# Time series of IOPs in SE Asia

## Contents



# 1 Introduction

This tutorial applies the methods described in https://wimsoft.com/Course/3/Time_series_SE_Asia.pdf to ESA-CCI Inherent Optical Properties (IOP) data.

The software used in this tutorial is WIM/WAM that can be downloaded from *https://wimsoft.com/Course/wam64.msi* (install using option *Typical*; run WIM, enter the license number is 9999591398). The software runs under Windows 10.

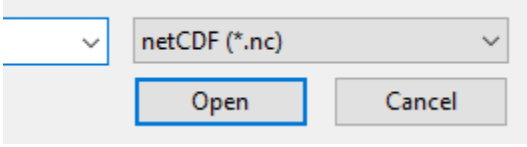
# 2 Data source

We are using ESA-CCI (Climate Change Initiative) monthly IOP data (version 6.0). Use an FTP client (e.g. Filezilla) to connect to ftp://oceancolour.org and navigate to

/occci-v6.0/geographic/netcdf/monthly/iop

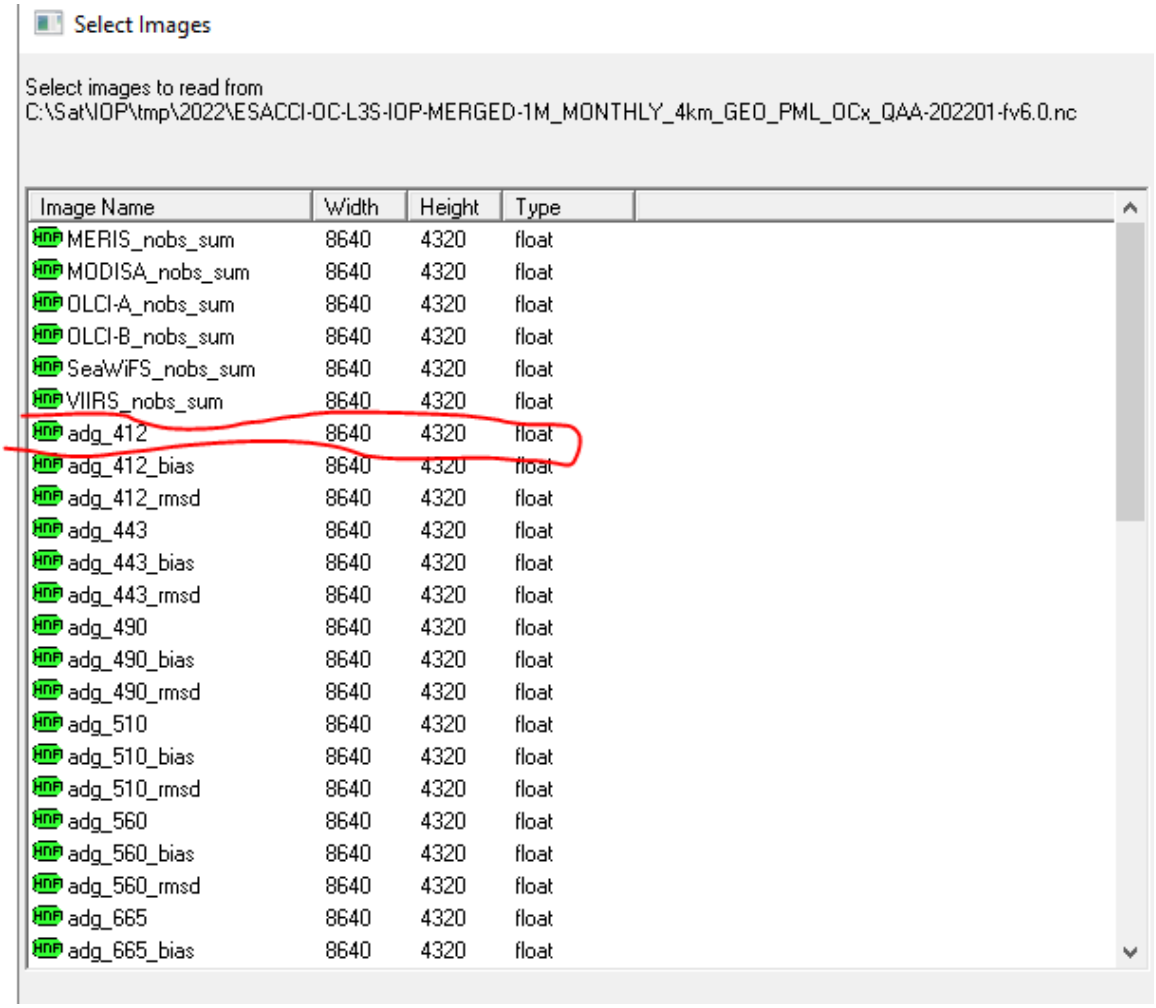
Make a new folder like *C:\Sat\IOP\tmp* and download the data files from selected years to this folder. Here we download just one year (2022) and get 12 monthly *.nc* files in folder *C:\Sat\IOP\tmp\2022*.

The files are about 2.5 GB in size and contain many datasets. You can look at the contents by opening a sample file with WIM. Remember to open the *.nc* file **as netCDF**. Set the **netCDF** option at bottom right:




You should make a connection between *.nc* files and WIM, so that you can just click (or double-click) on a *.nc* file in Windows and the file would open in WIM.

Confirm that you have a long list of individual datasets in the IOP file:




Here we are going to use just one dataset, *adg412*. To conserve disk space and speed up processing, we extract just *adg412* and can later discard the original 2.5 GB *.nc* files. You can extract *adg_412* using the provided batch file *extract.bat*.

```
cd Sat\IOP

extract.bat
```

The main command in the batch file is:

```
wam_extract_sds %FROMDIR%\%YEAR%\ESACCI*.nc adg_412
```

Here *%FROMDIR%\%YEAR%* is the directory where the *.nc* files are. *%YEAR%* is, of course, the year, as 2022. The batch file makes a folder *Monthly\adg_412* and moves the monthly global *adg_412* datasets to this folder. These files are in HDF4 format (*.hdf*) and can be opened in WIM as **HDF4** files. Again, you can open these files by just clicking (double-clicking) on the file in Windows after you have made a connection between *.hdf* files and WIM. The size of the extracted global *adg_412* files is about 50 MB which is still quite large. If you don't need global data and are interested only in a small sub-area, you can extract a smaller area by remapping to a regional map. Here we remap those global datasets to our SE Asia map *sea10.hdf* that was used

earlier in https://wimsoft.com/Course/3/Time_series_SE_Asia.pdf. You can do the remapping using a batch file *remap.bat*.

```
cd Sat\IOP

remap.bat
```

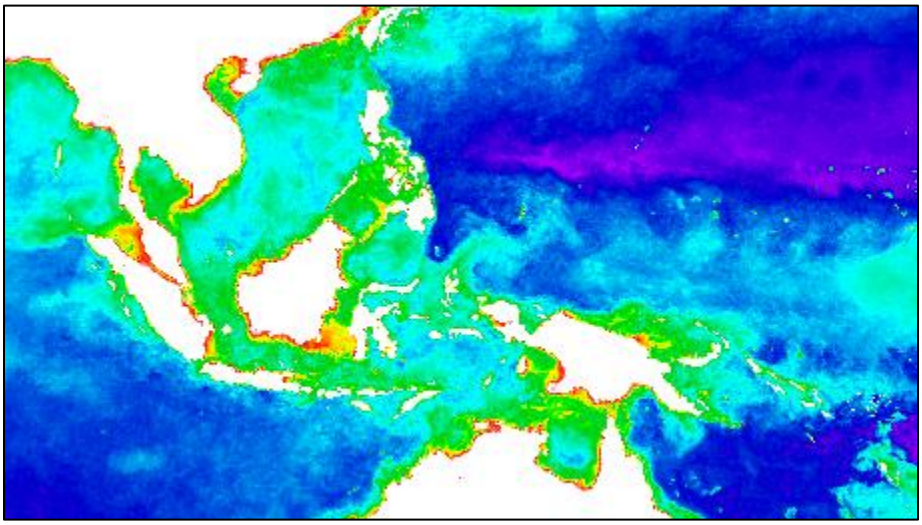
The main command in the batch file is:

```
wam_remap2 Monthly\adg_412\ESACCI-*.hdf  %MAP%  convert=logMinus4 colorFrom=90 colorTo=255
```

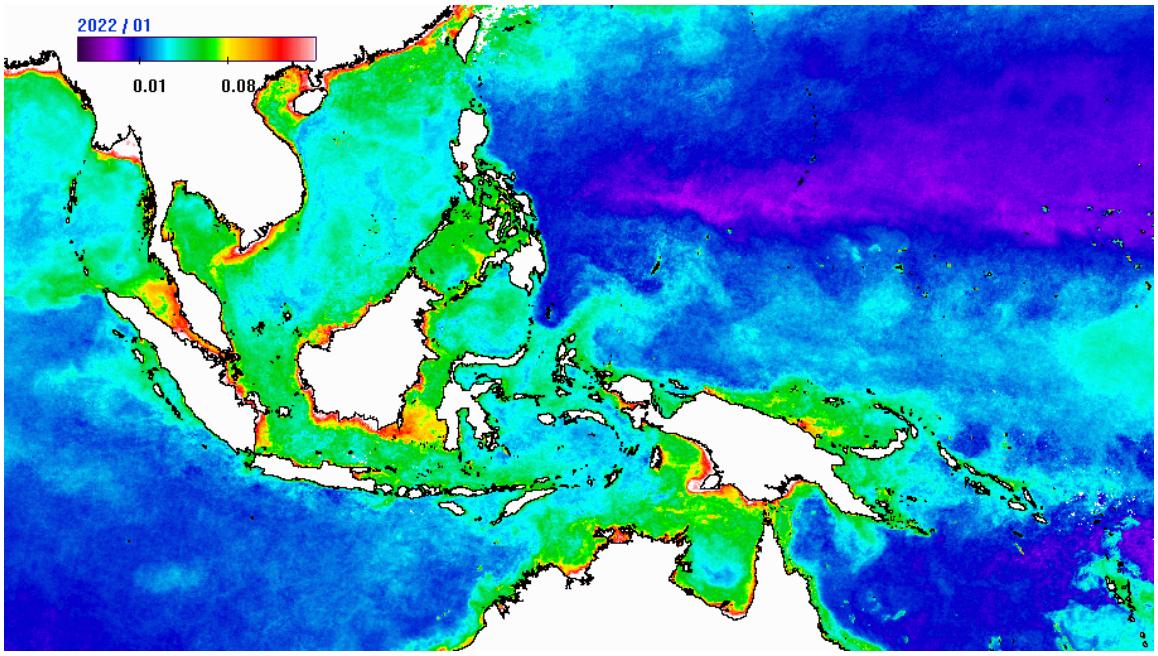
Make sure that the target map file (*%MAP%*) is defined and exists. Check and, if needed, edit the batch file *remap.bat*. In my case, I have defined the target map as:

```
set MAP=maps\sea10.hdf
```

The batch file makes a folder *Monthly\adg_412_sea10* and moves the regional mapped *adg_412* datasets to this folder. It also converts the *float32* pixels into log-scaled *byte* pixels and sets the color scaling in pixel values 90 to 255 that correspond to real values of 0.0023 to 0.66 $m^{-1}$. A sample monthly image file looks like this:



You can make an overlay image with dark coastlines and a color bar and overlay that on top of each image. I have made and overlay *C:\Sat\IOP\maps\ sea10_adg90-255.hdf* and a batch file for making the overlaid images *overlay.bat*. After you run overlay.bat you will get PNG images like for each of the matching HDF file. You can also make a GIF animation using the PNG images to show the annual cycle from January to December of 2022 (below). I used the Babarosa Gif Animator to make the animation but there are many other tools like that.




# *3* Extracting pixel statistics corresponding to a list of stations with *wam_match_nearest*

Assuming that we have a list of stations with measurements and we want to extract pixel values corresponding to our stations. The station list has to be a CSV file with columns: *Longitude, Latitude, Date, Time*, etc. Note the order! In this case we have Level-3 monthly composites and station time is not relevant in finding a match-up closest in time but for consistency with Level-2 match-ups we still need a time entry (it can be anything, e.g., 12:00). A sample station list is like that:

| Longitude | Latitude | DateUTC | TimeUTC | Location | Salinity | temperature |
|---|---|---|---|---|---|---|
| 103.8481 | 1.216 | 1/25/2022 | 11:00 | StJohns | 31.08 | 28.05 |
| 103.7398 | 1.159 | 1/25/2022 | 13:00 | Raffles | 31.11 | 28.15 |

You can create the list in Excel and save as a CSV file *station_list_mk.csv*.

Note that Excel has automatically changed the *Date* into the US format MM/DD/YYYY. I think that my software works also if the format is YYYY/MM/DD (need to test!). Note that the current station list has only *Salinity* and *temperature*, i.e. no measured CDOM. That means that we cannot actually "validate" the satellite data before we add CDOM data but we can extract the match-ups anyway and add CDOM later. We can evaluate the relationship between *Salinity* and *adg_412* (absorption of detritus and CDOM at 412 nm). We will use *wam_match_nearest* to find the match-ups nearest in time.

```
cd Sat\IOP

wam_match_nearest station_list_mk.csv Monthly\adg_412_sea10\*.hdf
```

The command found 24 match-ups and saved them in *station_list_mk_adg.csv*. These match-ups were made from remapped files that were also scaled with log scaling to make better visualizations. For more accurate match-ups we should find them from the original global files. In order keep the file *station_list_mk_adg.csv* that we just made, we rename it to *station_list_mk_adg_from_sea10.csv*. We run the command with the global files:

```
wam_match_nearest station_list_mk.csv Monthly\adg_412\*.hdf
```

This is taking more time as the image files are bigger but it found again 24 match-ups and saved them in *station_list_mk_adg.csv*. Note that using monthly satellite datasets can only give us some useful information if the variable does not change much at shorter time scales. For real match-up analysis we should be using daily or at least 5-day composited images and then set the maximum time difference, e.g., MaxDiffDays=5. There are many other options in wam_match_nearest that can be seen when typing just the name of the command. We can even use it with the original 2.5 GB *netCDF* files by specifying the sequence number of the dataset (0-relative), e.g., *sdsNumber=6* for *adg_412*. For example:

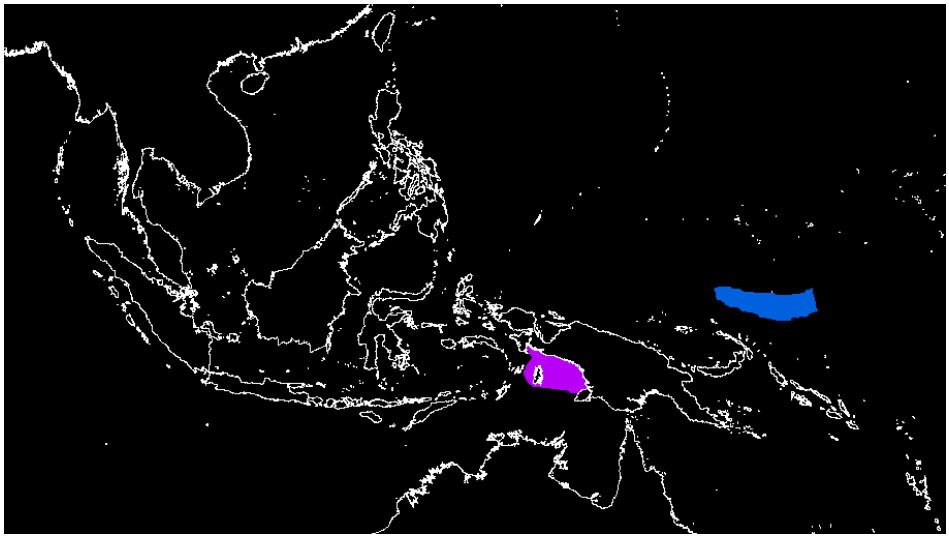
```
wam_match_nearest station_list_mk.csv ..\..\2022\*.nc sdsNumber=6
```

Note that I have moved the huge *.nc* files to a different location.

While finding match-ups from Level-3 files we have to keep in mind that there can be significant errors due to temporal and spatial aliasing. We normally use the *Mean* of the 3 x 3 pixel neighborhood as the representative satellite value. In case of the global ESA-CCI data this is 3 pixels mean approximately 3 * 4.65 ~ 14 km that is a huge distance in the coastal zone. You should also note the *Min* and *Max* range (in the match-up file) as they could show outliers. Obvious outliers can be eliminated by options like *ValidMin=X* and *ValidMax=Y*.

# *4* Creating areal statistics with *wam_statist_mask*

In the first tutorial https://wimsoft.com/Course/3/Time_series_SE_Asia.pdf we created an areal masks (filled with pixel values 1 and 2) for the *sea10.hdf* map. Here we use the same masks to create annual time series of *adg_412*.



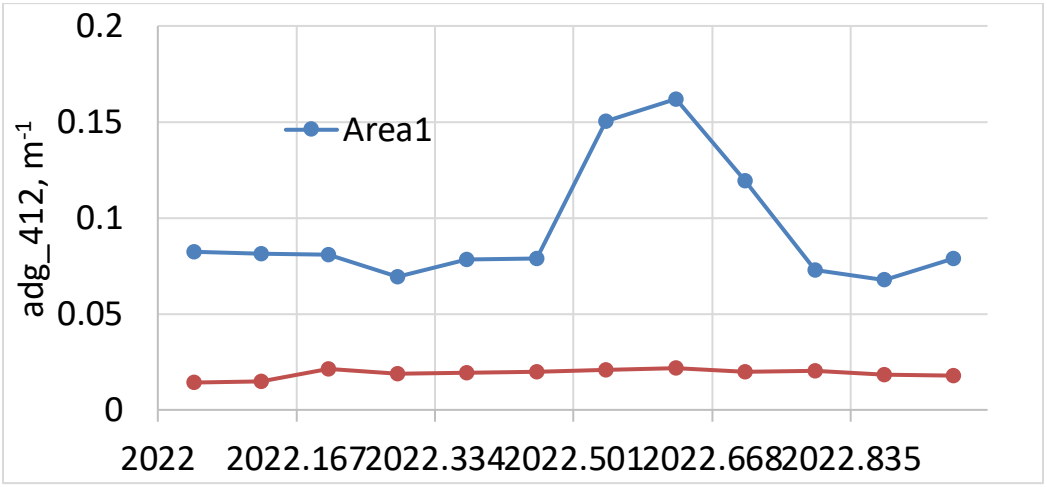
We will use the 12 monthly mapped datasets as our masks file is for the sea10.hdf map. We could also create a mask file for the global 8640 x 4320 dataset:

```
cd Sat\IOP

set MASK=Maps\sea10_mask1-2.hdf

wam_statist_mask Monthly\adg_412_sea10\*.hdf mask=%MASK%
```

Output was saved in _statist_grid_sea10_mask1-2.csv. Note that here areas 1 and 2 are alternating. In order to make plots in Excel we need to sort the lines by area numbers (1 and 2).

```
sortmasks _statist_grid_sea10_mask1-2.csv
```

You can now make plots using _statist_grid_sea10_mask1-2_sorted.csv. Below are annual plots of *adg_412* for areas 1 and 2.




You can access this tutorial at
https://www.wimsoft.com/Course/3/Time_series_IOP_SE_Asia.pdf

The data files used in this tutorial (excluding the original *.nc* files) can be found on my Google Drive at
https://drive.google.com/drive/folders/1kq1jKFGgW0mI2hKQaHLiTA8a45XXxaVR?usp=sharing

You can copy this *IOP* folder to your *Sat* folder.

WORK IN PROGRESS! TO BE UPDATED!

Questions? Ask Mati at mkahru@ucsd.edu !