Tropical Cyclone Climatology and Response to Vertical Wind Shear in MESACLIP

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The MESACLIP project[1] has produced an extensive sample of synthetic tropical cyclones (TCs) for long-term climate and "storyline" case studies.

Its resolution (0.25° atmosphere coupled to 0.1° ocean) allows new investigations into mesoscale TC processes, such as the impact of vertical wind shear (VWS) on TC intensity and structure in historical and future climates.

We present an initial survey of TC climatology and change in MESACLIP, using tracks[2] provided by Fu et al.[3] in the 10-member historical and RCP8.5 ensembles.

Historical TC Spatial and Intensity Distributions

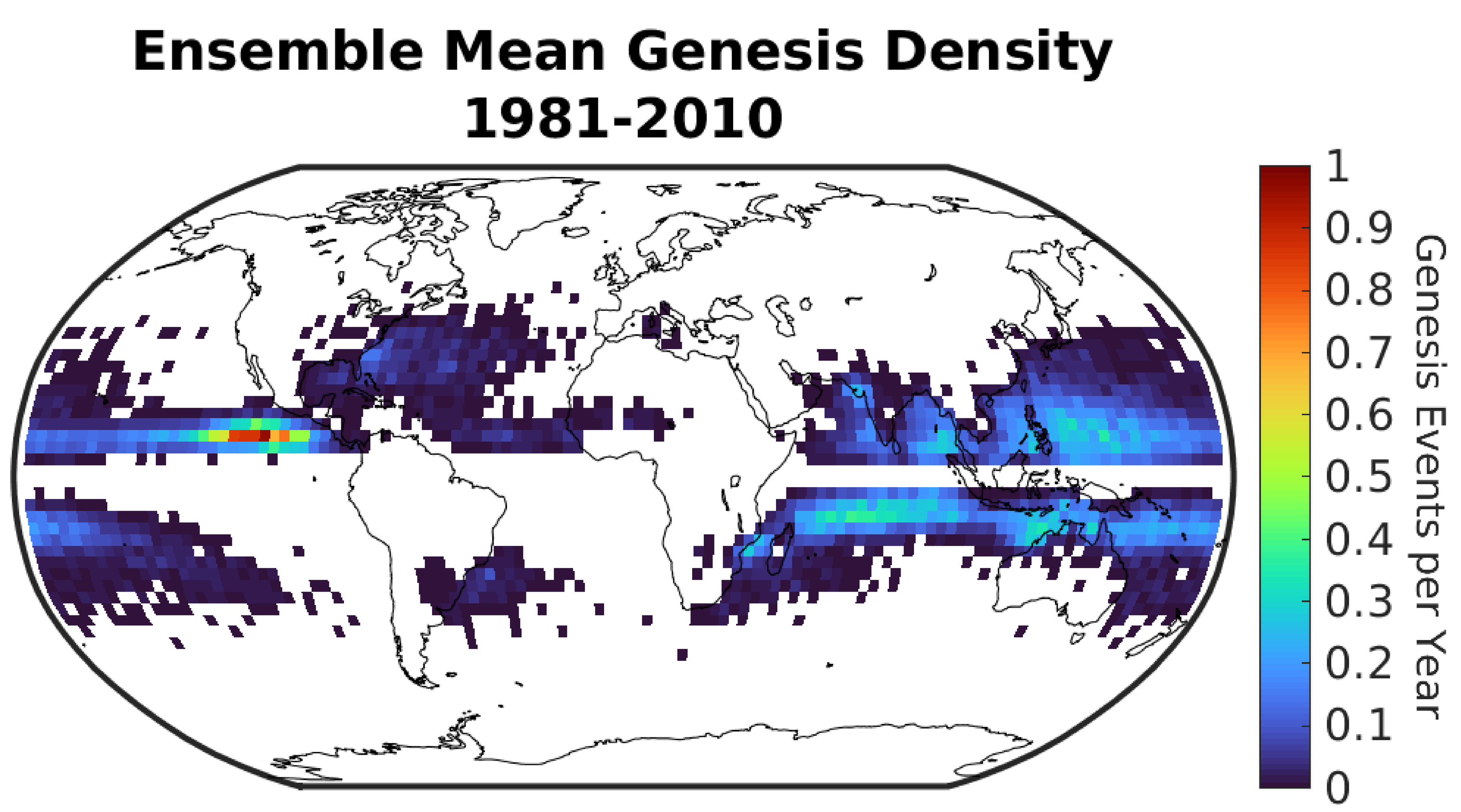


Figure 1: Global TC genesis density averaged across 10 ensemble members on a 3x3° grid. Note: RCP8.5 forcing begins in 2006 for all simulations. This analysis will be expanded to include other future scenarios.

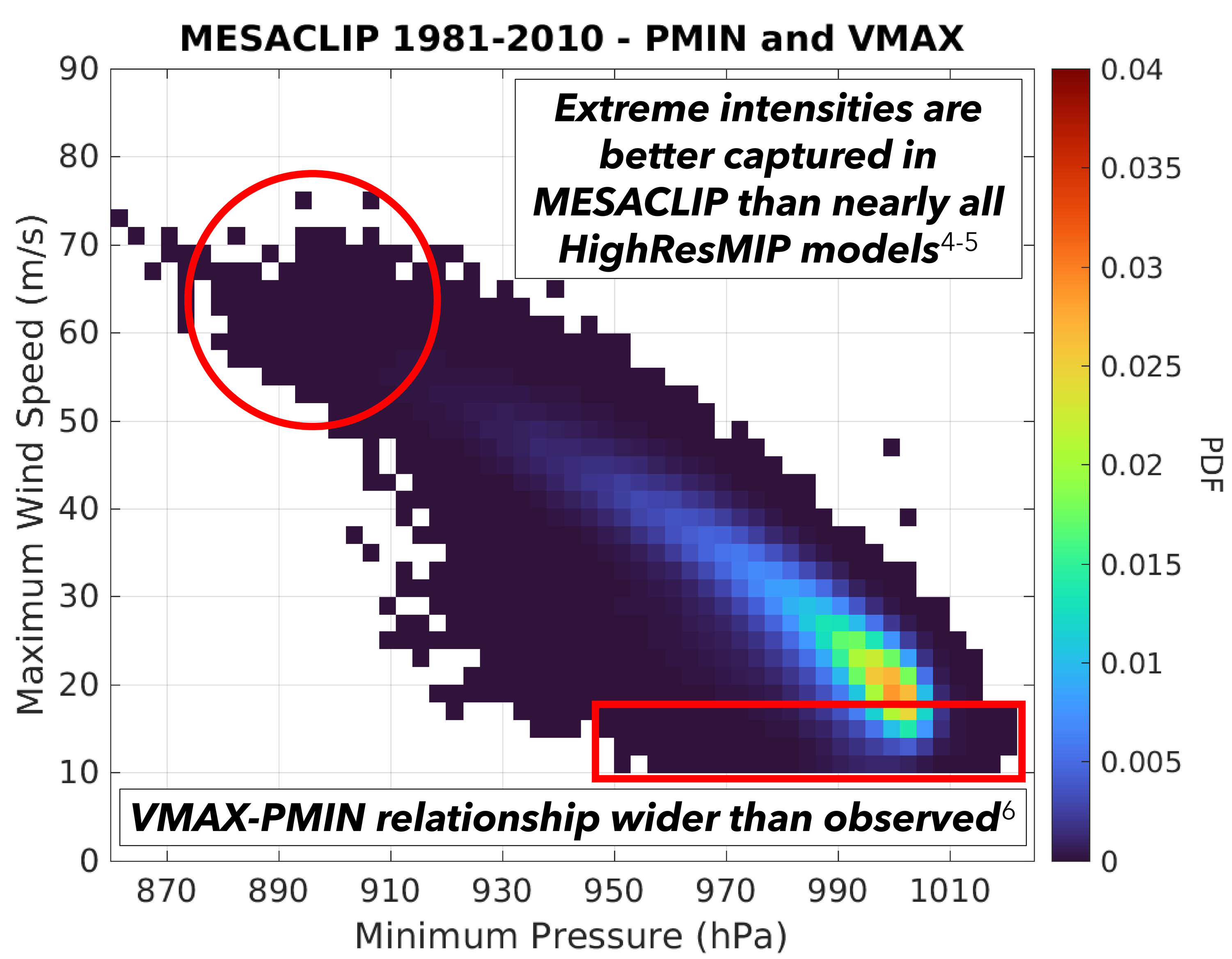


Figure 2: 2-dimensional histogram of TC historical TC intensity, as depicted by both minimum central pressure (PMIN, x-axis) and maximum wind speed (VMAX, y-axis).

Late-Century TC Changes in MESACLIP

- In line with most prior climate model studies[7], TC frequency decreases, track density shifts poleward, and mean intensity increases marginally.

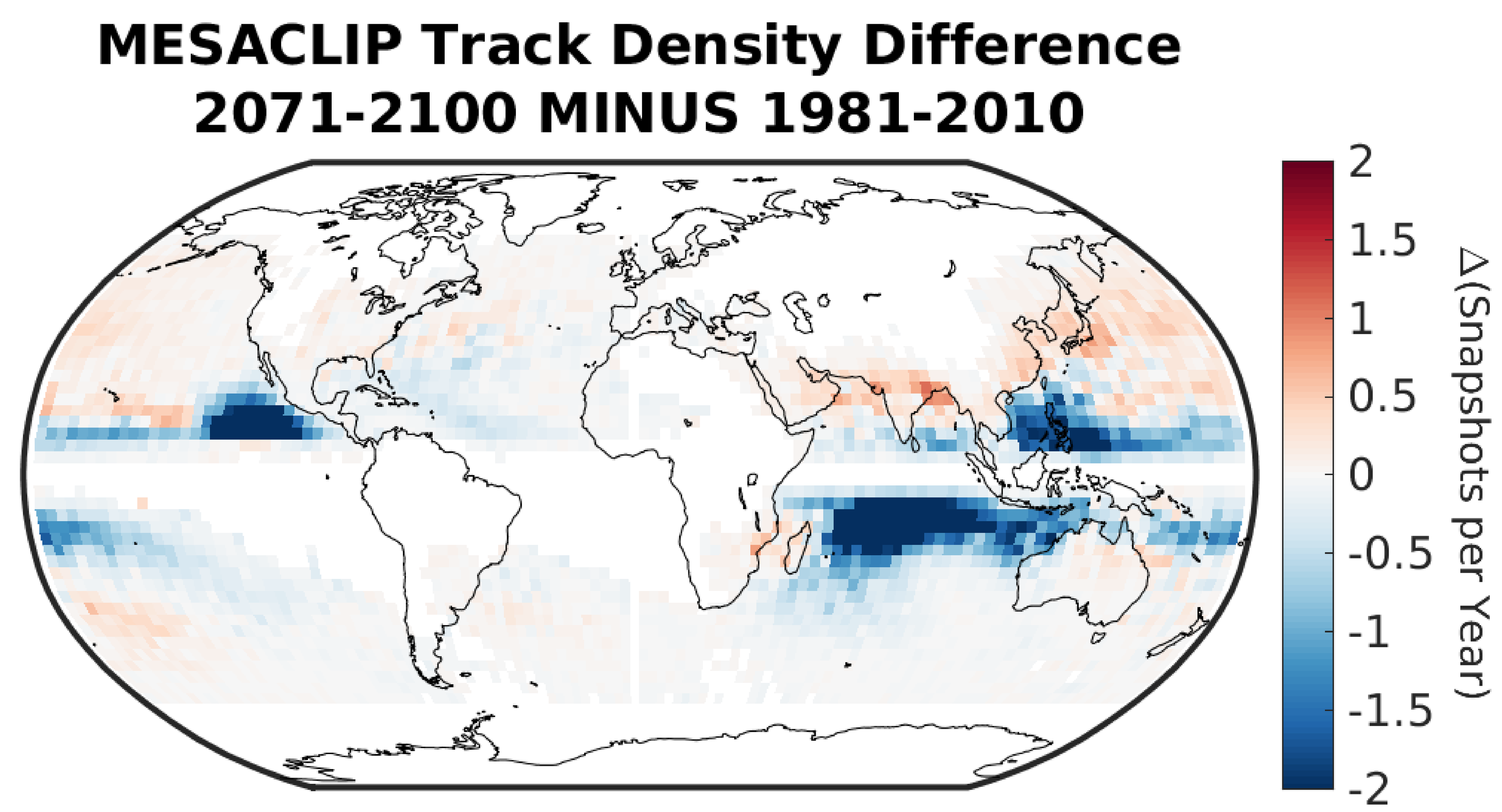


Figure 3: Difference in ensemble mean track density (total 6-hourly TC position snapshots in each 3x3° grid cell) between the recent-past and late-century in MESACLIP, using RCP8.5 forcing. Blue shading indicates less future TC track density.

- Rapid intensification/weakening are uncommon in MESACLIP, but the intensity change distribution widens by late-century.

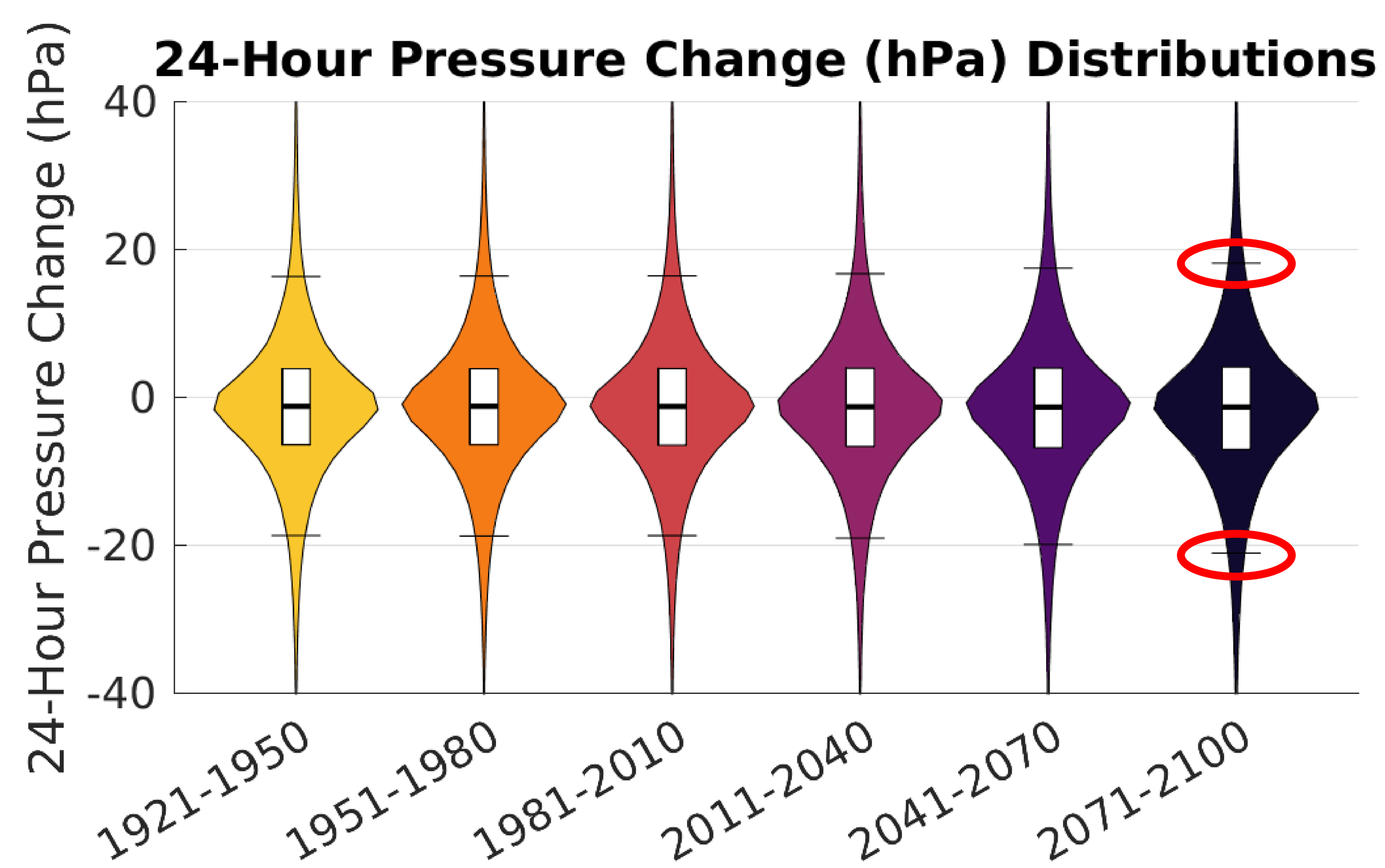
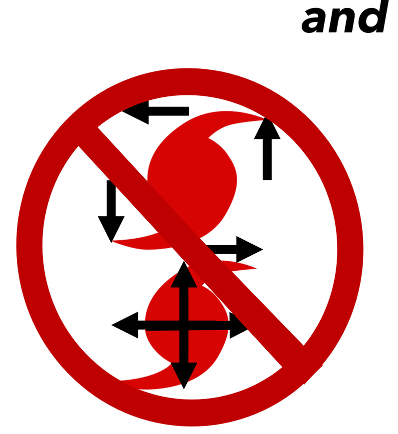


Figure 4: 30-year climatologies of 24-hour intensity change under RCP8.5 forcing. The median and interquartile range are shown by white boxes inside each violin, while the horizontal lines indicate the 5th and 95th percentiles in each 30-year sample.

Calculating VWS on the Individual TC Scale

VWS is a leading-order cause of uncertainty in future TC projections[8], and reduces predictability of individual TCs[9].



- We subtract the rotational and divergent winds from the full wind field[10] to isolate the TC's shear from the environmental shear.
- Winds are then averaged in a 0-500 km annulus to find the 850-250 hPa vector difference.[11]

The Response of TCs to Environmental VWS

VWS tilts the otherwise-upright TC vortex, induces asymmetric wind, convective, and thermodynamic structure, and can ventilate cooler, drier air into the vortex from the environment.[12]

- Changes in the shear imparted on TCs are volatile/basin-dependent. Notably, there is a net decrease in projected VWS in the West Pacific.

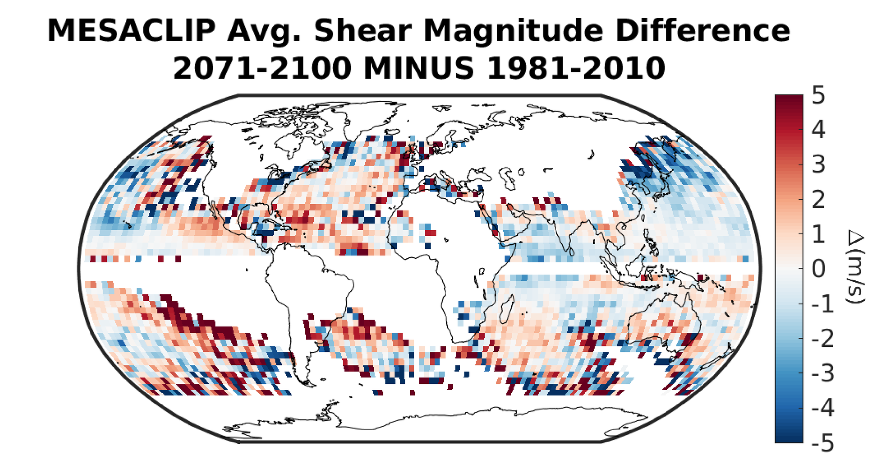


Figure 5: Projected change in VWS magnitude from recent-past to late-century under RCP8.5 forcing. Values of VWS considered here are those specific to the synoptic environments of modeled TCs.

- Predictability of TC intensity under moderate shear[13] (5-10 m/s) may worsen by late century, as more dramatic intensity changes occur at a greater proportion.

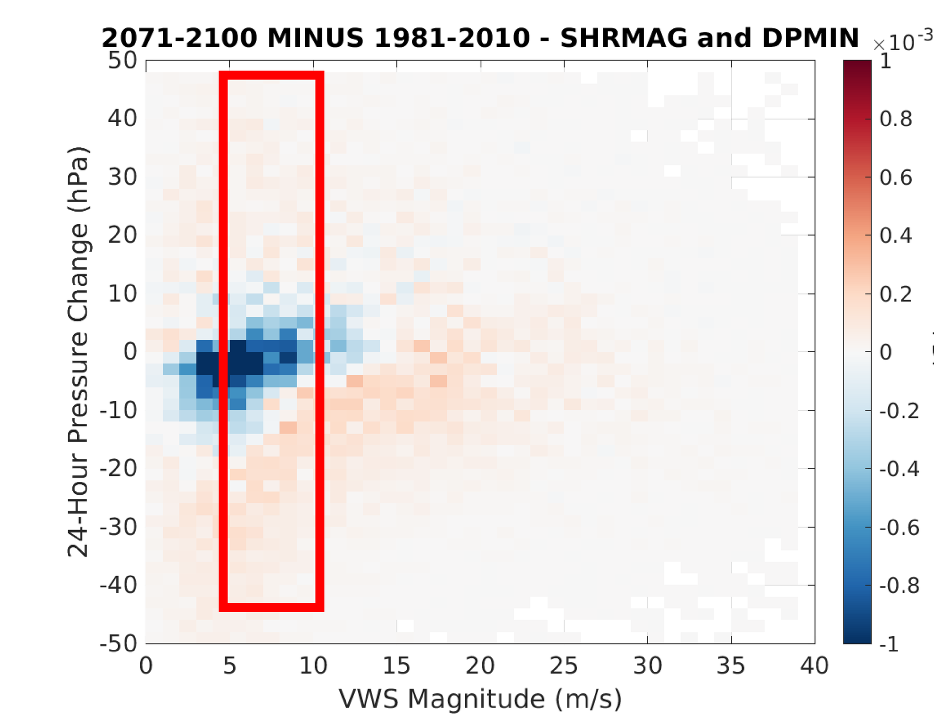


Figure 6: Difference between late-century and recent-past in the 2-dimensional histogram of TC events with a certain VWS magnitude, and future 24-hour intensity change (measured with pressure). The red box indicates the moderate VWS regime, for which operational intensity prediction is already poor.

- Ongoing work from our group will map where TC hazards may be most amplified, and whether TCs will become more or less resilient to VWS in the future. ***Early evidence suggests that, under warming, rainfall will be most amplified in the sector of the TC that is already rainiest.***

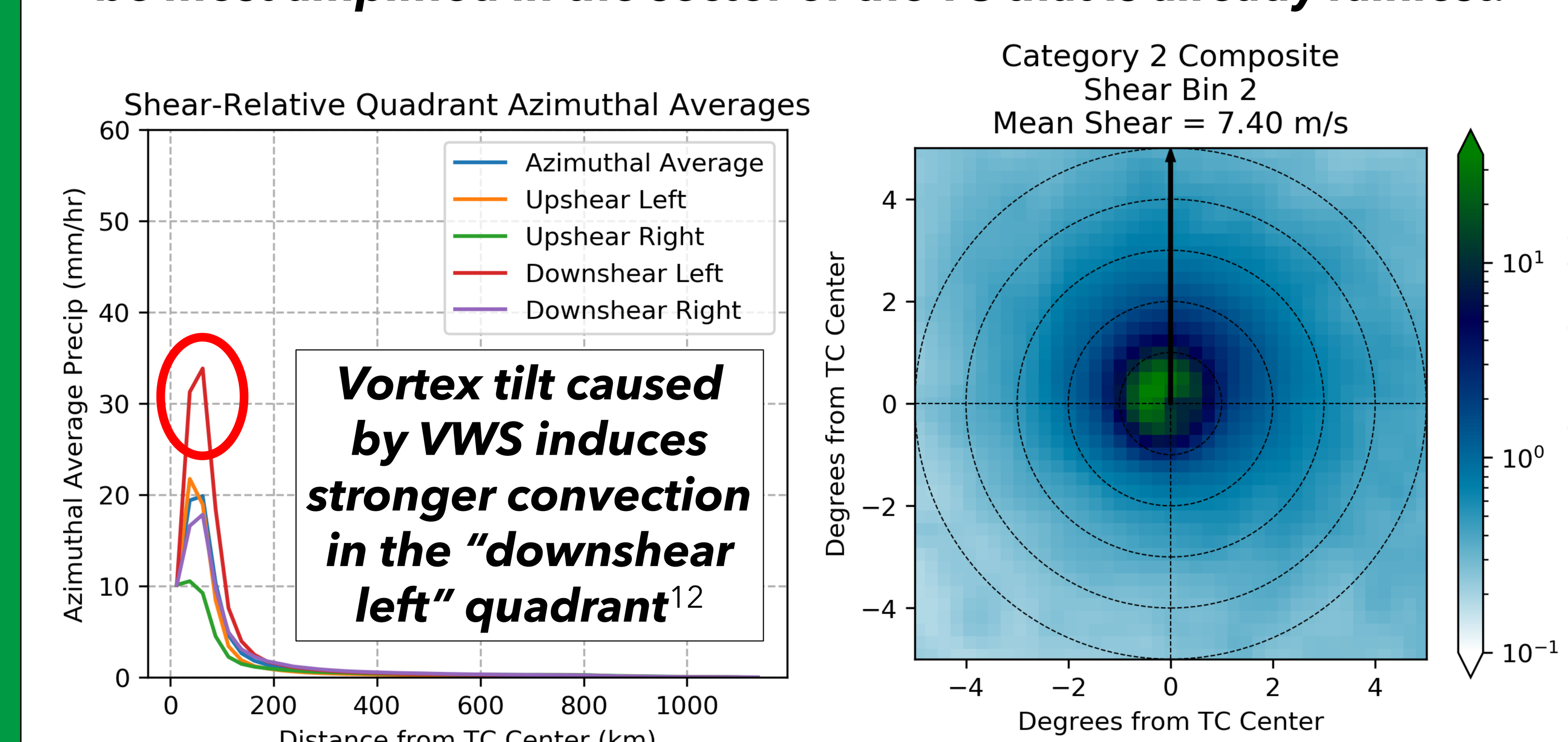


Figure 7: Composite mean VWS-relative rainfall structure, presented as radial profiles (left) and as a spatial map (right). Shown are the subset of RCP8.5 TCs with lifetime maximum intensity between 960-975 hPa ("Category 2" on a pressure-based scale[14]), under moderate vertical wind shear (5-10 m/s) at that time.

NOAA Model Diagnostics Task Force
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References

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