The SARvanna Project: SAR Mapping of Vegetation Structure in the African Savanna

Christiana Schmullius, Harold Annegarn-1, Charles Paradzay-1, Izak Smit-2, Wolfgang Lück-3,
Barend Erasmus-4, , Irena Hajnsek-5, Renaud Mathieu-6, Melanie Vogel-6, Konrad Wessels-7
Friedrich-Schiller-University Jena, Department for Earth Observation,
Loebdergraben 32, D-07743 Jena, Tel.+49(0).3641.9488-80/-81 Fax-82,
1-Univ.of Johannesburg, 2-SANParks, 3-CSIR-SAC, 4-Univ.of Witwatersrand,
5-DLR-HR, 6-CSIR-NRE, 7-CSIR-Meraka
Corresponding Author: c.schmullius@uni-jena.de

Abstract

This paper presents first results of the recently launched international project SARvanna. Radar remote sensing data can be used to map vegetation structure and plant water content, if at least one of the following conditions is being fulfilled: multi-frequency, multi-polarisation, multi-angle, interferometric or multi-temporal data acquisitions. The need to map vegetation structure in Kruger National Park, i.e. density and/or height of the prevailing species, is eminent considering biomass as a crucial food resource and also fire fuel. Since radar data cannot be used to distinguish plant communities if they do not differ in structure, the SARvanna project relates strongly to all optical remote sensing activities in Kruger Park to compare and apply their vegetation maps. Vice versa, SARvanna adds information about plant geometries and plant water content to the retrieved thematic products from optical reflectance measurements. SAR is a technical radar term and stands for Synthetic Aperture Radar, a synonym for modern radar systems.

Project Statement
The SARvanna project aims 1) to explore the information content of a set of multi-frequency, multi-polarization, multi-angle and bi-seasonal radar data from the SIR-C/X-SAR shuttle missions in April and October 1994, to 2) produce a vegetation structure map for the year 1994 and 3) to develop a monitoring concept for Kruger Park using the now available multi-mission radar data from ENVISAT ASAR, ALOS PALSAR and TerraSAR-X. An update of the SARvanna-map for 2009 and 15-year change detection shall be subject of a continuation project if successful.

Rationale
Kruger National Park was one of the critically selected “Super Sites” during the 1994 Shuttle Radar Laboratories SRL-1 and -2, a cooperation radar experiment between the US, German and Italian space agencies NASA, DLR and ASI to prepare future radar satellite missions. A Super Site was imaged as often as possible during the shuttle missions under varying radar incidence angles (compare Annex C), thus providing unique data sets to develop procedures for operational monitoring under similar technical conditions. Only with the start of the German TerraSAR-X satellite in 2007, these conditions can now be met by jointly exploring the operational German TerraSAR-X, European ENVISAT and Japanese ALOS radar satellite data. Therefore, the 14-year old shuttle data now regain timely importance. Surprisingly, the SIR-C/X-SAR data of the Kruger Park Super Site have not been widely explored yet. The SARvanna project will for the first time jointly investigate all acquired SIR-C/X-SAR data along the best possible geographical extent. Also, since April and October represent end of wet and end of dry season months, the research set-up to explore radar capabilities for plant water content retrieval are very good. Obviously, due to the past data acquisition in 1994, environmental databases (i.e. about former meteorological conditions) and botanical expertise

have to be consulted to allow interpretations. These activities will be coordinated with the Canadian project partner who is already analysing selected SIR-C data takes. The Austrian project partner has outstanding expertise in monitoring surface moisture with low resolution radar data. This information is crucial to understand whether the radar backscatter mechanism is dominated by surface moisture or vegetation structure.

Background
Due to the specific physical interactions of radar waves and natural surfaces, the information content of radar remote sensing data is related rather to the surface structure and geometry. Specifically for vegetation analysis, the water content within the plant structural components plays a key role. Due to the Super Site status of the Kruger National Park a complete and thus unique set of multi-parametric radar data had been acquired.

Due to the excellent GIS data base and the great regional expertise on environmental conditions, studies performed and validated in the Kruger National Park have excellent prerequisites to result in a solid development and application of new methodologies which then can be extrapolated to other savanna regions in the world. This is most certainly one of the reasons why Kruger National Park was one of the few SIR-C/X-SAR Super Sites.

Methodology
Synthetic Aperture Radar (SAR) and optical images of the Earth's surface will be analysed using state of the art techniques, such as interferometry, polarimetry, BRDF quantification and image up-scaling. These results will be correlated with an extensive set of ground truth data, collected in the Kruger National Park and surroundings, for validation. Imagery used will have a range of resolutions in terms of wavelength, acquisition angles, spatial definition, temporal repetition rate and polarimetric orientation. A unique multi-resolution dataset from the SIR-C space shuttle mission, imagery from the German TerraSAR-X and RapidEye satellite constellation as key data source together with imagery from ALOS, Radarsat 2 and MODIS will be used for the analysis.

Who will benefit from the project being achieved?
1) Kruger National Park will receive a vegetation structure map for major parts of the central Nkayeni and the northern Nxanatseni region,
2) Kruger National Park will receive a plan for a monitoring programme for vegetation structure mapping based on operational radar satellites,
3) Knowledge transfer in radar remote sensing is envisaged between South African and German graduate students.

Significance of the SARvanna results
The outcomes of the proposed activities will be of great significance to both the scientific remote sensing community in South Africa as well as a range of government departments that will be empowered with the provision of essential information on woody biomass and structure to enforce relevant legislation. The Kruger National Park will gain greater insight in their state of tree and bush cover which is an essential indicator of the impact that elephants have on their natural environment. The demonstration of woody biomass quantification will put South Africa in a key position to deliver a down stream service to the European / African GMES (Global Monitoring of Environment and Security) Africa programme. The RADAR images obtained are from recently launched satellites. Accordingly, the methods to be developed in this project are cutting edge research in terms of developing and validating algorithms for interpretation and quantification of woody biomass, specifically with respect to savanna biomes.