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ALPHA

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Climate variability and regional development

NIWA
Taihoro Nukurangi

Otago Regional Council

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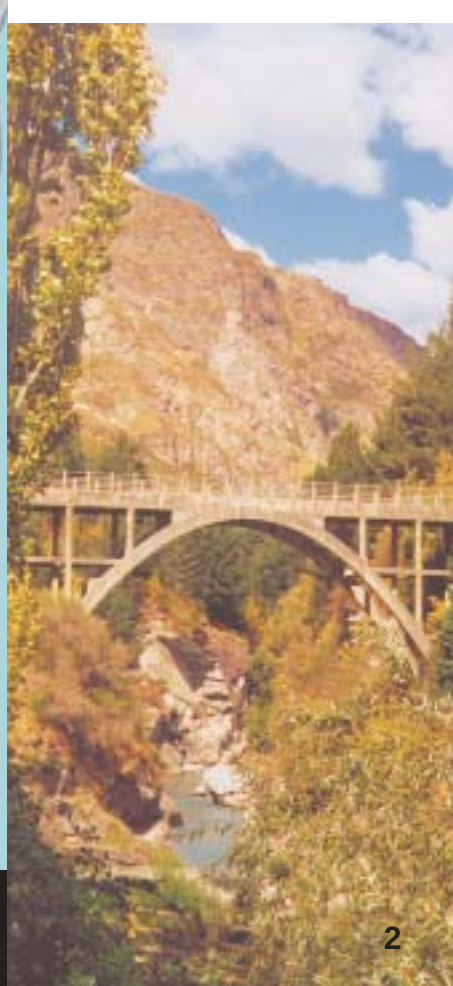

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the ROYAL SOCIETY of NEW ZEALAND


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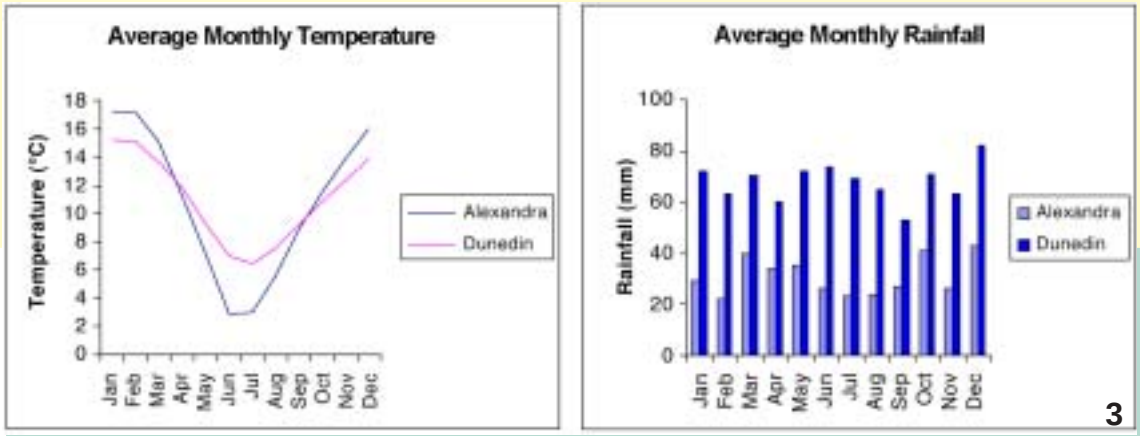
Science builds prosperity for Otago and provides a template for other New Zealand regions

Climate influences the way we live. It affects our customs, housing, food, clothing, health, leisure activities, transportation, farming practices, and much more. It controls essential natural resources such as water and vegetation and is a source of natural hazards such as drought, frost, flood and storm. Every aspect of our economy is influenced by climate. This is most evident in Otago, with its diverse climate and dramatic landscape. Otago's economy is built on tourism, farming, forestry, hydroelectricity and recreation – all of which are climate dependent. For example, climate determines the length of the growing season, the species of plants and trees that can be grown, the winter snow, the dry sunny days, and the amount of water for hydroelectricity generation.

Otago's climate

Otago's climate is the most varied and extreme in New Zealand and is influenced by the direction of the prevailing wind and the topography of the region. The Southern Alps provide a massive barrier to the strong moist westerly winds, making the mountains wet and the interior basins dry. Milford Sound has 6813 mm of rain annually, whereas Alexandra, just over 100 km away to the east of the Alps, has a total annual rainfall of 358 mm. The lower mountain ranges in the south and east of the region present a similar obstacle to southerly and easterly winds. Air temperatures vary widely between coastal and inland locations. Oceans mean moderate coastal temperatures; inland the contrasts are greater with hot summers, cold winters and a high diurnal temperature range. The lowest temperature recorded in New Zealand was –21.6°C at Ophir on 3 July 1995. Otago's climate presents some unexpected challenges to plan for and resolve.



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Climate Graphs

The above graphs of Dunedin (coastal) and Alexandra (inland) illustrate the large temperature differences inland and the low rainfall in the central basins.

Winds from the south can bring cold weather and snow that can smother sheep and damage power lines. Warm northwesterlies can bring persistent rain that melts alpine snow and overloads rivers. Easterlies can cause serious flooding in the coastal regions (Taieri floods of June 1980). Rain is good for hydro-electricity but not for flood-prone places like Queenstown. Air frosts are common in Otago from March to October and this may curtail the length of the growing season for some crops. Out of season frosts occur and this can be devastating for some crops. Droughts can occur during either El Niño or La Niña and are not only confined to summer dry periods. Although Otago's climate presents tough challenges, it also creates provides unique opportunities.

Diversification in farming and horticulture

Traditionally Otago produced apricots and wool. Today, land use has diversified with new crops such as grapes, olives, chestnuts and flowers being grown. Now there are also deer, ostrich and dairy farms. Prosperity depends on diversification and in order to diversify, farmers need to understand the climate and its impacts. They need to plan for frost and drought; and determine the length of the growing season and the species of plants and trees best suited to each location.

Winemaking in Central Otago

The Central Otago wine industry began in the mid–1800s but was short lived. Interest was revived following a DSIR trial in the1970s which showed that grapes could be successfully grown in areas sheltered from wind, protected from frost and with irrigation available. Animal pests are a problem; rabbits can destroy the growing vines while birds and wasps eat the ripening fruit. Rabbits are controlled by surrounding each block of vines with a rabbit-proof fence and netting is used to keep out birds and wasps.

Now the number one enemy is frost. Late frosts can wipe out much of the crop in one night. Central Otago's harsh growing conditions restrict the range of grape varieties that can be grown but these do produce grapes with unique characteristics resulting in high quality wines. Farmers are working with knowledge about the variability of the climate to make Central Otago a significant wine-growing area in New Zealand.

The growOTAGO project

The Otago Regional Council has recognised the need to sustainably develop the region's unique environment to build prosperity. In a three year **grow**OTAGO project scientists from NIWA, AgResearch and Landcare are using leading-edge techniques to produce climate and soil maps of Otago (most on a scale of 1:50 000). It is planned to produce maps of 28 different climate parameters, 4 soil maps and at least 13 tables for each region. The maps will be available on the internet and in hard copy. Information and data from this project will be available at the Otago Regional Council website: www.orc.govt.nz

This Alpha concentrates on the climate aspects of this study.

Temporary climate stations have been installed for one year in various parts of Otago by AgResearch and NIWA. This ensures that a comprehensive set of data is collected to cover each season. Scientists use data from these as well as from existing permanent stations and historic records to develop the climate maps. The maps give an overview of how conditions vary across the mapped regions, rather than precise climate and soil data for individual paddocks. The project addresses variability and extremes such as the lowest total rainfall expected to occur in one summer out of every five, as well as average climate conditions. The aim of **grow**OTAGO is to provide information to assist all those involved in climate-sensitive activities in Otago. Potential users include farmers adjusting their activities to better fit the natural variations in Otago's climate, groups assessing irrigation potential, horticulturalists interested in new crops, engineers addressing flood risk or choosing safe road surfacing material, tourism operators considering ski-field developments, companies investigating wind-power potential, electricity distributors assessing the maximum currents feasible through their high-voltage distribution lines, and foresters selecting suitable tree species.

Temporary climate stations near Becks. The success of **grow**OTAGO relies on community input. Many farmers have purchased their own climate stations or allowed them to be sited on their land.

Climate scientist producing maps at NIWA

Producing the climate maps

For most climate parameters, the information used in preparing the maps includes long-term observations in the region, one year's special observations at selected extra sites installed for the **grow**OTAGO Project, and detailed terrain data. The first step is to correct or discard faulty data. All the data, both short-term measurements and long-term climate observations are analysed to calculate the factors for which maps are to be produced.

To produce the "lowest summer rainfall map", the lowest rainfall expected to occur in one summer out of every five is estimated at each site. The rainfall at short-term **grow**OTAGO sites is compared with the values for the same season from permanent observation sites. Then rainfall data from each permanent site for this season is compared with the long-term climate record from that location. This allows adjustment for the fact that the **grow**OTAGO summer may have been drier than the long-term average. The resulting data is then put through a computer program which determines local relationships between the climate factors to be mapped (rainfall in this case) and the terrain. This program estimates the value of the climate factors across the whole map using a combination of nearest measurements and climate-terrain relationships to fill in the gaps between measurement locations. The calculated values are fed into a Geographic Information System which contains roads, rivers, place names and elevation data. For wind maps special computer modelling of how wind speeds up and slows down as it flows over and around hills is undertaken. For frost maps, patterns of temperature on cold clear nights are estimated from satellite observations.

Farmers studying interim maps at Oamaru

Many crops are susceptible to frost and it is of great value to farmers and horticulturists to plan for when the first and last frosts can be expected. The "last frost date" is the last date in the year that the minimum temperature falls below 0°C in a standard climate station. (Note that this is measured at 1.3 m above ground, not grass frost.) An unexpected late frost will burn off the new flower buds and destroy a crop so later flowering varieties may be more suitable to grow in some locations.

Creating the "last frost" map

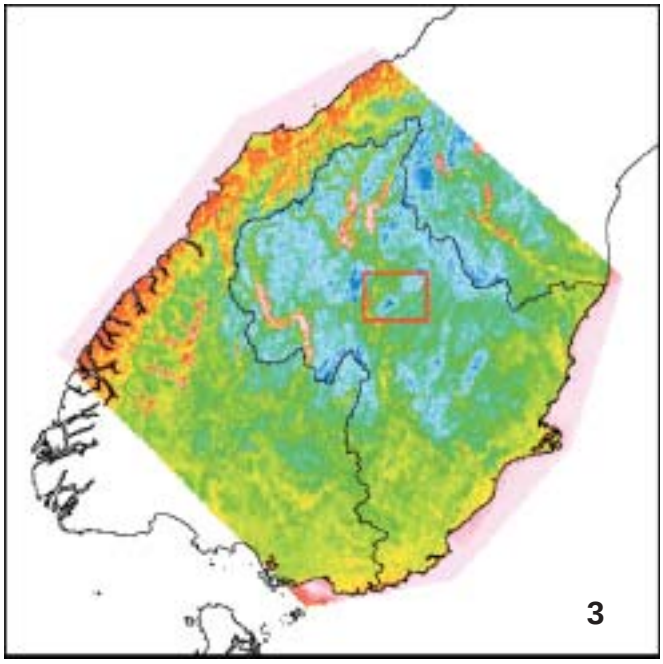
Step one

For each site at which temperature measurements are available the date the last frost is expected to occur in one year out of every five is estimated. This is the date by which the last frost should have occurred in 4 out of 5 years (80% of years). On average, once in every five years (20%) the last frost occurs later than this date.

On the map of climate stations (shown) each location is assigned a date of "last frost date" value.

Satellites used by weather forecasters carry infra-red sensors for measuring the temperature at various heights in the atmosphere. Some of those sensors can also provide information about temperature patterns over the ground on cold, frosty nights. A satellite image is a representation of the satellite data – generally a set of co-ordinates with a pixel value. Images from clear nights are preferred as clouds prevent surface temperature information being retrieved. In the image at left, the lakes show up as red (higher values) because the water is warmer than the surrounding ground at night. Bluer values indicate cooler areas. These could be tops of mountains or bottoms of broad valleys where the cold air has pooled at night.

The red rectangle in the satellite image represents the area that is being mapped in this example (right).



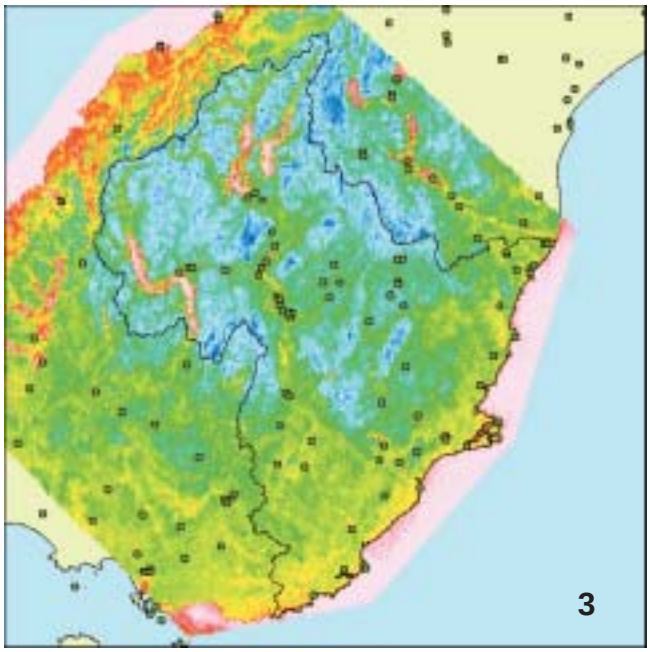
Step two

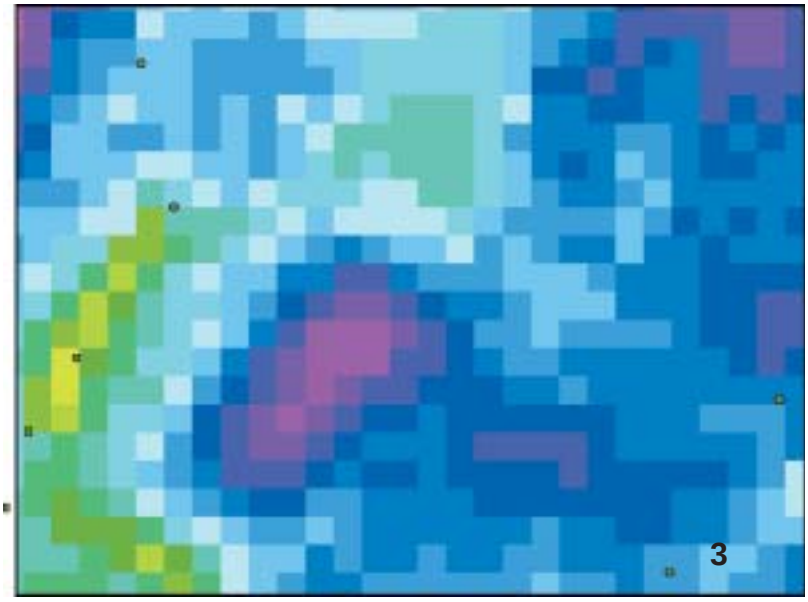
Data from a number of satellite images of the area are standardised and then averaged to capture the variability across a given area over a number of cold frosty nights rather than a single event.

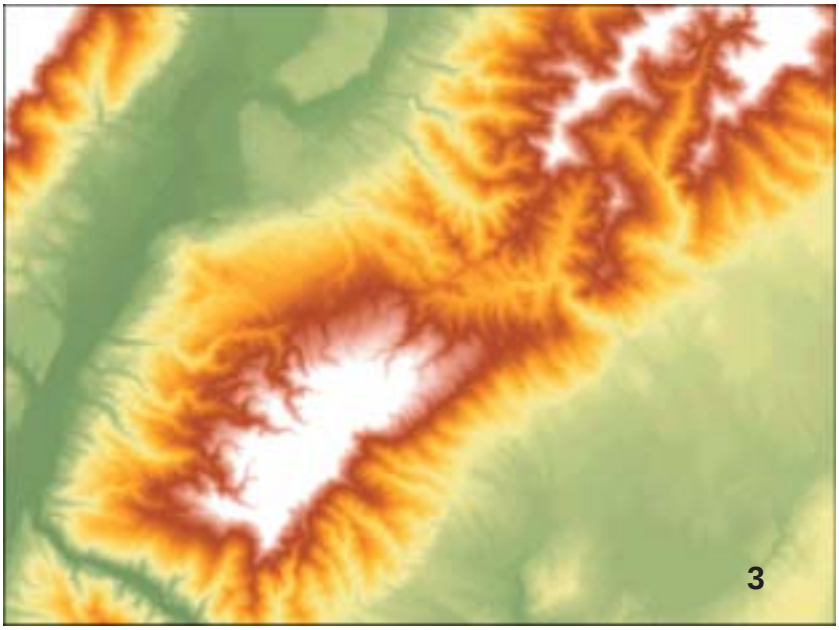
Step three

The satellite map is laid over the climate site data of last frost dates. This gives a "last frost" value for the pixels that they land on. The relationship between the frost values and the pixel value is determined. This relationship is applied through the other pixels to give a "last frost date" value at each kilometre over the whole region.

This is the resulting map of the "last frost date" for the area inside the red rectangle shown at step 2.



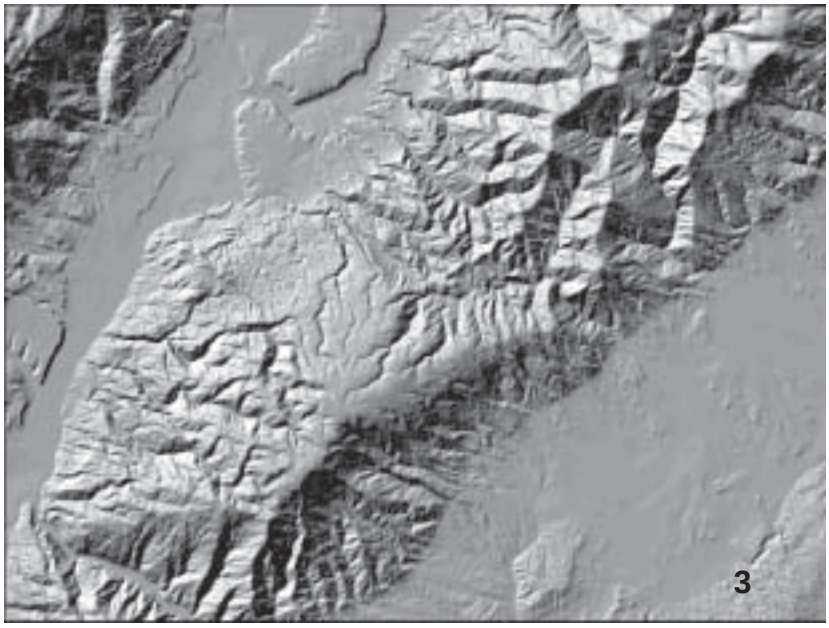




Blue tones represent later "last frost dates" and the areas in purple have the latest "last frost date"

Step four

Step 3 gives frost dates on a set of 1 km square pixels. The change of calculated frost date with elevation near each of these pixels is then used with detailed height information to build finer scale detail into the last frost date map.

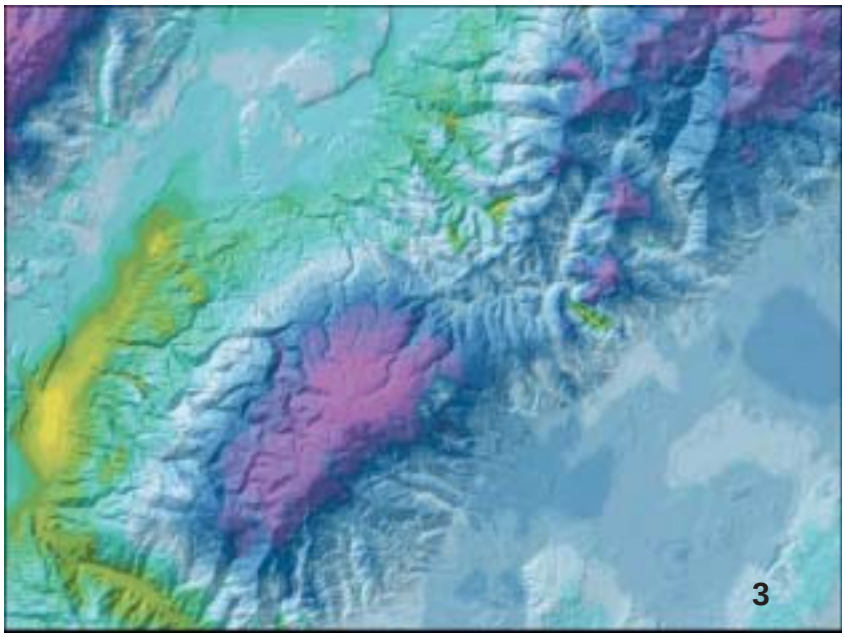


Step five

Hill-shading is produced from the 50 metre elevation data. This enables the reader to visualise the terrain of the area being mapped.

Step six

The hill-shading map is laid over the "last frost" data to produce the final map. A title and legend are added and the map is printed at A2 size.



Science in the community

The success of **grow**OTAGO relies on community input. Some farmers have purchased their own climate stations or allowed them to be sited on their land. New and historical records are shared to provide comprehensive information for all.

There have already been changes in land use over the years. For example, in Central Otago vineyards have been developed and in Coastal Otago hydrangeas have become an export flower crop. And in parts of Otago there has been growth in the number of dairy cows farmed.

Temporary climate station

Lauder permanent climate station

Falls Dam at the top of the Manuherika Valley

Blue Lake at St Bathans

Where to from here? Other New Zealand regions

A study has been completed with the Tararua District Council in June 2001. This climate mapping was not as high resolution, being to a scale of 1:250,000 and an independent soils study was conducted by Landcare Research. NIWA has also signed a contract for mapping climate and soils with the Kaipara and Far North District Councils in association with LandCare Research, HortResearch and Crop and Food Research. The conditions that certain crops require to be grown commercially will be analysed in this project.

Conclusion

Otago's future depends on understanding the climate and environment and making the most of it, by celebrating the best and guarding against the worst.The **grow**OTAGO project will provide a comprehensive set of climate and soil data which will be valuable as a basis for land development and diversification. NIWA is investigating the potential of the climate mapping techniques that have been developed, using the **grow**OTAGO Project as a template for other regions. A climate study using just existing data and producing 1:250,000 scale maps has been completed with the Tararua District Council in June 2001. In a new project with the Kaipara and Far North District Councils, NIWA, Landcare, HortResearch and Crop and Food Research are combining their skills to map the areas of crop suitability.

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Reviewed by: Richard Rhoades, HOD Mathematics, Heretaunga College; Dr David Wratt, Principal Scientist, Climate Applications, National Institute of Water and Atmospheric Research Ltd, (NIWA).

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