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Notes on characteristics of the response of near-shore current field to the onshore wind

O nekim značajkama odgovora priobalnog strujnog polja na vjetar

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INTRODUCTION

As part of the pollution transport studies, in the region of Split, several current measurement experiments have been completed. This work represents the analysis of one set of current data as influenced by typical wind events on the time scale of several days. Both the vertical and horizontal distribution of current vectors in the near-shore zone are described. The data basis is a time series of current vectors collected during September and October 1980. Two-surface bouys were moored as shown in Fig. 1. Current speed as well as temperature was recorded at depths of 10 and 30 m at each mooring at 20 minutes interval. Hourly wind data from the adjacent Marjan meteorological station were also available.

DATA ANALYSIS

The studied transect was across the mouth of the Bay and it was parallel to the prevailing wind during the experiment (ESE wind). Ispection of hourly current data indicated that tidal and other high-frequency oscillations had much smaller amplitude than those with period of several days and therefore only daily mean current vectors were analysed and compared with daily mean wind vectors. Daily mean wind vectors were calculated from data at 7 a.m., 2 p.m. and 9 p.m. each day. Mean wind for the whole period of curent measurements had magnitude of about 2.8 m/s toward W (265°) showing the prevalence of easterly winds during this period. The mean current vector at 10 m depth for both stations had a relatively large component in the direction of the mean wind (Table 1), while the mean current vector at 30 m had the component in the opposite direction. The west current component in the surface layer was more stable than the east one in deeper layers due to the fact that easterly winds have the same direction as the mean current along the Yugoslav coast (Z o r e - A r m a n d a *et al.,* 1979). Vertical distri-

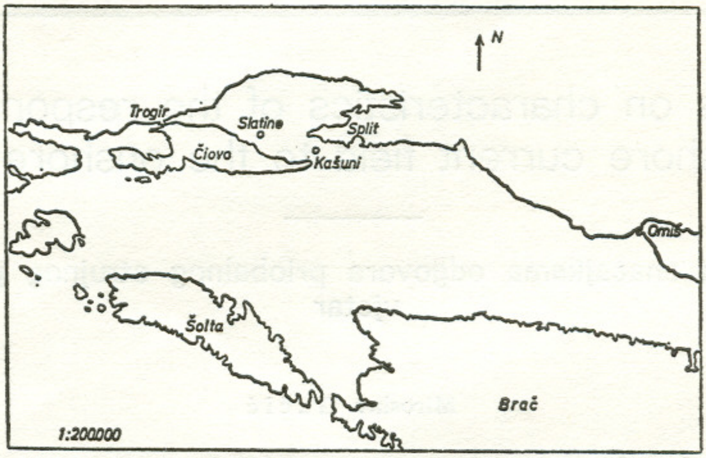

Fig. 1: Locations of moorings named Slatine and Kašuni.

bution of mean current vectors, can be explained in terms of the balance between the vertical transport of momentum and the horizontal pressure gradients as suggested by H a n s e n and R a t t r a y (1965). Another question is whether this vertical current distribution appears within shorter time scales; to check that, time-series of mean daily current vectors were analysed expressing current vectors in terms of the component parallel to the wind vector and normal to it. Current component parallel to the wind vector was defined as positive if it was in the same direction as the wind, while the component of the current vector normal to the wind was positive if it was to the right of the wind. In another words the current component normal to the wind was positive if there was an Ekman-like balance.

Table 1: Components of the mean current vector and their standard deviations. Units are cm/s.

K A Š U N I

	N-component	E-component	Depth
	3.1	—5.9	10 m
St. deviation	8.6	10.0	
	2.1	0,7	30 m
St. deviation	5.9	10.3	

S L A T I N E

	N-component	E-component	Depth
	4.8	—8.3	10 m
St. deviation	9.5	8.6	
	6.6	2.7	30 m
St. deviation	14.7	12.1	

The current component normal to the wind velocity was very small for both mean current for the whole period of the experiment and for daily mean current vectors. In another words, the angle between current vector and wind velocity was very small, in fact within the range of measurement error.

Time-series of both the wind-ward current component and wind speed are presented for both stations in Fig. 2. Surface currents were in phase with wind speed while in deeper layers the phase-lag between the wind speed and wind-ward current component was 180°. The correlation coefficient between the wind speed and wind-ward current component at the depth of 30 m was —0.6 and statistically significant at the 95% confidence level. The correlation coefficient would have been even higher if only situations with a strong wind were considered.

The orientation of the coast in the Bay results in a downward motion during the SE wind event, while during the NE wind event an upward motion occurs. The vertical distribution of current in the Bay creates this vertical

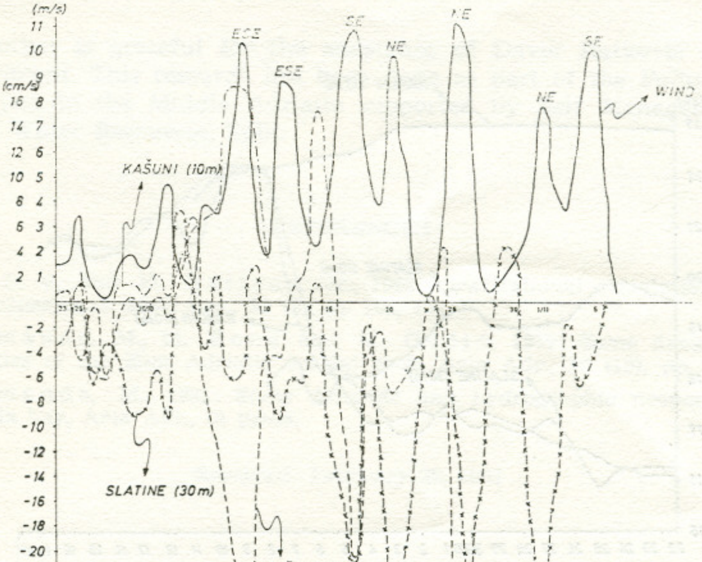

Fig. 2: Time-series of wind speed and wind-ward current component. Pozitive current component is in the direction of the wind, while the negative one is in the opposite direction.

motion. The vertical velocity was calculated from the relation obtained by integration of the continuity equation along the vertical and horizontal axes:

$$w = \frac{UH}{L}$$

w being vertical velocity, H vertical distance between the depth of zero vertical velocity and the depth where vertical velocity reaches maximum.

U is the horizontal velocity and L is the mean distance between moorings and coastline in the direction of the transect. It was also assumed that the shear in each layer is equal zero and that horizontal velocity decreased linearly toward the coast. Vertical velocities were calculated for 7 and 8 October 1980 and in both cases a value of about 7×10^{-4} m/s was obtained showing that surface waters can reach the bottom of the Bay in less than a day when influenced by a strong SE wind. The calculated magnitude of the vertical velocity is in agreement with values determined by Zore-Armanda (1981).

The temperature time-series were also informative. Fig. 3. shows only first part of time-series where the temperature changes were most markedly under the influence of vertical and horizontal transport caused by the wind. At the beginning of the record, sea water at both moorings in lower layers was almost of the same temperature, while the surface layer in the Bay was much cooler than the surface layer outside the Bay. On October 5 a strong SE wind started to blow causing vertical mixing and the temperature of the

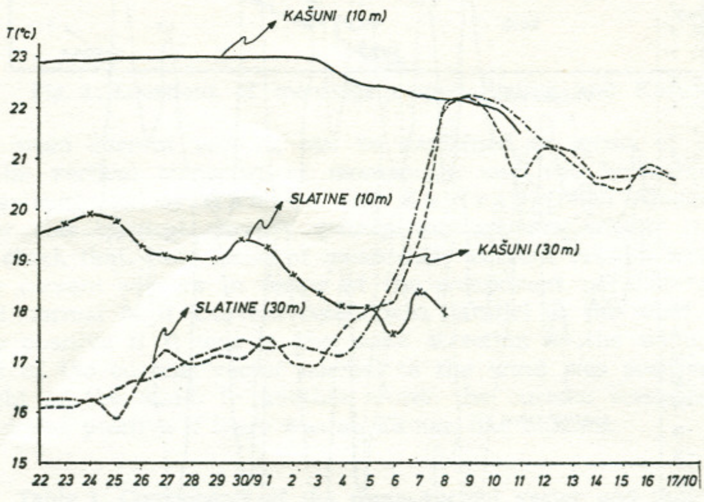

Fig. 3: Time-series of daily mean temperature for two moorings. Strong temperature increase at the depth of 30 meters coincides with the start of the SE-wind.

lower layer started to increase. It was, however, peculiar that after October 6 the sea water temperature of the bottom layer in the Bay was higher than the surface water temperature showing that horizontal advection had started to play a major role in the transport of water characteristics. From the fact that, during the whole period shown in Fig. 3, deeper layer water temperature was the same for both moorings, follows that this advection was along the mooring transect, i.e. parallel to the wind velocity.

Outside the Bay on October 8 the wind caused a complete mixing of the layer from 10 to 30 m.

CONCLUSIONS

Oscillations with a period smaller than a day in the bay Kaštelanski zaljev have been shown much smaller amplitude than the low-frequency oscillations forced by the wind.

The response of the current field to wind forcing normal to the coast could be described by the two-layer model; in the surface layer current was in the wind-ward direction while in deeper layers it was the opposite.

Current component normal to the wind was negligible.

Calculations of the vertical velocity indicated a value of about 7×10^{-4} m/s during a strong wind event.

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O NEKIM ZNAČAJKAMA ODGOVORA PRIOBALNOG STRUJNOG POLJA NA VJETAR

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KRATAK SADRŽAJ

Analizirani su rezultati mjerenja struja u Kaštelanskom zaljevu dobijeni 45-dnevnom kontinuiranom registracijom na dvije postaje. Ustanovljeno je da vjetar u površinskom sloju izaziva struju čiji se smjer podudara sa smjerom vjetra. U dubljim slojevima kut između vektora vjetra i struje iznosi približno 180°. Ovakva vertikalna struktura strujnog polja javlja se na vremenskim skalama dužim od jednog dana. U Kaštelanskom zaljevu se, kao posljedica ovakve vertikalne strukture, javlja vertikalno gibanje. Računata je vertikalna brzina za situacije u kojima puše SE-vjetar i dobijene su vrijednosti od oko 7×10^{-4} m/s.