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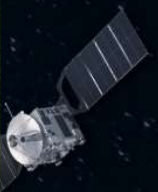
# Flood inundation mapping using Google Earth Engine

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Flood hazard, vulnerability and risk mapping

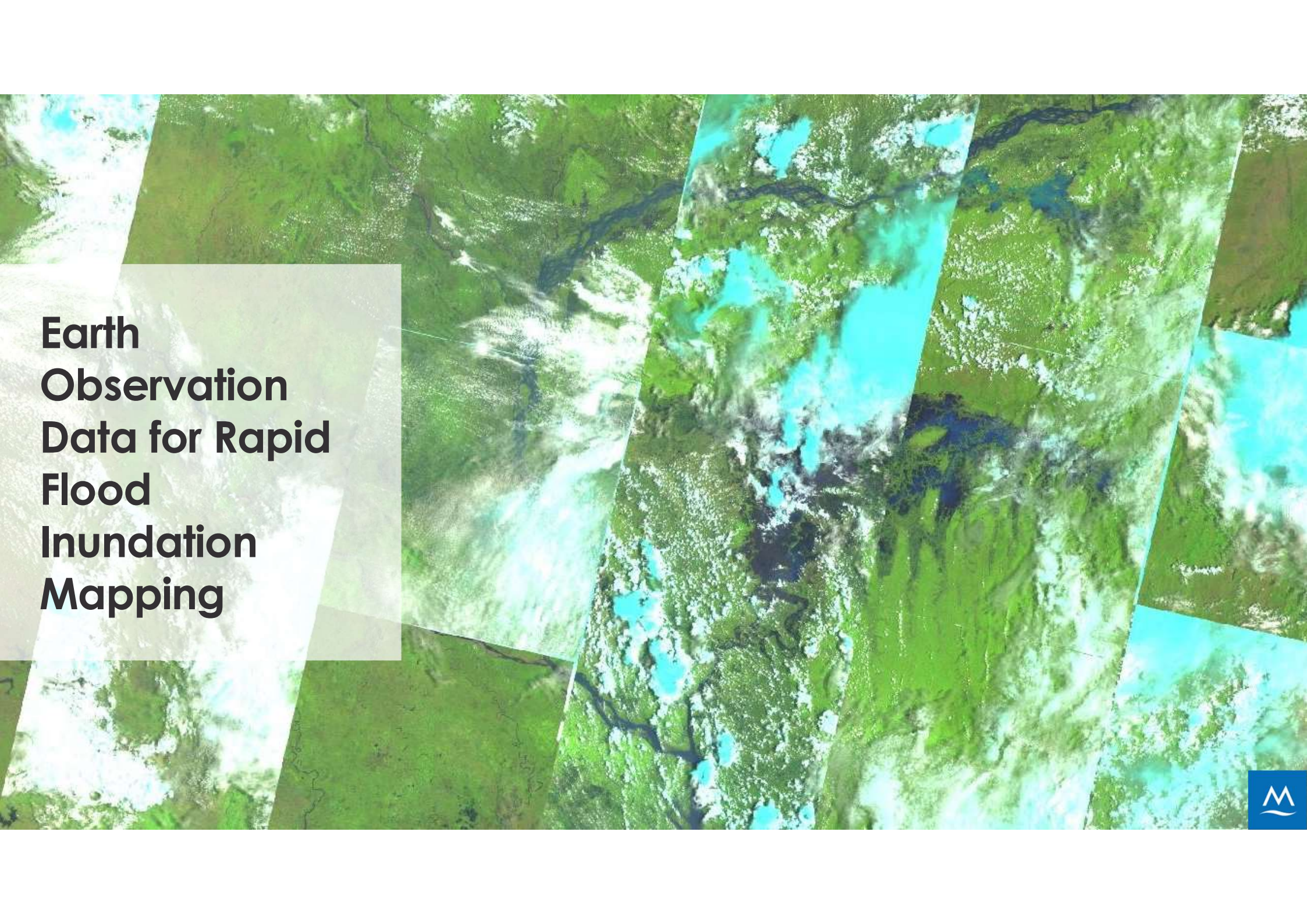
Flood early warning system

Flood inundation area

Flood damage assessment


Flood shelter suitability area



The background of the slide is a composite of several satellite images of a river basin. The images are arranged in a grid-like pattern, with some overlapping. The primary color is green, representing vegetation. Darker blue and black lines represent the river channels. Areas of light blue and cyan are overlaid on the green, indicating flood inundation. The text 'Earth Observation Data for Rapid Flood Inundation Mapping' is overlaid on a semi-transparent grey box on the left side of the image.

# Earth Observation Data for Rapid Flood Inundation Mapping



The background of the slide is a grayscale Synthetic Aperture Radar (SAR) image of a river valley. A dark, winding river is visible on the left side. A semi-transparent white rectangular box is overlaid on the left side of the image, containing the title text. At the bottom right, there is a teal-colored rectangular box containing a bulleted list of points. The overall image shows the texture of the ground and the structure of the river valley.

## Earth Observation for Rapid Flood Inundation Mapping

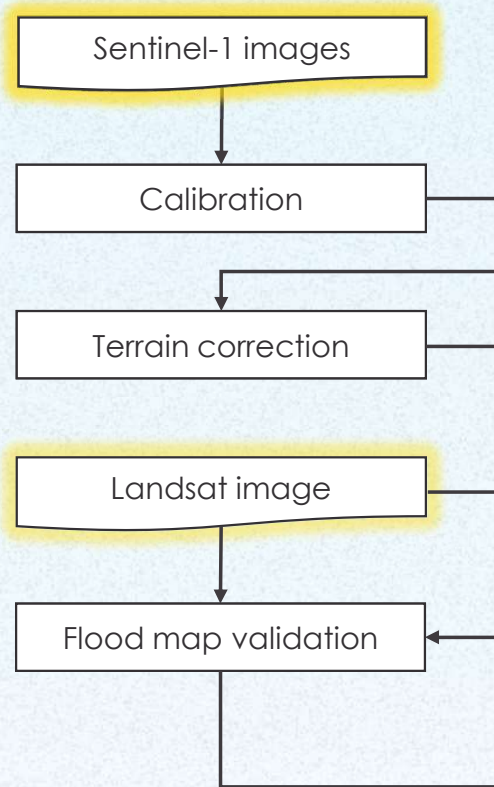
- SAR provides imagery on day-and-night;
- Clouds, fog and precipitation do not have any significant effect;
- Coverage area vast;
- Time series and frequent revisit ;
- Produce authentic flood inundation map;



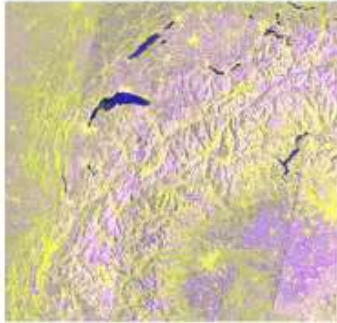
# Tools and Methods



# Tools and Methods



### Sentinel-1 SAR GRD: C-band Synthetic Aperture Radar Ground Range Detected, log scaling



DESCRIPTION BANDS IMAGE PROPERTIES TERMS OF USE

1. VV: single co-polarization, vertical transmit/vertical receive
2. HH: single co-polarization, horizontal transmit/horizontal receive
3. VV + VH: dual-band cross-polarization, vertical transmit/horizontal receive
4. HH + HV: dual-band cross-polarization, horizontal transmit/vertical receive

Each scene also includes an additional 'angle' band that contains the approximate incidence angle from ellipsoid in degrees at every point. This band is generated by interpolating the 'incidenceAngle' property of the 'geolocationGridPoint' gridded field provided with each asset.

Each scene was pre-processed with [Sentinel-1 Toolbox](#) using the following steps:

1. Thermal noise removal
2. Radiometric calibration
3. Terrain correction using SRTM 30 or ASTER DEM for areas greater than 60 degrees latitude, where SRTM is not available. The final terrain-corrected values are converted to decibels via log scaling ( $10 \cdot \log_{10}(x)$ ).

For more information about these pre-processing steps, please refer to the [Sentinel-1 Pre-processing article](#). For further advice on working with Sentinel-1 imagery, see [Guido Lemoine's tutorial on SAR basics](#) and [Mort Carty's tutorial on SAR change detection](#).

This collection is computed on-the-fly. If you want to use the underlying collection with raw power values (which is updated faster) see COPERNICUS/S1\_GRD\_FI\_OAT

Dataset Availability: 2014-10-03T00:00:00 -  
Dataset Provider: [European Union/ESA/Copernicus](#)  
Collection Snippet: `ee.ImageCollection("COPERNICUS/S1_GRD")`  
[See example](#)

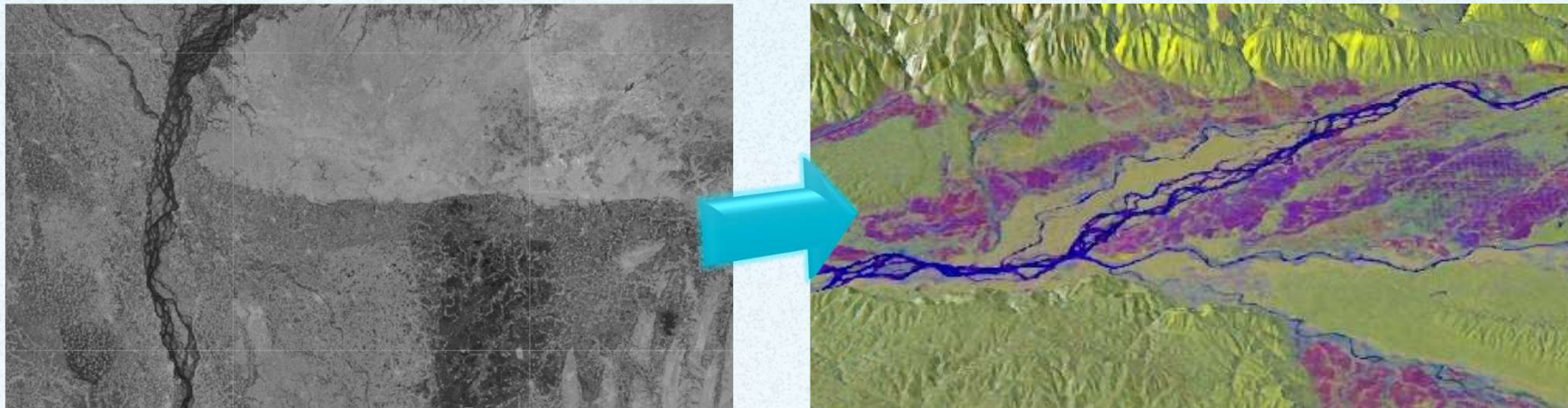
Tags: backscattering copernicus esa eu polarization radar sar sentinel

CLOSE IMPORT



# Exercise - 1

Creating a composite image for flood inundation mapping using Sentinel-1 data



Open the link: <https://tinyurl.com/24zbmzv4>

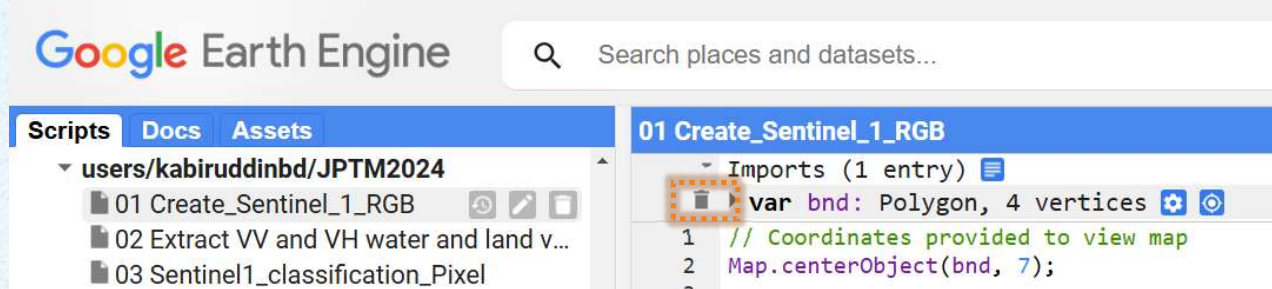
<https://code.earthengine.google.com/a9926a94a5264dca7c8c65eb754264c0>



# Exercise - 1

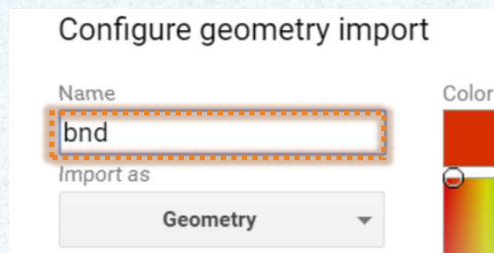
Creating a composite image for flood inundation mapping using Sentinel-1 data

**Task** Delete the existing boundary and digitized a new study boundary



**Task** Digitized a new study boundary

**Task** Rename default name "geometry" to "bnd"



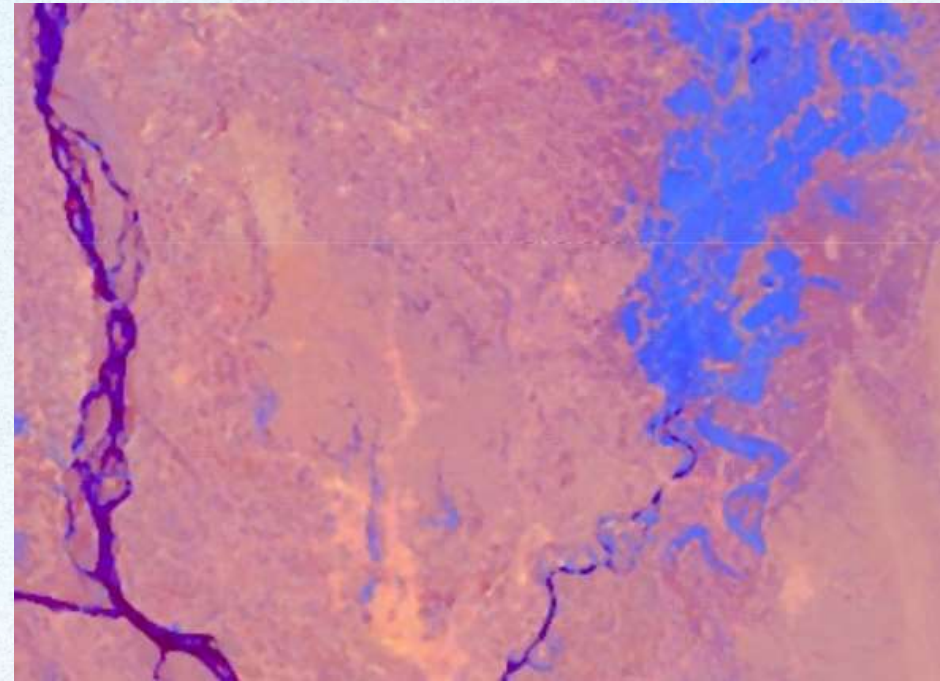
**Task** Run the code with new boundary



# Exercise - 1

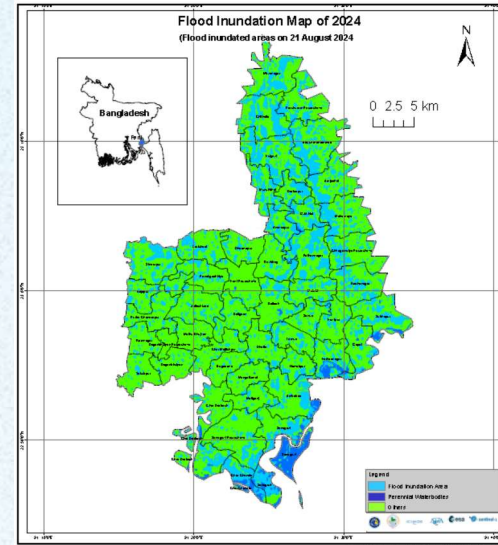
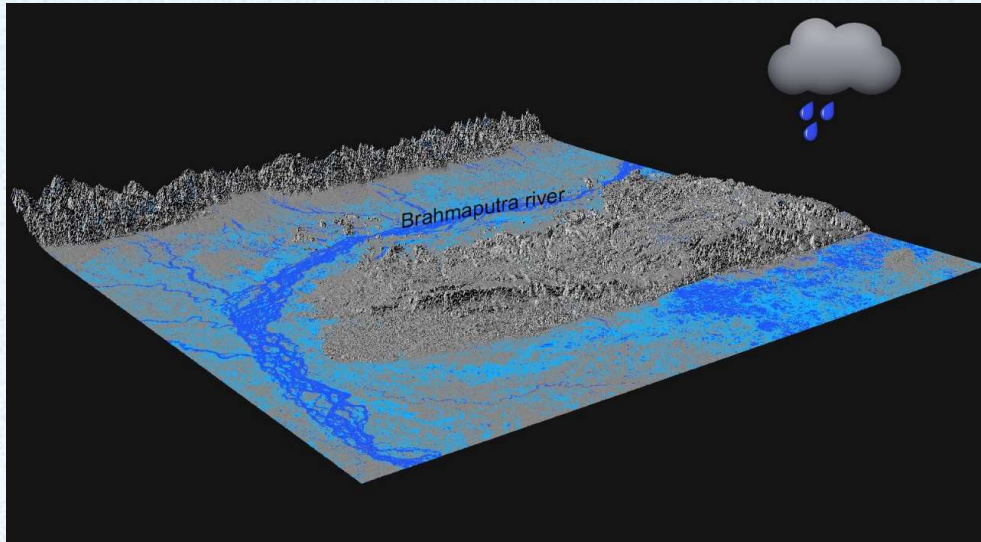
Creating a composite image for flood inundation mapping using Sentinel-1 data

```
01 Create_Sentinel_1_RGB Get Link Save Run  
77  
78  
79 // Create a Flood Image Composite using various bands  
80 var FloodImgComposite = ee.Image.cat([  
81   vvFloodSmoothed.rename('VVFlood_Filtered'),  
82   vhPreSmoothed.rename('VHPre_Filtered'),  
83   vvDifference.rename('VVDifference_Filtered'),  
84   vvvhFloodRatio.rename('VVVH_Flood_Ratio'),  
85   vhfloodSmoothed.rename('VHFlood_Filtered'),  
86   vvvhFloodSmoothed.rename('VVVH_Flood_Filtered')  
87   ]);  
88  
89 // // Create Flood Image Composite to the map  
90  
91 // Map.addLayer(FloodImgComposite.clip(bnd), {  
92 //   bands: ['VVFlood_Filtered', 'VHPre_Filtered', 'VVDifference_Filtered'],  
93 //   min: [-25, -25, -10],  
94 //   max: [0, 0, 10],  
95 //   gamma: 1.5  
96 // }, 'Flood Image Composite');  
97
```



# Exercise - 2

Flood inundation mapping using sentinel-1 for any chosen site/**boundary** and date



Open the link: <https://tinyurl.com/r789zje7>

<https://code.earthengine.google.com/00812066ce87f14bd7ea5038694ddf0e>



# Exercise - 2

The screenshot displays the Google Earth Engine (GEE) interface. At the top, the search bar contains "Search places and datasets...". The left sidebar shows a tree view of assets, including folders for "AFG", "BGD", and "bnd", with sub-assets like "BD\_500m\_costa...", "Mangrove", "bd\_buff\_h", "bd\_buff\_h\_clip", and "bd\_buff\_n". The main editor window shows a script titled "02 Sentinel1\_classifica...". The script code is as follows:

```
Imports (1 entry)
  var bnd: Table "bnd_buff"
1 // Coordinates provided to view map
2 Map.centerObject(bnd, 7);
3
4 // Selecting the pre-monsoon or pre-flood Copernicus Sentinel-1
5 var SenImgPre = ee.ImageCollection('COPERNICUS/S1_GRD')
6   .filterDate('2024-01-01', '2024-04-30')
7   .filterBounds(bnd);
8
```

The right sidebar contains the "Inspector", "Console", and "Tasks" panels. The "Tasks" panel shows a task named "Flood\_Map\_PB" with a "RUN" button. The main map area shows a satellite view of South Asia, with a legend in the bottom right corner:

- Flood inundation area (represented by a light blue square)
- Perennial water body (represented by a dark blue square)

The map shows flood inundation areas in light blue and perennial water bodies in dark blue across the region of India, Bangladesh, and parts of Southeast Asia.



# Exercise - 2

Task //Select the pre-flood Copernicus Sentinel-1 imagery

```
1 // Coordinates provided to view map
2 Map.centerObject(bnd, 7);
3
4 // Selecting the pre-monsoon or pre-flood Copernicus Sentinel-1
5 var SenImgPre = ee.ImageCollection('COPERNICUS/S1_GRD')
6   .filterDate('2024-01-01', '2024-04-30')
7   .filterBounds(bnd);
8
```

Task //Select the flooding time Copernicus Sentinel-1 imagery

```
30
31 // Selecting the flood Copernicus Sentinel-1
32 var SenImgFlood = ee.ImageCollection('COPERNICUS/S1_GRD')
33   .filterDate('2024-09-02', '2024-10-07')
34   .filterBounds(bnd);
35 print('Flood Image Collection:', SenImgFlood);
36 // Filtering flood time Copernicus Sentinel-1 image by metadata properties.
```



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# Exercise - 2

Task //If needed adjust the sentinel-1 backscatter threshold

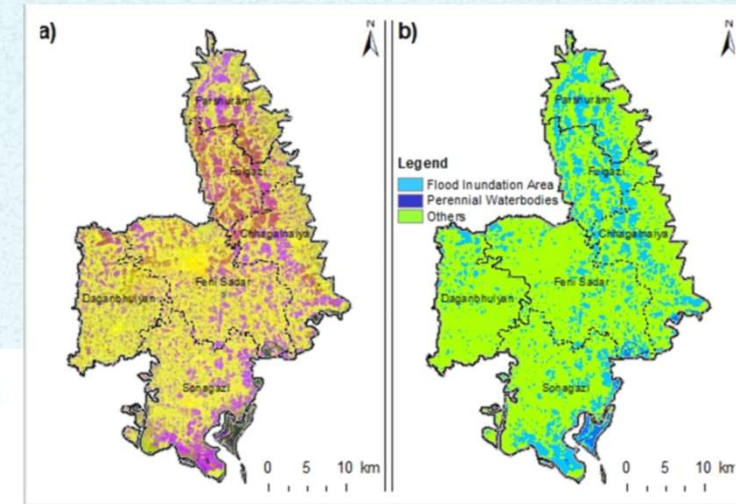
```
104
105 // Flood masking and mosaicking the Sentinel-1 image
106 var classifiedFloodPB = ee.ImageCollection([
107   vvFloodSmoothed.updateMask(vvFloodSmoothed.lt(-15.94)).visualize(floodVisualization),
108   vhPreSmoothed.updateMask(vhPreSmoothed.lt(-24.06)).visualize(floodVisualization),
109   vvvhFloodRatio.updateMask(vvvhFloodRatio.lt(-28)).visualize(floodVisualization),
110 |
111   waterMask_PreFlood.visualize({palette: ['BLUE']})
112 ]).mosaic();
```

Note: Exercise – 3 will show how we can determine the appropriate backscatter value

# Exercise - 2

**Task** Export the generated flood map

```
118
119 // ** Export the Pixel-Based Flood Map (Flood Map Pixel-Based PB) **
120 Export.image.toDrive({
121   image: classifiedFloodPB, // Clipped Pixel-Based Flood Map
122   description: 'Flood_Map_PB',
123   folder: 'a' // a is the folder name, please specify the Google Drive folder name
124   fileNamePrefix: 'Flood_Map_PB', // File name for the exported image
125   scale: 10, // Sentinel-1 resolution scale, recommended to export 30 meter scale
126   region: bnd, // Study area boundary
127   fileFormat: 'GeoTIFF',
128   maxPixels: 3e9 // Adjust this if necessary for larger regions
129 });
130
```



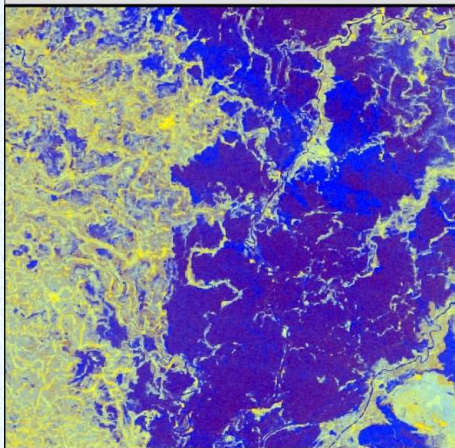


# Exercise - 3

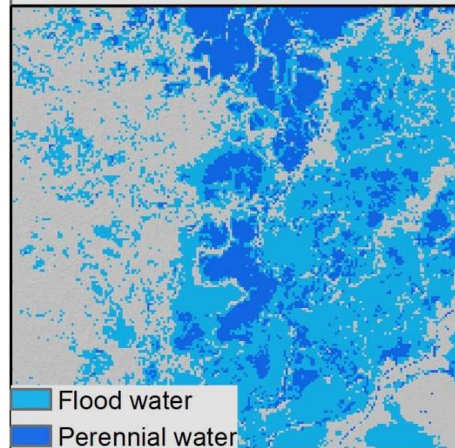
Determination of Copernicus sentinel-1 backscatter threshold to automatically flood inundation mapping in GEE and comparison of sentinel-1 based flood inundation map with Landsat-8 image



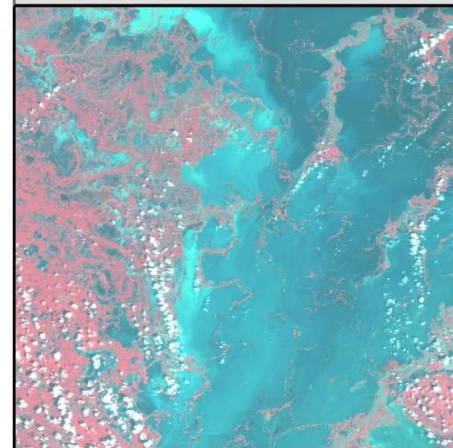
Sentinel-1 image, Date: 2019-09-19



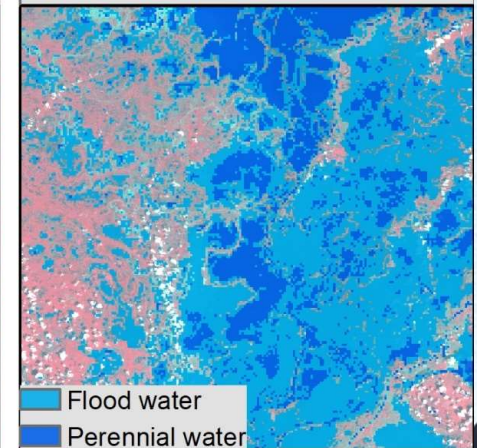
Flood map, Date: 2019-09-19



Landsat-8 image, Date: 2019-09-19



Overlaid flood map on Landsat image

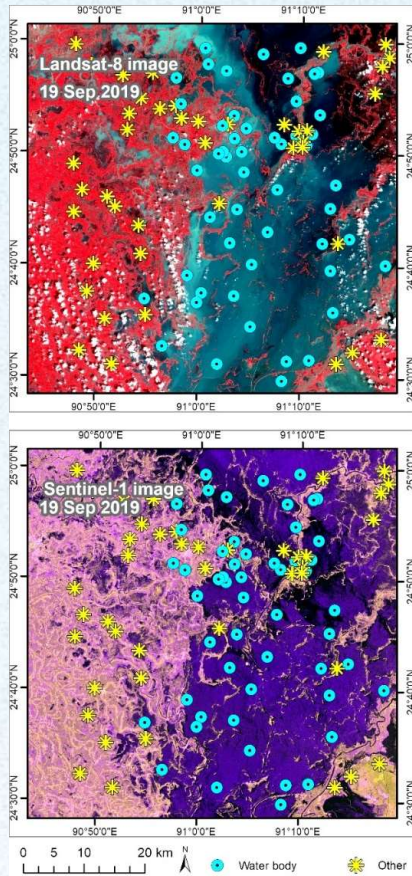


Open the link: <https://tinyurl.com/2djwe9tn>

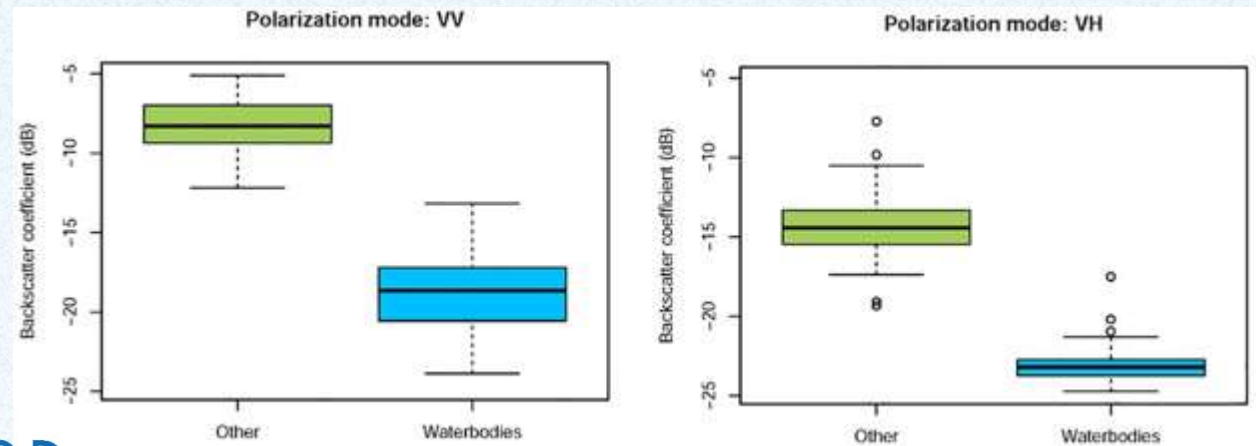
<https://code.earthengine.google.com/7fb06c3f197db41aef5d54127ca3d46>



# Exercise - 3



- Insert water and land samples on the Landsat image/Sentinel 1 image.
- Extract VH and VV-band backscatter (dB) statistics for water body and other samples.
- Find the interquartile range, mean and median value of waterbodies on the VH and VV-band backscatter (dB)
- Use the VH and VV-band backscatter (dB) for mapping



# Exercise - 3

The screenshot shows the Google Earth Engine web interface. At the top, the search bar contains "Search places and datasets...". The user's profile is "ee-kabiruddinbd". The left sidebar shows a file tree with folders for "users/kabiruddinbd..." and sub-folders for "01 Create\_Sentin...", "02 Sentinel1\_cla...", "03 Ext...", and "04 Sentinel1\_cla...". The main editor displays a script titled "03 Extract VV a...".

```
Imports (3 entries)
  var water: FeatureCollection (10 elements)
  var land: FeatureCollection (5 elements)
  var bnd: Polygon, 4 vertices

1 // Coordinates provided to zoom to a particular location in the s
2 Map.setCenter(93.5334, 24.2016, 9);
```

The right sidebar shows the "Inspector" and "Console" panels. The "Inspector" panel displays "VV and VH Polarization Int..." with a slider set to 1/4. The "Console" panel shows the instruction "Use print(...) to write to this console." The map view shows a satellite image of a coastal region with several blue and green location markers. The map includes a scale bar for 20 km and a "Report a map error" link.



# Exercise - 3

The image shows a GIS interface with a map of Dhunat, Sirajganj, and Chandaikona. A red polygon is overlaid on the map. A 'Geometry Imports' panel is visible, showing a layer named 'bnd (1 poly)' and a '+ new layer' button circled in red. A 'Configure geometry import' dialog box is open, with the following fields:

- Name: water (circled in red)
- Import as: FeatureCollection
- Properties table:

Property	Value
className	1 (circled in red)
- Color: #417af1 (with a color picker)
- Buttons: OK (circled in red), Cancel, and a trash icon.

# Exercise - 3

The image shows a GIS application interface. On the left, a map displays a red polygon. A 'Geometry Imports' panel is visible, with a '+ new layer' button circled in red. On the right, a 'Configure geometry import' dialog box is open. The dialog box contains the following fields and options:

- Name:** land (circled in red)
- Import as:** FeatureCollection
- Properties:**

Property	Value
className	2 (circled in red)
- Color:** #98ff00 (circled in red)

At the bottom of the dialog box, there are three buttons: 'OK' (circled in red), 'Cancel', and a trash icon.

# Exercise - 3

03 Extract VV and VH water and land value \*

Get Link

Save

Run

Reset

Imports (3 entries)

- var water: FeatureCollection (10 elements)
- var land: FeatureCollection (5 elements)
- var bnd: Polygon, 4 vertices

```
1 // Coordinates provided to zoom to a particular location in the study area
2 Map.setCenter(90.5284, 24.2916, 8);
3
4 // Pre-monsoon or pre-flood Copernicus Sentinel-1 Date: 2019-05-20
5 var SenImgPre = ee.Image('COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20190520T120441_20190520T120506_027311_031480_43CA');
6
7 // Flood inundation periods Copernicus Sentinel-1 Date: 2019-09-19
8 var SenImgFlood = ee.Image('COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20190919T235547_20190919T235612_029097_034D72_B042');
9
48 // Landsat image for comparison
49 var landsat = ee.Image('LANDSAT/LC08/C02/T1_RT/LC08_137043_20190920');
50 Map.addLayer(landsat, {bands: ['B5', 'B4', 'B3'], min: 2164, max: 20205}, 'Landsat 20 Sep 2019', false);
51
68
69 // Flood masking and mosaicking the Sentinel 1 image.
70 var FloodMap = ee.ImageCollection([
71   vvFloodSmoothed.updateMask(vvFloodSmoothed.lt(-17)).visualize(floodViz),
72   vhFloodSmoothed.updateMask(vhFloodSmoothed.lt(-21)).visualize(floodViz),
73   Sprevv_smoothedmask.visualize({palette: ['BLUE']}),
74 ]).mosaic();
75 Map.addLayer(FloodMap.clip(bnd), {}, 'Flood Map');
```



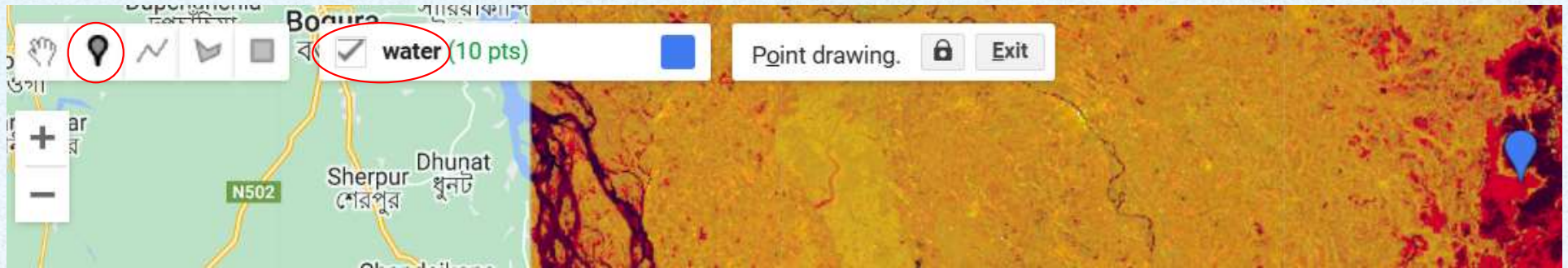
Task

Please change the backscatter value from line 71 and 72, and run code. Visually compare the results with Landsat image.



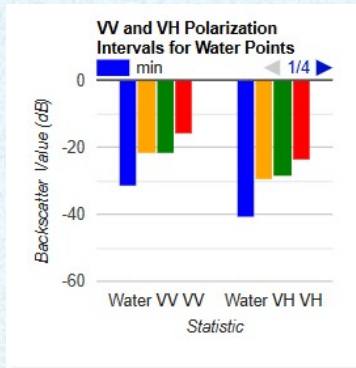
# Exercise - 3

Insert point for water and land



# Exercise - 3

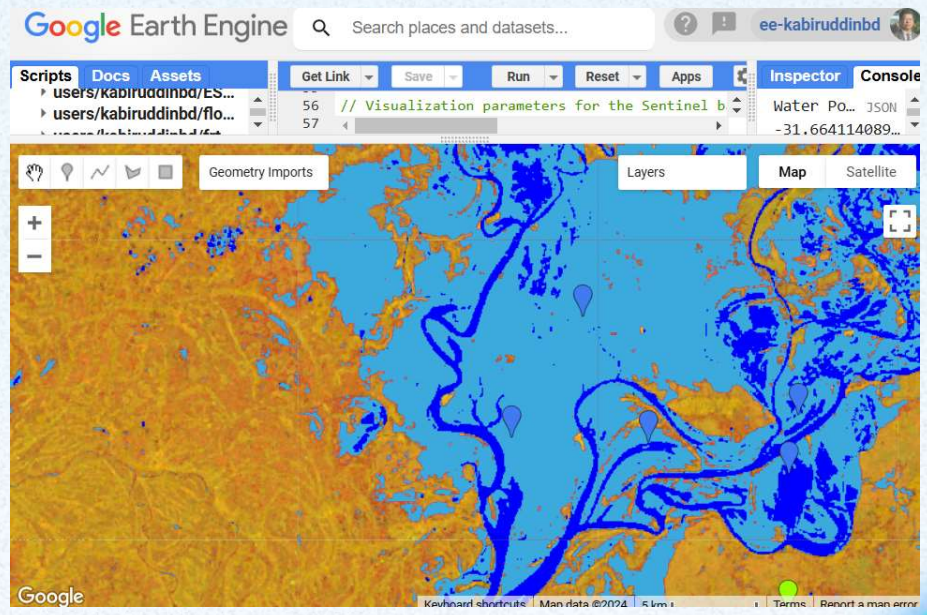
Please change the backscatter value from line 72 and 73 and run code. Visually compare the results with Landsat image.



- Water Points VV Min: [-31.664114089543798](#)
- Water Points VV Max: [-15.942186064300024](#)
- Water Points VV Mean: [-22.086264130646097](#)
- Water Points VV Median: [-21.98514182857053](#)
- Water Points VH Min: [-31.664114089543798](#)

```

69
70 // Flood masking and mosaicking the Sentinel 1 image.
71 var FloodMap = ee.ImageCollection([
72   vvFloodSmoothed.updateMask(vvFloodSmoothed.lt(-17)).visualize(floodViz),
73   vhFloodSmoothed.updateMask(vhFloodSmoothed.lt(-21)).visualize(floodViz),
74   Sprevv_smoothedmask.visualize({palette: ['BLUE']}),
75 ]).mosaic();
76 Map.addLayer(FloodMap.clip(bnd), {}, 'Flood Map');
  
```





# Exercise - 4

Using the Random Forest classification technique for flood inundation mapping

The screenshot displays the Google Earth Engine interface. On the left, the 'Scripts' panel shows a folder structure for 'users/kabiruddinbd/JPTM2024', with the script '02 Sentinel1\_classification Pixel' selected. The main editor shows the following code:

```
04 Sentinel1_classification_RF *
22 preFloodVH_VVDescend.select('VH').mean().rename('VHPre')
23 ].focal_median(100, 'circle', 'meters');
24
25 // Selecting the flood Copernicus Sentinel-1
26 var floodSentinel1 = ee.ImageCollection('COPERNICUS/S1_GRD')
27   .filterDate('2024-08-21', '2024-08-22')
28   .filterBounds(bnd);
29
30 print(floodSentinel1)
31 // Filtering flood time Copernicus Sentinel-1 image by metadata properties.
32
33
```

Below the code, a map visualization shows a satellite image of a region with a flood classification overlay. A legend titled 'Geometry Imports' is visible, listing: 'bnd (1 poly)', 'flood (130 pts)', 'water (60 pts)', and 'land (130 pts)'. The map shows a green area representing land, a blue area representing water, and a red area representing flood. A satellite icon is visible in the bottom right corner of the map area.

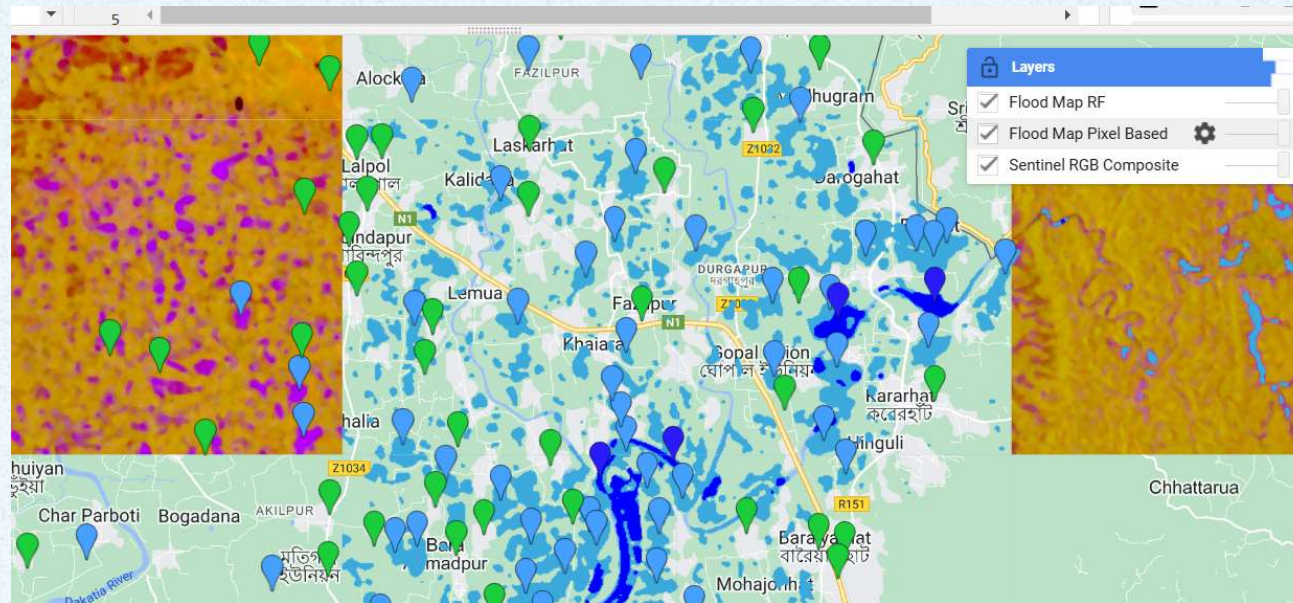
Open the link: <https://tinyurl.com/2djwe9tn>

<https://code.earthengine.google.com/ac3aa9fd4c2f6e53aada0c6d4b0b7214>



# Exercise - 5

Using the Random Forest classification technique for flood inundation mapping

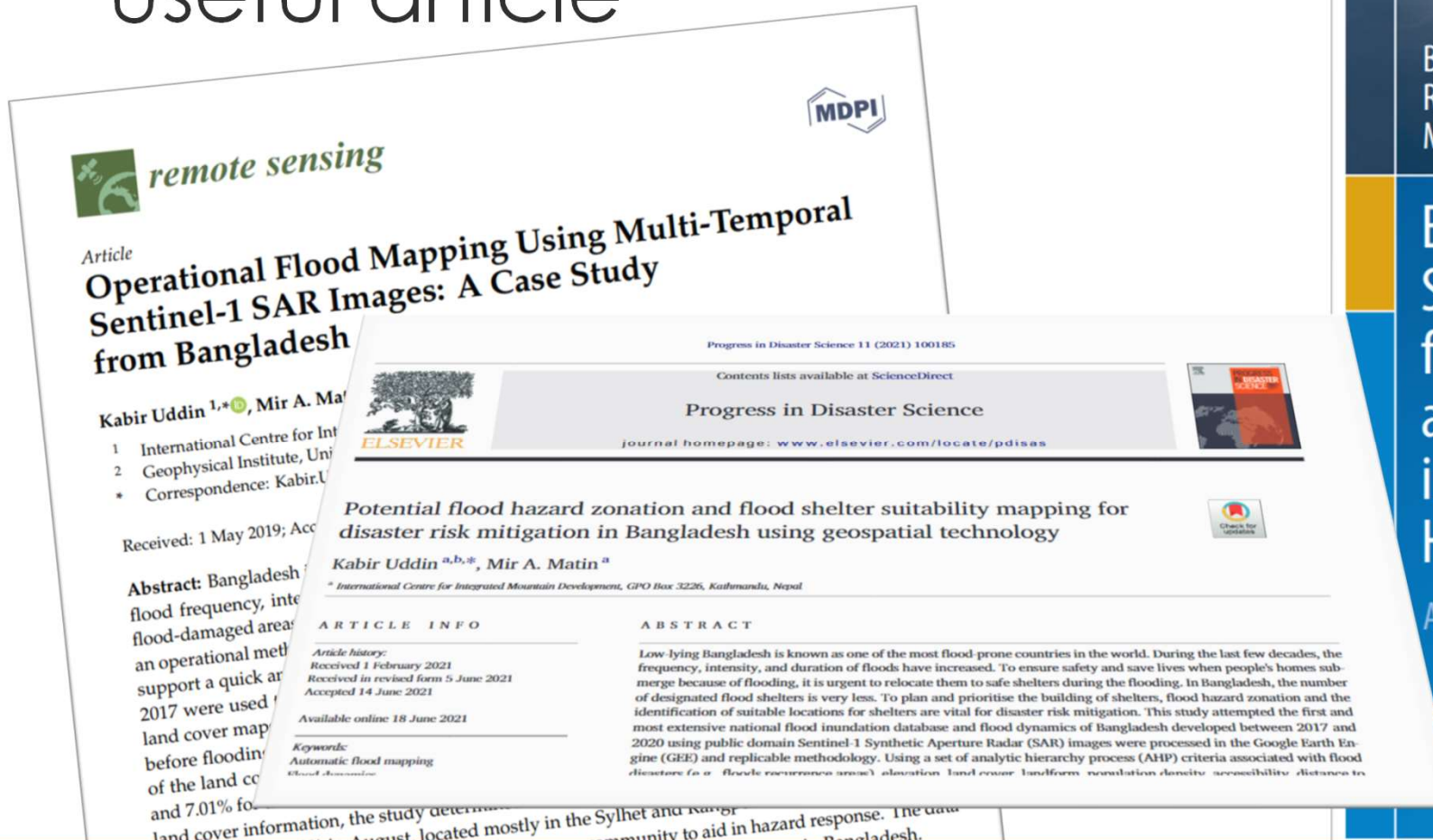


Open the link: <https://tinyurl.com/4e352w82>

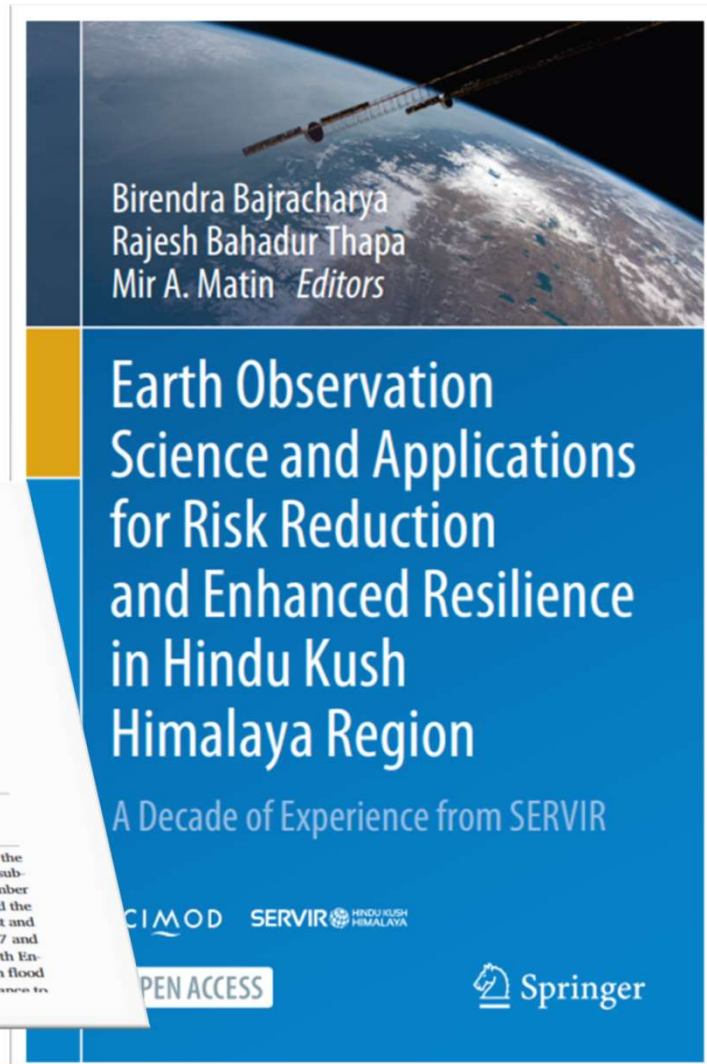
<https://code.earthengine.google.com/cbee2a9d18c5f94c3c2066b24050a8b5>



# Useful article



The image shows two overlapping document pages. The top page is the cover of the journal 'remote sensing' (MDPI), featuring the title 'Operational Flood Mapping Using Multi-Temporal Sentinel-1 SAR Images: A Case Study from Bangladesh' by Kabir Uddin and Mir A. Matin. The bottom page is an article from 'Progress in Disaster Science' (Elsevier) with the title 'Potential flood hazard zonation and flood shelter suitability mapping for disaster risk mitigation in Bangladesh using geospatial technology' by Kabir Uddin and Mir A. Matin. The article page includes an abstract, keywords, and article history.



The image shows the cover of a book titled 'Earth Observation Science and Applications for Risk Reduction and Enhanced Resilience in Hindu Kush Himalaya Region'. The cover features a satellite image of the Earth. The editors are Birendra Bajracharya, Rajesh Bahadur Thapa, and Mir A. Matin. The book is published by Springer and is available in Open Access. The cover also mentions 'A Decade of Experience from SERVIR' and lists the organizations CIMOD, SERVIR, and HINDU KUSH HIMALAYA.

[www.mdpi.com/2072-4292/11/13/1581](http://www.mdpi.com/2072-4292/11/13/1581)  
[https://link.springer.com/chapter/10.1007/978-3-030-73569-2\\_10](https://link.springer.com/chapter/10.1007/978-3-030-73569-2_10)  
[www.sciencedirect.com/science/article/pii/S2590061721000454](http://www.sciencedirect.com/science/article/pii/S2590061721000454)



Thank you

