Remote sensing for monitoring the water quality of Lake Sevan: FEASIBILITY AND LIMITATIONS

Shushanik Asmaryan
Deputy Director for Science
Head of GIS and remote sensing department
Center for Ecological-Noosphere studies NAS RA

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Overview: remote sensing techniques to assess Lake water quality

- Lake water quality is a key factor for human wellbeing and health.
- In situ measurements are traditionally conducted and widely accepted as instruments for water quality monitoring.
- In many regions, classical monitoring capacities are limited and in case of large water bodies they lack monitoring at the required spatial and temporal scales.

Remote sensing data and products provide synoptic, spatio-temporal views and their integration can lead to a better understanding of lake ecology and water quality.

Remote sensing has great potential for assessing spatio-temporal dynamics of water quality in a cost-effective and informative manner.

Satellite remote sensing data relevant for Lake Sevan and its water quality monitoring

- Landsat (ETM, OLI, TIRS)
- Sentinel (2; 3)
- ...

<table>
<thead>
<tr>
<th>Lake properties</th>
<th>Response variables</th>
<th>Remote sensing indicators</th>
</tr>
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<tbody>
<tr>
<td>Transparency</td>
<td>Turbidity</td>
<td>Colored dissolved organic matter</td>
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<tr>
<td></td>
<td>Secchi Disk Depth</td>
<td>Total suspended solids</td>
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<tr>
<td></td>
<td></td>
<td>Turbidity (NTU)</td>
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<td></td>
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<td>Secchi Disk Depth</td>
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<tr>
<td>Biota</td>
<td>Algae blooms</td>
<td>Chlorophyll-a (phytoplankton)</td>
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<td></td>
<td>Phenology</td>
<td>Phycocyanin (cyanobacteria)</td>
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<td>Hydrology</td>
<td>Water level</td>
<td>Time series analysis of Chl-a</td>
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<tr>
<td>Temperature</td>
<td>Epilimnic temperature</td>
<td>Bathymetry</td>
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<td>Ice phenology</td>
<td>Ice-out</td>
<td>Ice-out; time series analysis</td>
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<tr>
<td></td>
<td>Ice-duration</td>
<td>Ice-duration; time series analysis</td>
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Source: K. Dörnhöfer, N. Oppelt / Ecological Indicators 64 (2016)  
http://dx.doi.org/10.1016/j.ecolind.2015.12.009
Lake Sevan water quality to be assessed and monitored by remote sensing

**eoLytics Water Quality**: a web application allows users to control state-of-the-art satellite data processing within the EOMAP cloud.

**eoAPP**: free visualizer of EOMAP’s water quality products covering selected areas around the globe

Application for Lake Sevan:

- >1000 scenes of Sentinel3 OLCI were downloaded and geoprocessed for Lake Sevan

**Covering period**: 2017-2021

**Remote sensing indicators**:

- Chlorophyll – a
- Harmful Algae Bloom (HAB)

**Validation of the algorithms of Chl-a quantification**

Validation of results (Chl-a) derived from Sentinel 3 via eoLytics tools

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<th></th>
<th>r</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Sevan (BS)</td>
<td>0.576</td>
<td>0.000450 (&gt;0.001)</td>
</tr>
<tr>
<td>Small Sevan (SS)</td>
<td>0.607</td>
<td>0.00180 (&gt;0.001)</td>
</tr>
</tbody>
</table>

in situ measured Chl-a and its correlation with Sentinel 3 derived Chl-a by Python

Number of in situ measurements – 76
Period – per-month 2018-2021 (April –November)

Number of Sentinel 3 scenes - >700
Period – 2017-2021 (April –November)
The seasonal and spatial water quality dynamics in Lake Sevan over 5 years (2017-2021) based on Sentinel 3 OLCI:

a. Chl-a;
b. Harmful algae bloom (HAB)

Encountered problems and limitations

The algorithm of the quantification of Chl-a in water does not catch the high values!!!

HAB indicator works well and still reliable for qualitative assessment!!!

The problem stems from atmospheric correction, which cannot be fully performed for Sentinel-3 but can be done for Sentinel-2

Open source algorithm developed for Sentinel-2 in Google Earth Engine (GEE) platform
Currently

*Play with data - Making experimental visual assessment based on RGB imagery, SDD and HAB indicator, which enables to catch the bloom period...*

Conclusions

- There are methodological *limitations*, in particular the spatial and temporal scarcity of the in-situ monitoring needed to enhance the validation results of remote sensing algorithms developed for quantification of Chl-a and other qualitative parameters.
- However, the outcomes of HAB algorithm are reliable and in conjunction with Chl-a, SDD and the RGB remote sensing data shows the water bloom.

**Hence, at this stage we confirm that Sentinel-3 OLCI daily scenes and the EOAPP processing platform are feasible to detect the algae bloom period (based on HAB indicator) and so, envisaged these technologies to be included in the further monitoring system of Lake Sevan.**

Thank you

**SHUSHANIK ASMARYAN**

Deputy Director for Science
Head of GIS and remote sensing department

Center for Ecological-Noosphere studies NAS RA
E-mail: shushanik.asmaryan@cens.am; info@cens.am