



Monitoring Coastal and Estuarine Water Quality Using Remote Sensing and In Situ Data

Exercise 2

Prerequisites

- Installation of OCSSW on your computer
- MODIS and VIIRS chlorophyll data from Exercise-1
- SeaBASS and GCOOS in situ data from Exercise-1

Objectives

By the end of this exercise, participants will be able to:

- Compare/Validate MODIS and VIIRS chlorophyll data with SeaBASS in situ data
- Process MODIS and VIIRS Level-2 data from Level-1 using SeaDAS/OCSSW
- Generate algorithm coefficients from MODIS and VIIRS
 reflectance data and GCOOS observations*

*This last exercise is optional



Important Note

- This exercise is to learn water quality data validation and algorithm generation using sample data and will **not** yield statistically significant results!
- In practice, many more observations are required for the validation and algorithm generation from remote sensing and in situ data.



Download the Data Required for this Exercise

Download **Exercise-2_Datafiles** from the training webpage.

 ¹Level-2 chlorophyll mosaic images from Exercise-1:

A20171011-mosaic.dim (for MODIS) A20171011-mosaic.data (for MODIS) V20171011-mosaic.dim (for VIIRS) V20171011-mosaic.data (for VIIRS)

• Level-1A images:

A2017284181500.L1A_LAC (MODIS) V2017284191200.L1A_SNPP.nc (VIIRS)

¹These files are from Exercise-1

- **1SeaBASS in situ data from Exercise-1:** e29f6ffdc2_ntb1_chl.sb
- 1GCOOS in situ data file: GCOOS_20171011.sb

Open MODIS Image

- 1. In the SeaDAS window.
 - On the top ribbon go to File →
 Open Product and select
 A20171011-mosaic.dim. You will see the MODIS file name in the File Manager.
 - Click on the down arrow next to the file name A20171011-mosaic
 → Bands → chlor-a.
 - Double-click on chlor-a to get the image.

Note: Steps 1-6 are from Exercise-1





Add Land Mask to the MODIS Image

- 2. Click on the "Add coastline, land and water masks" icon 🔊 on the top menu bar:
 - Under Mask Name → LandMask, using the drop-downarrow select Gray and click on Create Masks.
 - You will get the MODIS image with the land mask.
- 3. Repeat Steps 1 and 2 for the VIIRS image: V20171011.mosaic.dim.

MODIS











Add SeaBASS Chlorophyll Data to the MODIS Image

- 4. In the **File Manager** panel highlight **chlor_a**:
 - From the top ribbon click on File \rightarrow Import \rightarrow Vector Data \rightarrow SeaBASS Data.
 - Navigate to the file
 e29f6ffdc2_ntb1_chl.sb and click on
 Open to add the SeaBASS data.





Add SeaBASS Chlorophyll-a Data to MODIS & VIIRS Images

- 5. SeaBASS data locations will be added to the image.
 - To change the symbology (i.e., symbol and color) of the SeaBASS locations, select Layer Manager → Vector data → SeaBASS filename (e29f6ffdc2_ntb1_chl.sb).
 - From the top ribbon go to Layer → Layer
 Editor.
 - In the Layer Editor window change Fill and Stroke to desired color and choose a Symbol to display.
- 6. Repeat Steps 4 & 5 for the VIIRS image **V20171011-mosaic.dim**.







Compare MODIS and SeaBASS Chlorophyll Data

- 7. Click on the MODIS chlor_a image.
 - From the SeaDAS Ribbon, click the first set of down arrows to find the Correlative Plot.
 - The Correlative Plot window will open.







Compare MODIS and SeaBASS Chlorophyll Data

- 8. In the Correlative Plot go to X-Axis & Y-Axis (chlor_a) selection window:
 - Select **Box size** of 3.
 - For Point data source select
 e29f6ffdc2_ntb1_chl.sb.
 - For Data field select CHL.
 - Set X-Axis (CHL) min and max to 0 and 20.
 - Set Y-Axis (chlor_a) min and max to
 0 and 20.
 - Select Show regression line.





Compare MODIS and SeaBASS Chlorophyll Data

- 9. MODIS and SeaBASS chlorophyll data points will be plotted.
 - There are four SeaBASS data points in the file, but the correlative plot shows only two in situ points. Why?
 - Take note of the regression relation and correlation coefficient R².













Process MODIS and VIIRS Level-2 Data from Level-1 using SeaDAS/OCSSW

Acquiring MODIS and VIIRS Level-1A Images

- MODIS and VIIRS L1A images can be obtained from NASA OceanColor Web.
- In Exercise-1, Level-2 Ocean Color data were downloaded (Steps 9 to 11). Bulk download procedure was demonstrated in the following webinar:
 - Monitoring Coastal and Estuarine Water Quality: Transitioning from MODIS to VIIRS
 - <u>https://appliedsciences.nasa.gov/join-mission/training/english/arset-monitoring-coastal-and-estuarine-water-quality-transitioning</u>
- Based on the SeaBASS data locations, the spatial domain of the images can be selected.
- For this exercise, instead of entire Gulf of Mexico domain, a smaller domain is selected (next slide).
- The next two slides provide the data selection and download instruction for your information, but for the exercise today, the images are made available to you and you can go directly to Step 16.



Acquiring MODIS and VIIRS Level-1A Images

13. Go to NASA OceanColor Web.

Go to **Data** \rightarrow Level 1&2 Browser and click on the map.

- The data selection screen will open.
- We will use 11 October 2017 for the case study:
 - In the Mission window, Click 2017 (year) and then on Oct (month).
 - In the October 2017 window, click on 11(date).
 - > Select MODIS Aqua and VIIRS Suomi-NPP.
 - Instead of Select one or more window, enter coordinates around the SeaBASS data in specify boundary coordinates or a single location.
 - Click on Find swaths.







Download MODIS and VIIRS Level-1A Images

- 14. Several swaths for MODIS and VIIRS for the selected date and region will be displayed.
- 15. Click on the MODIS and VIIRS swaths in which the SeaBASS data are located.
 - You will be provided with a selection of image file names, Quasi True Color images, and L1A and L2 mage data.
 - Click on L1A file and save to your computer.
 - MODIS files will be compressed (.bz2).
 - Double-click on the filename on Mac to unzip or use use bzip2 command on Linux/Windows.



 MOD00.P2017284.1815
 1.PDS

 A2017284181500.L1A
 LAC

 A2017284181500.L2
 LAC
 OC.nc

 A2017284181500.L2
 LAC
 IOP.nc

 AQUA
 MODIS.20171011T181510.L2.SST.nc

V2017284191200.L1A SNPP.nc V2017284191200.GEO-M SNPP.nc V2017284191200.L2 SNPP OC.nc V2017284191200.L2 SNPP IOP.nc



Process MODIS Geolocation File for Level-1A Image

16. Use the downloaded L1A swath for MODIS A2017284181500.L1A_LAC.

- 17. Open SeaDAS and make sure you have OCSSW installed in SeaDAS.
- On the top ribbon, click on SeaDAS-OCSSW to get a drop-down list of options.
 - Select modis_GEO.
 - A window will open.
 - In Primary I/O Files \rightarrow file \rightarrow click on (...) and select A2017284181500.L1A_LAC.
 - The **output** filename will be populated as **A2017284181500.L1A.GEO**.
 - Select refreshDB.
 - Click **Run** at the bottom.







Process MODIS Geolocation File for Level-1A Image

 If you experience an error message when generating the A2017284181500.L1A.GEO file, refer to the Download Methods instructions at webpage below to configure your username and password for authentication using a .netrc file.

https://oceancolor.gsfc.nasa.gov/data/download_methods/#downlo ad_sec

• We've also provided the A2017284181500.L1A.GEO file in the zipped folder for Exercise 2.

Process MODIS Level-1B from MODIS-1A Image

- A message window appears when the processing is complete, click OK.
- The MODIS geolocation file will be saved in the same directory as the L1A file.
- 19. From SeaDAS-OCSSW drop-down list
 - Select modis_L1B.
 - A window will open.
 - In Primary I/O Files → File → click on (...) and select:
 A2017284181500.L1A_LAC.
 - The **geofile** will be populated with **A2017284181500.L1A.GEO**.
 - Click **Run**.









Process MODIS Level-1B from MODIS-1A Image

- A message window opens when the processing is complete, click **OK**.
- You will see the three L1B files in _
 the same same directory as the L1A file.
- The L1B_LAC file now can be used to derive MODIS Level-2 geophysical parameter data.





Process MODIS Level-2 Data

20. From the **SeaDAS-OCSSW** drop-down list, select **I2gen**.

- A window with multiple options will open.
- In Primary I/O Files → ifile → click on (...) and select A2017284181500.L1B_LAC
- The geofile and ofile will be populated.
- Level-2 file will be:
 A2017284181500.L2_LAC_OC
- Click on Get Ancillary if you want the data for atmospheric correction of reflectance for the same date. Otherwise, the default climatological data will be used.







22

Process MODIS Level-2 Data

- 21. Click on the **Products** on the top of the **I2gen** window.
 - Explore Product Selector options. -
 - Deselect All Infrared wavelengths.

Main Products	Processing Options	Subsetting Options	Thresholds	Ancillary Inputs*	IOP Options	Miscellaneous	Calibration Option
Product Selector				Wavelength Li	miter		
Radiances/Reflect	ances			Deselect Al	ll Visible		
Derived Geophysic	al Parameters			Deselect Al	Near-Infrared		
 Ancillary/Meterological Principle 	gical/Geometric Paramet	ers		Salact All Is	afrarad		
Atmospheric Corre	ection Intermediates			Select All II	inareu		
Uncertainties/Erro	r Estimates			412	443		
Miscellaneous				469	488		
					547		
					678		
				748	859		
				869	1240		
				1640	2130		
				3750	3959		
				4050	6715		
				7325	8550		
				11000	12000		

Select MODIS Level-2 Data Processing Options

- 22. Click on the **Processing Options** on the top of the **I2gen** window.
 - a window will open with a list of options.
 - scroll down to aer_opt and select -99 No aerosol subtraction.

Note: Various aer_opt parameters can be explored to check which atmospheric correction scheme works best for a given region and sensor.

Sometimes atmospheric correction is ignored in optically complex or turbid/shallow waters to avoid uncertainties.





Select MODIS Level-2 Data Processing Options

- Scroll down and deselect maskcloud, maskhilt, and maskland.
- Scroll down further and select proc_ocean: 2
 - force all pixels to be processed as ocean.
- Click **Run**.

Processing takes a few minutes to complete.

Note: By turning the mask off for cloud, high light, and land pixels, and treating all pixels as ocean, this allows for more data pixels in images and avoids masking coastal pixels as land.





Select MODIS Level-2 Data Processing Options

- A message appears indicating that the L2 processing is complete.
- The L2 file **A2017284181500.L2_LAC_OC** will appear in the SeaDAS **File Manager** and the L2 file is saved in the directory where L1B file is.



		[2] A2017284181500.L2_LAC_OC_reprojected - [/Users/avmehta/Desktop/Exercise-2/A2017284181500.L2_LAC_OC_reprojected	ed.dim]
9	9 7	🕅 🖉 🖶 👄 🛋 🌫 ø ⋕ 🛛 🧼 🛞 🔤 🕨 🔍 🛸 🔩 🐝 🗳 🚢 🔍 🏷 🔑	Σ 🔛 😻 👑 🗧 🗧
	Color Manipulation 🛞 📃 🗉	File Manager	Layer Manager
5		ⓐ [1] A2017284181500.L2_LAC_OC	
		Metadata	
		🕨 🛄 Flag Codings	
a d		Vector Data	
70		Bands	
/			



Reproject MODIS Level-2 Data

23. In the **File Manager** window, click on the down arrow next to **A2017284181500.L2_LAC_OC**, and the down arrow next to **Bands**, then double-click to select **chlor_a**.

- The chlor_a image will be displayed in the SeaDAS window.
- On the top bar click on the Create reprojection of a file symbol.
- In the Reprojection window in I/O parameters, select the directory to save the reprojected data.





Reproject MODIS Level-2 Data

- In Reprojection Parameters, under Coordinate Reference System (CRS), Projection should be Geographic Lat/Lon (WGS 84).
- Click **Run**.
- When the processing is complete, you will see the reprojected file.
 A2017284181500.L2_LAC_OC_reprojected in the File Manager.

		Reprojection			
ile Help					
	I/O Parameters	Reprojection	Param	neters	
Coordinate Reference	System (CRS)				
Custom CRS					
Geodetic datum:	World Geodetic S	System 1984			٢
Projection:	Geographic Lat/	Lon (WGS 84)			
				Projection Para	meters
O Predefined CRS					Select
OUse CRS of					\$
Output Settings					
Preserve resolution	on 🗹 R	Reproject tie-poi	nt gri	ds	
Output Parame	eters No-d	lata value:	NaN		
Add delta lat/lon	bands Resar	mpling method:	Nea	arest	0
Output Information					
Scene width: 2772 p	ixel	Center longitu	de:	75°24'01" W	
Scene height: 2031 p	ixel	Center latitude	e:	30°33'19" N	
CRS: WGS84	(DD)			Show V	WKT
				Run	Close



Compare MODIS and SeaBASS Chlorophyll

- 24. Click on the down arrow next to **A2017284181500.L2_LAC_OC_reprojected**, and the down arrow next to **Bands**, doubleclick to select **chlor_a**.
 - Reprojected chlor_a image will be displayed in the SeaDAS window.
 - From the top ribbon, go to View → Tool
 Windows → Mask Manager.

View	Analysis	Layer	Vector	Raster	Optical	Tools	Window
Tool Tool	Windows bars			Develo	per		•
✓ State	usbar		-	Optical Control In-Situ Data Access			
✓ Synd ✓ Synd	chronise Im chronise Im	age Curs age View	sors vs	 Color Manipulation Uncertainty Visualisation 			tion
Show Only Editor 쇼泼↔				🗊 Lay	er Editor		
				🗐 Lay	er Manage	er	
100000	_			🥏 Mas	sk Manage	er	



Layer Manager	-	Mask I	Manager
Name	Ту	ре	Coloi
	Ma	ths	
LAND	Ma	ths	
PRODW	Ma	ths	
🗹 HILT	Ma	ths	
HIGLINT	Ma	ths	
HISATZEN	Ma	ths	
COASTZ	Ma	ths	
STRAYL	Ma	ths	



Compare MODIS L2 and SeaBASS Chlorophyll

- The Mask Manager window will open to the right side of the image window.
- Select **CLDICE** mask (choose a color other than white).
- This will mask non-water pixels.
- The L2 chlor_a will be displayed.
- 25. Import SeaBASS data to the image following Steps 4 and 5.
 - Follow Steps 7 to 11 to correlate MODIS and SeaBASS chlor_a.
 - Write down R^2 .





Process VIIRS Geolocation File for Level-1A Image

26. Use the downloaded L1A swath for VIIRS V2017284191200.L1A_SNPP.nc.

- 27. In SeaDAS, in the top ribbon click on **SeaDAS-OCSSW** to get a drop-down list of options.
 - Select geolocate_viirs...
 - A window will open.
 - In Primary I/O Files → ifile → click on
 (...) and select
 V2017284191200.L1A_SNPP.nc.
 - The **output** filename will be populated as V2017284191200.GEO-M_SNPP.nc.
 - Click **Run**.

	geolocate_viirs			
Primary I/O Files ifile //Users/avmehta/Desktop/Exer geofile_mod /Users/avmehta/Deskto	cise-2/V2017284191200.L1A_SNPP.nc pp/Exercise-2/V2017284191200.GEO-M	L_SNPP.nc		.
geofile_img				
geofile dab				
geome_unb				
static_lut_file				filter:
rsb_dynamic_lut_file				filter:
dnb_dynamic_lut_file				filter:
straylight_lut_file				filter:
cmn_lut_file				filter:
geo_lut_file				filter:
polar_wander_file				filter:
ter	rrain_path land_water_mask_path	pversion		
Load Parameters Save Paran	neters		o	pen in SeaDAS 8.1.0
		Run	Cancel	Apply ?



Process VIIRS Level-1B from Level-1A Image

- You will get a message when the processing is complete, click **OK**.
- You will see the GEO file in the same directory as the L1A file.
- 28. From the **SeaDAS-OCSSW** drop-down list select **calibrate_viirs...**
 - A window will open.
 - In Primary I/O Files → ifile → click on
 (...) and select
 V2017284191200.L1A_SNPP.nc.
 - Click Run.



calibrate	viirs			
Primary I/O Files				
ifile /Users/avmehta/Desktop/Exercise-2/V2017284191200.L1A	_SNPP.nc		<u> </u>	
11bfile_mod /Users/avmehta/Desktop/Exercise-2/V20172841912	00.L1B-M_SNPP.nc			
1bfile_img				
l1bfile_dnb				•
l1bfile_cdg				
static_lut_file			filter:	
rsb_dynamic_lut_file			filter:	
dnb_dynamic_lut_file			filter:	
straylight_lut_file			filter:	
cmn_lut_file			filter:	
polar_wander_file			filter:	
geo_lut_file			filter:	
terrain_path p	version			
Load Parameters Save Parameters			Open in SeaDAS	8.1.0
	Run	ancel	Apply	?
		_	_	-



Process VIIRS Level-1B from MODIS-1A Image

- A message window opens when the processing is complete. Click **OK**.
- VIIRS L1B file V2017284191200.L1B M_SNPP.nc is saved in the same same directory as the L1A file.
- The L1B-M_SNPP file now can be used to derive MODIS Level-2 geophysical parameter data.





Process VIIRS Level-2 Data

- 29. Follow Step 20 but use VIIRS L1B file V2017284191200.L1B-M_SNP.nc instead of the MODIS L1B file.
 - Follow Steps 21 to 25 to get reprojected VIIRS image.

Note: You will see fringes in VIIRS image before reprojection where the satellite zenith angle is large.

30. Follow Step 7 to correlate VIIRS and SeaBASS chlor_a.

– Write down R^2 .

			l2ger				
Main Products	Processing Options	Subsetting Options	Thresholds	Ancillary Inputs*	IOP Options	Miscellaneous	Calibration Options
Primary I/O Files -							
file /Users/avm	ehta/Desktop/Exercise-	-2/V2017284191200.L	1B-M_SNPP.nc				۰
eofile /Users/av	nehta/Desktop/Exercis	e-2/V2017284191200	.GEO-M SNPP.	nc			filter:
, oscis, an	nenta, besittop, exercis	,					
file /Users/avme	hta/Desktop/Exercise-	2/V2017284191200.L2	SNPP_OC.nc				
arfile							
anne							
Load Parameter	Retain Selecte	d IFILE Get Ancilla	ary -	Show Defaults	Suite OC	○	Save Parameters
<pre># PRIMARY INPUT C file=/Users/avmel geofile=/Users/avm ofile=/Users/avme # SUITE suite=OC</pre>	DUTPUT FIELDS nta/Desktop/Exercise- nehta/Desktop/Exercis hta/Desktop/Exercise-	2/V2017284191200.L1 e-2/V2017284191200 2/V2017284191200.Li	B-M_SNPP.nc .GEO-M_SNPP. 2_SNPP_OC.nc	nc			
# ANCILLARY INPU icefile=/Users/avm met1=/Users/avm met3=/Users/avm ozone1=/Users/avm ozone2=/Users/av	TS Default = climatolo ehta/Applications/ocs ehta/Applications/ocss ehta/Applications/ocss ehta/Applications/ocs mehta/Applications/oc	gy (select 'Get Ancillar) sw/var/anc/2017/284 w/var/anc/2017/284/ w/var/anc/2017/285/ w/var/anc/2017/28 ssw/var/anc/2017/28 ssw/var/anc/2017/28	' to download /N201728400_ N201728418_1 N201728500_1 N201728500_1 4/N201728500 5/N201728500	ancillary files) SEAICE_NSIDC_24h. MET_NCEPR2_6h.hdf MET_NCEPR2_6h.hdf MET_NCEPR2_6h.hdf)_O3_AURAOMI_24h.)_O3_AURAOMI_24h.	hdf hdf		



Users/avmehta/Applications/ocssw/var/anc/2017/284/N2017284 SST OIV2AV 24h.n

