Eutrophication detecting using Sentinel 2A, Sentinel 3 and HJ data

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Introduction

Algal blooms is one of the most critical phenomenon in inland waters, and it has been triggered in in several entrophicated lakes, such as Taihu Lake, Dianchi Lake and Erhai Lake in China. Algal bloom detecting result could be used as a key parameter in water quality monitoring, combing the results of all water optical sensitive parameters such as Chl_a, Suspended sediments and CDOM.

The practical is formed of two exercises related to water quality remote sensing.

Exercise 1 outlines the steps that will be taken in detecting algal blooms in inland lakes using remote sensing data including Multispectral Imager (MSI) of Sentinel-2A, Operational Land Imager (OLI) of Landsat 8 and Chinese CCD of HJ-1A/B. In this exercise, students will be familiarized with SNAP and sentinel-2 Tool Box. For long term imagery comperation, the batch processing included in SNAP and data analysis and mapping in QGIS will be included in this exercise as a glance.

Exercise 2 is on the objects to familiarize students with the atmospheric correction and water quality parameter detection toolbox for ESA EO data, including MSI (Sentinel-2A), OLCI (Sentinel-3). This exercise will guide the students through the procedures of installing C2RCC plugin, producing OLCI ocean color data for performing atmospheric corrections and water quality parameter detection.

Software involved in this exercise are free and open source, with no license restrictions, for researcher who is specificities in coastal and inland waters.

Useful links for Software and environment settings

1. **SNAP** and Sentinel-2, Sentinel-3 Tool Box. **Version 6.0 Prev5**

   http://step.esa.int/main/download/

2. **QGIS:** http://www.qgis.org/en/site/forusers/download.html

3. **Sen2Cor:** Sentinel2 L2 processor for atmospheric correction plugins

   http://step.esa.int/main/third-party-plugins-2/sen2cor/

   Sen2Cor Configuration and User Manual

   http://step.esa.int/thirdparties/sen2cor/2.4.0/Sen2Cor_240_Documenation_PDF/S2-PDGS-MPC-L2A-SUM-V2.4.0.pdf

4. Sen2Cor environmental setting software:

   Maven3: https://maven.apache.org/download.cgi

   Anaconda: https://anaconda.org/anaconda/python

5. **C2CRR**: Ocean color plugins (only need if SNAP V6.0 can't be installed successfully)

   https://github.com/bcdev/s3tbx-c2rcc

Study areas and Datasets

Erhai Lake, the second largest fresh water lake in the Yunnan province of China which has an inundation area of 251.3 km^2.

The shape of Erhai Lake looks like with an ear with the North-South length of the lake is 40 kilometres and the East-West width is roughly 7–8 kilometres.

Data involved:

1. **Sentinel_2A MSI Level_1C data:**
   1) S2A_MSIL1C_20161211T035142_N0204_R104_T47RPJ_20161211T035337.SAFE
   2) S2A _20161104_resample.dim
   3) S2A _20161204_resample.dim

2. **Sentinel-3 OCLI Level_1 data:**
   /S3A_OL_1_EFR____20161205T031956_20161205T032256_20161205T051940_0179_011_346_2520_SVL_O_NR_002.SEN3/xfdumanifest

3. **HJ-1A Level_1B data**
   HJ1A-CCD1-17-84-20161204-L2. Tiff

4. **Landsat 8 OCL Level_1B data:**
   LC81310432016309.tiff

5. **HAB results:**
   20161204-hj.tiff
   20161206-lc8.tiff
   20161211-s2.tiff

[HJ-1A and Landsat 8 OCL data download from website should be converted into geotiff when you use SNAP to process]

Exercise 1: Algal Blooms Detection

1. Pre-Processing of MSI Level_1B data

1.1 Crop

1.1.1 Open file : /S2A_MSIL1C_20161211T035142_N0204_R104_T47RPJ_20161211T035337.SAFE

1.1.2 Resampling at 10m

1.1.3 Crop study area

- ✓ Select: Raster/Subset
- ✓ Specify：Spatial Subset parameters/Geo Coordinates

  North latitude bound: 26.1
  West latitude bound: 100
  South latitude bound: 25.5
  East latitude bound: 100.4

1.2 View Ocean Color bands

1.2.1 Open subset file

1.2.2 View “Water” bands image

- ✓ Open the Near-inferred band (band 8) and SWIR band (band11) image.

1.2.3 View RGB image

- ✓ Open virtual colors combination image, Leave default MSI Natural colors and open it
- ✓ Change Red band to B7, Green band to B3, Blue band to B1, open the RGB combination image.
- ✓ Open the RGB image with band composite of R(11)G(8)B(4)

1.2.4 View Spectrum of Algal bloom water and Normal water

- ✓ Use Pin tools to select interested pixels
- ✓ Select: Optical/Spectrum View
- ✓ Change the color of each Pins, Select: Tool bars/Pin manager
- ✓ Check the Spectral radiation variation at different bands

2. Algal Index calculation in SNAP, including Sentinel-2A MSI, HJ-1A CCD and Landsat 8 OCL

2.1 FAI

- ✓ Select: Raster/band math
- ✓ Name the band as FAI
- ✓ Edit Expression as: (B8-B4)+(Band4-Band11)*0.1873

2.2 VB-FAH

- ✓ Select: Raster/band math
- ✓ Name the band as VB-FAH
- ✓ Edit Expression as: (B8-B3)+(Band3-Band4)*0.6144

2.3 Batch processing

2.3.1 Graph Producing

- ✓ Select: Graph Builder in tool bars
- ✓ Make a processing chain including:
  Resample --Subset--Band math for FAI&VB-FAH—Band merge
- ✓ Save the Graph as: mygraph_algalbloom.xml

2.3.2 Batch processing

- ✓ Rename the input data
- ✓ Select: Batch processing in tool bars
- ✓ Add the following scenes as input:
  S2A _20161104_resample.dim
  S2A _20161204_resample.dim

3. Long term Algal bloom risk analysis

3.1 Water and Cloud masks (take water mask as an example)

- ✓ Select: Optical/Preprocessing/Masking/IdePix/Sentinel-2 MSI
- ✓ Open FAI image in new product
- ✓ Select Mask Manager/lc_land
- ✓ Transparency: 0; Color: Gray
- ✓ Open lc_land image, save as lc_land.geotiff

3.2 Make you own water sharp vector in QGIS

- ✓ Open lc_land.geotiff in QGIS
- ✓ Use Raster to Vector conversion tools in QIS to get the water sharp file：
  QGIS/Raster/Conversion/Polygonize (Raster to Vector)
- ✓ Subset all Algal bloom images by shp files in QGIS

[Question] Is it necessary to apply 3.1&3.2 to each remote sensing images? Why?

3.3 Multi-sensors comparison between MSI, HJ-1A & Landsat OCL

- ✓ Apply step 1.1.4 and 2.1 to HJ-1A and Landsat OCL images

[Question] Which bands can be used for HJ-1A and Landsat OCL algal bloom index calculation?

- ✓ Select “Scatter Plot” in tool barCompare the following two pairs of results:
  Dec. 04 2016 HJ-1A VS. MSI
  Nov. 04 2016 Landsat VS. MSI

[Question] What is the difference between results from MSI, HJ-1A and Landsat OCL algal bloom detection results? Why?

3.4 Time series data analysis

- ✓ Import all the algal bloom detection images into QGIS
- ✓ Setup Layer Properties/style/ for each images
  Band render type: singleband pseudocolor
  Interpolation: Linear
  Label and color:
  VB_FAH <-HAB no algal blooms
  -HAB~0 level 1
  0~HAB level 2
  HAB~2*HAB level 3
  HAB=0.025 in this example
- ✓ Compare the spatial and temporal variations

Exercise 2: Water Quality Retrieval

1. Install C2RCC

C2RCC is a processor for retrieving water constituents in coastal and inland zones. The newest version of C2RCC supports MERIS, S2-MSI ,S3 OLCI ,Landsat-8 OLI ,MODIS and several sensors.

The latest C2RCC is integrated in SNAP 6.0 Pre5. If you are using SNAP 6.0 Pre5, there is no need to install C2RCC. Otherwise, to install C2RCC you should following steps on: https://github.com/bcdev/s3tbx-c2rcc

2. Water quality retrieval

2.1 Open the file

- ✓ Select: Optical/Thematic Water Processing/C2RCC
- ✓ Select I/O Parameters choose the Source product:

/S3A_OL_1_EFR____20161205T031956_20161205T032256_20161205T051940_0179_011_346_2520_SVL_O_NR_002.SEN3/xfdumanifest

2.2 Parameters setting

2.2.1 Auxiliary data modify

- ✓ Salinity 35 PSU (for inland waters)
- ✓ Temperature: 17.1 C

  Daily meteorological data could be download from：

  http://data.cma.cn/
- ✓ Ozone and Air pressure data could be download from:

  https://oceandata.sci.gsfc.nasa.gov/Ancillary/Meteorological/2016/
- ✓ Elevation: 1924m

2.2.2 Inherent optical parameters modify

Keep IOPs as default

2.2.3 Atmospheric correction parameters modify

Keep AC parameter as default

2.2.4 Run

2.3 Export results

2.3.1 Reprojection

2.3.2 Subset

2.3.3 Open multi or single band images

Click the right mouse botton/export view as image/full scence/save as geotiff image

[Question] Why we subset images after atmospheric correction and water quality retrieval?

Tips:

Which bands are used for FAI&VB_FAH calculation?

HJ-1A:

VB_FAH=(band4-band2)+[(band2-band3)*(830-560)]/(2*830-560-660)

Landsat:

VB_FAH=(band5-band3)+[(band3-band4)*(864.6-560)]/(2*830-560-654.6)

FAI=(band5-band4)+[(band4-band3)*(864.6-654.6)]/(1609-654.6)

Reference:

[1]. Qianguo Xing, Chuanmin Hu, 2016, Mapping macroalgal blooms in the Yellow Sea and East China Sea using HJ-1 and Landsat data: Application of a virtual baseline reflectance height technique, Remote Sensing of Environment, 178:113-126

[2]. Hu Chuanmin, 2009, A novel ocean color index to detect floating algae in the global oceans, Remote Sensing of Environment 113:2118-2129

[3]. Brockmann, Carsten; Doerffer, Roland; Peters, Marco; Kerstin, Stelzer; Embacher, Sabine; Ruescas, Ana, 2016, Evolution of the c2rcc neural network for sentinel 2 and 3 for the retrieval of ocean colour products in normal and extreme optically complex waters, Living Planet Symposium, Proceedings of the conference held 9-13 May 2016 in Prague, Czech Republic. Edited by L. Ouwehand. ESA-SP Volume 740, ISBN: 978-92-9221-305-3, p.54

[4]. Introduction about HJ-1A/B/C. http://cresda.com/EN/satellite/7117.shtml