STUDYING THE ACCURACY OF AFAR-BASED RADAR SOUNDING SYSTEM

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1. Introduction

The Russian upper-air network comprises 125 stations with 107 of them included in the 2005 operational plan. Most stations are equipped with upper-air radar systems AVK-1 that are highly radiative and power-consuming. Their microwave transceivers are very costly, their computers obsolete, and mechanics sophisticated. Service-life period of some of the “Meteorite” radars expired long ago. Therefore, the network updating has been undertaken in two directions: AVK-1 systems updating and installation of new upper-air radars MARL-A.

MARL-A is a radar system with active phased antenna array (AFAR) composed of 64 elements (Fig. 1), 100 W pulse power, and consumed power less than 500 W.

The beam is controlled by electronics in both planes, with automated slewing provided.

Some features of electronic scanning (no transit-time effects, high rate, stepwise mode) may cause additional errors in radiosonde target tracking whose accuracy needs to be specially investigated.

2. To evaluate the characteristics of AFAR and the radar in general in terms of both its adjustment and control in the course of operation, each radars set to be delivered includes a radiosonde mock-up. The latter is to be stationary installed at a 50-100 m distance at maximum possible height and is remotely controlled from an operator’s workplace. The mock-up serves to check the operability of each AFAR module and the performance of antenna in general. Electronic angular scanning within ± 15 deg. azimuth and elevation with a 1 deg. step is performed in an automated mode resulting in a spatial display of the antenna pattern and bearing characteristic (Figs. 2 and 3).

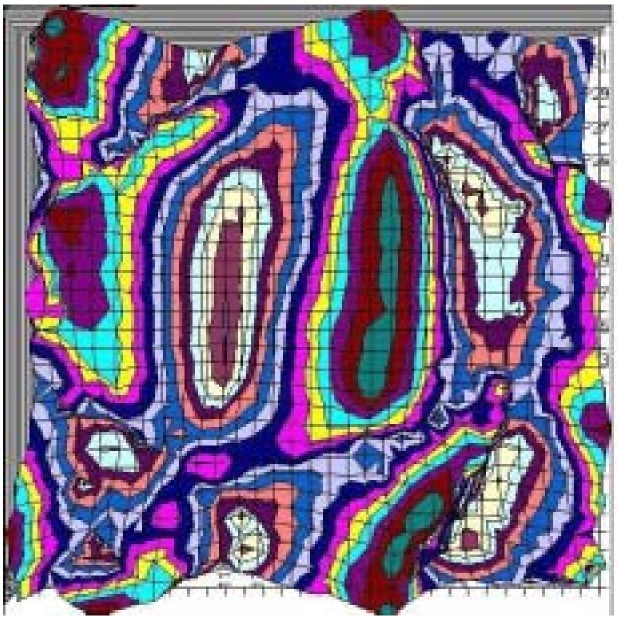

Fig.2 Azimuth pattern

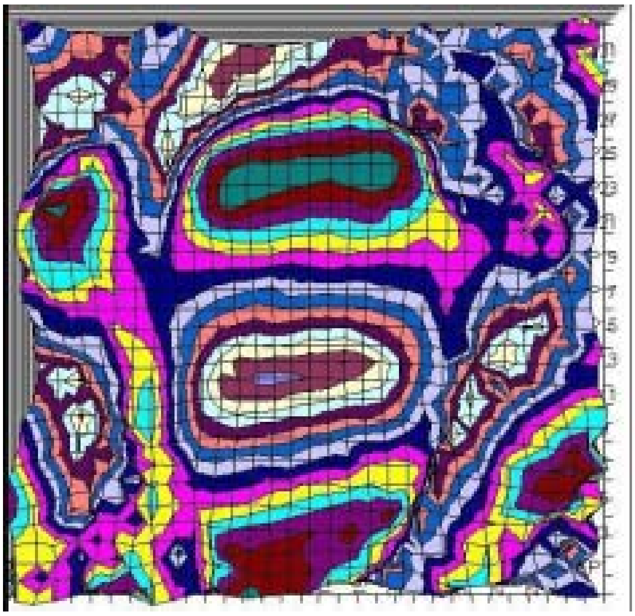

Fig. 3 Elevation pattern

Linearity, symmetry, and sufficient sloping of the bearing curve in both planes are critical for radiosonde angular tracking with high accuracy. The mock-up is also used to check the parameters of automatic lock-on to a target and mechanical antenna slewing.

Errors in the angular tracking of a moving target are readily revealed and both antenna orientation and leveling checked against the solar disk whose radio emission is sufficient for angular tracking to be performed in the working frequency range.

The r.m.s. sun-based elevation error for an well-adjusted MARL-A was found to be less than 0.1 deg. (Fig. 4), while systematic errors could be eliminated using either mechanical or software means.

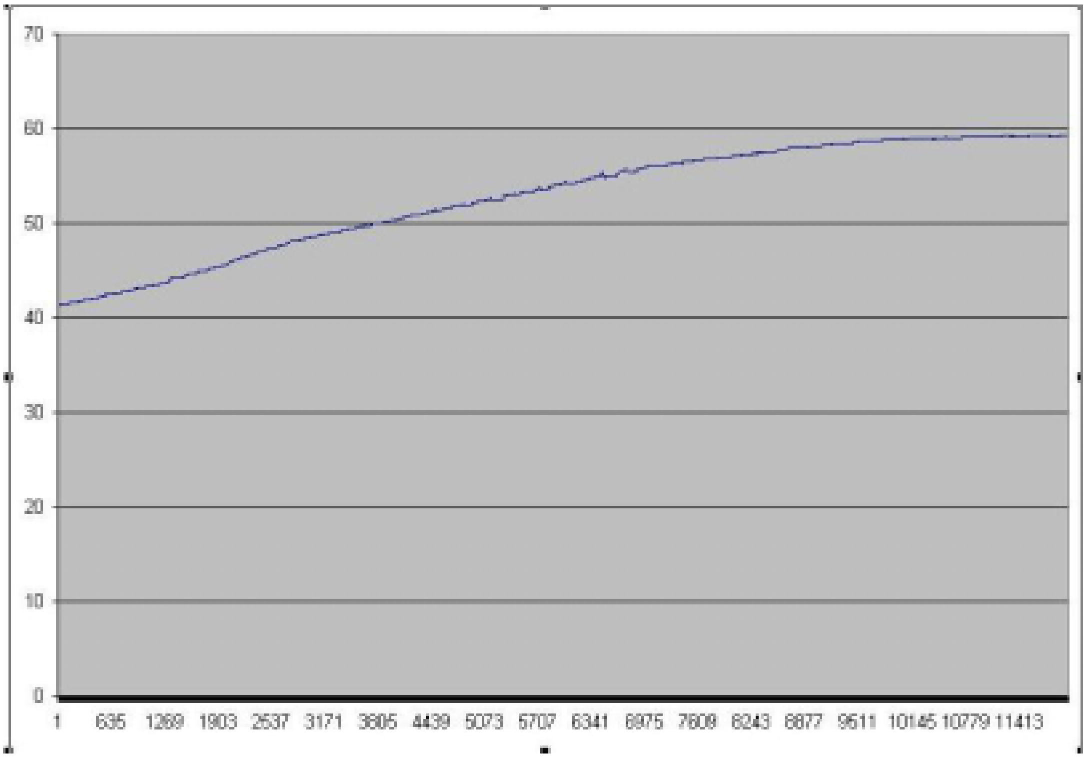

Fig. 4 Sun tracking in elevation

Under favorable conditions it was even possible to evaluate antenna pattern in the main lobe by solar radiation (Fig. 5 and 6).

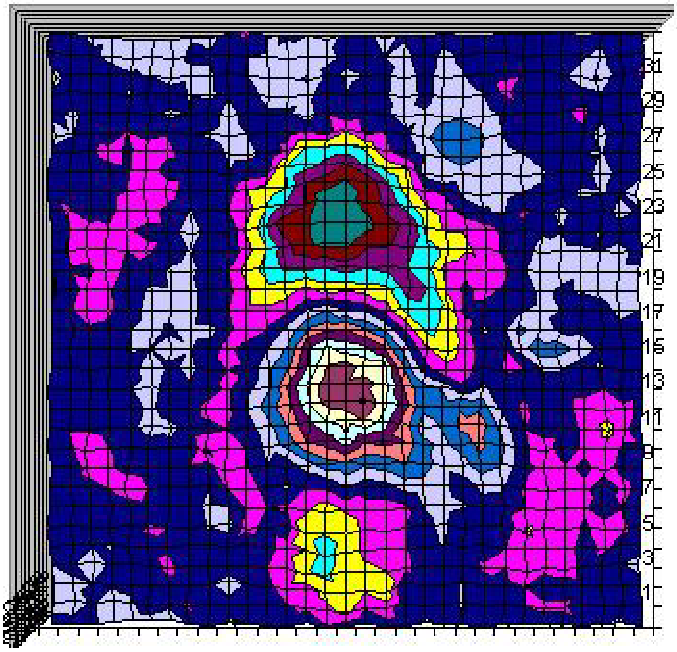

Fig.5 Sun pattern diagram

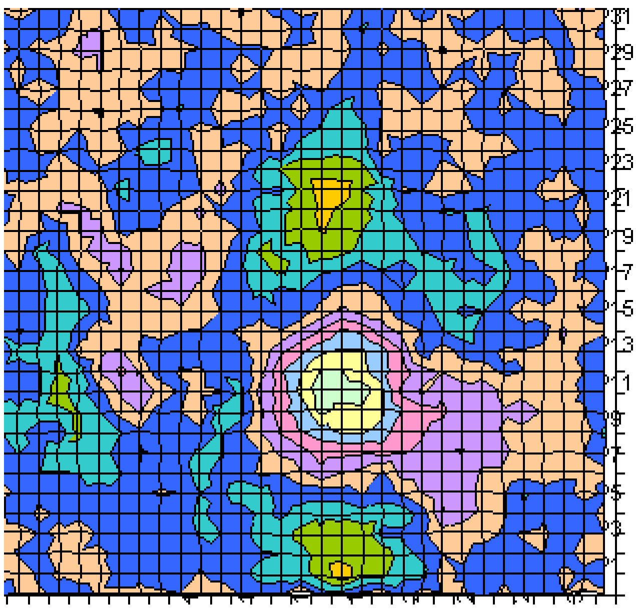

Fig.6 Sun main lobe

3. The final evaluation of the radio sounding accuracy of the new system MARL-A was performed by way of direct comparison of the coordinates and upper-air telegrams in paired radiosonde launches and their tracking independently with MARL-A and AVK-1 radar systems. The radars were mounted on top of the same building, 25 m apart, with a 4-m difference in height.

Figure 7 shows a fragment of synchronous records of elevation angle from the two radars with a 0.5-deg. offset. The r.m.s. angular difference in the distance range from 1 to 140 km was 0.16 deg, somewhat increasing at larger distances due different influences of the underlying surface on the two antenna types – paraboloid and AFAR. The contribution of the Earth’s reflections to elevation error was investigated when radiosonde was falling down. A noticeable departure from a continuous reduction of elevation angle was only observed below 6 degrees.

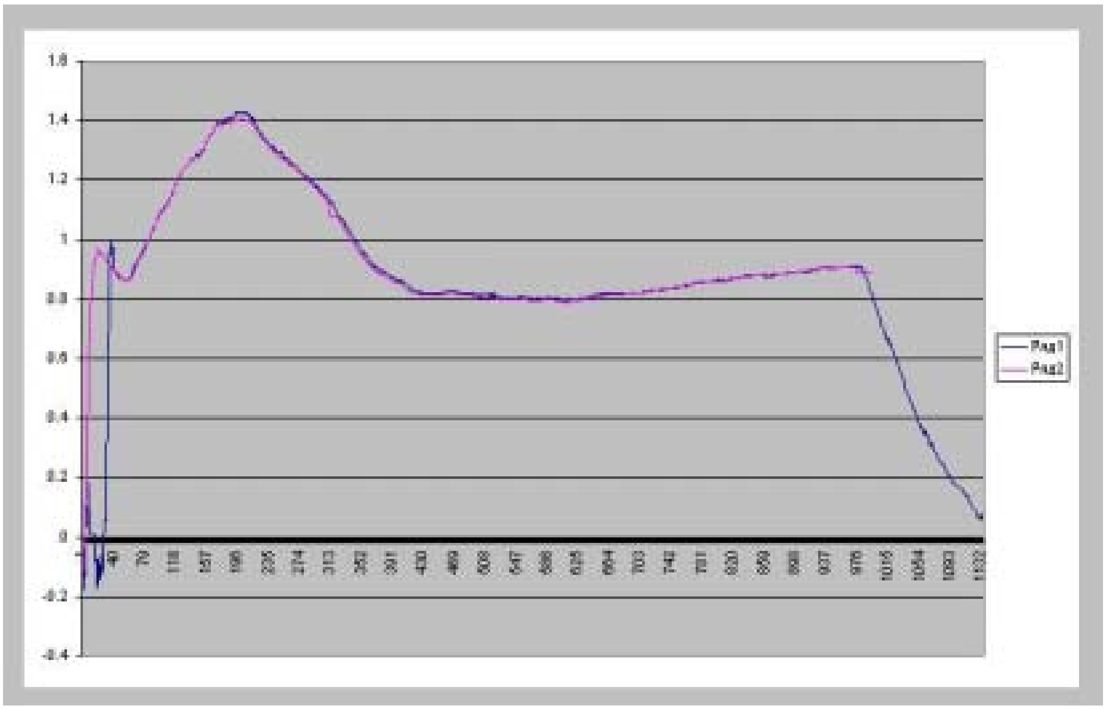

Fig.7 Tracking radiosondes with AVK and MARL

On the whole, 25 paired radiosonde launches were fulfilled. When compared, the telegrams revealed the difference between geopotential heights at standard levels less than 25 m up to a 50 hPa height.

4. Experiments were performed to track a single radiosonde simultaneously with two MARL-A radars that were 42 km apart and AVK-1 (Fig.8).

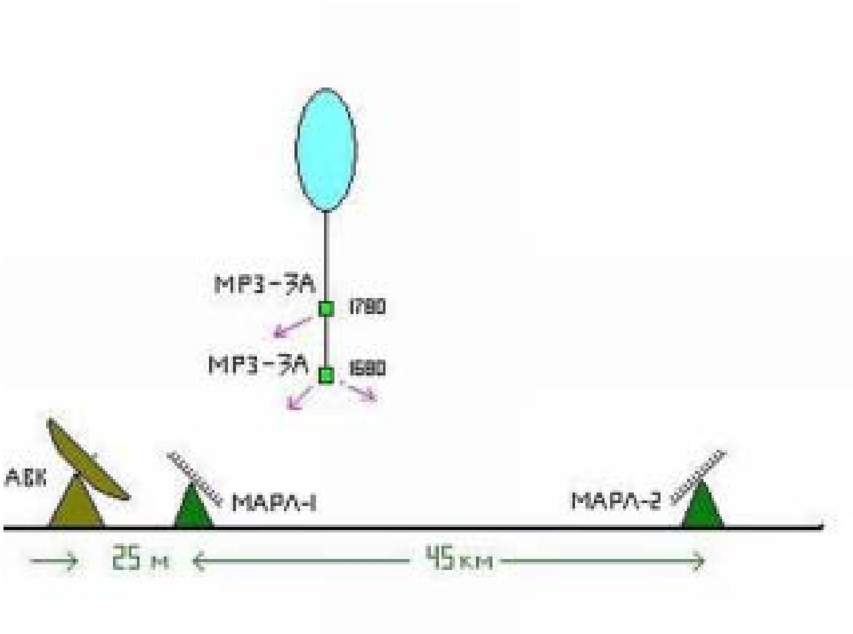

Fig.8 The sceme of experiment

The radiosonde was launched near the first radar. The second radar could start tracking beginning from 1-km height (1-deg. elevation). Figure 9 shows the zone of signal failure at angles of 3-4 deg. due to the influence of the earth surface. Further tracking with the second radar was stable and permitted evaluating errors in height measurements with an AFAR radar at small tracking angles.

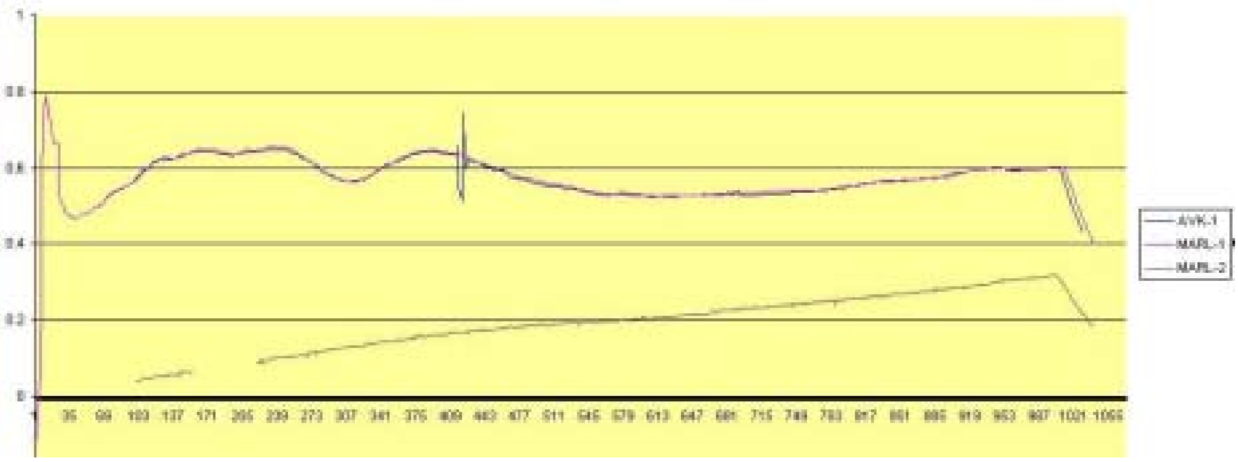

Fig.9 Elevation angle tracking with 3 radars

A thorough experimental study is to be performed to reveal the peculiarities of measuring wind by radar technique for different radiosonde distances. The wind profiles provided by the two radars at height over 5 km were found to agree fairly well.

5. Due to the paired launches of radiosondes with single-type temperature and humidity sensors it became possible to check once again the performance of these sensors, which are still in used for operational sounding on Russia's upper-air network. The dispersion of temperature differences (data reproducibility) was found to be 0.3^0C.

6. The new upper-air radar MARL-A with a phased antenna array, whose introduction on the Russia's network is under way, ensures the required accuracy of radiosonde angular tracking, with the leveling of error in geopotential height being no less correct than for the radar system AVK-1.

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