BROSS Local Server User Manual

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1. Introduction

BROSS ("Bangladesh Remote Sensing of Suspended Sediments") is an application co-developed by the Bangladesh Water Development Board (BWDB) and University of Washington SASWE Research Group. BROSS provides spatially and temporally distributed suspended sediment concentration (SSC) predictions for the Brahmaputra-Jamuna, Ganges-Padma, Padma, and Lower Meghna rivers of Bangladesh (Figure 1). BROSS uses satellite remote sensing imagery in the visible (red, green, blue) and near-infrared (NIR) spectra as inputs to models calibrated for Bangladesh rivers. BROSS is primarily intended to support BWDB in sustainably managing water resources and protecting human livelihoods throughout Bangladesh.

Figure 1: BROSS (local server tool) domain

BROSS has two operational platforms. One platform is called the 'local server', which operates using both a local desktop server and Google cloud. The second platform is Google Earth Engine. This manual provides user instructions for operating the BROSS local server tool. The link to this tool is http://depts.washington.edu/saswe/bross/. This is a living document stored at https://github.com/cbev/bross/blob/master/manual_user_SASWE.pdf.

The BROSS GEE tool is found at https://cbev.users.earthengine.app/view/bwdb-ssc-prototype and its living manual is found at https://github.com/cbev/bross/blob/master/manual_user_GEE.pdf.

Detailed technical background on the remote sensing and modeling techniques is found in the technical manual. We recommend that users who will be using SSC data from BROSS review the manual to understand the limitations and uncertainties of the data. The technical manual is a living document stored at https://github.com/cbev/bross/blob/master/manual_technical.pdf.

In this manual:

- Section 2 describes the BROSS local server tool and how it compares to the BROSS GEE tool
- Section 3 provides the mandatory and optional steps for operating the BROSS local server tool
- Section 4 provides troubleshooting questions
- Section 5 provides frequently asked questions (FAQs)
- Section 6 provides the disclaimer

2. Description of BROSS

The BROSS local server tool operates using data from the Landsat 8 satellite. Landsat 8 has been operational since 11 February 2013, has a 16-day revisit interval, and 30 m spatial resolution. The BROSS local server tool provides SSC estimates from Landsat 8 using two model options: regression and artificial neural networks (ANN). Table 1 summarizes the difference between the regression and ANN model performance, and further details are provided in the technical manual. The model outputs are in two forms: (1) a time series of SSC estimates for all Landsat 8 data at four in situ monitoring stations (‘Study sites” in tool; Bahadurabad, Hardinge Bridge, Baruria, and Mawa); and (2) instantaneous SSC maps over the BROSS domain (Figure 1) for Landsat 8 data from the past 6 months. The maps for the regression model are produced at 100m resolution and the maps for the ANN model are produced at 200m resolution. Figure 2 shows an example of these two outputs. Both the SSC time series and map data can be downloaded by the user.

Table 1: Statistical Tests for Model Performance of SSC Predictions for Landsat 8 (ANN vs Regression). *Stronger results for each satellite group and indicator is in* ***bold.***

Metric	ANN	Regression
Root mean square error (RMSE)	139 mg/L	**134 mg/L**
Coefficient of detemrination (r^2)	**0.74**	0.71
Anomaly correlation coefficient	**0.86**	0.83
Anomalies	**-102 mg/L**	-130 mg/L
Spearman r	**0.88**	0.81

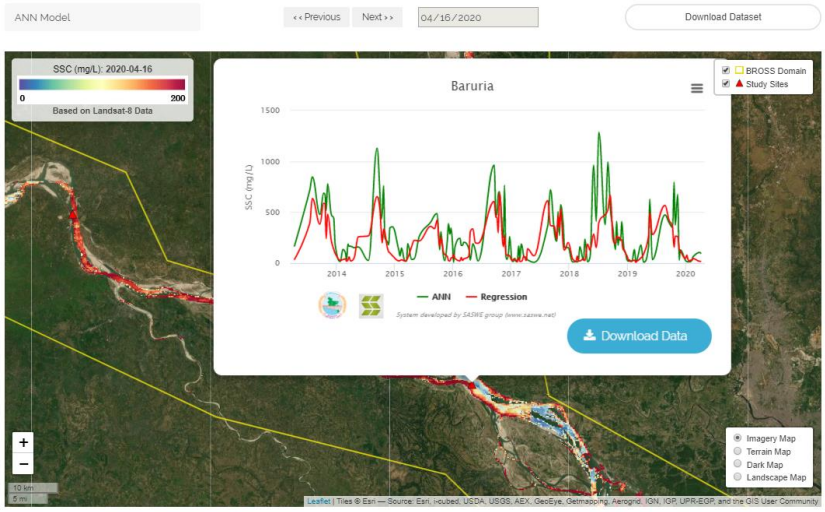

Figure 2: Example outputs of BROSS local server tool*. (1) A map of SSC from ANN model along the Padma river and (2) a long-term time series of SSC predicted from Landsat 8 satellite data using ANN and regression models at the Baruria monitoring point.*

BROSS computes/maps SSC only for pixels that are classified as water and cloud-free. Therefore, there may be limited pixels in regions with river widths narrower than map resolution (100 m or 200m), such as along the braided Jamuna river when flows are low. The base map is a static image of the land surface and does not necessarily align with the trajectory of the rivers (i.e., the water surface pixel locations) for the selected date. Cloud cover is a prominent issue during the monsoon season (June to September). It is possible that there are no cloud-free pixels for a given date and that the entire image will be excluded from BROSS results. Not all pixels impacted by land surface, clouds, and fog are masked perfectly, therefore users should be

especially cautious when interpreting data in river pixels that are shallow depth and/or near land, and during foggy/cloudy days. Limitations are further discussed in the technical manual.

The BROSS GEE tool provides the raw satellite reflectance data and SSC predictions from regression. The BROSS GEE tool has an accompanying computational notebook to generate SSC time series from ANN. Table 2 compares the key features of the two BROSS tools.

Table 2: Comparison of BROSS GEE and BROSS local server systems

Feature	Local server	Google Earth Engine
Mapped SSC from regression	X	X
Mapped SSC from ANN	X	
SSC time series from regression	X	X
SSC time series from ANN	X	Use separate computational notebook
SSC time series for user-defined region of interest		X
SSC time series auto-generated at in situ monitoring stations	X	
Satellite data availability	Landsat 8	Landsat 5, 7, 8; Sentinel-2; MODIS
Spatial resolution of maps	Regression: 100m, ANN: 200 m	Landsat: 30 m, Sentinel-2: 10 m, MODIS: 500 m
Temporal availability	Time Series: Full extent of Landsat 8 data Map: Past 6 months	Full extent of satellite data
Able to export time series	X	X
Able to export map	X	
Able to view values of individual pixels	X	X
Able to view and download satellite reflectance data		X
Data storage source	Local server	Google Cloud
Computing source	Google Cloud	Google Cloud
Computing language	Python	JavaScript

3. Operational steps

i. **Start application.** In a web browser, navigate to the BROSS local server tool website: http://depts.washington.edu/saswe/bross/

ii. By default, the initial SSC map that will appear is developed from the most recent Landsat 8 data using the regression model

iii. **Optional Steps**. Note that these steps can be conducted in any order

a. View the full (Landsat 8) time series of SSC predicted using the regression and ANN models at that site by clicking on a "Study site" symbol (red triangle) on the map

- To obtain the data as comma separated values, click on "Download data" at the bottom right corner of the time series box. You can copy and paste the displayed values into an Excel sheet or text editor.

b. V**iew SSC map from a different model (Regression or ANN)** by clicking on the "Regression Model" or "ANN Model" dropdown menu at the top left corner of the application window. Then, select the desired model.

- Note that it may take several seconds for the new map to load. Please be patient during this time and minimize interaction with the application.
- Note that the spatial resolution of the regression map is 100m and the ANN map is 200m.
- Table 1 (Section 2) and technical manual provide the difference in performance between the regression and ANN models for Landsat 8.

c. **View the SSC value of a single pixel on the SSC map** by clicking on the pixel. A callout box with the SSC value will pop-up.

d. **Export the SSC map on display as a .tif file** by clicking on the "Download Dataset" button on the top right hand corner of the application window.

e. **View SSC map from a different date over the past 6 months** by clicking the "<<Previous" or "Next >>" button at the top center of the application screen.

- Only 1st and 16th date of each month is available in the application. This is because Landsat 8 collects data every 16 days. Since there are multiple satellite images collected across the domain, data is grouped by the 1st and 16th date for convenience. The data was not necessarily collected on the 1st or 16th of the month. The actual dates that data were collected are shown in the time series for each study site.

- Note that it may take several seconds for the new map to load. Be patient during this time and minimize interaction with the application.

4. Troubleshooting

i. **Why does it say "*Image unavailable for selected date*" if they selected date has already passed?**

- If the date is greater than 6 months in the past, the image is no longer available on the local server
- If the image is less than 6 months in the past, the image is likely unavailable due to clouds and/or fog completely covering the BROSS domain. Cloud cover is a prominent issue during the monsoon season (June to September). It is also possible that there were other issues with the satellite data, such as an equipment issue.

ii. **Why does it say "*Image unavailable for selected date*" if the image is available for the same date with a different model (e.g., map is available for ANN but not regression for the same date)?** The spatial resolution of the maps from regression and ANN models are different (100m and 200m, respectively). Therefore, pixels that pass the tests to be classified as "water" and "cloud-free" for one model may not pass for the other. It is possible that all pixels failed the test for one model and the image is not available.

iii. **Why is a data point missing from the SSC time series at the "study site" if the map is available for that data?** The SSC computed for a "study site" is the spatial average of SSC for a reach that is roughly 3 times longer than the width of the river at the approximate location of the in situ monitoring point. At least 30% of the pixels in that reach much pass both the "water" and "cloud-free" tests for a data point to be computed for the time series. There may be many other pixels on the map that are classified as water and cloud-free.

iv. **The computation is taking too long or is timing out.** This is a known challenge in working with a large study domain, high resolution, and extensive computations. Please be patient when operating the system. After making one change, wait for the map to finish loading before going to the next change (a change, for example, would be changing the data or model, or zooming in/out of the map). If the system is persistently crashing

and/or persistently taking several minutes for a single change to occur, please submit the issue at *https://forms.gle/z7WSYt4b94rZFwh78*.

v. **Why do there appear to be "stripes" in some of the images?** Unfortunately, this is a known issue with Landsat data. Please see the following link for more information: https://www.usgs.gov/land-resources/nli/landsat/detector-striping?qt-science_support_page_related_con=0#qt-science_support_page_related_con

Do you have a troubleshooting question that is not shown? Please submit it at: https://forms.gle/z7WSYt4b94rZFwh78

5. Frequently Asked Questions (FAQ)

vi. **Can additional "study sites" (points to view/download automatically generated time series) be added?** Additional study sites may be added at the request of BWDB staff. We recommend adding study sites that need to be frequently monitored. However, please be aware that increasing the number of study sites will increase the map loading time. Please submit site name, location (latitude, longitude, and coordinate system), and justification for the request at: *https://forms.gle/z7WSYt4b94rZFwh78*

vii. **What is the uncertainty of the SSC predictions?** See the root mean square error (RMSE) in Table 1 for the respective regression or ANN model. The range of error is plus or minus the RMSE.

viii. **How do I cite this tool?** Click the "How to Cite" button at the top right of the application window for more information.

Do you have a question that is not shown? Please submit it at: https://forms.gle/z7WSYt4b94rZFwh78

6. Disclaimer

BROSS is a research grade platform that is continuously under development. Users should use the outputs at their own risk. Developers of the system do not accept any responsibility for erroneous data or outputs that may trigger improper decision making.