# Sentinel-1 SARデータを用いた市街地および水田域における浸水被害の後方散乱特性解析

## Flood damage analysis at built-up and rice paddy areas using Sentinel-1 SAR data


◯若林　裕之*1　・塚本　晋也*1

Hiroyuki Wakabayashi *1 , Shinya Tsukamoto *1

*1日本大学工学部

*1 College of Engineering, Nihon University

Email : wakabayashi.hiroyuki@nihon-u.ac.jp


## Research Background

・2019年10月6日午前3時にマリアナ諸島の東海上で発生した台風19号は12日に日本に上陸し,関東地方や東北地方では記録的な大雨となり甚大な被害をもたらした.
・福島県郡山市においても，阿武隈川，笹原川，逢瀬川等が氾濫を起こし，床上浸水6542件および床下浸水847件が発生した.

## Research Objectives

本研究では，郡山市内の台風19号による水田や都市域での浸水被害領域について，Sentinel-1のCバンドSARデータに現れる浸水被害の影響を明らかにすることを目的とする．浸水被害が発生した都市域や水田領域について，浸水被害が後方散乱係数やコヒーレンスにおよぼす影響について，後方散乱係数および干渉SAR解析を実施した.

## Extraction of flood damaged area

本研究で解析する浸水被害領域は住宅地を含む都市部(Built-up area)と水田域(Paddy field)とした。郡山市の阿武隈川および支流周辺は広い領域で浸水被害が発生した.

Built-up areaとPaddy fieldは浸水被害により異なる後方散乱係数の変化が見られるため，浸水被害の有無の違いも解析するために，合計9箇所の領域のデータを解析した.

**Table 1 List of sample areas in Koriyama city**

| site no. | flood or non-flood | land cover | area (ha) | area name |
|---|---|---|---|---|
| 1 | flood | built-up area | 234 | Chuo-Kogyo-Danchi |
| 2 | flood | paddy field | 52 | East of Chuo-Kogyo-Danchi |
| 3 | flood | built-up area | 133 | Shokuhin-Danchi |
| 4 | flood | paddy field | 25 | North of Fukuyama-Clean-Center |
| 5 | flood | built-up area | 31 | Teikyo Asaka |
| 6 | non-flood | built-up area | 38 | West of Koriyama station |
| 7 | non-flood | paddy field | 40 | South of Nihon Univerisity |
| 8 | non-flood | built-up area | 127 | Asaka-machi |
| 9 | non-flood | paddy field | 68 | South of Asaka-machi |

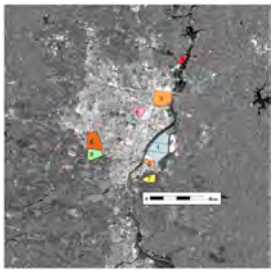


**Fig. Locations of sample areas in Koriyama city (on Oct.13 VV gamma-naught image)**

## Procedure of data pre-processing for Sentinel-1 SAR data

**Table 2 Characteristics of Sentinel-1 SAR IW mode**

| Satellite(Sensor) Observation mode | Sentinel-1A/1B IW mode |
|---|---|
| Center frequency (wave length) | 5.405 GHz(5.6 cm) |
| Ground range coverage | 251.8 km |
| Incidence angle | 29.1 - 46.0 deg. |
| Number of sub-swath | 3 |
| Spatial resolution (range x azimuth) | 20.3 - 20.5 m × 22.5-22.6 m |
| Number of looks (range x azimuth) | 5 × 1 |
| Pixel spacing (range x azimuth) | 10m × 10m |
| Noise Equivalent Sigma-0 (NESZ) | -22 dB |
| Polarization | VV+VH |
| Observation date and time(JST) Descending | ・Oct. 7 5:43(Sentinel-1A) ・Oct. 13 5:42(Sentinel-1B) ・Oct. 19 5:43(Sentinel-1A) |

**Backscattering approach(Gamma-naught)**

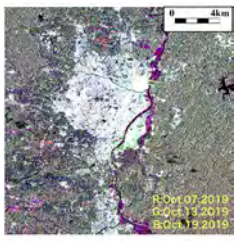
(1) Download Ground Range Detected(GRD) data from Open Access Hub.
(2) Apply accurate orbit data.
(3) Calibrate SAR data to get gamma-naught.
　・Thermal noise removal
　・Radiometric terrain flattening with SRTM-1
(4) Transform onto UTM coordinates with foreshortening correction.
　・Range-Doppler Terrain Correction with SRTM-1 (UTM Zone54, Pixel spacing=10.0m)

**Interferometric approach(Coherence)**

(1) Download Slant Range Complex (SLC) data from Open Access Hub.
(2) Apply TOPS co-registration to each sub-swath in the interferometric dataset.
(3) Apply De-burst procedure to fill the gap in the burst data to get continuous sub-swath data.
(4) Calculate Initial fringe and coherence in the interferometric formation procedure.
(5) Remove topographic phase using SRTM-1 DEM.
(6) Apply Goldstein filter.
(7) Transform onto UTM coordinates with foreshortening correction
　・Range-Doppler Terrain Correction with SRTM-1 (UTM Zone54, Pixel spacing=10.0m)

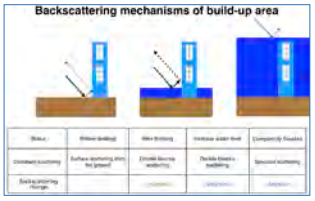
**Table List of InSAR dataset**

| InSAR dataset | $B_p$ (perpendicular baseline) | Acquisition time |
|---|---|---|
| pair-1 Descending | +14.20 m | ・Oct. 7 5:43(Sentinel-1A) |
| | | ・Oct. 13 5:42(Sentinel-1B) |
| pair-2 Descending | -29.65 m | ・Oct. 13 5:42(Sentinel-1B) |
| | | ・Oct. 19 5:43(Sentinel-1A) |
| pair-3 Descending | -25.23 m | ・Oct. 7 5:43(Sentinel-1A) |
| | | ・Oct. 19 5:43(Sentinel-1A) |




(a)


(b)



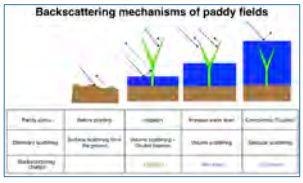




**Fig.1 Gamma-naught and coherence images covering Koriyama city area. (a)RGB colored gamma-naught image, and (b)RGB colored coherence image.**

## Results of data analysis

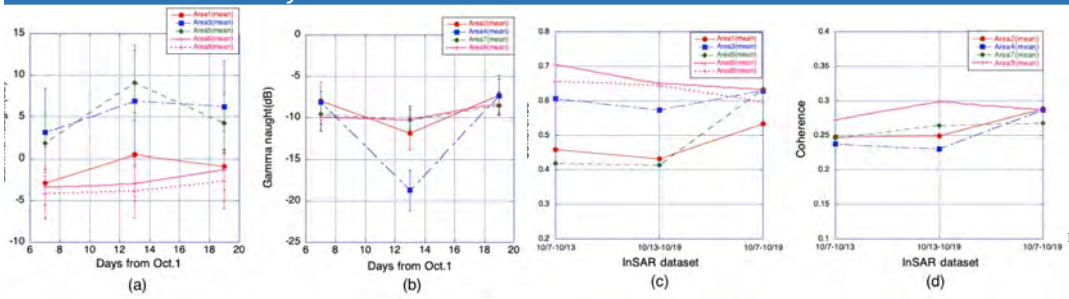



**Fig.2 Change of gamma-naught and coherence caused by flooding. (a)gamma-naught in built-up area, (b)gamma-naught in paddy field, (c)coherence in built-up area, and (d)coherence in paddy field.**

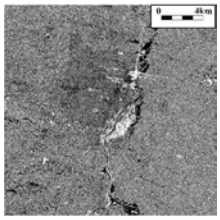
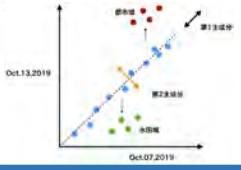


**Fig.3 Result of PCA analysis(2nd. component)**




## Summary

・浸水被害が発生した都市域では後方散乱係数が上昇し水田領域では減少した.
・浸水被害が発生すると都市域および水田ともにInSARコヒーレンスは減少するが，水田における減少量は非常に小さい.
・都市域および水田の浸水被害を両方とも検出する方法として時系列後方散乱画像の主成分分析が有効であることがわかった.


## Acknowlegements

・Sentinel-1データはESAから提供を受けた.
・本研究の一部は千葉大学環境リモートセンシング研究センター共同利用研究の支援を受け実施した。