Supplementary Information

Training Images				
Training Image	**Landsat ID**	**Acquisition Date**	**Row**	**Path**
1	LC08_006015_20230808	8-Aug-2023	15	6
2	LC08_007013_20240716	16-Jul-2024	13	7
3	LC08_003017_20230616	16-Jun-2023	17	3
4	LC08_008012_20150715	15-Jul-2015	12	8
5	LC08_008012_20190523	23-May-2019	12	8
6	LC08_006014_20210919	19-Sep-2021	14	6
7	LC08_008012_20150629	29-Jun-2015	12	8
8	LC08_004016_20160822	22-Aug-2016	16	4
9	LC08_005015_20240920	20-Sep-2024	15	5
10	LC08_007013_20160523	23-May-2016	13	7
11	LC08_002017_20160621	21-Jun-2016	17	2
12	LC08_008012_20160818	18-Aug-2016	12	8
13	LC08_004016_20150719	19-Jul-2015	16	4
14	LC08_008013_20170906	6-Sep-2017	13	8
15	LC08_008012_20150731	31-Jul-2015	12	8
16	LC08_009012_20201007	7-Oct-2020	12	9
17	LC08_002017_20170912	12-Sep-2017	17	2
18	LC08_001017_20230821	21-Aug-2023	17	1
19	LC08_004016_20151023	23-Oct-2015	16	4
20	LC08_006014_20190610	10-Jun-2019	14	6
Test Images				
Lake	**Landsat ID**	**Acquisition Date**	**Row**	**Path**
Base Camp	LC08_001017_20220818	18-Aug-2022	17	1
Iluliallup Tasersua	LC08_007014_20220828	28-Aug-2022	14	7
Isvand	LC08_005015_20210608	8-Jun-2021	15	5
North Midternæs	LC08_002017_20170710	10-Jul-2017	17	2
Russell	LC08_007013_20160726	26-Jul-2016	13	7
Tininnilik	LC08_009012_20200820	20-Aug-2020	12	9

Table S1: Scene Selection: Landsat 8 OLI images used in the training and testing datasets with Landsat ID, Acquisition Date, Row, and Path for each image.

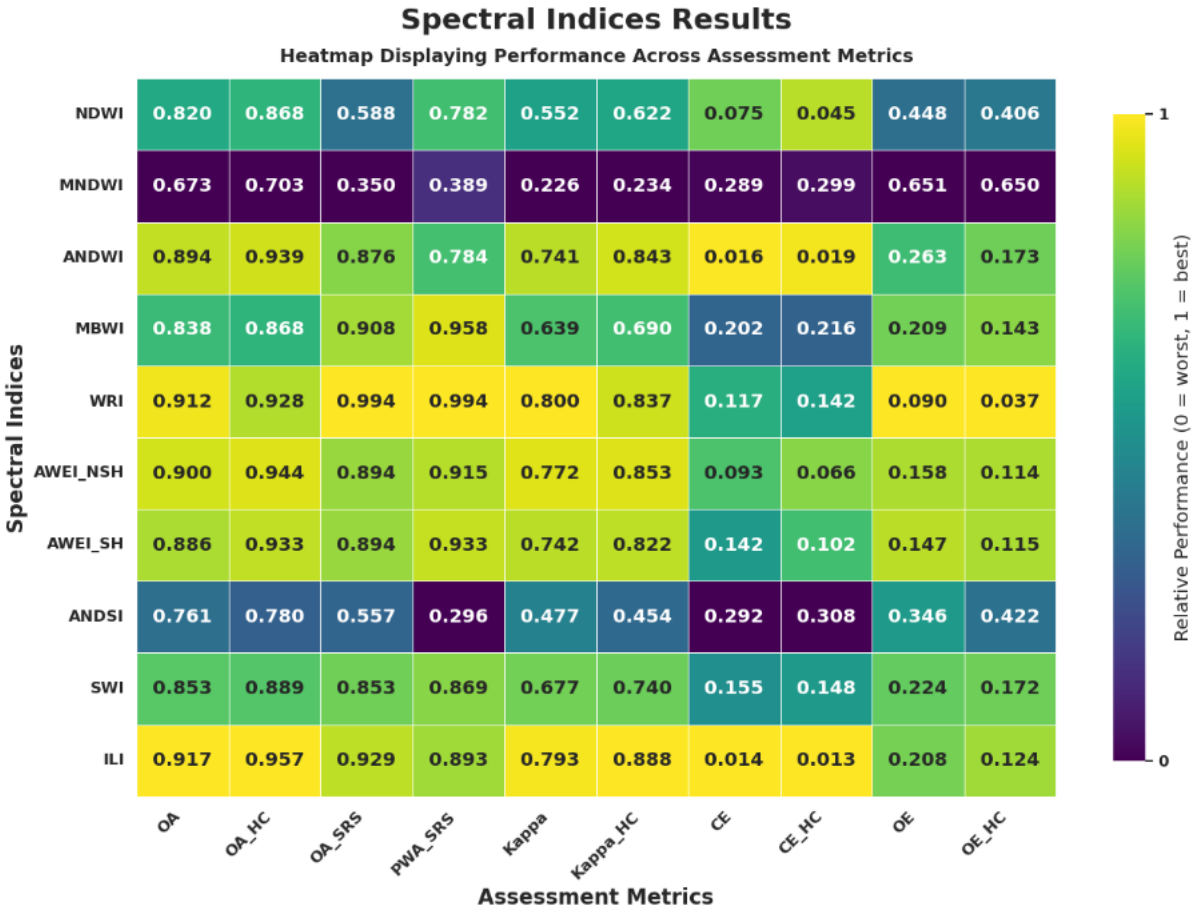


Figure S1: Spectral indices results: Heatmap displaying the relative performance for each of the six test lakes from the 10 spectral indices from the 10 assessment metrics, with 0 being the worst, and 1 being the best performing.

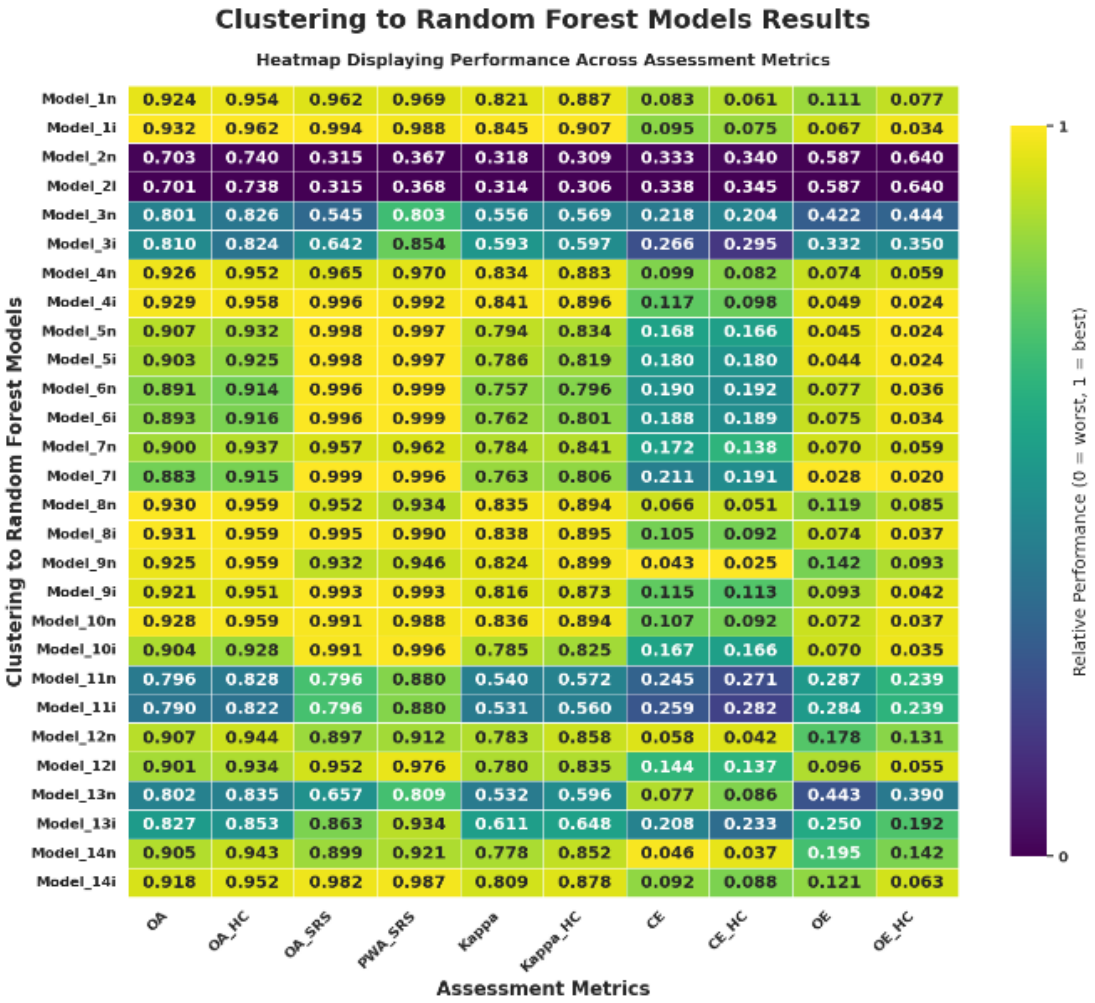


Figure S2: Clustering-to-random-forest results: Heatmap displaying the results for the 28 machine learning models from the 10 assessment metrics.

Supplemental Expert Elicitation Instructions

As an expert who has agreed to participate in the 'Expert Elicitation' portion of this research, you are to analyze and interpret the 100 pixels from six test images in Google Earth Engine (GEE).

Using optical remote sensing methods, this research aims to identify the best approach for tracking IML surface area and detecting GLOFs in Greenland and other High-Latitude regions throughout the Landsat era. To do so, I need to determine which method best identifies water in the surrounding environment. The data collected from the Expert Elicitation will be used as part of the validation data for this study.

Your task will be to interpret 600 pixels from six known GLOF-producing lakes from IMLs in Greenland, 100 pixels per lake. The lakes being used in this study are as follows, with the abbreviations used in the code being in parentheses:

- Lake Tininnilik (Tin)
- Russell Glacier Lake (Russell)
- Iluliallup Tasersua (IL)
- Isvand (Isvand)

- North Midternaes (NM)
- Base Camp (BaseCamp)

Resources Provided:

- Google Earth Engine Script titled ‘LastName_ExpertElicitation’
- Includes all code necessary (instructions on how to use below)
- Six test images
  - ‘BaseCamp_Test’
  - ‘IL_Test’
  - ‘Isvand_Test’
  - ‘NM_Test’
  - ‘Russell_Test’
  - ‘Tin_Test’
- Folder titled ‘LastName_ExpertElicitation’
- One Excel spreadsheet for identifying pixels titled ‘LastName_ExpertElicitation’
- Six CSV files for each test lake
  - ‘BaseCamp_LastName_ValPixels’
  - ‘IL_LastName_ValPixels’
  - ‘Isvand_LastName_ValPixels’
  - ‘NM_LastName_ValPixels’
  - ‘Russell_LastName_ValPixels’
  - ‘Tin_LastName_ValPixels’

GEE Layout:

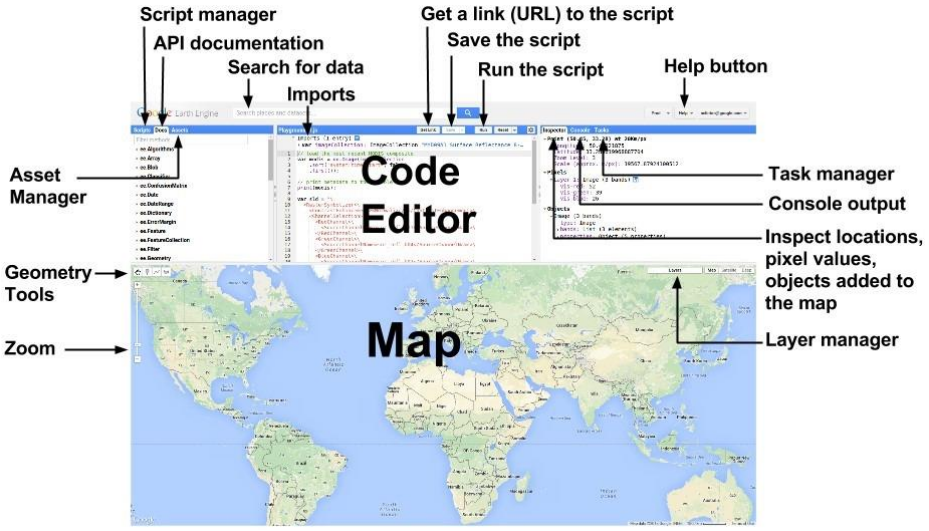


Figure S3: Layout of the Google Earth Engine (GEE) Code Editor with its main components labelled. Reproduced from the GEE Code Editor guide (Google, 2026), licensed under CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/).

Instructions:

1. Open the GEE file from the link provided.
   a. It should look like this:

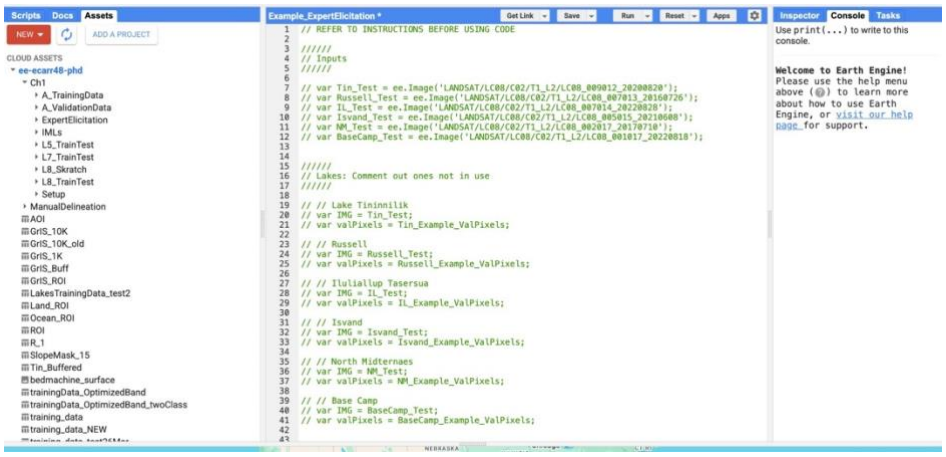


Figure S4: Step 1a: the expert elicitation script as it appears when first opened in the GEE Code Editor, showing the Assets panel (left), code editor (centre), and Console (right). GEE Code Editor screenshot (Gorelick et al., 2017).

2. Add CSV files as Assets.

    a. Click the red “New” button under the “Assets” panel.

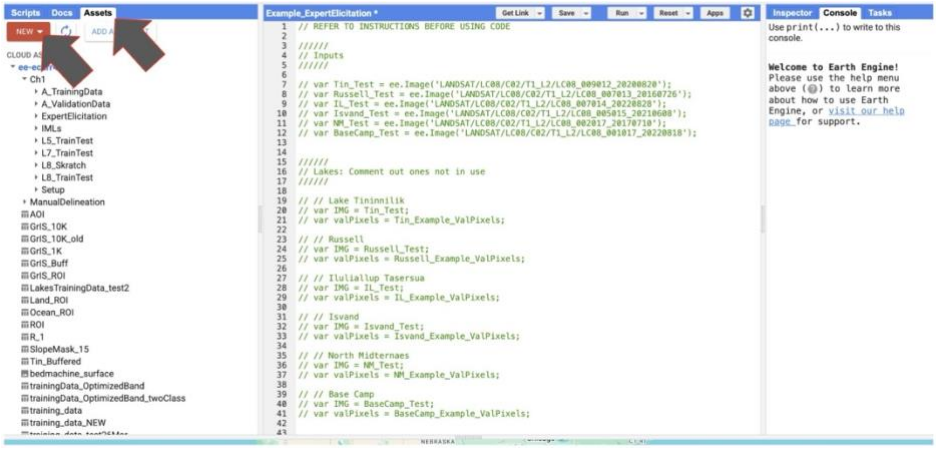


Figure S5: Step 2a: the "New" button in the Assets panel, used to begin uploading the validation-pixel CSV files. GEE Code Editor screenshot (Gorelick et al., 2017).

    b. Select CSV File

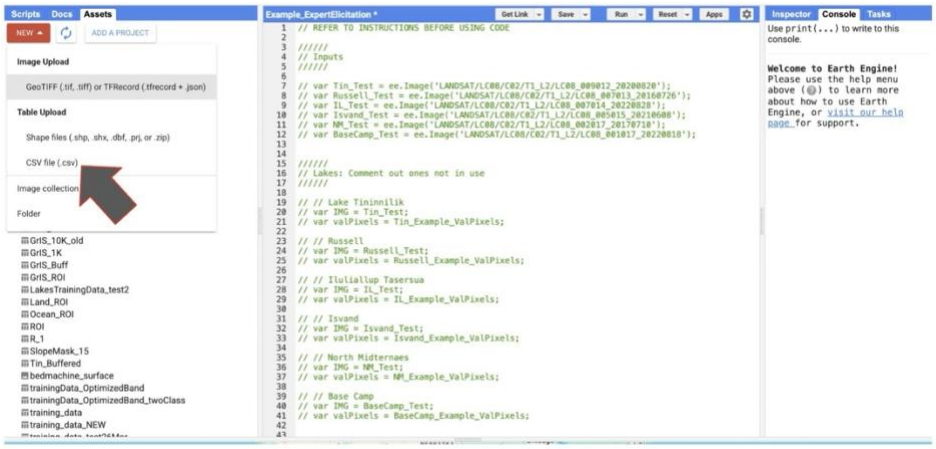


Figure S6: Step 2b: selecting "CSV file (.csv)" under Table Upload in the "New" menu. GEE Code Editor screenshot (Gorelick et al., 2017).

c. Click the red “Select” button to select your CSV file.

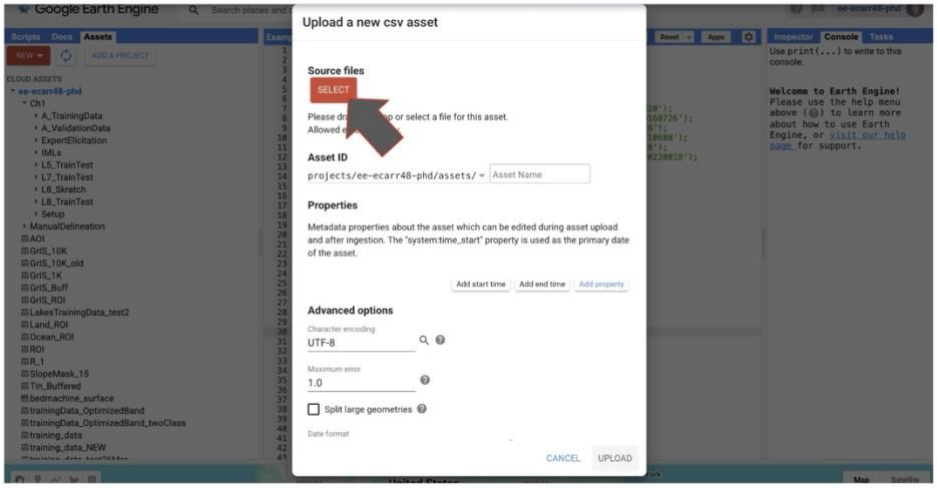


Figure S7: Step 2c: the "Upload a new csv asset" dialog with the "Select" button highlighted. GEE Code Editor screenshot (Gorelick et al., 2017); background map data © 2025 Google.

d. Select the CSV file to upload “Tin_Example_ValPixels.csv” is the example used for this demonstration, but you will upload all six CSVs.

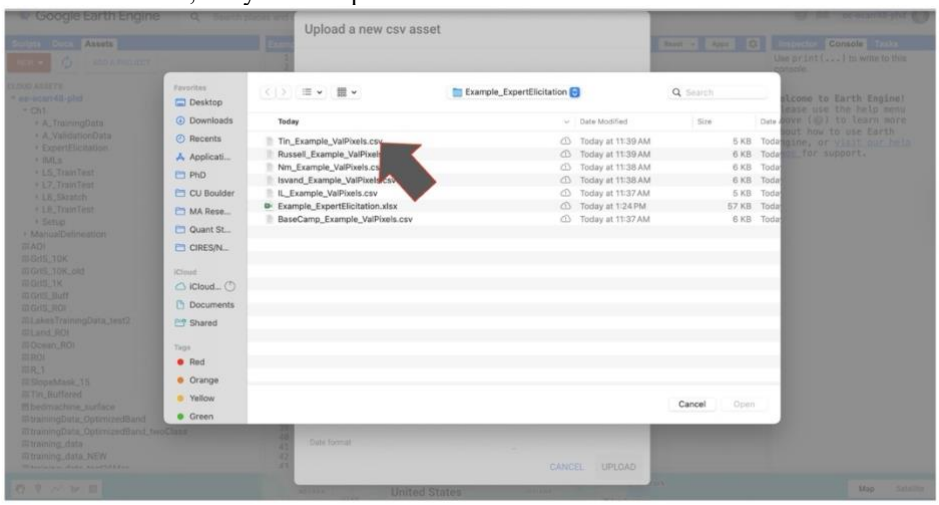


Figure S8: Step 2d: selecting the example file Tin_Example_ValPixels.csv from the local file browser. GEE Code Editor screenshot (Gorelick et al., 2017); background map data © 2025 Google.

e. Upload CSV file

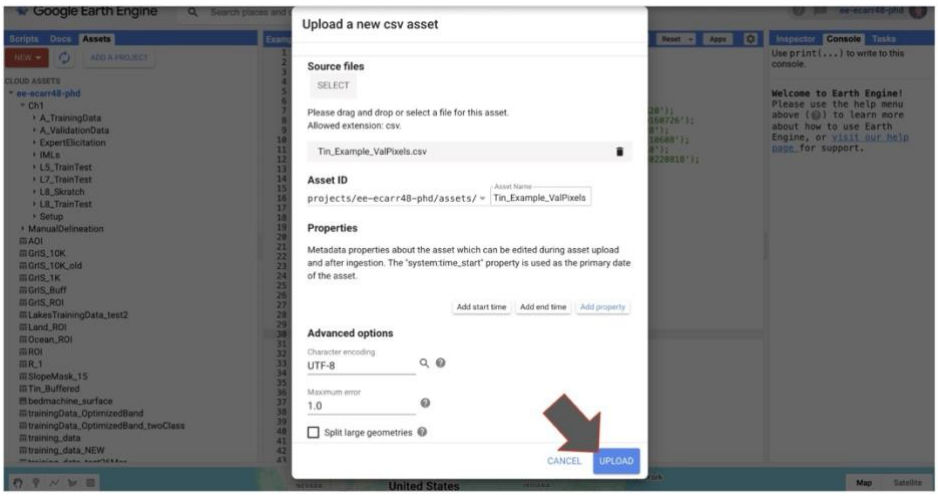


Figure S9: Step 2e: the upload dialog with the source file and asset ID entered and the "Upload" button highlighted. GEE Code Editor screenshot (Gorelick et al., 2017); background map data © 2025 Google.

f. Wait for the CSV file to finish uploading, then refresh the assets panel.

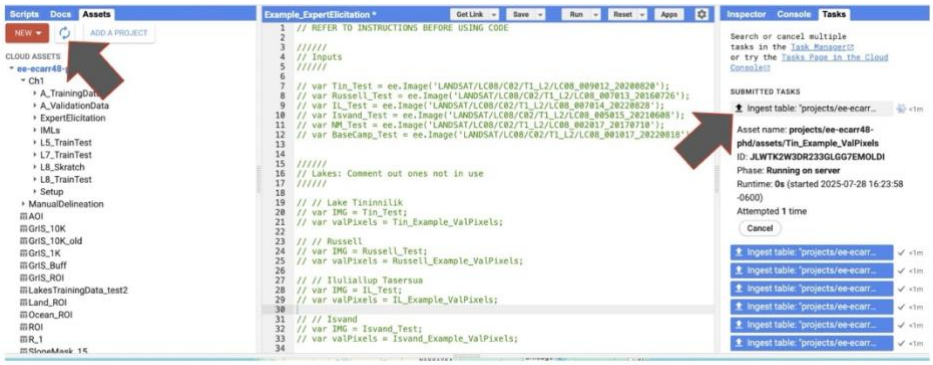


Figure S10: Step 2f: the CSV ingest task in the Tasks tab and the refresh button in the Assets panel. GEE Code Editor screenshot (Gorelick et al., 2017).

g. Find the uploaded CSV in the “Assets” panel and add it to the provided GEE Script.

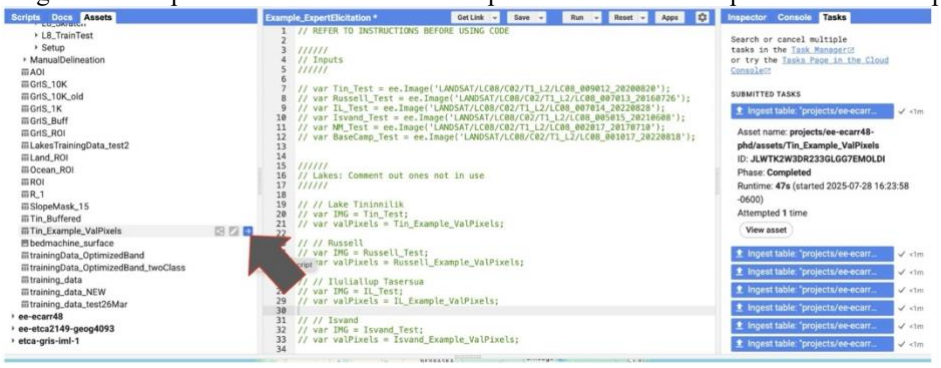


Figure S11: Step 2g: locating the uploaded Tin_Example_ValPixels table in the Assets panel and importing it into the script. GEE Code Editor screenshot (Gorelick et al., 2017).

h. Once added, the CSV file will appear as a ‘table’ under the “Imports” panel above the code editor.



Figure S12: Step 2h: the imported CSV listed as "table" in the Imports section above the code editor. GEE Code Editor screenshot (Gorelick et al., 2017).

i. Click on the purple ‘table’ text to rename the CSV file so that it accurately reflects the name of the original file, as well as the name that appears in the code editor. This will ensure that once the table is renamed, the code will run without needing to be edited.



Figure S13: Step 2i: clicking the default import name "table" to rename it. GEE Code Editor screenshot (Gorelick et al., 2017).

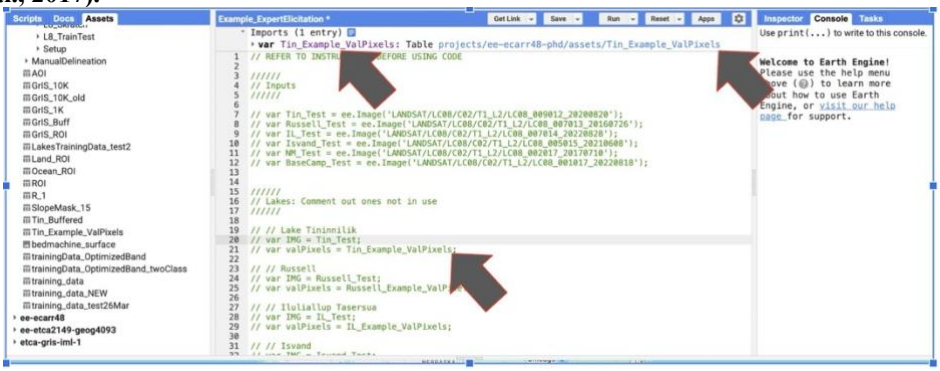


Figure S14: Step 2i (continued): the import renamed to Tin_Example_ValPixels, matching the variable name used in the script (line 21). GEE Code Editor screenshot (Gorelick et al., 2017).

j. Repeat with the remaining five CSV files and rename accordingly so that the ‘Imports’ look like the image below (the order of the CSV imports is not important). Ensure that each CSV file’s name is correct and matches the name in the code that will correspond with each lake.



Figure S15: Step 2j: the Imports section after all six validation-pixel tables have been imported and renamed. GEE Code Editor screenshot (Gorelick et al., 2017).

3. Import test images from the code

   a. Delete the code in lines 7 and 14, '/*' and '*/' respectively. This will turn the code from the green commented-out text to regular code ready for use.
   b. Optional: Convert the images to imports

      i. By hovering your mouse over the code for the images, a pop-up box will appear asking if you want the code to be added as an import. By clicking 'Convert', the image will be added to the Import panel above the code editor.

4. Run the code

   a. Once all your imports are ready, you can visualize the pixels. First, you will comment out the code for Lake Tininnilik (Lines 20-22). This can be done by highlighting the code and using 'Command + /' or by simply deleting the two forward slashes (//).



Figure S16: Step 4a: uncommenting the Lake Tininnilik inputs (lines 20–22) so that the script runs on that lake. GEE Code Editor screenshot (Gorelick et al., 2017).

   b. Then scroll down to line 70, where you will investigate the pixels. Again, '/*' and '*/' have been used to comment out the code until it is ready. The code splits the pixels into 0-49 and 50-99 for easier interpretation. First, comment out the '/*' on line 70 and the '*/' on line 123 so that the code can be used.

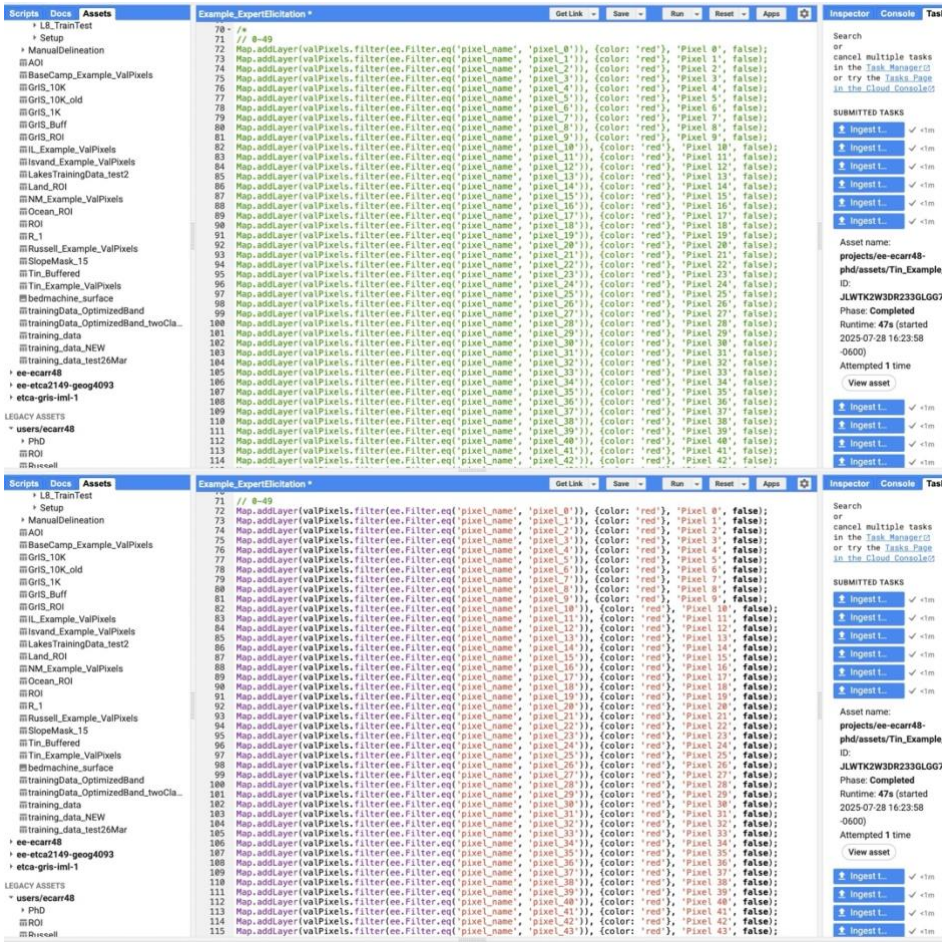


Figure S17: Step 4b: display code for validation pixels 0–49, (a) commented out with "/*" on line 70 and (b) ready to run after the comment markers are removed. GEE Code Editor screenshots (Gorelick et al., 2017).

c. Once complete, hit the 'Run' button.

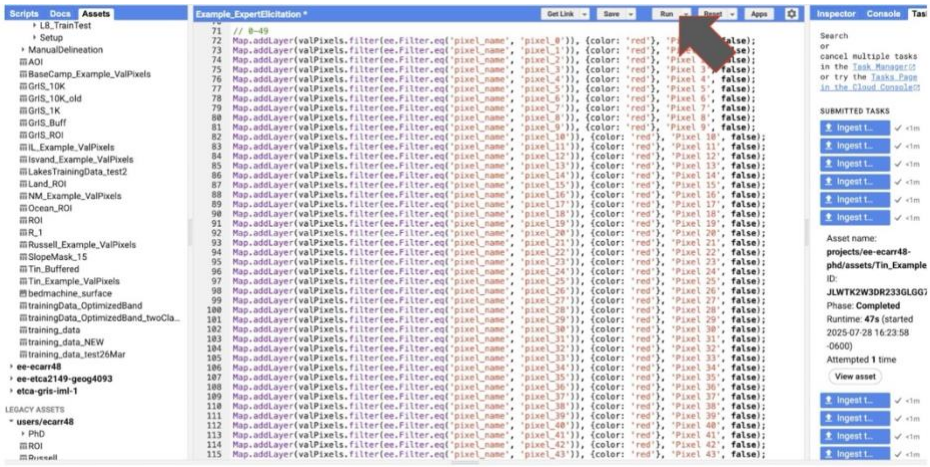


Figure S18: Step 4c: the "Run" button used to execute the script. GEE Code Editor screenshot (Gorelick et al., 2017).

d. After running the code, you pull up the code editor to visualize the map. You should be looking at the image of Lake Tininnilik.

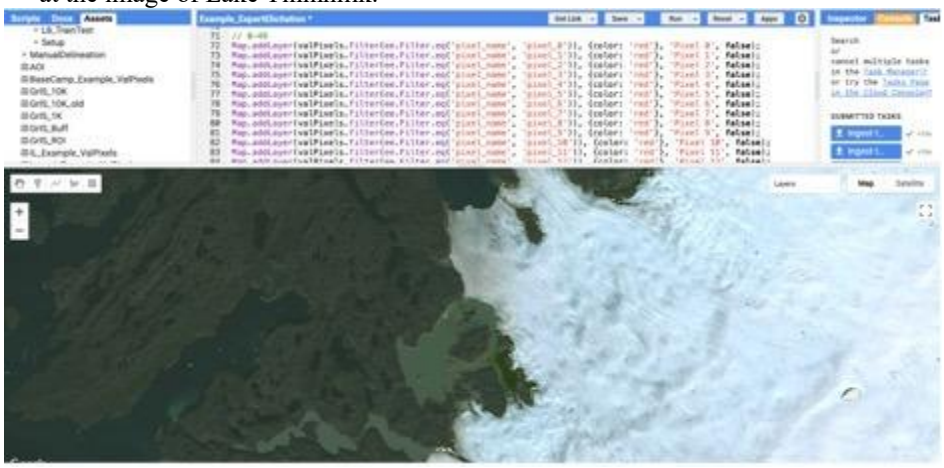


Figure S19: Step 4d: the Landsat 8 OLI test image of Lake Tininnilik (LC08_009012_20200820, 20 August 2020) displayed in the Code Editor map after running the script. Landsat 8 imagery courtesy of the U.S. Geological Survey (EROS Center, 2020); map data © 2025 Google. GEE Code Editor screenshot (Gorelick et al., 2017).

e. Get accustomed to different features of the map. You can use your mouse pad or the '+' and '-' on the top left of the map to zoom in and out. You can also toggle the 'Layers' button by hovering your mouse over it.

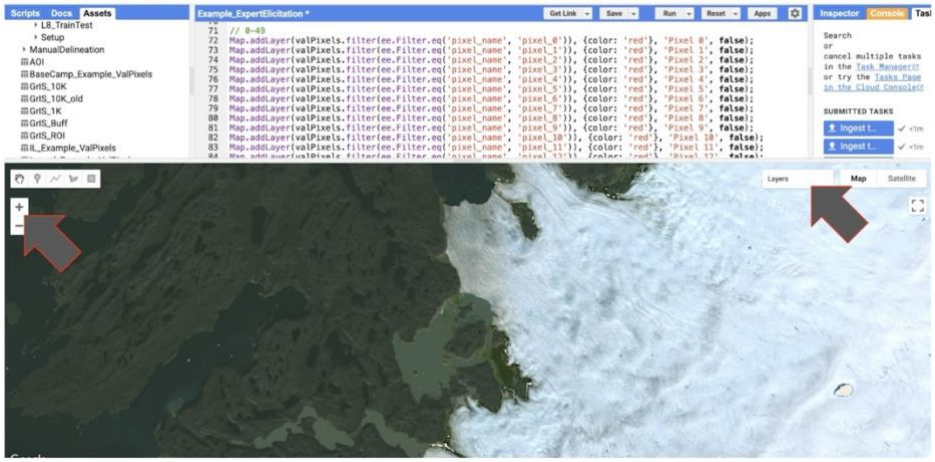


Figure S20: Step 4e: the zoom controls (top left) and "Layers" button (top right) of the Code Editor map, shown over the Lake Tininnilik test image. Landsat 8 imagery courtesy of the U.S. Geological Survey (EROS Center, 2020); map data © 2025 Google. GEE Code Editor screenshot (Gorelick et al., 2017).

f. When hovering over the 'Layers' button, the list of layers will open. It will contain pixels 0-49 and the name of the image. You can also lock the Layer panel so that it stays open by clicking on the small image of a lock; this will assist and make pixel interpretation easier.

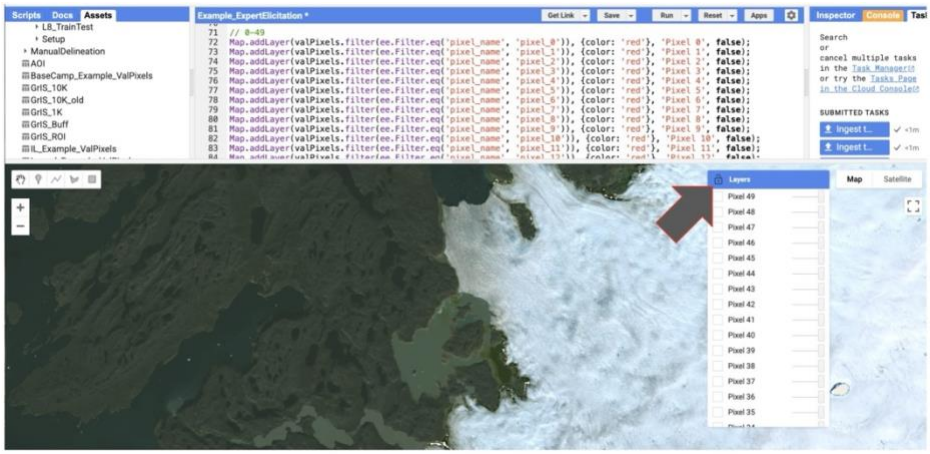


Figure S21: Step 4f: the expanded Layers panel listing the validation pixels (0–49) and the Lake Tininnilik test image. Landsat 8 imagery courtesy of the U.S. Geological Survey (EROS Center, 2020); map data © 2025 Google. GEE Code Editor screenshot (Gorelick et al., 2017).

g. Once complete, you are ready to interpret pixels.

5. Interpretation of pixels

a. Open your Excel file titled 'LastName_ExpertElicitation'

b. Within the file are seven tabs. One for each lake and a tab titled 'ColumnFill' that has all of the potential answers for your pixel interpretation. Do not edit this tab.
c. Find your way to the 'Tininnilik' tab.

d. You will find a table with six columns titled 'system:index', 'SR_B1', 'pixel_id', 'pixel_name', 'landCover', 'confidence', and '.geo.' The pixel_name and pixel_id values match the values in the GEE code. The 'landCover' and 'confidence' columns will be the only ones that are blank.
e. Using the GEE code, check off each pixel starting with Pixel 0 and interpret whether that pixel is over one of four land-cover classes: water, glacierIce, land, or lakeIce. If you believe it to be over something else, you can identify it as 'other.' Additionally, you will assign a confidence score to each pixel based on how sure you are that your interpretation is correct: high, medium, or low.
f. Once you have interpreted the first 50 pixels from Lake Tininnilik, you will return to the GEE code editor and type back in the '/*' on line 70 and the '*/' on line 123 to comment out the code. Then you will delete the '/*' on line 124 and the '*/' on line 177 so that you can inspect pixels 50-99.
g. Once you have completed Lake Tininnilik, you will repeat the process for the other five lakes. Either comment out the Lake Tininnilik variables or put two forward slashes before the code '//'.

6. Returning the data

a. Once you have finished interpreting all 600 pixels, you will save the Excel file titled 'LastName_ExpertElicitation' and email it back to me at ethan.carr@colorado.edu
b. I will use these results to interpret which method was best at identifying the lakes from the surrounding environment, and to choose which method should be used in further research.
c. Once research is complete, I will share my findings with the rest of the group.

References

Earth Resources Observation and Science (EROS) Center: Landsat 8-9 Operational Land Imager / Thermal Infrared Sensor Level-2, Collection 2, U.S. Geological Survey [data set], https://doi.org/10.5066/P9OGBGM6, 2020.

Google: Earth Engine Code Editor, Google Earth Engine Guides, https://developers.google.com/earth-engine/guides/playground, last access: 4 November 2026.

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., and Moore, R.: Google Earth Engine: Planetary-scale geospatial analysis for everyone, Remote Sens. Environ., 202, 18–27, https://doi.org/10.1016/j.rse.2017.06.031, 2017.