Ocean Color – Simultaneous Marine and Aerosol Retrieval Tool (OC-SMART)

User Guide (Python)

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1. Setup Python environment

We recommend setup the Python environment using Miniconda.

1.1 Install Miniconda. You may download Miniconda from https://docs.conda.io/en/latest/miniconda.html

1.2 If you would like to create a new conda environment, use command:

conda create -n <envname>

and then activate this environment use command:

conda activate <envname>

1.3 Setup Python version and install dependencies use following command:

conda install python=3.11.4

conda install numpy gdal scipy h5py netcdf4 urllib3 glob2 lxml requests

conda install -c conda-forge pyhdf pyproj

(Note: if conda report conflicts, please try: pip install pyhdf pyproj)

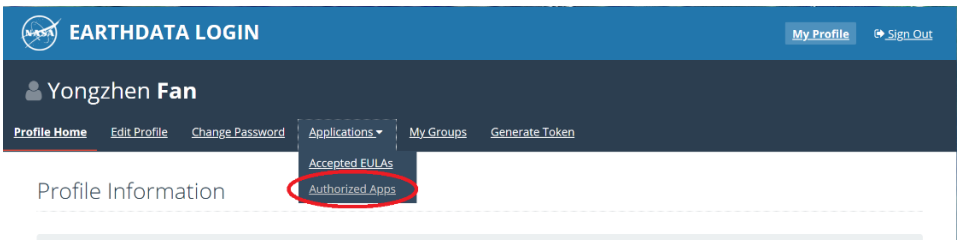
conda install -c swordman51 l8angles

2. Ancillary data downloading

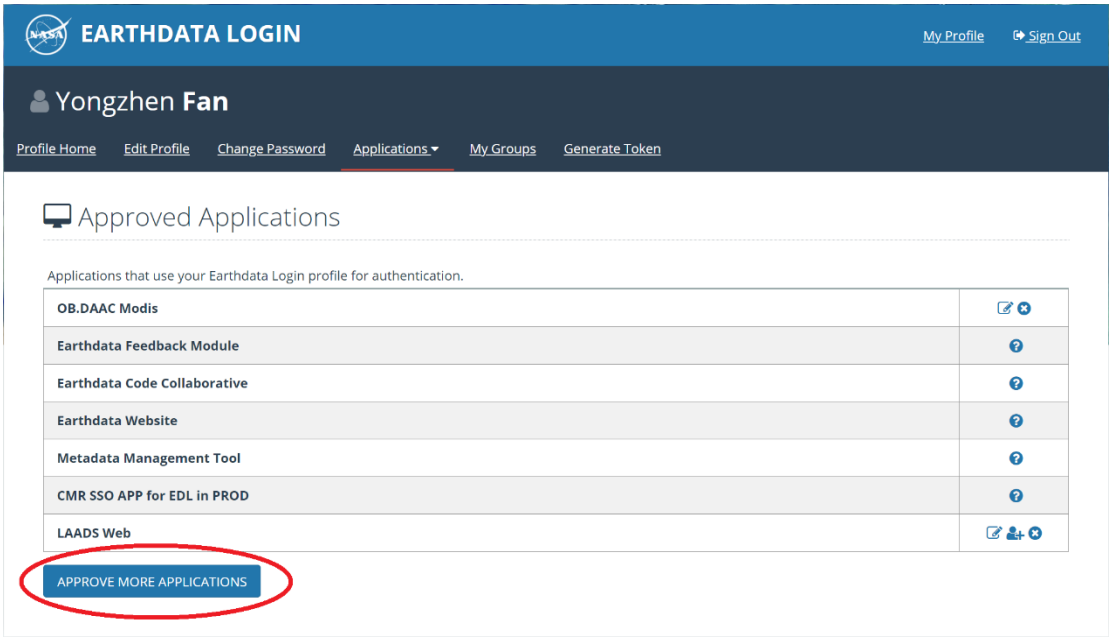
OC-SMART needs to download ancillary data from NASA OB.DAAC, the user must have an account on earthdata.nasa.gov and approve the application to download ancillary data.

2.1 If you don't have an account on Earthdata please go to https://urs.earthdata.nasa.gov/, click "Register" and follow the instruction to create your account.

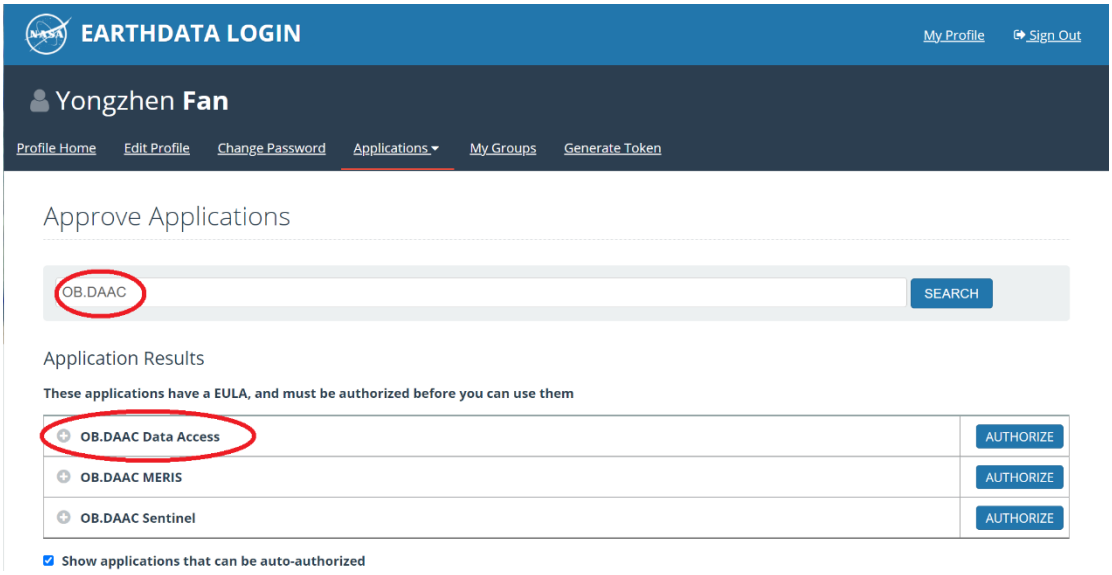
2.2 Login to your Earthdata account, click "Applications->Authorized Apps",



on the next page, click "Approve more Applications" at the bottom,



then search for "*OB.DAAC*" and check "Show applications that can be auto-authorized", then click "Authorize" on "*OB.DAAC Data Access*".



2.3 set up automatic authentication for data downloading

1) In OC-SMART package, locate the files "*.netrc*" and "*.urs_cookies*" in the '*DataDownloadAuthentication*' directory.
2) Replace 'USERNAME' and 'PASSWORD' in the "*.netrc*" and "*.urs_cookies*" file with your own Earthdata login credentials.
3) Copy the "*.netrc*" and "*.urs_cookies*" file to your home directory, i.e. /home/<*user account*>
4) Open terminal, go to your home directory and run command:

chmod 0600 ~/.netrc

3. How to run OC-SMART

3.1 System memory requirement

We recommend a minimum of 16GB of physical system memory to run OC-SMART, 64GB is recommended for best performance on larger images, such as GOCI, Landsat-8, Sentinel-2 and Sentinel-3. If physical memory is limited on your system, please increase the size of the virtual memory, i.e., the swap file, to 64GB.

3.2 Run OC-SMART

After downloading and unzip OC-SMART, you may run OC-SMART in command line or using a Python IDE, such as Spyder.

To run OC-SMART in command line, open terminal and navigate to the OC-SMART directory then run command:

python OCSMART.py

To run OC-SMART in a Python IDE, such as Spyder, open OCSMART.py in the IDE then click run.

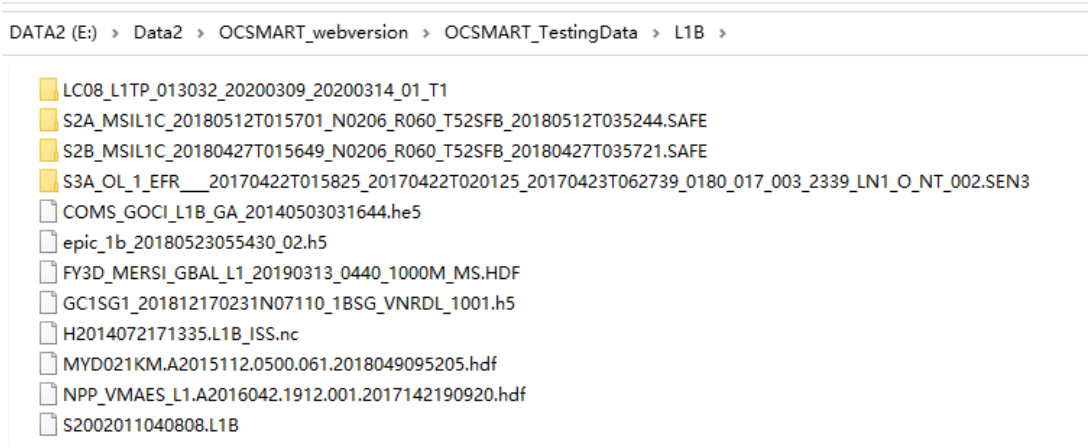
3.3 Supported sensor

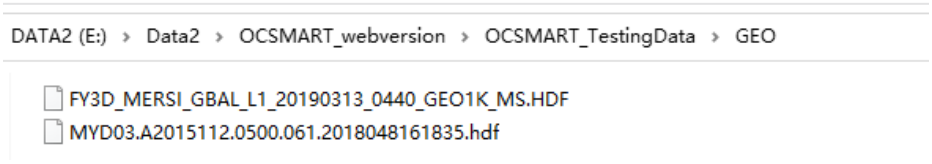
SeaWiFS, MODIS (Aqua and Terra), VIIRS (SNPP), GOCI (COMS), SGLI (GCOM-C), OLCI (Sentinel-3A/3B), MSI (Sentinel-2A and Sentinel-2B), EPCI (DSCOVR), MERSI-II (FY-3D), HICO (ISS), OLI (Landsat-8), OLI2 (Landsat-9), OCI (PACE, simulation).

3.4 Input data files

OC-SMART requires the level-1B(L1B) satellite reflectance data and the associated geolocation file as input. L1B data file for SeaWiFS can be acquired by processing the L1A data using NASA SeaDAS software.

The L1B satellite reflectance data file from all supported sensors can be located in a common directory. Some sensors, like MODIS and FY-3D MERSI-II have separated geolocation files, which MUST be located in a different directory. An example of the L1B and GEO directory may look like:





3.5 Input parameter setup

The input parameters of OC-SMART can be set in the file *OCSMART_Input.txt*.

3.5.1 The following example will process the entire satellite image:

l1b_path = ./L1B/	Directory where L1b data is located
geo_path = ./GEO/	Directory where geolocation data is located
l2_path = ./L2/	Directory where L2 output data will be located
l2_prod = aod, rrs, chl	List of L2 products (see section 3.5.2 for details)
solz_limit = 70.0	Maximum solar zenith angle (must be <=70)
senz_limit = 70.0	Maximum sensor viewing angle (must be <=70)

3.5.2 Supported Level 2 products

The following key words (case sensitive) are the supported level 2 products by OC-SMART:

aod	Aerosol Optical Depth at all wavelengths.
rrs	Normalized Remote Sensing Reflectance at all wavelengths.
chl	Chlorophyll_a concentration from the OCi and YOC algorithms.
tsm	Total Suspended Matter from the YOC algorithm.
aph	Chlorophyll_a absorption at all wavelengths from the MLNN algorithm.
adg	Absorption by detritus and gelbstoff at all wavelengths from the MLNN algorithm.
bbp	Particulate backscattering at all wavelengths from the MLNN algorithm.
at	Total absorption by water constituents at all wavelengths from the MLNN algorithm.
bt	Total scattering by water constituents at all wavelengths from the MLNN

algorithm.

Lt Total reflectance at the top of the atmosphere for all wavelengths.

Lrc Rayleigh corrected reflectance at the top of the atmosphere for all wavelengths.

Lr Rayleigh reflectance for all wavelengths.

3.5.3 Sub-image processing

There are 3 options to define a sub-image in OC-SMART. Your need to add following parameters for each option.

a) Define sub-image using a range of latitude and longitude. OC-MART will extract the sub-image defined by the north-west and south-east corner. To use this option, add following parameters in *OCSMART_Input.txt*

north = <*max latitude*>
south = <*min latitude*>
east = <*max longitude*>
west = < *min longitude* >

Note: use negative values for latitude in southern hemisphere and longitude in western hemisphere.

b) Define sub-image using center latitude/longitude and the size of a box. OC-SMART will find the pixel that is closest to the input center latitude/longitude and extract a sub-image in the same size as user defined. To use this option, add following parameters in *OCSMART_Input.txt*

latitude_center= <*latitude*>
longitude _center = < *longitude* >
box_width = <*number of pixels*>
box_height = < *number of scanlines* >

NOTE: i) use negative values for latitude in southern hemisphere and longitude in western hemisphere. ii) *number of pixels* and *number of scanlines* should be an odd number, if even numbers are given, the size of the output is (*number of pixels*+1) by (*number of scanlines*+1). iii) if the input center latitude/longitude is very close to the edge of the satellite image, OC-SMART only extract the part of the sub-image that is overlapped with the satellite image.

c) Define sub-image with range of the scanline and pixel number. To use this option, add following parameters in *OCSMART_Input.txt*

start_line = <start scanline number>
end_line = < end scanline number >
start_pixel = < start pixel number >
end_pixel = < end pixel number >

Note: i) input scanline and pixel number should be ZERO based. ii) This option can be used to process whole image in blocks if system memory is limited.

3.6 Output file

OC-SMART output level-2 (L2) product in HDF5 format. The output is compatible with NASA SeaDAS and ESA SNAP for visualization, and can be read by other software that support HDF5 format, such as Matlab, HDFView, Python, etc.

3.6.1 The L2 product include:

- Spectral aerosol optical depth (AOD)
- Spectral normalized remote sensing reflectance (Rrs)
- Spectral total absorption by particulates and CDOM in water (at)
- Spectral total scattering by particulates in water (bt)
- Spectral absorption by Phytoplankton (aph)
- Spectral absorption by detritus and gelbstoff (adg)
- Spectral backscattering by particulates (bbp)
- Chlorophyll_a concentration by NASA OCi algorithm (chlor_a(oci))
- Chlorophyll_a concentration by YOC algorithm (chlor_a(YOC))
- Total suspended matter by YOC algorithm (tsm(YOC))
- Solar zenith angle, sensor zenith angle and relative azimuth angle
- Latitude and Longitude
- L2_flags

3.6.2 L2_flags

- 0: Valid pixel
- 1: Satellite L1 reflectance unavailable (i.e., saturation or missing values)
- 4: Solar or sensor viewing angle out of range
- 16: Land
- 64: Cloud
- 256: Rayleigh corrected reflectance (Lrc) out of scope
- 1024: negative Rayleigh corrected reflectance (Lrc)

3.7 clean temporary files

OC-SMART will save ancillary files to your local drive, if storage space is limited, manually delete the ancillary files located in **./anc/** and **./ landmask_gsw/**.

4. Referencing

When acknowledging the use of OC-SMART for scientific papers, reports etc. please cite the following reference:

Fan, Y., Li, W., Chen, N., Ahn, J., Park, Y., Kratzer, S., Schroeder, T., Ishizaka, J., Chang, R, and Stamnes, K., (2020) "OC-SMART: A machine learning based data analysis platform for satellite ocean color sensors", Remote Sens. of Environ., Vol. 253, p11236, DOI: 10.1016/j.rse.2020.112236.

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