NOAA Hurricane Research

Frank Marks

NOAA HFIP Research Lead

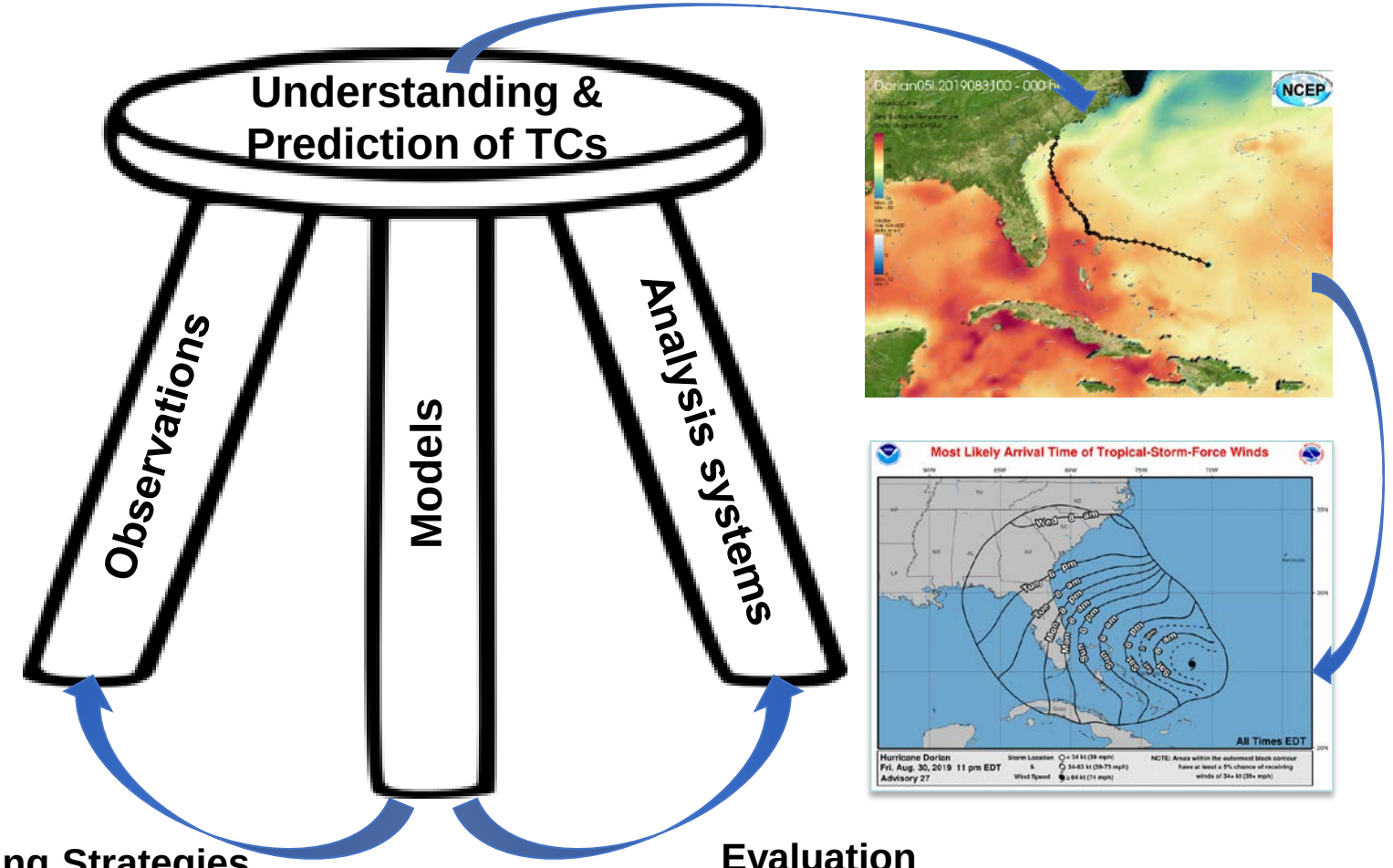
NOAA/AOML Hurricane Research Division

Vision

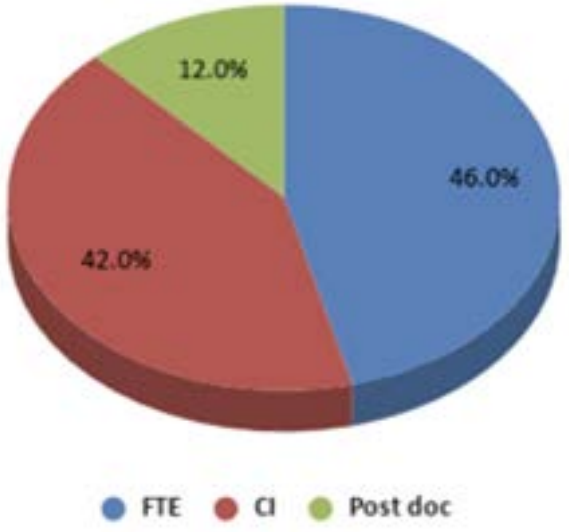
Advance understanding and prediction of tropical cyclone (TC) track, intensity, and structure change and their impacts utilizing observations, numerical models, and theory

NOAA's hurricane research focus for >60 years

Mission


Understanding & Prediction of TCs
Observations
Models
Analysis systems
FACETs
Observing Strategies
Evaluation
NCEP
Most Likely Arrival Time of Tropical-Storm-Force Winds
All Times EDT
Hurricane Dorian
Fri. Aug. 30, 2019 11 pm EDT
Advisory 27

HRD Personnel



- 48 Total Staff
- 24 Scientists
- 21 Science Support
- 3 Postdocs

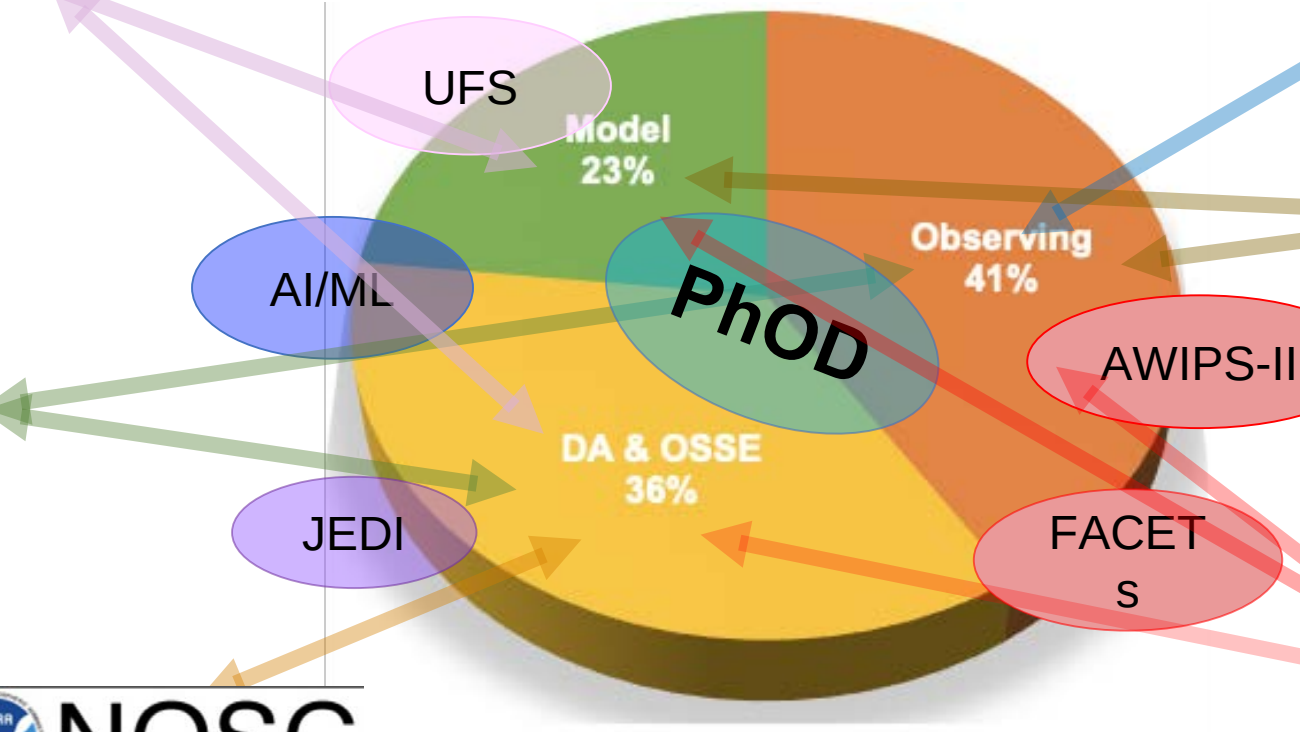
Activities & Collaborations

National Centers for Environmental Prediction
Environmental Modeling Center (EMC)

NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

NOAA HURRICANE HUNTERS

NCAR NATIONAL CENTER FOR ATMOSPHERIC RESEARCH



NOAA SATELLITES

NOSC

NATIONAL WEATHER SERVICE NHC NATIONAL HURRICANE CENTER

NOAA Intensity Forecast Experiment

- Collect observations over tropical cyclone life cycle
- Develop measurement technologies to provide improved situation awareness
- Improve understanding of processes important in intensity change

https://www.aoml.noaa.gov/our-research/hurricane-research-division/hurricane-field-program/

THE INTENSITY FORECASTING EXPERIMENT

A NOAA Multiyear Field Program for Improving Tropical Cyclone Intensity Forecasts

BY ROBERT ROGERS, SIM ABERSON, MICHAEL BLACK, PETER BLACK, JOE CIONE, PETER DODGE, JASON DUNION, JOHN GAMACHE, JOHN KAPLAN, MARK POWELL, NICK SHAY, NAOMI SURGI, AND ERIC UHLHORN

In probing the whole life cycle of these storms—not just mature hurricanes—IFEX is taking a new approach to developing physical understanding and forecast abilities as well as testing and enhancing real-time observational capabilities.

MOTIVATION FOR IFEX. One of the key activities in the National Oceanic and Atmospheric Administration's (NOAA's) strategic plan is to improve the understanding and prediction of tropical cyclones (TCs). The NOAA National Hurricane Center (NHC), a part of the National Centers for Environmental Prediction (NCEP), is responsible for forecasting TCs in the Atlantic and east Pacific basins, while NCEP's Environmental Modeling Center (EMC) develops the numerical model guidance for the forecasters. With support from NOAA's Hurricane Research Division (HRD) and others in the research community, continual progress has been made in improving forecasts of the TC track over the past 30 years (Franklin et al. 2003a; Aberson 2001). Advancements in state-of-the-art global and regional modeling systems at EMC and other operational numerical weather prediction centers have led to improvements in track skill over the past three decades, including a significant acceleration in improvements over the past decade. These advancements include improved assimilation of satellite and

AFFILIATIONS: ROGERS, ABERSON, BLACK, BLACK, CIONE, DODGE, GAMACHE, KAPLAN, AND POWELL—NOAA/AOML Hurricane Research Division, Miami, Florida; DUNION AND UHLHORN—Cooperative Institute for Marine and Atmospheric Studies, University of Miami, Miami, Florida; SHAY—Rosenstiel School for Marine and Atmospheric Science, University of Miami, Miami, Florida; and SURGI—NOAA/NWS/NCEP/Environmental Modeling Center, Washington, D.C.
CORRESPONDING AUTHOR: Robert Rogers, NOAA/AOML Hurricane Research Division, 4301 Rickenbacker Causeway, Miami, FL 33149
E-mail: Robert.Rogers@noaa.gov
The abstract for this article can be found in this issue, following the table of contents.
DOI:10.1175/BAMS-87-11-1523
In final form 19 June 2006

Rogers et al., BAMS, 2006

Hurricane Forecast Improvement Program (HFIP)

- Unified approach to guide & accelerate forecast improvements
  - improve prediction of rapid intensification & track
  - improve forecasts & communication of storm hazards
  - incorporate risk communication research to create more effective products

http://www.hfip.org

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
United States Department of Commerce

NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

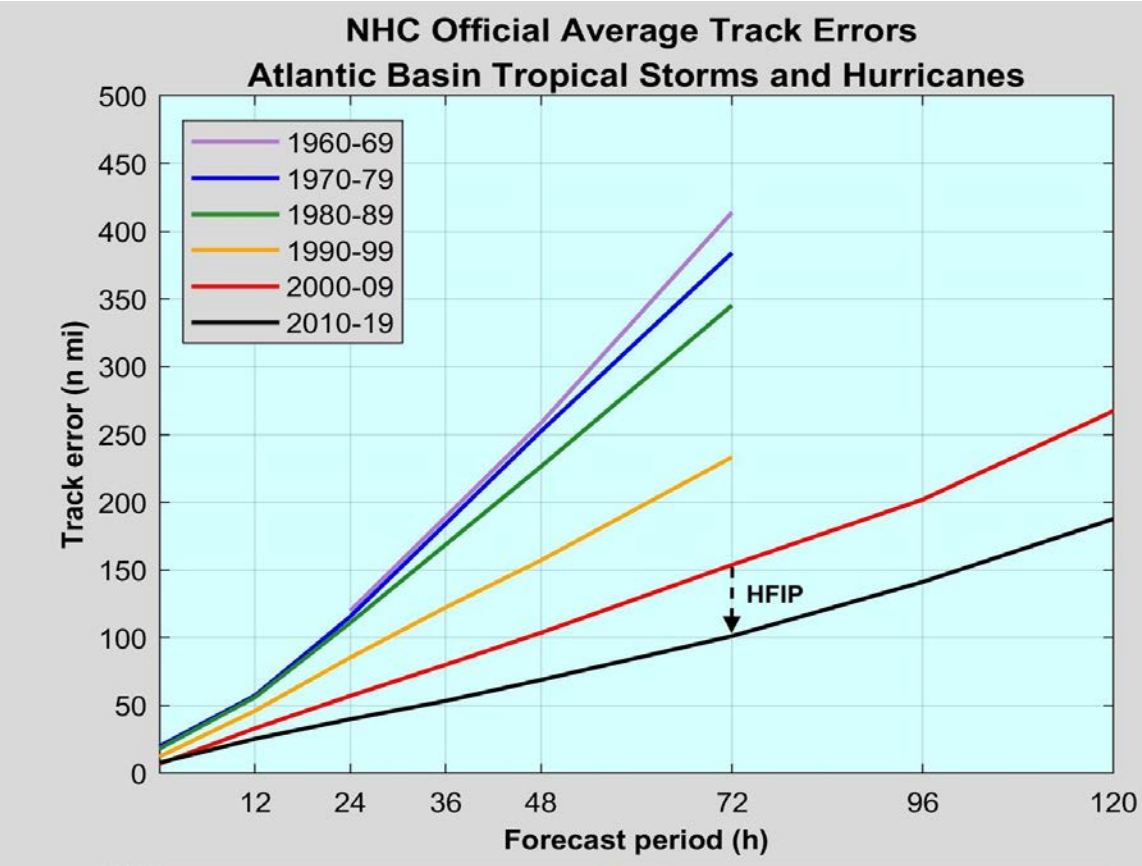
Hurricane Forecast Improvement Program
Five-Year Plan: 2019-2024

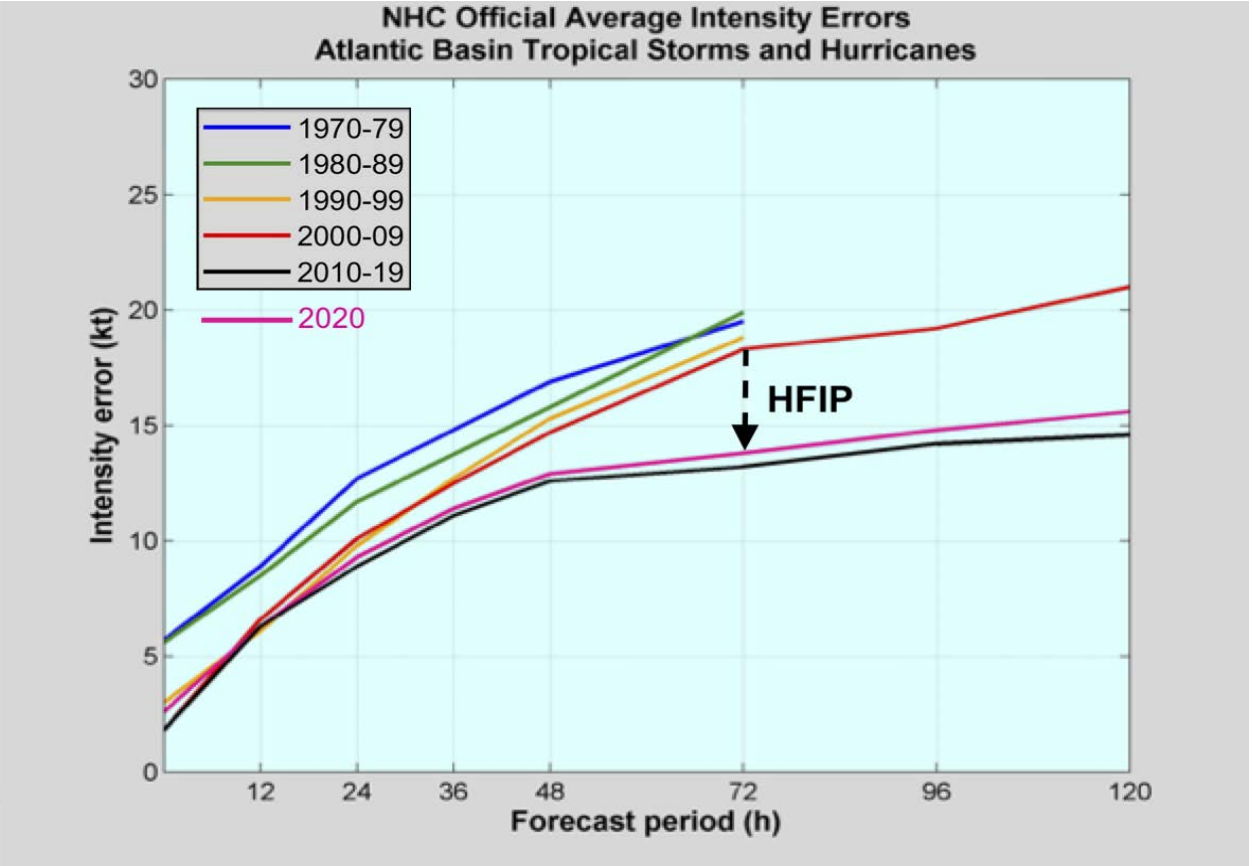
Proposed Framework for Addressing Section 104 of the Weather Research Forecasting Innovation Act of 2017

22 June 2018
Updated 25 June 2019

Gall et al., BAMS, 2013

Current State of the Art

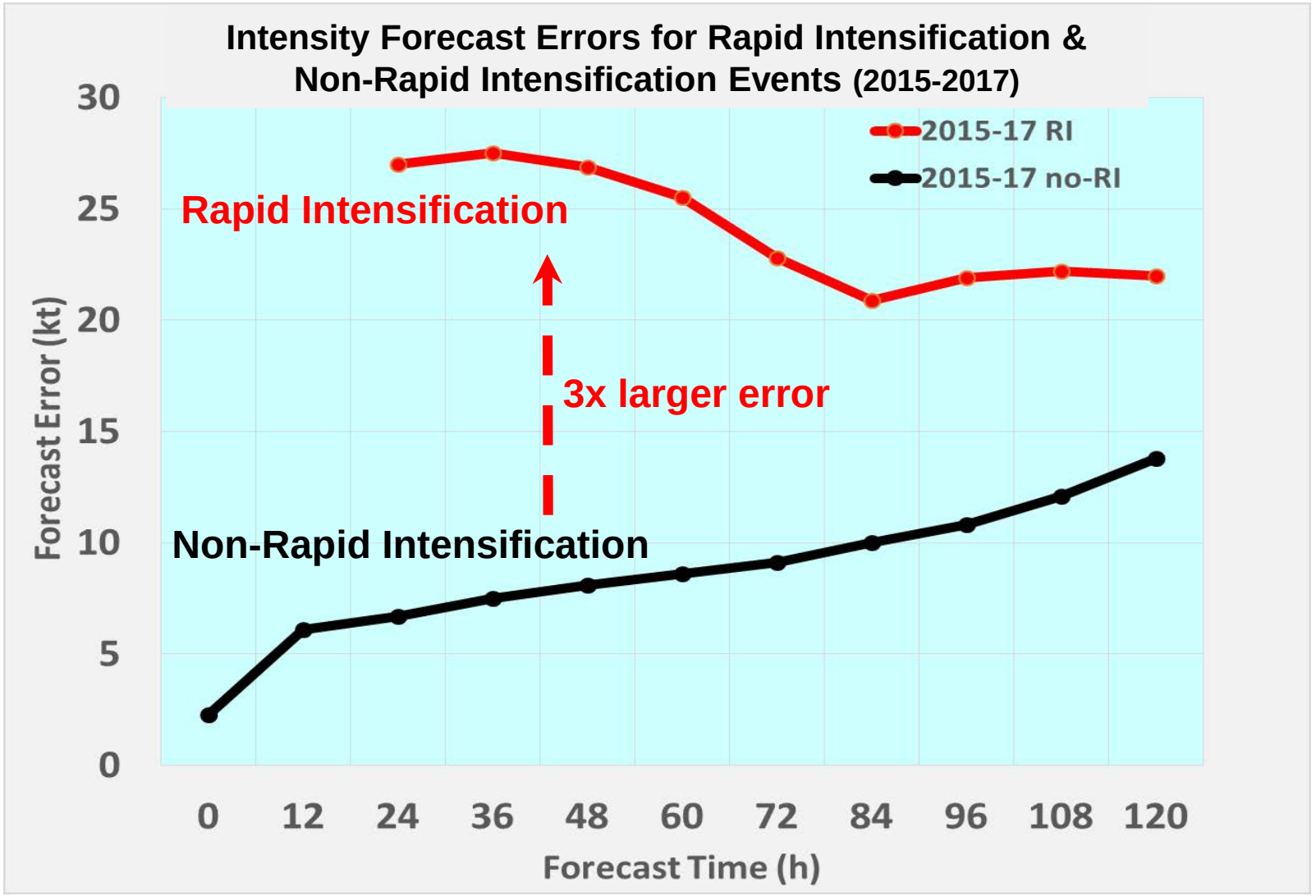




NHC Official Average Track & Intensity Errors (ATL basin)

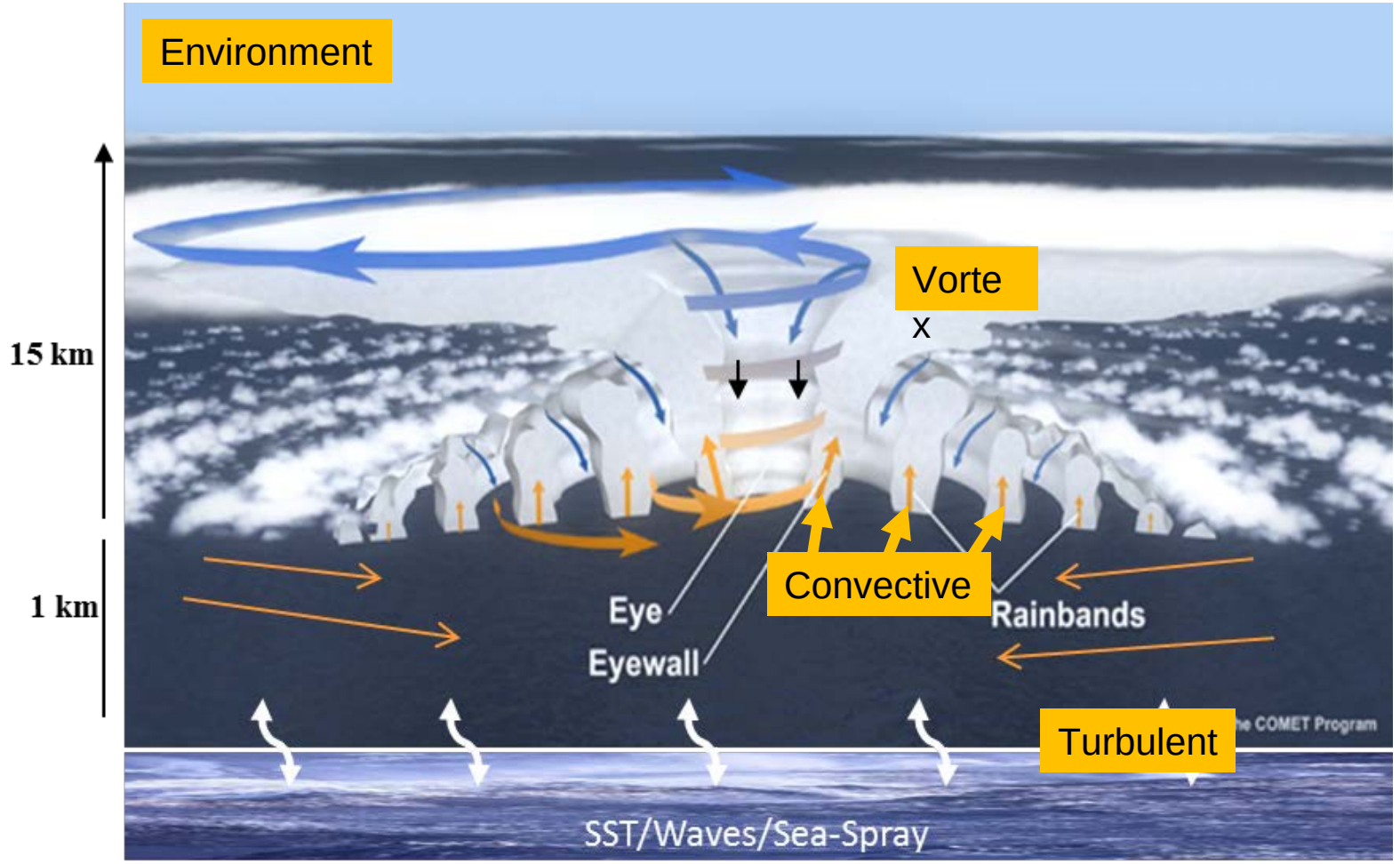
https://www.nhc.noaa.gov/verification/

Tropical Cyclone Intensity Forecasting



The Challenge: Tropical Cyclone Intensity Forecasting

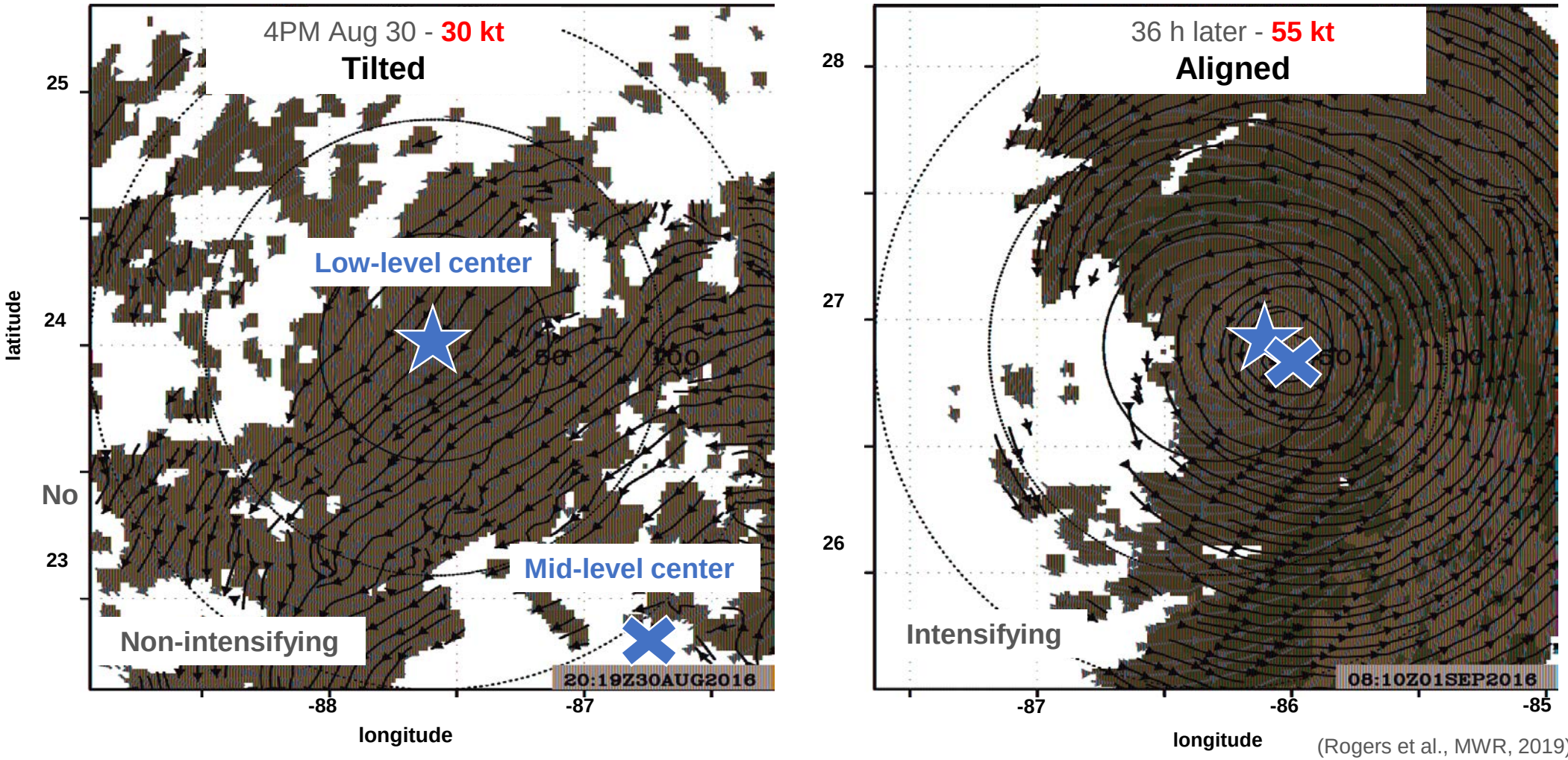
Multiscale nature of processes are major reason for this difficulty



RESEARCH RESULT

Vortex Scale

Vortex alignment in Hermine (2016)

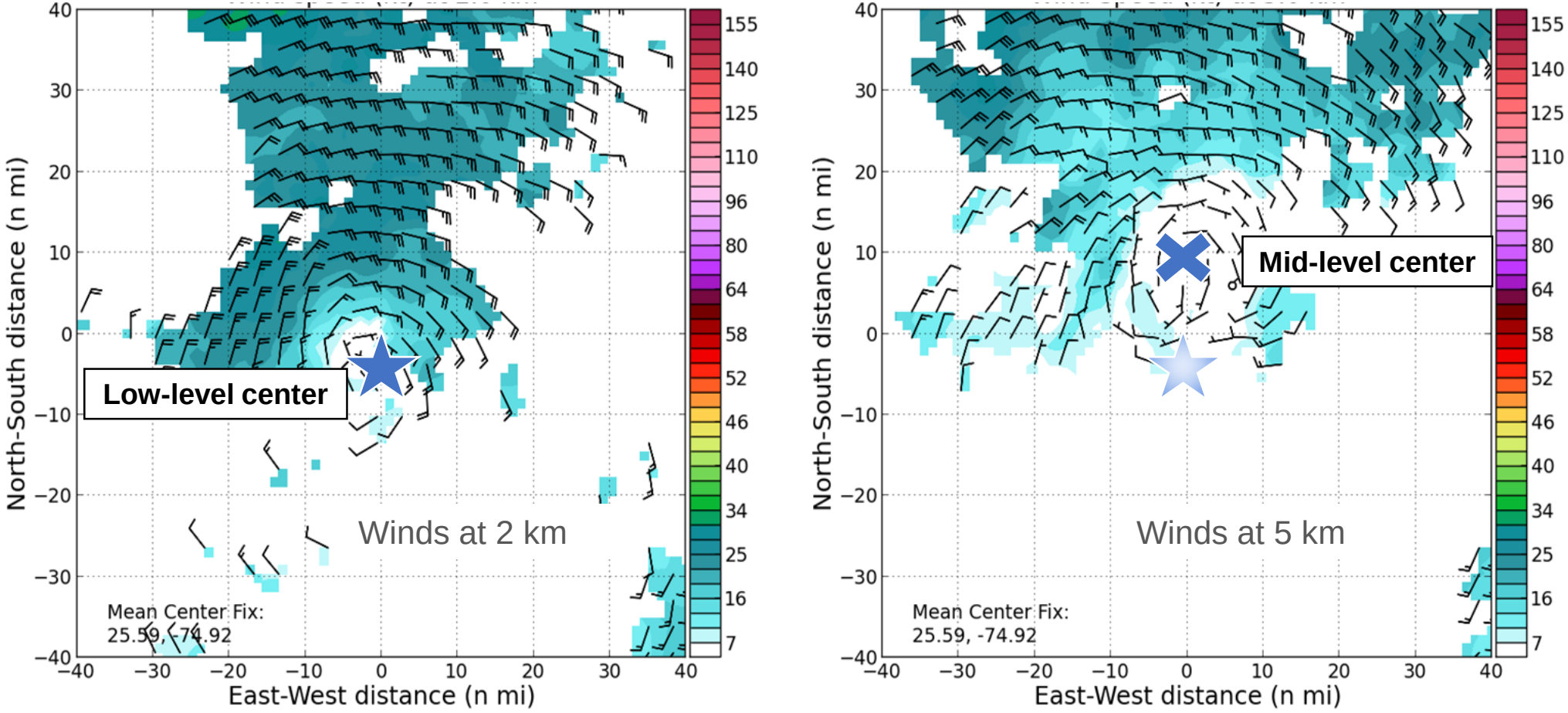


(Rogers et al., MWR, 2019)

OPERATIONAL APPLICATION

Vortex Scale

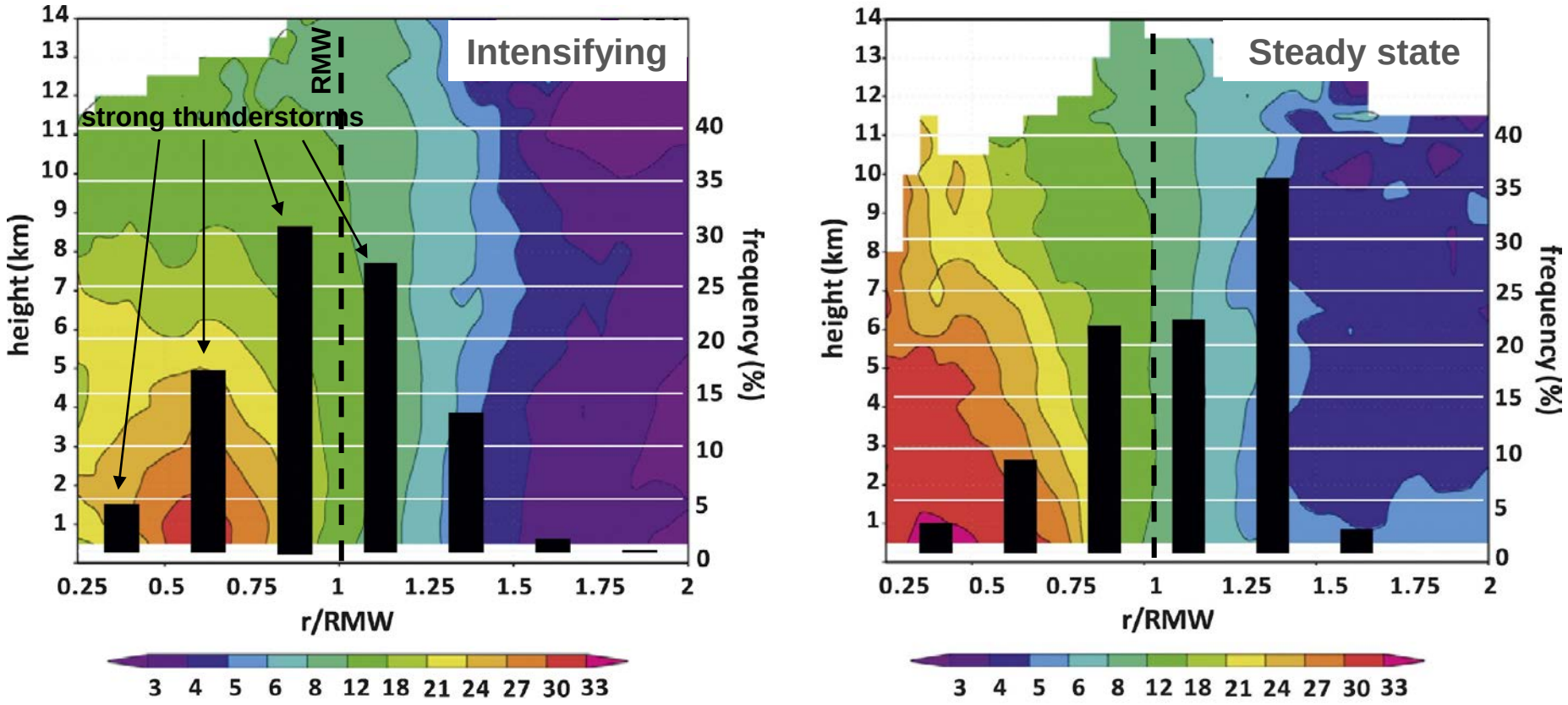
Real-time airborne radar observations of Humberto (2019)



RESEARCH RESULT

Convective Scale

Radial distribution of strong thunderstorms for intensifying (IN), steady-state (SS) storms

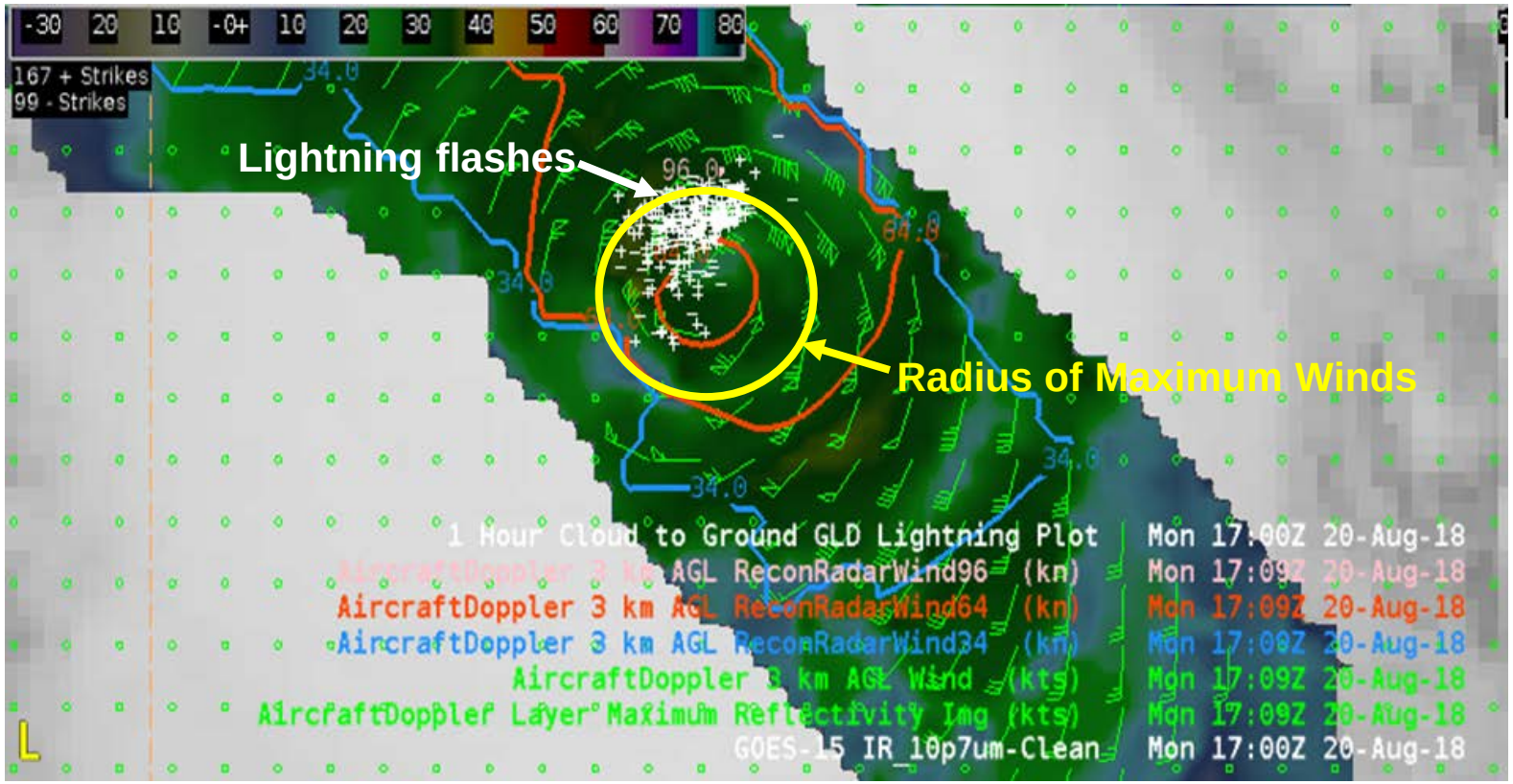


(Rogers et al., MWR, 2013)

OPERATIONAL APPLICATION

Convective Scale

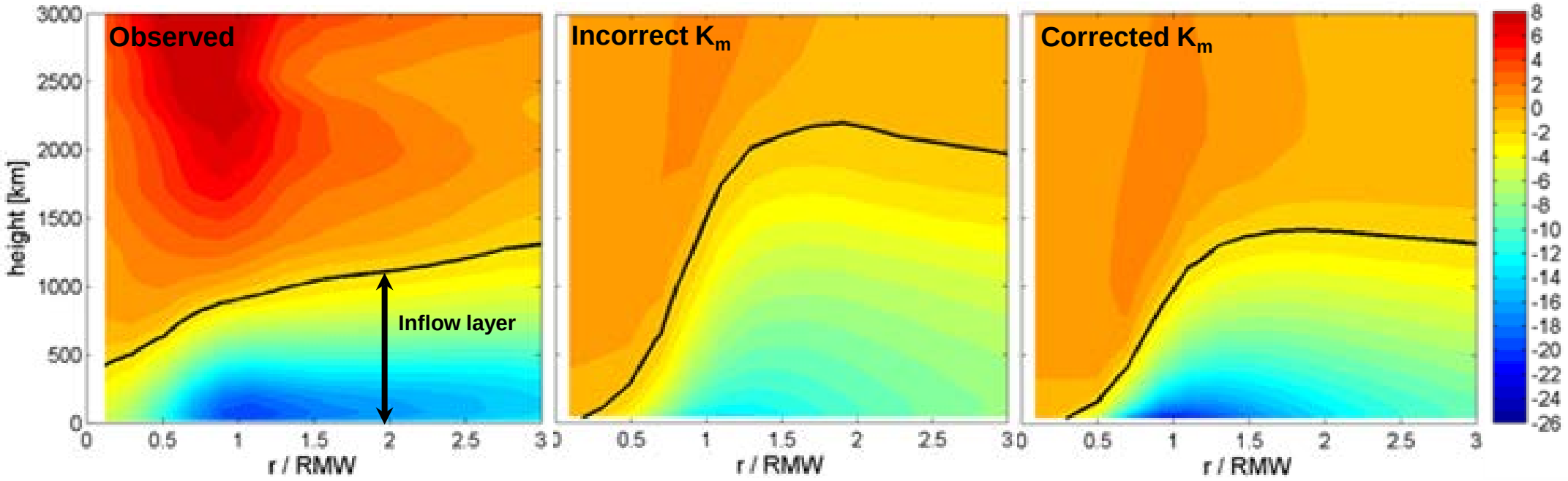
Real-time NHC **Advanced Weather Interactive Processing System (AWIPS-II)** display of airborne radar winds, satellite-detected lightning flashes in Hurricane Lane (2018)



RESEARCH RESULT

Turbulent Scale

Radial flow in hurricane boundary layer from **Hurricane Weather Research & Forecasting (HWRF)** model using different vertical eddy diffusivity (K_m)

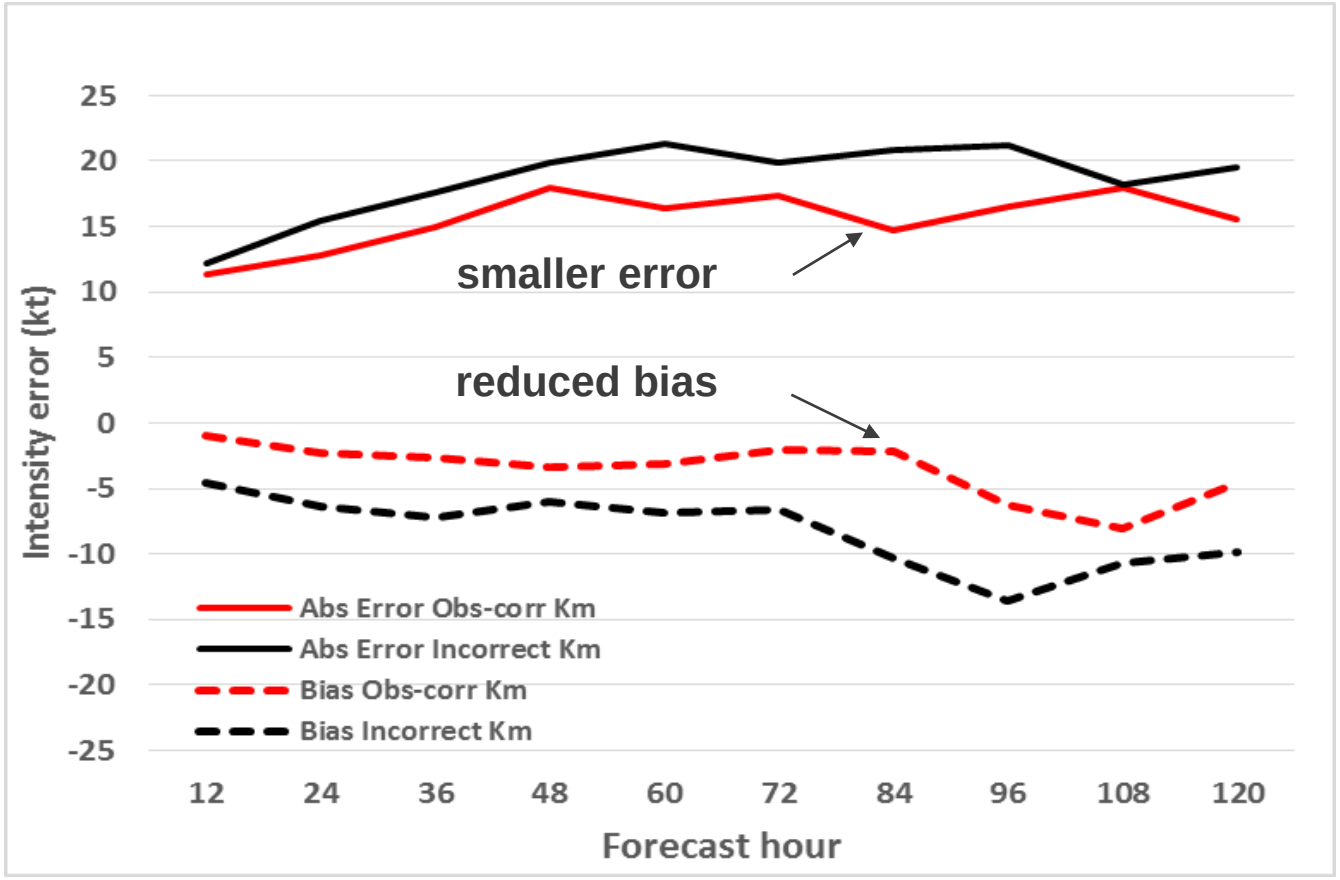


(Zhang et al., MWR, 2015)

OPERATIONAL APPLICATION

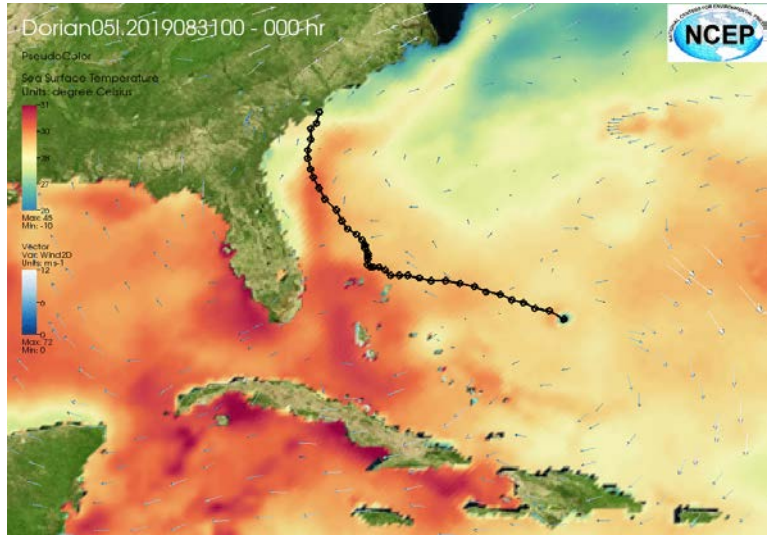
Turbulent Scale

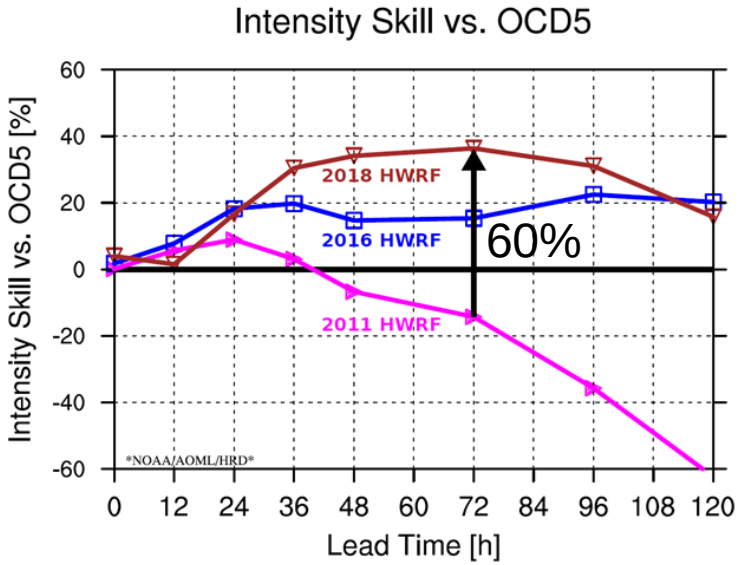
Intensity forecast errors for two Rapidly Intensifying hurricanes using different K_m in **HWRF** model (55 cases)



Model Developments: Operational HWRF

First ever high-resolution moving nested grid modeling system to run in NOAA operations for Hurricanes





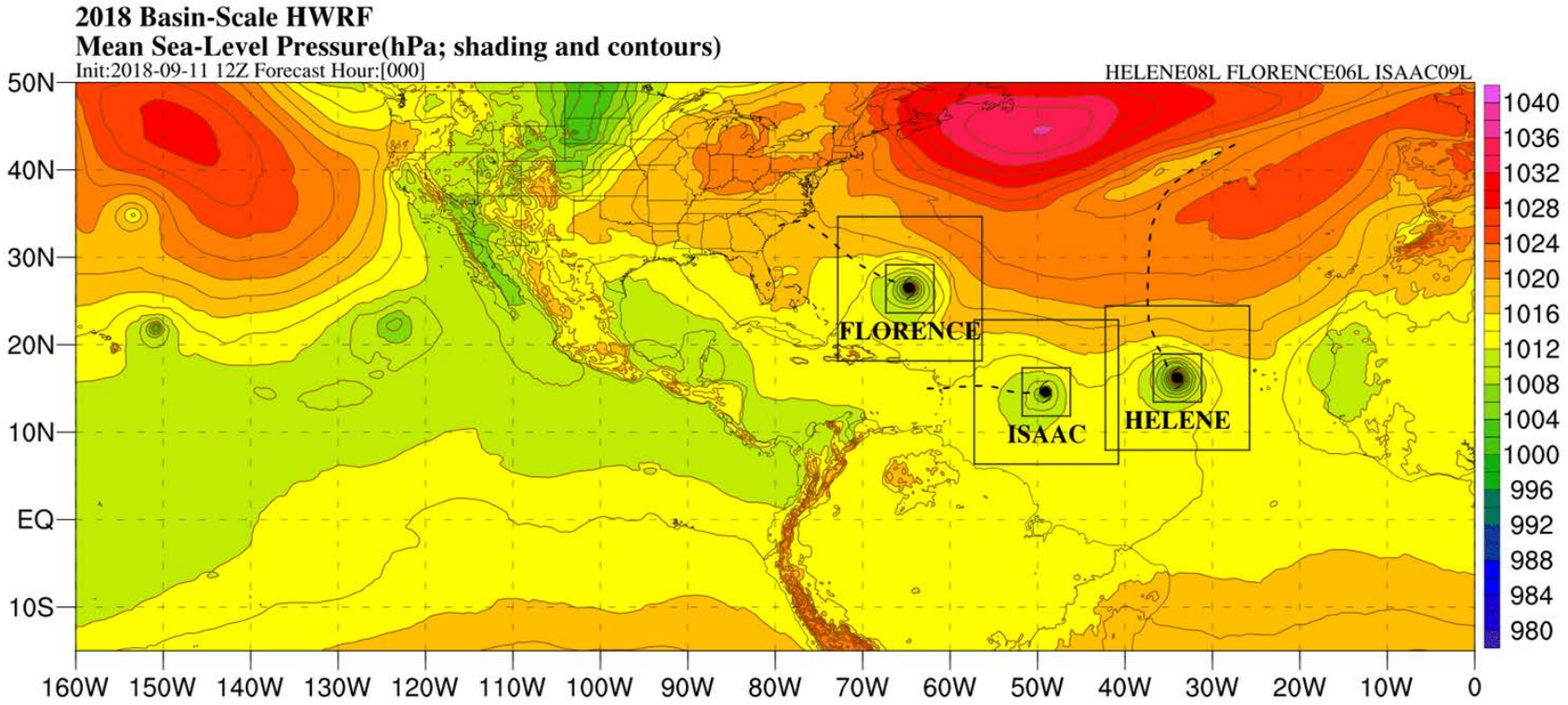
High-resolution nests, physics and DA advancements

NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

https://www.aoml.noaa.gov/hurricane-modeling-prediction/

Basin-scale HWRF (HWRF-B)

1. Built on collaborations
1. Multiple moving nests
1. Multi-scale interactions
1. Improved performance
1. Paving way to HAFS



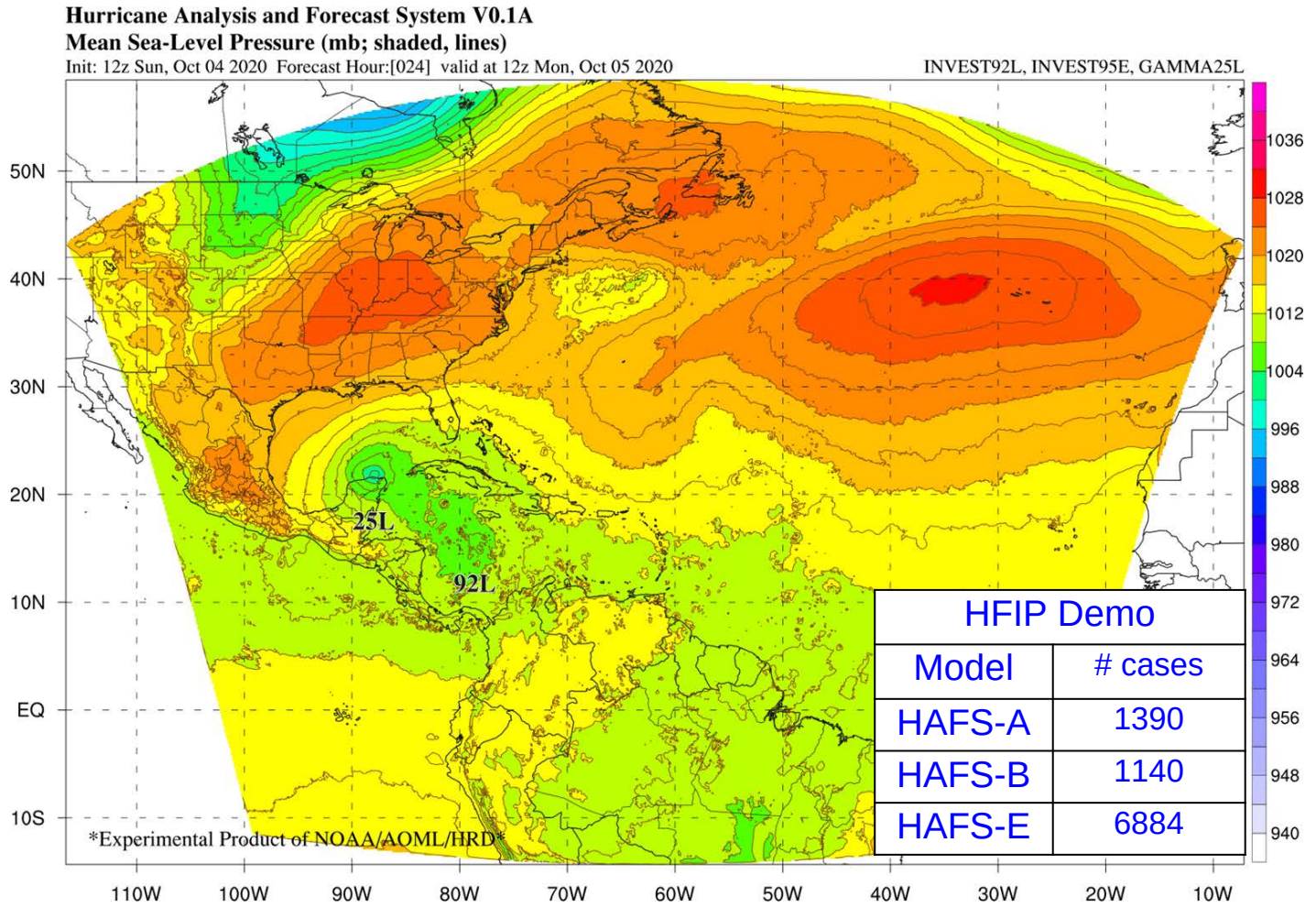
HRD collaborated with EMC, DTC, & RDHPCS

(X. Zhang et al, WAF 2016)
(Alaka et al WAF 2017)

Hurricane Analysis and Forecast System (HAFS)

- ✓ **HAFS v0.1A**: stand-alone regional (SAR) nest configuration over NATL basin, 3 km hor. res, 91L, mod. HWRF physics, VI, DA & ocean coupling
- ✓ **HAFS v0.1B**: Global-regional nest configuration over NATL basin, 3-km hor. res, 78L, mod. GFS physics & VI
- ✓ **HAFS v0.1E**: 17-member ensemble of HAFS v0.1A, 6-km hor. res, 64L, No ocean coupling, SKEB, SPPT, SHUM

https://storm.aoml.noaa.gov/basin

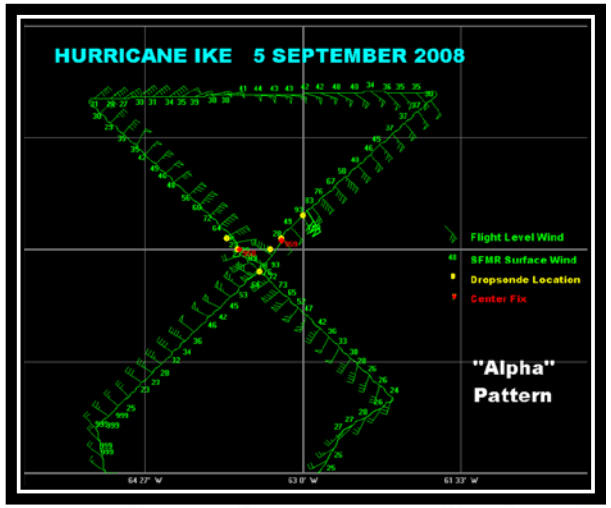


Data Assimilation Developments:

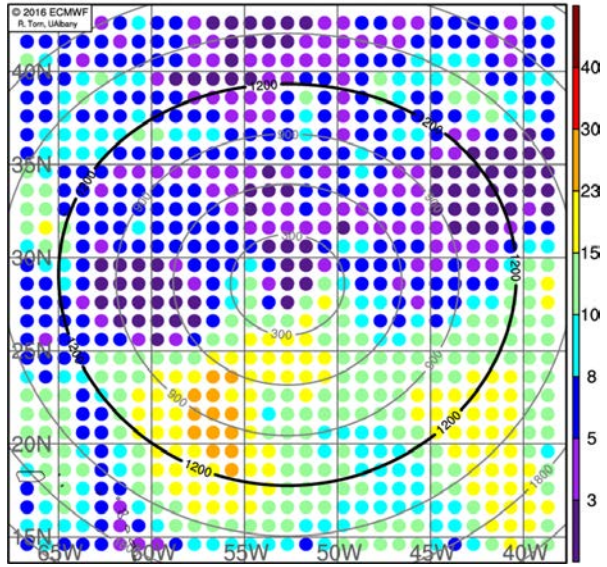
Evolving use of reconnaissance data

- Recon paradigm shift
- Model & data assimilation (DA) improvements
- Strategic sampling
- Smarter use of resources

OLD

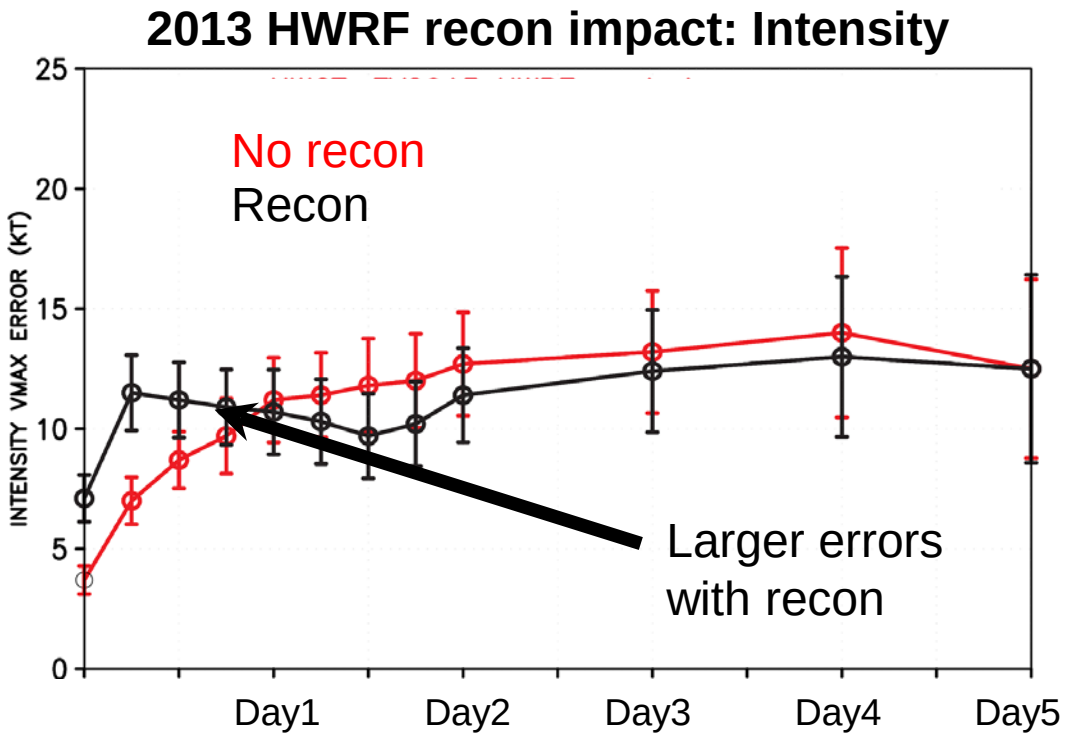


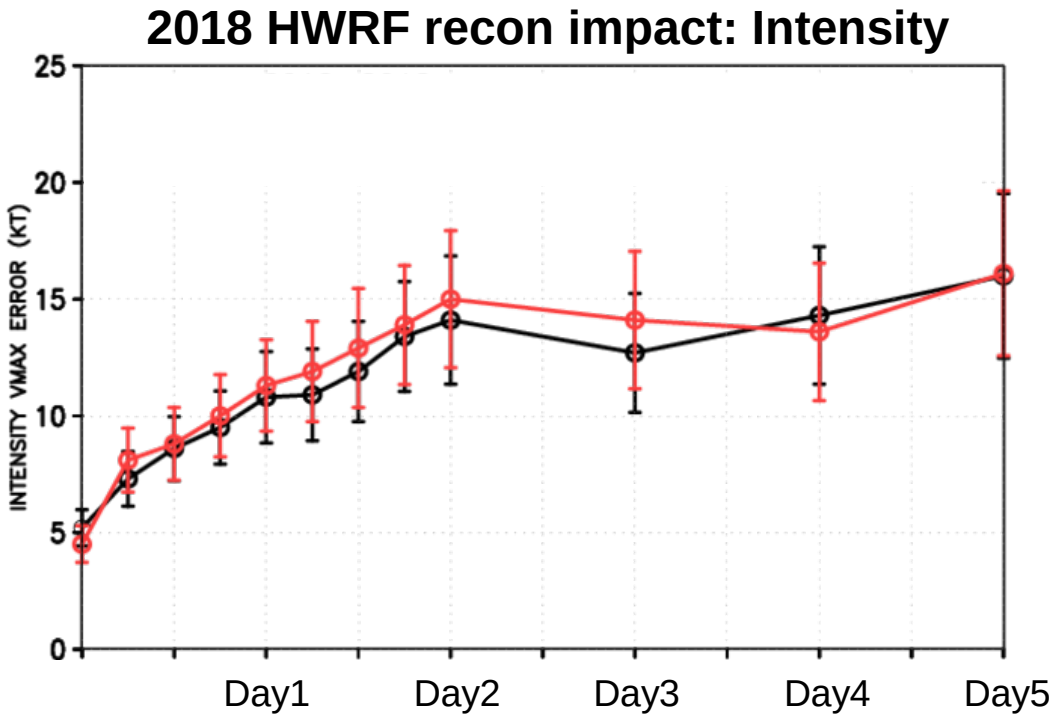
NEW



Courtesy SUNY Albany

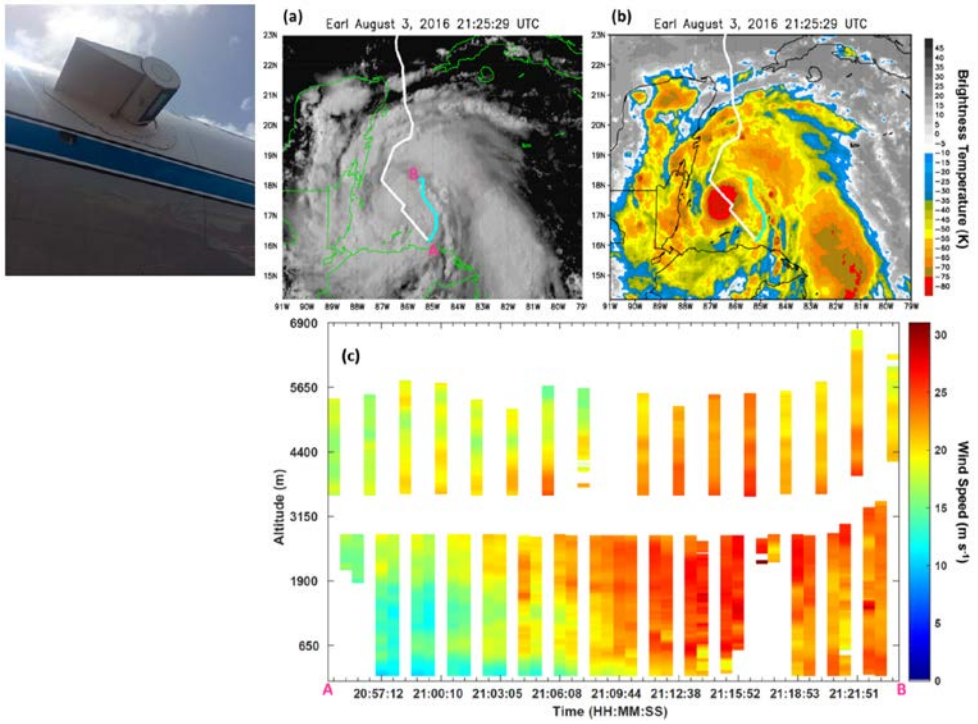
Better modeling and DA improves observations impact





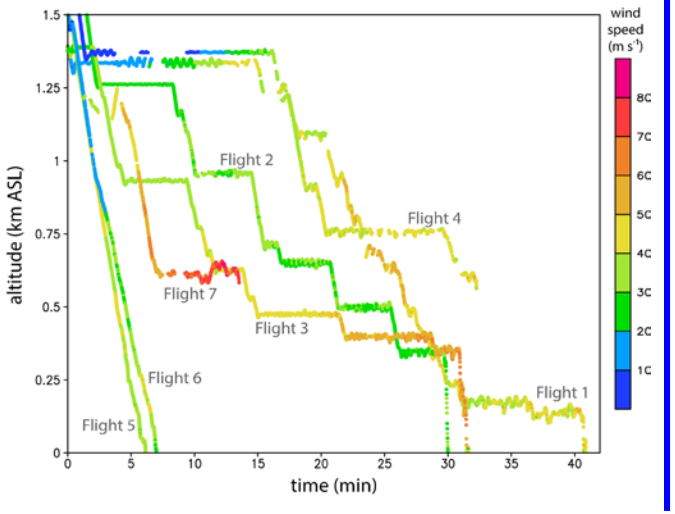
Emerging Observing Technology

Doppler **W**ind **L**idar (DWL)



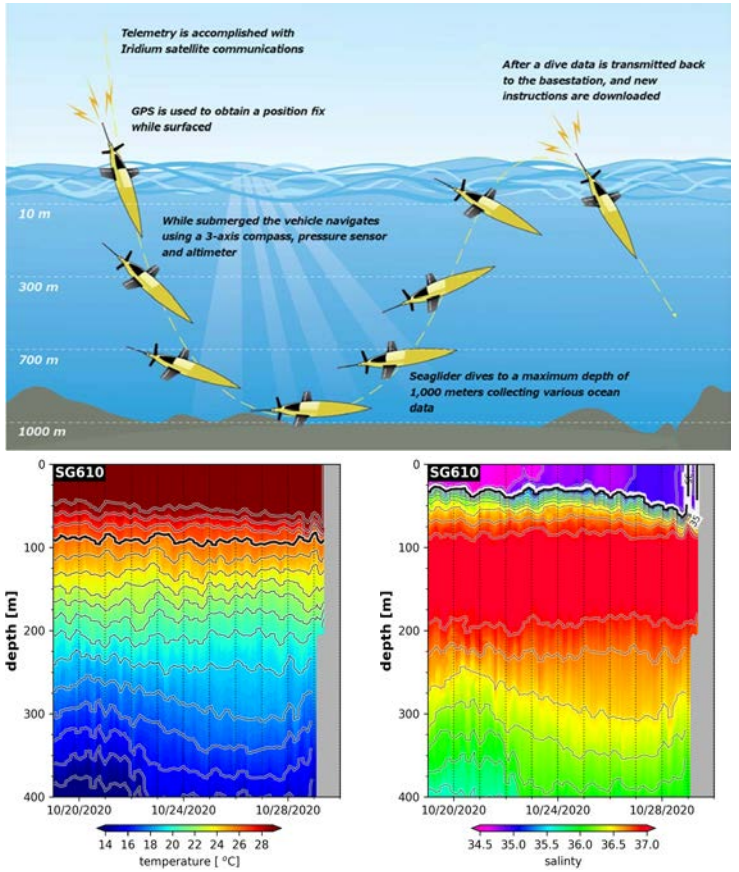
(Bucci et al, MWR 2021)

Small **U**nmanned **A**ircraft **S**ystems (sUAS)



(Cione et al, BAMS 2020)

Ocean **Gliders**



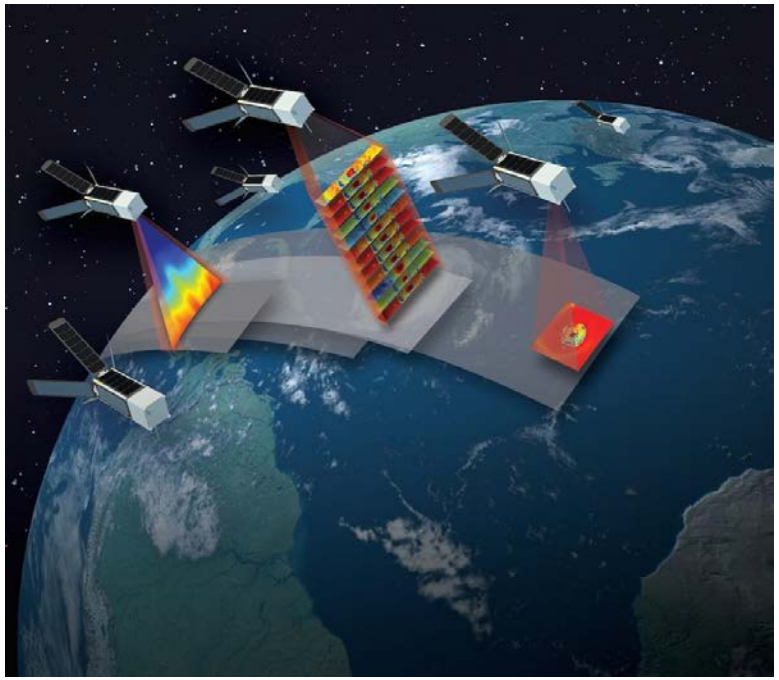
(Domingues et al, MWR 2020)

Micro-Satellite Observations

TROPICS -

Time-Resolved Observations of Precipitation structure & storm Intensity with a Constellation of Smallsats

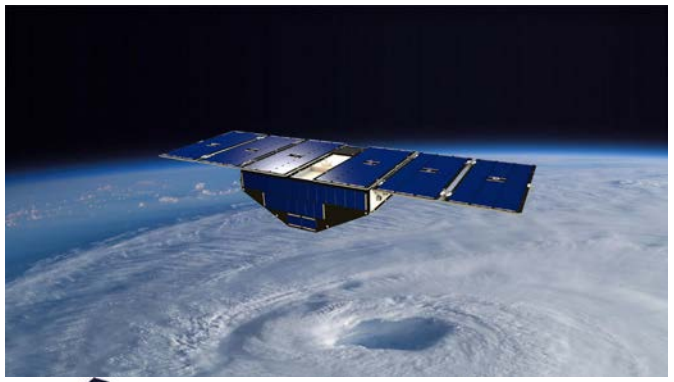
Rapid-refresh microwave obs
(temperature, moisture, & precipitation)

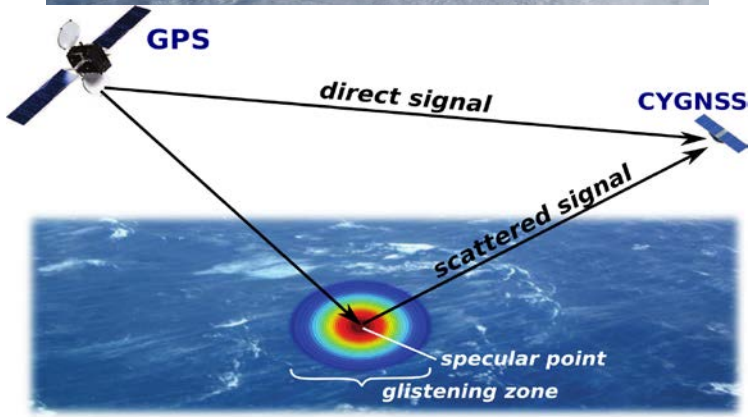


(Blackwell et al, QJ 2018)

CYGNSS -

Cyclone Global Navigation Satellite System





(Annane et al, MWR 2018)

Weather Act 2017

Section 104: "NOAA must improve hurricane forecasting including"…

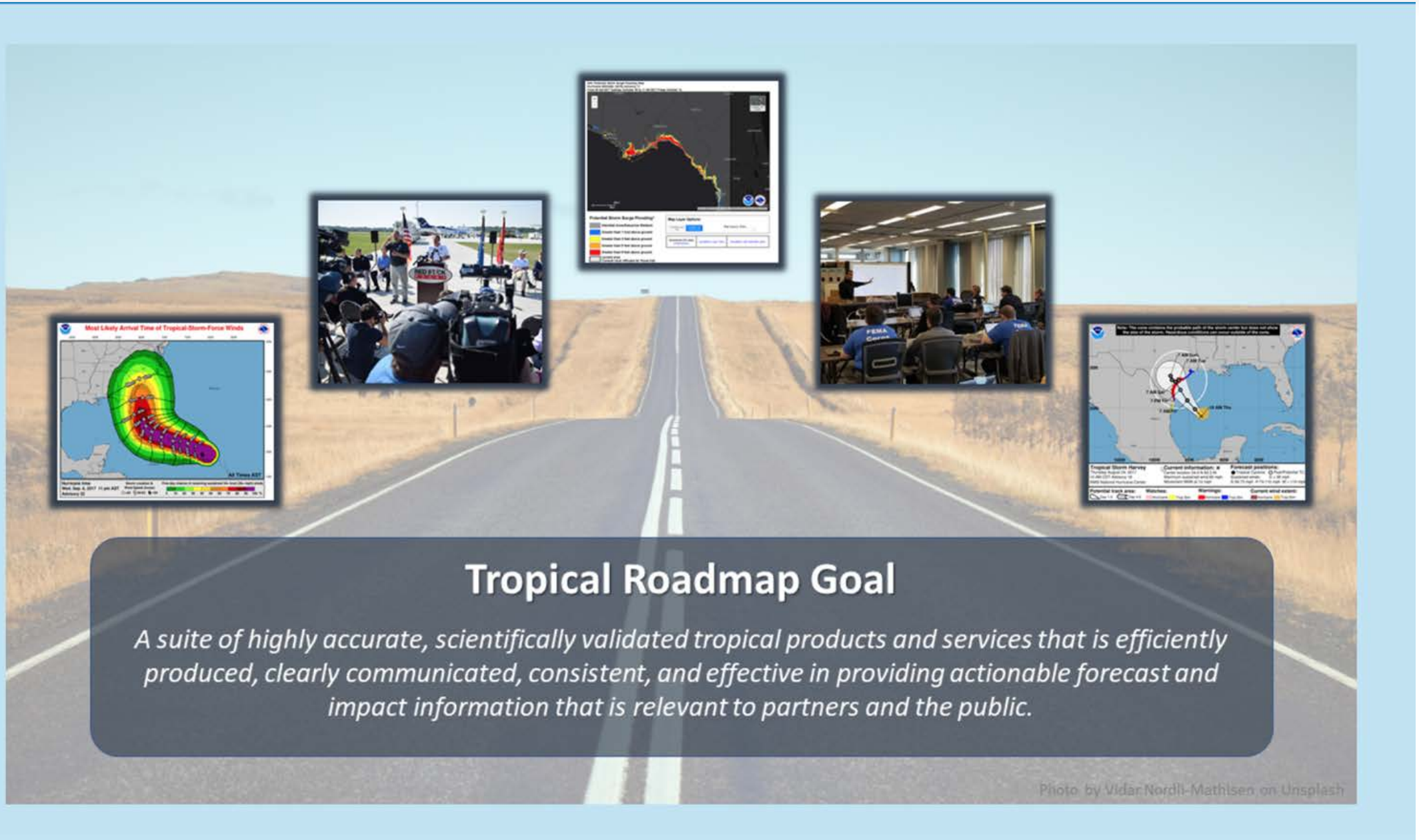
- **Risk communication research** to create more effective watch and warning products.

FACETs is…

Forecasting a Continuum of Environmental Threats

A framework that modernizes the creation, communication, and dissemination of risk-based, probabilistic hazard information to empower effective response

(Rothfusz et al, BAMS 2018)


Most Likely Arrival Time of Tropical-Storm-Force Winds
Tropical Roadmap Goal
A suite of highly accurate, scientifically validated tropical products and services that is efficiently produced, clearly communicated, consistent, and effective in providing actionable forecast and impact information that is relevant to partners and the public.
Photo by Vidar Nordli-Mathisen on Unsplash

Questions?

- Our blog
https://noaahrd.wordpress.com
- HRD Web page
https://www.aoml.noaa.gov/hrd
- Facebook (7,840 followers)
https://www.facebook.com/noaahrd
- Twitter (40,400 followers)
https://twitter.com/#!/HRD_AOML_NOAA