Verification of the Wind Wave Forecasting System for the Black, Azov and Caspian Seas

B.S. Strukov, A.A. Zelenko, Yu.D. Resnyansky, S.L. Martynov

Hydrometeorological Research Centre of Russian Federation (*zelenko@mecom.ru*)

1. Introduction

Since 2010, the Russian Hydrometeorological Centre is gradually putting into operation the components of the system aimed at operational wind wave forecasting in the World Ocean and seas of Russia: the Black, Azov, Caspian, Baltic, Barents, and White. The forecasting is performed through the computations with wind wave spectral models WAVEWATCH III and SWAN. The computations inherently involve the usage of meteorological forecast products [3]. At the first stage of the system exploitation the verification has been performed in appliance to the forecasts for the Black, Azov and Caspian Seas.

2. Forecasts

The forecasts were compiled up to 5 days using the WAVEWATCH III v. 3.14 model giving the output every 15 minutes. The initial conditions were taken from a previous 1 day forecast. The spatial grid resolution was about 10 kilometers in the Black Sea, 2 km in the Azov Sea and 6 km in the Caspian Sea. The model output data were interpolated in time within the 15-minute intervals and in space within a grid cell in order to ensure the temporal and spatial match of predicted and measured data.

3. Data for verification

Forecasting errors were estimated by comparing with satellite altimeter data on Significant Wave Height (SWH) from the Radar Altimeter Database System (RADS) supported by the Delft Institute for Earth-Oriented Space research (DEOS) [1]. The RADS is updated with altimeter data from Earth resources satellites, such as Jason-1, Jason-2, Envisat-1, ERS-2. The network of tracks for three of these satellites over the Black Sea-Caspian region and the spatial SWH data coverage over the Black Sea are shown in Figure 1.

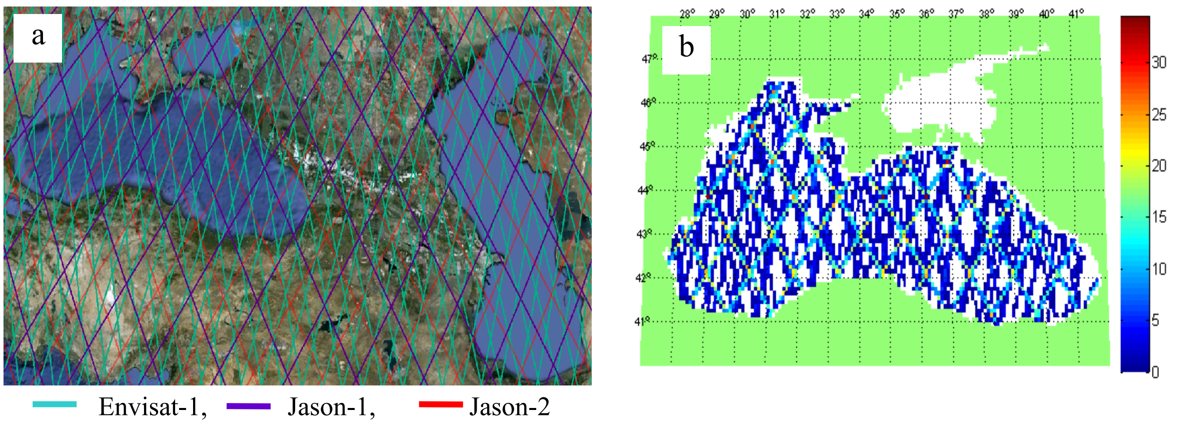

Figure 1. The network of tracks for Envisat-1, Jason-1 and Jason-2 satellites over the Black Sea-Caspian region (a), and the averaged number of data during a day in 1° × 1° cell over the Black Sea (b).

The accuracy of the satellite SWH data itself after bias calibration is max (0.4 m, $0.1 \times SWH_{measured}$) [2]. For additional noise filtering, only those data were selected from the original dataset, for which the standard deviation of the signal recorded more than 1700 times per second and then averaged over 1 sec time intervals, didn't exceed 0.1 m. The cases were also excluded, for which model and measured SWH values didn't exceed 0.05 m.

4. Forecast errors

The model and RADS data comparisons were performed through the time period 15.04.2011–30.11.2011.

Mean error (bias), root mean square error (RMSE) and correlation coefficient (CC) between forecasted and measured SWH values were selected as statistical measures of the forecast accuracy.

The absolute values of mean errors were relatively small during the period under consideration, slightly increasing with an increase of lead time from 0.01–0.08 m to 0.09–0.16 m. In most cases the bias has remained negative, indicating some underestimation of wave heights' prediction in comparison with measurements.

An example of scatter plots, giving an idea of the degree of compliance between forecasted and measured SWHs for the second forecast day, are shown in Figure 2, and the dependence of RMSE and CC on the lead time – in Figure 3.

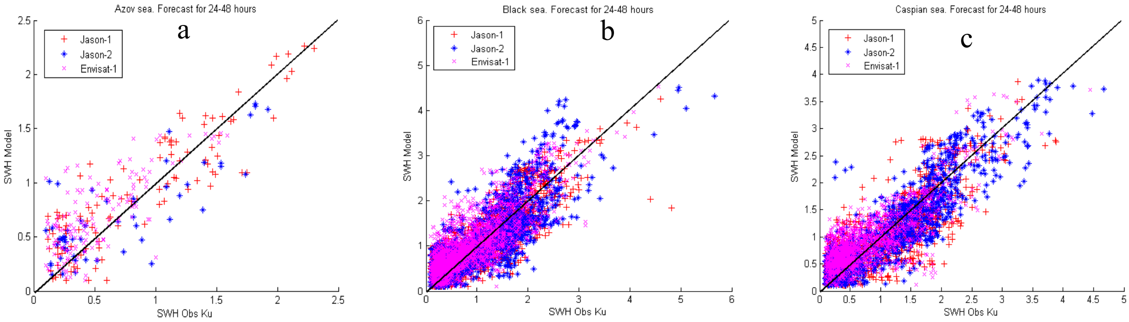

Figure 2. Scatter plots of prognostic and measured SWHs for the second forecast day over the period 15.04.2011–30.11.2011: (a) for the Azov Sea, (b) for the Black Sea, (c) for the Caspian Sea.

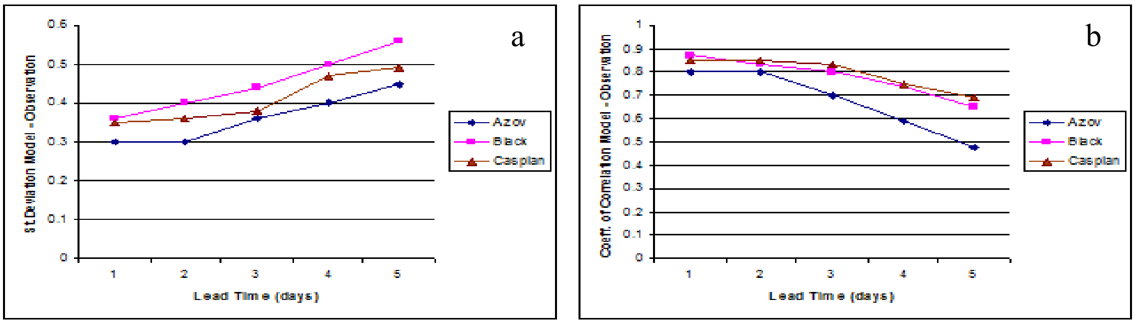

Figure 3. Mean-square difference between forecasted and measured SWHs (a) and correlation coefficient between them (b) for different lead times from 1 to 5 days for each of the Seas.

One can see in the figures that the RMSE of the forecast increases with extending of lead time (LT) from 0.3–0.36 m for the first day up to 0.45–0.56 m for the fifth day. Correlation decreases from 0.80–0.87 for the first day down to 0.48–0.69 for the fifth day.

5. Dependence on wind uncertainties

Deterioration of the forecast quality with LT increase is conditioned to a large extent by the increase of uncertainty of wind speed data used as input in the wave model. The increase of the correlation coefficient between the errors of forecasted SWH and the uncertainties of wind speed data with increasing LT (shown in the Table) makes it evident. The wind speed uncertainties were determined by comparing the wind speed from meteorological forecasting model with satellite wind measurements contained in the RADS database together with SWH data. Thus, we can expect that the accuracy of forecasts for the current version of the wind waves forecasting system will increase with improvement of weather forecasting.

Correlation coefficient between the errors of forecasted SWH and the uncertainties of wind speed data used as input in the wave model for different lead times from 1 to 5 days

Sea	Forecast lead time LT, days				
	1	2	3	4	5
Azov	0.57	0.57	0.69	0.76	0.82
Black	0.48	0.57	0.61	0.67	0.71
Caspian	0.47	0.52	0.54	0.63	0.62

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