**Obtaining Ekman Transport and Upwelling Index from the ERA-Interim**

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| * Exercise Title: Obtaining Ekman transport and upwelling index from the ERA-Interim. * Abstract: Ekman transport and upwelling index in the east coast of Peninsular Malaysia are calculated on the basic of the wind products obtained from the ERA-Interim. * Preliminary reading: Kok, P. H., Akhir, M. F. M., Tangang, F., & Husain, M. L. (2017). Spatiotemporal trends in the southwest monsoon wind-driven upwelling in the southwestern part of the South China Sea. *PLoS ONE*, *12*(2). https://doi.org/10.1371/journal.pone.0171979 * Required software: Matrix Laboratory (MATLAB) * Other Resources: NA * Version: 2017-11-12 | | | |
| Ekman transport (m3 s-1 m-1) at each grid point is calculated on the basic of the wind products obtained from the ERA-Interim by using the following equation:  (1)  Where is the wind stress, = 1025 kg m-3 is the density of seawater, and is the Coriolis parameter ( = 7.292×10-5 rad s-1 is the Earth’s angular velocity, and is the latitude). The x and y subscripts refer to zonal and meridional components of Ekman transport, respectively. (N m-2) is calculated as follows:  )1/2  )1/2  (2)  Where =1.22 kg m-3 is the density of air, =1.3×10-3 is the constant dimensionless drag coefficient, and is the zonal and meridional wind speeds at 10 m, respectively.    In order to obtain upwelling index (characterize by using Ekman transport), the calculated Ekman transport nearest to the coast must be resolved to the transport perpendicular to the coastline (.  Note: If the angle between the coastline and equator is right angle (90˚), the zonal component of Ekman transport is directly considered as upwelling index.  The calculation above can be done by using MATLAB. | | | |
| 1. Change downloaded ECMWF filename to 2014. 2. Launch The MATLAB. |  | | |
| 1. Click the icon as shown and browse for **OTGA** folder. |  | | |
| 1. Click “New Script” as shown. 2. Copy and paste the command below into “Editor”. |  | | |
| %Display information in .nc file  %ncdisp('filename.nc');  ncdisp('2014.nc');    %Extract longitude, latitude, u10 and v10  lon=ncread('2014.nc','longitude');  lat=ncread('2014.nc','latitude');  u10=ncread('2014.nc','u10');  v10=ncread('2014.nc','v10');    %Transpose u10 and v10  u10=permute(u10,[3 2 1]);  v10=permute(v10,[3 2 1]);    %Extract wind component for Jun  Jun\_u10=squeeze(u10(6,:,:));  Jun\_v10=squeeze(v10(6,:,:));  %The arrangement (Time,Laitude,Longitude), Jun is located at the time No.6, hence substitute time to 6.  %Plotting coastline  load ECPM\_shore.dat %Coastline  load ECPM\_pol.dat %Political Boundary  plot(ECPM\_shore(:,1),ECPM\_shore(:,2),'k','LineWidth',2); %Plot coastine and setting line color to black 'k' and line width '2'.  hold on  plot(ECPM\_pol(:,1),ECPM\_pol(:,2),'k','LineWidth',2);  %Plotting wind (Quiver)  scale\_factor=0.05; %Setting scale factor  quiver(lon,lat,Jun\_u10\*scale\_factor,Jun\_v10\*scale\_factor,'k','LineWidth',1,'AutoScale','off')    %Generating legend  quiver(101.5,4,2\*scale\_factor,0\*scale\_factor,'k','LineWidth',1,'AutoScale','off')  axis equal  xlim([101 106]) %Setting x axis limit  ylim([1 7]) %Setting y axis limit  xlabel('Longitude (^oE)','FontSize',10) %Label x axis  ylabel('Latitude (^oN)','FontSize',10) %Label y axis    %Jun (Search and replace according to month)  title('Wind for June') %Change accordingly  %Coriolis parameter  omega=7.292e-5;  f= 2\*omega\*sin(pi/180\*lat);    %Ekman transport  pa=1.22; %kgm^-3  pw=1025; %kgm^-3  cd= 1.3e-3;  Q=(pa\*cd)./(pw\*f);  Q1=repmat(Q,1,21); %Copy and paste into 21 column such that it has the same dimension as Jun\_u10.  Q2=double(Q1);    %For Jun  Jun\_W=(Jun\_u10.^2+Jun\_v10.^2).^0.5;  Jun\_QX=Jun\_W.\*Q2.\*Jun\_v10;  Jun\_QY=-Jun\_W.\*Q2.\*Jun\_u10;    %Map of ECPM and Ekman transport for Jun  %Coastline  figure  plot(ECPM\_shore(:,1),ECPM\_shore(:,2),'k','LineWidth',2); %Plot coastine and setting line color to black 'k' and line width '2'.  hold on  plot(ECPM\_pol(:,1),ECPM\_pol(:,2),'k','LineWidth',2);    %Quiver plot for Ekman transport  scale\_factor=0.08; %Setting scale factor  quiver(lon,lat,Jun\_QX\*scale\_factor,Jun\_QY\*scale\_factor,'k','LineWidth',1,'AutoScale','off')    %Generating legend  quiver(101.5,4,5\*scale\_factor,0\*scale\_factor,'k','LineWidth',1,'AutoScale','off')  axis equal  xlim([101 106]) %Setting x axis limit  ylim([1 7]) %Setting y axis limit  xlabel('Longitude (^oE)','FontSize',10) %Label x axis  ylabel('Latitude (^oN)','FontSize',10) %Label y axis    %Jun (Search and replace according to month)  title('Ekman Transport for June') %Change accordingly | | | |
| 1. Select “Editor” as shown. 2. Hit “Run”. | |  | |
| 1. Name it and save it in OTGA. | |  | |
| 1. Map of Ekman transport is plotted. | |  | |
| 1. Click “Edit” and select “Axes Properties”. | |  | |
| 1. Click “Desktop” and select “Figure Palette”. | |  | |
| 1. Under “New Subplots”, select “2D Axes” and highlight 2 rows and 2 columns. 2. Click the box located in 3. First row, second column for July. 4. Second row, first column for August. 5. Second row, second column for September. | |  | |
| 1. Go back to “Editor”, scroll until Jun\_u10=squeeze(u10(6,:,:)); Jun\_v10=squeeze(v10(6,:,:));   as highlighted in step 5, and change to  a) Jul\_u10=squeeze(u10(7,:,:)); Jul\_v10=squeeze(v10(7,:,:)); for July  b)  Aug\_u10=squeeze(u10(8,:,:)); Aug\_v10=squeeze(v10(8,:,:)); for August  and  c)  Sep\_u10=squeeze(u10(9,:,:)); Sep\_v10=squeeze(v10(9,:,:)); for September | | %Extract wind component for Jun  Jul\_u10=squeeze(u10(7,:,:));  Jul\_v10=squeeze(v10(7,:,:)); | |
| 1. In “Editor”, scroll until the end of command, highlight “Jun” and hit “Ctrl+F”, replace with “Jul”, click “Replace All”. | |  | |
| 1. Change “June” to “July”. 2. Hit “Run”, as described in step 7.   Ekman transport map for July will be plotted in first row, second column. | |  | |
| 1. Repeat step 13 until step 16 for August and September. | |  | |
| 1. Click “Insert” and select “Text Box”. Draw the text box and key in 5 m^3 s^-^1 m^-^1. 2. Repeat step 19 for July, August and September. | |  | |
| 1. Click “File” and select “Save as” to save the figure. | |  | |
| **Obtain Upwelling Index** | | | |
| 1. Obtain Upwelling Index at (4, 103.5) for June, July, August and September.   Latitude 4 located at row 13 in “lat”, while Longitude 103.5 located at row 11 in “lon”, hence we just need to extract Qx at row 13, column 11.  #Check the location of Lon & Lat coodinate in “Workspace”.  Since the coastline angle at (4, 103.5) is a right angle, hence directly extract Qx of each month to represent upwelling index (UI).  Copy and paste the command below into “Command Window”.  UI=[]; %Create empty file for upwelling index  UI(1,1)=Jun\_QX(13,11); %Extract Jun\_Qx at row 13, column 11 and put in into 1 row, 1 column of UI.  UI(2,1)=Jul\_QX(13,11); %Extract Jul\_Qx at row 13, column 11 and put in into 1 row, 2 column of UI.  UI(3,1)=Aug\_QX(13,11); %Extract Aug\_Qx at row 13, column 11 and put in into 1 row, 3 column of UI.  UI(4,1)=Sep\_QX(13,11); %Extract Sep\_Qx at row 13, column 11 and put in into 1 row, 4 column of UI. | | | |
| 1. Plotting line graph for upwelling index. | | | hold off  plot(UI,'k')%Plot Line Graph  hold on  xlabel('Month','FontSize',10) %Label x axis  ylabel('UI (m^3 s^-^1 m^-^1)','FontSize',10) %Label y axis  ax=gca;  ax.XTick=[1 2 3 4]; %Set x axis value  ax.XTickLabel={'Jun','Jul','Aug','Sep'}; %Set X label |