Time Series Observation of Wetland "Sakata" by PiSAR-2

Yoshio Yamaguchi*, Hiroyoshi Yamada*, Shoichiro Kojima**
*Department of Information Engineering, Niigata University, 950-2181, Japan
**National Institute of Information and Communication Technology, 184-8795, Tokyo

***Abstract* - This paper presents time series results of X-band fully polarimetric radar observation of wetland "Sakata" in Niigata, Japan, during 2013 to 2015. The polarimetric scattering power decomposition was applied to the data sets. The region was successfully imaged by a very high-resolution (30 cm) polarimetric airborne SAR system, which revealed the detailed characteristic response of the emergent plants (lotus and reed) and surrounding objects in this wetland area.**

***Index Terms* — Polarimetry, scattering power decomposition, wetland, PiSAR**

1. Introduction

Wetlands cover at least 6% of the earth surface. Wetland ecosystems play a key role in hydrological and bio-geo-chemical cycles and comprise a large part of the world's biodiversity and resources [1]. They provide critical habitat for a wide variety of plant and animal species, including the larval stages of many fish and insects, resort for migrating birds, forage for cattle grazing and bee flora. Wetlands also deliver a wide range of important services, including water supply, water purification, carbon sequestration, coastal protection, and outdoor recreation. Intact wetlands perform as buffers in the hydrological cycle and as sinks for organic carbon, counteracting the effects of the increase in atmospheric CO_2. Thus, their sustainable use ensures human and economic development and quality of life.

However, depending on the region, 30–90 % of the world's wetlands have already been destroyed or strongly modified mainly due to agriculture and urban development in many countries. Climate change scenarios predict additional stresses on wetlands, because of changes in hydrology, temperature increases, and a rise in sea level. Global warming causes methane stored in permafrost (peatland) release back into the air. This causes abrupt change in weather in arctic region.

Understanding the roles of wetland correctly and keeping the healthy condition are essential for sustaining environment. One of the inherent features for wetland monitoring is the distribution of emergent species. Vegetation patterns are considered an emergent feature of the local hydrological regime. They can be used as indicators of environmental conditions. Since the plant communities represent the amount of biomass accumulated above and below ground, it shares one of the earth's carbon stocks. If the vegetation is correctly mapped, the information will serve to monitor the wetland environment correctly.

As far as radar observation is concerned, reviews of frequency characteristics and polarization effect are well presented in [2]-[3]. Emergent plant communities cover more than 90% of the wetland area, and are usually dominated by a very few species. It is known that higher frequency above C-band is sensitive to these vegetation, i.e., suitable for emergent species monitoring. It is concluded in [2] that more frequency bands, more polarizations, and more incidence angles will contribute to increase the value of radar observation to wetland monitoring.

This paper presents time series observation results of wetland "Sakata" lagoon in Niigata, Japan, during 2013 to 2015. The second generation of airborne polarimetric and interferometric synthetic aperture system (PiSAR-2) in the X-band took flights over Niigata area, Japan, at three different times. The polarimetric scattering power decomposition has been applied to the data sets. The wetland region was successfully imaged with a very high-resolution (30 cm), in which detailed response of the emergent plants (lotus and reed) and surrounding objects were revealed.

2. Study Area

Sakata lagoon is Marsh, located in 37.48N, 138.52E, Niigata Prefecture, Japan. It has been registered as a RAMSAR site according to the Convention on Wetland of International Importance especially as migratory waterfowl habitat (Fig.1). It is a local wetland where more than 2000 migrating crane stay in winter.

During the flight campaign of PiSAR-2, the area was observed three times on 20130825, 20131017, and 20150303. The PiSAR-2 has a capability of fully polarimetric data take function with very high-resolution, 30 cm in the range direction with 30 cm azimuth resolution [4]. For exploring the possibility of PiSAR-2 system, some experimental flights have been conducted and demonstrated by National Institute of Information and Communication Technology (NICT),

Fig.1 Sakata Lagoon

Japan. Niigata was selected as one of the super-sites for the demonstration flight campaign.

3. Scattering Power Decomposition Images

All the data sets were calibrated using the responses from several trihedral corner reflectors deployed on the seashore for each flight. After the polarimetric calibration, scattering matrix data sets were generated and then processed by the general four-component scattering power decomposition with unitary transformation: G4U [5]. Time series of the polarimetric scenes are shown in Fig. 2, where RGB color-coding is used with Red for the double bounce, Green for the volume scattering, and Blue for the surface scattering. In the decomposition, we used 9x9 window size to derive each scattering powers, resulting in approximately 3 x 3 m resolution on the ground.

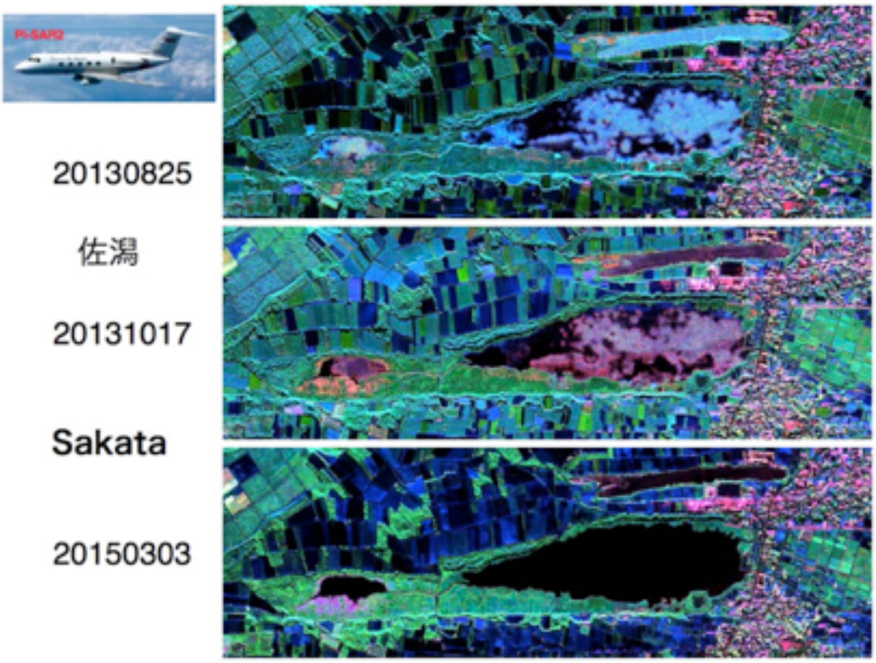

Fig. 2 Scattering power decomposition images of Sakata with Red for the double bounce, Green for the volume scattering, and Blue for the surface scattering

4. Discussion

For intuitive understanding of color decomposition image of Fig. 2, the scattering mechanisms in wetland is depicted in Fig. 3, where typical scattering phenomena are indicated. It is seen in Fig. 2 that color on the surface of Sakata completely changes from blue to red, and to black. This color change reflects the change of scattering mechanism from the surface scattering to the double bounce scattering, and to the mirror/specular reflection. On the August image, the main contribution of the surface scattering on the mid-lake is broad leaf of lotus in its most active period. The thick broad leaves act as dishes for X-band wave, reflecting surface scattering. This scattering causes blue color. On October image, the leaves are faded and stems become apparent. The water surface and stems generates the double bounce scattering power, yielding red color. In March image, all vegetation are gone and the surface becomes flat. This situation causes mirror reflection. Fig. 2 clearly depicts the lotus situation change.

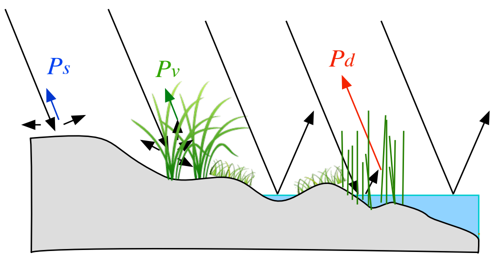

Fig. 3 Scattering mechanism in wetland

If we look the surrounding area, various situations can be revealed. A small pond left to Sakata exhibits a similar time series change. Tall stems caused orange color image (mixture of the double bounce and the volume scattering). The upper left areas of Sakata lagoon are sandy crop fields, and the right corner is residential area and small rice paddy field. Reed and other vegetation look green in the boundary region of the lagoon.

Residential houses and man-made structures look red and stable throughout season. Very high-resolution images identify the objects in the scene clearly.

5. Concluding Remarks

With the advent of very high-resolution and fully polarimetric SAR system, the wetland observation became into a new stage. Since acquired polarimetric data sets contain precise information on the observed scene, and since color of scattering power decomposition image represents scattering mechanism, it is possible to monitor the wetland environment successfully.

This work in part was carried out by grant in aid for scientific research (C), no. no.26420383, JSPS, Japan.

References

[1] W. J. Junk, S. An, C. M. Finlayson, B. Gopal, J. Květ, S. A. Mitchell, W. J. Mitsch, R. D. Robarts, "Current state of knowledge regarding the world's wetlands and their future under global climate change: a synthesis," Aquat. Sci. 75, 151–167, 2013.

[2] F. M. Henderson, A. J. Lewis, "Radar detection of wetland ecosystems: a review," Inter. J. of Remote Sensing., vol. 29, no. 20, p. 5809–5835, 2008.

[3] R. Touzi, A. Deschamps, and G. Rother, "Wetland characterization using polarimetric RADARSAT-2 capability," Can. J. Remote Sensing, vol. 33, no. 1, pp. S56-S67, 2007.

[4] M. Satake, T. Kobayashi, J. Uemoto, T. Umehara, S. Kojima, T. Matsuoka, A. Nadai, S. Uratsuka, "New NICT airborne X-band SAR system, PISAR-2: Current status and future plan," 3rd International Polarimetric SAR WS in Niigata 2012.

[5] G. Singh, Y. Yamaguchi, and S.-E. Park, "General four-component scattering power decomposition with unitary transformation of coherency matrix," IEEE Trans. Geosci. Remote Sens., vol. 51, no. 5, pp. 3014-3022, 2013.