4A.1 THE ENHANCED FUJITA SCALE: PAST, PRESENT AND FUTURE

Roger Edwards[1]
Storm Prediction Center, Norman, OK

James G. LaDue
NWS Warning Decision Training Branch
Norman, OK

John T. Ferree and Kevin Scharfenberg
NWS Office of Climate, Water, and Weather Services
Norman, OK

Chris Maier
NWS Office of Climate, Water, and Weather Services
Silver Spring, MD

William L. Coulbourne
Applied Technology Council
Rehoboth Beach, DE

1. INTRODUCTION

Owing to a historic lack of direct measurements of tornado strength, and the very limited number of remotely sensed tornado wind speeds at or near ground level compared to the number of tornadoes as a whole, damage surveying remains the most commonly employed method for indicating the strength of tornadoes in the United States. With total path areas of tornadoes covering only ~103 km2 of land area per year (vs. nearly 9×106 km2 for the nation's conterminous land area), the occurrence of a direct tornado strike to a fixed, sufficiently sturdy and well-calibrated wind measuring station, is quite rare. Only 28 direct, in situ tornado observations are evident between 1894-2008 — 26 from Table 1 in Karstens et al. (2010), plus a single tornado's strike on both a Texas Department of Transportation meteorological tower and a separate West Texas Mesonet site on 28 March 2007 (NCDC 2007). Even with the increasing number of mainly central U.S. tornadoes being sampled near ground by mobile radar (see Alexander and Wurman 2008 for a climatology thereof), combined with fortuitous, in situ surface encounters of either the deliberate (Karstens at al. 2010) or inadvertent (Blair et al. 2008) variety, these observations still only account for a tiny minority of events out of more than 1000 tornadoes recorded annually in the WSR-88D radar era. Furthermore, conventional wind sensors may not survive the most violent tornadoes, potentially under-sampling their intensity. Given those factors, the representativeness of brief, in situ observations of some tornado events with regard to tornadoes at large is uncertain at best.

For the foreseeable future, damage assessments likely will remain the principal means for estimating tornado intensity in most events, to the extent that cost and staffing availability permit National Weather Service (NWS) meteorologists to assess impacts in person. When in-person NWS surveys are not possible soon after an event, areas affected are remote or poorly accessible, and/or other logistics prevent timely and complete surveys, alternate sources of information must be relied upon exclusively. Such sources include field researchers, storm spotters and chasers, the news media, damage accounts from emergency management and law-enforcement officials, and remote photos and video from any reliable source. Occasionally, mostly for events of extreme damage or human impact, assessment teams may be used that include non-NWS experts; or independent assessments from such experts (e.g., Marshall 2002) are used to finalize the damage mapping and rating.

2. BACKGROUND

a. Fujita scale

T. Theodore Fujita pioneered the concept of organized, detailed tornado damage surveys, doing field examinations and refining his techniques until shortly before his death in 1998. His assessment of the Fargo, ND mesocyclone and tornado of 20 June

[1] *Corresponding author address:* Roger Edwards, Storm Prediction Center, National Weather Center, 120 Boren Blvd #2300, Norman, OK 73072; E-mail: roger.edwards@noaa.gov

Table 1. F scale (no longer in use in the U.S.) with accompanying wind estimates and damage descriptors.

Level	Wind Estimate in mph ($m\ s^{-1}$)	Descriptor
F0	40-72 (18-32)	Minor damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112 (33-50)	Moderate damage. The lower limit is [nearly] the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	113-157 (51-70)	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; high-rise windows broken and blown in; light-object missiles generated.
F3	158-206 (71-92)	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; skyscrapers twisted and deformed with massive destruction of exteriors; heavy cars lifted off the ground and thrown.
F4	207-260 (93-116)	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated. Skyscrapers and high-rises toppled and destroyed.
F5	261-318 (117-142)	Devastating damage. Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 m (109 yd); trees debarked; steel reinforced concrete structures badly damaged; incredible phenomena will occur.

1957 (Fujita 1959, 1992) was a landmark event. Fujita showed that a damage assessment could be performed in a systematic, analytic manner, with the goal of determining airflow characteristics of tornadoes and their immediate surroundings. Numerous surveys by Fujita and his colleagues followed during the ensuing decades, and over time Fujita's detailed storm survey techniques were adopted by other organizations including the NWS. Those efforts led to the development of the Fujita (F) scale (Fujita 1971, Fujita and Pearson 1973), a version of which was named "FPP" that included Pearson's path width and length ratings on a 0-5 scale. The damage scale (Table 1) assigned levels of destruction to "well-built" homes in a range of F0-F5 levels, and empirically related those levels to subdivisions of the Beaufort and Mach scales for wind speed estimation.

The F Scale for structural damage attained official adoption for nationwide NWS use by the late 1970s. In some later cases, Fujita also applied ratings up to F5 based on non-structural factors — e.g., to corn stubble in the Plainfield, IL tornado of 28 August 1990 and the geometry of cycloidal field marks from the Goessel, KS tornado of 13 March 1990 (Fujita 1992). Incidentally, his descriptions of the effects of winds at increasing F levels also included movement of automobiles. Cars are *not* damage indicators (DIs) in the current Enhanced Fujita (EF) Scale because of their extreme variability in construction, mass, mass distribution, material composition, and wind resistance at various speeds and impact angles.

Meanwhile, engineers at Texas Tech University began studying the effects of tornadoes and other airflows on various types of construction after the F5 Lubbock, TX tornado of 11 May 1970. This included occasional collaboration with Fujita, NWS meteorologists, other engineers and National Severe Storms Laboratory scientists. Those efforts (e.g., Minor et al. 1977) led to advancements in understanding how damage occurs, spurred the development of guidance on "safe rooms" (FEMA 2003), and fostered improvements in best-practices for home construction in high-wind areas and in tornado-shelter design.

In the 1970s-1980s, the Nuclear Regulatory Commission (NRC) funded a project to gauge tornado wind risk to nuclear power facilities, which included the consistent rating of historical tornadoes using the F Scale. This ultimately resulted in a massive published listing of tornadoes rated F2+ dating back to 1871, and killer tornadoes of any rating since 1680 (Grazulis 1993, Grazulis 1997). Grazulis' ratings were based largely on comparison of available, historic media accounts to Fujita's descriptions of wind effects at various F-Scale levels, and in latter decades, NWS ratings. Where his rating disagreed with that of the NWS, Grazulis specifically noted such.

Multiple tornado climatologies arose, each “aware” of the other but with its own occasionally unique tornado listings and F-Scale ratings. In addition to Grazulis, the NRC also at least partly funded parallel tornado databases at the University of Chicago (DAPPLE or Damage Area Per Path LEngth, after Abbey and Fujita 1979) and the National Severe Storms Forecast Center (Kelly et al. 1978). The latter was the predecessor to the Storm Prediction Center’s tornado dataset, which now comprises the official record of whole-tornado tracks in the conterminous U.S. To complicate matters further, NCDC maintains a dataset of tornado county-segments, which are stitched together to comprise the SPC data (Schaefer and Edwards 1999), but which remain available for research as “tornadoes” separately from the SPC records. The Chicago dataset essentially has vanished, while Grazulis’ data often are used in practice to augment the SPC dataset, especially prior to 1950.

Even in the same dataset, damage ratings may have been collected in inconsistent ways. For example, the SPC dataset from the 1950s through the early 1970s contains ratings performed remotely, primarily using archived newspaper accounts and photos, which were prone to emphasis on higher degrees of devastation (Schaefer and Edwards 1999). Once local NWS offices took over ratings from the late 1970s onward, a decrease in tornado ratings F2+ occurred. Additionally, some redistribution of tornado records among damage-rating bins may be occurring since the 1 February 2007 onset of EF-Scale ratings (Edwards and Brooks 2010, this volume). To some extent, such systematic adjustments constitute “shocks” (Thorne and Vose 2010) to the historical tornado data record that, at a minimum, should be acknowledged by researchers using it.

b. Enhanced Fujita scale

Within just a few years after the F Scale became the operational standard for U.S. tornado rating, concerns arose about its veracity, especially at higher wind speeds (Minor et al. 1977). Doswell and Burgess (1988) summarized several critical deficiencies in the F Scale, while acknowledging that it was the best available system at the time. They emphasized the F Scale’s subjective application in practice, and the potential unrepresentativeness of damage with respect to tornado intensity, suggesting that F-Scale ratings might have a margin of error of two or more categories either way. Marshall (2002) discussed the variability of damage ratings from person to person. Using the results of live-audience exercises, Edwards (2003) illustrated the subjectivity and interpersonal variation of F-Scale ratings for any given damage scene among several presented.

A destroyed damage indicator (DI) can be rated, at most, at the upper bound of a range of wind speeds assigned to that structure. Doswell and Burgess (1988) succinctly elucidated this quandary, which formed a fundamental motivator for development of more DIs than available in the F Scale, and ultimately, the EF Scale. Another motivator was the long-known tendency to underestimate tornado intensity due to a lack of rural DIs (e.g., Schaefer and Galway 1982, Doswell and Burgess 1988, Doswell et al. 2009).

A steering committee, composed of meteorologists and engineers, was convened in the early 2000s to discuss these concerns and incorporate an engineering-based understanding on the wind speeds leading to common failure levels of various potential DIs. (WSEC 2006). This led to the 28-DI EF Scale currently in use (Table 2), where each DI is layered into degrees of damage (DoDs) in order to assign a more precise range of probable winds responsible for a given level of damage. Minor wind speed recalibration was incorporated into the initial (derived) EF Scale for operational use (Table 3). The goal was to make the EF and F Scales more compatible and provide a more consistent tornado climatology, ideally for F- and EF-Scale ratings to equate as closely as possible. This way, an extremely time- and labor-intensive review of tens of thousands of historical tornadoes would not be necessary in order to revise their EF ratings in a systematic manner. Ideally, the F and EF Scales, for recordkeeping’s sake, should be equivalent. The actual impact of the EF Scale on the tornado climatology remains unclear, in light of previous “shocks” to the dataset, and given the limited sampling time since its February 2007 implementation. Early results indicate the effects are minor, mainly focused around shifts in relative distributions of strong (EF2-EF3) tornadoes (Edwards and Brooks 2010).

In the field, NWS assessors aim to survey an event as soon as possible after a wind event, preferably within a day, before substantial bulldozing, and other debris removal and damage repairs, have been undertaken by residents and local officials. Often using a Windows™-based software program called EFkit (e.g., Fig. 1), developed at the NWS Warning Decision Training Branch, damage surveyors match the observed damage with an appropriate DI if possible, then assign a DoD. Within a DoD, one then has the leeway to fine-tune a DoD level up or down from a default value, based on subjective assessment of mitigating factors, such as damage to adjacent DIs or available knowledge of the structural integrity (anchoring, attachments, construction materials, etc.). As such, the aforementioned subjectivity factors on the F Scale have not been eliminated, but can be applied more consistently.

Further, the much finer granularity of the EF Scale, in terms of specific DIs, allows for a more complete rating of tornadoes away from dense concentrations of structural targets (i.e., population centers). The extent to which the EF Scale has ameliorated longstanding issues with population biases in the tornado climatology (e.g., Schaefer and Galway 1982), however, remains unclear. Challenges also linger in mapping probable tornado intensity across areas devoid of current DIs (primarily in treeless areas such as grasslands, deserts and large stretches of open cropland). Even the utility of EF Scale for trees (DIs 27 and 28, Table 2) remains in question, especially for solitary trees whose damage cannot be viewed in context of a surrounding forest or other DIs.

For a more discussion on the historical succession from F to EF Scales, advantages, disadvantages, and commentary about their utility, see Doswell et al. (2009). For more details on NWS implementation, experiences, issues and examples of operational EF-Scale use, see LaDue and Mahoney (2006), and LaDue and Ortega (2008).

3. EF SCALE STAKEHOLDERS' MEETING

On 2-3 March 2010, an EF Scale Stakeholders' Meeting (hereafter EFSSM for brevity) was convened in Norman, OK. Participants consisted of a diverse assembly group of research and operational meteorologists, wind engineers, meteorological policy-makers and a plant biologist serving as a subject-matter expert on wind impacts on vegetation. The purposes were to review the EF Scale's background and progress so far (Section 1), assess its state, deliberate its future, and set at least preliminary foundations for its management and evolution. EFSSM participants viewed presentations on possible problems with existing DIs, additional data sources (e.g., aerial and high-resolution satellite imagery, mobile radars and in situ instruments), areas of potential refinement of DIs, and international damage assessment. Free-form discussions were held, covering issues such as inconsistency and subjectivity in ratings, variations in expertise and experience of surveyors from one event to another, staffing and resource restrictions, and effects of present and future tornado rating capabilities on the tornado climatology (Section 4).

Engineering discussions included variations in construction practices and structural integrity within any given DI, changes in vulnerability of single DIs based on directional wind angle and vertical velocity, full-scale testing facilities for wind effects on structures, inconsistencies in building codes and enforcement thereof, the effects of flying debris and surrounding surface roughness (buildings and terrain), and weakest points of failure. Wind speeds for the same DoDs of some DIs can be lowered by glass breakage. As illustrated by mobile homes and one- or two-family residences in the Greensburg, KS tornado of 4 May 2007 (Marshall et al. 2008), the large range of wind speeds assigned to DoDs caused apparent inconsistencies between damage and wind speed, including with adjacent DIs. Participants also spent a great deal of the meeting discussing topics such as the EF Scale's oversight, accountability, evolution, and adaptability in the future (Section 4).

Tornadoes long have been recognized as a global phenomenon (e.g., Wegener 1917, Feuerstein et al. 2005), having been recorded in every continent except Antarctica. As such, numerous nations share an interest in improving assessment of their damage. International research and involvement in tornado survey work and damage and intensity scales is well underway, and the EF Scale will be part of such discussions. To that end, EFSSM began to realize this imploration by Meaden et al. (2007):

> "A world meteorological scientific meeting should be held to rule on the most satisfactory tornado scale. No such world meeting—as distinct from U.S.-only meetings which considered only Fujita's scale—has ever been held to discuss the merits of wind-speed scales since the international Beaufort-scale discussions of the 1920s."

The EFSSM involved a few Canadian and German meteorologists, whose countries do not use the EF Scale at this time, and included a presentation on the physically derived Energy Scale (E Scale, after Dotzek 2009), which incorporates variables such as mass flux density.

4. FUTURE DIRECTIONS AND CONCERNS

a. Field use and scale oversight

Documented evidence (e.g., photographic and video), along with laboratory and numerical simulations, has shown great temporal and spatial variability in the fluid characteristics of tornadoes, even on the scale of DIs (singles to tens of m). Such factors include the presence of multiple suction vortices (Fujita 1970, Fiedler 2009) on scales ranging from nearly a km to as small as ~1 m, along with accelerations related to corner flow collapse (e.g., Lewellen and Lewellen 2007). These can contribute to tight spatial gradients, or rapid temporal changes, in tornado intensity, which can manifest themselves as extreme variations in damage between adjacent DIs, assuming the tornado encounters a representative density and composition of DIs. Furthermore, in addition to long-observed influences of flying debris on damage intensity, there is some evidence that even fine-scale debris, such as dirt and sand, can affect the flow of a tornado itself in the near-surface area where damage is done (Lewellen et al. 2008). The nebulous and complex relationship between actual gradations in damage, debris, and small-scale vortex variability raises three major issues, which for now have no clear answers:

1. *How much damage variation is due to actual effects of vortex dynamics, as opposed to great differences in the structural integrity between nearby DIs?* This is a major concern in tornado damage assessment in general, and for EF Scale estimation in particular. While perhaps never totally resolvable, this problem may be addressed through additional training of field surveyors in structurally-influential concepts of tornado dynamics, in conjunction with greater attention to (and metadata documentation of) failure modes of DIs (e.g., lack of anchoring).

2. *How much weight should be given to ambient damage when rating a singular DI, especially one that stands out well above (e.g., Fig. 2) or below the others?* At first, it may seem prudent to fine-tune the rating of the scene in Fig. 2 downward as EFkit allows, especially with little evidence of secure attachments or reinforcements. By contrast, how sure can one be that a short-lived suction vortex with winds in the EF3 range did not form, strike a critical part of the structure, and vanish within the confines of the site, especially given a lack of eyewitness information?

Table 2. Summary of damage indicators for the EF Scale. DI numbers link to web pages with DoD numbers, text descriptions, and wind speed thresholds for each DI.

DI Number with Hyperlink to DoDs	Damage Indicator	DI Acronym
1	Small barns, farm outbuildings	SBO
2	One- or two-family residences	FR12
3	Single-wide mobile home	MHSW
4	Double-wide mobile home	MHDW
5	Apartment, condo, townhouse (3 stories or less)	ACT
6	Motel	M
7	Masonry apartment or motel	MAM
8	Small retail building (fast food)	SRB
9	Small professional (doctor office, branch bank)	SPB
10	Strip mall	SM
11	Large shopping mall	LSM
12	Large, isolated ("big box") retail building	LIRB
13	Automobile showroom	ASR
14	Automotive service building	ASB
15	School: 1-story elementary (interior or exterior halls)	ES
16	School: junior or senior high school	JHSH
17	Low-rise (1-4 story) building	LRB
18	Mid-rise (5-20 story) building	MRB
19	High-rise (over 20 stories)	HRB
20	Institutional building (hospital, government or university)	IB
21	Metal building system	MBS
22	Service station canopy	SSC
23	Warehouse (tilt-up walls or heavy timber)	WHB
24	Transmission line tower	TLT
25	Free-standing tower	FST
26	Free standing pole (light, flag, luminary)	FSP
27	Tree - hardwood	TH
28	Tree - softwood	TS

Table 3. Comparison of wind speed ranges assigned to F and EF Scale levels.

FUJITA SCALE			DERIVED EF SCALE		OPERATIONAL EF SCALE	
F Level	Fastest 1/4-mi in mph ($m\ s^{-1}$)	3-s Gust in mph ($m\ s^{-1}$)	EF Level	3-s Gust in mph ($m\ s^{-1}$)	EF Level	3-s Gust in mph ($m\ s^{-1}$)
0	40-72 (18-32)	45-78 (20-35)	0	65-85 (29-38)	0	65-85 (29-38)
1	73-112 (33-50)	79-117 (35-52)	1	86-109 (38-49)	1	86-110 (38-49)
2	113-157 (51-70)	118-161 (53-72)	2	110-137 (49-61)	2	111-135 (50-60)
3	158-206 (71-92)	162-209 (72-93)	3	138-167 (62-75)	3	136-165 (61-74)
4	207-260 (93-116)	210-261 (94-117)	4	168-199 (75-89)	4	166-200 (74-89)
5	261-318 (117-142)	262-317 (117-142)	5	200-234 (89-105)	5	>200 (>89)

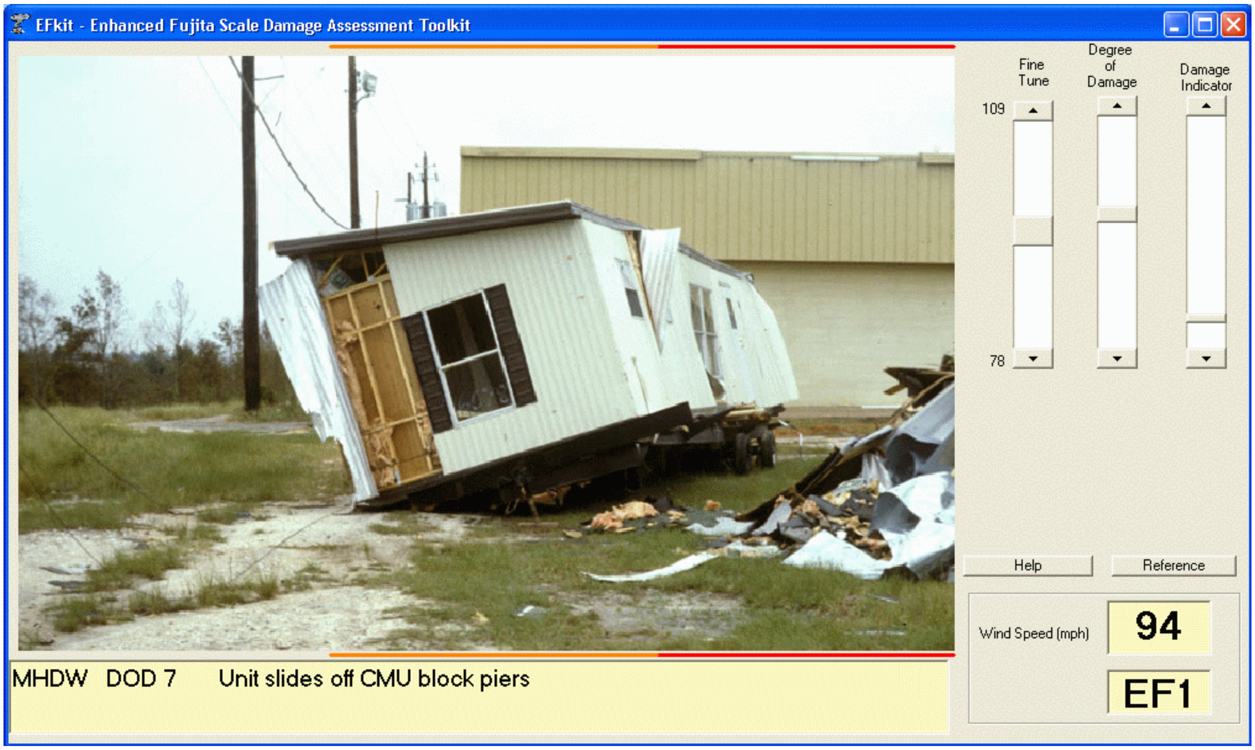

Figure 1. Screen example of EFkit PC software used in most NWS damage surveys as of this writing. Defaults of both values and photographic example are shown for a double-wide mobile home (MHDW) at DoD=7. Users can select the DI (right) and DoD (middle), while sliding the "Fine Tune" bar up and down to allow for some subjectively assessed leeway in rating – e.g., reducing the wind speed if much weaker or no adjacent damage is evident.

Figure 2. Site of the fatal destruction of a mobile home near Fulton, MO, by a rain-wrapped, F1-rated tornado on 10 April 2001; see Glass and Britt (2002) for meteorological documentation. At DoD 9 (complete destruction of unit), anywhere from EF1-EF3 can be assigned for this DI, with an EFkit default of EF2. The lack of damage to surrounding trees, and to the adjacent satellite TV receiver, indicates EF0 may be the most appropriate rating. *Photo courtesy NWS St. Louis.*

3. *What can be done to improve DI representativeness? What new DIs should be added, how, and why?* Efforts will continue to explore new potential DIs, especially for objects and structures more commonly found in rural and remote areas that can "fill in the gaps" in mapping damage paths. Such gaps do still exist, despite the presence of 28 DIs in the current EF Scale. Possibilities include center-pivot irrigators (Guyer and Moritz 2003), farm implements, grain bins and silos, rail cars, common oilfield equipment such as pumpjacks, and non-farm vehicles. Additionally, engineering and botanical studies will continue to reveal insights that could compel revision of wind estimates for existing DIs, or even blending of DIs (e.g., hardwood and softwood trees) for which the current distinctions might not be justifiable. How should the EF Scale account for variations in tree species, size, symmetry and soil conditions that can influence their breakage and toppling? How should the EF Scale evolve in step with changes in construction practices and codes, both with time and from place to place?

Given the incomplete nature of both the EF Scale and knowledge about wind effects, the scale will need to be fluid and evolutionary to some extent. This will allow the accommodation of new DIs and greater understanding of existing ones. Furthermore, an "unknown" category (Doswell et al. 2009) may be added to accommodate those events that still miss DIs. As with the F Scale, only a default rating of EF0 currently is available for such events, which could grossly misrepresent actual tornado strength.

Any such changes will require a formalized, documented procedure for revision of the EF Scale, as advocated by Doswell et al. (2009), but such a process does not exist currently. This issue was discussed at the EFSSM and recognized as necessary for 1) accountability and 2) the integrity and utility of the EF Scale in the future. Meeting participants will continue to work to establish an oversight team for the EF Scale[2]. At first, this team probably will consist mainly of a subset of EFSSM participants, but like the scale itself, should evolve with time. A key unanswered question is: how will such efforts be supported, financially and logistically, in the face of budgetary and workload uncertainties involving potential participants?

b. International utility

Given the global occurrence of tornadoes, internationally recognized practices for assessing their effects may prove advantageous in several ways, including more efficient scientific and engineering comparisons of tornado damage, damage mitigation techniques, and tornado climatologies. While EFSSM did not endorse any method outside the EF Scale, it was recognized that the future of the EF Scale can benefit from lessons learned abroad. Internationally developed standards for damage analysis and recordkeeping may result in relative calibration of the various scales in operational use. Smoother translation from one set of damage ratings to another then could be more feasible, perhaps akin to those for wind scales (including F Scale wind estimates) proposed by Meaden et al. (2007). Doswell et al. (2009) recommended, "…a continued discussion between atmospheric sciences and wind engineering in order to develop a synthesis of a (calibrated) E-scale and regionally adapted damage indicator / degree of damage decision matrices." If the EF Scale is adopted in other countries, DoDs may need recalibration to accommodate differences in prevailing construction practices and standards for various DIs relative to those in the U.S.

c. Tornado mapping and climatology

The presence of 28 diverse DIs (with more possible in the future) and GIS technology allows highly textured mapping of tornado damage paths, often at far finer scale than the $10^{-2\circ}$ latitude and longitude resolution of the existing SPC tornado data. GIS-based surveying already has been performed for a few years (e.g., LaDue and Ortega 2008), supplemented in some cases by digital cameras and video. Storm spotters and chasers also make numerous images of visible tornadoes and their parent storms available, both online via their personal pages, and directly to the NWS. High-resolution, proprietary satellite imagery also is available for purchase soon after some tornado events. Terabyte after terabyte of information potentially can be accumulated for some tornado events, especially when occurring in high-population areas and/or as parts of field experiments such as VORTEX-2.

[2] The term "ownership of the EF Scale" has been proposed; but the EFSSM consensus was that *everyone* who uses the scale "owns" it. Still, a dedicated team will be needed for its maintenance and oversight.

GIS technology and powerful software ensure that integrated, detailed damage mapping along paths is no longer just the domain of meticulous post-mortem research (as in Fujita's work), but can be done rapidly and timely, in an operational setting. The inevitable increase in high-resolution mapping of tornadoes, similar to and perhaps even finer in scale than the 3 May 1999 event maps in Speheger et al. (2002) raises important questions, including: for both tornado climatology and research, to what extent should digital metadata be affixed to the permanent tornado data, in what way, and under what kind of quality-control process? How can consistency in damage assessment procedures and mapping be ensured from one NWS jurisdiction to another, while allowing flexibility for local constraints in timeliness, staffing, expertise availability, etc.? What are the research implications of grouping relatively coarse historic records, many of which contain little more than a date, time, path length, max path width, rating and location, with richly textured, metadata-laden tornado maps of the future? Should purely damage-based EF-Scale ratings, especially in DI-deprived areas, be modulated by output from the increasing number and variety of mobile radars, fixed instruments and deployable devices? If so, in what ways, and with what designations in the climatological metadata, can this be done? How can satellite-based damage photos supplement ground surveys, and perhaps even replace them where the latter isn't fully possible?

Even without the necessary staffing and other resources to conduct a systematic reanalysis of tornado records, similar to the ongoing hurricane reanalysis project (Landsea et al. 2004), individual events have been, and will be, reassessed with potential EF-Scale implications. Studies of past outbreaks can reveal valuable new information about path characteristics and even aspects of tornado structure and behavior (e.g., Ostuno 2008) suitable for forensic reanalysis. This also raises inevitable questions such as: how can current understanding of DIs be used to revisit and revise ratings of past events, where sufficiently complete accounting exists of past damage? How should any such changes be reflected with metadata in the existing tornado database? How will such revisions impact the methods and integrity of statistical detrending (e.g., Doswell et al. 2006, Verbout et al. 2006) necessary to compare tornado records effectively from decade to decade, across major changes in record-gathering? What impacts will all this additional information have on risk-reduction and preparedness activities that depend on analyses of the tornado climatology? Should we revisit the notion of classifying tornadoes by their greatest single damage point, and instead invoke an integrated, textured approach? If so, how should tornadoes rated that way be compared to historic, peak-DI ratings?

This paper cannot cover all the implications and issues related to the EF Scale, some of which may be unforeseen. Still, we hope that the questions and topics discussed, along with a companion paper presented to the wind-engineering community (Lombardo et al. 2010), will stimulate focused, productive and beneficial discussion that results in ever-improving assessment and documentation of tornadoes worldwide, leading to better mitigation of the tornado-damage hazard.

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