Dear authors!

After reading of your interesting manuscript, I have some important remarks.

1. The accuracy of Pulkovo's catalog

1) At first. For meteorological purposes you must know only the **instrumental** extra-atmospheric stellar magnitudes for stars using for one-star daily monitoring. The Δ-method usually is used for its obtaining on the first step (see point 3). In this case we must know only magnitudes' **difference** for two selected stars (from Pulkovo's catalog in our case).Therefore, only **inside** accuracy and homogeneity of catalog are important. But in your manuscript you analyze sufficiently correctly the **outside** accuracy of different catalogs. It is true, but it is not connected with our meteorological purposes. In description of our catalog we wrote:

"The extra-atmospheric spectral fluxes were transformed to the absolute scale. To covert the extra-atmospheric quasi-monochromatic fluxes in the instrumental system to absolute energy units, the basic catalog of spectrophotometric standards was used. This catalog consist of secondary and tertiary spectrophotometric standards. Vega (α Lyr, HR 7001, HD 172167) has been used as the primary standard. Although some authors have suspected this star to be variable, the latest observations of high accuracy at the Vilnius Observatory do not find any changes of its brightness (J. Sperauskas, personal communication).

Several absolute calibrations of Vega are available (Kharitonov et al. 1968, Oke & Schild 1970, Tug et al. 1977, Hayes 1985). Some years ago, we performed our own absolute calibration of Vega with respect to National Primary Energy Standard of the USSR (Arkharov 1989; see Table 7). However, to preserve the uniform absolute system for all our seasonal catalogs, we always used the same energy distribution for Vega based on the absolute calibrations of Oke & Schild (1970) and Kharitonov et al. (1968). This compilative energy distribution is given in Table 1. The absolute energy distributions for the secondary standards were obtained by a direct tying up these stars to Vega and for the tertiary standards by tying up to some secondary standards."

From this text you can understand that data in Table 1 was used only as the same **constants** for convertation data from all seasonal catalogs to homogeneous photometric system, and its accuracy is not connected with inside accuracy of our catalog.

2) The accuracy for different stars in our catalog depends from number of observations. The list for monitoring must be select very careful. Usually we help to select best stars for any observational point. The best candidates are first, secondary, tertiary, extinctional standards, and non-variable stars with big number of observations (for example star HR 15 is not the best – it is known variable with period P=0.966222 d, 2.02-2.06 V). If the list of stars is selected correct, the accuracy will be sufficiently high.

Due to mentioned above I can not agree with your conclusion that:

“The bright star catalog of extraterrestrial references is noted as a major source of errors with an attendant recommendation that its accuracy, as well as its spectral photometric variability, be significantly improved”.

2. Bouguer method

(according to http://www.astronet.ru/db/msg/1169494/node45.html#BougerErr), (in Russian)

If one and the same star is observed in monochromatic light with a wavelength λ at two times t_1 and t_2, accordingly, at air masses $M(z_1)$ and $M(z_2)$, then the difference in the observed magnitudes, referred to the difference of the corresponding air masses, will give us the Bouguer coefficient of atmospheric extinction

$$\alpha(\lambda) = \frac{m(\lambda, t_1) - m(\lambda, t_2)}{M(z_1) - M(z_2)} \quad \textbf{(1)}$$

To obtain this coefficient, it is not necessary to know anything about the extra-atmospheric magnitude of the star, but if this magnitude is known (that is, the star is the standard), then

$$m(\lambda) - m_\circ(\lambda) = \alpha(\lambda) M(z). \quad \textbf{(2)}$$

Here is the equation of a straight line. This is the so-called *Bouguer line* . When a star with its motion passes various air masses on the celestial sphere, then the dependence of the attenuation Δm in the atmosphere (in stellar magnitudes) from $M(z)$ is a straight line with a slope $\alpha(\lambda)$. Extrapolating this straight line to the value, $M(z) = 1$ we obtain the magnitude of the star at the zenith, and, continuing the straight line even further to the value $M(z) = 0$, we obtain its extra-atmospheric magnitude.

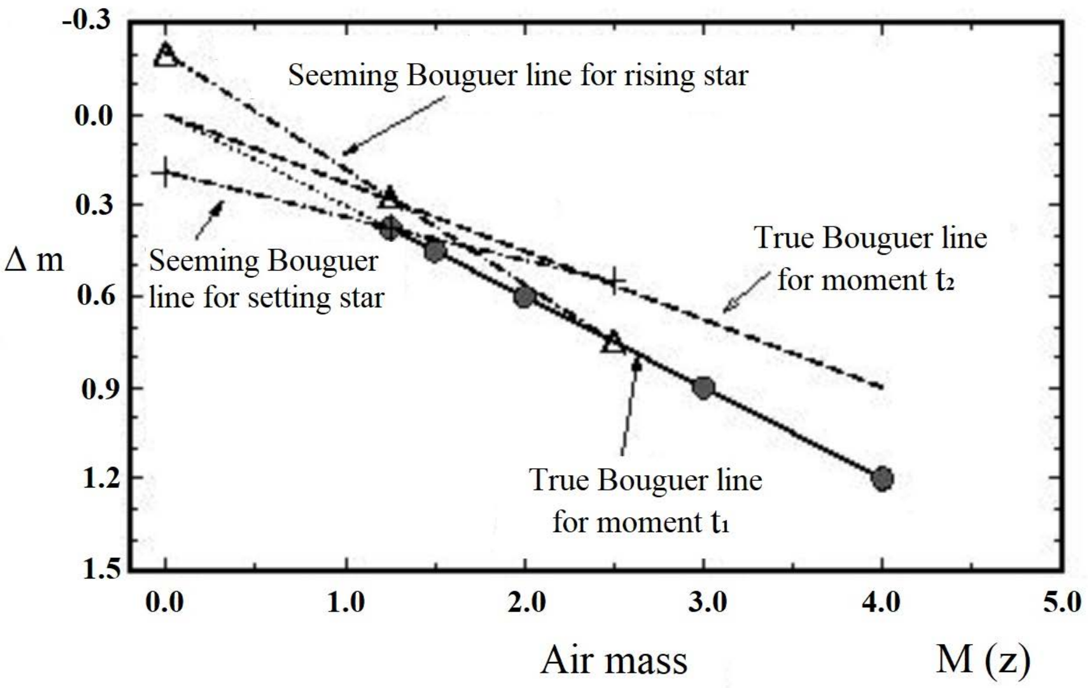

Fig. 1. Diagram of the Bouguer method and its errors when changing transparency

If atmospheric extinction were always constant in time, then the method would be perfectly ideal. But when the atmospheric absorption changes, the method can lead to gross errors. Let us assume for definiteness that during the observation session the extinction decreases. This is a fairly common phenomenon. From evening to late night, the temperature usually drops, droplets of water hanging in the atmosphere freeze and settle, daytime dust raised by human activity settles, etc. As the extinction coefficient decreases, the slope of the Bouguer lines decreases. Since the extra-atmospheric magnitude of the star does not depend on phenomena in the atmosphere, all these lines should converge at one point with coordinates [M(z) =0; Δm =0]. Since at the second, third and subsequent moments of time the slope of the Bouguer lines is different, the points can practically be on a strong straight line, but on another, and its extrapolation to M(z) =0 will give an incorrect extra-atmospheric value.

The main disadvantage of the classical Bouguer method is that it does not work with varying extinction. Extinction changes are typical. At lowland observatories (in Pulkovo, or at the Lindenberg observatory) nights with stable transparency are rare. They do not always appear at high-altitude observatories too. For example, at the high-altitude Tien Shan observatory, it happens that a star that has already passed through the meridian continues to become brighter. Under these conditions, the best thing that can be done by the Bouguer method is to check whether there was a change in extinction or not. To do this, a star is observed, by which the extinction is determined, first to the meridian (here the star rises, the air mass decreases, the points creep up the Bouguer line), and then after (here the star sets, the air mass increases). If the extinction has not changed, the points will go back along the same straight line. Unfortunately, this is rarely the case. On opposite sides of the meridian, the points fall on straight lines with different slopes, which characterizes the change in extinction. Of these two slopes, the average is sometimes taken or the hypothesis is accepted that the change in the extinction coefficient occurs linearly with time, or according to some other law. But, as a rule, the extinction changes quite arbitrarily, and these tricks still do not lead to an increase in accuracy.

3. Δ - method (Pulkovo’s version) and its using for meteorology.

Let's try to get rid of the influence of the varying extinction. Obviously, one star will not be enough. Firstly, the star will rise for a very long time, then it will go down for a long time. Naturally, the idea arises to observe practically at the same time instant (quickly one after the other) two stars at different zenith distances. This method is also called the Δ-method, the high and low star method, etc.

Let there are two stars A and B, when the values of extra-atmospheric magnitudes for its are known (from Pulkovo’s catalog in our case). So, one can have from one pair-dimension of stars A and B:

$$\alpha(\lambda) = \frac{[m_A(\lambda) - m_B(\lambda)] - [m_A^\circ(\lambda) - m_B^\circ(\lambda)]}{M(z_A) - M(z_B)}. \qquad \textbf{(3)}$$

It is advantageous to measure one standard near the zenith, and the second (usually in several minutes) rather low above the horizon. You should not choose the second star too low, as other distortions of the luminous flux will interfere there. It is convenient to choose a low star at an air mass no more 4. Observations of two stars are carried out quasi-simultaneously, and thus, using the pair method, we can determine the *instantaneous* value (for $t_{AB} = (t_A+t_B)/2$ i.e. $\alpha_\lambda(t_{AB})$) of the atmospheric extinction coefficient. I. e., we suppose that atmospheric extinction is the same for all direction during one pair-dimension only. **This method must not be used for daily atmospheric monitoring.** We use this method only for definition of the first approximation of values $\boldsymbol{\alpha_\lambda(t_{AB})}$ during nights selected for obtaining **instrumental** extra-atmospheric magnitudes $\mathbf{m_0}$ (needed for one-star monitoring). On the first step we obtain the polynomial dependence $\boldsymbol{\alpha_\lambda(t_{AB})}$ for all night. By analysis of this dependence we can select the nights with slow extinctional changings. Then we calculate for all observations during selected night (by using this polynomial dependence) the individual values $\boldsymbol{\alpha_\lambda(t_A)}$, $\boldsymbol{\alpha_\lambda(t_B)}$,and so on.

It is important to note, that in this case we use catalog data for calculation the value of magnitudes' differences ONLY. For monochromatic (ore quasi-monochromatic in our case) light these differences will be the same for all photometric systems. So, we can use the modification of formula (2) to calculations of $\mathbf{m_0}$ for every star used:

$$m_0(\lambda)=m(\lambda)-\alpha(\lambda)M(z) \quad \textbf{(4)}$$

Using (4) and individual values $\boldsymbol{\alpha_\lambda(t_A)}$, $\boldsymbol{\alpha_\lambda(t_B)}$,and so on, we can calculate individual values $\mathbf{m_0}$ for all observations of every star during night. Then we calculate mean values $\overline{m_0}$ for every star as first approximation for **instrumental** extra-atmospheric magnitude.

And as the last step of first approximation we calculate new individual values $\boldsymbol{\alpha_\lambda(t_i)}$ using $\overline{m_0}$ as $\mathbf{m_0}$ and formula:

$$\alpha(\lambda)=\frac{m(\lambda)-m_0(\lambda)}{M(z)} \quad \textbf{(5)}$$

These results we can use as first step for second approximation (iteration).

For most nights the three iterations are sufficient for obtaining good mean values $\overline{m_0}$ for all stars used.

4. Two small corrections.

1) Line 12 “i.e. at airmasses lower than 5” is not corrected. Must be “i.e. at airmasses less than 5”

2) Line 156 “(V < 3)”. More correct will be “(V <6)”.

I very hope that my remarks will be useful for you, and will take its into account during correction of final text of your manuscript.

With best regards,

Victor Novikov.

Pulkovo observatory.

novikov_victor@mail.ru