THE USE OF MULTI- OR SINGLE WAVE METHODS TO ELIMINATE TERRESTRIAL REFRACTION FROM GEODETIC MEASUREMENTS

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ABSTRACT

Refraction is a very important aspect of geodesy and astronomy: it is one of the main sources for troubles, papers and dissertations, at least in geodesy. Particular important is the vertical refraction because of the up- and down-asymmetry in the atmosphere. However, we must not forget that gravity does not only cause the asymmetry of the atmosphere, also the asymmetry of the mechanical parts of the instrument (bending of the tube, deformation and excentricity of the axis, etc.) and even an asymmetry of the mind of the observer. See figure 1. If it becomes possible to measure the refraction these effects will often become limiting factors for the accuracy.

However, at the moment the refraction is still (?) a problem and there are a number of ways to attack the difficulties. Four years ago Prilipin gave a survey of the different methods. He distinguished direct methods and indirect methods.

The indirect methods consist of intelligent averaging over different weather conditions and avoiding bad conditions. These are the methods currently in use; they might be improved by studying direct methods.

The direct methods, where measurements are used to determine the refraction, may be divided into four types (see figure 2):
A. Simultaneous meteorological measurements
B. Symmetrical measurements
C. Other single wavelength methods
D. Multiwavelength methods

A. Simultaneous meteorological measurements

The refraction may be calculated from measurements of temperature, temperature difference, humidity, humidity difference, radiation, wind observations, etc. For practical reasons such measurements can only be performed on a very small number of sites. Because interpolation and

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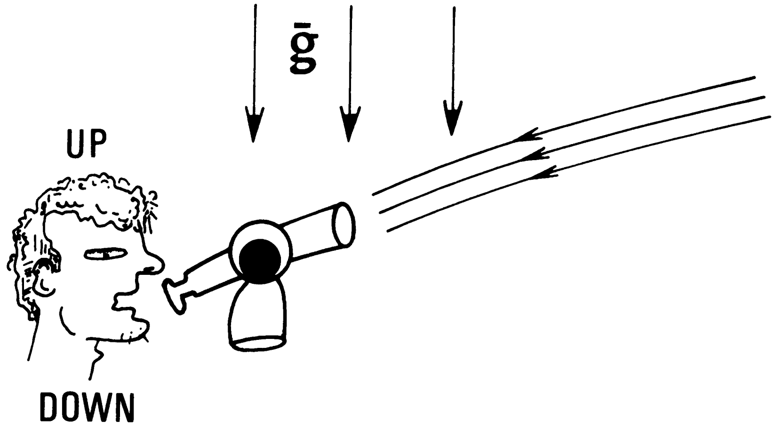

Figure 1. The influence of the gravity on the atmosphere, on the instrument and on the observer.

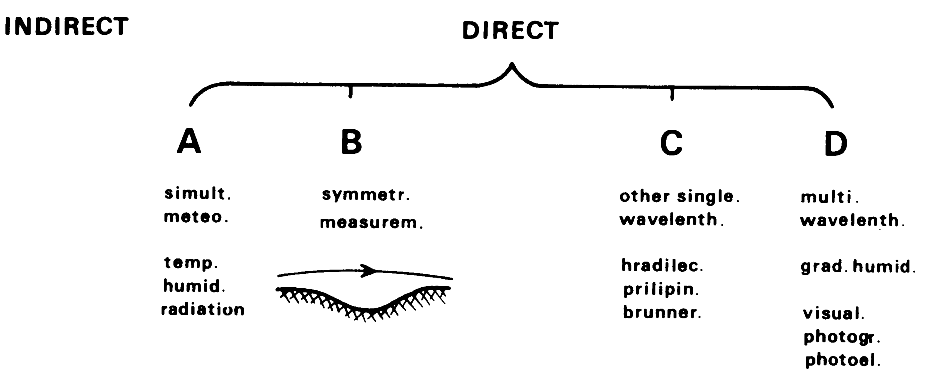

Figure 2. Methods to eliminate the terrestrial refraction.

extrapolation are necessary, studies of atmospheric models are urgently needed. Also the type of the terrain should be considered.

B. Symmetrical measurements

Angle measurements from both endpoints, measurements of angles from the midpoint towards both endpoints and other symmetrical measurements belong to this type that eliminates the symmetrical part of the refraction, i.e. the refraction of the symmetrical component of the curvature profile or of the "gradient n" profile.

Such symmetrical measurements will give good results for horizontal paths over a horizontal homogeneous terrain or for horizontal paths over a symmetrical valley. For sloping times and for asymmetrical profiles, however, a systematic effect of refraction will not be eliminated.

C. Other single-wavelength methods

Besides the above mentioned methods and the use of dispersion a number of procedures have been proposed or are in use:

1. The adjustment of the refraction coefficient for each site, including distance measurements over steep slopes. This method, used by Hradilec, will only work for great height differences.
2. Another method was proposed by Prilipin in Bulletin Géodésique. A special interferometer is used with two mirrors being moved along two bars making different angles with the wanted direction. If no feed-back is used the distance is limited to less than one kilometer by consequence of air turbulence.
3. This week the ideas of Brunner have been announced. He tries to find the refraction angle from the variations in the refraction. A thorough study of the instabilities of the atmosphere and a lot of experiments are still necessary to find the circumstances under which this method will work.

D. Multi-wavelength methods

When two wavelengths are used it is possible to eliminate the refraction angle more or less for an atmosphere of constant composition. The only relevant variation in the composition of the air is the variation of the humidity. It may be expected that the humidity gradient limits the accuracy of a vertical angle generally 0.02 seconds of arc per km.

It is not possible to eliminate the humidity effect in the refraction angle by using three wavelenghts because the required accuracy for the measurements and also for the dispersion functions for dry air and for water vapour is much too high if optical- and near optical wavelengths are used and with radio-waves precise angle measurements are impossible for terrestrial use.

In order to reach higher accuracies with multi-wavelength methods or to avoid risks of greater errors in unfavourable circumstances, better atmospheric models should be found: in particular relations between humidity variations and other atmospheric parameters like variations of temperature. An example of such a relation is given by the invariability of the relative humidity under certain conditions.

(During the symposium I learned that other important items to be studied are the fluctuations in the air and the distance between the paths for the two wavelengths.)

As to the instrumental realization three methods are used: visual, photographic and photoelectric. The visual methods are very restricted in the separation of both wavelengths.
The photographic method has the advantage that the averaging of the signals over long time intervals is very easy.
The photoelectric method is maybe the most complicated one, but the signal processing is possible in an almost optimum way.

DISCUSSION

E. Tengström: Thank you, Dr de Munck. This review was a very interesting complement to that one given by Prilepin in Stockholm 1974. It contained also new details and fresh points of view concerning these important problems.