

# IMPROVED OFFSHORE AND COASTAL WAVE FORECASTING



A C U S E A

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**2ND INTERNATIONAL WORKSHOP ON WAVES,  
STORM SURGES AND COASTAL HAZARDS**

**NOVEMBER 11, 2019; MELBOURNE, AU**

# MOTIVATION

US embraces offshore  
wind power

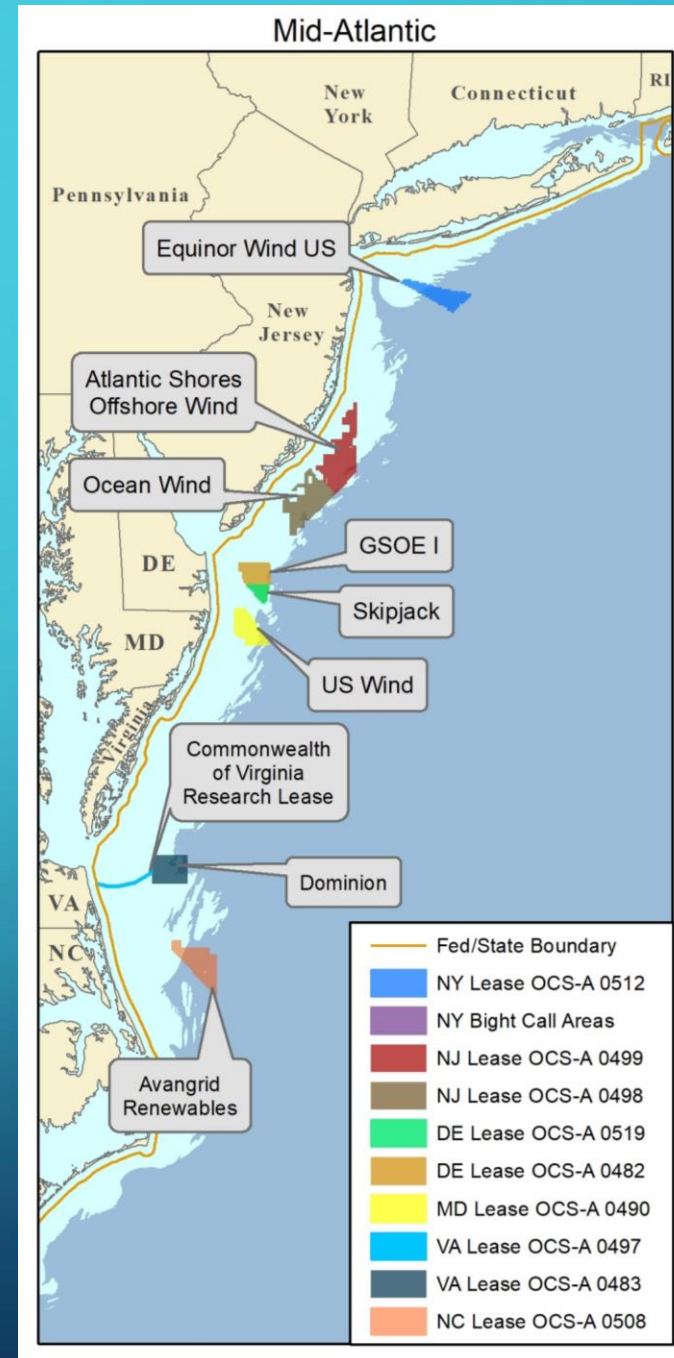
Predicted \$300 billion  
investment over next  
decade



# MOTIVATION

Mid-Atlantic states – 10 active lease areas

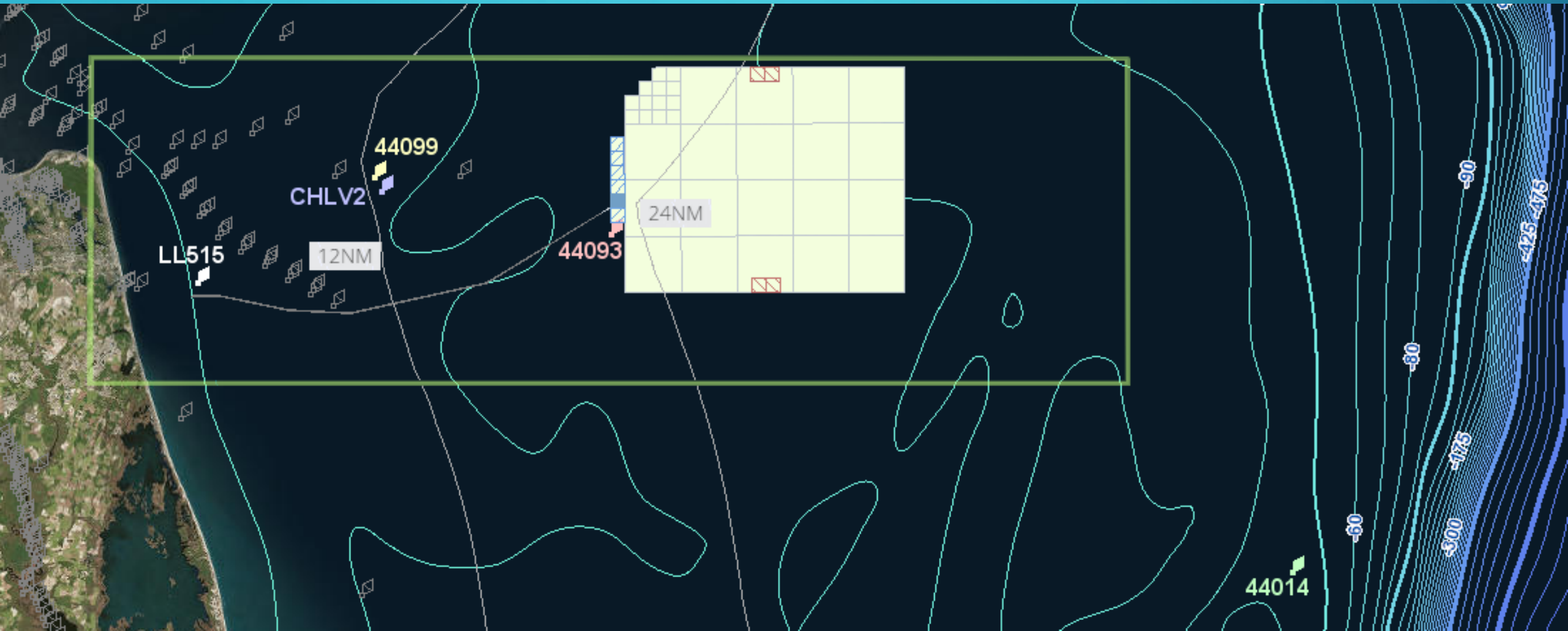
Serving 45% of Nation's population and energy needs

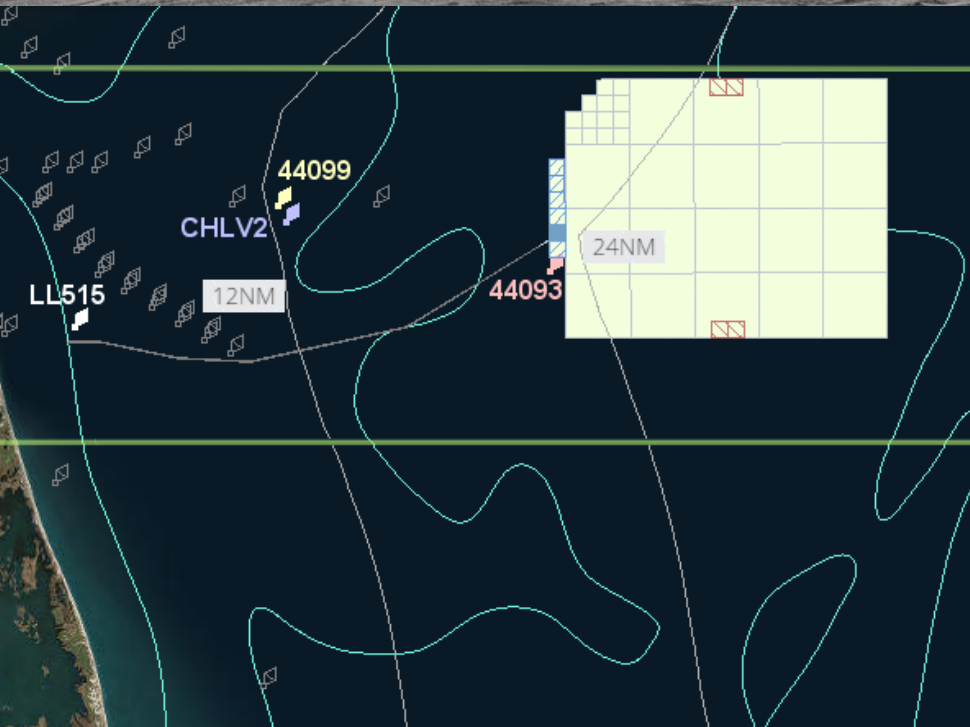




# Commonwealth of Virginia developing the first offshore project in US Federal Waters

Virginia has committed to procuring 200+ turbines by 2022





## MOTIVATION

Accurate / timely wave forecasts critical for safe and economical operations

## OBJECTIVE

Increase forecast accuracy to provide measurable improvement to offshore and coastal operations

# RESULT

A new forecasting approach:

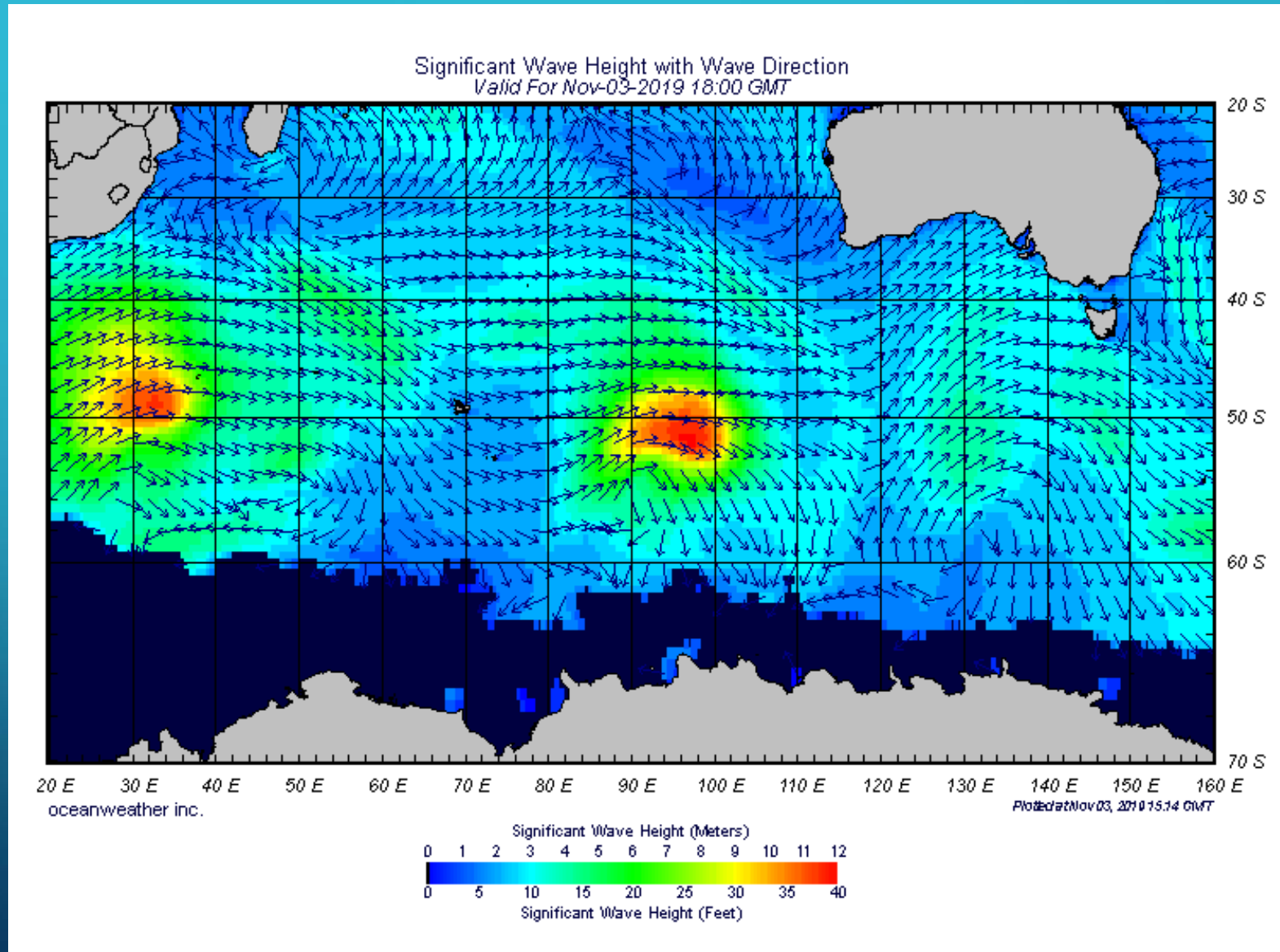
- Ingest operational forecasts
- Assimilate buoy observations
- Integrate 35 years of wave research
- Latest computing advancements

Significant gains in accuracy  
and run efficiency





# FOLLOW THE ENERGY... TRACE THE WAVE SYSTEMS!



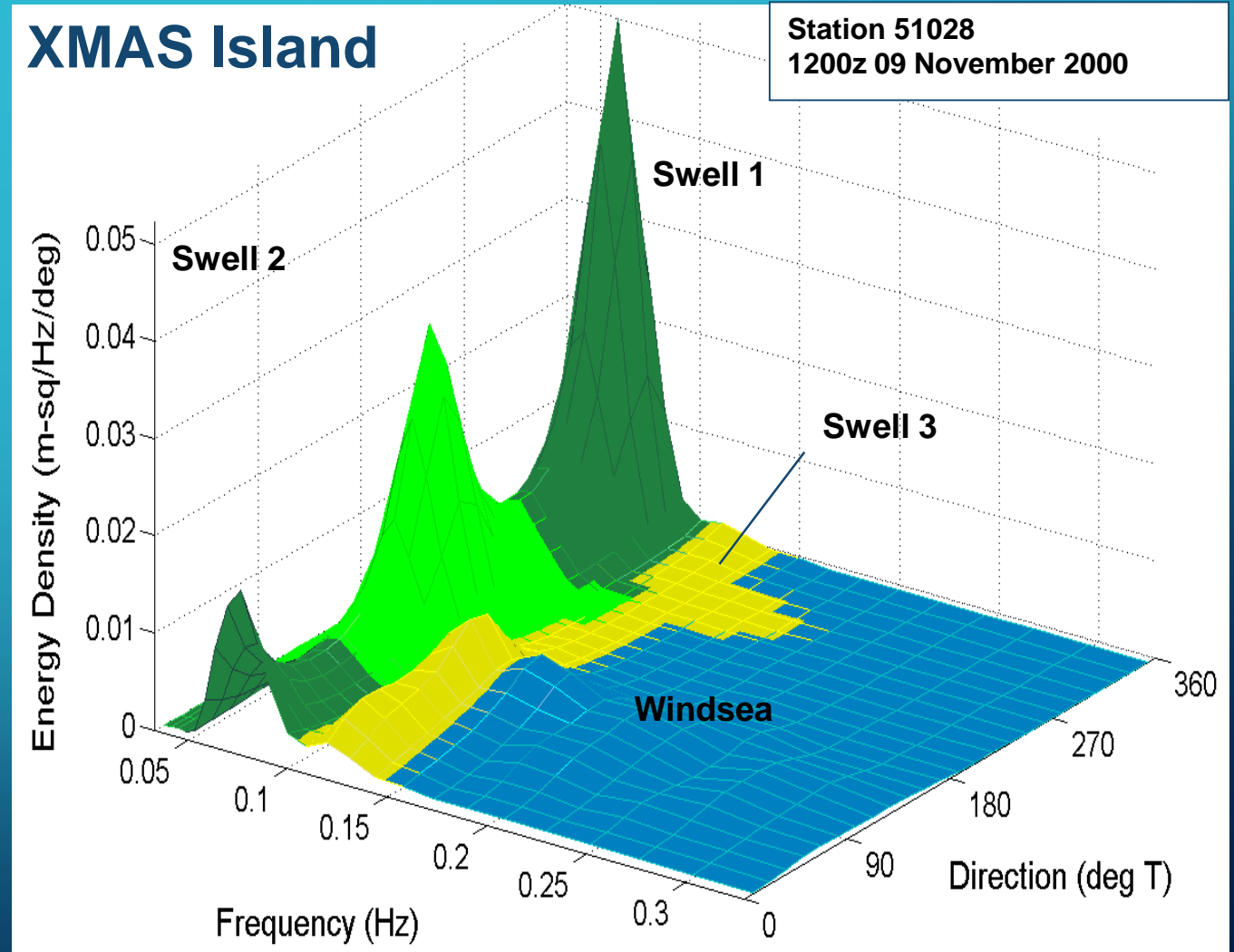
# IT STARTS WITH WAVE PARTITIONING

## Wave Component

A specific sea or swell peak in a directional (2D) wave spectrum

Gerling (1992)  
Hasselmann et al. (1994, 1996)  
Hanson & Phillips (2001)  
Tracey, Tracey and Hanson, 2007  
Portilla et al. (2009)

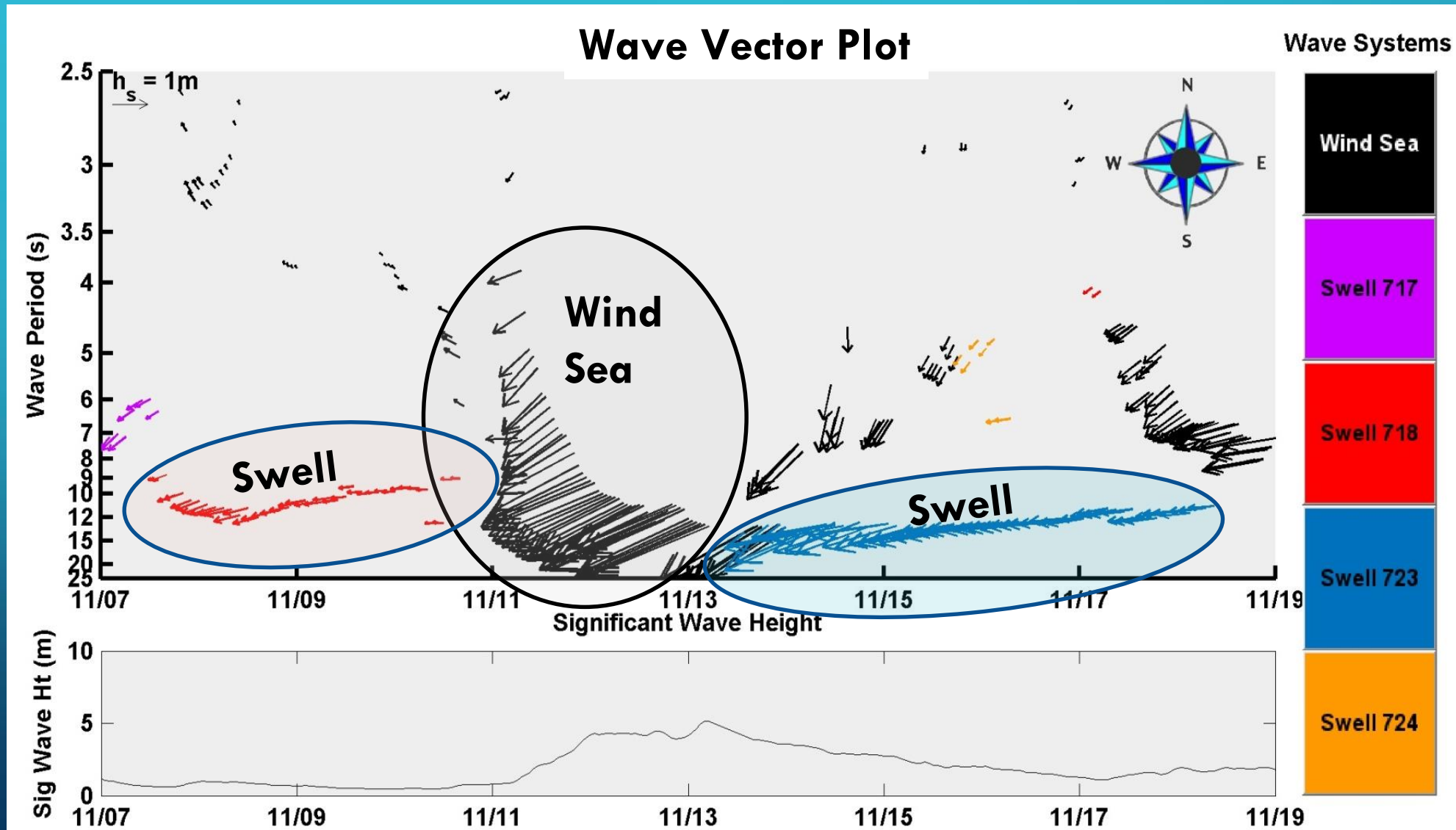
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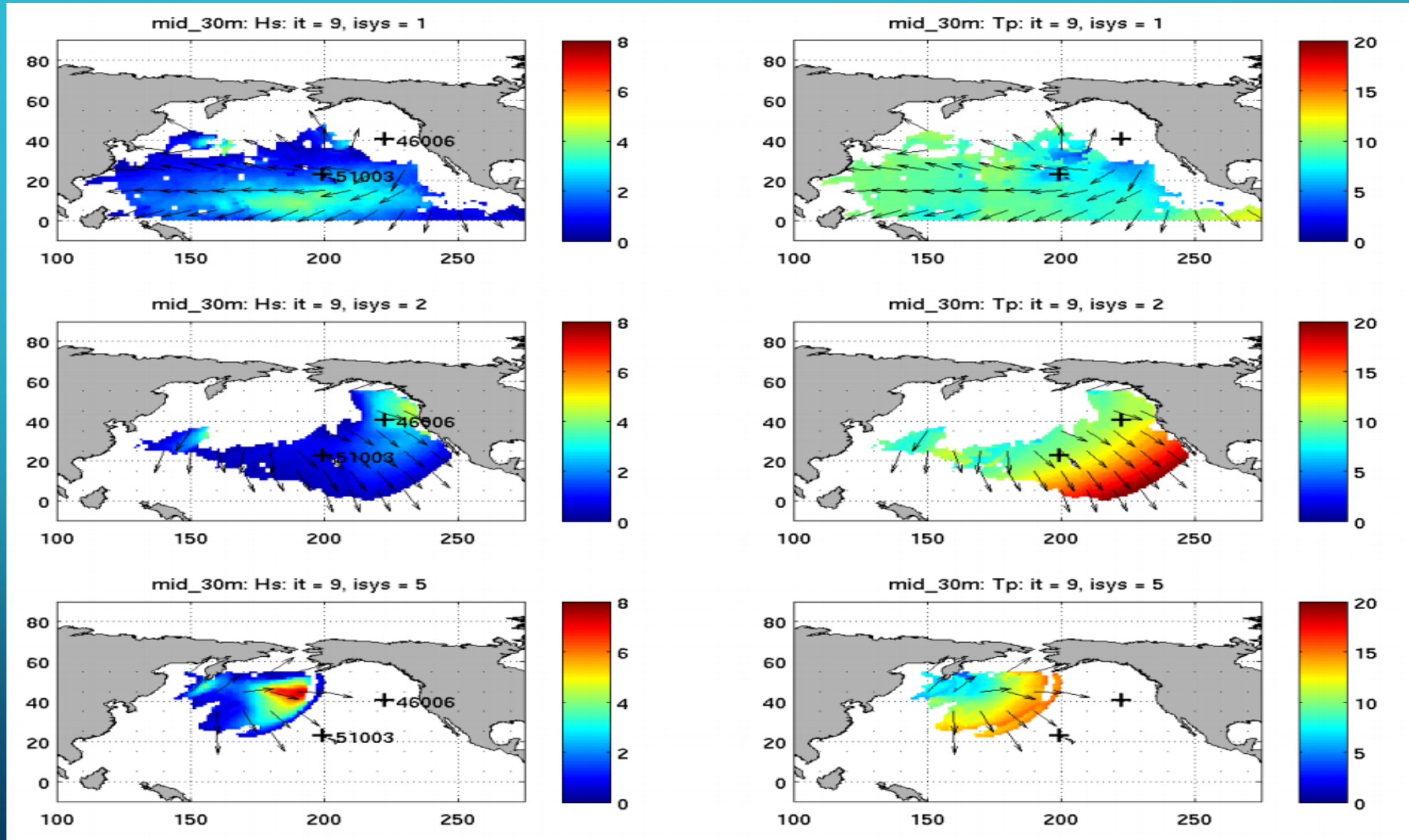
# TEMPORAL WAVE SYSTEM TRACKING

NOR'IDA: November 2009, North Carolina NDBC 44056



# SPATIAL WAVE SYSTEM TRACKING

van der Westhuysen, Hanson and Devaliere, 2013



Hs

Tp

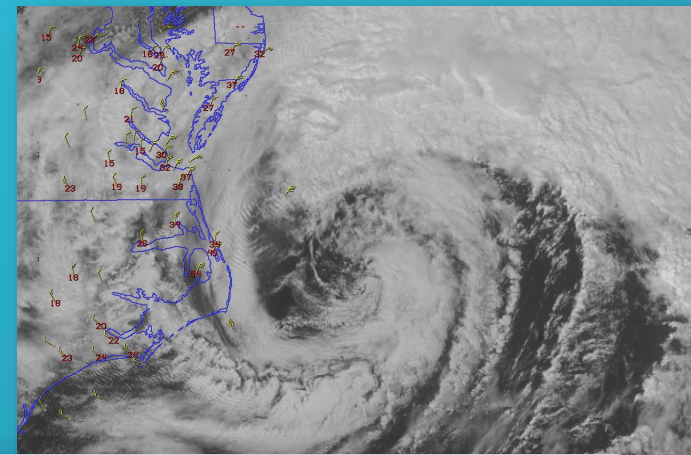
# WAVE FORECASTING RE-IMAGINED

## Wave System Approach

- Buoy data assimilation
- Nearshore wave model
- Hi-resolution nearshore bathymetry (FEMA, USGS, USACE)

## Modern Computing Techniques

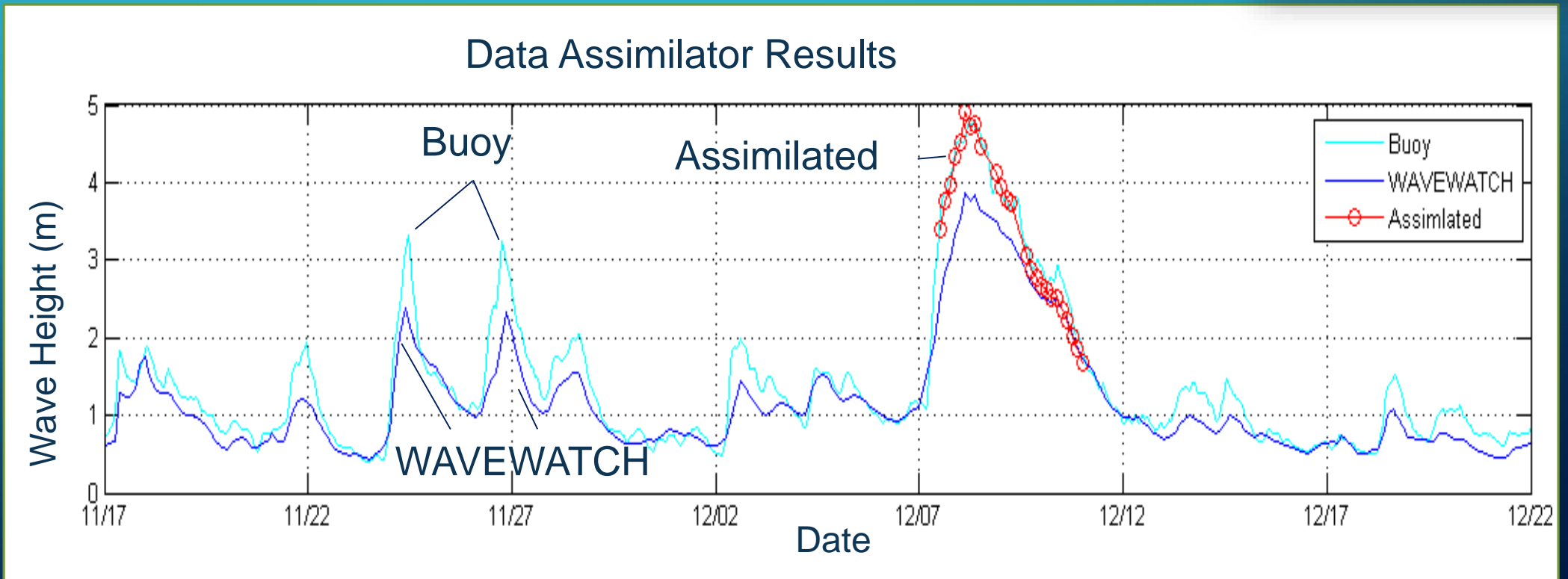
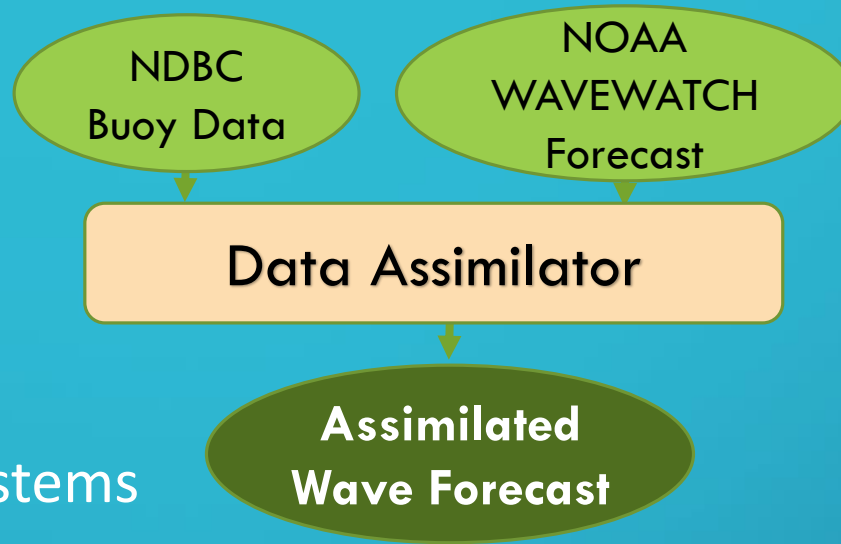
- Data Fusion — Merging data from the WWW
- Artificial Intelligence — Advanced machine learning algorithms
- State-of-the-Art Cloud Computing — Fast and efficient computing



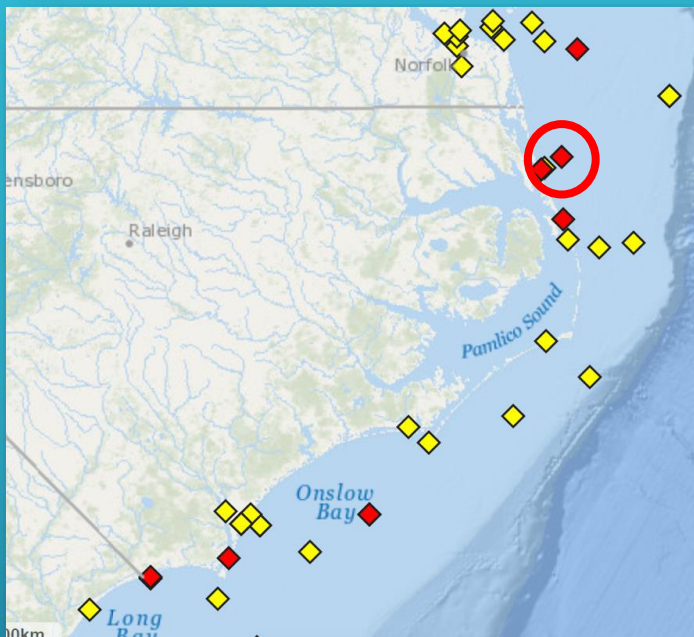


# DATA ASSIMILATION

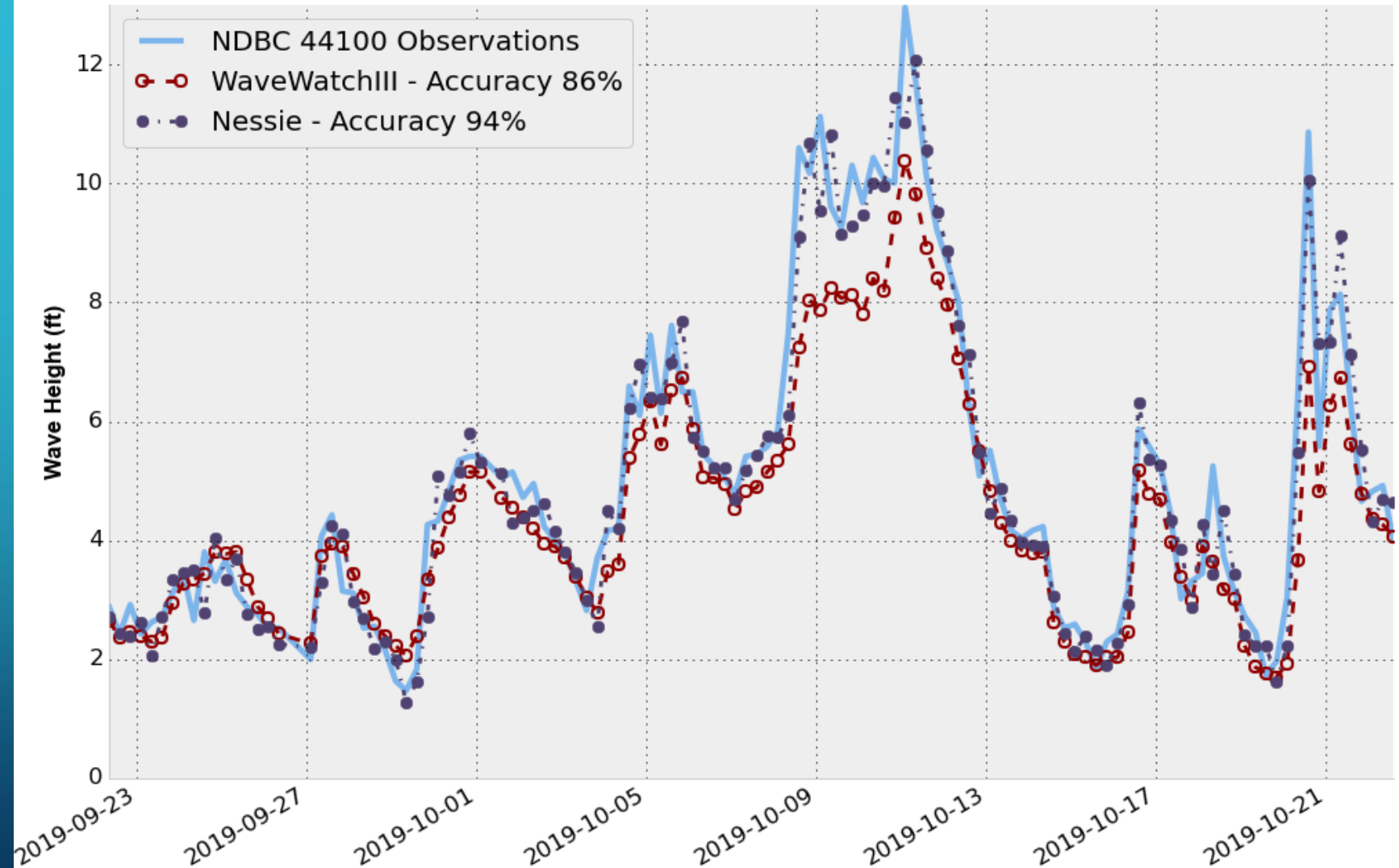
- Bulk Hs Assimilation (v. 1)
- Buoy bulk parameters
- Propagated through model wave systems



# 12-H FORECAST VALIDATION

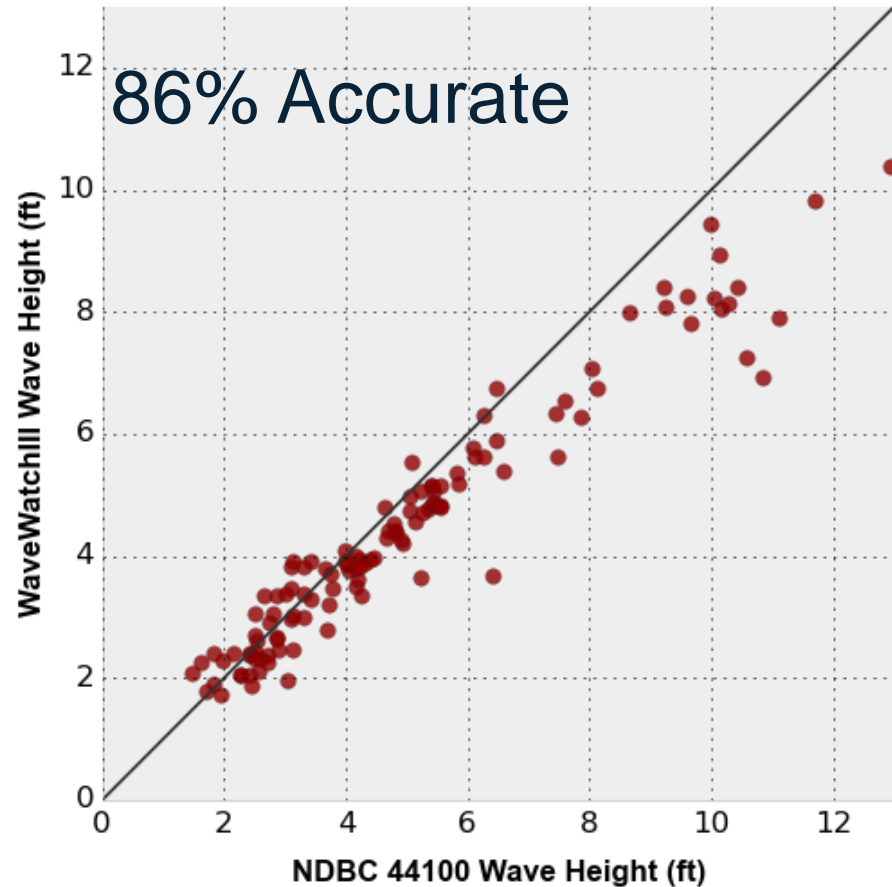


## STATION 44100 DUCK NC



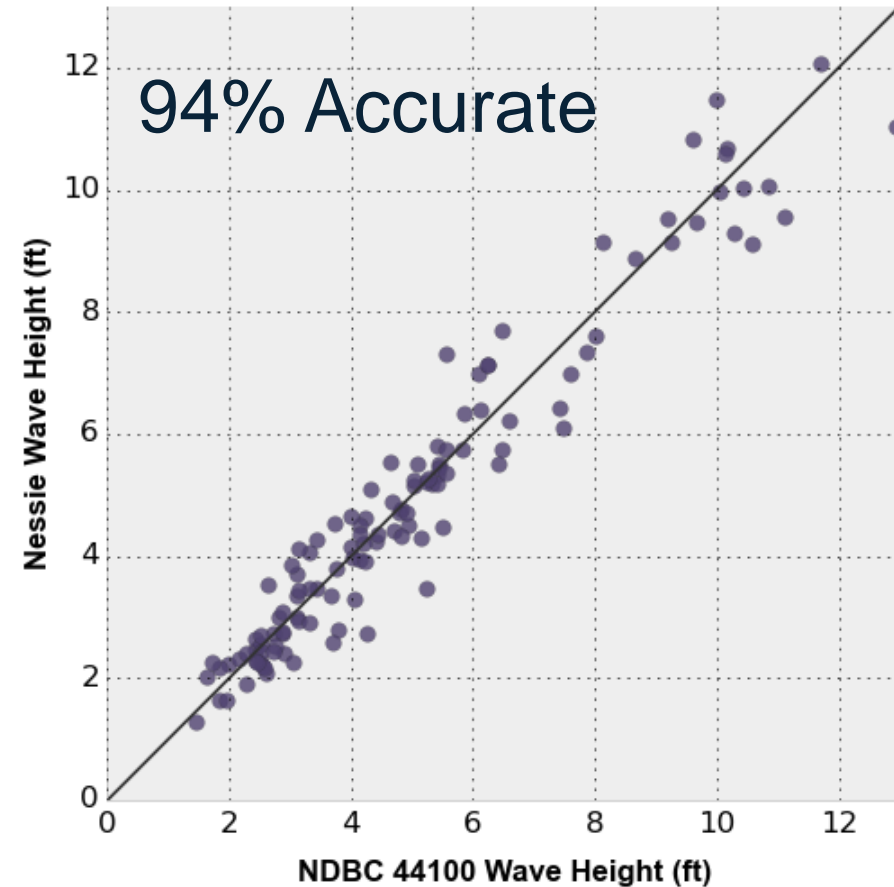
# 12-H FORECAST VALIDATION

## NOAA WAVEWATCH III



Accuracy (%)	86
RMS	0.99
Bias (ft)	-0.54
R2	0.94

## ASSIMILATED

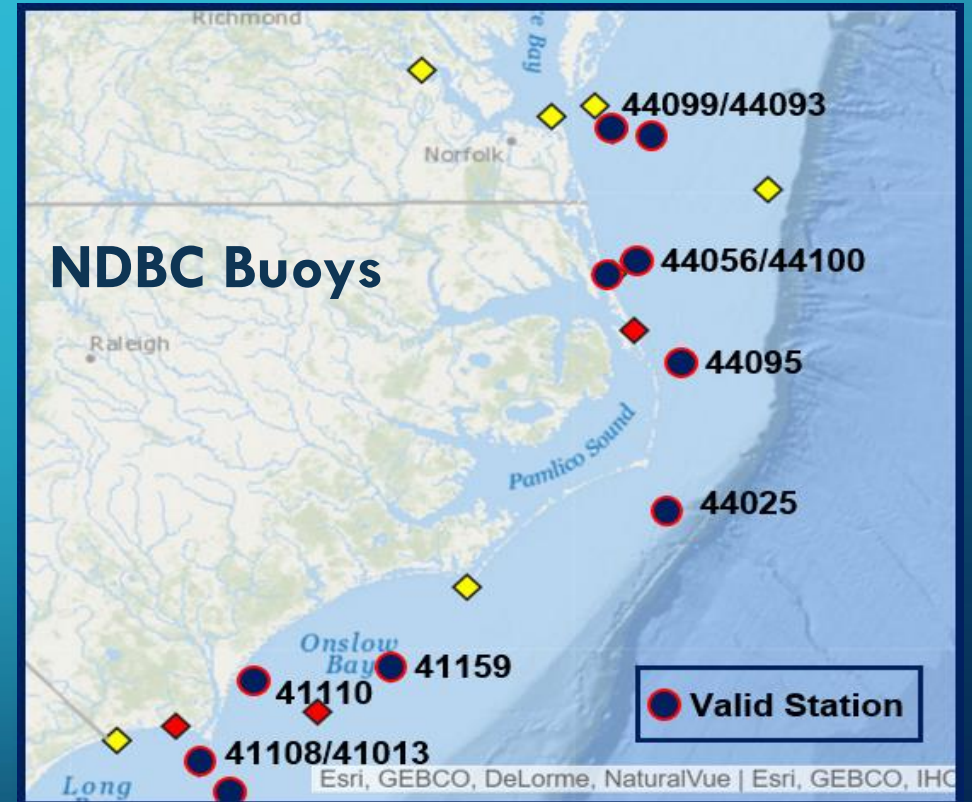
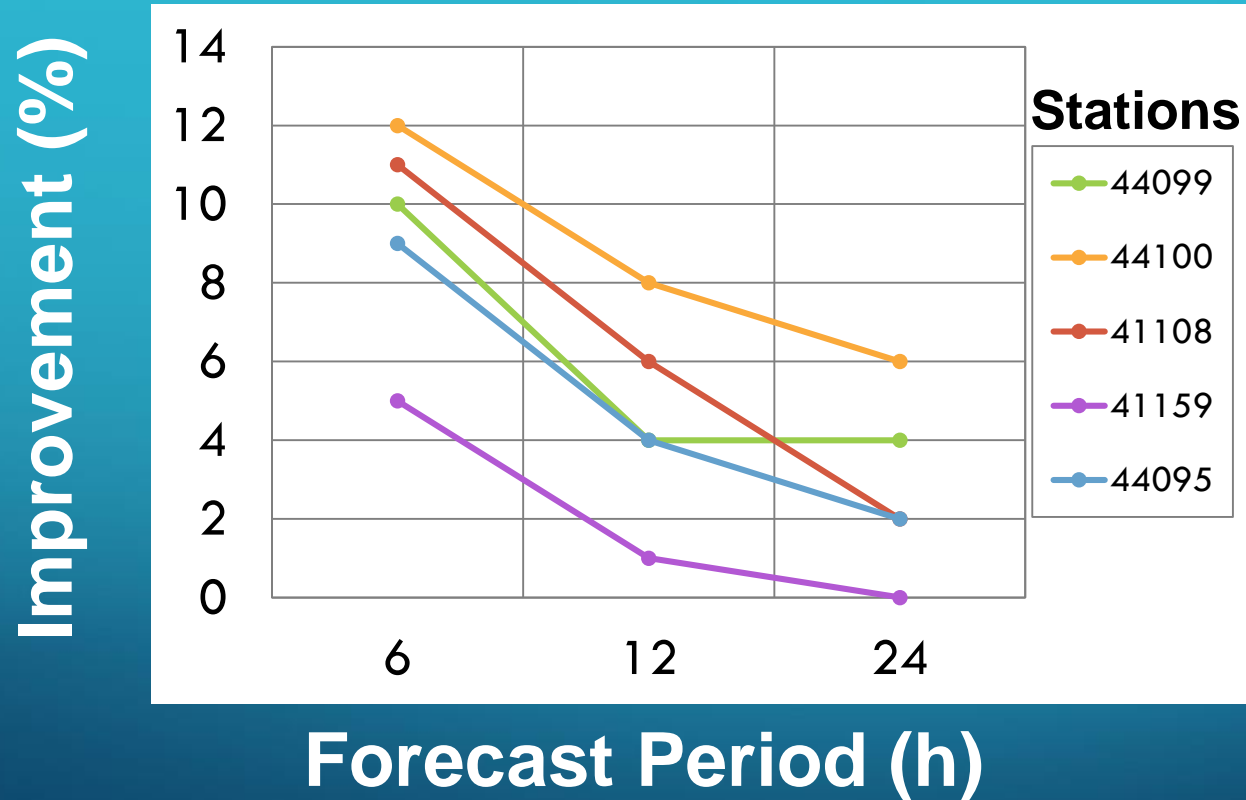


Accuracy (%)	94
RMS	0.65
Bias (ft)	-0.06
R2	0.94



# BULK ASSIMILATOR (v.1)

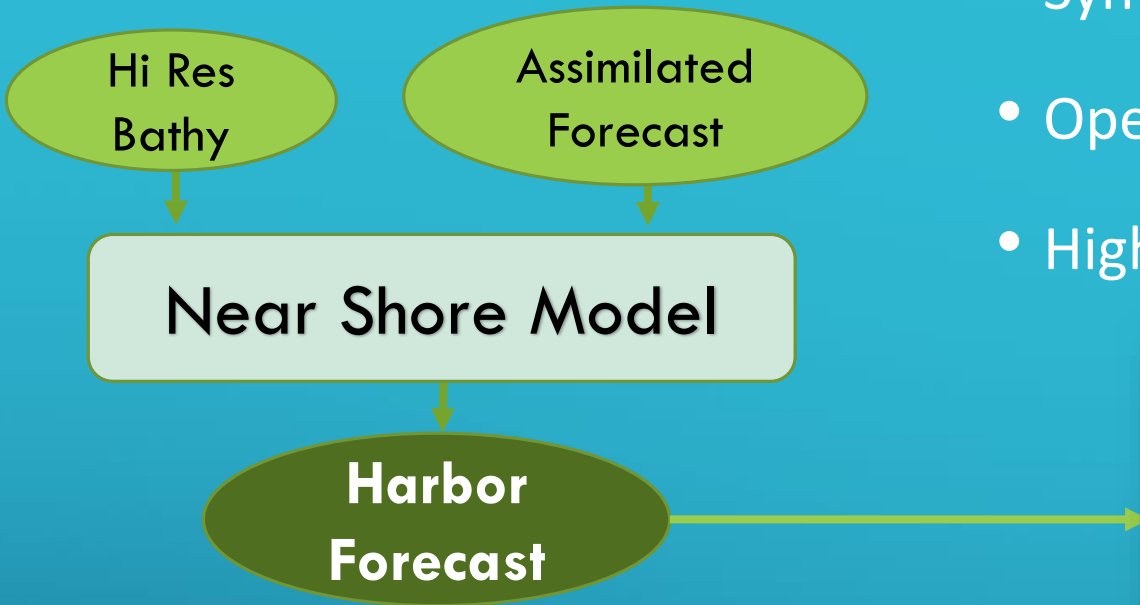
## H<sub>s</sub> FORECAST IMPROVEMENT



**Wave System Assimilator (v. 2) Coming Online**

# NEARSHORE MODEL

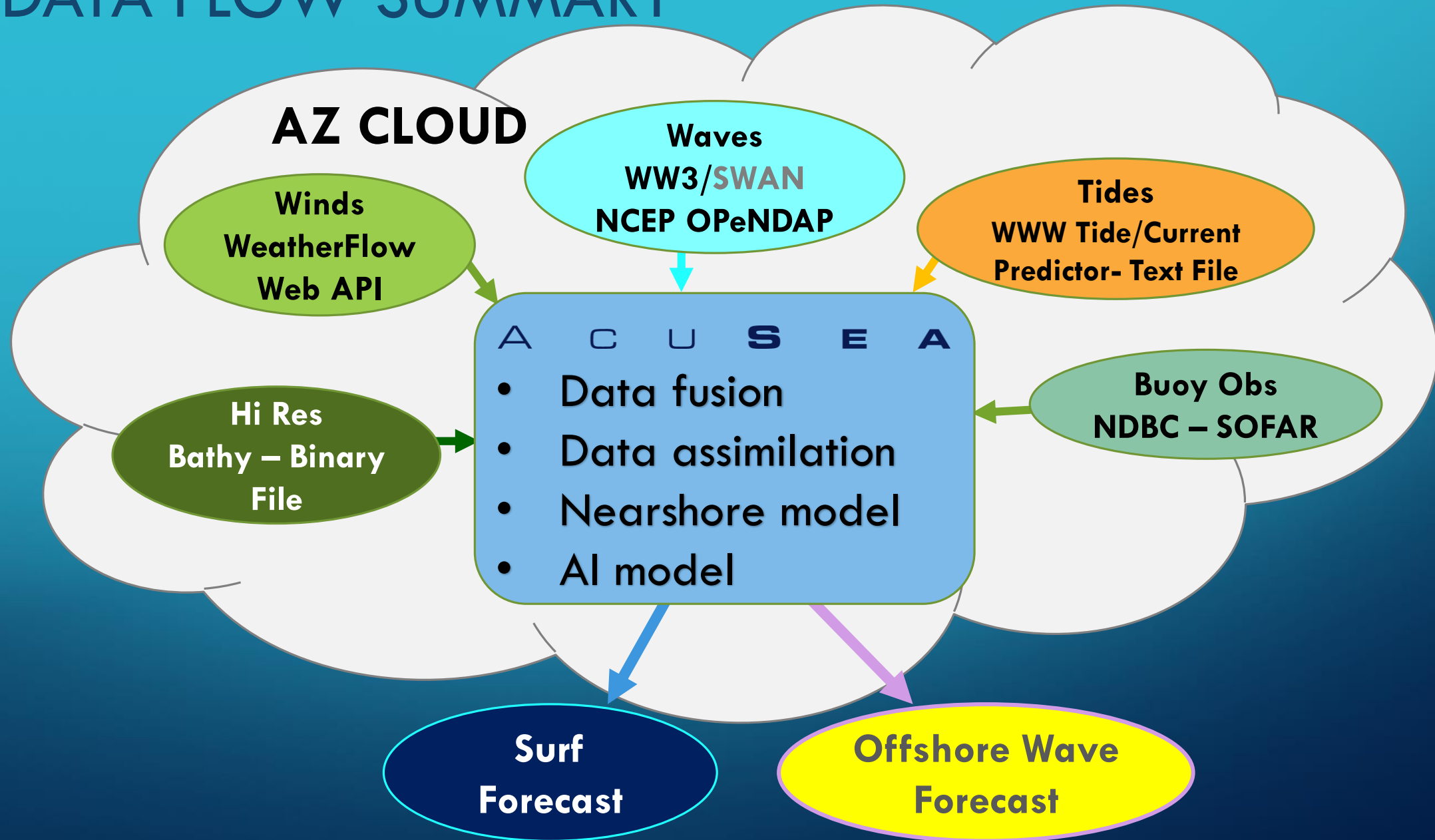
- Synthesizes 35 years of wave research
- Operates on assimilated wave systems (Hs/Tp/Dm)
- High computational efficiency



Used to explain extreme wave events at a commercially important UK LNG terminal



# DATA FLOW SUMMARY





# NESSIE SURF FORECAST

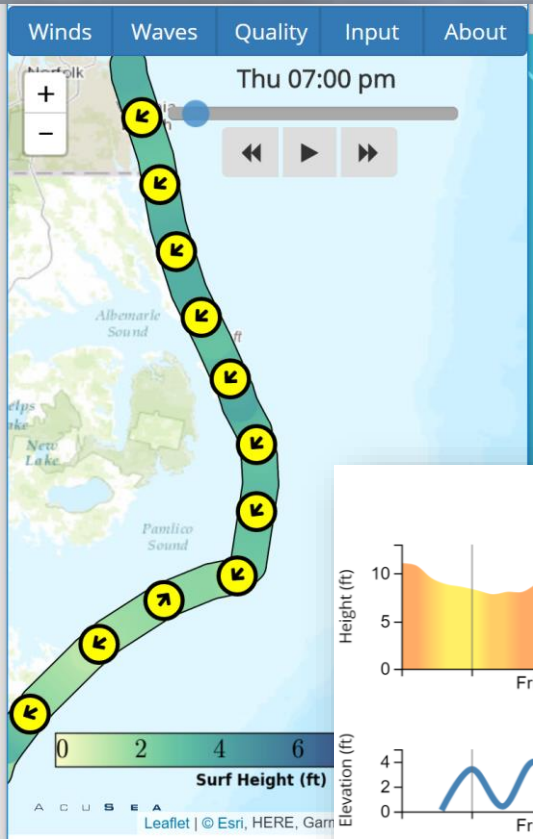
Mobile-friendly online site

## Operational Domains

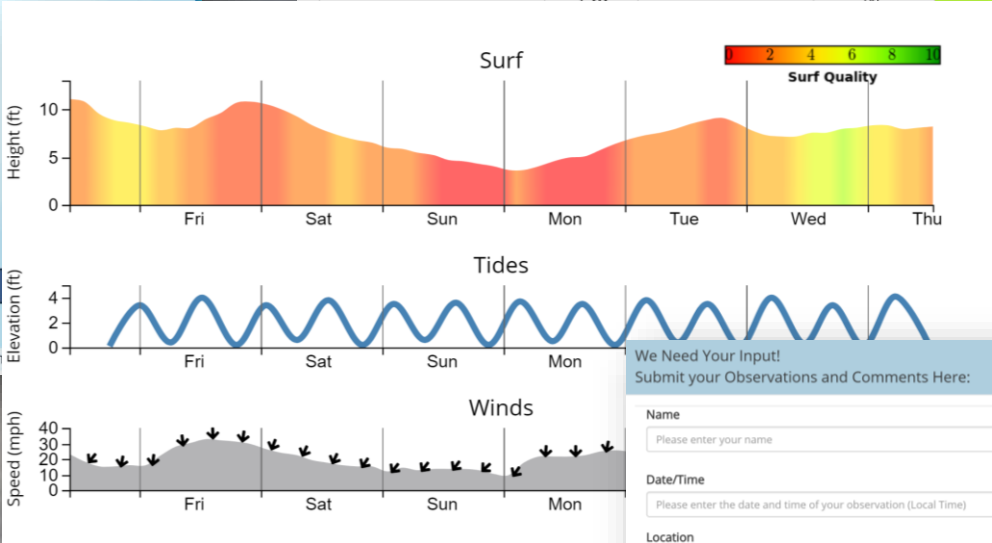
- Virginia
- North Carolina
- New Jersey
- Florida
- Hawaii

## Validation

The Surf Community helped us build an Outstanding Product...



Day	Winds	Tide	Waves	Quality
Thu 06/08 08:00 pm	23 mph N ☼	High (7:48 pm)	6-9 ft, 7 s NE	1-2
Thu 06/08 11:00 pm	17 mph N ☼	Falling ↓	6-9 ft, 7 s NE	2-4
Fri 06/09 02:00 am	15 mph NW ☼	Low (2:23 am)	5-7 ft, 7 s NE	3-5
Fri 06/09 05:00 am	15 mph NW ☼	Rising ↑	5-8 ft, 9 s E	4-6
Fri 06/09 08:00 am	14 mph W ☼	High (8:09 am)	5-7 ft, 8 s NE	4-6
Fri 06/09 11:00 am	11 mph W ☼	Falling ↓	5-7 ft, 8 s NE	5-7
Fri 06/09 02:00 pm	8 mph SW ☼	Low (2:04 pm)	4-6 ft, 8 s NE	7-9
Fri 06/09 05:00 pm	15 mph S ☼	Rising ↑	4-6 ft, 8 s NE	6-8



We Need Your Input!  
Submit your Observations and Comments Here:

Name

Date/Time

Location

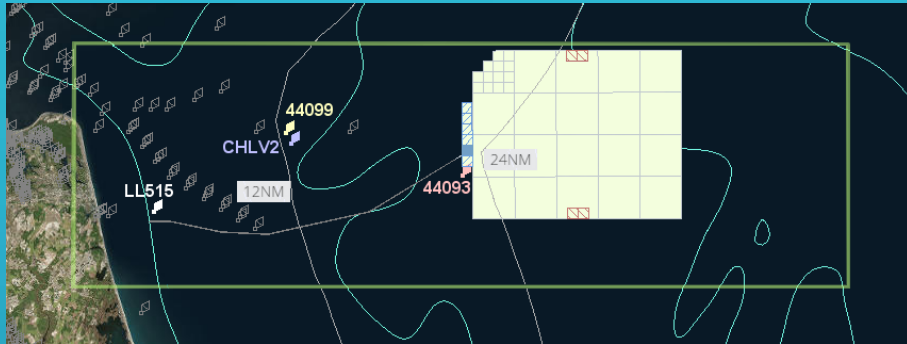
Surf Height (ft)

Quality (1-10) ☼

Comments



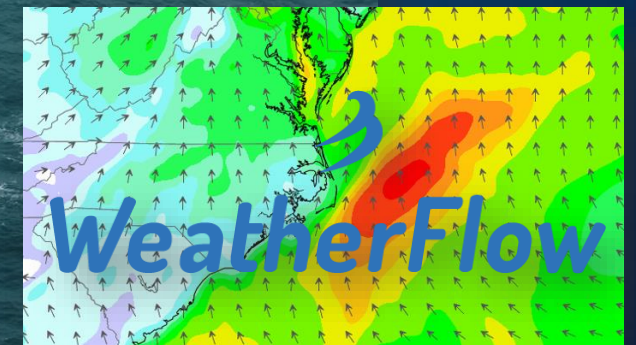
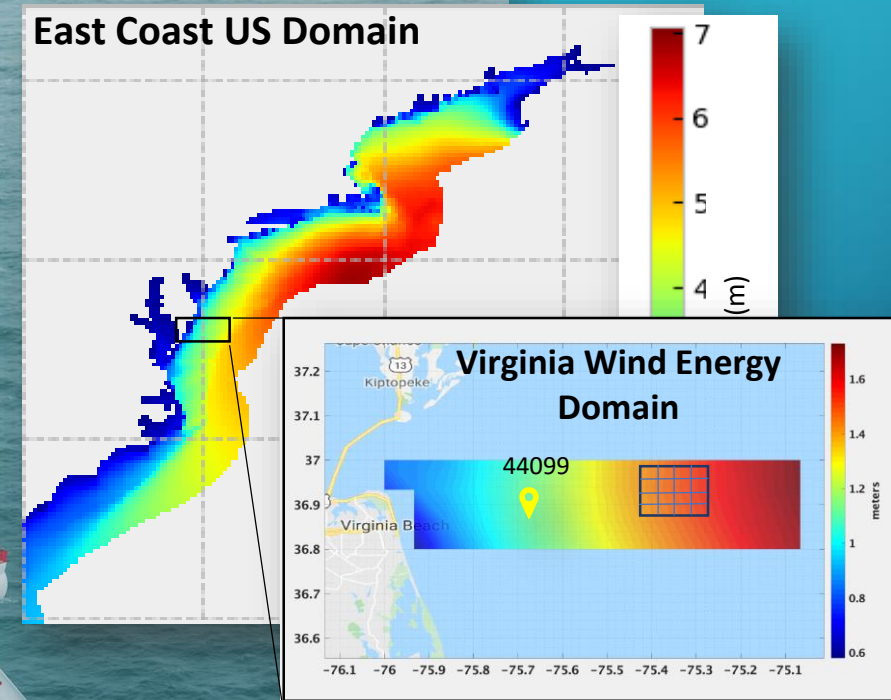
# OFFSHORE VIRGINIA WIND ENERGY AREA FORECAST



In partnership with...

- VA Dept Mines, Minerals and Energy
- Old Dominion University
- SOFAR Ocean Technologies
- WeatherFlow

A Portable Forecast  
Technology using Low-Cost  
Drop-in Buoy Observations





# WHAT'S NEXT?

- Wave system assimilator v.2



# WHAT'S NEXT?

- Wave system assimilator v.2
- Machine learning advancements

# WHAT'S NEXT?

- Wave system assimilator v.2
- Machine learning advancements
- Multiply portable forecast domains!



QUESTIONS...

