HAWAII PACIFIC AVIATION WEATHER SAFETY WORKSHOP

Mountainous Environment Hazards to Rotary Wing Operations

Vitalie Gumeniuc

June 09, 2023

High Altitude Wind Turbulence

What is a Designated Mountainous Area?

14 CFR Chapter 1
Subpart B—Designated Mountainous Areas (Est. 1956)

- *§ 95.19 Hawaii Mountainous Area.* (Est. 1962, Amended 1963)

Definition:

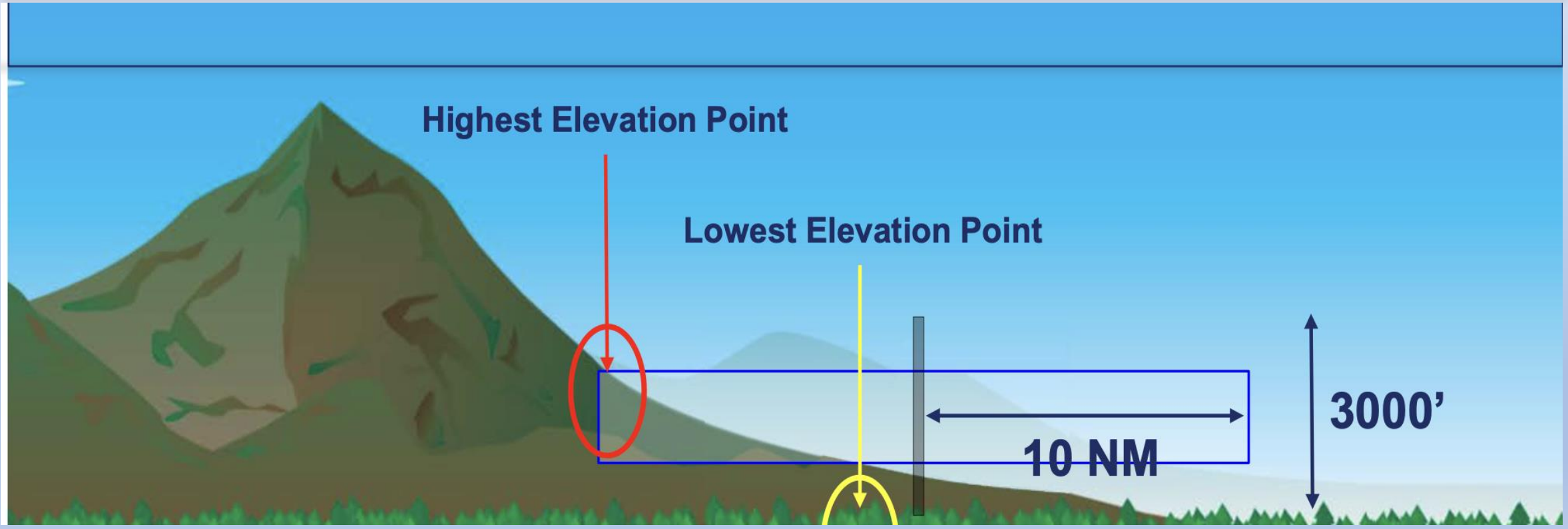
- ***Designated mountainous areas include those areas having a terrain differential exceeding 3’000 feet within 10 nautical miles within those one arc-second quadrangles overlying terrain or U.S. territorial waters.***

An area used to identify a terrain elevation differential exceeding 3,000 ft within:

1. A 10 NM radius from a specified point (“*Grid Method*”); or,

2. 10 NM from the centerline of a route or transition (“*Route Method*”).

Mountainous Area



High Altitude

- High Density Altitude
- Reduced lift capability
- Reduced engine performance
- Degraded overall maneuverability
- Landing distances are lengthened
- Load capabilities and rates of climb are reduced
- OGE power may not be available
- Accidents resulting from High Density Altitude and High Gross Weight are a major contributing factor for Army Aviation aircraft losses.

WHEELER - 838'MSL

CH-47 PERFORMANCE PLANNING CARD

For use of this form, see TC 3-04.12; the proponent agency is TRADOC.

POINT NAME: PHHI — **DEPARTURE DATA** — DTD ID:

OPERATING WT:	28600	T/O FUEL WT:	5800	LOAD:	0			
PRESSURE ALT:	730	FAT:	22	TAKE OFF GWT:	34400 / 34400			

FUEL MANAGEMENT

TIME:	QTY:	PPH:	BURNOUT:	RSV:

	DUAL ENGINE				SINGLE ENGINE			
	NO LOAD		WITH LOAD		NO LOAD		WITH LOAD	
MAX TQ AVAIL - 10 MIN. / S/E	100				123			
MAX TORQUE AVAIL - 30 MIN	100							
CONTINUOUS TORQUE AVAIL	100				101			
MAX GWT TO HVR 10 MIN. / SE IGE/OGE	50000	50000	50000	50000	40663	36969	40663	36969
MAX GWT TO HVR 30 MIN. IGE/OGE	50000	50000	50000	50000				
MAX GWT TO HVR CONT IGE/OGE	50000	50000	50000	50000				
PREDICTED HVR TQ - IGE/OGE	50	56	50	56	99	112	99	112
GO / NO GO TQ	87		87					
MAX MSN PROFILE GWT / VALIDATION	50000	81	50000	81				

POINT NAME: Cruise — **CRUISE DATA** — DTD ID:

AIRSPEED LIMIT:	163 / 163	LCT RET Vne:	96 / 96
PRESSURE ALT: 2000	FAT: 20	DRAG FACTOR:	0 / 0

	DUAL ENGINE		SINGLE ENGINE	
	NO LOAD	WITH LOAD	NO LOAD	WITH LOAD
MAX TQ AVAIL - 10 MIN. / S/E	100		120	
CONTINUOUS TORQUE AVAIL	97		97	
MAX GWT CONT PWR	50000	50000		
MAX R/C AND ENDURANCE IAS	72	72		
MAX RANGE IAS	138	138		
CRUISE SPEED - IAS	100	100	72	72
CRUISE TQ (+ DRAG FACTOR)	39	39	71	71
CRUISE FUEL FLOW	2070	2070	1470	1470
MINIMUM SINGLE ENGINE IAS			0	0
MAXIMUM SINGLE ENGINE IAS			138	138
MAX GWT S/E / SESC		50000	12590	12590

POINT NAME: Arrival — **ARRIVAL DATA** — DTD ID:

LANDING GWT:	33600 / 42100		
PRESSURE ALT: 300	FAT: 20		

	DUAL ENGINE				SINGLE ENGINE			
	NO LOAD		WITH LOAD		NO LOAD		WITH LOAD	
MAX TQ AVAIL - 10 MIN. / S/E	100				123			
MAX TQ AVAIL - 30 MIN.	100							
CONTINUOUS TORQUE AVAIL	100				104			
MAX GWT TO HVR 10 MIN. / SE IGE/OGE	50000	50000	50000	50000	40914	37197	*38069	*37197
MAX GWT TO HVR 30 MIN. IGE/OGE	50000	50000	50000	50000				
MAX GWT TO HVR CONT IGE/OGE	50000	50000	50000	50000				
PREDICTED HVR TQ - IGE/OGE	48	54	70	72	96	108	*141*	*145*

VS

POHAKULOA TRAINING AREA – 6190' MSL

CH-47 PERFORMANCE PLANNING CARD

For use of this form, see TC 3-04.12; the proponent agency is TRADOC.

POINT NAME: BAAF — **DEPARTURE DATA** — DTD ID:

OPERATING WT:	28600	T/O FUEL WT:	5800	LOAD:	0			
PRESSURE ALT:	6190	FAT	18	TAKEOFF GWT	34400 / 34400			

FUEL MANAGEMENT

TIME:	QTY:	PPH:	BURNOUT:	RSV:

	DUAL ENGINE				SINGLE ENGINE			
	NO LOAD		WITH LOAD		NO LOAD		WITH LOAD	
MAX TQ AVAIL - 10 MIN. / S/E	99				103			
MAX TORQUE AVAIL - 30 MIN	91							
CONTINUOUS TORQUE AVAIL	84				84			
MAX GWT TO HVR 10 MIN. / SE IGE/OGE	46788	46788	46788	46788	*33690	*30630	*33690	*30630
MAX GWT TO HVR 30 MIN. IGE/OGE	46788	46631	46788	46631				
MAX GWT TO HVR CONT IGE/OGE	46788	43872	46788	43872				
PREDICTED HVR TQ - IGE/OGE	53	60	53	60	*106*	*120*	*106*	*120*
GO / NO GO TQ	86		86					
MAX MSN PROFILE GWT / VALIDATION	44150	74	44150	74				

POINT NAME: Cruise — **CRUISE DATA** — DTD ID:

AIRSPEED LIMIT:	132 / 132	LCT RET Vne:	68 / 68
PRESSURE ALT 8000	FAT: 14	DRAG FACTOR:	0 / 0

	DUAL ENGINE		SINGLE ENGINE	
	NO LOAD	WITH LOAD	NO LOAD	WITH LOAD
MAX TQ AVAIL - 10 MIN. / S/E	94		97	
CONTINUOUS TORQUE AVAIL	80		80	
MAX GWT CONT PWR	43850	43850		
MAX R/C AND ENDURANCE IAS	71	71		
MAX RANGE IAS	124	124		
CRUISE SPEED - IAS	100	100	71	71
CRUISE TQ (+ DRAG FACTOR)	43	43	74	74
CRUISE FUEL FLOW	1954	1954	1453	1453
MINIMUM SINGLE ENGINE IAS			31	31
MAXIMUM SINGLE ENGINE IAS			113	113
MAX GWT S/E / SESC		40426	12560	12560

POINT NAME: BAAF — **ARRIVAL DATA** — DTD ID:

LANDING GWT:	30600 / 30600		
PRESSURE ALT 6190	FAT: 18		

	DUAL ENGINE				SINGLE ENGINE			
	NO LOAD		WITH LOAD		NO LOAD		WITH LOAD	
MAX TQ AVAIL - 10 MIN. / S/E	99				103			
MAX TQ AVAIL - 30 MIN	91							
CONTINUOUS TORQUE AVAIL	84				84			
MAX GWT TO HVR 10 MIN. / SE IGE/OGE	46788	46788	46788	46788	33690	30630	33690	30630
MAX GWT TO HVR 30 MIN. IGE/OGE	46788	46631	46788	46631				
MAX GWT TO HVR CONT IGE/OGE	46788	43872	46788	43872				
PREDICTED HVR TQ - IGE/OGE	46	52	46	52	91	103	91	103

Origin of wind and its causes

- Atmospheric pressure and temperature variations cause the air to move in two ways: ascending and descending currents (vertical motions) and the horizontal flow of air known as wind.
- Currents and winds or atmospheric circulation cause weather changes.
- Knowledge of the wind is essential for navigation, fuel management, load capabilities and flight safety purposes.

AVIATION WEATHER CENTER

NOAA NATIONAL WEATHER SERVICE

Local Forecast | Go | HOME | ADVISORIES | FORECASTS | OBSERVATIONS | TOOLS | NEWS | SEARCH | ABOUT | USER

Graphical Forecasts for Aviation - Winds

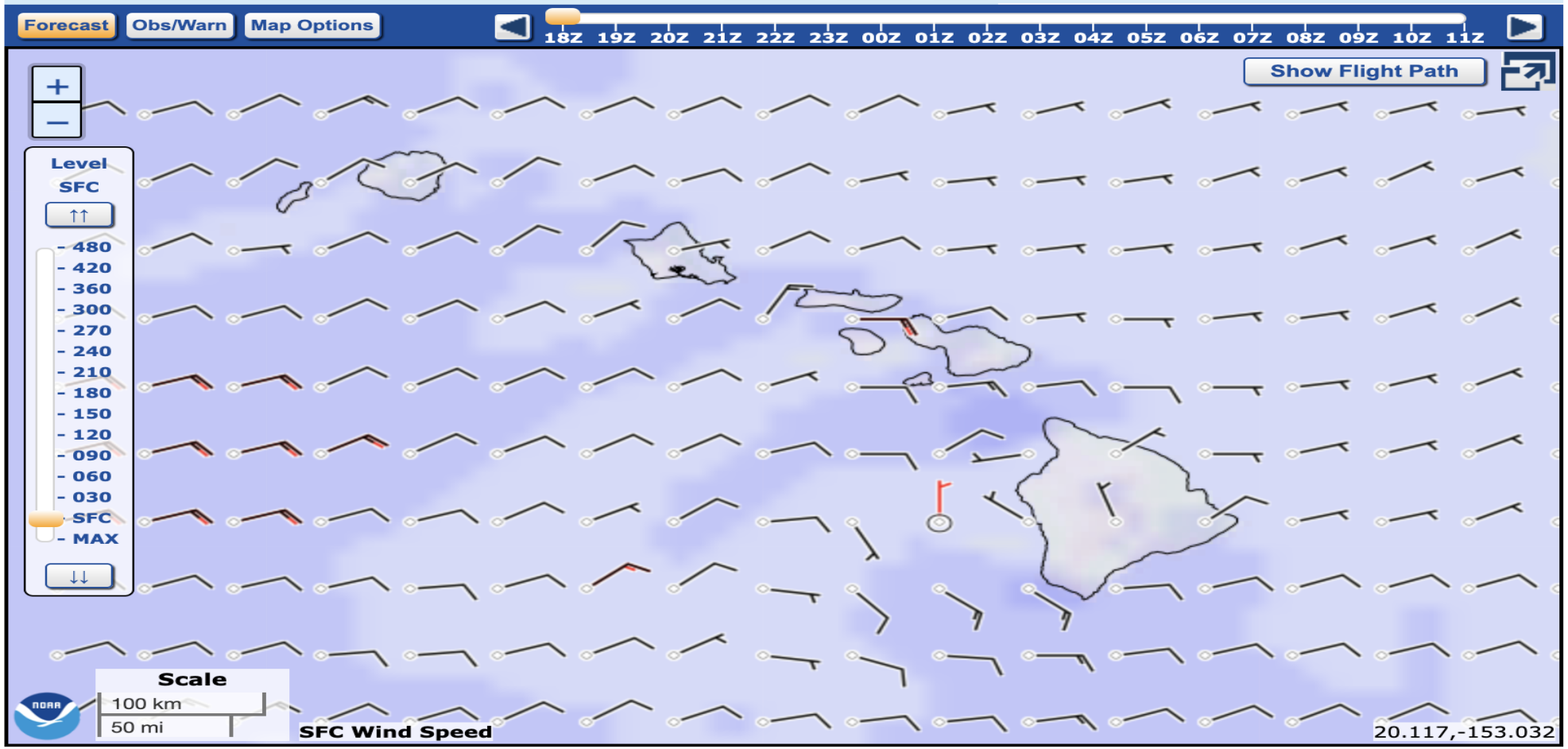
GFA Home | Info

TAF | CIG/VIS | Clouds | PCPN/WX | TS | Winds | LLWS | Turb | Ice

+1hr 1800 UTC Sat 27 May 2023

Forecast | Obs/Warn | Map Options

18Z 19Z 20Z 21Z 22Z 23Z 00Z 01Z 02Z 03Z 04Z 05Z 06Z 07Z 08Z 09Z 10Z 11Z



Wind Speed kt 0 10 20 30 40 60 80 100 120 140 160 180

Wind: Calm | 15kt | 60kt | 25G30kt

Warnings: Winter Storm WS | Blizzard BZ | Ice Storm IS | Storm ST | Gale GA | High Wind HW

AIRMETs: STG SFC Wind SfcWnd | LLWS LLWS

SIGMETs: Convective Conv | Thunderstorm TS | Trop Cyclone TC

Below SFC

Origin of wind and its causes

- In mountainous terrain, the winds are categorized into three types:

Prevailing - Upper-level winds.

Convective (local or valley) **-** Lower-level winds.

Surface winds – Layer of air lying close to the ground, less turbulent.

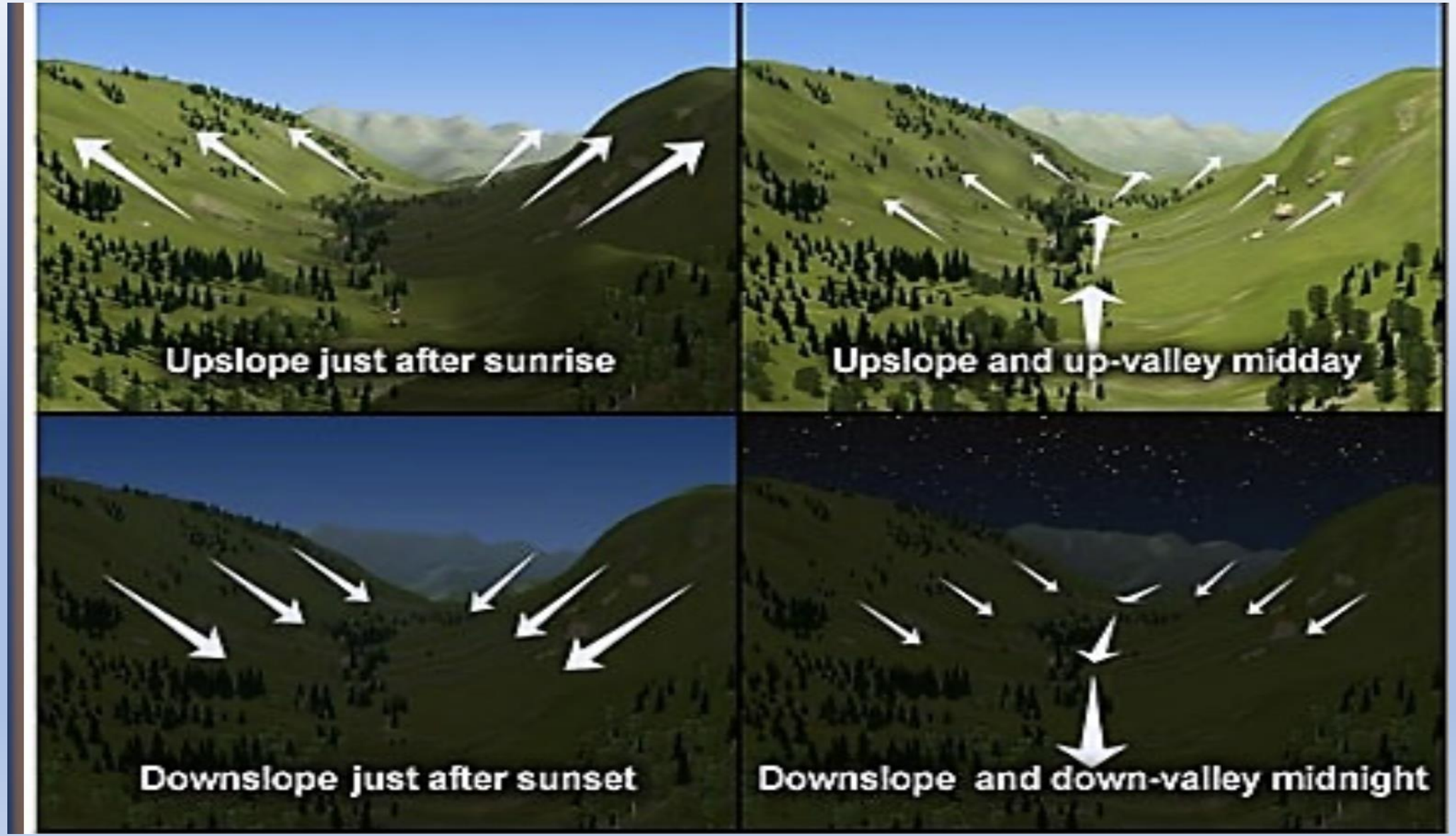
Prevailing wind

- Large scale direction and velocity of air mass movement.
- Generally, flows in horizontal fashion.
- Normally from northeast (trade winds) in Hawaii.

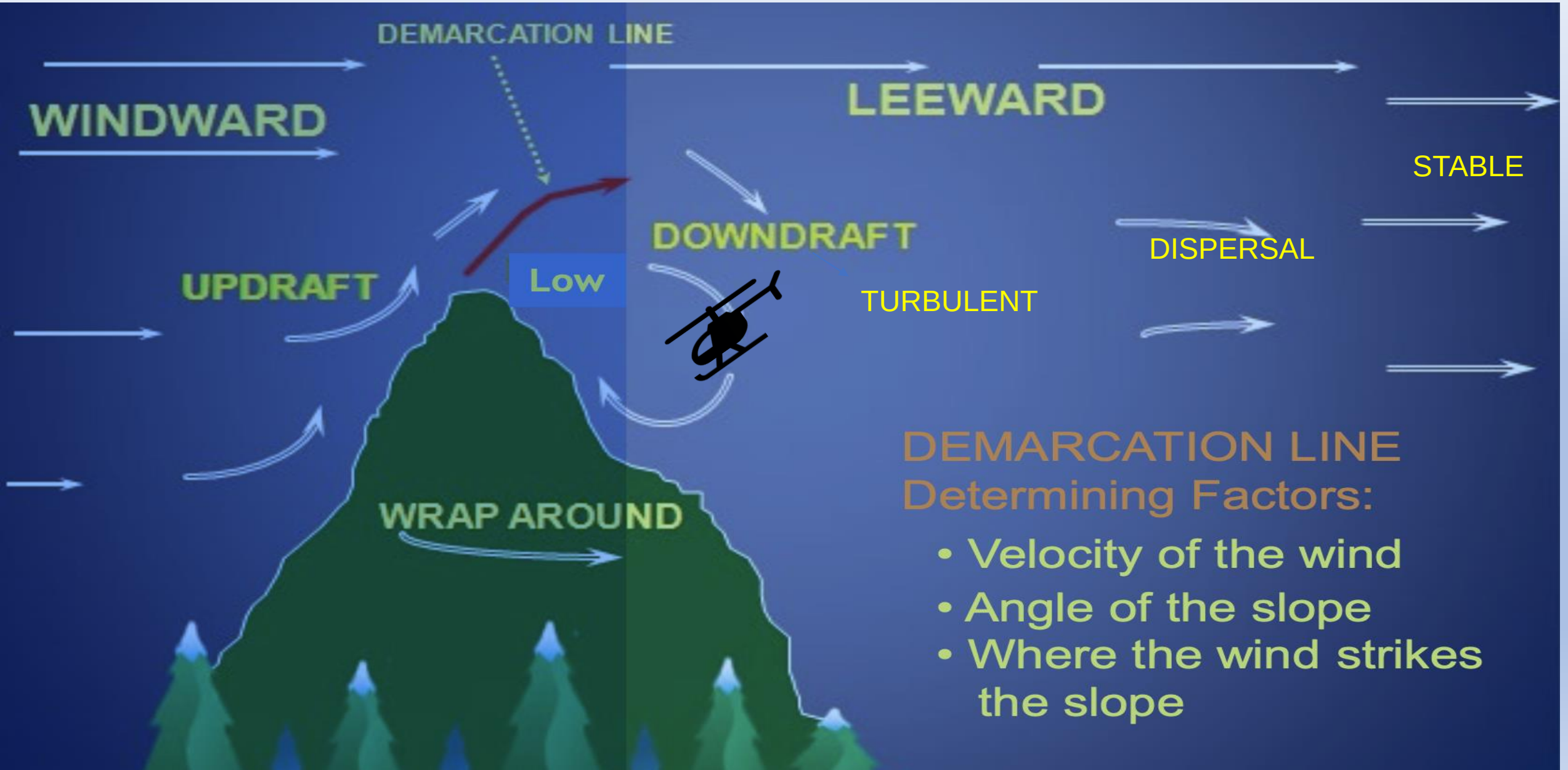
Convective winds (local or valley)

- Created by convection heating and cooling.
- Unstable air.
- Generally, flows parallel to larger valleys.
- Day – up flow / Night – down flow.

Convective winds (valley)



Wind zones


DEMARCATION LINE
WINDWARD
LEEWARD
STABLE
DOWNDRAFT
DISPERSAL
UPDRAFT
Low
TURBULENT
WRAP AROUND
DEMARCATION LINE
Determining Factors:
• Velocity of the wind
• Angle of the slope
• Where the wind strikes the slope

Summary

- Winds can often be dramatically different than forecast.
- Wind near surface often different than upper-level wind.
- The wind direction and velocity can change rapidly in mountainous terrain.
- Reduced Visibility: Mountains can generate weather phenomena such as fog, low clouds, or precipitation.

Turbulence and its causes

- Turbulence in aviation refers to the irregular and often unpredictable movement of air that can affect an aircraft during flight.

- It can range from mild bumps to more severe jolts and can be caused by various factors, such as weather conditions, atmospheric disturbances, and the interaction between different air masses.

FAA turbulence reporting criteria

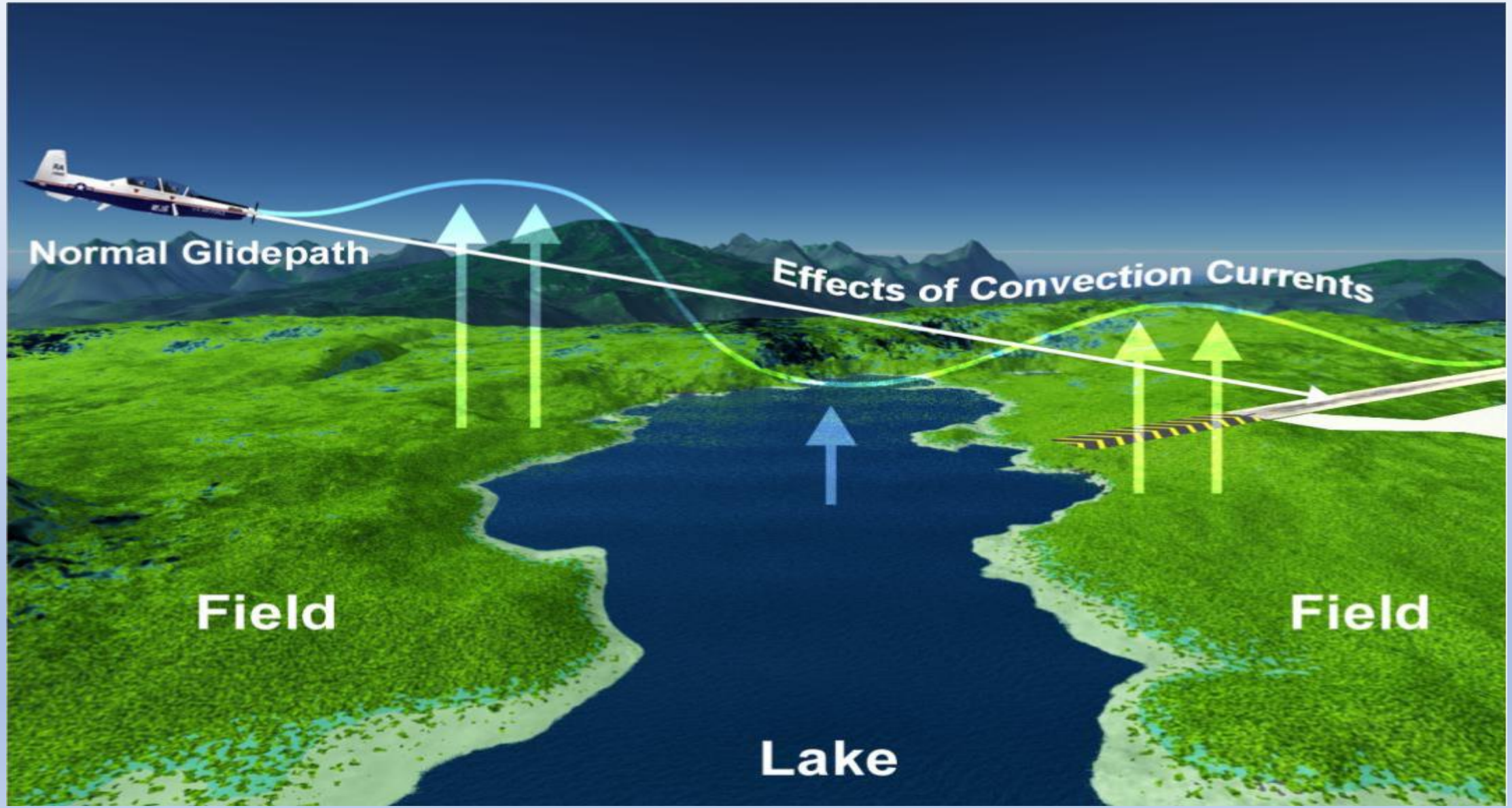
Intensity	Aircraft Reaction	Reaction Inside Aircraft
Light	Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw). Report as **Light Turbulence** Or Turbulence that causes slight, rapid, and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. Report as **Light Chop**.	Occupants may feel a slight strain against seat belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little or no difficulty is encountered in walking.
Moderate	Turbulence that is similar to Light Turbulence but of greater intensity. Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed. Report as **Moderate Turbulence** or Turbulence that is similar to Light Chop but of greater intensity. It causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude. Report as **Moderate Chop**.	Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.
Severe	Turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Report as **Severe Turbulence**.	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.
Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage. Report as **Extreme Turbulence**.	—

Turbulence and its causes

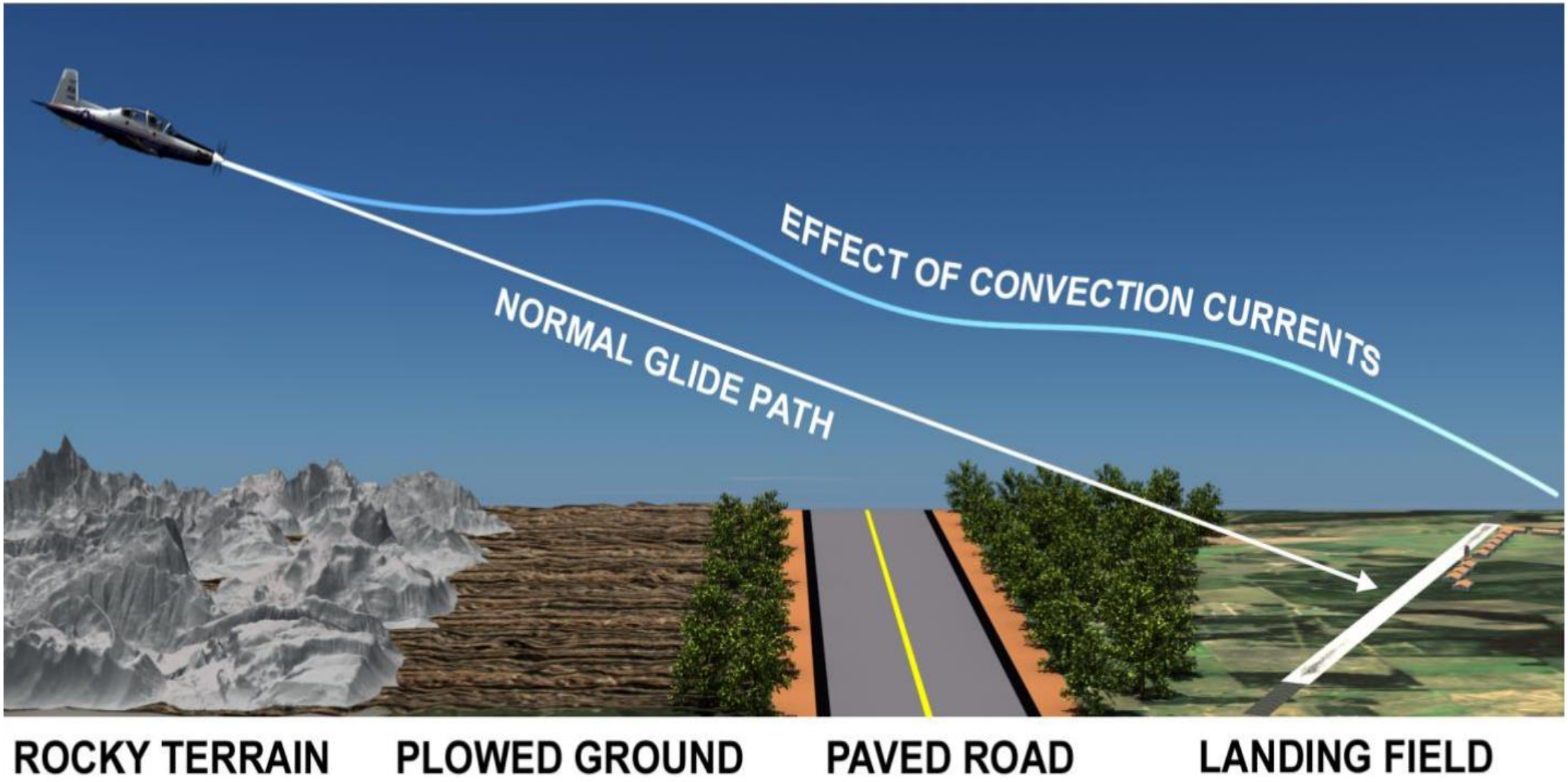
Turbulence types:

- ***Convective Turbulence:*** Caused by alternating currents of warm air rising and cooler air descending.
- ***Mechanical Turbulence:*** Caused by wind flowing over irregular terrain or obstructions, or by a marked change in wind speed or direction over a short distance.
- ***Mountain Wave Turbulence:*** Caused by air blowing perpendicular across the top of a mountain range. The most dangerous features of mountain waves are the turbulence in and below the rotor clouds.
- ***Frontal Turbulence:*** Produced when moving frontal boundaries are combined with convection and strong winds.
- ***High Altitude Turbulence:*** Variations in wind speed and direction principally in the vicinity of the jet stream and occurs above 10,000 feet. This is commonly called clear air turbulence (CAT) because of scant, visible evidence of its existence.

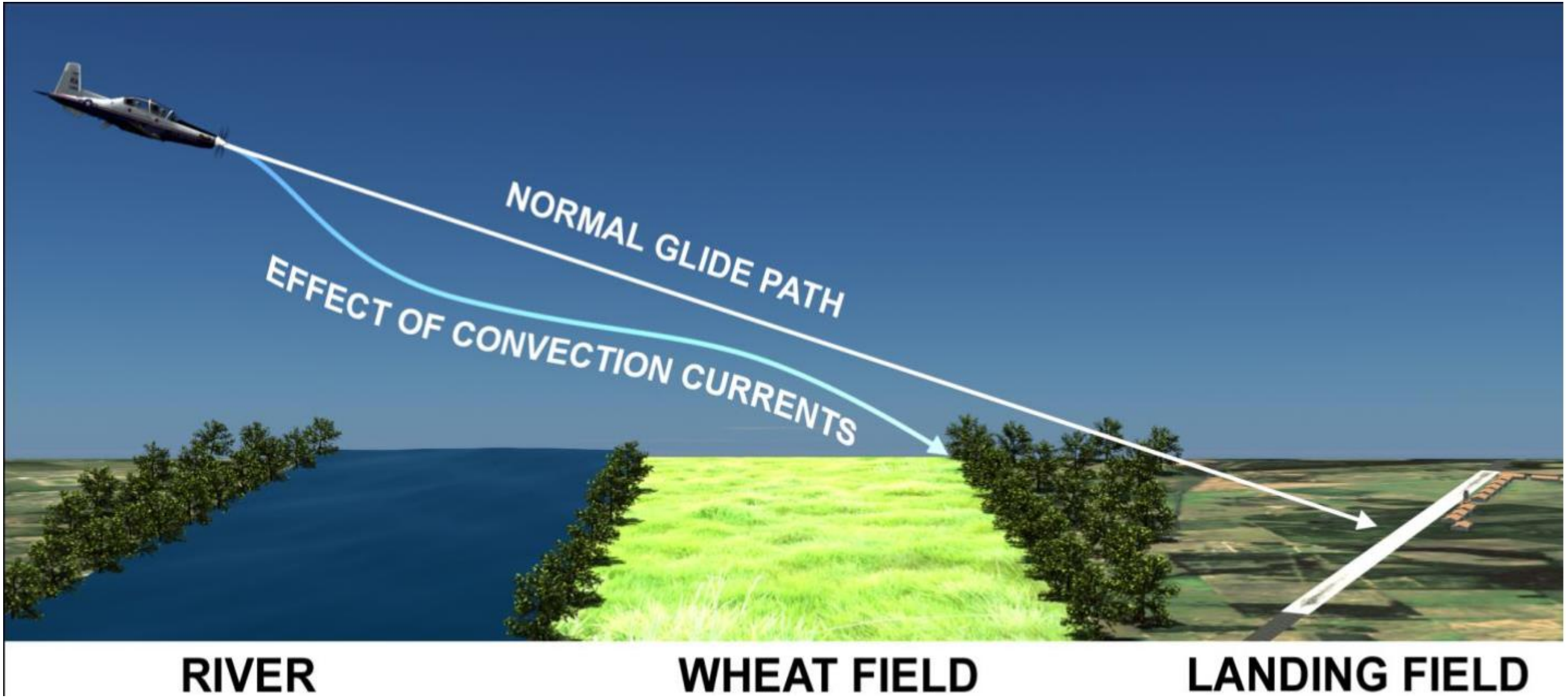
Strength of convective currents varies with composition of surface



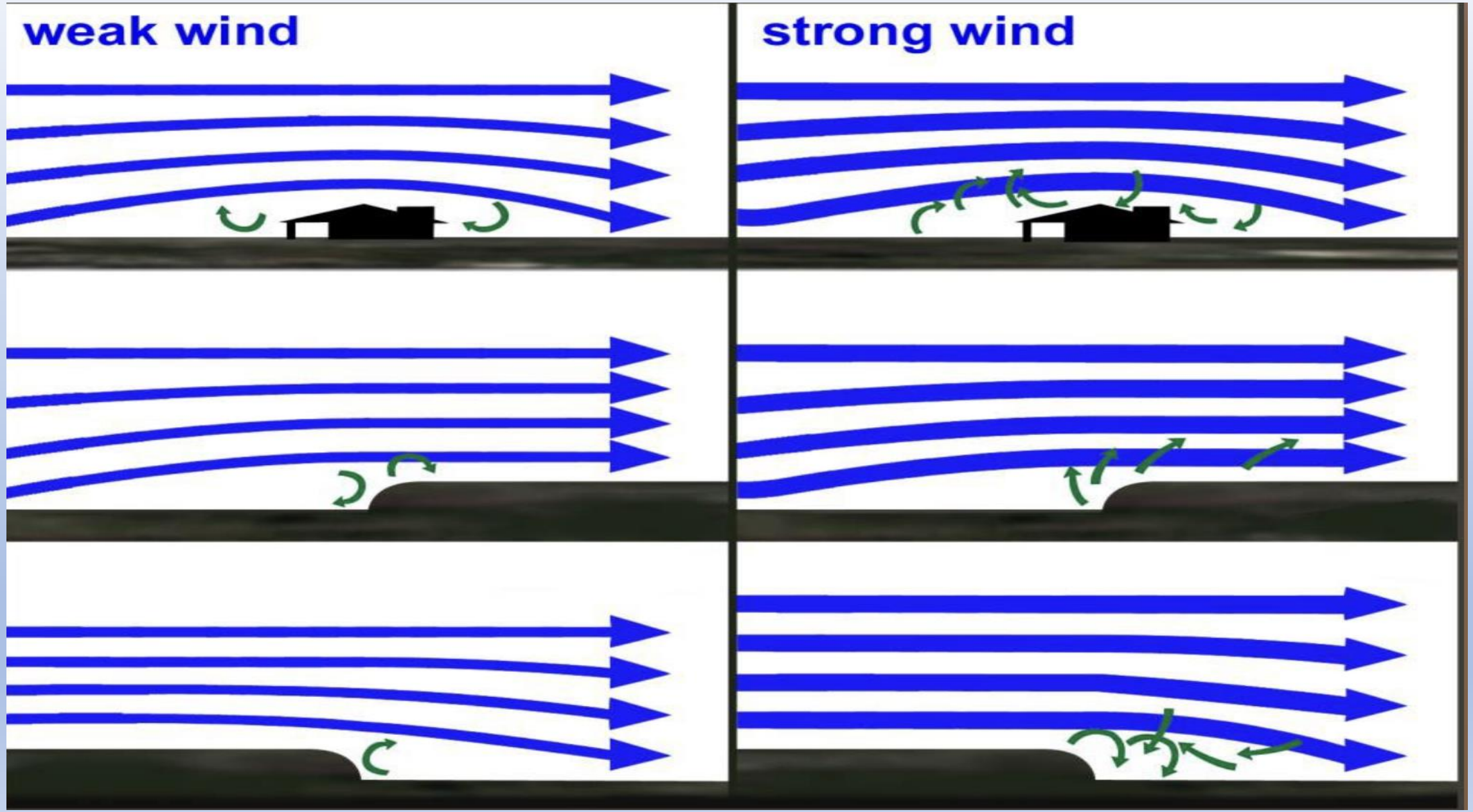
Updrafts may cause pilots to overshoot



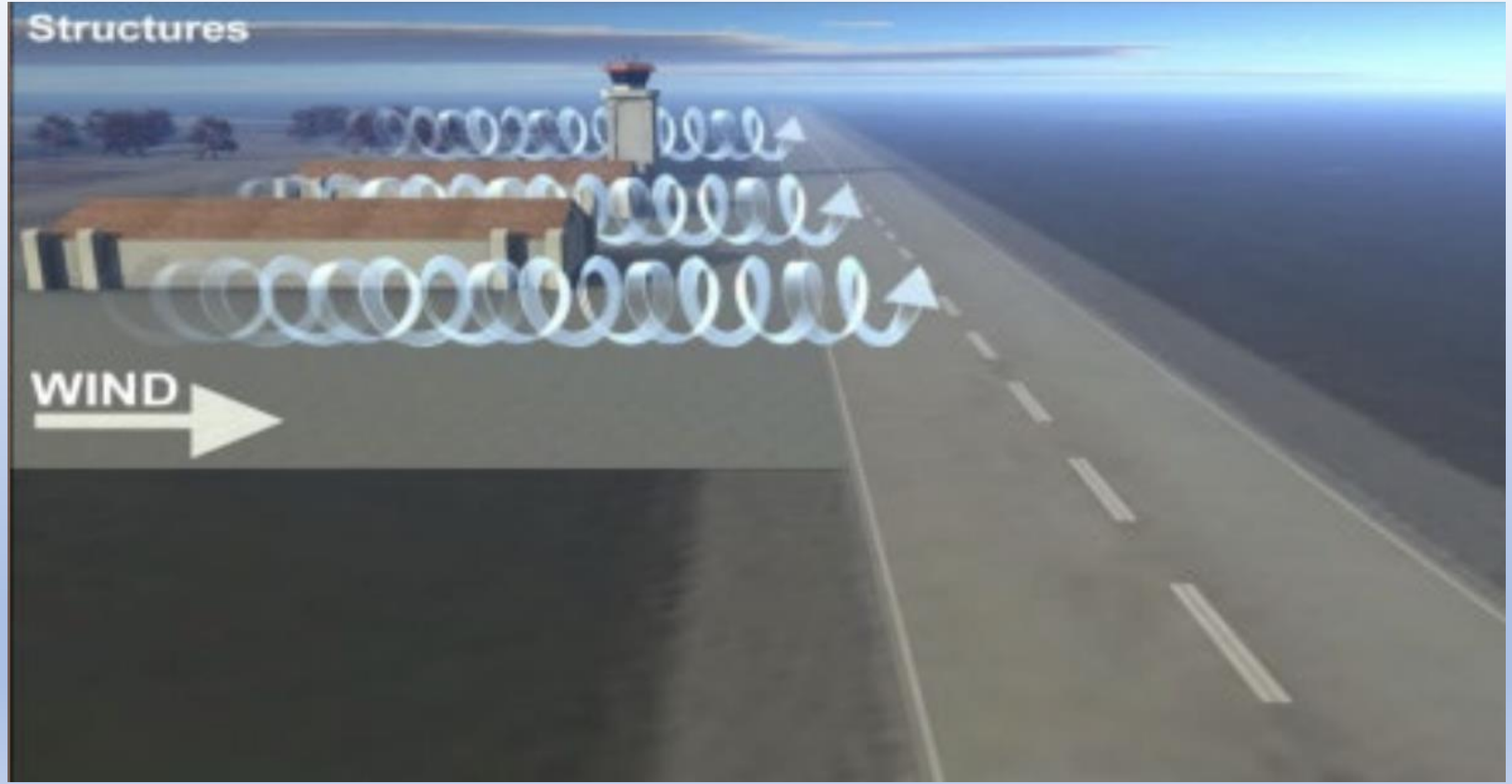
Downdrafts may cause pilots to undershoot



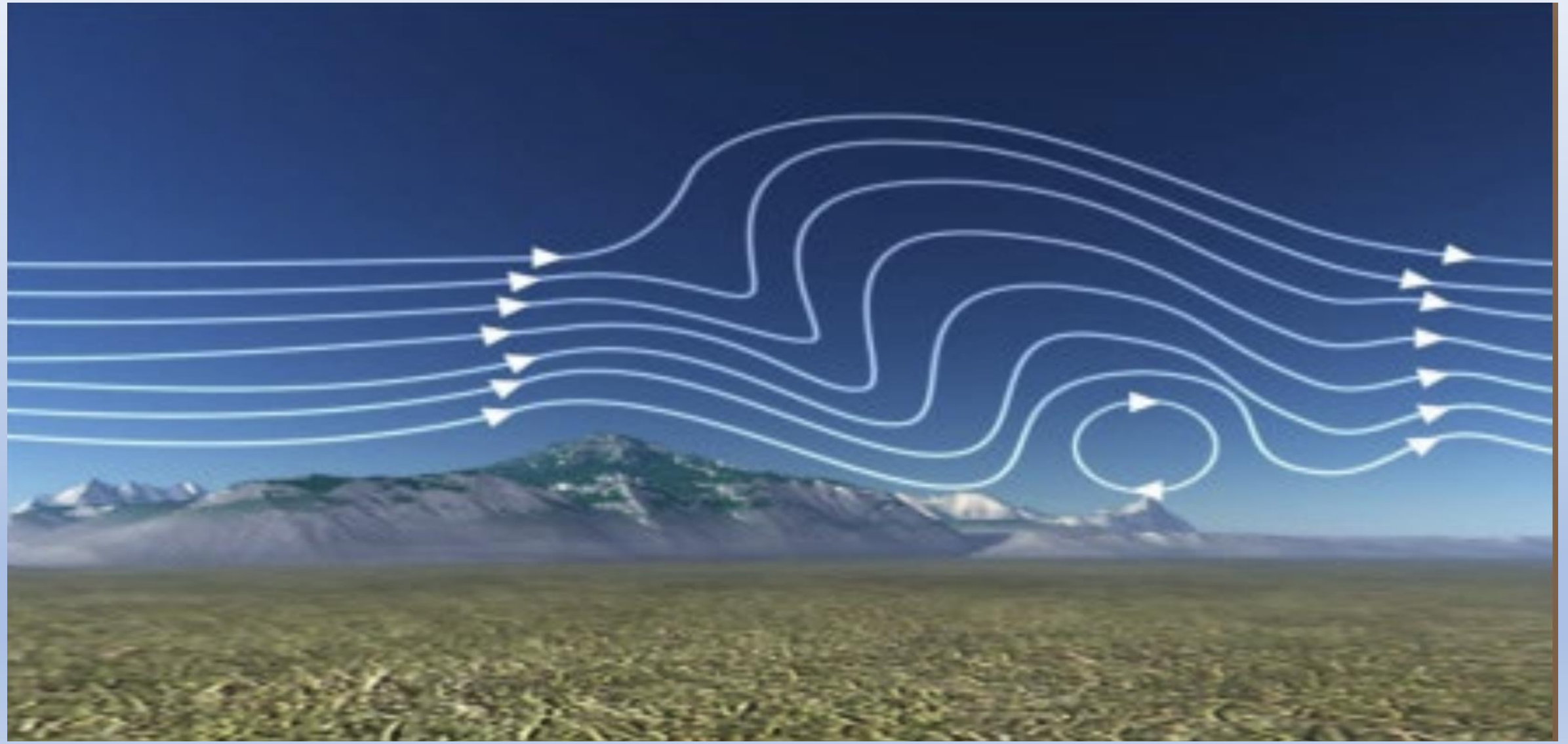
Surface obstructions cause eddies and other irregular wind movements



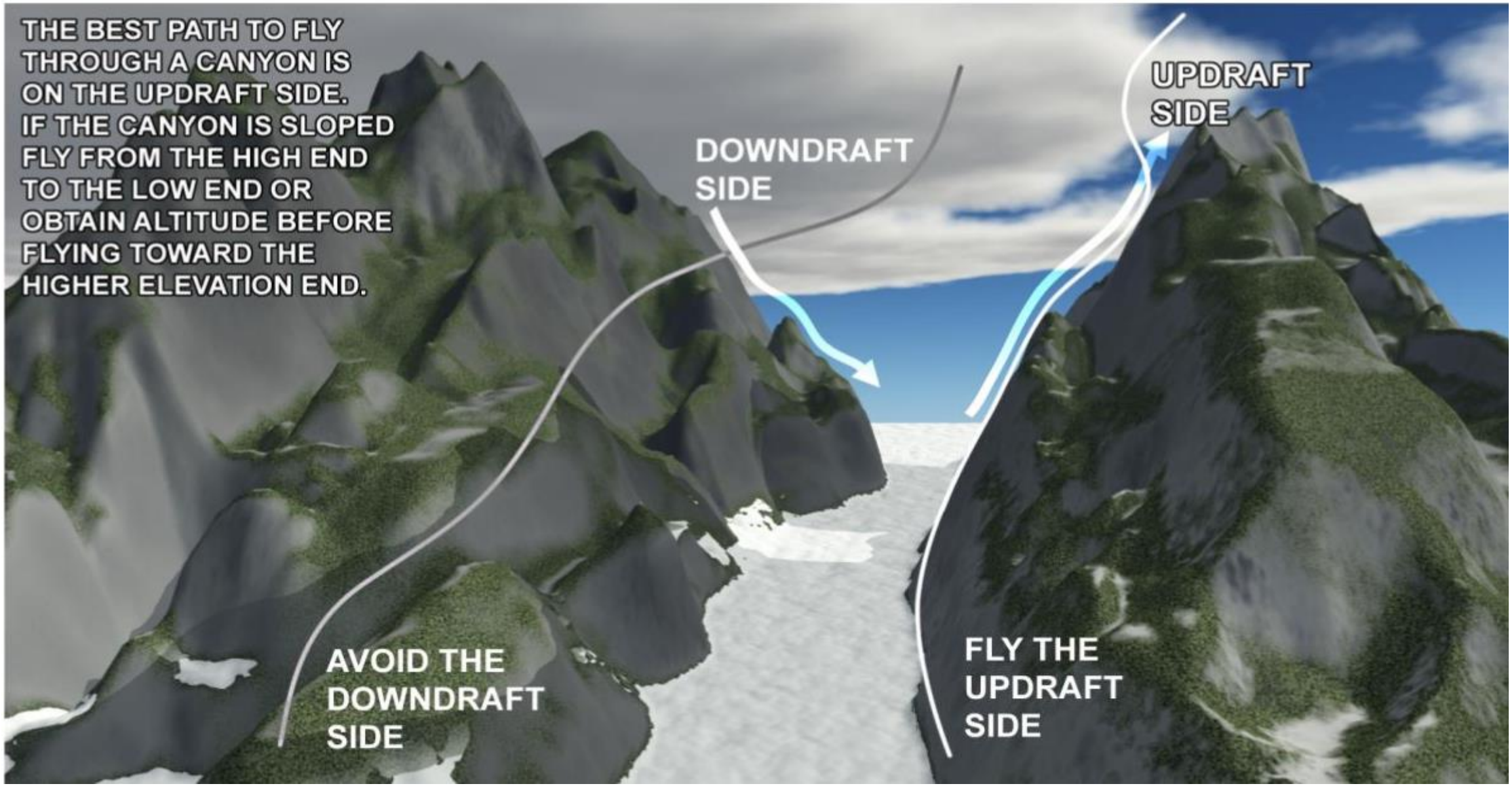
Buildings near landing areas may cause turbulence



Wind flow over mountain ranges produces turbulence



In a valley or canyon, safest path is on upslope wind side



The mountains funnel winds into passes and valleys, thus increasing wind speeds and intensifying turbulence (Venturi Effect).

Mountain wave

Near a mountain wave, the following conditions can exist:

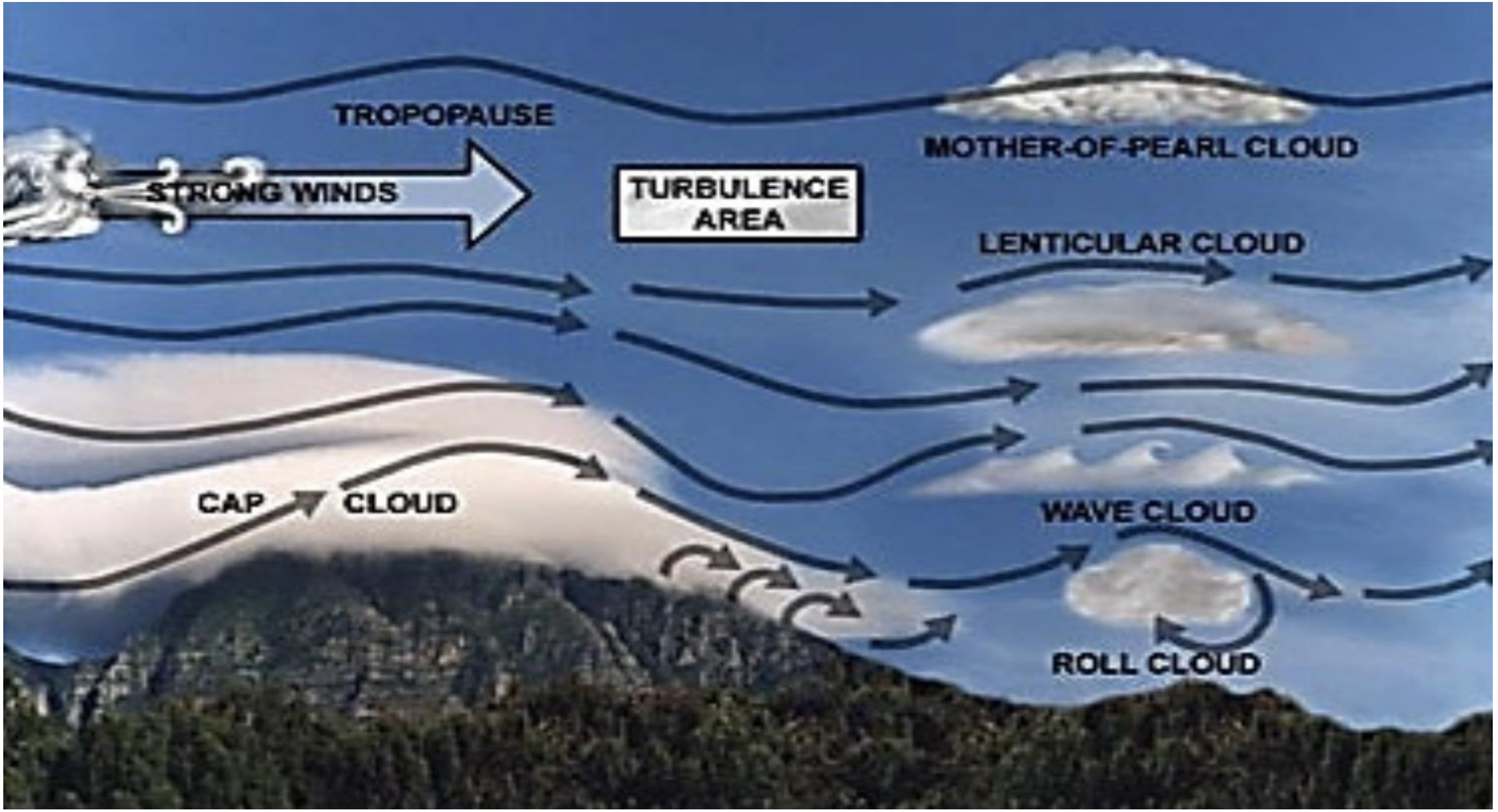
- Vertical currents of 2,000 FPM – 5,000 FPM.
- Turbulence varies from moderate to severe.
- Wind gusts up to 22 kts per hour between waves.
- Altimeter errors of as much as 1,000 feet.
- Icing.

Visual indicators of mountain wave:

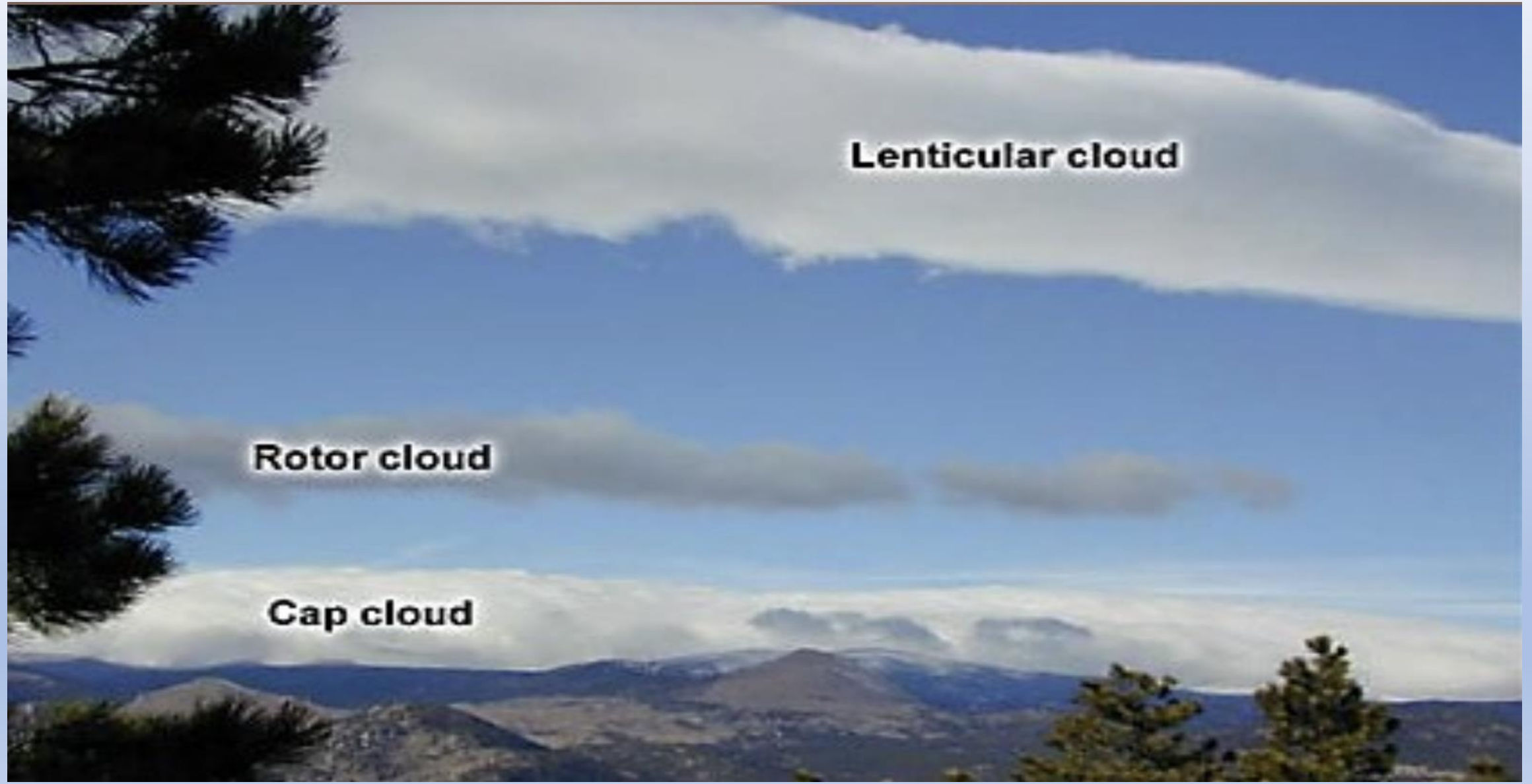
- Lenticular clouds
- Rotor clouds
- Cap clouds

- *Note: adequate moisture must be present for these clouds to form… a wave can be present without cloud formation.*

Typical cloud formation, main updraft and downdraft in mountain wave



Clouds associated with a mountain wave



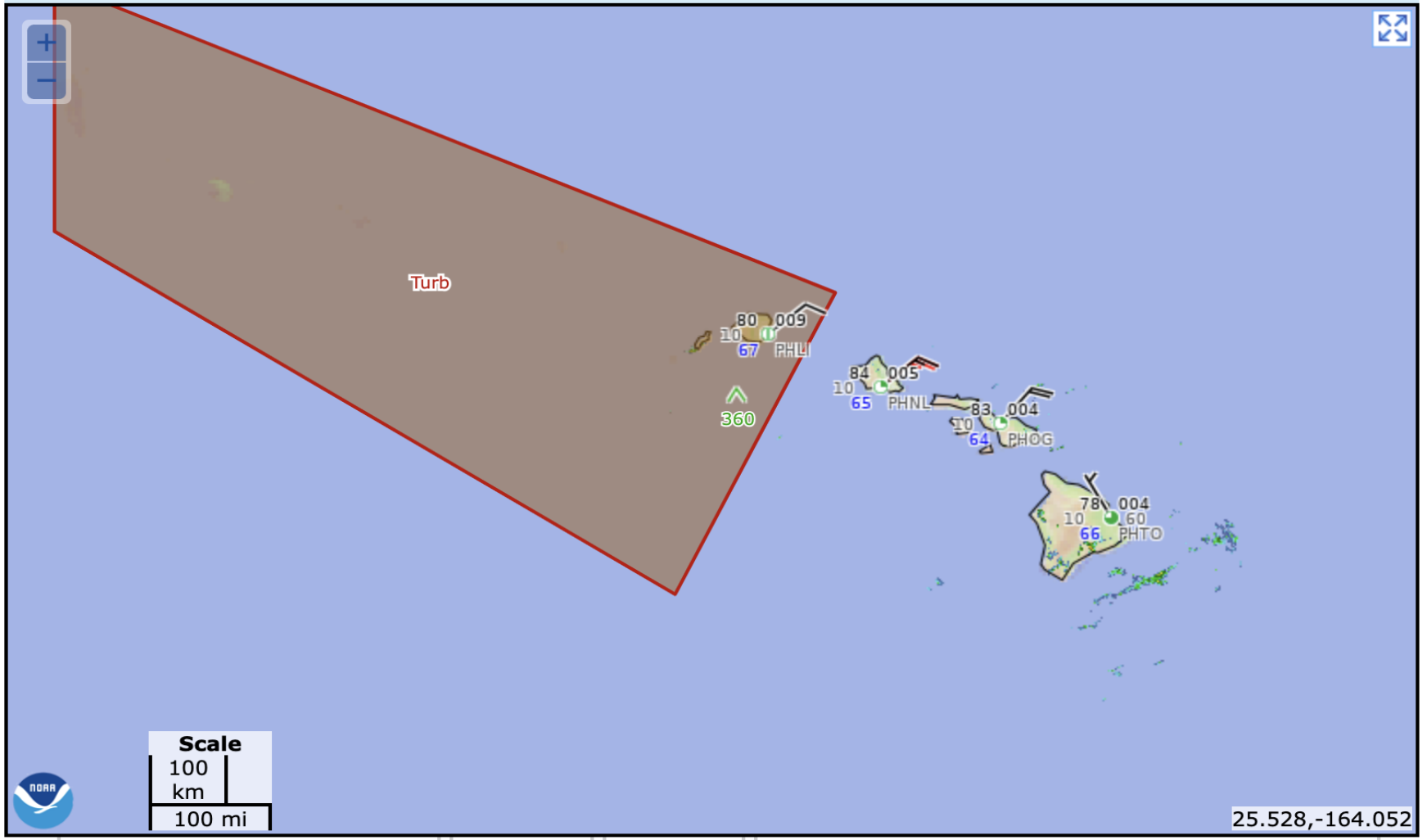
Aviation Weather Overview

Info

METARs | TAFs | AIR/PIREPs | SIGMETs | G-AIRMETs

NOTICE Please check out the experimental preview of an upcoming version of this site at Beta.AviationWeather.gov!

Data Overlay View Configure 2227 UTC Fri 26 May 2023



Flt Cat: MVFR IFR LIFR | SIGMET | CWA | GAIRMET TurbHi TurbLo LLWS SfcWnd Icing Frz IFR MtnObs

PIREP Turb: NIL LGT MOD SEV | PIREP Ice: NIL LGT MOD SEV | PIREP Other:

- DD FORM 175-1
- 17 OWS

FLIGHT LEVEL WINDS 010-050

FLIGHT WEATHER BRIEFING

ARMY

PART I – TAKEOFF DATA

1. DATE (YYYY-MM-DD)	2. ACFT TYPE/NO.	3. DEP PT/ETD	4. RWY TMP	5. DEWPOINT	6. TEMP DEV	7. PRES ALT	8. DENSITY ALT	ALTIMETER
2023-04-21	CH-47D 472	PHSF 21/1600 Z	+19 °C +66 °F	+13 °C +56 °F	°C °F	+5869 FT	+7890 FT	30.27 INS

9. SFC WIND	10. CLIMB WINDS	11. LOCAL WEATHER WATCH/WARNING/ADVISORY	12. RSC/RCR
27010KT T	01005KT (SFC-050)	NONE	N/A

13. REMARKS/TAKEOFF ALTN FCST T/O WX: 7SM FEW030

PART II – ENROUTE & MISSION DATA

14. FLT LEVEL/WINDS/TEMP		15. SPACE WEATHER				16. SOLAR		LOCATION
SEE BELOW SEE BELOW	SEE ATTACHED	NONE						PHSF (LOC)
050 PHSF – PHHI 10010KT/+15C			NO IMPACT	MARGINAL	SEVERE	BMNT	21/0518 Z	
		FREQ	X			SR	21/0608 Z	MR 21/0714 Z
		GPS	X			SS	21/1854 Z	MS 21/2049 Z
		RAD	X			EENT	21/1944 Z	ILLUM 5 %

17. CLOUDS AT FLT LEVEL					18. OBSCURATIONS AT FLT LEVEL RESTRICTING VISIBILITY				
YES	NO	X	IN AND OUT		X	YES	NO	TYPE	-SHRA 5SM

19. MINIMUM CEILING - LOCATION	20. MAXIMUM CLOUD TOPS - LOCATION	21. MINIMUM FREEZING LVL - LOCATION
035 FT AGL PHHI	070 FT MSL EN ROUTE	150 FT MSL EN ROUTE

22. THUNDERSTORMS OWS FCST					23. TURBULENCE OWS FCST				24. ICING OWS FCST					25. PRECIPITATION OWS FCST					
CHART 21/15Z-21/21Z					CHART 21/15Z-21/21Z				CHART 21/15Z-21/21Z					CHART 21/15Z-21/21Z					
X	NONE		AREA		X	NONE	IN CLEAR	IN CLOUD	X	NONE	RIME	MIXED	CLEAR		NONE	DRIZZLE	RAIN	SNOW	PELLET
	ISOLATED 1-2%		MT			LIGHT				TRACE					LIGHT		X		
	FEW 3-15%		MT			MODERATE				LIGHT					MODERATE				
	SCATTERED 16-45%		MT			SEVERE				MODERATE					HEAVY				
	NUMEROUS > THAN 45%		MT			EXTREME				SEVERE					SHOWERS		X		
HAIL,SEVERE TURBULENCE & ICING,HEAVY PRECIPITATION, LIGHTNING & WIND SHEAR EXPECTED IN AND NEAR THUNDERSTORMS					LEVELS NONE				LEVELS NONE					FREEZING					
LOCATION NONE					LOCATION NONE				LOCATION NONE					LOCATION PHHI					

PART III – AERODROME FORECASTS

26. DEST/ALTN	27. VALID TIME	28. SFC WIND	29. VSBY/WEA	30. CLOUD LAYERS	31. ALSTG	RWY TMP	PA
Destination 21/1730 Z PHHI WHEELER AAF / SCHOFIELD BA	TO 21/1730 Z 21/1830	29006KT °T	7	SCT025 BKN035	INS 29.94	+19 °C +66 °F	FT +819
Destination Z	TO Z	°T			INS	°C °F	FT
Destination Z	TO Z	°T			INS	°C °F	FT
Destination Z	TO Z	°T			INS	°C °F	FT
Destination Z	TO Z	°T			INS	°C °F	FT
Destination Z	TO Z	°T			INS	°C °F	FT
Destination Z	TO Z	°T			INS	°C °F	FT
Destination Z	TO Z	°T			INS	°C °F	FT

PART IV – COMMENTS/REMARKS

32. BRIEFED RSC/RCR		YES	X	NOT AVAILABLE	33. PMSV 125.10	34. ATTACHMENTS		YES	X	NO

35. REMARKS
FOR UPDATES/DEBRIEFS/REPORTING PIREPS PLEASE CALL PHHI WX @808-656-1016/17 OR WHEELER METRO/ PMSV 125.10

PART V – BRIEFING RECORD

36. WX BRIEFED TIME	37. FLIMSY BRIEFING NO.	38. FORECASTER'S INITIALS	39. NAME OF PERSON RECEIVING BRIEFING		MISSION ID / CONTROL #
E21/0400 Z	110PHSF192228186	JOB	VITALIE GUMENIUC		110PHSF192228186
40. VOID TIME	41. EXTENDED TO / INITIALS	42. WX REBRIEFED TIME / INITIALS	43. WX DEBRIEF TIME / INITIALS	FAX NO.	INTERNAL USE ONLY
21/0530 Z	Z	Z	Z		

FLIGHT LEVEL WINDS 010-050

Mitigating the hazards

- Helicopter pilots operating in mountainous environments require specialized training, experience, and knowledge of the area.
- Pre-flight planning, detailed weather briefings, and understanding local topography are crucial.
- Regular use of Graphical Forecasts for Aviation and other NWS products.
- Give a PIREP for the flight conditions
- ADS-B In (FIS-B and TIS- B)

Bibliography

- U.S. Department of Transportation, Code of federal Regulations, Title 14, Chapter I, Subchapter F, Part 95
- “Chapter 12, Weather Theory.” Pilot’s Handbook of Aeronautical Knowledge, U.S. Department of Transportation, Federal Aviation Administration, Flight Standards Service, Washington, D.C., 2022.
- United States Army Training Circular 3-04.14-2 Air Force Handbook 11-203, Volume 2 Flying Operations Weather for Aircrews -Products and Services 20 January 2016**.** Create space Independent Publishing Platform, 2 Mar. 2017.
- Federal Aviation Administration. *FAR/AIM, 2020 : Federal Aviation Regulations /Aeronautical Information Manual.* www.faa.gov, 23 Apr. 2023.