Summary

The objectives of this study include the investigation of the new fully polarimetric SAR (e.g. ALOS PALSAR) technology and their application to monitoring Earth's surface features over selected specific geological targets. A new fully polarimetric SAR classification scheme based on the target decomposition theorem and simple scattering model are being developed for typical volcanic surfaces but same approaches are also applied to inter-tidal regions along the solid Earth and Earth's hydrosphere boundary. It has been known that the L-band SAR is better suited for geological applications in the past. In this study, the L-band ALOS PALSAR data are used for the theoretical development as well as operational application developments for volcanoes and other coastal monitoring. The objectives of the original proposal has been changed as our research has progressed, as there have been justifiable events occurred during the execution of this research project. The research commenced with the award of an ALOS PALSAR research opportunity (PI No.: 139) and is still continuing with broader scope. Some of the key findings of this research will be discussed and presented below.

Keywords: Polarimetric SAR, POLSAR classification, volcanoes, inter-tidal flats, geological applications

1. Overview of the Research Progress

This ALOS PALSAR Application research was supposed to start on April 1, 2007, as specified in the “Confirmation Sheet” we received from Dr. Toshio Doura (Dated March 22, 2007). However, we were told that the deadline for ordering data was already over when we first submitted the ALOS PALSAR data on April 7th, 2007.

For this reason, we could not order the required data over three volcanoes we were initially going to investigate; Baekdu-san in northern China, Cerro Caquella in Bolivia, and Mt. Meru – Mt. Kilimanjaro in East Africa.

I was previously a PI for the JERS-1 SAR research program with NASA (Japan), and our laboratory had accumulated considerable amount of JERS-1 SAR data over Baekdu-san volcano, which were all descending orbit data. Available ALOS PALSAR data, which we were going to use along with the JERS-1 SAR, have now different orbit look direction, and we could not try the PS-InSAR type monitoring of the Baekdu-san volcano. Also, we could not order the ALOS PALSAR data over the Cerro Caquella or Mt. Meru - Mt. Kilimanjaro, and the original research objectives including the investigation of volcanoes and volcanic hazard research have been very much limited. At the same time, our research areas have been broadened to include monitoring of inter-tidal coastal regions of Korean peninsula and Bay of Fundy areas of Canada.

For this reason, our research has continued with the available ALOS PALSAR data over several Korean peninsula and Iceland study sites, including both active volcanoes and inter-tidal flats. This means that the theoretical objectives has remained same but the application field and validation sites have now been changed. However, our research has been progressing well with the excellent ALOS PALSAR data with a number of new publications. The following report below will summarize some of our research progress.

2. Backscattering Characteristics of Polarimetric SAR Signal in Inter-tidal Flats

The coastal zone of Korean peninsula is well known for its large tides and a vast expanse of intertidal flats. In this work, methods of extracting the roughness of the scattering surface of intertidal mudflats from polarimetric SAR data are investigated. The L-band NASA/JPL airborne SAR (AIRSAR) data, which were acquired on the intertidal zone during PACRIM-II Korea campaign on September 30, 2000, were first used for this research to estimate the roughness of the tidal mudflats in the study area. This was followed by fully polarimetric ALOS PALSAR data in two study areas in the west and southern coasts of Korean peninsula. The vertical and horizontal roughness parameters $k_s$ and $k_l$ will be estimated from co- and cross polarization backscattered coefficients using Integral Equation Model (IEM) and the semi-empirical model. Furthermore roughness parameters will be estimated from circular polarization coherence $|\rho_{RLL}|$ as well as the coherency matrix element $|S_{HH} - S_{VV}|^2$ using the extended-Bragg model.
In addition, the use of polarimetric decomposition techniques was introduced in order to mitigate the disturbing influence of secondary scattering processes and reduce system noise. The study area is famous in Korea as the nation’s leading cockle production area. Surface roughness can be used as a key parameter for describing the land-use characteristics in the intertidal flats. Roughness inversion algorithms proposed in this paper are useful to estimate the biogenic and physical roughness structures as well as fishery induced roughness disturbances in the intertidal mudflats. The same approach was also used in two additional study areas monitoring the submarine ground water study and also the oyster bed investigation.

3. Some of Important Research Results

Application of space-borne SAR for active volcano monitoring has traditionally utilized mostly differential InSAR (D-InSAR) approach, which has not required fully polarimetric SAR data. The following summarizes some of our research over several active volcanoes:

(i) For D-InSAR or SBAS InSAR is a very effective research and operational tool for monitoring active volcanoes, but it does not actually requires fully polarimetric SAR data.

(ii) Fully polarimetric SAR data are very effective for delineate different spatio-temporal flows of volcanic (pyroclastic) materials. However, we have been able to carry out sufficient in-situ field verifications, due to limited fully polarimetric SAR data availability and also due to logistic difficulties visiting active volcanoes while the SAR data are being acquired.

We have made significant progress in monitoring inter-tidal flat several coastal areas while our research with active volcanoes have been delayed as described above. The key research results over inter-tidal flats are

(i) Fully polarimetric SAR data can effectively image and identify submarine ground water in inter tidal flats, and

(ii) Fully polarimetric SAR (specifically X- and C-band) data can effectively image and identify the oyster beds in the inter-tidal flats.

Although the inter-tidal flat study has been continuing for three years until now, it requires both further theoretical modeling and field observation, we are quite excited with the newly found applications.

Further details of specific research results have already been published in refereed journals as listed below, and readers are referred to the publications.

4. Concluding Remarks

In this study, our study has been initially limited to volcanological investigation and volcanic hazard monitoring and mitigation research. However, initial scope of the study has been broadened later to include inter-tidal flat monitoring and application development research of fully polarimetric SAR along coastal areas including inter-tidal flats. We were not certain at the beginning how effective the space-borne fully polarimetric SAR systems for the above described geological applications. After studying the active volcanic areas and continuously changing inter-tidal flat areas with fully polarimetric SAR, we are now convinced that fully polarimetric SAR system is a very important research tool in volcanological and coastal geology investigation. There can be considerable differences in effectiveness in different geological applications, but fully polarimetric SAR is becoming the most important research and perhaps operational Earth observation tool.

5. Future Research Plans

We have started the POLSAR investigation of inter-tidal flats of Korean peninsula, we plan to expand this study to Bay of Fundy, Canada, and also plan to start the application development research in several areas, including the sea surface wind model with new L-band SAR systems such as ALOS 2 and other new SAR systems.

(A) The investigation of the characteristics of intertidal flats will be carried out with considerable amounts of new ground truth information in all X-, C-, and L-band SAR data.

(B) Sea surface wind model for L-band along with C- and X-band SAR data. In the RIO laboratory at the Seoul National University, we have considerable experience in estimating the sea surface wind from C-band SAR data, including both VV polarized ERS-1/2 and ENVISAT data and HH polarized RADARSAT-1/2 SAR data. With reference to these experience, we plan to develop new wind models and test with in-situ measurements.

6. Acknowledgements

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7. Conference Presentations related to this proposal ( PI # 139)

The titles of the abstracts of the paper presented at international conferences related to this ALOS PALSAR proposal are as follow:

(2006-present)


Kim S.W., D. J. Kim and W.M. Moon (2010) Monitoring of Active Volcano using Polarimetric Decomposition and SBAS D-InSAR, 3rd


8. Referred Publications related to this research proposal ( PI # 139)

The recent (2006 – present) publications submitted or published, which are related to the proposed ALOS PALSAR (PI No. = 139) are as follow:


