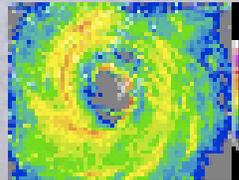


# Tropical Cyclone Track Research at AOML



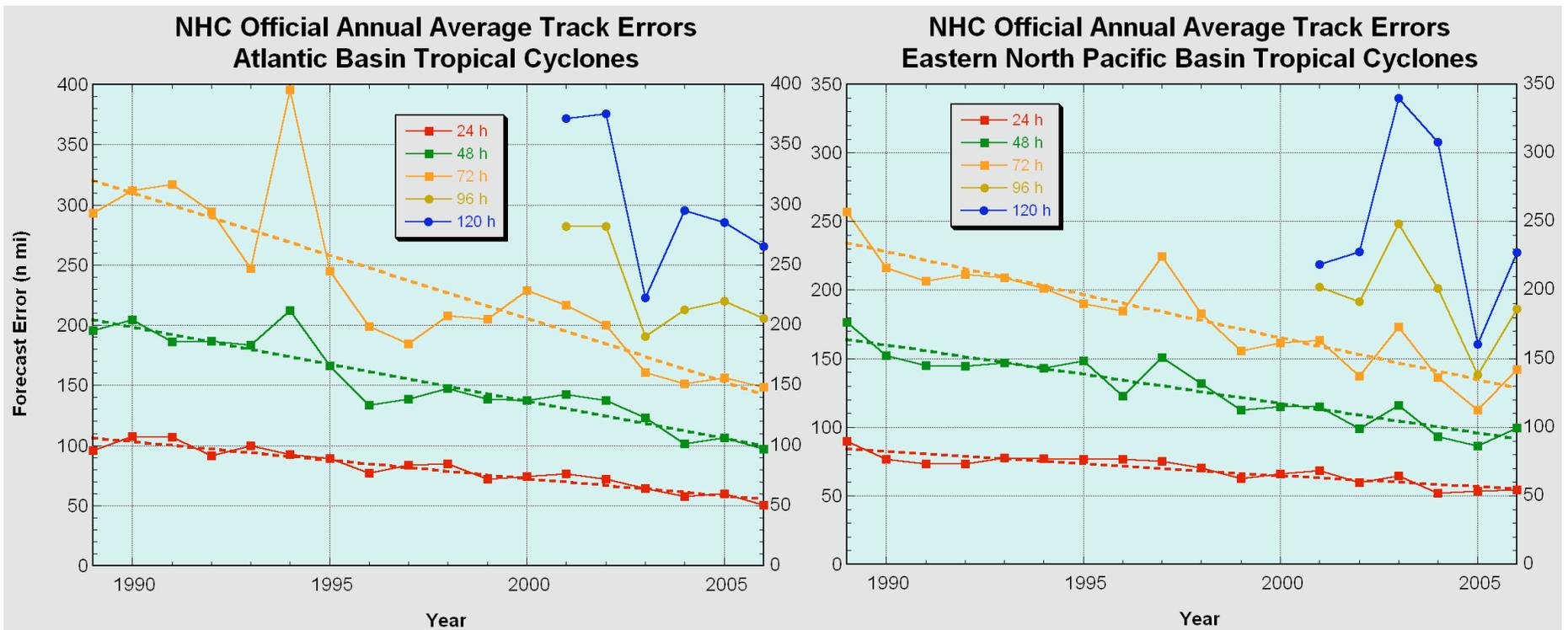
Sim Aberson  
AOML Program Review  
18-20 March 2008



# Background

All other forecasts (intensity, rainfall, waves, surge, etc.) depend on the track.

- How much better can we get (predictability limit)?
- How do we get to there?



# Predictability Limit

## Only a few theoretical studies

- 
- Aberson (1998) and Aberson and Sampson (2003) - the predictability timescale in which errors increase by a factor  $e$  is about 2.5 days in the Atlantic and Western Pacific Basins.
- 
- Significant room for improvement to track forecasts.

# Model Improvements

## Reynolds et al. (1994) and Zhu et al. (1996)

- In midlatitudes, most synoptic-scale model errors not due to model deficiencies.
- Largest forecast improvements by decreasing analysis error.

Analysis error decreased by

- improving observations
- improving data assimilation

**HRD has a unique ability to accomplish both**



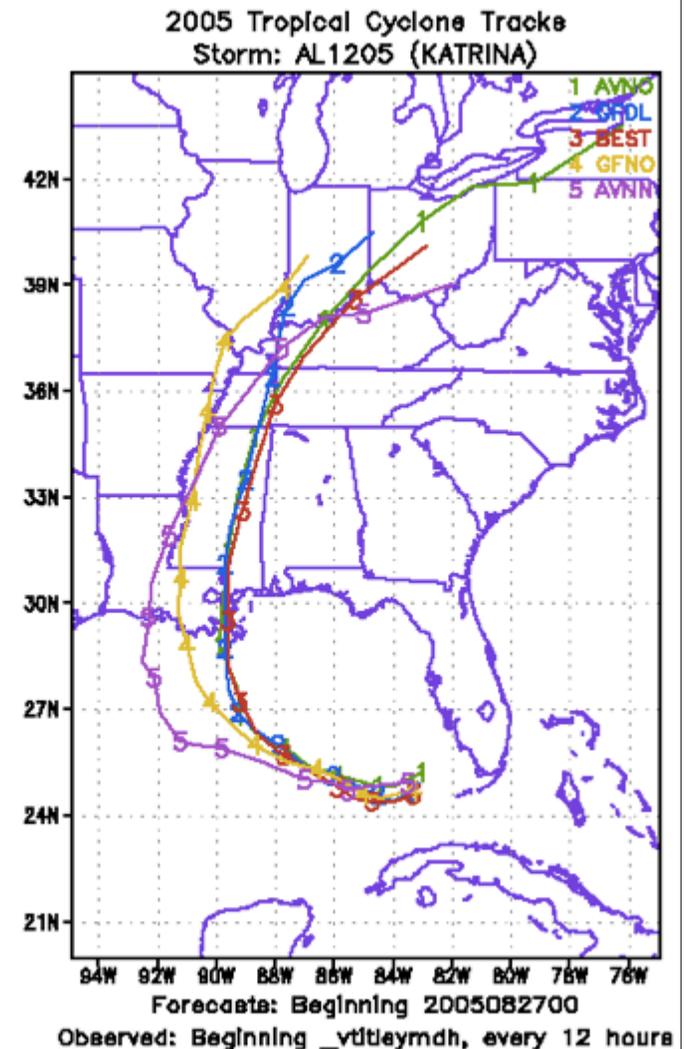
# Synoptic Surveillance

**1982 - 1996** Omega Dropwindsonde data from P-3s in the TC environment improved model forecasts by ~30%

**1996** NOAA purchased the G-IV and helped develop the GPS dropwindsonde for operational missions

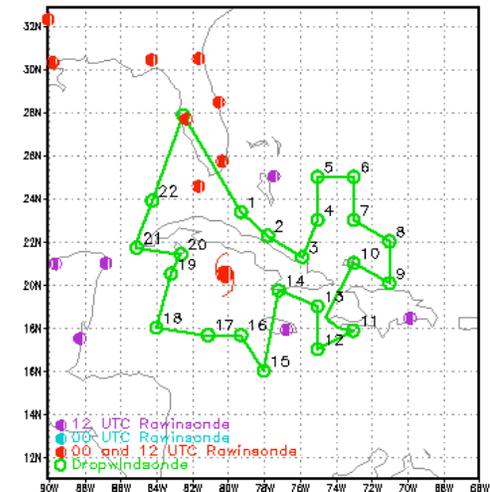
**1997-2006** HRD coordinated flights, staffed aircraft, and assessed the missions

**2007** transition to operations complete

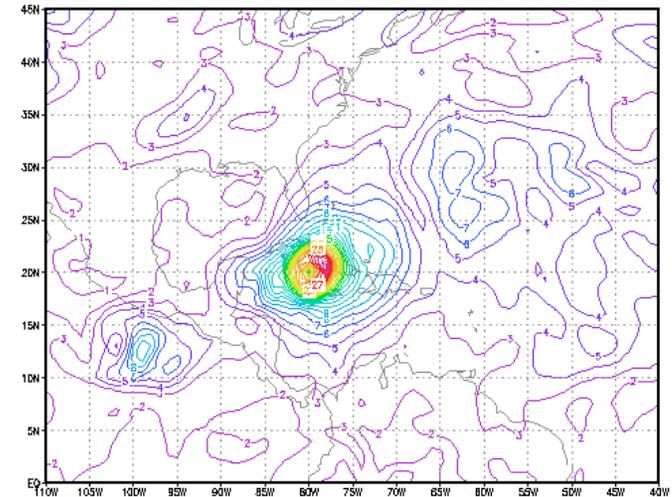


# Optimal Sampling Strategies

- **Most rapidly growing modes** - areas of large forecast spread in the NCEP ensemble forecasting system
- **Optimal sampling strategy** - entire target region with regularly spaced observations
- Assimilation of only the subset of data using this strategy - statistically **significant reduction of track forecast errors beyond using all the data**
- **Automatic flight track software** developed at HRD using this technique now running operationally at NHC



DLM wind variance 2004091012 48h

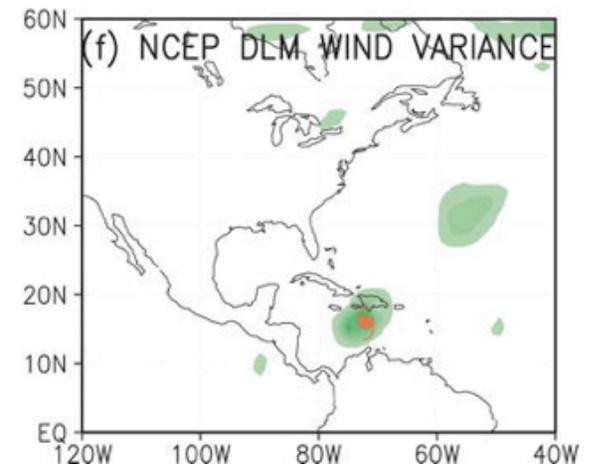
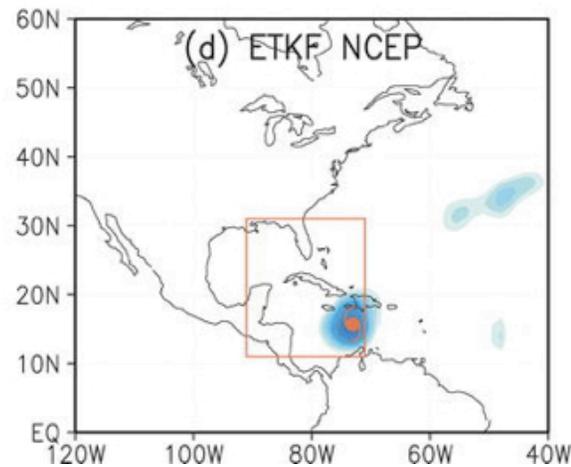
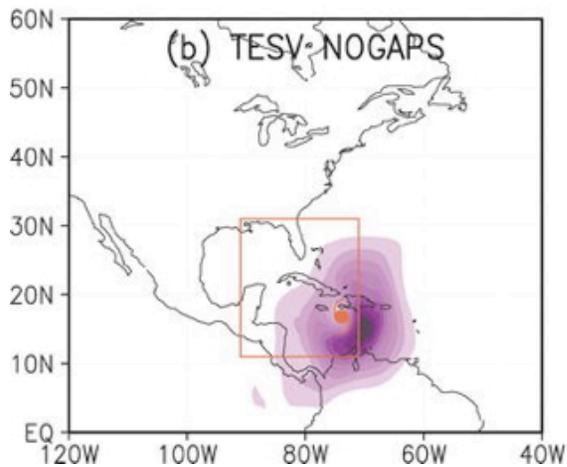
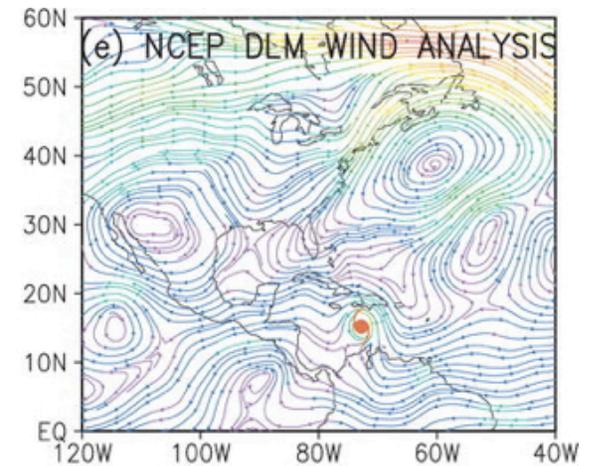
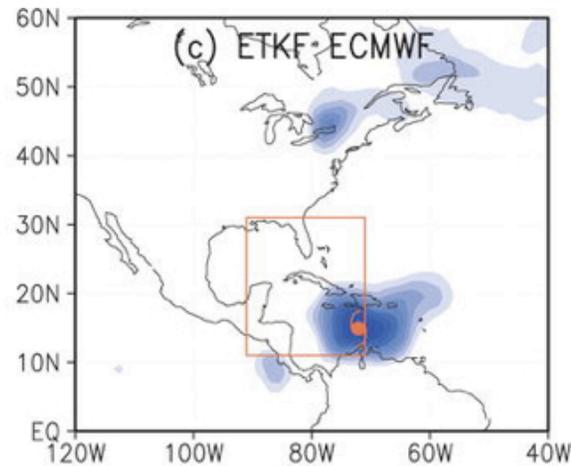
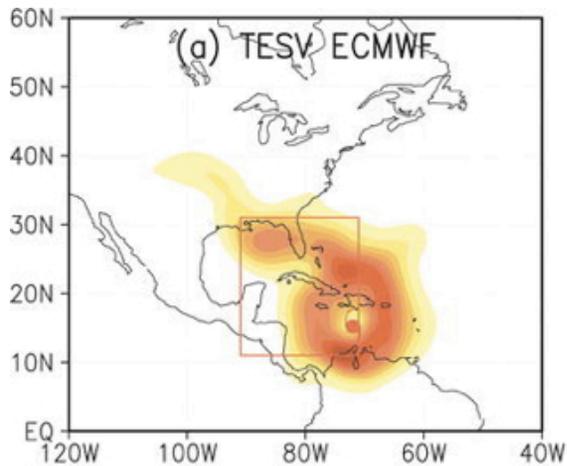


GAO: COLA/IECS

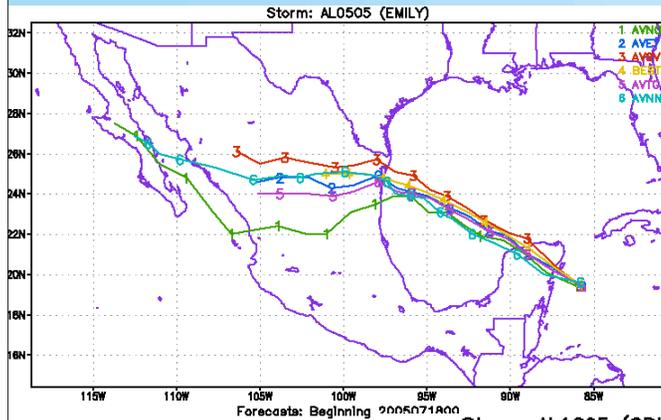
2004-09-10-1404

# Further Targeting Research

Testing of advanced targeting techniques with global partners (Majumdar et al. 2006)

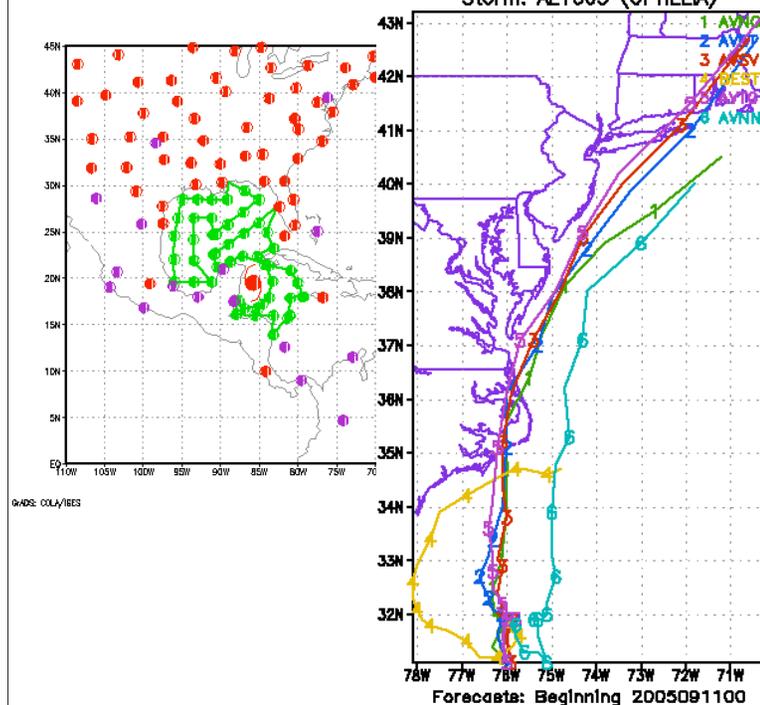


# Observing System Experiments



Compared to symmetric sampling:

- **ensemble spread** - slight degradation through 60 h.
- **ETKF** - degradations in the very short-term.
- **NRL singular vectors** - forecast improvements (small sample).

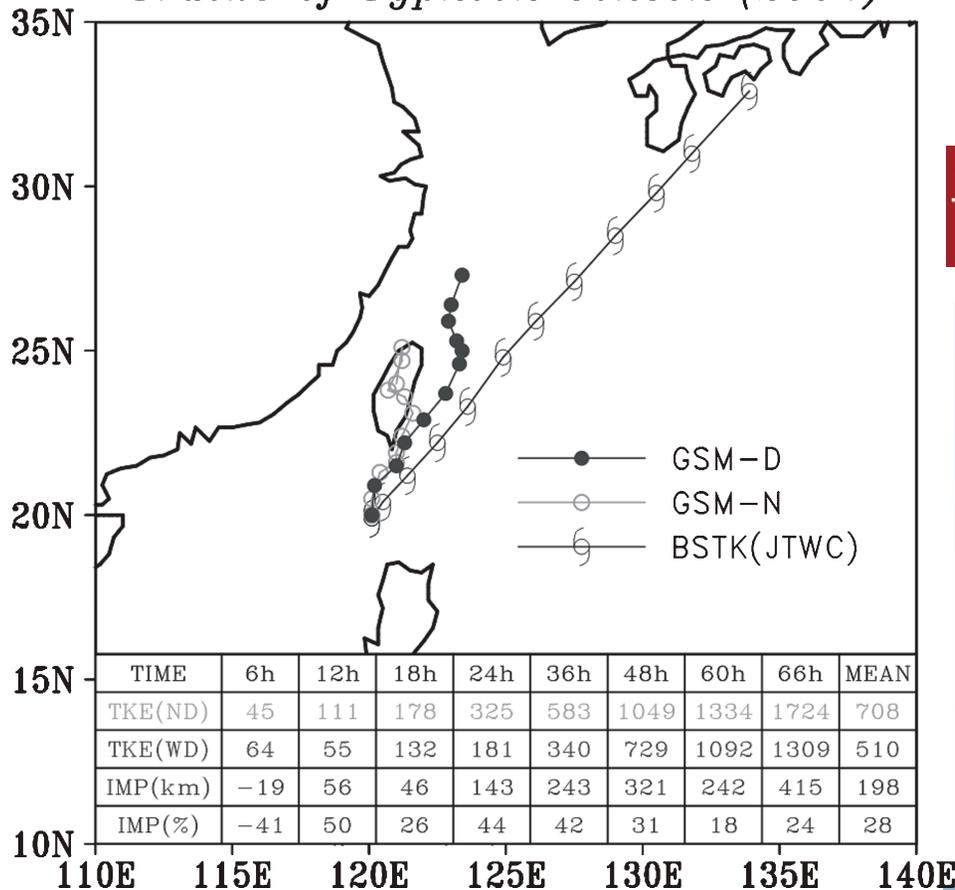


# DOTSTAR

Central Weather Bureau/National Taiwan University

India and Japan interested

Tracks of Typhoon Conson (2004)

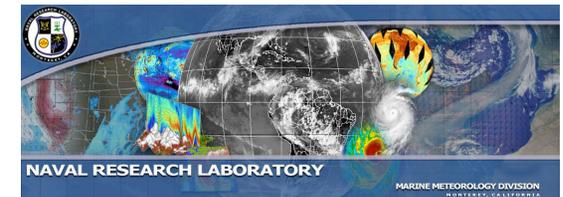
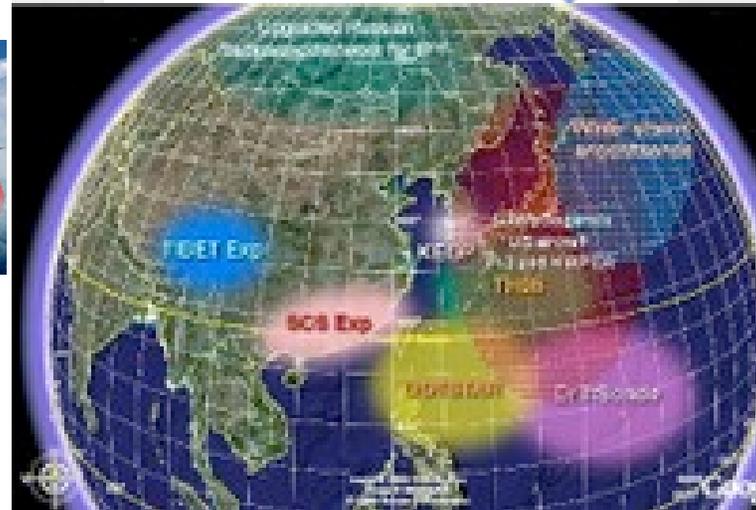


TYPHOON DYNAMICS RESEARCH CENTER  
[typhoon.as.ntu.edu.tw](http://typhoon.as.ntu.edu.tw)



# T-PARC

## THORPEX Pacific Area Regional Campaign



**Targeting** and **data assimilation** studies to improve short-range forecasts in Eastern Asian and the western North Pacific and downstream in the medium-range over the eastern North Pacific and North America, with special emphasis on **tropical cyclones** and **extratropical transition**.

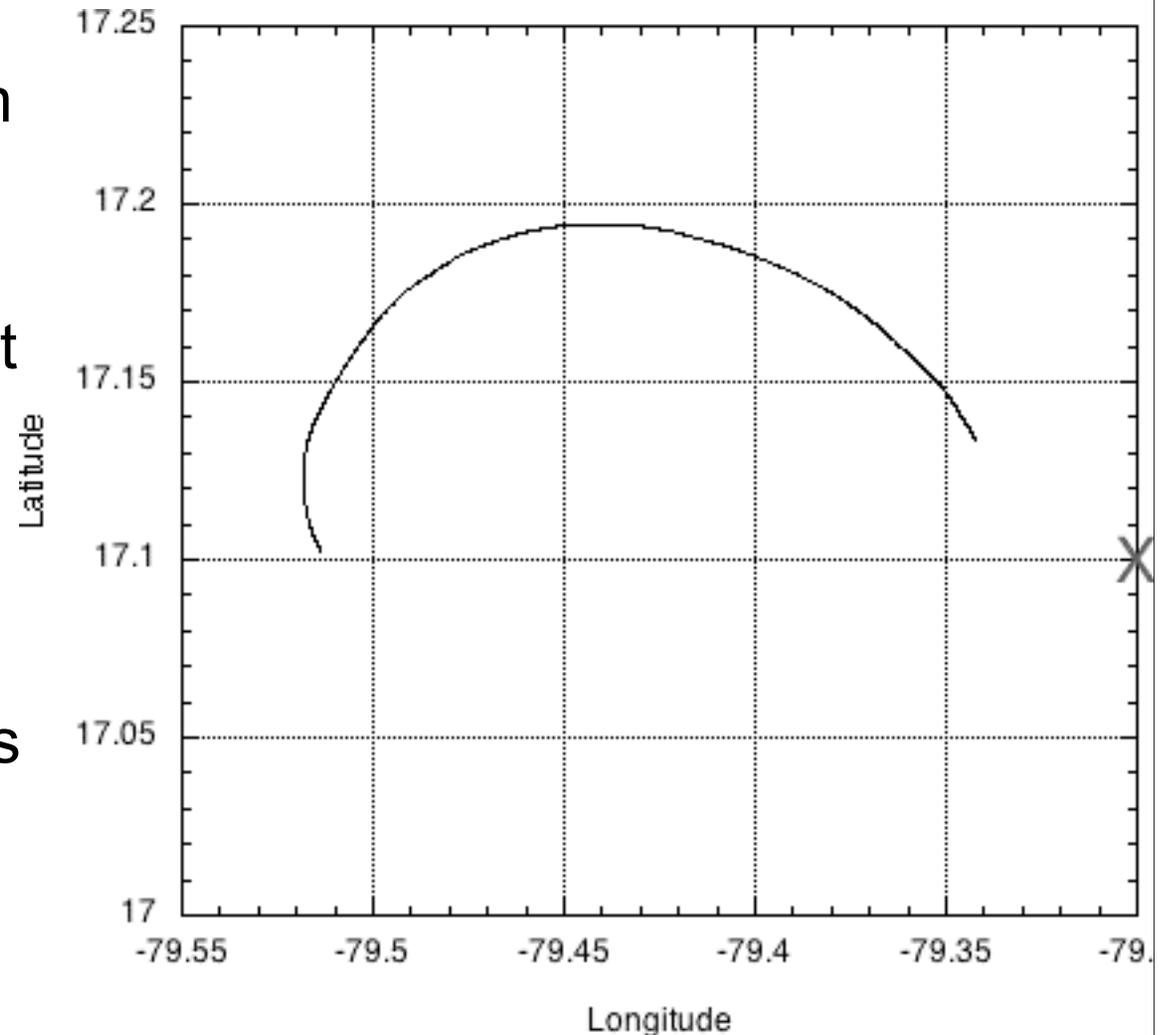
# Dropwindsonde Improvements

Current (TEMPDROP) message - release location and time to 11 km and 1 h accuracy

All data assimilated at that point.

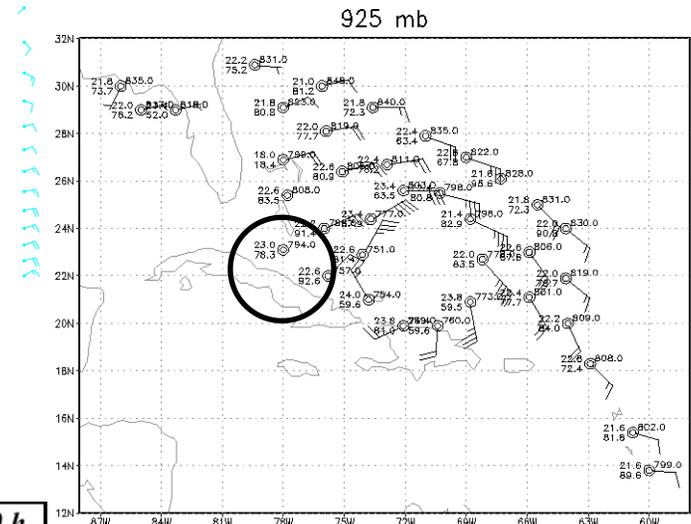
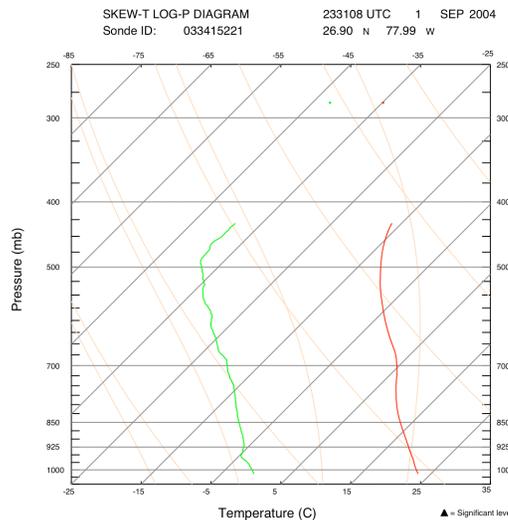
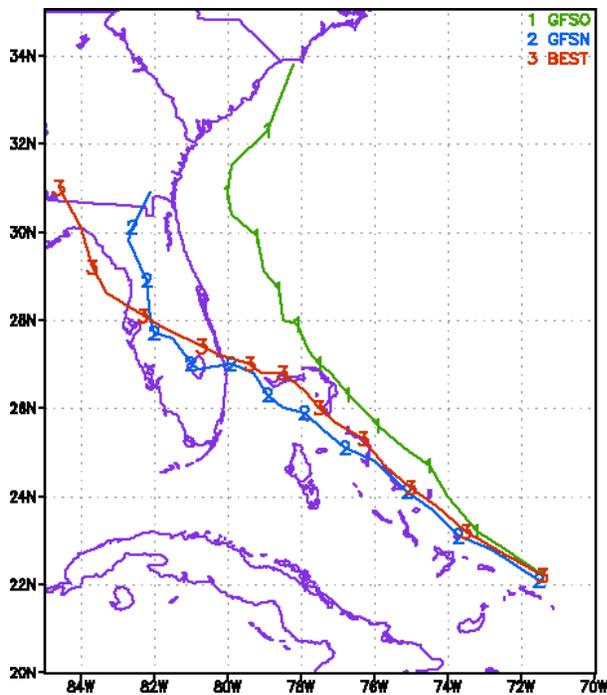
Message upgraded to include release and splash locations and times to 0.01 degree and 1 min accuracy for **mesoscale data assimilation**.

Dropwindsonde data within 11.1 km of storm center automatically removed from the assimilation in GFS and H-WRF.



# ASPEN Improvements

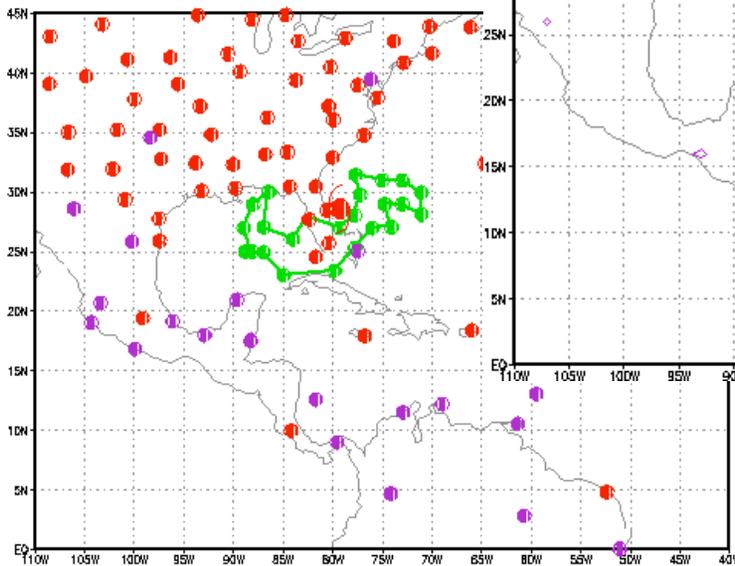
Working with NCAR to improve ASPEN for accurate quality control in the eyewall and synoptic environments.



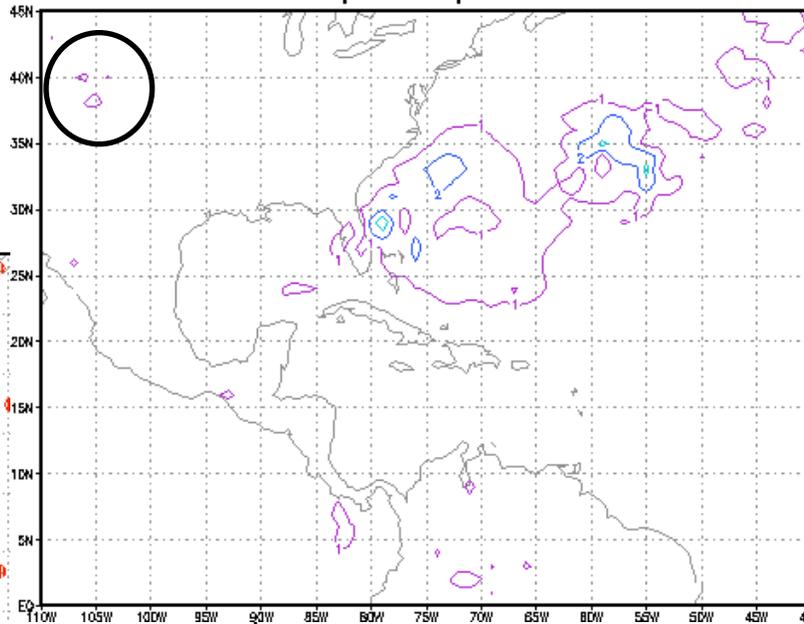
Model	12 h	24 h	36 h	48 h	60 h	72 h	84 h	96 h	108 h	120 h
GFSN	23	23	55	41	68	40	59	53	160	224
GFSO	31	69	52	86	101	170	253	361	387	567

# OSEs and Data Assimilation

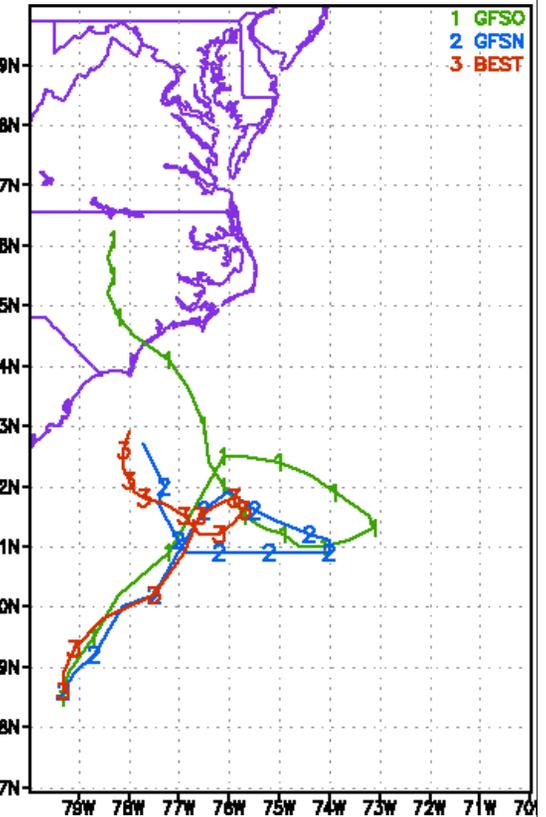
Impact spread into unstable region



DLM wind alldrop-nodrop 2005090900 00h



Studies of very large degradations



GWDS: COLY/IES

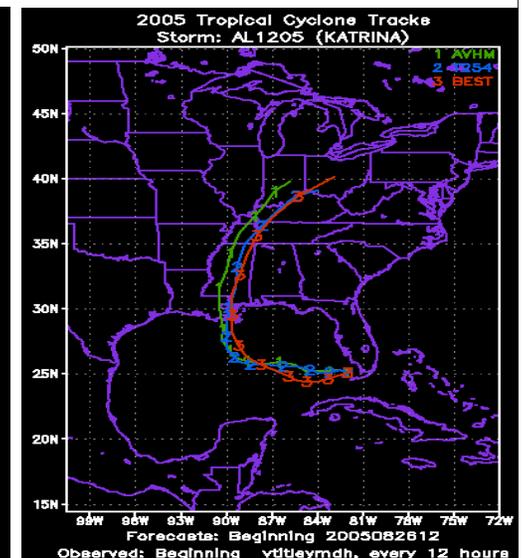
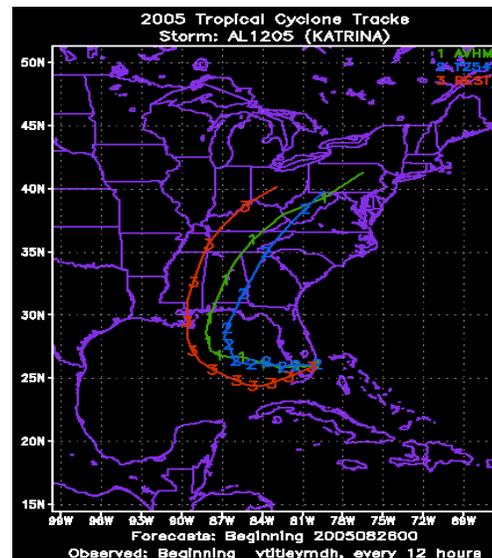
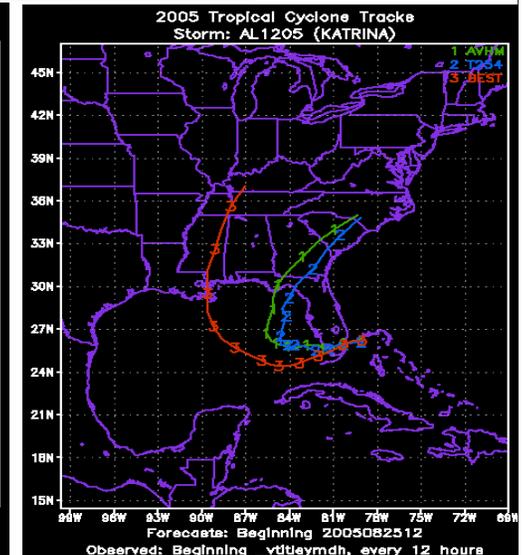
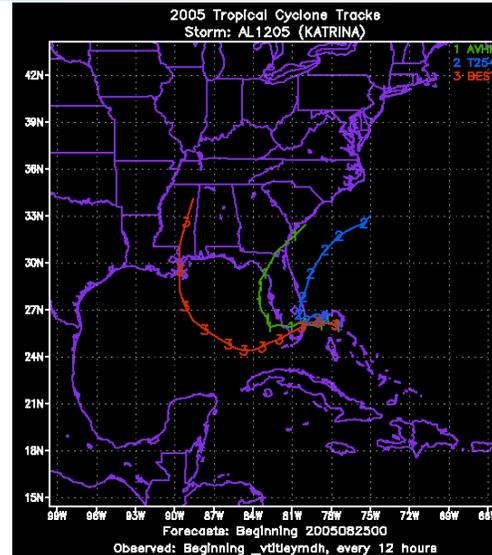
2008-08-01-14:48

<i>Model</i>	<i>12 h</i>	<i>24 h</i>	<i>36 h</i>	<i>48 h</i>	<i>60 h</i>	<i>72 h</i>	<i>84 h</i>	<i>96 h</i>	<i>108 h</i>	<i>120 h</i>
GFSN	40	0	15	44	131	212	175	174	146	100
GFSO	45	83	121	108	173	294	271	273	227	199

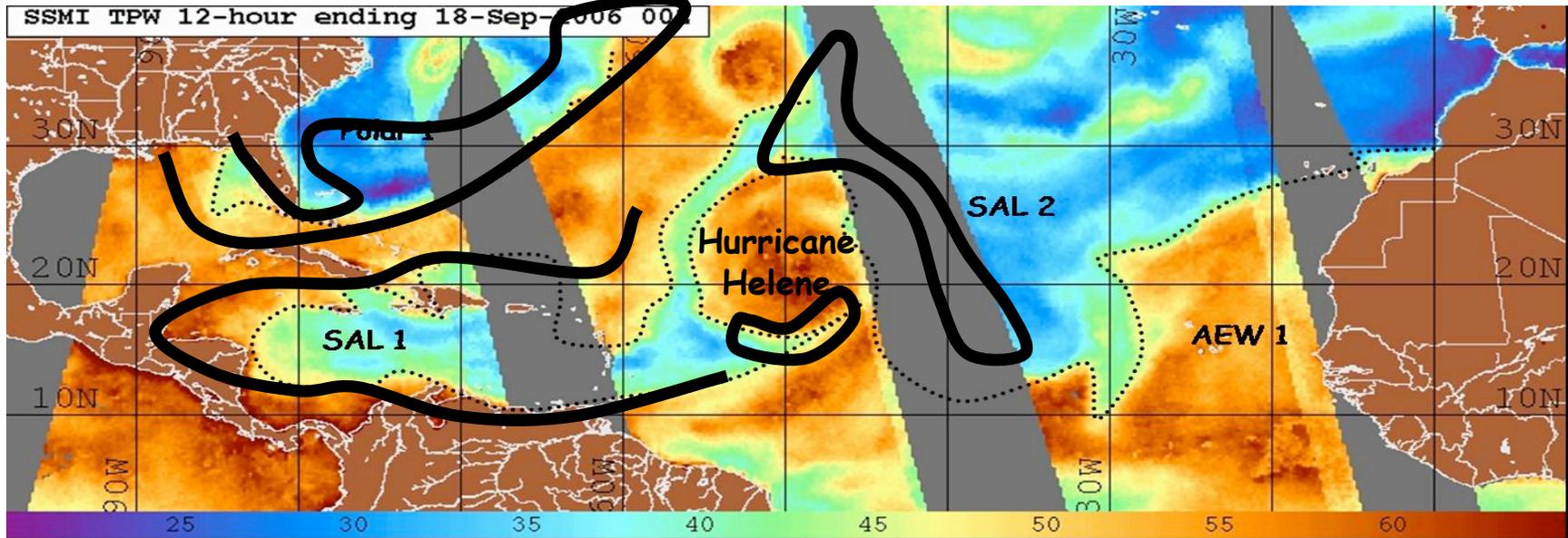
# Humidity

The impact of humidity data on TC track forecasts **as large as** that of wind and mass data.

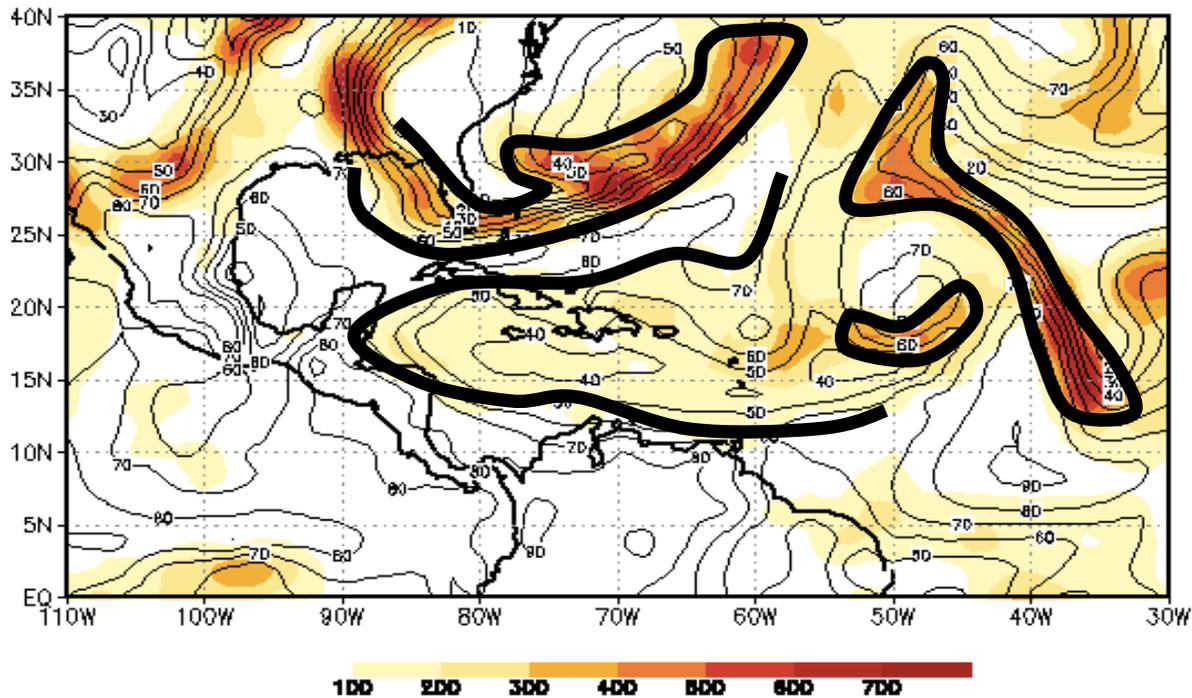
Assimilation of dropwindsonde humidity into the operational GFS starting in 2005.



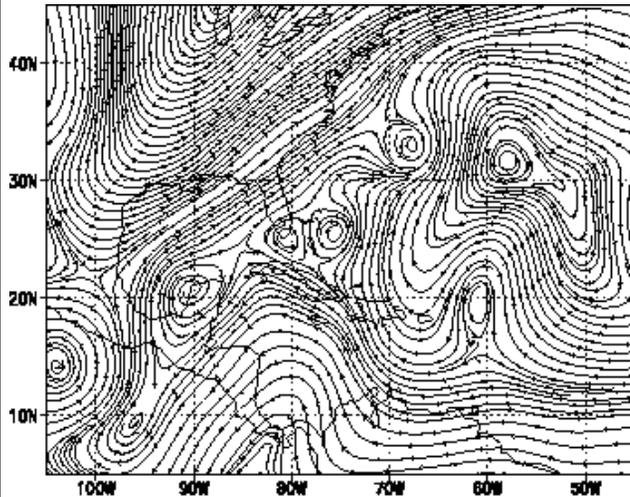
# Targeted Humidity Observations (Hurricane Helene)



Ensemble mean (contour) and variance (shaded) of RH at 700 hPa  
59-member NCEP ensemble initialized at 2006091600, 48-hr forecast

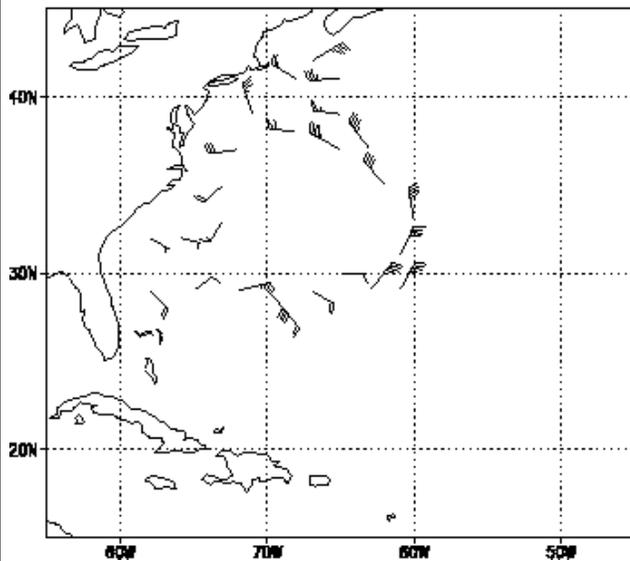
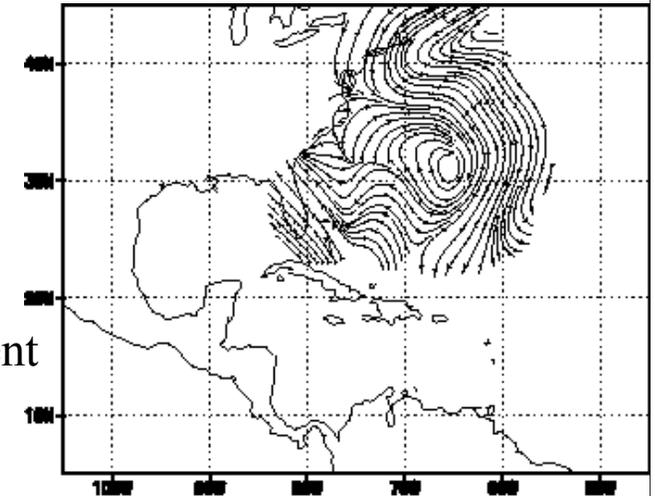


# Advanced Data Assimilation



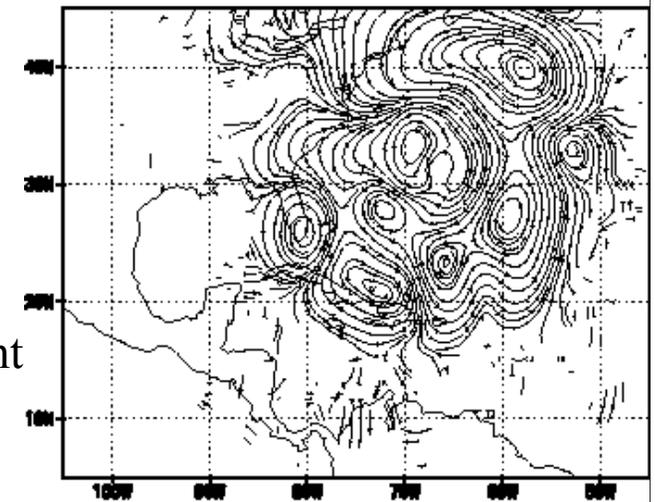
DLM wind first guess

3DVAR increment



Data assimilated

ETKF increment



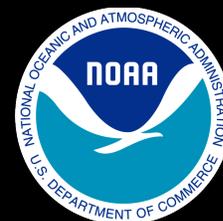
# The Future



- Targeted observations
- Data assimilation and ensembles
- In tandem with development of mesoscale model capabilities to improve intensity forecasts.

A satellite image of Earth from space, showing a large hurricane over the ocean. The hurricane is a large, circular storm system with a distinct eye and spiral cloud bands. The surrounding ocean is a deep blue, and the landmasses are visible in the distance. The word "QUESTIONS?" is overlaid in large, black, sans-serif font in the center of the image.

QUESTIONS?



# Background Material

