MORPHOLOGICAL ANALYSIS OF FLOOD INUNDATED REGIONS IN PADDY AREAS USING ALOS/PALSAR DATA AND ITS DISTRIBUTION ON THE GOOGLE EARTH DESIGN OF THE FUTURE DISASTER MANAGEMENT SYSTEM (FDMS)

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ABSTRACT:

Large floods occurred at the northern part of the Central Plain of Thailand in May of 2006. The ordinary class flood appeared in October of 2006 in the middle stream region of the Chao Phraya river of Thailand. The ALOS satellite obtained the PALSAR radar data at the flood by the emergency observation requests. The PALSAR data can easily to detect the water surface because its wave length is L-band. But it is rather difficult in the paddy field areas since usually paddy fields have water surface in its farmland block. Mathematical morphology method is one of the solutions of this problem. The author carried out the geometric correction and morphological filtering to the PALSAR data. The result images almost coincide with the reported flood regions. The morphological analysis shows good ability to the discrimination to the flood water surface from ordinary paddy field's inundated water. The ability of the PALSAR data recognition of the ground objects seems to be improved comparing to JERS-1/SAR. Addition to that, this method requires only once satellite data acquisition, light computer resources and short time to execute the task. Therefore this image processing procedure is suitable for the disaster early warning system. Then the next task is how to hand the result of satellite analysis to the decision maker or inhabitants. There are many kinds of Web based GIS platforms which become an interface with natural hazard stakeholders and inhabitants. The author tried to superimpose the ALOS/PALSAR data and its result of morphological analysis upon the Google earth image. And also the overlay procedure was done for the geo-morphological survey map for the prediction of flood time inundation along the Chao Phraya River in Thailand. This kind system will be a demonstration of the decision support tool or hazard information platform for large flood using satellite data and the integrated ISO's GIS standard (GML). Furthermore its concept will be extended to the distributed and collaborated web-GIS. To put it concretely, the following thing is considered. There are much of agricultural social facilities such as irrigation canals, head works, drainage pumps, water gates, etc. And those irrigation facility control system exists in rural areas. If the GIS data and its network are made by the GML standard, an usual GIS, such as agricultural product traceability system, sensor network system checking irrigation facilities, can be easily transformed into a disaster management GIS. And the disaster management GIS will be able to be integrated into one system with the usual GIS used by the concerning state and local governments or irrigation districts. Addition to that, the airborne Ku-band side-looking radar is developing in Japan. Its resolution is very good and it can get the ground condition of the disaster regions even at night or cloudy weather. The combination of those equipment can be the "Future Disaster Management System (FDMS)" concept just like the "Future Combat Systems (FCS)" of US Army.

1. INTRODUCTION

PALSAR data can be easy to detect the water surface because its wave length is L-band. But it is rather difficult in the paddy areas since usually paddy fields have water surface. Mathematical morphology method is one of the solutions to this conflict (Yamada, Y., 2003; 2007ac). The author carried out the geometric correction to the PALSAR data which had obtained at the 2006-May flood and the 2006-October flood in the Central Plain of Thailand. The morphological analysis shows good ability to the discrimination of the flood water surface from paddy water. This mathematical morphology method needs very light calculation and computer hardware requirements. And the most important merit of this method is to be demanded only once satellite scene at the flooding time. The conventional method of detecting flooded areas is to compare the before and after the flood. Therefore the result of this morphological method is very suitable for the early warning system of flood disaster. The author tried some experiment for making the future disaster management system.

2. MORPHOLOGICAL PROCEDURE

2.1 Data used

The data used in this analysis are ALOS/PALSAR Fine mode, level 1.5 on May 25th and May27th, 2006 for the northern part of the Central Plain of Thailand; and on October 12th, 2006 for the entire Chao Phraya river basin.

2.2 Mathematical morphology procedure

The mathematical morphology procedure is the followings. (1) The region under DN=2200 is considered as the water surface including paddy field and flood inundated areas. (2) 2 times morphological dilations at 3 by 3 size (3) morphological open operation at 12 by 12 size. The last procedure is for sieving out the minute polygons.

2.3 Results

2.3.1 Northern Central Plain of Thailand

The northern Central Plain of Thailand suffered from storm flood at the last period of May, 2006. The flood area is shown in Figure 1.ALOS/PALSAR data can be observed the flood by the emergency data acquisition request.

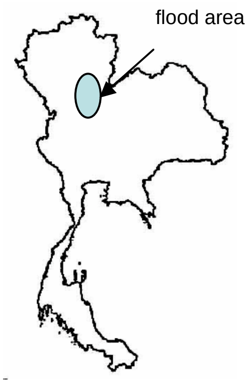

Figure 1. Storm flood area in Thailand

The result image after morphological operations indicates at Figure 2.

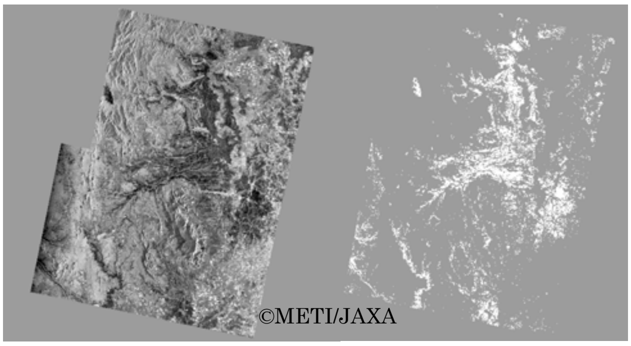

Figure 2. PALSAR image in Northern Central Plain ofThailand on May25, 2006 (left) and mathematical morphology operated image (right: white color)

The flood extent is open to public by JAXA is Figure 3. The Figure 3. image shows only upper side of the Figure 2. The morphological computational result in Figure 2. is in good agreement with the JAXA's flood extent.

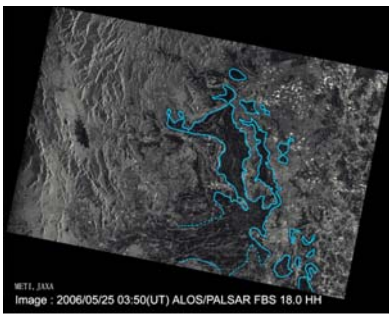

Figure 3. the upper stream PALSAR image of the flood areas (inside blue lines) reported by JAXA

Figure 4. indicates the flood situation at the two days after the Figure 2. image. The flood-inundated water seems to flow downstream during the two days. If it was the fact, it was estimated that the rice plants were slightly damaged because the end of May in this region is the beginning of rainy season. The dominant land use in this region is paddy rice fields and because of two or three times cultivation of rice plants, the major rice should be just seeded or transplanted and the flood inundated damage for the young rice plants will be light. Figure 5, 6 and 7 show that this is possible.

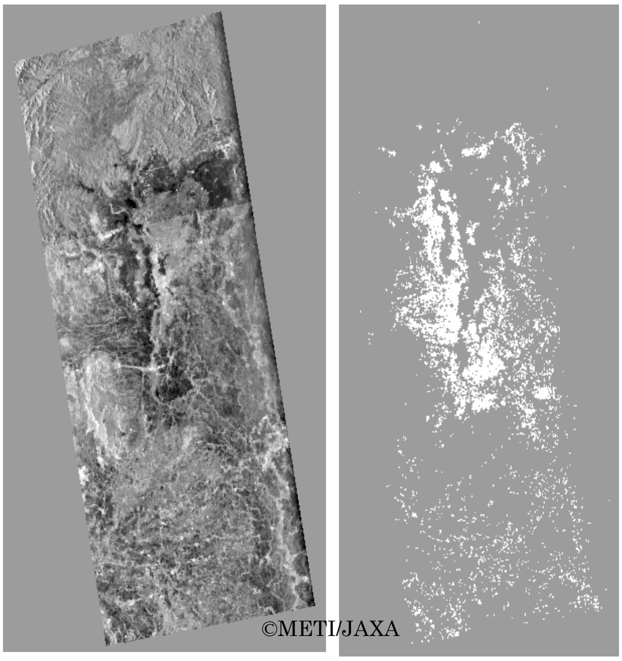

Figure 4. PALSAR image in Northern Central Plain of Thailand on May27, 2006 (left) and mathematical morphology operated image (right: white color)

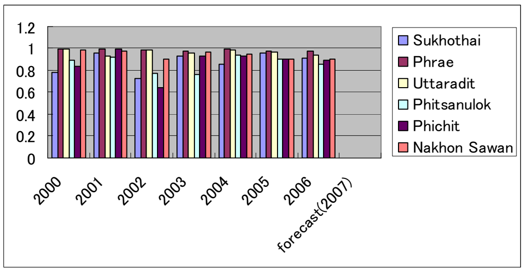

Figure 5. major rice harvested areas divided by the beginning planted areas in every province (FAOSTAT)

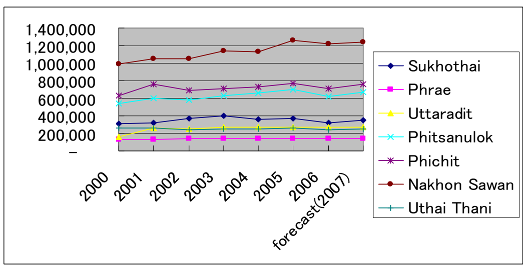

Figure 6. Major rice production for each province in the Northern part of Central Plain of Thailand (by FAOSTAT)

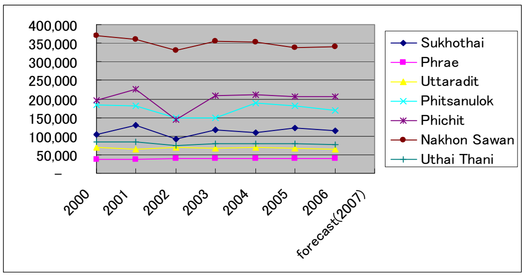

Figure 7. Major rice harvested areas for each province in the Northern part of Central Plain of Thailand (by FAOSTAT)

2.3.2. Geomorphological survey map (Ohkura,1989) and satellite data

The entire Chao Phraya river basin between Nakhon Sawan and Bangkok metropolis often suffer from flood at the end period of every rainy season. The rainy season usually begins in about May and it will end in about October. Figure 8. shows such kind PALSAR image and the result of mathematical morphology applied to the left image.

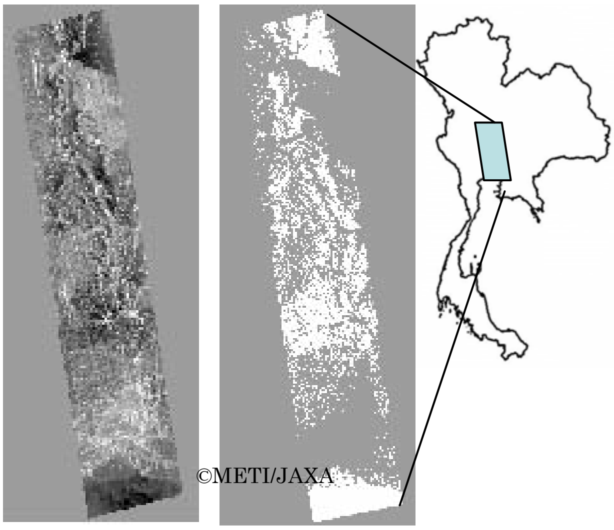

Figure 8. PALSAR image in the entire Chao Phraya river on October 12th, 2006 (left) and the result of morphological analysis (right, white color)

The author superimposed the result of morphological analysis as the flood possibility areas over the geo-morphological survey map (Figure 9). Though the surface land use is changed by farm land consolidation, the possibility flood areas agree with back marsh and delta category avoiding natural levees. The geo-morphological survey map represents the micro-topography and it reflects the process of formation of geographical features. As the flood time is the sediment procedure, the flood inundated areas should coincide with the geo-morphological survey map, even if the surface land use was changed. Therefore this kind of micro-topography map can be used for the flood hazard map.

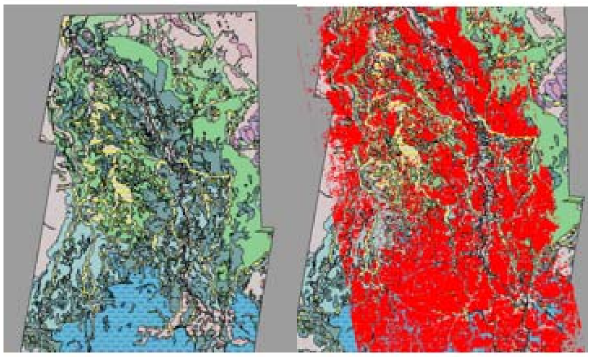

Figure 9. Geomorphological survey map (right) and the superimposed flood possible areas calculated by mathematical morphology operation from PALSAR image (left; red color)

3. HOW TO MAKE "FDMS"

It is very important that the results of flood extent estimation are handed to the people concerning to disaster aid or reduction. Therefore many kinds of global platform for disaster risk reduction on the Internet are proposed. The author converted the result of this Thailand flood analysis into KML format files and superimposed those files on the "Google earth" (Figure 10, 11). The KML is similar to the international Geospatial Information System standard, GML (Geography markup language) of OGC (Open Geospatial Consortium) or ISO19136. And The GML is a kind of data format for GIS data exchange and distribution using the Internet web, what we call, "GeoWeb" (Lake, 2004) . If every organization related to the disaster reduction adopts GML or KML, such kind of international standard data format, those organization's work in close cooperation with publishing its disaster information on the line in the near future. Furthermore Semantic Web will strengthen such kind "Geospatial Web" (Scharl, 2007). Those data standards can apply to the future disaster management system (FDMS).

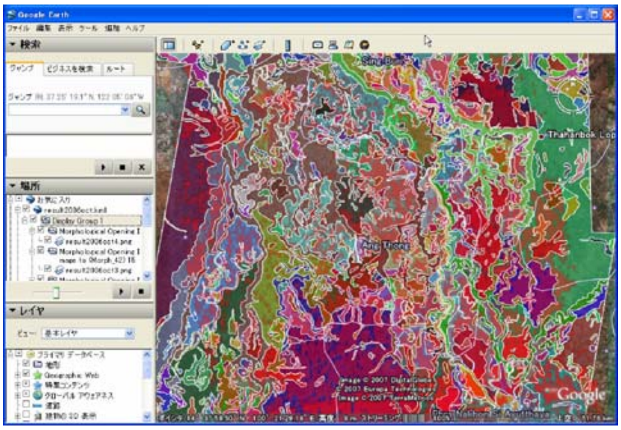

Figure 10. Google earth browser image and geo-morphological survey map on it

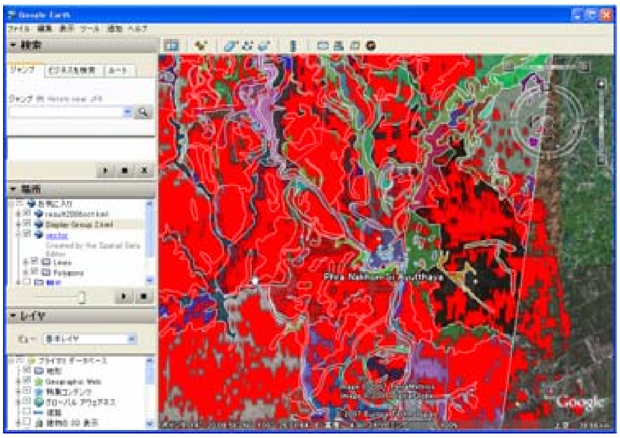

Figure 11. The calculated flood possible areas (red color) superimposed on the Google earth

4. CONCLUSIONS

The flood possible extents derived from PALSAR data using morphological procedure agree with the reported flood areas. And the calculation result using this method can be obtained very swiftly. Therefore this method is well matched with "the platform system for disaster-related information sharing". The technology of Geo-Web or Geospatial Semantic Web will be the foundation of such kind system in the next generation.

REFERENCES

Dougherty,E.R., 1992. *An Introduction to Morphological Image Processing.* SPIE Optical Engineering Press, U.S.A., pp.1-75.

Dougherty,E.R., 1993. *Mathematical Morphology in Image Processing*. Marcel Dekker, New York, pp.48-65.

Iisaka, J., 1989. Structural Spatial Information Extraction from Remotely Sensed Data, *Proceedings of IGARSS'89,Vancouver*, pp.1224-1227

Iisaka, J. and Sakurai-Amano, T., 1992. Spatial Association for Radar Image Interpretation, *Proceedings of IGARSS'92, Houston*, pp1200-1203

Iisaka, J. and Sakurai-Amano T., 1994. Terrain Feature Detection from SAR Data Based on Spatial Association of Objects, *Proceedings of the Tenth Thematic Conference on Geologic Remote Sensing*, *San Antonio, Texas*, pp9-12

Iisaka, J. and Sakurai-Amano, T., 1994. Terrain Feature Recognition for SAR Imagery Employing Spatial Attributes of Targets, *ISPRS Commission IV Symposium Spatial Information from Digital Photogrammetry and Computer Vision, Munich*, pp399-408

Iisaka, J. and Sakurai-Amano T., 1995. A Shape-based Object Recognition for Remote sensing. *IEEE IGARSS'95, Firenze, Italy, Vol.*1, pp.160-162.

Japan International Cooperation Agency & Royal Irrigation Department of Thailand, 1999. The Study on Integrated Plan for Flood Mitigation in Chao Phraya River Basin, *Final Report, Tokyo*

Lake, R., Burggraf, D.S., Trininic, M. and Rae L., 2004. *Geography Mark-up Language (GML) foundation for the Geo-Web*. John Wiley&Sons, England, pp.47-53, 58-59, 63.

Ohkura H., Haruyama S., Oya M., Vibulsresth S., Simking R., Suwanwerakamtorn R., 1989. A Geomorphological Land Classification for the Flood-inundated Area in the Central Plain of Thailand using satellite remote sensing technology (in Japanese). *Research Notes of the National Research Center for Disaster Prevention, Tsukuba,* No.83 pp.1-25

Oya,M., 2001. *Applied Geomorphology for Mitigation of Natural Hazards.* Kluwer, pp.1-9, 17-23.

MEXT Japan, 2005. Disaster Reduction Technology List on Implementation Strategies-A Contribution from Japan, pp103-111

Russ,J.C., 2002. *The Image Processing Handbook Fourth Edition*. CRC PRESS, U.S.A., pp.409-412, 417, 420-421

Scharl, A. and Tochtermann, K., 2007. *The Geospatial Web How Geobrowsers, Social Software and the Web 2.0 are Sharping the Network Society*. Springer-Verlag, London, pp.171-176, 185, 238-239, 254

Soille, P. and Pesaresi, M., 2002. Advances in Mathematical Morphology Applied to Geoscience and Remote Sensing. *IEEE Trans. On Geoscience and Remote sensing*, 40(9), pp.2042-2055

Soille, P., 2003. *Morphological Image Analysis Second edition*. Springer-Verlag, Berlin, pp.63-137.

Yamada, Y., 2000. Flood Analysis using Satellite data and Geomorphological Survey Map showing classification of flood-inundated areas. Proc. Supplement CD-ROM of XIXth ISPRS, Amsterdam, the Netherlands, Commision4, pp.1-5

Yamada, Y., 2002. Flood Damage Estimation on Agriculture for the Chao Phraya river basin in Thailand using JERS-1/SAR. Proc. DVD of ISPRS TC-VII symposium on resource and environmental monitoring, Hyderabad, India, Chapter 5.1, pp.1-5.

Yamada, Y., 2003. Relation between ground features and mathematical morphology using JERS-1/SAR data during flooding time in paddy areas. Proc. CD-ROM of IGARSS2003, Toulouse, France, chapter I_A15_07, pp.1-3

Yamada,Y., 2007a. Classification of Flood areas in the North Thailand and Indonesia using ALOS/PALSAR data, *Proceedings of JSPRS autumn conference 2007(in Japanese)*, Nagaoka, Japan, pp.125-126.

Yamada,Y., 2007b. Decision Support Tool or Hazard Information Platform for Large Flood using Satellite data, *Proceedings of JSRS autumn conference (in Japanese)*, Oosaka, Japan

Yamada,Y., 2007c. Discriminationg flood inundated areas from paddy fields using ALOS/PALSAR data, *Proceedings of JSPRS annual conference (in Japanese)*, Yokohama, Japan, pp.25-26.

Yamada,Y., 2007d. Enhancement of the rural and irrigation system infrastructure to disasters with a help of IT, *Proceedings* *of the 32nd ISRSE conference*, June, San Jose, Costarica

Yamada,Y., 2007e. Flood mapping for paddy areas in Thailand and Indonesia using PALSAR data, *Pro. DVD Of the first joint PI symposium of ALOS Data Nodes for ALOS science program*, Kyoto, Japan

Yamada,Y., Korver, M.W. and Utashiro, K., 2000. Data retrieval and mapping system with Global maps for the international statistics on agriculture using Web based GIS tool. Proc. of Global Mapping Forum2000, Hiroshima, Japan

Yamada, Y., Sakurai-Amano, T. and Takagi, M. 2002. Detection of flood damaged areas in the entire Chao Phraya River Basin from JERS-1/SAR images with a help of spatial information, P*roceedings of IEEE/IGARSS'02, Toronto*

Yamada,Y., Tingsanchali, T., et al. 2004. Rapidly Flood Extent Mapping Server Design and Experiment using Mathematical Morphology Recognition and Cooperated Disaster Information Servers on the Internet, Proc. DVD of XXth ISPRS, Istanbul, Turkey

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APPENDIX A. DATA USED IN THIS ANALYSIS

satellite/sensor	processing level(Fine mode)	data acquisition date	scene_ID
ALOS/PALSAR	1.5	2006/5/25	ALPSRP017663260
ALOS/PALSAR	1.5	2006/5/25	ALPSRP017663270
ALOS/PALSAR	1.5	2006/5/27	ALPSRP018030320
ALOS/PALSAR	1.5	2006/5/27	ALPSRP018030330
ALOS/PALSAR	1.5	2006/5/27	ALPSRP018030310
ALOS/PALSAR	1.5	2006/5/27	ALPSRP018030290
ALOS/PALSAR	1.5	2006/10/12	ALPSRP038160250
ALOS/PALSAR	1.5	2006/10/12	ALPSRP038160260
ALOS/PALSAR	1.5	2006/10/12	ALPSRP038160270
ALOS/PALSAR	1.5	2006/10/12	ALPSRP038160280
ALOS/PALSAR	1.5	2006/10/12	ALPSRP038160290

APPENDIX B. ANOTHER DATA

category	source
Thailand crop statistics	Regional Data Exchange System (RDES) with CountrySTAT - Asia and the Pacific GCP/RAS/184/JPN of the FAO Project(FAOSTAT)
Geomorphological survey map	Ohkura, H., etc. "Land Classification for the Flood-inundated Area in the Central Plain of Thailand using satellite remote sensing technology"