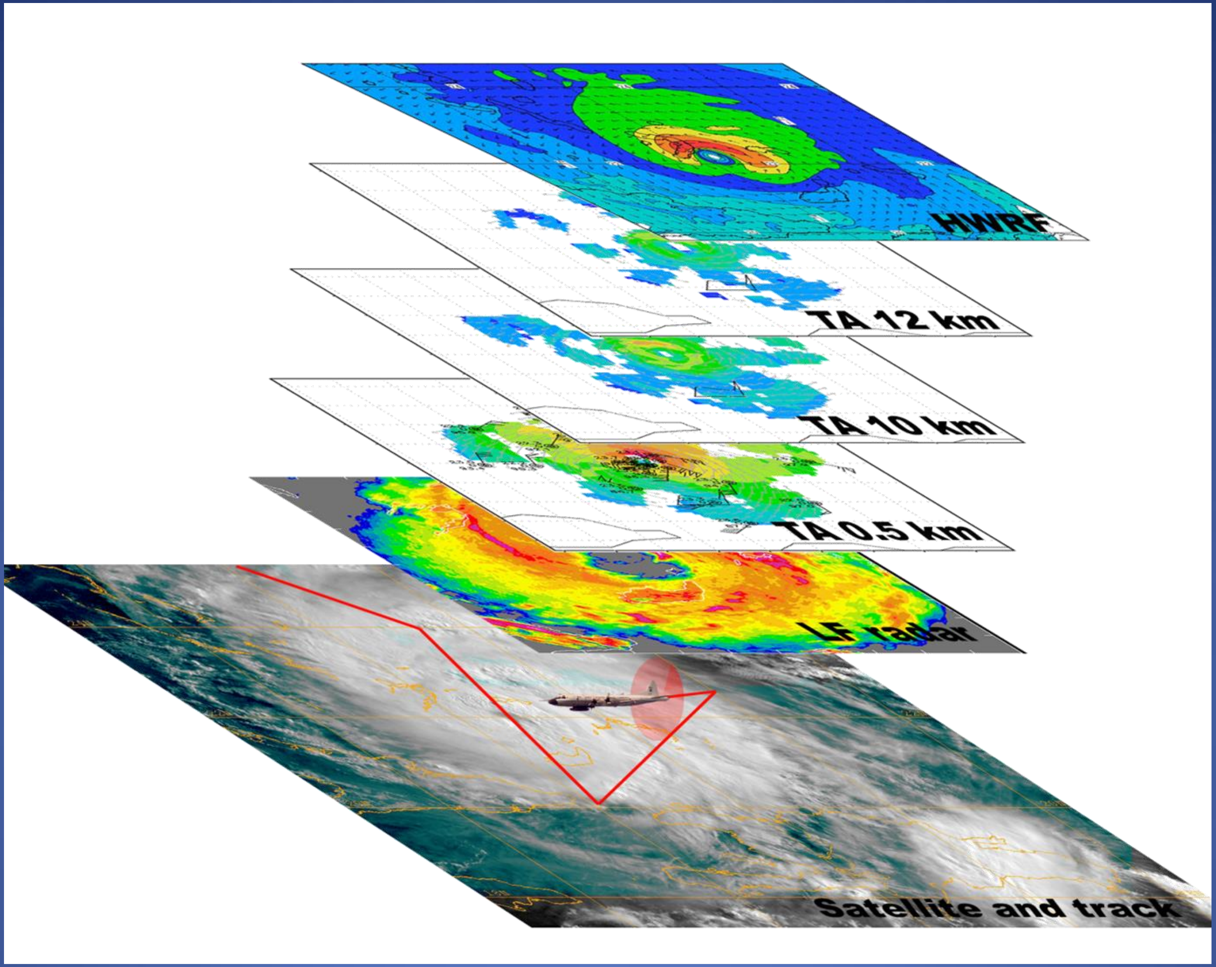


NOAA's Intensity Forecasting Experiment (IFEX)

Robert Rogers

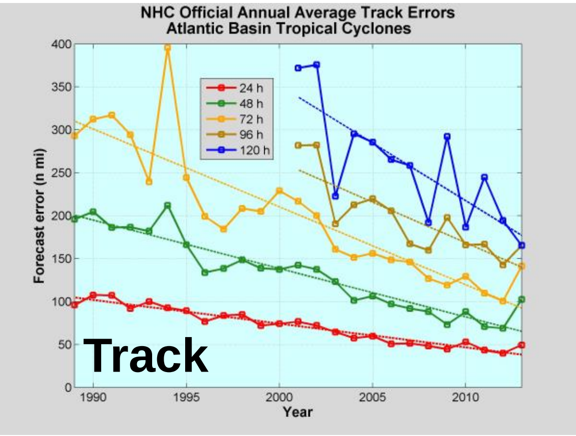
NOAA/AOML Hurricane Research Division
Miami, FL

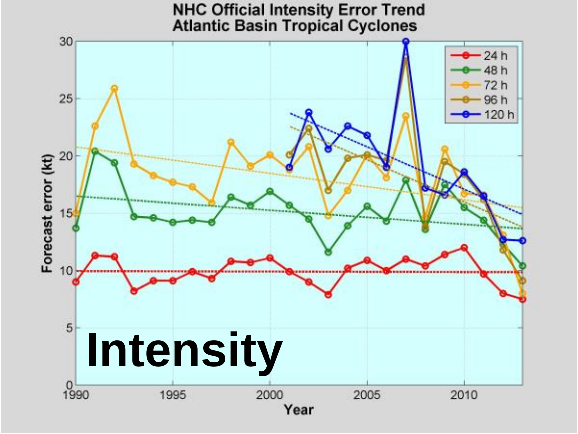
The challenge: TC intensity forecasting

- Advances in forecasts of TC intensity *lag* advances in TC track forecasts

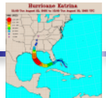
- Multiscale nature of processes are major reason
  - Environmental - O(1000 km) - troughs, shear
  - Vortex - O(1-100 km) - symmetric/asymmetric dynamics, VRWs
  - Convective - O(1 km) - convective bursts, vertical hot towers
  - Turbulent - O(1-100 m) - surface fluxes, PBL mixing, entrainment
  - Microscale - O(1mm) - hydrometeor production, latent heating

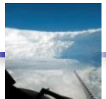
- NOAA is addressing this challenge with modeling, data assimilation, observations, and theory
  - Hurricane Forecast Improvement Project (HFIP) – modeling, data assimilation
  - Intensity Forecasting Experiment (IFEX) – observations, theory



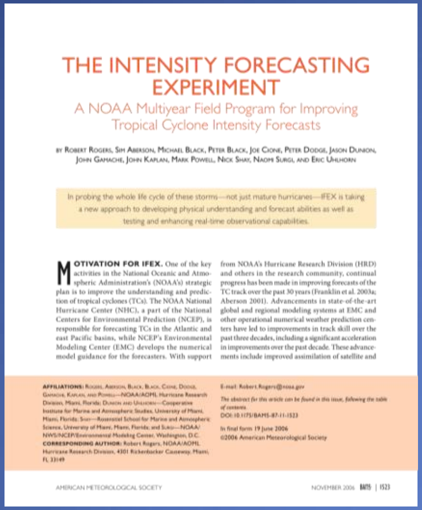


Forged over decades of field work, IFEX supports HFIP by serving as the key observational resource for initialization and evaluation of the model guidance





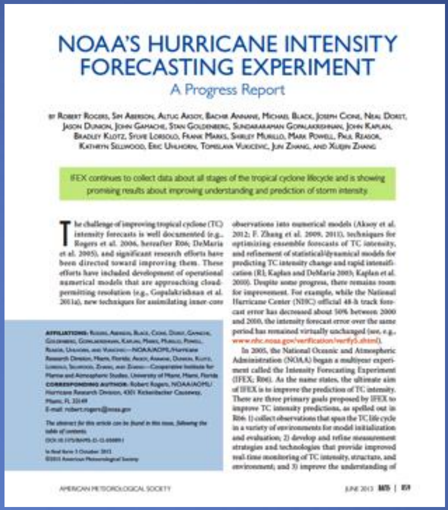
Intensity Forecasting Experiment (IFEX)



THE INTENSITY FORECASTING EXPERIMENT

A NOAA Multiyear Field Program for Improving Tropical Cyclone Intensity Forecasts

Rogers et al., BAMS, 2006



NOAA'S HURRICANE INTENSITY FORECASTING EXPERIMENT

A Progress Report

Rogers et al., BAMS, 2013

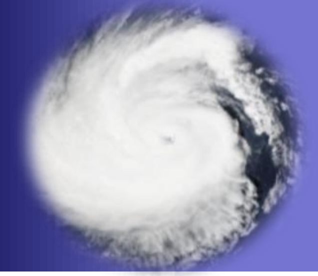
IFEX intended to improve prediction of TC intensity change by addressing three goals:

1) Collecting observations that span TC life cycle across scales for model initialization and evaluation
2) Developing and refining measurement technologies that provide improved real-time monitoring of TC intensity, structure, and environment
3) Improving understanding of physical processes important in intensity change for a TC at all stages of its life cycle

These goals provide the linkage between observations, modeling, DA, and theory that form the foundation of the work done at HRD

Intensity Forecast Experiment

Observing platforms and instruments



In-situ

- Wind, press., temp.

Expendables

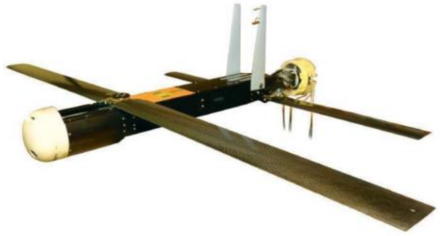
- Dropsondes
- AXBT, AXCP, buoy

Remote Sensors

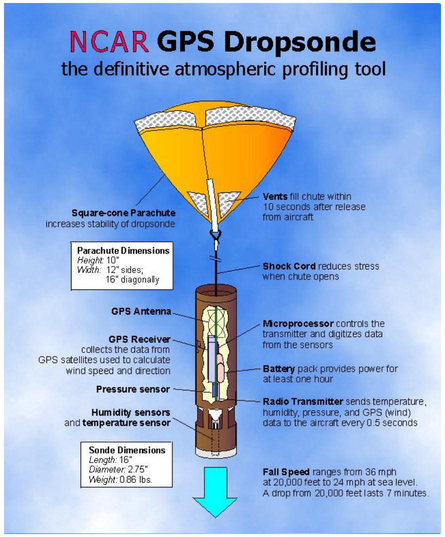
- Tail Doppler Radar(TDR)
- SFMR/HIRAD
- WSRA
- Scatterometer/profiler
- UAS

NASA Global Hawk

G-IV Tail Doppler Radar



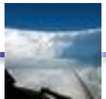
Coyote UAS



GPS Dropsonde

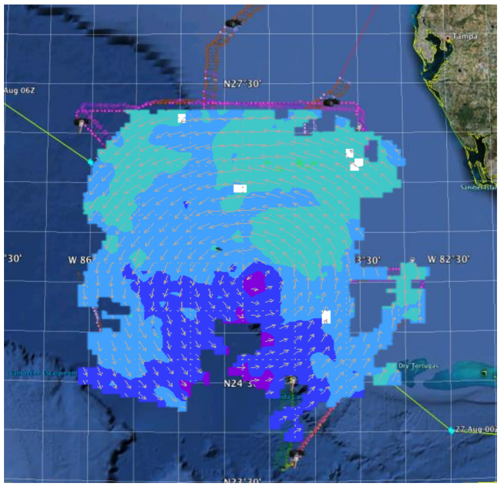
Doppler Wind Lidar



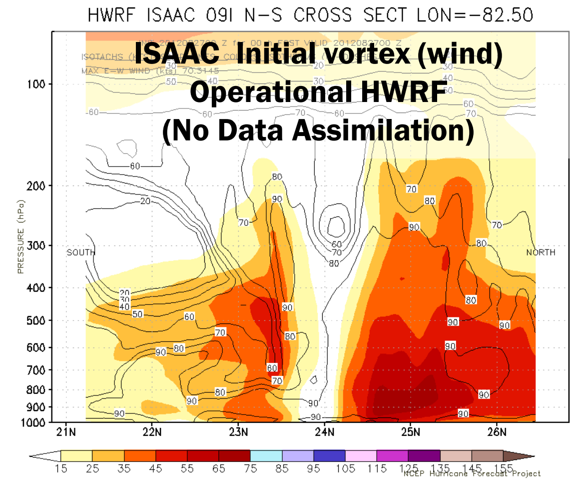


IFEX Goal 1: Assimilation of data into models

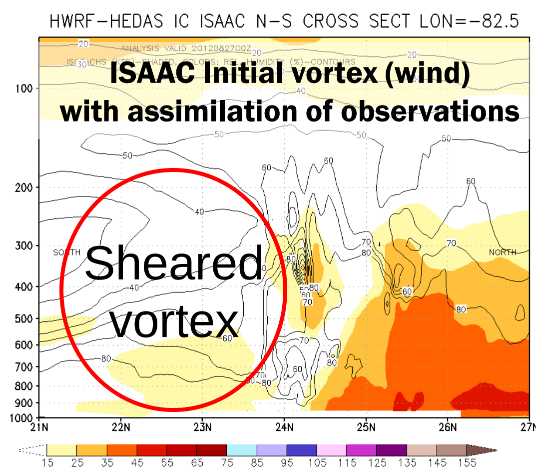
Impact Of Aircraft Observations On HWRF Forecast
- Improving Storm Structure At Initial Time -



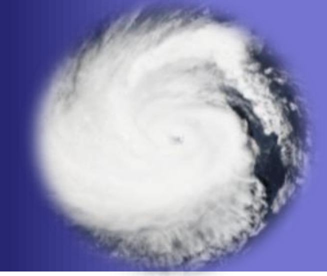
The Hurricane Research Division of AOML developed a state-of the-art inner core data assimilation system for HWRF (HEDAS) [Runs in real-time under HFIP]

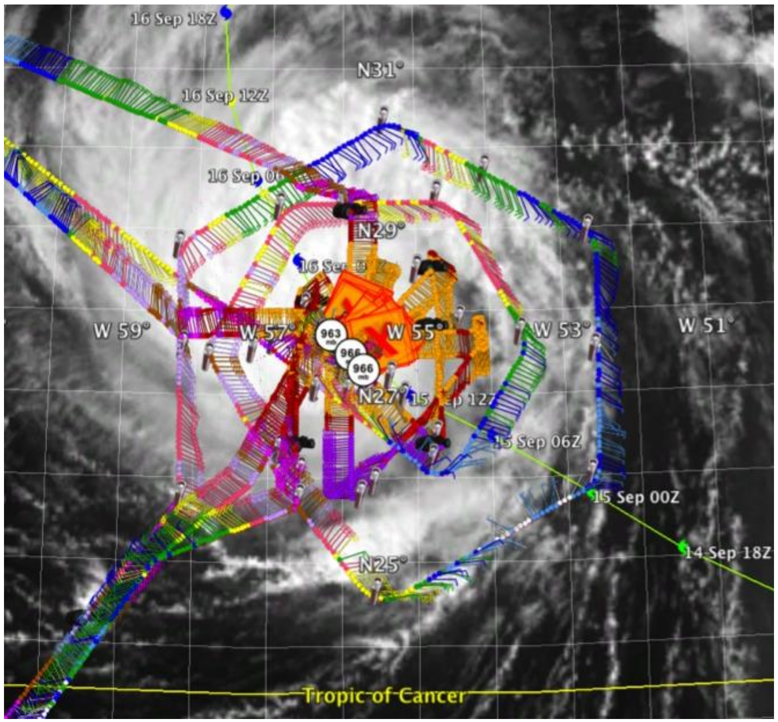


ISAAC (2012): Intensity Errors (kt)				
Forecast Hrs	**12**	**24**	**36**	**48**
Operational HWRF	**13**	**16**	**26**	**26**
With P-3 Data	**8**	**3**	**9**	**20**
# Cases	**9**	**7**	**5**	**3**

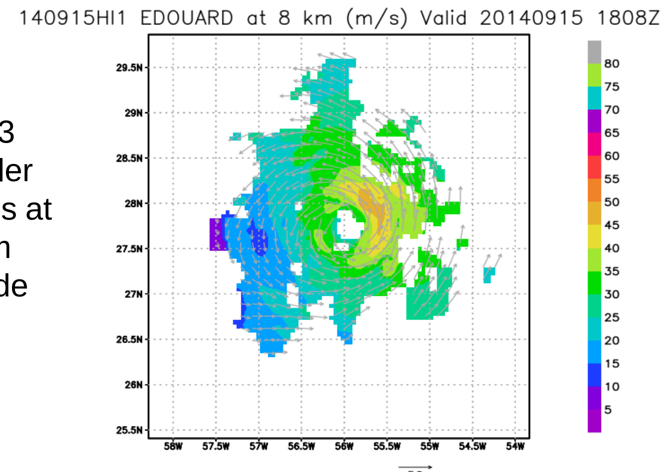


IFEX Goal 2: Develop & refine observing technologies: G-IV TDR

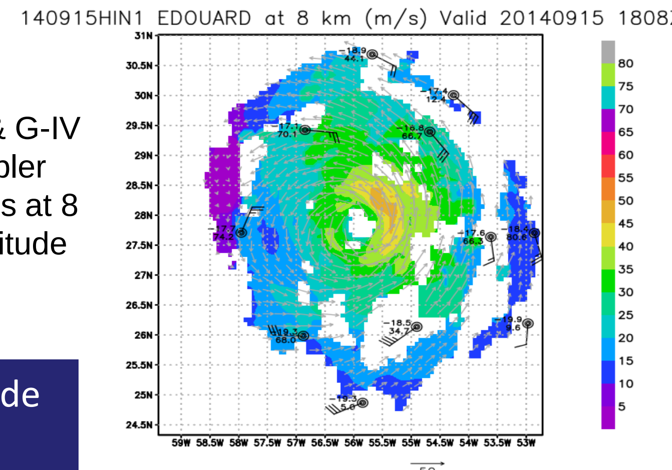




2 P-3 and G-IV flight track in Hurricane Edouard 15 September 2014



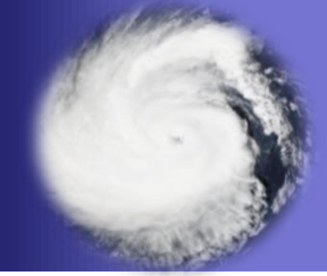
2 P-3 Doppler analysis at 8 km altitude

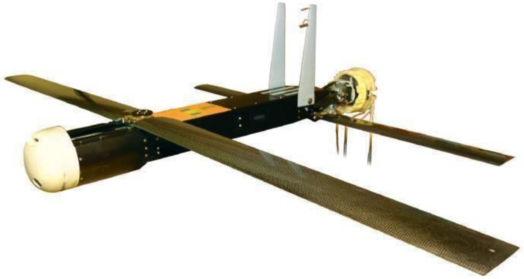


2 P-3 & G-IV Doppler analysis at 8 km altitude

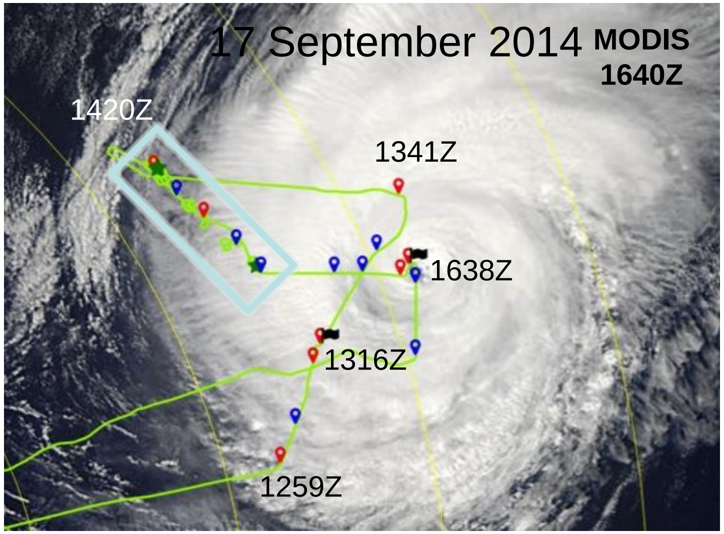
- G-IV Doppler can provide enhanced coverage, especially at higher altitude
- G-IV can be flown further from center to supplement environment and supplement P-3, or closer to center to “replace” P-3

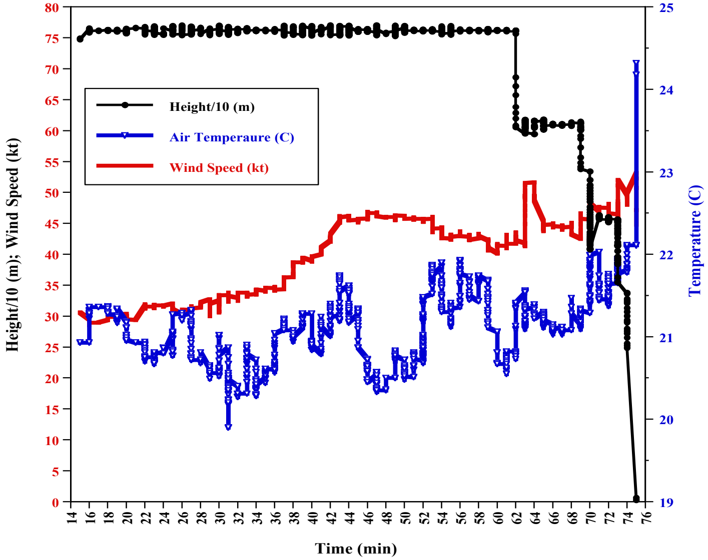
IFEX Goal 2: Develop & refine observing technologies: Coyote low-level UAS





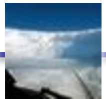
Coyote measurements in Hurricane Edouard (2014)





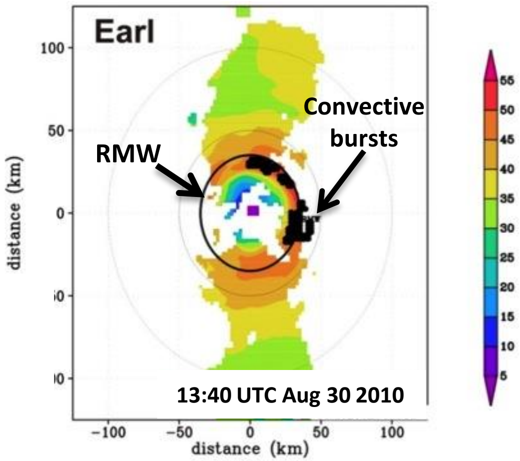
- released from P-3 like a dropsonde, can be controlled for ~2 h
- can get measurements down to surface, where manned aircraft can not safely reach

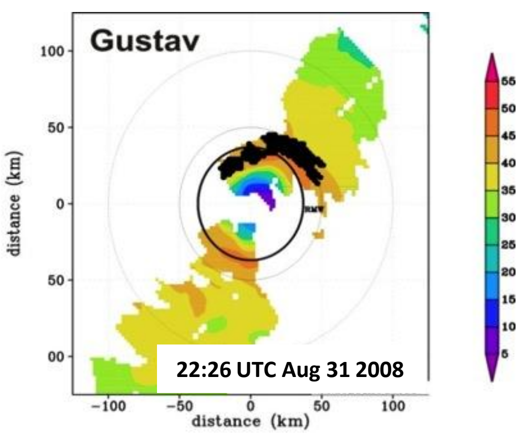




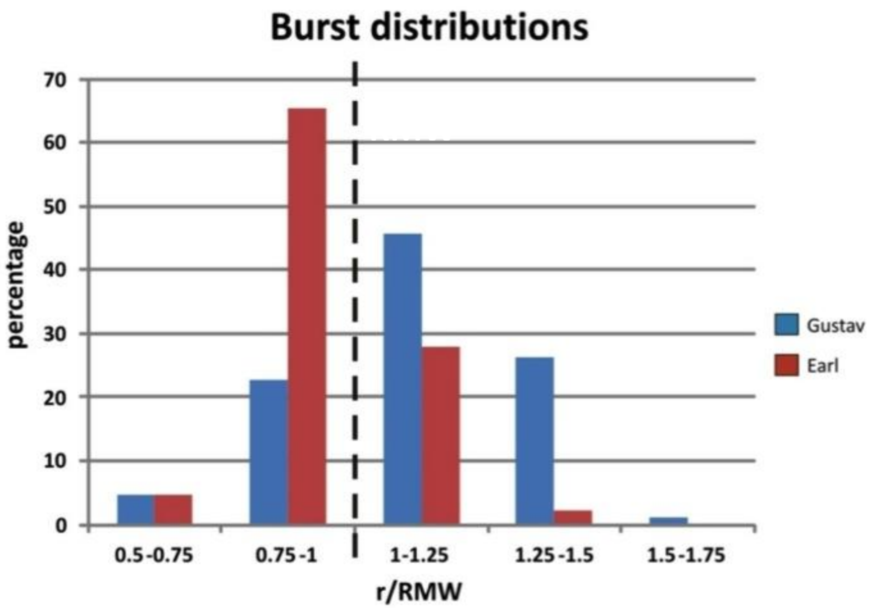
IFEX Goal 3: Improve understanding of physical processes: Rapid Intensification

TDR observation of wind speed at 2 km (shaded, m/s) and burst locations





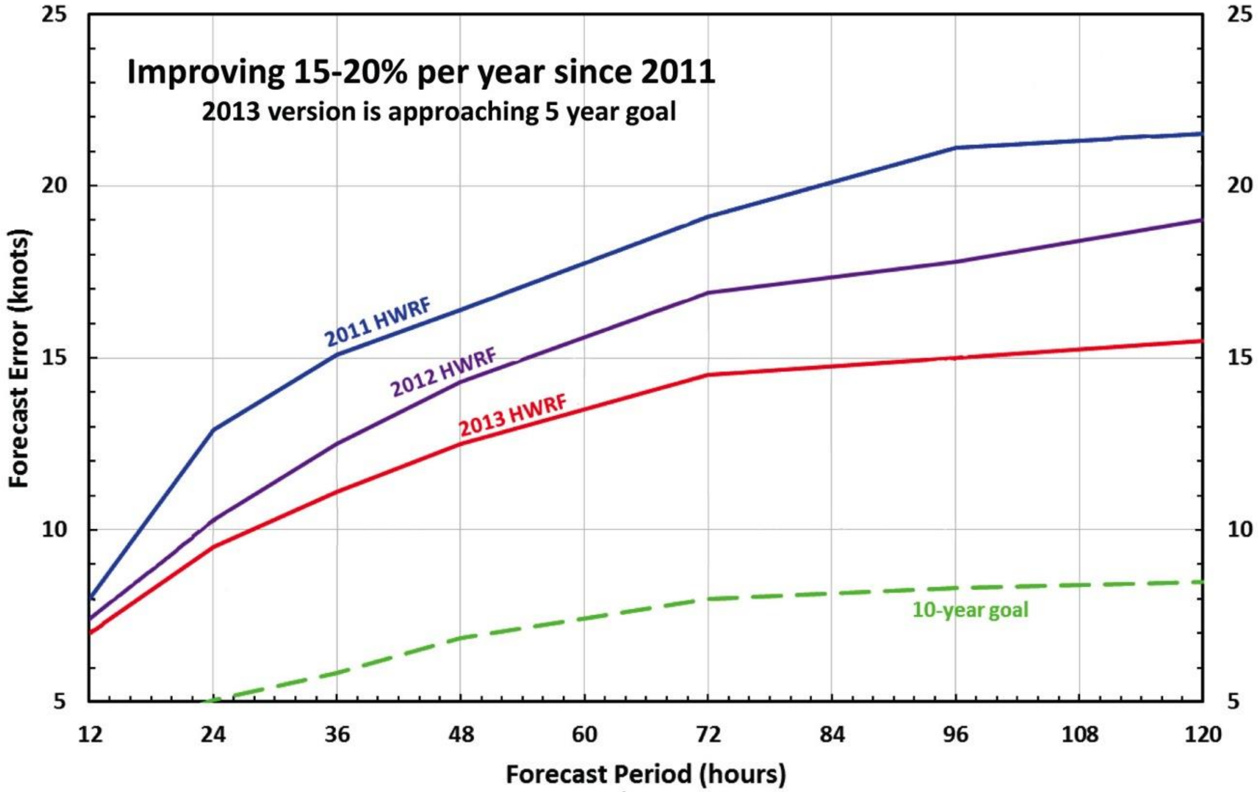
Radial distribution of convective bursts



- both storms ~ 50 m/s hurricane, RMW of ~35 km
- convective burst distribution peaked inside RMW for Earl, outside RMW for Gustav
- what causes differences in radial distributions of deep convection?

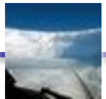
HWRF intensity forecast improvements

HWRF intensity forecast error

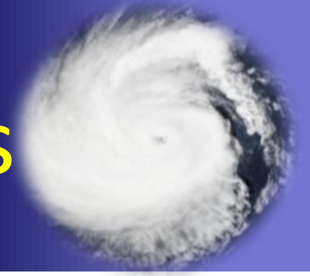


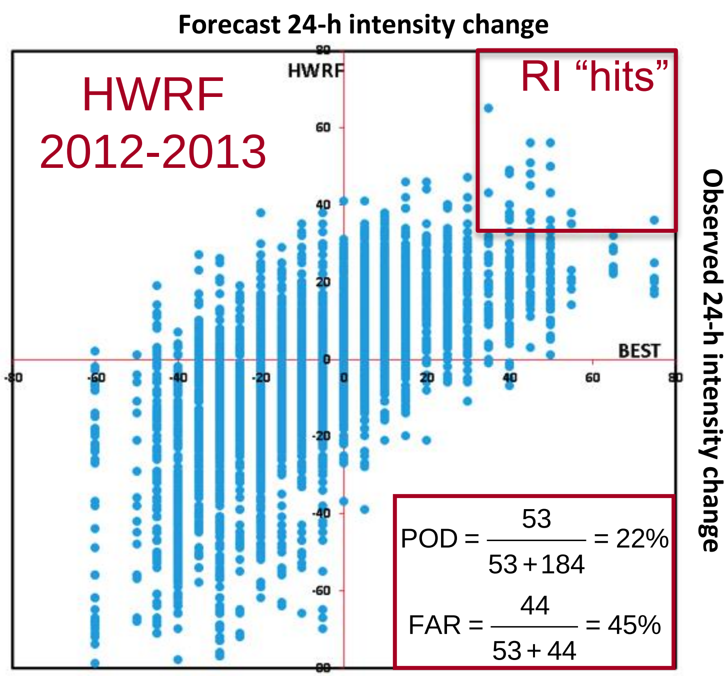
- Intensity forecast error for HWRF has decreased markedly over three years of model developments, but still more work to do

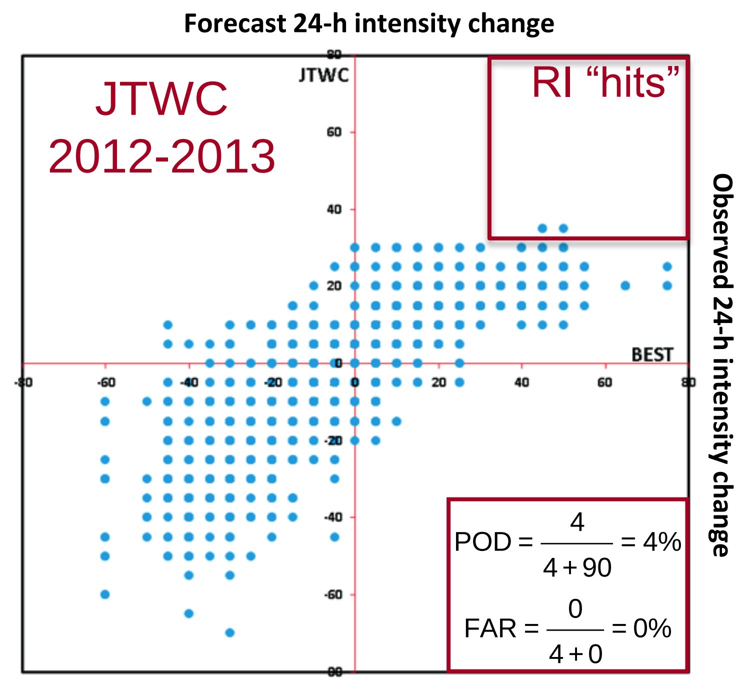




HWRF intensity forecast improvements

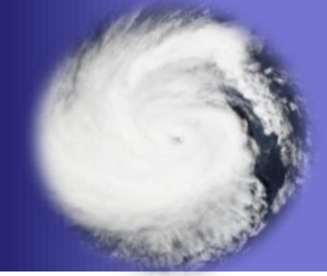






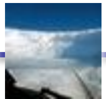
- HWRF Probability of Detection for RI is ~ 22% , much higher compared to operations and other models (previous analysis of RI for WPAC in 2012 showed <10% skill).

IFEX plans for 2015



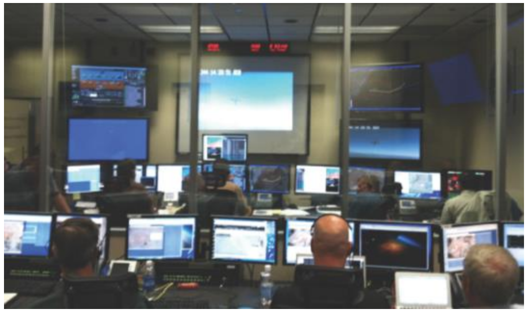
- Continue addressing IFEX/HFIP goals
  - IFEX Goal 1:
    - TDR missions
  - IFEX Goal 2:
    - Coyote deployment
    - Doppler Wind Lidar testing
    - Interactions with NOAA unmanned field campaign, Sensing Hazards with Operational Unmanned Technology (SHOUT)
  - IFEX Goal 3:
    - RI processes, especially early in lifecycle
    - TC intensification in shear
- Sustain our partnerships with EMC and NHC
- G-IV and one P-3 available
- Encourage greater awareness in broader TC community





NOAA SHOUT 2015

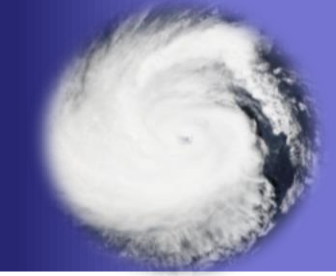
GOAL: Test prototype UAS concept of operations that could mitigate the risk of diminished high impact weather warnings in case of polar-orbiting satellite observing gaps



Global Hawk

- Flight level: ~55-60,000 ft
- Duration: ~24 h
- Range: 11,000 nm
- Payload: 1500+ lbs
- Deployment site: NASA Wallops Flight Facility, VA
- 5 week deployment (late Aug through Sep)
- Instrumentation: AVAPS, HAMSR, & HIWRAP

Outreach



- Our blog

http://noaahrd.wordpress.com

- HRD Web page

http://www.aoml.noaa.gov/hrd

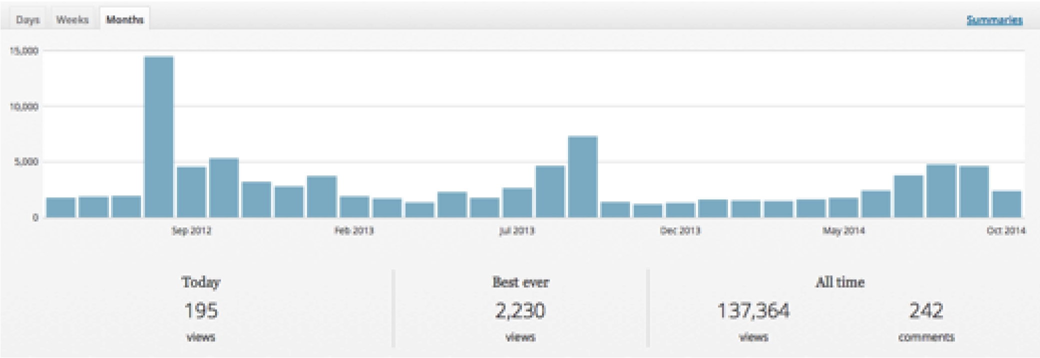
- Facebook (3,475 likes)

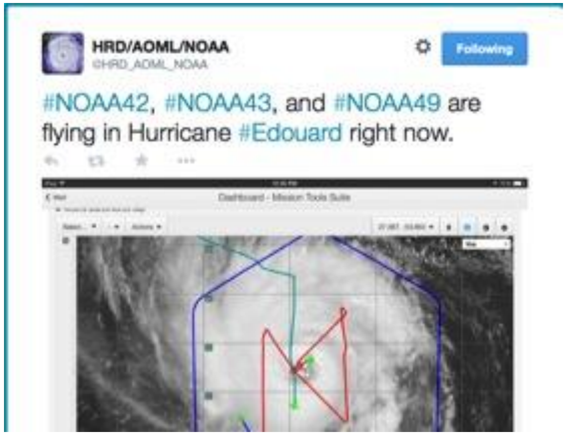
http://www.facebook.com/noaahrd

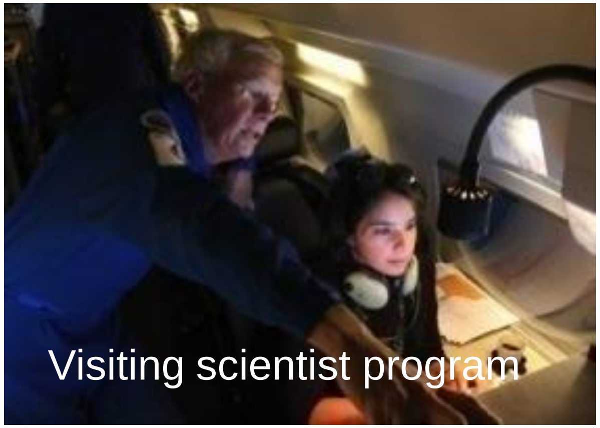
- Twitter (12,900 followers)

http://twitter.com/#!/HRD_AOML_NOAA

follow us on twitter





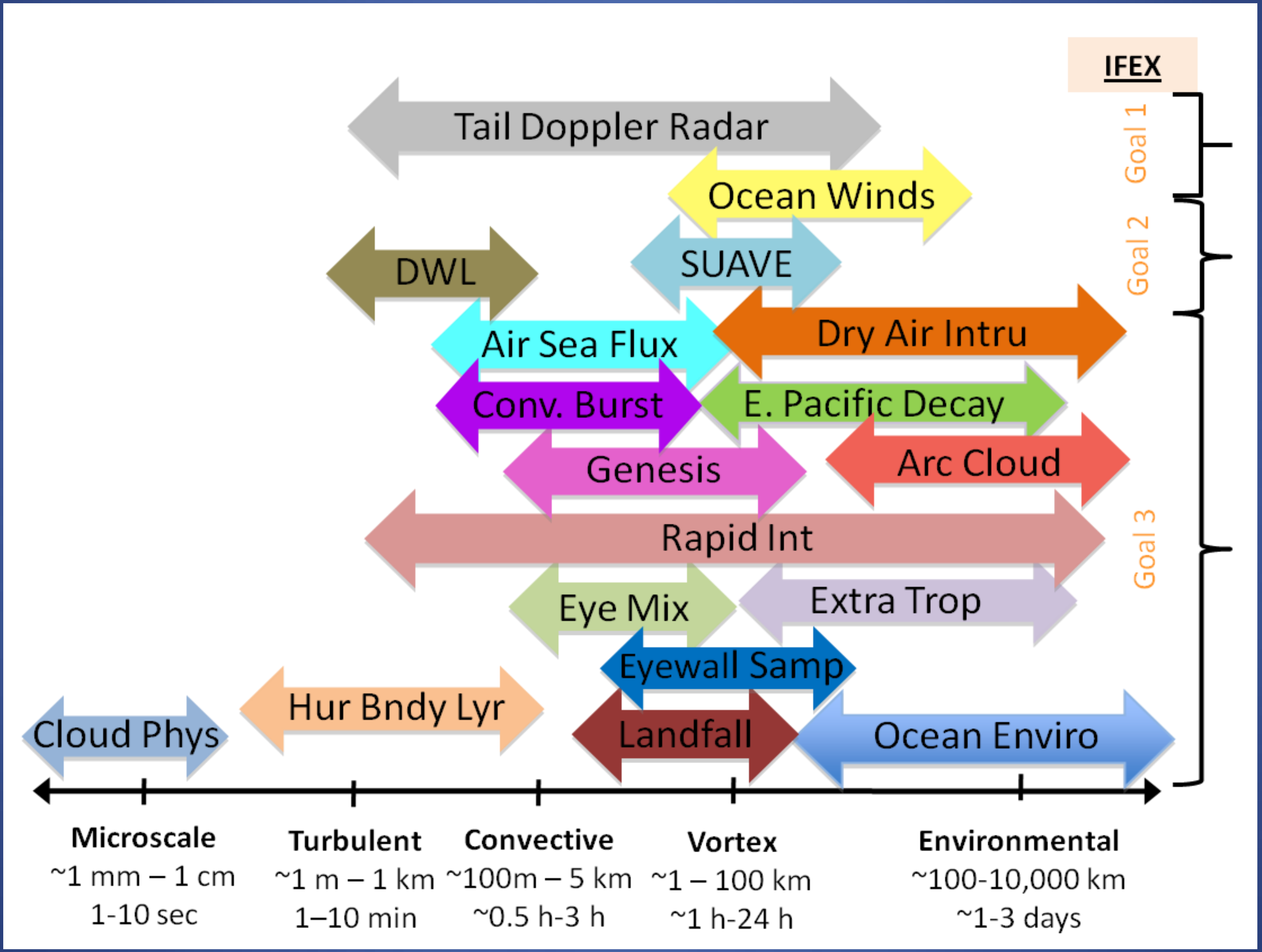



Thank you!
Hurricane Edouard

Extra slides

Goal 1: Collecting observations across scales

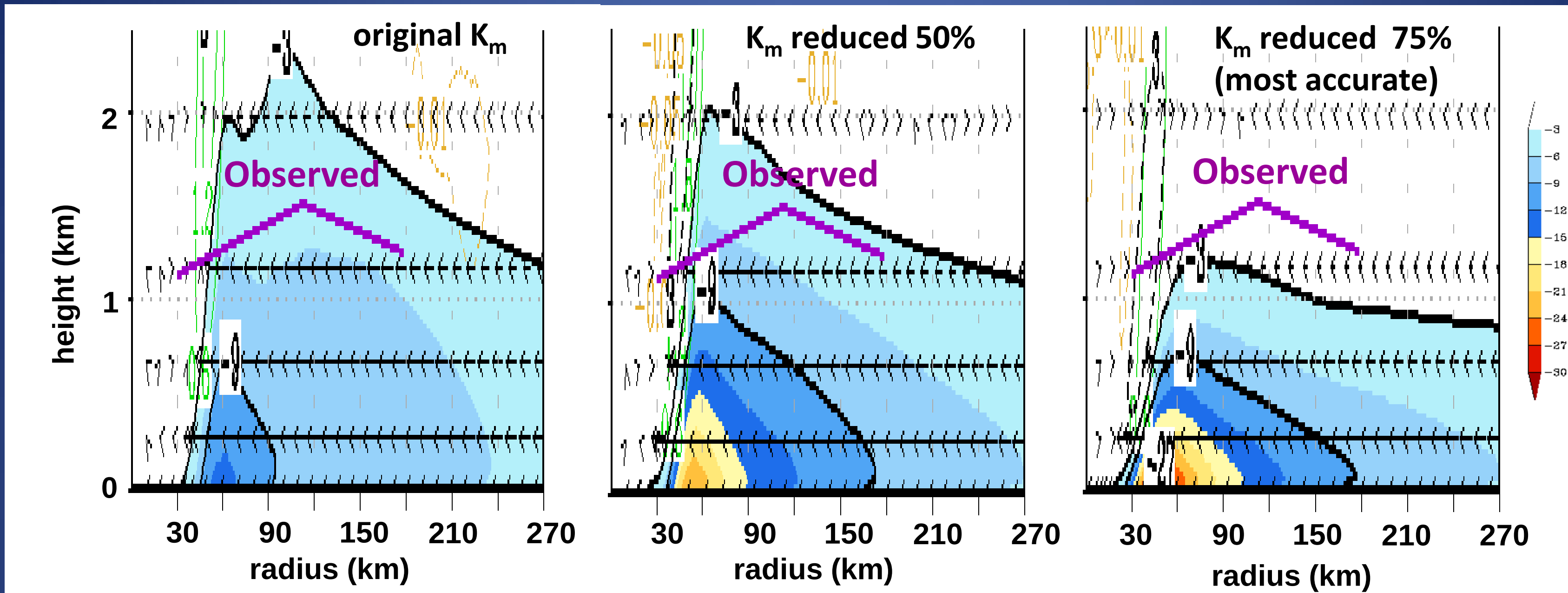
Spatial/temporal scales of IFEX flight experiments



IFEX experiments span the multitude of spatial and temporal scales important in TC intensity change

Goal 1: Numerical model evaluation

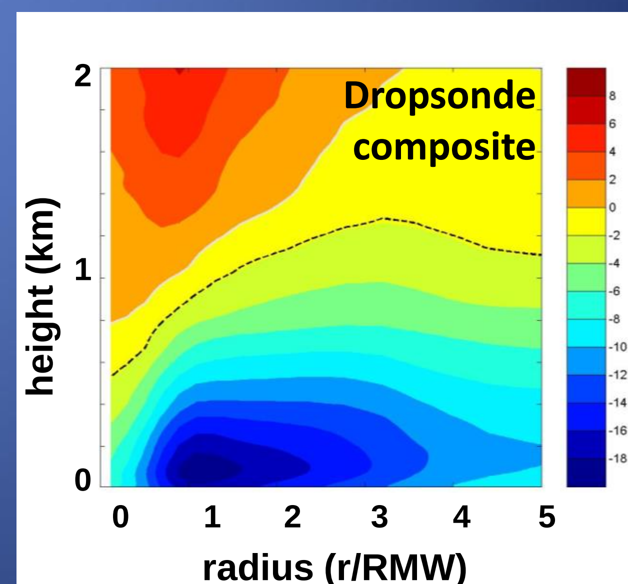
Sensitivity of radial wind (shaded, m s^{-1}) to vertical eddy diffusivity (K_m)



Gopal et al. 2012

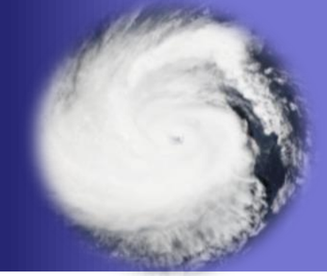
- Peak radial inflow stronger with more accurate K_m
- Depth of inflow layer more consistent with dropsonde composites using more accurate K_m

Dashed line is inflow layer depth from dropsonde composite



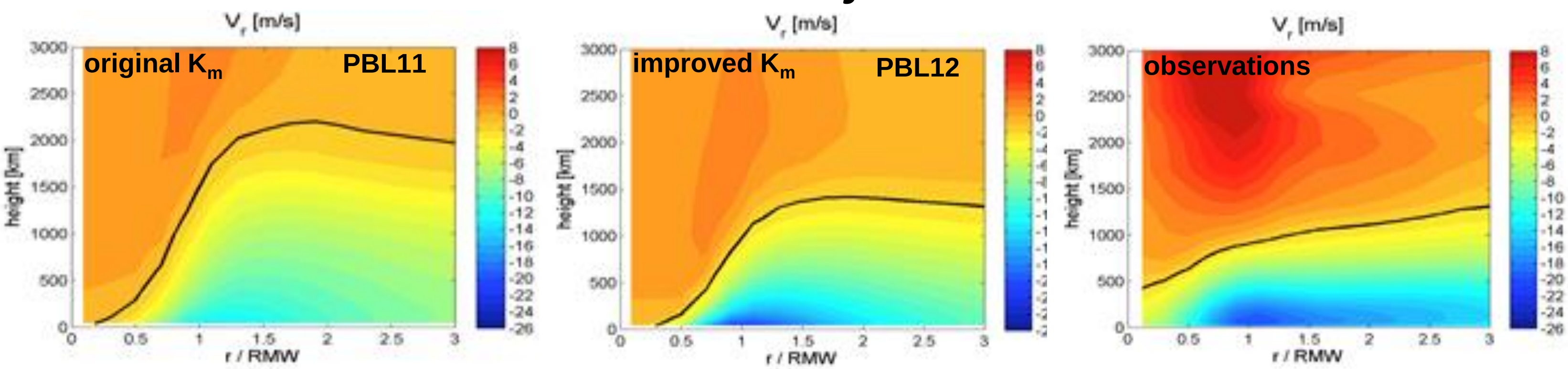
Zhang et al. 2011

Goal 3: Improve understanding of physical processes: PBL processes and RI

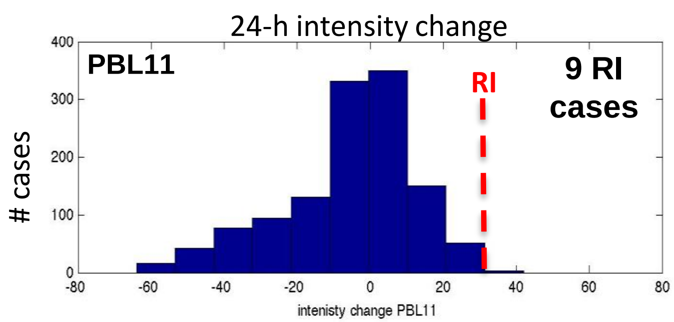


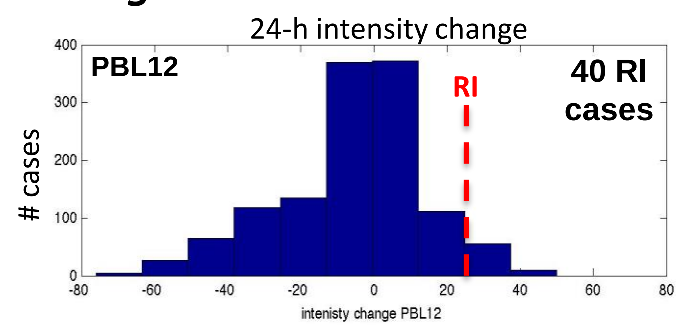
Impact of vertical eddy diffusivity (K_m) on HWRF RI prediction

Radial flow



Intensity change histogram





- using smaller (and more realistic) K_m improves inflow depth
- smaller K_m produces more RI cases

Zhang et al., MWR, 2015 (under review)