The City College of New York Grove School of Engineering

Earth System Science & Environmental Engineering

Remote Sensing

Mentor: Aleksandr Gilerson

Project Member: Josue Criollo

I. Table of Contents

II. Data Loading for Open Ocean

A. Finding level 2 image from VIIRS

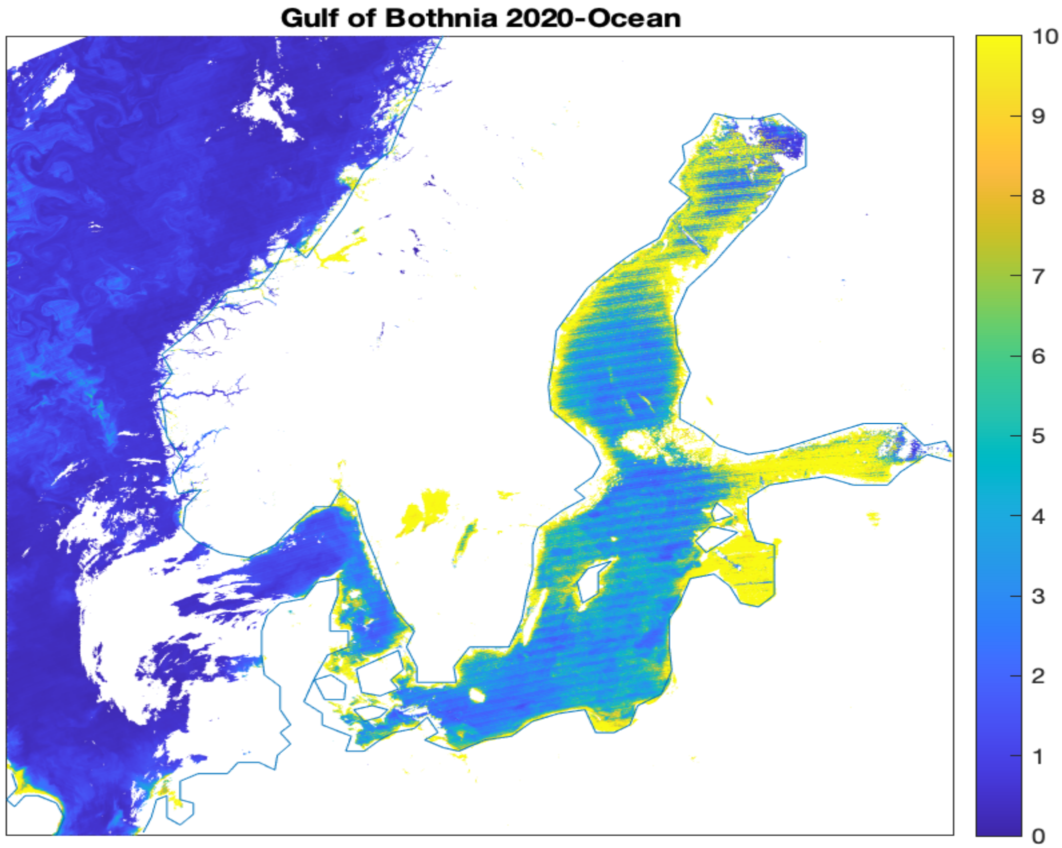
```
%%%%%%%%%% PART I: DATA LOADING- OUT IN THE OCEAN- WEST OF SWEDEN

load coastlines %this will help us better visualize the location we are
working with
filename='/Users/josuecriollo/Documents/Engr 301-remote
sensing/project/V2020152113600.L2_SNPP_OC.nc';%copy as pathname for each
location
```

B. Use coding format given (imageLIS.m)

```
LA=ncread(filename,'/navigation_data/latitude'); %nread command help us read
NetCDF source. it will query the library for the variable`s fill value
LA=double(LA); %with the double command, we can have double precision
LO=ncread(filename,'/navigation_data/longitude');
LO=double(LO);
```

C. Find coordinates of the coastline for your area and plot chl maps

```
axes('CLim',[0 10])
axesm('MapProjection','mercator','MapLatLimit',[52 67],'MapLonLimit',[0 30])
%how big the map will be and adjusted long and lat
surfacem(LA,LO,chlora); %project and add geolocated data grid to current map
axes. it constructs a surface lies flat in the horizontal plane with its
Cdata set to z.
plotm(LA(:,2),LO(:,1),'k');
plotm(coastlat,coastlon)%projects 2d lines and points on map axes
title('Gulf of Bothnia 2020-Ocean')
axis tight;
colorbar %this will display the content of chlorophyll in each region
```



D. Load data of Rrs (for all pixels and for each available wavelength) and chlor_ocx for all pixels into MATLAB. Load data of F0 and Tau_r into MATLAB.

```
%%%waveleght

wavelength1=ncread(filename,'/sensor_band_parameters/wavelength');
%wavelength from senso_band_parameters folder in hdf view
wavelength1=double(wavelength1);

%%%Rrs data

Rrs410=ncread(filename,'/geophysical_data/Rrs_410');
Rrs410=double(Rrs410);
Rrs671=ncread(filename,'/geophysical_data/Rrs_671');
Rrs471=double(Rrs671);
Rrs486=ncread(filename,'/geophysical_data/Rrs_486');%needed
Rrs486=double(Rrs486);
Rrs551=ncread(filename,'/geophysical_data/Rrs_551');%needed
Rrs551=double(Rrs551);
Rrs443=ncread(filename,'/geophysical_data/Rrs_443');%needed
Rrs443=double(Rrs443);

%%%%chl_ocx data

chlocx=ncread(filename,'/geophysical_data/chl_ocx');
chlocx=double(chlocx);

%%%chlor_a
```

```
chlora=double(ncread(filename,'/geophysical_data/chlor_a'));%chlorophill data
to have on the map
%%%F0 data

F0=ncread(filename,'/sensor_band_parameters/F0');
F0=double(F0);

%%%Tau_r data

Taur=ncread(filename,'/sensor_band_parameters/Tau_r'); %tau from sensor_band
folder in hdf view
Taur=double(Taur);
```

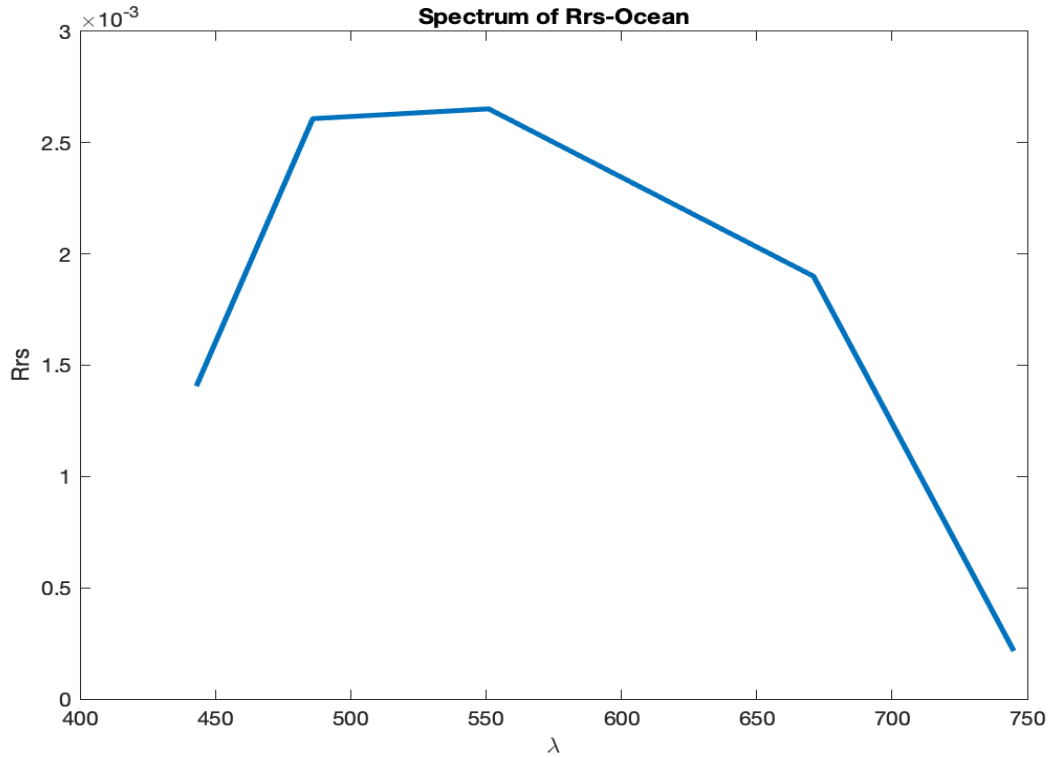
III. Analysis of Data at the Ocean

A. Choose the pixel chl>0

```
%%%%%%%%% PART 2: ANALYSIS OF DATA AT THE OCEAN

%%% Q5----choosing chlor_a val>0 and longitude/latitude
%we can also know the longitude and latitude using the same row and
%column(must match pixel of chlor_a)
%by looking at navigation_data on HDF viewer
row=1503;%we can choose the row
column=3097;%choosing column number
disp(chlora(row,column))%diplaying value of a particular cell chosen its
value: 0.7889
disp(LA(row,column))
disp(LO(row,column))
%longitude: 6.8132 East
%Latitude: 66.722 North
```

B. Plot the spectrum of Rrs for all available bands for the pixel

```
%%% Q6----plotting spectrum of Rrs

Rrs=[Rrs410(row,column) Rrs443(row,column) Rrs486(row,column)
Rrs551(row,column) Rrs671(row,column)];% this will display an array with all
rrs values using our chosen pixel.
disp(Rrs)
wavelength=[443 486 551 671 745]; %these values we can get from HDF viewer
under sensor band parameters (wavelength)
figure()
plot(wavelength, Rrs,'linewidth', 2.5) %run on command window
title('Spectrum of Rrs-Ocean');
xlabel('\lambda');
ylabel('Rrs');
```



C. VIIRS Chl algorithm is:

$$C_a = 10.0^{(0.2228 - 2.4683 R_{3V} + 1.5867 R_{3V}^2 - 0.4275 R_{3V}^3 - 0.7768 R_{3V}^4}$$

$$where\ R_{3V} = \log_{10}(R_{550}^{443} > R_{550}^{486})$$

$$R_{551}^{443} = Rrs(443) / Rrs(551);\ R_{551}^{486} = Rrs(486) / Rrs(551) -$$

$$the\ greater\ of\ these\ two\ values\ is\ used$$

1. Calculate Chl concentration for your pixel using VIIRS algorithm:

from Rrs(λ) and compare with the value in the product chlor_ocx. Make a conclusion about this comparison.

```
%%% Q7----calculation of chlo concentration

R443_551=Rrs443(row,column)/Rrs551(row,column); %given condition
disp(R443_551) %this gives us 1.372631408067248
R486_551=Rrs486(row,column)/Rrs551(row,column);
disp(R486_551)%this will give us 1.395789292184422
%since the bigger value is from R486_551, we use in the following formula
R_3v=log10(R486_551);
concentration=10.0.^(0.2228-2.4683*R_3v+1.5867*R_3v.^2-0.4275*R_3v.^3-
0.7768*R_3v.^4); %equation to calculate concentration
disp(concentration) %we get value of 0.7888
```

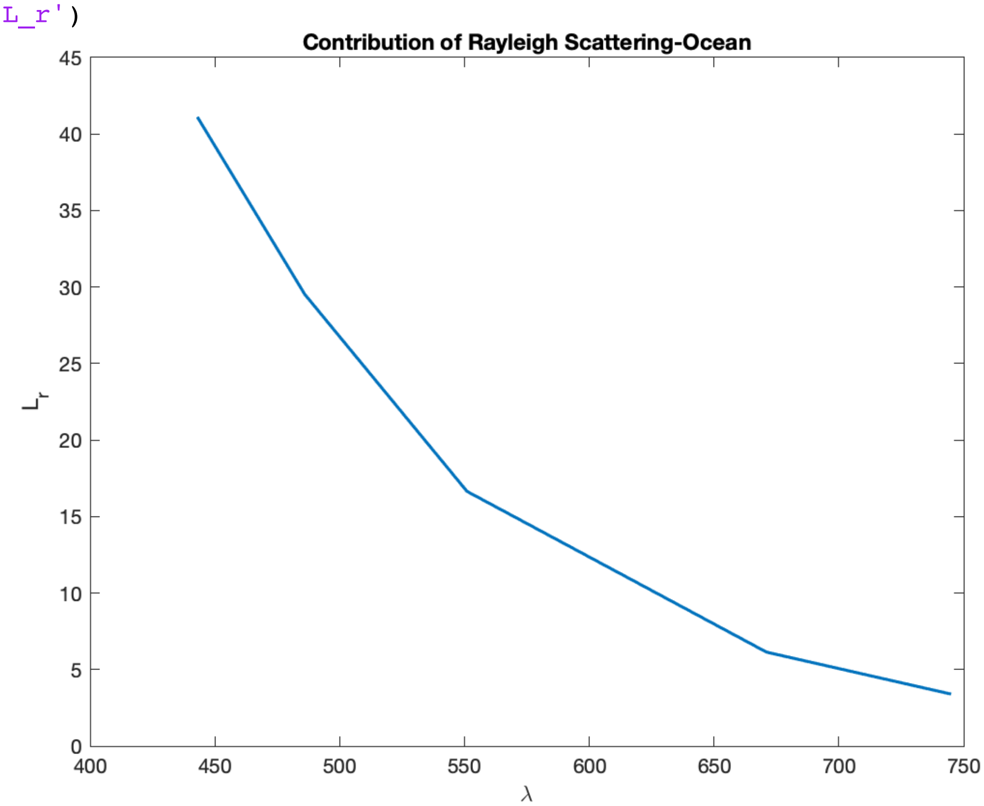
```
%if we compare to the actual Chlrocx value as found from HDF Viewer, the
%difference is only by 0.0457 since 0.8345-0.7888
```

IV. Propagation of the Open Ocean data to the top of the atmosphere

A. Contribution of Rayleigh Scattering

Use 50 degrees, and Determine the path radiance spectrum due to the Rayleigh scattering as $Lr(\lambda_i) = F0(\lambda_i) *Tau\_r(\lambda_i)*0.75/(4*pi*cos(\theta_v))$.

```
%%%%%%% III.PROPAGATION OF THE SURFACE DATA TO THE TOP OF THE ATMOSPHERE

%%% Q8----Contribution of Rayleigh scattering
format long %format to diplay complete values of usr F)(1,1), F0(2,1), etc
F0=[1902.14, 1987.74, 1841.22, 1504.5599, 1276.4299];%F0 data can be found in
sensor band parameter folder(HDF)
Tau_r=[0.23280, 0.16, 0.09738, 0.04395, 0.02865];
Lr=(F0.*Tau_r.*0.75)/(4.*pi.*cosd(50)); %equation for Rayleigh
disp(Lr)
%Results: 41.1158579,  29.53000105,  16.64789609,    6.1397722935,
3.39551378
%to better visualize, we can plot Lr vs lambda
figure()
plot(wavelength, Lr, 'linewidth', 1.5)
title('Contribution of Rayleigh Scattering-Ocean')
xlabel('\lambda')
ylabel('L_r')
```



B. Contribution of aerosol scattering

1. Determine aerosol optical thickness:

$\tau_a(862)$ = aot_862 and angstrom (coefficient) γ for your pixel in the hdf file.

```
%%% Q9---Contribution of aerosol Scattering

%we now need to load angstrom and aot863 data
aot862=ncread(filename,'/geophysical_data/aot_862'); %this can be gound in
geophysical data folder (aerosol optical thickness)
aot862=double(aot862);
angstrom=ncread(filename,'/geophysical_data/angstrom');
angstrom=double(angstrom);

%determe variables based on used pixel
aot862_pixel=aot862(row, column);
disp(aot862_pixel)%give a value of 0.10579999
angstrom_pixel=angstrom(row,column);
disp(angstrom_pixel)% gives a value of  0.54610004
```

2. Determine aerosol optical thickness for other wavelengths as:

$\tau_a(\lambda_i) = \tau_a(862)*(\lambda_i/862)^{-\gamma}$

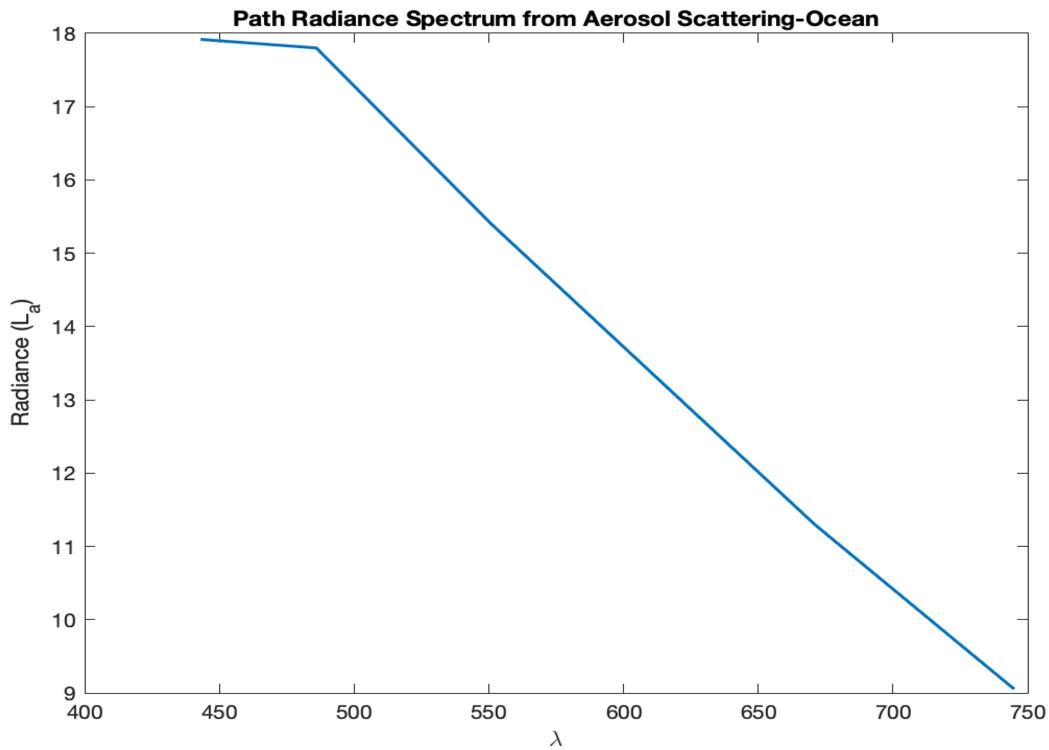
```
%determine the aerosol optical thickness for the wavelength

aerosol_thickness1=aot862_pixel.*(443/862).^-angstrom_pixel;%given that
œÑ_a=aot862
disp(aerosol_thickness1) %displays  0.152182640
aerosol_thickness2=aot862_pixel.*(486/862).^-angstrom_pixel;%wavelength 486
disp(aerosol_thickness2)%displays 0.14467520
aerosol_thickness3=aot862_pixel.*(551/862).^-angstrom_pixel;%wavelength 551
disp(aerosol_thickness3) %displays 0.13509002
aerosol_thickness4=aot862_pixel.*(671/862).^-angstrom_pixel;%wavelength 671
disp(aerosol_thickness4)%displays 0.121308996
aerosol_thickness5=aot862_pixel.*(745/862).^-angstrom_pixel;%wavelength 745
disp(aerosol_thickness5)%displays 0.114572829

all_aot=[aerosol_thickness1, aerosol_thickness2, aerosol_thickness3,
aerosol_thickness4, aerosol_thickness5];
disp(all_aot)
```

3. Determine the path radiance spectrum due to the aerosol scattering as

$La(\lambda_i) = F0(\lambda_i) * \tau_a(\lambda_i)*P_a/ 4*pi*\cos(\theta_v)$ where $P_a \approx 0.3$ is an approximate value for the aerosol phase function.

```
%determining the path radiance spectrum due to aerosol scattering

%the given formula is:
```

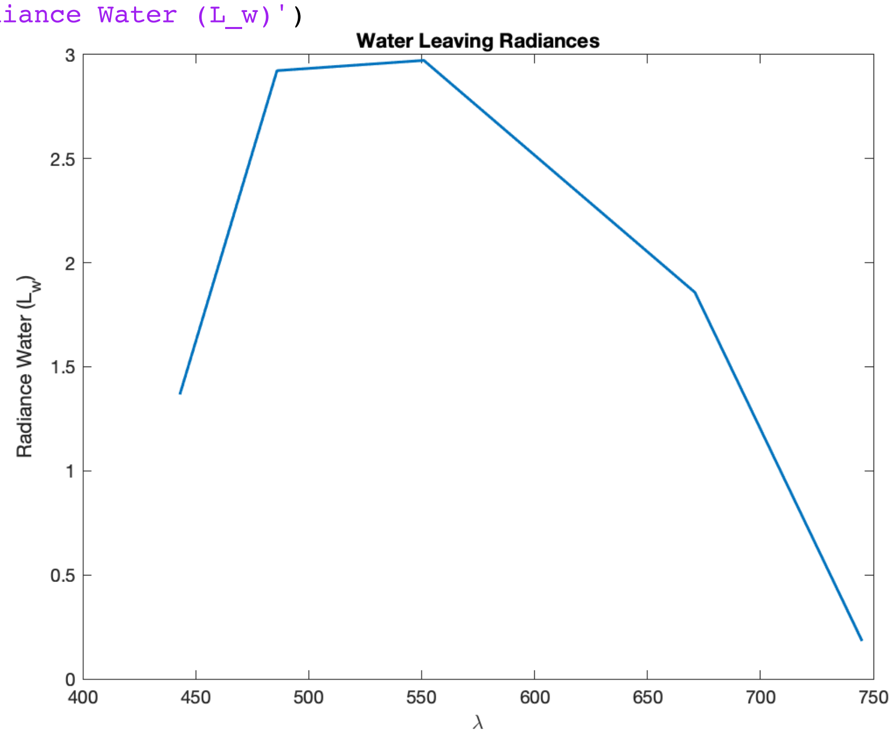
```
%La( λi) = F0(λi) * τa (λi)*Pa/ (4*pi*cos(θv)) , 50 deg, Pa=0.5
La443=F0(1)*aerosol_thickness1*0.5/(4*pi*cosd(50));%keep in mind
τ_a=aerosol_thickness
La486=F0(2)*aerosol_thickness2*0.5/(4*pi*cosd(50));
La551=F0(3)*aerosol_thickness3*0.5/(4*pi*cosd(50));
La671=F0(4)*aerosol_thickness4*0.5/(4*pi*cosd(50));
La745=F0(5)*aerosol_thickness5*0.5/(4*pi*cosd(50));
La=[La443, La486, La551, La671, La745];
%La values:  17.91844161, 17.80107955, 15.396486422
%11.297832663, 9.052556615

figure()
plot(wavelength, La, 'linewidth', 1.5)
title('Path Radiance Spectrum from Aerosol Scattering-Ocean')
xlabel('\lambda')
ylabel('Radiance (L_a)')
```



C. Load data of the center solar zenith angle (csol_z) and find the value csol_z for the pixel

```
%%%Q10-----Loading data from center solar zenith (csol_z). find its value for
%%%chosen pixel

csolz=ncread(filename,'/scan_line_attributes/csol_z'); %tau from sensor_band
folder in hdf view
csolz=double(csolz);
csolz_pixel=csolz(row, 1); %value from pixel, must not exceed 1 column
%value of csol_z pf the pixel is   35.090000152

%Transform surface Rrs values to water leaving radiances as:
%Lw(λi) = Rrs(λi)*F0(λi)* csol_z *exp(-(Tau_r + τa (λi))/csol_z);
```

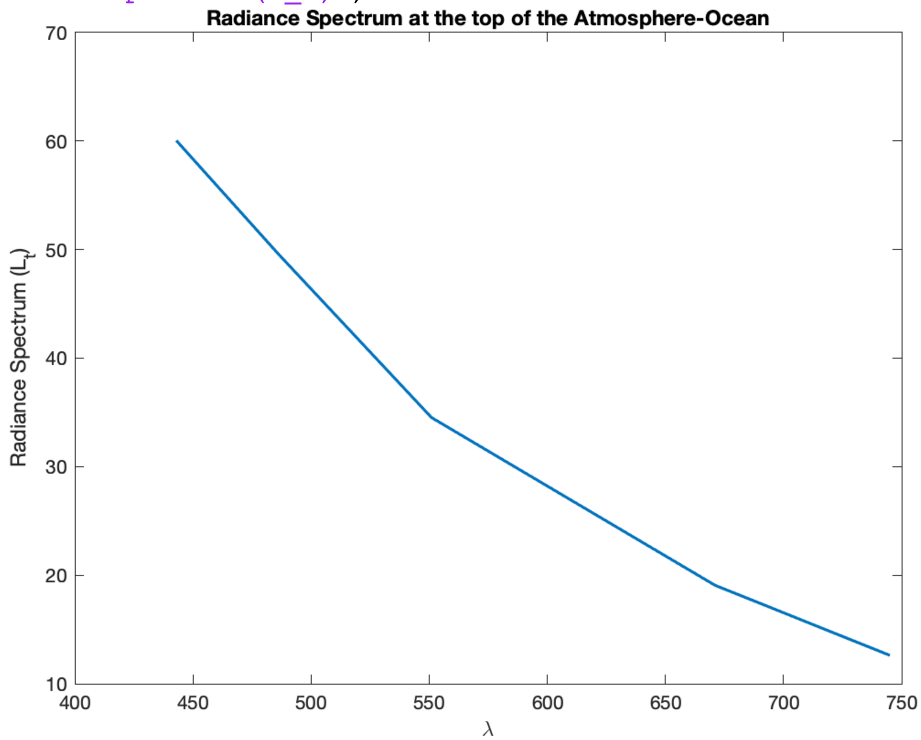
```
Lw443=Rrs(1).*F0(1)* cosd(csolz_pixel)
*exp(-(Tau_r(1)+aerosol_thickness1)/ cosd(csolz_pixel));
Lw486=Rrs(2).*F0(2)* cosd(csolz_pixel)
*exp(-(Tau_r(2)+aerosol_thickness2)/ cosd(csolz_pixel));
Lw551=Rrs(3).*F0(3)* cosd(csolz_pixel)
*exp(-(Tau_r(3)+aerosol_thickness2)/ cosd(csolz_pixel));
Lw671=Rrs(4).*F0(4)* cosd(csolz_pixel)
*exp(-(Tau_r(4)+aerosol_thickness2)/ cosd(csolz_pixel));
Lw745=Rrs(5).*F0(5)* cosd(csolz_pixel)
*exp(-(Tau_r(5)+aerosol_thickness2)/ cosd(csolz_pixel));
Lw=[Lw443, Lw486, Lw551, Lw671, Lw745];

%the values for Lw are: 1.367038323922396   2.923101600044429
2.972296599772395   1.857524682594283   0.182534269399266
figure()
plot(wavelength,Lw,'linewidth',1.5)
title('Water Leaving Radiances')
xlabel('\lambda')
ylabel('Radiance Water (L_w)')
```



D. Determine the radiance spectrum Lt at the top of the atmosphere for the pixel

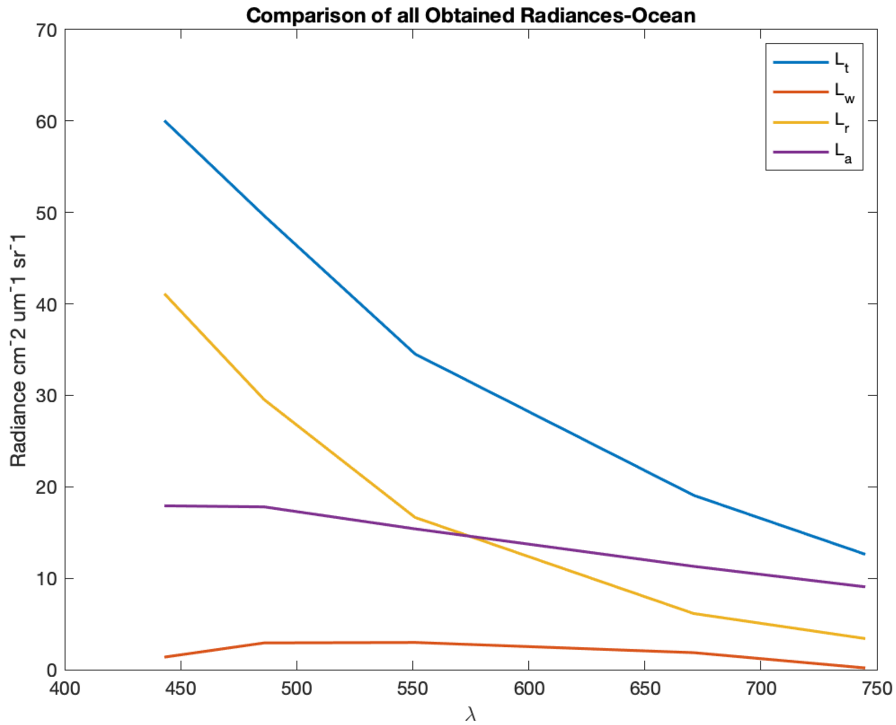
```
%%% Q11----- Determine the radiance spectrum Lt at the top of the atmosphere
for your pixel as

%Lt(λi) = Lr(λi) + La(λi) + Lw(λi) *ti,
%ti = exp(-(Tau_r(λi)+ τ (λi))/2cos(θv))
Lt443=Lr(1)+La(1)+Lw(1).*exp(-(Tau_r(1)+aerosol_thickness1)/(2*cosd(50)));
Lt486=Lr(2)+La(2)+Lw(2).*exp(-(Tau_r(2)+aerosol_thickness2)/(2*cosd(50)));
Lt551=Lr(3)+La(3)+Lw(3).*exp(-(Tau_r(3)+aerosol_thickness3)/(2*cosd(50)));
Lt671=Lr(4)+La(4)+Lw(4).*exp(-(Tau_r(4)+aerosol_thickness4)/(2*cosd(50)));
Lt745=Lr(5)+La(5)+Lw(5).*exp(-(Tau_r(5)+aerosol_thickness5)/(2*cosd(50)));
Lt=[Lt443, Lt486, Lt551, Lt671, Lt745];

%the values for Lt are:  60.047570112976786  49.637393283578390
34.524994597954141  19.071057837768777  12.611360821513651
```

```
figure()
plot(wavelength, Lt, 'linewidth', 1.5)
title('Radiance Spectrum at the top of the Atmosphere-Ocean')
xlabel('\lambda')
ylabel('Radiance Spectrum (L_t)')
```



E. Plot Spectra of Lt(λ), Lw(λ), Lr(λ), La(λ)) for your pixel and evaluate the contribution of all components to the total TOA radiance Lt(λ).

```
%%% Q12----Plot spectra of Lt(λ), Lw(λ), Lr(λ), La(λ)) for your pixel and
evaluate the contribution of all components to the total TOA radiance Lt(λ).
figure()
plot(wavelength, Lt, 'linewidth', 1.5)
hold on
plot(wavelength, Lw, 'linewidth', 1.5)
hold on
plot(wavelength, Lr, 'linewidth', 1.5)
hold on
plot(wavelength, La, 'linewidth', 1.5)
title('Comparison of all Obtained Radiances-Ocean')
xlabel('\lambda')
ylabel('Radiance cm^-2 um^-1 sr^-1')
legend('L_t','L_w','L_r','L_a')
```



V. Data Loading for Coastal

A. Find coordinates of the coastline for your area and plot chl maps

```
axes('CLim',[0 10])
axesm('MapProjection','mercator','MapLatLimit',[52 67],'MapLonLimit',[0 30])
%how big the map will be and adjusted long and lat
surfacem(LA,LO,chlora); %project and add geolocated data grid to current map
axes. it constructs a surface lies flat in the horizontal plane with its
Cdata set to z.
plotm(LA(:,2),LO(:,1),'k');
plotm(coastlat,coastlon)%projects 2d lines and points on map axes
title('Gulf of Bothnia 2020-Coastal')
axis tight;
colorbar %this will display the content of chlorophyll in each region
```

B. Load data of Rrs (for all pixels and for each available wavelength) and chlor_ocx for all pixels into MATLAB. Load data of F0 and Tau_r into MATLAB.

```
%%waveleght

wavelength1=ncread(filename,'/sensor_band_parameters/wavelength');
%wavelength from senso_band_parameters folder in hdf view
wavelength1=double(wavelength1);

%%%Rrs data

Rrs410=ncread(filename,'/geophysical_data/Rrs_410');
Rrs410=double(Rrs410);
Rrs671=ncread(filename,'/geophysical_data/Rrs_671');
Rrs471=double(Rrs671);
Rrs486=ncread(filename,'/geophysical_data/Rrs_486');%needed
Rrs486=double(Rrs486);
```

```
Rrs551=ncread(filename,'/geophysical_data/Rrs_551');%needed
Rrs551=double(Rrs551);
Rrs443=ncread(filename,'/geophysical_data/Rrs_443');%needed
Rrs443=double(Rrs443);

%%%%chl_ocx data

chlocx=ncread(filename,'/geophysical_data/chl_ocx');
chlocx=double(chlocx);

%%%chlor_a

chlora=double(ncread(filename,'/geophysical_data/chlor_a'));%chlorophill data
to have on the map
%%%F0 data

F0=ncread(filename,'/sensor_band_parameters/F0');
F0=double(F0);

%%%Tau_r data

Taur=ncread(filename,'/sensor_band_parameters/Tau_r'); %tau from sensor_band
folder in hdf view
Taur=double(Taur);
```

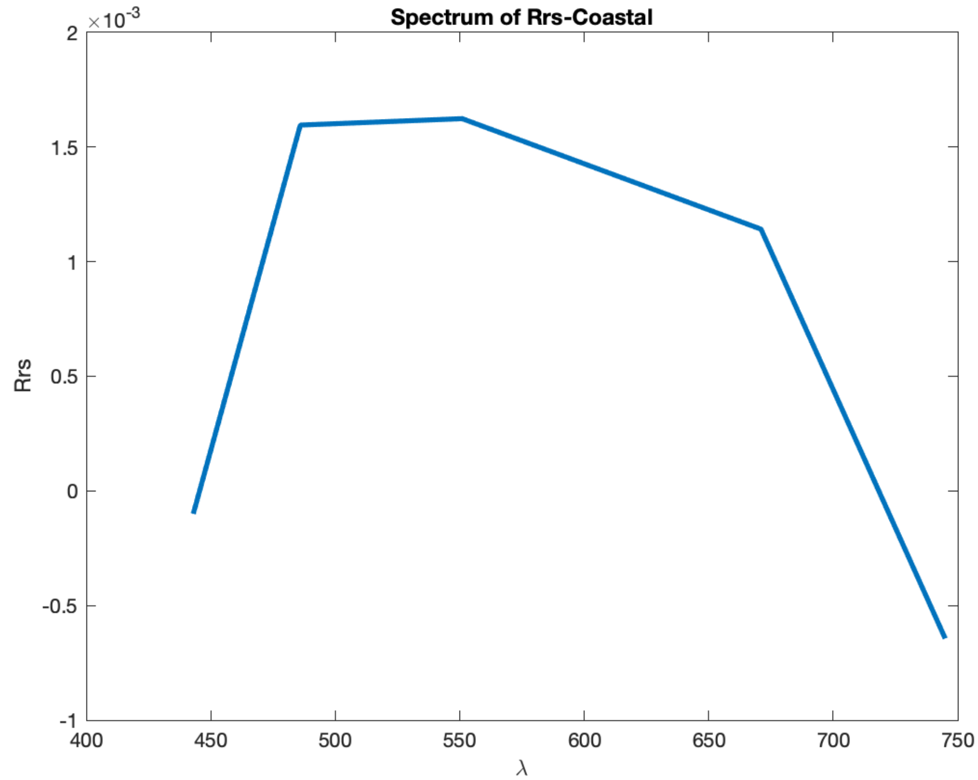
VI. Analysis of Data near the Coast

A. Choose the pixel chl>0

```
%%% Q5----choosing chlor_a val>0 and longitude/latitude
%we can also know the longitude and latitude using the same row and
%column(must match pixel of chlor_a)
%by looking at navigation_data on HDF viewer
row=1110;%we can choose the row
column=3042;%choosing column number
disp(chlora(row,column))%diplaying value of a particular cell chosen its
value: 0.7606
disp(LA(row,column))
disp(LO(row,column))
%longitude: 14.6840 East
%Latitude: 67.2733 North
%make a diagram on a piece of paper to find better points
```

B. Plot the spectrum of Rrs for all available bands for the pixel

```
%%% Q6----plotting spectrum of Rrs

Rrs=[Rrs410(row,column) Rrs443(row,column) Rrs486(row,column)
Rrs551(row,column) Rrs671(row,column)];% this will display an array with all
rrs values using our chosen pixel.
disp(Rrs)
wavelength=[443 486 551 671 745]; %these values we can get from HDF viewer
under sensor band parameters (wavelength)
figure()
plot(wavelength, Rrs,'linewidth', 2.5) %run on command window
title('Spectrum of Rrs-Coastal');
xlabel('\lambda');
ylabel('Rrs');
```



C. VIIRS Chl algorithm is as previously discussed

1. Calculate Chl concentration for your pixel using VIIRS algorithm:

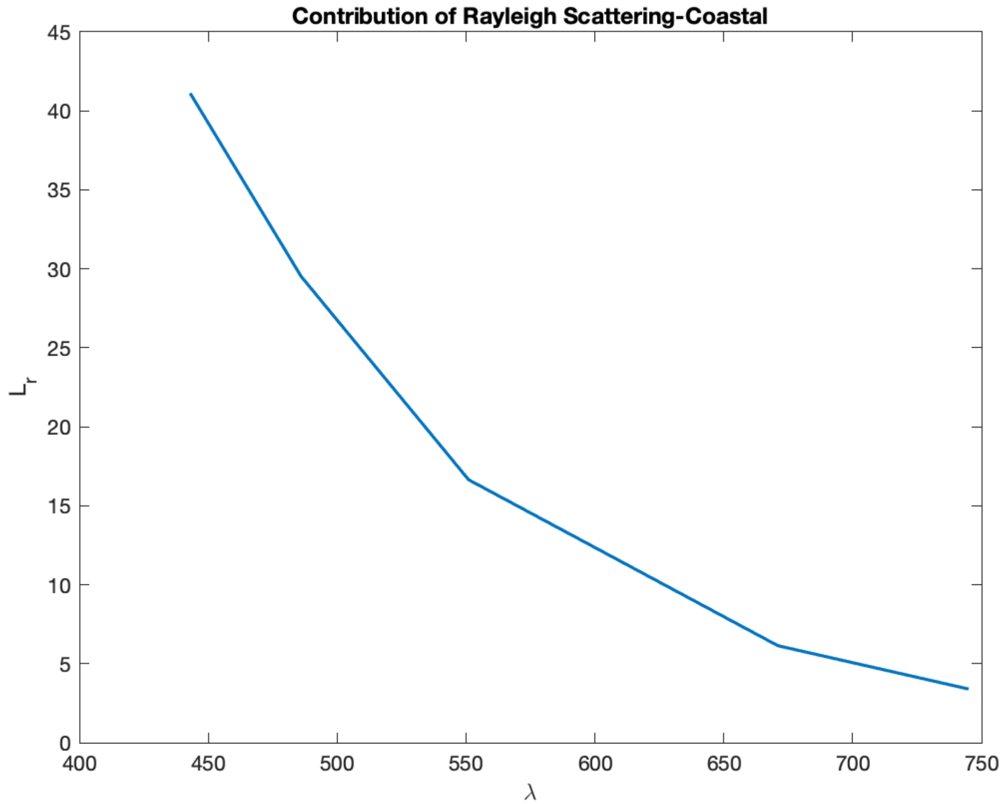
```
%%% Q7----calculation of chlo concentration

R443_551=Rrs443(row,column)/Rrs551(row,column); %given condition
disp(R443_551) %this gives us 1.397547857
R486_551=Rrs486(row,column)/Rrs551(row,column);
disp(R486_551)%this will give us 1.42206622
%since the bigger value is from R486_551, we use in the following formula
R_3v=log10(R486_551);
concentration=10.0.^(0.2228-2.4683*R_3v+1.5867*R_3v.^2-0.4275*R_3v.^3-
0.7768*R_3v.^4); %equation to calculate concentration
disp(concentration) %we get value of 0.75944905

%if we compare to the actual Chlorocx value as found from HDF Viewer, the
%difference is only by 0.8356 since 1.5963-0.7944
```

VII. Propagation of the Open Ocean data to the top of the atmosphere

A. Contribution of Rayleigh Scattering

```
%%% Q8----Contribution of Rayleigh scattering
format long %format to diplay complete values of usr F)(1,1), F0(2,1), etc
F0=[1902.14, 1987.74, 1841.22, 1504.5599, 1276.4299];%F0 data can be found in
sensor band parameter folder(HDF)
Tau_r=[0.23280, 0.16, 0.09738, 0.04395, 0.02865];
Lr=(F0.*Tau_r.*0.75)/(4.*pi.*cosd(50)); %equation for Rayleigh
disp(Lr)
%Results: 41.11585795,  29.53000105,  16.64789609,
%6.13977229,  3.39551378
%to better visualize, we can plot Lr vs lambda
figure()
```

```
plot(wavelength, Lr, 'linewidth', 1.5)
title('Contribution of Rayleigh Scattering-Coastal')
xlabel('\lambda')
ylabel('L_r')
```



B. Contribution of aerosol scattering

1. Determine aerosol optical thickness:

```
%%% Q9---Contribution of aerosol Scattering

%we now need to load angstrom and aot863 data
aot862=ncread(filename,'/geophysical_data/aot_862'); %this can be found in
geophysical data folder (aerosol optical thickness)
aot862=double(aot862);
angstrom=ncread(filename,'/geophysical_data/angstrom');
angstrom=double(angstrom);

%determine variables based on used pixel
aot862_pixel=aot862(row, column);
disp(aot862_pixel)%give a value of 0.10369999
angstrom_pixel=angstrom(row,column);
disp(angstrom_pixel)% gives a value of  1.29220003
```

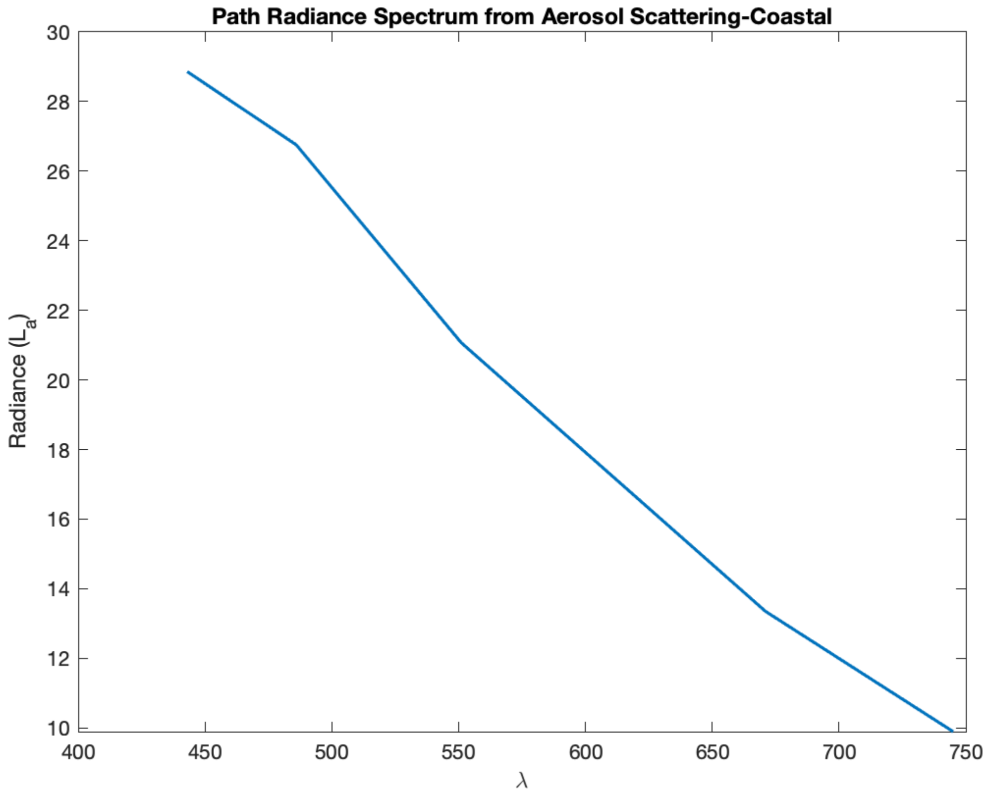
2. Determine aerosol optical thickness for other wavelengths as:

```
%determine the aerosol optical thickness for the wavelength

aerosol_thickness1=aot862_pixel.*(443/862).^-angstrom_pixel;%given that
τ_a=aot862
```

```
disp(aerosol_thickness1) %displays 0.245108486
aerosol_thickness2=aot862_pixel.*(486/862).^-angstrom_pixel;%wavelength 486
disp(aerosol_thickness2)%displays 0.21745522
aerosol_thickness3=aot862_pixel.*(551/862).^-angstrom_pixel;%wavelength 551
disp(aerosol_thickness3) %displays 0.18489499
aerosol_thickness4=aot862_pixel.*(671/862).^-angstrom_pixel;%wavelength 671
disp(aerosol_thickness4)%displays 0.143334388
aerosol_thickness5=aot862_pixel.*(745/862).^-angstrom_pixel;%wavelength 745
disp(aerosol_thickness5)%displays 0.125210543

all_aot=[aerosol_thickness1, aerosol_thickness2, aerosol_thickness3,
aerosol_thickness4, aerosol_thickness5];
disp(all_aot)
```

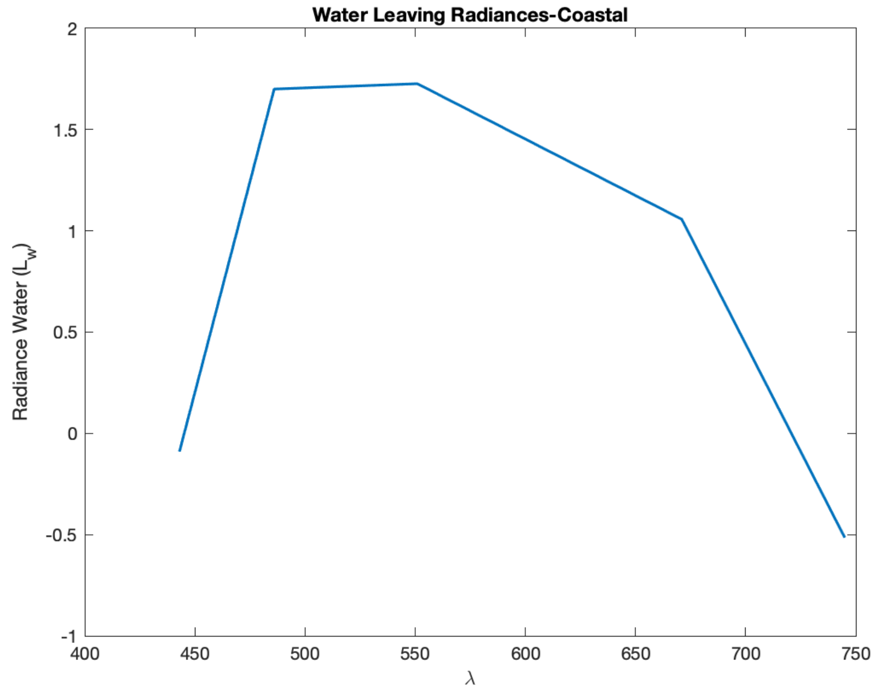
3. Determine the path radiance spectrum due to the aerosol scattering as:

```
%determining the path radiance spectrum due to aerosol scattering

%the given formula is:
% La( λi) = F0(λi) * τa (λi)*Pa/ (4*pi*cos(θv)) , 50 deg, Pa=0.5
La443=F0(1)*aerosol_thickness1*0.5/(4*pi*cosd(50));%keep in mind
τ_a=aerosol_thickness
La486=F0(2)*aerosol_thickness2*0.5/(4*pi*cosd(50));
La551=F0(3)*aerosol_thickness3*0.5/(4*pi*cosd(50));
La671=F0(4)*aerosol_thickness4*0.5/(4*pi*cosd(50));
La745=F0(5)*aerosol_thickness5*0.5/(4*pi*cosd(50));
La=[La443, La486, La551, La671, La745];
%La values:  28.8598101, 26.75605472, 21.07285949,
%13.349116502, 9.893057038

figure()
plot(wavelength, La, 'linewidth', 1.5)
title('Path Radiance Spectrum from Aerosol Scattering-Coastal')
xlabel('\lambda')
ylabel('Radiance (L_a)')
```



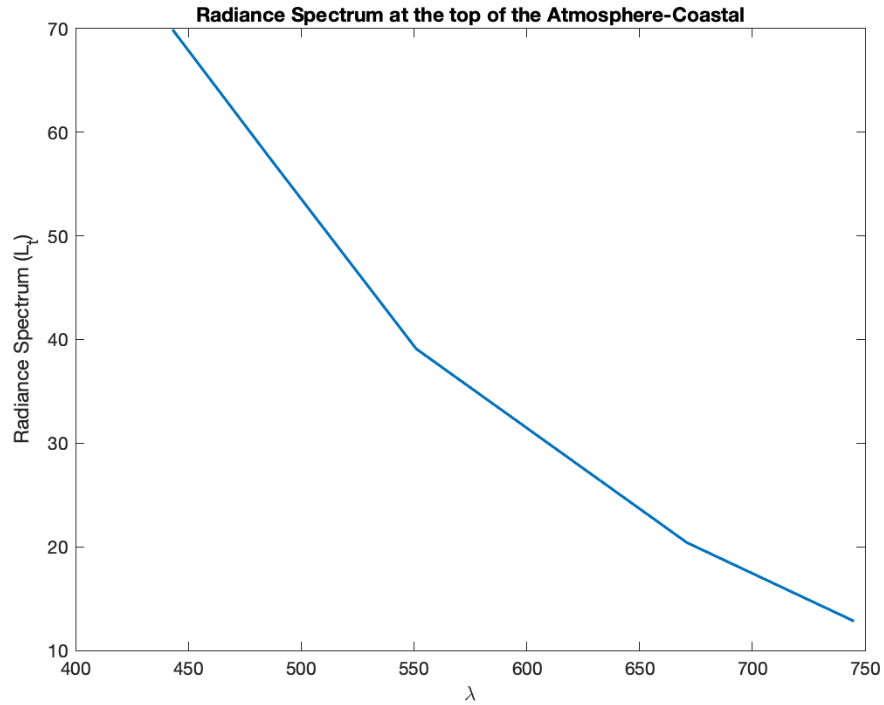
C. Load data of the center solar zenith angle (csol_z) and find the value csol_z for the pixel

```
%%%Q10-----Loading data from center solar zenith (csol_z). find its value for
%%%chosen pixel

csolz=ncread(filename,'/scan_line_attributes/csol_z'); %tau from sensor_band
folder in hdf view
csolz=double(csolz);
csolz_pixel=csolz(row, 1); %value from pixel, must not exceed 1 column
%value of csol_z pf the pixel is   32.8600006

%Transform surface Rrs values to water leaving radiances as:
%Lw(λi) = Rrs(λi)*F0(λi)* csol_z *exp(-(Tau_r + τa (λi))/csol_z);
Lw443=Rrs(1).*F0(1)* cosd(csolz_pixel)
*exp(-(Tau_r(1)+aerosol_thickness1)/ cosd(csolz_pixel));
Lw486=Rrs(2).*F0(2)* cosd(csolz_pixel)
*exp(-(Tau_r(2)+aerosol_thickness2)/ cosd(csolz_pixel));
Lw551=Rrs(3).*F0(3)* cosd(csolz_pixel)
*exp(-(Tau_r(3)+aerosol_thickness2)/ cosd(csolz_pixel));
Lw671=Rrs(4).*F0(4)* cosd(csolz_pixel)
*exp(-(Tau_r(4)+aerosol_thickness2)/ cosd(csolz_pixel));
Lw745=Rrs(5).*F0(5)* cosd(csolz_pixel)
*exp(-(Tau_r(5)+aerosol_thickness2)/ cosd(csolz_pixel));
Lw=[Lw443, Lw486, Lw551, Lw671, Lw745];

%the values for Lw are:  -0.090454489932129   1.700279319153863
1.726613674612160   1.057312632498294  -0.515133894483801
figure()
plot(wavelength,Lw,'linewidth',1.5)
title('Water Leaving Radiances-Coastal')
xlabel('\lambda')
ylabel('Radiance Water (L_w)')
```



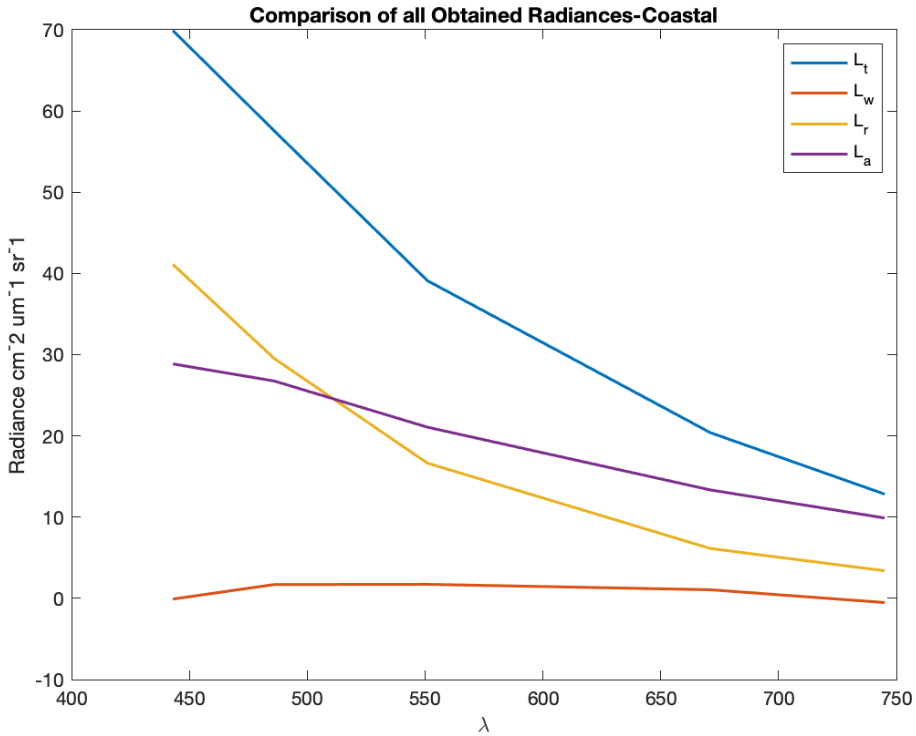
D. Determine the radiance spectrum Lt at the top of the atmosphere for the pixel

```
%%% Q11----- Determine the radiance spectrum Lt at the top of the atmosphere
for your pixel as

%Lt(λi) = Lr(λi) + La(λi) + Lw(λi) *ti,
%ti = exp(-(Tau_r(λi)+ τ (λi))/2cos(θv))
Lt443=Lr(1)+La(1)+Lw(1).*exp(-(Tau_r(1)+aerosol_thickness1)/(2*cosd(50)));
Lt486=Lr(2)+La(2)+Lw(2).*exp(-(Tau_r(2)+aerosol_thickness2)/(2*cosd(50)));
Lt551=Lr(3)+La(3)+Lw(3).*exp(-(Tau_r(3)+aerosol_thickness3)/(2*cosd(50)));
Lt671=Lr(4)+La(4)+Lw(4).*exp(-(Tau_r(4)+aerosol_thickness4)/(2*cosd(50)));
Lt745=Lr(5)+La(5)+Lw(5).*exp(-(Tau_r(5)+aerosol_thickness5)/(2*cosd(50)));
Lt=[Lt443, Lt486, Lt551, Lt671, Lt745];

%the values for Lt are:    69.9132971473534O4  57.5537307646349l3
39.106990134380624  20.402864805317751  12.831542849469034
figure()
plot(wavelength, Lt, 'linewidth', 1.5)
title('Radiance Spectrum at the top of the Atmosphere-Coastal')
xlabel('\lambda')
ylabel('Radiance Spectrum (L_t)')
```

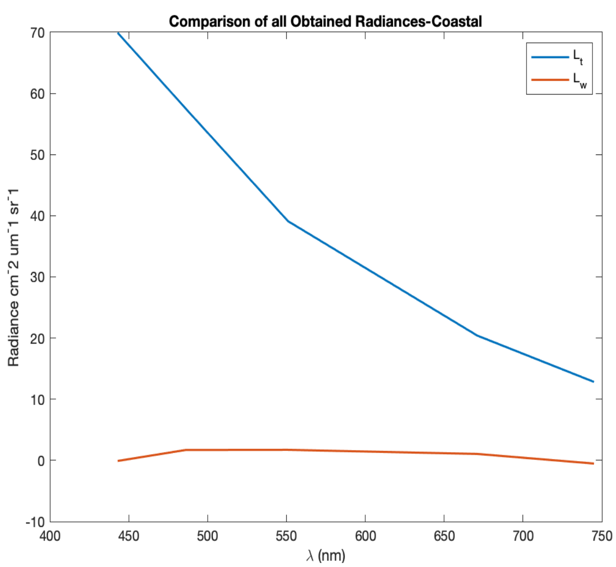


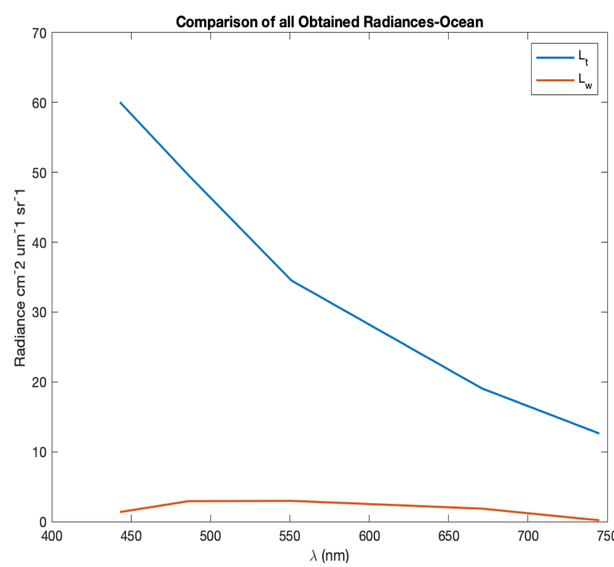
E. Plot Spectra of Lt(λ), Lw(λ), Lr(λ), La(λ)) for your pixel and evaluate the contribution of all components to the total TOA radiance Lt(λ).

```
%%% Q12----Plot spectra of Lt(λ), Lw(λ), Lr(λ), La(λ)) for your pixel and
evaluate the contribution of all components to the total TOA radiance Lt(λ).
figure()
plot(wavelength, Lt, 'linewidth', 1.5)
hold on
plot(wavelength, Lw, 'linewidth', 1.5)
hold on
plot(wavelength, Lr, 'linewidth', 1.5)
hold on
plot(wavelength, La, 'linewidth', 1.5)
title('Comparison of all Obtained Radiances-Coastal')
xlabel('\lambda')
ylabel('Radiance cm^-2 um^-1 sr^-1')
legend('L_t','L_w','L_r','L_a')
```



F. Compare the Spectra Lt(λ) and Lw(λ) for these two pixels





Comparing these two Radiances, we can see that there is actually a slightly difference in Lw, meanwhile Lt is greater at the Coastal pixel compared to the Ocean pixel.