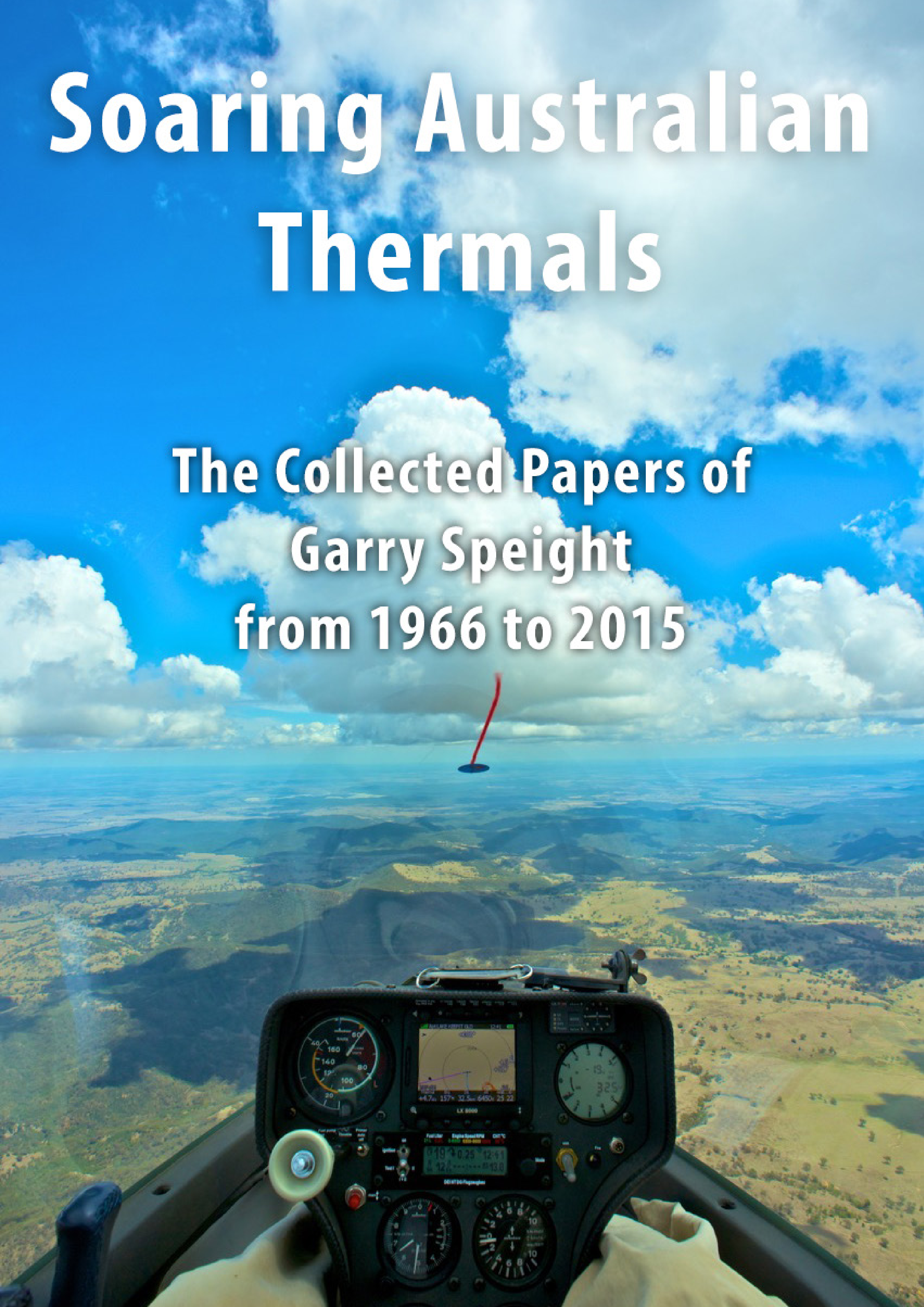
Soaring Australian Thermals

The Collected Papers of Garry Speight from 1966 to 2015



Thermals That Rotate, Part 1

By Garry Speight

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Many thermals rotate, and they may be the strongest of the day. You can soar better if you learn to work them. Circling against the rotation is a dream; circling with it, a nightmare!

Part 1: Do Thermals Rotate?

Soaring in thermals

A child, watching an eagle getting higher in the sky as it circles without flapping, may think that the bird is cleverly following a narrow current of air that twists upwards like a corkscrew. Glider pilots know the bird is soaring in a large mass of rising warm air, called a thermal.

A thermal may be more than 100m across, and the air in it mainly goes straight upwards, not twisting like a corkscrew. Sometimes the top of the thermal forms a cumulus cloud that shows something of its size and shape.

The eagle circles simply to stay inside the thermal. With wings outstretched, the eagle, like a glider, cannot stop still in the air, or even fly below a certain airspeed: the stalling speed. Flying a slow circle is the best way to climb using the lift of the thermal. Often the air rises several metres per second. Since soaring birds and gliders sink at only about one metre per second, these thermals can lift them up. Usually, birds and gliders climb just as well whether they circle to the left or to the right.

That is not to say that the air in the thermal never goes round and round as the child may have thought. Some thermals rotate.

The case against thermal rotation

Many pilots believe that thermals do not rotate, or think the subject not worth worrying about. They have never noticed anything that suggests enough rotation to affect thermal soaring. I believe this is because the effects of thermal rotation on a glider are so puzzling the pilot may take years to guess their true cause.

People say that they can't believe thermals rotate because they don't see clouds rotating. Clouds do rotate. Time-lapse films often show this, and you can see it by watching the first wisps of cumulus as they form in the morning[1].

There may also be a lot more rotation in the middle of a big cumulus than shows in the almost-dead air of the billowy cloud surface. Since the bottom of the cloud is just a flat grey mist, the thermal could be rotating as it goes into the cloud without leaving any sign.

In any case, the rotation is almost too slow to notice. A speed of just one circle per minute would strongly affect a glider.

Tornadoes, willy-willies and cyclones

Both tornadoes, and the larger sizes of willy-willy (or dust devil), are rotating masses of air that are like thermals. They are roughly circular in plan. As in a thermal, the most active part, or core, is around 30 to 80m in radius. They all have low air pressure and density.

Air flows in towards a place where the pressure is low. On a perfectly smooth ground surface the air might flow exactly towards the centre but, in reality, it is likely to twist a little one way or the other. Any slight tendency for the air mass to twist becomes a much faster rotation as it gets nearer to the centre.

On the earth's surface, the rotation of air (or water) tends to be cyclonic. Cyclonic rotation is different each side of the equator. At places south of the equator, the rotation is clockwise as seen from above. This is because the south side of the air mass is closer to the earth's axis than the north side is, so it travels eastwards with the earth at a slower speed. Cyclones, hurricanes, and typhoons that are hundreds of kilometres across always rotate cyclonically. Smaller masses of rotating air (or bathwater!) do not.

Experts think that 80% to 95% of tornadoes in the USA rotate cyclonically[2]. Perhaps not so many rotating thermals are cyclonic[3]. In his study of 375 "Sand Devils" in Egypt in 1932, WD Flower found that only 53% of them were cyclonic. On the other hand, Fred Hoinville, in his book "Halfway to Heaven", observed that, of 26 Australian willy-willies, "Twenty-four rotated clockwise; two rotated anti-clockwise." That is, over 90% were cyclonic.

How many thermals rotate?

Even if there were more data, the question "How many thermals rotate?" would be hard to answer. A thermal that rotates very slowly is just like one that does not rotate at all.

I think that a lot of Australian summer thermals, perhaps 5% or 10%, rotate fast enough to affect soaring in gliders.

One glider pilot, HV Senn, did experiments in Florida to measure thermal rotation. He found it hard to do, as he described in "Do Thermals Rotate" in "Soaring", June 1988, pages 42 to 45. Finally, he threw crumpled sheets of newspaper out of an open-cockpit glider as he flew across a thermal marked by circling gliders. He tracked the sheets of paper and noted the movement using a tape recorder.

He wrote: "Do thermals rotate? You bet they do!" Of 30 successful drops, Senn found at least half showed clear thermal rotation: 10 rotated cyclonically, and five anti-cyclonically. The speed of rotation, at a 50m radius, was up to four knots.

Soaring in thermals that rotate

I have often soared in thermals that seemed to be rotating. When soaring was difficult (and I had the thermal to myself), I reversed the turn to see if the thermal became easier to work. Sometimes it was just as difficult, but sometimes it was very much easier!

I started to notice the differences between thermalling in the two directions in rotating thermals. Other pilots have noticed some of these differences.

Here is my list of effects of flying with the rotation and against it.

Flying with the rotation

- The average rate of climb was much lower than in the strongest surges.
- The air was very rough.
- I had to hold the nose of the glider low to keep good control.
- Keeping the nose steady on the horizon did not give a steady airspeed.
- The core of the thermal seemed to be small; I could stay in it only with a very steep angle of bank, if at all.
- Once found, the core was easy to lose, and seemed to move around.

Flying against the rotation

- The average rate of climb was almost as high as in the strongest surges.
- The air was very smooth.
- I could hold the nose of the glider high while keeping good control.
- The airspeed stayed steady and the nose of the glider stayed at the right height without my moving the stick.
- The core of the thermal seemed to be large; I could easily stay in it with a moderate angle of bank.
- The core seemed to stay in one place; centring called for so few control movements, the glider almost flew itself.

What causes these effects?

All of these effects follow from the movement of the air in a rotating thermal, and the response of the glider to the air movement. Parts 2 and 3 of this article explain how and why.

Technical notes

1. The late Ann Welch (writing as AC Douglas) published a sequence of photos (Figure 27a-d) of

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a rotating thin cumulus in 1943 in her book "Cloud Reading for Pilots" (London, John Murray).

2. See this web page: [www-das.uwyo.edu/-geerts/cwx/notes/chap07/tornado_form.html] for a discussion of tornado rotation. Cyclonic tornadoes do not rotate cyclonically as a direct result of the earth's rotation (the Coriolis effect). They are spawned by supercell thunderstorms that are themselves mesocyclones. Even the mesocyclones are not driven by Coriolis, but seem to be accidental features, those with cyclonic rotation being maintained by wind shear. Similarly, any tendency for thermals to rotate cyclonically is only remotely related to Coriolis.

The wind shear near the ground contains plenty of vorticity, mainly horizontal. Some of it gets stood up on end in willy-willies and rotating thermals. It is not yet clear whether the process would tend towards cyclonic rotation.

3. AG Williams and JM Hacker ("Inside Thermals", Technical Soaring, 1992, 16(2), 57-64) analysed the structure of many thermals identified from instrumented traverses over Eyre Peninsula, South Australia. Thermals sampled at a level just over half way up the convective layer showed, on the average, a cyclonic rotation. In their opinion, this result was "produced by averaging together many non-rotating thermals with a small number of strongly rotating thermals".

A major gaggle, hopefully in an anti- clockwise thermal