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ESTIMATING THE EFFECT OF GLOBAL CLIMATE CHANGE ON OROGRAPHIC PRECIPITATION

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1. INTRODUCTION

Rainfall and snowfall are critical factors affecting the New Zealand economy. As weather and climate change over the coming decades strategic planning must incorporate forecast changes in precipitation patterns and amounts. By varying the input parameters of a simple parametric model of orographic rain we are able to produce estimates of the changes in the orographic component of individual precipitation events under various global climate change scenarios. Because New Zealand is a relatively mountainous nation surrounded by ocean, the orographic component is significant and contributes as much as 90% to the total precipitation in some areas.

2. THE MODEL

A very simple model developed by Sinclair (1994) has been used in the initial studies, since it has been well tested in field campaigns targeting orographic precipitation (Gray and Austin, 1993). The horizontal wind field is determined externally. Vertical motion is calculated assuming the near-surface air follows the terrain and the lifting decreases with height above this at a rate parameterised in the model. Conversion from vapour to precipitation is instantaneous but realistic fall speeds allow for horizontal transport of the precipitation.

3. STUDY AREA

The technique has been applied to the southern part of the North Island of New Zealand. The orography of this region is dominated by the Tararua Ranges, a small mountain chain running roughly South-West to North-East some 30 km wide and around 1000m high with peaks to 1500m. There is a narrow coastal plain around 10 km wide to the West and another 30 km wide to the East.

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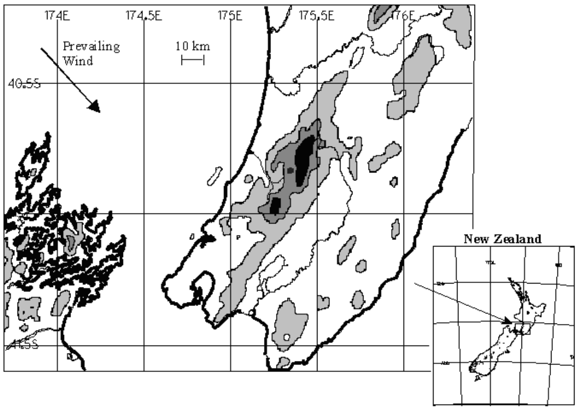

Figure 1: Map showing the location of the study area, covering the southern part of the North Island of New Zealand.

2. SCENARIOS

The climate scenarios have been drawn from the review by Mullan et al. (2001) of recent results from transient climate models. They concluded that by 2100 there would be an air temperature rise near the surface of approximately 2ºC around the southern North Island. Wind speed changes were not so well defined but an estimate of a 10% (or 5 kt) increase during precipitation events is consistent with the models and other results cited by Mullan et al. (2001).

5. RESULTS

Results suggest that, for the area chosen, a 2ºC change in temperature would lead to a 6 to 7 % increase in both maximum and catchment averaged precipitation rates for the storm case modelled. Similar increases are seen from a 10% increase in wind speed. Increasing both temperature and wind speed together leads to an increase in precipitation of just under 16% (Tables 1 & 2).

These changes describe only the orographic rain rate component and only the part of that due to increases in wind speed and temperature, and do not address other factors such as the changes in frequency or duration of storms. Nonetheless, the increases are significant and sufficient to indicate that regional climate change research needs to incorporate orographic precipitation processes to improve the reliability of climate change forecasts in regions such as New Zealand.

Table 1: Peak rainfall rates (mm.hr^{-1}) in the area, for the various scenarios (wet-bulb potential temperature Θ_W of 17 and 19 ºC, wind speed 40 and 50 kts) and the percentage changes with change in scenario.

	temperature (ºC)		increase in peak rainfall (%) due to temperature increase
	17	19	
windspeed (kts)			
45	15.1	16.0	6.0
50	16.1	17.0	5.6
increase in peak rainfall (%) due to wind increase	6.6	6.3	12.6

Table 2: Catchment averaged rainfall rates (mm.hr^{-1}) for the various scenarios (wet-bulb potential temperature Θ_W of 17 and 19 ºC, wind speed 40 and 50 kts) and the percentage changes with change in scenario.

	temperature (ºC)		increase in catchment average rainfall (%) due to temperature increase
	17	19	
windspeed (kts)			
45	10.2	10.9	6.8
50	11.1	11.8	6.3
increase in catchment average rainfall (%) due to wind increase	8.8	8.3	15.7

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