THE BASICS ABOUT TORNADOES

What is a tornado? According to the *Glossary of Meteorology* (AMS 2000), a tornado is *"a violently rotating column of air, pendant from a cumuliform cloud or underneath a cumuliform cloud, and often (but not always) visible as a funnel cloud."* Literally, in order for a vortex to be classified as a tornado, it must be in contact with the ground *and* the cloud base. Weather scientists haven't found it so simple in practice, however, to classify and define tornadoes. For example, the difference is unclear between an strong mesocyclone (parent thunderstorm circulation) on the ground, and a large, weak tornado. There is also disgreement as to whether separate touchdowns of the same funnel constitute separate tornadoes. It is well-known that a tornado may not have a visible funnel. Also, at what wind speed of the cloud-to-ground vortex does a tornado begin? How close must two or more different tornadic circulations become to qualify as a one multiple-vortex tornado, instead of separate tornadoes? There are no firm answers.

How do tornadoes form? The classic answer -- "warm moist Gulf air meets cold Canadian air and dry air from the Rockies" -- is a gross oversimplification. Many thunderstorms form under those conditions (near warm fronts, cold fronts and drylines respectively), which never even come close to producing tornadoes. Even when the large-scale environment is extremely favorable for tornadic thunderstorms, as in an SPC "High Risk" outlook, not every thunderstorm spawns a tornado. The truth is that we don't fully understand. The most destructive and deadly tornadoes occur from *supercells* -- which are rotating thunderstorms with a well-defined radar circulation called a *mesocyclone*. [Supercells can also produce damaging hail, severe non-tornadic winds, unusually frequent lightning, and flash floods.] Tornado formation is believed to be dictated mainly by things which happen on the storm scale, in and around the mesocyclone. Recent theories and results from the VORTEX program suggest that once a mesocyclone is underway, tornado development is related to the temperature differences across the edge of downdraft air wrapping around the mesocyclone (the *occlusion downdraft*). Mathematical modelling studies of tornado formation also indicate that it can happen without such temperature patterns; and in fact, very little temperature variation was observed near some of the most destructive tornadoes in history on 3 May 1999. The details behind these theories are given in several of the Scientific References accompanying this FAQ.

What direction do tornadoes come from? Does the region of the US play a role in path direction? Tornadoes can appear from any direction. Most move from southwest to northeast, or west to east. Some tornadoes have changed direction amid path, or even backtracked. [A tornado can double back suddenly, for example, when its bottom is hit by outflow winds from a thunderstorm's core.] Some areas of the US *tend* to have more paths from a specific direction, such as northwest in Minnesota or southeast in coastal south Texas. This is because of an increased frequency of certain tornado-producing weather patterns (say, hurricanes in south Texas, or northwest-flow weather systems in the upper Midwest).

Does hail always come before the tornado? Rain? Lightning? Utter silence? Not necessarily, for any of those. Rain, wind, lightning, and hail characteristics vary from storm to storm, from one hour to the next, and even with the direction the storm is moving with respect to the observer. While large hail *can* indicate the presence of an unusually dangerous thunderstorm, and *can* happen before a tornado, don't depend on it. Hail, or any particular pattern of rain, lightning or calmness, is not a reliable predictor of tornado threat.

How do tornadoes dissipate? The details are still debated by tornado scientists. We do know tornadoes need a source of instability (heat, moisture, etc.) and a larger-scale property of rotation (*vorticity*) to keep going. There are a lot of processes around a thunderstorm which can possibly rob the area around a tornado of either instability or vorticity. One is relatively cold *outflow* -- the flow of

wind out of the precipitation area of a shower or thunderstorm. Many tornadoes have been observed to go away soon after being hit by outflow. For decades, storm observers have documented the death of numerous tornadoes when their parent circulations (*mesocyclones*) weaken after they become wrapped in outflow air -- either from the same thunderstorm or a different one. The irony is that some kinds of thunderstorm outflow may help to *cause* tornadoes, while other forms of outflow may *kill* tornadoes.

Do tornadoes really skip? Not in a literal sense, despite what you may have read in many older references, news stories, or even damage survey reports. By definition (above), a tornado must be in contact with the ground. There is disagreement in meteorology over whether or not multiple touchdowns of the same vortex or funnel cloud mean different tornadoes (a strict interpretation). In either event, stories of skipping tornadoes usually mean

1. There was continuous contact between vortex and ground in the path, but it was too weak to do damage;
2. Multiple tornadoes happened; but there was no survey done to precisely separate their paths (very common before the 1970s); or
3. There were multiple tornadoes with only short separation, but the survey erroneously classified them as one tornado.

How long does a tornado last? Tornadoes can last from several seconds to more than an hour. The longest-lived tornado in history is really unknown, because so many of the long-lived tornadoes reported from the early 1900s and before are believed to be tornado series instead. Most tornadoes last less than 10 minutes.

How close to a tornado does the barometer drop? And how far does it drop ? It varies. A barometer can start dropping many hours or even days in advance of a tornado if there is low pressure on a broad scale moving into the area. Strong pressure falls will often happen as the mesocyclone (parent circulation in the thunderstorm) moves overhead or nearby. The biggest drop will be in the tornado itself, of course. It is very hard to measure pressure in tornadoes since most weather instruments can't survive. A few low-lying, armored probes called "turtles" have been placed successfully in tornadoes. This includes one deployment on 15 May 2003 by engineer/storm chaser Tim Samaras, who recorded pressure fall of over 40 millibars through an unusually large tornado. On 24 June 2003, another of Tim's probes recorded a 100 millibar pressure plunge in a violent tornado near Manchester, SD. Despite those spectacyular results, and a few fortuitous passes over barometers through history, we still do not have a database of tornado pressures big enough to say much about average tornado pressures or other barometric characterstics.

What is a waterspout? A waterspout is a tornado over water -- usually meaning non-supercell tornadoes over water. Waterspouts are common along the southeast U.S. coast -- especially off southern Florida and the Keys -- and can happen over seas, bays and lakes worldwide. Although waterspouts are always tornadoes by definition; they don't officially count in tornado records unless they hit land. They are smaller and weaker than the most intense Great Plains tornadoes, but still can be quite dangerous. Waterspouts can overturn small boats, damage ships, do significant damage when hitting land, and kill people. The National Weather Service will often issue special marine warnings when waterspouts are likely or have been sighted over coastal waters, or tornado warnings when waterspouts can move onshore.

What is a multivortex tornado? Multivortex (a.k.a. multiple-vortex) tornadoes contain two or more small, intense *subvortices* orbiting the center of the larger tornado circulation. When a tornado doesn't contain too much dust and debris, they can sometimes be spectacularly visible. These

vortices may form and die within a few seconds, sometimes appearing to train through the same part of the tornado one after another. They can happen in all sorts of tornado sizes, from huge "wedge" tornadoes to narrow "rope" tornadoes. Subvortices are the cause of most of the narrow, short, extreme swaths of damage that sometimes arc through tornado tracks. From the air, they can preferentially mow down crops and stack the stubble, leaving cycloidal marks in fields. Multivortex tornadoes are the source of most of the old stories from newspapers and other media before the late 20th century which told of several tornadoes seen together at once.

What is the original F-scale? Dr. T. Theodore Fujita developed a damage scale (Fujita 1971, Fujita and Pearson 1973) for winds, including tornadoes, which was supposed to relate the degree of damage to the intensity of the wind. This scale was the result. The original F-scale should not be used anymore, because it has been replaced by an enhanced version. Tornado wind speeds are still largely unknown; and *the wind speeds on the original F-scale have never been scientifically tested and proven*. Different winds may be needed to cause the same damage depending on how well-built a structure is, wind direction, wind duration, battering by flying debris, and a bunch of other factors. Also, the process of rating the damage itself is largely a judgment call -- quite inconsistent and arbitrary (Doswell and Burgess, 1988). Even meteorologists and engineers highly experienced in damage survey techniques often came up with different F-scale ratings for the same damage. Even with all its flaws, the original F-scale was the only widely used tornado rating method for over three decades. The enhanced F-scale takes effect 1 February 2007.

What is the Enhanced F-scale? The Enhanced F-scale (simple table or detailed 95 page PDF) is a much more precise and robust way to assess tornado damage than the original. It classifies F0-F5 damage as calibrated by engineers and meteorologists across 28 different types of damage indicators (mainly various kinds of buildings, but also a few other structures as well as trees). The idea is that a "one size fits all" approach just doesn't work in rating tornado damage, and that a tornado scale needs to take into account the typical strengths and weaknesses of different types of construction. This is because the same wind does different things to different kinds of structures. In the Enhanced F-scale, there will be different, customized standards for assigning any given F rating to a well built, well anchored wood-frame house compared to a garage, school, skyscraper, unanchored house, barn, factory, utility pole or other type of structure. In a real-life tornado track, these ratings can be mapped together more smoothly to make a damage analysis. Of course, there still will be gaps and weaknesses on a track where there was little or nothing to damage, but such problems will be less common than under the original F-scale. As with the original F-scale, the enhanced version will rate the tornado as a whole based on most intense damage within the path. *There are no plans to systematically re-evaluate historical tornadoes using the Enhanced F-scale.* A full PDF document on the Enhanced F-scale is online.

So if the original F-scale winds are just guesses, why are they so specific? Excellent question. Those winds were arbitrarily attached to the damage scale based on 12-step mathematical interpolation between the hurricane criteria of the Beaufort wind scale, and the threshold for Mach 1 (738 mph). Though the F-scale actually peaks at F12 (Mach 1), only F1 through F5 are used in practice, with F0 attached for tornadoes of winds weaker than hurricane force. Again, F-scale wind-to-damage relationships are untested, unknown and purely hypothetical. They have never been proven and may not represent real tornadoes. F-scale winds should not be taken literally.

What is a "significant" tornado? A tornado is classified as "significant" if it does F2 or greater damage on the Enhanced F scale. Grazulis (1993) also included killer tornadoes of any damage scale in his significant tornado database. It is important to know that those definitions are arbitrary, for scientific research. No tornado is necessarily *in*significant. Any tornado can kill or cause damage; and some tornadoes rated less than F2 probably could do F2 or greater damage if they hit a well-

built house during peak intensity.

What does a tornado sound like? That depends on what it is hitting, its size, intensity, closeness and other factors. The most common tornado sound is a continuous rumble, like a closeby train. Sometimes a tornado produces a loud whooshing sound, like that of a waterfall or of open car windows while driving very fast. Tornadoes which are tearing through densely populated areas may be producing all kinds of loud noises at once, which collectively may make a tremendous roar. *Just because you may have heard a loud roar during a damaging storm does not necessarily mean it was a tornado*. Any intense thunderstorm wind can produce damage and cause a roar.

TORNADO FORECASTING

Who forecasts tornadoes? In the U.S., only the National Weather Service (NWS) issues tornado forecasts nationwide. Warnings come from each NWS office. The Storm Prediction Center issues watches, general severe weather outlooks, and mesoscale discussions. Tornadoes in Canada are handled by the Meteorological Service of Canada. Very few other nations have specific tornado watch and warning services.

How do you forecast tornadoes? This is a very simple question with no simple answer! Here is a *very* generalized view from the perspective of a severe weather forecaster: When predicting severe weather (including tornadoes) a day or two in advance, we look for the development of temperature and wind flow patterns in the atmosphere which can cause enough *moisture, instability, lift, and wind shear* for tornadic thunderstorms. Those are the four needed ingredients. But it is not as easy as it sounds. "How much is enough" of those is not a hard fast number, but varies a lot from situation to situation -- and sometimes is unknown! A large variety of weather patterns can lead to tornadoes; and often, similar patterns may produce no severe weather at all. To further complicate it, the various computer models we use days in advance can have major biases and flaws when the forecaster tries to interpret them on the scale of thunderstorms. As the event gets closer, the forecast usually (but not always) loses some uncertainty and narrows down to a more precise threat area. [At SPC, this is the transition from outlook to mesoscale discussion to watch.] Real-time weather observations -- from satellites, weather stations, balloon packages, airplanes, wind profilers and radar-derived winds -- become more and more critical the sooner the thunderstorms are expected; and the models become less important. To figure out where the thunderstorms will form, we must do some hard, short-fuse detective work: Find out the location, strength and movement of the fronts, drylines, outflows, and other boundaries between air masses which tend to provide lift. Figure out the moisture and temperatures -- both near ground and aloft -- which will help storms form and stay alive in this situation. Find the wind structures in the atmosphere which can make a thunderstorm rotate as a supercell, then produce tornadoes. [Many supercells never spawn a tornado!] Make an educated guess where the most favorable combination of ingredients will be and when; then draw the areas and type the forecast.

That sounds really hard. What hardware and software tools do you use to help you forecast tornadoes? The most important hardware for forecasting at the Storm Prediction Center is the human hand. Numerous hand-drawn analyses of surface and upper-air data are still performed at SPC every day so forecasters can be intimately familiar with the weather features. SPC forecasters also use high-performance computer workstations (mainly running Unix and Windows 98), with a huge variety of software to display the things we need to help us forecast severe weather. The variety of those things is enormous: many kinds of computer model displays, satellite image loops, radar displays, wind profiler and radar-wind plots, data from surface weather stations,

upper air data from balloons and planes, lightning strike plots, weather data tables, multiple-source overlays, and more. It may sound trite; but by far, the most important software in the tornado forecast process is within the human brain. The forecaster must use it to sort all that information, toss out what is not needed, properly interpret what is needed, and put it into a coherent form -- all on a time deadline.

What is the role of Doppler radar in tornado forecasting? Each NWS forecast office uses output from at least one Doppler radar in the area to help to determine if a warning is needed. Doppler radar signatures can tell warning meteorologists a great deal about a thunderstorm's structure, but usually can't see the tornado itself. This is because the radar beam gets too wide to resolve even the biggest tornadoes within a few tens of miles after leaving the transmitter. Instead, a radar indicates strong winds blowing toward and away from it in a way that tells forecasters, "An intense circulation probably exists in this storm and a tornado is possible." Possible doesn't mean certain, though. That is why local forecasters must also depend on spotter reports, SPC forecast guidance on the general severe weather threat, and in-house analysis of the weather situation over the region containing thunderstorms, to make the best-informed warning decisions.

TORNADO DAMAGE

How is tornado damage rated? The most widely used method worldwide, for over three decades, was the F-scale developed by Dr. T. Theodore Fujita. In the U.S., and probably elsewhere within a few years, the new Enhanced F-scale is becoming the standard for assessing tornado damage. In Britain, there is a scale similar to the original F-scale but with more divisions; for more info, go to the TORRO scale website. In both original F- and TORRO-scales, the wind speeds are based on calculations of the Beaufort wind scale and have never been scientifically verified in real tornadoes. Enhanced F-scale winds are derived from engineering guidelines but still are only judgmental estimates. Because:

1. Nobody knows the "true" wind speeds at ground level in most tornadoes, and
2. The amount of wind needed to do similar-looking damage can vary greatly, even from block to block or building to building,

...damage rating is (at best) an exercise in educated guessing. Even experienced damage-survey meteorologists and wind engineers can and often do disagree among themselves on a tornado's strength.

Who surveys tornado damage? What's the criteria for the National Weather Service to do a survey? This varies from place to place; and there is no rigid criteria. The responsibility for damage survey decisions at each NWS office usually falls on the Warning-Coordination Meteorologist (WCM) and/or the Meteorologist in Charge (MIC). Budget constraints keep every tornado path from having a direct ground survey by NWS personnel; so spotter, chaser and news accounts may be used to rate relatively weak, remote or brief tornadoes. Killer tornadoes, those striking densely populated areas, or those generating reports of exceptional damage are given highest priority for ground surveys. Most ground surveys involve the WCM and/or forecasters not having shift responsibility the day of the survey. For outbreaks and unusually destructive events -- usually only a few times a year -- the NWS may support involvement by highly experienced damage survey experts and wind engineers from elsewhere in the country. Aerial surveys are expensive and usually reserved for tornado events with multiple casualties and/or massive degrees of damage. Sometimes, local NWS offices may have a cooperative agreement with local media or police to use their helicopters during surveys.

How can a tornado destroy one house and leave the next one almost unscratched? Most of the time, this happens either with multiple-vortex tornadoes or very small, intense single-vortex tornadoes. The winds in most of a multivortex tornado may only be strong enough to do minor damage to a particular house. But one of the smaller embedded subvortices, perhaps only a few dozen feet across, may strike the house next door with winds over 200 mph, causing complete destruction. Also, there can be great differences in construction from one building to the next, so that even in the same wind speed, one may be flattened while the other is barely nicked. For example, a flimsy, unanchored mobile home may be obliterated while all surrounding objects suffer little or no damage.

How do tornadoes do some weird things, like drive straw into trees, strip road pavement and drive splinters into bricks? The list of bizarre things attributed to tornadoes is almost endless. Much of it is folklore; but there are some weird scenes in tornado damage. Asphalt pavement may strip when tornado winds sandblast the edges with gravel and other small detritus, eroding the edges and causing chunks to peel loose from the road base. Storm chasers and damage surveyors have observed this phenomenon often after the passage of a violent tornado. With a specially designed cannon, wind engineers at Texas Tech University have fired boards and other objects at over 100 mph into various types of construction materials, duplicating some of the kinds of "bizarre" effects, such as wood splinters embedded in bricks. Intense winds can bend a tree or other objects, creating cracks in which which debris (e.g., hay straw) becomes lodged before the tree straightens and the crack tightens shut again. All bizarre damage effects have a physical cause inside the roiling maelstrom of tornado winds. We don't fully understand what some of those causes are yet, however; because much of it is almost impossible to simulate in a lab.

I've heard about tornadoes picking up objects and carrying them for miles. Does this happen? Who does research on it? Yes, numerous tornadoes have lofted (mainly light) debris many miles into the sky, which was then carried by middle- and upper-atmospheric winds for long distances. The vertical winds in tornadoes can be strong enough to temporarily levitate even heavy objects if they have a large face to the wind or flat sides (like roofs, walls, trees and cars), and are strong enough to carry lightweight objects tens of thousands of feet high. Though the heaviest objects, such as railroad cars, can only be airborne for short distances, stories of checks and other papers found over 100 miles away are often true. The Worcester MA tornado of 9 June 1953 carried mattress pieces high into the thunderstorm, where they were coated in ice, before they fell into Boston Harbor. Pilots reported seeing debris fluttering through the air at high altitude near the thunderstorm which spawned the Ruskin Heights MO tornado of 20 May 1957. There is a research group at the University of Oklahoma which studies tornado debris flight. If you personally know of a case of tornado debris carried long-distance, they have a hotline you can call to report it.

TORNADO SAFETY

What is a tornado watch? A tornado watch defines an area shaped like a parallelogram, where tornadoes and other kinds of severe weather are possible in the next several hours. It does not mean tornadoes are imminent -- just that you need to be alert, and to be prepared to go to safe shelter if tornadoes do happen or a warning is issued. This is the time to turn on local TV or radio, turn on and set the alarm switch on your weather radio, make sure you have ready access to safe shelter, and make your friends and family aware of the potential for tornadoes in the area. The Storm Prediction Center issues tornado and severe thunderstorm watches; here is an example. For more information on tornado watches and other SPC bulletins, go here.

What is a tornado warning? A tornado warning means that a tornado has been spotted, or that Doppler radar indicates a thunderstorm circulation which can spawn a tornado. When a tornado warning is issued for your town or county, take immediate safety precautions. local NWS offices issue tornado warnings.

Do mobile homes attract tornadoes? Of course not. It may seem that way, considering most tornado deaths occur in them, and that some of the most graphic reports of tornado damage come from mobile home communities. The reason for this is that mobile homes are, in general, much easier for a tornado to damage and destroy than well-built houses and office buildings. A brief, relatively weak tornado which may have gone undetected in the wilderness -- or misclassified as severe straight-line thunderstorm winds while doing minor damage to sturdy houses -- can blow a mobile home apart. Historically, mobile home parks have been reliable *indicators*, not attractors, of tornadoes.

Long ago, I was told to open windows to equalize pressure. Now I have heard that's a bad thing to do. Which is right? Opening the windows is absolutely useless, a waste of precious time, and can be very dangerous. Don't do it. You may be injured by flying glass trying to do it. And if the tornado hits your home, it will blast the windows open anyway.

I've seen a video of people running under a bridge to ride out a tornado. Is that safe? Absolutely not! Stopping under a bridge to take shelter from a tornado is a very dangerous idea, for several reasons:

1. Deadly flying debris can still be blasted into the spaces between bridge and grade -- and impaled in any people hiding there.
2. Even when strongly gripping the girders (if they exist), people may be blown loose, out from under the bridge and into the open -- possibly well up into the tornado itself. Chances for survival are not good if that happens.
3. The bridge itself may fail, peeling apart and creating large flying objects, or even collapsing down onto people underneath. The structural integity of many bridges in tornado winds is unknown -- even for those which may look sturdy.
4. Whether or not the tornado hits, parking on traffic lanes is illegal and dangerous to yourself and others. It creates a potentially deadly hazard for others, who may plow into your vehicle at full highway speeds in the rain, hail, and/or dust. Also, it can trap people in the storm's path against their will, or block emergency vehicles from saving lives.

The people in that infamous video were extremely fortunate not to have been hurt or killed. They were actually not inside the tornado vortex itself, but instead in a *surface inflow jet* -- a small belt of intense wind flowing into the base of the tornado a few dozen yards to their south. Even then, flying debris could have caused serious injury or death. More recently, on 3 May 1999, two people were killed and several others injured outdoors in Newcastle and Moore OK, when a violent tornado blew them out from under bridges on I-44 and I-35. Another person was killed that night in his truck, which was parked under a bridge. For more information, meteorologist Dan Miller of NWS Norman has assembled 25-slide online presentation about this problem.

So if I'm in a car, which is supposed to be very unsafe, and shouldn't get under a bridge, what can I do? Vehicles are notorious as death traps in tornadoes, because they are easily tossed and destroyed. Either leave the vehicle for sturdy shelter or drive out of the tornado's path. When the traffic is jammed or the tornado is bearing down on you at close range, your only option may be to park safely off the traffic lanes, get out and find a sturdy building for shelter, if possible. If not, lie flat in a low spot, as far from the road as possible (to avoid flying vehicles). However, in open

country, the best option is to escape if the tornado is far away. *If the traffic allows, and the tornado is distant*, you probably have time to drive out of its path. Watch the tornado closely for a few seconds compared to a fixed object in the foreground (such as a tree, pole, or other landmark). If it appears to be moving to your right or left, it is not moving toward you. Still, you should escape at right angles to its track: to your right if it is moving to your left, and vice versa -- just to put more distance between you and its path. If the tornado appears to stay in the same place, growing larger or getting closer -- but not moving either right or left -- it is headed right at you. You must take shelter away from the car or get out of its way fast!

I have a basement, and my friend said to go to the southwest corner in a tornado. Is that good? Not necessarily. The SW corner is no safer than any other part of the basement, because walls, floors and furniture can collapse (or be blown) into any corner. The "safe southwest corner" is an old myth based on the belief that, since tornadoes usually come from the SW, debris will preferentially fall into the NE side of the basement. There are several problems with this concept, including:

1. Tornadoes are not straight-line winds, even on the scale of a house, so the strongest wind may be blowing from any direction; and
2. Tornadoes themselves may arrive from any direction.

In a basement, the safest place is under a sturdy workbench, mattress or other such protection -- and out from under heavy furniture or appliances resting on top of the floor above.

What is a safe room? So-called "safe rooms" are reinforced small rooms built in the interior of a home, which are fortified by concrete and/or steel to offer extra protection against tornadoes, hurricanes and other severe windstorms. They can be built in a basement, or if no basement is available, on the ground floor. In existing homes, interior bathrooms or closets can be fortified into "safe rooms" also. FEMA has more details online.

What about community tornado shelters? Community tornado shelters are excellent ideas for apartment complexes, schools, mobile home parks, factories, office complexes and other facilities where large groups of people live, work or study. FEMA has some excellent design and construction guidance for these kinds of shelters; and a licensed engineer can help customize them to the needs of your facility.

What about tornado safety in sports stadiums or outdoor festivals? Excellent question -- and a very, very disturbing one to many meteorologists. Tornadoes have passed close to such gatherings on a few occasions, including a horse race in Omaha on 6 May 1975 and a crowded dog track in West Memphis AR on 14 December 1987. A supercell without a tornado hit a riverside festival in Ft. Worth in 1995, catching over 10,000 people outdoors and bashing many of them with hail bigger than baseballs. Just in the last few years, tornadoes have hit the football stadium for the NFL Tennessee Titans, and the basketball arena for the NBA Utah Jazz. Fortunately, they were both nearly empty of people at the time. There is the potential for massive death tolls if a stadium or fairground is hit by a tornado during a concert, festival or sporting event -- even with a warning in effect. Fans may never know about the warning; and even if they do, mass-panic could ensue and result in casualties even if the tornado doesn't hit. Stadium and festival managers should work with local emergency management officials to develop a plan for tornado emergencies -- both for crowd safety during the watch and warning stages, and (similar to a terrorism plan) for dealing with mass casualties after the tornado.

I am a school administrator, and I don't know where to start with developing a safety plan. Can you help? Gladly. Every school is different, so a safety plan which works fine for one may not be well-suited for another. There is a website with preparedness tips for school administrators which can provide helpful tips in devising a safety plan. These strategies can be adapted for nursing homes, dorms, barracks and similar structures as well.

I am seeking advice to protect employees in a large, one-story commercial building that has pre-poured cement outer walls and a metal roof. We have no basement, the interior offices are drywall partitions with a dropped ceiling and there does not appear to be any area that is secure. The local fire department has no suggestions. This manner of construction is very common; however, it's hard to know the integrity of any particular building without an engineering analysis, preferably by hiring a specialist with experience in wind engineering. My experience doing damage surveys is that large-span, pre-fab, concrete and metal beam buildings are very sturdy up to a "break point" -- which can vary a lot from site to site -- but then crumple quickly and violently once that threshold is reached. A concrete-lined (and -topped) safe room with no windows is recommended. This is an emergency bunker that may double as a restroom, break room or employee lounge, but should be big enough to fit all occupants in the event of a warning. For more information on safe rooms, see FEMA's safe room page, which deals mainly with residential construction, but which can be adapted for office use. As noted there, the Wind Engineering Research Center at Texas Tech University also provides technical guidance about shelters. Their toll free number is 1-(888) 946-3287, ext. 336.

Could we have some sort of alert system where a computer automatically calls people in a tornado warning to let them know they could be in danger? This idea has some merit. Right now, though, there are several logistical problems. First, a tornado may take out phone lines, or the power to run them. Barring that, the phone network reaches saturation pretty easily if someone (or something) tries to try to dial thousands of numbers at once. Finally, people would need to be patient and willing to accept a majority of false alarm calls. Most tornado warnings do not contain tornadoes, because of the uncertainties built into tornado detection which we can't yet help. And even when a tornado happens, it usually hits only a tiny fraction of the warned area (again, because of forecasting uncertainties); so most people called by the automated system would not be directly hit.

Our office would like to print signs (universal symbol image type signs) similar to "emergency exit," "fire extinguisher," etc. that could be used to identify designated tornado shelter areas. Can you provide me with a graphic or something I can use? Sure! There isn't a universal tornado shelter symbol yet. Any such sign should be very bold and noticeable -- yet designed to be simple, with minimal visual clutter, so even a small child can recognize it. In response to this question, here is one possible tornado shelter sign which may be printed and used freely. There are also versions with arrows pointing right, left, up, and down. The signs ideally should be printed in color, on heavy card stock or sticker paper for durability.

From: FEMA website