2018-A-1286-GOMRI - Impact of Vertical Resolution in Lagrangian Analysis on the Shelf

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Abstract

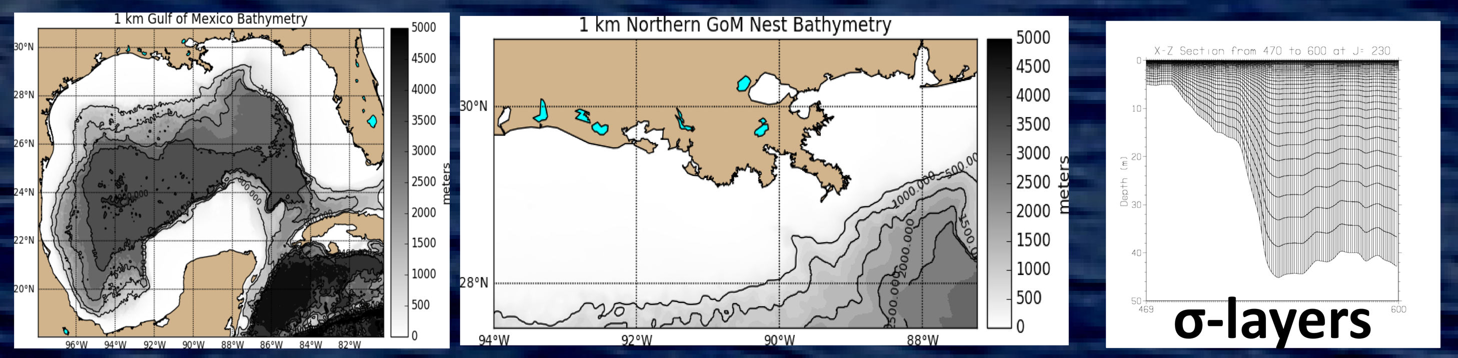
Fresh water outflows from the Mississippi River southwest passage strongly affect coastal processes in the Mississippi Bight region. Strong vertical stratification results that controls the mixing of momentum flux from the atmosphere. This situation presents a challenging problem for numerical models to represent the vertical structure and associated physics. We use the Consortium for Advanced Research on Transport of Hydrocarbon in the Environment (CARTHE) Submesoscale Processes and Lagrangian Analysis on the Shelf (SPLASH; http://carthe.org/splash/) field experiment in April, May 2017 during which several dense surface drifter deployments were conducted in the area. A 1 km horizontal resolution Navy Coastal Ocean Model (NCOM) of the Gulf of Mexico (GoM) was run during the experiment. Initiated in 2012, this model of the GoM has been running in real-time in support of multiple CARTHE at sea experiments (GLAD 2012, SCOPE 2013, LASER 2016). This simulation uses measurements made by the US Geological Survey along the northern GoM to estimate riverine discharge into the model basin. Prior work had indicated the model vertical structure was not sufficient. A local nested NCOM at the same 1 km resolution is set up over the SPLASH experiment area to understand the effect of improved vertical resolution. Comparisons of the surface currents of the nested models with SPLASH drifters are made to evaluate the effect of resolution in the vertical computational grid. Strong stratification near the surface due to fresh water from Mississippi River runoff is more accurately resolved resulting in improved prediction of near-surface currents when compared to observed drifter speeds.

Assimilative Navy Coastal Ocean Model

NCOM is a primitive equations model that uses real-world observations to constrain the model as it moves forward in time (NCOM; Barron et al., 2006). Observational data are assimilated into NCOM via Navy Coupled Ocean Data Assimilation System (NCODA; Cummings, 2005). NCODA assimilates quality controlled remotely sensed sea surface temperature (SST) and sea surface height anomaly (SSHA), as well as *in situ* observations such as temperature and salinity at the surface and subsurface profiles from ships, buoys, and Argo floats.

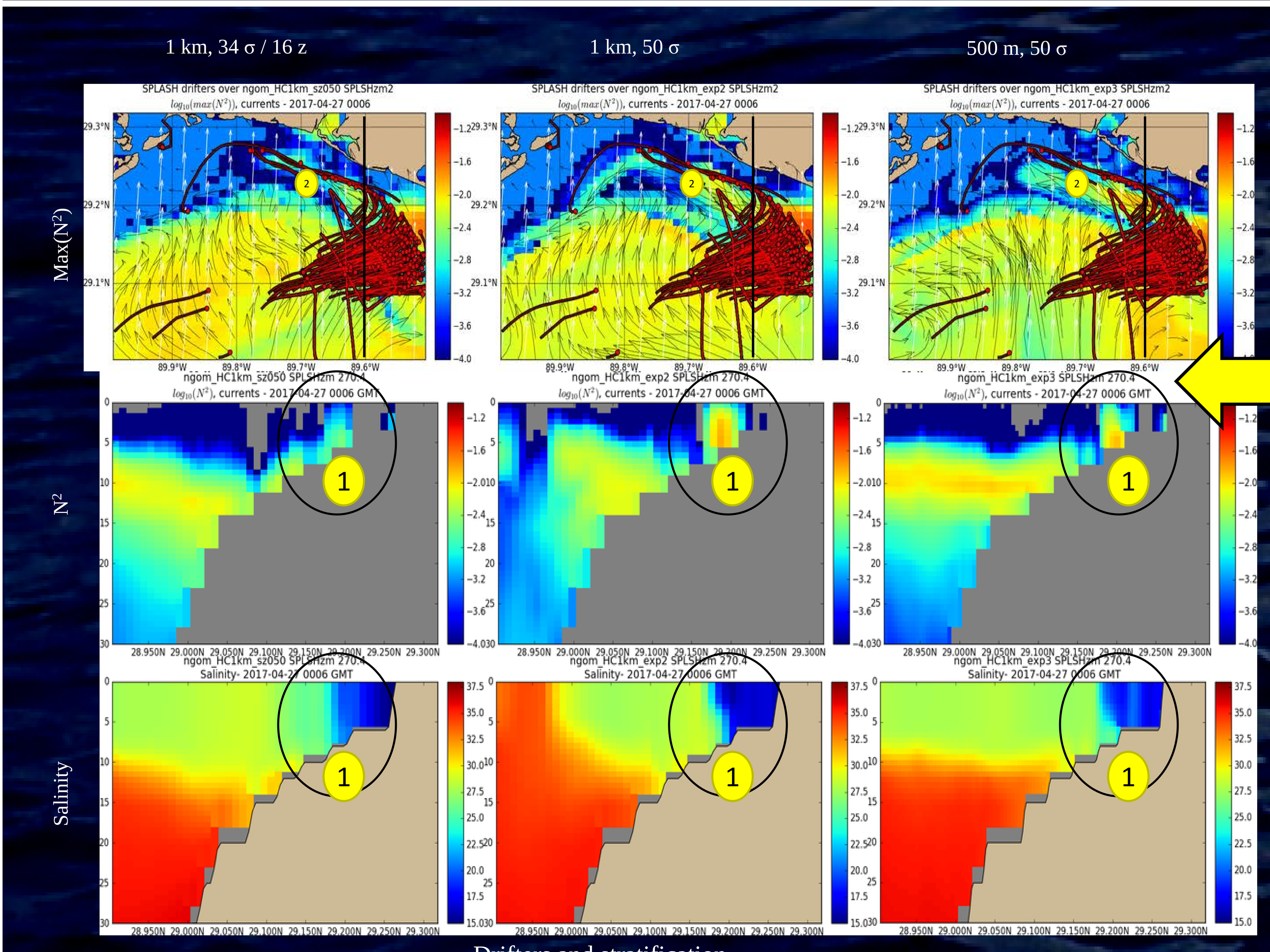
Approach

Three Northern GoM (NGoM) simulations are used to evaluate the effect of improved vertical and horizontal resolution. The host 1 km horizontal whole-GoM uses a vertical grid comprised of 49 total layers; 34 terrain-following σ-layers above 550 meters and 15 lower z–levels. The σ coordinate structure has higher resolution near the surface with the surface layer having 0.5 m thickness. The NGoM nests are used with refined vertical resolution. A nest with the same vertical structure as the entire GoM host simulation is used as a control (SZ050). A second nest with only σ coordinates throughout the 50 layers is used for added vertical resolution over the shelf and coastal areas (Exp2). The third nest uses the same σ-only vertical grid as the second nest, but with a doubled horizontal grid of 500 meter resolution (Exp3).



The full Gulf of Mexico domain (left) is represented in a 1 km resolution setup (left), and nested experiments provide higher vertical and horizontal resolution (middle).

Experiment	Horizontal	Vertical grid
SZ050	1 km	34 σ ending at 550 m depth over 15 Z levels
Exp2	1 km	50 σ layers
Exp3	500 m	50 σ layers

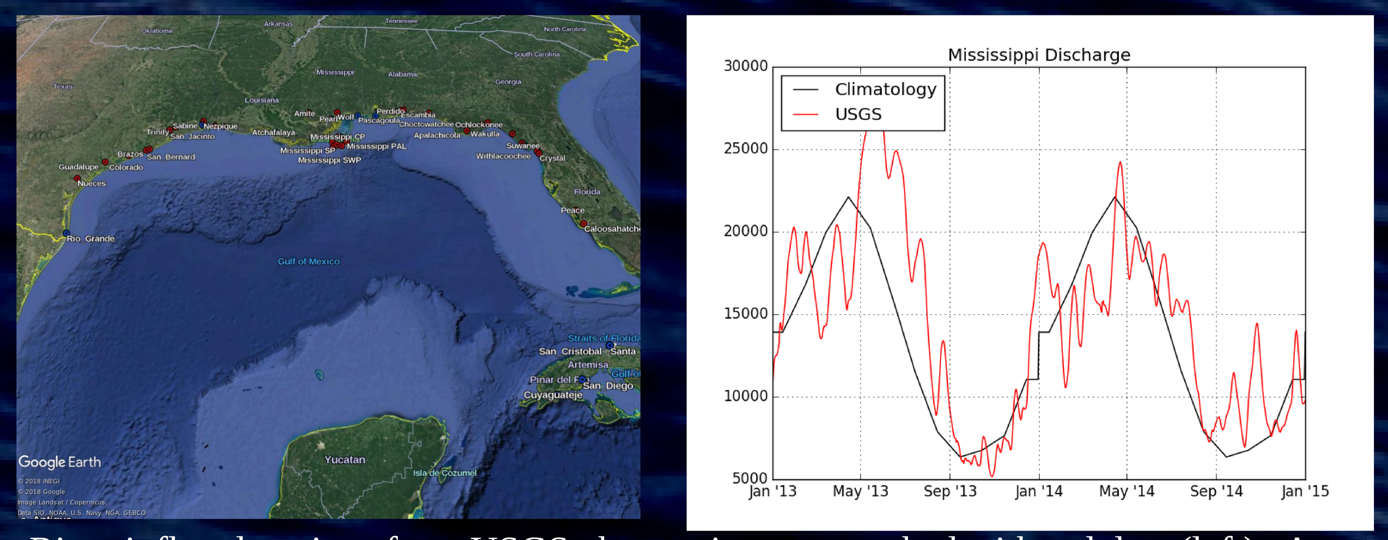


April 27, 06 GMT, southerly winds result in northward flow. The high stratification 3 km offshore is due to the fresh coastal water overriding salty water offshore (1). Surface currents in the stratified coastal jet intensify as vertical and horizontal resolution are increased (2). The increased resolution provides transports that match observations more closely. The $log10$ of the square of the Brunt Vaisala frequency ($N2$) is plotted for longitude transect 89.6° W. Max ($N2$) in the water column is plotted in the surface view.

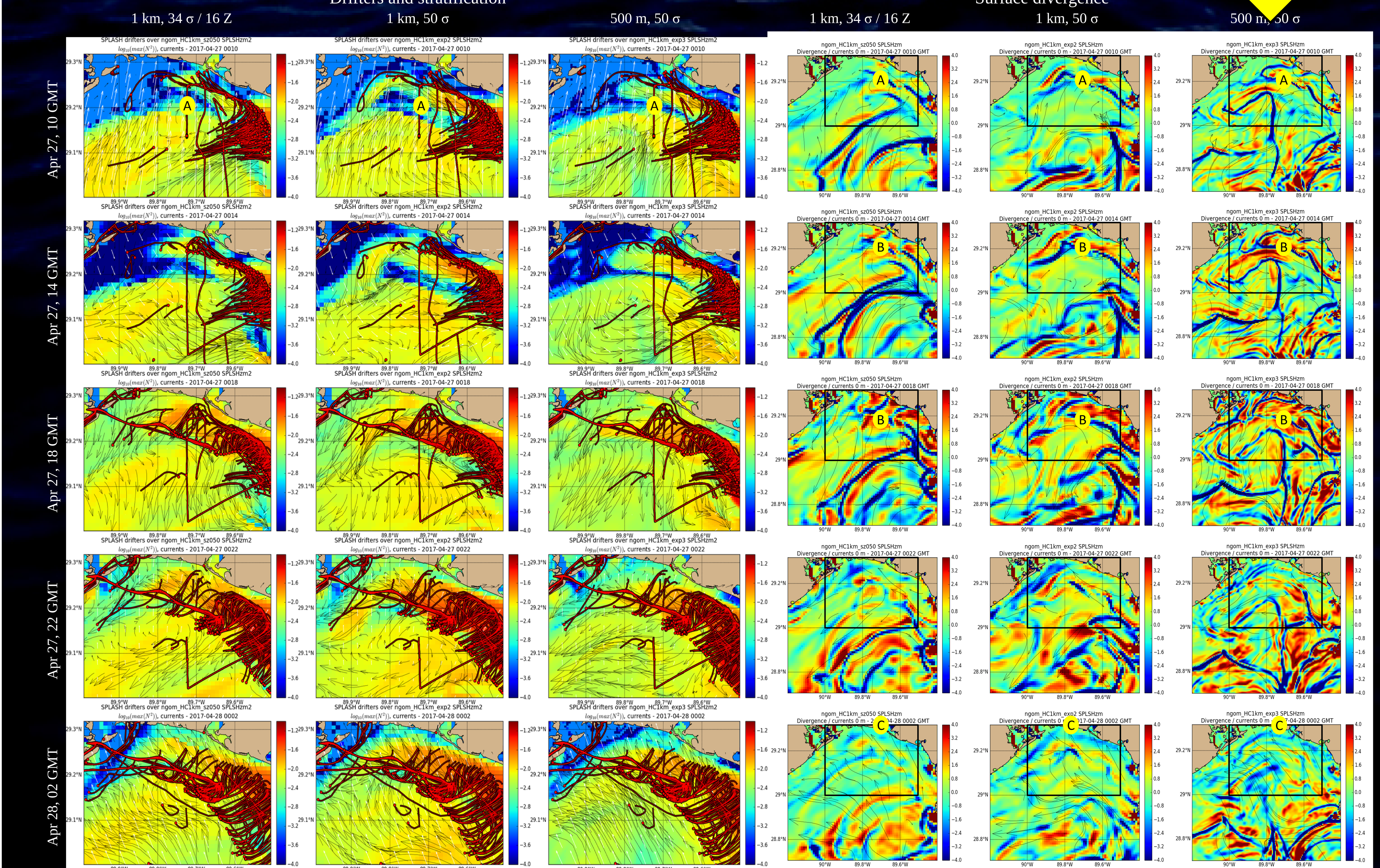
April 27, 10 GMT to April 28, 02 GMT, southerly winds reverse near 11 GMT and remain weakly northerly until after 18 GMT when southerly winds return. The westward movement of drifters quickly stops at 04/27 10 GMT, and drifters move offshore. Initially (04/27 10 GMT), the drifters are observed to be on the northern side of a high stratification line and coincident with a high convergence line (A). From 04/27 10 GMT to 04/27 18 GMT, the front in the model results moves to the south roughly coincident with the drifter movement (B). Also note the broad area increase in divergence during 04/27 18 GMT. The convergence line dissipates by 04/27 22 GMT. Convergence begins to form closer to shore by 04/28 02 GMT, which recaptures the drifters later (C).

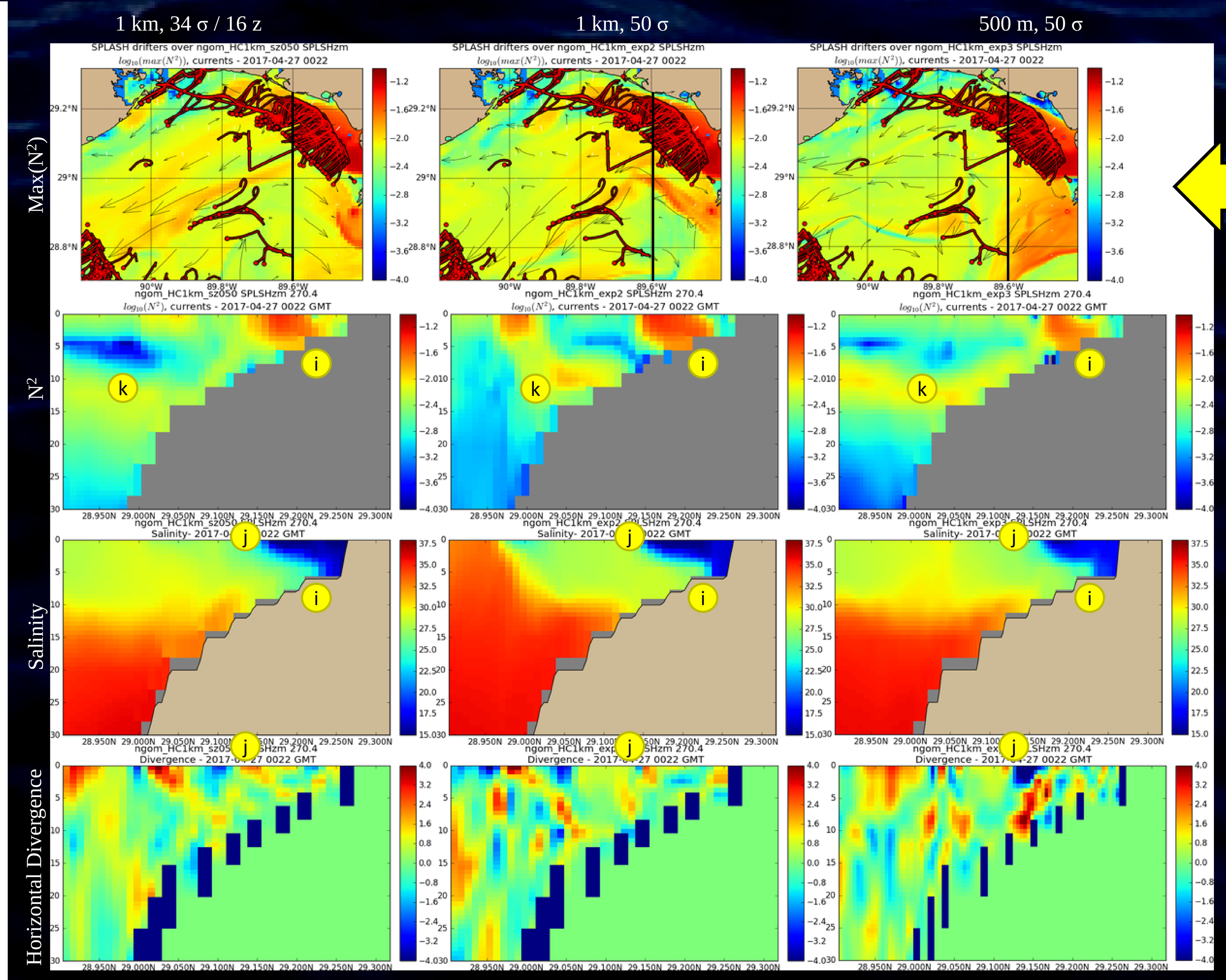
Observed River Input

Implemented in the GoM (Bartels, 2017), the USGS Water Data website is queried for discharge at predetermined station numbers. The station closest to the model discharge point are used, and water temperature observations are used if within 50km of an outlet. Otherwise, climatological temperature is used. Single stations can be split into multiple outlets (Mississippi River). Multiple stations can be merged into one outlet.



River inflow locations from USGS observations are marked with red dots (left). An example of climatological and observed Mississippi River transport (right) is used in the numerical model simulations.





April 27, 22 GMT. As drifters move offshore, the vertical stratification (mainly controlled by salinity, i) interacts with surface forcing to produce a convergent front at the southern edge of the fresh coastal water (i). As the fresh water front moves southward, a convergence forms on the leading edge (j). This convergence is more clearly represented in the higher vertical and horizontal resolution experiment. In addition, the stratification at 15 m depth is stronger in the higher vertical resolution experiments (k).

Acknowledgements

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