AGRICULTURAL FIELDS MONITORING USING ALOS DATA

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1. INTRODUCTION

Agriculture makes products using large land, and this is suitable to remote sensing for monitoring agriculture. At January 2006, Japanese earth observation satellite named ALOS was launched. ALOS had two optical sensors and one Synthetic Aperture Radar (SAR) sensor. PRISM is panchromatic optical sensor, and had fine resolution (2.5m) and 3 directions (fore, nadir and back) observations for generation of digital elevation models. AVNIR-2 is multi-bands (blue, green, red and near infrared) optical sensor and had 10m resolution. PALSAR is L-band SAR and had full polarimetric observation ability. This paper shows the application of remote sensing and GIS for agricultural fields monitoring using ALOS data.

2. UNDERSATANDING JAPANESE AGRICULTURE USING AVNIR-2 DATA[1]

AVNIR2 has wide swath width, fine resolution and high positioning ability. Using AVNIR2 data of 4 May 2006, 2 May 2008 and 17 September 2008, we compare with each agricultural field in Japan at May and September (Fig.1). From end of April to early May, there are many holidays named “Golden Week”, and in the holidays, farmers and their family work at paddy for trans-planting young rice. Middle of September is just before rice harvesting time, and growing time of soybean. Color composite of Fig. 1 is RGB=NIR:R:G, and high vegetation area is reddish.

At Fig.2, left image is acquired at 4 May 2006 and right image is at 2 May 2008 in Ishikari plain in Hokkaido. In Hokkaido, the climate is not a planting rice season yet at early May for the cold weather condition. Therefore, it is not flooding in the paddy field. The mainly red part is winter wheat. The number of red lots in 2006 is larger than at 2008. The reason of decrease number at 2008 is the wheat production has centralized and each filed size in bigger.

Fig. 3 is the image of Tsugaru Plain in Aomori Prefecture; left image is 2 May 2008 and right is 17 September 2008. The rice field is flooding in the left image on the transplanting rice season in Golden Week (Japanese holiday Period). The rice field is a pink color on September 17 and the rice plant almost grows up. The place where the image in this September is white is a cloud, and the shadow of cloud has blackened.

In Fig. 4, the left image of is 2 May 2008 and the right image is 17 September 2008 at the Yokote basin in Akita Prefecture. On May 2, transplanting young rice is just starting at paddy field and flooding area of paddy field is small, and there are small parts of black with flooding paddies in left image. At the right image, mainly pink parts are rice growing and very bright parts in a central right edge are after harvesting rice. There are rad color parts and the parts are soybean growth fields.

Fig. 5 is Shonai Plain in Yamagata Prefecture, left image is 2 May 2008 and the right image is 17 September 2008. At left image, a lot of rice fields are flooding in early May. At right image, there are same the dark red places, and at the places the soybeans were growing in middle of September. The rice field is pink at the image in September.

Fig. 6 is an image at Saga Plain in Saga Prefecture on 2 May 2008. In this area, weather condition is suitable for double cropping, and early May wheat and barley of winter crops are growing, and after harvest the winter crops young, rice will be transplanting.

Fig. 7 is an image at Aso Valley in Kumamoto Prefecture on 2 May 2008. The Aso Valley area is also suitable for double cropping, and almost single cropping area because of human resource. In the area, there are a lot of livestock.

Fig. 8 shows the image of Ishikari Plain (left), the Hachirogata Polder (center), and the Yokote Basin (right) in May 2008 at the same scale. Ishikari plains are the model area of large scale agriculture at Hokkaido, and one field size is large. However, the Hachirogata Polder is larger than Ishikari. On the other hand, the rice field area is small though the Yokote basin is a typical region in an excellent rice field with long history.

The transplanting young rice is observed all over the Japan in early May except Hokkaido Island and two crops system area.

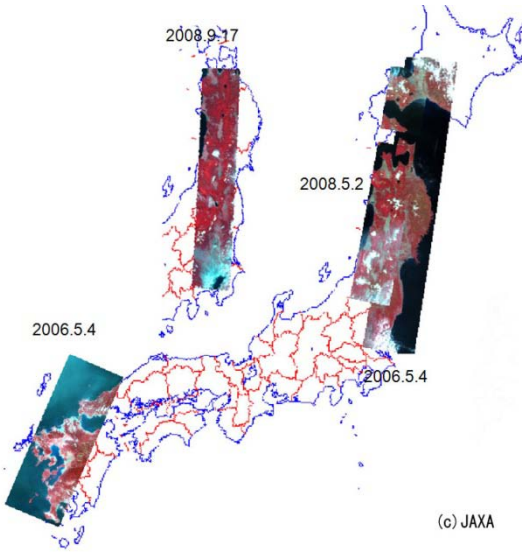

Fig. 1 AVNIR2 images for the agricultural monitoring in Japan

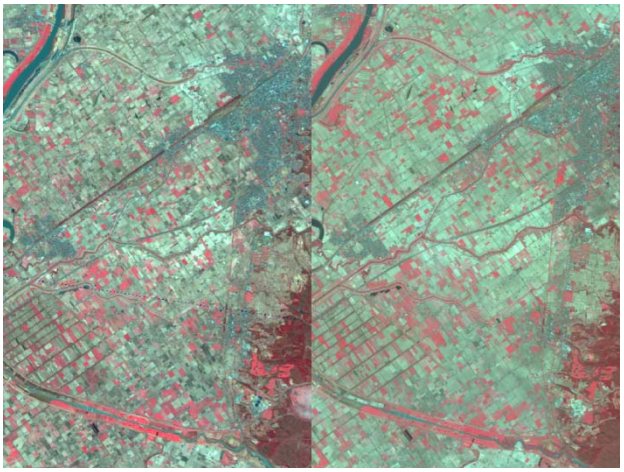

Fig. 2 Ishikari Plain in 2008 and 2006 on early May

Fig. 3 Tsugaru Plain at early May and middle September in 2008

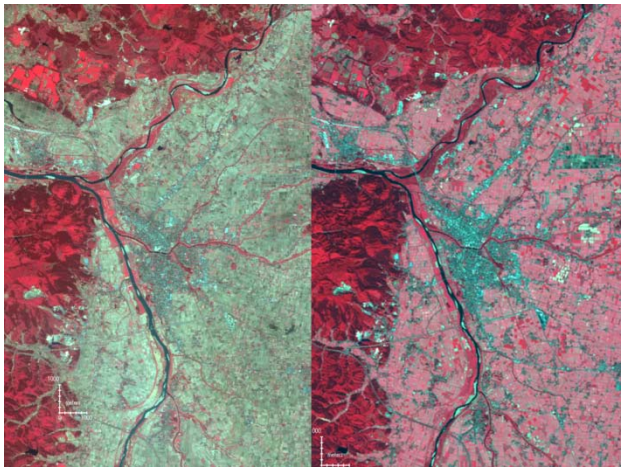

Fig. 4 Yokote Basin at early May and middle September in 2008

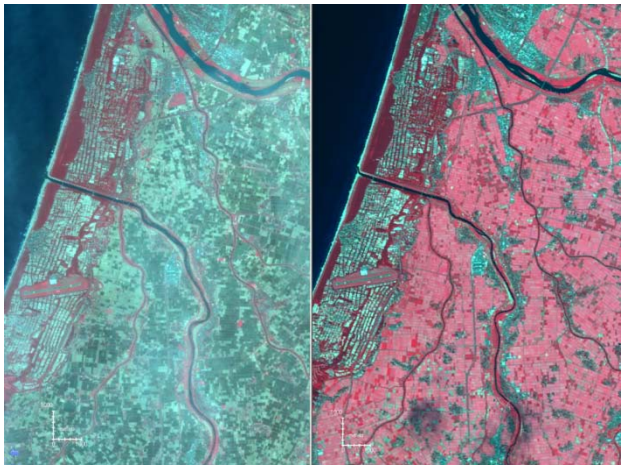

Fig. 5 Shonai Plain at early May and middle September in 2008

Fig. 6 Saga Plain at early May in 2008

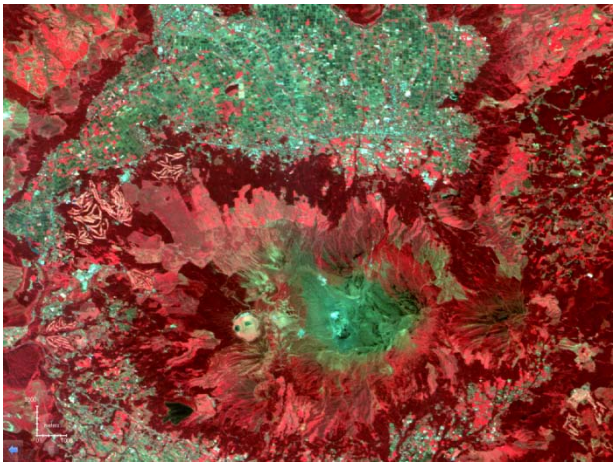

Fig. 7 Aso Valley at early May in 2008

Fig. 8 Ishikari Plain, Hachirogata Polder and Yokote Basin at early May in 2008

3. UNDERSATANDING JAPANESE AGRICULTURE USING PALSAR DATA

PALSAR has the clouds free ability, and we are monitoring Japanese paddy fields using single and multi-polarimetric mode. At Asian monsoon area include Japan, almost crops are growing at rain season, and the clouds free ability is very attractive. PALSAR is not only a single-polarimetric observation of HH (reception, transmission) that sends the micro wave of horizontally-polarized wave (H) and receives it by H, but also sends vertically-polarized wave (V), and VV and HV that receives V and H are possible. Full polarimetric mode means HH・VH・VV・HV observation at the same time. Full polarimetric observation data can make Pauli Image. Full polarimetric data of PALSAR at middle April, late May and late August are processed to Pauli Images (Fig. 9 and 10). At the Pauli Images, blue is HH+VV and mainly surface scattering, green is HV and mainly volume scattering, and red is HH-VV and mainly double-bounce scattering. All seasons at sea area and middle April at paddy area are blue, all seasons at forest area are green, and all seasons at urban area and late August at paddy area are red. In middle April, it is plowing time at paddy field and surface of paddy is bare soil. At May, rice is small and paddy surface is almost only water. At August, rice is growing, and double-bounce scattering observe at water surface and rice stems.

Fig. 11 is a Pauli Image of Shichiriga-hama at Tsugaru City in Aomori Prefecture at three times, and the area of the image is 6.5km in east and west, and 13km in the south and north. Half upper left is the Sea of Japan, and the color is blue because surface scattering occurs at ruggedness by the ocean wave. The diagonal belt from right top to left bottom and mountainous parts of lower right are forests and these parts are green, because of volume scattering from forests. The place in which it is displayed in blue in the land in April is almost agriculture fields. The ruggedness on bare soil appears blue in April. In May these blue area turns to black because paddy field are filled with water for transplanting young rice and water surface at paddy fields is almost flat. Satellite micro-waves are scattering on the surface of the water and the micro-waves advance forward, don't return to the satellite. The parts are blackening. The place in this rice field has reddened in the image in August. This is because of double bounce scattering at water

surface and rice body in the paddy field and micro-waves are returning to the satellite.

Fig. 12 is a Pauli Image of Mt. Iwaki in Aomori Prefecture. There is a snow in the top of a mountain part and it appears blue in April image for surface scattering. The parts of August are green because of the volume scattering in when the leaves are already developed. The parts are blackening because the leaves are not developed with trees in May.

Fig. 13 is a Pauli Image of Omagari District at Daisen City in Akita Prefecture. Omono River is dark or blue stripe where the stripe diagonally flows from and upper right to the left side and the stripe of Tama River is curving from the central left to bottom of the image. The town areas are red places at three time and both sides of Omono River because there are double bounce due to scattering with the building and road. At the agricultural field in April, the ruggedness on the soil surface occur surface scattering and it appears blue color. The surface of the water is observed in May and the rice field has blackened in the image. The reflecting micro wave reddens by double bounce scattering of water surface and rice body on August in rice paddy field.

Fig. 14 is Mt. Kurikoma that stands at the prefectural boundary in Iwate Prefecture and Miyagi Prefecture. The top of mountain area of Fig. 14 has same phenomena as Fig. 12 of Mt. Iwaki. The area is blue at April by snow, dark at May by non leaf trees, and green in August by developed leaves trees.

Fig. 15 is a Pauli Image of the center part of Sendai City. The Hirose River the diagonal flow the upper left to lower right and Natori River is flowing from the right to the left at bottom part of image. Unban area has many buildings and this makes red color because of double bounce scattering with road and the building. At the river side of Hirose River and Natori River, the majority of remainder is blue because of surface scattering. Forest area is green because of volume scattering by the forest trees. The feature of the urban area is not to be admitted the difference at three times.

Fig. 16 is Pauli Image of Sendai Airport Area. This area is about 20 km south from Central of Sendai City. The airport runway looks black as well as the surface of the water. At rice paddy fields, blue in April, dark in May and redden in August are similar to the image of Sichiriga-hama in Figure 11 and Daisen city in Fig. 13

By the analysis results of Fig. 10 – Fig. 16, in middle April, it is plowing time at paddy field and surface of paddy is bare soil. At May, rice is small and paddy surface is almost water. At August, rice is growing, and double-bounce scattering observe at water surface and rice body. All seasons at sea area and middle April at paddy area are blue, all seasons at forest area are green, and all seasons at urban area and late August at paddy area are red in the Pauli images.

All the rice paddy fields of August are rad color by double bounce scattering in the Pauli images as we mentioned. At paddy field, winter wheat is growing at April and May, nevertheless blue on April and dark on May at paddy field, and there is no red color at paddy field. At rice paddy fields, double bounce scattering occurs with water surface and rice body. Water surface is necessary, and with soil surface and crop body, micro-wave cannot make strong double bounce.

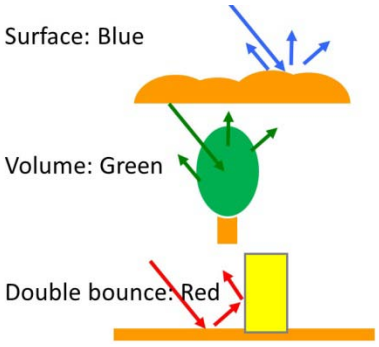

Fig. 9 Three Components of Pauli Image

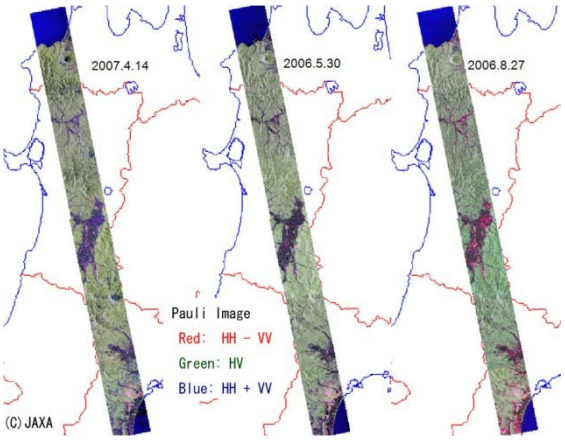

Fig. 10 Pauli Images of PALSAR for the agricultural monitoring in Japan

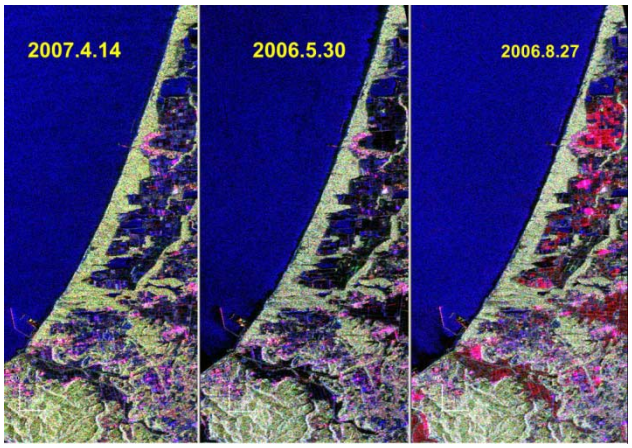

Fig. 11 Pauli Image of Shichiriga-hama, in Aomori Prefecture.

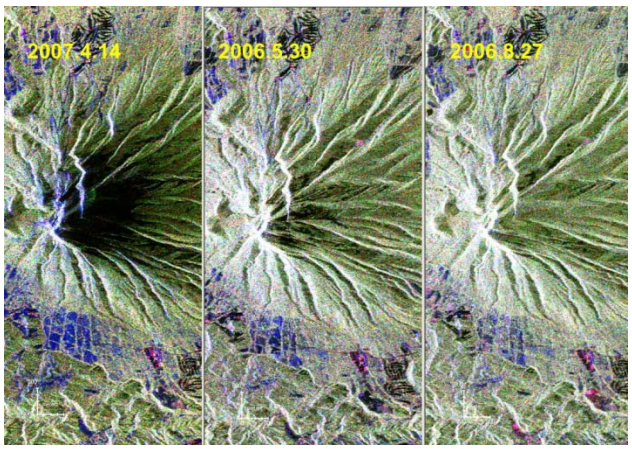

Fig. 12 Pauli Image of Mt. Iwaki, in Aomori Prefecture

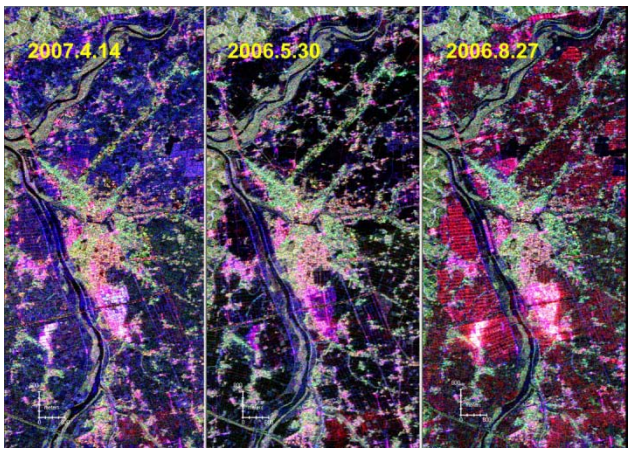

Fig. 13 Pauli Image of Daisen City, Yokote Basin, in Akita Prefecture

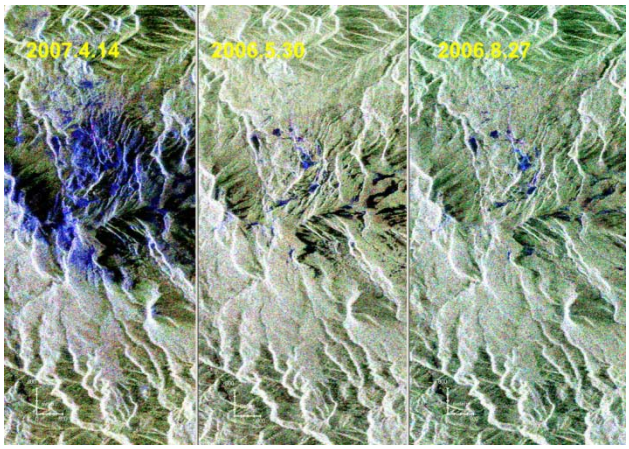

Fig. 14 Pauli Image of Mt. Kurikoma, Migagi-Iwate-Akita Prefecture

Fig. 15 Pauli Image of Sendai City, Miyagi Prefecture

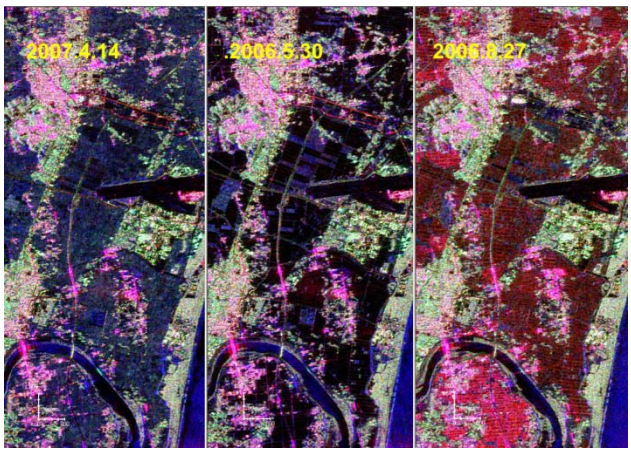

Fig. 16 Pauli Image of Sendai Airport Area, Miyagi Prefecture

4. UNDERSTANDING OF CYCLONE NARGIS DAMAGE AT 2008 USING PALSAR DATA[2]

The personal damage and the life poverty are largely reported, and agricultural damage is hardly reported with Cyclone Nargis that hit Myanmar on 2 and 3 May 2008 (Fig. 17). Then, the understanding of the agricultural damage was studied using the PALSAR data. The flood region was judged by the single polarimetric data of flooding period and almost one year before image, and the agricultural realities in the flood region were performed using the full polarimetric observation data in the middle of March 2007 and the early May, and clarifying the agricultural situation of early May. After that, agricultural damage of the cyclone was estimated.

The data of 6 May 2008 were immediately after cyclonic and just flooding were occurring period, and the data of 11 June 2006 were 11 months ago from the event. The flooding period data were yellow and the before data of 11months were blue in Fig. 19. Basically, it becomes a surface of the water when it is flooded, it doesn't return to the satellite by the specular scattering, and it darkened. For this reason, flood damage area blue at overlay area. In this region, the rainy season start at May and the rice field doesn't have water in the beginning of May, and there is water for planting rice in the middle of June. At coastal zone, flood areas were black because there is water in paddy at both times. Blue or black places are cyclone damage area, and damage area spread about 130km from costal to inside. Fig. 19 showed the Pauli Image by the PALSAR full-polarimetric observation on 1 May 2007 and 16 March 2007. At Pauli Image synthesizes the color, blue is the surface scattering, green is volume scattering, and red is double bounce scattering.

The image in March is seen red parts, and disappears in May and it means rice grows in March at red parts. At May, it seems to be harvested though grows up at one and half months from meddle of March. There are a lot of rice plants of the dry-season cropping ((1), (2), and (4) in Fig.19). At (2) in Fig. 19, the place where which March is mainly blue, and May is black, is water surface at both times. There is wave by the wind in March, and is it because of not being in May. It seems that there were fishponds. At coast parts of Myanmar, there is no dry season cropping ((5) in Fig. 19) because river water includes salt by ocean water and the water cannot use for irrigation.

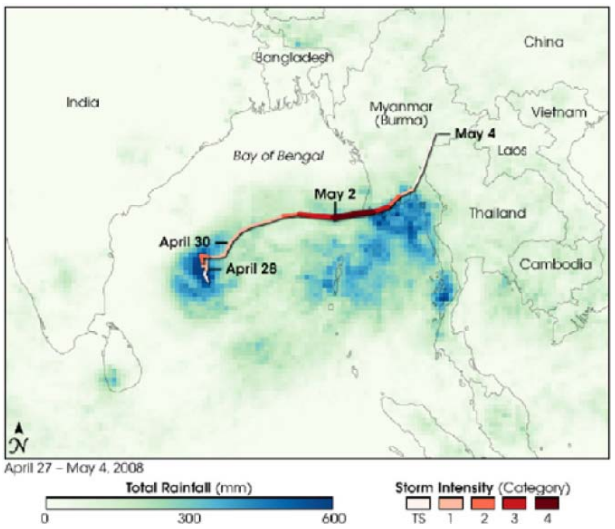

Fig. 17 The Route of Cyclone Nargis and Rain Fall Amount (From NASA HP: Earth Observatory Natural Hazards)

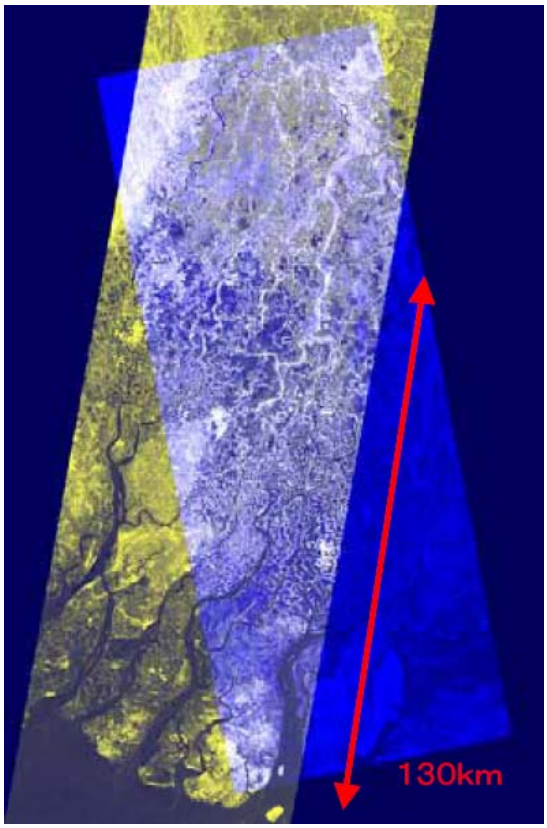

Fig. 18 Overlay PALSAR Image of 6 May 2008 and 11 June 2006
R and G: 2008.5.6 B: 2006.6.11

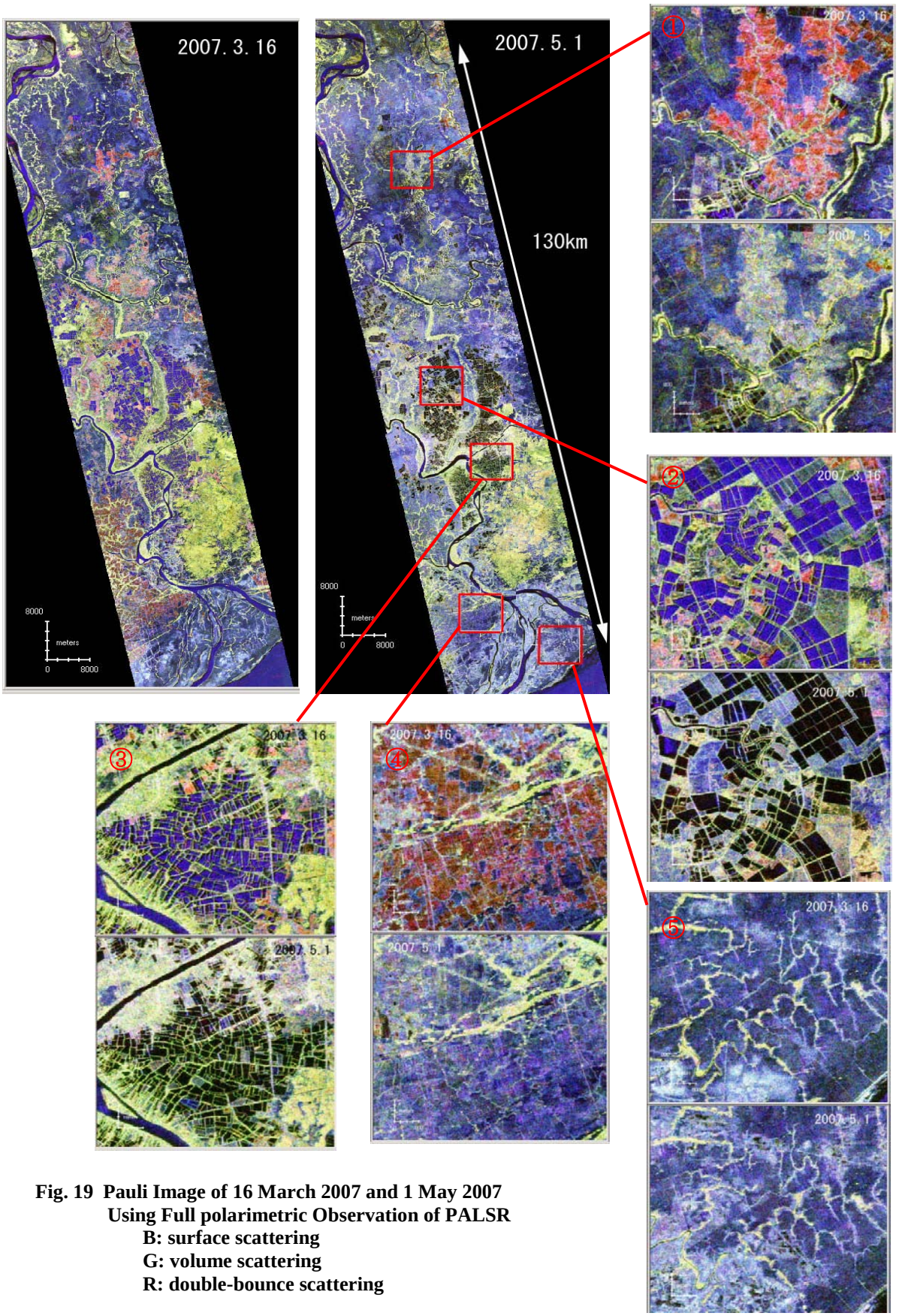

Fig. 19 Pauli Image of 16 March 2007 and 1 May 2007
Using Full polarimetric Observation of PALSR
B: surface scattering
G: volume scattering
R: double-bounce scattering

Dry season is from November to April, and rainy season is from May to October. The early May when the cyclone Nargis attacked, is just start rainy season. Before planting rice of the rainy season work, and the harvest ends almost and it is guessed there was not so much direct damage to rice field. However, it is thought that there are a lot of fishponds in this region, and was a great deal of damage in the fish and facilities. Moreover, it seems that there were the damages such as the agricultural buildings, the machines, materials, and dwellings are also large.

5. CONCLUSIONS

By the collaboration with JAXA, we can use a lot of ALOS data, especially AVNIR2 and PALSAR data. Using AVNIR2, we can realize as follows;

1. The transplanting young rice is observed all over the Japan in early May, except Hokkaido Island and two crops system area.
2. Using middle of September data and RGB=Band4/3/2 color composite data, easily distinguish as rice is pink color and soybean is dark red places

Using Pauli Image of full-polarimetric mode PALSAR data, we can realize as follows;

1. All seasons at sea area and middle April at paddy area are blue, all seasons at forest area are green, and all seasons at urban area and late August at paddy area are red.
2. All the rice paddy fields of August are rad color by double bounce scattering in the Pauli images. At paddy field, winter wheat is growing at April and May, nevertheless blue on April and dark on May at paddy field, and there is no red color at paddy field. At rice paddy fields, double bounce scattering occurs with water surface and rice body.

Using PALSAR data for the agricultural damage of Myanmar with Cyclone Nargis 2008, we can realize as follows;

1. Cyclone damage area were spread about 130km from costal to inside at Myanmar.
2. At the early May, before transplanting young rice of the rainy season, and almost the harvest of dry season were ended
3. Direct damage or rice production was not so much. However, it is thought that there were a lot of fishponds in this region, and were many damages in the fishes and facilities. Moreover, it seems that the agricultural building, the machine, materials, and dwellings were also damaged.

ALOS data are suitable agricultural monitoring not only Japan, but also all over the world. We expect long time operation of ALOS, and ALOS-2 and ALOS-3 will be launch in very near future.

6. REFERENCES

[1] Genya SAITO, “Agricultural Monitoring Using ALOS Data”, in the International Symposium on Integrated Field Science -Understanding for each and integrated eco-system using remote sensing-, *Journal of Integrated Field Science*, vol. 6, pp. 148-148, 2009

[2] Itsumi YATSU, Katsuya YABE, Daisuke KUNII and Genya SAITO, “Agricultural Characteristics and Interpretation of Cyclone Damage in Myanmar Using Satellite Data”, *Proceedings of the 29th Asian Conference on Remote Sensing*, cd-rom, 2008