# CHAPTER 5: EAST COAST LOW RISKS

Bruce Harper and Ken Granger

## The East Coast Low Threat

East coast lows, also known as *east coast cyclones, winter cyclones* or *easterly trough lows*, are one of a family of low pressure systems which most often develop during the winter months along the east coast of Australia between 25ºS and 40ºS latitudes (Holland and others, 1987; Hopkins and Holland, 1997). These large scale storm systems often develop rapidly and can become quite intense, with storm force winds extending over wide areas. These events contribute significantly to flooding and wind damage along the coastal margins as well as marine accidents, storm surge and beach erosion in South-East Queensland.

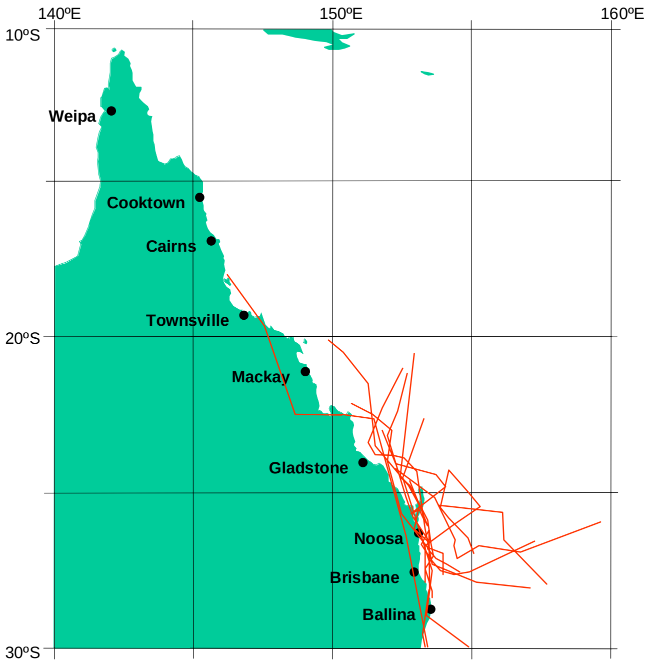
Prior to the introduction of satellite imagery in the early 1960s, many east coast lows were classified as tropical cyclones. While their impacts may be similar or even possibly greater in some cases, the east coast low has a different physical mechanism and a highly asymmetrical poleward cloud pattern where the heaviest rainfall frequently occurs. Another feature of east coast low development is the tendency for clustering of events when conditions remain favourable. For example, near Brisbane, almost one third of events occur within 20 days of a preceding event (Allen and Callaghan, 2000).

The effect of these storms on nearby coastal areas can be severe, frequently with loss of life and property from flooding and maritime incidents. The first documented east coast low in Queensland occurred in August 1846 when the vessel *Coolangatta* was driven ashore in the area now bearing its name (Allen and Callaghan, 2000). Bureau of Meteorology estimates indicate approximately 35 deaths in the region can be attributable to east coast lows over the period 1973 to 1999, the majority being due to flooding.

Unfortunately, east coast lows have not been systematically recorded in the manner that tropical cyclones have been since the turn of the century. They are typically more complex systems which are often difficult to categorise. Accordingly, many of the studies have concentrated on detailed investigations of historical weather charts and station observations to reconstruct a time history of occurrences. The longest assembled record available (1880 to 1980) is from PWD (1985), which considered the region from Tweed Heads south to Gabo Island, near Bass Strait. This study classified the various storm systems into six categories, depending on their synoptic situation, as summarised in Kemp and Douglas (1981). Holland and others (1987) considered the period 1970-1985 and used three broad classifications. Hopkins and Holland (1997) broadened this to 1958-1992 and Allen and Callaghan (2000) focussed on 1976-1997 when wave data was available.

## The East Coast Low Phenomenon

East coast lows typically form after a low or deep trough intensifies in the upper atmosphere over eastern Australia. A low pressure system then develops at sea level near the coast to the east of the upper level system, often intensifying rapidly. These cells of low pressure are typically quite small relative to the broad synoptic features, but can interact with developing high pressure systems to the south to produce severe gale conditions over periods of up to several days (Allen and Callaghan, 2000; Callaghan, 1986). These storm systems draw their energy from a combination of strong ocean temperature gradients, coastal convergence, uplift and a supply of moist sub-tropical air at the surface. The East Australian Current and the Great Dividing Range are principal players in the development of these storms, the circulation centres of which often track very close to the coast over considerable distances. An example of the tracks of several prominent systems is shown in Figure 5. 1.




| Dates |
|---|
| 21-Jun-1950 |
| 10-Jul-1954 |
| 17-Jul-1965 |
| 08-Jun-1967 |
| 24-Jun-1967 |
| 06-Jul-1973 |
| 06-May-1980 |
| 20-May-1981 |
| 20-Jun-1983 |
| 08-Apr-1984 |
| 24-Apr-1989 |
| 31-May-1996 |

**Figure 5. 1 Selected tracks of east coast lows affecting SE Queensland**

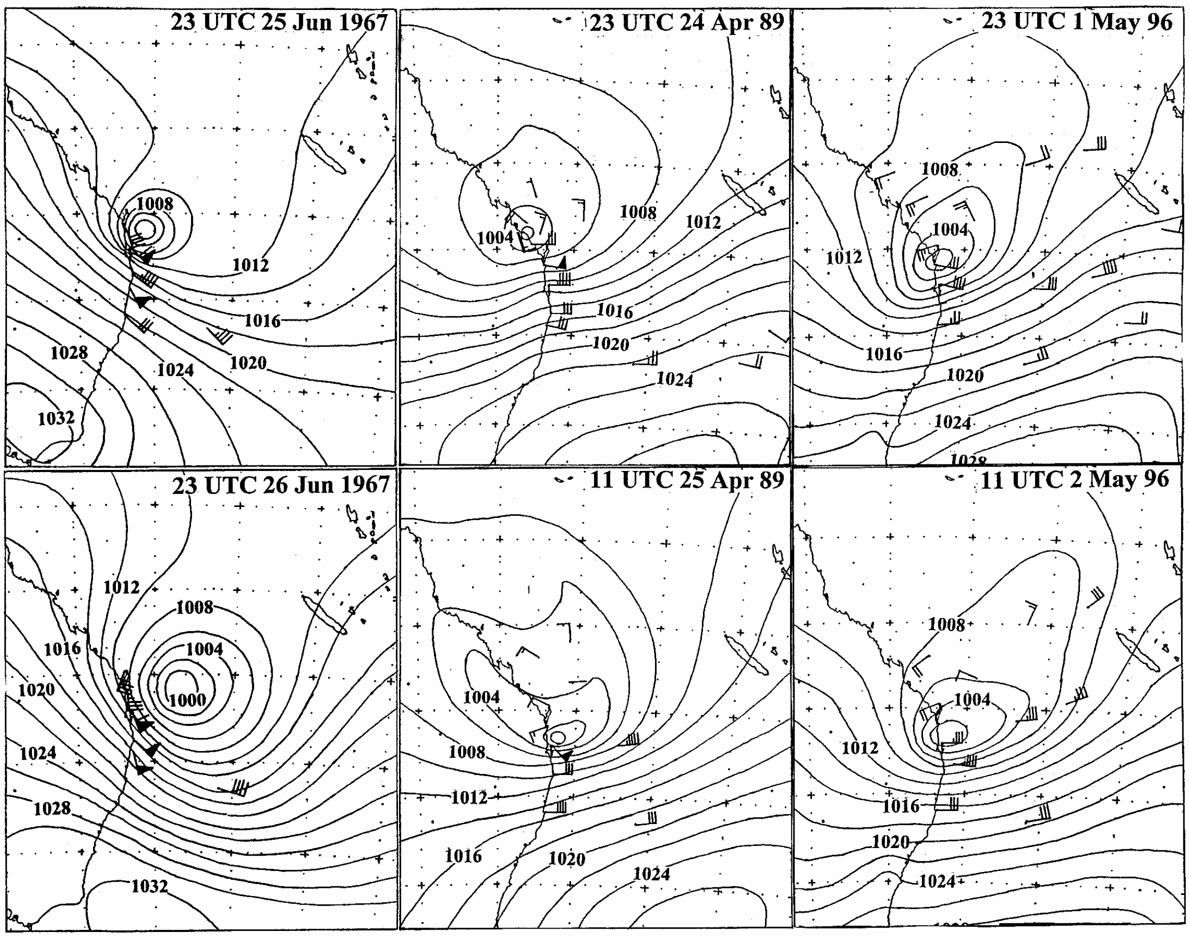



**Figure 5. 2 Examples of three east coast low synoptic developments.**

Although their centres may be close to the coast, their impacts extend over considerable distances, as can be seen in the three examples in Figure 5. 2 where the steep gradients in the surface pressure fields and regions of strong onshore winds are indicated. The onshore flow is responsible for the heavy rains and, combined with the extended fetch regions over the ocean, the generation of high waves. Storm surge is also possible, whereby the strong clockwise winds create a net onshore flow at the surface causing a rise in water levels along the coast. The 'inverted barometer' pressure effect can also be significant, with some east coast lows having central pressures below 990 hPa. Wave setup caused by breaking wave processes at the coast also contributes to the total storm tide impact.

While Chapter 4 presents the case for enhanced tropical cyclone activity during periods of highly positive SOI, the east coast low phenomena appears sometimes to be negatively correlated with the SOI, or sensitive to rapid changes in the SOI (Hopkins and Holland 1997). Figure 5.3, for example, shows the relationship between the SOI and the annual anomaly (deviation from the mean occurrence) of east coast lows for the period of more reliable data from 1950 – 1997. In this case, both data sets have been smoothed to indicate the 5 year running mean. The interaction over this period is compelling enough to suggest that east coast low occurrences affecting South-East Queensland are higher during periods of negative SOI (*El Niño* periods) and lower during positive SOI periods (*La Niña* periods). However, the intensity appears to be higher during *La Niña* periods, probably because of the enhanced trade winds and the higher SST anomaly, which both affect the rate of intensification.

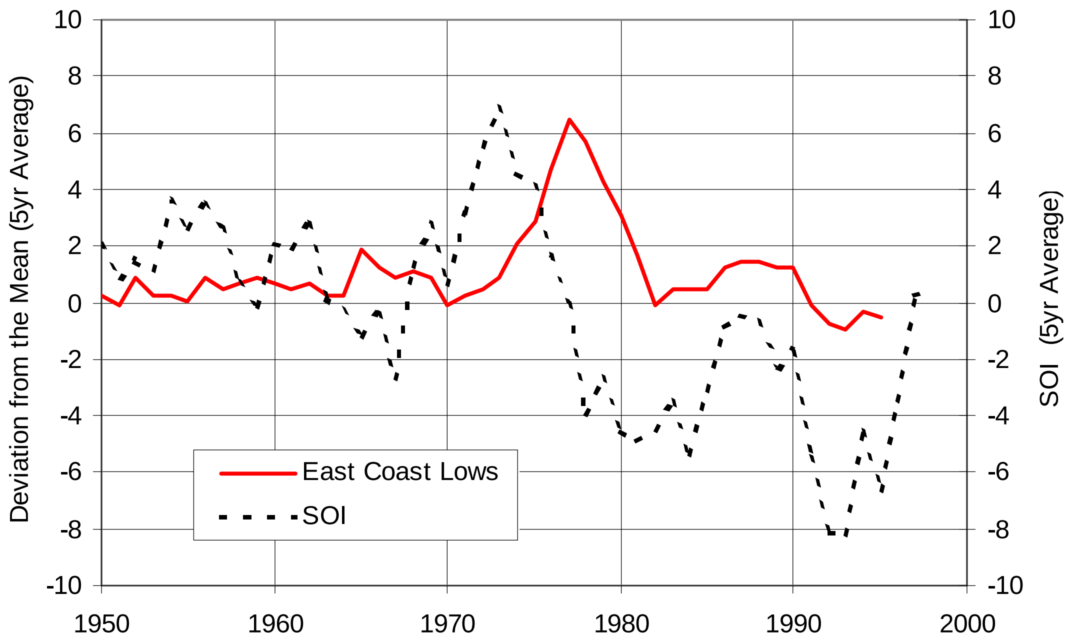



**Figure 5. 3 East coast low and SOI relationships for South-East Queensland.**

<u>Rainfall</u>: Almost all east coast low events cause widespread heavy rains, concentrated around the poleward side of the low pressure core where warm equatorial air ascends into the cooler airmass. Hopkins and Holland (1997) found that, considering the east coast between 20ºS and 40ºS latitudes, over 16% of heavy-rain days were directly related to east coast low systems. A heavy-rain day was defined as one in which the daily rainfall exceeded 10 times the long-term monthly mean daily rainfall at selected coastal recording stations. Their study shows that peak daily rainfall from such systems can exceed 250 mm in South-East Queensland while rain-associated damage attributable to all east coast lows is estimated in millions to tens of millions of dollars per year and may contribute up to 7% of all major Australian disasters since 1967.

Severe wind: Mean wind speeds recorded in the South-East Queensland region during the passage of east coast lows are typically around 50 to 60 knots (26 to 31 m/sec) with peak gusts reaching as high as 85 knots (44 m/sec). These speeds are generally within the range established under the Wind Loading Code and applied by local governments throughout the region. There should be only limited damage to buildings constructed since the introduction of that code in 1983. Older buildings may be at risk, especially those in more exposed locations such as along the waterfront or on exposed ridges. The severe wind risk associated with tropical cyclones, which is also relevant to east coast low winds, is analyzed in detail in Chapter 4.

Extreme Waves: Allen and Callaghan (2000) presents an analysis of wave conditions measured offshore of Point Lookout on North Stradbroke Island for the 21 year period October 1976 to December 1997, which was largely free of major tropical cyclone influences. This spaned the available wave recording period at that time, with allowances for outages and changed recording techniques. Their data set included waves from tropical cyclones as well as east coast lows and these were separately subjected to statistical extreme value analyses. Slightly higher waves for a given return period were predicted for east coast lows, probably because of their higher frequency of occurrence, wide area of influence and often extended south-east fetch. Table 5.1 summarises the estimated significant wave height (Hs) as a function of ARI. Note that individual maximum wave heights can approach twice the height of the significant wave, which is a statistical measure of wave height.

As these waves propagate towards shore they are modified by the near-shore bathymetry and will progressively break as the water shallows. Near the beach face, the breaking process can produce a quasi-steady increase in the local water level which is termed wave setup. This is typically between 10% and 15% of the incident breaking wave height and adds to the storm surge impact as described below. When combined, wave height, setup and surge provides the opportunity for severe beach erosion, such as that experienced during the period of extended storm activity (east coast lows and tropical cyclones) during 1967 along the Gold Coast (see Chapter 4 for more details).

**Table 5. 1 Predicted extreme wave heights due to east coast lows in SE Queensland (after Allen and Callaghan, 2000)**

| Average Recurrence Interval (ARI) yrs | Predicted Significant Wave Height Hs m |
|---|---|
| 2 | 4.9 |
| 5 | 5.7 |
| 10 | 6.1 |
| 20 | 6.5 |
| 50 | 6.9 |
| 100 | 7.2 |

Storm Surge: The detailed basis of storm surge generation is covered in Chapter 4 in regard to tropical cyclones, but the same mechanisms apply also for east coast lows. The main differences between the storm surge generating potential of these two types of storm systems relate to the gradient of wind speed and pressure over the horizontal extent of the storm. Also, east coast lows tend to only move parallel to the coast. Typically, this means that a landfalling tropical cyclone is capable of producing a higher storm surge on the coast than a parallel-to-the-coast moving east coast low because its energy is often more focussed. However, an intense east coast low may exceed the total storm surge from a weak tropical cyclone, particularly when wave setup is an important component of the total water level. These differences were accounted for in the BPA (1985a and b) studies into storm tide in the region, discussed in Chapter 4. One of the assumptions of that study was that the peak surge height caused by an east coast low on the open coast might be approximated as about 6% of the peak significant wave height Hs. Using Table 5.1 as a guide, the 100 year ARI storm surge could then be of the order of 0.4 m. Wave setup would be, say, about 0.7 m on the coast, thus exceeding the surge component. Astronomical tide levels must then be included to arrive at the total water level for any particular situation.

Table 4.3 in Chapter 4 presents some historical storm surge and storm tide levels for the South-East Queensland region and Table 4.4 summarises predicted storm tide levels for a number of sites where studies have been carried out. East coast low impacts are especially noticeable in the many low lying coastal regions in and around Moreton Bay. When ocean water levels become elevated during periods of relatively high tides, the strong south-east winds acting on the shallow Bay waters can further exacerbate the problem. For example, at Beachmere near the mouth of the Caboolture River, flooding from the sea is a relatively common event, with water levels exceeding the Highest Astronomical Tide (HAT) level on an annual basis, rather than the expected 1 in 19 year average without storm surge effects (data collected by resident P. Whitehouse).

### The South-East Queensland East Coast Low Experience

In this brief overview, a composite data set has been created based essentially on PWD (1985), using their categories E, S, I and C for the northern sector, and Allen and Callaghan (2000) using their type 1 and 2 events. Two additional heavy rain events from Hopkins and Holland (1997) were also included. This composite set covers the 118 year period 1880 – 1997 and considers only those east coast low events which had some impact on South-East Queensland. On this basis the areal extent of the data set is within about a 500 km radius of Brisbane. Figure 5. 4 presents this data set as an annual frequency of occurrence histogram, overlaid by a 5 year running mean and an exponential trend line.

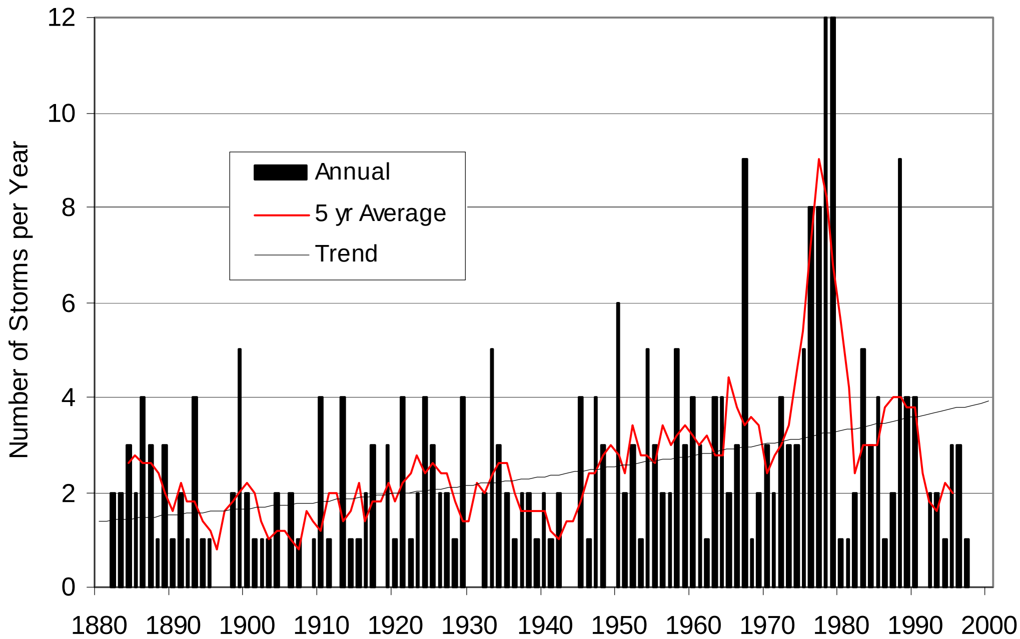



**Figure 5. 4 Historical record of east coast lows affecting South-East Queensland**

The incidence of these types of storms can be seen to fluctuate quite widely from one year to the next, with none in some years and the highest incidence being twelve in 1978/79. The long term average annual occurrence is about 2.5 storms per year but since 1960 the average has increased to 3.7. While the frequency of occurrence prior to 1960 will be affected to some extent by the lack of routine satellite coverage, the approximate doubling of frequency of storms over the past 30 years appears highly significant (Hopkins and Holland, 1997) and to some extent appears linked to broader climatic indices such as the SOI. It is noted that the incidence of east coast lows is significantly greater than that of tropical cyclones in the South-East Queensland region (see Chapter 4).

East coast lows, because of their frequency of occurrence and ability to rapidly intensify, are the major cause of marine incidents in the South-East Queensland region. Small craft are often extensively damaged at their moorings and even larger ships have met disaster. The 1600 tonne *Cherry Venture,* one of the more notable shipwrecks in recent history, was driven ashore south of Double Island Point - a victim of the severe July 1973 east coast low.

Appendix E is derived from Bureau of Meteorology records and presents historical accounts of significant east coast low events which are known to have affected South-East Queensland.

**Interpretation**

The major impact of east coast lows on South-East Queensland will be in terms of potential storm tide and severe waves, wind damage and flooding. The levels of total risk for both severe wind, storm tide and flood will be similar to that detailed in Chapters 4 (Cyclones) and 7 (Flood).

**Forecasting and Warnings**

Typically, warnings for severe east coast lows would be issued by the Bureau of Meteorology in Queensland under the title of a *Severe Weather Warning*. Warnings of potential flooding impacts from east coast lows are prepared by the Bureau of Meteorology Flood Warning Centre in Brisbane, as described in Chapter 7.

The Bureau of Meteorology issues marine weather warnings for sea and swell conditions associated with east coast lows. The BPA provides access to real time wave buoy data to assist in the warning preparation.

Storm surge warning procedures for east coast lows follow similar procedures to those described for tropical cyclones in Chapter 4.

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