Upper Air Instrumentation in Russia
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Although amount of Russian upper-air stations has reduced significantly in 1990-s with its 111 stations reporting twice per day to WMO GTS Russia remains the great aerological country.

The national Russian upper-air network currently consist of 128 stations, 113 are operating for now and the other are mothballed. Additionally there are two research stations in Antarctica and one in Arctic. All the stations except Arctic and Antarctica ones perform two observations per day, Arctic and Antarctica stations perform one observation per day. The impact of Russian upper-air network was clearly demonstrated in the Dec-Mar 2015 when due to budgetary constraints Roshydromet reduced amount of soundings to one per day /1/.

Fig 1. Russian upper-air network

Several stations were revived in the second half of 2000-s due to implementation of the National Hydromet Modernization Project. The implementation of this project allowed to increase the quantity of the observations but did not allow improving their quality. Lot of radars were replaced by new ones. 28 Vektor-M and 36 MARL-A aerological radars were installed during the Project. Nonetheless, still many old-generation AVK-1 radars are in operation. Although they have been essentially modernized in 1990-s (unreliable hardwired microcomputers were replaced with PC based data processing systems, solid-state microwave modules displaced non-durable electro vacuum devices) their maintenance becomes more and more difficult.

Despite to the modernization, according to the results upper air data quality monitoring, both national and ECMWF /2/, Russia has one of the last place in the world. This is due to several reasons. The basic operating principle used in the Russian upper-air observation for now is the secondary radar technique. And within the Modernization Project the principle was not changed and still the same. Performance of MARL-A and Vektor-M tracking is similar to one of well-maintained AVK-1. It’s well known that radar heights performance of radar angles degrades at low elevations which are not seldom under strong winds aloft often happen in Russia, especially in winter.
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Fig 2. Upper-air radar MARL-A

The low cost of the radars technology radiosondes allowing using cheap radiosondes without pressure sensors is one of the main reasons for its use at this time. The current cost of the radiosonde in Russia is about 25 US dollars. Usage of the low cost radiosondes does not allow improving quality of the observations, because these radiosondes use analog telemetry for transmitting measurement data and not a
perfect temperature sensor. This sensor uses an outdated temperature measurement technology. Used thermistors has rather big dimensions, large uncertainty and nonnormable radiation errors.

Fig 3. Upper-air station Vektor-M

Fig 4. Russian radiosondes. In the upper row from left to right – AK2-02, I-2012. In the bottom row from left to right are MRZ3-AK1 and RZM-2.

The main problem from using sondes, which are compatible with ground radars in respect to radio signal parameters and telemetry format, is that ground stations' software implements the radiation correction scheme developed for MMT-1 (honestly speaking, with its mounting design used in MRZ). This is a shortage of an open interoperable sounding system, we actually implemented with our radars, Dr. J. Nash once warned about – potential radiosonde and data processing inconsistency. Most of operational radiosondes (MRZ-3AK1 known as BAR, RZM-2, AK2-02, I-2012) use MMT-1 rod
thermistor as MRZ-3A did. But AK2m (denoted with code figures 90 in TEMP messages), a newer version of AK2-02, uses another one. From our monitoring results using AK2m doesn't harm weather forecast. But it may harm climate applications and therefore isn't good isn’t for GUAN.

Fig 5. The temperature sensors of AK2m (top) and AK2-02 (bottom).

Russian radiosondes do not use goldbeaters skin humidity sensors anymore. Instead, most of them use HIH-5031 Honeywell integrated polymer humidity sensors. As well as goldbeaters skin sensors, HIH-5031 is not certified for humidity measurements below -40°C both due to low response time and temperature induced errors.

The only exception is RZM radiosondes (code figures 68 and 69). Till recently they used Sencera capacitance humidity sensor which was of similar or worse performance than HIH5031. Since at least 2015 the manufacturer introduced a new humidity sensor which is certified for temperatures up to -70°C and provides data in UT/LS region looking more adequately that other sensors. We plan to perform some test flights using MODEM radiosondes as independent reference

The radiosondes MRZ aren't produced anymore, manufacturer had gone. New radiosonde types mimic MRZ using digital transducer but transmit analog telemetry. Only recently (2014-2015) two new models appear with digital transmission - MRZ-3K and RZM-C.

Fig 6. Russian digital sondes for MARL-A and Vektor-M stations (on the left - MRZ-3K, on the right - RZM-C)

One of main mechanism of assessing quality of upper air observations is intercomparison of the upper-air systems. But last time Russian upper-air systems took part in WMO sponsored comparison in 1989. Because of that and as they are used locally they are less known to data users community.

The last intercomparison in Yangjiang, China in 2010 was without Russian upper-air systems. This happened because the main operational Chinese system had the similar secondary radar principle used in Russia and had the same operational frequency. So due to the problem with radio interference Russian system could not participate in the comparison.
Russian specialist have positive experience with using GNSS based upper-air system for observations. During the Sochi Winter Olympic Game in 2014 the main instrument for upper air observation was a MODEM upper-air system SR10 with radiosondes M2K2-DC.

One of the main aims of the Roshydromet is increasing the quality of the upper-air observation. It is expected that next 2-3 years part of the upper-air observation will be performed with a new GNSS based system.

Currently there are a few new developments of the upper-air instruments in Russia. This developments are based on GNSS technology and uses both GPS and GLONASS navigation systems to measure the coordinates of the radiosondes.

Fig 7. Russian upper-air system based on GLONASS/GPS technology

References
1. Bruce Ingleby et al., 2016. Global radiosonde network under pressure. ECMWF Newsletter No. 149 (In preparation)