Combining channels to increase the differences between coniferous and hardwood vegetation in satellite images

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Research methods

In the study of the distinctness of coniferous and deciduous vegetation, Landsat–7 images were used. In the k-th spectral channel, the brightness distance between the pixels of these objects:

$$D_k^{ij} = B_k^{Fi} - B_k^{Cj}, \quad i = 1, \dots, N_F, \quad j = 1, \dots, N_C. \qquad (1)$$

Here N_F and N_C is the number of hardwood and coniferous pixels in the existing reference fragments B_k^{Fi} and B_k^{Cj} the corresponding luminance in the *k*-th channel.

For the aggregate of pixels in this channel:

$$\Delta_k = M\left\{D_k^{ij}\right\} - 2\,\sigma\left\{D_k^{ij}\right\}. \qquad (2)$$

A positive value of Δ_k in the assumption of Gaussian statistics for the brightness of objects corresponds to the probability of their difference at the level of approximately 0.95.

To increase the distinctness of vegetation, *m* spectral channels of Landsat–7 were integrated with a resolution of 30 meters. The unification is performed by forming a distance in a conditionally orthogonal spectral basis:

$$D_m^{ij} = \sqrt{\left(B_1^{Fi} - B_1^{Cj}\right)^2 + \left(B_2^{Fi} - B_2^{Cj}\right)^2 + \dots + \left(B_m^{Fi} - B_m^{Cj}\right)^2}, \qquad (3)$$

$$i = 1, \dots, N_F, \qquad j = 1, \dots, N_C$$

Here D_m^{ij} is the brightness distance between two pixels in *m* channel. For a group of pixels, the distance Δ_m is defined similarly to (2).

The second feature introduced is the spectral angle between the brightness vectors:

$$\varphi_m^{ij} = arccos\frac{\left(\vec{B}^{Fi}, \vec{B}^{Cj}\right)}{\left|\vec{B}^{Fi}\right|\left|\vec{B}^{Cj}\right|}. \qquad (4)$$

For a group of pixels, the difference θ_m in the spectral angle between rocks in *m*-dimensional space is determined similarly to (2).

Experimental results

At the first stage, differences in the brightness of coniferous and deciduous species along spectral channels were determined. Here, the maximum differences (2) were obtained for the fourth channel of the July image and amounted to 14.36 for brightness in the range 0 – 255.

When combining spectral channels, the maximum difference of rocks in brightness (ratios 3 and 2) is 19.44 when combining 6 channels of the July image. This is 1.35 times more than the maximum difference in one channel. The greatest differences between the rocks in the spectral angle (4) and (2) are 5.72 degrees when combining 1, 4, 7 channels of the July image.

When aggregating both spectral channels and seasonal images (3) and (2), the greatest distinguishability of rocks in spectral brightness increases to 31.35 when combining images of February, May, July and November. This is 2.18 times more than the best result for one channel. The results obtained are shown in the table. No significant gain was obtained for the spectral angle.

Number of combined seasonal snapshots					
1	2	3	4	5	6
19,44 14.07.2000 (1–5, 7)	19,85 21.02.2000 (1–5) 24.11.1999 (1,2,4,5,7)	27,76 21.02.2000 (1–5) 14.05.2010 (1,2,4) 14.07.2000 (1–5, 7)	31,35 21.02.2000 (1–5) 14.05.2010 (1,2,4) 14.07.2000 (1–5, 7) 24.11.1999 (1,2,4,5,7)	29,98 21.02.2000 (1–5) 14.05.2010 (1,2,4) 14.07.2000 (1–5, 7) 12.10.2001 (1–5,7) 24.11.1999 (1,2,4,5,7)	24,22 21.02.2000 (1–5) 28.04.2001 (1–5,7) 14.05.2010 (1,2,4) 14.07.2000 (1–5, 7) 12.10.2001 (1–5,7) 24.11.1999 (1,2,4,5,7)

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