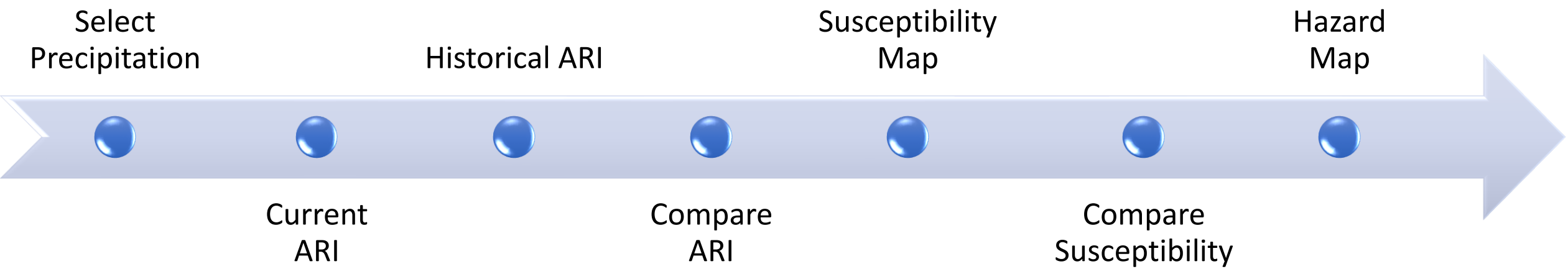


Running LHASA version 1 in Google Earth Engine

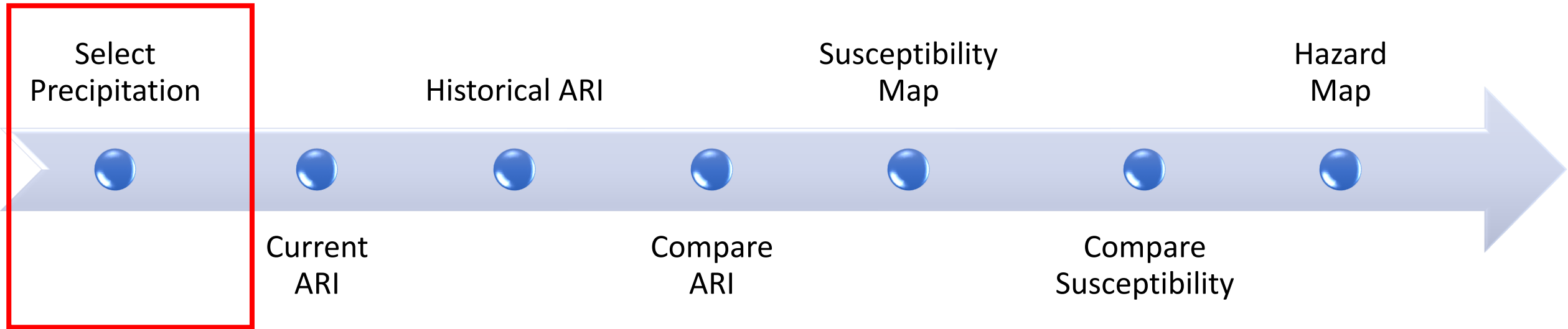
Dr. Nishan Kumar Biswas

Methodology

LHASA version 1



Step 1: Precipitation



Requirements:

- 1) Access to code window of Earth Engine
- 2) Precip_Visualization_Code.txt

Precipitation availability in Google Earth Engine (GEE)

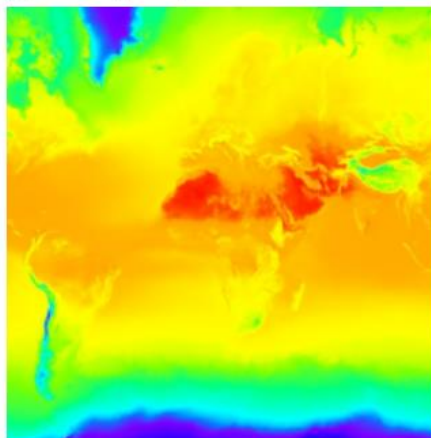
Datasets tagged

Filter list of datasets

34 different datasets

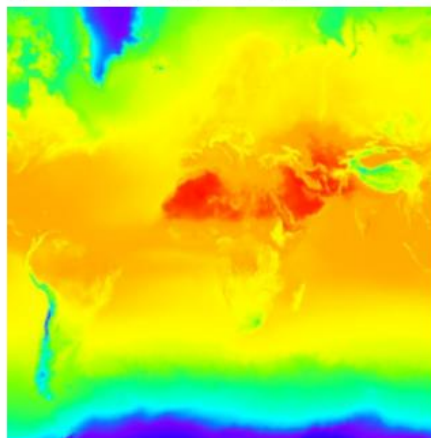
Link: <https://developers.google.com/s/results/earth-engine/datasets/?q=precipitation>

ERA5 Daily Aggregates - Latest Climate Reanalysis Produced by ECMWF / Copernicus Climate



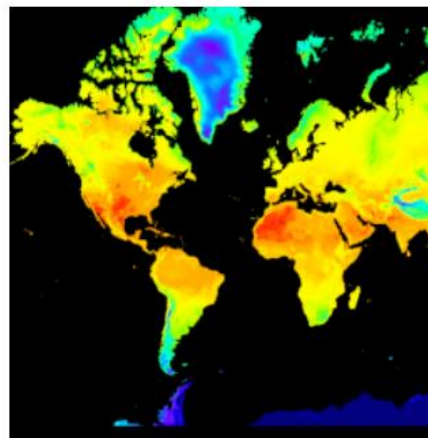
ERA5 is the fifth generation ECMWF atmospheric reanalysis of the global climate. Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset. ERA5 replaces its predecessor, the ERA-Interim reanalysis.

ERA5 Monthly Aggregates - Latest Climate Reanalysis Produced by ECMWF / Copernicus Climate



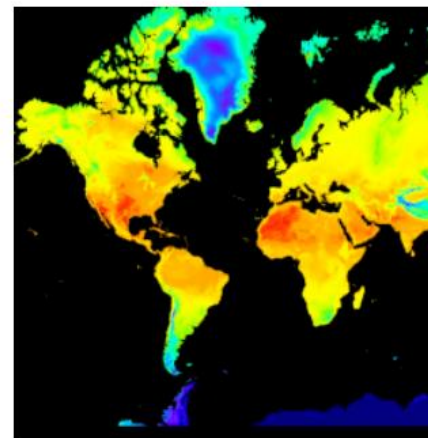
ERA5 is the fifth generation ECMWF atmospheric reanalysis of the global climate. Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset. ERA5 replaces its predecessor, the ERA-Interim reanalysis.

ERA5-Land Hourly - ECMWF Climate Reanalysis



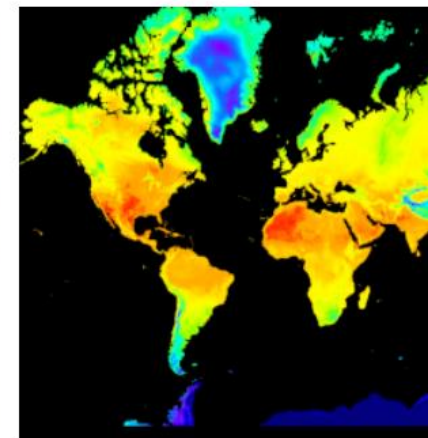
ERA5-Land is a reanalysis dataset providing a consistent view of the evolution of land variables over several decades at an enhanced resolution compared to ERA5. ERA5-Land has been produced by replaying the land component of the ECMWF ERA5 climate

ERA5-Land Monthly Averaged - ECMWF Climate Reanalysis



ERA5-Land is a reanalysis dataset providing a consistent view of the evolution of land variables over several decades at an enhanced resolution compared to ERA5. ERA5-Land has been produced by replaying the land component of the ECMWF ERA5 climate

ERA5-Land Monthly Averaged by Hour of Day - ECMWF Climate Reanalysis



ERA5-Land is a reanalysis dataset providing a consistent view of the evolution of land variables over several decades at an enhanced resolution compared to ERA5. ERA5-Land has been produced by replaying the land component of the ECMWF ERA5 climate

First, import precipitation data in GEE
<https://code.earthengine.google.com/>

Searching and selecting precipitation

The screenshot displays the Google Earth Engine web interface. At the top, the browser address bar shows 'code.earthengine.google.com'. The main header includes the 'Google Earth Engine' logo and navigation tabs for 'Scripts', 'Docs', and 'Assets'. A search bar in the top right contains the text 'IMERG'. A dropdown menu is open below the search bar, listing search results under 'PLACES' and 'RASTERS'. The 'RASTERS' section is highlighted, showing several precipitation datasets: 'GPM: Global Precipitation Measurement (GPM) v6' (with an 'import »' link), 'GPM: Monthly Global Precipitation Measurement (GPM) v6', 'OpenLandMap Precipitation Monthly', 'TRMM 3B42: 3-Hourly Precipitation Estimates', and 'TRMM 3B43: Monthly Precipitation Estimates'. The main map area shows a satellite view of South and Southeast Asia, with labels for countries like India, Bangladesh, Myanmar, Laos, Thailand, Vietnam, Cambodia, and the Philippines. The interface also includes a 'Scripts' panel on the left with a 'Filter scripts...' field and a 'NEW' button, and a 'Console' panel on the right showing a JSON output: '[1600732800000,1600819200000]'. The bottom of the page features a 'Google' logo, 'Keyboard shortcuts', 'Map data ©2022 Google, TMap Mobility', a scale bar for 200 km, and a 'Terms of Use' link.

Importing precipitation

currentARI - Earth Engine Code Editor | lhasav1_mekong | EIS_freshwater - Google Drive | Concept note and agenda - Google Doc

code.earthengine.google.com

Google Earth Engine

Scripts Docs Assets

Filter scripts... NEW

Owner (3)

- users/nbiswas/default
- users/nbiswas/lhasa-gee
- users/nbiswas/lhasav1_mekong
 - ARICalc
 - currentARI
 - lhasav1

Writer

Reader (8)

- users/fadwiputra/shared
- users/google/datasets
 - AAFC_ACI.js
 - AHN_AHN2_05M_INT.js
 - AHN_AHN2_05M_NON.js
 - AHN_AHN2_05M_RUW.js
 - ASTER_AST_L1T_003.js
 - AU_GA_AUSTRALIA_5M_DEM.js
 - AU_GA_DEM_1SEC_v10_DEM-H.js
 - AU_GA_DEM_1SEC_v10_DEM-S.js
 - CGIAR_SRTM90_V4.js
 - CIESIN_GPWv4_ancillary-data-grids.js

Surat

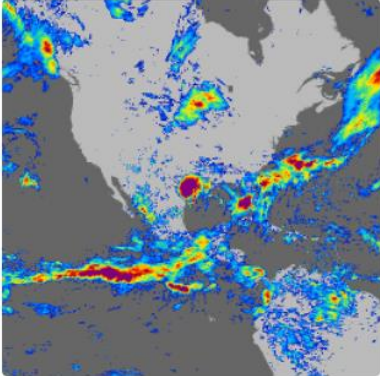
Hyderabad

Bengaluru

Chennai

GPM: Global Precipitation Measurement (GPM) v6

DESCRIPTION BANDS TERMS OF USE CITATIONS DOIS



Global Precipitation Measurement (GPM) is an international satellite mission to provide next-generation observations of rain and snow worldwide every three hours. The Integrated Multi-satellitE Retrievals for GPM (IMERG) is the unified algorithm that provides rainfall estimates combining data from all passive-microwave instruments in the GPM Constellation.

This algorithm is intended to intercalibrate, merge, and interpolate all satellite microwave precipitation estimates, together with microwave-calibrated infrared (IR) satellite estimates, precipitation gauge analyses, and potentially other precipitation estimators at fine time and space scales for the TRMM and GPM eras over the entire globe. The system is run several times for each observation time, first giving a quick estimate and successively providing better estimates as more data arrive. The final step uses monthly gauge data to create research-level products. See [IMERG Technical Documentation](#) for more details on the algorithm.

Documentation:

- [Algorithm Theoretical Basis Document](#)
- [IMERG Quality Index](#)
- [Caveats for IMERG extension into TRMM era](#)
- [IMERG Technical Documentation](#)

Dataset Availability

2000-06-01T00:00:00 -

Dataset Provider

[NASA GES DISC at NASA Goddard Space Flight Center](#)

Collection Snippet

```
ee.ImageCollection("NASA/GPM_L3/IMERG_V06")
```

See example

Tags

climate geophysical gpm

half-hourly imerg jaxa

nasa precipitation weather

CLOSE IMPORT

Importing precipitation

code.earthengine.google.com

Google Earth Engine

Scripts Docs Assets

Filter scripts... NEW

- Owner (3)
- Writer
- Reader (8)
 - users/fadwiputra/shared
 - users/google/datasets
 - AAFC_ACI.js
 - AHN_AHN2_05M_INT.js
 - AHN_AHN2_05M_NON.js
 - AHN_AHN2_05M_RUW.js
 - ASTER_AST_L1T_003.js
 - AU_GA_AUSTRALIA_5M_DEM.js
 - AU_GA_DEM_1SEC_v10_DEM-H.js
 - AU_GA_DEM_1SEC_v10_DEM-S.js
 - CGIAR_SRTM90_V4.js
 - CIESIN_GPWv4_ancillary-data-grids.js
 - CIESIN_GPWv4_population-count.js
 - CIESIN_GPWv4_population-density.js
 - CIESIN_GPWv4_unwpp-adjusted-pop
 - CIESIN_GPWv4_unwpp-adjusted-pop
 - COPERNICUS_CORINE_V18_5_1_100
 - COPERNICUS_S1_GRD.js
 - COPERNICUS_S2.js
 - COPERNICUS_S3_OLCI.js

Resolution
11132 meters
Bands Table

DESCRIPTION BANDS TERMS OF USE CITATIONS DOIS

Name	Description	Min*	Max*	Units
HQobservationTime	PMW source time	0	29	min. into half hour
HQprecipSource	PMW source sensor identifier			

HQprecipSource Bitmask

- Bits 0-3: PMW source sensor identifier
 - 0: No observation
 - 1: TMI
 - 2: (unused)
 - 3: AMSR
 - 4: SSMI
 - 5: SSMIS
 - 6: AMSU
 - 7: MHS
 - 8: SAPHIR
 - 9: GMI
 - 10: (unused)

Dataset Availability
2000-06-01T00:00:00 -
Dataset Provider
[NASA GES DISC at NASA Goddard Space Flight Center](#)
Collection Snippet
`ee.ImageCollection("NASA/GPM_L3/IMERG_V06")`
[See example](#)

Tags
climate geophysical gpm
half-hourly imerg jaxa
nasa precipitation weather

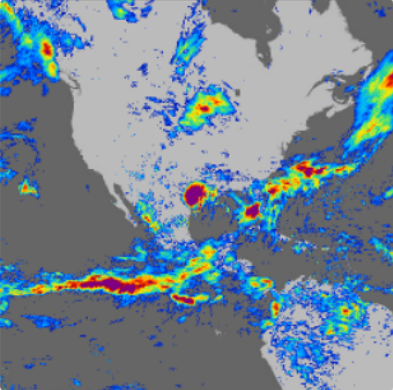
CLOSE IMPORT

Importing precipitation

code.earthengine.google.com


PowerPoint Presentation
servirglobal.net

GPM: Global Precipitation Measurement (GPM) v6



Dataset Availability
2000-06-01T00:00:00 -

Dataset Provider
[NASA GES DISC at NASA Goddard Space Flight Center](#)

Collection Snippet 
`ee.ImageCollection("NASA/GPM_L3/IMERG_V06")`

[See example](#)

Tags
climate geophysical gpm
half-hourly imerg jaxa
nasa precipitation weather

	DESCRIPTION	BANDS	TERMS OF USE	CITATIONS	DOIS
◦ 14: CRIS					
HQprecipitation	merged PMW precipitation		0	120	mm/hr
IRkalmanFilterWeight	Kalman filter weight for IR		0	100	%
IRprecipitation	IR precipitation		0	79.5	mm/hr
precipitationCal	snapshot precipitation - calibrated		0	174	mm/hr
precipitationUncal	snapshot precipitation - uncalibrated		0	120	mm/hr
probabilityLiquidPrecipitation	probability of liquid precipitation phase		0	100	%
randomError	calibrated-precipitation random error		0.24	250	mm/hr

CLOSE IMPORT

Importing precipitation

The screenshot shows the Google Earth Engine interface with a modal window for the 'GPM: Global Precipitation Measurement (GPM) v6' dataset. The modal window is titled 'GPM: Global Precipitation Measurement (GPM) v6' and contains the following information:

- DESCRIPTION** tab selected.
- Global Precipitation Measurement (GPM) v6** title.
- Dataset Availability**: 2000-06-01T00:00:00 -
- Dataset Provider**: [NASA GES DISC at NASA Goddard Space Flight Center](#)
- Collection Snippet**:

```
ee.ImageCollection("NASA/GPM_L3/IMERG_V06")
```
- See example** link.
- Tags**: climate, geophysical, gpm, half-hourly, imerg, jaxa, nasa, precipitation, weather.
- Documentation** section with links:
 - [Algorithm Theoretical Basis Document](#)
 - [IMERG Quality Index](#)
 - [Caveats for IMERG extension into TRMM era](#)
 - [IMERG Technical Documentation](#)
- IMPORT** button (highlighted with a red box).
- CLOSE** button.

The background shows the Google Earth Engine interface with a map of India and a sidebar with a file tree. The console on the right shows some JSON output.

Imported precipitation

The screenshot displays the Google Earth Engine web interface. At the top, the browser tabs include "ari_demo - Earth Engine Code Editor", "lhasav1_mekong", "EIS_freshwater - Google Drive", and "Concept note and agenda - Google Doc". The address bar shows "code.earthengine.google.com".

The main interface is divided into several sections:

- Left Panel (Assets):** Shows a tree view of assets. Under "users/nbiswas/lhasav1_mekong", the "ari_demo" folder is selected. Other folders include "ARICalc", "currentARI", and "lhasav1".
- Top Panel (Script Editor):** Displays the script for "ari_demo". It shows an import statement: `var imageCollection: ImageCollection "GPM: Global Precipitation Measurement (GPM) v6"`. The script is currently empty, with only the import line visible.
- Right Panel (Inspector/Console):** Contains a message: "Welcome to Earth Engine! Please use the help menu above (?) to learn more about how to use Earth Engine, or visit our help page for support."
- Bottom Panel (Map):** Shows a map of the United States with state names labeled. Major cities like Chicago, New York, Los Angeles, San Diego, and Houston are marked. The map is in "Map" mode, with "Satellite" mode also available. A scale bar at the bottom right indicates 500 km.

The Google logo is visible in the bottom left corner of the map area.

Rename precipitation variable

The screenshot displays the Google Earth Engine web interface. At the top, the browser tabs include "ari_demo - Earth Engine Code Editor", "lhasav1_mekong", "EIS_freshwater - Google Drive", and "Concept note and agenda - Google Doc". The address bar shows "code.earthengine.google.com".

The main interface is divided into several sections:

- Left Panel (Assets):** Shows a tree view of assets. Under "users/nbiswas/lhasav1_mekong", the "ari_demo" folder is selected. Other folders include "ARICalc", "currentARI", and "lhasav1".
- Script Editor (ari_demo *):** Contains a single line of code: `var imerg: ImageCollection "GPM: Global Precipitation Measurement (GPM) v6"`. The variable name "imerg" is highlighted with a red box.
- Right Panel (Inspector/Console):** The "Console" tab is active, displaying a welcome message: "Welcome to Earth Engine! Please use the help menu above (?) to learn more about how to use Earth Engine, or visit our help page for support."
- Bottom Panel (Map):** Shows a map of the United States with state names and major cities like Chicago, New York, Los Angeles, San Diego, and Houston. The map is in "Map" mode, and a scale bar indicates 500 km.

Draw a geometry or upload a study area shapefile

The screenshot displays the Google Earth Engine web interface. At the top, the browser address bar shows the URL `code.earthengine.google.com`. The main header includes the Google Earth Engine logo and a search bar containing the text "IMERG".

The interface is divided into several panels:

- Left Panel (Scripts):** Shows a list of scripts under the "Owner (3)" section, including "users/nbiswas/default", "users/nbiswas/lhasa-gee", and "users/nbiswas/lhasav1_mekong". The "lhasav1_mekong" folder is expanded, showing sub-folders like "ARICalc", "Precipitation_LHASAv1", "ari_demo", "currentARI", and "lhasav1".
- Top Panel (Script Editor):** The title bar reads "Precipitation_LHASAv1 *". It contains a code editor with the following JavaScript code:

```
Imports (2 entries)
  var imerg: ImageCollection "GPM: Global Precipitation Measurement (GPM) v6"
  var geometry: Polygon, 4 vertices
```
- Right Panel (Inspector/Console):** The "Inspector" tab is active, displaying the message: "Use print(...) to write to this console."
- Map Panel:** The main map area shows a satellite view of Southeast Asia. A yellow polygon is drawn over a region covering parts of Thailand, Laos, and Cambodia. The map includes various geographical labels such as "Chiang Mai", "Vientiane", "Bangkok", "Siem Reap", and "Hanoi".

At the bottom of the map, there is a toolbar with icons for drawing and navigation. A dropdown menu is open, showing "geometry (1 poly)" selected. Other options include "Rectangle drawing" and "Exit". The bottom right corner of the map panel includes a scale bar (100 km) and a "Terms of Use" link.

Copy and paste code to display precipitation

```
// Selecting appropriate variable
var precip = imerg.select('precipitationCal');
// Selecting a date to visualize precipitation
var date = '2015-07-30';
// Converting date string into a ee formatted date
var precipDate = ee.Date(date).getRange('day');
//Filtering, summing, and dividing precipitation
var prcp1day = precip.filterDate(precipDate).sum().divide(2);
// Using color palette to make visualization better
var palette = [
  '000096','0064ff', '00b4ff', '33db80', '9beb4a',
  'ffeb00', 'ffb300', 'ff6400', 'eb1e00', 'af0000'];
// Visualization parameter using the color palette mentioned above
var precipitationVis = {min: 0.0, max: 100.0, palette: palette};
// Adding layer on the map
Map.addLayer(prcp1day.clip(geometry), precipitationVis, "Precipitation")
```

Displayed precipitation

The image shows a Google Earth Engine interface. A 'New Script' window is open, displaying the following code:

```
Imports (2 entries)
  var imerg: ImageCollection "GPM: Global Precipitation Measurement ..."
  var geometry: Polygon, 4 vertices

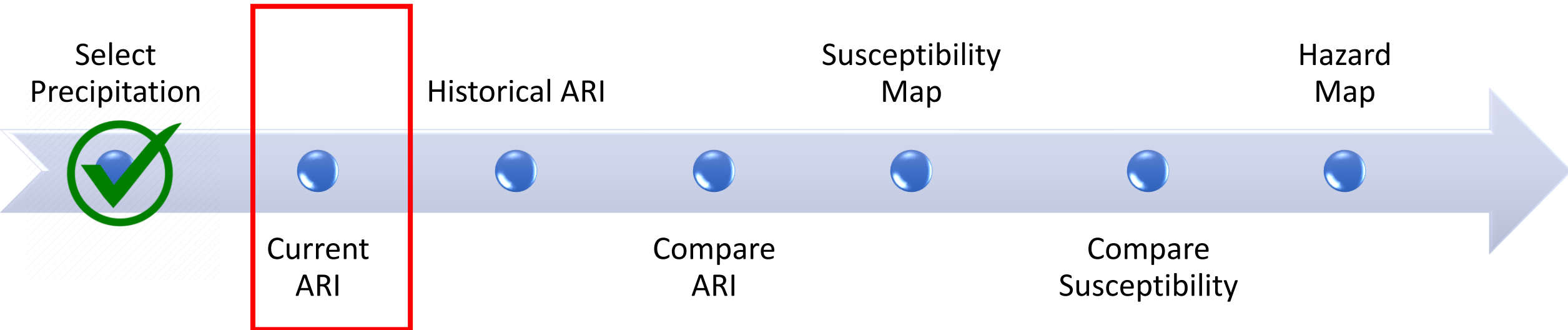
1 // Selecting appropriate variable
2 var precip = imerg.select('precipitationCal');
3
4 // Selecting a date to visualize precipitation
5 var date = '2015-07-30';
6 // Converting date string into a ee formatted date
7 var precipDate = ee.Date(date).getRange('day');
8 //Filtering, summing, and dividing precipitation
9 var prcp1day = precip.filterDate(precipDate).sum().divide(2);
10 // Using color palette to make visualization better
11 var palette = [
12   '000096', '0064ff', '00b4ff', '33db80', '9beb4a',
13   'ffeb00', 'ffb300', 'ff6400', 'eb1e00', 'af0000'];
14 // Visualization parameter using the color palette mentioned above
15 var precipitationVis = {min: 0.0, max: 100.0, palette: palette};
16 // Adding layer on the map
17 Map.addLayer(prcp1day.clip(geometry), precipitationVis, "Precipitation")
```

The map below the script shows a precipitation visualization over a region including India, China, and the Philippines. The precipitation is visualized using a color scale from blue (low) to red (high). The map interface includes a search bar, a 'Map' button, and a 'Satellite' button. The console on the right shows the message 'to write to this console.'

Now you are ready to use Precipitation!!

LHASA version 1

Step 2: Current ARI



Requirements:

- 1) Access to code window of Earth Engine
- 2) ARI_Calculation_Code.txt, available in [SERVIR Landslide Page](#)

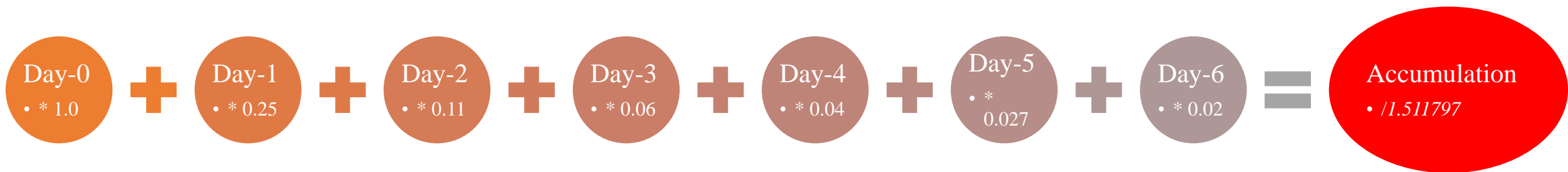
Antecedent Rainfall Index (ARI)

ARI calculation formula:

$$\text{Antecedent Rainfall Index (ARI)} = \frac{\sum_{t=0}^6 P_t W_t}{\sum_{t=0}^6 W_t}$$

$$\text{Where } W_t = (t + 1)^{-2}$$

Here, P = precipitation, t =days, w =weightage



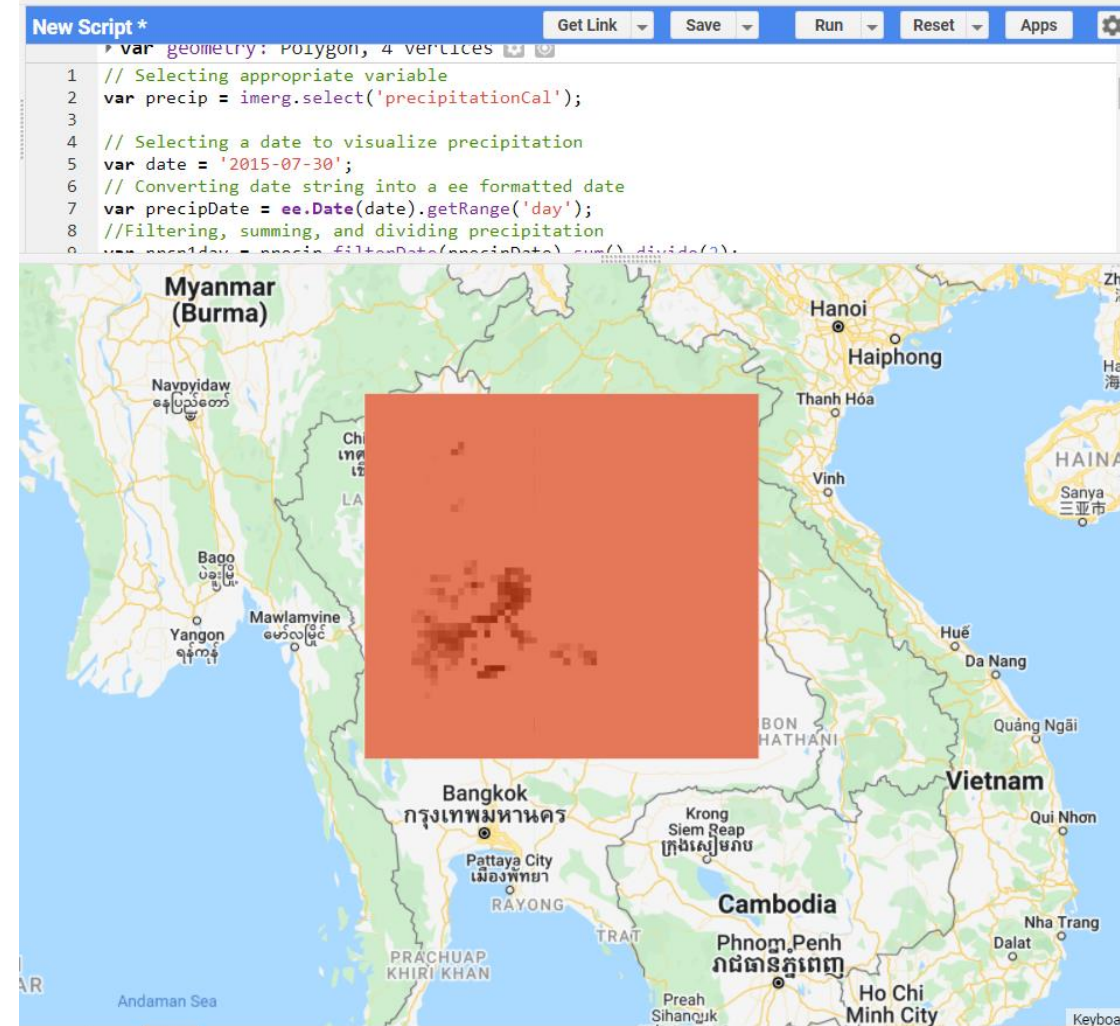
Copy and paste code to calculate ARI from precipitation

```
var precipDate = ee.Date(date)
// Selecting days to consider for calculating ARI
var daysOfWeek = ee.List.sequence(0,6,1);
  // Declaring list of weightage for those days
var weight = ee.List([1.0,0.25,0.111,0.0625, 0.04, 0.02778, 0.02040816]);
// Summing up weightage
var ws = 1.511797;
// calculate the daily precipitation in this case we just use the immerg data
var ari = ee.ImageCollection(daysOfWeek.map(function(m){
  // parse M to a number
  m = ee.Number.parse(m);
  // set the date range
  var startDay = precipDate.advance(m.multiply(-1),"day");
  // Offsetting one day to make a 24 hour span
  var endDay = startDay.advance(1,"day");
  // get the weight
  var w = ee.Number.parse(weight.get(m));
  // get the rainfall of day x
  var dayPrecip = ee.Image(precip.filterDate(startDay,endDay).sum()).divide(2);
  // multiply with weight factor
  var riDay = dayPrecip.multiply(ee.Image(w));
  return riDay;
})).sum().divide(ws).rename('api').clip(geometry);
Map.addLayer(ari, {}, "Current ARI of " + date)
```

Code to calculate ARI from precipitation

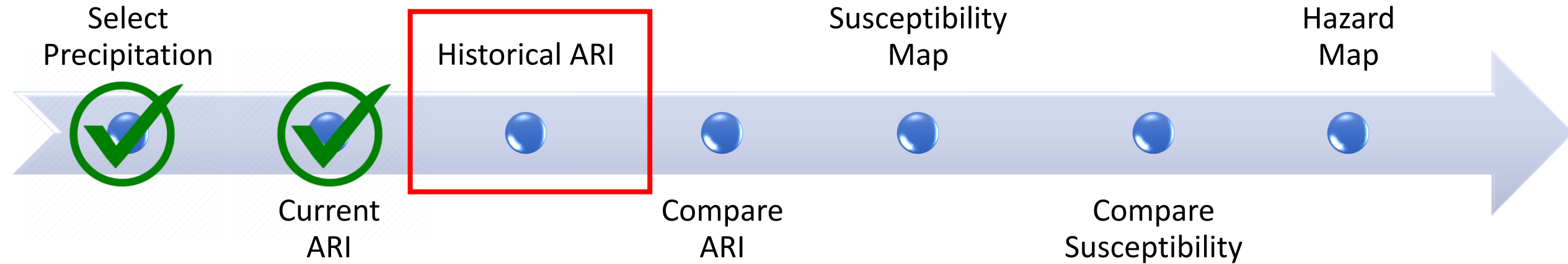
```
1 // Selecting appropriate variable
2 var precip = imerg.select('precipitationCal');
3
4 // Selecting a date to visualize precipitation
5 var date = '2015-07-30';
6 // Converting date string into a ee formatted date
7 var precipDate = ee.Date(date).getRange('day');
8 //Filtering, summing, and dividing precipitation
9 var prcp1day = precip.filterDate(precipDate).sum().divide(2);
10 // Using color palette to make visualization better
11 var palette = [
12   '000096', '0064ff', '00b4ff', '33db80', '9beb4a',
13   'ffeb00', 'ffb300', 'ff6400', 'eb1e00', 'af0000'];
14 // Visualization parameter using the color palette mentioned above
15 var precipitationVis = {min: 0.0, max: 100.0, palette: palette};
16 // Adding layer on the map
17 Map.addLayer(prcp1day.clip(geometry), precipitationVis, "Precipitation")
18
19 // Selecting days to consider for calculating ARI
20 var precipDate = ee.Date(date)
21 var daysOfWeek = ee.List.sequence(0,6,1);
22 // Declaring list of weightage for those days
23 var weight = ee.List([1.0,0.25,0.111,0.0625, 0.04, 0.02778, 0.02040816]);
24 // Summing up weightage
25 var ws = 1.511797;
26 // calculate the daily precipitation in this case we just use the imerg data
27 var ari = ee.ImageCollection(daysOfWeek.map(function(m){
28   // parse M to a number
29   m = ee.Number.parse(m);
30   // set the date range
31   var startDay = precipDate.advance(m.multiply(-1),"day");
32   // Offsetting one day to make a 24 hour span
33   var endDay = startDay.advance(1,"day");
34   // get the weight
35   var w = ee.Number.parse(weight.get(m));
36   // get the rainfall of day x
37   var dayPrecip = ee.Image(precip.filterDate(startDay,endDay).sum()).divide(2);
38   // multiply with weight factor
39   var riDay = dayPrecip.multiply(ee.Image(w));
40   return riDay;
41 })).sum().divide(ws).rename('ari').clip(geometry);
42 Map.addLayer(ari, {}, "ARI of " + date)
43
```

RG



LHASA version 1

Step 3: Historical ARI

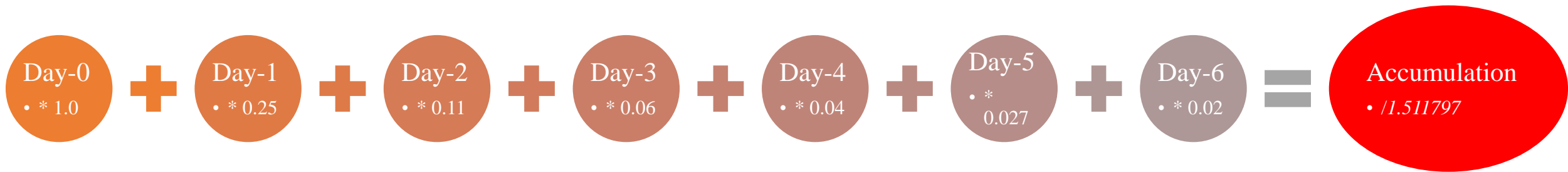


Historical ARI: Methodology

$$\text{Antecedent Rainfall Index (ARI)} = \frac{\sum_{t=0}^6 P_t W_t}{\sum_{t=0}^6 W_t}$$

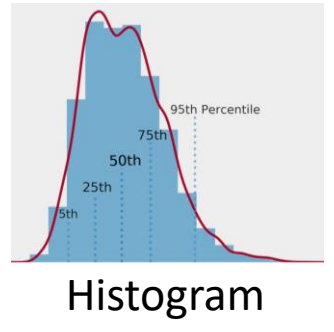
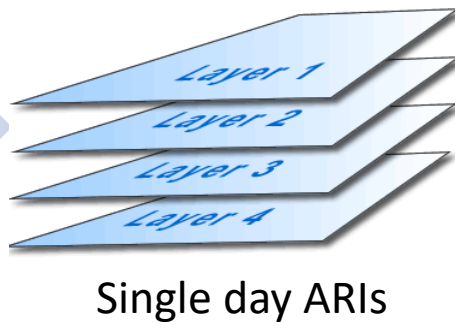
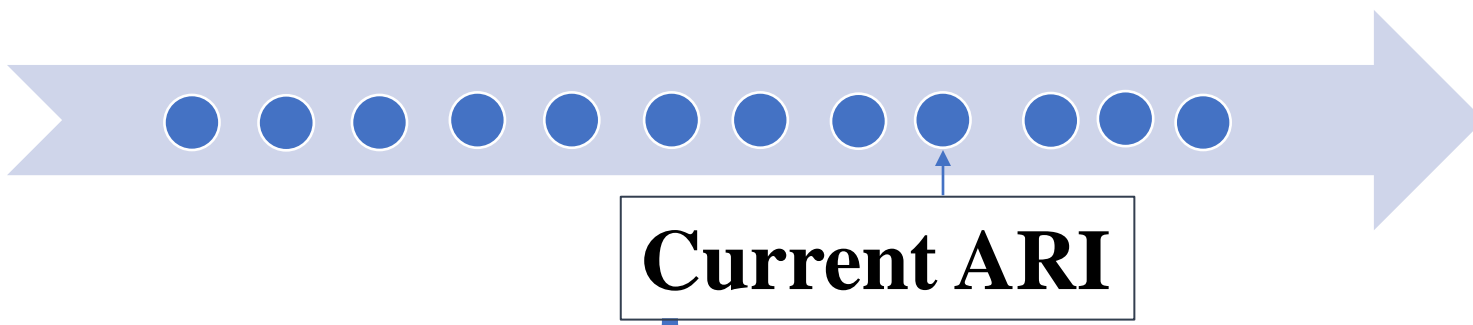
$$\text{Where } W_t = (t + 1)^{-2}$$

Here, P = precipitation, t =days, w =weightage



Historical ARI: Methodology

Start Iteration End



Current ARI

Single day ARIs

Histogram

Historical ARI

$$\begin{aligned} & \text{Day-0} \cdot * 1.0 \quad + \quad \text{Day-1} \cdot * 0.25 \quad + \quad \text{Day-2} \cdot * 0.11 \quad + \quad \text{Day-3} \cdot * 0.06 \quad + \quad \text{Day-4} \cdot * 0.04 \quad + \quad \text{Day-5} \cdot * 0.027 \quad + \quad \text{Day-6} \cdot * 0.02 \quad = \quad \text{Accumulation} \cdot /1.511797 \end{aligned}$$

Historical ARI Calculation

Write the code in a fresh GEE project
<https://code.earthengine.google.com/>.

First, follow page 7-14 to import precipitation and draw geometry. Try to draw the geometry close to or bigger than in you did on page 14.

Historical ARI Calculation

The screenshot displays the Google Earth Engine web interface. At the top, the browser address bar shows the URL `code.earthengine.google.com`. The main interface is divided into several panels:

- Scripts Panel:** Shows a script titled "Precipitation_LHASAv1 *". The code includes:

```
Imports (2 entries)
  var imerg: ImageCollection "GPM: Global Precipitation Measurement (GPM) v6"
  var geometry: Polygon, 4 vertices
```
- Inspector Panel:** Shows "Manage tasks." and "UNSUBMITTED TASKS" with a task named "p95thARI_Mekong" and a "RUN" button.
- Map Panel:** Displays a map of Southeast Asia. A green polygon is drawn over Laos, covering parts of Chiang Rai, Nan, Lamphun, Lampang, Udon Thani, and Khon Kaen provinces. The polygon is labeled "geometry (1 poly)" in the top-left corner of the map area.

The map shows major cities like Hanoi, Haiphong, Vinh, Vientiane, Bangkok, and Manila. The Google logo is visible in the bottom-left corner, and map data is attributed to 2022 Google.

Historical ARI Calculation

Historical Antecedent Rainfall Index Calculation code in GEE

////////***** Historical ARI Calculation for LHASA V1 implementation *****

// Step 1: declaration of the appropriate variables

```
var imerg = ee.ImageCollection("NASA/GPM_L3/IMERG_V06")  
var precip = imerg.select('precipitationCal');
```

Saying that we will select precip variable

// declaring the days 0-6 of a whole week

```
var daysofWeek = ee.List.sequence(0,6,1);
```

Saying that we will consider 7 last days

// declaring the weights for the individual days

```
var weight = ee.List([1.0,0.25,0.111,0.0625, 0.04, 0.0278, 0.02040816]);
```

// Sum of the weightage factors

```
var ws = 1.511797;
```

Weightage for those days

// set time period of 20 years

```
var start = ee.Date.fromYMD(2001,1,1);
```

```
var end = ee.Date.fromYMD(2021,1,1);
```

Timeframe to calculate ARI using data of last 20 years

// set date bounds for ARI starting from 7th day

```
start = start.advance(7,"day");
```

```
var nDays = (end.difference(start,"day"));
```

```
var seq = ee.List.sequence(1,nDays,1);
```

Calculating the days from the 7th and making a list of it

Historical ARI Calculation

//// Step 2: Function to iterate through days to generate ARI Layers

```
var historical_ari = ee.ImageCollection(seq.map(function(n){  
  return ee.ImageCollection(daysOfWeek.map(function(m){  
    // parse to number for serverside computation  
    m = ee.Number.parse(m);  
    // set the day  
    var startDay = start.advance(n,"day").advance(m.multiply(-1),"day");  
    var endDay = startDay.advance(1,"day");  
    // get the weights  
    var w = ee.Number.parse(weight.get(m))  
    // select precip layers, filter based on date, sum, divide, clip  
    var dailyrain= ee.Image(precip.filterDate(startDay,endDay).sum().divide(2).clip(geometry));  
    // multiply ari with weight factor  
    var riDay = dailyrain.multiply(w);  
    // Return rainfall index of that day  
    return riDay;  
  })).sum().divide(ws)  
}));
```

Mapping over the list to calculate

Historical ARI

Mapping over 7 days to return an image of
a single day ARI

Selecting a one-day span

Selecting weight of that day

Select precip, filter, sum, divide, clip

Multiplying with the weightage

Returning rainfall index of that day

Summing 7 day's rainfall index and
dividing by weight

Getting the 95th percentile from the
precipitation histogram

Historical ARI Calculation

//// Step 4: Adding 95th percentile image in the map

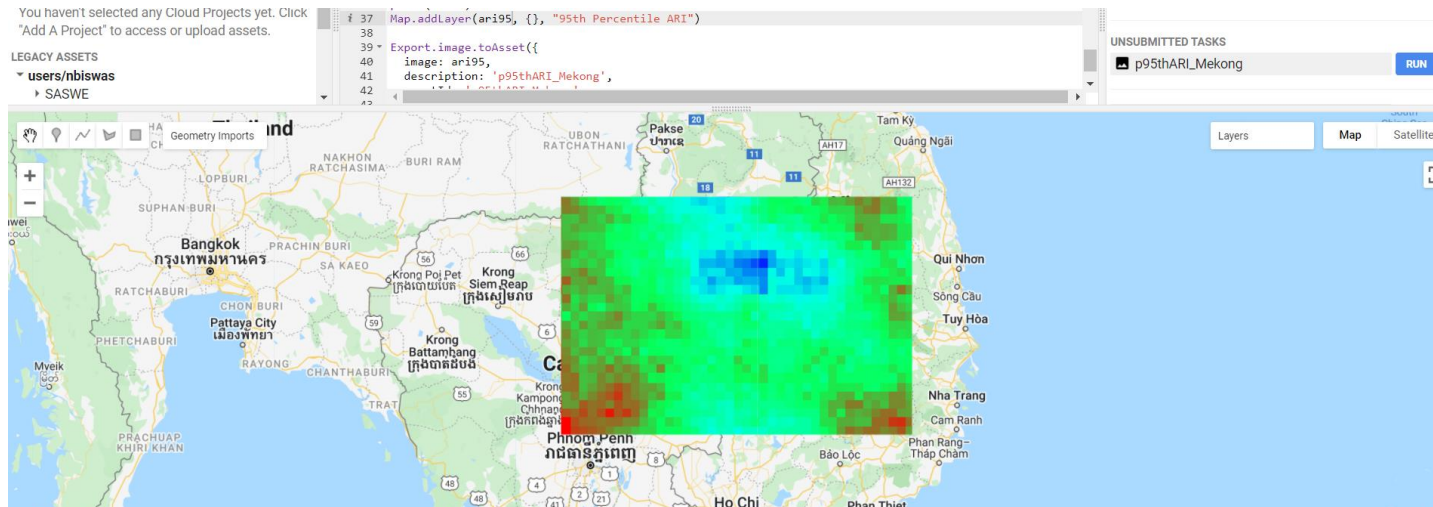
```
Map.addLayer(ari95, {}, "95th Percentile ARI")
```

Adding historical ARI in GEE Map

//// Step 5: Exporting 95th percentile map in GEE Asset

```
Export.image.toAsset({  
  image: ari95,  
  description: 'p95thARI_Mekong',  
  assetId: 'p95thARI_Mekong',  
  region: geometry  
});
```

Exporting historical ARI in GEE



Complete Code to Historical ARI

The screenshot displays the Google Earth Engine interface. On the left, the 'Scripts' panel shows a tree view of scripts, with 'ARICalc' selected under the user 'users/nbiswas/lhasav1_mekong'. The main editor shows the following code:

```
8 // set time period of 20 years
9 var start = ee.Date.fromYMD(2001,1,1);
10 var end = ee.Date.fromYMD(2021,1,1);
11
12 // set date bounds for ARI starting from 7th day
13 start = start.advance(7,"day");
14 var nDays = (end.difference(start,"day"));
15 var seq = ee.List.sequence(1,nDays,1);
16 print(seq)
17
18
19 var historical_ari = ee.ImageCollection(seq.map(function(n){
20   return ee.ImageCollection(daysOfWeek.map(function(m){
21     // parse to number for serverside computation
22     m = ee.Number.parse(m);
23     // set the day
24     var startDay = start.advance(n,"day").advance(m.multiply(-1),"day");
25     var endDay = startDay.advance(1,"day");
26     // get the weights
27     var weight = ee.Image.constant(1).divide(((ee.Image.constant(m).add(1).multiply(ee.Image.constant(1).divide(2)).clip(geometry)));
28     // calculate ari for day
29     var ariDay = ee.Image(precip.filterDate(startDay,endDay).sum().divide(2).clip(geometry));
30     // multiply ari with weight factor
31     ariDay = ariDay.multiply(weight);
32     return ariDay;
33   })).sum().divide(ws)}));
34
35 var ari95 = historical_ari.reduce(ee.Reducer.percentile([95])).clip(geometry);
36 print(ari95)
37 Map.addLayer(ari95, {}, "95th Percentile ARI")
38
39 Export.image.toAsset({
40   image: ari95,
41   description: 'p95thARI_Mekong',
42   assetId: 'p95thARI_Mekong',
43   region: geometry
44 });
```

On the right, the 'Tasks' panel shows a list of tasks. The 'UNSUBMITTED TASKS' section is highlighted with a red box and contains one task: 'p95thARI_Mekong' with a 'RUN' button. Below it, a list of submitted tasks is shown:

Task Name	Status	Time
Ingest image: "projects/earthengine-lega...	✓	<1m
p95thARI_Mekong	✓	25m
p95thARI_Mekong	✗	9m
stDeviation	✓	3m
mean	✓	8m
max	✓	12m
stDeviation	✓	12m
mean	✓	5m

Historical ARI Calculation

The screenshot displays the Google Earth Engine web interface. In the center, a script editor titled 'ARICalc *' shows JavaScript code for calculating the Area Ratio Index (ARI) over a 20-year period. A modal dialog box titled 'Task: Initiate image export' is open, allowing the user to configure the export task. The dialog includes the following fields and options:

- Task name (no spaces) ***: p95thARI_Mekong
- Coordinate Reference System (CRS)**: EPSG:3857
- Scale (m/px)**: 1000
- Storage Type**: Radio buttons for DRIVE, CLOUD STORAGE, and EE ASSET (selected).
- Earth Engine Asset...**: users/nbiswas/ p95thARI_Mekong
- Pyramiding policy**: MEAN

At the bottom of the dialog are 'CANCEL' and 'RUN' buttons. The background interface shows a script list on the left, a map at the bottom, and a task manager on the right.

Historical ARI Calculation

The screenshot displays the Google Earth Engine web interface. The top navigation bar includes the Google Earth Engine logo, a search bar, and user profile icons. The main workspace is divided into three panels: Scripts, Code Editor, and Task Manager.

Scripts Panel: A tree view on the left shows the project structure under 'users/nbiswas/lhasav1_mekong', including a folder named 'ARICalc'.

Code Editor: The central panel shows a JavaScript script titled 'ARICalc *'. The script calculates the 95th percentile of the Annual Recurrence Interval (ARI) for precipitation data from 2001 to 2021. It uses the `ee.Date`, `ee.List`, `ee.ImageCollection`, and `ee.Reducer` classes. The script sets a 20-year time period, defines date bounds starting from the 7th day of the month, and calculates the ARI for each day, weighted by precipitation. Finally, it exports the 95th percentile ARI as an asset named 'p95thARI_Mekong'.

```
8 // set time period of 20 years
9 var start = ee.Date.fromYMD(2001,1,1);
10 var end = ee.Date.fromYMD(2021,1,1);
11
12 // set date bounds for ARI starting from 7th day
13 start = start.advance(7,"day");
14 var nDays = (end.difference(start,"day"));
15 var seq = ee.List.sequence(1,nDays,1);
16 print(seq)
17
18
19 var historical_ari = ee.ImageCollection(seq.map(function(n){
20   return ee.ImageCollection(daysOfWeek.map(function(m){
21     // parse to number for serverside computation
22     m = ee.Number.parse(m);
23     // set the day
24     var startDay = start.advance(n,"day").advance(m.multiply(-1),"day");
25     var endDay = startDay.advance(1,"day");
26     // get the weights
27     var weight = ee.Image.constant(1).divide(((ee.Image.constant(m).add(1).multiply(ee.Image.constant(1).divide(2).clip(geometry)))));
28     // calculate ari for day
29     var ariDay = ee.Image(precip.filterDate(startDay,endDay).sum().divide(2).clip(geometry));
30     // multiply ari with weight factor
31     ariDay = ariDay.multiply(weight);
32     return ariDay;
33   })).sum().divide(ws)}));
34
35 var ari95 = historical_ari.reduce(ee.Reducer.percentile([95])).clip(geometry);
36 print(ari95)
37 Map.addLayer(ari95, {}, "95th Percentile ARI")
38
39 Export.image.toAsset({
40   image: ari95,
41   description: 'p95thARI_Mekong',
42   assetId: 'p95thARI_Mekong',
43   region: geometry
44 });
```

Task Manager: The right panel shows a list of tasks. A red box highlights the text: "Search or cancel multiple tasks in the Task Manager". Below this, a list of tasks is shown, including 'p95thARI_Mekong' (9m), 'stDeviation' (3m), 'mean' (8m), 'max' (12m), and another 'stDeviation' (12m). The 'p95thARI_Mekong' task is currently selected.

Map: The bottom panel shows a map of the region, with labels for 'Haiphong', 'Thanh Hóa', and 'CHIANG RAI'. The map is currently in 'Map' mode.

Historical ARI Calculation



Earth Engine Task Manager

Use this page to search and cancel multiple [tasks](#). This page will display tasks that have been submitted until 10 days after they have completed, failed, or cancelled.

Search

Showing 9 of 9 tasks

<input type="checkbox"/>	Bulk cancel mode	Cancel Task
>	p95thARI_Mekong	<1m
>	Ingest image: "projects/earthengine-legacy/assets/users/nbiswas/Sus..."	<1m
>	p95thARI_Mekong	25m
>	p95thARI_Mekong	9m
>	stDeviation	3m
>	mean	8m
>	max	12m
>	stDeviation	12m
>	mean	5m

Historical ARI Calculation

The screenshot displays the Google Earth Engine web interface. The top navigation bar includes the Google Earth Engine logo, a search bar, and utility icons. The main interface is divided into three primary sections: Assets, Code Editor, and Inspector/Console/Task Manager.

Assets Panel (Left): Shows a tree view of assets. Under the 'users/nbiswas' folder, the asset 'p95thARI_Mekong' is highlighted with a red box.

Code Editor (Center): Contains a JavaScript script for calculating the 95th Percentile ARI. The script is as follows:

```
8 // set time period of 20 years
9 var start = ee.Date.fromYMD(2001,1,1);
10 var end = ee.Date.fromYMD(2021,1,1);
11
12 // set date bounds for ARI starting from 7th day
13 start = start.advance(7,"day");
14 var nDays = (end.difference(start,"day"));
15 var seq = ee.List.sequence(1,nDays,1);
16 print(seq)
17
18
19 var historical_ari = ee.ImageCollection(seq.map(function(n){
20   return ee.ImageCollection(daysOfWeek.map(function(m){
21     // parse to number for serverside computation
22     m = ee.Number.parse(m);
23     // set the day
24     var startDay = start.advance(n,"day").advance(m.multiply(-1),"day");
25     var endDay = startDay.advance(1,"day");
26     // get the weights
27     var weight = ee.Image.constant(1).divide(((ee.Image.constant(m)).add(1).multiply(ee.Image.constant(1)).sum().divide(2)).clip(geometry));
28     // calculate ari for day
29     var ariDay = ee.Image(precip.filterDate(startDay,endDay).sum().divide(2).clip(geometry));
30     // multiply ari with weight factor
31     ariDay = ariDay.multiply(weight);
32     return ariDay;
33   })).sum().divide(ws)}));
34
35 var ari95 = historical_ari.reduce(ee.Reducer.percentile([95])).clip(geometry);
36 print(ari95)
37 Map.addLayer(ari95, {}, "95th Percentile ARI")
38
39 Export.image.toAsset({
40   image: ari95,
41   description: 'p95thARI_Mekong',
42   assetId: 'p95thARI_Mekong',
43   region: geometry
44 });
```

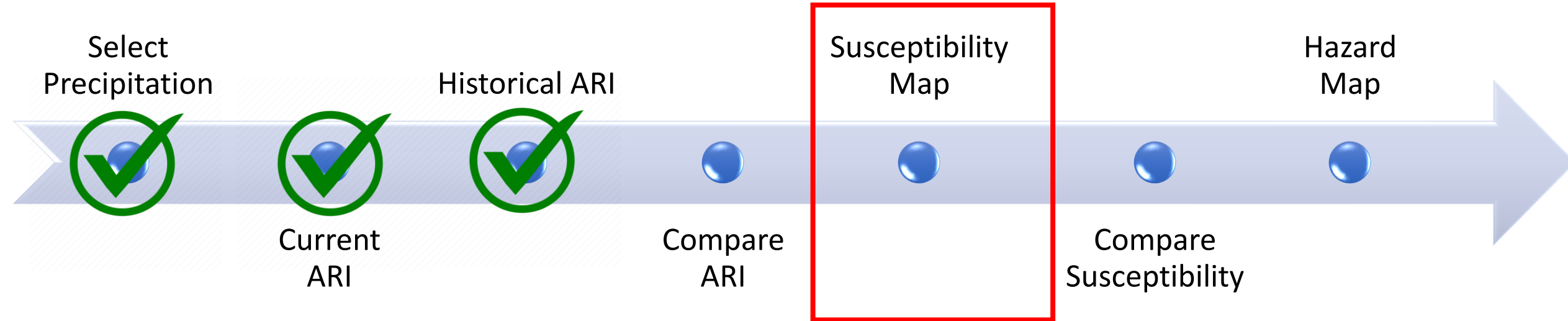
Task Manager (Right): Shows a list of tasks. The task 'p95thARI_Mekong' is highlighted with a red box, indicating it is the current task being viewed or managed.

Task Name	Status	Duration
p95thARI_Mekong	Completed	<1m
Ingest image: "projects/earthengine-lega...	Completed	<1m
p95thARI_Mekong	Completed	25m
p95thARI_Mekong	Completed	9m
stDeviation	Completed	3m
mean	Completed	8m
max	Completed	12m
stDeviation	Completed	12m
mean	Completed	5m

The bottom of the interface shows a map of the region, with labels for 'Haiphong', 'Thanh Hóa', and 'CHIANG RAI'. The map is currently in 'Map' mode.

LHASA version 1

Step 5: Susceptibility Map Ingestion

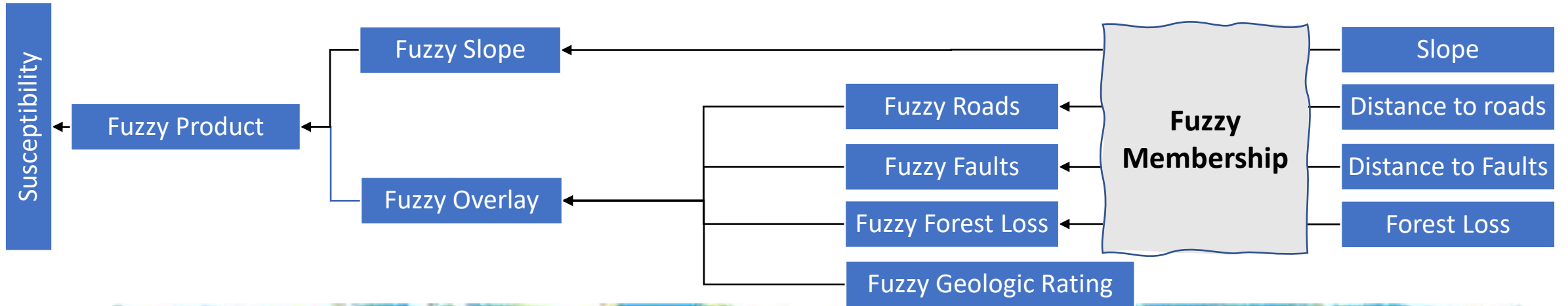


Requirements:

Susceptibility_Code.txt, available in [SERVIR Landslide Page](#)

Susceptibility_map_clipped.tif- [Download the NASA Landslide Susceptibility map](#), and clip to your region of interest.

Susceptibility Map



Importing susceptibility map in GEE

1. [Download the NASA Landslide Susceptibility map](#), and clip to your region of interest.
2. Import the Susceptibility Map your current GEE project

Importing susceptibility map in GEE

The screenshot displays the Google Earth Engine web interface. At the top, the browser address bar shows `code.earthengine.google.com`. The main interface is divided into several sections:

- Top Bar:** Contains the Google Earth Engine logo, a search bar for places and datasets, and utility icons for help, chat, and user profile.
- Navigation Tabs:** Includes 'Scripts', 'Docs', and 'Assets'. The 'Assets' tab is highlighted with a red box.
- Assets Panel (Left):** Shows a tree view of assets under the user 'nbiswas'. The 'Assets' folder is expanded, listing sub-folders like 'ARICalc', 'Precipitation_LHASAv1', 'ari_demo', 'currentARI', 'lhasav1', and 'precipVisARI'. Other sections include 'Owner (3)', 'Writer', and 'Reader (8)'.
- New Script Editor (Center):** A text area for writing code, currently showing a single line with the number '1'.
- Inspector, Console, and Tasks (Right):** The 'Console' tab is active, displaying a welcome message: 'Welcome to Earth Engine! Please use the help menu above (?) to learn more about how to use Earth Engine, or visit our help page for support.'
- Map (Bottom):** A map of the United States and parts of Mexico. Major cities like Los Angeles, San Diego, Las Vegas, Chicago, Houston, New York, and Toronto are labeled. The map is in 'Map' mode, with a 'Satellite' option also visible. A scale bar at the bottom indicates 500 km.

Importing susceptibility map in GEE

The image shows a screenshot of the Google Earth Engine (GEE) web interface. The browser address bar displays 'code.earthengine.google.com'. The main interface is divided into several sections:

- Top Bar:** Contains the 'Google Earth Engine' logo, a search bar for 'Search places and datasets...', and navigation icons.
- Left Panel (Assets):** Shows 'NEW' (highlighted with a red box), 'ADD A PROJECT', and a list of assets under 'users/nbiswas' including 'SASWE', 'lhasa', 'reservoirs', 'NERRegionboundary', 'Precipitation_Stations', 'VSPolygons', and 'VSPolygons_2'.
- Center Panel (New Script):** A code editor with a single line of code: '1'.
- Right Panel (Inspector/Console):** The 'Console' tab is active, displaying a welcome message: 'Welcome to Earth Engine! Please use the help menu above (?) to learn more about how to use Earth Engine, or visit our help page for support.'
- Bottom Panel (Map):** A map of the United States and Mexico, with major cities like Los Angeles, San Diego, Las Vegas, Chicago, Toronto, and New York labeled. The map is in 'Map' mode.

At the bottom of the page, there is a footer with 'Google', 'Honolulu', 'Hilo', 'Keyboard shortcuts', 'Map data ©2022 Google, INEGI', '500 km', and 'Terms of Use'.

Importing susceptibility map in GEE

The screenshot displays the Google Earth Engine web interface. At the top, the browser address bar shows 'code.earthengine.google.com'. The main header includes the 'Google Earth Engine' logo and a search bar. Below the header, there are tabs for 'Scripts', 'Docs', and 'Assets'. The 'Assets' tab is active, and a dropdown menu is open, listing various upload options. The option 'GeoTIFF (.tif, .tiff) or TFRecord (.tfrecord + .json)' is highlighted with a red rectangular box. Other options include 'Table Upload' (Shape files, CSV file, Image collection, Folder) and 'Image Upload'. The central area shows a 'New Script' editor with a single line of code. On the right, the 'Inspector', 'Console', and 'Tasks' panels are visible. The 'Console' panel displays a welcome message: 'Welcome to Earth Engine! Please use the help menu above (?) to learn more about how to use Earth Engine, or visit our help page for support.' The bottom portion of the interface shows a map of the United States and Mexico, with major cities like Los Angeles, San Diego, Chicago, and New York labeled. The map includes zoom controls and a 'Map/Satellite' toggle.

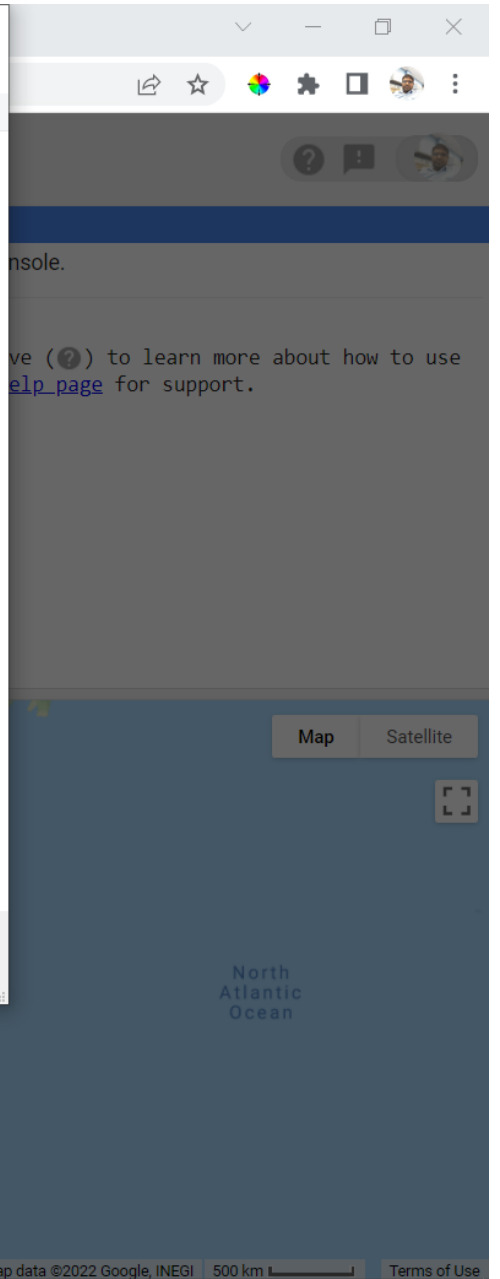
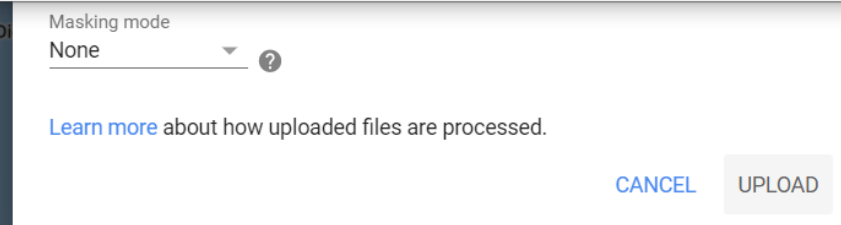
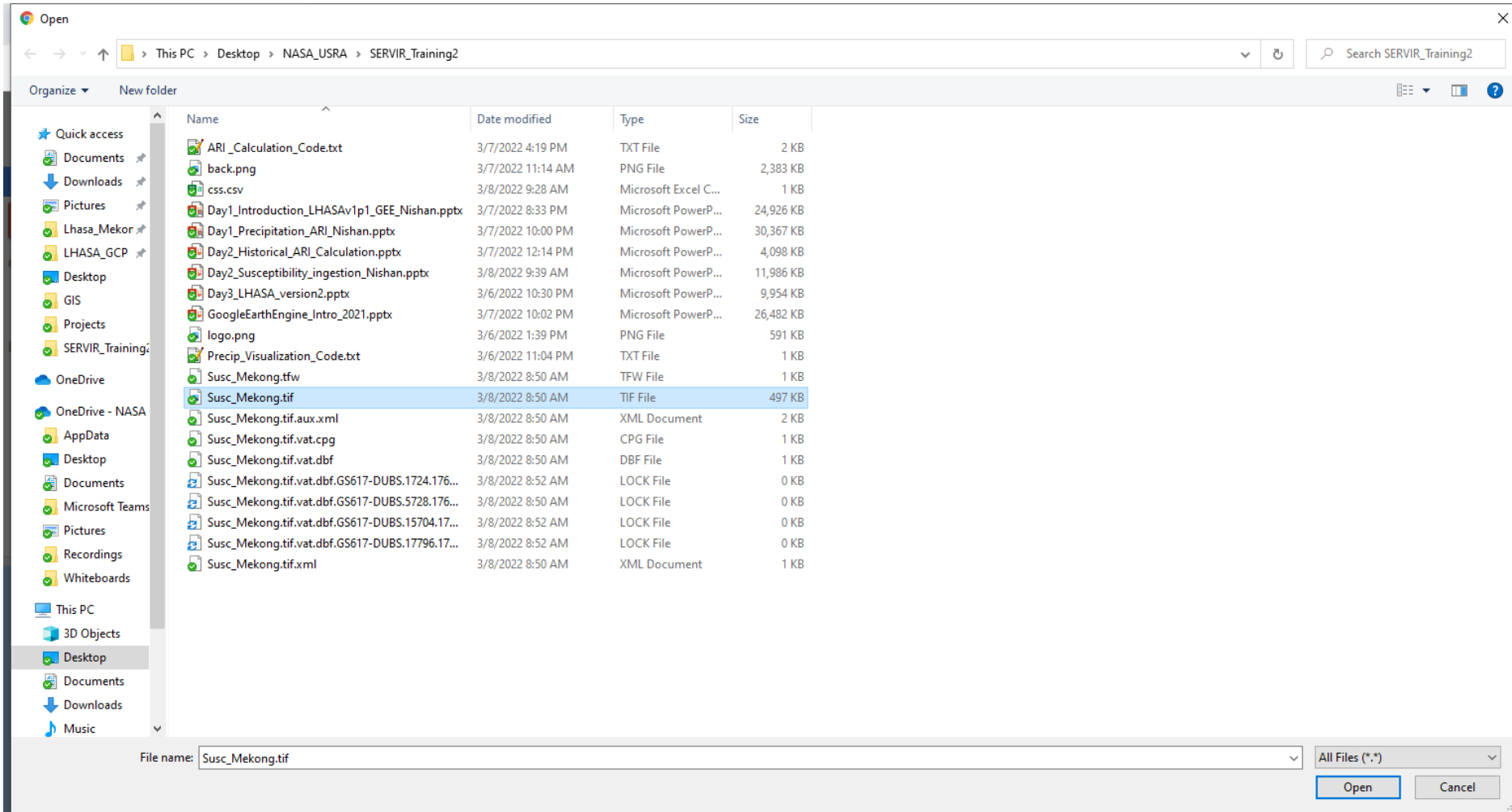
Importing susceptibility map in GEE

The image shows a screenshot of the Google Earth Engine (GEE) web interface. A dialog box titled "Upload a new image asset" is open in the center. The dialog has several sections:

- Source files:** A red box highlights a red "SELECT" button.
- Asset ID:** A dropdown menu shows "users/nbiswas/" and a text input field contains "Asset Name".
- Properties:** A section for metadata properties with buttons for "Add start time", "Add end time", and "Add property".
- Advanced options:** Two dropdown menus: "Pyramiding policy" set to "MEAN" and "Masking mode" set to "None".

At the bottom of the dialog are "CANCEL" and "UPLOAD" buttons. The background shows the GEE interface with a map of North America and the "Assets" panel on the left.

Importing susceptibility map in GEE



Importing susceptibility map in GEE

New Script - Earth Engine Code Editor x +

code.earthengine.google.com

Google Earth Engine

Search places and datasets

Scripts Docs **Assets** New Script

NEW ADD A PROJECT

CLOUD ASSETS

You haven't selected any Cloud Projects yet. Click "Add A Project" to access or upload assets.

LEGACY ASSETS

- users/nbiswas
 - SASWE
 - lhasa
 - reservoirs
 - NERRegionboundary
 - Precipitation_Stations
 - VSPolygons
 - VSPolygons_2

Upload a new image asset

Source files

SELECT

Please drag and drop or select files for this asset.
Allowed extensions: tiff, tif, json, tfrecord or tfrecord.gz.

Susc_Mekong.tif

Asset ID

Asset Name
users/nbiswas/ Susc_Mekong

Properties

Metadata properties about the asset which can be edited during asset upload and after ingestion. The "system:time_start" property is used as the primary date of the asset.

Add start time Add end time Add property

Advanced options

Pyramiding policy
MEAN ?

Masking mode
None ?

CANCEL UPLOAD

Map Satellite

North Atlantic Ocean

Honolulu

Keyboard shortcuts Map data ©2022 Google, INEGI 500 km Terms of Use

Importing susceptibility map in GEE

The screenshot shows the Google Earth Engine (GEE) interface with a modal dialog box titled "Upload a new image asset". The dialog is centered over the main interface, which includes a search bar, navigation tabs (Scripts, Docs, Assets), and a map view.

Upload a new image asset

Source files

SELECT

Please drag and drop or select files for this asset.
Allowed extensions: tiff, tif, json, tfrecord or tfrecord.gz.

Susc_Mekong.tif

Asset ID

Asset Name
users/nbiswas/ Susc_Mekong

Properties

Metadata properties about the asset which can be edited during asset upload and after ingestion. The "system:time_start" property is used as the primary date of the asset.

Add start time Add end time Add property

Advanced options

Pyramiding policy
MEAN ?

Masking mode
None ?

CANCEL **UPLOAD**

Importing susceptibility map in GEE

The screenshot displays the Google Earth Engine (GEE) interface. At the top, the browser address bar shows 'code.earthengine.google.com'. The main interface is divided into several sections:

- Navigation and Search:** Includes the 'Google Earth Engine' logo, a search bar for 'Search places and datasets...', and navigation icons.
- Script Editor:** A central area for writing code, currently showing a 'New Script' with a single line of code.
- Inspector and Console:** On the right, there are tabs for 'Inspector', 'Console', and 'Tasks'. The 'Tasks' tab is highlighted with a red box. The console displays a welcome message: 'Welcome to Earth Engine! Please use the help menu above (?) to learn more about how to use Earth Engine, or visit our help page for support.'
- Assets Panel:** On the left, there are sections for 'CLOUD ASSETS' and 'LEGACY ASSETS'. Under 'LEGACY ASSETS', a folder named 'users/nbiswas' is expanded, showing sub-items like 'SASWE', 'lhasa', 'reservoirs', 'NERRegionboundary', 'Precipitation_Stations', 'VSPolygons', and 'VSPolygons_2'.
- Map:** The bottom half of the screen shows a map of North America, with state and city names labeled. The map is in 'Map' mode, as indicated by the 'Map' and 'Satellite' buttons in the top right corner of the map area.

Importing susceptibility map in GEE

The screenshot displays the Google Earth Engine (GEE) interface. At the top, the browser address bar shows 'code.earthengine.google.com'. The main interface is divided into several sections:

- Top Bar:** Includes the 'Google Earth Engine' logo, a search bar for 'Search places and datasets...', and navigation icons.
- Left Panel (Assets):** Shows 'CLOUD ASSETS' with a message: 'You haven't selected any Cloud Projects yet. Click "Add A Project" to access or upload assets.' Below this, 'LEGACY ASSETS' are listed under the user 'users/nbiswas', including folders like 'SASWE', 'Ihasa', 'reservoirs', and various data layers like 'NERRegionboundary', 'Precipitation_Stations', and 'VSPolygons'.
- Center Panel (New Script):** A script editor with a single line of code on line 1.
- Right Panel (Tasks):** A task manager showing a list of tasks. The first task, 'Ingest image: "projects/earthengine-legacy/assets/users/nbiswa..."', is highlighted with a red box. Other tasks include 'p95thARI_Mekong', 'stDeviation', 'mean', 'max', and another 'stDeviation'.
- Bottom Panel (Map):** A map of the United States and surrounding regions (Mexico, Canada). The map is in 'Map' mode, showing state and city boundaries. Major cities like Los Angeles, San Diego, Las Vegas, Chicago, New York, and Houston are labeled. The map includes a scale bar (500 km) and a 'Terms of Use' link.

Importing susceptibility map in GEE

The screenshot displays the Google Earth Engine (GEE) interface. At the top, the browser address bar shows 'code.earthengine.google.com'. The main interface is divided into several sections:

- Top Bar:** Includes the 'Google Earth Engine' logo, a search bar for 'Search places and datasets...', and navigation icons.
- Left Panel (Assets):** Shows 'NEW' and 'ADD A PROJECT' buttons. Below are sections for 'CLOUD ASSETS' (with a message: 'You haven't selected any Cloud Projects yet. Click "Add A Project" to access or upload assets.') and 'LEGACY ASSETS' (listing folders like 'users/nbiswas' and sub-folders like 'SASWE', 'Ihasa', 'reservoirs', and various data layers).
- Center Panel (New Script):** A code editor area with a '1' line number and buttons for 'Get Link', 'Save', 'Run', 'Reset', and 'Apps'.
- Right Panel (Tasks):** Titled 'Manage tasks.', it contains a search bar and a list of tasks. A red box highlights the text 'Search or cancel multiple tasks in the [Task Manager](#).' Below this, a list of tasks is shown, including 'Ingest image: "projects/earthengine-legacy/assets/users/nbiswa..."', 'p95thARI_Mekong' (checked, 25m), 'p95thARI_Mekong' (unchecked, 9m), 'stDeviation' (checked, 3m), 'mean' (checked, 8m), 'max' (checked, 12m), and another 'stDeviation' (checked, 12m).
- Map:** A satellite view of the United States and parts of Mexico, with state and city labels. The map includes navigation controls like zoom in (+) and zoom out (-) buttons, and a 'Map/Satellite' toggle.

At the bottom of the page, there are links for 'Keyboard shortcuts', 'Map data ©2022 Google, INEGI', a scale bar for '500 km', and a 'Terms of Use' link.

Importing susceptibility map in GEE



Earth Engine Task Manager

















Use this page to search and cancel multiple [tasks](#). This page will display tasks that have been submitted until 10 days after they have completed, failed, or cancelled.

Search

Showing 8 of 8 tasks

Bulk cancel mode

Cancel 1 task

>	Ingest image: "projects/earthengine-legacy/assets/users/nbiswas/Sus..."	 	<1m
>	p95thARI_Mekong	 	25m
>	p95thARI_Mekong	 	9m
>	stDeviation	 	3m
>	mean	 	8m
>	max	 	12m
>	stDeviation	 	12m
>	mean	 	5m

Importing susceptibility map in GEE

The screenshot displays the Google Earth Engine (GEE) interface. The top navigation bar includes 'Scripts', 'Docs', and 'Assets'. The 'Assets' panel on the left shows a tree view of assets under the user 'users/nbiswas'. The asset 'Susc_Mekong' is highlighted with a red box. The 'Tasks' panel on the right shows a list of tasks, with the first task, 'Ingest image: "projects/earthengine-legacy/assets/users/nbiswa..."', highlighted with a red box. The main map area shows a satellite view of the United States and Mexico.

Assets Panel:

- Cloud Assets: You haven't selected any Cloud Projects yet. Click "Add A Project" to access or upload assets.
- Legacy Assets:
 - users/nbiswas
 - SASWE
 - lhasa
 - reservoirs
 - NERRegionboundary
 - Precipitation_Stations
 - Susc_Mekong**
 - VSPolygons
 - VSPolygons_2
 - p95thARI_Mekong

Tasks Panel:

- Ingest image: "projects/earthengine-legacy/assets/users/nbiswa..." ✓ <1m
- p95thARI_Mekong ✓ 25m
- p95thARI_Mekong ✗ 9m
- stDeviation ✓ 3m
- mean ✓ 8m
- max ✓ 12m
- stDeviation ✓ 12m
- mean ✓ 5m

Importing susceptibility map in GEE

*New Script - Earth Engine Code Editor

code.earthengine.google.com

Google Earth Engine

Search places and datasets...

Scripts Docs Assets New Script * Get Link Save Run Reset Apps Inspector Console Tasks

Asset details

DELETE SHARE IMPORT Edit (click to preview)

Image: Susc_Mekong

DESCRIPTION BANDS PROPERTIES

This raster represents the susceptibility map of the Lower Mekong Region.

Image ID

users/nbiswas/Susc_Mekong

Date

Start date:

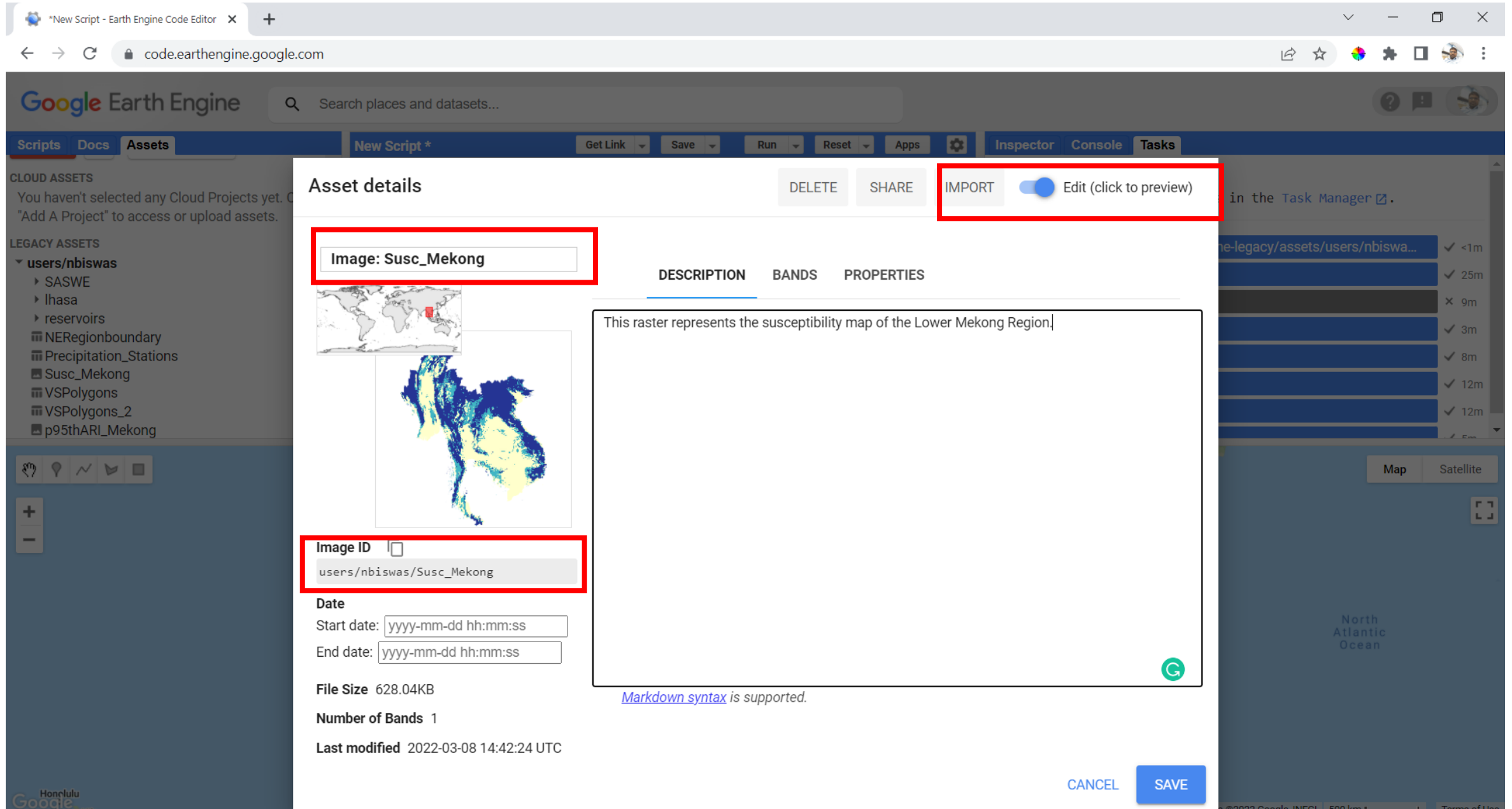
End date:

File Size 628.04KB

Number of Bands 1

Last modified 2022-03-08 14:42:24 UTC

CANCEL SAVE



Importing susceptibility map in GEE

New Script - Earth Engine Code Editor x +

code.earthengine.google.com

Google Earth Engine

Search places and datasets...

Scripts Docs **Assets** New Script Get Link Save Run Reset Apps Inspector Console Tasks

CLOUD ASSETS
You haven't selected any Cloud Projects yet. Click "Add A Project" to access or upload assets.

LEGACY ASSETS
users/nbiswas
SASWE
Ihasa
reservoirs
NERegionboundary
Precipitation_Stations
Susc_Mekong
VSPolygons
VSPolygons_2
p95thARI_Mekong

Asset details DELETE SHARE **IMPORT** Edit

Image: Susc_Mekong

DESCRIPTION BANDS PROPERTIES

No description.

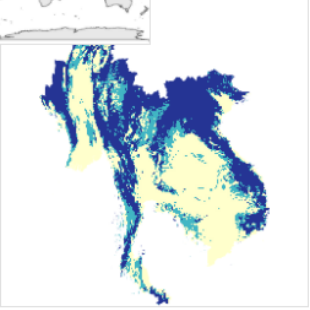




Image ID 
users/nbiswas/Susc_Mekong

Date
Start date: NA
End date: NA

File Size 628.04KB

Number of Bands 1

Last modified 2022-03-08 14:42:24 UTC

CLOSE

Map Satellite

North Atlantic Ocean

Honolulu Guadalajara Santa Keyboard shortcuts Map data ©2022 Google, INEGI 500 km Terms of Use

Importing susceptibility map in GEE

The screenshot displays the Google Earth Engine (GEE) interface. At the top, the browser address bar shows 'code.earthengine.google.com'. The main header includes the 'Google Earth Engine' logo and a search bar. Below the header, there are tabs for 'Scripts', 'Docs', and 'Assets'. The 'New Script *' editor is open, showing a code editor with the following code:

```
Imports (1 entry)
  var image: Image users/nbiswas/Susc_Mekong (1 band)
```

The code editor is highlighted with a red box. To the right of the code editor, there are buttons for 'Get Link', 'Save', 'Run', 'Reset', and 'Apps'. Below the code editor, there is a 'Tasks' panel with the following tasks listed:

Task Name	Status	Duration
Ingest image: "projects/earthengine-legacy/assets/users/nbiswa..."	✓	<1m
p95thARI_Mekong	✓	25m
p95thARI_Mekong	✗	9m
stDeviation	✓	3m
mean	✓	8m
max	✓	12m
stDeviation	✓	12m
mean	✓	5m

The bottom half of the screen shows a map of the United States and Mexico. A 'Webex Meeting Reminder' notification is visible in the bottom right corner, indicating a 'Winter 2022 GMAO Seminar Series' meeting at 10:00 AM - 11:00 AM, hosted by Thomas, Natalie P. (GSFC-610.1) at UNIVERSITY ... The notification includes 'Snooze' and 'Join Meeting' buttons.

Importing susceptibility map in GEE

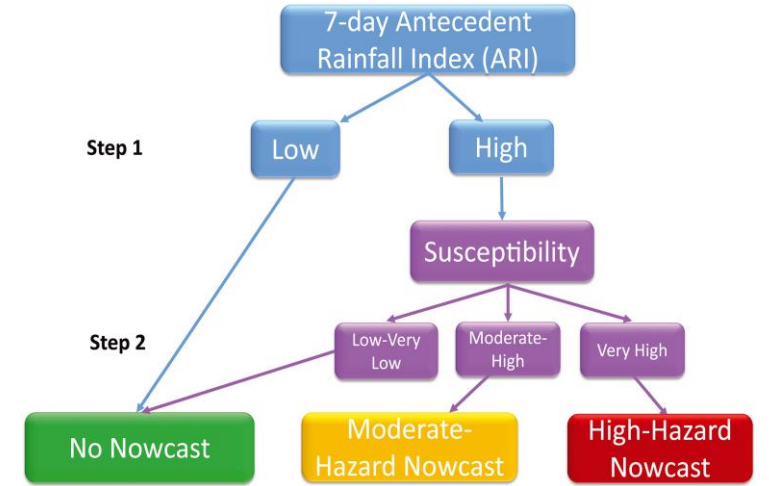
The screenshot displays the Google Earth Engine interface. The top navigation bar includes the Google Earth Engine logo and a search bar. Below the navigation bar, there are tabs for 'Scripts', 'Docs', and 'Assets'. The 'Assets' tab is active, showing a list of assets under the user 'users/nbiswas'. The 'New Script' editor is open, showing a script with two lines of code highlighted in a red box:

```
var susc: Image users/nbiswas/Susc Mekong (1 band)
1 Map.addLayer(susc, {min:0,max:5,palette:"yellow,orange,red,purple"}, "Susceptibility Map")
2 Map.centerObject(susc)
```

The map below the script shows a susceptibility map of the Mekong region, with a color scale from yellow (low susceptibility) to purple (high susceptibility). The map includes labels for various countries and cities, such as Afghanistan, Pakistan, India, Bangladesh, China, and the Philippines. The map is centered on the Mekong region, and the 'Layers' panel on the right shows the 'Susceptibility Map' layer.

Map.addLayer(susc, {min:0,max:5,palette:"yellow,orange,red,purple"}, "Susceptibility Map")
Map.centerObject(susc)

Step 4 and 6: ARI and Susceptibility Comparison



Select
Precipitation



Current
ARI

Historical ARI



Compare
ARI

Susceptibility
Map



Compare
Susceptibility

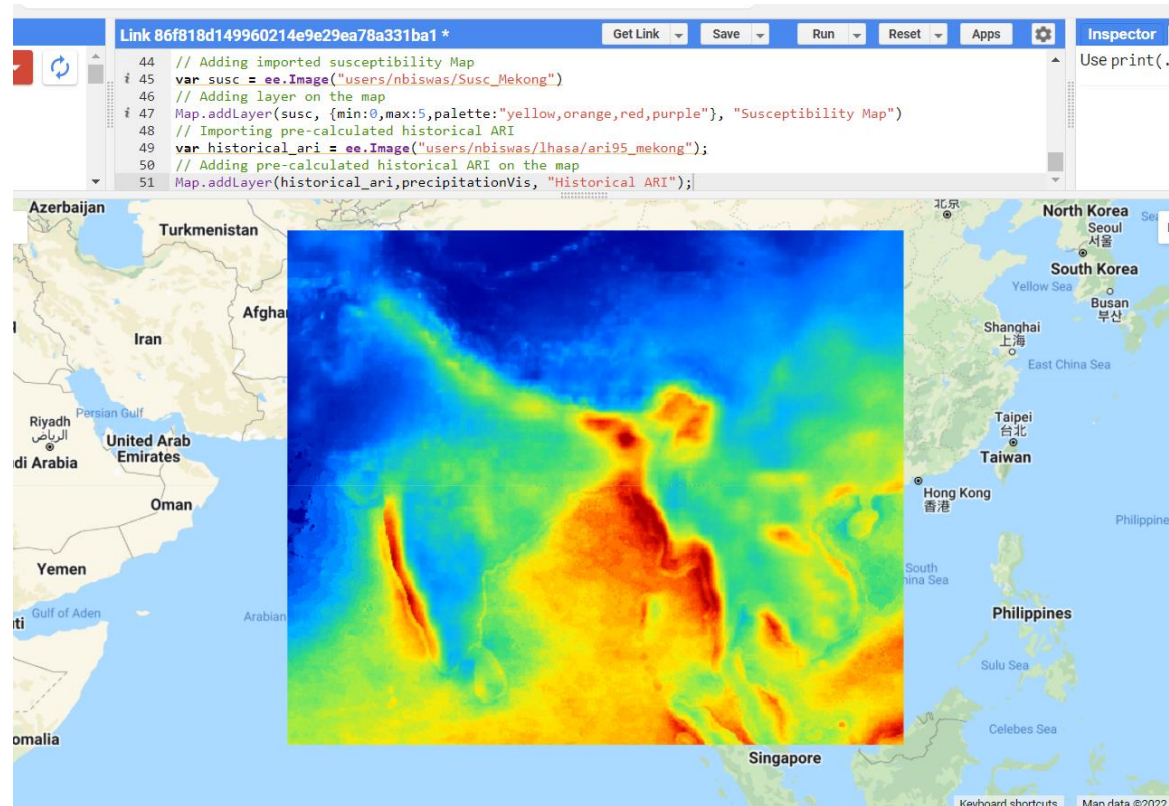
Hazard
Map



Sharing pre-calculated ARI in GEE

Add these lines below the earlier code:

```
// Adding pre-calculated historical ARI  
var historical_ari = ee.Image("users/nbiswas/lhasa/ari95_mekong");  
// Adding pre-calculated historical ARI on the map  
Map.addLayer(historical_ari,precipitationVis, "Historical ARI");
```



Comparison of ARI and Susceptibility

////////***** Applying decision tree algorithm *****

```
// Checking the area where current ARI is greater than historical ARI  
var heavy_rain = ari.gt(historical_ari).rename('Heavy Rainfall');
```

ARI > 95th Percentile of Historical Precip

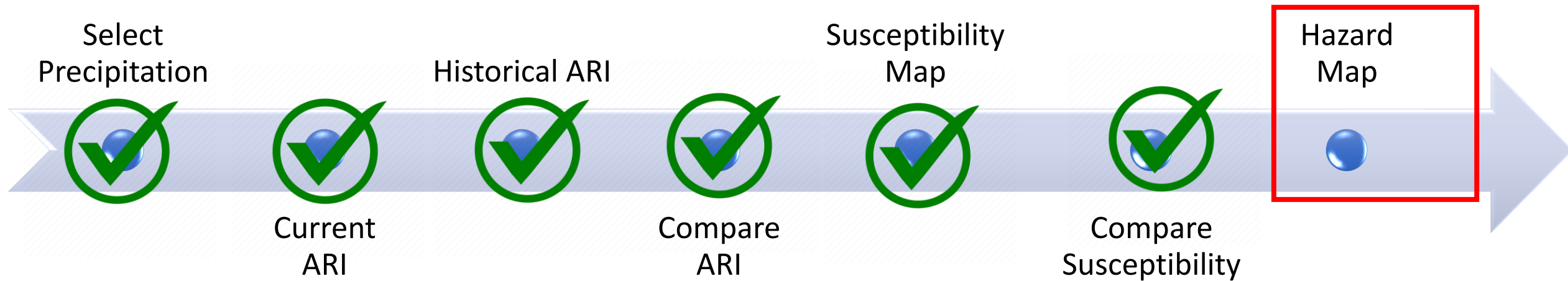
```
// Current ARI > historical ARI and Susceptibility value greater than 2 is moderate hazard zone  
var moderate = heavy_rain.and(susc.gt(2)).rename('Moderate_Nowcast');
```

Comparing with
Susceptibility map

```
// Current ARI > historical ARI and Susceptibility value greater than 4 is high hazard zone  
var high = moderate.and(susc.gt(4)).rename('High_Nowcast');
```

Comparing with
Susceptibility map

Step 7: Hazard Map Visualization



Hazard Map Visualization: Adding layers on the Map

```
// Adding layer on the map
```

```
Map.addLayer(prcp1day.clip(geometry), precipitationVis, "Precipitation")
```

Adding precipitation layer

```
// Adding current ARI Layer
```

```
Map.addLayer(ari, precipitationVis, "Current ARI of " + date)
```

Adding current ARI layer

```
// Adding historical ARI Map
```

```
Map.addLayer(historical_ari, precipitationVis, "Historical ARI");
```

Adding historical ARI layer

```
// Adding Susceptibility Map layer on the map
```

```
Map.addLayer(susc, {min:0,max:5,palette:"yellow,orange,red,purple"}, "Susceptibility Map")
```

Adding susceptibility map

```
// Adding heavy_rain on the map
```

```
Map.addLayer(heavy_rain, {min: 0.0, max: 1.0, palette: ['red','blue']}, "Heavy Rain");
```

Adding heavy rain map

```
// Adding moderate hazard map layer on the map
```

```
Map.addLayer(moderate, {min:0, max:1, palette:'yellow'}, 'moderate-hazard');
```

Adding moderate hazard map

```
// Adding high hazard map layer on the map
```

```
Map.addLayer(high, {min:0, max:1, palette:'red'}, 'high-hazard');
```

Adding high hazard map

Complete code and Map

```

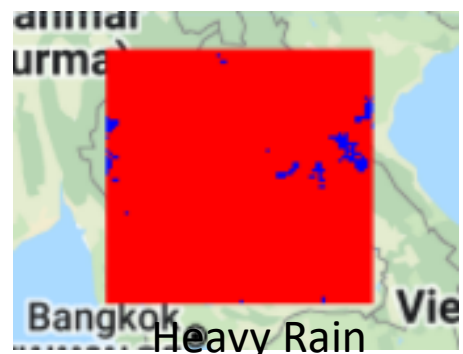
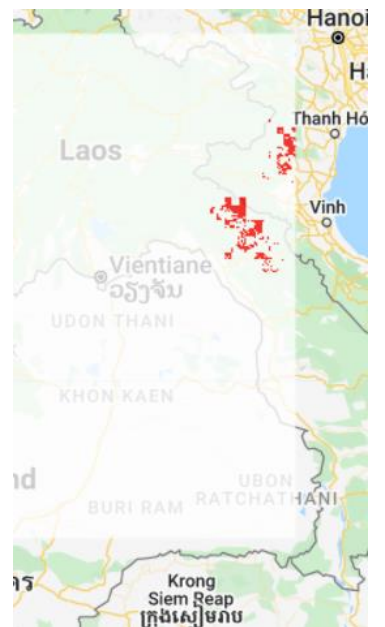
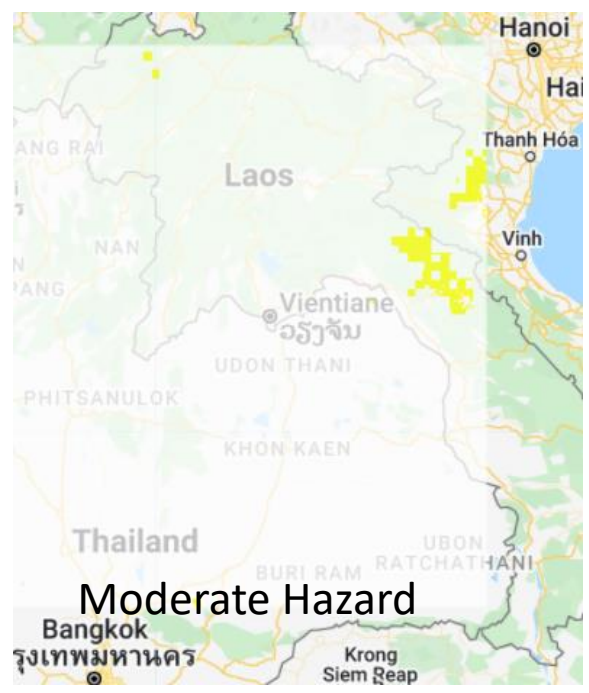
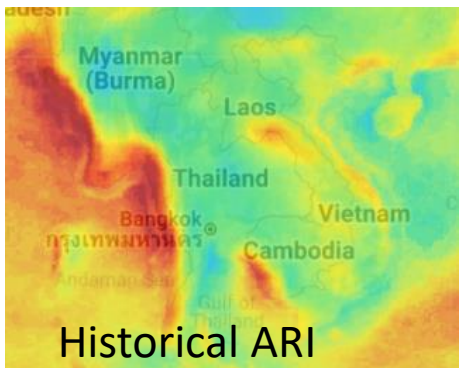
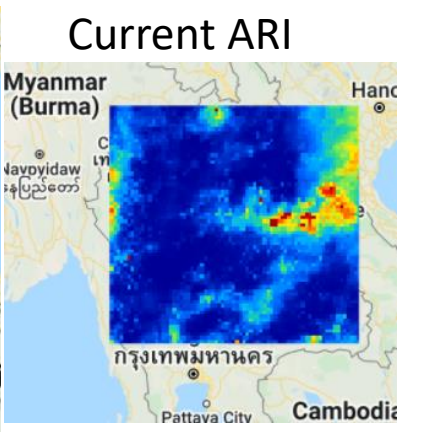
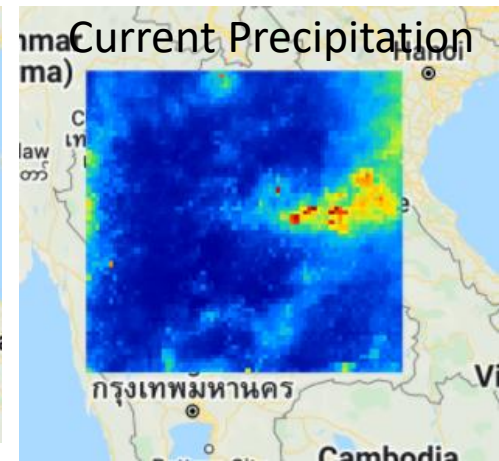
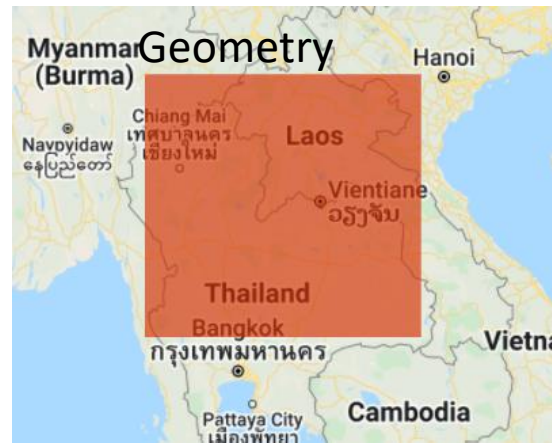
Imports (2 entries)
var imerg: ImageCollection "GPM: Global Precipitation Measurement (GPM) v6"
var geometry: Polygon, 4 vertices
// Selecting appropriate variable
var precip = imerg.select('precipitationCal');
// Selecting a date to visualize precipitation
var date = '2015-07-30';
// Converting date string into a ee formatted date
var precipDate = ee.Date(date).getRange('day');
// Filtering, summing, and dividing precipitation
var prcp1day = precip.filterDate(precipDate).sum().divide(2);
// Using color palette to make visualization better
var palette = [
  '000096', '0064ff', '00b4ff', '33db80', '9beb4a',
  'ffeb00', 'ffb300', 'ff6400', 'e1e000', 'af0000'];
// Visualization parameter using the color palette mentioned above
var precipitationVis = {min: 0.0, max: 100.0, palette: palette};
// Adding layer on the map
Map.addLayer(prcp1day.clip(geometry), precipitationVis, "Precipitation")

var precipDate = ee.Date(date)
// Selecting days to consider for calculating ARI
var daysofWeek = ee.List.sequence(0,6,1);
// Declaring list of weightage for those days
var weight = ee.List([1.0,0.25,0.111,0.0625, 0.04, 0.02778, 0.02040816]);
// Summing up weightage
var ws = 1.511797;
// calculate the daily precipitation in this case we just use the imerg data
var ari = ee.ImageCollection(daysofWeek.map(function(m){
  // parse M to a number
  m = ee.Number.parse(m);
  // set the date range
  var startDay = precipDate.advance(m.multiply(-1),"day");
  // Offsetting one day to make a 24 hour span
  var endDay = startDay.advance(1,"day");
  // get the weight
  var w = ee.Number.parse(weight.get(m));
  // get the rainfall of day x
  var dayPrecip = ee.Image(precip.filterDate(startDay,endDay).sum()).divide(2);
  // multiply with weight factor
  var riDay = dayPrecip.multiply(ee.Image(w));
  return riDay;
})).sum().divide(ws).rename('ari').clip(geometry);
Map.addLayer(ari, {}, "Current ARI of " + date)

// Adding pre-calculated historical ARI
var historical_ari = ee.Image("users/nbiswas/lhasa/ari95_mekong");
// Adding pre-calculated historical ARI on the map
Map.addLayer(historical_ari,precipitationVis, "Historical ARI");

// importing susceptibility Map
var susc = ee.Image("users/nbiswas/Susc_Mekong")
// Adding layer on the map
Map.addLayer(susc, {min:0,max:5,palette:"yellow,orange,red,purple"}, "Susceptibility Map")
// Applying decision tree algorithm
// Checking the area where current ARI is greater than historical ARI
var heavy_rain = ari.gt(historical_ari).rename("Heavy Rainfall");
// Adding heavy_rain on the map
Map.addLayer(heavy_rain,{min: 0.0, max: 1.0, palette: ['red','blue']}, "Heavy Rain");
// Current ARI>historical ARI and Susceptibility value greater than 2 is moderate hazard zone
var moderate = heavy_rain.and(susc.gt(2)).rename("Moderate_Nowcast");
// Adding moderate hazard map layer on the map
Map.addLayer(moderate,{min:0, max:1, palette:'yellow'},'moderate-hazard');
// Current ARI>historical ARI and Susceptibility value greater than 4 is high hazard zone
var high = moderate.and(susc.gt(4)).rename('High_Nowcast');
// Adding high hazard map layer on the map
Map.addLayer(high,{min:0, max:1, palette:'red'},'high-hazard');

```



Summary

- Imported susceptibility data in GEE
- Imported precalculated ARI in GEE
- Compared ARI and susceptibility
- Prepared LHASA hazard map and Visualized in GEE Map

Select
Precipitation



Current
ARI



Historical ARI



Compare
ARI



Susceptibility
Map



Compare
Susceptibility



Hazard
Map



LHASA version 1

Optional add-on: Exposure Analysis

Steps:

1. Open code window of GEE
2. Import study area in GEE (need to have a polygon shapefile)
3. Open complete model code
4. Import study area inside code
5. Select a date
6. Run LHASA Model
7. Visualize hazard map
8. Exposure analysis
9. Visualize exposure layers

Step 8: Exposure analysis

```
//////////***** Population Exposure Analysis *****  
// Selecting population data source (WorldPop population density data)  
var worldPop = ee.ImageCollection("WorldPop/GP/100m/pop")  
// Filter data for Thailand and year of 2020  
var WP_2020 = worldPop.filter(ee.Filter.inList('country',['THA'])).filter(ee.Filter.equals('year', 2020));  
// Selecting appropriate variable  
var population = WP_2020.select('population').mosaic().clip(geometry);  
// Multiplying moderate hazard layer with population to see population who are exposed to moderate hazard zone  
var moderate_popexp = moderate.multiply(population).rename('Moderate_popexp');  
// Adding moderate hazard population exposure layer on the map  
Map.addLayer(moderate_popexp,{min:0, max:1, palette:['white', 'blue', 'yellow', 'orange']},'Moderate Exposure');  
// Multiplying high hazard layer with population to see population who are exposed to high hazard zone  
var high_popexp = high.multiply(population).rename('High_popexp');  
// Adding high hazard population exposure layer on the map  
Map.addLayer(high_popexp,{min:0, max:1, palette:['white', 'yellow', 'orange', 'red']},'High Exposure');
```

Step 8: Exposure analysis

The screenshot displays the Google Earth Engine web interface. The browser address bar shows 'code.earthengine.google.com'. The search bar contains 'worldpop'. The left sidebar shows a file tree with folders for 'Owner (4)' and 'Writer', and a 'Reader (8)' section. The main editor area shows a script titled 'Day2_susceptibility' with the following code:

```
61 Map.addLayer(moderate,{min:0, max:1, palette:['white', 'yellow']}, 'moderate-hazard' );
62 // Current ARI>historical ARI and Susceptibility value greater than 4 is high hazard zone
63 var high = moderate.and(susc.gt(4)).rename('High_Nowcast');
64 // Adding high hazard map layer on the map
65 Map.addLayer(high,{min:0, max:1, palette:['white', 'red']}, 'high-hazard');
66
67 ////////////////***** Day 3 Population Exposure Analysis *****
68 // Selecting population datasource (Worldpop population density data)
69 var worldPop = ee.ImageCollection("WorldPop/GP/100m/pop");
70 // Filter data for Thailand and year of 2020
71 var WP_2020 = worldPop.filter(ee.Filter.inList('country', ['THA'])).filter(ee.Filter.equals('year', 2020));
72 // Selecting appropriate variable
73 var population = WP_2020.select('population').mosaic().clip(geometry);
74 // Multiplying moderate hazard layer with population to see population who are exposed to moderate hazard zone
75 var moderate_popexp = moderate.multiply(population).rename('Moderate_popexp');
76 // Adding moderate hazard population exposure layer on the map
77 Map.addLayer(moderate_popexp,{min:0, max:1, palette:['white', 'blue', 'yellow', 'orange']}, 'Moderate Exposure');
78 // Multiplying high hazard layer with population to see population who are exposed to high hazard zone
79 var high_popexp = high.multiply(population).rename('High_popexp');
80 // Adding high hazard population exposure layer on the map
81 Map.addLayer(high_popexp,{min:0, max:1, palette:['white', 'yellow', 'orange', 'red']}, 'High Exposure');
82
```

The right sidebar shows the 'Inspector' panel with the text: 'Use print(...) to write to this console.' The bottom of the interface shows a map of Southeast Asia, including parts of Thailand, Vietnam, and Cambodia, with labels for 'Andaman Sea', 'Gulf of Thailand', 'Ho Chi Minh City', 'Can Tho', and 'Uông Tàu'.

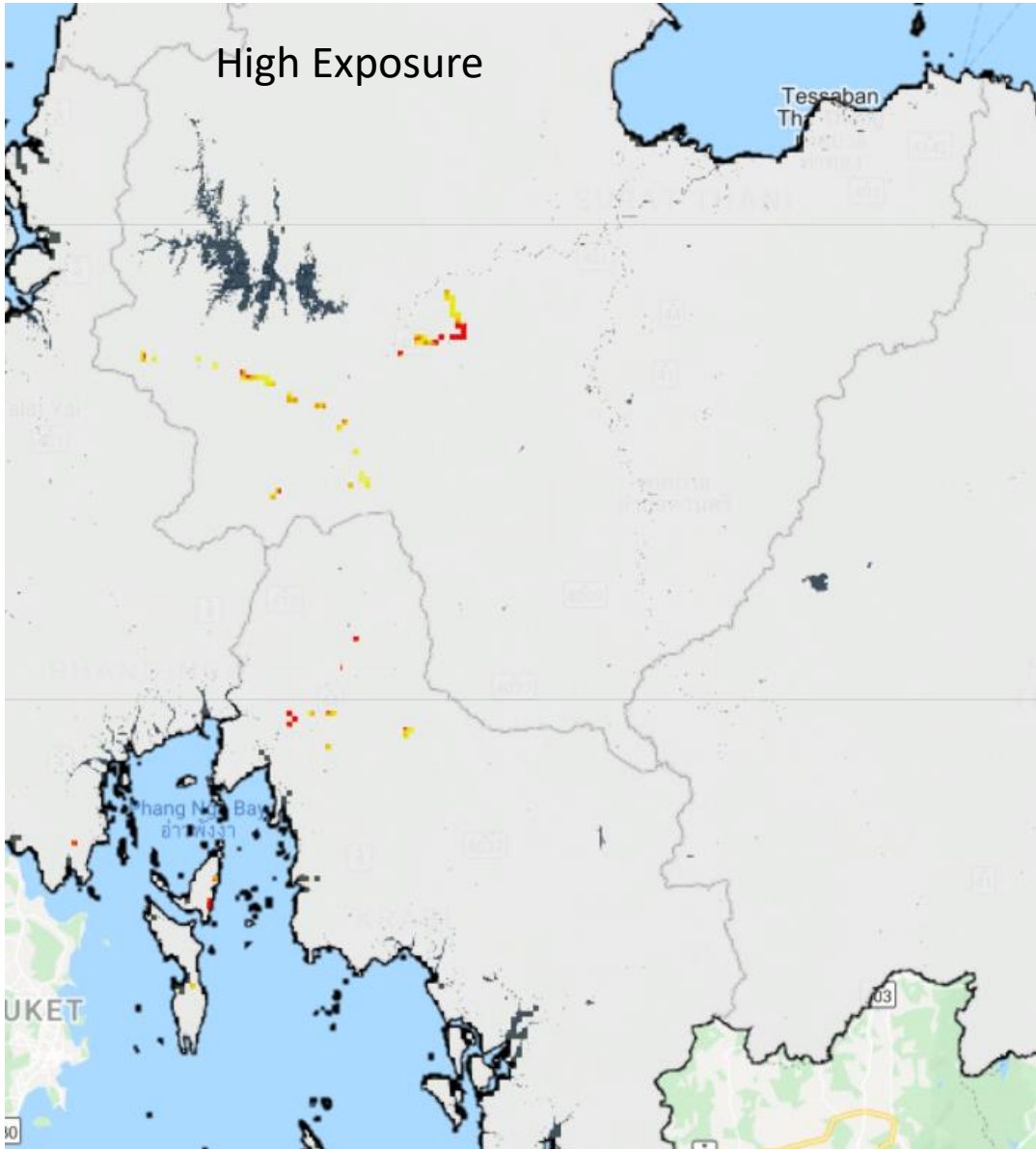
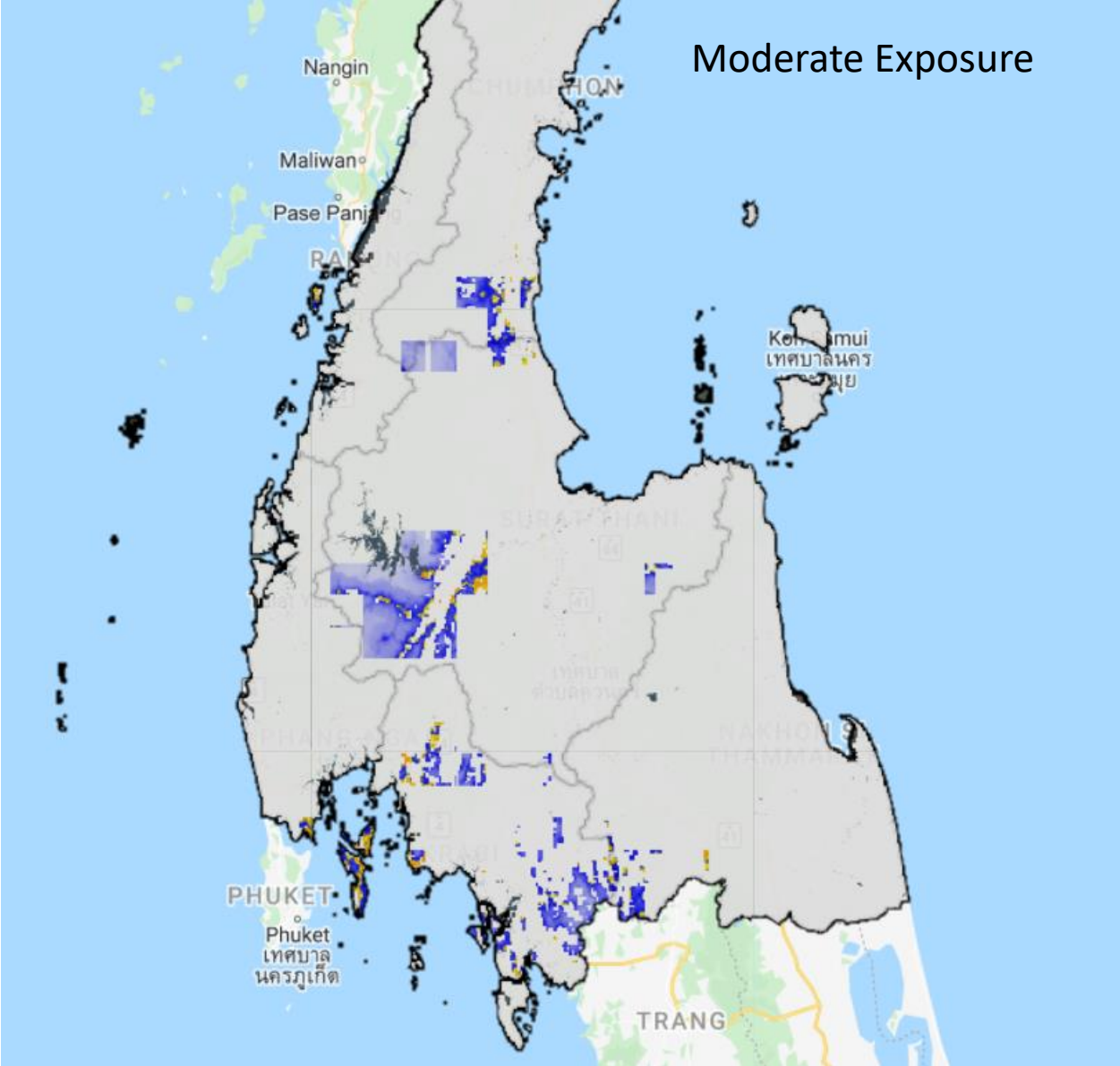
Step 8: Exposure analysis

The screenshot displays the Google Earth Engine web interface. At the top, the browser shows the URL `code.earthengine.google.com`. The main header features the Google Earth Engine logo and a search bar containing `worldpop`. Below the header, there are tabs for `Scripts`, `Docs`, and `Assets`. The `Scripts` tab is active, showing a script titled `Day2_susceptibility`. The script code is as follows:

```
65 Map.addLayer(high,{min:0, max:1, palette:['white', 'red']}, 'high-hazard');
66
67 ////////////////////////////////////////////////// Day 3 Population Exposure Analysis //////////////////////////////////////
68 // Selecting population datasource (Worldpop population density data)
69 var worldPop = ee.ImageCollection("WorldPop/GP/100m/pop")
70 // Filter data for Thailand and year of 2020
71 var WP_2020 = worldPop.filter(ee.Filter.inList('country', ['THA'])).filter(ee.Filter.equals('year', 2020));
72 // Selecting appropriate variable
73 var population = WP_2020.select('population').mosaic().clip(geometry);
74 // Multiplying moderate hazard layer with population to see population who are exposed to moderate hazard zone
75 var moderate_popexp = moderate.multiply(population).rename('Moderate_popexp');
76 // Adding moderate hazard population exposure layer on the map
77 Map.addLayer(moderate_popexp,{min:0, max:1, palette:['white', 'blue', 'yellow', 'orange']}, 'Moderate Exposure');
78 // Multiplying high hazard layer with population to see population who are exposed to high hazard zone
79 var high_popexp = high.multiply(population).rename('High_popexp');
80 // Adding high hazard population exposure layer on the map
81 Map.addLayer(high_popexp,{min:0, max:1, palette:['white', 'yellow', 'orange', 'red']}, 'High Exposure');
82
```

Below the script editor, a map of Vietnam is displayed, showing the Andaman Sea to the west and the Gulf of Thailand to the south. Major cities like Phnom Penh, Ho Chi Minh City, and Can Tho are labeled. The map interface includes a toolbar on the left with navigation and layer controls, and a `Layers` panel on the right. The `Inspector` panel on the far right contains the text: "Use print(...) to write to this console."

Step 9: Visualize exposure layers





Together, we can build a clearer picture of landslides.

Our Mission

NASA scientists are building an open global inventory of landslides and we need your help! Knowing where and when landslides occur can help communities worldwide prepare for these disasters. Become a citizen scientist and you can help inform decisions that could save lives and property today.

[Report Landslides »](#)



Connect with Us

Twitter: [@LandslideReport](#)

Facebook: [LandslideReporter](#)

SciStarter: [Join us on our project page](#)

Connect with the Community

Google Groups: [Landslide Reporter Community](#)

For queries, email Nishan Biswas: n.biswas@nasa.gov

NASA Landslide group: <https://gpm.nasa.gov/landslides/index.html>

References

- Stanley, T., & Kirschbaum, D. B. (2017). A heuristic approach to global landslide susceptibility mapping. *Natural hazards*, 87(1), 145-164. [Link](#)
- Kirschbaum, D., & Stanley, T. (2018). Satellite-based assessment of rainfall-triggered landslide hazard for situational awareness. *Earth's future*, 6(3), 505-523. [Link](#)
- Emberson, R., Kirschbaum, D., & Stanley, T. (2020). New global characterisation of landslide exposure. *Natural Hazards and Earth System Sciences*, 20(12), 3413-3424. [Link](#)
- Emberson, R., Kirschbaum, D., & Stanley, T. (2021). Global connections between El Nino and landslide impacts. *Nature communications*, 12(1), 1-11. [Link](#)