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Sensitivity of TerraSAR-X interferometric data during crop growing season

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Few studies deal with crop parameters monitoring (especially crop height) by using interferometric data. They are mainly based on satellite images acquired at C-band by ERS1/2 by using the repeat-pass method. The recent launched of new generation of spacecraft allows acquiring successive images at shorter revisit time and at higher spatial resolution (several meters).
The objective of this study is to evaluate the potentialities of X-band radar interferometric data for crop monitoring. Multi-temporal interferometric coherence time courses are analysed together with the sensitivity to the vegetation height for five crops (corn, rapeseed, soybean, sunflower and wheat). Coherence results are compared with those obtained with backscattering coefficients and optical data.

The study is in the framework of the MCM'10 experiment (http://www.cesbio.ups-tlse.fr/fr/mcm.html) carried out over an agricultural region located in the South West of France. Objectives of the experiment consist in improving knowledge on agrosystems functioning, combining ground measurements and high resolution satellite images acquired in optical, thermal and radar domains. Microwave data used in this work are provided by the SAR antenna functioning at 9.65GHz onboard TERRASAR-X satellite. Complex images are collected using StripMap (SM) and SpotLight (SL) modes at two contrasted incidence angles (27.3° and 53.3°) and at high spatial resolution (pixel spacing ranges from 1 and 3 m). Optical acquisitions are performed by Formosat-2, Spot 4/5 satellites. Ground measurements are collected the closest to each satellite acquisition (maximum offset of 2 days). They consist in qualitative (land use, agricultural practices...) and quantitative (crop height, crop biomass...) measurements. Overview of the experiment is given in Baup et al., 2012 presented in this conference.

The approach is based on the use of successive acquisitions to derive coherence maps, with a minimum time lag of 11 days (corresponding to the satellite repeat orbit cycle). Each images couple acquired with the same mode and same incidence angle is processed by using DORIS and ADORE softwares. Interferograms and coherence images are computed after co-registration. At the end, thirteen coherence images are computed at 27.3° in SM mode and nine at 53.3° in SL mode all along the year 2010.

The coherence temporal variations derived from SM mode at medium incidence angle (27.3°) are similar over summer crops (corn, soybean, sunflower). During the first phenological stages, from sowing to full vegetation cover, coherence values decrease from $\sim$0.9 to a saturation level close to 0.6. Empirical relationships, estimated between coherence and the vegetation height for those different crops, indicate two different periods: (i) a high sensitivity with an exponential decrease as vegetation height increases and (ii) a saturation phase for height values depending on the considered crop (45 cm for sunflower, 50 cm for soybean and 150 cm for corn). Whatever crops, a strong correlation is observed between ground data and coherence values (r^2=0.90, rrmse=10%). Similar analyses performed by using optical data (NDVI) and radar backscattering coefficient ( ) highlight the complementary of all these approaches.

This approach is in the framework of the next generation of satellite mission: COSMO-SkyMed, TamDEM-X, RADARSAT constellation mission (RCM)...