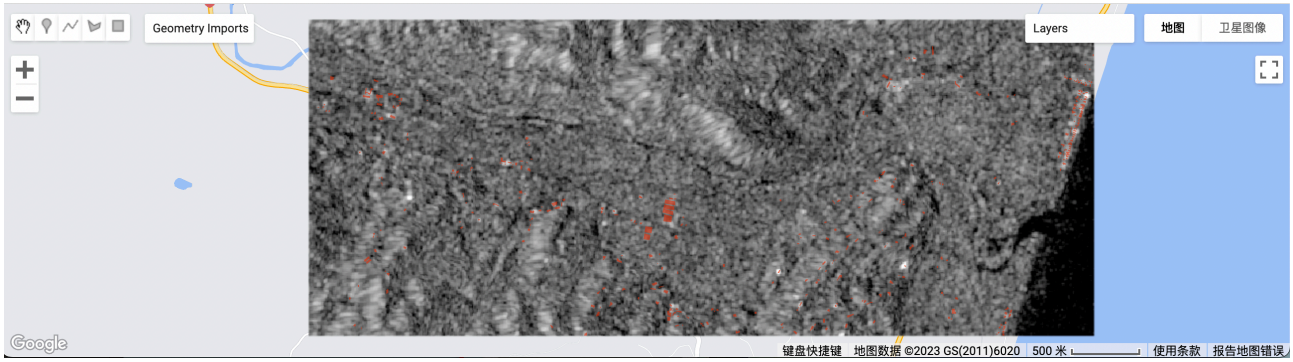
Esk River flood content damage assessment

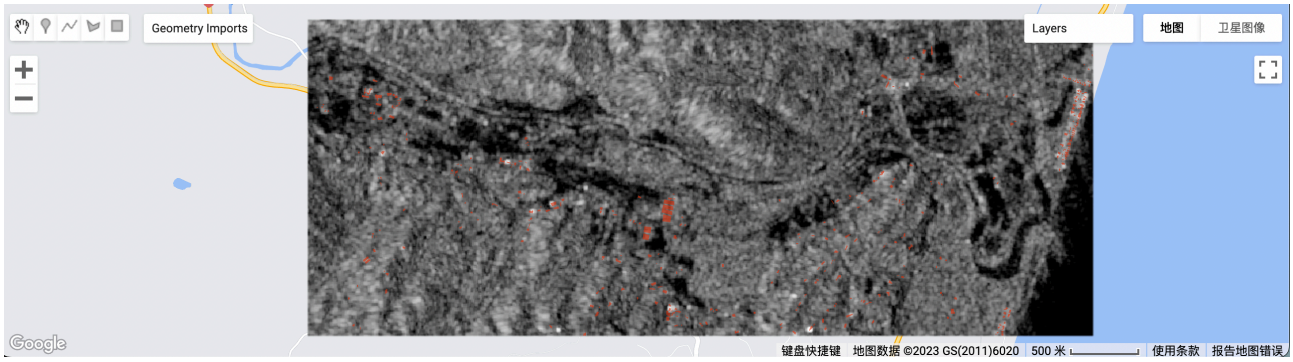
The Esk River meanders through Hawke's Bay on the eastern side of New Zealand's North Island. Flanked by hills to its north and south, the valley acts as a natural conduit for cyclones and deluges, directing them from the east towards the west. Nestled within the valley's lower expanse is the rural community of Eskdale. This scenic region is adorned with a plethora of vineyards, wineries, and orchards, and is also home to several resort hotels. In February 2023, Cyclone Gabrielle unleashed its fury on the Esk Valley, bringing with it torrential rains. Data sourced from the Tutira Cws weather station highlighted the intensity of this downpour: for ten straight hours, the 24-hour rainfall exceeded 300 mm, climaxing at an astounding 333.8 mm at 11 am on February 14th. The Esk Valley's unique trumpet-like geography exacerbated the situation, channeling the waters and leading to severe flooding. As a result, significant structural damages were reported throughout the region. In this project I will attempt to analyze the coverage of floods near Eskdale.

Method

Before assessing the extent of the flooding I found photos of some flood-hit locations near the Esk Valley through the media and some social platforms. Zeelandt Brewery, Eskdale War Memorial Church, and Linden Estate Winery can be identified through photo location information and some details. Photos of these areas will help judge how well the produced images match reality. In this project I used Google Earth Engine to confirm the extent of the flood. The first step was to create a geometry near the Esk River as an area of interest. This mainly includes the Eskdale area downstream of the river, which is the most severely damaged area. Initially, I planned to use NDWI to determine the impact range of floods, but the effect was very unsatisfactory. The reason is that the hurricane has shrouded the target area under thick clouds for a long time, which affects both the green light band and the near-infrared band used for calculations. So I chose synthetic aperture radar instead. SAR uses active microwaves to obtain ground information and is less affected by the atmosphere. This project mainly uses the VH band from Sentinel-1. When the surface is covered with water, the VH polarisation will be reduced, which is very suitable for flood range detection. By consulting the information, we can know that the flood roughly occurred from February 12 to 16, 2023. Therefore, the remote sensing images of the entire January of 2023 are selected as comparison images before the flood, and February 10 to 16 are the images after the flood. After adding the images before and after the flood to the map, you can get the following results.

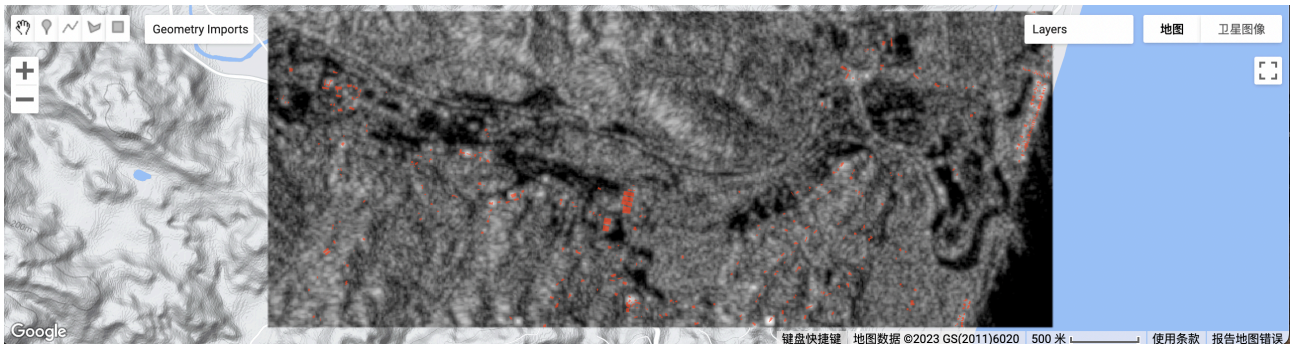


BEFORE



AFTER

Since the water body will reduce the reflectivity of VH, the area covered by the water surface will appear dark. By comparing the images before and after the flood, it can be clearly seen that the dark coverage area increased significantly after the flood. Next, reduce the speckle noise in the SAR image by creating a RefinedLee filter, making the transition smoother.

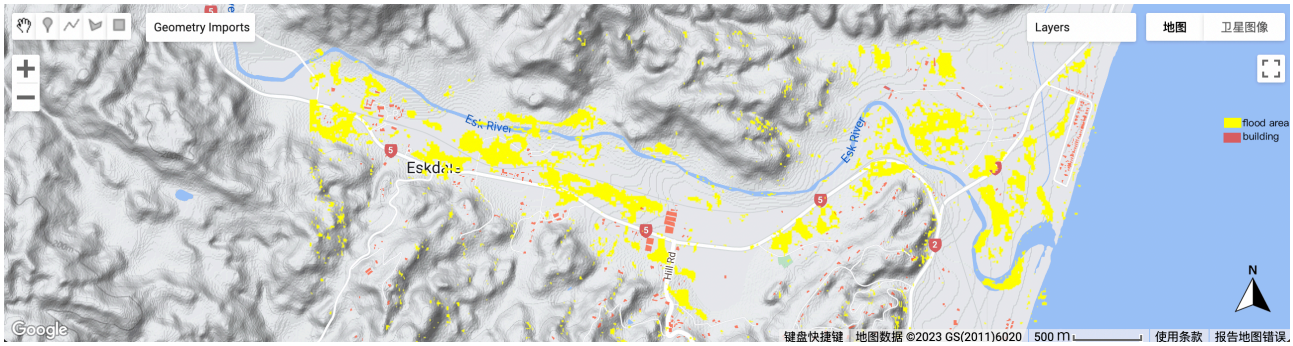


AFTER_FILTER

The final step is flood detection and visualization. It identifies areas where significant changes in radar reflectivity occur. A threshold of −20 dB is used to differentiate between water and other land cover. Areas that were not flooded before the hurricane and were flooded after the hurricane are highlighted. Potential flood areas are shown in yellow.

Result

In the flood extent map, the yellow area represents the range of the flood, and the red points are the buildings in the area. Due to the orbital cycle of Sentinel–1, we were unable to capture data at the height of the flood. However, the created imagery still clearly shows a substantial amount of water accumulation in the flat areas on both sides of the Esk River. The areas around Eskdale and the river's estuary seem to be the hardest hit. Based on the topography of the Esk River valley, the floodwaters primarily span areas roughly 500–1000 meters wide, trapped between elevated terrains on either side. By observing the distribution of houses, we can find that the main property damage caused by floods is concentrated in the Eskdale area, because buildings and plantations are concentrated here.



FLOOD EXTENT

Discussion

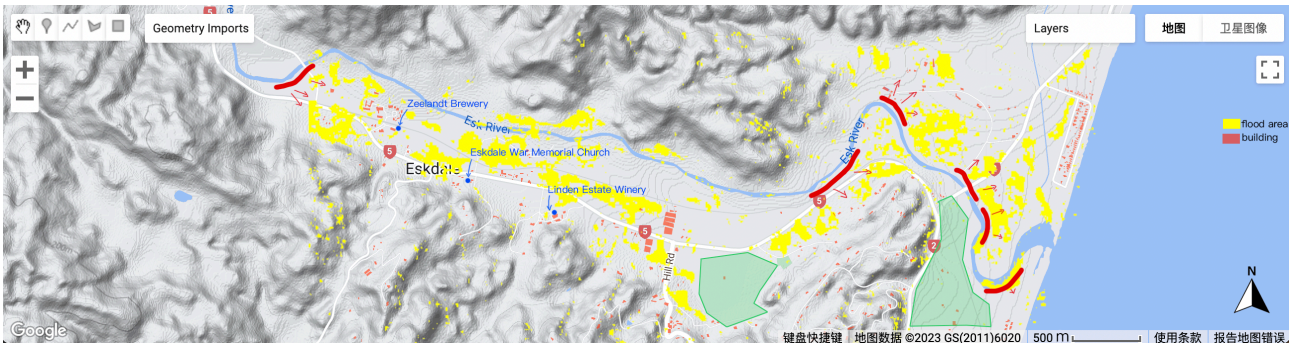
Flooding at Linden Estate. Photo / Warren Buckland

LINDEN ESTATE

Eskdale War Memorial Church is still standing following the flooding. Photo / Warren Buckland

ESKDALE WAR MEMORIAL CHURCH

IMAGE OF ZEELANDT BREWERY



When comparing real-life photographs with the flood extent map, we first look at the Linden Estate Winery. It is situated on the edge of the Esk River valley and is on relatively higher ground, so it wasn't severely affected. However, there are evident signs of flooding in the slightly lower areas not far from it. This photograph was likely taken after the floodwaters had receded somewhat. When juxtaposed with the modified flood map mentioned earlier, the scenarios seem to align reasonably well. From the photos, it is evident that the Eskdale War Memorial Church, located on the edge of the river valley, didn't suffer significant damage. However, its fence is piled high with dead branches and grass washed down by the floodwaters, indicating the flood at its peak reached this location. The third site is the Zeelandt Brewery, situated closer to the Esk River in an open area. It sustained the most damage, with only its rooftop visible. Surrounding structures and fields also appear devastated and buried in silt, indicating that this area is one of the most affected. From the information gathered from the photos, the intensity of the flooding was much greater than what my flood extent map depicted. This discrepancy was due to the temporal resolution of Sentinel-1. Its revisit cycle is six days, which meant it unfortunately missed capturing the flooding at its worst. However, there were still some insights from the map-making process.

Areas shielded by uplands seemed to be relatively safer. The regions I marked in green on the map were mostly unaffected by the floodwaters. Conversely, areas where the river made significant bends appeared to experience greater damage, with extensive silt deposition and standing water. In this project, I also attempted to use the NDBI (Normalised Difference Built-up Index) to determine the extent of buildings. However, due to the presence of a significant amount of exposed land in the vicinity, scattered buildings, and several other factors, the results were far from satisfactory. Consequently, I opted for manually delineating the building extents. Remote sensing is influenced by various factors, so perhaps establishing a topographic model using DEM (Digital Elevation Model) and then simulating the flood impact computationally would offer a more accurate approach.

Conclusion

The main objective of this project is to study the flood extent of the Esk River valley. In February 2023, Cyclone Gabrielle brought extreme rainfall to New Zealand, resulting in a devastating flood disaster. Due to prolonged cloud cover around the Esk River, I used the VH band of Sentinel-1 SAR for flood range analysis. Although the maximum flood coverage was not obtained due to the satellite orbit cycle, the existing flood map can still help assess the impact of the flood to a certain extent. It can be seen which areas still have a large amount of flood residue after the flood peak and can also be used to determine which areas are relatively less affected. Obtaining more accurate maps may require the use of other methods or analysis with other remote sensing satellites.

code review

google earth engine code：
https://code.earthengine.google.com/cd357dbee412e0171ac9b87d3caee5cd