

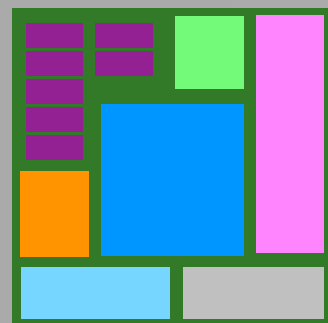
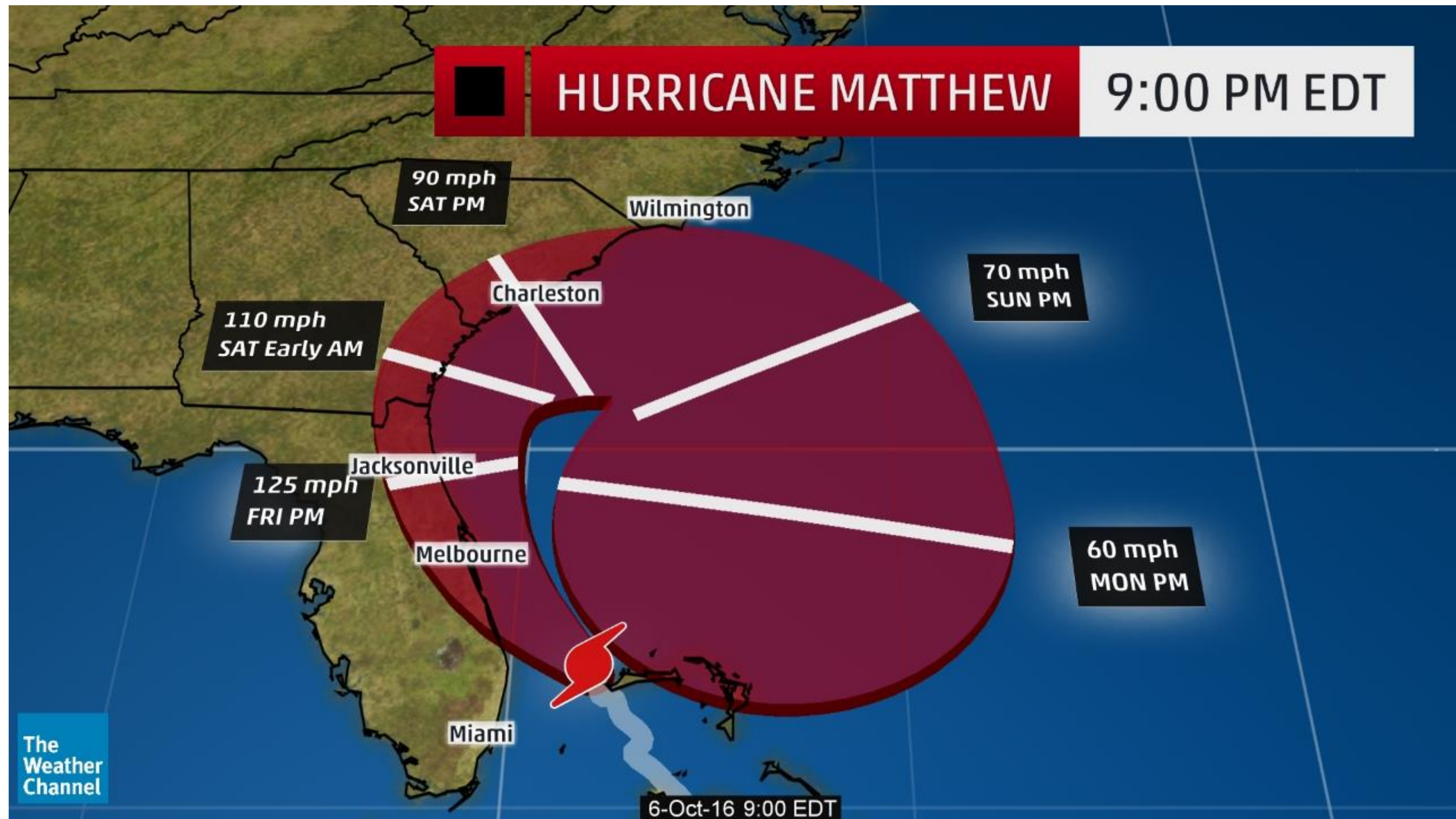
# Enhancing decision making through narrative and simulation

Dr. Cameron MacKenzie, Research Associate  
Simulation, Modeling, and Decision Science Program

Presentation to Argonne National Laboratory  
October 7, 2016







Hurricane Matthew

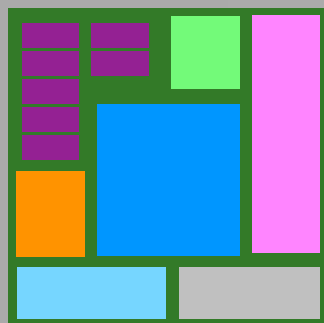


## Task environment

- Too much information
- Uncertainty
- Dynamic information sources (frequent updates)

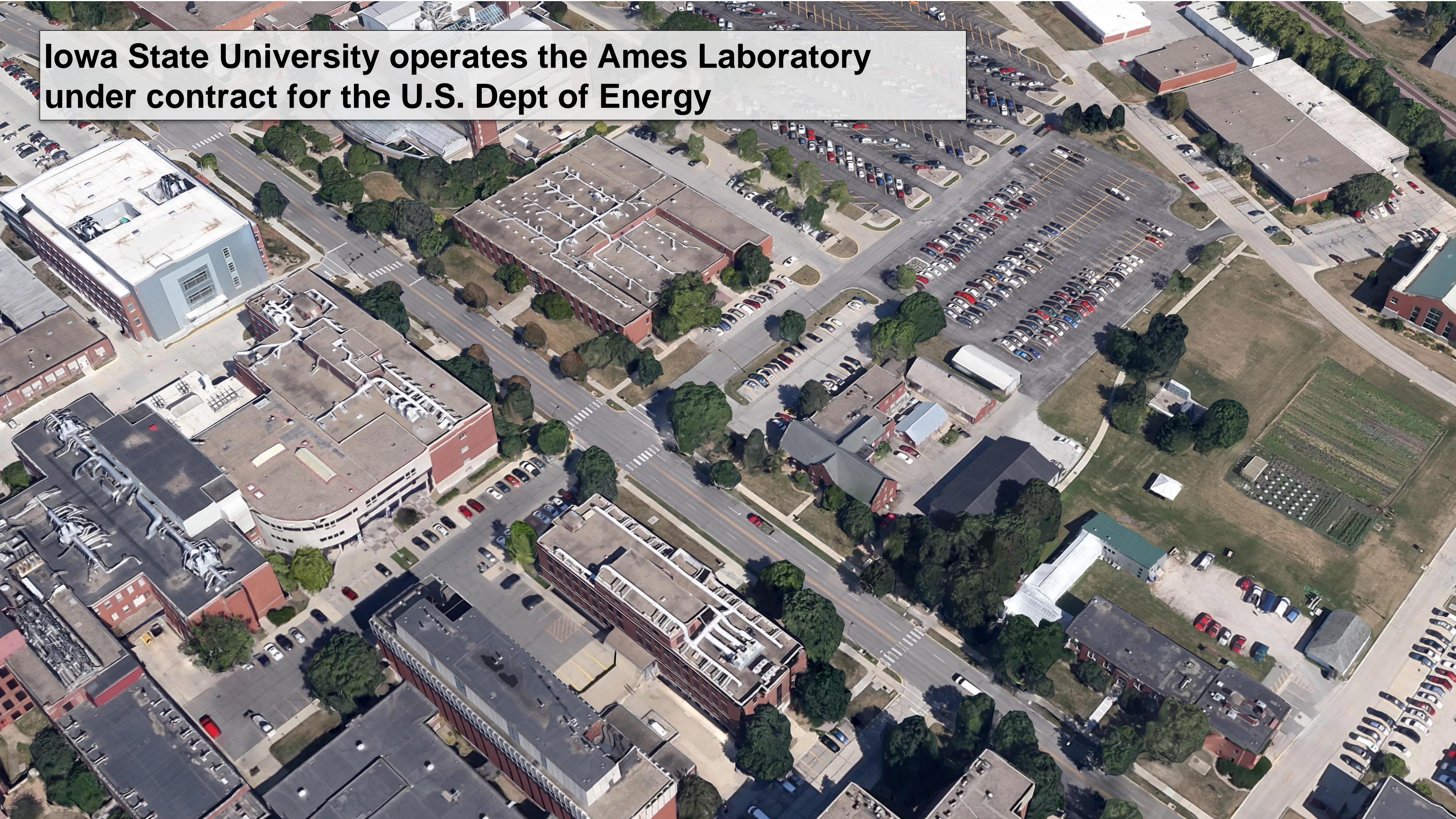
## Formation of expertise

- Highly variable context
- Dynamic information sources
- Few learning opportunities
- Ambiguous feedback





**Iowa State University operates the Ames Laboratory  
under contract for the U.S. Dept of Energy**

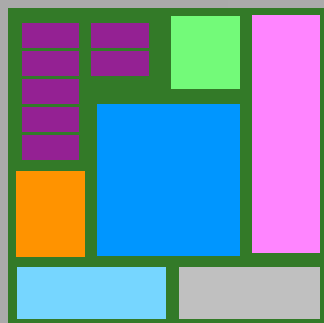


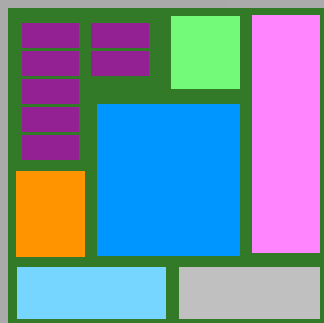
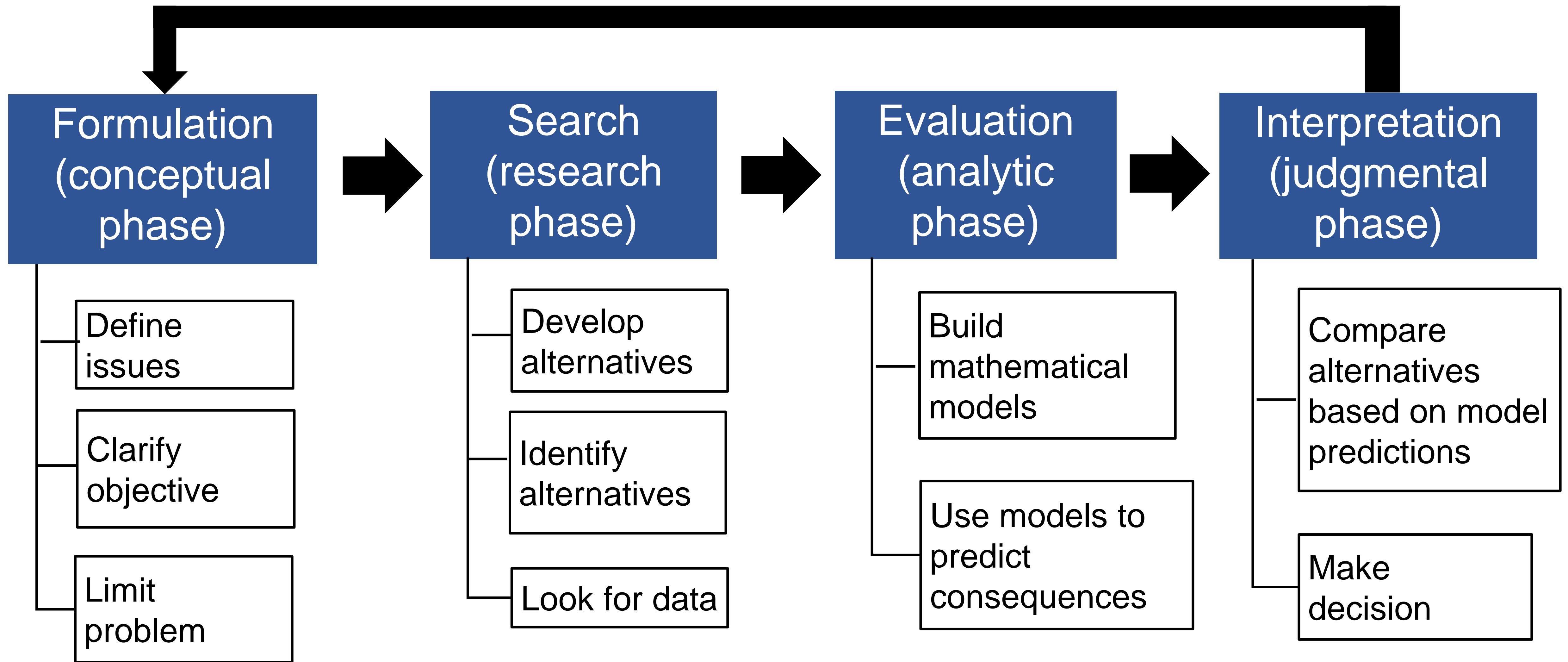


## Fundamental Research Question

How can we improve decision making and learning in complex systems in which energy, people, and the environment meet?

1. Narrative theory of decision making
2. Training for complex decisions with simulation

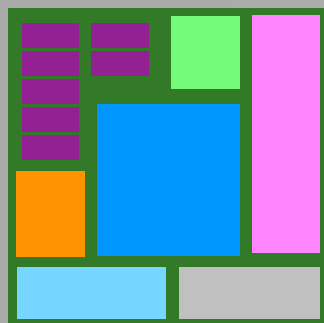




Analytical decision-making process

- Lack of familiarity for decision makers
- Contradicts natural way decisions are made
- Individualistic rather than collaborative
- Process may not be documented
- Time consuming

**How to integrate the analytical decision-making process with a more natural, engaging decision-making process?**



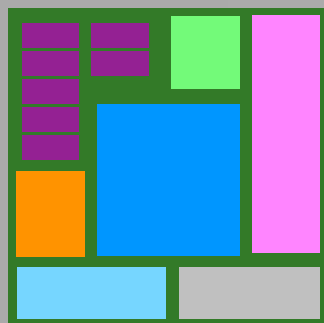
Limitations





## What engages us?

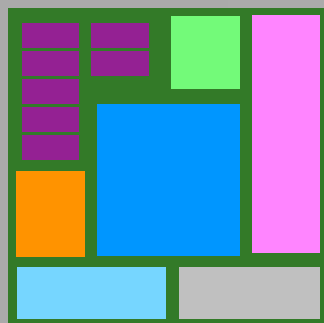
- Agents of change and events
- Purpose, unfolding meaning over time
- Tension and release



Narrative theory



- Seeks to describe how people make decisions
- Provides framework
- Helps us make sense of the world and events, build coherence and connection
- Links the past to the present
- Lets us use the present (and past) to forecast about the future





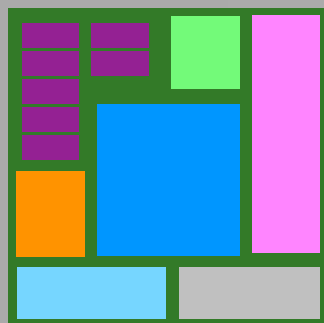
Metadata: Information about the raw data or the model

Paradata: Information about how humans process and interpret data and models

Document

- Why a model was selected
- Why an alternative was chosen
- Which factors are important to analysis or decision

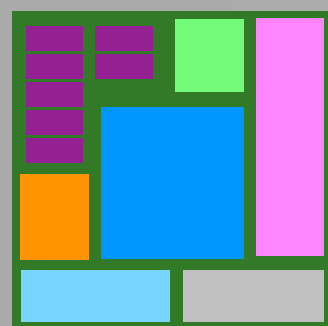
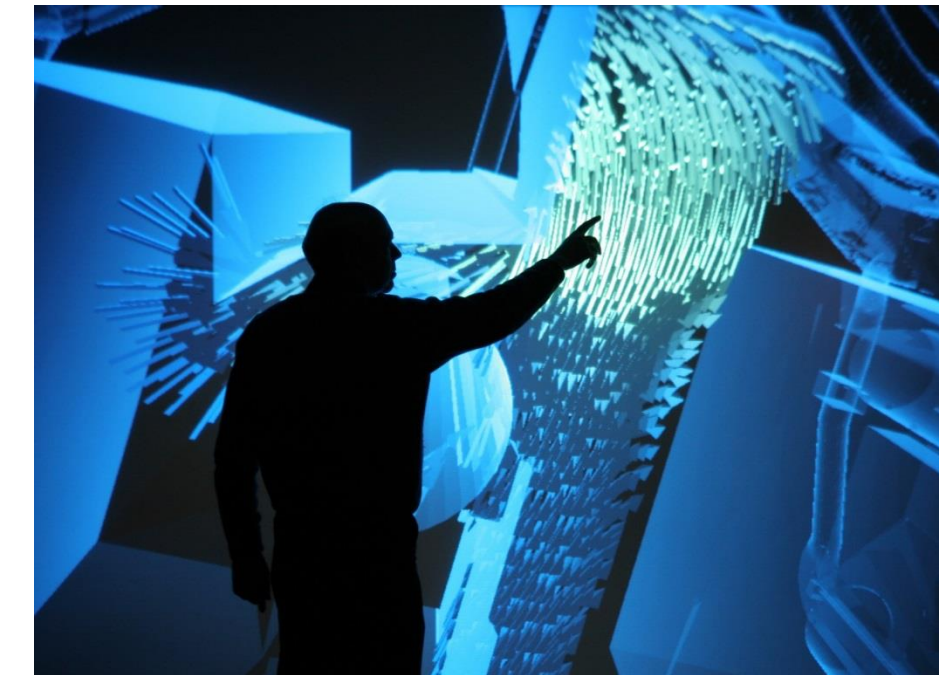
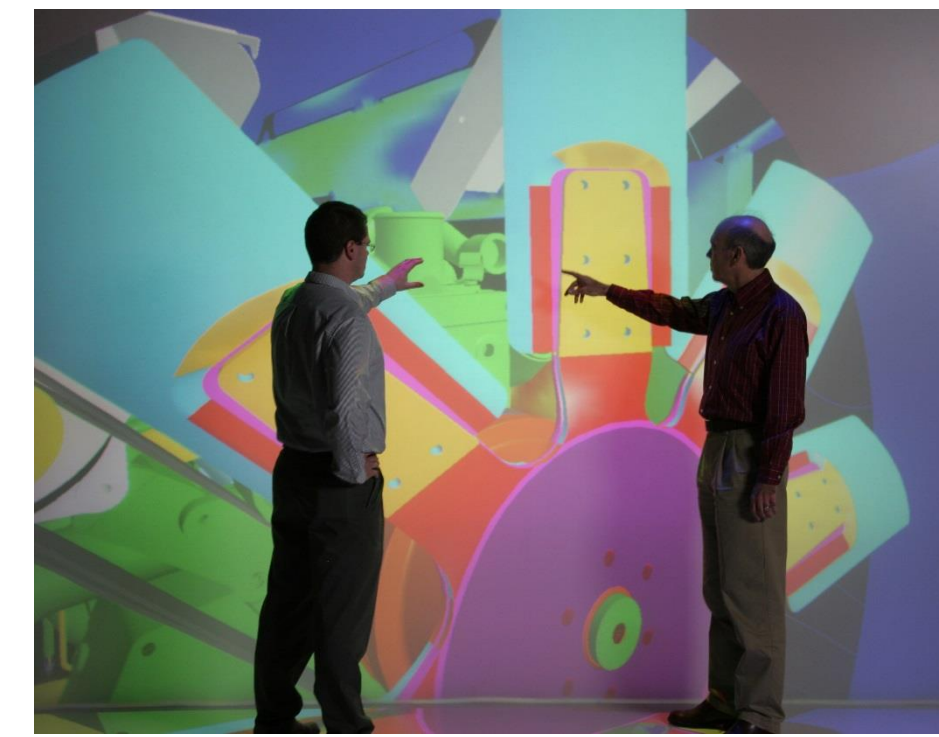
**Query**



Paradata



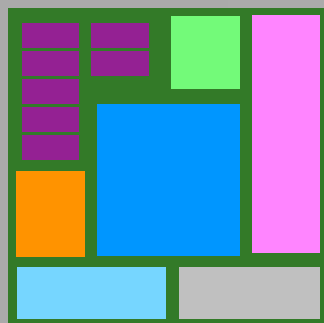
- Create a narrative framework to engage decision makers with analysis
- Build a narrative framework into a simulation
- Communicate with the public and promote consensus among decision makers via a narrative



Proposed integration of narrative with analysis



- Bind modeling and decision-making process together
- Engage decision makers emotionally
- Promote learning and experience
- Develop shared experiences among multiple decision makers and stakeholders
- Connect more closely to decision maker's ultimate goals
- Query decision-making process

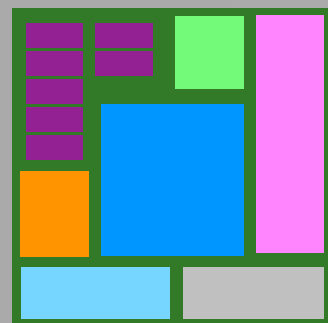
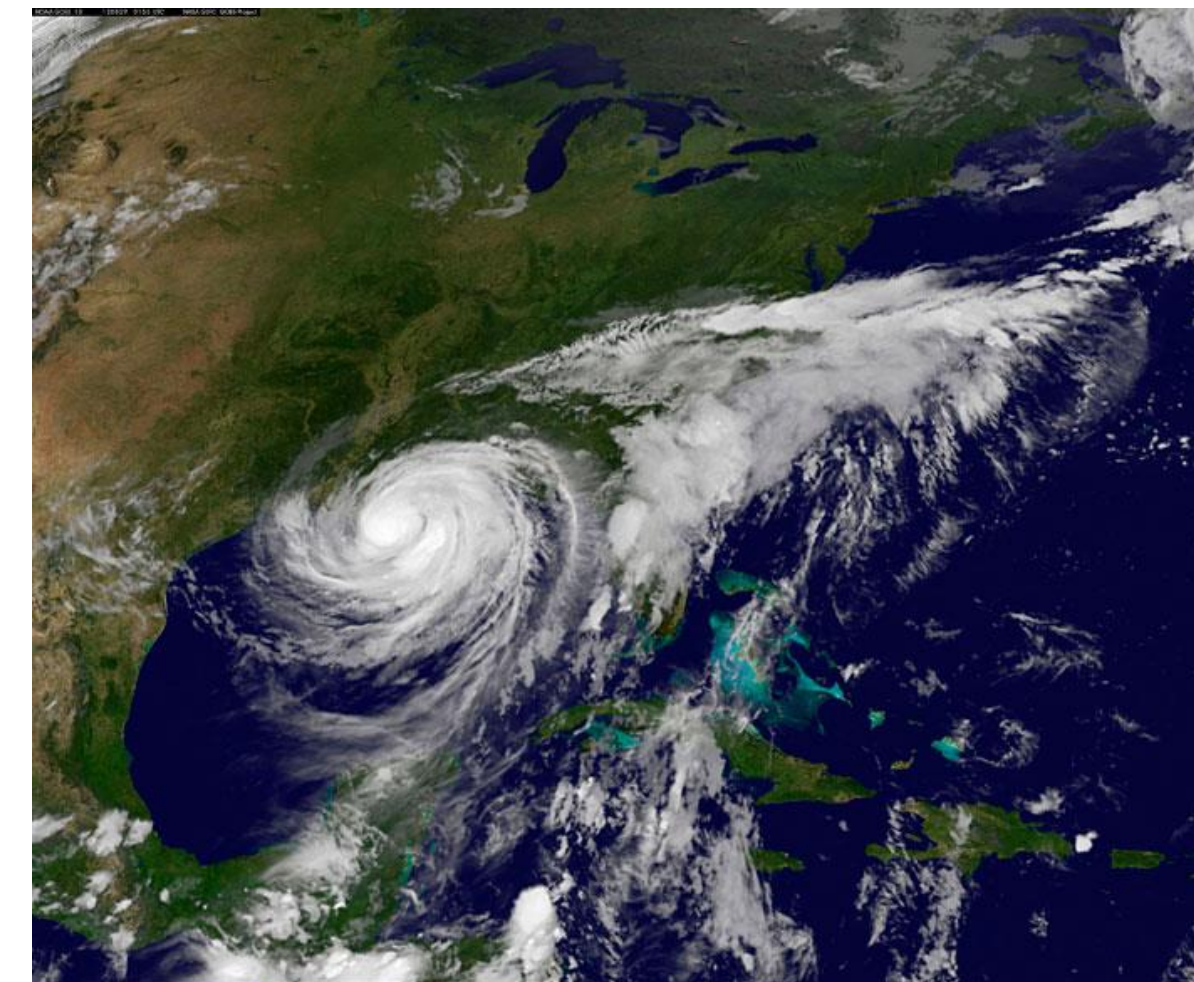


Benefits of narrative framework





Lt. Gen.  
Rex McMillian

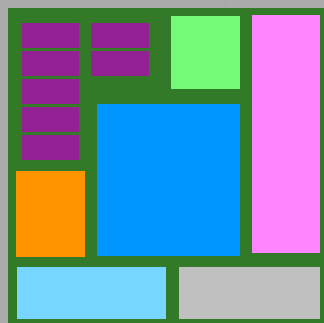


U.S. Marine Forces Reserve (MFR)



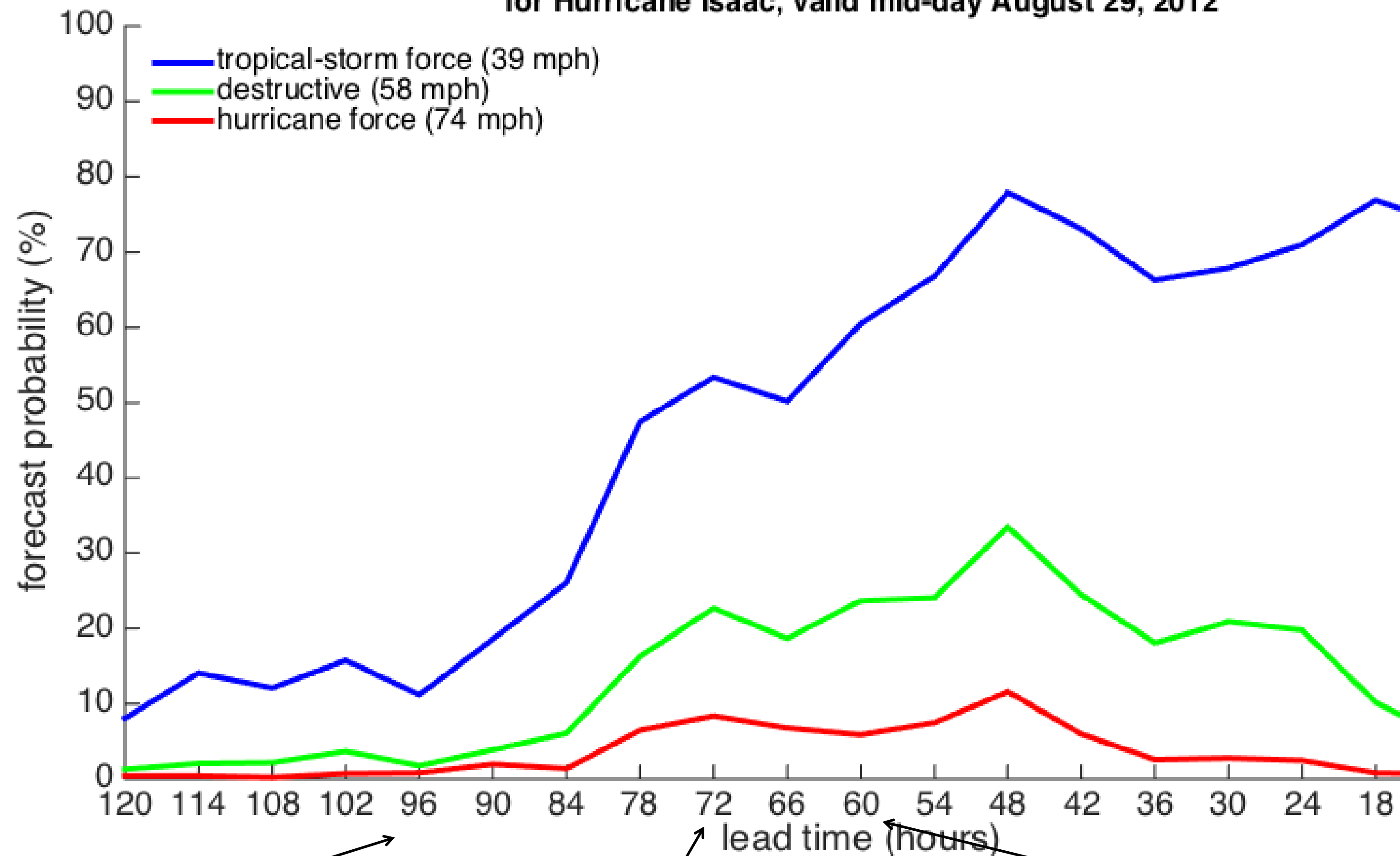
## Hours before arrival of 36-mph winds

1. 96 hours: Send advance emergency relocation staff (ERS) to alternate headquarters
2. 96 hours: Send liaison officers to local municipal emergency operations centers
3. 72 hours: Send rest of ERS to alternate headquarters
4. 72 hours: Activate remain behind element to stay if evacuation ordered
5. 60 hours: Evacuate or shelter in place
6. 48 hours: Transfer command and control to alternate headquarters





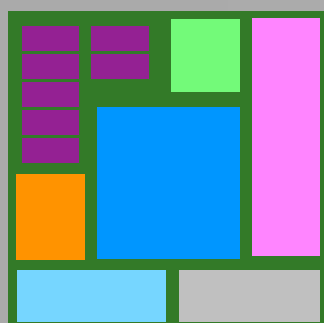
National Hurricane Center wind-speed probability forecasts  
for Hurricane Isaac, valid mid-day August 29, 2012



Deploy  
advance team

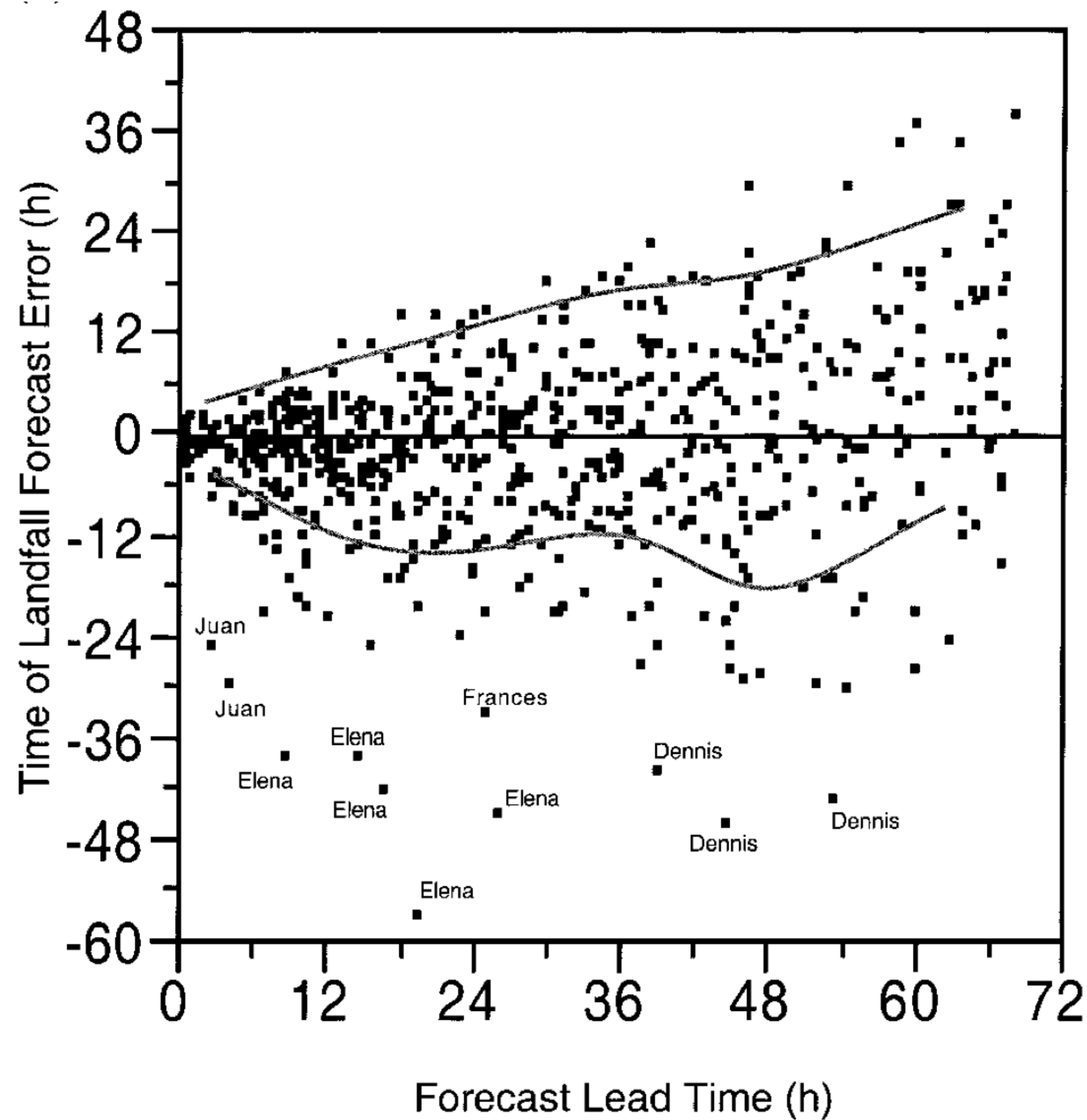
Deploy  
away team

Order evacuation or  
shelter-in-place

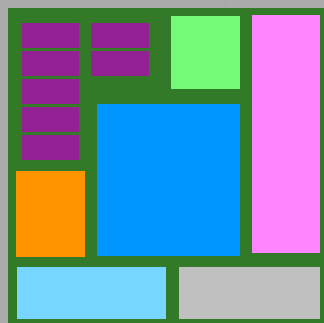


MFR hurricane decision simulator





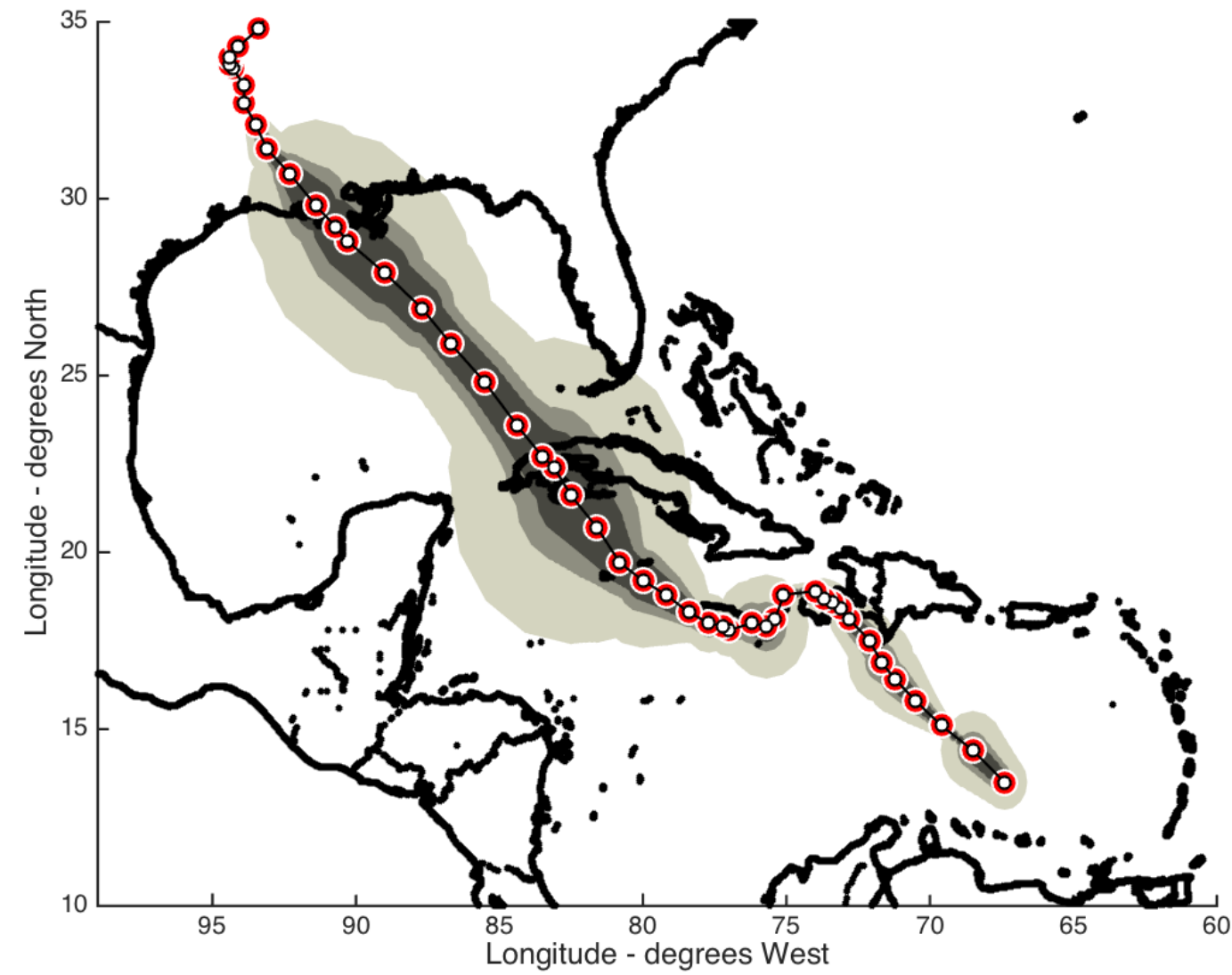
Powell, M.D. & Aberson, S.D.  
 (2001) Accuracy of United States  
 tropical cyclone landfall forecasts  
 in the Atlantic Basin. *Bulletin of the  
 American Meteorological Society*  
 82(12): 2749-2767.



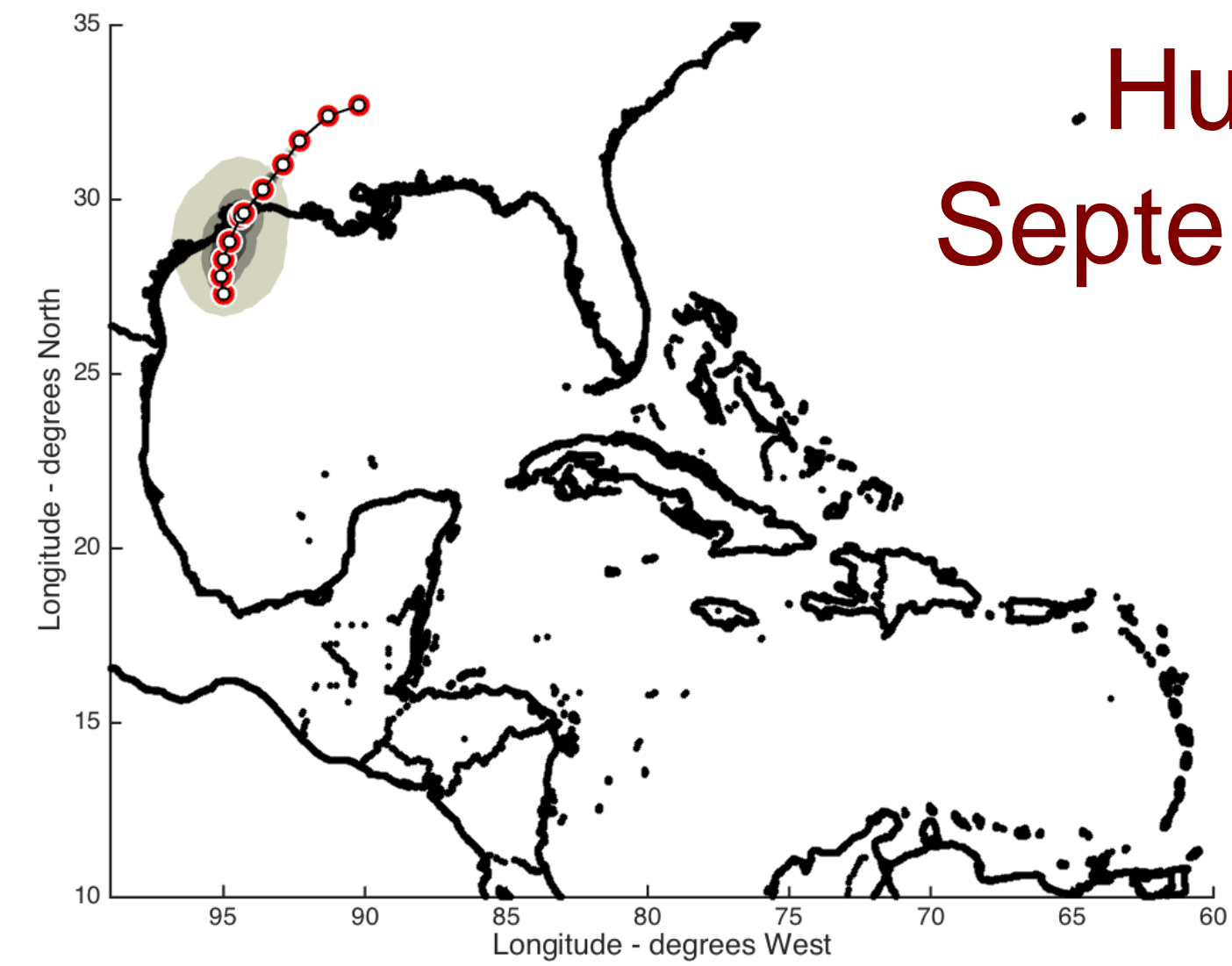
Error in forecast lead time



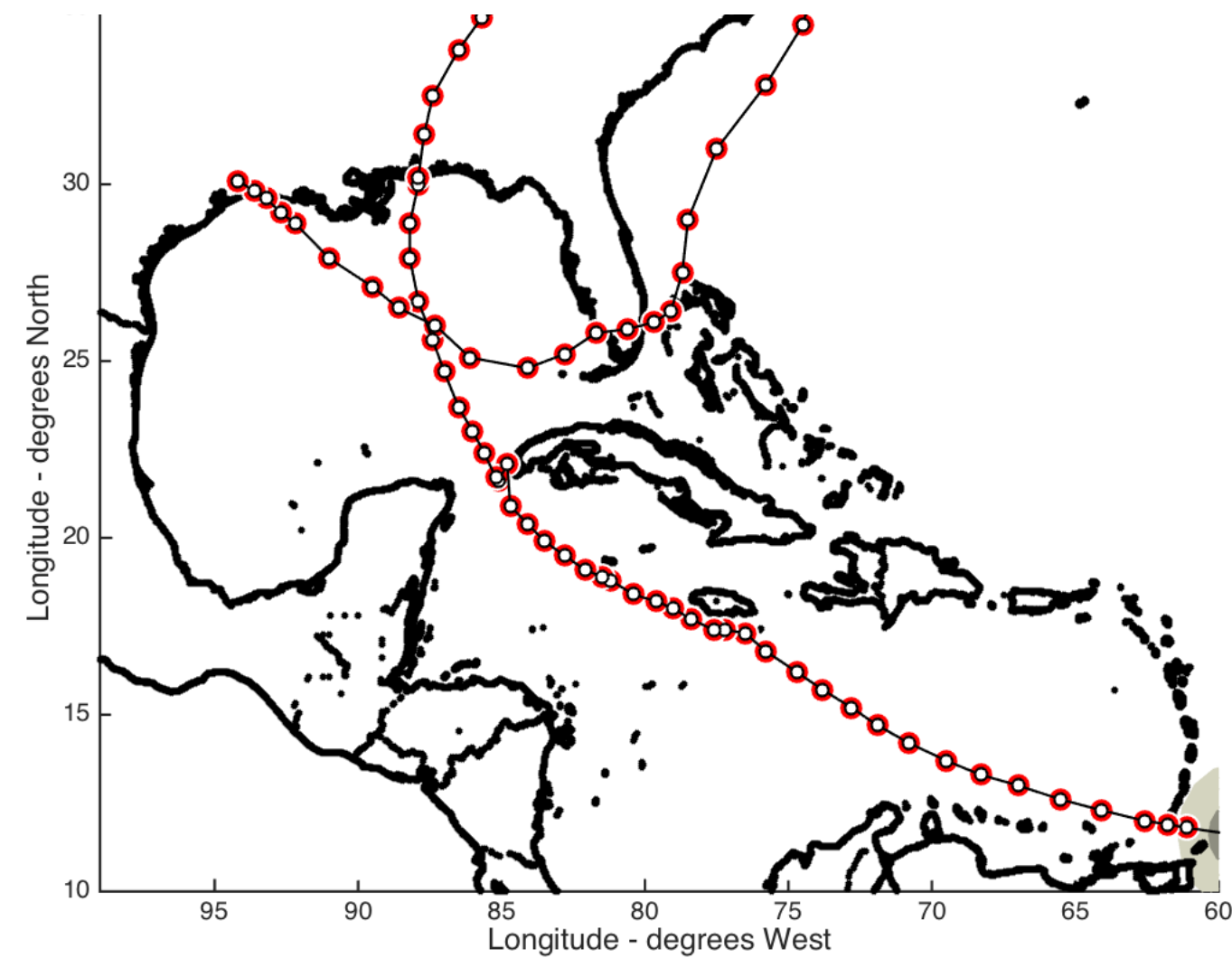
Gustav  
August 2008



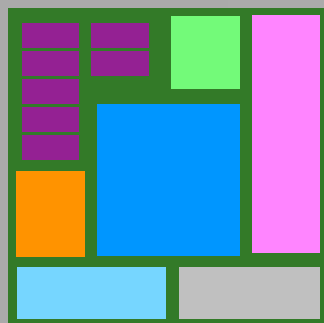
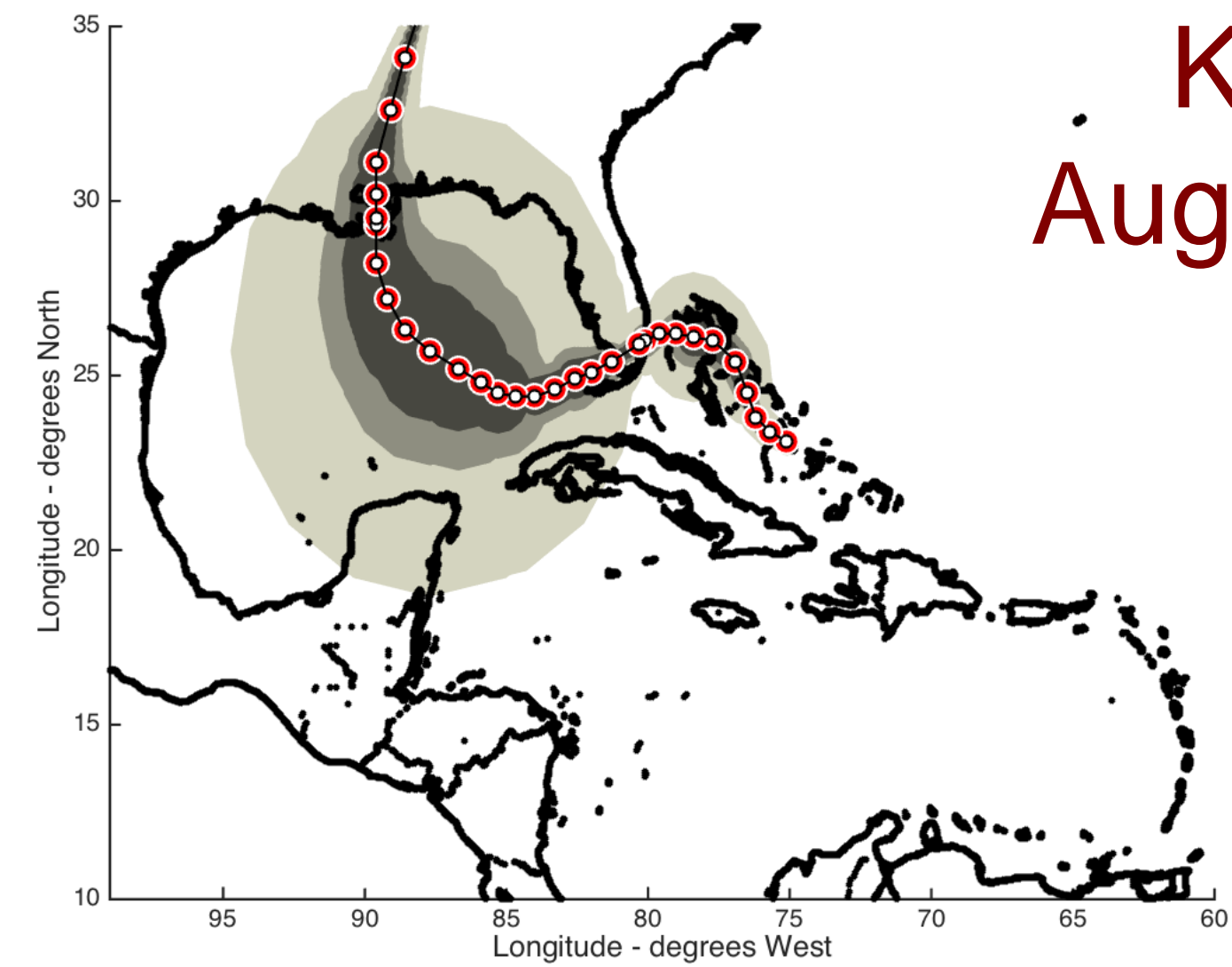
Humberto  
September 2007



Ivan  
August 2004



Katrina  
August 2005



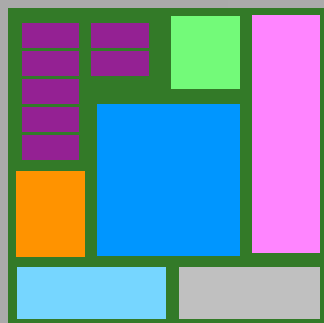
Every storm is different



## Key characteristics

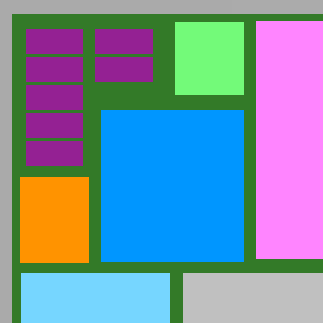
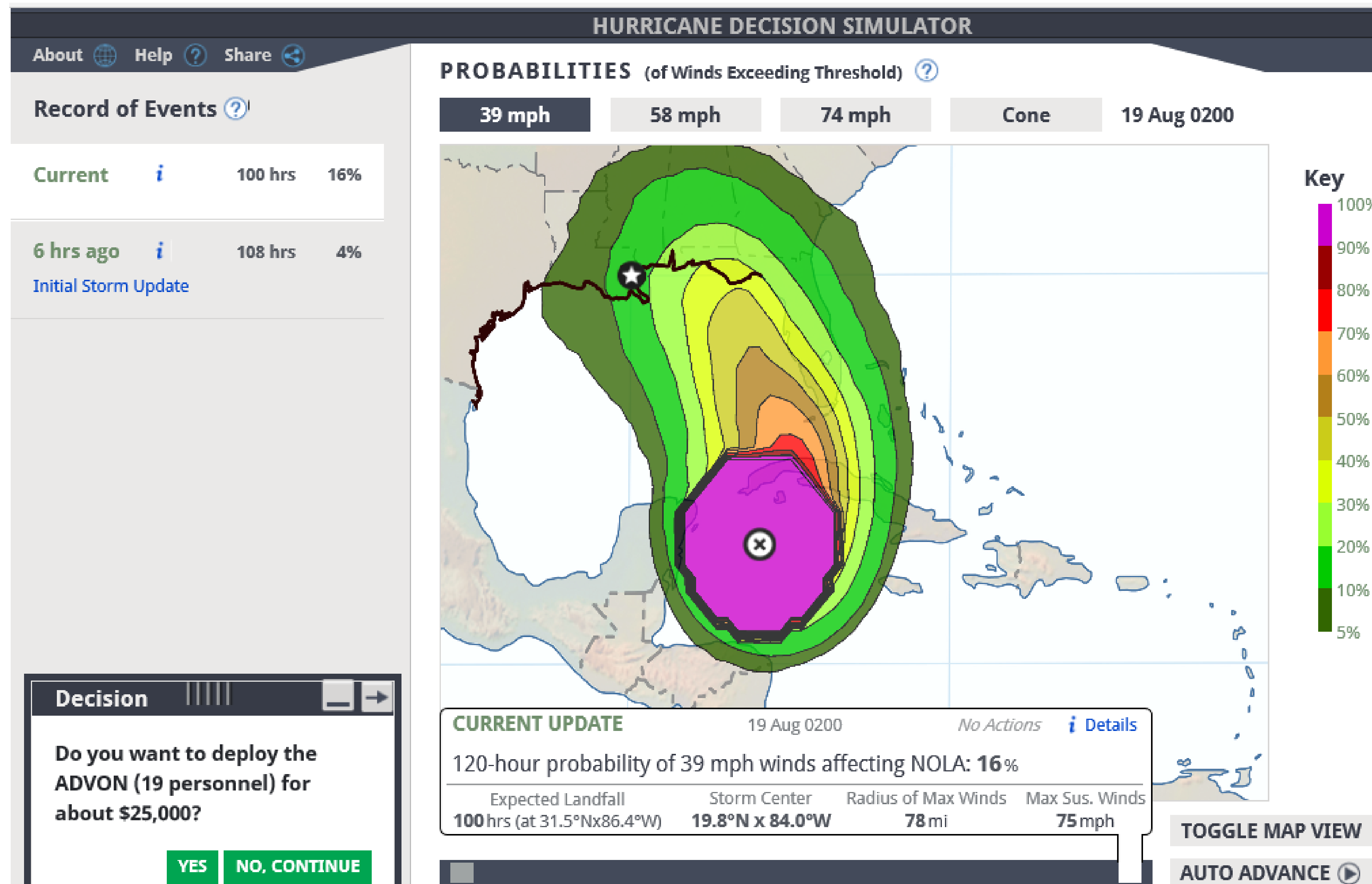
- Storm model (storm and forecasts)
- User decisions
- Actions of other entities (city and state decisions)
- Consequences of storm plus decisions
- Quickly experience many storms

<http://eddy.nps.edu/hurricaneSim/simulation?#>



Training tool for hurricane decisions





# Hurricane Decision Simulator



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[Help](#)
[Share](#)

# HURRICANE DECISION SIMULATOR

## Record of Events

Current

51 hrs

27%

ERS(P) arrives at alternate HQ, O/O assu...

6 hrs ago

59 hrs

30%

Establish communications with ADVON

12 hrs ago

68 hrs

13%

Establish communications with ADVON

18 hrs ago

76 hrs

15%

BPT provide staff updates

24 hrs ago

88 hrs

18%

BPT provide staff updates

30 hrs ago

95 hrs

12%

BPT provide staff updates

36 hrs ago

100 hrs

16%

Deployed ADVON

Deployed liaison officers

Deployed ERS to alternate HQ

Activated RBE

Because the ADVON team was deplo...

RBE, ERS, and CAT rosters are validated

39 mph

58 mph

74 mph

Cone

20 Aug 1400

Decision

Do you want to give the order to evacuate, shelter in place, or neither? Evacuation costs about \$300,000 per day until evacuated personnel return.

The HURREVAC timeline recommends making this decision 60 hours prior to the arrival of tropical storm force winds if hurricane force winds are expected to follow.

EVAC

SHELTER

NO, CONTINUE

CURRENT UPDATE

20 Aug 1400

Actions

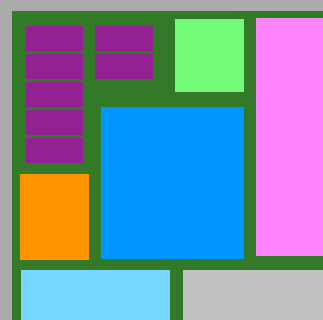
Details

120-hour probability of 39 mph winds affecting NOLA: 27%

Expected Landfall	Storm Center	Radius of Max Winds	Max Sus. Winds
51 hrs (at 30.0°N x 84.8°W)	23.3°N x 81.4°W	60 mi	48 mph

TOGGLE MAP VIEW

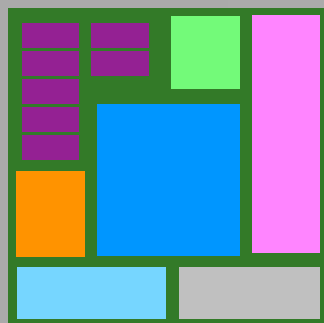
AUTO ADVANCE



# Hurricane Decision Simulator



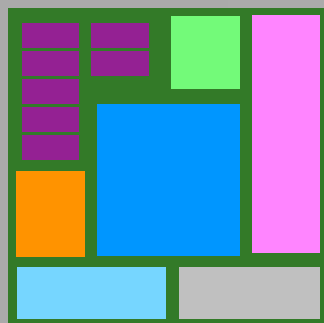
- Two hurricane scenarios with about 40 personnel
- Learned about unexpected behavior of hurricanes
- Focused on inherent uncertainty and ambiguity in hurricane forecasting
- Tension between wanting to get Marines evacuated as soon as possible and the high costs of evacuation



Tabletop exercise



- How effective is the Hurricane Decision Simulator?
- What does a user learn about the behavior of hurricanes?
- How well does the simulator provide information that allows the user to adjust his or her decisions?
- Does practicing with probabilities help the user make better decisions?

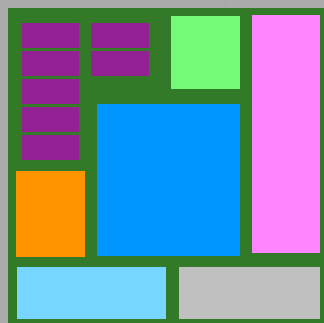


Follow-on work at Ames Lab



- Narrative framework can help connect analytical process with naturalistic decision making
- Simulation can help train decision makers for complex systems
- Integrating narratives within simulations can provide decision makers with engaging and meaningful tools

Cameron MacKenzie  
camacken@ameslab.gov



## Conclusions