Some results of the airborne imaging radar program in the Philippines

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Abstract: SAR imagery offers a reliable mode of image acquisition over tropical countries for various applications. The Philippines participated in two missions to the Pacific Rim by NASA in 1996 and 2000 that saw the deployment of the AIRSAR instrument. This paper discusses the Philippine experience in the use of polarimetric and interferometric radar datasets for diverse applications, including hazards mapping, geologic and geomorphologic mapping, and land cover mapping. The results are discussed in the light of present efforts at capacity building in remote sensing, attempts at operationalizing the use of SAR for priority applications, and future ambitions in remote sensing.
Keywords: SAR, Philippines, mapping, polarimetric SAR

1. Introduction

The use of optical satellite images for various sustainable development applications in tropical countries such as the Philippines is limited by the illumination and weather conditions prevailing at the time of image acquisition. In this regard, synthetic aperture radar (SAR) imagery offers a reliable mode of image acquisition because of the imaging radar's cloud-penetration and all-day/all-night acquisition capabilities.

By the mid-1990s, the Philippines already had significant experience with the processing and analysis of SAR imagery, but this had been with single-frequency, single-polarization images such as those acquired by ERS-1, JERS-1, Radarsat and Intera Star-1, and only at the pilot project level. However, an invitation from the National Aeronautics and Space Administration (NASA) to selected Asian countries to participate in the first deployment of the Airborne Synthetic Aperture Radar (AIRSAR) in 1996 provided remote sensing users in the Philippines the opportunity to work for the first time with multi-frequency and multi-polarization imaging radar for various applications.

This paper discusses the country's experience in the use of polarimetric and interferometric radar datasets acquired by the AIRSAR instrument for various priority applications, mainly hazards mapping, geologic and geomorphologic mapping, and land cover mapping.

2. The Philippine AIRSAR Program

The AIRSAR instrument was deployed twice in the Philippines —on September 1996 and November 2000. The first deployment was carried out under the framework of a national project entitled "Analysis of POLSAR and TOPSAR datasets for resource management and development planning activities" while the second deployment was implemented through the national project entitled "Acquisition and exploitation of AIRSAR and MASTER datasets for applications in food security, environmental management, and natural hazards monitoring". Both projects were funded by the Department of Science and Technology.

The first project sought to evaluate the potential of polarimeric and interferometric SAR datasets for

geologic studies, mineral prospecting, volcanic hazards assessment, coastal zone management, land use mapping, determination of crop morphology, and soil moisture assessment. Five government agencies and one academic institution participated in this project.

The second project, which is still ongoing, seeks to develop operational and scientific methodologies for the processing and analysis of AIRSAR datasets, among other objectives. It is conceived as a first step that will take the country from conducting pilot-level applications of remote sensing technology to doing operational activities. This second project has a wider participation.

The imaged sites were Balayan Bay, Batangas Bay, Canlaon Volcano, Cebu, Davao del Norte, Laguna, Lingayen Gulf, Magat Watershed, Marikina Watershed, Mayon Volcano, Metro Manila, Mount Pinatubo, Panay Island, Parker Volcano, Polillo Island and Taal Volcano.

3. Some results

1) Volcanic hazards mapping

The country's geologic and tectonic setting makes it prone to volcanic hazards. There are 22 active volcanoes in the country and six are considered most active. Four of the six most active volcanoes, namely Canlaon Volcano, Mayon Volcano, Mount Pinatubo and Taal Volcano, have been imaged in 1996 by the AIRSAR instrument. Mount Pinatubo was imaged again in 2000. Volcanic hazard maps serve as the basis for hazard mitigation and disaster-preparedness plans. This type of map has been prepared for both Canlaon Volcano [1] and Mount Pinatubo [2] aided by AIRSAR images.

1996 AIRSAR images were used to delineate the extent of historic pyroclastic and lava flow deposits of Mayon Volcano [3-4]. With the same data, DEMs were used to determine the morphology of Mayon's notched summit, which served as a model domain for computational fluid dynamic simulations of its explosive eruptions [5]. DEMs were also processed to generate slope aspect and shaded relief maps, aiding in the identification of fractures on Mayon's flanks [6].

At present, a crater morphology study of Parker Volcano in Mindanao is being undertaken. In 1995, a portion of its crater lake collapsed unleashing torrents and destroying lives and property. The crater lake still poses a hazard to residents in nearby settlements.

2) Geologic and geomorphologic mapping

The same method of using slope-aspect and shaded relief images for identifying lineaments [7] had been applied for structural mapping in geothermal sites. In a case study on the Bulalo geothermal field, lineament structures identified through slope-aspect and shaded relief data were targeted prior to fieldwork and verified in the field. The intersection of these newly identified structures with previously recognized fractures in Bulalo, defined the current producing field in the site [8].

AIRSAR data had also been demonstrated to be effective in mapping major lithologies, geomorphologic features and land cover in a tropical environment [9]. In coastal Panay and Guimaras Islands, several geologic cover types, namely Buenavista Limestone, Quaternary Alluvium, and Guimaras Diorite were identified based primarily on texture. Three landforms (fluvio-denudational, fluvial and fluvio-marine) were also identified. In the uplands of Panay Island, AIRSAR data was used to identify lineaments and fold structures in support of gold exploration [10].

At present, images covering the Kotkot-Lusaran and Mananga Watersheds in Cebu are being analyzed for the purpose of forest cover boundary delineation and geologic structural mapping.

3) Land cover mapping

Three studies on land cover mapping using AIRSAR imagery involved the use of novel image classification techniques to improve map accuracy. The first study used a hierarchical classifier in a forest environment [11] while the two others used polarimetric signature analysis [12] and linear discriminant analysis in a coastal environment [13] in Panay Island with results that are comparable to, if not better than, conventional classifiers. The studies demonstrated the effectiveness of AIRSAR data for accurate land cover mapping using non-conventional classifiers.

Present efforts are concentrated on land cover mapping of Marikina Watershed for the purposes of change detection, identification of destructive anthropogenic activities, and flood hazards assessment, rice mapping in Laguna and mapping urban poverty morphology in Metro Manila.

4) Other applications

Also in Panay Island, the stage of growth of rice as well as soil moisture levels in paddy fields were determined from the AIRSAR image by inspecting the variation in radar backscatter across frequencies and polarization [14].

In the province of Davao del Norte, a set of AIRSAR images were interpreted in order to help identify actual and potential breeding sites of mosquitoes responsible for the prevalence of malaria and schistosomiasis.

4. Moving towards an operational remote sensing program

The first project has demonstrated the applicability of airborne imaging radar to support various mapping activities. Having established that, the second project is now concerned with finding the applications where this technology may be made operational. This objective achieves great significance when considering the fact that many spaceborne remote sensing missions to be launched in the near future will carry multi-frequency,

multi-polarization SAR in their payloads. In addition, considering the tropical setting of the country where heavy cloud cover is common, radar remote sensing will occupy a prominent position in any program related to the operationalization of remote sensing in the country.

Initially, the operationalization of remote sensing will not be seen in all the applications covered by the two projects as this will involve the prioritization of applications. This makes perfect sense for a developing country with limited resources. Therefore, in line with the thrust of the present national government and based on the results of the two projects, two candidate applications can be the management of natural hazards and sustainable environmental management.

In order for the operationalization of remote sensing to materialize, certain preconditions must be existent. First, there should be a critical mass of human resources who have functional knowledge in the processing and analysis of imaging radar data. The two projects have produced a few experts, but continued collaboration with foreign organizations and aggressive manpower development through higher education are still needed.

Next, the appropriate infrastructure for radar image processing must also be in place. The two projects and the participating agencies have invested in the required hardware and software for this purpose and these are installed at various academic and government institutions. However, the maintenance and updating of this infrastructure becomes a critical issue considering that developments in hardware and software occur at a rapid pace and the associated costs can be prohibitive.

The maturity of the technology in the context of the proposed priority applications, harmonization of remote sensing-related activities, advancement in basic and applied scientific research in these fields and sustained government support are also important prerequisites.

5. Conclusions

The study outlined some results of the airborne imaging radar program in the Philippines. Results from two national projects demonstrated the potential of imaging radar for various applications. The use of this technology may be operationalized for natural hazards management and sustainable environmental management. However, operationalization entails the presence of certain prerequisite conditions, some of which have yet to be realized.

The Philippines acknowledges the important role of remote sensing in support of sustainable development. It seeks to sustain, and even expand, in the future the use of remote sensing, including imaging radar, for resource management, development planning and other activities.

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