Rapid Mapping of Natural Disasters Using Senitinel-1 SAR Imagery

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INTRODUCTION

Natural disasters can cause catastrophic effects ranging from damage of property and landscapes to loss of life. The SAR Amplitude Intensity Variation (SAIV) technique will be used to rapidly map natural hazards, such as floods and landslides. SAR is a remote sensor that operates in the range of microwaves. SAR can operate day and night and in most weather conditions. SAIV was tested by evaluating flooding along the Pungwe River in Mozambique after Cyclone Idai.

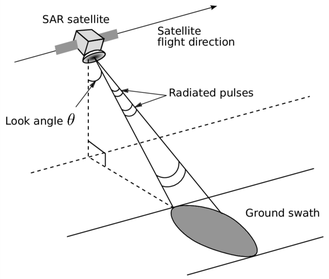

Fig 1. Geometry of the flight path of a SAR remote sensor. Incident ray emits from the satellite to the ground target. (ESA)

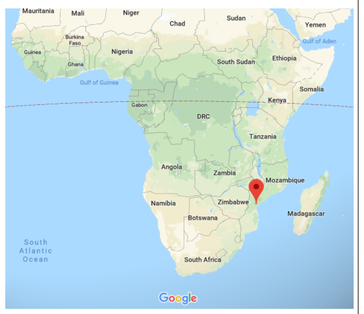

Fig 2. Location of Mozambique in Google Maps view. Pinpoint indicates area of flooding.

HYPOTHESIS

Changes of ground surface features due to hazards, such as floods and landslides, can be detected by analyzing the variation in backscatter intensity of SAR amplitude images.

BACKGROUND

The strength or intensity of the reflected echo is the backscatter. Backscatter for a target area will vary based on the conditions on the ground. Darker areas represent regions of low backscatter, implying that very little energy echoed towards the antenna. Brighter areas represent regions of high backscatter, implying a large portion of the energy was echoed towards the antenna. SAIV analyzes the change in backscatter intensity.

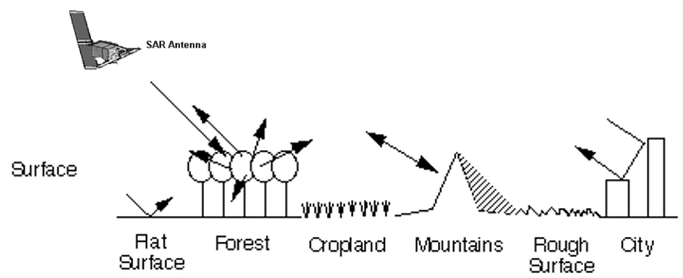

Fig 3. Intensity of backscatter based on target ground conditions. (ESA)

METHODS

Assessment of the flooded area was performed using Sentinel-1 SAR imagery provided by the European Space Agency (ESA). This research uses Sentinel-1 Level 1 Ground Range Detected High Resolution Dual Polarized (GRD-HD) data. The flooded area was mapped by comparing the amplitude of the radar backscatter before and after the cyclone. Cyclone Idai made landfall in Mozambique near Beira on March 14, 2019 and dissipated on March 21,2019. Based on this timeline the sensing period was limited to 3/1/2019 through 4/1/2019. In total six images that span the time interval of the cyclone were downloaded. SAR amplitude images were plotted onto a map view in QGIS. Repeating this method for each image spanning the disaster created a time series of the flooding caused by Cyclone Idai.

Acquisition Date	Path	Frame
13-Mar-2019*	174	1109
19-Mar-2019	174	1112
19-Mar-2019	174	1117
25-Mar-2019	174	1109
25-Mar-2019	174	1115
31-Mar-2019	174	1112

Table 1. Dates of Sentinel 1A/B, C-Band ascending SAR amplitude images used for flood mapping via a flood-free reference image (indicated with *) and post-cyclone images.

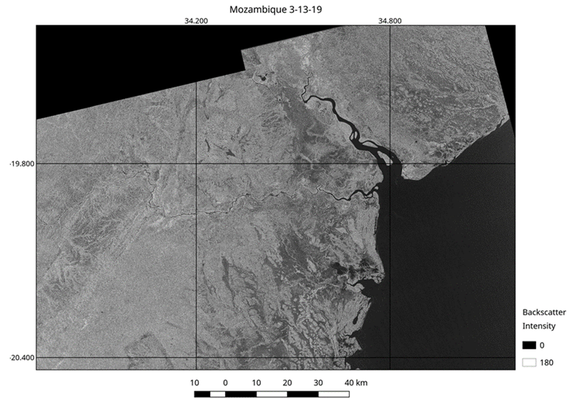

Fig 4. Flood-free reference SAR amplitude image of Mozambique before Cyclone Idai makes landfall.

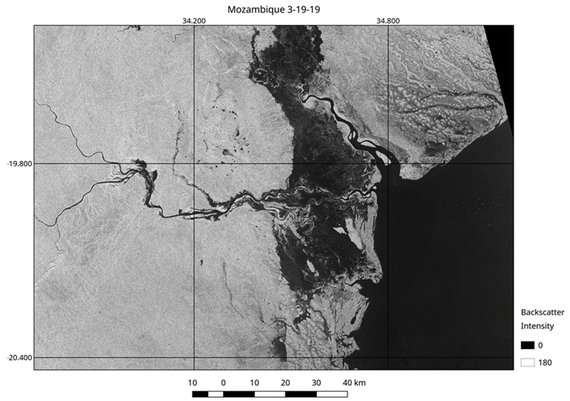

Fig 5. Post-cyclone SAR amplitude image of Mozambique on March 19, four days after Idai makes landfall

RESULTS

An optical image provided by NASA displays the cloud cover over Southeast Africa during the storm. The flood map created via SAIV displays the widest range of flooding to be approximately 20 km across from the eastern coast. The results agree with the ESA's analysis, mapping the flooded areas surrounding Buzi River and Pungwe River. The backscatter variation represents where a change in amplitude was detected between the flood free reference SAR image and the post-cyclone SAR image. In order to improve results, solutions to filter or smooth background noise and to merge multiple SAR images are being researched. This would increase clarity of the change in backscatter intensity and create an enhanced map view of the location of potential damage.

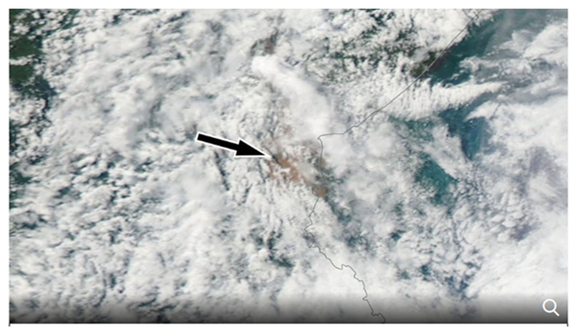

Fig 6. Optical image over Southeast Africa during Cyclone Idai. Flood distribution is obstructed by cloud coverage. Arrow points to area of flooding in Mozambique. (NASA)

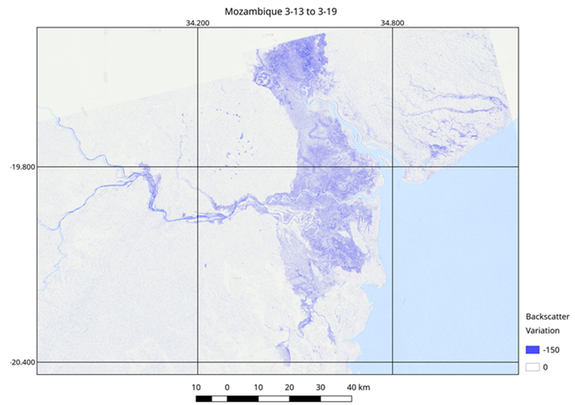

Fig 7. Flood map of Mozambique created via SAIV method. Blue indicates areas of standing water at time of acquisition.

DISCUSSION

The flood maps produced using the SAIV technique were qualitatively validated through comparison with independent analysis performed by the ESA. It is concluded that the SAIV method can detect changes in ground surface features due to inundation caused by the cyclone. The rapid production of maps such as these is essential for providing accurate and up to date reports to aid in emergency response and hazard mitigation.

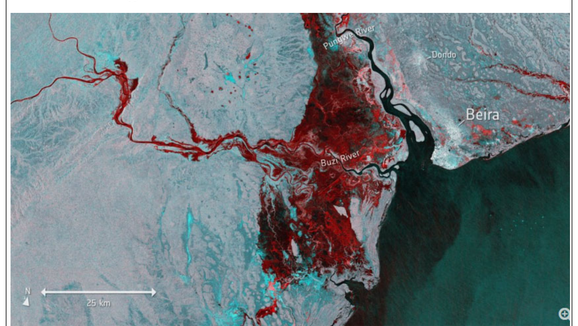

Fig 8. Flood map produced by ESA displaying the flooding caused by Cyclone Idai in Mozambique between the Pungwe and Buzi River. Red indicates areas of flooding. (ESA)