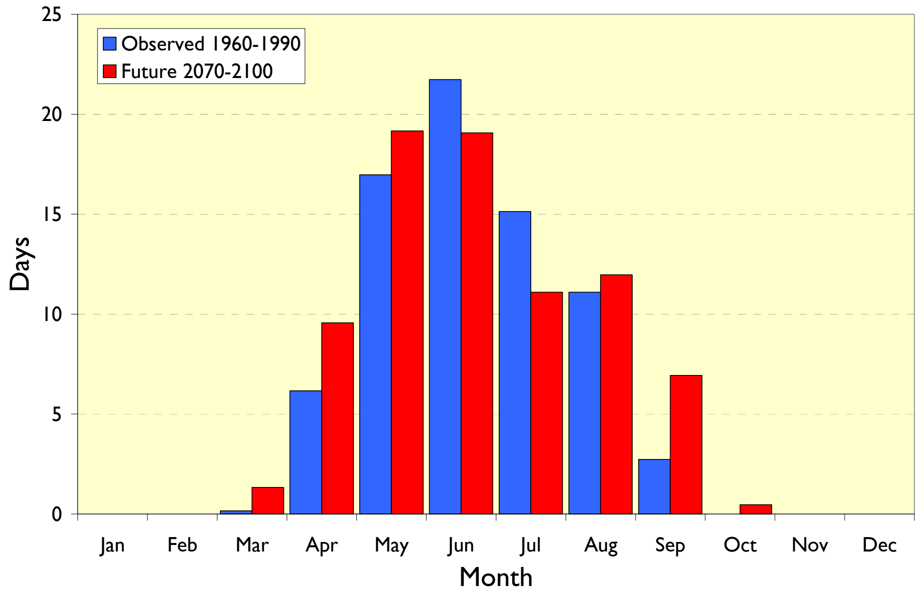

Figure 11: Average Number of Accessible & Growing Days by Month for Prabost

This chart shows that the number of accessible <u>and</u> growing days will increase during April and September in particular.

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 Prabost '74, '77 and '84 were amongst the driest on record while '66, '73 and '81 were amongst the wettest. Figure 12 and Table 1 show a comparison of the driest years for the observed and future periods.

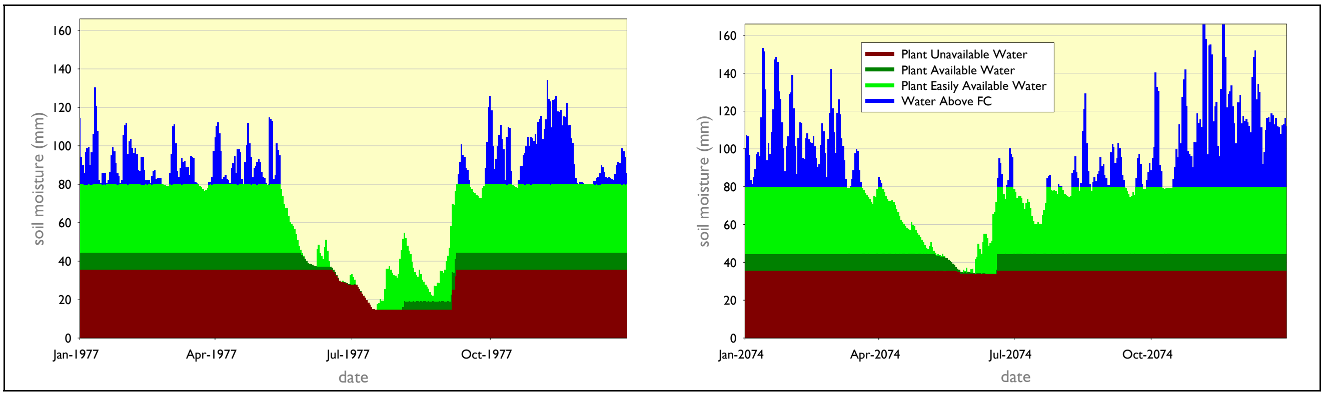

Figure 12: Dry year for the observed period (left) and future period (right)

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 (200mm) which is retained in the soil for a few days until it runs off.

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

	Observed	Future
Days at Saturation Point	0	4
Days at or above Field Capacity	246	263
Days of Plant Easily Available Water	337	354
Days of Plant Available Water	359	365
Days of Plant Unavailable Water	6	0

The data suggests that during a dry year in the future there seems to be less risk of water being unavailable to the crop. Figure 13 and Table 2 show a comparison of the wettest years.

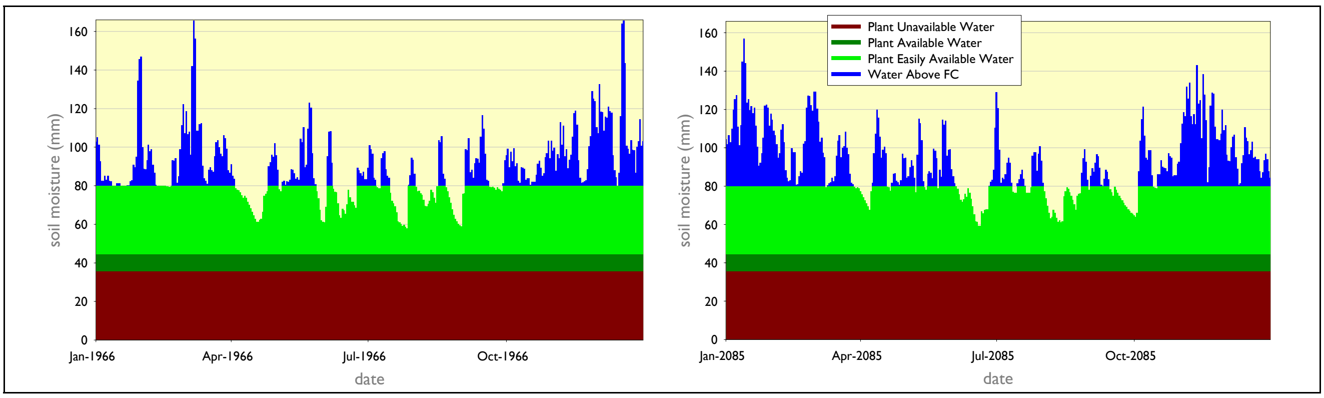

Figure 13: Wet year for the observed period (left) and future period (right)

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

	Observed	Future
Days at Saturation Point	3	0
Days at or above Field Capacity	304	312
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 more water at or above field capacity during the winter period but less days of saturated soil.

Figure 14 shows a typical observed and future year. It suggests that there may be an increase in excess of water in the soil during winter.

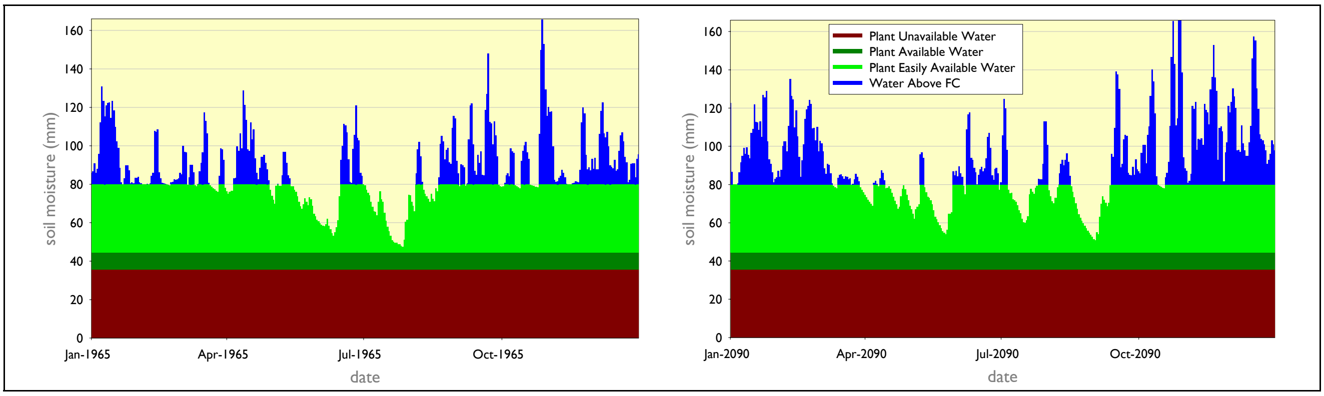

Figure 14: Typical year for the observed period (left) and future period (right)

Figure 15 shows 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.

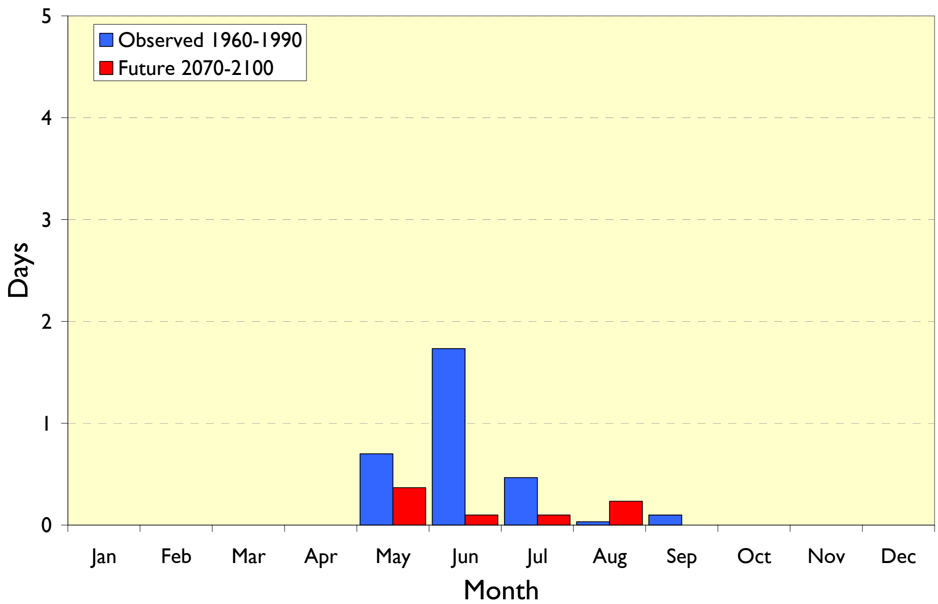

Figure 15: Average Days by Month where water is not easily available to plant

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).

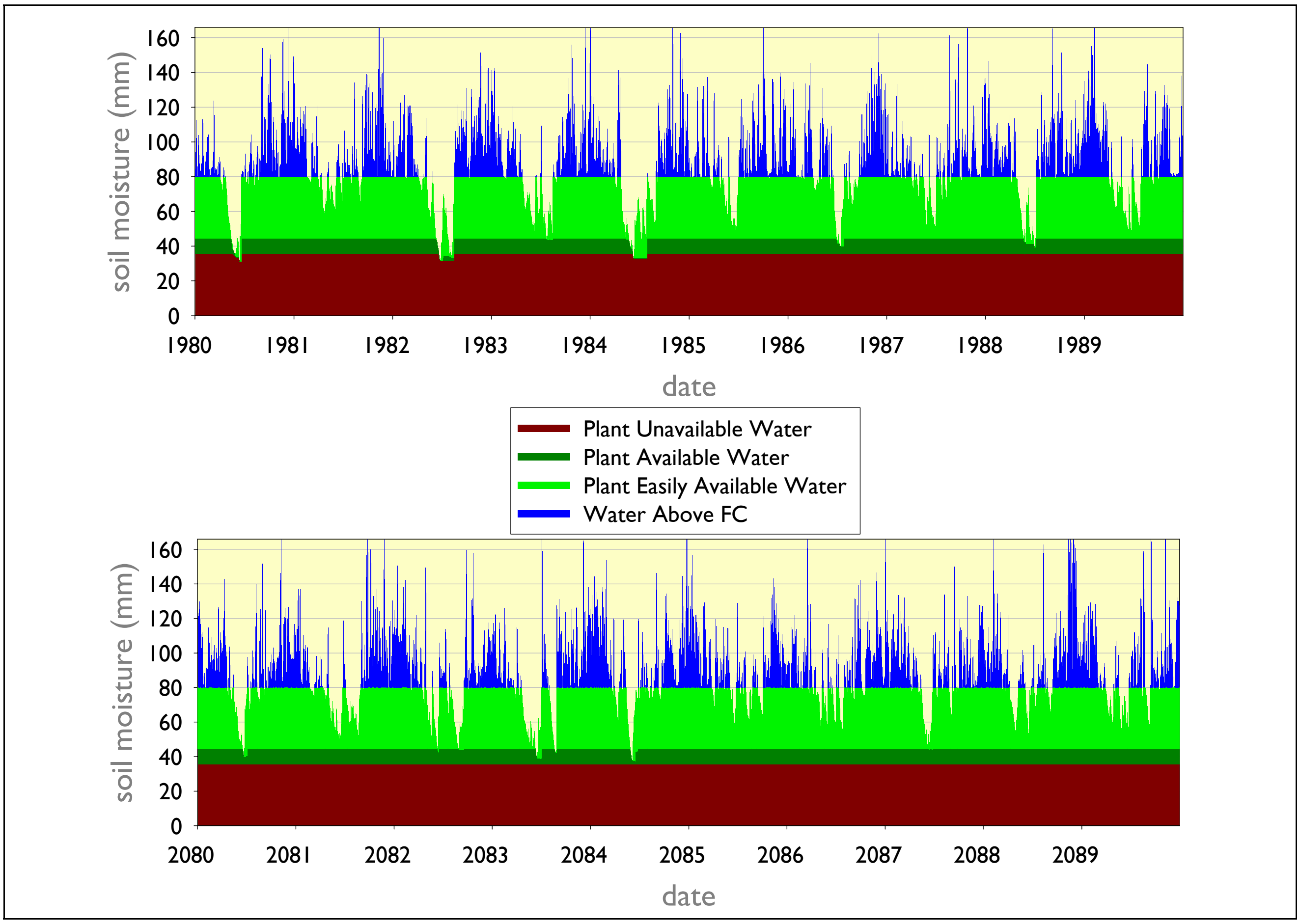

Figure 16: Soil Moisture Profiles for Prabost 1980's (top) and 2080's (bottom)

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

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