German Aerospace Center

Radar remote sensing – research for agriculture and climate

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The 2014 harvest season is coming to an end, and throughout Germany the signs are of good yields for wheat, corn and similar crops. But the differences are large depending on the location. Hence, for optimum cultivation, it is important to be constantly aware of the condition of the soil and the crops. Radar images are particularly suitable for providing large-scale observations – using an aircraft or a satellite.

Techniques and processes specific to radar remote sensing are being developed at the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) in Oberpfaffenhofen. The scientists have almost completed their test campaign for 2014 and have generated a comprehensive set of high-resolution radar images of agricultural areas that provide information on the entire growing period for crops. The radar measurements by aircraft and satellite were carried out from May to September 2014 over Wallerfing, near Deggendorf, in Bavaria. The data is supplemented with detailed measurements taken on the ground.

"For us it is a bonus that, thanks to the excellent cooperation with local farmers, a unique data set of field measurements exists for validating our Synthetic Aperture Radar (SAR) algorithms," says Thomas Jagdhuber from the DLR Microwaves and Radar Institute.

Local measurement, global significance

Depending on the wavelength, radar sensors can penetrate to ground level even through tall vegetation. In the recent study, the researchers have been using the F-SAR antenna developed at DLR to take measurements at different wavelengths. One image can then be used to gain wide-scale knowledge of various properties of a region, such as crop height, cultivation density, plant structure, soil roughness, soil moisture and biomass. These parameters are not only important for precision agriculture, but also for hydrological issues and climate research.

For example, the soil properties provide farmers with information for targeted irrigation or protecting their land against flooding or erosion. The measurements provide climate researchers with information on the water cycle and its interaction with the local climate. As a result, scientific forecasts for regional climate change and other effects can be improved.

The radar data on the biomass is equally valuable to climate researchers and farmers. As a natural carbon sink, biomass directly influences the greenhouse effect – a vital research area for climate experts. Farmers can use the biomass to estimate crop yields in advance for production of both food and energy (biogas).

Pioneering processes

However, the radar images do not immediately provide information on the individual parameters. The radar signals have to be differentiated before the information can be derived. To do this, the DLR developers use remote sensing methods such as SAR polarimetry, polarimetric SAR interferometry and polarimetric SAR tomography. These specific algorithms are then further refined for various parameters relating to each of the different stages of crop growth. As a result, the backscattering effect of crops and the soil can be separated and hence the soil moisture, ground roughness and vegetation parameters can be determined. “To do this, new algorithms for 3D characterisation of vegetation are being developed,” says Hannah Jörg from the DLR Microwaves and Radar Institute.

The ongoing developments are also being used during preparations for a new research project at the DLR Microwaves and Radar Institute – Tandem-L. This involves a proposal for a highly innovative radar satellite mission to observe Earth and its environment – globally, continuously and with unprecedented quality and resolution. The aim of Tandem-L is to observe the landmass of the Earth in 3D on a weekly basis and monitor critical environmental parameters. The associated research activities are combined into the Helmholtz Association (Helmholtz-Gemeinschaft; HGF) Alliance 'Remote Sensing and Earth System Dynamics', with cooperation from eight German research institutes and 11 universities. The flight campaigns were also organised as part of this project.

About the campaign

Flights over Wallerfing for radar remote sensing have been conducted since 2008 as part of a collaboration between the DLR Microwaves and Radar Institute (Irena Hajnsek, Ralf Horn) and the Department of Geography and Geographical Remote Sensing at Ludwig Maximilian University in Munich (Ralf Ludwig). The team has been using the DLR Dornier Do 228 research aircraft that is operated by the DLR Flight Experiments Facility in Oberpfaffenhofen.The target area of Wallerfing is particularly well suited to the research work because of the large range of crops grown there. Since 2010, it has been the official test area for reference measurements performed by the German radar satellite missions TerraSAR-X and TanDEM-X. In future, Wallerfing may also be used as a test area for the proposed Tandem-L radar satellite mission.

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Radar image of Wallerfing in the C-band

The colour coding of the radar image indicates the type of vegetation coverage and the soil characteristics. The range of colours reflects the varying amounts of backscattering of the radar signal at different polarisations. Dark areas, on the other hand, indicate smooth, level surfaces that only return the radar signal weakly. In this image, roads stand out as black lines. This is a fully polarimetric RGB image of the Wallerfing test region, created using data acquired in the C-band (five centimetre wavelength) on 12 May 2014.

Radar image of Wallerfing in the L-band

Fully polarimetric RGB image of the Wallerfing test region, created using data acquired in the L-band (23 centimetre wavelength) on 22 May 2014. The brighter the appearance of an object in the radar image, the rougher its surface is or the more complex its structure. For example, trees and woods appear green to white here, as they change and scatter the incoming radar signal strongly at different polarisations. Radar sensors using this longer wavelength can penetrate the ground. Hence, the red and blue colours in particular indicate the soil properties beneath the vegetation.

DLR's Dornier Do 228 research aircraft preparing for the measurement campaign

The Dornier Do 228 DLR research aircraft, with its white antenna mount for the F-SAR sensor, on the apron in Oberpfaffenhofen.

Field measurements

Field measurements of the vegetation and soil being conducted by DLR scientists.

Credit: DLR (CC-BY 3.0).

Portable measurement probe

Soil moisture measurement being performed with a portable probe in a still sparsely vegetated cornfield.

Credit: DLR (CC-BY 3.0).

Radar reflector

Trihedral reflector in Wallerfing used as a reference target for calibrating the SAR data. With such radar reflectors, 100 percent of the incoming radiation is reflected. It operates using a similar principle to reflectors on a bicycle.
