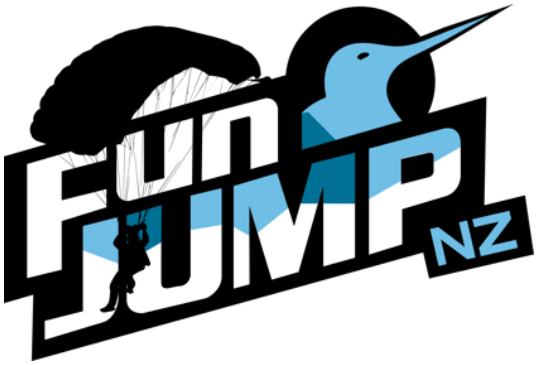


Wind Calculator

User guide and calculation manual

This app estimates how fast a skydiving canopy flies forward through the air, and therefore how strong a headwind it takes before you stop moving forward over the ground, or start going backwards. It also shows how that changes with height as the wind gets stronger. This document has two parts: a user guide (how to use each control and read each graph) and a calculation manual (the maths behind the numbers, and its limits).

Please read first. Every number in the app is an **estimate**. Canopy manufacturers do not publish forward airspeeds, so the lift coefficients used here are estimated per canopy class, not measured per canopy. The app is a planning and teaching aid. It does not replace your drop zone wind limits, your instructors, or your own judgement on the day.

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Part 1: User guide

The idea in one minute

Your canopy flies forward through the air at some speed (its **airspeed**). If you fly straight into a headwind, your speed over the ground is the airspeed minus the wind. When the wind equals your airspeed you hover over one spot (the **hold speed**). Any stronger and you go backwards. Heavier wing loading means a faster canopy, so it holds in stronger wind.

Step by step

1. Pick your canopy. Use the dropdown, grouped by brand (Jyro, Performance Designs, Aerodyne, Fluid Wings, Reserves, Other). The note under it shows the canopy class and the loading range the manufacturer or the app expects. If your canopy is not listed, pick one with a similar planform and performance, or choose **Custom** at the bottom and enter your own lift coefficient (see Part 2). Until you choose, the results stay empty on purpose.

2. Choose your units. Speeds can be shown in knots, mph or km/h. Weights can be entered in lb or kg. Changing the speed unit converts the gust and wind numbers you have already typed.

3. Set your wing loading. Use the toggle. **I know my wing loading** shows a slider (0.4 to 5.0 lb/ft^2) and a box where you can type the number. **Calculate it for me** shows a separate calculator: choose lb or kg, enter your body weight, your gear weight (typically about 25 lb or 11 kg for a rig, jumpsuit and helmet) and your canopy size in ft^2 or m^2. The app divides total weight by canopy area. The wing loading in use is always shown in lb/ft^2 and kg/m^2. If it is outside the normal range for that canopy, a red warning appears.

4. Set the air (under More options). Enter the landing elevation and the air temperature. Hot or high air is thinner, so the same canopy flies faster through it. The app shows the resulting density altitude. (The live weather section can fill these in for you.)

5. Gust allowance (under More options). Enter how much stronger the gusts are than the average wind. The app uses this to show a safer limit and a dashed line on the graphs.

6. Flight mode (under More options). Full flight is the default and the best case for penetration. Rear risers, half brakes and front risers apply a rough speed adjustment (see Part 2).

The wind simulator (the quickest way to understand it)

Right under your canopy settings is a picture of a parachute flying to the **right**. Wind arrows point **left** when the wind comes from the front (a headwind). The number on the canopy is your estimated speed over the ground, as a range. Drag the wind slider (from 80 knots of tailwind on the left to 80 knots of headwind on the right) and watch the number change. The ground and the wind lines also move to show it. The status box under the picture tells you in plain words what is happening:

Colour	What it means
Green: FORWARD	You are moving forward over the ground with good progress.
Orange: FORWARD, BUT SLOW	Wind is above about 60% of your airspeed. You still move forward but a gust or some sink could stop you.
Yellow: COMING STRAIGHT DOWN	The wind is about equal to your airspeed. You hardly move over the ground and may drift either way.
Red: GOING BACKWARDS	The wind is stronger than your canopy airspeed. The ground speed is negative.
Blue: TAILWIND	Wind from behind adds to your speed. Ground speed can be very high.

The coloured bar above the slider shows these zones for your canopy and loading. Three buttons jump the slider to no wind, to where progress gets slow, and to where you stop. Use the unit buttons to show knots, mph or km/h.

Reading the results

Card	What it means
Airspeed in still air	The range of speeds your canopy flies through the air. Shown as low to high because of the uncertainty.
Hold still at	The headwind at which your ground speed reaches zero. Above this you go backwards. Low end of the range is the cautious number.
Caution starts around	About 60% of the hold speed. A rule of thumb for when forward progress is getting poor, not an official limit.
Max mean wind allowing for gusts	The low-end hold speed minus your gust allowance. A gust can briefly add that much wind on top of the average.

Graph 1: ground speed against headwind

The horizontal axis is the headwind, the vertical axis is your forward speed over the ground. The blue band is the estimated range: the black line is the high estimate and the teal line is the low estimate. Where a line crosses the zero line you stop. The pink area below zero means going backwards. The amber dashed line marks the gust limit. The table below the graph gives the same figures in rows.

Graph 2: wind by height

This is the one most people find most useful. The vertical axis is height above ground, the horizontal axis is speed. The blue band is your canopy airspeed range (it widens a little with height because the air gets thinner). The black line is the wind speed at each height, and the red dashed line adds your gust allowance. Wind is usually stronger higher up, so the line leans right as it climbs. **Where the black line moves into the blue band, you stop making forward progress at that height.** A sentence under the graph gives the approximate height, and the table lists wind and ground speed at 50 to 3000 ft.

Live weather and the manual estimate

Under **Wind source** you can use a **Live forecast** or a **Manual estimate**. For live data, search for your drop zone by place name (or tap Use my location) and pick a forecast hour. The app then fills in temperature, air pressure, elevation and a gust allowance from the forecast, and builds the wind profile from the forecast winds at about 10, 80, 120 and 180 m and at pressure levels above that. If you are offline or want to test a scenario, use the Manual estimate: enter the surface wind and choose the terrain type, and the app estimates how the wind increases with height.

Practical tips

• Judge conditions by the **low-end** numbers and the height graph, not the high-end ones.
• Remember wind near the ground is often lower than wind at 500 ft. Check the height graph for where you stop making headway.
• Use your windsock and local knowledge before the live forecast. A forecast model cannot see hills, buildings, trees, sea breezes or rotor.
• Brake lines that have shrunk can leave a canopy partly in brakes with the toggles up. That reduces penetration. Have your rigger check them.
• Install it on your phone: open the site, choose Add to Home Screen (iPhone: Share, then Add to Home Screen; Android: menu, then Install app).

Part 2: How the calculations work

1. Wing loading

Wing loading is total weight divided by canopy area:

Wing loading = (body weight + gear weight) ÷ canopy area

Weights are converted to pounds and areas to square feet. Example: 75 kg body + 11 kg gear = 86 kg = 189.6 lb. On a 140 ft^2 canopy that gives 189.6 ÷ 140 = 1.35 lb/ft^2 (6.6 kg/m^2). Conversions used: 1 lb = 0.4536 kg, 1 ft^2 = 0.0929 m^2, 1 lb/ft^2 = 4.882 kg/m^2.

2. Airspeed

A canopy in steady straight flight balances weight with lift. That gives the standard wing equation, solved for speed:

$$V = \sqrt{(2 \times W \div (\rho \times S \times C_L))} \quad \text{or, with W/S = wing loading:} \quad V = \sqrt{(2 \times (W/S) \div (\rho \times C_L))}$$

W/S is wing loading in newtons per square metre (1 lb/ft^2 = 47.88 N/m^2), ρ is air density in kg/m^3, C_L is the canopy lift coefficient on its nominal area, and V comes out in m/s. The app converts to knots (× 1.944), mph (× 2.237) or km/h (× 3.6). The key consequence is that **speed rises with the square root of wing loading**. Going from 1.3 to 2.2 lb/ft^2 makes a canopy about 30% faster.

3. Lift coefficient by class

C_L is the hardest number to know. Published research on ram-air wings gives values of roughly 0.5 to 0.7, and a US Forest Service training guide quotes about 20 to 25 mph maximum airspeed for a large lightly loaded main. Performance Designs states that different models of the same size fly at about the same speed, with wing loading the biggest factor. So the app groups canopies into classes with an estimated C_L range. Flatter-trimmed, higher-performance wings get a lower C_L and so a higher speed. The low end of the speed range uses the high C_L and the high end uses the low C_L.

Class	C_L range	Typical loading checked
Student / docile	0.58 to 0.72	0.6 to 1.2
Sport	0.54 to 0.68	1.0 to 1.7
Performance	0.50 to 0.64	1.3 to 2.2
High-performance	0.48 to 0.62	1.6 to 2.8
Hyper-performance	0.44 to 0.58	2.2 to 4.5
Tandem / reserve	0.58 to 0.72	0.9 to 1.4 / 0.8 to 1.5

Where a manufacturer publishes a loading range for a canopy (Jyro and Aerodyne in this version), that range is used for the warning instead of the class range. Which class each model sits in is my judgement from manufacturer descriptions, and can be corrected in the code (see Part 3). **Custom** uses the lift coefficient you enter, plus or minus 0.04.

4. Air density (elevation and temperature)

Density comes from the ideal gas law using pressure and temperature: ρ = p ÷ (287.05 × T), with T in kelvin. Pressure at your elevation uses the standard atmosphere, $p = 101325 \times (1 - 2.25577 \times 10^{-5} \times h)^{5.25588}$ Pa, with h in metres. If you load live weather, the forecast surface pressure replaces that. Thinner air gives a higher true airspeed because V is proportional to 1/√ρ. The density altitude shown is the standard-atmosphere altitude with the same density.

5. Flight mode adjustments

Mode	Speed multiplier (low to high)	Basis
Full flight	1.00	Baseline
Rear risers	0.85 to 0.95	Estimate
Half brakes	0.65 to 0.80	Estimate
Front risers	1.10 to 1.25	Estimate

These multipliers are **assumed tuning factors** applied to the calculated full-flight speed. They are not derived from the lift equation. The sources I found confirm the direction (brakes reduce forward speed, front risers add it) but give no figures, so the values are rough and an experienced canopy pilot may well disagree with them. Treat anything other than full flight with extra caution.

6. Hold speed, caution and gust limit

Ground speed in a straight headwind = airspeed − wind. This is a simplified one-line model: both speeds are **horizontal speeds measured along the wind direction**. The app does not model the full velocity vector of the canopy (descent, turns or crosswind drift). **Hold speed** is the wind at which that reaches zero, so it equals the airspeed range. **Caution** is 60% of that (a rule of thumb). The **gust-adjusted limit** is the low-end airspeed minus the gust allowance, because the gust adds to the average wind. Both the wind and the speeds are always in a straight headwind. Crosswinds are not modelled.

7. Wind by height

Wind speed is built as a profile with height above ground. **Manual estimate:** a power law, $\text{wind}(h) = \text{wind}_{10\ \text{m}} \times (h \div 10\ \text{m})^{\alpha}$, with $\alpha = 0.14$ for open flat ground, 0.20 for rural with some trees and 0.28 for suburban or heavily treed ground. **Live forecast:** wind at about 10, 80, 120 and 180 m above ground from the weather model, plus winds at pressure levels (1000 to 850 hPa) converted to height above ground using the model elevation, with straight-line interpolation between points. The canopy airspeed is also corrected for height. Air density is compared at the landing elevation and at landing elevation plus height above ground, using a local standard-atmosphere approximation: $V(h) = V_{\text{ground}} \times [\ (1 - k(E + h)) \div (1 - kE)\ ]^{-2.128}$, where $k = 2.25577 \times 10^{-5}$ per metre, E is the landing elevation above sea level and h is height above ground (both in metres). So airspeed rises slightly with height. The approximation ignores temperature differences from the standard lapse rate. The graph marks the first height where wind ≥ airspeed.

8. Live weather data

Live data comes from Open-Meteo.com (a free forecast service, CC BY 4.0, free for non-commercial use), the same service the Winds Aloft site uses outside North America. The app requests temperature, surface pressure, 10 m wind, gusts and wind at several heights, for the 24 hours from now in your location's local time. The gust allowance is set to the forecast gust minus the forecast 10 m wind. This is model output on a coarse grid, so use it as a guide only.

Worked examples

Scenario	Calculation	Result
Sport class canopy, loading 1.3, sea level, 15°C	$V = \sqrt{(2 \times 62.2 \div (1.225 \times C_L))}$, C_L 0.68 and 0.54	24 to 27 kts (27 to 31 mph)
Same canopy at 2000 ft, 25°C	Density 1.101 instead of 1.225 kg/m^3	25 to 28 kts
Hyper-performance canopy, loading 2.5, sea level, 15°C	C_L 0.58 and 0.44	36 to 41 kts
Caution and gust limit for the first row	60% of 24 to 27 kts; gust 5 kts	14 to 16 kts; gust limit 19 kts

Part 3: Limits, and how to improve accuracy

What the app does not model

• Wind direction other than a straight headwind, turns, and crosswind drift.
• Turbulence, rotor, thermals and gusts beyond the allowance you enter.
• Local terrain, obstructions and sea breeze (the live model cannot see them).
• Canopy age, line trim, brake line shrinkage, exact exit weight with clothing, and canopy size effects. Smaller canopies have more drag from the jumper and lines.
• The glide angle correction (airspeed is a few percent lower than the simple formula on a descending glide path).
• Diving, swooping and braked flare manoeuvres.

Where the uncertainty is

The biggest uncertainty is the lift coefficient for each canopy. It is estimated by class, not measured. As a practical planning estimate, treat the results as potentially plus or minus 10 to 15%. This is a cautious rule of thumb, not a statistical error bound calculated from the equations. The largest sources are the assumed lift coefficient and the actual local wind. A second is wind: real wind at your landing area can differ a lot from a forecast or a windsock reading.

Improving it with your own data (GPS method)

1. Log a GPS track (a watch, phone app or logger that records ground speed). 2. At a steady altitude well clear of the ground and other canopies, fly a straight, steady, full-flight leg downwind, then a straight, steady, full-flight leg upwind, at the same brake setting. 3. Read the average ground speed on each leg. Then:

$$\text{Airspeed} = (\text{downwind ground speed} + \text{upwind ground speed}) \div 2$$
$$\text{Wind} = (\text{downwind ground speed} - \text{upwind ground speed}) \div 2$$

These equations assume the wind and the canopy airspeed stay approximately constant between the two legs, and that both legs are flown on the same heading directly into and directly with the wind. A broad diagonal flight does not give a valid result. Repeat a few times and average. To get the canopy's lift coefficient from a measured airspeed:

$$C_L = 2 \times (W/S) \div (\rho \times V^2) \quad (W/S \text{ in } N/m^2 = lb/ft^2 \times 47.88;\ V \text{ in } m/s)$$

Enter that value under **Custom** in the app to get a result tuned to your canopy at your loading. If you gather results for several canopies and loadings, the class values in the code can be replaced with them. Doing this for each canopy at two or three loadings would also confirm whether speed really follows the square root of wing loading for it.

Changing the canopy list and numbers

The canopy list and class values are in the script at the bottom of **index.html**. **const C** holds the lift coefficient ranges, **const T** the typical loading ranges, **const M** the flight-mode multipliers and **const L** the canopy list. Each canopy entry is [name, class, note] with an optional manufacturer loading range. Edit and redeploy the folder to Netlify.

Sources used

Jyro canopy progression chart and wing loading guidance (jyro.com); Performance Designs product pages and the "Wing Loading and Its Effects" seminar notes; Aerodyne main canopy selector; Fluid Wings product pages; US Forest Service Ram-Air Parachute Training Guide (2018); published ram-air wing aerodynamics studies; Open-Meteo.com forecast API; Mark Schulze's Winds Aloft (markschulze.net/winds).

Disclaimer. This tool gives estimates for education and planning only. It is not a substitute for drop zone wind limits, instructor advice or your own assessment of the conditions. Fun Jump NZ accepts no liability for decisions made using it.