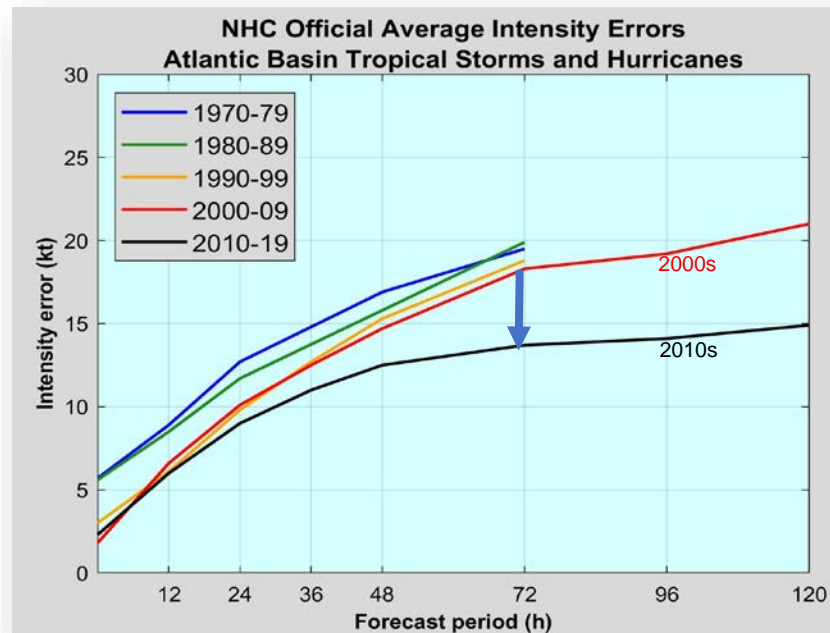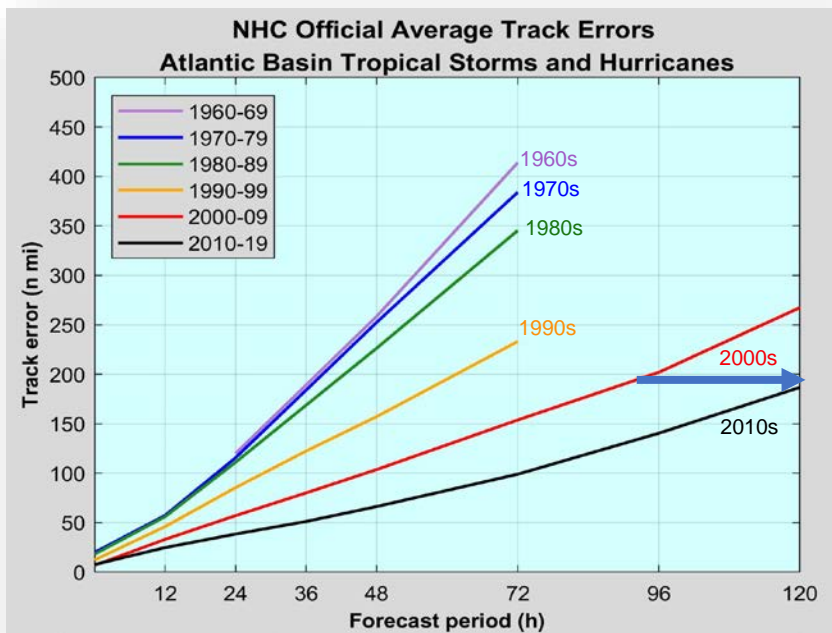# Hurricane Research at NOAA

Frank Marks

Vision

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

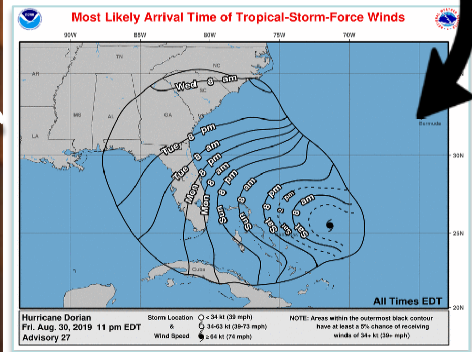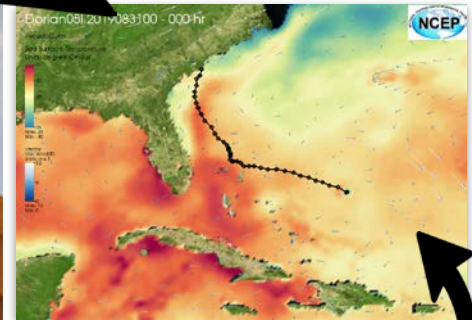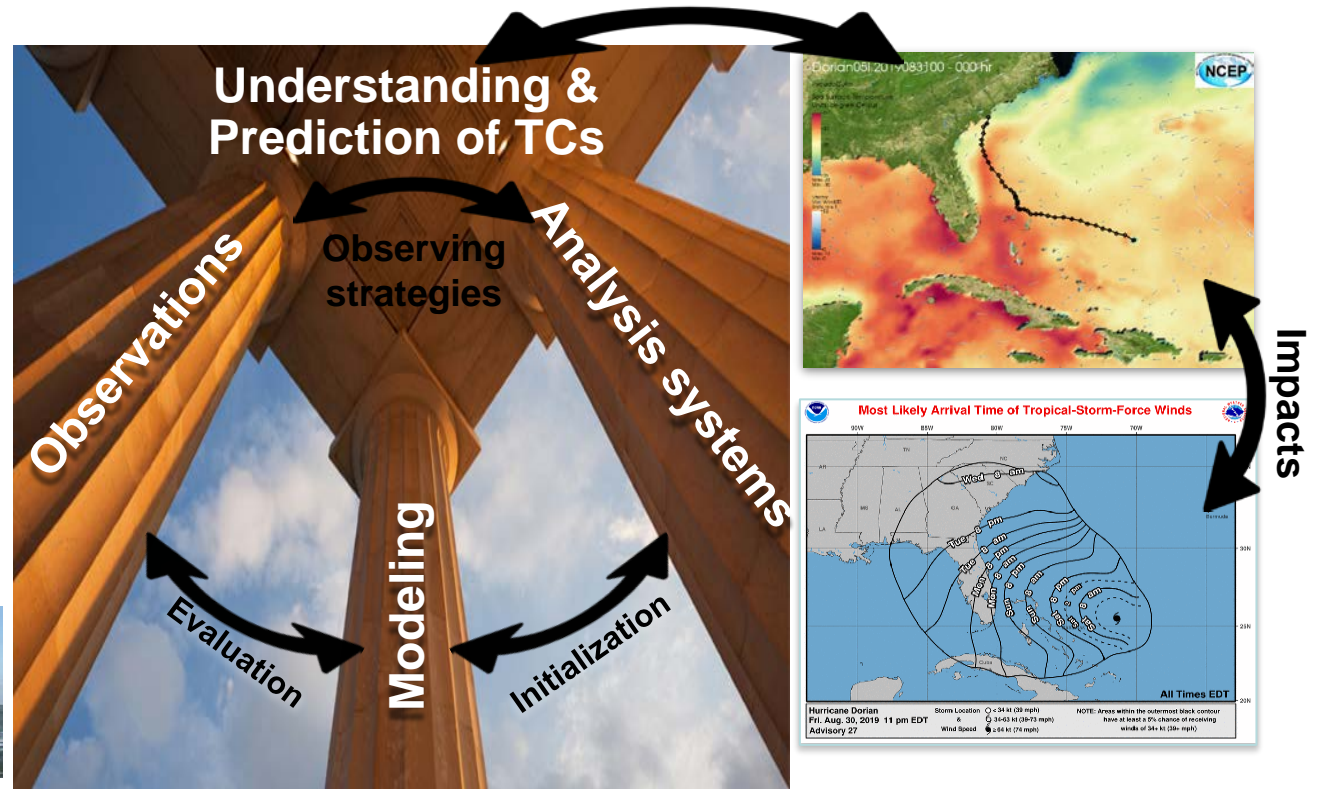**NOAA's hurricane research focus for >65 years**

NOAA's Atlantic Oceanographic and Meteorological Laboratory
U.S. Department of Commerce

Current State of the Art

Operational Forecast Performance

Courtesy John Cangialosi & James Franklin (NWS/NHC)

How?

Hurricane Forecast Improvement Program

- Unified approach to guide & accelerate forecast improvements since 2008

  - 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's Atlantic Oceanographic and Meteorological Laboratory
U.S. Department of Commerce

Challenge: Hurricane Intensity Forecasting

Multiscale nature of processes are major reason for this difficulty
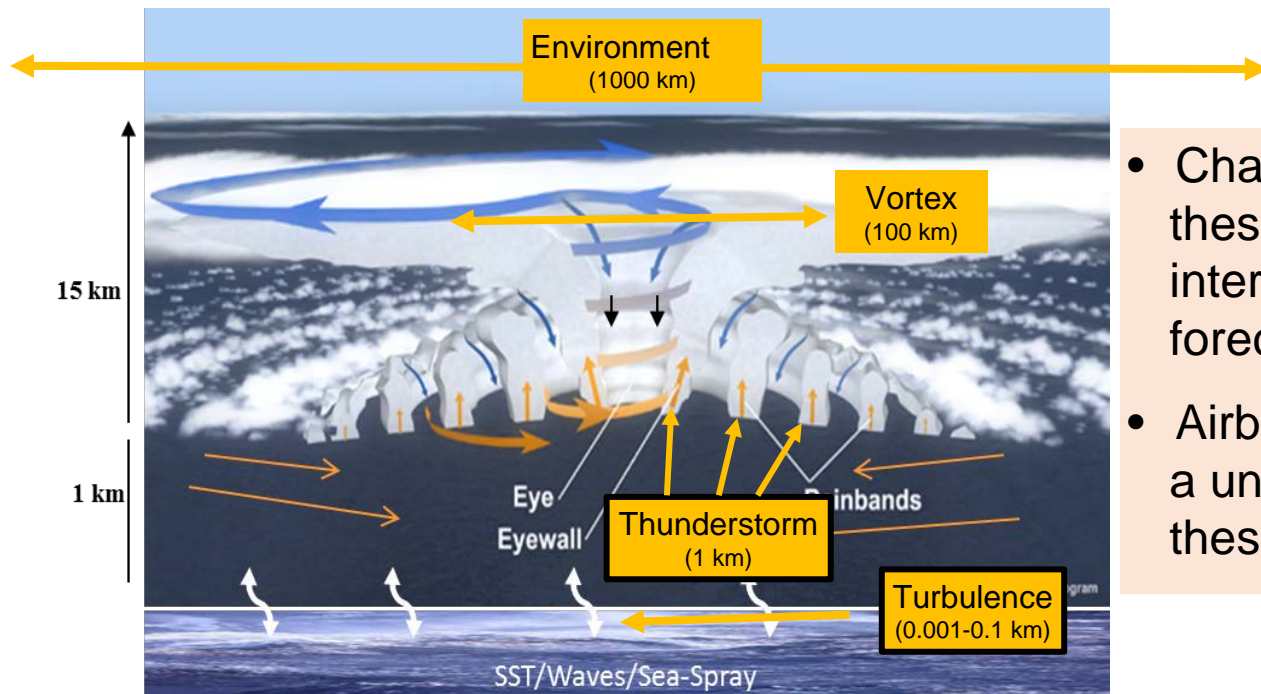
- Characterizing & understanding these processes & their interactions are key steps in forecast improvement

- Airborne observations provide a unique opportunity to study these processes across scales

Courtesy Robert Rogers (AOML/HRD)
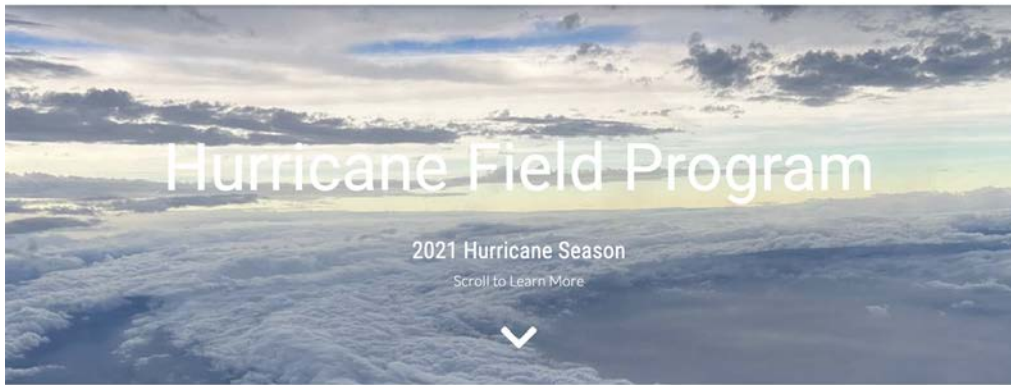
NOAA Intensity Forecast Experiment
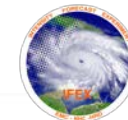
- Collect observations over tropical cyclone's life cycle

- 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/

P-3

NOAA Hurricane Hunters

https://www.omao.noaa.gov/learn/aircraft-operations

G-IV

Hurricanes FAQ

REDDIT AMA

Major Research Areas

Characterize, Understand, & Predict Processes Important to TC Evolution - IFEX

https://www.aoml.noaa.gov/2021-hurricane-field-program-data/

https://www.aoml.noaa.gov/dynamics-and-physics/
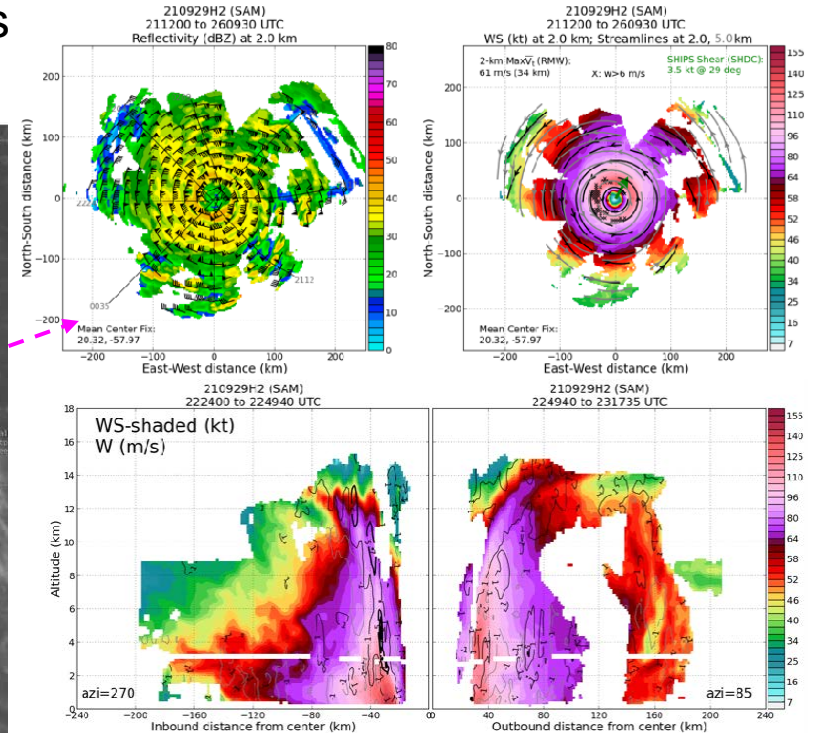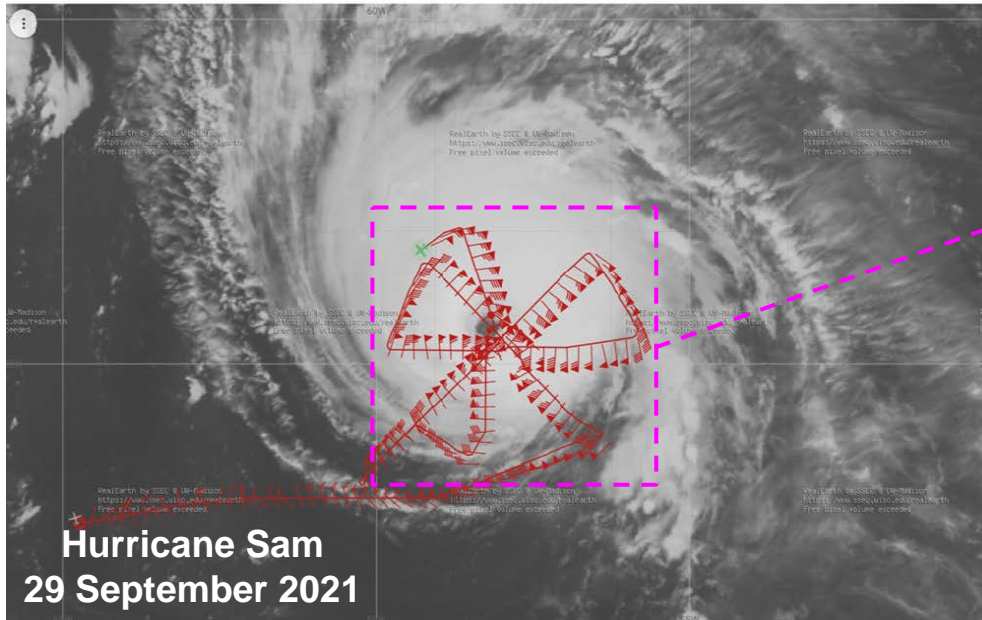
2021 Atlantic Hurricane Season
by the numbers

21

Named Storms

Average is 14

Ana	Larry
Bill	Mindy
Claudette	Nicholas
Danny	Odette
Elsa	Peter
Fred	Rose
Grace	Sam
Henri	Teresa
Ida	Victor
Kate	Wanda
Julian	

7

Hurricanes

Average is 7

4

Major Hurricanes

Average is 3

8

Storms made U.S. landfall

NOAA Hurricane Hunters

467

P-3 & G-IV flight hours

52

Operational (39) & research (13) missions

146

Tail Doppler radar analyses transmitted

Aircraft-Deployed Instruments

1324

GPS dropsondes

131

Airborne eXpendable BathyThermographs (AXBTS)

8

ALAMO Floats (AOML/PhOD & Navy)

https://www.aoml.noaa.gov/2021-hurricane-field-program-data/

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Major Research Areas
Improve representation of TC structure

TDR data combined with satellite-detected lightning in AWIPS-II during Hurricane Lane (2018) flights
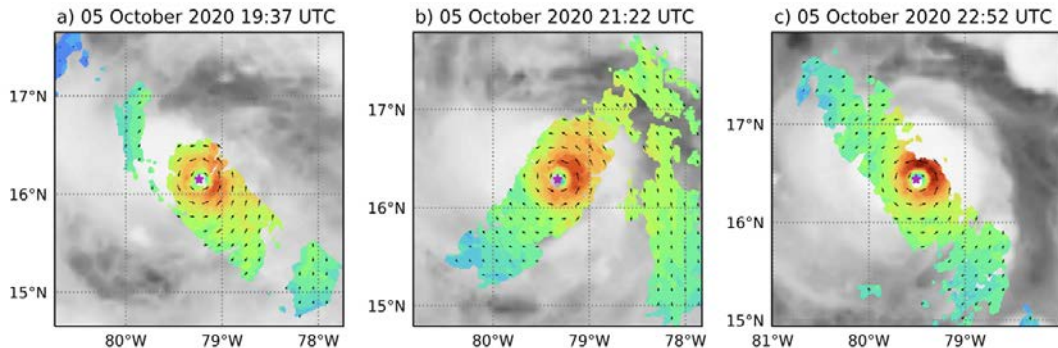
TDR-derived winds from sequence of passes in Hurricane Delta (2020) while rapidly intensifying

Courtesy Robert Rogers (AOML/HRD)

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and Meteorological Laboratory
U.S. Department of Commerce

Major Research Areas

Optimize use of Observations to
Improve Analysis & Forecasts

Hurricane Elsa 5 July 2021

https://www.aoml.noaa.gov/our-research/qosap-program/
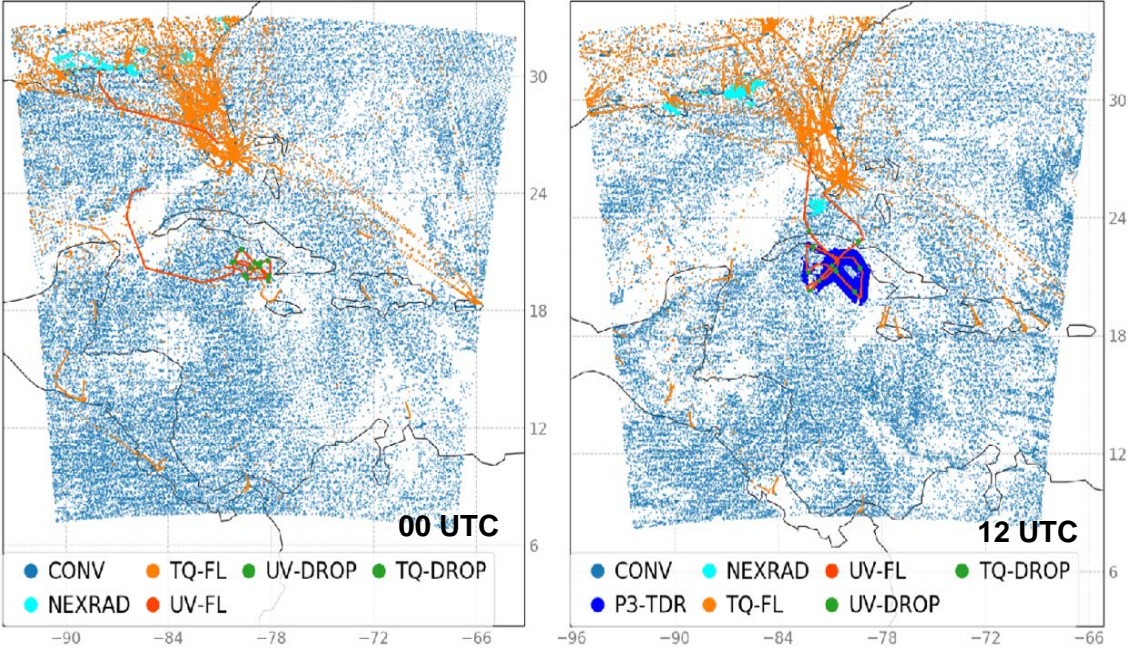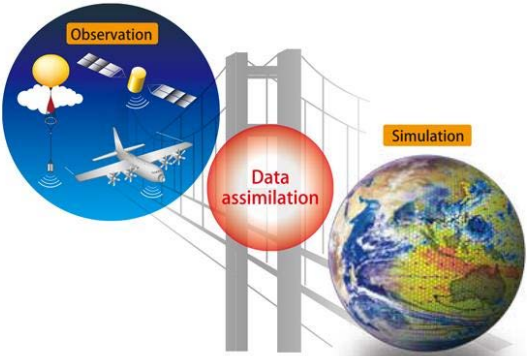
https://www.emc.ncep.noaa.gov/gc_wmb/vxt/HATCF/

Courtesy Zhan Zhang (NWS/EMC)

Major Research Areas

Advance Hurricane Forecast Guidance: HWRF -> HAFS

Hurricane Sam (18L) 00 UTC 26 September 2021
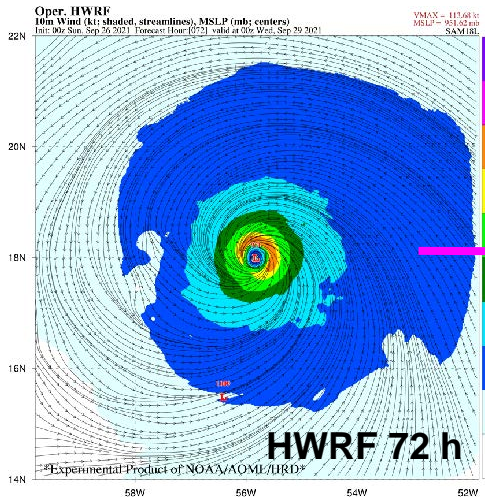
HAFS: Moving Nests in Global FV3

HWRF 72 h

HAFS-B 72 h
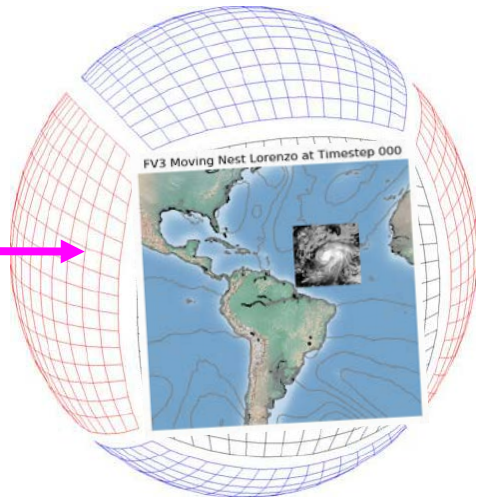
Courtesy Bill Ramstrom (AOML/HRD)

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

https://storm.aoml.noaa.gov/basin/?projectName=BASIN
https://www.emc.ncep.noaa.gov/HAFS/HAFSv0p2a/index.php

https://hfip.org/hafs

Major Research Areas

Improve understanding of intensity change

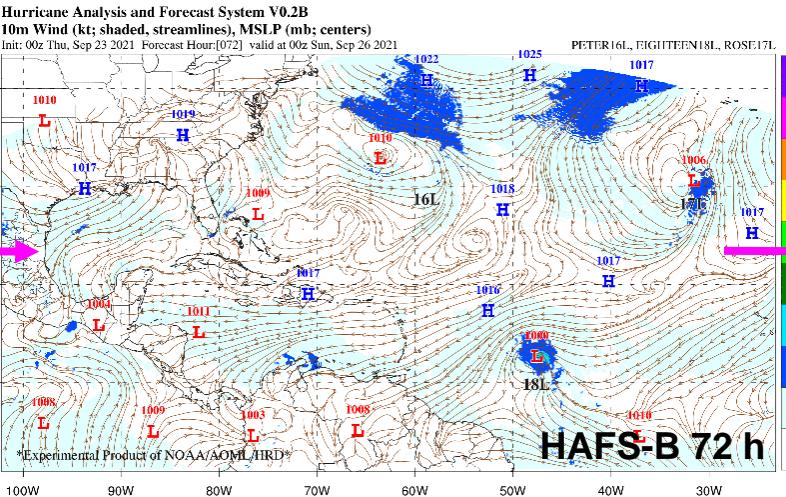- Characterizing Inner-core Structure & Intensity Change

- Intensity Change in Vertical Wind Shear

- Boundary Layer Processes & Air-sea Interactions

- Secondary Eyewall Formation & Replacement Cycles

- Genesis & Development of weak systems

- Most recent research focused on structures associated with intensity change processes
- Research used tail Doppler radar & GPS dropsonde data
- Both composite (multi-case) & case study frameworks
  - Composites provide robustness
  - Case studies can provide temporal evolution
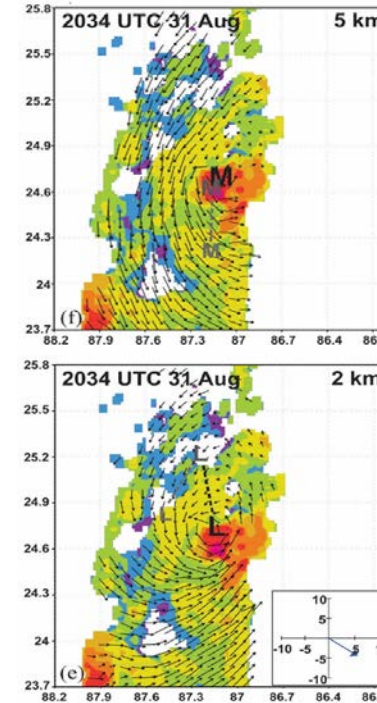
- Low-level center repositioned underneath midlevel center over ~3 h period
- Repositioning consistent with low-level stretching in deep, moderate convection around midlevel center

Courtesy Robert Rogers (AOML/HRD)

Major Research Areas

Characterize, Understand, & Predict Processes Important to TC Landfall Impacts

Hurricane Ida 29 August 2021

Tower Data

DOW Data
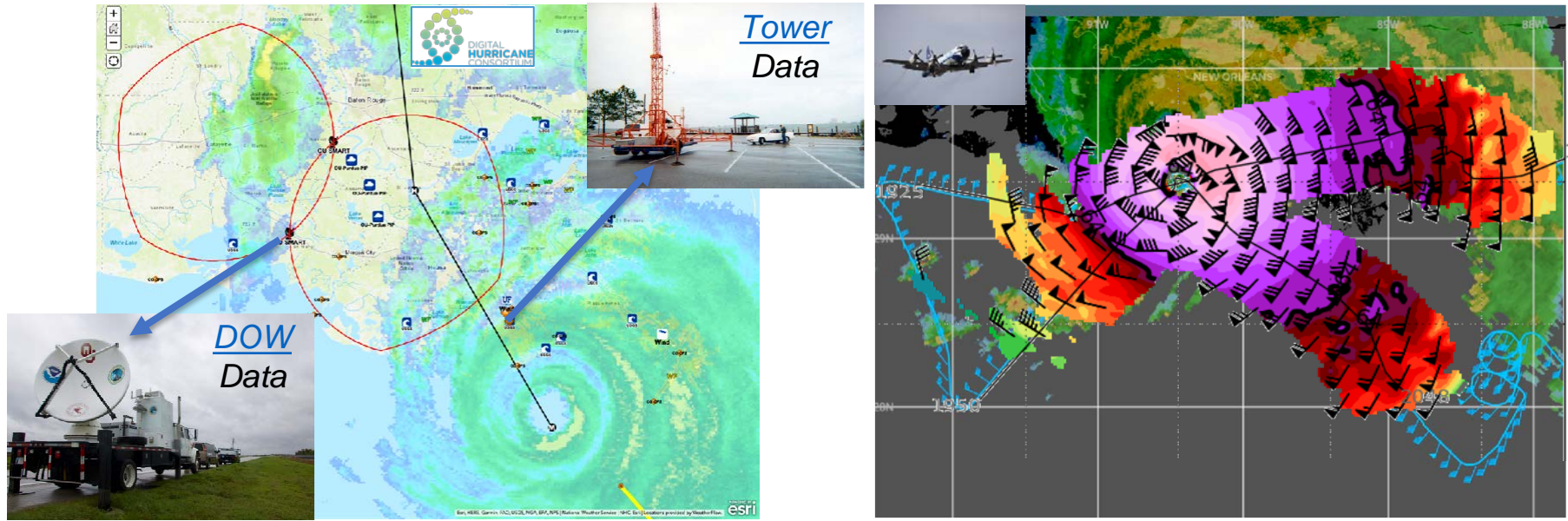
https://www.weather.gov/sti/coastalact_elements   Courtesy Forrest Masters (UF), Mike Biggerstaff (OU) & Digital Hurricane Consortium

Emerging Research Areas

Optimize use of upper ocean & air-sea interface observations to improve analysis, forecasts & understanding

https://aoml1.geocollaborate.com/follow/index.html
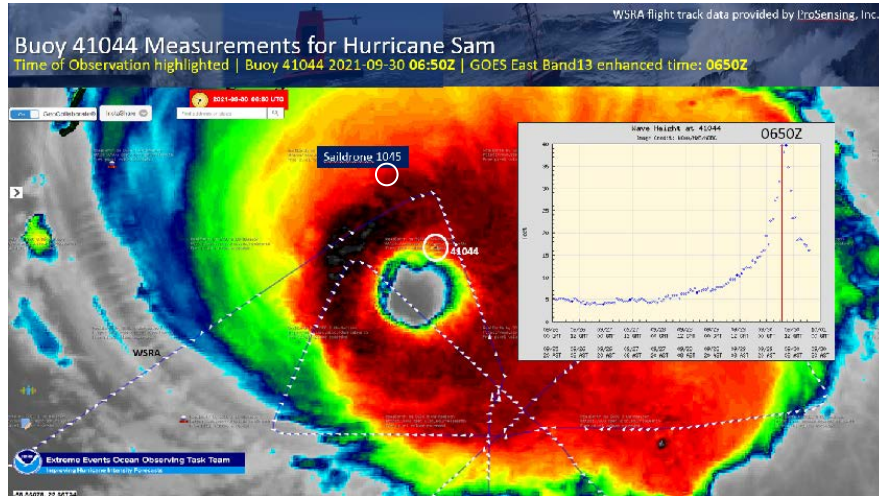
Courtesy Dave Jones (StormCenter)

https://www.youtube.com/watch?v=uQM_03zuSAI

Courtesy Greg Foltz (AOML/PhOD) & Saildrone

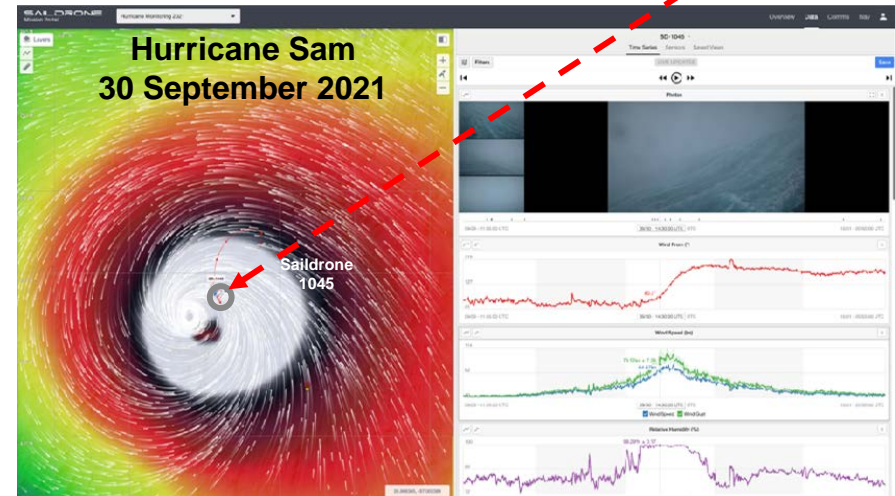# Emerging Research Areas

Optimize use of Satellite Observations to Improve Analysis & Forecasts

NOAA's Atlantic Oceanographic and Meteorological Laboratory
U.S. Department of Commerce
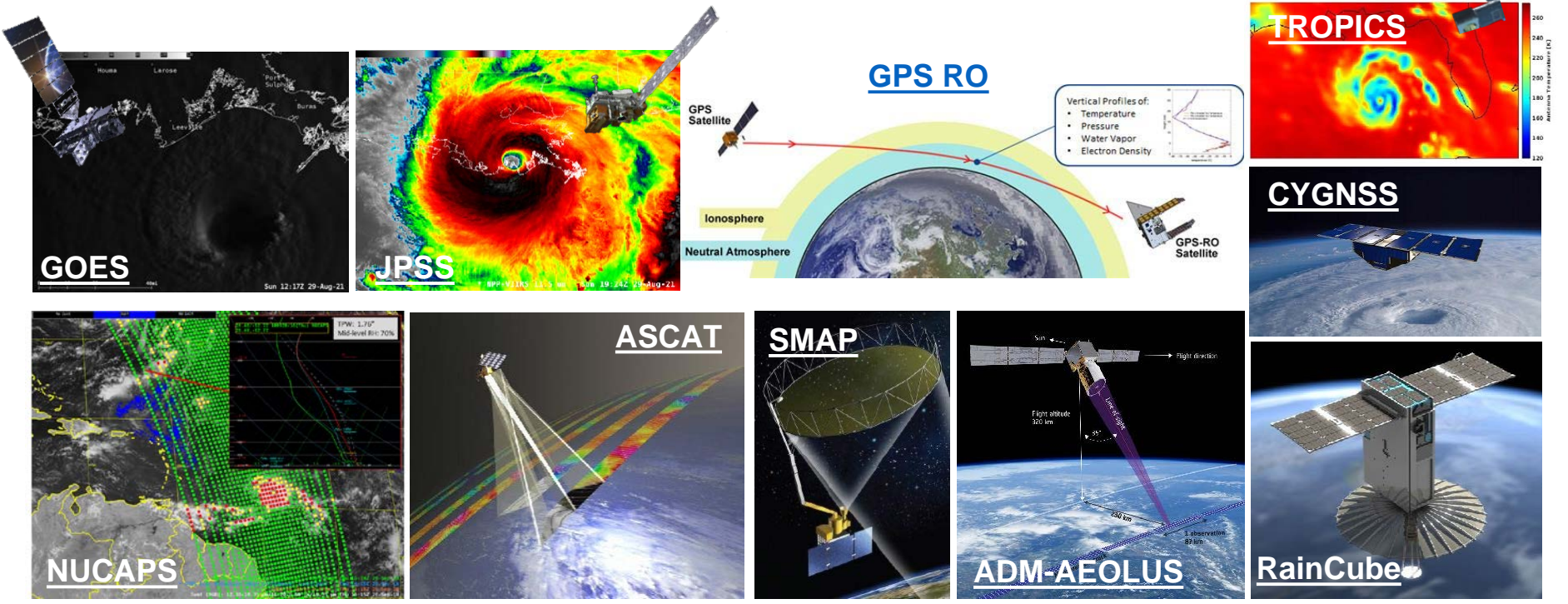
Emerging Research Areas

Address Hurricane Forecast Guidance Uncertainty: Ensembles

https://www.emc.ncep.noaa.gov/HAFS/HAFSEPS/tcall.php

Courtesy Zhan Zhang (NWS/EMC)
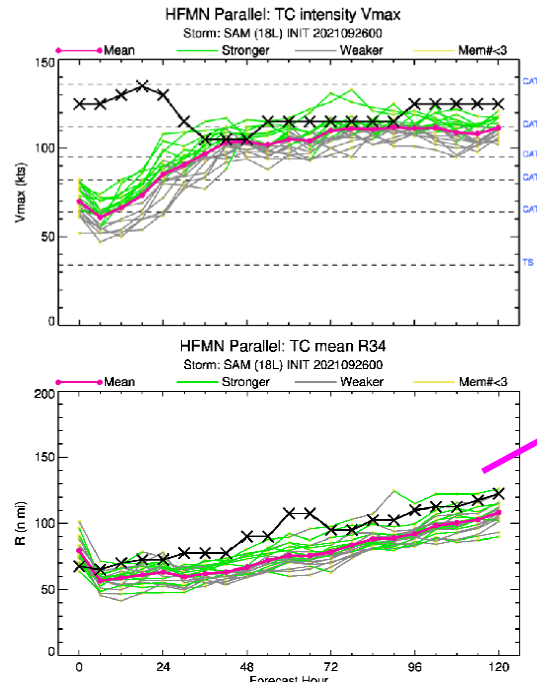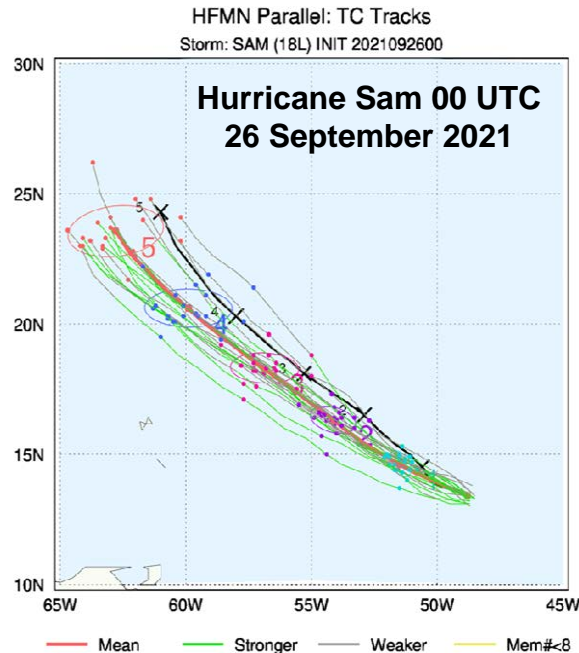
Emerging Research Areas
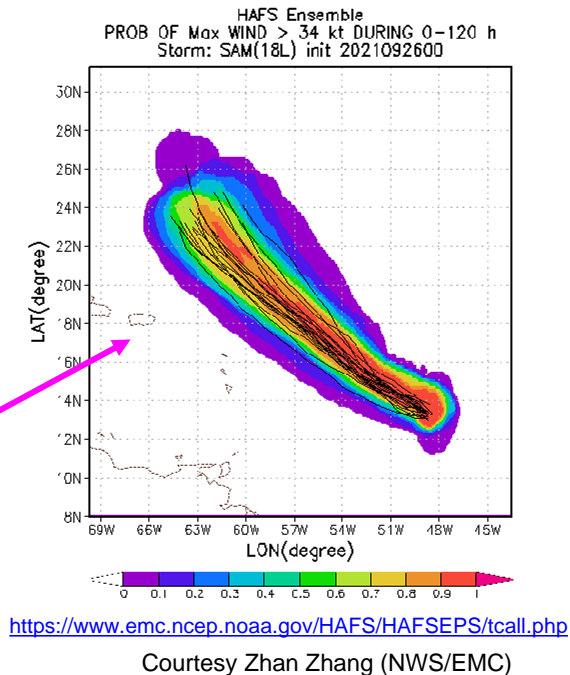
Address Hurricane Forecast Guidance Uncertainty: Machine learning models

CNN architecture

Random Forest Architecture

Basic concept of SVM

Courtesy Mu-Chieh Ko (AOML/HRD)

NOAA's Atlantic Oceanographic
and Meteorological Laboratory
U.S. Department of Commerce
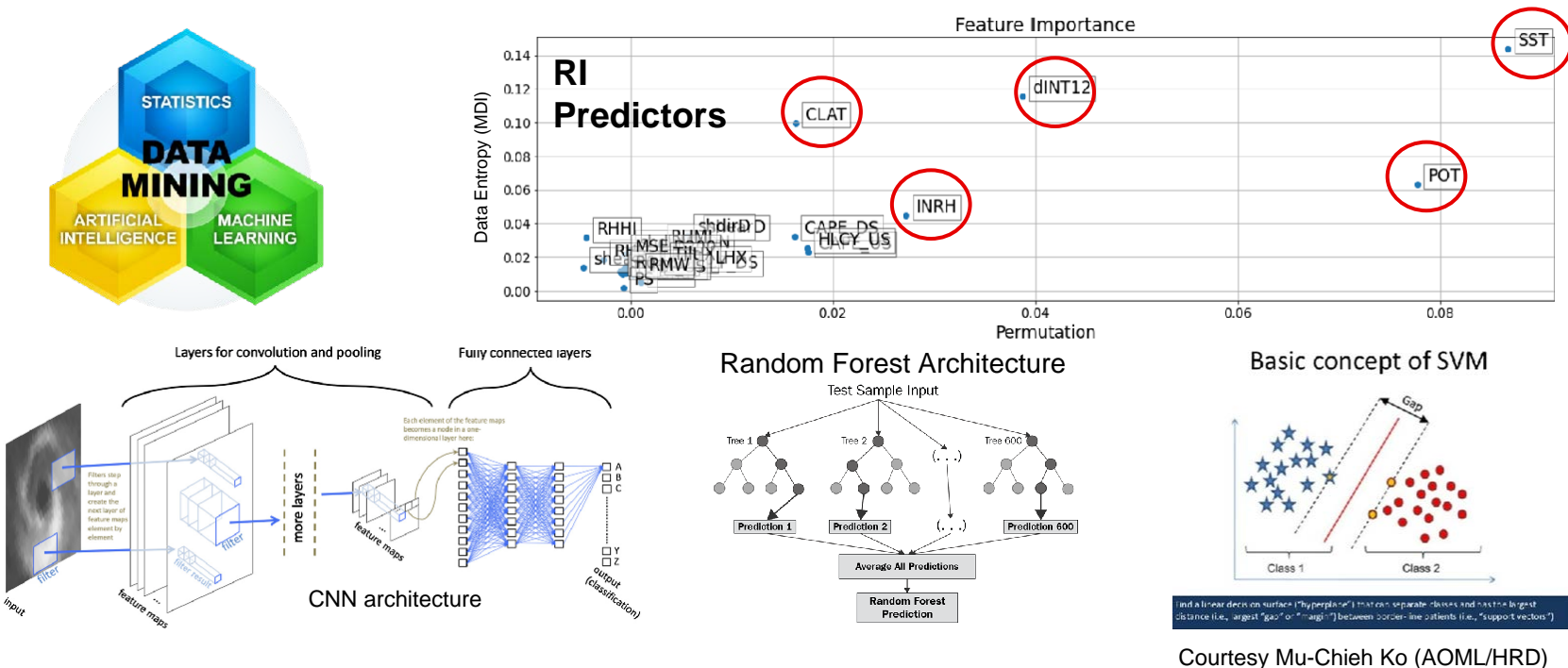
Emerging Research Areas

Improve forecast communication of hazards: Link SBES & Physical Science

GRID-BASED THREAT PROBABILITIES — OBSERVATIONS & GUIDANCE — THE FORECASTER — THREAT GRID TOOLS — USABLE OUTPUT — EFFECTIVE RESPONSE — VERIFICATION

INTEGRATED SOCIAL / BEHAVIORAL / ECONOMIC SCIENCES

Forecasting A Continuum of Environmental Threats (FACETs)

https://wpo.noaa.gov/Programs/FACETs

https://sites.google.com/a/noaa.gov/tropical-roadmap/home?authuser=0

Courtesy Jessica Schauer (NWS)

Questions?

frank.marks@noaa.gov
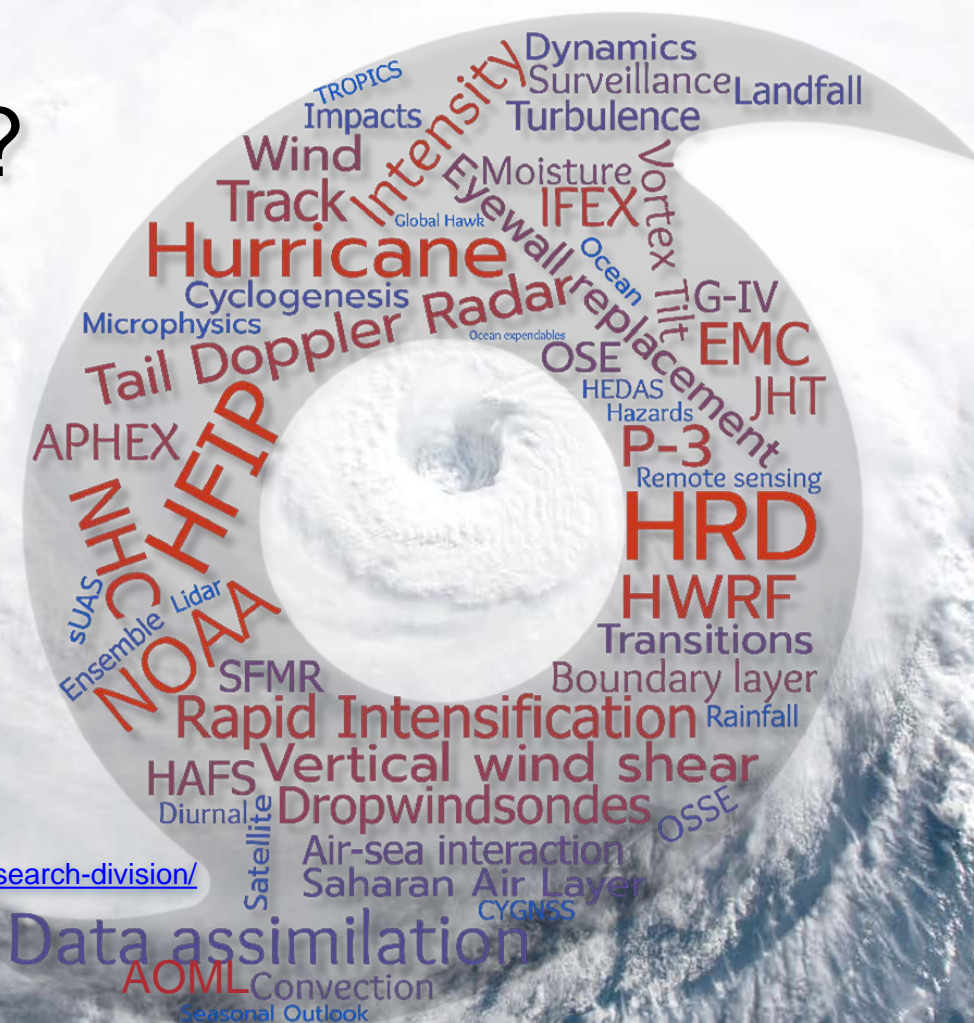
http://www.hfip.org
https://noaahrd.wordpress.com/
https://www.aoml.noaa.gov/hurricane-research-division/
REDDIT AMA
Hurricanes FAQ