# Using ScanEx IMAGE Processor for forest cover dynamics mapping

Global changes of forest cover are an important indicator of the environmental health. In the European part of Russia the reduction of intact old-growth forests acreage to the north and north-east due to the frontal advance of intensive industrial felling in remote and undeveloped areas has been observed for the past decades, as well as the large-scale replacement of native conifer forest in taiga zone by secondary small-leaved one (mostly, as a result of logging).

Earth remote sensing data has been increasingly used to assess the pace of the ongoing processes and forest cover dynamics mapping. Based on space imagery data one may do the analysis of the vegetation dynamics for the period of quarter of the century. Due to the need of extracting information from a large number of multi-temporal images, acquired from different satellites the choice of correct software becomes very important. ScanEx Image Processor 2.0 is the example of the universal tools of space imagery data processing, developed by ScanEx R&D Center. The software package contains a complete set of tools, required to handle RS data – from import and preliminary image geometric correction up to arithmetic operations with rasters and building 3D terrain models (*http://www.scanex.ru/ru/software/ imageprocessor/ImageProcessor_Manual_Rus.zip*).

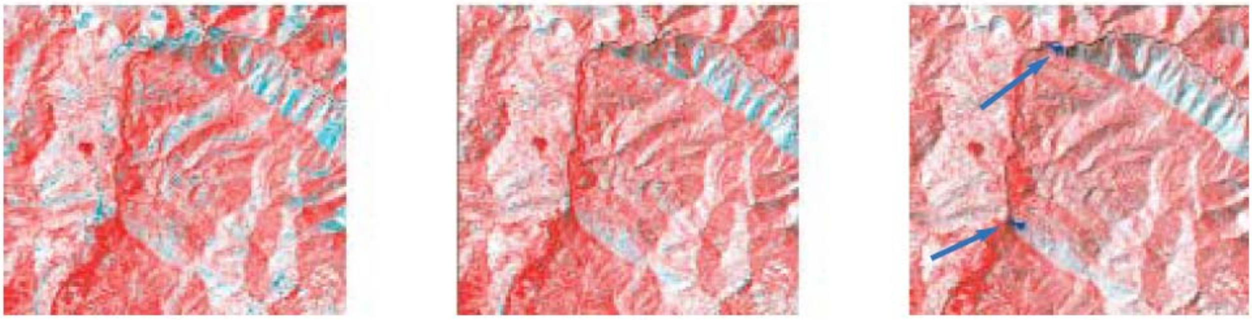
The purpose of the project to assess the man impact on forests in European part of Russia was to generate 1:2 500 000 scale maps reflecting the consequences of 1980-2006 clearcuts. The project objectives included, in particular, the analysis of fresh clearcuts, burnt, underwood and middle-aged forest stand spatial distribution. This method was based on the stage-by-stage comparison of multi-temporal images of the same area and on change detection. Greenpeace Russia and NGO Transparent World were involved in this project implementation. Overview of remote sensing data used in the project is presented in the table below.

A serious problem during the multi-temporal images analysis was the requirement of geometric correction with maximum possible accuracy of rasters spatial overlay for further change detection.

**Space images used to for forest cover monitoring**

| Satellite | Scanner | Swath width, km | Number of channels | Spatial resolution, m | Acquisition date | Data source |
|---|---|---|---|---|---|---|
| Landsat-4/5 (USA) | MSS | 185 | 4 | 80 | 1982–1999 | GLCF* |
| | TM | 183 | 6; 1 thermal | 30; 120 | | |
| Landsat-7 (USA) | ETM+ | 183 | 6; 1 pan, 1 thermal | 30; 15; 60 | 1999–2005 | GLCF |
| SPOT-2 (France) | HRV | 60 | 3; 1 pan | 20; 10 | 2006 | ScanEx R&D Center |
| SPOT-4 (France) | HRVIR | 60 | 4; 1 pan | 20; 10 | 2006 | ScanEx R&D Center |
| IRS-1C/1D (India) | Liss-3 | 142 | 3; 1 thermal | 23,6; 70,5 | 2006 | ScanEx R&D Center |
| | Pan | 70 | 1 | 5,8 | | |

* http://glcf.umiacs.umd.edu/index.shtml



а) б) в)

**Automatic geolocation and geometric correction of images in ScanEx Image Processor 2.0:**
**а) source Landsat-7 (ETM+) and IRS (Liss-3) overlaid images**
**б) co-registered images after automatic co-registration**
**в) co-registered images after automatic co-registration with preliminary geolocation based on control points (shown with arrows)**

The tasks were complicated by the fact that images had different spatial resolution (6–80 m).

Geometric correction – is the transition from the image coordinate system to the cartographic one. Additional data is required for “correct” correction – ground control points (GCP) with known geographic coordinates and digital elevation models (DEM). ScanEx Image Processor, along with standard geolocation tools, has a fully-automatic tool of separate channels and images combination, called co-registration.

In our case co-registration is the combination of two or more raster images. It is required to select one of the rasters as a reference, then find control points, connecting the reference and processed rasters and do the transformation. During automatic co-registration GCPs are searched for using the automatic raster images correlation. The method of hierarchy image correlation, enabling to search for GCPs with sub-pixel accuracy for images with different spatial resolution, has been developed in this software application. On the upper levels of hierarchy smaller-size copies (scale pyramids) of images are used in search for ground control points, whereas the co-registration of images occurs on the lower level. The lower the level is - the smaller is the size of local window and search radius. Such pattern considerably expedites the processing.

Here is the example of the multi-temporal and multi-sensor images processing technique, employed in the project. At first stage a complete coverage of reference ortho-rectified images, acquired by ETM+ sensor onboard Landsat-7 satellite, for the entire territory was created. All other (earlier or later) images were co-registered with ETM+ images in automatic co-registration mode in ScanEx Image Processor software. Notably, the automatic co-registration of rasters being processed with reference layer basically meant their geometric ortho-correction, which was especially important for IRS images.

Best results in accuracy and speed of in-line image geolocation were achieved in the mode, when images were first manually co-registered based on two-three typical GCPs and then co-registered automatically (see figure).

For automatic co-registration with reference Landsat-7 (ETM+) layer using a PC with Intel Pentium 4, CPU 3,2 GHz and 3 GB RAM it took: about 1 min for Landsat (MSS, 4 bands and TM, 5 bands), 3 min for IRS (Liss, 3 bands), 10 min for IRS (PAN, 1 band), around 4 min for SPOT-2, -4 (4 bands). Therefore, geometric transformation of about 80 multi-temporal and multi-sensor images, used in the project, was done within 5 man/days. In the same manner ScanEx Image Processor’s co-registration module was used by Greenpeace Russia when working on the “World’s Intact Forests Landscapes” and “Sochi Olympics” projects (for Sochi national park).

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