Visualizing the Uncertainty in Hurricane Path Prediction

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NHC Visit

Miami, FL

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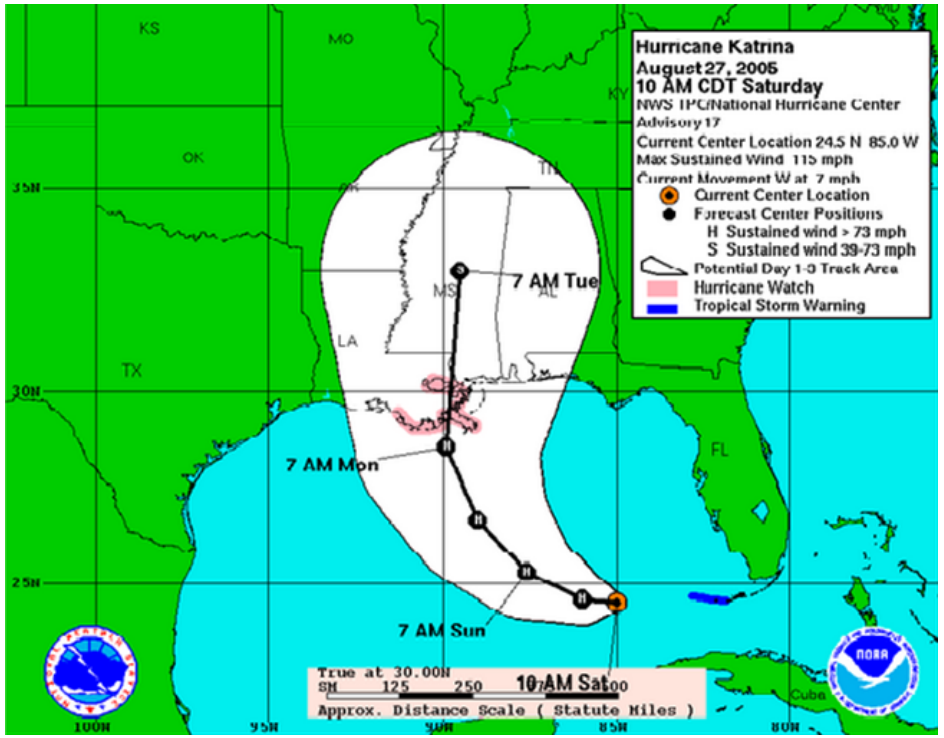
Outline

- Uncertainty cone visualization
- Alternative ensemble visualization
  - review of the algorithm
  - experimental evaluation
  - ideas to move forward
  - demonstration

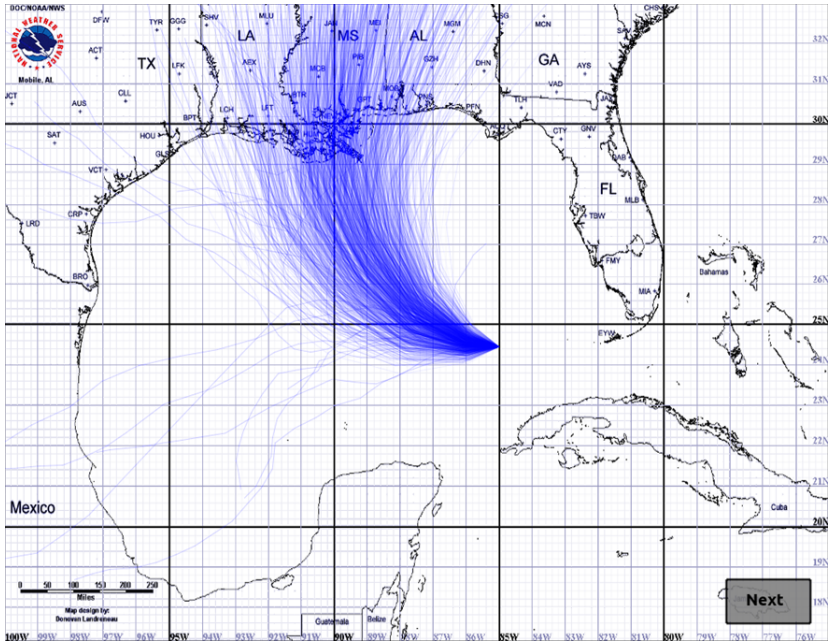
Uncertainty Cone

- Binary display
- Missing 1/3 of outcomes
- Predicted path overemphasized
- Cone open to misinterpretation
- Time represented
- Simple graphic

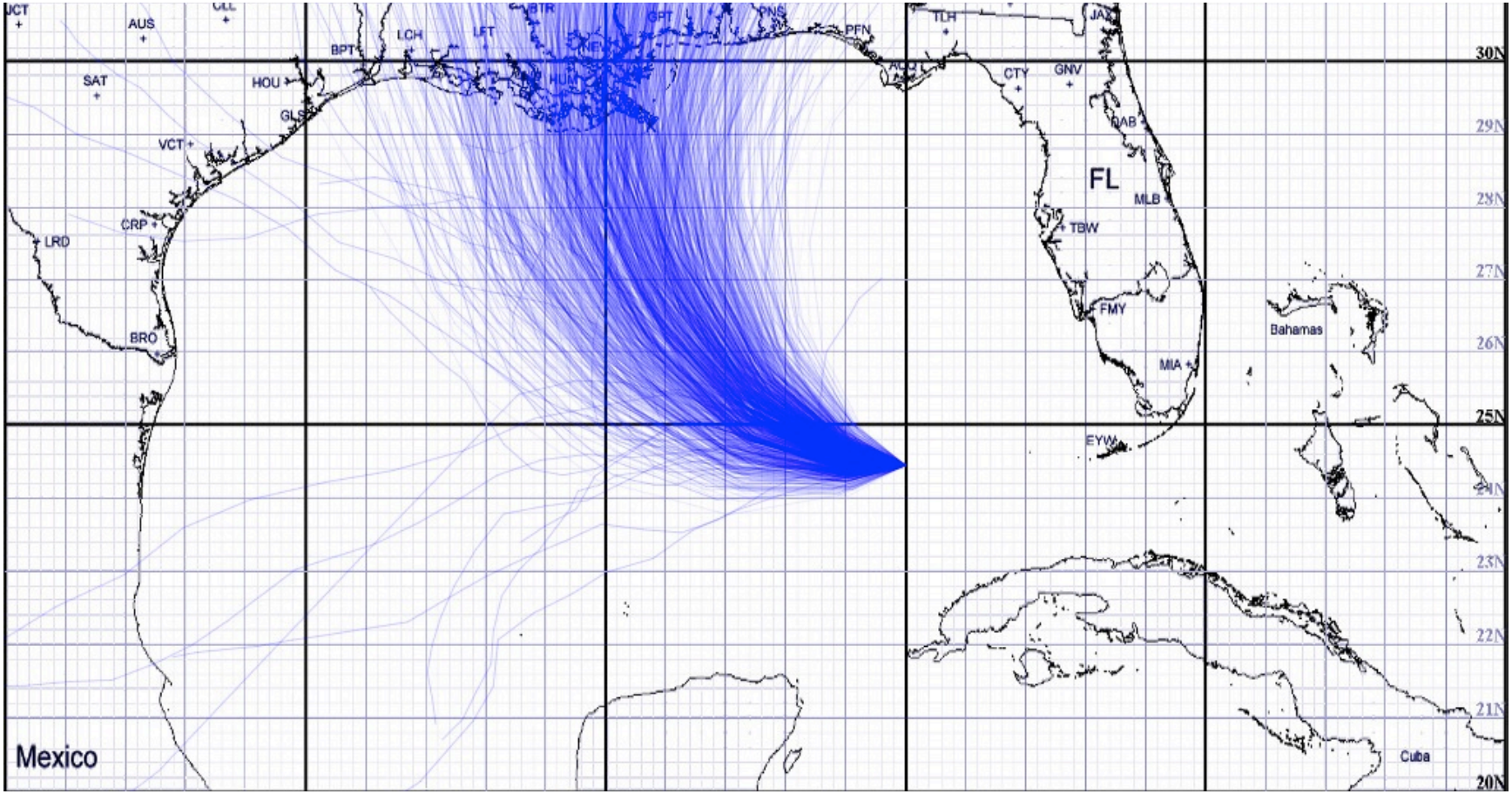


Proposed Ensemble Display

- Distribution explicit
- No hard boundary, has outlier hinting
- No predicted path
- Tracks are intuitive
- Time not represented
- Distributed graphic



Ensemble Display is dynamic



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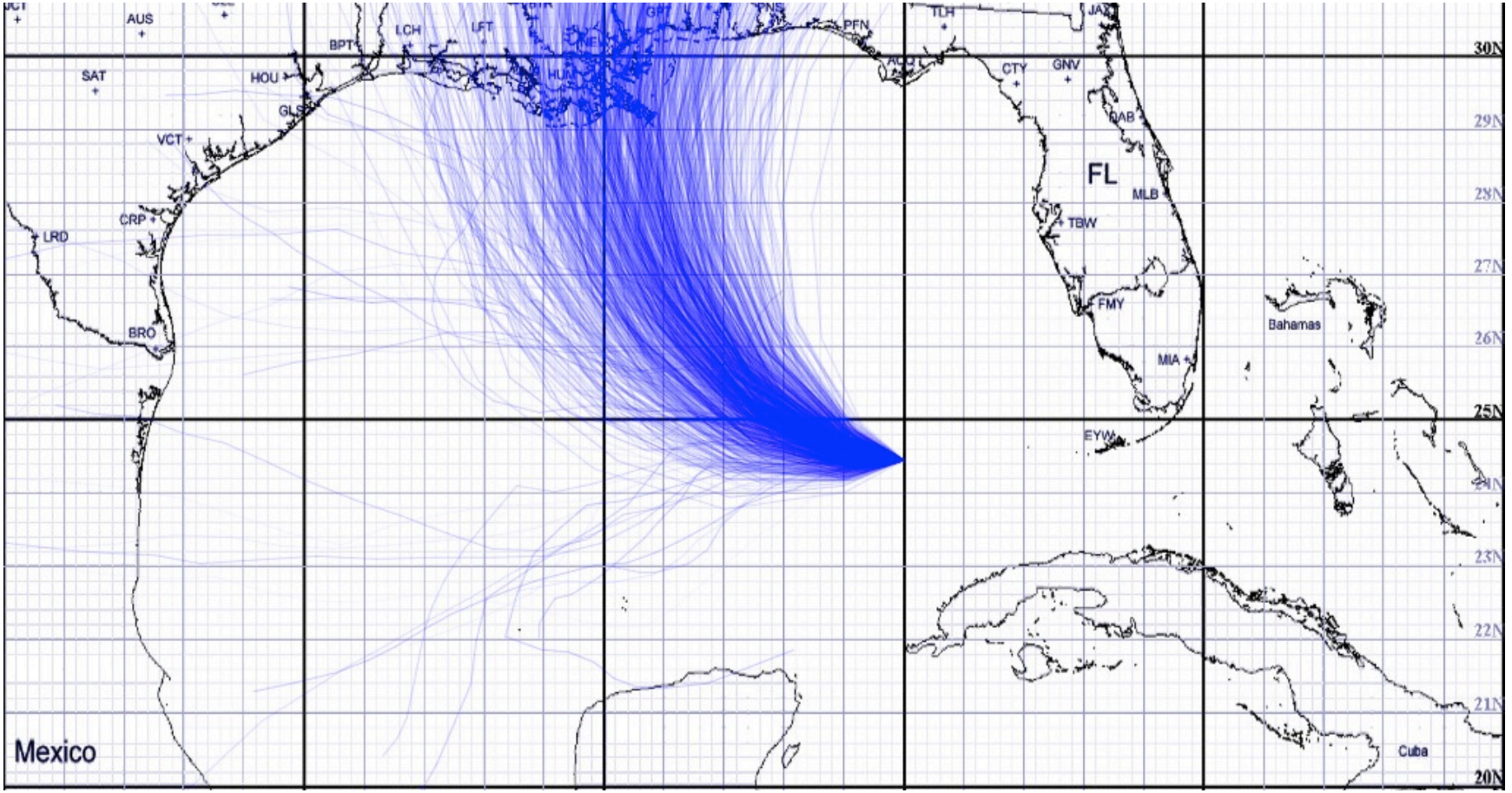


Two Models Used for Path Generation

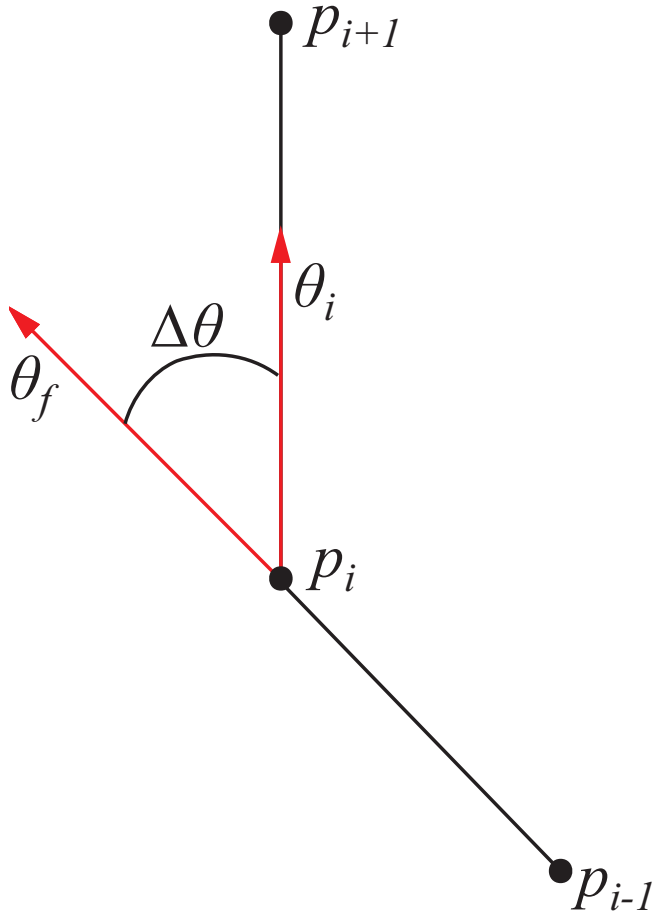
- Predicted: based on the current NHC advisory
  - Set of pdf's distributed over time
- Historical: based on historical hurricane behavior
  - Set of pdf's distributed spatially

Predicted Model

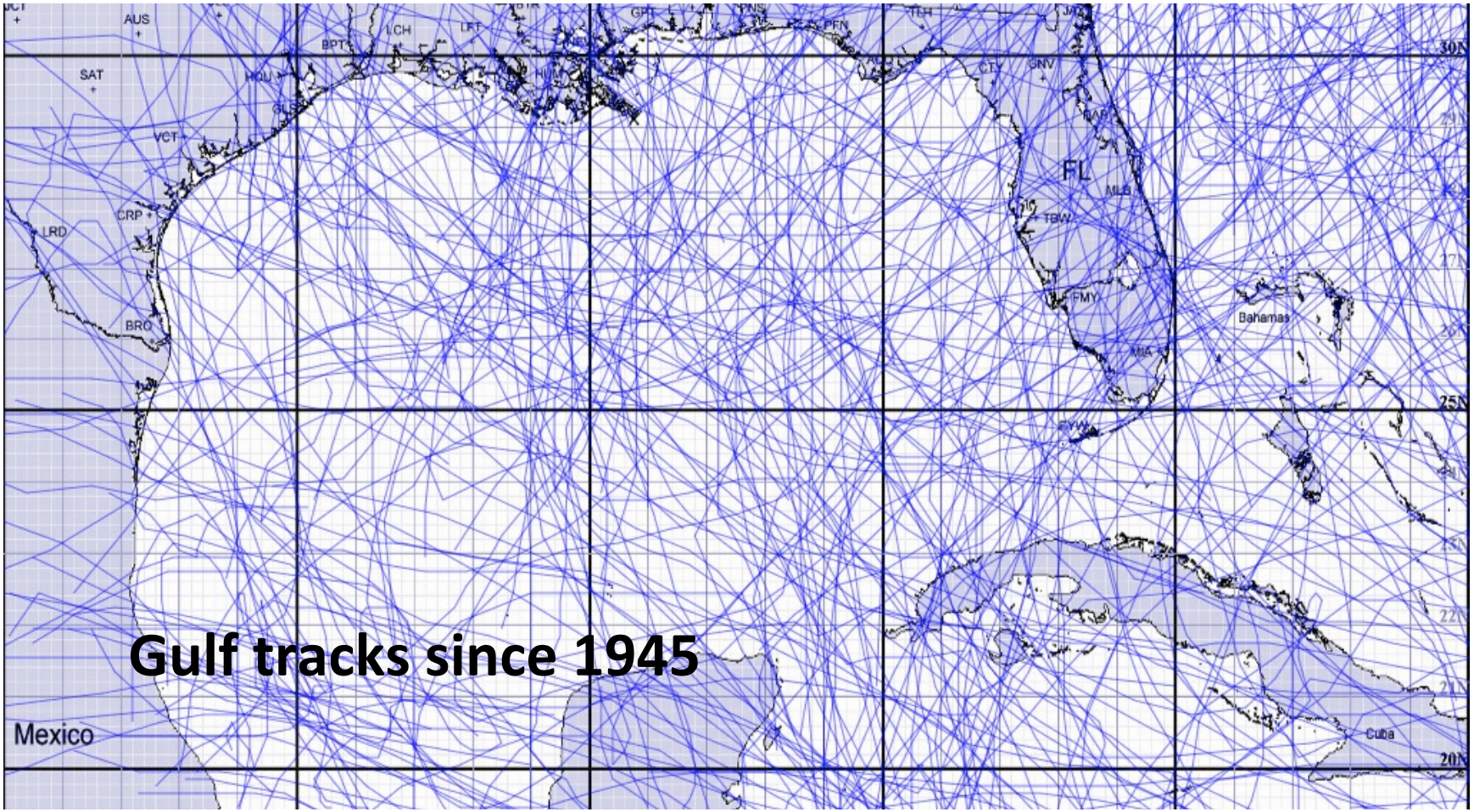
For each 3 hour segment on uncertainty cone edge and predicted path

- get initial and final bearing
- calculate bearing change
- 2-sided normal distribution
  - predicted path is mean
  - cone sides are 2 sigma

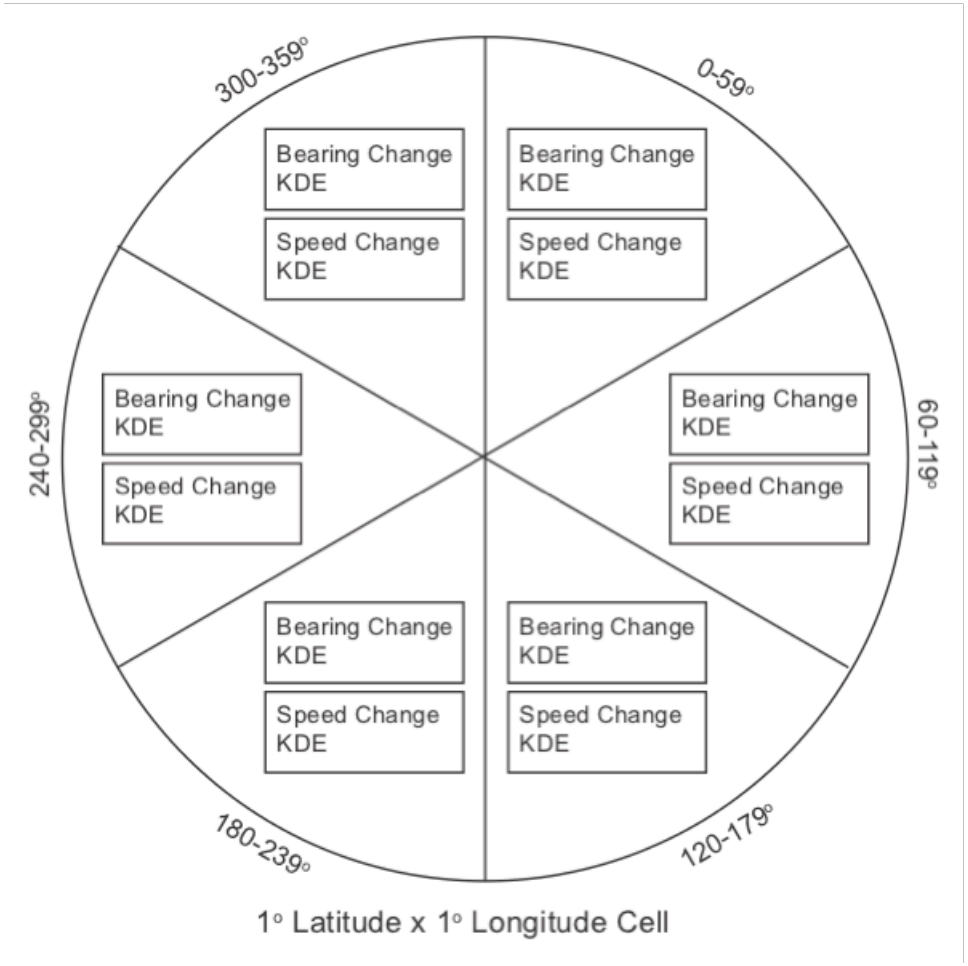
Similar idea for speed



Historical Model

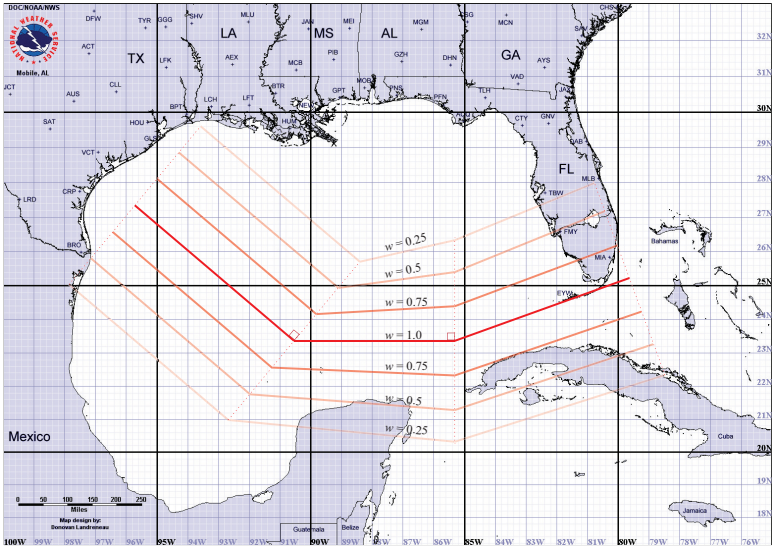


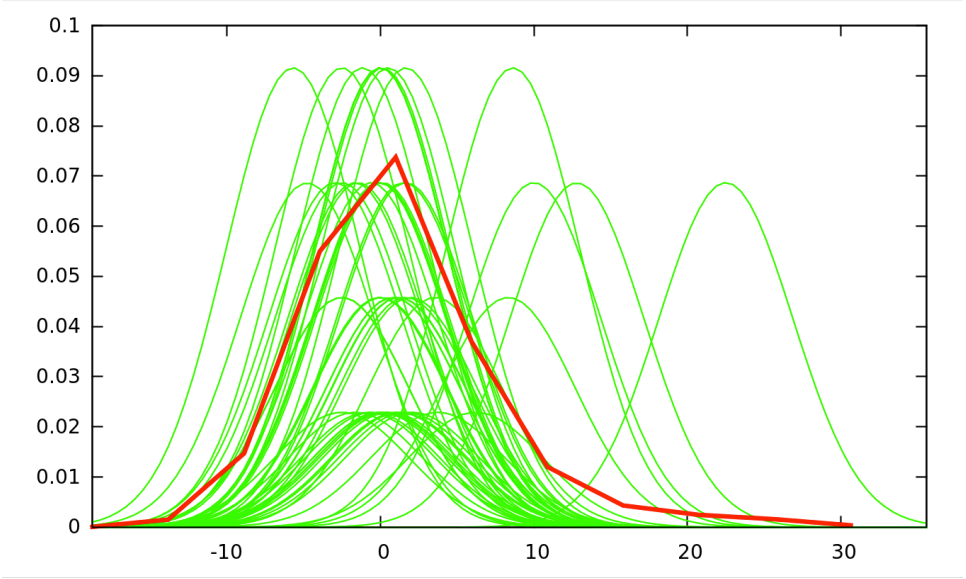
Historical Model



basic spatial cell

Historical Model





Extrapolation of paths

Kernel density estimator

Algorithm

Input: current NHC advisory

Build pdfs for predicted and historical models

Empty the list of tracks

loop forever

Generate New Track

Store in track list with time stamp

Lower opacity of tracks with age

Delete completely transparent tracks

Display all tracks

Algorithm

Generate New Track

Input: prebuilt pdfs, advisory, path list

start with advisory speed and bearing

for each 3 hour time step **do**

Determine Speed and Bearing Change

integrate over 3 hours

update position, speed, and bearing

Algorithm

Determine Speed and Bearing Change

Input: pdfs, time, speed, bearing, advisory, path list

Choose Predicted or Historical Model

If predicted model

select pdf by time

else

select pdf by position, speed & bearing

sample pdf for bearing and speed change

Algorithm

Choose Predicted or Historical Model

Input: advisory, path list

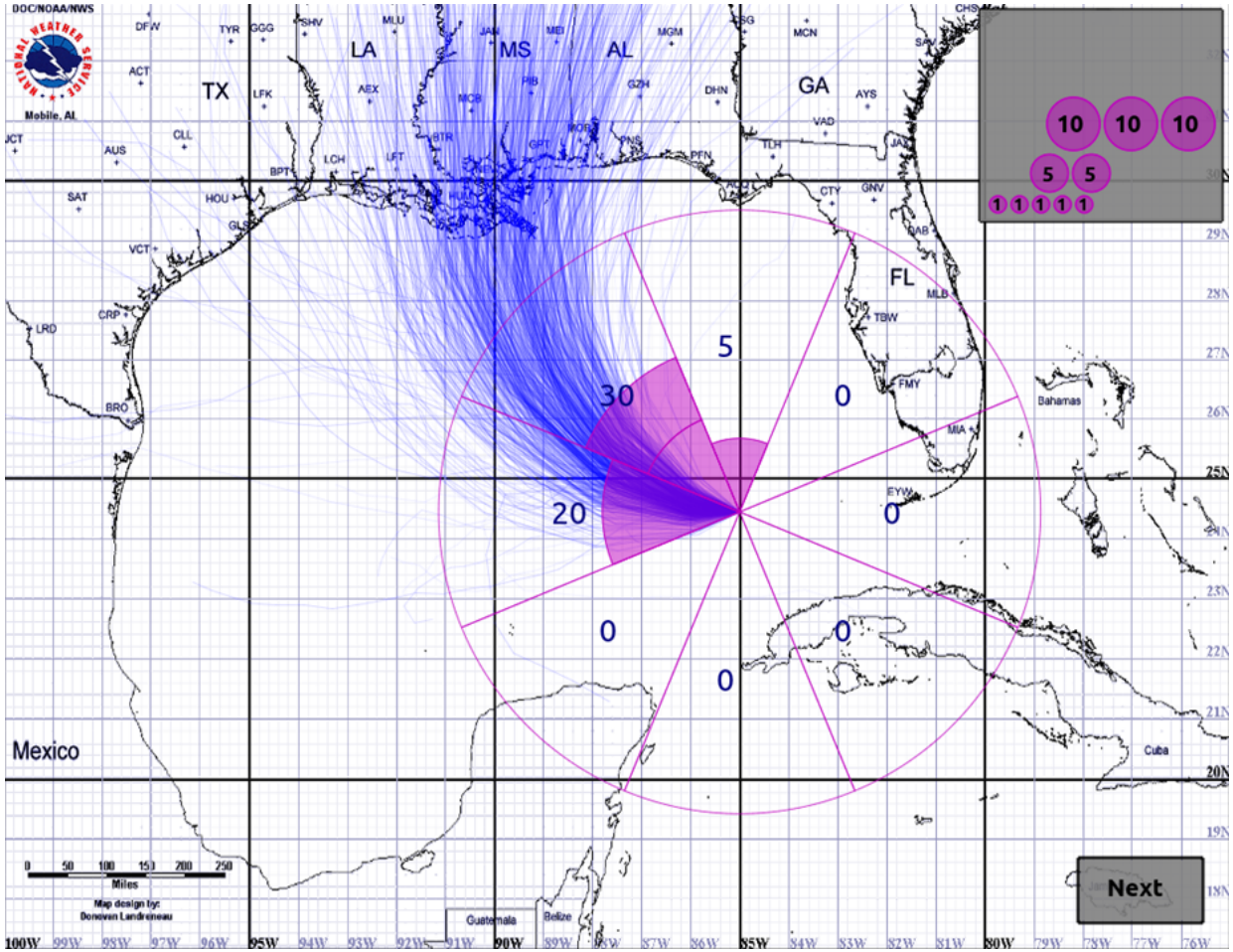
If > 68% of paths lie in uncertainty cone

95% historical, 5% predicted

else

1% historical, 99% predicted

Experimental Evaluation



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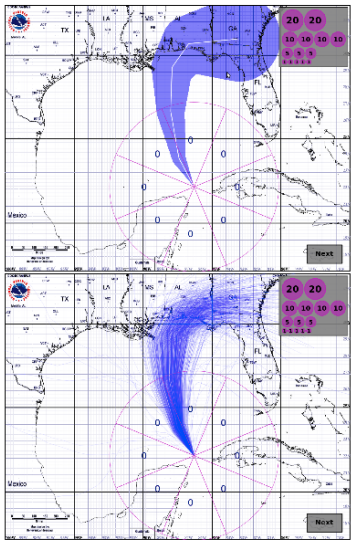
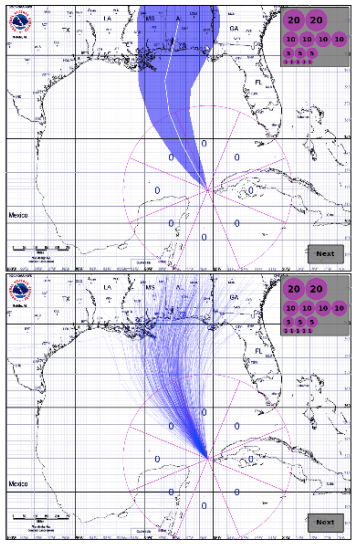
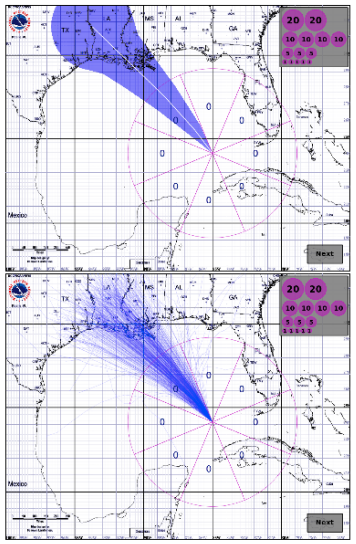


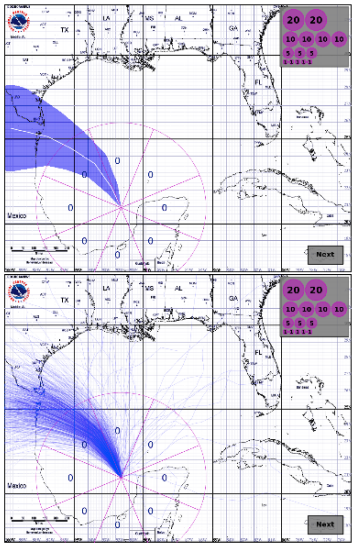
Case 1



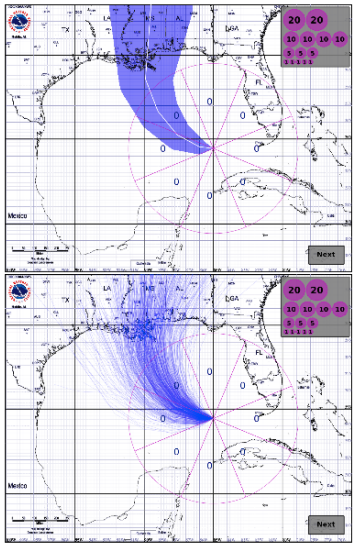
Case 2



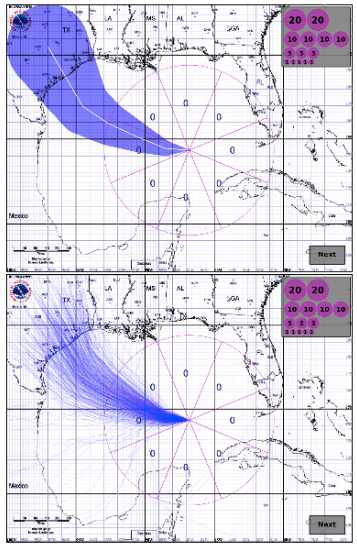
Case 3



Case 4

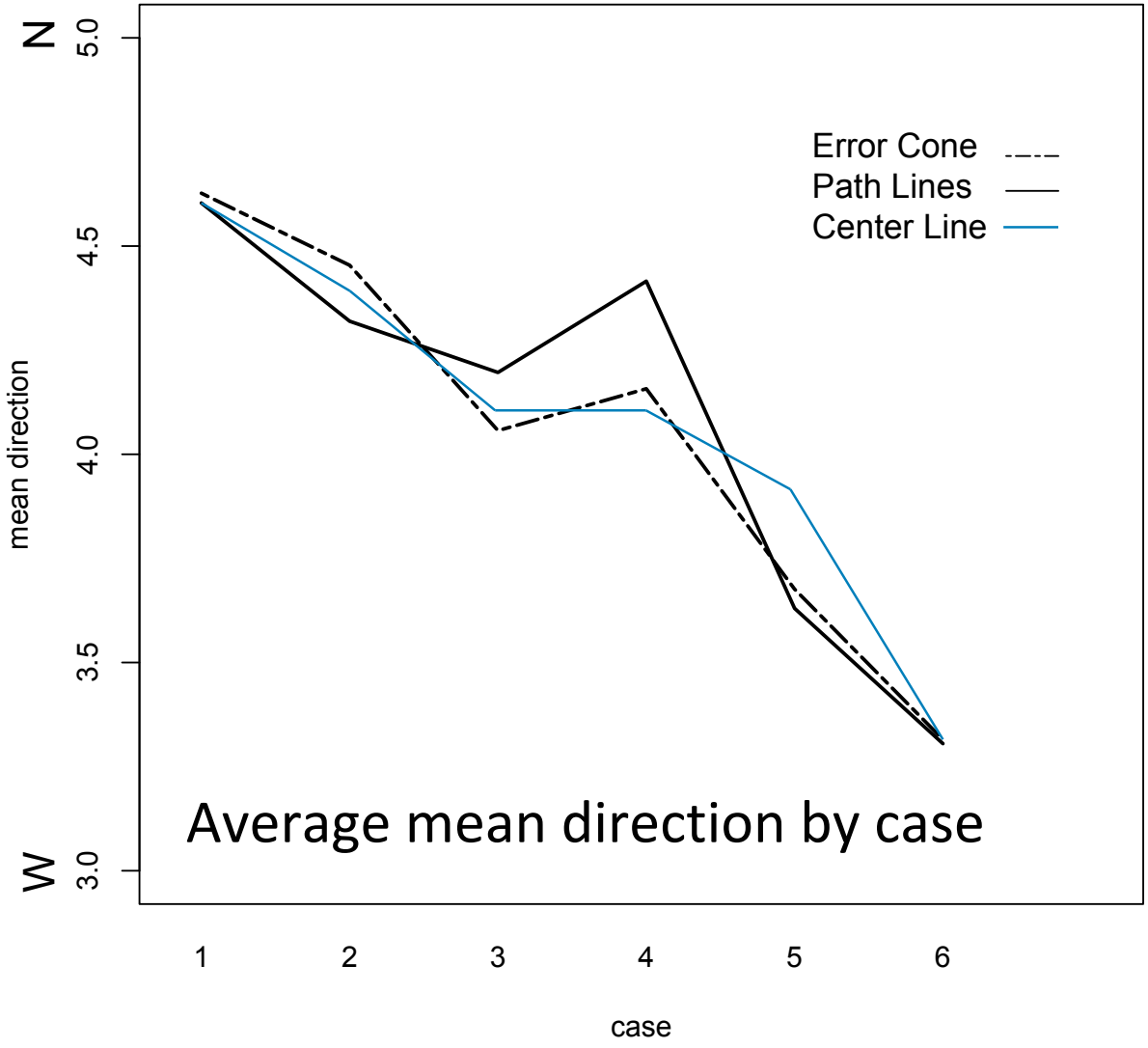


Case 5

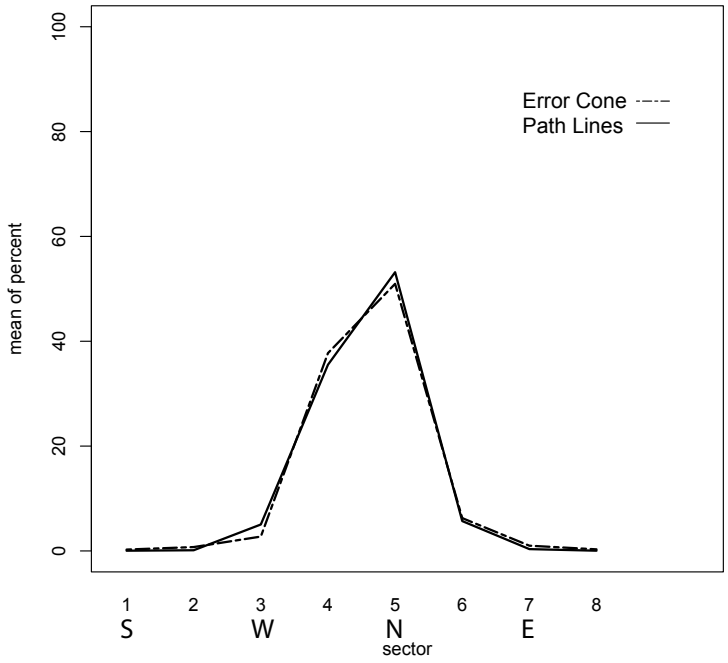


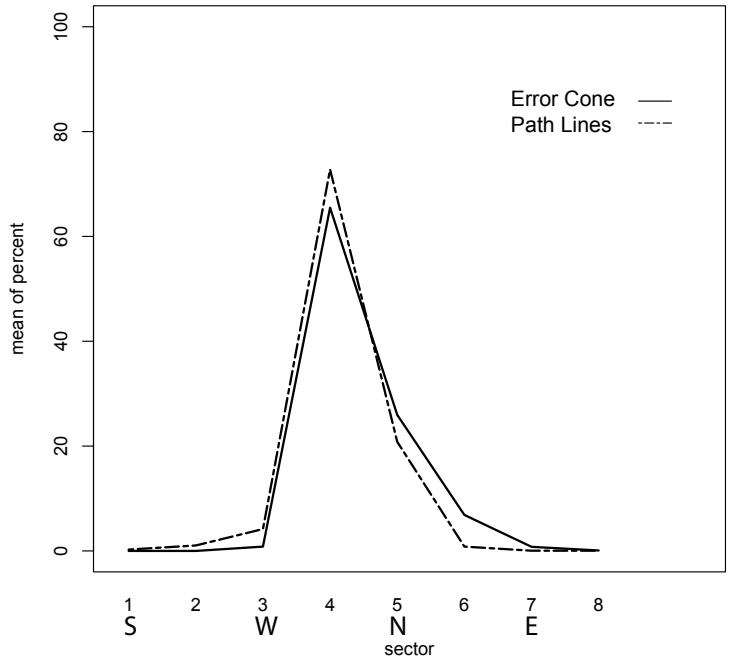
Case 6

Experimental Evaluation



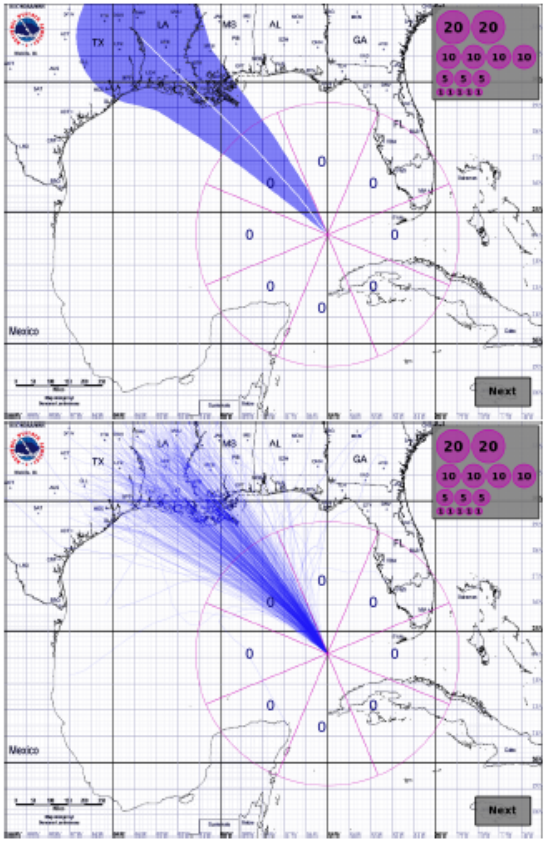
Experimental Evaluation





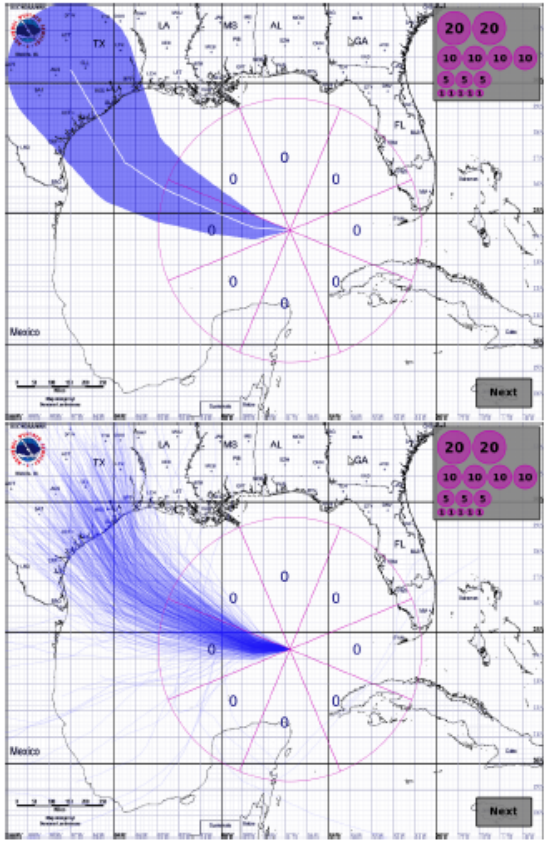
profiles with low and high significant difference

Least and Most Similar Cases



Case 3

Least Similar



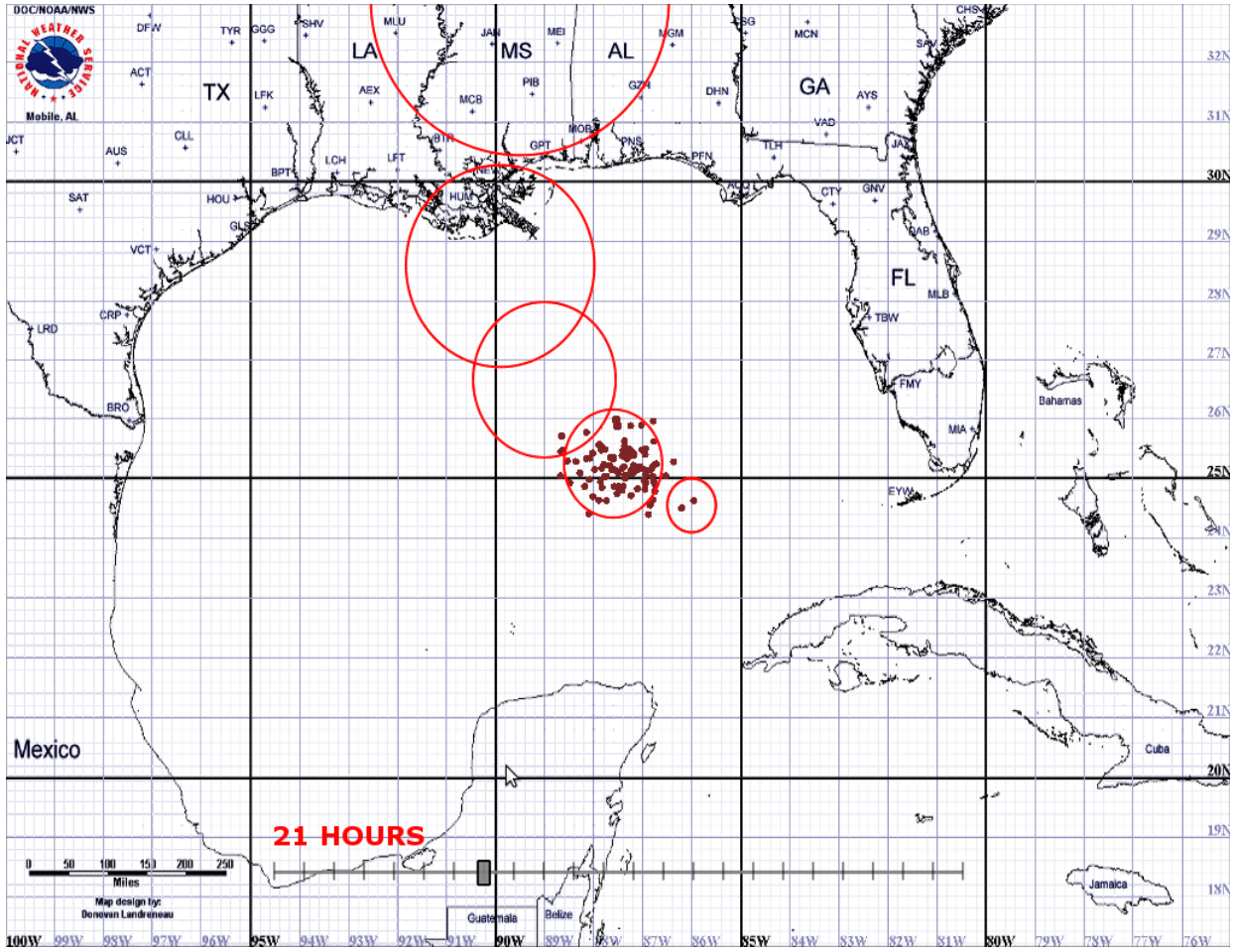
Case 6

Most Similar

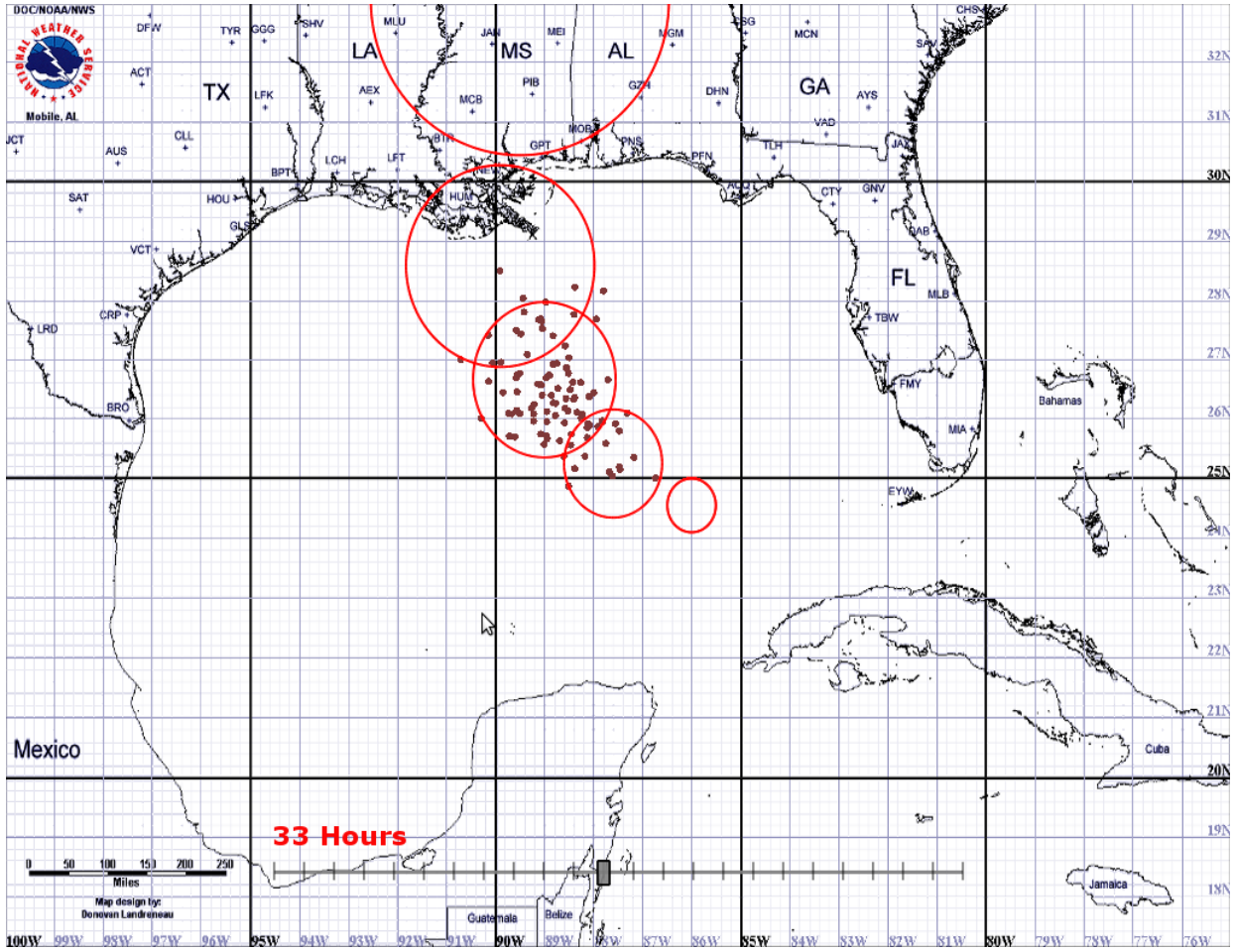
User Survey

- 26 participants
- All but one preferred ensemble display
  - mean 1.56 out of 5, s.d. 0.53
- Consistent critique of ensemble display
  - visually interesting and provided better insight
  - but, more cognitively demanding

Looking ahead: adding Interaction



Looking ahead: adding Interaction



Demonstration

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