Instructions for Lightning Avoidance

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Abstract

Lightning is a massive electrostatic discharge between the electrically charged regions within clouds or between a cloud and the Earth's surface. While many may find lightning visually appealing due to the immediacy of its appearance (10 microseconds or less), as well as the nonlinear, relative complexity and nonuniformity of its structure due to the short step size and random distribution of higher conductive regions, generally causing a current to channel an indirect pathway for the transfer of electric charge through normally nonconductive media such as air, glass, leaves, and soil, lightning is also dangerous. In the past, lightning functioned as a mythology in which God used storms as tools to punish the wicked. In the present, the lightning mythology becomes reinvented and recontextualized in terms of risk management and disaster prevention. While risks can never be entirely avoided, they can nonetheless be identified, prioritized, and minimized in order to reduce threat probability. The seemingly random nature of thunderstorms cannot guarantee the individual or group absolute protection from lightning strikes; however, being aware of, and following proven lightning safety guidelines can greatly reduce the risk of injury or death.

Intentionality / Avoidance / Digital Rights Management / Injury

When the accumulated electric charges in a thunderstorm become sufficiently large, lightning discharges take place between opposite charge regions, between charged regions and the ground, or from a charged region to the neutral atmosphere. In recent years it has become clear that lightning can be artificially initiated, or triggered, in clouds that would not normally produce natural lightning discharges. A typical flash of cloud-to-ground lightning is initiated by electrical breakdown between the small positive charge region near the base of the cloud and the negative charge region in the middle of the cloud. The preliminary breakdown creates channels of air that have undergone partial ionization—the conversion of neutral atoms and molecules to electrically charged ones. Like poetry, air is essentially a non-expressive medium. In technical terms, a thunderstorm is said to develop when the atmosphere becomes “unstable to vertical motion.” Spectroscopic measurements reveal that the air molecules, principally those of nitrogen, oxygen, and water, are split into their respective atoms and that on average one electron is removed from each atom. The conversion of neutral air molecules to completely ionized plasma occurs in a few microseconds.

FIGURE 8.1. Issue Crawler Map of Online Copyright Debate, November 2006

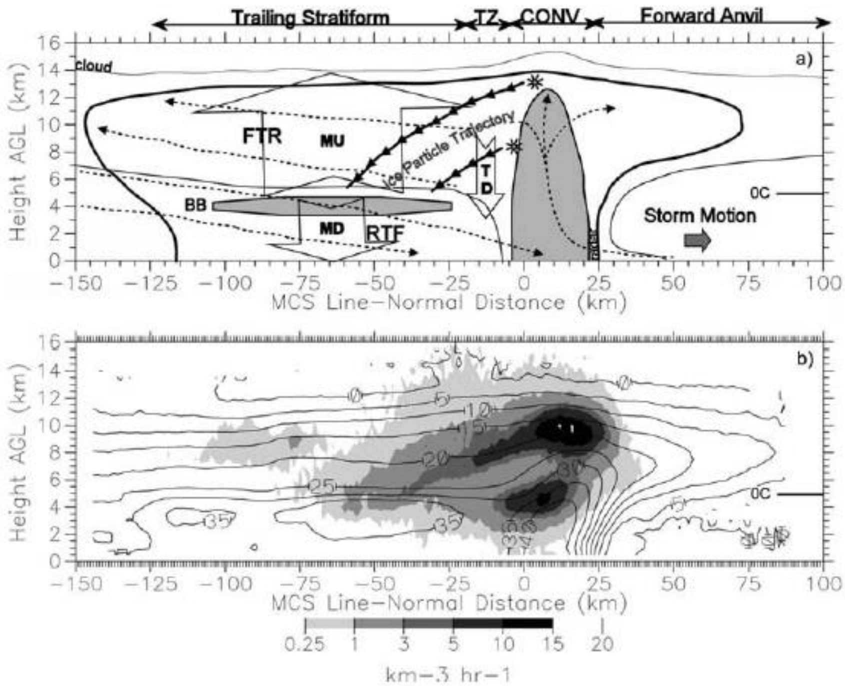

Figure 1. (a) A Line-normal vertical cross section of a conceptual model of the kinematic and precipitation structure and (b) the corresponding line-normal vertical composite of radar reflectivity (dBZ, contours every 5 dBZ) and VHF lightning source density ($km^{-3}\,h^{-1}$, shaded as shown) of a mature leading-line, trailing-stratiform (LLTS) mesoscale convective system (MCS). Key regions of the conceptual model structure are highlighted at the top, including the convective (CONV) region and transition zone (TZ). The thin line depicts the visual or satellite detected cloud boundary. The bold line depicts the radar observed outline of precipitation. The shaded areas indicate regions of enhanced precipitation or larger radar reflectivity, including the radar bright band (BB). The dashed arrows depict important storm-relative flow fields, including the ascending front-to-rear (FTR) and descending rear-to-front (RTF) flows. The bold, repeating arrows indicate the approximate trajectories of ice particles, which are represented by asterisks. The direction of storm motion and height of the 0°C isotherm are indicated. Large block arrows indicate the approximate locations of the mesoscale updraft (MU), mesoscale downdraft (MD), and transition zone downdraft (TD) [adapted from *Carey et al.*, 2005].

Instructions for Lightning Avoidance

Know the weather and have an escape plan. Know how long it will take you to reach safety and watch the sky. Use the 30-30 rule to estimate distance of storm. Actually, don't even bother to count the first 30—when you see lighting or hear thunder, you should be making your way to safety or deciding if it is time to implement your safety plan. Generally speaking, if you see lightning and/or hear thunder, you are already at risk. Louder or more frequent thunder and lightning activity means the risk for lightning injury or death is increasing. Lightning can strike within a 10 mile radius even if no rain, sun shining, etc. (some report up to 15 miles). High winds, rainfall, and cloud cover often act as precursors to actual cloud-to-ground strikes, but not necessarily. Many lightning casualties occur in the beginning as the storm approaches, or within 30 minutes after the storm has passed.

Avoid open areas such as fields, construction sites, and recreation areas. Avoid water such as ocean, lakes, swimming pools, rivers. Avoid high places. Avoid trees. Avoid small open structures such as bus stops, rain shelters, picnic shelters, dugouts, gazebos. Avoid bleachers (metal or wood). Avoid metal fences or metal objects such as carts, agricultural or construction equipment, golf carts, telephone lines or power lines, pipelines, or steel fabrications. Avoid leaning against cars or metal objects such as bicycles and motorcycles. Avoid holding metal objects such as fishing rods, golf clubs, ski poles, tennis rackets, tools.

Factors Leading to Incorrect Decisions and Possible Injury

1 Belief in myths about lightning and its effects and what to do.
2 Improper education about lightning risks and safety measures.
3 Lack of planning by coaches, parents, referees at sporting events, and activity or outing organizers as to possible shelter to take during a thunder storm. Adults should be aware that they are always responsible for the children in their care, particularly if it is an outdoor activity such as soccer, football, camping, etc.
4 Incorrect estimate of the danger of a possible lightning strike.

While any death is a blow to a family, eventually the family readjusts and goes on. However, for those who have a relative who suffers significant disability from lightning, life changes forever and the dreams of that family and the survivor may be markedly altered. The family income be tremendously decreased if the survivor was one of the breadwinners, or the spouse or another family member may have to quit work to care for the survivor if the disability is great enough. Lightning tends to be a nervous system injury and may affect any or all parts of the nervous system: the brain, the autonomic nervous system, and the peripheral nervous system. When the brain is affected, the person often has difficulty with short-term memory, coding new information and accessing old information, multitasking, distractibility, irritability and personality change. A great quote sums it up perfectly: "Patients have difficulty in all areas that require them to analyze more items of information than they can handle simultaneously. They present (appear) as slow because it takes longer for smaller than normal chunks of information to be processed. They present as distractible because they do not have the spare capacity to monitor irrelevant stimuli at the same time as they are attending to the relevant stimulus. They present as forgetful because while they are concentrating on point A, they do not have the processing space to think about point B simultaneously. They present as inattentive because when the amount of information that they are given exceeds their capacities, they cannot take it all in." Early on, survivors may complain of intense headaches, ringing in the ears, dizziness, nausea, vomiting and other post-concussion types of symptoms. Survivors may also experience difficulty sleeping, sometimes sleeping excessively after the injury but changing during the next few weeks to inability to sleep more than two or three hours at a time. A few may develop persistent seizure-like activity several weeks to months after the injury.

Many may suffer personality changes because of frontal lobe damage and become quite irritable and easy to anger. The person who wakes up after the injury often does not have the ability to express what is wrong with them, may not recognize much of it or deny it, becomes embarrassed when they cannot carry on a conversation, work at their previous job, or do the same activities that they used to handle. As a result, many self-isolate, withdrawing from church, friends, family and other activities. Friends, family and co-workers who see the same external person may not understand why the survivor is so different. Friends may stop coming by or asking them to participate in activities or survivors may self-isolate out of embarrassment or irritability. As with other disabilities, families who are not committed to each other are more likely to break up. Obviously, depression becomes a big problem for people who have changed so much and lost so much. Suicide is something that almost all severely injured people have thought about at one time or another. Occasionally, those who do not have access to medical care or who do not understand what is happening may self-medicate with alcohol and other drugs, particularly those who have previously sought solace with these compounds. It is very important that the family and friends of the survivor maintain supportive contact even though it requires an adjustment in their relationship with the survivor. An injury such as this is an injury to the family, not just to the person hit.

Survivors often complain of easy fatigability, becoming exhausted after only a few hours of work. Many return to work but find that they cannot multitask and do all of the activities that are required at their job. Another common, but often delayed, problem for some survivors is pain, also a difficult problem to quantify and manage. The pain may not be from chronic intense headaches but may be in the back (perhaps from compression and disc injury from the intense muscle contractions which may throw a person several yards at the time of the injury), or in an extremity. Some may have nerve entrapment syndromes and a small number may eventually develop Sympathetically Mediated Pain Syndrome (SMPS). Sometimes the functional tests that are ordered are testing the wrong thing. An electromyogram (EMG) measures only the largest nerve fibers, the motor fibers, which are seldom affected by lightning injury. Smaller pain carrying nerve fibers are not tested by EMG so that a normal EMG means little when ordered for someone with pain. Likewise, the standard EEG measures primarily surface readings of the brain and misses seizure activity in several deeper regions.

Instructions for Lightning Avoidance

A house or other substantial building offers the best protection from lightning. In assessing the safety provided by a particular structure, it is more important to consider what happens if the structure gets struck by lightning, rather than whether the structure will be hit by lightning. For a shelter to provide protection from lightning, it must contain a mechanism for conducting the electrical current from the point of contact to the ground. These mechanisms may be on the outside of the structure, may be contained within the walls of the structure, or may be a combination of the two. On the outside, lightning can travel along the outer shell of the building or may follow metal gutters and downspouts to the ground. Inside a structure, lightning can follow conductors such as the electrical wiring, plumbing, and telephone lines to the ground.

If you feel hairs on your head, leg or arms tingling and standing on end, you are in an extremely high electric field. If you or any member of your group experiences any of these signs, it should be taken as an indication of immediate and severe danger. The response to any of these signs should be to instantly (seconds matter) drop and move away from all packs, remove metal shoe fittings, spread out, and adopt the lightning position. Do not ignore these signs and do not try to run to safety, unless safety is literally seconds away. If any of these signs are detected, the probability of a close discharge is high and every effort should be made to minimize injuries and the number of injured.

Subject / Error / Classification / Range

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CRDEC-TR-88059

AD-A199 599

ELECTRICAL PROPERTIES OF ATMOSPHERIC MOIST AIR: A SYSTEMATIC, EXPERIMENTAL STUDY

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September 1988

U.S. ARMY
ARMAMENT
MUNITIONS
CHEMICAL COMMAND

Aberdeen Proving Ground, Maryland 21010-5423

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S) CRDEC-TR-88059	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION CRDEC 6b OFFICE SYMBOL (If applicable) SMCCR-RSP-P	7a NAME OF MONITORING ORGANIZATION
6c ADDRESS (City, State, and ZIP Code) Aberdeen Proving Ground, MD 21010-5423	7b ADDRESS (City, State, and ZIP Code)
8a NAME OF FUNDING/SPONSORING ORGANIZATION CRDEC 8b OFFICE SYMBOL (If applicable) SMCCR-RSP-P	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER U.S. Army Science and Engineering Fellowship
8c ADDRESS (City, State, and ZIP Code) Aberdeen Proving Ground, MD 21010-5423	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification)
Electrical Properties of Atmospheric Moist Air: A Systematic, Experimental Study

12 PERSONAL AUTHOR(S)
Carlon, Hugh R., U.S. Army Fellow

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Technical	FROM 86 May TO 87 May	1988 September	31

16 SUPPLEMENTARY NOTATION

17 COSATI CODES

FIELD	GROUP	SUB-GROUP
04	01	

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Atmospheric electricity, Field strengths, Electrical conductivity, Surface films, Static electricity, (Continued on reverse)

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

Systematic new measurements of the electrical properties of atmospheric moist air in a closed container near sea level are presented. Data were taken using a vapor electrical conductivity cell of new design. The cell consisted of 40 parallel square plates, each 26.5 cm^2, and separated by 0.66 cm. The cell insulators were isolated from the cell plates by use of a technique that completely eliminated insulator leakage as a source of experimental error. Thus, very sensitive measurements could be made in still or moving air even at near-saturation humidity. Measurements were made over a wide range of humidities and electric field strengths ranging from near zero to 3 kV/cm.

(Continued on reverse)

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL SANDRA J. JOHNSON	22b TELEPHONE (Include Area Code) (301) 671-2914 22c OFFICE SYMBOL SMCCR-SPS-T

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

18. SUBJECT TERMS (Continued)

Water vapor
Humidity
Atmosphere
Ions

19. ABSTRACT (Continued)

Many new insights into the behavior of moist air in electric fields were gained, including: (1) a very steep equilibrium dependence of conductivity (ion or charge carrier content) upon humidity; (2) "hysteresis" effects; (3) increasing complexity of behavior at field strengths greater than a few hundred volts per centimeter; and (4) regions where the conductivity of near-saturated air was constant over a range of field strengths. All results were consistent with the view that ions are produced in moist air from thin water films on conductive surfaces between which an electric field exists. This effect could contribute significantly to the earth's global current.

Subject / Error / Classification / Range (cont.)

Lightning events can be detected (i.e. "read") by their proximity. It is important to make a distinction between striking distance, R_s, and attractive radius, R_a. The striking distance is defined as the distance between the object to be struck and the tip of the downward-moving leader at the instant that the connecting (upward) leader is initiated from the object (Uman 1987). It depends solely on the charge of the downward leader and hence return-stroke current. On the other hand, a calculation of attractive radius also takes into account the geometry of the object to be struck, i.e. the structure and air terminal. This is done by including physical considerations of the ionization processes of streamer and leader development (Petrov et al. 2000; D'Alessandro k Gumley 2001). In general, the attractive radius has a smaller magnitude than the corresponding striking distance, although the striking distance can be used in place of the attractive radius if only a rough approximation is required.

In the past, lightning detectors, both inexpensive portable ones for use on the ground and expensive aircraft systems, detected low frequency radiation because at low frequencies the signals generated by cloud-to-ground (CG) lightning are stronger (have higher amplitude) and thus are easier to detect. In the present, RF sensors and light pulse sensors can usefully be connected in a "coincidence circuit" which requires both kinds of signals simultaneously in order to produce an output. If such a system is pointed toward a cloud and lightning occurs in that cloud, both signals will be received; the coincidence circuit will produce an output; and the user can be sure the cause was lightning. When a lightning discharge occurs within a cloud at night, the entire cloud appears to illuminate. In daylight these intracloud flashes are rarely visible to the human eye; nevertheless, optical sensors can detect them. Looking through the window of the space shuttle in early missions, astronauts used optical sensors to detect lightning in bright sunlit clouds far below.

Surface Readings / Difference / Negotiation / Transfer

If your skin tingles or your hair stands on the end, a lightning strike may be about to happen. Crouch down on the balls of your feet with your feet close together. Keep your hands on your knees and lower your head. Get as low as possible without touching your hands or knees to the ground. If you are swimming, fishing or boating and there are clouds, dark skies and distant rumbles of thunder or flashes of lightning, get to land immediately and seek shelter. If you are in a boat and cannot get to shore, crouch down in the middle of the boat. Go below if possible. If you are on land, find a low spot away from trees, metal fences, pipes, tall or long objects. If you are in the woods, look for an area of shorter trees. Crouch down away from tree trunks.

When an individual is struck by lightning, the primary current arc travels outside the body, a phenomenon known as “flashover.” Some authors hypothesize that this phenomenon is protective, causing the current to flow over, rather than through, the body. However, this immense current likely generates large magnetic fields perpendicular to the body surface, which in turn induce secondary electric currents within the body. When lightning hits the ground, current spreads out from the contact point such that if a casualty is standing nearby with feet apart, the potential difference between the feet may be in the range of 1500 V. When lightning directly strikes a victim's upper body, a very large potential difference between the upper and lower body is established.

Atmosphere / Appropriation / Procedure / Threat

If you are caught outside in a storm, always look for appropriate shelter. Do not take any chances—lightning can use you as a path to the earth just as easily as it can use any other object. Appropriate shelter would be a building or a car (see the "lightning myth" sidebar at the bottom of the page to find out why). If you do not have anywhere to go, then you should avoid taking shelter under trees. Trees attract lightning. Put your feet as close together as possible and crouch down with your head as low as possible without touching the ground. Never lay down on the ground. After lightning strikes the ground, there is an electric potential that radiates outward from the point of contact. If your body is in this area, current can flow through you. You never want the current to have the ability to pass through your body. This could cause cardiac arrest, not to mention other organ damage and burns. By making your body as low to the ground as possible and minimizing the amount of your body in contact with the ground, you can lower the possibility of a lightning-related injury. If a strike were to occur near you, the current would have a much more difficult time flowing through your body in this position.

If you are indoors, stay off the phone. If you must call someone, use a cordless phone or cell phone. If lightning strikes the phone line, the strike will travel to every phone on the line (and potentially to you if you are holding the phone). Stay away from plumbing pipes (bath tub, shower). Lightning has the ability to strike a house or near a house and impart an electrical charge to the metal pipes used for plumbing. This threat is not as great as it used to be, because PVC (polyvinyl chloride) is often used for indoor plumbing these days. If you are not sure what your pipes are made of, wait it out. For more information on lightning and related topics, check out the links on the next page.

[redacted]

Lightning-Associated Deaths — United States, 1980–1995

A lightning strike can cause death or various injuries to one or several persons. The mechanism of injury is unique, and the manifestations differ from those of other electrical injuries. In the United States, lightning causes more deaths than do most other natural hazards (e.g., hurricanes and tornadoes) (*1*), although the incidence of lightning-related deaths has decreased since the 1950s (*1,2*). The cases described in this report illustrate diverse circumstances in which deaths attributable to lightning can occur. This report also summarizes data from the Compressed Mortality File of CDC's National Center for Health Statistics on lightning fatalities in the United States from 1980 through 1995, when 1318 deaths were attributed to lightning.

Case Reports

Case 1. In April 1997, a 34-year-old woman in Florida was struck by lightning at approximately 12:30 p.m. after a severe thunderstorm had passed through the area. She had gone into her back yard to tend animals in a pen. As she walked toward the pen gate, lightning stuck her, throwing her several feet. A neighbor immediately administered cardiopulmonary resuscitation (CPR) but could not revive her and called the emergency medical service (EMS). EMS personnel were unable to resuscitate her, and she was pronounced dead at the scene. She had metal screws in her breast pocket and a cordless hand drill in her hand. The clothing of her upper torso was torn. Autopsy findings included arborization—erythematous marks in a branching pattern

Lightning — Continued

characteristic of lightning injury—on her left anterior torso but no other visible pathology related to the lightning strike.

Case 2. In July 1997, a 47-year-old man in Florida was struck by lightning while golfing at a driving range at approximately 5:30 p.m. The skies reportedly were clear but a storm may have been forming in the area. EMS personnel arrived at 5:40 p.m. and found him without a pulse or spontaneous respirations. He was intubated at the scene, but resuscitation efforts were unsuccessful. He was transported to an emergency department, where his pulse rate and blood pressure were obtained. However, his pupils were fixed and dilated, and he was unresponsive to stimuli. A computerized tomogram (CT) of his head showed cerebral edema but no hemorrhage. Bloody drainage was noted from his nose and right ear. He gradually became hypotensive, and his blood pressure failed to increase with intravenous fluid. He was pronounced dead at 1:25 p.m. the following day. Autopsy indicated burns on his left hand and a second-degree burn with vesicle formation on his right back. His heart had epicardial petechiae on the anterior and posterior surfaces. His brain was edematous and had hypoxic injury to the neurons.

Case 3. In September 1996, a 14-year-old boy in Washington was struck by lightning while riding his motorcycle during a thunderstorm. A bolt of lightning struck a tree near the motorcyclist, traveled along the trunk of the tree, then jumped from the tree to the motorcycle and the rider's feet and groin. Persons who saw the incident found him apneic and immediately began CPR. He was transported to the nearest hospital and was in cardiac arrest on arrival. Although he was successfully resuscitated and admitted to a hospital, he died 5 days later. Autopsy findings included a soft swollen brain with axial herniation and hypoxic injury to the neurons. The right side of his chest had singed hair, a healing burn injury, and damage to the underlying pectoralis muscles. His heart had multiple microscopic foci of myocardial necrosis, and his kidney had pink tubular casts consistent with myoglobinuria.

Sum[redacted]

This paper discusses the phenomenon of lightning as it typically happens; how to seek relative safety when caught in a backcountry lightning storm; typical lightning injuries; some tips on teaching lightning risk management in the backcountry; an overview of first aid, and incident reporting guidelines. It can not be emphasized enough, that **being outdoors exposes us to random lightning hazard, no matter what actions we take.**

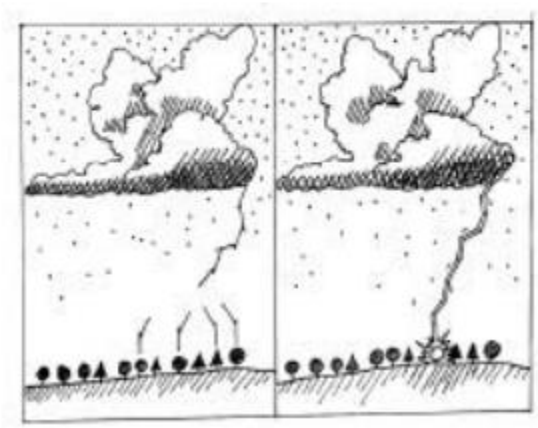
Most ground strikes occur immediately below a cumulonimbus cloud. Rarely, a bolt of lightning can move horizontally and strike somehwere "out of the blue" (out of the blue sky) as far as 10 miles (16km) away. These horizontal strikes are rare and unpredictable, so they shouldn't affect our decisions. Using the the 50 m search distance of stepped leaders (see above), lightning tends to hit the closest object within range at the end of the last step. Lightning tends to hit elevated sharp terrain features like mountain tops. Lightning tends to hit tall trees in open areas, with objects twice as high receiving roughly 4X the strikes[4]. Lightning tends to hit bushes in the desert if the bush is sticking up higher than the flat ground around it. Lightning tends to hit a boat on the water, especially if it has a tall mast. Lightning can still hit flat ground or water, but more randomly than it hits elevated objects. Even a few less feet of height can make a difference in improving your odds of not being the struck object. This is why the first part of getting into the lightning position is lowering yourself down to decrease your height. Lightning tends to hit long electrical conductors. Metal fences, power lines, handrails, measuring tapes, bridges and other long metallic objects can concentrate currents. Wet ropes also conduct current and should be treated with the same respect as wires. Longer objects tend to concentrate more current and reach more strike points.

Surface Arcs / Injury / Association / Despair

Ground currents occur with each strike and cause roughly half of all lightning injuries. Ground currents are driven by the enormous potential differences[7] that appear in the Earth near the ground strike point. Typical lightning-to-ground strikes inject roughly 30,000 amps into the Earth: since the Earth resists electrical flow, large potential differences will appear in the ground all around the strike point. How far the current flows varies wildly since strike current and ground conductance easily vary by orders of magnitude. But the closer you are to the direct strike, the stronger the ground current. If you are standing with your legs separated, if you are on all fours, if you are in a prone position on the ground, or if you are touching a long metallic object, you maximize your exposure to potential differences that arise from ground currents.

LIGHTNING MYTH #1

The tallest objects in a storm **don't** always get struck by lightning. It's true that taller objects are closer to the clouds, but as discussed previously, lightning can strike the ground at a close distance to a tall object. Taller objects may have a higher possibility of a strike, but where lightning is concerned, the strike path is not predictable.

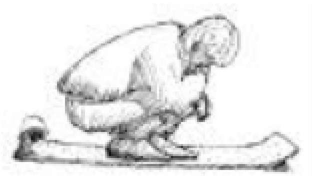


[redacted] see.

The potential difference that appears between your legs or across your prone body can drive significant currents through and over your body. You can minimize your exposure to ground potential differences and ground currents by: keeping your feet close together, by not getting in a prone position, by assuming the lightning position on additional insulation such as a foam pad, and by not removing your shoes with thick rubber soles. These actions can help minimize the amount of ground current going through your body, but some experts think these efforts are moot compared to getting to a safer location. We need to be careful that we don't give students a false sense of security by getting in this defensive position. High current surface arcs appear to be associated with some fraction of all cloud-to-ground discharges, during the return stroke. They appear in photographs as bright arcs of light radiating from a strike point like spokes of a wheel, in the air just above the ground's surface (see figure 2). These long hot horizontal currents have been measured up to 20 meters in length and may get longer. If you are in the path of a surface arc you are likely to conduct some of the surface arc current through or over your body. Since surface arcs emanate from the base of trees struck by lightning, never seek shelter near a tree.

Avoid trees because they are taller than their surroundings. Tall trees are especially adept at generating streamers that attract strikes. If you need to move through a forest while seeking safer terrain, stay away from the tree trunks as you move. You should also avoid open areas that are 100 m wide or wider. Lone trees are especially dangerous: the laws of probability say you are hundreds of times safer in a forest with hundreds of trees than you are near a lone tree in an open space. Assume the lightning position when at risk. This will reduce the chances of getting a direct strike and it may reduce the other effects of lightning, but it offers no guarantees. Some scientists argue that it only moves you up to 0.1 on the 10-scale; others argue that it is muchmore valuable because the data says that no one in this position has ever been hurt. This position includes squatting (or sitting) and balling up so you are as low as possible without getting prone. Wrap your arms around your legs, both to offer a safer path than your torso for electrons to flow from the ground, and to add enough comfort that you will choose to hold the position longer. Close your eyes.

While the prone position is lower, being spread out increases potential for ground current to flow through or across you. Keep your feet together so you don't create potential for current to flow in one foot and out the other. If you have any insulated objects handy, like a foam pad or a



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soft pack full of clothes, sit on them. Avoid backpacks with frames since the frame may concentrate current. Don't touch metallic objects like ice axes, crampons, tent poles or even jewelry. You won't get a warning that a strike is imminent because the lightning event from cloud to ground and back occurs faster than you can blink an eye, so stay in the lightning position until the storm passes. The lightning position reduces the chances of lightning injurying you as badly as if you were standing, but is no substitute for getting to safer terrain or structure if it is immediately available. A dangerously close strike actually offers a moment of opportunity to move, while the electrical field rebuilds itself. But in wide open country or gentle rolling terrain there are no simple terrain advantages, so use this position to reduce exposure. If you are concerned enough to assume the lightning position, you should have your group dispersed at least 50' apart to reduce the chances of multiple injuries. Ground current may spontaneously trigger your leg muscles to jump while in the lightning position, so take care to avoid being near hazards when you drop into this position. Anecdotal injury data shows that persons with metal cleats on their shoes are more prone to injury. So take crampons off while in the lightning position. But if taking crampons off will slow your descent from a hazardous spot, leave them on to reach safer terrain faster, since terrain is a much better protector than the lightning position is.

Current through the torso or brain can stop the heart or stop breathing. Hearts often restart themselves quickly, but it can take the breathing control center longer to recover. Cardiac or respiratory arrest that isn't restarted quickly will eventually cause anacrobic conditions that make recovery problematic. Current through the tissues can also lead to numbness, paralysis or other nervous system dysfunction. Lightning victims can get burned from the high current electricity that turns into heat in conductors that resist its flow. Strike victims can get linear burns from head to feet along the skin, punctuate (spotted) burns, or feathering skin marks (not really burns) from the charge flowing over their skin. They can get secondary burns from metallic objects like belt buckles and jewelry that heat up from the current. Burns can also occur from lightning ignited clothing.

Large entry and exit burn wounds from lightning strikes are rare. Most victims have a flashover effect (current travels over their skin) that saves them from the more severe wounds: these people can get linear or punctuate burns or feathering patterns. But flashover can also travel into orifices, which may explain the many ear and eye problems that result from lightning strikes. Wet people may carry more current over their skin, instead of through their bodies, reducing their injuries. It is not suggested that you intentionally get wet in case you are struck, but it does mean that you shouldn't be scared that being wet will increase the risk for you. The explosive force of lightning can result in direct or indirect trauma resulting in fractures or soft tissue injuries. Watch for explosive injuries at the feet. The high current can also trigger significant muscles spasms that can fracture bones.

Electrical injury can injure the brain. Immediate problems may include altered consciousness, confusion, disorientation or amnesia. Long term problems may include anything from headaches and distractibility to persistent psychiatric disorders and dementia[12]. All patients require a complete body survey and careful evaluation for head, spinal, long bone, or cardiac injuries; peripheral pulses and sensory and motor status should be assessed. Check the skin for small hidden burns. The patient in cardiopulmonary arrest may require prolonged CPR, especially respiratory support if spontaneous pulse and blood pressure return. Unlike normal triage protocols, first attention and resources should be directed to those who appear dead and those requiring immediate support of airway and breathing. Any patient who has shown any signs and symptoms of lightning injury should be evacuated for further evaluation and treatment.

Evaluation / Possibility / Clouds / Exam

A person who has been struck by lightning may appear to be dead—he isn't breathing, his heart has stopped. Yet swift cardiopulmonary resuscitation and, if needed, artificial support usually revive the victim to normal status (although some suffer impaired vision or hearings). As with any emergency, the initial exam (airway, breathing, circulation, and a brief neurological assessment) guides further evaluation and treatment. During this preliminary exam, life-threatening conditions are rapidly identified and simultaneously managed.

Airway / Breathing / Circulation / Control

A lightning strike acts as a massive direct-current countershock that depolarizes the entire myocardium at once, usually resulting in asystole and respiratory arrest (which causes 75% of lightning-injury deaths)(3). Asystole is normally followed by a spontaneous return of sinus rhythm. However, respiratory apnea may persist (the respiratory center is temporarily paralyzed), leading to anoxia and secondary cardiac arrest. Therefore, always initiate cardiopulmonary resuscitation (CPR) on those victims who appear to be dead. Studies have recorded revival after prolonged pulselessness and apnea. Start intravenous fluids to support cardiovascular resuscitation and to treat secondary conditions such as hypovolemic shock.

AMERICAN SCIENTIST, *57*, **3**, 306–316, 1969

"DEATH" FROM LIGHTNING AND THE POSSIBILITY OF LIVING AGAIN

By HELEN B. TAUSSIG

MY INTEREST in this subject was aroused when my neighbor's son was struck by lightning as he was returning from a golf course. He was thrown to the ground. His shorts were torn to shreds and he was burned across his thighs. When his companion sat him up, he screamed "I'm dead, I'm dead." His legs were numb and blue and he could not move. By the time he reached the nearest hospital he was euphoric. His pulse was very slow. His electrocardiogram showed a normal slow rhythm with only minor changes. He was kept in the hospital overnight. His burns healed completely and he was well thereafter. Until this accident I had not known that a person could be struck by lightning and recover.

A while later I learned of a second accident. A young couple were caught in a thunderstorm. They took refuge under a shed and during a lull started to run for the club house. They were near an ash tree when struck by lightning. Both were thrown to the ground. When the young woman regained consciousness she could not move, but as soon as she could, she realized her companion was motionless. She tried to give artificial respiration but to no avail. Could any of us give adequate artificial respiration immediately after being struck by lightning? Alas, no further effort was made to resuscitate the young man and he died. The young woman was taken to a hospital where she was found to have minor burns and an elevated blood pressure; within a few hours her blood pressure returned to normal. She was discharged the following day and has remained well. The father of the young man wrote me that, at his son's funeral, a nun had said that "his son's trip to Heaven was short." Yes, that road to Heaven is fantastically short. The great tragedy is that none of the people at the club house and, I fear, none of the doctors at the hospital knew that that young man had traveled on one of the few two-way streets to Heaven. Indeed, his father wrote me that he would always feel that if he or I had been there, his son might have lived again. This statement made me realize how little I knew about the possibility of resuscitation of a person "killed" by lightning; so I studied the medical literature. I had not realized the number of spontaneous recoveries or the importance of prolonged artificial respiration; far less did I realize how complete recovery could be if the "dead" were promptly treated. In truth, "death" from lightning may be a highly reversible death.

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Title: TABLE 1

TABLE 1
Cloud computing models

Cloud computing model	Description
Internal Clouds	The most common form. Local virtualization and management software are integrated into existing infrastructure to connect servers, storage, networks, data, and applications. Managed in-house, the goal is to seamlessly shift storage, computing power, or other resources from one place to another, providing end-user divisions all the resources they need at any time.
External Cloud Hosting	Any IT service deployed and managed, either in-house or outsourced, on remote IT infrastructure. An external private cloud may be accessed over a wide area network (WAN); while an external public cloud is accessed through the internet (Goodman, 2009). Example providers include Rackspace, Terramark, Equinix (EQIX), AT&T, and IBM.
Traditional Software as a Service (SaaS)	Also known as hosted software or software on-demand. Developed and hosted by a vendor, SaaS is rented to end-users over the internet (Levinson, 2007). All users use the same software; it is not customized. Examples include free email at Yahoo and Google, and productivity apps from Microsoft, Zoho, Desktone, ThinkGrid, Salesforce.com, LeanLogistics, and Ketera.
Hybrid or Modular Approach	Can include a mix of internal and external cloud services along with SaaS, allowing for IT-on-demand for workgroups rather than enterprises. Examples include smaller-scale on-demand services such as CloudShare, Soonr, and Microsoft Azure, which offer mini versions of the macro cloud.

Based on Fogarty, 2010.

Image Caption: Cloud computing models

Article Title: The Internet Jurisdiction Risk of Cloud Computing.

Source: Information Systems Management, Fall2010, Vol. 27 Issue 4, p334-339, 6p, 2 Charts
Chart; found on p335

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Confusion / Disturbance / Affect / Depression

Amnesia, confusion, restlessness, disorientation, hysteria, and aggression are common after a lightning strike, and tend to last about three to four weeks (2, 3, 5). Interview family members or significant others to determine what would be normal behavior for the victim. Lightning victims often suffer disturbances of affect, memory, and sleep patterns that may persist for months. Mental depression is common—resulting frequently from the victim's phobias regarding thunder, lightning, and death—and may mandate psychotherapy and neurological follow-up. Once stabilized, alert, and oriented, the lightning-injured person doubtless will have many qurestions and concerns about what happened. Airing feelings in a supportive, caring environment is beneficial.

Experience / Confusion / Charge / Routine

Lightning victims who experience only minor confusion and amnesia may be discharged home from the ED, with a responsible adult available to watch for changes in level of consciousness. Discharge instructions include head-injury precautions and directions about the care of the superficial burns. As with any head-injured patient, a lightning victim should return to the ED immediately if he experiences chest pain, palpitations, shortness of breath, or increased pain anywhere. Lightning victims who have retrograde amnesia may not fully understand what's happened to them, and so should be monitored closely. In these cases, a routine check-up with a physicial within 24 hours is advised.

Instructions for Lightning Avoidance

The origin of the term *cloud computing* is unclear. The expression *cloud* is commonly used in science to describe a large agglomeration of objects that visually appear from a distance as a cloud and describes any set of things whose details are not inspected further in a given context. In analogy to the above usage the word *cloud* was used as a metaphor for the Internet and a standardized cloud-like shape was used to denote a network on telephony schematics and later to depict the Internet in computer network diagrams. The cloud symbol was used to represent the Internet as early as 1994,[23][24] in which servers were then shown connected to, but external to, the cloud.

In meteorology, a cloud is a visible mass of liquid droplets or frozen crystals made of water or various chemicals suspended in the atmosphere above the surface of a planetary body. These suspended particles are also known as aerosols and are studied in the cloud physics branch of meteorology. Estimates of the indirect climatic effect of aerosols are based on the theory of cloud droplet formation advanced by the Swedish scientist Hilding Köhler in the 1920s and 1930s (*3, 4*). Köhler assumed that clouds consist of "activated" water droplets that grow spontaneously after they have reached a critical size corresponding to a critical value of the supersaturation of water vapor. Köhler further assumed that the aerosol is composed of a completely soluable salt and that particles are in thermodynamic equilibrium until the point of spontaneous growth. Indeed, it is still generally assumed that a cloud forms only in a supersaturated water environment with all the solute coming from the particle. It has recently become clear, however, that soluble gases (*5, 6*), slightly soluble solutes (*7*), and surface tension depression by organic substances (*8*) also influence the formation of cloud droplets, in a manner unforeseen by Köhler.

As predicted by Köhler some 80 years ago, droplet activation places an upper limit on the supersaturation of water vapor that can be reached in the atmosphere. Given sufficient solute or enough depression of surface tension, or a combination of the two, the supersaturation in agiven situation will decrease. At high aerosol and soluble trace gas concentrations and for low cooling rates, strict activation is not necessary for formation of a visible cloud; indeed, a continuum exists from ambient aerosol to wetter and wetter particles to unactivated clouds to activated ones. What is seen as "cloud" can, in reality, be a collection of droplets ranging from fully activated to unactivated.

By affecting cloud optical properties, these chemical phenomena may lead to non-negligible global negative forcing (*17*) and may be as important regionally as the Tworney effect itself. To assess the importance of the indirect climatic effect of aerosols, one seeks a robust connection between cloud droplet population and a prognostic variable from global aerosol models. How that link might depend on chemical cloud activation effects, including variations in aerosol chemical composition, solute water solubility, solute surface tension lowering, and condensation of trace gases, remains to be determined. Lack of global data on these activation effects poses addictional uncertainty beyond that already recognized by the Intergovernmental Panel on Climate Change (*1*), making the largest uncertainty in estimating climate forcing even larger.