

# Seasonal changes of polarimetric characteristics of forest

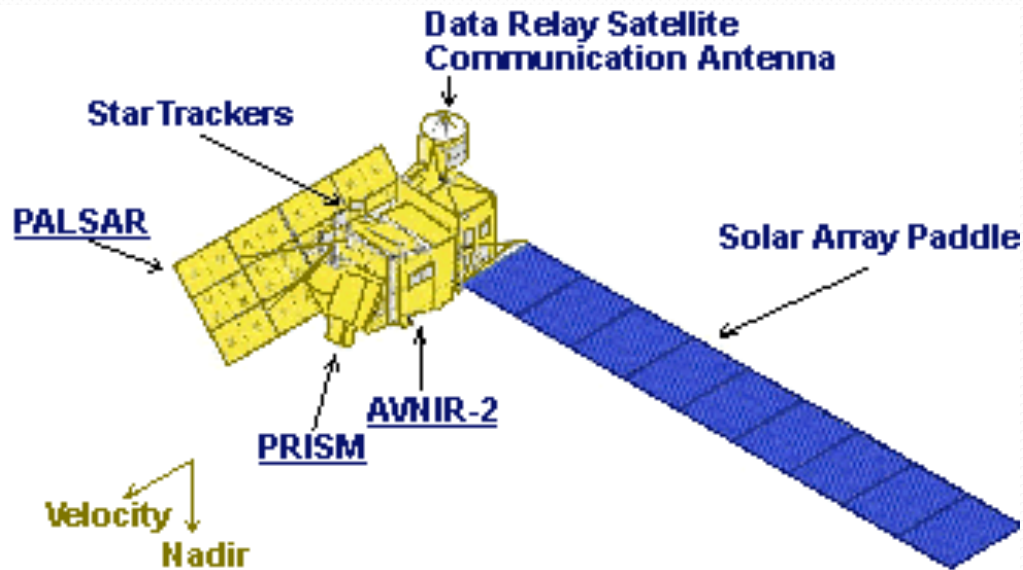
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## Polarimetric data for the Baikal region

- Polarimetric radar remote sensing data (RDZ) in the Baikal region are scanner images in the microwave range of C-and L-bands (5 and 25 cm), obtained with a synthetic aperture radar during a mission in the Shuttle in 1994 and in the L-band - ALOS PALSAR c 2006 to 2011.
- Polarimetric data contain information about scattering matrix at each stage and the files are a universal binary raster format sequential streams of bytes (BSQ), and small text files support.
- To display and analysis of remote data protection software used by ENVI and PolSARPro.
- Data were obtained from the German and Japanese space agencies in the framework of international projects ERS AO-3 SIBERIA, INTAS 97-1040, № 05KRSTK-022935.

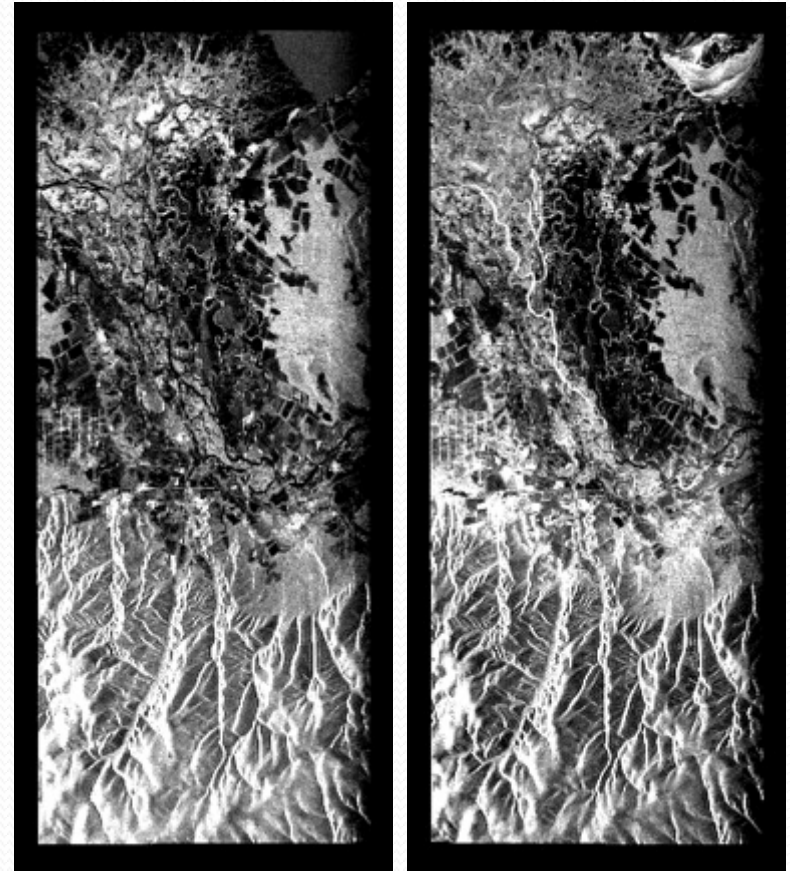
# Main features SAR



| <b>SIR-C/X-SAR</b>               | <b>ALOS PALSAR</b>    |
|----------------------------------|-----------------------|
| USA NASA/<br>DLR/ DARA           | Japan<br>JAXA (NASDA) |
| 1994                             | 2006-2011             |
| L,C,X<br>(1.25, 5.3,<br>9.6 GHz) | L<br>(1.27 GHz)       |
| 15-55 degrees                    | 8-30 degrees          |
| 10-30 m                          | 24-89 m               |
| 225 km                           | 692 km                |
| 57 degrees                       | 98 degrees            |

# Polarimetric information

- The base of satellite data with full polarimetric information is small and consists mainly of images obtained with a synthetic aperture radar ALOS PALSAR Japan Aerospace Exploration Agency JAXA L-band (wavelength 24 cm) in 2006-2011 [1,3]. To evaluate temporal changes necessary to match the shooting conditions.
- The figure shows pair of image on September 28 and November 13, 2006 Forest vegetation has a high reflectivity, and it corresponds to the brighter areas: forests of pine and mixed foothills of Hamar-Daban on the south side, Kudarinskogo forestry - in the northeast, a fragment of pine solid-birch forest Stepnodvortsovogo - on the west side. Along the river and in the delta and there are numerous islands of forest vegetation, forest plantations, reeds, etc.



ALOS PALSAR radar images September 28 and November 13, 2006.

# The method of classification

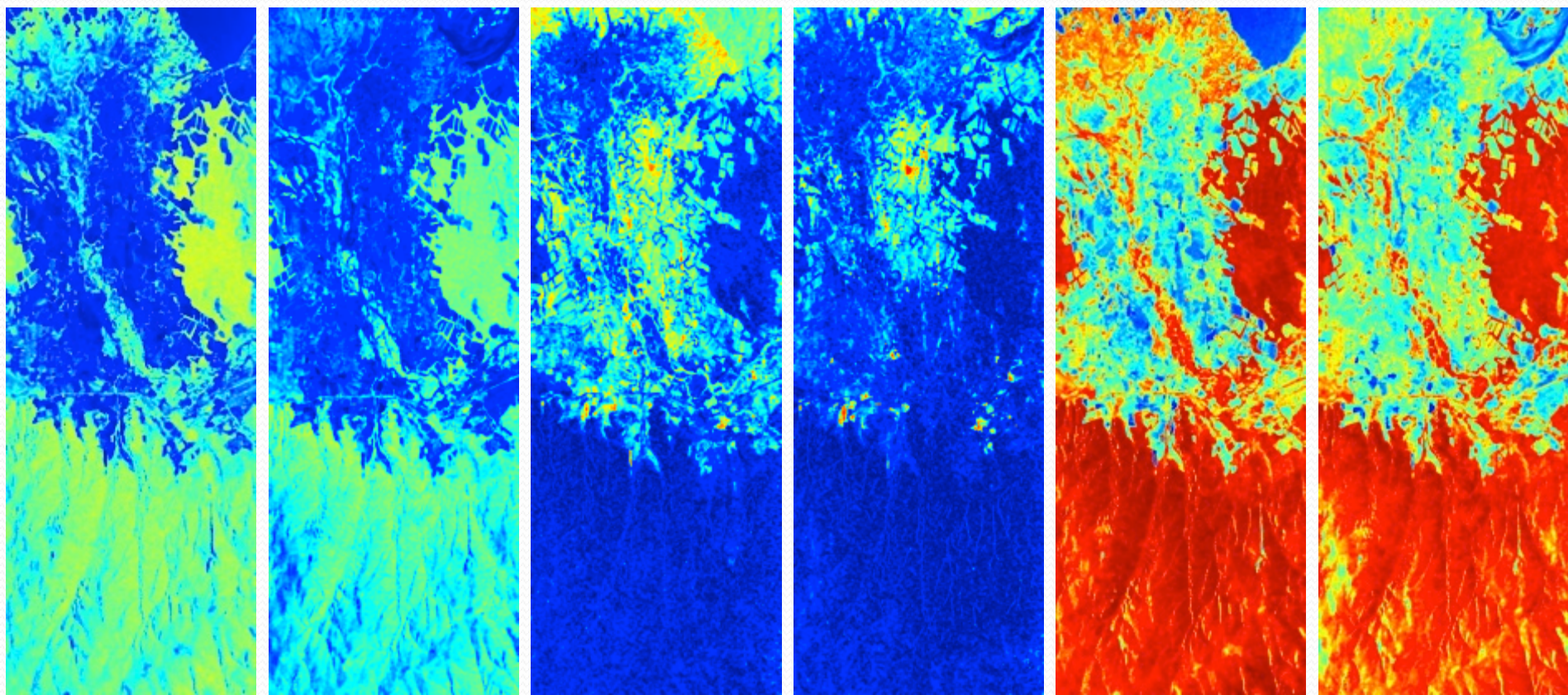
- This report used polarimetric classification of objects offered Cloude and Pottier<sup>1</sup> [1997]. This is one of the most effective methods of classification of natural and artificial objects using polarimetric radar data with synthetic aperture. The method is based on a combination of polarimetric scattering decomposition of goals and finding the extrema of the function described by the complex polarimetric covariance matrix. The method of Claude and Pottier is based on the decomposition of the coherence matrix eigenvalue  $\lambda_i$  and eigenvectors  $e_i$ .

$$\langle T \rangle = \lambda_1 \cdot e_1 \cdot e_1^{*T} + \lambda_2 \cdot e_2 \cdot e_2^{*T} + \lambda_3 \cdot e_3 \cdot e_3^{*T}$$

- Analysis of the eigenvectors of the coherence matrix [T] allows a decomposition of the types of scattering mechanisms.  
On the basis of eigenvalues  $e_i$  are defined by three parameters: the entropy H, anisotropy A and  $\alpha$ .

<sup>1</sup>Cloude S.R. and E. Pottier, 1997, "An Entropy-Based Classification Scheme for Land Applications of Polarimetric SAR", *IEEE Trans GRS*, vol. 35(1), pp. 68-78.

# Seasonal changes in the parameters H, A and $\alpha$

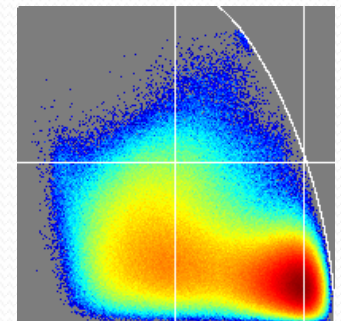
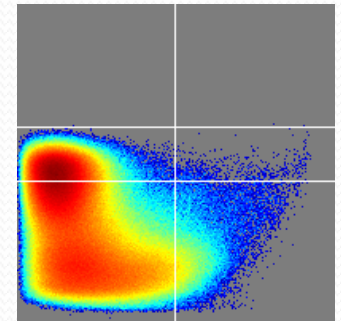
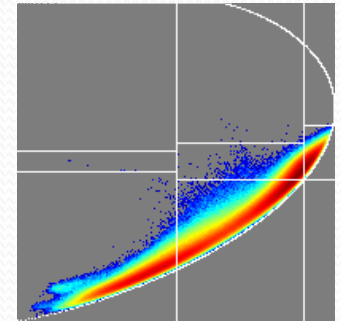
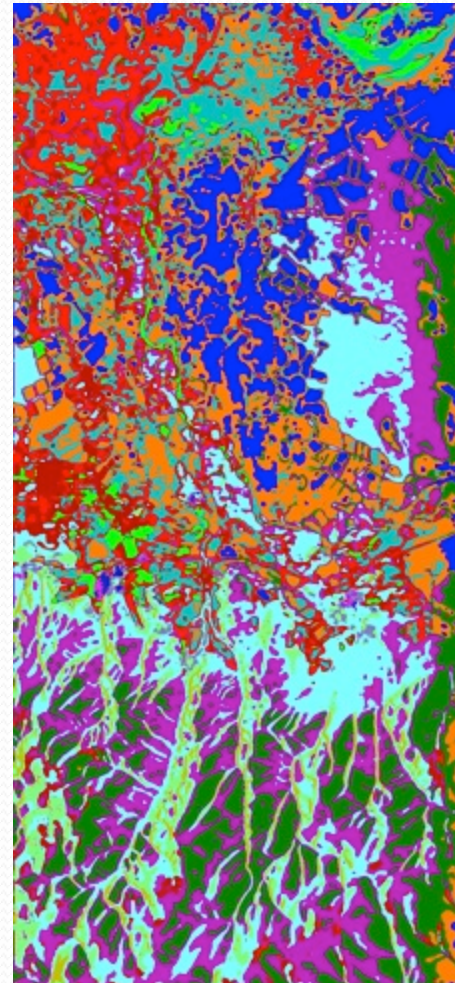
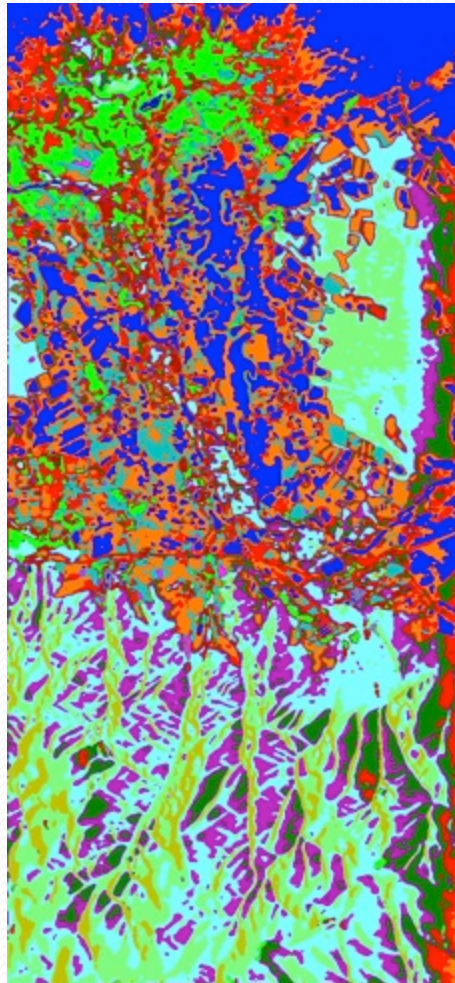
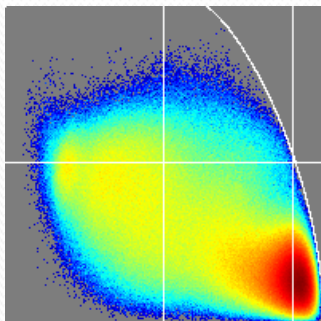
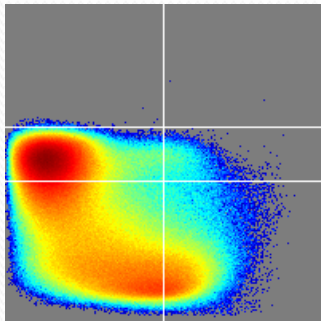
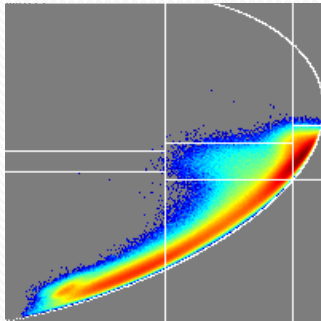


Parameter  $\alpha$ , which characterizes the dominant type of scattering ( $\lambda_1$ ).

The anisotropy A of the two minor types of scattering ( $\lambda_2$ ,  $\lambda_3$ ).

The entropy H characterizes order and chaotic scattering of the radar response of the eigenvalues of the matrix of coherence ( $\lambda_1$ ,  $\lambda_2$ ,  $\lambda_3$ ).

# Seasonal changes in the results of the Claude-Pottier classification



## Season variations of the H-A-alpha-classification results

Forest vegetation is divided into zones, respectively, the volume scattering of high, medium and low entropy (classes 2, 5 and 8).

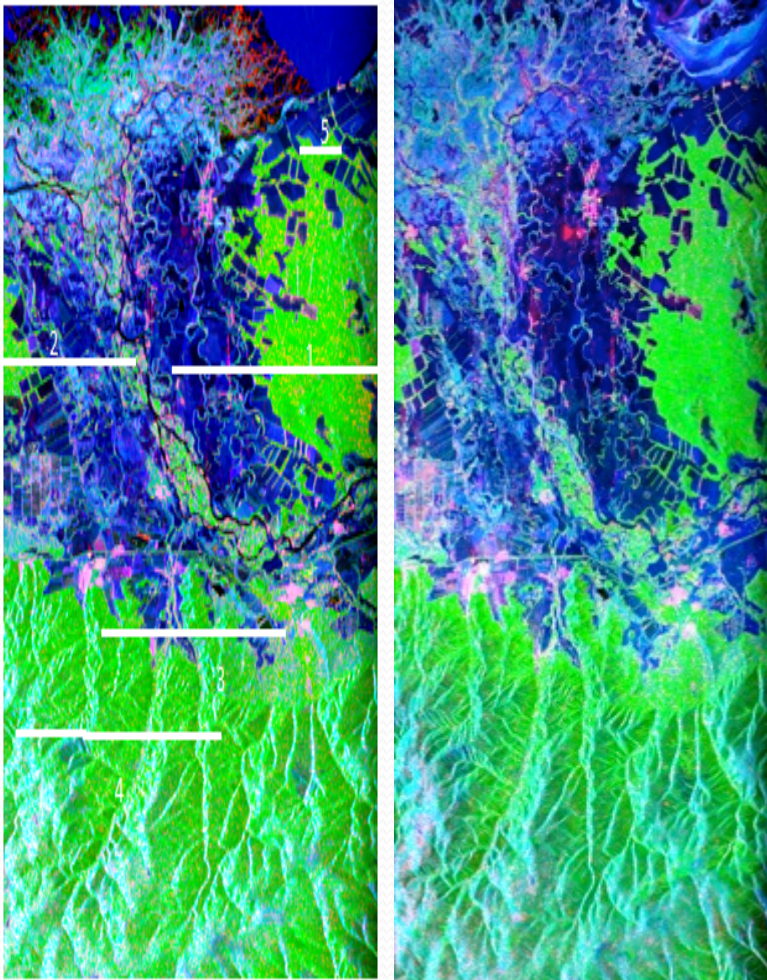
In passing from autumn to winter image there is a significant decline in the share of volume scattering:

- in the whole scene from 39.41% to 21.75%;
- for class 2 - from 27.08% to 12.98%
- for class 5 - 11.33% to 8.77%:
- for class 8 is marked, barely noticeable fluctuation of the order of thousandths of percent.

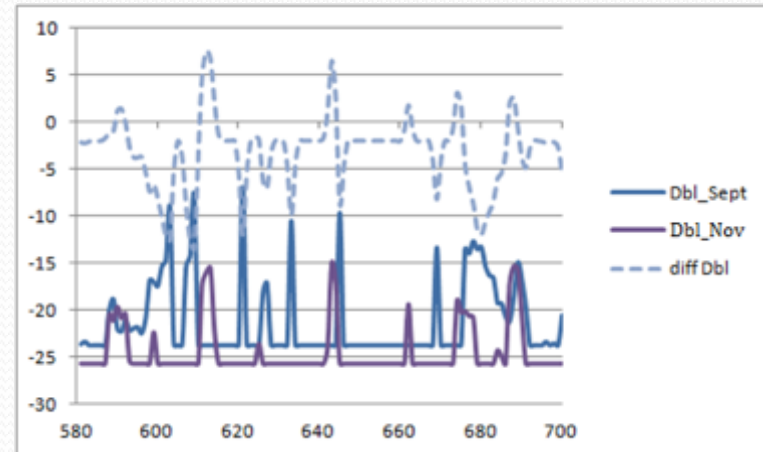
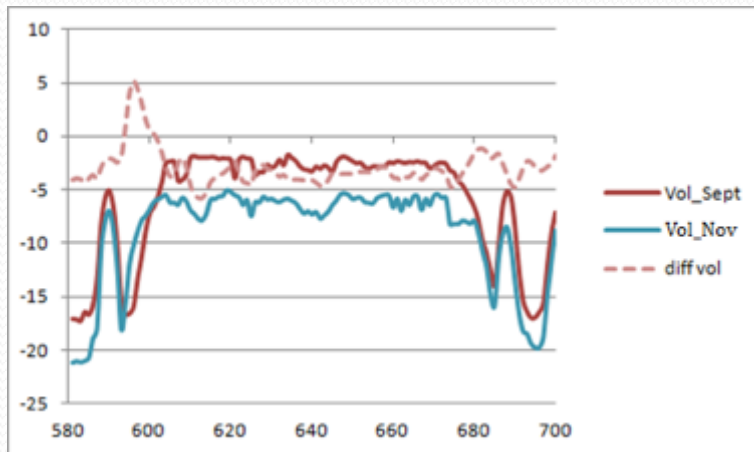
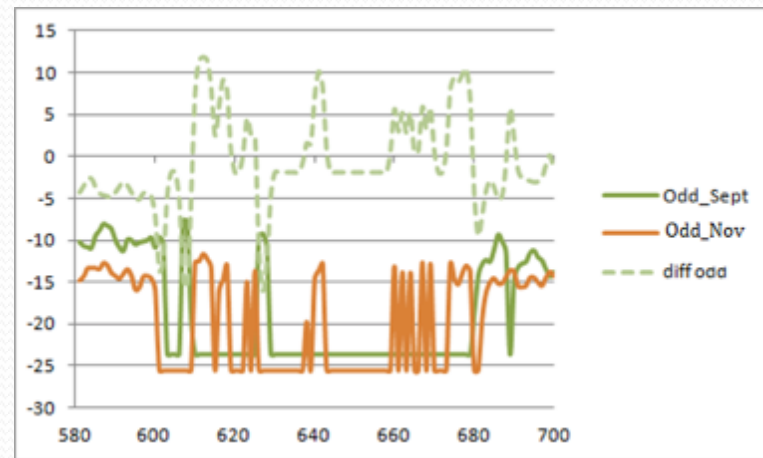
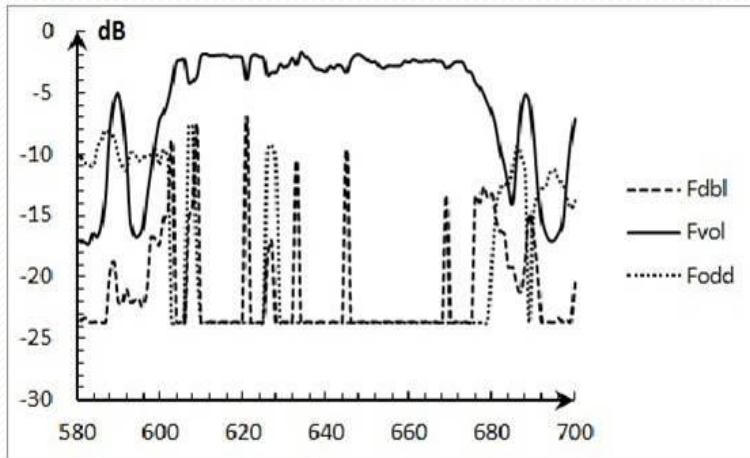
At the same time there was an increase in the proportion of the surface of the scattering medium, and low entropy (classes 6 and 9) in the whole shot with a 61.14% to 78.25%, with the main increase is observed in the zone of high entropy (class 6) with 37.81% up to 52.76%.

Proportion of double-scattering (grades 1, 4 and 7) also decreased from 0.45% to 0.0014%.

# Freeman decomposition



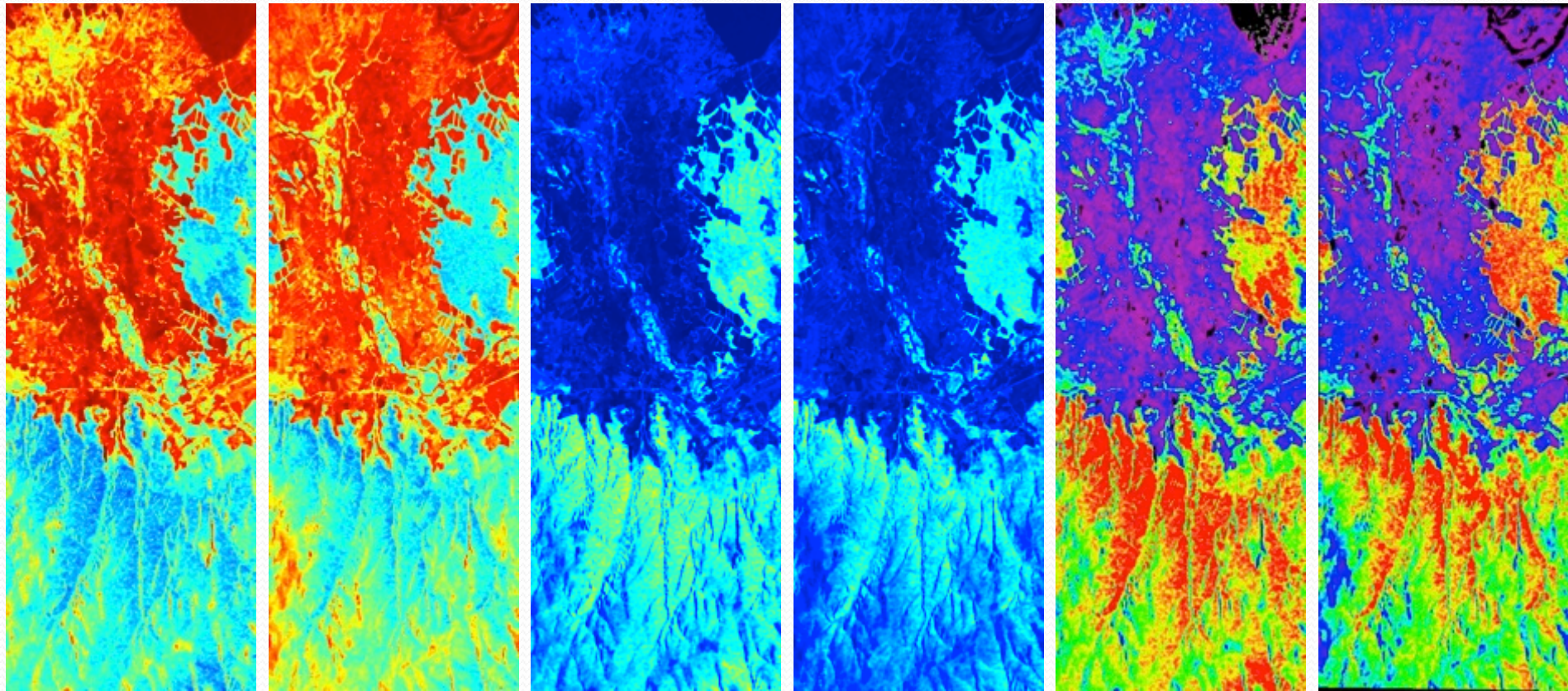
# Seasonal changes in Freeman components



## Seasonal changes in components of the Freeman

|                   | Fvol             | Fodd              | Fdbl              |
|-------------------|------------------|-------------------|-------------------|
| <b>28/09/2006</b> | $-2,76 \pm 0,13$ | $-22,04 \pm 0,35$ | $-21,75 \pm 0,61$ |
| <b>13/11/2006</b> | $-6,24 \pm 0,09$ | $-22,32 \pm 0,74$ | $-24,76 \pm 0,35$ |
|                   | $3,48 \pm 0,15$  | $0,28 \pm 0,85$   | $3,00 \pm 0,58$   |

## Polarimetric characteristics

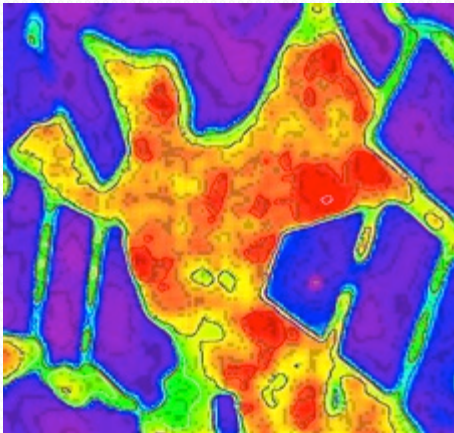
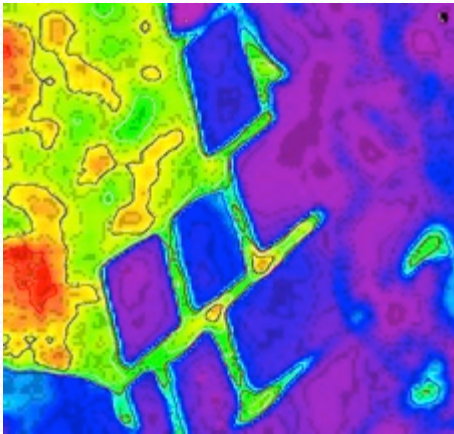


The degree of polarization

pedestal height

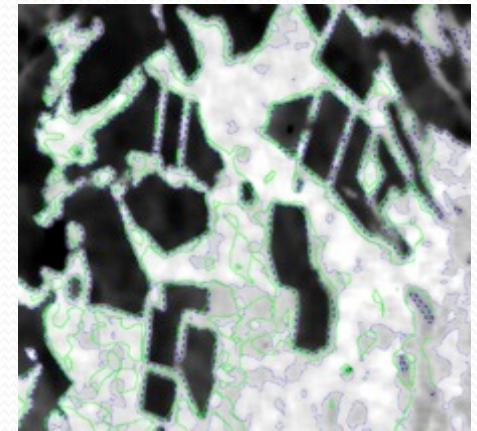
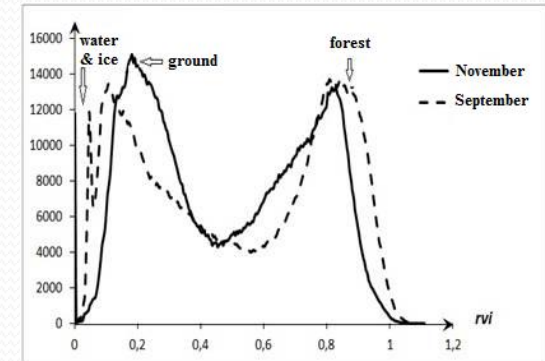
Radar vegetation index  
rvi

## Local maps of woodlands rvi

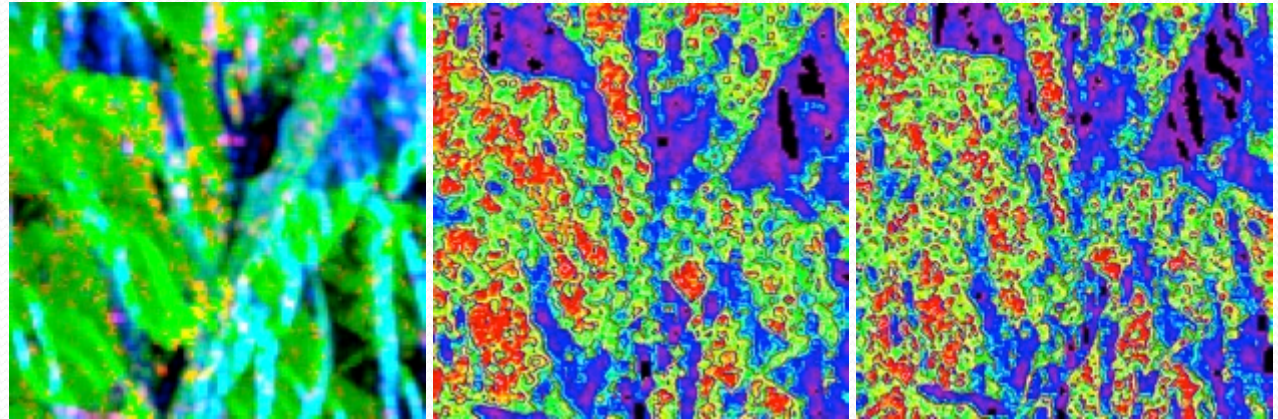
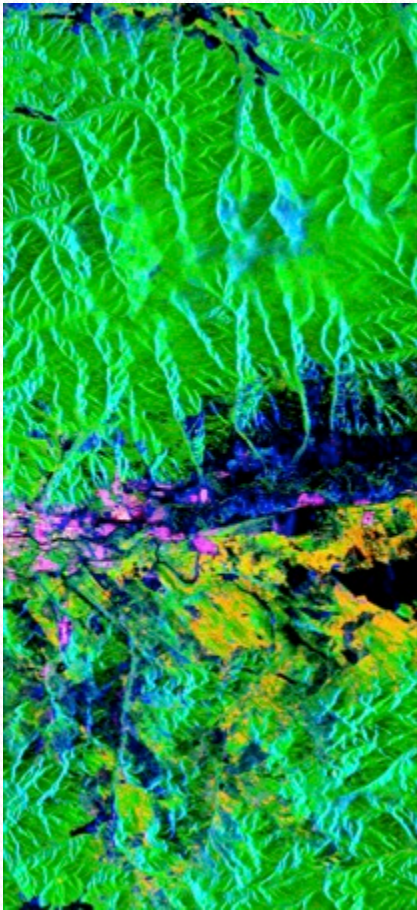


Two fragments of images RVI September 28, 2006 for forest plots with contour lines at the levels of RVI 0.5, 0.6, 0.7, 0.8, 0.9, 1.

At the last fragment of November 13, 2006 a combination of contour lines of RVI: blue dashed lines correspond to the levels of the index of 0.6 and 0.8 in November, the green solid lines - in September.



## Forested areas near the city of Ulan-Ude



RGB-Freeman decomposition of Ulan-Ude and the surrounding area, based on radar data May 28, 2007.

Fragment of RGB-image Freeman decomposition.

RVI April 17, 2009 and May 28, 2007 for the forest areas on the Upper Berezovka with contour lines at the levels of RVI 0.5, 0.6, 0.7, 0.8, 0.9, 1.

## Conclusion

- Comparison of the polarimetric characteristics showed seasonal changes in scattering processes. In particular, for the forest in winter there is a decrease of such indices as the radar vegetation index and the proportion of the volume scattering due to the overall decrease in biomass and growth of the role of surface scattering.
- For the test area of pine forest on the basis set expansion Freeman reducing the bulk and two-time component to 3-3.5 dB, and the stability of the surface components.



**Thank you  
for your attention**