THE HONEST BROKER

US Extreme Weather and Climate Change Dashboard

Methodology & Sources — data provenance, detection framework, reliable-trend windows, and known limitations for every variable tracked.

A project by Roger Pielke Jr., author of The Honest Broker

Detection Framework

This dashboard evaluates every variable against the Intergovernmental Panel on Climate Change's (IPCC) own framework for detecting a change in climate — not an informal read of whether a chart's line trends up or down.

Detection is the process of demonstrating that climate, or a system affected by climate, has changed in a defined statistical sense, without providing a reason for that change. An identified change is detected in observations if its likelihood of occurrence by chance due to internal variability alone is small — IPCC's glossary gives <10% as an example threshold. Attribution, evaluating the relative contribution of specific causal factors, is a separate, larger undertaking (typically requiring climate model simulations run with and without a given forcing) that this project does not perform. Nothing in this document or on the site is an attribution finding.

Trend statistics use the Mann-Kendall test and Sen's slope — nonparametric methods that don't assume normally distributed data, standard in the climate-trend literature. A trend is called statistically significant only at $p < 0.10$, matching IPCC's stated example threshold rather than the more common $p < 0.05$ convention.

A trend that clears IPCC's likelihood criterion alone is not automatically labeled a "Detected Change" on this site. IPCC's glossary text is a likelihood definition and does not itself specify a magnitude threshold, so a second, disclosed check is applied: the trend's total fitted change (Sen's slope × window length) must also be at least 25% of the variable's 90% ("very likely") historical range — the same band shown as shading on each chart. A trend that is statistically real but small next to normal variability is reported as such, not smoothed into an unqualified "detected" label. The 66%/90% shading itself follows IPCC's calibrated-language convention ("likely" / "very likely"), computed as the 17th–83rd and 5th–95th percentile range of observed values within the selected window — a reference envelope for how much a variable normally varies, not a forecast interval.

Each panel defaults to a documented reliable-trend window — the span of the record over which a variable's measurement is genuinely comparable year to year, given instrumentation and methodology changes (Doppler radar deployment, satellite-based measurement, reference-network construction) — but every window can be widened or narrowed on the site itself.

Heat Waves

Source: NOAA GHCN-Daily, ~1,218-station HCN reference network (ncei.noaa.gov/pub/data/ghcn/daily) | Reliable window: 1895–present

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The heat wave index is built directly from station records rather than NOAA's originally named source (the Accumulated Heat Wave Index), which turned out to be a frozen analysis that stopped updating in 2021. A per-station 90th-percentile trailing-4-day-mean threshold stands in for the original Kunkel et al. method, whose exact statistical procedure was never made fully public. 1895 is the year station density first becomes nationally meaningful.

Complementary metrics

- **TXx** — the single hottest daily high temperature each year (IPCC AR6/ETCCDI standard, no percentile threshold).
- **WSDI** (Warm Spell Duration Index) and **TN90p** (warm nights) — ETCCDI/CLIMDEX standard indices against a fixed base period.
- **NOAA nClimGrid-Daily comparison** — the same TXx/WSDI definitions run on a homogenized, spatially averaged national series rather than raw per-station data, to check whether a detection verdict is robust to the choice of underlying dataset. The two constructions can genuinely disagree: per-station TXx shows a detected decrease over its full 1895–2025 record (anchored by the 1930s Dust Bowl), while the shorter (1951–present) nClimGrid-Daily series shows a detected increase, consistent with IPCC's "since the 1950s" framing. WSDI on the homogenized series is this dashboard's headline heat-wave detection metric.

Tornadoes & Hail

Source: NCEI Storm Events Database (ncei.noaa.gov/stormevents) | Reliable window: 1997–present (tornadoes)

Storm Events records one row per county a tornado's path crosses, not one row per physical tornado. Physical tracks are reconstructed by chain-merging county-segment rows whose begin/end coordinates and timing align, before any counting takes place. This reconstruction is validated against the well-documented 1974 Super Outbreak (7 F5s) and the 2011 Super Outbreak (6 EF5s); the pre-reconstruction row count had overstated both severely. 1997 is the empirically identified point where the NEXRAD Doppler radar deployment (1988–1997) settles the annual count into a new, sustained level.

Hail has no reliable trend window at any point in its record. Report counts track population density, spotter-network growth, and reporting practice far more than any real climate signal — NCA5 (2023) states the hail trend is still not confidently quantified.

Complementary metrics

- **Tornado days** — distinct calendar days with at least one tornado, less sensitive to the NEXRAD-era detection artifact than a raw count; reliable from 1954.
- **Outbreak size** — mean tornado count on 6+-tornado days (Galway 1977; Tippett, Lepore & Cohen 2016).
- **CAPE-based instability** (ERA5 reanalysis) — an environment-based proxy independent of human reports, reliable from 1979 (the start of satellite data assimilation). CAPE alone, without wind shear, is not a tornado-probability index.

Flooding (Streamflow)

Source: USGS NWIS daily discharge, HCDN-2009/GAGES-II reference gauges (waterservices.usgs.gov/nwis/dv) | Reliable window: 1957–present

The headline index is the percentage of the 741–742 HCDN-2009 reference gauges — a curated network minimally altered by dams, diversions, or urbanization — currently at or above their own historical 90th percentile for the day of year. 1957 is the first year weekly network coverage never drops below 50% of the full gauge network.

Complementary metrics

- **Peak flow** (Annual Maximum Series) — the traditional USGS flood-frequency-analysis construction: the share of gauges whose single highest daily discharge that year exceeded that gauge's historical 90th percentile of annual peaks.
- **Heavy precipitation extremes** (Rx1day/Rx5day) — standard ETCCDI indices from station precipitation data, a distinct construction from streamflow with meaningfully higher IPCC AR6 detection confidence, since station precipitation is not confounded by dams, diversions, or land-use change the way streamflow is. Heavy precipitation is not the same as flooding: AR6 WG1 Ch.11 states "there is not always a one-to-one correspondence between an extreme precipitation event and a flood event, or between changes in extreme precipitation and changes in floods."

Drought

Sources: US Drought Monitor (droughtmonitor.unl.edu), NOAA nClimDiv PDSI, USGS NWIS | Reliable window: full downloaded record for each product

The headline series is the US Drought Monitor's weekly D2+ ("severe drought or worse") categorical area percentage, available from 2000. USDM's five native categories (D0 abnormally dry through D4 exceptional drought) are cumulative in the source data, and every category is independently selectable on the site. The Palmer Drought Severity Index (PDSI), a single meteorological/soil-moisture index from NOAA's nClimDiv product, is used as a long-record context layer back to 1895.

Complementary metrics

- **SPEI** (Standardized Precipitation-Evapotranspiration Index) — an independently derived drought index computed from GHCN-Daily temperature and precipitation, using the Hargreaves PET formula rather than PDSI's formula, since PDSI's formula has been documented to overstate warming-driven drying (Milly & Dunne 2017).
- **Low-flow** (hydrologic drought) index — the mirror image of the flooding page's high-flow index: the share of HCDN-2009 reference gauges at or below their own historical 10th percentile for the day of year, a runoff-based drought signal distinct from precipitation/soil-moisture measures.

Winter Storms

Source: NCEI Regional Snowfall Index (ncei.noaa.gov/access/monitoring/rsi), live ArcGIS REST service | Reliable window: 1950–present

RSI scores each significant winter storm on spatial extent, snowfall amount, and population affected, in each of six fixed US regions. The headline metric counts Category 3+ (major) storms rather than the raw storm count, which likely conflates a real signal with growth in the observing network over time. RSI's catalog has a genuine multi-month reporting lag; a current-season figure will typically be incomplete for several months after a given winter.

Complementary metrics

- **Heavy snowfall days** — station-level physical snowfall extreme (GHCN-Daily), mean days per year a station's snowfall crosses its 90th-percentile threshold, restricted to a snowy-climate station subset.
- **Cyclone minimum pressure / peak wind** — from the CEDA extratropical cyclone track catalog (Gray et al. 2024). Fritzen, Lang & Gensini (2021), an independent, peer-reviewed NARR-based climatology, found no significant East Coast bomb-cyclone trend. The CEDA catalog was found to be intensity-pre-filtered (64% of all its tracks are bomb cyclones, versus ~7% in Fritzen et al.'s unfiltered data), which invalidates a raw count from it as a frequency measure — pressure and wind, which measure severity rather than frequency, remain informative about the pre-filtered population the catalog retains.

Wildfire

Sources: MTBS (mtbs.gov), NIFC (nifc.gov) | Reliable window: 1984–present (MTBS), 1983–present (NIFC)

Two independent products, shown as separate panels rather than merged: MTBS (Monitoring Trends in Burn Severity) measures satellite-derived burned area from Landsat, available from 1984, when its homogeneous methodology began. NIFC (National Interagency Fire Center) measures fire count from official reporting, available from 1983; NIFC's live data does not extend before 1983 at all. MTBS's most recent year typically lags NIFC's by 1–2 years due to satellite QA processing time.

Complementary metrics

- **Large-fire count** — MTBS fires of 1,000+ acres, a large-fire-specific complement to NIFC's total count, which is dominated by small fires.
- **Fire season length** — the 5th–95th percentile span of large-fire ignition day-of-year, resistant to single-outlier distortion.
- **Fire weather** (Vapor Pressure Deficit) — from gridMET (University of Idaho Climatology Lab), a fire-weather driver metric independent of fire suppression, fuel management, or wildland-urban-interface growth, and the metric the wildfire climate-attribution literature (Abatzoglou & Williams 2016) centers on.

Tropical Cyclones (US-Landfalling Hurricanes)

Source: NHC HURDAT2 Atlantic best track (nhc.noaa.gov/data/hurdat) | Reliable window: 1900–present (landfall counts/ACE), 1982–present (rapid intensification)

Continental US landfalls (Alaska, Hawaii, and Puerto Rico excluded) are detected geometrically against a real US land polygon rather than read from HURDAT2's landfall flag, which has documented gaps — 11 well-known 1971–1980 landfalls it misses entirely. A storm making more than one continental US landfall is counted once per landfall. Category is assigned from the exact landfall fix's wind, not a storm's peak wind at any other point in its life.

Complementary metrics

- **Accumulated Cyclone Energy** (ACE) — full-lifetime ACE of each landfalling storm, attributed to its landfall year.
- **Rapid intensification** — landfalling storms with a 30kt+ wind increase within any 24-hour period (Kaplan & DeMaria 2003), reliable from 1982 given the accuracy this metric requires from two closely spaced wind estimates.
- **Landfalling storm rainfall** — peak storm-total rainfall from NOAA's Weather Prediction Center, reliable from 1970.

Loss Normalization

Sources: Weinkle et al. (2018) [hurricanes]; Simmons, Sutter & Pielke Jr. (2013) [tornadoes]; Downton, Miller & Pielke Jr. (2005) [floods] | Coverage: 1900–2025 (hurricanes), 1950–2025 (tornadoes), 1903–2025 (floods)

A disaster loss "normalization" asks what a historical storm, tornado outbreak, or flood would cost if it happened today, adjusting for the fact that there is simply more built up, more populated, and more valuable property in harm's way now than there was decades ago — inflation, population growth, and growth in wealth per person, all combined. This is an economic-loss question, distinct from the physical-hazard detection covered elsewhere in this document: economic loss data is not appropriate for the detection or attribution of changes in climate variables, and normalized-loss series carry no "detected change" verdict.

Each series uses the "full" normalization method — Consumer Price Index inflation plus growth in exposed wealth (population and per-capita/structure wealth) — rather than a simple inflation-only adjustment, following each hazard's own published methodology, each continued through more recent working data. The three source series arrive normalized to three different base years (2025 for hurricanes, 2026 for tornadoes, 2020 for floods); rebasing each onto a single common 2026-dollar basis with BLS CPI-U (bls.gov/cpi) is the only additional step applied here.

Hurricanes and tornadoes are treated differently from flooding for the "share of GDP" figure. For hurricanes and tornadoes, share-of-GDP divides the normalized 2026-dollar figure by a single current US GDP level (BEA) — the dollar figure is the authoritative series, and the percentage is a rescaling of it into a "share of today's economy" unit. Flooding runs the opposite direction: its share-of-GDP figure divides each year's normalized loss by that same year's own real, contemporaneous GDP (MeasuringWorth), and this percentage is the authoritative series, with the dollar figure rescaled from it against a single fixed reference year's real GDP. Both charts in every hazard's pair have the same shape either way; only the direction of derivation differs for flooding.

The flood series' own supplied data ran only through 2019; 2020–2025 were added using NWS Storm Data national annual totals rebased with a GDP-ratio method — mathematically equivalent to the CPI-plus-wealth method used elsewhere, but a simpler, site-added approximation rather than Downton, Miller & Pielke Jr.'s own more detailed exposure model, a disclosed methodological seam at the 2019/2020 boundary. Deliberately not used for any of this: ICAT's Hurricane Loss dataset, which splices two incompatible loss measures together in a way that manufactures a spurious trend (Pielke Jr. 2025), and NOAA's "Billion Dollar Disasters" dataset (Pielke 2024).

References

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Known Limitations

Streamflow and USDM drought's reliable windows are download-boundary artifacts, not discovered data-quality boundaries — unlike heat waves' empirically found 1895 cutoff, these variables' start years simply reflect how far back each live feed reaches, so the whole downloaded record is treated as reliable.

Wildfire's two panels measure different things on different timelines and should not be read as a single series.

Hurricane landfall counts use a simplified continental-US geometry test (a single buffered country polygon plus a bounding box), and a storm that weakens below hurricane intensity before reaching the coast is correctly excluded even if popularly remembered as a hurricane (e.g. Fern, 1971).

This dashboard performs detection only. Attribution — evaluating the relative contribution of specific causal factors to an observed change — requires model-based analysis this project does not undertake. A side-by-side comparison of how IPCC AR6 has characterized each hazard and how it compares to this site's findings is available on the Detection & Attribution page.

This document summarizes the data sources, construction, and disclosed limitations behind every variable on the US Extreme Weather and Climate Change Dashboard. All source data comes from official US government agencies (NOAA/NCEI, USGS, NIFC) or peer-reviewed academic catalogs, linked by name above. A project by Roger Pielke Jr.