ERRORS IN UPPER-LEVEL WIND COMPUTATIONS

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ABSTRACT

The evaluation of upper-level wind data by means of balloon-tracking methods involves a number of determinative and random errors. These errors depend on the precision in locating the points of the balloon track, which in their turn are related to the accuracy of measuring quantities such as azimuth, elevation angle, slant range, balloon height, and time.

Since the number of quantities needed for plotting the horizontal projection of the balloon's track by radar systems is supernumerary, the observations may be arranged in three classes. The purpose of this paper is to determine which of these classes yields the best precision of measure in wind speed and direction.

Moreover the errors are considered as a function of balloon height, wind speed, rate of ascent and time interval between two successive measured points. For special cases the extreme values of the random errors dependent on the location of the balloon's trajectory with regard to the direction of observation is presented in the form of tables.

1. Introduction

Before drawing any conclusions about special features of the upper-wind structure such as windshear, wind maximum and variability of wind the limitations of the evaluation of the wind data which are inherent in the observational techniques should be taken into account. Defects in the overall performance of the instrumental system produce determinative and random errors which at times can result in computed wind speeds being as much as 20 kn too high or too low.

The errors are caused by the operating limitations in measuring the quantities which together are used in upper-wind computation. These independent measured quantities are slant range (r), elevation angle (ϵ), azimuth (α) balloon height (h) and time interval (τ). Apart from azimuth and time interval, only two of the three remaining quantities need be used in wind evaluation. Therefore the wind observations can be arranged in three classes, notably those of height-elevation (h, ϵ), range-elevation (r, ϵ) and range-height (r, h) observations. Actually, the three classes of observation may be applied using radar techniques. Observations with a radio-direction finding system or theodolite belong to the class of (h, ϵ) observations.

The problem arises as to which class of observation yields the most accurate result. In order to answer this question the random errors are computed for each method of observation separately and the results thereof compared with each other. As outcome the working area is divided into three parts in which one of the methods is the most suitable one.

Further the magnitude of the errors is examined and the extreme values are determined in reference to the direction of the balloon's track relative to the direction of observation. Moreover the influence on the random errors may be studied which is effected by a change of ascent rate s and time interval τ.

2. Computation of the upper-wind data

The conventional method of upper-wind evaluation involves projection of the sounding- or pilot-balloon's trajectory on a horizontal plane through the point of observation. Azimuth and elevation angle or slant range are measured and recorded at the end of each time interval (usually one minute). The actual heights of the balloon above ground level are obtained from the radiosonde pressure altitude data or from the ascent rate of the pilot balloon. The projections of the balloon's positions are plotted on a polar diagram and the wind speed and direction determined graphically.

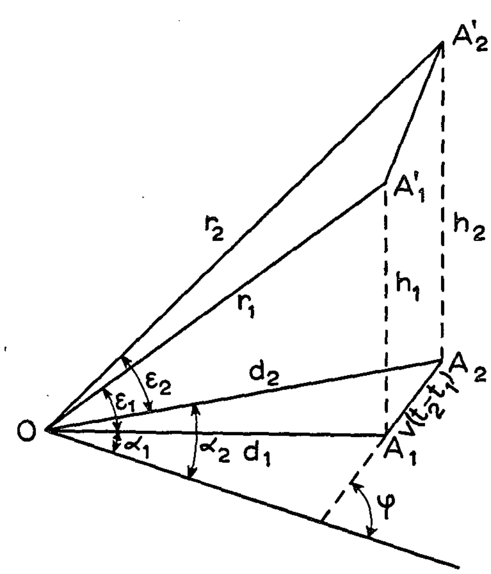

FIG. 1. Balloon's trajectory and its projection on the horizontal plane through the point of observation.