Lab 1

MATLAB and the moving Average

0. Preface, Introduction, and/or Abstract

Moving average is a calculation to analyze data points by creating a series of averages of different subsets of the full data set. In lab 1, we will create some functions that work as moving average in MATLAB by the equation given and observe how the plot changes when changing the variables M into different values. Then we will extend the 1D moving average to the 2D moving average to deal with the image given.

1. Sections

1.1. Read the data(2.1 in Lab)

Before using the data to plot or analyze, I first need to load the data to MATLAB. The type of original data is a txt from the coast of Oceanside, California. I will use a function to load them.

```
function [data, count] = readbuoydata(datafile)
fid = fopen(datafile,'r');
tline = fgetl(fid);
tline = fgetl(fid);
[A,count] = fscanf(fid,'%d %d %d %d %d %f %f %d %f %f',[10 inf]);
data.date = datenum([A(1:5,:); zeros(1,size(A,2))]')';
data.Hs = A(6,:); % significant wave height
data.Tp = A(7,:); % peak period
data.Dp = A(8,:); % peak period direction
data.Ta = A(9,:); % average period
data.SST = A(10,:); % sea surface temperature
fclose(fid);
end
```

When using the function above, we can write as following:

```
[data, count] = readbuoydata('045200603.txt');
```

`045200603.txt` is the txt that stores the data. This txt should be placed in the same file of code.

1.2. Write a script to plot peak period(T_p), and the significant wave height (H_s)(2.2 in Lab)

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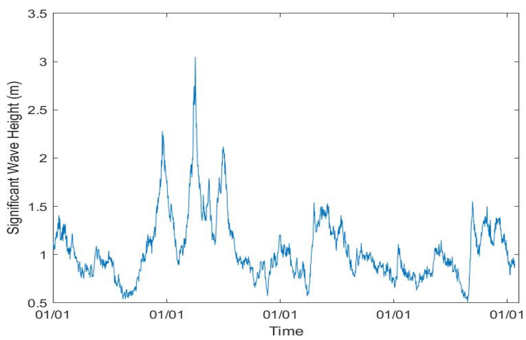
After loading from 1.1, we can plot the how peak period and significant wave height change with time by the original data. The code of plotting is as follows.

```
plot(data.Hs)
datetick('x',19,'keeplimits');
xlabel('Time')
ylabel('Significant Wave Height (m)')
plot(data.Tp)
datetick('x',19,'keeplimits');
xlabel('Time')
ylabel('Peak Period')
```



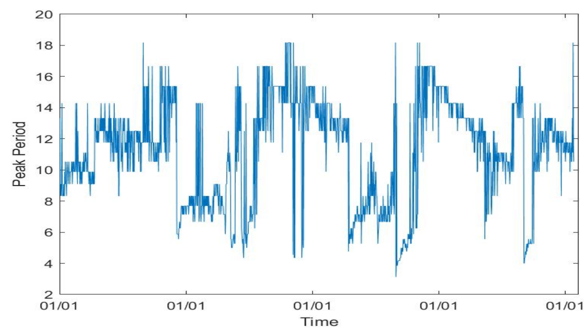


Figure1:Significant wave height(top) and peak wave period(bottom) of the Oceanside offshore(through original data).

1.3. Writing a moving average function(2.3 in Lab)

Since the original data has a lot of noise, it is difficult to analyze. So we use the moving average to filter the noise and make them smoother. This experiment we will try three different values of the M and analyze the difference the graphs show.

```
function ave_Hs(M,data)
global strings Hs;
for i = 1 : M-1
data = [0 data];
end
for i = M : length(data)
sum = 0;
for j = 0 : M-1
sum = sum + data(i-j);
Hs(i-j) = (sum)/M;
end
end
end
```

There are two variable in this function. ‘M’ is the variable we will change from 5 to 51 and ‘data’ is the string for the value of significant wave height.

1.4. The graph of significant wave height in different M(2.4 in Lab)

We set M = 5, 21, 51 respectively to see how the curves change.

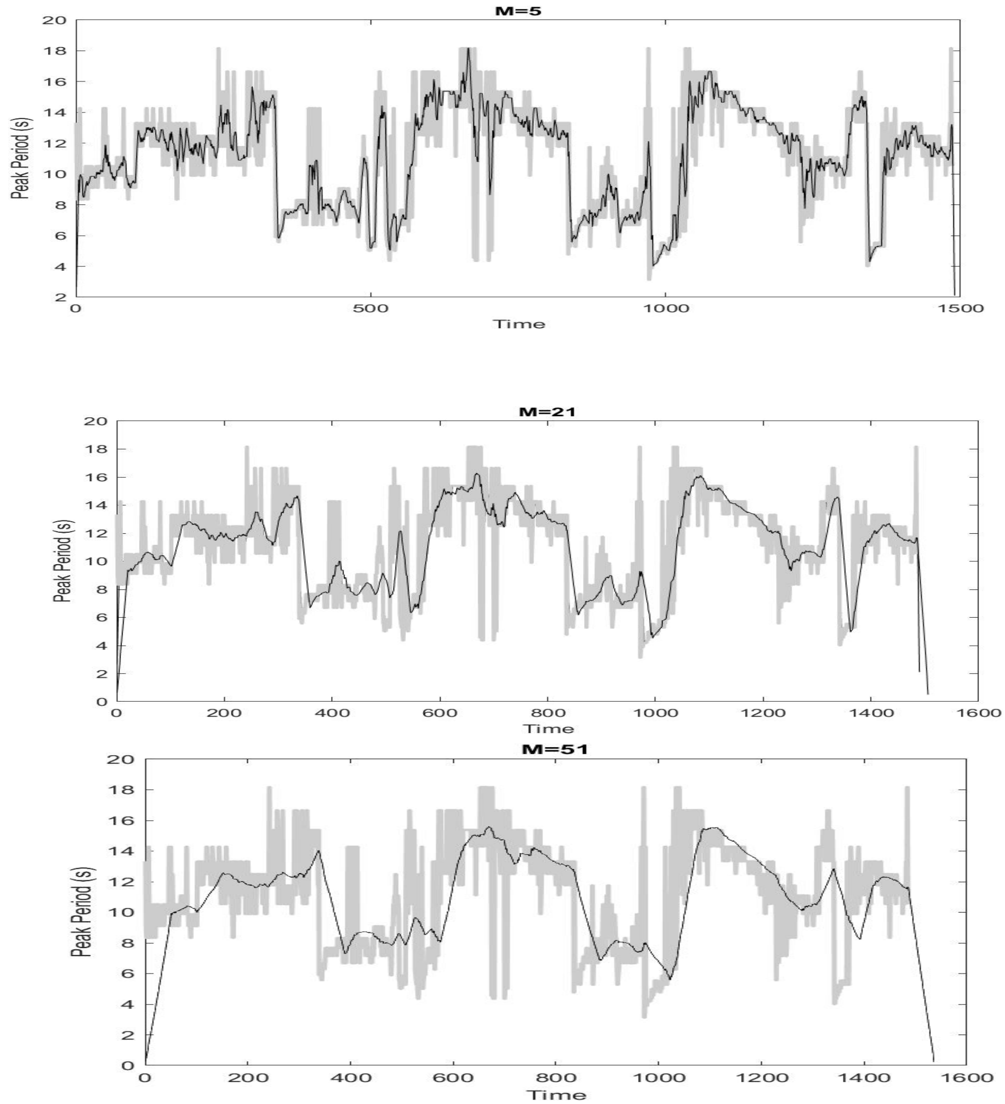


Figure 2: Moving averages of peak period data with different M(M=5, 21, 51.)

1.5. Answer questions(2.5 in lab)

1: What do you observe as M increases?

I find that the curves are becoming smoother and the peak becomes less obvious when the M increases.

2: Why do you think you observe this thing?

Because when the M increases, more data nearby will be used to average when filtering. The peak won't be very obvious since it was pulled down by the data nearby.

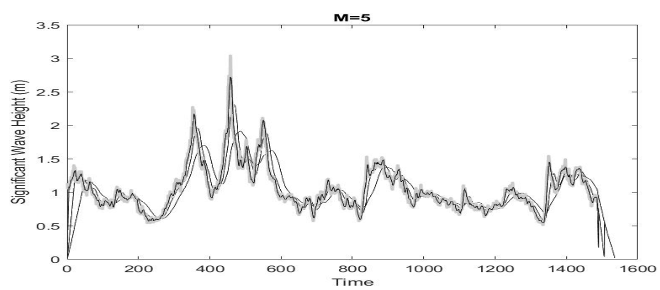
3:What is happening at the beginning of the averaged dataset, and why does it happen?

The beginning of the dataset is much less than the original data, because when we use the equation(2), we first need to add M-1 zeros at the beginning of the data so that the output will be the same length as input. For example, the first average data will be 1/5 comparing to the original data when M=5.

4:What happens to the running average when the peak period suddenly drops?Are these drops preserved? Are the wave trains more clear?

The running average will not drop so much as the original one, and the drop also has a delay comparing to the original drop. Less drops are preserved as the M increases. The wave train is more clear and easy to analyze as M increases. But if M is too big, it may lose some details(like sudden drops) that may be useful.

1.6. Repeat 2.4 for the Hs data(2.6 in Lab)



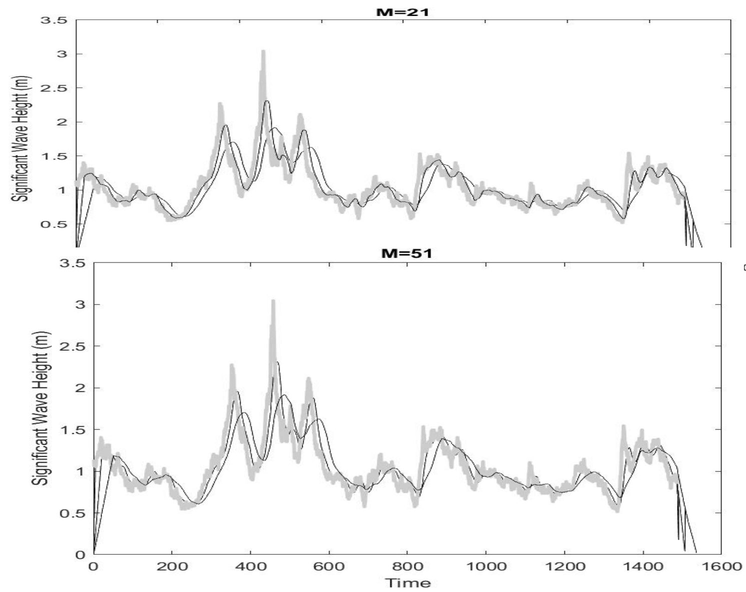


Figure 3: Significant Wave height with different M(M = 5, 21, 51.)

1.7. The peak shift related to the M(2.7 in the Lab)

I do observe the situations that peaks in the data move to later times! The size of the this shift are becoming bigger as the M increases. The reason why they move is the when using the equation (2), the x[n] is averaged with the M-1 data before it. So, when when the peak occurs it won't show immediately since it is averaged with M-1 data before peaking. You need to accumulate enough data after peaks and then it can be shown on the moving average graph.

1.8. Redo 2.4 and 2.6 using equation (3)(2.8 in lab)

Equation (3) is applied in order to improve the delay caused by the average.The code is as follows:

```
function ave_Hs_improved(M,data)
global strings Hs;
for i = 1 : (M-1)/2
data = [0 data];
end
for i = 1 : (M-1)/2
data = [data 0];
end
for i = (M-1)/2 : length(data)-(M-1)/2
sum = 0;
```

```
for j = -(M-1)/2 : (M-1)/2-1
sum = sum + data(i-j);
Hs(i-j) = (sum)/M;
end
end
```

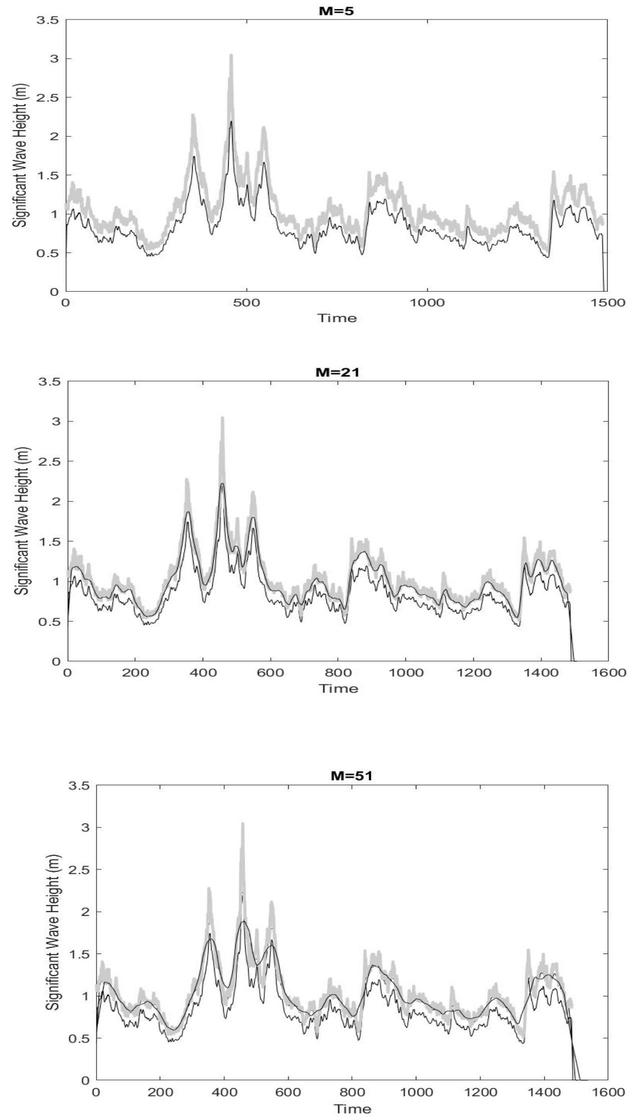


Figure 4: Significant Wave height with different M(M = 5, 21, 51)

2.1.Write a function that implements 2-D moving average

The code is as follows:

```
function ace_2D(M,data)
global DA2D;
global out1;
X = zeros(512,1,'uint32');
for i = 1 : (M-1)/2
data = [X data];
end
for i = 1 : (M-1)/2
data = [data X];
end
for i = (M-1)/2 + 1 : 512+(M-1)/2
sum = 0;
for j = -(M-1)/2 : (M-1)/2
sum = sum + data(:,i-j);
% display(sum(1));
end

DA2D(:,i-(M-1)/2) = (sum)./M;
end
end
function ace_2DY(M,data)
global DA2D;
global out1;
Y = zeros(1,512,'uint32');
for i = 1 : (M-1)/2
DA2D = [Y ; data];
end
for i = 1 : (M-1)/2
DA2D = [DA2D ; Y];
end
for i = (M-1)/2 + 1: 512-(M-1)/2
sum = 0;
for j = -(M-1)/2 : (M-1)/2
sum = sum + DA2D(i-j,:);
end
out1(i-(M-1)/2,:) = (sum)./M;
end
end
```

2.2 Predict the outcome(Lab in 3.2)

Using 2-D moving average technique will blur the image. The larger M we use, the more vague the image becomes.

2.3Plot in different M(Lab in 3.3)

Figure 5: the plot of the boat in different M(M=3, 5, 7)

```
global DA2D;
global out1;
DA2D = zeros(512);
I = imread('boat.gif');
```

```
% imshow(I)
ace_2D(3,I);
ace_2DY(3,DA2D);
A = im2uint8(mat2gray(out1));
imshow(A)
```

2.4 Answer for questions(Lab in 3.4)

As the M increases, the image becomes more vague. The moving average will blur the emotionally moving imagery and if the M is too large, we will be unable to see why this image is emotionally moving.

2. Conclusion

The moving average can be not only used in 1-D data processing. But we need to be careful when the M becomes too big since some details that we want may also me averaged. The moving average can also be extended to 2-D image processing as well.

3. Acknowledgments

Thanks for the TA gives us the illustration on the basic principle of how moving average works at the section.