The Abdus Salam
International Centre
for Theoretical Physics

Future projections in tropical cyclone activity over multiple CORDEX domains using RegCM4

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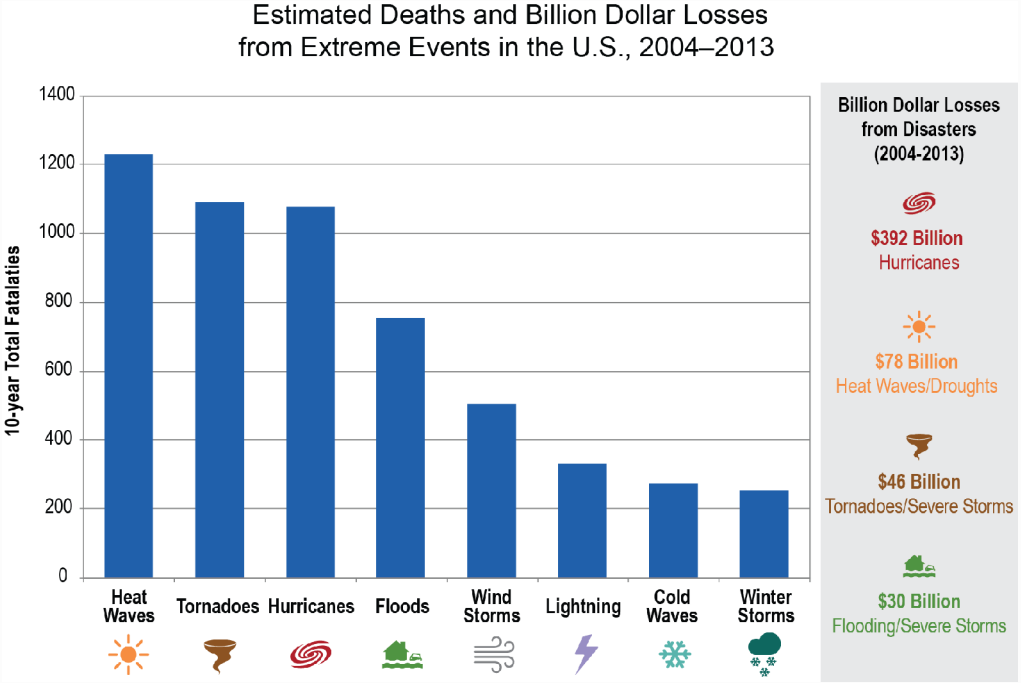
Introduction

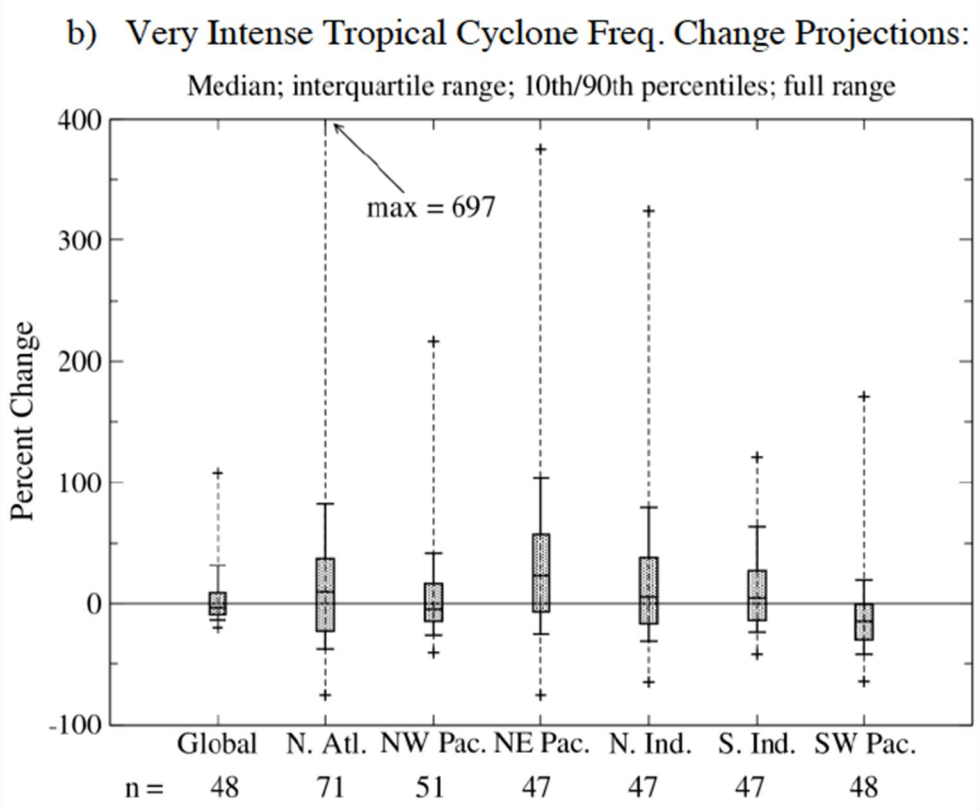
- The question of how tropical cyclones (TCs) could change with future anthropogenic warming is an important issue, particularly because of the large societal impacts from TCs and their damage (Knutson 2019).



https://health2016.globalchange.gov/extreme-events/figures/estimated-deaths-and-billion-dollar-losses-extreme-events-united-states-2004

Introduction

- Although several studies have addressed this topic, there remains much uncertainty about changes in TC intensity and TC rainfall on the regional scale, calling for further regional investigations.

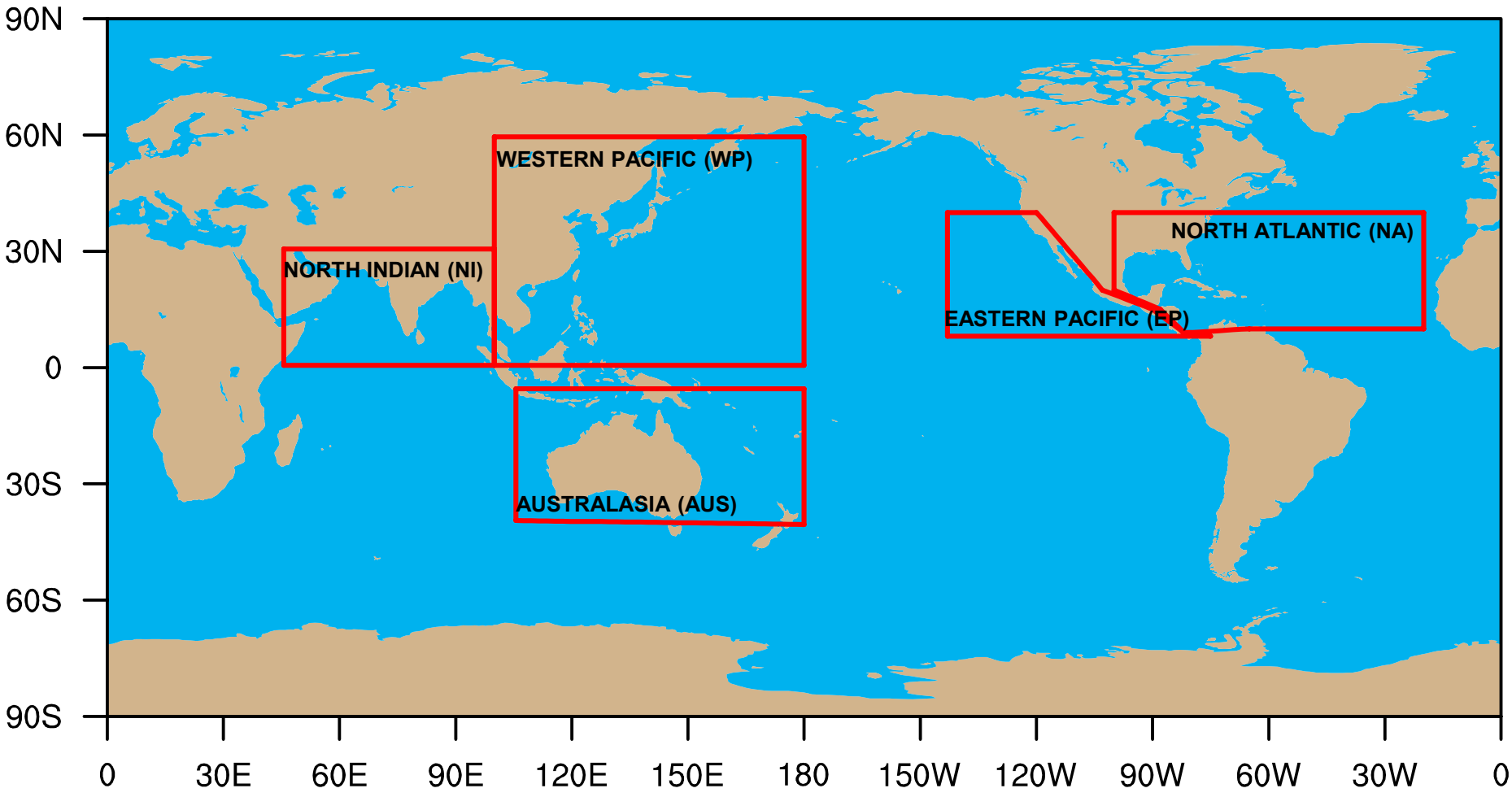


Knutson et al. 2019

Objective

To investigate the potential changes in tropical cyclone (TC) activity for future climate conditions over four CORDEX domains, using an ensemble of simulations using the ICTP Regional Climate model (RegCM4).

Regions of study



Method

Observations:

International Best Track Archive for Climate Stewardship (IBTrACS version 4)

Simulations:

RegCM4 at a spatial resolution of 25 km. The simulations were driven by three GCMs, which covering a range of climate sensitivities in the CMIP5 program.

Periods analyzed:

- *Historical*: 1995-2014

RCP2.6 and RCP8.5

- *Mid-future*: 2041-2060
- *Late-future*: 2080-2099

List of GCMs

- MPI-ESM-MR (all basins)
- HadGEM2-ES (AUS, EP, NA)
- NorESM1-M (AUS, NI)
- MIROC5 (NI)
- GFDL-ESM2M (EP, NA)

Method

The TC detection method employed here is the objective-tracking algorithm, TRACK (Hodges 1999).

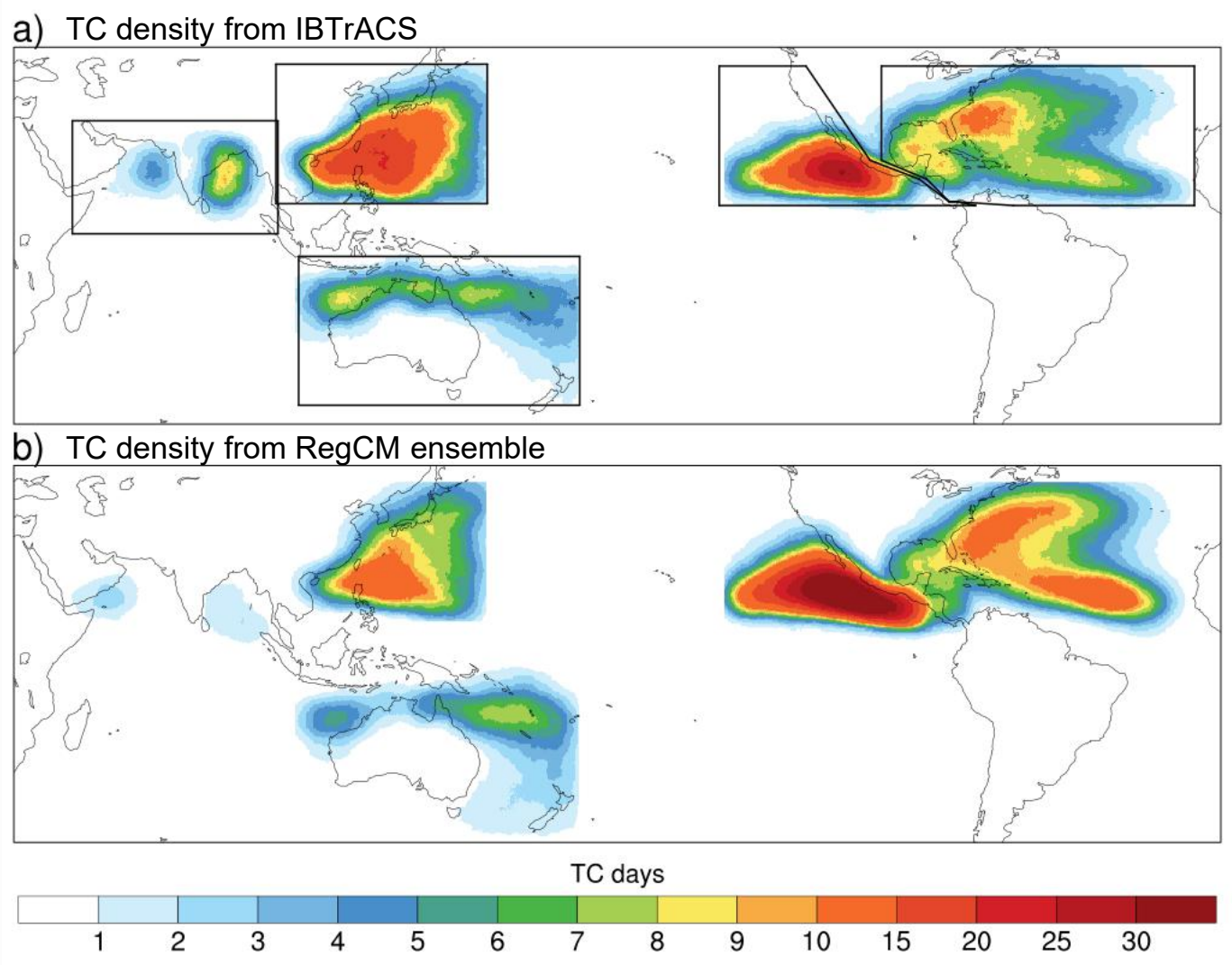
The results presented here are only for the ensemble mean.

Here we analyze:

- Geographical distribution
- Intensity (maximum wind speed)
- Precipitation-associated TCs
- Genesis potential index (GPI) and potential index (PI)

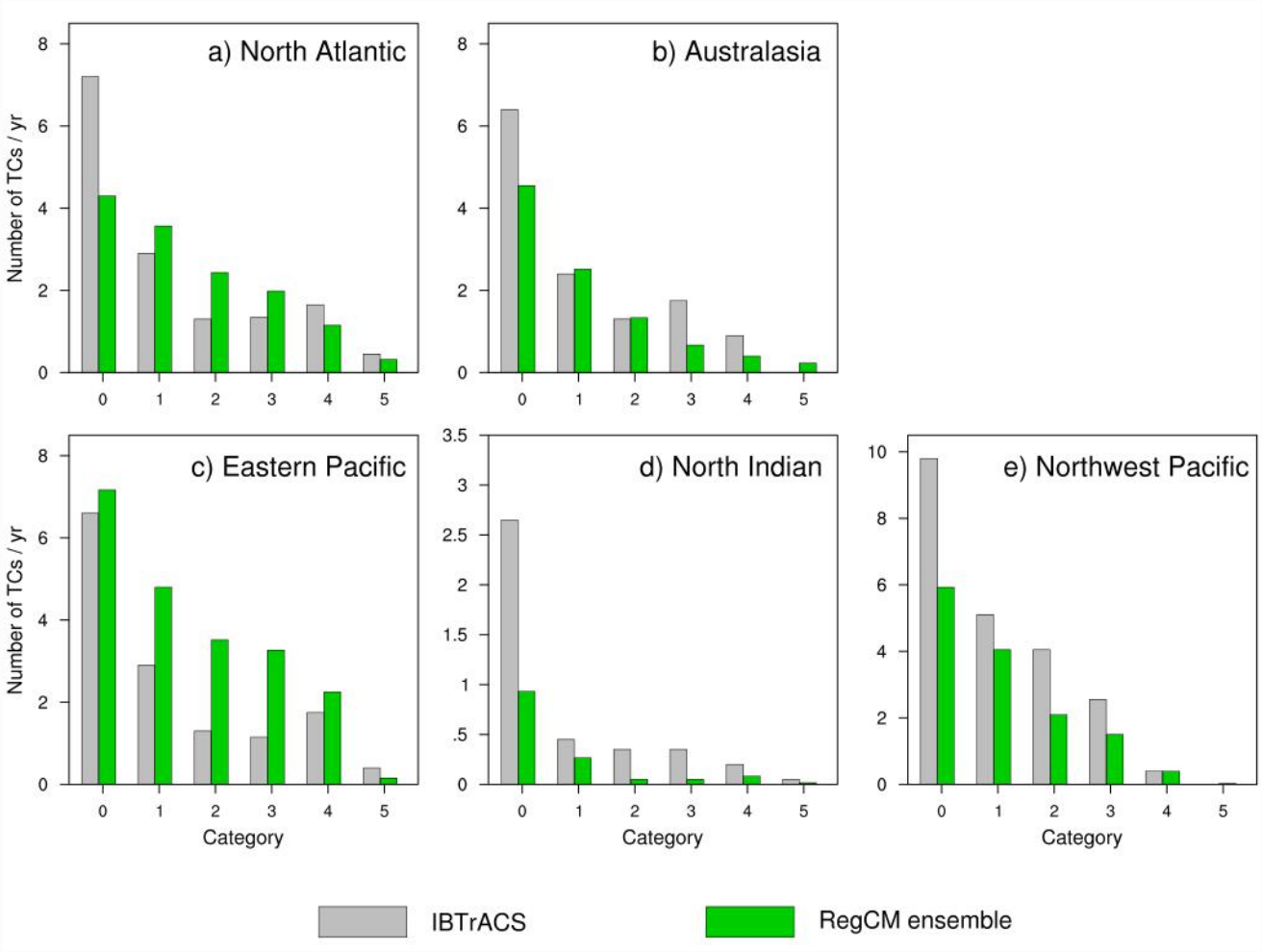
How well does RegCM4 represent the TC features?

Validation: Track density



RegCM4 is able to capture the geographic distribution of TC frequency.

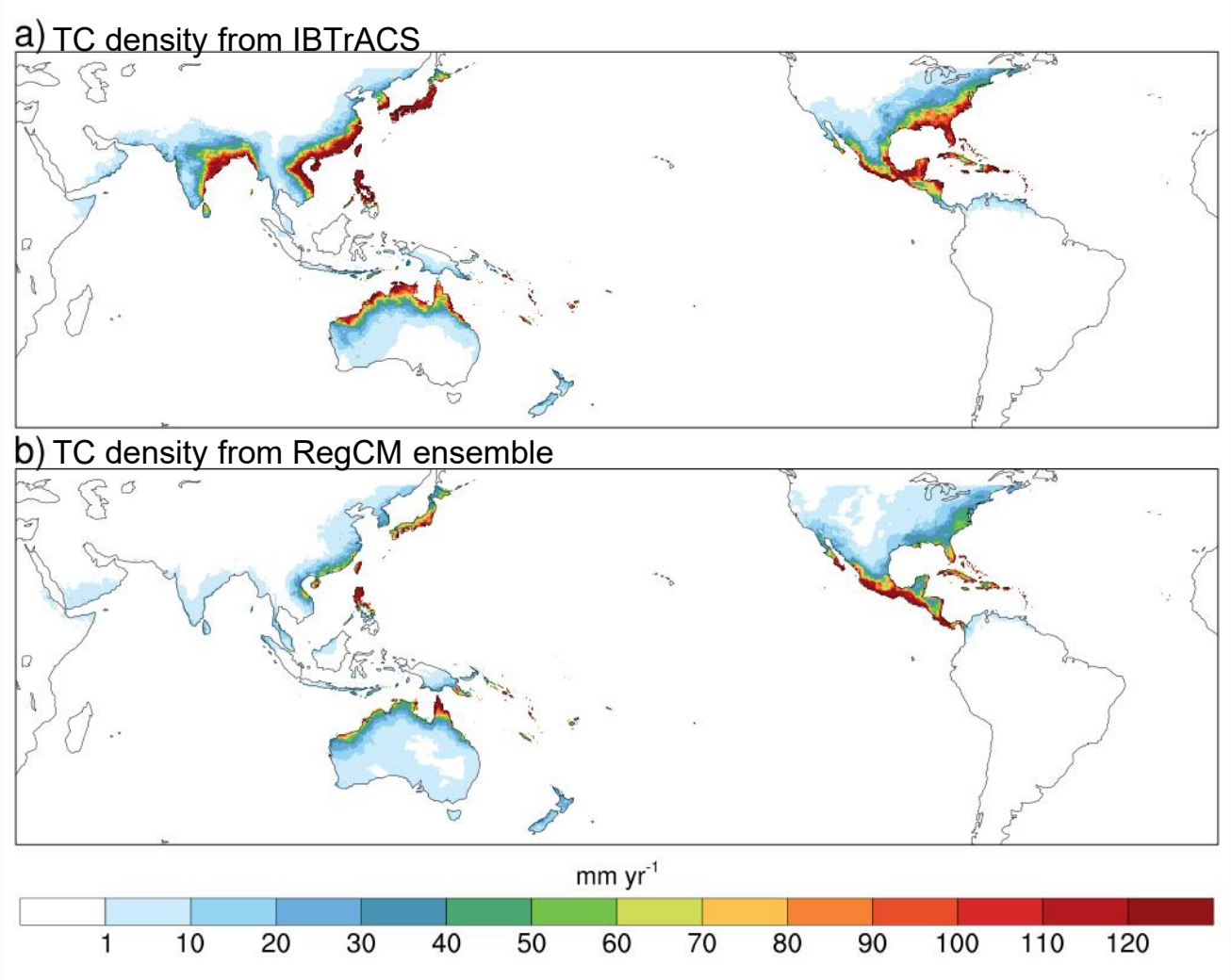
Validation: Annual number of TC by Saffir-Simpson scale



The peak value of the maximum 10m wind speed over the TC lifetime is used.

The statistical method of bias correction used is similar to the method used by Zhao and Held (2010).

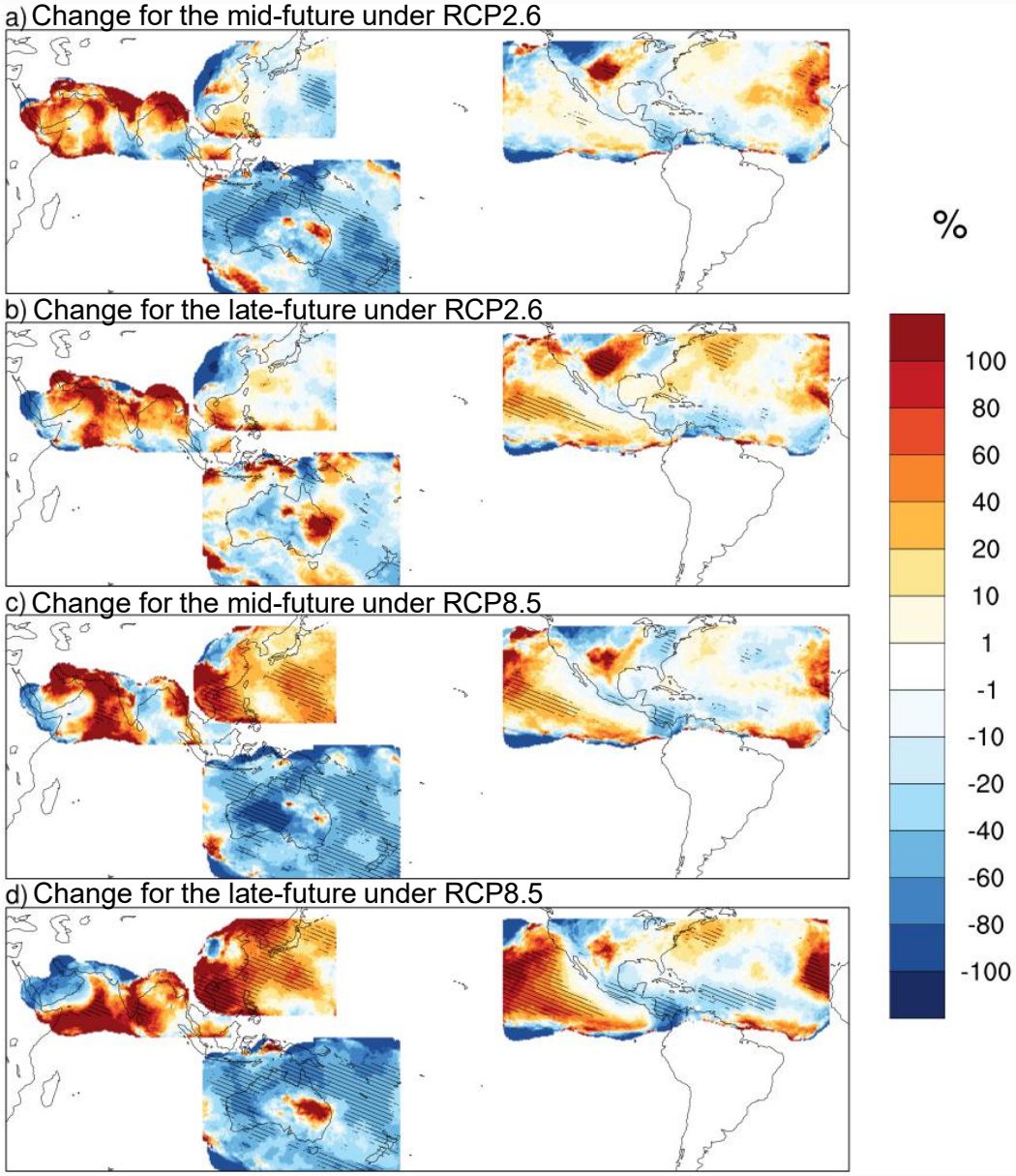
Validation: TC rainfall



RegCM4 simulations underestimate TC rainfall

Future projections of TC characteristics

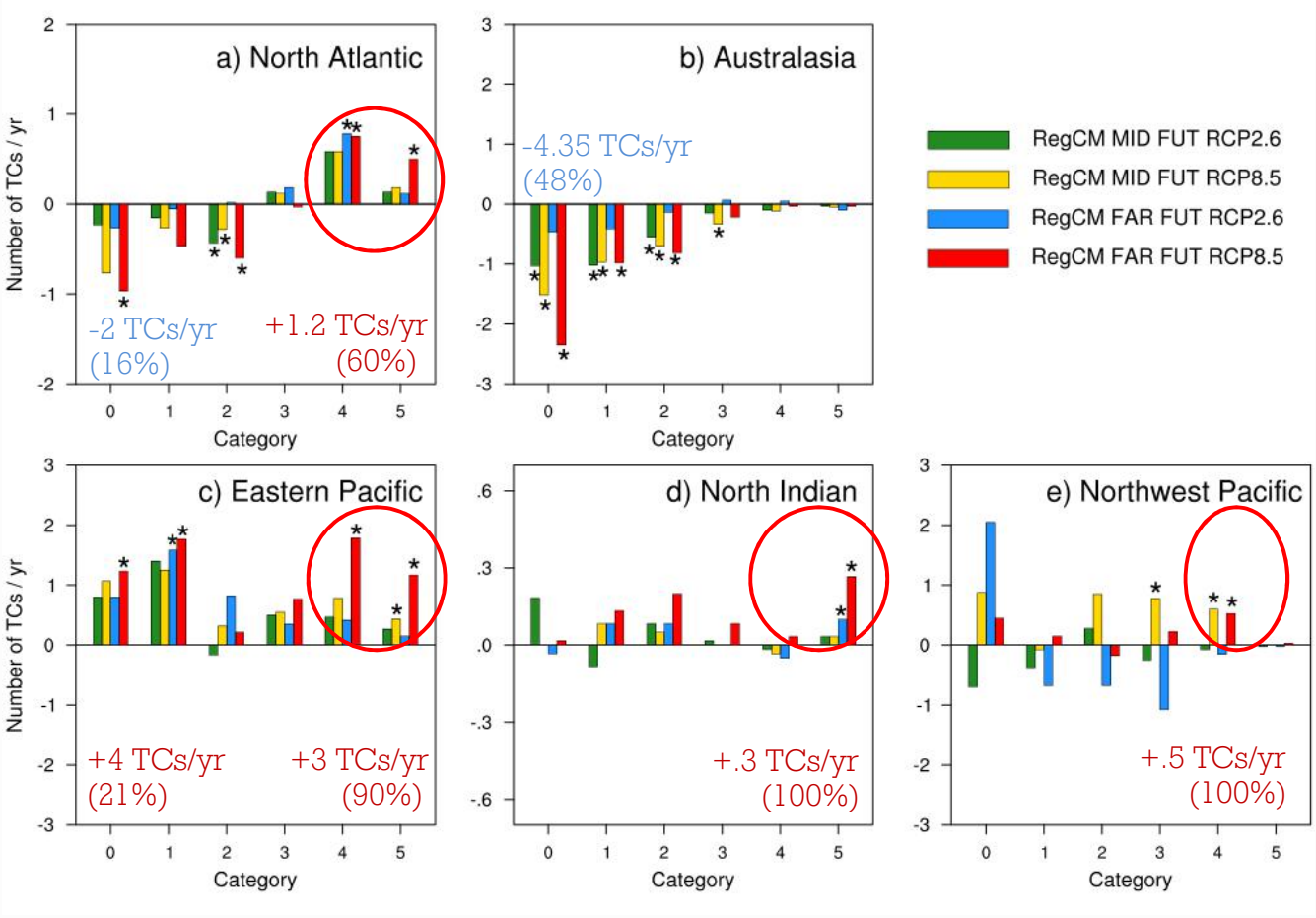
Future projections: Changes in track density



The simulations project a consistent decrease of TC density in Australasia and an increase in North Indian Ocean and Eastern Pacific.

Hatched areas show where changes are significant at a 95% confidence level, based on the Wilcoxon rank-sum test.

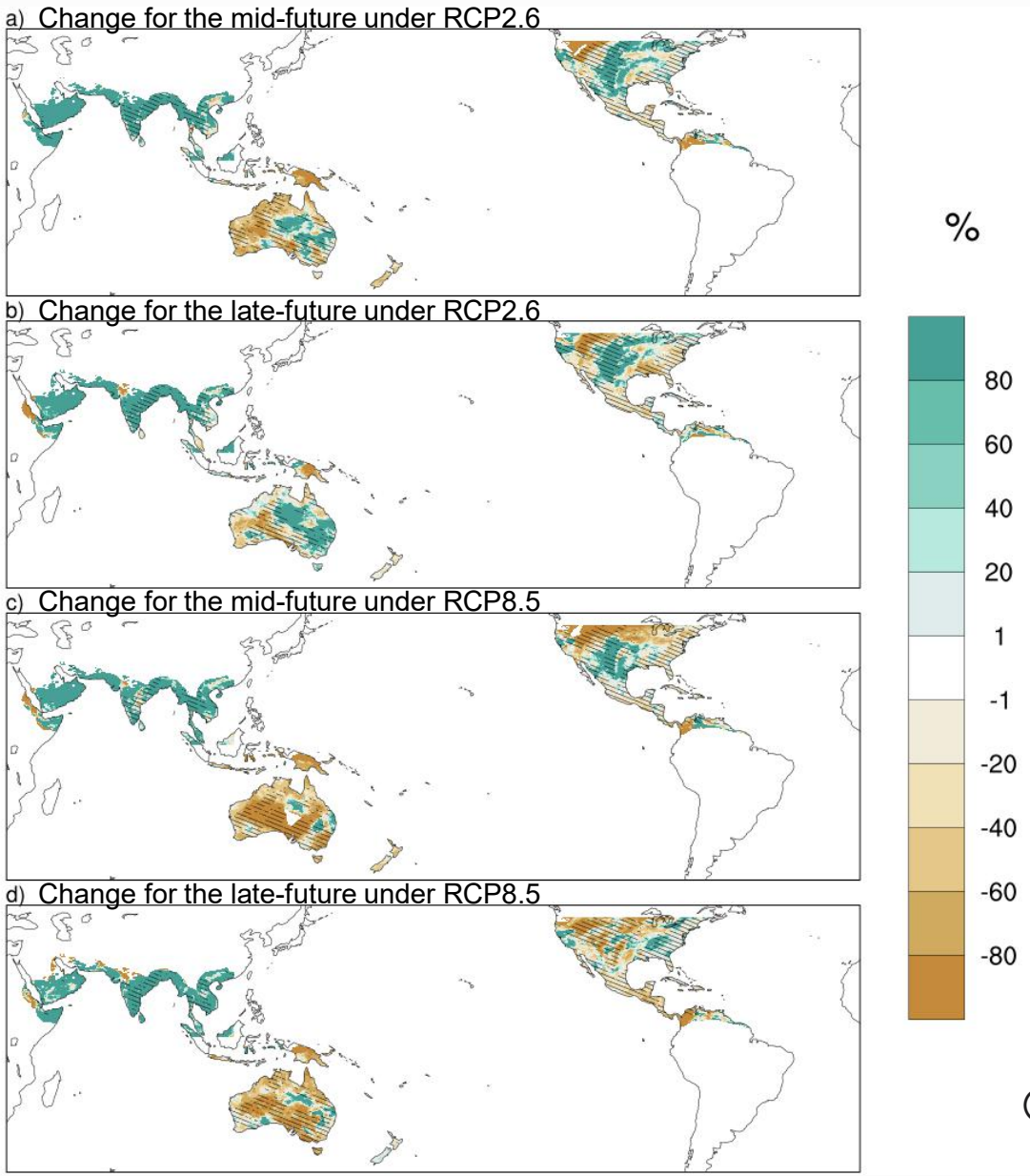
Future projections: Changes in the intensity



The model shows an increase in very intense TCs.

Asterisk symbols show where changes are significant at a 95% confidence level, based on the Wilcoxon rank-sum test.

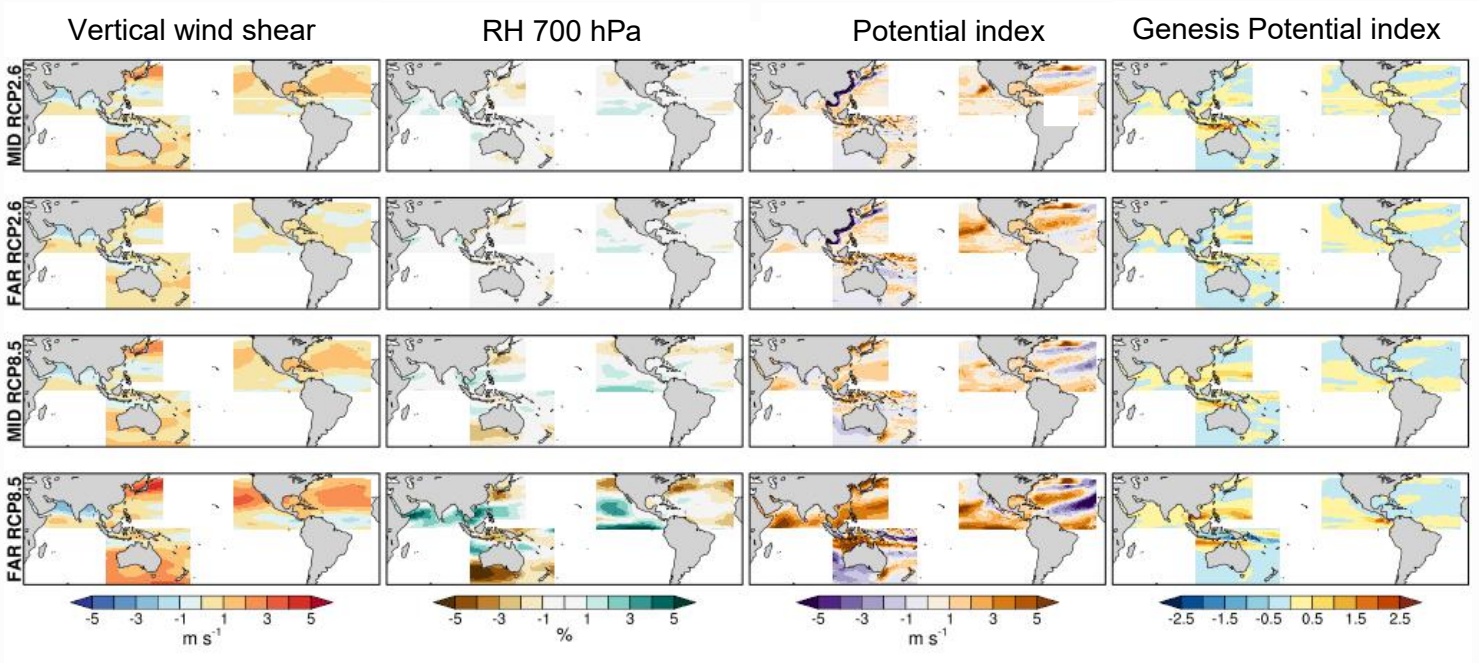
Future projections: Change in TC total rainfall (%)



RegCM4 shows reduced TC precipitation over Australasia, Mexico and Central America

Hatched areas show where changes are significant at a 95% confidence level, based on the Wilcoxon rank-sum test.

Future projections: Change in GPI and the three main genesis factors



Changes in TC frequency over the North Indian and the Eastern Pacific Ocean could be related to an increase in mid-tropospheric relative humidity. While the changes in North Atlantic and Australasia could be associated with an increase in wind shear over these basins.

Concluding remarks

- The RegCM4 captures most of the features of the observed TC climatology.

- RegCM4 projects significant increases of TC frequency in Western Pacific and India Ocean and decreases in Australia and Mexico.

- The projections show an increase in the frequency of the strongest TCs over the Eastern Pacific, the Northern Atlantic, Western Pacific and the North Indian Ocean.

- The change in TC rainfall exhibits a statistically significant decrease over Australia, Mexico and Central America.

Thank You!

Questions?

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References

- Hodges, K. I. (1999) Extension of spherical nonparametric estimators to nonisotropic kernels: An oceanographic application. Monthly Weather Review, 127 (2). pp. 214-227.

- Knutson, T., S.J. Camargo, J.C. Chan, K. Emanuel, C. Ho, J. Kossin, M. Mohapatra, M. Satoh, M. Sugi, K. Walsh, and L. Wu: Tropical Cyclones and Climate Change Assessment: Part II. Projected Response to Anthropogenic Warming. Bull. Amer. Meteor. Soc., 0, https://doi.org/10.1175/BAMS-D-18-0194.1

- Zhao, M. and I.M. Held, 2010: An Analysis of the Effect of Global Warming on the Intensity of Atlantic Hurricanes Using a GCM with Statistical Refinement. J. Climate, 23, 6382–6393, https://doi.org/10.1175/2010JCLI3837.1