# Recent Frost Trends for New Zealand

Frost is a significant hazard for New Zealand's land based sector and can have a direct impact on production volumes and quality in crops, pastures and forest. Climate change has the potential to alter frost frequency and intensity but has not been previously studied in a New Zealand setting. In response to this gap in knowledge The Ministry for Agriculture and Forestry (MAF) commissioned NIWA to examine recent frost trends.

## Frosts, primary production and climate change

Frosts occur when the surface of plants are cooled to below the dew point of the surrounding air. This creates conditions where ice crystals grow either on the surface of the plant or within plant cells. There are two main types of frost:

- 'Radiation' frosts occur when heat is lost from the ground to the atmosphere on clear still evenings causing plants to become colder than the surrounding air.

- 'Advection' or wind frosts occur when a very cold air mass moves across the plant canopy as part of a broader weather system, and are relatively rare in New Zealand.

Frost risk is the combination of both the frequency of frost events, and their impact on the farm business. Management actions can be implemented by producers to avoid or reduce physical damage from frost. Managing frost risk can be expensive and so it is important to know the frost characteristics in a given area and match management techniques accordingly.

Climate change brings the prospect of reduced frost risk due to warmer temperatures. National level studies have confirmed the warming trend for New Zealand as a whole, but other locally focussed studies and anecdotal reports suggest that frosts have become more frequent in some locations. Given this background there is significant interest, particularly in the agricultural sector, in determining whether there have been any trends in frost occurrence and/or intensity around the country over the past 30-40 years.



Ministry for Primary Industries
Manatū Ahu Matua

A resource developed through the Climate Change Technology Transfer Programme

## Methods of studying frost

Frost risk was examined in this study by detecting trends in ‘screen frosts’. This is a ‘proxy’ for frost, used extensively in weather and climate science. It is assumed that a frost occurs when the minimum temperature falls below 0°C in a measurement screen 1.2 meters above the ground. This definition does not fully describe frost risk for the primary sector. Whether or not ice crystals form and vegetative tissue is damaged can depend on a range of factors including humidity, temperature gradients through the soil and frost hardiness of plants. Despite this, the meteorological definition used has a practical advantage in that it supports more widespread analysis of frost using the climate monitoring network. Three main steps are typically used by scientists to examine climate trends and were used to detect frost trends in this study.

***Climate data:*** considerable effort is needed in sourcing and quality control of data to ensure that any trend detection is real and not a result of a station change, urban heat island effects, or any other measurement problem. Suspect data can be ‘homogenised’. The frost analysis shown here is based on two sets of data: 112 quality controlled minimum temperature records (1972–2008) and NIWA’s virtual climate station network (1972–2008).

***Trend detection****:* Climate scientists use a variety of methods to detect trends. These might be linear when a trend is known to be the same direction over time, or non-linear when changes in the direction and/or rate of a trend occur. Statistical tests can be used to determine if the trends are significant (i.e., what is the chance that the trend detected is a result of error?). Trend detection in this study is carried out using a standard linear method, ordinary least squares regression, and the results are aggregated in time and across the country and regions (Figures 1 to 3).

***Climate attribution***: Further steps are needed to discern what processes are driving trends. This typically involves correlating trends with climate processes in association with physical climate modelling experiments. A formal attribution analysis was not undertaken in this study.

## National frost trends

Across New Zealand as a whole the study found strong evidence that frosts have been decreasing between 1972 and 2008. This is evident as reduced frost days, and increasing minimum and frost temperatures (Figure 1). On the whole this equates to an average decline of 1 frost day per decade. These trends are consistent with previous national level analyses for New Zealand and the Pacific, and while no formal attribution analysis was carried out, they are also consistent with the process of global warming.

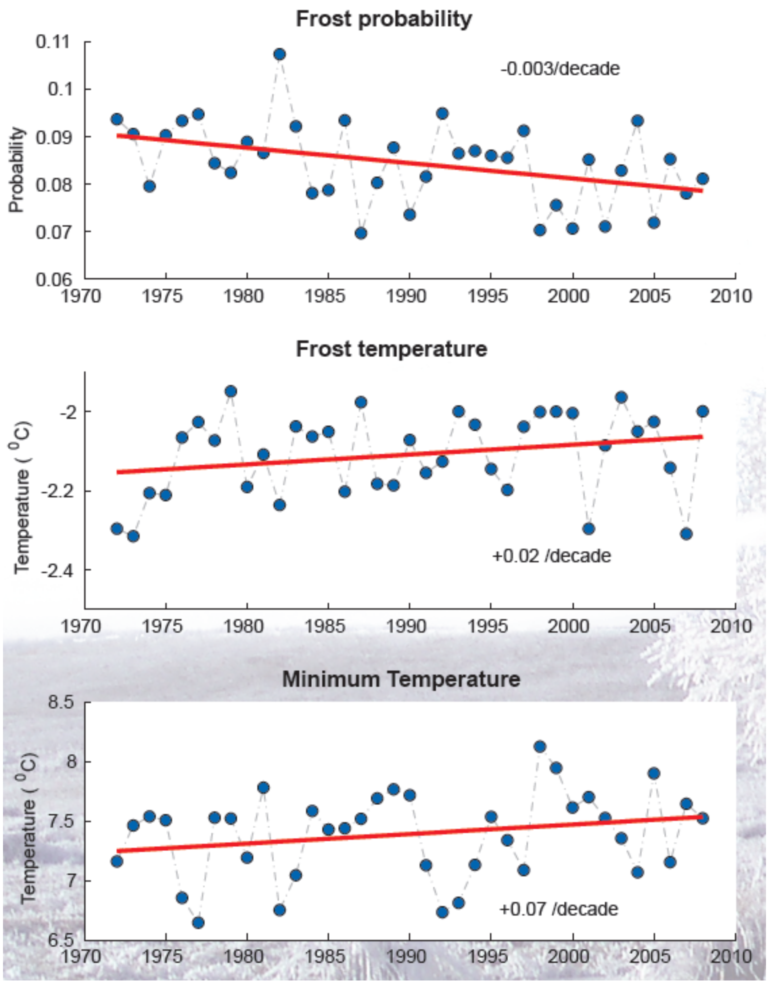


Figure 1: National composite trends in frost frequency, frost temperature and minimum air temperature. Based on homogenised data from 112 climate stations.

## Regional frost trends

Examining individual climate stations, approximately 70 percent of the 112 analysed had reduced frost days (a 'warming'), while 30 percent had increased frost days indicating a 'cooling' (Figure 2). When only the growing season (October-April) was taken into account, far fewer sites exhibited reduced frost days. This weakened trend indicates that most of the change in frost frequency is occurring outside of the growing season.

The study detected a distinct regional pattern in the trends, consistent with New Zealand's maritime climate and topography. Two regions experienced increased frost frequency: parts of the Wairarapa and the lower Canterbury plain south to below Dunedin (Figure 3a). The areas of strongest warming occurred in the higher altitude alpine regions of both Islands. These trends were found to be statistically significant (Figure 3b).

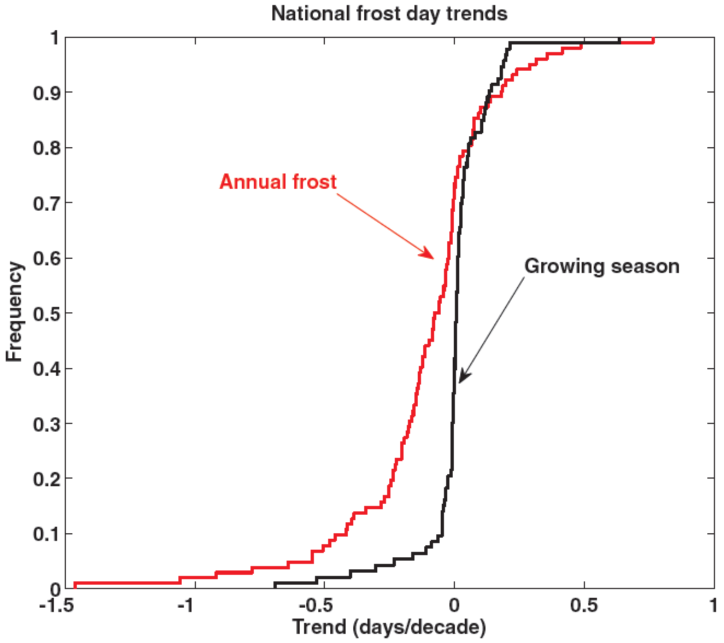


Figure 2: Cumulative distribution showing the number of stations (frequency) with positive or negative trends.

The coastal and low lying zones, of the country generally exhibited no change — showing no trend, or slight increases, or decreases in frost occurrence that were not statistically significant.

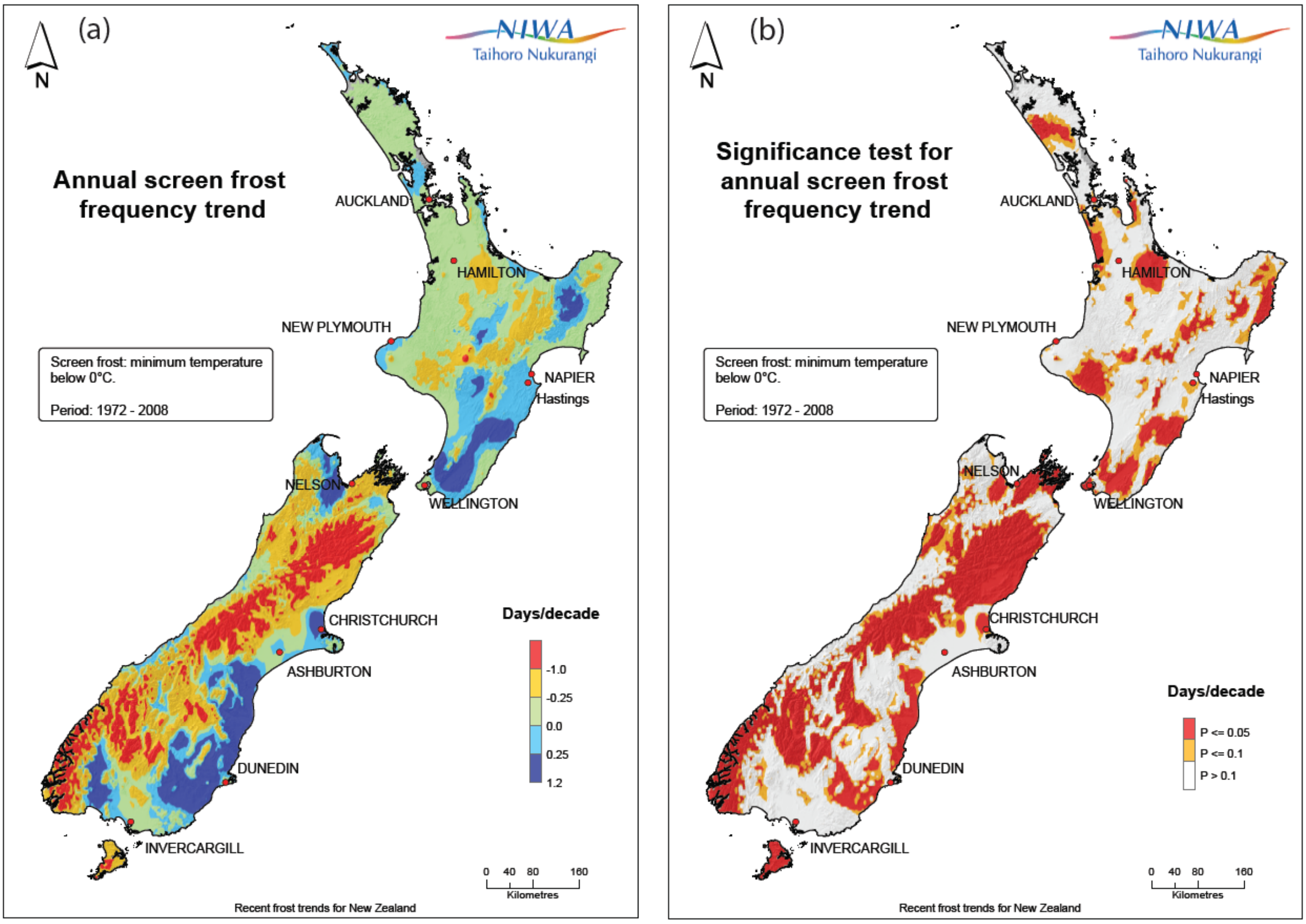


Figure 3: Maps of frost frequency trends (a) and significance test (b). Analysis based in NIWA's Virtual Climate Station Network.

## Will the regional trends continue?

Good quality, widespread temperature data is not yet available for a long enough time period in New Zealand to assess how trends and regional patterns might change in the future under the combined influences of projected anthropogenic global warming and decadal natural variability.

## Implications for adaptation

When developing an adaptation response to changing frost risk it should not be assumed that a single global or national trend will apply to every region. New Zealand's maritime climate has potential to modify the overall global signal, and as found in this study, it is plausible that regional and sub-regional trends can run counter to the direction of those detected at the national and global scale.

Adaptation to a changing climate by modifying frost risk management will need to be carefully targeted to address the understood drivers and effects of frost in a particular area, as well as the future frequency of frosts. For management of production systems, damaging frost should continue to be considered a natural hazard, where diligent monitoring of day to day weather information and matching actions to long term trends is the best pragmatic approach.

## Further information

The full technical report that this summary is based on is freely available at: http://www.climatecloud.co.nz/CloudLibrary/2011-14-recent-frost-trends-for-new-zealand[1].pdf

The following articles provide further information on frost:


- Ireland, W. (2005) Frost and crops, frost prediction and plant protection, Wiley and Sons.
- Salinger, M.J. and Mullan, A.B. (1999). New Zealand climate: temperature and precipitation variations and their link with atmospheric circulation 1930-1994. International Journal of Climatology 19: 1049–1071. Salinger, M.J. and Griffths (2001) Trends in New Zealand daily temperature and rainfall extremes, International Journal of Climatology, 21: 1437:1452.
- Salinger, M.J.; Renwick, J.A.; Mullan, A.B. (2001). Interdecadal Pacific Oscillation and South Pacific climate. International Journal of Climatology 21: 1705-1721.