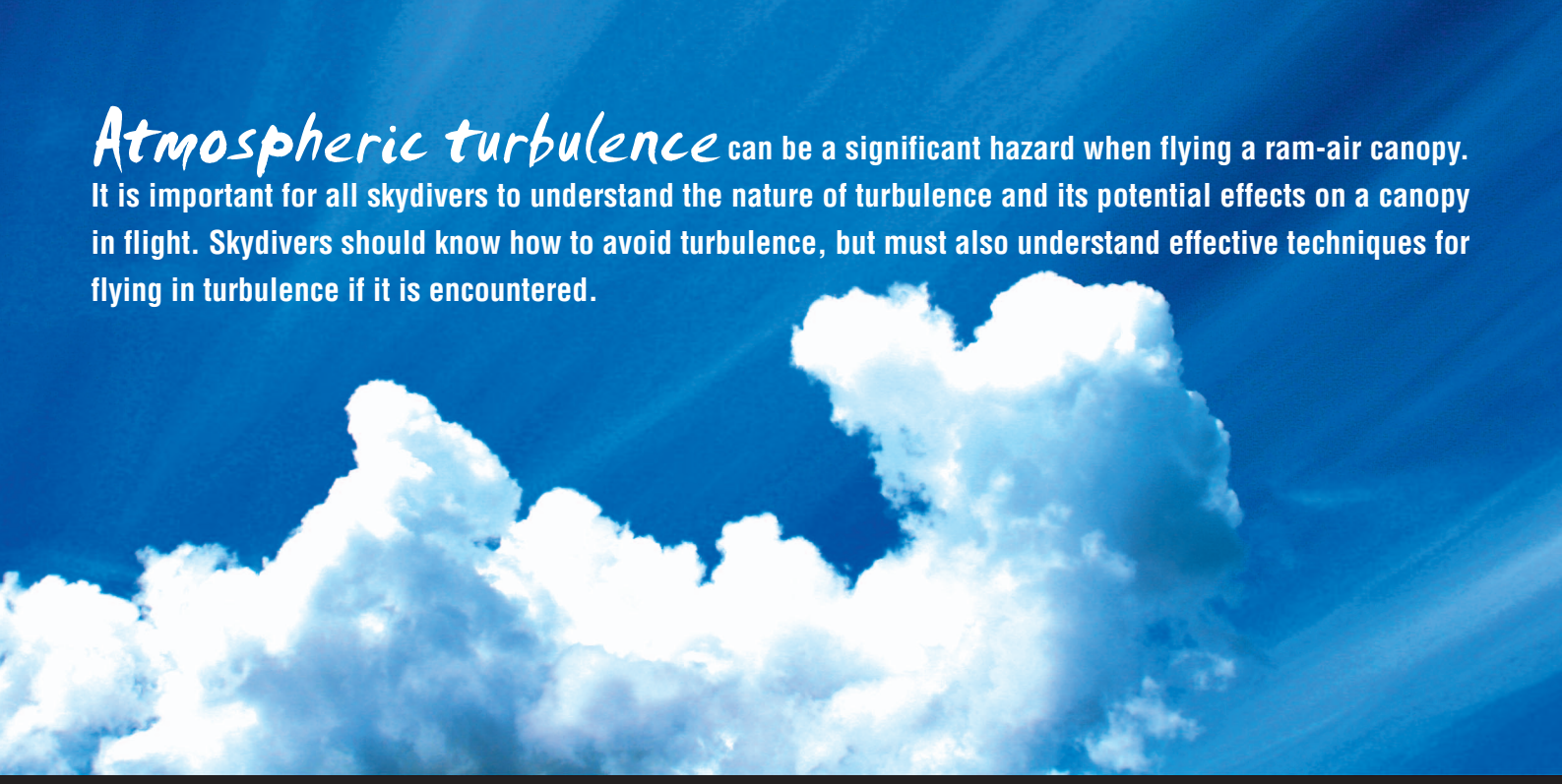

Atmospheric turbulence can be a significant hazard when flying a ram-air canopy. It is important for all skydivers to understand the nature of turbulence and its potential effects on a canopy in flight. Skydivers should know how to avoid turbulence, but must also understand effective techniques for flying in turbulence if it is encountered.

Presented by Scott Miller at the 2005 PIA Symposium and 2006 APF Conference.

Turbulence

The Invisible Hazard

Some knowledge of **basic aerodynamics** is helpful when discussing turbulence:

When flying a canopy you feel **relative wind** created by the movement of your body and canopy through the air.

Lift is generated by the flow of relative wind around the canopy. The speed of this flow (airspeed) can affect the amount of lift generated by the wing.

Angle of attack is the angle at which the relative wind intersects a particular section of a wing. As with changes in airspeed, changing the angle of attack can affect the amount of lift created. In normal flight the wing will have a **positive** angle of attack. If the angle of attack at a particular section of the wing reaches **zero**, that part of the wing will not create lift. An extremely high **(critical)** angle of attack will cause the wing to stall. A **negative** angle of attack can cause lift to be created in the "wrong" direction. For example, aerobatic planes are able to fly inverted by maintaining a negative angle of attack.

The movement of air across the ground can be called **atmospheric wind. Under normal conditions, atmospheric wind only affects the speed and direction of the canopy's movement across the ground.** In spite of the beliefs held by some jumpers, a steady wind will not affect the canopy's airspeed, angle of attack, or any other aspect of its aerodynamic performance in flight; neither you nor your canopy will be able to "feel" the atmospheric wind when you are flying. The only wind the canopy or the pilot will normally feel in flight is relative wind created by the movement of the canopy through the air.

> "Turbulence occurs when there are sudden, abrupt changes in the velocity of the atmospheric wind"

Velocity is a combination of speed and direction. If the speed of the wind changes, the direction changes, or both change at the same time, we can say there has been a change in the velocity of the wind.

Turbulence occurs when there are sudden, abrupt changes in the velocity of the atmospheric wind. Unlike steady wind, turbulence can change a wing's airspeed and angle of attack, thereby altering the lift produced by the wing. These changes may only affect a certain part of the wing, or they may affect the entire wing at once. Turbulence can cause a canopy to slow down, speed up, turn, climb, or dive and can also partially or severely distort the shape of the canopy.

Types of Turbulence

If you stay in one location, and the velocity of the wind changes at that location, we call this a gust. The strength of a **gust** is determined by the difference between the sustained wind speed and the peak (gust) speed. Larger differences usually create more hazardous flying conditions.

If you move from one location to another and there is a significant change in the velocity of the wind between those two points, we call this **wind shear**. You experience wind shear on days when the wind is very strong when you first open your canopy, but is much lighter once you

Thunderstorms are created by large-scale thermal activity in the atmosphere and produce severe turbulence that can extend a significant distance from the visible portion of the storm. Any time there are thunderstorms in the vicinity, or it appears that one might be developing, keep a close watch on the weather and use good judgment before boarding the aircraft. Large, heavy aircraft like commercial airliners are much more resistant to the effects of turbulence than skydiving canopies, but even the pilots of these aircraft normally try to remain several miles away from large thunderstorms. As with dust devils, advice from experienced local jumpers can be valuable in areas where thunderstorms are common.

Flying in Turbulence

In some situations turbulence can cause a canopy to "collapse," or suddenly lose its normal shape. Because this can be the most startling and noticeable effect of turbulence, skydivers often focus on the need to keep a canopy "pressurised" in turbulent conditions. Unfortunately this philosophy can have undesirable effects.

For example, many skydivers have been told that if they experience turbulence they should apply 25% to 50% brakes in order to keep the canopy from collapsing. This did seem to help some early ram-air canopies fly more smoothly in turbulence, but most modern designs actually handle turbulence better while flying at full glide. A modern canopy may actually experience more significant effects from turbulence when flown in brakes.

It is also important to realize that a canopy can be severely affected by turbulence without collapsing or distorting. Turbulence may cause sudden, unwanted heading changes or a sudden loss of altitude with or without any visible distortion of the wing. In fact, many of the effects that we experience under canopy in turbulence are actually similar or identical to those experienced in a rigid-winged aircraft. Rather than resulting from a loss of pressure, these effects can be explained as sudden changes in airspeed or angle of attack affecting either the entire wing or part of it.

As in any other situation, flying the canopy should be your main priority in turbulent conditions. If the canopy suddenly starts to turn, dive, or drop you must be ready to react to these changes and keep the canopy on your intended flight path, especially if this happens near the ground. Even if the canopy does start to distort or collapse, in most cases only part of the canopy is affected and it will quickly recover on its own. Preventing the canopy from turning or diving will give it more time to recover. Trying to keep your canopy "pressurised," or trying to "re-inflate" the part of the canopy that has collapsed, may actually distract you from the more important task of controlling your heading and rate of descent.

If turbulence does cause the canopy to start turning or diving near the ground, use smooth but deliberate toggle inputs to:

1) **stop or reduce any sudden loss of altitude;**
2) **keep the canopy level and on heading, stopping any significant bank or turn; and**
3) **keep the canopy flying toward a clear, safe landing area.**

For example, if the canopy suddenly banks or turns to the right on final approach, smoothly but quickly pull the opposite (left) toggle as far as is needed to get the wing level and stop the turn. If you have enough altitude to do so safely, smoothly steer back on to your original heading.

If the canopy suddenly surges or dives during the last few seconds of your final approach you may need to start flaring early in order to stop the canopy from accelerating and minimise the altitude lost.

If you feel a sudden turn or drop after you start to flare, **keep flaring the canopy!** Focus on a clear area in front of you and try to make the canopy fly straight while you continue pushing both toggles down.

If the canopy starts to climb while you are flaring, focus on a clear area in front of you and **keep the canopy flying straight.** When the canopy starts to descend again, continue flaring.

Always be ready to perform a parachute landing roll (PLR) when landing in turbulent conditions. Turbulence may cause you to land much harder than you expect to and a PLR may be necessary.

You should be ready to take any or all of these actions in case you encounter strong turbulence close to the ground; however, it is certainly not necessary to react to every small bump you feel. Flying at full glide will usually reduce the amount of turbulence you feel in the first place and make the effects less severe. When making turns in turbulent conditions, particularly at lower altitudes, keeping the turns smooth and steady will also help. Quick, abrupt turns can make a canopy more susceptible to the effects of turbulence.

High-Performance Landings

Jumpers who practice high-performance "swoop" landings sometimes feel less turbulence than those who perform more conservative landings. This suggests that there is an advantage to making a faster approach in turbulent conditions, but there can also be disadvantages.

First of all, if you do not normally make high-speed approaches then a gusty, bumpy day is probably not the best time to start practicing them. Many jumpers use a turn to generate speed during a high-performance landing. As we mentioned earlier, a canopy can be more susceptible to turbulence during a turn. Particularly in turbulent conditions, jumpers who make standard, conservative approaches or smooth "carving" front riser approaches face less risk than those who make quick, snappy "hook" turns.

As mentioned earlier, the speed of the wind itself will not change the aerodynamic performance of a canopy, including the amount of altitude required to recover from a certain manoeuver. This distance is known as the length of the **recovery arc.** Unlike steady wind, turbulence **can** affect the length of the recovery arc. Since the effects of turbulence are difficult to predict, jumpers making high-speed approaches should use extra caution whenever significant turbulence might be present in the landing area.

Front riser inputs distort the shape of the wing to some degree and may make a canopy more susceptible to the effects of turbulence. If you feel the front riser pressure suddenly decrease during a high-speed approach, smoothly release the front risers and return to a more conservative flight mode.

If a canopy's steering lines are too short it may "hobble" or "buck" when the front risers are pulled. Although this is annoying and can reduce the effectiveness of the front risers, it is usually not dangerous in smooth air; however, the hobbling may be exaggerated by turbulent conditions, possibly to the point of being dangerous.