“Cell phone tower mounted meteostation and standard meteostation data four seasons inter comparisons.”

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1. Introduction

It is well known, that the space and time density of meteorological observations is in the direct connection with the quality of long term and especially short term weather forecasts. The implementation of a meteorological station on a cell phone towers, is probably the most cost-effective way for fast expanding of the observational net. RPA “Typhoon” works on the creation of Special Automatic Net of Meteorological Observation (SANMO) on the basis of cellular communication towers since 2008.

Nevertheless some scientists, and decision makers have expressed a lot of doubt (the discussion was initiated by WMO secretariat on CIMO-XV meeting in Helsinki at 2010) regarding quality of the data obtained by such “non standard” stations. The terms “non standard” in this case is not correspond to the sensors – all of them are standard, but it is corresponding to the installation site. The point is that CIMO guide exactly describes all the requirements to the place, surroundings and the heights of installation of each individual sensor. The cell tower meteorological station is not satisfying any of these requirements.

The main purpose of this article is in describing of the current status of the cell tower meteorological stations in Roshydromet, and in presenting of the main results of inter comparisons with the standard meteorological station.

2. Cell tower AWS net description

The essence of such net is that automatic weather stations (AWS), which are placed on standard cell communication tower, measure set of parameters:

- wind speed and direction;
- atmospheric pressure (reduced to sea level);
- air temperature;
- relative air humidity;
- Rainfall intensity and accumulation.

The example of mounting of the sensors is presented on the Fig.1

The results of measurements are transmitted to the regional Center of Hydro meteorology and Monitoring of Environment (CHME) by the use of standard communication channel (cell network) every hour. Then the data are passed to Hydro Meteorology Center of Russian Federation, where they used in NWP system.

We have elaborated a number of requirements, which are applicable for the selection of a cell phone towers appropriate for the meteorological station installation. Among them are:

- Tower must be free from the objects, which can disturb meteorological parameters (forest, high buildings, etc in the vicinity of 300m.);
- tower have to have possibility for access and service all the year round;
- design of tower should allow to install sensors in according to requirements for observational net.

Figure 1 Wind speed and direction sensor, temperature and humidity sensor and precipitation sensor are placed on cellular communication tower

The general view of the meteorological station on the cell phone tower is presented on the Fig.2

Figure 2 Overall view of placement weather station on cellular tower

Six weather stations are placed on cellular communication tower in the Kaluga region and one in the Moscow region at the moment. The Fig. 3 demonstrates the current locations of these stations on the map.

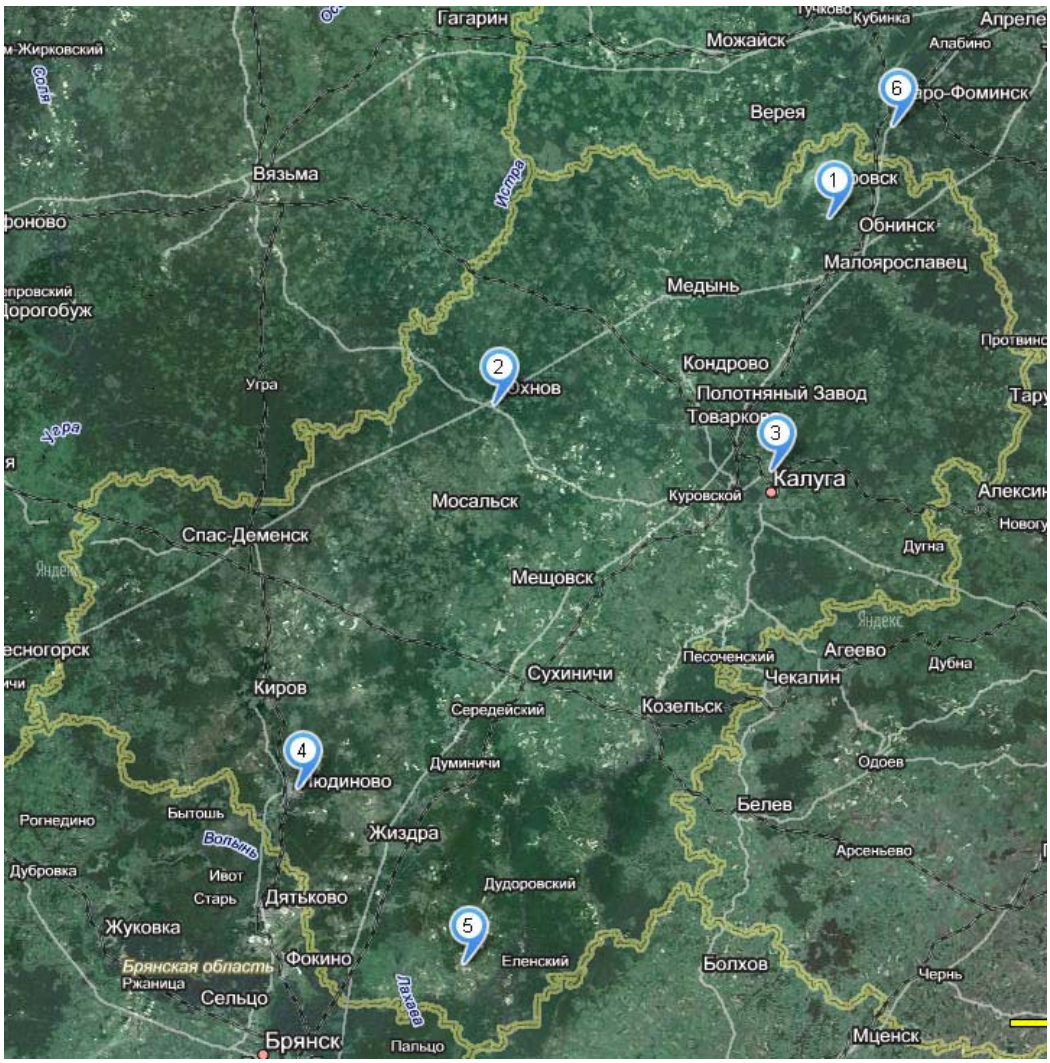

Figure 3 Locations of the cell tower meteorological stations (1-Timashovo, 2-Uhnov, 3-Volkovo, 4-Ludinovo, 5-Hvastovichi, 6-Naro-Fominsk).

3 Inter comparisons of the data

Unfortunately we do not have any tower station in direct neighborhood to the standard meteorological station at the moment. To make comparisons as much proper as possible, we have selected two tower stations, which have the standard meteorological stations within the radius 10km. These stations are: 1.The station in village Volkovo (near Kaluga) which is located 7.2 km northwest from standard observation point in Grabtsevo (see Fig. 4); 2. The station in village Elagino (Moscow region) which is located 5.4 km south from standard observation point in Naro-Fominsk (see Fig. 5).

As it was mentioned above, the on-line information from SANMO is transmitted every hour, but for comparison only, the data was sorted out to create the set of the data received in the standard observation time: 00, 03, 06, 09, 12, 15, 18, 21 GMT. Figures below show the results of comparison for different individual parameters, measured by SANMO, and the same corresponded parameters, measured by standard meteorological station. The data at the time series plots are presented versus number of measurement. As we have used 8 measurements a day, thus the number 8 is corresponding to the first 24 hours, number 16 to the next one and so on.

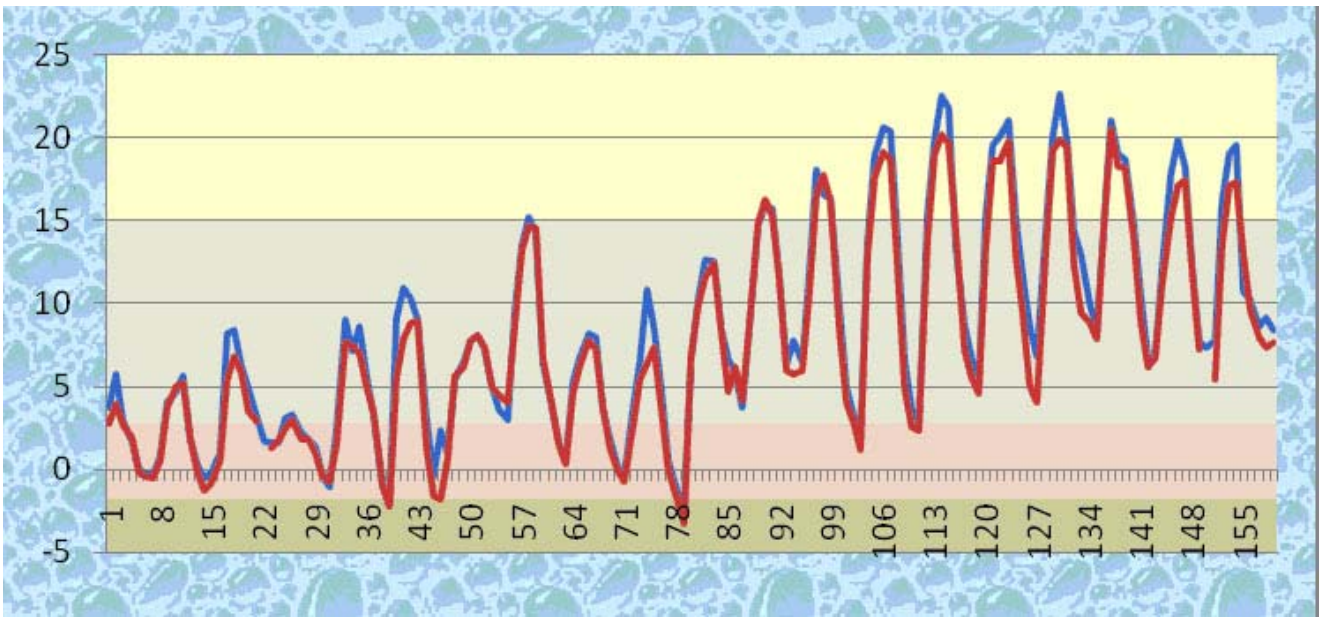

Figure 4 Time series of temperatures (ºC) in Volkovo (blue) and standard station in Grabtsevo (red). March 2011

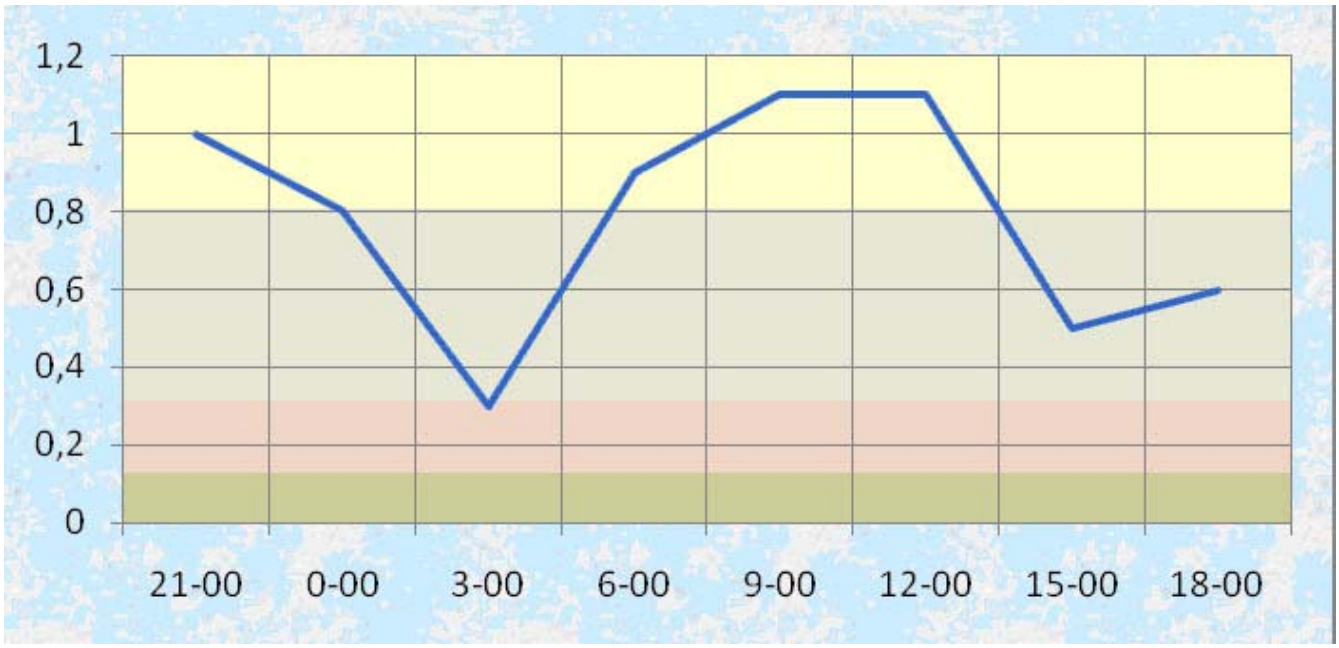

Figure 5 Average differences between temperatures (ºC) in Volkovo and Grabtsevo during the day. March 2011

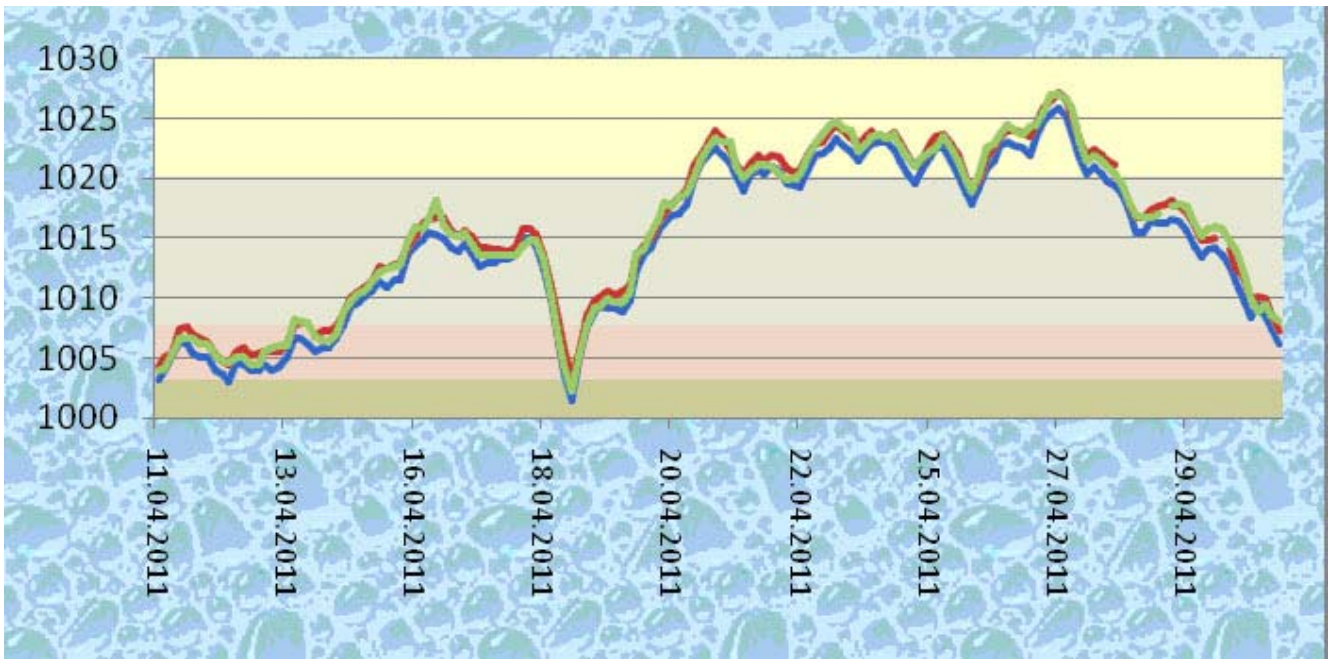

Figure 6 Time series of atmospheric pressure (GPa) reduced to sea level in Volkovo (blue) and standard stations in Grabtsevo (red) and in Maloyaroslavets (green)

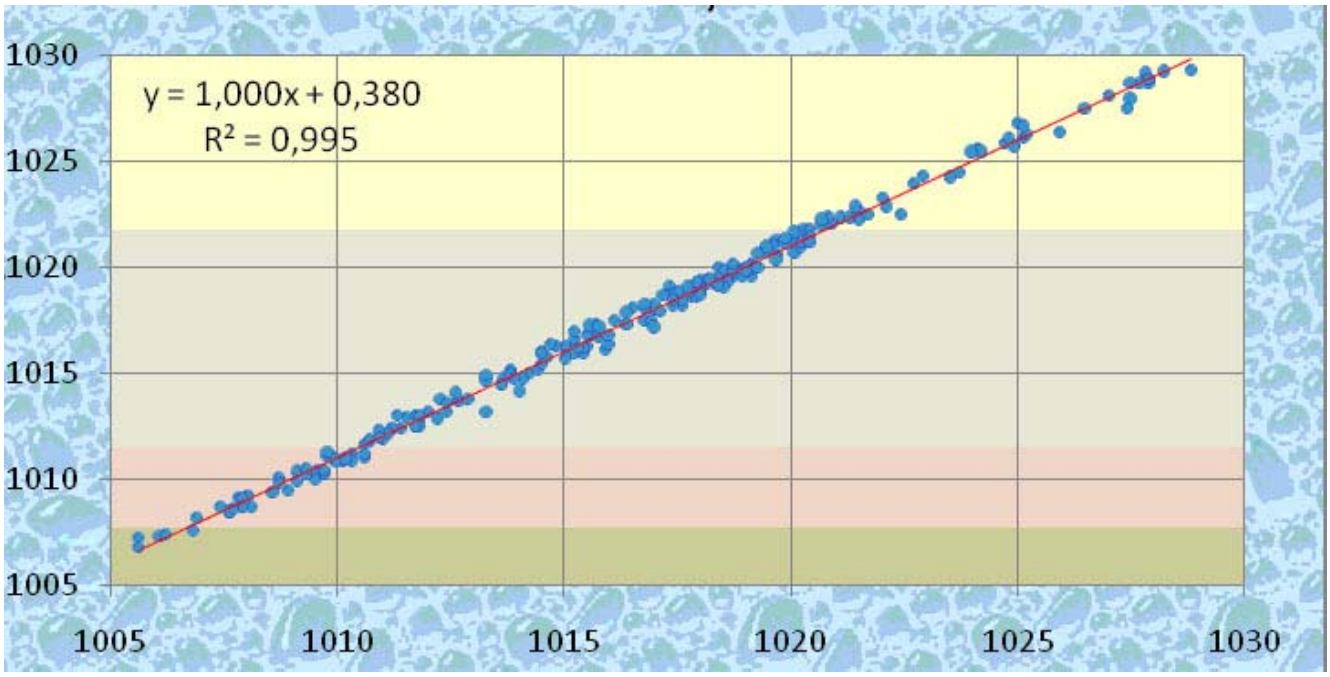

Figure 7. Atmospheric pressure (GPa) data fit between Volkovo (x-coordinate) and Kaluga (y-coordinate). April 2011

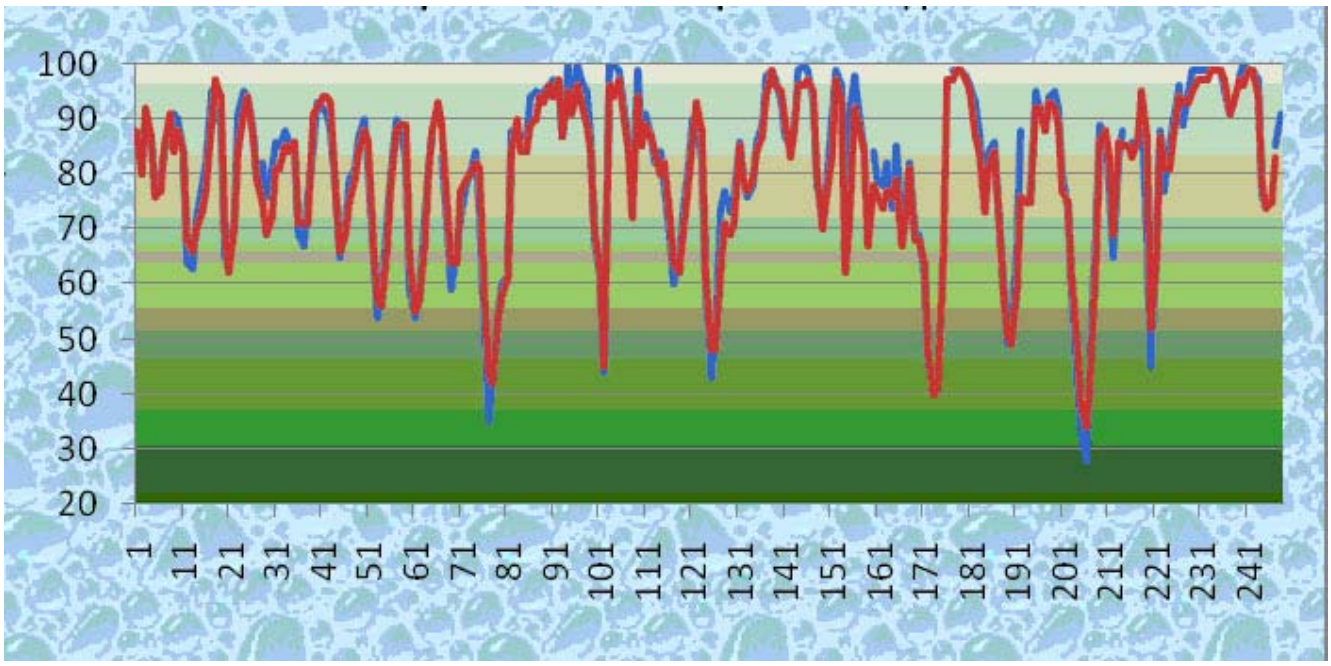

Figure 8 Time series of relative humidity (%) in Elagino (blue) and standard station in Naro-Fominsk (red). March 2012

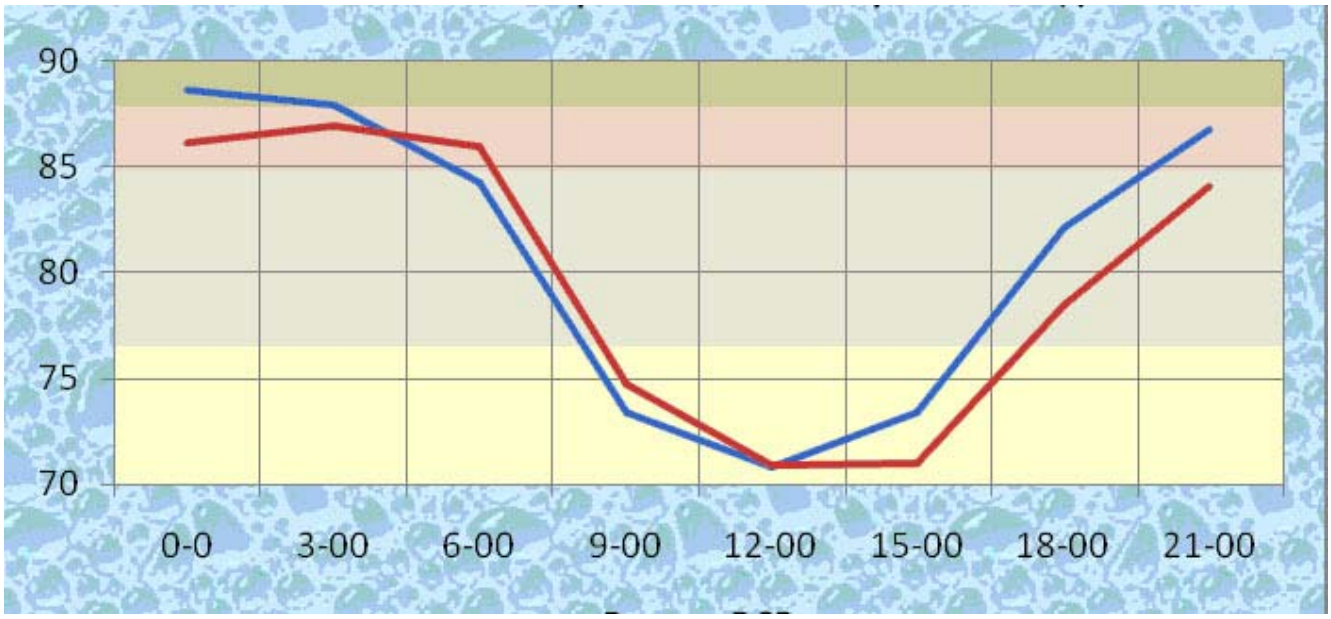

Figure 9 Average value of relative humidity (%) in Elagino (blue) and in Naro-Fominsk (red) during 24 hours. March 2012

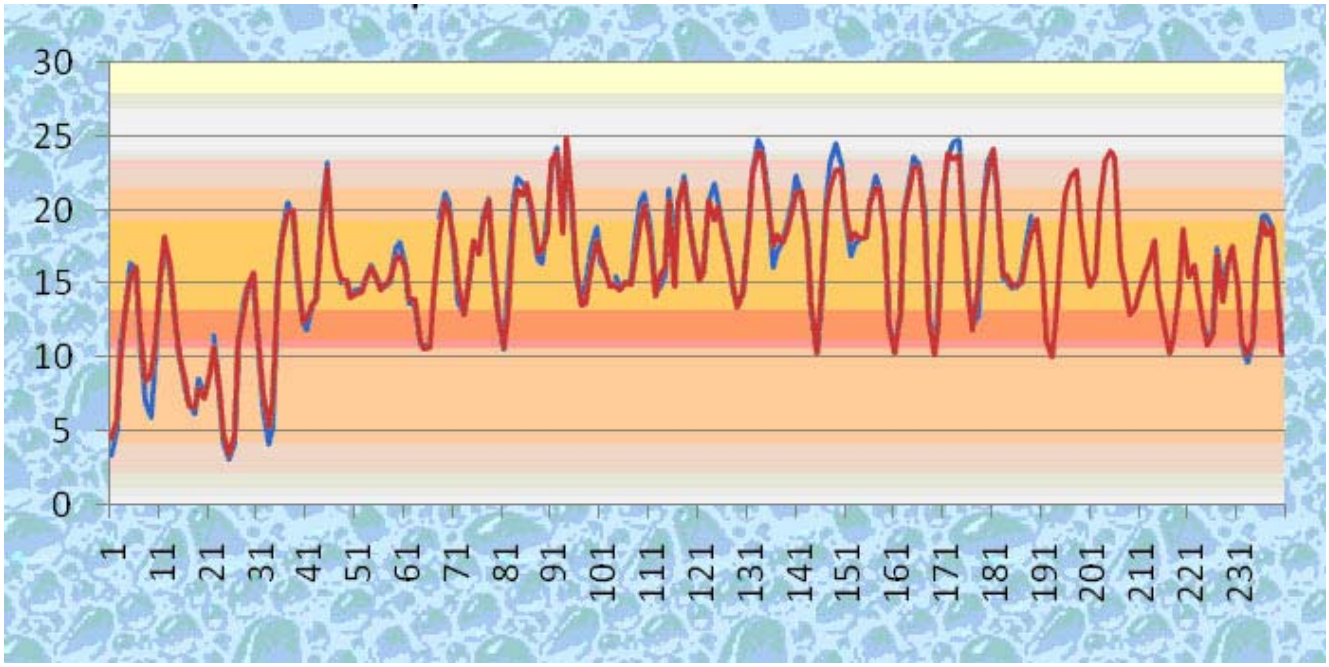

Figure 10 Time series of temperature (ºC) in Elagino (blue) and standard station in Naro-Fominsk (red). June 2012

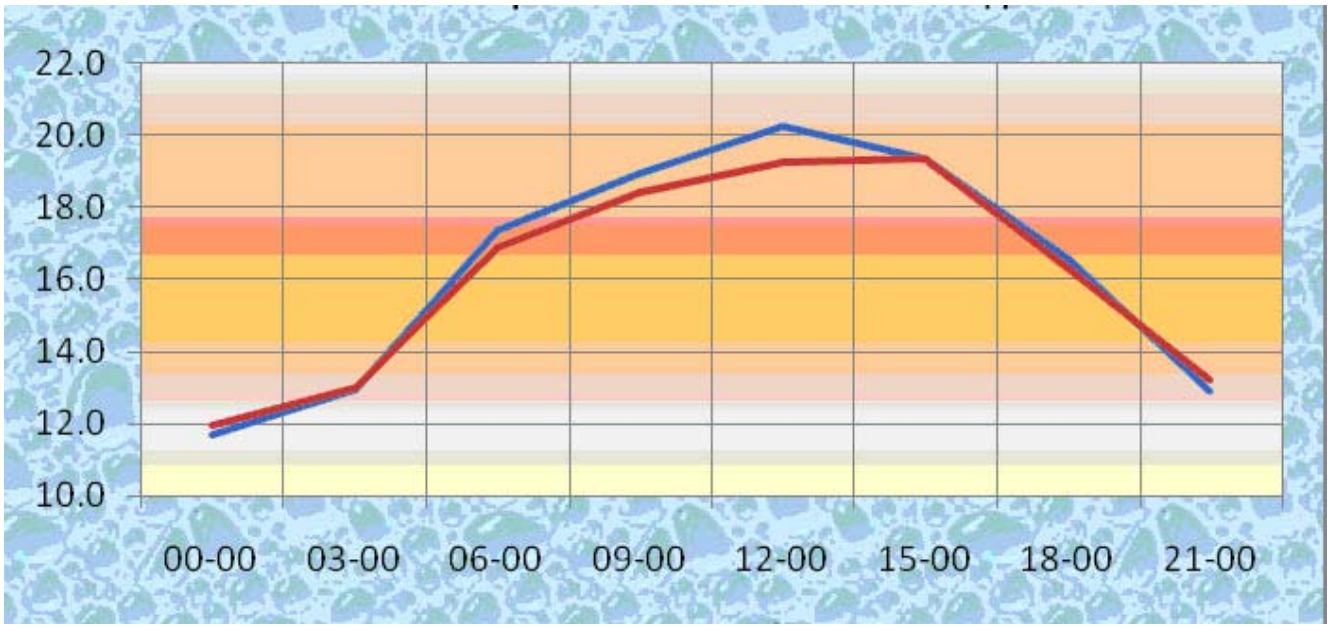

Figure 11 Average value of temperature (ºC) in Elagino (blue) and Naro-Fominsk (red) during 24 hours. June 2012

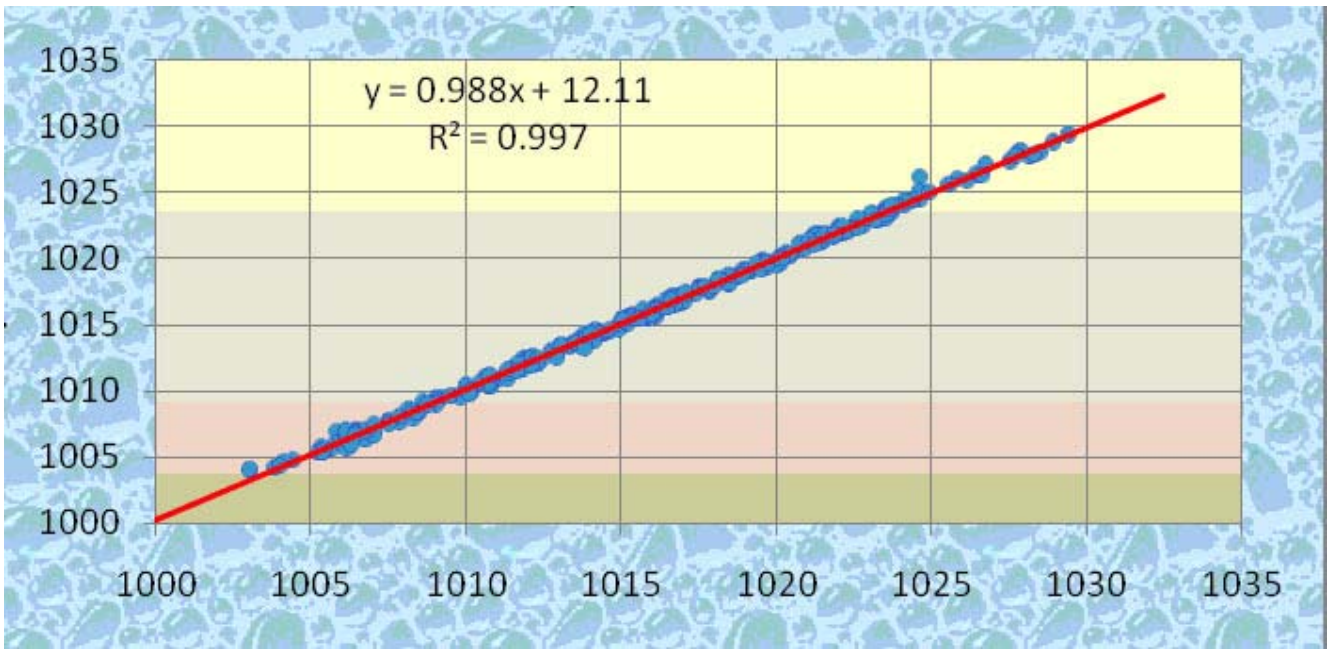

Figure 12 Atmospheric pressure (GPa) data fit between Elagino (x-coordinate) and standard station in Naro-Fominsk (y-coordinate). May 2012

It is easy to see from the above pictures that despite of a few kilometer distance between locations of the cell phone towers and standard meteorological stations, the direct time series comparisons provides us with very promising results. It seems, such a phenomena just indicates that temperature, humidity and pressure are very conservative within the distance of tenth kilometers (at flat environment of course).

But unfortunately it is not applicable at all to the wind speed and direction at 10 m height – even the minor obstacles like trees and heels on the distance between cell phone tower and standard meteorological station will potentially influence on the measured values. Moreover, the wind pulsation, caused by the atmosphere turbulence, will be recorded by cell tower meteorological station and by standard one with the time delay equal to the distance divided by wind speed (if the direction of wind is parallel to the strait line between the places.)

To process the wind data inter comparisons, we have applied correlation function analysis. The first attempt indicates immediately very unsustainable results: day from day the correlation functions for wind direction demonstrated absolutely different behavior. Thus we have sorted out our data depending on the average wind direction, and then we got the clear picture with sustainable results.

It was surprising, that the maximum of wind speed correlation functions was shifted with the time delay, but was independent on the wind direction and always exceeds 0.95 (with norm of correlation function to 1). Fig. 13 demonstrates the example of such correlation function.

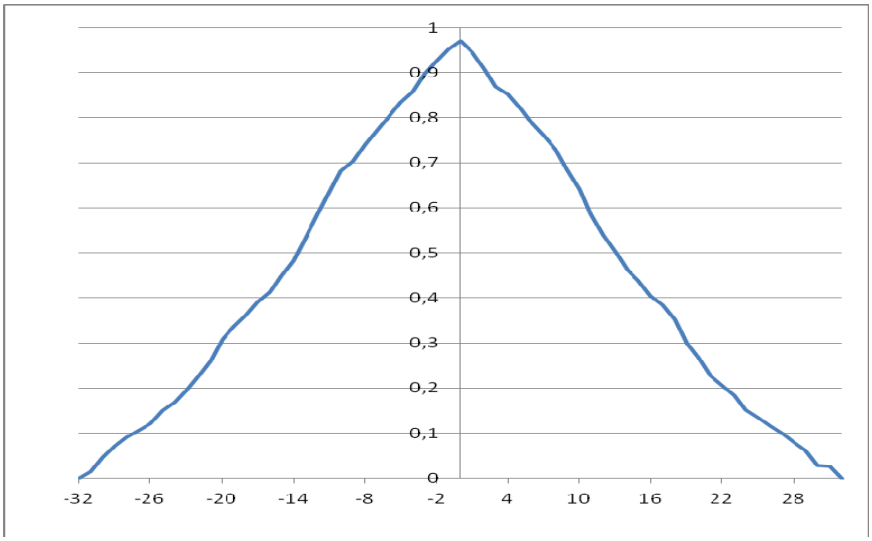

Figure 13 Example of wind speed correlation function

As regarding the wind direction, it was found, that correlation function maximum is less than the same for wind speed almost always, but steel exceeds 0.9. On top of that, when the wind direction corresponds to the direction of aerodynamic shadow for cell tower mounted station, and then the correlation function maximum decreased up to the value 0.7. The example of such situation is presented on the Fig 14.

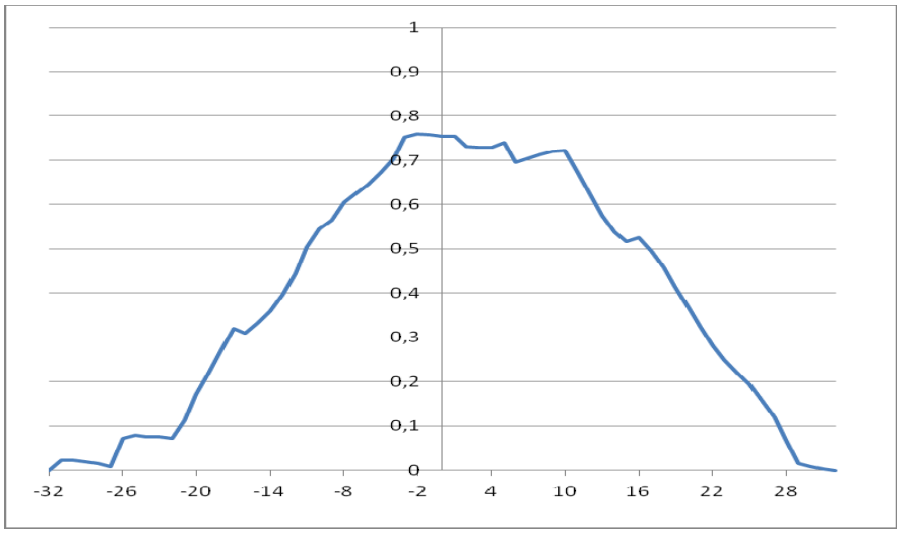

Figure 14 Example of wind direction correlation function

4 Summaries

1. It was shown that, comparisons for temperature, humidity, pressure and wind speed were surprisingly sustainable.
2. Only wind direction data demonstrated visible divergence and just in case when wind direction is corresponding to the aerodynamic shadow of the wind sensor
3. . The results of this work allow to state that the meteorological stations mounted on the cell phone tower are able to provide reliable data for 4 main meteorological parameters, and wind direction should be revised in case of specific situation
4. The specific situation, when the wind direction data are not useful, can be very easy calculated a-priory from the topological information about orientation of the cell tower and position of the wind sensor. Alternative solution is in utilization of two wind direction sensors.