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5 **Increased North Atlantic Tropical Cyclone Risk in the Wake of a "Super" El Niño**
6 **Event**

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37 Increased North Atlantic Tropical Cyclone Risk in the Wake of a “Super” 38 El Niño event

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51

52 **Abstract**

53 The El Niño-Southern Oscillation (ENSO) is among the most influential modes of climate variability on
54 Earth, dramatically reshaping global weather patterns. It is therefore a key driver of regional extremes
55 and has been recognized as a key risk predictor for a wide range of natural hazards, from drought and
56 wildfire to extreme rainfall and flooding. Considerable attention has been paid to the role El Niño plays
57 in suppressing same-season North Atlantic hurricane activity, but relationships at longer lead times have
58 been less studied despite considerable potential preparedness and planning implications. In 2026,
59 multi-model predictive ensembles are indicating a high likelihood of an exceptionally strong El Niño
60 event by autumn, offering a rare opportunity to deliver new insights regarding multi-year hurricane risk
61 with near real-time relevance. Here, we report findings drawn from a tropical cyclone probabilistic event
62 set conditioned by large ensemble climate model simulations (CESM2-LENS). We find that strong El
63 Niño events more than double the baseline likelihood (+120%) of La Niña conditions in the subsequent
64 year, and are therefore a leading (year-ahead) indicator of increased United States hurricane landfall
65 risk. Based on current (June 2026) operational ENSO forecasts, we further find that the risk of US
66 landfalling major hurricanes in 2027 may be considerably higher than baseline (+23%) following
67 decreased risk in 2026 (-28%). These are actionable findings across both the public and private sectors,
68 which have expressed growing interest in physically grounded, multi-year risk estimates to inform timely
69 decisions beyond the present year.

70

71 **Introduction**

72 The El Niño–Southern Oscillation (ENSO) is among the most consequential modes of natural climate
73 variability on Earth, altering global weather patterns and thereby modulating risk across a wide range
74 of natural hazards, including tropical cyclones, droughts, wildfires, and extreme rainfall. Its effect on
75 North Atlantic tropical cyclone (TC) activity is one of the most robust teleconnections in tropical
76 meteorology (1). During ENSO warm phase (El Niño) events, fewer than average TCs typically occur
77 in the Atlantic basin (1-2) due to enhanced upper-tropospheric vertical wind shear, which is highly
78 unfavourable for TC genesis and intensification. Conversely, ENSO cool phase (La Niña) events
79 strongly favour active Atlantic TC seasons due to reduced wind shear. This relationship plays a

80 prominent role in probabilistic seasonal forecasting of Atlantic hurricane risk, widely used by
81 governments and the insurance industry to support disaster preparedness and financial decisions.

82
83 From a climate system perspective, El Niño events liberate years' worth of energy stored in the
84 subsurface tropical Pacific Ocean into the atmosphere, where it is subsequently dissipated. This
85 contributes to elevated global temperatures and induces large-scale thermal imbalances that can
86 substantially alter atmospheric circulation. In doing so, ENSO behaves as a semi-periodic recharge
87 oscillator (3, 4) in which major warm (El Niño) events prime the ocean-atmosphere coupled system
88 toward subsequent cool (La Niña) conditions by depleting the Pacific subsurface warm water reservoir.
89 Once depleted, the coupled system tends to overshoot its equilibrium, leading to an increased likelihood
90 of La Niña conditions not only in the immediate aftermath, but for several years thereafter (5) —
91 favourable to elevated Atlantic TC activity.

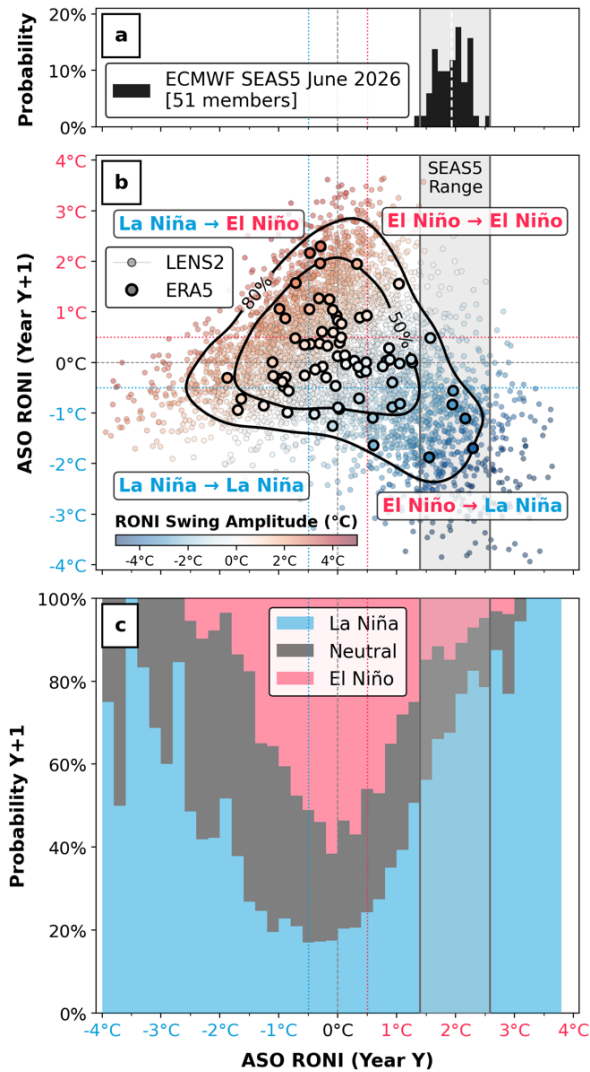
92
93 Despite this, comparatively less attention has been paid historically to the subsequent multi-year
94 downstream consequences of strong El Niño (SEN) events for Atlantic TC risk. In the observed historical
95 record, very strong (so-called “super”) El Niño events are rare but consequential in this respect. Whether
96 this small historical sample reflects a physically robust and predictable pattern rather than coincidence,
97 however, has not to date been rigorously tested — largely because current operational seasonal
98 predictions address only the present year. Yet reinsurers, capital providers, infrastructure operators,
99 and public agencies increasingly require physically grounded views of extreme risk on multi-year
100 horizons that current outlooks cannot provide; there is, therefore, a pressing practical imperative to
101 extend credible TC risk estimates one to two years ahead.

102
103 As of June 2026, a broad consensus has emerged among most national climate predictive services that
104 a SEN event is likely to emerge during the Atlantic hurricane season. The current situation thus offers
105 a rare opportunity, and clear motivation, to leverage the inherent predictability of ENSO to characterise
106 the probabilistic multi-year TC hazard trajectory that typically follows, and to translate that trajectory into
107 actionable risk estimates. This Brief Report seeks to answer the following questions: (1) What is the
108 probabilistic evolution of ENSO in the years following a strong El Niño event? and (2) What are the
109 implications for North Atlantic hurricane risk in the years following (i.e., 2027 and 2028) should a very
110 strong El Niño event ultimately materialise in 2026?

111 112 **Results**

113 We find clear evidence, using both observational and climate model-based perspectives, that El Niño
114 events in general (and very strong events in particular, like the predicted 2026 event) significantly shift
115 the ENSO probability distribution during the subsequent 1-2 years to favour La Niña conditions, and
116 therefore increase United States hurricane risk during that period. SEAS5 (6) Ensemble forecasts
117 initiated in June 2026 for Aug-Oct (ASO) 2026 indicate very high probability (95%) of at least a strong
118 event (i.e., Relative Oceanic Niño Index RONI>1.5C), with nearly half (45%) of members reaching so-
119 called “Super” El Niño territory (RONI>2C; Fig. 1a). Observational data (ERA5 Reanalysis - 7) and
120 climate model simulations (CESM2-LENS - 8) both demonstrate a clear asymmetric distribution of
121 temporal evolutions: strong positive ASO RONI in current year is followed almost exclusively (90% of
122 years) by neutral-to-negative ENSO in the subsequent year whereas El Niño persistence is rare (10%
123 of years) (Fig. 1b). The strongest El Niño events are generally associated with the largest ENSO
124 amplitude swings, as well as the strongest subsequent year La Niña events, despite considerable
125 variability (Fig. 1b). In CESM2-LENS, an ASO RONI of 1.5-2.5C (the predicted range in 2026) is

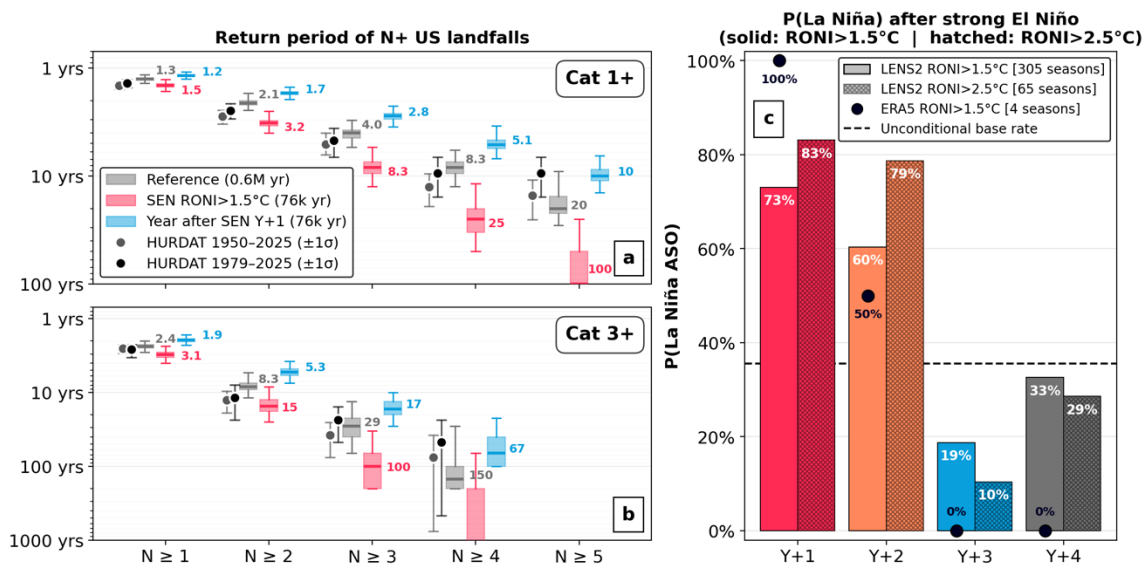
126 associated with ~55-78% probability of subsequent La Niña conditions (Fig. 1c), approximately double
 127 the ~34% baseline likelihood.
 128



129

130 **Figure 1. Year-ahead El Niño-Southern Oscillation (ENSO) phase predictability from current-**
 131 **season Aug-Oct (ASO) Relative Oceanic Nino Index (RONI).** (a) Forecast distribution for ASO
 132 2026 RONI values from the ECMWF SEAS5 ensemble (using June 2026 initial conditions). The grey
 133 shaded region represents the forecast range; over 95% SEAS5 members indicate a strong El Niño
 134 during ASO 2026. (b) Year-ahead (Y+1) ASO RONI (vertical axis) as a function of current year (Y)
 135 ASO RONI (horizontal axis) across the CSM2-LENS climate model large ensemble (1950-2025).
 136 Scatterplot points are coloured according to inter-annual ASO RONI swing amplitude (reds (blues)
 137 denote positive (negative) changes), and observed data (ERA5 reanalysis, 1950-2024, overlaid as
 138 large circles). Black contours outline the region containing 50% and 80% of the CSM2-LENS data
 139 after applying a Kernel Density Estimate. (c) Year-ahead probability of La Niña, Neutral and El Niño
 140 conditions (vertical axis) as a function of current-year ASO RONI (horizontal axis). Vertically oriented
 141 grey bands across each panel represent the SEAS5 2026 predicted range (1.4C-2.6C; mean =1.93C),
 142 which implies a ~55-78% probability of La Niña conditions during ASO 2027. Vertical dashed lines
 143 denote the NOAA-defined RONI threshold for El Niño (red, $\geq +0.5$) and La Niña (blue, ≤ -0.5)
 144 events.

145 We further demonstrate, using the climate-connected UTC stochastic TC event set (9), that the
 146 increased probability of La Niña following SEN events translates to heightened North Atlantic hurricane
 147 landfall risk – with the greatest increases occurring for the rarest and most potentially consequential
 148 events. We confirm prevailing understanding that SEN events decrease same-year ASO risk (-19% for
 149 all landfalls and -28% for major hurricane landfalls - Figs. 2a,b), but also newly demonstrate that the
 150 subsequent “La Niña rebound effect” is associated with a comparably large increase in year-following
 151 risk (+22% for major hurricane landfalls, reaching +30% for “Super” El Niño events specifically).
 152 Additionally, we find that the increased probability of La Niña persists, albeit to a lesser degree, in the
 153 second year following a SEN event (Fig. 2c) – suggesting that North Atlantic hurricane risk can remain
 154 elevated for multiple consecutive years.
 155



156 **Figure 2. Risk of hurricanes landfalling risk in the United States (US) during and following**
 157 **strong El Niño (SEN) events.** (a) Return period associated with N or more US landfalls in a season
 158 at or above Saffir-Simpson Category 1 intensity during the reference period (1979-2025, grey), SEN
 159 years (red) and the year following SEN years (blue) as estimated by the UTC model (9). Boxes show
 160 bootstrapped uncertainty ($\pm 1\sigma$) across equal-size blocks of 200 stochastic years; grey and black
 161 circles show NOAA/HURDAT (12) observed return periods for 1950-2025 and 1979-2025,
 162 respectively. (b) Same as a, but for major hurricanes only (\geq Category 3). (c) Probability of La Niña in
 163 ASO at multi-annual time horizons (Y+1 to Y+4) after SEN and “Super” El Niño events (left and right
 164 vertical bars, respectively) in the CESM2-LENS large ensemble and in observations (ERA5; black
 165 dots representing four historical years meeting the criterium). The black dashed horizontal line
 166 represents the climatological average La Niña likelihood.
 167
 168
 169

170 **Discussion**

171 Here, we present new findings regarding the conditional multiyear-ahead predictability of ENSO and its
 172 subsequent effect on North Atlantic TC risk. SEN events substantially increase the risk of landfalling
 173 hurricanes in the United States in the following year due to the more than doubled likelihood of La Niña
 174 conditions. This “rebound effect” is observed both in the real world and in climate model simulations,
 175 and the effect size scales with the intensity of the event, with the greatest risk profile shift occurring at
 176 the upper end of the hurricane landfall intensity and frequency distribution. By leveraging the large
 177 synthetic sample size of strong El Niño events occurring in a 51-member climate model large ensemble

178 containing hundreds of simulated SEN events, we can discern much clearer relationships than would
179 be possible if considering only the handful present in the observed record.

180

181 Our key results are as much operational as scientific. The ENSO signal is one of the most physically
182 grounded global-scale drivers of extreme weather and natural hazard risk, extending far beyond the
183 North Atlantic basin and to phenomena as diverse as wildfire and severe convective storms (10, 11). It
184 has thus become a predictor routinely relied upon by forecasters, (re)insurers, and public agencies to
185 anticipate and prepare for the season ahead. Our analysis suggests that it may be possible to push the
186 useful horizon of physical risk estimates into a window that existing seasonal outlooks do not cover: the
187 year ahead, and possibly beyond. Such longer lead times could enable more efficient governmental
188 pre-allocation of disaster mitigation and response resources as well as capital allocation in (re)insurance
189 markets, since present-day seasonal outlooks often arrive too late to be fully incorporated into decision-
190 making. This may be especially relevant for North Atlantic TC risk as the strongest signal emerges for
191 the most extreme events – precisely the “tail scenarios” that drive both insured losses and broader
192 societal risk.

193

194 Finally, the timeliness of our analysis is underscored by the high likelihood of a strong, or even very
195 strong to historic, El Niño event in 2026. Should such forecasts come to fruition, the global societal and
196 economic impacts will likely be considerable. Our analysis here implies that impacts arising from the
197 subsequent ENSO rebound effect could linger for a year or more, potentially offering the silver lining of
198 year-ahead predictability for hazards including North Atlantic TC landfalls that will hopefully prove useful
199 in mitigating and responding to extreme events.

200

201 **Materials and Methods**

202 We use current-year operational seasonal predictions (ECMWF SEAS5 ensemble, 6), single-model
203 large ensemble simulations for the historical period (CESM2-LENS, 8), and historical observations
204 (ERA5 Reanalysis for 1950–2025, 7) to quantify ENSO evolution following observed and simulated El
205 Niño events. We adopt the Relative Oceanic Niño Index (RONI) as a primary metric of ENSO amplitude
206 and define a SEN as August–October (ASO) RONI > 1.5 °C. To evaluate US landfall risk, we use the
207 climate-connected Unified Tropical Cyclone (UTC) model (9) to generate a stochastic tropical cyclone
208 catalogue driven by CESM2-LENS climate. Results are expressed as the return period for experiencing
209 N or more landfalls in a single season. Observed return periods from the NOAA/HURDAT US landfall
210 record (12) for two periods (1950–2025 and 1979–2025) are also displayed in Figure 2 to facilitate
211 comparison to UTC-derived values. Additional details can be found in the Extended Methods section
212 contained in the Supplementary Information file.

213

214 **Data availability:** A public archive with the re-gridded bias corrected RONI index used with the source
215 code to generate the analysis and visual are available in [10.5281/zenodo.20933752](https://zenodo.org/record/20933752). The stochastic
216 tropical cyclone event set is part of Reask’s proprietary UTC product, which can be licensed from Reask
217 (for commercial purposes) and will be made available upon reasonable request for expressly non-
218 commercial scientific research purposes by contacting Nicolas Bruneau (nico@reask.earth).

219

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223 visualizations used in this publication and assume full responsibility for the accuracy and integrity of the
224 code, data presentation, and final manuscript content.

225 **Author Contributions:** NB, RD, DLS, HC and TL jointly designed the analysis described in this study.
226 NB implemented most of the analysis, performed the simulations, and generated visualisations. NB,
227 RD, DLS, HC and TL jointly prepared the manuscript and discussion.

228 **Competing Interest Statement:** NB and TL are employed by Reask, a climate risk company that
229 provides climate-adjusted tropical cyclone catastrophe modelling and real-time forecasting tools to
230 insurers, reinsurers, and financial institutions. RD and HC are employed by OAK Global, a London-
231 based specialist (re)insurance underwriting group operating in the Lloyd's market. OAK Global is a client
232 of Reask. DLS serves as an advisor to multiple entities (including Reask, Inigo, and ClimateCheck) on
233 topics related to natural hazards and climate change. DLS's work on this manuscript was partially
234 supported by Reask.

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263 **Supplementary Information: Extended Methods**

264 **Climate data**

265 Three monthly datasets are used in this study:

- 266 • ERA5 Reanalysis (1) for 1950-2025, gridded historical observations.
- 267 • CESM2-LENS (2), single-model large ensemble simulations for the same historical period. Only
268 the 50-member Smoothed Biomass Burning simulations are used. CESM2-LENS simulations
269 offer physically consistent realisations while preserving the year-to-year physical variability).
- 270 • ECMWF SEAS5 (3) operational seasonal predictions initialised in June 2026. The ECMWF
271 SEAS5 June 2026 forecast (51 members) is used to place the current event within this
272 distribution.

273 CESM2-LENS model represents many aspects of ENSO well: its dominant timescale, tropical and
274 extratropical precursors, the composite evolution of El Niño and La Niña events, and ENSO
275 teleconnections (4). The principal bias is amplitude: ENSO is about 30% stronger than observed (larger
276 still in the historical ensemble), with peak variability displaced toward the central rather than eastern
277 Pacific, which limits the diversity of simulated El Niño patterns. We therefore use CESM2-LENS to
278 characterise El Niño-to-La Niña transitions while acknowledging this amplitude bias.

279 All monthly data sets have been re-gridded to a 1-degree latitude / longitude grid while CESM2-LENS
280 and ECMWF SEAS5 have been bias-corrected to ERA5 over the 1980-2020 period; a mean bias
281 correction is applied pixel-wise monthly; no standardisation is applied. The bias correction is then
282 applied to each member separately, ensuring that: on average, all the members are unbiased to ERA5
283 over the period 1980–2020, while retaining the relative variability of each member. This constitutes the
284 input climate data of the UTC stochastic model detailed below.

285 As an informal sensitivity test, we also ran the analysis with or without re-gridding and bias correction.
286 While final values do vary from year to year, the outcomes and strength of the findings were also
287 insensitive to this choice (around +/- 1% in probability of La Niña in year Y+1 conditioned to an ASO
288 SEN in year Y). We have also run the analysis using a different sea surface temperature (SST) dataset,
289 the NOAA Extended Reconstruction SSTs Version 5 (ERSSTv5 (5) vs ERA5).

290

291 **Relative Oceanic Niño Index (RONI) analysis**

292 To quantify the strength and evolution of ENSO for both observed and simulated El Niño events, we
293 adopt the Relative Oceanic Niño Index (RONI), which removes the long-term tropical-mean warming
294 trend, and recently has been adopted as NOAA's operational ENSO (6), as a primary metric of ENSO
295 amplitude and define a SEN as August–October (ASO) RONI > 1.5 °C. RONI swing amplitude is
296 calculated as the simple difference between consecutive calendar years. The stack histogram in Figure
297 1c is computed on 0.1C equal bins.

298 **US Landfall risk**

299 To evaluate US landfall risk, the climate-connected UTC model (7) has been forced by the bias-
300 corrected 50 smoothed biomass burning CESM2-LENS members to generate a stochastic tropical-
301 cyclone catalogue (250 stochastic seasons per member-year, resulting in about 600k stochastic years);
302 we focus on the satellite-era 1979-2025. We count distinct storms crossing the US coastline (50 miles
303 coastal gates) at Category-1+ ($\geq 33 \text{ m s}^{-1}$) and Category-3+ ($\geq 50 \text{ m s}^{-1}$) intensity. We compare three
304 populations: the climatological reference (all years), strong-El Niño years (Y with ASO RONI > 1.5C),
305 and the years immediately after (Y+1). Results are expressed as the return period for experiencing N

306 or more landfalls in a single season (counting only the maximum intensity at landfall for storms with
307 multiple landfalls).

308 Uncertainty is estimated by bootstrapping 200-year blocks of stochastic activity, so all three populations
309 are compared on equal sample sizes. Observed return periods from the NOAA/HURDAT US landfall
310 record (8) for two periods (1950–2025 and 1979–2025) are overlaid with $\pm 1\sigma$ bootstrap ranges for
311 informative purposes.

312 We note that the projection for present and future landfall rates and return periods is only driven by the
313 ENSO filtering here and we do not enforce particular SSTs, vertical wind shear, or steering flows in it as
314 we would in a seasonal forecast application where the UTC model would be directly forced by the
315 ECMWF SEAS5 6-month lead forecast.

316 **Data availability**

317 A public archive with the re-gridded bias corrected RONI index used with the source code to generate
318 the analysis and visual are available in 10.5281/zenodo.20933752. The stochastic tropical cyclone
319 event set is part of Reask's proprietary UTC product, which can be licensed from Reask (for commercial
320 purposes) and will be made available upon reasonable request for expressly non-commercial scientific
321 research purposes by contacting Nicolas Bruneau (nico@reask.earth).

322 The different public datasets used in this study can be accessed at:

323 - ERA5: [https://cds.climate.copernicus.eu/datasets/reanalysis-era5-single-levels-monthly-](https://cds.climate.copernicus.eu/datasets/reanalysis-era5-single-levels-monthly-means?tab=overview)
324 [means?tab=overview](https://cds.climate.copernicus.eu/datasets/reanalysis-era5-single-levels-monthly-means?tab=overview)

325 - ECMWF SEAS5: [https://cds.climate.copernicus.eu/datasets/seasonal-monthly-single-](https://cds.climate.copernicus.eu/datasets/seasonal-monthly-single-levels?tab=overview)
326 [levels?tab=overview](https://cds.climate.copernicus.eu/datasets/seasonal-monthly-single-levels?tab=overview)

327 - CESM2-LENS: <https://www.cesm.ucar.edu/community-projects/lens2>

328 - ERSSTv5: [https://climatedataguide.ucar.edu/climate-data/sst-data-noaa-extended-](https://climatedataguide.ucar.edu/climate-data/sst-data-noaa-extended-reconstruction-ssts-version-5-ersstv5)
329 [reconstruction-ssts-version-5-ersstv5](https://climatedataguide.ucar.edu/climate-data/sst-data-noaa-extended-reconstruction-ssts-version-5-ersstv5)

330 - Hurricane US landfalls: https://www.aoml.noaa.gov/hrd/hurdat/All_U.S._Hurricanes.html

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