

4.3 Structure Change Forecasting

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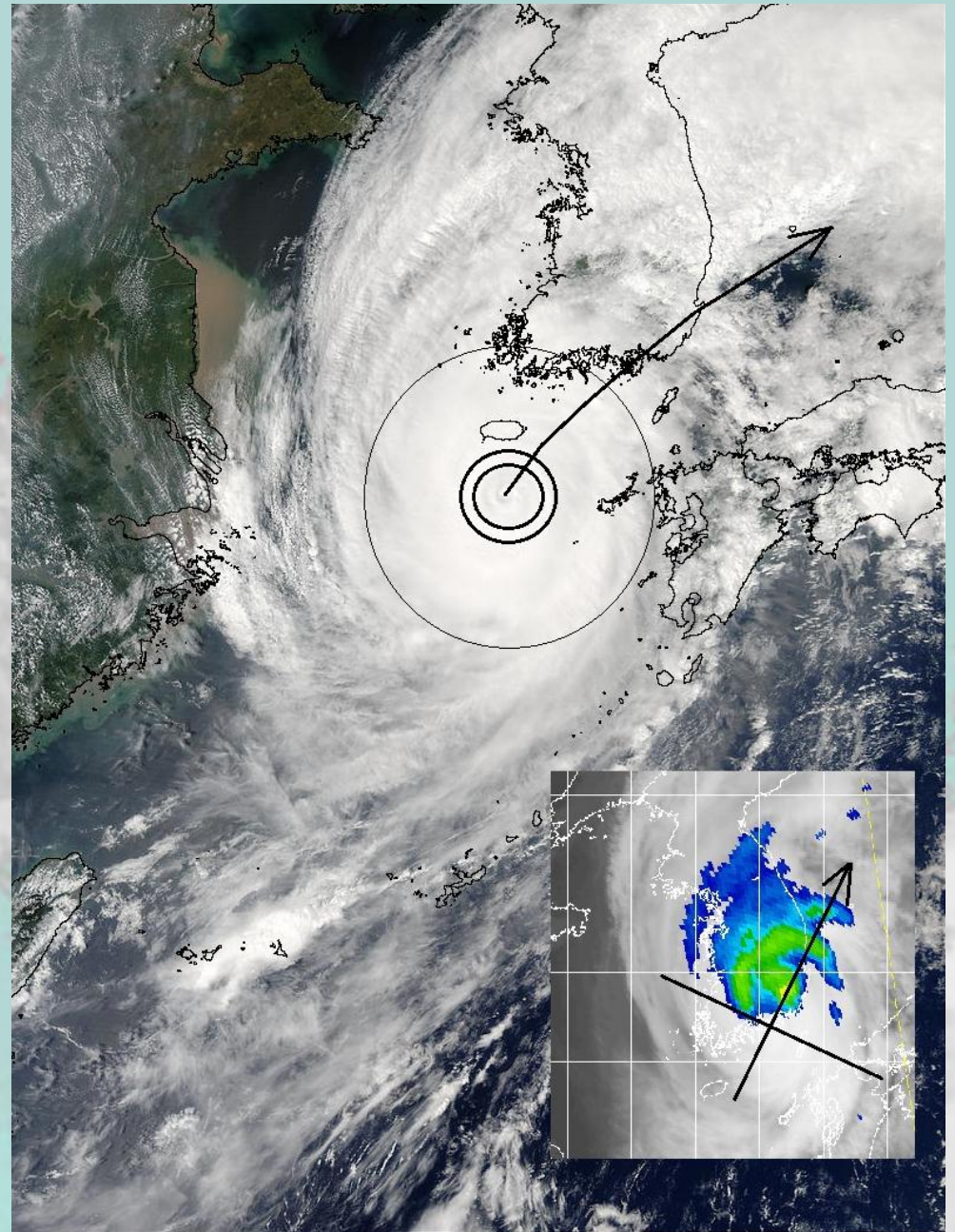
Pennsylvania State University, USA

TC Structure Concerns...

- Size
- Vertical Profile
- Radial Profile
- Asymmetries
- Evolution through time

Think 4 dimensions **x** (east/west), **y** (north-south), **z** (height/pressure), **t** (time)

*Various metrics –
wind, humidity,
temperature, pressure*



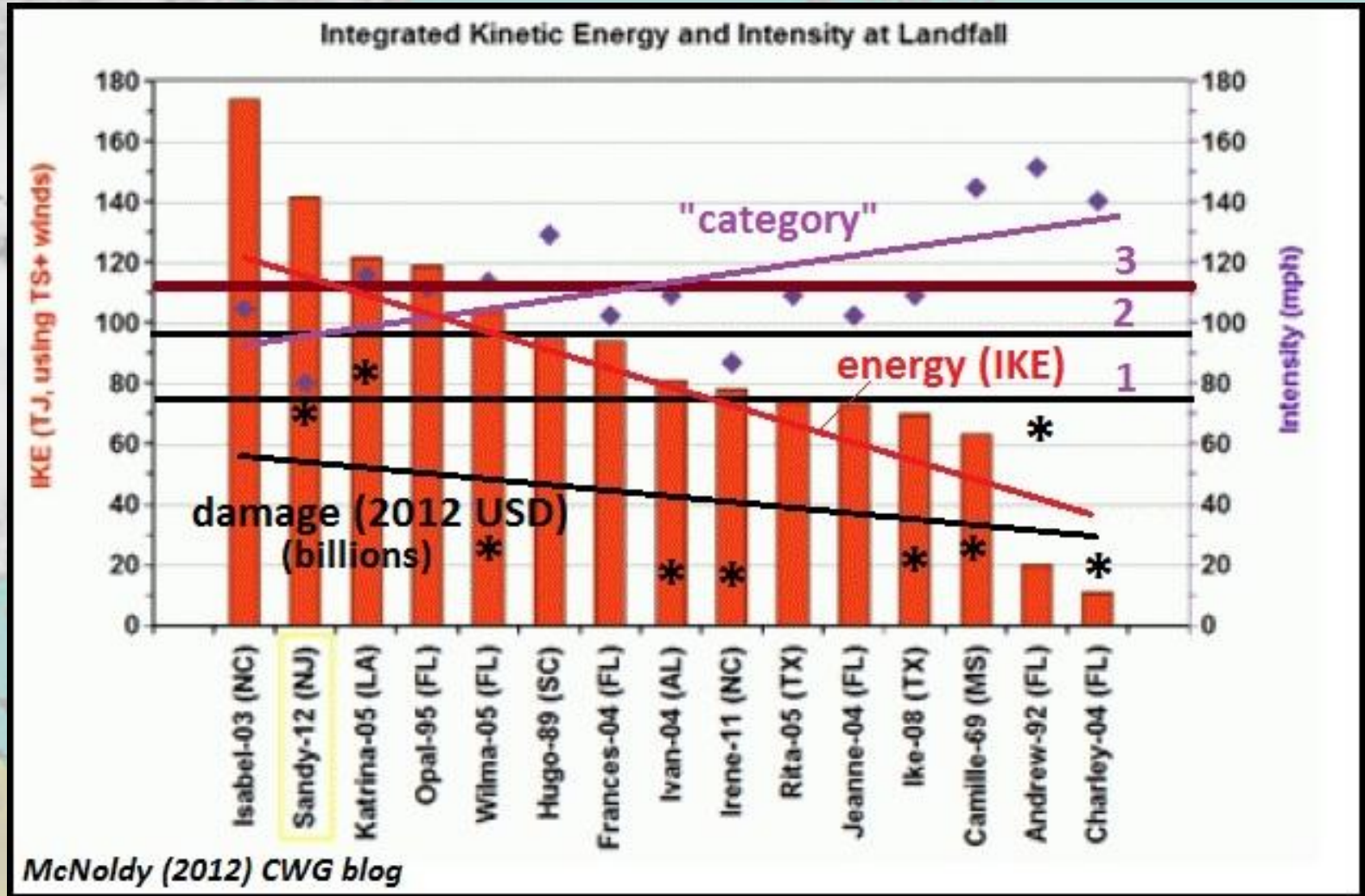
OUTLINE

Aspects of TC Structure Prediction

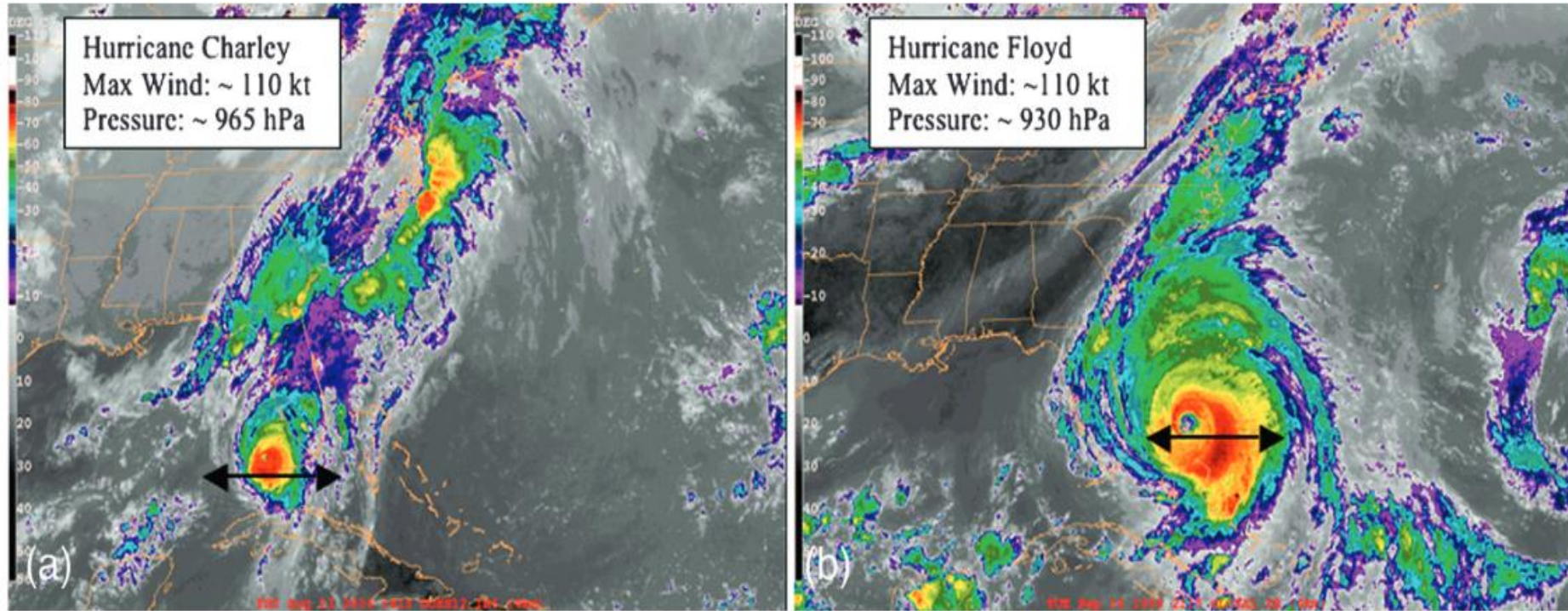
- Initial size - dependence (on environmental humidity)
- Initial size - and subsequent track/intensity
- Model initialization issues
- Thermal structure and rapid intensification (RI)
- Effect of eyewall replacement cycles (ERCs)
- Topographic influences
- “Guidance on guidance”
- Verification metrics (NWP)
- Extratropical Transition (ET)
- Relation to damage potential
- Considerations regarding Climate Change

Structure (size) matters:

larger storms often bring greater surge (fatalities, damage)



Same intensity (max wind speed) – much different central pressure / overall energy



ACE (accumulated cyclone energy) for Floyd was roughly
2.5X larger at this time than Charley

Hill and Lackmann (2009)

Initially humid ambient environment favors large TCs

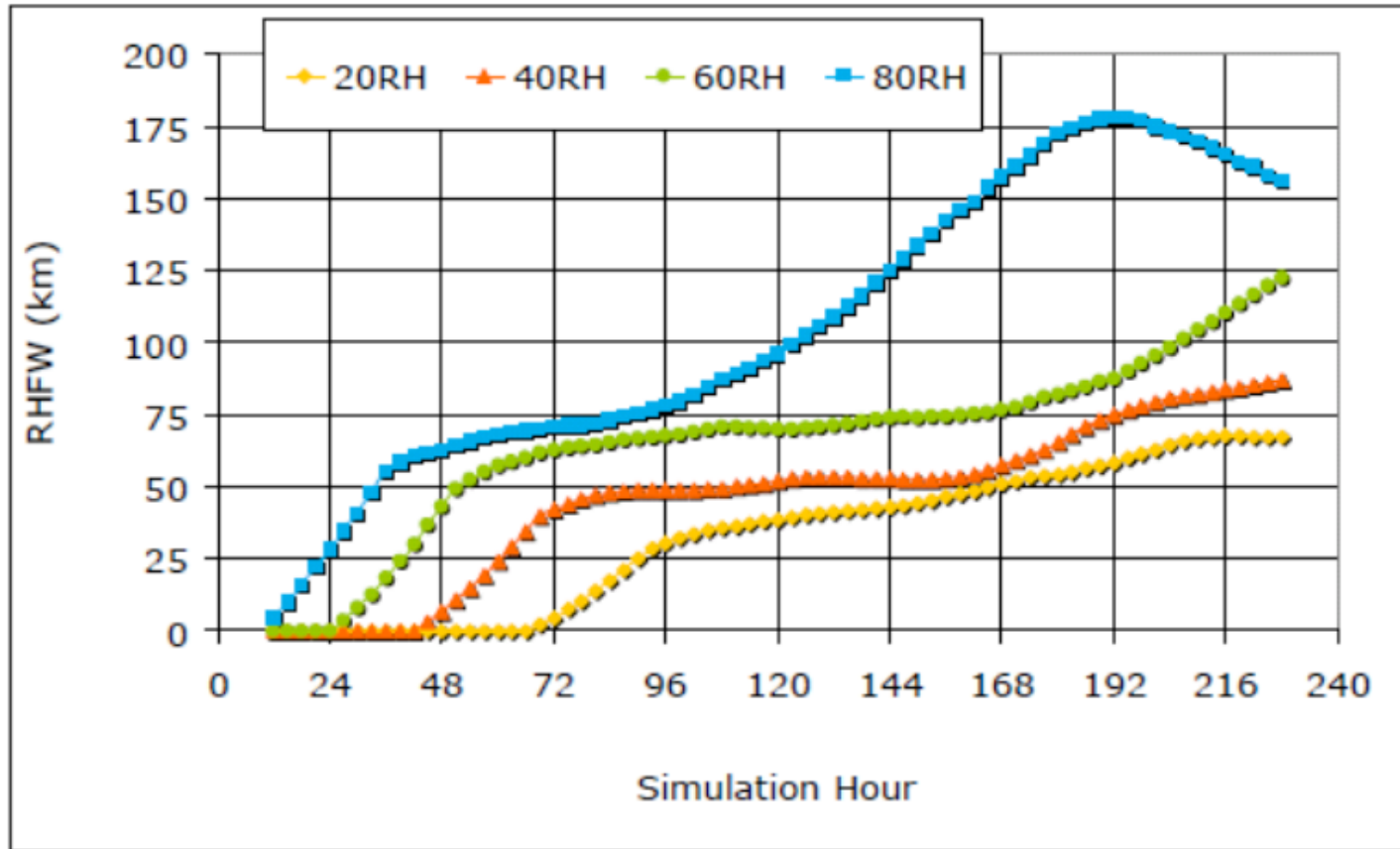
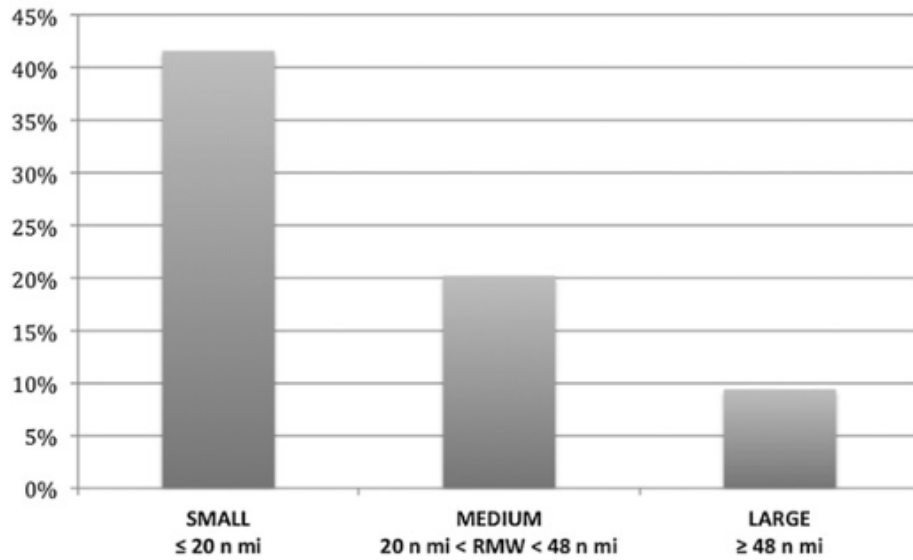


Figure 25. Evolution of the radius of hurricane-force winds (at 10 m) from various model simulations of a tropical cyclone with different initial conditions for environmental relative humidity

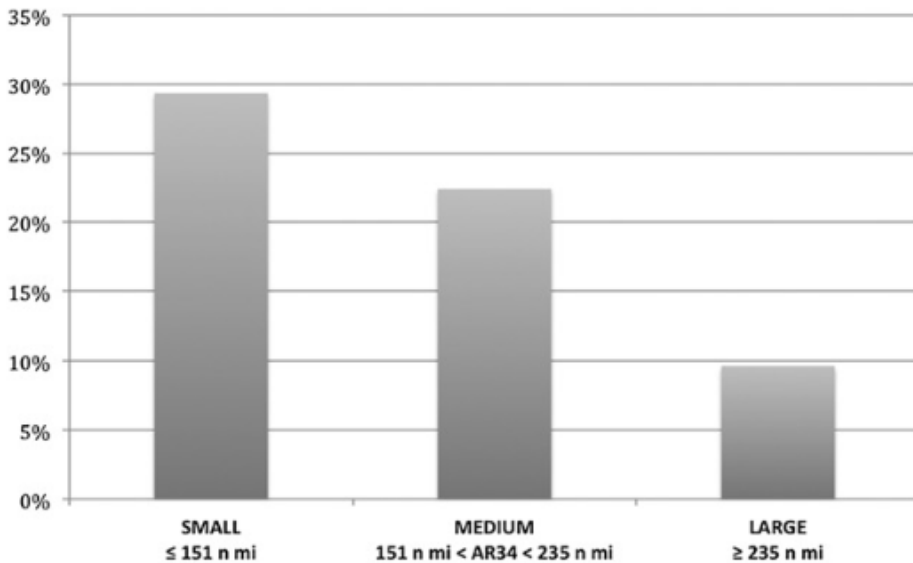
Influence of TC size parameter on subsequent RI (rapid intensification) potential

Carrasco and Landsea (2014)

(a) Probability of RI for Each Size Category in RMW

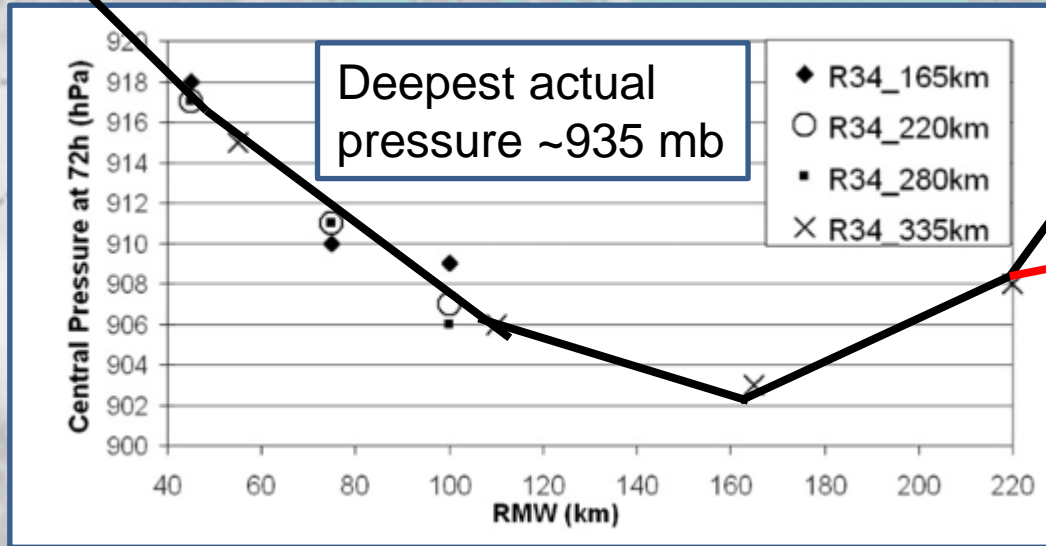


(b) Probability of RI for Each Size Category in Average 34 kt Radii

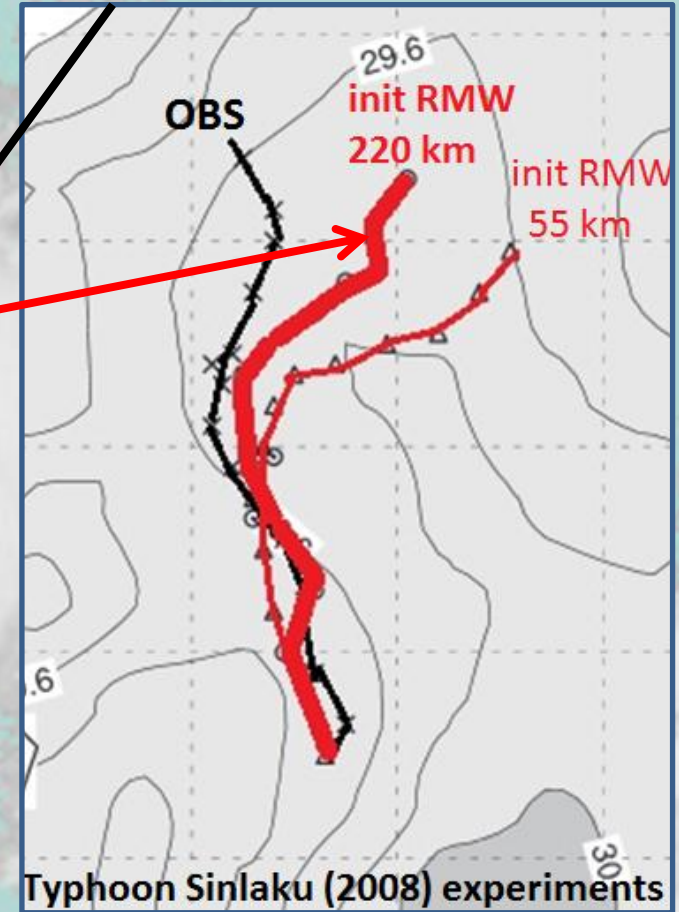


Initial vortex specification experimentation

Leroux et al. (2013)

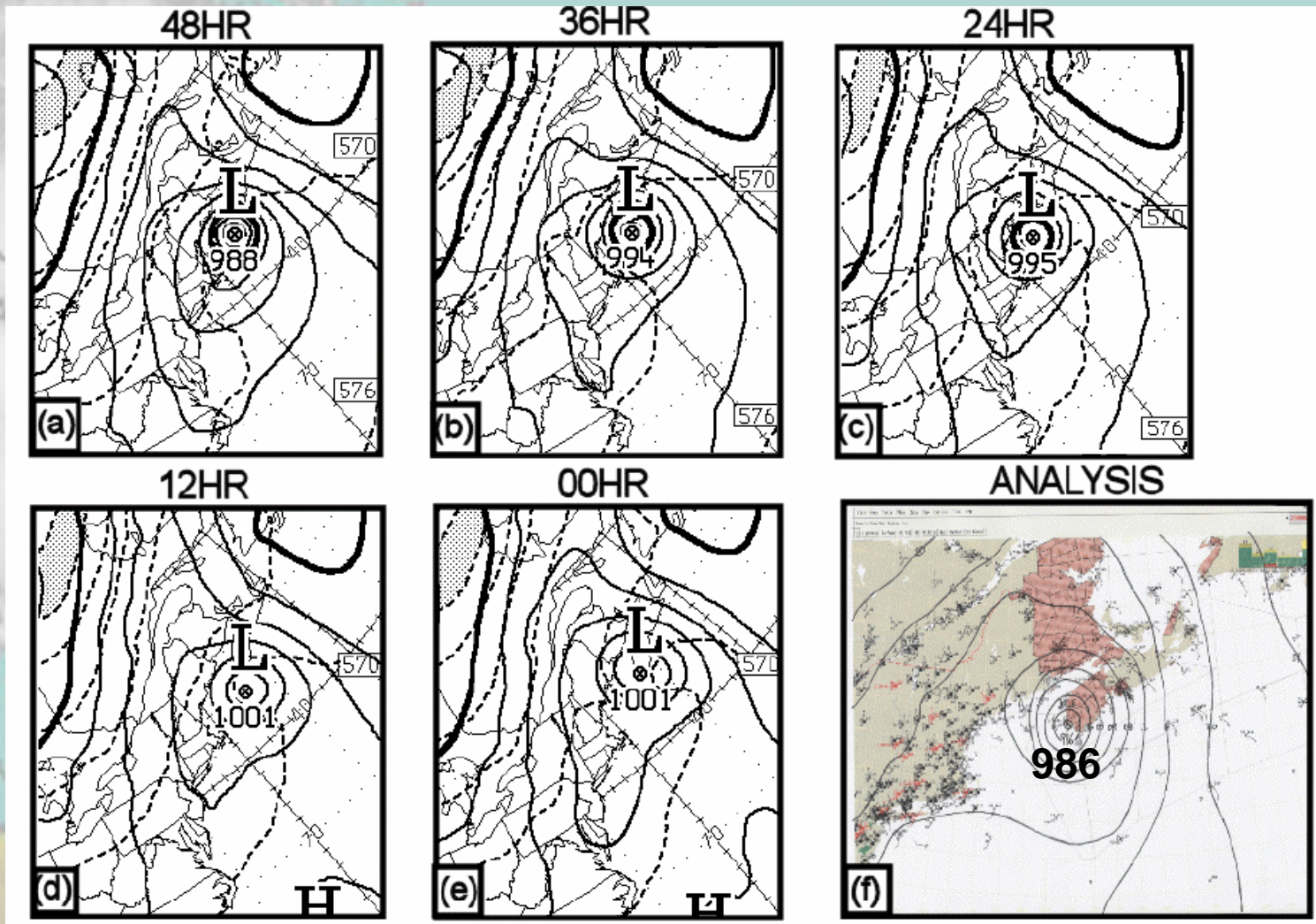


72-h central pressure forecast (hPa) vs initial RMW (km) for 0.15° resolution experiments SM6 SM18 (Table 1). Experiments are classified by groups of initial R34 values as indicated in the legend.



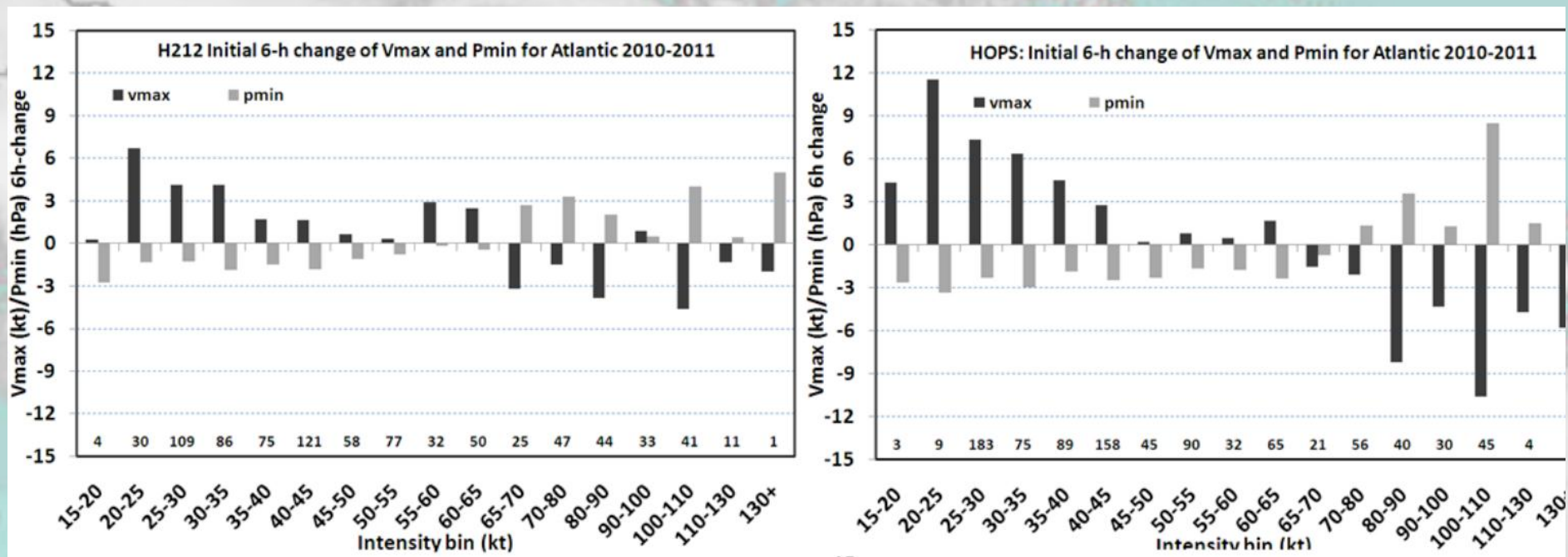
Compact storm prescription for Sinlaku intensifies too fast/deep, and tracks too far east
The pathway to possible RI depends on vortex initialization in the numerical model

48-hour forecast verifying better than 00HR! – spin-up issue (poor initialization) – Canadian GEM. Similar case in 2011 (Ophelia)



HWRF high resolution model improvements

Tallapragada et al. (2013)



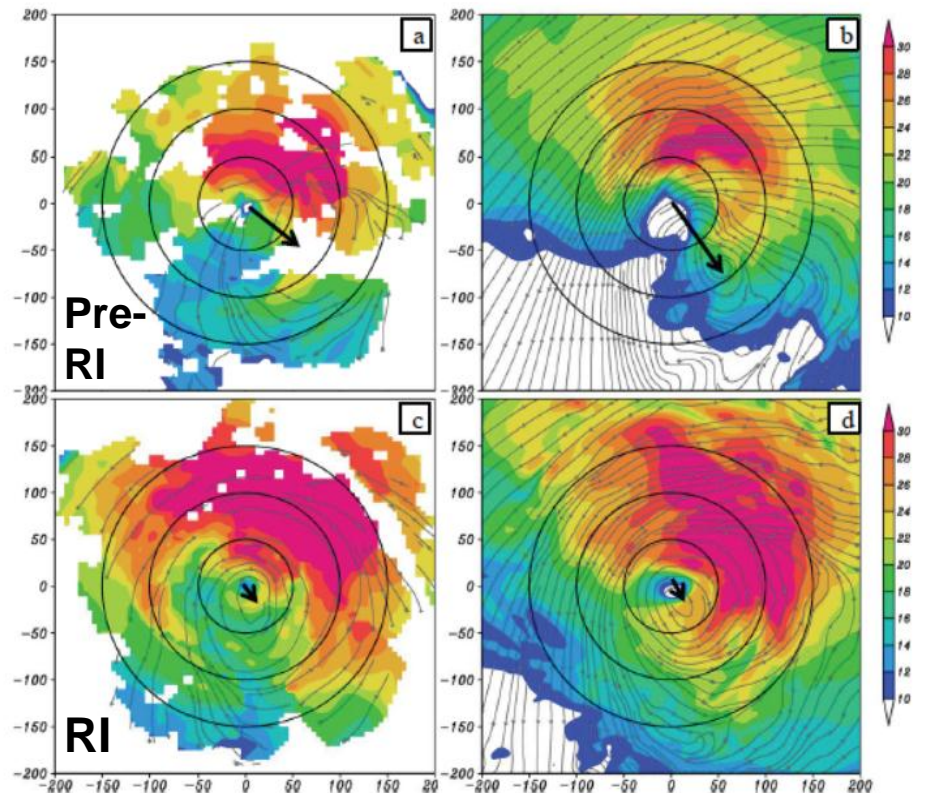
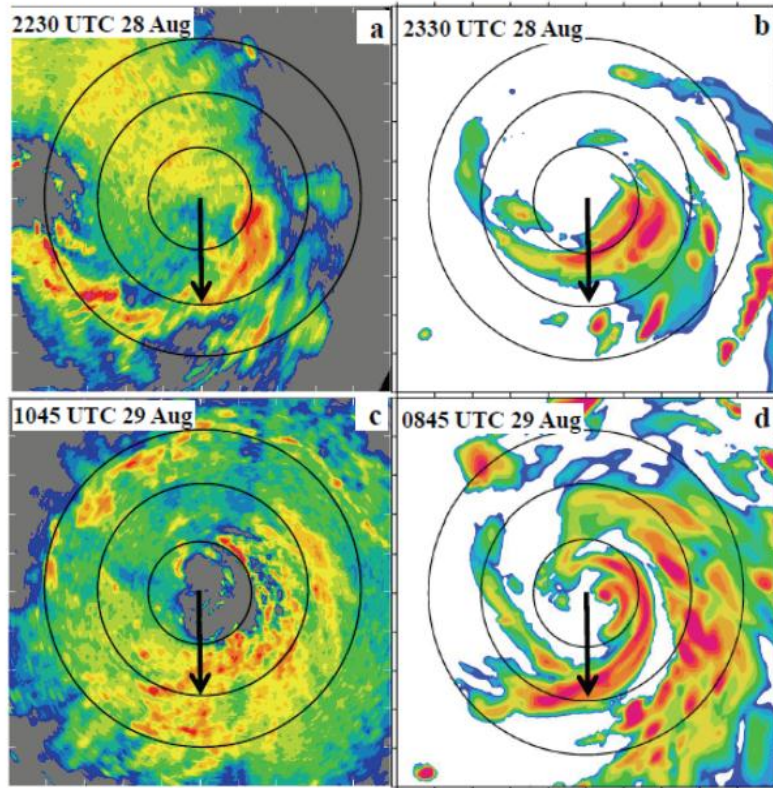
“spin-up” artifacts reduced 😊

HWRF high resolution model improvements (verification)

Tallapragada et al. (2013)

reflectivity

2-km wind speed / streamlines



Aircraft

Model

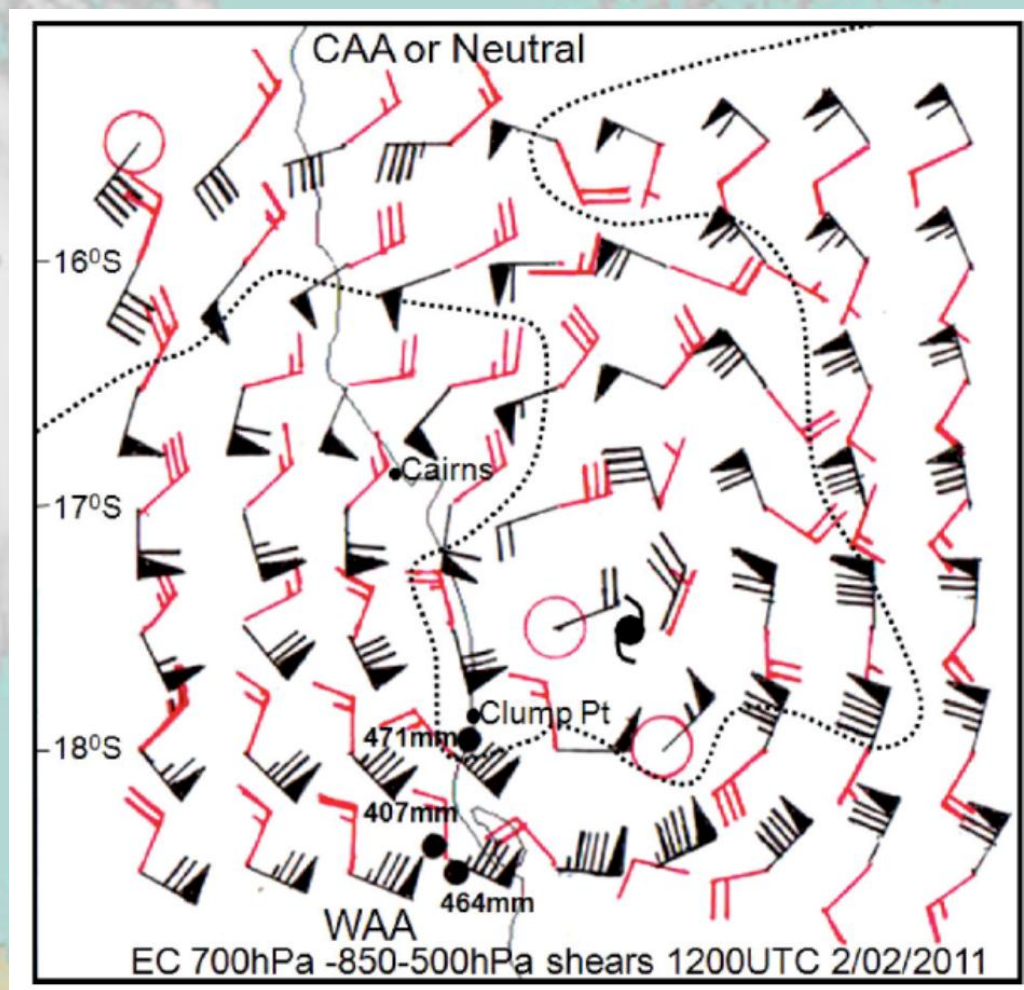
Aircraft

Model

Diagnostic for intensification/RI

aerial extent of lower tropospheric warm advection greater than cold advection

Callaghan (2011-2014)

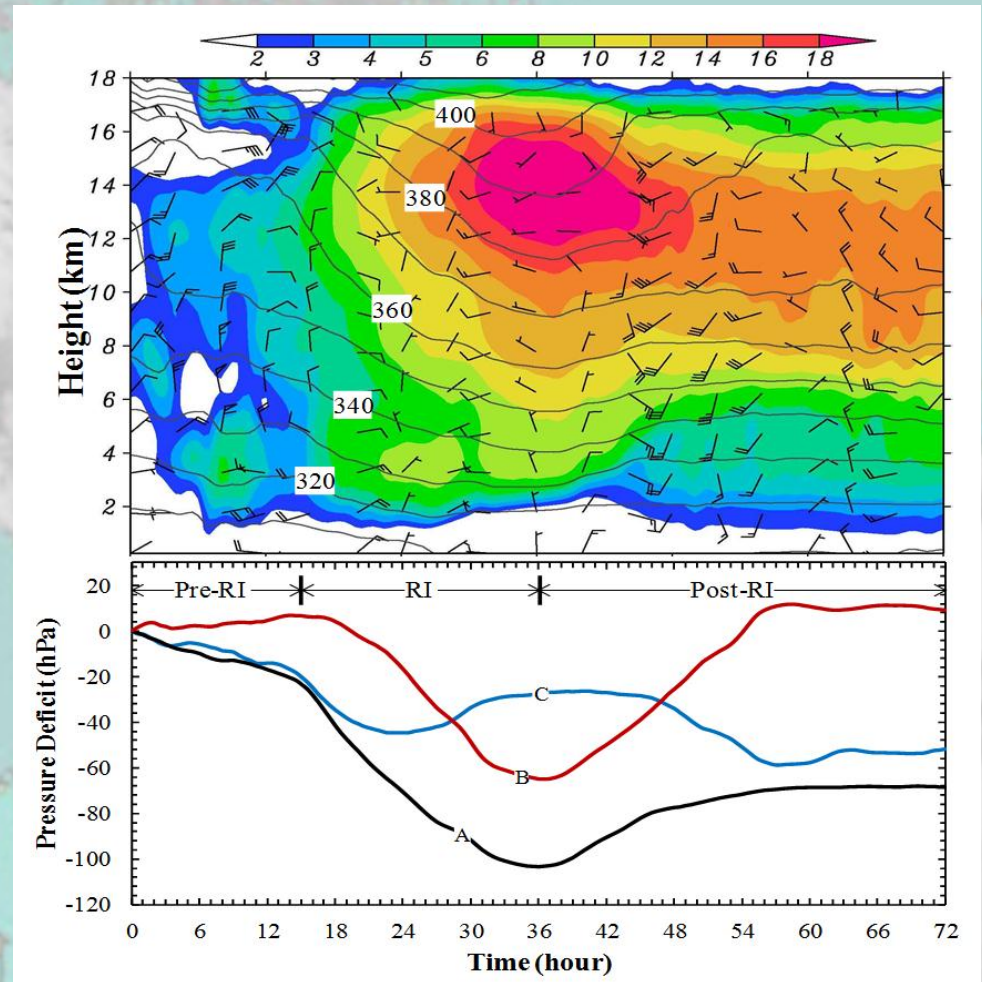


Note: directionally-varying shear (red) across the storm circulation at 700 (black)

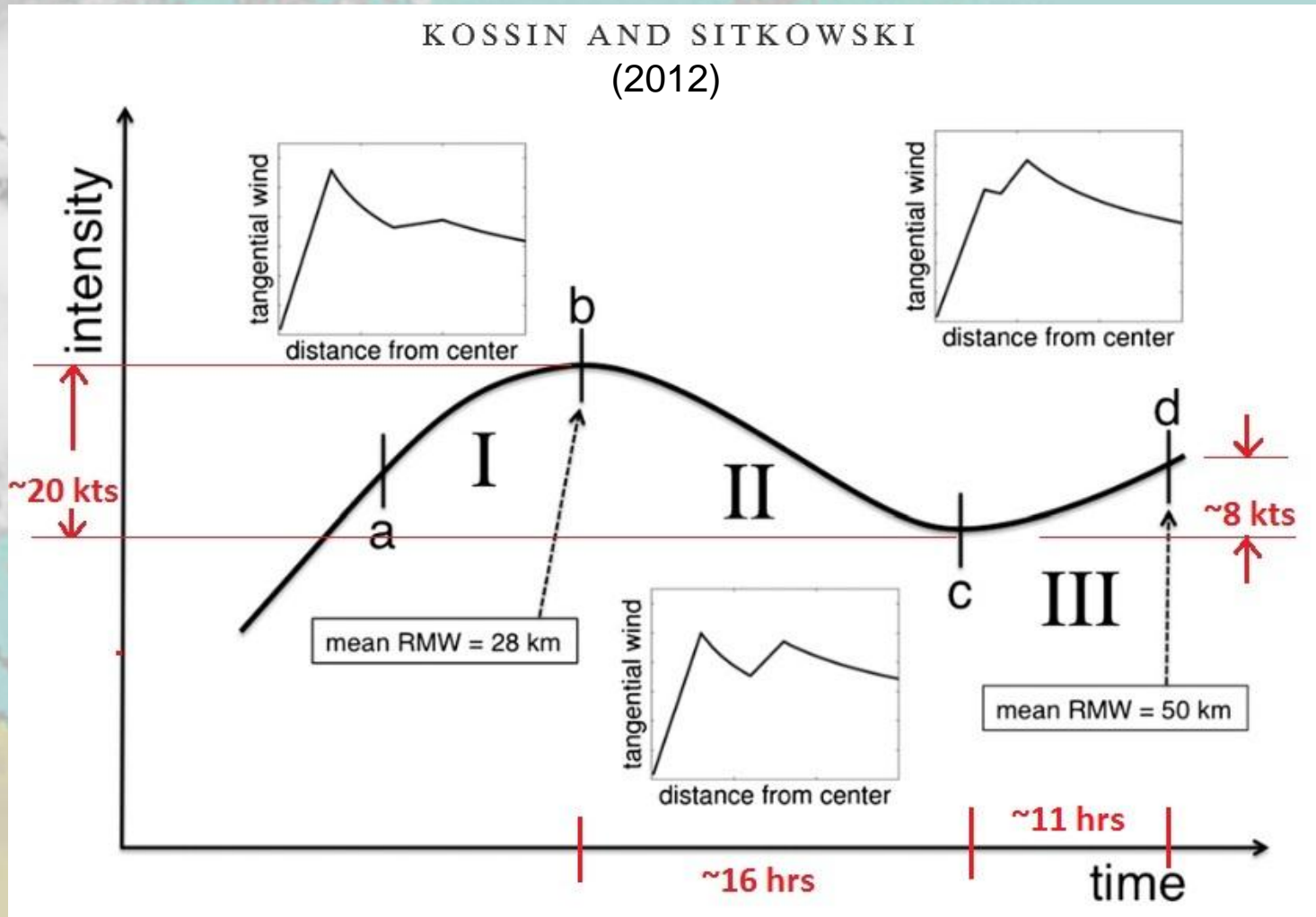
Hurricane Wilma simulation: 1-km WRF model

Zhang and Chen (2012)

pressure deficit: contribution from stratospheric subsidence-induced warming above the 380-K theta surface (curve B) and diabatic warming below (curve C)

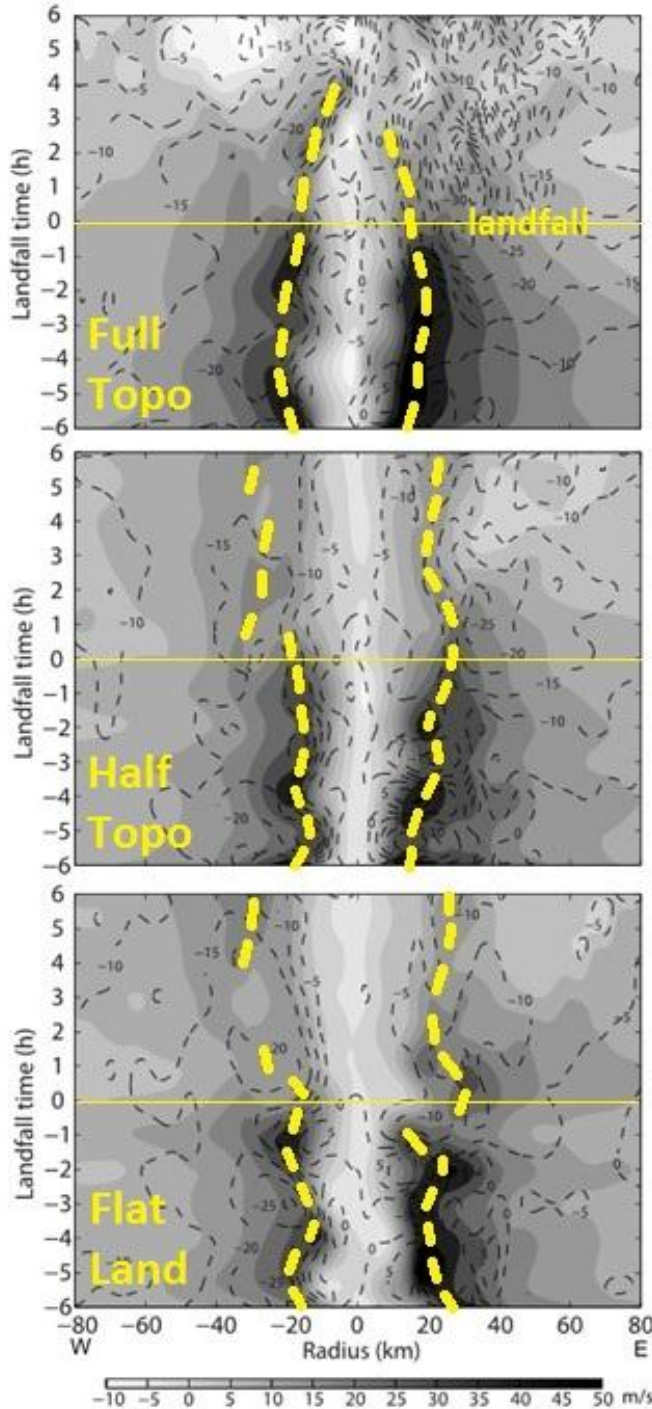


Typical eyewall replacement cycle (ERC) profiles

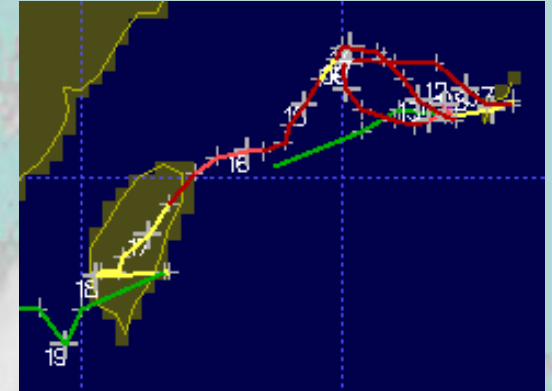


Landfall of Typhoon Nari (2001)

Yang et al. (2011) GRL



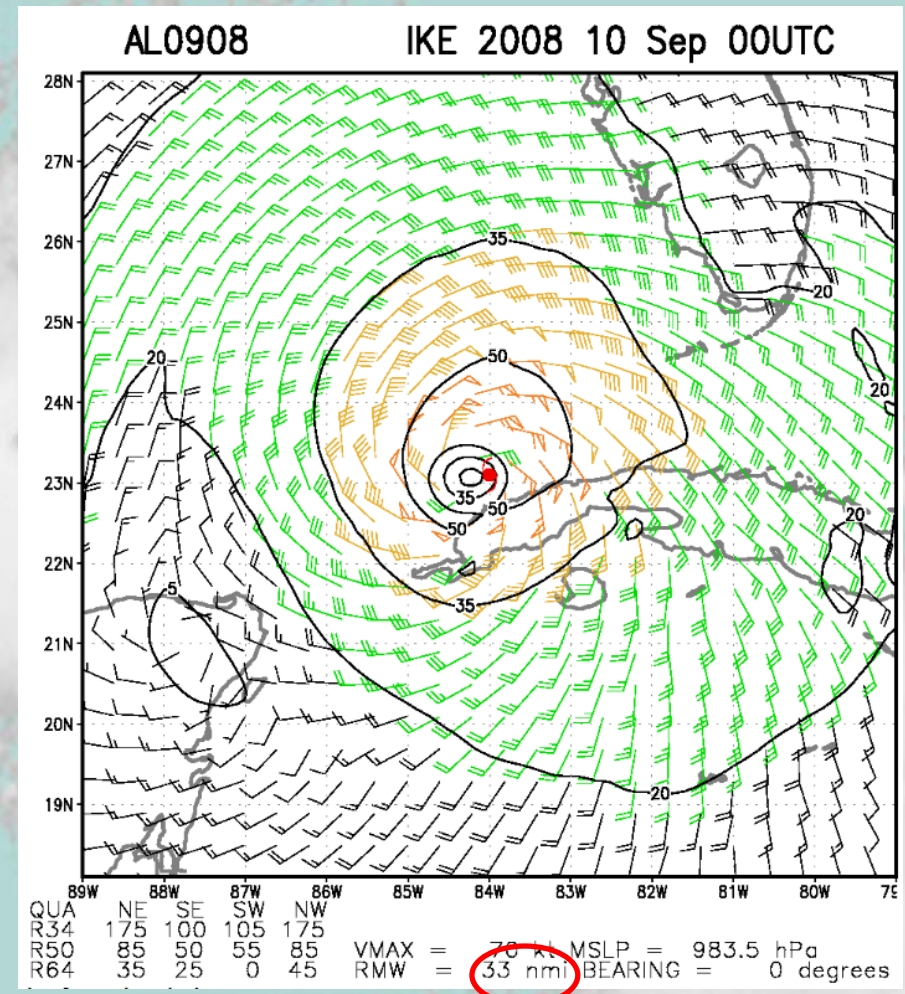
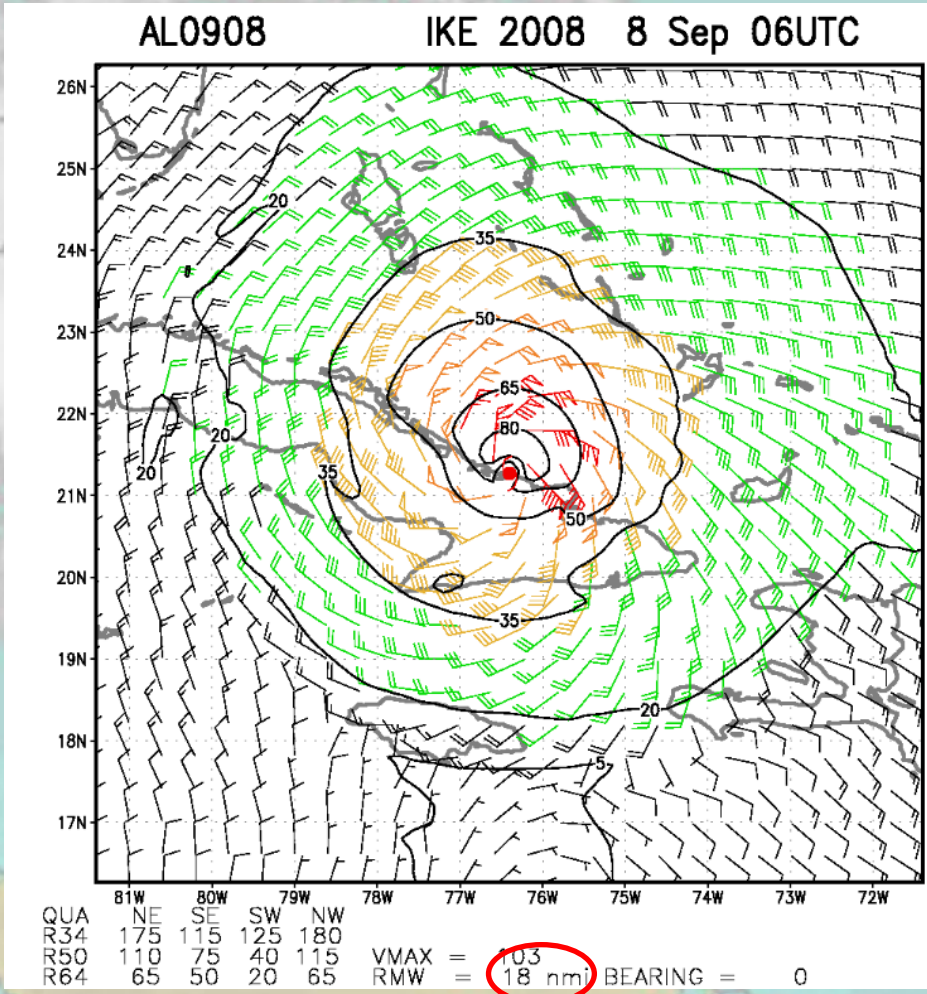
2-km MM5
Simulations
Tangential wind (shaded)
Radial inflow (dashed)



In full topo simulation:

- RMW contraction
- Large radial inflow
- Contraction begins ~2 hours before landfall
- Convective “ball” can be harbinger to either RI or rapid

Hurricane Ike structure change over Cuba – RMW expands by factor of ~2 (Knaff and DeMaria 2006)

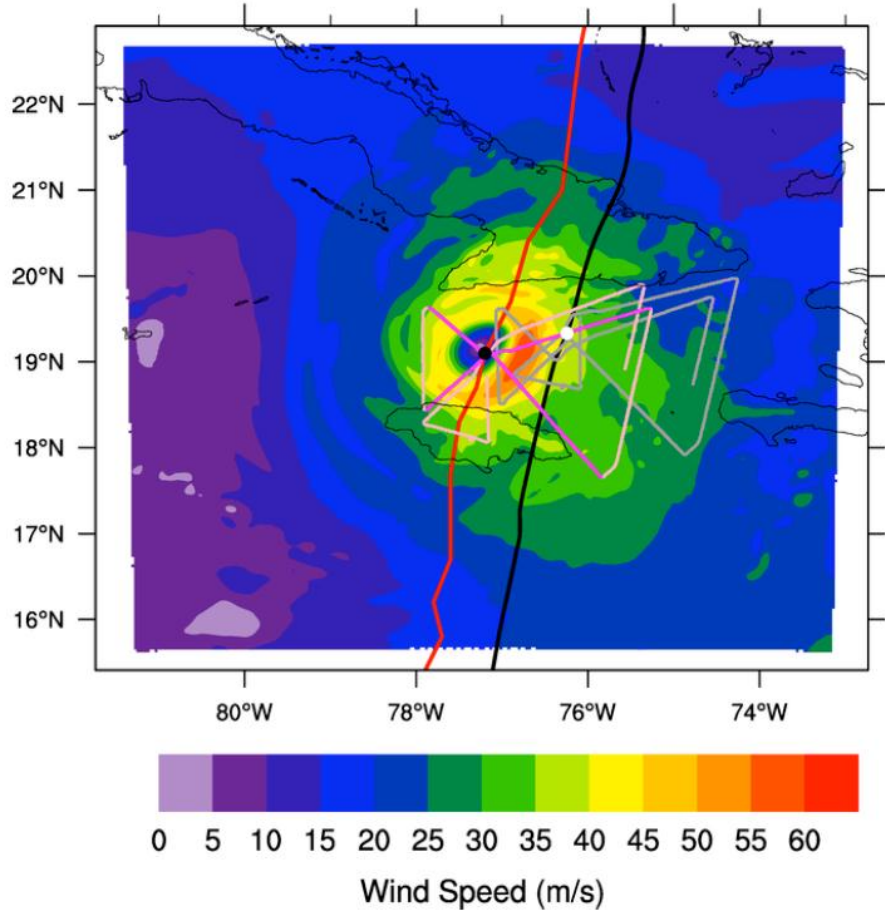


Hurricane Sandy HWRF Wind Speed Near Flight Level

Analysis:
2012102300

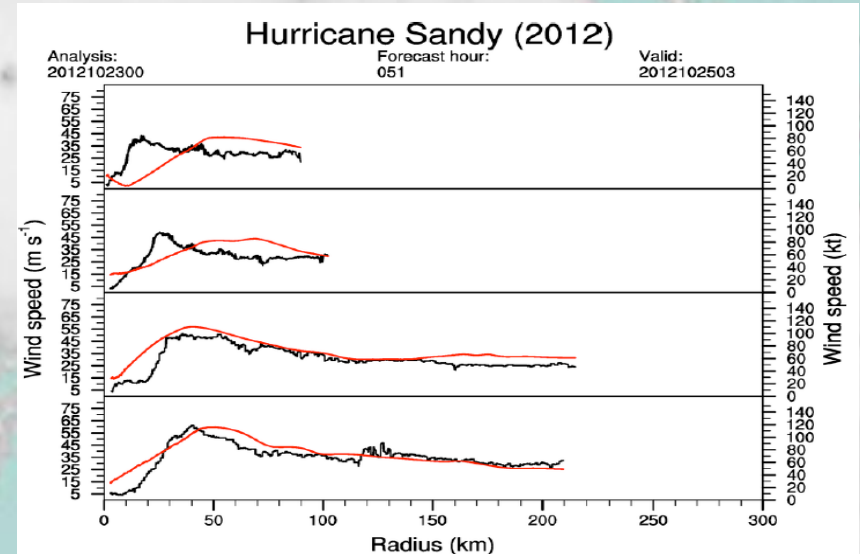
Forecast hour:
051

Valid:
2012102503



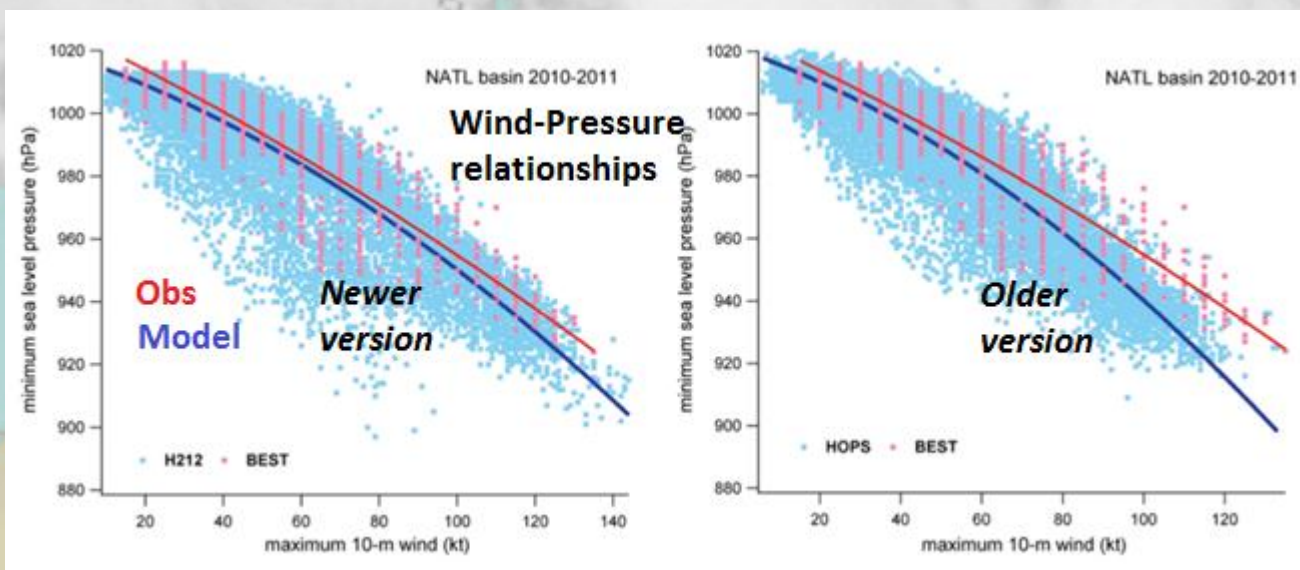
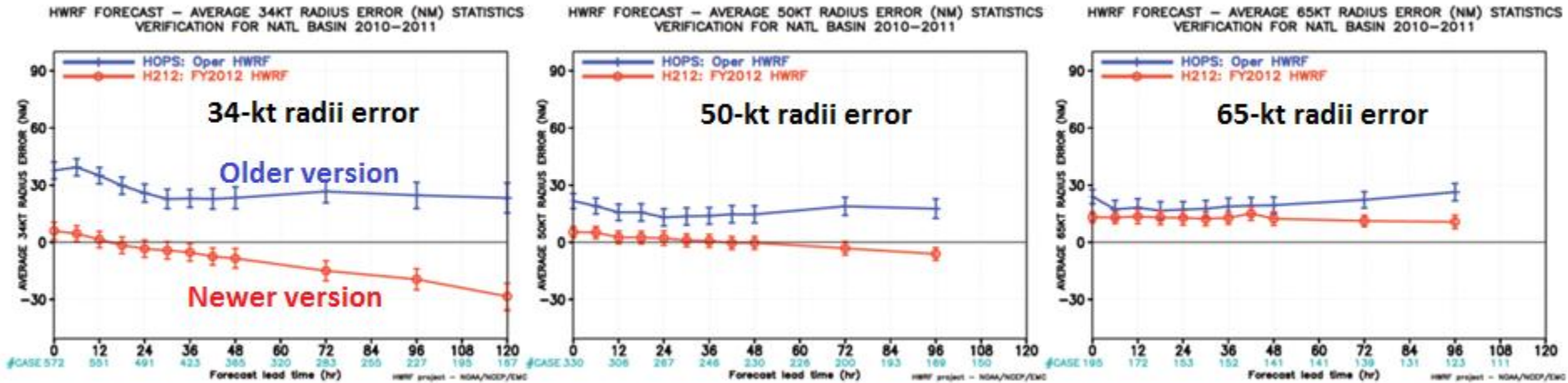
Assessing NWP structure predictions
Vigh (2014)

Flight-level winds (black)
Model-predicted flight
level-equivalent (red)



Evaluating performance of HWRF's upgrades

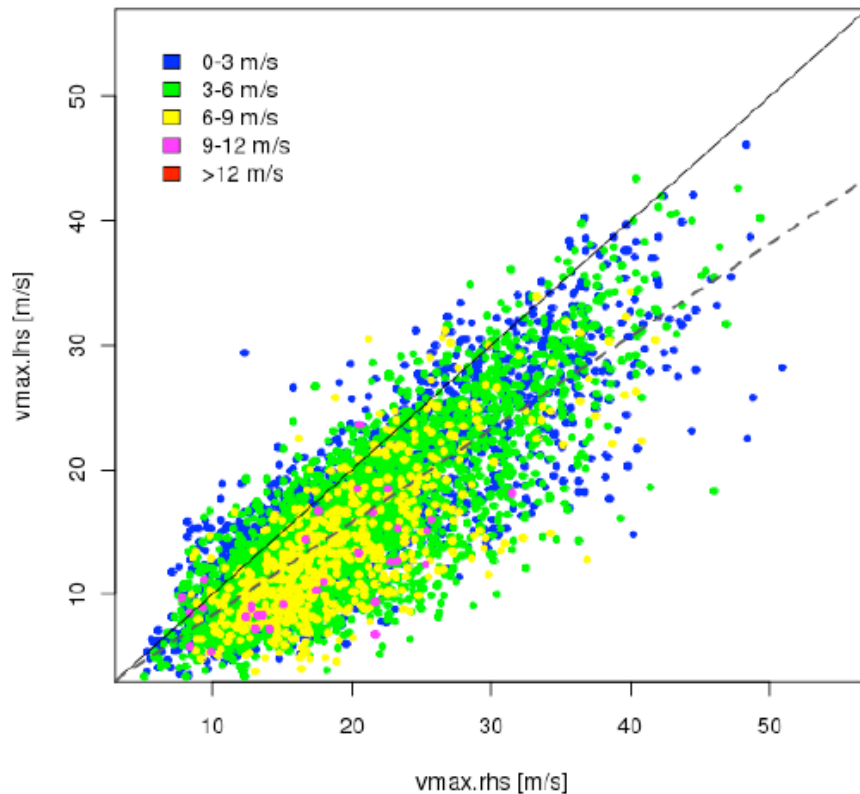
Tallapragada et al. (2012)



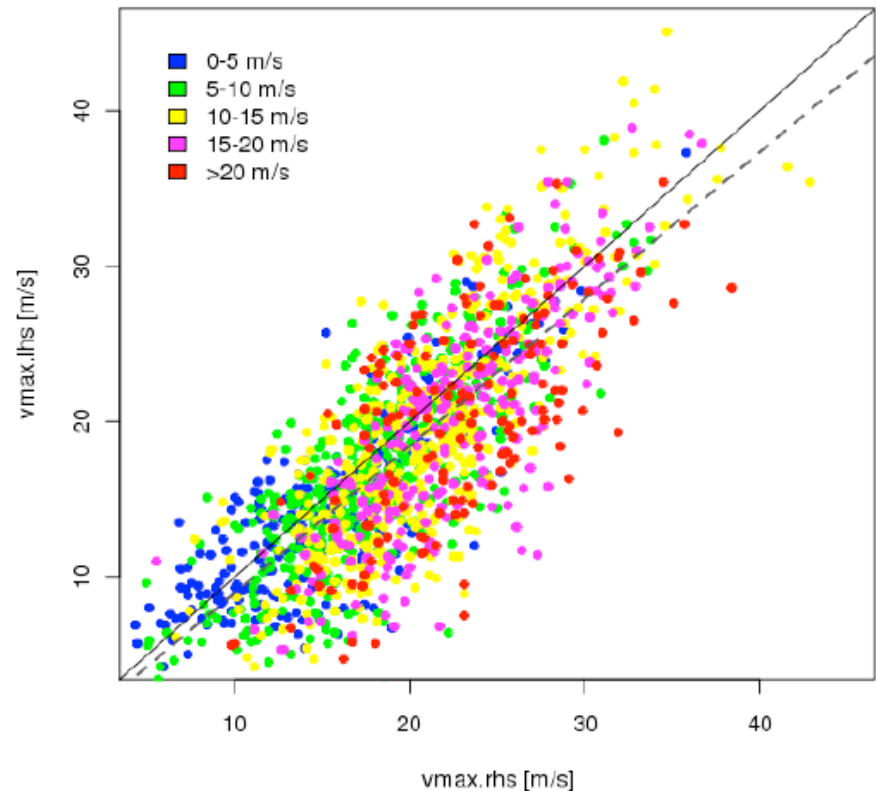
Northwest Pacific study of Max winds right-/left-of-track using reanalysis data

Loridan et al. (2014)

fully tc snapshots



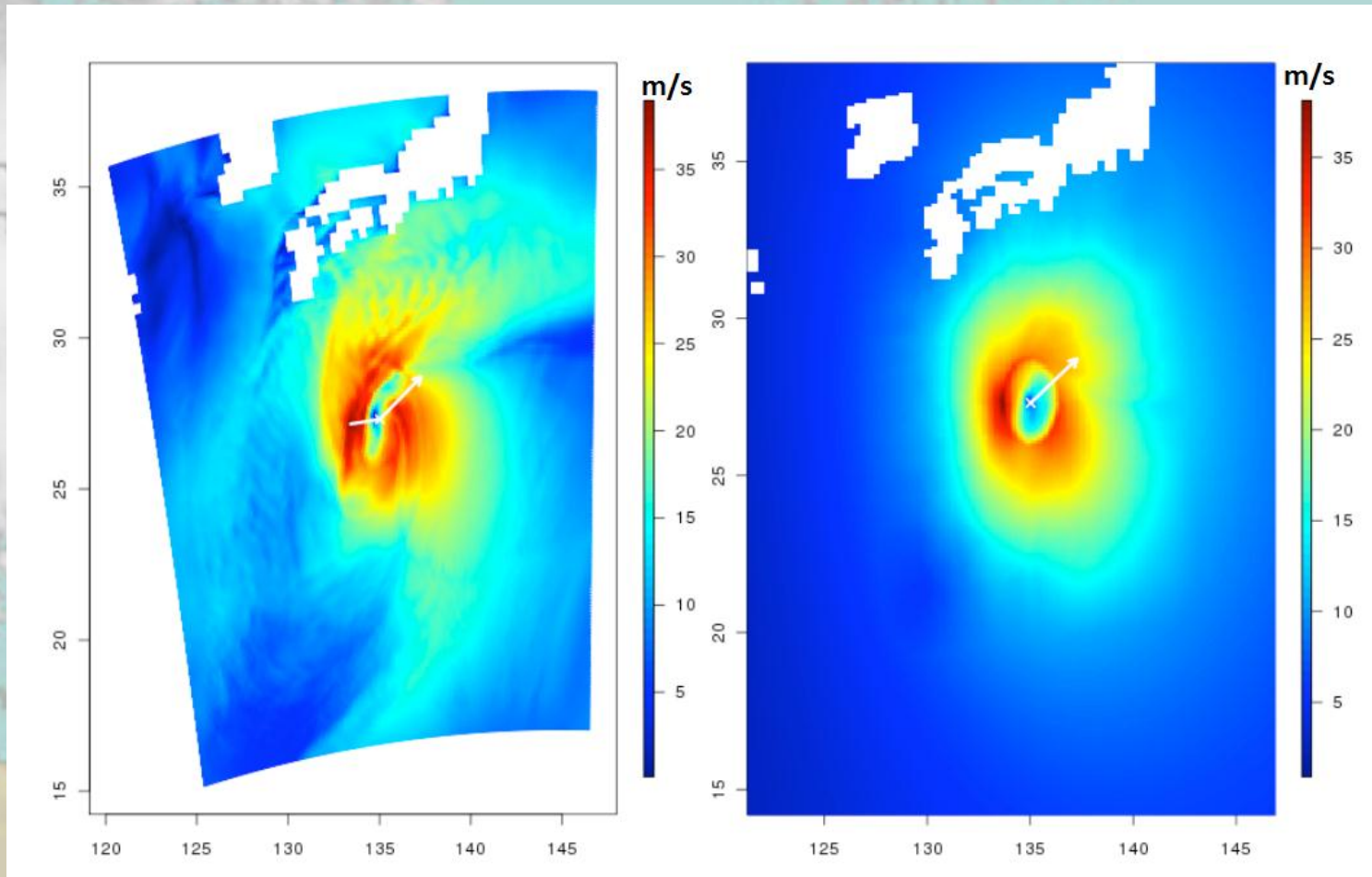
Transitioning and fully et snapshots



Many more left-of-track maxima for faster-moving, ET-type scenarios compared to purely-tropical events

Parametric wind field representing the left-of-track ET structure

Loridan et al. (2014)

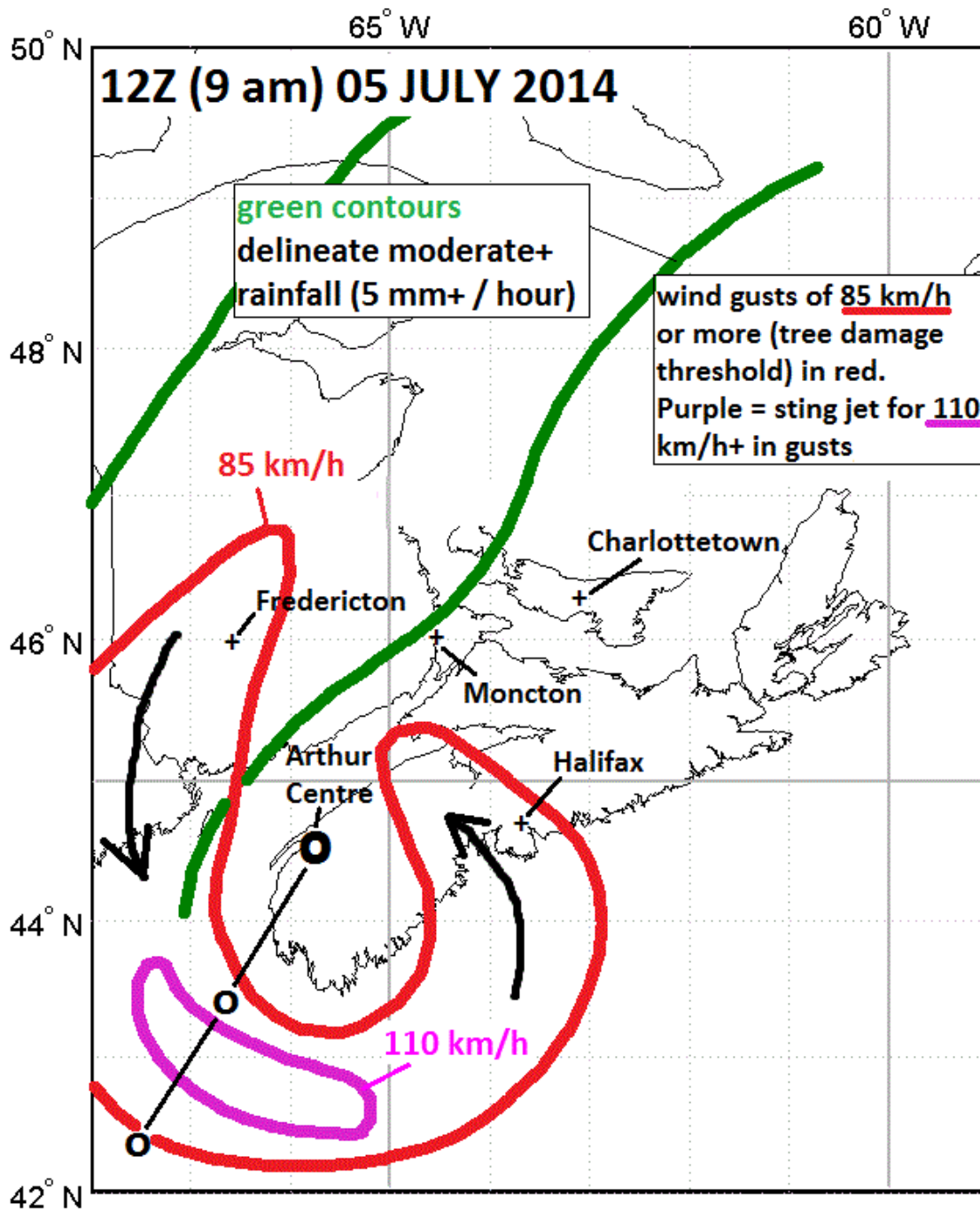


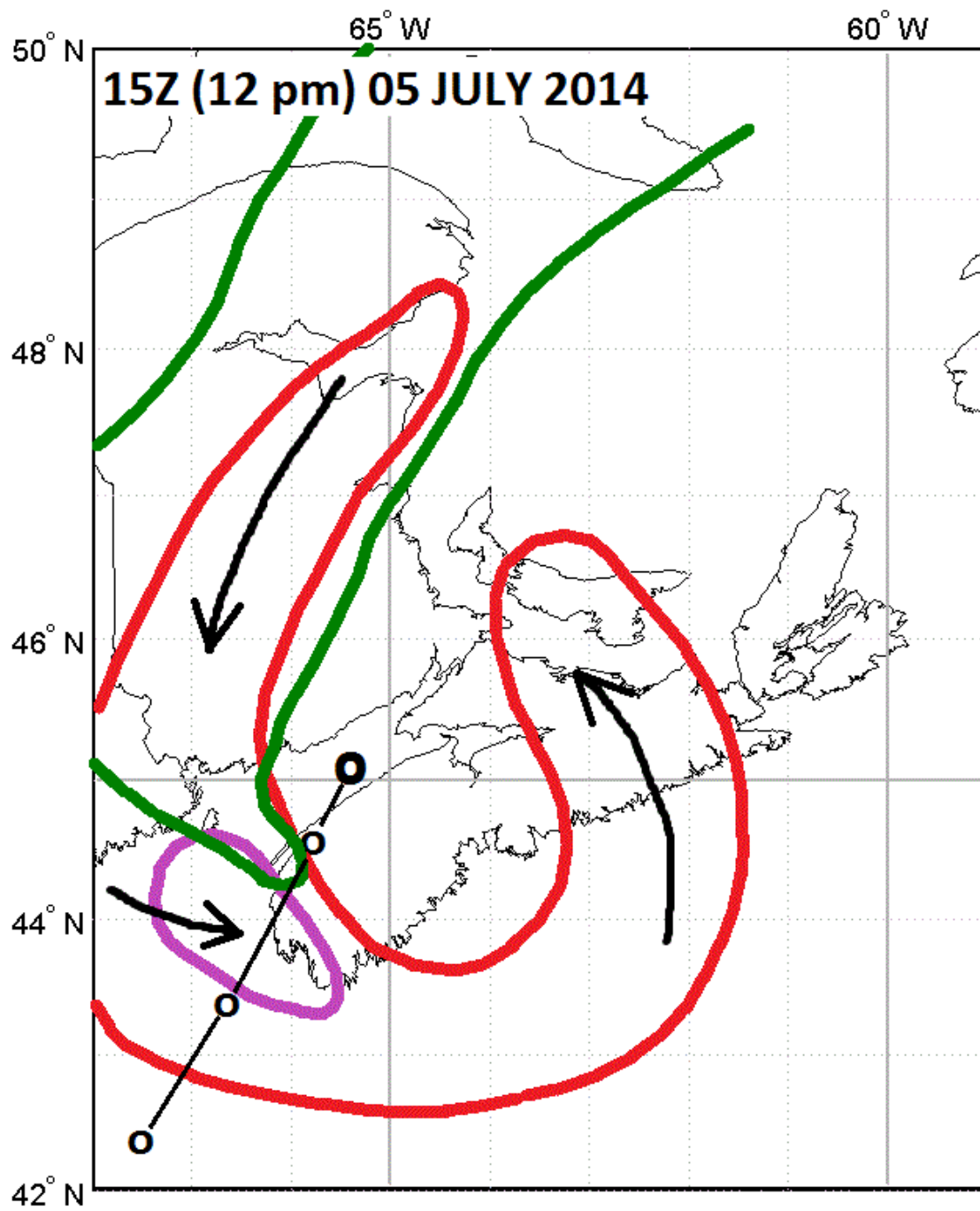
Important for future risk assessment from ET cyclones

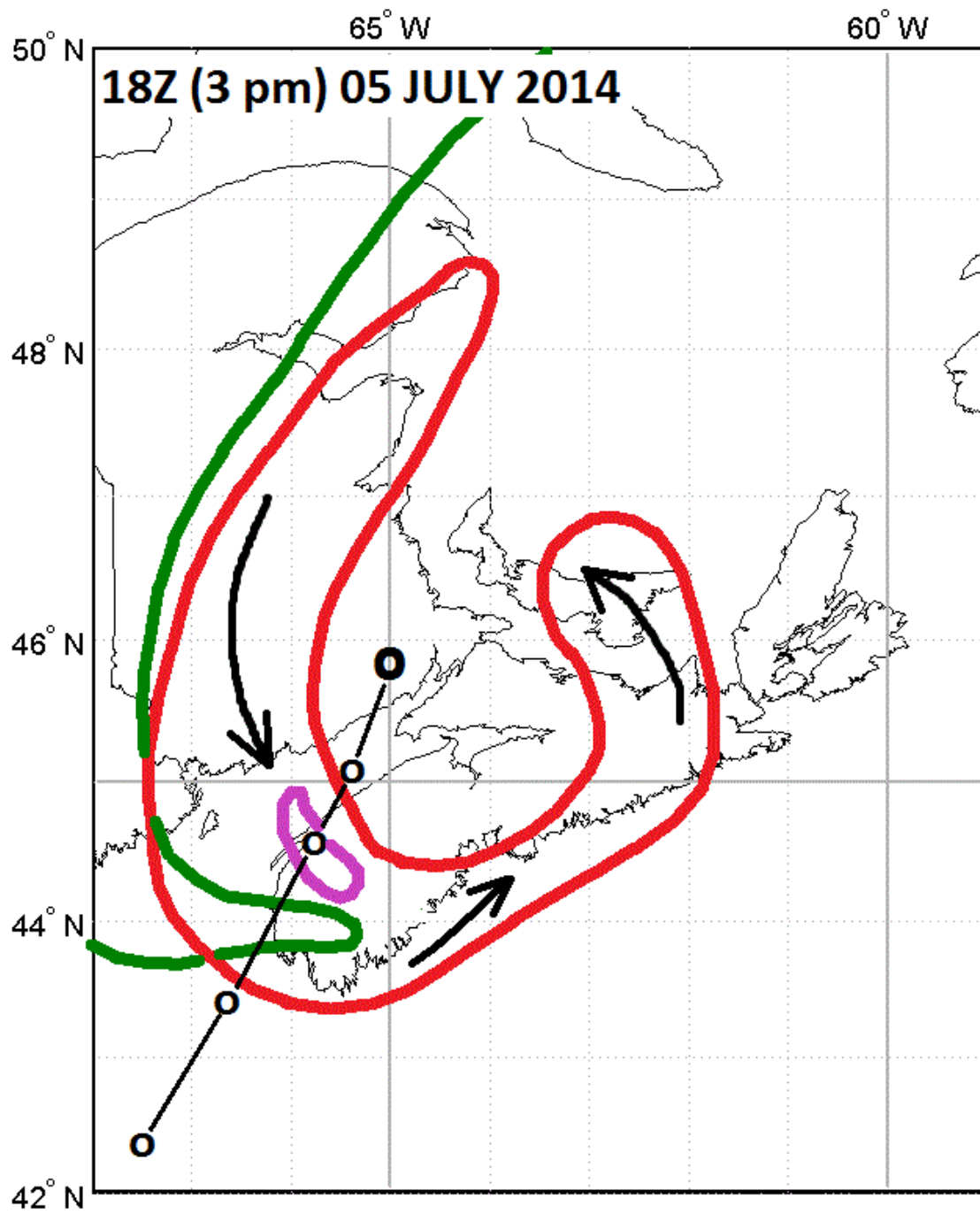
A satellite image of a tropical storm system, likely Post-Tropical Storm Arthur 2014, showing a well-defined eye and spiral cloud bands over the Pacific Ocean. The storm is positioned in the lower right quadrant of the frame. The background shows the outlines of continents and islands in shades of brown and tan, with the ocean in a light blue-grey hue.

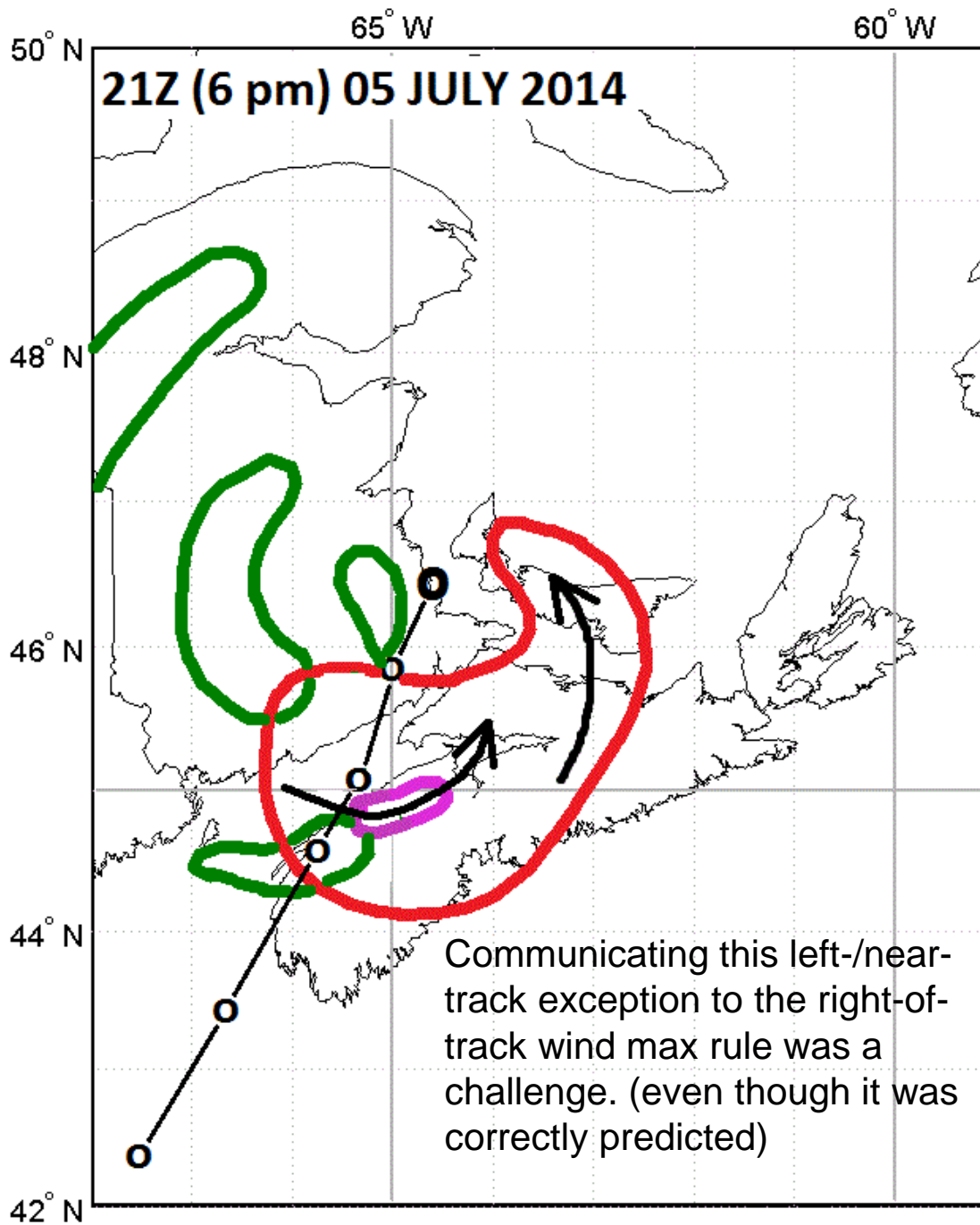
Wind and rainfall evolution during Post-Tropical Storm Arthur 2014

Case of damaging winds confined
to near-track and left-of-track

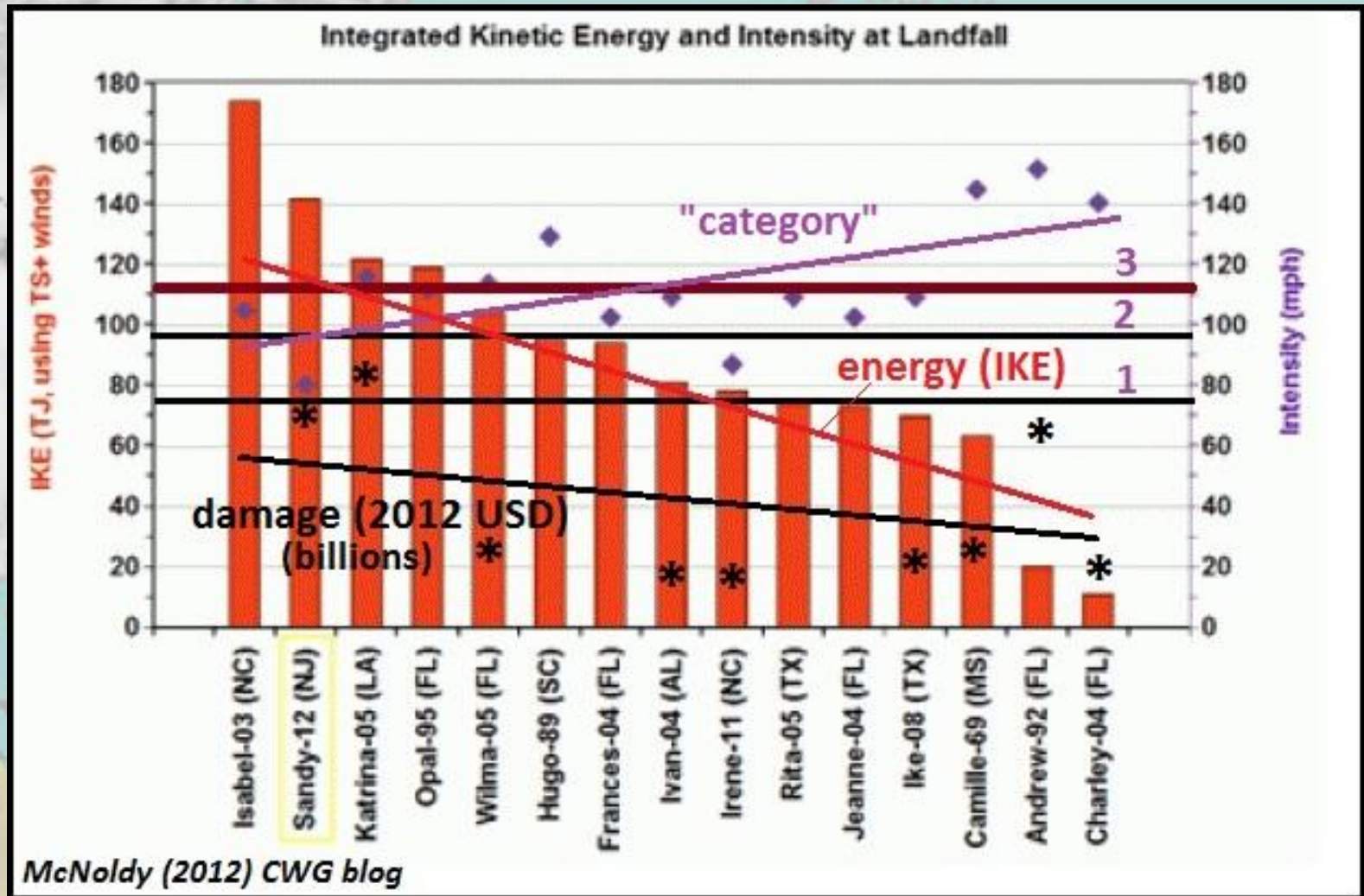








Recall:



Guishard (2014) RPI/BIOS

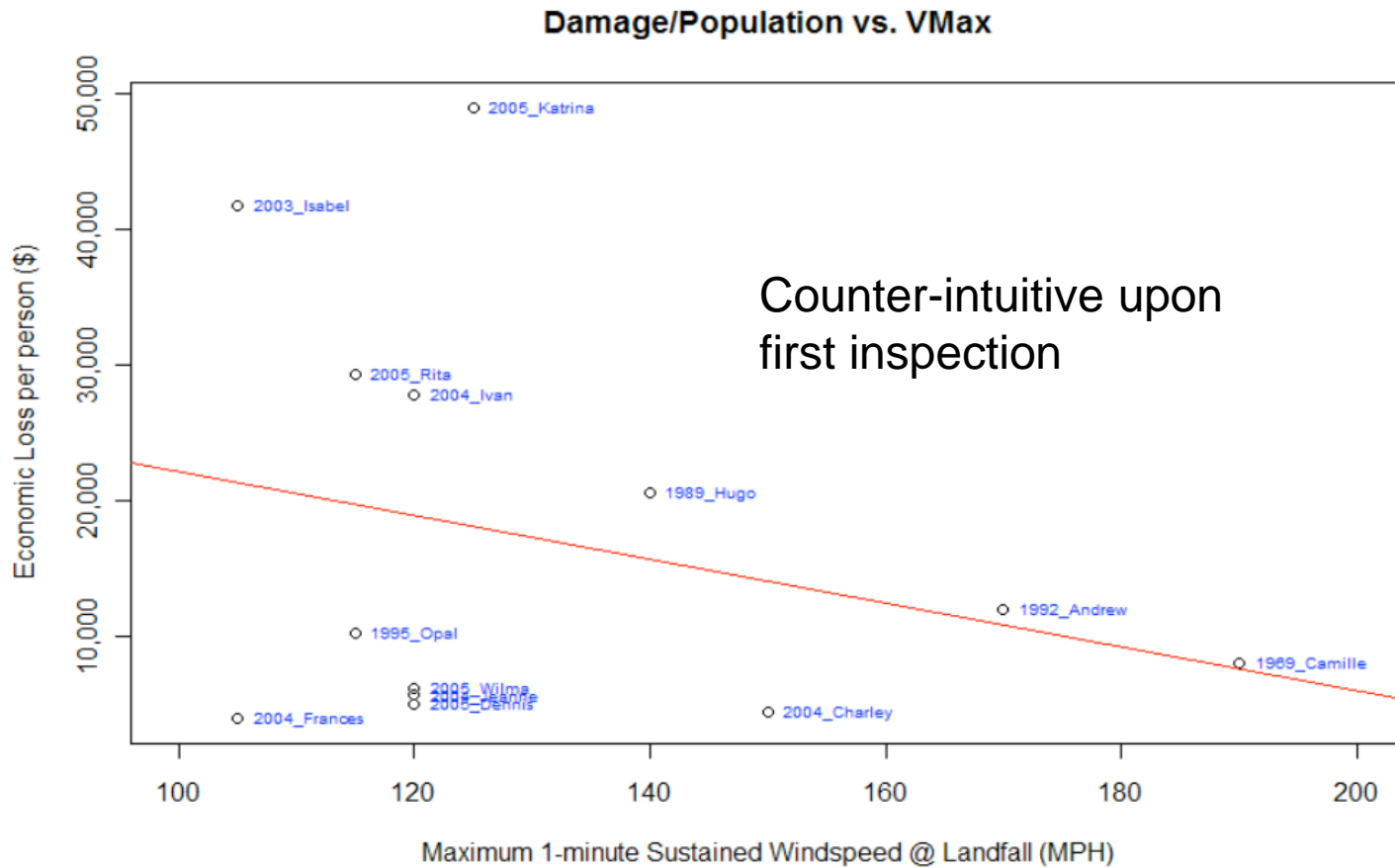


Figure 6. Scatterplot and Linear regression of maximum sustained winds at landfall (Powell and Reinhold, 2007), vs. Economic Damage per unit Population (from Murnane and Elsner 2012) Linear regression function is $y = -160.37x + 38167$, with $R^2 = 0.0725$

Guishard (2014) RPI/BIOS

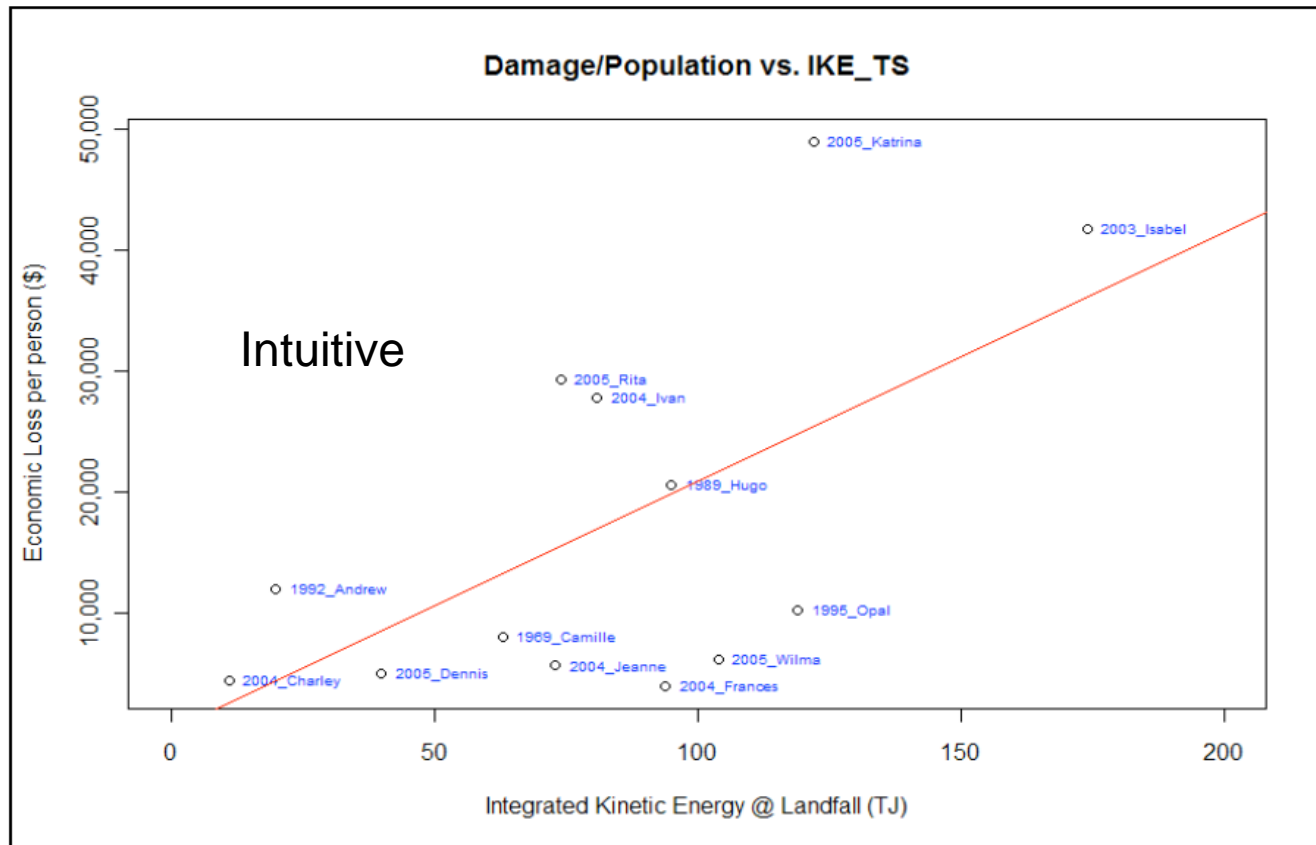


Figure 5. Scatterplot and Linear regression of Integrated Kinetic Energy within the tropical storm wind radius (Powell and Reinhold, 2007), vs. Economic Damage per unit Population (from Murnane and Elsner 2012) Linear regression function is $y = 206.15x + 289.78$, with $R^2 = 0.3581$

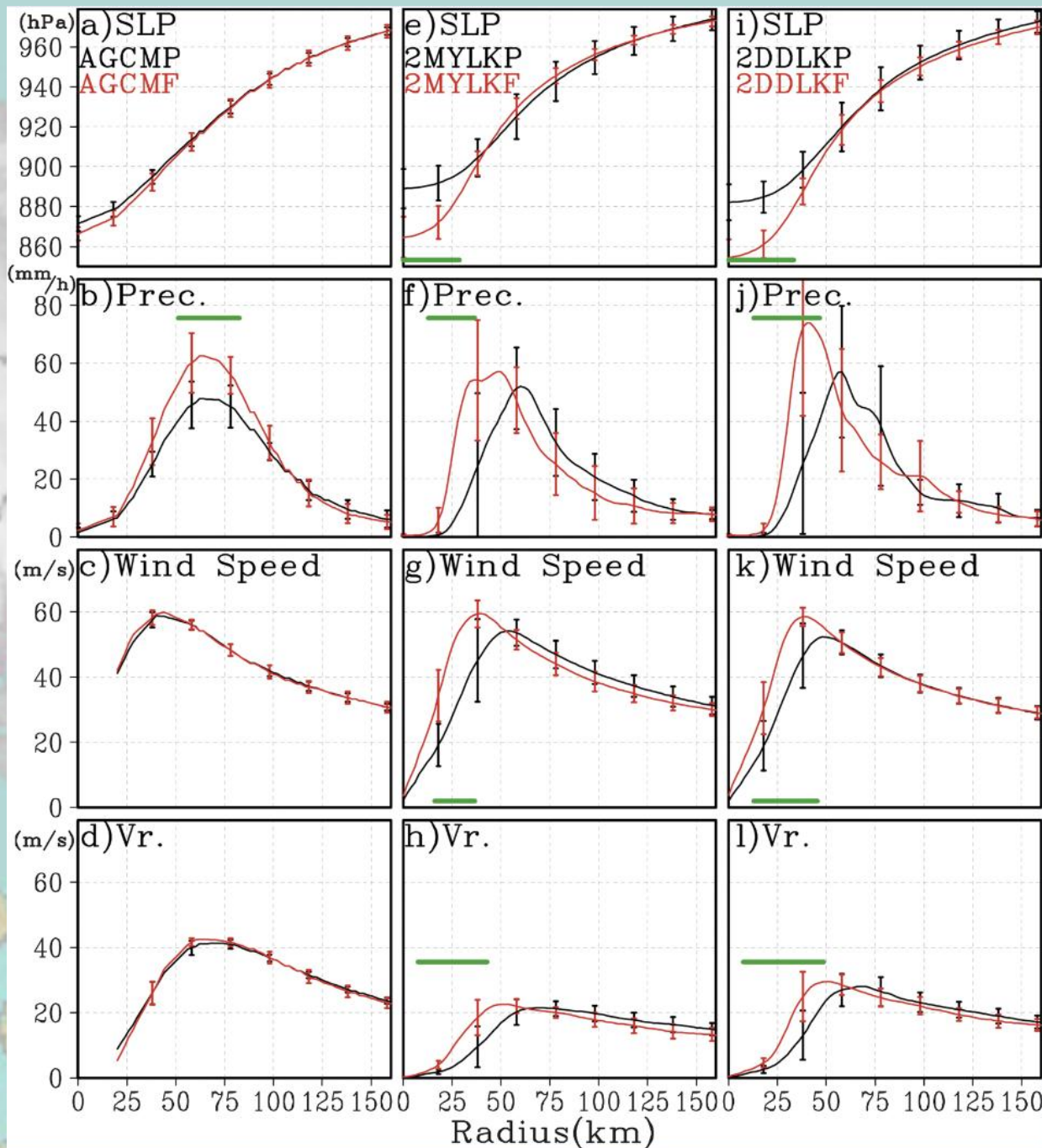
Contemplation for discussion groups....

- Do we need an enhanced hurricane intensity scale? *(IKE-based scale with close connection to traditional scale would be pivotal in the transition)*
- There has been an enhanced Fujita scale for tornadoes....time is nigh for tropical cyclones
- Worth thinking about and for discussion during the breakout groups

Kanada et al. (2013)

2-km non-hydrostatic model
used to downscale a 20-km
an AGCM to study sub-900-
mb TCs

MYLK and DDLK are different
boundary layer schemes



Acknowledgements/Contributors to pre-meeting report and presentation

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