# Hyannis Air Service
# Special Emphasis Training

Flying in Mountainous Terrain and in Non-Radar environments

# Mountain Flying

## Mountain Wave Development

# WINDS

Winds associated with mountains can be broken down into three main categories:

- Prevailing winds: upper-level winds flowing predominately from west to east in the continental US.
- Local winds: also called valley winds, are created by convection heating & cooling. They flow parallel to larger valleys. During the day, these winds tend to flow up valley; at night, they flow down valley.
- Surface winds: the layer of air which lies close to the ground. It is less turbulent than prevailing & local winds.

# Mountain Flying

All pilots who fly near mountainous terrain must deal with the potential for mountain-induced severe wind events, particularly during takeoff and landing

Takeoff and landing concerns include:

- experiencing turbulent air with inadequate stall margins
- loss of directional control on or near the runway
- rolling moments that surpass aircraft roll authority
- downdraft velocities that exceed the climb capability of the aircraft

“Strong” winds are those that are at least <u>20 knots.</u>

Cape Air
NANTUCKET AIRLINES

# Mountain Flying

Forecast and actual wind speeds at ridge level can be determined from the FD (Forecast Winds and Temperatures Aloft) and UA (PIREPS) products, respectively

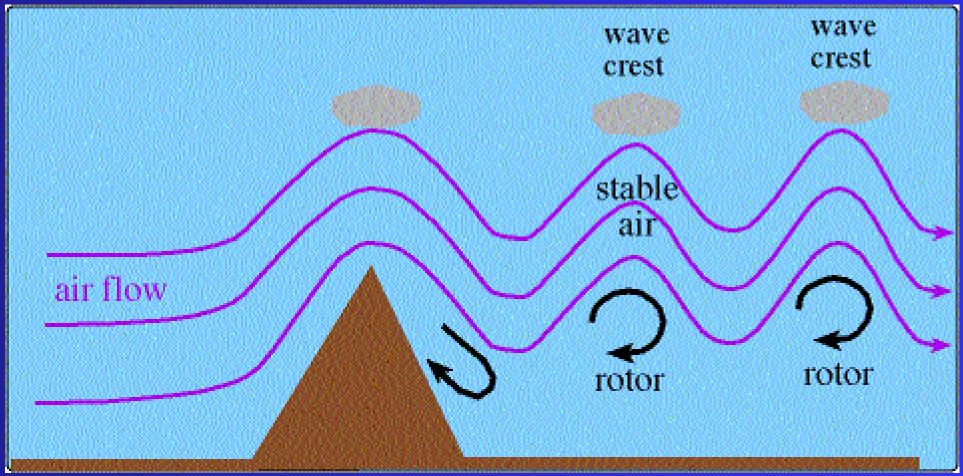
| FT | 3000 | 6000 | 9000 | 12000 | 18000 | 24000 | 30000 | 34000 | 39000 |
|---|---|---|---|---|---|---|---|---|---|
| BDL | 3048 | 3258-11 | 3162-14 | 3171-16 | 3090-24 | 7912-35 | 792150 | 297450 | 296847 |
| BGR | 2950 | 3256-14 | 3251-18 | 3155-22 | 3137-28 | 3051-37 | 304541 | 292539 | 292140 |
| CAR | 3047 | 3330-14 | 3241-18 | 3332-21 | 3327-26 | 3328-38 | 321238 | 990036 | 111039 |
| PWM | 3056 | 3155-11 | 3156-16 | 3155-21 | 3152-30 | 3061-38 | 296844 | 295341 | 303342 |
| EMI | 3213 | 3125-04 | 2951-07 | 2862-12 | 2878-22 | 2975-33 | 780547 | 780855 | 297251 |
| ACK | 2948 | 3146-12 | 3052-14 | 3063-18 | 8008-24 | 8026-36 | 802151 | 298646 | 296845 |
| BOS | 3052 | 3151-12 | 3151-15 | 3056-19 | 8100-25 | 8024-36 | 800049 | 297447 | 295944 |
| BML | 2950 | 3260-14 | 3267-18 | 3268-22 | 3158-28 | 3141-36 | 304444 | 294142 | 293142 |
| ACY | 3033 | 3242-05 | 3050-09 | 2963-12 | 2874-22 | 2983-33 | 790748 | 790353 | 277653 |
| ALB | 3050 | 3256-12 | 3259-15 | 3166-18 | 3089-25 | 7911-36 | 792051 | 297451 | 286846 |
| BUF | 3214 | 3427-07 | 3328-12 | 3038-17 | 2968-26 | 2877-36 | 289350 | 298152 | 285850 |
| JFK | 3042 | 3151-09 | 3155-11 | 3063-14 | 2981-23 | 2894-35 | 790651 | 298552 | 287950 |
| PLB | 2953 | 3347-13 | 3348-18 | 3252-23 | 3167-30 | 3086-37 | 306445 | 304043 | 283444 |
| SYR | 3036 | 3241-13 | 3252-15 | 3159-20 | 3076-26 | 7900-36 | 790850 | 296749 | 285648 |
| CLE | 1022 | 2023-06 | 2649-06 | 2646-12 | 2765-22 | 2776-35 | 278649 | 279256 | 287051 |

# Mountain Flying

There are two atmospheric characteristics leading to mountain wave formation:

- *Atmospheric stability*
- *Wind Strength*

A parcel of air within a stable air mass moving over a mountain will undergo wave motion.




Cape Air NANTUCKET AIRLINES

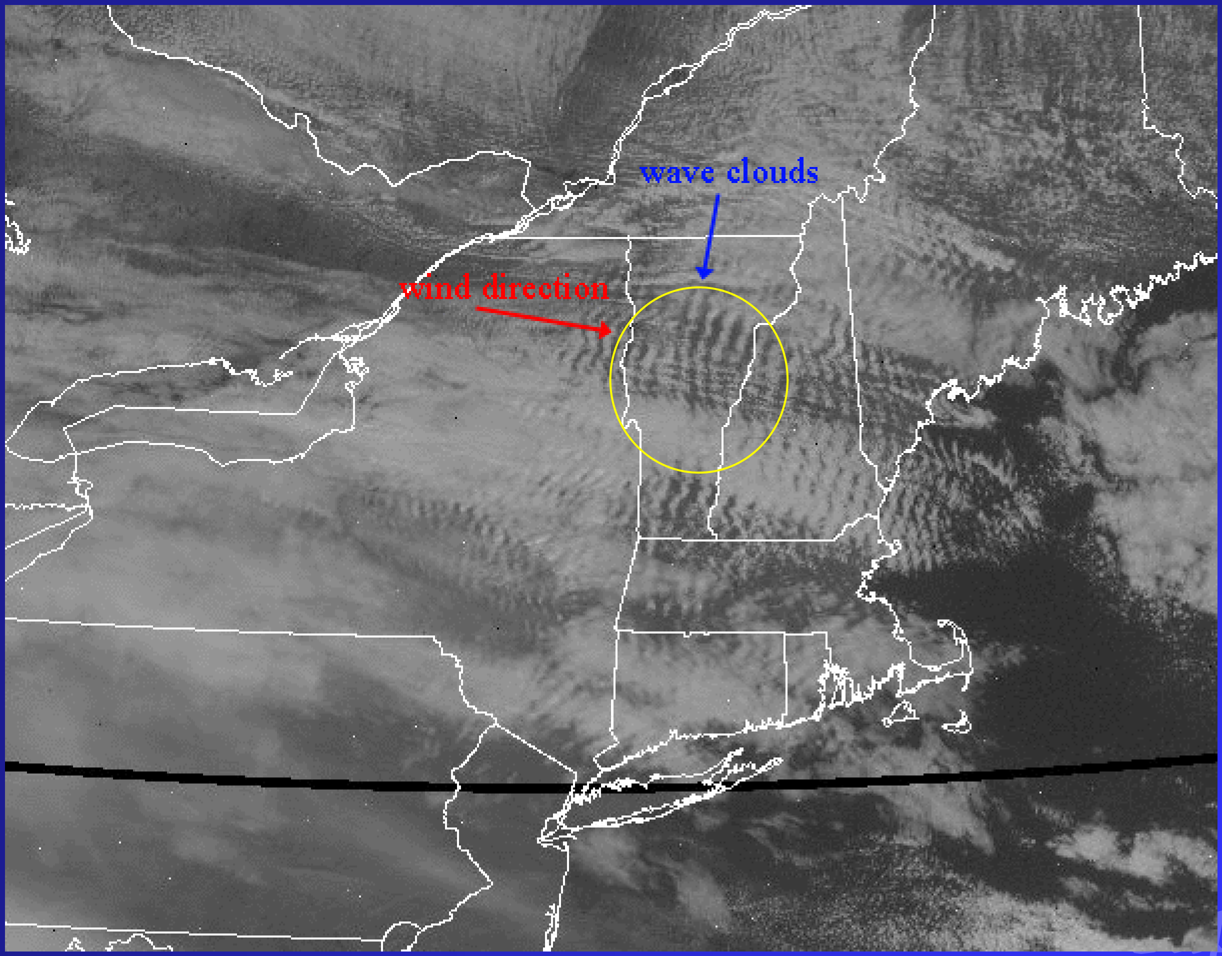
# Mountain Flying

Satellite imagery can give an indication of  the likely existence of a mountain-induced gravity wave.

There will be indications of clouds that have a stationary upstream edge over or near the known location of a mountain range, with the orientation of this upwind edge generally parallel to the orientation of the range.

# Mountain Flying

Here's an example:




Cape Air
NANTUCKET AIRLINES

# Mountain Flying

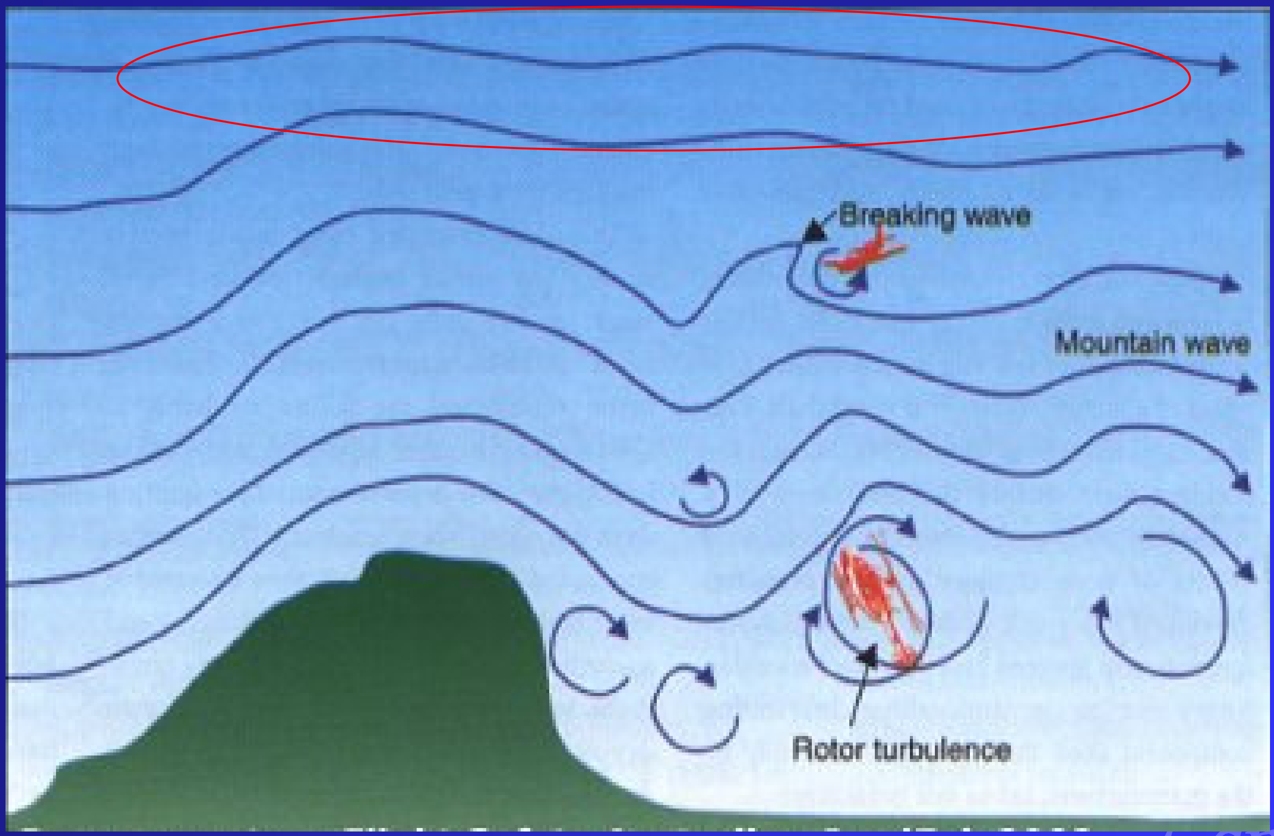
When mountain waves are present, it is common for a rotor zone to develop near or below ridge level on the downwind side of the mountain, under a wave crest and associated lenticular cloud (if sufficient moisture is present). This is an area of potentially severe-to-extreme wind shear and turbulence.

From a distance, a rotor cloud might look like an innocuous cumulus cloud; however, the downwind side of the rotor cloud will typically be rounded in the direction of rotation of the rotor, with cloud tags or streamers at the bottom of the cloud mass. The latter features appear to be rapidly forming and dissipating, thereby giving some sense of rotation within the cloud.

Cape Air
NANTUCKET AIRLINES

# Mountain Flying

Staying well above the terrain is the best solution!



# Mountain Flying

Lenticular Cloud

Rotor Clouds

Cape Air NANTUCKET AIRLINES

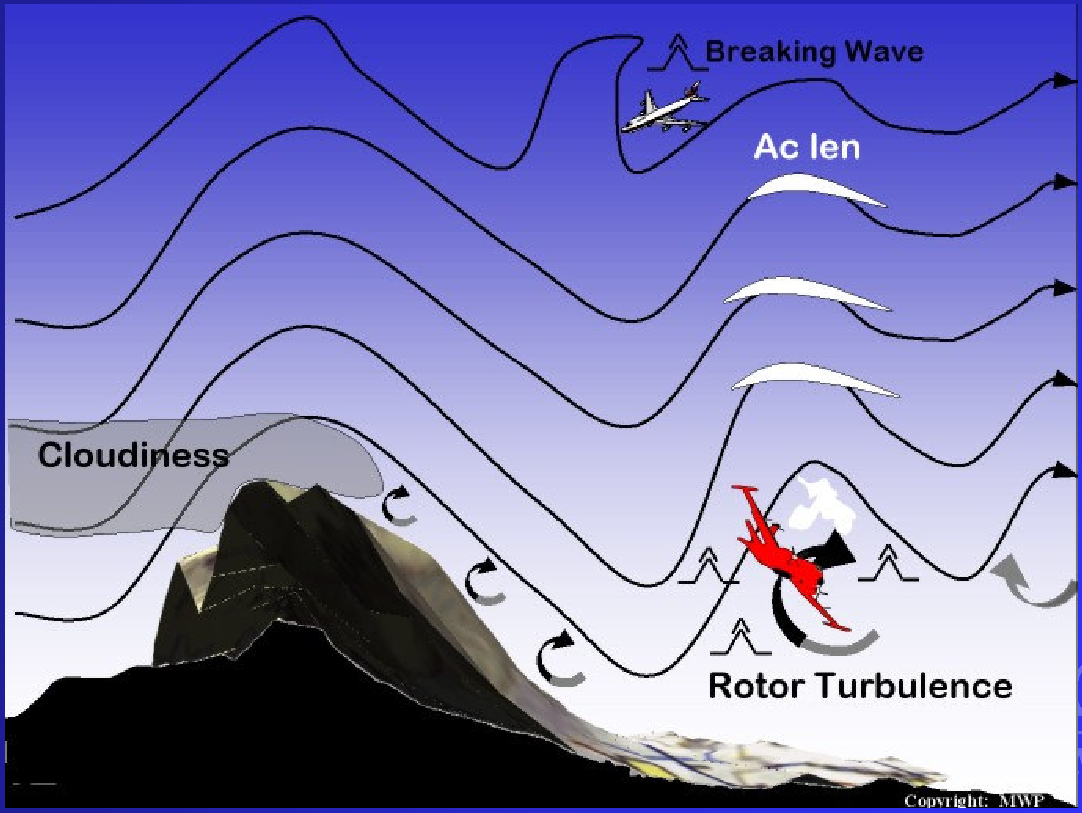
# Mountain Flying

A concentrated shear zone and turbulence can develop in the stable air associated with a temperature inversion when strong vertical shear is present above the inversion.

Check for a “cold pool of air” in the valley with strong winds aloft.

Cape Air
NANTUCKET AIRLINES

The greatest chance for small-scale horizontal vortices with breaking vertically propagating waves and windstorms is when wind surges interact with foothill terrain downwind of the main topographic feature that is causing the vertically propagating wave.

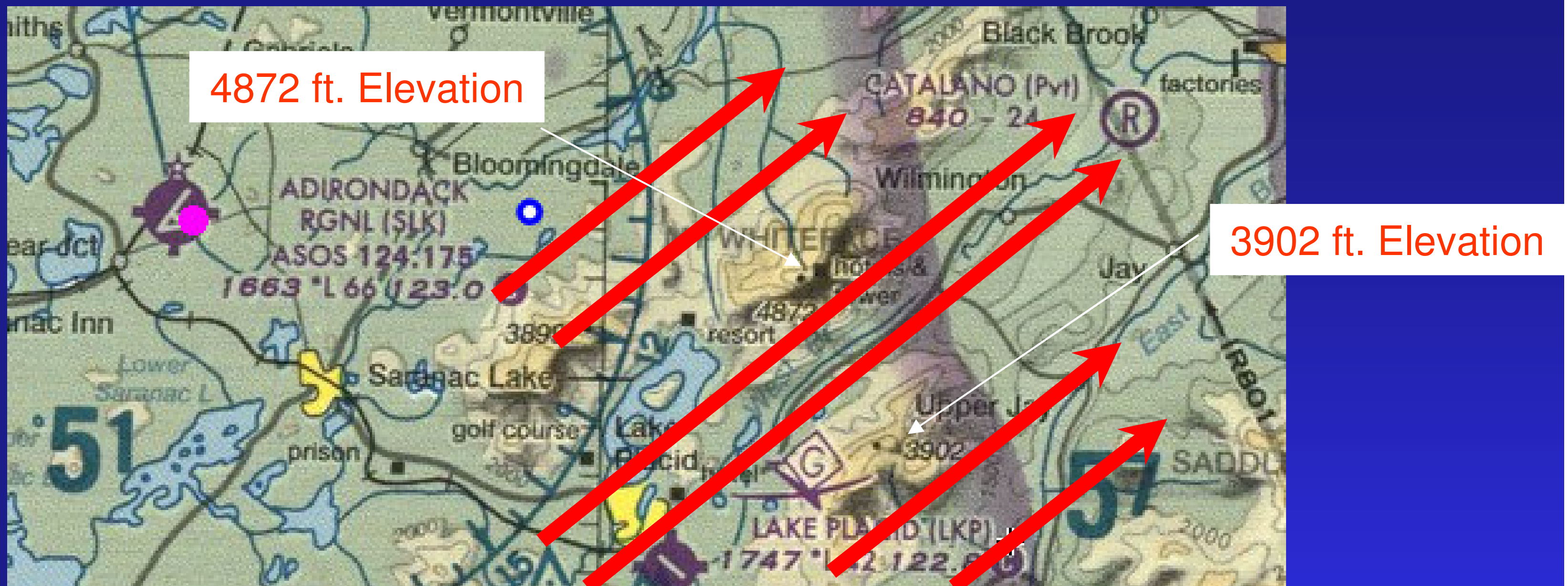


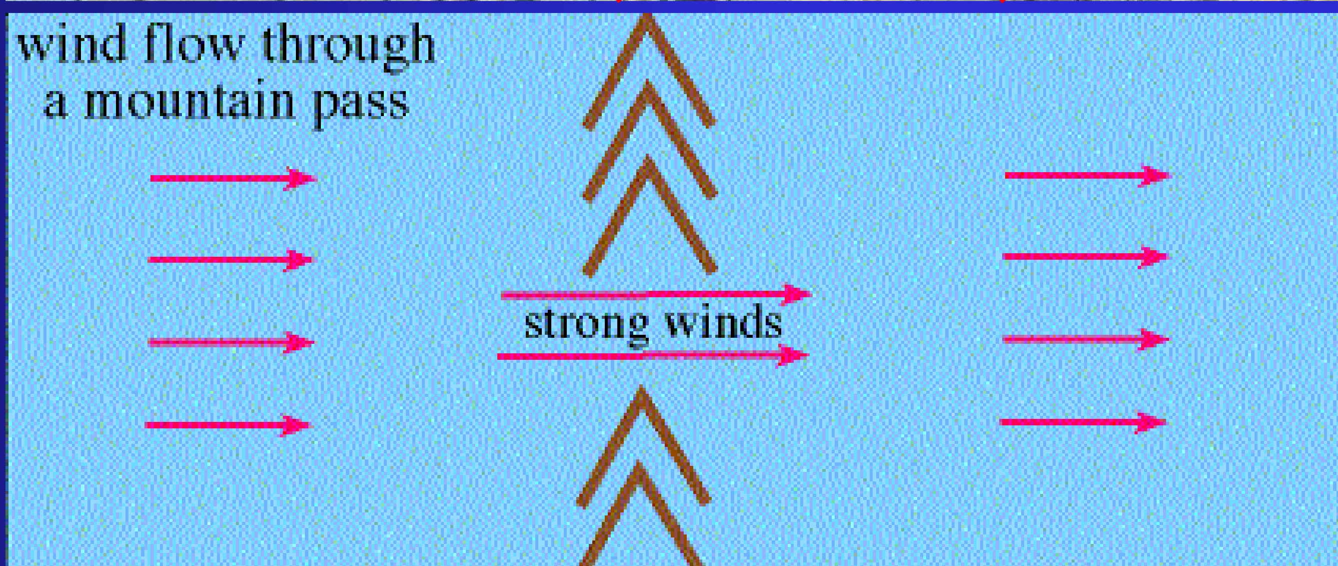

Cape Air NANTUCKET AIRLINES

# Mountain Flying: The Venturi Effect

- The venturi effect of mountains and mountain passes accelerates winds over ridges and through passes. Stronger-than-forecast winds should be expected in these areas, especially within 5000 ft. of terrain.
- Caution should be used when approaching a pass with the winds perpendicular to the wind flow.
- When traveling though a pass perpendicular to  the wind, stronger wind speeds can be expected.

# The Venturi Effect



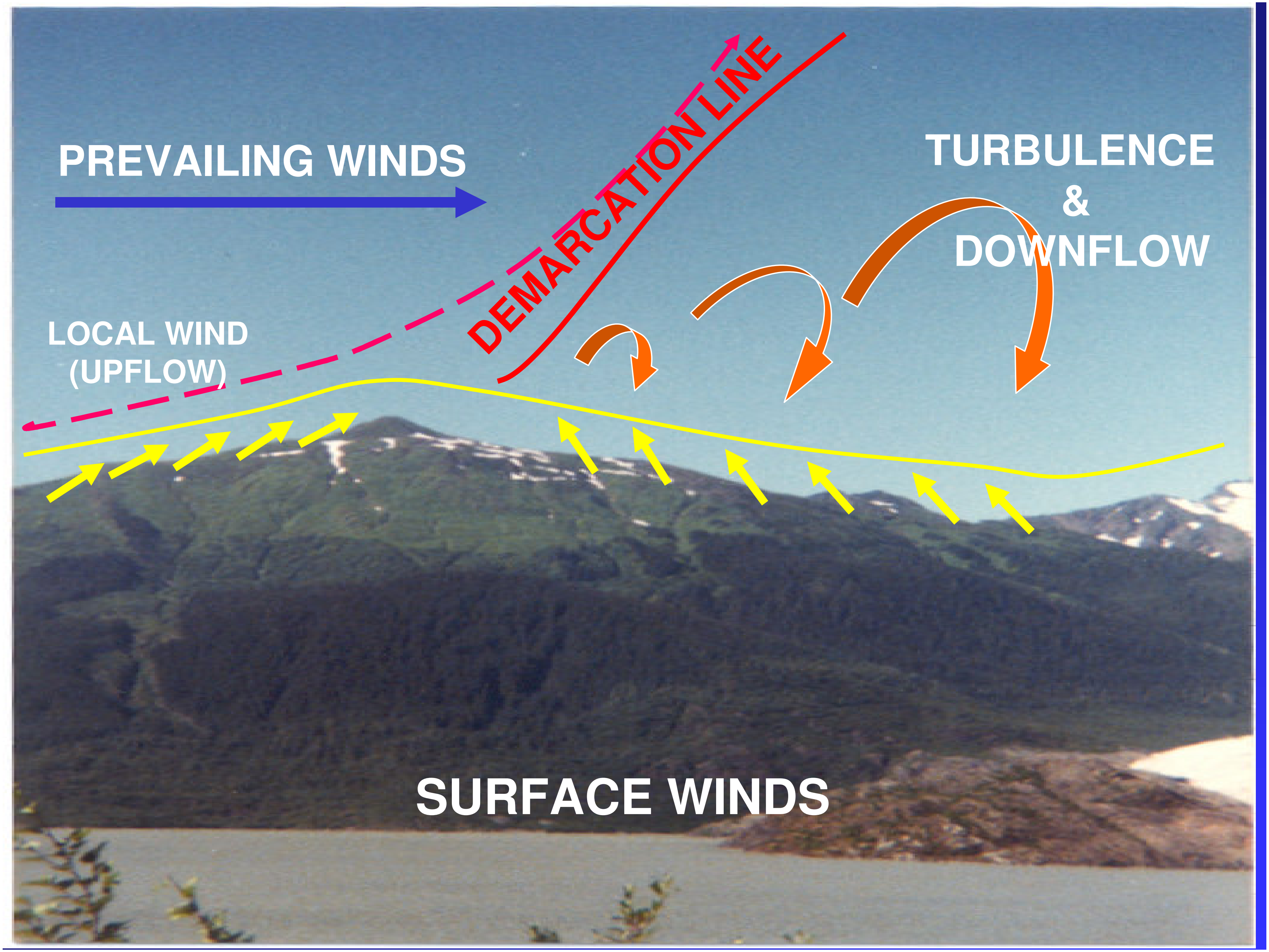



# Mountain Flying: Demarcation Line

Demarcation line: the point which separates the up flow from the down flow of air.

- It forms from the highest point of the mountain & extends diagonally upward.
- The velocity of the wind and the steepness of the uplift slope will determine the position of the demarcation line.
- Generally, the higher the wind speed and steeper the terrain, the steeper the demarcation line.

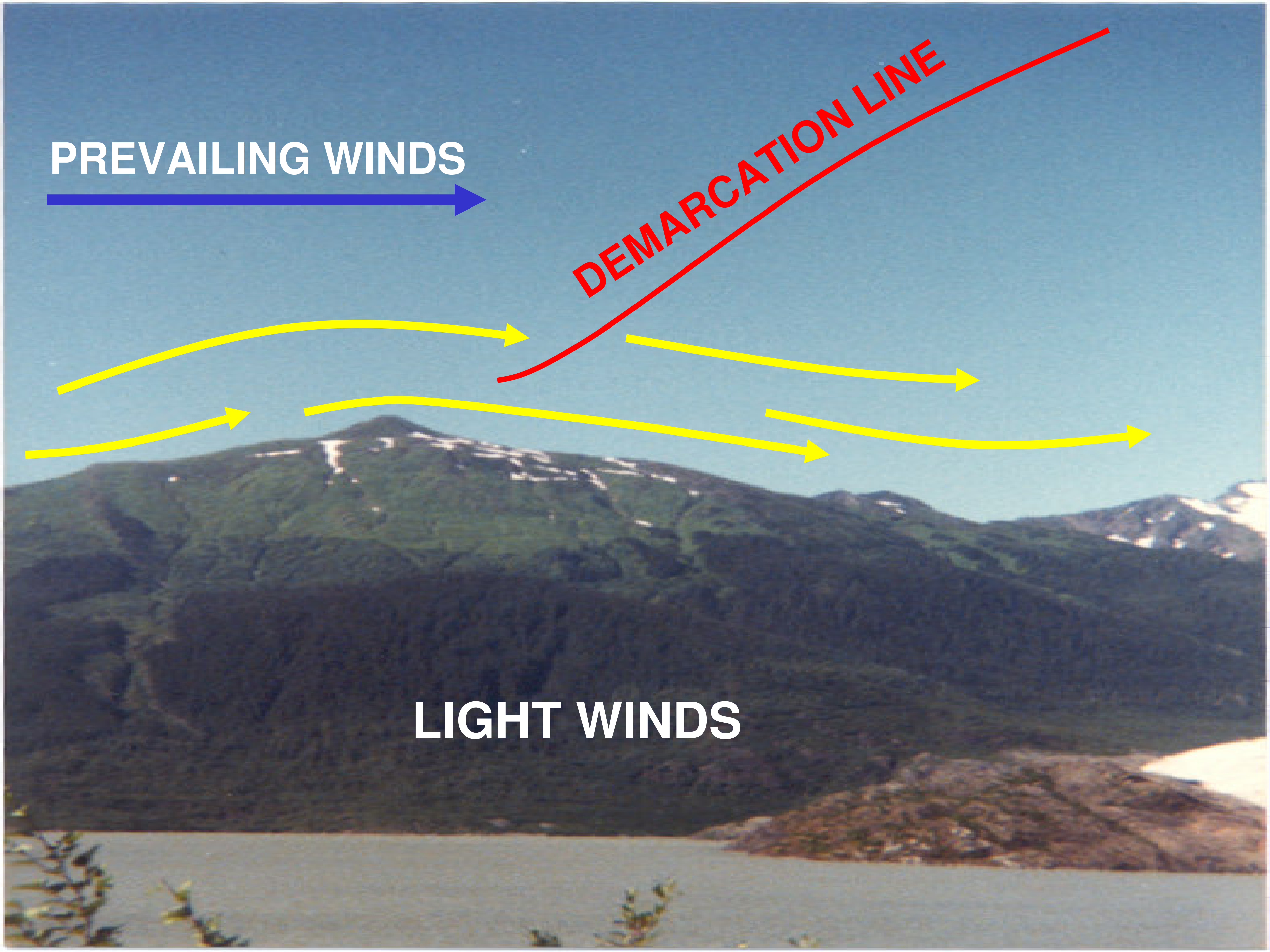
Cape Air NANTUCKET AIRLINES


PREVAILING WINDS
DEMARCATION LINE
TURBULENCE
&
DOWNFLOW
LOCAL WIND
(UPFLOW)
SURFACE WINDS

# LIGHT WINDS

Light wind: 1-10 knots

- Accelerates slightly on the upslope, giving rise to a gentle updraft.
- Follows the contour of the terrain feature over the crest.
- At some point past the crest, they turn into a gentle downdraft.

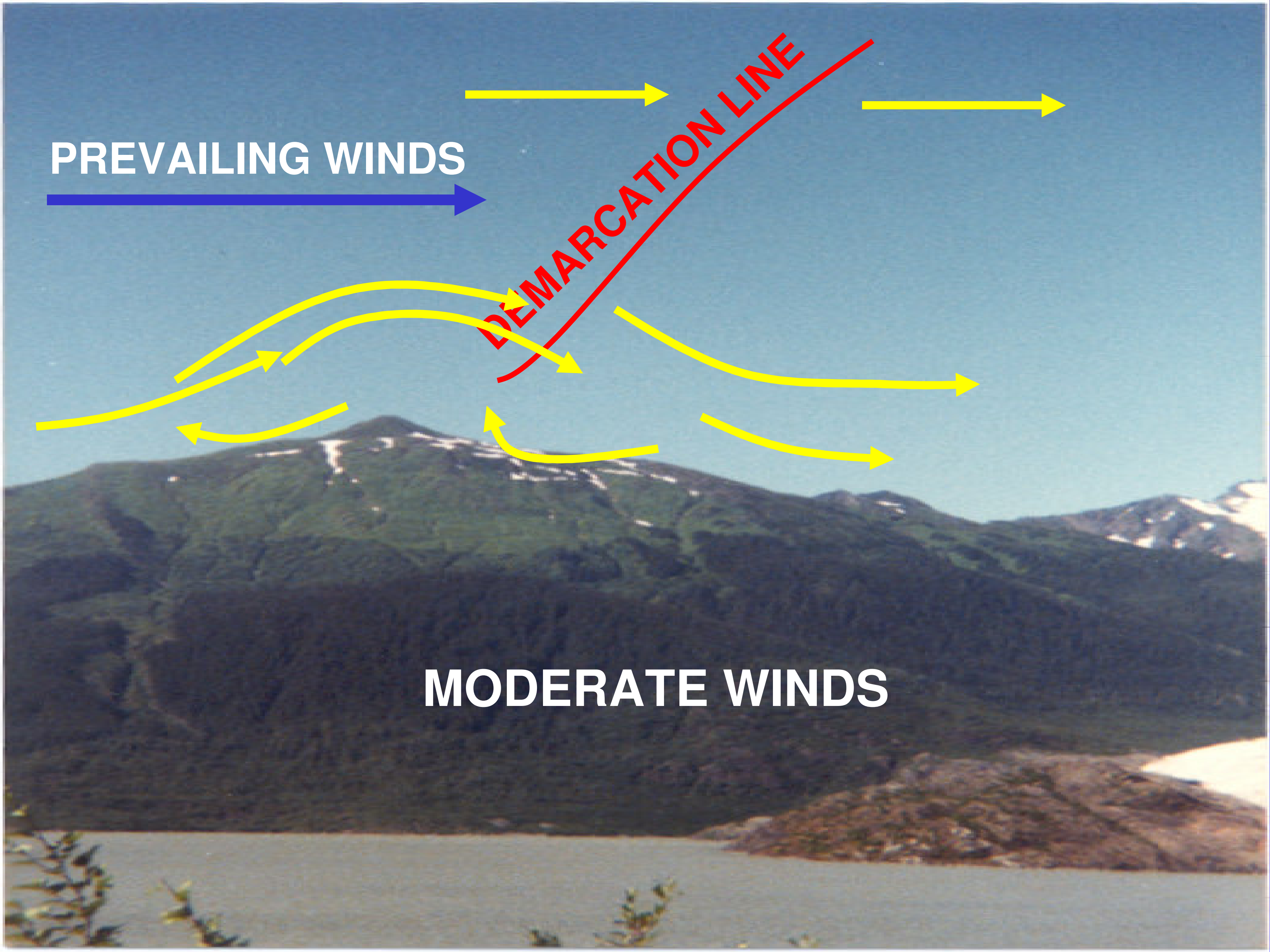

PREVAILING WINDS
DEMARCATION LINE
LIGHT WINDS

# MODERATE WINDS

Moderate wind: 11 to 20 knots

- Will increase the strength of the updrafts and downdrafts and create moderate turbulence.
- An updraft will be experienced on the lee (the side sheltered from the wind) slope near the crest of the mountain.
- The demarcation line forms closer to the hill crest and is steeper

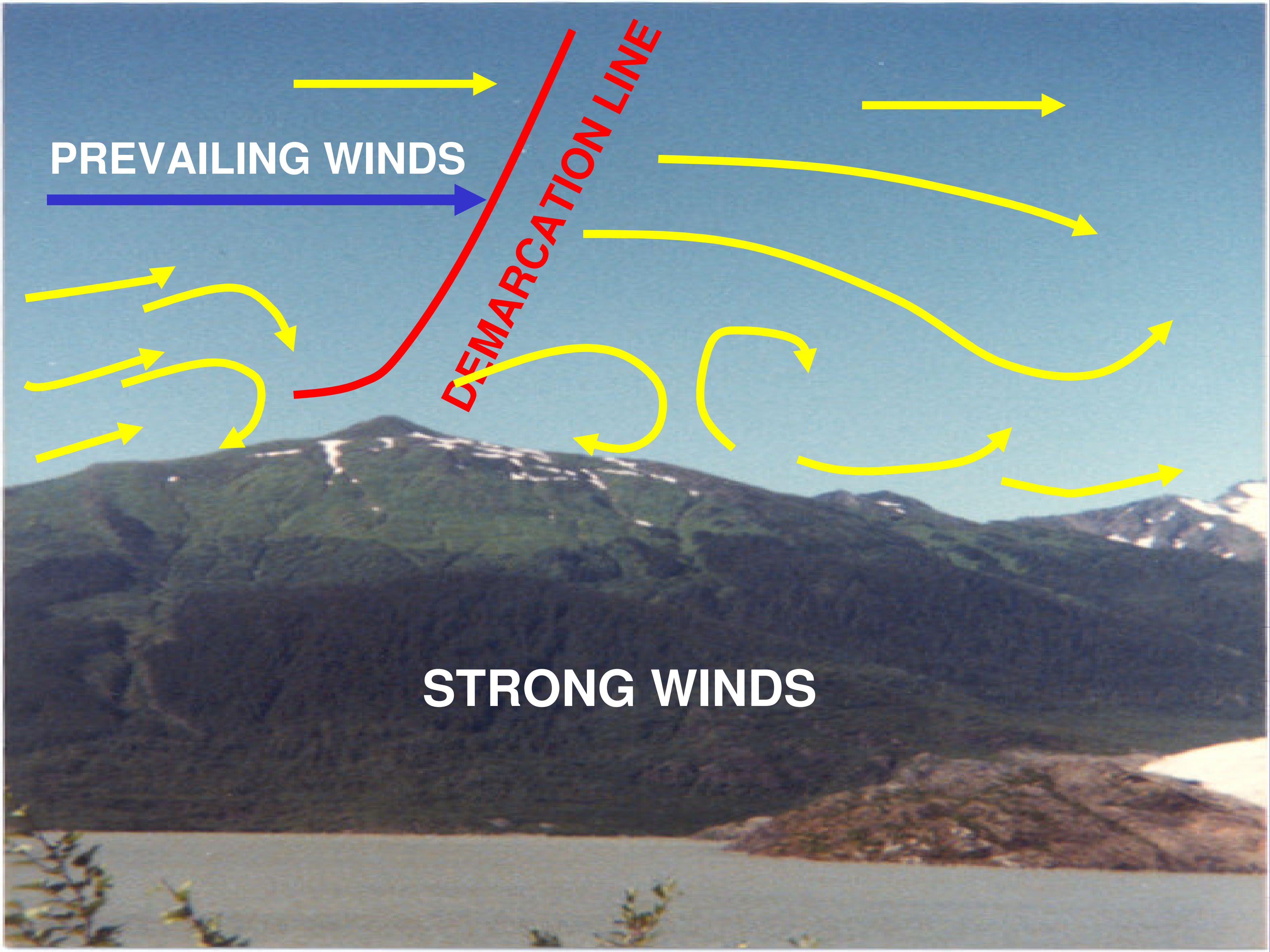
Cape Air
NANTUCKET AIRLINES


PREVAILING WINDS
DEMARCATION LINE
MODERATE WINDS

# STRONG WINDS

Strong winds: above 20 knots

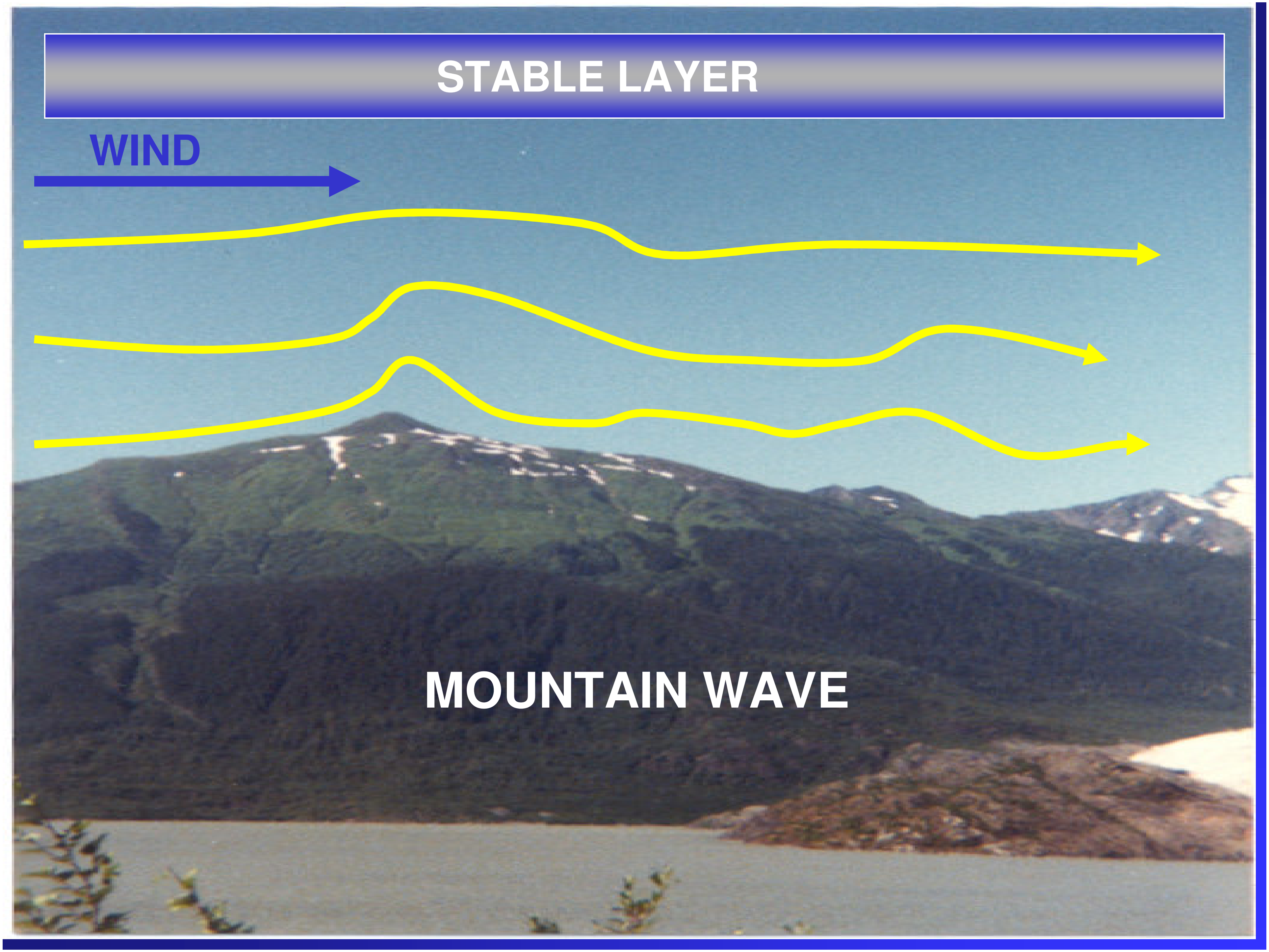
- The demarcation line will move forward to the leading edge of the hill crest
- Demarcation becomes progressively steeper and the severity of updrafts, downdrafts, and turbulence will also increase.


PREVAILING WINDS
DEMARCATION LINE
STRONG WINDS

# MOUNTAIN WAVE

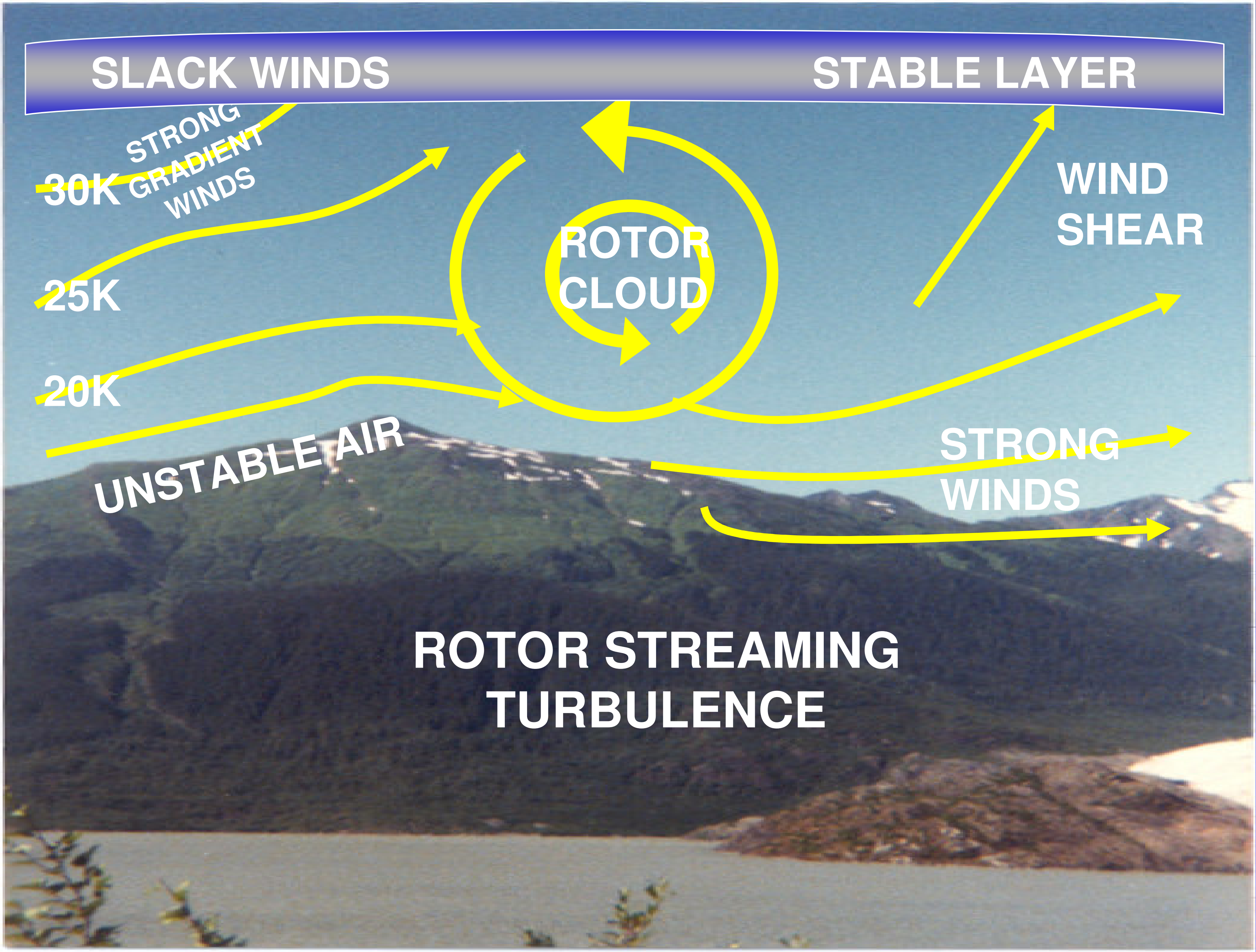
The following conditions can exist in a Mountain Wave:

- Vertical currents of 2,000 fpm are common, 5,000fpm possible
- Moderate to severe turbulence
- Gusty winds
- Moderate to Severe Icing


STABLE LAYER
WIND
MOUNTAIN WAVE

# Non-Steady Horizontal Roll Vortices

- Roll vortices can develop in non-steady wind flow over a mountain ridge
- The roll vortices develop and move downwind from the mountain
- These roll vortices will occur in a generally turbulent environment.  Aircraft encounters can lead to locally severe turbulence and strong rolling moments
- Traveling vortices may present a greater hazard for aircraft because of the added velocity components.
- *Pilots should watch for blowing dust, snow, and debris at the surface*


SLACK WINDS
STABLE LAYER
STRONG GRADIENT WINDS
30K
25K
20K
ROTOR CLOUD
WIND SHEAR
UNSTABLE AIR
STRONG WINDS
ROTOR STREAMING TURBULENCE

# Icing Concerns

- Orographic clouds form when moist air is lifted by flowing up the side of a mountain.
- As the parcel of air is lifted, it cools and forms a cloud. Such clouds can contain a large volume of water and, in some cases, large droplets.
- The larger the droplet, the faster ice can build.

# Icing Concerns

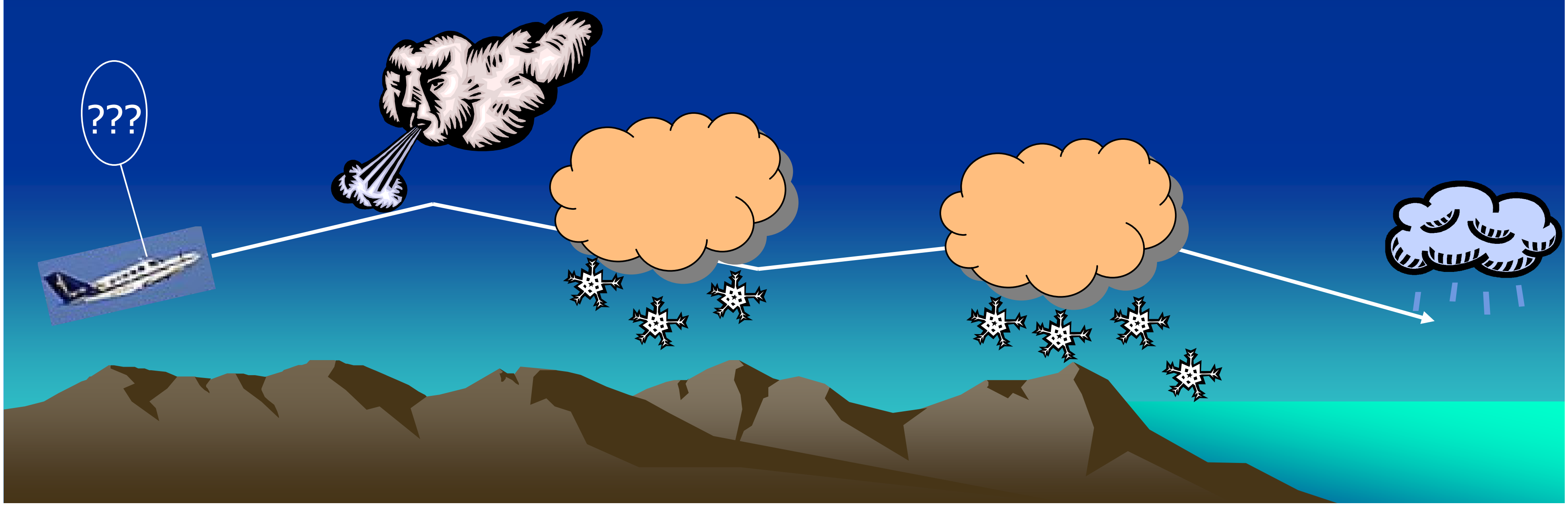
- Wave clouds, recognized by their “wavy” tops, can have high liquid water contents.  Continued flight along a wave may result in airframe icing.

- Avoid flight in wave clouds and, as always, check PIREPS and check the freezing level before flying through orographic clouds.

Cape Air
NANTUCKET AIRLINES

# Choose route wisely

- Avoid areas of high terrain.  Icing caused by orographic lifting can be some of the most hazardous.
- Choose a route that allows you to select a better altitude even if it takes you out of the way.  Better a 45 minute flight in the clear than a 25 minute flight fighting through the ice.



# Choose altitude wisely

- This may be the view @ 6000', while there is moderate mixed icing @ 4000'.
- Cloud top reports and temperatures aloft are essential pieces of preflight information!

Cape Air
NANTUCKET AIRLINES

# Mountain Flying: Departures

# Departures in Non-Radar environments

Today, the most significant and demanding navigational requirement is the need to safely separate aircraft.

In a non-radar environment, ATC does not have an independent means to separate air traffic and must depend entirely on information relayed from flight crews to determine the actual geographical position and altitude.

In this situation, precise navigation is critical to ATC's ability to provide separation.

In a non-radar environment, ATC has no independent knowledge of the actual position of your aircraft or its relationship to other aircraft in adjacent airspace.  Therefore, ATC's ability to detect a navigational error and resolve collision hazards is seriously degraded when a deviation from a clearance occurs.

# AIM 5-2-4: Abbreviated IFR Departure Clearance

- In both radar and nonradar environments, the controller will state "Cleared to (destination) airport as filed…" or:
- If a DP or DP Transition is to be flown, specify the DP name, the current number, the DP transition name, the assigned altitude, and additional instructions (departure control freq., beacon code, etc.) necessary to clear a departing aircraft via the DP or DP transition route filed.
- Additionally, in a nonradar environment, the controller will specify one or more fixes, as necessary, to identify the initial route of flight.

EXAMPLE: Cessna Three One Six Zero Foxtrot cleared to Charlotte Airport as filed via Brooke, maintain seven thousand

# AIM 5-2-7: Instrument Departure Procedures

Unless specified otherwise, required obstacle clearance for all departures, including diverse, is based on the following:

- pilot crossing the departure end of the runway at least 35 feet above the departure end of runway elevation
- climbing to 400 feet above the departure end of runway elevation before making the initial turn
- maintaining a minimum climb gradient of 200 feet per nautical mile (FPNM), unless required to level off by a crossing restriction, until the minimum IFR altitude.

# AIM 5-2-7: Instrument Departure Procedures (cont)

A greater climb gradient may be specified in the DP to clear obstacles or to achieve an ATC crossing restriction.

If an initial turn higher than 400 feet above the departure end of runway elevation is specified in the DP, the turn should be commenced at the higher altitude.

If a turn is specified at a fix, the turn must be made at that fix. Fixes may have minimum and/or maximum crossing altitudes that must be adhered to prior to passing the fix.

# If there is a DP published, we must comply with it.

**RUTLAND, VT**

RUTLAND STATE

TAKE-OFF MINIMUMS: **Rwy 1,** 2300-3 or std. with a min. climb of 270' per NM to 3500. **Rwy 13,** NA. **Rwy 19,** 2800-3 or std. with a min. climb of 510' per NM to 4500. **Rwy 31,** 2900-3 or std. with a min. climb of 420' per NM to 4500.

DEPARTURE PROCEDURE: **Rwy 1,** climb direct DYO NDB, cross DYO NDB at or above 6000, if not at 6000, depart DYO NDB on bearing 325° to 6000 before proceeding on course. **Rwys 19,** climbing right turn direct DYO NDB, cross DYO NDB at or above 6000, if not at 6000, depart DYO NDB on bearing 325° to 6000 before proceeding on course. **Rwy 31,** climbing right turn direct DYO NDB, cross DYO NDB at or above 6000, if not at 6000, depart DYO NDB on bearing 325° to 6000 before proceeding on course.

# AIM 5-3-1: ARTCC Communications

When operating in a nonradar environment:

- On initial contact, the pilot should inform the controller of the aircraft's present position, altitude and time estimate for the next reporting point.

***Example:***

(*Name) CENTER, (aircraft identification), (position), (altitude), ESTIMATING (reporting point) AT (time)*.

- After initial contact, when a position report will be made, the pilot should give the controller a complete position report.

***Example:***

(*Name) CENTER, (aircraft identification), (position), (time), (altitude), (type of flight plan), (ETA and name of next reporting point), (the name of the next succeeding reporting point), AND (remarks)*.

# AIM 5-3-2: Position Reporting

**Position reports should include the following items:**

- Identification
- Position
- Time
- Altitude or flight level (include actual altitude or flight level when operating on a clearance specifying VFR-on-top)
- Type of flight plan (not required in IFR position reports made directly to ARTCCs or approach control)
- ETA and name of next reporting point
- The name only of the next succeeding reporting point along the route of flight
- Pertinent remarks

Cape Air
NANTUCKET AIRLINES

# AIM 5-3-3: Additional Reports

When not in radar contact, give an additional report:

- When leaving the final approach fix inbound on final approach (nonprecision approach), or
- When leaving the outer marker or fix used in lieu of the outer marker inbound on final approach (precision approach).

Give a corrected estimate at anytime it becomes apparent that the previously-submitted estimate is in error in excess of 3 minutes.

Cape Air
NANTUCKET AIRLINES

# Departure Emergency Strategy

Prior to departure, the PIC should conduct a briefing which should include:

- Departure procedures
- Takeoff minimums
- A strategy to return for landing in the event of an engine failure in VFR, Marginal VFR and IFR conditions.
- MSA, obstructions, aircraft performance and ATC instructions should all be considered

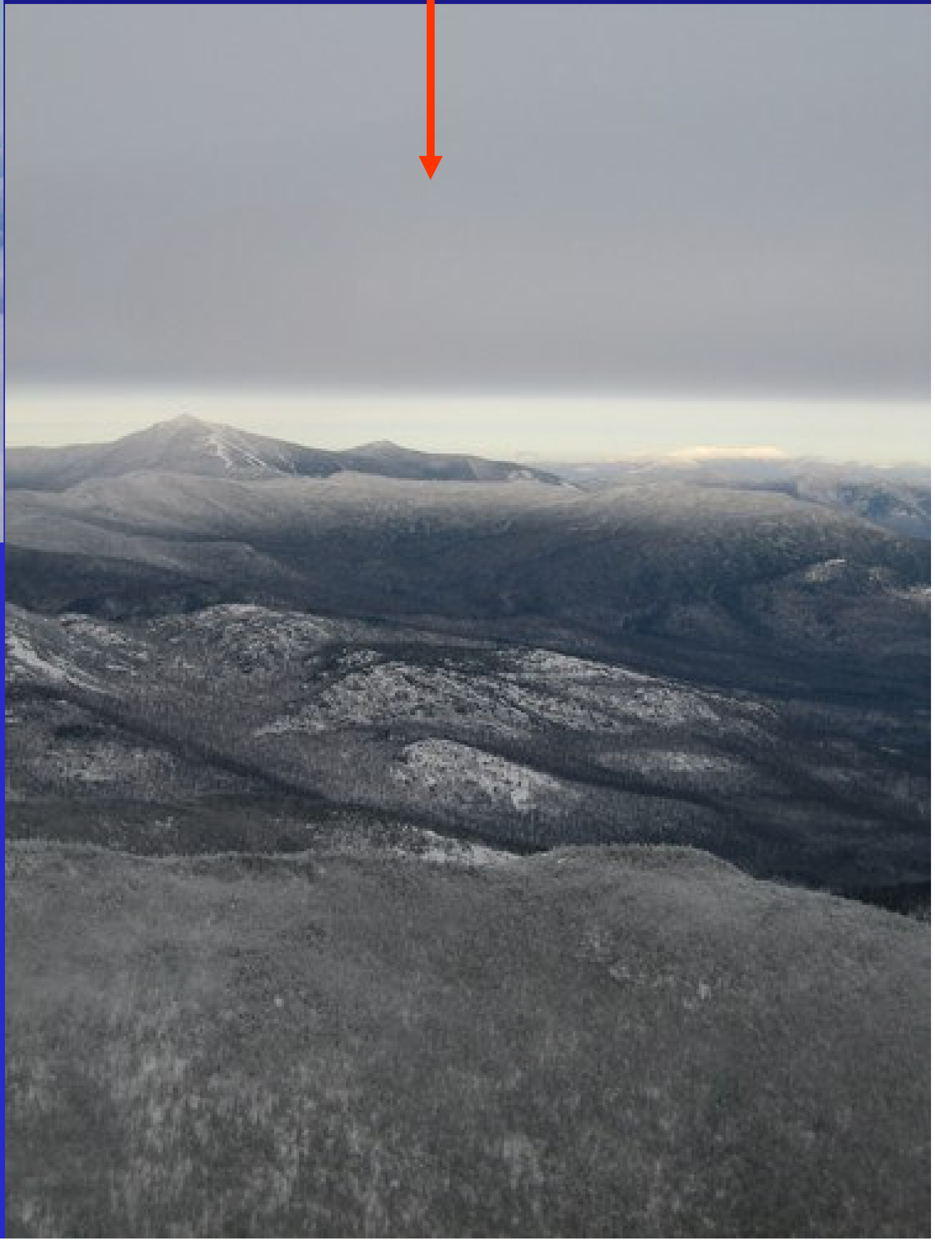
Cape Air
NANTUCKET AIRLINES

# Enroute - VFR

- Checking forecasts for Mountain Obscuration, in addition to mountain waves is a critical part of pre-flight preparation.

- Check SIgmets and local weather for ceilings. Remember: Ceilings are AGL and in mountainous terrain, ground level can vary greatly over a short distance.

VFR below a layer, mountain tops can be obscured by low visibility.



VFR above a layer, you might be closer to the terrain than you think!

Not a good day to go “V”!

Cape Air
NANTUCKET AIRLINES

# En Route – On Airway

- Hyannis Air Service is authorized to conduct Class I en route navigation.
- While on an airway, we can descend to the MEA or MOCA. In the example below, the MOCA is 3000 ft.

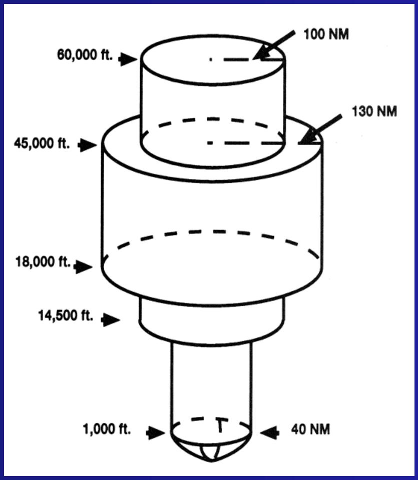

*Reminder, the MOCA only guarantees obstacle clearance.

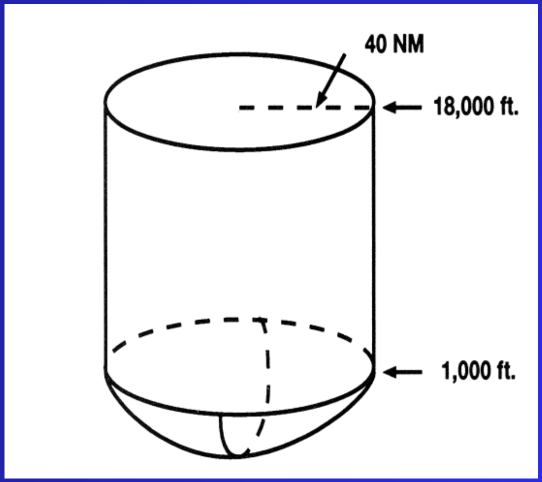
It does not guarantee communication coverage.

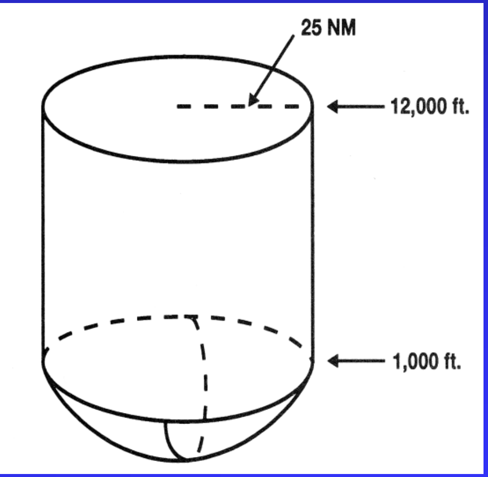
Cape Air
NANTUCKET AIRLINES

# En Route – Off Airway

In order to fly off-airway, the PIC is responsible for determining that the off-airway routing lies within the operational service volume of the facilities used.




Cape Air
NANTUCKET AIRLINES

# En Route

In addition, the required facilities must be available, operational and enable navigational performance to meet the degree of accuracy required for air traffic control over the route of flight specified in the ATC clearance.

Be sure to check NOTAMs and the AF/D.

**SARANAC LAKE** N44°23.07′ W74°12.27′ NOTAM FILE SLK.
(L) VOR/DME 109.2 SLK Chan 29 at Adirondack Rgnl. 1650/14W.
VOR portion unusable:
252°–037° byd 15 NM blo 10,000′
038°–058° byd 15 NM blo 5000′
038°–058° byd 24 NM blo 10,000′
059°–100° byd 15 NM blo 10,000′
DME portion unusable all radials byd 38 NM blo 5000′
RCO 122.1R 109.2T (BURLINGTON FSS)

# En Route

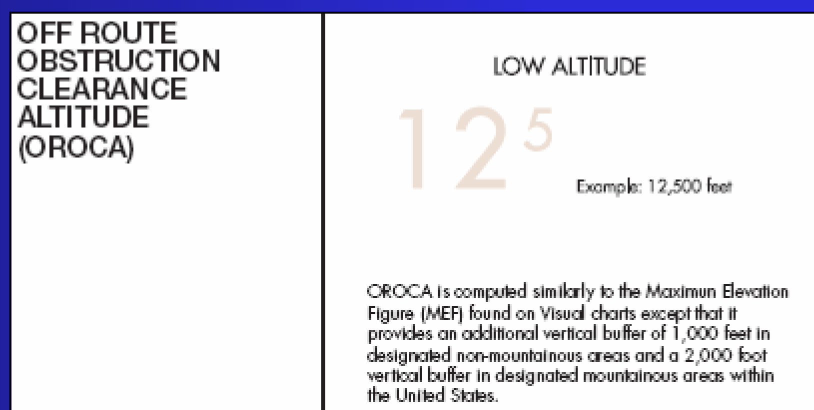
Once we have determined that we are within the service volume and that the navigation aid is operational at our location, we can decide what altitude we can descend to.

A quick check of the en route low altitude chart will be necessary.

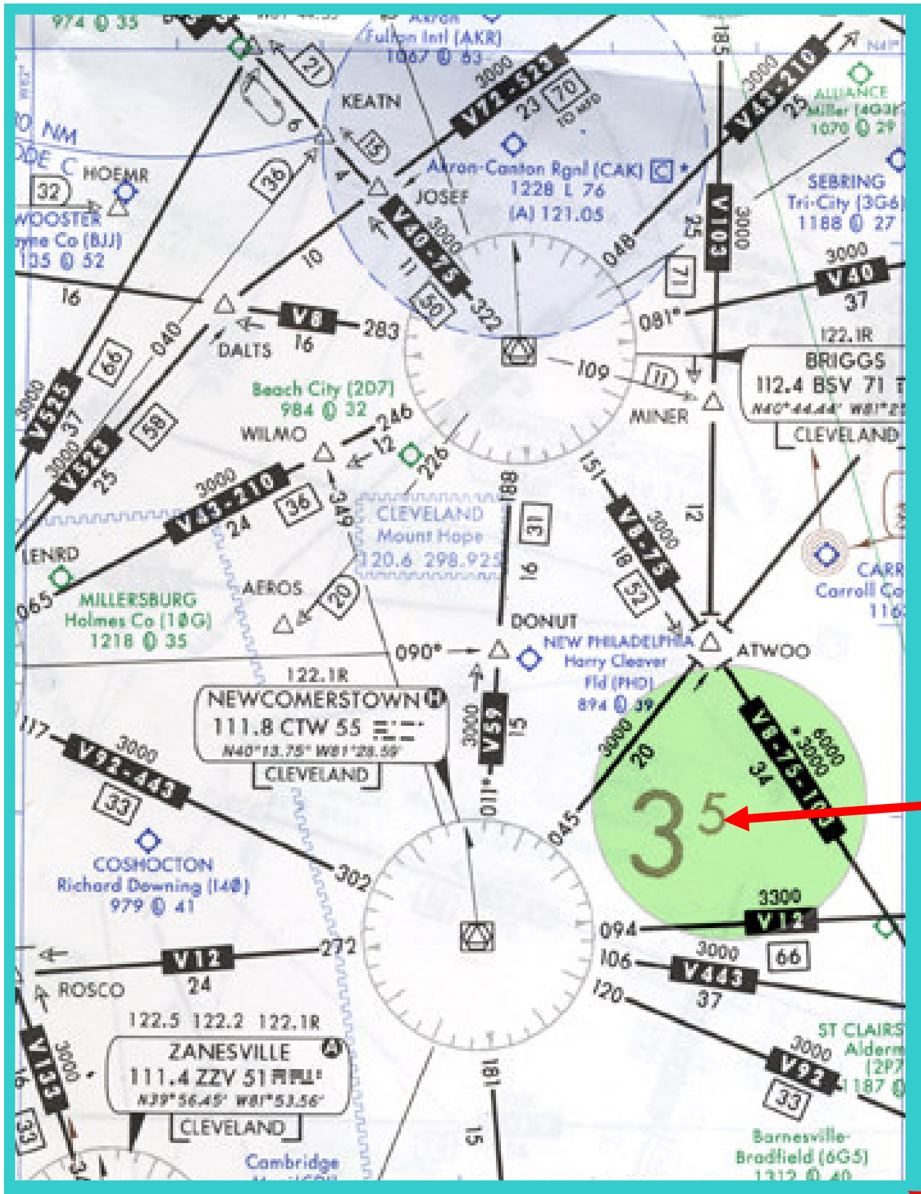
# En Route

The OROCA (or MORA) provides obstruction clearance with a 1000 ft. buffer in non-mountainous areas and 2000 ft. in mountainous areas.

It does not provide for NAVAID signal coverage or communication coverage.




Cape Air NANTUCKET AIRLINES




The number highlighted is the OROCA. The OROCA for this grid area is 3500 ft.

The Grid Area is shown in quadrangles bounded by ticked lines of latitude and longitude.

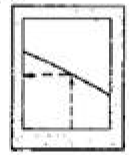
Cape Air
NANTUCKET AIRLINES

# En Route Emergencies

A check of our performance charts will assure us that we will be able to maintain at least the MORA or MOCA in the event of an engine failure en route.

For example, if we are flying at a pressure altitude of 10,000 feet and our OAT is 26℃ we will be able to hold our altitude at a weight of 6850 lbs or less.

# ENGINE INOPERATIVE SERVICE CEILING



CONDITIONS:

1. Engine Inoperative Climb Configuration.

NOTE:

1. Engine Inoperative service ceiling is the maximum altitude where the airplane has the capability of climbing 50 feet per minute with one engine inoperative and feathered.
2. Increase indicated service ceiling 100 feet for each 0.10 inch Hg. altimeter setting greater than 29.92.
3. Decrease indicated service ceiling 100 feet for each 0.10 inch Hg. altimeter setting less than 29.92.
4. This chart provides performance information to aid in route selection when operating under FAR 135.181 and 91.119 requirements.

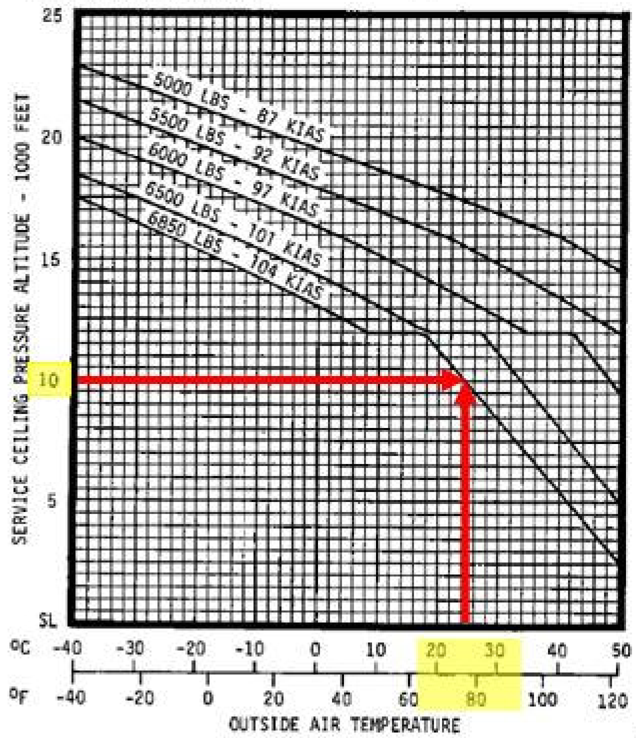
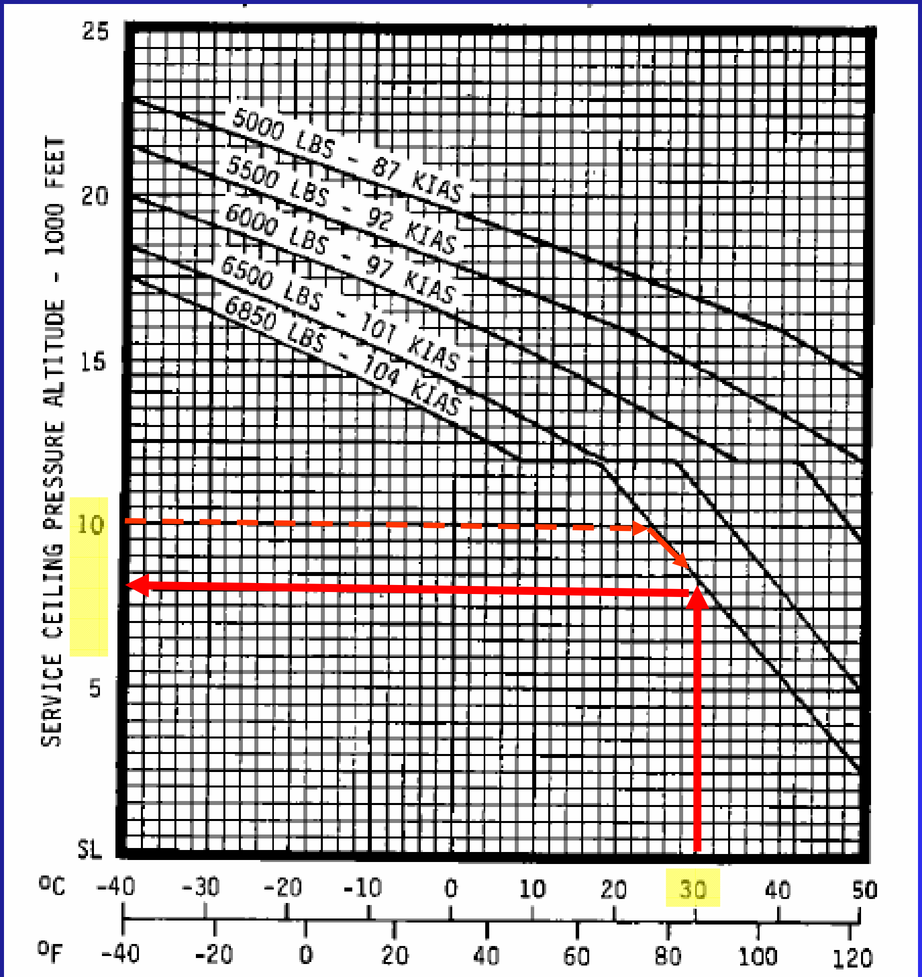



Figure 5-17

# En Route Emergencies

However, if the OAT were 30°C in the same scenario, the maximum altitude we could hold would be 8000 ft.



# En Route Emergencies

While flying over mountainous terrain, it is not advisable to travel off-airway unless you are certain of your minimum altitudes at all time.

You should also have a plan of action in case of an icing encounter or engine failure.

A thorough check of charts and the weather every flight will enhance safety and remove doubt.

Cape Air
NANTUCKET AIRLINES

# Mountain Flying
# Approach Phase

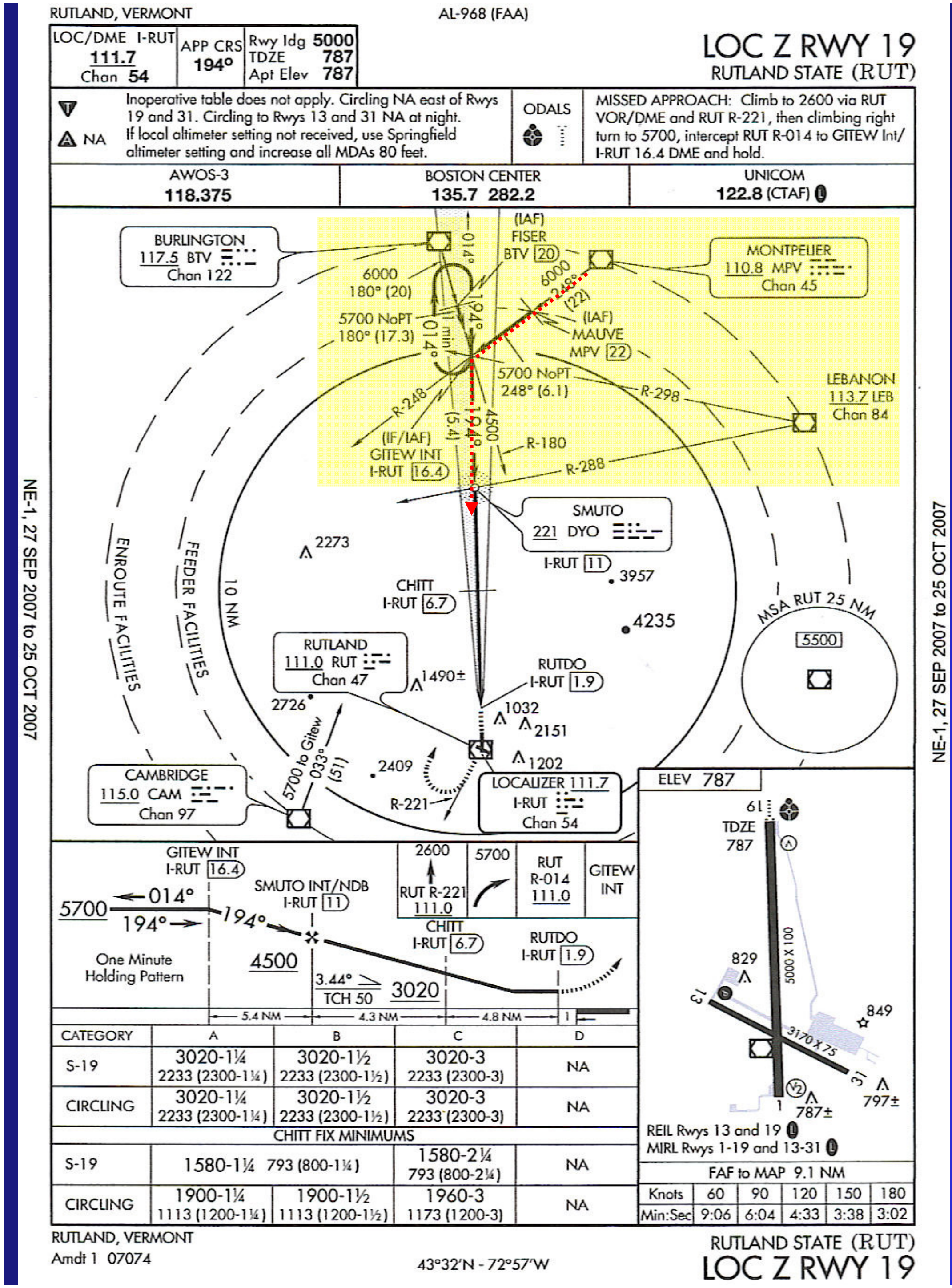
# Non-radar Environment

In the absence of radar vectors, an instrument approach begins at an IAF.

An aircraft that has been cleared to a holding fix that, prior to reaching that fix, is issued a clearance for an approach, but not issued a revised routing such as *"proceed direct to…"* is expected to proceed via the last assigned route, a feeder route if one is published on the approach chart and then to commence the approach as published.

# Non-radar Environment

If, by following the route of flight to the holding fix, the aircraft would overfly an IAF or the fix associated with the beginning of a feeder route to be used, the aircraft is expected to commence the approach using the published feeder route to the IAF or from the IAF as appropriate.  The aircraft would be expected to overfly and return to the IAF or feeder route.




If ATC cleared you "Direct Montpelier, cleared for the LOC Z RWY 19 Approach...", what would your course of action be?

- Direct MPV.
- Get established on the MPV 248° radial.
- Descend to 6000'.
- Cross MAUVE (MPV 22 DME) and descend to 5700'.
- After 6.1 more miles, join the LOC RWY 19 inbound.
- Once established, descend to 4500' until crossing SMUTO.
- Make all required position reports when not in radar contact.

Cape Air NANTUCKET AIRLINES

# Non-radar Environment

For aircraft operating on unpublished routes, an altitude is assigned to maintain until the aircraft is *established* on a segment of a published route or IAP.

According to the ICAO, established is:

- Within half-scale deflection for ILS or VOR
- Within ±5° of the required NDB bearing

Cape Air
NANTUCKET AIRLINES

# AIM 5-4-7: Instrument Approach Procedures

When cleared for a specifically prescribed IAP, pilots shall execute the entire procedure commencing at an IAF or an associated feeder route as described on the IAP chart unless an appropriate new or revised ATC clearance is received, or the IFR flight plan is cancelled.

# AIM 5-4-21: Missed Approaches

Pilots must ensure that they have climbed to a safe altitude prior to proceeding off the published missed approach, especially in non-radar environments.

Abandoning the missed approach prior to reaching the published altitude may not provide adequate terrain clearance.

Additional climb may be required after reaching the holding pattern before proceeding back to the IAF or to an alternate.

# Arrivals in Mountainous Terrain

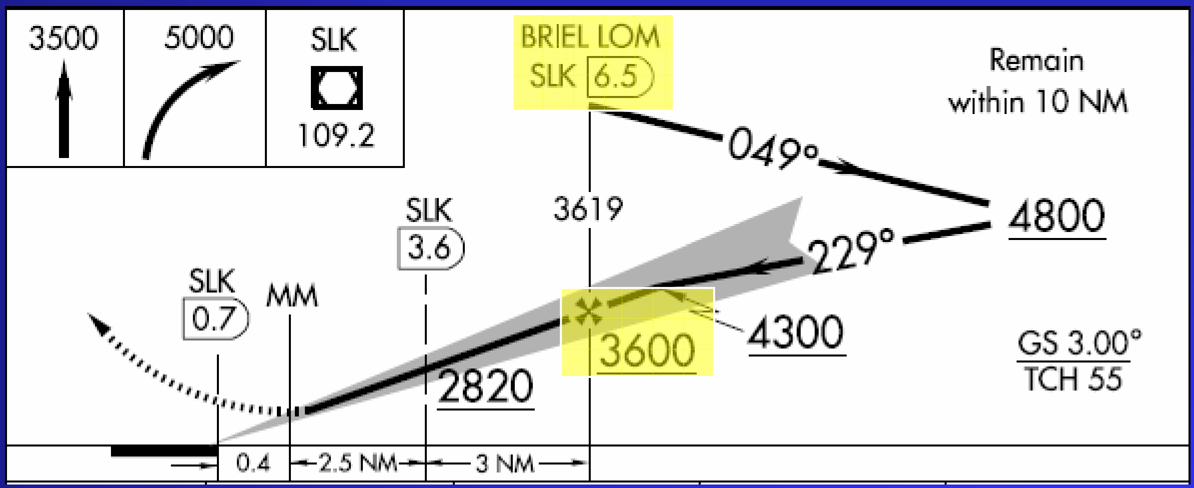
Pilots are reminded to verify the following on approaches to runways in mountainous terrain:

- Verify your position at night. Make sure you are positive of the height of the terrain below you prior to making a descent.
- Do not descend below MSAs prior joining the final approach course or intercepting a VASI / PAPI glidepath.
- Cross-check all altitudes on approaches. Glideslope intercept altitude is key.

Cape Air
NANTUCKET AIRLINES

# Arrivals in Mountainous Terrain

To determine the DME at which you will intercept the glideslope, check the profile view on your approach plate:




At an altitude of 3600 ft. we will intercept the glideslope at 6.5 DME. But, what if we were told to intercept at 6000 ft.?

# Arrivals in Mountainous Terrain

To determine the DME at which we would intercept the glideslope at 6000 ft. we apply the 3:1 rule. In other words, a 3° glideslope rises 300 ft for every mile you are away from the antenna. So, take your altitude (MSL) and subtract the field elevation. Then divide that number by 300.

For SLK:

6000 MSL – 1663 (field elevation) = 4337 ft.

4337 ft. / 300 = 14.5 miles.

We can expect to join the glideslope at 14.5 DME if we are at 6000 ft. This will verify that our glideslope is functioning and that we do not have a “false” glideslope.

*Thank you for your attention during this presentation.*

# Arrivals in Mountainous Terrain

The link below is to an accident where the crew failed to cross-check their instruments during an approach to SLK.

http://www.mtc.gob.pe/portal/transportes/aereo/aeronautica civil/alar_tool_kit/pdf/ap_jul95.pdf

Cape Air
NANTUCKET AIRLINES

# Remember:

- Check the Weather
- Review Sectionals and En Route Charts for terrain
- Thoroughly brief Departure and Approach Procedures
- Always have a plan in case of an emergency or abnormality
- Always know where you are in relation to terrain
- If in doubt – climb!