Image processing of cloud fields based on satellite data

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ABSTRACT

The method is considered of determining the direction of movement of cloud fields based on a series of images of clouds received from open sources.

Keywords: maps clouds, movement vector, optical flow, Google Maps.

The development of modern science and technology allow to obtain large amounts of data associated with the passive sensing of the Earth. The global determination derived from the satellite information about the weather and atmospheric processes is the most important factor in meteorological research. Of particular value is the information about the weather condition over those areas where the network of meteorological stations and posts is extremely rare or non-existent. The accumulated information allows us to estimate meteorological parameters and atmospheric conditions. The greatest amount of data is the satellite photographs of cloud cover. Since the cloudiness is one of the important factors influencing the climate formation, there is a need in the processing of this type of data.

Existing approaches are intended primarily for the storage and transfer of snapshots of clouds and not focused on the evaluation of the integral of cloud parameters, such as speed and direction of travel. Knowledge about the integral characteristics of the cloud in the first place can be used to generate short-term forecasts. In addition, such information would be useful in aviation meteorology and various scientific studies.

Currently, there is an opportunity to obtain the information about the cloudiness as from specialized and from public sources. The specialized sources include various transnational research satellites with a variety of remote sensing for environmental monitoring and climate change. The open sources is a set of open-source mapping applications for web-browsers, with aggregation of remote sensing (satellite images Landsat, SPOT, Quickbird), for example, services such as Google Maps, Open Weather Map, Wunderground (Fig. 1). Today, there are many meteorological Web service that exposes its APIs for different purposes. There is a possibility to obtain a graphical, textual (archival or current) meteorological data and media-meteorological data in the form of records of weather events, films with the information from the radar. Moreover, the API is implemented, including, and using the above standard communications protocols

The most advanced and accessible tools are API Google maps. The service is based on remote sensing data (satellite images Landsat, SPOT, Quickbird) and topographic maps. Any point of the world is displayed with an accuracy of 1:25000 on the basis of data obtained after 2003. Pictures provided by EarthSat and made from Landsat-7, camera ETM+, the ground resolution of 15 m, multispectral image obtained by combining the original 30-meter multispectral color images from a 15-meter panchromatic data obtained simultaneously with multispectral (pansharpening). The necessary information is provided to us in the form of satellite images, with an interval of 1 hour, over an area with definite coordinates. We propose the use of API Google maps to determine the current state of cloud fields and "transparency windows".

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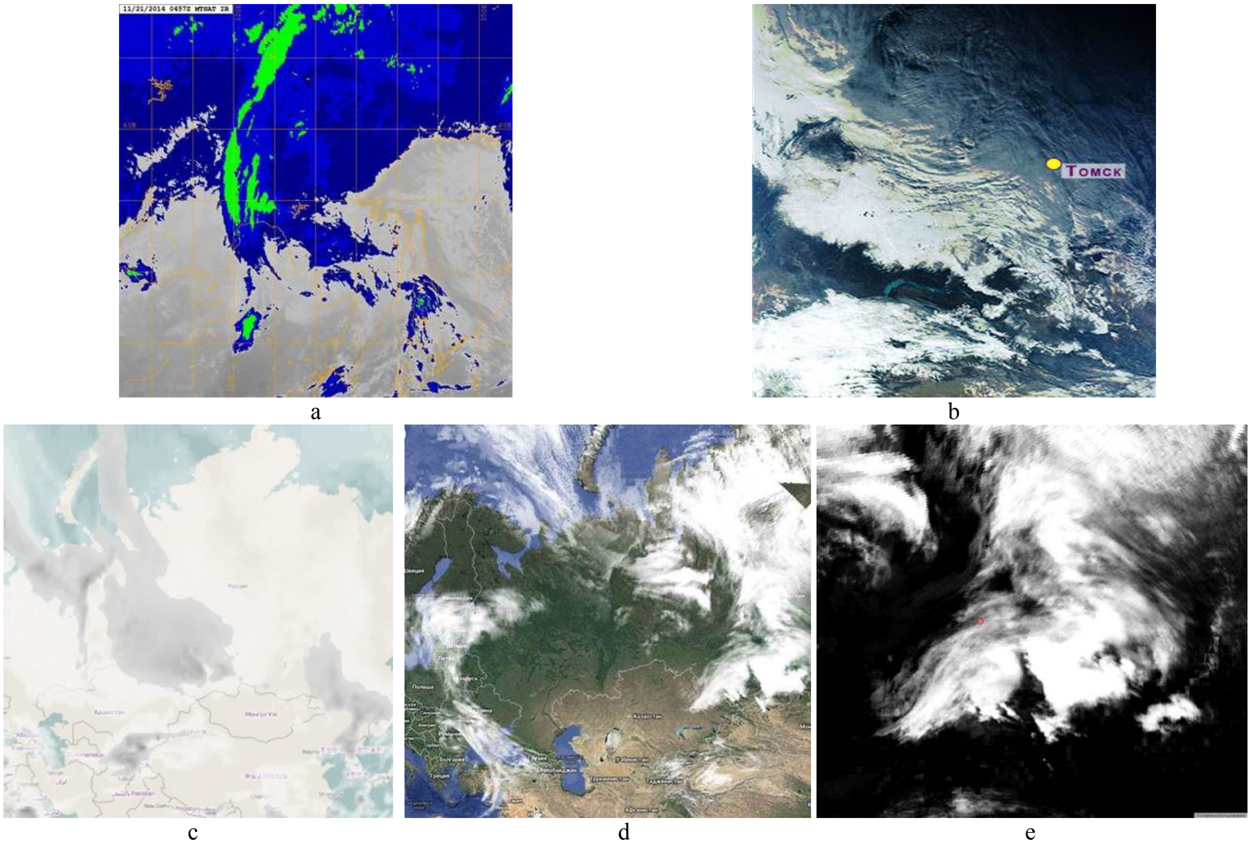

Fig. 1. Cloud image obtained from open sources: a – EUMETSAT (Satellite Image Infrared: Siberia); b – Institute of Atmospheric Optics (TERRA Visual channel NPP); c – Open weather map service; d – Google Maps service; e – a portion of the image of the cloud layer (Google Maps) without the underlying surface.

The instrumental method of determining the speed and direction of cloud movement is described in [1]. The method is based on the integrated use of digital camera and LIDAR. The algorithm for computing image moments is the basis for processing obtained images of cloudiness. The main drawback of this approach is the fact that it is impossible to take into account a variability of cloud forms, e.g., when a cloud movement is observed in the neighboring frames visually, and due to changing its shape the coordinates of mass center remain unchanged. This problem can be solved by dividing each region of a cloud field into separate subregions. Then, the parameters are calculated for each area and contribute to the overall result. However, the task is more difficult and requires pre-processing of the original image of cloudiness. The result of processing of two images of cloudiness is presented in Fig. 2.

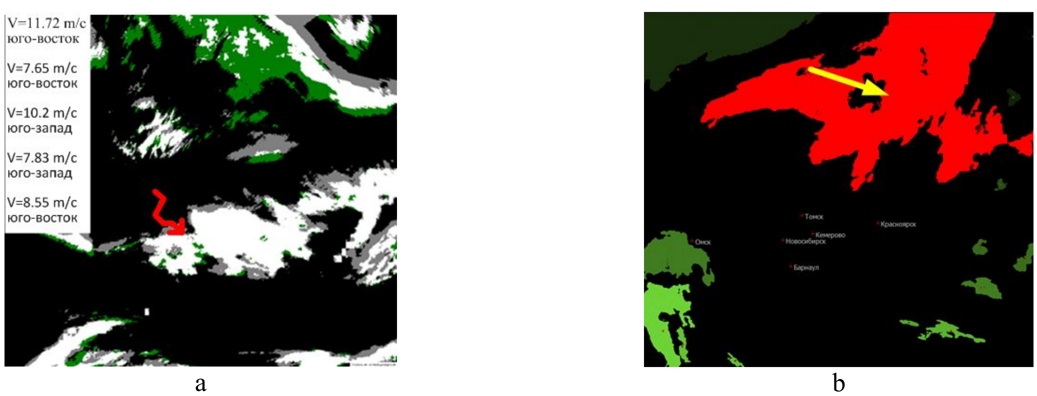

Fig. 2. Visualization of the displacement cloud vector calculated on the basis of the method of momentums: a – result of moving throughout the frame; b – result of moving a particular region.

We propose a modified algorithm to calculate the cloud fields movement without partitioning into regions based on the technology called the optical flow. The optical flow is a technology used in various fields of computer vision to determine shifts, segmentation, selection of objects, video compression, i.e. the image of apparent motion, which is a shift of each point between two images. In fact, it is a velocity field. There are two variants of the optical flow: a density optical flow and a selective optical flow. The selective flow calculates a shift of some given points; the density flow calculates a shift of all pixels in an image.

Among the large number of methods for determining optical flow it is possible to allocate the most frequently used:

- Phase correlation;
- Differential methods;
- Block methods.

A variation of the density flow used in our algorithm is the block matching method. With a sliding scan window by the two neighboring frames, these frames are compared on some signs, and in case of maximum similarity the displacement vector is calculated. To determine the similarity measure the correlational approach can be used. The disadvantage of this approach is the time-consuming calculation, and the need for setting a threshold value for making a decision about the similarity of the images. The algorithm of similarity measurement between the image block based on the sum of absolute differences is deprived of such defects. Calculating the sum of absolute differences it is performed in a reasonable time and gives acceptable results for quality. Really used and has good speed performance through the use of SIMD Extensions (which let you perform many simultaneous subtraction without using "intelligent" by means of processor parallelism). The essence of the algorithm is illustrated in Fig. 3.

2	5	5
4	0	7
7	5	9

a

2	7	5	8	6
1	7	4	2	7
8	4	6	8	5

b

0	2	0	5	0	3	3	3	1
3	7	3	3	4	5	0	2	0
1	1	3	3	1	1	1	3	4

c

Fig. 3 Search for the reference image (template) on the image pretender: a - a pattern; b - the analyzed image; c - the absolute difference between the template and the location in the image.

In Fig. 3 for the analyzed image (the elements of the array represent the intensity value at the point), there are three unique points that we can compare with the template. For each of these three difference images (in absolute value) are considered to be the sum of the values of the elements. For this example they will be equal to 20, 25 and 17, respectively. Based on these values, we can assume that the right part of the image is most similar to the image pattern, since it has the lowest sum of absolute differences compared with other positions.

In our work, the calculation of the direction of movement of clouds in the frame is made using the algorithm for measuring the similarity between image blocks on the basis of this algorithm. The plot, the size of which is chosen based on the size of the image, the previous image is a pattern for searching the current image. The position at the current frame, where the sum of absolute differences with the pattern will be minimal, will be considered as similar to the plot of the previous image (Fig. 4). To increase the rate of image processing, at the stage of calculation of the optical flow, it is advisable to use the parallel computing system for local area networks [4].

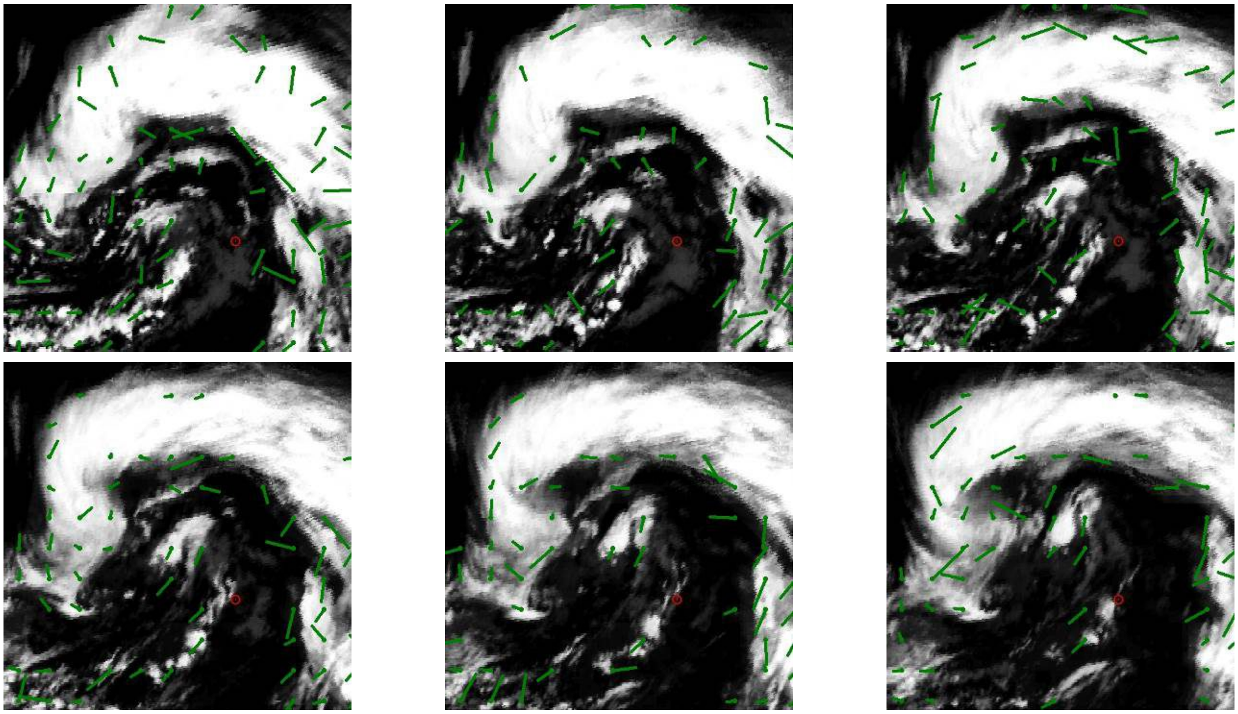

Fig. 4. Visualization of cloud motion vectors, based on the calculation of the density of optical flow.

Thus, we can calculate the beginning and the end of the motion vector area of cloudiness and knowing the time between shots and zoom-bound to earthly coordinates, we can calculate the speed of the clouds [2, 3]. The displacement vector of cloudiness, resulting from the use of this approach, will describe the movement of cloud in detail, and allow to construct more accurate forecasts.

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