https://www.worldatlas.com/aatlas/infopage/gulfofmexico.htm

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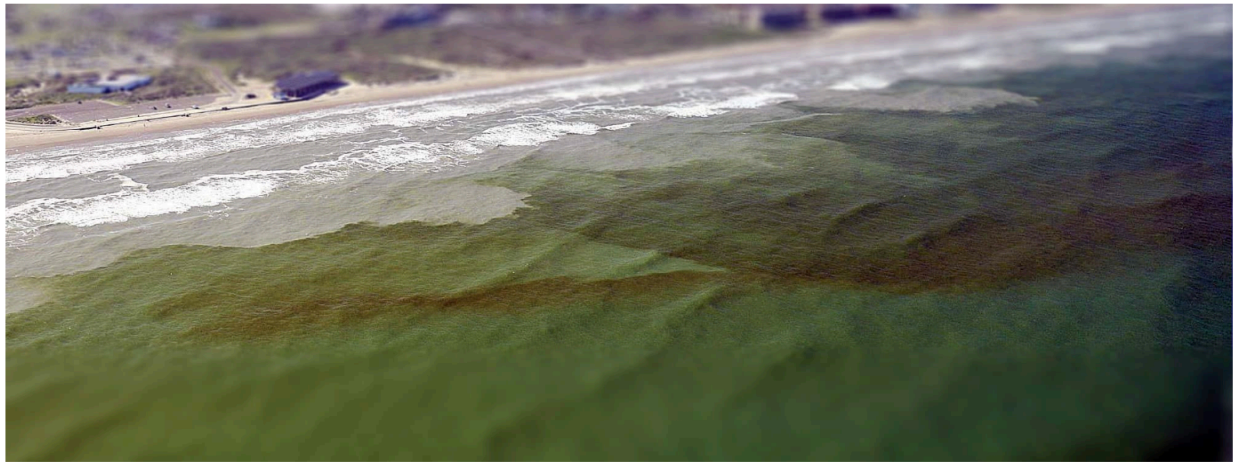
Using Python to Compare Models and Plot Particle Distribution Following the Lagrangian Flow Network in the Gulf of Mexico

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)

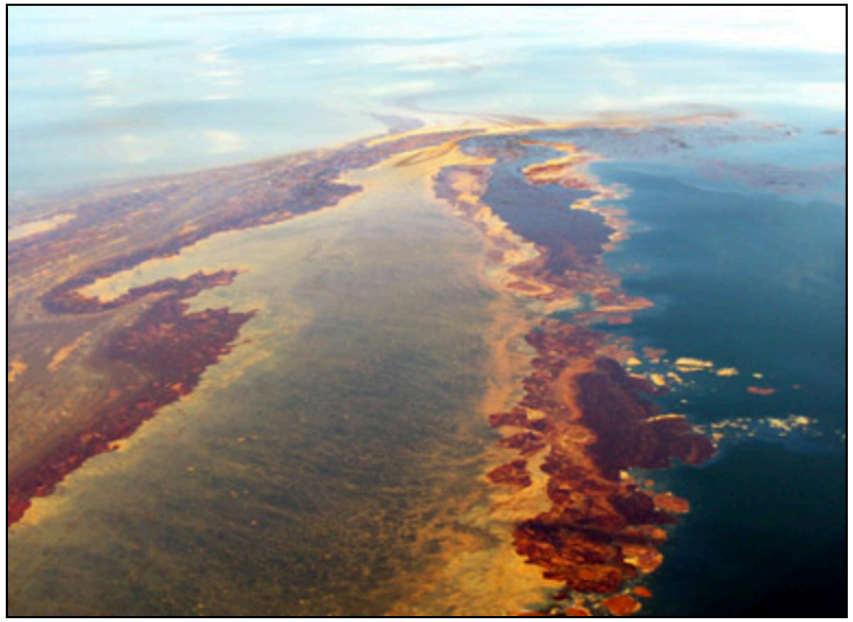


Figure 3. Oil at the surface near the Deepwater Horizon accident site. Photo credit: Vernon Asper, May 7, 2010.

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

Introduction

- Loop Current (LC)
  - Tropical waters enter the Gulf of Mexico (GoM) through the Yucatan Channel
  - Exits around Florida and becomes the Gulf Stream

Weisberg et al.

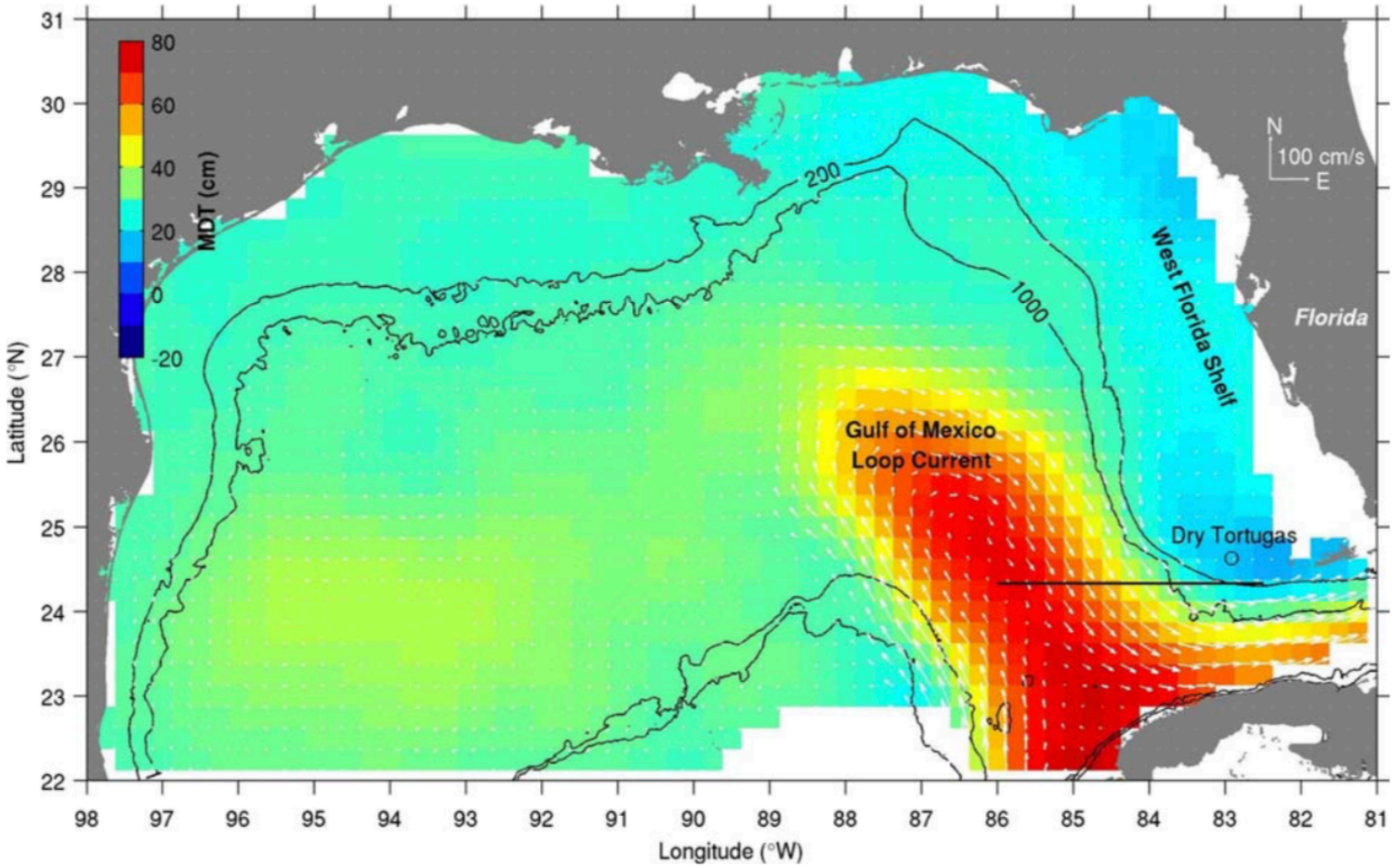
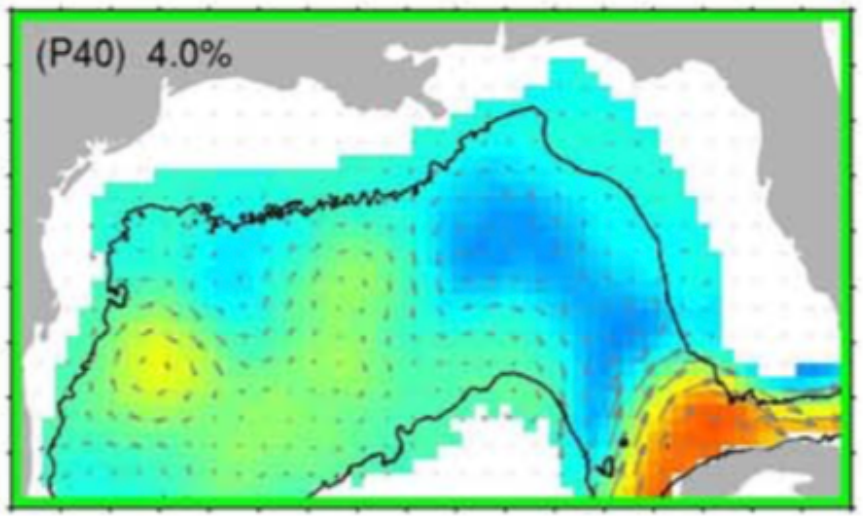
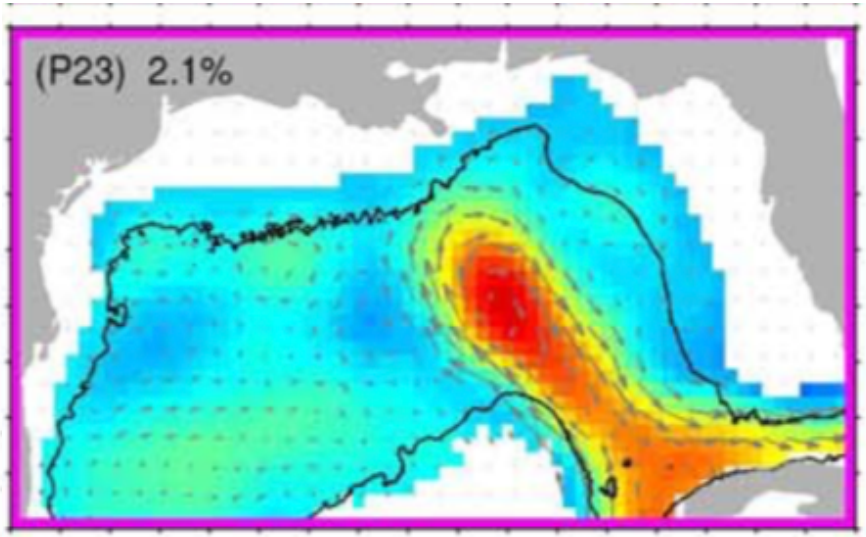


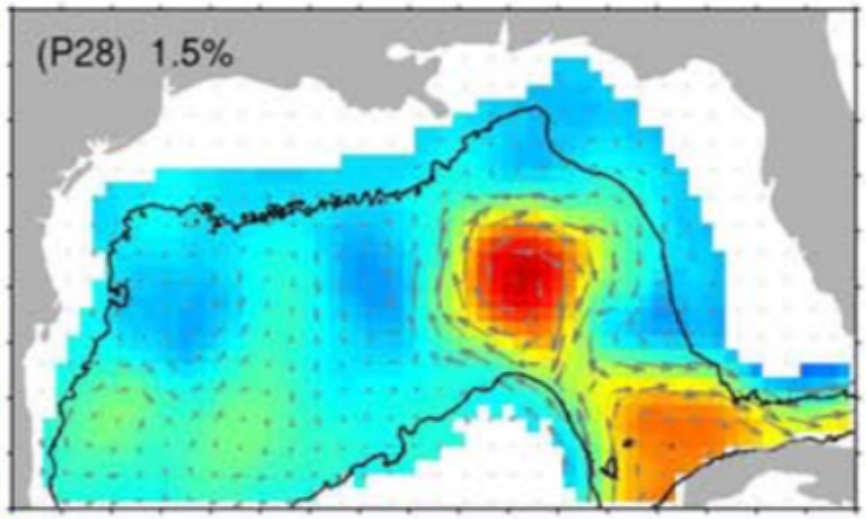
Figure 1. Mean dynamic topography (MDT) of MDT_CNES-CLS2013 and calculated surface geostrophic velocity vectors for the Gulf of Mexico. The deep Gulf of Mexico is distinguished from the coastal ocean by the 200 and 1,000 m bathymetric contours, and a zonally oriented line is drawn at 24° 20′ N for later purposes. The Dry Tortugas is shown as an open circle.

Introduction

- **LC 3 main states:**
  1. Retracted (green)
  2. Extended (magenta)
  3. Detached (no highlight)







Weisberg et al. Fig. 6

Introduction

- HYCOM – HYbrid Coordinate Ocean Model
  - Surface elevation (m), temperature (deg C), salinity (psu), water velocity (m/s)

- GEKCO - Geostrophic and EKman Current Observatory
  - Surface height (cm), surface water velocity (cm/s), pressure (Pa)

Introduction

- Lagrangian: follows particles as they move over time
  - Eulerian: tracks particles that flow through one region over time

- Lagrangian Flow Networks (LFN):
  - Self-organizing maps (SOM, machine learning) made from observational data on the GoM LC state will composite our LFN model.

Introduction

- **Particle Matrices**
  - Boxes *i* are the starting particle locations at the beginning of the run (time t_0)
  - Boxes *j* are the final particle locations at the end of the run (time $t_0 + \tau$)

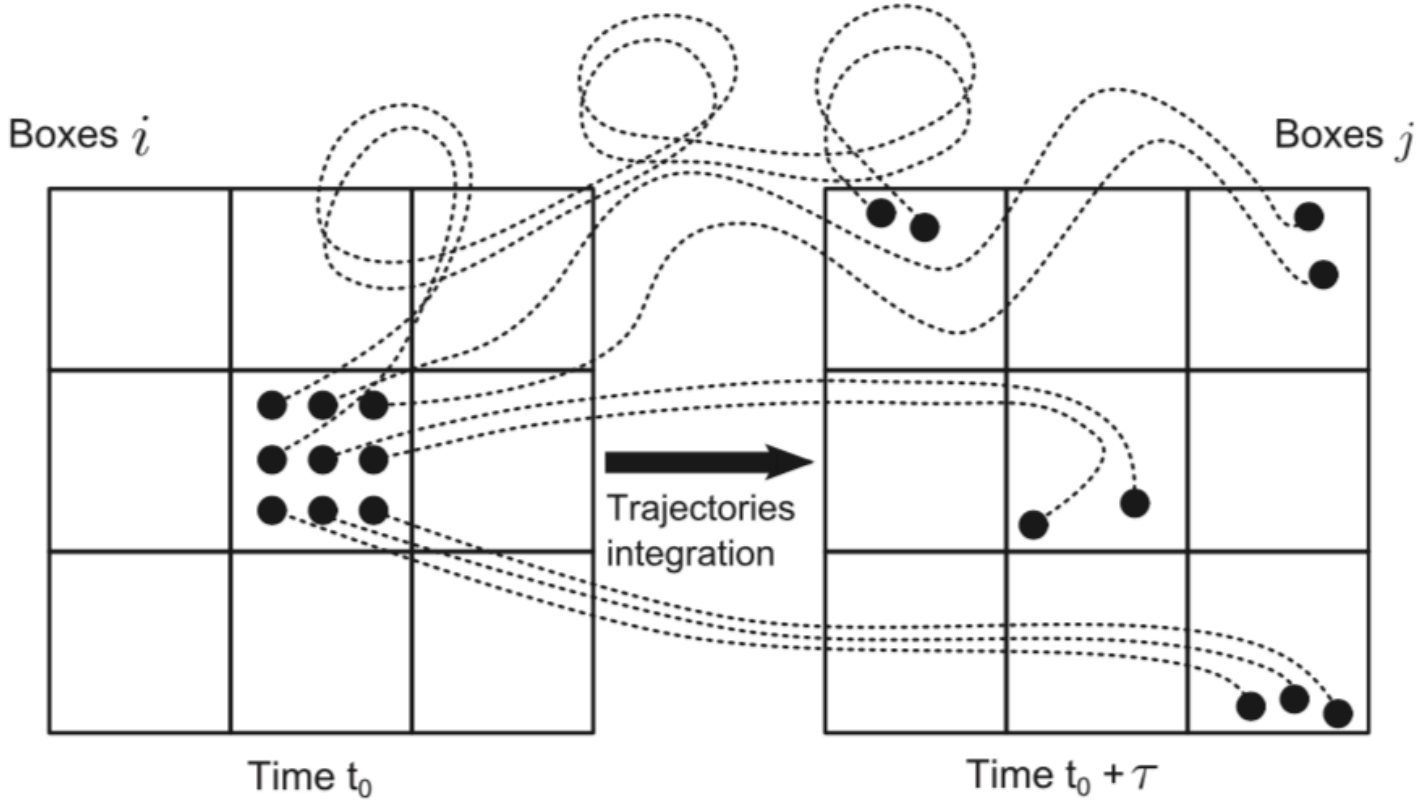


FIG. 1. Transport matrix construction from tracer's advection, following Eq. (3).

$$\mathbf{P}(t_0, \tau)_{ij} \approx \frac{\text{number of particles from box } i \text{ to box } j}{N_i}$$

Ser-Giacomi et al. Fig. 1 & Eq. 3

Research Questions

1. Do the HYCOM and GEKCO models output of sea surface height and velocity patterns correspond?

2. Do the HYCOM and GEKCO outputs resemble Weisberg et al. Figures?

Reasoning:

- LFN particle distribution relies on the HYCOM model for predictions
- Defending the reliability of HYCOM is seminal

Methods:
Plotting HYCOM and GEKCO

- **Using one month.**

```
>>file = '/Users/xfm684/Documents/Research/HYCOM/hycom_gomu_501_2002*0100_t000.nc'
```

- **GoM reanalysis from HYCOM imported to xarray**

```
>>test = xr.open_mfdataset(file, decode_times = False)
```

- **Plot sea surface elevation**

```
>>plt.subplot(2,2,1)

>>m.pcolormesh(test.lon, test.lat, test.surf_el[0,:,:])
```

- **Use quiver plot to show velocity vectors**

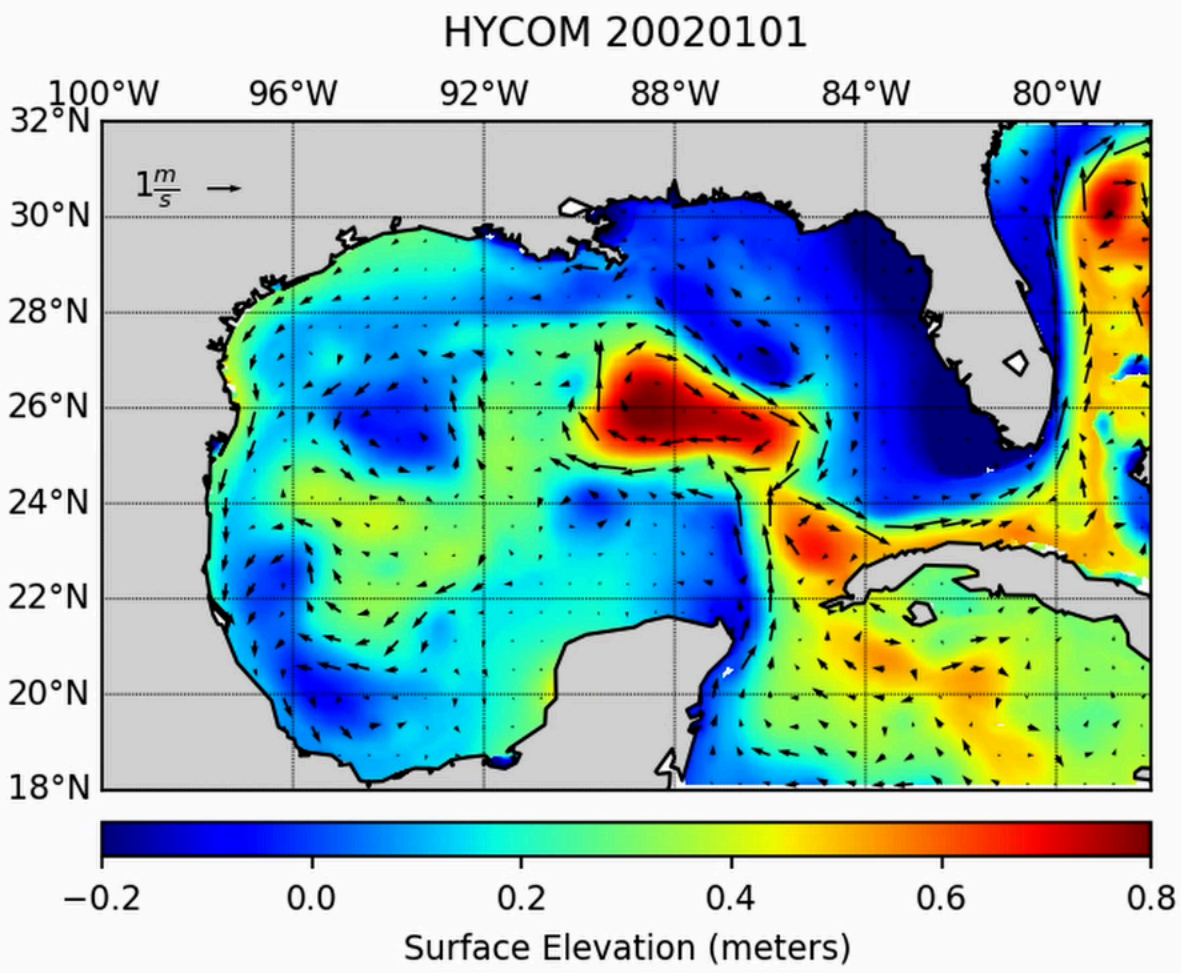
```
>>q = plt.quiver(test.lon, test.lat, test.u[0,0,:,:], test.v[0,0,:,:])
```

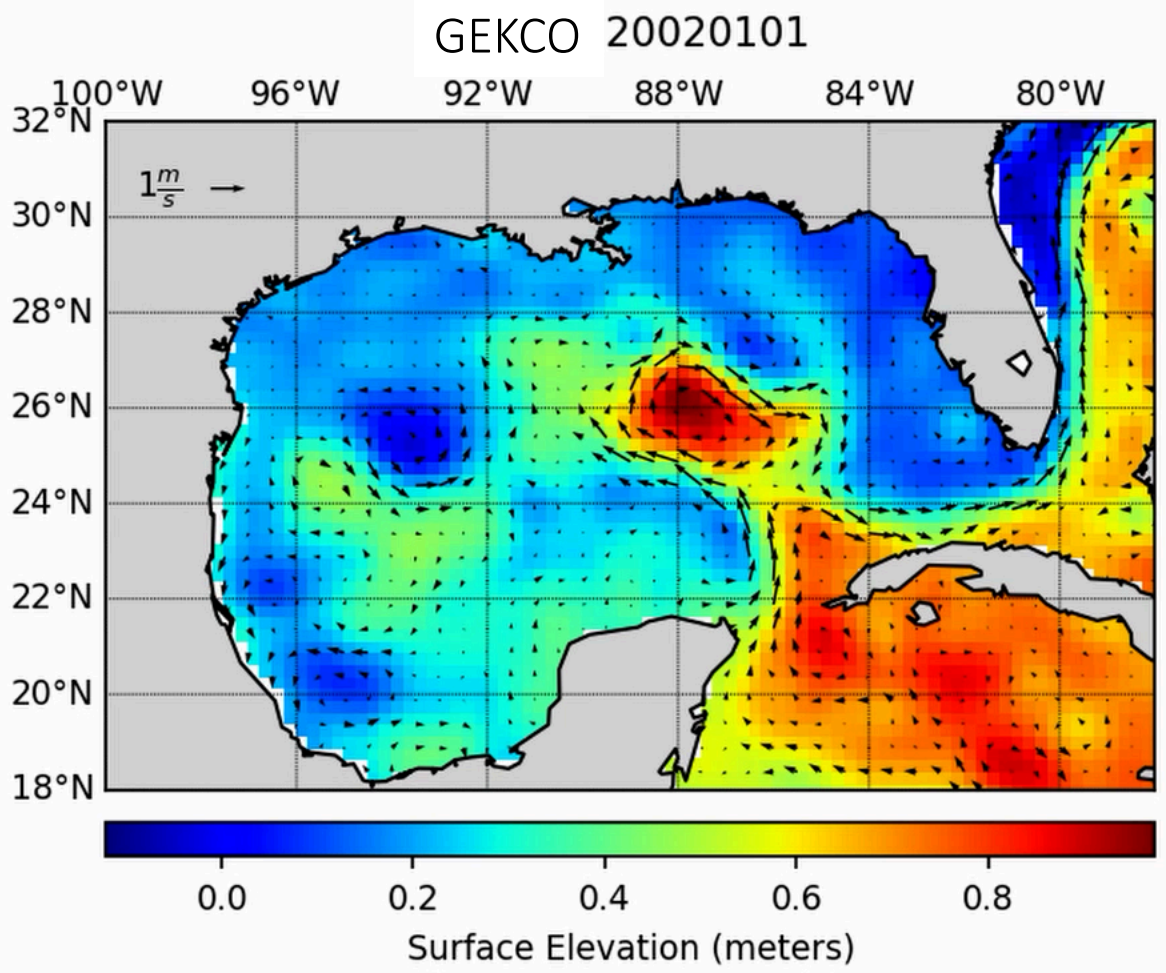
- **Repeat for GEKCO data**

```
>>plt.subplot(2,2,2)
```

Results

- HYCOM and GEKCO model output patterns correspond



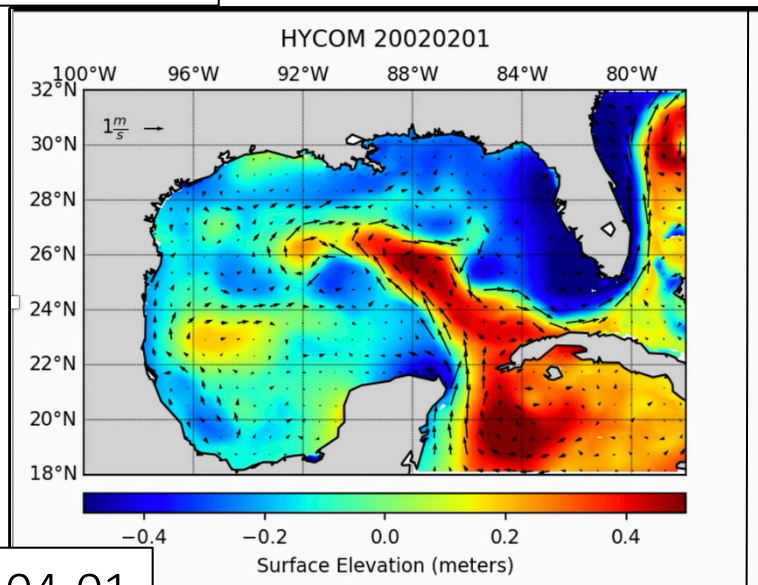


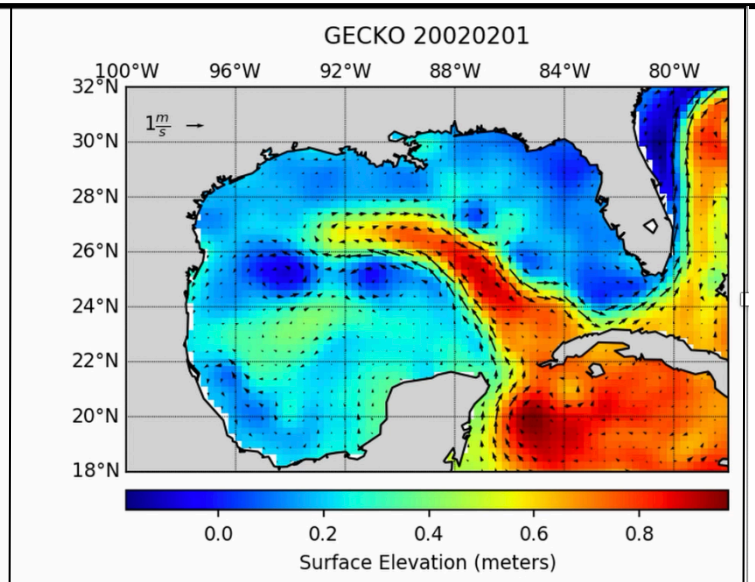
HYCOM

GEKCO

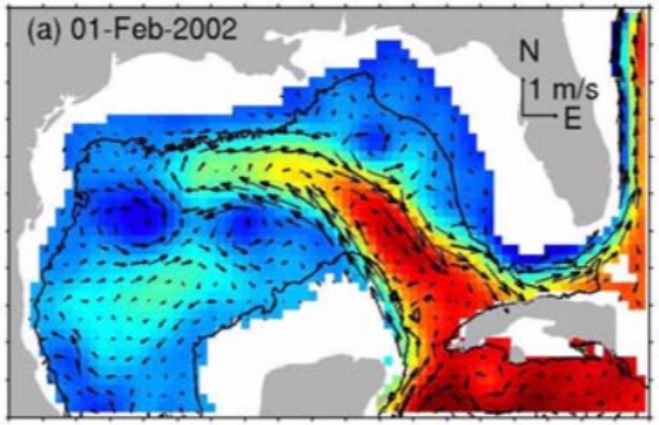
Weisberg et al.

2002-01-01





Weisberg et al. Fig. 3



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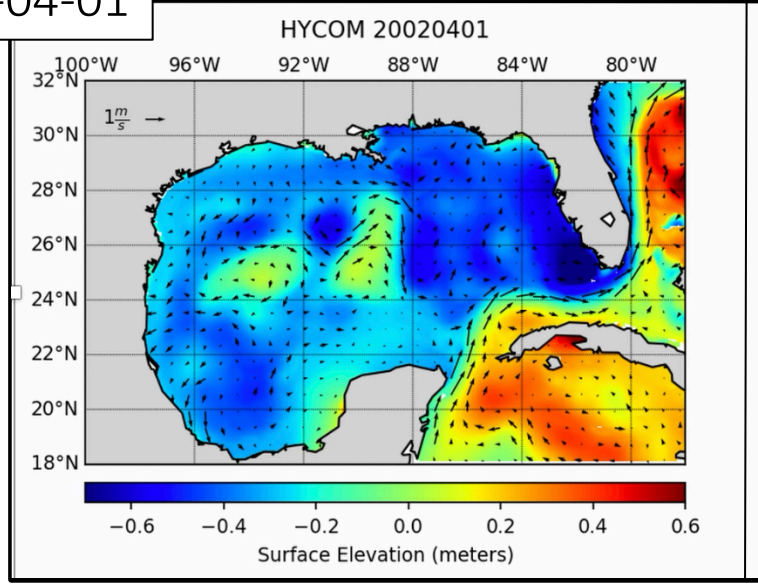
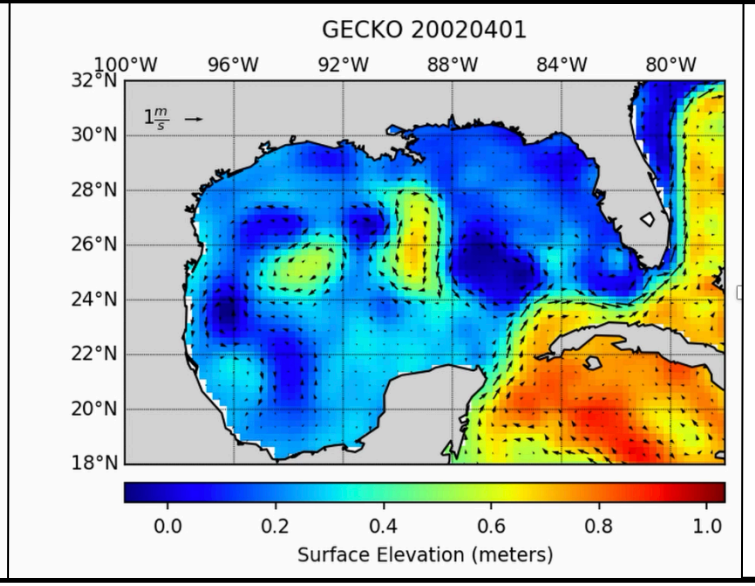
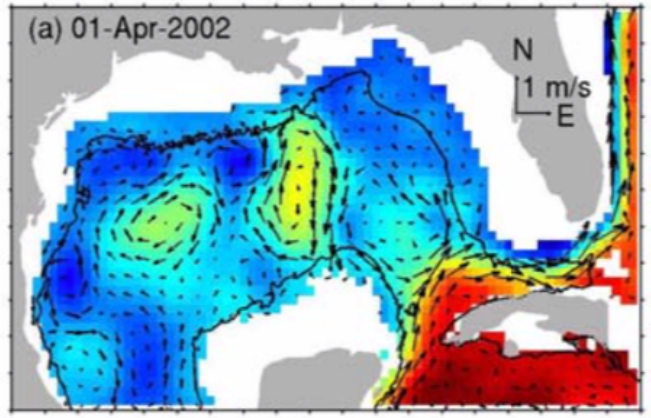




Weisberg et al. Fig. 4



Discussion

- HYCOM and GEKCO model output agree.
- HYCOM and GEKCO output agrees with the Weisberg et al. Figures.
- Relevance: LFN code runs on HYCOM data which has proved its reliability.

~Back up your data constantly~

Questions?