SIOC 221A Homework 8 **Julia Dohner**
Prof. Sarah Gille Due Date: November 30, 2017

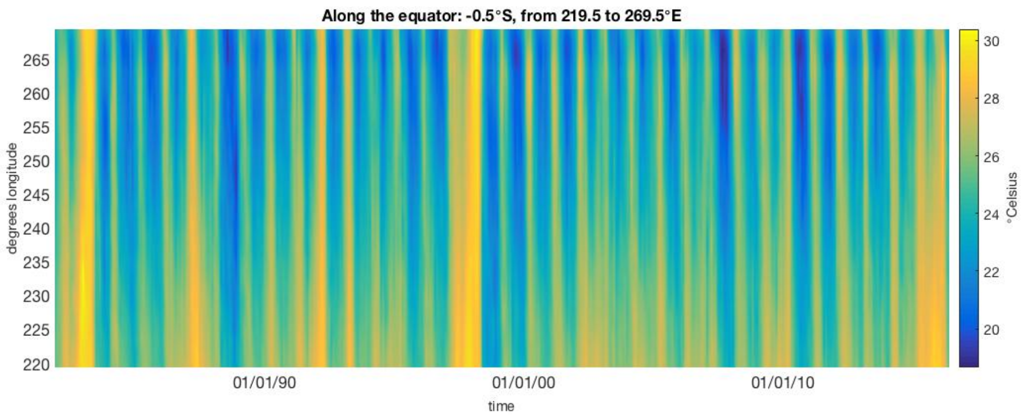
1. Aliasing.

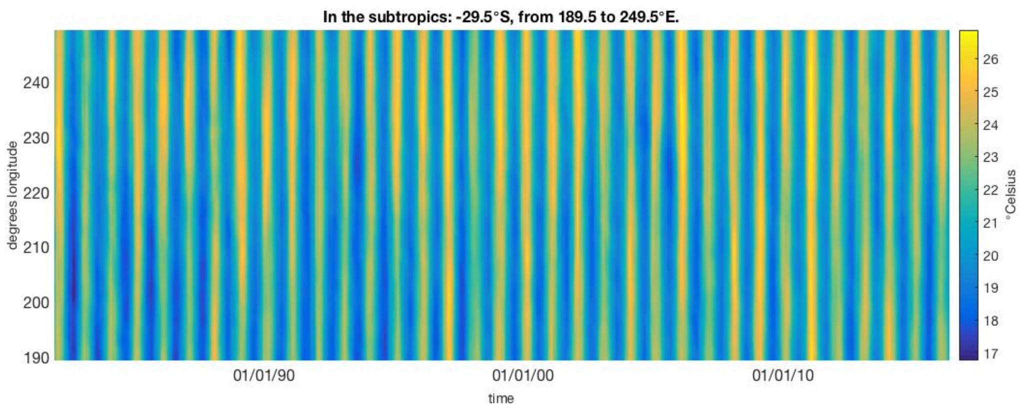
The aliasing period of the fast orbit for the M2 tidal cycle is 12.3857 days, and for the S1 tidal cycle is 152.6098 days. The aliasing period of the science orbit for the M2 tidal cycle is 65.6178 days, and for the S1 tidal cycle is 154.0388 days.

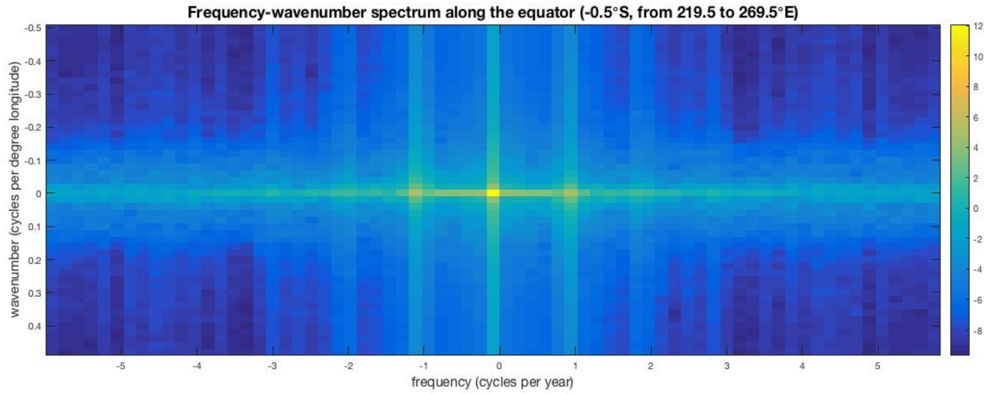
The satellite should operate in the fast orbit for at least 24.7714 days to provide multiple realizations of the M2 tidal cycle, and 305.2196 days for the S1 tidal cycle. The satellite should operate in the science orbit for at least 131.2356 days to provide multiple realizations of the M2 tidal cycle, and 308.0776 days for the S1 tidal cycle.

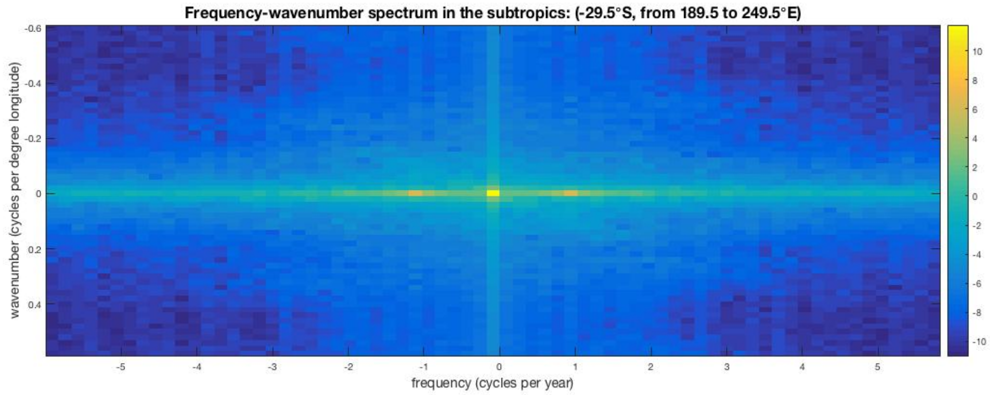
2. Frequency-wavenumber spectra.

It appears that there is a difference in energy propagation between the tropics and the subtropics. The frequency-wavenumber spectrum of the tropics shows peaks that are more strongly influenced by longitude (as suggested by the energy along the vertical) than does the spectrum of the subtropics. This suggests that there is some sort of zonal energy transport along the equator, perhaps picking up on equatorial Rossby and Kelvin waves. On the other hand, such waves are not possible off the equator (where Coriolis begins to take effect), which may be why we don't see the same longitudinal dependence in the frequency-wavenumber spectrum of the subtropics. Both plots do show peaks close to one cycle per year, matching the annual cycle.






Frequency-wavenumber spectrum along the equator (-0.5°S, from 219.5 to 269.5°E)
wavenumber (cycles per degree longitude)
frequency (cycles per year)


Frequency-wavenumber spectrum in the subtropics: (-29.5°S, from 189.5 to 249.5°E)
wavenumber (cycles per degree longitude)
frequency (cycles per year)

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% file SIOC 221A HW 8
%
% author Julia Dohner, with help from Annie Adelson
%
% due date November 30, 2017

clear all; close all;


%% aliasing


f_M2=24/12.42; % cycles per day
f_S1 = 24/24;

% fast sampling
f_sampling_fast=1/(0.99349);% cycles per day
f_Nyquist_fast=f_sampling_fast/2;

% M2 aliasing in fast sampling
M_fast_M2=floor(f_M2/f_Nyquist_fast);% compute the integer ratio of the two frequencies.
alias_fast_M2 = f_M2 - floor(f_M2/f_Nyquist_fast)*f_Nyquist_fast;
% Note: if M is odd then reset
if(rem(M_fast_M2,2)~=0)
    alias_fast_M2=f_Nyquist_fast-alias_fast_M2;
end
alias_period_fast_M2 = 1/alias_fast_M2

% S1 aliasing in fast sampling
M_fast_S1=floor(f_S1/f_Nyquist_fast);% compute the integer ratio of the two frequencies.
alias_fast_S1 = f_S1 - floor(f_S1/f_Nyquist_fast)*f_Nyquist_fast;
% Note: if M is odd then reset
if(rem(M_fast_S1,2)~=0)
    alias_fast_S1=f_Nyquist_fast - alias_fast_S1;
end
alias_period_fast_S1 = 1/alias_fast_S1

% science sampling
f_sampling_sci=1/(20.86455);% cycles per day
f_Nyquist_sci=f_sampling_sci/2;

% M2 aliasing in science sampling
M_sci_M2=floor(f_M2/f_Nyquist_sci);% compute the integer ratio of the two frequencies.
alias_sci_M2 = f_M2 - floor(f_M2/f_Nyquist_sci)*f_Nyquist_sci;
% Note: if M is odd then reset
if(rem(M_sci_M2,2)~=0)
    alias_sci_M2=f_Nyquist_sci - alias_sci_M2;
end
alias_period_sci_M2 = 1/alias_sci_M2

% S1 aliasing in science sampling
M_sci_S1=floor(f_S1/f_Nyquist_sci);% compute the integer ratio of the two frequencies.
alias_sci_S1 = f_S1 - floor(f_S1/f_Nyquist_sci)*f_Nyquist_sci;
% Note: if M is odd then reset
if(rem(M_sci_S1,2)~=0)
    alias_sci_S1=f_Nyquist_sci - alias_sci_S1;
end
alias_period_sci_S1 = 1/alias_sci_S1
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%% Frequency-wavenumber spectra

time = [];
lat = [];
lon = [];
sst = [];

% time units = 'days since 1800-1-1 00:00:00'
time = [time; ncread(strcat('sst.mnmean.nc'),'time')];
% units are degrees north
lat = [lat; ncread(strcat('sst.mnmean.nc'),'lat')];
% units are degrees east
lon = [lon; ncread(strcat('sst.mnmean.nc'),'lon')];
% sst dimensions are lon,lat,time (360x180x415)
sst = [sst; ncread(strcat('sst.mnmean.nc'),'sst')];

date0=datenum(1800,1,1);% give reference date (first date)
time2 = double(time)+date0;

% slab a: Along the equator: -0.5 S, from 219.5 to 269.5 E.
lat_a_ind = find(lat == -0.5);
lon_a_ind = find(lon == 219.5);
lat_a = lat(lat_a_ind);
x = 219.5:269.5; % calculating how far along to go in lon vector
last_lon_a = lon_a_ind + length(x) -1;
lon_a = lon(lon_a_ind:last_lon_a);
% sst dimensions are lon,lat,time (360x180x415)
time_a = time2(:);
sst_a = sst(lon_a_ind:last_lon_a,lat_a_ind,:);

sst_a2 = squeeze(sst_a);
sst_a3 = sst_a2;
% time on y axis, location in x, sst in color
figure('name','Along the equator: -0.5\circS, from 219.5 to 269.5\circE');
pcolor(time_a,lon_a,sst_a3);
shading interp;
h = colorbar; ylabel(h,'\fontsize{14}\circCelsius');
set(gca,'FontSize',16);
title('\fontsize{16}Along the equator: -0.5\circS, from 219.5 to 269.5\circE');
xlabel('\fontsize{14}time');
ylabel('\fontsize{14}degrees longitude');
datetick('x','mm/dd/yy')
axis tight

% slab b: In the subtropics: -29.5?S, from 189.5 to 249.5?E.
lat_b_ind = find(lat == -29.5);
lon_b_start = find(lon == 189.5);
lat_b = lat(lat_b_ind);
y = 189.5:249.5; % calculating how far along to go in lon vector
last_lon_b = lon_b_start + length(y) -1;
lon_b = lon(lon_b_start:last_lon_b);
% sst dimensions are lon,lat,time (360x180x415)
time_b = time2(:);
sst_b = sst(lon_b_start:last_lon_b,lat_b_ind,:);

sst_b2 = squeeze(sst_b);
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sst_b3 = sst_b2;
% time on y axis, location in x, sst in color
figure('name','In the subtropics: -29.5\circS, from 189.5 to 249.5\circE');
pcolor(time_b,lon_b,sst_b3);
shading interp;
h = colorbar; ylabel(h,'\fontsize{14}\circCelsius');
set(gca,'FontSize',16);
title('\fontsize{16}In the subtropics: -29.5\circS, from 189.5 to 249.5\circE.');
xlabel('\fontsize{14}time');
ylabel('\fontsize{14}degrees longitude');
datetick('x','mm/dd/yy')
axis tight


%%
% compute frequency/wavenumber spectra using at least some amount of
% averaging/segmenting


% slab a: Along the equator: -0.5 S, from 219.5 to 269.5 E.

N_data = floor(length(time2)/6)*6;% use some number of datapoints divisible by 6
N = N_data/6; % length of each chunk of data (aka segment length)
M = N_data/N; % number of segments splitting data into
p = 50; % number of rows (in this case number of longitude values)

% break data into segments
sst_a4 = sst_a3(1:end-1,1:N_data);
sst_a5 = reshape(sst_a4, p, N, M);

% compute fft in time (inner fft) and space (outer fft)
st_a = fftshift(fft2(sst_a5))./p./N;% fft in 2-D, normalizing

% time and space increments
t_diff = diff(time);
t_diff_mean = mean(t_diff);
dt = 1/t_diff_mean; % time interval
dz = 1; % 1 degree longitude

% fundamental frequency and wavenumber
%df=1./N./dt; % time
df = 1/N/dt*dt*12; % in cycles per year
dk=1./p./dz; % space

% average amplitudes for all realizations
% amplitudes: (*conj is same as abs of value^2)
amp_a=st_a.*conj(st_a)./df./dk;

% creating frequency and wavenumber vectors for plotting purposes
f=[-fliplr(1:(N/2)) 0 (1:(N/2-1))].*df;% frequency
k=[-fliplr(1:(p/2)) 0 (1:(p/2-1))].'.*dk;

spec_a_avg = mean(amp_a,3);% average amplitudes
figure('name','Frequency-wavenumber spectrum along the equator (-0.5 S, from 219.5 to
269.5 E)');
imagesc(f,k,log(spec_a_avg));% y axis is longitude, x axis is time
h = colorbar;
title('\fontsize{16}Frequency-wavenumber spectrum along the equator (-0.5\circS, from
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219.5 to 269.5\circE)');
xlabel('\fontsize{14}frequency (cycles per year)'); % data taken monthly
ylabel('\fontsize{14}wavenumber (cycles per degree longitude)');

%% slab b: In the subtropics: -29.5 S, from 189.5 to 249.5 E.

N_data = floor(length(time2)/6)*6;% use some number of datapoints divisible by 6
N = N_data/6; % length of each chunk of data (aka segment length)
M = N_data/N; % number of segments splitting data into
p_b = 60; % number of rows (in this case number of longitude values)

% break data into segments
sst_b4 = sst_b3(1:end-1,1:N_data);
sst_b5 = reshape(sst_b4, p_b, N, M);

% compute fft in time (inner fft) and space (outer fft)
st_b = fftshift(fft2(sst_b5))./p_b./N;% fft in 2-D, normalizing

% time and space increments
t_diff = diff(time);
t_diff_mean = mean(t_diff);
dt = 1/t_diff_mean; % time interval
dz = 1; % 1 degree longitude

% fundamental frequency and wavenumber
%df=1./N./dt; % time
df = 1/N/dt*dt*12; % in cycles per year
dk=1./p./dz; % space

% average amplitudes for all realizations
% amplitudes: (*conj is same as abs of value^2)
amp_b=st_b.*conj(st_b)./df./dk;

% creating frequency and wavenumber vectors for plotting purposes
f=[-fliplr(1:(N/2)) 0 (1:(N/2-1))].*df;% frequency
k=[-fliplr(1:(p_b/2)) 0 (1:(p_b/2-1))].'.*dk;

spec_b_avg = mean(amp_b,3);% average amplitudes
figure('name','Frequency-wavenumber spectrum in the subtropics (-29.5 S, from 189.5 to
249.5 E)');
imagesc(f,k,log(spec_b_avg));% y axis is longitude, x axis is time
h = colorbar;
title('\fontsize{16}Frequency-wavenumber spectrum in the subtropics: (-29.5\circS, from
189.5 to 249.5\circE)');
xlabel('\fontsize{14}frequency (cycles per year)'); % data taken monthly
ylabel('\fontsize{14}wavenumber (cycles per degree longitude)');
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