



Short-range Forecasting Research

**Short Range Forecasting Division
Technical Report No 19**

WAM / UKMO

**Wind Wave Model Intercomparison
Part 2**

**Running the UKMO Wave Model at
at higher resolution**

by

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WAM/UKMO wind wave model intercomparison

Part 2: Running the 2nd generation UKMO model at higher resolution.

1 Introduction.

The WAM/UKMO wind wave model intercomparison (Gunther and Holt, 1992) compared the UKMO 2nd generation (2G) and WAM 3rd generation (3G) wave models using winds for November 1988 from both the UK Met Office and ECMWF. The wave models were run on a 3^0 by 3^0 global grid. The UK Met Office winds came from the NWP model operational during 1988, which had a higher resolution than the wave grid used for the hindcast study. Previous work (Holt, 1991) has shown that for optimal performance of any wave model the wave model grid should match the wind grid, to obtain maximum information from the wind field. This study complements the first part of the UKMO/WAM intercomparison by running the UKMO wave model at the resolution of the wind data, 1.875^0 by 1.5^0 .

2 The Hindcast.

The UK Met Office wave model was run on the "Cyber" resolution global grid, 1.875^0 latitude by 1.5^0 longitude. As in the original hindcast, the model was started from rest. In this study 16 direction components were used, giving a directional resolution of 22.5^0 , compared to the resolution of 15^0 used in Part 1. This was the operational resolution of the UK Met Office wave model as run on the Cyber computer. Output from the model gridpoint nearest to the buoy was compared with observations, for a number of buoys. The buoy positions are shown in Figure 1.

3 Verification and results:

A summary of the verification statistics for windspeed is shown at Figure 2. Although the same windfield was used as in Part 1 of the intercomparison, in the first part of the study the winds were interpolated onto the coarser grid and the nearest gridpoint to the buoy on that grid compared with the buoy observations. Figure 2 shows that for all the Pacific buoys the model windspeeds at the nearest gridpoint were greater on the higher resolution grid, particularly at buoys 46001 and 46002. The timeseries of modelled and observed values at 46001 (Figure 6b) shows this to arise from one storm only, when the model windspeed was much greater than observed. At the Atlantic buoys the impact was less, but these buoys still show a positive windspeed bias. There were only small changes in the RMS windspeed errors when resolution was increased.

Figure 3 shows the mean wave height bias for each of the wave model runs - the UKMO model using UKMO winds on both grids, and also the WAM model run using ECMWF winds on the coarse grid. At each of the buoys the bias of the UKMO model at higher resolution is still negative, but the bias is much reduced from the run on the coarse grid. The RMS error in wave height was also reduced by running at higher resolution (Figure 3b). The improvement is greatest in the Pacific, both in the Central and Northern Pacific buoys. The impact at the Atlantic buoys was smaller, but still showed a reduction in the bias. At these buoys the sea state is dominated by locally generated windsea.

Following part 1 of the study it is convenient to consider the wave model performance in the three different regions :

In the Central Pacific the first part of the study identified a particular problem with the handling of swell in the UKMO model. This was still present in the run with higher resolution. Figure 4 shows the 1d spectrum at the point nearest to Buoy 51002 at 00z November 26th. The "spectral gap" in the UK wave model around 0.1 Hz is clearly shown, and this was present at both resolutions. The increase in wave height (and consequent reduction in bias) at this time came from energy at frequencies around 0.2 Hz rather than from any improvement at swell frequencies. A time series of wave height, Figure 5, shows that the model wave heights on the higher resolution grid were uniformly higher and closer to observed values throughout the month at the verification point. The improvement was not due to any single extreme event being better resolved. The RMS errors in wave height were also lower on the higher resolution grid.

In the North Pacific the simulation was much better at all the buoys, though the worst performance was still at Buoy 46002. Figure 3 shows the reduction in mean bias of over 0.5m compared to the WAM grid, though wave heights were still generally lower than observed. The timeseries for 46001 (Figure 6a) shows that the bias was dominated by individual events. Some peaks in wave height were better captured, but not all, and the reduction in wave height over 26th-27th Nov was less well handled. There was a tendency for background wave heights to be lower than observed, with extreme events overforecast, thus compensating to reduce the mean bias. This was particularly true at Buoy 46002. An extreme waveheight of 13m at Buoy 46004 was however well modelled (Figure 7).

At the North Atlantic buoys off the Eastern USA, where conditions are dominated by locally generated windsea, the improvement due to increasing resolution was smaller. Timeseries (Figure 8) show that model wave heights for some individual storms were closer to observed, but some were overforecast and some underforecast, thus compensating to reduce the mean bias.

4 Conclusions

The greatest impact of increasing the resolution of the wave model grid was the improvement in verification at the buoys in the Pacific. The mean bias was still negative at all buoys, but was reduced by up to 60 cm compared to the values from the coarser grid. In the Northern Pacific the improvement was mainly due to better timing and position of extreme wave height events, in some of which the model heights were greater than observed. This offset the general trend of wave heights being lower than observed at other times. In the Central Pacific wave heights were closer to observed for much of the time. A comparison of the modelled and observed 1d spectra showed on one occasion that this improvement was due to the local windsea being slightly higher. The problem with swell in the model remained, but was not accentuated at higher resolution.

The verification statistics from this study showed that the second generation UK Met Office wave model on a 1.875 by 1.5 degree global grid with 22.5 degrees resolution in direction performed as well as, or better than, the third generation WAM model (Cycle 3) run on a 3 degree by 3 degree global grid with 15 degrees resolution in direction. Future work will address the handling of swell in the UKMO wave model, both in the separation of windsea from swell and in the formulation of the dissipation of swell energy. This should lead to further improvements in the performance of the wave model.

Acknowledgments : The wave model run at higher resolution was carried out by Ms Sophie Kelsall.

References :

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|--------------------------|------|--|
| Gunther, H
and Holt M | 1992 | WAM/UKMO wind wave model intercomparison, Summary Report.
ECMWF. (Also available as S Division Technical Report No 8) |
| Holt, M W | 1991 | Trials of increased resolution in space and direction for the wave model.
S Division Technical Note No 58. |

Figures :

- Figure 1 Buoy locations
- Figure 2 Mean windspeed bias and RMS error at the buoys.
- Figure 3 Mean wave height bias and RMS error at the buoys.
- Figure 4 1D spectra for 00z 26/11/1988 at Hawaii.
- Figure 5 Timeseries of wave height at Hawaii.
- Figure 6 Timeseries of wave height and windspeed at Buoy 46001, North Pacific.
- Figure 7 Timeseries of wave height at Buoy 46004, North Pacific
- Figure 8 Timeseries of wave height at Buoy 44011, western Atlantic.

Figure 1

BUOYS USED IN WRM/UK INTERCOMPARISON

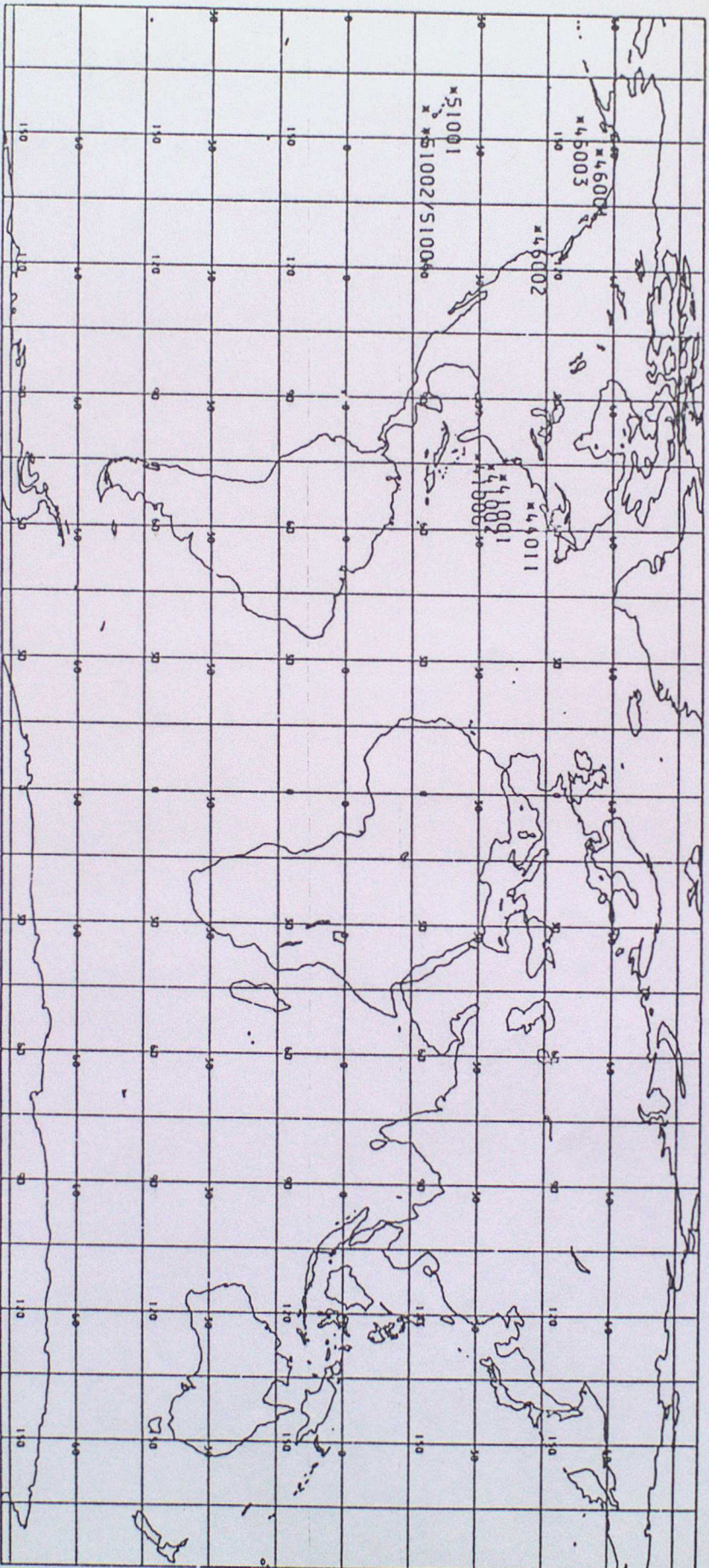


Figure 2

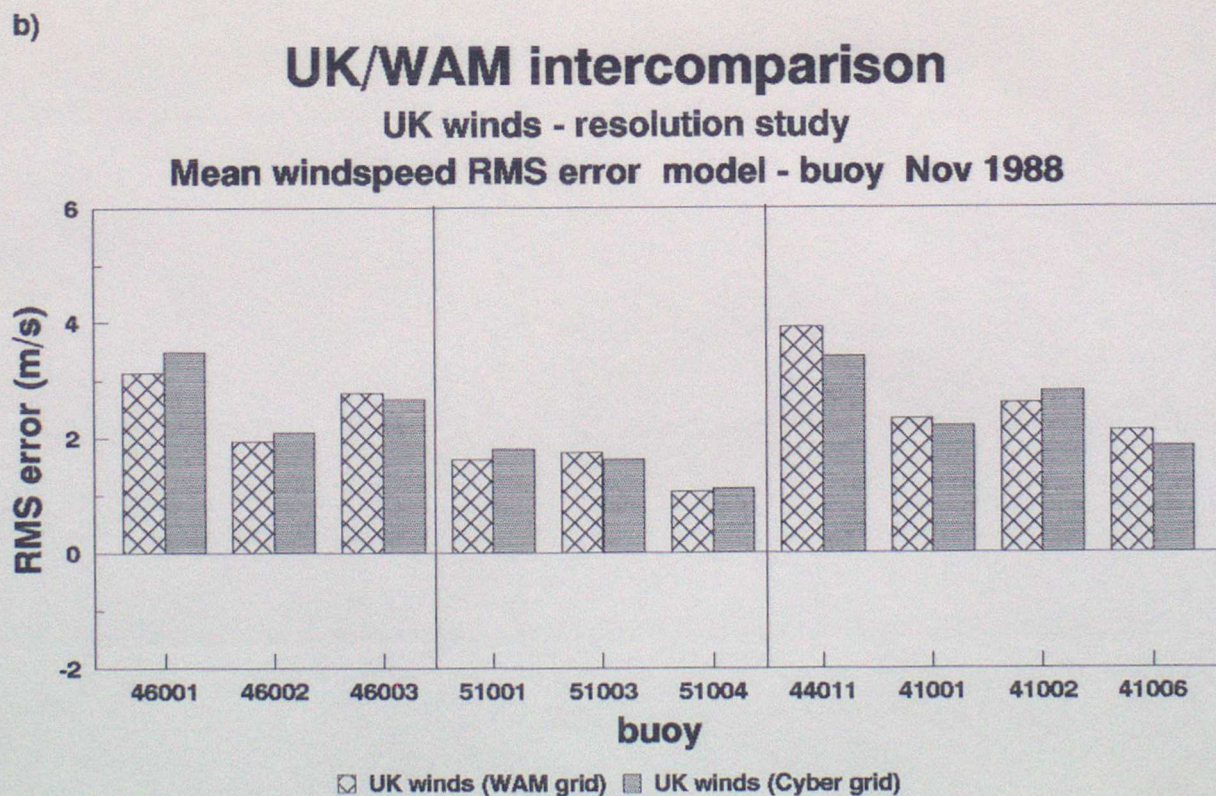
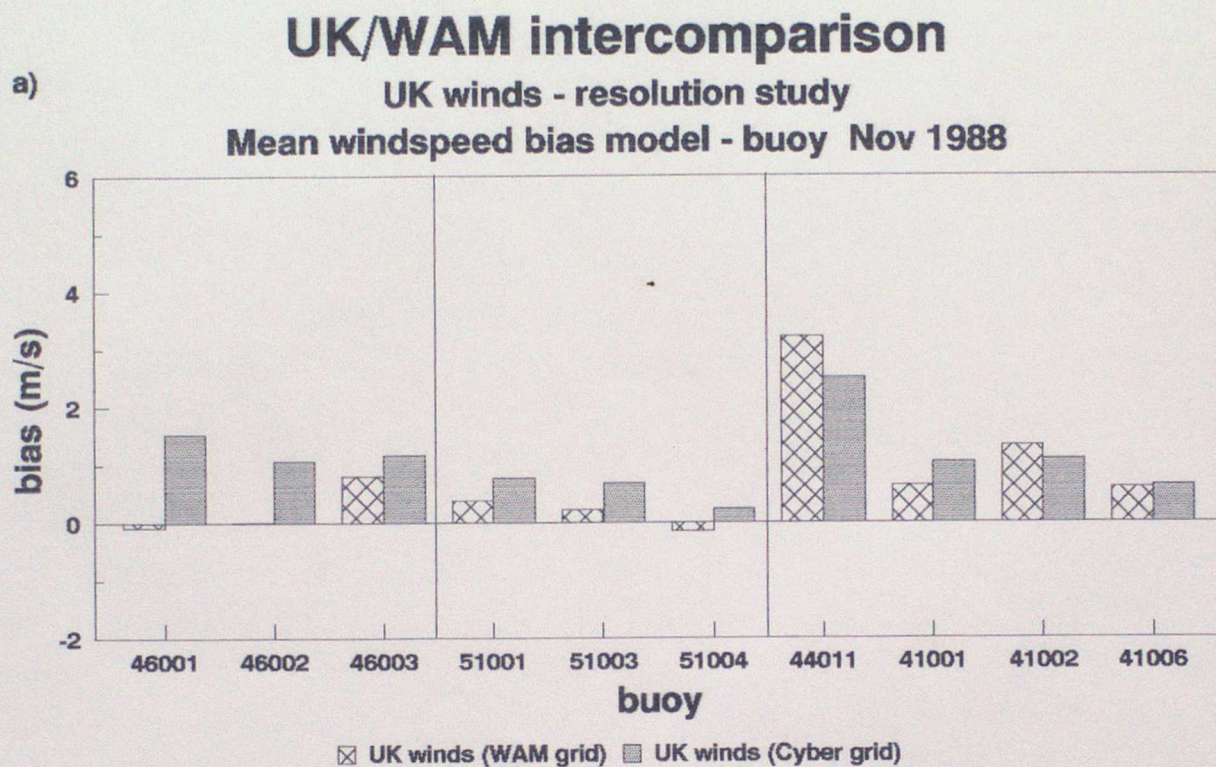
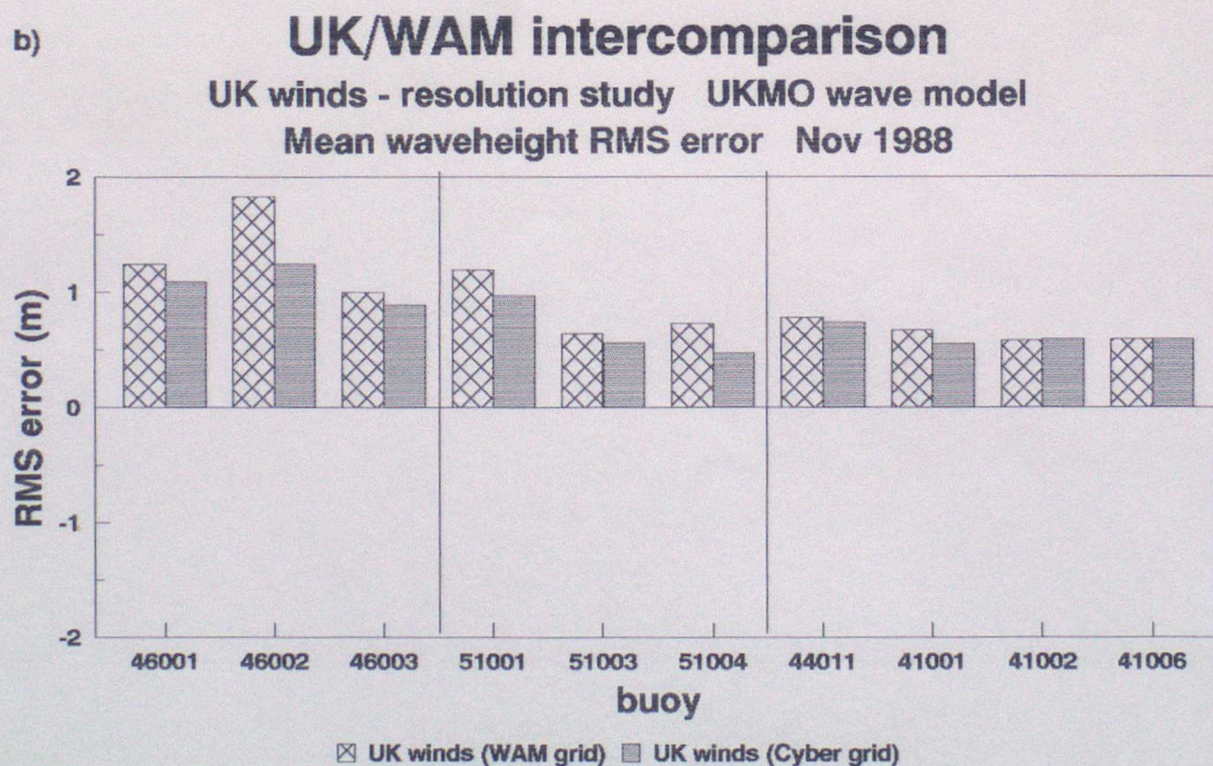
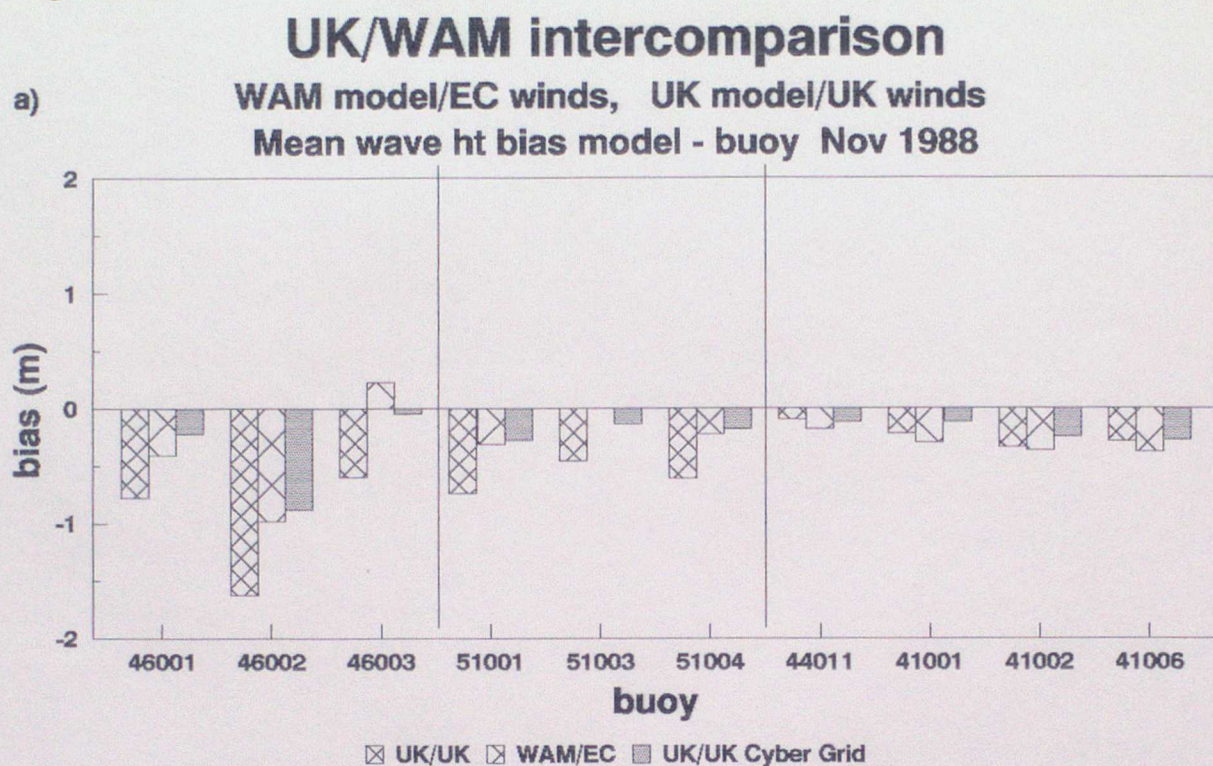
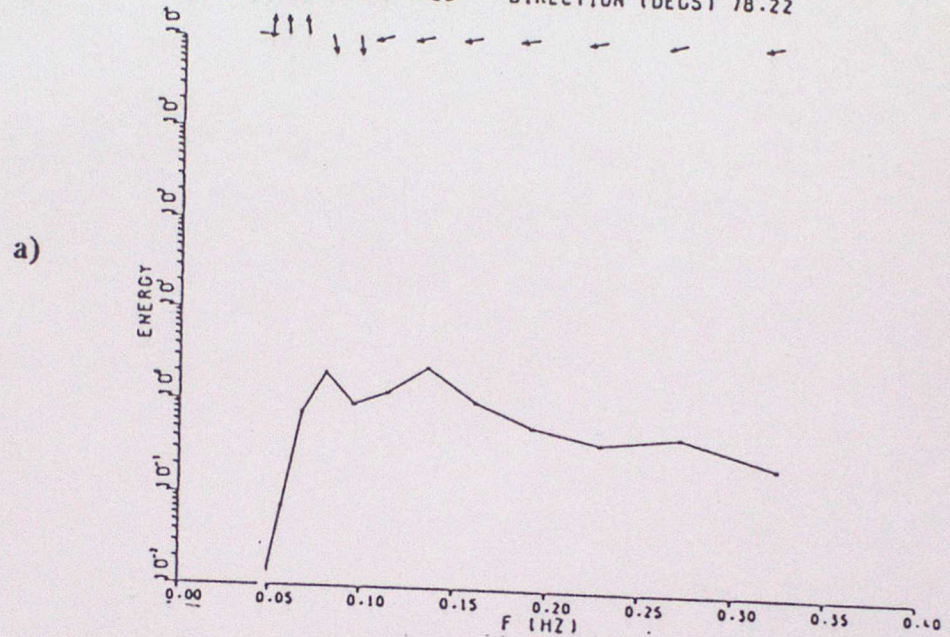


Figure 3



WAM INTER UK/UK WAM GRID
 LAT: 18.00N LONG: 159.00W

0Z 26/11/88 HS=2.04 M
 WIND SPEED (M/S) 7.26 DIRECTION (DEGS) 78.22



WAM INTER UK/UK CYBER GRID
 LAT: 17.25N LONG: 156.56W

0Z 26/11/86 HS=2.17 M
 WIND SPEED (M/S) 7.49 DIRECTION (DEGS) 90.00

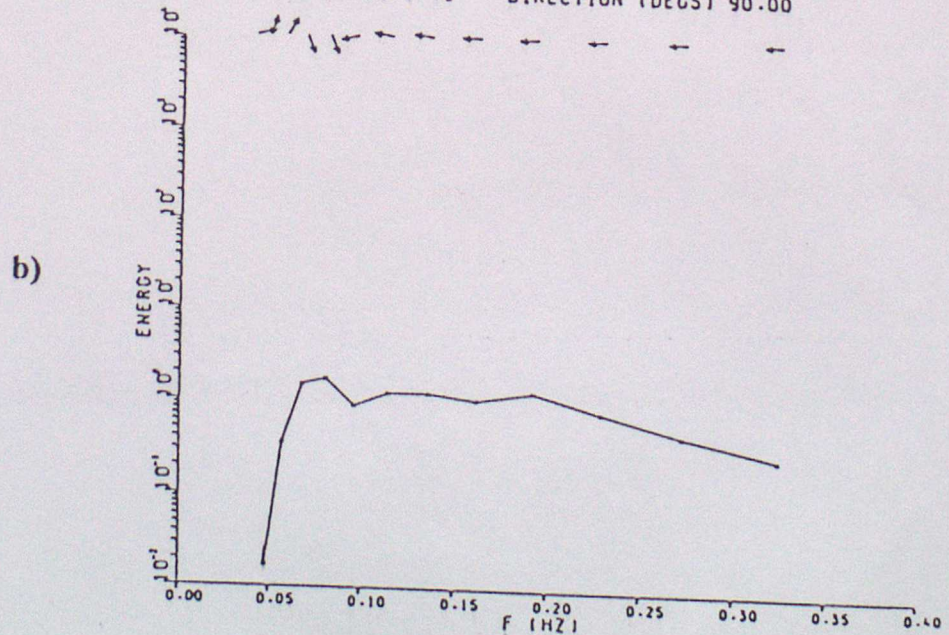
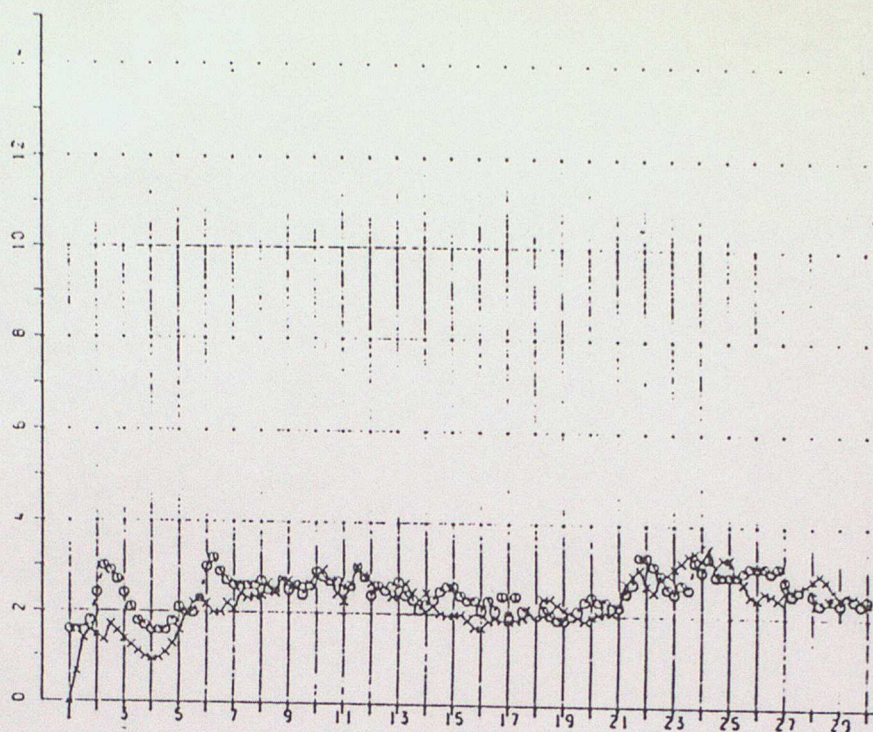


Figure 4 1D spectra for 00z 26/11/1988 at Hawaii (51002).
 a) WAM grid b) Cyber grid

a)



DATA FOR 11/1988 CYBER GRID

51004

WAVE HEIGHT (M)

ooo OBSERVED

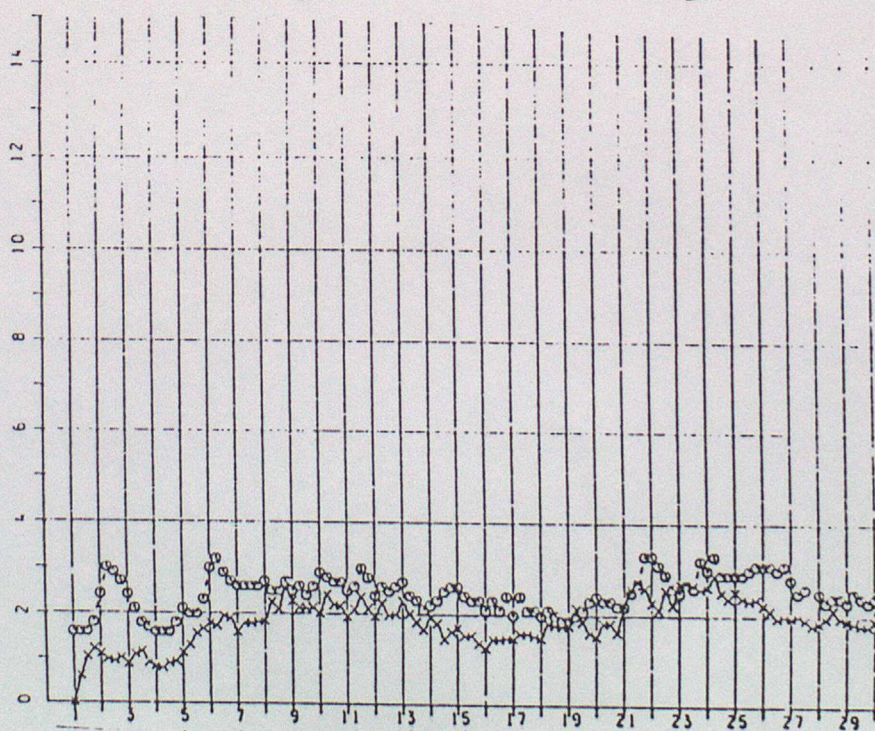
xxx UK MODEL

Figure 5 Timeseries of wave height at Hawaii (51004).

a) Cyber grid

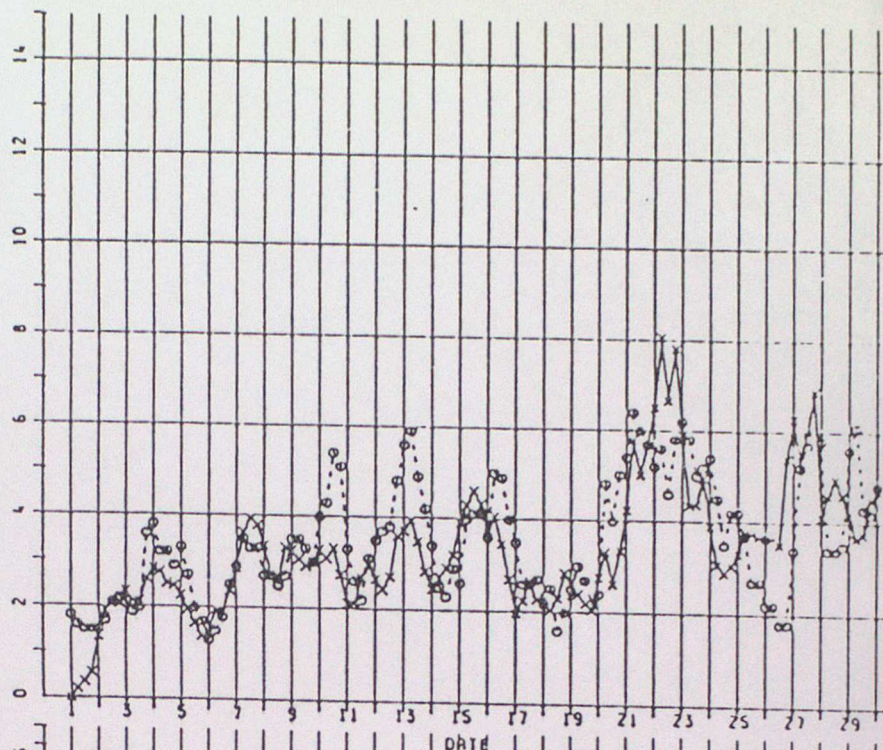
b) WAM grid

b)

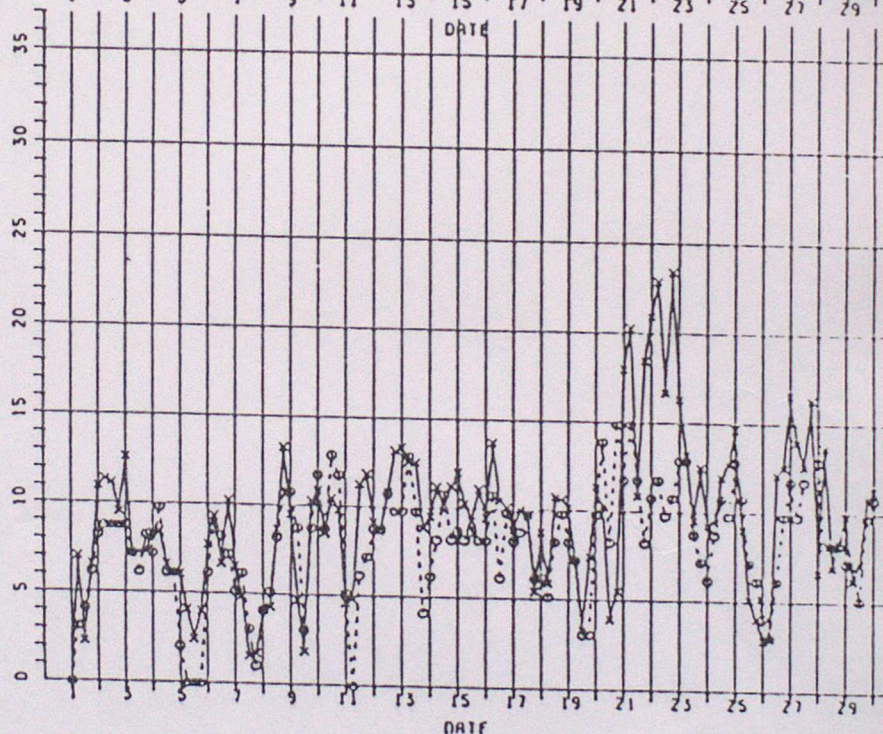


DATA FOR 11/1988 WAM GRID

a)
WAVE HEIGHT (M)



b)
WIND SPEED (M/S)



46001

WAM INTERCOMPARISON

DATA FOR 11/1988 CYBER GRID

OOO OBSERVED

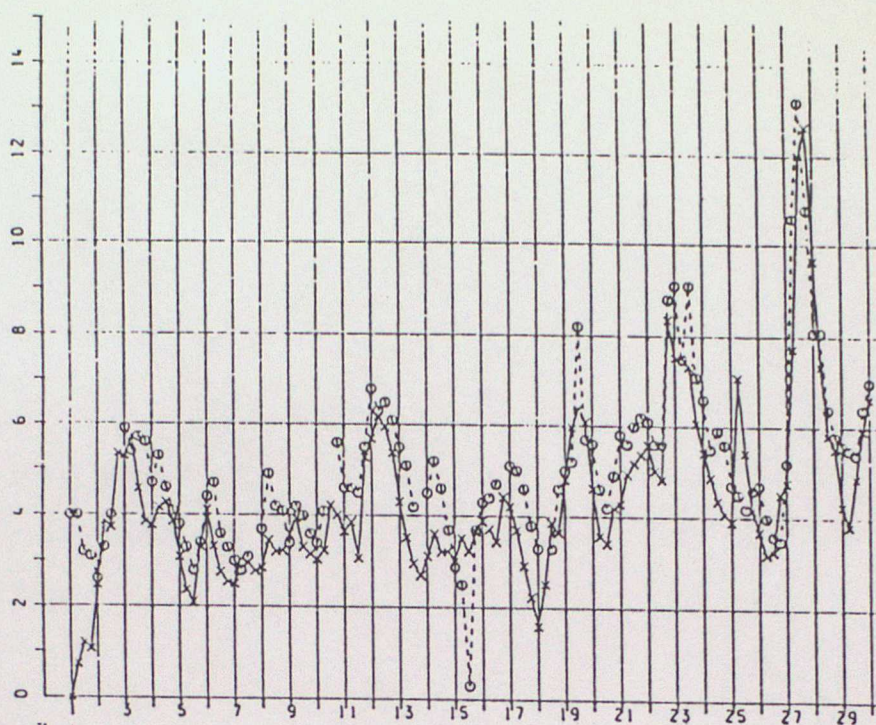
XXX UK MODEL

Figure 6 Timeseries of wave height and windspeed at Buoy 46001, North Pacific, from the run on the Cyber grid.

a) wave height (m)

b) Windspeed (m/s)

a)



DATA FOR 11/1988 CYBER GRID

46004

ooo OBSERVED

xxx UK MODEL

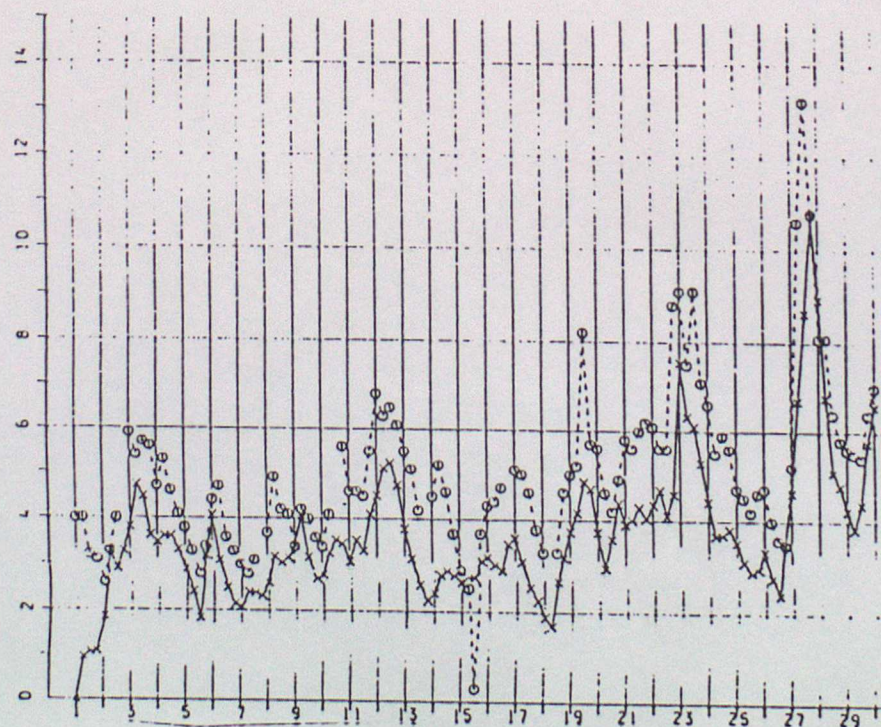
WAVE HEIGHT (M)

Figure 7 Timeseries of wave height at Buoy 46004, North Pacific.

a) Cyber grid

b) WAM grid

b)



DATA FOR 11/1988 WAM GRID

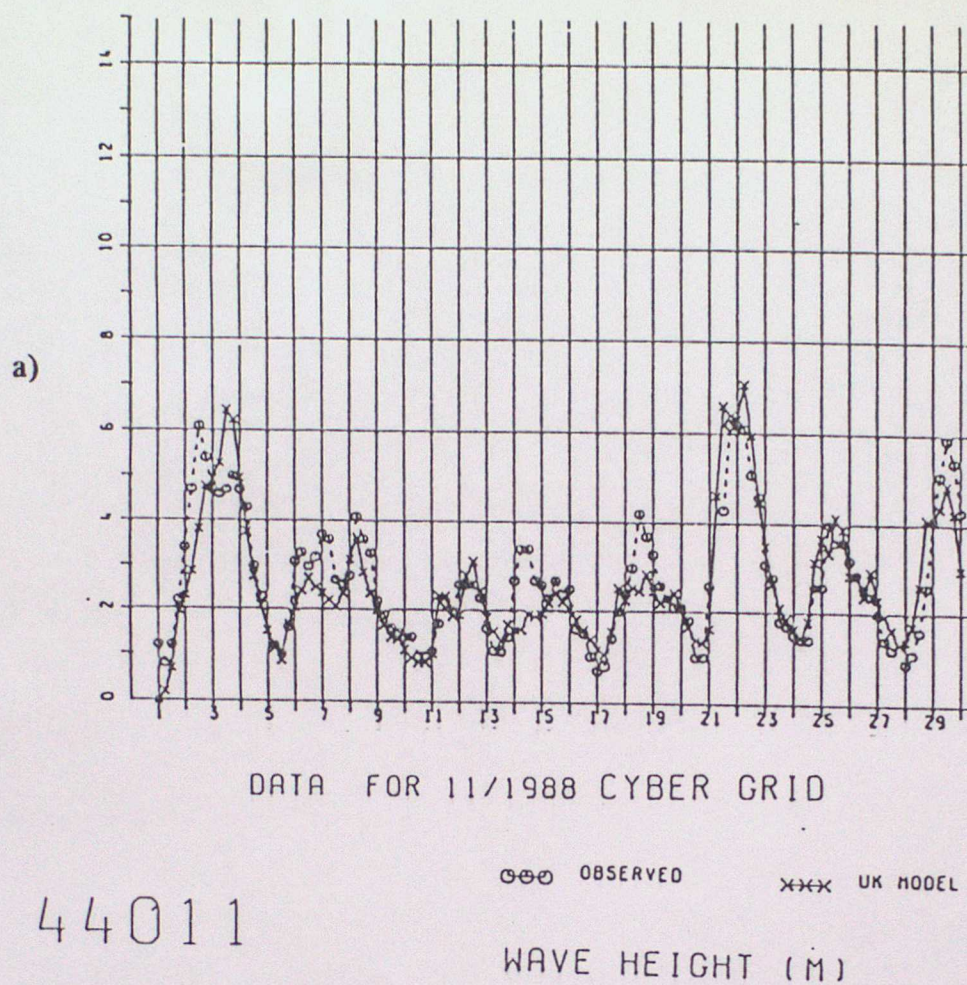


Figure 8 Timeseries of wave height at Buoy 44011, western Atlantic
 a) Cyber grid
 b) WAM grid

