WET SEASON CLIMATE VARIABILITY IN THE NORTH

THINK LIKE A COTTON PLANT: A 'GOLDILOCKS' LOOK AT CLIMATE IN THE NORTH

by Paul Grundy (QDPI/CottonInfo)

Climate variability during the tropical wet season is the most significant management challenge for cotton production in Northern Australia. Identifying when conditions are most likely to be 'just right' can help reduce climate risk.

There are many challenges in northern production regions related to input costs, soils and distance to markets, but it is climatic variability and the opportunities to manage it that underpins whether investment to overcome these challenges is likely to provide a worthwhile return. For example, ameliorants to address low soil pH are expensive. The return on this investment depends on weather conditions being reliable enough over the longer term to realise the potential yield increases.

Weather parameters critical for producing cotton with high yields and quality are:

- Radiation – Cotton requires at least 20MJ or more of sunlight per square metre per day to avoid yield loss. Heavy cloud reduces photosynthate production and can trigger significant shedding.
- Night temperatures – Cotton prefers night temperatures from 17°C to 23°C. Nights at or above 24°C cause yield loss similar to a cloudy day. Cool nights slow growth and minimum temperatures at or below 11°C can impact fibre quality.
- Day temperatures – Cotton prefers day temperatures from 25°C to 34°C (between 28-32°C is optimal). Days at or above 35°C challenge the plants' ability to regulate leaf temperature, causing negative impacts.
- Rainfall – Ideally avoided anytime from boll opening onwards. Not only is it associated with lower radiation, it can increase the risk of boll rots and interfere with field operations.

These parameters matter. Sub-optimal weather conditions can cause abortion of fruiting structures, reduced boll size, delayed crop maturity and/or lower lint quality.

Interpreting the climate graphs

The graphs included in this resource depict the median (mid point) and variability of climate factors of half months (approx fortnightly periods) over the last 85 years.

Graphs are coloured-coded for the climate factors of radiation, maximum and minimum temperatures and rainfall, and icons depict climate considerations that may impact crop development or yield.

See the back page for a detailed explanation of the colours and symbols used in this publication.

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BEST PRACTICE

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MANAGING FOR CLIMATIC VARIABILITY

Factoring climatic variability into crop planning involves both understanding the timeline for cotton growth and consideration of the seasonal climate of a given location based on local weather records.

Cotton crop timeline

Where possible, select a sowing date that will avoid subsequent crop flowering and boll filling coinciding with periods that have a high probability of being climatically unsuitable.

For November to February sowings, crops will flower within 45-55 days and require at least 90 days of good conditions once flowering commences to set yield.

If poor conditions cannot be avoided during this period, plants may compensate for climate-induced boll loss if the weather parameters become favourable and time allows.

For example, if the first month of flowering is interrupted, an additional month will be required to compensate for fruit shedding losses.

Sufficient resources (e.g. soil moisture, favourable conditions, nutrition, crop protectants) will still be needed during this time.

The likely crop development timeline can be compared against known climatic records to determine the potential suitability of a location for cotton production or a sowing time strategy.

Finding the pattern in weather records

High variability within and between seasons makes it difficult to define climatic patterns. Standard monthly climatic averages provide limited insight, as they hide variability and can be skewed by extreme events.

Using half-monthly median values together with the potential variability (indicated by the range between the highest and lowest 10% of years) offers greater insight for climate risks. Examining key parameters (e.g. the number of nights at or above 24°C) this way provides a climate overview that is more useful from a cotton production perspective.

Note that because most months have more than 28 days, these half month periods can contain up to 16 days.

The following analysis presents the median values for radiation, temperature stresses and rainfall for Kununurra (WA), Douglas Daly (NT), Etta Plains (Flinders region, QLD) and Walkamin (Atherton Tablelands, QLD), utilising a combination of actual and gridded records from the SILO weather database between 1960 and 2026.

It's important to avoid assumptions by remembering that each half-month value is discrete from, but contributes to the seasonal patterns (e.g. the wettest 'fortnightly' periods may not necessarily take place in the wettest years.)

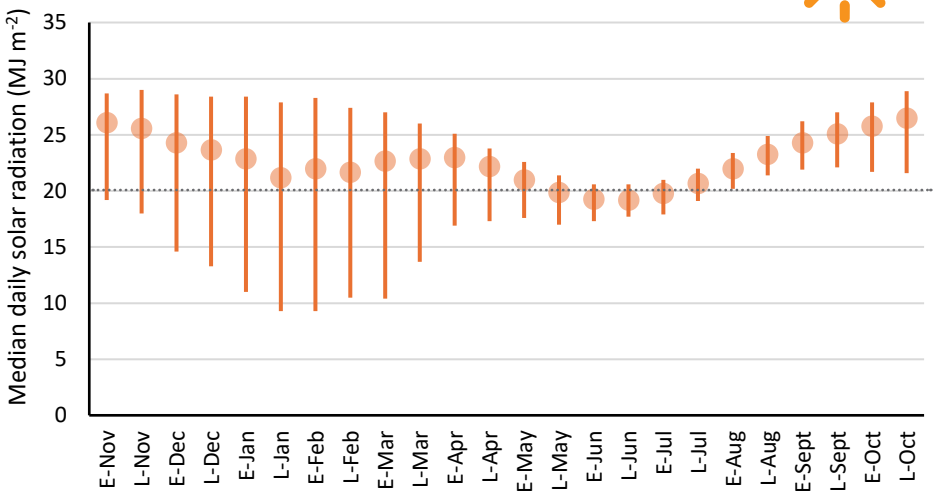
Kununurra

Median daily radiation (1960–2025)

Median daily radiation remains above the required 20 MJ/m²/day throughout the wet season, with monsoon cloudiness peaking during January and February.

In the cloudiest 10% of fortnights, radiation is likely to restrict fruit retention and boll filling, but this risk declines rapidly during March and is low from April onwards. The sunniest 10% of fortnights receive ample radiation, although extreme heat associated with sunshine and high humidity may offset some of this benefit.

From mid-May, shorter days reduce radiation and begin to limit growth. Cooler conditions partly compensate by slowing crop development, allowing growth to continue at a reduced rate (unless night temperatures frequently fall below 11°C).

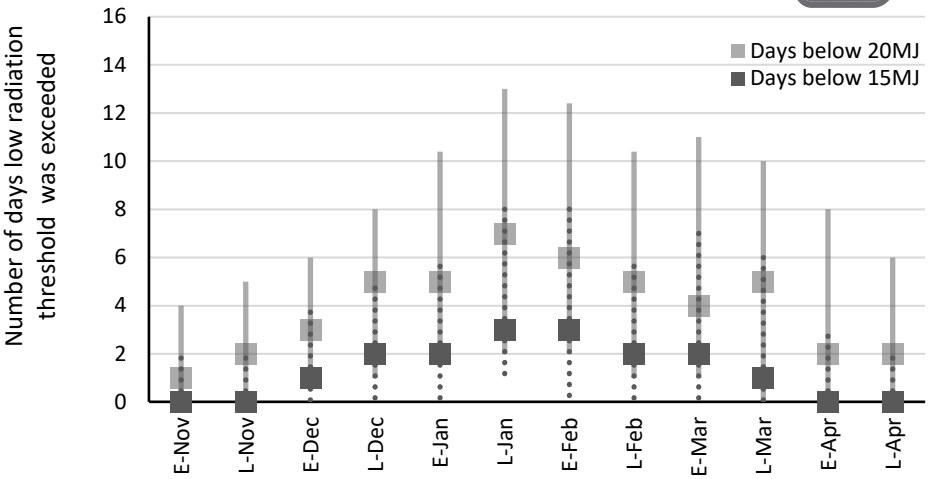


Number of days (per half month) below 20 and 15 MJ/m²/day

Days below 20 MJ/m²/day increase the risk of fruit shedding once cotton begins flowering. Days below 15 MJ/m²/day impose more severe stress and may cause square loss prior to flowering.

Low-radiation days are most frequent in late January, with the median around four to five days per fortnight below 20 MJ/m²/day until the end of March, indicating a sustained risk during early flowering and boll filling for crops sown in January or February.

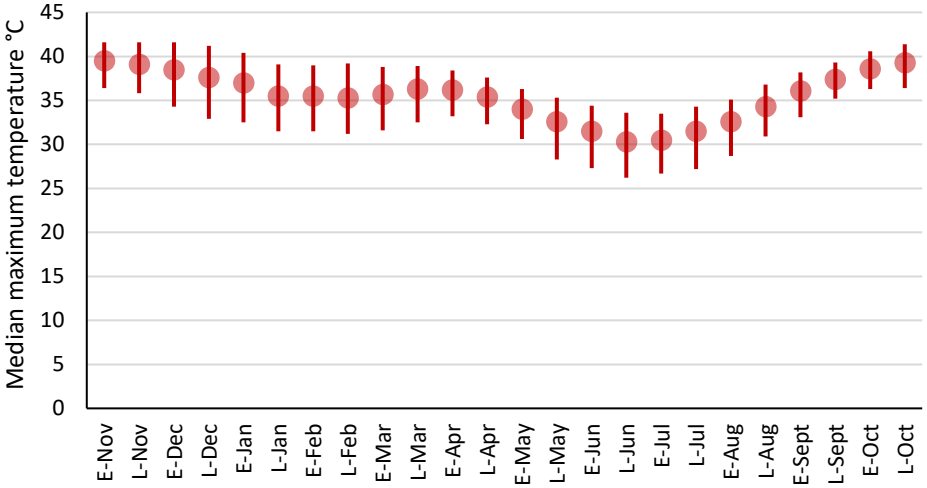
For these counts, the percentile direction is reversed relative to the daily radiation figure: The upper end of the error bar represents more days below the threshold, while lower end represents fewer low-radiation days —the reverse of the above daily radiation figure.



Median maximum daytime temperature

Median maximum temperatures indicate that heat is likely to constrain cotton growth and make crop establishment more difficult from October to early January.

From mid-March to early September, daytime maximums are generally favourable for flowering and boll filling. This assessment is based on maximum temperature alone; other factors may limit production during this period.



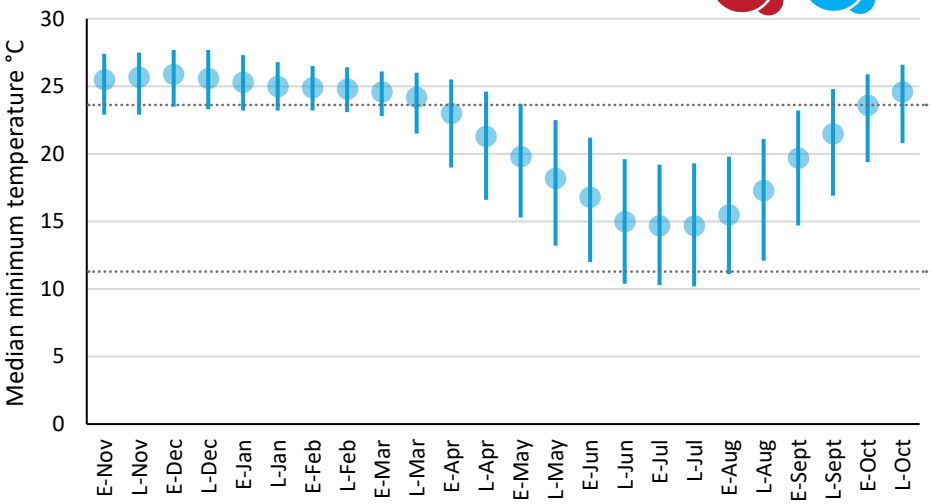
Kununurra

Median minimum overnight temperature

Hot nights of 24°C or above are common from November to mid-March, increasing the risk of increased night respiration that disrupts assimilate production leading to stress and fruit shedding.

Overnight temperatures are generally favourable for cotton growth from mid-March until late May or early June. Cooler nights from mid-June to late August significantly slow crop growth and development.

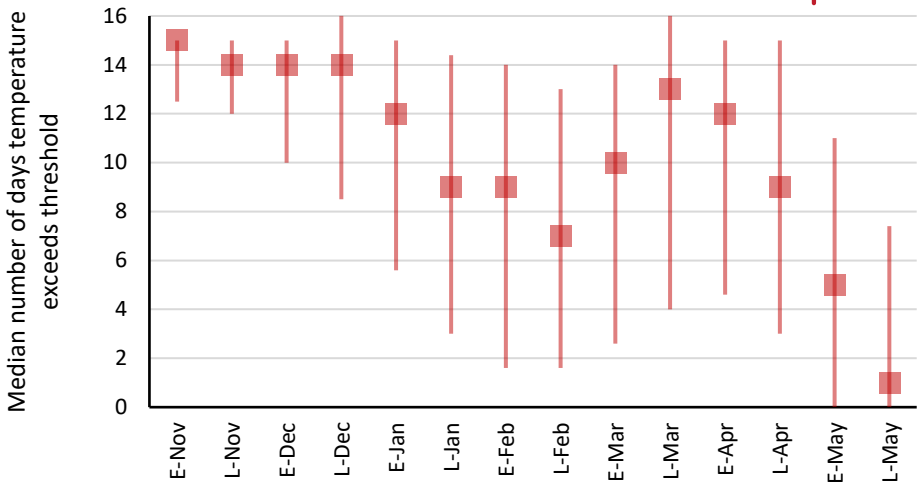
During the coldest 10% of seasons, cold shock will cause flower or young boll shedding, reduced boll size and produce boll deformity. Lint quality will be negatively affected for crops maturing bolls at this time.



Number of days (per half month) reaching or exceeding 35°C

Hot days are frequent from November to late December, with the median reaching 14 days per fortnight—effectively every day.

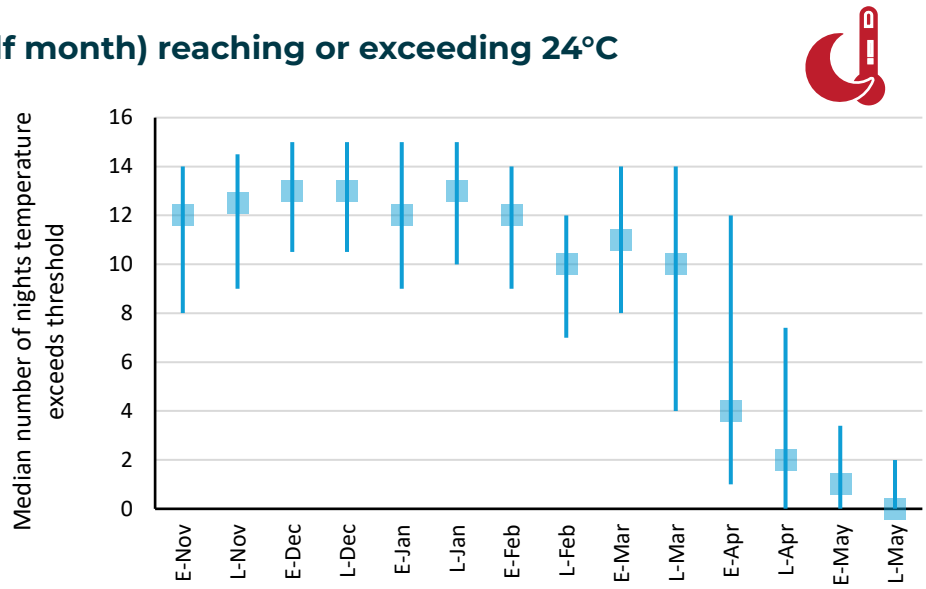
Wet-season cloud and rainfall reduce the frequency of excessively hot days from January to April, although sunny days during this period are still likely to exceed 35°C.



Number of nights (per half month) reaching or exceeding 24°C

Hot nights remain common from November to late March, with a median of 10–13 nights per fortnight.

Even the coolest 10% of comparable fortnights record 7–11 hot nights. Cotton flowering during this period faces a high risk of heat stress and poor fruit retention.



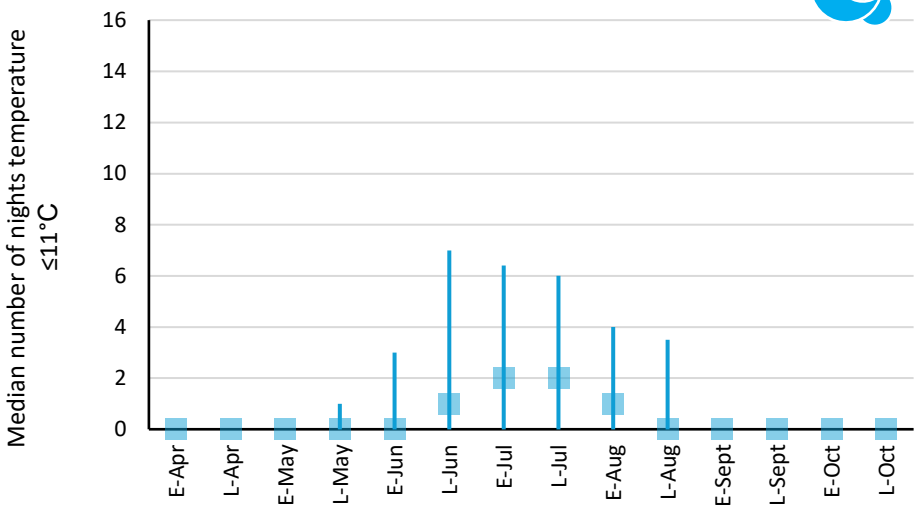
Kununurra

Number of nights (per half month) at or below 11°C

The main risk period extends from late June to early August, when cold nights can slow boll filling and maturation and increase the likelihood of reduced fibre quality.

During the coldest 10% of comparable fortnights, four to seven nights fall to 11°C or below. Under median or warmer conditions, these nights are uncommon or absent.

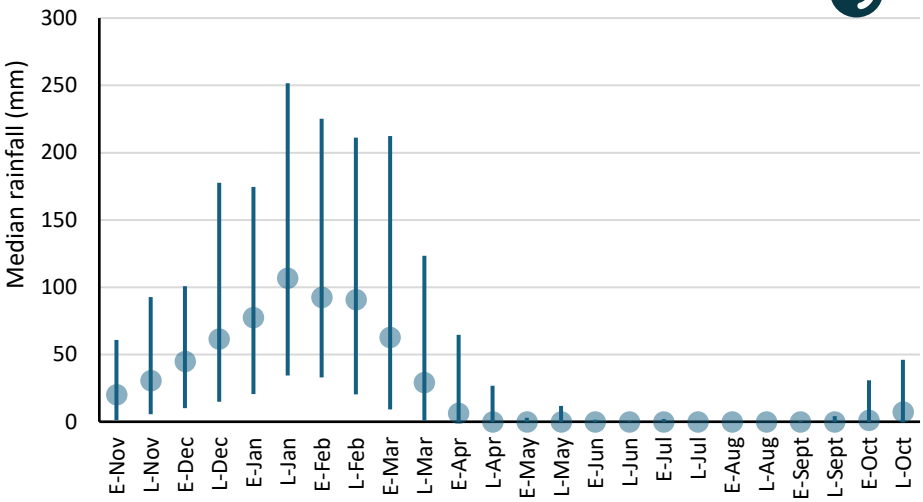
The risk is therefore greatest for late-maturing crops still carrying immature bolls in cooler than average seasons.



Median half monthly rainfall (mm)

Rainfall peaks in late January and remains high throughout February. Totals generally decline during March, although the first half of the month can still be very wet during the wettest 10% of seasons. From April onwards, the likelihood of significant rainfall becomes low.

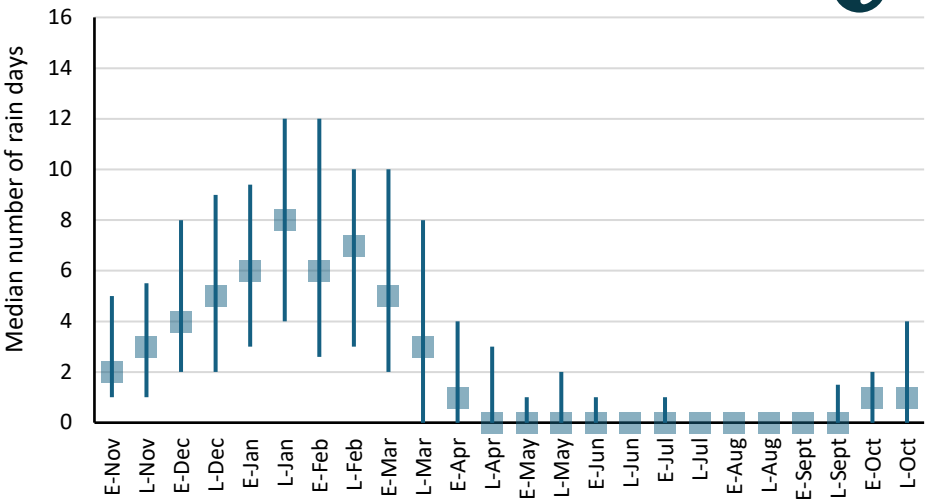
Sowing from mid-January to early March will depend on intermittent opportunities between rainfall events and will require a flexible approach. Fields should have effective drainage to reduce waterlogging and allow timely machinery access after rain.



Median number of rain days (≥1 mm) per half month

The number of rain days broadly follows the seasonal pattern of total rainfall. Early March is a transition period, with a median of five rain days per 'fortnight', increasing to around ten during the wettest 10% of seasons.

Compared with late January, the median falls by around two rain days in early February, indicating potential sowing opportunities after the initial January rainfall peak in some seasons. This is agronomically important because mid-February sowing aligns flowering with the rapid improvement in radiation and growing conditions from late March onwards, making it a desirable time to plant.

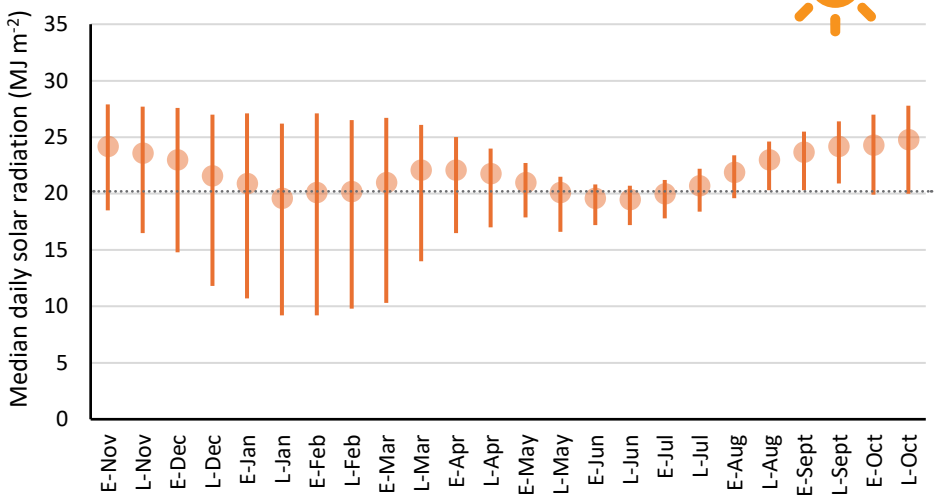


Douglas Daly

Median daily radiation (1960–2025)

Median radiation is marginal from early January to early March, with fortnightly values close to 20 MJ/m²/day because of wet-season cloudiness. Cloudiness peaks from late January to late February, when the cloudiest 10% of comparable fortnights receive only around 10 MJ/m²/day. These conditions create a substantial risk of poor flower and boll retention. Radiation improves during March, although potentially damaging periods of cloudiness can still occur throughout April.

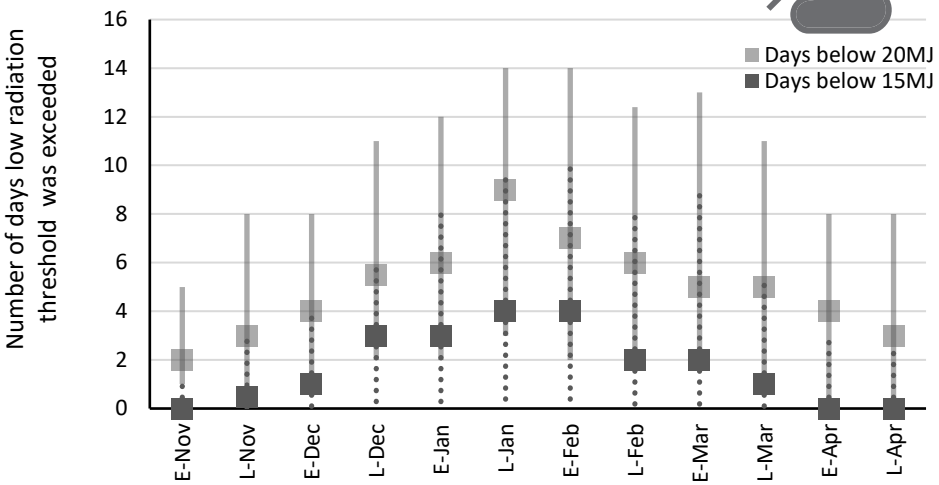
From mid-May, shorter days reduce radiation and begin to limit growth. Cooler conditions partly compensate by slowing crop development, allowing growth to continue unless night temperatures frequently fall below 11°C.



Number of days (per half month) below 20 and 15 MJ/m²/day

Days below 20 MJ/m²/day increase the risk of fruit shedding once cotton begins flowering. Days below 15 MJ/m²/day impose more severe stress and may cause square loss even before flowering. At Douglas Daly, low-radiation days are most frequent in late January. The median remains around four to five days per fortnight below 20 MJ/m²/day until the end of March, creating sustained risk during flowering and boll filling for crops sown from late December to early February.

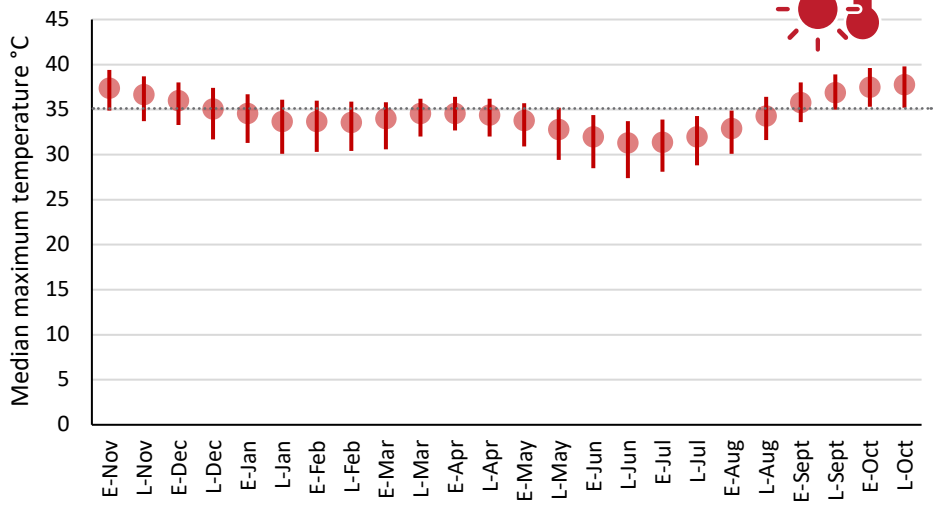
Burdekin research found that cumulative radiation loss was more important than the sequence of cloudy days: three cloudy days had a similar effect whether consecutive or separated. Cotton can compensate for the associated fruit loss if subsequent soil moisture and temperature conditions support continued growth. This will be a challenge in rainfed systems in some seasons. For these counts, the percentile direction is reversed relative to the daily radiation figure: The upper end of the error bar represents more days below the threshold, while lower end represents fewer low-radiation days —the reverse of the above daily radiation figure.



Median maximum daytime temperature

Median maximum temperatures indicate that daytime heat is likely to constrain cotton growth and make crop establishment more difficult from early September to early December. Increasing wet-season cloud moderates maximum temperatures from late December into January.

From January until early September, daytime maximums are generally favourable for cotton growth, flowering and boll filling, although other climatic factors may be limiting during parts of this period.

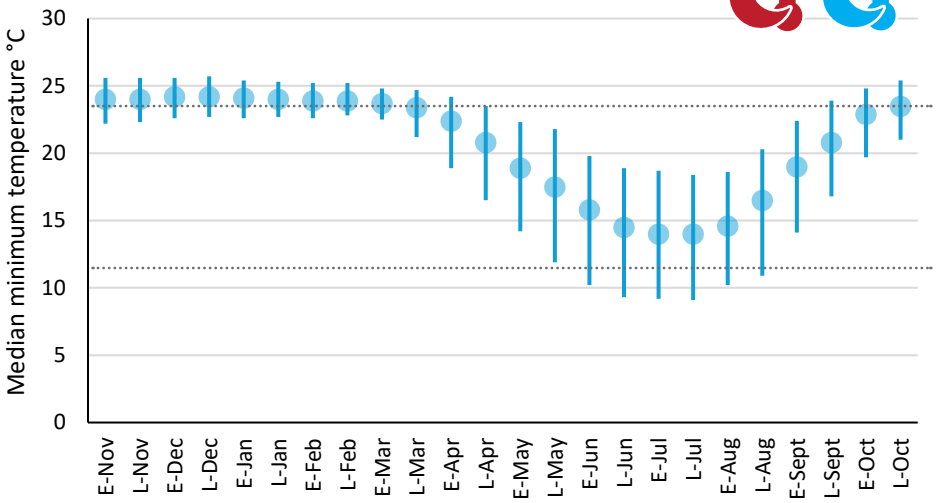


Douglas Daly

Median minimum overnight temperature

Hot nights of 24°C or above are common from November to late March, increasing the risk of heat stress and fruit shedding. Median overnight temperatures move into the favourable range from mid-March and remain suitable until the end of May, although hot nights can still occur during the March transition.

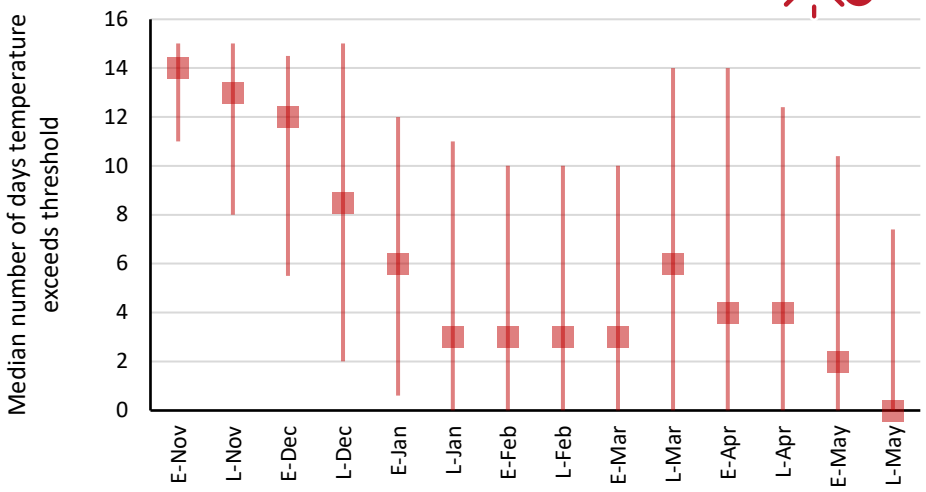
Cooler nights from mid-June to late August significantly slow crop growth and development. During the coldest 10% of seasons, cold shock may cause flower or young boll shedding, reduce boll size and produce boll deformities.



Number of days (per half month) reaching or exceeding 35°C

Hot days are frequent from November to mid-December. Wet-season cloud and rainfall generally reduce their frequency thereafter, although the hottest 10% of comparable periods record 12–15 days above 35°C, indicating substantial heat risk in drier, less cloudy seasons.

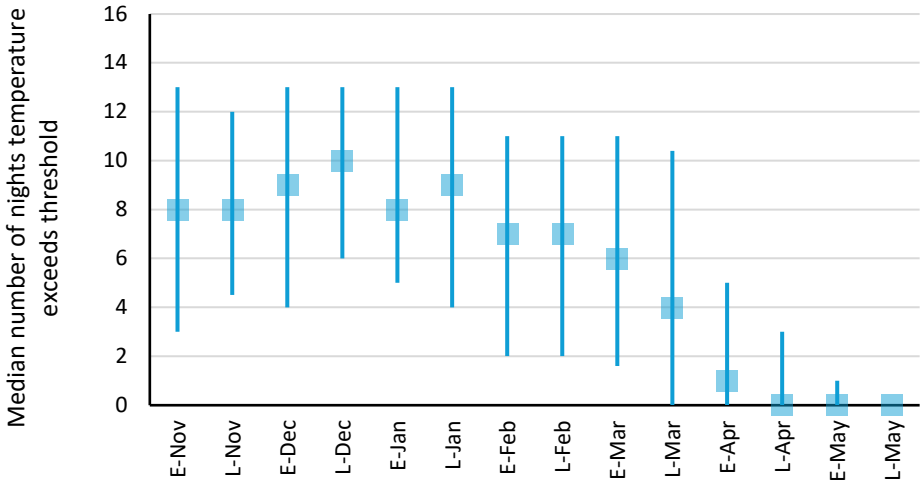
January–February flowering remains challenging under hot days. Hotter seasons increase heat stress and fruit shedding, while milder seasons are often cloudier and wetter, with low radiation also limiting fruit retention.



Number of nights (per half month) reaching or exceeding 24°C

Hot-night risk is moderate to high from November to late February, with a median of seven or more nights per period. During the hottest 10% of periods, almost every night can exceed 24°C. In contrast, hot nights are infrequent from late January to early March during the coolest 10% of seasons.

January–February flowering remains challenging under hot nights. Hotter seasons increase heat stress and fruit shedding, while milder seasons are often cloudier and wetter, with low radiation also limiting fruit retention.

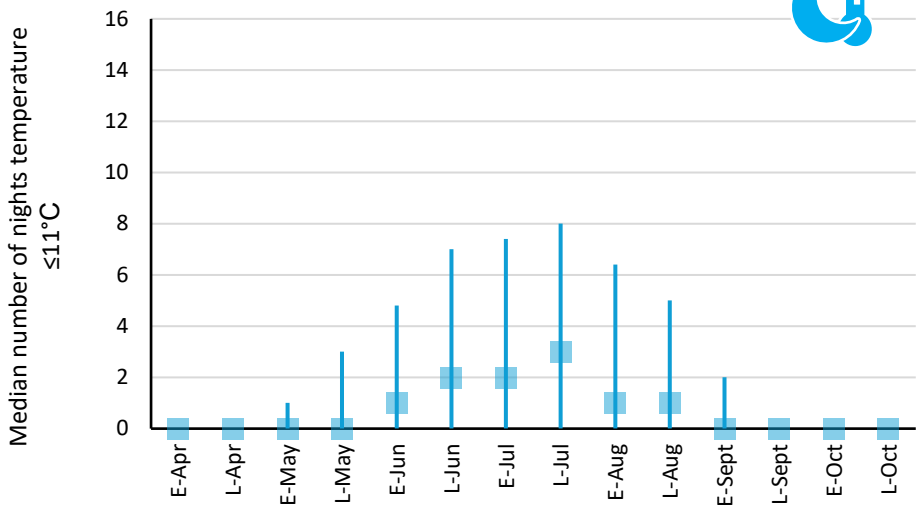


Douglas Daly

Number of nights (per half month) at or below 11°C

The main risk period extends from late June to late August, when cold nights can slow boll filling and maturation and increase the likelihood of poor fibre quality. During the coldest 10% of comparable fortnights, five to eight nights fall to 11°C or below.

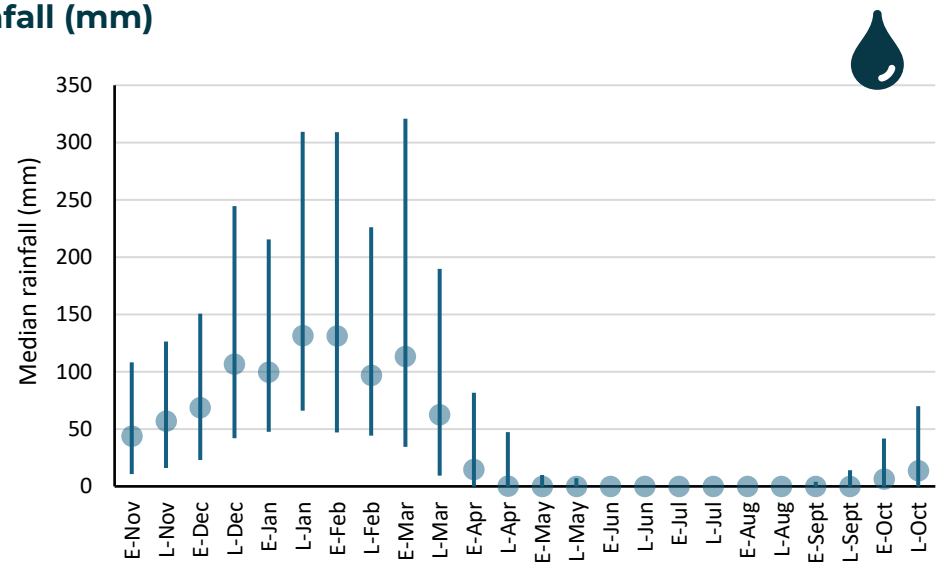
Under median or warmer conditions, these nights are uncommon or absent. The risk is therefore greatest for late-maturing crops still carrying immature bolls.



Median half monthly rainfall (mm)

The most reliable rainfall occurs from late December to early March, with median totals peaking from late January to early February. The first half of March can still receive very high rainfall and records the largest totals dur-ing the wettest 10% of seasons, likely reflecting tropical lows that are more frequent towards the end of February and early March.

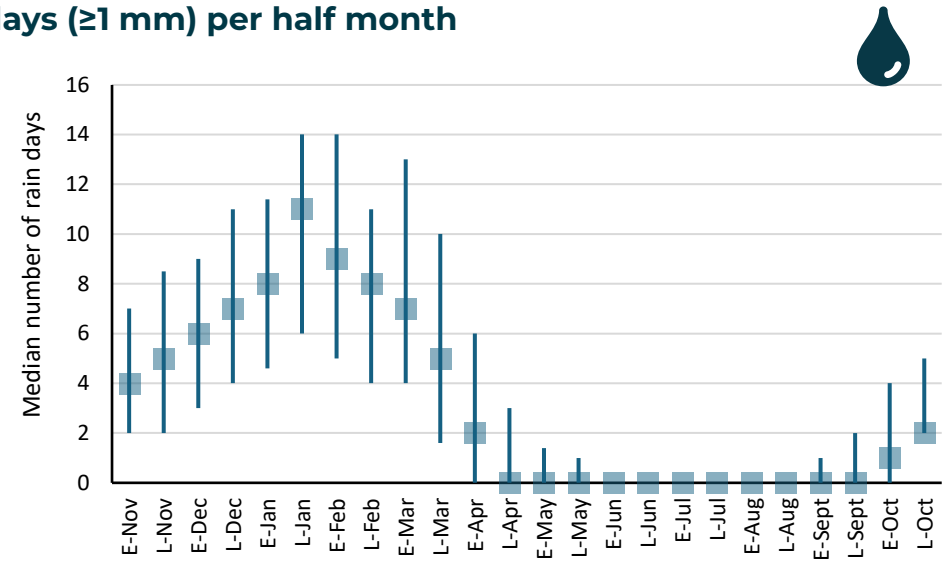
Wet-season sowing therefore carries risks for delayed field access or delug-es sealing in sown seed particularly on loamy soils that might hard set. A challenge for rain grown crops will be the rapid decline in rainfall in some seasons from late March onwards which may limit the ability of crops to compensate boll shedding and mature or mature later-set bolls.



Median number of rain days (≥1 mm) per half month

Rain-day frequency broadly follows the seasonal pattern in total rainfall. During the wettest 10% of comparable periods, rain can occur on almost every day. The upper range of rain days increases during the latter half of the wet season, consistent with a greater influence from monsoon troughs and embedded tropical lows.

Frequent rainfall leaves few opportunities for soils to dry, increasing trafficability risks and complicating timely sowing, spraying and other field operations.

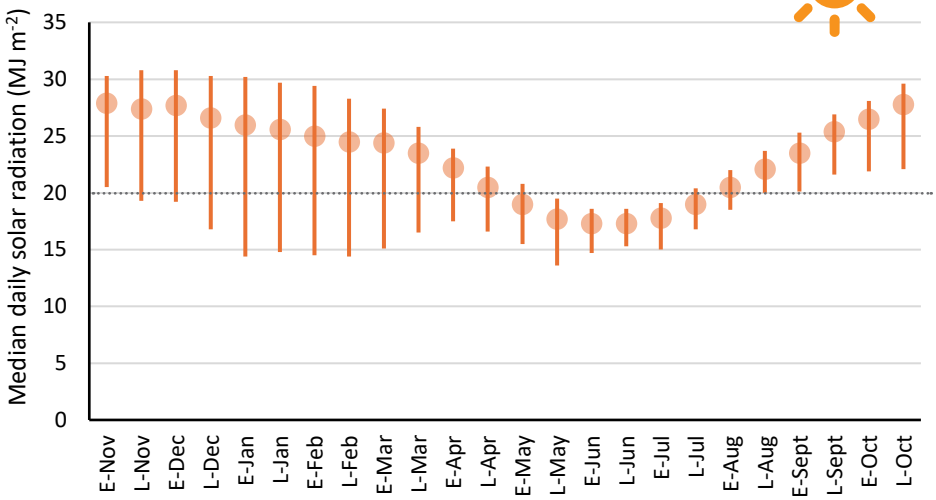


Etta Plains

Median daily radiation (1960–2025)

The Lower Flinders is generally not a radiation-limited environment compared with wetter cotton-production regions of northern Australia. Median radiation remains WELL above 20 MJ/m²/day throughout the wet season from December to late March.

Individual cloudy fortnights can fall well below 20 MJ/m²/day, creating short-term risks to flower and boll retention. However, the historical pattern indicates that low radiation is an intermittent rather than persistent sea-sonal constraint. During the sunniest fortnights, very high temperatures are more likely to limit growth and fruit retention.

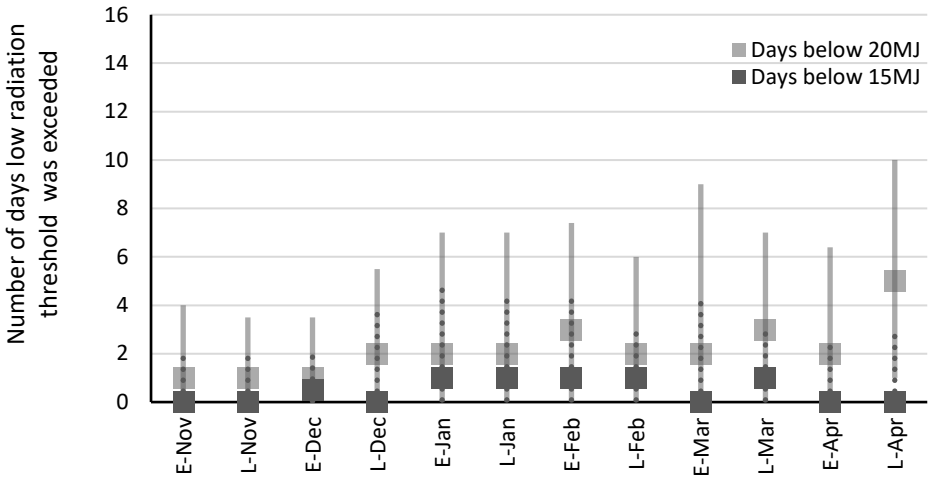


Number of days (per half month) below 20 and 15 MJ/m²/day

Days below 20 MJ/m²/day are generally infrequent, while days below 15 MJ/m²/day are rarer still. Low-radiation days become more frequent by April as occasional late wet-season cloud combines with shortening day length.

Overall, the historical record indicates that low radiation is not a major constraint to cotton production in the Lower Flinders, particularly when compared to other northern regions. However, cloudy fortnights can occur and may reduce fruit retention and yield when they coincide with flowering and boll filling.

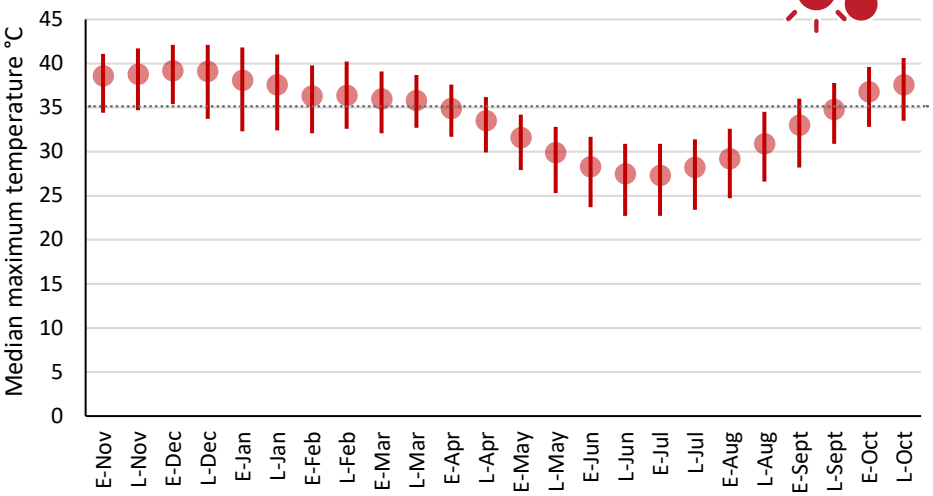
For these counts, the percentile direction is reversed relative to the daily radiation figure: The upper end of the error bar represents more days below the threshold, while lower end represents fewer low-radiation days —the reverse of the above daily radiation figure.



Median maximum daytime temperature

High daytime temperatures are a major constraint to cotton production in the Lower Flinders. **From October to late January, maximum temperatures frequently reach levels likely to stress the crop.**

Wet-season cloud generally moderates daytime temperatures later in summer, although extreme heat can persist in some seasons. These conditions make crop establishment more challenging for growing in December, increase crop water and irrigation demand, and may reduce fruit retention if they coincide with flowering.

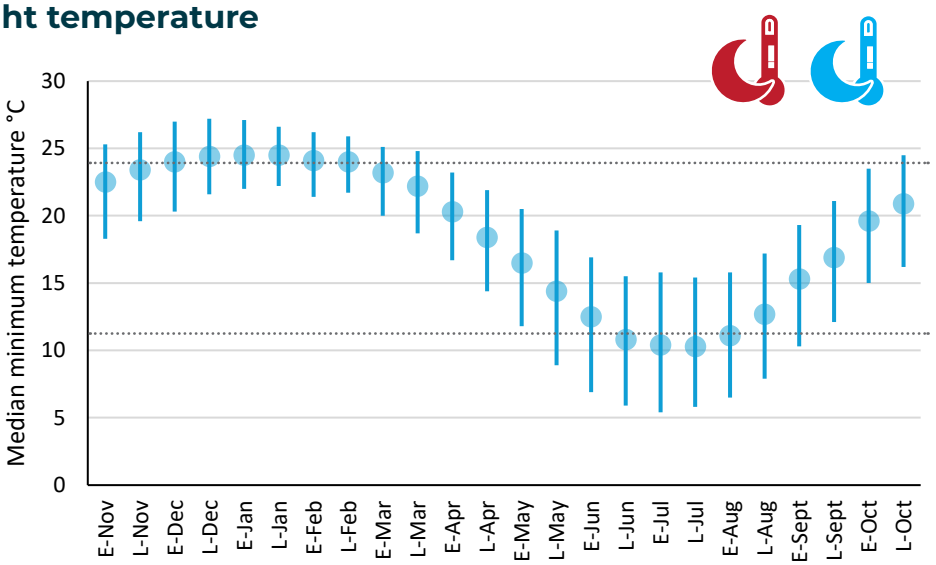


Etta Plains

Median minimum overnight temperature

The Lower Flinders' more arid climate allows better overnight cooling, resulting in hot nights being less frequent than at other wetter northern locations. Hot nights are most likely from early December to late February.

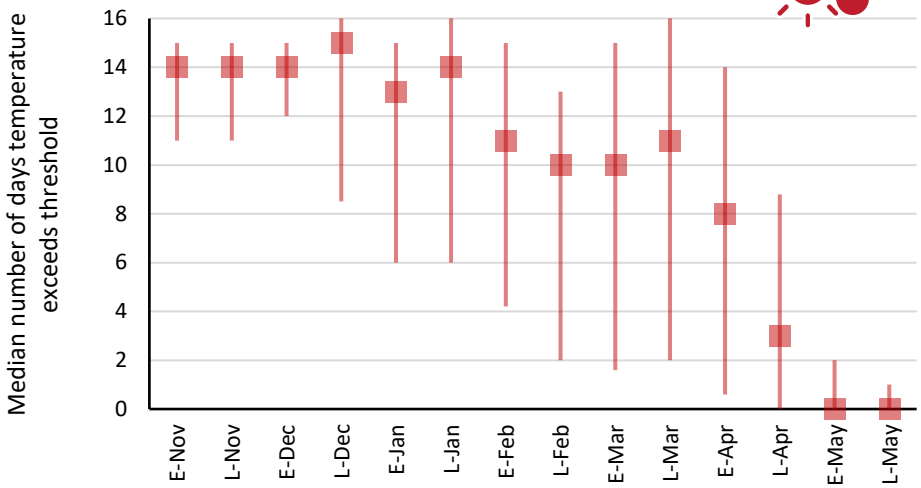
From late May, median minimum temperatures fall to levels that will substantially slow crop and boll development, limiting the effective growing season. The majority of bolls therefore need to be close to maturity by mid-to-late May to reduce the risk of incomplete maturation and poor fibre quality.



Number of days (per half month) reaching or exceeding 35°C

Days of 35°C or above occur almost continuously from November to late January and can remain frequent through to April. This creates a substantial heat risk during crop establishment and reproductive growth and increases crop water and irrigation demand.

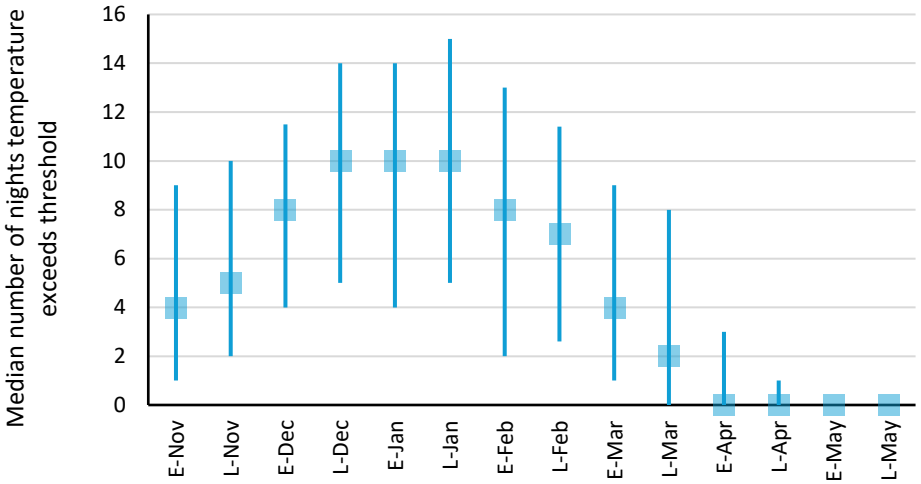
Crops flowering during this peak may experience combined day and night heat stress, increasing the risk of fruit shedding and boll deformities.



Number of nights (per half month) reaching or exceeding 24°C

Hot nights become more frequent from December, peak from late December through January, and then gradually decline.

Crops flowering during this peak may experience combined day and night heat stress, increasing the risk of fruit shedding and boll deformities.

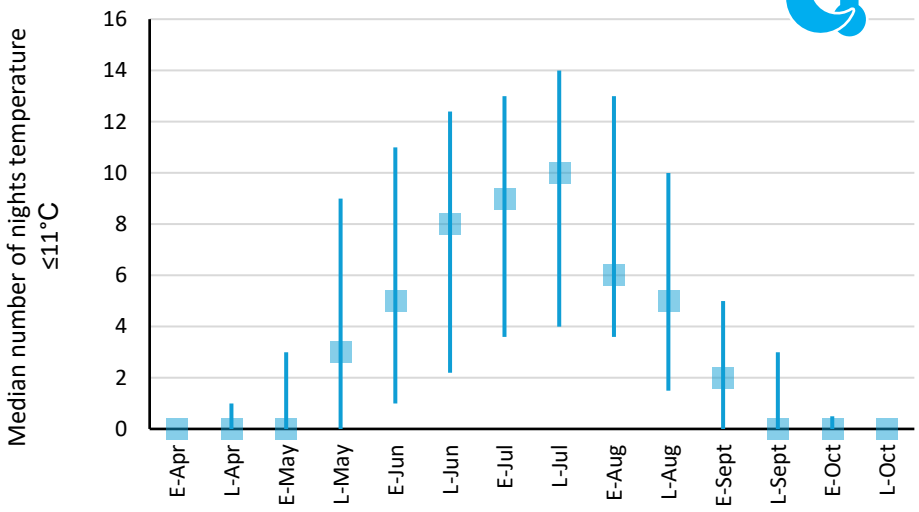


Etta Plains

Number of nights (per half month) at or below 11°C

Cold nights are a major seasonal risk in the Lower Flinders. Their frequency increases rapidly from early June and can begin during May in cooler seasons, placing a firm limit on the effective growing season. Most bolls should therefore be mature by mid-to-late May to avoid delayed boll filling, incomplete maturation, yield loss and poor fibre quality.

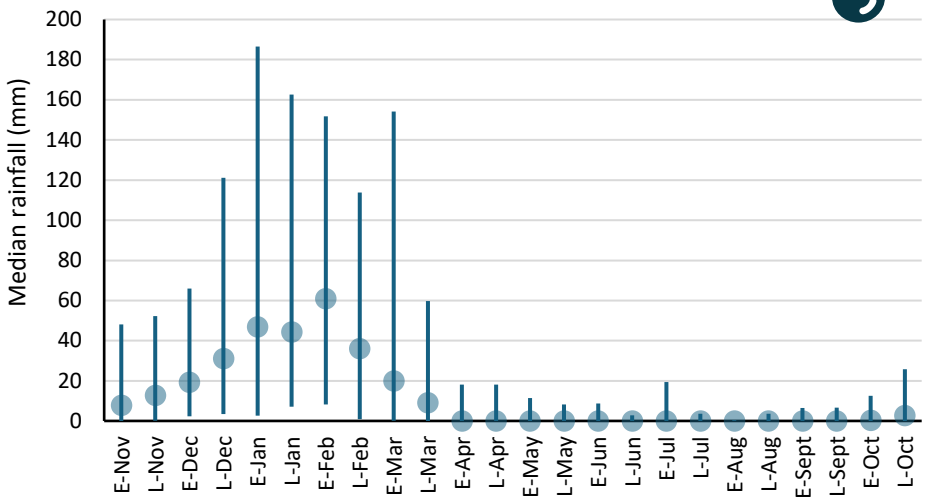
Overnight conditions are colder than at Emerald, largely because the drier, clearer climate allows more rapid overnight cooling. Consequently, late maturing cotton is unlikely to be as reliable in the Lower Flinders as it has been at Emerald since the advent of 'grown on' cropping.



Median half monthly rainfall (mm)

Rainfall peaks in early February at a median of around 60 mm, substantially lower than at other northern cotton-production locations. The large difference between median totals and the wettest 10% of seasons from late December to early March highlights the Lower Flinders' transition between wetter coastal regions and the arid interior. Median totals of 35–60 mm across four to six rain days suggest that the majority of falls are modest, punctuated in some seasons by major events in between drier periods.

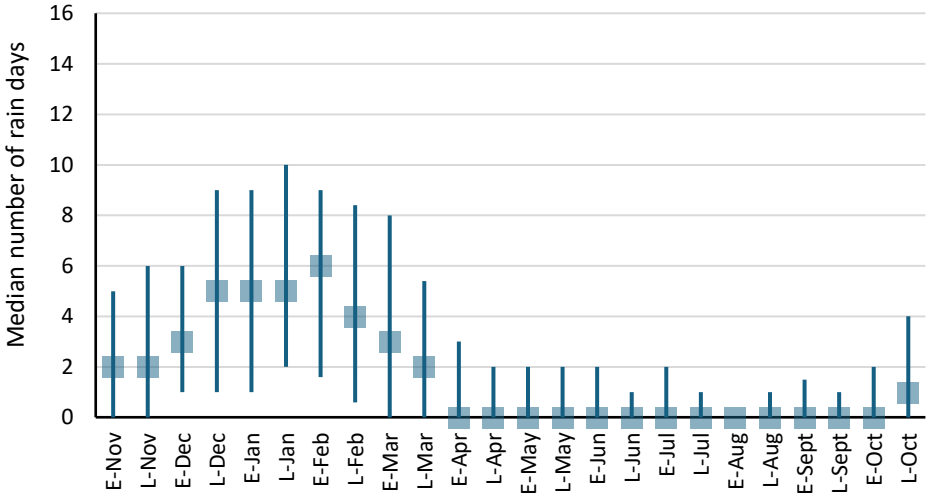
Rainfall is less likely to disrupt field operations for several weeks compared with wetter more northerly regions. Delays are more likely to last 7–10 days, although this will depend on soil type and drainage. December sowing is likely to require pre-irrigation in most seasons.



Median number of rain days (≥1 mm) per half month

Rain-day frequency broadly follows the seasonal pattern in total rainfall. Considered together, the median rainfall and rain-day figures suggest an average of approximately 5–20 mm per rain day, although individual falls will vary.

During the wettest 10% of seasons, the greatest rainfall risk is concentrated in December and January—earlier than the late January to early March peak observed at wetter more northern locations. Fewer rain days are consistent with lower cloudiness and more dry periods during the wet season. This improves field access and radiation but increases the likelihood that pre-irrigation or supplementary irrigation will be required during the summer months.

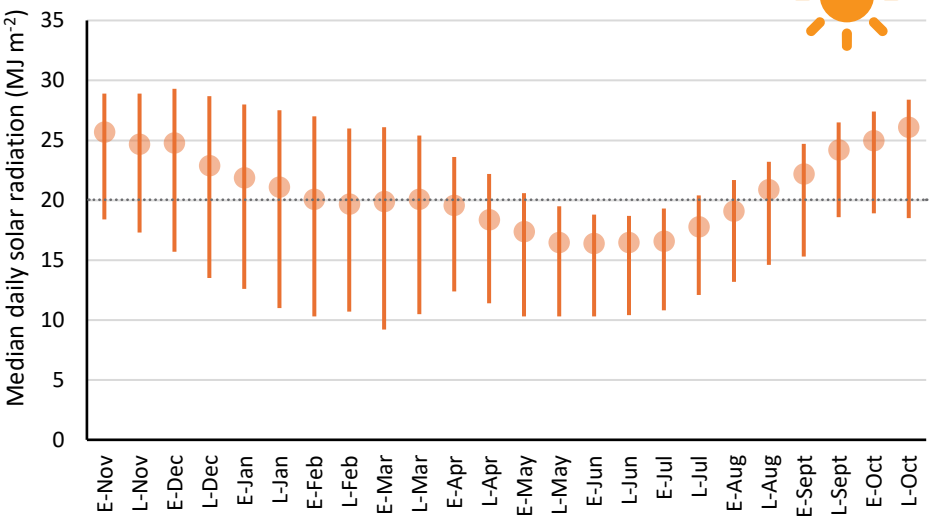


Tablelands

Median daily radiation (1960–2025)

Median radiation becomes potentially limiting from early February as wet season bursts or frequent partial cloud reduces sunlight, challenging flower and boll retention. Unlike drier northern production regions, the risk of cloud-related low radiation persists through much of the year and is lowest before the wet season, from late September to early November. This pattern reflects the region's proximity to the coast, moist onshore airflow and higher elevation.

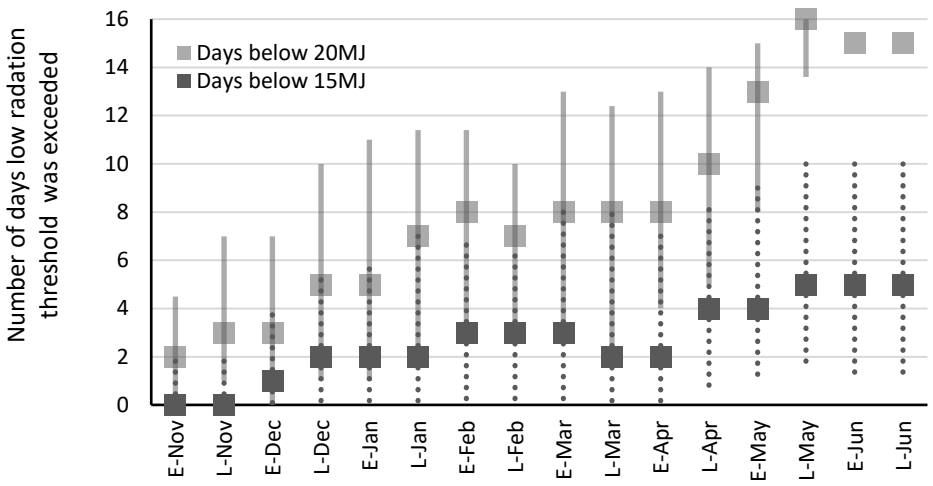
From May, lower radiation coincides with cooler conditions, slowing crop growth and boll development. This can delay crop maturity and, in some seasons, increase the risk of immature fibre and low micronaire.



Number of days (per half month) below 20 and 15 MJ/m²/day

The Tablelands differs from other northern production regions. From January to early April, the median indicates that around half the days in each paried fall below 20 MJ/m²/day. This increases rapidly from late April, reaching 14 days per fortnight by June as shorter days combine with frequent partial cloud. Cotton will therefore regularly experience radiation levels that can slow growth and increase fruit-shedding risk. Compensatory growth is likely to be required in many seasons.

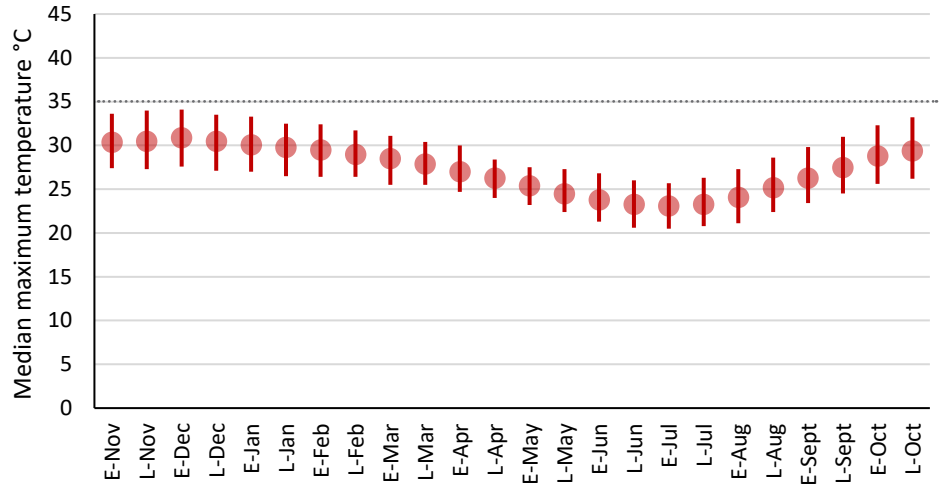
Days below the more severe 15 MJ/m²/day threshold generally remain at two to five per fortnight. However, this rises to around six to eight days during the cloudiest 10% of wet-season fortnights, creating substantial risk when these periods coincide with flowering and boll filling. For these counts, the percentile direction is reversed relative to the daily radiation figure: The upper end of the error bar represents more days below the threshold, while lower end represents fewer low-radiation days —the reverse of the above daily radiation figure.



Median maximum daytime temperature

Compared with other northern cotton-production regions, the Tablelands has a mild daytime temperature environment with little risk of extreme heat. Median maximum temperatures are generally favourable for cotton growth from October to May.

Days above 35°C are rare, occurring approx-imately once every few years. **Daytime heat is not a constraint for crop establishment, flowering or boll filling on the Tablelands.**

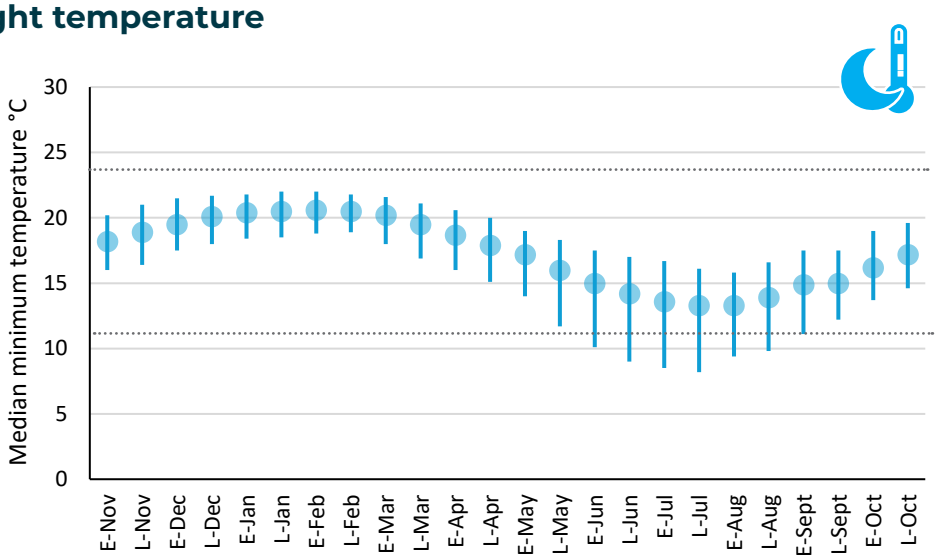


Tablelands

Median minimum overnight temperature

Because of the region's elevation, hot nights of 24°C or above are exceptionally rare. Analysis of individual days indicates that they occur only a few times per decade.

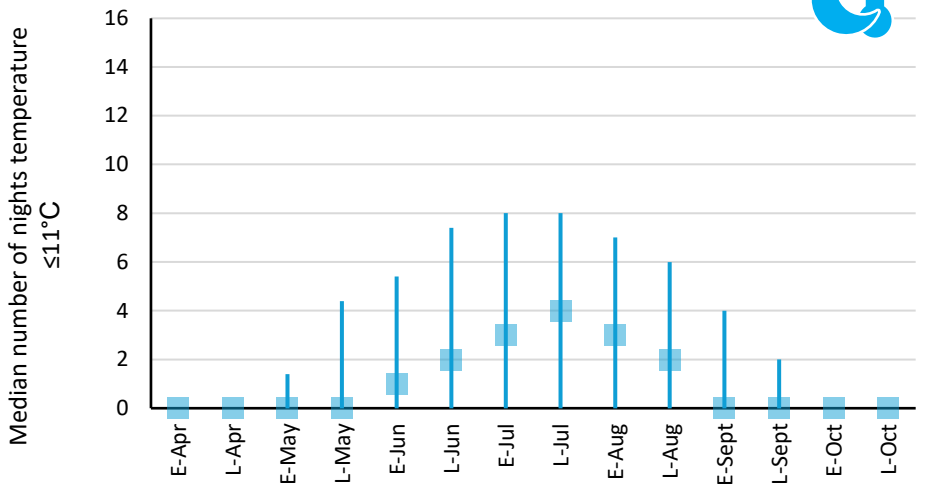
Hot nights are not a constraint for cotton production on the Tablelands. Cool overnight temperatures during the dry season present the greater risk and are examined below.



Number of nights (per half month) at or below 11°C

Under typical conditions, the main risk period extends from mid-July to early August, when cold nights can slow boll filling and maturation and reduce fibre quality. During the coldest 10% of comparable fortnights, five to eight nights fall to 11°C or below across the broader June–August period.

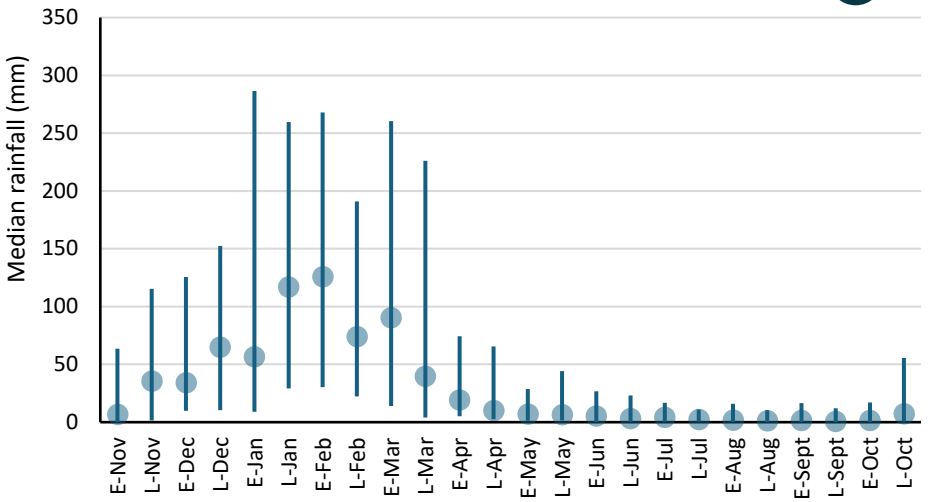
In warmer seasons, these temperatures are uncommon and the risk is minimal. Crops still carrying immature bolls during mid-winter are most exposed.



Median half monthly rainfall (mm)

Median rainfall indicates relatively drier periods in early January and late February within the main wet-season period from late December to early March. However, the early January period has recorded the highest totals during the wettest 10% of seasons, showing that this apparent window for improved trafficability is unreliable and can be interrupted by major rainfall events.

Rainfall declines rapidly during April, even in wetter seasons. This generally improves field access and reduces waterlogging risk, but increases the crop's reliance on irrigation or stored soil moisture as the season progresses.

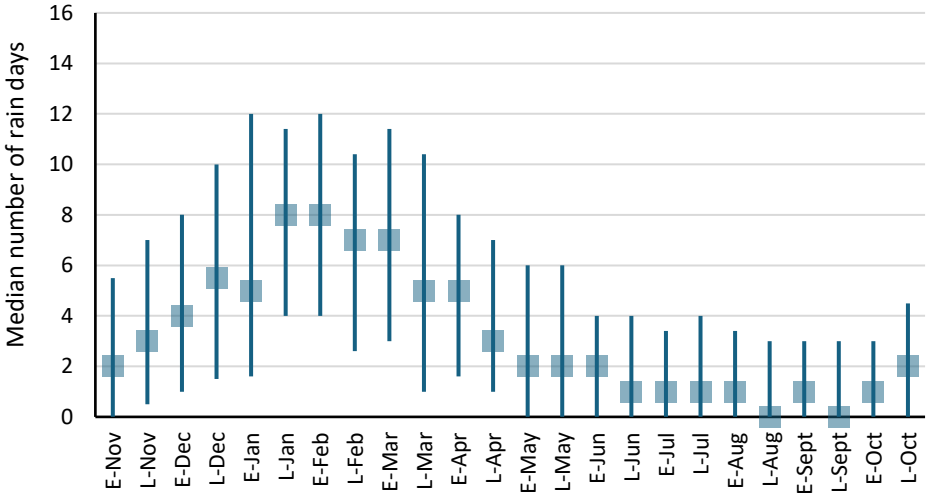


Tablelands

Median number of rain days (≥1 mm) per half month

Rain-day frequency broadly follows the seasonal pattern of median rainfall. From late January to early March, rain is recorded on about half the days in each fortnight. During the wettest 10% of comparable periods, most days receive rain from late December to late March.

Even where individual falls are small, repeated wet days provide few opportunities for soils and crops to dry. This can delay sowing, spraying and machinery access and contributes to the Tablelands' persistent wet-season cloud and low-radiation risk.



It can also increase the likelihood of foliar disease occurrence particularly in crops that have closed the inter-rows which enhances the micro-climate for disease outbreak. Boll opening prior to April has a high risk of boll rot. November planting therefore presents boll rot risks.

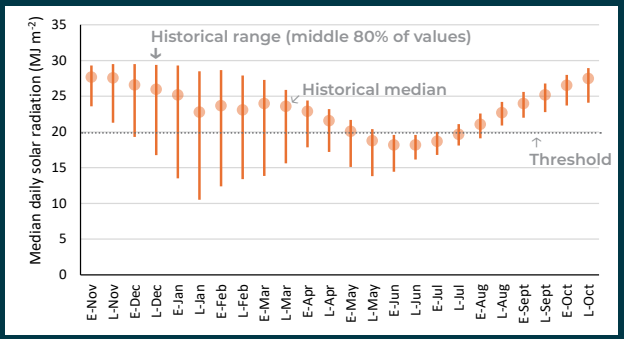
Climate influences to look out for

	Issue	Potential impact
	Radiation levels	Sufficient radiation is required to produce enough photosynthates to set and develop bolls. Low radiation will prompt plants to shed fruit and reduce the potential to fill retained bolls.
	Cloudiness (low radiation)	Radiation levels below 20 MJ per day will reduce yield. The cloudiness graphs include the number of days below the 20 MJ threshold and the number of days below 15 MJ, where significant impact on the crop would be expected.
	Rainfall	In addition to its association with cloudiness (low radiation), rainfall can become a crop management issue, either disrupting in-field operations or causing boll rots once bolls begin to open.
	Hot days	Days at or above 35°C challenge the plants' ability to regulate leaf temperature, causing negative impacts. Ideal day temperatures for cotton production are from 28-32°C.
	Hot nights	Nights at or above 24°C cause energy loss through extra respiration demand with the impact being similar to a cloudy day.
	Cold nights	Cool nights slow growth and temperatures at or below 11°C can impact fibre quality.
.....	Thresholds	· Radiation <20 MJ/m²/day · Days ≥35°C · Nights ≥24°C or ≤11°C

Interpreting the climate graphs

The median historical half-monthly values from 1960 to 2025 are indicated by a circle (actual values) or a square (median number of days that something occurred).

The upright bar indicates the most common historical range of variability (the upper and lower 10% of values have been excluded), providing insight into the likelihood that particular threshold points will be reached in each period. The longer the bar, the the more variable the data is.



Climate values are coloured-coded: orange for radiation (and grey for low radiation caused by cloud), red for maximum temperatures, blue for minimum temperatures and teal for rainfall.

Climate parameter thresholds are indicated by a dotted horizontal line.

Graphs developed October 2026 by Paul Grundy, QDPI. The author acknowledges the financial support of the Cotton Research and Development Corporation.

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