www.csiro.au

Future Projections of the East Australian wave climate

M.A. Hemer[1], K.M. McInnes[1], and R. Ranasinghe[2]

[1] Sea Level Rise and Coasts Team. Climate Change Research Group, CAWCR, Australia.

2. UNESCO-IHE and TUDelft, Delft, The Netherlands.

Australian Government
Department of Climate Change

Australian Government
Bureau of Meteorology

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology

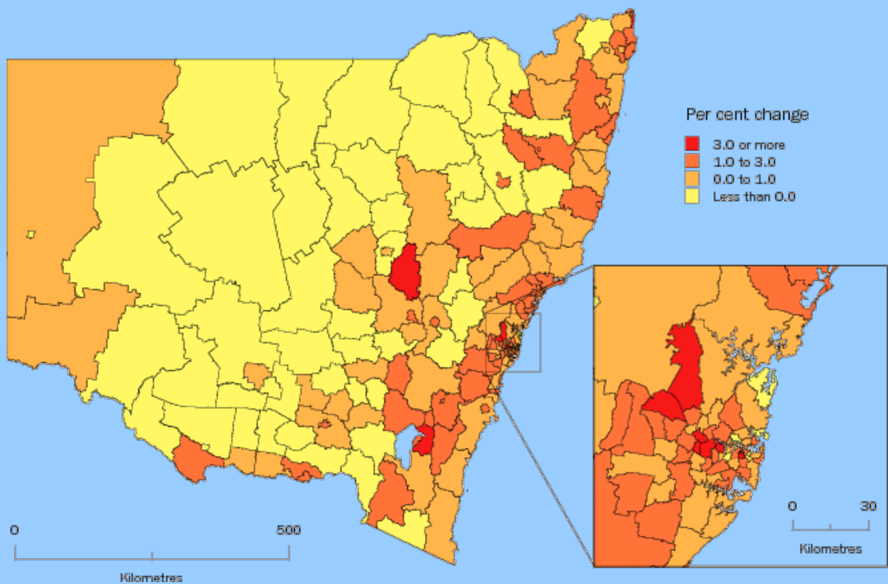
CSIRO

National Research FLAGSHIPS
Climate Adaptation

CSIRO

Motivation: New South Wales coastal impacts

Population Pressures



NSW Population: 7 million (1 in 3 Australians)

63% in Sydney. 20% other coastal LGAs.

1% pa Growth (~ 3% in coastal LGAs)

Source: ABS

Climate Pressures

Photo: Narrabeen Beach (Andrew Short)

Present climate:

Coastal hazards cost NSW Govt $AU 200million/yr

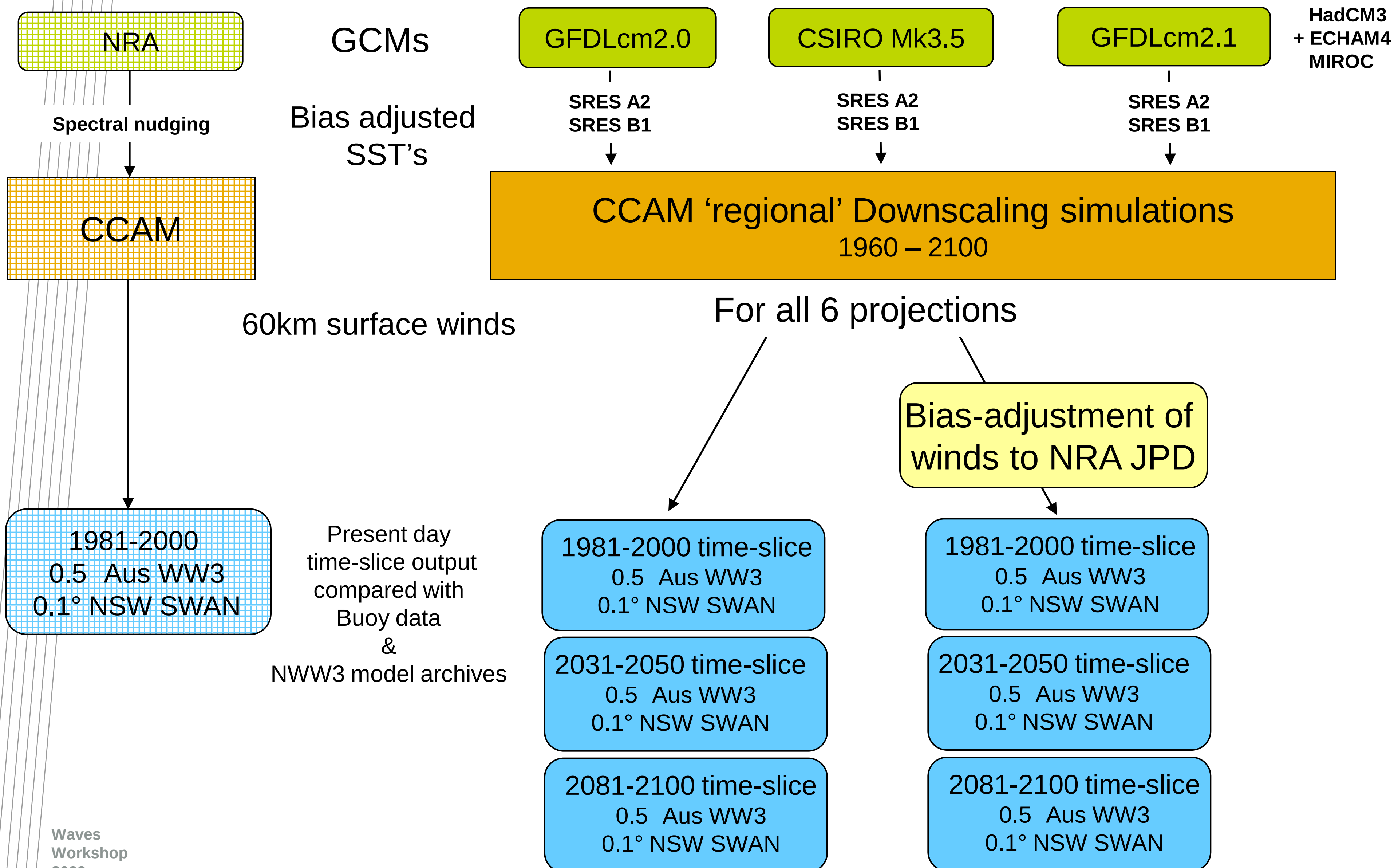
Future climate (surge and SLR impacts)

➢200,000 buildings at risk.

20 cm SLR + 1 in 50yr storm surge

⇒ ~110 m retreat of Narrabeen Beach, $AU 230million local damage

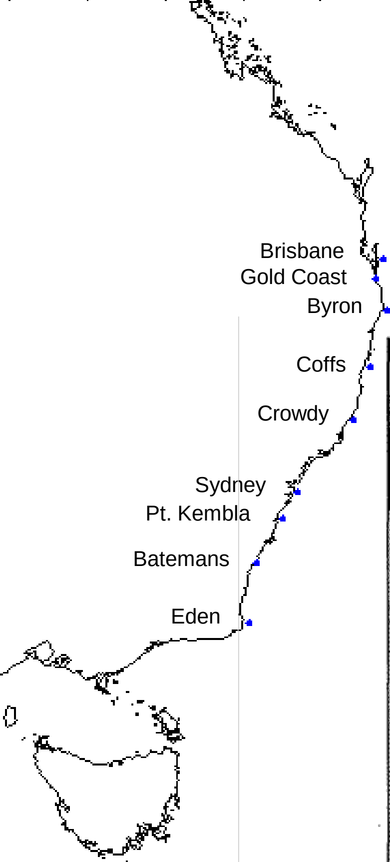
Methodology



Conclusions

- Bias adjustment of CCAM winds is required to significantly improve present-climate wave model to waverider buoy fit
- Surface winds bias-adjustment is a greater adjustment than projected climate change, or ensemble variability.
- NSW Wave Model present-climate Hs distribution has the same distribution ($p<0.05$) as buoy Hs distribution.
- Modelled present-climate Tp and Dp distributions differ significantly from buoy distributions (but provide a better relative fit than NWW3 archives)
- Preliminary projections (single ensemble (CSIRO Mk3.5) for single scenario (SRES A2)):
  - Decreasing wave height along the NSW coast (~1cm/decade decrease in mean Hs), brought about via decreasing frequency of mid-latitude (extra-tropical) cyclones.
  - Less southerly events, leads to anticlockwise rotation of mean wave direction (~1 /decade).

NSW Wave climate



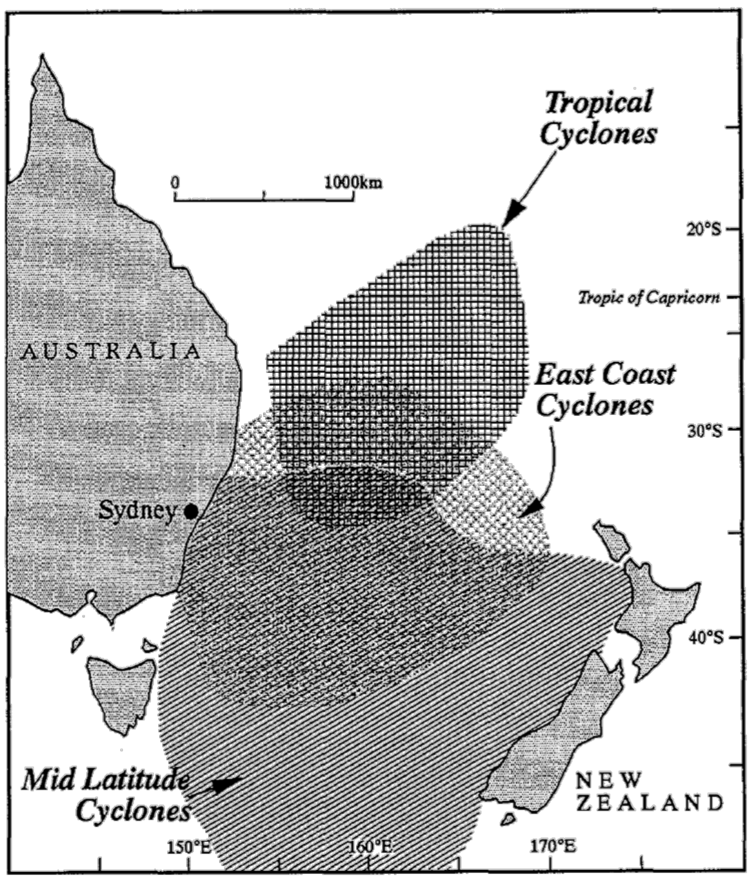
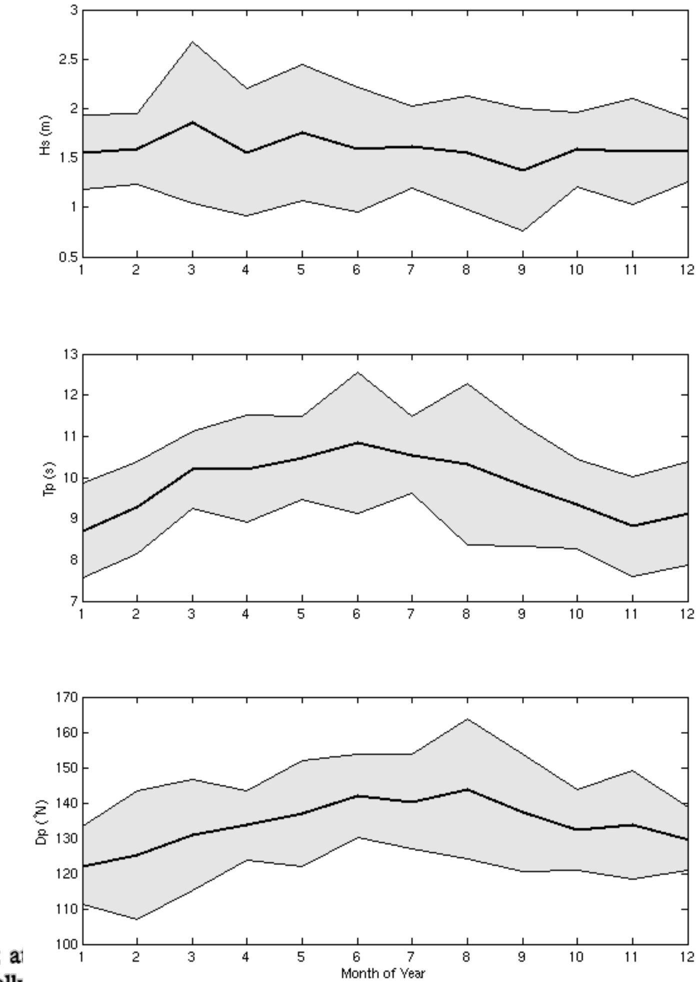


Fig. 13. Summary of type and area of major wave generation for cyclonic waves arriving at Sydney. Note that cyclones travel in and out of these areas but, while in the areas, will usually produce waves which reach Sydney. This summary is based on the data in Figs 9, 10 and 11.

Sydney waverider mean annual cycle



(Short and Trembanis, 1992)

Dynamically Downscaled Regional Climate Projections

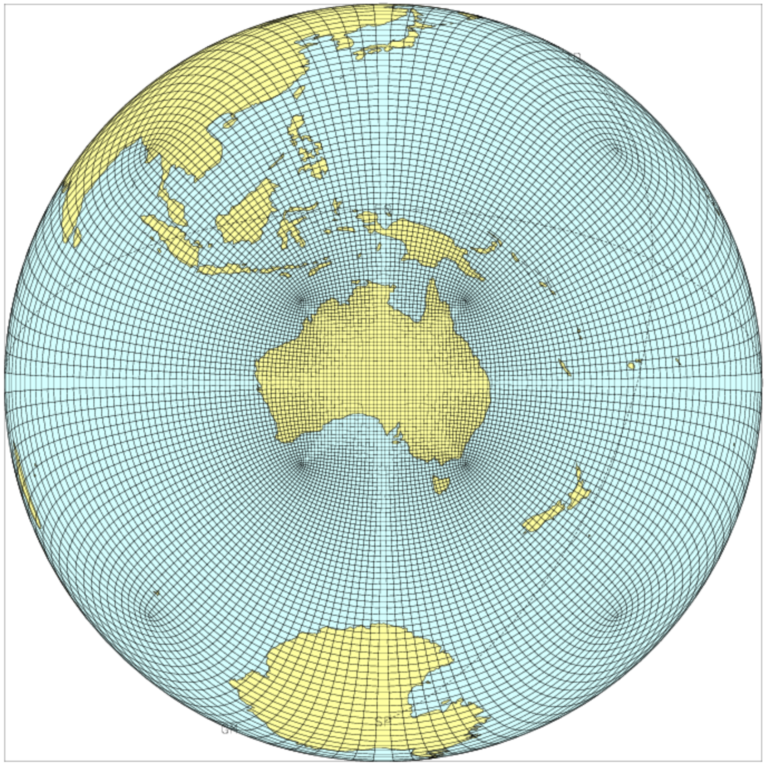
(Katzfey, 2009)

- Using CSIRO Cubic Conformal Atmospheric Model (CCAM), simulate regional climate with large scale atmospheric and SST forcings from a variety of CMIP3 GCMs.

  Bias-corrected SST's, No Spectral Forcing.

- 60 km resolution regional climate simulations developed for future climate projections, does not require lateral BC's.

- Outputs surface winds, which are being used to force a regional wave model to determine projected wave climate along Australia's east coast.

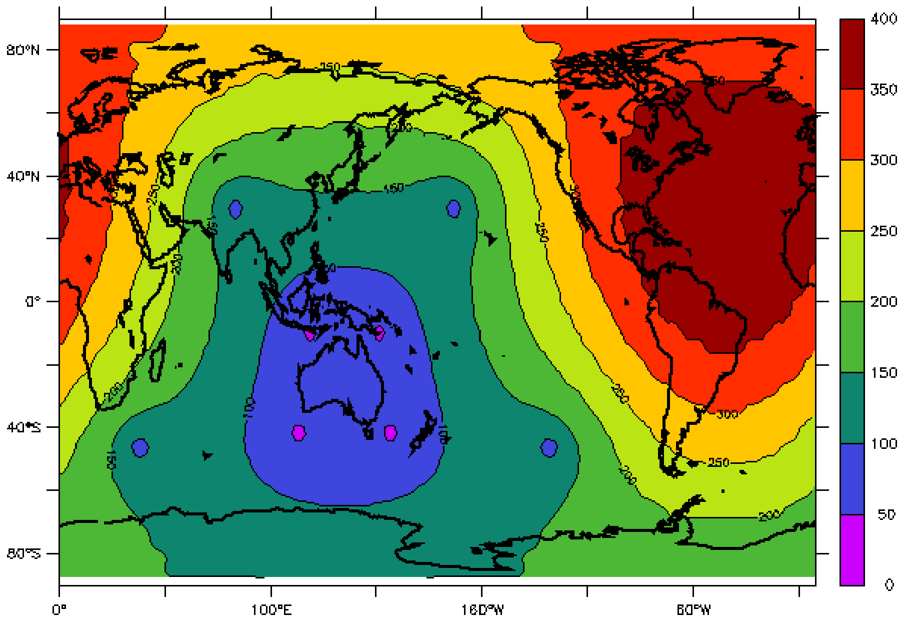


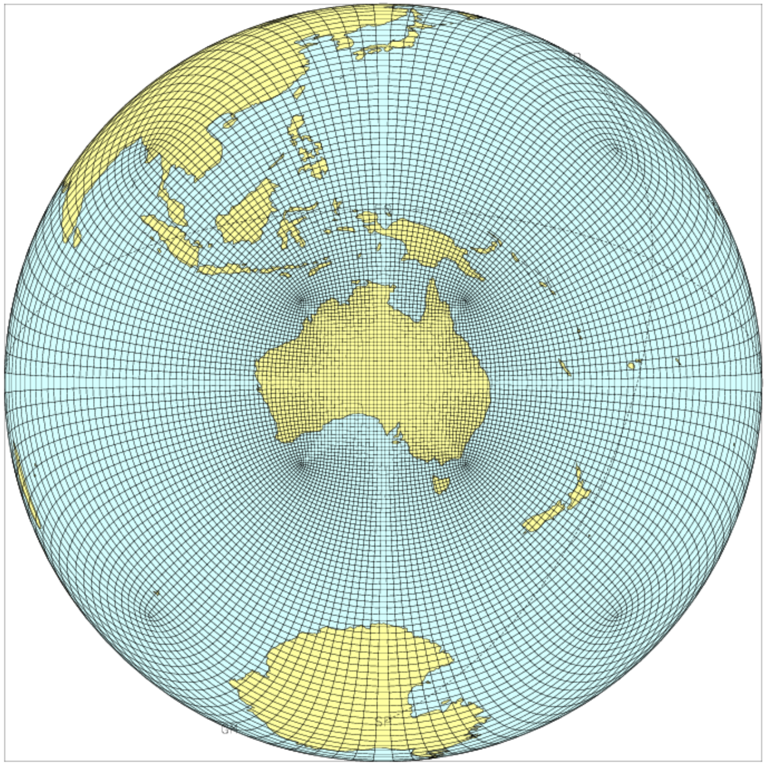
The stretched conformal cubic grid used for the 60 km resolution study

Dynamically Downscaled Regional Climate Projections
(Katzfey, 2009)

- Using CSIRO Cubic Conformal Atmospheric Model (CCAM), simulate regional climate with large scale atmospheric and SST forcings from a variety of CMIP3 GCMs.

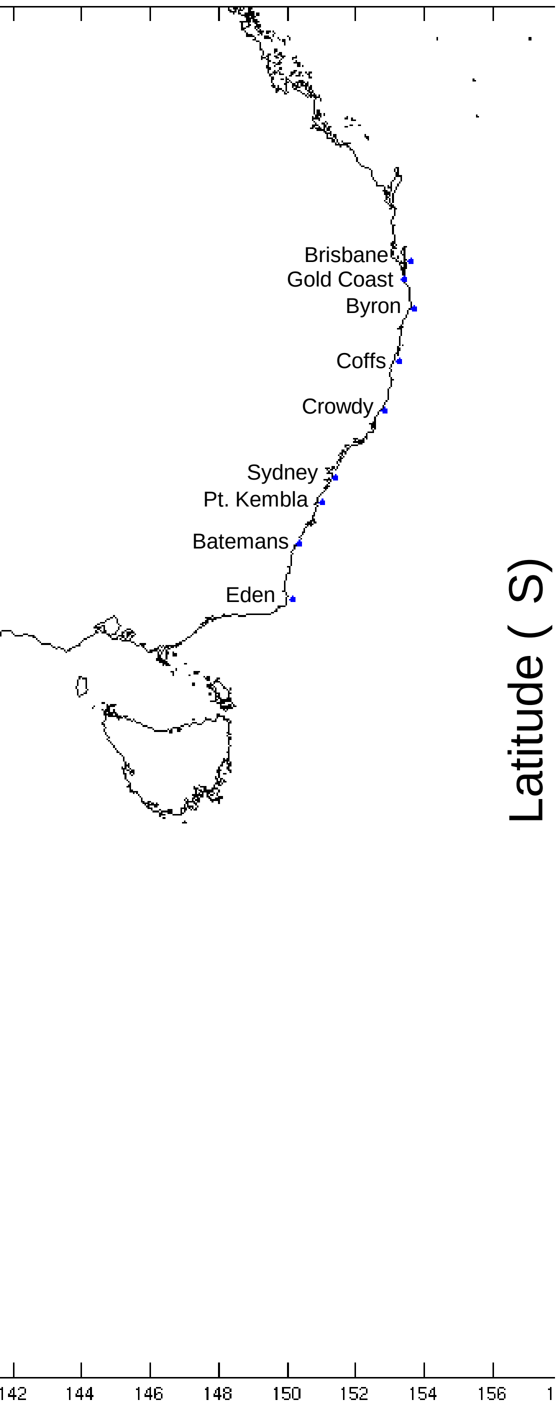
Bias-corrected SST's, No Spectral Forcing.

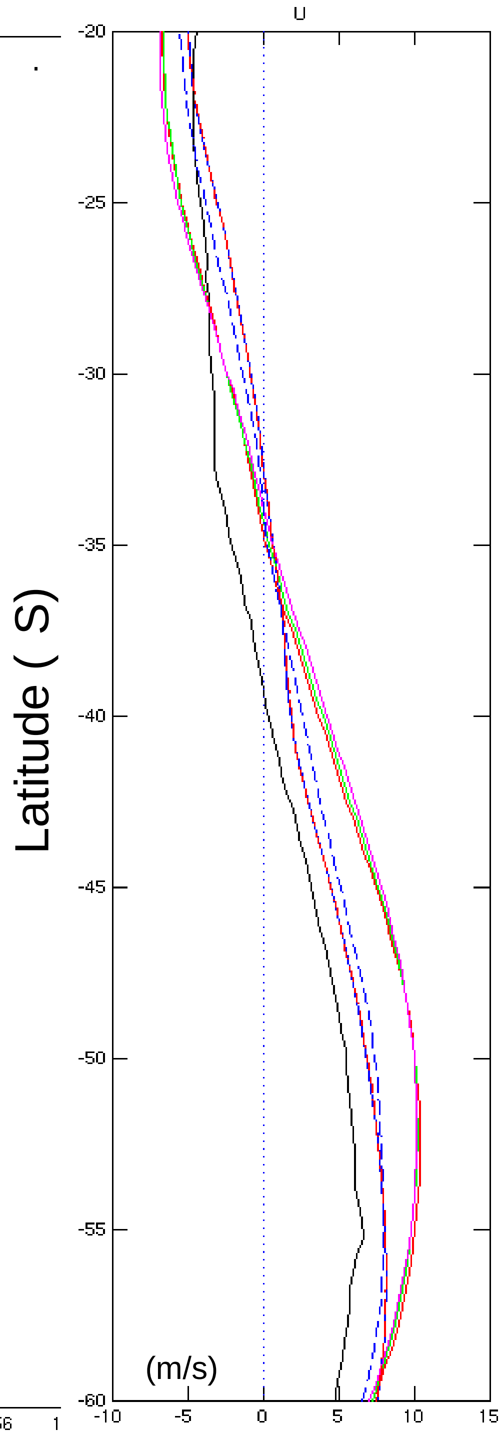


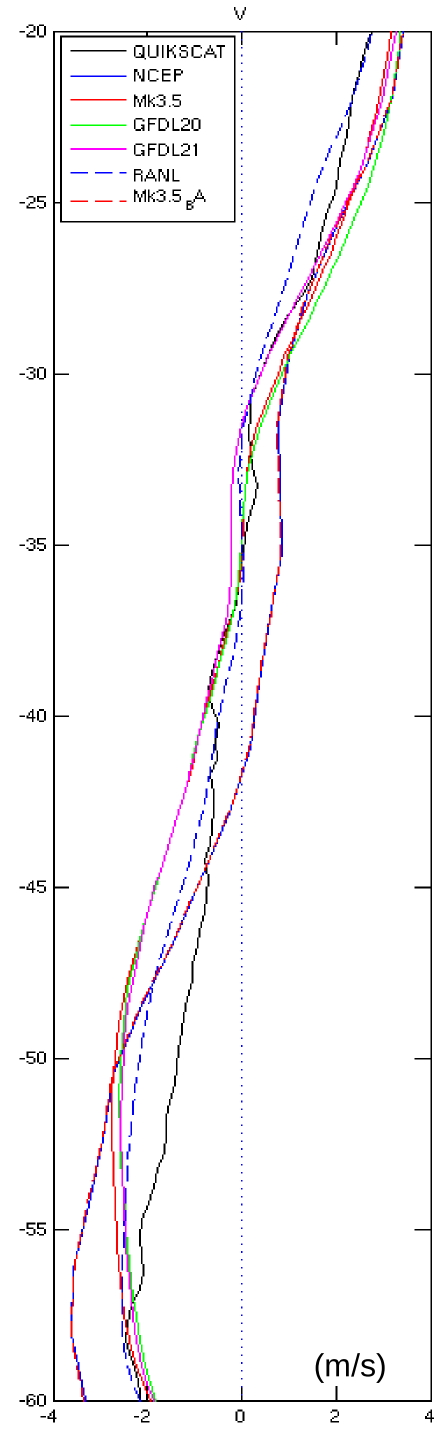


The stretched conformal cubic grid used for the 60 km resolution study

Present Climate Mean Surface winds



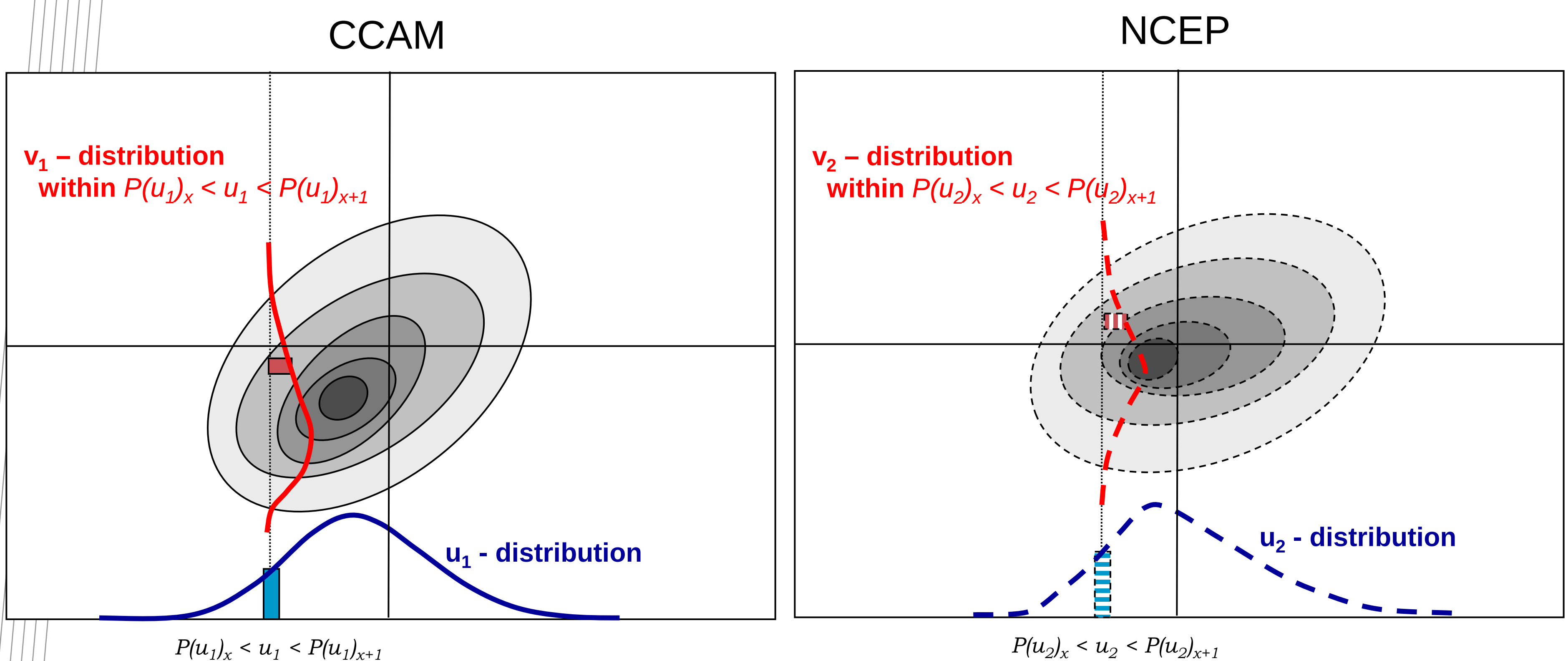




1981-2000 Mean winds.
155 E transect

Includes bias-adjusted Mk3.5 winds
(overlay NCEP)

JPD Bias Adjustment (Surface winds)



$$u_{cor}\,(P(u_1)_x) = u_1\,(P(u_1)_x) + u_{bias}(P(u)_x)$$

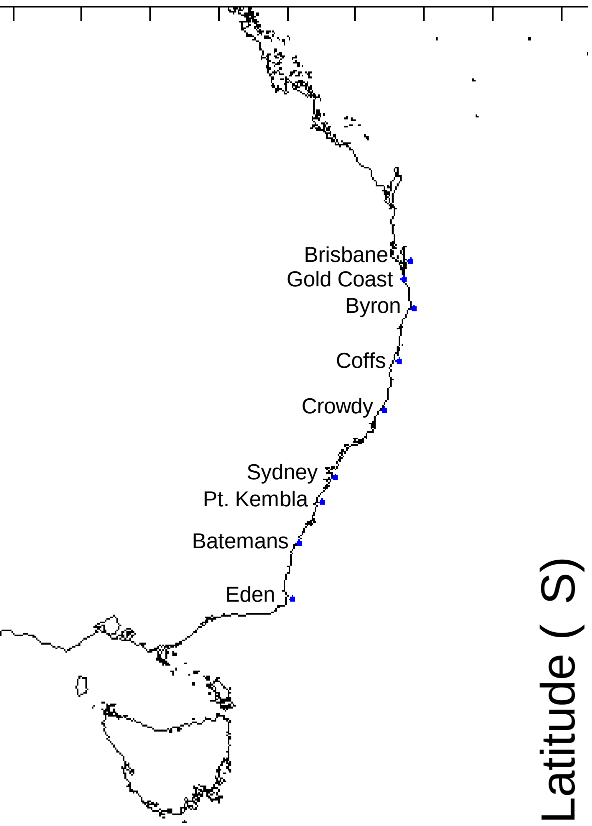
$$v_{cor}\,(P(u_1)_x, P(v_1)_y) = v_1\,(P(u_1)_x, P(v_1)_y) + v_{bias}(P(u)_x, P(v)_y)$$

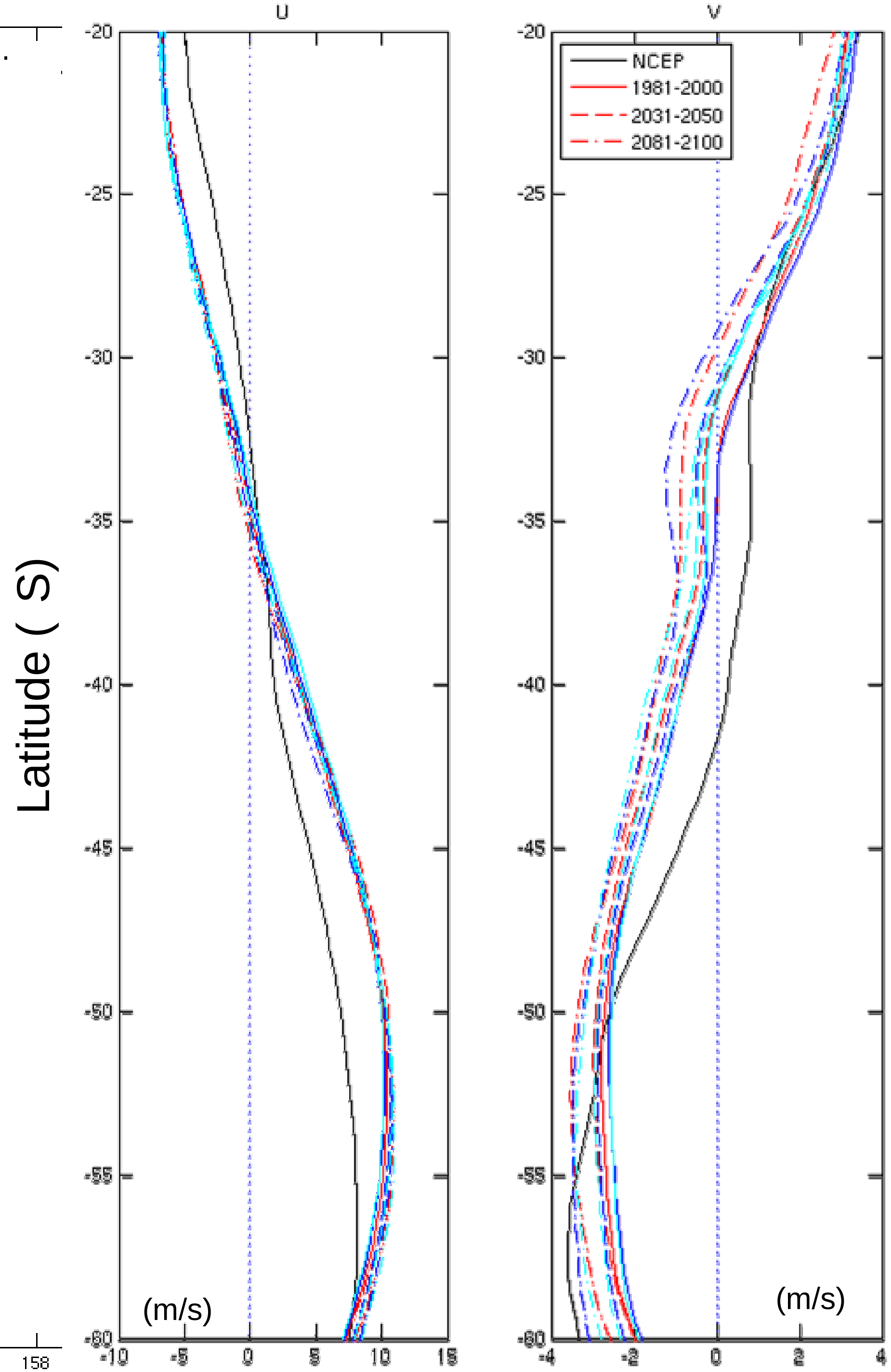
Archive ubias ($P(u)_x$) and vbias ($P(u)_x$, $P(v)_y$) for each model grid cell, to correct future time-slices

Mean Surface winds:
Multi-model ensembles

Time-slice projections:
SRES A2 scenario

NCEP
Mk3.5
GFDLcm2.0
GFDLcm2.1





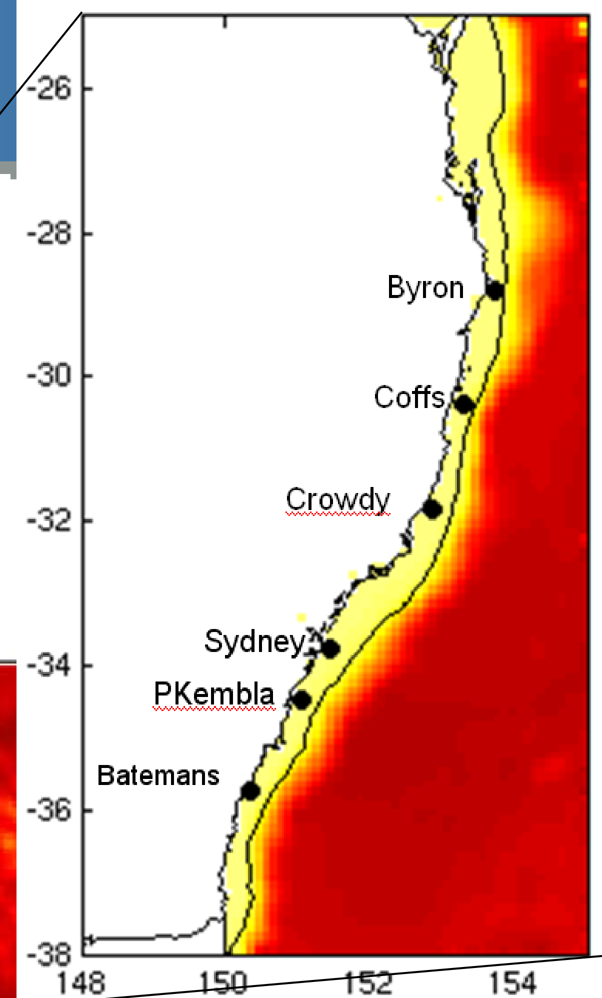
Little difference between
Multi-model ensembles

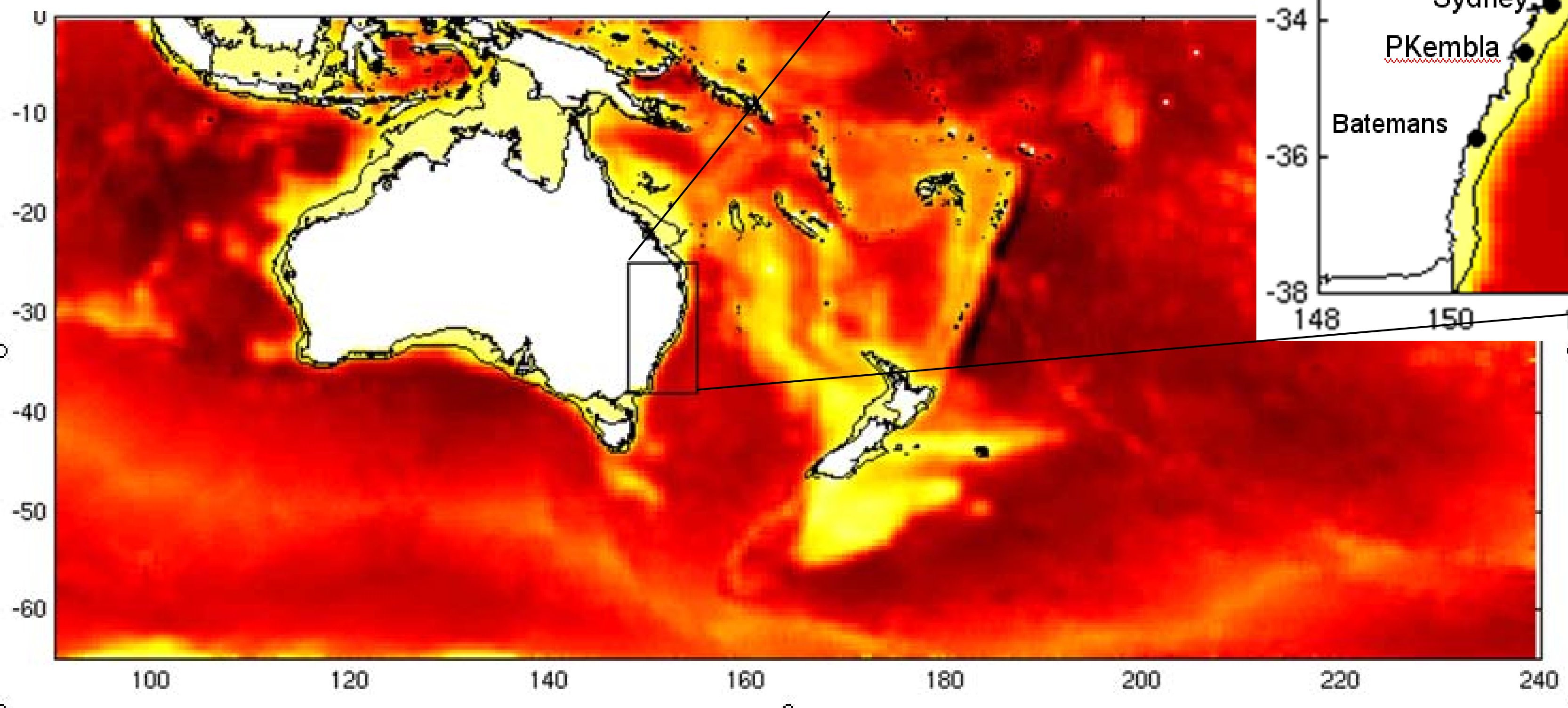
Wave modelling

Large domain:
- WaveWatch3 (version 2.2)
- 0.5 latitude-longitude grid
- tuning (5yr NRA winds) => stabsh = 1.1

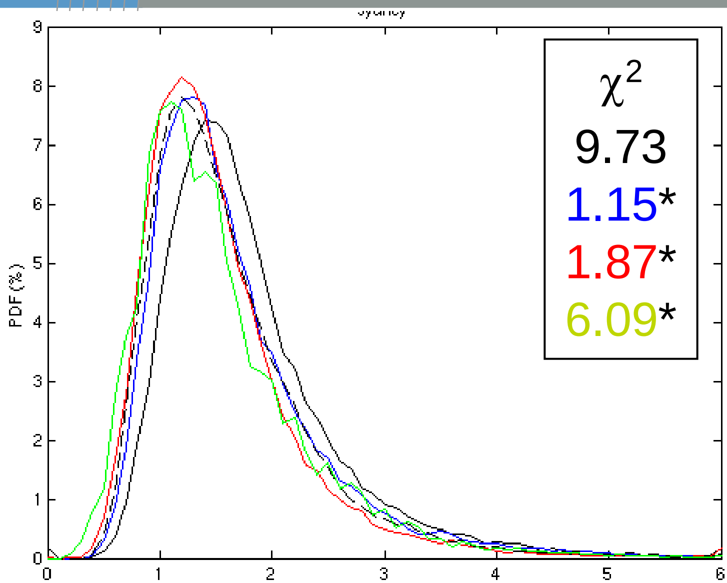
Nested domain:
- SWAN (version 40.72AB)
- 0.1° latitude-longitude grid
- tuning (5yr NRA winds) => Rogers et al. (2002) WC, with n=1.25

Both models: f (24 bins) Є [0.04,0.5], Dir (15 resolution)





Sydney wave-rider comparisons (present-climate: 1981-2000)



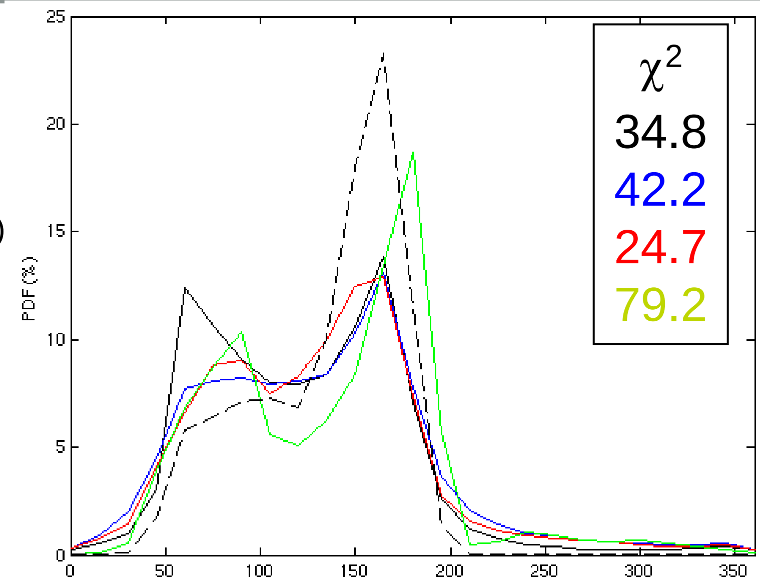
Hs (m)

χ^2 - statistic

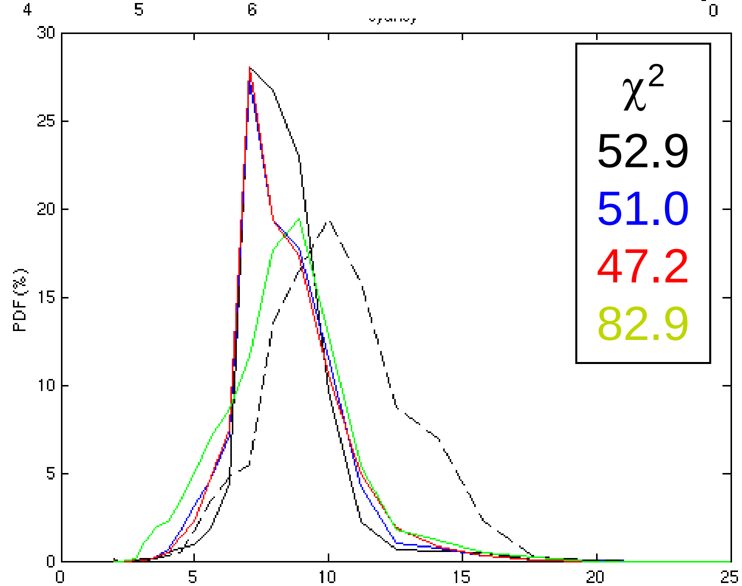
$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

O_i: modelled Dist (i^{th} bin)

E_i: Buoy Dist (i^{th} bin)



Dp (N)

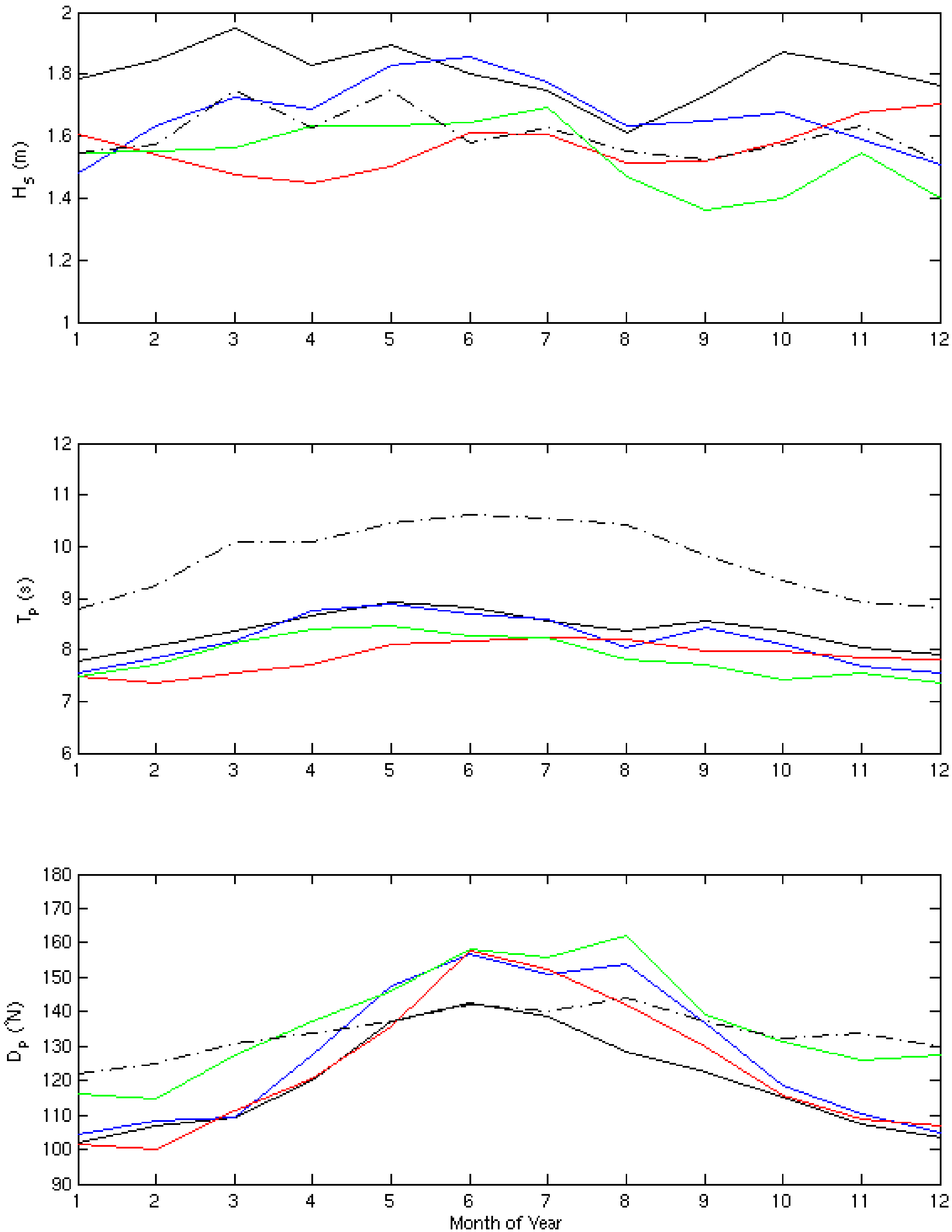


Tp (s)

- - - Buoy data
CCAM Mk3.5
CCAM Mk3.5-BA
NRA
NWW3

* Denotes distributions are the same, χ^2 goodness-of-fit statistical test ($p<0.05$)

Sydney mean annual cycle (1981-2000 mean)



RMSE (H_s)
0.209
0.099
0.102
0.108

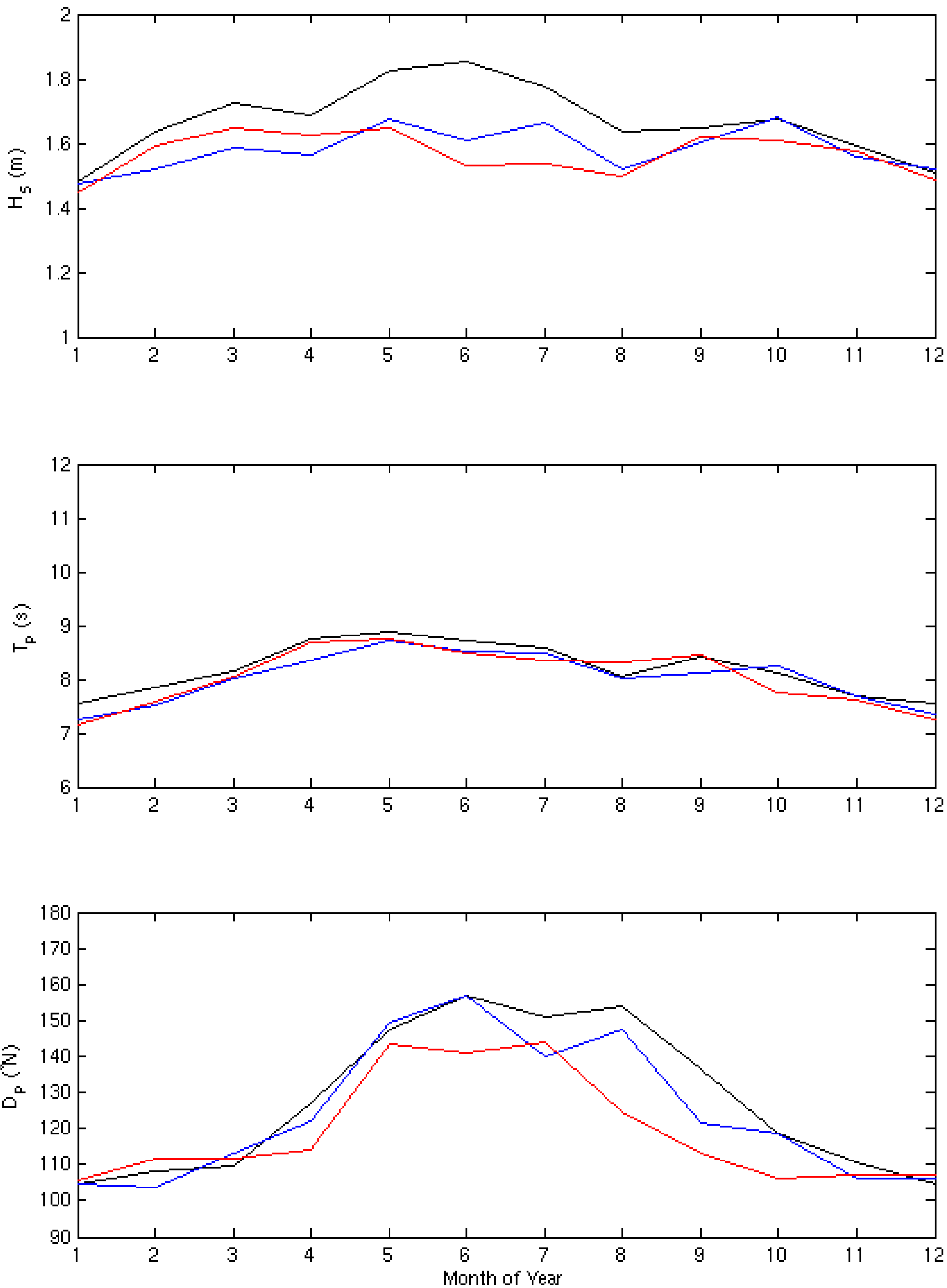
RMSE (T_p)
1.46
1.64
1.58
1.92

RMSE (D_p)
17.2
15.9
13.9
9.80

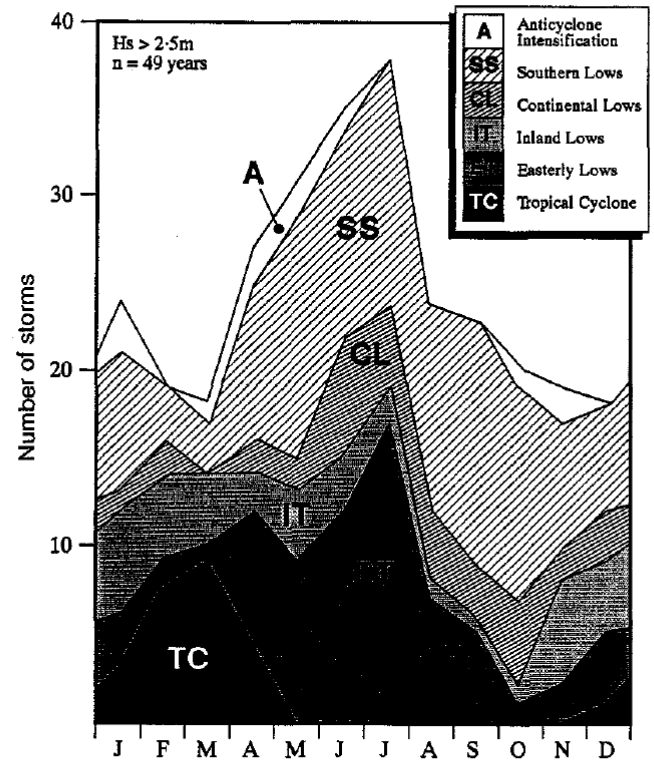
- - - Buoy data
CCAM Mk3.5
CCAM Mk3.5-BA
NRA
NWW3

Preliminary projections:

CSIRO Mk3.5-BA, SRES A2



Mean Annual Cycle:
1981-2000
2031-2050
2081-2100



Occurrence of storm events on NSW central coast
(Short & Treneman, 1992)