

# Diagnosing the Large Swell Event Associated with the Extratropical Transition of Hurricane Florence

**Mark Willis**

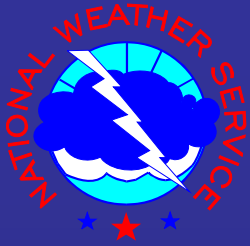
**National Hurricane Center**

**Tropical Analysis and Forecast Branch (TAFB)**

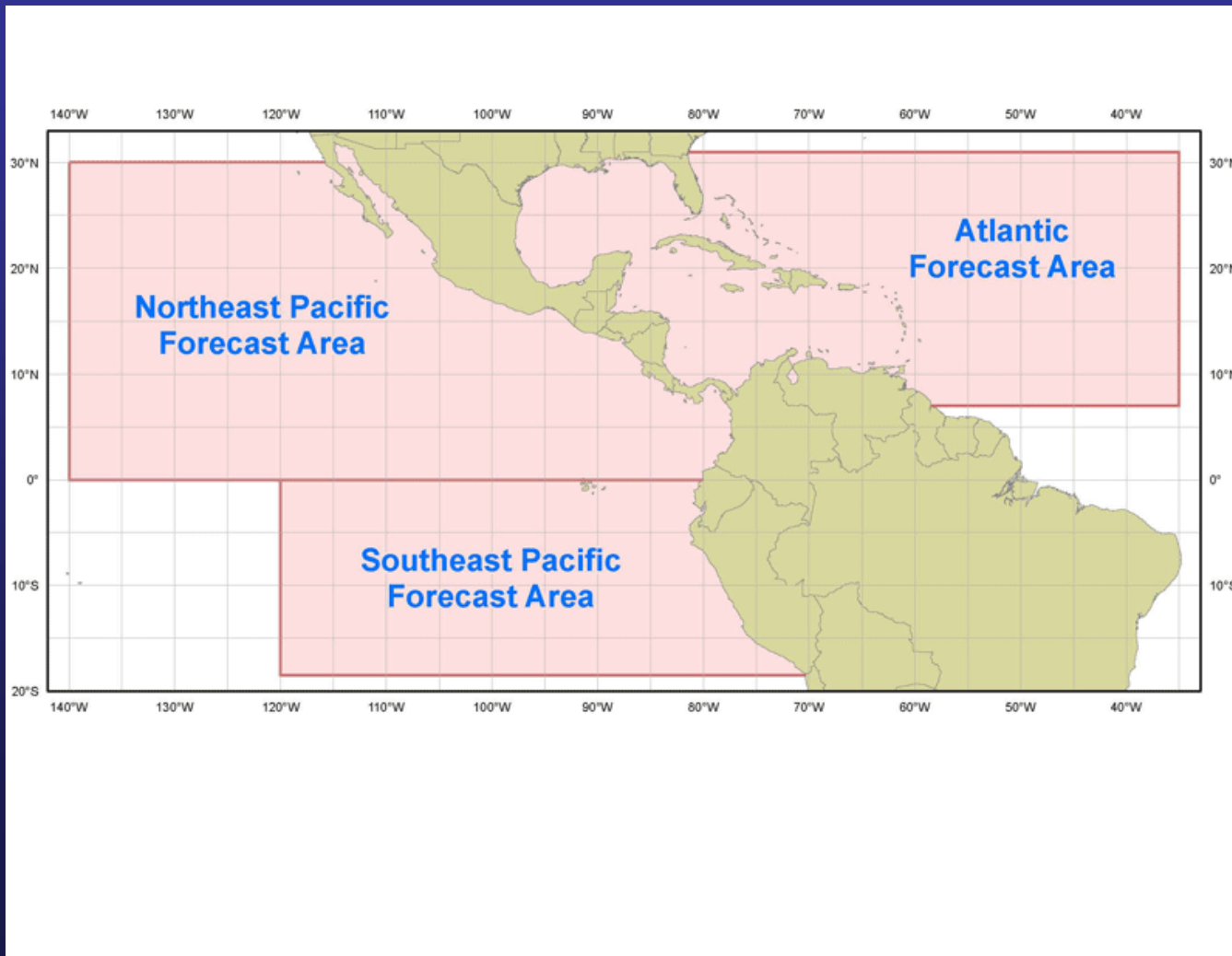
**Thanks to: Jack Beven, Robbie Berg, John Cangioli, and Jamie Rhome.**

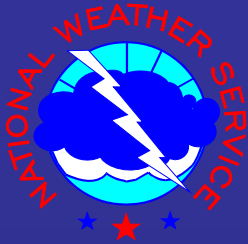


**© Danny Moody**



# TAFB Area of Responsibility

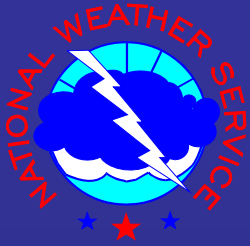




# MOTIVATION



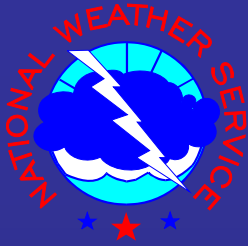
- **PROTECT LIFE AND PROPERTY – At least two drownings, hundreds of ocean rescues, erosion, and flooding resulted from this swell event.**
- **22% of all tropical cyclone related deaths are offshore or surf related (2<sup>nd</sup> only to inland flooding), Rappaport (2000).**
- **Improve public misperceptions of swell events from tropical cyclones – the category and type of storm don't matter!**
- **Wave model guidance did not represent the peak of the swell event very well. Why?**
- **Improve NWS/NCEP marine forecast products.**



# METHODOLOGY



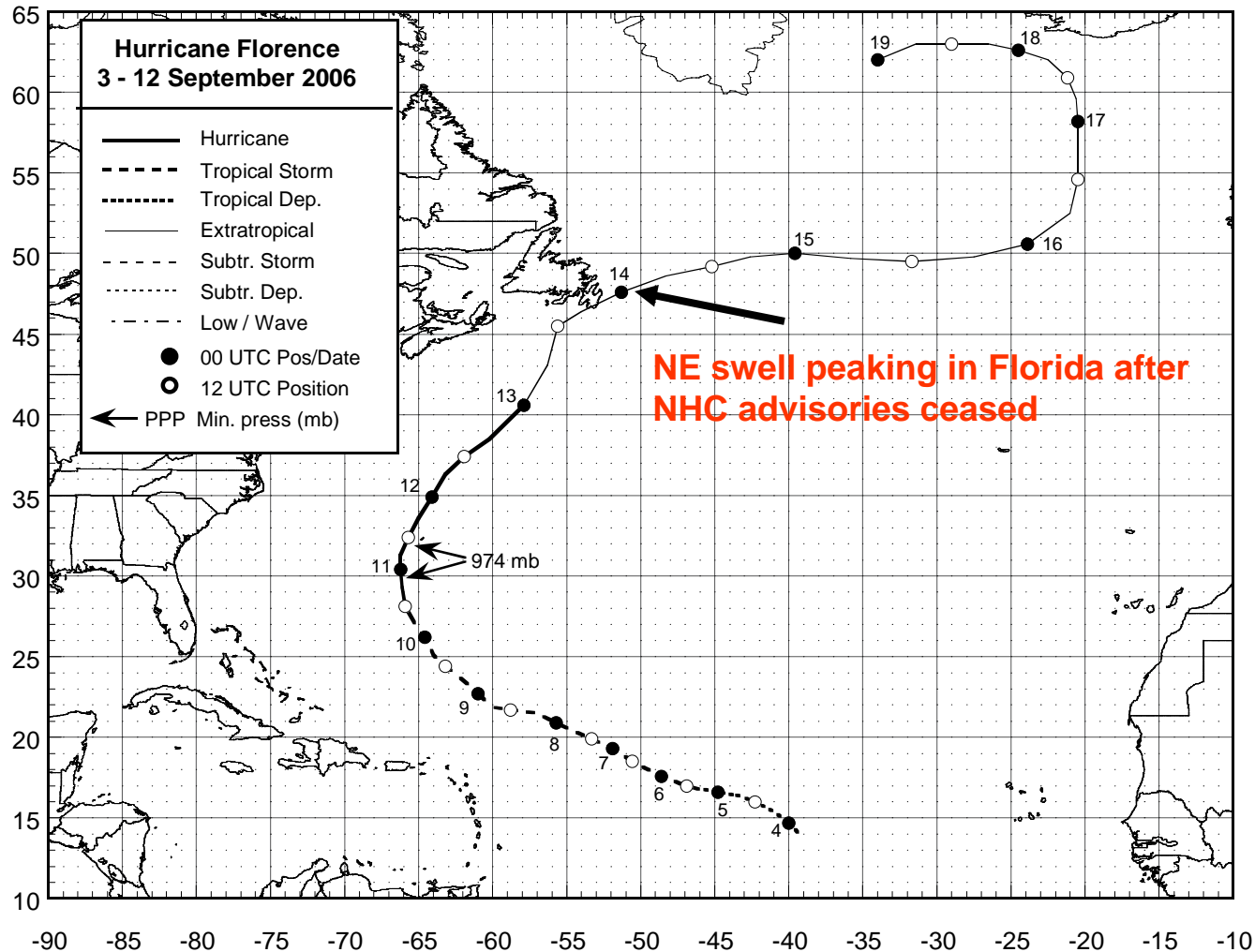
- A detailed case study was performed to understand the social and scientific challenges associated with the large swell event from Hurricane Florence.
- Gain an understanding for the meteorology in hindsight – what atmospheric patterns made the waves so big?
- Compared strengths and weaknesses in the available wave model guidance at TAFB – NWW3, NAH WW3, WNA WW3, FNMOC WW3.
- Located problems in the GFDL and GFS wind forcing that led to problems in the NAH and WNA models.
- Compared swell of Florence (Cat 1) to Luis (Cat 4).



# CONCLUSIONS

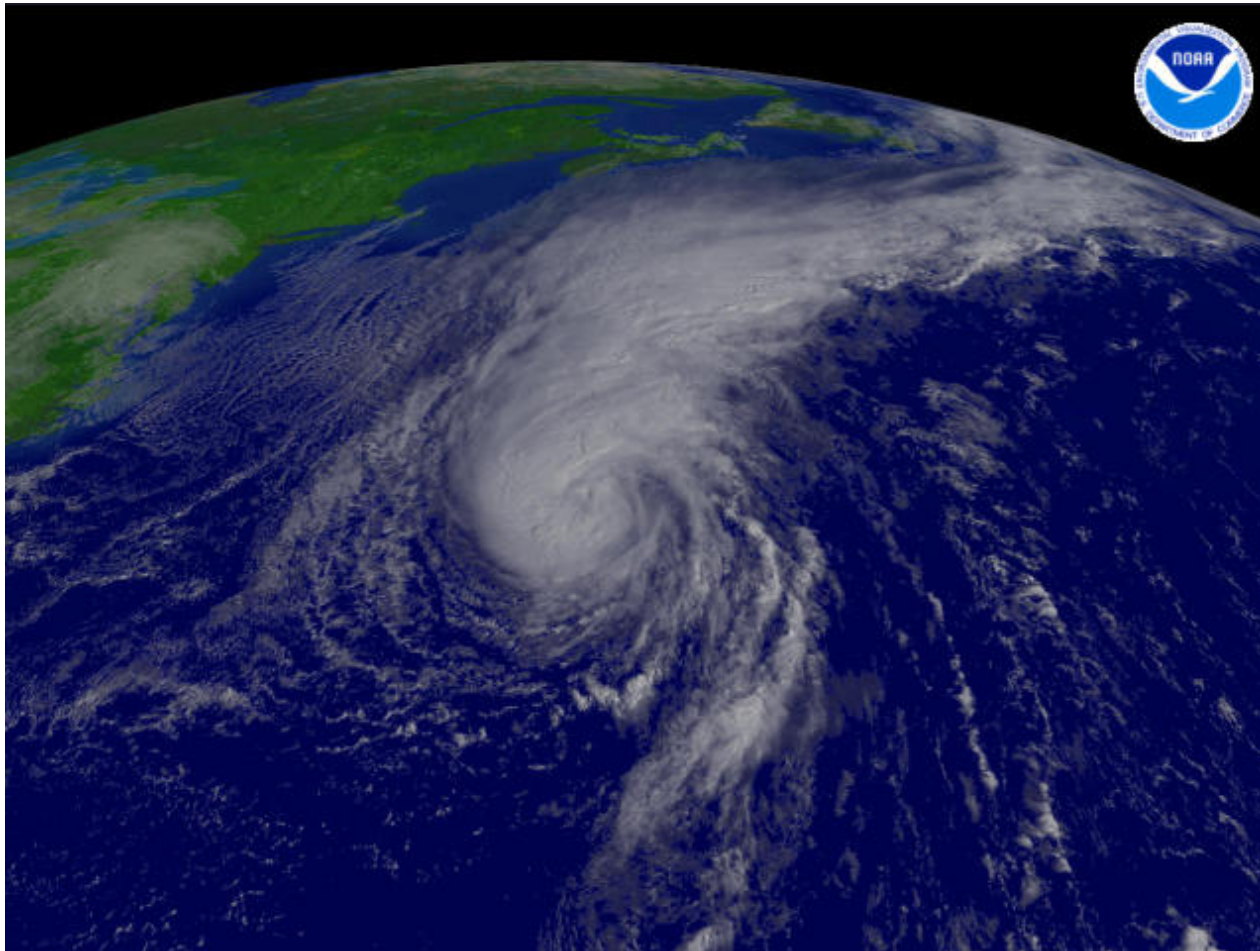
- This uniquely large swell event was due to: large storm from origin, ET, interaction with strong Canadian high pressure that built south.
- NAH and WNA WW3's low with height and **period** offshore Florida on 14 Sept due to problems in the GFDL and GFS wind forcing on 13 Sept.
- WW3's OVERestimated the heights and low with the **periods** off Cape Hatteras for the same reason.
- As marine forecasters, we always need to get a handle on the wind progs first, then waves.
- NAH isn't always better than WNA for tropical cyclones – especially ones going through ET.
- Further outreach is needed to inform the public of potential indirect dangers of tropical cyclones (Swell and Surf!), and the misperceptions of the Saffir Simpson scale.

# Hurricane Florence ( Sept 2006)

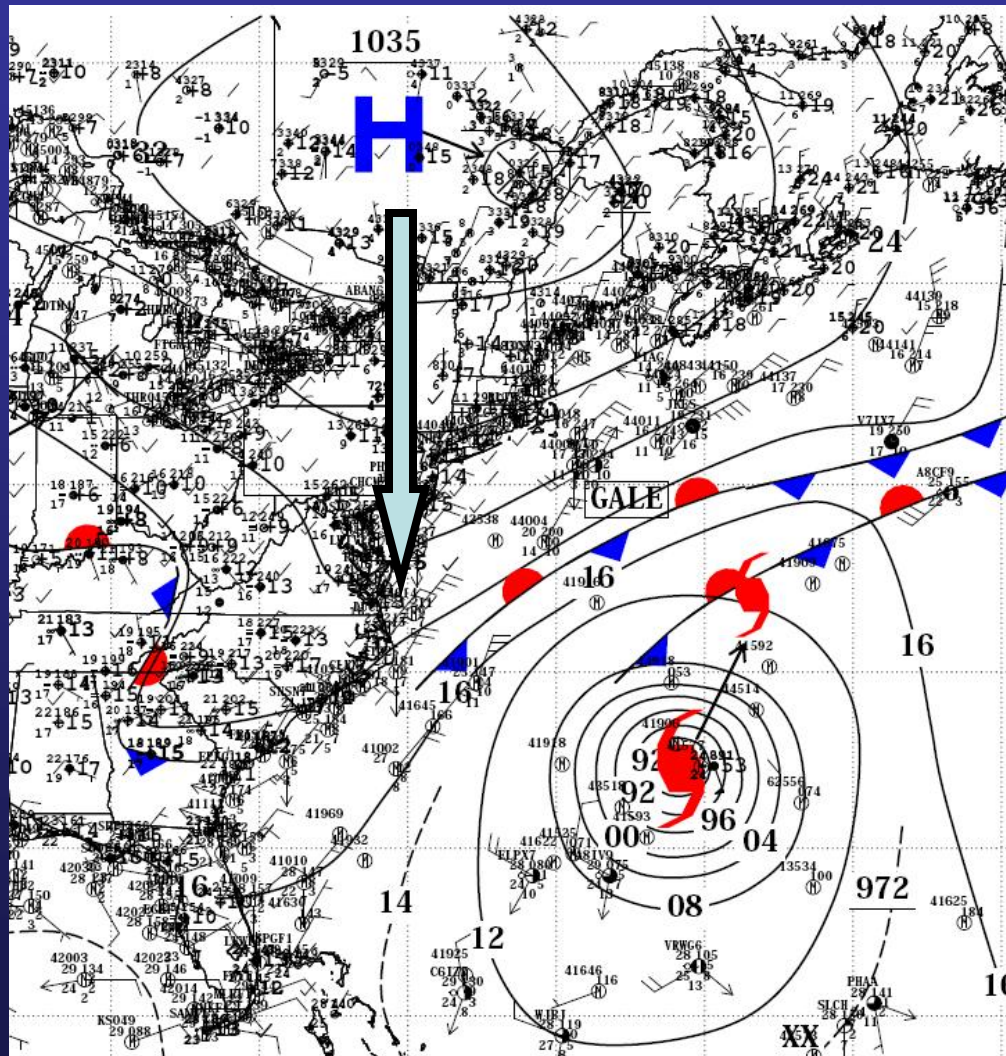




# Hurricane Florence ( Sept 2006)



# THE METEOROLOGY

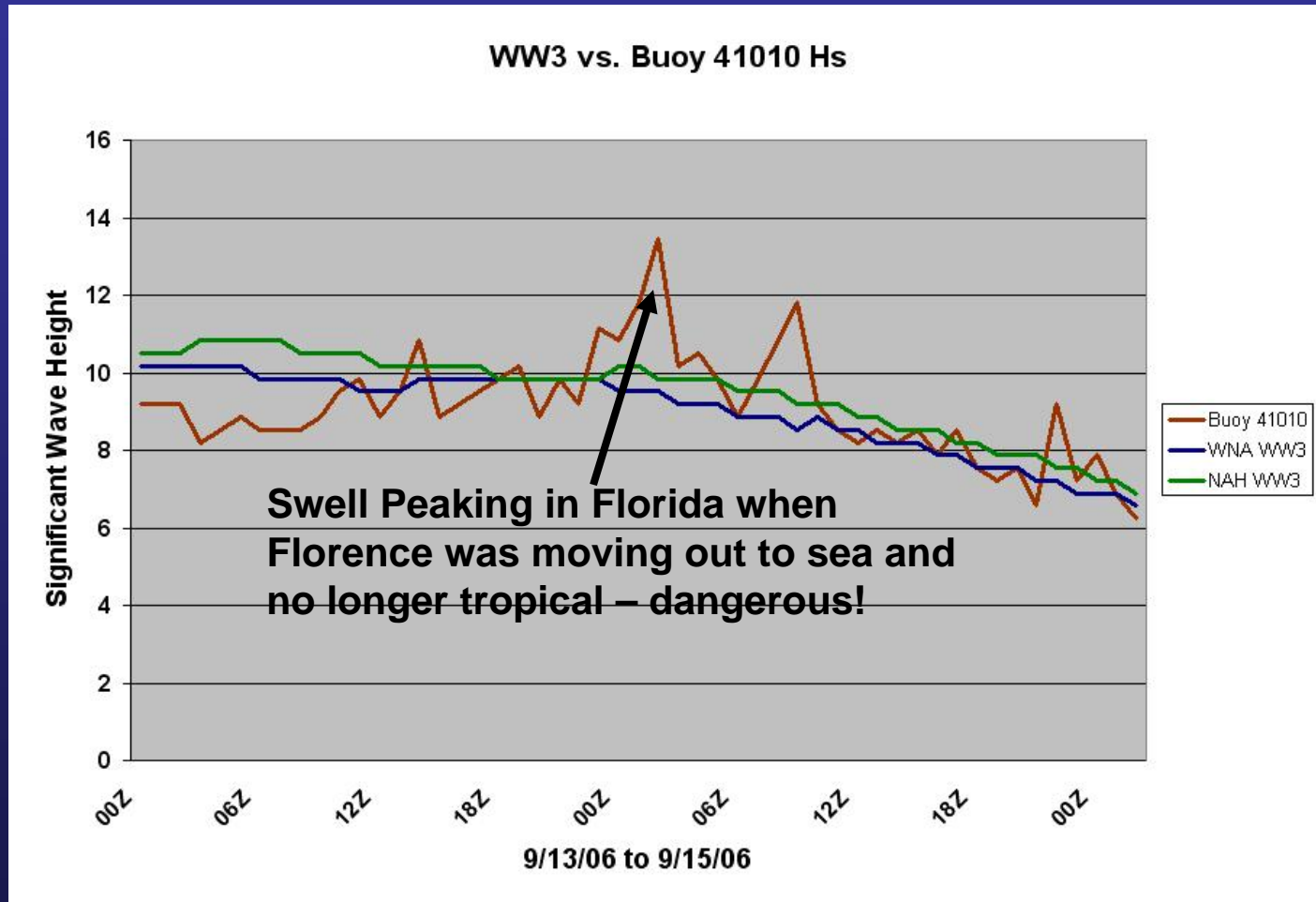


- Large storm from origin.
- Strong high pressure over Canada built south 11-13 Sept.
- This allowed significant NE fetch to build SW towards Florida.
- Led to peak of swell in FL as Florence seemingly was not a threat and moving out to sea.

NWS/NCEP Unified Surface Analysis 12Z 11 Sept 2006

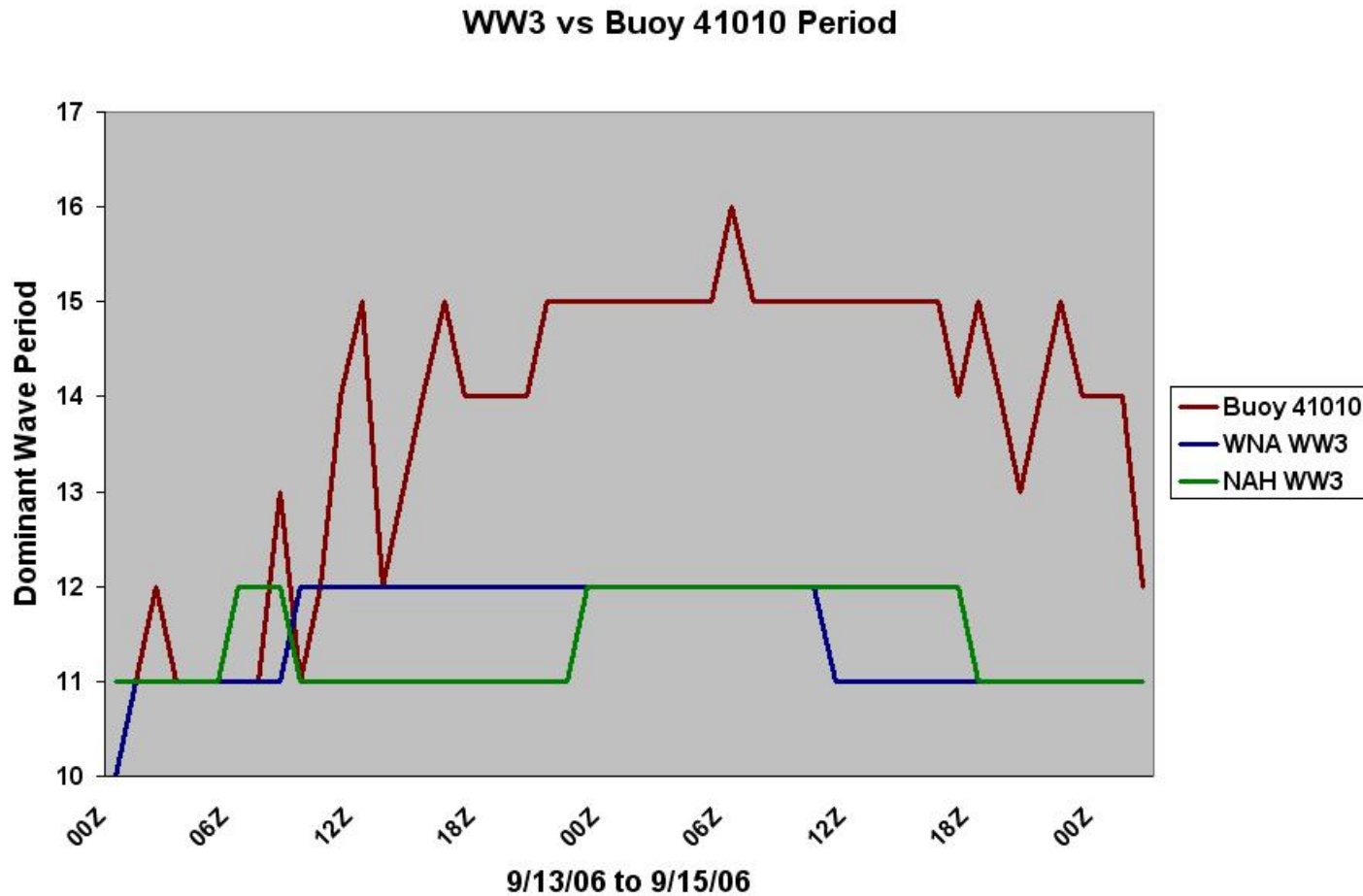


# Wave Model Verification



Wave heights offshore Central Florida

# Wave Model Verification



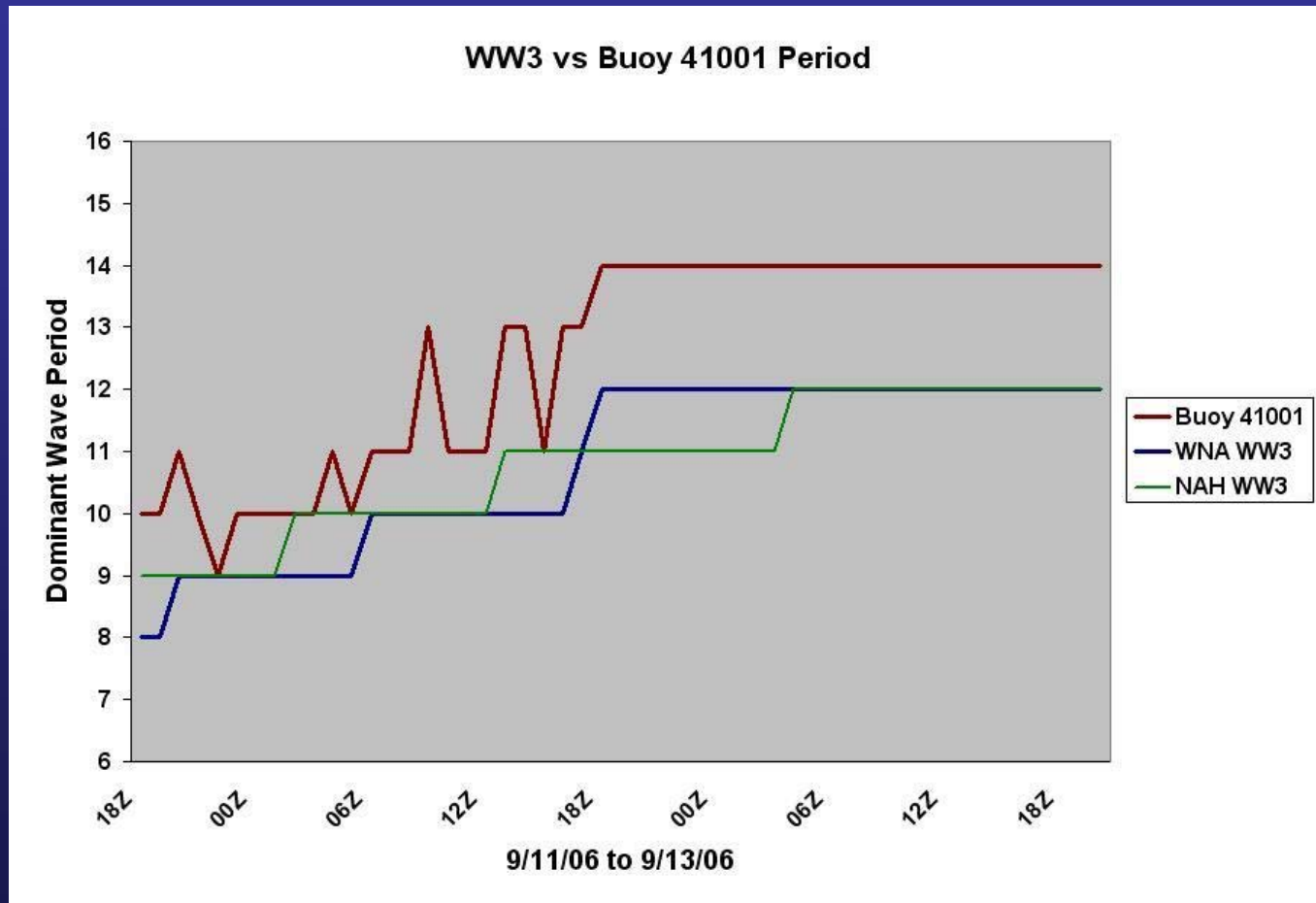
Wave periods offshore Central Florida

# Wave Model Verification



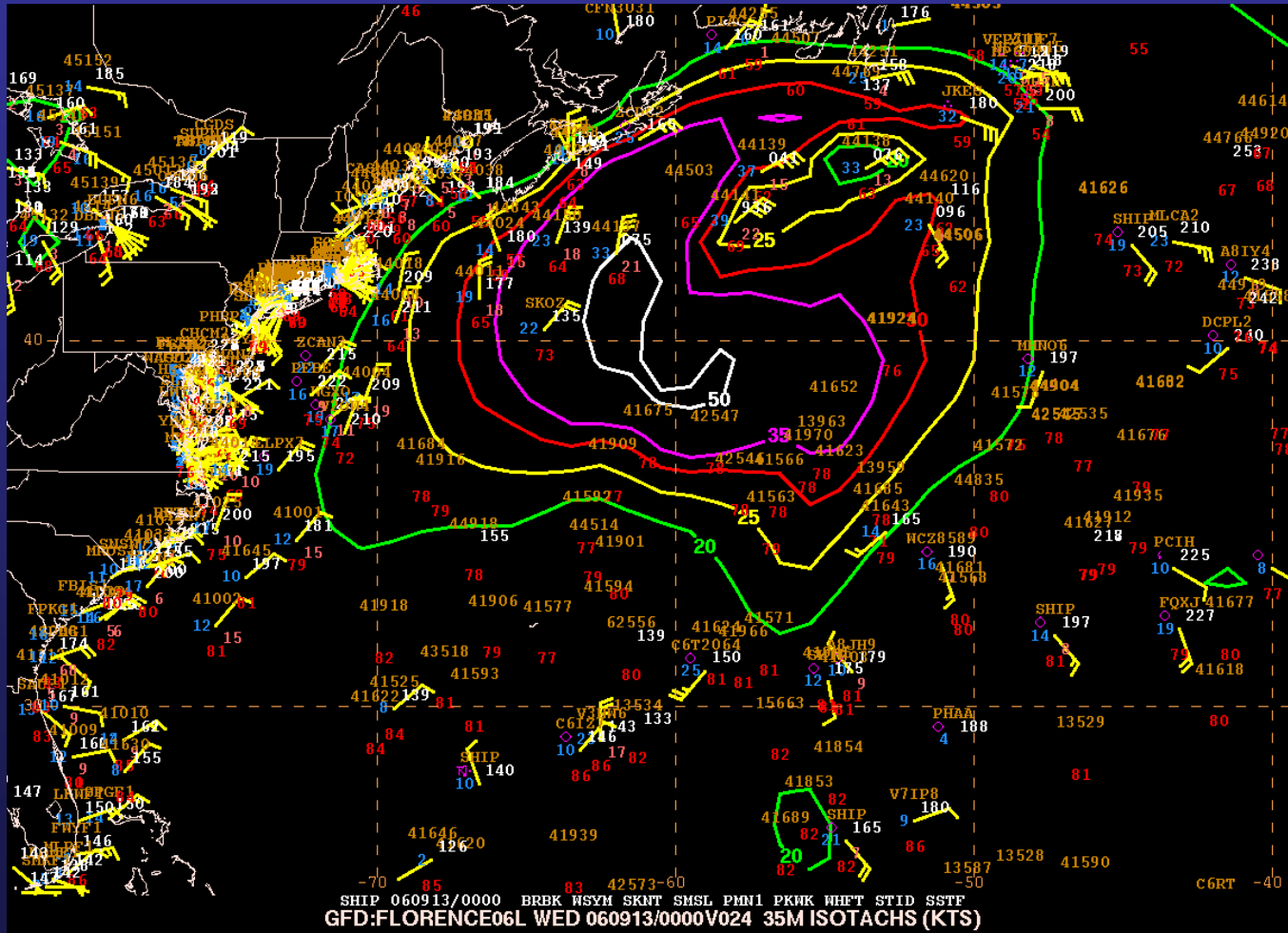
Wave heights offshore Cape Hatteras

# Wave Model Verification



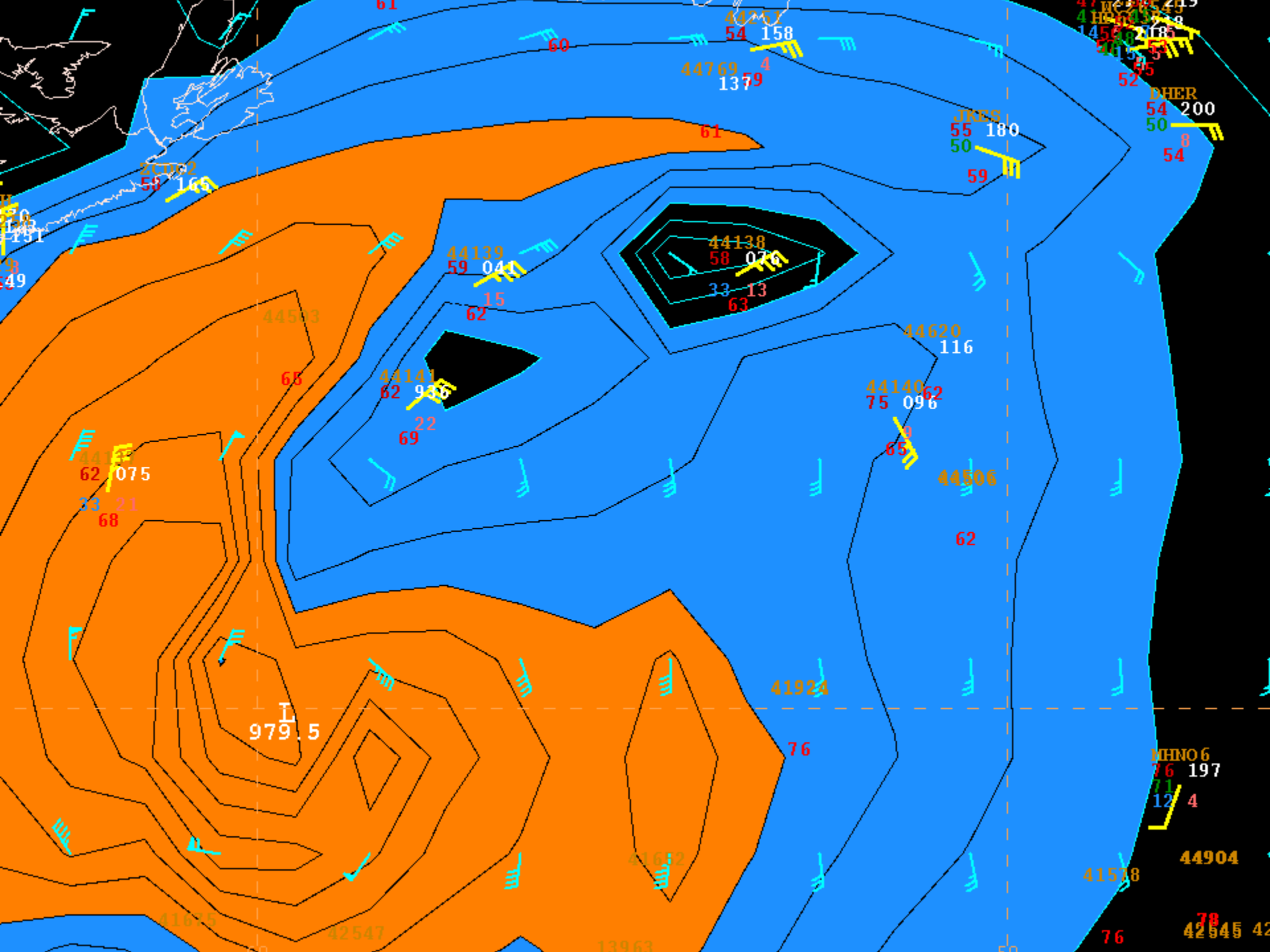
Wave periods offshore Cape Hatteras

# Why were the NAH and WNA WW3's off? – The wind forcing!

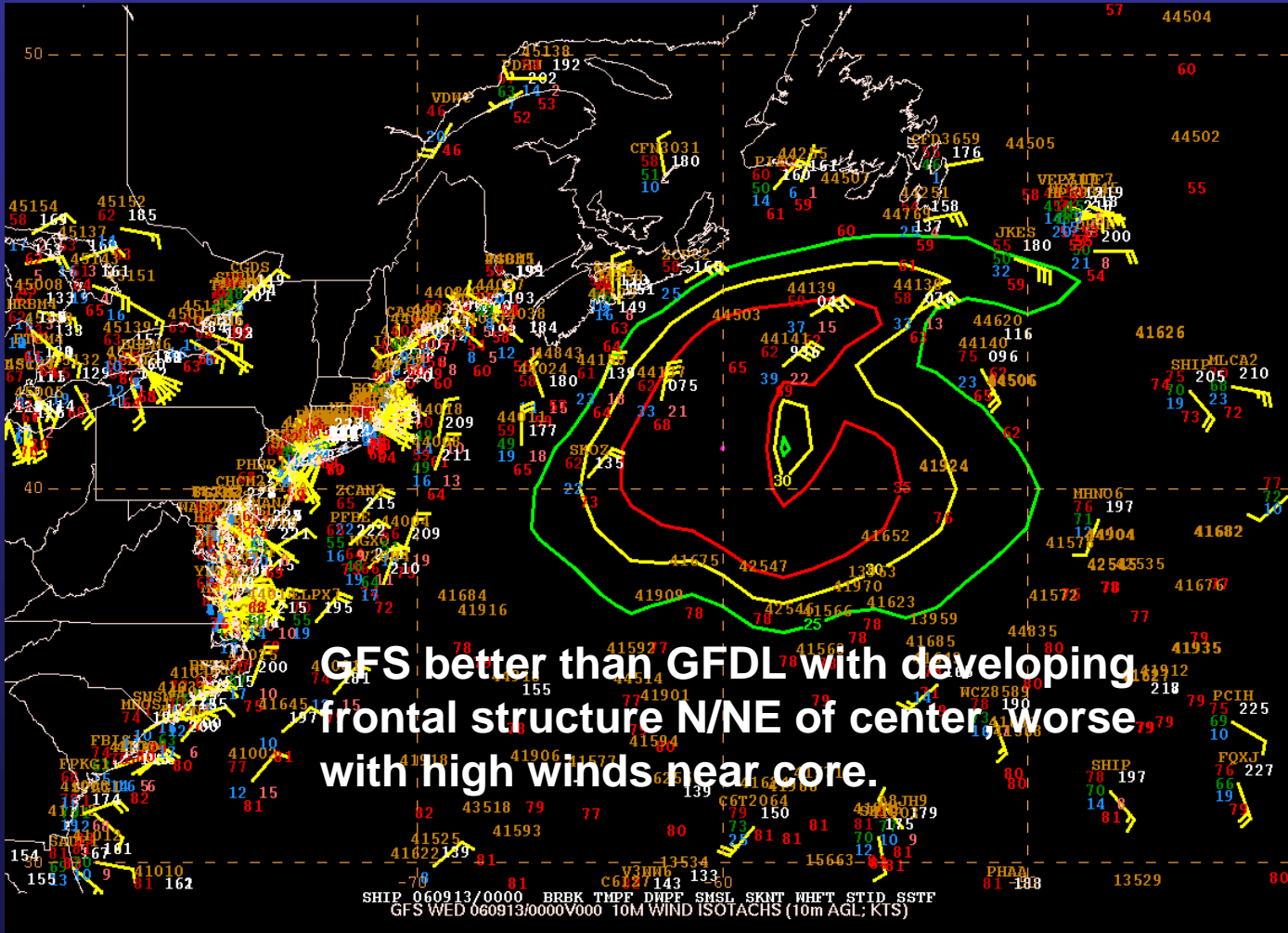


## GFDL Winds (used in NAH WW3) vs. Observations



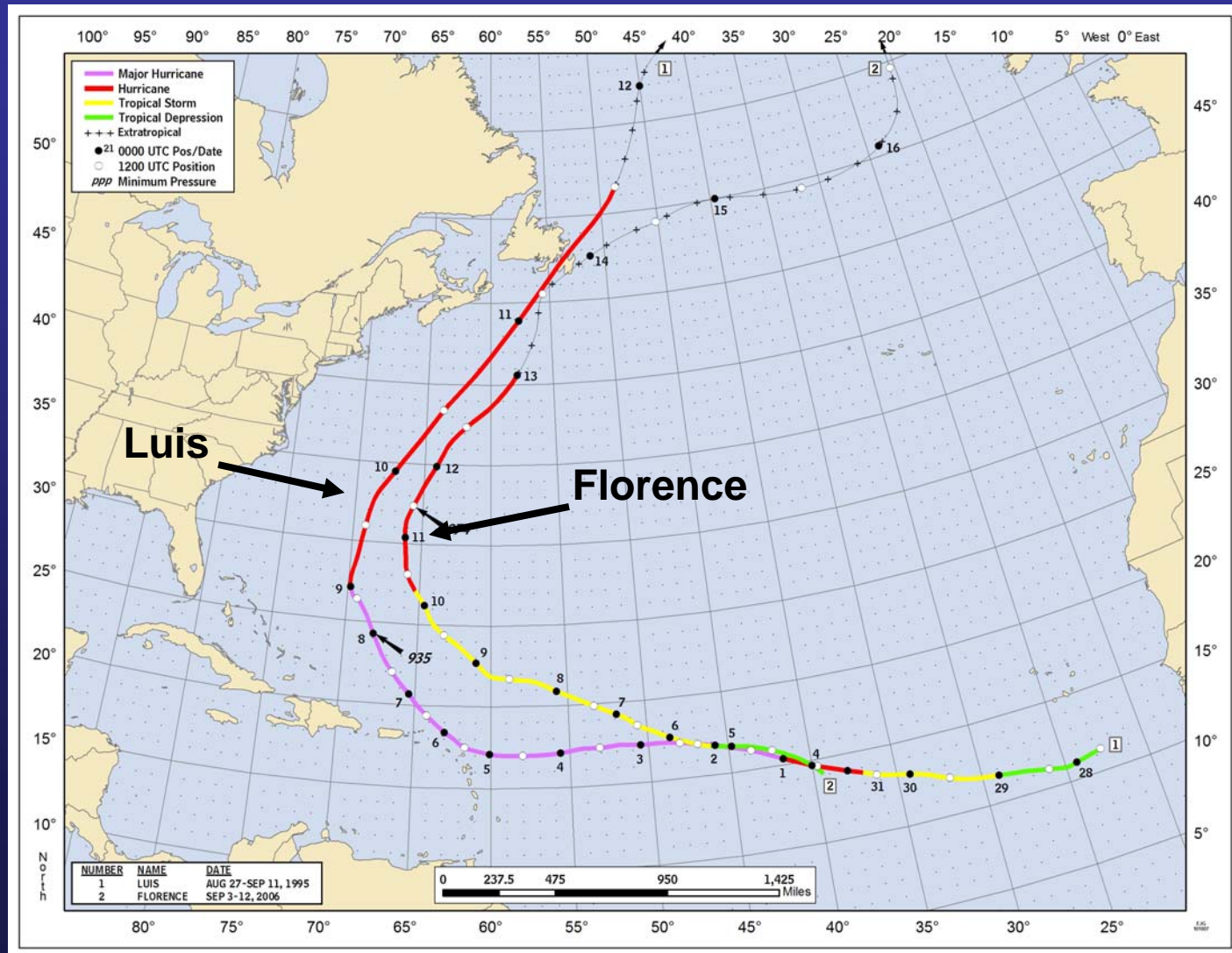


# Why were the NAH and WNA WW3's off? – The wind!



## GFS Winds (used in WNA WW3) vs. Observations

# Florence (Cat 1, 2006) vs. Luis (Cat 4, 1995)





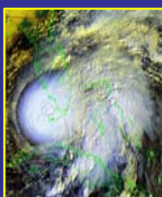
# Saffir-Simpson Scale

\* Denotes major hurricane

## Category 1

Winds: 74-95 mph  
(64-82 kt)

Pres: > 980 mb  
29.94" Hg

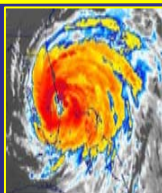


- **Storm surge:** 4-5 ft above normal. Some coastal road flooding and minor pier damage.
- **Wind Damage:** Primarily to unanchored mobile homes, shrubbery, and trees. Some damage to poorly constructed signs. Scattered downed power lines and power outages.

## Category 2

Winds: 96-110 mph  
(83-95 kt)

Pres: 965-979 mb  
28.50-28.91" Hg

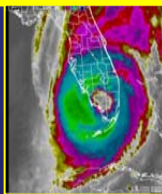


- **Storm surge:** 6-8 feet above normal. Coastal and low-lying escape routes flood 2-4 hours before arrival of the center.
- **Wind Damage:** Some roofing material, doors, and window of buildings. Considerable damage to shrubbery and trees with some trees blown down. Considerable damage to mobile homes, poorly constructed signs, and piers. Small craft in unprotected anchorages break moorings. downed power lines and power outages.

## Category 3\*

Winds: 111-130 mph  
(96-113 kt)

Pres: 945-964 mb  
27.91-28.47" Hg

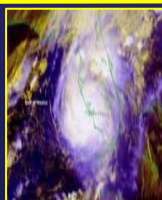


- **Storm surge:** 9-12 ft above normal. Low-lying escape routes cut by rising water 3-5 hours before arrival of the center of the hurricane. Flooding near coast destroys smaller structures with larger structures damaged by battering from floating debris. Terrain lower than 5 ft above mean sea level may be flooded inland 8 miles or more.
- **Wind Damage:** Some structural damage to small residences and utility buildings with minor amount of curtain wall failures. Foliage blown off trees and large trees blown down. Mobile homes and poorly constructed signs destroyed. Numerous downed power lines and power outages.

## Category 4\*

Winds: 131-155 mph  
(114-135 kt)

Pres: 920-944 mb  
27.17-27.88" Hg

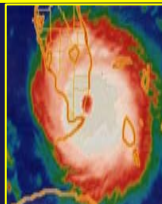


- **Storm surge:** 13-18 ft above normal. Low-lying escape routes may be cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of structures near the shore. Terrain lower than 10 ft above sea level may be flooded requiring massive evacuation of residential areas as far inland as 6 miles.
- **Wind Damage:** Extensive curtain wall failures with some complete roof failures on small residences. Shrubs, trees, and all signs are blown down. Complete destruction of mobile homes. Extensive damage to doors and windows. Widespread damage to power lines and power outages.

## Category 5\*

Winds: > 155 mph  
(> 135 kt)

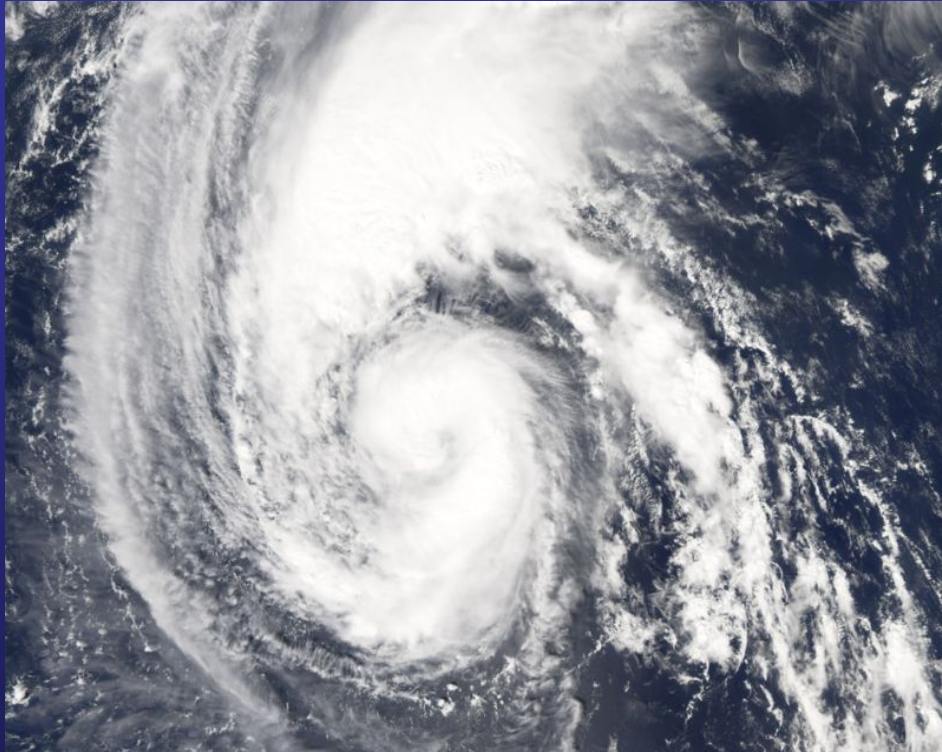
Pres: < 920 mb  
< 27.16" Hg



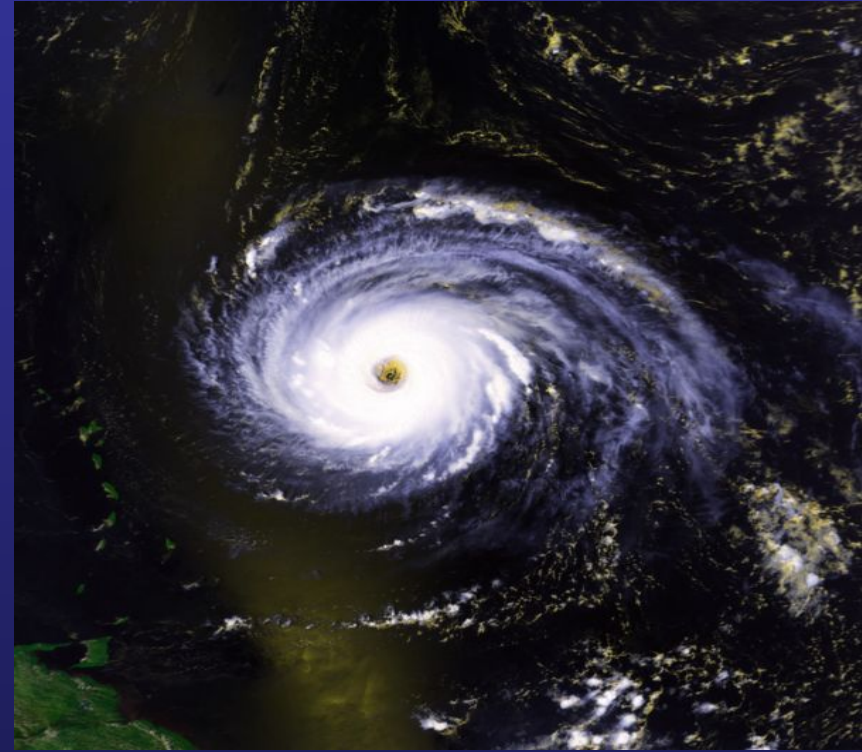
- **Storm surge:** > 18 ft above normal. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of all structures located less than 15 ft above sea level and within 500 yards of the shoreline.
- **Wind Damage:** Complete roof failure on many residences/industrial buildings. Some complete building failures with small utility buildings blown over or away. All shrubs, trees, and signs blown down. Complete destruction of mobile homes. Severe and extensive window and door damage. Extensive damage to power lines and widespread power outages.



# Florence (Cat 1, 2006) vs. Luis (Cat 4, 1995)



**FLORENCE MAX 70 KT**



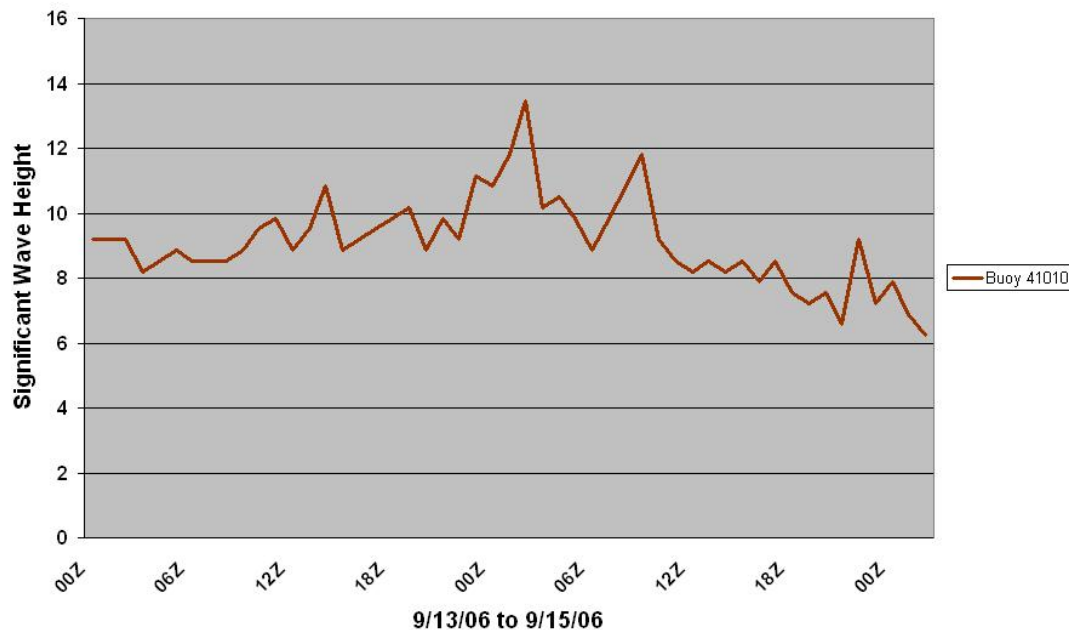
**OR LUIS MAX 120 KT ?**

**Which storm created the largest swell offshore Florida?**

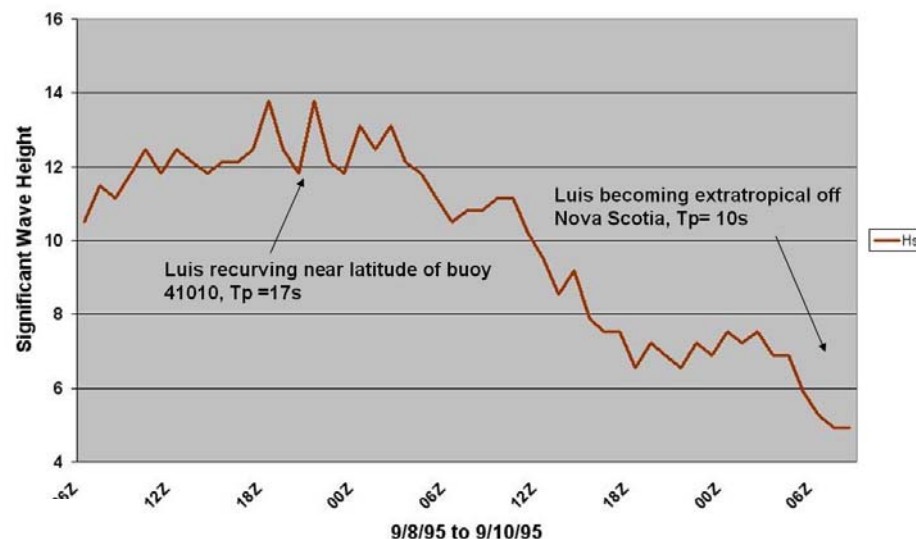


**And the winner is...TIE! Both swell events peaked around 14' at 16s. Not unusual for Oahu, but very unusual for Florida.**

**Buoy 41010 Hurricane Florence 2006**



**Buoy 41010 Hurricane Luis 1995**



**Saffir Simpson Scale not valid for swell events. Outreach needed to teach the public this.**

# Swell photos







**Thank You.  
Questions,  
Comments?**