Tarea 3

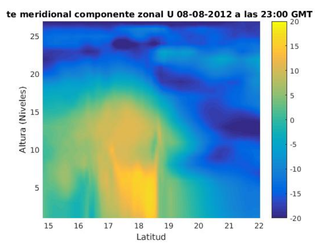
Pedraza-Espitia S.

1. Corte meridional

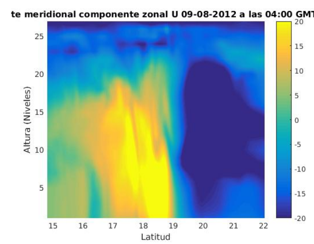
Realizar un programa que realice y grafique un corte meridional de U en donde se observe el paso del huracán y guardar las gráficas de cuatro tiempos diferentes en formato jpg.

```
% author Pedraza-Espitia S.
% corte meridional
close all
clear all
%Ruta = ['/media/salva/exfat/'];
Ruta = ['/media/sal/exfat/'];
Arch = [Ruta,'wrfout_d02_2012-08-08_00_UVW.nc'];
% atributos, variables y dimensiones
Tiempo = ncread(Arch,'Times')';
Times_l = length(Tiempo);

XLAT = ncread(Arch,'XLAT', [1 1 1], [Inf Inf 1], [1 1 1]);
XLAT = double(XLAT);
XLONG =  ncread(Arch,'XLONG', [1 1 1], [Inf Inf 1], [1 1 1]);
XLONG = double(XLONG);
Niveles = 1:27;
Xlatitud = XLAT(1,:);
[Niveles,Xlatitud] = meshgrid(Niveles,Xlatitud);
figst = [24 29 34 39];
num = 1;
Un94 = ncread(Arch,'U',[200 1 1 1],[1 inf inf Inf], [1 1 1 1]);
Un94 = double(squeeze(Un94));
figure
for tt=1:46
    clf;
    year = Tiempo(1,1:4);
    mes = Tiempo(1,6:7);
    dia = Tiempo(tt,9:10);
    hora = Tiempo(tt,12:13);
    mins = Tiempo(tt,15:16);
    pcolor(Xlatitud,Niveles,Un94(:,:,tt)), shading interp
    ylabel('Altura (Niveles)')
    xlabel('Latitud')
    title(['Corte meridional componente zonal U ',...
        dia,'-',mes,'-',year,' a las ',hora,':',mins,' GMT'])
    caxis([-20 20])
    colorbar
    %title(tt) % codigo para obtener 4 imagenes jpeg:
    if figst(num) == tt
```

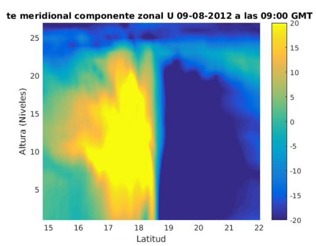
```
        %fig.PaperUnits='inches';
        nombreimg = ['t3fig',num2str(tt),'.jpeg'];
        print(nombreimg,'-djpeg','-r0')
        if num < 4
            num = num+1;
        else
            continue
        end
    end
    pause(0.2)
end
```



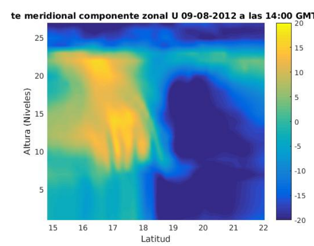
(a) ii=24



(b) ii=29



(c) ii=34



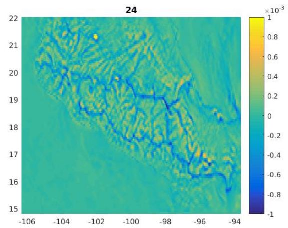
(d) ii=39

Figura 1: Evolución de la componente U en un corte meridional (longitud fija $\approx$ -94^o)

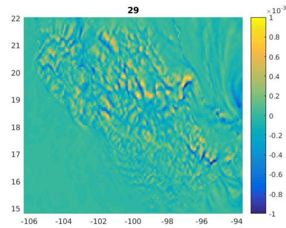
2. Divergencia

Hacer un programa que calcule la divergencia del viento a 10 metros, utilizando diferencias finitas centradas, sin emplear funciones de matlab (DIV), y guardar las gráficas resultantes de cuatro tiempos diferentes. Tomar en cuenta que la latitud y longitud que proporciona el modelo están en grados y deberán convertirse a metros.

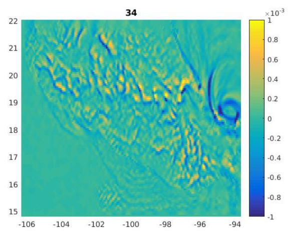
En la siguiente Sección 3 se fusionan el ejercicio de obtener divergencia y rotacional en un sólo script. Las gráficas que se piden se muestran en la Figura 2.



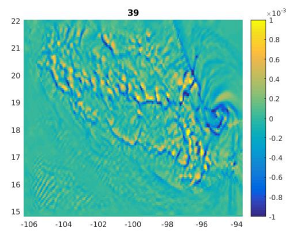
(a) ii=24



(b) ii=29



(c) ii=34



(d) ii=39

Figura 2: Divergencia en 4 tiempos distintos, una divergencia positiva implica una fuente y una negativa indica hundimiento o sumidero.

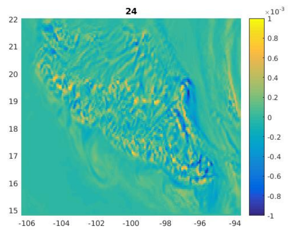
3. Rotacional

Hacer un programa que calcule el rotacional del viento en el nivel 8, utilizando diferencias finitas centradas, sin emplear funciones de matlab (CURL), y guardar las gráficas resultantes de cuatro tiempos diferentes. Tomar en cuenta que la latitud y longitud que proporciona el modelo están en grados y deberán convertirse a metros.

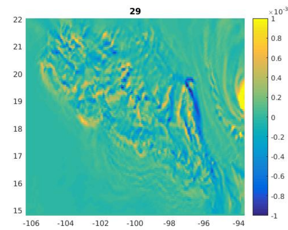
```
% author Pedraza-Espitia S.
% divergencia y rotacional
close all
clear all

%Ruta = ['/media/salva/exfat/'];
%Ruta = ['/media/sf_salida_WRF/'];
Ruta = ['/media/sal/exfat/'];
Arch = [Ruta,'wrfout_d02_2012-08-08_00_UVW.nc'];
%ncdisp(Arch)

Tiempo = ncread(Arch,'Times')';
Times_l = length(Tiempo);
        % [DesdeX , Y, T] [HastaX, Y, T] [cUAL]
XLAT = ncread(Arch,'XLAT', [1 1 1], [Inf Inf 1], [1 1 1]);
XLAT = double(XLAT);
XLONG = ncread(Arch,'XLONG', [1 1 1], [Inf Inf 1], [1 1 1]);
XLONG = double(XLONG);

U10 = ncread(Arch,'U10');
```

```
V10 = ncread(Arch,'V10');


for ii=1:Times_l(1)
     Uii = double(U10(:,:,ii));
     Vii = double(V10(:,:,ii));
     Speed = sqrt(Uii.^2+Vii.^2);
     pcolor(XLONG,XLAT,Speed), shading flat, caxis([0 30]),colorbar
     pause(.1)
end

%% convertir diferenciales Dx Dy
[xx,yy,tt] = size(U10);
R = 6370e3;
[Nx,Ny] = size(XLAT);

Del2X = zeros(Nx,Ny);
Del2Y = zeros(Nx,Ny);
for ii = 2:Nx-1;
     for jj = 2:Ny-1
          Del2X(ii,jj) = R*cos((pi/180)*XLAT(ii,jj))*(XLONG(ii+1,jj)-XLONG(ii-1,jj))*pi/180;
          Del2Y(ii,jj) = R*(XLAT(ii,jj+1)-XLAT(ii,jj-1))*pi/180;
     end
end

Div = zeros(Nx,Ny,tt);
Rot = zeros(Nx,Ny,tt);
%% calculo divergencia
for kk=1:tt
     U=double(U10(:,:,kk));
     V=double(V10(:,:,kk));
     for ii = 2:Nx-1;
          for jj = 2:Ny-1;
               Div(ii,jj,kk) = (U(ii+1,jj)-U(ii-1,jj))/Del2X(ii,jj) + (V(ii,jj+1)-V(ii,jj-1))/Del2Y(ii,jj);
          end
     end
end

figst = [24 29 34 39];
num = 1;
for kk=1:Times_l(1)
    pcolor(XLONG,XLAT,Div(:,:,kk)),shading flat, caxis([-1e-3 1e-3]),colorbar
    title(int2str(kk))
    if figst(num) == kk
          nombreimg = ['t3div',num2str(num),'.jpeg'];
          print(nombreimg,'-djpeg','-r0')
          if num < 4
               num = num+1;
          else
               continue
          end
    end
    pause(.2)
end
```

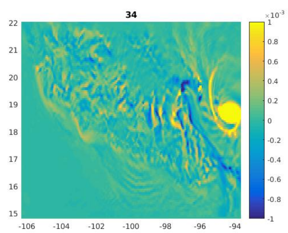
```
%% calculo Rotacional
Uu = ncread(Arch,'U');
Vv = ncread(Arch,'V');
for kk=1:tt
    U=double(Uu(:,:,8,kk));
    V=double(Vv(:,:,8,kk));
    for ii = 2:Nx-1;
        for jj = 2:Ny-1;
            Rot(ii,jj,kk) = (V(ii+1,jj)-V(ii-1,jj))/Del2X(ii,jj) - (U(ii,jj+1)-U(ii,jj-1))/Del2Y(ii,jj);
        end
    end
end

figst = [24 29 34 39];
num = 1;
for kk=1:Times_l(1)
   pcolor(XLONG,XLAT,Rot(:,:,kk)),shading flat, caxis([-1e-3 1e-3]), colorbar
   title(int2str(kk))
   pause(.2)
   if figst(num) == kk
        nombreimg = ['t3rot',num2str(num),'.jpeg'];
        print(nombreimg,'-djpeg','-r0')
        if num < 4
            num = num+1;
        else
            continue
        end
   end
end
```



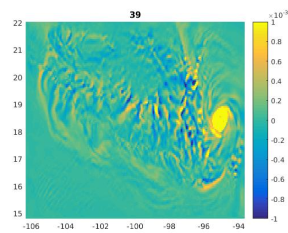
(a) ii=24



(b) ii=29



(c) ii=34



(d) ii=39

Figura 3: Rotacional en 4 tiempos distintos, se calcula sobre una superfice (nivel 8) y esto implica que sólo resulte una componente que es perpendicular a la superficie, el rotacional sigue la regla de la mano derecha y es proporcional a la velocidad angular.

4. Resolver $y' = cos(t) + sin(t)$ usando RK4

Considera la ecuación diferencial $y' = cos(t) + sin(t)$ con $y(t = 0) = 1$ y $h = 0.1$. Escribe un código para calcular la solución con el método de Runge-Kutta de orden 4. Recuerda que:

$$\begin{aligned}
k_1 &= h * f(t_i, y_i) \\
k_2 &= h * f(t_i + h/2, y_i + k_1/2) \\
k_3 &= h * f(t_i + h/2, y_i + k_2/2) \\
k_4 &= h * f(t_i + h, y_i + k_3)
\end{aligned}$$

$$y_{i+1} = y_i + 1/6(k_1 + 2k_2 + 2k_3 + k_4)$$

```
clear all
h = 0.1;
t=0;
y = 1;

fprintf('Paso 0: t = %6.3f, y = %18.15f\n',t,y);
for ii = 1:126
    k1 = h*(cos(t) + sin(t));
    k2 = h*(cos(t+ h/2) + sin(t+ h/2));
    k3 = h*(cos(t+ h/2) + sin(t+ h/2));
    k4 = h*(cos(t+ h) + sin(t+ h));
```

```
    y = y + (k1+2*k2+2*k3+k4)/6;
    t = t+h;
    T(ii) = t;
    Y(ii) = y;
    fprintf('Paso %d: t = %6.3f, y = %18.15f\n',ii,t,y);
end

plot(T,Y);
```

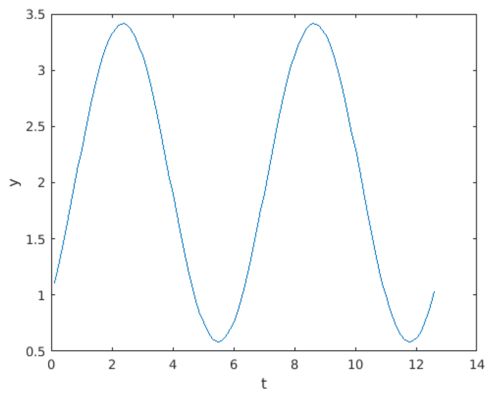


Figura 4: Solución de $y' = \cos t + \sin t$.

5. Resolver $y' = y - 2 * t^3 + 2$ con RK4

Considera la ecuación diferencial $y' = y - 2 * t^3 + 2$ con $y(t = 0) = 0.5$. Escribe un código para calcular la solución con el método de Runge-Kutta de orden 4.

```
clear T Y
h = 0.01;
t=0;
y =.5;

RK_f = @(t,y) y - 2*t^3 + 2;
fprintf('Paso 0: t = %6.3f, y = %18.15f\n',t,y);
for ii = 1:400
    k1 = h* RK_f(t,y);
    k2 = h* RK_f(t+h/2,y+k1/2);
    k3 = h* RK_f(t+h/2,y+k2/2);
    k4 = h* RK_f(t+h,y+k3);
    y = y + (k1+2*k2+2*k3+k4)/6;
    t = t+h;
    T(ii) = t;
    Y(ii) = y;
    fprintf('Paso %d: t = %6.3f, y = %18.15f\n',ii,t,y);
end

plot(T,Y, 'c');
```

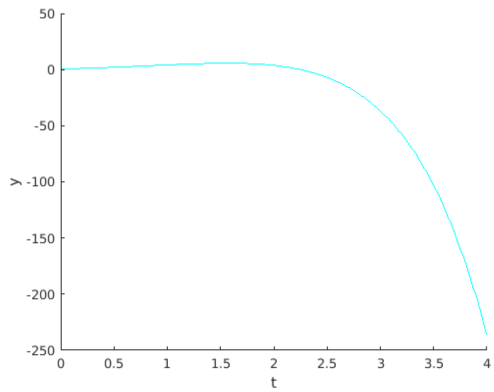


Figura 5: Solución de $y' = y - 2t^3 + 2$.

6. Aguas soméras

$$\frac{\partial u}{\partial t} - fv = -g\frac{\partial h}{\partial x} \tag{1}$$

$$\frac{\partial v}{\partial t} + fu = -g\frac{\partial h}{\partial y} \tag{2}$$

$$\frac{\partial h}{\partial t} + H\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) = 0 \tag{3}$$

$$\frac{\partial[(1)]}{\partial x} \Rightarrow \frac{\partial^2 u}{\partial x \partial t} - f\frac{\partial v}{\partial x} = -g\frac{\partial^2 h}{\partial x^2} \tag{4}$$

$$\frac{\partial[(2)]}{\partial y} \Rightarrow \frac{\partial^2 v}{\partial y \partial t} + f\frac{\partial v}{\partial y} = -g\frac{\partial^2 h}{\partial y^2} \tag{5}$$

$$[(4) + (5)] \Rightarrow \frac{\partial}{\partial t}\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) + f\left(\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}\right) = -g\left(\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2}\right) \tag{6}$$

$$\frac{\partial[(3)]}{\partial t} \Rightarrow \frac{\partial^2 h}{\partial t^2} + H\frac{\partial}{\partial t}\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) = 0 \tag{7}$$

$$\begin{aligned}[(7) - H * (6)] \Rightarrow & \frac{\partial^2 h}{\partial t^2} + H\cancel{\frac{\partial}{\partial t}\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right)} - H\cancel{\frac{\partial}{\partial t}\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right)} \\ & - Hf\left(\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}\right) = g\left(\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2}\right)\end{aligned}$$

$$\Rightarrow \frac{\partial^2 h}{\partial t^2} - Hf\left(\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}\right) - gH\left(\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2}\right) = 0 \tag{8}$$

$$\frac{\partial[(1)]}{\partial y} \Rightarrow \frac{\partial^2 u}{\partial y \partial t} - f\frac{\partial v}{\partial y} = -g\frac{\partial^2 h}{\partial y \partial x} \tag{9}$$

$$\frac{\partial[(2)]}{\partial x} \Rightarrow \frac{\partial^2 v}{\partial x \partial t} + f\frac{\partial u}{\partial x} = -g\frac{\partial^2 h}{\partial x \partial y} \tag{10}$$

$$[(9) + (10)] \Rightarrow \frac{\partial}{\partial t}\left(\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}\right) = f\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) \tag{11}$$

$$[(3)] \Rightarrow \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) = -\frac{1}{H}\frac{\partial h}{\partial t} \tag{12}$$

$$[(12) \text{ y } (11)] \Rightarrow \frac{\partial}{\partial t}\left(\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}\right) = -f\frac{1}{H}\frac{\partial h}{\partial t} \tag{13}$$

$$\frac{\partial[(8)]}{\partial t} \Rightarrow \frac{\partial}{\partial t}\frac{\partial^2 h}{\partial t^2} - Hf\frac{\partial}{\partial t}\left(\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}\right) - gH\frac{\partial}{\partial t}\left(\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2}\right) = 0 \tag{14}$$

$$[(11) \text{ y } (14)] \Rightarrow \frac{\partial}{\partial t}\frac{\partial^2 h}{\partial t^2} - Hf^2\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) - gH\frac{\partial}{\partial t}\left(\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2}\right) = 0 \tag{15}$$

$$[(12) \text{ y } (15)] \Rightarrow \frac{\partial}{\partial t}\frac{\partial^2 h}{\partial t^2} - Hf^2\left(-\frac{1}{H}\frac{\partial h}{\partial t}\right) - gH\frac{\partial}{\partial t}\left(\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2}\right) = 0 \tag{16}$$

$$\frac{\partial}{\partial t}\frac{\partial^2 h}{\partial t^2} + f^2\left(\frac{\partial h}{\partial t}\right) - gH\frac{\partial}{\partial t}\left(\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2}\right) = 0 \tag{17}$$

$$\frac{\partial}{\partial t}\left[\frac{\partial^2}{\partial t^2} + f^2 - gH\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)\right]h = 0 \tag{18}$$