JERICHO TECHNICAL REPORT 05

Lyme Bay wave data.

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November 1998

Introduction

Wave measurements from Lyme Bay have been obtained from a buoy operated by the UK Met. Office, from a bottom-mounted pressure sensor in a water depth of about 10 m operated by the Institute of Oceanographic Sciences (data held by BODC), and from satellite radar altimeters: Geosat, ERS and TOPEX. Details of these data sets are described below, and a comparison of monthly mean wave heights estimated from these sources described.

BODC data from the West Bexington pressure sensor, December 1987-May 1995

This pressure sensor was installed in 1987 (by IOS Taunton) at 50° 40'N, 2° 40'W where the mean water depth is about 10 m. The data set, held by BODC, extends from 22 December 1987 to 6 May 1995. This is quite a good data set with some breaks in recording but only isolated gaps during periods with records. Most gaps were for about 2 weeks but longer ones were:

20 October 1989	to	9 April 1990
26 March 1992	to	7 March 1993
13 November 1993	to	22 January 1994

The fundamental sampling interval throughout this data set is 1.5 hours, with records at 0000, 0130, 0300, 0430 etc, but there are frequent periods of more rapid sampling, with some records taken as close as 11 minutes apart. Rapid sampling appears to occur whenever significant wave height rises above about 2.5 m, so any climate statistics derived from the complete data set, such as monthly means or the cumulative probability distribution, would be severely biased high. Figure 1 shows histograms of all the data from 1991 and of data from the 'standard' 1.5 hour records.

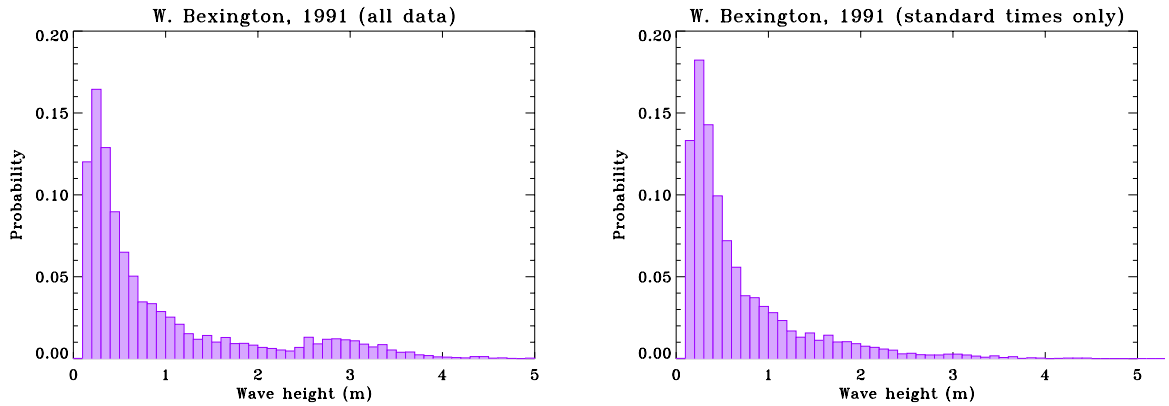


Figure 1

Only 1 record gave significant wave height less than 0.1 m (at 0.09 m) - although there are many records between 0.1 and 0.2 m - suggesting that the instrument cannot measure such low values.

The highest recorded Hs from all the data 5.13 m. Occurrences of all values greater than 4 m, together with the zero up-crossing wave period, Tz, are given in Table 1 below: Note the preponderance of dates in 1994-1995 (although sampling is not uniform throughout the years, with for example a gap of a year from March 1992 to March 1993).

Time	da te	Hs(m)	Tz(s)
1630	1 Feb 1988	4.16	7.92
2133	1 Jan 1991	4.98	7.78
2133	3 Feb 1994	4.84	8.22
2326	31 Mar 1994	4.52	7.81
0022	1 April 1994	4.44	7.74
0956	8 Dec 1994	5.12	7.99
0022	23 Jan 1995	4.60	8.73
1833	16 Feb 1995	4.27	7.58

Table 1 Records with Hs>4 m from the W. Bexington pressure sensor

UK Met.O. data from buoy July 1983 - December 1997

These records, from a buoy near 50.6°N 2.7°W, contain a very poor data set of wave heights. The only values which look as if they might be acceptable are those for 21 April 1994 to 15 August 1994 (although there are some days with Hs constantly at 0.5 m which would need further investigation); 1 January 1997 to 21 February 1997 (except for 4 outliers with Hs= 7 - 8 m); and 11 March 1997 to 1 December 1997.

Outside these periods, the data are either missing or clearly useless. Some examples:

a. July 1983 - January 1987: all Hs missing (set to -32768) except for one record on 26 November 1986 with Hs = 10 m

b. February 1987 to 25 November 1987: Hs = 0 throughout

c. 25 November 1987 to 30 November 1987: Hs = 8.5 m throughout

d. December 1987 to 7 April 1988: Hs = 0. throughout

e. September 1990 to 17 May 1991: some gaps, otherwise Hs = 0 or -32768

f. 27 September 1991 to 21 January 1994: a few gaps, otherwise Hs = 0 or -32768

g. 15 August 1994 to December 1996: no records

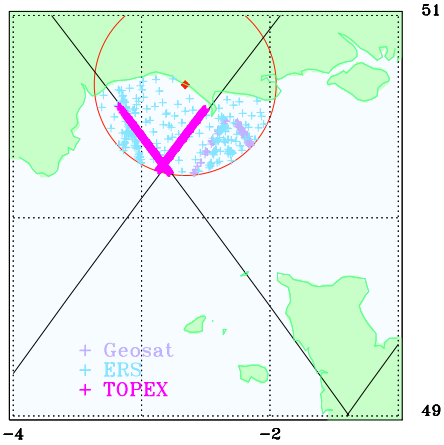
h. December 1997: Hs = 0 (except for 2 records with Hs=7 m, and seven with Hs=2 m)

Altimeter data, April 1985 to May 1998

Altimeter data within 50 km of the West Bexington pressure sensor, sited at 50° 40'N, 2° 40'W, were extracted from the database of Geosat, ERS-1 and TOPEX data; these are at 1 second (6 - 7 km) intervals. There were a total of 2345 validated records.

Figure 2 shows the location of the pressure sensor and a circle of 50 km radius about this position, and estimated tracks of TOPEX, repeated every ten days, together with the locations of the records from the three altimeters.

Figure 2



Geosat: These data extend from November 1996 to December 1989, but Geosat was slow to acquire lock on the sea surface as it came off the land which resulted in a poor data return within the 50 km circle, providing only 3% of the total records. Moreover, Geosat's tracks were to the South and East of Portland Bill so the data are hardly representative of conditions at the pressure sensor.

ERS-1:These data cover the periods April 1992 - October 1993 and April 1994 - March 1995, and because the satellite was in a 168-day repeat for much of the time, the data are fairly uniformly spread throughout the 50 km circle. There are 206 1 Hz values, making up 9% of the total 1 Hz data set.

TOPEX: TOPEX Ku-band data from October 1992 to June 1998 constitute the largest part of the data, 88%. This altimeter is in a 10-day repeat with two transect of the 50 km circle passing within about 20 km and 30 km of the pressure sensor; see Figure 2.

Comparison of altimeter and pressure sensor estimates of monthly mean wave height

The altimeter and West Bexington pressure sensor data only coincide during the period March 1993 to April 1995 (except that December 1993 is missing from the pressure sensor records). Monthly calendar mean wave heights calculated from the two data sets are shown in Figure 3 - using only the pressure sensor records at the 'standard' times of 0300, 0430 etc.

There is clearly a good linear relationship between the monthly mean Hs from the altimeter and from the pressure sensor, with a correlation coefficient of 0.98 and root residual mean square about the principal component shown in the figure of 0.074 m. The intercept and slope of this line are 0.124 and 1.65 respectively, with standard error of both about 0.1 so the intercept is not significant.

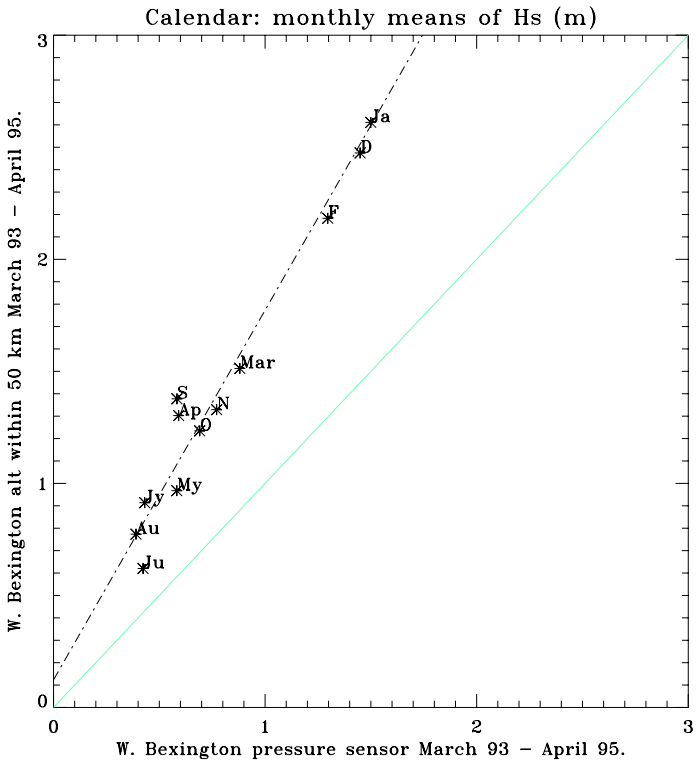


Figure 3

Figure 4 shows a similar plot but for the 20 individual monthly means from the period March 1993 to April 1995. The correlation coefficient and rrms are 0.92 and 0.10, the intercept and slope are 0.039 and 1.79, not significantly different (at 95% level) from values from the calendar means.

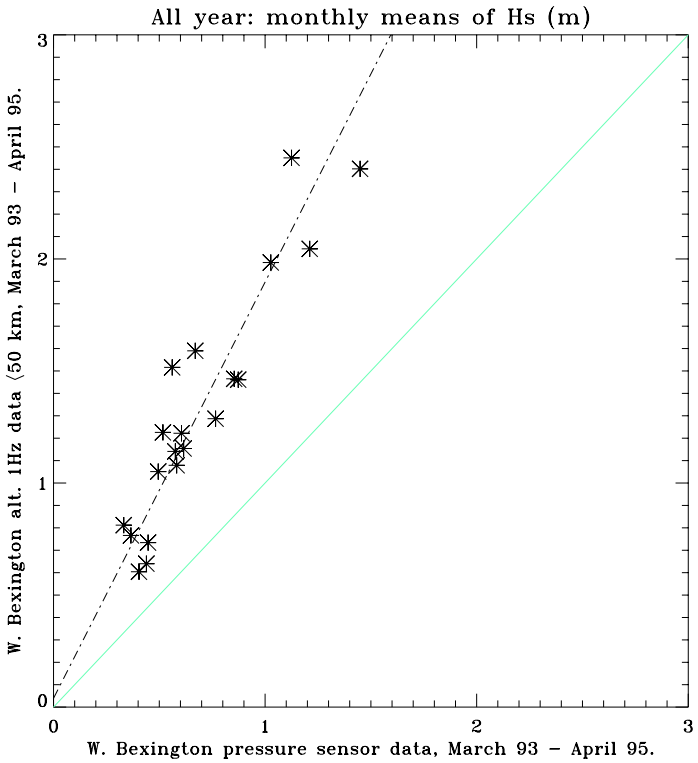


Figure 4

Trend of mean wave height towards the coast

The relationship shown in Figures 3 and 4 indicate that monthly mean wave heights at the near-shore pressure sensor are about 0.6 those from the altimeter measurements within 50 km of the pressure sensor. Data from TOPEX track 61 - the ascending track shown in Figure 2 reaching the coast near Portland Bill - have been investigated for any supporting evidence of this decrease in mean wave height. TOPEX 1 Hz data (at about 6 km intervals) from 200 repeats along this track north of 50°N were interpolated on to common locations along the track, and the means at each location were averaged. Results are shown in Table 2 and in Figure 5.

Number	Latitude	Mean Hs (m)
199	50.02	1.61
199	50.06	1.56
200	50.10	1.54
200	50.14	1.54
199	50.18	1.48
199	50.22	1.46
199	50.26	1.42
198	50.31	1.35
199	50.35	1.30
199	50.39	1.26
199	50.43	1.24
199	50.47	1.20
137	50.51	1.15

Table 2

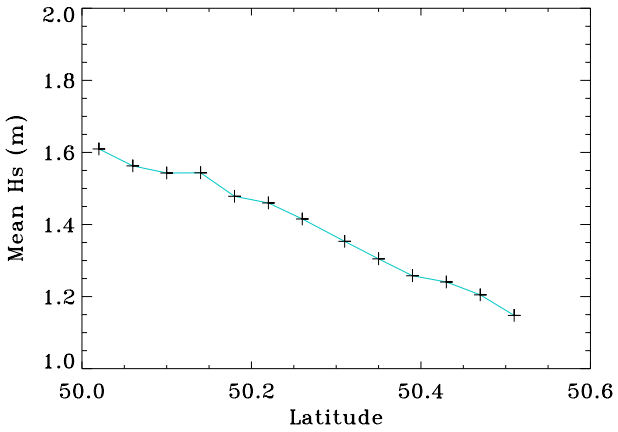


Figure 5 Mean wave height from 200 passes of TOPEX into Lyme Bay.

The trend in Figure 5 is clearly comparable to the observed difference in monthly mean between the pressure sensor and that from satellite data from the general area.

Distribution of wave height throughout the year

Figure 6 shows the cumulative probability distribution of the pressure sensor wave heights, from 10632 records at the standard times between March 1993 and April 1995. The probability axis is scaled so that data from a Fisher-Tippett Type 1 (FT-1) distribution would

lie on a straight line. The top of the figure is the probability of the 10-year return value, assuming 3-hourly observations. These data are clearly not from an FT-1, particularly towards the lower tail with a very large number of wave heights less than 0.5 m (as also seen in the 1991 data shown in Figure 1). The upper tail also 'breaks away' from an FT-1; this might be a physical limitation due to the finite water depth, but is more likely to be due to the high auto-correlation in this time series at 1.5 hour intervals. A straight line through the bulk of the data extrapolates to a 10-year return value of about 6.5 m.

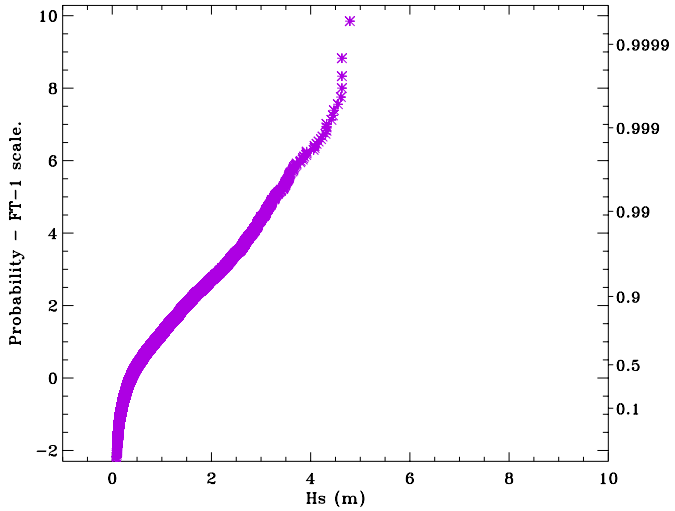


Figure 6 Cumulative probability distribution of Hs from the West Bexington pressure sensor from March 1993 to April 1995.

Figure 7 shows examples of the distribution of the TOPEX wave heights at the locations along Track 61 described in the above section. These data are a much better fit to the FT-1; the line obtained by maximum likelihood and the estimated values of the two parameters of the FT-1 are shown on these figures. The 10-year return value from these lines decrease steadily from 9.0 m at 50.02°N to 6.8 m at 50.51°N. There is some evidence at the more northerly locations that the numbers of very low wave heights are increasing, but not to anything like the extent seen in Figure 6 - where the water depth is thought to be considerably more shallow.

Conclusions

The quality of the wave height data from the Met.-Office buoy in Lyme Bay recorded from July 1983 - December 1997 is too poor for useful analysis.

A comparison of the BODC pressure sensor data from 50° 40'N, 2° 40'W and satellite altimeter data for two years of common operation (from March 1993 to April 1995) indicate that satellite data taken from a small area (a circle of radius 50 km) can give a very different distributions of Hs from that obtained from a sensor at a near-shore site within this circle, but if an altimeter track is available nearby, with satellite moving towards and not off the land, then analysis of the 1 Hz altimeter data can provide a reasonable estimate of the spatial variation in wave height.

For this location of Lyme Bay there appears to be a good, simple linear relationship between the monthly means from the altimeter and from the near-shore pressure sensor, suggesting that between-year variations in means obtained from the altimeter data are indicative of the between-year variations at the near-shore site.

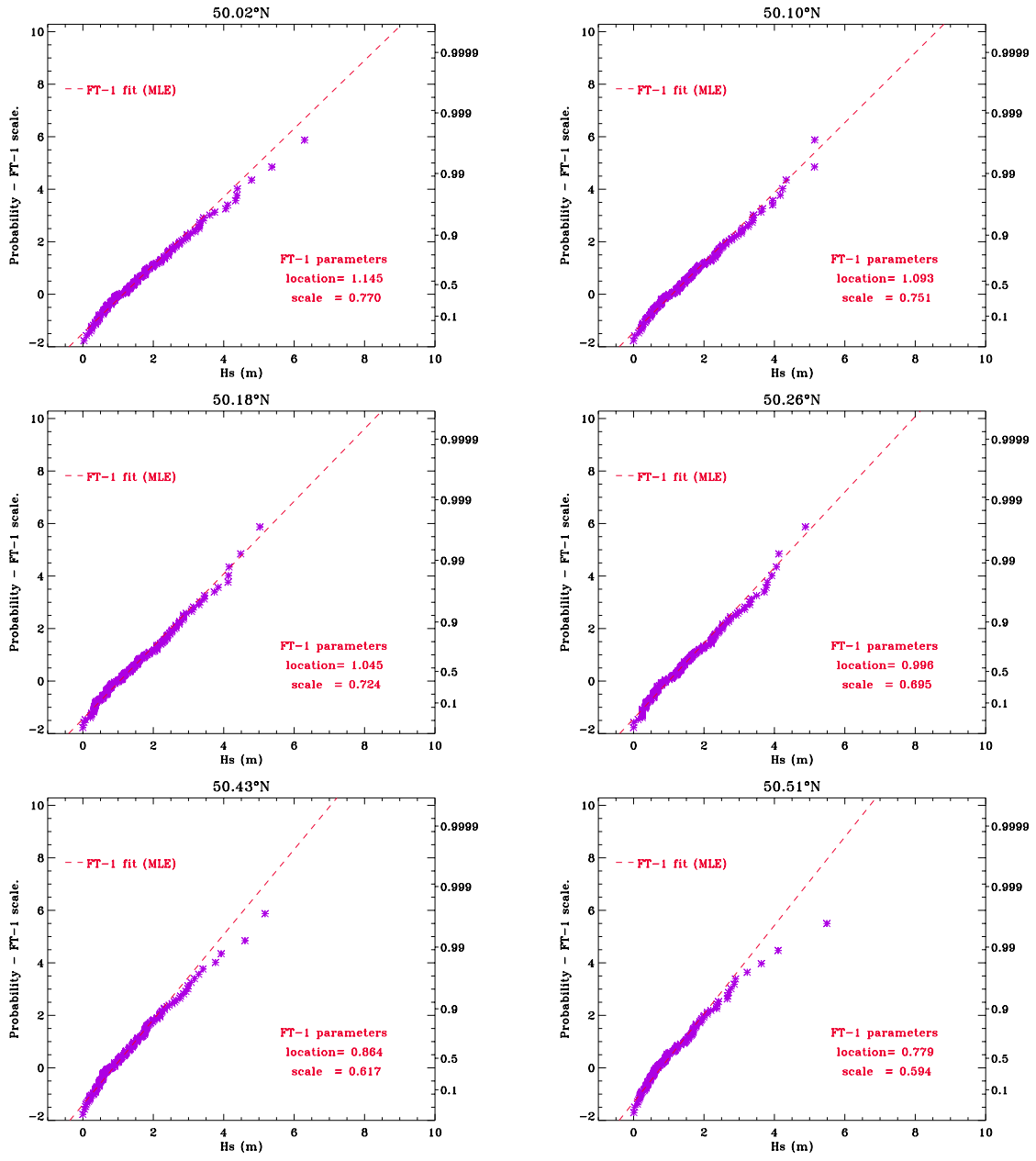


Figure 7 Cumulative probability distributions of wave height at various latitudes from TOPEX data along Track 61.