Satellite-Derived Roughness Data for Hydrology Applications in Areas Affected by Urbanization

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Purpose of the Study

Satellite radar images are a new source for roughness data. This study compares the new dataset to conventionally used datasets in order to evaluate its usability and constraints.

Study Site

The 150 km^2 Walnut Gulch Experimental Watershed is located in southeastern Arizona. It is part of the San Pedro watershed and includes the town Tombstone. The semi-arid watershed is in the transition zone between the Sonoran and the Chihuahuan desert. The western part is dominated by shrub vegetation while the eastern part is dominated by grasses.

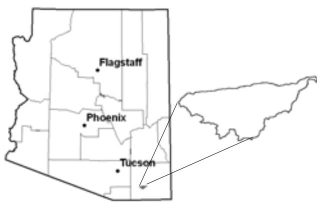

Figure 1: Location of the study site in Arizona

Data

Satellite Radar Data

Figure 2: A new approach by Rahman et al. (submitted) uses Radar satellite images to display surface roughness. The dataset is based on two Radar images with different incident angles. At least one Radar scene with dry ground conditions is necessary in order to extract surface roughness from the backscatter signal. The roughness is measured as average height of micro-topography per pixel. The unit is centimeters. The signal includes surface and subsurface rock fragments as well as vegetation to a certain degree. Thus, the data is suitable for areas with sparse vegetation such as southeastern Arizona.

Traditionally Used Data

Figure 3: A dataset which is traditionally used in hydrologic modeling is based on the Southwest ReGAP land cover dataset. A look-up table with Manning's N roughness values for each land cover class is available for the AGWA hydrological modeling package. There are five value classes.

Figure 5: As part of a Ph.D. thesis Sano (2000) conducted pinmeter measurements in Walnut Gulch. These measurements show micro-topography similar to the radar roughness image with the difference that the pinmeter does not penetrate the soil. These data are available as point files which resemble the average of three measurements at one location.

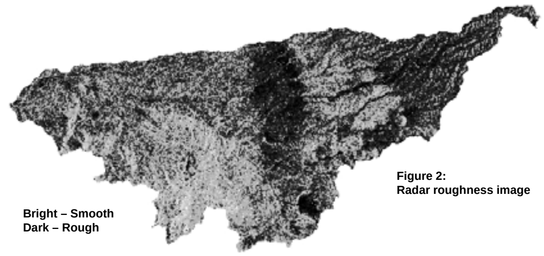

Figure 2: Radar roughness image

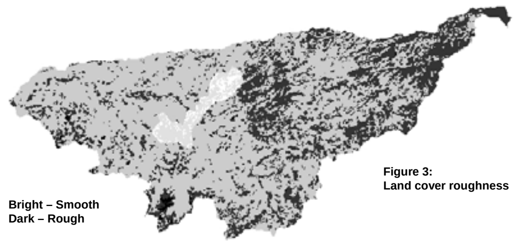

Figure 3: Land cover roughness

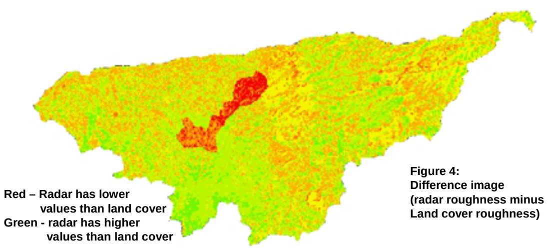

Figure 4: Difference image (radar roughness minus Land cover roughness)

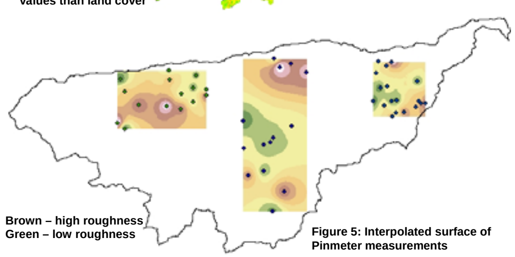

Figure 5: Interpolated surface of Pinmeter measurements

Method

In order to display differences between the two roughness images it was necessary to bring the units into a common format. The units of the radar image was RMS height in cm per pixel while the units for the land cover roughness was Manning's N (s/m$^{0.33}$). A z-value was calculated for both images. This allowed to subtract one image from the other in order to reveal differences.

Figure 4 shows the subtracted image (radar minus land cover). Orange and red colors show areas with lower radar roughness values than land cover roughness values. Green colors show areas where the radar roughness is higher than the land cover roughness. Yellow areas delineate areas with minor differences between the two roughness images.

The third dataset consisted of 47 pinmeter measurements that were available as point data. The point data were interpolated to a surface using the IDW method. Further research will compare the point data to the matching grid cells in the two roughness grids.

Preliminary Results and Conclusion

The visual comparison of the radar roughness image and the land cover roughness image shows that certain features come out in both images. It is also noticeable that the radar image shows higher data resolution with floating point values instead of five classes for the land cover roughness, as well as higher spatial resolution.

Problems of the radar image are speckle (noise) and influences of topography. The problem for the land cover roughness is that it is estimated and leaves soil or topography information completely out.

The difference image (Figure 4) shows that the radar roughness is lower in low roughness areas and higher in high roughness areas. This supports the idea of higher data resolution in the radar image. Also visible is that the values for urban areas deviate a lot between the two datasets. The urban area does not stand out in the radar image at all.

The results suggest that radar roughness can be a useful input in hydrologic models. However, effects of urbanization were not visible in the radar data. Further research needs to reveal if the added detail in the radar roughness is useable data or speckle (noise).