# River Network Detection Project Proposal

M Srinivasan (IMT2021058), Siddharth Kothari (IMT2021019),
Sankalp Kothari (IMT2021028)

## 1 Project Outline

This project aims to develop a methodology for extracting rivers and tributaries from Sentinel-1 Synthetic Aperture Radar (SAR) data using SNAP and Python for flood mapping and rescue applications.

### 1.1 Data Acquisition

- **Sentinel-1 data selection**

  1. Define the Area of Interest (AOI) based on the flood-prone region.
  2. Choose appropriate Sentinel-1 scenes based on:
     (a) *Acquisition mode*: Interferometric Wide Swath (IW) mode provides good spatial resolution and coverage for river extraction.
     (b) *Polarization*: Dual-polarization (VV and VH) data offers valuable information for water-land discrimination.
     (c) *Temporal coverage*: Acquire pre-flood and post-flood scenes for change detection and flood extent identification.

- **Sentinel-1 Data access**

  1. Use the Sentinels Scientific Data Hub or online platforms like Copernicus web browser.

### 1.2 Data Pre-Processing

Even though Sentinel Hub makes satellite data readily accessible and provides some basic processing, pre-processing an image sourced from Sentinel Hub is still often necessary for several reasons such as :

- Corrections for sensor characteristics and errors

  1. **Calibration** Satellite instruments have specific gains and offsets that distort the raw data. Calibrating the data corrects for these instrumental limitations, ensuring accurate representation of the actual Earth surface properties.

2. **Speckle reduction** Inherent in SAR data, speckle noise appears as granular texture and can obscure true features. Speckle filtering techniques suppress this noise, improving image clarity and facilitating accurate analysis.

- Geometric considerations

1. **Terrain correction** Due to Earth's topography, satellite images appear distorted. Applying a Digital Elevation Model (DEM) corrects for these distortions, presenting a more accurate geometric representation of the land surface
2. **Geometric resampling** Images may have varying resolutions or projections. Resampling adjusts the image geometry to a desired resolution and projection, allowing for consistent analysis and comparison with other data sources

- Preparation for specific analysis:

1. **Normalization** Backscatter values in SAR data can vary across different acquisitions due to factors like satellite position and atmospheric conditions. Normalization techniques apply consistent scaling to different scenes, enabling reliable comparison and feature extraction.
2. **Band manipulation**: Combining different satellite bands (e.g., VV and VH polarization) in specific ratios can enhance certain features like water bodies or vegetation, making them easier to identify and extract.
3. **Subsetting** Focusing on a specific Area of Interest (AOI) from the larger image reduces processing time and data storage requirements, making analysis more efficient.

* *Speckle filtering:* Reduce speckle noise inherent in SAR data using filters like Lee or Boxcar Filter. * *Terrain Correction:* Apply Digital Elevation Model (DEM) data to correct for topographic distortions. * *Backscatter normalization:* Normalize backscatter values to improve radiometric consistency across different acquisitions. * *Subset creation:* Extract the AOI from the pre-processed data for further analysis.

## 1.3 Image Processing using Python

1. **Channel manipulation**: Combine VV and VH bands using various ratios (VV/VH, VH/VV) to enhance water features.
2. **Thresholding**: Apply appropriate thresholding techniques (Otsu, Multi-level) to segment water bodies from land.
3. **River network extraction**: Implement algorithms like skeletonization or centerline extraction to delineate the main river course and tributaries.
4. **Change detection**: Analyze pre-flood and post-flood data to identify flooded areas and track changes in river morphology.

## 1.4 Deliverables

1. Extracted river network datasets (shapefiles or GeoTIFFs) with main course and tributaries.
2. Flood inundation maps showing the extent of flooding based on pre-flood and post-flood analysis.

3. Visualizations and reports documenting the methodology and results.

## 1.5 Tools and Libraries

1. GIS software (QGIS, ArcGIS) for visualization and analysis
2. Python libraries for image processing (OpenCV, NumPy, SciPy)
3. SNAP software for pre-processing (downloadable from ESA)

## 1.6 Potential Applications

1. Floodplain mapping and inundation modeling for flood risk assessment.
2. Real-time flood monitoring and emergency response during flood events.
3. Supporting navigation and rescue operations in flooded areas.
4. Studying river dynamics and environmental monitoring.

## 1.7 Additional Considerations

1. Availability of accurate DEM data is crucial for terrain correction.
2. Choose appropriate thresholds and algorithms based on the specific characteristics of the target rivers and floodplains.
3. Incorporate in-situ data like river gauge measurements for validation purposes.
4. Consider advanced techniques like machine learning for automated river extraction and flood detection.