# Monitoring and modelling surface moisture in north-east Jordan using ERS SAR data

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## Abstract

The monitoring and modelling of soil moisture is important both for hydrological and geomorphological studies. In semi-arid and arid regions the measurement and monitoring of soil moisture conditions is made more difficult because of unpredictable rainfall, the nature of desert soils and sediments, accessibility and the costs of financing projects. Remotely sensed data offers good temporal and high spatial coverage at a reasonably low cost. To assess the usefulness of a remote sensing approach to soil moisture monitoring in desert regions, a time series of ERS-1 and ERS-2 SAR images were acquired between March 1995 and April 1998 of the north-eastern desert of Jordan. Previous research has demonstrated the sensitivity to soil moisture and surface roughness of the backscatter coefficient of the ERS SAR system. The following objectives were addressed: (1) To assess and exploit the ability of the ERS SAR instrument to monitor geomorphological and hydrological changes in the desert environment. (2) To calibrate theoretical microwave scattering models using field reference data (soil moisture, surface roughness, soil texture, climatic parameters and vegetation) and assess their application to desert environments. (3) To simulate the dependence of the backscatter coefficient on soil moisture fluctuations and surface roughness changes with the aim of improving the understanding of microwave interactions with desert surfaces. (4) To investigate the potential for extraction of quantitative soil moisture estimates from ERS SAR data.

Analysis of multitemporal backscatter coefficients, expressed in decibels (dB), for some desert surfaces show fluctuations of up to 6 dB during or after periods of rainfall. Basalt boulder or stone surfaces show very stable backscatter properties regardless of soil moisture conditions. This is because the roughness parameter dominates the scattering mechanism. Detailed analysis of surface roughness measurements and calculations are presented. To understand the scattering processes, the physical optics (PO), geometric optics (GO), small perturbation (SP) and integral equation models (IEM) were calibrated using field data. The results show the limitations of using the PO, GO and SP models in this natural environment, caused by the restrictive model validation domains. The calibration of the IEM yielded much better results, correlation coefficients greater than 0.8 were achieved between predicted and observed backscatter coefficients. Retrieval of soil moisture estimates with the IEM yielded a confidence level of 80%.

ERS SAR has demonstrated an ability to detect changes in the surface properties of desert surfaces. However, to improve model accuracy, detailed information on surface roughness properties, or a second image band of data is necessary. Future research should focus on interferometry and multi-parameter systems (e.g. ENVISAT) to improve dryland soil moisture estimates.