Hurricanes and Warming: Wetter and Stronger

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Urbanization and Harvey’s Flooding in Houston

Scientists Have Figured Out Why Big Hurricanes Keep Missing the U.S.

Time (4 January, 2017)

The U.S. coast is in an unprecedented hurricane drought — why this is terrifying

Washington Post (August 4, 2018)
2017…

Harvey

Van Oldenborgh et al. (2017, ERL)

Irma

Maria

Images: NASA
2018

Florence

Michael

Images: NASA

Image: NOAA
IPCC-AR5 Assessment of 21\textsuperscript{st} century TC projections: uncertain in North Atlantic

From $\sim$CO$_2$ doubling

IPCC (2013)
Projected increase in the fraction of storms making “Rapid Intensification”

Bhatia et al. (2018)

Observed increase in “RI ratio” since mid-1980s

Robust projection for increased TC rain rate: exceeds Classius-Clapeyron Scaling

Knutson et al. 2013
Tropical and Extratropical Cyclones Different


Asymmetric  
“Cold core”  
Larger

Symmetric  
“Warm core”  
Compact

All images: NASA
TCs can become ETCs (extratropical transition)
Atlantic hurricane density projected to shift to northeast: larger fraction of storms making ET

2056-2100 minus 1961-2005

ET storms threat to Northeast US and Europe

Liu, Vecchi, Smith and Murakami (2017)
TC Observations suggest a century-scale shift has occurred.

1878-2008 TC Density Trend

Vecchi and Knutson (2011, J. Climate)
Projected TC rainfall along North East: wetter storms and poleward shift of tropical phases of storms

Projected poleward shift in the latitude of extratropical transition

Liu, Vecchi, Smith and Murakami (2018)
You may recall Harvey (2017)…

*Photos: Cindy Yeilding*

*Image: NASA*

*Photo: Marc Morrison*
Harvey wetter because of global warming

Even with past climate warming Harvey extremely unlikely event (1 in a few thousand year event)
Urbanization Also Enhanced Harvey’s Rainfall and Flooding in Houston

Harvey’s rainfall accounting for urbanization

Harvey’s rainfall Houston replaced with grassland

25-30 August 2017

Changes to runoff (paving, buildings) additionally enhanced flooding.

Together urbanization increased flooding odds by ~20x (average)

Zhang, Villarini, Vecchi and Smith (2018, Nature)
Change in surface cover/infiltration combined with urban rainfall enhancement to worsen Harvey flooding

- Cypress Creek
- Halls Bayou
- Sims Bayou

Zhang, Villarini, Vecchi and Smith (2018, Nature)
Summary

• Harvey wetter from global warming.
• Urbanization increased Harvey rainfall and flooding in Houston
• What is combined climate and urbanization impact: now? in future?

• Projected increase in East Coast TC rainfall, and European storms of tropical origin

• Projected increase in top speeds of tropical cyclones and rates of “rapid intensification”

• Sea level rise & demographic changes key to future risk.
Preview for 2020 meeting

- New paradigm for global TC frequency
  [Vecchi et al. 2019.a submitted]

- Atlantic hurricanes over the past millennium
  [Vecchi et al. 2019.b in prep.]

- Understanding Indian Ocean Cyclones
  [Sun et al. 2019 in prep.]

- Homogeneized Atlantic “Major” hurricanes
  [Vecchi et al. 2019.c in prep.]