

Coastal Monitoring in of Okhotsk Sea Using an Autonomous Mobile Robot

**V. Beliakov¹⁾, P. Beresnev¹⁾, V. Filatov¹⁾, A. Kurkin¹⁾, V. Makarov¹⁾, E. Pelinovsky^{1,2)},
D. Tugin¹⁾, A. Zaytsev³⁾ A.Yalciner⁴⁾, and D. Zeziulin¹⁾**

1)Nizhny Novgorod State Technical University n.a. R.E. Alekseev, Nizhny Novgorod, Russia,
aakurkin@gmail.com

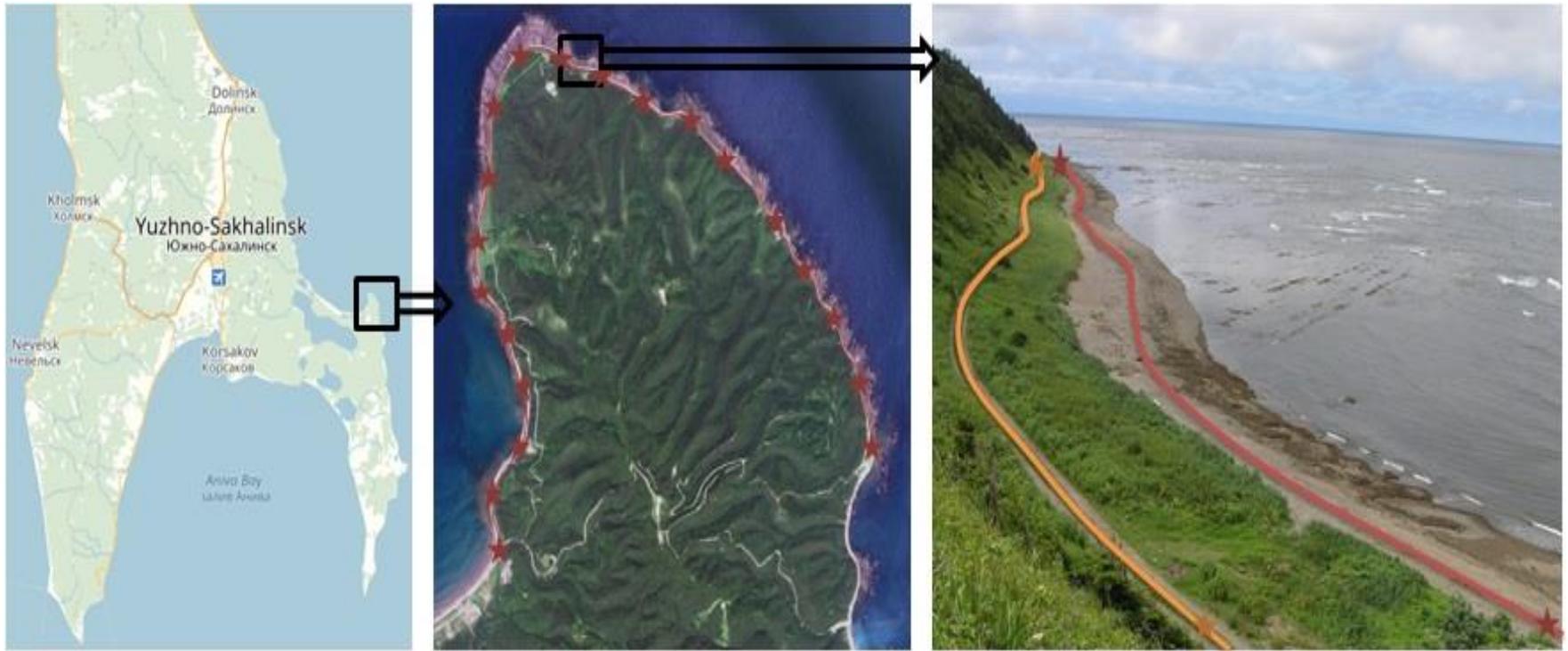
•2)Institute of Applied Physics, Russian Academy of Sciences, Nizhny Novgorod, Russia , pelinovsky@gmail.com

3)Special Research Bureau for Automation of Marine Researches, Far Eastern Branch of Russian Academy of Sciences, Uzhno-Sakhalinsk, Russia, aizaytsev@mail.ru

4)Middle East Technical University, Department of Civil Engineering, Ocean Engineering Research Center, Ankara, Turkey, yalciner@metu.edu.tr

INRODUCTION

In order to design, construction and safe operation of the modern coastal infrastructure, proper assessment of marine extreme events using highest quality data is necessary. Therefore better understanding of marine extreme events can be possible and their occurrence and future possible effects on marine infrastructure can be estimated properly. Therefore the tools produced using recent technological developments are helpful for the achievement in this direction. In this study the Autonomous Mobile Robot (AMR) is used. AMR is consisted of camera for recording the route and environment, radar to detect sea state, instruments for measuring wind speed and direction, different sensors to measure atmospheric pressure, temperature, precipitation, relative humidity, and penetrometer for detecting ground surface characteristics. It is also with different sensors, hardware, software and data transmission devices which collect and send the data in real time to the server in the research center. It follows the pre specified route along the coast. AMR is used in the field in Sakhalin Island in May and June 2016 and the coastal processes are measured, analyzed and discussed for better understanding of extreme marine events. This work summarizes the functions and capability of the instruments used in the pilot measurement program, performance of AMR, analysis and results of measured data with discussions.



Main objective of this study is to perform a pilot measurement program to collect the data on waves characteristics, surface currents, nearshore ground characteristics, meteorological parameters during the pilot survey using modern high capacity survey equipment along the coastal zone of Sakhalin Island (near Svobodny cape, $46^{\circ} 50' 50.3''\text{N}$, $143^{\circ} 25' 59''\text{E}$) in two months period between May and June 2016.

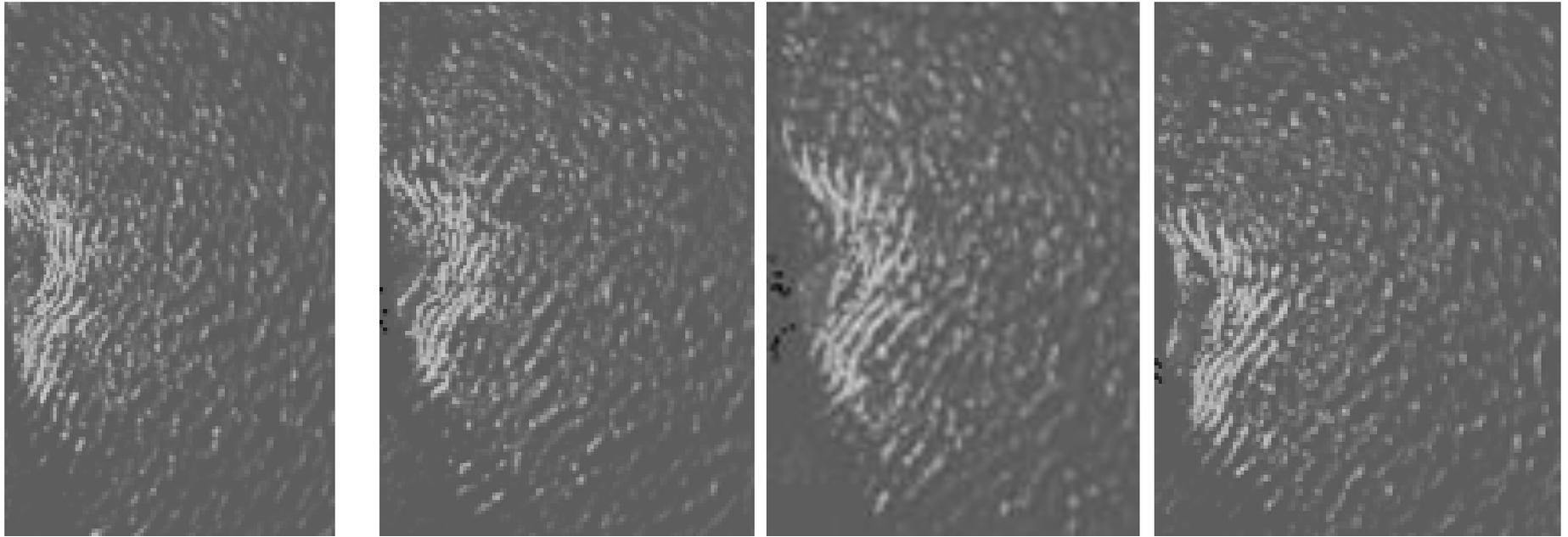
from the ground and 400 m distance from the shore. During measurement by a radar the AMR stands still.

Obtained yielded and results of processing are extremely important for understanding of the nature of sea natural disasters and safety of coastal infrastructure and sea activity in coastal water areas, in particular, around implementation of oil and gas projects and intensive navigation and fishery. On the basis of results of research estimates of risks of marine natural hazards in these areas have to be made.



The parameters measured during the pilot survey are i) sea state and hence wave characteristic by means of radar, ii) meteorological data on wind speed and direction, atmospheric pressure, temperature, precipitation, relative humidity, iii) ground surface characteristics. Its smooth movement, short diameter of turning circle, torque, stability, economy in fuel consumption, high capacity sensors are important characteristics. A ship radar mounted on AMR detects the sea surface deformation by means of radar.

Work of a complex throughout all term of expedition has shown that all its systems reliably function in required service conditions. In this connection, all declared researches continued rather successfully



The data and information on the vehicle location in geographical coordinates, vehicle speed, the number of the connected satellites and signal strength from of each satellite, elevation from the sea level during its mission are transmitted to the server at the research center. The main focus of the next stage of the pilot survey is to measure the sea state, sea surface disturbance, and atmospheric parameters. Sample pictures of sea state measured by radar at Svobodny cape towards Mordvinov's gulf are shown in Figure 3.

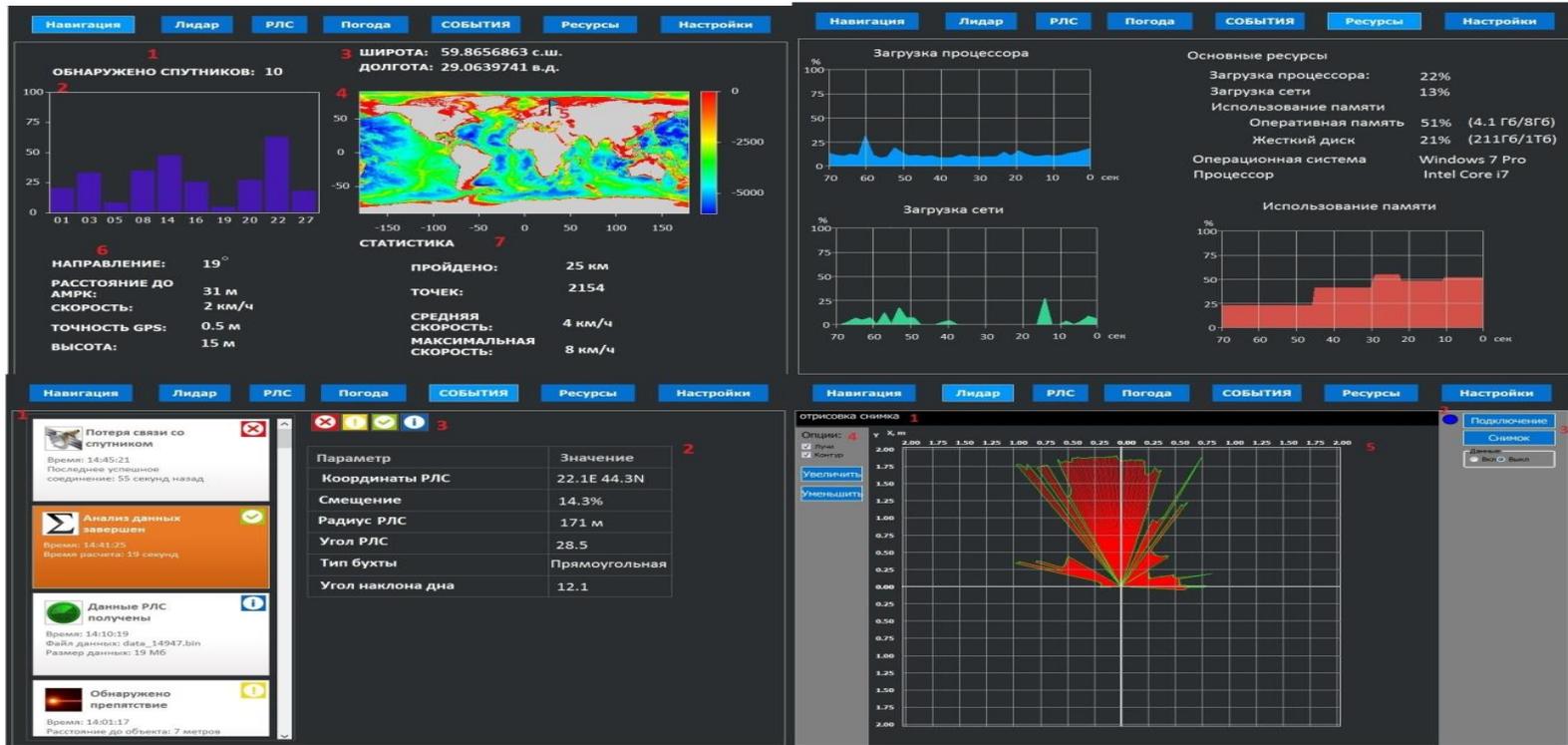
The images are used for the comparison and verification of the sea surface pictures obtained from radar and wave data from pressure measurements. Those images are extracted from the synchronized video stream taken by AXIS Q6044-E camera which is mounted on AMR during its mission. One of the snapshot extracted from video stream is shown



During quiet weather (rather calm sea) radar does not detect reflected signals (Figure, left). During the storm, radar detects the accurate echo signals (Figure, right). A sample record of sea state in the Okhotsk sea during a three-point storm occurred on June 02, 2016 is also shown

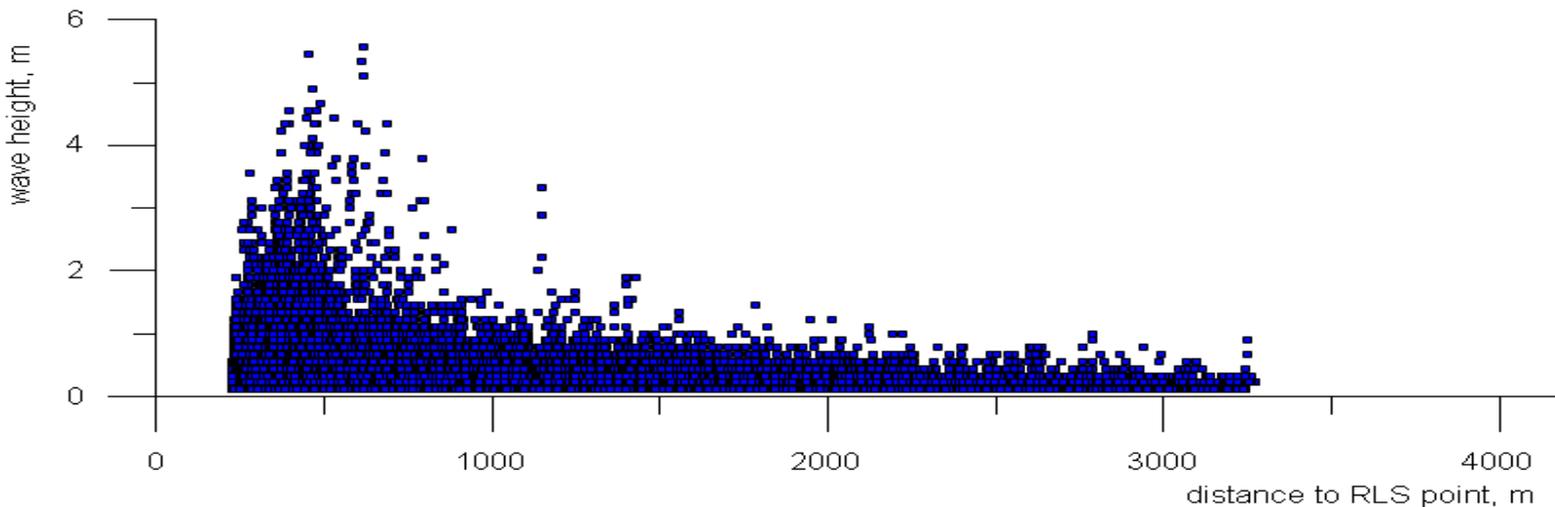
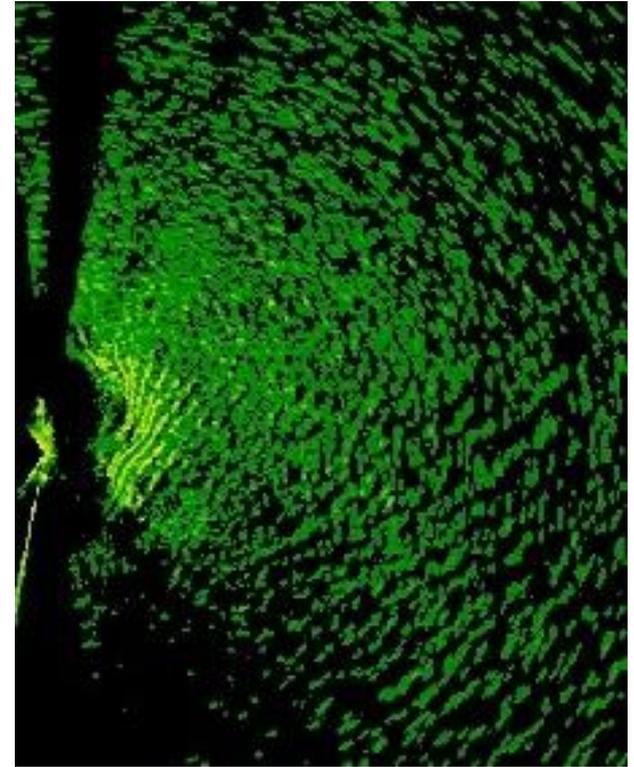


Graphic user interface measuring equipment of autonomous mobile robot



The autonomous mobile robotic complex allows to execute the following volume of experimental research. Intensity measurements reflections of waves by means of the radar, and also measurement of a condition of the atmosphere (atmospheric pressure, temperature, relative humidity, the direction of wind, wind speed). To carry out standard maneuvers in the pilotless mode: the movement on the set corridor at a short distance and at a long distance, the curvilinear movement on the set corridor (a turn, "snake"), the movement to a control point and back, the movement through control points.

The change of reflected signal intensity with respect to distance from the radar (AMR) is investigated. The intensity change versus distance as a sample graph is plotted in Figure. In Figure, the change of detected wave height with respect to distance from the radar location is presented. It is observed that the parameter extracted from reflected signal diminishes with distance from the radar location. The strong intensity and higher waves are observed at a distance of 500m from the radar location. One of the reason of increased signal intensity at 500m distance is that there is shelf and shallow region there.



CONCLUSION

A new Autonomous Mobile Robot is developed and used in a pilot field survey in Sakhalin. AMR is capable of remote controlling, maneuverable under difficult field conditions and equipped with different sensors for field measurements at the coastal zone and real time data transmission. The wave characteristics and sea state is measured by radar. Other parameters such as surface current, meteorological parameters such as wind characteristics, temperature, humidity, atmospheric pressure, precipitation, ground characteristics, vehicle speed and location are measured simultaneously during its mission. The performance of the AMR is also tested. It is observed that the intensity of reflected signals of radar becomes weaker with respect to distance between radar and reflection point in the sea.

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