http://www.wetter-foto.de/

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http://www.wetter-foto.de/

Robert Prentice

30/30 Lightning Safety Rule

Go indoors if, after seeing lightning, you cannot count to 30 before hearing thunder. Stay indoors for 30 minutes after hearing the last clap of thunder.

- http://www.usatoday.com/weather/gallery/lightning/frame.htm

Alford's plane hit by lightning Thursday night

ALBUQUERQUE, N.M. (AP) - Former Iowa coach Steve Alford and his family were given quite the jolt on their way to New Mexico.

Their plane was hit by lightning Thursday night. The incident happened about 20 minutes after leaving the airport in Cedar Rapids.

Alford and his wife, along with their three children, two University of New Mexico officials and two pilots were on board a private jet. Passengers described a "bang" when the plane was hit.

The 10-seat private jet wasn't damaged, and the flight continued uninterrupted.

Alford was introduced as New Mexico's coach Friday afternoon.

http://www.sirlinksalot.net/lightning.html

http://www.straightdope.com/columns/040917.html (Ball lightning)

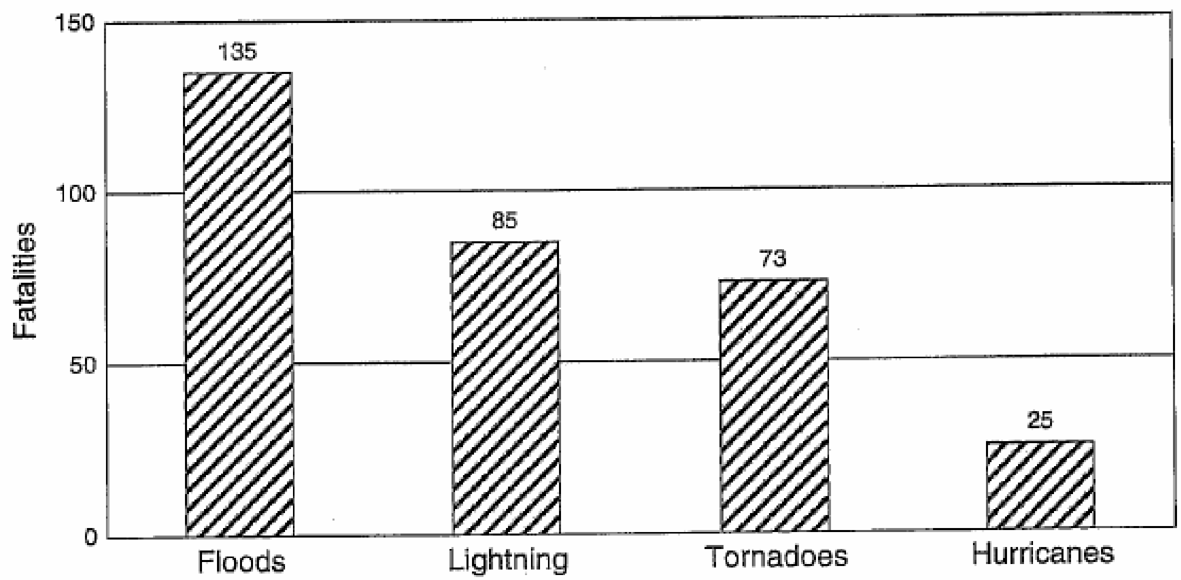
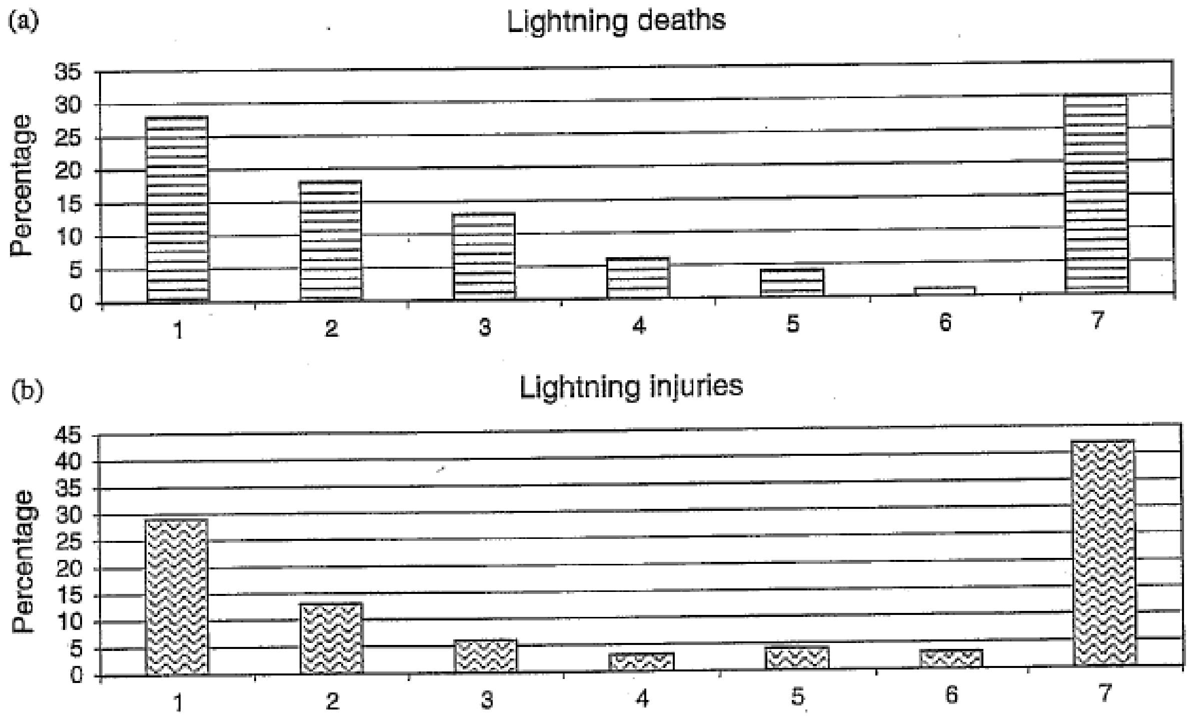
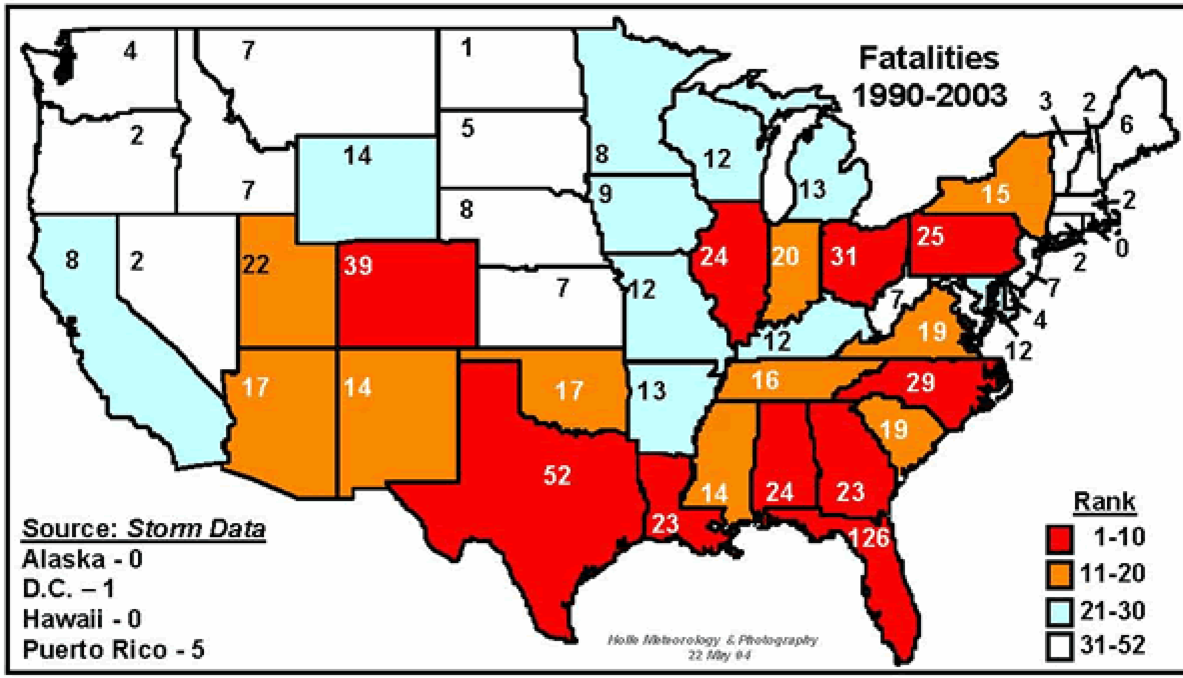


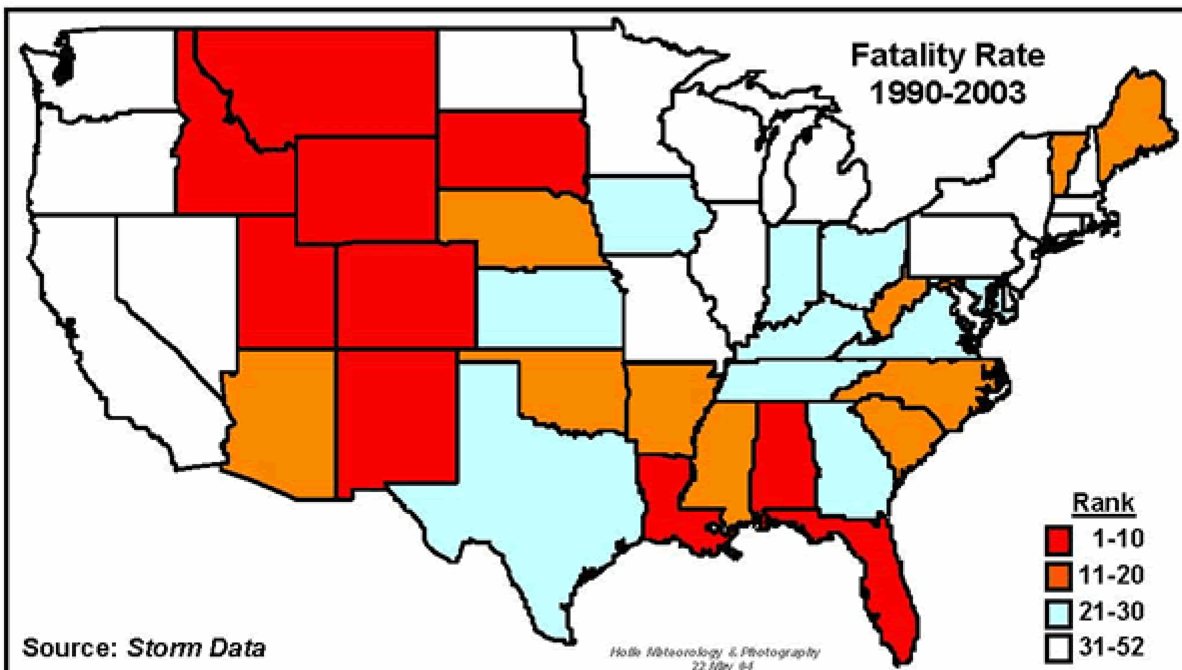
Fig. 19.1. Average annual number of storm-related deaths in the United States, 1966–95. Adapted from *Storm Data*, US National Climatic Data Center, NOAA, Ashville, North Carolina.



1. Open fields, ball fields, parks, etc.
2. Under trees.
3. Boating, fishing, water-related, etc.
4. Golf courses.
5. Farming, construction, near heavy machinery, etc.
6. On telephone, radios, electronics, etc.
7. Various other/unknown.

Fig. 19.2. The places of occurrence (1–7) of (a) lightning deaths 1959–96 and (b) lightning injuries 1960–96 in the United States. Adapted from *Storm Data*, US National Climatic Data Center, NOAA, Ashville, North Carolina.


Fatalities
1990-2003
4
7
1
2
5
14
7
8
8
8
9
12
13
3
2
6
15
2
24
20
31
25
0
22
39
2
8
2
7
12
7
4
12
19
12
17
14
17
13
16
29
19
52
14
24
23
23
126
Rank
1-10
11-20
21-30
31-52
Source: *Storm Data*
Alaska - 0
D.C. – 1
Hawaii - 0
Puerto Rico - 5
Holle Meteorology & Photography
22 May 04


Fatality Rate
1990-2003
Rank
1-10
11-20
21-30
31-52
Source: *Storm Data*
Holle Meteorology & Photography
22 May 04

BAMS Sept 2006

Fig. 2. Looking west-northwest from Virginia Tech's Lane Stadium as lightning strikes at a distance of 0.6 miles (1 km). The strike occurred at 8:50 p.m. on 27 Aug 2000, moments before the opening kickoff (courtesy of the Roanoke Times 2000).

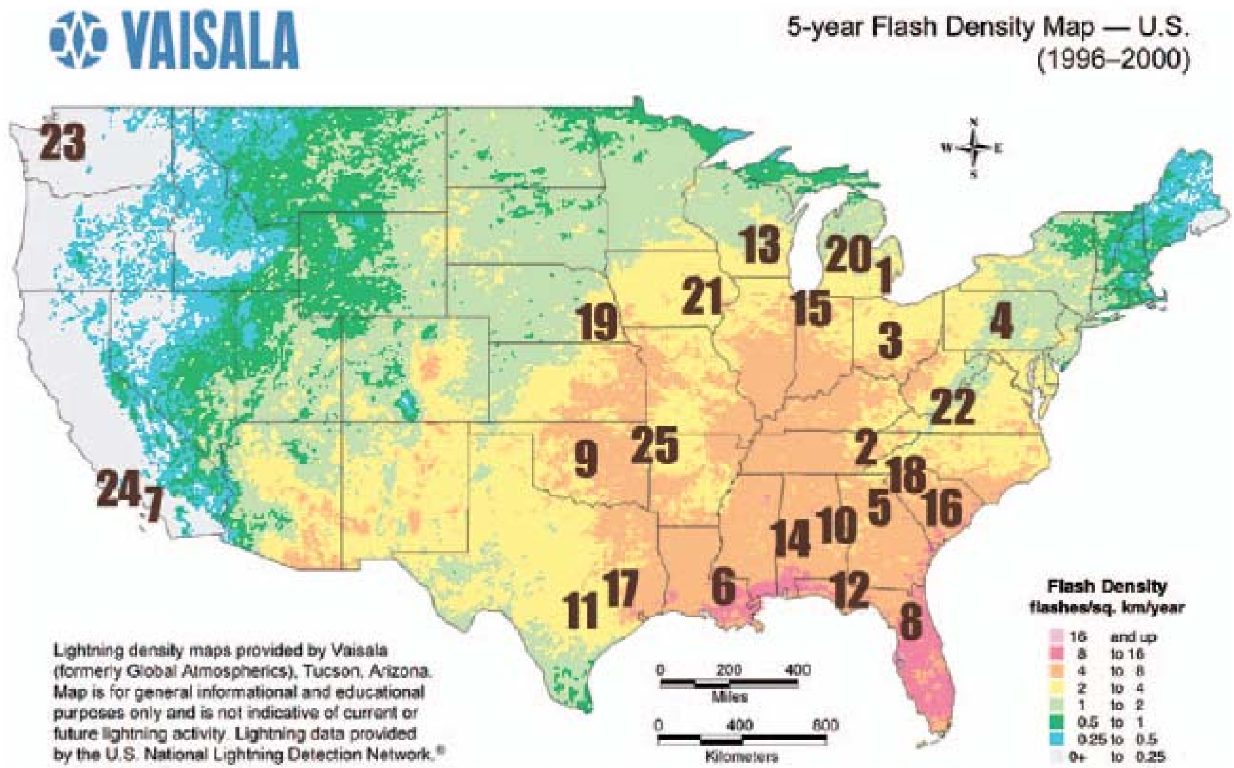


Fig. 1. Average density of lightning strikes over 5 years. Strike density is measured in strikes per square kilometer per year. Black numbers (1–25) denote the 25 largest National Collegiate Athletic Association (NCAA) Division I football stadiums based on average per game attendance for the 2005 season. Table 1 provides more information on each school. Although the base map is made from older data, these were the best-calibrated data available at the time of publication (base map courtesy of Vaisala 2005).

Lightning Safety Rules

- Postpone outdoor activities if thunderstorms are imminent. This is your best way to avoid being caught in a dangerous situation.
- Move to a sturdy building or car. Do not take shelter in small sheds, under isolated trees, or in convertible automobiles. Stay away from tall objects such as towers, fences, telephone poles, and power lines.
- If lightning is occurring and a sturdy shelter is not available, get inside a hard top automobile and keep the windows up. Avoid touching any metal.
- Utility lines and metal pipes can conduct electricity. Unplug appliances not necessary for obtaining weather information. Avoid using the telephone or any electrical appliances. Use phones ONLY in an emergency.

NOAA

- Do not take a bath or shower during a thunderstorm.
- Turn off air conditioners. Power surges from lightning can cause serious damage.

If Caught Outdoors and No Shelter Is Nearby

Todd Heitkamp

- Find a low spot away from trees, fences, and poles. Make sure the place you pick is not subject to flooding.
- If you are in the woods, take shelter under the shorter trees.
- If you feel your skin tingle or your hair stand on end, squat low to the ground on the balls of your feet. Place your hands over your ears and your head between your knees. Make yourself the smallest target possible and minimize your contact with the ground. DO NOT lie down.
- If you are boating or swimming, get to land and find shelter immediately!

Medical Symptoms Associated with Lightning

- **Skin Effects**.
  - Burns are described as linear, punctate, full-thickness burns, feathering or flowering (Lichtenberg figures
  - thermal burns from ignited clothing or heated metal, or combinations
  - Hair burning and skin lacerations also are characteristic of lightning.
  - Steam burns secondary to lightning are caused by vaporization of sweat or rainwater on the victim's skin,
  - lightning victims observed to give off a particular odor like burning sulphur or ozone or nitrous fumes or dilute sulphuric acid or ammonia
- **Vascular Effects**. electrical injuries to blood vessels causing disruption producing considerable hemorrhage or thrombosis.
- **Musculoskeletal Effects**.
  - Mechanical blunt force injury may be the result of falls or of spontaneous nerve excitation
  - One unusual eye-witnesss case is that of lightning-induced muscle spasms ejecting a young adult male fifteen feet off a chair into a brick wall, with a broken back and a broken collar bone
  - Muscle cells exposed to extreme heat create pores in the cell membranes in a process called electroporation: cell rupture
  - While lightning tends to travel along outer surfaces (skin effect), observed cases of cardiovascular damage (pericardial and aortic tears and myocardial contusion) indicate this is not always the case.
- **Cardiac Effects**.
  - Aortic evidence include tearing of a portion of the media andblood in the aortic adventitia, torn posterior pericardium,
  - massive suffision of blood in the interventricluar septum as well as the anterior and posterior left ventriclar free wall, and myocardial contusions confirmed microscopically
  - Deaths from electrical accidents usually are due to cardiac arrhythmias. They occur when current travels across the thorax. He notes AC current usually is associated with ventricular fibrillation and DC current with asystole. In some cases arrhythmias are delayed for up to 12 hours however.
- **Neurologic Effects**.
  - focal petechial hemorrhages and chromatolysis of pyramidial cells, Purkinje?s cells of the cerebellum, and anterior horn cells
  - A leading indicator is localized ballooning of myelin sheaths.
  - Lesions of the brain should be investigated, especially processes involving cerebral infarction, hypoxic encephalopathy due to cardiac arrest, basal ganglial degeneration and intracranial hematomas.
- **Pulmonary Effects**. In domestic animals lightning evidence may be found in cellular damage to the respiratory and cardiac centers in the fourth ventrical as well as with damage to the anterior surface of the brainstem
- **Renal Effects**. In 5%-22% of cases observed, reports electrical injury to kidneys. This is due to massive tissue destruction as a result of related rhabdomyolysis and myoglobinuria.
- **Abdominal and GI Effects**. Hemorrhagicnecrosis of the intestines and gallbladder, liver failure, gastrointestinal homorrhage from stomach and duodenal ulcers, curling ulcers, acute appendicitis, pancreatitis, small bowel perforation, slenic injuries, and mesenteric abdominal trauma.
- **Eye Effect**.
  - Suggested that 55% of lightning victims suffer ocular effects due to thermal or electrical damage, intense heat, contusion from the thunder shock wave or combinations of these factors.
  - Cataracts typically develop within a few days, although cases have been seen where they ocurred as late as two years afterwards.
- **Ear Effects**.
  - High pressure shock waves from thunder, measuring up to ten atmospheres may create blast effects leading to ruptured tympanic membranes.
  - sensorineural hearing loss from the intense noise and shock wave accompanying thunder
- **Other Effects**.
  - Two thirds of lightning survivors had some degree of lower extremity paralysis.
  - Often they appeared cold, clammy, mottled, insensate, and pulseless.

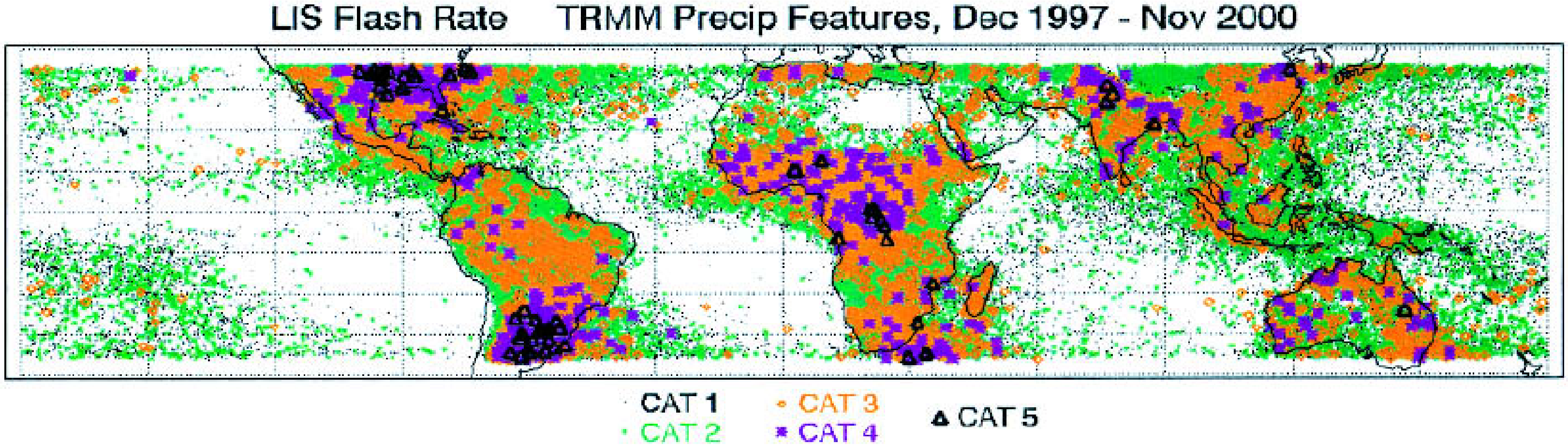


FIG. 2. Precipitation features with LIS-observed lightning as a function of flash rate category (CAT-1–CAT-5).

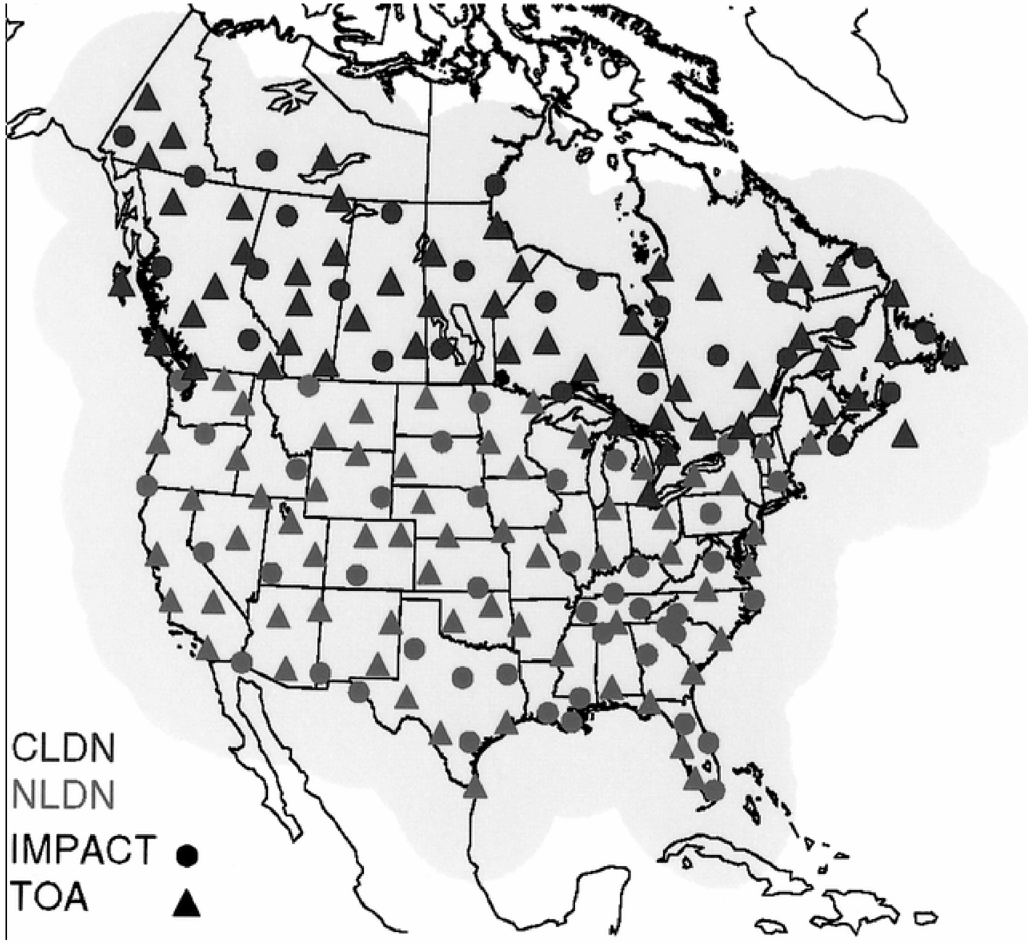
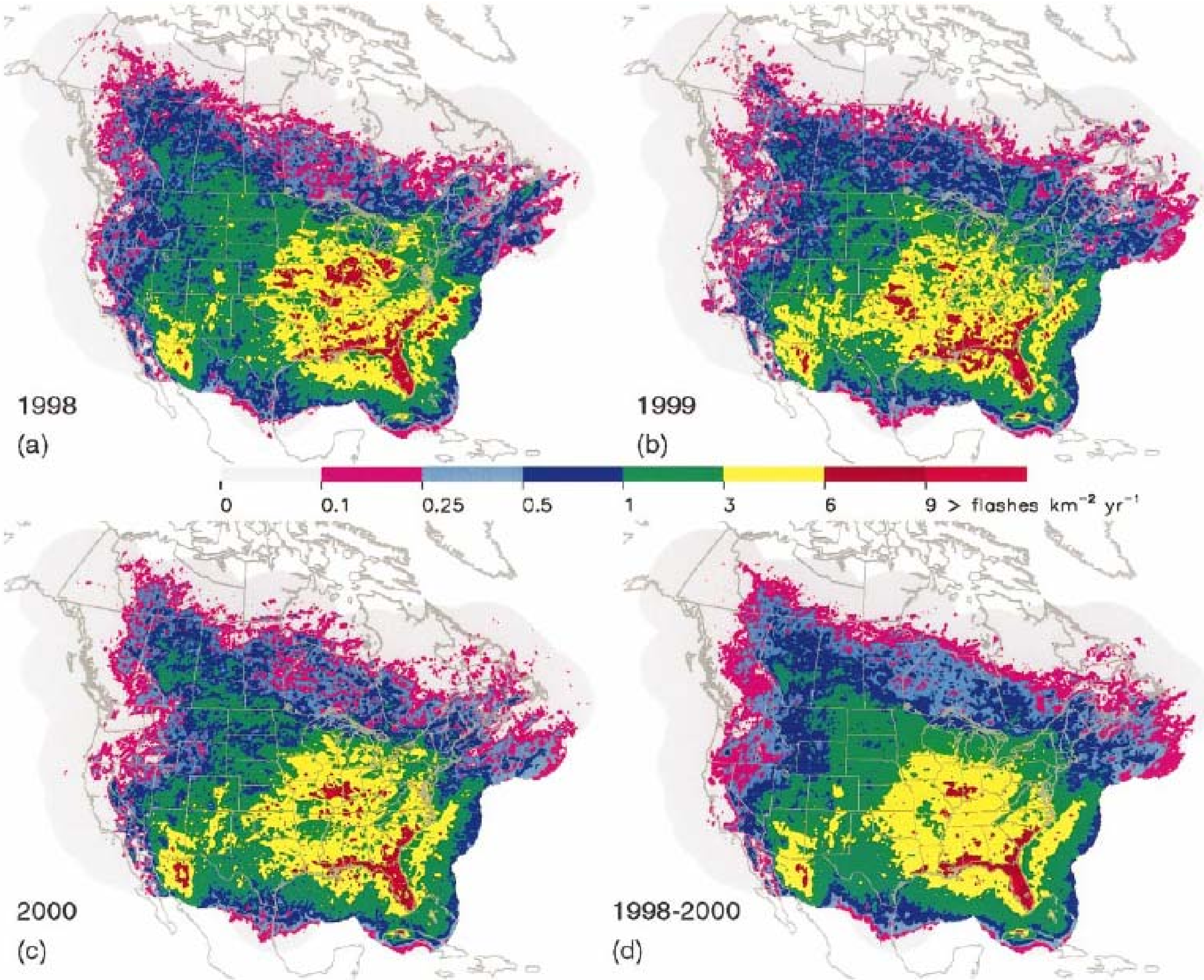


Fig. 1. The total area covered by the NALDN is shown in light gray. Blue symbols represent the CLDN composed of 87 sensors, and red represents the NLDN of 106 sensors. Each network is composed of IMPACT/ES and TOA sensors. Triangles mark the TOA sensor locations and circles mark IMPACT/ES sensor locations



1998
(a)
1999
(b)
0
0.1
0.25
0.5
1
3
6
9 > flashes km⁻² yr⁻¹
2000
(c)
1998-2000
(d)

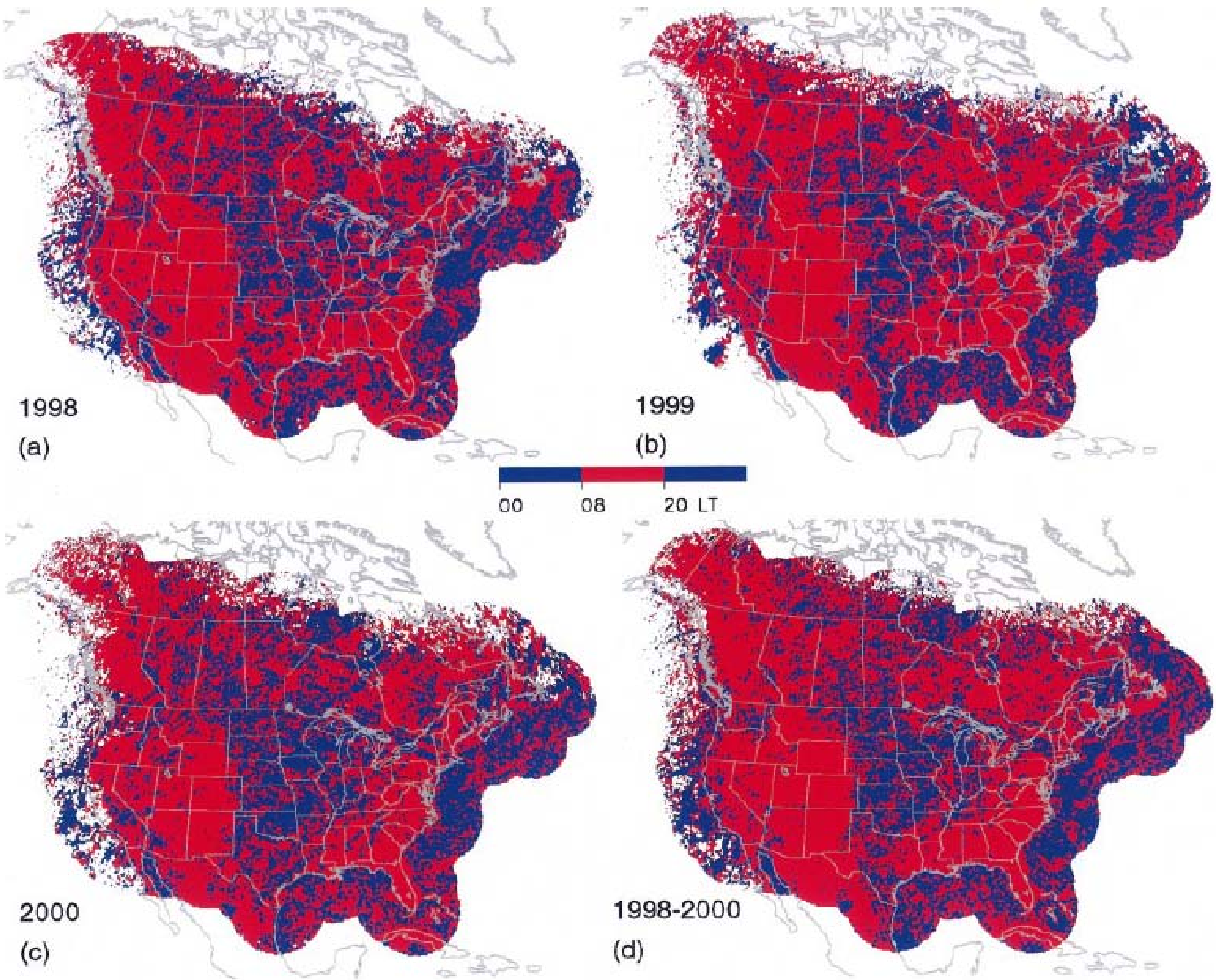


FIG. 3. The local hours of maximum ground flash density are plotted for two time increments, from 0800 to 2000 LST in red and from 2000 to 0800 LST in blue. Thus, red shows maximum lightning in daytime and blue is at night.

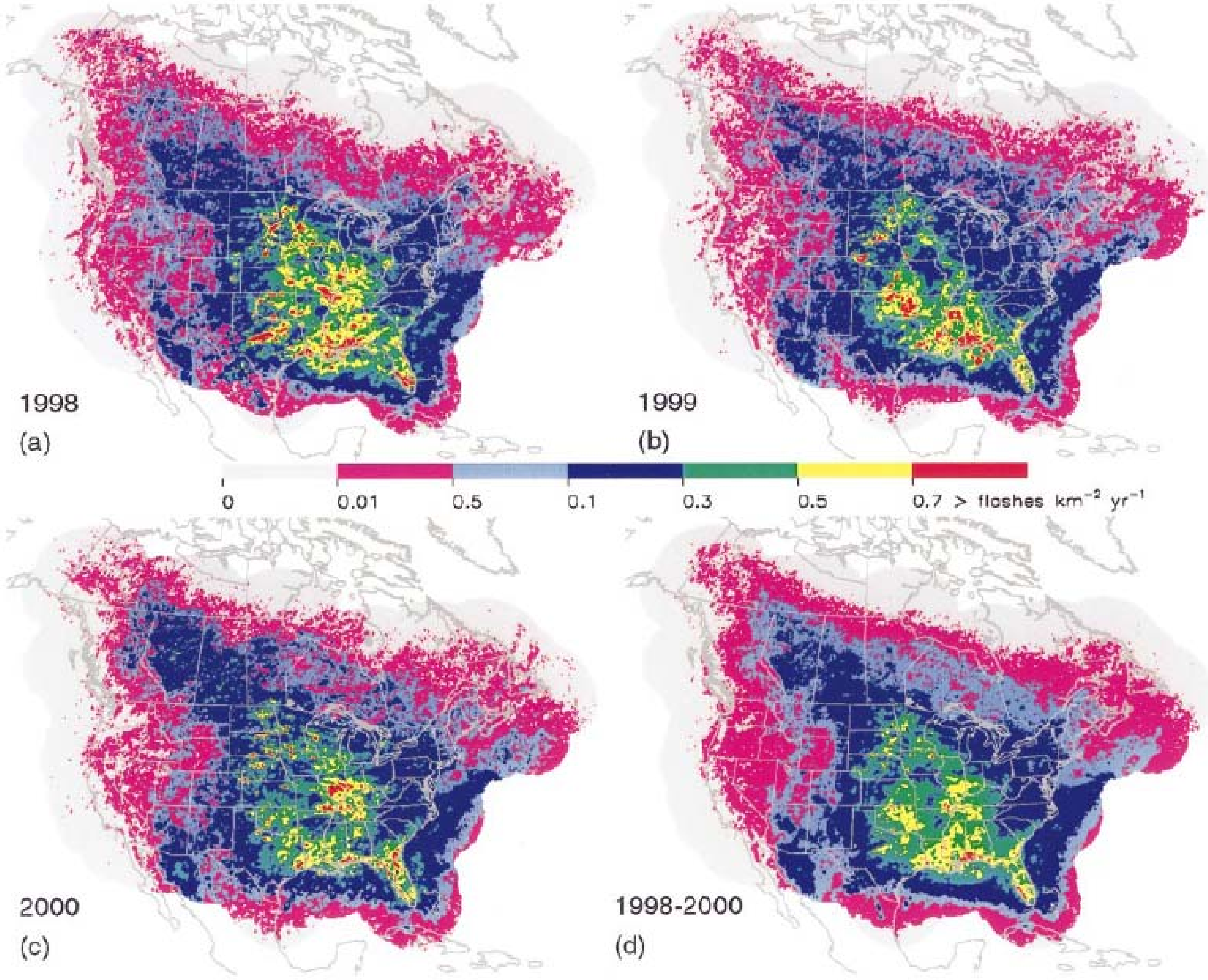


FIG. 4. Same as in Fig. 2 except the positive ground flash density is plotted by color.

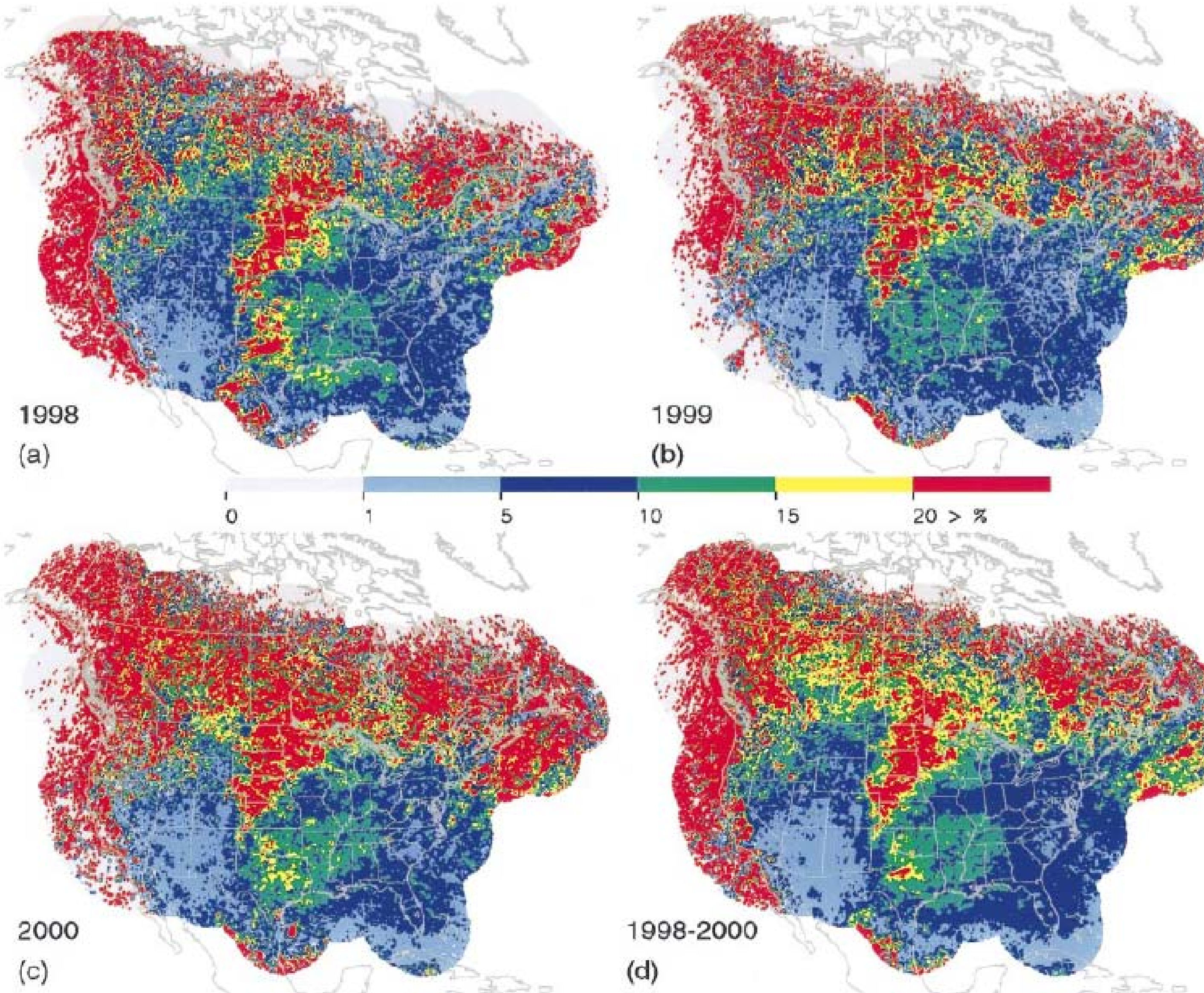


FIG. 5. Same as in Fig. 2 except the percentage of lightning ground flashes lowering positive charge is color shaded.

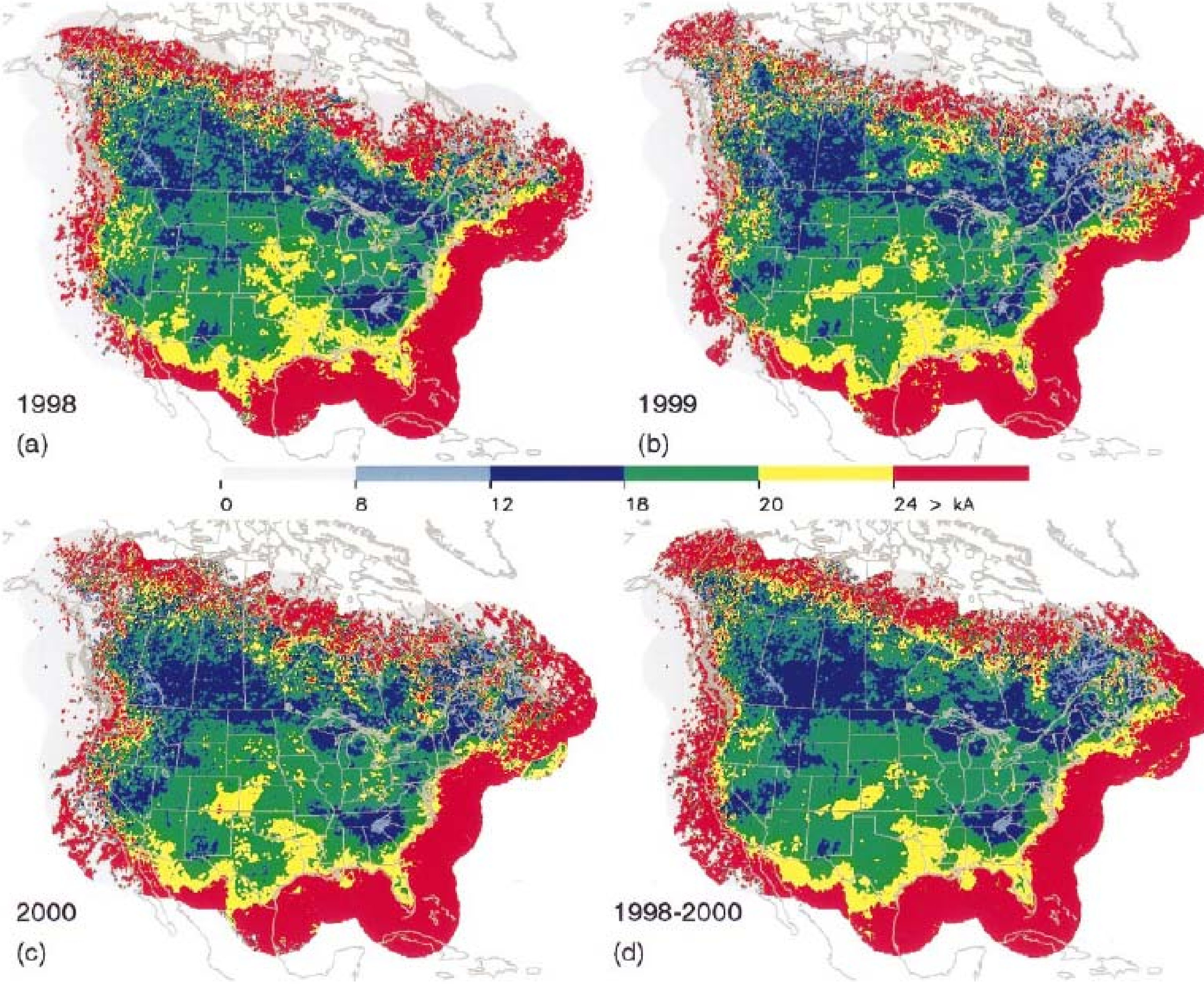


FIG. 6. Same as in Fig. 2 except the negative median peak current is shaded for ground flashes lowering negative charge.

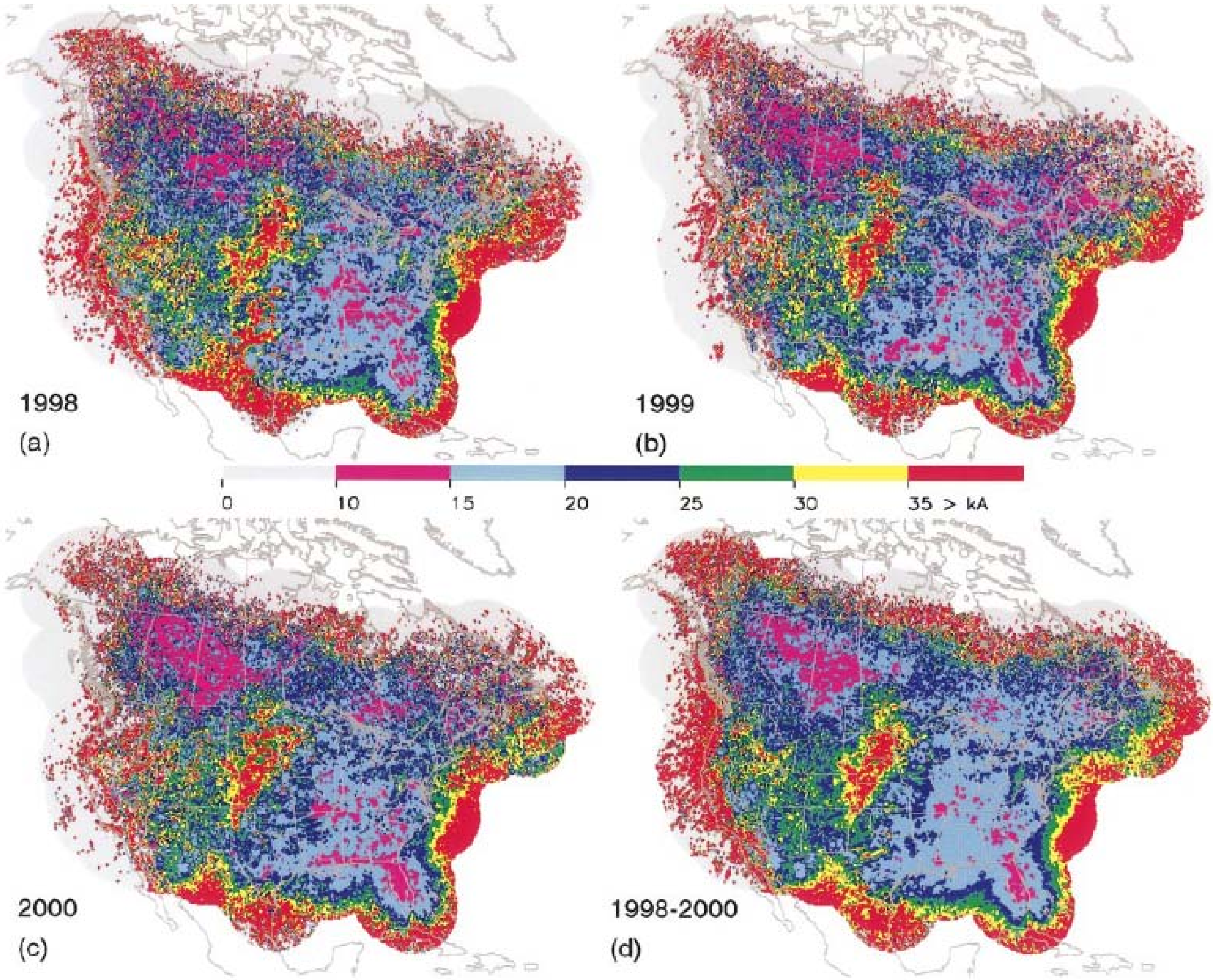


FIG. 7. Same as in Fig. 2 except for positive median peak currents.

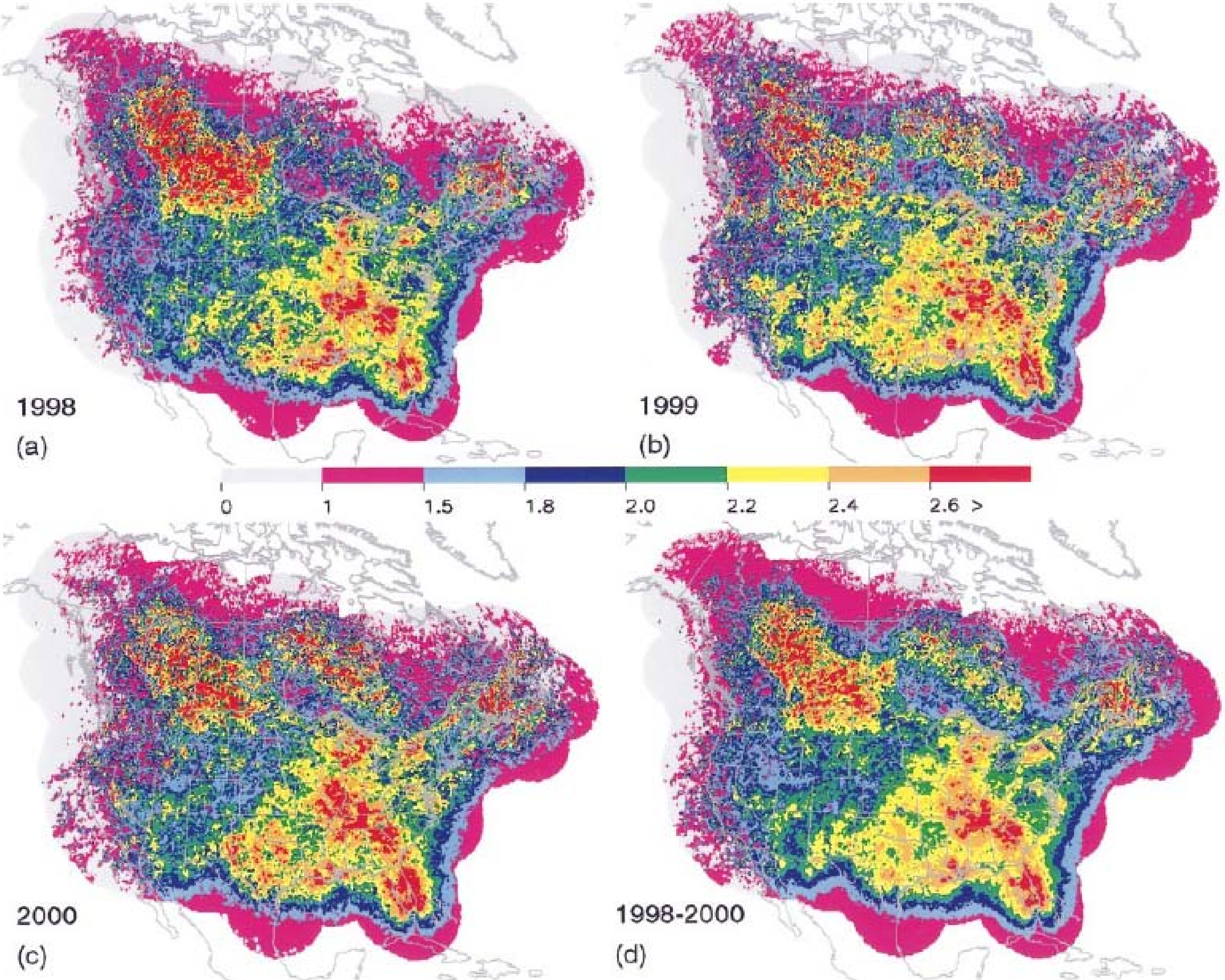


FIG. 8. Same as in Fig. 2 except for mean negative multiplicity.

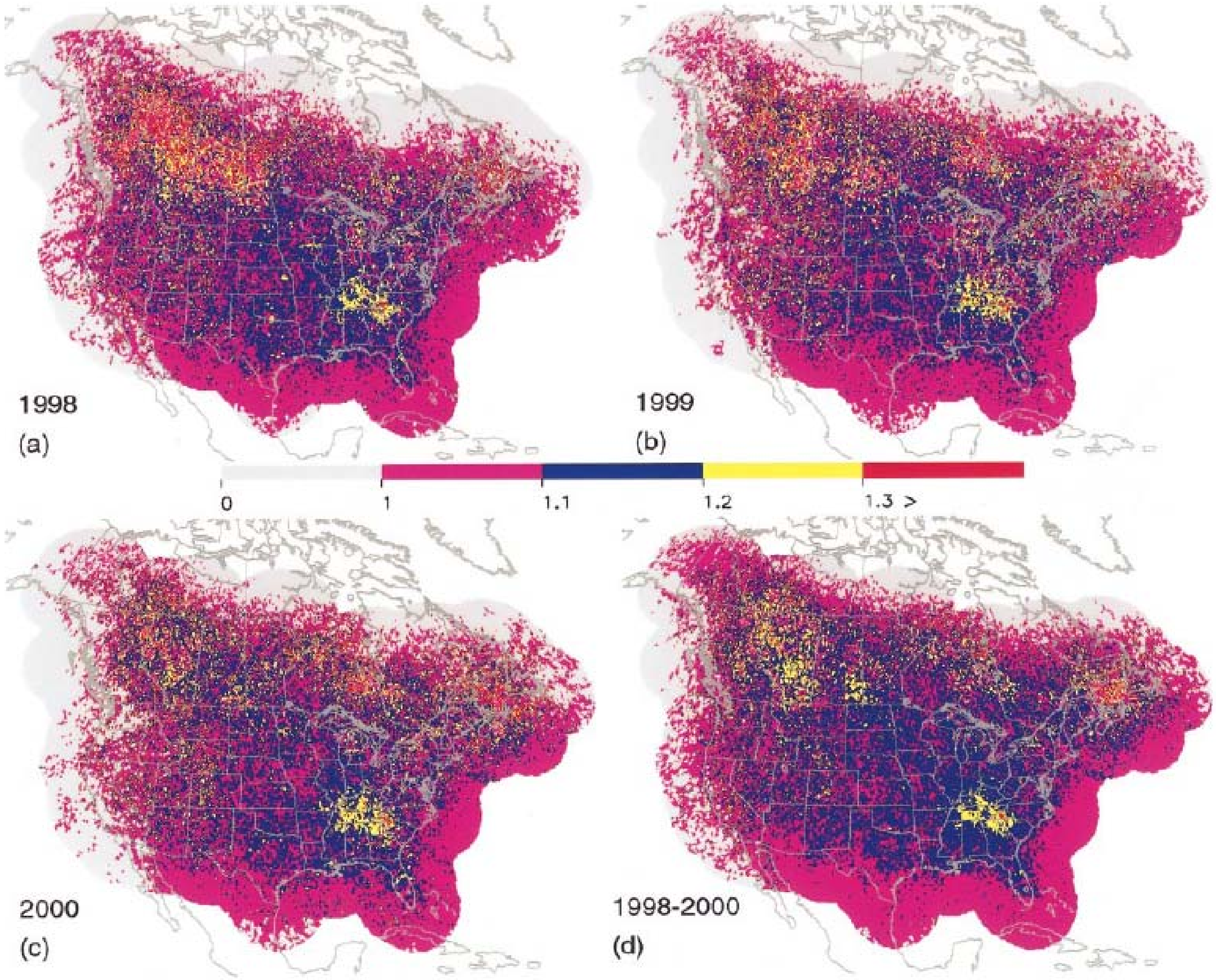
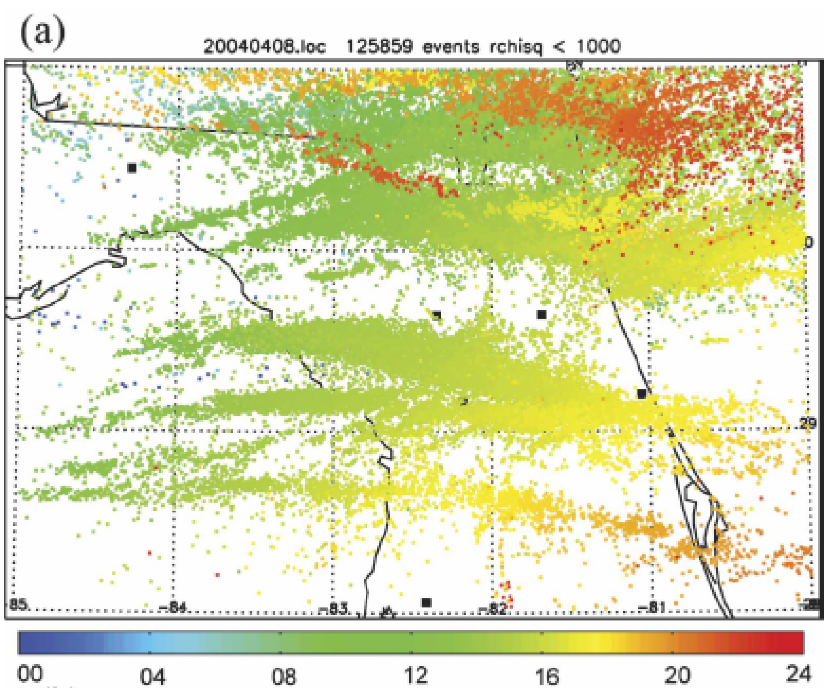


FIG. 9. Same as in Fig. 2 except for mean positive multiplicity.



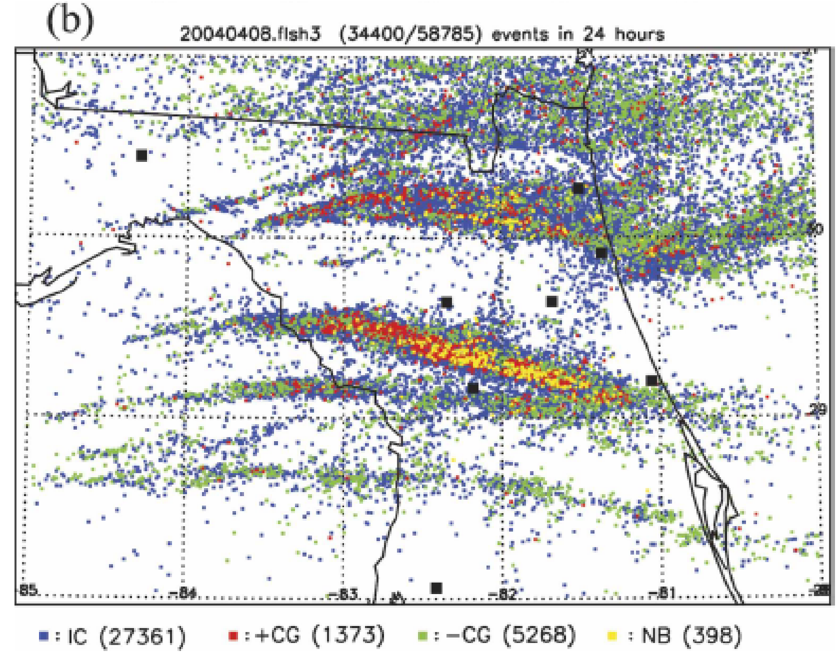


FIG. 5. LASA observation of a frontal storm on 8 Apr 2004. (a) Temporal and spatial evolution of the storm. Colors and source locations indicate storm became active at 0800 UTC (0400 local time) west of the Florida Peninsula and moved eastward to the Atlantic Ocean during a period of about 14 h. (b) Flashes classified to four types and are marked by different colors. ICs were plotted first and were subsequently overlaid by −CGs, NBEs, and +CGs.

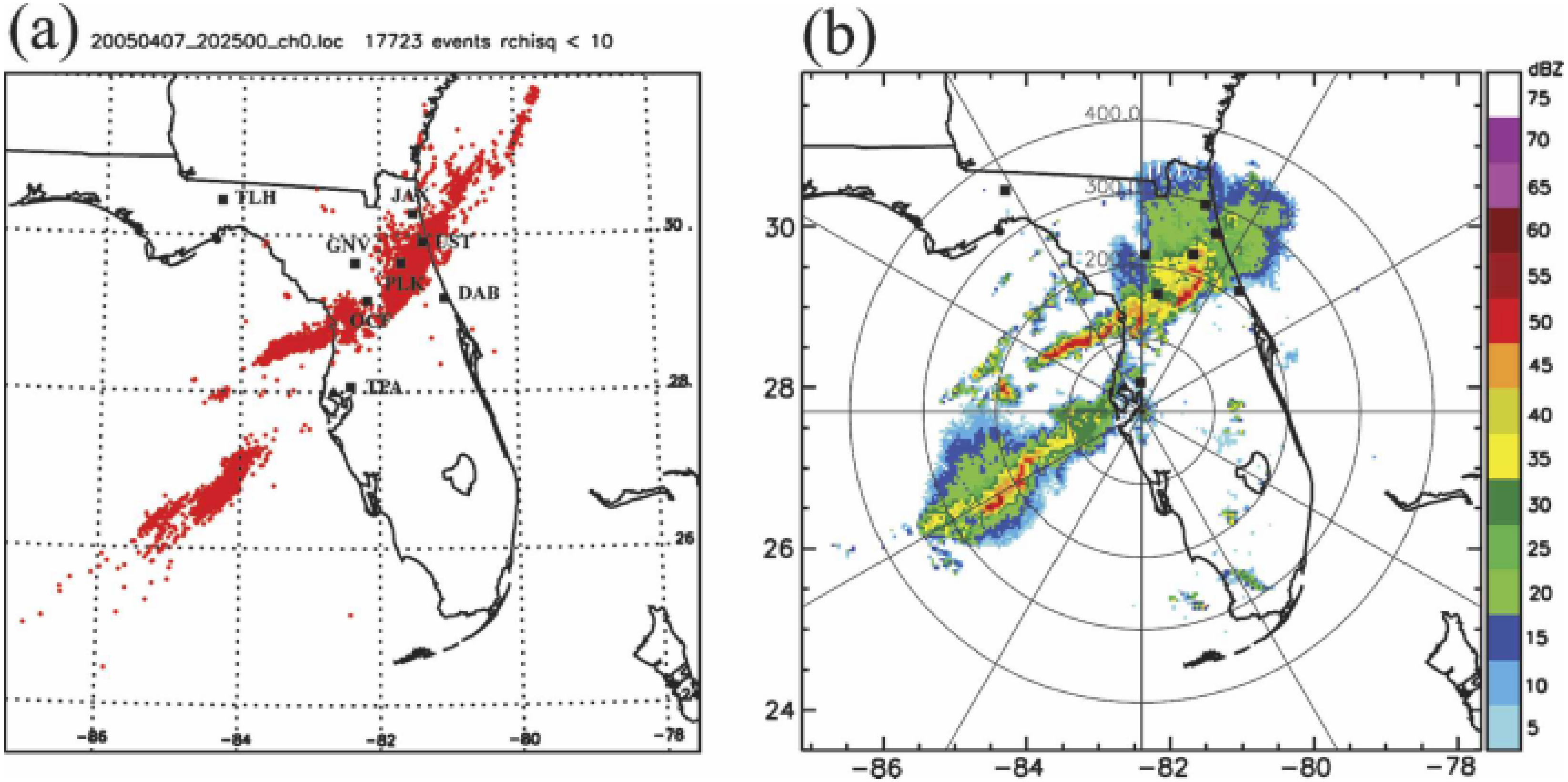


FIG. 2. LASA lightning observations compared to NEXRAD radar reflectivity during a 5-min interval. (a) Black squares mark LASA stations and red dots represent located lightning sources. Six stations form a dense array centered at PLK and two remote stations form longer baselines. (b) The NEXRAD plan position indicator (PPI) scan at the same time interval. Notice that radar coverage is smaller than the expansion of the storm/lightning activity.

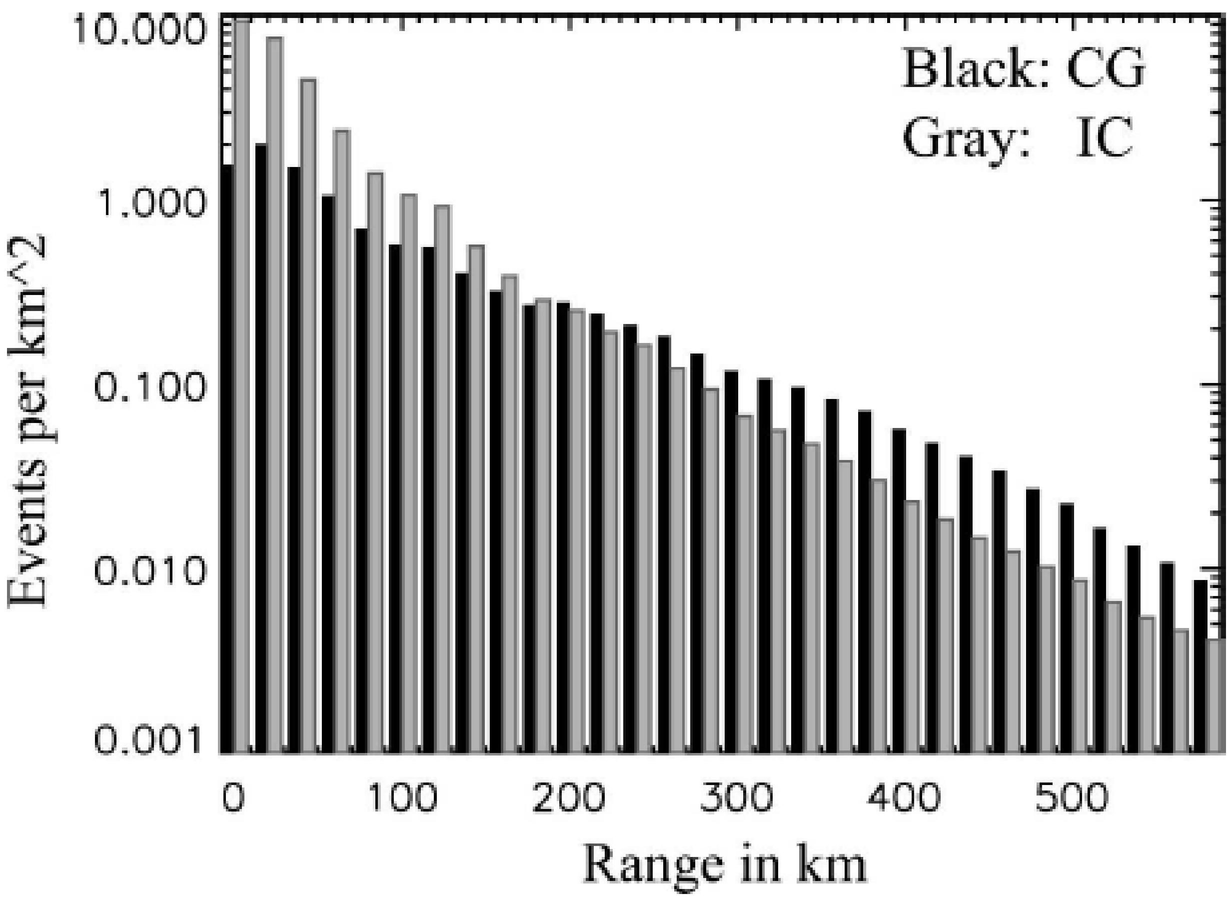


FIG. 9. Distribution of LASA located IC and CG flashes during August 2004. Flash numbers are normalized to unit area (1 km^2) at each range.

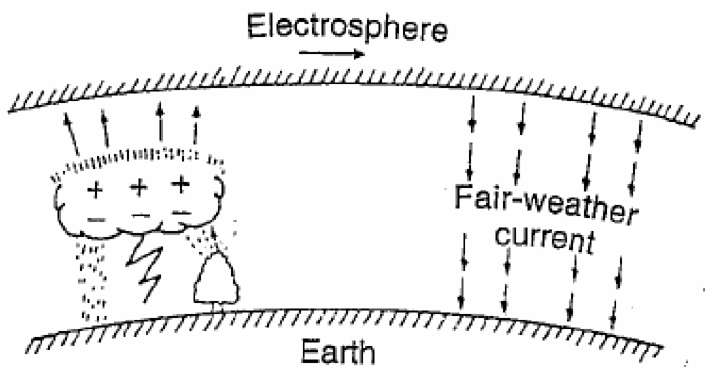


Fig. 1.4. Illustration of the global electric circuit. Shown schematically under the thundercloud are precipitation, lightning, and corona. Adapted from Pierce (1974).

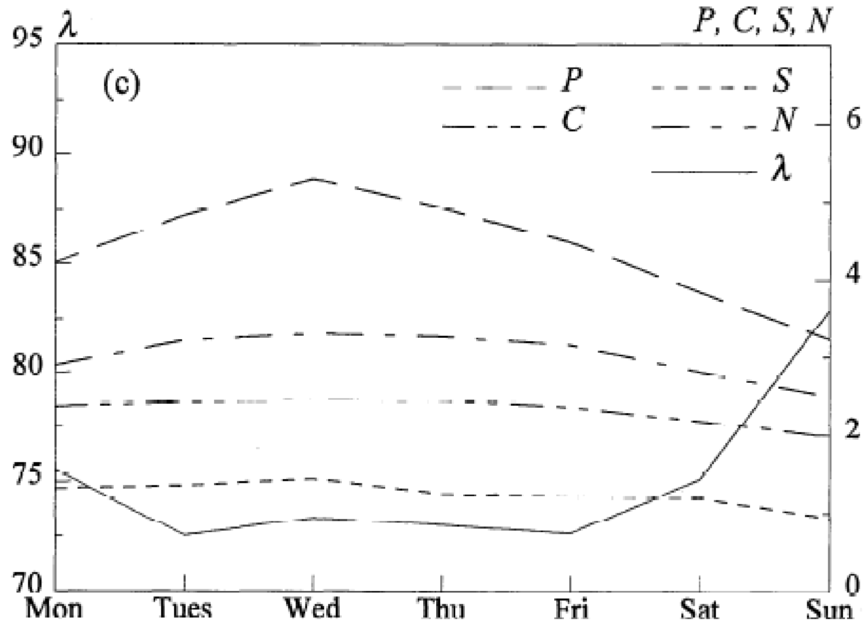


Figure 1. The relative contributions by daily change of hourly values and annual change of daily values to the (a) variances of and (b) correlations between λ and pollutant concentrations, together with the (c) annually averaged weekly variations of total atmospheric electrical conductivity λ (10^{-16} Ω^{-1} m^{-1}) and concentrations of aerosol particles *P* (haze per 305 m of air), carbon monoxide *C* (ppm), sulfur dioxide *S* (100^{-1} ppm), and nitrogen dioxide *N* (100^{-1} ppm).

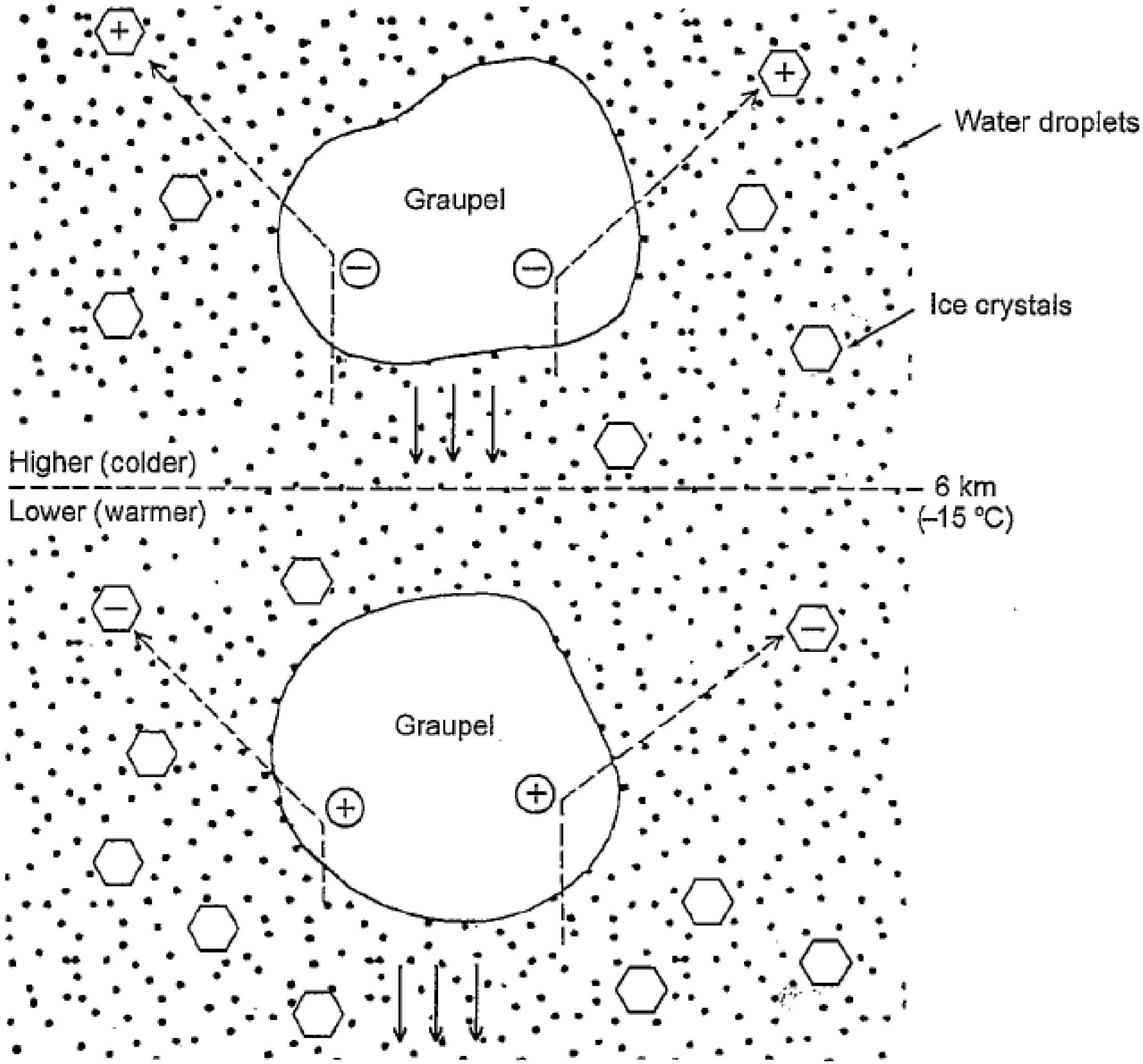


Fig. 3.13. Charge transfer by collision in the graupel–ice mechanism of cloud electrification discussed in subsection 3.2.6. It is assumed that the reversal temperature T_R is -15 °C and that it occurs at a height of 6 km.

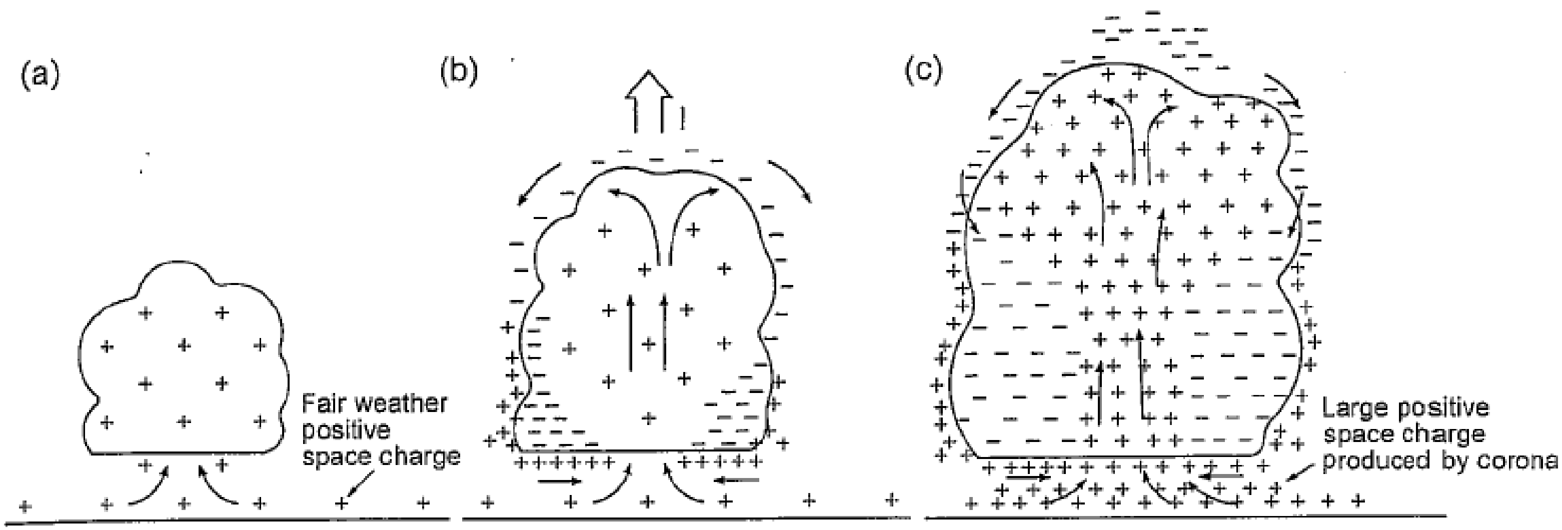


Fig. 3.12. Illustration of the convection mechanism of cloud electrification discussed in subsection 3.2.6. Adapted from MacGorman and Rust (1998).

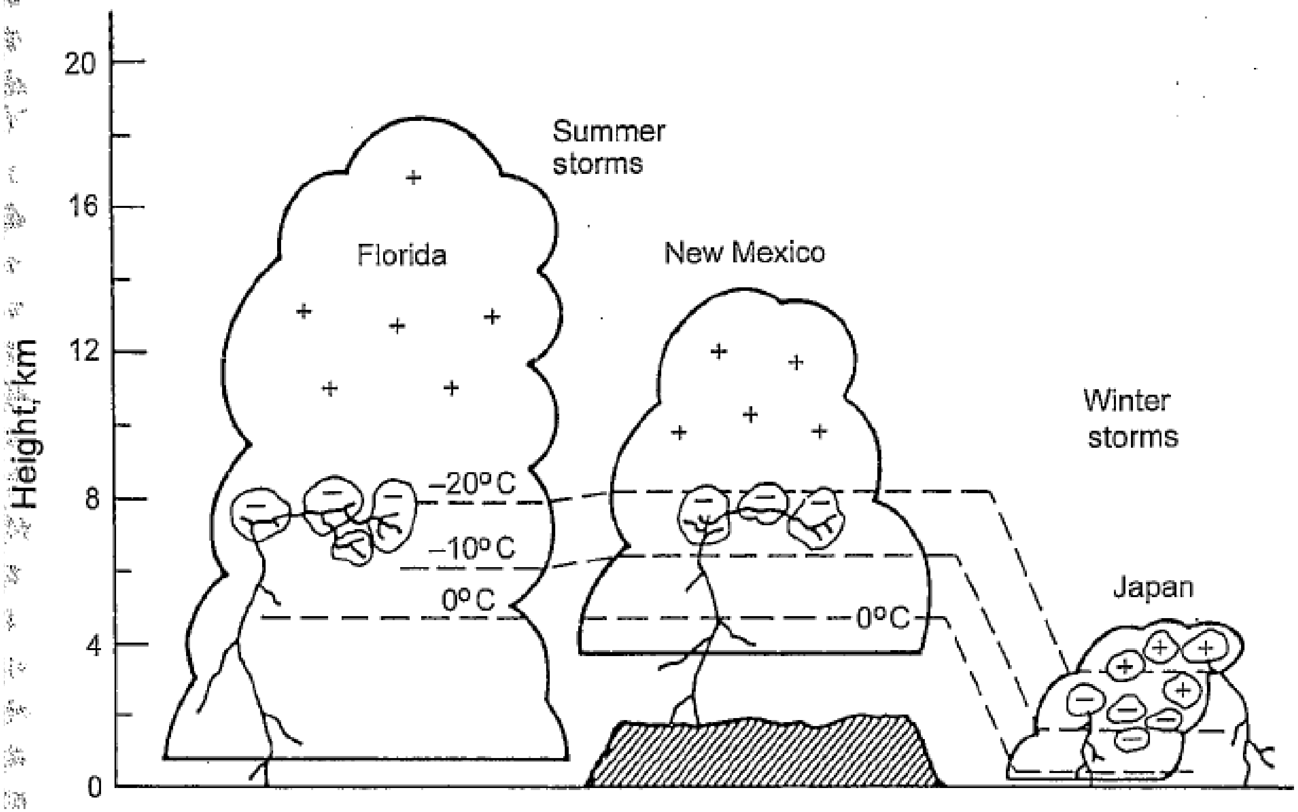


Fig. 3.7. The locations, shown by the small irregular contours inside the cloud boundaries, of ground flash charge sources observed in summer thunderstorms in Florida and New Mexico and in winter thunderstorms in Japan, using simultaneous measurements of electric field at a number of ground stations. More information on the charge structure of winter thunderclouds in Japan is found in Chapter 8. Adapted from Krehbiel (1986).

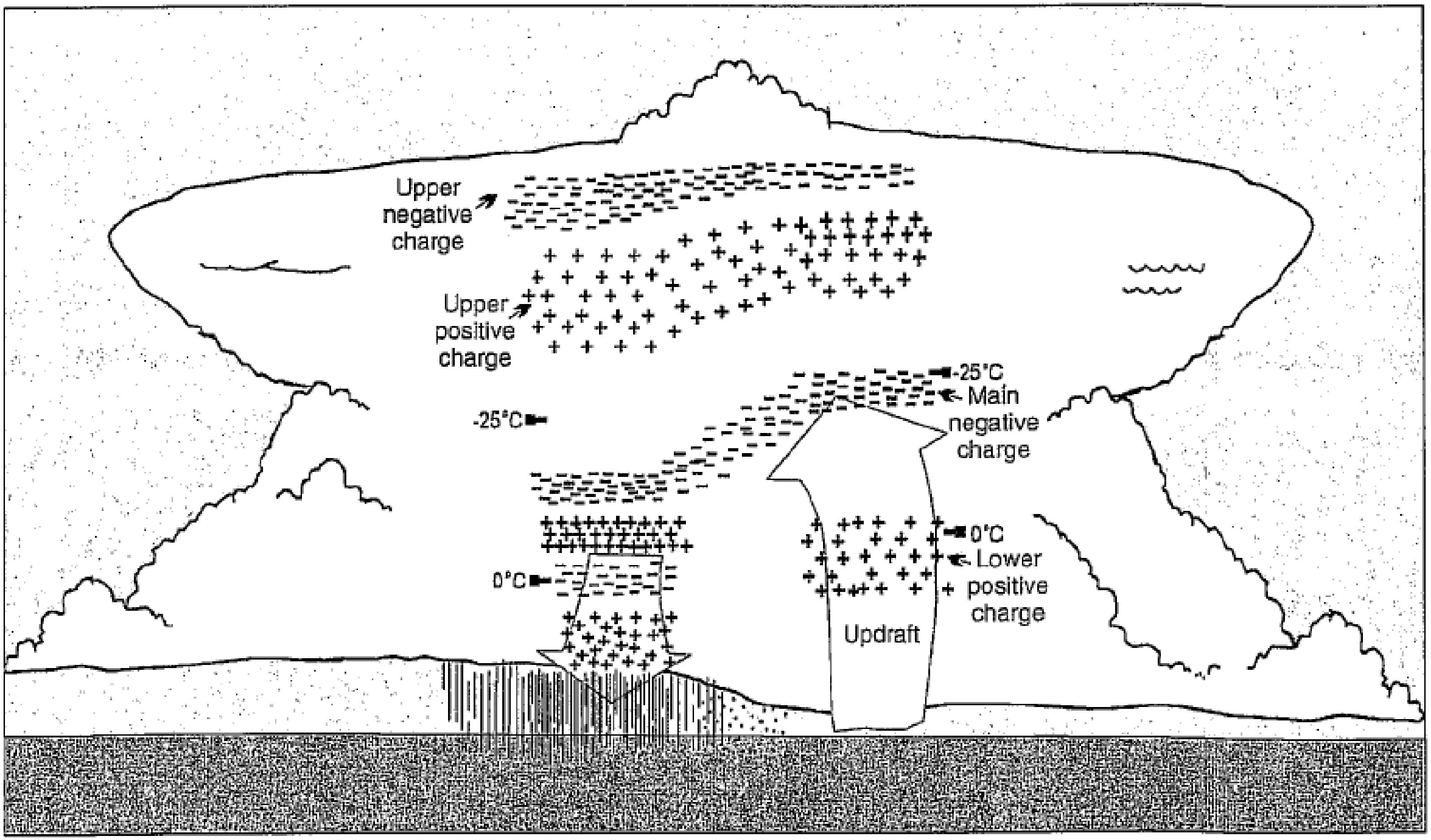


Fig. 3.11. Schematic of the basic charge structure in the convective region of a thunderstorm. Four charge layers are seen in the updraft region, and six charge layers are seen outside the updraft region (to the left of the updraft in the diagram). The charge structure shown applies to the convective elements of mesoscale convective systems (MCS), isolated supercell storms, and New Mexican air-mass storms. Note that there is a variability in this basic structure, especially outside the updraft. Adapted from Stolzenburg *et al.* (1998b).

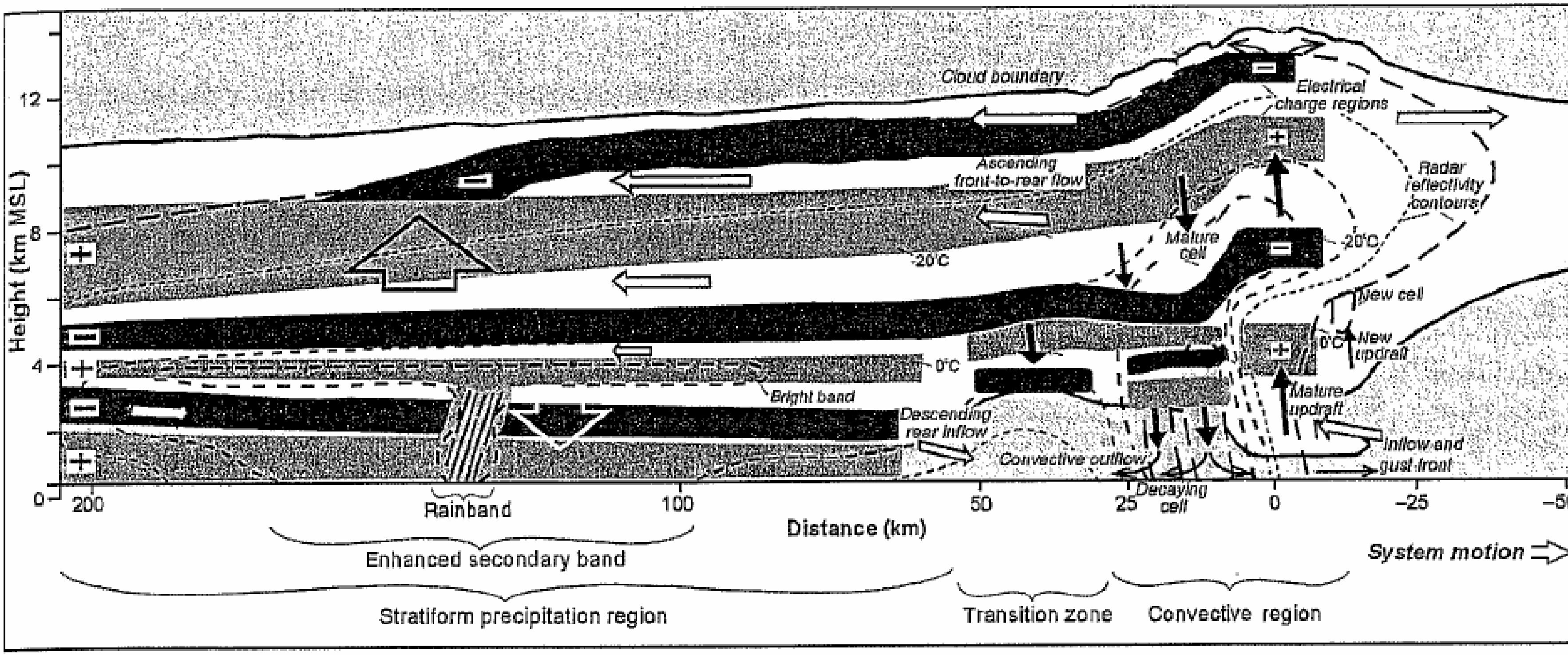


Fig. 3.15. Conceptual model of the charge structure of an MCS. Positive charge layers are indicated by the light grey shading and negative layers are indicated by the dark shading. The broken lines are radar reflectivity contours. In the convective region and the transition zone, the thick solid arrows depict convective updrafts and downdrafts, and the thin solid arrows show divergent outflows. The smaller open arrows represent system-relative flows, which are mainly horizontal. The mesoscale updraft and downdraft in the stratiform region are depicted by large open arrows (black and white outlines, respectively). There are four horizontally extensive cloud charge layers in the part of the stratiform precipitation region farthest behind the convective region, the fifth (lowermost) charge layer being seen in the stratiform region entirely below the cloud. An additional (negative) charge layer extends from the convective region through the nearest part of the stratiform region above all the other layers. Adapted from Stolzenburg *et al.* (1998c).

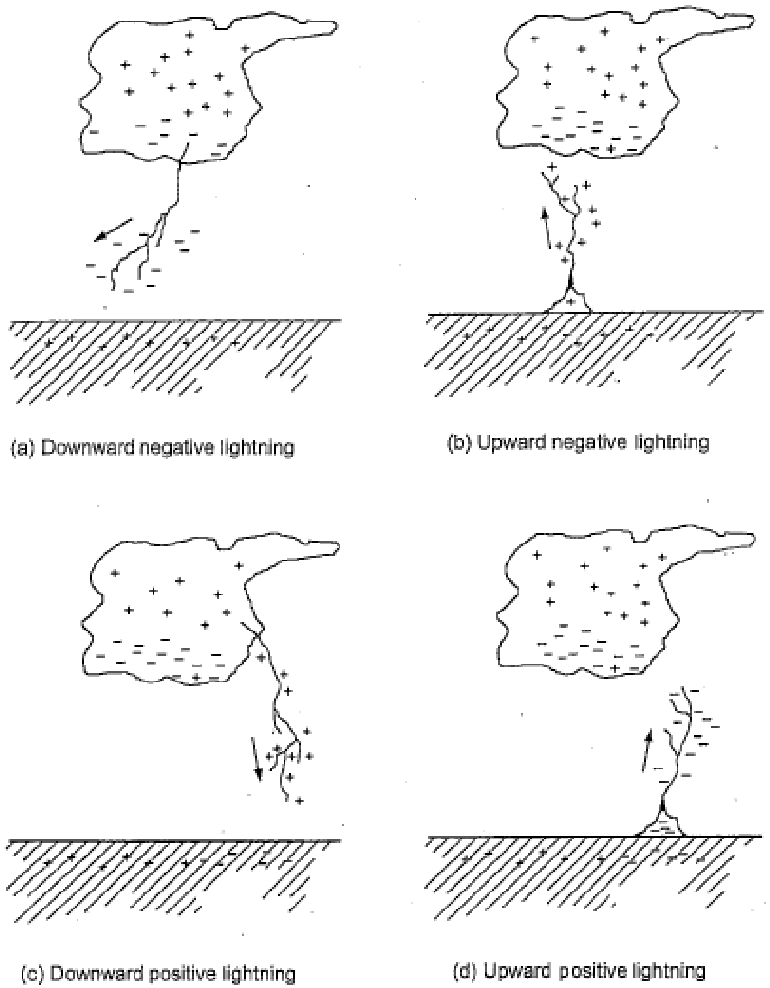


Fig. 1.1. Four types of lightning effectively lowering cloud charge to ground. Only the initial leader is shown for each type. In each lightning-type name given below the sketch, the direction of propagation of the initial leader and the polarity of the cloud charge effectively lowered to ground are indicated.

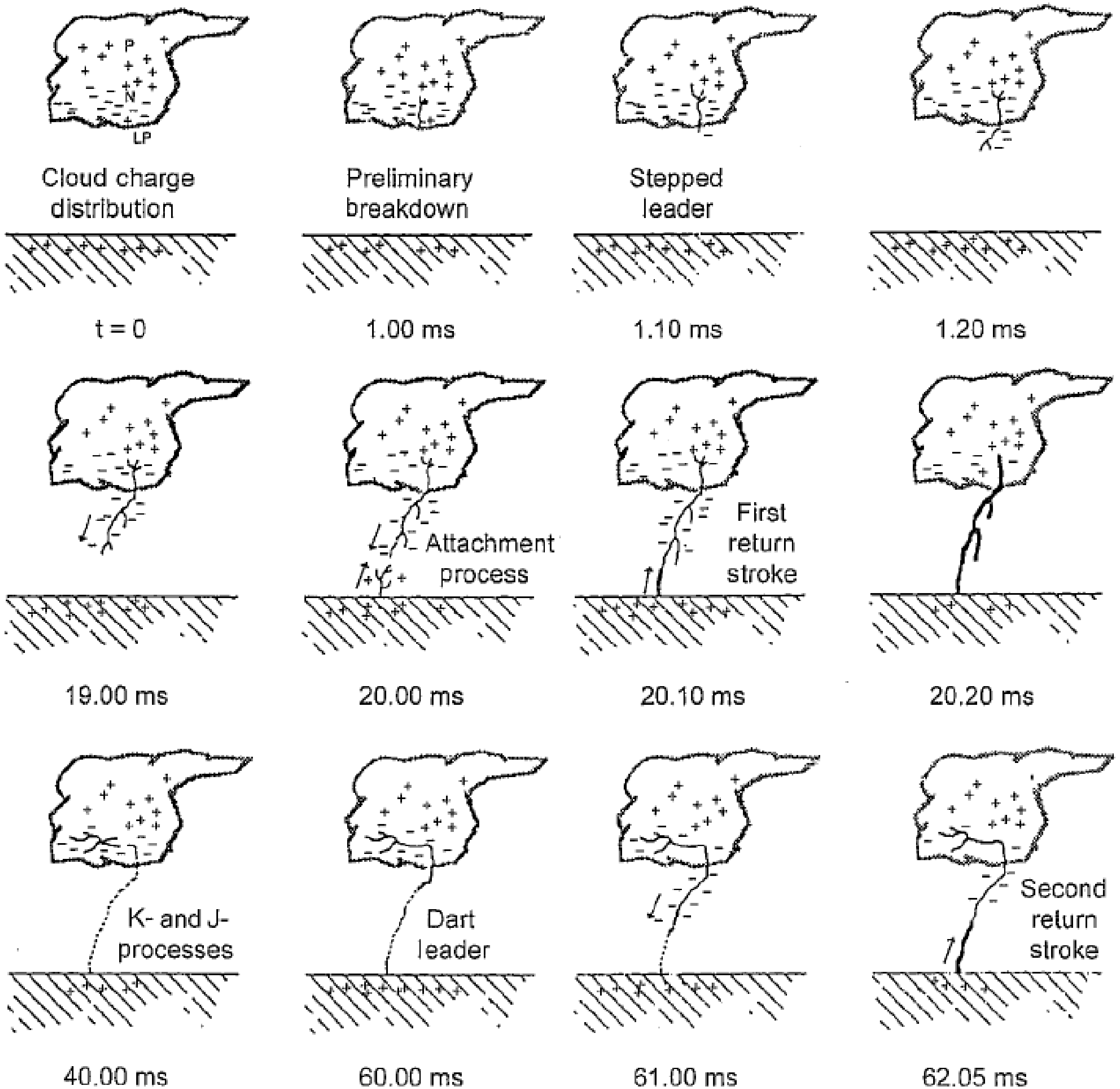


Fig. 4.3. Various processes comprising a negative cloud-to-ground lightning flash. Adapted from Uman (1987, 2001).

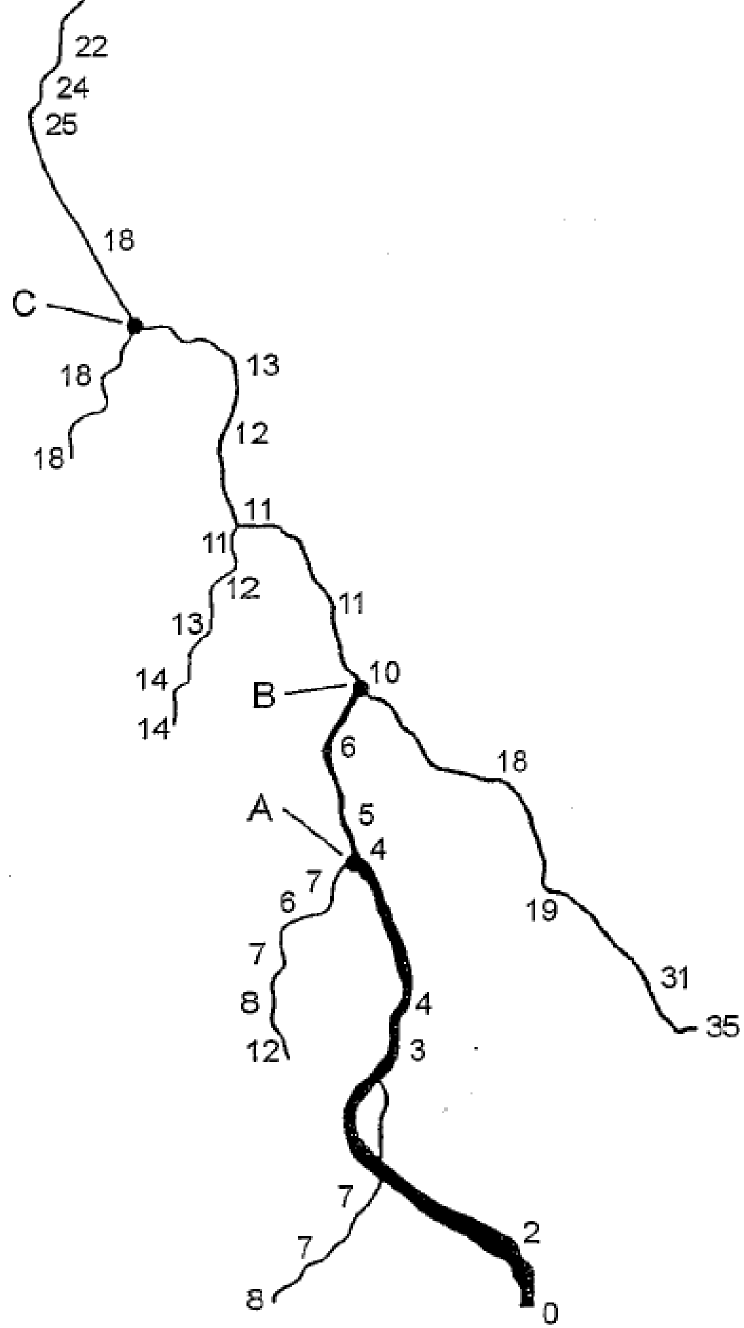


Fig. 4.36. The luminous development of a first return stroke. The numbers indicate the time of arrival in microseconds of the

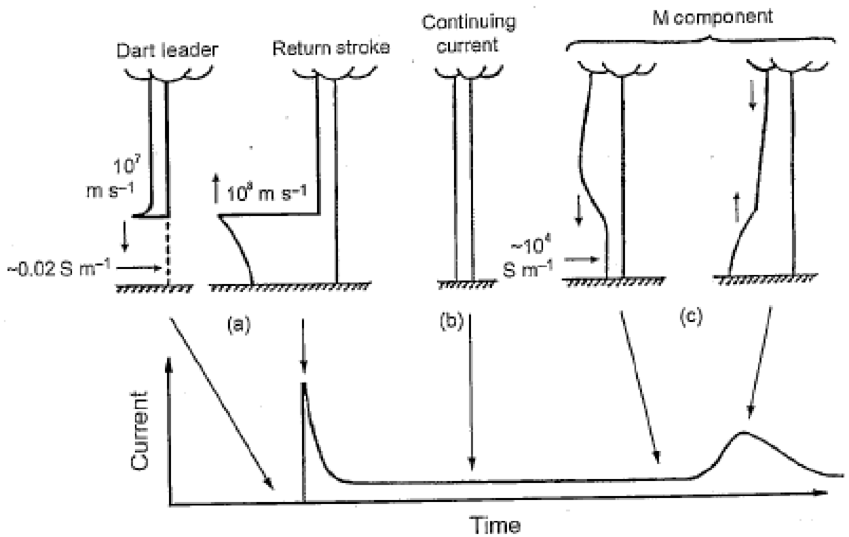


Fig. 1.2. Schematic representation of current versus height profiles for three modes of charge transfer to ground in negative lightning subsequent strokes: (a) dart-leader–return-stroke sequence, (b) continuing current, and (c) M-component. The corresponding current versus time waveform represents the current at the ground.

Table 1.1. *Characterization of negative cloud-to-ground lightning*

Parameter	Typical value[a]
Stepped leader	
Step length, m	50
Time interval between steps, μs	20–50
Step current, kA	> 1
Step charge, mC	> 1
Average propagation speed, m s^{-1}	2×10^5
Overall duration, ms	35
Average current, A	100–200
Total charge, C	5
Electric potential, MV	~ 50
Channel temperature, K	~ 10 000
First return stroke[b]	
Peak current, kA	30
Maximum current rate of rise, kA μs^{-1}	≥10–20
Current risetime (10–90 percent), μs	5
Current duration to half-peak value, μs	70–80
Charge transfer, C	5
Propagation speed, m s^{-1}	$(1–2) \times 10^8$
Channel radius, cm	~ 1–2
Channel temperature, K	~ 30 000
Dart leader	
Speed, m s^{-1}	$(1–2) \times 10^7$
Duration, ms	1–2
Charge, C	1
Current, kA	1
Electric potential, MV	~ 15
Channel temperature, K	~ 20 000
Dart-stepped leader	
Step length, m	10
Time interval between steps, μs	5–10
Average propagation speed, m s^{-1}	$(1–2) \times 10^6$
Subsequent return stroke[b]	
Peak current, kA	10–15
Maximum current rate of rise, kA μs^{-1}	100
10–90 percent current rate of rise, kA μs^{-1}	30–50
Current risetime (10–90 percent), μs	0.3–0.6
Current duration to half-peak value, μs	30–40
Charge transfer, C	1
Propagation speed, m s^{-1}	$(1–2) \times 10^8$
Channel radius, cm	~ 1–2
Channel temperature, K	~ 30 000
Continuing current (longer than ~ 40 ms)[c]	
Magnitude, A	100–200
Duration, ms	~ 100
Charge transfer, C	10–20

Table 1.1. (*cont.*)

Parameter	Typical value[a]
Overall flash	
Duration, ms	200–300
Number of strokes per flash[d]	3–5
Interstroke interval, ms	60
Charge transfer, C	20
Energy, J	$10^9 - 10^{10}$

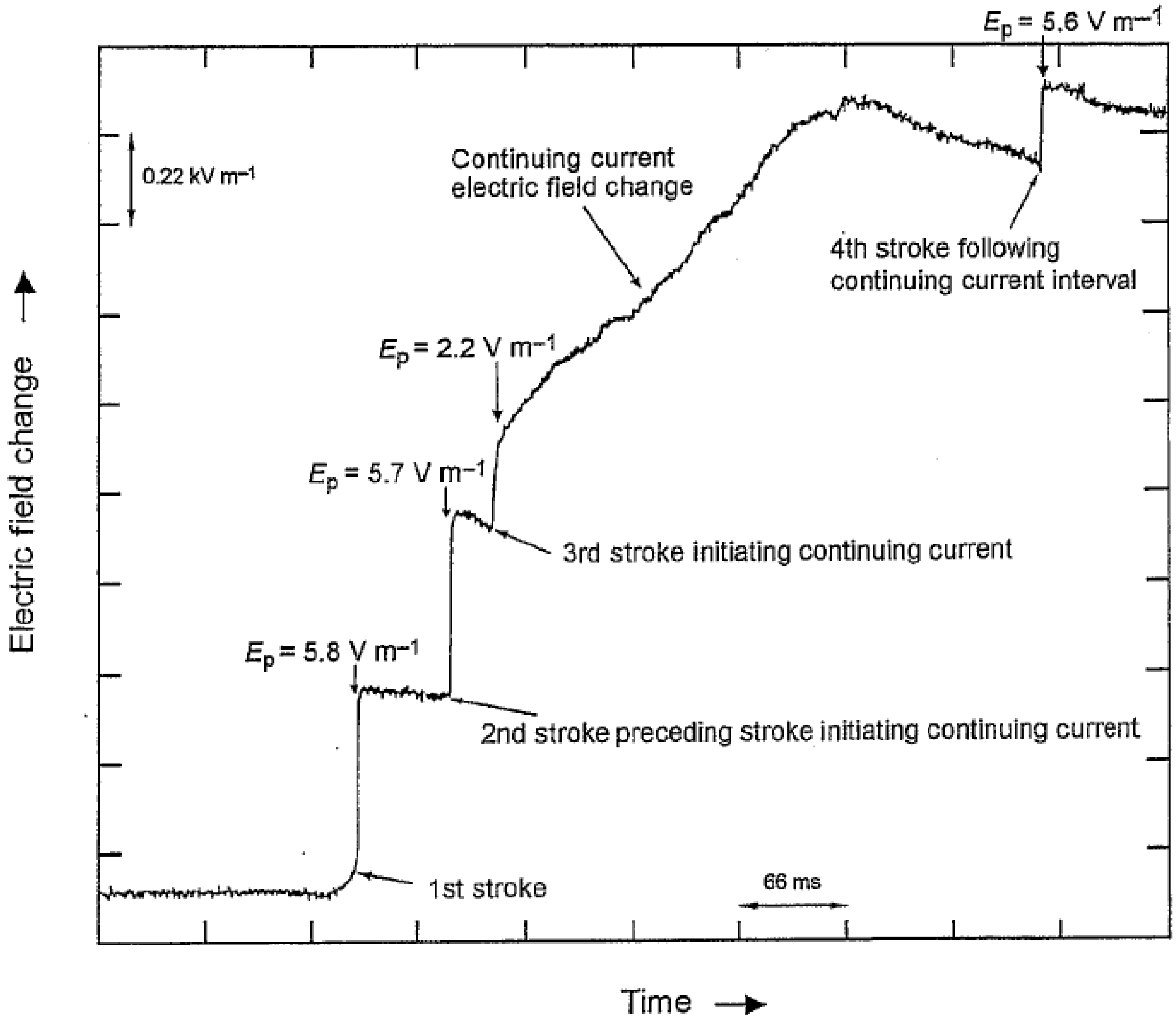


Fig. 4.49. Overall electric field change for a four-stroke flash with a long continuing current following the third stroke. The flash occurred in Florida on 27 July 1979 at 2240:14 UT and at a distance of 6.5 km. Microsecond-scale initial electric field peaks are not resolved in this figure, but their values E_p (normalized to 100 km) are given. A positive electric field change (atmospheric electricity sign convention, subsection 1.4.2) deflects upward. Adapted from Rakov and Uman (1990a).

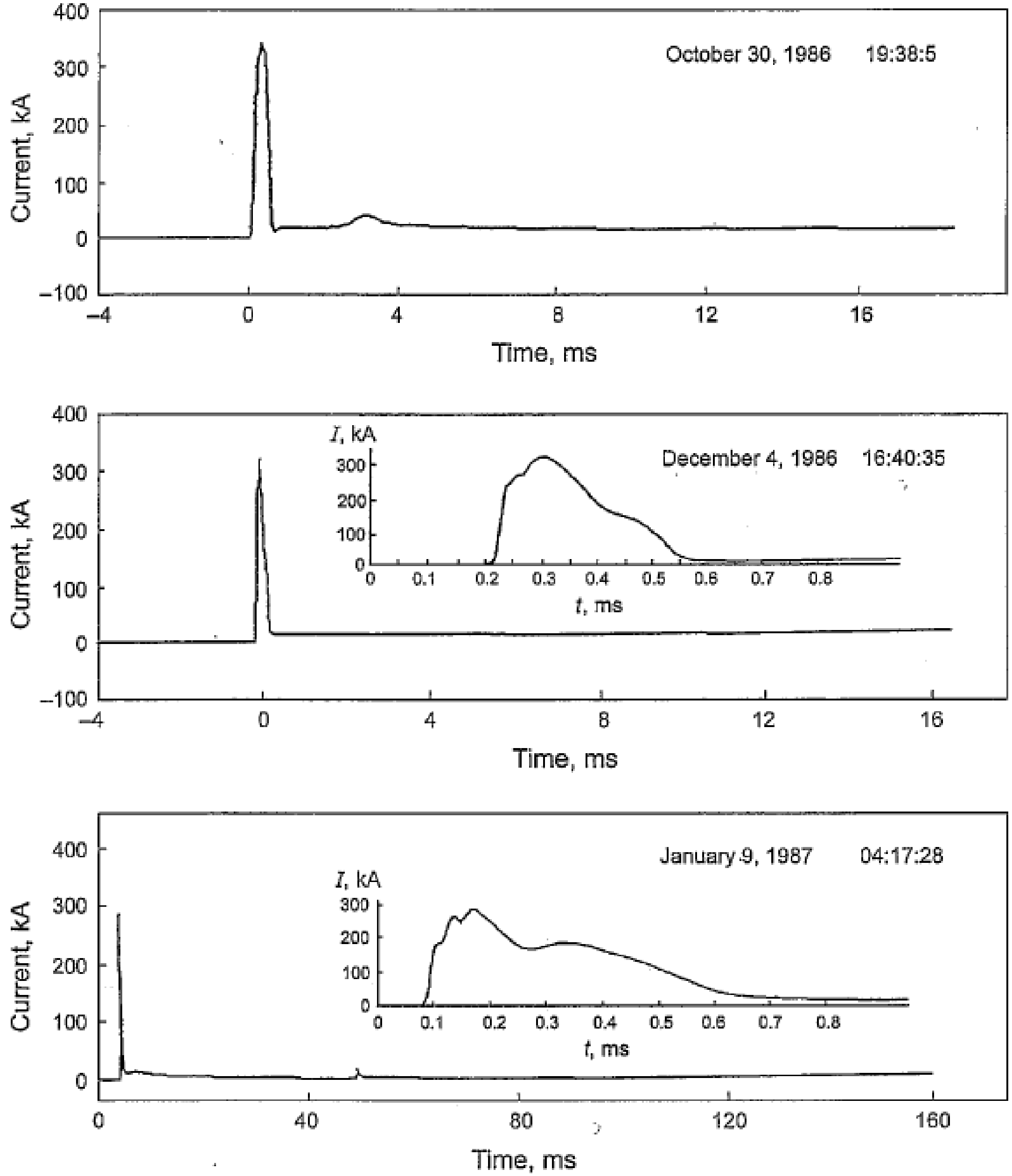


Fig. 5.1. Directly measured currents in three positive lightning discharges in Japan. The insets in the middle and bottom diagrams show the current on an expanded scale. Note the very large peaks, from top to bottom 340, 320, and 280 kA, of the initial pulses, which are followed by continuing currents. The transferred charges are 330, 180, and 400 C, respectively. Adapted from Goto and Narita (1995).

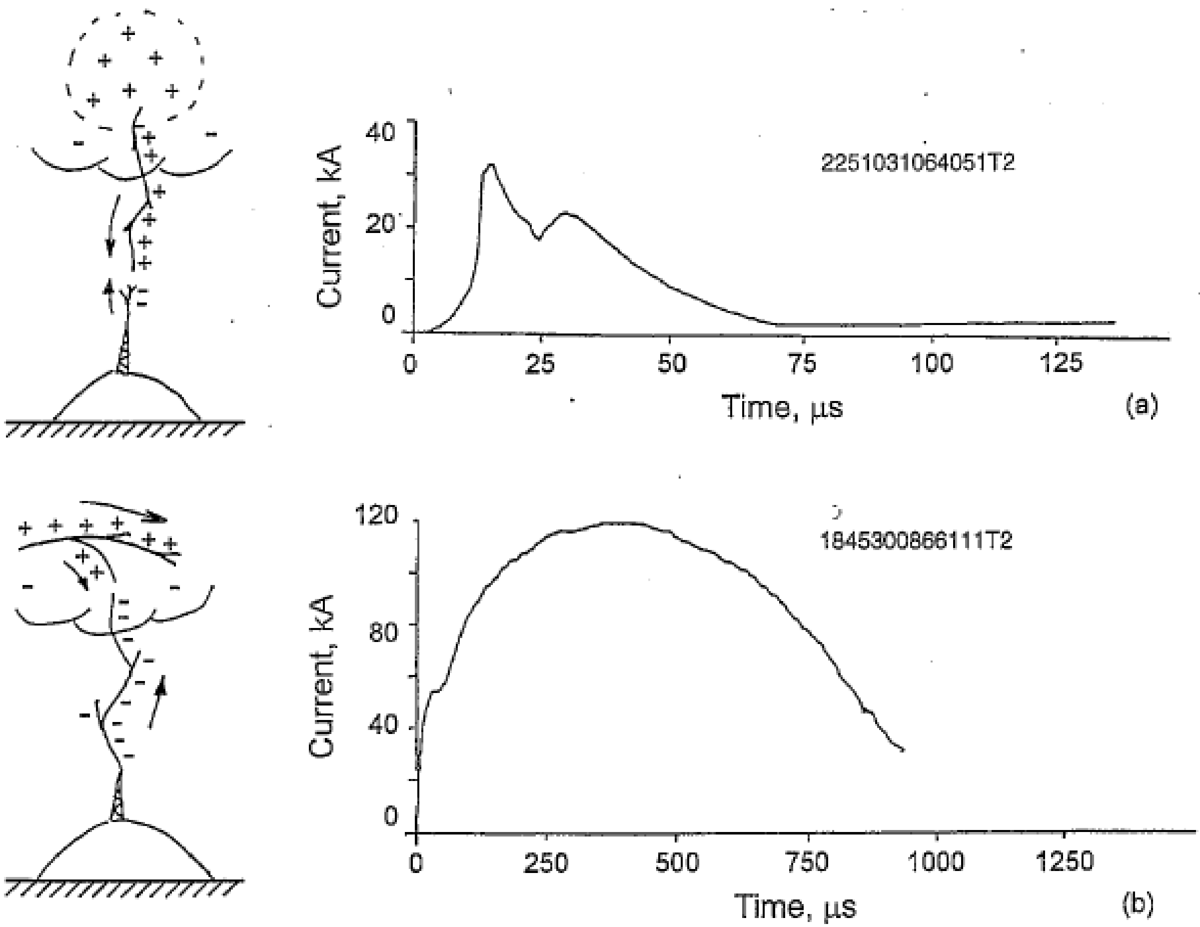


Fig. 5.6. Examples of two types of positive lightning current waveforms observed by Berger: (a) a microsecond-scale waveform (right-hand panel) and a diagram (left-hand panel) illustrating the type of lightning that might have led to its production; (b) a millisecond-scale waveform (right-hand panel) and a sketch (left-hand panel) illustrating the type of lightning that might have led to its production.

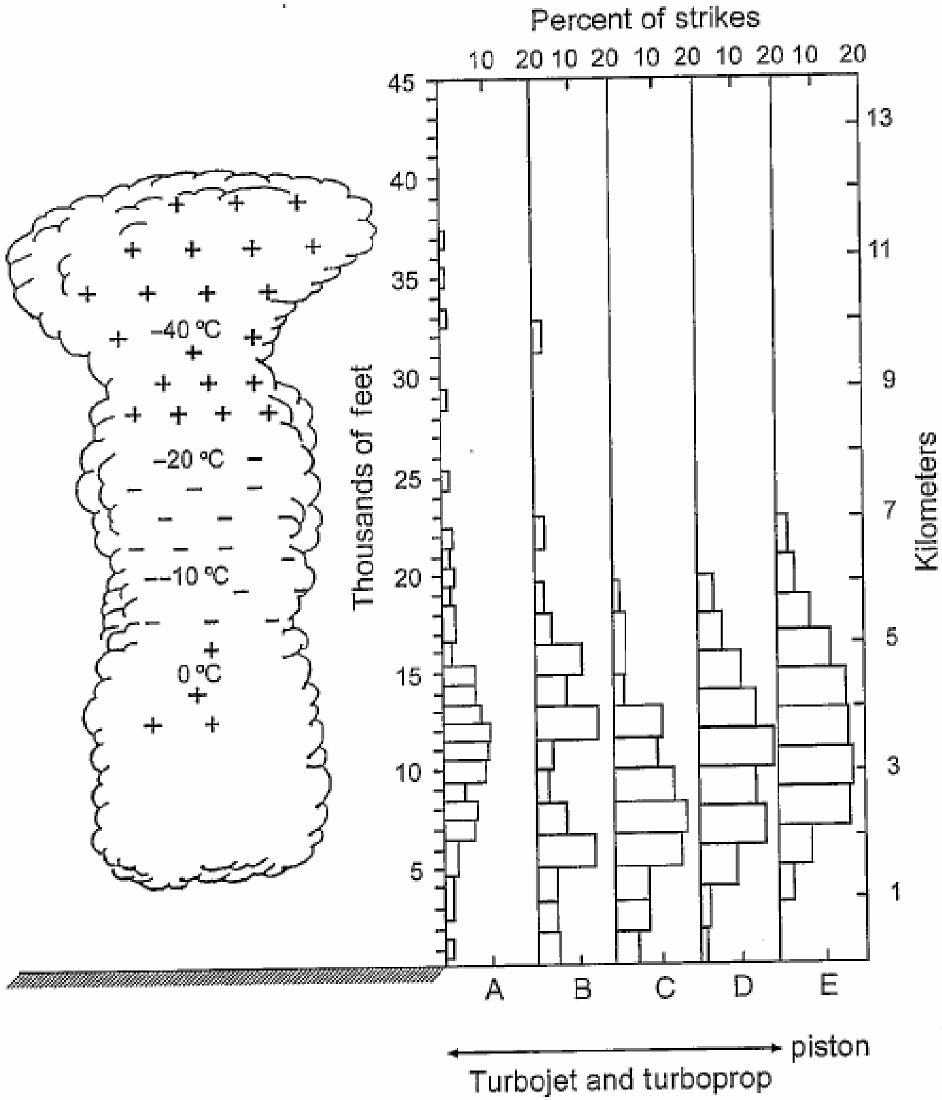
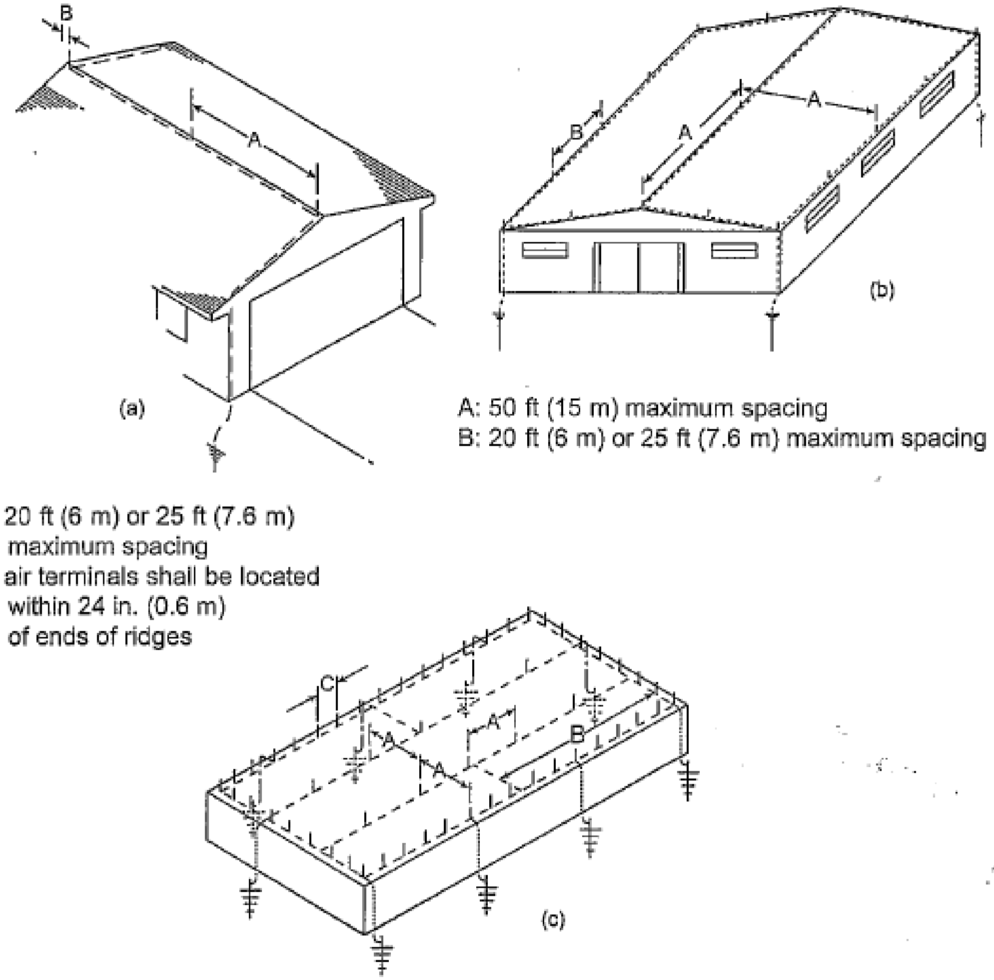


Fig. 10.2. Aircraft lightning incidents versus altitude. Adapted from Fisher *et al.* (1999) with a correction to their typical summer thunderstorm charge distribution (subsection 3.2.1). A, USA (Plumer 1971–5); B, Europe/S.A. (Anderson 1966–74); C, USSR (Trunov 1969–74); D, UK/Europe (Perry 1959–75); E, USA (Newman 1950–61).



(a)
A: 20 ft (6 m) or 25 ft (7.6 m) maximum spacing
B: air terminals shall be located within 24 in. (0.6 m) of ends of ridges

(b)
A: 50 ft (15 m) maximum spacing
B: 20 ft (6 m) or 25 ft (7.6 m) maximum spacing

(c)
A: 50 ft (15 m) maximum spacing between air terminals
B: 150 ft (45 m) maximum length of cross run conductor permitted without a connection from the cross run conductor to the main perimeter or down conductor
C: 20 ft (6 m) maximum spacings between air terminals along edge

Fig. 18.1. Lightning protection of ordinary structures via diversion as recommended by NFPA-780.

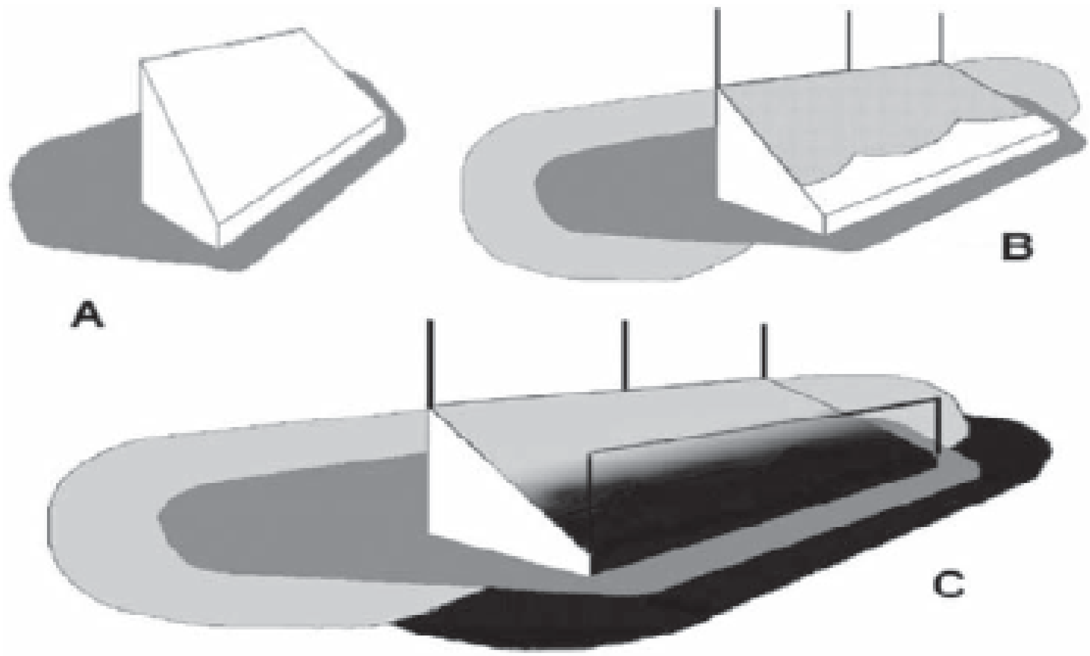


Fig. 3. Various zones of protection from lightning. (a) Zone of protection (dark gray) created by stand-alone seating. (b) Augmented zone of protection (light gray) created by fitting the existing seating area with three air terminals (lightning rods). (c) Additional zone of protection (black) created by hanging a caternary (shield wire) across the front of the seating area.