

Responses to comments by reviewer #1

The manuscript "A hydrodynamic model for Galveston Bay and the shelf in the northwestern Gulf of Mexico" by Du et al. presents a detailed study on development, validation and implementation of an unstructured grid model in the Gulf of Mexico and adjacent estuarine bays. The impact of the remote river discharge from Mississippi and Atchafalaya on the hydrodynamics in the Galveston Bay is assessed. Overall, the model was well established, and carefully validated. The model results are quite reliable. A large-scale unstructured model is very helpful in identifying the effect of shelf processes on a specific estuary. The unstructured model provides great flexibility in covering the large GOM domain and resolving the complex shoreline and bathymetry in the estuaries. This study presents a good example of research on estuary-shelf interaction. The manuscript is well written and organized, and several new findings are provided, thus it merits a publication after some minor revision.

Thanks very much for the helpful comments and suggestions.

My main suggestions are:

1) More focus could be paid on the physics, like how the buoyancy induced coastal current from the Atchafalaya and Mississippi Rivers affects the advective transport and mixing at the mouth of the Galveston Bay;

It is a good suggestion. In the revised manuscript, we plan to add Fig. A showing the salinity and vertical diffusivity profile along a section through Trinity Bay, ship channel, and Texas Shelf off Galveston Bay. The stratification, salt intrusion, as well as the vertical mixing, will be further discussed based on Fig. A. Some interesting points include: 1) salt intrusion is enhanced by July wind; 2) July wind also causes a stronger stratification on the Texas shelf off Galveston Bay; and 3) vertical mixing is reduced in the area where salinity-induced stratification is enhanced, such as the shelf region and near the bay entrance.

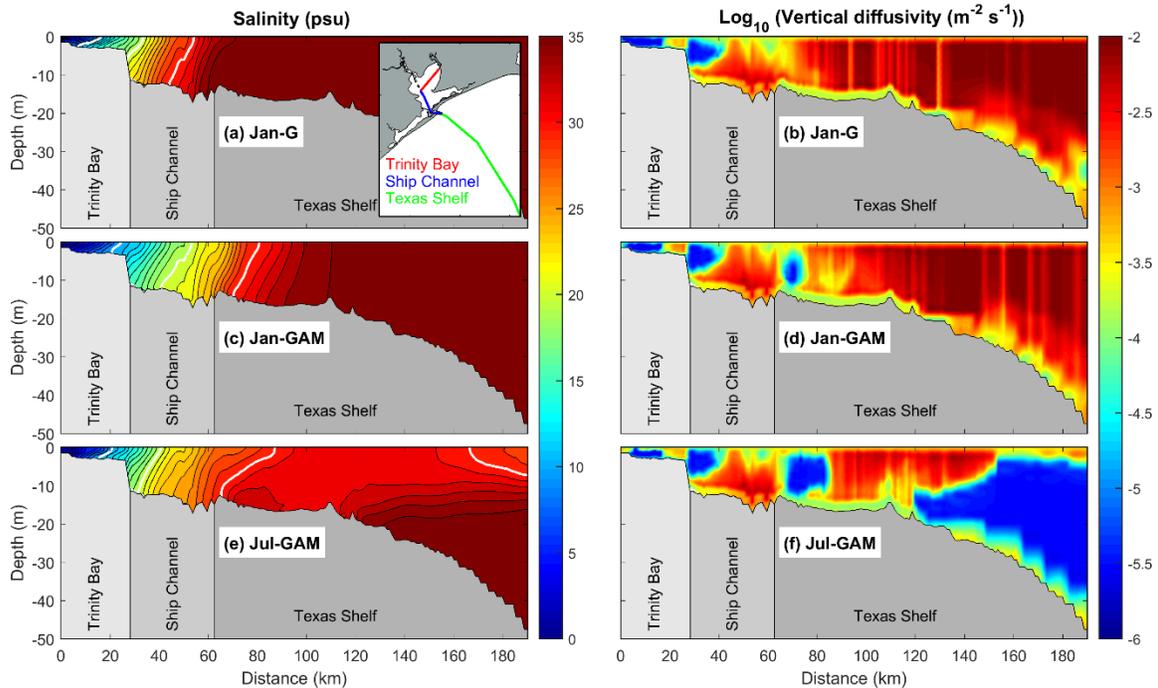


Figure A: Salinity (left panels) and logarithm of vertical diffusivity (right panels) for the section through Trinity Bay, ship channel, and Texas Shelf: see the inset in (a) for the section location.

2) How about the advantage of this unstructured grid in resolving the narrow and deep channel? How important is this resolution in reproducing salt intrusion? Based on my previous experience, this model seems a little difficult to simulate salt intrusion in the Pearl River Estuary. The model results always seem overmixed than observations;

This is a good point worthy of discussion. The necessity of resolving the deep ship channel has already been investigated by Rayson et al. (2015-Ocean Modeling). This study compared three different grids (with/without resolving the ship channel) in Galveston Bay, and demonstrated that salinity and sub-tidal velocity are better predicted when the important topographic features (e.g., ship channel) are well resolved. It is well known that the deep channel plays a key role in advecting saltwater from coastal ocean to an estuary. We did not have measurement showing the salt intrusion along the channel, but comparison with the salinity observations at the mid-bay station clearly shows that our model can reproduce the salinity variation at this station, which cannot be achieved without reproducing the salt intrusion processes.

For the over-mixed problem in some estuarine applications, here are some suggestions or experiences we have.

- (1) Vertical grid matters a lot. There are several options in the SCHISM for the vertical grid, including pure sigma grid, hybrid s-z grid, and more advanced LSC². It would be important to have fine resolution at the pycnocline.
- (2) Bathymetry and horizontal grid are important to resolve sharply-changing bathymetric features, such as the ship channel. The SCHISM model doesn't

require bathymetry smoothing. Bathymetry smoothing may induce some unrealistic vertical mixing (see Ye et al., 2018-Ocean Modeling).

- (3) The boundary condition might play a role. Both river input and the stratification at the ocean boundary can affect the stratification. The ocean boundary condition matters especially when the target estuary is not that far away from the ocean boundary.

3) How Galveston and other estuaries affect the shelf processes, e.g., how they impact the coastal current, and water column stratification and mixing?

It is a good suggestion to further discuss the effect of river input on the shelf processes. We may add another figure showing how the shelf transport is affected by the Mississippi-Atchafalaya River input as well as the wind forcing (Fig. B), which shows that the Mississippi-Atchafalaya River input enhances the shelf transport by 12-18% and that the July wind dramatically reduces the downcoast shelf transport. We also plan to discuss more about stratification and mixing based on Fig. A, which shows interesting changes in terms of water column stratification and mixing. One of the most obvious change is the stronger stratification and weaker vertical mixing over the Texas Shelf under July wind, compared to that under January wind.

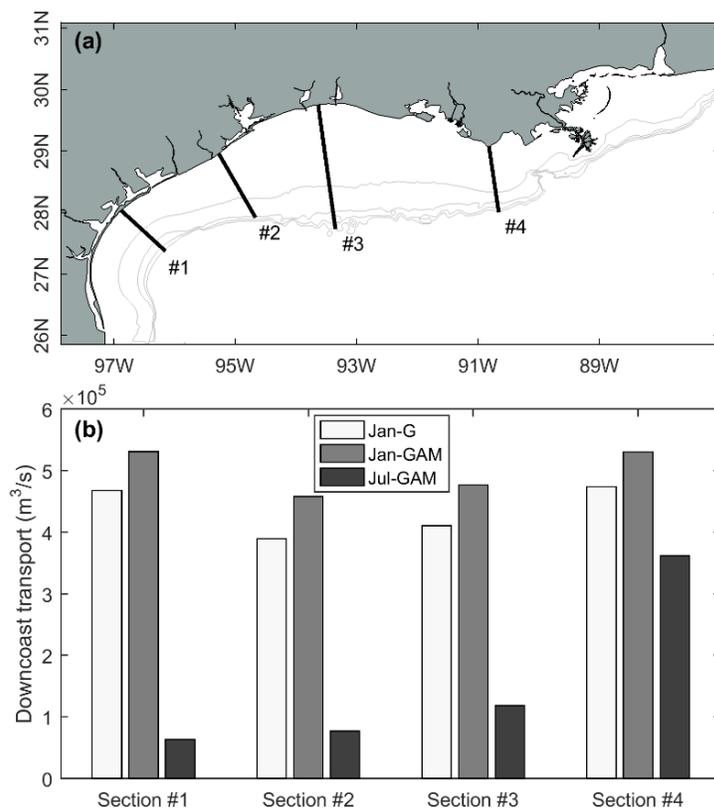


Figure B: (a) The location of four selected sections over the Texas-Louisiana Shelf and (b) the downcoast shelf transport for three numerical experiments. The grey lines in (a) indicate the 50, 100, 150, and 200 m bathymetric contours.