NOAA Hurricane Research

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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

Observing Strategies
Evaluation

FACETs
HRD Personnel

- 48 Total Staff
- 24 Scientists
- 21 Science Support
- 3 Postdocs
Activities & Collaborations

- UFS
- Model 23%
- Observing 41%
- DA & OSSE 36%
- AI/ML
- JEDI
- PhOD
- AWIPS-II
- FACETS
- NOAA's Atlantic Oceanographic and Meteorological Laboratory
- Environmental Modeling Center (EMC)
- NOAA SATELLITES
- NOAA FORECAST IMPROVEMENT PROJECT
- National Centers for Environmental Prediction
- NCAR
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/
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

Gall et al., BAMS, 2013

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
Current State of the Art

NHC Official Average Track & Intensity Errors (ATL basin)

https://www.nhc.noaa.gov/verification/
Tropical Cyclone Intensity Forecasting


- Rapid Intensification
  - 3x larger error
- Non-Rapid Intensification
The Challenge: Tropical Cyclone Intensity Forecasting

Multiscale nature of processes are major reason for this difficulty
Vortex Scale

Vortex alignment in Hermine (2016)

(Rogers et al., MWR, 2019)
Vortex Scale

Real-time airborne radar observations of Humberto (2019)

Low-level center

Mid-level center

Winds at 2 km

Winds at 5 km
RESEARCH RESULT

Convective Scale

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

(Rogers et al., MWR, 2013)
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)
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)
Turbulent Scale

Intensity forecast errors for two Rapidly Intensifying hurricanes using different $K_m$ in HWRF model (55 cases)
First ever high-resolution moving nested grid modeling system to run in NOAA operations for Hurricanes

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

(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

Courtesy SUNY Albany
Better modeling and DA improves observations impact

2013 HWRF recon impact: Intensity

No recon
Recon
Larger errors with recon

2018 HWRF recon impact: Intensity
Emerging Observing Technology

**Doppler Wind Lidar (DWL)**

**Small Unmanned Aircraft Systems (sUAS)**

**Ocean Gliders**

(Bucci et al, MWR 2021)

(Cione et al, BAMS 2020)

(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)

CYGNSS -
Cyclone Global Navigation Satellite System

(Blackwell et al, QJ 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)
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.
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