DERIVATION OF SURFACE SOIL MOISTURE USING MULTI-ANGLE ASAR DATA IN THE MIDDLE STREAM OF HEIHE RIVER BASIN

Shuguo WANG[(1)(2)], *Xin LI* [(1)] , *Rui JIN*[(1)]

(1) Cold and Arid Regions Environmental and Engineering Research Institute of Chinese Academy of Sciences, Lanzhou, 730000, P.R.China

(2) Graduate University of Chinese Academy of Sciences

Email: sgwang@lzb.ac.cn

ABSTRACT

Soil moisture is a key state variable of the land surface and governs important process such as the rainfall-runoff transformation and the partitioning of latent and sensible heat fluxs. The variation of soil moisture and its spatial distribution is highly dynamic and need to be monitored frequently. Heihe river basin is a typical in-land river basin in northwest of China, and the selected study region is the artificial oasis in the middle stream of the watershed, which is in semiarid area. Therefore, the management of water resources is very significant for crop yield, environment protection and other things relating to the people daily life.

SAR remote sensors measure microwave energy backscattered by natural surfaces. This scattered energy depends on the geometrical and the dielectric properties of surfaces. A large body of literatures has discussed the feasibilities and methods to derive surface soil moisture from SAR observations, whatever in bared or vegetation covered soils. However, the influence of soil roughness on the scattering progress limits the ability to correctly estimate volumetric water content values unless detailed roughness measurements are acquired.

In this study, we propose using several temporally closed (25/27/28, June, 2008), APP mode (HH-HV), ENVISAT-ASAR images to retrieve surface roughness and soil moisture simultaneously. The main steps are, 1) Firstly, the process of the multi-angle images, including calibration, noise filter, and, for the test site is relatively flat in terrain, so it is unnecessary to rectify the geometric distortion dependent on the DEM, a good image-to-image registration have been done and which was essential for this study since backscatter of corresponding pixels of two images were differenced in computing roughness of that pixel. 2) Some researchers have reported that the difference in backscatter ($\Delta\sigma_0$) between two different incidence angles, keeping all other parameters constant, is in proportion to roughness only. Thus, in the second step, based on the simulations of the most widely-used, physically based surface backscattering model, Advanced Integral Equation Model (AIEM), we could find the $\Delta\sigma_0$ has good relationship with the functions of the roughness parameters, consequently, we could obtain the correlation length (l) and root mean squared height (*rms*) variation of the surface. 3) Finally, the soil moisture could be inversed pixel by pixel in virtue of the estimation of the roughness parameters in step 2 combined with the forward model AIEM.

The study area was chosen in Linze grassland observation station (100°04′E, 39°15′N, 1394 m in elevation). The land use types are diverse in this area, with wetland, grassland, salinized bare soils and crop fields distributed in the vicinity. Ground truth measurements took place on 27, June, 2008. We setup 5 different sample sites, each one is 360m×360m in size, sites B and C are sali-alkalization land with short grass sparsely covered which could be regarded as bare soils, while the vegetation cover in site A is bulrush, alfalfa and barley are planted in site D and E respectively, both of them are irrigated farmland. The surface soil moisture (0-5cm) surveyed by Time Domain Reflectometry (TDR) in sites D and E, for the sake of saline effect,

gravimetric sampling method were adopted in other 3 sites. Besides, we made the measurement of surface roughness by using the pin profiler to get the two statistical parameters, *l* and *rms* height at each water content sampling point.

The retrieved results show it is a good agreement with the ground-measured soil moisture in bare soils, whereas a discrepancy exists in vegetated areas. After using the simple but effective water-cloud model to diminish the vegetation scattering effect, the inversion results could be improved as well. The difference between the estimated and ground measured roughness *rms* height value maybe owing to the mismatch of the observation point scale and the retrieved pixel scale.

REFERENCES

[1] A.K. Fung, Z. Li and K. Chen. "Backscattering from a Randomly Rough Dielectric Surface," *IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING,* vol. 30, pp. 356-369, 1992.

[2] K.S. Chen, T.-D. Wu, L. Tsang, Q. Li, J. Shi and A.K. Fung. "Emission of Rough Surfaces Calculated by the Integral Equation Method With Comparison to Three-Dimensional Moment Method Simulations," *IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING,* vol. 41, pp. 90-101, 2003.

[3] M. Zribi and M. Dechambre. "A new empirical model to retrieve soil moisture and roughness from C-band radar data," *Remote Sensing of Environment,* vol. 84, pp. 42-52, 2002.

[4] M. Zribi, S.L. He¡ägarat-Mascle, B.K. C. Ottle¡ä and C. Guerin. "Surface soil moisture estimation from the synergistic use of the (multi-incidence and multi-resolution) active microwave ERS Wind Scatterometer and SAR data," *Remote Sensing of Environment,* vol. 86, pp. 30-41, 2003.

[5] M. Zribi, N. Baghdadi, N. Holah, O. Fafin and C. Gue¡ärin. "Evaluation of a rough soil surface description with ASAR-ENVISAT radar data," *Remote Sensing of Environment,* vol. 95, pp. 67-76, 2005.

[6] N. Holah, N.B. T, M. Zribi, A. Bruand and C. King. "Potential of ASAR/ENVISAT for the characterization of soil surface parameters over bare agricultural fields," *Remote Sensing of Environment,* vol. 96, pp. 78-86, 2005.

[7] M. Rahman, M. Moran, D. Thoma, R. Bryant, C.H. Collins, T. Jackson, B. Orr and M. Tischler. "Mapping surface roughness and soil moisture using multi-angle radar imagery without ancillary data," *Remote Sensing of Environment,* vol. 112, pp. 391-402, 2008.

[8] E.P. Attema and F.T. Ulaby. "Vegetation modeled as a water cloud," *Radio Science,* vol. 13, pp. 357-364, 1978.

[9] A. Loew, R. Ludwig and W. Mauser. "Derivation of Surface Soil Moisture From ENVISAT ASAR Wide Swath and Image Mode Data in Agricultural Areas," *IEEE Transactions on Geoscience and Remote Sensing,* vol. 44, pp. 889-899, 2006.

[10] Y. Oh, K. Sarabandi and F.T. Ulaby. "An Empirical Model and an Inversion Technique for Radar Scattering from Bare Soil Surfaces," *IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING,* vol. 30, pp. 370-381, 1992.

[11] P.C. Dubois, J.v. Zyl and T. Engman. "Measuring Soil Moisture with Imaging Radars," *IEEE Transactions on Geoscience and Remote Sensing,* vol. 33, pp. 915-926, 1995.

[12] J. Shi, J. Wang, A.Y. Hsu, P.E. O'Neill and E.T. Engman. "Estimation of Bare Surface Soil Moisture and Surface Roughness Parameter Using L-band SAR Image Data," *IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING,* vol. 35, pp. 1254-1266, 1997.

[13] M. Zribi, N. Baghdadi, N. Holah and O. Fafin. "New methodology for soil surface moisture estimation and its application to ENVISAT-ASAR multi-incidence data inversion," *Remote Sensing of Environment,* vol. 96, pp. 485-496, 2005.