Assessing accuracy of wind hazard calculations using climate modelled data

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1 INTRODUCTION

As part of the Climate Futures for Tasmania project (CFT) Geoscience Australia's Risk and Impact Analysis Group (RIAG) is conducting a severe wind hazard assessment for Tasmania under current climate conditions as well as two future climate scenarios. The assessment uses climate-simulated data generated by a high resolution regional model. A poster presented to this workshop shows the main results of the project [1]; a brief description of the methodology developed for the project is discussed in a paper also presented to this workshop [2].

In this paper three possible sources of error in the calculation of the severe wind hazard (using the methodology discussed in [2]) will be examined and recommendations on ways to improve the model results will be provided.

2 THE STATISTICAL MODEL

The core of statistical model is the fitting of extreme value (EV) distributions to point-specific anemometer observations. EV distributions allow wind analysts to make inferences about the magnitude and frequency of extreme events well beyond the range of years available in the observed record.

The statistical model uses the Generalised Pareto Distribution (GPD) to calculate the return period (RP) of wind hazard. Its main feature is an automatic algorithm to calculate the appropriate threshold to fit the GDP to given maximum daily wind speeds [3].

3 REGIONAL CLIMATE MODEL

The climate simulations used for this project were produced by CSIRO's Conformal-Cubic Atmospheric Model (CCAM). Simulations focusing on Tasmania on a lat-long grid of 0.1 degrees, using IPCC scenario A2, for the period 1960 to 2100 were utilized. Five nested coupled general circulation models were used to drive these CCAM simulations (dynamic downscaling) as shown in Table 1 [4]. We extracted maximum hourly mean wind speeds (10 metre height) from each of the five ensemble components for the period 1961-1990 (current climate), using the NCO Tools. These speeds were then transformed to maximum daily mean wind speed using the R package 'zoo'.

4 CLIMATE MODEL BENCHMARK

The benchmark used in this project is the current climate simulations provided by the NCEP/NCAR reanalysis project extracted for the period (1961-1990). This project uses a state-of-the-art analysis/forecast system to perform data assimilation using past data from 1948 to the present [5]. The resolution of the NCEP/NCAR reanalysis data has been dynamically downscaled to the same resolution of the five-member ensemble using CCAM [4].

5 POSSIBLE SOURCES OF ERROR

To assess the quality of the wind hazard results using climate-simulated data, the 500-yr RP of wind hazard for a number of combinations of the five-member ensemble will be calculated and compared against the benchmark.

Fig. 1 shows an elevation contour map of Tasmania with the grid used in this project. The state contains mountainous regions (maximum elevation approx 1500 meters) in the west and north east of the island. Fig. 2 shows the 500-yr RP of mean wind speed in Tasmania calculated by the statistical model using the benchmark wind speeds. Only wind speeds under current climate conditions are considered. The black circles show the location of three selected wind recording stations (at Hobart, Launceston and Wynyard airports). All wind speeds are in m/s.

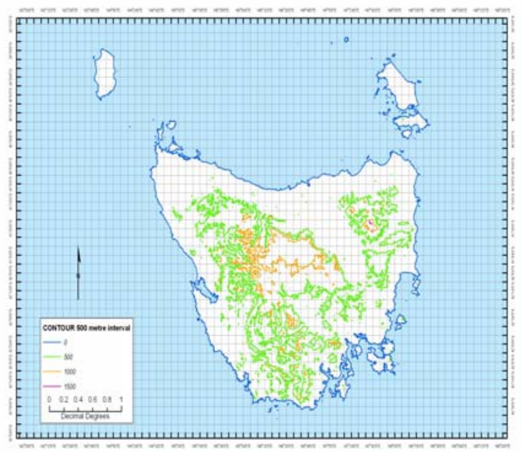

Fig. 1. Contour map of Tasmania.

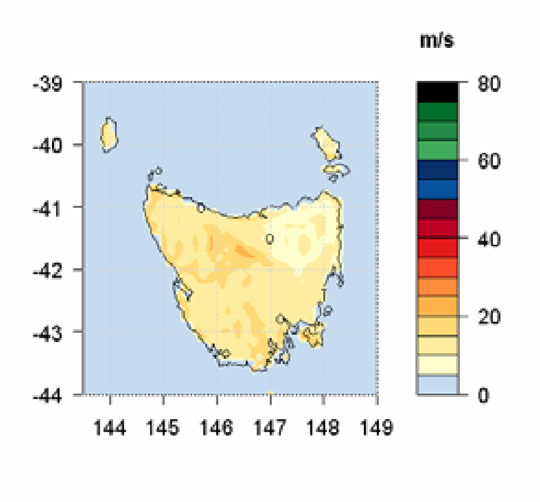

Fig. 2. Benchmark 500-yr RP mean wind speed.

5.1 Comparison of ensemble members with benchmark

Fig. 3a,b,c,d,e show the difference in percentage between the benchmark and each one of the ensemble components for the 500-yr RP of mean wind speeds. Table 1 presents the mean absolute error (MAE) between each component and the benchmark, where RP_i = 500-yr RP of ensemble member *i*; RP_{benchm} = 500-yr RP of benchmark and *n* is the number of cells in grid (only land cells used).

The difference in percentage is given by the expression,

$$\text{Diff (\%)} = |RP_i - RP_{benchm}|/RPbenchm \qquad (1)$$

The MAE is given by:

$$MAE = (1/n)\ \boldsymbol{\Sigma}\ |RP_i - RP_{benchm}| \qquad \text{for all cells } i \qquad (2)$$

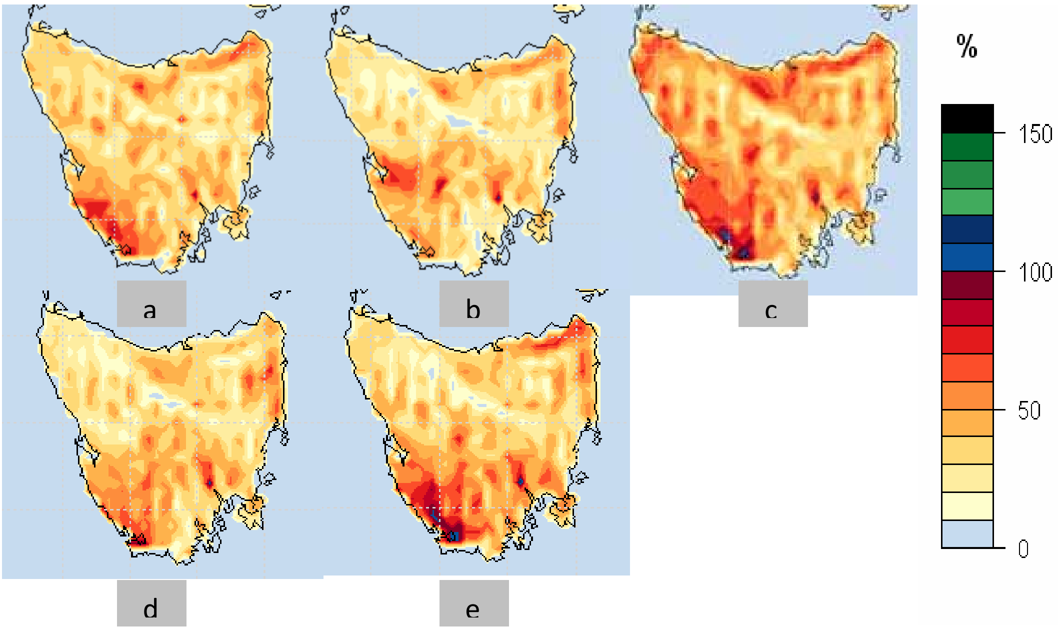

Fig. 3. Percentage difference of ensemble member 500-yr RP with benchmark.

Table 1. CCAM drivers

	Ensemble member	MAE (Figure 3)
a	CSIRO mark 3.5	5.1
b	ECHAM 5	4.5
c	GFDL 2.1	6.5
d	MIROC 3.2	4.8
e	UK Had MC3	5.6

Table 2. MAE of test 1, 2 and 3.

Test	Description	MAE
1	500-yr RP of average wind speeds	5.34
2	Average of the 5 component 500-yr RP	5.28
3	Joining all simulations into a single vector	6.80

5.2 Test 1: Comparison of the five-member average with the benchmark.

Fig. 4 shows the difference of the 500-yr RP five-component *average* mean wind speed and the benchmark. The average wind speed was calculated as the average time-series of the individual five member time-series of wind speeds. Table 2 (test 1) presents the MAE value.

5.3 Test 2: Comparison of the average RP using each member ensemble RP's

Fig. 5 shows the difference of the 500-yr RP five-component *average* return period and the benchmark. In this test the RP of each member mean wind speed was calculated first and then the average RP of the five calculated RPs was found. Table 2 (test 2) presents the corresponding MAE value.

5.4 Test 3: Comparison of joint five-member wind speeds with benchmark

In this test the wind speeds of each of the five-member ensemble were joined into a single vector of wind speeds. The joint vector is equivalent to 150 years of maximum daily wind speed data. Fig. 6 shows the difference of the 500-yr RP of the single vector and the benchmark, the comparison with the benchmark is summarised in Table 2 (test 3).

6 DISCUSSION AND RECOMMENDATIONS

The comparison of the ensemble members with the benchmark, summarised in Fig. 3 and Table 1, shows that the accuracy of the simulations produced by CCAM using each one of the GCM drivers presented in Table 1 varies greatly. The most accurate model is the German model ECHAM5 with a MAE of 4.5. The least accurate is the US model GFDL 2.1 with a MAE of 6.5. Australia's CSIRO model (Mark 3.5) rates third. The problem for most models is to accurately represent the wind conditions in the mountainous region of the south west. In practical applications the two or three more accurate ensemble members can be selected for wind hazard studies instead of using all ensemble members. This not only improves results but also reduces processing time.

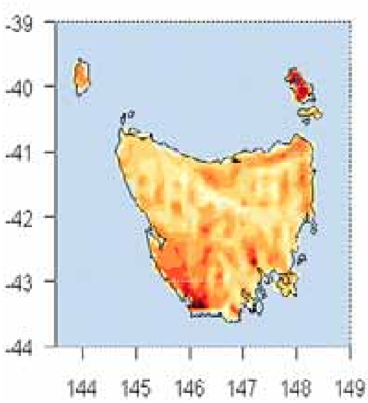

Fig. 4. Average wind speeds.

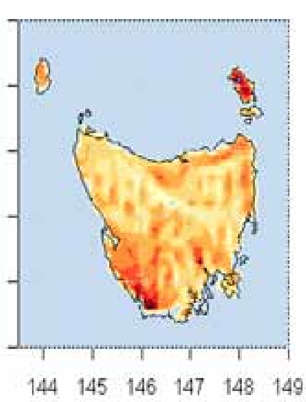

Fig. 5. Average 500-yr RP.

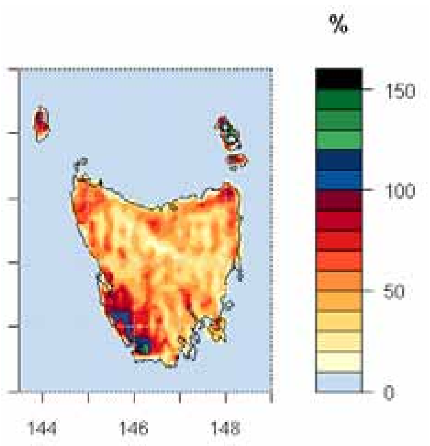

Fig. 6. All 5 sim in single vector.

Tests 1 and 2 are important because both calculate the ensemble RP using two different methods. In the former the average time-series wind speed is calculated and then its corresponding RP is found. In the latter the RP for each member wind speed is calculated first with a substantial increase in processing time. Fig. 4 and 5, and Table 2 show that there is almost no difference in terms of accuracy. The results presented in [2] were generated using Test 2. In Test 3 all simulations were joined to form a single vector instead of taking the average of the simulations as in Test 2. In this case there are more high values and as expected the 500-yr RP substantially increases with respect to Test 2. Processing a larger vector also increases CPU time.

For future work, differences between observed and CCAM-modelled mean wind speeds at the selected recording stations will be calculated and the bias introduced by CCAM area-average values assessed and methods to correct the bias explored.

7 REFERENCES

[1] Sanabria L.A., Cechet R.P. (2010). "Severe Wind Hazard using Dynamically Downscaled Climate Simulations - Results". Poster presented to the 14th AWES workshop. Canberra, August 5-6.

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[3] Sanabria L.A., Cechet R.P. (2007). "A Statistical Model of Severe Winds". GA Record 2007/12.

[4] Corney, S., J.J. Katzfey, J.L. McGregor, M. Grose, J. Bennett, C.J. White, G. Holz and N.L. Bindoff, Climate Futures for Tasmania technical report: methods and results on climate modelling, Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Tasmania, in press (due 2010).

[5] Kalnay et al. The NCEP/NCAR 40-year reanalysis project, Bull. Amer. Meteor. Soc., 77, 437-470, 1996 http://dss.ucar.edu/datasets/ds090.0/docs/bams/bams1996mar/bamspapr-bm.pdf.