Tropical Cyclone Track

Overview

• Track forecasting is a relatively simple problem
  – “Cork in a stream” analogy

• Important atmospheric features that control track are relatively large and easy to measure
Tropical Cyclone Models

Statistical and Dynamical

• Statistical
  – Tells you what *normally occurs* based on the behavior of previous storms in *similar situations* (i.e., storm location, time of year, current motion, intensity, environment)

• Dynamical
  – Attempt to predict what will happen in this *specific situation*
Tropical Cyclone Models

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Tropical Weather Outlook

Tropical Cyclone Models

Spaghetti Plots

MAJOR HURRICANE JOAQUIN (AL11)

• What does this set of lines represent?
• Do they accurately convey the uncertainty in the track forecast?
• Are they all created equal?
• What’s missing?
Tropical Cyclone Models

Spaghetti Plots

20 April 2017

2017 National Hurricane Conference
Tropical Cyclone Models

Extrapolated Motion

Useful if models aren’t handling initial motion well in the very short term

No utility beyond 6 or 12 hours at most
Tropical Cyclone Models

Climatology and Persistence

Used as a baseline to compare other forecasts with

Not used as a forecast tool
Tropical Weather Outlook

Tropical Cyclone Models

Global Models

- Best forecast models for TC track
- Developed for general weather forecasting
- Handle large-scale pattern and steering flow well

- Can’t see details of TC inner core
- Sometimes struggle with storm structure and intensity, which can affect track forecasts
Tropical Cyclone Models

Regional Hurricane Models

- Developed specifically for TCs
- Higher resolution means they can potentially do better job of handling interactions between TC and environment
- Limited coverage means features far away from TC may not be handled as well, which can degrade longer-range forecasts
Tropical Cyclone Models

Consensus Models

Typically the best track guidance, especially if the member models all show a similar forecast scenario.

Doesn’t work well when members forecast very different track scenarios.
• If you’re looking at model track plots, you’re not seeing the whole picture
  • Some of the best guidance isn’t publicly available for proprietary reasons
  • No sense of continuity from cycle to cycle for the various models, trends, etc.
  • Don’t have the forecaster’s perspective and knowledge to know model strengths and weaknesses, trends, etc.
Consensus Models

Examples – Tropical Storm Cristobal (2014)

• Model errors are often random (e.g., small variations on a common theme)

• Consensus frequently cancels out these random errors, resulting in a better forecast
Consensus Models

**Examples – Tropical Storm Cristobal (2014)**

- Model errors are often random (e.g., small variations on a common theme)
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Consensus Models

Examples – Hurricane Joaquin (2015)

- Consensus approach doesn’t always work, especially when model scenarios are completely different.
- Sometimes the forecaster might want to exclude certain models and form a “selective consensus”, if the discrepancies among the models can be resolved.
- Resolving these discrepancies is very difficult.


- GFSI
- GFDI
- HWFI
- ERGI
- TVCA
- EMXI

Consensus Example 20 April 2017 2017 National Hurricane Conference
Four consecutive runs of the GFDL model for Wilma on 19 October 2005 showed tremendous variability in track and forward speed.

5-day forecast points ranged from the Caribbean to northern New England over the course of 4 runs.

This suggests very low confidence in the track forecast and that the track is very sensitive to small changes in the analysis or forecast of features in the atmosphere, including the TC itself.
Considerable variability from storm to storm, with no clear best model at 48-h across the board.
TC track errors from the NAM are about 50% higher than the GFS.

The NAM should not be used for TC forecasting.
“Invests” are suspect areas that NHC is interested in looking at more closely for a variety of reasons.

Model guidance for invests should be treated with extreme caution:
- Guidance for invests can be unreliable and show large swings from one cycle to the next for several reasons:
  - The models may not have a good representation of the invest in the initial analysis (can be too weak, too strong, or in the wrong place)
  - The initial position and motion of invests can be highly uncertain
  - Invests can be relocated many 10s of miles from one cycle to the next as new data become available

Always refer to the TWO, Potential Tropical Cyclone advisories, and products from your local WFO for information about possible tropical cyclones!
Large track forecast errors often result from the following scenarios:

1. Low predictability in the large-scale steering pattern
2. Misrepresentation of TC structure in models, resulting in improper steering flow
3. Weak steering currents, resulting in track being driven by mesoscale or convective scale factors
TC Track Forecasting

Forecast Challenges – Low Predictability in Large-Sale Flow

Hurricane Matthew track guidance

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Early in Joaquin’s life cycle, it appears the cyclone’s track was sensitive to the intensity and structure of the cyclone in the models.

Deep-layer steering flow was similar in both GFS and ECMWF forecasts from 1200 UTC 29 September cycle.

- ECMWF vortex was deeper
- GFS vortex was shallow and didn’t feel deep-layer steering flow
• Previous official forecast exerts a strong constraint on the current forecast

• Credibility can be damaged by making big changes from one forecast to the next, and then having to go back (flip-flop, windshield-wiper)
  – Changes to the previous forecast are normally made in small increments
  – We strive for continuity within a given forecast (e.g., gradual changes in direction or speed from 12 to 24 to 36 h, etc.)

• As a result, NHC official forecasts are often slower to reflect big changes than the model guidance
Forecast Continuity
Hurricane Dennis – 12Z 6 July 2005

Official forecast near model consensus in western Florida panhandle

- Official Forecast
- Consensus
Guidance shifts sharply westward

Official forecast nudged westward into Alabama
Little overall change to guidance, but NOGAPS shifts slightly eastward

Little change in official forecast
Rest of the guidance shifts eastward

Official forecast is now near the center of the guidance and close to the actual track

![Map of Hurricane Dennis]

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Global models are the most skillful for TC track prediction.

Consensus aids are more skillful than most individual models, and often beat the official track forecast:
- NHC forecasters have philosophical constraints on the official forecast that leads to a certain amount of response lag.
- May contribute to forecast biases and slightly poorer performance than the consensus.

While it is possible to beat the models from time to time, model performance has improved significantly over the years, and they are very difficult to beat consistently.
Concluding Remarks

• Large track forecast errors often occur due to
  – Uncertainty in large-scale atmospheric flow
  – Uncertainty in TC intensity and structure

• Track guidance for invests should be treated with extreme caution
Thank You