The phase diagram of soaring: flight mode transitions in combinations of isolated and aligned lift patterns

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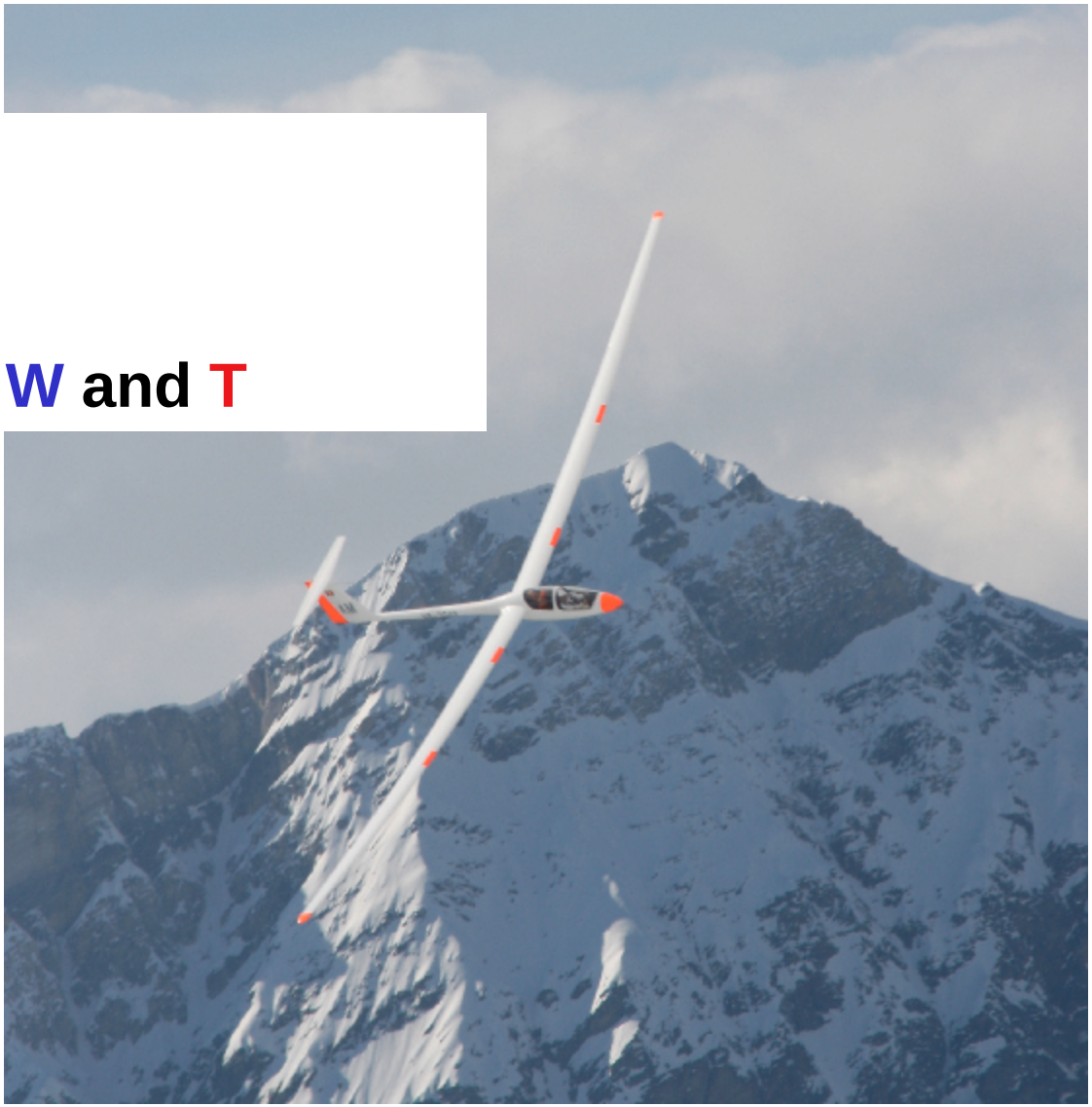
Outline

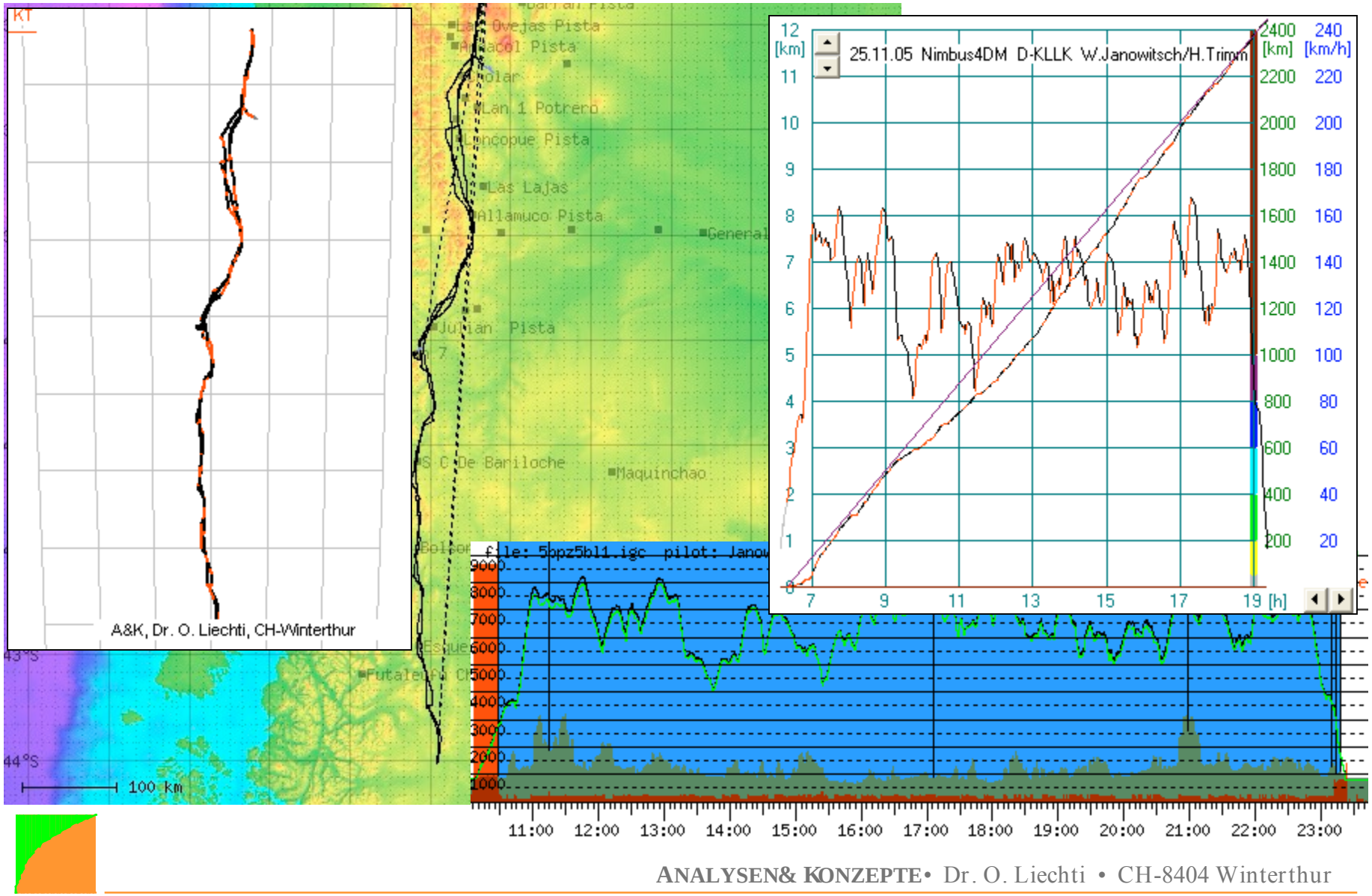
- Introduction
- PFD with thermals
- PFD with wind and thermals

Soaring in wind and thermals

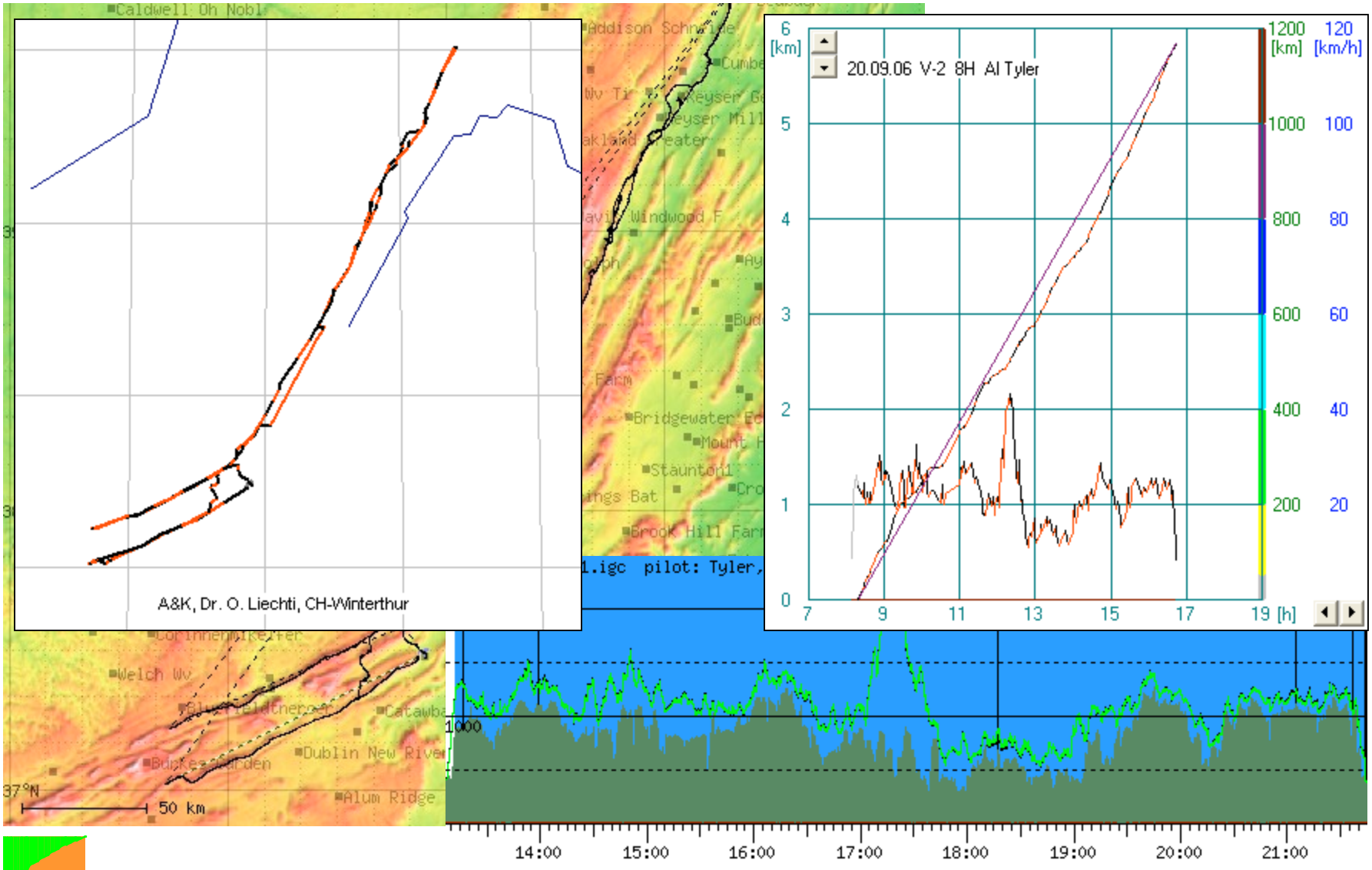
- Wave
- Ridge lift
- Thermals
- Combination of W and T



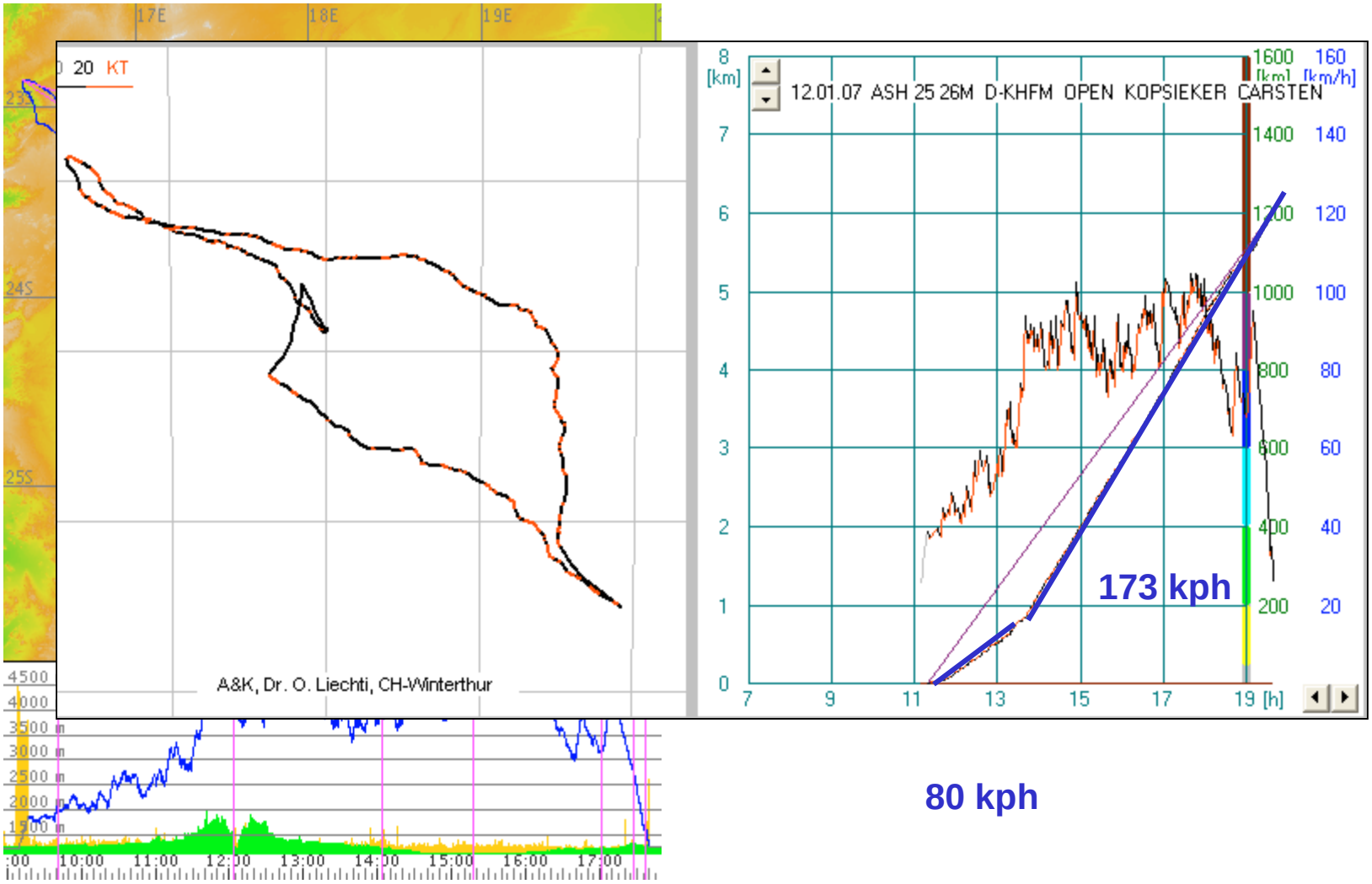
Wave: 13 h, 2‘400 km, 192 **kph**



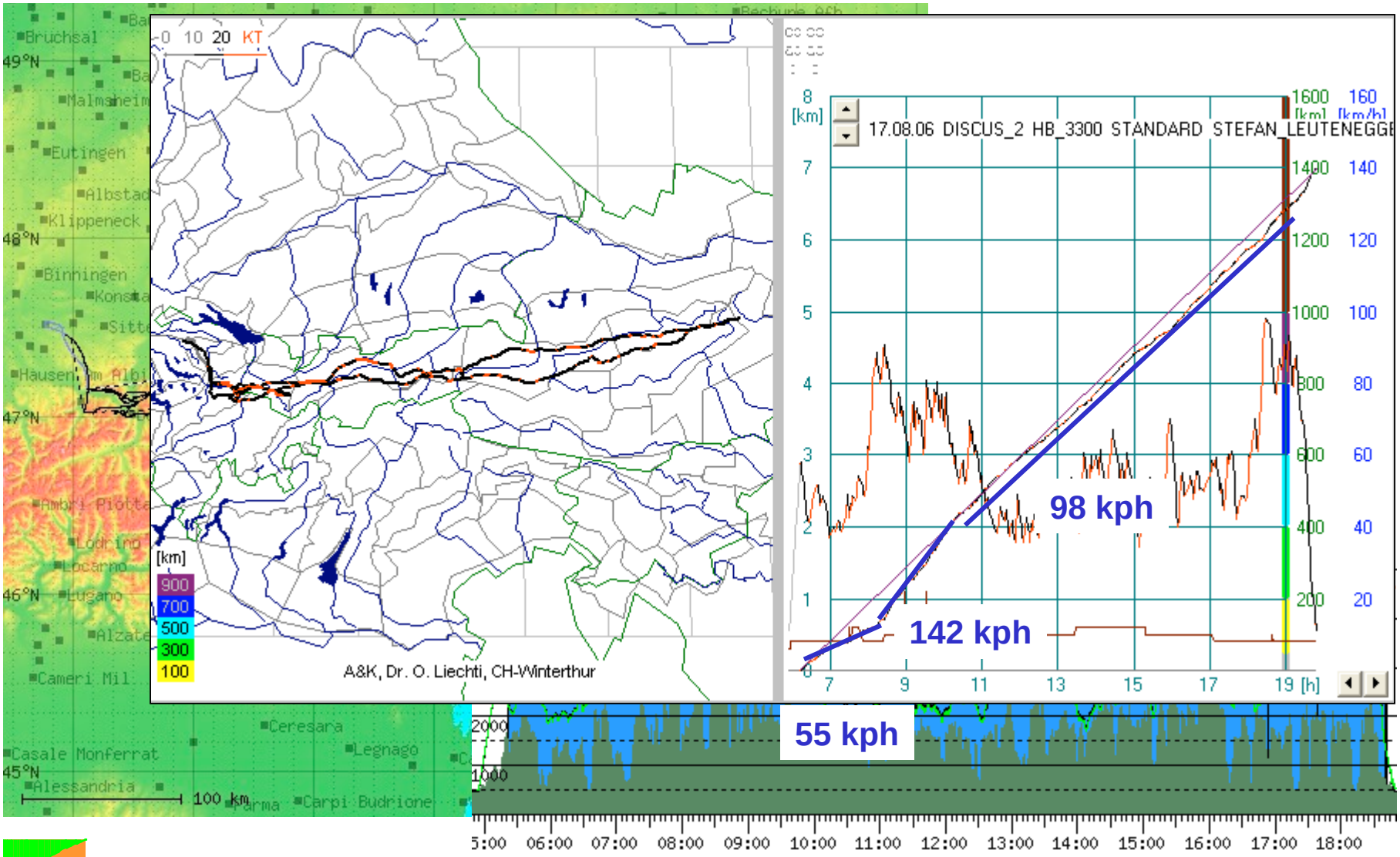
Ridge: 8.5 h, 1‘180 km, 138 **kph**



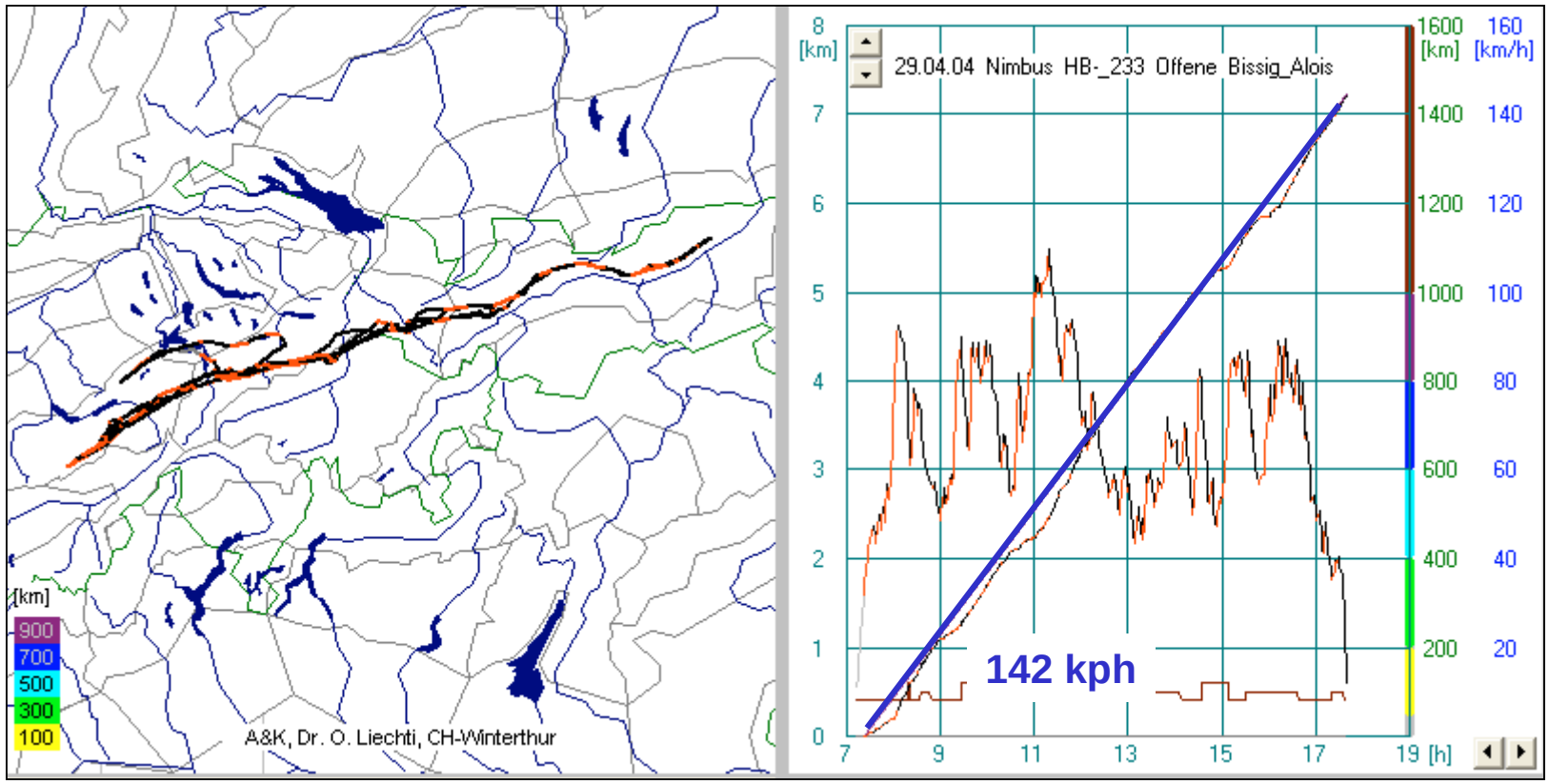
Thermals: 7.75 h, 1‘186 km, 153 **kph**



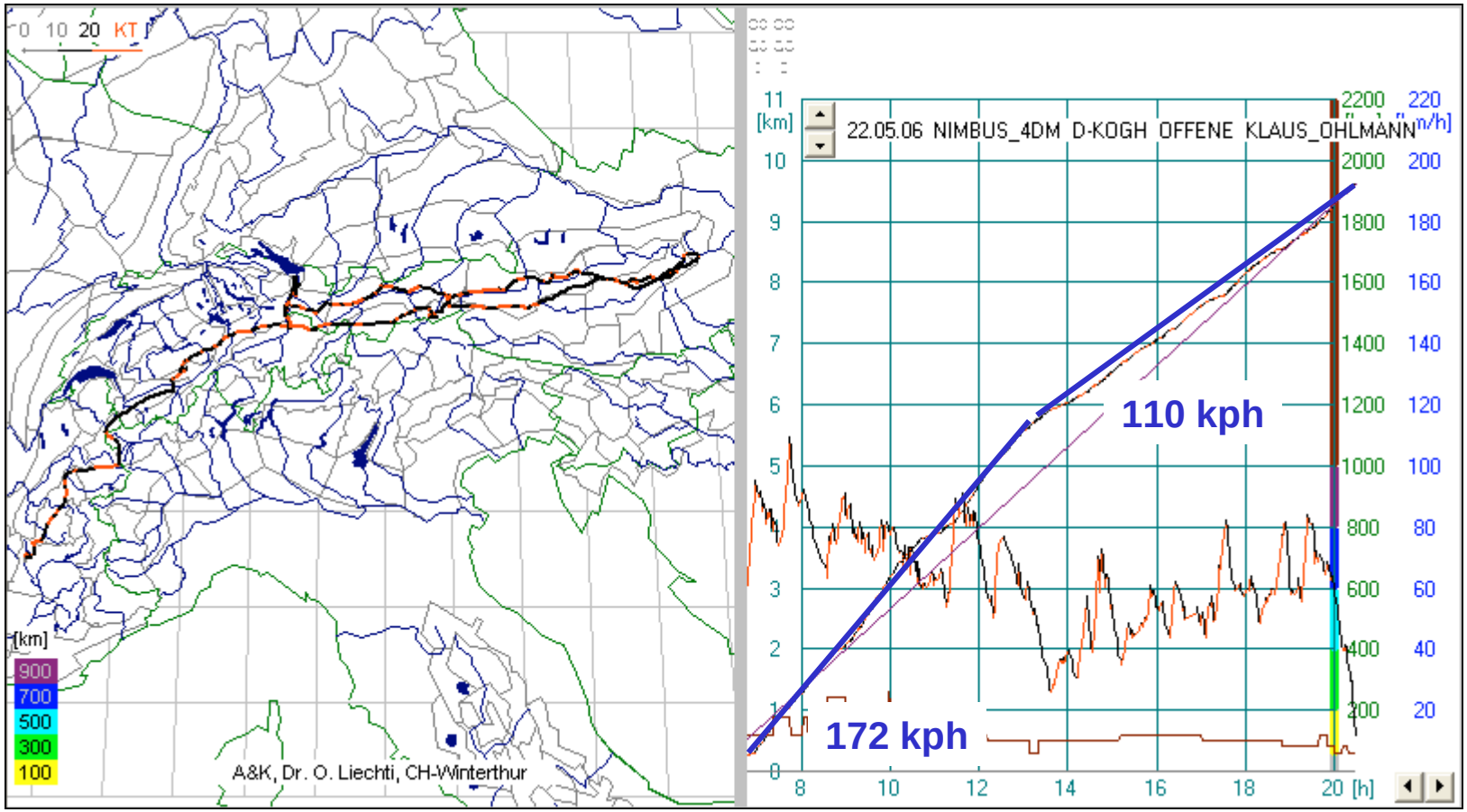
Combination: 13.5 h, 1‘400 km, 103 **kph**



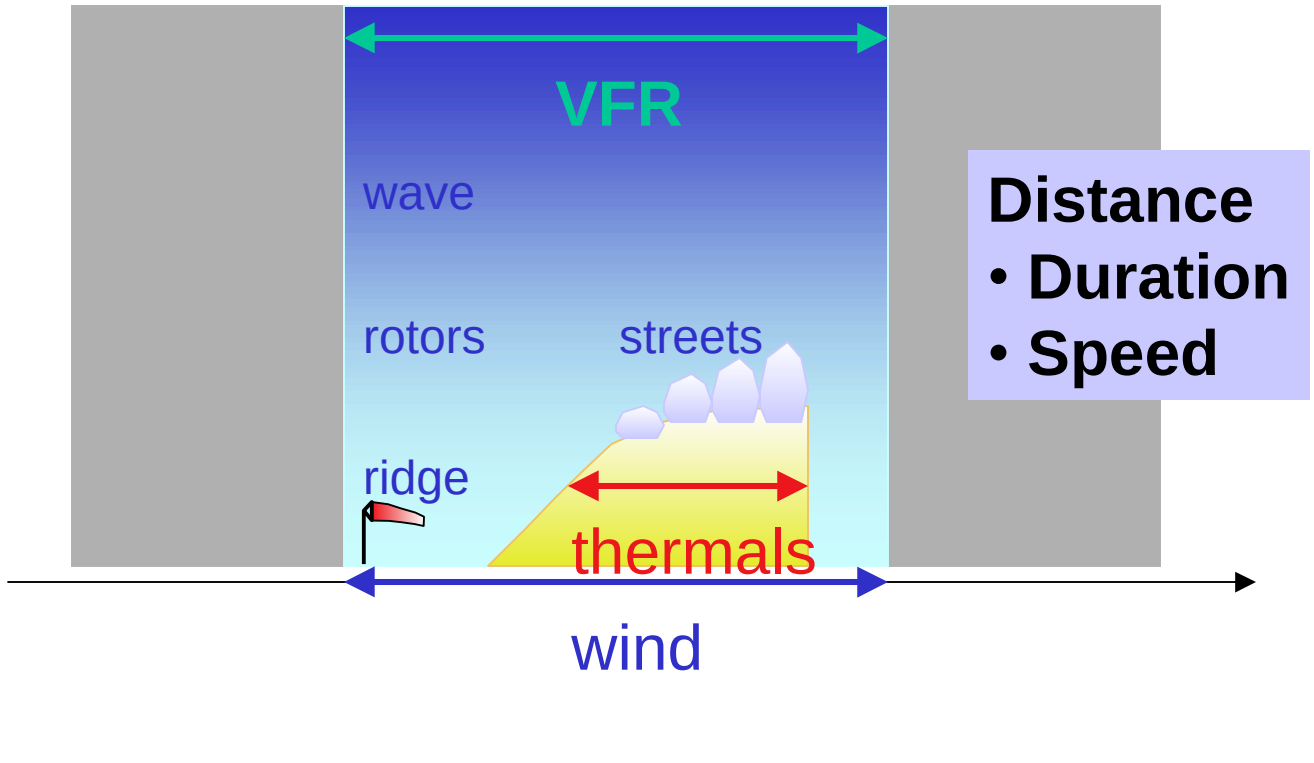
Combination: 10.5 h, 1‘430 km, 142 **kph**



Combination: 14.5 h, 1‘900 km, 132 **kph**



Flight distance in cross-country soaring



Soaring speed

- climb rate
- spatial lift distribution: isolated, aligned
- flight polar
- pilot skill and experience

Weather controls the duration, the strength and the spatial distribution of updrafts.

Predictions of these weather elements provide the potential flight distance (PFD).

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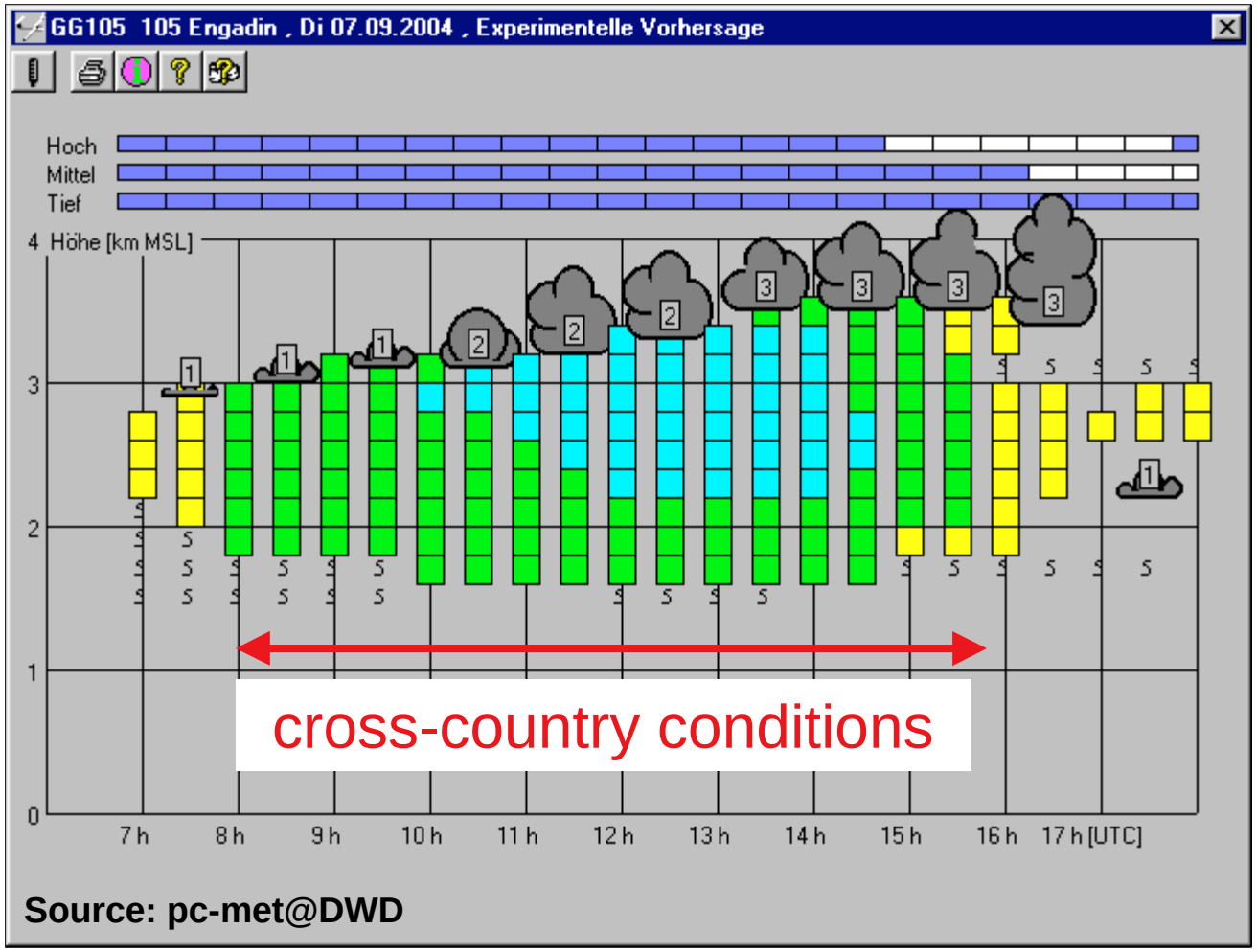
Regional thermal forecast



Source: pc-met@DWD

Stratiform Clouds

Cumulus Clouds

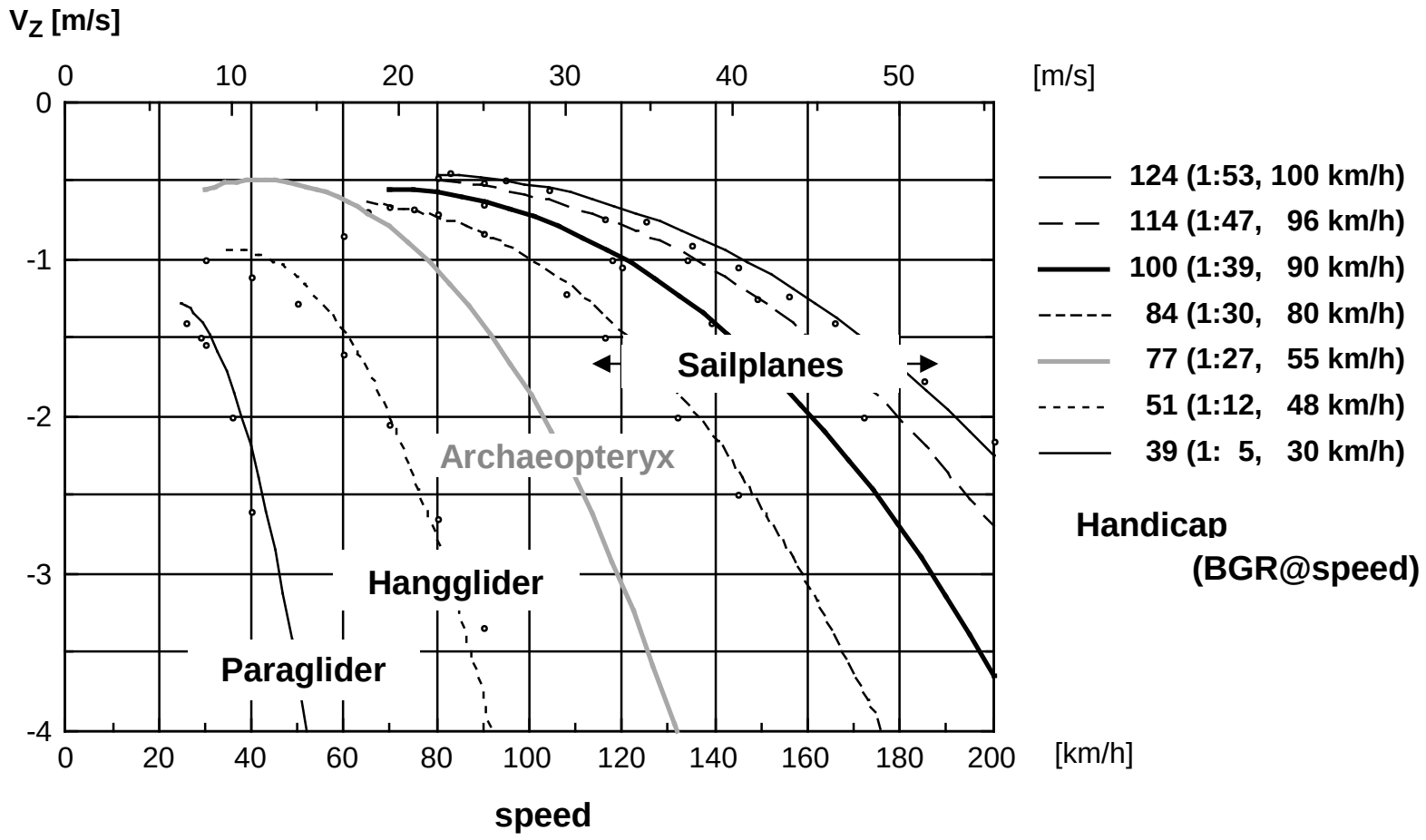
mittleres Steigen	Schichtwolken
< 0.1 m/s	0 Achtel
01. - 0.8 m/s	1-2 Achtel
0,9 - 2 m/s	3-4 Achtel
2,1 - 3 m/s	5-7 Achtel
> 3 m/s	8 Achtel

Avg. Lift **Clouds**

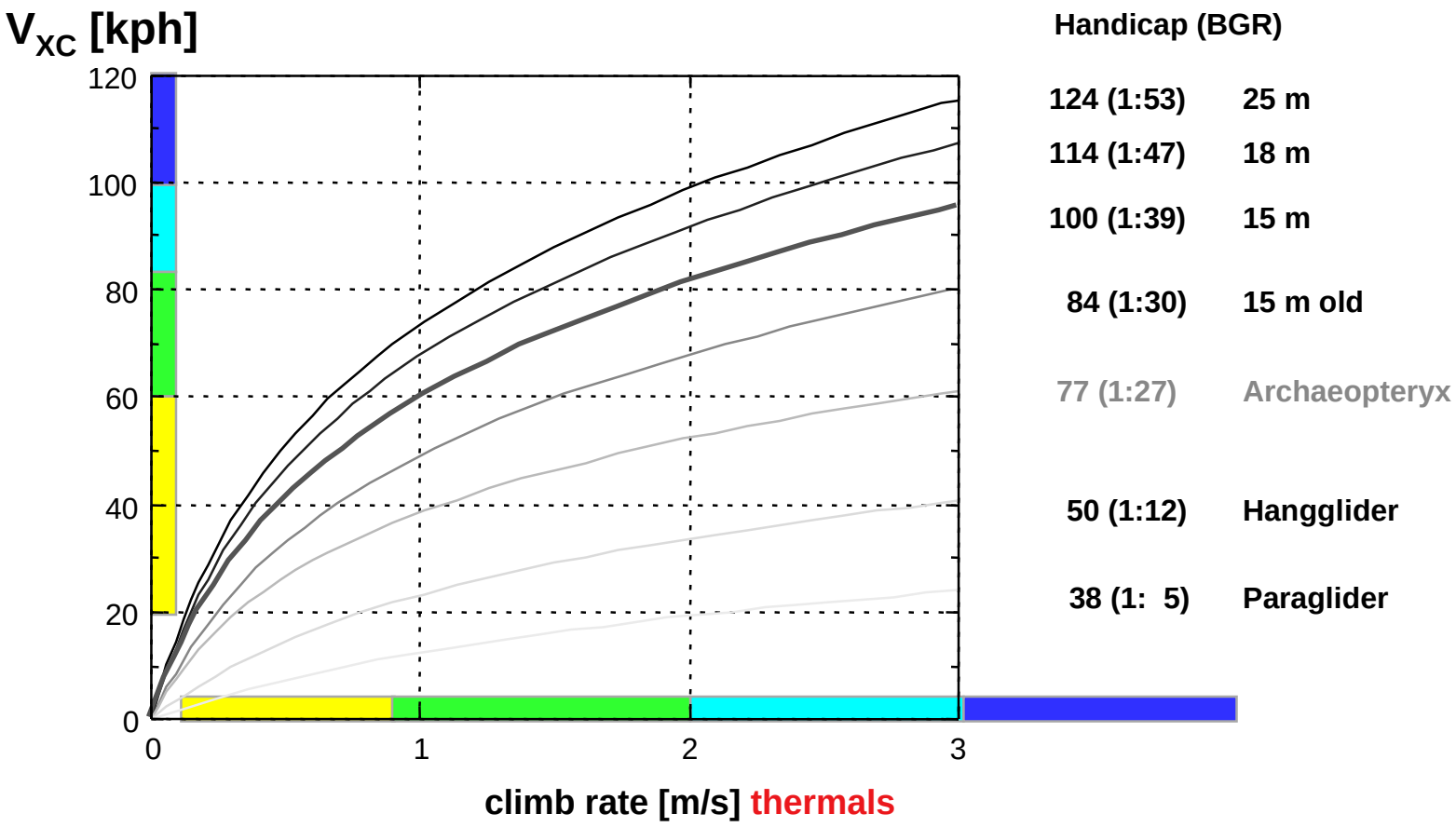
Climb rate --> cross-country speed

- **flight polar**
- **speed-to-fly theory for *isolated* lift**
- **cross-country speed**
- **potential flight distance (PFD)**

Flight polar

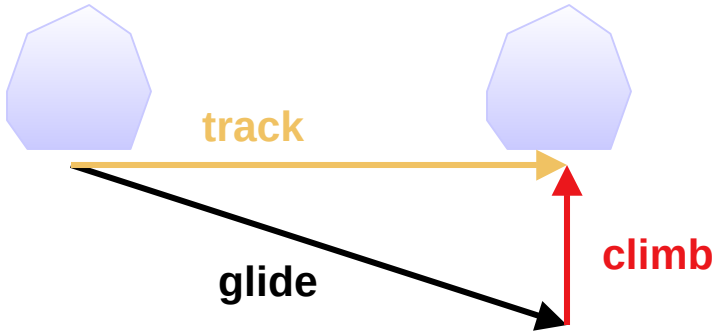


Optimum cross-country speed

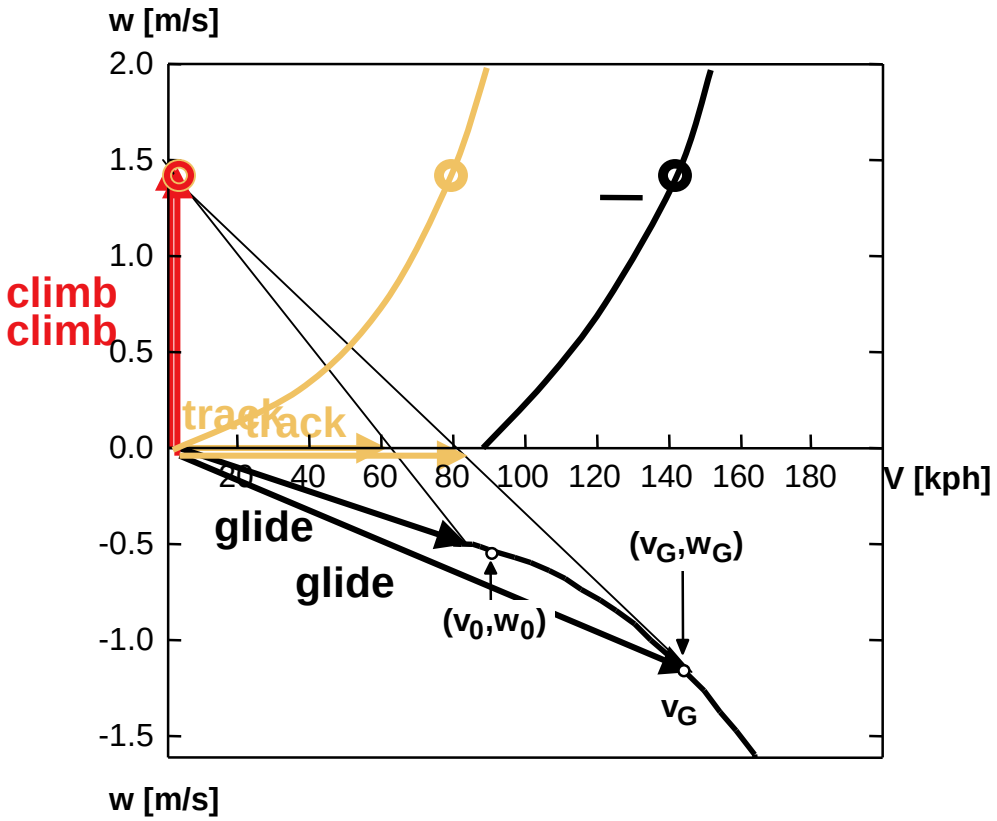


Speed-to-fly theory

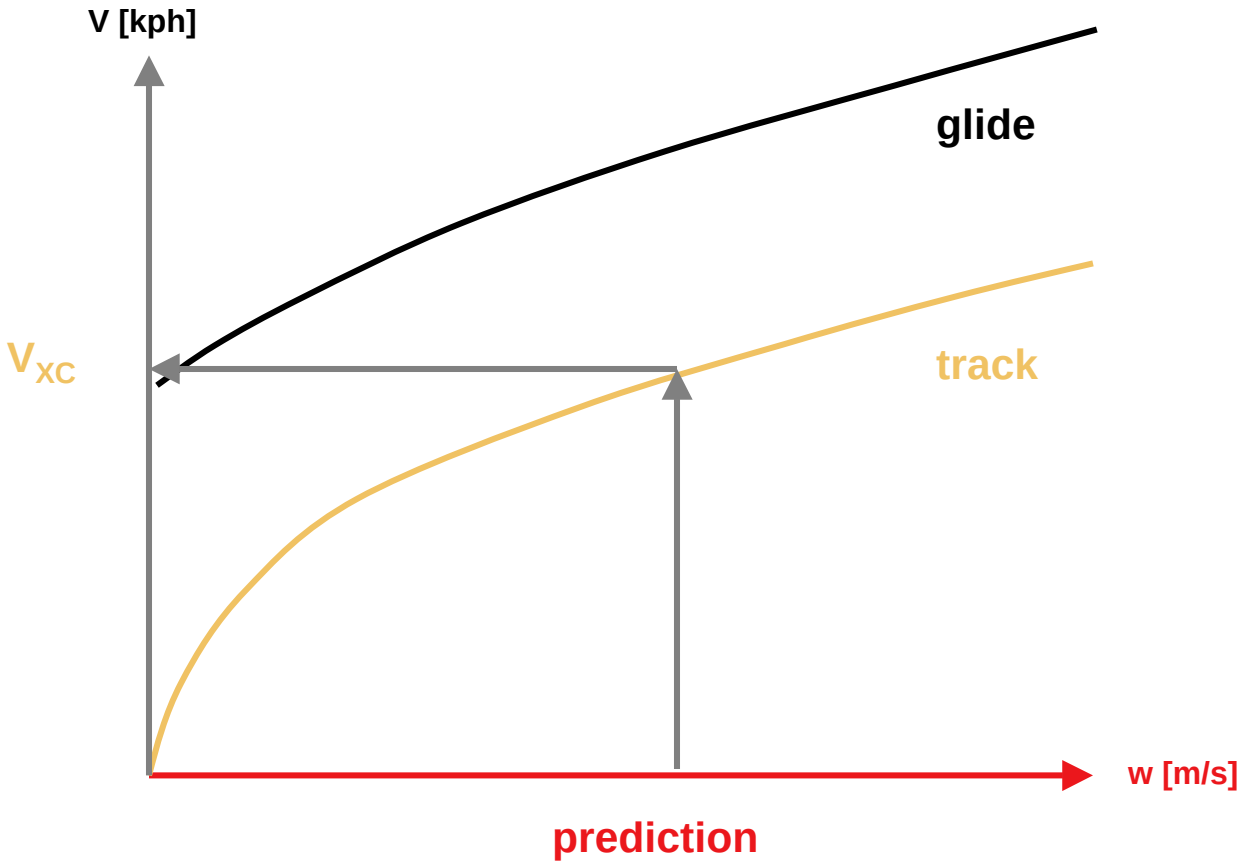
flight path vectors



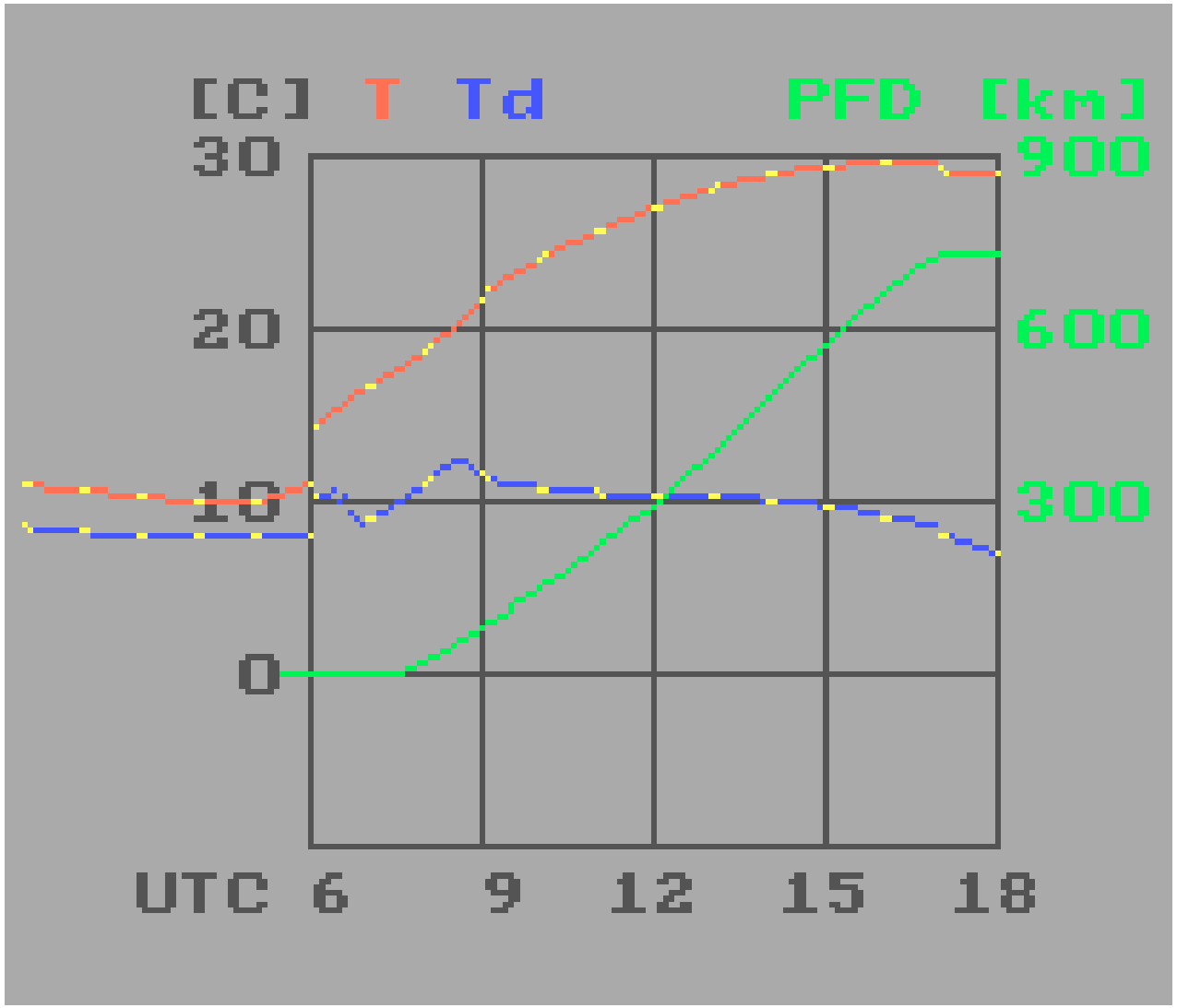
speed vectors



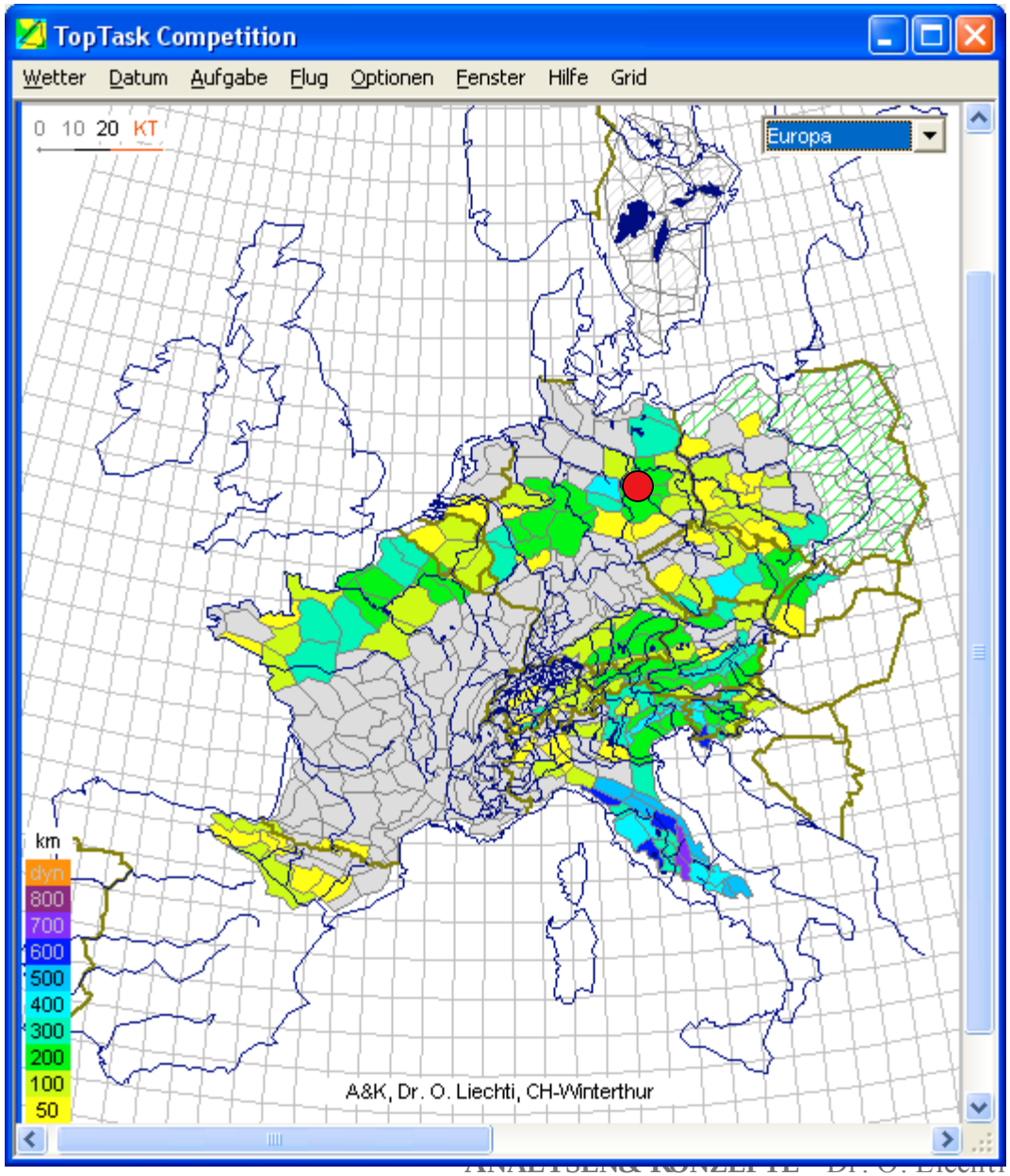
result: $V_{Glide}(w_{Thermal})$, $V_{Track}(w_{Thermal})$



Potential flight distance (PFD)



PFD map


TopTask Competition
Wetter Datum Aufgabe Flug Optionen Fenster Hilfe Grid
0 10 20 KT
Europa
km
dyn
800
700
600
500
400
300
200
100
50
A&K, Dr. O. Liechti, CH-Winterthur

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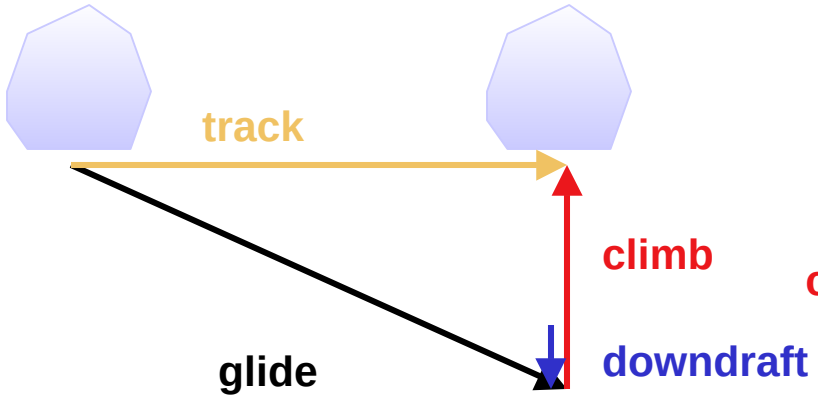
Approach

- **Wind induces airmass vertical motion in aligned patterns**

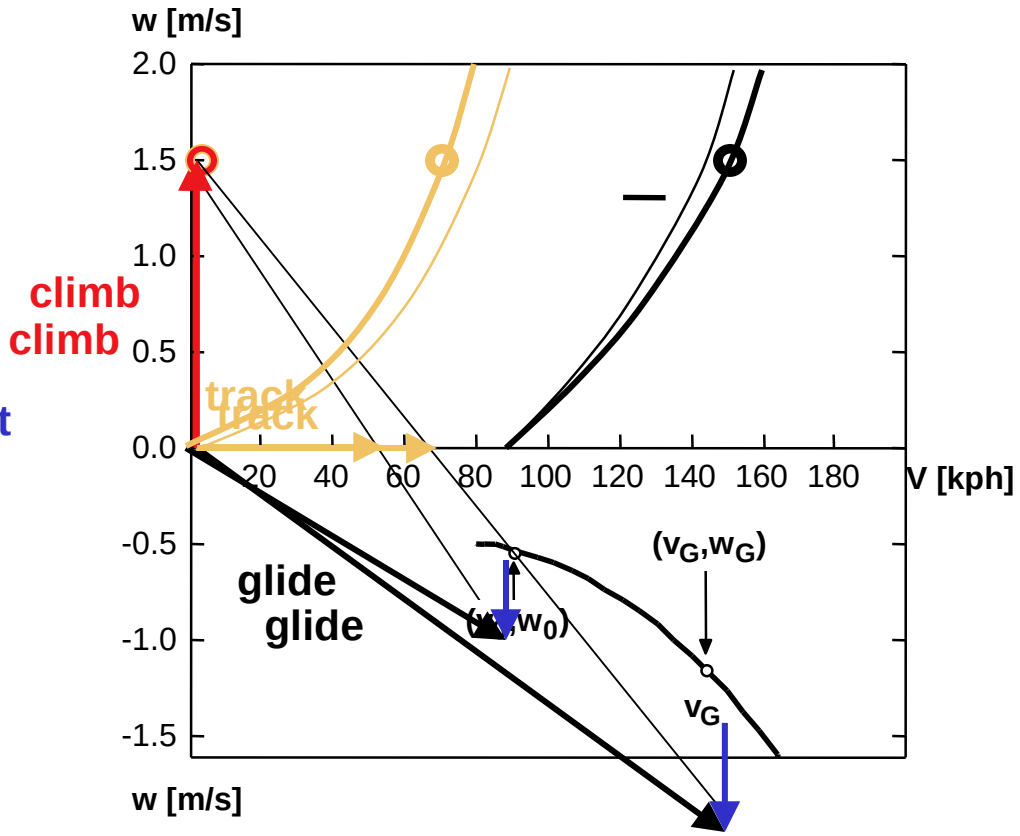
- **Speed-to-fly theory with airmass vertical motion during the glide**

Speed-to-fly in sinking airmass

Path vectors

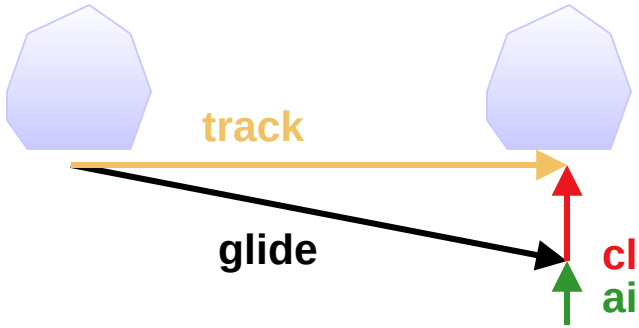


Speed vectors

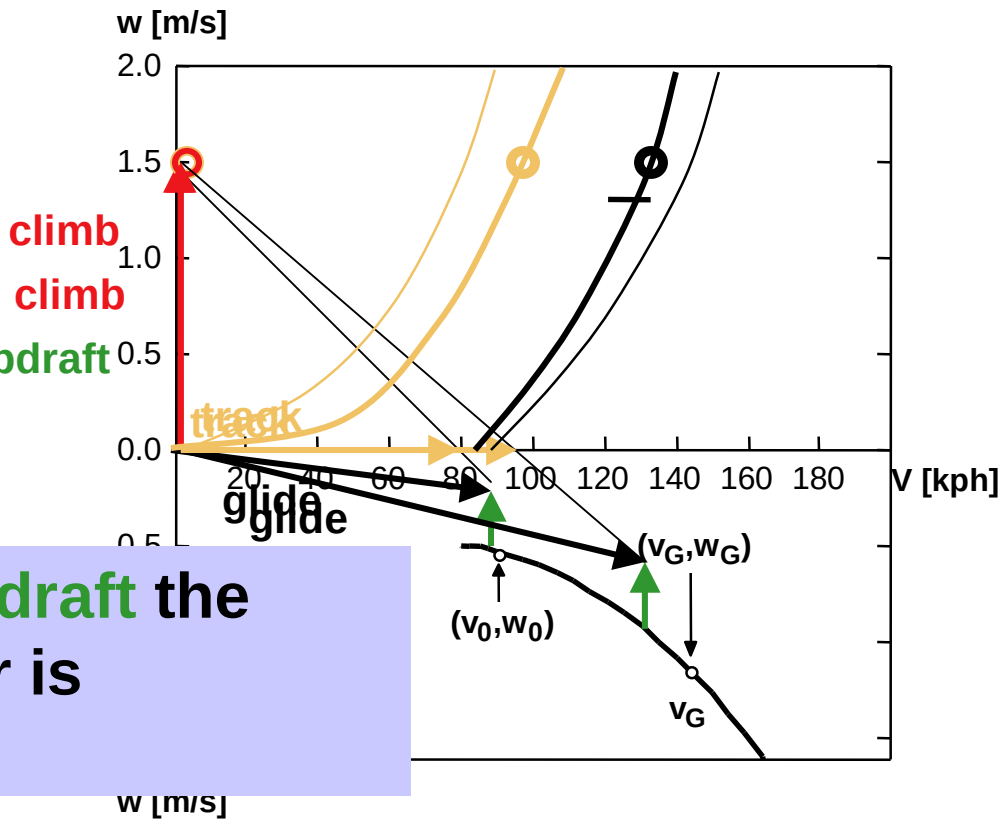


Speed-to-fly in rising airmass

Path vectors

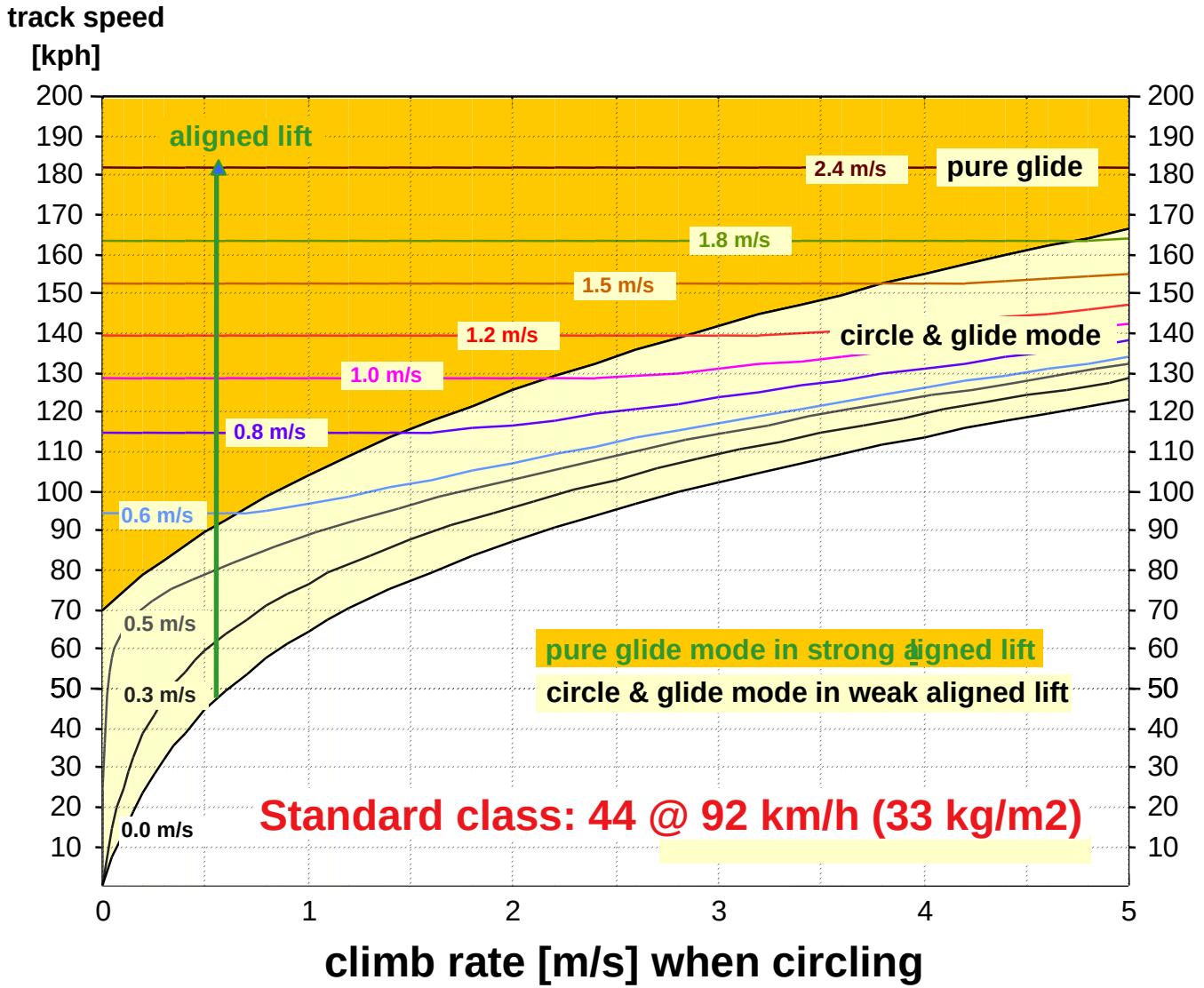


Speed vectors

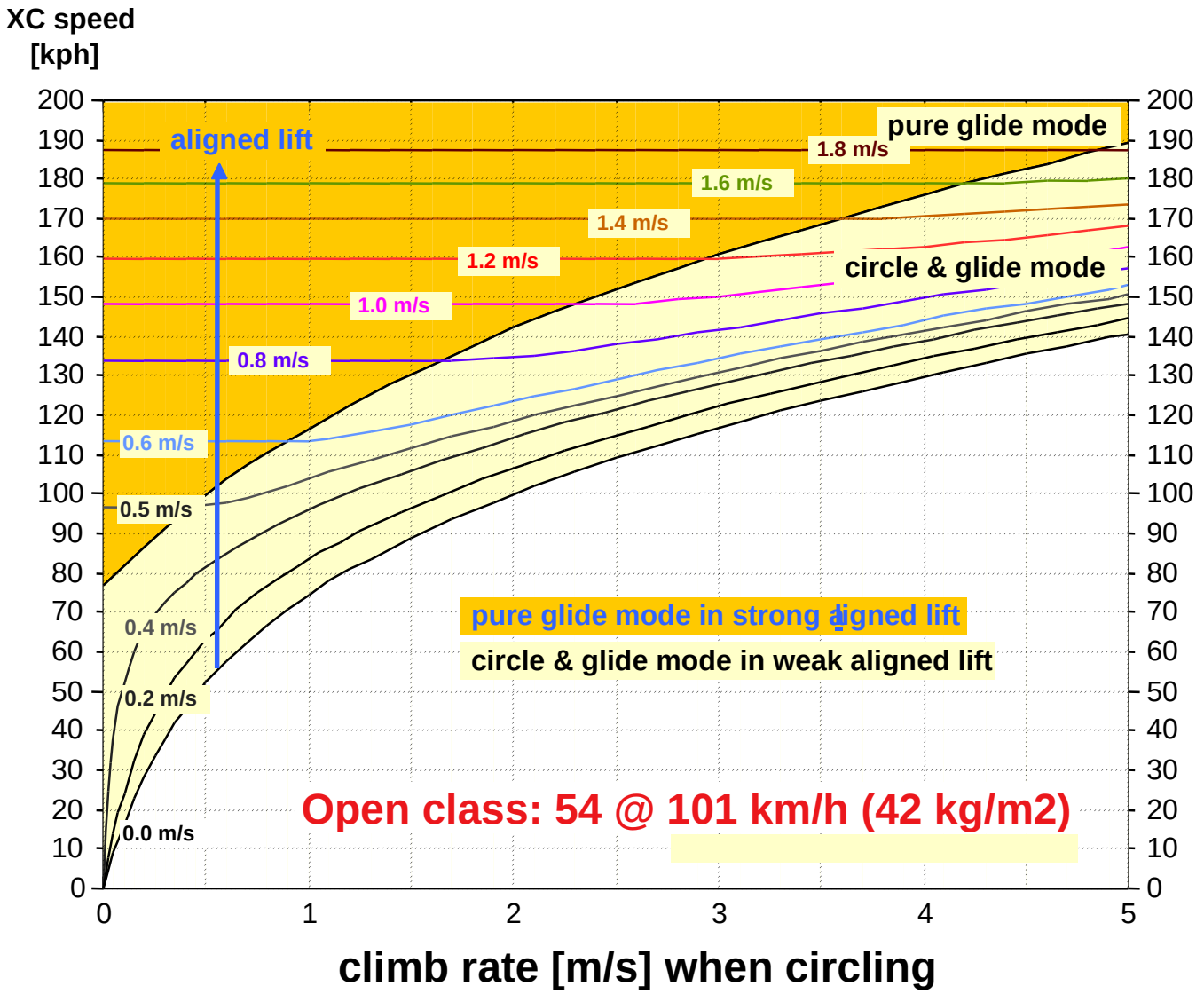


With sufficient airmass updraft the minimum sink of the glider is compensated ....

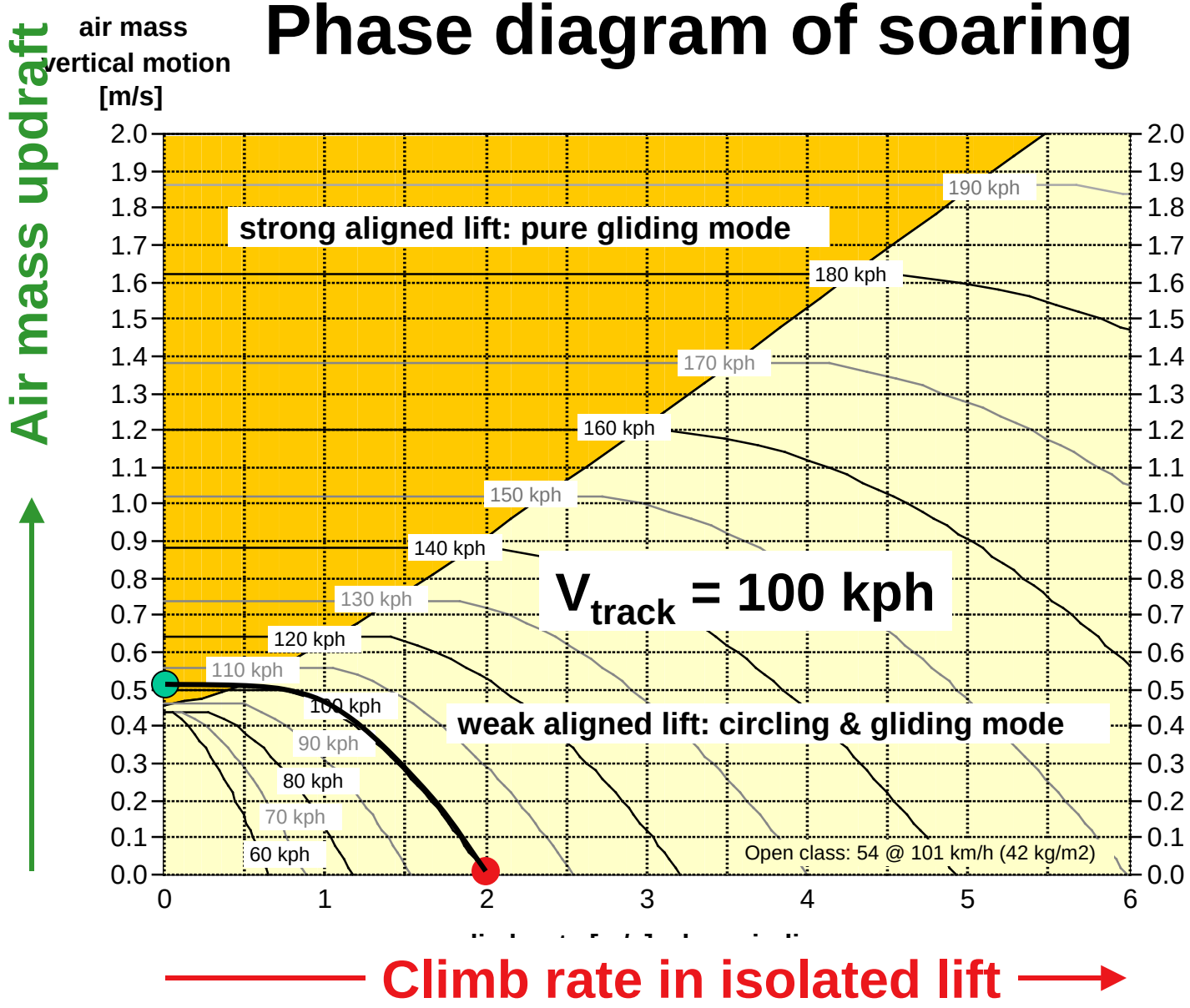
V_{Track} in rising airmass (standard class)



V_{track} in rising airmass (Open class)



Phase diagram of soaring



Summary

- **Speed-to-fly theory for isolated lift can be extended to aligned lift**
- **The time fraction spent climbing is the order parameter controlling the phase transition from „*climb*&*glide mode*“ to „*pure glide mode*“**

- **Predicted aligned lift can be used for flight planning ... How about such predictions?**