A comparison of partitioning when applied to HF radar and wave model spectra

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ABSTRACT

It is useful to partition ocean wave spectra for the classification of wind sea and swell and for detecting weaknesses in models or measuring systems. In this study various partitioning scheme have been investigated and their effectiveness, robustness and feasibility for use in automated systems taken into consideration. The partitioning scheme used by Hasselmann et al. (1996) appears to be the most useful for fully automated processes and therefore the performance of the partitioning method has been analyzed by comparisons of spectra from the Wavewatch III model, the Swan model and from HF radar. This comparison suggests that specific processes are needed to manage the effect of noise and sensitivity on the partitioning method when looking at the different spectra. The research has focused on the Celtic sea region for the 2003 to 2005 period when the Pisces radar system was operational. In addition a Directional Waverider buoy was deployed in the area and the buoy's reconstructed spectra have also been considered.

Partitioning methods

Partitioning of the ocean wave spectrum into different components is a useful tool. It allows for a spectrum to be represented with a reduced set of statistics without having to average over the entire spectrum. After partitioning the wind sea and swell components can be identified, which gives a more detailed picture of the physical situation and can lead to the identification of weaknesses in the models or measurements.

The partitioning methods used by Gerling (1992) and Hasselmann et al. (1994) are both based on the geometric properties of the spectrum. Gerling's method partitions the spectra by increasing a threshold and finding which parts of the spectrum become disconnected as the threshold rises. Hasselmann's method is based on a steepest ascent algorithm; the scheme essentially calculates the basins of attraction of each peak. One of the main disadvantages of Gerling's method is that the partitions are not necessarily distinct. For many cases a partition may be identified, but as the threshold increases this may be split into further disconnected regions. A choice then needs to be made about whether to consider the larger partition or the various smaller partitions. Gerling stated that this process needs to be done manually which restricts the application of this partitioning method for large sets of data or for automated processes such as data assimilation. An advantage of the Gerling method is the natural way in which a noise floor can be removed by thresholding above a certain level; it is certainly beneficial to apply such a process when partitioning noisy radar spectra. Guillaume (Guillaume, 1990; Lefevre et al., 2005) proposed a method of partitioning which first located the peaks within a spectrum. The maximum peak is then considered and all the bins within a certain frequency and direction range are assigned to that peak, and the process is repeated for the next highest peak. The major problem with this method is that it does not take the spread of a wave train into consideration.

Many other schemes which simply partition the spectra by identifying a wind sea have also been proposed. However, all these methods rely on knowledge of the wind speed and since reliable wind speeds are not currently available from HF radar, these methods are unsuitable for this application. They also tend to only

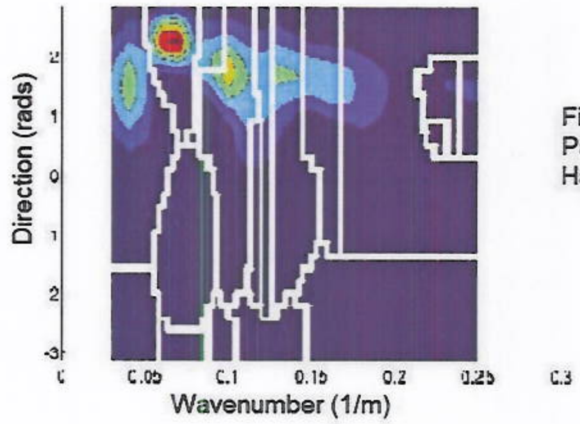

Fig 1a)
Partitioned using
Hasselmanns' method

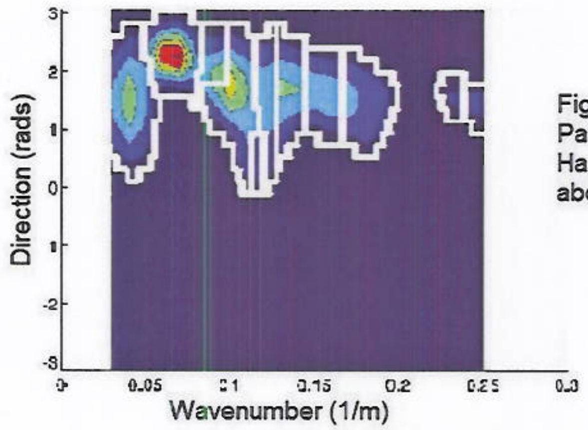

Fig 1b)
Partitioned using
Hasselmann's method
above a threshold of 1

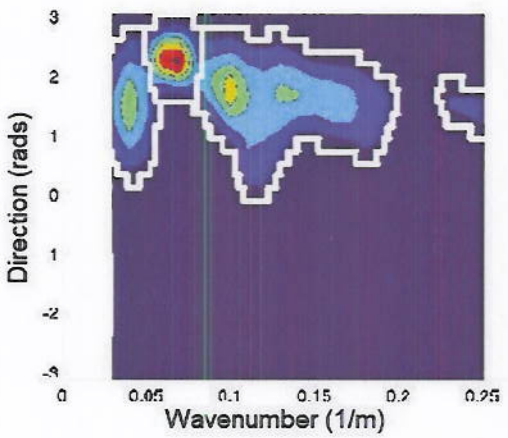

Fig 1c)
partitioned using
Hasselmann's method, a
threshold of 1 and
Hasselmanns' conditions
for combining partitions

Figure 1. A partitioned radar wavenumber spectrum. 0 radians is north, 1.57 is east, etc.

consider one swell partition and so much of the detail in the spectra may still be lost. Overall the Hasselmann et al. (1994) method for partitioning appears to be the most robust for use in fully automated processes.

Managing the effects of noise and sensitivity on the partitioning scheme

Partitioning will often be over-sensitive and will identify partitions related to noisy peaks. It is therefore necessary to introduce conditions for which partitions should be merged or removed. Hasselmann et al (1996) proposed the following specifications for combining partitions:

1. The peaks are too close.
2. The trough separating the peak is not low enough.
3. The spread is larger than the square distance between the peaks.

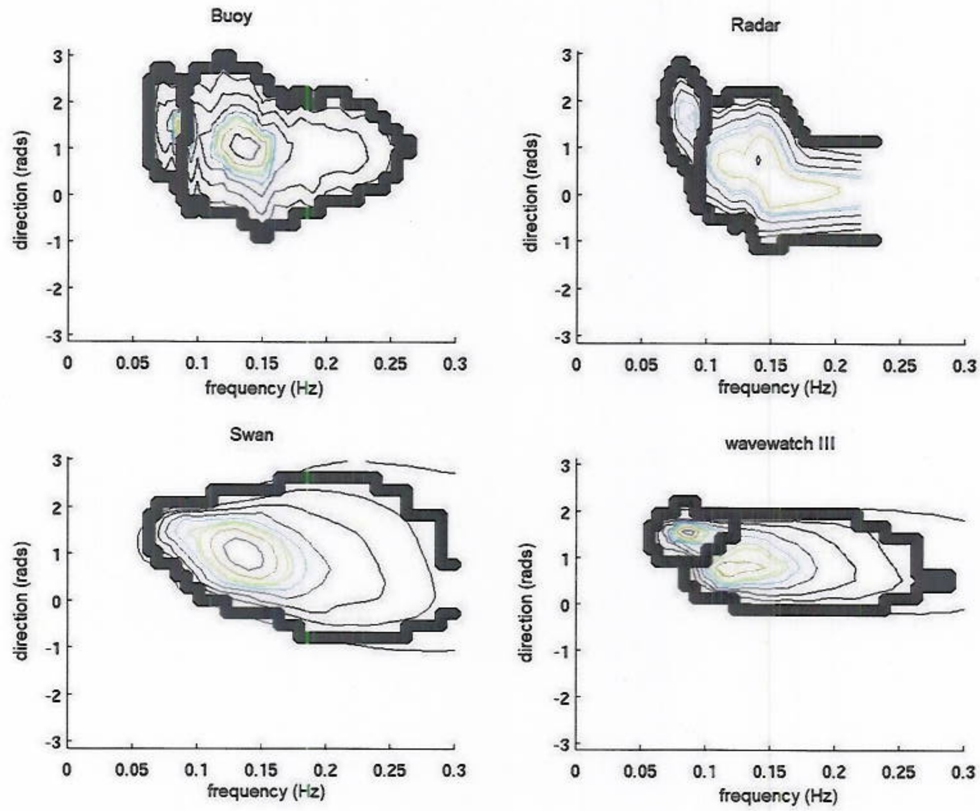

Figure 2. Partitioned spectra from the HF radar, buoy, Swan model and Wavewatch III model for the buoys location in the Celtic Sea at 06:00 12/01/2005.

Hanson et al. (2000) also suggested that partitions with a total energy below a certain level should be discarded and as discussed previously it also seems sensible to apply the partitioning only above a certain threshold. Figure 1 shows the affect of applying these noise controls to a radar measured spectrum, the improvement caused by applying the noise removal methods appears to be significant.

This partitioning scheme has also been applied to spectra outputted from the Swan and Wavewatch III spectral wind-wave models and to spectra estimated from a directional Waverider buoy. Analysis was performed to tune the partitioning scheme for each of the models and observations. It was found that different thresholds and modifications of the Hasselmann et al. (1996) conditions are required for the spectra from the radar, buoy and models in order to optimize the performance. The partitioning scheme and the above mentioned noise control methods were applied to directional frequency spectra from the buoy, radar and models for the location of the buoy in the Celtic sea at 06:00 12/01/2005 and the results can be seen in Figure 2.

Conclusions

The Hasselmann et al. (1994) partitioning scheme, along with the specifications for combining and discarding partitions of Hasselmann et al. (1996) and Hanson (2000) have shown good results. In many cases such as Figure 2, the spectra are partitioned as we would expect. There are obviously some cases where the partitioning scheme is not so successful, but the conditions for combining partitions and removing noise have been chosen to be as robust as possible. From the results in Figure 2 it is possible to identify the key characteristics of the ocean surface at that time. In these spectra a higher frequency partition with large spread has been identified and this is likely to be the wind sea, and in all but the Swan spectra a lower frequency partition which probably corresponds to swell is also seen. Figure 2 also illustrates an example where a possible deficiency in the Swan model has been identified, that is an underestimation by the model of energy in the lower frequencies. This study will now be extended to comparing the mean parameters of cross assigned partitions and to further investigations of the success of the chosen tuning parameters.

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