Flood Mapping With Sentinel-1

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Floods are one of the most destructive natural hazard worldwide that causes severe economic, environmental, and human losses. The main reason for flood mapping using radar images is that the water bodies generally create a very smooth (in the absence of strong winds) surface. The incident radar pulse will be scattered away from the radar sensor (specular reflection) and the radar image over that area will be very dark due to little return of the radar pulse. The surrounding rough land surface will be much brighter, due to higher return, thereby distinguishing it from the water surface. In order to distinguish flooded areas from permanent water bodies, an image acquired during the flood needs to be compared with another image acquired when there was no flood.

I have developed a script to describe the capabilities of the Sentinel-1 radar images for flood mapping in three case study areas. The script is adapted to Sentinel-1 IW GRD images with VV polarization and helps in visualization of flooded areas. The visualization allows to quickly determine the extent of the damaged areas regardless of weather conditions. Also it can be helpful to recognize the flood patterns. The algorithm works great for separating flooded areas from permanent water bodies and land areas. It must be used only in multi-temporal processing with two images before and during the flood.

First case study:

In March and April 2019, Iran experienced heavy rains, and the level of main rivers increased quickly. The destruction of infrastructure, private and public property was extensive and widespread. The cities of Aghghala, Gomishan and their surrounding villages were severely affected.

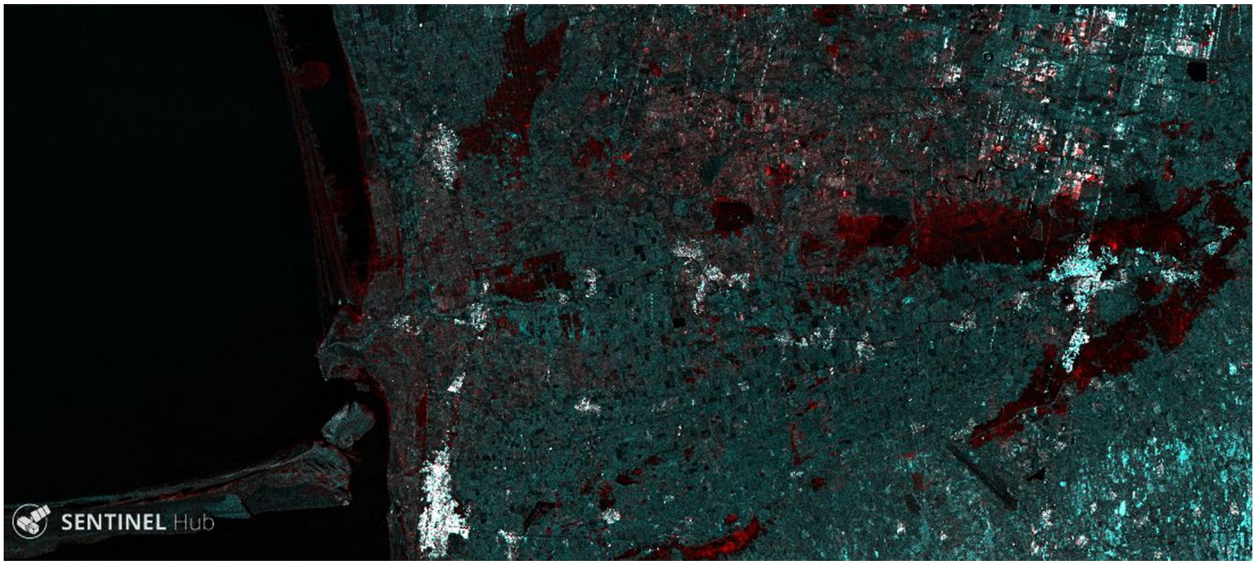

Fig. 1. Flood mapping in Aghghala, Iran using an image during the flood on 2019/03/23 and a reference image before the flood from 2019/03/11. R=2019/03/11,B,G=2019/03/23.

Second case study:

Iran also experienced another widespread flooding in January 2020. Flash floods affected the provinces of Hormozgan, Sistan and Baluchestan, and … in southern Iran. These floods led to blocked roads and damaged houses, bridges, and water supplies. Heavy rainfall also caused extensive damage to crops and livestock.

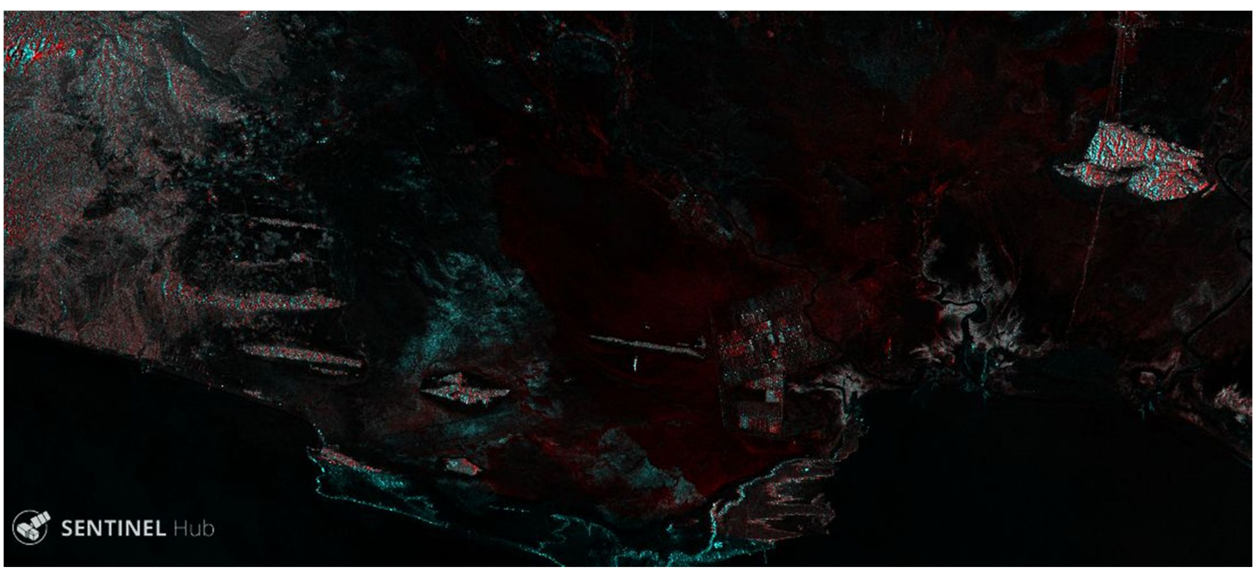

Fig. 2. Flood mapping in Kalani, Iran using an image during the flood on 2020/01/13 and a reference image before the flood from 2020/01/04. R=2020/01/04,B,G=2020/01/13.

Third case study:

The third case study is over the western area of Rio Grande do Sul State, in Brazil. The heavy rain began on around January 14, 2019, and MetSul Meteorologia recorded 497mm of rainfall in 72 hours in the state of Uruguaiana.

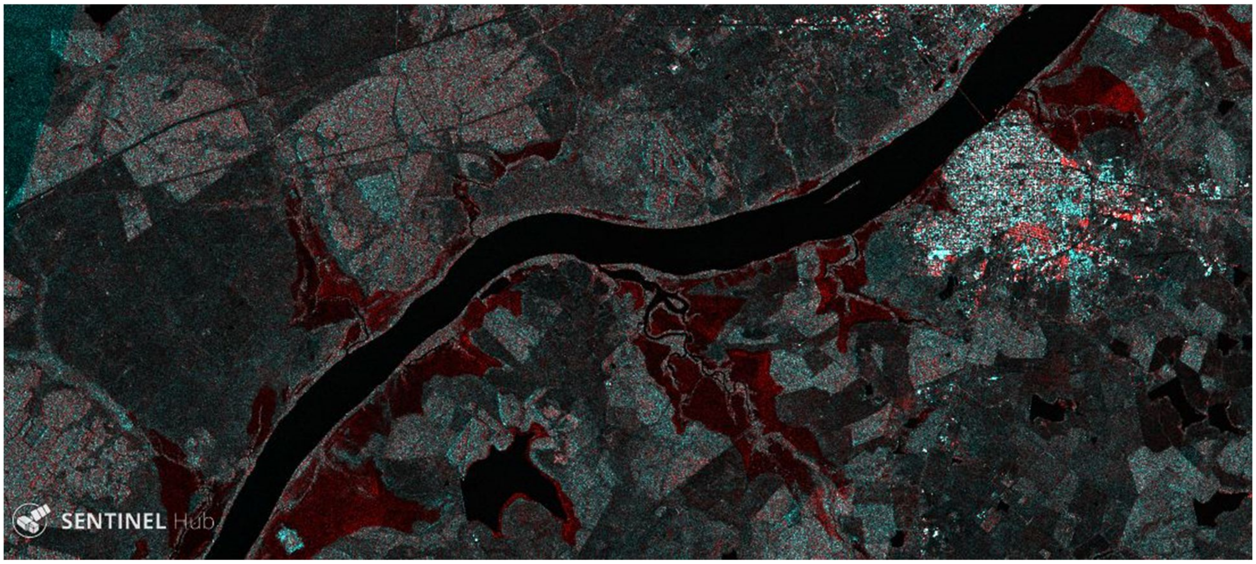

Fig. 3. Flood mapping in Uruguaiana, Rio Grande do Sul, Brazil using an image during the flood on 2019/01/14 and a reference image before the flood from 2019/01/06. R=2019/01/06,B,G=2019/01/14.

In three above-mentioned areas, the $[1.5 \times VV_{\mathrm{before\_flood}}, 1.5 \times VV_{\mathrm{during\_flood}}, 1.5 \times VV_{\mathrm{during\_flood}}]$ combination is used for [R, G, B]. This combination allows to discriminate between flooded areas and permanent water bodies, land, … (unflooded areas). The permanent water bodies are shown as black due to the specular reflection and so darkness of all three channels. The flooded areas are often displayed in red, due to the darkness of green and blue channels and the brightness of red channel. However, the flooded urban areas do not appear dark. This is because, in these regions, there are multiple scatterers, such as buildings, that send parts of the signal back towards the radar. Also, the presence of water at the base of the vegetation, buildings, and … results in a double-bounce scattering. These can be identified through their high response at VV and different colours (e.g. cyan) in the RGB image.

To separate flooded from unflooded a threshold is selected on the difference values between the before and during flood backscatters. The figures below show the acquired maps in the first study area with thresholds 0.05 (top) and 0.08 (bottom). Low values correspond to the less affected areas (black colour), and high values correspond to the more affected areas (red colour).

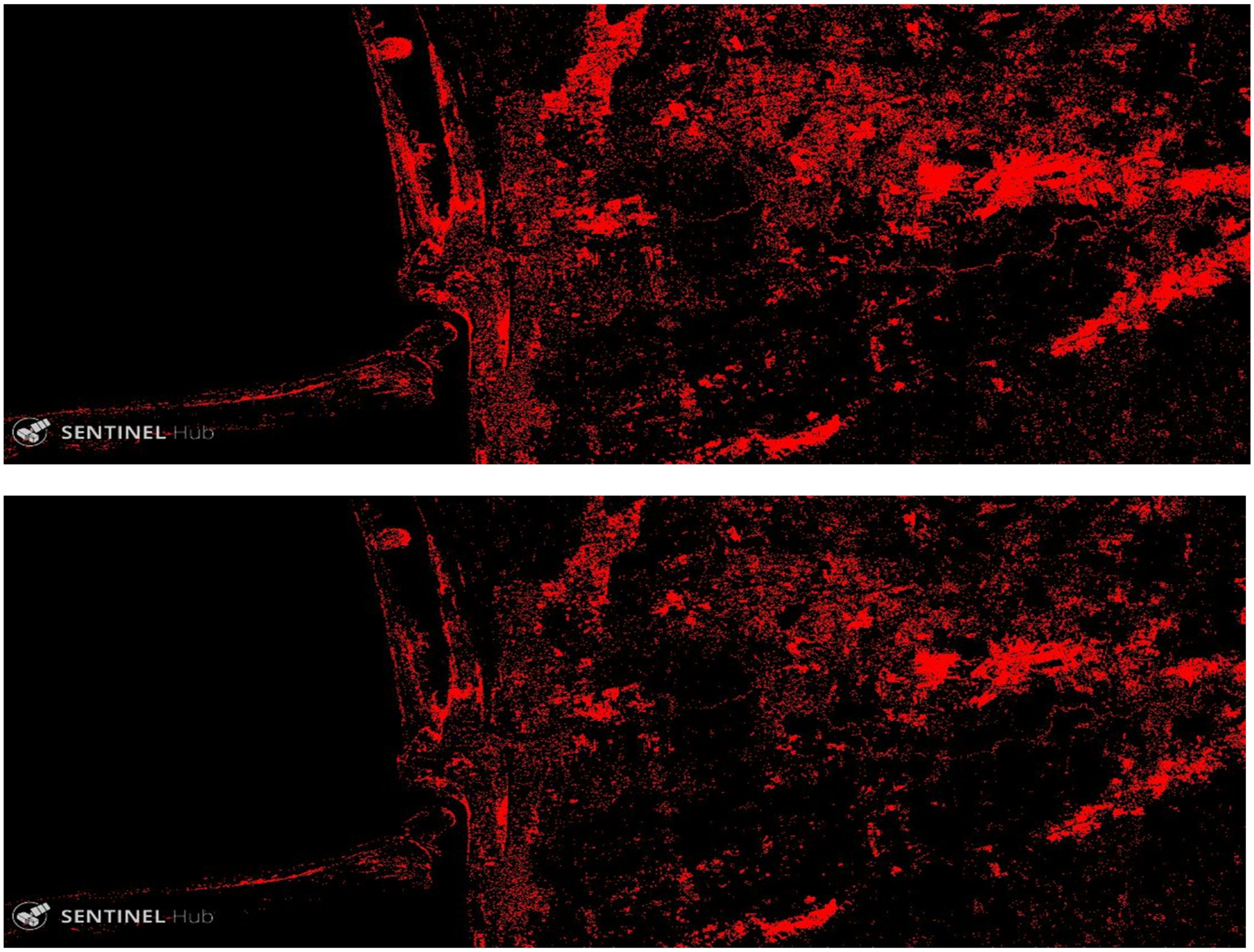

Fig. 4. The outputs of applying thresholds of 0.05 (top) and 0.08 (bottom) for the first case study.