**Model for climate change induced changes in wind patterns on the turbidity pressure on seagrass meadows in Bokevik bay**

This model uses the field flume derived seagrass density dependent resuspension thresholds to assess the effects of climate change induced changes in mean winds and storm frequency on the turbidity pressure on seagrass meadows growing on fine sand and coarse sand.

Loading wind data and wind direction - fetch curve

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

clear dates

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); % correcting wind speed to 10 m above ground

load('fetch.txt');

Making 10 degrees bins for fetch

figure;

yyaxis left

hold on

plot(fetch(:,4),'-b','linewidth',2);

count = 1;

for i = 1:10:351

fetch\_binned(count) = mean(fetch(i:i+9,4));

count = count+1;

end

xlabel('Wind direction (degrees)')

ylabel('Fetch (m)')

set(gca,'Ycolor','b')

bins = [5:10:355];

bar(bins,fetch\_binned,'facealpha',0.3);

for i = 1:length(bins)

binmin(i) = i\*10-9;

binmax(i) = i\*10;

frequency\_binned(i) = length(speed(direction >= binmin(i) & direction <= binmax(i)))./length(speed);

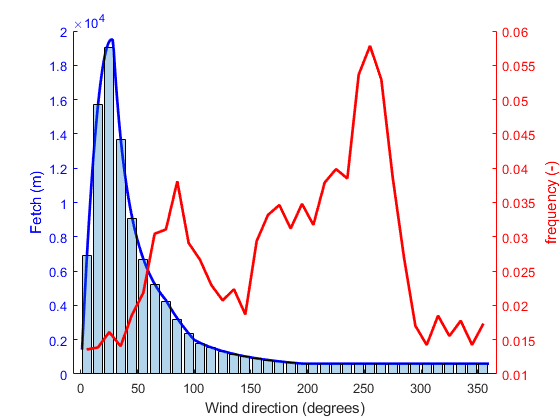
end

yyaxis right

plot(bins,frequency\_binned,'-r','linewidth',2);

ylabel('frequency (-)')

set(gca,'YColor','r')



**Deriving the Weibull distribution parameters for the wind speed distributions for each wind direction bin.**

This only works for values above 0, so we turn zero wind speeds into 0.01 m/s.

speed(speed == 0) = 0.01;

speed(isnan(speed) == 1) = 0.01;

for i = 1:length(bins)

[wblparam(i,:)] = wblfit(speed(direction >= binmin(i) & direction <= binmax(i)));

end

Now that we have the Weibull distribution parameters, we can change them in order to impose

* a 5, 10 and 15 % increase in mean winds, without increasing storminess

for i = 1:length(bins)

wind\_baseline(:,i) = wblrnd(wblparam(i,1),wblparam(i,2),100000,1);

end

meanspeed\_baseline = mean(wind\_baseline);

stormfreq\_baseline = 100 - invprctile(wind\_baseline,13.9);

increase = [1.05 1.1 1.15];

for i = 1:length(increase)

Weibull\_A{i} = wblparam(:,1).\*increase(i);

Weibull\_B{i} = wblparam(:,2);

end

for i = 1:length(bins)

for j = 1:length(Weibull\_A)

wind\_medincr{j}(:,i) = wblrnd(Weibull\_A{j}(i),Weibull\_B{j}(i),100000,1);

stormfreq\_medincr{j}(:,i) = (100 - invprctile(wind\_medincr{j}(:,i),13.9))./stormfreq\_baseline(i);

while abs(1-stormfreq\_medincr{j}(:,i)) > 0.01

if stormfreq\_medincr{j}(:,i) < 1

Weibull\_B{j}(i) = Weibull\_B{j}(i) - 0.01;

elseif stormfreq\_medincr{j}(:,i) > 1

Weibull\_B{j}(i) = Weibull\_B{j}(i) + 0.01;

end

wind\_medincr{j}(:,i) = wblrnd(Weibull\_A{j}(i),Weibull\_B{j}(i),100000,1);

stormfreq\_medincr{j}(:,i) = (100 - invprctile(wind\_medincr{j}(:,i),13.9))./stormfreq\_baseline(i);

end

end

end

* a 5,10 and 15 % increase in storm frequency, without changing mean winds

for i = 1:length(increase)

Weibull\_A{i} = wblparam(:,1);

Weibull\_B{i} = wblparam(:,2);

end

for i = 1:length(bins)

for j = 1:length(Weibull\_A)

wind\_stormincr{j}(:,i) = wblrnd(Weibull\_A{j}(i),Weibull\_B{j}(i),100000,1);

stormfreq\_stormincr{j}(:,i) = (100 - invprctile(wind\_stormincr{j}(:,i),13.9))./stormfreq\_baseline(i);

while stormfreq\_stormincr{j}(:,i) < increase(j)

Weibull\_B{j}(i) = Weibull\_B{j}(i) - 0.001;

wind\_stormincr{j}(:,i) = wblrnd(Weibull\_A{j}(i),Weibull\_B{j}(i),100000,1);

stormfreq\_stormincr{j}(:,i) = (100 - invprctile(wind\_stormincr{j}(:,i),13.9))./stormfreq\_baseline(i);

end

end

end

**Calculating turbidity pressure**

First, we solve the JONSWAP equations to yield wave height and wave period

wind = [{wind\_baseline} wind\_medincr wind\_stormincr];

h = 1; % water depth in m

g = 9.81; % gravitational acceleration

L = zeros(100000,36);

k = zeros(100000,36);

for i = 1:length(wind)

F\_star = g.\*fetch\_binned./wind{i}.^2;

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

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

H = wind{i}.^2.\*H\_star./g;

Tp = wind{i}.\*Tp\_star./g;

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

Then, we can calculate near-bed orbital velocities using linear wave theory

wb1 = waitbar(0,['iteration ',num2str(i),'/7']);

for j = 1:length(wind{i}(1,:))

for m = 1:length(wind{i})

count = 1;

l{count} = 0;

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

while abs(l{count+1} - l{count}) > 0.01

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

count = count+1;

end

L(m,j) = l{count};

k(m,j) = (2\*pi)/L(m,j);

clear l

end

waitbar(j/length(wind{i}(1,:)));

end

close(wb1)

U{i} = H.\*w./(2.\*sinh(k.\*h));

end

Based on the linear regressions from Figure 4 in the paper, we can derive ucrit - blade area relations, so that we can translate ucrit into blade area for the different sediment types.

Ucrit\_line = [0:0.01:0.5];

Ablade\_coarse = (Ucrit\_line-0.19)./0.17;

Ablade\_fine = (Ucrit\_line-0.15)./0.12;

Now we calculate the exceedance probability of a given ucrit, which yields the turbidity pressure over the range of typical ucrits.

for i = 1:length(wind)

for j = 1:length(Ucrit\_line)

Ucrit\_exc{i}(j,:) = 100 - invprctile(U{i},Ucrit\_line(j));

for k = 1:length(bins)

stormfreq\_U{i}(j,k) = 100 - invprctile(wind{i}(U{i}(:,k) > Ucrit\_line(j),k),13.9);

end

Ucrit\_exc\_full(j,i) = sum(Ucrit\_exc{i}(j,:).\*frequency\_binned);

stormfreq\_U\_full(j,i) = nansum((stormfreq\_U{i}(j,:)./100).\*(Ucrit\_exc{i}(j,:)./100).\*...

(100./Ucrit\_exc\_full(j,i)).\*frequency\_binned).\*100;

end

end

**Assessment**

figure;

axis([0 1.5 0 40])

hold on

for i = 2:4

plot(Ablade\_fine,Ucrit\_exc\_full(:,i),'-r');

plot(Ablade\_coarse,Ucrit\_exc\_full(:,i),'--r');

end

for i = 5:7

plot(Ablade\_fine,Ucrit\_exc\_full(:,i),'-b');

plot(Ablade\_coarse,Ucrit\_exc\_full(:,i),'--b');

end

plot(Ablade\_fine,Ucrit\_exc\_full(:,1),'-k','linewidth',2);

plot(Ablade\_coarse,Ucrit\_exc\_full(:,1),'--k','linewidth',2);

xlabel('Blade area (m^2) per m^2 seabed surface (-)')

ylabel('P(u > u\_{cr})')

p(1) = plot(NaN,NaN,'-k');

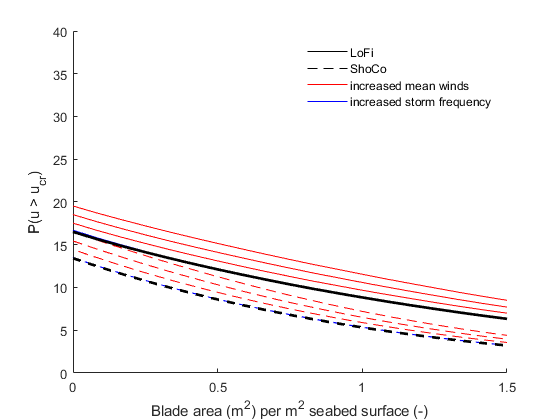
p(2) = plot(NaN,NaN,'--k');

p(3) = plot(NaN,NaN,'-r');

p(4) = plot(NaN,NaN,'-b');

legend([p(1) p(2) p(3) p(4)],{'LoFi','ShoCo','increased mean winds','increased storm frequency'})

legend BOXOFF



figure;

axis([0 1.5 0 100])

hold on

plot(Ablade\_fine,stormfreq\_U\_full(:,1),'-k');

plot(Ablade\_coarse,stormfreq\_U\_full(:,1),'--k');

xlabel('Blade area per m^2 seabed surface (-)')

ylabel('Storm % u > u\_{cr}')

p(1) = plot(NaN,NaN,'-k');

p(2) = plot(NaN,NaN,'--k');

p(5) = plot(NaN,NaN,'-k');

p(3) = plot(NaN,NaN,'-b');

p(4) = plot(NaN,NaN,'-r');

legend([p(1) p(2) p(5) p(3) p(4)],{'LoFi','ShoCo','Bokevik bay','Fully exposed, low','Fully exposed, high'})

legend BOXOFF

