Early Career Scientist Involvement in the PRE-Depression Investigation of Cloud-systems in the Tropics (PREDICT) Field Experiment

Kyle Griffin
John Sears
Brian Tang

Contributions from Clark Evans, Heather Archambault, **Jason Cordeira**, Cody Fritz, Thomas Galarneau Jr., Saska Gjorgjievska, Alexandria Johnson, William Komaromi, Sarah Monette, Paytsar Muradyan, Brian Murphy, Michael Riemer, Daniel Stern, Segayle Thompson

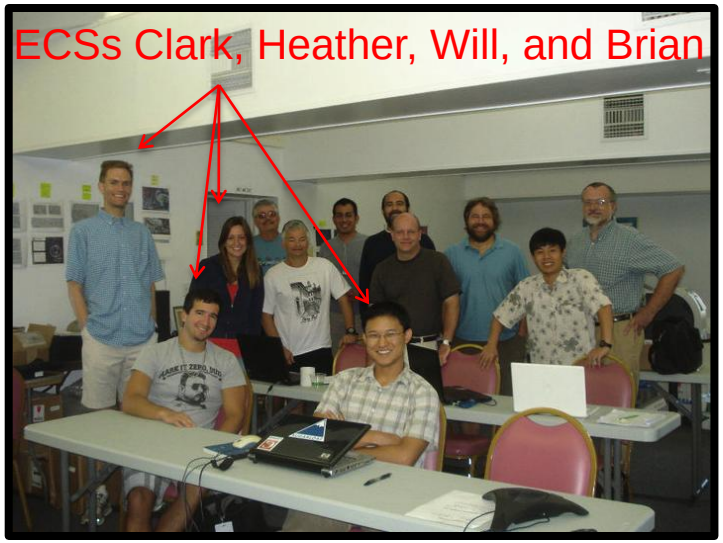
PREDICT Workshop
June 8, 2011
Monterey, CA

Motivation

“I believe there was a lot of insight and responsibility gained by being held accountable on a daily basis. The ability to make and contribute to forecast product generation and decisions that influence not only yourself, but a much, much larger contingency definitely fostered a unique two-week education and real-world experience, one that I'm not likely to forget anytime soon.” - Jason Cordeira

People Behind PREDICT

- Twelve Principle Investigators
  - representing nine institutions
- Over seventy scientists and support staff



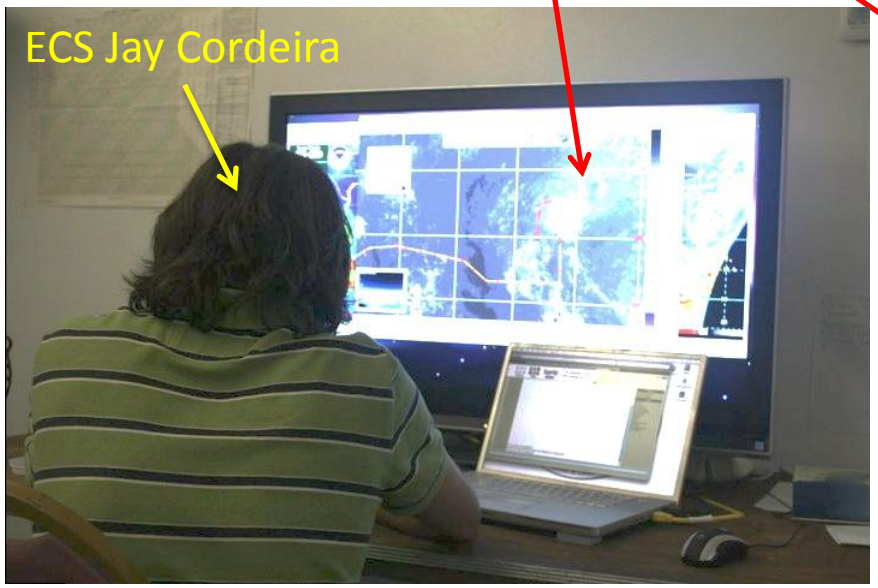
- Seventeen Early Career Scientists (ECSs)
  - e.g., graduate students and post-doctoral researchers
  - representing eleven institutions
  - backgrounds in meteorology and related fields

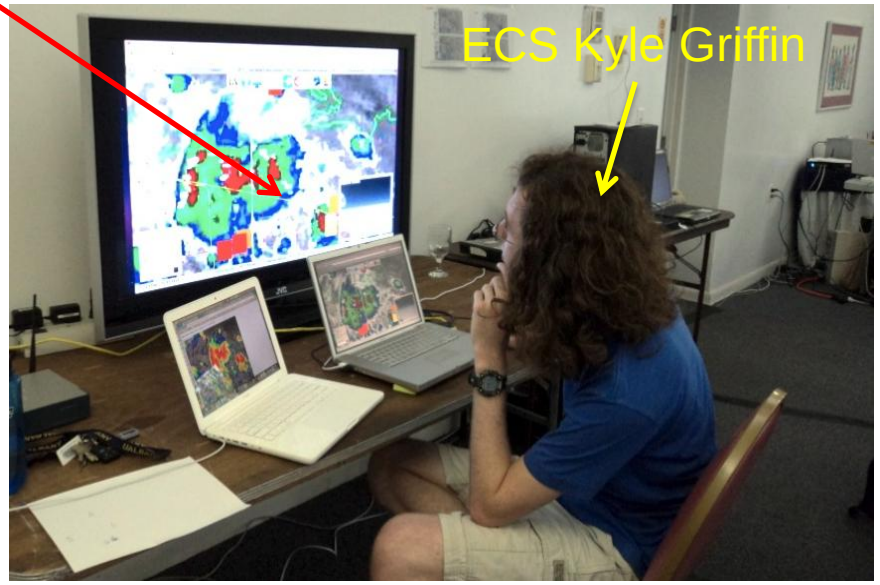
ECS Involvement in PREDICT

- ECS involvement critical to the success of the field experiment
- ECSs:
  - provided forecast support for mission flights (preflight and nowcasting duties during flight)
  - presented daily weather briefings
  - generated and comprehended novel forecast and analysis products that were used in weather briefings and by PIs in mission planning
  - obtained, processed, and quality controlled data from missions

ECS Involvement in PREDICT

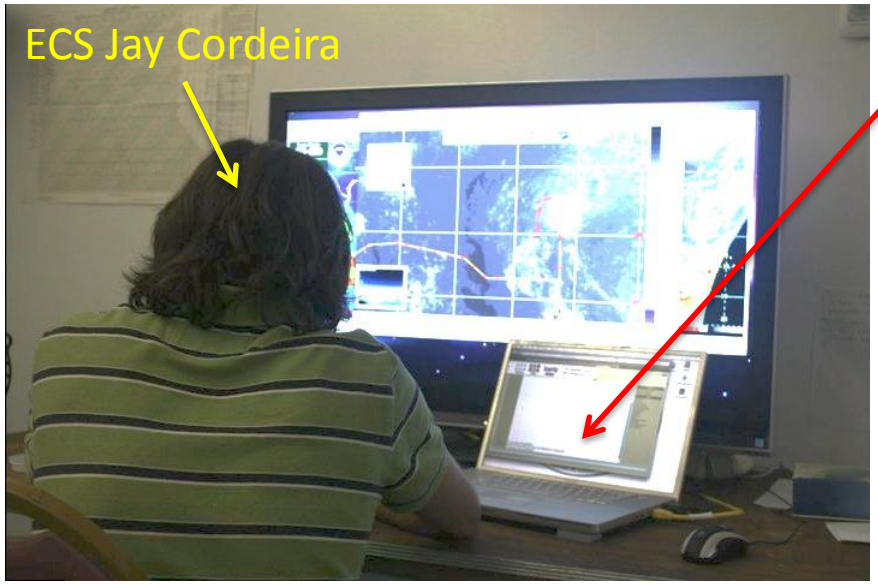
- Detailed forecast support for mission flights
  - monitored G-V flight track, satellite and radar evolution, overshooting cloud tops

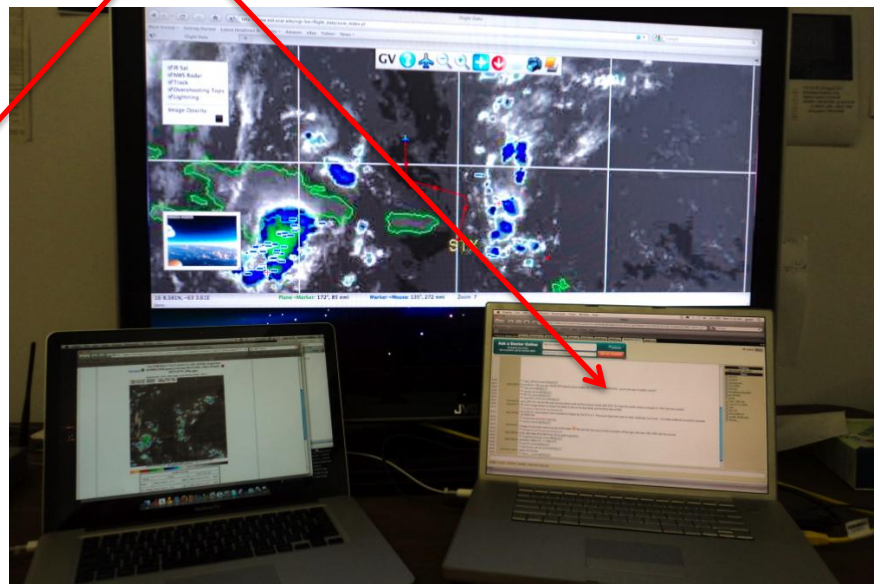




ECS Involvement in PREDICT

- Detailed forecast support for mission flights
  - monitored G-V flight track, satellite and radar evolution, overshooting cloud tops
  - participated in live chat room discussions with PIs, operations, and aircraft crew





ECS Involvement in PREDICT

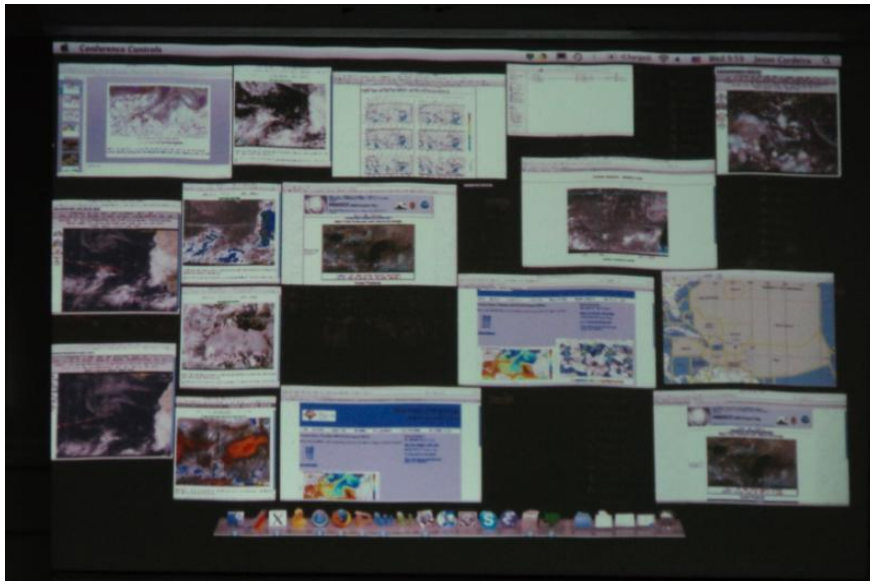
PI Michael Montgomery interacting with the G-V aircraft during a flight

ECS Involvement in PREDICT

- ECS involvement critical to the success of the field experiment
- ECSs:
  - provided forecast support for mission flights (preflight and nowcasting duties during flight)
  - presented daily weather briefings
  - generated and comprehended novel forecast and analysis products that were used in weather briefings and by PIs in mission planning
  - obtained, processed, and quality controlled data from missions

ECS Involvement in PREDICT

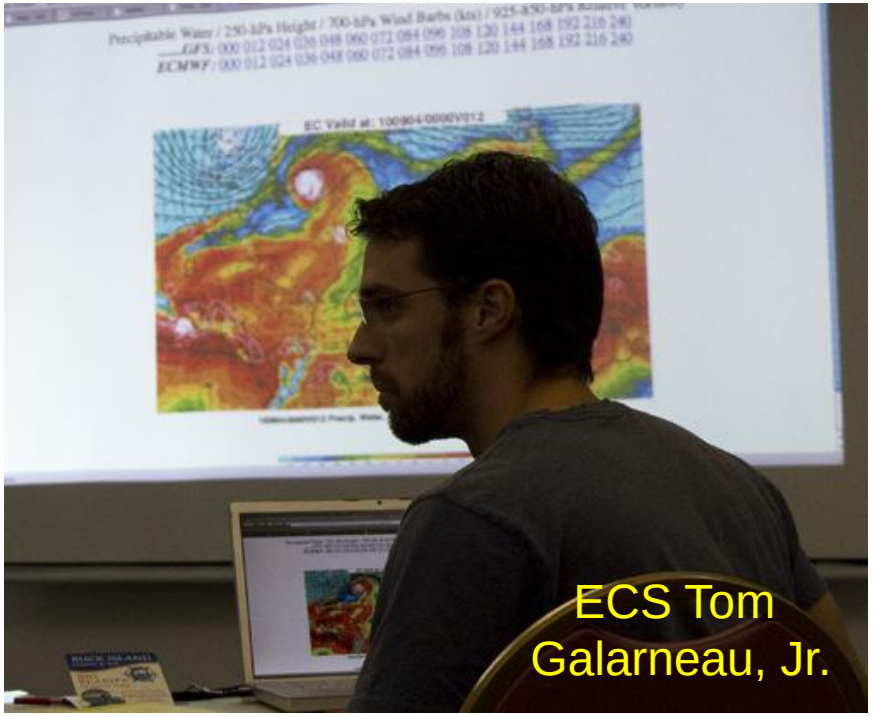
- Daily Weather Briefings
  1. Tri-Agency weather discussions with GRIP and IFEX
  2. PREDICT daily weather briefings



ECS Involvement in PREDICT

- Daily Weather Briefings
  - summarized basin-, synoptic-, and meso-scale atmospheric conditions over the North Atlantic
  - provided detailed forecasts

ECSs Tom Galarneau, Jr. and John Sears with PI Lance Bosart

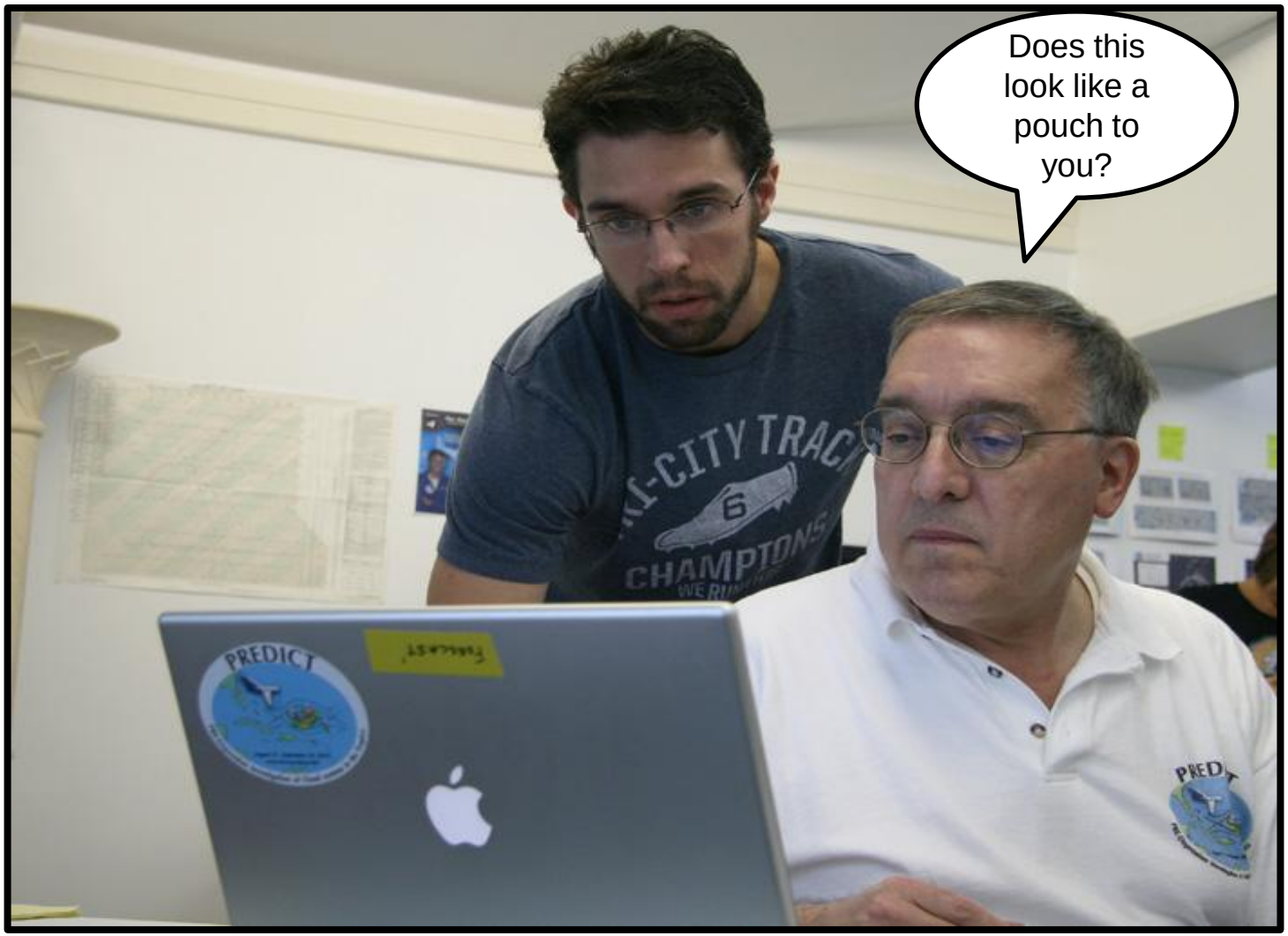


ECS Involvement in PREDICT

ECS Tom Galarneau, Jr. and PI Lance Bosart preparing for a weather briefing

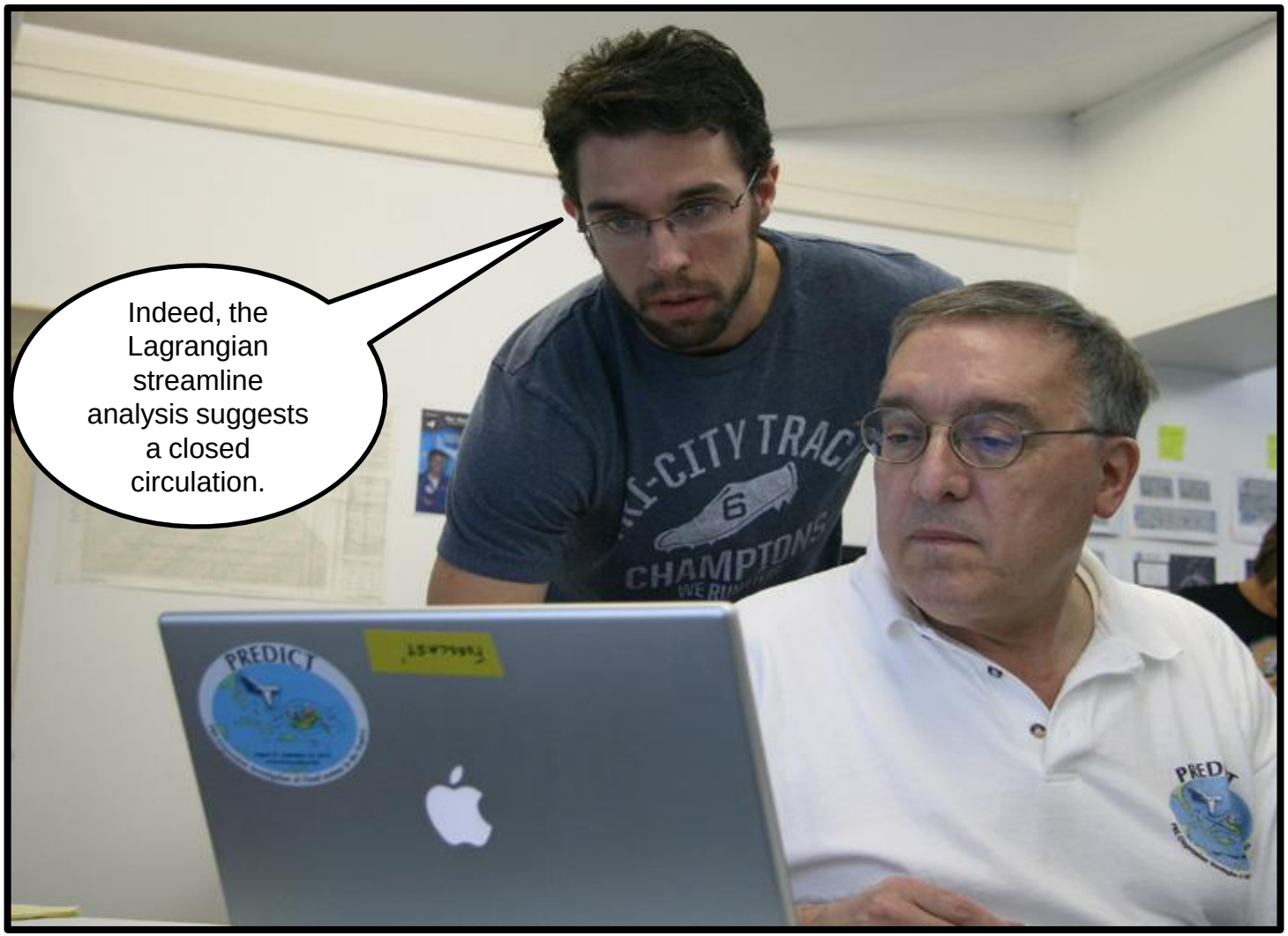
ECS Involvement in PREDICT

ECS Tom Galarneau, Jr. and PI Lance Bosart preparing for a weather briefing



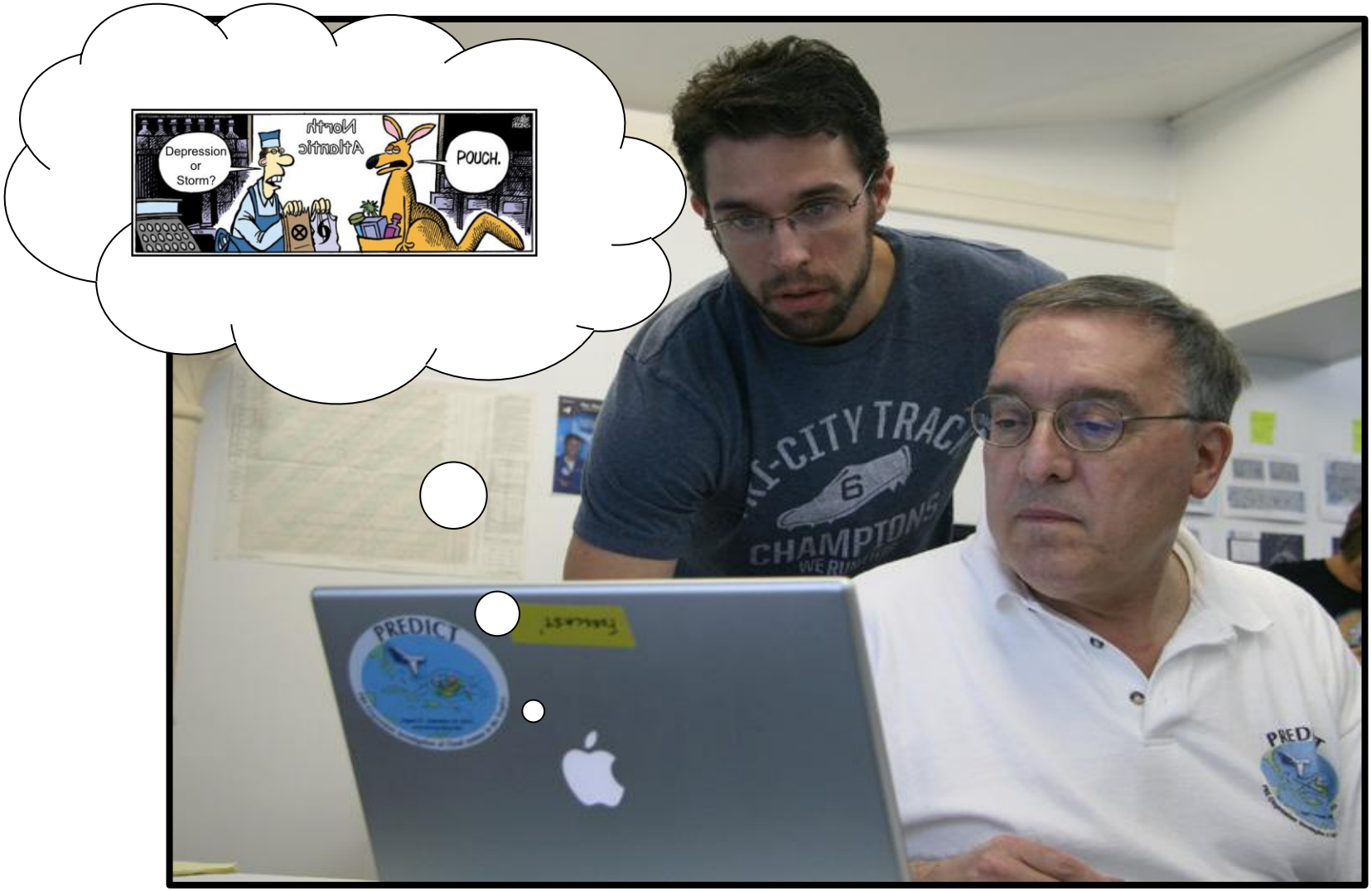
ECS Involvement in PREDICT

ECS Tom Galarneau, Jr. and PI Lance Bosart preparing for a weather briefing



ECS Involvement in PREDICT

ECS Tom Galarneau, Jr. and PI Lance Bosart preparing for a weather briefing

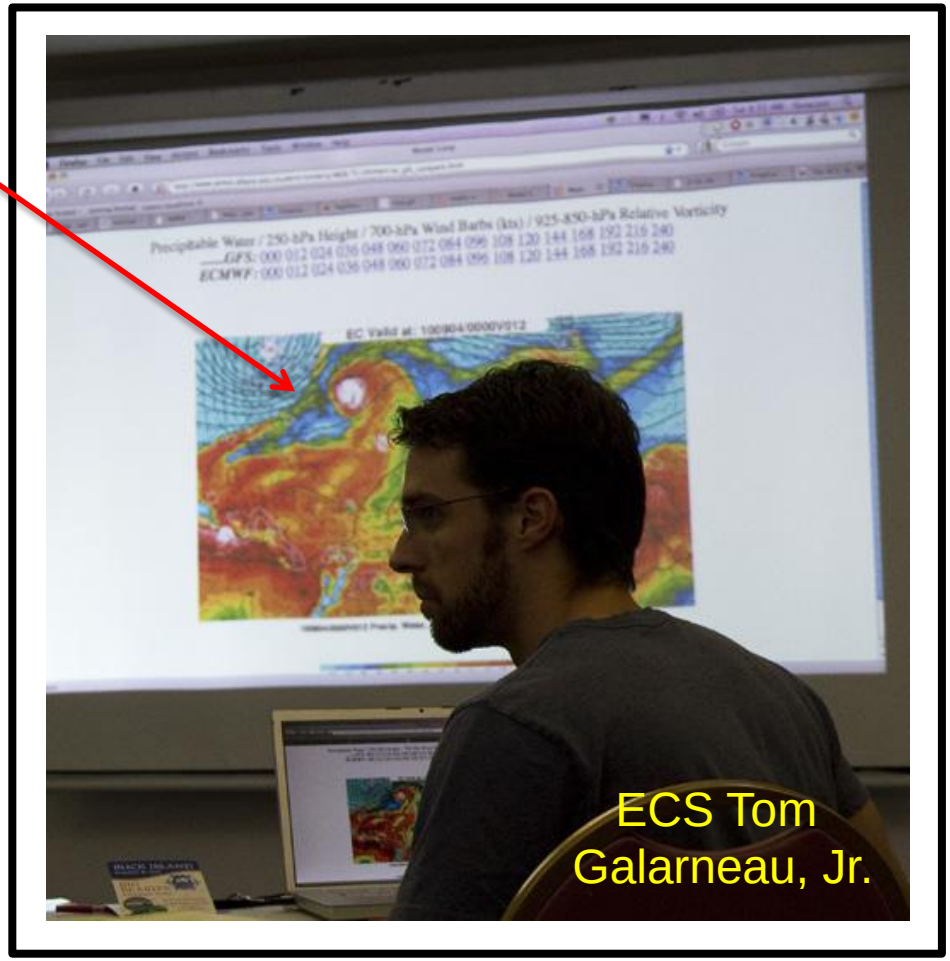


ECS Involvement in PREDICT

- ECS involvement critical to the success of the field experiment
- ECSs:
  - provided forecast support for mission flights (preflight and nowcasting duties during flight)
  - presented daily weather briefings
  - generated and comprehended novel forecast and analysis products that were used in weather briefings and by PIs in mission planning
  - obtained, processed, and quality controlled data from missions

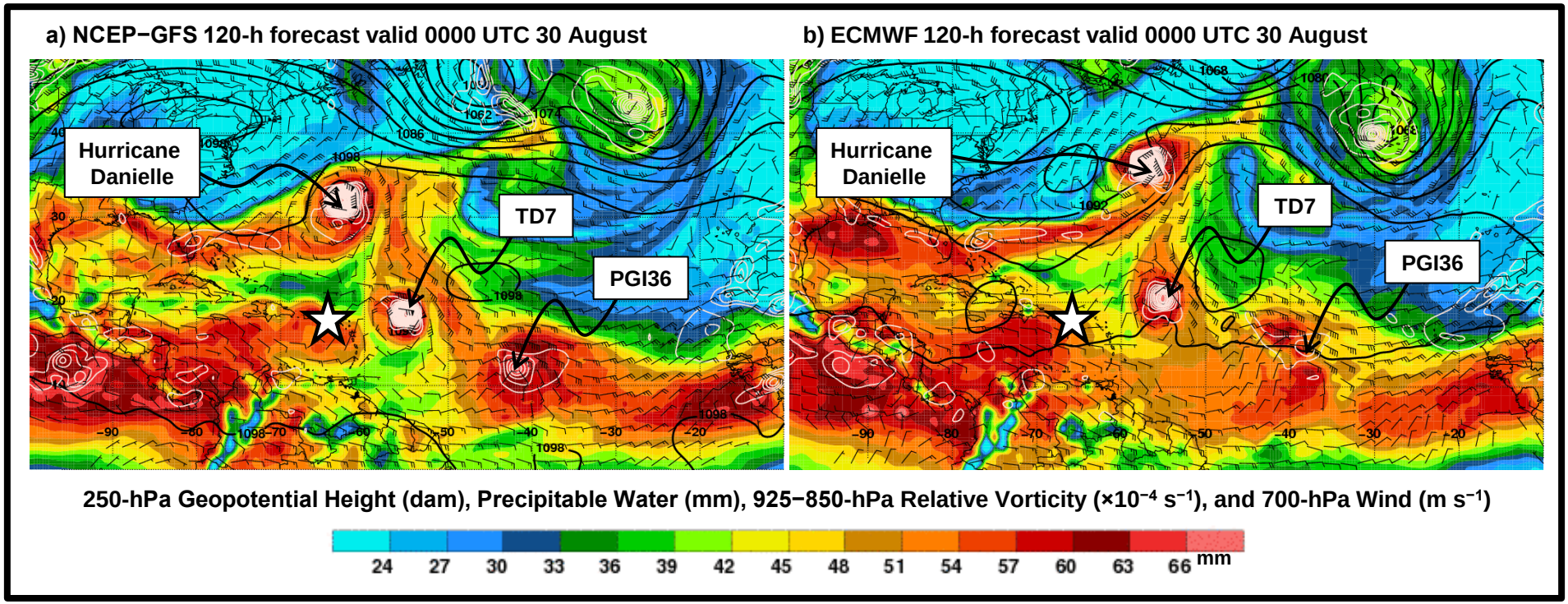
ECS Involvement in PREDICT

- Generation of novel forecast and analysis tools
  - precipitable water “comparisons”
  - isentropic potential vorticity
  - standardized anomalies
  - closed streamline Lagrangian analyses
  - pouch tracking and continuity diagrams
  - overlay plots



ECS Involvement in PREDICT

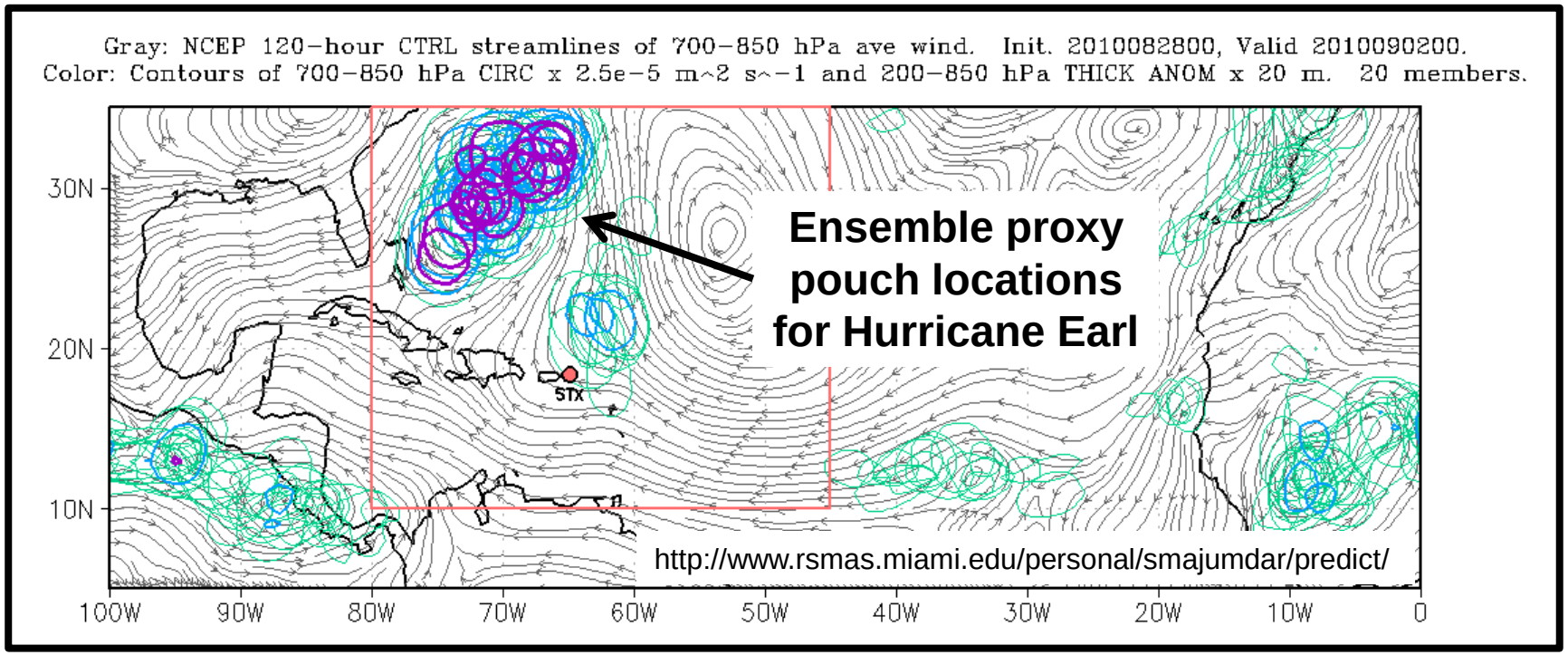
- Generation of novel forecast and analysis tools



Comparison between the NCEP-GFS and ECMWF 120-hour forecasts valid 0000 UTC 30 August. Note the difference in locations of Hurricane Danielle, Tropical Depression 7 (Earl), and PGI36.

ECS Involvement in PREDICT

- Comprehension of novel forecast and analysis tools, e.g.:
  - pouch tracking diagnostics
  - ensemble forecast systems



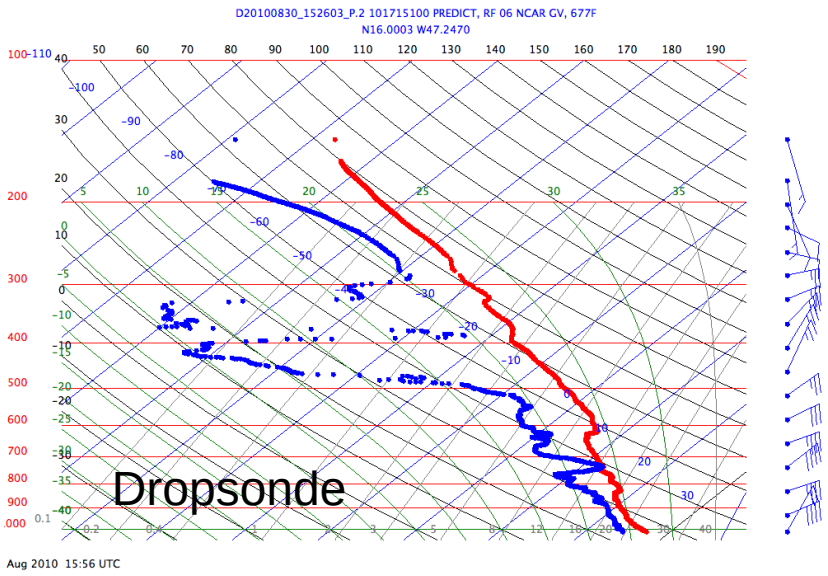
ECS Involvement in PREDICT

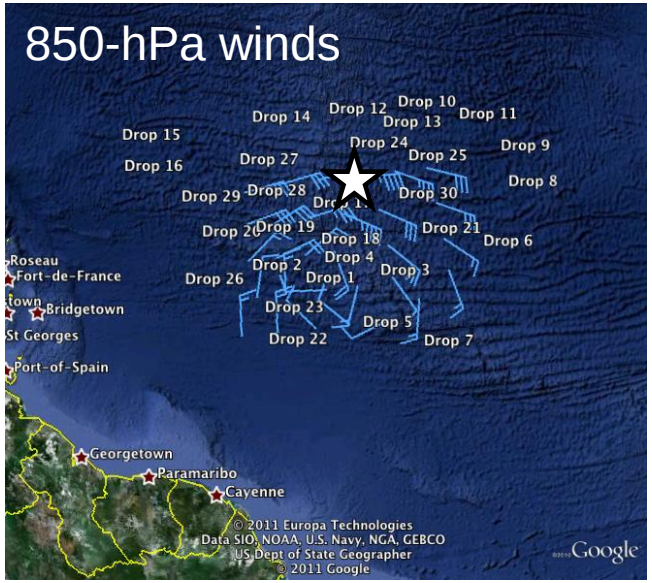
- ECS involvement critical to the success of the field experiment
- ECSs:
  - provided forecast support for mission flights (preflight and nowcasting duties during flight)
  - presented daily weather briefings
  - generated and comprehended novel forecast and analysis products that were used in weather briefings and by PIs in mission planning
  - obtained, processed, and quality controlled data from missions

ECS Involvement in PREDICT

- Obtained, processed, and quality controlled data from missions
  - dropsondes

Research Flight 05 into PGI-36L (Pre-Fiona) on 30 August 2010

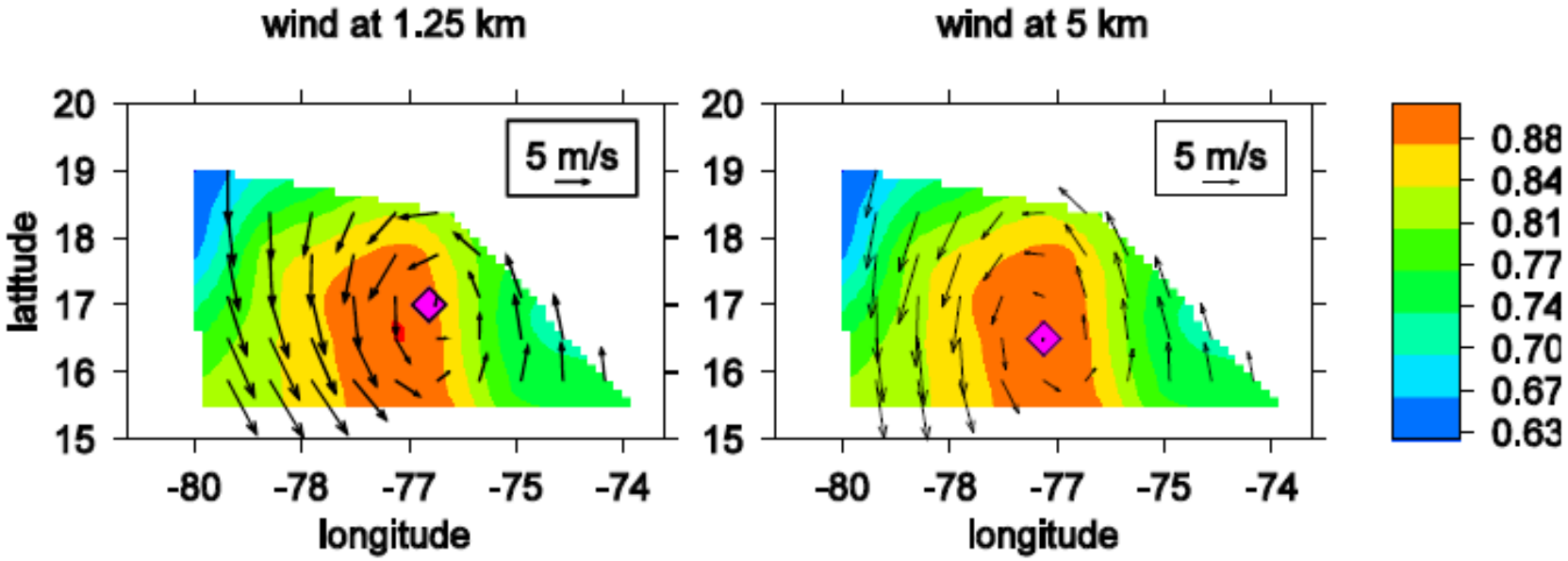




NHC upgraded PGI-36 to TS Fiona immediately following our flight

ECS Involvement in PREDICT

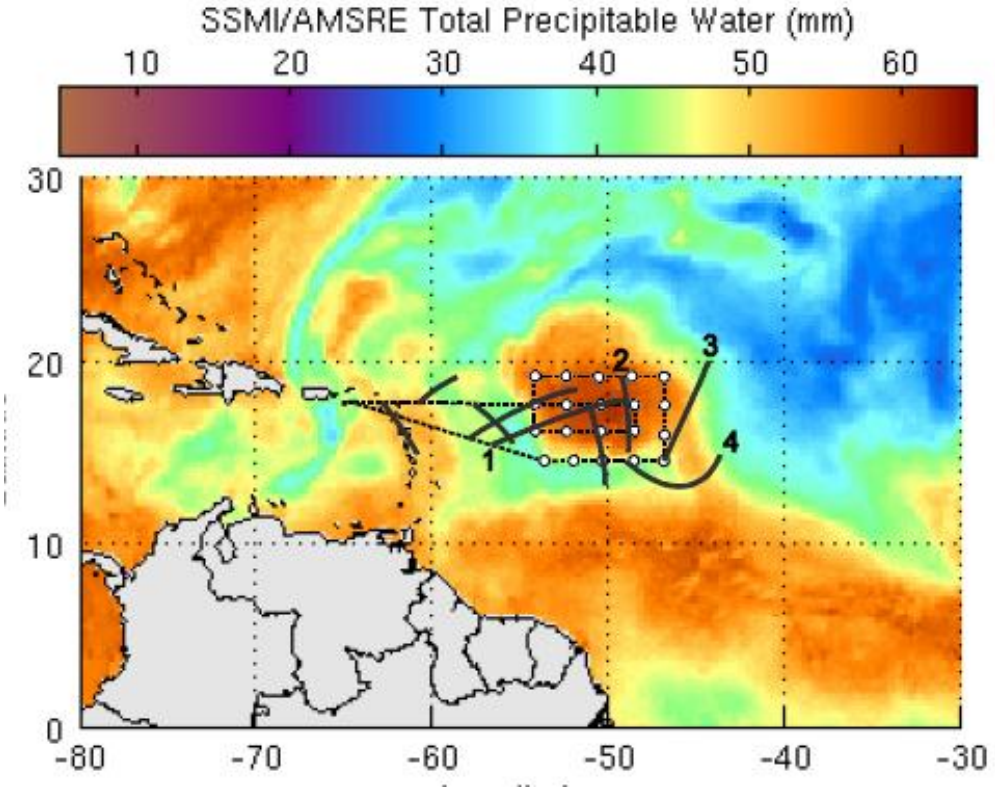
- Obtained, processed, and quality controlled data from missions
  - 3D VAR analysis of dropsonde data (Gjorgjievska)



ECS Involvement in PREDICT

- Obtained, processed, and quality controlled data from missions

  - GNSS (Global Navigation Satellite Systems) Instrument System for Multistatic & Occultation Sensing (Johnson, Muradyan, & Murphy)



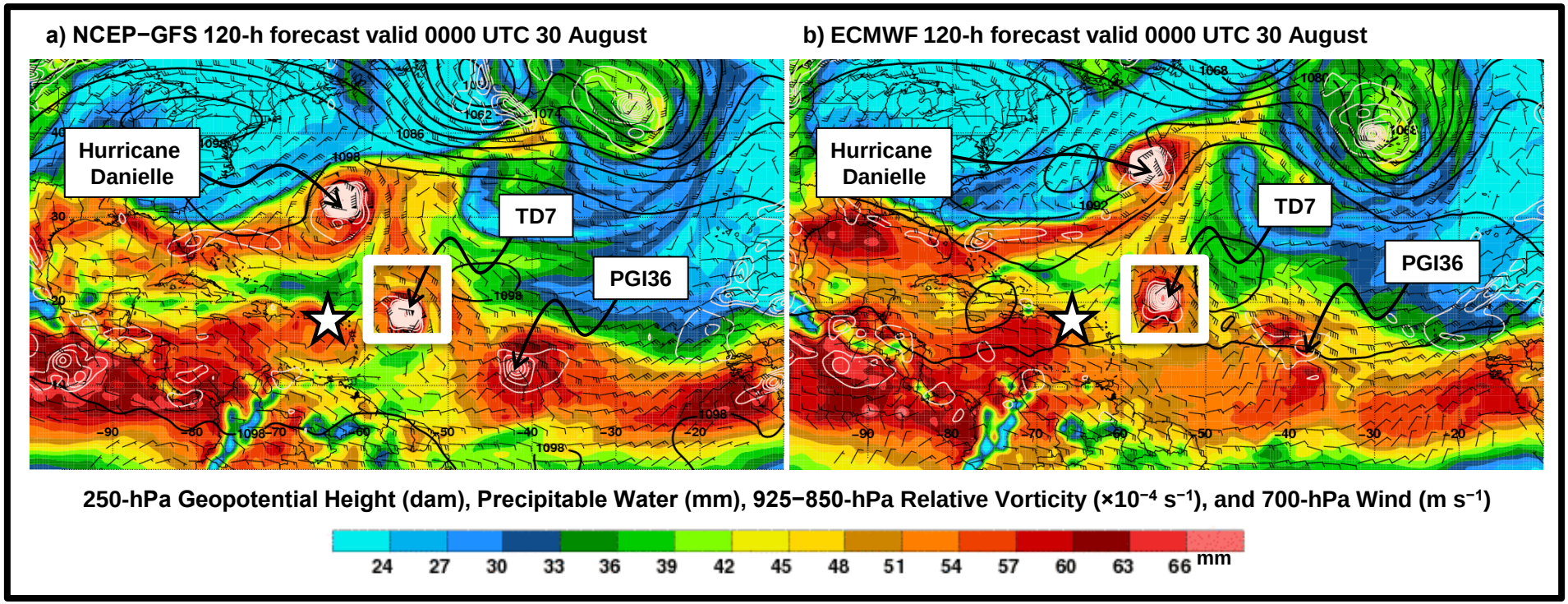
ECS Involvement in PREDICT

Helped deploy dropsondes.
And in some cases, take over for the pilot…

Outreach with local radio show on St. Croix (H. Archambault).

ECS Involvement in PREDICT

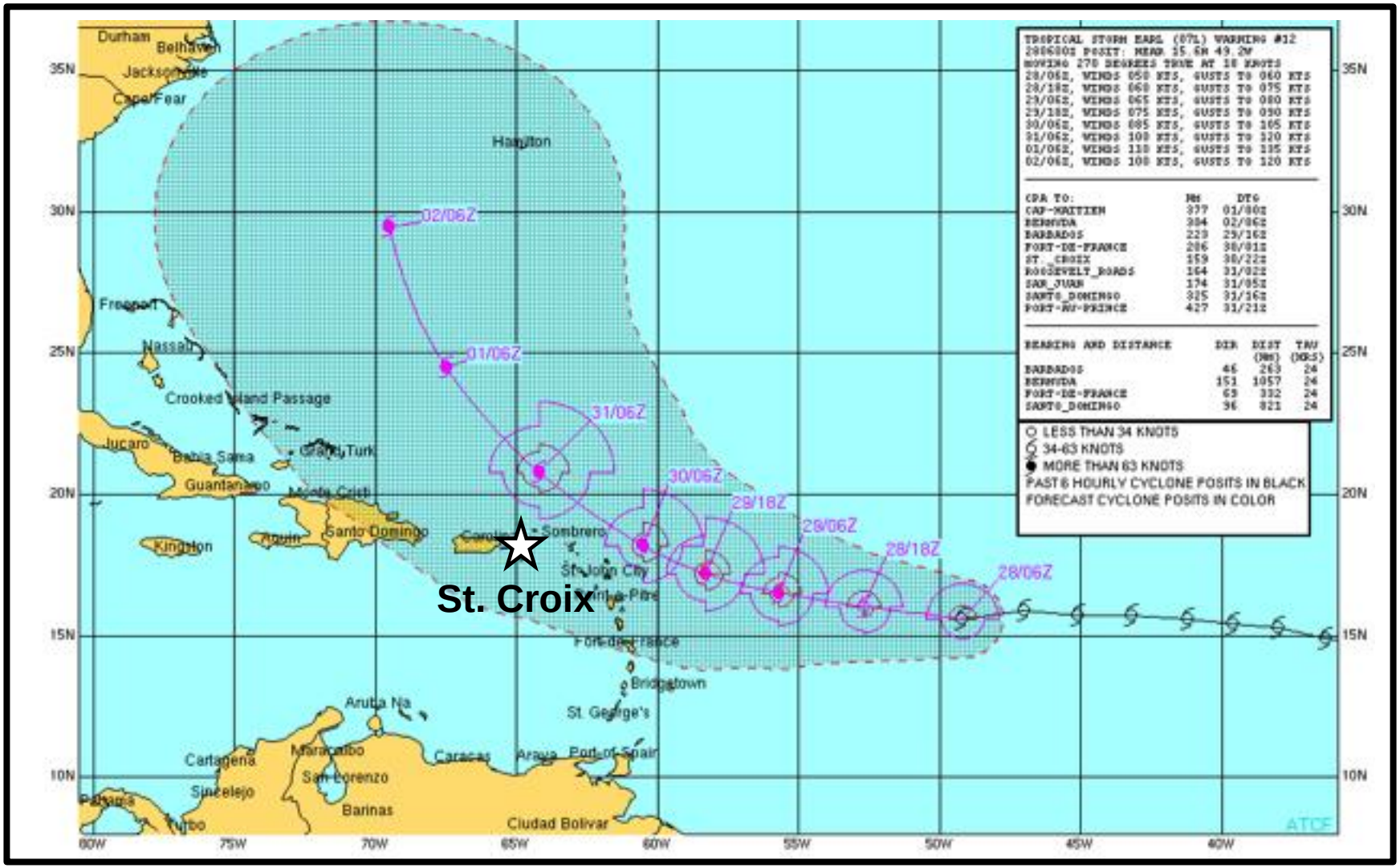
- Earl's close call and a potential evacuation



Comparison between the NCEP-GFS and ECMWF 120-hour forecasts valid 0000 UTC 30 August. Note the difference in locations of Hurricane Danielle, Tropical Depression 7 (Earl), and PGI36.

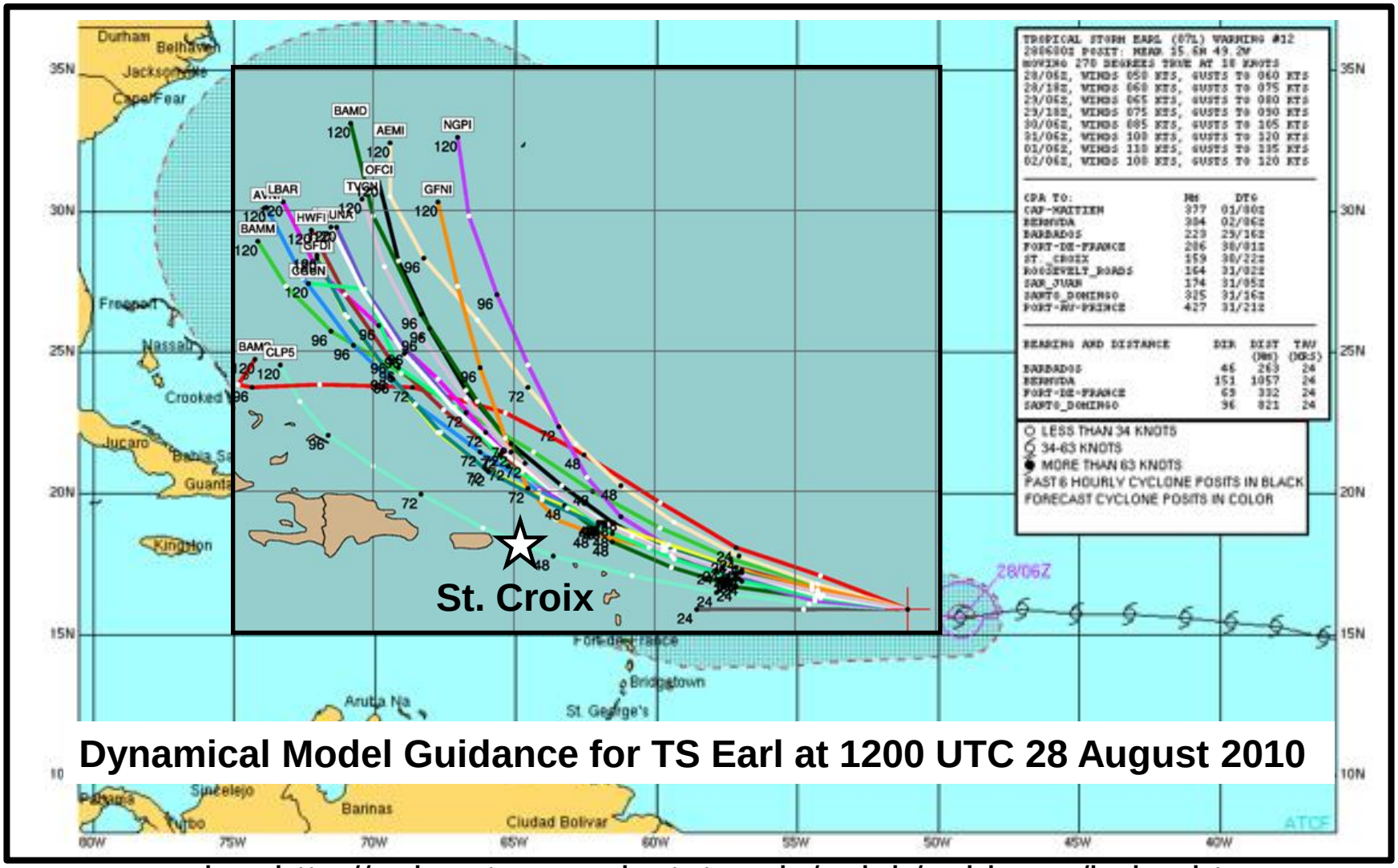
ECS Involvement in PREDICT

Tropical Storm Earl Forecast: 0600 UTC 28 August 2010



ECS Involvement in PREDICT

Tropical Storm Earl Forecast: 0600 UTC 28 August 2010

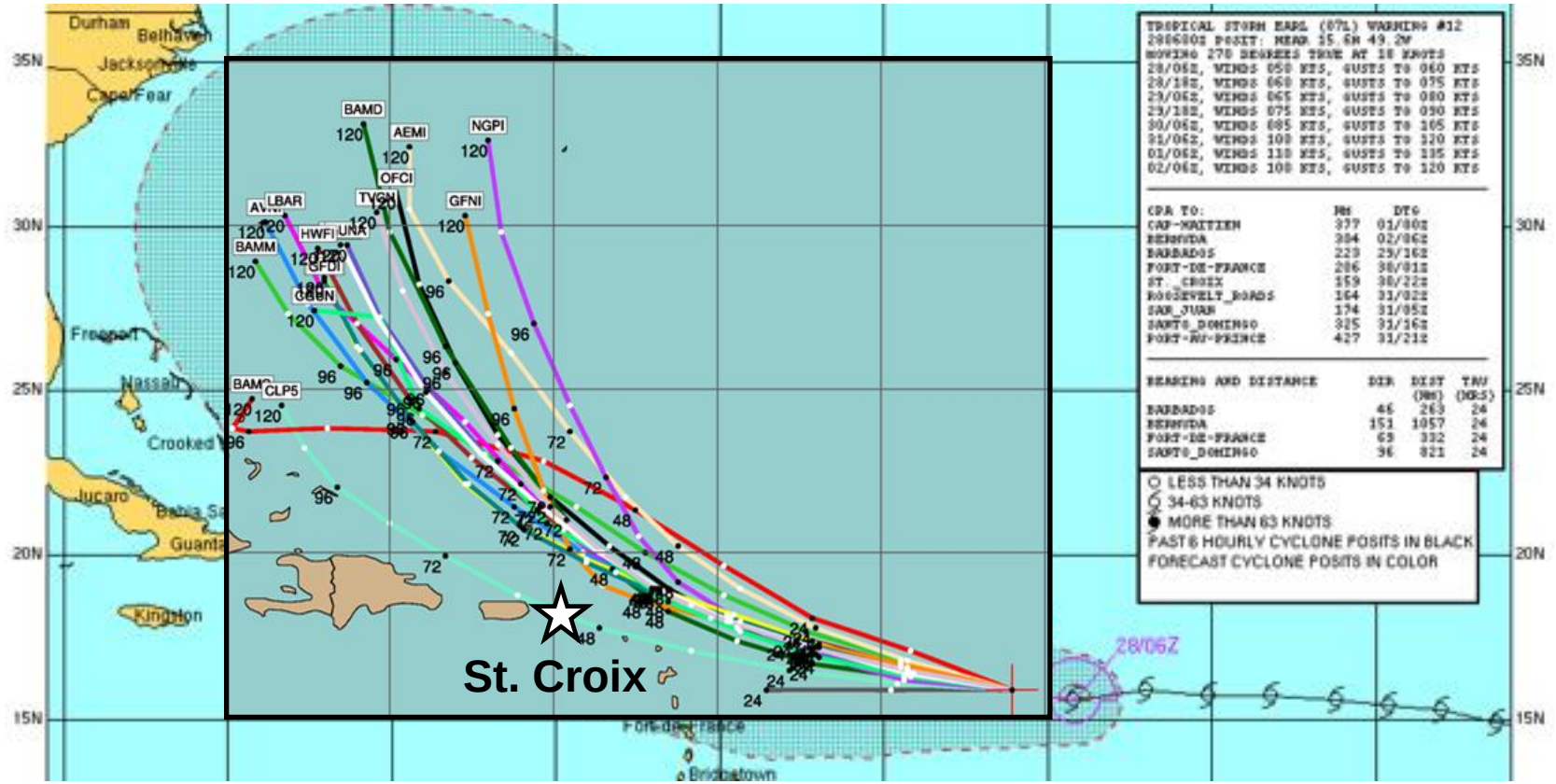


Dynamical Model Guidance for TS Earl at 1200 UTC 28 August 2010

overlay: http://euler.atmos.colostate.edu/~vigh/guidance/index.htm

ECS Involvement in PREDICT

Tropical Storm Earl Forecast: 0600 UTC 28 August 2010

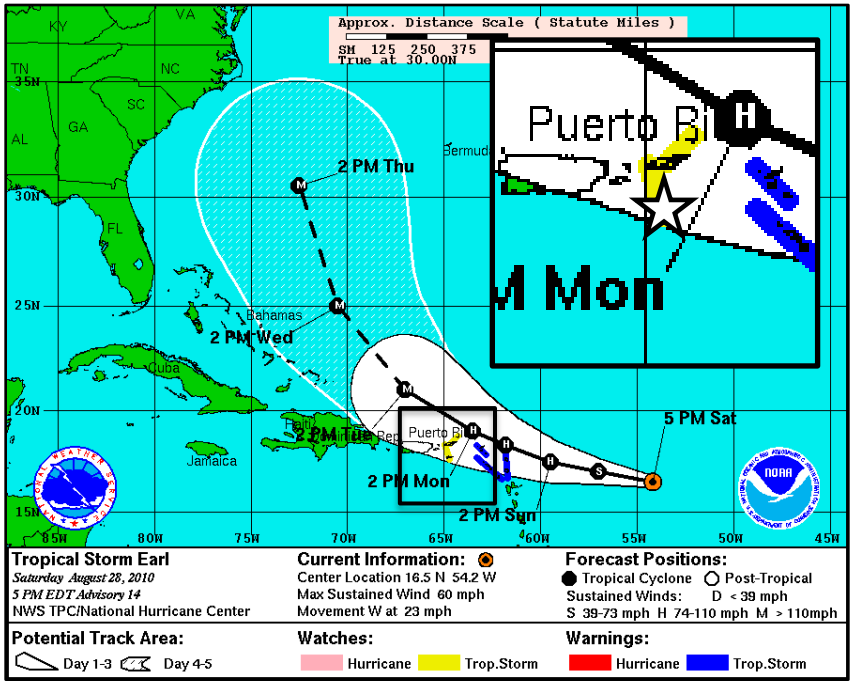


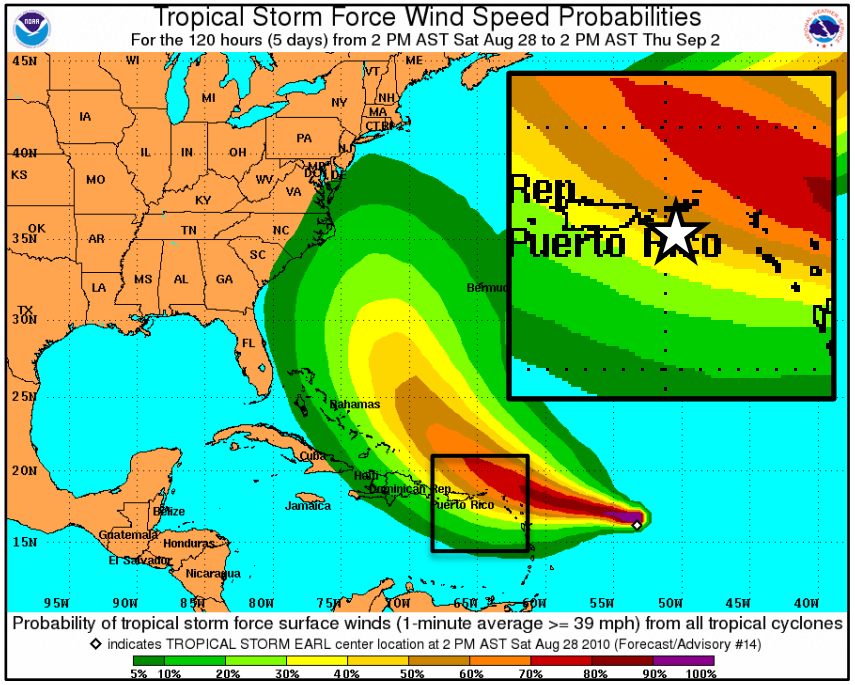
Project managers had to consider an evacuation of the NCAR G-V aircraft and all or portions of the scientific and support staff in advance of Earl's potential arrival.

ECS Involvement in PREDICT

- Decision-making process for potential evacuation involved collaborative discussions between PREDICT PIs, ECSs and EOL staff
- Two ECS forecasters contributed to obtaining and disseminating forecast information for evacuation decisions

ECS Involvement in PREDICT

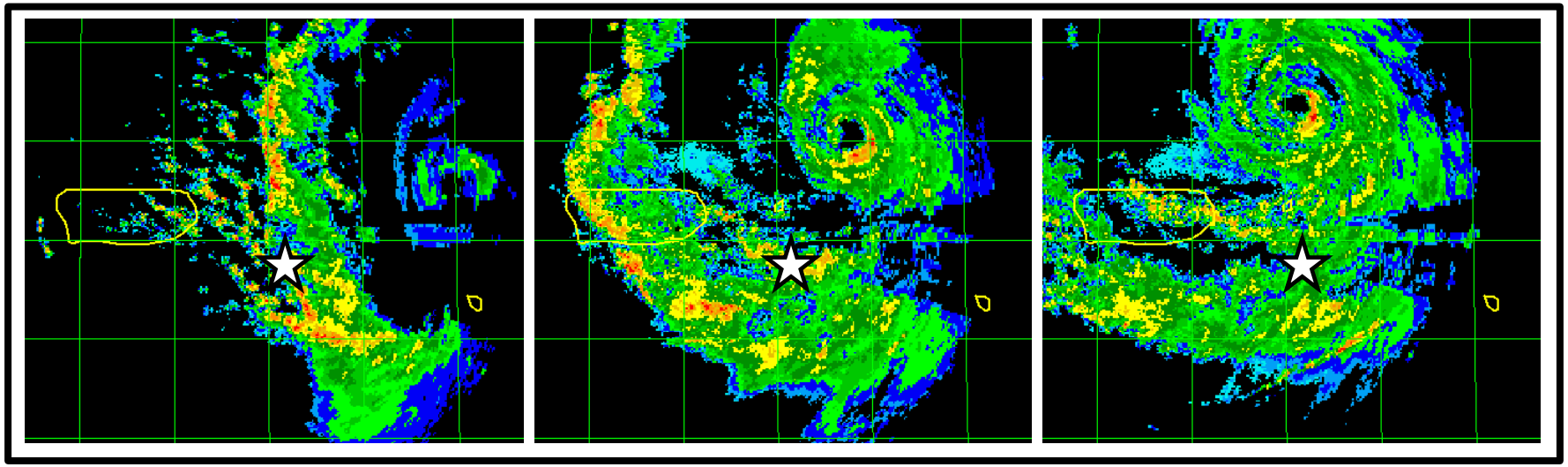




- Special ECS-led afternoon weather briefing on 28 August 2010
- Forecasts relied upon NHC probabilistic products
  - "cone of uncertainty" and graphical wind speed exceedance products
- NCAR G-V evacuated to Barbados
- Voluntary personnel evacuation

ECS Involvement in PREDICT

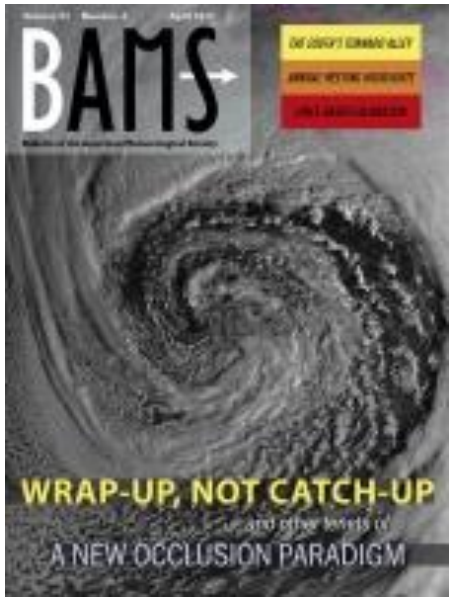
Earl on San Juan radar at 1200, 1800, and 2200 UTC 30 August 2010



- Evacuation discussion was a unique opportunity to:
  - help lead a group toward a decision where tens to hundreds of thousands of dollars could be spent based upon the decision
  - sit in the proverbial “hot seat” (e.g., being on the record and held accountable)
  - experience a high level of responsibility and pressure

ECS's paper to appear in BAMS

Evans, C, H. Archambault, J. Cordeira, C. Fritz, T. Galarneau Jr., S. Gjorgjievska, K. Griffin, A. Johnson, W. Komaromi, S. Monette, P. Muradyan, B. Murphy, M. Riemer, J. Sears, D. Stern, B. Tang, and S. Thompson, 2011: The PRE-Depression Investigation of Cloud-systems in the Tropics (PREDICT) field campaign: Perspectives of early career scientists. *Bull. Amer. Meteor. Soc.*, submitted.



ECSs Research Contributions

“For my future research it was particularly helpful that I had the opportunity to discuss the newly developed forecast product during our weather briefings. The numerous comments and questions from PIs and ECSs alike helped to clarify the strengths and weaknesses of the product and helped to focus my future research in this and new areas. As my research so far has made much use of numerical and theoretical models, taking part in research flights during PREDICT was an outstanding opportunity to observe and study cloud-scale processes and the interaction of scales in the real atmosphere.” – Michael Riemer

ECSs Research Contributions

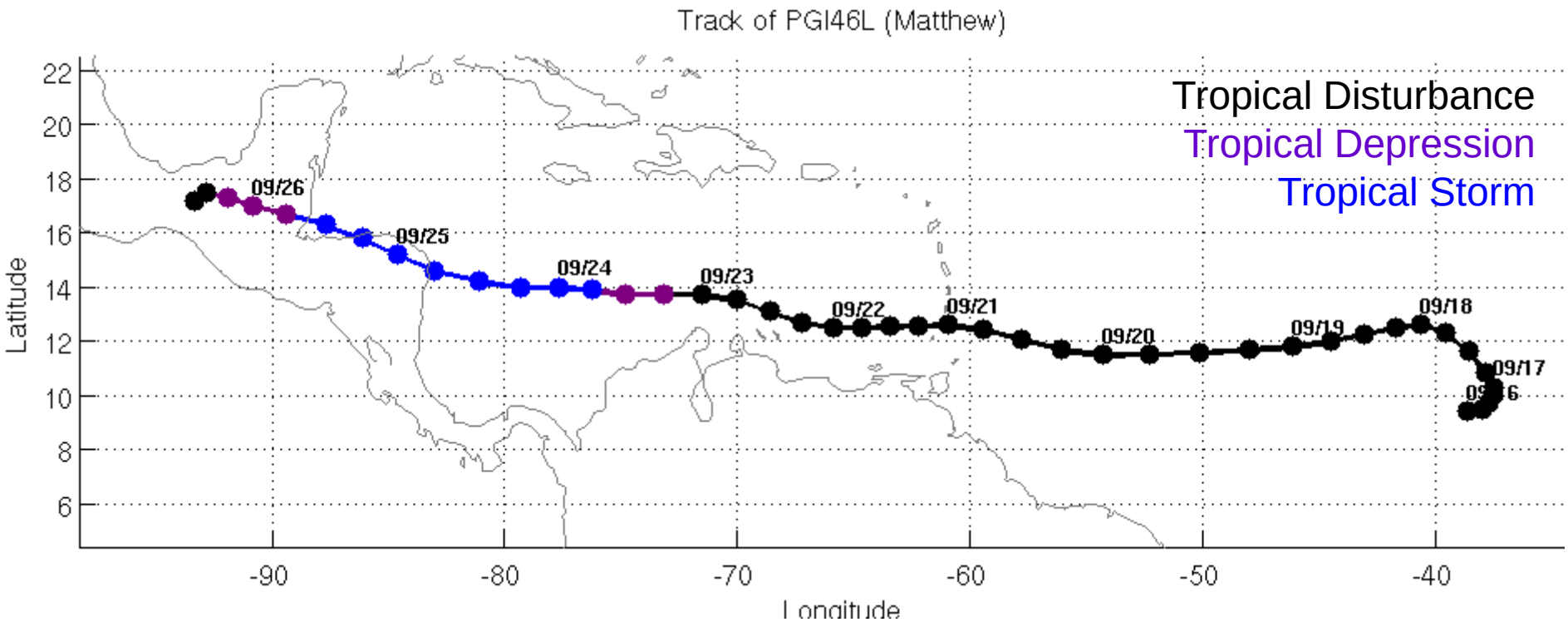
- ECSs will be using data from PREDICT to form the basis for their M.S., Ph.D., or early career research. For example:
  - John Sears (Wisconsin) is investigating the role of upper levels in TC genesis
  - Sarah Monette (Wisconsin) is investigating further applications for her “overshooting tops” satellite product
  - Will Komaromi (Miami) is investigating dropsonde data for developing and non-developing TCs
  - Kyle Griffin (Albany) is investigating the genesis of Hurricane Karl in the Lesser Antilles region during PREDICT
  - Brian Tang and Clark Evans (NCAR) are investigating the genesis of Tropical Storm Matthew in the Western Caribbean during PREDICT
  - Michael Riemer (Mainz) is investigating flow structure manifolds to better understand the evolution of tropical disturbance pouches and how they are influenced by the external environment

ECSs Research Contributions

- ECSs will be using data from PREDICT to form the basis for their M.S., Ph.D., or early career research. For example:
  - John Sears (Wisconsin) is investigating the role of upper levels in TC genesis
  - Sarah Monette (Wisconsin) is investigating further applications for her “overshooting tops” satellite product
  - Will Komaromi (Miami) is investigating dropsonde data for developing and non-developing TCs
  - Kyle Griffin (Albany) is investigating the genesis of Hurricane Karl in the Lesser Antilles region during PREDICT
  - Brian Tang and Clark Evans (NCAR) are investigating the genesis of Tropical Storm Matthew in the Western Caribbean during PREDICT
  - Michael Riemer (Mainz) is investigating flow structure manifolds to better understand the evolution of tropical disturbance pouches and how they are influenced by the external environment

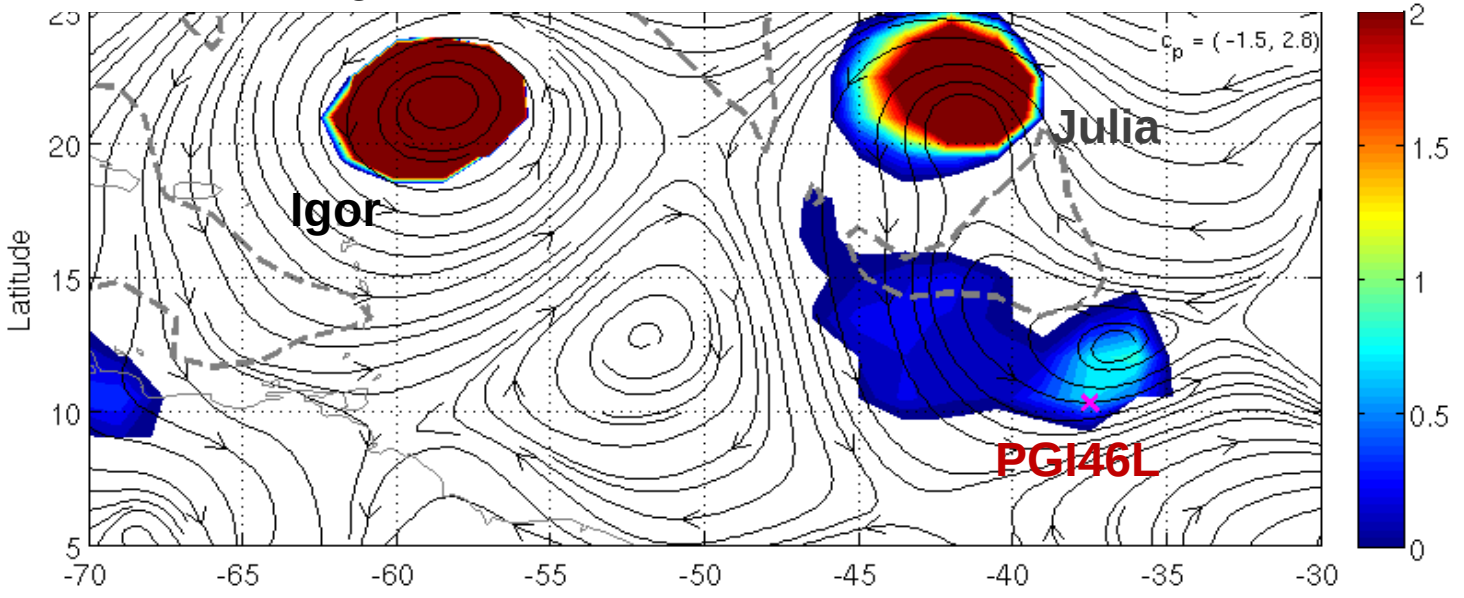
What caused PGI46L (Matthew) to form and initially amplify?

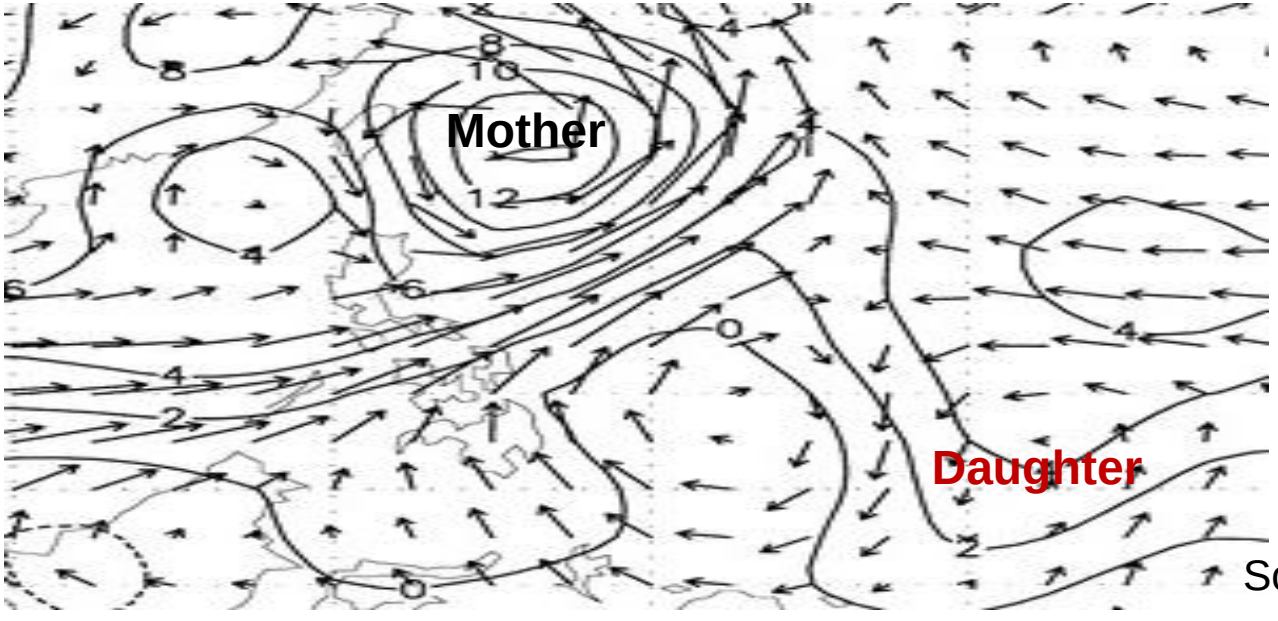
Did not appear to be arise out of an easterly wave.



Mother-daughter mechanism at play (via Rossby wave radiation)?

Co-moving streamlines and OW at 850 mb on 9/17/10 00Z





Sobel & Bretherton 1999

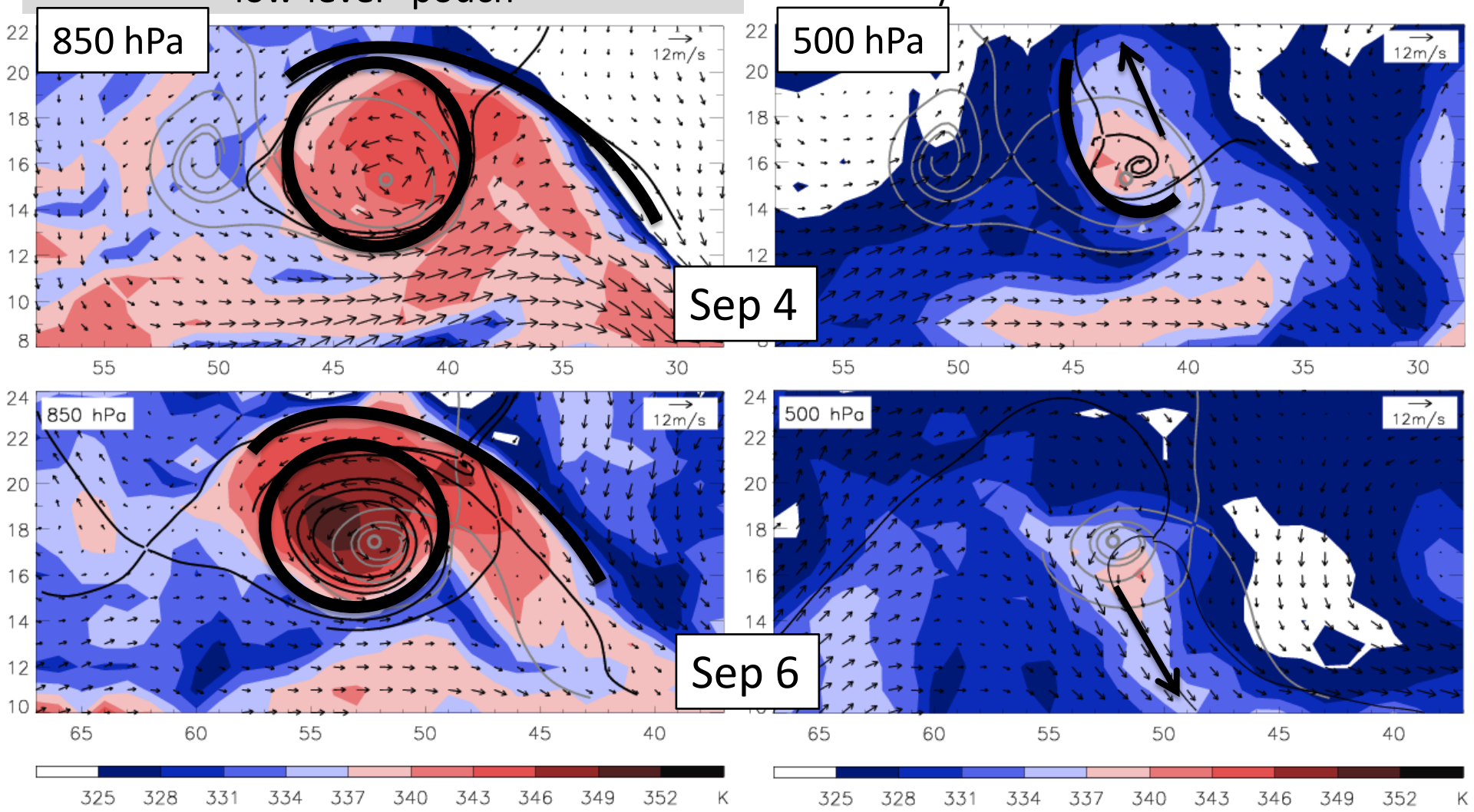
ECSs Research Contributions

- ECSs will be using data from PREDICT to form the basis for their M.S., Ph.D., or early career research. For example:
  - John Sears (Wisconsin) is investigating the role of upper levels in TC genesis
  - Sarah Monette (Wisconsin) is investigating further applications for her “overshooting tops” satellite product
  - Will Komaromi (Miami) is investigating dropsonde data for developing and non-developing TCs
  - Kyle Griffin (Albany) is investigating the genesis of Hurricane Karl in the Lesser Antilles region during PREDICT
  - Brian Tang and Clark Evans (NCAR) are investigating the genesis of Tropical Storm Matthew in the Western Caribbean during PREDICT
  - Michael Riemer (Mainz) is investigating flow structure manifolds to better understand the evolution of tropical disturbance pouches and how they are influenced by the external environment

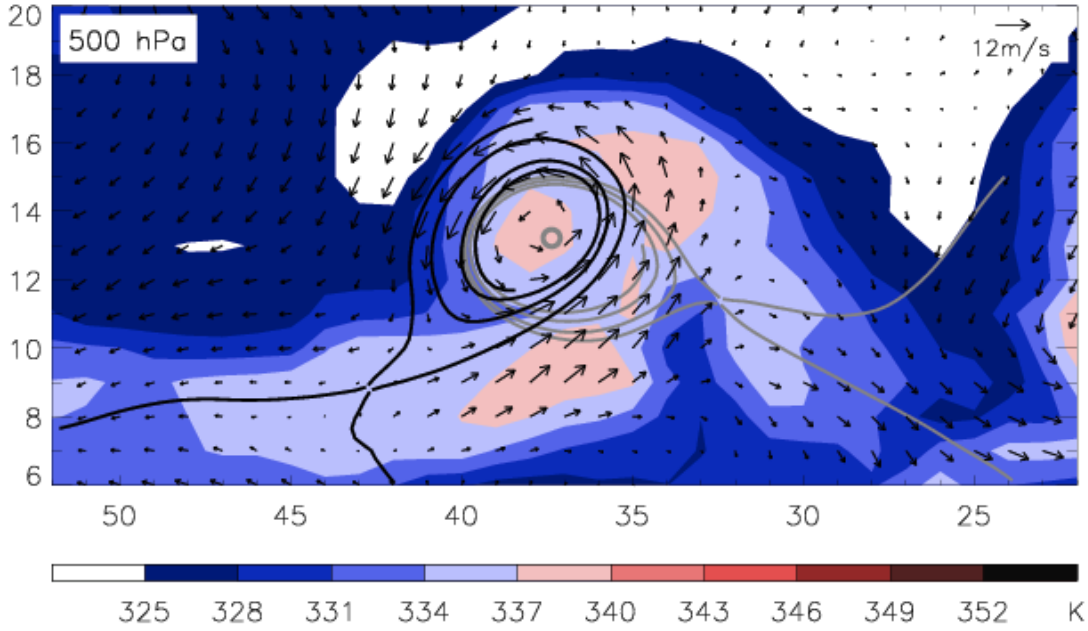
Ex-Gaston's struggle →

Manifolds indicate protection from low-θ_e environment, build-up of in high-θ_e within low-level "pouch"

"Export" of high-θ_e at midlevels, highly detrimental mid-level dynamics and thermodynamics



Equivalent potential temperature (color), manifolds ("dividing streamline", black), wind (arrows) in co-moving frame, pouch center ○ and 700 hPa manifolds (gray) for reference

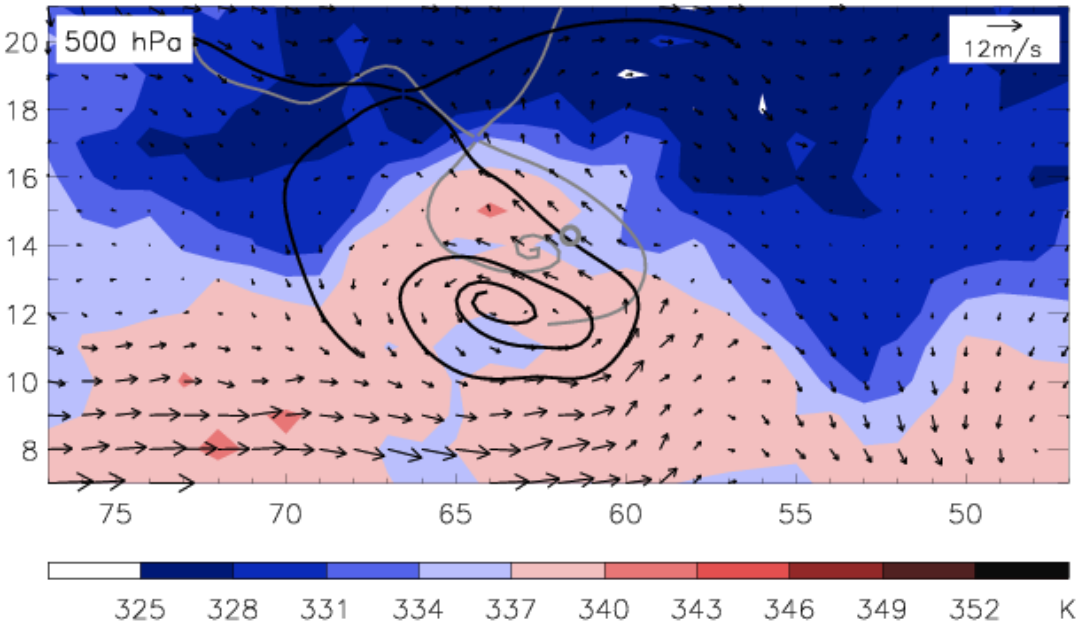


For comparison: Gaston on Sep 2

Much more favorable kinematic and thermodynamic conditions at 500 hPa at that time

For comparison: pre-Karl on Sep 11

More favorable thermodynamic (and kinematic) conditions at 500 hPa



ECSs Research Contributions

- ECSs will be using data from PREDICT to form the basis for their M.S., Ph.D., or early career research. For example:
  - John Sears (Wisconsin) is investigating the role of upper levels in TC genesis
  - Sarah Monette (Wisconsin) is investigating further applications for her “overshooting tops” satellite product
  - Will Komaromi (Miami) is investigating dropsonde data for developing and non-developing TCs
  - Kyle Griffin (Albany) is investigating the genesis of Hurricane Karl in the Lesser Antilles region during PREDICT
  - Brian Tang and Clark Evans (NCAR) are investigating the genesis of Tropical Storm Matthew in the Western Caribbean during PREDICT
  - Michael Riemer (Mainz) is investigating flow structure manifolds to better understand the evolution of tropical disturbance pouches and how they are influenced by the external environment

Diagnostic Variables

- Derived from CIMSS Satellite Wind Analyses (1.0 Deg.):
  1) Tangential/Radial Winds
  2)

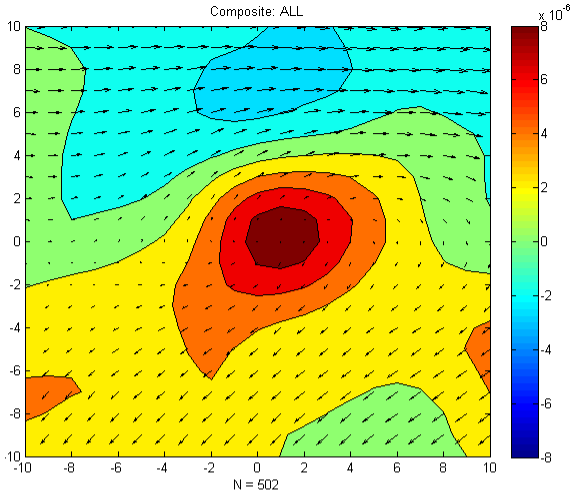
Divergence/ Convergence	Relative Vorticity	Eddy Flux Convergence	Mass Flux
		Eddy flux convergence of relative angular momentum around a circle of radius r.	Mass of air moving out of a circle of radius r.

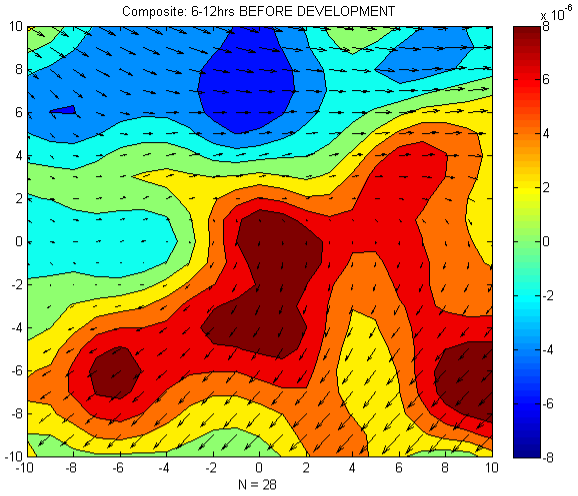
- GFS Model Data (1.0 Deg.):

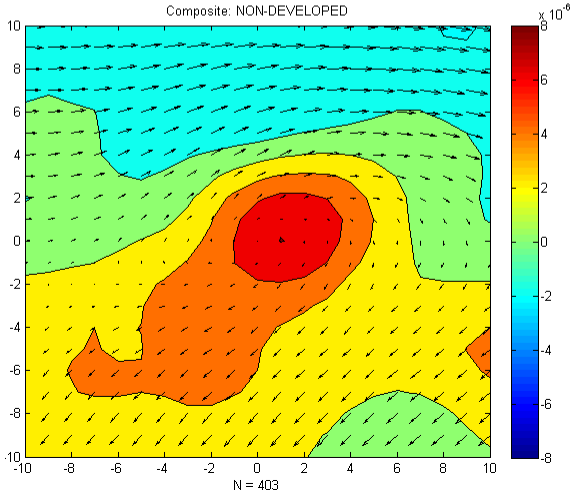
Inertial Available Kinetic Energy	Ertel's Potential Vorticity
Evaluated on isentropic surfaces (330K-380K) using UW-NMS model.	Evaluated on isentropic surfaces (330K-380K) using UW-NMS model.

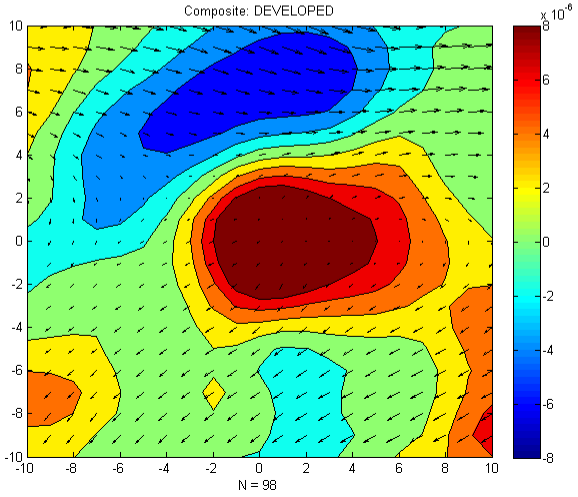
CIMSS Composite Analyses: Divergence and Vorticity

- Based on 502 pouch-centered CIMSS analyses in tropical ATL from 2010
- Shown is composited 200hPa Divergence (red is strong) for all cases (u/l), pre-developing only (u/r), non-developing (l/l), and already developed systems (l/r). 200hPa composited wind vectors are also plotted. The pre-developing analyses reflect 6-12 hrs before TCG (from NHC Best Tracks).
- ***The pre-dev composite indicates much stronger divergence relative to the non-dev composite. Also suggests outflow channels***.





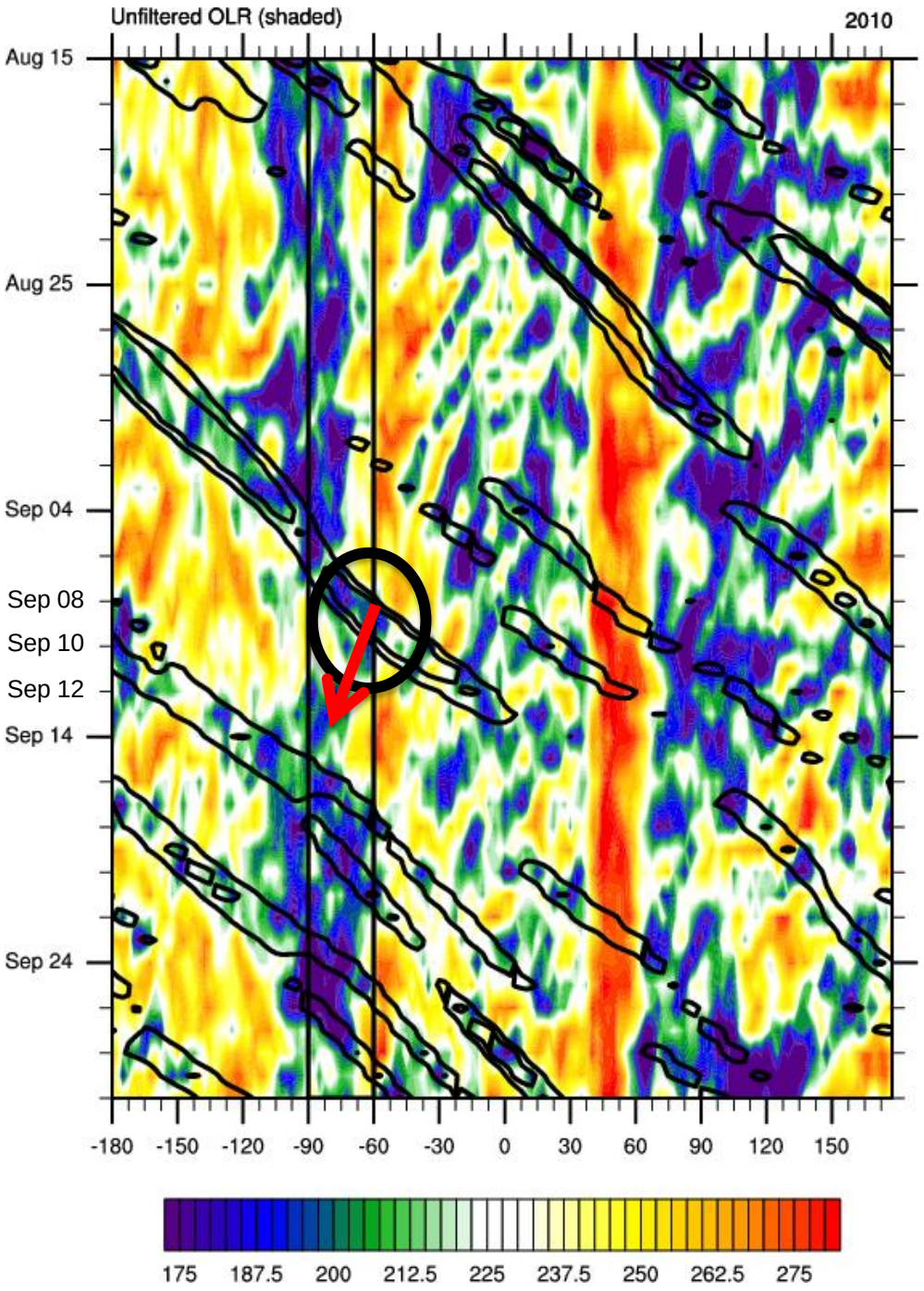




RESULTS

ECSs Research Contributions

- ECSs will be using data from PREDICT to form the basis for their M.S., Ph.D., or early career research. For example:
  - John Sears (Wisconsin) is investigating the role of upper levels in TC genesis
  - Sarah Monette (Wisconsin) is investigating further applications for her “overshooting tops” satellite product
  - Will Komaromi (Miami) is investigating dropsonde data for developing and non-developing TCs
  - Kyle Griffin (Albany) is investigating the genesis of Hurricane Karl in the Lesser Antilles region during PREDICT
  - Brian Tang and Clark Evans (NCAR) are investigating the genesis of Tropical Storm Matthew in the Western Caribbean during PREDICT
  - Michael Riemer (Mainz) is investigating flow structure manifolds to better understand the evolution of tropical disturbance pouches and how they are influenced by the external environment

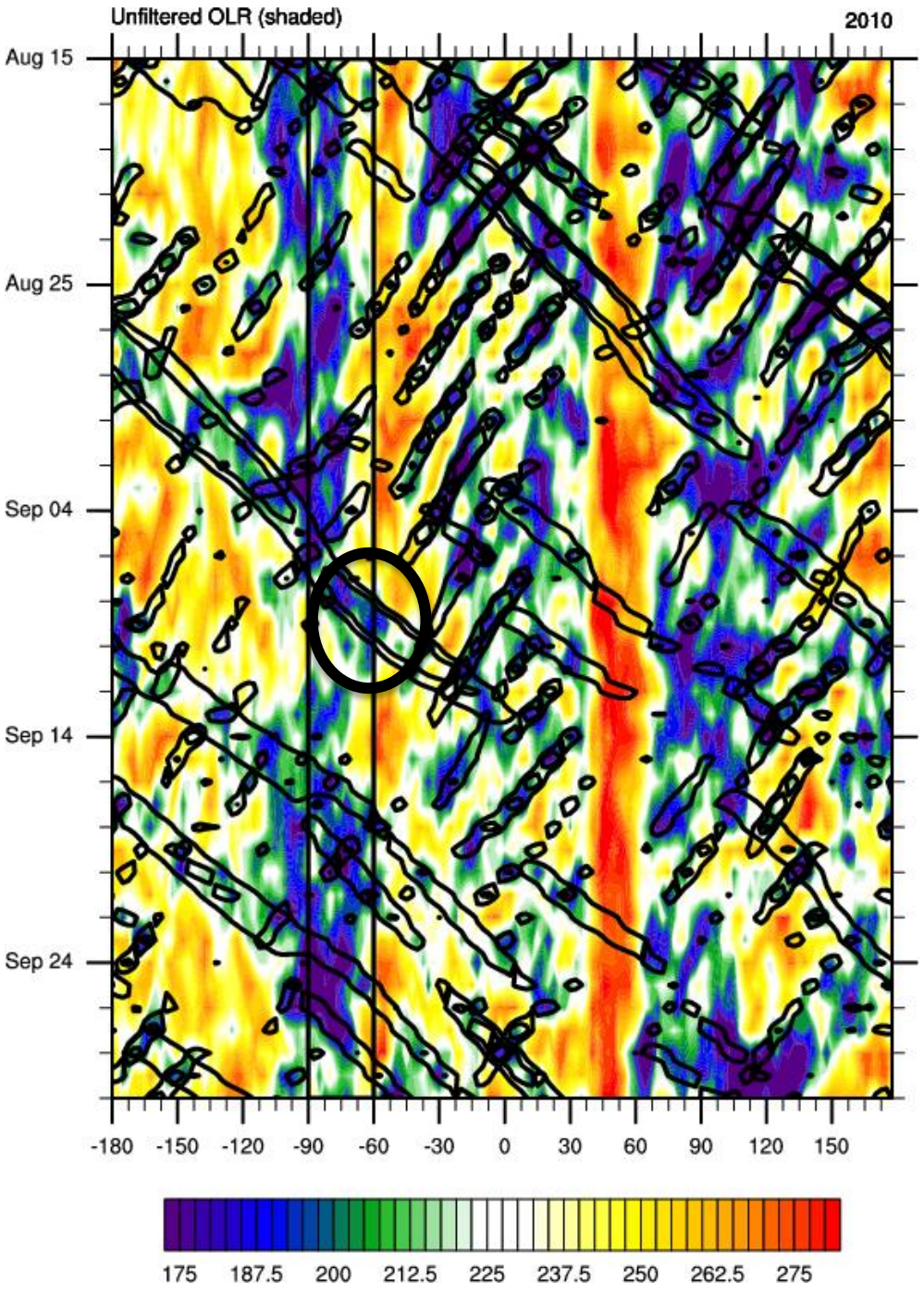


Initial spin-up around 0000 UTC 9 September timed with the passage of the convectively-active phase of a Kelvin wave

No appreciable convective signal can be tracked for about 3 days prior

Hovmöller and NHC TCR on Karl suggest possible origins with African easterly wave (AEW)

Unfiltered OLR data (shaded)
Kelvin wave filtered OLR anomalies (contoured in black)
Figure courtesy of Michael Ventrice

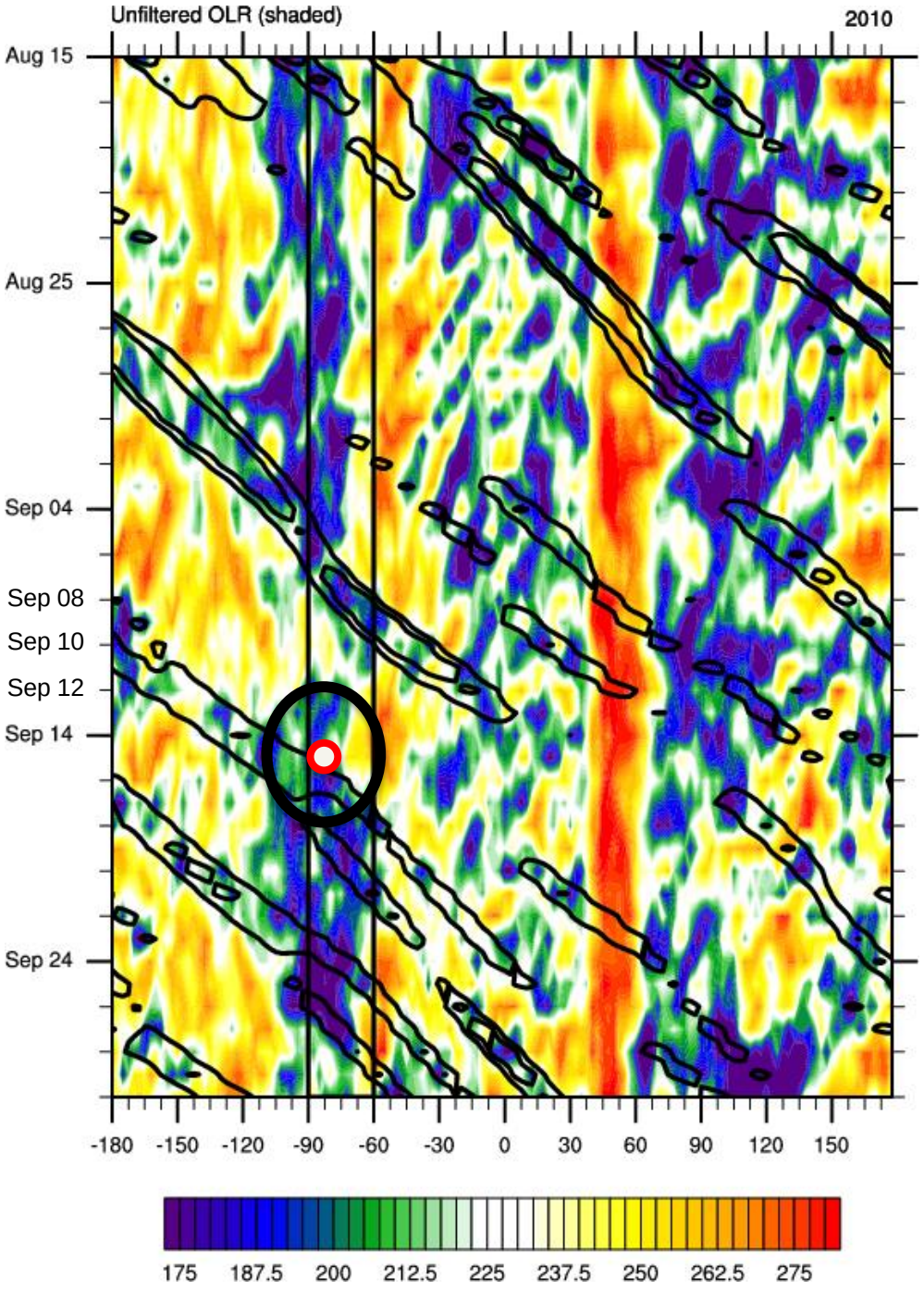


Hovmöller and NHC TCR on Karl suggest possible origins with AEW

Data time-filtered for TD-type waves suggests a predecessor disturbance, but drops out of OLR data by 6 September

Also suggestions of MRG-type wave, but this is difficult to distinguish from AEW-dominated pattern

Unfiltered OLR data (shaded)
2-10 day easterly wave filtered OLR anomalies (contoured in black)
Figure courtesy of Michael Ventrice



As pre-Karl propagates westward through Caribbean, convection pulses (semi-evident in presented OLR data)

Karl's genesis is timed with the leading edge of the convectively active phase of a second, weaker Kelvin wave

However, more uncertainty is associated with the filter-derived presence of this wave

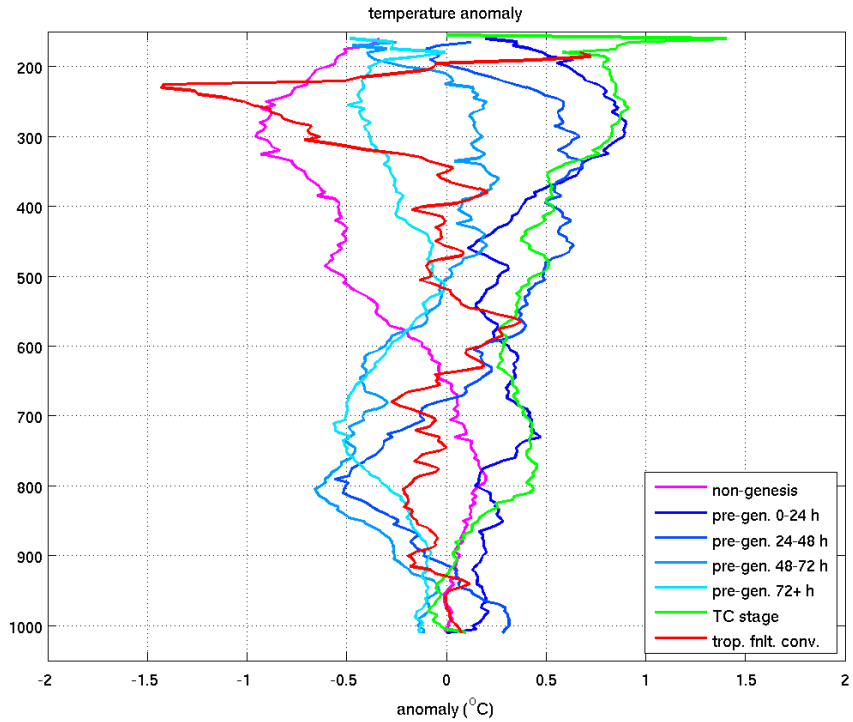
Unfiltered OLR data (shaded)
Kelvin wave filtered OLR anomalies (contoured in black)
Figure courtesy of Michael Ventrice

ECSs Research Contributions

- ECSs will be using data from PREDICT to form the basis for their M.S., Ph.D., or early career research. For example:
  - John Sears (Wisconsin) is investigating the role of upper levels in TC genesis
  - Sarah Monette (Wisconsin) is investigating further applications for her “overshooting tops” satellite product
  - Will Komaromi (Miami) is investigating dropsonde data for developing and non-developing TCs
  - Kyle Griffin (Albany) is investigating the genesis of Hurricane Karl in the Lesser Antilles region during PREDICT
  - Brian Tang and Clark Evans (NCAR) are investigating the genesis of Tropical Storm Matthew in the Western Caribbean during PREDICT
  - Michael Riemer (Mainz) is investigating flow structure manifolds to better understand the evolution of tropical disturbance pouches and how they are influenced by the external environment

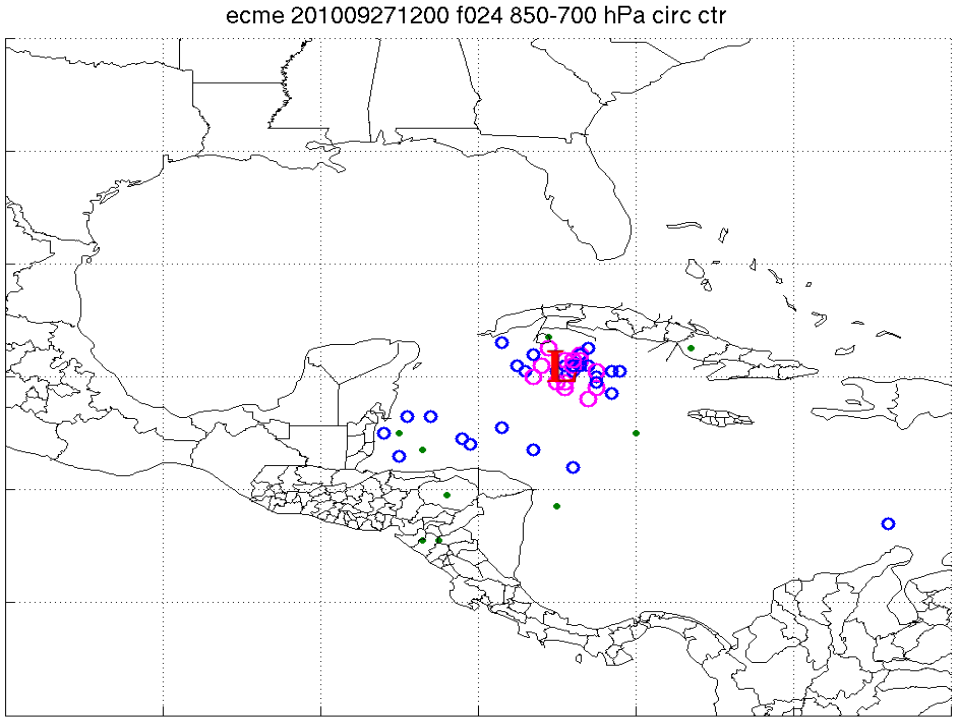
PREDICT-inspired student research

PREDICT dropsonde data is currently being analyzed as a part of student research



See tomorrow's session by Majumdar and Komaromi

Use of ensembles as a tool in forecasting genesis during PREDICT has inspired ensemble-based genesis sensitivity studies



See Friday's session by Komaromi