Estimation of wind regime from combination of RCM and NWP data in the Gulf of Riga (Baltic Sea)

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Introduction

The Gulf of Riga is a semi-enclosed gulf located in the eastern part of the Baltic Sea. Reliable wind climate data is crucial for wind energy development however there are no long term observations offshore. The objective of this study is to create high resolution wind parameter datasets for the Gulf of Riga using a combination of climate and numerical weather prediction (NWP) models.

NWP → RCM (1981 – 2010) → Bias Correction Function

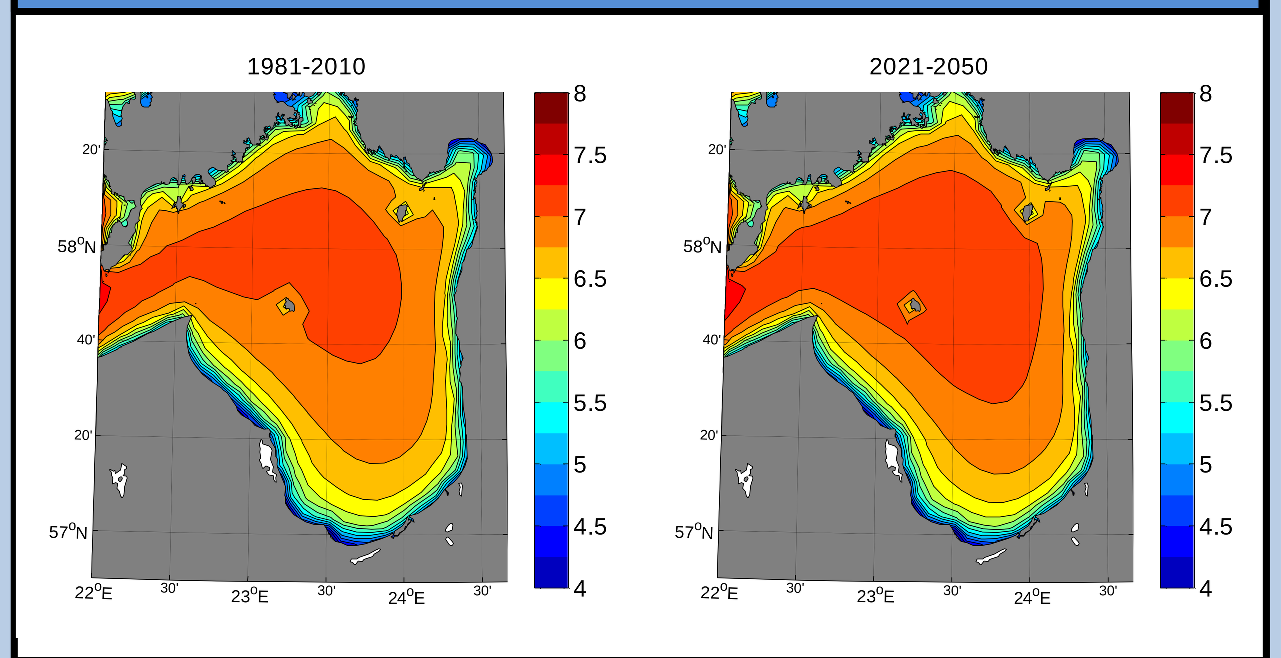
RCM (1981 – 2010) + Bias Correction Function = Bias corrected RCM (1981 – 2010)

RCM (2021 – 2050) + Bias Correction Function = Bias corrected RCM (2021 – 2050)

Results

Mean annual wind speed in the Gulf of Riga (m/s)

Bias corrected RCM



Conclusions

1. The ensemble of RCM predicts a slight increase (~ 1.5 %) in the mean annual wind speed over the gulf of Riga in the near future (2021-2050).
2. The bias correction method has been successfully applied to wind data using NWP model results instead of observations.
3. Results show that the annual mean wind speed in the central part of the Gulf of Riga is close to 7 m/s.
4. The lowest monthly wind speed is in spring (Apr, May), the highest is in the autumn months (Nov, Dec).

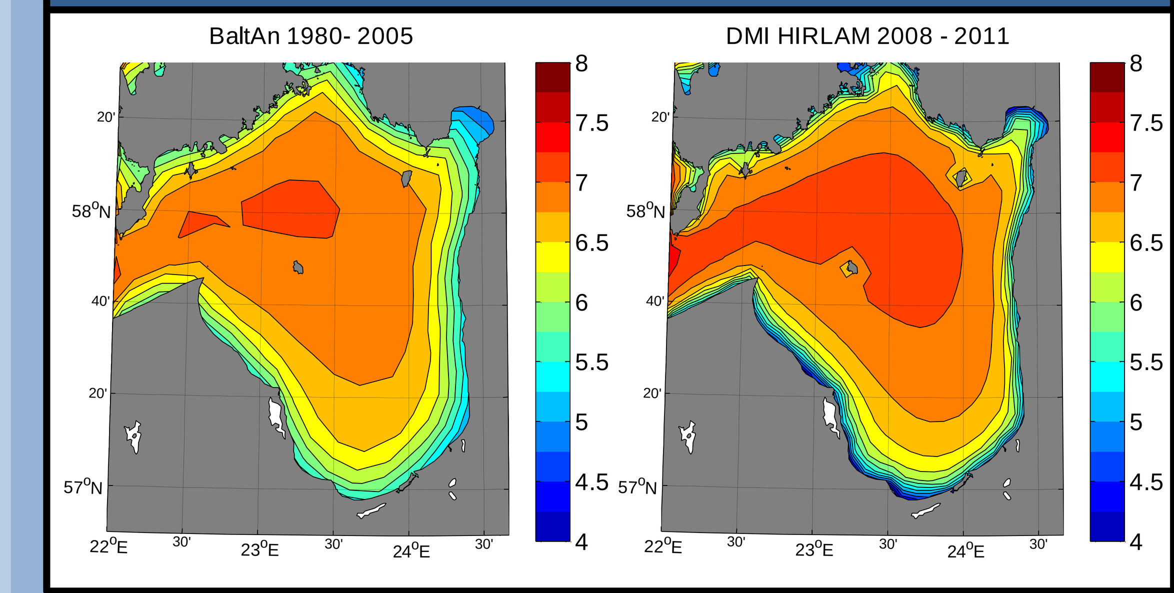
Bias correction method in detail

The bias correction method (Sennikovs, 2009) uses quantile mapping to acquire a dataset that has the temporal signal of the RCM with the statistical properties of the target model. To acquire future projections the same bias correction function as for contemporary climate is used.

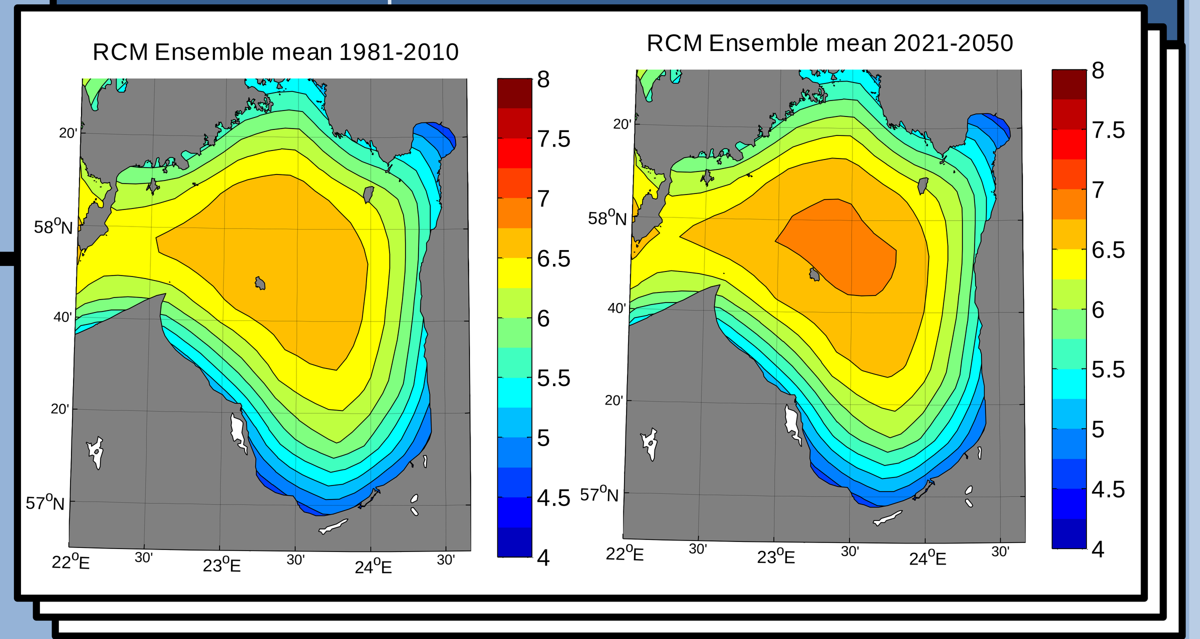
The models used in this study are an ensemble of Regional Climate Models (RCM, ENSEMBLES, 20 runs are considered) and as target model high resolution NWP data from DMI HIRLAM (Sass, 2002). Initial analysis was done using BaltAn65 reanalysis (Luhamaa, 2011).

Mean annual wind speed in the Gulf of Riga (m/s)

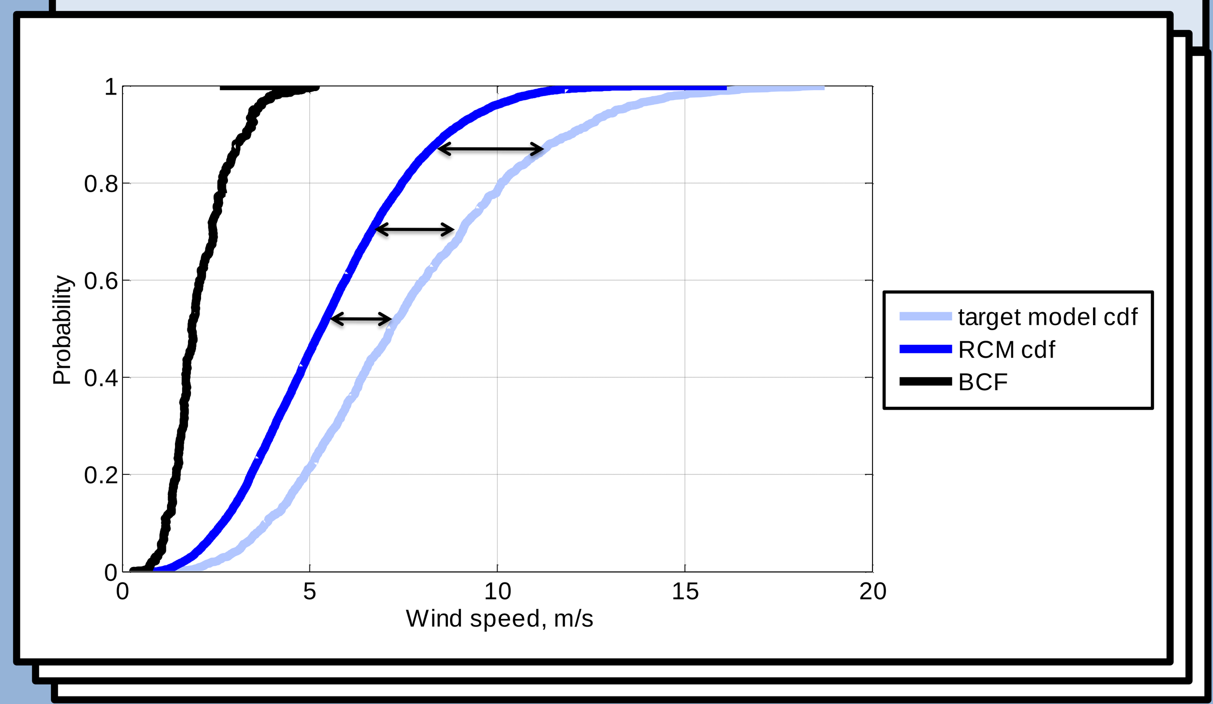
DMI HIRLAM (2008 – 2011, ~ 5 km resolution) or **BaltAn65** (1980 – 2005, ~ 11km resolution)



Ensemble of RCMs
spatial resolution ~ 25 km



Ensemble of Bias Correction Functions



The Bias Correction Function (BCF) describes the difference in cumulative distributions of wind speeds.
The value of the BCF is the difference in wind speeds as a function of probability.

1. In the bias correction process the grid of the target model is used and the RCM is interpolated to it.
2. For each grid point a cumulative distribution function (cdf) of the wind speed w is constructed using the entire available time period, for each RCM and high resolution model separately.
4. At each grid point for every RCM a bias correction function BCF is calculated using the RCM and the high resolution data set. The BCF is expressed as a function of probability

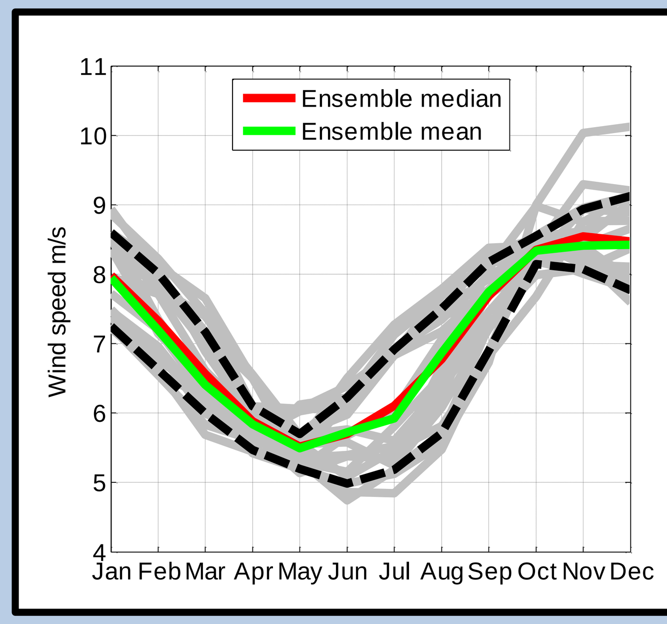
$$\mathbf{BCF_{RCM}(P) = w_{hi\text{-}res}(P) - w_{RCM}(P).}$$

5. The bias corrected RCM time series w'(t) are calculated as:

$$\mathbf{w'_{RCM}(t) = w_{RCM}(t) + BCF_{RCM}(P(w_{RCM}(t))).}$$

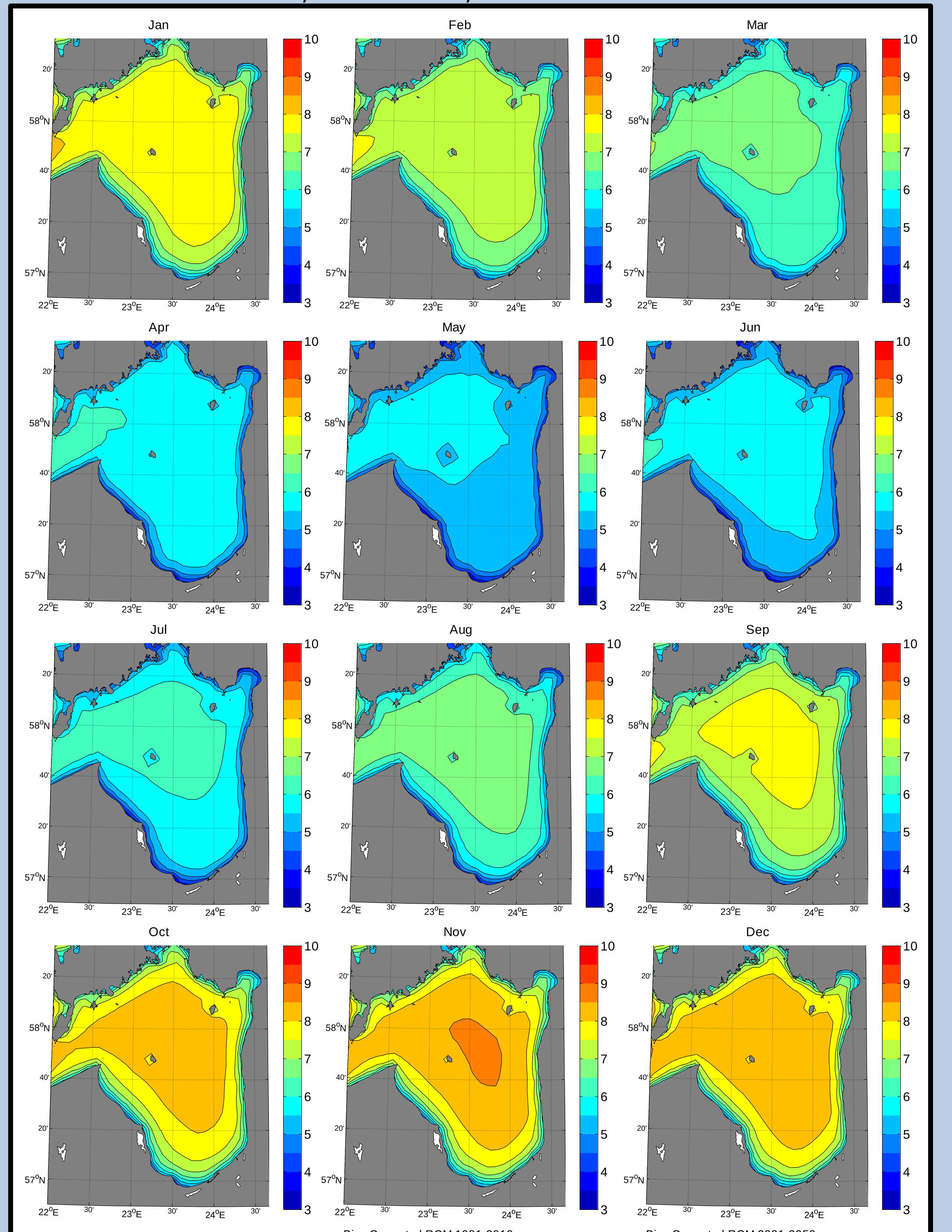
For each time series point $w_{RCM}(t)$ we find the cdf value for the given wind speed $P = cdf(w_{RCM}(t))$ and the value of the BCF corresponding to the probability .
The value of the bias correction function is added to the original wind speed to acquire the bias corrected value.
6. For future RCM datasets the future cdf are used but the BCF calculated from contemporary data is used.

Multimodal statistics and uncertainty estimation

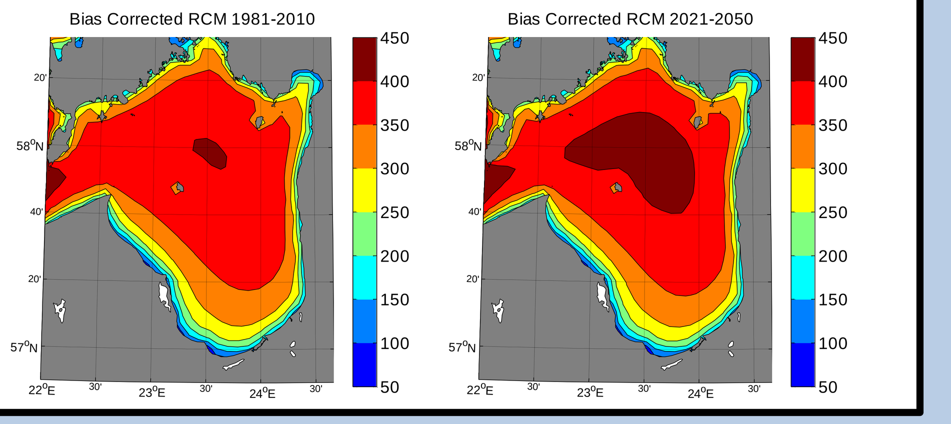


Monthly mean values of wind speed for a grid point in the centre of the Gulf of Riga. Bias Corrected RCM data, averaged for years 1981-2010. Each ensemble member is plotted in grey. Ensemble median and mean is shown in red and green. Dashed lines show the 17th and 83rd percentile of the ensemble.

Monthly mean wind speed (m/s)
bias corrected RCM, 1981-2010, ensemble median



Annual mean wind energy density (W/m^2) bias corrected RCM, ensemble mean



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References: Luhamaa A. et al. (2011), High resolution re-analysis for the Baltic Sea region during 1965–2005 period. Clim Dyn 36:727–738.
Sass BH. et al. (2002), The operational DMI-HIRLAM system 2002-version, Danish Meteorological Institute, Technical Report 2002
Sennikovs, J., Bethers, U. (2009), Statistical downscaling method of regional climate model results for hydrological modelling. 18th World IMACS / MODSIM Congress, Cairns, Australia.