Seeking improved short-term TC intensity change understanding and forecasting through synthesis of reconnaissance and remotely sensed datasets

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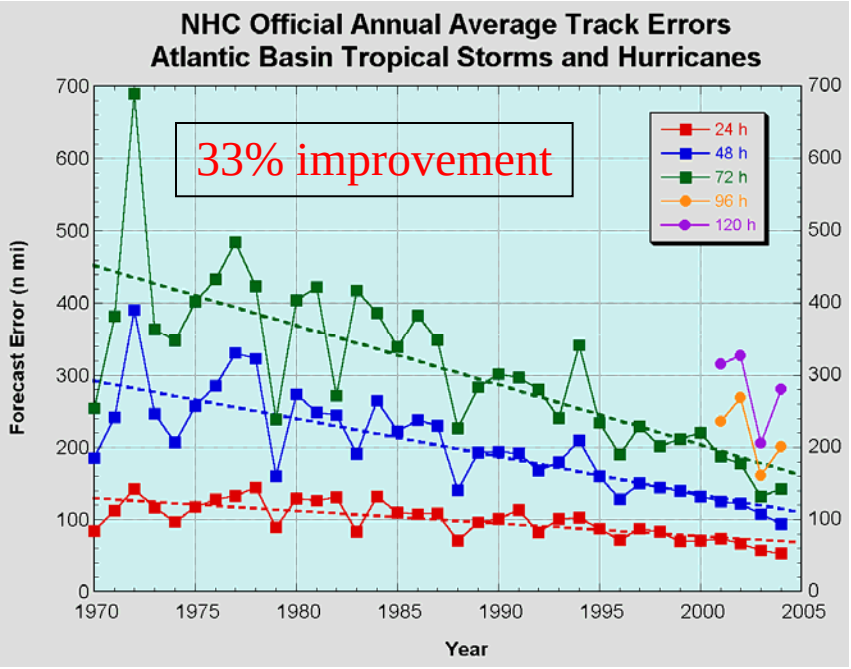
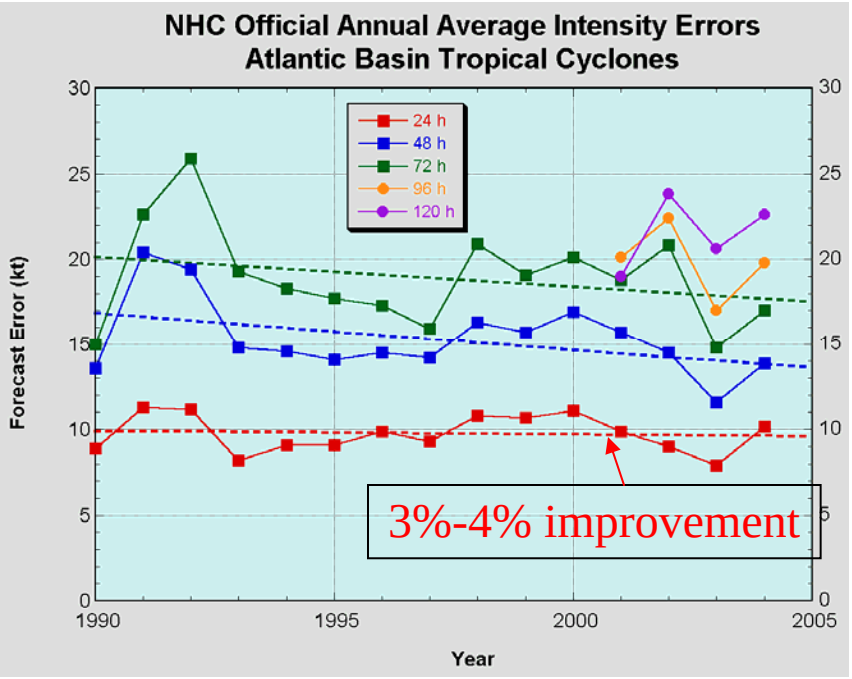
Motivation

- Despite a strong relationship between track and intensity in CLIPER (steering), real-time forecasts do not demonstrate such a relationship. Why?

- Also, relatively small difference between track performance using highly different initializations (e.g. HWRF, GFDL, vs. GFS).





Possible explanations:

- The existing intensity improvement is simply due to improvement in environmental forecasting (steering, underlying ocean) rather than storm itself?
- We are not exploiting inner core observations sufficiently, in particular in NWP initialization and statistical guidance (SHIPS?)
- We have reached a predictability limit with regard to convection timescales and its feedback on the larger scale (even with a small Rossby deformation radius environment)?
- Note that these explanations are not mutually exclusive.

Funded Research:

- To determine if preliminary research by Piech and Hart (2008) can be extended to produce an additional benchmark for short-term intensity change guidance.

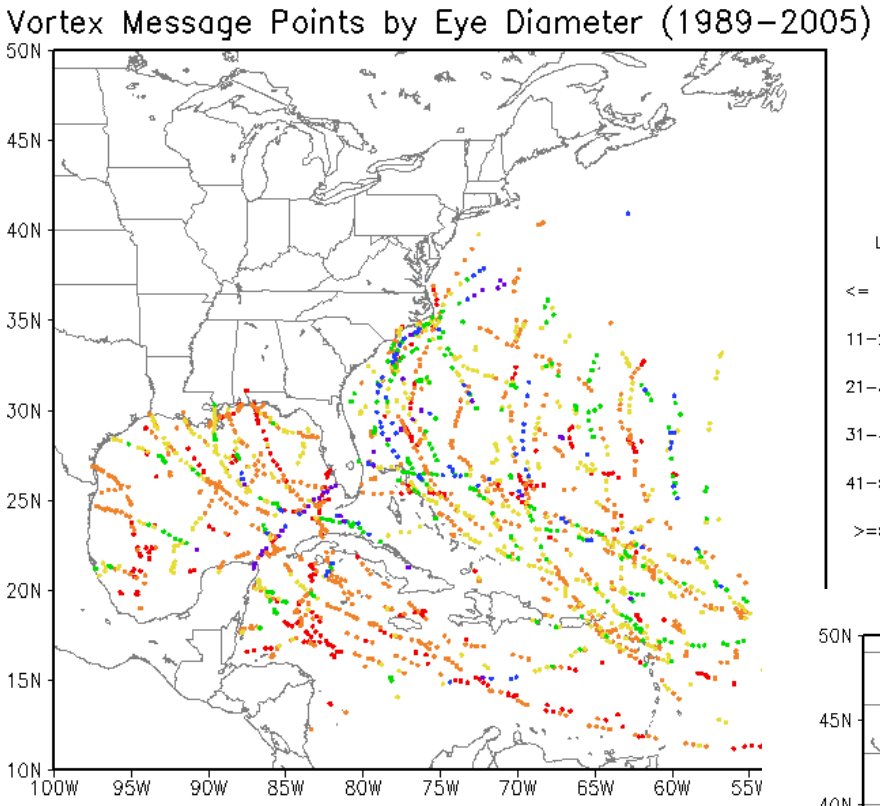
- To determine why there are “regimes” of existence for preferred complex eyewall structure (concentric, elliptical), and to utilize those regimes for improved short-term intensity change forecasting.

- To exploit the foundation of Sawyer-Eliassen balance to address the two goals above.

- To utilize lightning and other remotely sensed observations and their organization in time and space to improve the understanding of the role of lightning in hurricanes in the context of the regime changes described above.

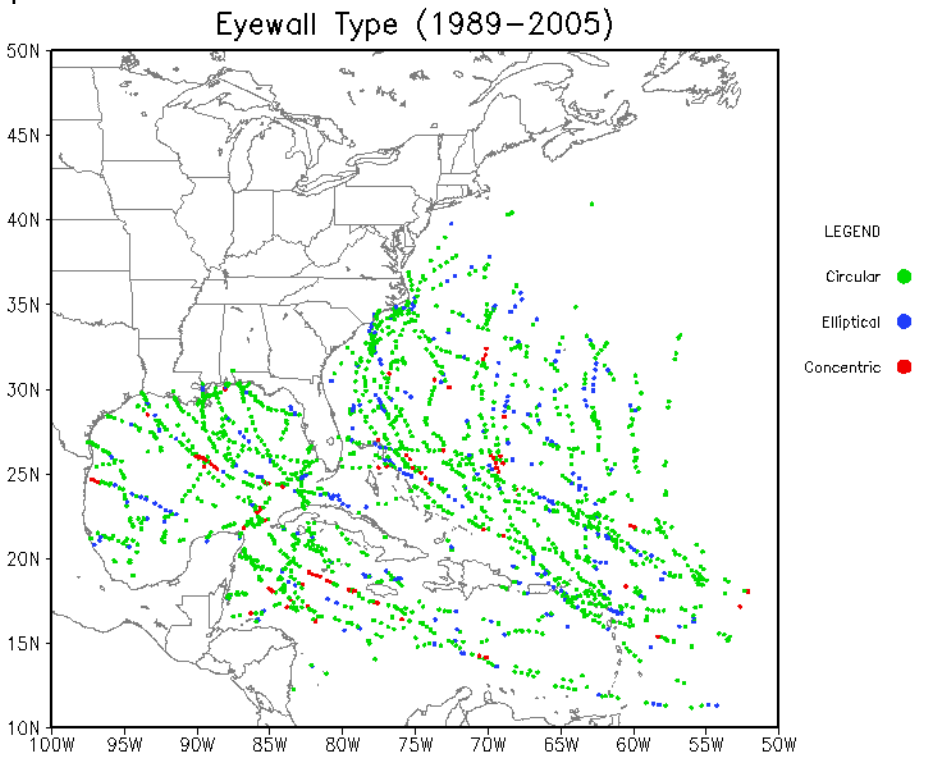
Research Front 1

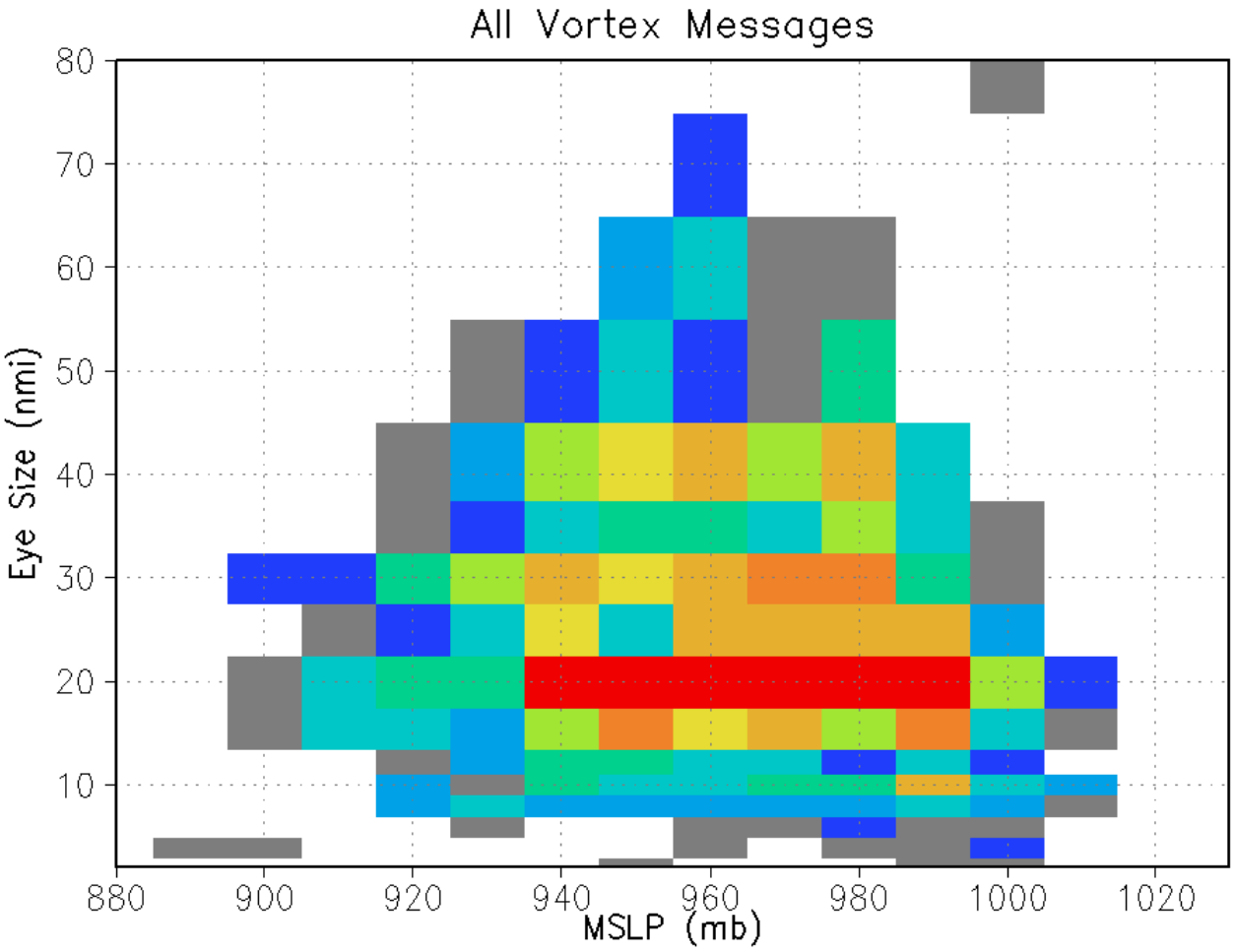
- Improved forecasting of short-term intensity change using inner-core eye structure
  - Eye type (circular, concentric, elliptical)
  - Eye size
  - Thermodynamics of eye and outside eye
- Initially using Atlantic reconnaissance vortex message database and extending to remotely-sensed equivalents



Atlantic Vortex Message Database: 1989-2005

Approximately 3,000 reports over 100 storms





How does this observed TC existence compare to those given by:

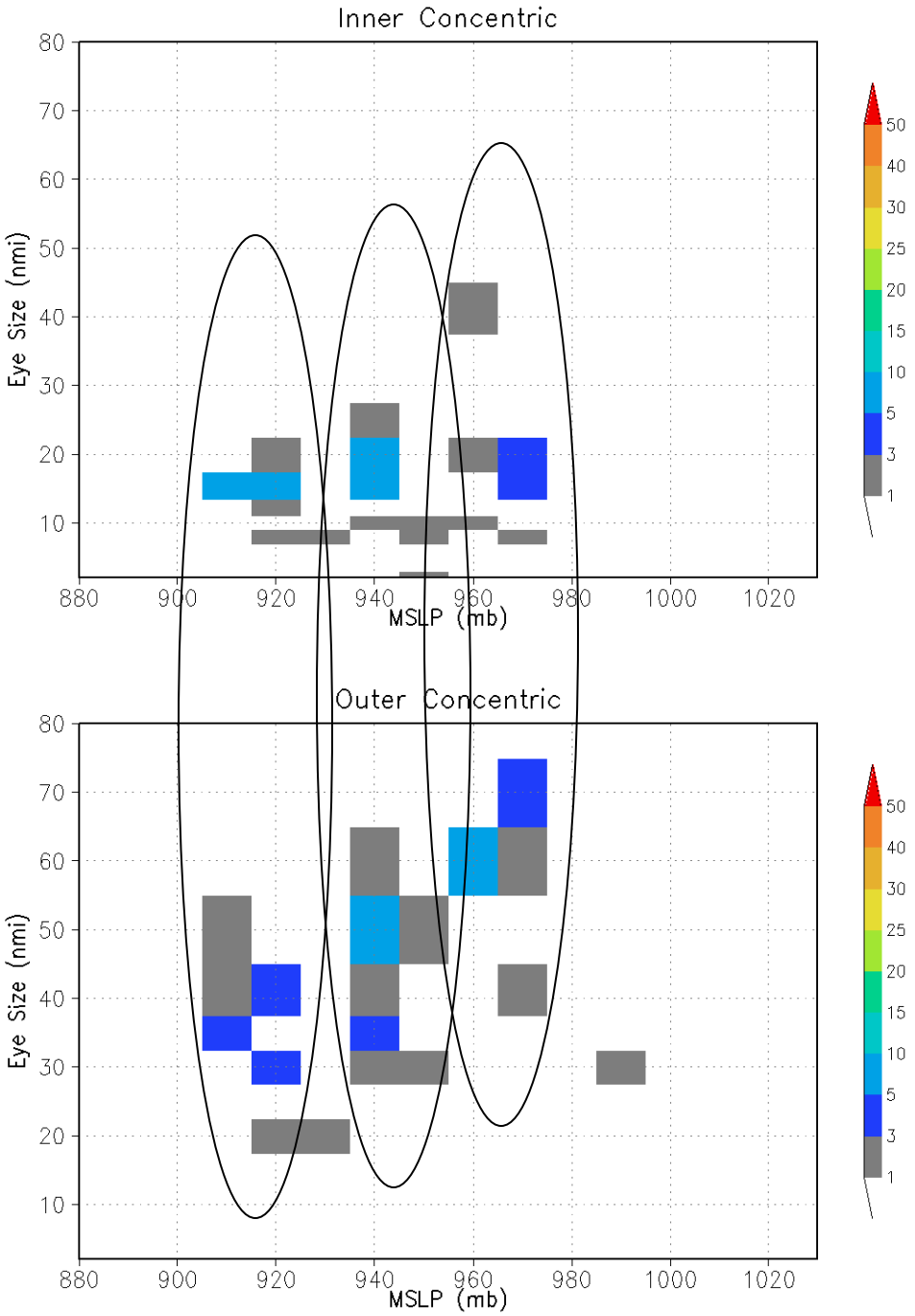
NWP analysis (3dvar, 4dvar)

NWP analysis (synthetic/bogus)

NWP forecasts (HWRF, WRF, GFDL)

Other basins?

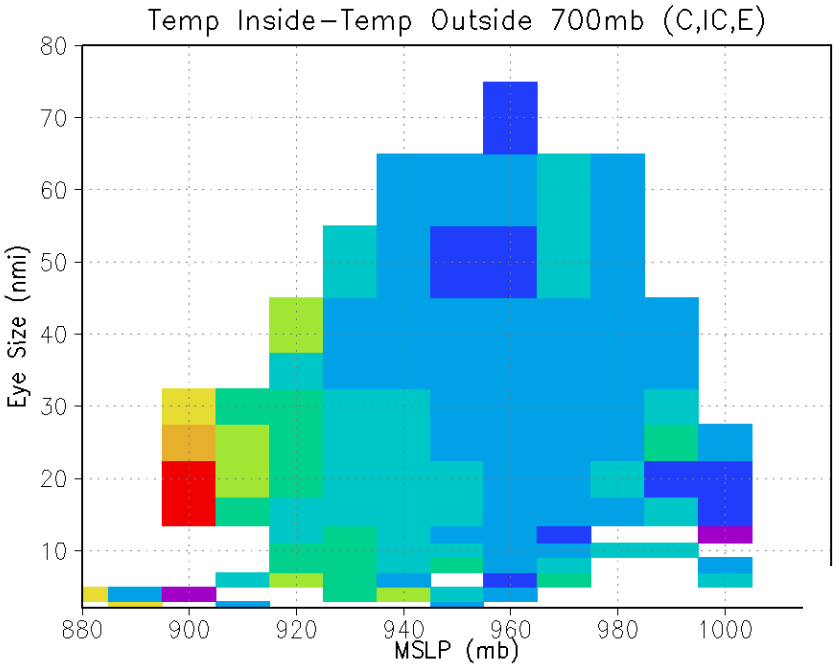
Also, what precludes existence of TCs in the white area?

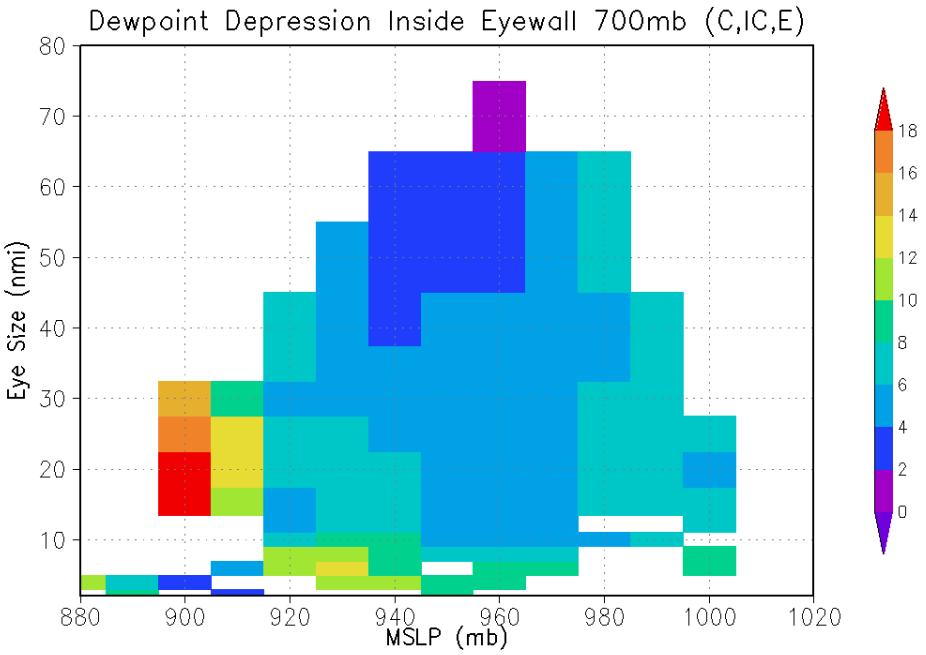


- Settle into three areas which leads to a theory that these areas could be "regimes" for concentric occurrence

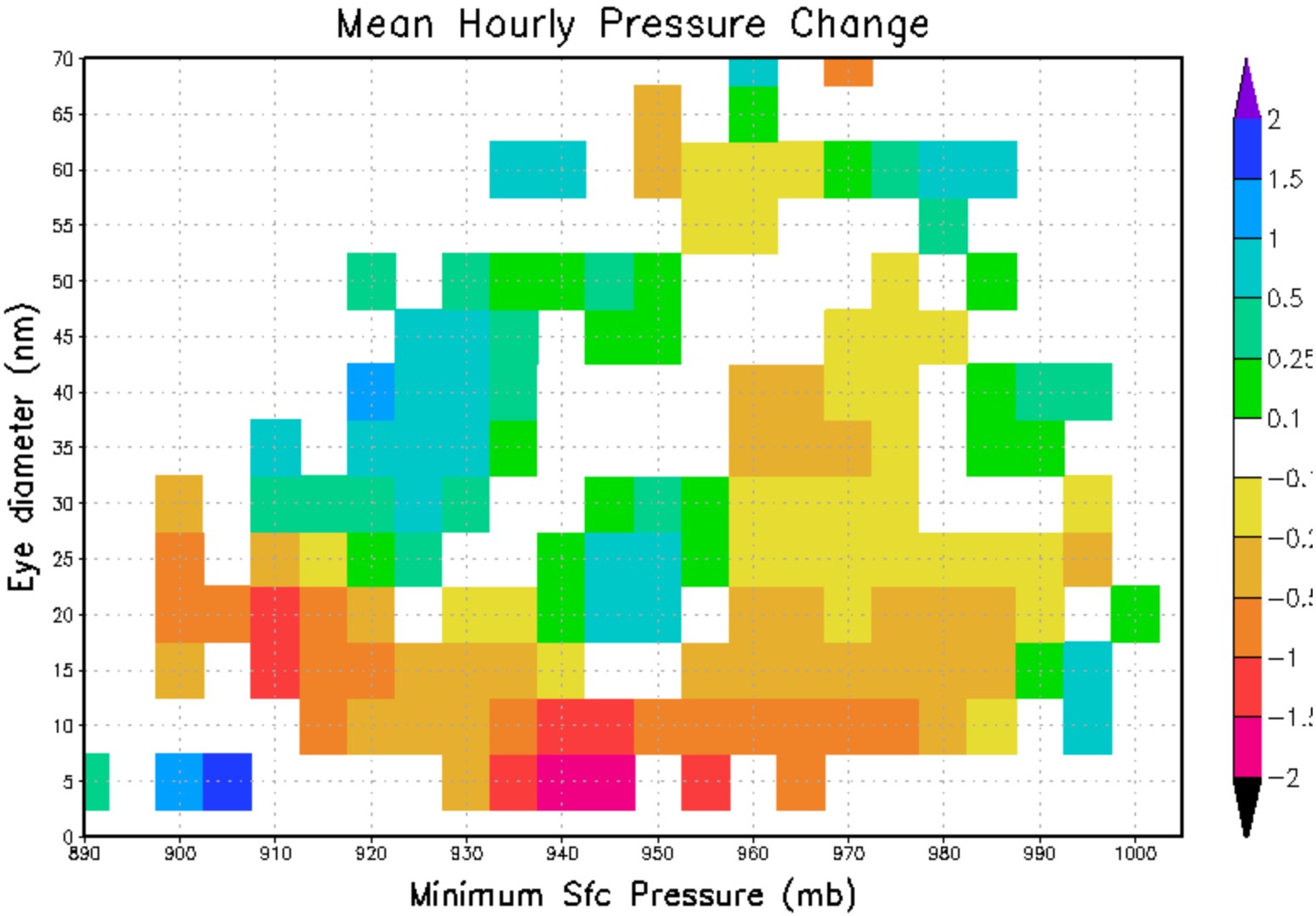
- Why do these regimes exist?

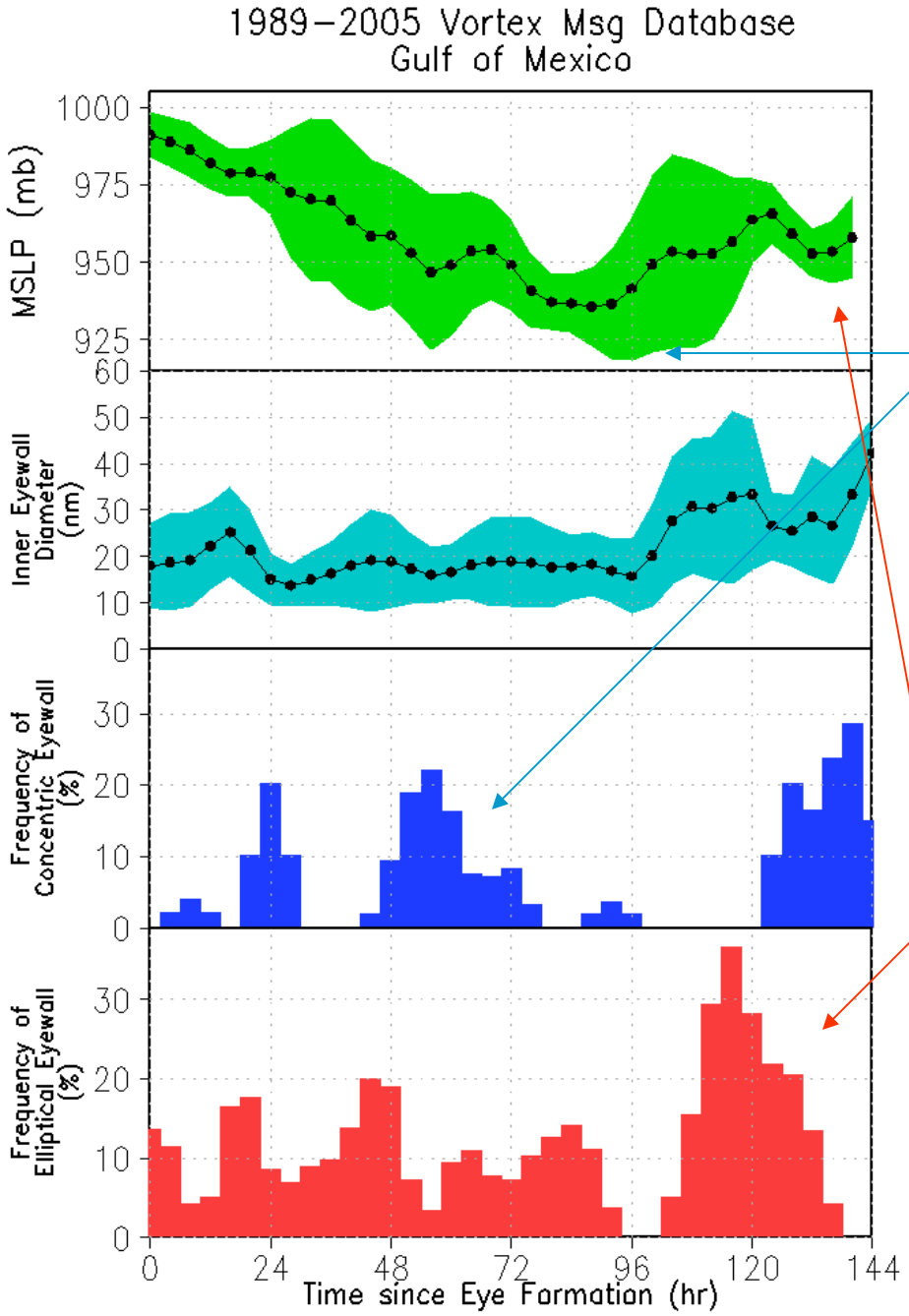
- Does NWP show this?


Temp Inside−Temp Outside 700mb (C,IC,E)
Eye Size (nmi)
MSLP (mb)
80
70
60
50
40
30
20
10
880
900
920
940
960
980
1000
18
16
14
12
10
8
6
4
2
0


Dewpoint Depression Inside Eyewall 700mb (C,IC,E)
Eye Size (nmi)
MSLP (mb)
80
70
60
50
40
30
20
10
880
900
920
940
960
980
1000
1020
18
16
14
12
10
8
6
4
2
0

Forecast Guidance that needs to be compared to SHIPS



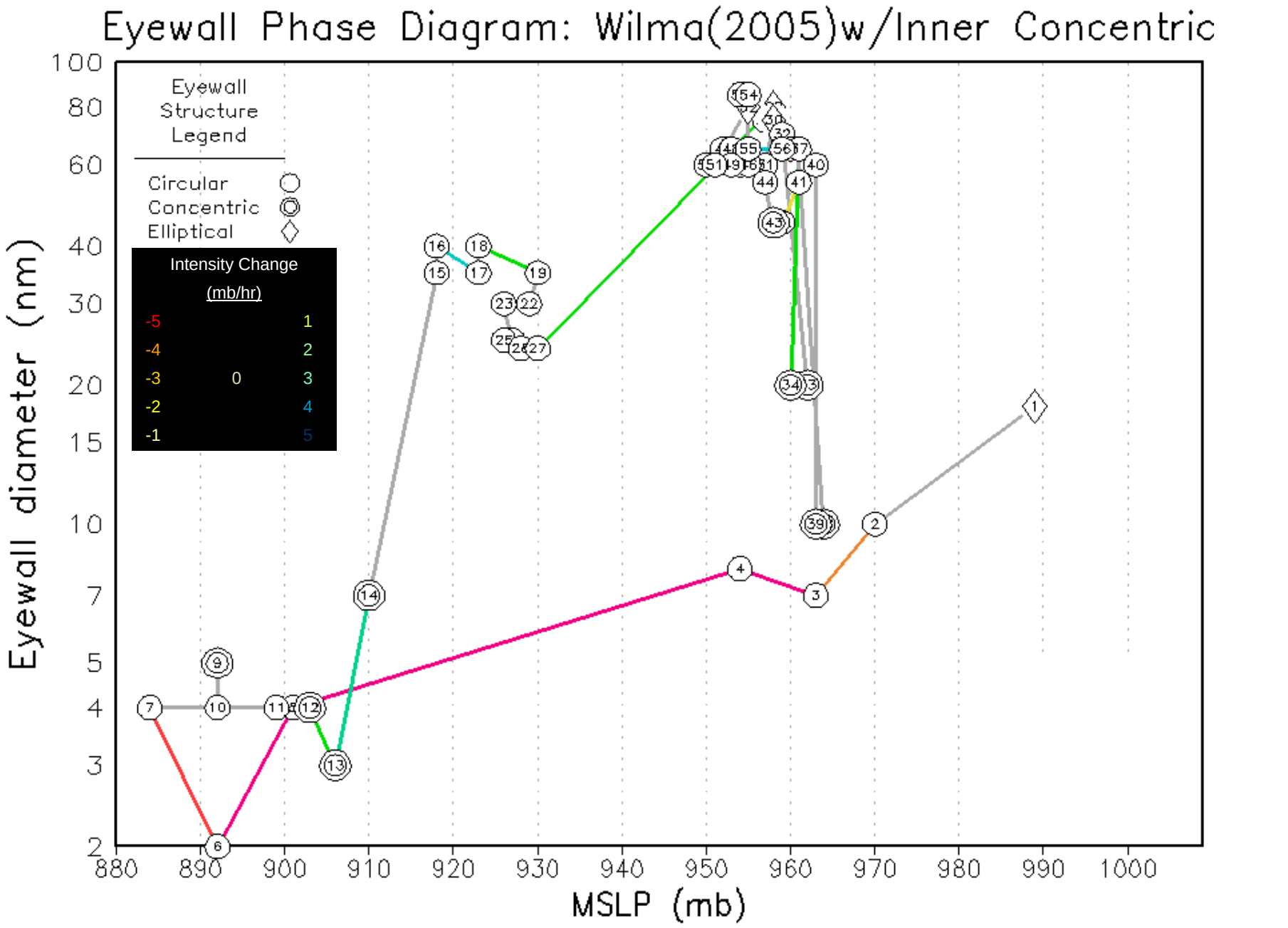


Eyewall cycles are most evident in this composite

Standard deviation decreases after enhanced period of concentric activity

Standard deviation decreases after enhanced period of elliptical activity

Perhaps these cycles can be used to develop predictive tools?


Eyewall Phase Diagram: Wilma(2005)w/Inner Concentric
Eyewall Structure Legend
Circular
Concentric
Elliptical
Intensity Change (mb/hr)
-5
-4
-3
-2
-1
0
1
2
3
4
5
Eyewall diameter (nm)
MSLP (mb)
100
80
60
40
30
20
15
10
7
5
4
3
2
880
890
900
910
920
930
940
950
960
970
980
990
1000

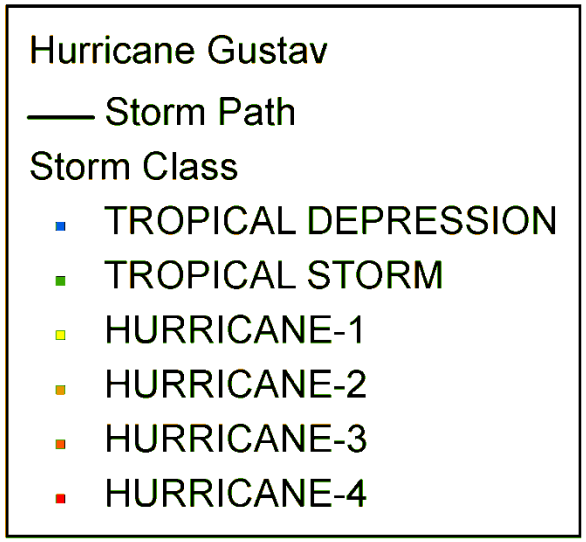
Research Front 2

- Improved understanding and forecasting of short-term intensity change using lightning distribution in time, space, and type
  - What are lightning data telling us about TCs?
  - What is it a proxy for?
  - How can this be incorporated into models?
  - How can we add forecaster insight to model forecasts?

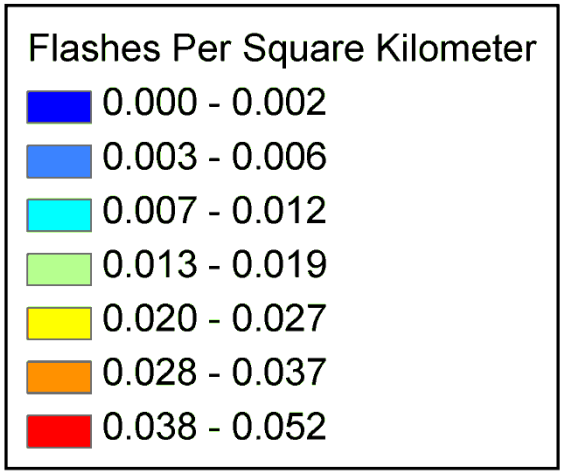
Gustav 2008

- Positions at 3 h intervals
- Vaisala LLDN lightning within 100 km radius of TC center—centered ± 1.5 h of each position

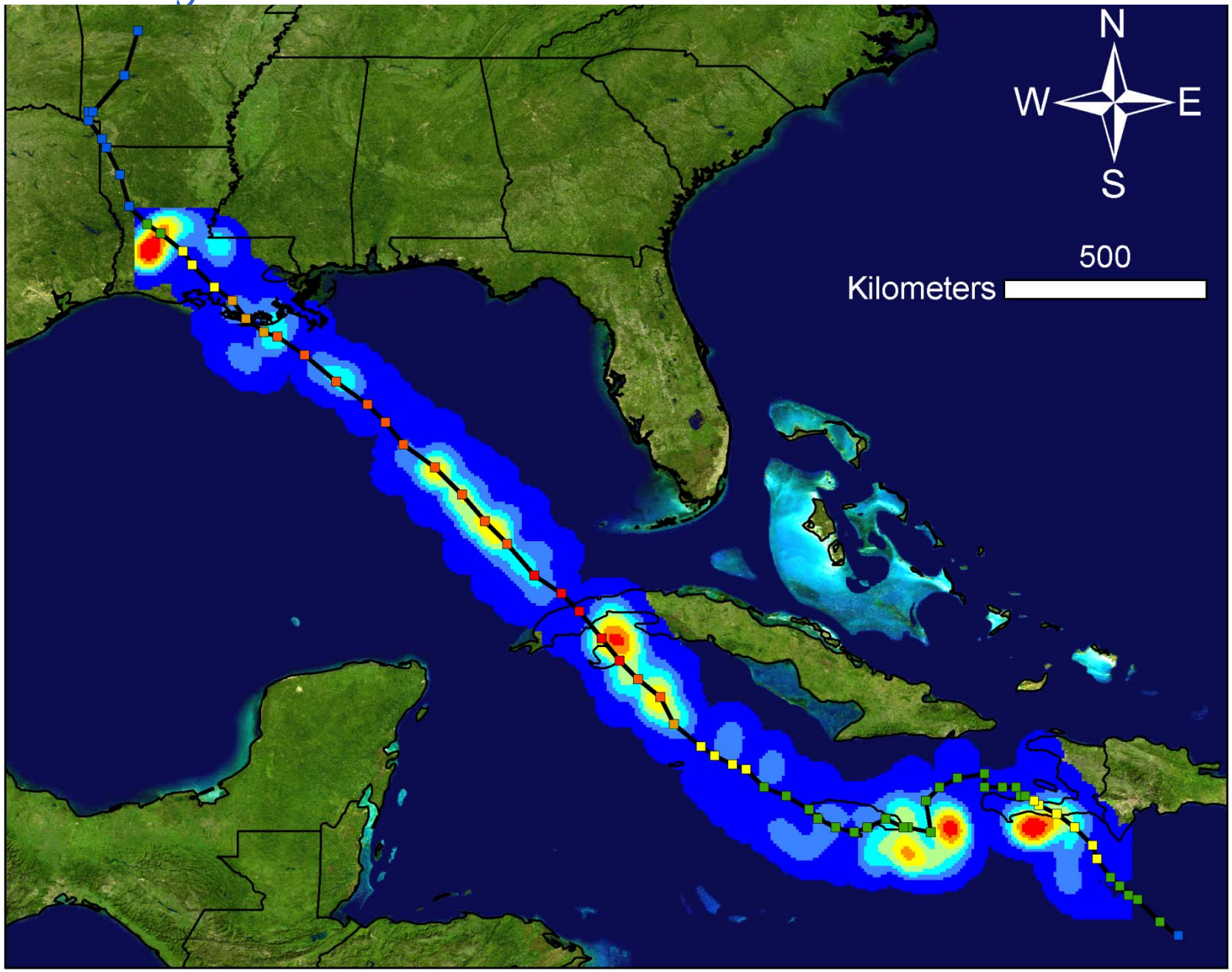
TC Strength



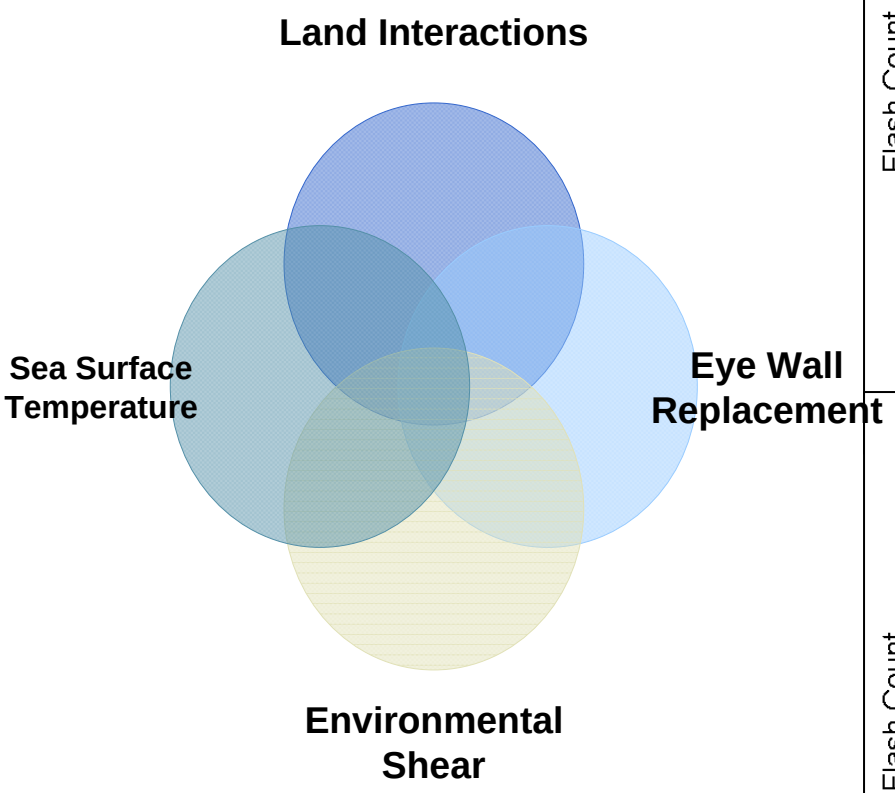
Flash Density

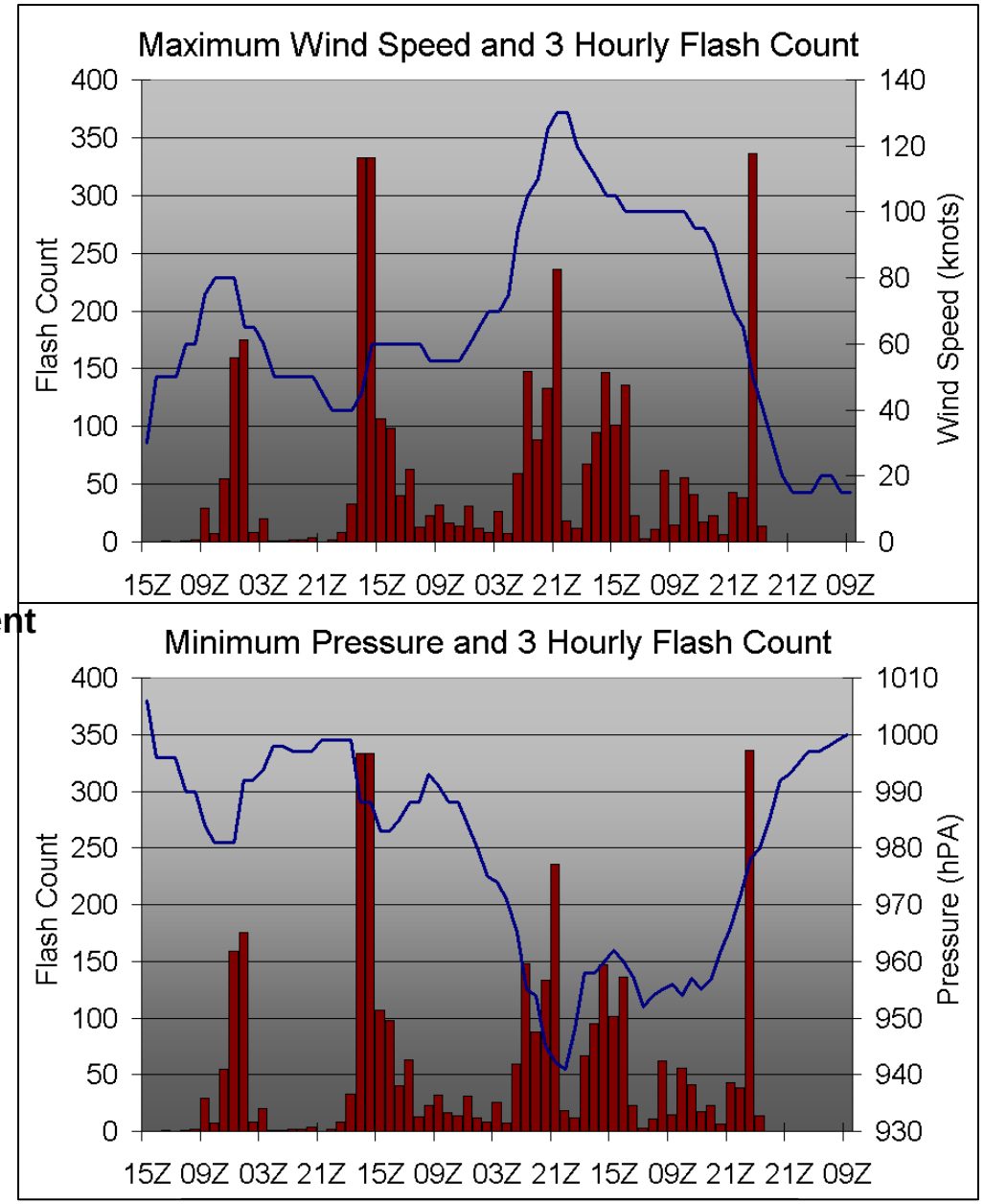


Density of Flashes Linked with Storm



Gustav Time Series



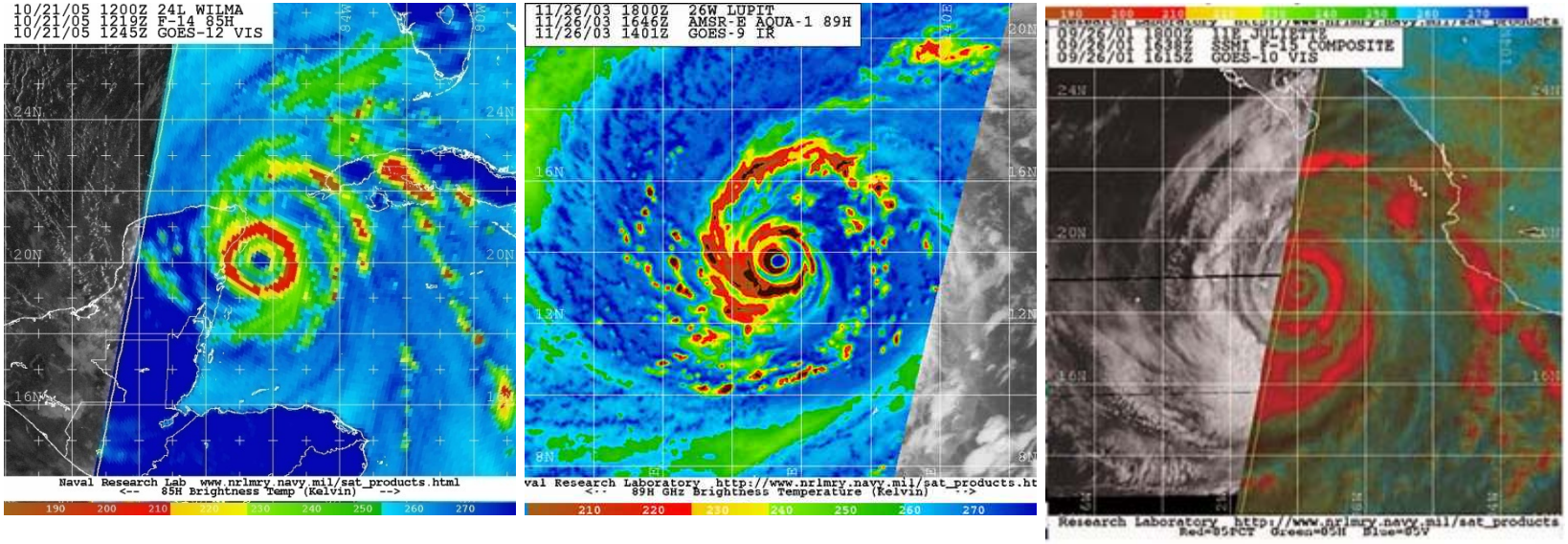


Synthesis: Research Plan

- 2009: Test using 1988-2000 vortex-message based climatology as intensity and eye size change guidance
- Testing analog trajectories in eyewall phase space
- Verify on 2001-2008 independent dataset
- How does 1-12hr forecast guidance compare to benchmarks:
  - SHIPS
  - Persistence
  - NWP

Research Plan

- 2010: Produce a database of vortex-message-type structure from remotely sensed satellite information and reexamine the short-term guidance based upon it



Images courtesy of Mr. Jeff Hawkins, NRL

Research Plan

- 2009-10: Produce multicase composites of lightning distribution in the hours leading up to rapid intensity change (+ or -)

- Ascertain whether the distribution of lightning in time and space be used, in conjunction with other parameters, to improve prediction of intensity change?

- Build upon the growing foundation of lightning research to flesh out what lightning is a proxy for in hurricanes.

Research Plan

- 2011-12: Synthesize lightning composites and vortex message climatology, along with other conventional meteorological and ocean analyses into a storm-structure-based forecast tools that predicts 1-24hr into the future

- Robust statistical analysis of forecast tool compared to existing forecast standards:
  - SHIPS
  - HWRF, GFDL

Acknowledgments

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