USING PYTHON TO COMPARE MODELS AND PLOT PARTICLE DISTRIBUTION FOLLOWING THE LAGRANGIAN FLOW NETWORK

BY: JESSICA STEVENS

INTRODUCTION

- TRANSPORT, DISPERSAL AND CONNECTIVITY WITHIN AND OUTSIDE OF THE GULF OF MEXICO (GOM) DUE TO THE EFFECTS OF THE LOOP CURRENT (LC) IS A CRUCIAL PROCESS TO UNDERSTAND.

Weisberg et al. Fig. 10

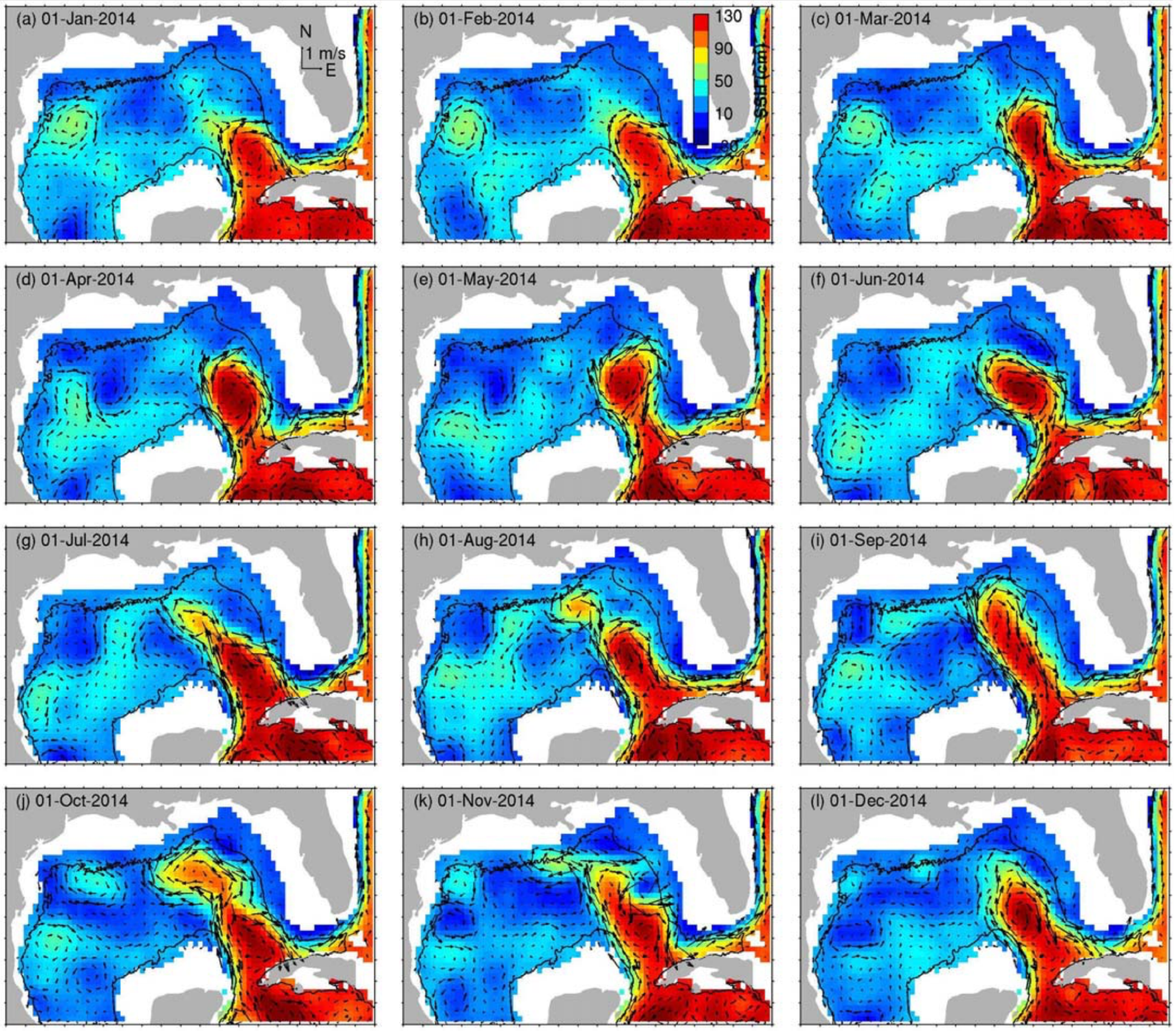
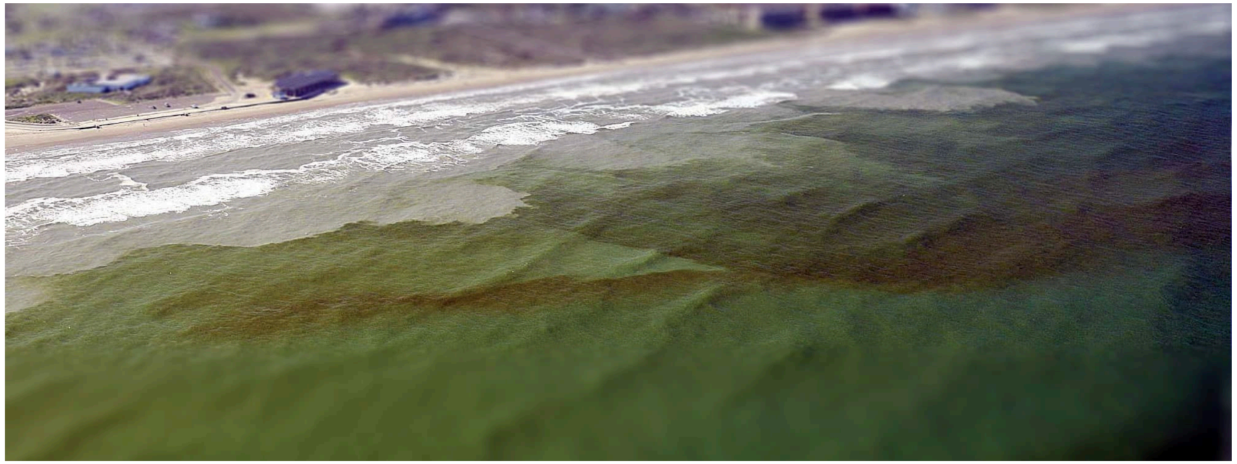


Figure 10. Snapshots of the sea surface height and surface geostrophic velocity vectors in the Gulf of Mexico on the first day of each month for 2014. The black line is the 1,000 m isobath.

BACKGROUND

- BIOLOGICAL TRANSPORT
  - EX. MESOPHOTIC CORAL CONNECTIVITY
- RETENTION PROCESSES
  - EX. HARMFUL ALGAL BLOOMS, RED TIDE
- POLLUTANT TRANSPORT
  - EX. DEEPWATER HORIZON OIL SPILL



Blooms of harmful algae, like this "red tide" off the coast of Texas, can cause illness and death in humans and animals.

(US Department of Commerce & National Oceanic and Atmospheric Administration 2019)

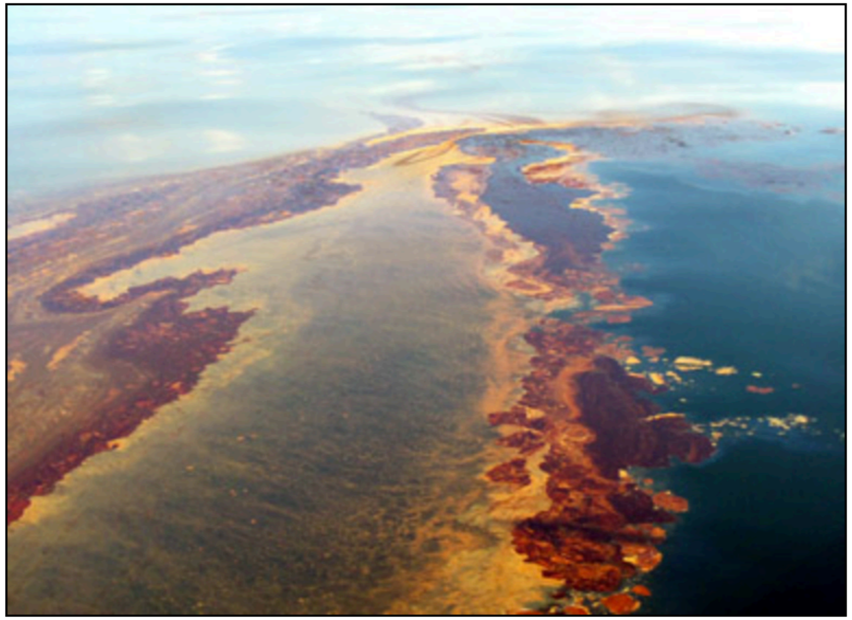


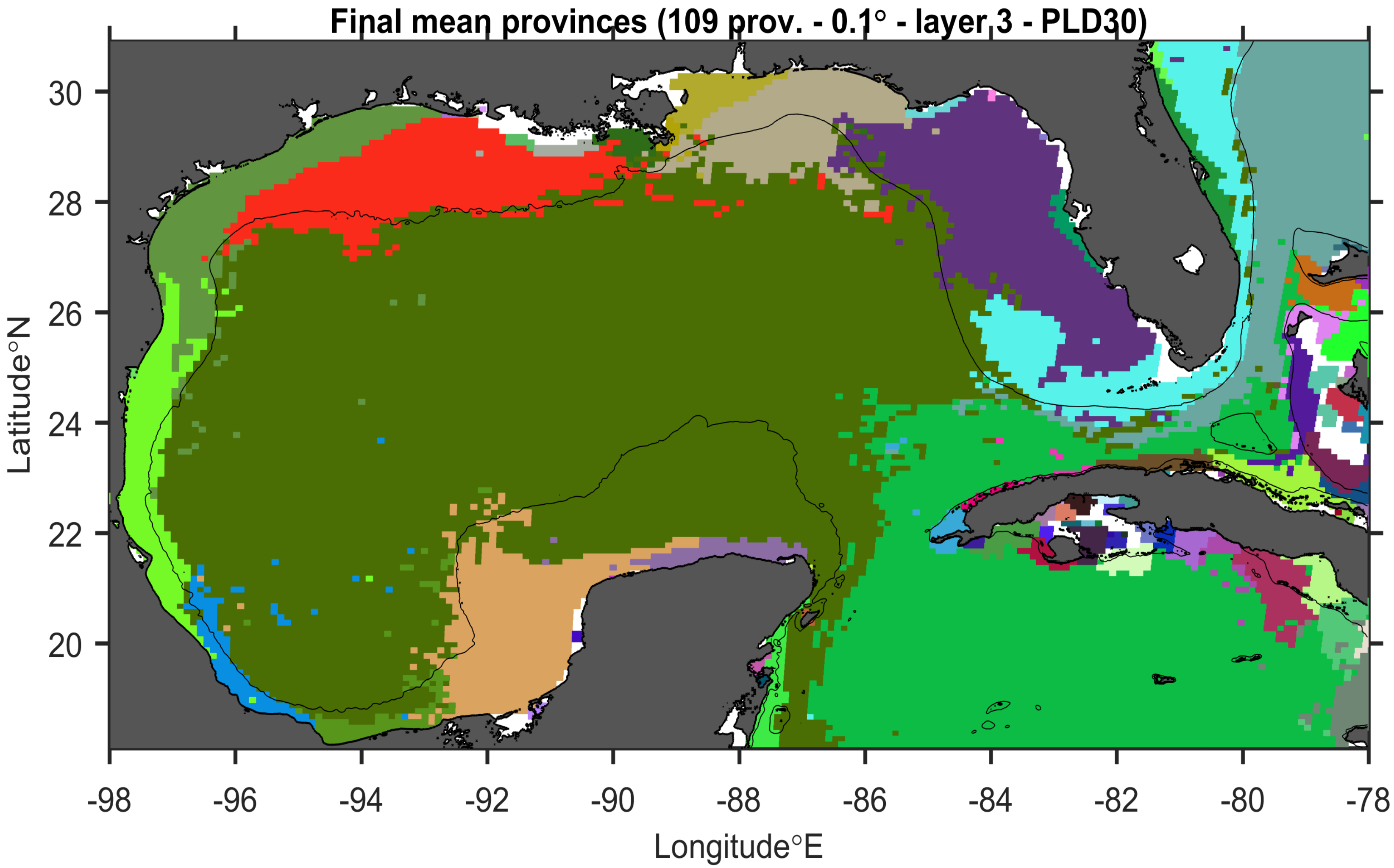
Figure 3. Oil at the surface near the Deepwater Horizon accident site. Photo credit: Vernon Asper, May 7, 2010.

https://gcrl.usm.edu/whaleshark/oil.impact.php.

RESEARCH QUESTION

- DOES THE FLOW OF THE LOOP CURRENT CREATE CONNECTIVITY PATTERNS IN THE GULF OF MEXICO?

- HYPOTHESIS: YES, IT DOES CREATE CONNECTIVITY MATRICES ACROSS THE GOM.



Preliminary connectivity matrix in the Gulf of Mexico by Enrico Ser-Giacomi, Vincent Rossi, and Cheryl Harrison

METHODS

- USING NETWORK THEORY AND LAGRANGIAN OCEANOGRAPHIC MODELING (LAGRANGIAN FLOW NETWORKS, LFN) ALONG WITH SELF-ORGANIZING MAPS, WE WILL ASSESS OCEAN CLIMATE STATES.

```
path = '/Users/xfm684/Documents/Research/HYCOM/hycom_gomu_501_'
tail = '00_t000.nc'
```

```
name = '20020101'
test = xr.open_dataset(path+name+tail, decode_times=False)

########## P L O T ##############

limN, limS, limE, limW = 32, 18, -78, -100

fig = plt.figure(figsize=(16,12), facecolor = 'w')
## m is map projection
m = Basemap(projection='cyl', llcrnrlon=limW, \
      urcrnrlon=limE, llcrnrlat=limS, urcrnrlat=limN, resolution='l')
# resolution options: crude, low, intermediate, high, full

m.drawcoastlines()
m.fillcontinents(color='lightgrey')

# now add in some data:
var = test.surf_el[0,:,:]
var_name = "Surface Elevation"
punits = "meters"
## projection must be applied (m)
x, y = m(test.lon,test.lat)
im1 = m.pcolormesh(x,y,var,zorder = 0, cmap = 'jet', vmin=-.2, vmax=.8) ##this is where you add t
he color is basemap
cbar = m.colorbar(im1,location='bottom',pad="5%")
cbar.set_label(var_name + ' ('+ punits + ')')

U = test.water_u[0,0,:,:]
V = test.water_v[0,0,:,:]
Q = plt.quiver(x[::11], y[::11], U[::11, ::11], V[::11, ::11])#,headlength=1, headaxislength=1)#,
linewidth=0.5)
qk = plt.quiverkey(Q, 0.1,0.9,1, r'$1 \frac{m}{s}$', labelpos='W')

dlat = 2
dlon = 4
m.drawparallels(np.arange(-90.,90.,dlat), linewidth=0.5, labels=[1,0,0,0])
m.drawmeridians(np.arange(-180.,180.,dlon), linewidth=0.5, labels=[0,0,1,0])

plt.title('HYCOM ' + name, y=1.08)
# fig.savefig('HYCOM_' + name)
```

HYCOM AND GECKO PLOTS

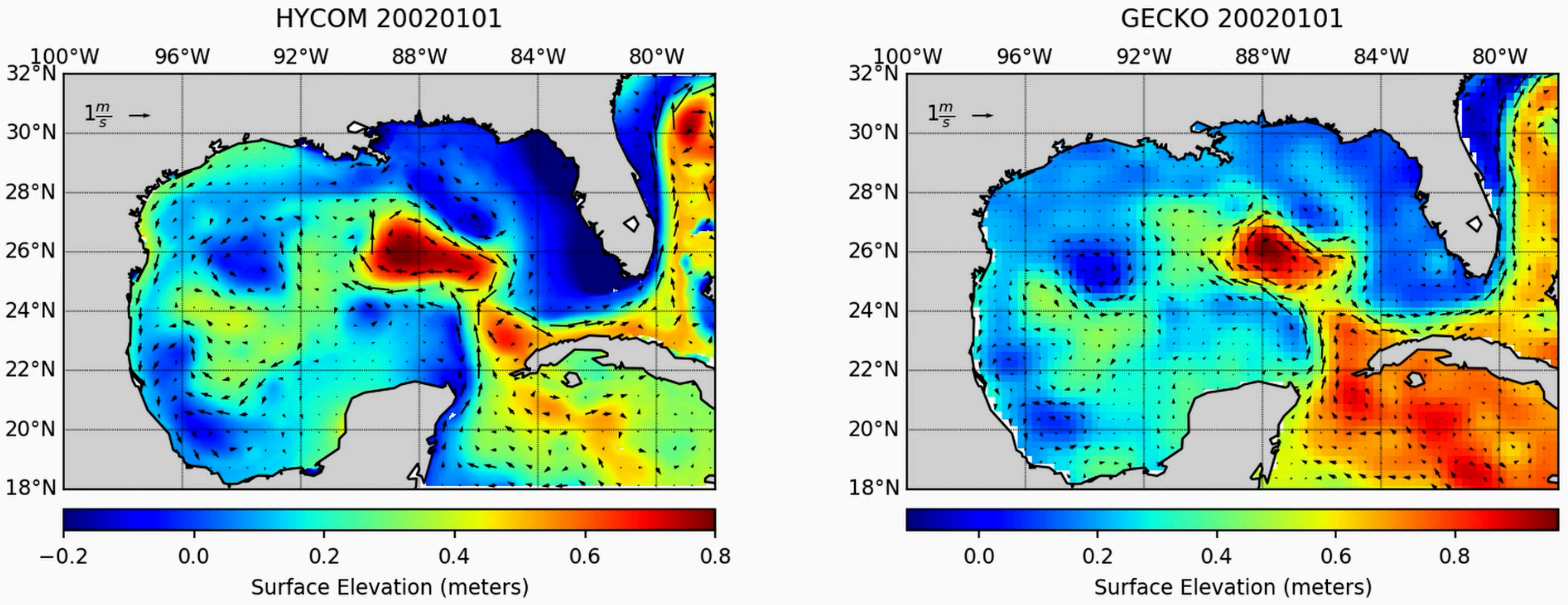
```
#### H Y C O M ####
h_path = '/Users/xfm684/Documents/Research/HYCOM/hycom_gomu_501_'
h_tail = '00_t000.nc'
h_name = '20020101'
h_test = xr.open_dataset(h_path+h_name+h_tail, decode_times=False)

limN, limS, limE, limW = 32, 18, -78, -100
h_m = Basemap(projection='cyl', llcrnrlon=limW, \
      urcrnrlon=limE, llcrnrlat=limS, urcrnrlat=limN, resolution='l')

h_var = h_test.surf_el[0,:,:]
h_var_name = "Surface Elevation"
h_punits = "meters"
h_x, h_y = m(h_test.lon,h_test.lat)

h_U = h_test.water_u[0,0,:,:]
h_V = h_test.water_v[0,0,:,:]
```

```
#### G E C K O ####
g_path = '/Users/xfm684/Documents/Research/GECKO/v_gekco2_'
g_tail = '.nc'
g_name = '20020101'
g_test = xr.open_dataset(g_path+g_name+g_tail, decode_times=False)

limN, limS, limE, limW = 32, 18, 282, 260
g_m = Basemap(projection='cyl', llcrnrlon=limW, \
      urcrnrlon=limE, llcrnrlat=limS, urcrnrlat=limN, resolution='l')

g_var = g_test.h[0,:,:]/100
g_var_name = "Surface Elevation"
g_punits = "meters"

g_x, g_y = m(g_test.lon,g_test.lat)

g_U = g_test.u[0,:,:]/100 #because it's in centimeters and I want m/s
g_V = g_test.v[0,:,:]/100
```

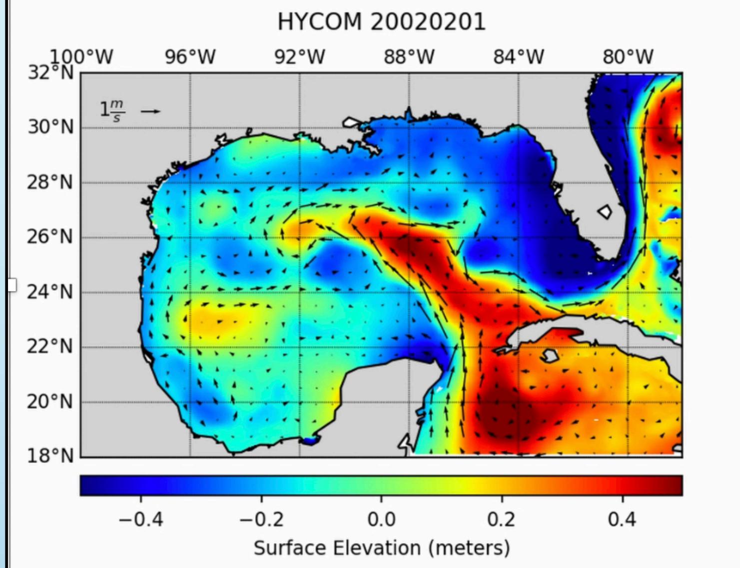
```
mpl.rcParams['font.size'] = 9
fig, ax = plt.subplots(figsize=(20,16), facecolor = 'w', ncols = 2)


plt.subplot(2,2,1)
h_m.drawcoastlines()
h_m.fillcontinents(color='lightgrey')
im1 = h_m.pcolormesh(h_x,h_y,h_var,zorder = 0, cmap = 'jet', vmin=-.2, vmax=.8) ##this is where y
ou add the color is basemap
cbar = h_m.colorbar(im1,location='bottom',pad="5%")
cbar.set_label(h_var_name + ' ('+ h_punits + ')')
h_Q = plt.quiver(h_x[::15], h_y[::15], h_U[::15, ::15], h_V[::15, ::15], scale=30)#,headlength=1,
headaxislength=1)#, linewidth=0.5)
h_qk = plt.quiverkey(h_Q, 0.1,0.9,1, r'$1 \frac{m}{s}$', labelpos='W')
dlat = 2
dlon = 4
h_m.drawparallels(np.arange(-90.,90.,dlat), linewidth=0.5, labels=[1,0,0,0])
h_m.drawmeridians(np.arange(-180.,180.,dlon), linewidth=0.5, labels=[0,0,1,0])
plt.title('HYCOM ' + h_name, y=1.08)



plt.subplot(2,2,2)
g_m.drawcoastlines()
g_m.fillcontinents(color='lightgrey')
im1 = g_m.pcolormesh(g_x,g_y,g_var,zorder = 0, cmap = 'jet') ##this is where you add the color is
basemap
cbar = g_m.colorbar(im1,location='bottom',pad="5%")
cbar.set_label(g_var_name + ' ('+ g_punits + ')')
Q = plt.quiver(g_x[::2], g_y[::2], g_U[::2, ::2], g_V[::2, ::2])#, scale=.01)#,headlength=1, head
axislength=1)#, linewidth=0.5)
qk = plt.quiverkey(Q, 0.1,0.9,1, r'$1 \frac{m}{s}$', labelpos='W')
dlat = 2
dlon = 4
g_m.drawparallels(np.arange(-90.,90.,dlat), linewidth=0.5, labels=[1,0,0,0])
g_m.drawmeridians(np.arange(-180.,180.,dlon), linewidth=0.5, labels=[0,0,1,0])
plt.title('GECKO ' + g_name, y=1.08)

fig.savefig('20020101')
```

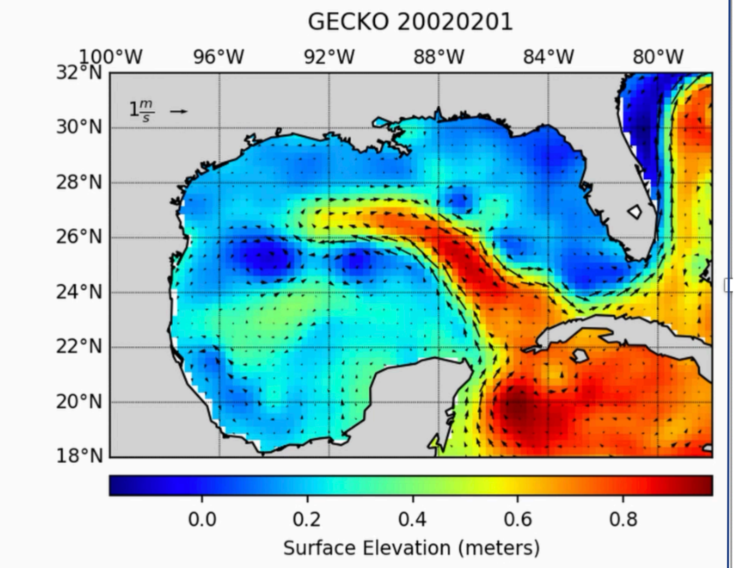
RESULTS

- HYCOM AND GECKO MODEL OUTPUT ARE IN AGREEANCE

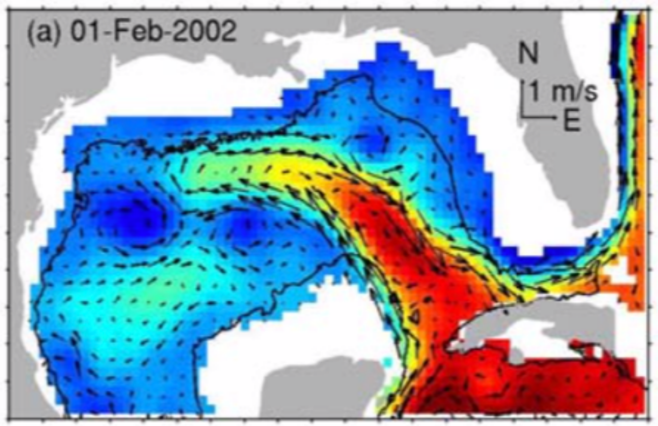


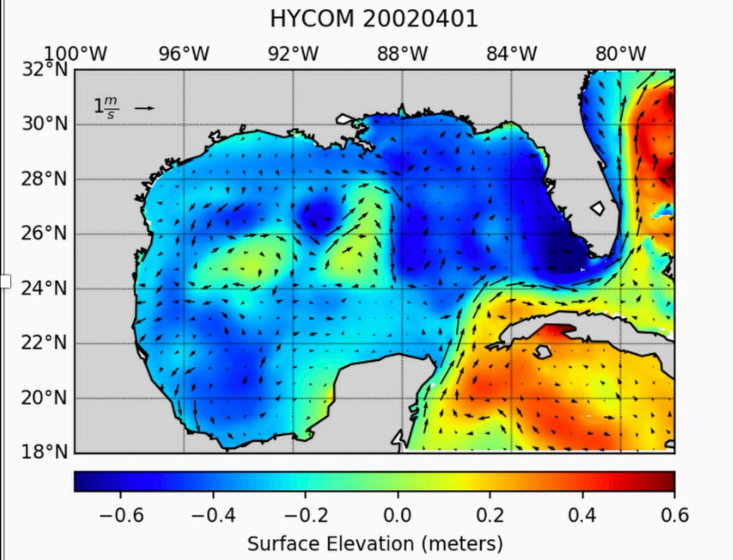
HYCOM GECKO AND WEISBERG ET AL.

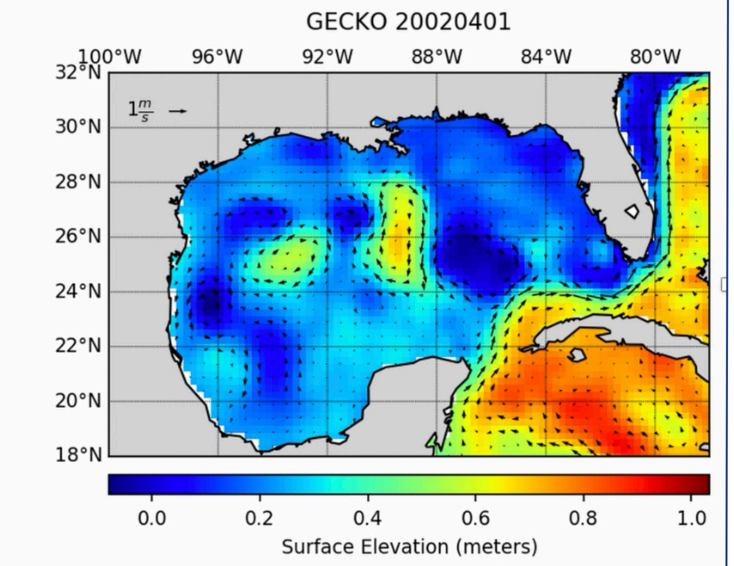




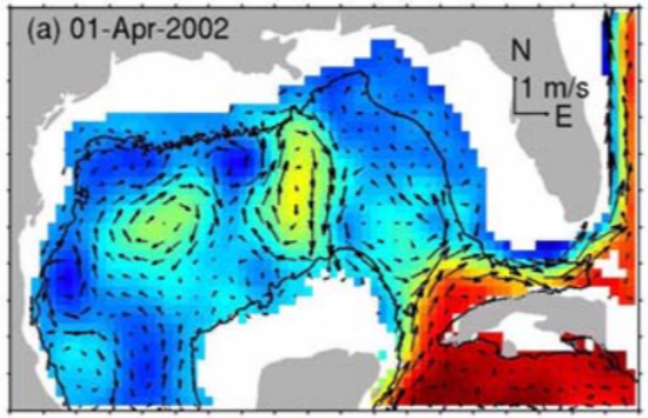
Weisberg et al. Fig. 3







Weisberg et al. Fig. 4



DISCUSSION

- MATRIX CONSTRUCTION WASN'T COMPLETED ON TIME TO ANSWER THE HYPOTHESIS.
- HYCOM AND GECKO MODEL OUTPUT AGREEANCE OFFERS CONFIDENCE IN THE LIKELY ACCURACY OF THE LFN OUTPUT
- HYCOM AND GECKO OUTPUT AGREES WITH THE WEISBERG ET AL. FIGURES.

~BACK UP YOUR DATA CONSTANTLY~

QUESTIONS?