14B.6 ESTIMATED CONVECTIVE WINDS: RELIABILITY and EFFECTS on SEVERE-STORM CLIMATOLOGY

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1. BACKGROUND

By definition, convectively produced surface winds ≥50 kt (58 mph, 26m s^{-1}) in the U.S. are classified as severe, whether measured or estimated. Other wind reports that can verify warnings and appear in the Storm Prediction Center (SPC) severe-weather database (Schaefer and Edwards 1999) include assorted forms of convective wind damage to structures and trees. Though the "wind" portion of the SPC dataset includes both damage reports and specific gust values, this study only encompasses the latter (whether or not damage was documented to accompany any given gust). For clarity, "convective gusts" refer to all gusts in the database, regardless of whether thunder specifically was associated with any given report.

Severe-convective-gust reports since 1950 are available online from SPC in comma-separated and GIS formats, via http://www.spc.noaa.gov/wcm/. Assorted biases and secularities in this data have been discussed in the literature. Doswell (1985) described the process by which estimated gusts were entered to that time, often with no distinction from measured events. Weiss et al. (2002) illustrated:

- A roughly threefold increase in severe-gust reports from 1970–1999 (their Fig. 1), and
- A distinct preference for gusts to cluster around marginal-severe thresholds (58 mph, 50 kt, 26 m s^{-1}) and mph integers ending in zero or five (their Fig. 2). This indicated a dominant influence of estimated gusts in the data, despite the lack of consistent documentation of measured versus estimated sources in that era.

Doswell et al. (2005) documented, among other factors: sharp discontinuities in convective gust-report density across borders of National Weather Service (NWS) county warning areas, changes within those areas over time, and proliferation of gusts in the 1990s and early 2000s from nonstandard sensors (mesonet and privately deployed sensors) of unknown or differing calibrations. Trapp et al. (2006) noted substantial spatiotemporal misrepresentation of convective wind-damage areas by associated wind reports, and contended that use of peak-wind estimates for damage is, "essentially arbitrary and fraught with potential errors."

In 2006, NCDC (now NCEI) *Storm Data*, from which the SPC database is directly derived, began to record whether gust reports were measured by an instrument or estimated. Formats before and after this change are exemplified in Fig. 1. *Storm Data* contains default entries of "Thunderstorm Wind" followed by values in parentheses with an acronym specifying whether a gust was measured (MG) or estimated (EG), along with the measured and estimated "sustained" convective wind categories (MS and ES respectively). MGs from standard ASOS and AWOS observation sites are available independently prior to 2006 and have been analyzed in previous studies [e.g., the Smith et al. (2013) climatology and mapping]; however specific categorization of EGs and their conterminous comparison with MGs from *Storm Data* necessarily begins in 2006. For more details on *Storm Data* convective-wind policy, see NOAA (2007).

The quality and reliability of EGs (especially compared to MGs) has been challenged, mostly for nonconvective winds and controlled-testing situations, but only speculatively for bulk convective wind reports. Doswell et al. (2005) stated, albeit with no sourcing or citation: "Human observers typically overestimate the wind speed, owing to a lack of experience with extreme winds." The lead author's three decades of anecdotal observations from storm-observing experience strongly support their contention, but likewise have no analytic basis.

By contrast, Miller et al. (2016a, hereafter M16) performed the most thorough known examination of nonconvective EGs. They used daily wind data from the U.S. Global Historical Climatological Network (GHCN; Menne et al. 2012), applied gust factors, then in turn, compared to nearest actual or assumed human-estimated reports available in *Storm Data*. [Unspecified gust reports were assumed to be human-estimated.] Further assumptions were made in proximal terms: that a GHCN-derived gust factor was representative on the scale of NWS forecast zones (or roughly meso-β scale). Gust factors used were in relatively "flat" land away from the western U.S. and Appalachians, smaller terrain features over the Plains, Midwest, South, and Gulf and Atlantic coastal states. However, no further mitigation was performed to account for local terrain irregularities

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A

Storm Data and Unusual Weather Phenomena

Location	Date	Time Local/ Standard	Path Length (Miles)	Path Width (Yards)	Number of Persons Killed	Injured	Estimated Damage Property	Crops	Character of Storm
									June 2005
IOWA, Central									
Marion County									
Pella	**04**	**2036CST**			**0**	**0**	**1K**		**Thunderstorm Wind (G52)**
Appanoose County									
Centerville	**04**	**2040CST**			**0**	**0**	**10K**		**Thunderstorm Wind (G57)**
Jasper County									
Newton	**04**	**2045CST**			**0**	**0**	**1K**		**Thunderstorm Wind (G50)**

B

Storm Data and Unusual Weather Phenomena

Location	Date	Time Local/ Standard	Path Length (Miles)	Path Width (Yards)	Number of Persons Killed	Injured	Estimated Damage Property	Crops	Character of Storm
									May 2011
ARKANSAS, Northwest									
Crawford County									
2 NE Rudy	23	2022CST			0	0	25.00K	0.00K	Thunderstorm Wind (56EG)
	Several mobile homes were damaged by strong thunderstorm wind near Rudy.								
	Note: The estimated wind gust of 56 knots is equivalent to 64 mph.								
Crawford County									
Van Buren	23	2023CST			0	0	5.00K	0.00K	Thunderstorm Wind (52MG)
	Strong thunderstorm wind snapped power poles and blew down trees. An Emergency Manager measured wind gusts to 60 mph with these storms.								
	Note: The measured wind gust of 52 knots is equivalent to 60 mph.								

Figure 1: Screen captures of cropped portions of Storm Data pages for: a) 4 June 2005 in Iowa, exemplifying pre-specification-era gust format, and b) 23 May 2011 in Arkansas. In (b), EG and MG signify estimated and measured gusts, respectively. Note that neither the source of the EG nor instrument information for the MG are given. Gust values (kt) in parentheses.

such as the Ozarks, Mesabi Iron Range, Ouachita Mountains, Raton Mesa, Caprock Escarpment, or Black Hills, that do exist within those broader “flat” physiographic provinces. Regardless of those limitations, they found that estimates of gradient-wind gusts disproportionately resided in the upper portion of the observed distribution, and were statistically improbable overestimates.

While M16 found an overestimation of non-convective wind speeds by humans, their proximity criterion is too large spatially to apply on the convective scale, for similar observational versus human-estimate comparisons. Furthermore, nonconvective scenarios do not necessarily contain multi-sensory factors potentially influencing human convective-wind estimation, including: rapid accelerations and decelerations in seconds, visual impairment due to outflow dust or heavy precipitation, overlap of wind noise with sounds from thunder and precipitation, and inconsistent presence or lack of reference indicators as used in the Beaufort scale (Curtis 1897; null 1914, 1925). Unknown influences also exist from psychological duress imparted by those factors, as well as from the mere presence of a dark and unnerving storm, and non-wind convective hazards such as lightning and hail.

Immersive experience with wind estimation appears to matter in controlled settings. Using an anemometer-calibrated indoor chamber, Pluijms et al. (2015) determined that expert sailors judged wind speed and direction better than non-sailors. This implies that experienced storm chasers and spotters likewise may estimate wind more accurately than novices or the general public, and may justify a breakdown of estimations by source as per M16. However, *Storm Data* contains no systematic information on experience levels within each stated estimation source. Pluijms et al. (2015) also used a maximum speed of ≈5 kt (2.6 m s^{-1}), an order of magnitude below NWS severe criteria. Given these limitations and the results of M16, breakdowns by source are justifiable, but not with fine granularity. Discussion of explicitly psychological factors (e.g., frightening wind noise, lightning and thunder, dark clouds) is beyond the scope of this study.

Agdas et al. (2012, hereafter A12) conducted a wind-chamber experiment on 76 *in situ* human subjects. These individuals were tasked to estimate wind speeds of 10, 20, 30, 40, 50, and 60 mph (4.5, 8.9, 13.4, 17.9, 22.3, and 26.8 m s^{-1} respectively), all applied to each subject in random speed order. As with M16, errors with wind speeds were smaller among those reporting more exposure to high wind—in their case, Florida tropical cyclones. Convective effects (lightning, precipitation, extreme gustiness, etc.) were not considered explicitly in the A12 study either. The gap between actual and perceived NWS severe-threshold winds is represented by the dark gray area between the blue and red lines in Fig. 2. Positive absolute wind-estimate errors grew with increasing speed, beginning at 30 mph (13 m s^{-1}), and nonlinearity of estimates became greater with strengthening speeds after 20 mph (9 m s^{-1}). Highest tested winds of 60 mph (27 m s^{-1}) were perceived to be 75 mph (33.5 m s^{-1}), an overestimate by 1.25.

A controlled, large-sample human study of wind-gust estimation in real convective scenarios is practically impossible. As such, A12 findings, as summarized graphically in Fig. 2 and annotated for actual and perceived "severe" winds, likely represent the best available numerical approximations to overestimation factors. Results from the A12 perception curve therefore will be incorporated into a portion of this work (section 2d).

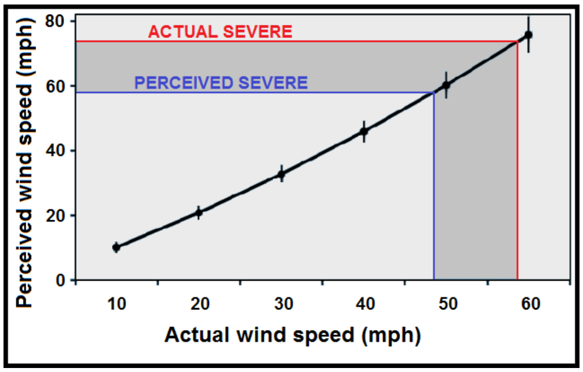

Figure 2: Human-perceived versus actual wind speeds in wind-chamber testing, with point values at testing intervals. Horizontal and vertical scales not equal (see axes). Black vertical bars represent 95% confidence intervals at 10-mph (4.5 m s^{-1}) intervals. Dark gray shade represents the difference domain between actual (red) and perceived severe (blue) wind. Adapted from Agdas et al. (2012).

From interpolation along the slope, NWS 58-mph (26-m s^{-1}) severe criteria (red) would be perceived as ≈73 mph (32.6 m s^{-1}), very close to the operationally used 65-kt (74.8 mph or 33.4 m s^{-1}) "significant" severe criteria (Hales 1988). That represents a 1.26 perceived/actual (P/A) ratio. P/A ratios of 1.24–1.26 (rounded to hundredths) were computed for severe values along the curve, including values extrapolated to those beyond "actual" wind speeds of 60 mph (26.8 m s^{-1}) in A12. The extrapolated A12 curve shows only low-order slope change within the range of observed speeds from our data, such that P/A ratio stays at 1.24 (changes are beyond significant digits) when "actual" winds exceed 70 mph. Perceived 58-mph marginal-severe gusts (dark blue) would correspond to subsevere, 48–49 mph (≈22 m s^{-1}) actual wind. Expressed as a fraction for comparison, the A12-derived "estimated" values are ≈1/5–1/4 over measurement, versus the ≈1/3 overestimate factors determined more indirectly by M16 for nonconvective winds.

2. DATA and METHODS

The wind-gust subset of the SPC convective database, as earlier described, contains specific tracking of measured and estimated reporting for each event beginning in 2006. As such, available 2006–2015 data are used herein, sorted first by MG and EG categories. For 2006–2015, 124 sub-severe values (119 estimated, 5 measured) were found in the SPC data and removed from the analysis set. A total of 150 343 filtered convective-wind values remain for the 10-y analysis period, encompassing 15 120 MGs, 35 MSs, 135 001 EGs and 187 ESs.

For MGs, *Storm Data* does not supply calibration information regarding source anemometers, nor other consistent specifics on either human or instrumental sources (e.g., Fig. 1b); therefore, no such filtering can be done in this study. All gusts within each category (MG and EG) are treated without preference in terms of instrument reliability or potential classification error, acknowledging that systematic mechanical differences across instrument classes and misfiled reports may affect our results in unknown ways[2].

The reasoning by which sustained (ES and MS) events are segregated from gusts in *Storm Data* is neither given in the publication's documentation, nor specified in most entry comments. No regulations or guidelines for distinguishing sustained wind from gusts are specifically elucidated in convective-wind *Storm Data* policy either (e.g., NOAA 2007, p. 70). Given their relatively minuscule sample sizes (0.14% and 0.23% of total estimated and measured events, respectively), the sustained winds will be included within the EG and MG categories for our analytic purposes, which encompass severe convective winds as a whole. Thus, EG and MG hereafter refer to *all* estimated and measured values, respectively. Figure 3 shows the geographic report distribution for the decadal period of our study.

Values further were sorted by the aforementioned ≥65-kt operational definition of "significant" wind, and by state, for comparison between wind-strength categories and across different parts of the contiguous U.S. (CONUS). Based on the results of Smith et al. (2013), we hypothesized that significant-severe gusts should be more common in the western CONUS and Great Plains states, and that MGs would be a greater portion of the data in those regions than east of the Mississippi River. Based on Weiss et al. (2002) and operational experience with storm reports, we also hypothesized that values corresponding to digits ending in 0 and 5 (mph) would exhibit peaks relative to surrounding speeds for EGs but not MGs.

[2] Some EGs possibly were MGs and vice versa, given M16's findings that ≈5000 *nonconvective* winds measured by automated stations were misclassified as estimates from 1996–2013. The extent of any such erroneous transpositions in the convective dataset is not known, and cannot necessarily be modeled statistically from M16's nonconvective assumptions covering a partly different time period.

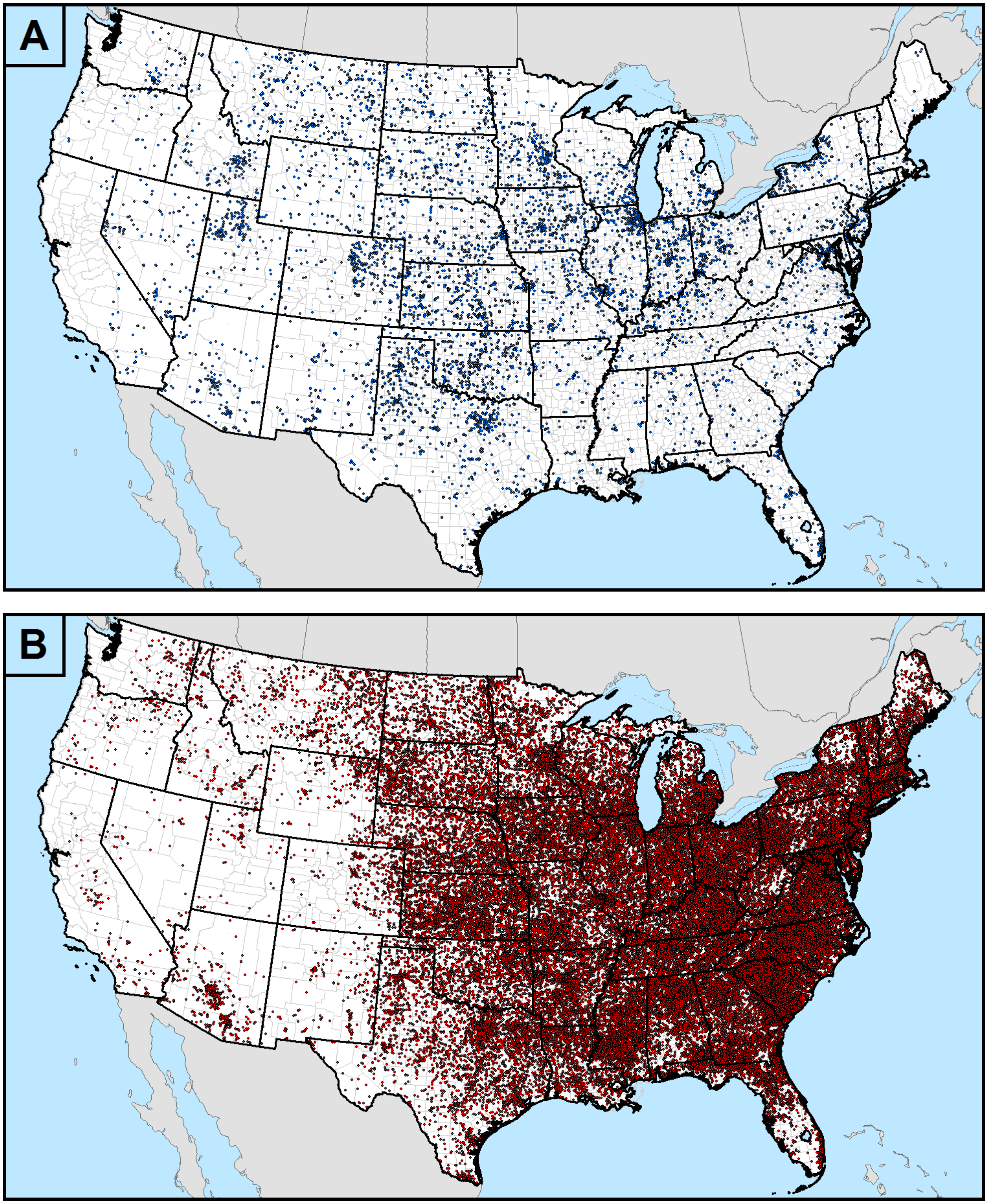

Figure 3: Geographic distribution of convective-gust reports, 2006–2015: a) measured, blue and b) estimated, red.

In order to assess potential population and population-density influences on the wind data, population figures by state were obtained from the U.S. Census Bureau via their online data portal (http://www.census.gov/data.html) for the census year 2010, which was in the middle of our sampling period. This enabled state-by-state analysis of convective-gust reports against population controls, as well as when incorporating the land area of each state.

Finally, to assess the potential impact of normalizing severe-windspeed data for human factors, we applied the A12 reduction factor to the EG data. This was motivated by a generalized, experience-based hypothesis that a majority of EGs would drop below severe limits, once adjusted for A12's experimentally verified human overestimation bias.

3. ANALYTIC RESULTS and INTERPRETATIONS

a. Basic windspeed data

On the whole, both MG and EG report counts exhibited pronounced decreases with speed at near-logarithmic rates (Fig. 4). The most pronounced exception was with the EGs at mph speeds ending in 0 or 5, as expected. In each such case, these artifacts added at least an order of magnitude to report totals, as did a category that was not expected: values ending in 0 or 5 in kt. By the time values exceeded 100 mph (87 kt, 45 m s^{-1}), the sample size steadily decreased on a logarithmic scale to ~10^1 total events from ~10^4 at marginal-severe thresholds.

Away from those ending digits, MGs (blue) typically outnumbered EGs, except at the largest values (≥90 kt) where sample size was small. No physical explanation exists for actual atmospheric production of winds an order of magnitude greater for integers ending in 0 or 5 by any measurement scale, versus those ending in, say, 4 or 7. This very strongly suggests that those EG "spikes" are secular artifacts.

As somewhat apparent in logarithmically scaled Fig. 4, and even more so in linearly scaled Fig. 5, MGs likewise exhibit relative peaks at values ending in the digits 0 or 5 (mph and kt). Though much lower in relative amplitude compared to neighboring values than EGs, the differences remain pronounced, especially on a linear ordinate. This defies physical explanation in the real atmosphere. While *Storm Data* offers insufficient information to establish definitive sourcing for this almost certainly nonmeteorological artifact (e.g., rounding), the misclassifications of nonconvective winds discussed in the section 2 footnote indicate similar errors may contribute to the "spikes" for MGs here as well. *On a logarithmic scale*, the decrease in MG counts with strength conforms closely to a linear best fit, even with the aforementioned secularities that are relatively minor in amplitude compared to those in the EG data.

A pronounced EG peak also is evident at the 50-kt (58-mph, 25.7 m s^{-1}) severe threshold (Fig 4)—the minimum speed criterion that can verify a warning (damage also verifies warnings, but is not considered in this study). That value contained 54 229 reports, compared to 366 51-kt (59-mph, 26.2 m s^{-1}) EGs. This represents *a decrease of two orders of magnitude across 1 kt (0.5 m s^{-1}) of wind speed,* also with no known physical cause. A somewhat less-pronounced MG peak also exists at the marginal-severe threshold (Fig. 5). Preferential clustering of EGs at NWS warning criteria also has been documented in the nonconvective gust data (e.g., Fig. 6). These data collectively suggest a strong secular influence of warning-verification practices on gust values that get recorded into the climatology, akin to verification-threshold effects on hail-data collection (e.g., Amburn and Wolf 1997; Allen and Tippett 2015).

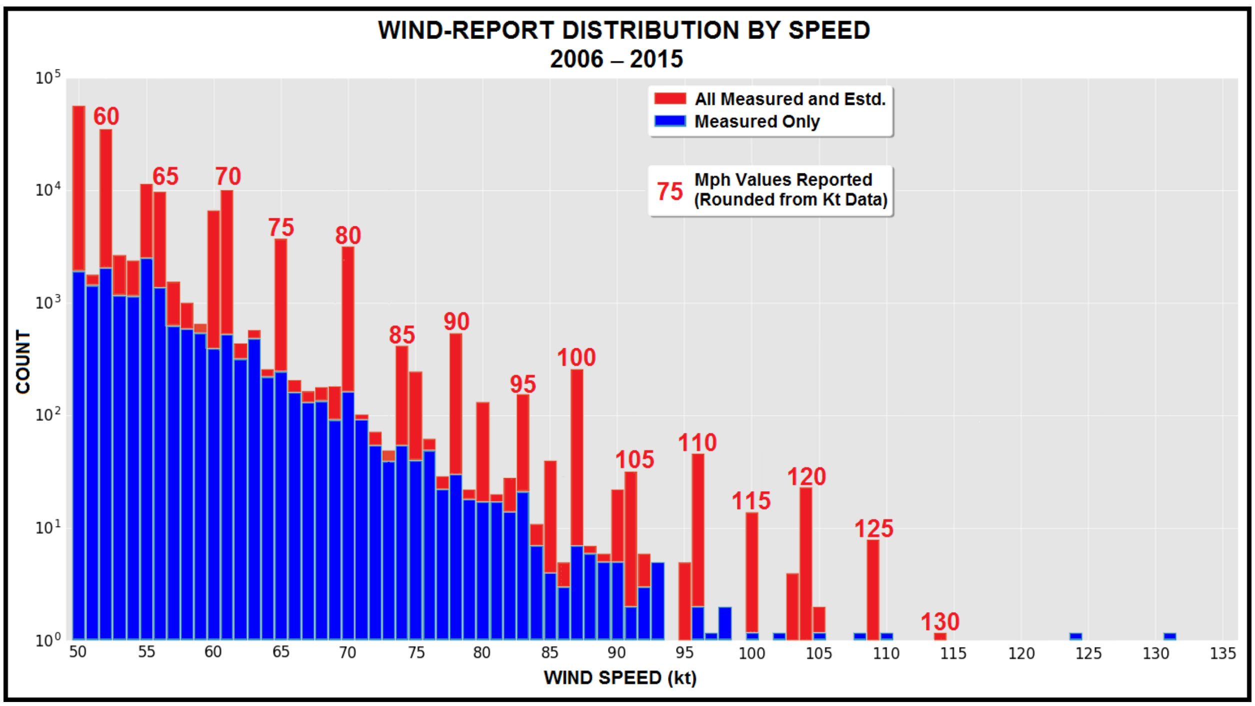

Figure 4: Histogram of wind-report distribution. Ordinate *logarithmically* scaled by event count, abscissa *linearly* scaled by wind speed (kt). Measured reports in blue, estimated counts in red, such that stacked height of each combined red and blue pillar represents total count for that speed value. Red numbers correspond to originally reported mph values.

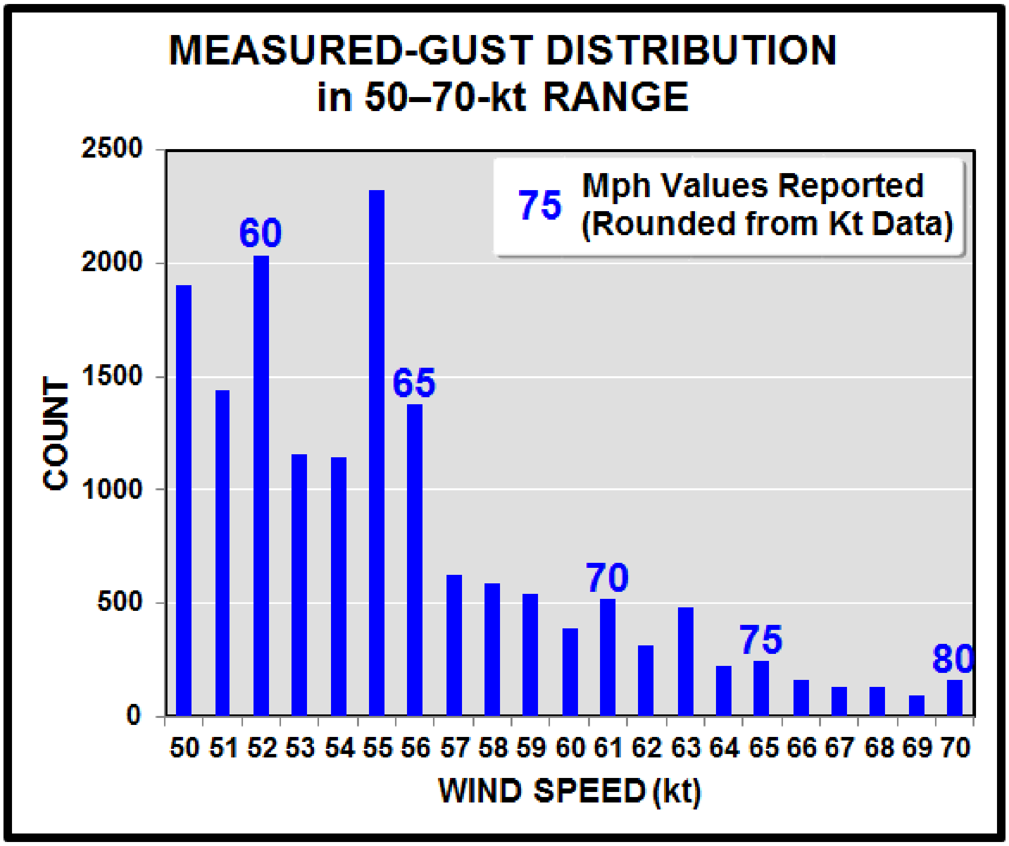

Figure 5: Histogram of the 50–70 kt subset of MGs, ordinate scaled *linearly*. Blue numbers represent mph speeds.

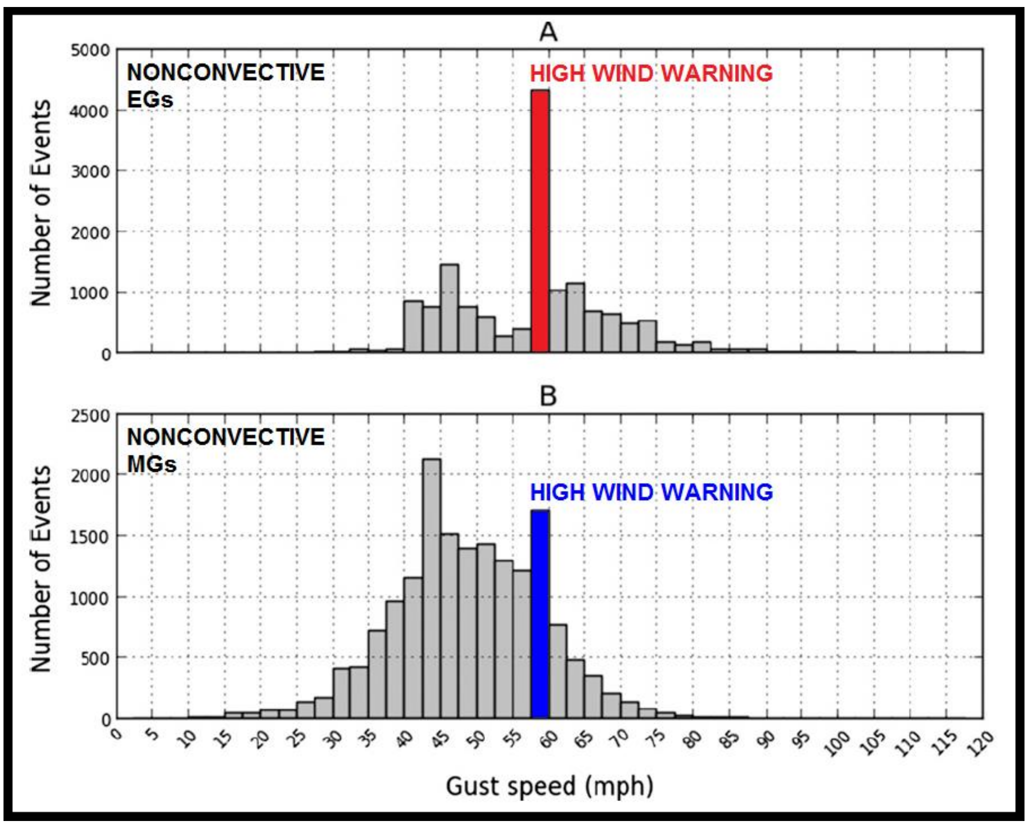

Figure 6: Linear-scaled histograms of *nonconvective* report counts as follows: a) human EGs from *Storm Data*, b) MGs from the Global Historical Climatology Network (Menne et al. 2012) U.S. daily station data. Bins including the NWS 58-mph (26.4 m s^{-1}) nonconvective warning criterion, which matches that for severe convection, are labeled with the MGs in blue and EGs in red, as elsewhere herein. Adapted from Fig. 1 in Miller et al. (2016b).

b. Geographic distributions

Severe-convective gust data show pronounced discontinuities and shifts across the CONUS. As visually evident in Fig. 3a, MGs are most common in a roughly triangular corridor from the southern Great Plains to the northern Plains, Upper Midwest and lower Great Lakes. Within this broad area, relatively dense nodes appear in population centers such as Chicago-Milwaukee, Dallas-Fort Worth, Oklahoma City, Denver, Kansas City, Saint Louis, Indianapolis, Minneapolis-Saint Paul, and Omaha. A pronounced relative minimum in MGs within this area exists over the Nebraska Sandhills, likely related to lack of both observation stations and population, except for a north–south strand corresponding to a major transportation corridor (U.S. 81).

Compared to the contiguous Plains and Midwest regions, lesser densities of MGs exist from the Appalachians to the East Coast and across the Gulf Coast region and Florida, except for a relatively higher concentration around the DC metro area. Despite much lower population density (not shown), the Great Plains states exhibit noticeably greater concentration and absolute numbers of MGs compared to the Atlantic and Gulf Coast States. This is consistent with the findings of Smith et al. (2013), which overlap our study by four years, and which likewise suggest a dominant meteorological cause, as does the presence of low MG densities over the sparsely populated Rocky Mountain West.

Relatively large MG concentrations also appear in Fig. 3a over southeastern Idaho, northern Utah (notably the Great Salt Lake Desert and embedded mountain ranges, as as well as the urban corridor), and around the Phoenix and Tucson metropolitan areas of southern Arizona. In addition to a relative density of surface-observing sites, even over the deserts, the northern Utah maximum collocates with a meteorological tendency for severe-wind-producing mesoscale convective systems to occur over this area (Seaman et al. 2016, this conference). Farther west, a striking lack of MGs is evident over both densely and sparsely populated areas of central and northern California, as well as southern California from the Los Angeles metro area westward. This also suggests a meteorological influence dominating those from either population or observation-site density. However, MG gaps across northern Arizona, western New Mexico, and around the Nevada Test and Training Range ("Area 51") region of south-central Nevada, appear to correspond to a dearth of available observing sites. Sparseness of MGs over the North Woods of Maine and Minnesota, and around Lake Superior, may be both meteorological and population-related.

In contrast, EG concentration (Fig. 3b) generally increases from the Rockies eastward to the East Coast, except for relative population minima across parts of the Appalachians, Maine, the Adirondack region of northeastern New York, and the Lake Superior region. A pronounced EG minimum over central and southern Florida, including the coastal corridors, appears not to be population-driven. Maxima in EGs over southern Arizona, however, appear to be population-related, as well as around the Twin Cities of Minnesota and the Dallas-Fort Worth Metroplex. Curiously, a relative concentration of EGs appears over the California Central Valley, where several observing sites exist, yet MGs are absent in the decade of record.

The ratio of EGs and MGs exhibits striking differences across the CONUS (Fig. 7). The highest proportion of EGs to MGs is over parts of New England, where sample sizes for gusts are relatively minimized, and over the Southeast (excluding Florida), where sample sizes are large. South Carolina, in particular, has a 78:1 ratio of EGs to MGs. This is partly related to the relative lack of MGs in that area (Fig. 3a), but also likely involves secular factors. The EG/MG ratio decreases westward toward the Intermountain West; in fact, Utah and Nevada offer more MGs than EGs by ≈3:1–4:1 proportions. Oklahoma has the lowest EG/MG ratio of the Plains states east of the Rockies. Explicit sourcing of Oklahoma reports via *Storm Data* will be needed to determine the influence of the relatively anemometer-dense Oklahoma Mesonet (Brock et al. 1995), which was in operation during the entire study period. By contrast, neighboring Kansas more than doubles the EG/MG ratio, but not only because of a lack of a state mesonet; Kansas also has a greater concentration of EGs independent of MGs (Fig. 3b) than any of the other Plains states.

Gust records normalized and mapped by state land area (not shown) reveal that EGs per unit area increase eastward from minima over the West Coast and Great Basin to maxima over the Southeast, Mid Atlantic and southern New England. South Carolina again stands out relative to other Southeastern states, with 73 EGs per 1000 km^2, whereas Maryland (much smaller in size but with 42% of South Carolina's EG count) has 94 EGs per 1000 km^2, highest among states. Oklahoma had the greatest number of MGs per 1000 km^2, with 7.5, strongly indicating an influence of the state's mesonet. Otherwise, the Mid Atlantic and central Plains had relatively maximized EG-density values, with minima across California and the Great Basin.

Data also were sorted according to the operationally customary 65-kt (33.4 m s^{-1}) "significant severe" threshold (Hales 1988). Nationwide, 6.3% of EGs were significant, compared to 8.8% of MGs. When mapped, the proportion of significant EGs is greatest across the Plains and Rocky Mountain regions (Fig. 8), except for a low-sample-size anomaly in DC. By contrast, the proportion of MGs that are significant exhibits little regional change (not shown) outside of 20% and 18% anomalies over Oregon and Utah, respectively, and another low-sample-size/high-percentage anomaly in DC.

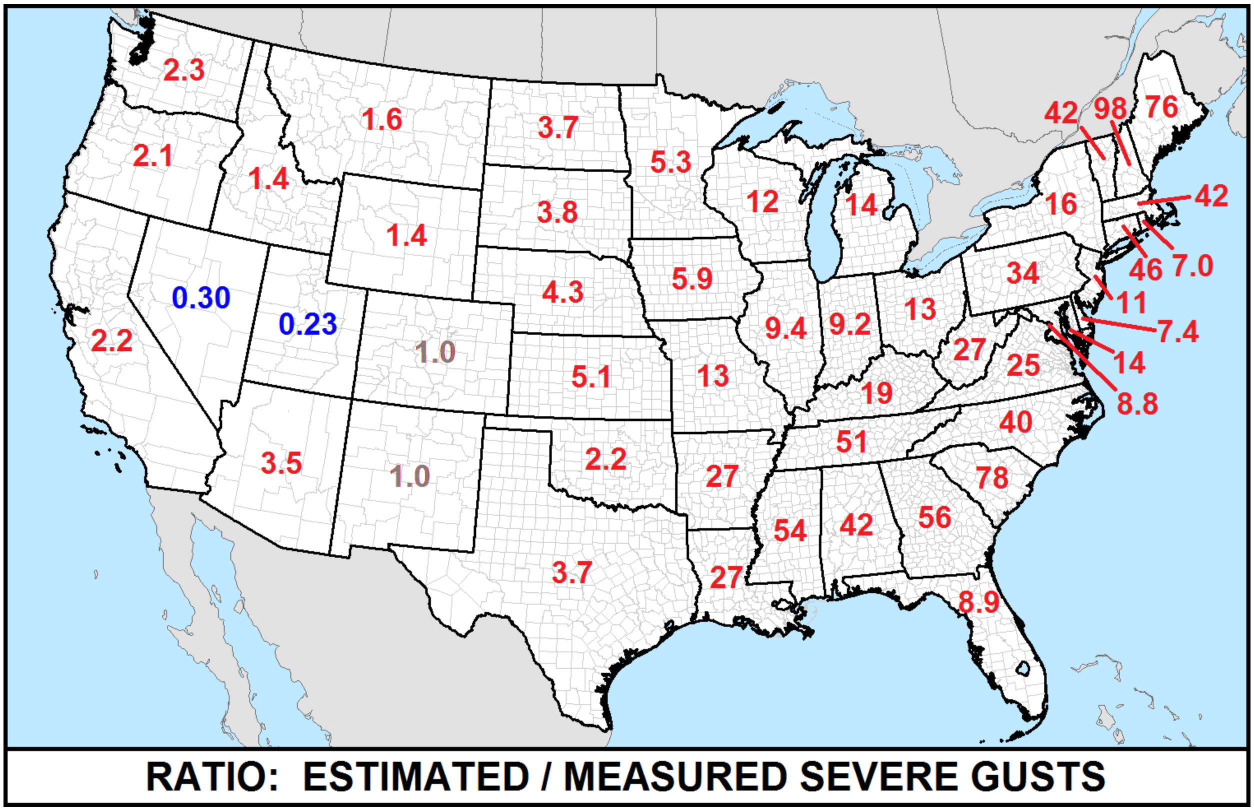

Figure 7: Map of EG/MG ratio by state, 2006–2015. Red (blue) numbers correspond to ratios above (below) unity. Ratios round to unity over Colorado and New Mexico (red-gray).

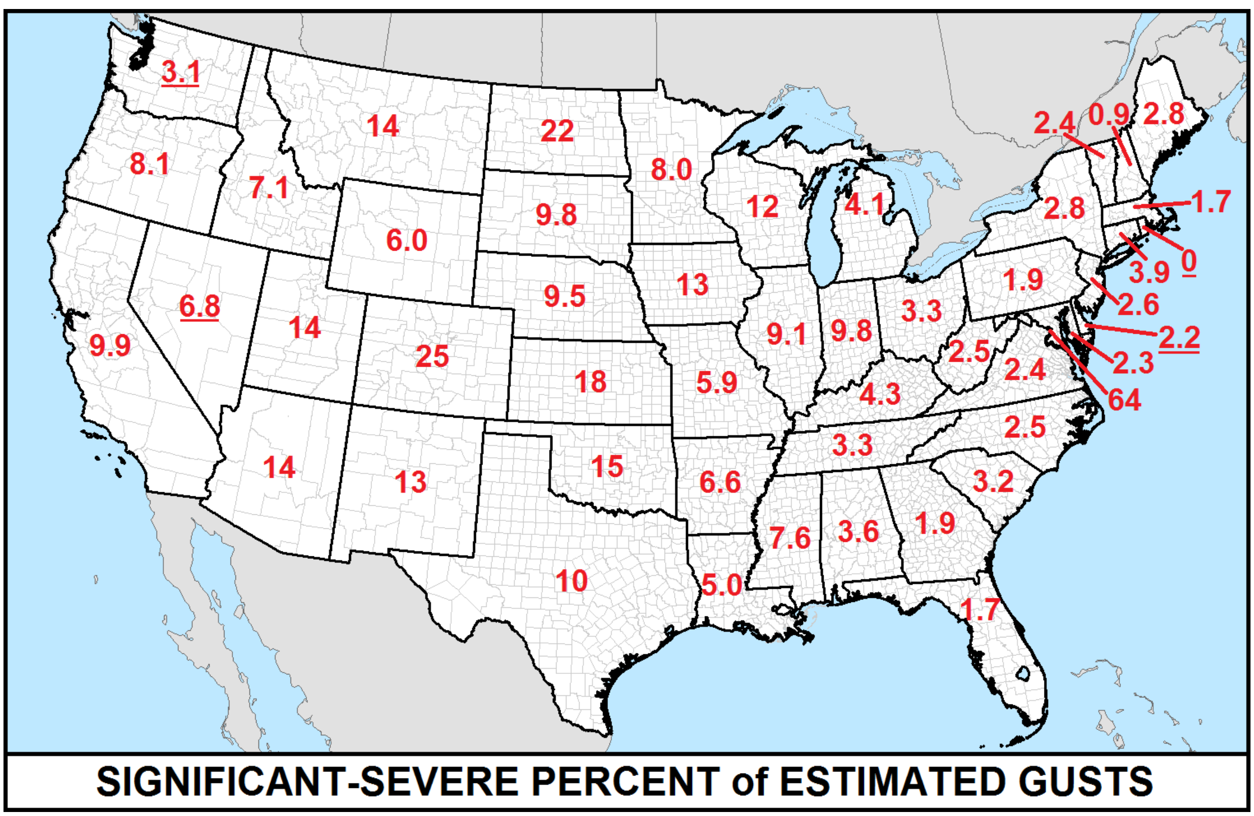

Figure 8: Map of percent of EGs ≥65 kt (33.4 m s^{-1}), 2006–2015. Underlined values come from sample sizes <10.

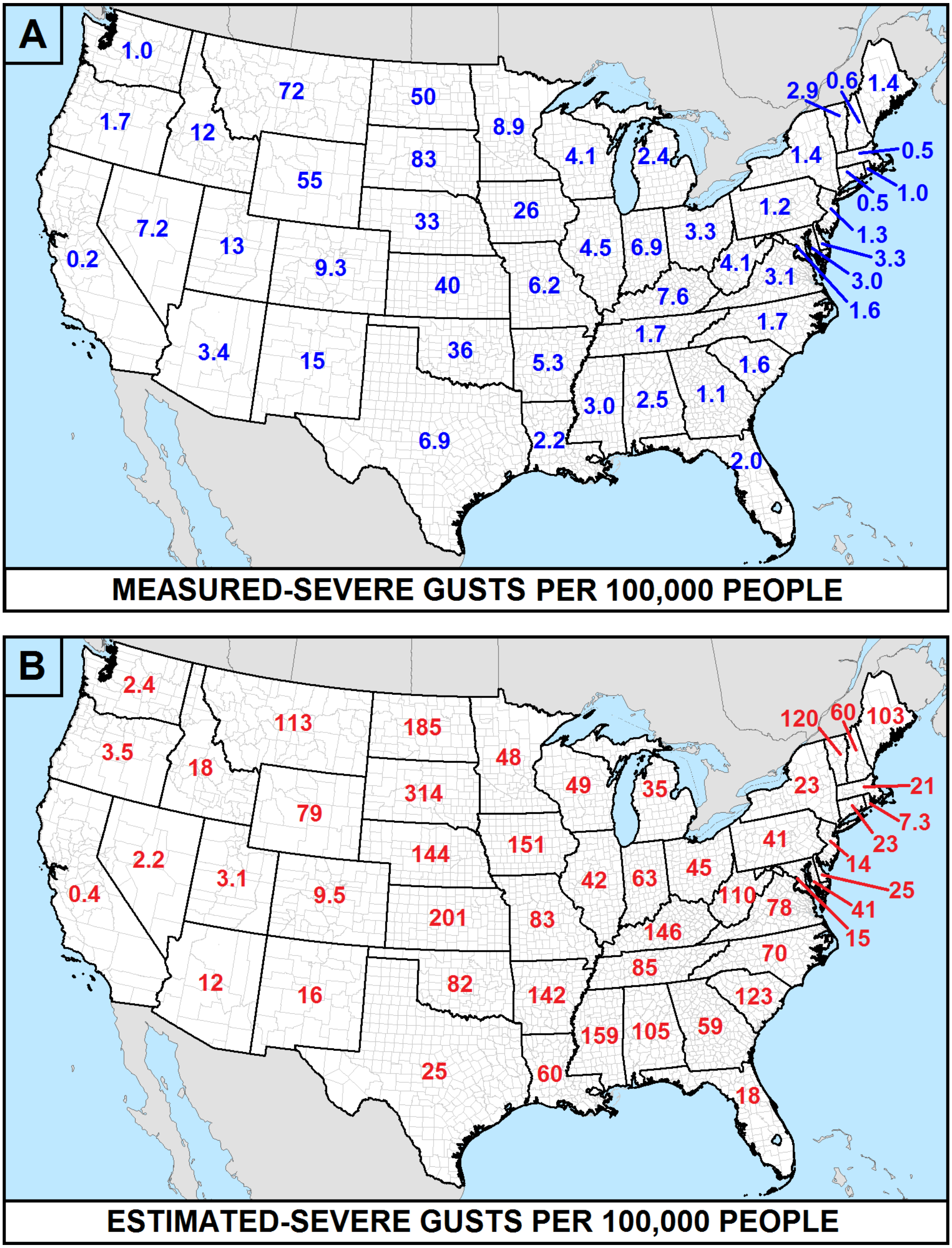

Figure 9: State- map per 100 000 people of a) MGs in blue and b) EGs in red.

c. Population controls

Population influences on the EG and MG data are readily apparent in mapping, as in the metropolitan geospatial clustering in Fig. 3 and as discussed above. When normalizing the data by state populations (Fig. 9), one characteristic stands out most prominently: the relatively high number of both MGs and EGs per 100 000 people in the central CONUS (Great Plains to Mississippi River) and Rocky Mountain States, which are relatively sparsely populated compared to areas to their east and to California. The Southeast, thanks largely to its high absolute volume of EGs (e.g., Fig. 3b), also has high EG tallies per capita, similar to the central CONUS and Rockies. California, with its CONUS-leading state population and overall dearth of MGs (Fig. 3a), has the lowest MG total per capita in the CONUS (Fig. 9b).

Ratios of the values in Fig. 9b to those in Fig. 9a (not shown) are near unity for Colorado and New Mexico, as is the case for population-unadjusted ratios in Fig. 7. Similarly, Utah and Nevada also exhibit anomalous population-adjusted higher proportions of MGs to EGs. Population-adjusted EG/MG ratios are greatest in the Southeast and New England as in Fig. 7—the latter also with relatively low sample size. Overall, population normalization does little to change the distribution of EG/MG *ratios* between states.

d. Modulation for wind-tunnel results

As noted in section 1, A12 test subjects estimated winds at ≈1.25 times actual speeds; in other words, perceived winds can be reduced by ≈0.8 to obtain adjusted "actual" winds. We use a rounded 1.25 P/A ratio for all estimates, since the rounded P/A variation in A12 is within ±0.01 of that for all MG or EG winds at severe levels. Doing so reduces all values <73 mph (32.6 m s^{-1}), or 126 474 data points (93% of all EGs), to below severe limits. Put another way, *normalizing estimates based on human-testing results leaves only 7% of the EG data as severe*.

Figure 10 visually illustrates the gap between measured and adjusted values with increasing speeds using the A12 P/A ratio, showing adjusted benchmarks for severe and significant-severe gusts. Values are given in kt owing to *Storm Data* unit conventions per Fig. 1 (i.e., when logged, mph values are converted to rounded kt in the dataset). The highest recorded EG of 113 kt (130 mph, 58 m s^{-1}) adjusts to 90 kt (104 mph, 46.5 m s^{-1}). Marginal-severe EGs of 50 kt (58 mph, 26.7 m s^{-1}) reduce to 40 kt (46 mph, 20.6 m s^{-1}).

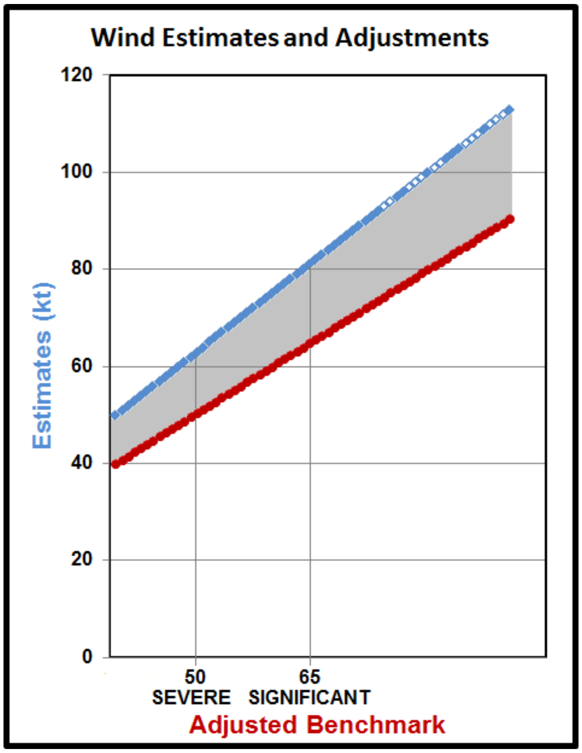

Figure 10: Estimated (blue) and vertically corresponding adjusted (red) data points spanning EGs of 50–113 kt (58–130 mph, 26–58 m s^{-1}). *Dots represent data-point values, not sample size at each.* EG values with null points (e.g., no records exist of 97–99-kt EGs) are hollowed. X-axis labeled for severe and significant-severe adjusted values (kt). Gray area represents the spread between original and adjusted EGs. Analogously to Fig. 2, the horizontal lines (y-axis values) can be considered "perceived" and the vertical lines (x-axis values) "actual".

4. SUMMARY and DISCUSSION

The severe-wind data are deeply suffused with artifacts that evade physical justification, as exhibited in section 3a. Aside from the human-bias modulations to speeds themselves, discussed below, one method of bulk control would be to reduce the counts of winds ending in 0 or 5 (kt or mph) either 1) to a count value interpolated between adjacent integers that are not affected by the secularity, or 2) the corresponding level on a best-fit curve applied to data excluding the "spikes". Further analyses are planned on our dataset to explore these and other possible ways to adjust for the peaks with integers ending with 0 and 5 that is apparent in Fig. 4. Time trends in gust values have not been examined yet, whether nationally or by state or region, and may reveal secularities related to changes in data collection.

Though we judged the 1.25 P/A ratio to be a most-representative reduction curve from EGs to MGs, individuals' estimation skill should vary considerably, as also indicated by A12. Results herein should be used for evaluating bulk data, not "repairing" any given single estimate. The larger (≈1.33) overestimation factor of M16 also may be valid in some convective scenarios, regardless. Our use of ≈1.25 P/A ratio therefore should be considered conservative in evaluating a large-sample grouping of estimated convective gusts. As such, we suggest that estimated values <73 mph (32.6 m s^{-1}) may be disregarded for purposes of bulk research on the severe-wind data, and all estimates reduced by 0.8

for "apples to apples" comparison. As noted above, this means only ≈7% of all estimates would be retained as strictly severe winds with the reduction factor applied. Furthermore, since 73-mph values represent 0.07% of the EG dataset used herein, effectively *all convective-wind estimates less than hurricane force* (74 mph, 64 kt, 33 m s^{-1}; Simpson 1974) *may be considered subsevere*.

Tabulation and mapping of *normalized* estimated reports can be done readily with report-log data, in near-real time, on a daily basis, and in parallel with tabulation and display of original raw reports. This would illustrate both numeric and geographic shifts imparted by wind-tunnel-based reduction of human-estimated values to those that most probably were severe in reality. Where measured and estimated gusts exist in very close proximity, the former should be used; though answering the question of precisely how close is outside of the scope of this study.

The adjustment factor will not ameliorate the aforementioned discontinuities ("spikes") in the data inherent to observers' customary use of EG integers that end in 0 or 5 (kt or mph). In nations not using English units, relative frequency maxima analogously should appear where estimated metric values (whether in m s^{-1} or km h^{-1}) end in 0 or 5. Such determinations could be done, customized to units used in areas such as parts of Europe, where relatively robust datasets recently have been accumulated (e.g., the European Severe Weather Database; Dotzek et al. 2009).

Results herein reveal that human estimators (generally spotters, storm chasers and public sources) preferentially offer convective wind estimates based on either minimal thresholds to verify as severe (50 kt, 26 m s^{-1}), or digits ending in 0 and 5 when using either mph or kt. The difference in EG versus MG report counts, at these most-commonly estimated values, is consistently close to one order of magnitude for speeds up to about 90 kt (46 m s^{-1}) (Fig. 4); thereafter, sample size becomes very small. This raises issues with implications for mapping and weighting of bulk convective wind data, as well as for forecast verification. For example, if not reduced in magnitude per the discussion above, should EG (MG) *counts* at those specific speeds be reduced (increased) by a factor of ten to compensate for the secular count differences, especially in areas of high (low) population or high (low) density of structures and trees to damage? Also assuming no magnitude reduction:

- Should forecast-verification metrics (especially for outlooks and watches, but perhaps even warnings) be weighted heavily toward measured-wind reports? If so, in what way, and how should observationally data-sparse areas be verified?
- Should planar or gridded EG coverage be detrended by corresponding density of MGs in the same regions or states, in order to normalize them for the sake of verifying outlooks and watches? For example, in a given geographic area where the ratio of EGs to MGs (Fig. 7) is ≈20:1, one may require 20 EGs per grid unit to count the same as 1 MG for verifying a forecast. This would require new areal forecast-verification methods that are more sophisticated, but likely more physically representative, than the one-size-fits-all nationwide metrics currently employed.

Alternatively, given the overestimation findings referenced above, should EGs weaker than hurricane force be discarded entirely for verification purposes (as well as for research use)? These and other issues are likely to arise from objective, scientifically based consideration of the disparity between EGs and MGs, both in terms of magnitude and report counts.

On individual human levels, possibilities exist for improvement in wind-gust reporting. An innovative, experiential approach to spotter training conceivably may involve personal calibration with severe winds in a chamber, where one may be available, in order to improve estimates through personal immersion. In the meantime, spotters should be encouraged to measure winds using calibrated, scientific-grade anemometers. These would be sited out of the lee of obstacles, placed at standard 10-m heights if at fixed sites, and if on mobile or portable platforms, situated above vehicular slipstreams.

One avenue of further investigation should be comparison of proximal MGs and EGs in a convective setting, analogous to M16's nonconvective work. Anecdotal evidence and operational experience suggest similar overestimation factors in convective and nonconvective events, with respect to A12 testing that is used in ours. One recent example, among numerous possibilities nationwide since 2006, was from a forward-propagating convective complex straddling the border of North and South Dakota on 10 August 2016. The Mobridge, SD, automated station at 0516 UTC measured a peak gust of 47 kt (54 mph, 24 m s^{-1}). According to a local NWS storm report, a "trained spotter" in Mobridge estimated 65-mph (56.5 kt, 29 m s^{-1}) thunderstorm winds at 0520 UTC (Fig. 11). Rather consistent with our bulk findings, this event contained an apparent overestimate to a digit ending in 5, at a factor of 1.2, and also with a time estimate rounded to a digit ending in zero. The same thunderstorm complex did produce measured severe gusts elsewhere along its track, at other times.

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KMBG 100541Z AUTO 36019G28KT 3SM TSRA BR FEW011 BKN022 OVC08019/17
A2986 RMK AO2 PK WND 33047/0516 WSHFT 0512 LTG DSNTALQDS RAB07 TSB08
P0095 T01890172

PRELIMINARY LOCAL STORM REPORT
NATIONAL WEATHER SERVICE ABERDEEN SD
1225 AM CDT WED AUG 10 2016

..TIME...     ...EVENT...        ...CITY LOCATION...      ...LAT.LON...
..DATE...     ....MAG....        ..COUNTY LOCATION..ST..  ...SOURCE....
              ..REMARKS..

1220 AM       TSTM WND GST       MOBRIDGE                 45.54N 100.44W
08/10/2016    E65 MPH            WALWORTH             SD  TRAINED SPOTTER
```

Figure 11. Sub-severe raw METAR observation (top, in kt, medium gray shade) and severe spotter estimate in a local storm report (bottom, light gray shade, in mph) for convective gusts at Mobridge, SD, 10 August 2016. Peak speeds are underlined in red.

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