



# Evaluation of Hurricane Humberto (2007) Using Advanced Research WRF (ARW)

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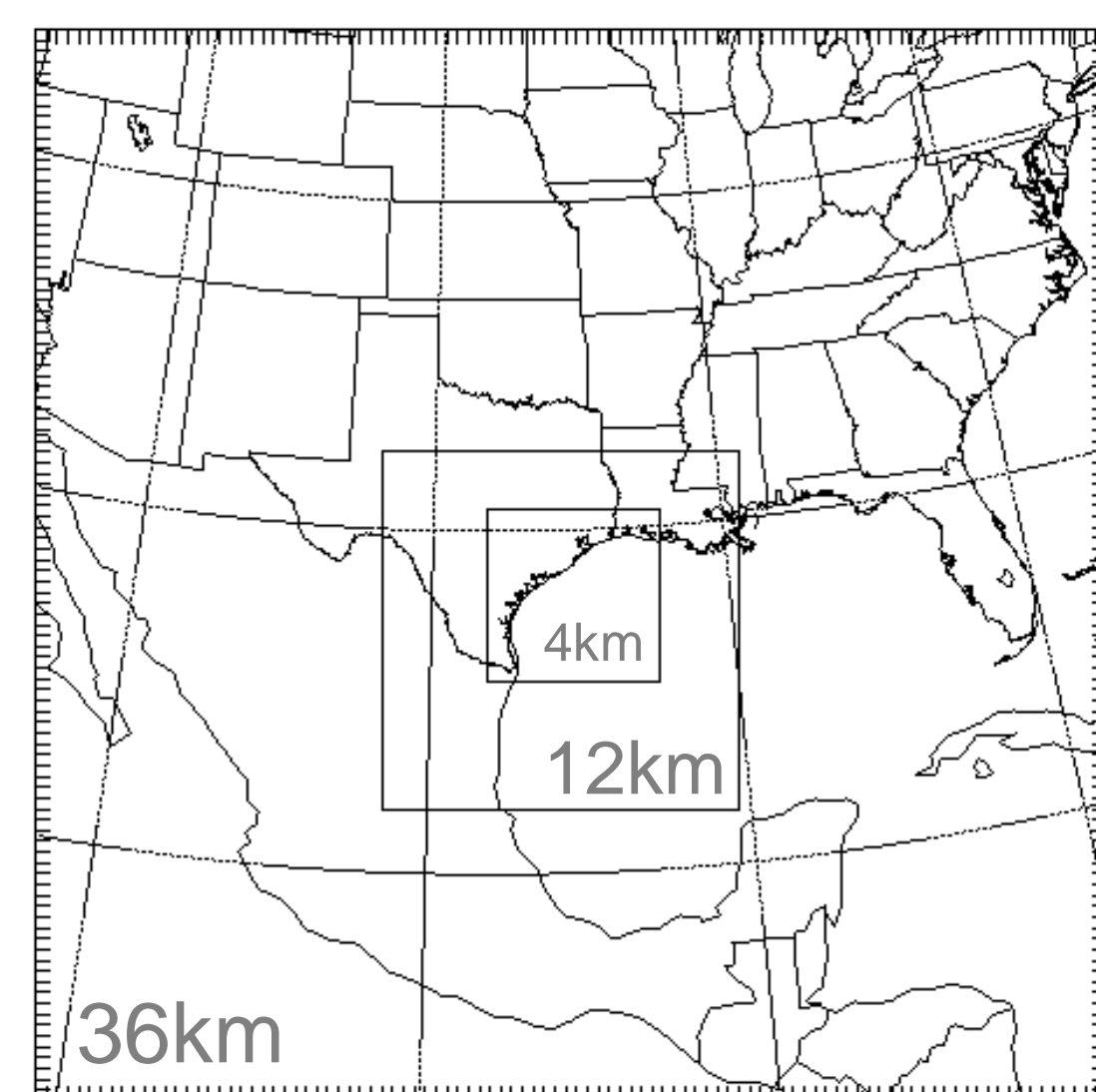


## OBJECTIVES

Model simulations can provide details about tropical cyclones not available from observations, namely the ever important boundary layer processes. This study first finds the parameterization schemes that provide most correct simulation of Hurricane Humberto (2007), followed by an look at the processes present during the cyclone's life.

## METHODS

Using North American Regional Reanalysis (NARR) and GFS 0.5° SST data for boundary conditions, many model runs were completed using differing microphysical schemes. Analysis “nudging” was then added to the runs to help resolve the cyclone. Using NCAR Command Language (NCL) scripts to provide surface pressure, winds, and radar reflectivity, the accuracy of the model run was judged against



observations. Unidata's Interactive Data Viewer (IDV) was used for analysis of the cyclone. ARW was run with 3 model domains of 4km, 12km, and 36km from 9Z on Sep. 12<sup>th</sup> to 15Z on Sep. 13<sup>th</sup> (TD formed at 15Z on 12<sup>th</sup> and made landfall at 7Z on the 13<sup>th</sup> near High Island, Texas).

## CONCLUSIONS

A model simulation of Hurricane Humberto (2007) without model nudging could not be achieved during this study. With analysis nudging, the low was well defined and followed the observed track. This inclusion of analysis nudging allowed for sufficiently accurate data for analysis. This analysis showed very distinct vortical hot towers (VHTs) throughout the model run. VHTs have been hypothesized to play a strong role in the intensification and formation of tropical cyclones (Hendricks & Montgomery, 2004; Montgomery et al., 2006; etc.). Following this assumption, it is not a far stretch to conclude that vortical hot towers played at least a part in the formation and intensification of Humberto.

North American Regional Reanalysis data courtesy of NCAR

Observational data from National Hurricane Center

Radar images courtesy of UCAR

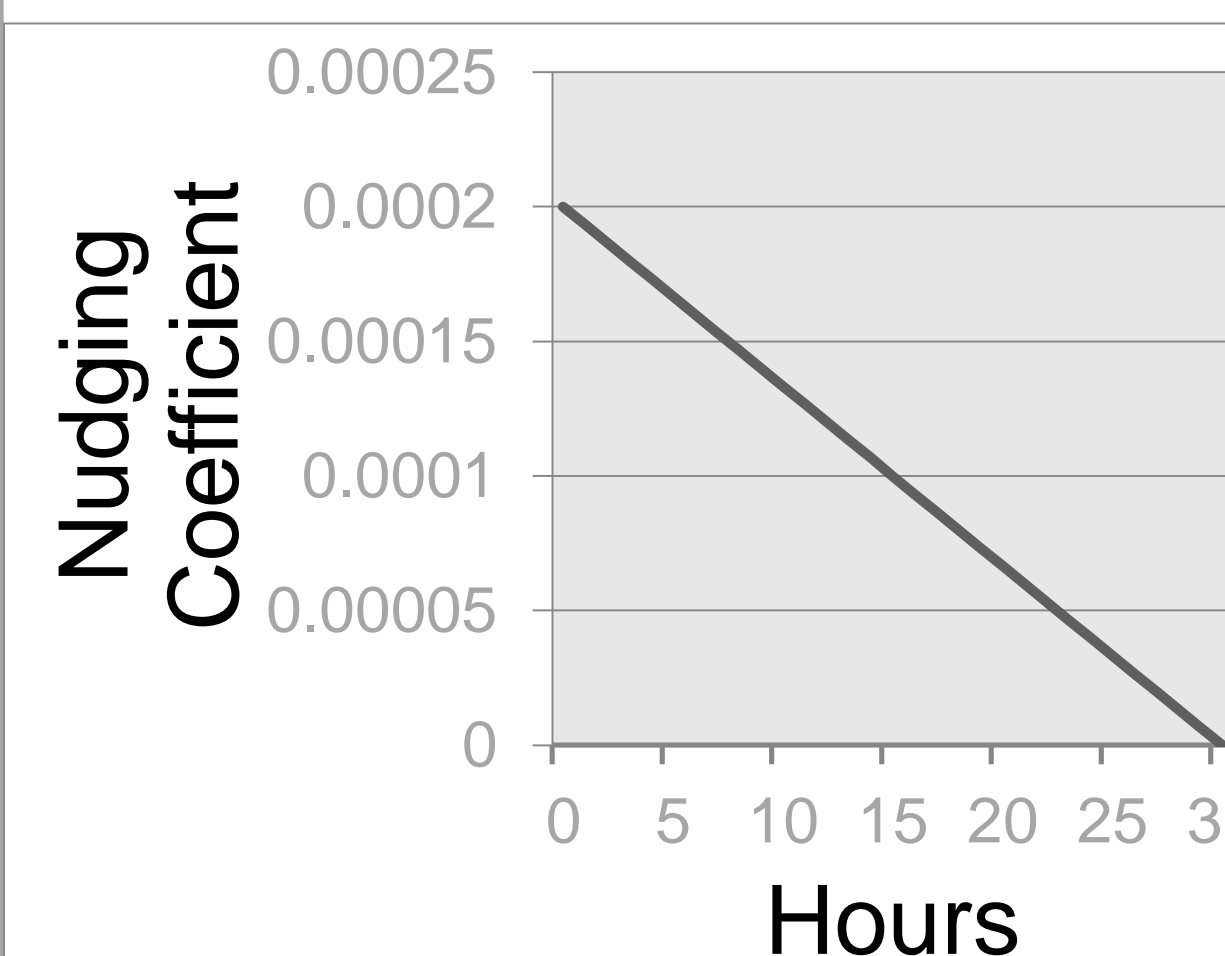
Special thanks to Dr. Larry Hopper for his guidance.

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## “NUDGING” THE MODEL

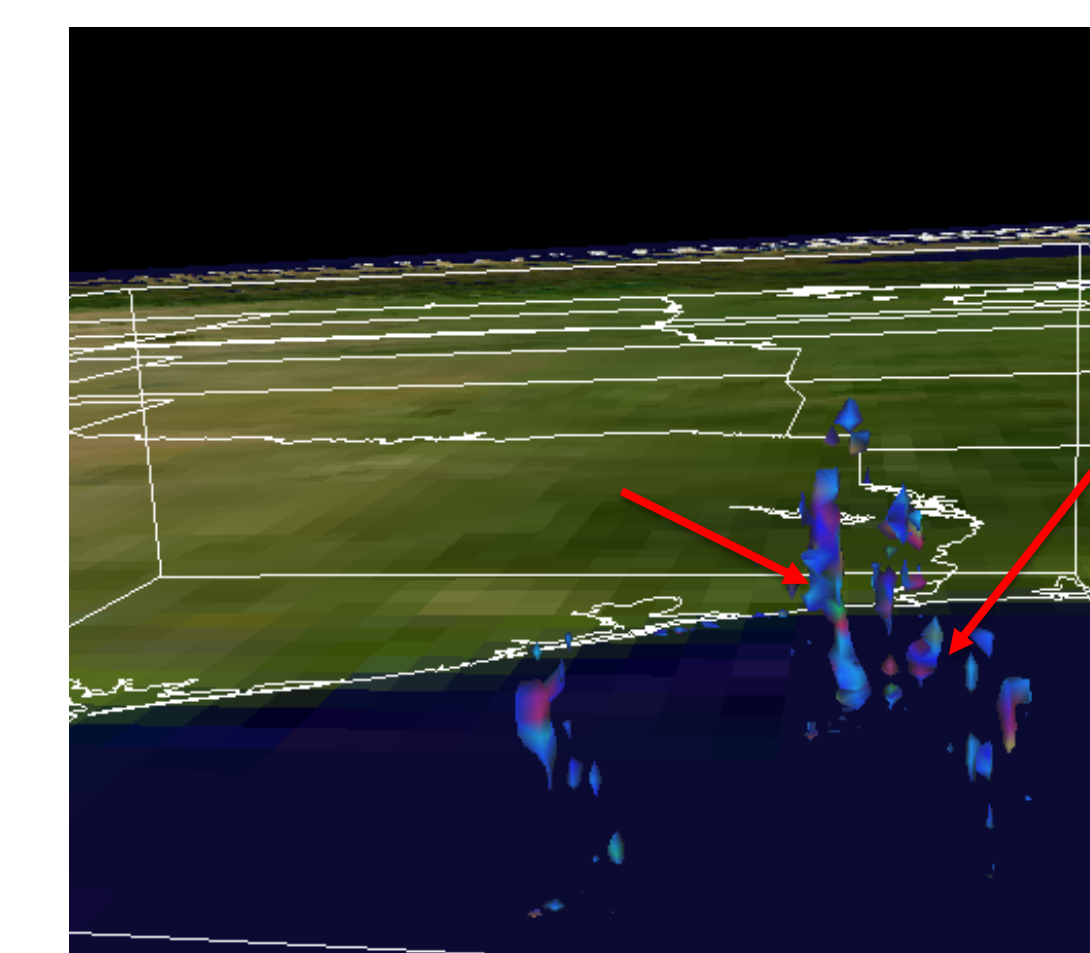
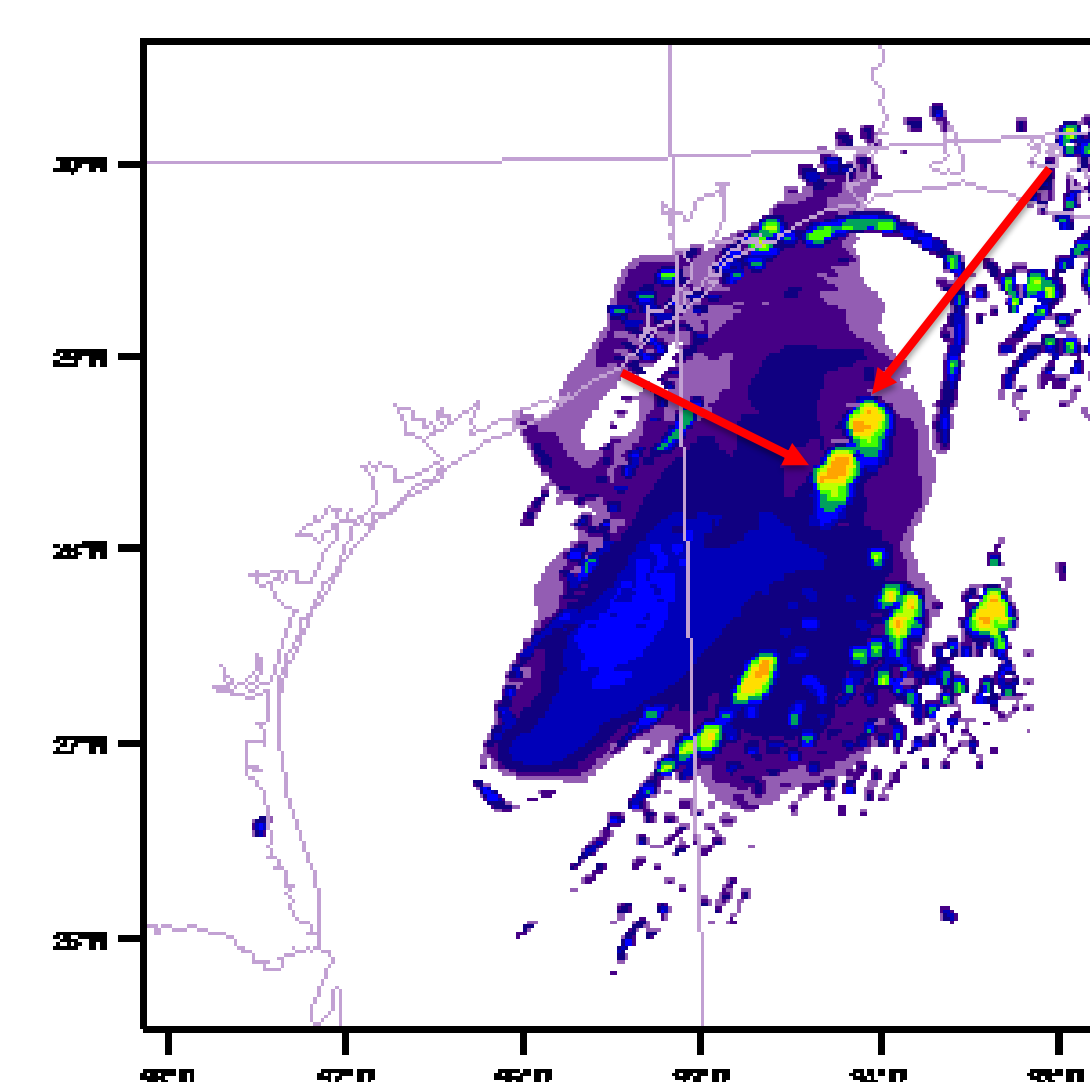
OBSERVATIONS 23Z	WITHOUT ANALYSIS NUDGING 23Z	WITH ANALYSIS NUDGING 23Z
Central Pressure: 998mb Wind Speed: 45kts	Central Pressure: No Low Wind Speed: No Low	Central Pressure: 1011mb Wind Speed: 35kts



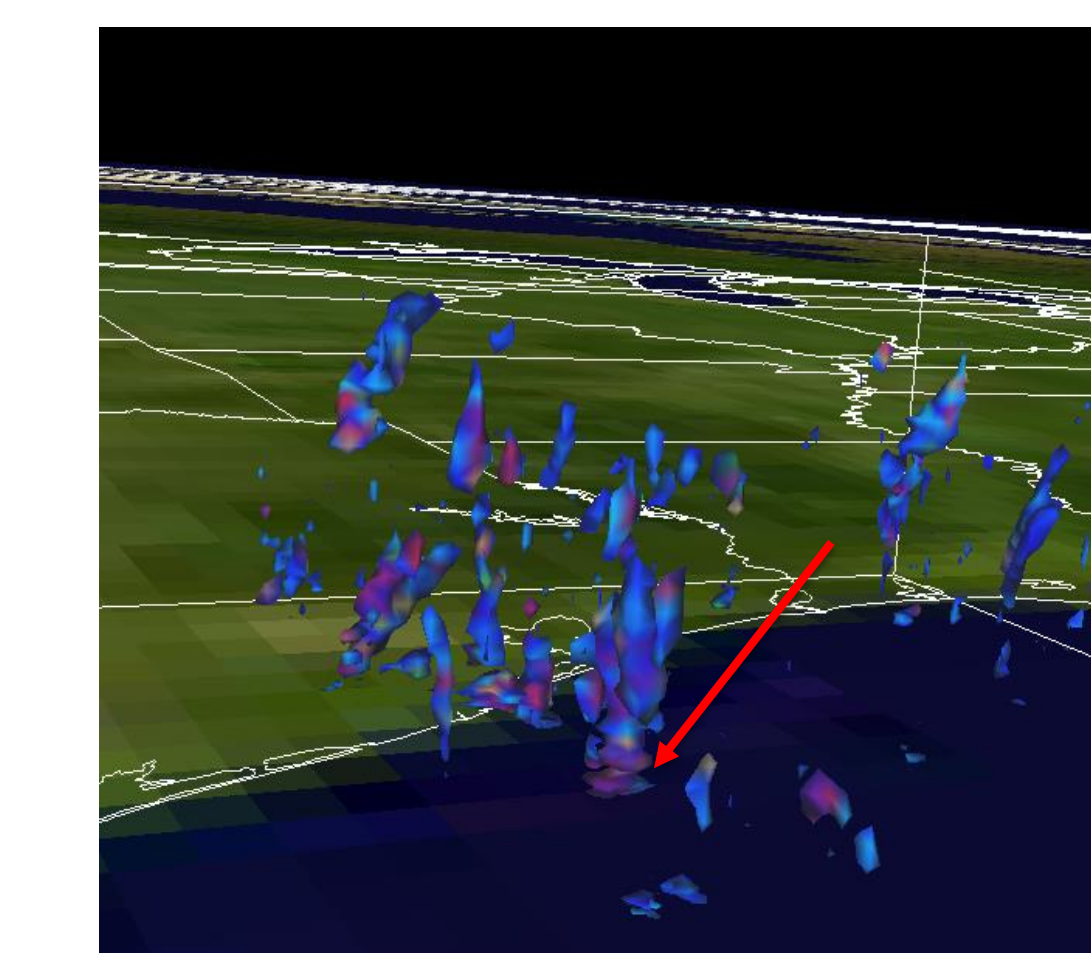
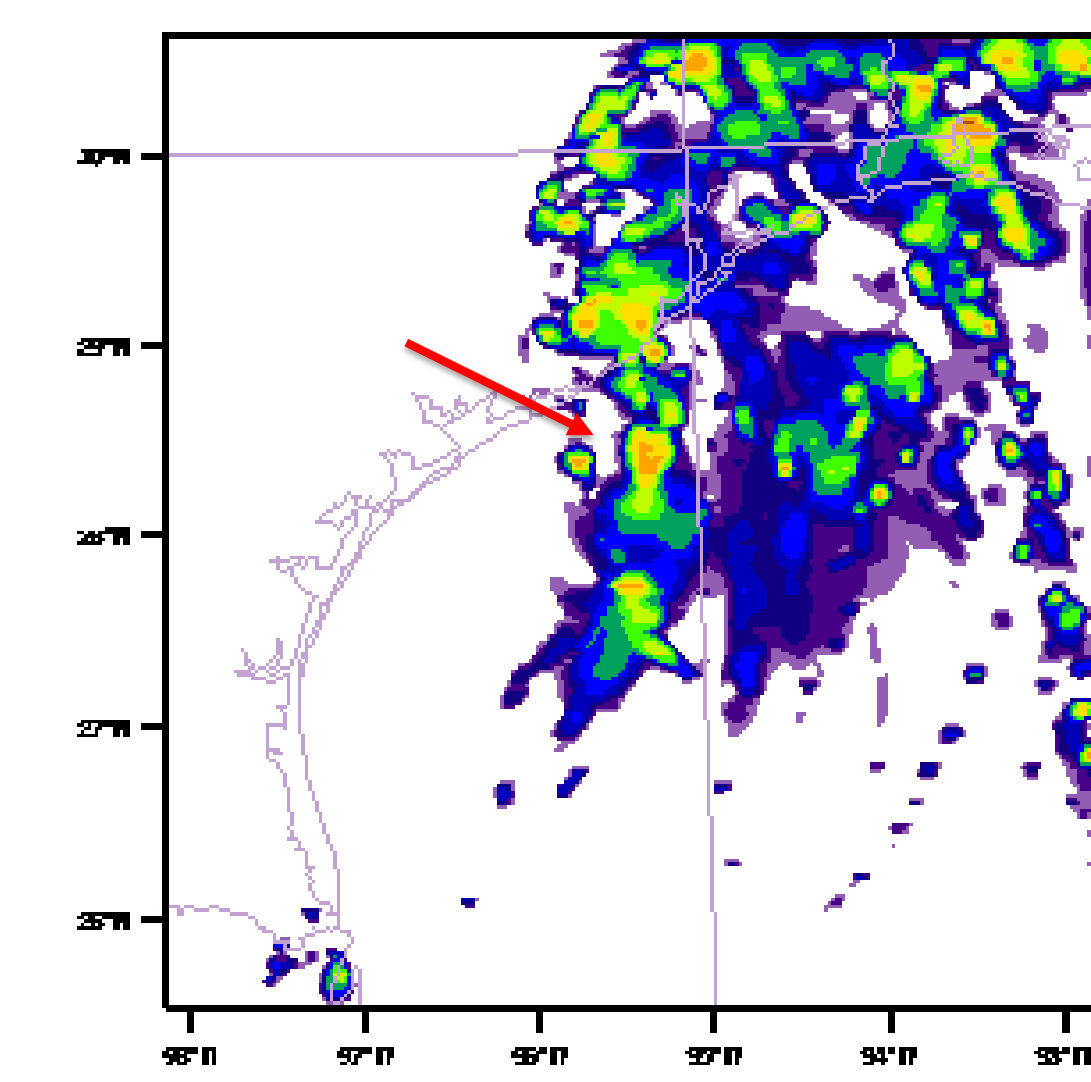
Analysis nudging was tested because of the lack of low pressure formation using multiple different combinations of parameterizations, model domains, and “spin up” times. Analysis nudging is the process of combining the input analysis with the model output by “nudging” the output values closer to those of the input analysis using different weighting functions. The nudging was performed throughout the run with decreasing intensity. Nudging of temperature was turned off in the boundary layer, and nudging of water vapor was turned off throughout the domain. Despite this, the model still underestimated central pressure and wind speed. This could possibly be due to model nudging with the lower resolution analysis data (NARR has horizontal resolution of 32km). However, the parameterization schemes could have also inhibited strengthening.

## VORTICAL HOT TOWERS

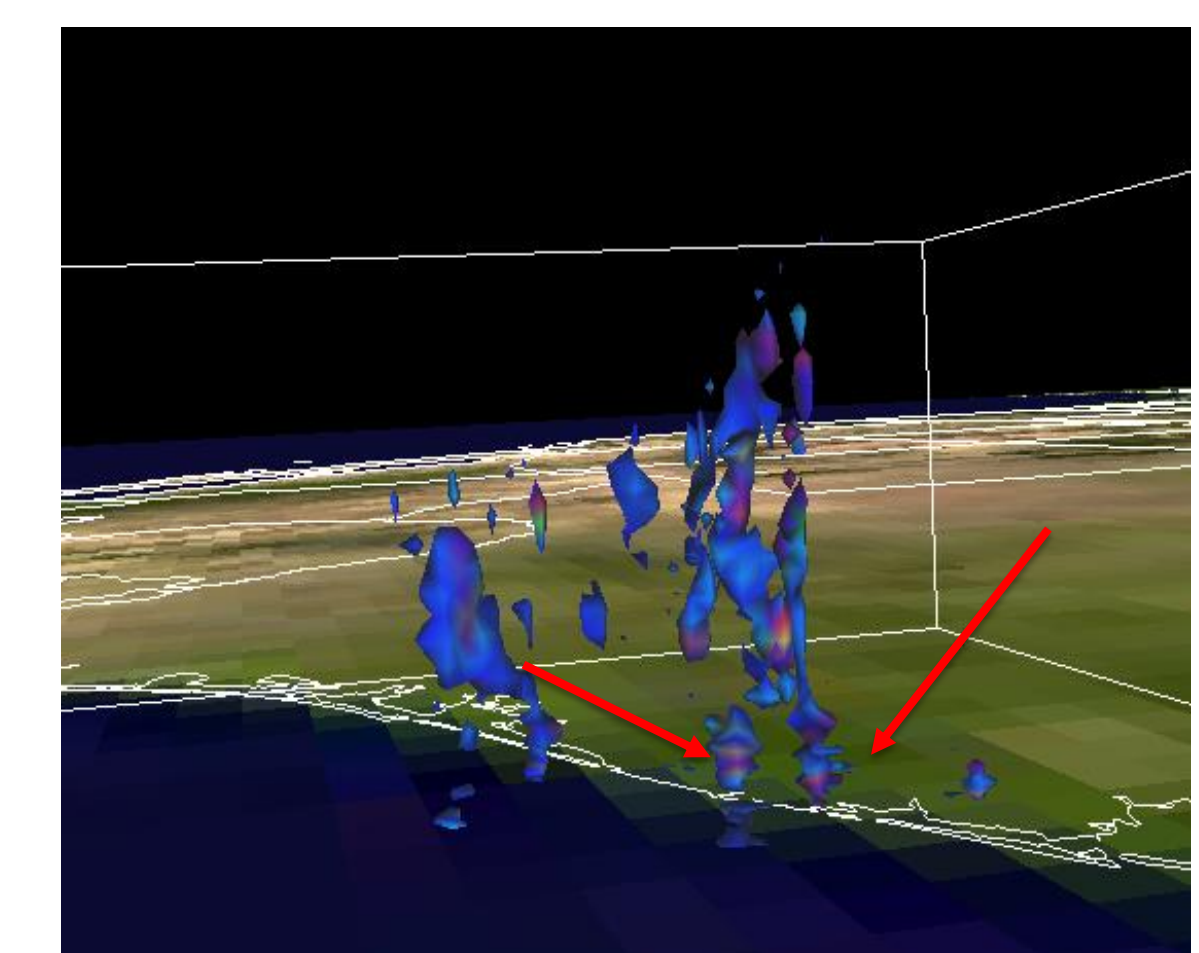
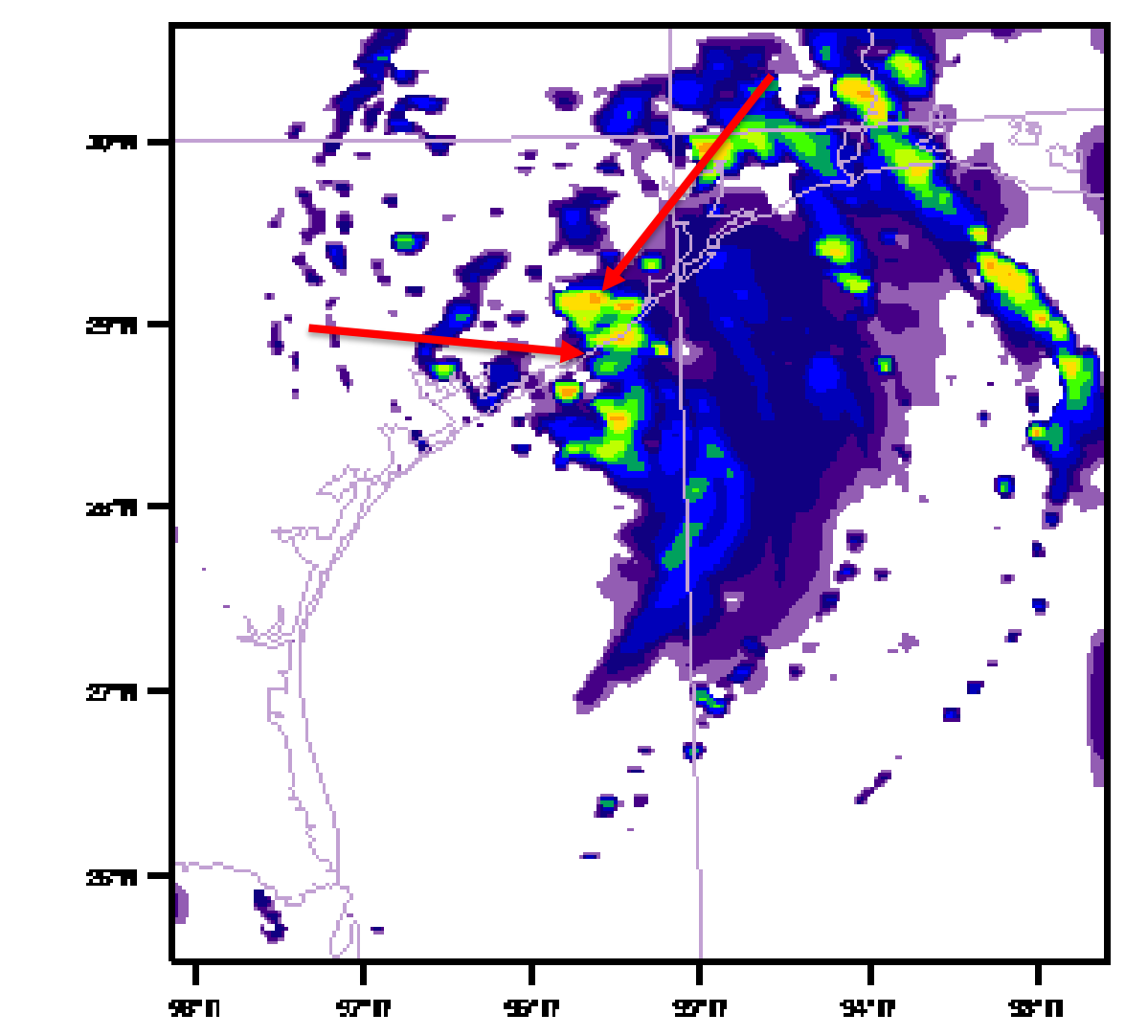
Vortical hot towers (VHT) are localized cumulonimbus towers with strong positive vorticity. In this model simulation of Humberto, VHTs are present and merge just hours before the National Hurricane Center declared Humberto a tropical depression. Sang et al. (2008) stated that these VHTs are the “basic” structures of cyclone formation and intensification. As the storm intensifies, the VHTs seem to become more localized around the storm center. As this occurs, the central pressure drops and winds increase.



13Z 9/12



20Z 9/12



00Z 9/13