The Perceived Value of Improving Hurricane Forecast Accuracy

Brian McNoldy [1]
Renato Molina [2]
David Letson [2]
Pallab Mozumder [3]
Matthew Varkony [2]

1 – Univ. of Miami/RSMAS
Dept. of Atmospheric Science
2 – Univ. of Miami/RSMAS
Dept. of Marine Ecosystems & Society
3 – Florida International Univ.
Dept. of Earth & Environment

ROSENSTIEL SCHOOL OF MARINE AND ATMOSPHERIC SCIENCE

FLORIDA INTERNATIONAL UNIVERSITY

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Why Strive to Improve Forecasts?

- More accurate hurricane forecasts help the government, municipalities, and the public to prepare, evacuate, and stage resources for quicker recovery
- Impacts will never be eliminated, but can be partially mitigated.
- Track and intensity forecasts have already improved a lot over the decades (HFIP!)… ***are further improvements still valuable?***

Experiment Design Overview

- Builds on work by Letson et al. (2007), Lazo and Waldman (2011), Martinez (2020), and others
- Use observed trends of track and intensity error reduction over the prior decade to inform realistic potential reductions in the coming decade
- Survey 4650 respondents in areas affected by Hurricanes Florence (3150) and Michael (1500) using a *contingent valuation method*
  - Questions focus on intensity, track, and rainfall
  - We recognize that those three attributes are intertwined in reality, but we treat them as separate priorities
- Gauge *"willingness to pay"* (WTP) for certain future improvements by proposing proportional tax increases to a household that would last ten years

Hurricane Forecast Scenarios

- Derive linear trends of error reduction of critical 72-hour forecasts of track and intensity over the 2008-2018 period.
  - Consider those to be the baseline "*status quo*" rates of improvement.
- For the future (2028), *we assume forecasts will still improve*, but at rates of 80%, 100%, and 120% of the status quo…

Hurricane Forecast Scenarios

- Historical and hypothetical 72-hour hurricane forecast errors of track (left) and intensity (right).

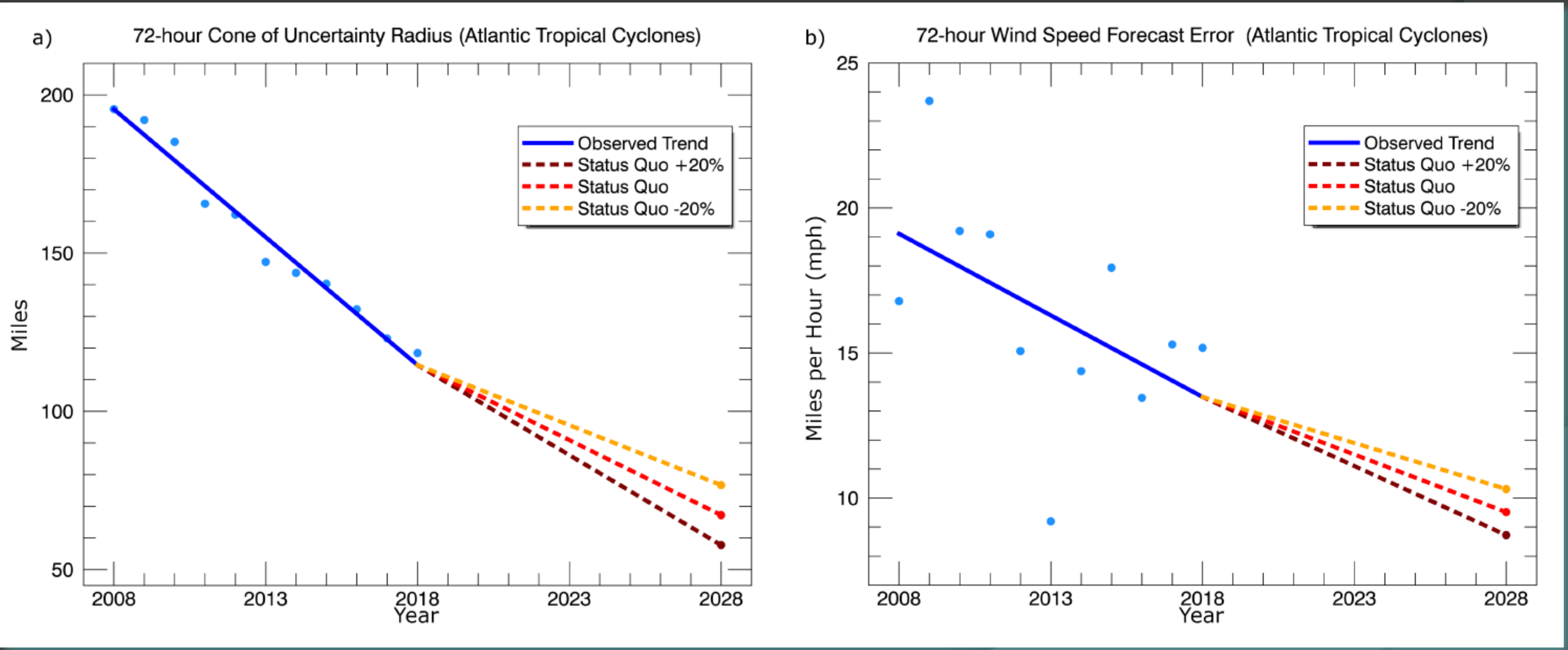
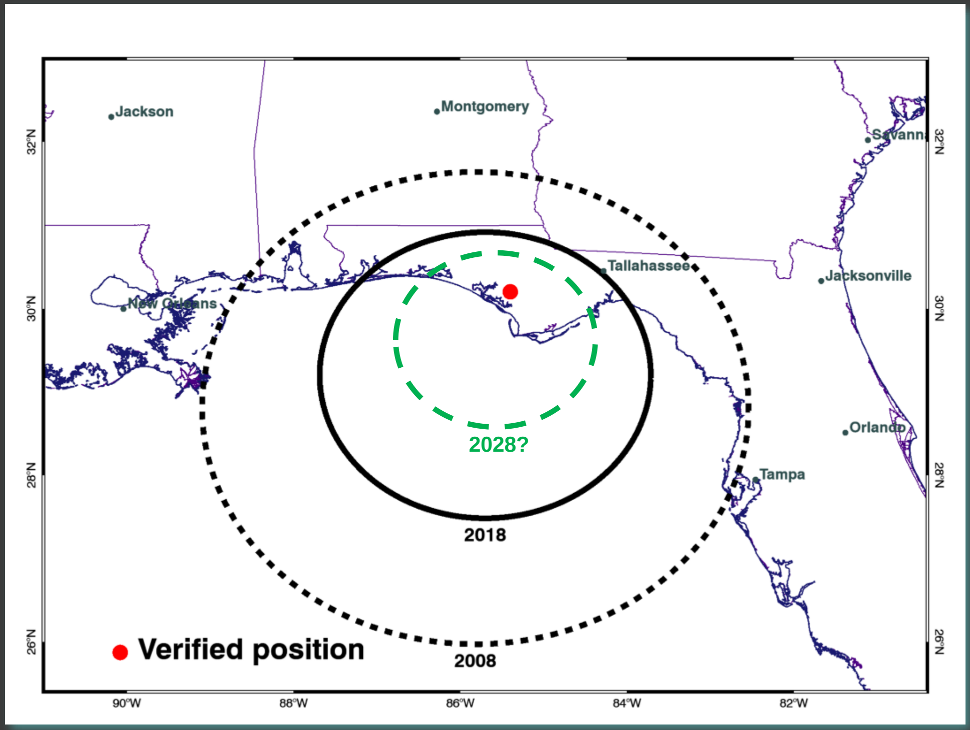


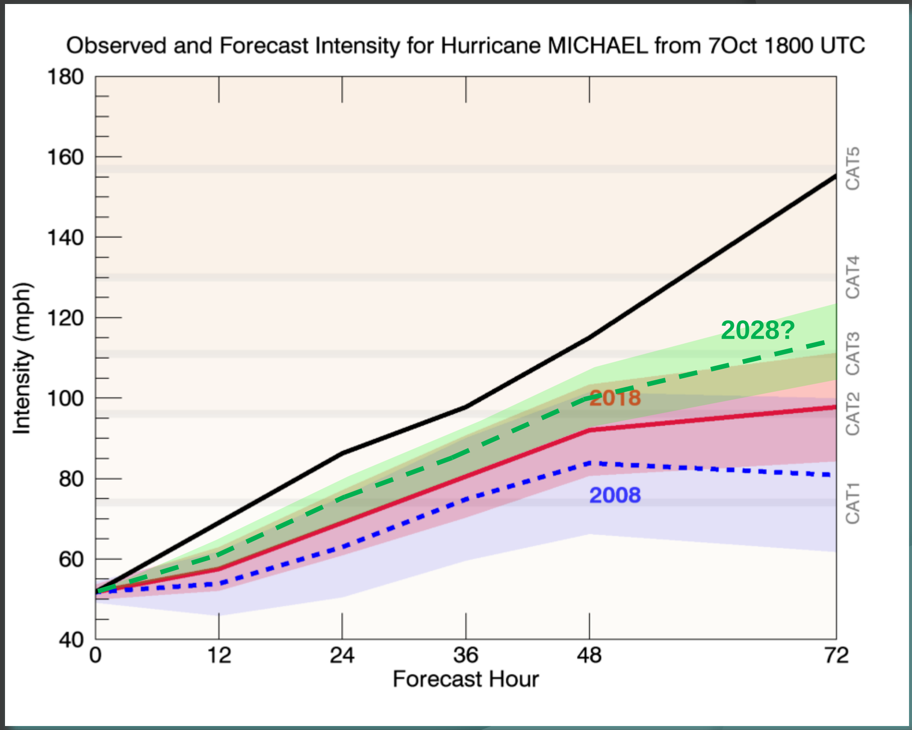
Figure 1 of Molina et al., 2021

Hurricane Michael Example

- Not only should future forecasts become *more accurate* in a deterministic sense, but there should also be *less uncertainty* surrounding them.



Valid for the NHC track forecast made 72 hours prior to landfall. Red dot is the actual “best track” value closest to landfall. Circles represent size of Cone of Uncertainty at 72 hours in different years.



Valid for the NHC intensity forecast made 72 hours prior to landfall. Black line is the actual “best track” values leading up to landfall. Translucent wedges represent average intensity uncertainty in different years.

What About Rain?

- Use parametric model, *PHRaM* (Lonfat et al. 2007), to create rainfall accumulation swaths from storm forecasts
  - Accounts for storm size, intensity, track, wind-shear-based asymmetry, and topographic effects
- Use NHC's Monte Carlo ensemble for wind speed probabilities (DeMaria et al. 2009)… 1000 realizations of each forecast
  - Accounts for specified track and intensity uncertainty scenarios
- Generate map-based probabilistic rainfall forecasts from this ensemble approach, *P-Rain* (Marks et al. 2020, 2021), to create scenario comparison products -- **see 13C.2 tomorrow morning!!**
  - Specifically, present respondents with an area where there is a >10% chance of an under-forecast of significant rain

Survey Methodology

- A double-bounded dichotomous choice elicitation over different forecast attributes and improvement scenarios

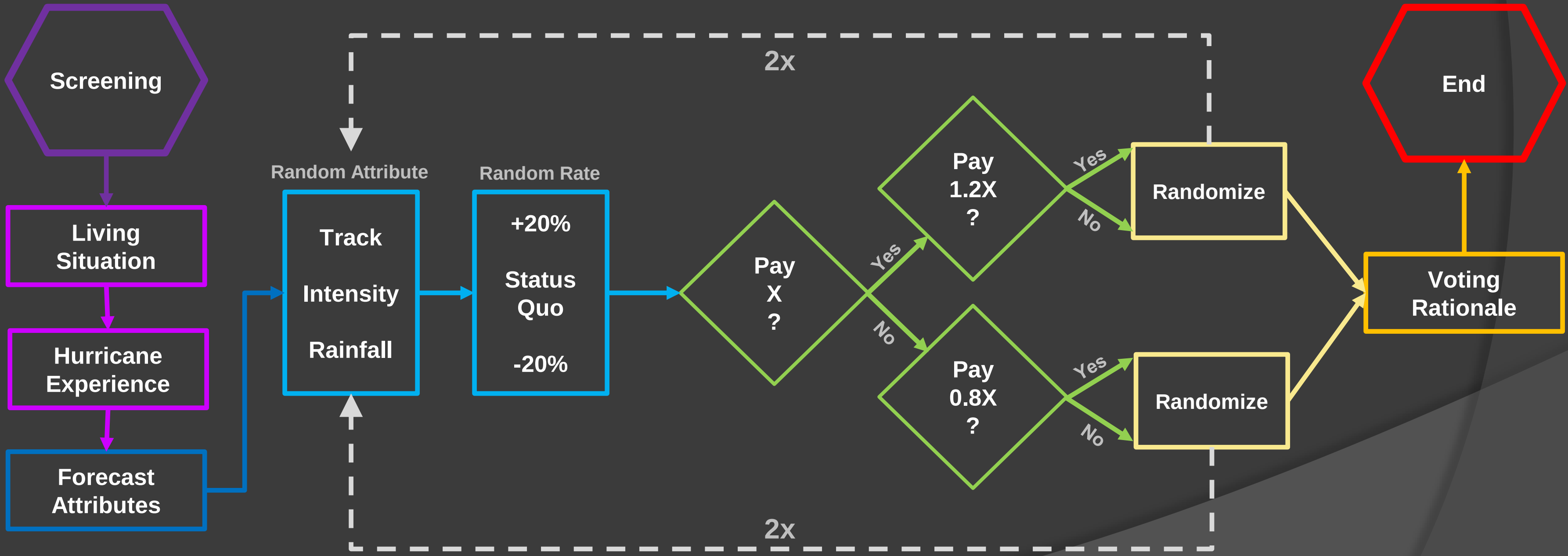


Figure 2 of Molina et al., 2021

Willingness to Pay

- Averaged over the full sample, people valued improvements in intensity the most, followed by track, and then rainfall.

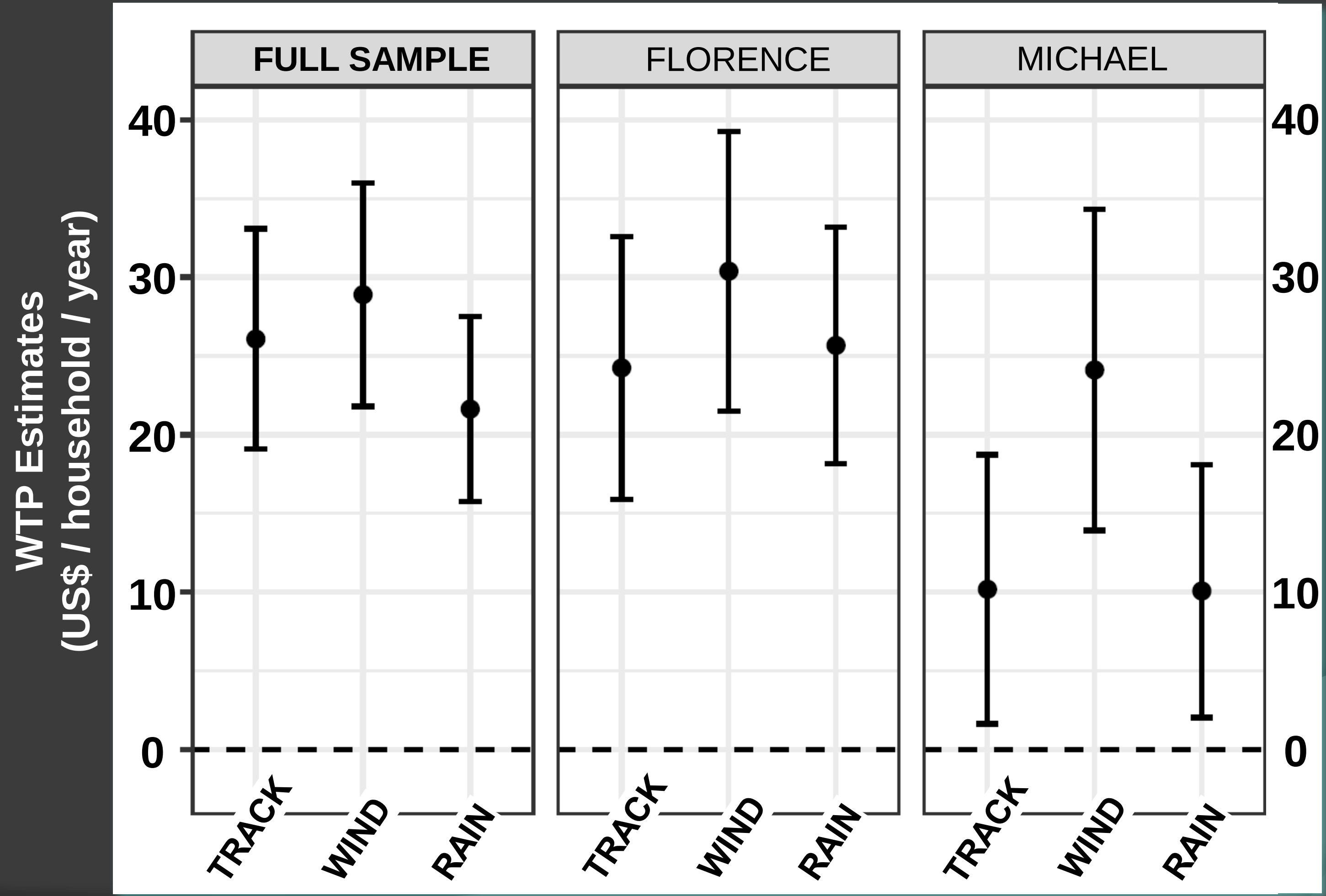


Figure 5 of Molina et al., 2021

Willingness to Pay, extrapolated

- Estimates from this sample were \$22-29 of tax increases per household per year, or \$50-67 million just across those affected counties.
- Extrapolate to all U.S. counties affected by hurricane-related winds of >40 mph from 2008-2018
  - total annual WTP is \$493-645 million, or about \$10-13 per capita

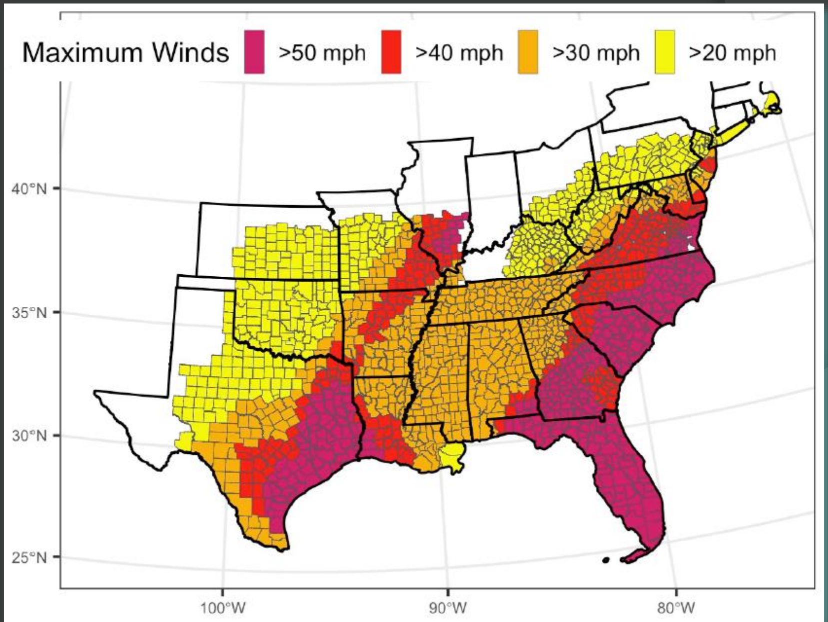


Figure 6 of Molina et al., 2021

Summary

- Observed trends of hurricane forecast errors inform a range of potential future trends, and modeling tools help to create a realistic set of hypothetical forecast scenarios
- A large-scale survey determines the public's willingness to pay for future improvements and which storm attributes they value more (intensity > track > rainfall)
- Results show that the public still values further improvements in forecast accuracy, and *the perceived value greatly exceeds the current operational program costs*
- Interdisciplinary collaborations in hurricane research integrate insights from varied fields

Molina, R., D. Letson, B. McNoldy, P. Mozumder, M. Varkony, 2021: Striving for improvement: The perceived value of improving hurricane forecast accuracy. *Bull. Amer. Meteor. Soc.*, **102**, 1-41.