Examining the climate and its variations

The second step of this systems approach to understanding the influence of climate on lamb survival was to generate estimates of the climate over the past 20 years (1980-1999) and for the future (2030-2049). To create climate data for the sites chosen (**Error! Reference source not found.**), the NIWA virtual climate station network was used. This data could then be examined to understand current and future trends and variability and be applied to the lamb survival modelling.

Predicting the climatic variation now and in the future

Climate data was generated to match local sites within the four regions of the catchment groups by the National Institute of Water and Atmospheric Research (Hendrikx *et al.* 2009). NIWA used the Virtual Climate Station (VCS) network (Tait 2008; Tait *et al.* 2006) to extract current climate data (1980-1999) from the closest grid points to appropriate locations within each catchment. These locations (**Error! Reference source not found.**, Table 1) are indicative of the relative locations of climatic zones of interest within each catchment.

Climate information was also generated for three future (2030-2049) climate projections, associated with the A1B, A1F1 and B1 emissions scenarios used by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC 2007). These future climates, based on different emission scenarios, are 'middle of the road' (A1B), 'upper emissions' (A1F1), and 'lower emission' (B1). The current changes in temperature are reflecting the A1F1, upper emissions, scenario.

The output of the global climate model has a low spatial resolution and is therefore not appropriate to apply at the scale that was required for the type of local climate modelling required for this study. Therefore the global model output was statistically downscaled to the 5km grid intervals used in the VCS network as described in (MfE 2008).

Further variability was added to the future climate data by adjusting rainfall events. The percentage increase in extreme rainfall depths is expected to be approximately 8% per degree Celsius of temperature increase (MfE 2008) and the data sets were adjusted accordingly, by removing small rainfall events and adding them to large events at the quoted amount.

Unfortunately the VCS network has not yet included wind run. Therefore, the wind run at each location was chosen from the nearest weather station of similar altitude and aspect. With relatively little known about the predictability of average wind run variation, the current and future models of climate used the same wind data. When records were incomplete, data from the same period in other years was substituted.

A full description of the climate modelling and data outputs is given by Hendrikx *et al.* (2009) in the accompanying report. Further descriptions of the wind run data and its selection are given in the methodology for the modelling at each site.

Climate modelling outcomes

Predicted climate and variability

The projected climate data for three future scenarios for 2030-2049 was modelled from the global climate models provided by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC 2007), based on three different emission scenarios. Daily historical (1980-1999) and future temperature and rainfall data was generated for seven locations representing a range of sheep farming environments in the lower South Island (Table 1). This data was generated from the NIWA virtual climate station (VCS) which predicts the climate on a grid at 5 km spacing's. This downscaling of the global climate models provided enough detail to examine potential climate changes at a regional scale. As such it is the changes in lamb survival, rather than the actual values that will be comparable between now and the future.

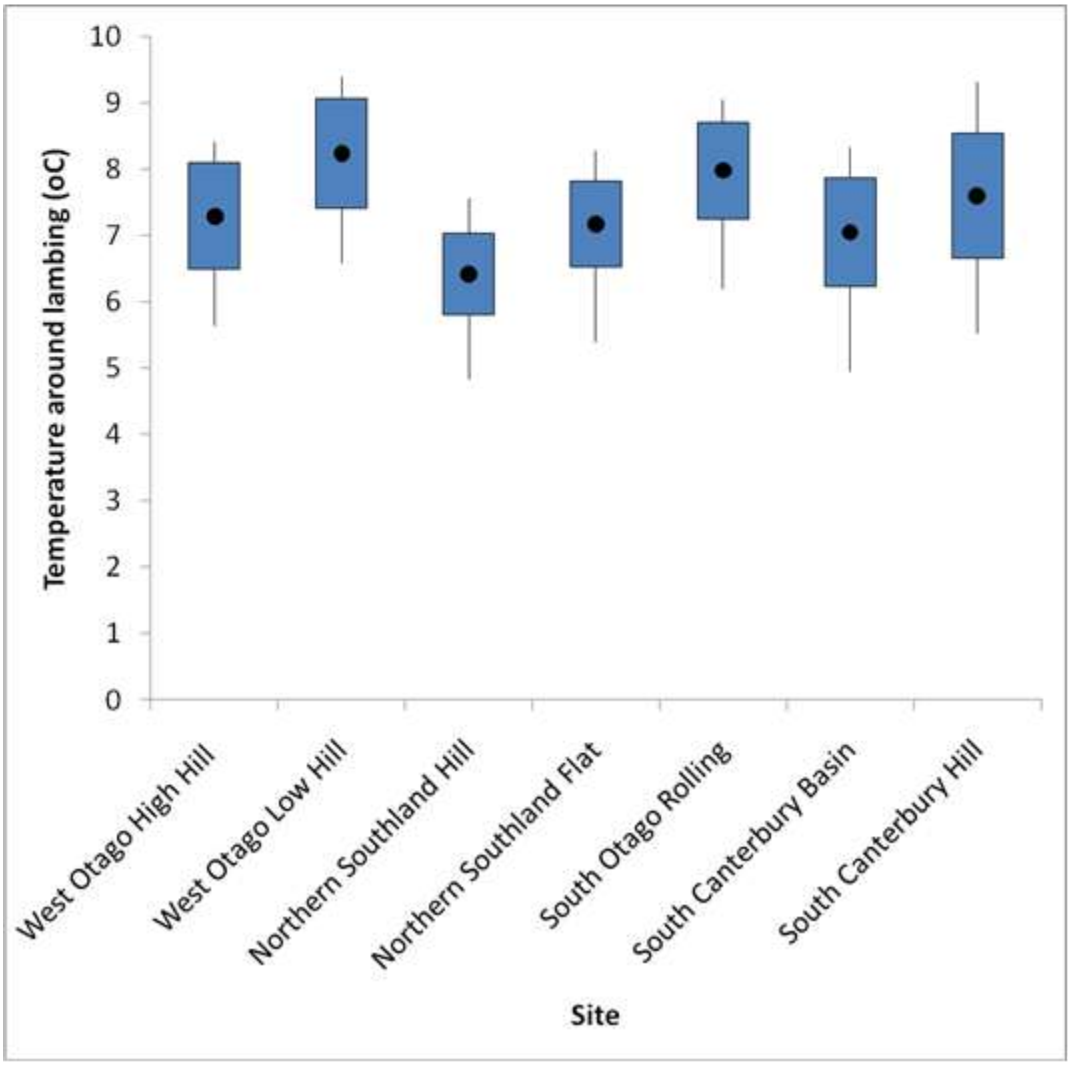
Table 1. Sites chosen for climate prediction and lamb survival studies

	Longitude	Latitude	Altitude	Scanning percentage	Normal Mating date
West Otago High Hill (Wohelo/Wilden)	-45.725	169.175	626	177	10-May
West Otago Low Hill (Raes Junction/Island Block)	-45.725	169.425	422	177	1-May
Northern Southland Hill (Athol Hill)	-45.425	168.575	480	174	15-Apr
Northern Southland Flat (Mossburn/Five Rivers)	-45.675	168.325	256	174	15-Apr
South Otago Rolling (Te Houka/Balclutha)	-46.225	169.675	70	184	6-Apr
South Canterbury Basin (Farilie Basin)	-44.125	170.825	300	172	9-Apr
South Canterbury Hill (Fairlie Hill)	-43.975	170.925	577	155	25-Apr

Temperature

The average and variation in current temperatures (1980-1999) around lambing, presented in Figure 1, indicate that the temperature into which lambs are being born is relatively constant across the regions. This mainly reflects the seasonal growth pattern of pastures and will represent the timing of the beginning of significant spring growth to support the increasing feed demand of a ewe once lactation begins.

Figure 1. Variations in the present average temperature from two weeks before until three weeks after mean lambing date over twenty years (1980-1999) for 7 sites (box represents 1 standard deviation around the mean, lines represent maximum and minimum readings).



The variation of temperature is represented by the box and whisker plot. The box represents one standard deviation from the mean, or approximately two thirds of the seasons recorded. The whiskers indicate the maximum and minimum temperatures. The data indicates that the minimum temperature recorded is more the exception that the norm, as the majority of the readings are clustered more towards the maximum, as represented by the relative lengths of the minimum and maximum lines.

Average temperatures (Table 2) during lambing rose in all regions by between 0.6 and 1.2^{o}C, as predicted by the global models. This provided an opportunity for farmers of changing lambing date, by, on average 10 days. In regions where summer moisture deficits are now, or will be an issue in the future, this advancement will be particularly important to continue a supply of finished lambs before the onset of the summer dry period.

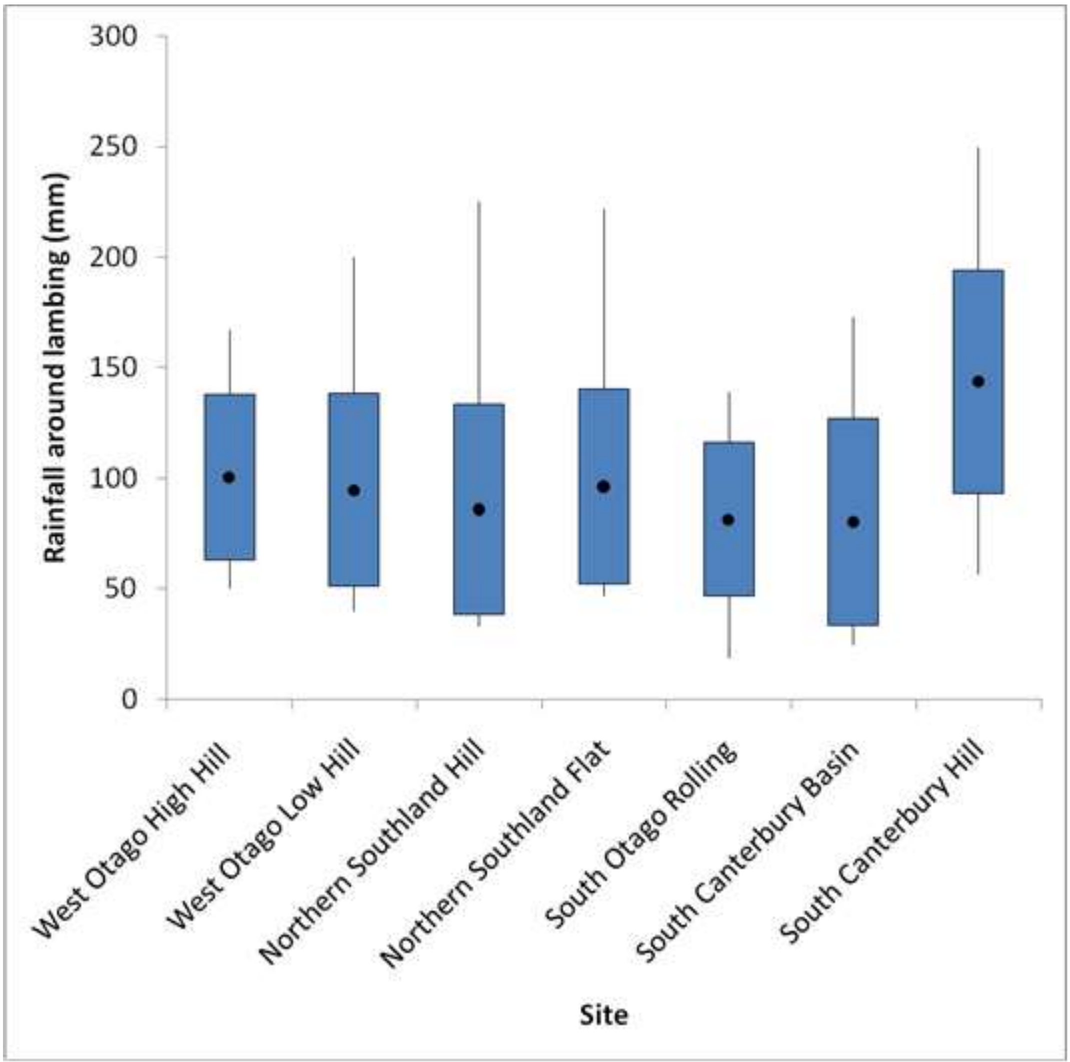
Table 2. Mean temperature before and during lambing at 7 sites throughout the lower South Island at present (1980-1999) and in three future (2030-2049) climate change scenarios

	Average temperature (^{o}C)			
Site	Present	Future B1	Future A1B	Future A1F1
West Otago High Hill	7.29	7.74	7.99	8.30
West Otago Low Hill	8.24	8.69	8.94	9.27
Northern Southland Hill	6.42	6.92	7.21	7.58
Northern Southland Flat	7.17	7.68	7.98	8.35
South Otago Rolling	7.98	7.82	8.12	8.50
South Canterbury Basin	7.05	7.65	7.99	8.41
South Canterbury Hill	7.60	8.11	8.39	8.75

Rainfall

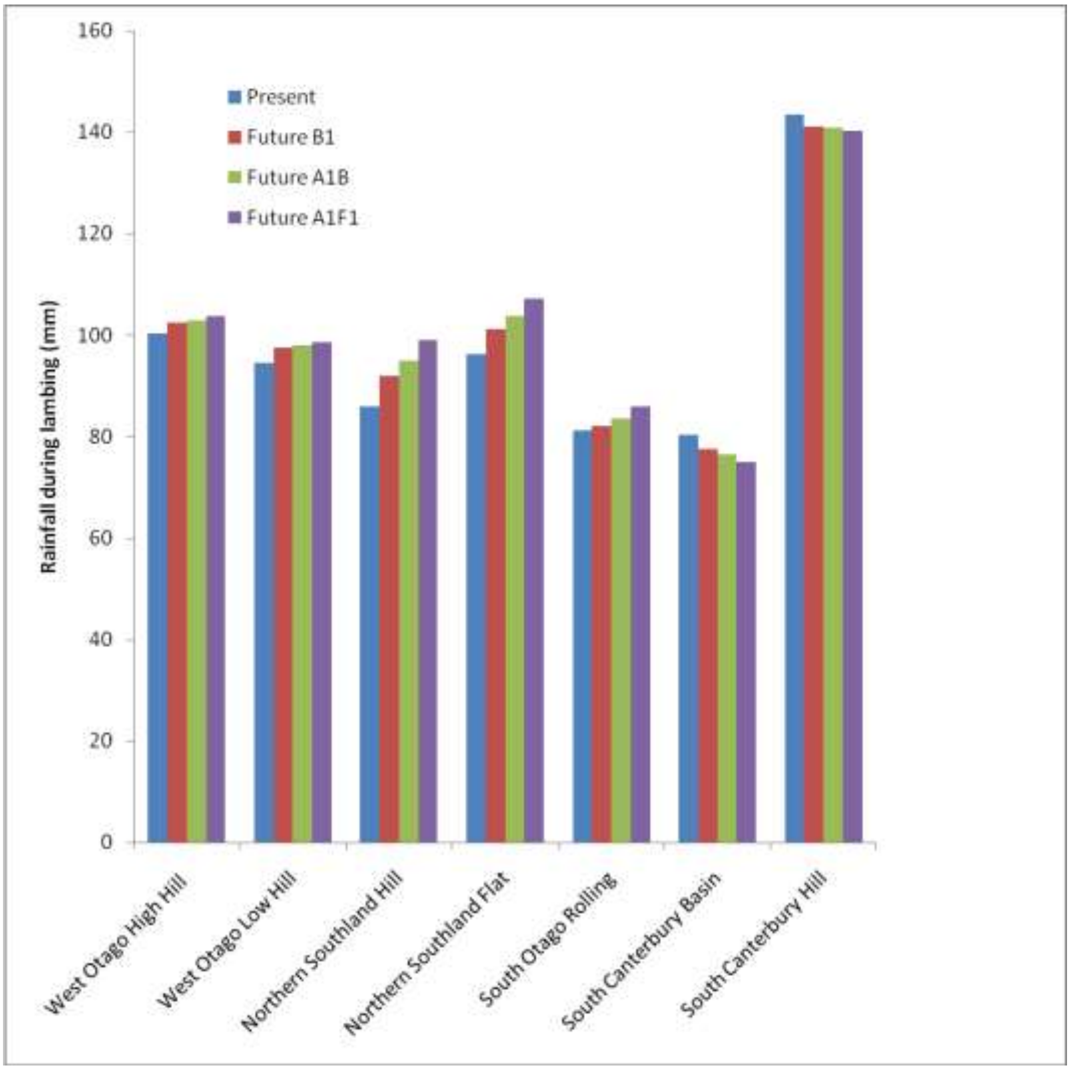
Rainfall during lambing was variable, depending on region (Figure 2). South Otago and South Canterbury Basin were slightly lower than Northern Southland and West Otago, while South Canterbury Hill had the highest average rainfall. The most variable rainfall amounts were at the Northern Southland and South Canterbury Hill sites. South Otago was the least variable. Of note with these rainfall patterns is the high variability in all results. The difference in rainfall around lambing from year to year ranged by between 120 and over 200 mm between years at any one site. This extreme range in rainfall means that farmers are already dealing with high variability in the current climatic extremes.

Figure 2. Variations in the present average rainfall from two weeks before until three weeks after mean lambing date over twenty years (1980-1999) for 7 sites (box represents 1 standard deviation around the mean, lines represent maximum and minimum readings).



When predicting potential rainfall for the future the more southern and western sites had small increases in the average amount of rain during lambing, while the South Canterbury sites had mild decreases (Figure 3).

Figure 3. Current (1980-1999) and future predicted (2030-2049) average rainfall around the time of lambing for 7 sites throughout the lower South Island.



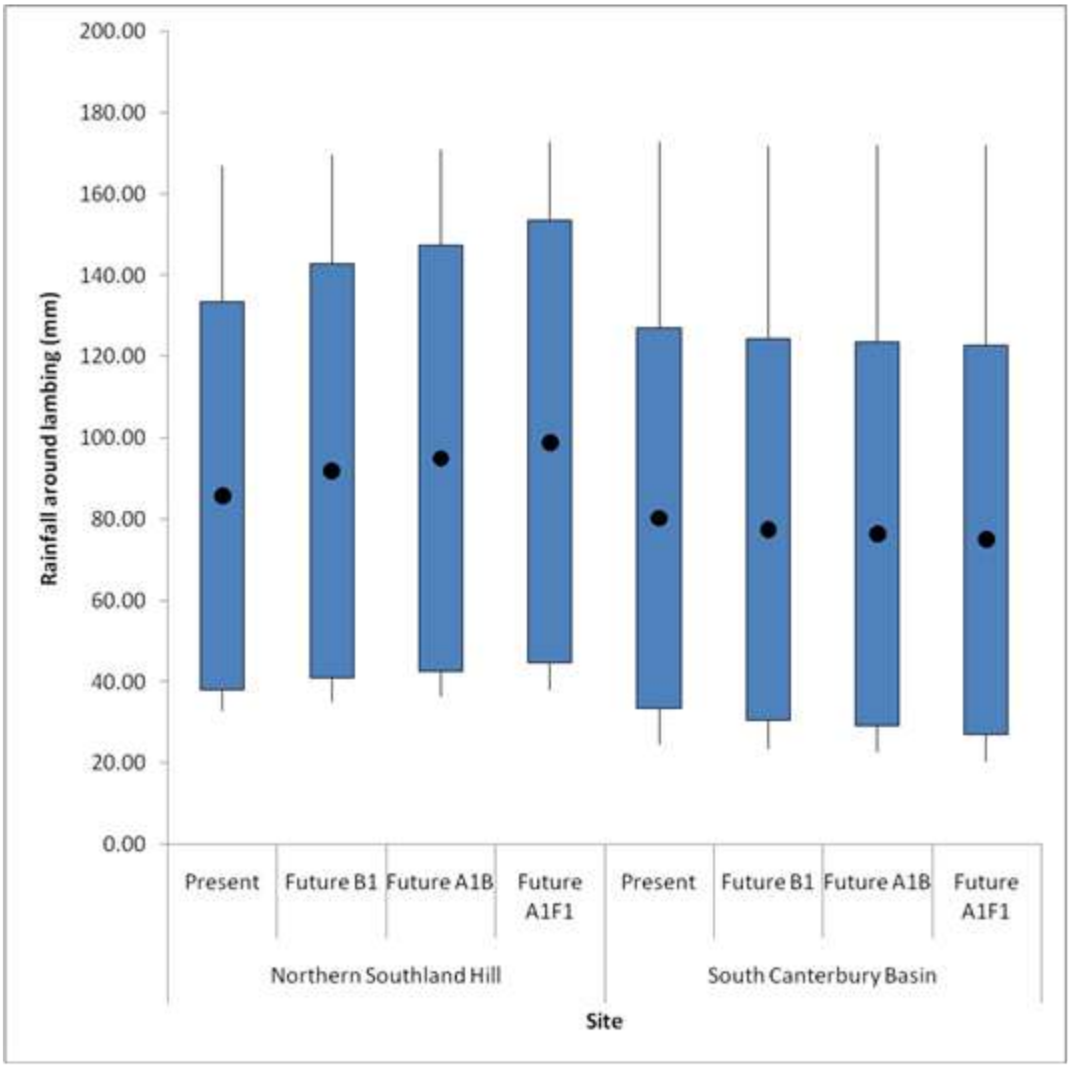
The variability in rainfall is compared at the Northern Southland Hill and South Canterbury Basin sites (Figure 4). These are chosen because they have the greatest increase and decrease in rainfall respectively. In general the actual variability in rainfall and the extremes are affected only slightly, though the standard deviation (where approximately 66% of the rainfall values will fall) does increase. It is thought that this relatively small shift in extremes is due to an already highly variable climate.

Figure 4. Variability of the rainfall in future (2030-2049) climate predictions compared to that of the present (1980-1999) for 2 sites (box represents 1 standard deviation around the mean, lines represent maximum and minimum readings).

Wind run

Wind run is not predicted by the NIWA VCS and therefore actual records from meteorological stations close to the chosen sites, or representative of the sites were used. Therefore, this information is less accurate, though does provide some degree of information about the variability of the impacts of wind chill. The windiest sites were the Northern Southland and South Canterbury hill sites (0). This is consistent with previously reported summaries of wind run, noting that wind run increases with elevation at a rate of 10% for every 100 m increase in altitude (Dawber & Edwards 1978). This does not appear to be reflected in the West Otago Hill predictions, which may reflect the site of the met station from which the records were taken. Another reason for lower wind run than expected may be the point nature of the data, having been extrapolated from a single reading at 9 am each morning, rather than a full daily wind run. This highlights the problems that the VCS has in attempting to predict wind run, as very few stations have full records for actual wind run.

Figure 5. Variations in the present average wind run from two weeks before until three weeks after mean lambing date over twenty years (1980-1999) for 7 sites (box represents 1 standard deviation around the mean, lines represent maximum and minimum readings).



The calmest site was the South Canterbury Basin, reflecting previous observations that the inland South Island basins are much calmer than surrounding hills and more exposed sites (Cossens 1987).

Climate modelling conclusions

Variability in New Zealand climate is a given. Future trends towards more variability will only reinforce the types of resilient farms systems that are now in place.

Increases in temperature due to predicted global warming will aid in improving lamb survival, or will provide the opportunity for farmers to lamb slightly earlier in the cool southern climates.

Changes in rainfall are small, and current variability seems to be conserved, with maximum and minimum rainfall amounts over lambing remaining relatively similar.

Wind run records are limited and prediction of future wind run is not currently available. However, given the trends with temperature and rainfall, variation in current wind run may be adequate to help predict future lamb survival.