THE EFFECTS OF WIND GRADIENT

Flying in strong winds can be inspiring, but the BGA safety team looks at implications of flying in extreme wind conditions

'Fifty knots plus half the wind speed.' You probably use a rule-of-thumb like this to determine your minimum approach speed. Fifty knots – or the corresponding figure for your glider and payload – is chosen to give a margin over the stall for light gusts and modest errors of speed control, and give enough energy to complete the flare with the control authority to do so. In some cases and jurisdictions, aircraft are designed so that a specified multiple of the stall speed satisfies these requirements.

The second term – half the wind speed – is to allow for turbulence and wind gradients. With the right approach speed, we should always be able to make a safe landing.

Some pilots really enjoy the challenge of flying in strong winds. Our sport began with adventurous flying and, whether it involves epic distances, stratospheric wave, hilltop expeditions or ridge-running, it can certainly be inspiring. However, our usual training that all situations are recoverable doesn't always hold in extreme winds and, although pilots usually prepare thoroughly, there have been some high-profile accidents.

A much-respected pilot lost his life as a consequence of a cable break on a windy day. According to the AAIB report [1], the weak link broke when the glider had a speed of 84kt at a height of 120ft. In the recovery, the glider reached 280ft at an airspeed of 76kt. These figures illustrate an important point because in calm air, and neglecting drag, a 160ft pull-up from 84kt would reduce the airspeed to just 59kts; conversely, slowing from 84kt to 76kt would leave the glider at only 180ft. The apparent energy gain – the same as flying through a 17kt thermal – probably came from pulling up into a wind gradient: the dynamic soaring method that albatrosses are thought to use for long-distance flight [2]. Relative to the ground, the glider will indeed have slowed down more, but the stronger wind will have reduced the loss of airspeed. It presumably is also why the weak link failed in the cable.

Descent through a wind gradient

The problem comes when the process is reversed. As the glider dives through the wind gradient, it can't pick up airspeed as quickly as normal and a lot of height can be lost in the attempt. Indeed, in a strong wind gradient it can be impossible to gain speed in a dive [3]. To the pilot, this will feel like ferocious sink but, unlike sink, the effect of a wind gradient is worsened by speeding up to cross it, and can last down to the ground.

In smooth airflow, the wind speed rises logarithmically with height and 20kts at the windsock will mean 35kts at 300ft [4]. Ground features and atmospheric instability alter these figures, though: gradients are steeper in stable air over rough or wooded areas than over flat land in an unstable atmosphere [5].

Rotor and turbulence

There can be real sink too. As well as ridge flow, wave and convection, downdraughts and turbulence such as rotor involve vertical motion, often part of a circulatory vortex flow with comparable speeds horizontally and vertically. The vertical motion has to decrease near the ground as the earth is impenetrable, but there can still be local variations, including reversals, in the horizontal wind. Low down, these variations can occur on a smaller scale, typically comparable with the distance from the obstacle that causes them, and the resulting gradients will be stronger and more localised. Ridge and mountain pilots deliberately fly faster when they're close to terrain.

The effects of these variations depend upon their scale and the height at which you're flying. Roughly speaking, wind gradients above circuit height give enough height to recover, while below windsock height they are small enough to fly through provided you have adequate airspeed, though their localised effect could affect lateral control. The greatest problems can be in between, at approach heights. This is why ridge-top sites often require an impressively high approach speed and a final turn within the airfield boundary. Beware that a safe approach could mean flying at close to the glider's rough air speed limit.

Launching into a wind gradient

A winch launch involves the same height band as the approach, so a higher airspeed is appropriate before rotation into the full climb, and the rotation needs to be slightly slower [6]. If that puts you close to the glider's maximum winch speed, maybe it's time to think again. If there's a launch failure, you'll again need a higher approach speed to allow for speed loss through the gradient [7].

BGA training for after a launch failure is to land ahead if it's safe to do so. With a strong headwind and wind gradient, approaches can be made very steeply. If a turn is needed, different pilots may have different instincts. Someone used to flying from a large, flat airfield will generally turn downwind so that the drift helps position the glider for approach. A ridge pilot, on the other hand, might turn into wind to avoid curl-over and exploit any lift, with the option of a field in the valley. Wind gradients affect these two actions differently.

Manoeuvring in a wind gradient

Turning steeply in a wind gradient has its own hazards. The stronger wind aloft will blow the higher wing downwind, steepening the turn onto downwind and, conversely, resisting roll into the base leg and final turns. The design code CS22 specifies a minimum roll rate that translates directly to the wind gradient in which a given bank angle can be sustained [8]. Shallow turns are less susceptible, but, as the radius of a turn increases with airspeed, the temptation will be to bank steeply.

Bank can itself give problems in a wind gradient, again because the wings sample different wind strengths. When flying into wind, the upper wing will have a greater airspeed. Combined with its greater speed in a turn, the need to counter gradient-induced roll and the difficulty maintaining airspeed in a wind gradient, this introduces a spin risk to which gusts could also contribute. This is exacerbated by the instinctive tendency to judge low turns by reference to ground features, which can result in steep and over-ruddered turns.

Strong wind adventures

Strong winds and gradients bring conflicting considerations that take us closer to physical and aircraft limits and reduce the margin for error. High workload, quickly evolving situations and physical discomfort don't help the pilot to cope with them. Launch failure eventualities need careful assessment.

Adventurous flying in more extreme conditions can involve techniques that aren't just extensions of normal rules. This is doubtless part of its attraction. However, there are situations from which it might not be possible to recover; and, while there is knowledge out there from previous pioneers, you might be exploring the unknown.

Tim Freegarde and the BGA safety team

STRONG WINDS AND GRADIENTS INTRODUCE CONFLICTING CONSIDERATIONS THAT REDUCE THE MARGIN FOR ERROR

■ For more information about wind gradients, see Ken Stewart's *The Glider Pilot's Manual* [9] and the ICAO *Manual on Low-level Wind Shear* [10].

[1] AAIB investigation G-CFNG *https://tinyurl.com/flyright1921*
[2] G Sachs et al, PLOS ONE 7 (9), e41449 (2012) *https://tinyurl.com/flyright1922*
[3] If the headwind gradient in knots per 100ft, multiplied by the airspeed in knots, exceeds 1100 (in SI units: wind gradient x airspeed > g).
[4] Wind profile calculator *https://tinyurl.com/flyright1923*
[5] Met. Office, *Forecaster's Handbook*, p1-10 (1997) *https://tinyurl.com/flyright1924*
[6] BGA Instructor Manual, section 16 *https://tinyurl.com/flyright1925*
[7] BGA Instructor Manual [6], section 14
[8] In SI units, this equals the roll rate in rads/s divided by $\sin^2$(bank angle); a 60° turn will be overpowered by a gradient of 25kt/100ft.
[9] K Stewart, *The Glider Pilot's Manual*, 4th ed, pp109-113 (2003)
[10] ICAO, *Manual on Low-level Wind Shear*, Doc 9817 (2005) *https://tinyurl.com/flyright1926*

PREVIOUS 'FLY RIGHT' ARTICLES

The Perils of Distraction (Apr/May 19)
Keeping Safe in Thermals (June/July 19)
Why It Is Good to Think Ahead (Aug/Sep 19)

■ Clubs can obtain printed copies of Safety Briefings from the BGA Office.