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Preliminary report on spectral characteristics of bora on the island of Rab*

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Some results of measurements of the bora wind in the island of Rab during the experiment searching for the influence of the wind on sea waves and currents are shortly presented. The used piesoelectric wind sensor enabled to resolve velocity in the 1 sec intervals and so the spectra of the bora were computed also to the very high frequencies. These spectra show the most important peaks to be at periods greater than several minutes. This result is in an agreement with our earlier findings of periods in bora greater than approx. 5 minutes in location in Vipavska dolina (Rakovec and Petkovšek, 1983).

Prethodno priopćenje o spektralnim karakteristikama bure na otoku Rabu

Prikazani su neki rezultati mjerenja bure na otoku Rabu za vrijeme eksperimenta u kojem se ispitivao utjecaj vjetra na morske valove i strujanje. Upotrijebljeni piezoelektrični senzor za vjetar omogućio je uzorkovanje na 1 sekundu, pa su tako i spektri bure izračunani do vrlo visokih frekvencija. Iz njih se vidi da su najvažniji vrhovi kod perioda dužih od nekoliko minuta. Ti se rezultati slažu s nekim ranijim nalazima o periodama u buri dužim od oko 5 minuta na lokaciji u Vipavskoj dolini (Rakovec i Petkovšek, 1983).

In March 1986, some measurements of bora wind were carried out in the region between Senj and the island of Cres, together with measurements of waves and sea currents in an experiment, organised by the Hydrographical Institute of the Yugoslav Navy. Our organisation participated in the measurements of wind characteristics at Lopar on the island of Rab. The purpose of the experiment was to establish the response of the sea to the wind in this area, which is characterized by the frequent occurence of strong bora. In this report only some features of spectra of bora will be briefly considered.

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To obtain data on wind velocity on a very fine time scale, a piesoelectric sensor was mounted together with a standard rotational anemograph on a roof of the house, about 6 m from the ground. The filter of the instrument is almost rectangular with the window between 1 and 10^{-3} Hz. So the data contain the information on wind fluctuations with periods greater than 1 sec. Our sampling interval was chosen to be 1 second as well. The output of a sensor (voltage) was used as the input to the function generator, converting the values of voltage to the frequencies of the rectangular waves. These frequencies were recorded onto magnetic tape later digitalised with a microcomputer. As the frequencies were roughly proportional to the square of velocity (because the sensor responds to the pressure on it), square roots of digital data were used to be the time series for further spectral analysis.

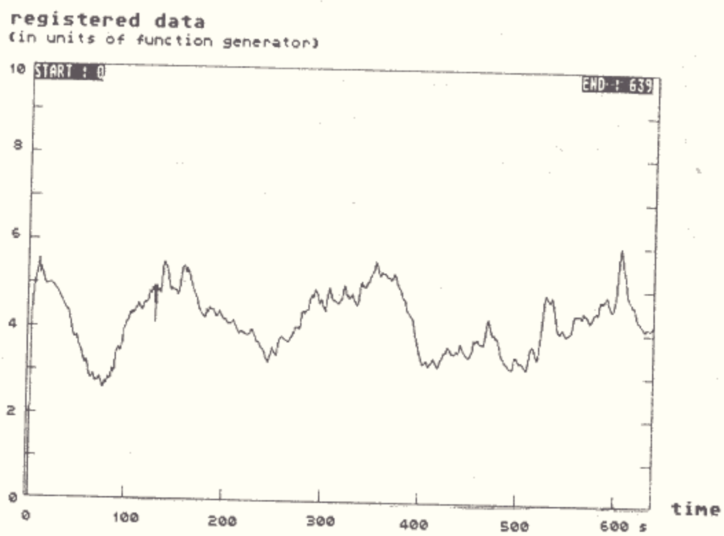

Figure 1. A part of registered values of intensity of bora wind in the island of Rab on March 27, 1986 in the morning. The registered data with piesoelectric sensor are roughly proportional to the square of velocity.

Having computed the time correlation functions of the time series, the fast Fourier transformation had to be applied. To smooth the results, Parzen's window in the form reported by Pančev (1976) was used over 90% of the data in the correlation function. Zero frequency was omitted from the analysis and no prewhitening was applied.

Some tests of the obtained prevailing periods are presented here on an example of bora on March 27. 1986. with strong fluctuations in velocity (Fig. 1). The corresponding dominant periods for the case of 1024 data, collected in about 17 minutes, can be seen in Fig. 2: the most expressed are those at 5.7 minutes, at 2.8 to 2.4 minutes and 1.3 minutes.

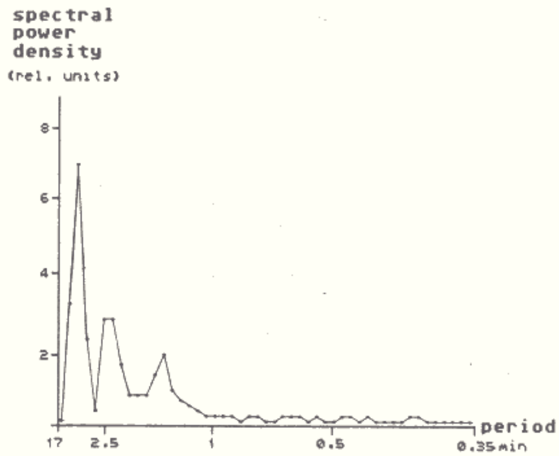

Figure 2. Spectral presentation of the first 1024 data (about 17 min). Square root of original data was used for computation of spectral power density.

How can we establish the representativeness of these peaks?

1. What do we get with some other window, for example with the one with narrower main lobe? Hann's raised-cosine window has approximately half the width of the main lobe of the Parzen's window (Ge kinli an Yavuz, 1983), and so the resolution of the estimates is better. With this window small oscillations in a spectrum are diminished, the

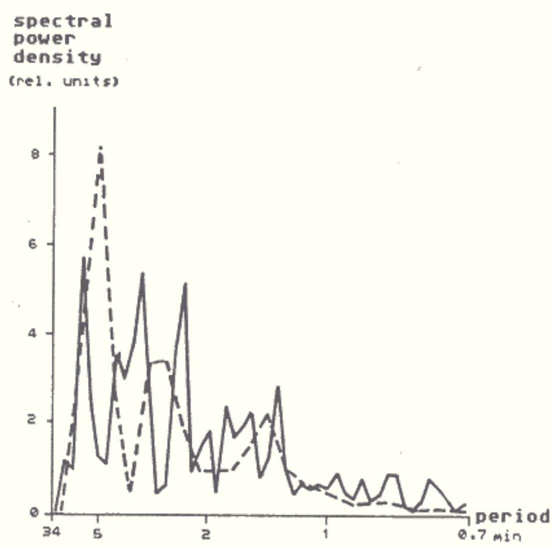

Figure 3. Spectral power density from Fig. 2, presented in different scale (dashed line), to be compared with spectral power density computed from 2048 data (about 34 min, full line).

peak at 1.3 minute is broadened and enhanced, while the one at 2.6 minute is depressed. But if we compare the data with the same (Hann's) window for another set of 1024 data about an hour later, we obtain another strong peak from 8.5 to 2.4 minutes (so comprehending the one at 5.7 minutes) and a much weaker one at 1.3 min. It seems that this bora is not stationary.

2. For a better resolution of the longer periods we make spectral analysis on 2048 data (about 34 minutes), starting at the same time as with the first estimation of a spectrum. The peak at 5.7 minutes broadens to 8.5 minutes (Fig. 3), while the one from 2.8 to 2.4 minutes divides in two peaks at 3.1 and 2.1 minutes: with longer time of measurements also the estimates of longer periods become more distinguishable, with less noise in a spectrum.

3. If we take the first 2048 data and the last 2048 data (of the total number of about 3600 data, so that the two sets partly overlap), we get the estimation of non-stationarity of this bora with the better resolution of longer periods. In the second part of the data (dashed line in Fig. 4) the peak at 8.5 remains, while the two at 3.1 and 2.1 minutes tend to join again at the period of 2.8 minutes.

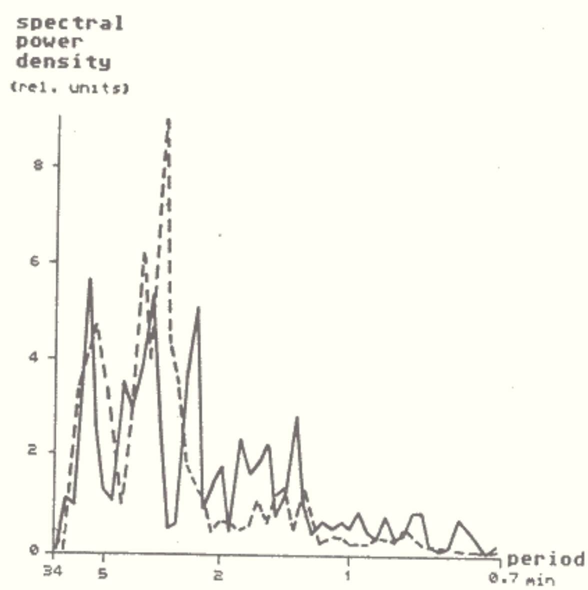

Figure 4. Spectral power density as in Fig. 3 (full line) in comparison, to the one, computed for another 2048 data (about half an hour later, dashed line).

So we can make a draft conclusion for the bora, in the morning of March 27. that the most dominant feature are periods somewhere between 5.5 and 8.5 minutes, while other spectral components vary in time.

We are only going to mention another extreme case with a very smooth set of data (Fig. 5) in the afternoon of March 16: there is only one peak in a spectrum (Fig. 6), and again close to the mentioned one, between 2.4 and 8.5 minutes, but of course with more

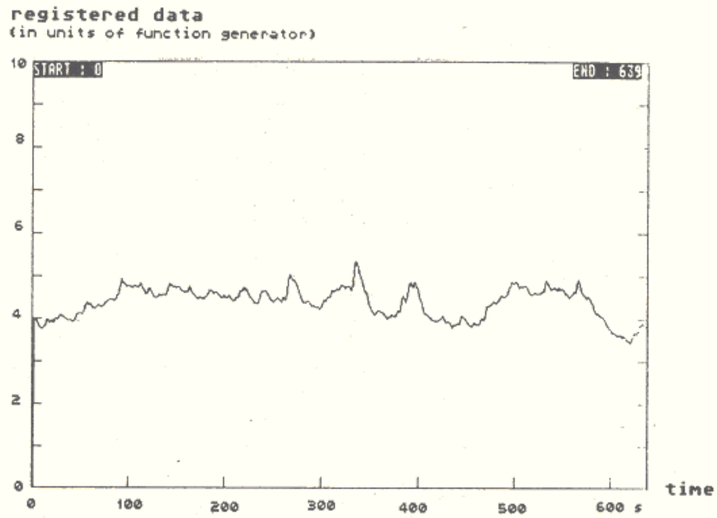

Figure 5. As Fig. 1, but for small fluctuations of wind velocity on March 16, 1986 in the afternoon.

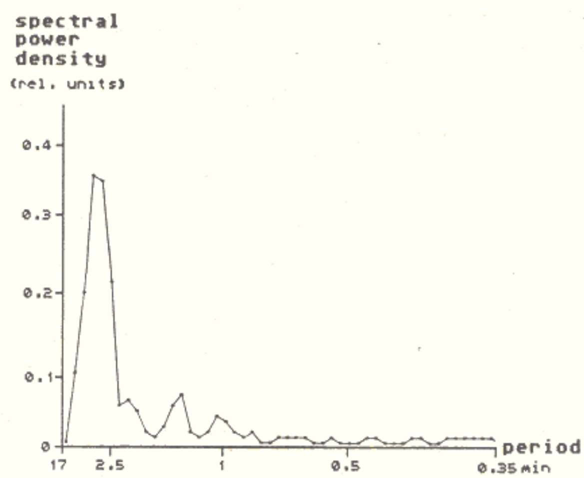

Figure 6. As Fig. 2, but for March 16 data. The strongest peak has a value 743 in comparison to 8009 in Fig. 2 (both units are relative, but comparable).

than 10 times smaller energy. Periods from 1 to 10 minutes are dominant also in all the collected data, while those shorter periods carry only white noise.

Deeper insight will be possible by further analyses of all collected spectra together, also in logarithmic scale, to get the k^{-x} dependence of energy distribution on a wave number.

Acknowledgements

The Hydrographical Institute of the Yugoslav Navy has kindly invited us to participate in measurements. Dr. A. Smirčić from this institution designed the experiment and we are indebted to him. Prof. A. Čadež constructed the sensor and suggested its use for wind measurements, Prof. Z. Petkovšek took a great part at measurements and B. Dintinjana (all three are from the author's institution) helped with digitalisation of the data. Their help is greatly appreciated.

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