Damaging spring frosts a result of 'blocking' highs

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AT A GLANCE…

A series of significant frost events occurred throughout August and September of 2016 in the grain regions of Western Australia, and in October in the South Australian grain region.

In this update we provide some information on the extent of the frosts, their impact, and the weather conditions that produced them.

Western Australia

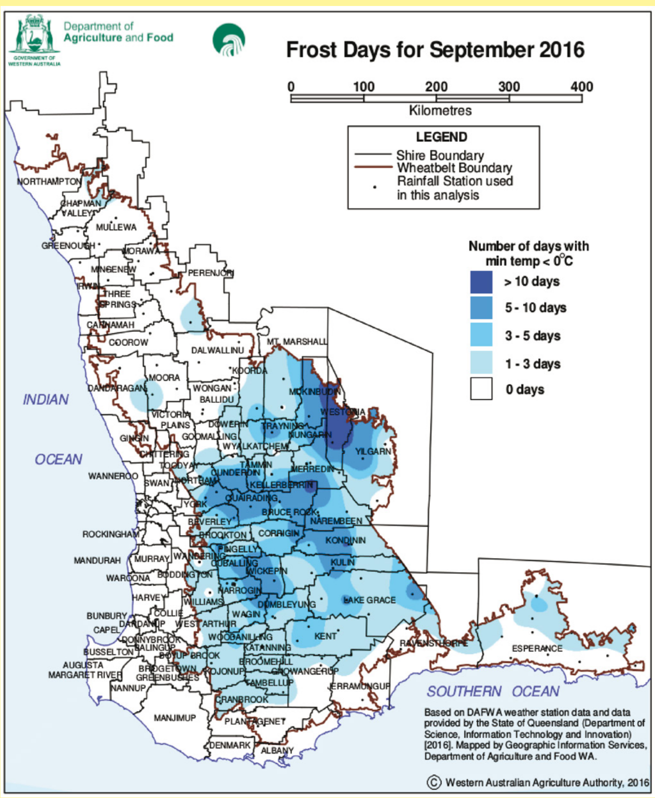
At least four significant frosts occurred during late August and September in the central and eastern WA grainbelt. In late September and early October a further three frost events affected the Upper Great Southern and Lakes district.

The combined effect of these frosts has caused considerable yield losses to barley and wheat and to a lesser extent canola and lupin crops. While some crops escaped damage because of their advanced growth stage, many cereals were damaged at a range of growth stages from booting through flowering and grain fill.

Due to the severe nature of the frost events the crops were also damaged across large areas of the landscape and in elevations and soil types where frost damage does not typically occur.

The most damaging event was on August 23–24 and September 23–24 as this was preceded by light rainfall in the Great Southern, Central and Eastern wheatbelt. The Central and Eastern wheatbelt and the Lakes District reported the largest losses of about 25–85 per cent across the cropping program in these regions. The prevalence of frost days through September for WA is shown in Figure 1 and shows some regions with up to 10 frost days for the month.

FIGURE 1: WA frost days in September 2016



The frosts that occurred in southwest WA through the spring followed a similar sequence. Typically, a cold front passed through southwest WA in the day or two preceding the frost event. This frontal passage brought an initial burst of cold air over the region. The frontal passage was then followed by rapid development of a high into the region

The rapidly developing high helped trap the cold air in the region and entrain (incorporate) further cold dry air from southern latitudes. The high also brought clear skies, which enhanced the radiative heat loss from the surface at night. These conditions sustained frost conditions for two or more days (in most cases) as the high developed in position.

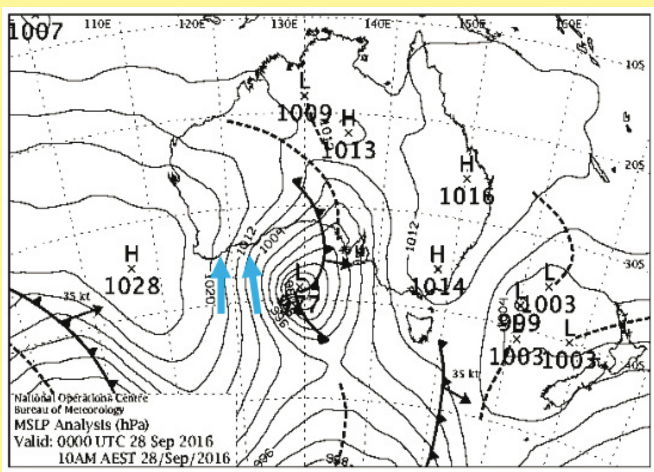
A synoptic chart that typifies this configuration is shown for the frosts of September 28 (Figure 2). It shows the high moving into position behind the front and strong southerly flow over the region.

The question arises as to why these highs resulted in severe frost, but not every high in the region does. The centre of every high pressure system provides clear still nights but it seems that this is necessary – but not sufficient – for frost.

Persistent highs and severe frosts

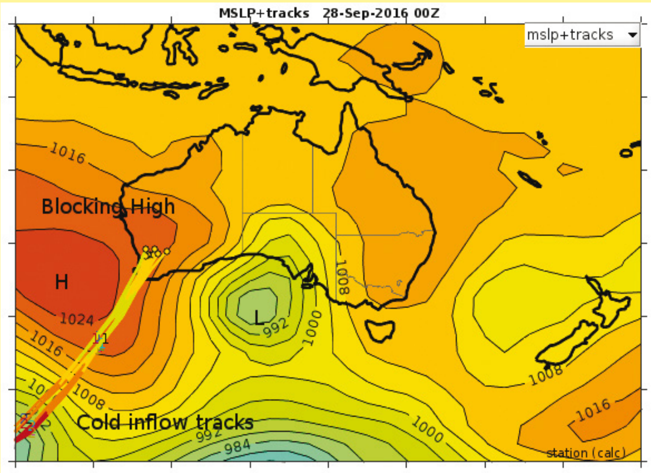
Our research shows that the answer is related to the fact that these highs are developing rapidly and forming persistent highs known as `blocks'. The developing block is more efficient at

FIGURE 2: Mean sea level pressure on September 28, 2016



Blue arrows indicate the flow of cool air from the Southern Ocean generated by anticlockwise flow around the high pressure system in the Indian Ocean and the clockwise flow around the cut-off low pressure system in the Great Australian Bight.

FIGURE 3: Back trajectory of air parcels on September 28, 2016



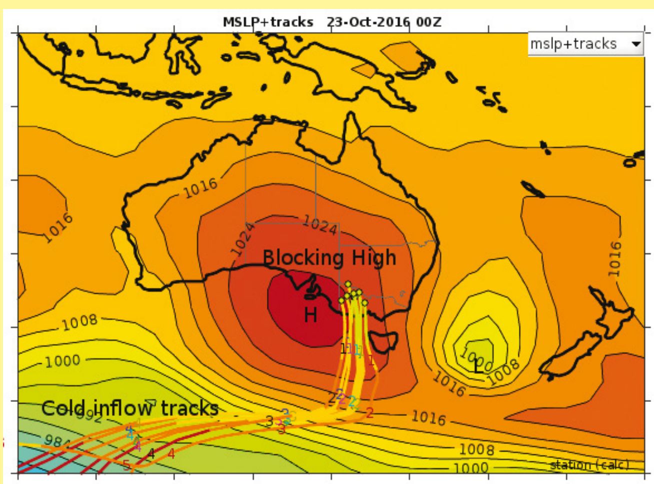
bringing cold, dry air into the region from the polar regions than ordinary highs.

The trajectories for the air parcels that were at the surface at the time of the frost on September 28, are shown in Figure 3. The developing block has entrained air to the surface that originates polewards of 50 degrees south in the middle troposphere. This air is exceptionally cold and dry when it is brought to the surface by the time the frost occurs.

Such extreme southerly origin air trajectories are not associated with most high pressure systems in the region and occur mostly in association with the developing blocking high.

The month of September in particular was unusual in displaying numerous blocking events in the Tasman Sea and in southwest WA. These two blocks occurred together and 'pinched' the trough in between over the continent. This pinched trough in turn generated an unusual number of cutoff lows in the Bight (as in Figure 2) that went on to generate persistent storms over southeast Australia in September.

FIGURE 4: Back trajectory of air parcels on October 23, 2016



Work is being undertaken to assess forecast and management options for mitigating extreme temperature impacts on grain production as part of the GRDC's multidisciplinary National Frost Initiative. Our work shows that southwest WA spring frosts are more likely to occur when a blocking high develops just to the west of southwest WA.

Research is ongoing to determine why blocks are favoured more here in some springs than others. We know that these blocks depend on conditions upstream in the atmosphere over the Indian Ocean, and so we are focusing on what determines the variability there, and to what extent these conditions can be forecast at various lead times.

South Australia

In South Australia, most of the frost damage occurred in late September and late October. Damage occurred in the Mid North, upper Eyre Peninsula and southern Mallee cropping regions. The October damage occurred on the 19th and 23rd and like in WA – while some crops escaped damage due to their advanced growth stage, many cereals were damaged at a range of stages from booting through flowering and grain fill.

The late frost was particularly damaging to some pulse and canola crops. The yield losses were estimated to be from 25 per cent to near total crop loss in some cases. The subsequent quality downgrades of wheat, barley, canola and pulses contribute 30 to 50 per cent of the financial loss.

Most of the South Australian grains belt had well above average growing season rainfall and, apart from crops directly affected by storms, many growers reported one of the best seasons ever with high rainfall and limited damage from frost and heat.

This makes it especially difficult for the minority of growers affected by these late frosts.

In some cases the impact of the frost was relatively insensitive to topography, with damage at the top of rises as well as hollows. This pattern reflects the strong advection (transfer) of cold air into the damaged regions.

The strong cold advection in these SA frosts can be seen in Figure 4 for October 23. Cold, dry air has been advected from well south of the region down into the surface at the time of the frost event (as shown by the set of air parcel trajectories).

The event on October 23 also coincides with the growth of a blocking high in the Bight following passage of a frontal system in the days prior. That is, the profile of this event is similar to the WA events in displaying strong cold air advection in the wake of frontal passage and as a blocking high establishes itself.

The main difference is that for SA the block needs to be established in the Bight in order to direct these very cold and dry airflows into the region.

To sum up

In this study we found that severe frosts are preceded by the rapid development of blocking high pressure systems. Frosts occur when these developing highs are situated to the west of the frosted region and advect particularly cold, dry air down to the surface during the frost event.

Our work is ongoing to establish the conditions that control the variability of blocking high pressure systems and to assess the potential for forecasting conditions which are more or less conducive to their occurrence.

Due to the unpredictability and potentially devastating impact frost can have on crops, growers are encouraged to adopt a comprehensive management plan which includes pre-season, in-season and post-event tactics.

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