**Calibration of Jonswap model**

Model calibration for the Jonswap equations used for calculating near-bed orbital velocities in *"Wind exposure and sediment type determine the resilience and response of seagrass meadows to climate change"*

close all

clear variables

cd('C:\Users\jcdes\OneDrive - NIOZ\PhD\Field work\Kristineberg jun-aug 2018');

load('dates.mat');

months = month(dates(129551:end-6)); % month numbers, starting january 2011 until december 2018

years = year(dates(129551:end-6)); % year numbers, starting january 2011 until december 2018

dates = dates(129551:end-6); % dates, starting january 2011 until december 2018

data = load('winddata.txt');

direction = data(129551:end-6,1); %wind direction in degrees, starting in august 2010 until december 2018

speed = data(129551:end-6,2); % wind speed in m/s

z = 15; %height at which wind speed is measured in m

speed = speed.\*(10/z).^(1/7);

fetchmap = load('fetch.txt'); % fetch - wind direction relation

load('fetch.mat')

**Calculating the fetch corresponding to the wind data timeseries**

This part produces fetch.mat. It takes a long time to run so it's normally turned off.

% fetch = ones(length(speed),1);

% for i = 1:length(direction)

% if direction(i) == 0

% direction(i) = mean([direction(i-1) direction(i+1)]);

% speed(i) = mean([speed(i-1) speed(i+1)]);

% end

% for j = 1:length(fetchmap)

% if direction(i) == fetchmap(j,1)

% fetch(i,:) = fetchmap(j,4);

% end

% end

% end

**Calculating wave height and period from Jonswap equations**

g = 9.81; % gravitational acceleration (m/s^2)

F\_star = g.\*fetch./(speed.^2);

H\_star = 0.0016.\*sqrt(F\_star);

Tp\_star = 0.286.\*(F\_star.^0.333);

H = (speed.^2).\*H\_star./g; % wave height (m)

Tp = speed.\*Tp\_star./g; % wave period (s)

**Calculating near-bed velocity from linear wave theory**

h = 2; % water depth (m)

w = (2\*pi)./Tp; % wave angular velocity (rad/s)

% linear wave theory

for i=1:length(H)

count = 1;

l{count}(i) = 0;

l{count+1}(i) = (g/(2\*pi))\*Tp(i)^2;

while abs(l{count+1}(i) - l{count}(i)) > 0.0001

l{count+2}(i) = ((9.81\*Tp(i)^2)/(2\*pi))\*tanh((2\*pi\*h)/l{count+1}(i));

r = l{count+1}(i)-l{count}(i);

count = count +1;

end

L(i,:) = l{count}(i); % wave length (m)

k(i,:) = (2\*pi)/L(i); % wave number (-)

end

U = H.\*w./(2.\*sinh(k.\*h)); % peak near-bed orbital velocity (m/s)

**Calculating wave height and fetch from ADV data**

load('Uwaves\_ADV.txt');

load('Tpwaves\_ADV.txt');

%Selecting the Jonswap numbers over the duration of the ADV timeseries

Uwaves\_Jonswap = U(50903:51234);

windselection = speed(50903:51234);

fetchselection = fetch(50903:51234);

directionselection = direction(50903:51234);

clear L

clear k

clear l

w = (2\*pi)./2.5;

for i=1:length(Uwaves\_ADV)

count = 1;

l{count}(i) = 0;

l{count+1}(i) = (g/(2\*pi))\*2.5^2;

while abs(l{count+1}(i) - l{count}(i)) > 0.0001

l{count+2}(i) = ((9.81\*2.5^2)/(2\*pi))\*tanh((2\*pi\*h)/l{count+1}(i));

r = l{count+1}(i)-l{count}(i);

count = count +1;

end

L(i,:) = l{count}(i);

k(i,:) = (2\*pi)/L(i);

end

Hwaves\_ADV = (Uwaves\_ADV.\*(2.\*sinh(k.\*h)))./w;

Hstar\_ADV = (Hwaves\_ADV.\*g)./(windselection.^2);

Fstar\_ADV = (Hstar\_ADV./0.0016).^2;

Fetch\_ADV = (Fstar\_ADV.\*windselection.^2)./g;

**Fitted fetch curve on fetch back calculated from ADV data**

clear fetchmeans

for i = 1:360

fetchmeans(i,:) = mean(Fetch\_ADV(directionselection == i));

fetchstd(i,:) = std(Fetch\_ADV(directionselection == i));

end

fetchmeans(isnan(fetchmeans)) = NaN;

fetchmeans(fetchmeans > 30000) = NaN;

fetchmeans = round(fetchmeans)';

angles = fetchmap(:,1)';

figure;

hold on

plot(angles,fetchmap(:,2),'--k','linewidth',1)

plot(angles,fetchmeans./1000,'.k','markersize',7)

plot(angles,fetchmap(:,4)./1000','-','Color',[1 0 0.2],'linewidth',1)

xlabel('Wind direction (degrees)')

ylabel('Fetch (km)')

legend('observed','back-calculated','fit')

legend BOXOFF

axis([0 360 0 25])

Chart

Description automatically generated

**Comparing Jonswap results to ADV data**

%Appending a datetime timeseries

load('Bok-V101.vhd');

datetimes = datetime(Bok\_V101(1:332,3),Bok\_V101(1:332,1),Bok\_V101(1:332,2),Bok\_V101(1:332,4),0,0);

fig = figure;

Cright = [1 0 0.2];

Cleft = [0.2 0.5 1];

set(fig,'defaultAxesColorOrder',[Cleft;Cright]);

ax = subplot(2,2,1,polaraxes);

hold on

polarhistogram(deg2rad(direction),deg2rad(0:10:360),'FaceColor',[0 0 0],'FaceAlpha',1,'Linewidth',0.01)

polarhistogram(deg2rad(direction(speed<13.9)),deg2rad(0:10:360),'FaceColor',[0.5 0.5 0.5],'FaceAlpha',1,'Linewidth',0.01)

polarhistogram(deg2rad(direction(speed<7)),deg2rad(0:10:360),'FaceColor',[1 1 1],'FaceAlpha',1,'Linewidth',0.01)

ax.ThetaDir = 'clockwise';

ax.ThetaZeroLocation = 'top';

polarplot(deg2rad(fetchmap(:,1)),fetchmap(:,4)/5,'r','Linewidth',1);

ax.RTickLabel = {'0','5','10','15','20'};

legend('U > 13.9 m s^{-1}','U > 7 m s^{-1}','U < 7 m s^{-1}','fetch [km]')

legend BOXOFF

title('A')

subplot(2,2,2)

yyaxis left

plot(datetimes,windselection,'-','Color',[0.2 0.5 1],'Linewidth',1)

ylabel('U (m s^{-1})')

yyaxis right

plot(datetimes,directionselection,'-','Color',[1 0 0.2],'Linewidth',1)

ylabel('Wind direction (degrees)')

title('B')

set(gca,'box','off')

subplot(2,2,3)

plot(datetimes,Uwaves\_ADV,'-','Color',[0.2 0.5 1],'Linewidth',1)

hold on

plot(datetimes,Uwaves\_Jonswap,'-','Color',[1 0 0.2],'Linewidth',1)

legend('u\_{ADV}','u\_{Jonswap}')

ylabel('u (m s^{-1})')

legend BOXOFF

title('C')

yticks([0 0.25 0.5 0.75 1])

ytickformat('%.2f')

set(gca,'box','off')

%Removing small waves from correlation analysis

Uwaves\_ADV(Uwaves\_Jonswap < 0.1) = [];

Uwaves\_Jonswap(Uwaves\_Jonswap < 0.1) = [];

Uwaves\_Jonswap(Uwaves\_ADV < 0.1) = [];

Uwaves\_ADV(Uwaves\_ADV < 0.1) = [];

%Calucating correlation

[r,p] = corrcoef([Uwaves\_ADV,Uwaves\_Jonswap],'Rows','complete');

%Calculating the RMSE

RMSE = sqrt(nanmean((Uwaves\_ADV-Uwaves\_Jonswap).^2));

subplot(2,2,4)

loglog(Uwaves\_ADV,Uwaves\_Jonswap,'.','Color',[0.2 0.5 1])

hold on

plot([0.05 0.6],[0.05 0.6],'--k','Linewidth',1)

axis([0.1 0.6 0.1 0.6])

xlabel('u\_{ADV} (m s^{-1})')

ylabel('u\_{Jonswap} (m s^{-1})')

title('D')

yticks([0.1 0.2 0.4 0.6])

xticks([0.1 0.2 0.4 0.6])

xtickformat('%.1f')

ytickformat('%.1f')

text(0.2,0.4,['R^2 = ',num2str(r(1,2)^2,'%.2f')]);

set(gca,'box','off')

Chart, scatter chart

Description automatically generated

Making a figure for measured wind velocity and calculated nearbed orbital velocity between June 7 2016 - 12:00 and June 9 2016 - 12:00, during which a turbidity event was observed during relatively low wind speeds but with favorable direction.

windselection = speed(47328:47376);

Uwaves\_Jonswap = U(47328:47376);

ucrit = 0.16;

t1 = datetime(2016,6,7,12,0,0);

t2 = datetime(2016,6,9,12,0,0);

datetimes = t1:hours(1):t2;

figure;

yyaxis right

plot(datetimes,windselection,'-','Color',[0.2 0.5 1]);

set(gca,'Ycolor',[0.2 0.5 1]);

ylabel('wind velocity (m s^{-1})')

yyaxis left

hold on

plot(datetimes,Uwaves\_Jonswap,'-','Color',[1 0 0.2]);

set(gca,'Ycolor',[1 0 0.2]);

ylabel('u\_{nearbed} (m s^{-1})')

plot([min(datetimes) max(datetimes)],[ucrit ucrit],'--','Color',[1 0 0.2]);

Chart, line chart, histogram

Description automatically generated