# Macroclimate

## Fact Sheet Objectives

- Define the scale of the *macroclimate* in both time and space
- Highlight some of the potential macroclimate impacts on horticulture
- Suggest some property-level response strategies that can mitigate impacts from macroclimatic factors

## Macroclimate scale

A useful way to view climate in relation to orchard management is to think of the climate within the orchard (the *microclimate)*, and how that can be influenced to some extent by day-to-day management practices, and the climate beyond the orchard (the *macroclimate)*, which we cannot influence.

How extensive is the macroclimate? Some typically used categories or scales of climate can each be viewed in three dimensions—time, horizontal distance, and vertical height above the ground. Working definitions of these climate scales, by the World Meteorological Organization, are shown in Figure 1. In practice, there is some overlap between the different climate scales, and so categories cannot be rigidly defined.

| Scale | Time Dimensions |
|---|---|
| Microclimate | 1 sec to 1 hour |
| Mesoclimate | 1 hour to ½ day |
| Macroclimate | ½ day to 1 week |
| Global climate | 1 week & longer |

| Scale | Horizontal Dimensions |
|---|---|
| Microclimate | 1 mm to 1 km |
| Mesoclimate | 1 km to 100 km |
| Macroclimate | 100 to 10,000 km |
| Global climate | 10,000 km to global |

| Scale | Vertical Dimensions |
|---|---|
| Microclimate | 1 mm to 10 m |
| Mesoclimate | 10 m to 1 km |
| Macroclimate | 1 km to 20 km |
| Global climate | 20 km to 100 km |

*Figure 1. Climatic Scales Defined by Time and Distance*

## Macroclimate factors

In choosing an orchard location, planning its layout and budgeting for long-term financial success, it is vital to be familiar with the macroclimate aspects of the orchard. This knowledge will ensure that orchard design and establishment make best use of the climatic features of the location and that the risk of crop damage or failure (as well as the potential for success) is well understood.

### Distance from the sea

*Land and sea breezes* – land adjacent to the sea can be subjected to quite strong winds that are caused by temperature differences between the land and the sea.

*Cloudiness and fog* – land near the sea can at times be persistently cloudy when there are periods of onshore, moist wind flow. Fog is also common in low coastal areas.

*Temperatures* – proximity to the sea can result in some modification of extreme temperatures. For example, the climate in coastal areas is less extreme (in terms of hot summers and cold winters) than in inland Central Otago.

**Latitude**

*Solar angle* – the further south the property is, the lower the solar angle and the lower the overall radiation levels reaching the ground (although cloudiness is also a factor). For example, Gisborne's average global solar radiation is 14.5 $MJ/m^2$/day (mega joules per square metre per day), while further south at Dunedin Airport the figure is 12.4 $MJ/m^2$/day.

*This Central Otago orchard, with its prominent frost-fighting wind machine, will suffer frost both from cold air draining off the mountains and from radiation frosts on calm night.* *(photograph by Alan Blacklock, NIWA).*

*Length of daylight* – a benefit of being further south is that the number of summer daylight hours is greater.

*Prevailing winds* – NZ's prevailing wind direction is westerly. This is because the country is located in the prevailing westerly airstream that circulates around the globe between latitudes 30° and 65° south The Westerlies will be weaker and less prevalent, with more days of easterlies in the north and stronger and more prevalent in the south.

**Height above sea level**

*Air temperatures* – typically decrease with height at the rate of 0.6 °C per 100 metres. This height factor influences the length of the growing season (shorter growing seasons at higher altitudes) and may influence the risk of frost (typically, more frosts at higher altitudes, but local topography is also a factor).

**Topography**

*Valleys* – produce their own local valley wind systems because of differences in the way air lying within valleys gains or looses heat, and because valleys can modify regional (mesoclimate) and local (microclimate) scale wind flows.  Large valley systems, or breaks in mountain chains can act like large funnels substantially increasing wind speeds and prevalence of winds e.g. Cook Strait and the and areas adjacent to the Manawatu Gorge

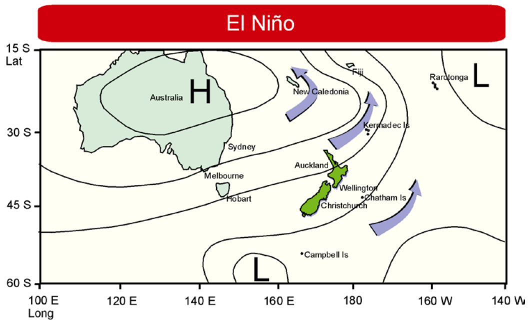
*Irregular terrain and hills* – when air flows over terrain that is not uniform, for example the Southern Alps, areas of both high and low pressure are created. These can cause acceleration of the wind speed, reverse wind direction flows along the ground against the dominant wind flow, and turbulence in the low pressure areas called *lee eddies*.  There may also be turbulence at the face of a hill or obstacle, often referred to as a *bolster eddy.*

*Orographic influence on rainfall* – moist air condenses as it rises on the windward slopes of mountain ranges, and precipitates out, leaving the air mass drier as it descends the lee side. These types of clouds are called *orographic clouds* and develop in response to lifting caused by the topography. As a result of the topography, local climates are normally wetter on the windward side of mountain ranges, and drier on the opposite or leeward side.

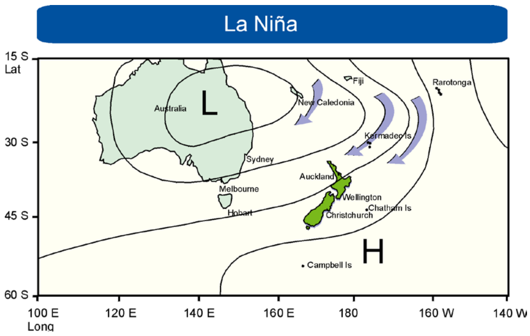
*Foehn wind* – a warm dry wind that occurs on the leeward slopes of a ridge of mountains e.g. the 'Canterbury Nor'wester'. The air is first forced upward over the western slopes of the Southern Alps, cooling as it encounters the lower pressures of higher altitudes. If, however, it reaches its condensation temperature, the cooling is somewhat reduced because of the release of latent heat that results from water vapour condensing into liquid water. As the air flows downward over the leeward slopes, it is warmed as it encounters the greater pressures of lower altitudes. This warming, however, is greater than the cooling that occurred during the ascent, so that the air is both warmer and drier than it was originally.

# Global climate

**Pacific-wide climate fluctuations, particularly the El Niño/La-Niña-Southern Oscillation, have partly predictable effects on New Zealand climate.**




*During an El Niño season, New Zealand is typically cooler, with more winds from the southwest. The west coast of the South Island generally gets more rain.*




*During a La Niña season, New Zealand is typically warmer, with more winds than usual from the northeast. The northeast coasts of the country are exposed to wetter conditions from the moist north-easterly airflow, particularly during summer, autumn, and winter. In a La Niña spring, there is often an increase in westerly winds.*

*El Niño-Southern Oscillation (ENSO),* ***El Niño*** – occurs when the tropical eastern Pacific Ocean becomes warmer than usual. During El Niño seasons, New Zealand typically experiences an increase in westerly and south-westerly winds. This can result in drier conditions and droughts along the east coast while southern and south-western coasts are often cooler and wetter.

*El Niño-Southern Oscillation,* ***La Niña*** – coincides with lower than normal tropical Pacific Ocean surface temperatures. La Niña typically brings more frequent warm, moist, easterly and north-easterly winds, with higher chances of wetter conditions along northern and eastern coastlines, especially in the North Island.

*Interdecadal Pacific Oscillation (IPO)* – is similar in some ways to the Southern Oscillation, although its periodic changes occur on a much longer time scale, usually 20 years or more. The IPO appears to have links with ENSO although the relationship is complex. A recent change in the IPO may have occurred in 1998, which may mean that the El Niño weather pattern will be less frequent over the next two decades than it has been since 1977.

*Global warming* – the earth's atmosphere has been slowly getting warmer over the last 150 years, at least partly because of an increase in greenhouse gas emissions into the atmosphere from human activity. Scientists believe that the average temperature could rise between 1.4°C and 5.8°C in the next 100 years. New Zealand probably won't be as affected by climate change as some other countries, but our weather is likely to become more extreme. Some regions could have more droughts, particularly in eastern New Zealand, while other regions could have heavier rainfall. The sea level is likely to rise and there could also be greater pest and disease problems. A warmer climate could be better for growing some crops, but worse for others.

# Managing macroclimate factors

Consider macroclimate factors in orchard planning and management to ensure helpful macroclimate features are maximised, while protecting the orchard environment against macroclimate risks.

### Weather risk assessment

Find out the climatological risk from weather hazards in the area and how to minimise their impact both through orchard design and robust budgeting.

Weather hazards include frost, hail, dry spells, wind, heat, floods, low rainfall, and cool growing seasons. Know their frequency and their probable effects. For example, what are the likely effects from a 1 in 10 year storm or flood? Also important is matching your risk assessment to crop growth requirements, such as frost-free periods, and minimum accumulations of chill units or growing degree-days.

### Shelter belts

Shelter belts across dominant wind directions can help to slow down the wind flow within the orchard. However, be sure not to create turbulence by 'over-blocking' the wind flow (the porosity of the windbreak should be about 40%), or by blocking the outflow of cold air from the orchard.

### Use of slope and aspect

Use slope and aspect to maximise solar reception. Planting the orchard on a north-facing slope will improve the angle to the sun, and therefore capture more incoming solar radiation. The crop layout—spacing and row direction—will also influence how much solar radiation reaches the soil surface through gaps in the foliage.

### Use of solar horizon

Ensure the best use of the solar horizon. Plant in areas where sunshine is available for the longest period, i.e., minimise the interference from hills and tall trees.

## Summary

- Macroclimate can be defined as the climate beyond the orchard environment
- Macroclimate impacts on a locality depend on local geographical features as well as regional and global scale climate patterns
- Orchard location and layout planning can maximise good features of the macroclimate, and help to protect against climate risk

## Further information

NIWA's National Climate Centre: www.niwa.co.nz/our-science/climate

Climate Summaries: www.niwa.co.nz/our-science/climate/publications/all/cs Temperature, rainfall and sunshine data from across New Zealand

Seasonal Climate Outlook: www.niwa.co.nz/our-science/climate/publications/all/seasonal-climate-outlook Air temperature, rainfall, soil moisture and river flow predictions for the coming season.

Obtaining Climate Data from NIWA: www.niwa.co.nz/our-science/climate/our-services/data The National Climate Database is an archive of climate observations.

MetService: www.metservice.com/rural/index regional weather around New Zealand

Climate and weather terms and definitions: NIWA www.niwa.co.nz/our-science/climate/information-and-resources/terms, Australian Government Bureau of Meteorology www.bom.gov.au/climate/glossary/

El Nino/Southern Oscillation (ENSO): www.esrl.noaa.gov/psd/enso// and http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.pdf

Climate change information New Zealand: www.climatechange.govt.nz

*The View from the Ground. A farmer perspective on climate change and adaptation.* G Kenny, M Fisher. 2003. Available from Hawke's Bay Regional Council, Environment Canterbury, Environment Bay of Plenty, or Earthwise Consulting Ltd Hawke's Bay or www.mfe.govt.nz/publications/climate/view-from-the-ground-jul03/view-from-the-ground-jul03.pdf

## Acknowledgements

Information provided by Alan Porteus, NIWA. Factsheet compiled by Plant & Food Research. A MAF Sustainable Farming Fund Project.