Practical 8 Reliable Oceanographic Data Sources: Introduction to Sea State And Wind Wave Characterization

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CONTENTS

Introduction

This document summarizes the content of the practical lesson and provides the instructions to follow the practical exercise. The document contains a brief description of the dataset used in the exercise. The link and instructions to download the data from the official provider (https://cds.climate.copernicus.eu). Additionally, this instruction sheet contains the Matlab code used in the exercise for mean and extreme wave characterization.

The use of this guide will facilitate the practical lesson and it is recommended keep it open and/or printed.

Through the instruction sheet the students will found four MC question. The students should provide the answer at the end of the practical lesson. The answer will be based on the outputs of the code, but to answer the question they will be requested to rewrite part of the code with the guidance of the tutors.

Aims of the practical lesson

The practical lesson aims to introduce the student to the sea state and wind wave characteristics. The practical introduces the statistics for the analysis of the wind waves for the mean and extreme wave climate characterization and using the main publically available wave data repositories. During the practical lesson the student will learn how to:

-Login and locate wave data from the Copernicus climate portal.

-Download wave data from the Copernicus climate portal corresponding to the ERA5 reanalysis

-Basic processing of the netcdf files to prepare data to be used for wave climate characterization. Visualization, extraction of subsets, concatenate files, etc.

-Compute basic statistics for the mean wave characterization including wave energy flux for a given spatial domain.

-Extraction of time series in some locations for the different wave parameters

-Characterization and representation of the mean wave climate from the wave time series

-Characterization and representation of the extreme wave climate from the wave time series

Dataset and data provider

The dataset used in this practical corresponds to the wave characteristics of the ERA5 reanalysis. **ERA5** is the fifth generation ECMWF reanalysis for the global climate and weather for the past 4 to 7 decades. Currently data is available from 1950, split into Climate Data Store entries for 1950-1978 (preliminary back extension) and from 1979 onwards (final release plus timely updates, this page). ERA5 replaces the ERA-Interim reanalysis (https://cds.climate.copernicus.eu/). The main characteristics of the dataset are summarized in the Table 1.

Since the length of the time series requested of the wave climate analysis is long and the amount of data to be requested and downloaded is considerable. In order to avoid delay in the download and data request. The wave dataset has been provided in **the folder DATA inside the zip folder SEAeuMDLcoursePS8.**

Table 1. Main characteristics of the ERA5 reanalysis (https://cds.climate.copernicus.eu/).

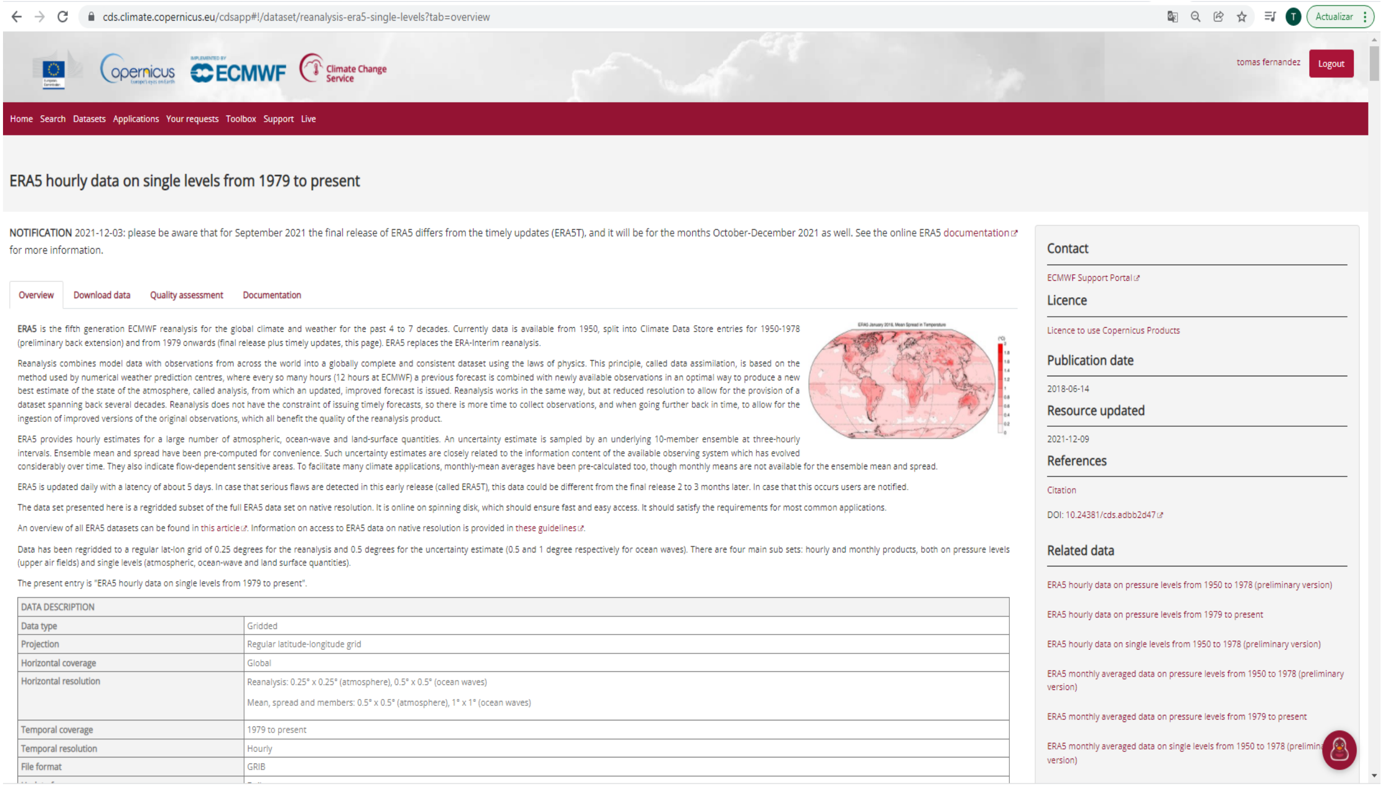
DATA DESCRIPTION	
Data type	Gridded
Projection	Regular latitude-longitude grid
Horizontal coverage	Global
Horizontal resolution	Reanalysis: 0.25° x 0.25° (atmosphere), 0.5° x 0.5° (ocean waves) Mean, spread and members: 0.5° x 0.5° (atmosphere), 1° x 1° (ocean waves)
Temporal coverage	1979 to present
Temporal resolution	Hourly
File format	GRIB
Update frequency	Daily

The Copernicus Earth Observation Program of the European Union provides climate data and information through the Climate Data Store of the Climate Data Service. The climate Data Store is a freely available service to provide a wide range of climate data including past period and future projections for the different climate change scenarios. Additionally, the system provides the CDS Toolbox. This Toolbox allows the use of raw data to cloud computing through a programming interface. This system allow you create your applications and script in Python and run them on the CDS computers (https://cds.climate.copernicus.eu/toolbox/doc/index.html).

Data request and download

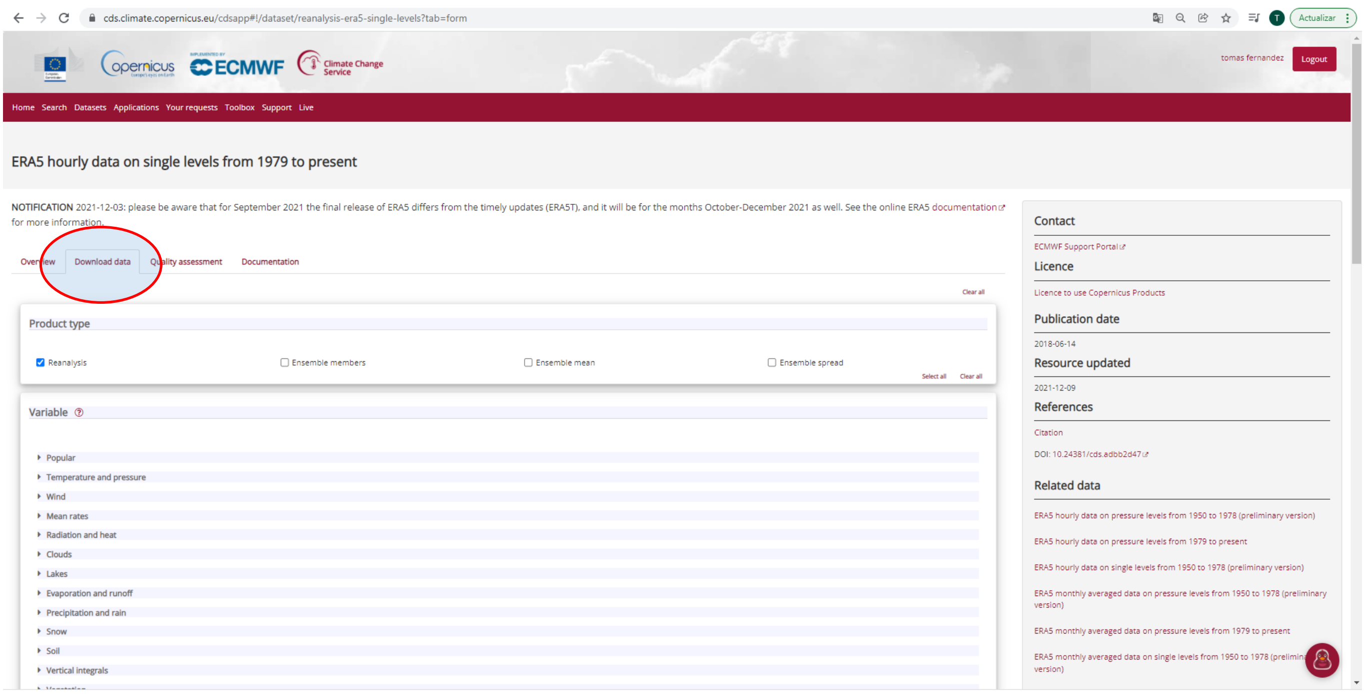
Logging in CDS using your credentials and locate the reanalysis ERA5 on single levels

https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=form

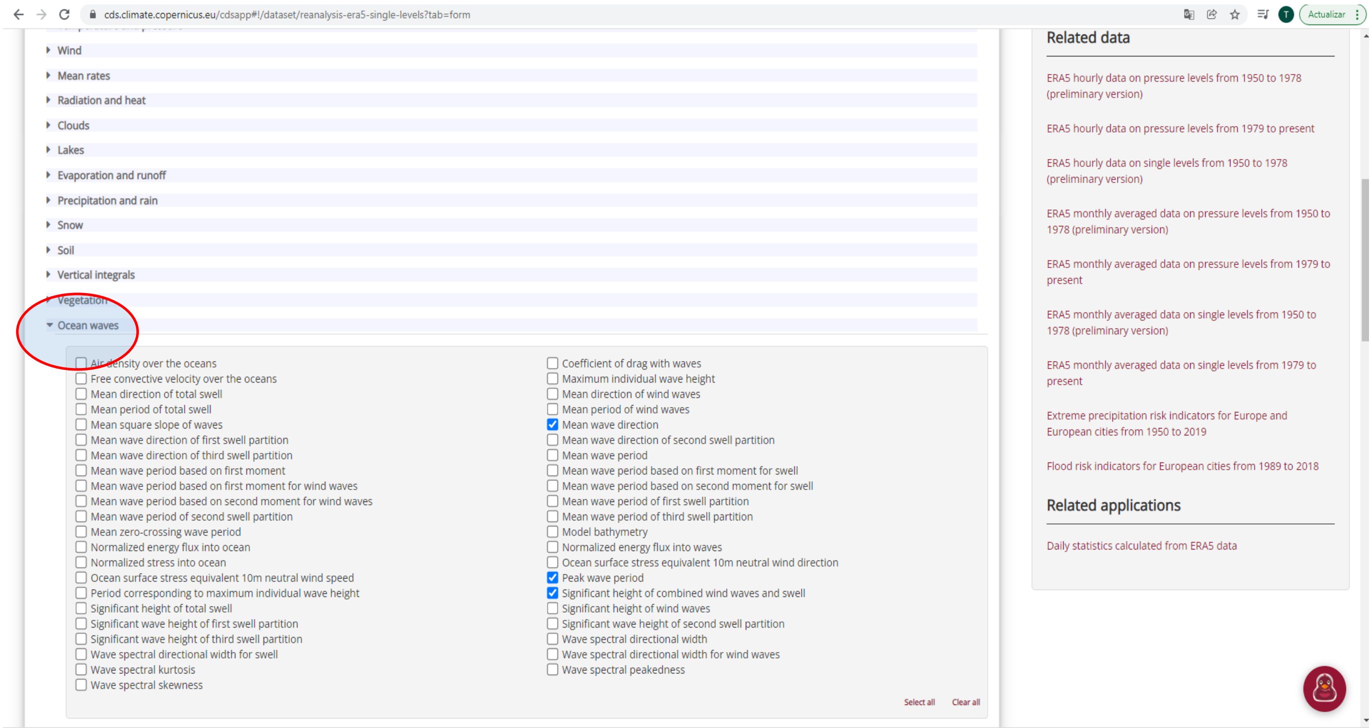


Tab overview summarize the main characteristics of the ERA5

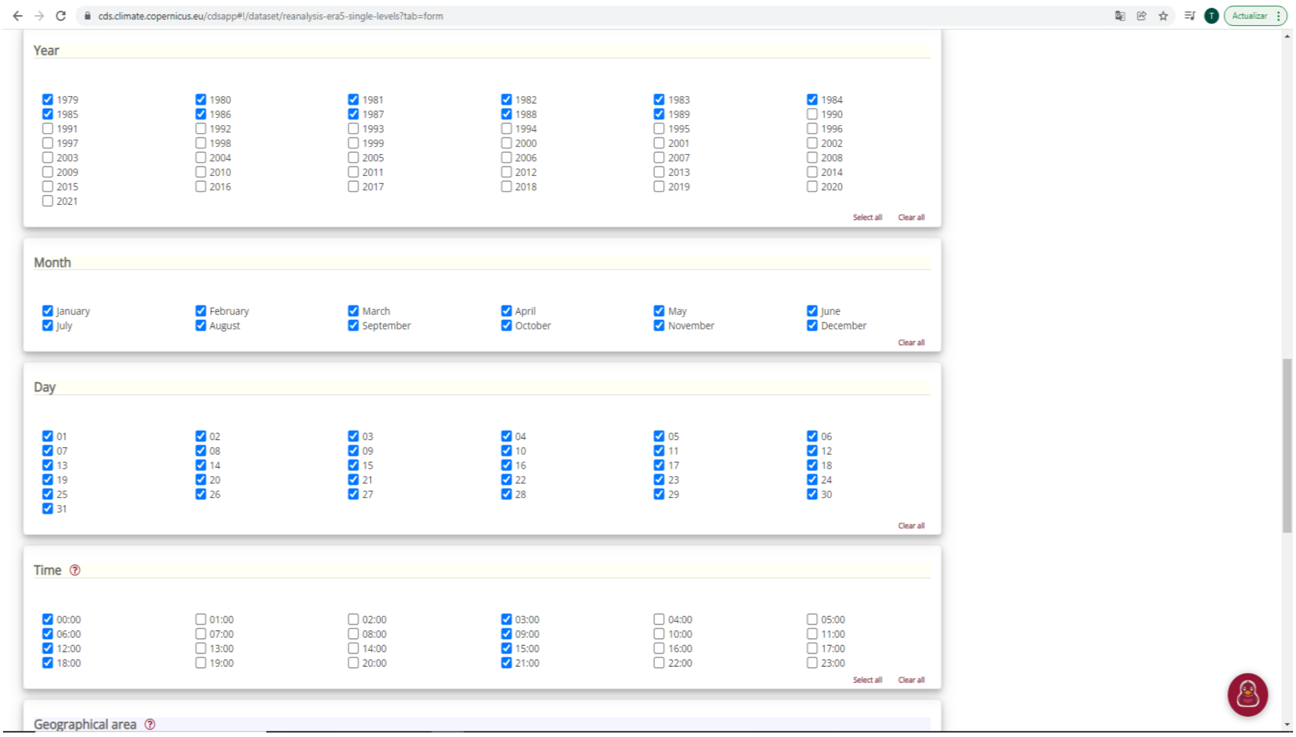
Move to the Tab Download data



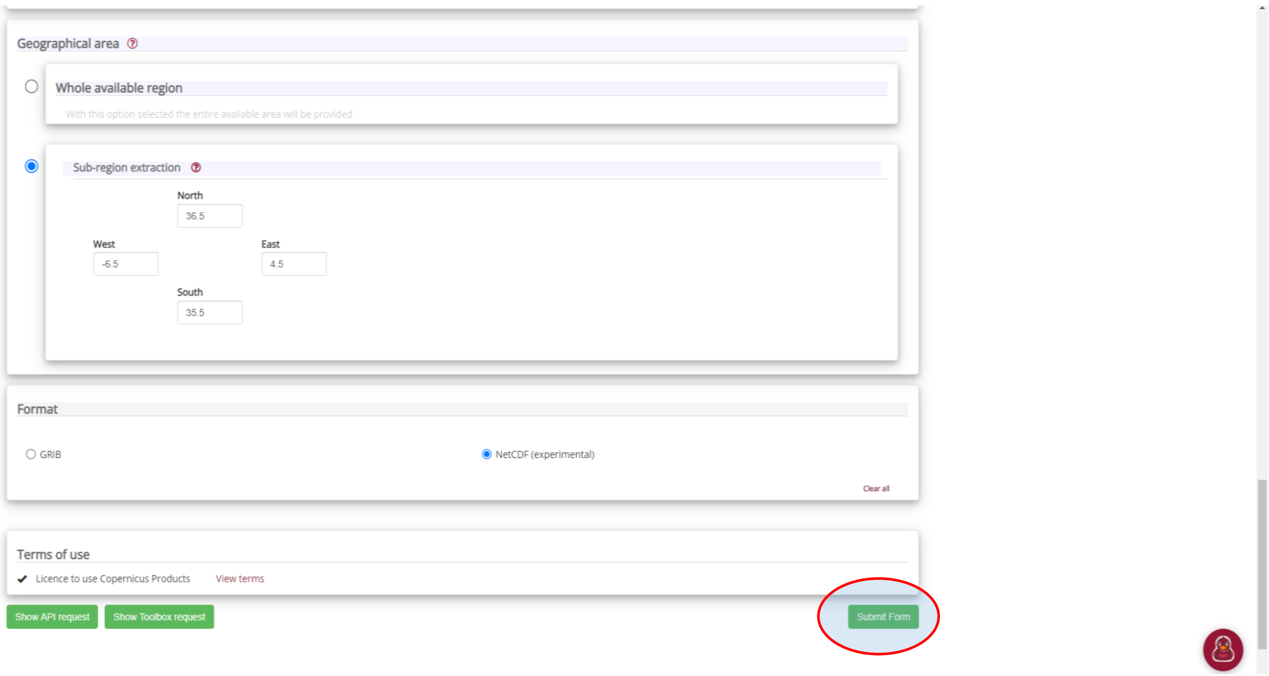
In the field variable open Ocean Waves and Select the requested variables Mean wave direction Peak wave period and Significant height of combined wind waves and swell



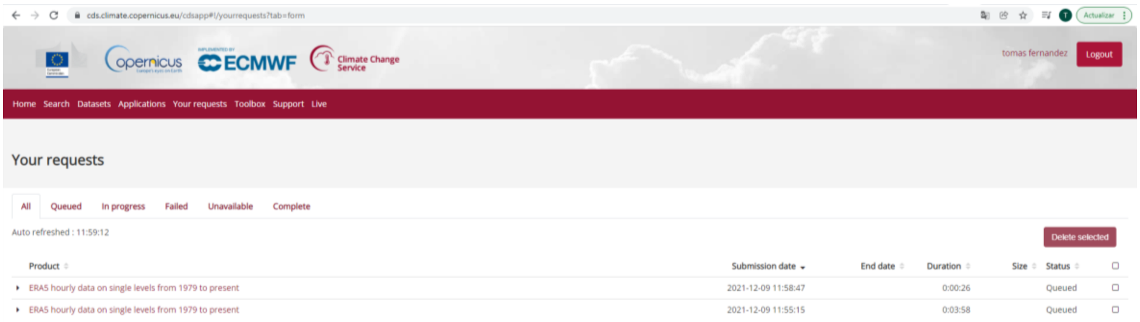
Select the temporal coverage and frequency of wave data

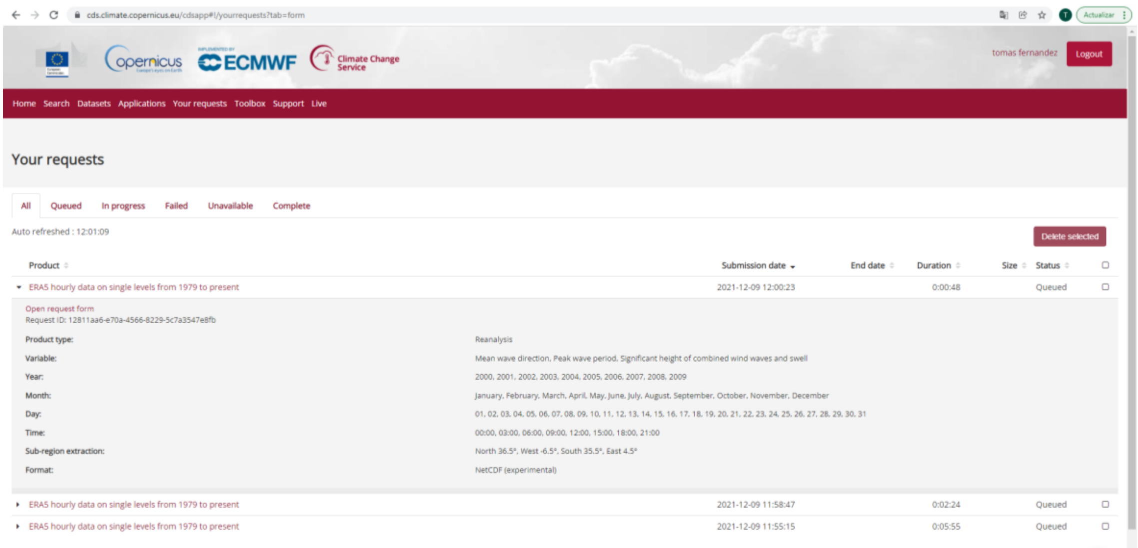


Select the Geographical area by longitude and latitude window and mark file format (netcdf) and Press submit form to submit your request



Then you can see your request and explore the details, the status of your request. When the request is delivered you can download it





IMPORTANT REMARK: The registration should be done BEFORE the practical session.

Software and data requirements

Before the practical lesson the student should have installed and tested the software and script requested.

Software: the full version of Matlab should be installed. Include all the toolbox during the installation. Install trial version or full academic if it is allowed for your university. Trial version 2021b has been tested.

Script: the code to be used in the practical session has been included in the folder **SCRIPT inside the zip folder SEAeuMDLcoursePS8.** The student should unzip the folder tsEva-01_R2014bsted that contains the matlab toolbox for extreme value analysis (EVA). This toolbox can be downloaded from https://github.com/menta78/tsEva/archive/0.1_R2014b.zip

compass2cart	02/15/2019 12:53 PM	MATLAB Code	1 KB
density2scatter	10/31/2018 12:37 PM	MATLAB Code	2 KB
DistribucionNPuntos	11/23/2011 5:14 PM	MATLAB Code	1 KB
PS8_WAVE_CLIMATE	12/10/2021 8:02 PM	MATLAB Code	17 KB
tsEva-0.1_R2014b	09/19/2017 4:28 PM	zip Archive	5,118 KB
WindRose	04/02/2016 7:19 AM	MATLAB Code	18 KB

IMPORTANT REMARK: The software installation and software testing should be done BEFORE the practical session.

Characterization of wave climate

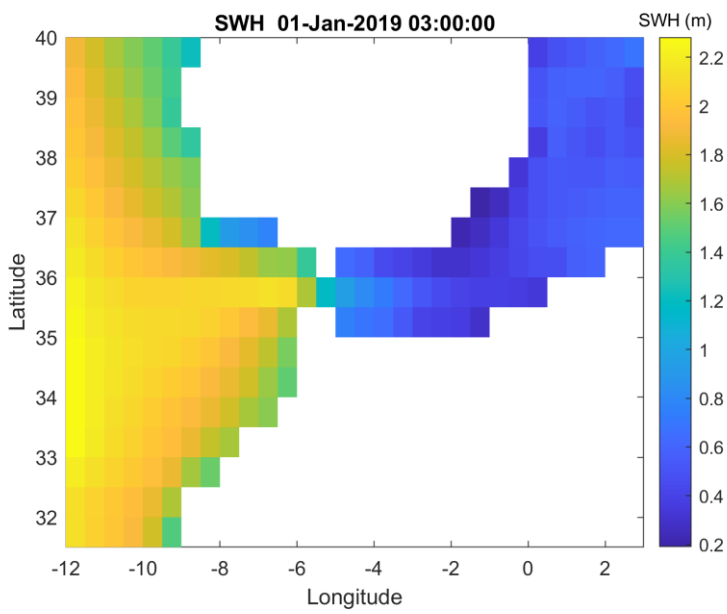
Initialize Matlab and open the main script "PS8_WAVE_CLIMATE.m"

Add the path of the folder and subfolder and change directory to the data folder

```
%add path to the directory with the matlab rutines and script provided and generate the path for
the subfolder
%CHANGE to your own path
addpath(genpath('C:\Users\Tomas\Documents\DOCENCIA\SEAeu\SEAeuMDLcoursePS8'))
% Change directory to the data folder
cd C:\Users\Tomas\Documents\DOCENCIA\SEAeu\DATA %CHANGE to your own path
```

Inspection of a netcdf file in matlab and plot the field of significant wave height (SWH)

```
%Inspection of file contents
%file info
finfo=ncinfo('r_ERA5_UVP_20190101.nc')
%Read and plot SWH
filen=fullfile('2019','r_ERA5_UVP_20190101.nc');
lon=ncread(filen,'longitude');
lat=ncread(filen,'latitude');
time=ncread(filen,'time');
t_unit=ncreadatt(filen,'time','units');
tjul=(time/24)+datenum(t_unit(13:end-2),'yyyy-mm-dd HH:MM:SS');
swh=ncread(filen,'swh');
%plot swh
pcolor(lon,lat,swh(:,:,2)');shading flat;
%set plot labels
title(['SWH  ', datestr(tjul(2))]);
xlabel('Longitude');
ylabel('Latitude');
%set colorbar
hc=colorbar;
title(hc,'SWH (m)')
%Define filename and resolution for the figure
fileNameImage='SWH_example'% indicate the filename
resImage='-r300'%Indicate the resolution dpi
%Save the image
print('-dpng',resImage, fileNameImage)
```



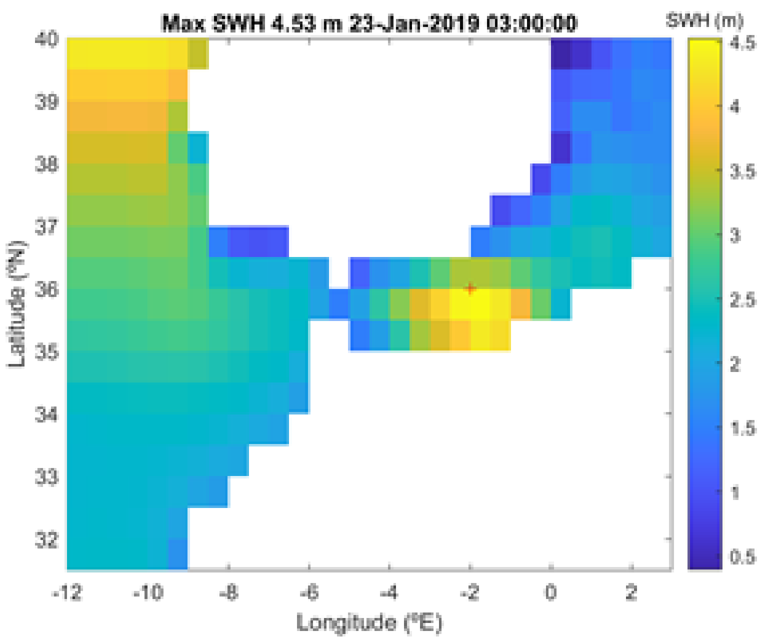
Read and plot a given date

QUESTION

1) Calculate the minimum of the swh filed for 20.01.2019 at 9 h

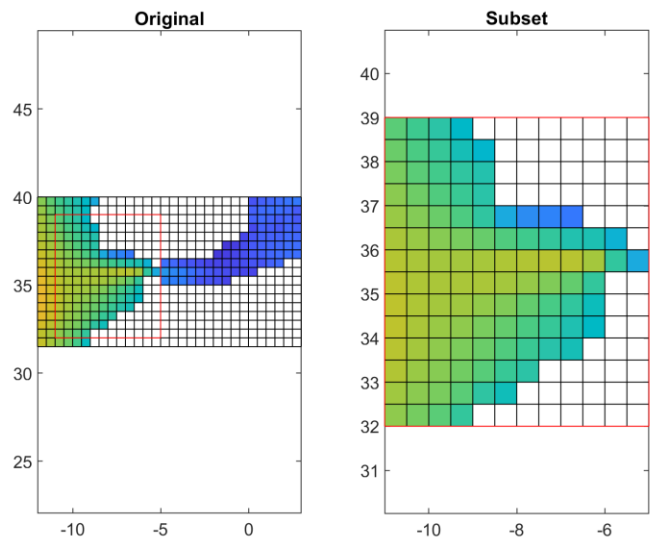
```
% Read and plot a given date
dat_in='2019-01-23 03:00:00'
[val,in]= min(abs(tjul-datenum(dat_in,'yyyy-mm-dd HH:MM:SS')))
figure;
pcolor(lon,lat,swh(:,:,in)');shading flat;
hold on; %allows plot on top
%calculate the max of SWH in the area for the wiven date
dmap=squeeze(swh(:,:,in))';%Extract slice from 3D matrix correspoding to dat_in
SWHmax=max(dmap(:));%Calculate the maximum
% find the location of the maximum SWH
[X,Y]=meshgrid(lon,lat);
locMax=[X(find(dmap(:)==SWHmax))  Y(find(dmap(:)==SWHmax)) ]
plot(locMax(1),locMax(2),'+r')
%set plot labels
title(['Max SWH ',num2str(nanmax(SWHmax),'% 10.2f'),' m ' ,datestr(tjul(in))]);
xlabel('Longitude (°E)')
ylabel('Latitude (°N)')
```

```
%set colorbar
hc=colorbar
title(hc,'SWH (m)')

%Define filename and resolution for the figure
fileNameImage='SWH_example2'% indicate the filename
resImage='-r300'%Indicate the resolution dpi
%Save the image
print('-dpng',resImage, fileNameImage)
```



Extract a subset and concatenate swh wave field for the full period 2010-2020

```
clear all; %clean workspace
close all; %close all figures
%Read lon and lat filed
filen=fullfile('2019','r_ERA5_UVP_20190101.nc')
lon=ncread(filen,'longitude');
lat=ncread(filen,'latitude');
swh=ncread(filen,'swh');

LonlatWindw=[-11 -5 32 39];
%SEARCH ALTYMETRY IN LAT LON WINDOW
        posLo=find(lon>=LonlatWindw(1)&lon<=LonlatWindw(2));
        posLa=find(lat>=LonlatWindw(3)&lat<=LonlatWindw(4));
%Check subset
 figure;
 subplot(1,2,1)% prepare figure with two horizontal panel (left panel)
pcolor(lon,lat,swh(:,:,1)');axis equal;hold on
%plot selected window
plot([LonlatWindw(1) LonlatWindw(2) LonlatWindw(2) LonlatWindw(1) LonlatWindw(1)],
...
     [LonlatWindw(3) LonlatWindw(3) LonlatWindw(4) LonlatWindw(4) LonlaWindw(3)],'r')
%modify color scale
caxis([0 3])
%insert title
title('Original')
 subplot(1,2,2)% prepare figure with two horizontal panel (right panel)
pcolor(lon(posLo),lat(posLa),swh(posLo,posLa,1)');axis equal;hold on
plot([LonlatWindw(1) LonlatWindw(2) LonlatWindw(2) LonlatWindw(1) LonlatWindw(1)],
...
     [LonlatWindw(3) LonlatWindw(3) LonlatWindw(4) LonlatWindw(4) LonlaWindw(3)],'r')

caxis([0 3]) %
 title('Subset')
%Define filename and resolution for the figure
fileNameImage='SWH_subset'% indicate the filename
resImage='-r300'%Indicate the resolution dpi
%Save the image
print('-dpng',resImage, fileNameImage)
```



```
% Extract subset and concatenate variables for the whole period
fl=dir('20*')%store the names of directories with that contain the data
swhAll=[]
timeAll=[];
for i=1:length(fl)
  fn= dir (fullfile(fl(i).name,'*.nc'))% store the names of the *.nc files of each
directory
  for j=1:length(fn)

     filen= fullfile(fl(i).name,fn(j).name);
if i==1 & j==1
lon=ncread(filen,'longitude');
lat=ncread(filen,'latitude');
end
time=ncread(filen,'time');
t_unit=ncreadatt(filen,'time','units');
tjul=(time/24)+datenum(t_unit(13:end-2),'yyyy-mm-dd HH:MM:SS');
swh=ncread(filen,'swh');

[m,n,o]=size(swhAll);
swhAll(:,:,o+1:o+length(tjul))=[swh(posLo,posLa,:)];
timeAll=[timeAll;tjul];
  end
end
swhAll=swhAll(:,:,2:end); %remove first field zeros added in first iteration
```

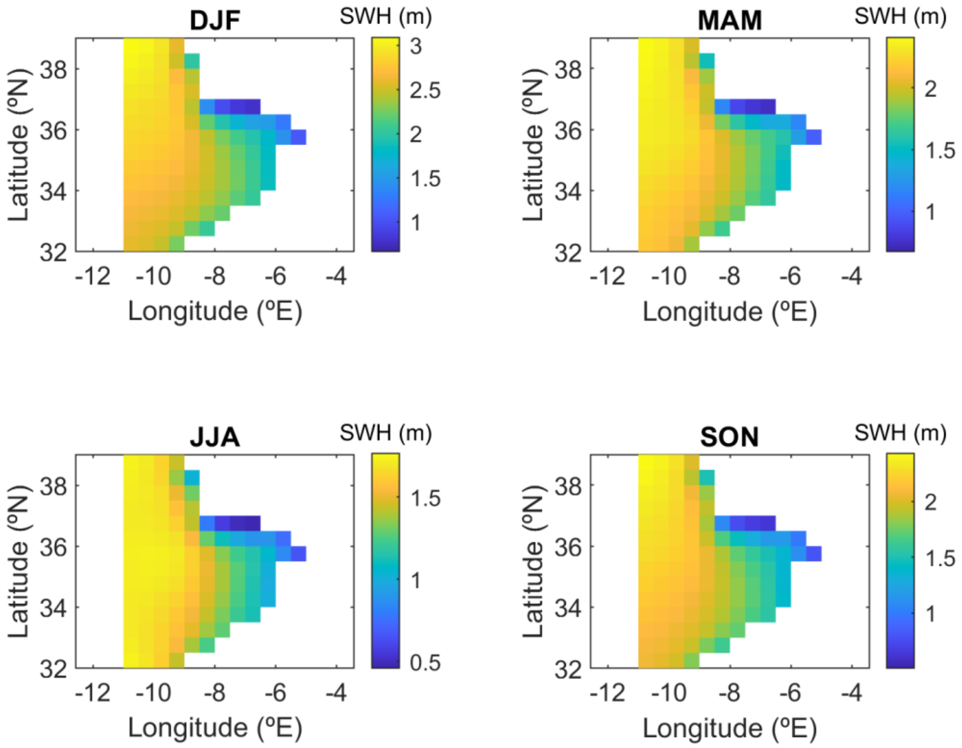
Mean wave climate: Seasonal Variation

QUESTION

2) Calculate the median of the 99 percentile of the mean wave period for Summer season for the same subset

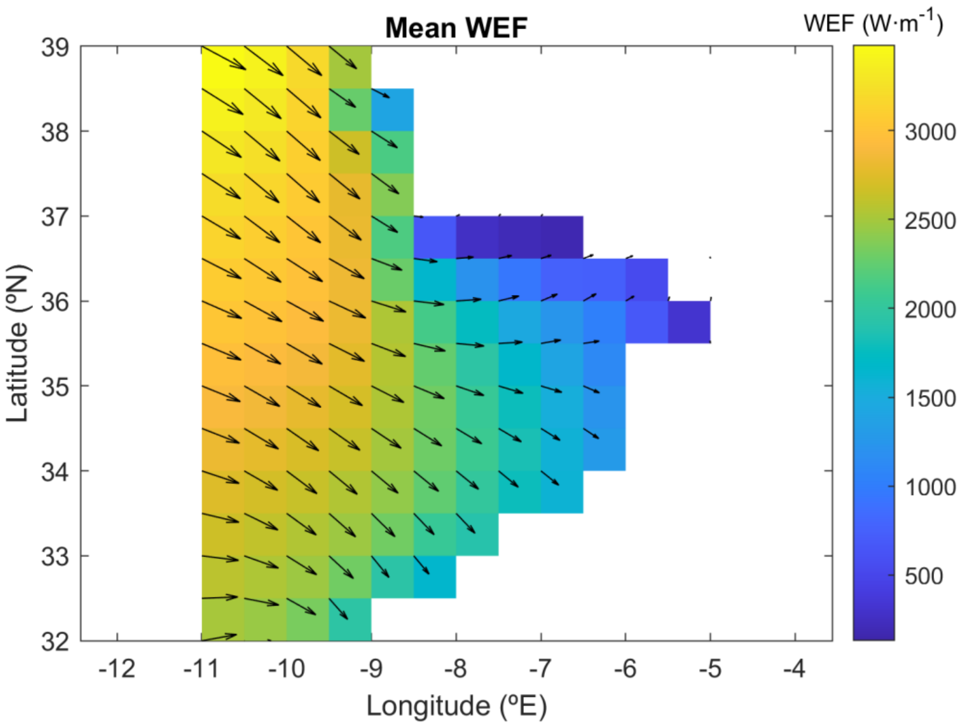
```
%% MEAN WAVE CLIMATE%%
% Basic Statistics
max_SWH = max(swhAll, [], 3);
min_SWH = min(swhAll,[], 3);
mean_SWH = mean(swhAll, 3);
med_SWH = median(swhAll, 3);
P99_SWH=prctile(swhAll,99,3);

% SEASONAL WAVE CLIMATE
tvec=datevec(timeAll);
SeasoN(1).Pos=find(tvec(:,2)==12 | tvec(:,2)==1 | tvec(:,2)==2);SeasoN(1).Label='DJF';%Winter:DJF
SeasoN(2).Pos=find(tvec(:,2)==3 | tvec(:,2)==4 | tvec(:,2)==5);SeasoN(2).Label='MAM';%Spring:MAM
SeasoN(3).Pos=find(tvec(:,2)==6 | tvec(:,2)==7 | tvec(:,2)==8);SeasoN(3).Label='JJA';%Summer:JJA
SeasoN(4).Pos=find(tvec(:,2)==9 | tvec(:,2)==10 | tvec(:,2)==11);SeasoN(4).Label='SON';%Autumm:SON
%Get limits for colorbar
for i=1:length(SeasoN);
  data=swhAll(:,:,SeasoN(i).Pos);
  posmat = mean(data,3);
  colorL(i,:)=[min(posmat(:)) max(posmat(:))];
end
 colorL= [min(colorL(:))   max(colorL(:))];
figure;
setColorLim=0% 0 set automatic color / 1 use color range
for i=1:length(SeasoN);
  data=swhAll(:,:,SeasoN(i).Pos);
  posmat = mean(data,3);
  subplot(2,2,i);
    pcolor(lon(posLo),lat(posLa),posmat');shading flat;axis equal
xlabel('Longitude (°E)');
ylabel('Latitude (°N)');
```

```
hc=colorbar
if setColorLim==1;
caxis(colorL);
end
title(hc,'SWH (m)')
title(SeasoN(i).Label)
end
%Define filename and resolution for the figure
fileNameImage='Seasonal_SWH% indicate the filename
resImage='-r300'%Indicate the resolution dpi
%Save the image
print('-dpng',resImage,fileNameImage)
```



Calculate the mean wave energy flux

```
%% WAVE ENERGY FLUX
%WEF=((1025*9.81)/(64*pi))*mwpAll.*swhAll.^2
% Extract subset of Mean Wave Periodand concatenate variables for the whole period
fl=dir('20*')%store the names of directories with that contain the data
mwpAll=[]
mwdAll=[]
for i=1:length(fl)
  fn= dir (fullfile(fl(i).name,'*.nc'))% store the names of the *.nc files of each
directory
  for j=1:length(fn)
     filen= fullfile(fl(i).name,fn(j).name);
mwp=ncread(filen,'mwp');
mwd=ncread(filen,'mwd');
time=ncread(filen,'time');
t_unit=ncreadatt(filen,'time','units');
tjul=(time/24)+datenum(t_unit(13:end-2),'yyyy-mm-dd HH:MM:SS');
[m,n,o]=size(mwpAll);
mwpAll(:,:,o+1:o+length(tjul))=[mwp(posLo,posLa,:)];
mwdAll(:,:,o+1:o+length(tjul))=[mwd(posLo,posLa,:)];
  end
end
mwpAll=mwpAll(:,:,2:end); %remove first field zeros added in first iteration
mwdAll=mwdAll(:,:,2:end); %remove first field zeros added in first iteration
%WEF=((1025.*9.81)./(64.*pi))*mwpAll.*swhAll.^2;
[m,n,o]=size(mwpAll)
for i=1:o
  WEF(:,:,i) = ((1025.*9.81)./(64.*pi)).*mwpAll(:,:,i).*swhAll(:,:,i).^2;
end
mean_WEF = mean(WEF,3);
mean_mwdAll=mean(mwdAll,3);
%Transform compass in to Cartesian coordinates
theta=[mean_mwdAll(:)];
rho=[mean_WEF(:)];
for i=1:length(rho)
 [um,vm] = compass2cart(theta(i),rho(i));
 if ~isempty(um)
 UV(i,:)=[um vm];
 else
    UV(i,:)=[NaN NaN]
 end
end
Uswh=reshape(UV(:,1),size(mean_WEF));
Vswh=reshape(UV(:,2),size(mean_WEF));
figure
pcolor(lon(posLo),lat(posLa),mean_WEF');shading flat;axis equal%Plot magnitude
hold on
quiver(lon(posLo),lat(posLa),-Uswh',-Vswh','k')%Plot vector for MWF direction;
title('Mean WEF');
xlabel('Longitude (°E)')
ylabel('Latitude (°N)')
%set colorbar
hc=colorbar
title(hc,'WEF (W·m^{-1})')
%Define filename and resolution for the figure
fileNameImage='Mean_WaveEnergyFlux'% indicate the filename
resImage='-r300'%Indicate the resolution dpi
%Save the image
print('-dpng',resImage,fileNameImage)
```

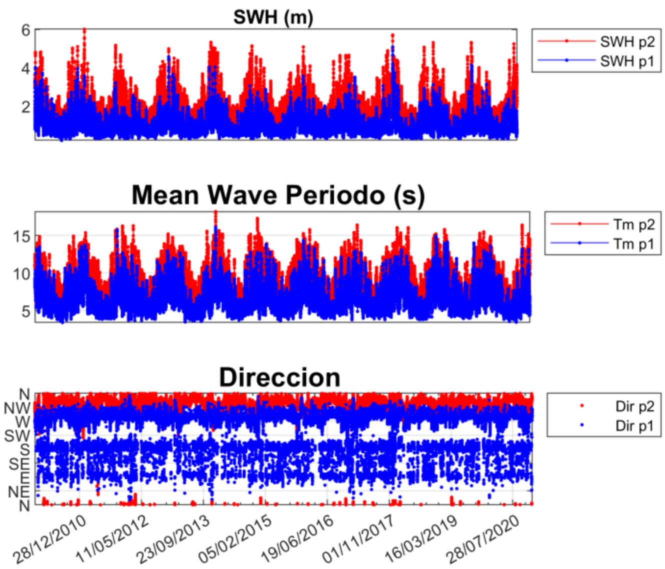


Extract time series in some locations to compute mean wave climate

```
%% WORKING WITH TIME SERIES
%Extract time series of two coastal point
%Define points locations
p1=[-5.8 36.2] %Spain;
p2=[-9 33] %Morroco;
xy=[p1;p2]
%Linear interpolation of wave characteristics into the location included in xy
for i=1:o
  swhPoints(i,:)= griddata(double(lon(posLo)),double(lat(posLa)),swhAll(:,:,i)',xy(:,1),xy(:,2));
  mwdPoints(i,:)= griddata(double(lon(posLo)),double(lat(posLa)),mwdAll(:,:,i)',xy(:,1),xy(:,2));
  mwpPoints(i,:)= griddata(double(lon(posLo)),double(lat(posLa)),mwpAll(:,:,i)',xy(:,1),xy(:,2));
end
```

Plot the time series of SWH, mean wave period (MWP) y mean wave direction (MWD).

```
% plot time series
figure
%plot SWH
subplot(3,1,1);
plot(timeAll,swhPoints(:,2),'.-r');hold on;
plot(timeAll,swhPoints(:,1),'.-b');hold on;
title(['SWH (m) '],'FontName','Arial','fontweight','bold','fontsize',10,'color','k');
axis([timeAll(1) timeAll(end) min(swhPoints(:)) max(swhPoints(:))])
datetick('x','dd/mm/yyyy','keeplimits','keepticks');
set(gca,'XMinorTick','on')
set(gca,'XTick',[])
legend('SWH p2' , 'SWH p1','Location','northeastoutside')
%plot MWP
subplot(3,1,2);
plot(timeAll,mwpPoints(:,2),'.-r');hold on;
plot(timeAll,mwpPoints(:,1),'.-b');hold on;
title(['Mean Wave Periodo (s) '],'FontName','Arial','fontweight','bold','fontsize',14,'color','k');
axis([timeAll(1) timeAll(end) min(mwpPoints(:)) max(mwpPoints(:))])
datetick('x','dd/mm/yyyy','keeplimits','keepticks');
set(gca,'XMinorTick','on')
legend('Tm p2','Tm p1','Location','northeastoutside')
    grid on
    set(gca,'XTick',[])
%plot MWD
subplot(3,1,3);
% plot(date_num,SprTp,'.-g');hold on;
plot(timeAll,mwdPoints(:,2),'.r');hold on;
plot(timeAll,mwdPoints(:,1),'.b');hold on;
title(['Direccion '],'FontName','Arial','fontweight','bold','fontsize',14,'color','k');
axis([timeAll(1) timeAll(end) 0 360])
datetick('x','dd/mm/yyyy','keeplimits','keepticks');
set(gca,'Ytick',(0:45:360),'YtickLabel',{'N','NE','E','SE','S','SW','W','NW'});
set(gca,'XMinorTick','on')
legend('Dir p2','Dir p1','Location','northeastoutside')
grid on

%Define filename and resolution for the figure
fileNameImage='SWH_timeSeries'% indicate the filename
resImage='-r300'%Indicate the resolution dpi
%Save the image
print('-dpng',resImage,fileNameImage)
```

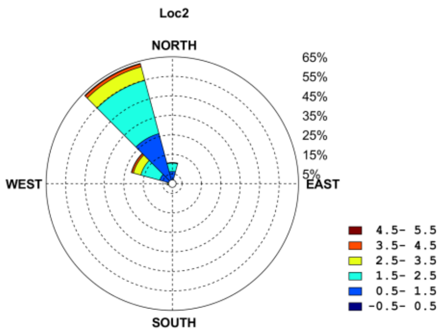


Plot a wave rose (a polar diagram) with the frequency of the SWH

QUESTION

3) Which is the second most frequent direction of SWH in the location -7.5W, 36.5?

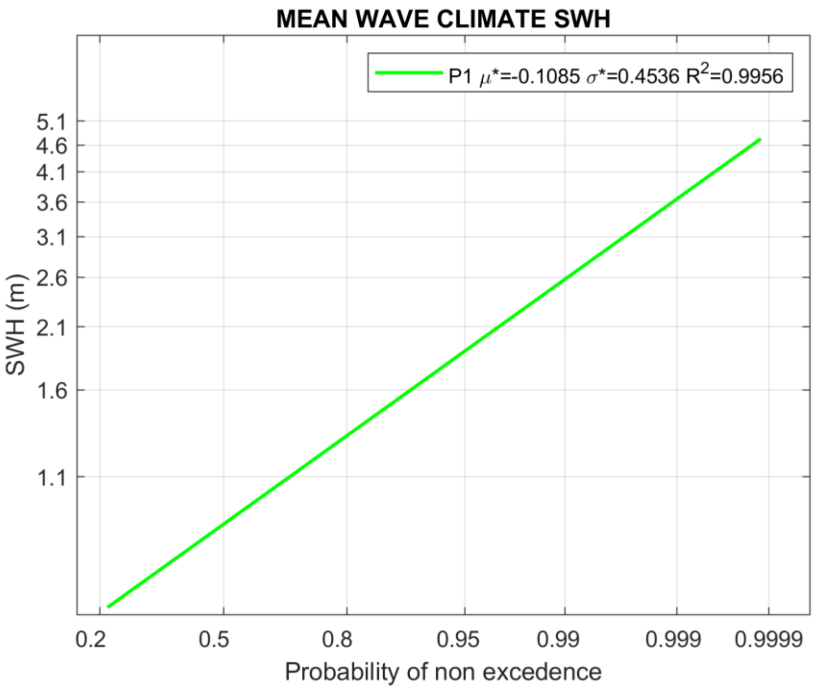
```
%% Plot polar diagram Wave Rose
for i=1:length(xy(:,1))
mod=swhPoints(:,i);
dir=mwdPoints(:,i);
hbins=(0:1:5)';
dbins=0 : 30 : 330;
fbins=[5:10:65];
figure
w = WindRose(gca, dir, mod,dbins ,hbins,fbins, ['Loc',num2str(i)]);
end
%Define filename and resolution for the figure
fileNameImage='SWH_WaveRose'% indicate the finename
resImage='-r300'%Indicate the resolution dpi
%Save the image
print('-dpng',resImage,fileNameImage)
```



Calculate the mean wave regime fitting to a log-normal distribution and plot the results

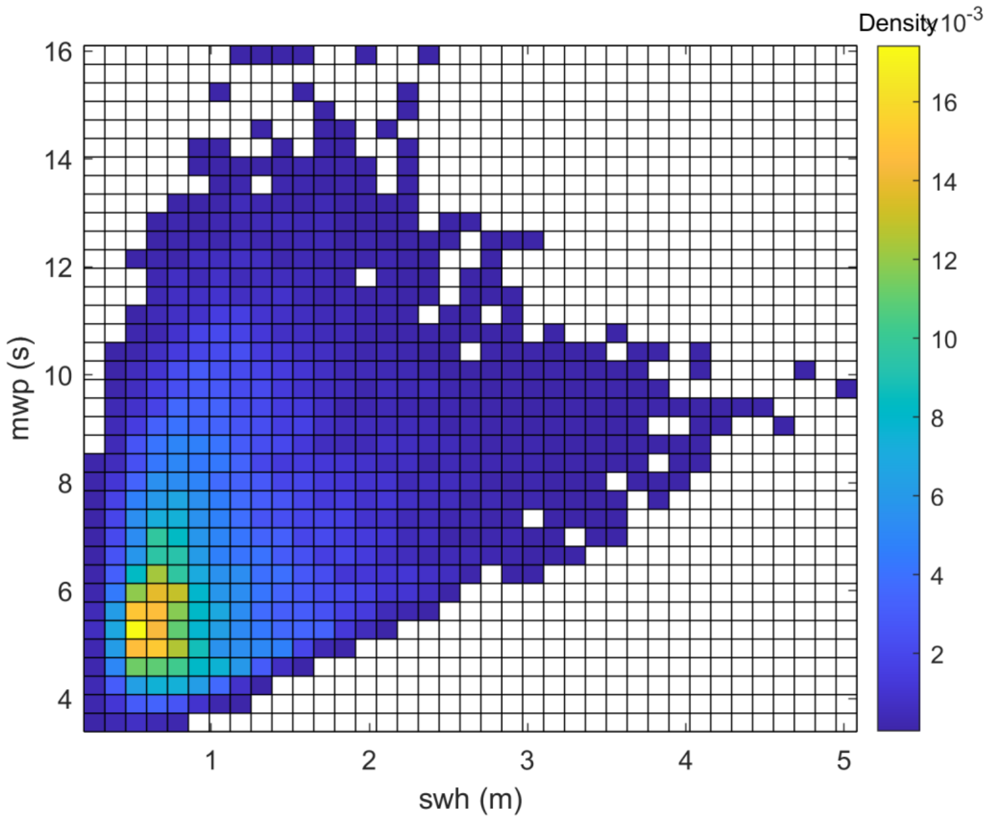
```
%% WAVE CLIMATE SCALAR
%Calculate the mean wave climate
%Prepare the time series
A=[datevec(timeAll)];
A=[A(:,1:4) swhPoints(:,1)];
m=min(A(:,5));
M=max(A(:,5));
%Prepare
NPuntos=150;
[YY,prob]=DistribucionNPuntos(A(:,5),NPuntos);
y=log(YY);
dum=find(prob>=0.2 & prob<=0.9999);
x=norminv(prob,0,1);
n=length(x(dum));
xm=mean(x(dum));
ym=mean(y(dum));
Sxx=sum(x(dum).^2)-n*(xm)^2;
Sxy=sum(x(dum).*y(dum))-n*xm*ym;
Syy=sum(y(dum).^2)-n*ym^2;
```

```
a1=Sxy/Sxx;
a0=ym-a1*xm;
z=a1*x(dum)+a0;
SSR=Sxy^2/Sxx;
SSE=Syy-SSR;
SST=SSR+SSE;
R2=SSR/SST;
mu=a0;
sigma=a1;
P=[0.001 0.01 0.05 0.2 0.5 0.8 0.95 0.99 0.999 0.9999];
P100=P*100;
r=length(P);
%PLOT the mean wave climate
figure
plot(x(dum),z,'-g','linewidth',1.5);
title('MEAN WAVE CLIMATE SWH');
xlabel('Probability of non excedence');
set(gca, 'xtick', norminv(P));
set(gca, 'xticklabel', P);
ylabel('SWH (m)');
yes=[floor(10*min(A(:,5)))/10:ceil(1*(max(A(:,5))-
min(A(:,5))))/10:max(A(:,5))+(1*(max(A(:,5))-min(A(:,5))))/10];
DUM=find(yes~=0);
set(gca, 'ytick',log(yes(DUM)'));
set(gca, 'yticklabel', yes(DUM));
textLeg=strcat('P1' ,' \mu*=',num2str(mu,4),' \sigma*=',num2str(sigma,4),'

legend(textLeg);
grid on

%Define filename and resolution for the figure
fileNameImage='SWH_LogNormal'% indicate the finename
resImage='-r300'%Indicate the resolution dpi
%Save the image
print('-dpng',resImage,fileNameImage)
```



Calculate de distribution of SWH and MWP in the Location 1 and calculate the most frequent pair value

```
%Joint Distriubtion swh and mwp
ht=[swhPoints(:,1) mwpPoints(:,1)]; %vector contaning swh and mwp for point 1
[scatterMag,XI,YI,PI] =density2scatter([100 100],ht,0);%calculate density of the mwp
and swh pair
figure
pcolor(XI,YI,PI)
xlabel('swh (m)')
ylabel('mwp (s)')
hc=colorbar
title(hc,'Density')

%Calculate the most frequent combination of Hs-Tp value and display in the command
window
[val,in]=max(PI(:));
disp(['Max. Density for Hs ', num2str(XI(in)), ', Tp ', num2str(YI(in)) ,' pair'])

%Define filename and resolution for the figure
fileNameImage='swh_mwp_JointDistribution'% indicate the finename
resImage='-r300'%Indicate the resolution dpi
%Save the image
print('-dpng',resImage,fileNameImage)
%
```



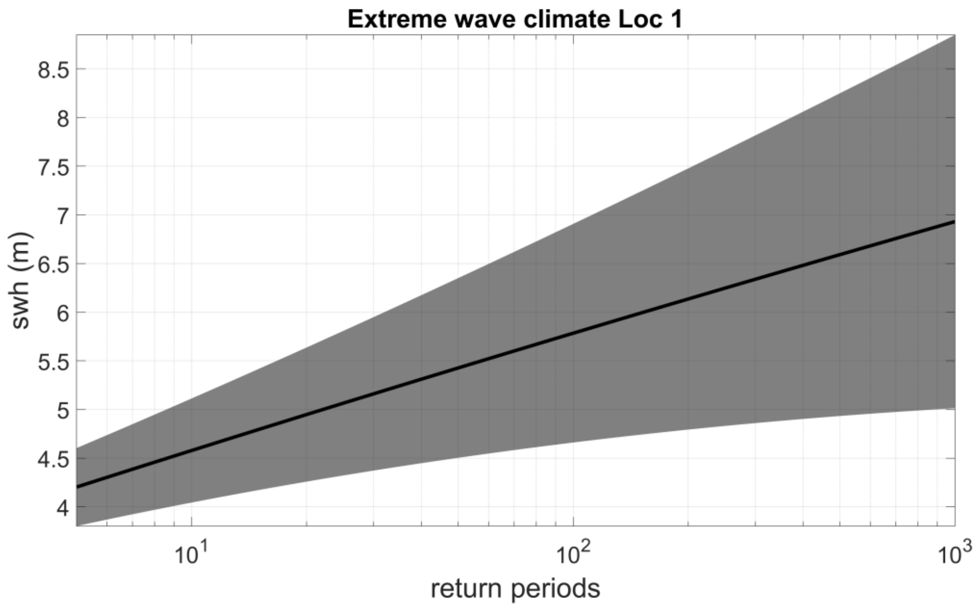
Extreme wave climate

Calculate the extreme wave climate for the Location 1 using the Matlab toolbox and plot swh for the different return periods

QUESTION

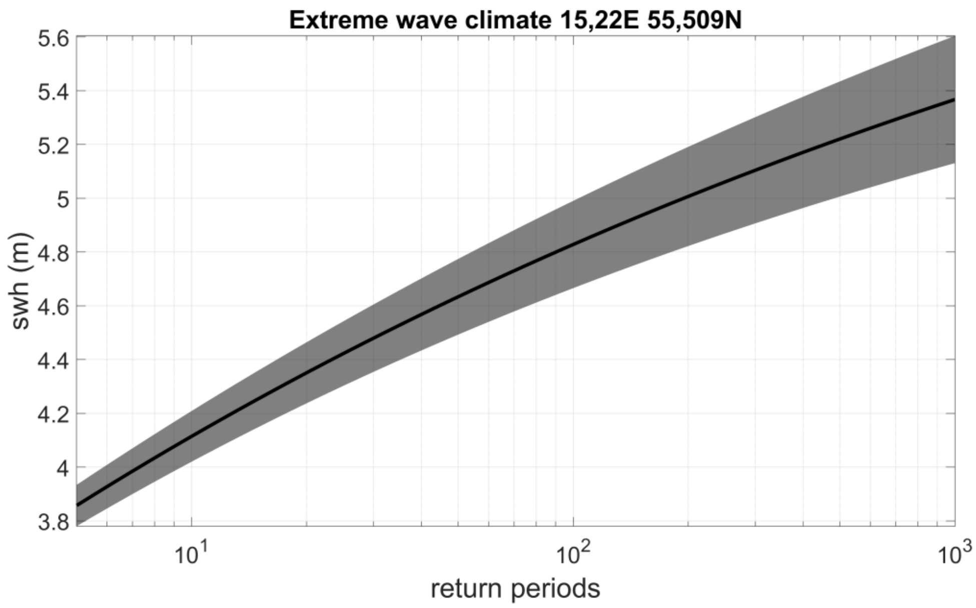
4) Which is the SWH corresponding to the return period of 5 years for the location -7.5W, 36.5N?

```
%% EXTREME WAVE CLIMATE
%Add the path to your unziped tsEva* folder noot needed if you already unzip
addpath (genpath('C:\Users\Tomas\Documents\SCRIPT_MATLAB\tsEva-0.1_R2014b'))%CHANGE
to your path

timeAndSeries = [timeAll swhPoints(:,1)];%create the time sieres
minPeakDistanceInDays = 3;%Indicates the peak distance (in days)  to be considered an
independent event
disp('stationary fit of extreme value distributions (GEV, GPD) to a time series');
statEvaParams = tsEvaStationary(timeAndSeries, 'minPeakDistanceInDays', minPeakDis-
tanceInDays);
[hndl,returnPeriods, returnLevels, retrunLevelsErrs]= tsEvaPlotReturnLevelsGPDFromA-
nalysisObj(statEvaParams,1);
close all;
%computeError
supRLCI = returnLevels + 2*retrunLevelsErrs;
infRLCI = returnLevels - 2*retrunLevelsErrs;
  maxRL = max(supRLCI);
  minRL = min(infRLCI);
%plot results
f = figure;
phandles{1} = f;
f.Position = [0, 0, 1300, 700] + 10;
h = area(returnPeriods, cat(1, infRLCI, supRLCI - infRLCI)', 'linestyle', 'none');
h(1).FaceColor = [1,1,1];
h(2).FaceColor = [0.5 0.5 0.5];
hold on;
phandles{2} = h;
phandles{3} = plot(returnPeriods, returnLevels, 'color', [0 0 0], 'linewidth', 3);
hold on;
set(gca, 'Xscale', 'log');
ylim([minRL maxRL]);
xlim([min(returnPeriods), max(returnPeriods)]);
grid on;
set(gca,'layer','top');
set(gca, 'fontsize', 20);
xlabel('return periods', 'fontsize', 24);
ylabel('swh (m)', 'fontsize', 24);
title ('Extreme wave climate Loc 1');

%Define filename and resolution for the figure
fileNameImage='EVA_Location1'% indicate the finename
resImage='-r300'%Indicate the resolution dpi
%Save the image
print('-dpng',resImage,fileNameImage)
```



The time series is too short to be compute larger return period, this can be seen in the large confidence interval. Let's compare the plotted results with a proper lime series longer enough to minimize the error for the longer return period.

```
%%  Longer time series is requested to compute extreme wave climate
DAT=load('timeAndSeries_waves_015_220E_055_509N');
timeAndSeries = [DAT.timeAndSeries];
minPeakDistanceInDays = 3;%Indicates the peak distance (in days)  to be considered an independent events
disp('stationary fit of extreme value distributions (GEV, GPD) to a time series');
statEvaParams = tsEvaStationary(timeAndSeries, 'minPeakDistanceInDays', minPeakDis-tanceInDays);
[hndl,returnPeriods, returnLevels, retrunLevelsErrs]= tsEvaPlotReturnLevelsGPDFromA-nalysisObj(statEvaParams,1);
close all
%computeError
supRLCI = returnLevels + 2*retrunLevelsErrs;
infRLCI = returnLevels - 2*retrunLevelsErrs;
  maxRL = max(supRLCI);
  minRL = min(infRLCI);
%plot results
f = figure;
phandles{1} = f;
f.Position = [0, 0, 1300, 700] + 10;
h = area(returnPeriods, cat(1, infRLCI, supRLCI - infRLCI)', 'linestyle', 'none');
h(1).FaceColor = [1,1,1];
h(2).FaceColor = [0.5 0.5 0.5];
hold on;
phandles{2} = h;
phandles{3} = plot(returnPeriods, returnLevels, 'color', [0 0 0], 'linewidth', 3);
hold on;
set(gca, 'Xscale', 'log');
ylim([minRL maxRL]);
xlim([min(returnPeriods), max(returnPeriods)]);
grid on;
set(gca,'layer','top');
set(gca, 'fontsize', 20);
xlabel('return periods', 'fontsize', 24);
ylabel('swh (m)', 'fontsize', 24);
title ('Extreme wave climate 15,22E 55,509N');
%Define filename and resolution for the figure
fileNameImage='EVA_LongTimeSeries'% indicate the finename
resImage='-r300'%Indicate the resolution dpi
%Save the image
print('-dpng',resImage,fileNameImage)
```


Extreme wave climate 15,22E 55,509N
swh (m)
return periods
5.6
5.4
5.2
5
4.8
4.6
4.4
4.2
4
3.8
10^1
10^2
10^3