The determination of wind pollution zone around city Omsk by using NOAA data.

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Abstract - The given work solves two basic tasks. The first task is the development of algorithm for allocation of wind pollution zone around of industrial city. The second task is the estimation of serviceability and errors of the developed algorithm. The speed of snow thawing at the spring period was chosen as an identification attribute of a degree of pollution. The serviceability of algorithm is appreciated by the received results. The borders of errors are appreciated. NOAA data is used as the initial information.

Keywords: Ash and Dust Pollution, Snow Thawing, NOAA Data.

1. INTRODUCTION

Each industrial city makes a plenty of polluting substances. The industrial pollution render harmful influence on an environment. In the given work one of kinds of pollution - ash and dust particle is considered. Sources of this kind of pollution are the industrial enterprises, thermal power stations, transport etc. The basic messenger of the given kind of pollution is the wind.

We should answer two questions. The first question - where there are pollution and second question - what size of pollution. For the answer to the put questions the technique of identification of a pollution zone under the satellite images is offered. As an identifiable attribute of a pollution degree the speed of thawing of snow was chosen. The speed of thawing of snow in the spring period strongly depends on presence in snow the ash and dust particles, transported by a wind (Handbook, 1986). The given dependence is explained as follows. The polluting particles reduce albedo of a snow cover. It results in more intensive absorption of solar radiation. In result the snow stronger gets warm and accordingly thaws earlier. We assume, that the areas subject to strong pollution will be released from snows earlier, than area, in which pollution weak. Thus, the task is reduced to definition of changes of border of a snow cover in the spring period.

2. SUBSTANTIATION OF ALGORITHM

In the given work the multichannel images of a terrestrial surface were used which were received by the NOAA satellites. The choice of the NOAA series satellite is determined by the following circumstances. First - each working satellites makes a minimum 2 images of the same region of the Earth per day. Thus, the good temporary covering is provided. Second, the NOAA satellites has sunsyncronous orbits. It provides shooting at an approximately constant phase angle of the Sun. Third, the satellite images cover a wide strip of a terrestrial surface. And last, the NOAA data are free-of-charge and can be received through Internet. In the table the wavelengths for all bands of the NOAA satellites are given.

Table. Bands wavelengths of NOAA satellites.

Bands number	Wavelengths (μ)	
	NOAA - 12, 14	NOAA 16, 17
1	0,58 - 0,68	0,58 - 0,68
2	0,725 - 1,00	0,725 - 1,00
3	3,55 - 3,99	N/A
3A (day)	N/A	1,58 - 1,64
3B (night)	N/A	3,55 - 3,99
4	10,30 - 11,30	10,30 - 11,30
5	11,50 - 12,50	11,50 - 12,50

The algorithm of allocation of a snow cover on the satellite images uses features of a spectrum of snow. In a Figure 1 typical spectrum of radiation of a snow cover is represented. Number of a range corresponds to number of the band from the table. From the analysis of a spectrum follows that for identification of a snow cover most suitable are by used of the first and third channels. The choice is defined by two reasons. First - in these channels the maximal contrast of brightness is observed. Second - spectrum of radiation of snow in these channels strongly differs from spectra of other types of surfaces

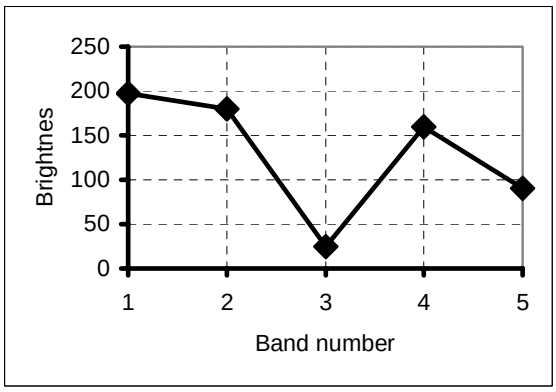

Figure1. Typical spectral dependence of brightness of a snow cover from NOAA data.

The quantitative estimation of presence and capacity of a snow cover was carried out with use of the normalized differential snow index NDSI, which was calculated under the formula

$$NDSI = \frac{(b1 - b3)}{(b1 + b3)},$$

where b1 and b3 brightness in the first and third channels accordingly

The calculated thus index changes from -1 up to + 1 depending on presence and capacity of a snow cover (De Abreu, 1995), as allows to determine border it. The definition of border of a snow cover occurred by the following criterion: at NDSI $\leq$ 0,03 the territories was considered free from snows, at NDSI $\geq$ 0,05 the territories was considered as covered of snow, the value NDSI = 0,04 was chosen as boundary.

3. THE RESULTS OF ALGORITHM USES

The offered algorithm was used for determination of a pollution zone in vicinities of Omsk city. The geographical coordinates of researched territory made: northern latitude from 54º up to 56º 30' and east longitude from 72º 30' up to 75º 50'. Base ellipsoid was chosen WGS - 84. As the size of a displayed site of a terrestrial surface was small, the rectangular projection was used. The final results for 2003 are given on Figure2. The contours of the river Irtish are given in Figure2 for orientation.

The contours marked on Figure2 by shading correspond to areas free from snows. The small internal contour (index 2) corresponds to a date started of the period of snow thawing - March 29, 2003. The given contour coincides with urban territory. This concurrence is the first confirmation of serviceability of the offered algorithm. The large external contour (index 1) corresponds to a date ending of the period of snow thawing - April 18, 2003. That contour shows a zone of maximal dissipation of ash and dust particles. Common extension of a pollution zone in a northeast direction is determined by a prevailing direction of a wind. The wind determines a direction and zone of primary dissipation of particles polluting on snow cover. This result is the second confirmation of serviceability of the offered algorithm.

Represented on Figure2 the large contour (the index 1) shows territory which appreciably influence ash and dust pollution. The spatial extent of territory is characterized by the following sizes. The area is equal 480 020 ± 46 000

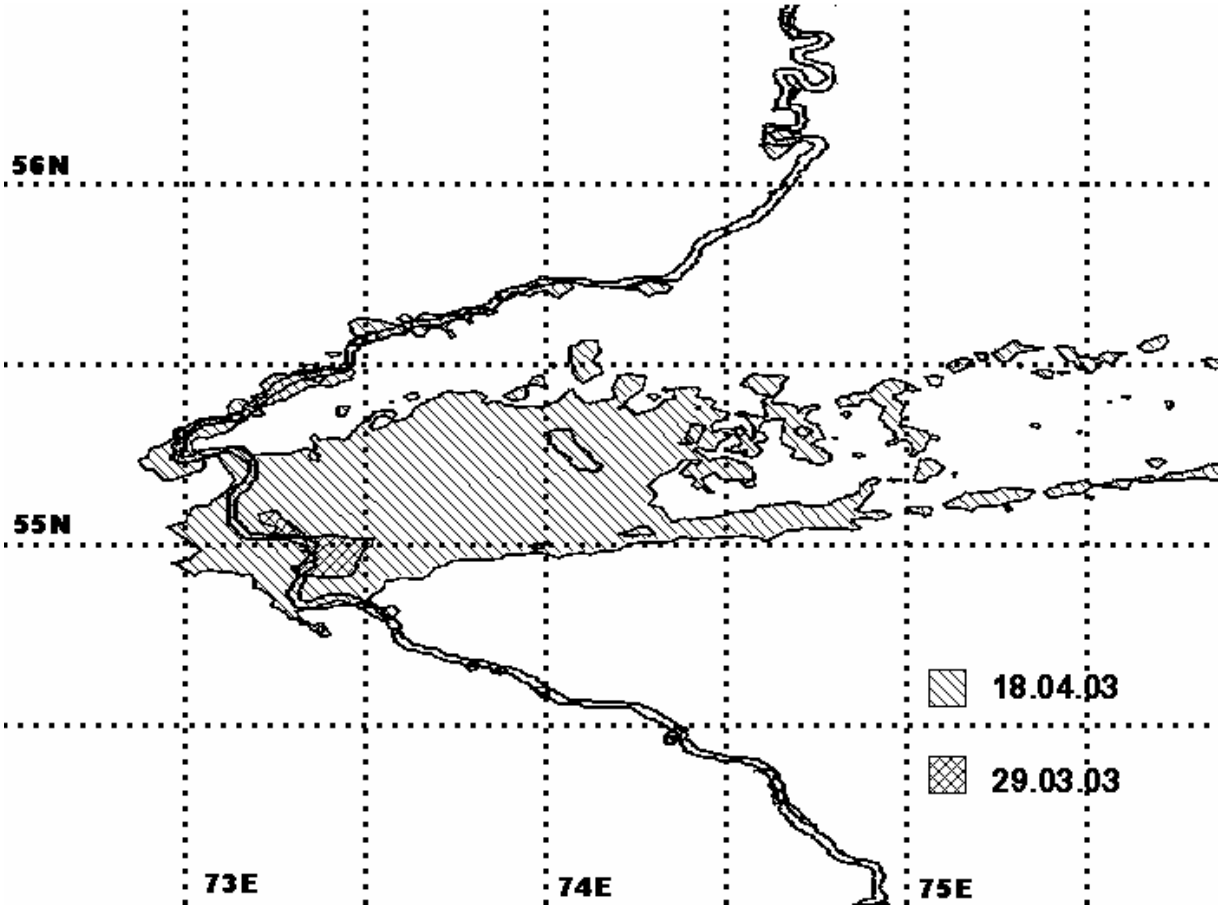

Figure 2. Borders of territory free from a snow cover in the beginning and at the end of the period of thawing - March 29 and April 18, 2003 accordingly. The small internal contour (index 2) corresponds to the beginning of the period of thawing. The large external contour (index 1) corresponds to the ending of the period. For simplification of orientation in figure the contours of the river Irtish are given.

hectares, the relative error makes approximately 10%. The maximal extent of a zone of pollution makes 135,21 ± 1,7 km, the extent on latitude makes 66,8 ± 1,7 km, the extent on a longitude makes 134,07 ± 1,7 km. On Figure2 the influence of the railway which passes approximately on latitude N55º is traced.

The offered algorithm allows determine real sources of pollution. On Figure3 the fragment of a map of vicinities of Omsk city is given. On the specified fragment are put the contour lines of NDSI. Contour lines are constructed using NOAA data for April 11, 2003. The color of contour lines varies from white to grey and back up to white. The internal white lines correspond to the very dirty snow. They are marked with figures from 1 up to 4. The external white lines correspond to the clean snow. They have not marks. The contours marked in figures 3 and 4, correspond to that part of city, which is characterized in maximal density of the population. The contours 1 and 2 are extended in a northeast direction. In the basis of a contour 2 the factory on processing petroleum is located. In the basis of a contour 1 the powerful thermal power station which uses stone coal is located. Thus three basic sources ash and dust particles are allocated.

4. BASIC RESULTS

1. It is necessary to recognize the algorithm, offered by the author, of definition of a wind pollution zone efficient.
2. The influence of urban emissions is traced on distances up to 100 km from cities.
3. As the basic sources of the given type of pollution it is necessary to recognize area of dense urban building, thermal power station and factory on processing petroleum.

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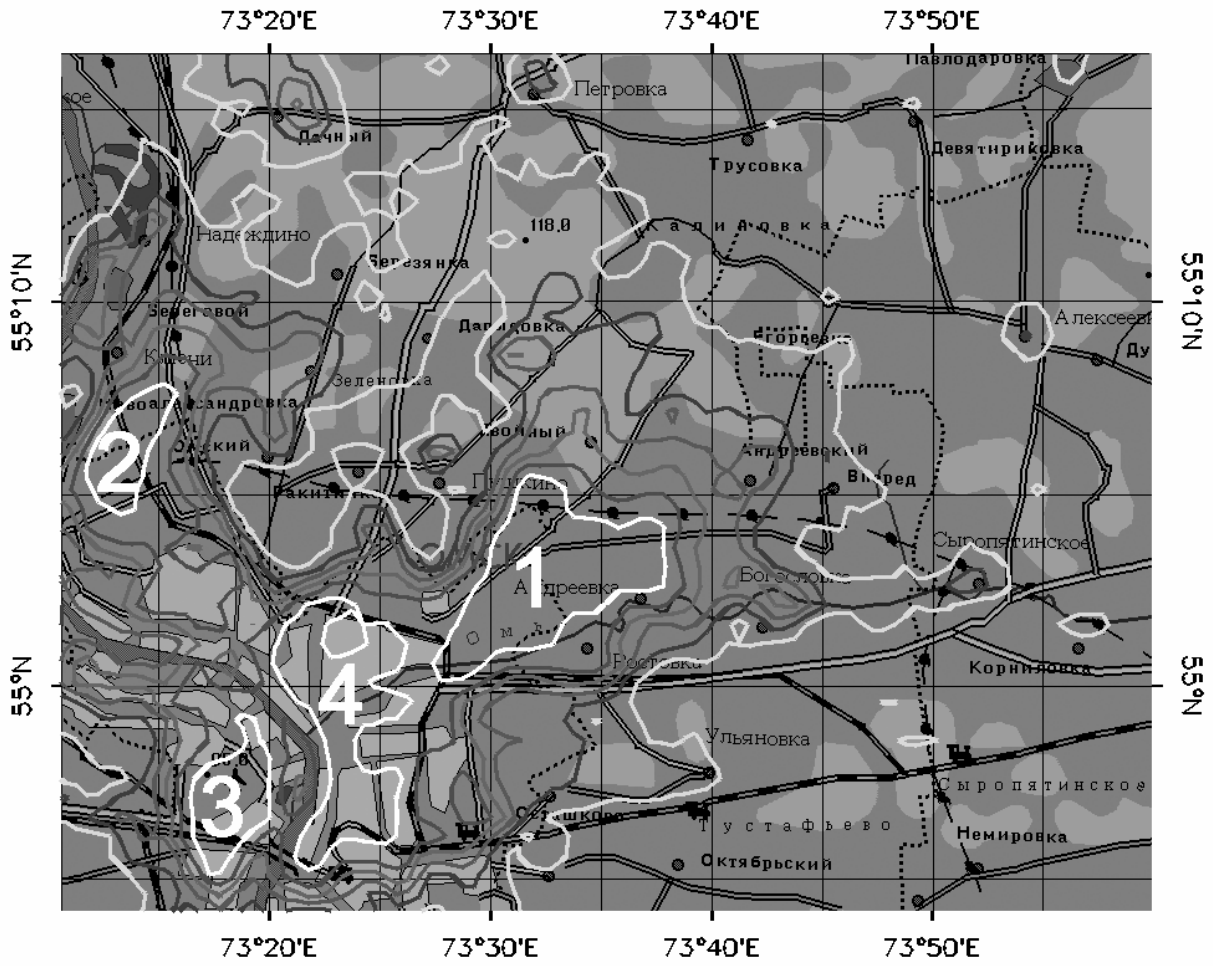

Figure3. Contour lines of NDSI for April 11, 2003.

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6. REFERENCES

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