Tropical cyclones and climate change: Recent results and uncertainties

Suzana J. Camargo¹, Chia-Ying Lee¹, Adam H. Sobel^{1,2} and Michael K. Tippett²

1 Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, USA

2 Department of Applied Physics and Applied Mathematics, Columbia University, New York, NY, USA

Future Projections – TCs

- Based on theory and models
- Increase in storm surge due to sea level rise (SLR)
- Globally averaged intensity of TCs shift towards stronger storms 2-11% by 2100
- <u>Globally averaged frequency of TCs: decrease 6-34%</u>
- Increases of ~ 20% of the precipitation rate within 100km of the storm center (mean and peak)
- Projected changes for individual basins uncertain.
- Regions with hurricane occurrence is NOT expected to change.



Tropical Cyclones and Climate Change Assessment

Knutson et al., BAMS 2020, doi:10.1175/BAMS-D-18-0194.2

Part II: Projected Response to Anthropogenic Warming

Thomas Knutson, Suzana J. Camargo, Johnny C. L. Chan, Kerry Emanuel, Chang-Hoi Ho, James Kossin, Mrutyunjay Mohapatra, Masaki Satoh, Masato Sugi, Kevin Walsh, and Liguang Wu

- **Highest confidence:** SLR + warming: leads to higher storm inundation levels.
- Medium to high confidence:
 - Increase of TC precipitation rates (~ 14%)
 - Global average intensity increase (~ 5%)
 - Increase of proportion of cat 4-5 TCs (13%)
- Mixed confidence:
 - Poleward shift
 - Frequency of intense TCs
 - Slowdown in TC translation speed
 - Decrease in global TC frequency

TC frequency projections – increase in uncertainty







Bhatia et al., J. Climate 2018



Vecchi et al., Clim. Dyn, 2019

Yoshida et al., GRL 2017

Columbia HAZard model (CHAZ):



A generator of synthetic TCs <u>genesis</u>, <u>track</u>, <u>intensity</u>, <u>and</u> <u>winds are functions of</u> <u>the environment</u>

MONTHLY PI, vorticity, humidity, shear, large-scale circulation DAILY winds





Chavas et al. 2015, JAS

Lee, Tippett, Sobel & Camargo, JAMES 2018

Figures by Chia-Ying Lee

CHAZ climate change simulations



Example: one ensemble member Forced by one CMIP5 model

Figures by Chia-Ying Lee

CHAZ Climate change simulations



CHAZ Climate change simulations

Genesis Indices and climate change

-2

-4

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-4

-6

-2

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SOVE 05 1005 150W M13

-2

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205

405

16

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-4

16012

BOW.

1005

0E

Tropical Cyclone Genesis Index - TCGI

Tippett et al., J. Climate 2011

HiRAM – perfect model experiment

Column Integrated Relative Humidity

Saturation Deficit

SD = CIWV - CIWVs

CIWV = column integrated water vapor CIWVs = saturated column integrated water vapor

Camargo et al., J. Climate 2014

CHAZ climate change simulations -Frequency changes

Saturation Deficit & Relative Humidity

CHAZ climate change simulations - Frequency changes

CHAZ climate change simulations - Intensity changes

CHAZ climate change simulations Intensity + frequency changes

Conclusions

- Projections of TC frequency have become more uncertainty in the last few years.
- CHAZ results show that TC frequency is sensitive to the type of humidity variable used when downscaling future projections.
- Work in progress: can we determine which is the "best" CHAZ simulation for the present climate?