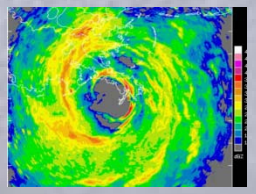
Evaluating Numerical Models to Improve the Prediction of Tropical Cyclone Intensity

Robert Rogers

AOML Program Review

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Outline

- Background and motivation
- Examples
  - Surface winds
  - Boundary layer structure
  - Humidity
  - Microphysics
  - Rainfall

Background and motivation

Improvements in intensity forecasts have lagged improvements in track forecasts

Numerical model guidance can be key contributor to intensity forecasts

Limitations in numerical models a significant contributor to slower improvements in intensity forecasts

- inadequate specification of the TC vortex in the initial conditions
- deficient representation of physical processes
- insufficient resolution

Background and motivation

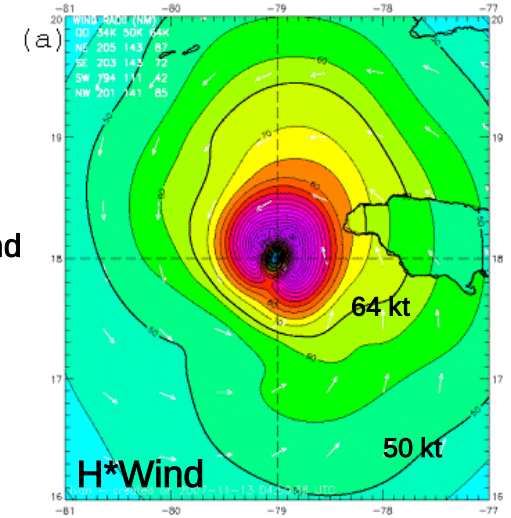
Comparing numerical models with observations in a robust manner can identify deficiencies in the models and lead to improvements in those models

HRD is uniquely positioned to contribute to this effort through a combination of data collection and analysis and numerical model experiments

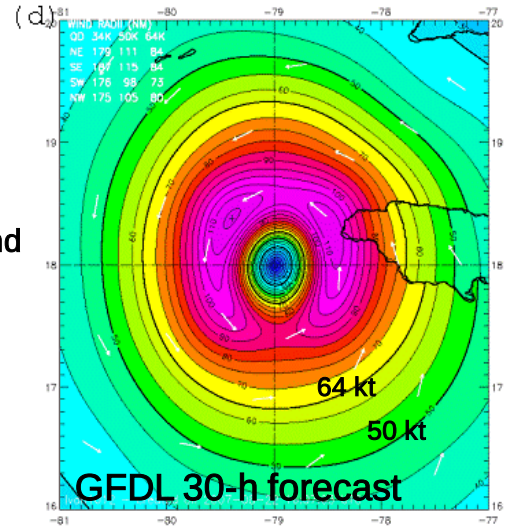
Surface wind structure

How well do numerical models predict magnitude and distribution of surface wind field?

Peak wind 142 kt

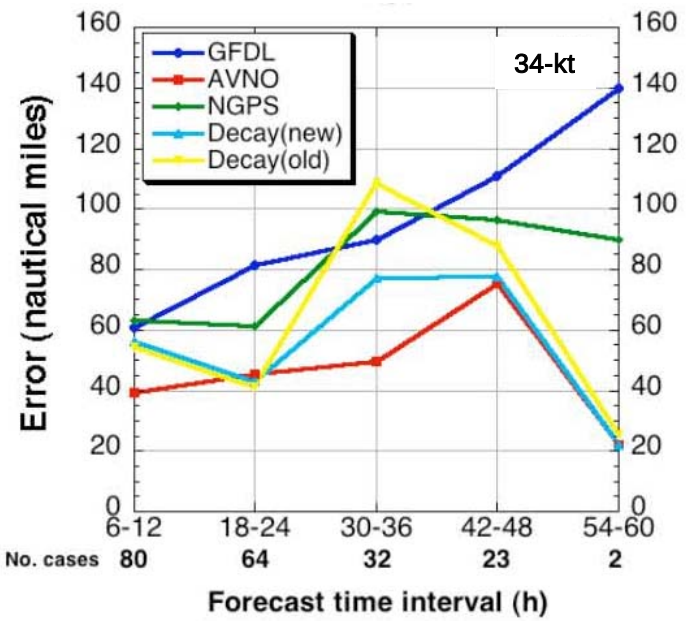


Peak wind 105 kt



Surface winds (kt) for Hurricane Ivan valid 18 UTC Sept. 11

Errors in forecasts of radial location (nm) of 34-kt wind radii for landfalling TCs



Comparisons between models and observations

- peak wind weaker
- RMW larger, 34- and 64-kt isotachs at larger radii
- wind field more symmetric

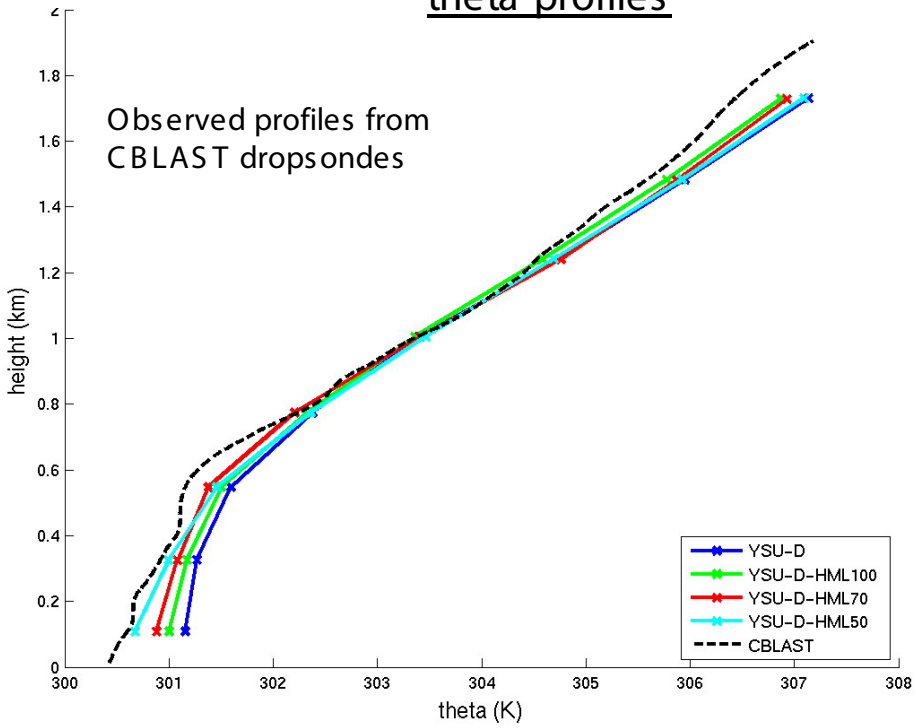
Possible deficiencies

- initial vortex too large, symmetric
- resolution too coarse

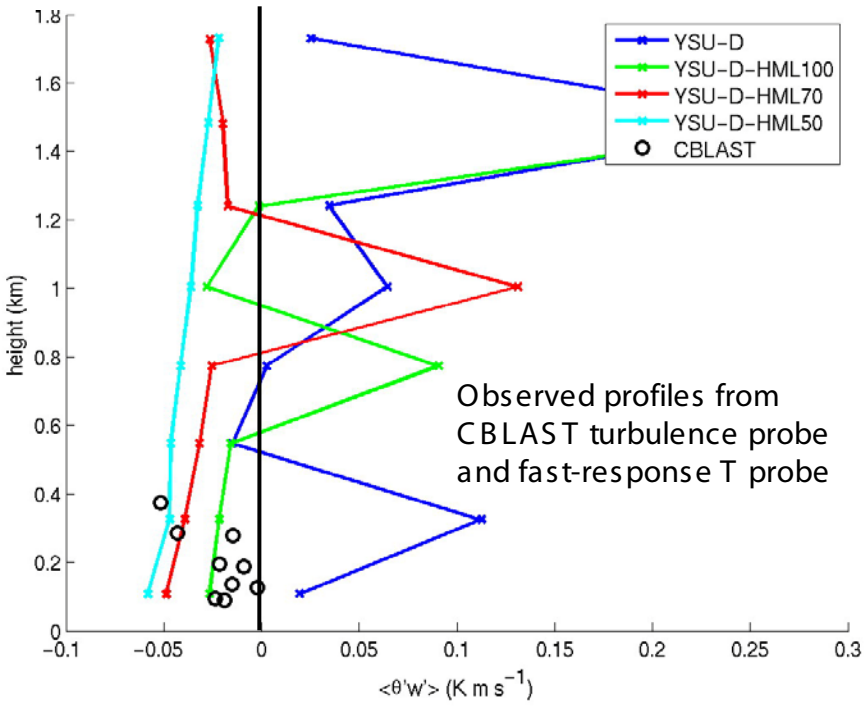
Boundary layer structure

How well do numerical models depict the mean and turbulence structure of the tropical cyclone boundary layer?

theta profiles



sensible heat flux profiles



Comparisons between models and observations

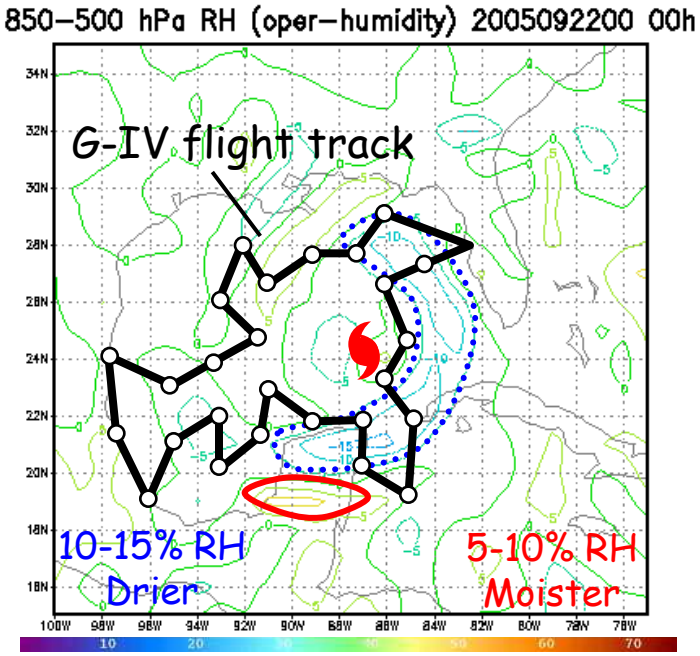
- uncoupled model boundary layer is too warm; coupling improves profile
- uncoupled heat flux is in wrong direction

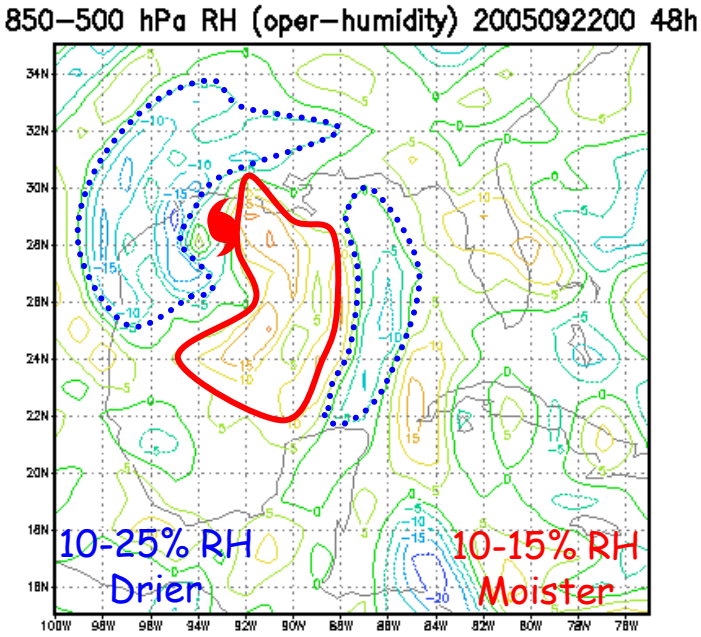
Possible deficiencies

- heat and moisture transfer coefficients specified incorrectly
- sea-spray effects not represented adequately

Humidity

How well do numerical models represent initial humidity fields?





Comparisons between models and observations

- low- to mid-tropospheric air too moist around east side of storm in initial fields of control runs
- bias persists throughout forecast

Possible deficiencies

- moisture data from dropsondes not routinely incorporated into operational analyses until 2006

Microphysics

How well do numerical models depict the magnitude and distribution of hydrometeors and vertical velocity?

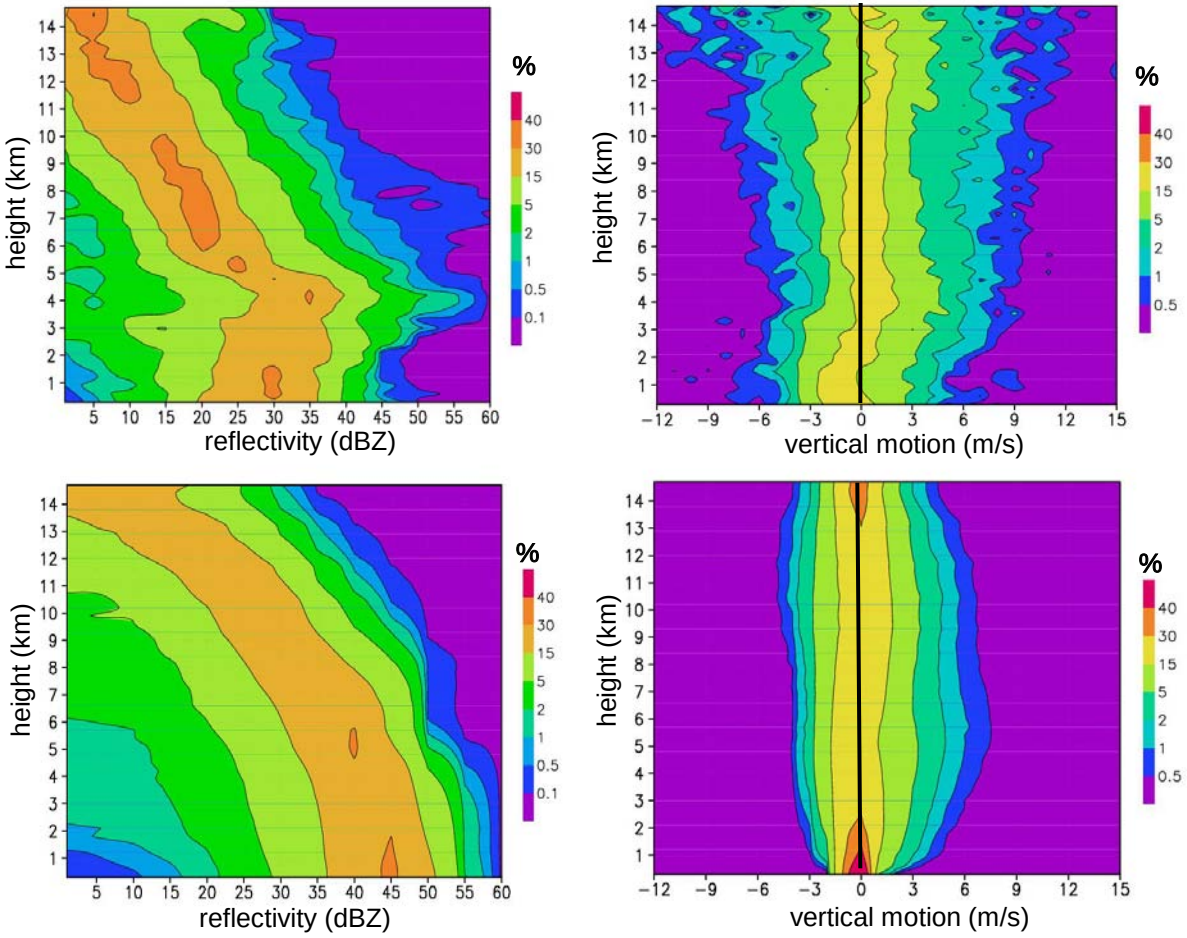
Contoured frequency by altitude diagrams (CFADs)

Eyewall reflectivity

Eyewall vertical motion

airborne Doppler radar

numerical model



Comparisons between models and observations

- higher reflectivity in models, less decrease with height above melting level
- vertical motion weaker in model, distribution narrows with height

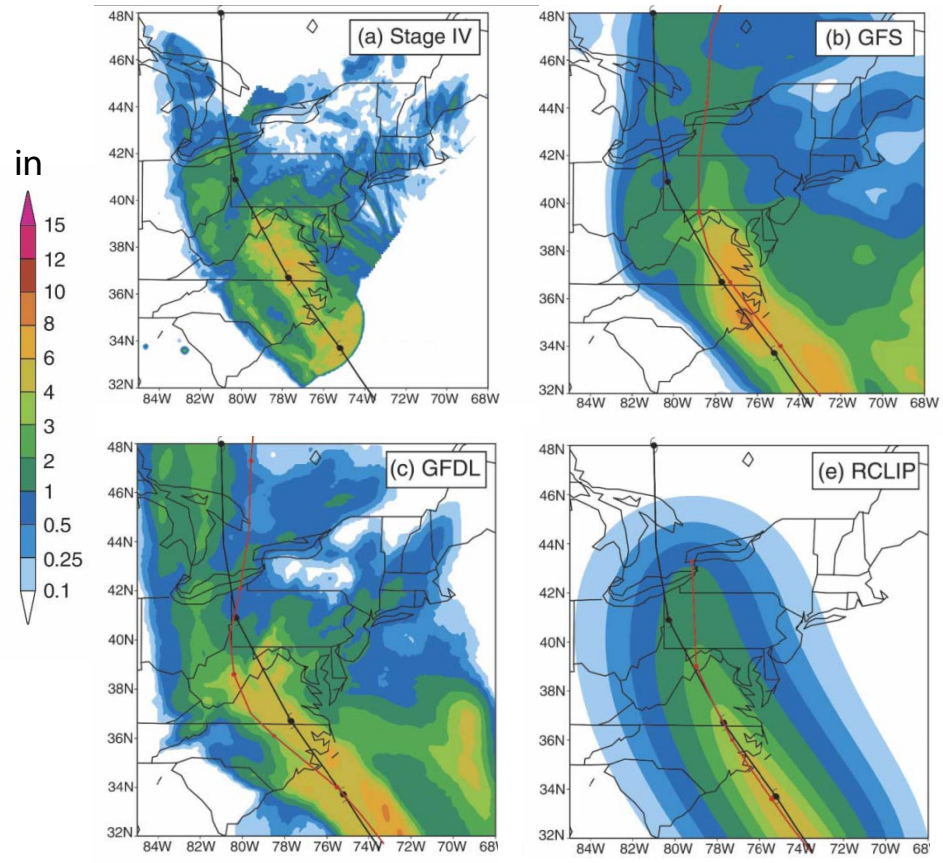
Possible deficiencies

- graupel, snow production terms too high in model
- fall speeds too small in model

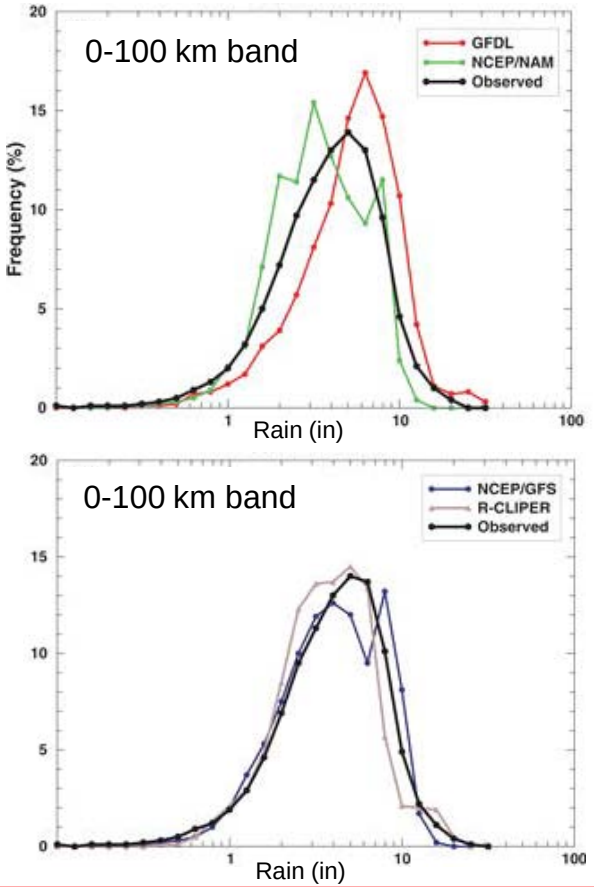
Rainfall

How well do numerical models depict the magnitude and distribution of tropical cyclone rainfall?

72-h rainfall (in) from Hurricane Isabel (2003)



PDFs of rain flux



Comparisons between models and observations

- GFDL (NAM) produces too much (too little) rain in inner core
- GFS, R-CLIPER produce inner-core distribution well

Possible deficiencies

- errors in convective, microphysical parameterizations
- resolution deficiencies compensating?

Summary

- HRD involved in several model evaluation activities
  - surface winds
  - boundary layer structure
  - humidity
  - microphysics
  - rainfall
- HRD uniquely positioned to contribute to these activities
- Insights gained from evaluations can guide activities toward improving model parameterization, initialization, ultimately intensity forecasts

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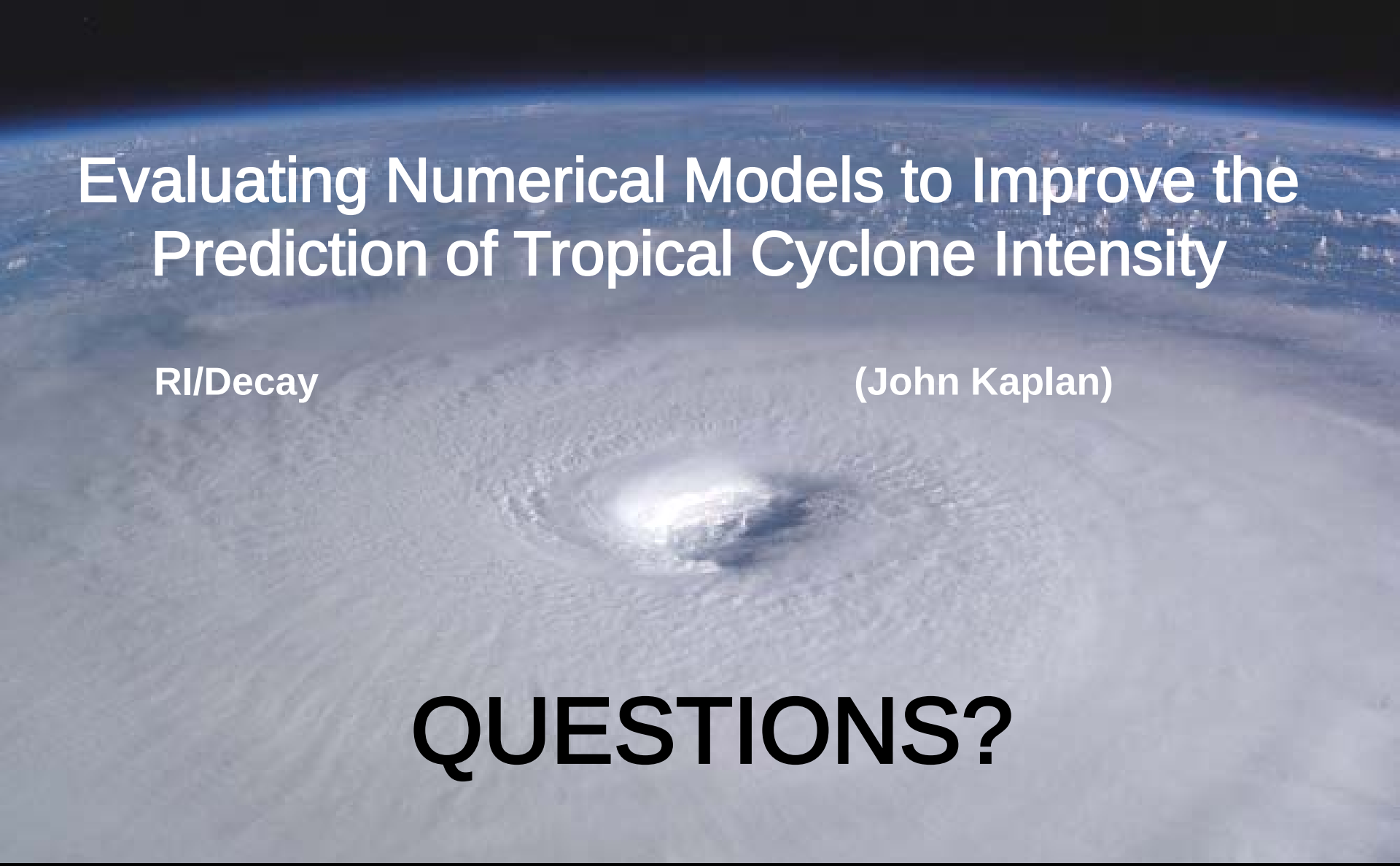
RI/Decay **(John Kaplan)**



QUESTIONS?

Background Material