Mapping Roughness Length in Urban and Suburban Areas using ERS Interferometric SAR Data

A contribution to subproject SATURN

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Summary

For an area near Bonn, Germany several tests with synthetic mode ERS SAR interferometry data as well as with CORINE land use data have been performed. The major aim of the tests was to investigate how the typical scattering of the relative phase measurement found in the synthetic interferometry correlates with the aerodynamic roughness length. The results show a high correlation between roughness classes derived as a function of the standard deviation of the unwraped phase within a 500m x 500m grid cell and the roughness for all major land use categories.

Aim of the research

Transport velocity and deposition rates of atmospheric pollutants, such as SO_x, NH_x, NO_y, vary with the structure of the surface. This structure, called roughness length, is required by environmental pollutant transport and deposition models. Until now land use data from optical remote sensing systems were used to map roughness length. The disadvantage of this method is the uncertainty in the image classification, and the high cost of data processing. The data source for roughness length can be the interferometry with Synthetic Aperture Radar (INSAR). The interferometry technique is described in detail by Hartl and Thiel(1993). The principal aim of the research is the development of a mapping procedure for roughness length from synthetic ERS interferometry and real mode SRTM data.

Activities during the year

For the research area Bonn a subdomain grid has been created using the MM5 TERRAIN preprocessor. Its dimensions are 49 cells with 37 rows, the cell size is 500 meters and the projection is Lambert. Images of the image pair acquired at 26.03.92 and 29.03.92 with a baseline length of 107 meters were processed. The unwrapped ERS SAR interferometry data were projected to Lambert and intersected with the subdomain grid. For each grid cell the standard deviation of the unwrapped phase has been calculated and transformed into 4 roughness classes. As shown in previous reports the scattering magnitude of the phase values depends in the synthetic interferometry on the length of the base line. Therefore, the roughness classes cannot directly be converted into roughness length values. Real mode interferometry data from the SRTM mission will help to overcome the problem of varying base line lengths.
Evaluation of the developed method requires comparison data. Therefore, two additional roughness length maps of the research area have been derived. The first one is based on the land cover data from the CORINE land cover mapping program. For each grid cell the majority land use category has been calculated. Assuming that each land use category forms a roughness class, roughness length values have been assigned to each land use category (see Table 1). The second map is based on a method developed by Van Dop (1983). The average z_0 values in a 500 x 500 m grid are calculated as an area-weighted averages of a drag coefficient C_D

determined in each grid. The method assumes that the roughness length of a particular area can be determined by roughest sub-area within it. The maximum roughness length values produced by this method are lower compared to those produced with the majority land use.

Table1 Roughness length (z_0)values for major land use categories (Deursen et al., 1993)

Land Use Category	Roughness Length in cm
Open water large	1
Open water small	8
Agriculture	15
Low vegetation area	15
Urban	100
Deciduous forest (closed canopy)	121
Coniferous forest (closed canopy)	134

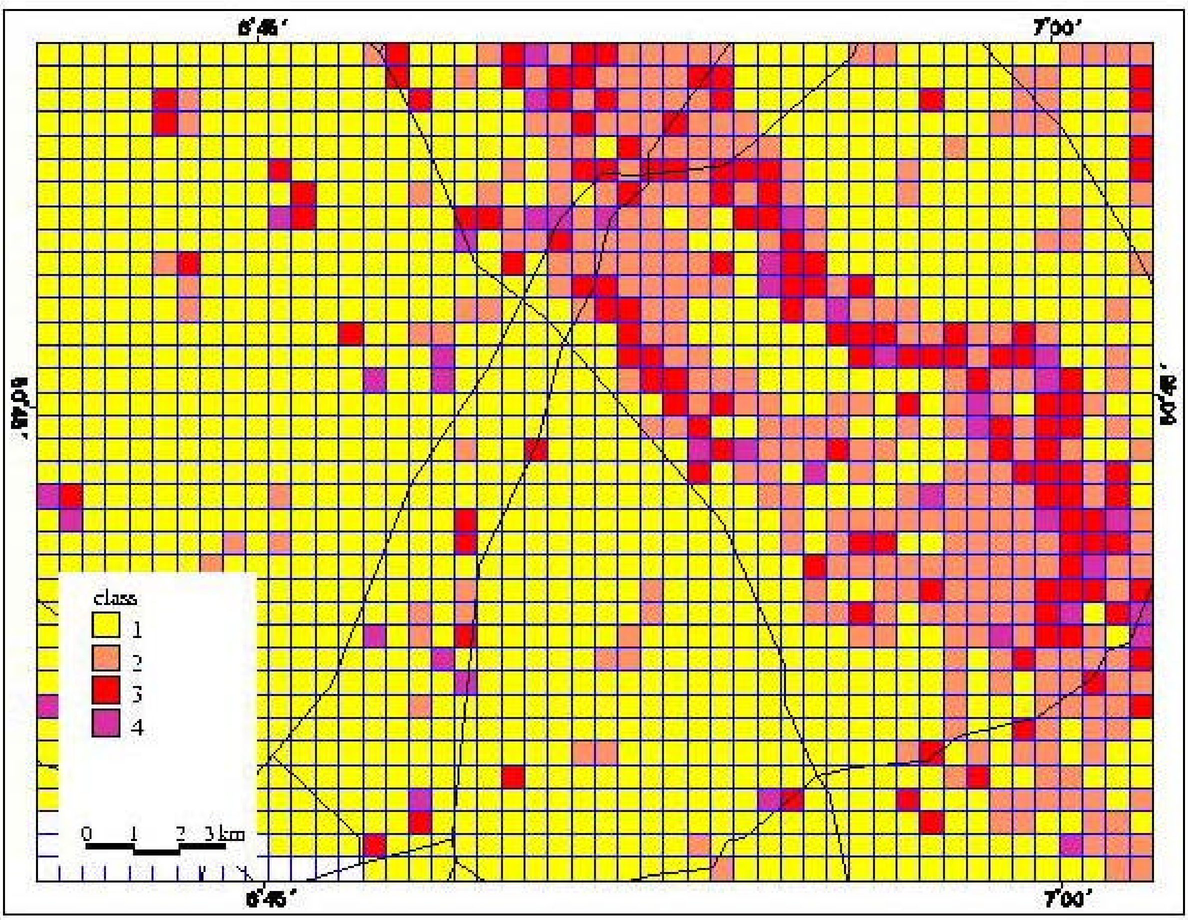

Figure 1 Roughness class derived from synthetic interferometry data

Principal results

The results of the roughness class mapping with interferometry data are shown in Figure 1. Compared to the roughness length map derived from the CORINE land use data (see Figure 2) similar patterns are found. Highest values occur within forest and urban areas. Also, more details can be seen related to scattered trees and scrub and scattered urban areas. It must be pointed out that the roughness classes depicted in Figure 1 have been calculated without knowledge of the land use. However, there is one exception. Waters show a very high standard deviation values. The reason is the decorrelation caused by significant change of the object between the acquisition of the image pairs. This should, however, only occur in the synthetic interferometry.

Problems:

- The magnitude of the phase scattering used as measure for the roughness depends in the real mode interferometry on the base line length.
- Moving objects cause a decorrelation and are interpreted as a high roughness class
- The scattering may be only a result of a decorrelation in the synthetic interferometry and not related to the roughness of the surface. However, tests with real mode air-borne interferometry data conducted in 2000 indicate such scattering even in the real mode.

Main conclusions

Although a universal function for transforming roughness classes in the roughness length values is not available yet it can be stated that the interferometric SAR-Data is a very promising source of information for mapping roughness length required by environmental models. The studies show that comparable data can be obtained using interferometric data..

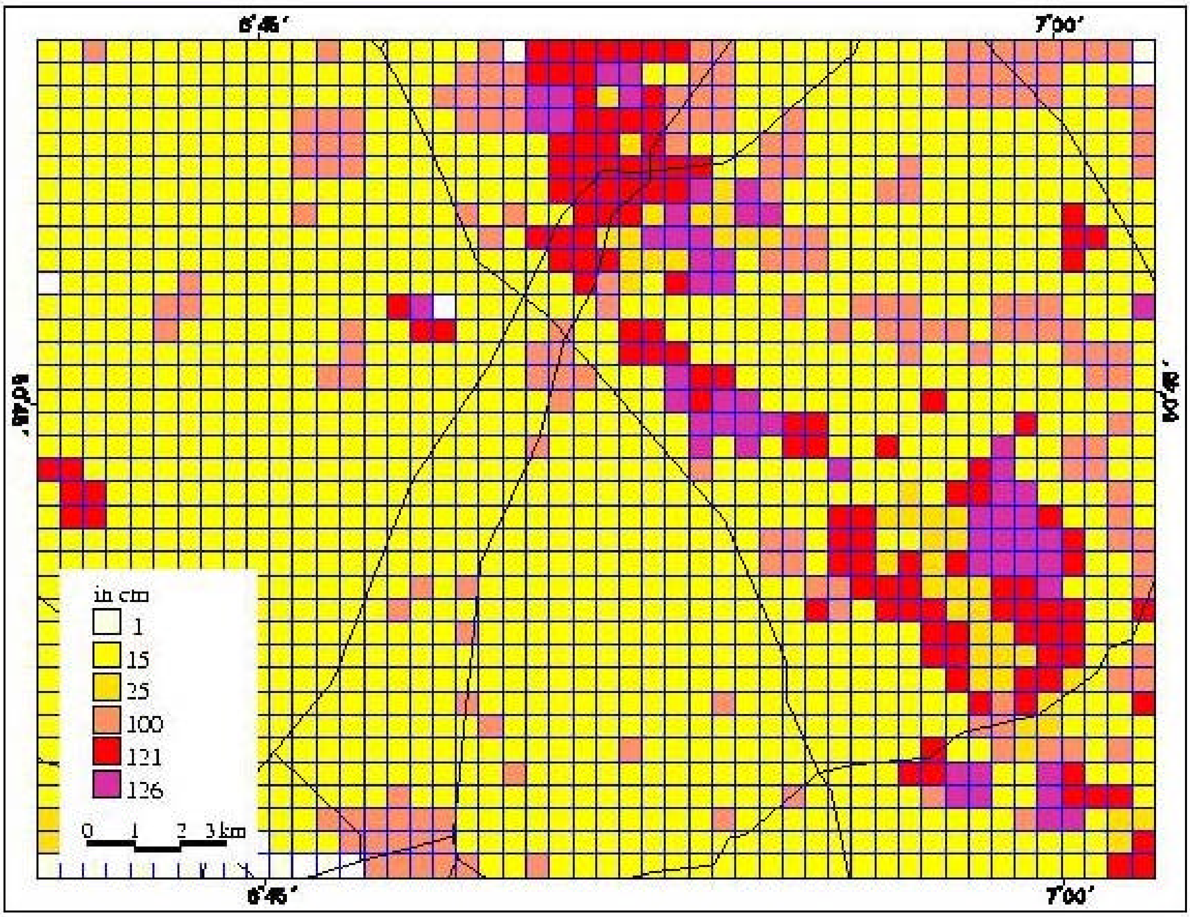

Figure 2 Roughness length map derived from CORINE land use data

Aims for the coming year

The main aim for the coming year is the acquisition and use of real-time interferometry data from the SRTM-Shuttle Mission. The processing of the SRTM SAR data has been started at the

DLR, Oberpfaffenhofen, end of the year 2001. These data will be used to study the influence of the decorrelation in the synthetic interferometry. In addition, transfer function for the calculated phase standard deviation classes to the roughness length will be investigated.

References

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