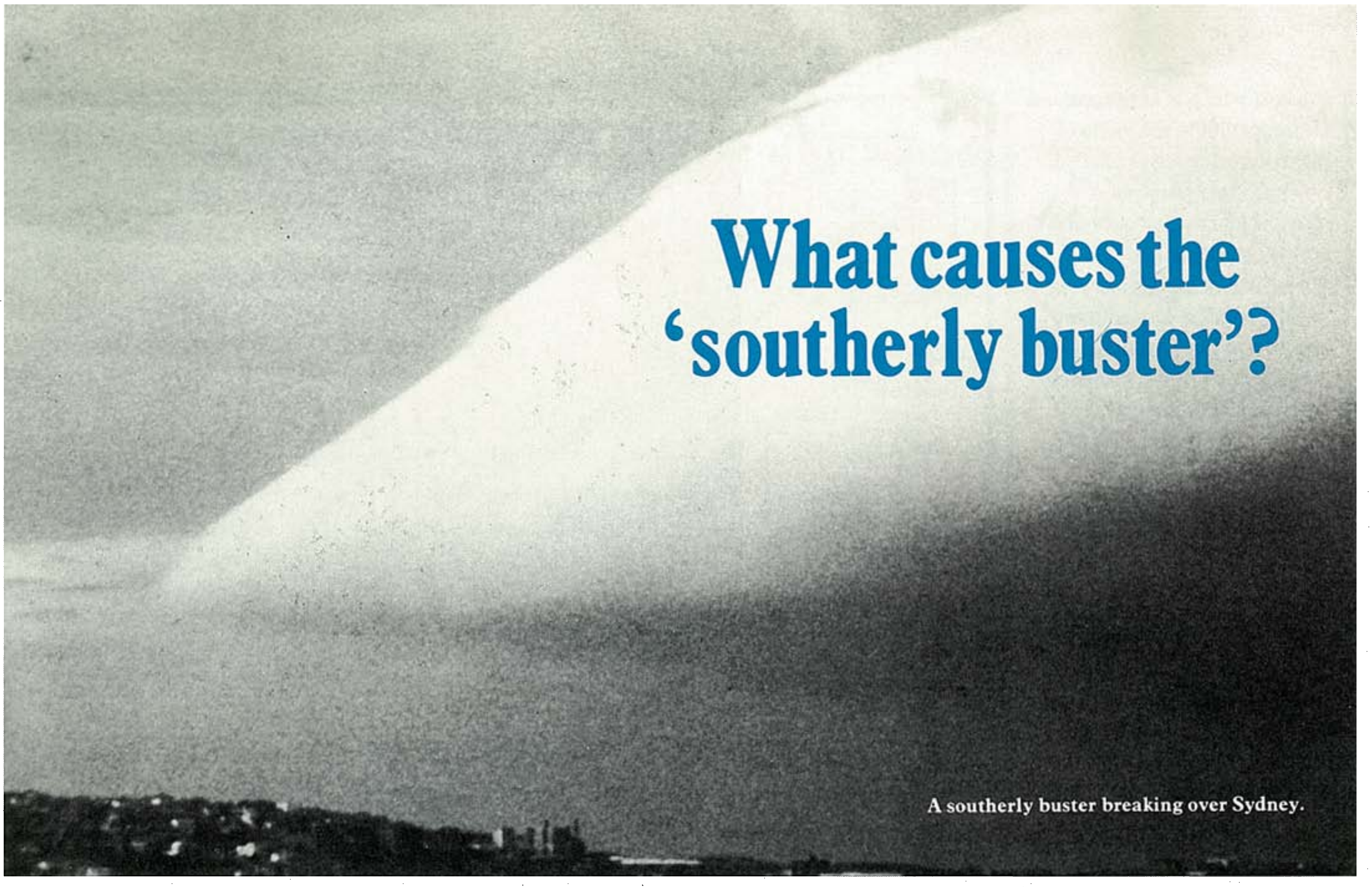
What causes the ‘southerly buster’?


A southerly buster breaking over Sydney.

A ‘southerly buster’ is the colloquial name given to a particularly strong southerly wind change along the coast of New South Wales. It is an important feature of Sydney’s weather, and the novice yachtsman soon learns to look out for it.

The approach of a strong southerly buster is often characterized by a spectacular rolling cloud bank appearing from the south and at right angles to the coast. Its sighting sends yachts and other small craft scurrying for shelter.

Weather records show that southerly busters occur about 32 times each year, with varying intensity. They are most common, and also strongest, in the spring and summer. They are always associated with the passage of a cold front through eastern Australia, giving rise to a sudden fall in temperature and an abrupt change in wind direction and strength.

What causes them? They are not simply the straightforward manifestation of a passing cold front, because the same front can pass through western and southern Australia in an unexceptional mild way.

It is difficult to explain their behaviour in terms of normal meteorological mechanisms because they have usually come and gone within a day. The regular weather observing network will only record a few observations during that time, so that it is rare to capture a southerly buster on a daily weather map. The weatherman would be indeed fortunate to receive observations of the hour-by-hour progress of such an animal because observations of barometric pressure, temperature, wind direction, and wind strength are scanty and irregular over the ocean. Trying to uncover what amplifies a normal cold front into a turbulent southerly buster is therefore difficult.

Dr Peter Baines and Mr Sandy Troup of the CSIRO Division of Atmospheric Physics have proposed a model of the southerly buster which seems to explain its behaviour surprisingly well. Although the lack of ‘hard-core’ meteorological data prevents them from verifying the model in detail, the broad features common to most southerly busters seem to fit it quite nicely.

The core of the scientists’ model is this: the southerly buster, they say, is caused by a cold front interacting with the large barrier posed by the Great Dividing Range.

Cold wedge

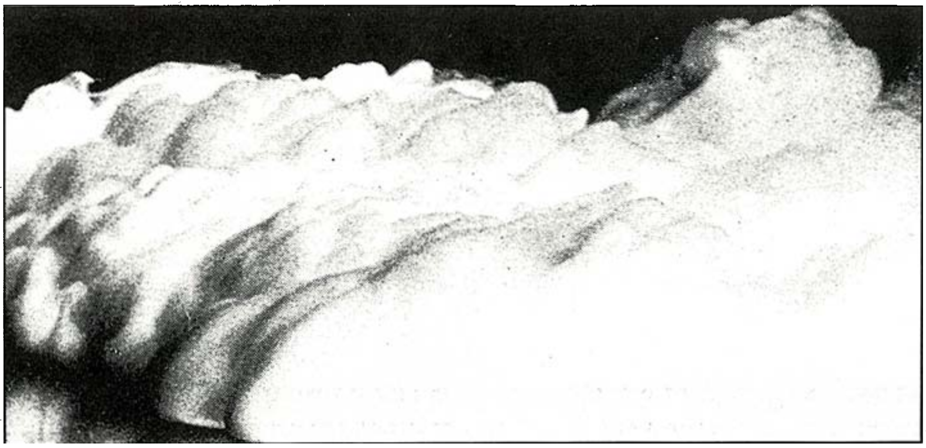
First, let’s look at how an undisturbed cold front behaves. In its ideal form, it consists of a wedge of cold dense air moving into a region of warm light air. The diagram shows what happens. The main effect is that the ‘flying wedge’ forces warm air up, producing the high cloud bank typical of cold fronts.

A secondary effect, less easily appreciated, is that the moving front must be accompanied by a wind in the cold air at right angles to the direction of motion of the front. This wind (called a geostrophic wind) is necessary to dynamically balance the forces at work: principally the pressure difference between the warm and cold air and the coriolis force produced by the earth’s rotation. In the Southern Hemisphere the wind will blow to the left (when sitting on the ‘nose’ of the front and looking ahead), and in the Northern Hemisphere it will blow to the right.

They plan to fly the aircraft, equipped with meteorological instruments, through a southerly buster.

Now what happens if this wind is blocked, say by a range of mountains? The question can be answered by the model proposed by the CSIRO scientists. In south-east Australia, under the right conditions, the wind will move northwards, resulting in a southerly buster.

Commonly a cold front travels through this area of Australia in a north-easterly direction, the same direction as the general orientation of the Great Divide. The geostrophic wind accompanying the front therefore strikes our alps face on.



What happens when a body of heavy salty water (coloured with milk) is released into a tank of fresh water.

In this situation, principles of fluid mechanics tell us that the wind must veer northwards along the range. This mountain-hugging jet of air is none other than a southerly buster.

It heads north, not south, for the same reason the geostrophic wind goes left, not right: because of the coriolis force. A similar situation exists when ocean tides encounter the edge of a continent—a 'Kelvin wave' is produced, which runs along the coast in a direction dependent on whether it's in the Northern or Southern Hemisphere. Thus, along the coast of New South Wales, tide peaks are observed to run northwards along the coast.

Rolling by gravity

The jet of air shooting up the coast will move faster than the main body of the front, and so will race ahead of it in the same way as the foamy head of an ocean wave runs ahead of its parent. Both are so-called 'gravity currents' which roll forward like an avalanche, instead of propagating like ripples on a pond.

Gravity currents are at work in a number of common meteorological phenomena—whenever cold air 'spills' out onto the ground and rolls along displacing warm air. A good example is the outflow from a thunderstorm head. In the Sudan, the rolling air from the thunder-cloud becomes laden with red dust as it travels along the ground, so that the phenomenon (called a haboob) becomes dramatically visible. The familiar sea breeze is another, more common, example.

The photograph shows a gravity current produced by releasing a body of heavy salty water, coloured with milk, into a tank of fresh water. The resemblance of the advancing fluid to the rolling bank of cloud seen in a southerly buster is remarkable. Both of them show the characteristic breaking head wave, with turbulence behind.

The reasoning that leads us to expect the jet of air to move ahead of the front on the coastal side of the mountains also demands that the front slow down on the inland side. The front therefore progressively develops an S-shaped head, a feature that is commonly seen on weather maps of the region.

Confirmation that the model fits the real world comes from other quarters as well.

Southerly busters are strongest in summer, just as you would expect from a gravity current that in this period possesses the greatest difference in density between itself and its warm surroundings. The winds rarely reach much further north than Port Macquarie, N.S.W., and this is possibly due to the gaps in the mountain range near there, most notably the Hunter Valley.

This mountain-hugging jet of air is none other than a southerly buster.

Indirect verification comes from looking at similar geographical situations in other lands and checking whether they experience phenomena similar to our southerly buster.

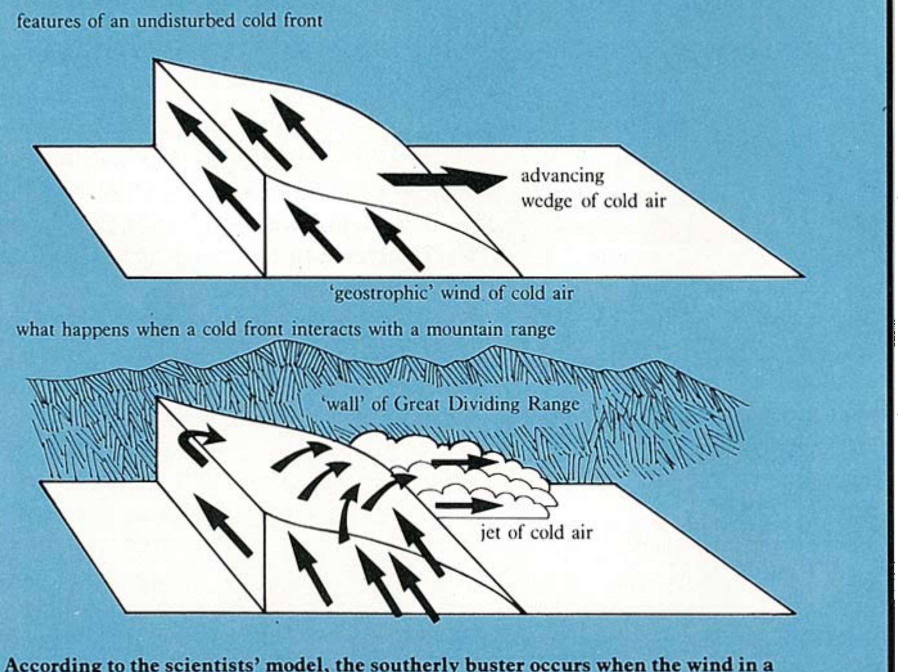
Indeed, fronts impinging on the land mass of southern Africa are very similar in character to those in Australia, and observers have described a coastal jet leading a front on the eastern side of the mountains there. In New Zealand, S-shaped deformations of fronts over the South Island are commonly observed and have been routinely plotted on weather charts for many years.

Dr Baines and Dr Chris Coulman of the CSIRO Division of Cloud Physics are hoping to organize an experiment this summer to confirm the model. They plan to fly the Cloud Physics aircraft, equipped with meteorological instruments, through a southerly buster.

More about the topic

The Southerly Buster—a coastally trapped gravity current? P. G. Baines and A. J. Troup. *Proceedings of a Workshop on Fronts, Royal Meteorological Society, Australian Branch,* May 1977, 11.7–11.9.

How a southerly buster forms



According to the scientists' model, the southerly buster occurs when the wind in a cold front strikes the mountains of the Great Divide. A jet of cold air rushes up the coast ahead of the main front.