JERICHO TECHNICAL REPORT 24

Application of SWAN in the Holderness region, 3

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1 JONSWAP into SWAN

The aim of the modelling is to utilise the data available from satellite altimeters to derive boundary conditions for the coastal wave model which can then be used to derive the wave energy in shallow water areas.

The wave parameters available from the satellite consist of estimates of significant wave height and zero upcrossing period (Tz). The wave model SWAN requires a full spectrum, so it is necessary to make some assumptions about the actual shape of the wave spectrum.

Several experiments have been performed which illustrate how the model results are affected when the input spectrum is assumed to be a JONSWAP spectrum with a specified significant wave height (Hs), peak period (Tp), direction, and directional spread. This was done by using the parameters of Hs, Tp, Tz, direction and spread output by the buoy at N3 as input to the model and comparing the results obtained from the model using the full two directional spectrum on the boundary.

1.1 Wave height at the boundary

In all previous runs of SWAN it has been found that the spectra input to the model and output by the model on the boundary at N3 were very close to identical. When using JONSWAP spectrum as input it was found that, when the wind direction was not aligned with the wave direction, a small additional amount of wave energy was apparent in the model output at N3. It is likely that the reason for this is that because the input spectrum contained no wind sea in the wind direction the model had to add some in order for the iterative solution to converge.

While the size of this error when viewed in terms of significant wave height is not great, the error does propagate through to N1, where the model already had a tendancy to overpredict the wave height, so it was thought wise to remove this additional bias.

This was achieved by subtracting from the input significant wave height at the boundary an amount equal to the difference between the input and output boundary wave heights of the run. The model was then re-run using these new values of wave height. The new results showed no bias at the boundary. The results described in the next section used this procedure to derive the correct boundary wave height.

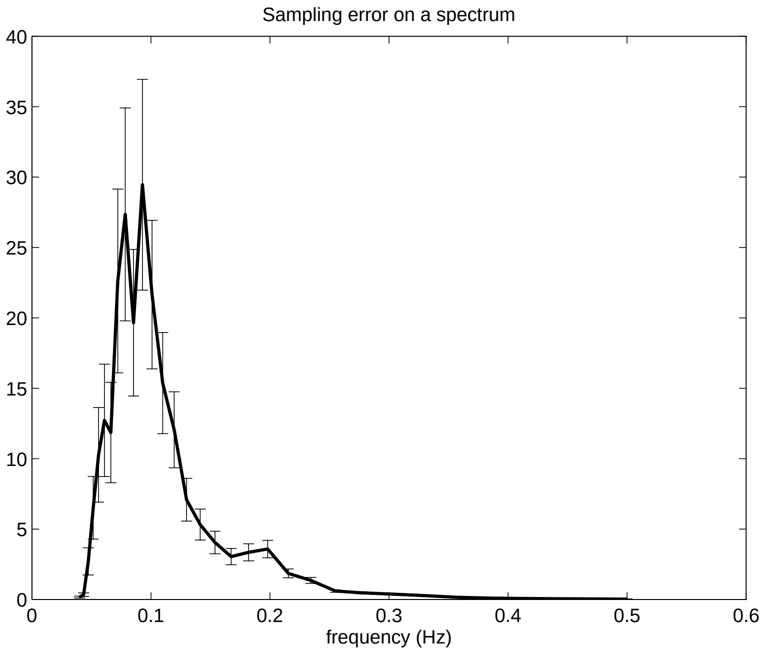

Figure 1: Sampling error on an N3 spectrum

1.2 Peak period

The JONSWAP spectrum uses a peak period as one of its principal parameters. While this is a standard parameter output by the wave buoy, it is not necessarily a very good choice, since an erroneous period can easily be chosen if the buoy spectra are noisy or there is a bimodel spectrum.

Figure 1 shows one of double peaked spectra from N3 with the error bars due to the sampling error. It is clear that the errors are significant compared to the apparent double peaked nature.

The zero up-crossing period (Tz) is also output by the waverider buoy, and this parameter is more stable, but still may not be representative if the spectrum is bimodal with swell and wind sea components.

It is not completely straightforward to derive a good JONSWAP spectrum from the zero up-crossing period, since it requires numerical integration and iteration and SWAN will only accept a peak period. Since the satellite is producing Tz not Tp we need to be able to convert between the two.

Figure 2 shows some numerical results for Tz/Tp for a JONSWAP spectrum in deep water (blue line) and that in 30 metres water depth (green line). Also plotted on this diagram are the value for Tz/Tp actually observed at N3 during the storm of 1-3 January, 1995. Figure 3 shows the same thing but includes all the results for the winter of 1994-1995.

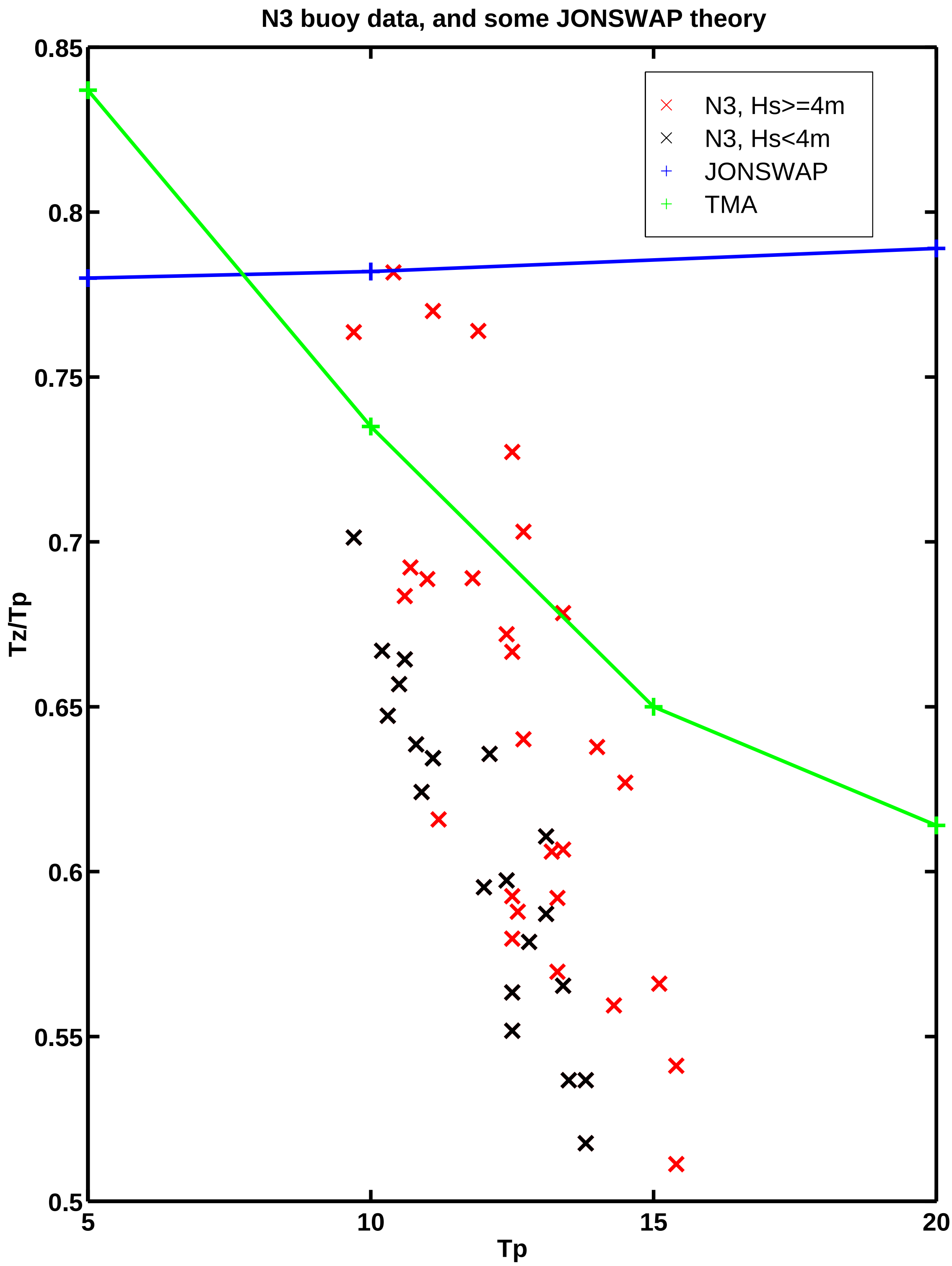

Figure 2: Tz/Tp vs Tp for the 1-3 January 1995 storm

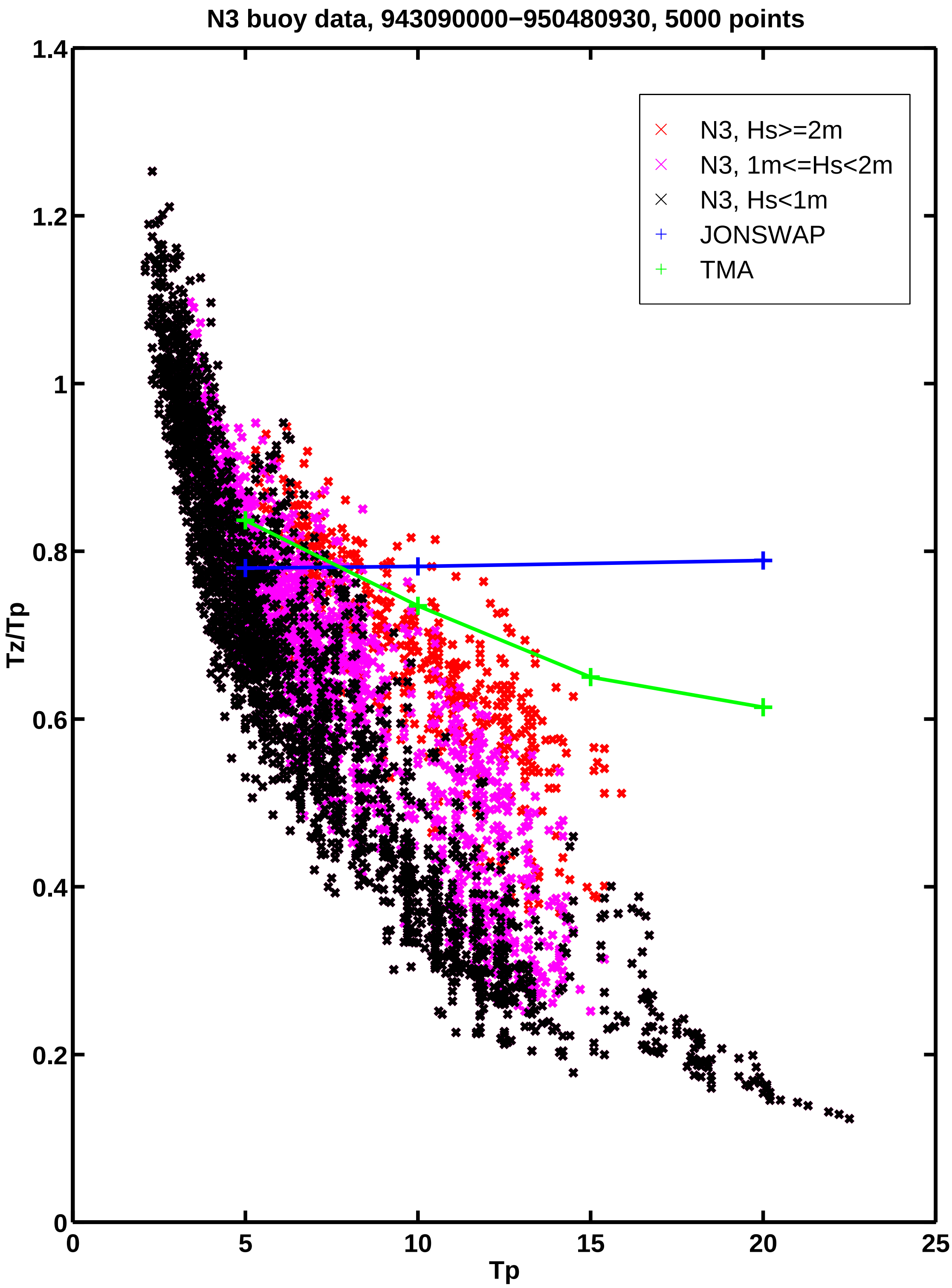

Figure 3: Tz/Tp vs Tp for the 1994-1995 winter

Table 1: Differences between model and buoy Hs(m) at N2

Run	Mean	standard deviation
Full spectra	0.029	0.33
Tp from buoy	-0.14	0.31
Tz from buoy	-0.040	0.31

To assess the sensitivity of the model to the different ways of defining the boundary spectra three model runs of the 1-3 January 1995 storm were compared. The first is the run referred to in previous reports, using the full buoy spectrum at N3 at the boundary. The second run uses the buoy derived value of Tp and a JONSWAP spectrum and the third run used the Tz measured by the buoy assuming Tp=Tz/0.78, which is the approximate relation for the JONSWAP spectrum in deep water. All runs are made with Madsen bottom friction, depth variation, but not including currents.

Figure 4 shows the comparison of wave heights throughout the storm at the buoy stations. There is only a small difference between the results from the three runs, the overall mean and bias of the differences between the N2 results of the model and the buoy are show in table 1.

Figures 5 and 6 show the differences in the frequency spectra. These are far more apparent than the differences in the wave height. Figure 4 shows a case where the two JONSWAP spectra agree well but neither compare well with the buoy, and Figure 5 shows the more typical case where the Tp run fits the true spectral form more accuturately than does the Tz run.

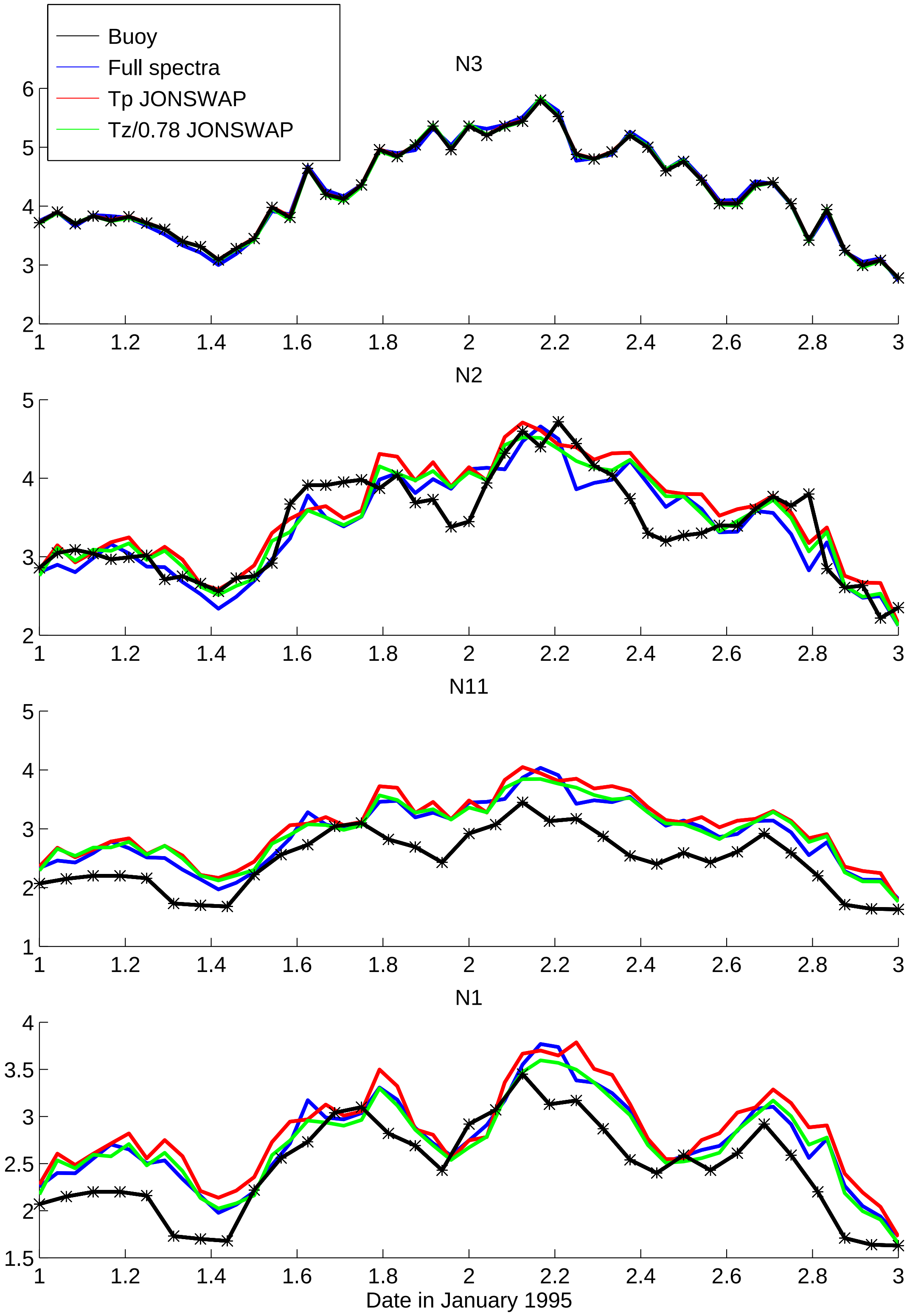

Figure 4: Results using different periods. The y-axes are significant wave height in metres

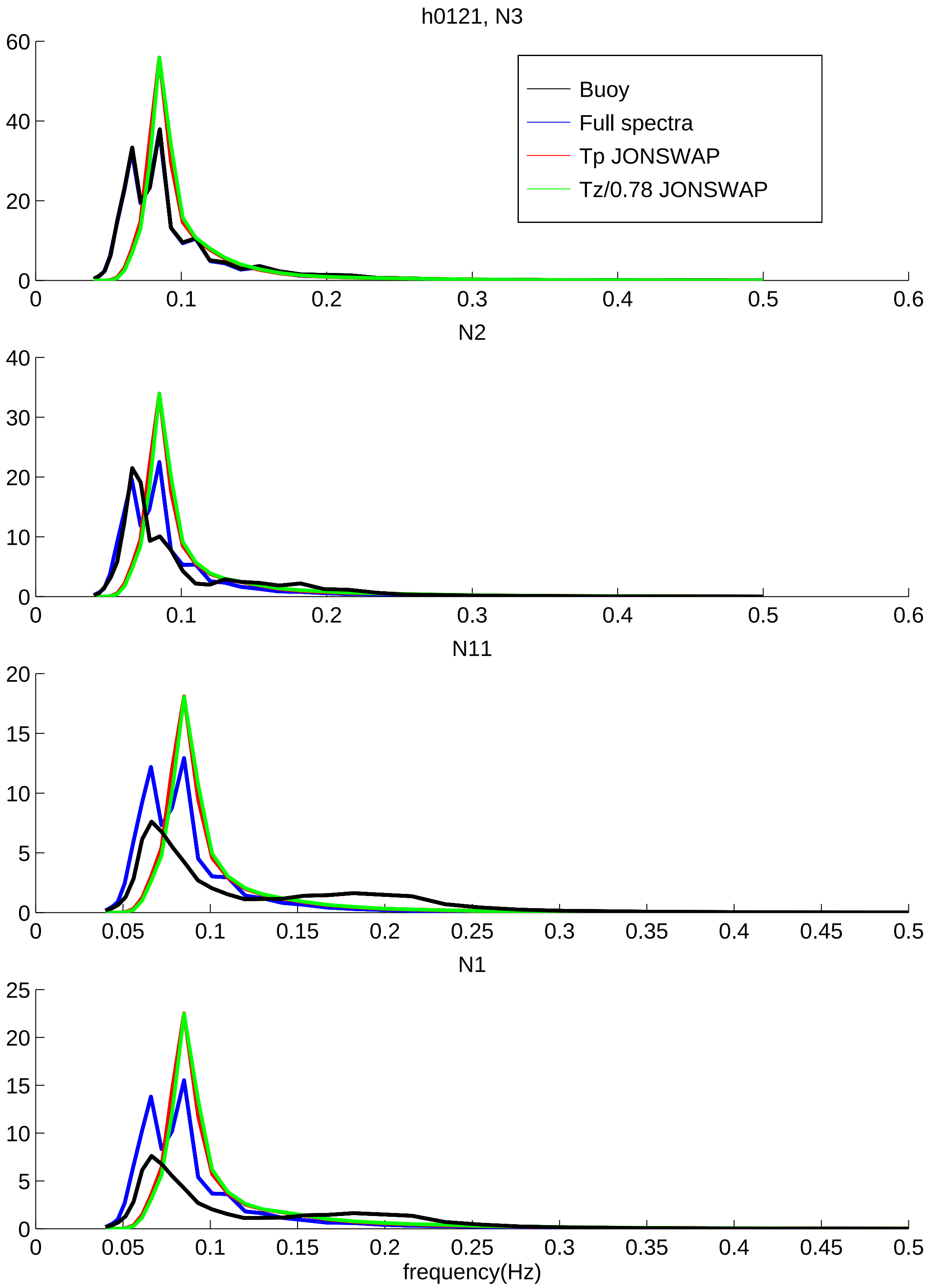

Figure 5: Spectral results where Tp is poor choice

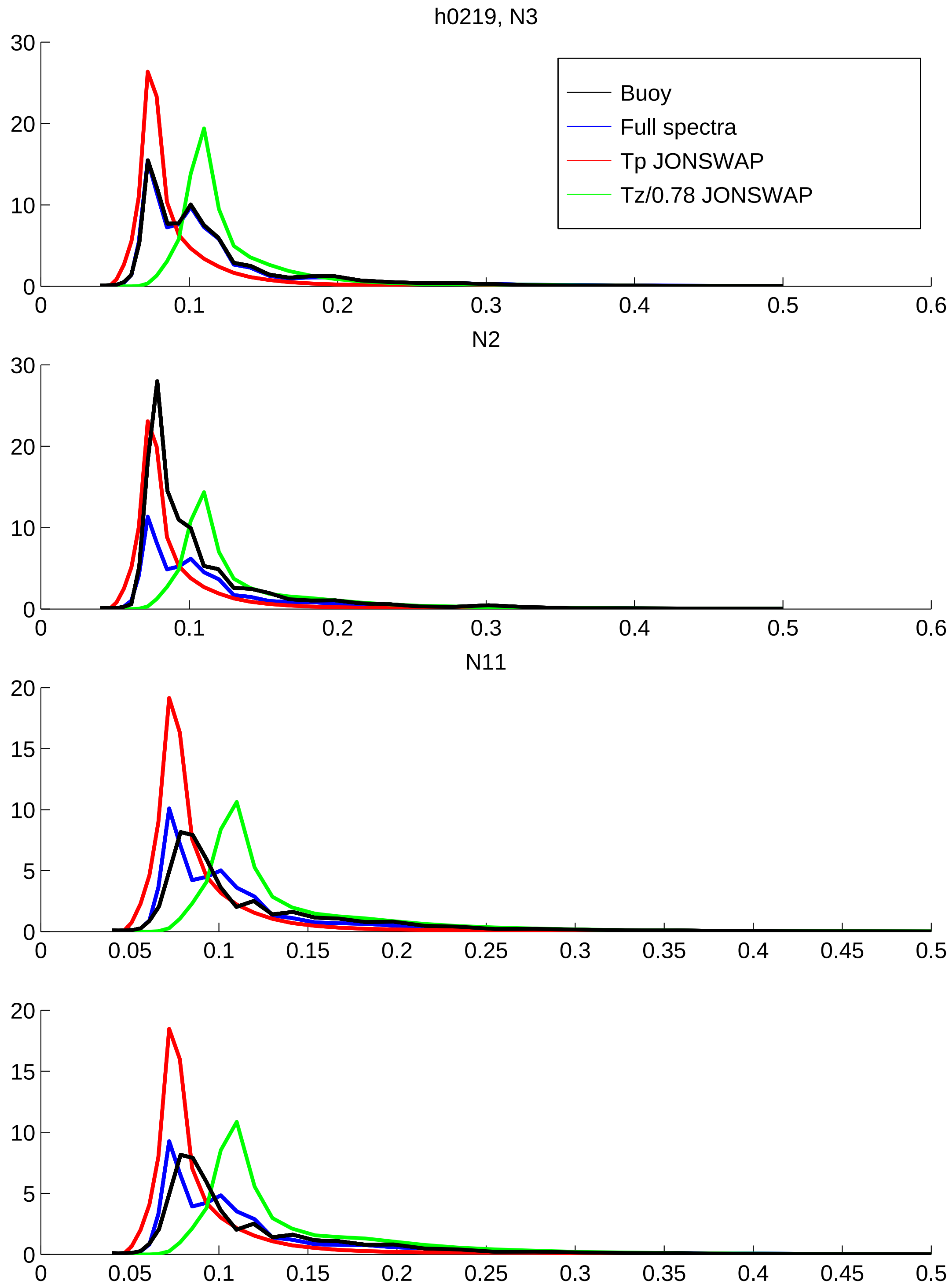

Figure 6: Spectral results. The spectrum derived using Tz appears very unrealistic

2 EXTREME events

The estimates for extreme wave events at N3 have been received from David Carter at SOS. Some initial runs of SWAN have been performed using these runs as boundary forcing to the model.

Since we are interested in the results in very shallow water, an additional, shallower, output point for spectra has been chosen at 4.98 meters mean water depth, inshore from N1.

2.1 Results

SWAN as been run for the 1, 100 and 1000 year extreme events. To assess the range of variation due to uncertainties in the boundary parameters, seven runs have been performed for each event. The first run, uses the average parameters supplied by SOS. For all the other runs only one parameter is varied from the average values. The wave height is varied according to the 1 standard deviation figure given by SOS. The period is varied to take account of the uncertainty in its derivation and also the uncertainties described in the previous section. The direction is varied through 50 degrees from close to northerly to east-north-easterly. The wind is at all times assumed to be 15 m/s along the same direction as the waves. In addition to these runs, the average run was re-run on approximate high and low tides.

The results are shown in figures 7, 8, 9, and 10. The plots show various parameters plotted as a function of distance along a line approximately perpendicular offshore which passes close to point N1, N2 and N3.

One interesting feature to note is that the variation in the results in shallow water are more greatly effected by the change in the water depth due to the tide than anything else. This variation is also greater than the difference between the different events. This means that the distribution of extreme events is of a quite different form to that derived at N3, and the joint probability of wave height and water depth is of critical importance.

It is shown clearly in 10 that the effect of the shallowing bottom acts make the difference in the 100 year and 1000 year event only very slight as far as 8 km offshore. From these results alone one would conclude that severe effects on the coast will not be caused by an increase of the 100 year wave height, since it is already effectively depth limited. If, however, the 1 year extreme were to increase in size or if increased storminess caused the 1 year event to become more frequent than at present, then signifcant effects at the coast are to be expected.

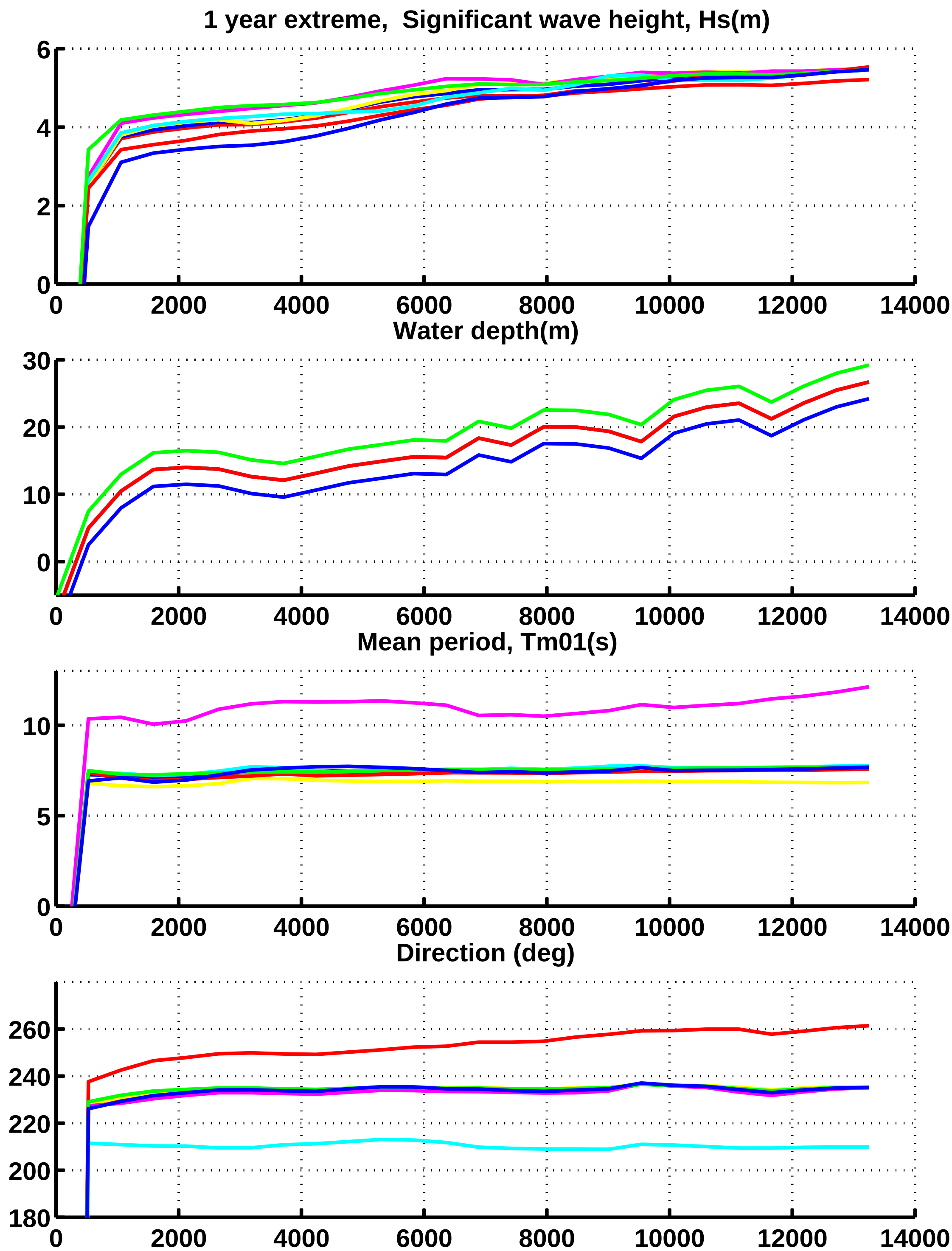

Figure 7: 1 year extreme events.

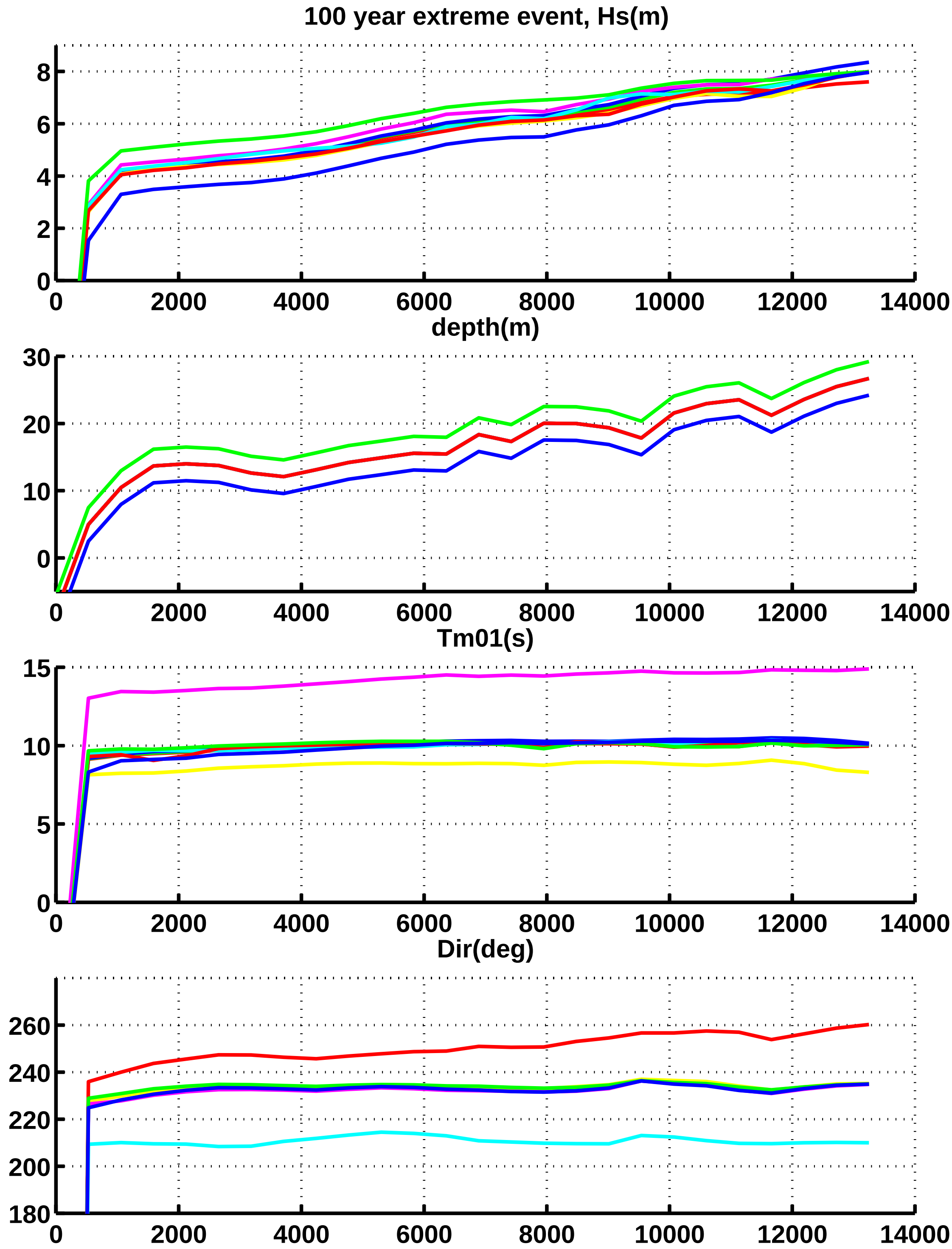

Figure 8: 100 year extreme event. Not how, compared to the 1 year extreme event, the variation due to uncertainty in the boundary conditions is small compared to the variation caused by the tide.

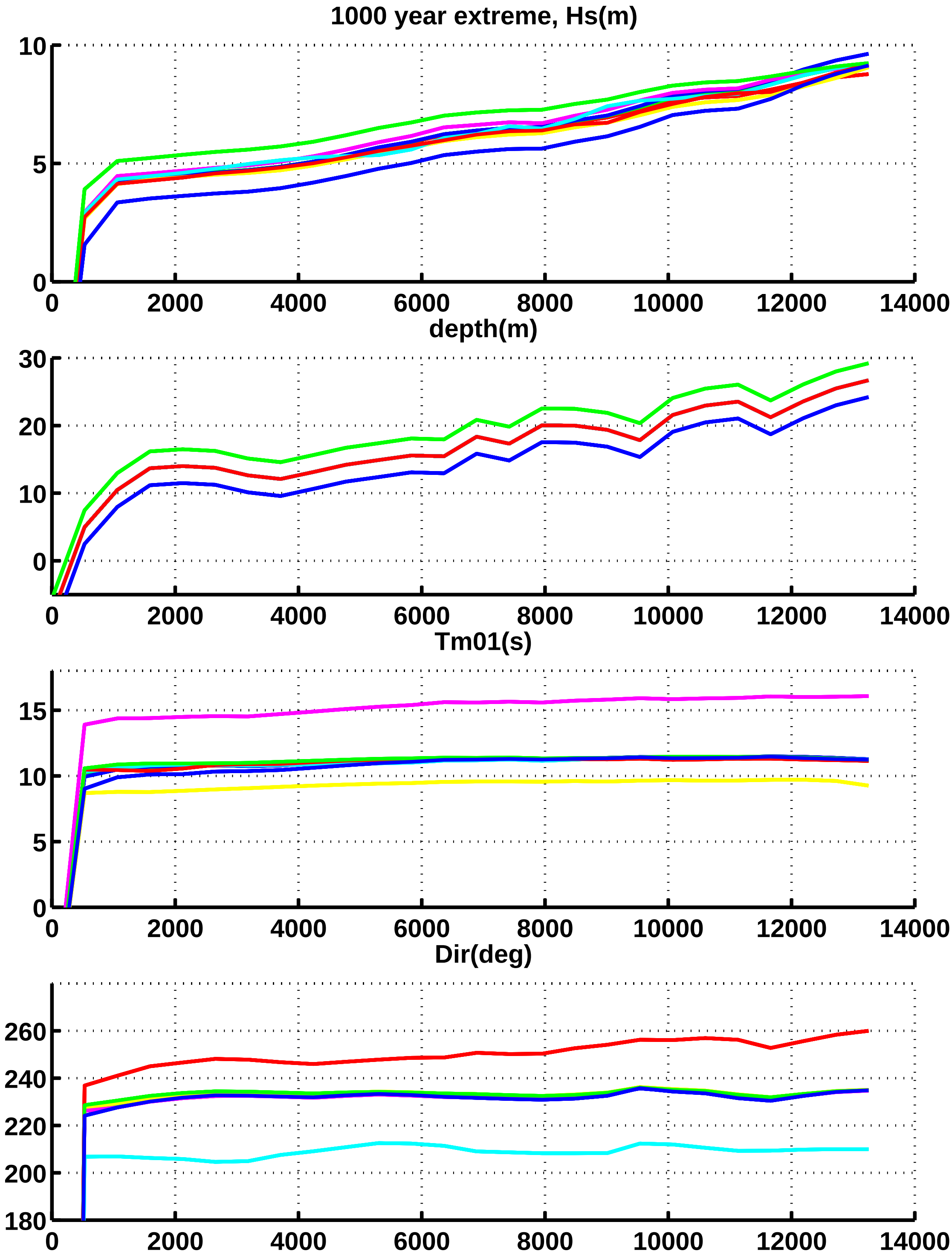

Figure 9: 1000 year event.

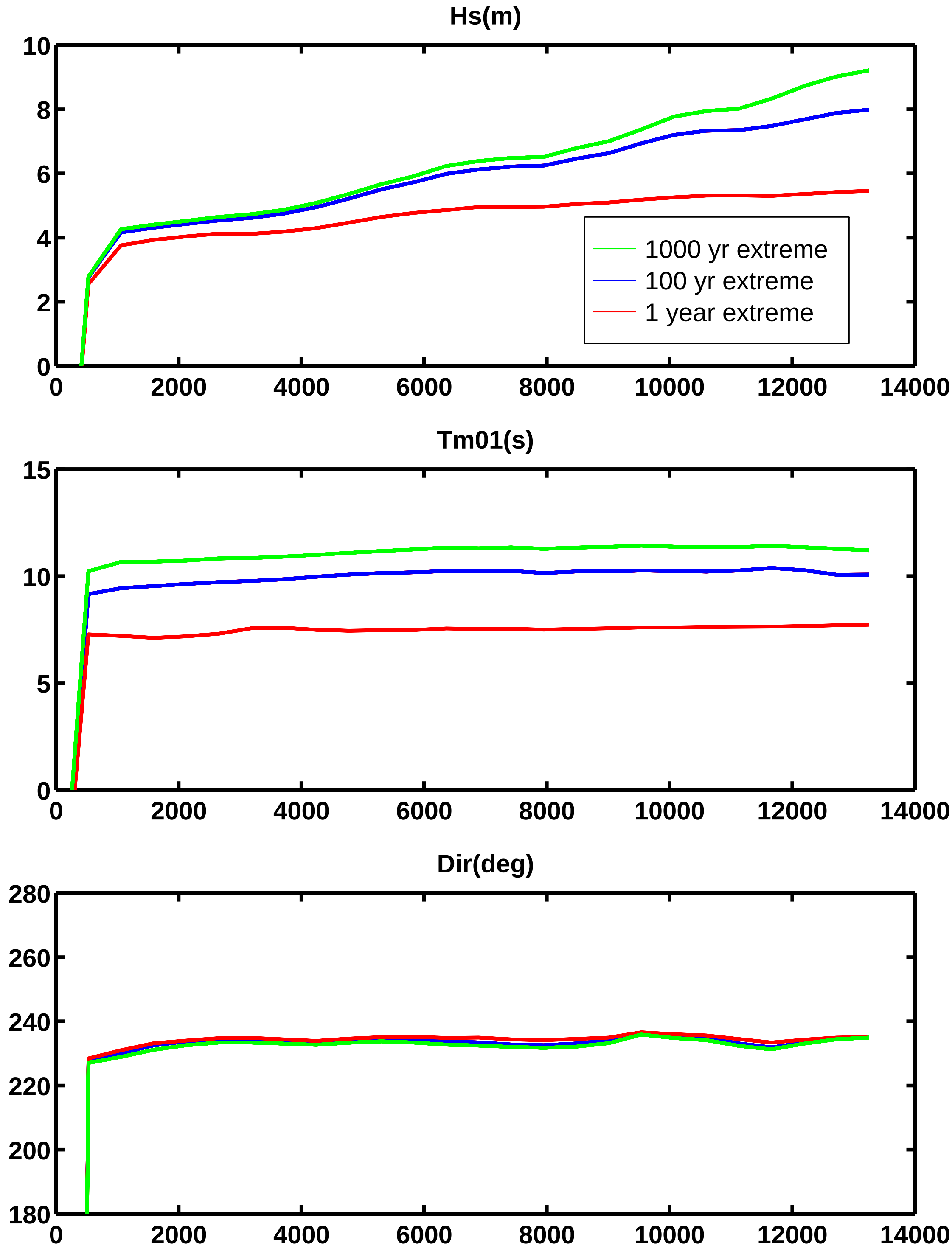

Figure 10: Comparison of the 'average runs' for the three events. Not the similarity in Hs up to quite a high distance offshore.