Monitoring Water Quality Using Satellite Image Processing

Africa Flores (SERVIR Global) and Amita Mehta

5, 12, and 19 September 2018
Course Outline

**September 5**
Overview and Analysis of NASA Remote Sensing Data for HAB Monitoring

**September 12**
Introduction to SeaDAS for Image Processing and Data Analysis

**September 19**
Image Analysis Exercise Using SeaDAS
Learn More About ARSET

http://arset.gsfc.nasa.gov/
Outline for Week 3

• Overview of Image Processing
• Ocean Color Science Software (OCSSW)
• Demonstration: Analysis of Landsat-8 OLI Image Using SeaDAS/OCSSW
• Convert L-1 data to atmospherically corrected L-2 data
  – Focus: Lake Victoria
• Demonstration: Using Landsat-8 OLI Band Reflectance and In Situ Data for Algorithm Development
  – Focus: Gulf of Mexico
• Summary
Overview of Image Processing: Ocean Color Science Software (OCSSW)

Acknowledgement: Daniel Knowles (Daniel.s.Knowles@nasa.gov)
Ocean Biology Processing Group
Installation of OCSSW

- OCSSW can be installed or updated for various sensors
- GUI Configuration
  - Automated or...
    - Edit
      ```
      ${SEADAS_HOME}/config/seadas.config.seadas.ocssw.root = [OCSSW_root_dir]
      ```
- Command Line Configuration
  - User needs to set
  - Edit ".bashrc" (or equivalent) home file:
    ```
    export OCSSWROOT=${SEADAS_HOME}/ocssw
    source $OCSSWROOT/OCSSW_bash.env
    ```
- Processor failure will occur if mission not installed
  (and log message may not identify problem)

**Note:** For OLCI-S3A currently command line only available
To install: install_ocssw.py -i
  
  ```
  ${OCSSWROOT}-b v7.4 --olci
  ```
OCSSW Processing Options

- Level-1: Browser and Map Generator
- Level-2: Browser and Map Generator
- Level-1 to Level-2 Generator
- Get Ancillary Data for Atmospheric Correction
- Geo-location and Calibration [for MODIS and VIIRS only]
- Extractors: Spatial and By Products
- Level-2 Binning For Level-3
- Level-3 Binning from multiple Level-3 files
- Level-3 Map Generator
- Level-3 Metadata Dump
- Multi-Level processing
Demonstration: Convert Landsat 8 (OLI) L-1 Data to Atmospherically Corrected L-2 Data
Demonstration: Assessing MODIS L2 data with In Situ Data - Use of custom algorithms to derive Chl-a
Summary
Current Satellite Missions for Water Quality Monitoring

- Landsat 7 (4/15/1999 – present)
- Landsat 8 (2/1/2013 – present)
- Terra (12/18/1999 – present)
- Sentinel-2A (6/23/2015 - present)
- Sentinel-2B (3/7/2017 – present)
- Sentinel-3A (2/16/2016 – present)
## Satellites and Sensors for Monitoring Water Quality

<table>
<thead>
<tr>
<th>Satellites</th>
<th>Sensors</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat 7</td>
<td>Enhanced Thematic Mapper (ETM+)</td>
<td>185 km swath; 15 m, 30 m, 60 m; 16 day revisit</td>
</tr>
<tr>
<td>Landsat 8</td>
<td>Operational Land Imager (OLI)</td>
<td>185 km swath; 15 m, 30 m, 60 m; 16 day revisit</td>
</tr>
<tr>
<td>Terra &amp; Aqua</td>
<td>MODe rate Resolution Imaging Spectroradiometer (MODIS)</td>
<td>2330 km swath; 250 m, 500 m, 1 km; 1-2 day revisit</td>
</tr>
<tr>
<td>Suomi NPP &amp; Joint Polar Satellite System</td>
<td>Visible Infrared Imaging Radiometer Suite (VIIRS)</td>
<td>3040 km swath; 375 m - 750 m; 1-2 day revisit</td>
</tr>
<tr>
<td>Sentinel 2A and 2B</td>
<td>Multi Spectral Imager (MSI)</td>
<td>290 km swath; 10 m, 20 m, 60 m; 5 day revisit</td>
</tr>
<tr>
<td>Sentinel 3A</td>
<td>Ocean and Land Color Instrument (OLCI)</td>
<td>1270 km swath; 300 m; 27 day revisit</td>
</tr>
</tbody>
</table>

Reference
NASA Water Quality Data and Tools

Data Available from MODIS and VIIRS:
• Chlorophyll Concentration
• Sea Surface Temperature
• Particulate Organic Carbon
• Particulate Inorganic Carbon
• Inherent Optical Properties

Data Access Tools:
• Ocean Color Web: https://oceancolor.gsfc.nasa.gov/
• Giovanni: https://giovanni.gsfc.nasa.gov/giovanni/

Data Processing Software:
• SeaDAS: https://seadas.gsfc.nasa.gov/
Water Quality Parameters from Remote Sensing Observations

Quantitative Technique

Algorithms use optical, NIR, IR, and MW remote sensing observations for quantitative water quality monitoring in lakes, estuaries, and coastal oceans.

See a review in Golizadeh et al., 2016 and references included in the review.

Challenges in Monitoring Water Quality (WQ)

- For accurate and quantitative WQ monitoring analysis of spatially and temporally co-located, in situ measurements and satellite observations are required.
- Feasibility of WQ monitoring in coastal and inland water bodies depends on spatial, temporal, and spectral resolutions of remote sensing observations.
- Difficult to separate WQ parameters when sediments, dissolved matter, and Chl-a all are present.
- It is not possible to characterize algal types or toxins only from remote sensing observations.
- Remote sensing reflectance has to be corrected to account for contributions from atmospheric constituents such as aerosols.
- Optical remote sensing observations cannot view the surface in the presence of clouds.
Operational Water Quality Monitoring

• Combination of data from multiple satellites is useful for monitoring water quality
• Monitoring water quality in inland lakes depends on the size of lakes
  – Landsat can monitor close to 170,240 lakes globally
  – MODIS/OLCI would resolve ~1,862 lakes globally [Wilson Salls, EPA]
• Examples of remote sensing-based regional water quality monitoring:
  – Cyanobacteria Assessment Network (CyAN)
  – Lake Erie HAB Tracker
  – NOAA Coast Watch
  – Copernicus Marine Environment Monitoring Service
  – Near Real-Time Algal Bloom Monitoring Services in the North Atlantic
  – All of these tools are discussed in the ARSET Training Introduction to Remote Sensing for Harmful Algal Blooms
Thank You