First Results of Data Base Analysis for Bolshemurtinskii

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1. Data Base

The data base used in this analysis comprises the four test sites in the Bolshemurtinskii forestry enterprise located in the central part of the Krasnoyarsk Oblast. The area is relatively flat which means that the distortion of radar images by the topography is modest. The ERS data come from the scene with track 348 and frame 2457. Two of the four test sites are only partly covered by this scene, i.e. not all data from the Bolshemurtinskii forestry enterprise enter into the analysis. The three images available for this scene are listed in Table 1 and the weather conditions during the acquisitions can be seen in Figure 1. The days before the September 1997 acquisitions were characterised by relatively high temperatures with day time maxima up to 20°C and night time temperatures above 5°C. Some rain (≈ 5 mm) fell 5 day prior to the first ERS tandem acquisition. Also for the summer 1998 image temperatures were well above 0°C with some 25 mm of rainfall in the three days interval before the image take.

The generation of a DEM was possible and hence ERS GTC products are available. To generate the ERS data base we used the "erode" programme with 2 pixels and the "p_av" programme.

Image	Mission	Orbit	Date
ERS-1 Tandem	ERS-1	32400	September 25, 1997
ERS-2 Tandem	ERS-2	12727	September 26, 1997
Third Image	ERS-2	16735	July 3, 1998

Table 1: ERS images from track 348, frame 2457.

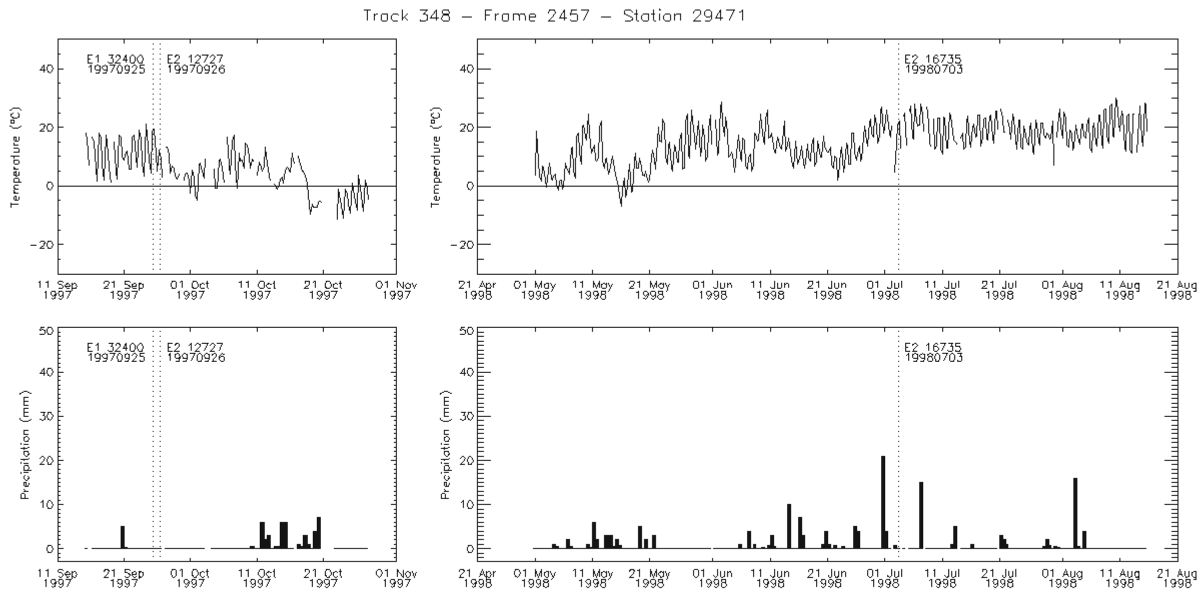

Figure 1: Temperature and precipitation series from station 29471 (93.13°E, 56.90°N). The acquisition dates of the ERS images are indicated by the vertical lines.

2. Analysis Method

For a quick visual analysis of the relationship of radar parameters with selected ground parameters we have developed some IDL routines. For example, Figure 2 shows the User Interface to display various radar parameters versus growing stock volume. The user interface allows for example to chose the test sites, the radar parameters (e.g. σ^0 in natural or logarithmic units), and the minimum number of pixels of the ground truth polygons. Other routines to display radar parameters versus land cover category, dominant tree species, and average tree height are available. We are happy to provide the IDL code to any partner who might be interested. But attention: IDL programming knowledge is necessary to adapt the IDL routines for reading different data base formats. In the future the routines will also allow to display JERS data.

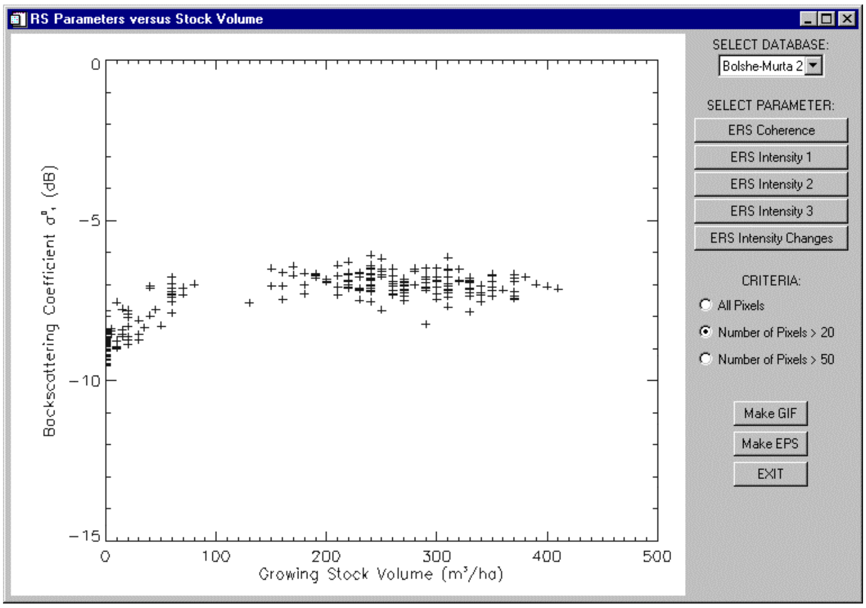

Figure 2: User Interface for displaying various radar parameters versus growing stock volume.

In the following chapters, the dependencies of the coherence, backscatter intensities, and backscatter intensity changes on

- land cover category;
- stock volume;
- dominant tree species;
- average tree height;

are discussed. In all following plots data stem from all ground truth polygons that are covered by the ERS scene, i.e. from all four test sites.

3. Stock Volume

For all four test sites the functional dependence of the radar parameter on growing stock volume is more or less the same, which indicates a high quality of the GTC products over the entire scene. This is in fact the reason why data from all test sites can be meaningfully included in one plot. Figure 3 shows the scatter plot coherence ρ (20 pixels) versus growing stock volume. It is remarkable that there are hardly any outliners, at least in the case when only polygons with a size greater than 20 respectively 50 pixels are displayed. For growing stock volumes at and close to zero ρ is around 0.7. With increasing growing stock volume ρ decreases until about 100 m^3/ha. From then on the average value of ρ is about 0.4.

Plots of the backscatter intensity σ^0 versus growing stock volume can be seen in Figure 4. As expected there is very little correlation between these two quantities, but still an increase of σ^0 until growing stock volumes of about 100 m^3/ha is clearly visible. This is not just the case for the summer acquisition (as displayed in Figure 4) but also for the two tandem images from September 1997. If only data from one test site would have been shown then this functional dependence would have been even more evident (Figure 2).

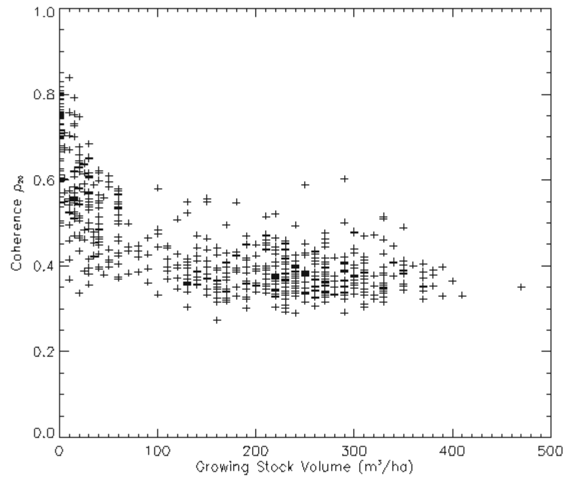

Figure 3: Coherence from 20 pixels window versus growing stock volume (m^3/ha) for polygons greater in size than 20 (left) respectively 50 (right) pixels.

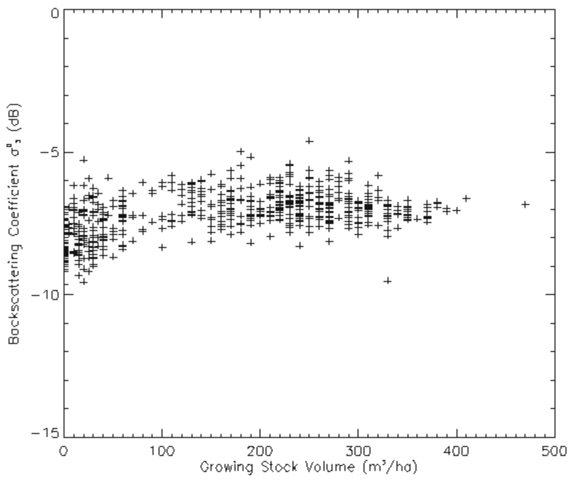

Figure 4: Backscattering coefficient σ^0 in decibels versus growing stock volume (m^3/ha) for the summer acquisition (July 3, 1998) for polygons greater in size than 20 (left) respectively 50 (right) pixels.

As a last point, we ask if there is a relation between growing stock volume and backscatter intensity changes. In principle, one might expect that for high growing stock volumes σ^0 remains rather stable (when the trees carry leaves at both acquisitions), while for low values σ^0 may change due to vegetation phenology and changes in the dielectric properties of the ground surface. The left-hand side plot of Figure 5 shows the difference of the images from September 25 and July 3 (in dB). One can recognise that there is hardly any change between these two images, apart from a small increase by about 0.5 dB from September to July for growing stock volumes smaller than about 100 m^3/ha σ^0. The wetter soil conditions in July might serve as explanation. On the other hand, there is a more significant change between the two tandem images. The right-hand side plot of Figure 5 shows that σ^0 values decrease by 1 dB from September 25 to 26, independent of growing stock volume. Such a short term change cannot be related to vegetation cover effects. Therefore one might speculate that either the ground surface was drier on September 26 than on September 25 or that due to dew there was some free water in the vegetation canopy on September 25. It is however remarkable that this effect is not moderated by the vegetation cover.

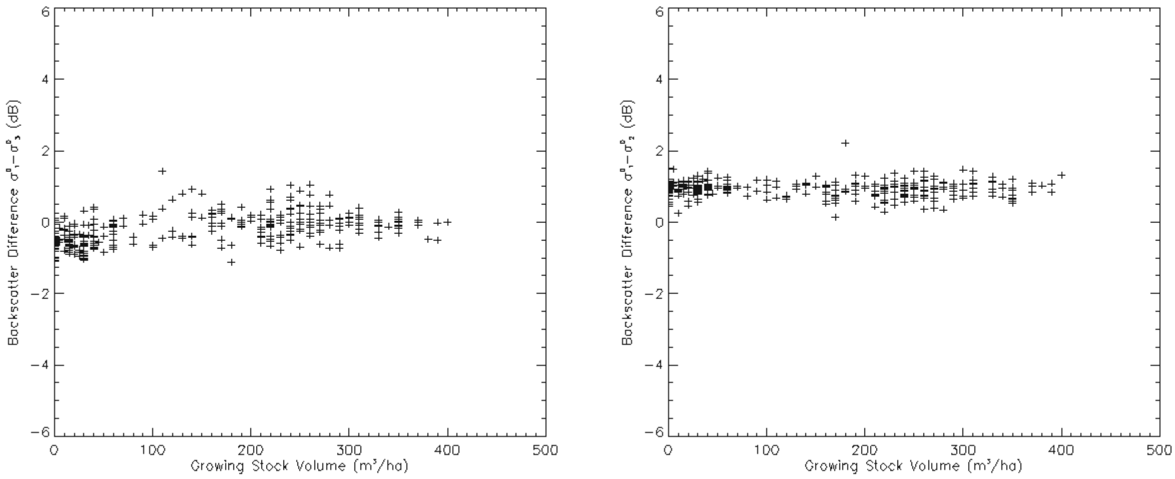

Figure 5: Backscatter intensity change between ERS-1 tandem (September) and summer (July) acquisition (left side) and ERS-1 and ERS-2 tandem acquisitions (right side) in m for polygons greater in size than 20 pixels.

4. Land Cover Category

In the Bolshemurtinskii forestry enterprise only six land cover categories occur: natural stand, unclosed natural forest, forest plantation, unclosed forest plantation, burned forest (only one polygon), and clear cut area. Figure 6 shows the expected relative dependence of the coherence ρ (derived from 20 x 20 pixels windows) on these land cover classes: clear-cut areas and burned forest are high coherence areas with ρ values greater then about 0.6. Forested areas are characterised by lower ρ values, but do not decrease below 0.3. Also for the backscatter intensity the expected dependencies can be observed (Figure 7) but the differences between the classes are small. Also, as the discussion the last chapter has shown, σ^0 does change within the classes from one acquisition to the next.

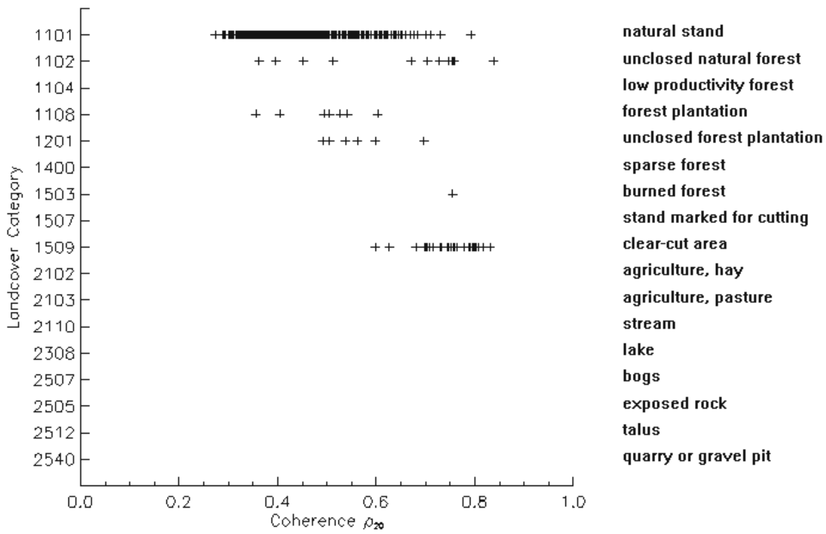

Figure 6: Coherence from 20 pixels window versus land cover categories for polygons greater in size than 20 pixels.

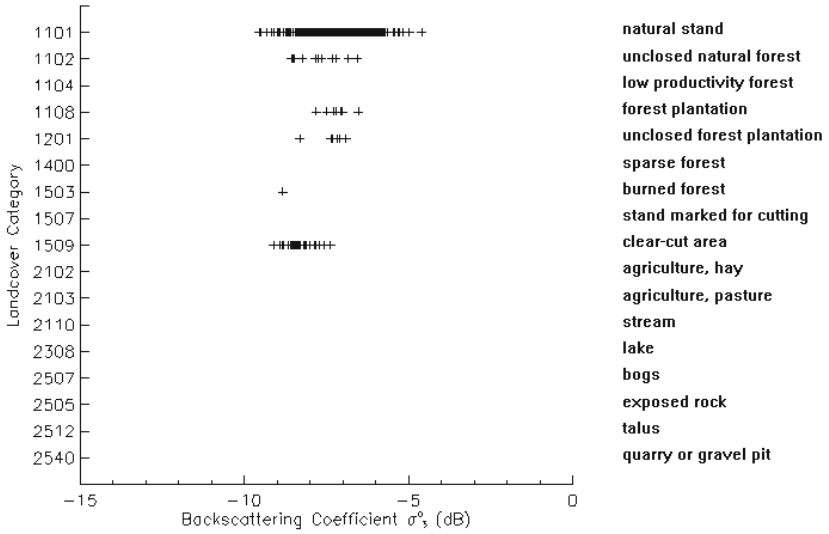

Figure 7: Backscattering coefficient σ^0 in decibels versus land cover category for the summer acquisition (July 3, 1998) for polygons greater in size than 20 pixels.

5. Dominant Tree Species

The "dominant tree species" of one polygon was defined as the tree species for which the KF number (composition) is greater than 5. If in a stand no species has a KF greater than 5 then no dominant tree species is given. Clearly, this definition represents an oversimplification, but should still allow to investigate how the different structure of the different trees influences the backscattering behaviour. Let us first regard the coherence. Figure 8 shows that ρ is basically independent of tree species. There is also no difference between evergreen and deciduous trees. This suggests that the leaves were still on the trees on September 25/26, a hypothesis that is supported by night time temperatures above 5°C in the preceding few days. Like ρ, also the backscattering coefficient σ^0 does not provide information on tree species, neither the absolute value (Figure 9) nor the backscatter change.

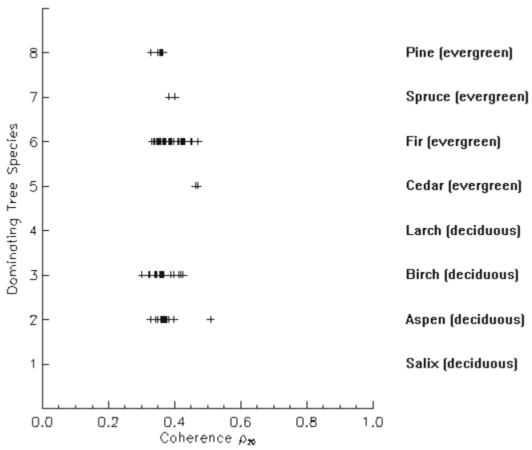

Figure 8: Coherence from 20 pixels window versus dominant tree species for polygons greater in size than 50 pixels and for growing stock volume greater than 100 m^3/ha.

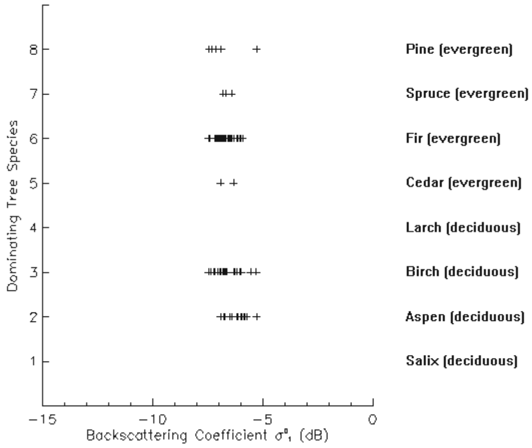

Figure 9: Backscattering coefficient σ^0 in decibels versus land cover category for the ERS-1 tandem acquisition (September 25, 199) for polygons greater in size than 50 pixels and for growing stock volume greater than 100 m^3/ha.

6. Average Tree Height

The average tree height was defined as the tree height of the different species within one polygon weighted by the KF number. As this quantity should be related to growing stock volume similar relationships with radar parameter should be observed. This is indeed the case as can be seen in Figures 10 and 11. It is eyecatching that a saturation effect, as has been observed at around 100 m^3/ha growing stock volume, is not evident in the plots of ρ and σ^0 versus average tree height. Also the correlation is better: for ρ the coefficient of determination R^2 is 0.75 for average tree height and 0.6 for growing stock volume; for σ^0 the values are 0.49 and 0.4 respectively.

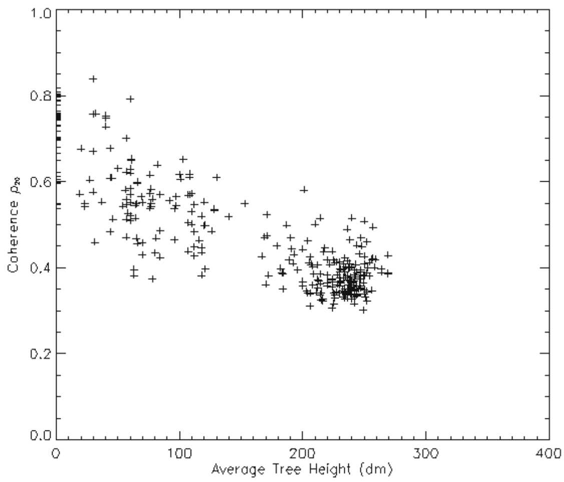

Figure 10: Coherence from 20 pixels window versus average tree height for polygons greater in size than 50 pixels.

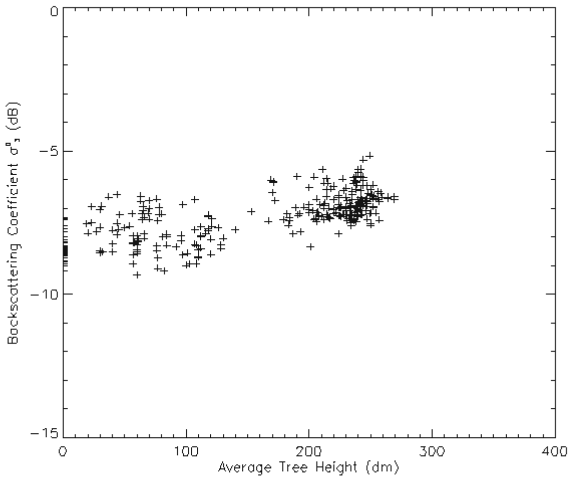

Figure 11: Backscattering coefficient σ^0 in decibels versus average tree height for the summer acquisition (July 3, 1998) for polygons greater in size than 50 pixels.

7. Conclusions

The results demonstrate the high quality of both the ground truth data base from the Bolshemurtinskii forestry enterprise (forest inventory was updated in 1998) and the ERS GTC products. Also, it must be mentioned that the area is rather flat. In general, the analysis confirms the dependence of the coherence on growing stock volume and land cover category, but in this example, also σ^0 may provide some relevant information. Backscatter intensity changes on the other hand seem to bear no information. As expected no relationship with tree species could be found. Further, a good relationship to average tree height was found, and it is suggested that this parameter is considered in further analysis.