Spatiotemporal modelling & automated *in-situ* sensors to monitor Harmful Algal Blooms(HABs)

Case Study-Lake Victoria

Presenter:
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Introduction

- Harmful Algal Blooms (HABs), a phenomena which turns water bodies dark blue-green due to eutrophication; potentially harming humans and animals e.g., massive fish deaths, etc.
  (Santoleri et al., 2003), WHO
- Development, stability, and density of the phenomenon affect some environmental factors Lake Surface Air Temperature (LSAT), Sea Surface Temperature (SST) *(Tang et al, 2006)*
- Hence, quantifying the spatial distributions of HABs in L. Victoria is of great significance, which requires high spatiotemporal monitoring. (Sitoki et al., 2012)
- There however exists that niche to support the space observations with a near-real time geointelligent in-situ monitoring and reporting system.

Problem statement

- The rapidly escalating demographics along L. Victoria riparian reserves has negatively impacted water quality through deposits of agricultural, industrial runoff and sewer refuse eutrophicating the said region. (Burkholder et al., 2006; MOH)

- Deterioration in water quality initiates ecosystem conflicts, poor economic growth, reduced tourism, poor water quality furthermore baring achievement of SDG 6 & 14- Clean Water and Sanitation. (Hecky et al., 2010)

- Coupling wide spread spatiotemporal monitoring, and automated *in-situ* sensors will play a big deal in return. This would inform the Govt. and the general public the affected zones, calling for immediate remedy actions.

Justification

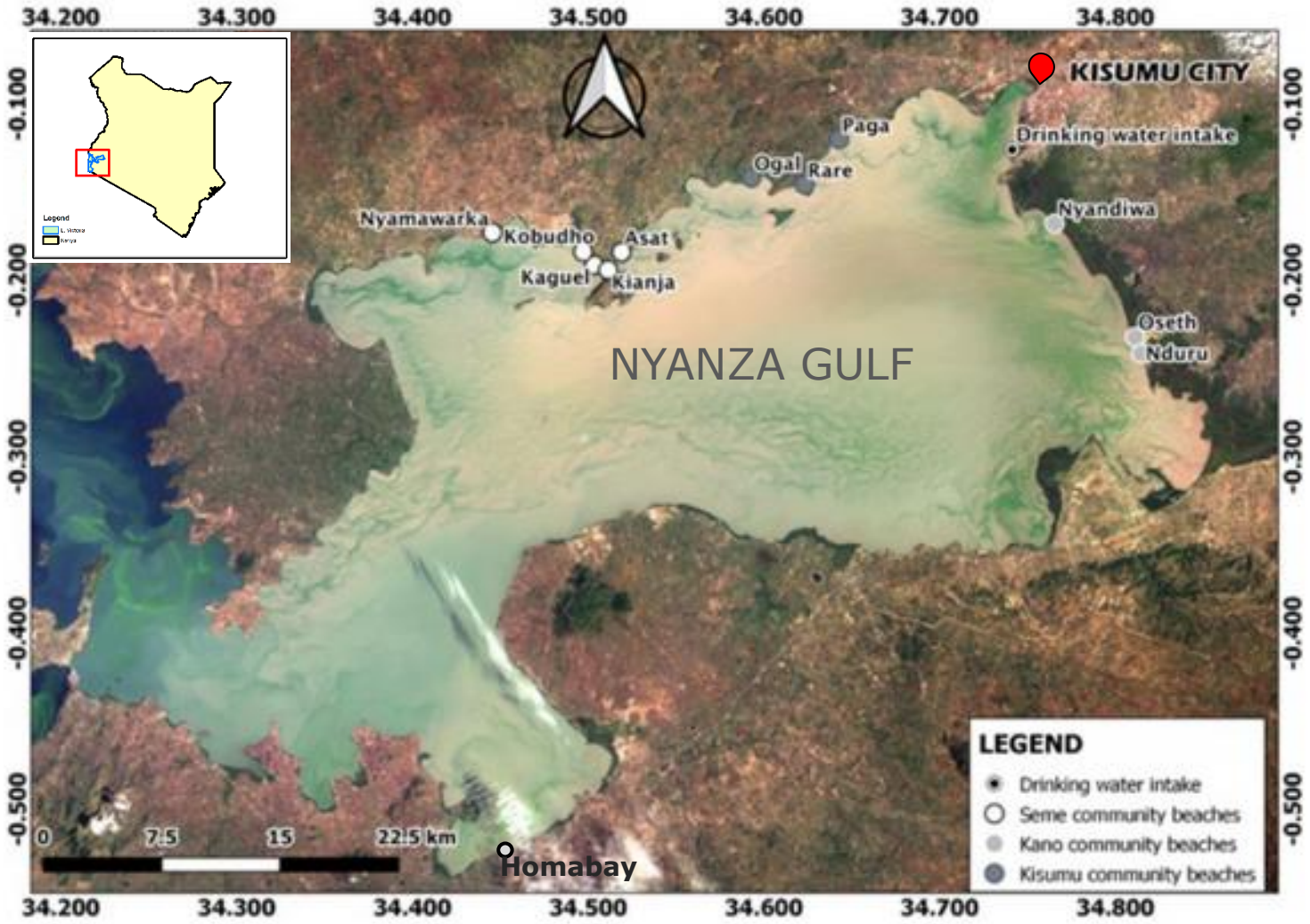
Image Sources: Standard Media KE, KMFRI, allAfricawaters

General and specific objectives

- To detect, monitor and report the occurrence of Harmful Algal Blooms(HABs) in Lake Victoria, Kisumu basin.

  - To monitor chlorophyl-a(chl-a) concentration from L8 OLI images.
  - To monitor Lake Surface Air Temperature(LSAT) from L8 TIRS images as another HAB indicator in L. Victoria.
  - To develop automated Internet of Things (IoT) *in situ* sensors, Applicable in near real-time to monitor and report geo-tagged Water quality data.

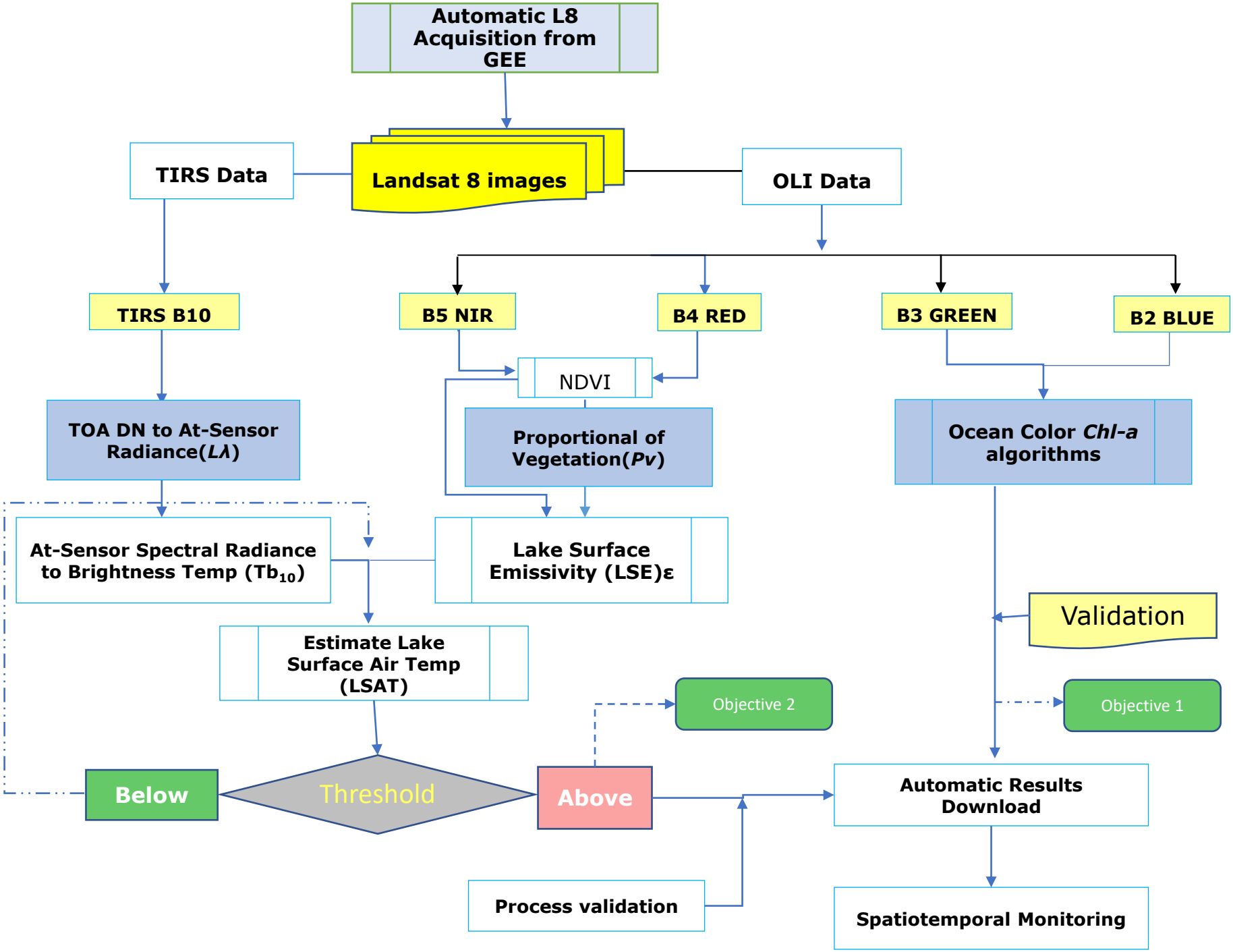
Study Area


34.200
34.300
34.400
34.500
34.600
34.700
34.800
-0.100
-0.200
-0.300
-0.400
-0.500
KISUMU CITY
Drinking water intake
Paga
Ogal
Rare
Nyandiwa
Nyamawarka
Kobudho
Asat
Kaguel
Kianja
Oseth
Nduru
NYANZA GULF
Homabay
0
7.5
15
22.5 km
LEGEND
Drinking water intake
Seme community beaches
Kano community beaches
Kisumu community beaches

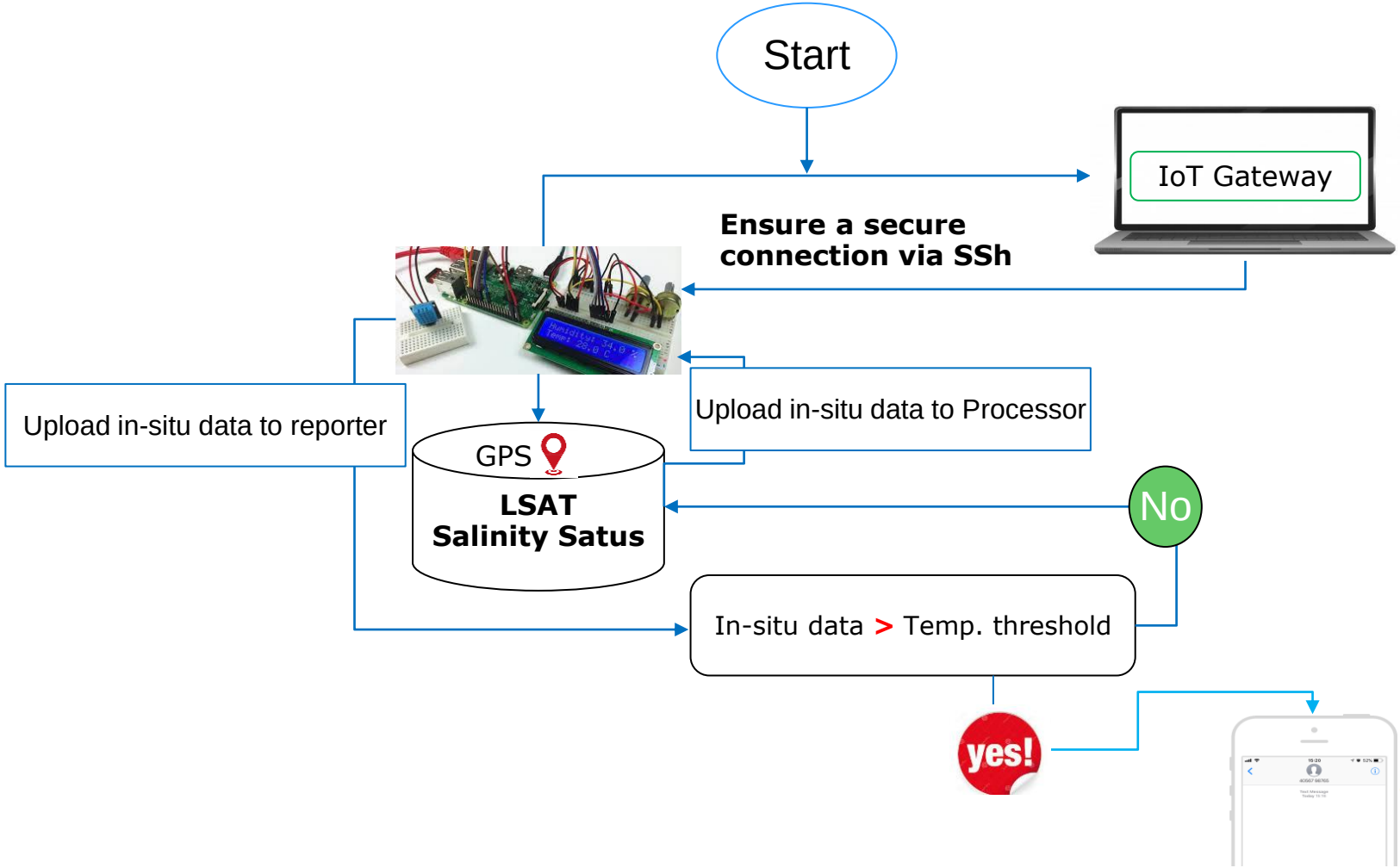
Overall Methodology : Data and Materials

Data Type	Source	Role/Use
Landsat 8 OLI (30m, 16 days)	Google Earth Engine (2015-2021)	Spatiotemporal HAB Monitoring
Landsat 8 TIR (100m, 16 days)	Google Earth Engine (2015-2021)	Lake Surface Water Temperature Monitoring(LSWT)
Meteorological Data	Kenya Marine & Fisheries Research Institute-KMFRI (2015-2021)	Water Quality assessment
In-Situ Data	In-situ Sensors 2021 Onwards	Continued In-Situ Algal Monitoring

Tool/Material	Role	Availability
Google Earth Engine (GEE)	Geocomputation & Processing	Freely Available
QGIS/ArcMap, R & Python	Further Analysis & Maps	Free
Microcontroller & Sensors	In-Situ data Monitoring	Local Purchase
KiCAD	Design the Schematics & basic Circuits	Free & Open source


Automatic L8 Acquisition from GEE
Landsat 8 images
TIRS Data
OLI Data
TIRS B10
B5 NIR
B4 RED
B3 GREEN
B2 BLUE
NDVI
TOA DN to At-Sensor Radiance(Lλ)
Proportional of Vegetation(Pv)
Ocean Color Chl-a algorithms
At-Sensor Spectral Radiance to Brightness Temp (Tb10)
Lake Surface Emissivity (LSE)ε
Validation
Estimate Lake Surface Air Temp (LSAT)
Objective 2
Objective 1
Below
Threshold
Above
Automatic Results Download
Process validation
Spatiotemporal Monitoring

Overall methodology



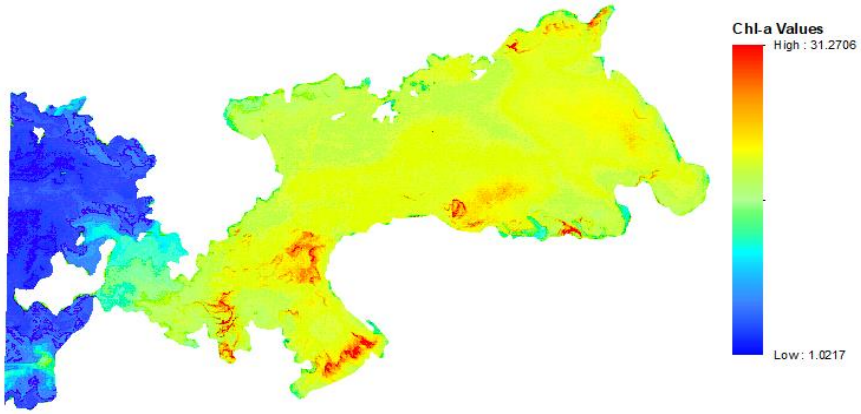
HAB reported dates, from 2015

Year	Date and Month	Reporting body
2015	12th January, 22nd February	Nasa Earth data, KMFRI
2016	23rd July	KMFRI
2017	04th August	Africa great Lakes
2018	27th January	KMFRI, Nasa Earth Data
2019	18th August	KMFRI
2020	29th August,	KMFRI
2021	No Data	None Reported

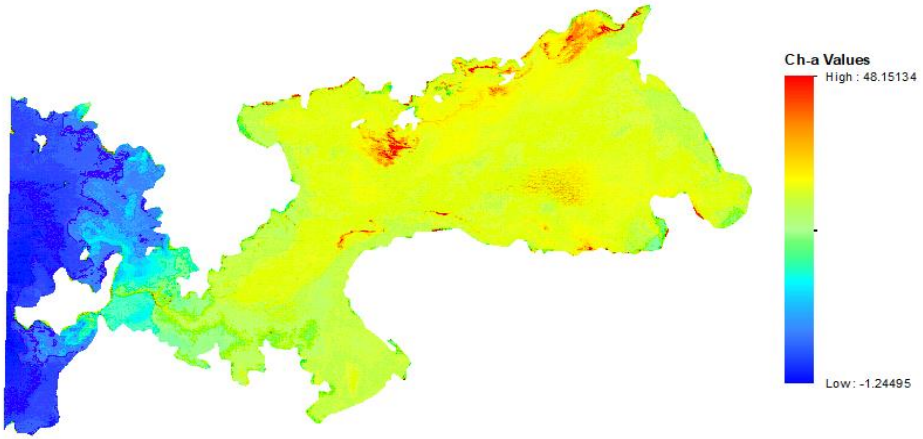
Table 3: HABs reported in Lake Victoria, (KMFRI, NASA Earth Data)

Results (a) : Chl-a Distribution Maps

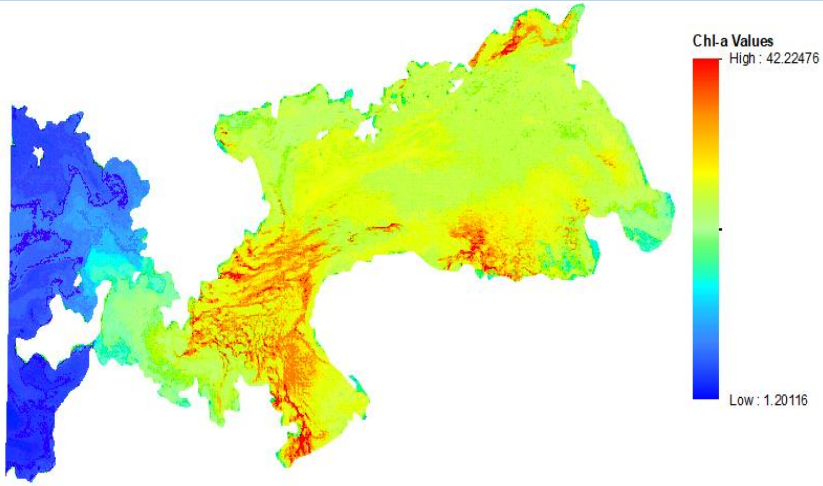
12th January 2015



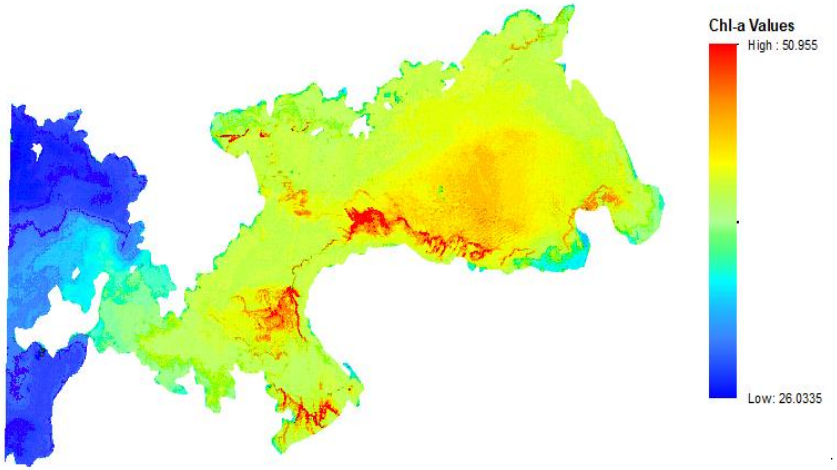
23rd July 2016



04th August 2017

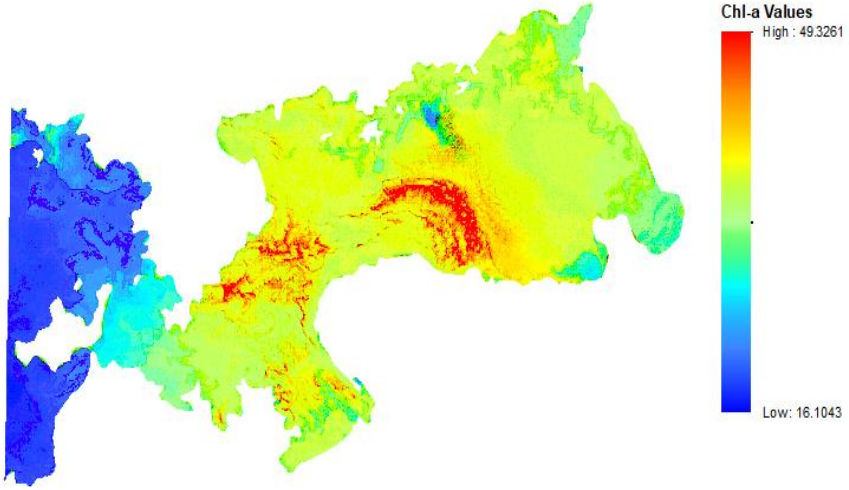


27th January 2018

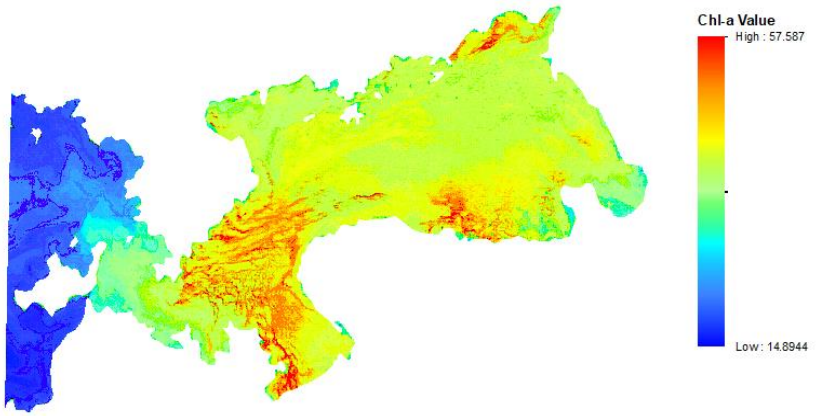


Chl-a Distribution Maps, Cont'd

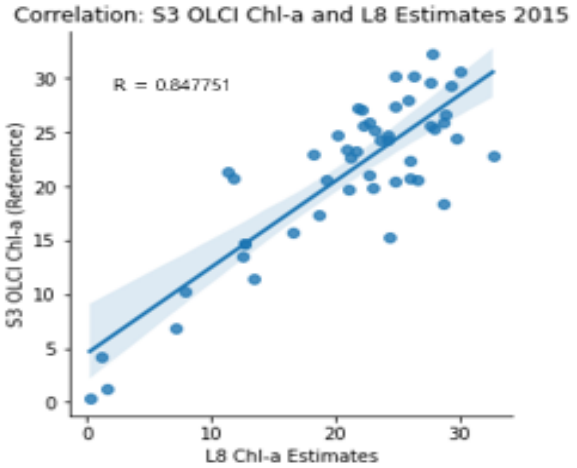
18th August 2019

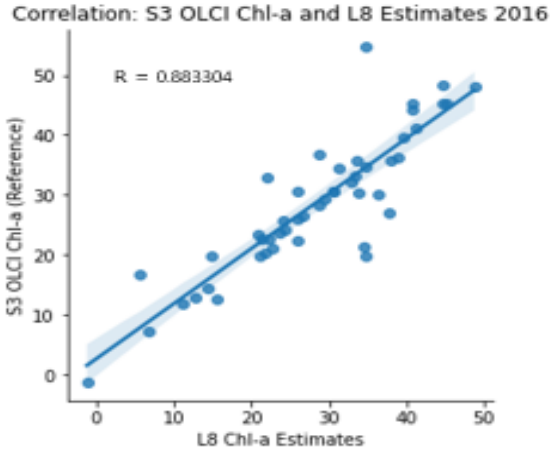


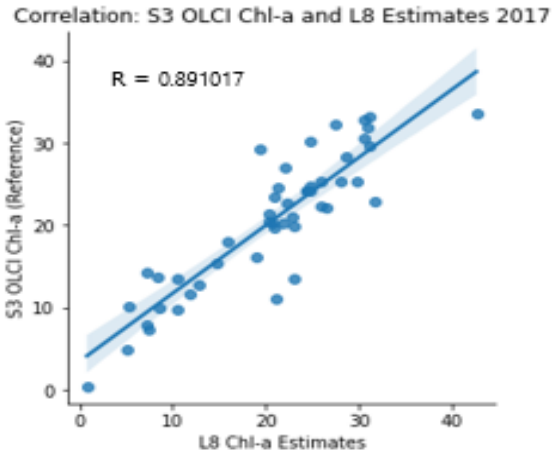
29th August 2020

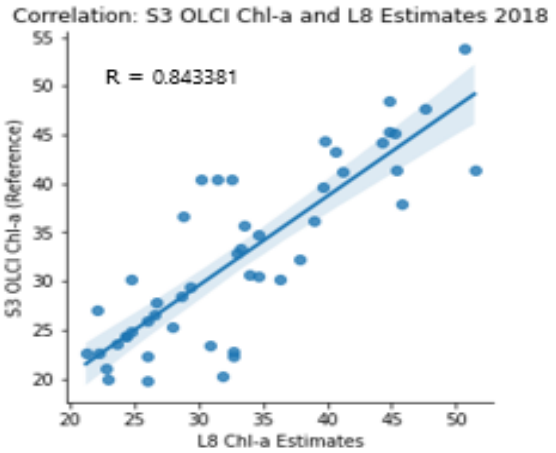


Accuracy Assessment of Chl-a Estimates









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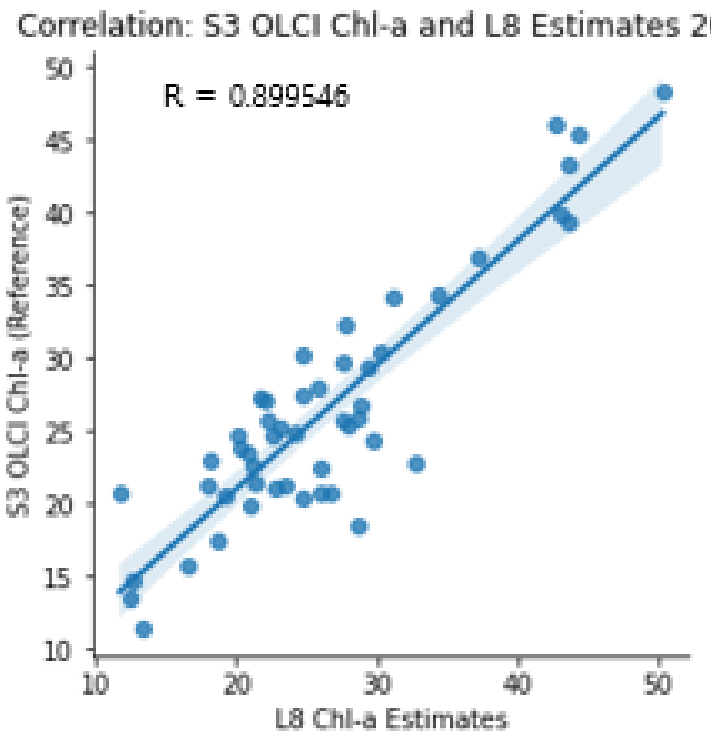
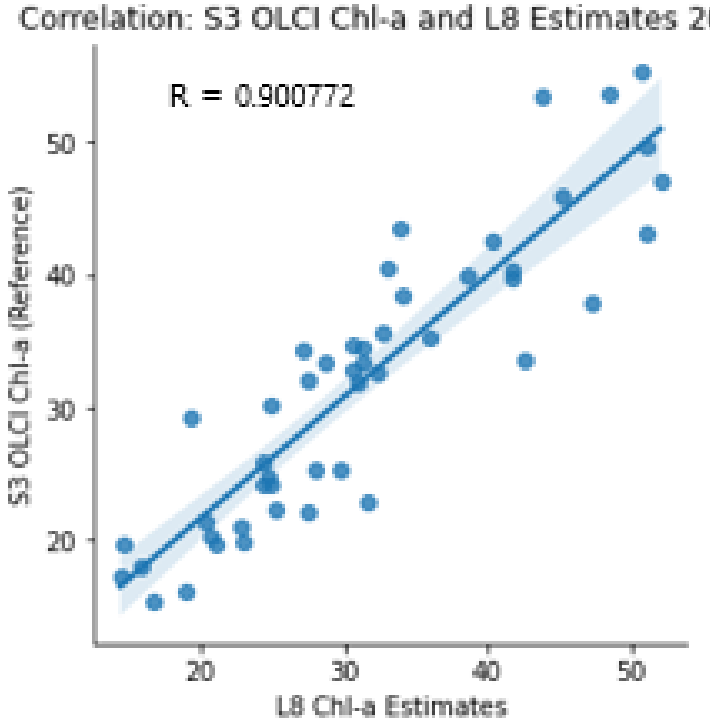
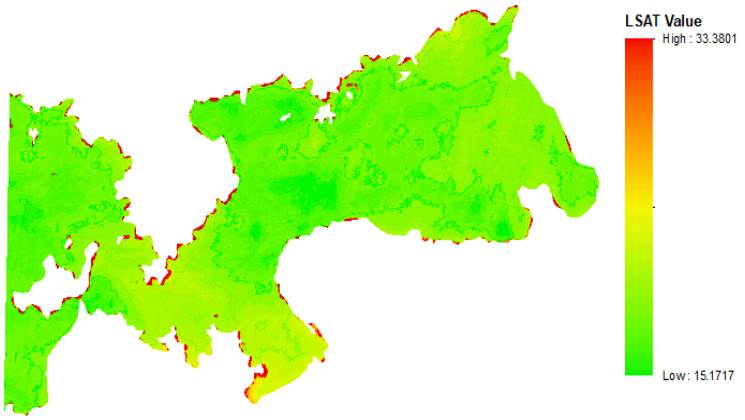


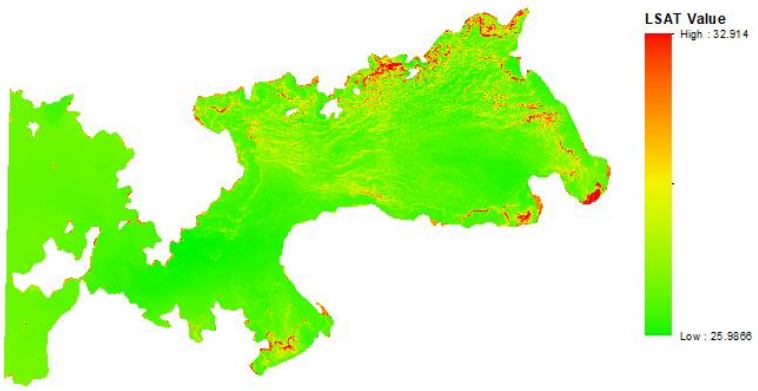


Results (b): High LSAT recorded during bloom Events

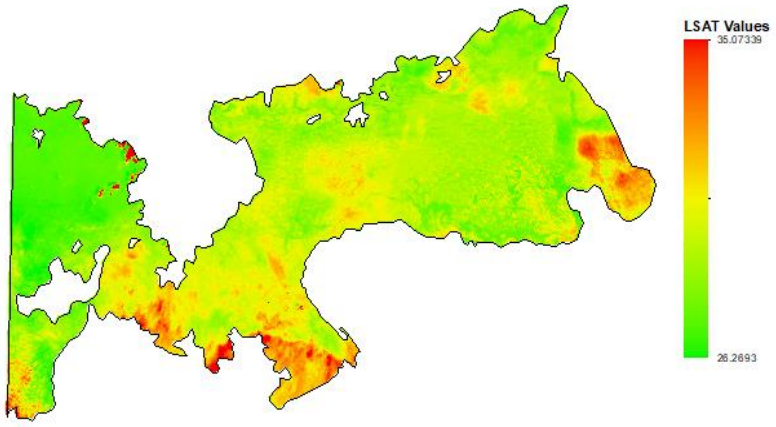
12th January 2015



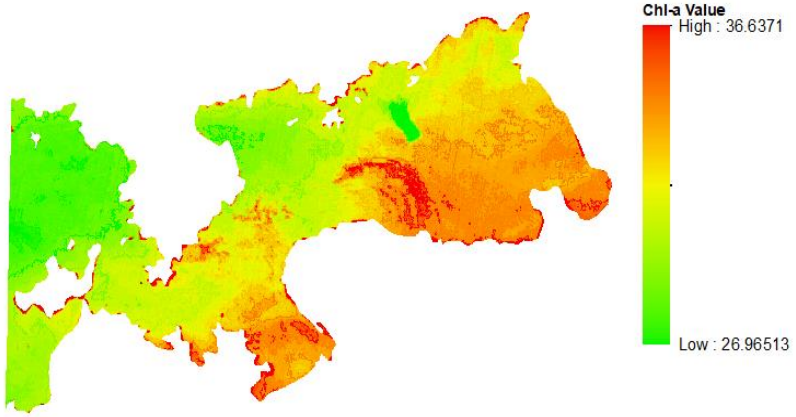
23rd July 2016



04th August 2017

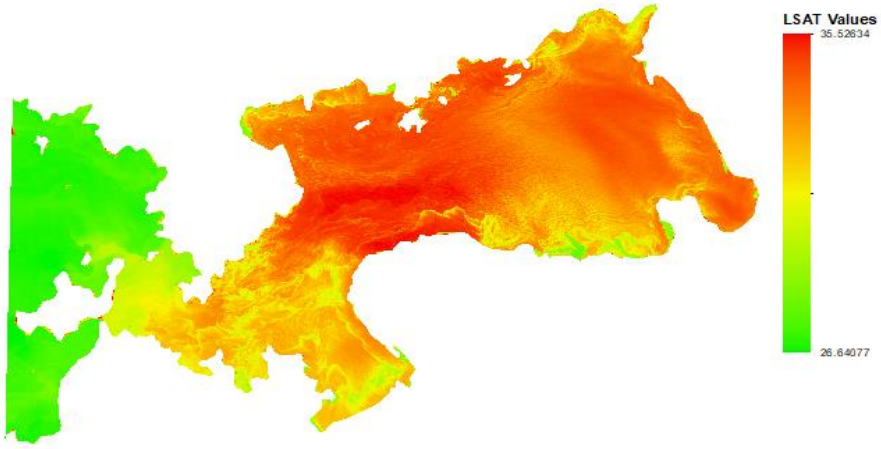


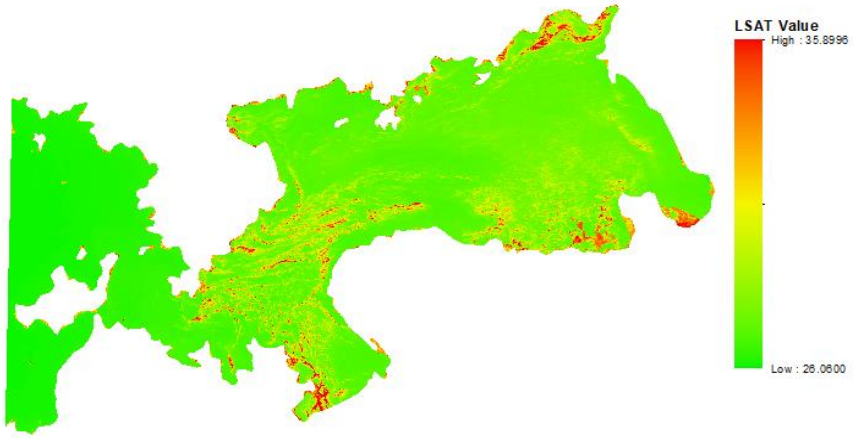
27th January 2018



Results (b): High LSAT recorded during bloom Events

18th August 2019	29th August 2020

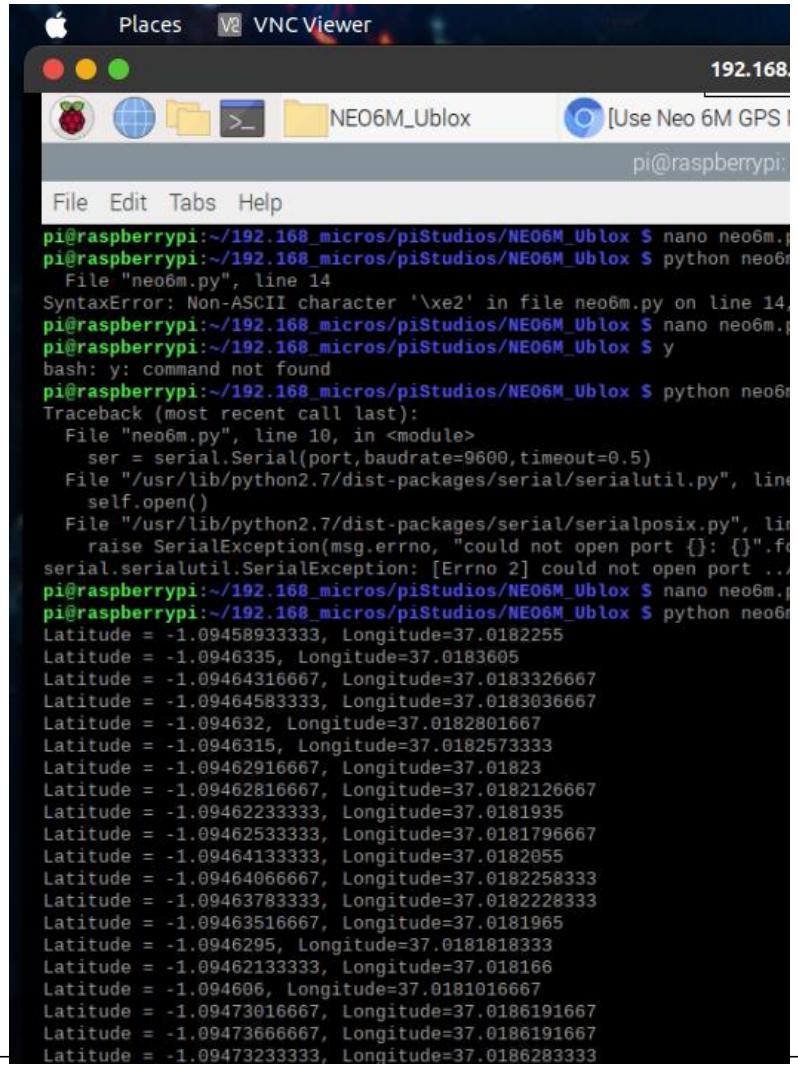




Accuracy assessment for LSAT Estimates

- Still having problems with getting a better reference data

Obtaining GPS Location, Water Temp and Relative Humidity from Sensors.




```
pi@raspi-53 ~/sensors/dht11 $ time sudo ./dht11 -r 10
1, humidity: 44.0 | temperature: 23.0
2, humidity: 43.0 | temperature: 23.0
3, humidity: 44.0 | temperature: 23.0
4, humidity: 44.0 | temperature: 23.0
5, humidity: 43.0 | temperature: 23.0
6, humidity: 43.0 | temperature: 23.0
7, humidity: 43.0 | temperature: 23.0
8, humidity: 43.0 | temperature: 23.0
9, humidity: 43.0 | temperature: 23.0
10, humidity: 43.0 | temperature: 23.0

real    0m11.710s
```

Project Timeline

	June - July	August	Sep	Oct	Nov	Dec
Chl-a	Literature Rev (Restructure)	Data Acquisition Preliminary results	Chl-a spatiotemporal Maps - Done			
LSWT	Literature Rev (Restructure)		LSAT spatiotemporal Maps - Done			
IoT	Literature Rev. Acquire all sensors	Unit tests	Long Range comm.		Full Data Acquisition and Dissemination	

Thank you for your attention! Questions?