NOAA's Intensity Forecasting Experiment

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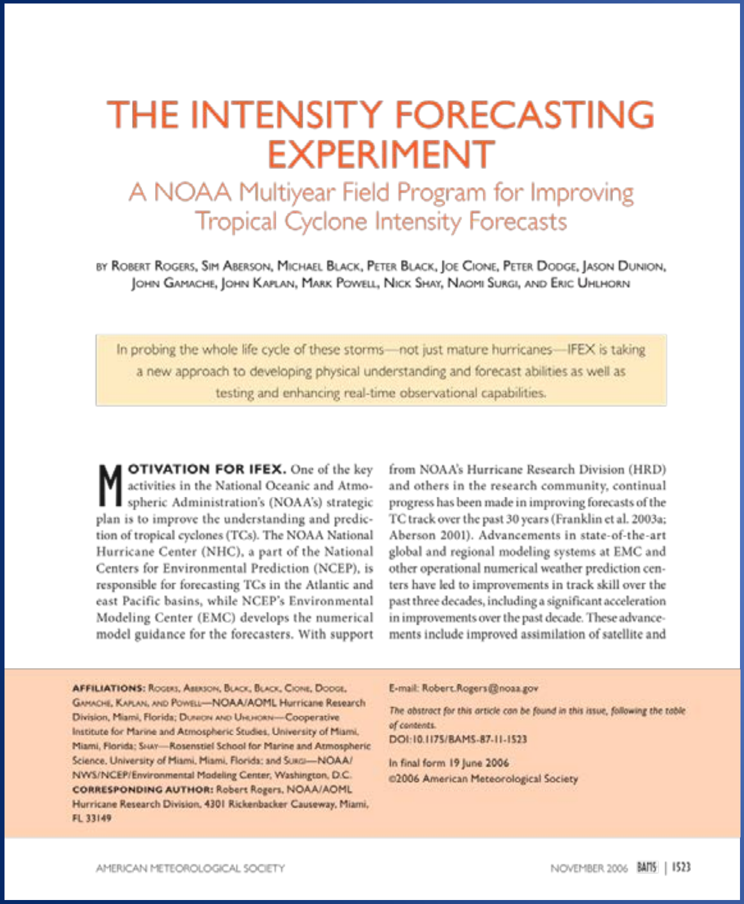
Intensity Forecasting Experiment (IFEX; Rogers et al., BAMS, 2006)



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

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IFEX intended to improve prediction of TC intensity change by:

1) collecting observations that span TC life cycle in a variety of environments 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

Percentage (%) of on-station aircraft flight hours

	Pre- IFEX 1956-2004	IFEX 2005-2011
Pre-TD	**4.3**	**9.9**
TD	**7.2**	**5.5**
TS	**26.8**	**37.1**
Cat 1-2	**31.6**	**24.8**
Cat 3-5	**30.0**	**22.7**

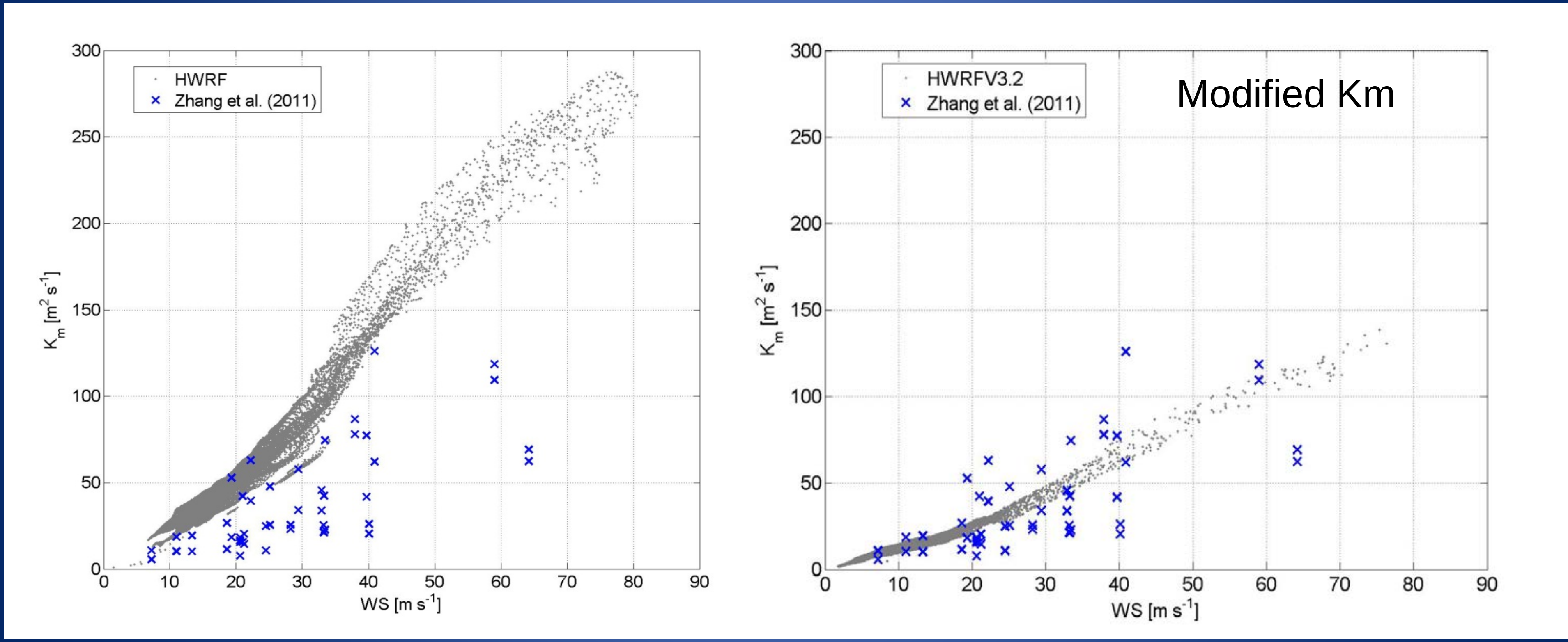
Pre-IFEX: 8020 total hours flown
IFEX: 2526 total hours flown

Notable storms (2006-2011) flown by NOAA aircraft

Storm	Dates of NOAA missions	NOAA Aircraft	Dropsondes	Operational Radar analyses	Comments
TS Debby	Aug 24-26 2006	N49 (2)	59	0	SAL
TS Helene	Sept 14-20 2006	N42 (4), N49 (4)	209	2	SAL
Hurr Felix	Aug 31 - Sept 3 2007	N42 (2), N43 (2)	46	5	RI, major hurricane
TS Ingrid	Sept 12-18 2007	N42 (3), N43 (3)	66	13	Sheared system
TS Karen	Sept 25-28 2007	N42 (1), N43 (1)	5	7	Sheared system
TS Fay	Aug 14-19 2008	N42 (3), N43 (3), N49 (4)	212	19	Genesis, landfall
Hurr Gustav	Aug 28 - Sept 3 2008	N42 (3), N43 (4), N49 (4)	253	18	Lifecycle; first realtime transmission of superobs
Ike	Sept 5-15 2008	N42 (6), N43 (3), N49 ([illegible])	419	16	Lifecycle; first realtime use of superobs in DA
Hurr Kyle	Sept 23-27 2008	N42 (4), N43 (4)	59	22	Genesis
Hurr Paloma	Nov 7-8 2008	N43 (3), N49 (2)	99	13	RI
Hurr Bill	Aug 18-21 2009	N43 (5), N49 (6)	288	13	Lifecycle; SAL
TD #2	July 6-8 2010	N42 (3), N49 (2)	121	19	Genesis
Earl	Aug 28 - Sept 3 2010	N42 (5), N43 (6), N49 ([illegible])	393	35	RI and mature phase; with NASA GRIP DC-8 and Global Hawk
Hurr Karl	Sept 12-16 2010	N42 (2), N43 (2), N49 (4)	175	11	Genesis, RI; with NASA GRIP DC-8 and Global Hawk and NSF PREDICT G-V
Hurr Tomas	Nov 3-6 2010	N42 (3), N43 (2), N49 (1)	81	17	Sheared system
Irene	Aug 22-27 2011	N42 (4), N43 (3), N49 (9)	494	25	Lifecycle monitoring
Hurr Rina	Oct 25-27 2011	N42 (4), N49 (2)	129	8	Sheared system

IFEX Goal 1: Model evaluation

Modification of vertical eddy diffusivity (Km) in the operational HWRF model based on in situ measurements



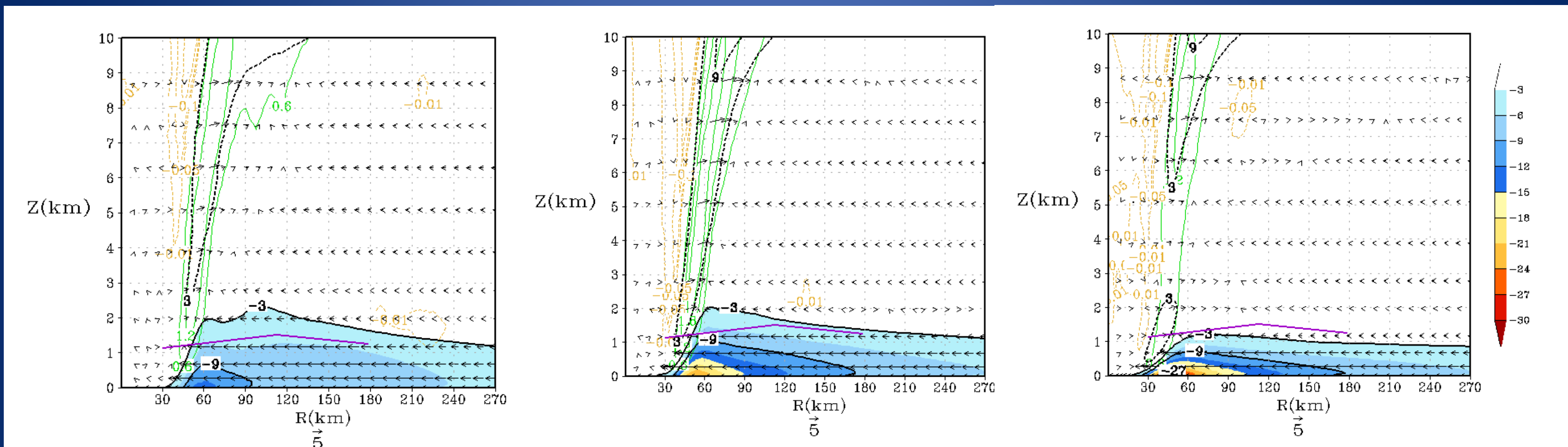
MRF-type PBL schemes are too diffusive

IFEX Goal 1: Model evaluation

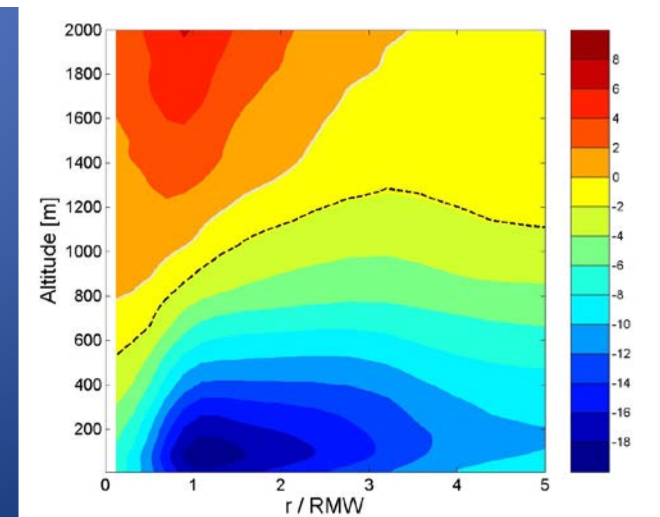
Sensitivity of axisymmetric radial wind to vertical eddy diffusivity

(Gopalakrishnan et al. 2012 JAS, in review)

Original Km in HWRF | Km reduced 50% | Km reduced 75%



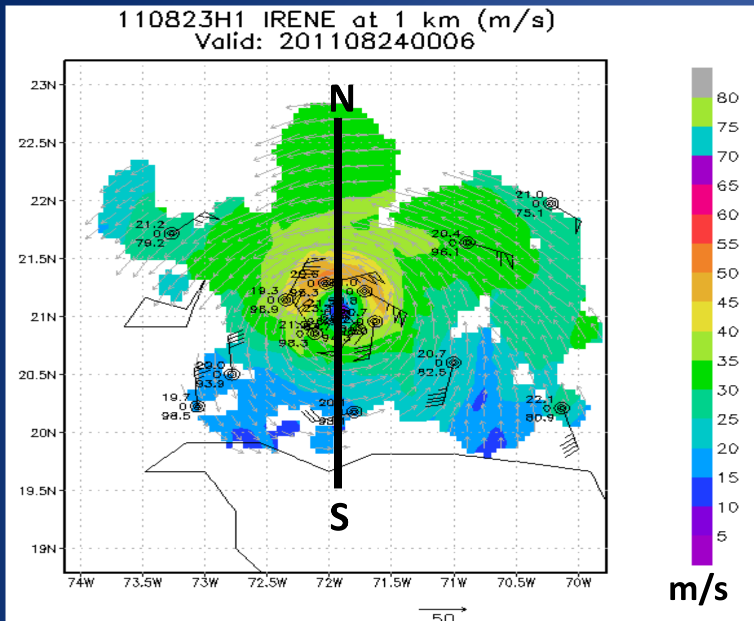
- peak radial inflow stronger with more accurate Km
- depth of inflow layer more consistent with dropsonde composites using more accurate Km

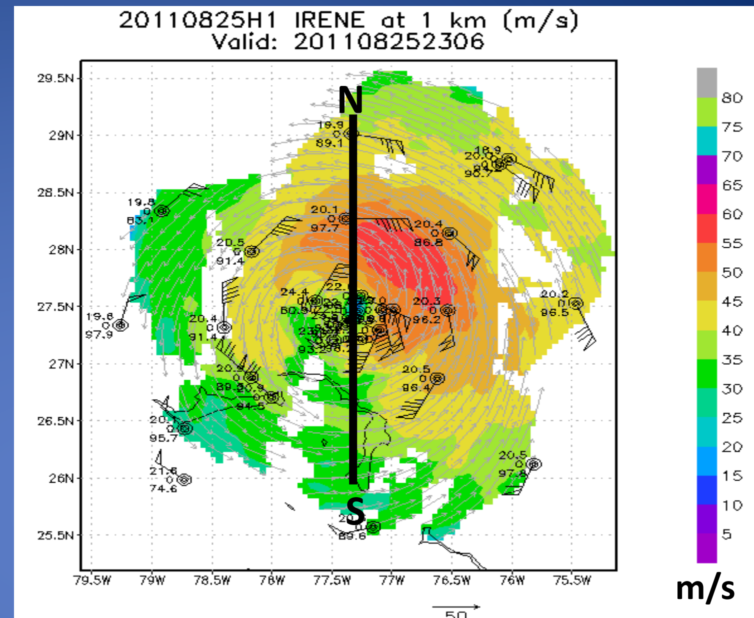


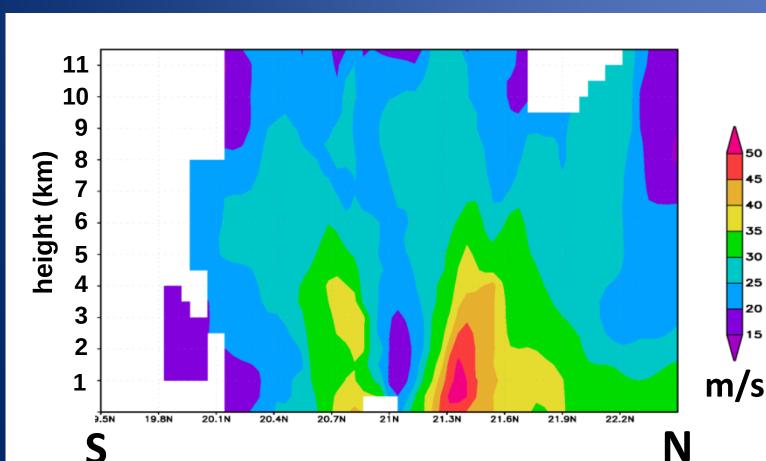
Dashed line is inflow layer depth from dropsonde composite (Zhang et al. 2011 MWR: On the characteristic height scales of the hurricane boundary layer).

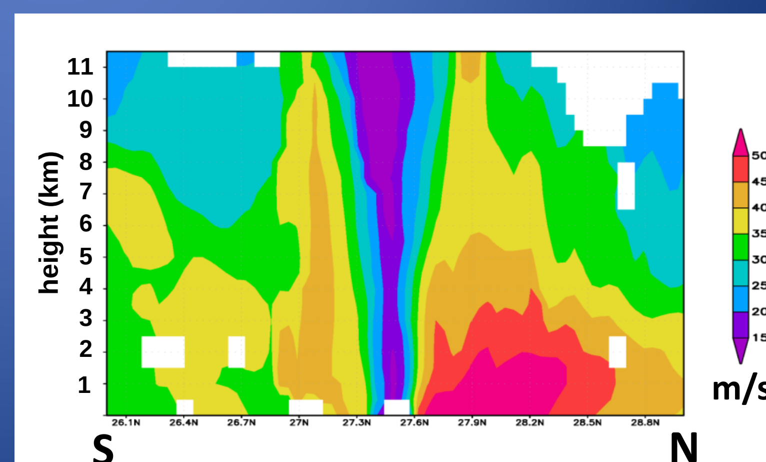
IFEX Goal 2: Real-time monitoring of TC structure and intensity

P-3 Tail Doppler and Dropsonde Measurements in Hurricane Irene (2011)







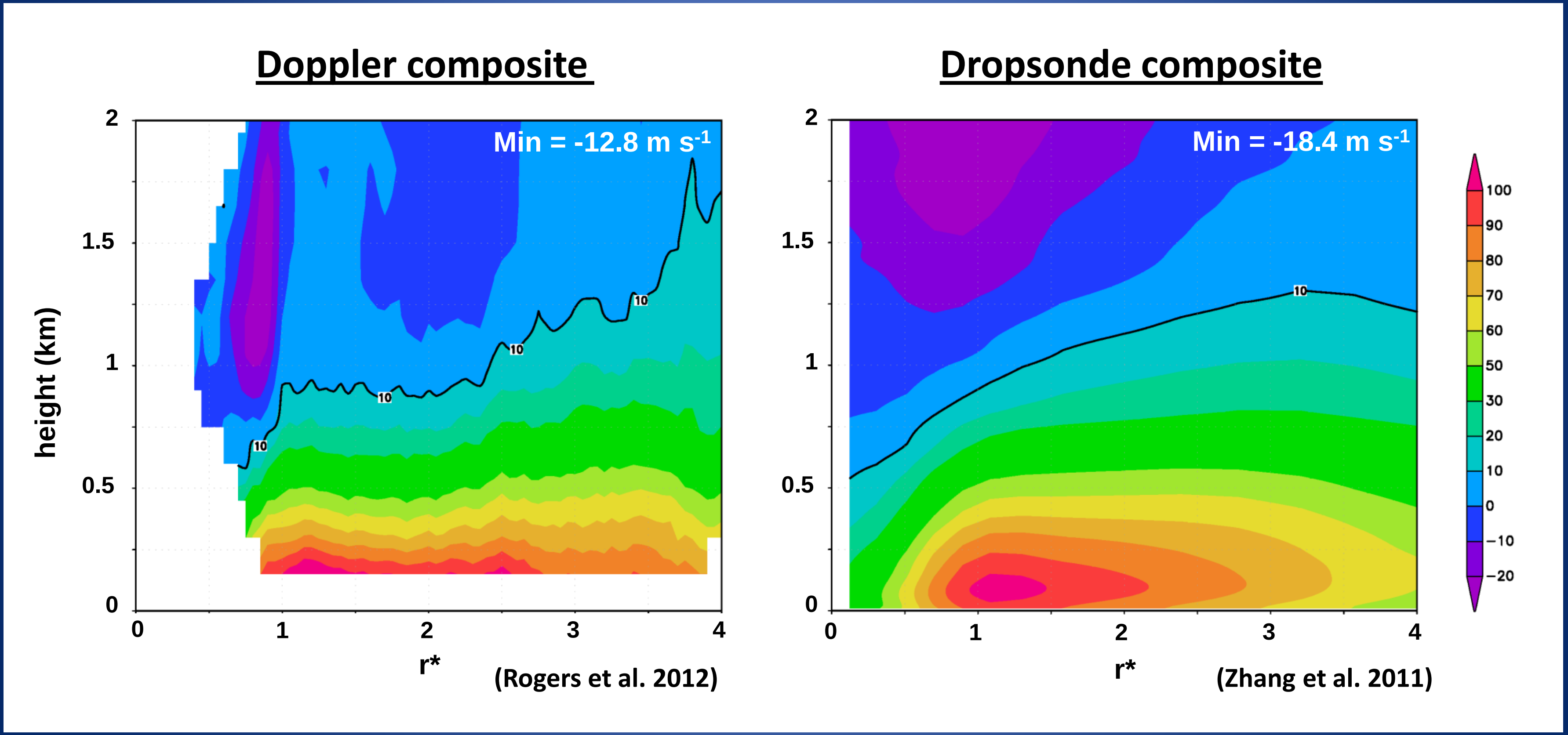


Flight 110823H1 **Flight 110825H1**

IFEX Goal 3: Improved understanding of intensity change processes

Axisymmetric radial inflow from composite datasets

Radial flow scaled by peak value at/near surface (shaded, %)

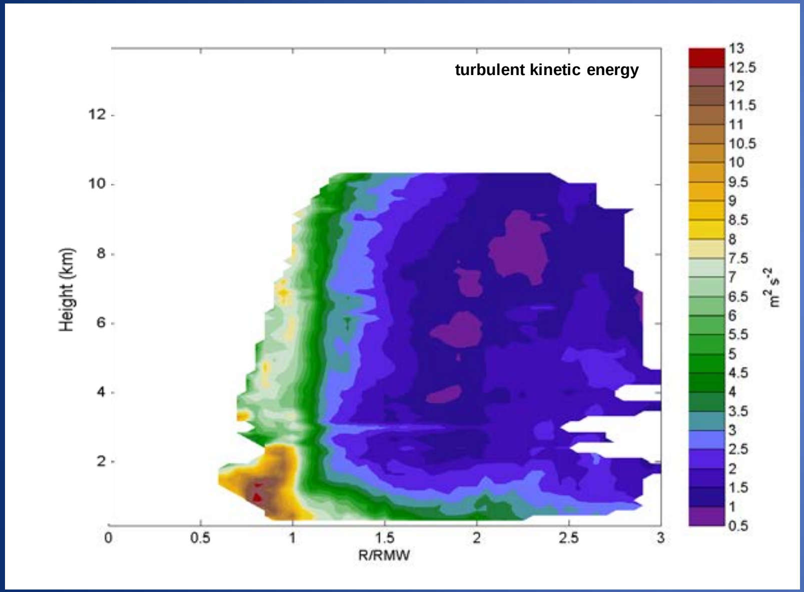


• similar inflow layer depth, radial flow structure despite completely different composite members, data sources, analysis methodology

IFEX Goal 3: Improved understanding of intensity change processes

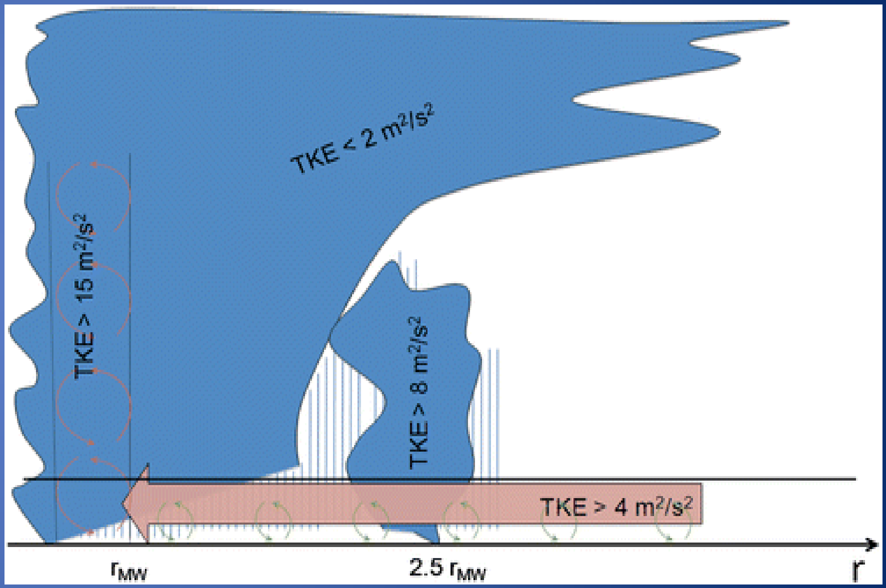
Turbulence kinetic energy structure of inner core

Composite of TKE from airborne Doppler



Rogers et al. (2012)

Conceptual model of TKE in inner core



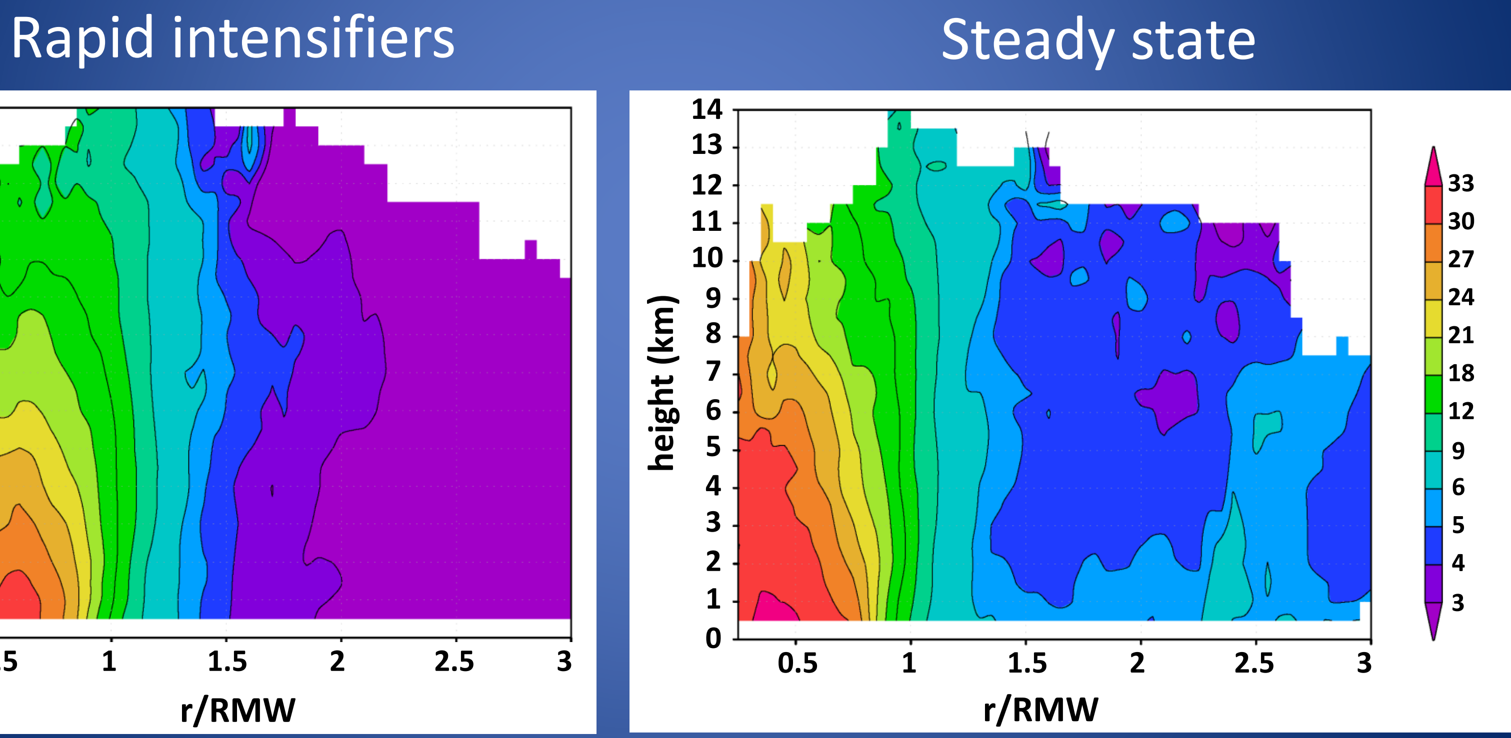
Lorsolo et al. (2010)

- TKE maximized within hurricane PBL, along inner eyewall edge
- secondary maximum sometimes evident in presence of rainbands, secondary eyewalls

IFEX Goal 3: Improved understanding of intensity change processes

TC inner-core structure and rapid intensification

Composite mean vertical vorticity (x 10^{-4} s^{-1})

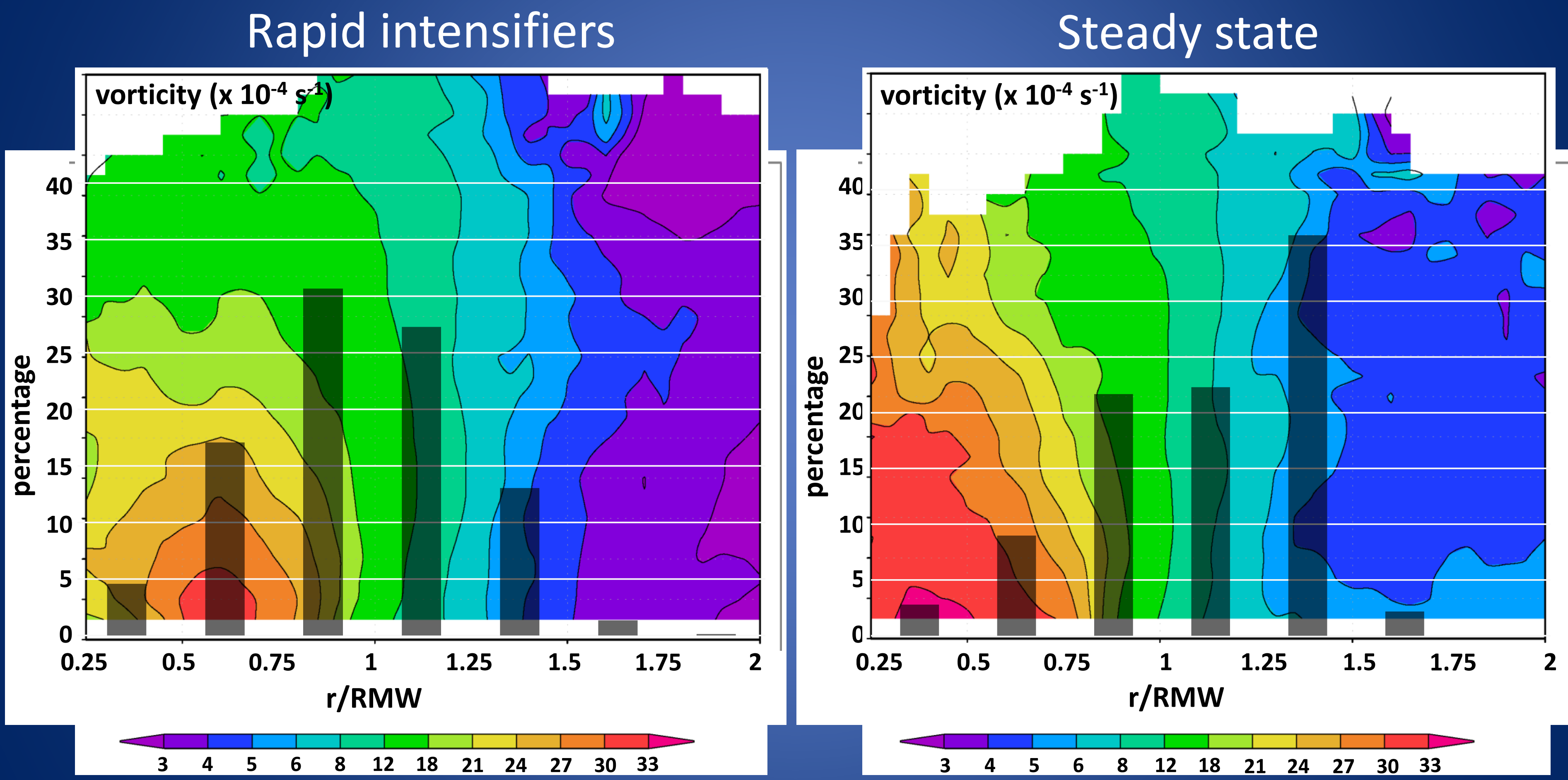


- more ring-like structure in eyewall vorticity, lower outer-core vorticity for RI cases

IFEX Goal 3: Improved understanding of intensity change processes

TC inner-core structure and rapid intensification

Radial distribution of convective bursts



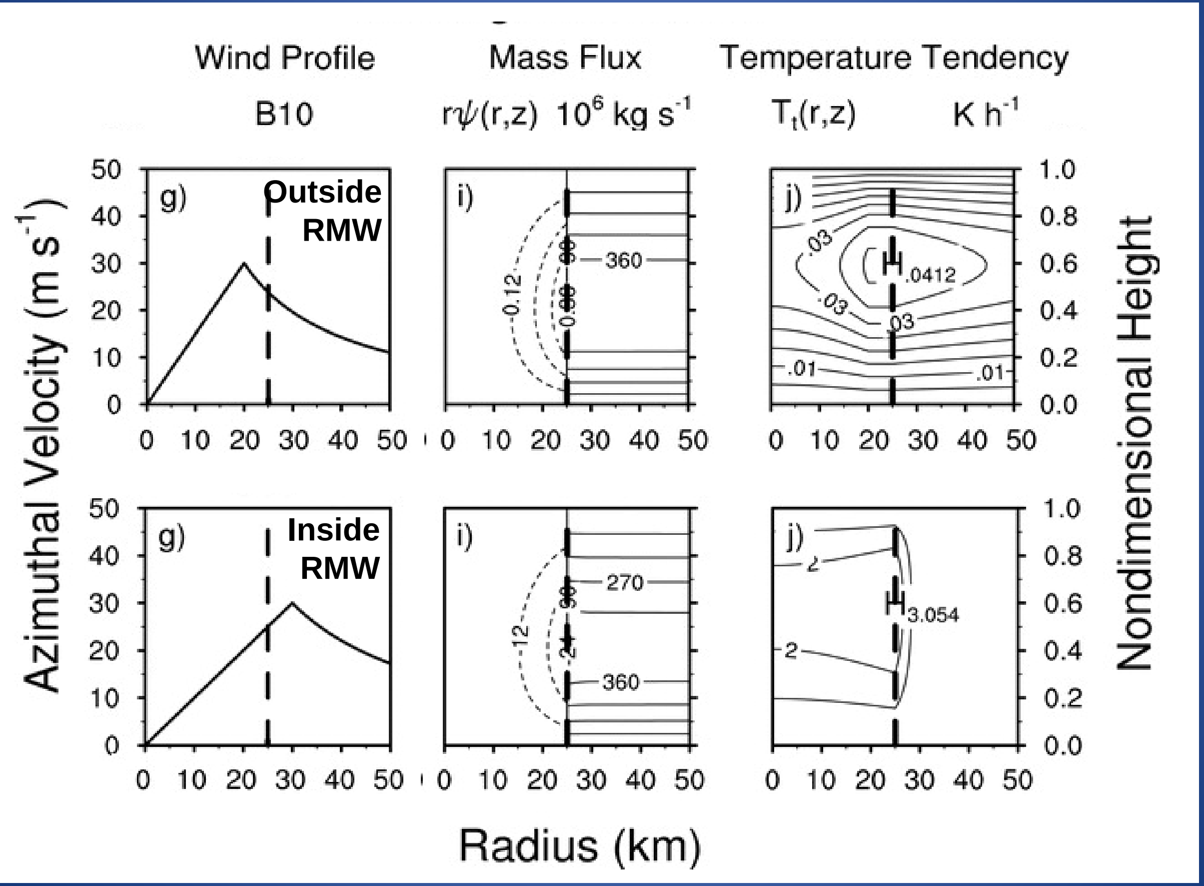
RI cases show

- radial distribution of convective bursts that peaks inside RMW compared with outside RMW for SS cases

IFEX Goal 3: Improved understanding of intensity change processes

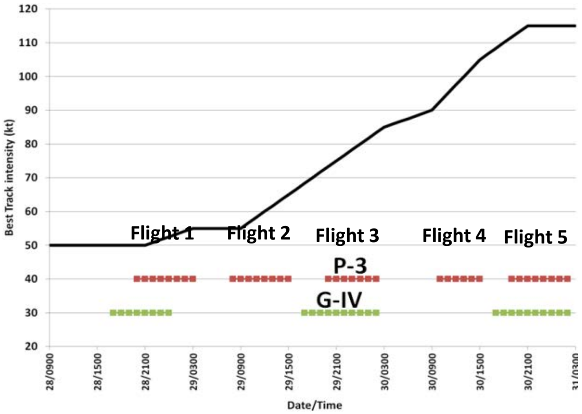
TC inner-core structure and rapid intensification

Radial location of diabatic heating



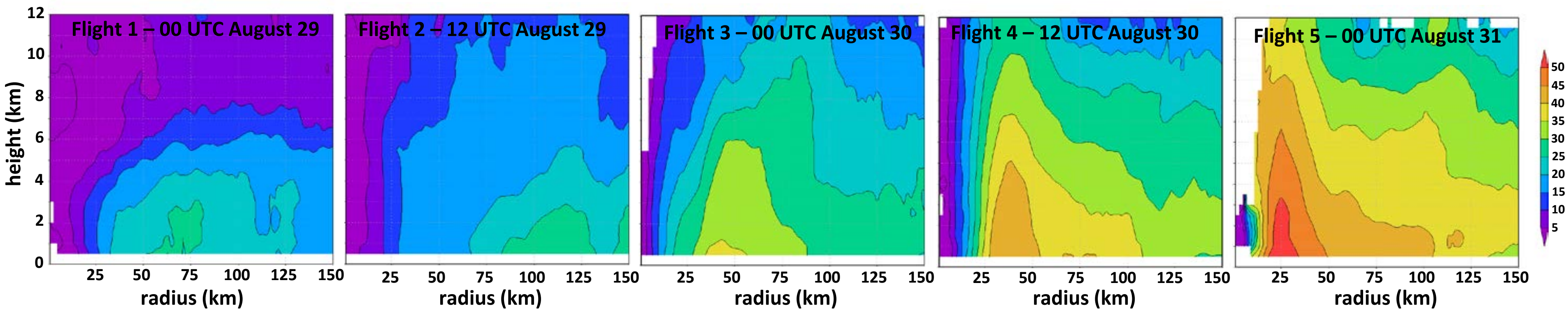
(adapted from Vigh and Schubert, 2009)

Example from individual case: Earl (2010)

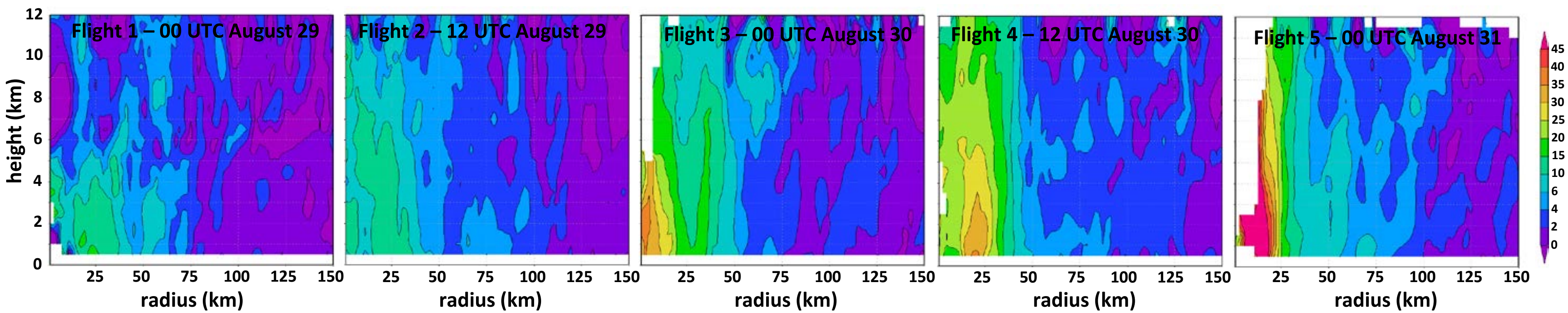


Sampling times of NOAA aircraft during Earl's RI

Axisymmetric tangential wind (shaded, m s^{-1})

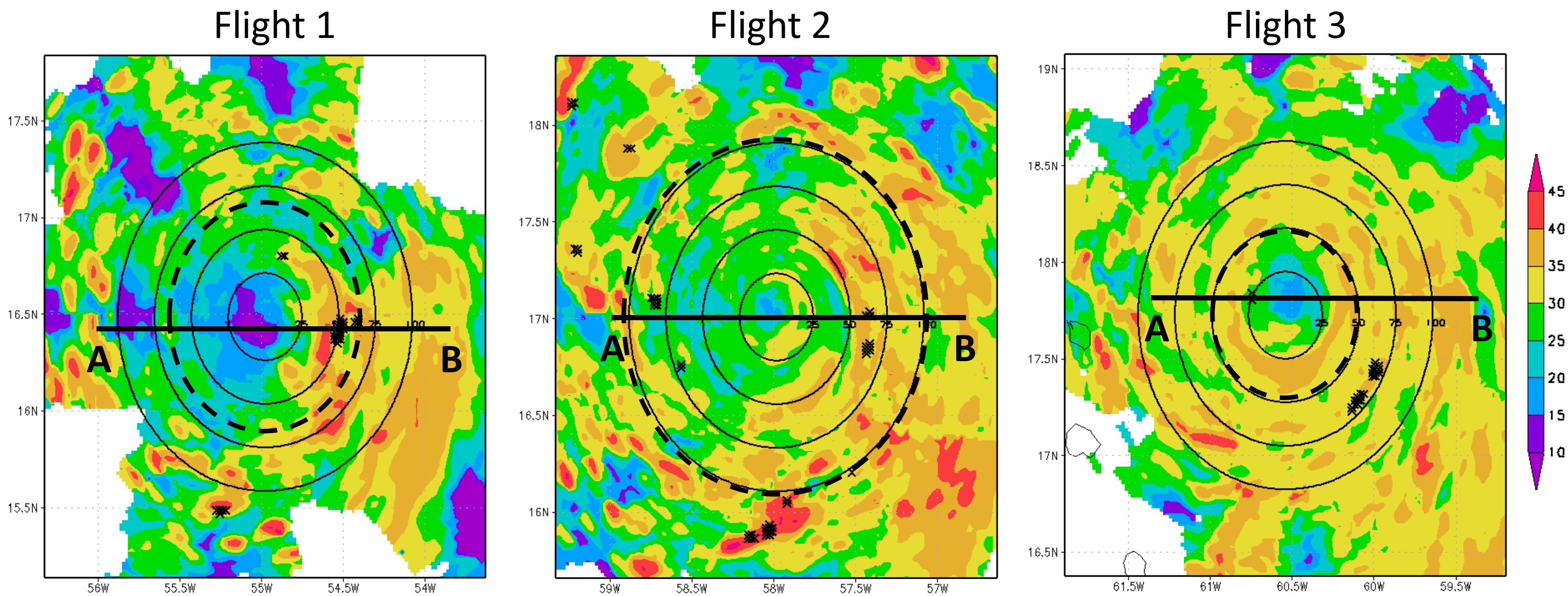


Axisymmetric vorticity (shaded, x 10^{-4} s^{-1})



Example from individual case: Earl (2010)

Reflectivity (shaded, dBZ) at 2 km altitude

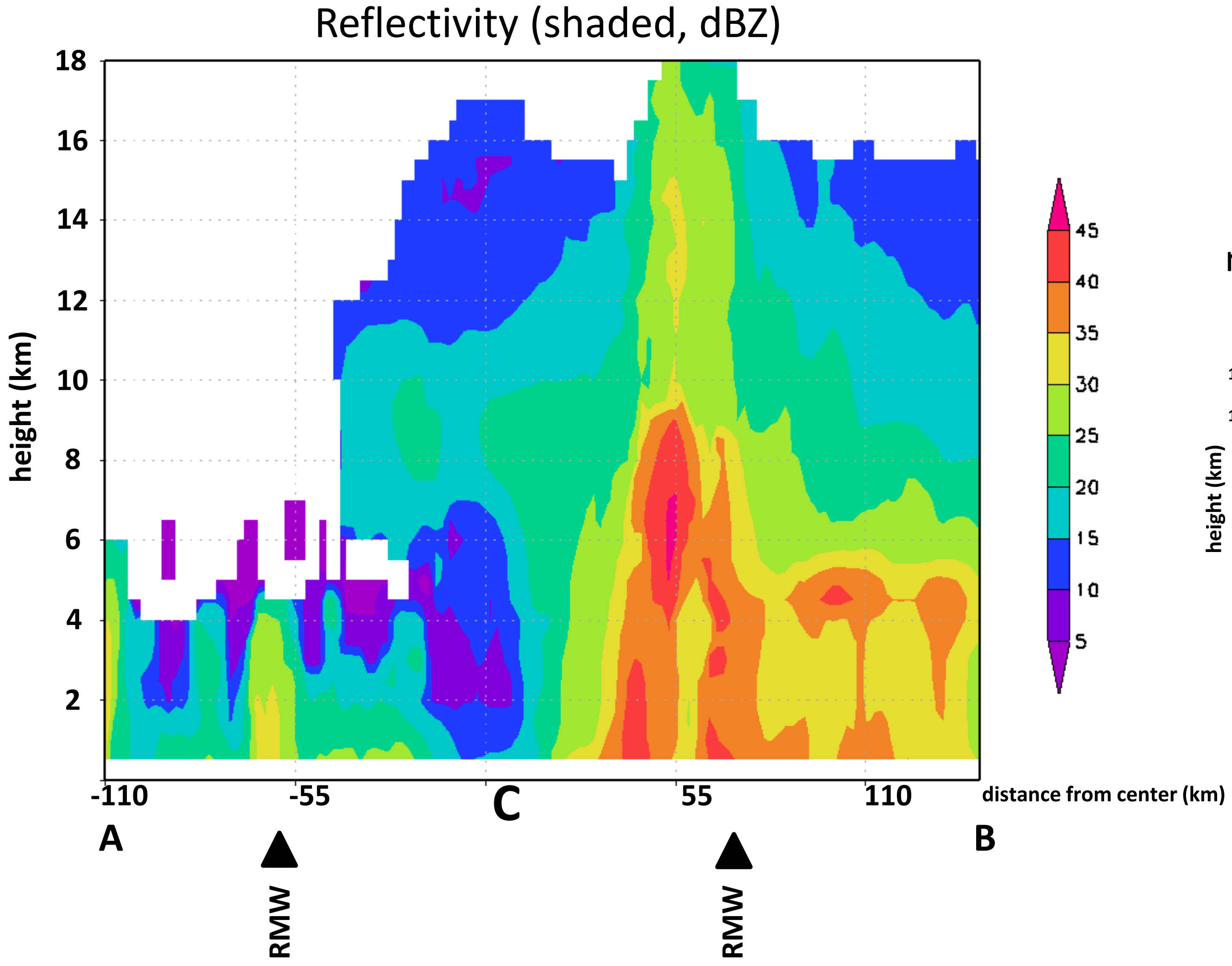


- RMW

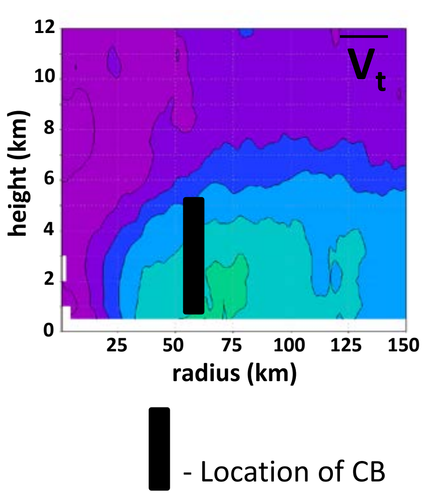
x - convective burst (CB) location

Example from individual case: Earl (2010)

Flight 1



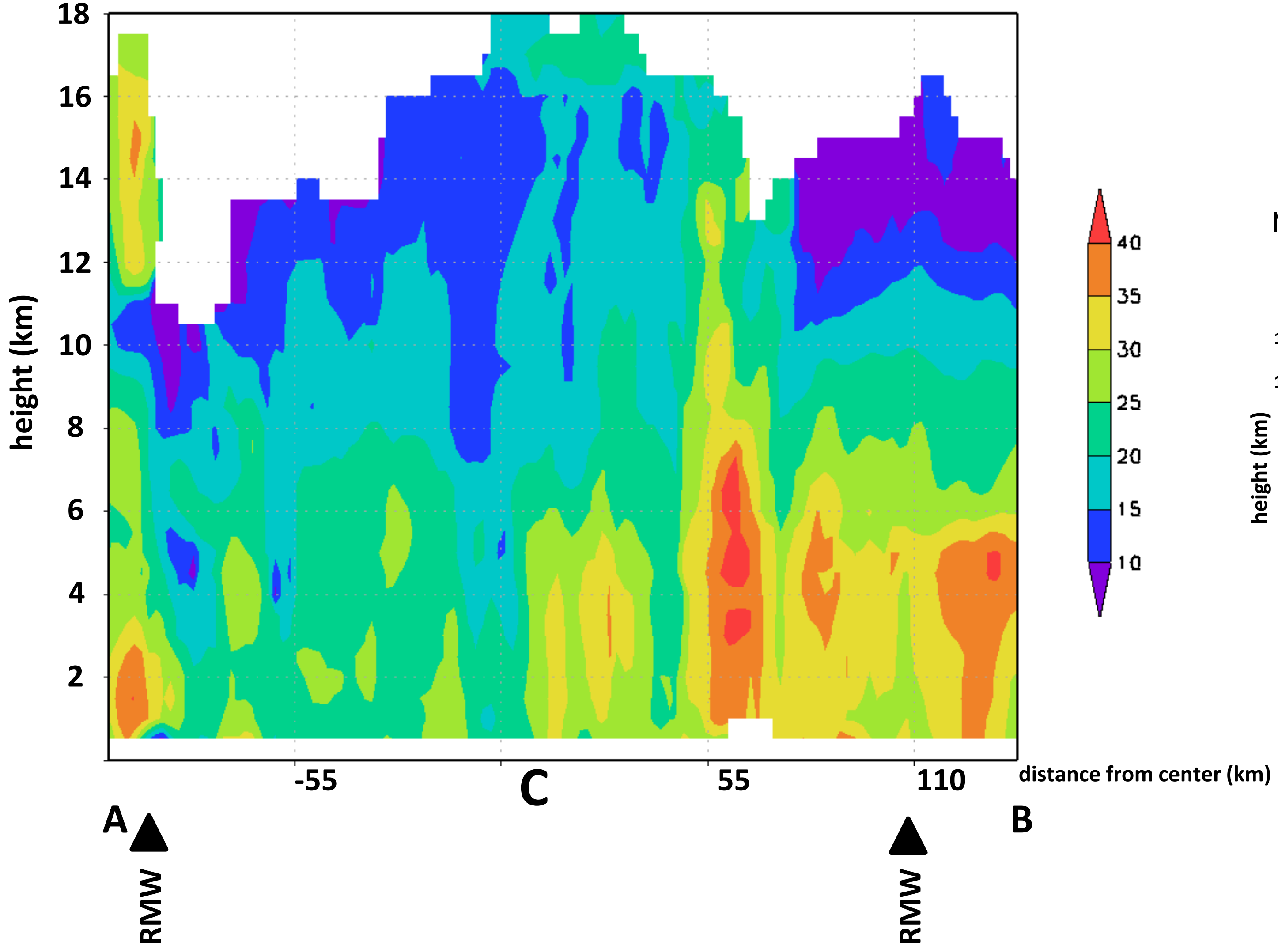
Radial location of CB relative to symmetric tangential wind



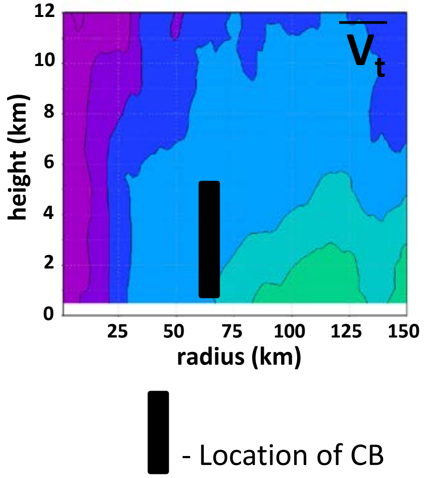
Example from individual case: Earl (2010)

Flight 2

Reflectivity (shaded, dBZ)



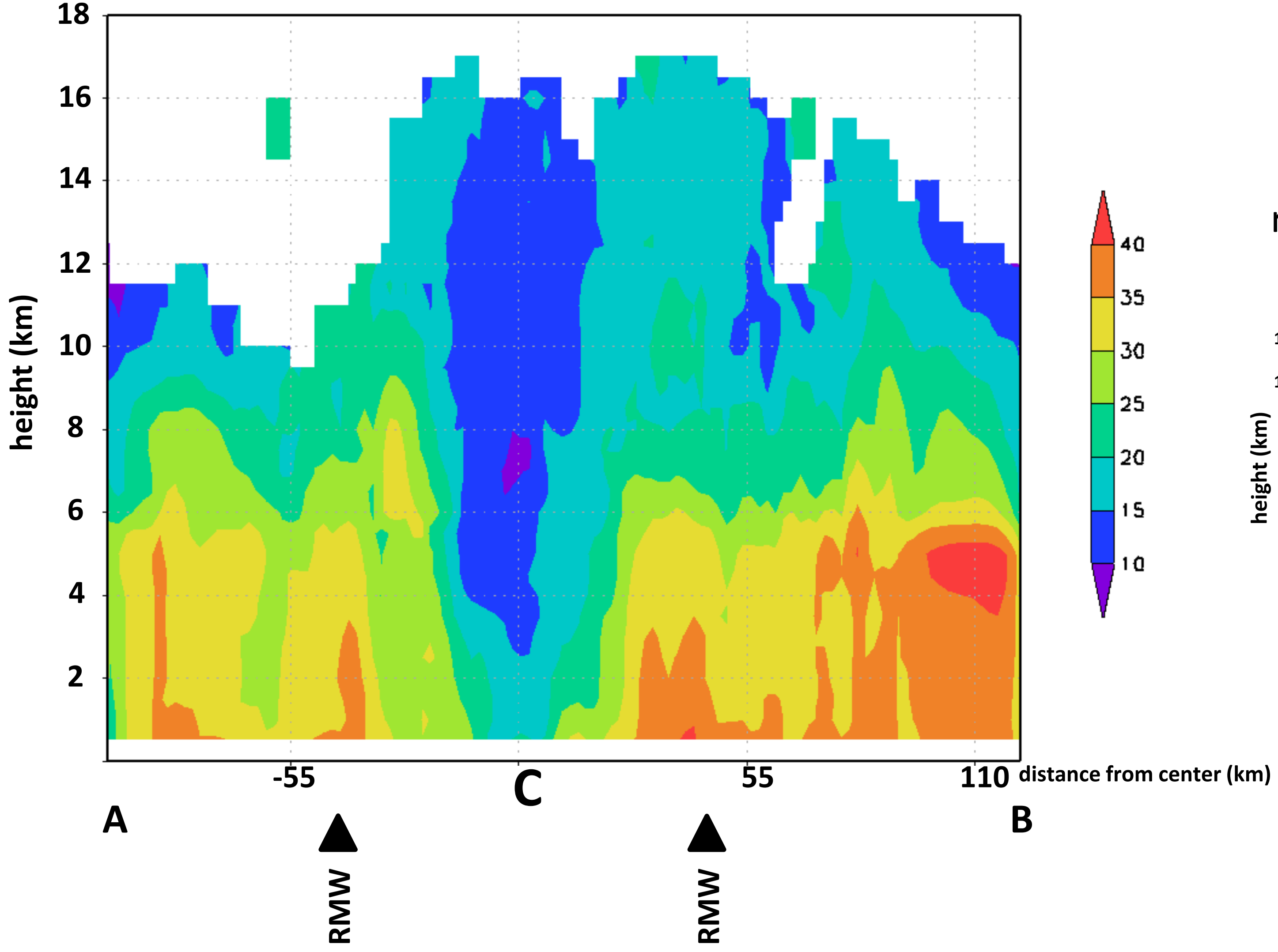
Radial location of CB relative to symmetric tangential wind



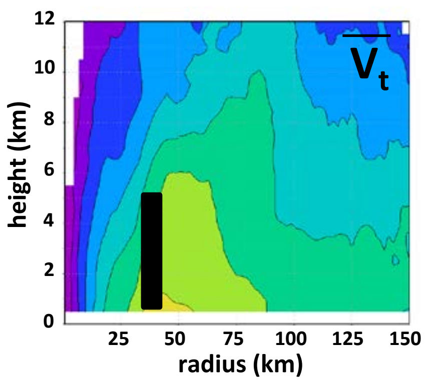
Example from individual case: Earl (2010)

Flight 3

Reflectivity (shaded, dBZ)



Radial location of CB relative to symmetric tangential wind

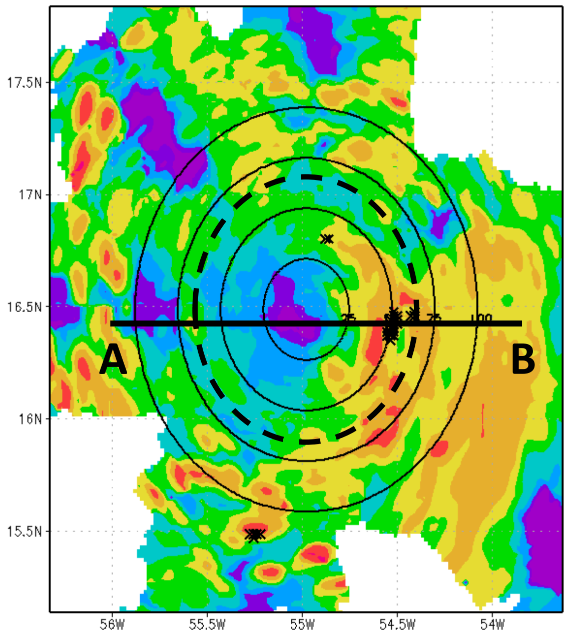


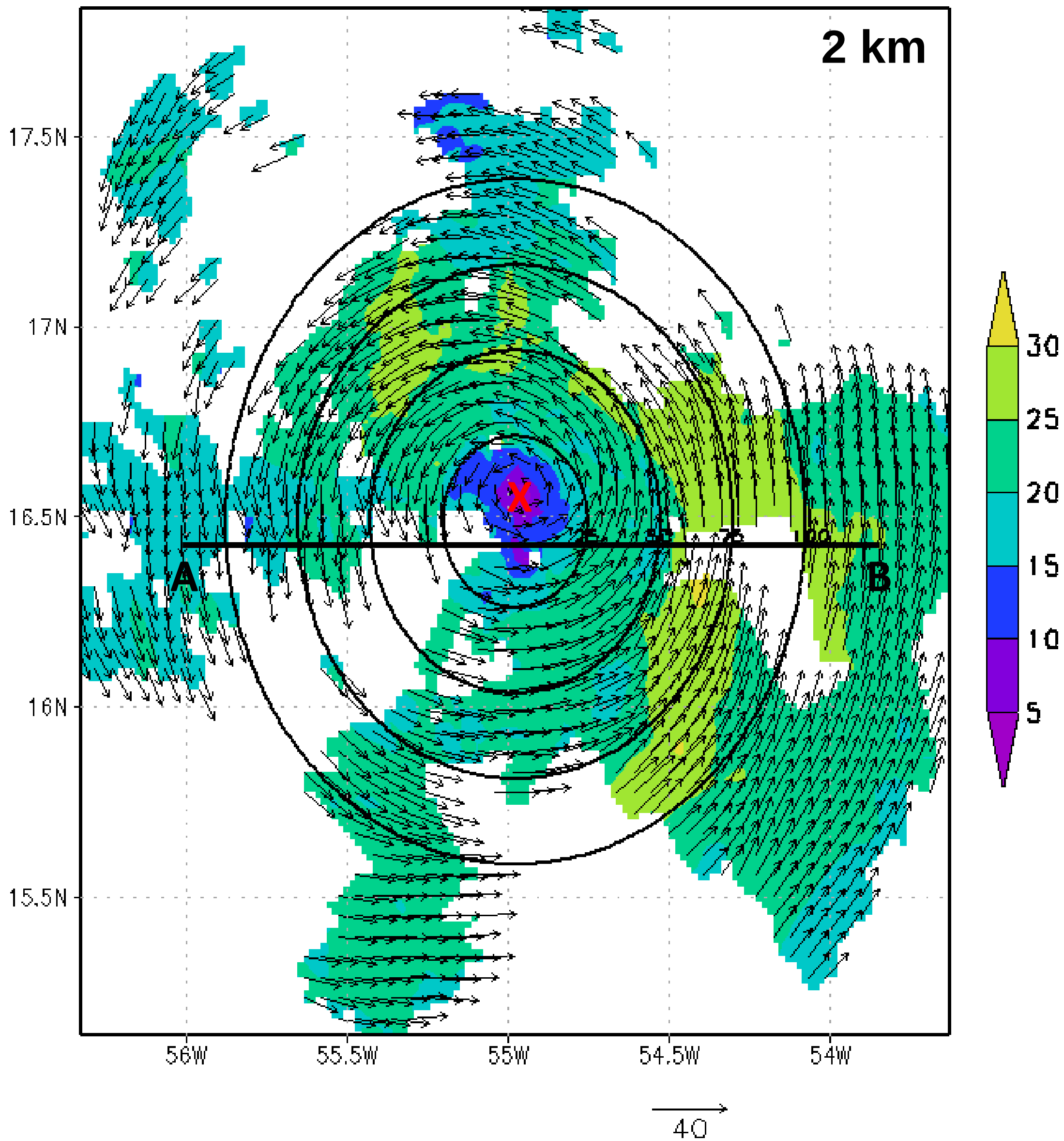
- Location of CB

Example from individual case: Earl (2010)

Wind speed and vectors (shaded, m s^{-1}) in Flight 1

Flight 1

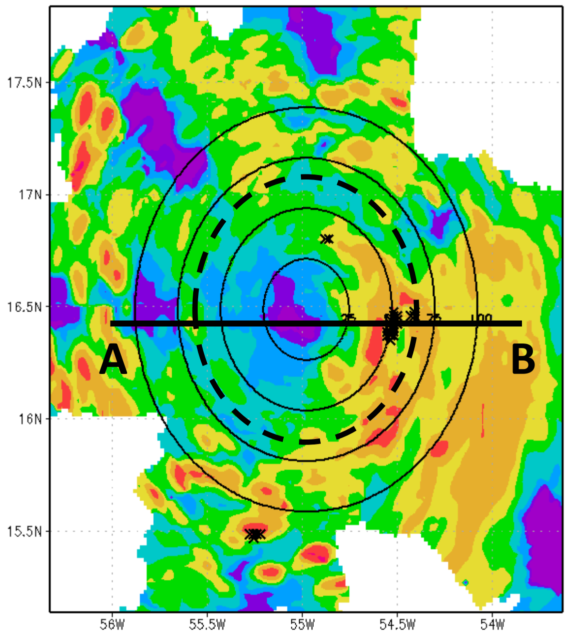


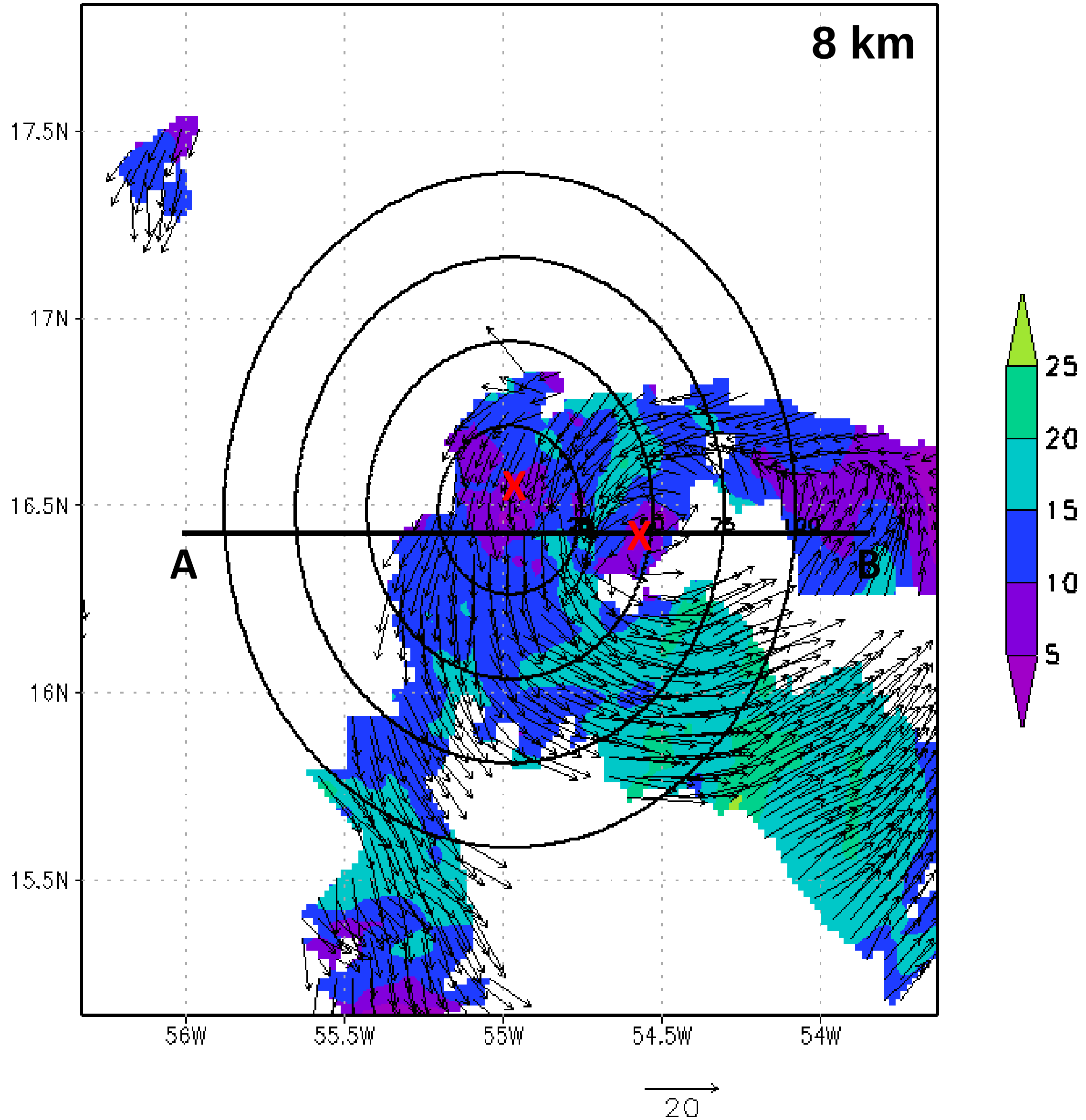


Example from individual case: Earl (2010)

Wind speed and vectors (shaded, m s^{-1}) in Flight 1

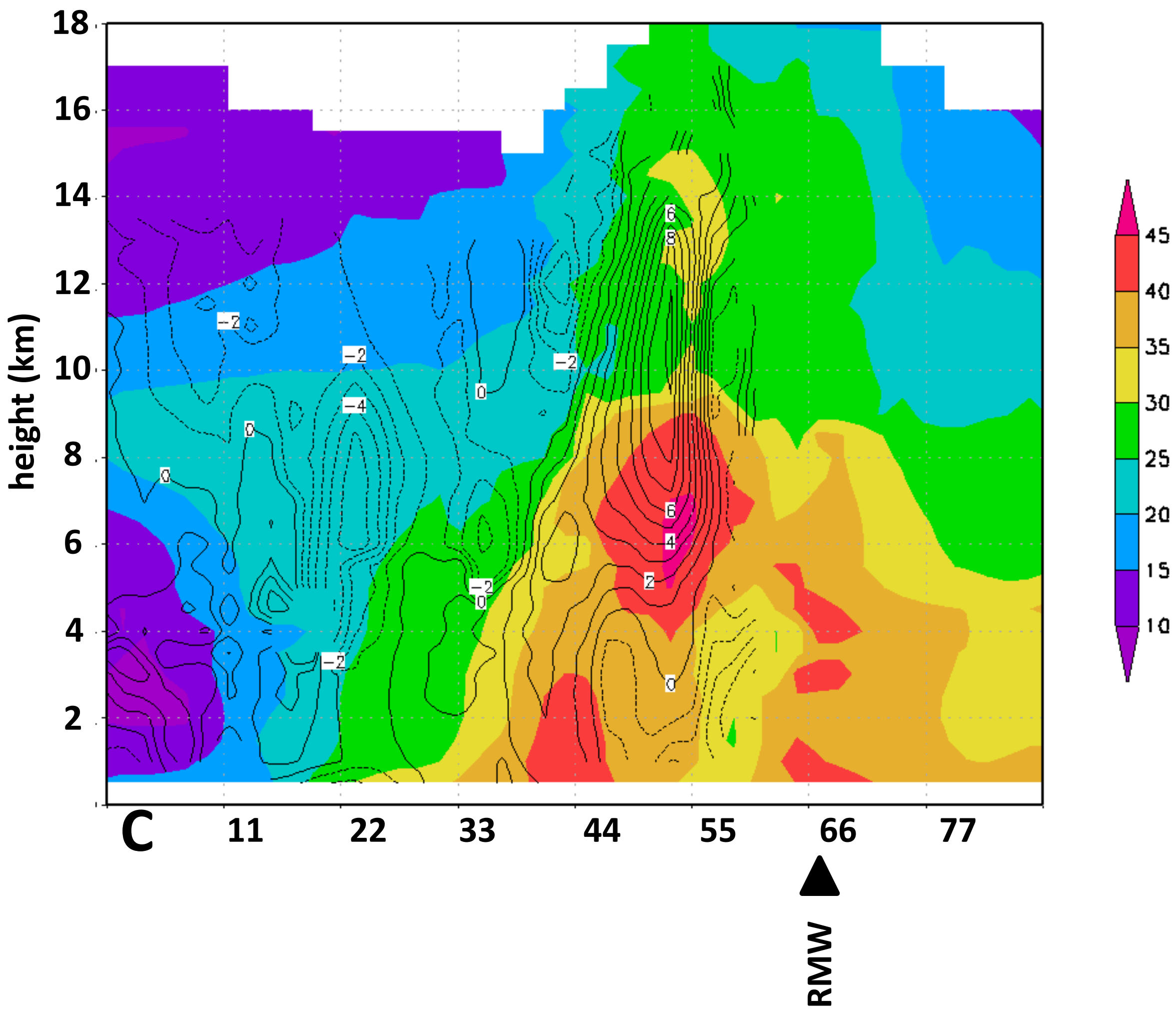
Flight 1





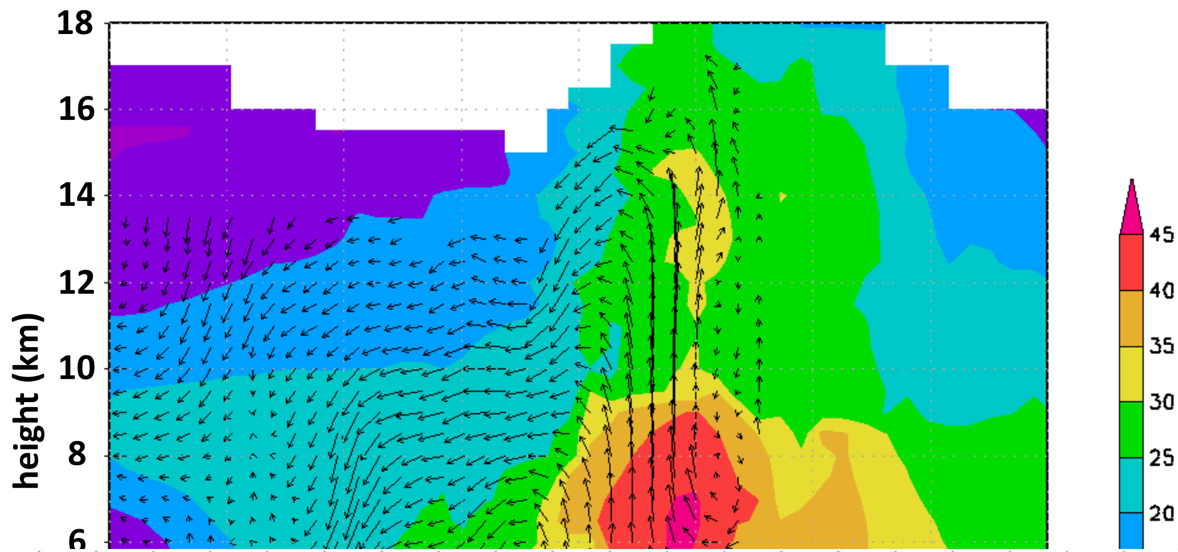
A closer look at CB from Flight 1

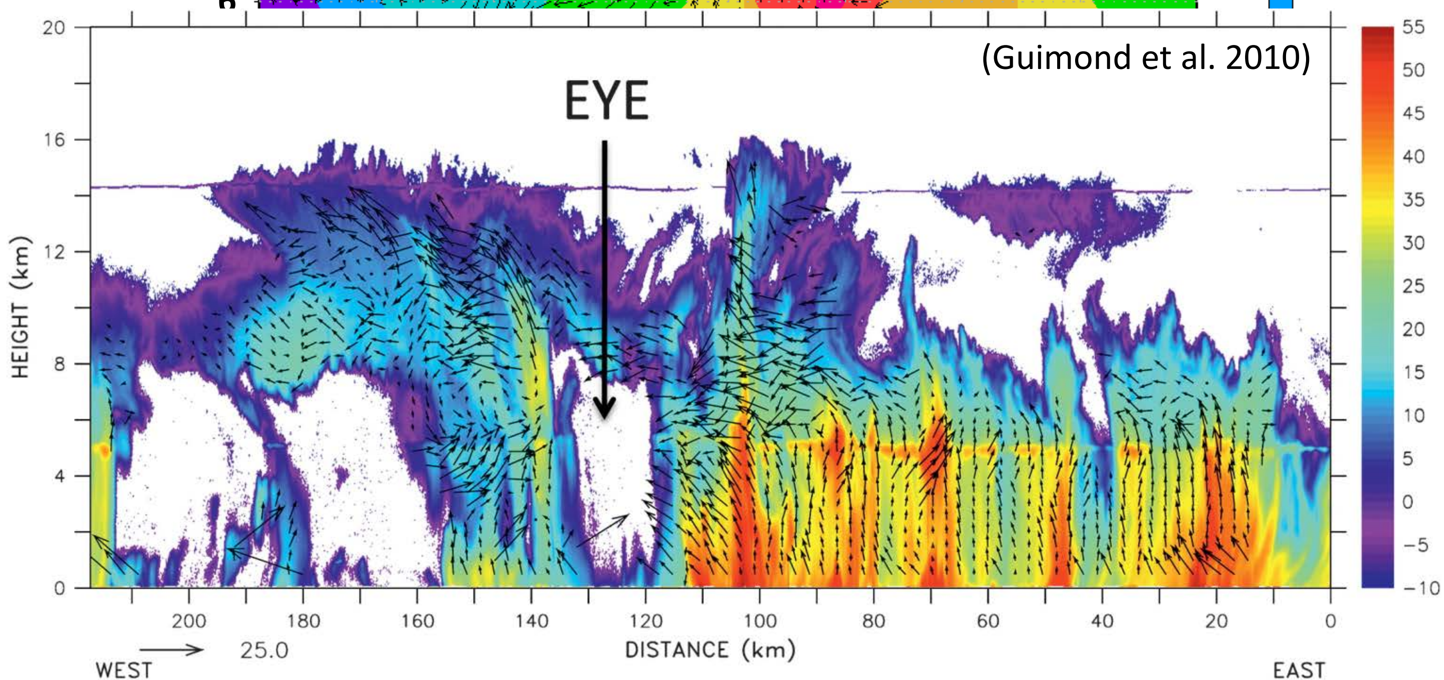
Reflectivity (shaded, dBZ) and vertical velocity (contour, m s^{-1})



A closer look at CB from Flight 1

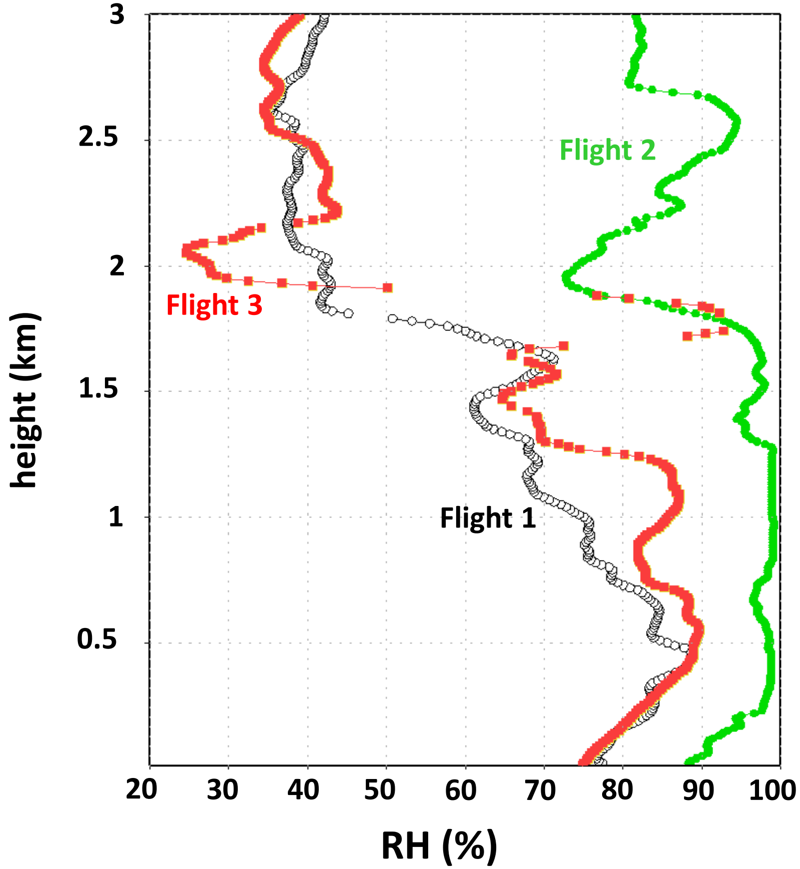
Reflectivity (shaded, dBZ) and flow (vector, m s^{-1})





Case study: Earl (2010)

Average relative humidity (%) from all sondes between 0 and 0.5 x RMW



Accessing the IFEX data

http://www.aoml.noaa.gov/hrd/data_sub/hurr.html

- Review HRD data policy, at http://www.aoml.noaa.gov/hrd/datapolicy.html
- Flight-level and SFMR data (netCDF)
- Lower-fuselage, tail Doppler radar images
- Dropsonde data (multiple formats)
- Mission summaries
- H*Wind surface wind analyses

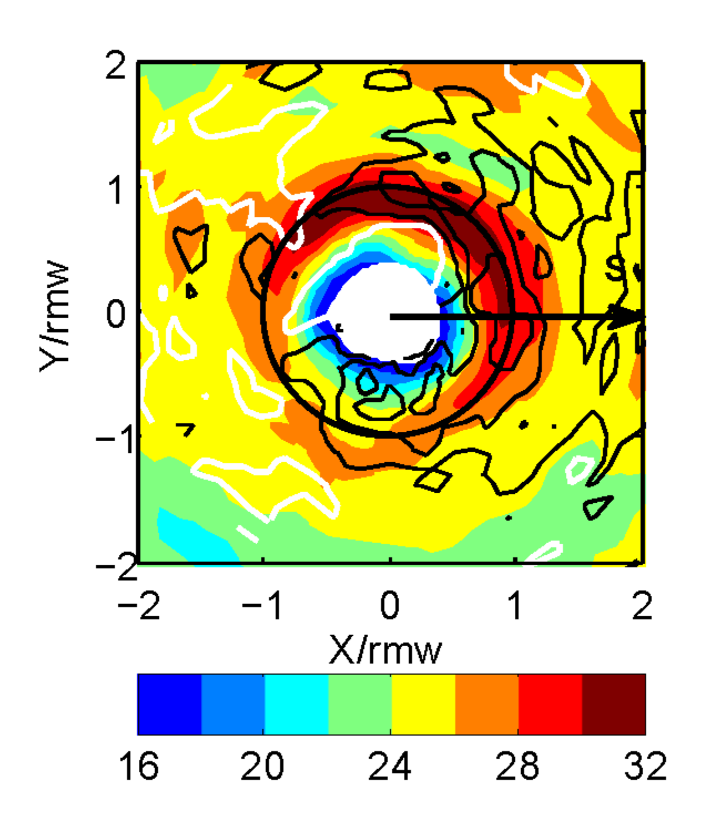
Extra slides

IFEX Goal 3: Improving understanding of processes important in TC intensity change

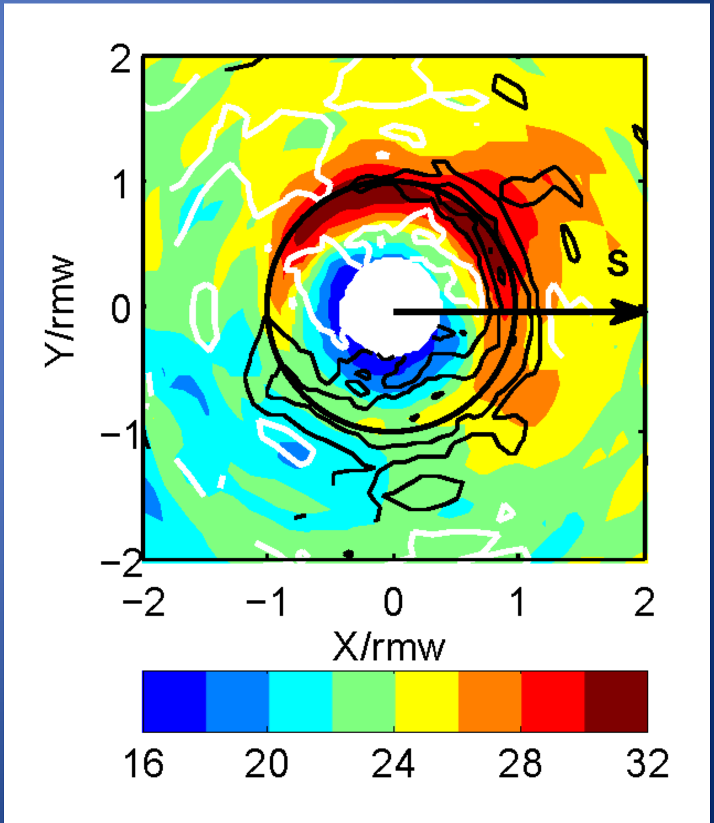
TC inner-core structure and rapid intensification

Shear-relative reflectivity at 2 km (dBZ)

Rapid intensifiers



Steady state



- greater coverage of eyewall reflectivity for RI cases