Tropical Cyclone Track Research at AOML
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?
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.
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
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).
Central Weather Bureau/National Taiwan University

India and Japan interested

Tracks of Typhoon Conson (2004)

<table>
<thead>
<tr>
<th>TIME</th>
<th>6h</th>
<th>12h</th>
<th>18h</th>
<th>24h</th>
<th>36h</th>
<th>48h</th>
<th>60h</th>
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<td>IMP(km)</td>
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<td>56</td>
<td>46</td>
<td>143</td>
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<td>44</td>
<td>42</td>
<td>31</td>
<td>18</td>
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DOTSTAR

TYPHOON DYNAMICS RESEARCH CENTER

typhoon.as.ntu.edu.tw

AOML Program Review
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.

<table>
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<tr>
<th>Model</th>
<th>12 h</th>
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<th>36 h</th>
<th>48 h</th>
<th>60 h</th>
<th>72 h</th>
<th>84 h</th>
<th>96 h</th>
<th>108 h</th>
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925 mb
OSERs and Data Assimilation

Impact spread into unstable region

Studies of very large degradations

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AOML Program Review
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

Aberson and Etherton 2003
• Targeted observations
• Data assimilation and ensembles
• In tandem with development of mesoscale model capabilities to improve intensity forecasts.
QUESTIONS?
Background Material