

CHAPTER 6: SEVERE THUNDERSTORM RISKS

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The Thunderstorm Threat

The term ‘thunderstorm’ is a generic description of a relatively small scale convective process which can occur when the atmosphere is moist and unstable. Cumulo-nimbus clouds then rapidly develop, potentially reaching heights of up to 20 km, with associated lightning, thunder, severe wind gusts from downdrafts, heavy rain and large hail. Many thunderstorms are typically short-lived (up to an hour) and limited in size (up to 10 km in diameter) but can traverse large distances during that time and are capable of inflicting significant damage (Kessler, 1983). Individual storm impacts can vary significantly both in space and time. In Australia, a *severe thunderstorm* is defined as a thunderstorm which causes one or more of the following phenomena (BoM, 1995a):

- a tornado;
- wind gusts of 90 km/h or more at 10 m above the ground;
- hail with diameter of 20 mm or more at the ground;
- an hourly rainfall intensity in excess of the 10 year ARI for a region (about 70 mm/h or greater, dependent on the location and previous rainfall).

Ironically, lightning is not used as a discriminator of thunderstorm intensity. Almost all convective storms will exhibit some lightning and hence some thunder and there is no established link between lightning display and overall storm intensity.

South-East Queensland is a region that is particularly susceptible to severe thunderstorms, especially during the summer months. For example, the highest recorded wind gust from 48 years of data at Brisbane airport occurred during a severe ‘supercell’ thunderstorm in January 1985. The peak wind gust was 184 km/h but only affected a limited area - it was the accompanying 60 mm diameter hail which devastated several northern suburbs with a damage swath up to 10 km wide (Jhamb and others, 1985). This represented a record insurance payout of about \$300 million in present values (based on ICA, 1998). The April 1999 hailstorm, which affected 22 000 properties in Sydney and caused an Australian record \$1.7 billion in insurance losses, is an indication of the enormous damage potential of such storm systems in densely built-up metropolitan regions.

While tropical cyclones are potentially capable of greater destruction on a wide geographic scale, severe thunderstorms dominate the annual wind speed records in South East Queensland and, together with flooding and lightning, are responsible for most of the annual damage to property.

The Thunderstorm Phenomenon

Genesis: Thunderstorms typically occur when dense cold air overlies warm moist air and uplift is initiated by one of several possible factors such as solar heating, orographic (topographic) effects or fronts and troughs (BoM, 1995a). Strong localised upward currents of air can develop as the heat energy stored in the moist warm air is converted to kinetic energy high in the clouds. During this process, condensation of the moist air occurs at altitude, together with separation of positive and negative electrical charges, leading to the generation of lightning. Hail is formed by the freezing of raindrops at very high levels. These are then thought to grow steadily in size while being recirculated throughout the storm by powerful updrafts and downdrafts. When the weight of the circulating water and ice can no longer be supported by the updrafts, they fall to earth in concentrated shafts, dragging the surrounding air downwards and causing strong ‘downburst’ winds at the surface. When conditions are favourable, mature thunderstorms can form in very short periods of time and have highly organised

motion comprising complementary up- and down-drafts. Sometimes, practical warnings for such events are not possible.

The most common type of thunderstorm is termed the *ordinary* cell, which is limited in size and lifespan, but can produce short bursts of severe weather. *Multi-cellular* storms are more persistent and larger in impact, formed by successive cell generation on the forward left flank, allowing them to move transverse to the prevailing wind and to present a broader impact front. Several other variants also exist, but the most dangerous form is termed the *supercell* thunderstorm, which is schematically illustrated in Figure 6. 1 (BoM, 1995b).

The *supercell* is typically an isolated form and always has the potential to be severe because of its strong and persistent rotating updraft, which dissipates at the upper levels forming the characteristic anvil and overshoot of clouds. Vertical wind shear (i.e. wind speed increasing with height) is important in the development of severe storms such as *supercells*. The shearing effect serves to separate the updrafts from the downdrafts, thus creating a circulation. In a normal thunderstorm the downdraft tends to fall back into the updraft, effectively dissipating the storm's energy. Hail and heavy rain is associated with the downdraft zones and under some specific conditions may also form a tornado towards the left rear flank of the storm cell. This small but rapidly rotating column of air descends below the cloud base, reaching the surface with devastating consequences. Thankfully, the strength of severe winds from thunderstorms is inversely related to the area they impact. For example, very severe downdrafts (or microbursts) can attain speeds of more than 200 km/h and affect areas up to 1 km wide, while severe tornadoes might have winds in excess of 400 km/h but are typically restricted to widths of less than 100 m (Fujita, 1981).

As the storms translate at speeds typically in the range of 40 to 50 km/h, these relatively narrow impact widths become long swaths of potentially very high damage. *Supercells* may have a lifespan of several hours and present an impact front as wide as 40 km. Records of damage generally indicate 'pulsing' whereby the ground level impacts tend to fluctuate, probably depending on the supply of material held aloft by the updrafts (Harper and Callaghan, 1998). Very severe *supercells* can exhibit almost continuous damage fronts for several hours as combinations of wind, rain and hail.

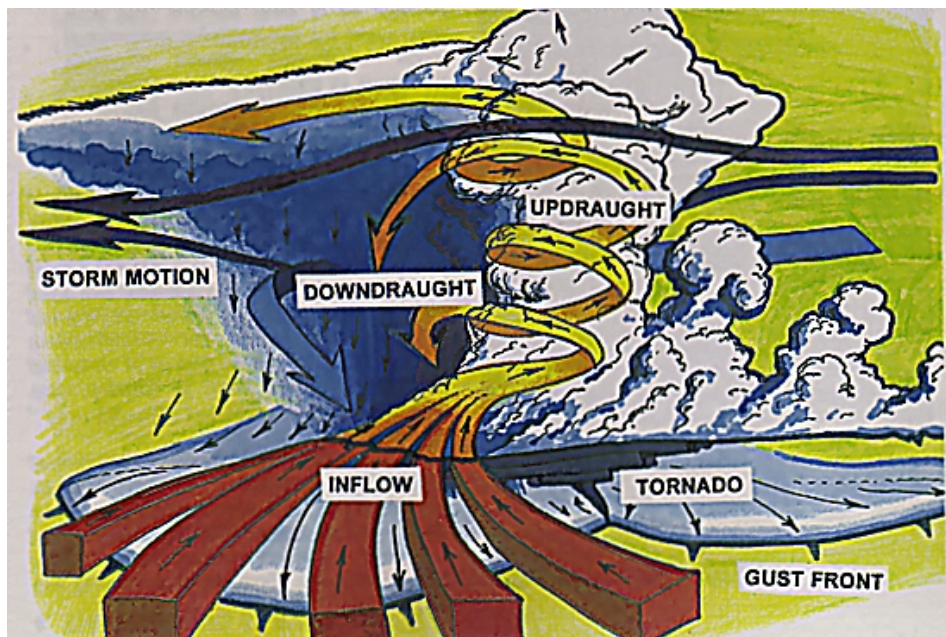


Figure 6. 1 Schematic illustration of a supercell severe thunderstorm [BoM diagram].

The increasing sophistication of radar systems is allowing greater insight into the structure of such storms. For example, Doppler radars now routinely used in the USA can measure wind speeds based on the movement of airborne particles within a severe thunderstorm and help to detect the presence of tornadoes. Doppler radar coverage is not yet available for South-East Queensland, however, forecasters have access to 3D enhanced radar such as shown in Figure 6. 2. This depicts the horizontal and vertical extent of several severe thunderstorms which wreaked havoc across Brisbane suburbs on 16th December 1998. Thousands of motor vehicles were heavily damaged by hail, the largest reported hailstone being 100 mm in size at Bracken Ridge. The total damage bill was estimated as \$76 million with the most affected suburbs being Clayfield, Windsor, Wilston, Albion, Northgate and Wavell Heights.

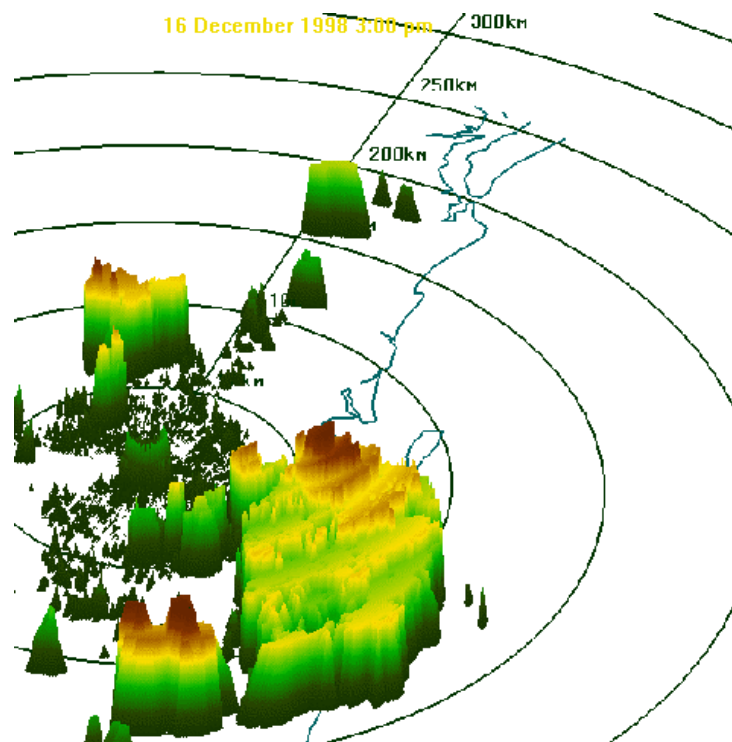


Figure 6. 2 Example of a 3D radar view of severe thunderstorms over Brisbane

Climatology: The most recent review of severe thunderstorm climatology in South-East Queensland was undertaken to assist in estimating likely long-term risks to insurers (SEA, 1997). This study combined various datasets from the Bureau of Meteorology and undertook a number of analyses to determine the frequency and intensity of severe thunderstorms within 150 km of Brisbane. The review relied on a number of earlier studies which considered the synoptic conditions for the occurrence of severe storms. Principal amongst these was Callaghan (1988), which used a 10 year data set containing only storms with high radar reflectivity regions (>60 dBZ) thus ensuing only potentially severe storms with very heavy rain and/or hail were considered. After some simplification, Callaghan's analysis leads to essentially four classes of severe thunderstorms in the region, based on broad synoptic pre-cursor types as follows (Harper and Callaghan, 1998):

Type A: SE Change	(23%)
Type B: Strong NW Flow	(17%)
Type C: Weak NW Flow	(43%)
Type D: Other	(17%)

Callaghan also proposed a strong association between both storm intensity and track as a function of the regional topography; these being related to:

- the highland regions to the south and west providing elevated convective heat sources and hence buoyant air;
- for storms to reach the coast, a generally westerly steering current at middle levels and providing vertical wind shear is needed to sustain severe storms;
- low level convergence on the coastal plain which compensates for the loss of buoyancy in moving off the ranges;
- the interaction between the sea breeze and frontal/trough systems generates and intensifies severe thunderstorms in the populated coastal plains region.

Destructive Winds: The structure of severe winds in thunderstorms is significantly different from those in tropical cyclones. Instead of the wind being essentially horizontal, driven by the large scale pressure gradient, it originates as a vertical ‘downburst’ from high within the thunderstorm cloud structure, as schematised in Figure 6.3. The descent time may be several minutes, depending on the height of the storm. The downburst consists of a mass of colder air which, when it impacts the ground, spreads radially and horizontally, creating very sharp increases in wind speed. The forward speed of the storm then adds to the downburst speed, creating an elongated ‘footprint’ of damage which may be a few kilometres wide and about three times its width in length. The increase in wind speed and change in direction is often particularly rapid, typically reaching a maximum within a minute or less of initially calm starting conditions.

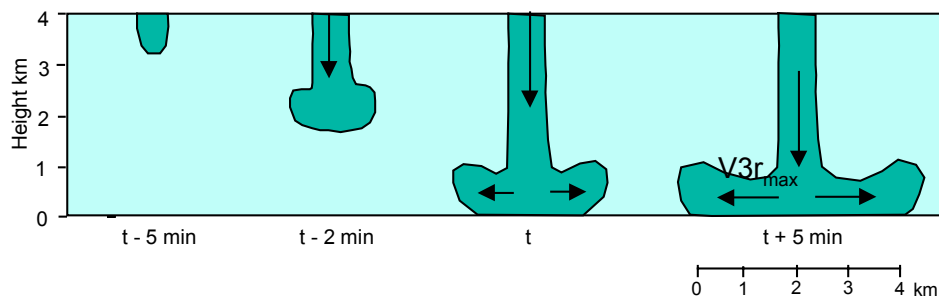


Figure 6. 3 Schematic example of a thunderstorm ‘downburst’ (after Hjelmfelt, 1988).

Tornadoes are features which may accompany severe supercell thunderstorms and are normally found at the left rear sector of the storm. Their exact origin is still largely unexplained but they clearly represent an extension of the strong rotational updrafts which exist within supercell storms. Peak wind speeds are estimated to approach 450 km/h in the largest tornadoes, although actual measurements are sparse. Their spatial size is small, ranging from just a few tens of metres up to a few kilometres. Track lengths typically vary from 1 km upwards and can extend for over 100 km if conditions are favourable. Contrary to popular belief, Australian tornadoes can be just as destructive as their US counterparts.

Because downburst winds increase so rapidly and tornado winds are so concentrated, the concept of mean and gust winds is less relevant than for tropical cyclones. Essentially the mean wind in a downburst is also the gust and the actual surface turbulence levels can be much lower than in tropical cyclones. This has ramifications for ‘long’ or ‘large’ structures such as transmission lines, where the wind pressure may be much more constant over a wide area than is typically the case in more turbulent wind conditions. Also, ‘long’ structures act as ‘tornado traps’; their lateral width being more likely to intersect the relatively narrow swath which a tornado might create. A number of overhead power transmission line failures have occurred in South-East Queensland linked with severe thunderstorms.

Hail: Bureau of Meteorology records suggest that approximately 30% of all severe thunderstorms produce damaging hail, with actual sizes varying depending on the strength of the recirculating updrafts in the storm system. Hail is thought to grow by the accumulation of super-cooled water droplets as the hail nucleus is supported by the strong updrafts. Eventually, the mass of ice particles cannot be maintained and the hailstones typically fall in intermittent 'shafts' which form damage swaths at ground level due to the forward movement of the storm. These swaths vary from a few kilometres in width and up to 10 kilometres in length. However, the formation of hail (and lightning) is not completely understood. For example, the extremely rapid development of the hailstorm depicted in Figure 6.2 tends to question the simple recirculating theory and suggests a shorter and more direct mechanism for hail generation is possible.

Heavy Rainfall: A thunderstorm, with its strong moist updrafts, is a storehouse of precipitation. Whether this manifests as rain or hail depends on the particular storm features and atmospheric conditions on the day. Supercells and single cell thunderstorms are normally not responsible for levels of precipitation that cause flash flooding (BoM, 1995a) but rather it is the multicellular, or so-called mesoscale convective, systems which are responsible for the greatest sustained rainfall rates.

The speed at which a raindrop approaches the ground depends not only on its size but also the strength of the downdraft in which it is imbedded. Hence a 9 m/s falling drop may be subject to a further 10 m/s downdraft velocity, providing a very high rainfall rate. The most intense rain generally occurs under the core of the storm cell just after the first rainfall reaches the ground. It then spreads gradually and typically lasts for up to about 15 minutes. Flash floods typically occur when a storm moves relatively slowly across an area with limited drainage paths and high runoff capacity so that a large amount of rain falls in a small area and causes a high impact.

Lightning: Almost all storms produce some lightning and associated thunder, although there are no reliable methods for predicting overall storm intensity on that basis (BoM, 1995a). An average thunderstorm produces a few lightning flashes each minute and generates several hundred megawatts of electrical power during its lifetime. The source of this electrical energy is not completely understood but the more widely accepted theories involve charge generation and separation due to the production of solid precipitation (graupel or hail). It is postulated that the negatively charged larger particles settle relative to smaller positively charged particles, thus creating the charge separation distance over the height of the cloud convection layer.

Cloud-to-cloud discharges often occur between the positive and negative centres, resulting in extensive luminosity, but are of little concern at the ground. Cloud-to-ground lightning develops as the potential gradient between the base of the cloud and the ground increases, and eventually exceeds the insulating capacity of the air (Kessler, 1983). Cloud-to-ground lightning originates from the cloud as invisible (to the eye) discharges termed *stepped leaders*, because of their discrete method of advance. Positive charges are then induced in the underlying ground and when the discharge is about 10 to 100 m above ground, a travelling spark moves up from the ground to meet it. After contact, a large current is established with the cloud base, and the highly luminous lightning stroke propagates upwards. This return stroke is actually the visible portion of the stroke and is normally followed in quick succession by a number of secondary strokes before the charge is sufficiently dissipated to break the connection. In the case of isolated tall structures such as buildings or towers, the stepped ladder begins from the ground upwards. Most lightning strokes are negative, transferring negative charge from cloud to ground, but positive strokes can also occur. Thunder is generated during the stroke due to the rapid increase in air temperature surrounding the stroke. This creates a shock wave that initially travels faster than the speed of sound and generates a 'sonic boom' effect. Audible detection is limited to about 25 km from the stroke.

Traditionally, the collection of 'thunder day' statistics at observing stations has been used to estimate the occurrence and distribution of lightning across the state. However, this leads to fairly inaccurate sampling of the true occurrence. Following a period of development of remote sensing techniques for lightning detection in the late 1970s, magnetic direction-finding systems were established and have

been operating in South-East Queensland for more than 15 years. The first system was jointly operated by (now) Telstra and Energex. Recently, more accurate time-of-arrival lightning tracking systems have been commercially developed and their information is able to be purchased by lightning sensitive industry sectors, including sporting bodies. Based on the analysis of about six years of lightning flash data by Quelch and Byrne (1992), the ground flash density (flashes/sq km/yr) for estimated discharges in the range of 30 to 100 kA is more than 2 along the coastal ranges and nearby hinterland. In the metropolitan region of Brisbane, levels as high as 0.5 are common, making lightning a relatively common impact from severe thunderstorms. Each year in Australia, lightning claims up to 10 lives and causes over 100 injuries.

The South-East Queensland Thunderstorm Experience

SEA (1997) assembled all the available data for the region over the period 1967 to 1996 and identified various deficiencies in terms of completeness of information and consistency in recording which need to be taken into account when drawing statistical conclusions from the data. Nevertheless, the study led to the following summary conclusions for the area within a 150 km radius of Brisbane:

- there are, on average, about 20 days each year when severe thunderstorms occur in the region;
- on each of these days there are often up to 5 individual storm systems involved,
- the thunderstorm ‘season’ is mainly October through April;
- predominant approach direction is from SW;
- the typical forward speed of storms is 40 km/h;
- approximately 30% of severe storm days involve severe hail;
- tornadoes occur on average about 1 day per year in the region; and,
- the most damaging storms appear to be of Type A (south-east change).

Appendix F provides a summary record of the more damaging severe storms which have occurred across the South-East Queensland region, dating back to 1956. These are certainly not all of the potentially severe thunderstorms that have occurred, but only those where significant damage was actually reported. Based on the Appendix F data, **Figure 6. 4** shows the variation in annual occurrence over the 45 years of record. The largest number of damaging storms (eight) in any one year occurred in 1995 and 1999, with 1998 a close second. The average frequency of damaging storms is two per year over this period. The 5 year running mean of annual occurrences is also shown for comparison, highlighting some apparent cyclical activity over this time, and with an increasing trend being apparent in later years. As outlined by SEA (1997) though, these apparent trends in increased damaging storm occurrences over the past 15 to 20 years need to be considered within the context of the significantly expanding metropolitan regions and increased media access. The more densely populated the region becomes, the greater the frequency of damage resulting from severe storms will increase. This effect is especially important as the region begins to develop more in an east-west fashion, thus providing more elements at risk beneath the potentially damaging storm swaths from the south-west quadrant.

Figure 6. 5 shows the distribution of storm occurrences on a monthly basis over this period of time. The storm season typically begins in October and ends in April. December ranks as the most affected month with over 30% of occurrences, closely followed by November with 27%. January is next with about 17% and the other months, with the exception of May to August, make up the remaining 26%.

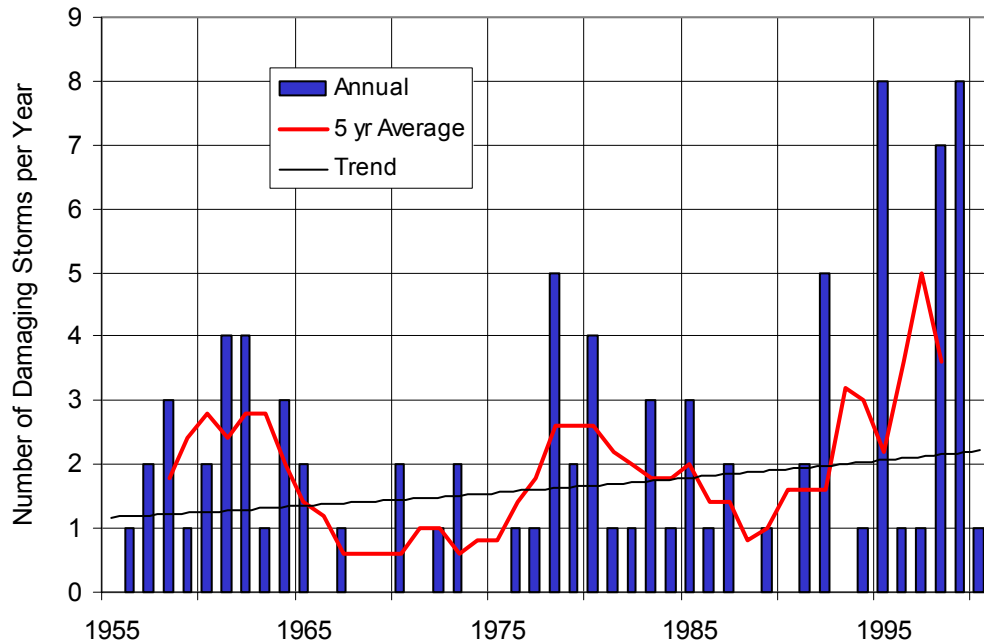


Figure 6. 4 Historical record of damaging thunderstorms affecting South-East Queensland

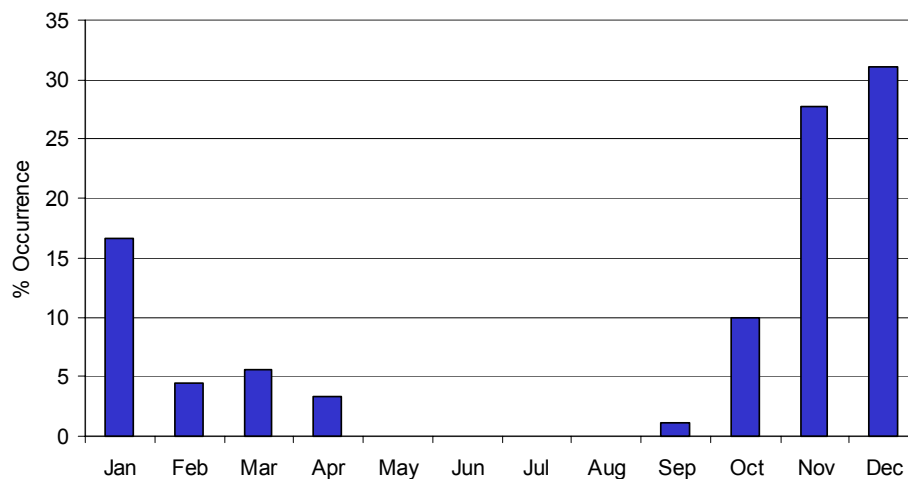


Figure 6. 5 Monthly distribution of damaging thunderstorms affecting South-East Queensland

In spite of the identified deficiencies in the database of severe storms (see Appendix F), the cyclical record in Figure 6.6 suggests possible influences with the Southern Oscillation Index (SOI) of the type already identified for tropical cyclones and east coast lows. To assist in this comparison, Figure 6.6 also presents a 5 year running mean of the deviation from the annual average occurrence, or mean anomaly, compared with the 5 year smoothed SOI over the same period. Certainly, during the 1970s, the enhanced SOI or *La Niña* cycle appears to have been associated with a decrease in occurrences of damaging storms while in the reverse or *El Niño* period, occurrences appear near-normal or generally enhanced. The recovery of the SOI to *La Niña* status over 1999/2000 appears also to be associated with a relatively reduced incidence of damaging storms in 2000. These trends are of course indicative only and further research may indicate other more relevant reasons for the cyclical behaviour.

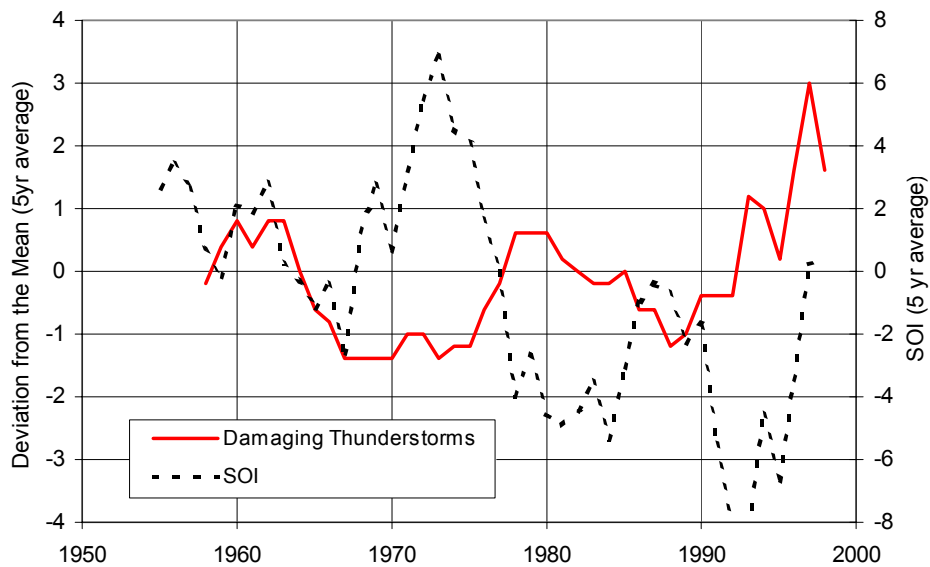


Figure 6. 6 Damaging thunderstorms and SOI relationships for Sout-East Queensland

Destructive winds from thunderstorms occur much more frequently in the South-East Queensland region than do the severe winds brought by tropical cyclones. They also act over much smaller areas. As a result, thunderstorms tend to cause localised but sometimes severe damage in a few suburbs, rather than affecting the whole community. Figure 6. 7 summarises the occurrence of severe wind gusts (> 90 km/h) recorded at a number of airport sites over the past 60 years (from SEA, 1997). Each airport is separately shown, together with the only two instances when tropical cyclone winds exceeded 90 km/h (1954 and 1974), although there were a number of occasions on which cyclonic winds came close to this value.

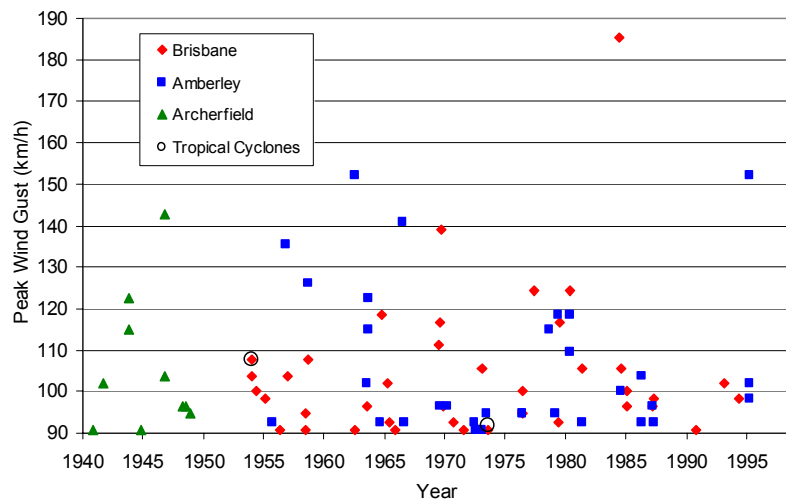


Figure 6. 7 Severe wind gusts recorded at South-East Queensland airport sites 1940 to 1995

The likelihood of experiencing severe thunderstorm winds at any point in South-East Queensland on a long-term basis can then be estimated from statistical analyses, as shown in Figure 6. 8 (after SEA, 1997). This shows the datasets recorded at Brisbane and Amberley together with a statistical best fit line which is the average of separate analyses for each airport. This analysis estimates the 100 year ARI to be about 170 km/h and the 1000 year ARI winds at about 220 km/h. It also suggests that the highest recorded wind gust of 184 km/h in 1985 has an ARI of about once in every 200 years. It

should be noted that these statistics apply for a single point location such as a house, whereas the chance of experiencing these wind gusts anywhere in the region is significantly greater. That is why emergency services regularly need to respond to damage caused by severe thunderstorms every season.

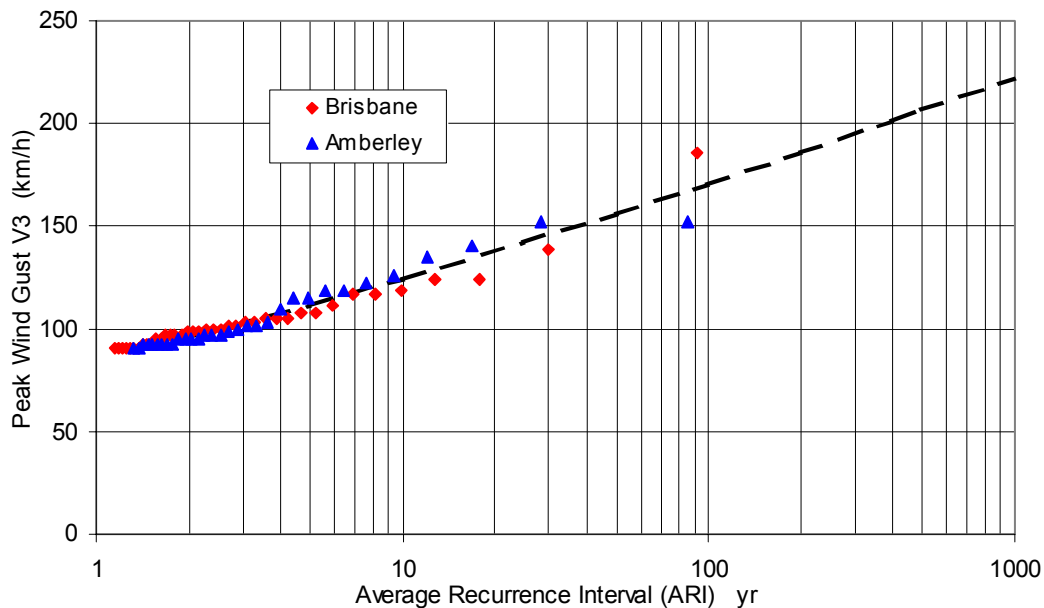


Figure 6. 8 Estimated point probabilities of severe thunderstorm wind gusts in South-East Queensland (after SEA 1997).

In South-East Queensland coastal regions the topographic variability may tend to limit the longevity of tornadoes but not necessarily their strength. Figure 6. 9 shows one of two severe tornadoes which damaged farms and forest plantations on 29 November 1992, near Gin Gin.

There have been at least 15 confirmed or suspected tornadoes in the region over the past 45 years. In November 1973 a tornado, between 100 m to 230 m wide, cut a 51 km swath of damage from Brookfield through Nathan to Eight Mile Plains and across Redland Bay. It unroofed 500 houses, damaged around 1400, with 500 being declared structurally unsafe. The impact of a re-occurrence of such a storm with the present extent of suburban development would be increased many times over. Figure 6. 10 shows some of the housing damage at Macgregor which illustrates the destructive capacity of such systems.



Figure 6. 9 A tornado during the Bucca storm in November 1992



Figure 6. 10 Tornado damage from the November 1973 event in Brisbane

In the South-East Queensland region, reliable reports have been made of hail up to 120 mm in size (rockmelon size). In the Toowoomba hailstorm of 1976 there was one report of a 200 mm 'chunk'. During the descent from high in the cloud, several pieces of hail can coalesce, forming ragged non-spherical shapes that break apart after impact. The most significant hailstorm in Brisbane was in January 1985, where a supercell caused extensive damage in two separate parts of the city over about a half hour period. The largest hail was approximately 63 mm in diameter (tennis ball size). The recent Sydney hailstorm in April 1999 had common hail sizes up to 63 mm but there were several reports of hail of between 80 and 120 mm. Figure 6. 11 shows some examples of hail from the November 1995 storm which damaged the roofs of more than 300 homes in the western Brisbane suburb of Bellbowrie.



Figure 6. 11 : Examples of large hail capable of breaking tile roofs.

Statistical data on the occurrence of hail is extremely limited and rarely verifiable. While the Bureau of Meteorology observation network records the number of 'hail days' at official recording stations, this gives no discrimination of size. Hail size is typically reported by members of the public or gleaned from newspaper reports.

Thunderstorm Risks

The risks posed by destructive winds to buildings and infrastructure elements have been dealt with in Chapter 4, whilst the risks associated with the flash flooding and landslides that can be triggered by intense rainfall episodes are covered in Chapters 6 and 8 respectively. Whilst the areas affected by any given single thunderstorm will be much smaller than that affected by a tropical cyclone or east coast low, for those caught in the path of severe thunderstorms the impact is no less serious. Buildings can be destroyed, infrastructure brought down or dislocated and people killed. They are serious hazards indeed.

Thunderstorms have six main adverse impacts:

- disruption of power supply (and the subsequent knock-on affect on water supply, etc) from lightning strike or downed power lines;
- road and rail access cut because of flash flooding, traffic accidents or fallen vegetation and/or power lines;
- damage to houses due directly to severe winds, hail or storm water, or indirectly by wind-blown debris;
- personal fear, injury or death from both direct and indirect causes;
- significant insurance losses to both buildings and possessions such as cars;
- fires and/or fatalities caused by lightning strikes.

Damage to housing and infrastructure due to hail is a progressive failure, dependent upon the hail size and to some extent on the angle of attack. Windows are normally the first affected and will break at around the 30 to 40 mm hail size (SEA, 1999). Aluminum awnings, external shades and vinyl sidings are also susceptible to hail damage at about this size. Roofs and guttering are normally next to fail, especially aged AC sheeting, brittle tiles and aged corrugated iron. There were several reports from the 1995 Bellbowrie storm of hail penetrating both roof tiles and the plaster board of the ceiling before damaging furniture inside the building.

When roof integrity is lost, significant rainwater entry occurs and contents damage rapidly rises. As has been witnessed with the 1999 Sydney event, delays in roofing repair can severely exacerbate the consequential losses. In past events involving hail sizes in the order of 80 mm, some insurance losses in South-East Queensland have reached 25% of the insured value of the property (SEA, 1999). Motor vehicle damage can also be very extensive when hail sizes exceed 40 mm. Because many severe thunderstorms cross the metropolitan area around 6 pm, they coincide with daily peak traffic periods and can cause significant road chaos. It should also be remembered that large hail is a significant personal hazard and serious injuries can be sustained by people (or animals) unable to gain shelter.

Specific lightning protection is required for commercial and industrial buildings and structures to provide isolation for electrical, telecommunications and computer equipment and personnel who operate such systems. As well as the immediate impact of the peak current from a lightning strike, earth potential rise (EPR) is a common cause of extensive damage to underground cables and is the most common form of injury through the use of telephones during an electrical storm (Quelch and Byrne, 1992). Telephone subscribers are warned against the possibility of lightning-induced electrical or acoustic shock if the handset is used during thunderstorms.

Fatalities from lightning strike are quite rare, however during the period 1803 – 1991 some 650 people were killed by lightning strike in Australia. These fatalities are especially seasonal and gender/age-based. Over 85% of all outdoor lightning strike victims have been males between the ages of 15 and 19 struck between midday and 6pm in the summer months of November to February. Historically, most outdoor fatalities involved those working on the land, however, urbanization and the rise in outdoor recreation, especially water related sports, golf and cricket, is changing this statistic (Coates and others, 1993).

In the period from February 1998 to September 2000 there were 12 042 cloud-to-ground lightning discharges registered by the GPATS Lightning Position and Tracking System (LPATS) over land in the South-East Queensland study area. Even with this short period of records it is clear that they were distributed more-or-less evenly across the region – there were certainly no areas in which lightning was not a potential problem, nor were there areas that appeared to receive an abnormally high incidence of lightning strokes. Figure 6.12 illustrates the cloud-to-ground strokes recorded on two separate days, 24 November 1998 (in red) and 22 March 1999 (in blue) are also shown highlighted in the figure to illustrate the extent of lightning possible during a 24 hour period. GPATS (Global Position and Tracking Systems P/L) is a commercial operation that manages an Australia-wide lightning detection system.

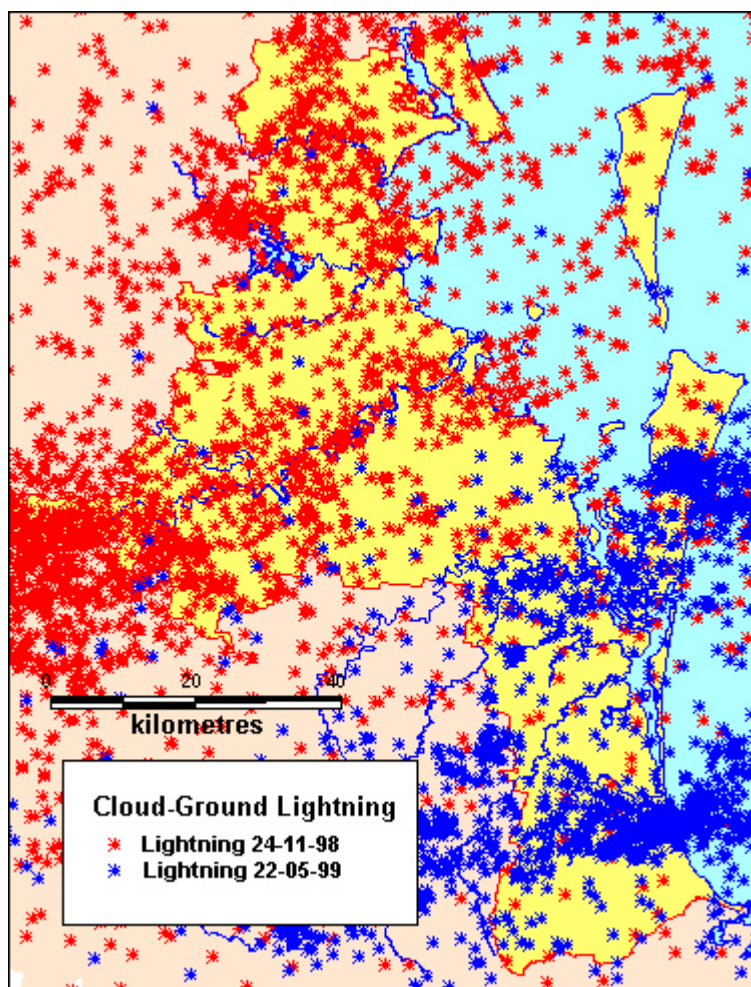


Figure 6. 12 Cloud-to-ground lightning strokes for 24 November 1998 and 22 March 1999

Interpretation

Whilst it can be anticipated that at least one damaging thunderstorm could have an impact somewhere in South-East Queensland in any given year, and that their impact could be both lethal and destructive, their impacts will tend to be localised and somewhat random in their distribution. They are such common events that most of the population now take the warnings of severe storms issued by the Bureau of Meteorology quite seriously and attempt to get themselves and/or their cars at least under cover.

There are no appropriate statistics by which to measure the severe thunderstorm total risk.

Community Awareness

There is perhaps a greater awareness of the risks posed by severe storms in South-East Queensland than there is for any other hazard. This is no doubt due to the frequency with which severe thunderstorms occur across the region and the media attention that they attract. Most people in the region have experienced, or know of someone who has experienced, hail damage to their house or car in recent years, for example. The impact of the 1999 Sydney hail storm, which was heavily reported by the electronic media, may also have reinforced the storm risk message.

It is perhaps ironic, however, that people tend to be more concerned about the welfare of their cars in response to a warning about the possible threat of hail than they are about their own personal safety in the face of more significant threats from tropical cyclones or floods, for example.

Forecasting and Warnings

The Bureau of Meteorology (BoM, 2000) is responsible for issuing warnings for all severe weather events. South-East Queensland lies within the Southeast Coast Warning Region, which extends from the Sunshine Coast south to the New South Wales border and west to Toowoomba. Operational procedures for the issuing of severe thunderstorm warnings from the Brisbane office of the Bureau detail three distinct phases: (a) Monitoring Phase, (b) Advice Phase and (c) Warning Phase.

As is evident from the foregoing physical description of these phenomena, their rapid and unpredictable development poses many challenges for weather forecasters. The public also need to appreciate the practical difficulties of not only detection but also in disseminating timely warnings to the community through media outlets, which are not always fully staffed at critical times. Input from the public at large remains an important element in providing timely warnings to the whole community for these small-scale short-duration severe weather events.

In the monitoring phase, a continuous watch is kept for the precursors of strong convection and for the occurrence of potentially severe thunderstorms. Sources of information used by the forecasters include synoptic, upper wind and temperature data, radar and satellite imagery, analytic fields derived from the above information, and prognostic fields from computer models. In addition, special observations are received from a network of over 60 volunteer *Storm Spotters* in South-East Queensland. These individuals receive basic observer training from the Bureau and report the occurrence of severe thunderstorms and the conditions associated with them via a dedicated FREECALL telephone link to Bureau forecasters. This ensures the Bureau is made aware of any potentially severe storm activity as soon as possible. *Storm Spotters* also record and report their observations through the return of special 'Severe Thunderstorm Reporting Cards' which add valuable information to the historical archive of storm occurrence and damage.

A *Severe Thunderstorm Advice* is an early alerting message for the community and is prepared when severe thunderstorms are expected within the next four to six hours. A number of specific atmospheric indices are used to determine when such a situation is likely, even without the actual formation of storms. Typically, these 'top priority' advices are made available for noon radio news services and outline the degree of thunderstorm threat for that afternoon. The *Advice* is updated at least two-hourly until a cancellation advice is issued.

In the event that thunderstorms, which are approaching, or are already within, the warning area are expected to be severe, or a report of a severe event has been received, then a *Severe Thunderstorm Warning* is issued. These are necessarily short term forecasts, usually valid for a maximum of two hours. Such warnings may mention the possibility of flash flooding when this is considered likely, large hail if applicable and tornadoes if a confirmed ground report has been received. It is not possible to reliably detect tornadoes from presently installed radar technology, although some classical vertical structures are indicative of strong and possibly rotating updrafts. More reliable tornado and downburst detection will become possible when 3D Doppler radar coverage can be made available for the Brisbane region. In particularly hazardous situations, the Bureau authorises the use of the *Standard Emergency Warning Signal (SEWS)* to provide additional media impact to the warnings.

In many instances thunderstorms develop to the severe stage within the warning zone and sometimes within the coastal plain where the majority of the population is located. Therefore, to provide practical lead-time it is sometimes necessary to issue warnings before there is any clear evidence of severity

from radar echoes or observations. Accordingly, *Severe Thunderstorm Warnings* are issued hourly as top priority and increased to half-hourly when there is specific evidence of severity. Specific warning cancellations are also issued as appropriate and media outlets are carefully instructed on the period of validity of specific warnings so as to not cause confusion for the public.

The final role of the Bureau of Meteorology is to undertake assessment of its own performance and to document the outcomes from the severe weather event. It does this by compiling annual verification statistics and maintaining a database of events. The aim of the Severe Thunderstorm Warning Service is to provide a probability of detection of 70% or greater of severe events, a false alarm ratio of 40% or less, and at least thirty minutes lead time (i.e. time between the issue of a warning and the occurrence of the severe phenomena) on 70% of occasions.

Further Information

More detailed information on the levels of exposure of individual neighborhoods or properties to the severe thunderstorm risks outlined here should be referred to the respective local government council.