RAPID DAMAGE ASSESSMENT MAPPING DUE TO TYPHOON RAI USING SENTINEL-1 SAR IMAGES

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1. BACKGROUND

1.1 Introduction

Typhoon Rai, locally known as Odette, was a category 5 typhoon that has recently devastated several municipalities and cities in southern Philippines. The typhoon has brought tremendous damage to residential, agricultural, and industrial areas amounting to about PhP 11.5 bn in economic losses that affected around 135,000 ha of crops and around 2 million infrastructures as estimated by the Philippines' National Disaster Risk Reduction and Management Committee (NDRRMC, 2022).

Part of the country's relief response to the disaster and an important component of the ongoing rehabilitation efforts is the creation of rapid damage assessment maps used to estimate the extent of the damages caused by Typhoon Rai. Given the travel restrictions brought about by the COVID-19 pandemic that limit field mapping activities, the use of downstream satellite data through remote sensing for damage assessment has been a viable and practical option due to the wide coverage areas of the available images and to the availability of scenes that were captured a few days after the typhoon.

For this study, Sentinel-1 synthetic aperture radar (SAR) datasets have been utilized by the Philippine Space Agency (PhilSA) to map possible locations of damaged areas along the path of Typhoon Rai. This was done by stacking intensity coherence maps derived from Sentinel-1 SAR data and deriving their differences through change detection. It is hoped to be shown in this study that the use of SAR data is a practical option in rapid disaster response mapping, especially for typhoons, as SAR data is generally not affected by significant cloud cover that are typically present during and after storms.

1.2 Study Area

Study areas identified for this research are select municipalities and cities where Typhoon Rai passed during its course within the Philippine area of responsibility (PAR), namely, Cebu Island, Palawan Island, Surigao City, and Siargao among others.

These study areas were chosen due to the following factors: (a) estimated economic impact of the Typhoon to the location from local government units (LGU), news, and other sources, (b) extent of estimated damages by the NDRRMC, (c) availability of Sentinel-1 data that is near the time when the typhoon passed through, and (d) availability of other reference datasets such as those generated by the United Nations Satellite Center (UNOSAT) and United Nations Institute for Training and Research (UNITAR).

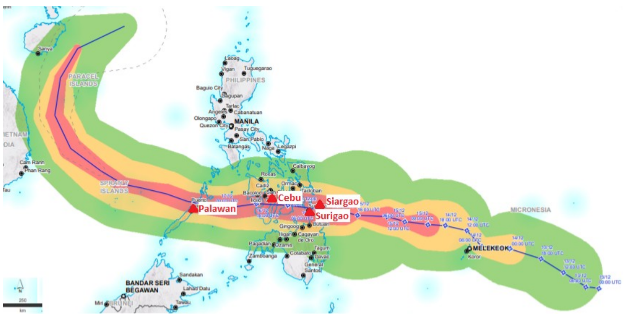

Figure 1. Path of Typhoon Rai that affected areas in the southern Philippines. Red polygon indicates wind speeds of up to 120 kph, yellow indicates sppeds of up to 90 kph, while green is up to 60 kph. Adapted from (OCHA 2021).

1.3 Data Sources

Sentinel-1 data used in this study were downloaded from the Scihub Copernicus website (https://scihub.copernicus.eu/dhus/#/home). Additional supporting datasets such as very high resolution (VHR) images from the Airbus disaster response activation charter (https://geodelivery.intelligence-airbusds.com/main.html) and preliminary damage assessment maps from UNOSAT/UNITAR (https://unitar.org/maps).

2. METHODOLOGY

2.1 Related works

Plank (2014) gave a comprehensive review of SAR applications as used in rapid damage assessment mapping wherein the author enumerated the numerous studies and researches that had used multi-temporal SAR data from various satellites (i.e. ALOS PALSAR, ENVISAT, Radarsat, TerraSAR-X, ERS, etc.). It was pointed out that damage assessment mapping using SAR generally falls within two categories, either by using SAR interferometric coherence or through intensity correlation.

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Through the numerous studies enumerated in (Plank, 2014), it was noted that the two methods perform almost similarly at 40-60% accuracy, with the intensity correlation method performing slightly better. Given this, the intensity correlation method shall be the only focus of this study.

In the examples enumerated by Plank (2014), qualitative methods were used in assessing accuracy (i.e. visual comparison of results to other damage assessment maps) and this shall also be adapted in this study.

2.2 Data Processing

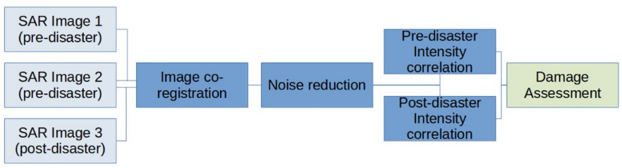

Figure 2. An overview flowchart of the processing steps used in this study wherein two-pairs of SAR images with short baselines were used to generate intensity correlation images which are then compared for change detection.

Fig. 2 shows the data processing methodology employed in this study. First, at least three Sentinel-1 images are downloaded. It is recommended that two images before the calamity be used along with another one taken after the typhoon. The two pre-disaster SAR images are co-registered and stacked together. The same process is applied to the pre-disaster SAR image taken near the date when the typhoon passed over the study area and to the post-disaster SAR image. In order to minimize noise (i.e. speckles), a noise reduction algorithm is applied (i.e. multi-look). After which, coherence estimation is then done to compute how correlated the intensity pixels between the master and slave images are. Once this coherence estimation is done for both the pre-disaster image pair and pre- and post-disaster image pair, damage assessment is finally done by applying a change detection algorithm. All processing were done in ESA SNAP using the Sentinel-1 Toolbox and other related radar applications (https://step.esa.int/main/toolboxes/snap/).

Processing methodology used in this study is similar to those discussed in Plank (2014), SPA (2020), and Hoffman (2007) wherein coherence maps were derived from SAR imageries to estimate damages caused by disasters such as typhoons, floods, and earthquakes.

3. RESULTS AND CONCLUSIONS

3.1 Rapid Damage Assessment Maps

Sample preliminary damage assessment maps are shown in Fig 3. It can be seen that the rapid damage assessment using Sentinel-1 was able to capture the extent of damaged areas at built-up locations at Talisay City and Mactan Island, as validated qualitatively (i.e. visual inspection and comparison with UNOSAT/UNITAR maps) using pre- and post- VHR images of the study areas. Damage estimate visualization was derived using the average coherence index (ρ) table from (Hoffman, 2007) where the ratio of intensity coherence was used to estimate if the area is severely damaged (i.e. $\rho \geq 2.5$), significant damaged ($2.5 > \rho \geq 2.0$), or lightly damaged ($2.0 > \rho \geq 1.5$).

Figure 3. Damage assessment map at Talisay City (row 1) and part of Mactan Island (row 2) Cebu. Images on the left are from Google and show the situation prior to Typhoon Rai. Images at the middle are from SPOT 6 and show the situation after the typhoon. Images on the right show the damaged areas as estimated using Sentinel-1, with basemap from OSM. Red indicates severely damaged blocks, orange means significant damage, while yellow means light damage estimates.

3.2 Conclusions and Recommendations

Rapid damage assessment mapping is an important part of disaster response and rehabilitation activities. It is shown in this study that rapid damage assessment mapping using Sentinel-1 SAR intensity correlation images provide invaluable information to end-users. Preliminary results have also given complementary damage estimate maps to decision makers, in addition to those provided by UNOSAT/UNITAR, other local mapping agencies, and from limited field validation conducted by local government units and NDRRMC.

It is recommended that other methods using SAR (i.e. interferometry) be also utilized in future mapping activities, as well as VHR imagery for classification and analysis (i.e. ML, GLCM, etc.) as applied to rapid damage assessment mapping.

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