Cloud elements detection on the panoramic images of the sky

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ABSTRACT

The paper gives a short overview of methods of cloud detection and sky cloud cover level determination based on panoramic sky images obtained with the wide angle lenses of type «Fisheye».

Keywords: panoramic images, cloudiness, cloud amount, color model, standard deviation.

The presence and condition of cloudiness significantly affects the visibility, reliability of optical communication, location and transmission of electromagnetic energy on the slopes within the atmosphere and Earth-Space. Therefore, we understand the importance of observing the state of the cloud and its treatment in order to assess of both meteorological characteristics and the direction and the rate of transfer.

In practice of observing the whole sky (Allsky system), single-chamber device with ultra-wide panoramic lens of the "fish-eye" are widely used [1, 2]. Currently in the world there is a developed network of wide survey Allsky stations to monitor clouds and stars. These stations are mainly used to monitor and any analysis is not implied of the current situation and predictions.

In the analysis of Allsky images the main problem is an adequate partitioning of the original images into two classes – clouds/background. The most obvious method for the detection of cloudiness on the image may be the use of the standard algorithm for motion detection based on the comparison of background image that does not contain clouds and images with clouds. Naturally, the main problem will be obtaining a "clean" image. One of the options of the solution lies in the numerical modeling of the formation of the light field of the atmosphere due to the scattering of solar radiation in the cloudless atmosphere considering both geophysical factors as applied to the Allsky observations [3], and the aerosol composition of the atmosphere. Naturally, when using this approach, the result of detection of the cloud will depend on the quality of the simulation of the background image.

The most common solution of the division of the image into zones sky/clouds is the use of algorithms based on the color composition of the image pixels, in which the additive color model RGB is generally used. The main idea of the method is based on the information that for the clear sky will be the predominant blue color, respectively, using the threshold limit for the ratio of the intensities ratio in the color channels we can accurately divide the image into two conventional classes – the sky/clouds (Fig. 1, b).

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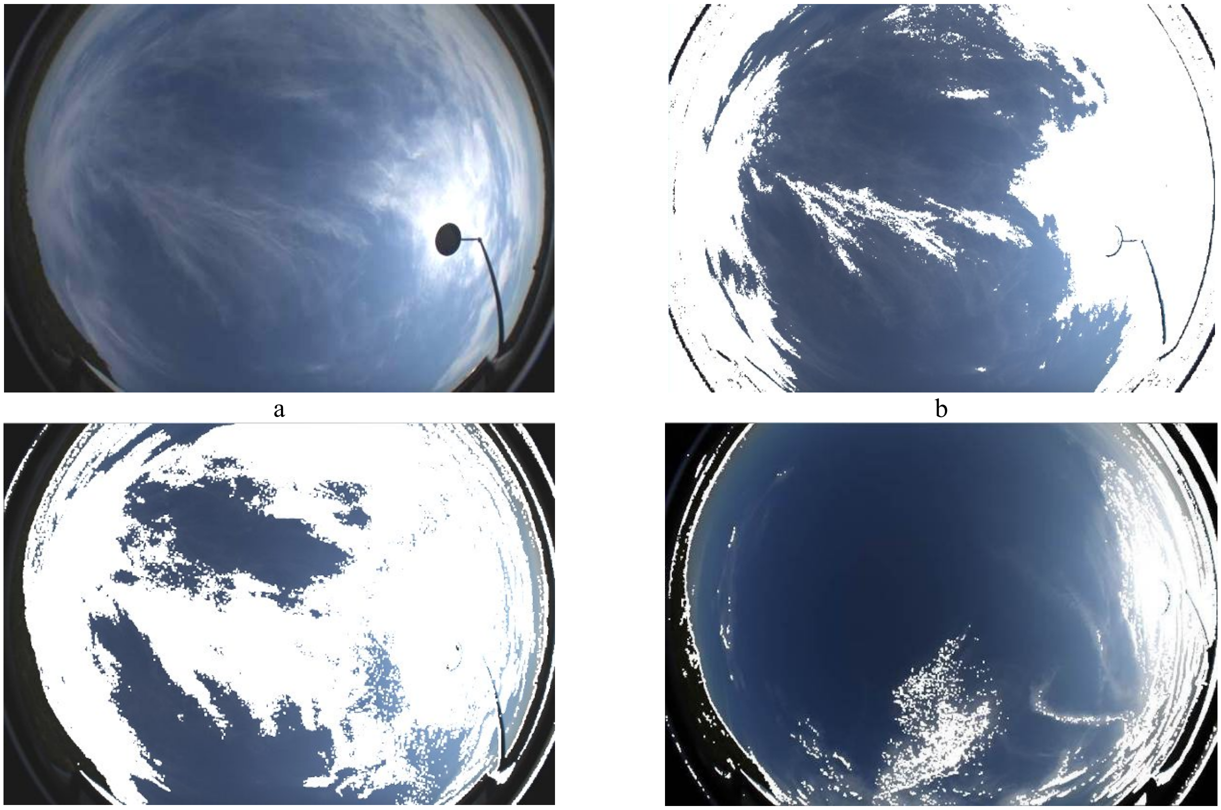

a b c d

Fig. 1. The results of processing allsky images, using two color models: a – original image; b – the result of the allocation of clouds by using RGB model, cloudiness 18%; c – the result of the allocation of clouds by using HSV model, cloudiness 70%; d – the unfortunate result of selection of cloudiness using HSV model.

Naturally, the result of this separation is primarily affected by the type of the camera used and the prevailing weather conditions. However, in solving problems related to image processing and analysis it believed that the high dependence between the color components, mixing the color information and brightness make RGB model is not the best choice for applications using color properties of an object. Besides, the important problem is the correct choice of threshold values. At a qualitative description of color we use three of its subjective attributes: hue, saturation and lightness. Therefore, for better detection of clouds, we have developed a threshold classifier based on the use of HSV color model. Information about the hue H and the saturation S allows to build a sturdy dividing rule, which at least, as compared to the RGB system, is dependent on the imaging device (Fig. 1, c).

In these experiments we selected the most optimal threshold value, when using the HSV color model but, nevertheless, there are situations when the chosen values do not allow to properly extract the clouds in the image (Fig. 1, d).

To construct the separating rule of higher quality we propose an approach that uses both the color information and the statistical information. In this method, the image is scanned by the pixel-by-pixel rectangular window, and the following calculation are made:

1. Standard deviation (SD) of brightness in the current position of the window;
2. Calculation of color distances;
3. The construction of two images that contains information about the SD distance and color distance and obtaining the new image by dividing the respective component;
4. Quantization and thresholding the resulting image.

Calculation of brightness in the window standard deviation is based on the assumption that the areas containing no cloudiness have uniform intensity distribution and, therefore, the SD will have significantly smaller value than in areas with clouds. The color distance is calculated from the difference of the two average values of histograms of color channels. As the most optimal in this case, we choose the red and green channels. The result of the proposed algorithm is presented in Fig. 2.

To eliminate errors associated with visible perspective distortion and distortion of the lens, it is necessary to calibrate the panoramic images [4]. Based on a series of fixed images one can calculate the direction and speed of the cloud. To calculate a motion vector we used for the image processing of cloud fields an algorithm based on satellite data [5].

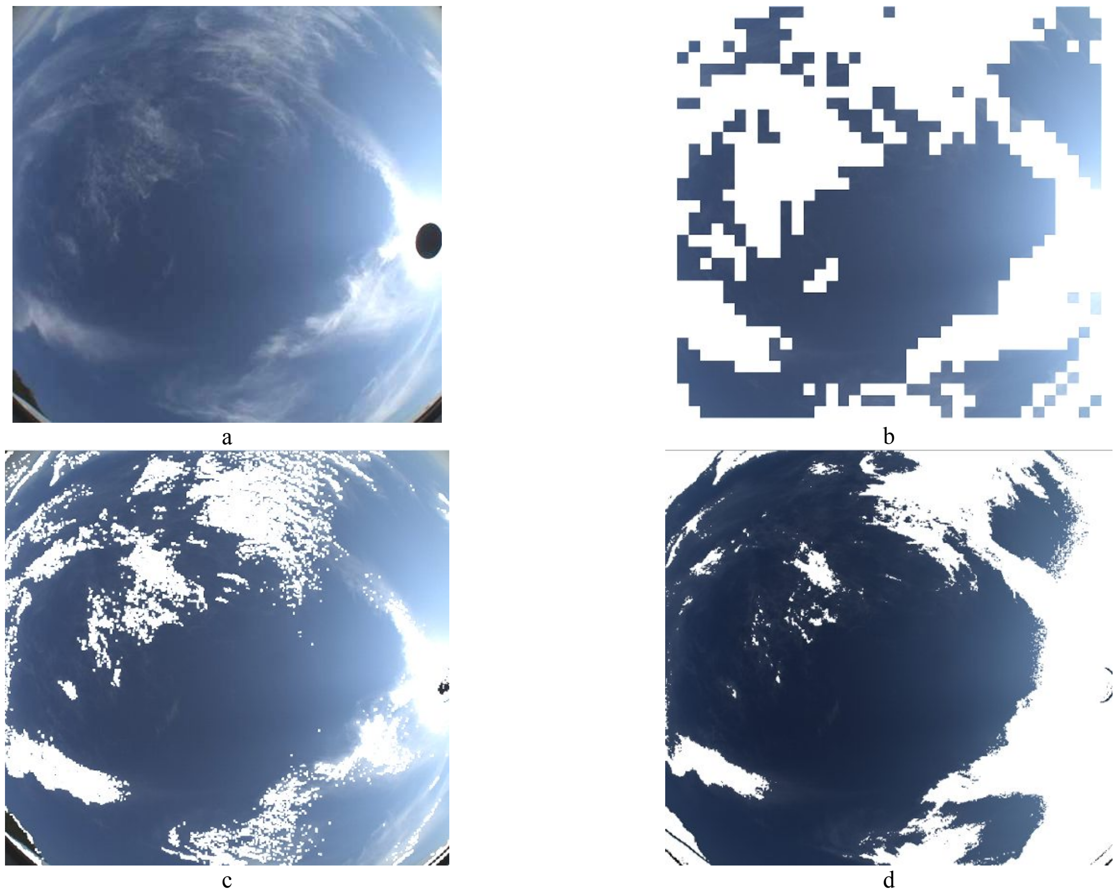

Fig. 2. Comparison of the results of the various algorithms. a - a fragment of the image containing allsky cloudy; b - the result of processing the proposed algorithm, cloudiness 47%; c - processing result using RGB model, cloudiness 20%; d - the result of processing using HSV model, cloudiness 25%.

After separation of the image into two classes sky / clouds, it is advisable to partition areas depending on the density and the transparency of cloudiness. Layout calculation is executed based on the ratio of the difference and the sum of red and blue color channel. An example of such marking is shown in Fig. 3.

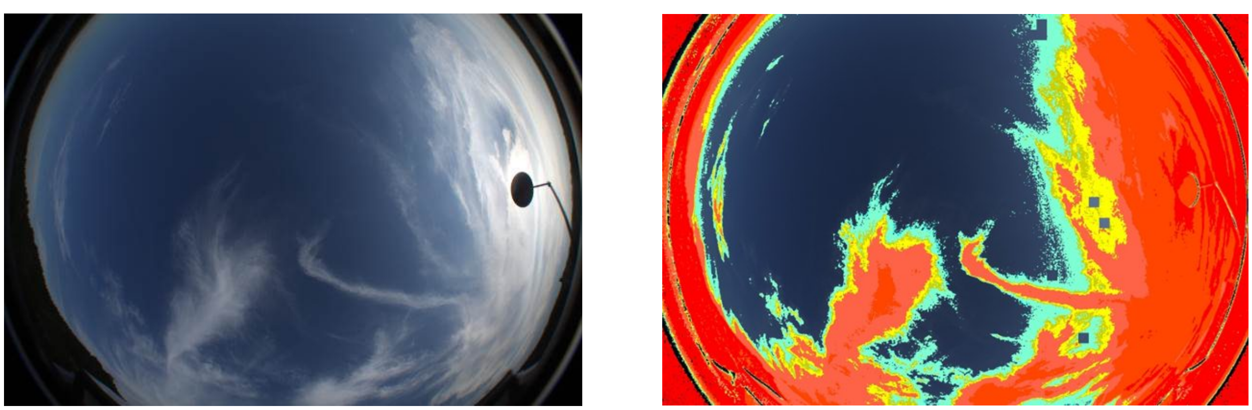

Fig. 3. The original image and cloud element detection result with a region marking

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