A Rapid Forecasting and Mapping System (RFMS) for storm surge and coastal flooding

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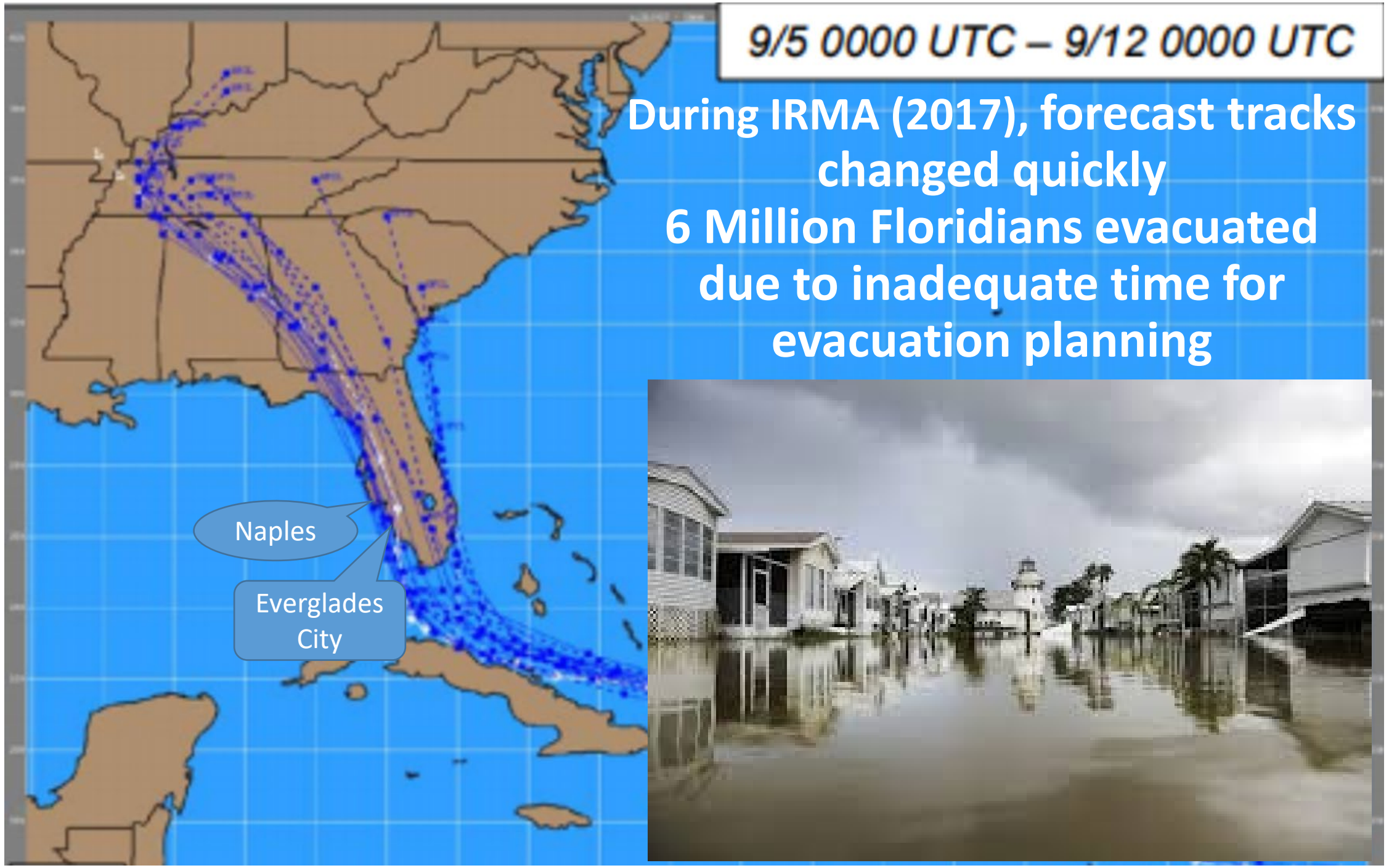
July 21, 2022

Unifying Innovations in Forecasting Capabilities Workshop (UIFCW)

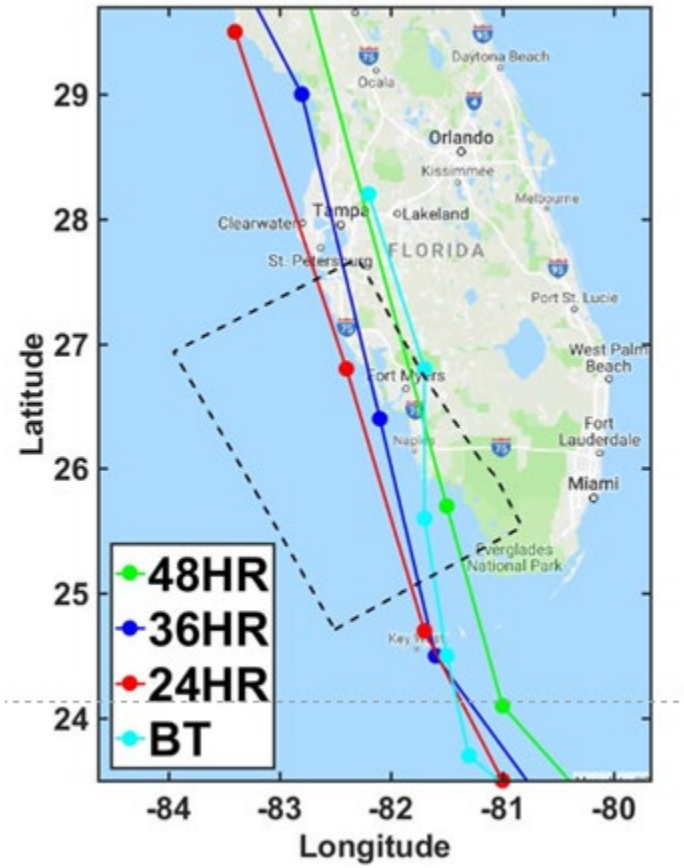
SECOORA Sea Grant Florida UF UNIVERSITY of FLORIDA NOAA NCCOS Collier County


9/5 0000 UTC – 9/12 0000 UTC
During IRMA (2017), forecast tracks changed quickly
6 Million Floridians evacuated due to inadequate time for evacuation planning
Naples
Everglades City

Why is a RFMS needed?

- Hurricanes can change quickly before landfall (e.g., Irma 2017)
- High-fidelity real-time forecasting system is slow
- Surge atlas (MOMs) are static and non-probabilistic
- Some flood maps are outdated

- RFMS can enhance:
- Real-time evacuation planning
- Pre-season planning for many “what-if” storm scenarios
- Quick and frequent update of flood maps

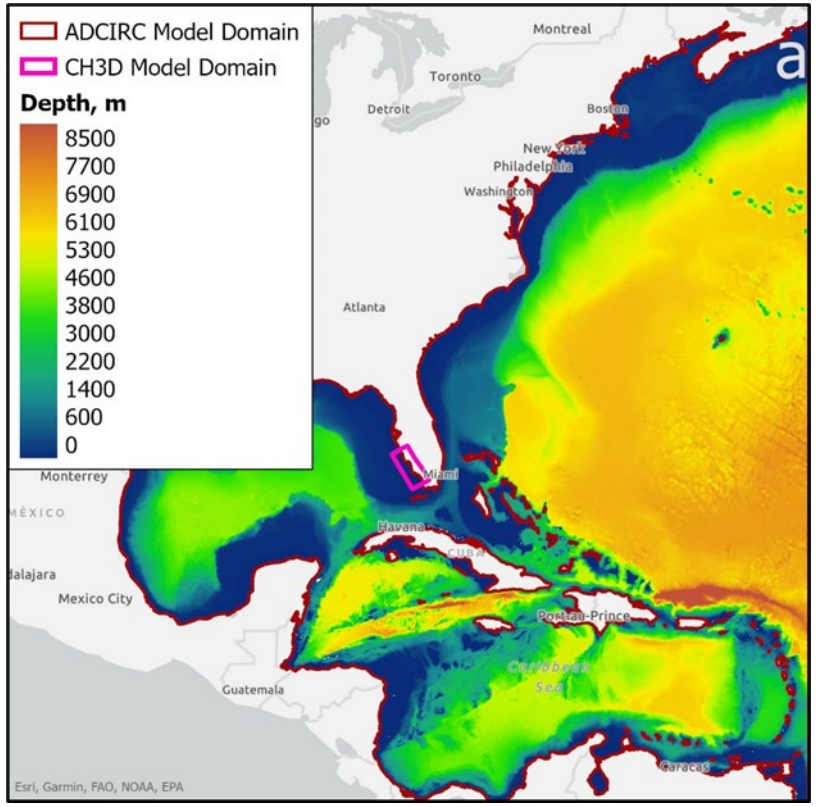


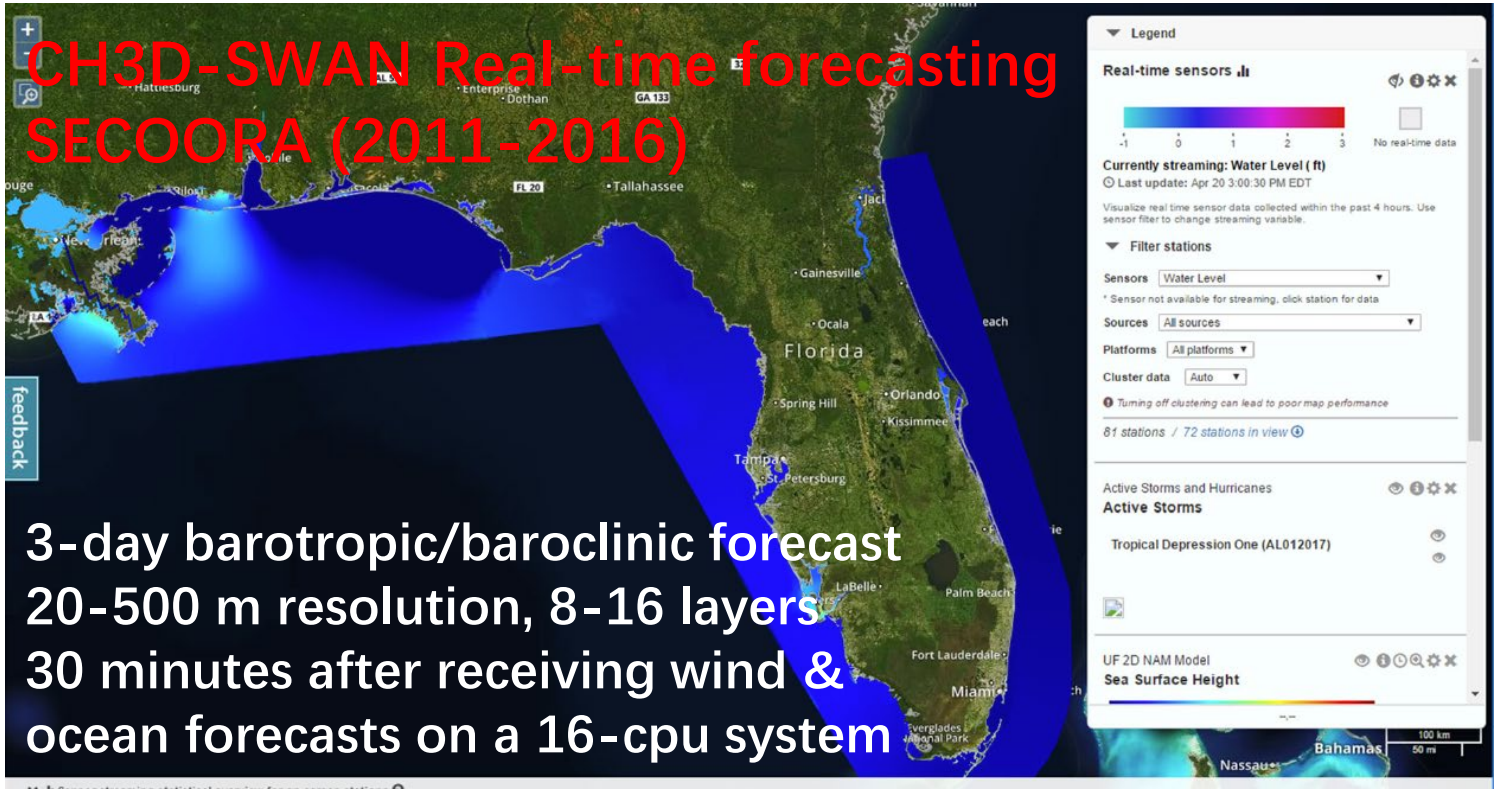
Most destroyed houses in Mexico Beach during Michael 2019 are outside FEMA Flood Zones

FEMA maps were based on limited storm data

Need to revise FLOOD MAPS quickly after a hurricane season

CH3D-SWAN Vegetation-Resolving Coastal Modeling System

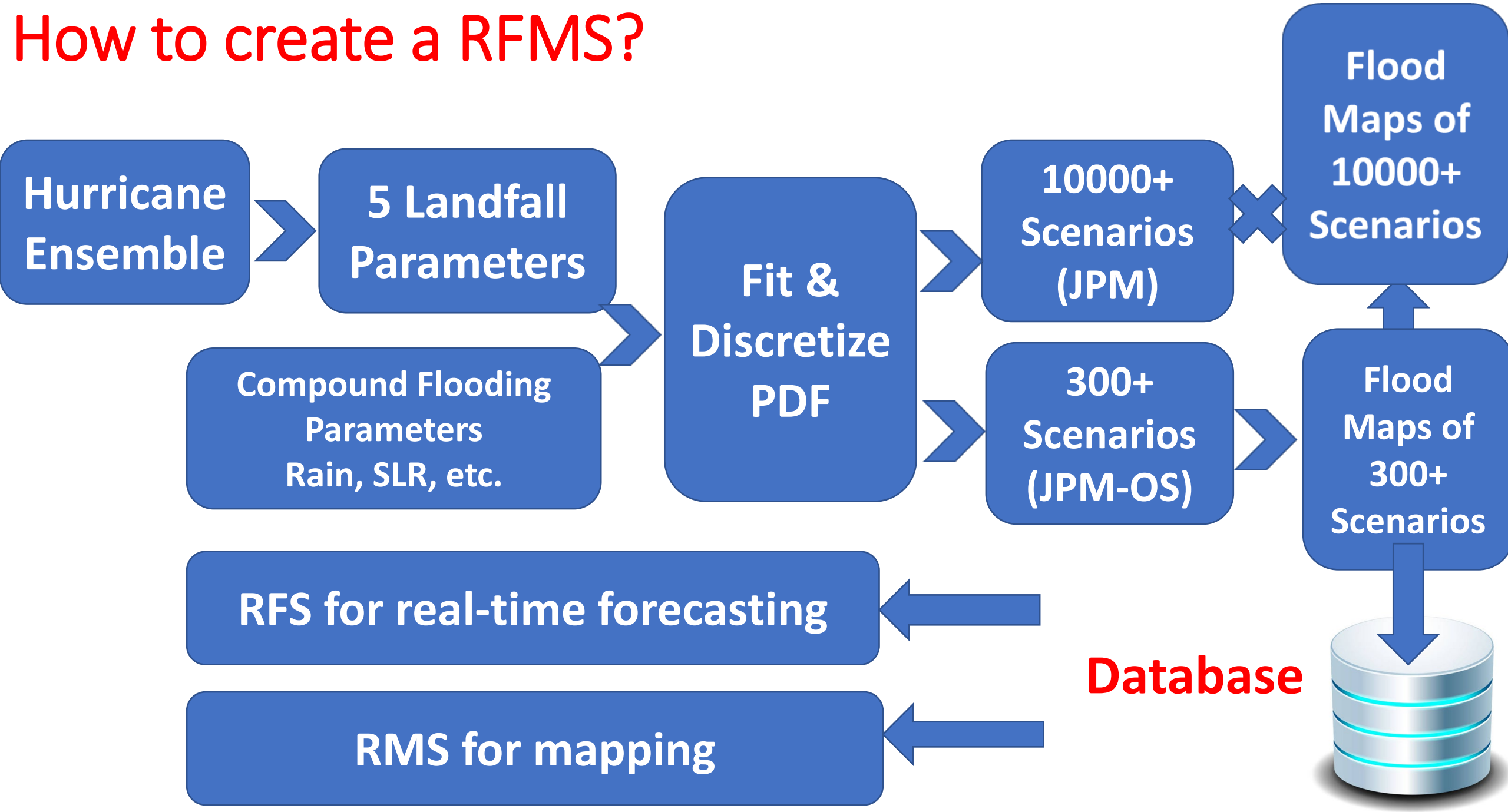




High-Resolution CH3D-SWAN can produce:

1. Realtime forecast of coastal inundation during a single storm
2. Maximum coastal inundation maps for 300-500 optimal storms

How to create a RFMS?



A Rapid Forecast and Mapping System (RFMS), Yang, Paramygin, Sheng, *Weather and Forecasting* (2020)

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Hurricane Irma Discussion Number  42
NWS National Hurricane Center Miami FL       AL112017
1100 AM EDT Sat Sep 09 2017

FORECAST POSITIONS AND MAX WINDS

INIT  09/1500Z 22.8N  79.8W  110 KT 125 MPH
 12H  10/0000Z 23.4N  80.7W  115 KT 130 MPH
 24H  10/1200Z 24.5N  81.6W  120 KT 140 MPH
 36H  11/0000Z 26.4N  82.1W  120 KT 140 MPH
 48H  11/1200Z 29.0N  82.8W  100 KT 115 MPH
 72H  12/1200Z 34.5N  86.0W   25 KT  30 MPH...POST-TROP/INLAND
 96H  13/1200Z 36.0N  89.0W   25 KT  30 MPH...POST-TROP/INLAND
120H  14/1200Z 37.0N  88.5W   20 KT  25 MPH...POST-TROP/INLAND
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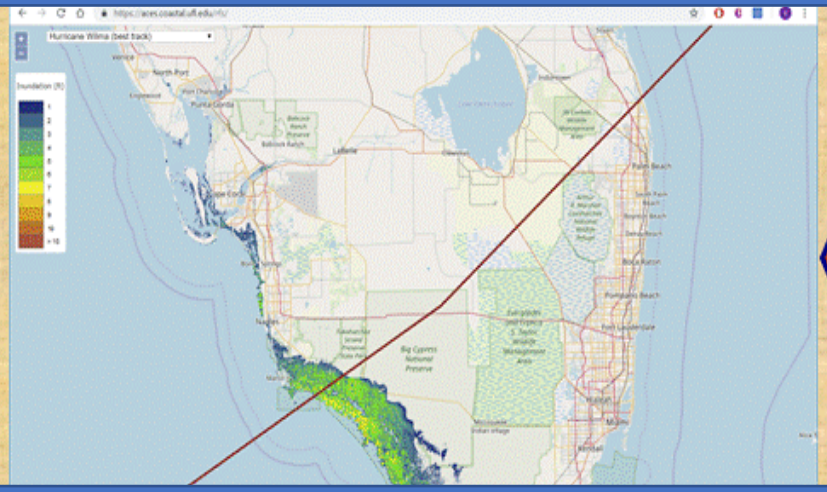
1.Storm Advisory from NOAA/NHC

Pressure Deficit (mb)	Rmax (miles)	Forward Speed (mph)	Heading Direction	Landfall Location
89	68	11.25	0	-40

2.Determine Storm Parameters

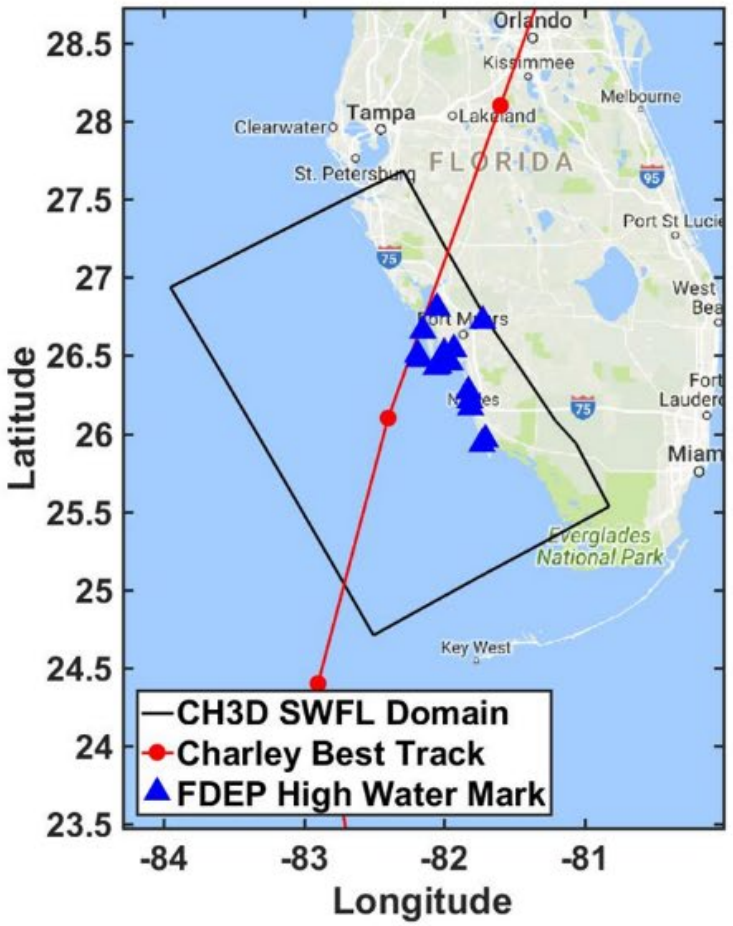


4. Flood Map on Web in one minute

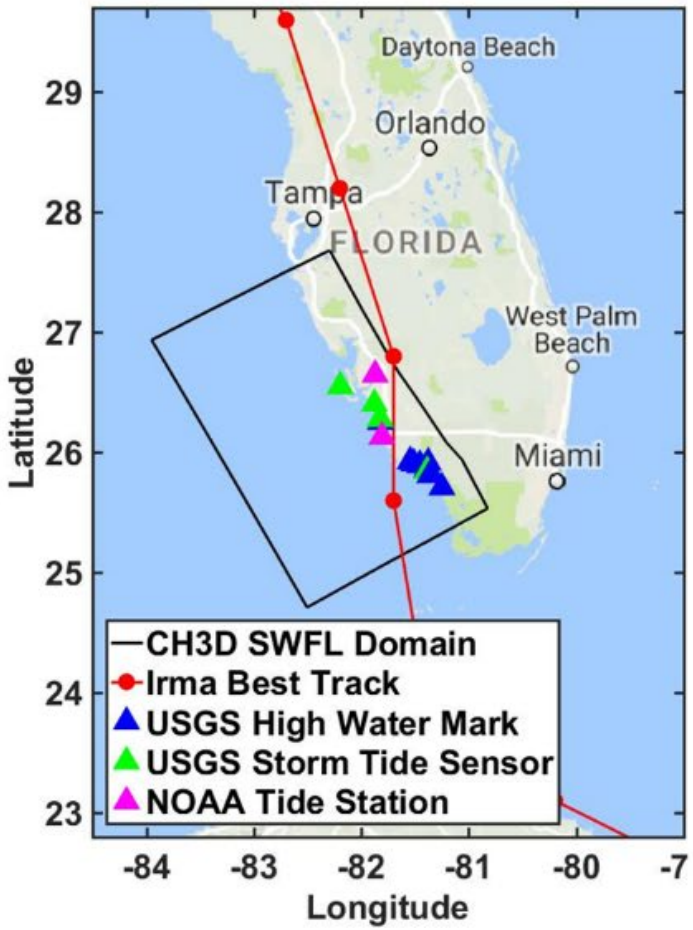
3. Interpolate Flood Height from Database

Application of RFMS

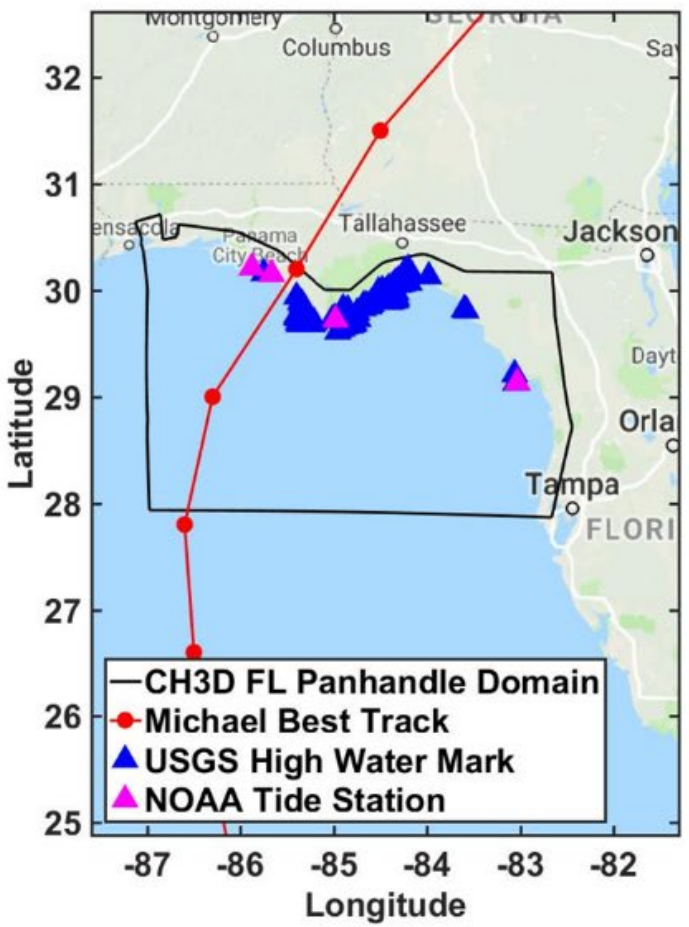
https://link.springer.com/article/10.1007/s11069-019-03807-w



Charley (2004)



Irma (2017)



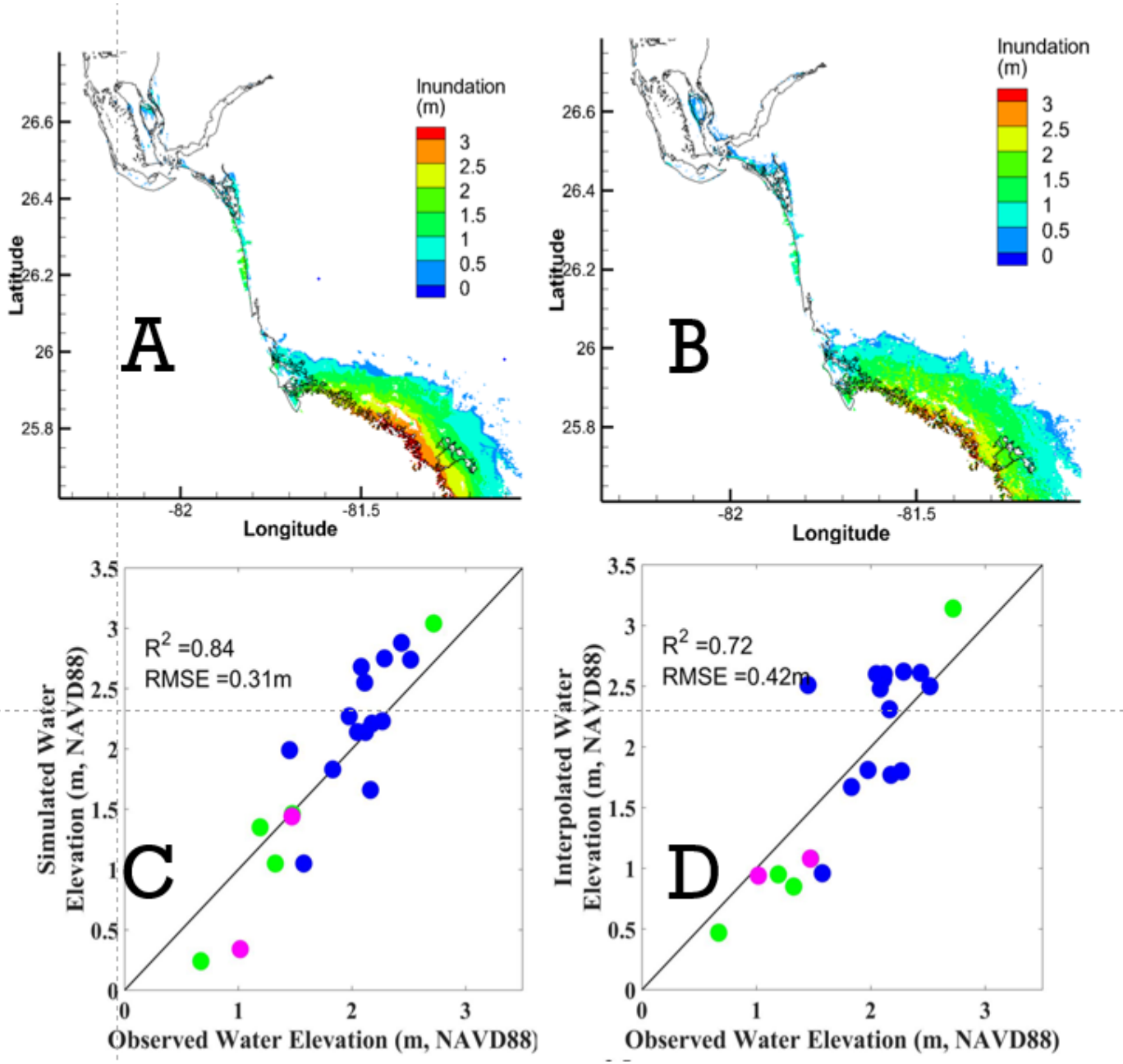
Michael (2018)

Hurricane Irma (2017)

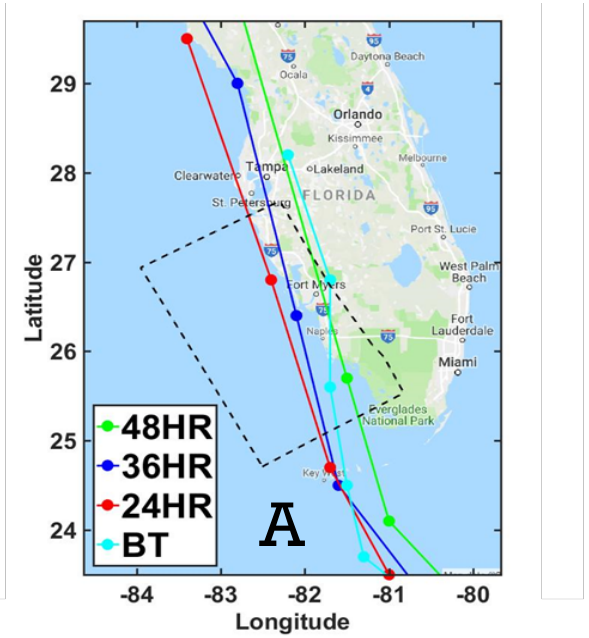
Direct simulation (Left) and RFMS (Right) compare well with data

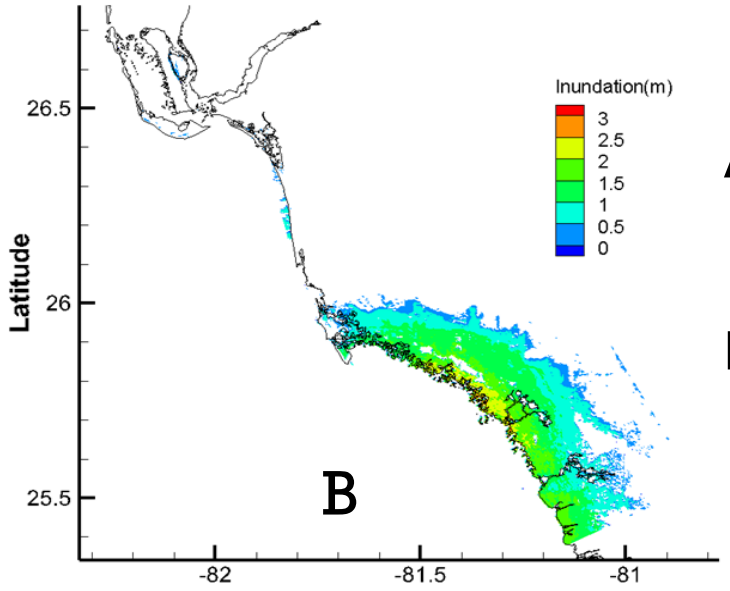
RMSE reduced when more accurate wind field is used

High Water Marks are of mixed quality



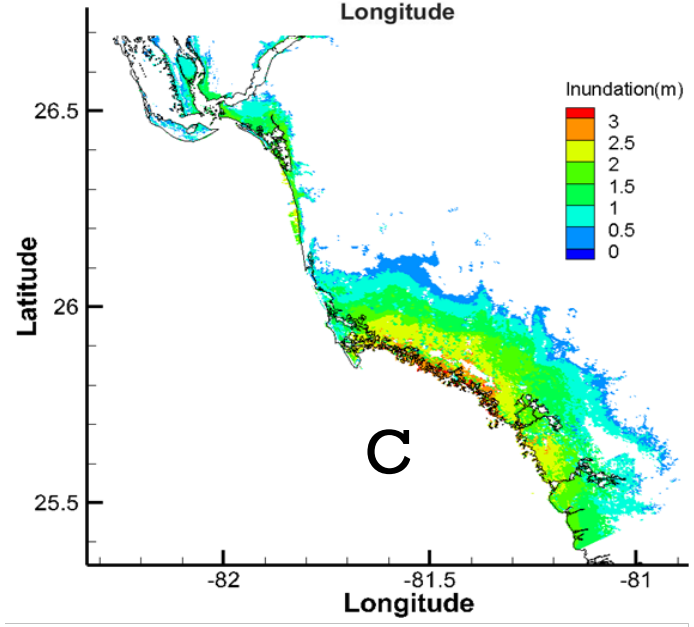
Sudden Change in Forecast Advisory can lead to 100% change in total inundation in 24 hours!

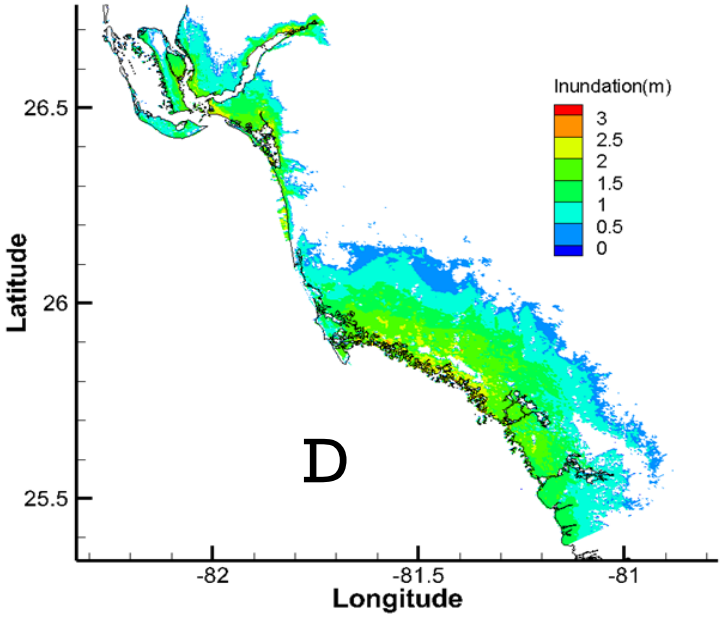




A: IRMA forecast tracks moved westward

B: 48-HR advisory

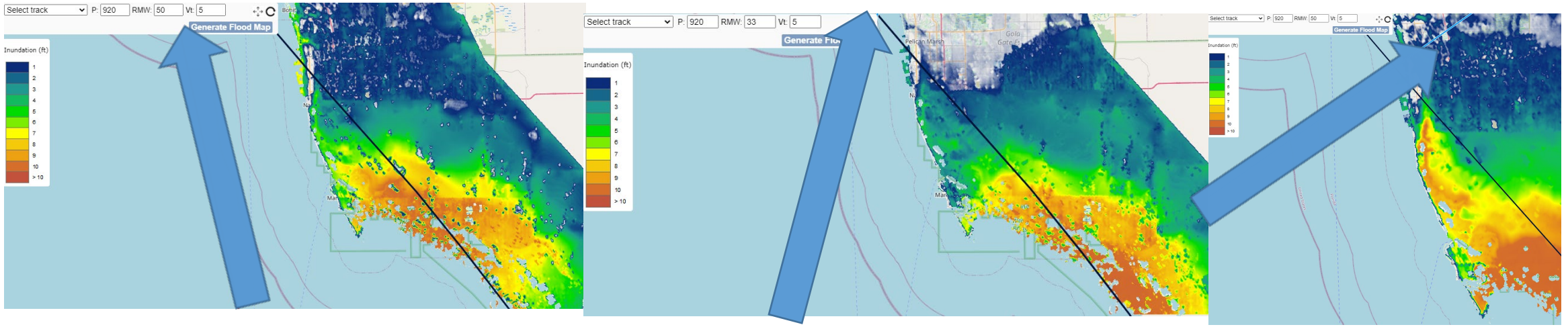




C: 36-HR advisory

D: 24-HR advisory

RFMS Application – What-if Scenarios for Planning



Given a track, RFMS generates a maximum flood map in 3 sec on a PC (57 sec for graphics)

Aided Collier County evacuation and planning

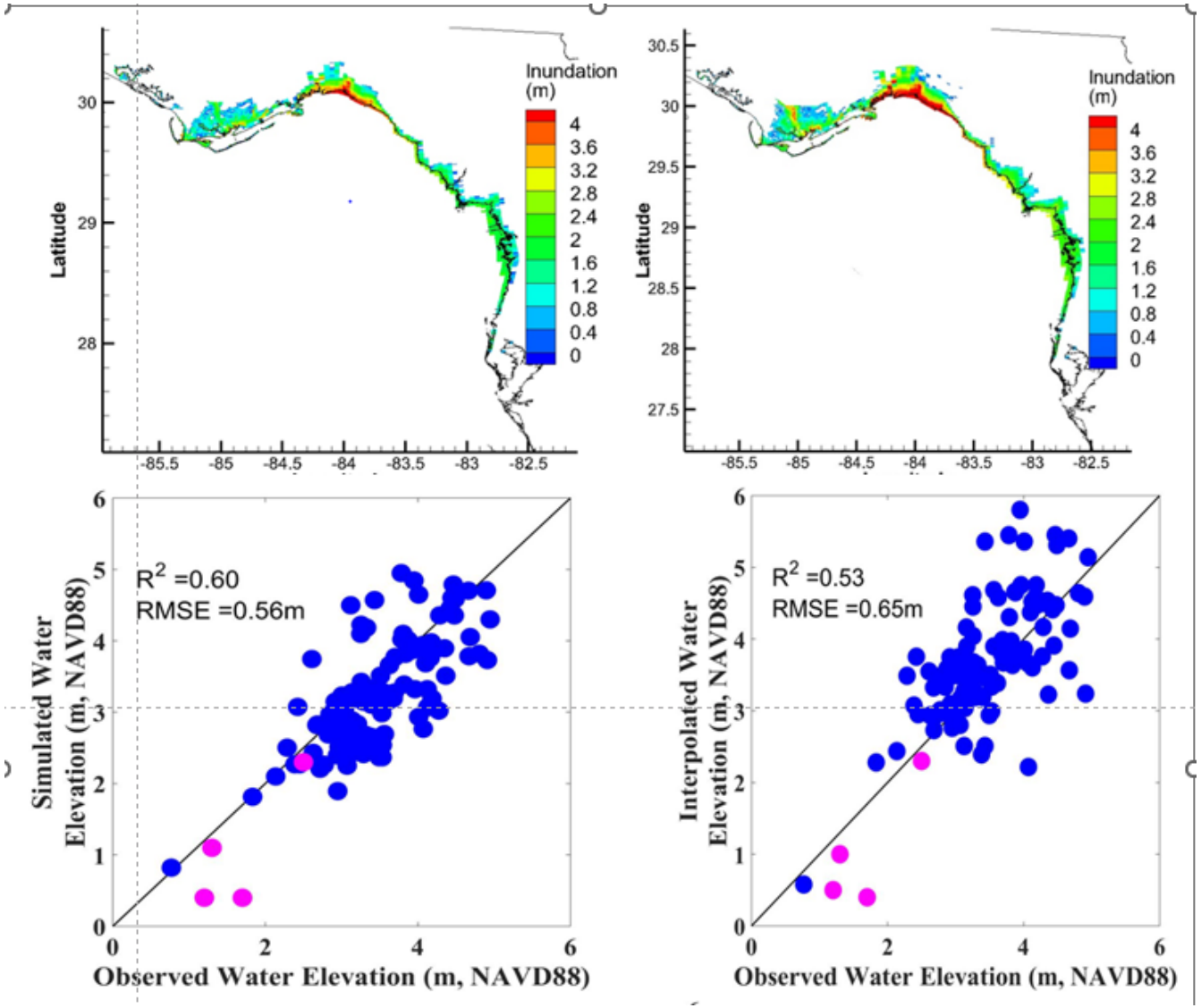
Hurricane Michael (2018) With Rapid Intensification

Direct simulation (Left) and RFMS (Right) gave similar results which compare well with data

Finer grid size reduces the RMSE

High Water Marks of poor quality

1% flood elevation in Mexico is increased by 1 ft if Michael is included in the hurricane ensemble



Summary

- **RFMS, based on high-fidelity coastal surge-wave model predictions for 300+ optimal storms in a coastal region, can be used to produce:**
- **Real-time forecast of maximum coastal inundation -> aid evacuation planning**
- **Design flooding scenarios -> aid pre-season evacuation and resilience planning**
- **1% flood map -> quick and frequent update of flood maps**

https://link.springer.com/article/10.1007/s11069-019-03807-w

- **Estimate flooding during design storms, e.g., 1% storm, 10% storm vs. 1% flood**
- **RFMS can be produced for the entire Atlantic and Gulf coasts**
- **High quality high frequency inundation data needed to verify model flood**