Department of Science, Information Technology and Innovation

Wave data recording program

Tweed Heads/Brisbane wave climate annual summary May 2014–April 2015

Coastal Impacts Unit

Queensland Government

Prepared by

Kane Nielsen and Robert Wall
Coastal Impacts Unit
Science Delivery Division
Department of Science, Information Technology and Innovation
PO Box 5078
Brisbane QLD 4001

Coastal data report No. 2015.1

July 2015

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Acknowledgements

This report has been prepared by the Department of Science, Information Technology and Innovation. Acknowledgement is made of James Donald; Kieran Harper; Gary Hart; John Maher; John Mohoupt; Colin Newport; Paul Pinjuh; John Ryan; Jeff Shortell; Jim Waldron; Duncan Ward; and Mitch Whatley.

Cover photo: Tweed Waverider buoy 13 May 2010

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1. Introduction

This summary of wave climate from the Tweed Heads and Brisbane wave sites is one of a series of technical wave reports prepared annually by the Coastal Impacts Unit of the Department of Science, Information Technology and Innovation (DSITI).

The information presented here summarises the primary analyses of wave data recorded using Datawell directional Waverider buoys positioned off Tweed Heads and Brisbane for the period from 01 May 2014 to 30 April 2015. The data recorded covers all of the seasonal variations for one year, and includes the 2014–15 cyclone season.

Data is presented in a variety of graphical and tabulated forms, exploring the relationship between the measured wave parameters that define the sea state.

This report has been prepared for the Tweed River Entrance Sand Bypassing Project to summarise the primary analyses of wave data collected at the Tweed Heads and Brisbane wave sites and presents wave climate information for the reporting period from 01 May 2014 to 30 April 2015.

The wave data collected for the current year of recording is statistically compared to the long-term average conditions at the sites. Brief details of the recording equipment, the methods of handling raw data and the type of analyses employed are provided within this report.

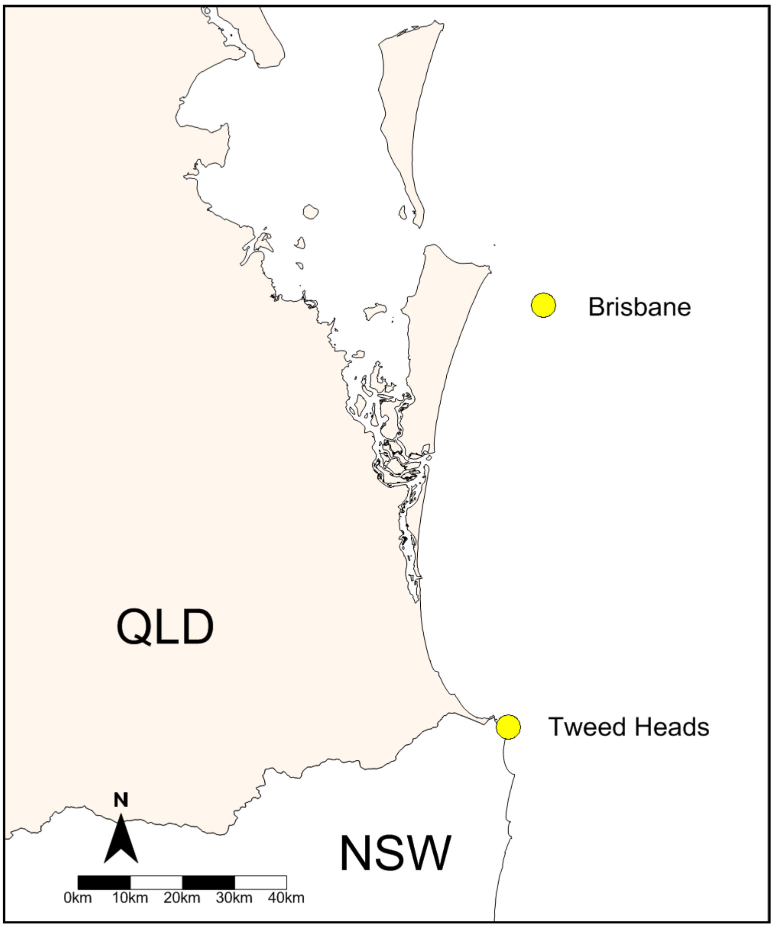


Figure 1.1: Tweed regional wave recording sites – Locality plan

1.1 Recording

DSITI's Coastal Impacts Unit wave recording program uses the Waverider system manufactured by Datawell of the Netherlands to measure sea surface fluctuations. Directional Waverider buoys were in operation at Tweed Heads and Brisbane during the period of this report.

1.1.1 Brisbane

The directional Waverider buoy at the Brisbane site measured vertical accelerations by means of an accelerometer placed on a gravity-stabilised platform. This platform is formed by a disk which is suspended in fluid within a plastic sphere placed at the bottom of the buoy. Two vertical coils are wound around the plastic sphere and one small horizontal coil is placed on the platform. The pitch and roll angles are defined by the amount of magnetic coupling between the fixed coils and the coil on the platform. Measuring this coupling gives the sine of the angles between the coils (x and y axes) and the horizontal plane (= platform plane). An additional accelerometer unit measures the forces on the buoy with respect to its x and y axes.

A fluxgate compass provides a global directional reference with which to orient the buoy. The acceleration values that are relative to the buoy are then transformed into values that are relative to the fixed compass. The measured acceleration values are filtered and double integrated with respect to time to establish displacement values for recording.

Only waves with frequencies within the range of 0.033–0.64 Hz can be captured by the buoy, due to physical limitations of the system. Wave motion with higher frequencies can't be followed / ridden properly due to the dimensions of the buoy, while lower frequency waves apply very small acceleration forces that become undetectable (Datawell, 2010).

1.1.2 Tweed Heads

The directional Waverider buoy at the Tweed Heads site used the GPS satellite system to calculate the velocity of the buoy (as it moves with the passing waves) from changes in the frequency of GPS signals according to the Doppler principle. For example, if the buoy is moving towards the satellite the frequency of the signal is increased, and vice-versa. The velocities are integrated through time to determine buoy displacement. The measurement principle is illustrated in Figure 1.2, which shows a satellite directly overhead and a satellite at the horizon. In practice the GPS system uses signals from multiple satellites to determine three-dimensional buoy motion.

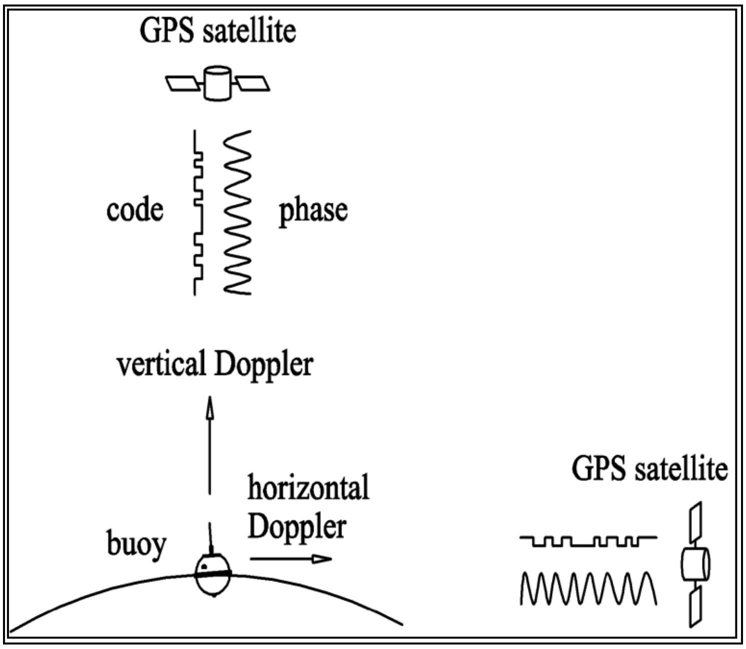


Figure 1.2: The GPS wave measurement principle (Source: Datawell)

At both Tweed Heads and Brisbane, the vertical buoy displacement representing the instantaneous water level and calculated directional data are transmitted to a receiver station as a modulated high-frequency radio signal. The directional Waverider receiver stations on shore are each comprised of a desktop computer system connected to a Datawell receiver/digitiser. The water level data at each site is digitised at 0.78 seconds intervals (1.28 Hz) and stored in bursts of 2048 points (approximately 26 minutes) on the hard disk of the computer.

The proprietary software running on the computer controls the timing of data recording, and processes the data in near real time to provide a set of standard sea-state parameters and spectra that may be accessed remotely via a Telstra NEXTG® link. Recorded data and analysis results are downloaded every two hours to a central computer system in Brisbane for checking, further processing, and archiving.

Further information on the operation of the Waverider buoy and the recording systems can be obtained from the reference sources listed in Section 5 of this report.

1.2 Laboratory calibration checks

Waverider buoys used by DSITI are calibrated before deployment and also after recovery. Normally, a buoy is calibrated once every 12 months. Calibration of accelerometer buoys is performed at DSITI’s Deagon site using a buoy calibrator to simulate sinusoidal waves with vertical displacements of 2.7 metres. The calibrator is electrically controlled and the frequency may be adjusted from 0.016–0.25 Hz. It is usual to check three frequencies during a calibration. The following characteristics of the buoy are also checked during the calibration procedure:

- compass
- phase and amplitude response
- accelerometer platform stability
- platform tilt
- battery capacity
- power output.

Calibration of the GPS buoy involves placing it in a fixed location on land for a period of several days while it records data. This location should be such that there are no obstructions between the buoy and the orbiting GPS satellites. A GPS buoy in calibration should produce result showing no displacements between records – any differences can be attributed to errors in the transmission signal between the GPS buoy and the orbiting satellites or to faults in the buoy.

There are no adjustments to the recorded wave data, based on the laboratory calibration results. Monthly averages are calculated based on available data and no wave data records are rejected based on low capture rates. Research (Bacon & Carter, 1991 and Allan & Komar, 2001) has suggested rejecting entire records where less than a certain threshold has been recorded. All Queensland wave-recording sites generally have high-percentage capture rates for the seasonal year and thus minimal bias is introduced into calculations.

1.3 Wave recording and analysis procedures

The computer-based, wave-recording systems at Tweed Heads and Brisbane record data at half-hourly intervals.

Raw wave data transmitted from the buoys is analysed in the time domain by the zero up-crossing method (see Appendix A – Zero up-crossing analysis) and in the frequency domain by spectral analysis using Fast Fourier Transform (FFT) techniques to give 128 spectral estimates in bands of 0.01 Hz. The directional information is obtained from initial processing on the buoy, where datasets are divided into data sub-sets and each sub-set is analysed using FFT techniques. The output from this processing is then transmitted to the shore station, along with the raw data, where it undergoes further analysis using FFT techniques to produce 128 spectral estimates in bands of 0.005 Hz.

The zero up-crossing analysis is equivalent in both the Brisbane (accelerometer) and Tweed (GPS) systems. Wave parameters resulting from the time and frequency domain analysis included the following:

Table 1: Wave parameters involved in the analysis

S(f)	energy density spectrum (frequency domain)
Hsig	Significant wave height (time domain), the average of the highest third of the waves in the record.
Hmax	The highest individual wave in the record (time domain).
Hrms	The root mean square of the wave heights in the record (time domain).
Tsig	Significant wave period (time domain), the average period of the highest third of waves in the record.
Tz	The average period of all zero up-crossing waves in the record (time domain).
Tp	The wave period corresponding to the peak of the energy density spectrum (frequency domain).
Tc	The average period of all the waves in the record based on successive crests (time domain).
Direction (Dir; Dir_p)	The direction that peak period (Tp) waves are coming (in º True North). In other words, where the waves with the most wave energy in a wave record are coming from.
SST	The sea surface temperature (in º Celsius) obtained by a sensor mounted in the bottom of the buoy.

These parameters form the basis for the summary plots and tables included in this report.

1.4 Data losses

Data losses can be divided into two categories: losses due to equipment failure; and losses during data processing due to signal corruption. Common causes of data corruption include radio interference and a spurious, low-frequency component in the water-level signal caused by a tilting platform in the accelerometer-based Waverider buoy. Obstructions in the data path between the GPS buoy and the orbiting satellites can also cause data corruption and loss of signal.

Analysis of recorded data by the computer systems includes some data rejection checks which may result in a small number of spurious and rejected data points being replaced using an interpolation procedure, otherwise the entire series is rejected.

As discussed above, the various sources of data losses can cause occasional gaps in the data record. Gaps may be relatively short, caused by rejection of data records or much longer if caused by malfunction of the Waverider buoy or the recording equipment.

2. Overview

No attempt has been made to interpret the recorded data for design purposes or to apply corrections for refraction, diffraction and shoaling to obtain equivalent deep-water waves. Before any use is made of this data, the exact location of the buoy, and the water depth in which the buoy was moored, should be noted (Table 2 and Table 3). Details are presented in the location history plan (Figure 3.1). Data capture rates for each wave site over the seasonal year are presented in Table 4.

Table 2: Deployment details for the Tweed Waverider buoy

Latitude	Longitude	Depth (m)	Deployed date	Removal date
28°10.910'S	153°34.555'E	22	21/01/2014	17/04/2015
28°10.870'S	153°34.485'E	20	17/04/2015	current

Table 3: Deployment details for the Brisbane Waverider buoy

Latitude	Longitude	Depth (m)	Deployed date	Removal date
27°28.400'S	153°37.630'E	70	4/02/2014	31/10/2014
27°29.475'S	153°37.955'E	70	31/10/2014	31/03/2015
27°29.600'S	153°37.960'E	70	31/03/2015	current

Table 4: Wave recording program; percentage data capture May 2014 – April 2015

Station	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Avg.
Tweed Heads	99.66	99.79	93.35	99.80	99.79	99.46	99.79	99.80	99.80	99.78	99.80	93.40	98.69
Brisbane	100	99.79	99.80	99.80	99.79	93.28	99.79	99.80	99.80	99.78	97.58	99.79	99.08

A summary of major meteorological events, where the recorded Hsig value reached the storm threshold wave height of two metres for Tweed Heads and four metres for Brisbane, for the period from 01 May 2014 to 30 April 2015 is shown in Table 5. Wave parameters Hsig, Hmax, Tp, and other relevant information are listed for each event. Only storm and cyclone events that contributed to the Hsig reaching the storm threshold value are listed in Table 5.

Notes:

1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).
2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

Table 5: Significant meteorological events May 2014 – April 2015

Tweed Heads Storm threshold value: 2.0 metres (Hsig)				
Date	**Hsig (m)**	**Hmax (m)**	**Tp (s)**	**Event**
18/05/2014 2:00	2.0 (2.1)	3.4 (3.5)	9.2	A high pressure area persisting in the Tasman Sea caused a weak ridge to form over a majority of the Queensland coast.
17/08/2014 2:00	2.5 (2.7)	4.0 (4.6)	7.5	On the 17th, an East Coast Low was present off the coast of central New South Wales for two days with an associated trough along the entire east coast.
28/08/2014 10:30	3.2 (3.5)	5.1 (6.3)	12.4	From the 26th to the 28th, there was a low pressure system off southeast Queensland and several coastal troughs with embedded low pressure systems.
13/12/2014 8:30	2.3 (2.5)	4.0 (5.2)	11.6	A trough located across Queensland resulted in severe thunderstorms in the southeast from the 11th to the 13th.
28/12/2014 1:00	2.0 (2.2)	3.4 (3.5)	9.8	A trough splitting two high pressure areas in the Tasman Sea persisted from the 27th to the 29th.
12/01/2015 14:30	2.0 (2.3)	3.3 (3.8)	10.8	There was a monsoon trough present off the northeast coast of Queensland as well as a trough moving west to east across New South Wales in to the Tasman Sea.
23/01/2015 9:00	2.6 (2.7)	4.5 (5.1)	10.5	From the 21st, severe thunderstorms impacted the central Queensland coast with a trough extending along the eastern coastline resulting in thunderstorms on the 23rd in southeast Queensland.
11/02/2015 10:30	2.0 (2.1)	3.7 (4.0)	8.1	A high pressure system moving east through the Tasman Sea to the south island of New Zealand generated a firm ridge affecting Queensland persisting from the 10th to 12th.
22/02/2015 17:00	3.1 (3.5)	5.3 (6.6)	10.1	TC Marcia formed on the 18th off the central coast of Queensland and intensified over the following days whilst tracking south to deteriorate in to a low off the southeast Queensland coast.
1/04/2015 11:00	2.1 (2.2)	3.5 (4.1)	7.9	An area of high pressure off the central coast of New South Wales persisted from the 29th of March to the 1st of April.
30/04/2015 22:00	2.1 (2.3)	3.5 (3.9)	7.2	On the 29th, a strong upper trough in the southeastern interior of Queensland moved off the southern coast on the 30th generating damaging winds and large swells.

Brisbane				
3/02/2015 23:30	4.1 (4.4)	6.6 (7.4)	9.7	TC Ola formed over the eastern Coral Sea on January 31st and remained present until the 3rd of February. This led to increased southerly winds and tides along the Queensland coast
22/02/2015 14:30	4.2 (4.5)	7.2 (8.5)	10.2	TC Marcia formed on the 18th off the central coast of Queensland and intensified over the following days whilst tracking south to deteriorate in to a low off the southeast Queensland coast.

Denotes peak Hsig event

Details of the wave recorder installations for the Tweed Heads and Brisbane sites are shown on the first page of each site section, including information on buoy location, recording station location, recording intervals and data collection.

The wave climate data presented in this report is based on statistical analyses of the parameters obtained from the recorded wave data. Software programs developed by DSITI provide statistical information on percentage of time occurrence and exceedance for wave heights and periods. The results of these analyses are presented in Figure 3.3–Figure 3.5 and Figure 4.3–Figure 4.5. In each of these three figures for each site, the term 'All data' refers to the entire available dataset collected for Tweed Heads (20.25 years) since 13 January 1995 and Brisbane (37.5 years) since 31 October 1977. In addition, similar statistical analysis provides monthly averages of wave heights for the seasonal year and all data.

Daily wave recordings, average water temperature and peak direction (Dir_p) recordings are shown for the period from 01 May 2014 to 30 April 2015. Directional wave roses for the same period are also presented. These wave roses summarise wave occurrence at Tweed Heads and Brisbane by indicating their height, direction and frequency. Each branch of a wave rose represents waves coming from that direction with branches divided into Hsig segments of varying range. The length of each branch represents the total percentage of waves from that direction with the length of each segment within a branch representing the percentage of waves, in that size range, arriving from that direction for all wave periods. Note that the wave rose is only intended as a visual guide to the wave climate at the site.

This report covers the period from 01 May 2014 to 30 April 2015 to align with the Tweed River Entrance Sand Bypassing Project environmental monitoring periods. For the purposes of analysis, summer has been taken as the period from 01 November to 30 April of the following year and winter covers the period 01 May to 31 October in any one year.

3. Tweed Heads

Tweed Heads

Wave recording station

Details of data collected

2014-2015 season

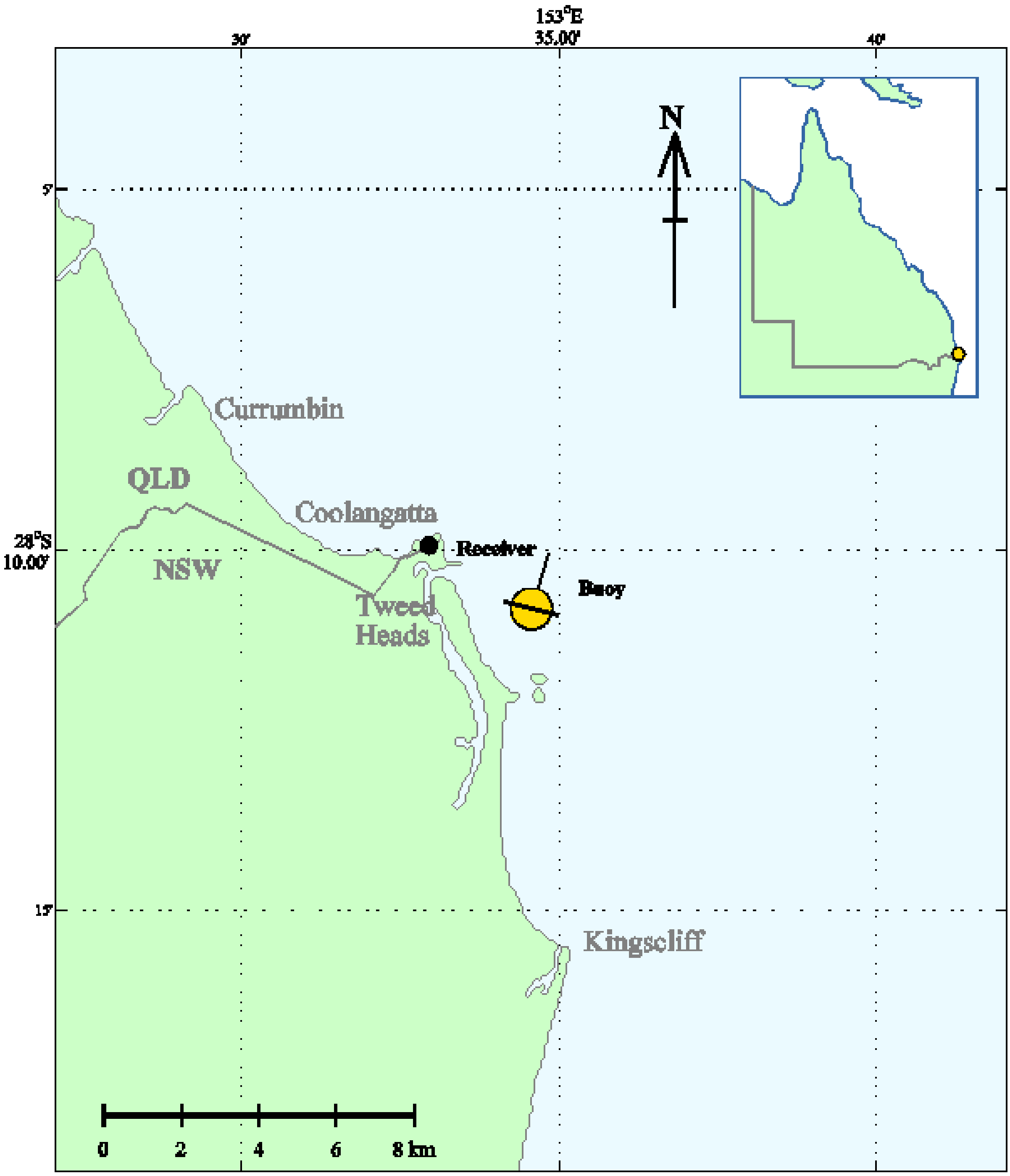
Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 360.17
Gaps in data used in analysis (days)	= 4.81
Number of records used in analysis	= 17288

All data since-1995

Maximum possible analysis years (last record - first record)	= 20.29
Total number of years used in analysis	= 19.98
Gaps in data used in analysis (years)	= 0.31
Number of records used in analysis	= 299505

Table of highest ranked un-smoothed waves at Tweed Heads

Rank	Date(Hs)	Hs (m)	Date(Hmax)	Hmax (m)
1	03/05/1996 01:00	7.5	02/05/1996 14:30	13.1
2	28/01/2013 08:30	6.7	28/01/2013 09:00	11.8
3	06/03/2004 01:00	6.1	05/03/2004 23:30	11.1
4	21/05/2009 19:30	5.6	30/06/2005 06:30	9.9
5	24/05/1999 05:00	5.2	22/05/2009 07:00	9.7
6	04/03/2006 20:30	5.2	04/03/2006 12:00	9.6
7	12/06/2012 10:00	5.2	25/03/1998 22:30	9.5
8	15/02/1995 11:30	5.2	15/02/1995 15:30	9.3
9	30/06/2005 09:00	4.9	12/06/2012 11:30	9.3
10	24/03/2004 06:00	4.8	02/02/2001 02:00	9.1



Latitude	Longitude	Depth (m)	Deployed date	Removal date
28°10.910'S	153°34.555'E	22	21/01/2014	17/04/2015
28°10.870'S	153°34.485'E	20	17/04/2015	current

Figure 3.1: Tweed region – Locality plan

Table 6: Wave conditions 2014-15 – Tweed Heads (see also Figure 3.6)

Month	Average Hsig (m)	Min Hsig (m)	Max Hsig (m)	Average of Peak Period (Tp) Directions (Ø TRUE)	90% of waves within the range of (m)	No. of Days When Hsig> 2m	No. of Days When Hsig< 0.75m	Events where Hsig> 3m and date of storm
May-14	1.01	0.26	2.08	100	0.5 - 1.5	1	14	
Jun-14	0.92	0.32	1.92	103	0.5 - 1.5	0	16	
Jul-14	0.86	0.39	2.04	105	0.5 - 1.3	1	18	
Aug-14	1.39	0.47	3.47	92	0.8 - 2.4	9	4	28th
Sep-14	0.98	0.49	1.65	100	0.6 - 1.4	0	17	
Oct-14	1.02	0.56	1.74	94	0.7 - 1.4	0	13	
Nov-14	1.11	0.66	1.71	82	0.8 - 1.5	0	8	
Dec-14	1.16	0.64	2.55	93	0.8 - 1.9	5	6	
Jan-15	1.32	0.58	2.73	91	0.8 - 2.0	5	3	
Feb-15	1.7	0.73	3.49	95	0.9 - 2.7	12	1	19th, 22nd, 23rd
Mar-15	1.09	0.58	1.92	92	0.8 - 1.6	0	6	
Apr-15	1.29	0.67	2.29	96	0.8 - 1.9	4	3	
May to April	**1.15**	**0.26**	**3.49**	**95**	**0.6 - 1.9**	**37**	**109**	**4 days**

Table 7: Mean Values, Tweed Heads

Month	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May Apr
Mean Hsig(m) 2014–15	1.01	0.92	0.86	1.39	0.98	1.02	1.11	1.16	1.32	1.7	1.09	1.29	1.15
Mean Hsig(m) Average from 1995–2015	1.34	1.2	1.18	1.11	1.09	1.13	1.15	1.15	1.34	1.48	1.45	1.36	1.25
Average of Peak Period (Tp) Directions (Ø TRUE) 2014–15	100	103	105	92	100	94	82	93	91	95	92	96	95
Average Peak Period (Tp) Directions (Ø TRUE) 1995–2015	100	101	103	100	93	92	92	93	91	96	93	98	96

Mean Hsig= ∑Hsig/ N

Average of Peak Period (Tp) Directions = ∑D / N

Where:

Hsig= Significant wave height

D = Direction at Peak Period (Tp)

N = number of records

Table 8: Weighted Mean Values, Tweed Heads (see also Figure 3.6)

Month	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May Apr
Weighted Mean Hsig(m) 2014–15	1.08	0.99	0.91	1.54	1.04	1.06	1.14	1.24	1.39	1.83	1.14	1.36	1.23
Weighted Mean Hsig (m) 1995–2015	1.63	1.38	1.32	1.28	1.18	1.24	1.24	1.27	1.49	1.64	1.62	1.49	1.4
Weighted Mean of Peak Period (Tp) Directions (Ø TRUE) 2014–15	95	102	106	89	101	90	81	97	88	90	88	96	94
Weighted Mean of Peak Period (Tp) Directions (Ø TRUE) 1995–2015	88	96	99	94	93	91	95	91	88	93	88	95	93

Weighted mean Hsig= (∑Hsig2.5 / N) 0.4

Weighted Mean Direction = ∑(Hsig2.5*D) / ∑Hsig2.5

Where:

Hsig= Significant wave height

D = Direction at Peak Period (Tp)

N = number of records

Table 9: Hsig percentage (%) occurrence, Tweed Heads

Hsig (m)	0 0.5	0.5 1	1 1.5	1.5 2	2 2.5	2.5 3	3 3.5	3.5 4	4 4.5	4.5 5	5 5.5	5.5 6	6 6.5	6.5 7
May 95–Apr 15	1.10	34.12	41.21	15.77	5.21	1.54	0.60	0.24	0.12	0.05	0.02	0.01	0.01	0.00
May 14–Apr 15	1.15	39.32	43.83	11.55	2.97	0.90	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00

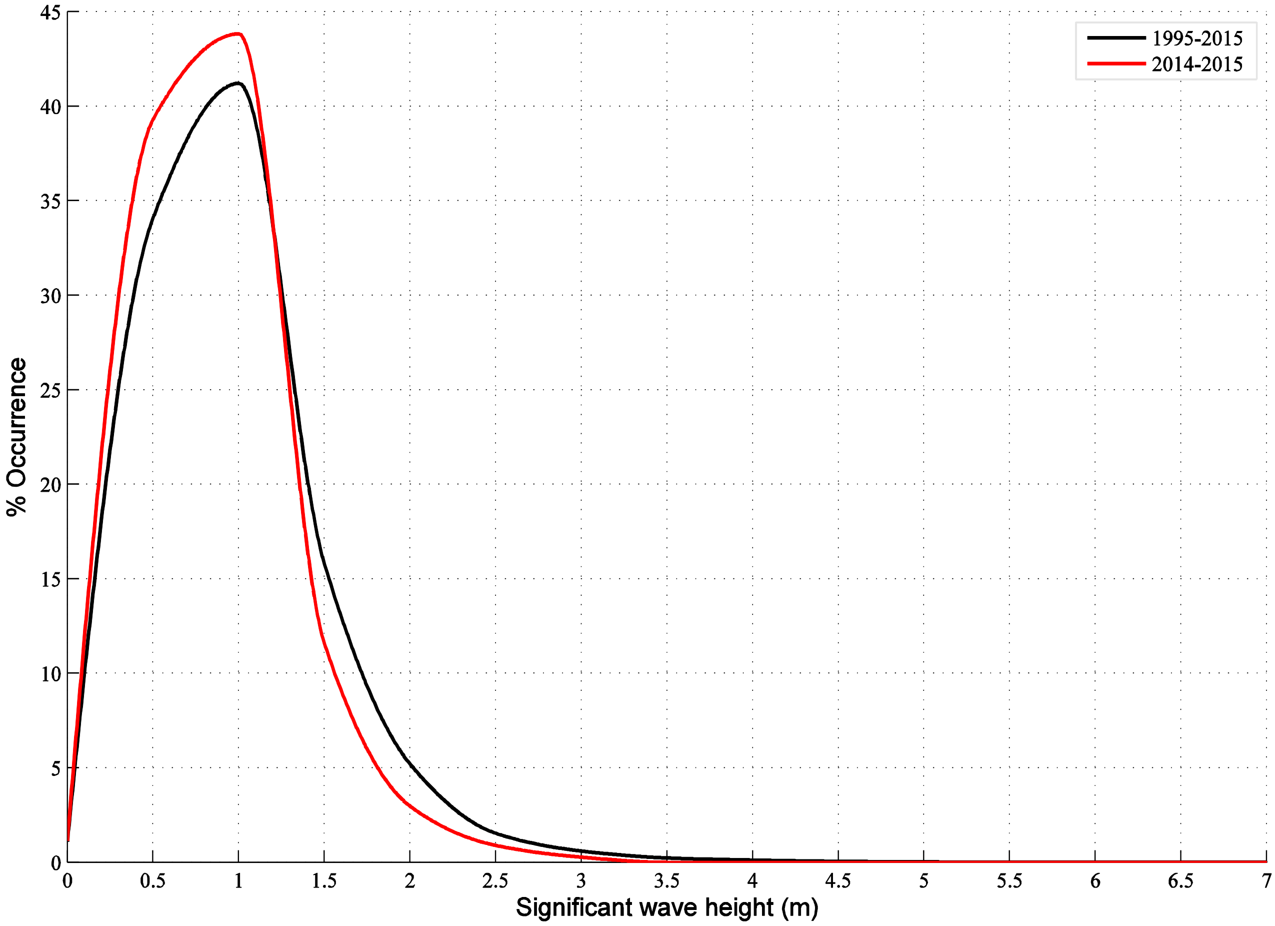


Figure 3.2: Tweed region – Hsig percentage (%) occurrence

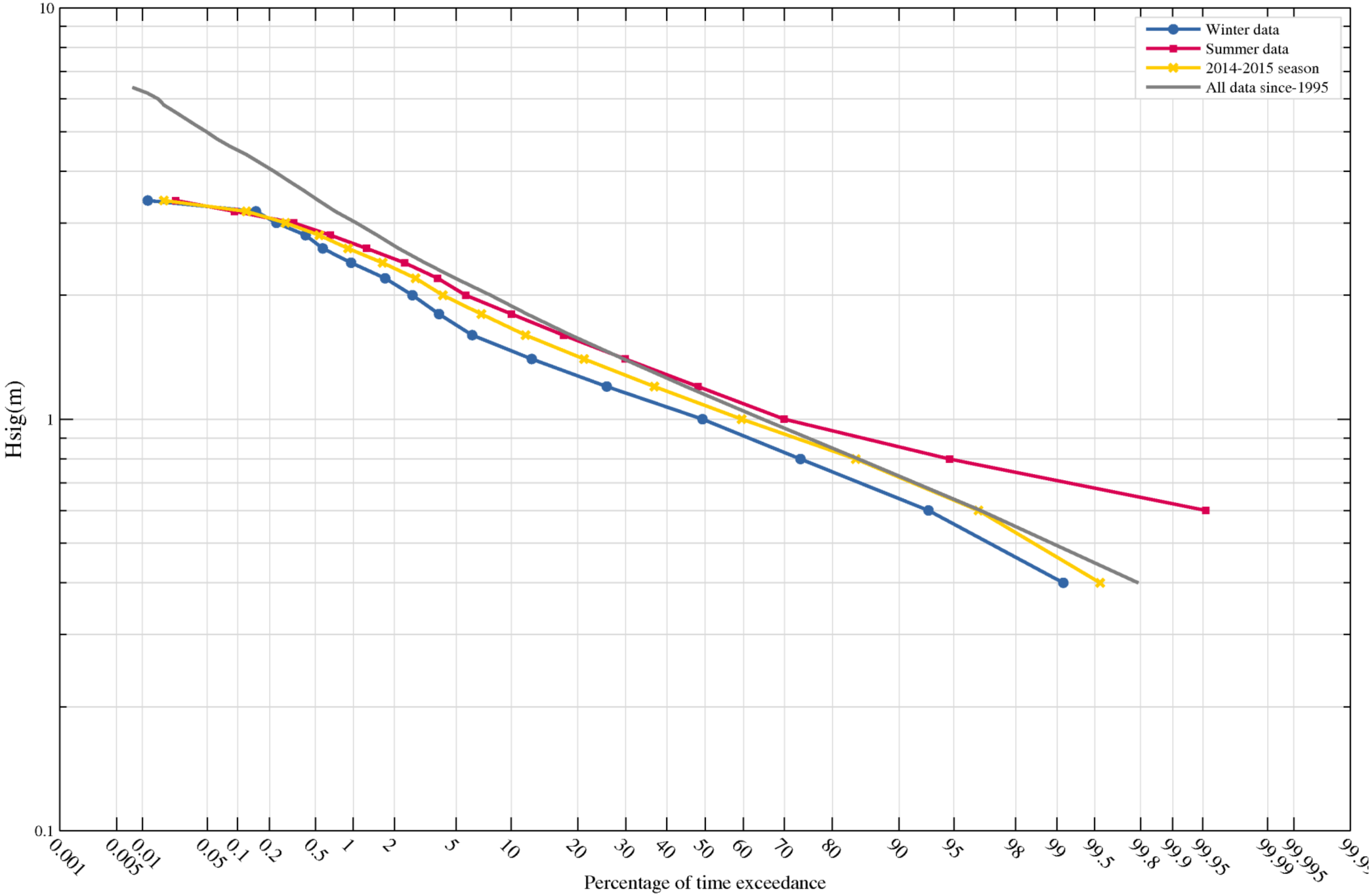


Figure 3.3: Tweed region – Percentage (of time) exceedance of wave heights (Hsig) for all wave periods (Tp)

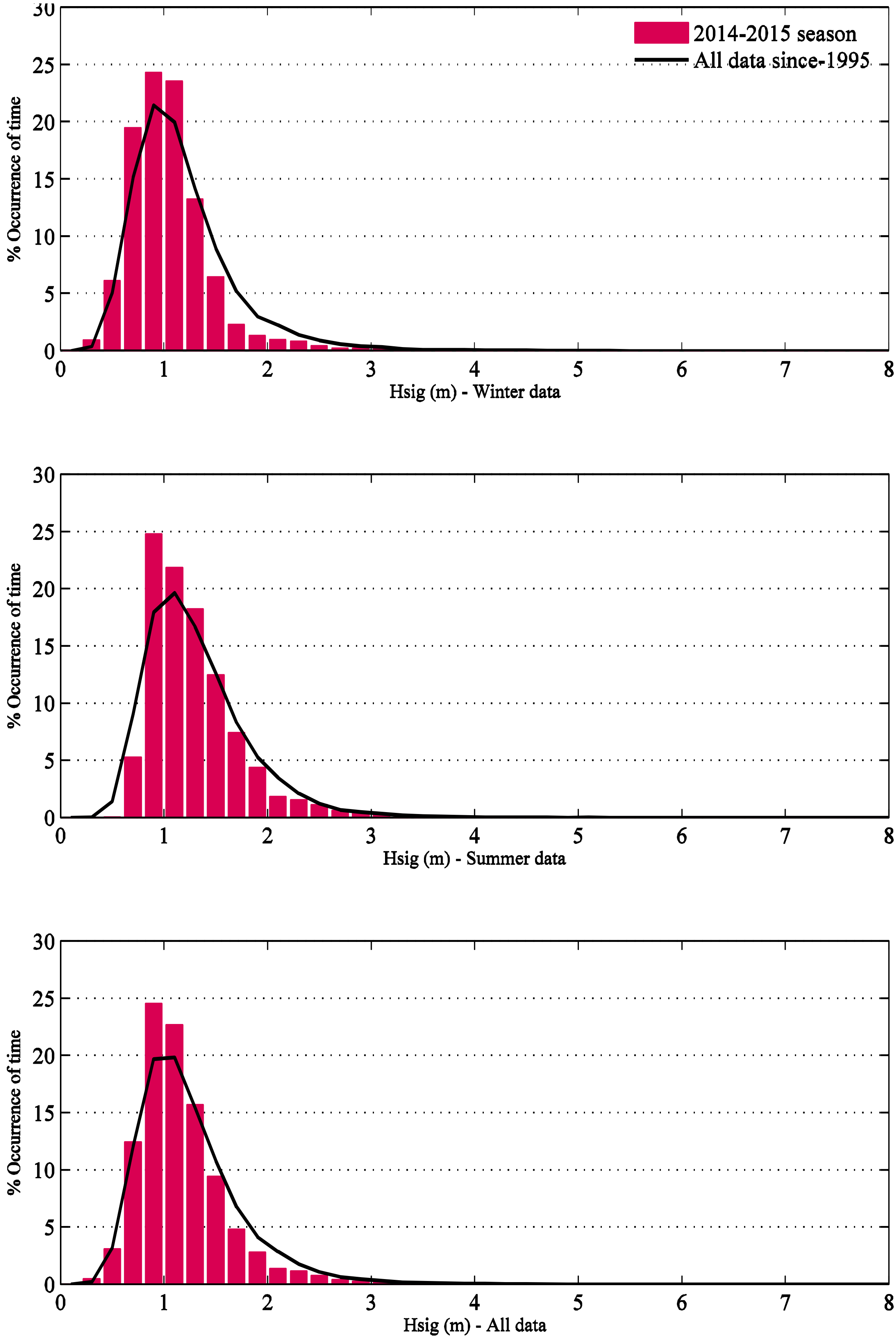


Figure 3.4: Tweed region – Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

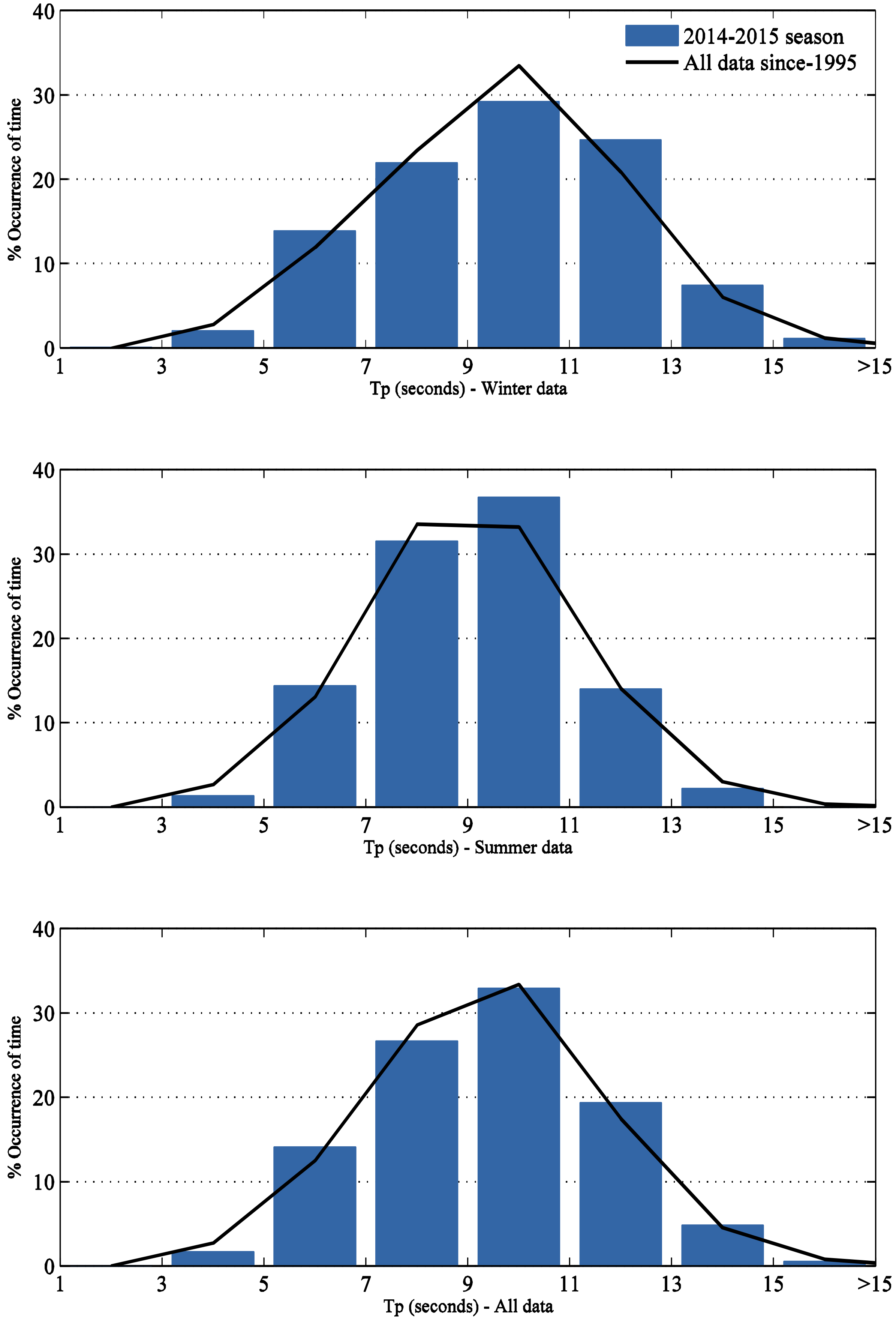


Figure 3.5: Tweed region – Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

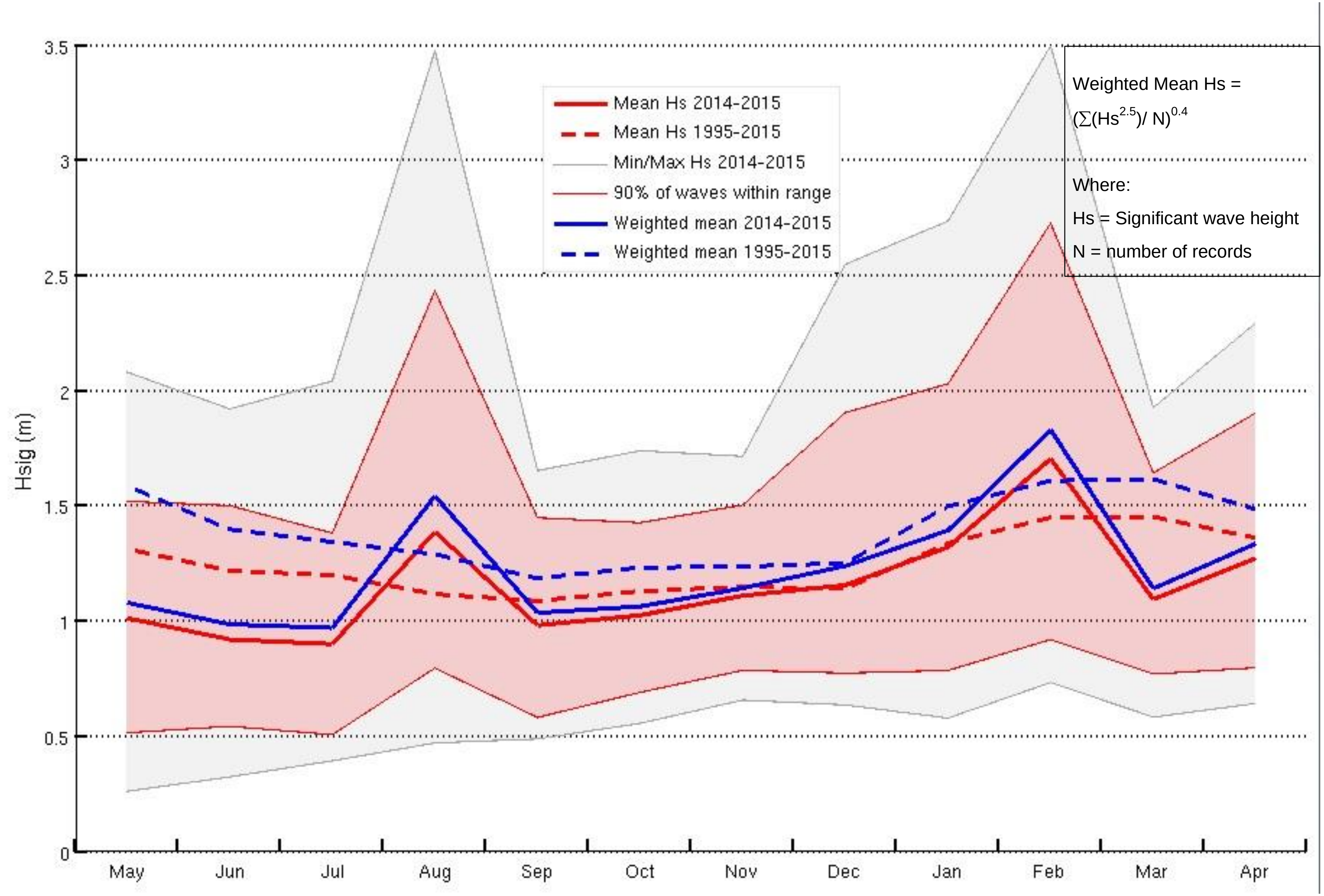


Figure 3.6: Tweed region – Plot of monthly averages for seasonal year and for all data, for wave heights (Hsig). The weighted mean Hs provides an indicative potential for sediment transport.

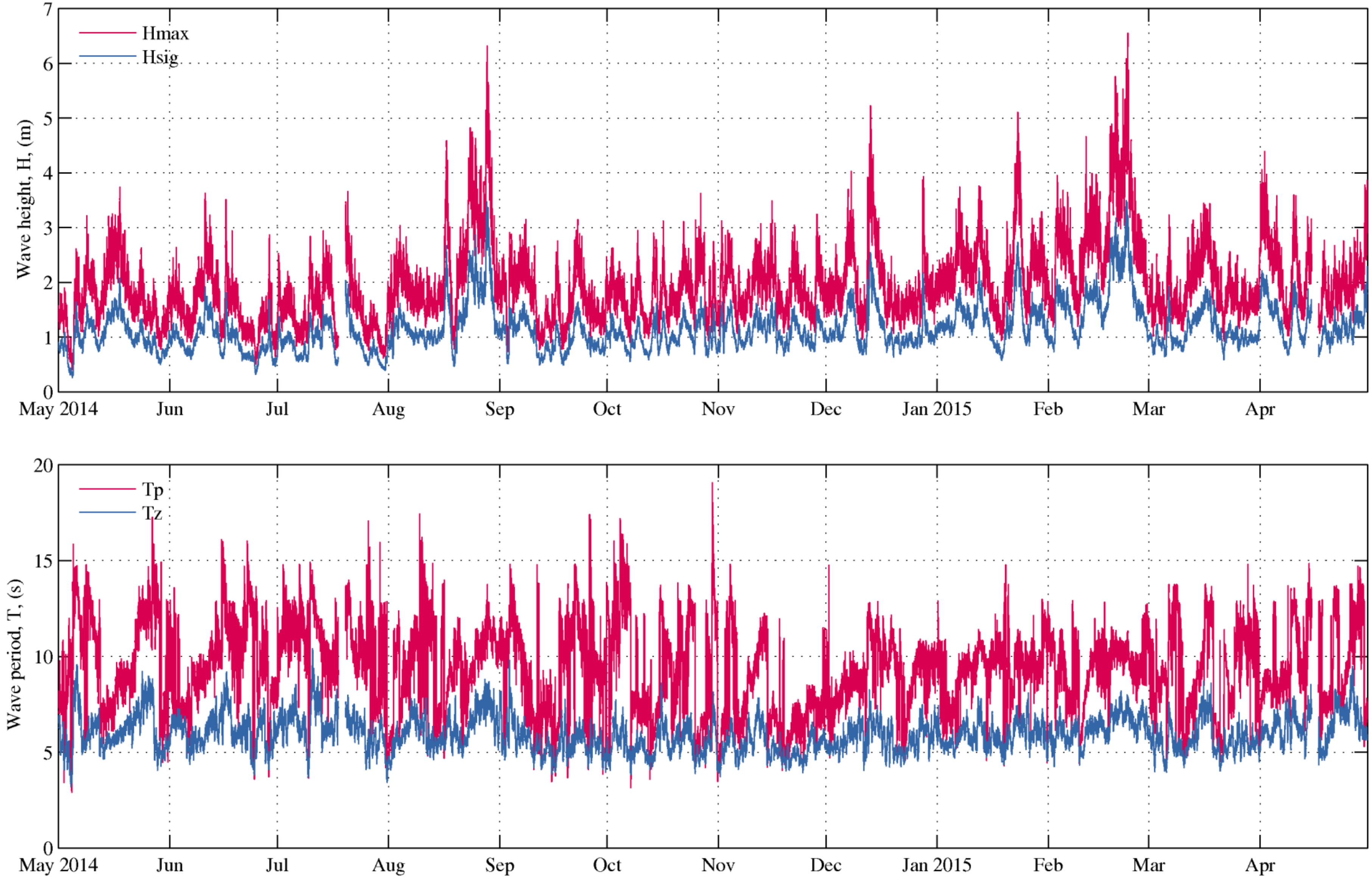


Figure 3.7: Tweed region – Daily wave recordings

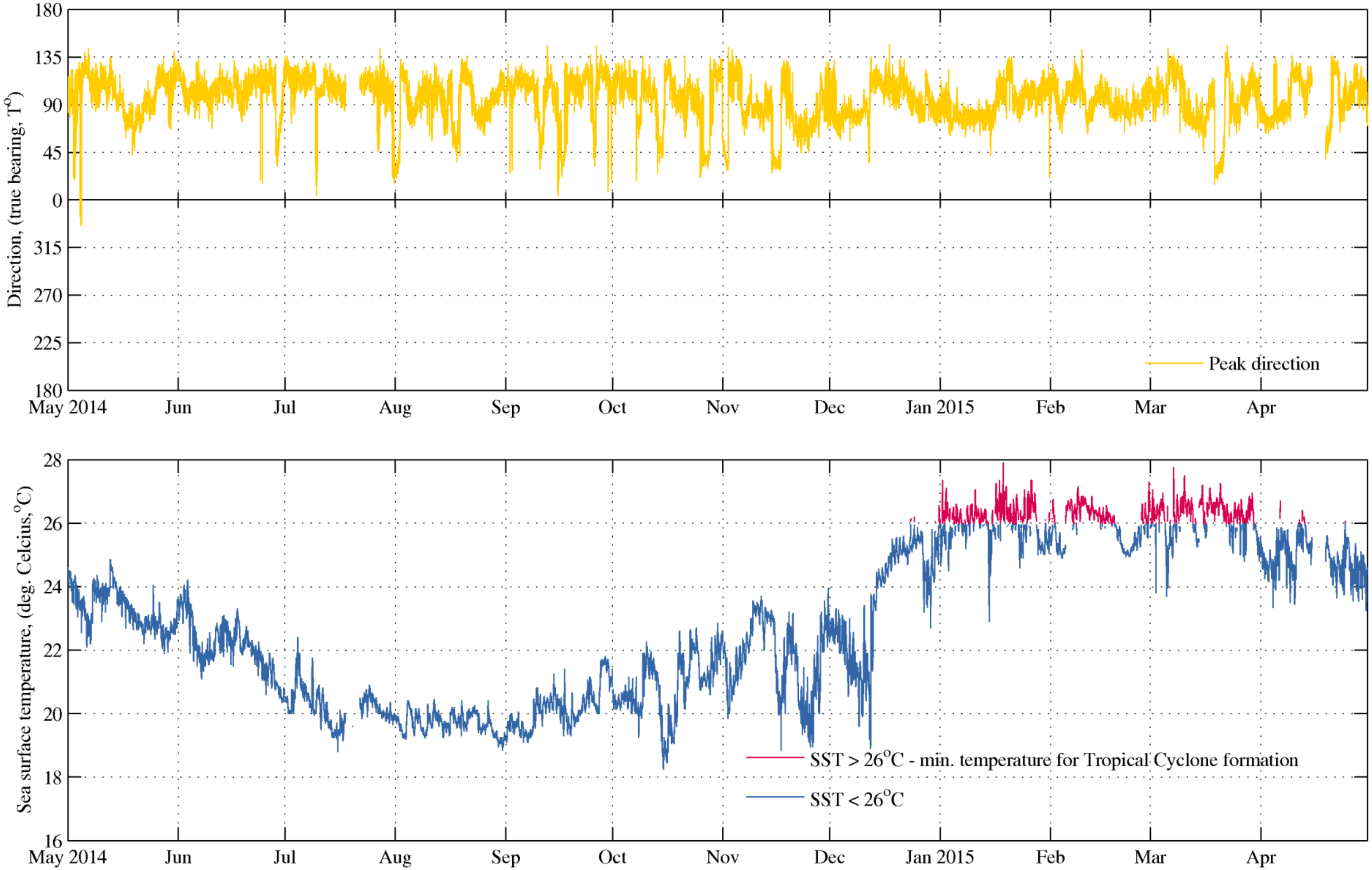
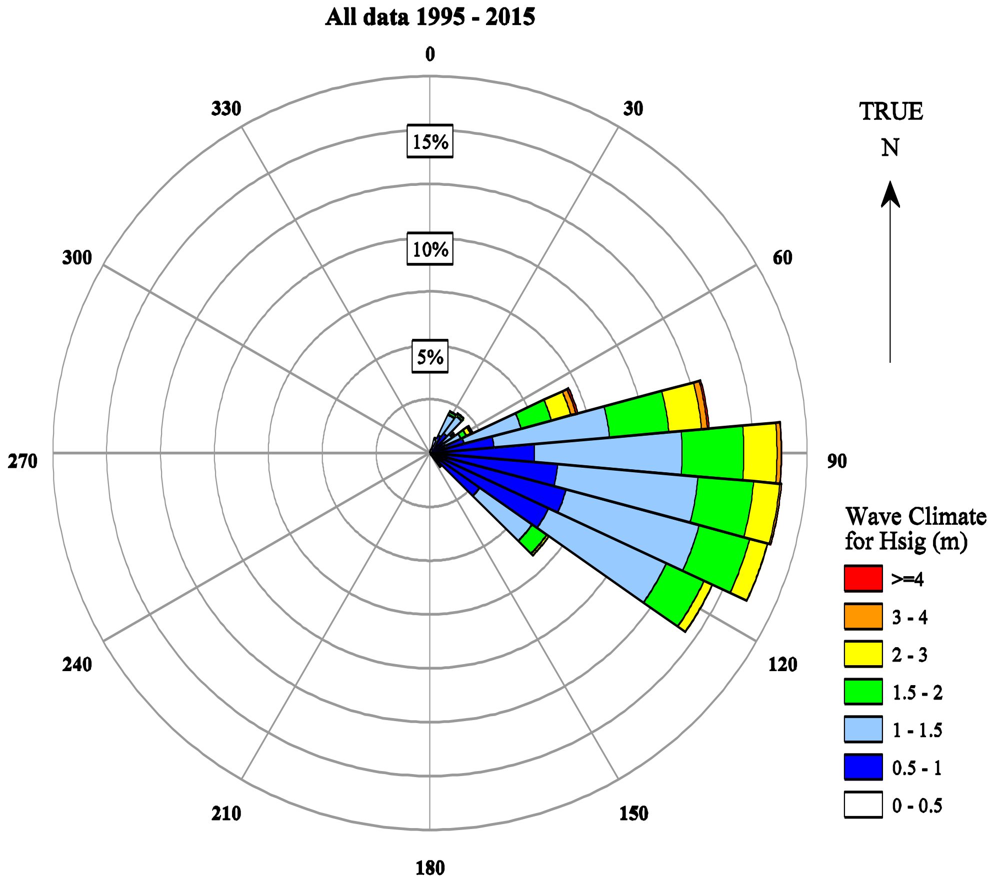


Figure 3.8: Tweed region – Sea surface temperature and peak wave directions



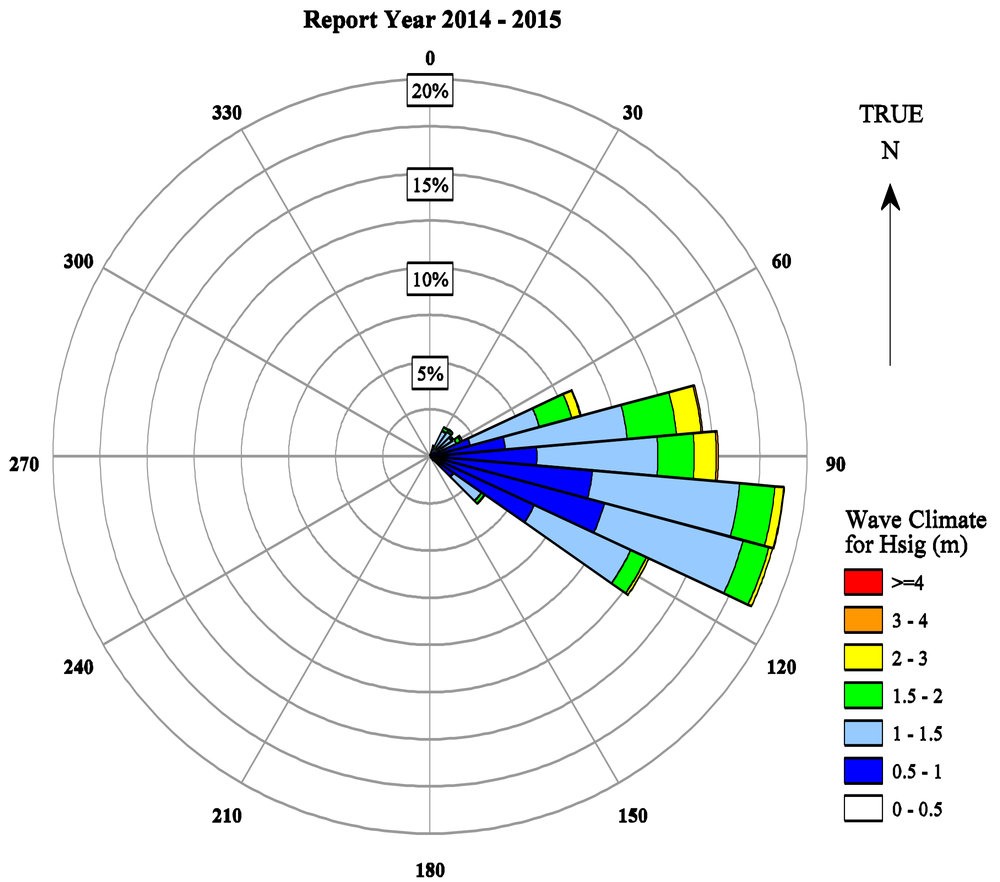


Figure 3.9: Tweed region – Directional wave rose

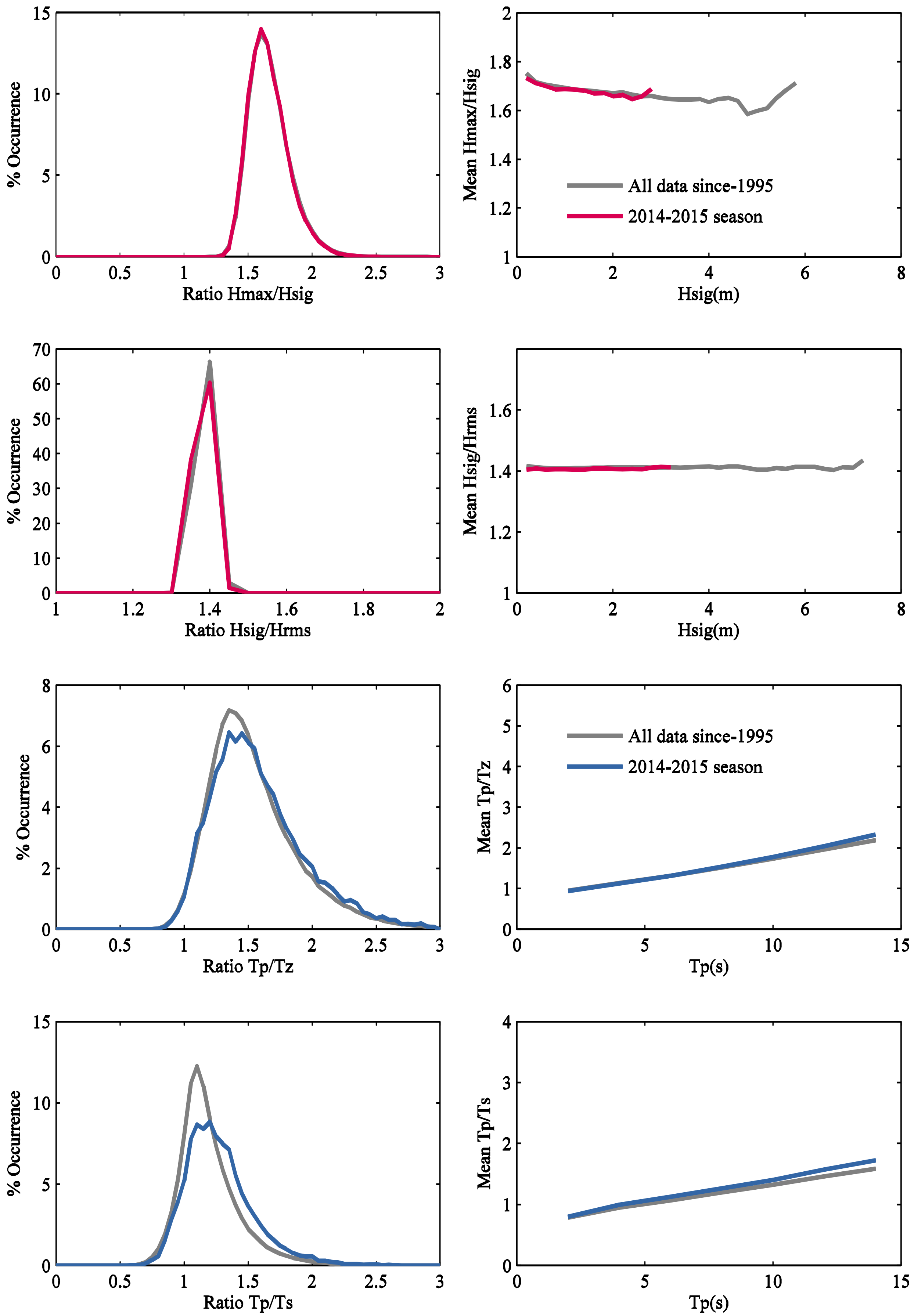


Figure 3.10: Tweed region – Wave parameter relationships

4. Brisbane

Brisbane

Wave recording station

Details of data collected

2014-2015 season

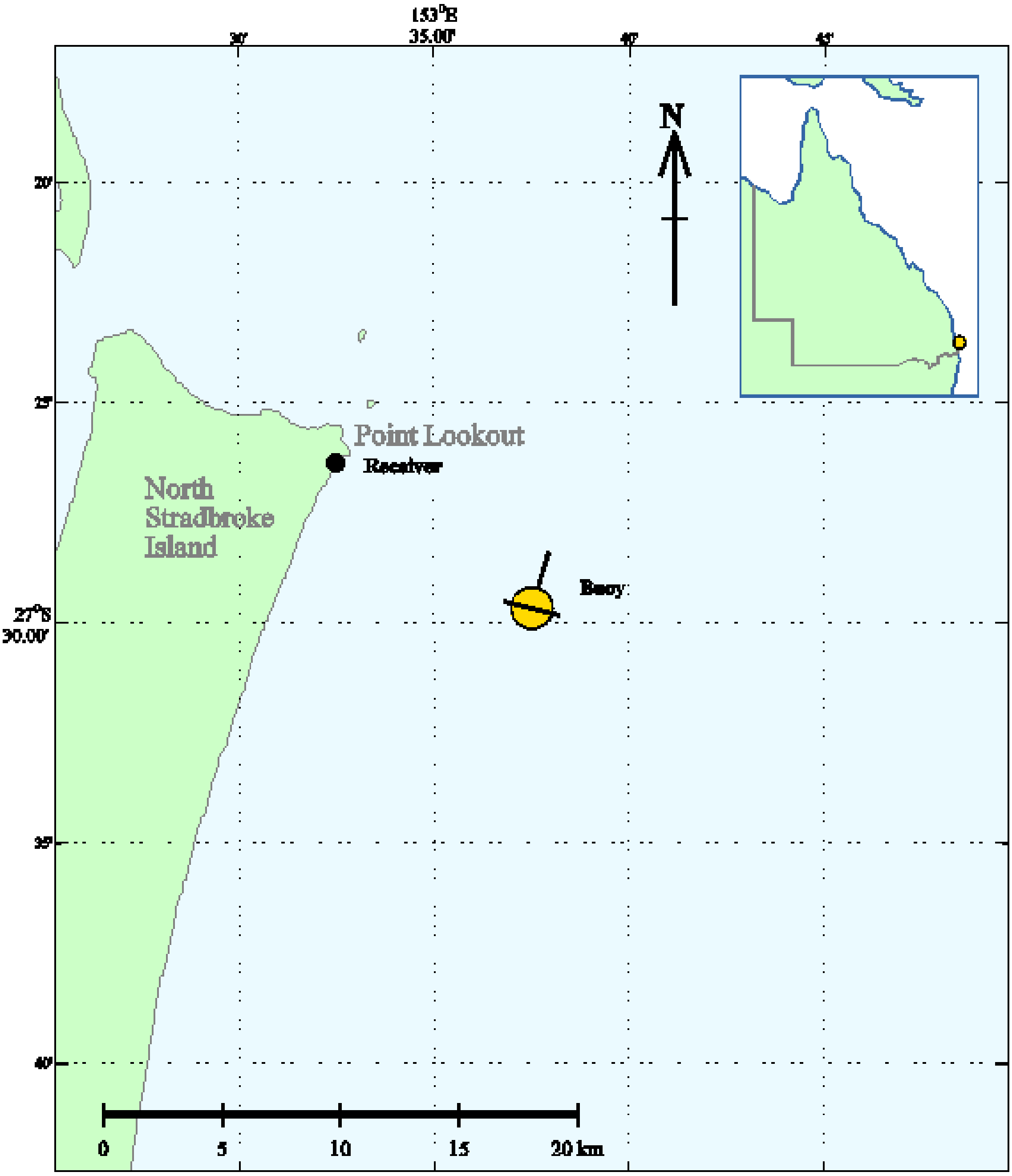
Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 361.40
Gaps in data used in analysis (days)	= 3.58
Number of records used in analysis	= 17347

All data since-1976

Maximum possible analysis years (last record - first record)	= 38.50
Total number of years used in analysis	= 26.79
Gaps in data used in analysis (years)	= 11.71
Number of records used in analysis	= 328358

Table of highest ranked un-smoothed waves at Brisbane

Rank	Date(Hs)	Hs (m)	Date(Hmax)	Hmax (m)
1	17/03/1993 10:30	7.4	04/03/2006 21:00	16.8
2	04/03/2006 09:00	7.2	05/03/2004 17:30	14.3
3	28/01/2013 07:30	7.1	17/03/1993 03:30	13.1
4	05/03/2004 17:30	7.0	02/05/1996 14:00	12.8
5	02/05/1996 20:30	6.9	15/02/1995 06:30	12.2
6	15/02/1995 06:00	6.4	28/01/2013 07:30	12.1
7	23/08/2008 23:00	6.4	15/02/1996 19:00	12.1
8	12/06/2012 09:30	6.4	24/08/2008 02:00	11.5
9	06/06/2012 19:30	6.3	26/03/1998 07:00	11.5
10	31/12/2007 03:00	6.3	06/06/2012 19:30	11.1



Latitude	Longitude	Depth (m)	Deployed date	Removal date
27°28.400'S	153°37.630'E	70	4/02/2014	31/10/2014
27°29.475'S	153°37.955'E	70	31/10/2014	31/03/2015
27°29.600'S	153°37.960'E	70	31/03/2015	current

Figure 4.1: Brisbane region – Locality plan

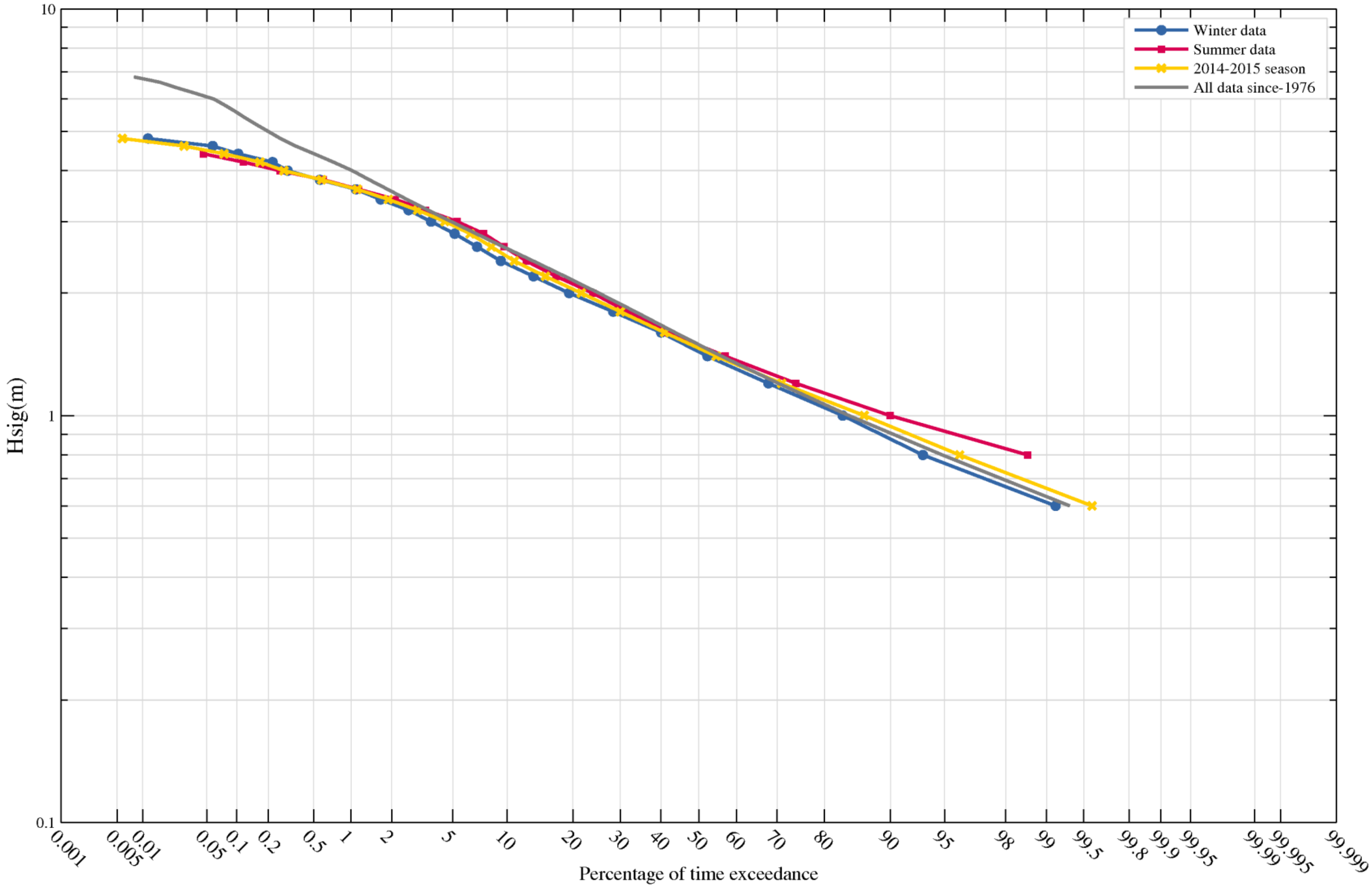


Figure 4.2: Brisbane region – Percentage (of time) exceedance of wave heights (Hsig) for all wave periods (Tp)

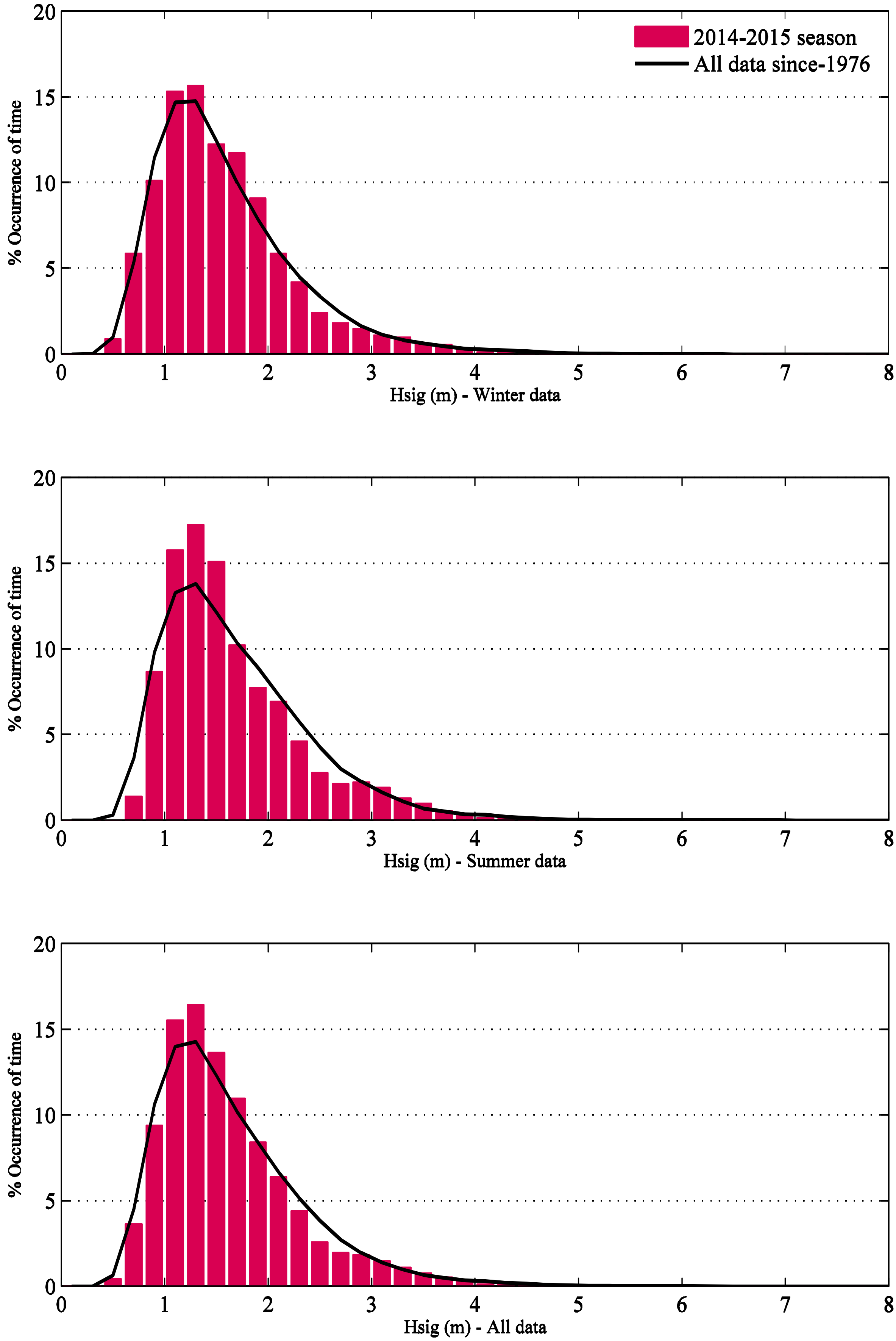


Figure 4.3: Brisbane region – Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

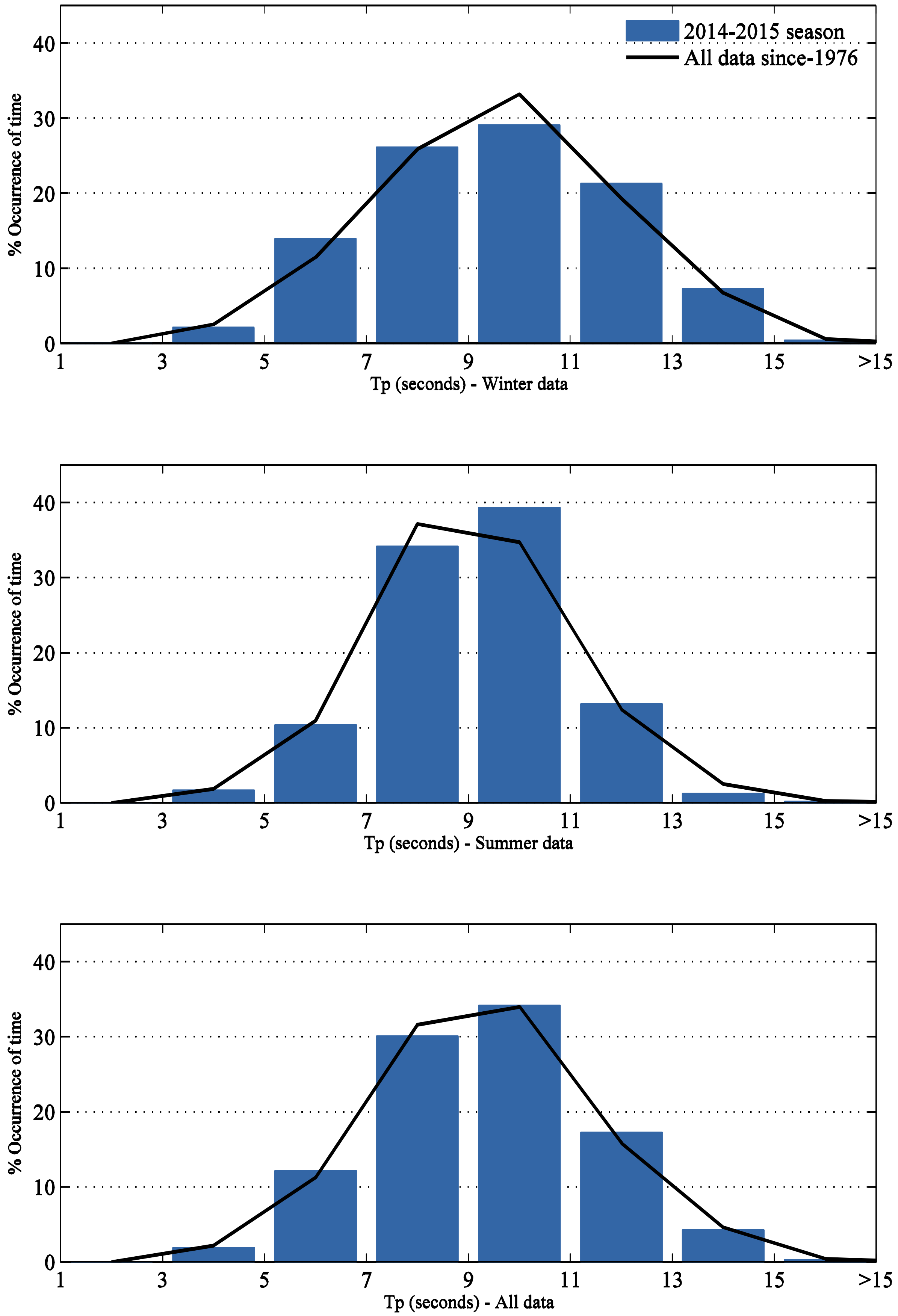


Figure 4.4: Brisbane region – Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

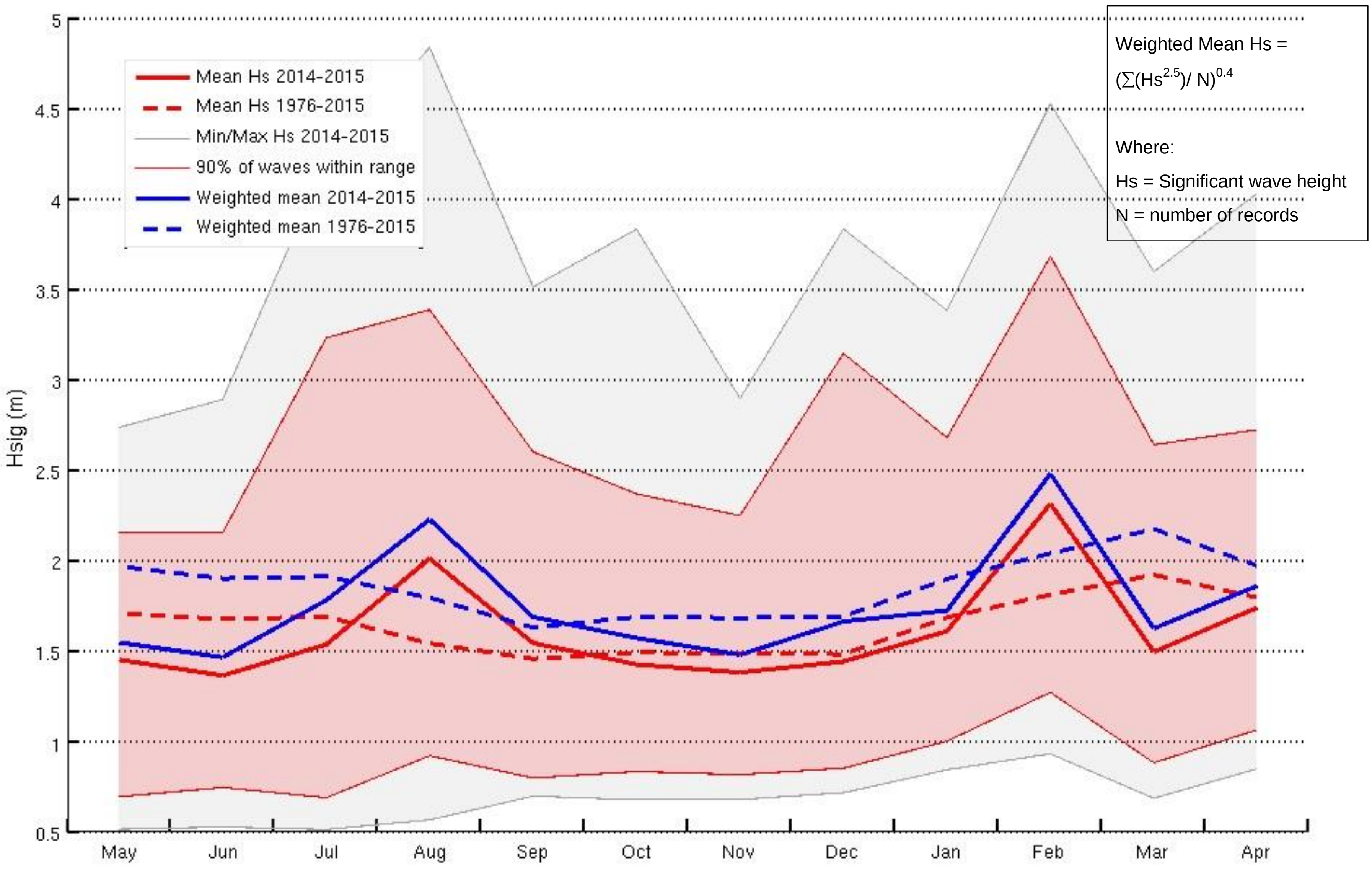


Figure 4.5: Brisbane region – Plot of monthly averages for seasonal year and for all data, for wave heights (Hsig). The weighted mean Hs provides an indicative potential for sediment transport.

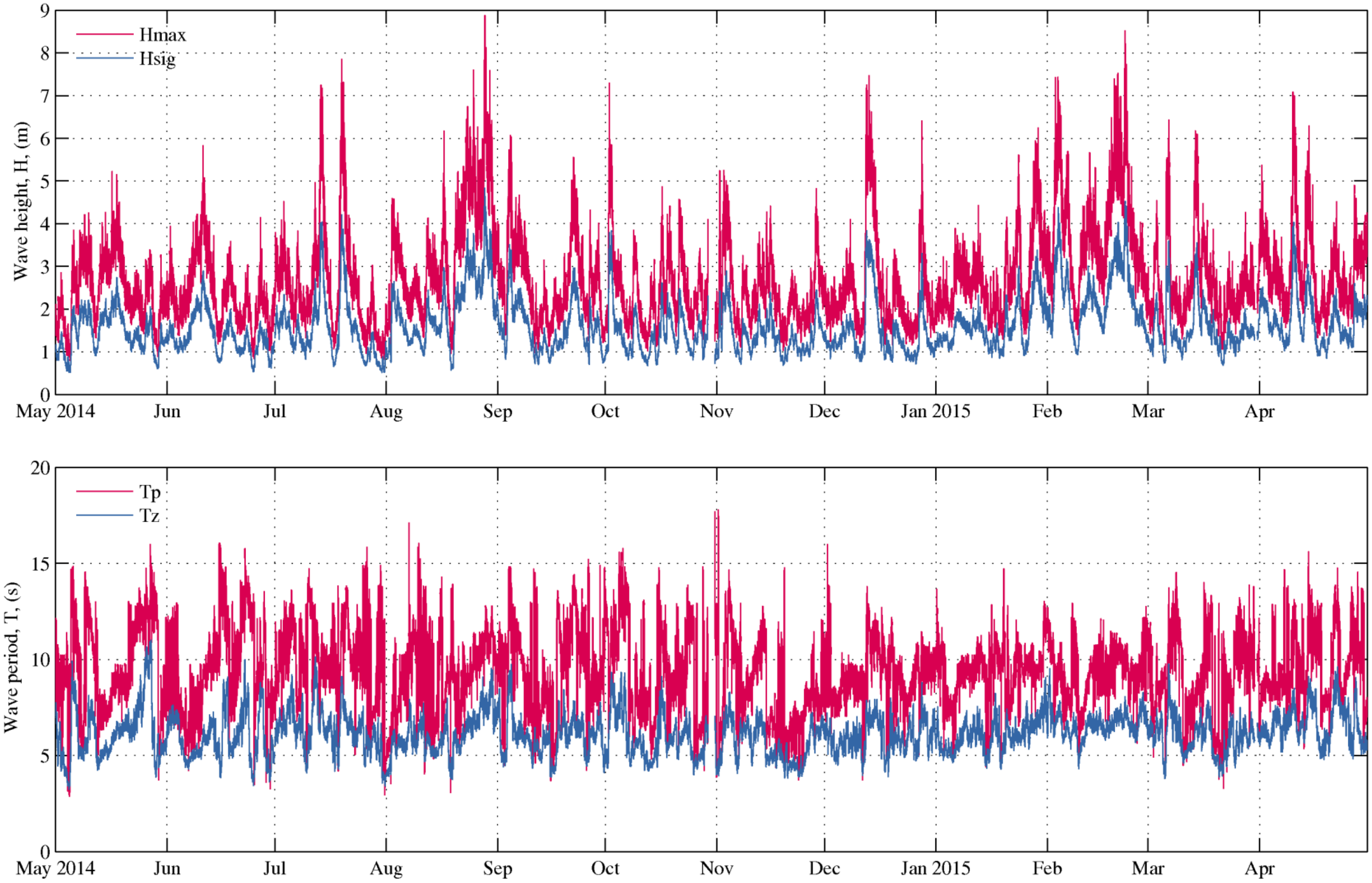


Figure 4.6: Brisbane region – Daily wave recordings

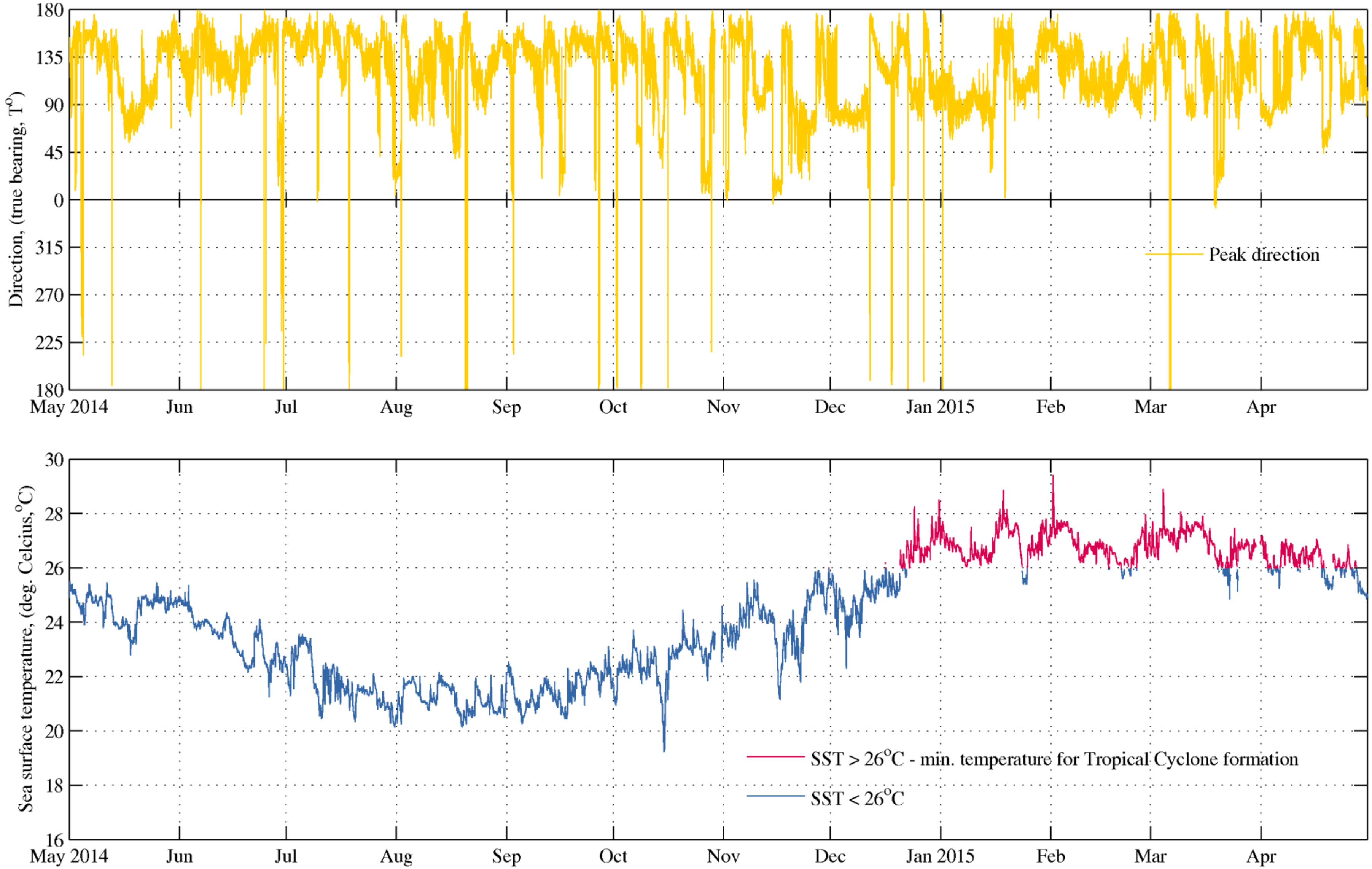
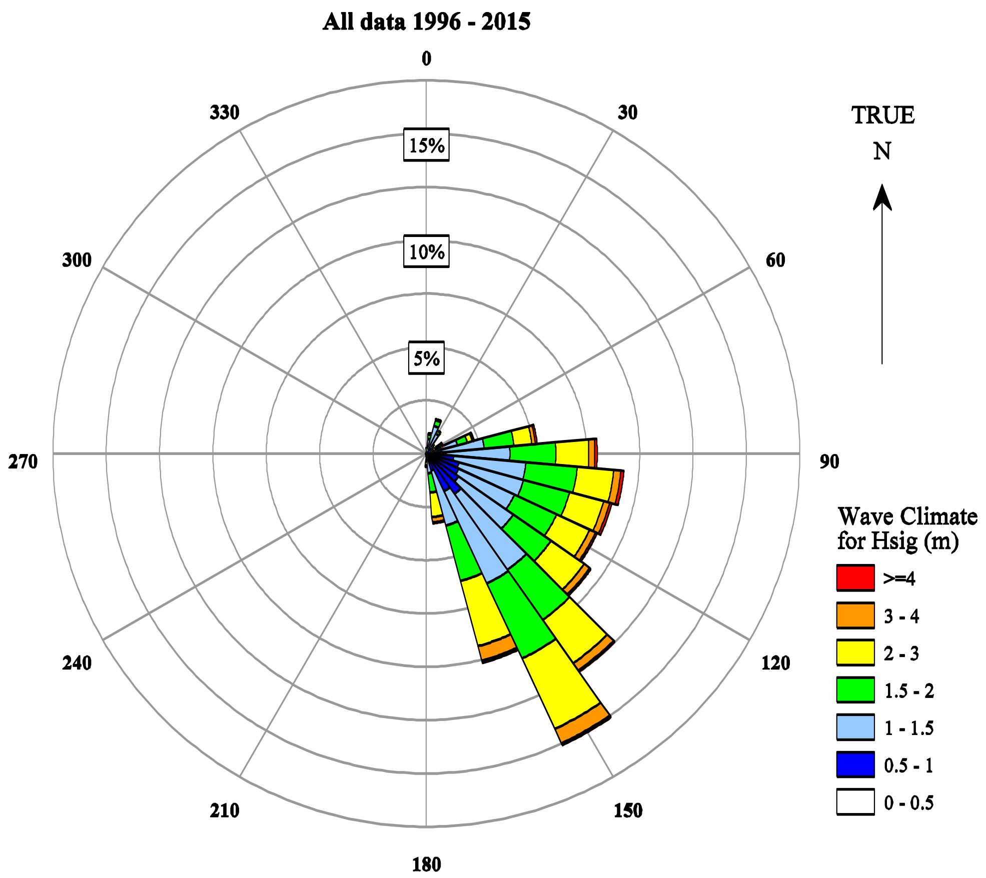


Figure 4.7: Brisbane region – Sea surface temperature and peak wave directions



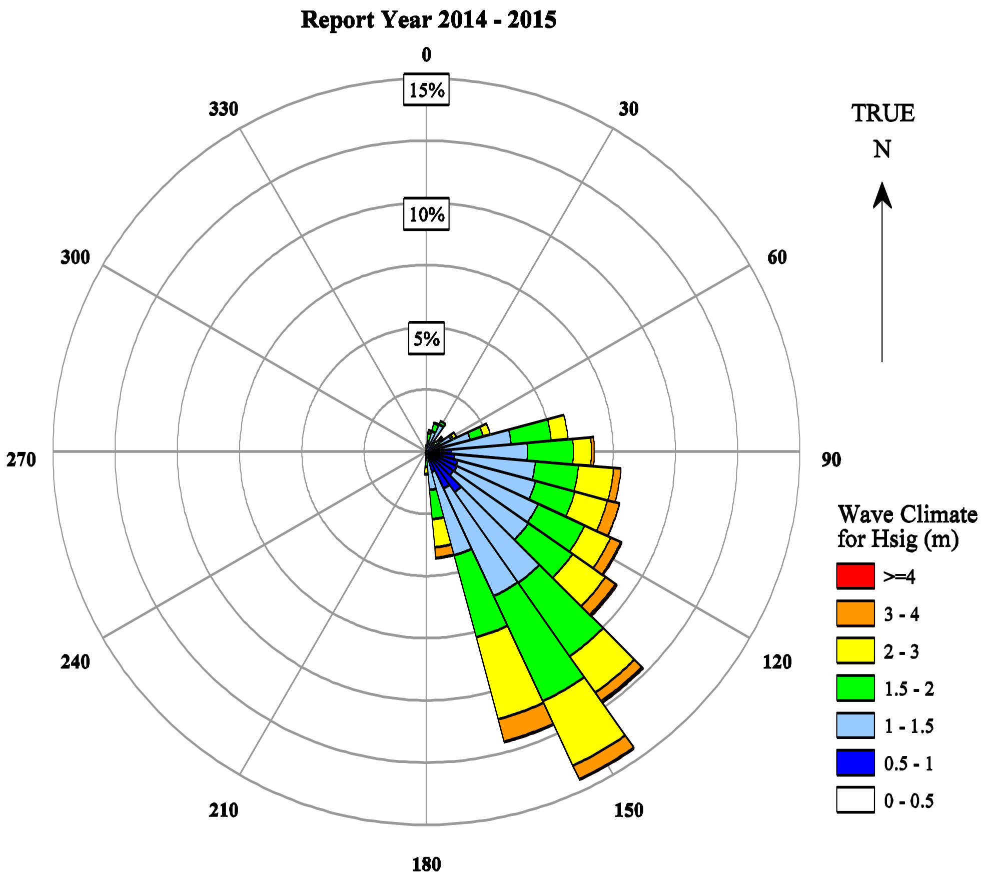


Figure 4.8: Brisbane region – Directional wave rose

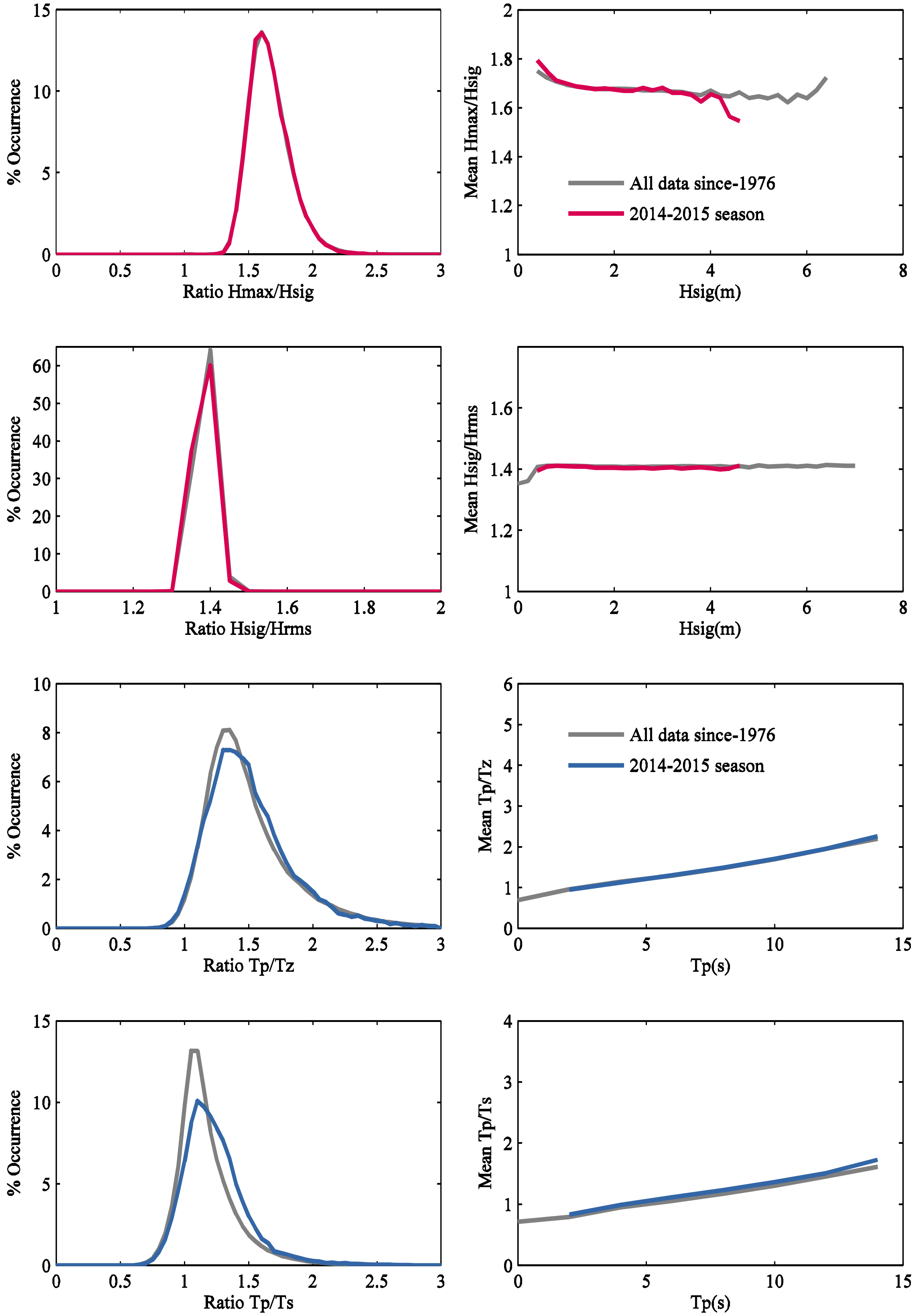


Figure 4.9: Brisbane region – Wave parameter relationships

5. References

Allan, J., & Komar, P. (2001). Wave climate change and coastal erosion in the US Pacific Northwest. *Proceedings of the 4th Conference on Ocean Wave Measurement and Analysis* (pp. 680–690). San Francisco: ASCE.

Australian Hydrographic Service. (2011). *Australian National Tide Tables.*

Bacon, S., & Carter, D. (1991). Wave climate changes in the North Atlantic. *Int. J. Climatol*, 545–558.

Datawell. (2000). *Operations and Service Manual for Directional Waverider.* Haarlem, Netherlands.

Datawell. (2010). *Datawell Waverider Reference Manual WR-SG; DWR-MkIII, DWR-G.* Haarlem, Netherlands.

Forristall, G., Heideman, J., Leggett, I., Roskam, B., & Vanderschuren, L. (1996). Effect of Sampling Variability on Hindcast and Measured Wave Heights. *Journal of Waterway, Port, Costal and Ocean Engineering, Vol 122, No. 5*, 216–225.

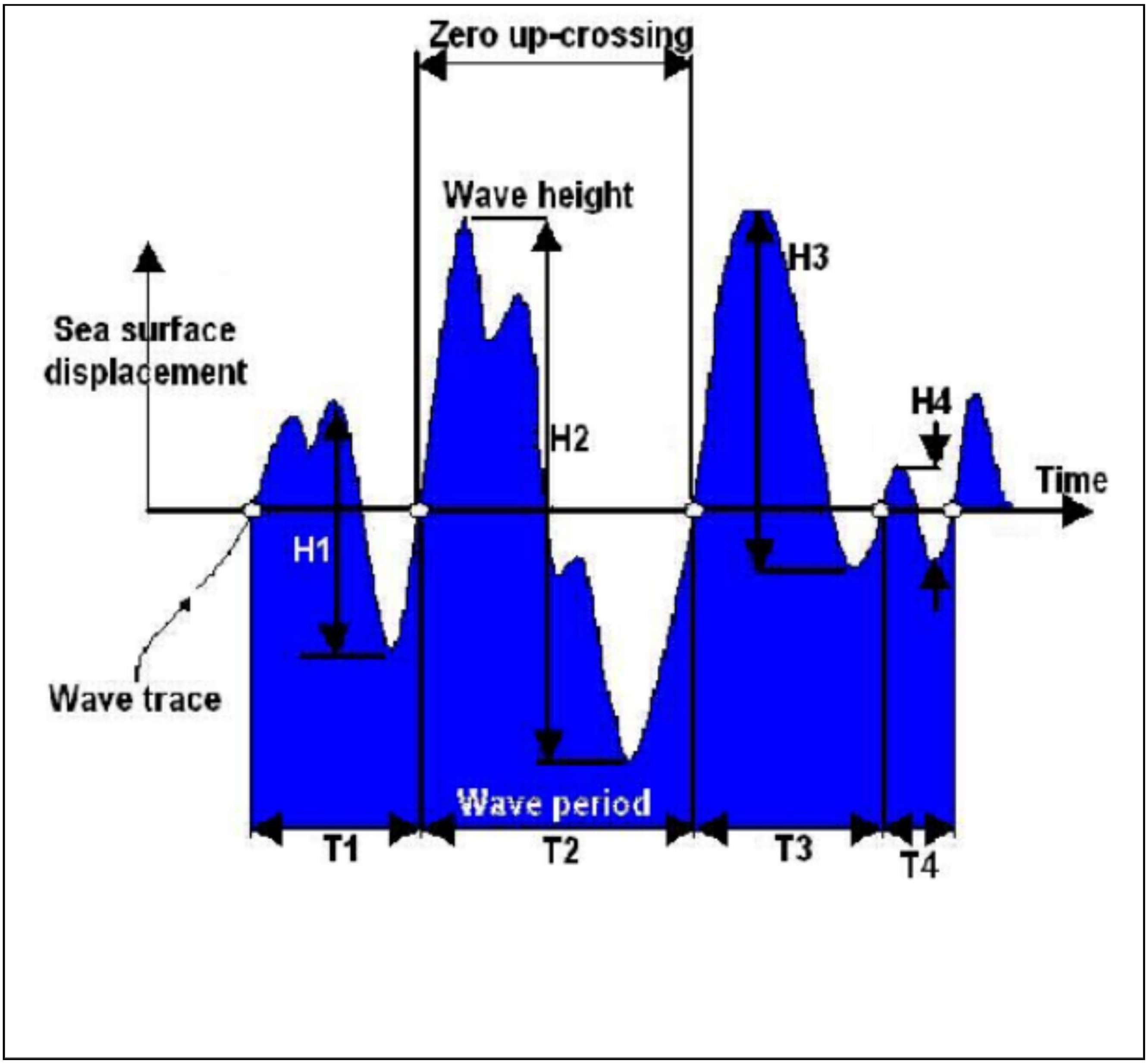
Appendix A – Zero up-crossing analysis

Zero crossing analysis

A direct, repeatable, and widely accepted method to extract representative statistics form wave data recorded by a wave measuring buoy. For zero up-crossing (used by DSITI), a wave is defined as the portion of the record between two successive zero up-crossings of the mean water line.

Waves are ranked (within their corresponding periods), and statistical wave parameters are computed in the time domain.

An explanation of wave parameters is presented in the Glossary.



Appendix B – Glossary of Terms

Parameter	Description
Hsig	The significant wave height (in metres), defined as the average of the highest one-third of the zero up-crossing wave heights in a 26.6-minute wave record. This wave height closely approximates the value a person would observe by eye. Significant wave heights are the values reported by the Bureau of Meteorology in their forecasts.
THsig	The average period of the highest one-third of zero up-crossing wave heights.
Hrms	Root mean square wave height from the time domain.
Hmax	The maximum zero up-crossing wave height (in metres) in a 26.6-minute record.
Tc	The average crest period (in seconds) in a 26.6-minute record.
Tz	The average of the zero up-crossing wave periods (in seconds) in a 26.6-minute record.
H10	Average of the highest 10 percent of all waves in a record.
TH10	The period of the H10 waves.
THmax	Period of maximum height, zero up-crossing.
Tzmax	The maximum zero crossing in a record.
Hm0	Estimate of the significant wave height from frequency domain $4\sqrt{m_0}$.
T02	Average period from spectral moments zero and two, defined by $\sqrt{m_0/m_2}$.
Tp	Wave period at the peak spectral energy (in seconds). This is an indication of the wave period of those waves that are producing the most energy in a wave record. Depending on the value of Tp, waves could either be caused by local wind fields (sea) or have come from distant storms and have moved away from their source of generation (swell).
Direction (Dir; Dir_p)	The direction that peak period (Tp) waves are coming (in º True North). In other words, where the waves with the most wave energy in a wave record are coming from.
HAT	HIGHEST ASTRONOMICAL TIDE is the highest water level which can be predicted to occur at a particular site under average weather conditions. This level may not be reached every year.
AHD	AUSTRALIAN HEIGHT DATUM is the reference level used by the Bureau of Meteorology in Storm Tide Warnings. AHD is very close to the average level of the sea over a long period (preferably 18.6 years), or the level of the sea in the absence of tides.
Wave setup	The increase in mean water level above the SWL towards the shoreline caused by wave action in the surf zone. The amount of rise of the mean water level depends on wave height and beach slope such that setup increases with increasing wave height and increasing beach steepness. It can be very important during storm events as it results in a further increase in water level above the tide and surge levels.
Astronomical tide	Or more simply, the tide is the periodic rise and fall of water along the coast because of gravitational attraction on the water by the moon and sun. When the moon, sun and earth are in line their combined attraction is strongest and the tide range is greater (spring tides). When the moon and sun are at right angles to each other (in relation to the earth) the effect of the attraction is somewhat reduced and the tide range is smaller (neap tides).
Predicted tide	The tide expected to occur under average meteorological conditions. Tide predictions are typically based on previous actual tide readings gathered over a long period (usually one year or more). The sun, moon and earth are not in the same relative position from year to year. Accordingly, the gravitational forces that generate the tides, and the tides themselves, are not the same each year.

Other published wave data reports in this series

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Tweed Heads Wave Climate Summary 2008-2009	Report No. 2009.1	01 May 2008 – 30 April 2009
Tweed Heads Wave Climate Summary 2009-2010	Report No. 2010.1	01 May 2009 – 30 April 2010
Tweed Heads Wave Climate Summary 2010-2011	Report No. 2011.1	01 May 2010 – 30 April 2011
Tweed Heads Wave Climate Summary 2011-2012	Report No. 2012.1	01 May 2011 – 30 April 2012
Tweed Heads Wave Climate Summary 2012-2013	Report No. 2013.1	01 May 2012 – 30 April 2013
Tweed Heads Wave Climate Summary 2013-2014	Report No. 2014.1	01 May 2013 – 30 April 2014