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Improving the accuracy of the radar rainfall estimates using gage adjustment techniques: Case study for west Anatolia, Turkey

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Abstract

In this work, Balikesir (a city in west Anatolia, Turkey), meteorological weather radar rainfall measurements are statistically analyzed and adjusted by using a network of automatic raingage (AWOS). To improve the accuracy of rainfall measurements of the Balikesir weather radar, a statistical analysis is performed by considering 16 operational raingages among 20 within the circular area with a radius of 120 km, the center being at the radar site. Firstly, the assessment factor (AF), which is the ratio of the overall total rainfall amount (*R*) calculated by radar to the overall total rainfall amount (*G*) measured at the raingage in a selected time period, is obtained for the coordinates of each raingage on the radar image. The regression coefficients are determined from AF regression equation by means of a weighted multiple regression technique using spatial variables which are taken to be the distance between radar and raingage (*D*), the topographical height of raingage (HG) and the minimum height above the raingage that the target is visible from the radar (HV_{min}). To improve the radar rainfall in all 720 × 720 pixel in a radar image, approximate HV_{min} values are determined for some areas on a radar image after their exact values have been found for the raingage points. Finally, a new radar product called SCR (Statistically Corrected Rain), which can be run operationally on radar software, is developed by the authors. Within the 48-h period of rainfall, the observed total amount at the raingage is obtained as 803.80 mm (50.24 mm average), while radar estimated 314.00 mm (19.63 mm average), indicating an absolute mean error of 30.61 mm. With the analysis used in this paper, the absolute mean error is reduced to 16.46 mm and RMSE is reduced from 36.04 to 18.78 mm. The overall assessment of the whole analysis in comparison with the existing literature, possible drawbacks and their causes are given in the conclusion part.

Keywords: Meteorological radar; Raingage; Rainfall; Measurement errors

1. Introduction

Meteorological weather radars provide information about the direction, the location and the speed of meteorological targets and are essential for nowcasting and forecasting of the severe weather events. In recent years the significance of highly resolved rainfall information in space and time for hydrological applications increased steadily. Weather radar systems provide this information but the derivation of quantitatively reliable radar rainfall estimates is still known to be problematic (Krämer et al., 2005). Radar rainfall may suffer from different error sources such as clutter, electronic calibration problems, attenuation, antenna main lobe and side lobes, beam geometry and broadening, orography and beam shielding,

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anomalous propagation and vertical reflectivity profile, etc. The underestimation of rainfall using radar often occurs in the presence of high orography. This is due to the increasing illuminated volume with range as well as the effect of a decreasing vertical profile of radar reflectivity with height, combined with beam shielding and/or occultation by orography. These effects are in turn complicated by an increased non-homogeneous beam filling effect (Gabella et al., 2005).

In this study, a regression equation is generated having three time-independent variables which can affect the bias between radar and ground rainfall measurements. These variables are chosen to be the distance between radar and raingage (D), the topographical height of raingage (HG) and the minimum height above the raingage that the target is visible from the radar (HV_{min}). The variable D is related to the beam broadening, HG is related to orography and HV_{min} is a bias source caused by beam shielding. Sixteen raingages, which are operational among twenty raingages in the circular area, the radius of which is 120 km with the radar location as being the center, are used in this study.

The radar beam height increases when the horizontal radar range increases. At longer distances, the radar may not detect echoes that are below the bottom of the antenna beam pattern. Besides, the radar beam may hit a "bright band" region and detect higher reflectivity than what exists at ground level. If low elevation angles are used, the beam may hit the ground and detect clutter echo. Some techniques such as Doppler filtering or FFT (Fast Fourier Transform) are already used by the radar's built-in softwares in order to eliminate some of the clutter.

2. Gage adjustment by weighted multiple regression method

This method is used to improve the accuracy of radar rainfall measurements due to the error sources mentioned in the Introduction. It is an optimization process using the radar rainfall calculated by means of the Z–R relationship and Automatic Raingage (AWOS) rainfall observations in the coverage area of the radar.

In this study, the rainfall occurrences between 24 and 25 November 2005 at Balikesir and its vicinities are selected. It is seen that almost a factor of 2.5 difference between 48-h total radar rainfall and 48-h total AWOS rainfall measurements (see Table 2).

For each AWOS point, the assessment factor (AF), which is the ratio of total radar rainfall (R) to the total gage rainfall (G) occurred in a selected time frame, is defined as in Eq. (1) where index j represents the raingage number, which runs from one to sixteen in our case. To obtain the radar rainfall amount, each pixel referring to an AWOS site in a radar image and eight neighbouring pixels to an AWOS pixel are averaged by means of an IDL programming language code. The pixels with zero values are excluded while applying the

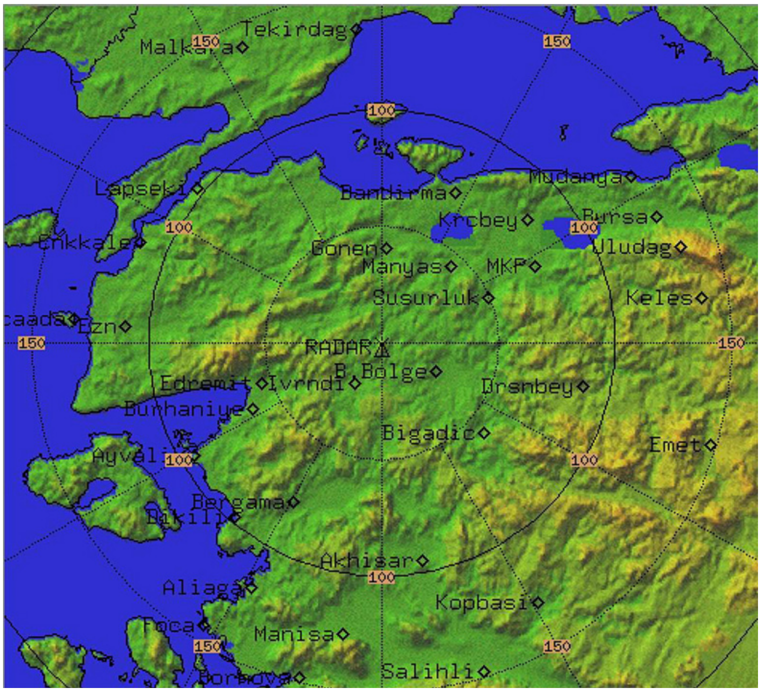

Fig. 1. AWOS locations around the Balikesir radar.