An Analysis of the 23 November 2014 Gulf Coast Seiche

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Event Overview

On 22 November, 2014, a line of thunderstorms developed over the Central Texas coast and moved east into the Gulf of Mexico. The line of storms moved along the coast with a Mesoscale Convective Vortex (MCV) crossing the coast around Constance or Holly Beach in the early morning hours of the 23 November. As the MCV moved ashore water quickly rose above the moderate flood stage threshold and fell back again along the coast of Cameron and Vermilion Parishes. This event traveled east with the line of storms although water levels remained at or below minor flood stage in Vermilion Bay to Amerada Pass. The seiche resulted in an estimated $75,000 in damage to property along the Gulf Coast.

Fig 1. Photographs of the impacts and damage caused by the seiche along the Louisiana coast.

Hydrographs

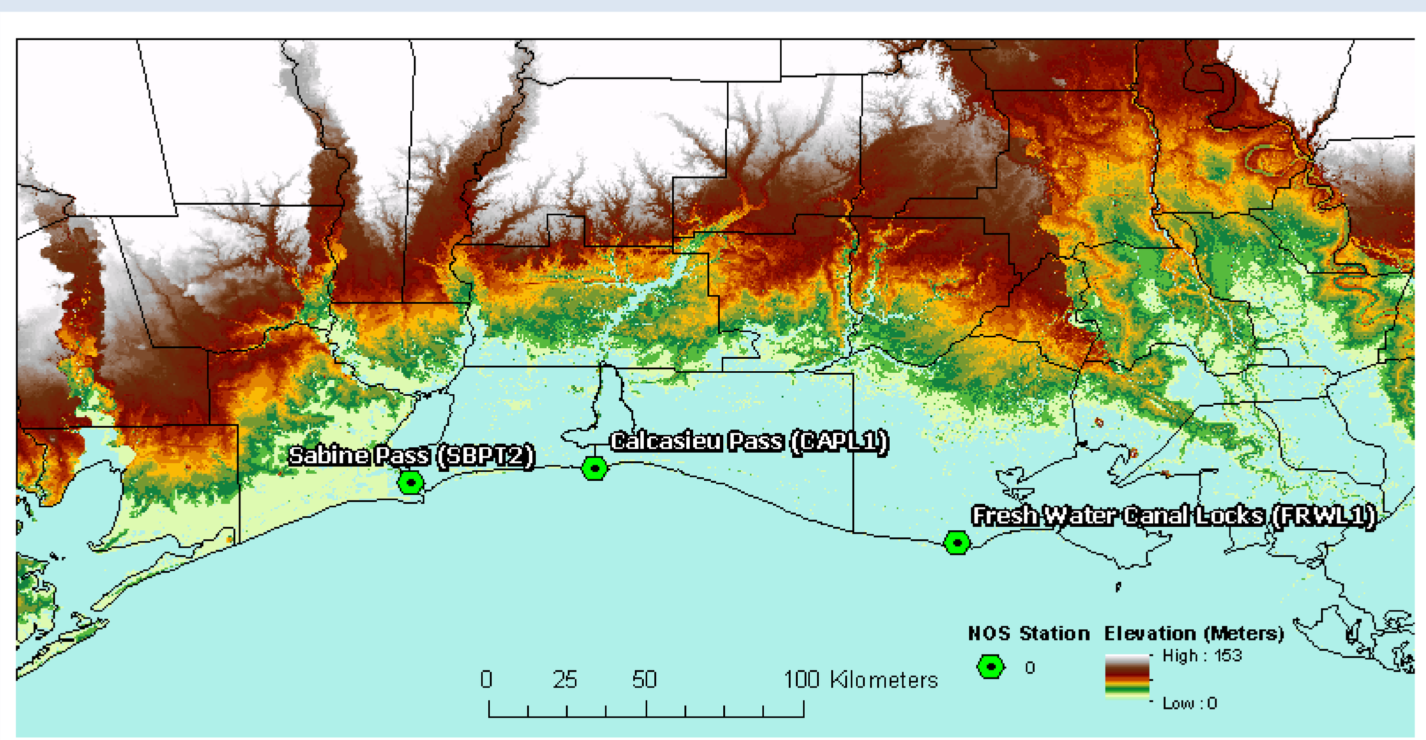

Fig 2. Digital Elevation Model of the Louisiana and Texas coastline with locations of selected National Ocean Service (NOS) C-MAN stations.

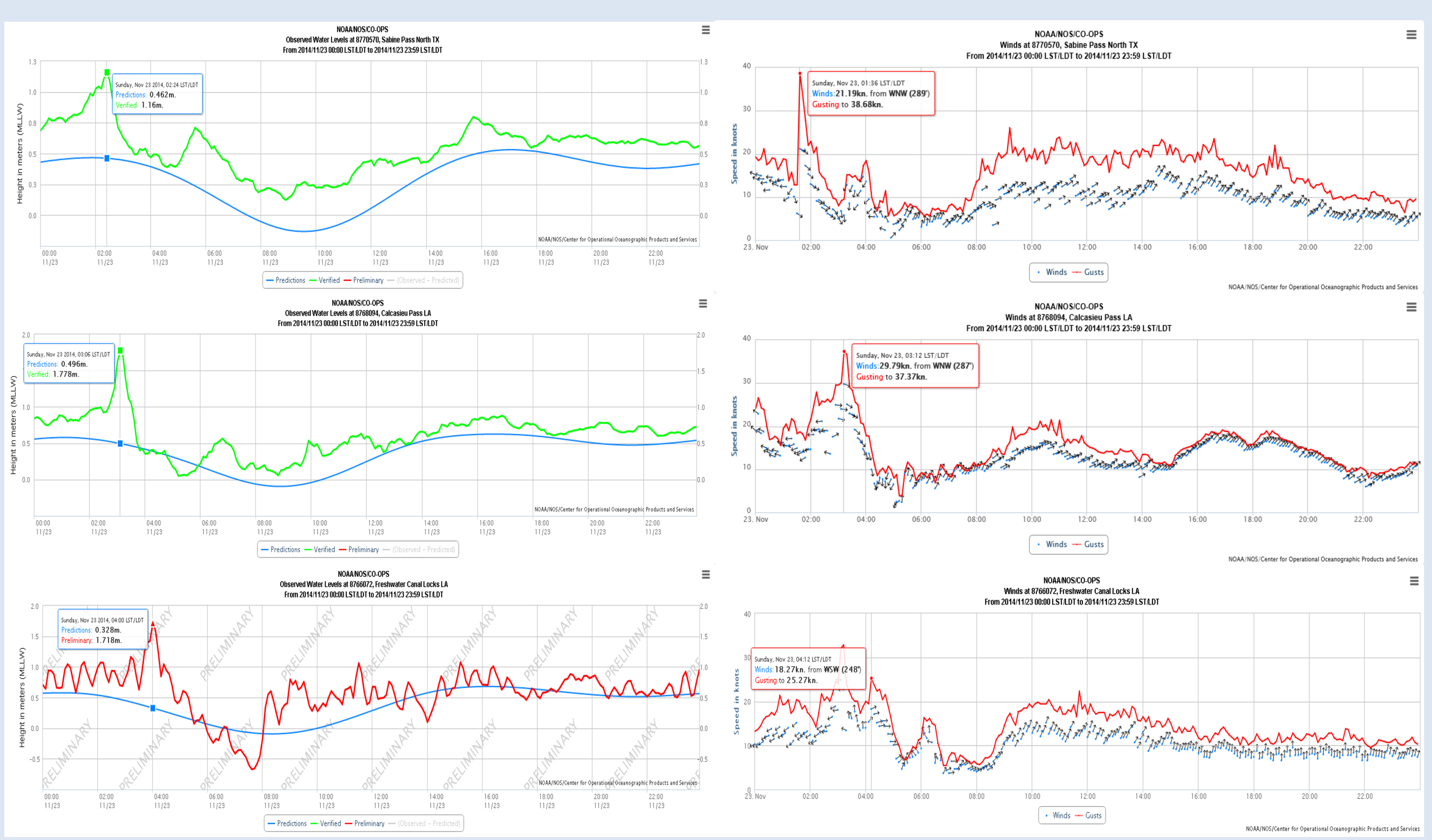

Fig 3. Hydrographs and weather observations from NOS C-MAN stations covering 0000 LST to 2359 LST 23 November.

Synoptic Analysis

Seiche Events Composite | 22 November 2014

500 hPa Height Anomaly & Mean

850 hPa Wind Speed & Direction

Surface Pressure

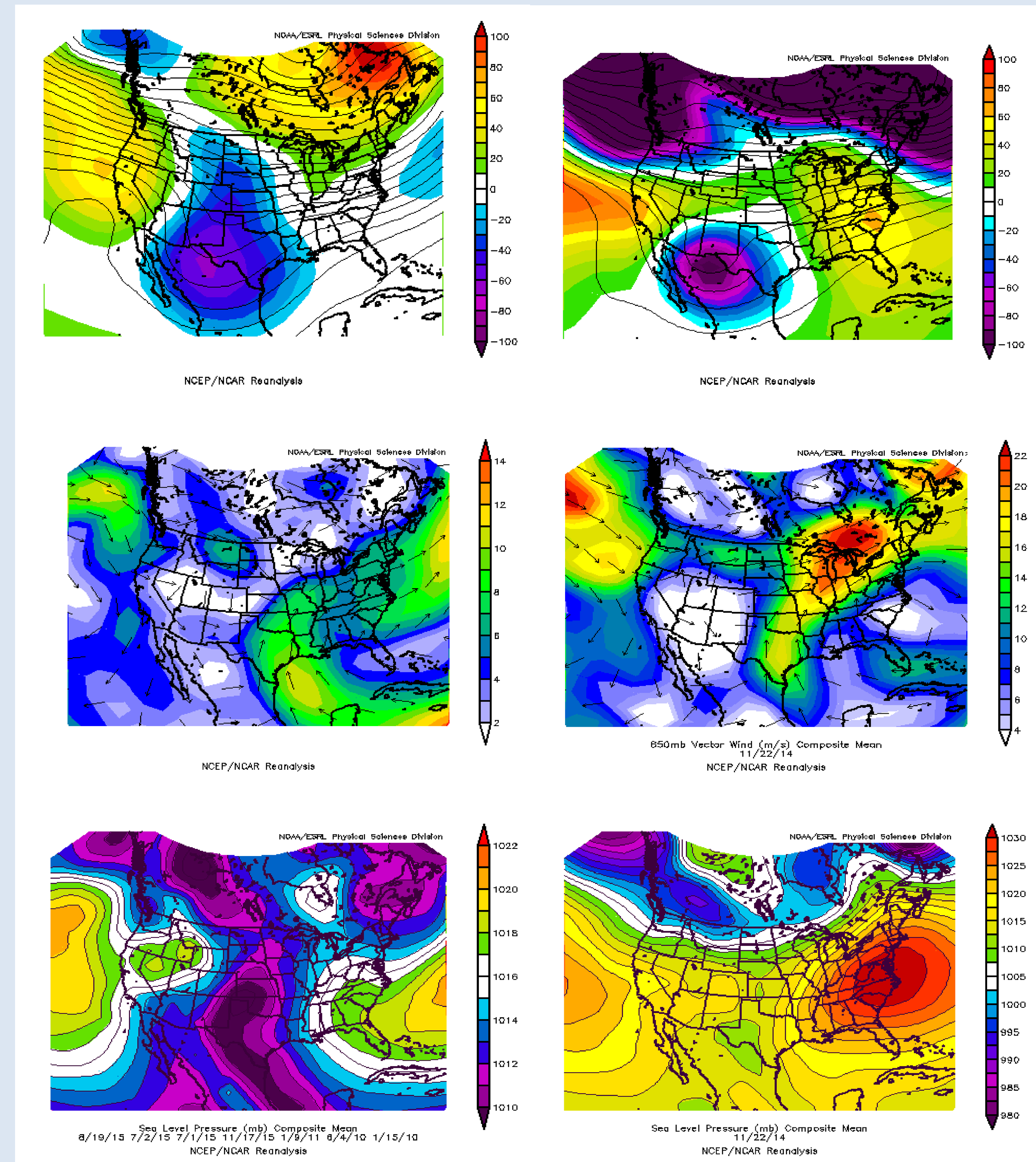

Fig 4. Comparison of 22 November 2014 (right images) 500 hPa geopotential height, 850 hPa wind speed and direction and mean sea level pressure with a composite (left images) of seven days which produced seiches in the Lake Charles warning area. Images provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/

Mesoscale Analysis

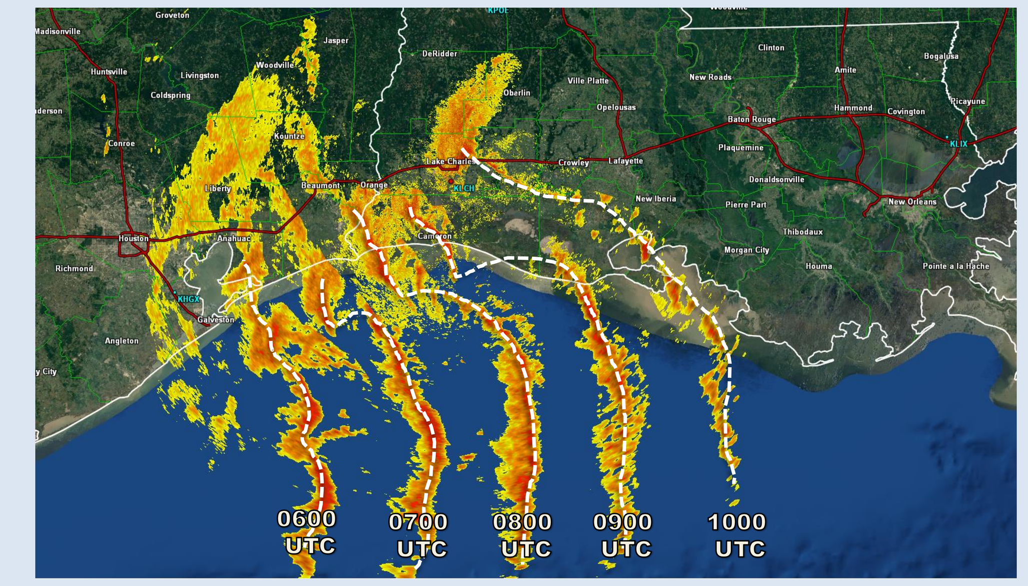

Fig 5. Composite of reflectivity greater than 37 dBZ showing progression of the Gulf Coast MCS from 0600 UTC to 1000 UTC 23 November 2014.

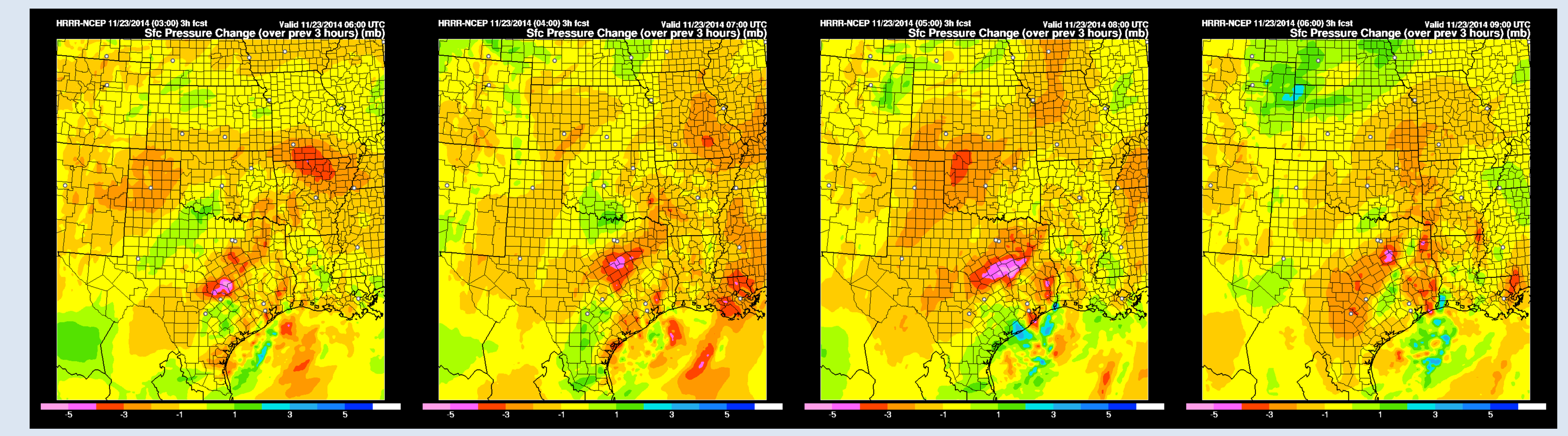

Fig 6. HRRR 3 hour surface pressure change analysis from 0600 UTC to 0900 UTC 23 November 2014.

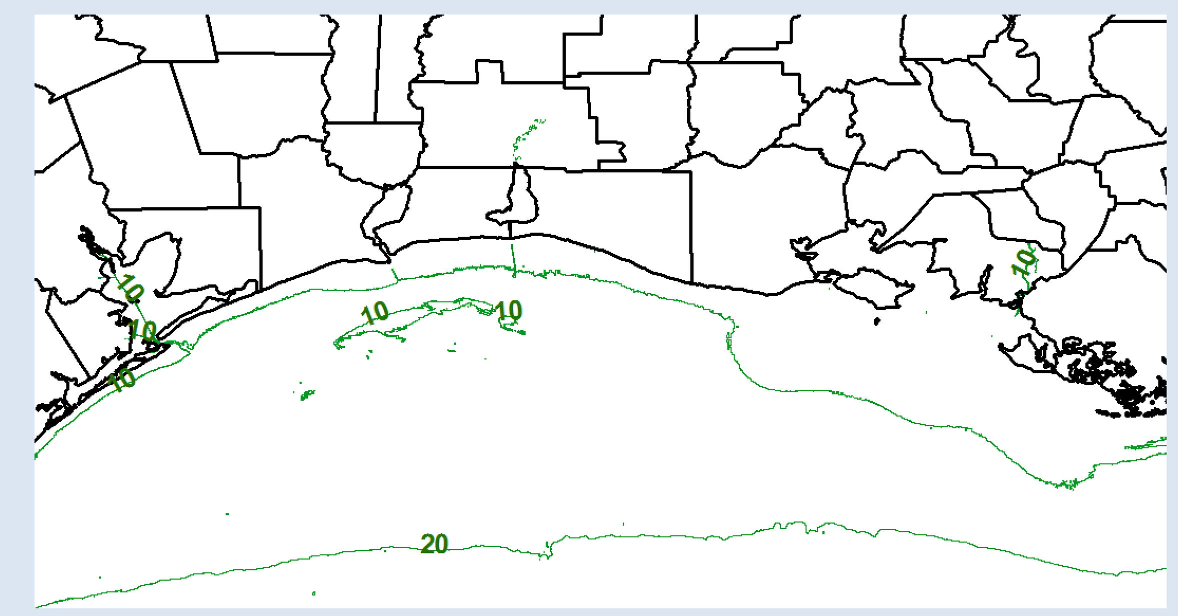

Fig 7. Contours of theoretical resonance frequency (ms^{-1}) based on Gulf of Mexico bathymetry.

Summary

Comparison with a composite of seven days on which seiches were recorded indicated larger 500 hPa geopotential height anomalies (Fig 4.) associated with the shortwave trough located over the Mexican Plateau. The ridge centered over the eastern United States also exhibited larger geopotential height anomalies compared to the composite event. A 15 ms^{-1} (29 kt) 850 hPa jet contributed to deep layer shear supportive of organized convection in the warm and moist air mass ahead of the surface low. The MCS developed over South-Central Texas and paralleled the Gulf Coast (Fig 5.) as it moved east during the early hours of 23 November. A 1030 hPa surface high pressure resulted in a larger easterly component to the gradient wind compared to a composite of events. The increased easterly component of the wind likely resulted in greater Ekman which enhanced the heightened sea level prior to the seiche.

Churchill et al. (1995) derived that wave height responds to the sum of the forcing from the atmospheric pressure gradient and from wind stress. While a pressure drop was recorded with the seiche, Fig 6. shows neither a strong nor persistent pressure gradient along the leading edge of the MCS. The 2.6-5.1 ms^{-1} (5-10 kt) increase in wind speed is also insufficient to account for the nearly 1 m swell. Both Churchill et al. and Paxton and Sobien (1998) reached the similar finding that forcing from wind stress and the pressure gradient alone could not explain the magnitude of solitary swells observed along the Florida coast. Both studies attributed the observed magnitude to a resonant wave which developed between an atmospheric perturbation moves at the phase speed of a shallow water wave. Paxton and Sobien state that the phase speed (C) of a shallow wave for a given depth of water (H) can be determined by: $C = \sqrt{gH}$. Based on the bathymetry of the Gulf of Mexico, the theoretical resonance wave speed for the offshore waters of Texas and Louisiana ranges from 10 to 20 ms^{-1} (Fig 7.). The MCS propagated to the northeast at ~15 ms^{-1} (Fig 5.), which falls within the resonance speed of the offshore waters, and likely resulted in the amplification of the water wave. Therefore, as in the aforementioned studies, wave resonance appears to be the main factor which influenced the observed magnitude of the seiche.

Anticipating Future Events

The low elevation of Southeast Texas and Southwest Louisiana (Fig 2.) renders the area vulnerable to coastal surge events. Vulnerability will increase in the future due to a combination of subsidence, sea level rise, increasing population, and industrial development throughout the area. Therefore, the ability to anticipate when a seiche can occur should be assessed.

Pattern recognition (Fig 4.) can assist in determining if a synoptic scale environment has historically been favorable for the development of a seiche. These environments display many similarities to those which result in coastal flooding. A mesoscale forcing mechanism, such as the wind shift associated with the leading edge of an MCS, is necessary to initiate a seiche (Fig 3).

The limited sample size of observed seiches has prevented the determination of whether the magnitude of a seiche can be anticipated in advance. However, the magnitude of coastal flooding has shown consistent correlations between all three NOS observing stations in previous events. Therefore, the magnitude and impact of an individual seiche can be better assessed once its crest or trough is fully sampled at one site.

References

Dean D. Churchill, Sam H. Houston, and Nicholas A. Bond, 1995: The Daytona Beach Wave of 3–4 July 1992: A Shallow-Water Gravity Wave Forced by a Propagating Squall Line. *Bull. Amer. Meteor. Soc.*, **76**, 21–32.
Charles H. Paxton and Daniel A. Sobien, 1998: Resonant Interaction between an Atmospheric Gravity Wave and Shallow Water Wave along Florida's West Coast. *Bull. Amer. Meteor. Soc.*, **79**, 2727–2732.

Questions?

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