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15 A Potential Explanation for the Global Increase in Tropical Cyclone Rapid Intensification  
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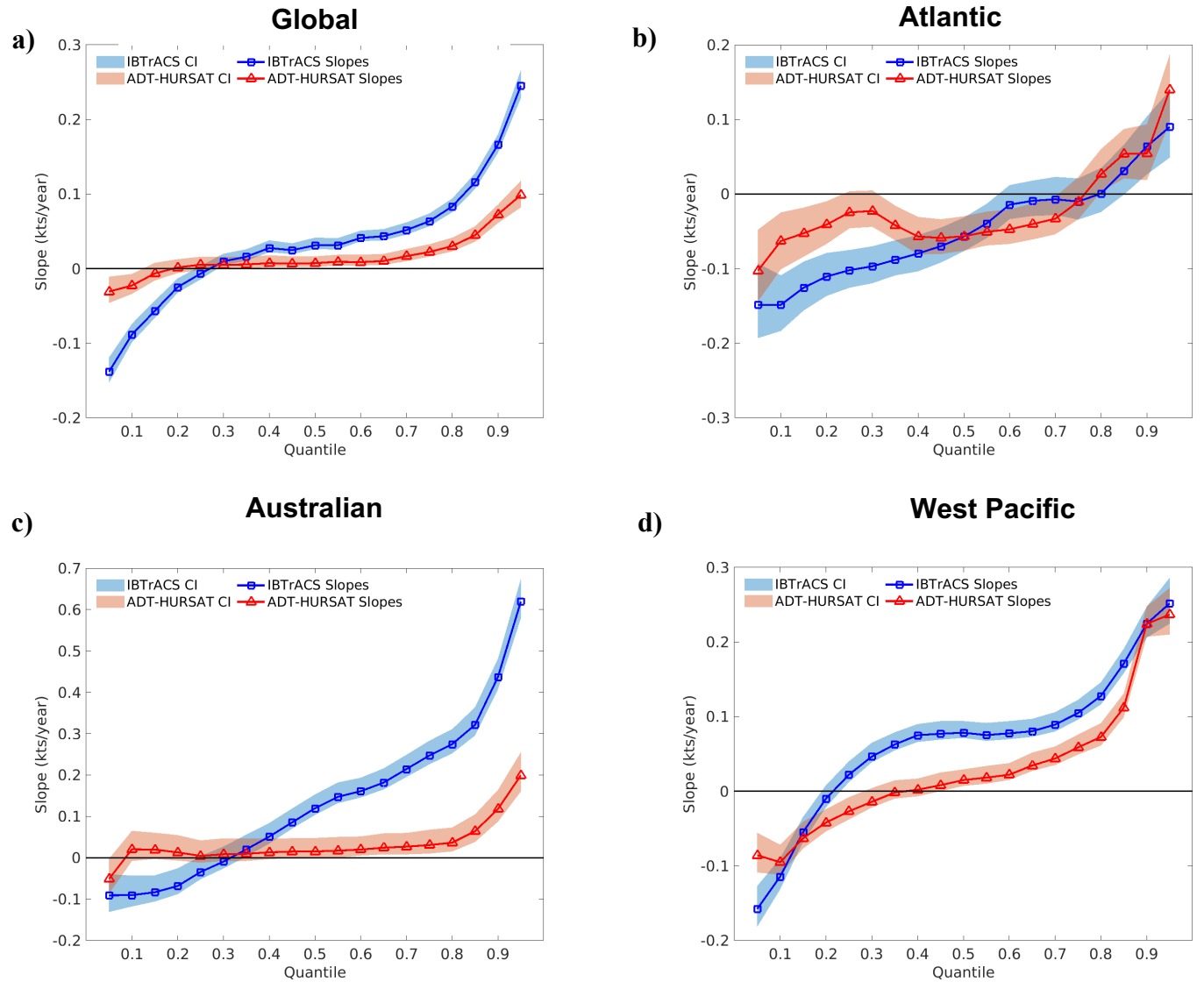
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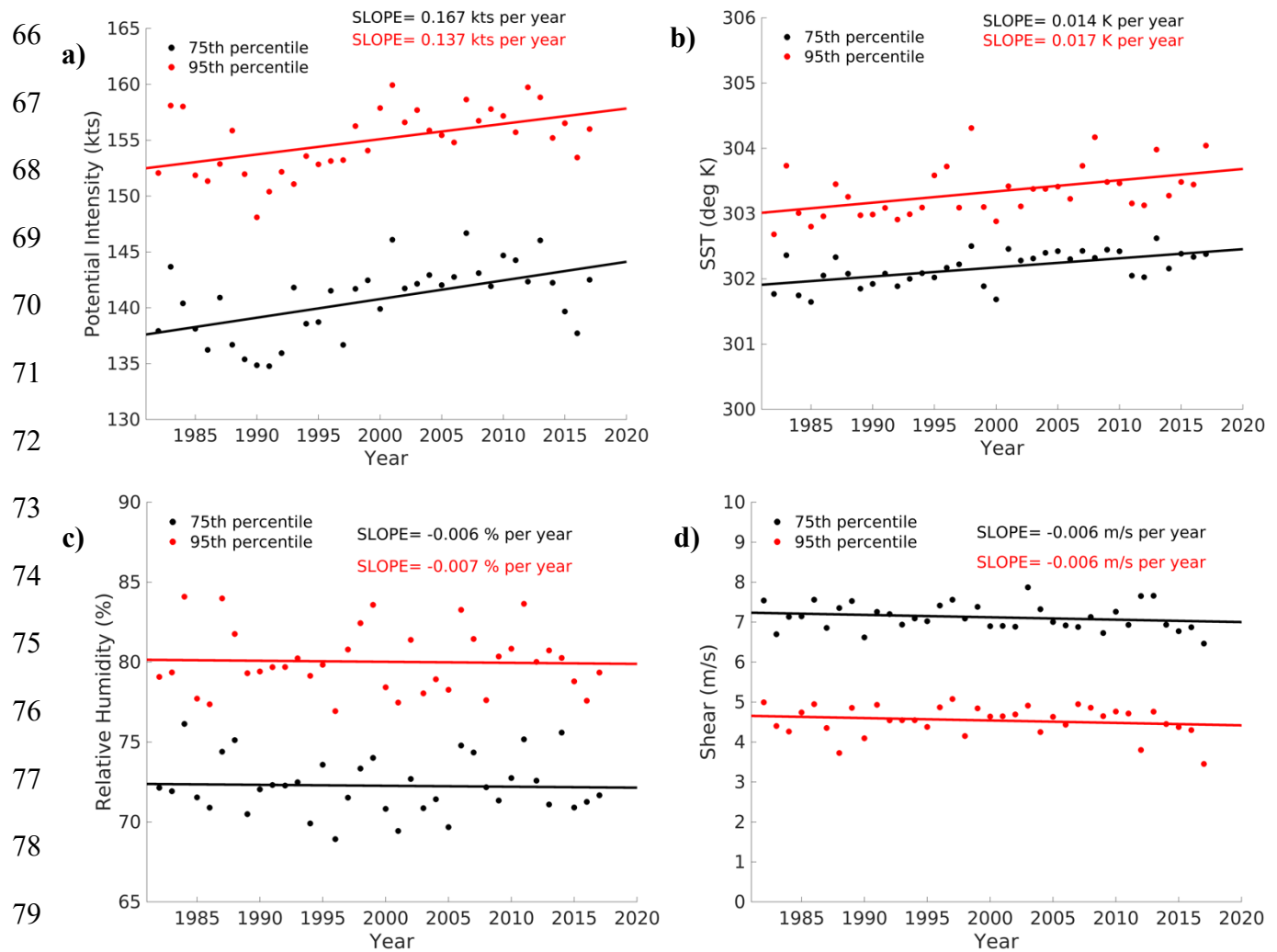
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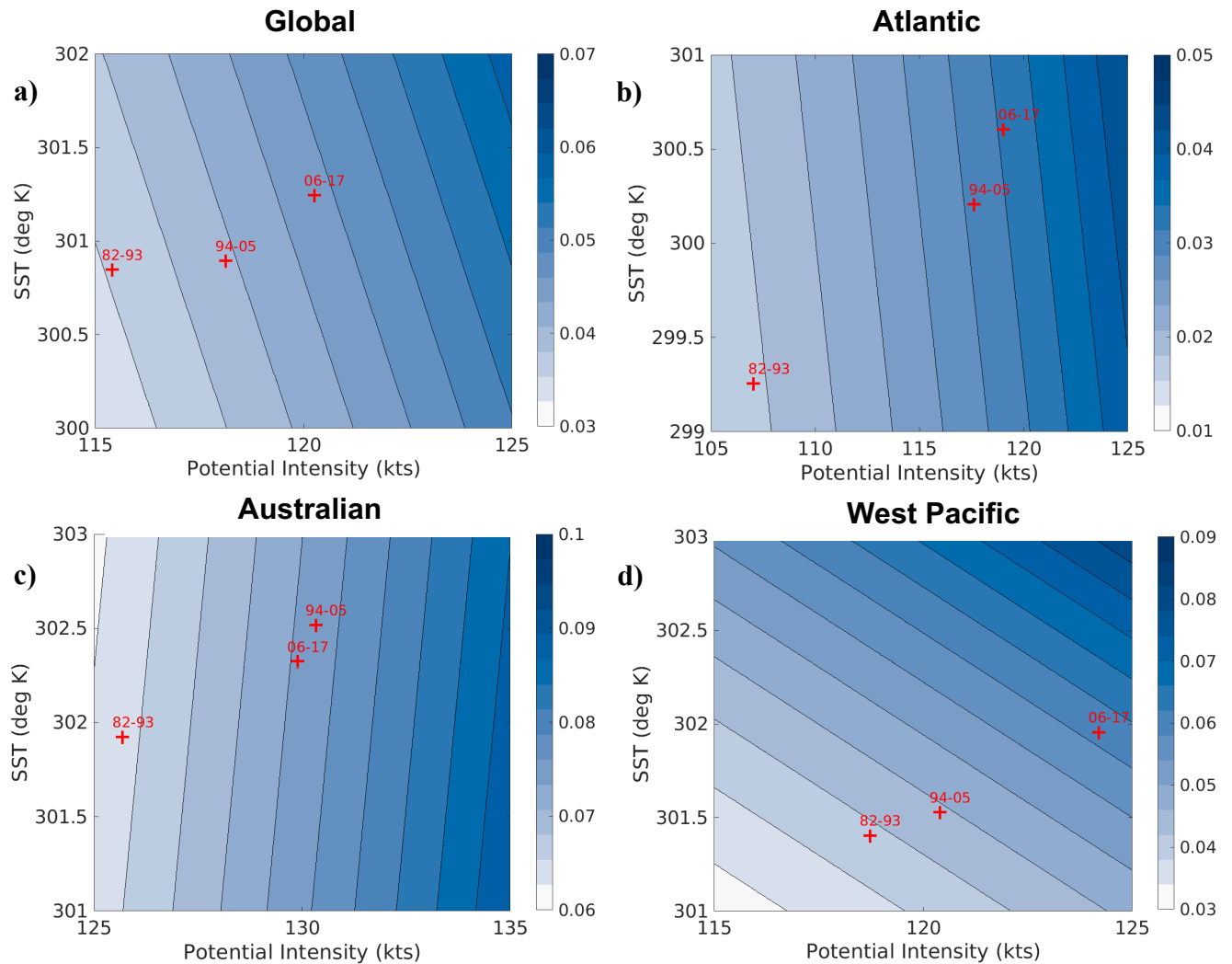
Supplementary Fig. 1: Quantile Regression

Quantile regression of 24-h intensity changes. Slope of the quantiles for 24-h intensity changes during the period 1982–2017 in four basins: (a) Global, (b) Atlantic, (c) Australian, (d) West Pacific. (a–d) Slopes are shown for IBTrACS (blue) and ADT-HURSAT (red). The squares and triangles represent the slope derived from least squares regression of intensity change as a function of year for each quantile from 0.05 to 0.95 in steps of 0.05. Shading represents the 5th and 95th percentiles of the regressions with randomly perturbed observational data (Methods).



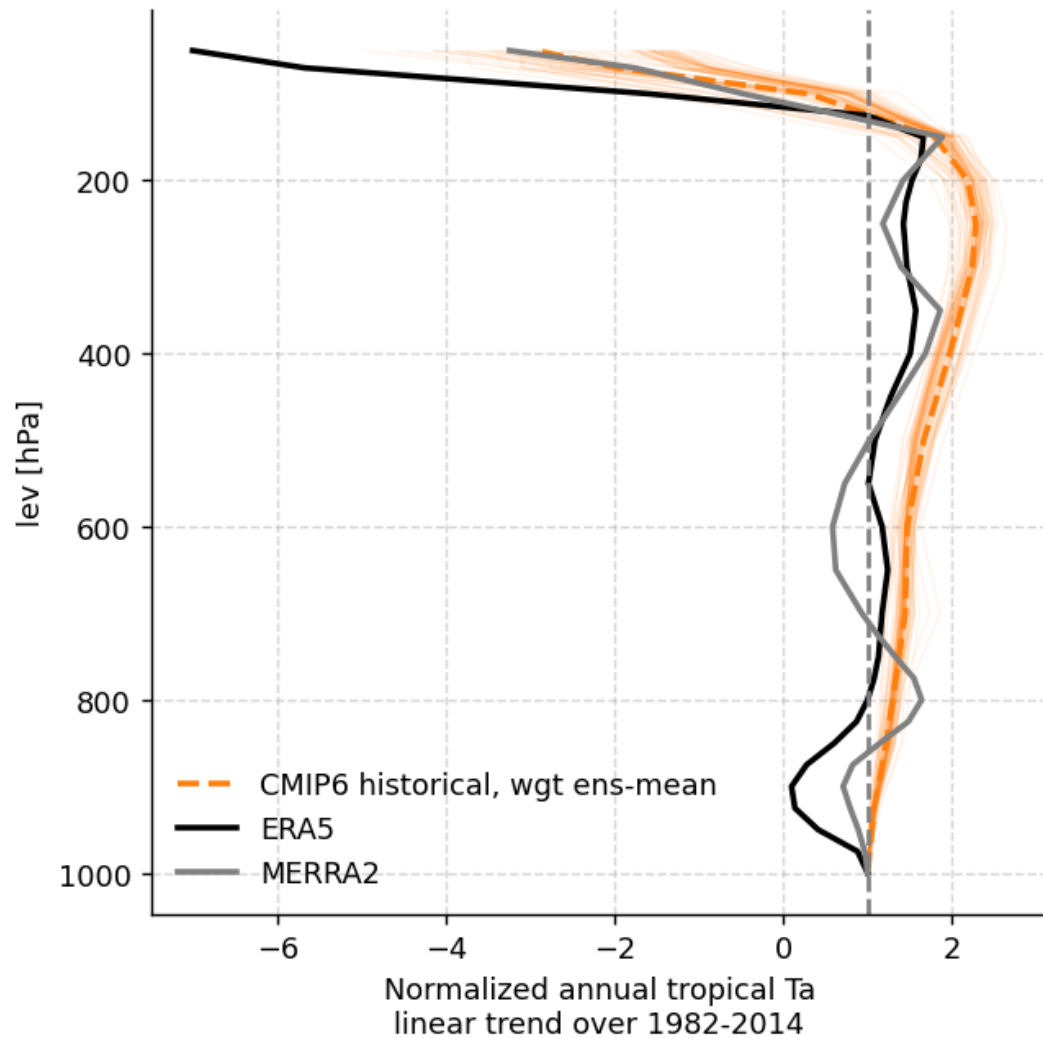
Supplementary Fig. 2: Storm-Local Environment Trends

**a-d** Observed trends in the 75<sup>th</sup> (black) and 95<sup>th</sup> percentile (red) of ERA5 storm-local environments over the 36-year period 1982–2017 using (a) potential intensity (PI) (b) sea surface temperature (SST) (c) relative humidity (RH) (d) vertical wind shear (SHR) data. The methodology used to calculate the storm-local environments is detailed in the Methods section. Annual values are denoted by dots, and the slope derived from least squares regression of annual values are included for each percentile and environmental parameter.



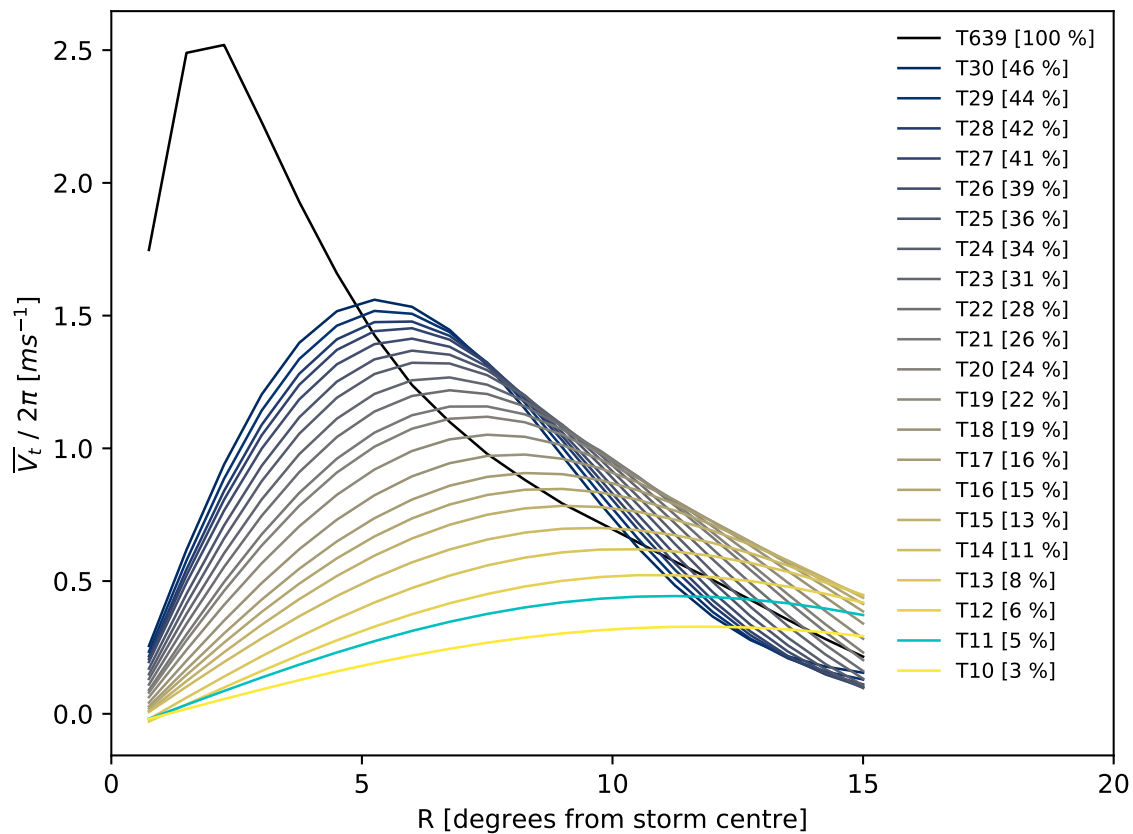
Supplementary Fig. 3: Time Evolution of the Probability of Rapid Intensification vs. Sea Surface Temperature and Potential Intensity

**a-d** The probability of IBTrACS rapid intensification (RI) in four regions: (a) Global, (b) Atlantic, (c) Australian, (d) West Pacific is contoured based on a logistic regression with two predictors, ERA5 sea surface temperature (SST) and potential intensity (PI). The contour shading represents the probability of RI with darker colors corresponding to higher probabilities of RI. The mean values of SST and PI for the first (1982-1993), second (1994-2005), and third (2006-2017) terciles are plotted as red plus signs.



Supplementary Fig. 4: Vertical Profile of Tropical-Mean Linear Trends

Trends in the tropospheric vertical profile of annual mean air temperature ( $T_a$ ) in ERA5 (black), MERRA2 (grey), and CMIP6 simulations (orange; ensemble mean is bolded, and ensemble members are dashed lines) over the period 1982–2014. Trends were computed for the ocean gridboxes between 30°N–30°S and heights ranging from 1000–50 hPa. Values for grid boxes were only included if potential intensity (PI) is available at the location for the historical, hist-nat and hist-GHG experiments. Vertical profiles were normalized by values at 1000 hPa.



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134 Supplementary Fig. 5: Spectral Filtering Sensitivity Testing

135 Tropical cyclone tangential wind ( $V_t$ ) as a function of cyclone radius ( $R$ ) for the full, native  
 136 ERA5 resolution (T639) and for truncations in the range T30–T10.  $V_t$  was computed on a radial  
 137 grid and composited for all tropical cyclones. The value in brackets gives the percentage of the  
 138 T639 circulation remaining in the spectrally filtered field, estimated by taking the difference  
 139 between the T639 and filtered fields, integrated between 0–5°. T11 was used to prepare storm-  
 140 local environments because it removed 95% of the composited tropical cyclones' circulations.

| Variable/Basin | AL        | EP        | WP        | SP        | AU        | GL        |
|----------------|-----------|-----------|-----------|-----------|-----------|-----------|
| RH             | 60.4%     | 71.9%     | 67.8%     | 68.4%     | 67.8%     | 67.4%     |
| SHR            | 9.2 m/s   | 7.9 m/s   | 9.5 m/s   | 10.9 m/s  | 10.1 m/s  | 9.3 m/s   |
| SST            | 300.8 K   | 300.4 K   | 302.0 K   | 301.7 K   | 302.4 K   | 301.4 K   |
| PI             | 129.0 kts | 130.6 kts | 132.4 kts | 132.0 kts | 133.6 kts | 131.3 kts |
| RI             | 5.3%      | 8.5%      | 8.7%      | 7.1%      | 8.5%      | 7.7%      |

Supplementary Table 1: Critical Environmental Thresholds for Each Basin

Logistic regression is used to determine critical ERA5 environment thresholds for each basin and environmental parameter. The variable “RI” corresponds to the percentage of 24-hour IBTrACS intensity changes that exceed 30 knots in each basin. A critical threshold is defined as the environmental parameter value that yields the mean probability of a 24-hr wind speed exceeding 30 knots between 1982-2017.

| Thresholds<br>Met/Basins | AL       | EP       | WP         | SP       | AU       | GL         |
|--------------------------|----------|----------|------------|----------|----------|------------|
| 0                        | 9/715    | 9/627    | 22/1873    | 6/540    | 9/427    | 41/4035    |
| 1                        | 22/1030  | 51/1617  | 108/2992   | 10/560   | 36/677   | 207/7082   |
| 2                        | 77/1404  | 121/1541 | 272/3425   | 37/498   | 85/862   | 588/8340   |
| 3                        | 91/1050  | 176/1082 | 408/2617   | 52/390   | 78/590   | 862/6222   |
| 4                        | 40/306   | 83/326   | 225/948    | 53/248   | 22/152   | 428/1925   |
| Total Cases              | 239/4505 | 440/5193 | 1035/11855 | 158/2236 | 230/2708 | 2126/27604 |

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150 Supplementary Table 2: Rapid Intensification Ratios for Different Critical Thresholds

151 Table shows the number of times that the ERA5 storm-local environmental parameters satisfied

152 each number of critical thresholds (second number) and the number of observed rapid

153 intensification (RI) events (first number) for these situations.

| Sea Surface Temperature |                                         | Potential Intensity |                                         | Relative Humidity |                                         | Wind Shear      |                                         |
|-------------------------|-----------------------------------------|---------------------|-----------------------------------------|-------------------|-----------------------------------------|-----------------|-----------------------------------------|
| Model                   | Ensemble Members<br>(Total=101 members) | Model               | Ensemble Members<br>(Total= 87 Members) | Model             | Ensemble Members<br>(Total= 97 Members) | Model           | Ensemble Members<br>(Total= 93 Members) |
| ACCESS-CM2              | 3                                       | ACCESS-CM2          | 3                                       | ACCESS-CM2        | 3                                       | ACCESS-CM2      | 1                                       |
| ACCESS-ESM1-5           | 3                                       | ACCESS-ESM1-5       | 3                                       | ACCESS-ESM1-5     | 3                                       | ACCESS-ESM1-5   | 3                                       |
| BCC-CSM2-MR             | 3                                       | BCC-CSM2-MR         | 3                                       | BCC-CSM2-MR       | 3                                       | BCC-CSM2-MR     | 3                                       |
| CESM2                   | 3                                       | CESM2               | 3                                       | CESM2             | 1                                       | CESM2           | 3                                       |
| CNRM-CM6-1              | 10                                      | CNRM-CM6-1          | 9                                       | CNRM-CM6-1        | 10                                      | CNRM-CM6-1      | 10                                      |
| CanESM5                 | 46                                      | CanESM5             | 41                                      | CanESM5           | 45                                      | CanESM5         | 38                                      |
| FGOALS-g3               | 1                                       | FGOALS-g3           | 1                                       | FGOALS-g3         | 3                                       | FGOALS-g3       | 3                                       |
| GFDL-ESM4               | 1                                       | GFDL-ESM4           | 1                                       | GISS-E2-1-G       | 5                                       | GFDL-ESM4       | 1                                       |
| GISS-E2-1-G             | 5                                       | GISS-E2-1-G         | 5                                       | HadGEM3-GC31-LL   | 5                                       | GISS-E2-1-G     | 5                                       |
| HadGEM3-GC31-LL         | 5                                       | HadGEM3-GC31-LL     | 5                                       | IPSL-CM6A-LR      | 10                                      | HadGEM3-GC31-LL | 5                                       |
| IPSL-CM6A-LR            | 10                                      | IPSL-CM6A-LR        | 10                                      | MIROC6            | 3                                       | IPSL-CM6A-LR    | 10                                      |
| MIROC6                  | 3                                       | MIROC6              | 3                                       | MRI-ESM2-0        | 5                                       | MIROC6          | 3                                       |
| MRI-ESM2-0              | 5                                       |                     |                                         | NorESM2-LM        | 1                                       | MRI-ESM2-0      | 5                                       |
| NorESM2-LM              | 3                                       |                     |                                         |                   |                                         | NorESM2-LM      | 3                                       |

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155     Supplementary Table 3: CMIP6 Models and Ensemble Members for Analysis

156     Table shows the CMIP6 models and ensemble members used for tropical-mean comparisons for

157     each environmental variable. To be included in the sample, each model required an ensemble

158     member for historical, hist-nat, and hist-GHG simulations.