IAA

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General Aviation Safety Council of Ireland

EGAST
Component of ESSI
European General Aviation Safety Team

FLIGHT CLOSE TO HIGH GROUND

FOR GENERAL AVIATION PILOTS

SAFETY PROMOTION LEAFLET

CONTENT

INTRODUCTION

Pilots who wish to operate from airfields in mountainous areas, sometimes called 'altiports', must be trained for a 'Mountain Rating'. However, in order to travel between two areas of flatter land, pilots without that training may wish to fly across hills or mountains. Several of these pilots and their passengers have suffered fatal accidents while attempting to cross mountains, or even quite low hill ranges.

This leaflet gives some basic information and advice to pilots of light aircraft who wish to cross ranges of hills or mountains, although the advice of qualified mountain flying instructors is strongly recommended.

As in all flying, pre-flight preparation is essential for success. Study your route and the shape of the land, so you are ready to escape from problems. It is also essential to study and understand the aviation weather forecast, and always expect conditions to be worse.

AIR FLOW

a. General

A hill or mountain range is often a barrier between different types of weather. Be prepared to meet either of these weather systems during a flight across the hills.

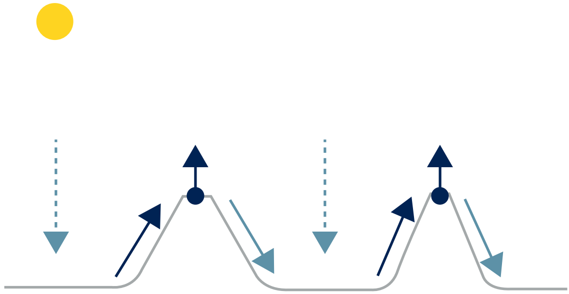
Wind is the most important factor in the weather over and around hills and mountains. You must know what wind is forecast at the altitudes you intend to fly, but even small hills will create local changes to the gradient wind. In mountainous areas the horizontal and vertical flows produced by the terrain may make the gradient wind almost irrelevant.

b. Daily heat effects

At night, the ground cools, and the air touching the ground cools with it. As it cools, air at a hill top becomes denser (heavier) than the air at the same altitude around it. It then tends to flow downhill into the valley below, often continuing through the morning. This is “katabatic” flow and is found very often in mountainous areas.

During the day, the reverse may happen, especially if there are no clouds. The hill top is generally heated by the sun’s rays as much as the valley. After a period of heating, the air in contact with the hill top will be warmer than the air at the same altitude around it, therefore less dense (lighter) so more likely to rise in convection currents. That convection from the hill top encourages air from the hillside to flow upwards to replace the rising air, especially up slopes which are also being heated by the sun directly.

This “anabatic” flow is generally less strong than katabatic flow. However, if air is moving up a slope which is being directly heated by the sun, a slope in shadow may be influenced by what is effectively katabatic flow to replace the air in the bottom of the valley.

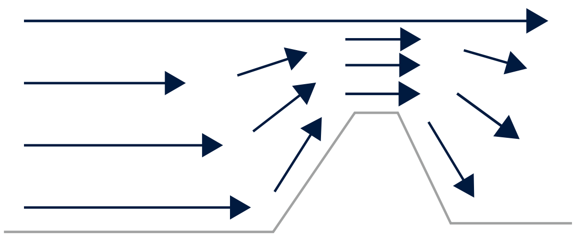


The sun’s effect on slopes

A combination of anabatic and katabatic flows up and down small valleys leading into a larger one often produces a local effect over a 24 hour period. A wind flows down the main valley (perhaps quite strongly) during the night and early morning, and then reverses direction to flow up the main valley by midday. This effect is independent of the gradient wind.

c. Cross-ridge flow

Wind which meets a ridge or line of hills cannot flow through it. Winds at altitude are almost always stronger than the gradient wind. The flow close to the top of the ridge will often be similar to the picture, especially if the air is stable.

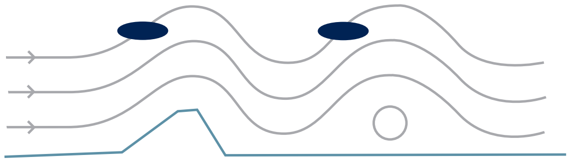


Cross-ridge flow

The wind becomes much stronger as the air crosses the top of the ridge, and the air pressure there also reduces (as 'Bernoulli' suggests), producing a 'hill error' in altimeters. Stronger winds produce more severe turbulence, and downwind of the ridge the air is sinking, perhaps faster than an aircraft's engine can overcome. Similar turbulence and downdrafts are often found downwind of a line of cliffs when flying over the sea.

When the winds at increasing heights above the ground are from more or less the same direction, and where a more stable layer lies between two unstable layers, the rising air on the windward side of the ridge may not become “squeezed”, but produce a similar rise in the air above it. This will be followed by a descent downwind of the ridge.

If the wind increases with height, the descending air downwind of the ridge may ‘bounce’ back upwards again. This produces a smooth form of wave motion in the atmosphere which can extend for a long distance downwind (or to ‘lee’) of the ridge, and to great heights, even into the stratosphere. The vertical motion may exceed a thousand feet per minute at times, and glider pilots use the rising air to make high and sometimes long flights. For the pilot of a powered aircraft, the sinking air is a hazard - downwind of the ridge, the aircraft may not be able to climb, even with full power selected. The best action may be to turn downwind until the sinking air starts to rise again, when a turn can be made back into wind.



Wave motion and rotor

At the bottom of a wave 'bounce', the "trough", the surface wind is stronger than the gradient wind. Under the wave "crest", it is lighter. If the motion at low altitudes is strong, the first 'bounce' may induce a circulation in the air below it. This "rotor" can produce not only severe turbulence, but possibly also a surface wind which is the complete reverse of the gradient wind.

Wave cloud

As atmospheric conditions change, the wavelength may change quite rapidly. Pilots approaching to land in the lee of a ridge must be prepared for sudden changes in the surface wind as well as downdrafts.

Conditions do not always allow waves to form. If for example the wind reduces with height above the ridge line, the whole wave motion may break down into turbulence flowing downwind from the ridge top. This "rotor streaming" turbulence is usually worst at the altitude of the ridge top, and may cause control difficulties or even structural failure.

d. Funnelling

Although unstable air will rise over high ground, stable air usually takes the easiest route, and flows round an obstruction rather than over it. Air will try to flow between hills and along valleys. Even in unstable air with a notable gradient wind, if heating effects are weak (for example under cloud), the wind will follow the valleys rather than climb.

This "funnel effect" will increase the speed of the flow to more than the gradient wind, especially as the valleys narrow and where a valley floor rises to cross a 'saddle' or pass between two hills. Valleys usually twist and turn, and the surface wind may sometimes flow completely opposite the gradient direction.
In general, the narrower the valley, the stronger the wind.
Turbulence can be expected where valleys meet, and also downwind of any ridge which juts into the valley.

e. Combinations

Hills and ridges are never isolated, and the flow over and round one hill has an effect on the flow over and around the next one, and its neighbours. Wave motion from one hill will interfere with flow from another, creating more turbulence than might be expected from the flow over one hill only.

To fully understand the interaction between these flows and the winds along valleys requires a considerable amount of study and local knowledge.

CLOUD AND VISIBILITY

a. Hill fog

Where air flow upwards, it cools. If moist air flowing up a ridge cools below its 'dew point', cloud will form. It may form above the hill top, or on the slope where it will hide the ground from view, and it may be impossible to see the difference between cloud and a snow covered hilltop.

Because air may have arrived along valleys from different starting points, cloud may form, or its base may change, without warning. Even a sloping valley floor may suddenly become covered in cloud.

Cumulus forming

In unstable air, the upward motion will cause convection currents to rise vertically from a slope, forming cloud, perhaps cumulonimbus, extending outwards from the peak.

b. Wave cloud

Wave motion may produce obvious "lenticular" clouds, which form in the rising air and die where the air is sinking. A cloud which appears to 'roll' in the sky indicates 'rotor' turbulence and should be avoided by a large distance; the only safe option for a light aircraft may be to turn back.

However, the wave pattern may only be recognisable by the gaps in a broken cloud sheet produced by the descending air, and not by seeing lenticular cloud in the rising air. If cloud gaps appear to stay over the same point on the ground, be prepared for the effects of wave motion. Rate of climb will be slow in the sinking air, and patches of cloud will continue to form in front of the downwind edge of the gap, possibly around the climbing aircraft. Even in apparently smooth wave conditions, there can be severe turbulence where rising and sinking air meet.

c. Turbulence indications

Cloud often indicates turbulence, especially if it is ragged or appears to be 'tumbling'. However the lack of cloud does not mean a lack of turbulence!

d. Visibility

Sinking air usually produces no cloud. However, it also prevents dust and moist air from rising and mixing with the air above, so visibility on the surface or on an approach to land can be very poor. There may also be a considerable wind shear as an aircraft descends or climbs through any temperature inversion.

In unstable air, precipitation from towering cumulus or cumulonimbus may reduce visibility and hide the ground ahead. Snow showers severely reduce visibility, and snow covered ridges can produce “whiteout”.

a. Navigation

Features, even mountains, may not be easily identifiable from above. Cloud forming over them may hide their shapes, and the different light levels as sunlight strikes the ground below can confuse pilots who are navigating visually. Apart from using GPS, pilots should use terrestrial navigation in combination with dead reckoning.

True airspeed for a given indicated airspeed increases with altitude. Winds at altitude are usually stronger than at lower levels. Navigation calculations must be accurate.

b. Performance

Aircraft performance reduces with altitude. Less power is available from piston engines without turbochargers, and the power required to maintain level flight increases. The IAS for best rate of climb also reduces.

Human performance also reduces at high altitudes. Unless the aircraft cabin is pressurised, pilots must use supplemental oxygen when flying above an altitude of 13,000 feet, or if flying above 10,000 feet for more than 30 minutes. Even below 10,000 feet, the ability of many pilots, especially those who smoke, to make calculations and sensible decisions will reduce, unless supplementary oxygen is used. Unfortunately, an affected pilot will not notice a problem, or believe he has one.

If flying well above the horizon, with no distant object in the field of view, eyes tend to focus at close range. Pilots must deliberately re-focus on a distant object to be able to see approaching aircraft.

c. Flight close to mountain tops

The previous paragraph may encourage pilots to fly as low as they can above the mountain tops, or cloud tops if cloud is present. Unfortunately, the wind flows described earlier can easily drag an aircraft down as it approaches a ridge line or saddle. Turbulence downwind of a ridge has been known to cause light aeroplanes to break up.

What is the air doing here?

Light patterns and snow may make it difficult to distinguish close peaks from distant ones, so a pilot may not realise he is approaching a ridge. To minimise the hazards of sink or turbulence, overfly mountain ranges as high as your aircraft performance and oxygen system allows. If mountain waves are forecast or apparent, many mountain flying instructors recommend pilots to stay at least as high above the mountains as the mountains are above the local terrain.

d. Cloud avoidance

The increased probability and effect of icing should discourage pilots from flying in cloud over hills.

VALLEY FLYING

a. Why?

Should I?

Earlier paragraphs should deter you from attempting to fly along valleys. However, there may be good reasons to fly through a range of hills or mountains below the peaks, and if you plan to do so, obtain proper instruction. If all the forecast winds up to well above the elevation of the peaks are very light, the hazards may appear acceptable.

b. Flight alongside a hill range

Flying along the downwind side of a range of hills is very risky, and should be avoided if possible. Flying along the upwind side should be relatively safe, although updrafts close to the hillside may lift a light aircraft into any cloud which is forming, especially if the sun is shining on the slope. In broad valleys, fly to the right of the centre.

c. Valley navigation

It is difficult to choose the correct valley to follow unless the pilot is totally familiar with the area. Even vertical features are often hidden. Valleys which lead through a range of hills are usually major road routes with settlements beside them, but it is not always possible to identify these. It is vital to plan headings, and times to turn, accurately, and refer to the plan before turning.

VHF signals are blocked by the terrain, and NDB signals bend. GPS signals may also be screened by the high ground, so do not rely too much on them.

d. Valley hazards

Weather changes rapidly in valleys. Several pilots have turned back, only to find their escape route has been closed by fog, snow or heavy rain.

Other types of aviators also use hill slopes. Watch out for them.

Power lines, telephone wires, and cable cars make valleys even more hazardous. These are mainly found close to the slopes, but they can all, especially power lines, stretch across valleys. Although most states place markers along the most hazardous ones, cables and wires can be almost impossible to see in certain light conditions, and even the supporting posts may be difficult to spot.

e. Valley following

Valleys often end in slopes which are steeper than a light aircraft's best angle of climb, frequently just after a bend. Always be ready to turn round. Know how to make a minimum radius turn in your aircraft, and what that radius is. Practice the technique regularly over flat ground, and do not continue if the valley ahead may be narrower than your turning circle.

The sun shining on a slope encourages updrafts, which then encourages downdrafts on shaded slopes. Fly along the sunny side of a valley; it will not only reduce the risk of downdrafts but also reduce your turning radius. Never turn towards a hill.

f. Airspeed maintenance

There is no usable horizon below the hill tops. Know the recommended turbulence speed for your aircraft, achieve it and trim to it in smooth air. Valley floors are not level; monitor airspeed closely. If speed tries to reduce, be ready to lower the nose to regain it immediately; in a downdraft you may need quite a steep attitude.

g. Bends

Follow the sunny side of a valley, but try to apply the ‘racing line’ technique to give maximum visibility around bends, unless high-speed military traffic is likely. Move over towards the outside of the bend early, and do not continue around a bend if you cannot see the valley beyond it.

h. Height to fly

Over uninhabited countryside it is tempting to fly closer to the ground than the legal minimum. It is not safe to do so. You should fly as high as you can while staying far enough below cloud to have a clear view ahead and around. In a single engined aircraft you should ideally be able to glide to a forced-landing area.

i. Ridge crossing

Crossing from one valley to another over a saddle or ridge offers all the hazards described earlier. It is probably quite safe to cross from one sunny windward slope to another, but try to avoid flying over a downwind or shaded area. However it may be possible in light winds if the pilot can gain sufficient height beforehand.

Always climb above the ridge well before the actual crossing. This minimises the risk of descending into the hill. It also gives a view of the other side to identify the route beyond and what wind flow is likely to be encountered. You can also see aircraft coming the other way.

Approach the ridge from along it rather than directly towards. If a downdraft is encountered, you lose less distance and time when turning through 120 degrees than turning through 180. Always know your escape route and be ready to take it.

Crossing a ridge line

EMERGENCIES

a. Turbulence

Always be ready for turbulence. If you encounter unexpected problems, try to maintain the attitude which normally gives turbulence speed if you can, rather than trying to chase it. Do not apply large angles of bank; make smooth control movements to turn gently towards calmer air.

b. Engine failure

If a forced landing is necessary, safe landing fields may be difficult to find, although pre-flight preparation may help. Multi-engined aircraft may be unable to maintain enough altitude to cross a ridge line. Remember the advice for valley flying and navigate towards low ground.

Ideally, fly high enough to be able to reach a wide valley if power fails. However do not stretch a marginal glide trying to cross a ridge line.

Fields will be small and sloping. A straight part of a major road may provide the best forced landing option. Landing into wind reduces groundspeed, so identify the wind direction early, perhaps by flying in circles as you descend. Landing uphill shortens the landing run, but may be downwind.

c. Diversion and survival

Know where you can find safe diversion airfields with no wind or turbulence problems. Carry sufficient fuel to reach one at all times, and always be ready to turn back. File a flight plan or make sure a responsible person knows your route.

Wear, or at least carry, clothing and equipment to survive on the hill tops if you have to make a forced landing.

SUMMARY

- Study the weather forecast but expect things to deteriorate rapidly
- Fly as high as cloud, aircraft performance and oxygen allow
- Remember your performance reduces with altitude
- If a mountain wave is forecast, stay at least as high above the hills as the hills are above the local terrain
- Obtain instruction before planning to fly in valleys
- Avoid valleys in even moderate winds
- Never approach a ridge into wind, cross others high at an angle
- Fly along the sunny side of valleys, but beware of wires
- Turn round before the valley gets too narrow to do so
- Practise steep turns regularly
- Always know your escape route and be ready to take it
- Carry plenty of fuel and be ready to turn back or divert
- Carry clothing and equipment to survive on the hill tops
- Cross mountains along recommended VFR transit routes, where published.
- Know where you can find safe diversion airfields with no wind or turbulence problems.

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June 2013

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