Wind Engineering Related research at NIWA New Zealand

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1 INTRODUCTION

Over the past several years there has been renewed interest in wind engineering related research at New Zealand's National Institute for Water and Atmospheric Research (NIWA). This interest has been sparked by (i) a number of recent severe wind events in New Zealand, (ii) the inclusion of severe winds as a hazard in RiskScape, (iii) the development of the GERRIS CFD model and it's participation in the Bolund intercomparison (http://bolund.risoe.dk), and (iv) a greater investment by utility and network companies in infrastructure vulnerable to extreme winds.

The purpose of this presentation is to provide an Australian audience with a summary of recent and ongoing wind engineering related research at NIWA and the New Zealand framework in which this research is conducted. Additionally, we will be seeking feedback on an upcoming observing, modelling and wind-tunnel testing program to be carried out over the next 15 months. This research project is a joint effort in co-operation with GNS, OPUS, and the University of Auckland

2 BELMONT TOPOGRAPHIC MULTIPLIER PROJECT

New Zealand's hilly, often mountainous, terrain is oriented approximately SSW-NNE along the spine of both its main islands and is in the path of often strong, predominantly zonal (westerly) wind that occur at these latitudes. The wind flow is strongly influenced by the hilly terrain over which it passes, with both valleys and hill crests experiencing stronger, and in some instances much stronger, wind speeds than over flat terrain. These topographic effects on wind speed are recognised in the AS/NZS Loading Standards 1170[1] – a reference document for the NZ building code which prescribes the minimum strengths and stiffnesses of buildings.

Within the Standard wind forces are prescribed as the product of the wind's kinetic energy (mV^2) and a shape-related pressure coefficient, C_{pe}. Topographic enhancement is allowed for with a topographic multiplier, M_t ($1<M_t<1.73$ resulting in up to 3x wind force), which depends on hill's shape and steepness, and the site's distance from the hill crest. The NZ Standard also requires a Lee Multiplier, M_L be applied within Lee Zones. While the physical basis for including these effects is clear, the methods by which these factors are calculated is unfortunately weak and when determining Lee Zones possibly ambiguous. This fact combined with some recent severe wind events (2004 Molesworth Windstorm[2], 2007 Taranaki Tornadoes[3], 2008 Greymouth windstorm[4], and the 2010 Wellington southerly storm, in which gusts of 60 m/s and 77 m/s were recorded at 2 sites – both with significant topographic effects involved) and the inclusion of winds as hazard in RiskScape has caused renewed[1] interest in wind engineering and a

[1] The establishment of a "platform" approach to funding natural hazards science in New Zealand and the addition of some "new" money has had an immediate impact in that it has provided a co-operative framework for scientists at NIWA, GNS, Opus, and the University of Auckland to collaborate on this research.

questioning of the guidance offered by the loadings code. Consequently a new research project has just been funded which (as of April 2010) will provide the basis for reviewing the calculation methods in the Standard for M_t and hopefully at a later stage provide clarity with respect to the demarcation of sites within Lee Zones. This research project will focus on measurements and modelling of topographic speed-up effects within the Belmont Regional Park near Wellington. The area is typical of much New Zealand hill country (see Fig. 1) where infrastructure, is located. The terrain is not simple, a lower range upstream and parallel to the highest elevations adds complexity to the situation.

Fig. 1 Image looking NW over hill-country typical of Belmont Regional Park near Wellington. The circled red-cross marks the position of a 60 m mast with 4 anemometers on it at an elevation of about 250 m . The orange line marks the position of part of a High Voltage Transmission line

Measurements are planned to be made during a 3 week period in late spring[2] 2010. While a design wind event is not anticipated in such a short period, it is long enough that a strong northerly-north west wind is a virtual certainty. Eight portable masts (5 m high) and 2 sodar will be deployed, and access to data from a 60 m mast with 4 anemometers has been negotiated. While the sodar performance will be compromised for winds greater than about 20 m/s, we plan to place the sodar in less windy locations, and still expect some useful information to be obtained for speed-ups estimates. Siting of the masts will be aided by prior GERRIS[5] CFD modelling (see GERRIS topography in Fig 2.) under idealized NW flow . Additional wind tunnel estimates using a 3-D replica of the terrain will be made by OPUS to compare against both GERRIS and the observations. The results will be compared against calculations made using the methods as outlined in the loadings code.

[2] The period has to be after lambing as the park is a working farm owned by Wellington Regional Council.

Another aim of the research is to quantify the wind forces generated on towers of various configurations, which in the case of both distribution and communication networks are often located at or near hill crests. The provision of pressure sensors and wind gauges across existing towers is expected to enable more appropriate drag coefficients to be determined for such towers, thereby providing justification for determining strengthening provisions either as additional appendages are added to existing towers, or as new towers are commissioned. It is intended that these elements will be included in each phase of the experimental programme, with the results being used as justification for alternative design solutions when tower modifications are required.

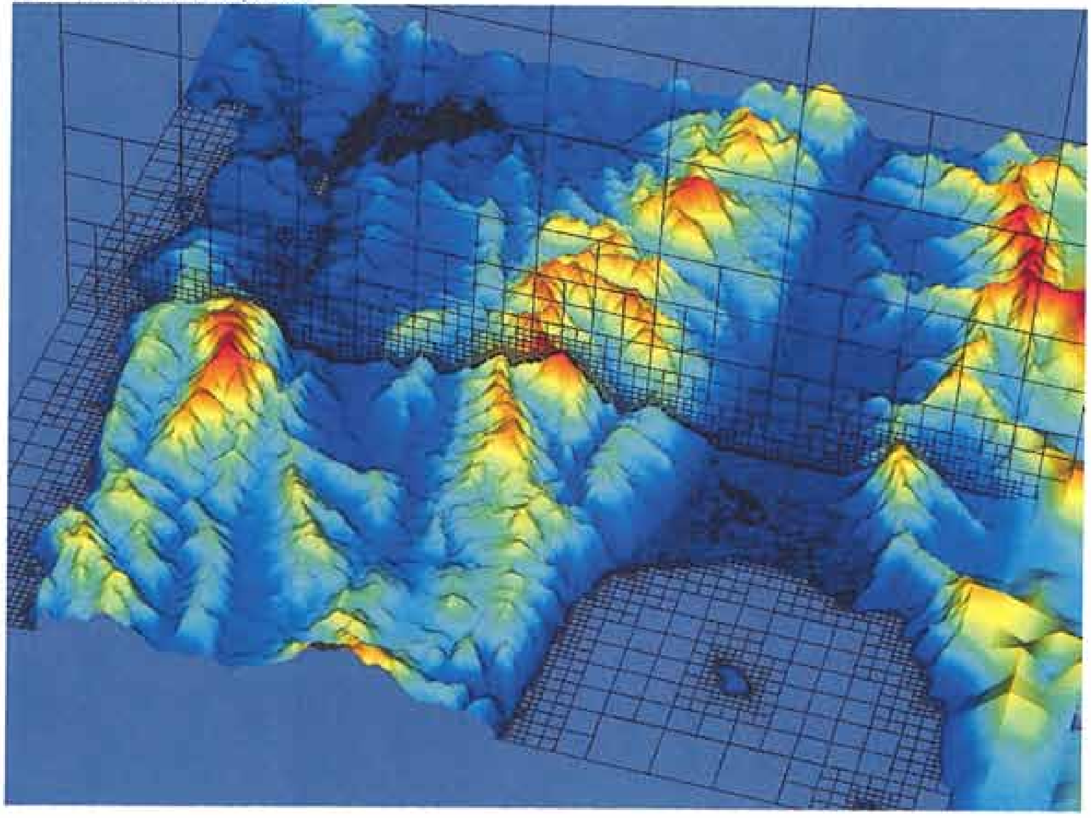

Fig. 2 GERRIS topography and adaptive grid along a NW-SE cross-section through Belmont Park (western half of the domain).

3 AREAS OF ONGOING RESEARCH WITHIN RISKSACPE

At NIWA additional wind engineering related research falls under RiskScape (which is now also part of the Natural Hazards platform). Part of the planned research is to make a relatively high number (at least 8) of wind observations (3 second intervals) during an extreme wind event – where an extreme event is defined as one causing wind damage to houses. GERRIS modelling of the event will also form part of this project. Three New Zealand cities (Wellington, Christchurch, and Napier) have been chosen and sites selected beforehand for which portable weather stations can be deployed. The sites have been chosen as being in generally exposed suburbs. The project does depend on accurate weather warnings and sufficient advance notice to deploy he equipment. Staff assigned to the post-event damage survey will also be sent to the region at the same time as the equipment is deployed, so the survey can be done as soon after the event as possible. In practice these plans have so far been difficult to execute as the forecast models struggle to differentiate between strong, severe, and extreme wind events. The Wellington wind storm of March 12 2010, mentioned earlier, would have been an ideal case but the forecasts while getting the timing of the vigorous southerly change correct to the exact hour were too coarse (horizontal resolution) to give winds exceeding the pre-established alert thresholds. We have also had a false-alarm in which the instruments were deployed needlessly in Christchurch. In early June 2010, a very large and deep low pressure system which brought heavy rains and caused widespread flooding in the eastern South Island was also forecast to bring 40-50 knot sustained easterly winds over Banks peninsula and exposed (to the east) parts of Christchurch. The very strong winds never eventuated although a strong (but ho-hum) southerly did eventually occur . the portable stations had been dismantled by then.

Another part of ongoing work within RiskScape is the development of a framework to allow a clear comparison of risk between the different types of hazards (Earthquake, Tsunami, flooding, storms (wind) and land-slides. The various hazards are all analysed in different ways, so the best common format, which would allow comparison across them all, is the loss curve. This gives the annual probability that any given level of loss will be equalled or exceeded. Loss curves for the different hazards can be of different shape, although all will be monotonically decreasing measures of probability with increasing loss. Wind is problematic in that for convective or tornadic events causing extreme winds there is a random element in terms of location and the damage done will more than likely depend on direction.

4 REFERENCES

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