



Turbulence Perspectives

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Discus 2A sailplane
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Objectives

- Basic Principles and Categories
- Pre-Briefing Guide to Find it
 - ◆ Internet
 - ◆ NWS Products
- In-Flight Strategies to Deal with it
 - ◆ My experience as a sailplane pilot
 - ◆ Accident reports and incidents from working at Los Angeles ARTCC



Basic Principles - Categories

- What is it?
- Qualitative Measures and Quantitative Measures
- Classifications
 - ◆ Low Level Turb (LLT)
 - Convective – Thermals
 - Surface Roughness
 - ◆ Clear Air Turb (CAT)
 - ◆ Turb Near Thunderstorms (TNT)
 - ◆ Mountain Wave Turb (MWT)



Turbulence – What is it?

- The Velocity is Chaotic and Random
- Bumpiness in Flight
- An irregular condition of flow
- Random variations space and time
- Only statistical averages can be discerned

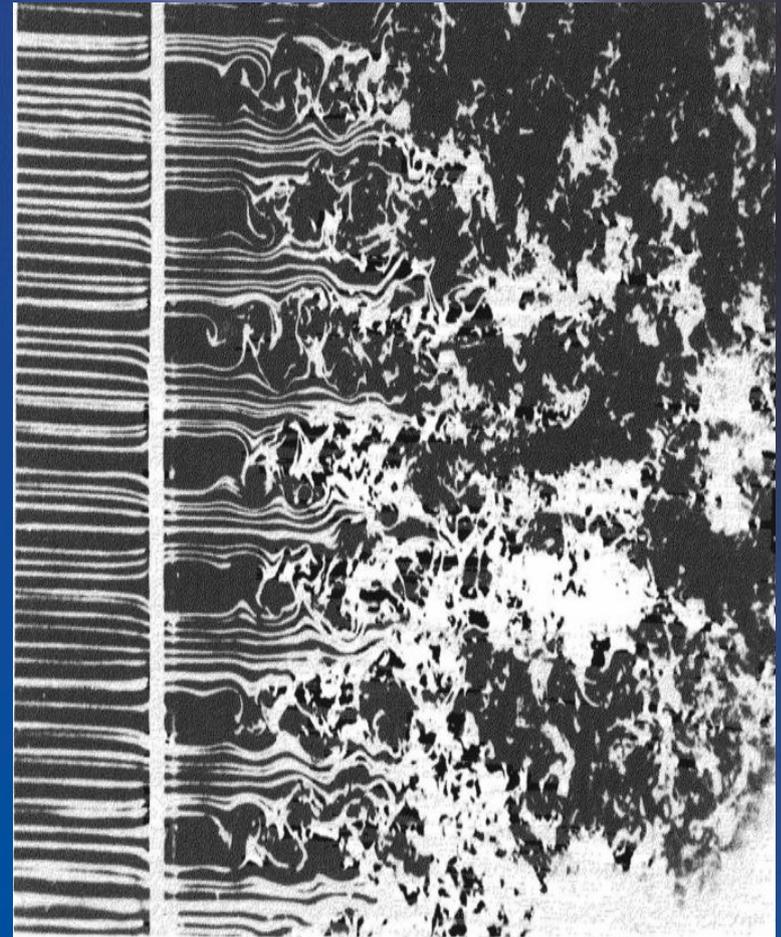


Figure 1-1. Turbulent production by flow through a grid. Reprinted, with permission, from Milton Van Dyke, *An Album of Fluid Motion*, fig. 152.



Famous Turbulence Quotes

“Turbulence is the most important unsolved problem of classical Physics” - Richard Feynman -

“I am an old man now, and when I die and go to heaven there are tow matters on which I hope for enlightenment. One is quantum electrodynamics, and the other is turbulence motion of fluids. And about the former I am rather optimistic” - Horace Lamb -

“Big whorls have little whorls, which feed on their velocity, And little whorls have lesser whorls, and so on to viscosity” - Lewis Richardson -



Turbulence Qualitative Criteria - Light

- Momentary, slight, erratic changes in attitude or altitude
- Occupants feel slight strain on belts; Unsecured objects displaced slightly
- Occasional – less than 1/3 time
- Continuous – more than 2/3 time



Turbulence Qualitative Criteria - Moderate

- Changes in attitude control.. but aircraft in positive control all times
- Occupants feel definite strains against belts
- Unsecured Objects dislodged



Turbulence Qualitative Criteria - Severe

- Large abrupt changes attitude or altitude. Large changes in airspeed
- Aircraft momentarily out of control
- Occupants forced violently against belts
- Unsecured objects tossed about



Turbulence Qualitative Criteria - Extreme

- Aircraft tossed violently about practically impossible to control.
- May cause structural damage

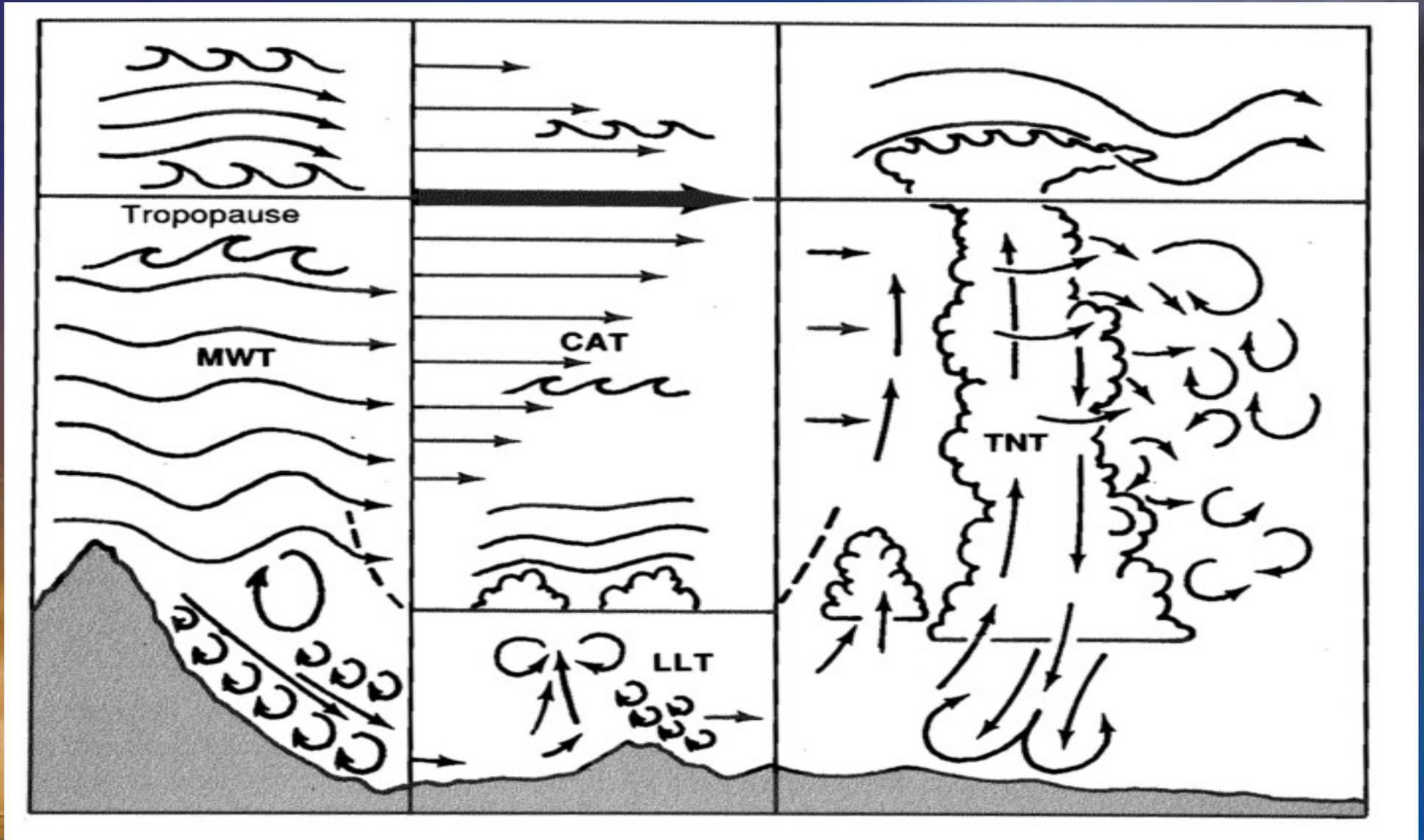




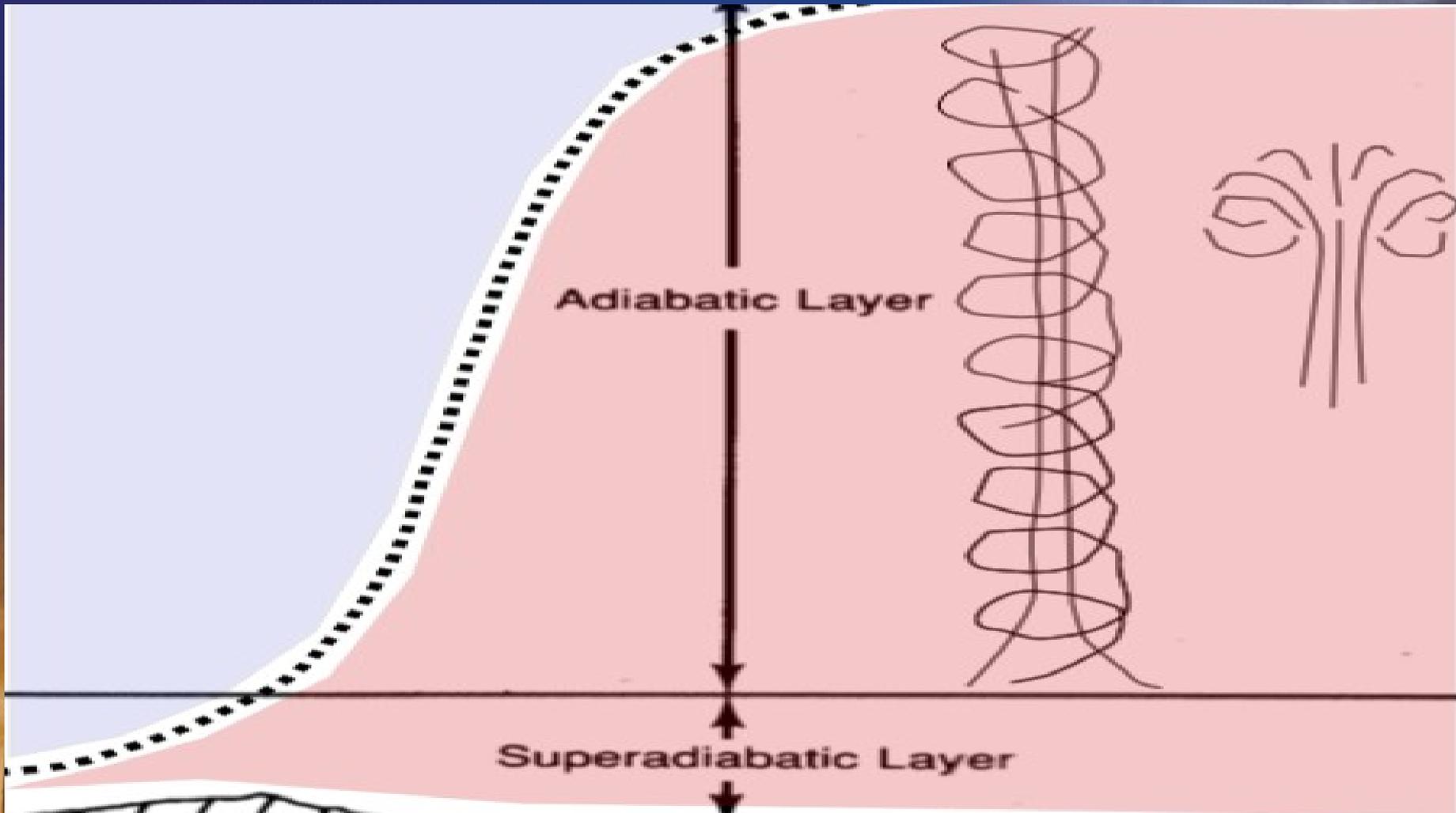
QUANTITATIVE CRITERIA

| | AIRSPEED FLUCTUA TION - KTS | VERTICAL ACCEL - G | DERIVED GUST - FPM |
|-----------------|--|-------------------------------|-------------------------------|
| LIGHT | 5 – 14.9 | 0.20 – 0.49 | 300 – 1199 |
| MODERATE | 15 – 24.9 | 0.50 – 0.99 | 1200 – 2099 |
| SEVERE | = < 25 | 1.0 – 1.99 | 2100 – 2999 |
| EXTREME | | = < 2.00 | = < 3000 |

Classifications Overview



PBL - Convective





Thermals – Dry Convection

- Surface buoyancy – light winds
- Thermal strengths – rule of thumb
200fpm per km height of thermal layer
- Pre-Flight Brief – Internet sources
- In-Flight – Watch for cumulus.. dust devils
- Mostly LGT to MOD turbulence



Thermal Convection Info Sources

- NWS Office Web Pages – Soaring Forecast
- DrJack.net – Subscription Required

RUC BLIPMAP California-Nevada Viewer
 BLIPMAP™ - Boundary Layer Information Prediction MAP
 Created by Dr. John W. (Jack) Glendening, Meteorologist
 For experienced BLIPMAP users - requires javascript
Registration (free) and a valid registration cookie are necessary for this viewer to work.
 "Registered-only" users can view "Thermal Updraft Velocity", "Buoyancy/Shear Ratio", and all "Previous Day" BLIPMAPs. Subscribers can view all BLIPMAPs. To register or see Registration Information. Registered users can subscribe at Subscription Page; for further info, see Subscription Information. Registered/Subscriber users here or check their registration cookie status here.
 For additional on-line information: [BLIPMAP HELP page](#)

BLIPMAPs predict thermal soaring conditions resulting from surface heating of the Boundary Layer, by post-processing numerical weather prediction data. BLIPMAPs are well suited to the needs of soaring pilots. Users of this viewer are assumed to be familiar with BLIPMAP and its parameters, as described in the [parameter information webpage](#). [BASIC thermal forecast parameters](#) gives a short list of the parameters most important for thermal soaring.

[View INSTRUCTIONS](#)

Current Day: **THU APR 5** The "current day" changes shortly after 22Z [Forecast Availability](#)

Current Times: **15Z** (9h) **18Z** (9h) **21Z** (12h) **0Z** (12h) **3Z** (9h)

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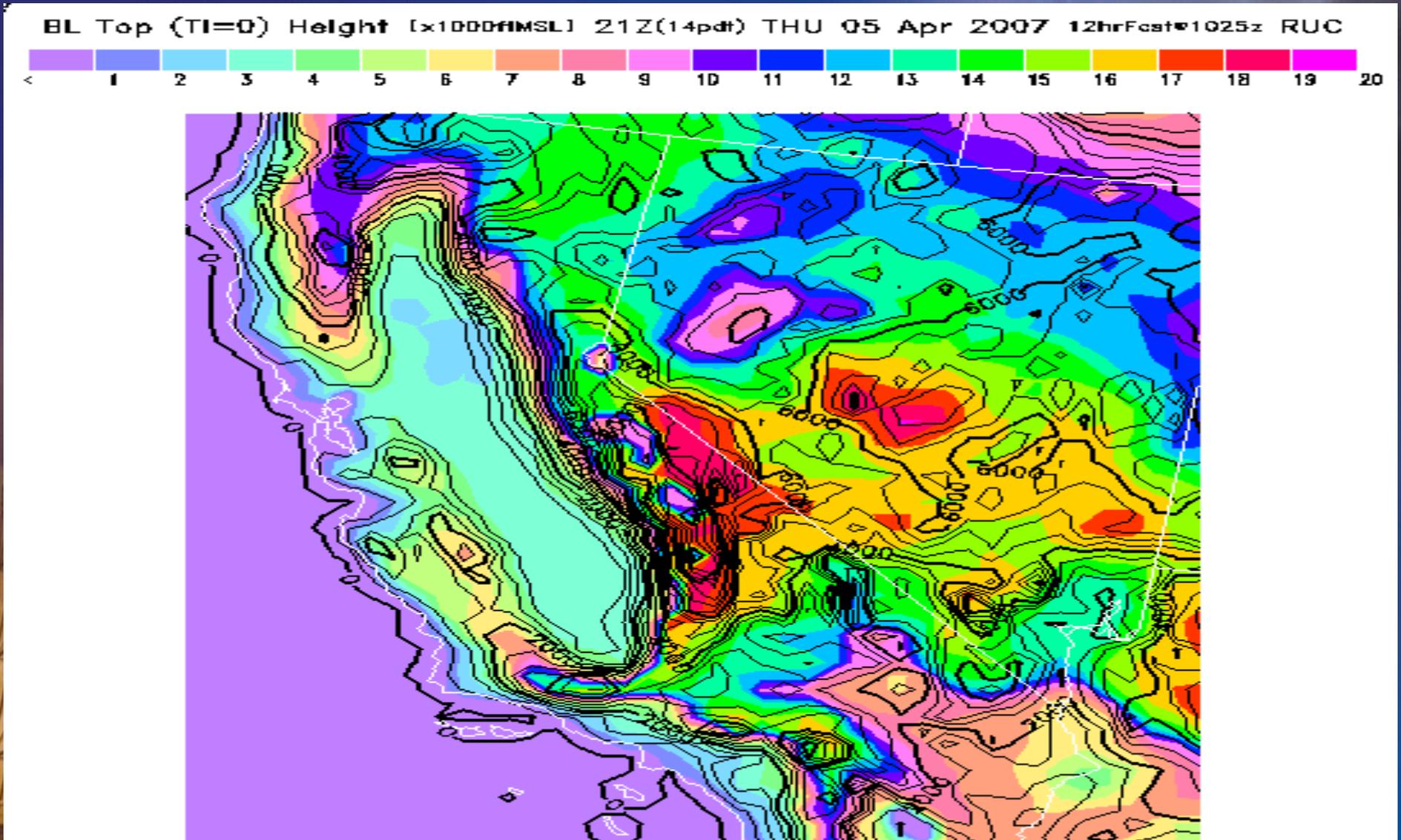
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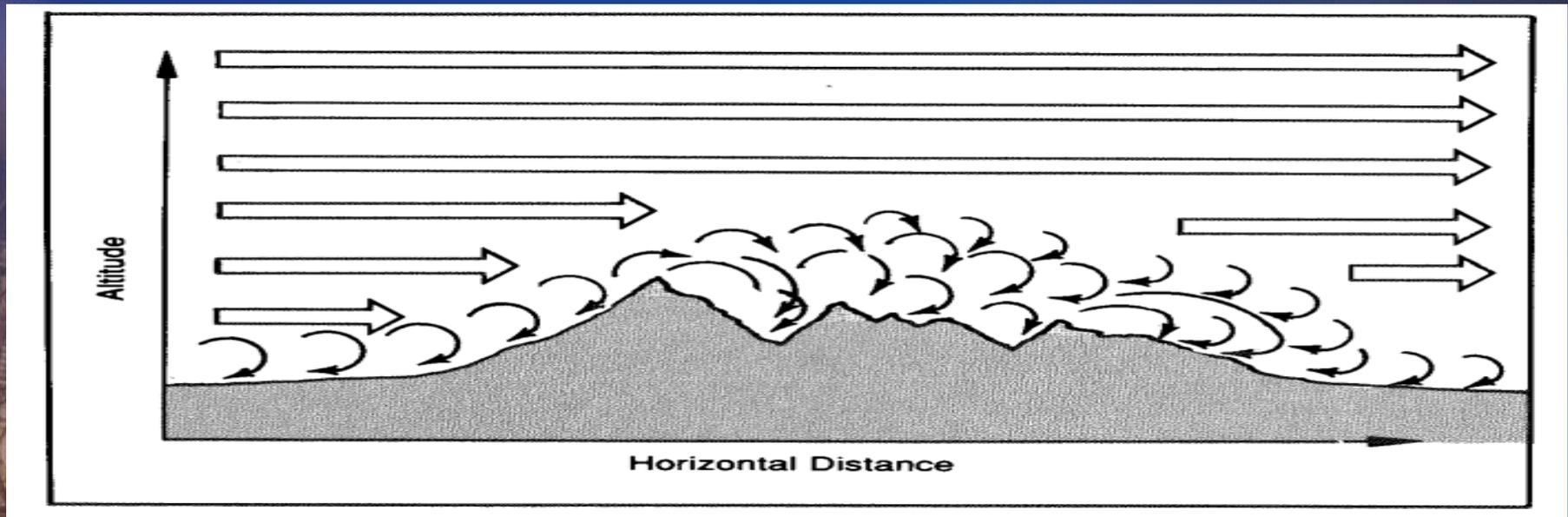
Thermal Height Map Dr Jack.net





Mechanical Turb – LLWS

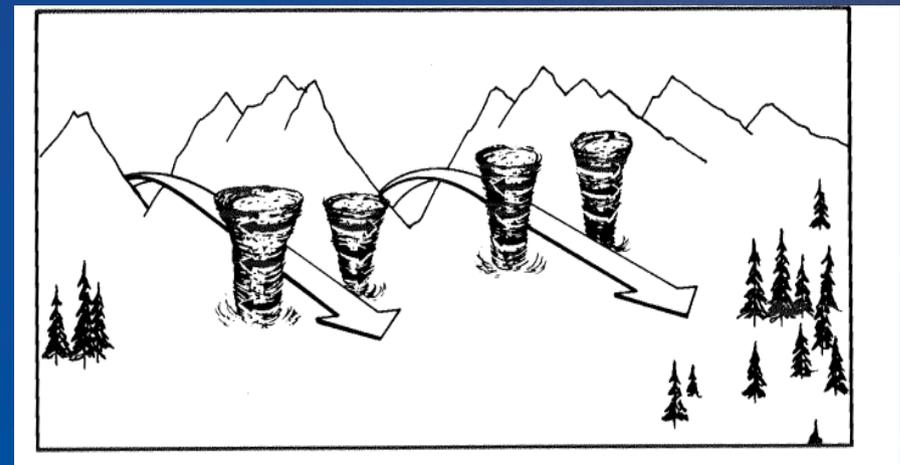
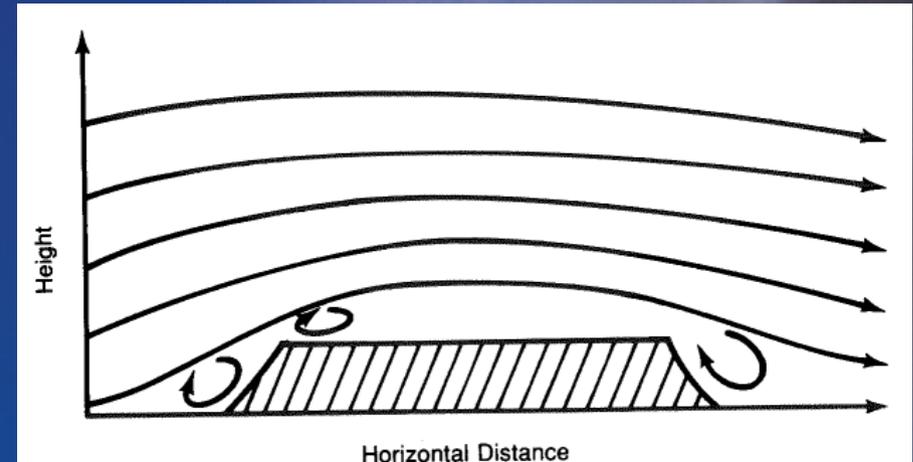
- Rules of Thumb
 - ◆ >30KTS within 3000agl – Moderate Turb
 - ◆ >45KTS – Severe Turb





More Mechanical Turbulence Scenarios

- Turb over or near edge of plateau
- Shear induced Turb near mountainous gaps or passes

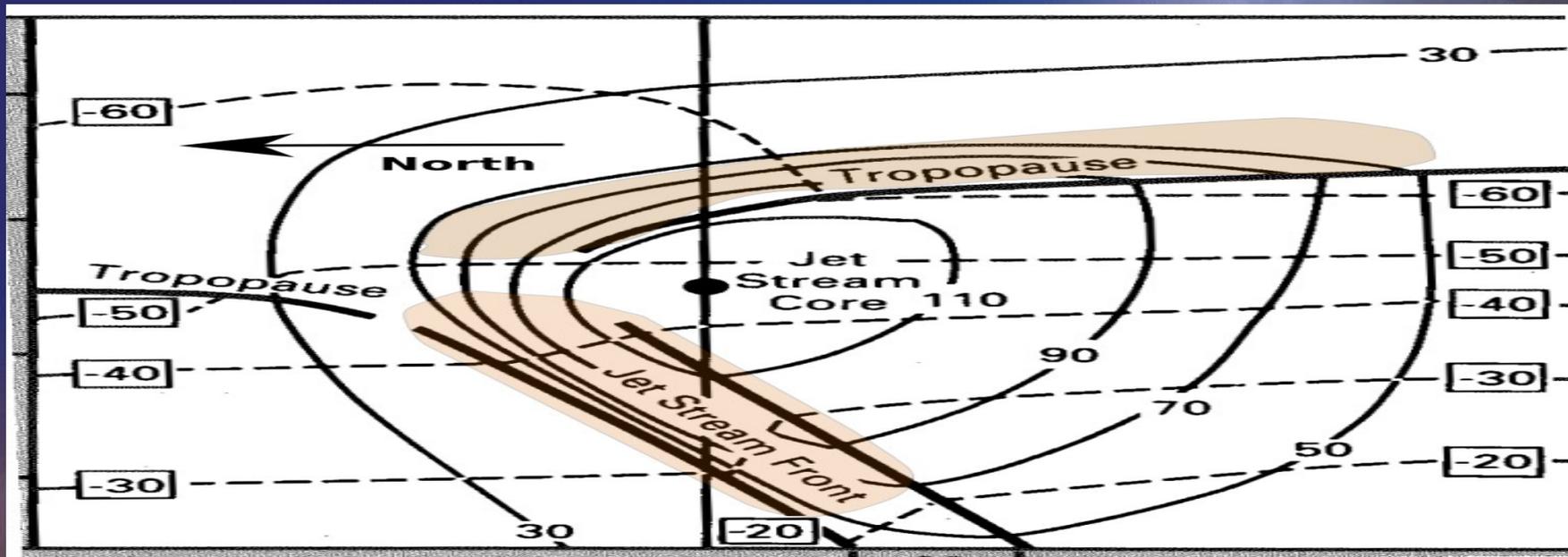




Clear Air Turbulence – CAT

- Shear with Jet Stream
- Breaking Waves - Kelvin Helmholtz (KH) Waves
- ADDS – Graphical Turb Guidance (GTG) is the best guidance for pre-flight planning and forecasts of CAT

CAT Related to Jet Streams



- Turbulence related to wind shear
 - ◆ North side of jet
 - ◆ Tropopause above Jet



Shear Layers – Patches of Breaking Waves

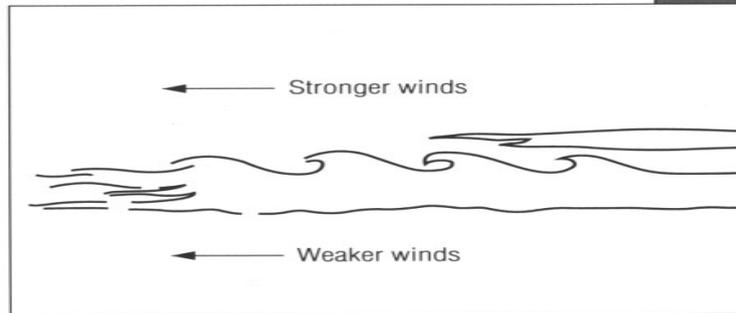


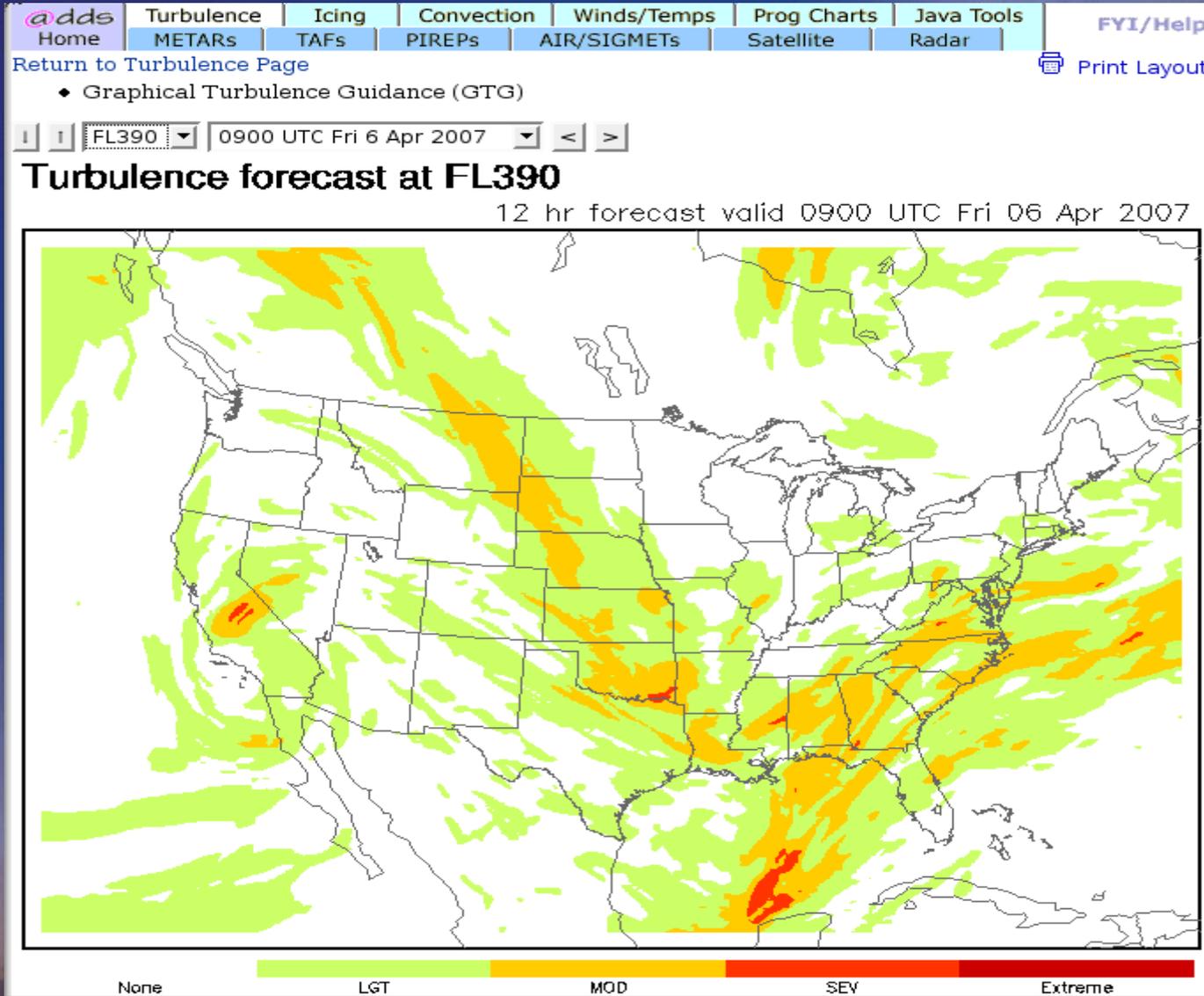
Fig. 6. Clouds associated with Kelvin/Helmholtz waves over Laramie, Wyoming (photograph ©, B. Martner).



- CAT is frequently associated with intermittent patchy turbulence outbreaks – stretched in thin layers along direction of wind



ADDS - Graphical Turbulence Guidance - GTG



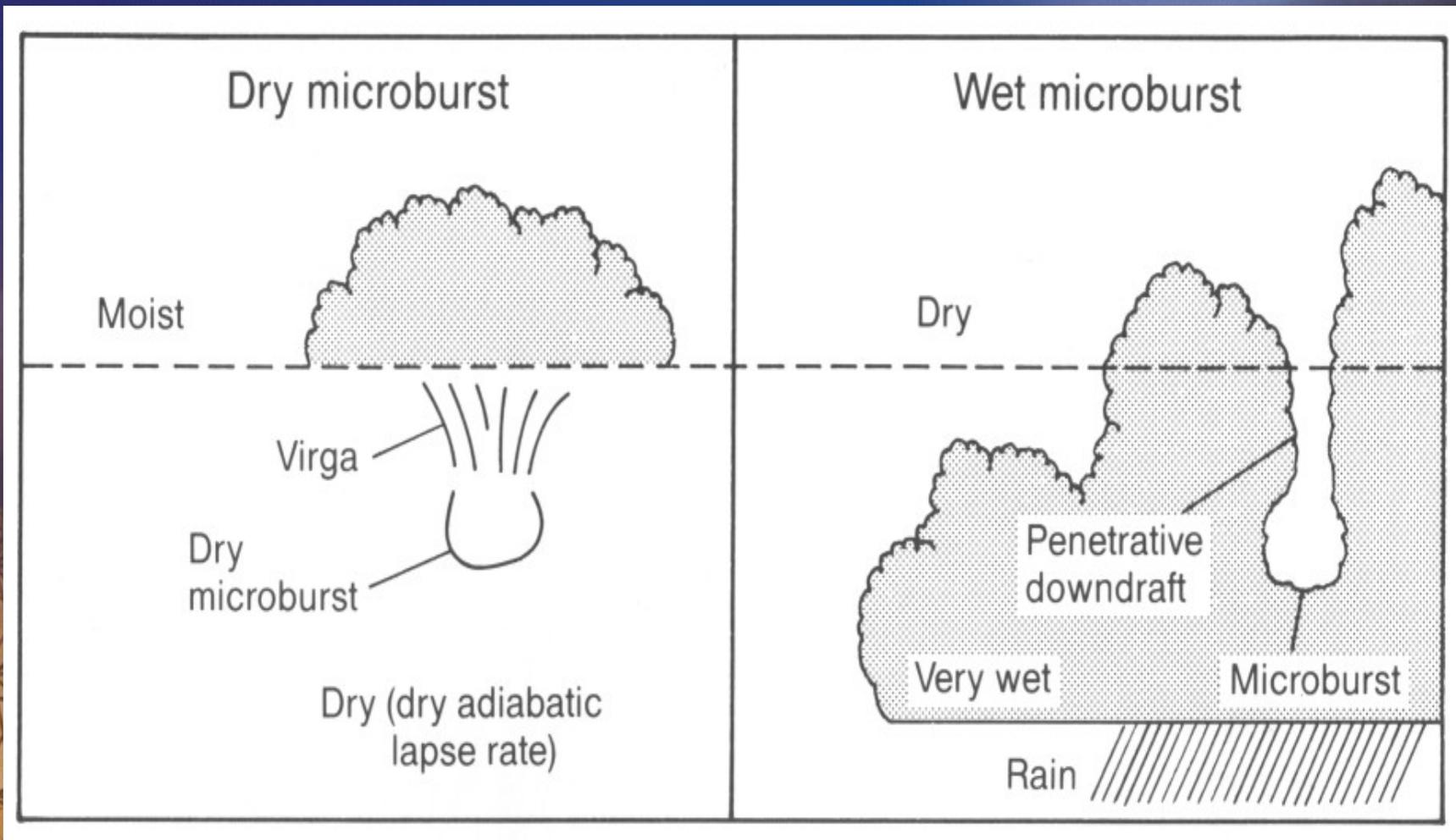


Turb Near Thunderstorms

- Do not fly within 20miles of severe thunderstorms
- Downbursts/Microbursts
- Gust Fronts
- Do not fly under the anvil of a large CB
- Pilots View – Look at hazards near large thunderstorms and Supercells



Dry and Wet Microbursts



Idealized Microburst

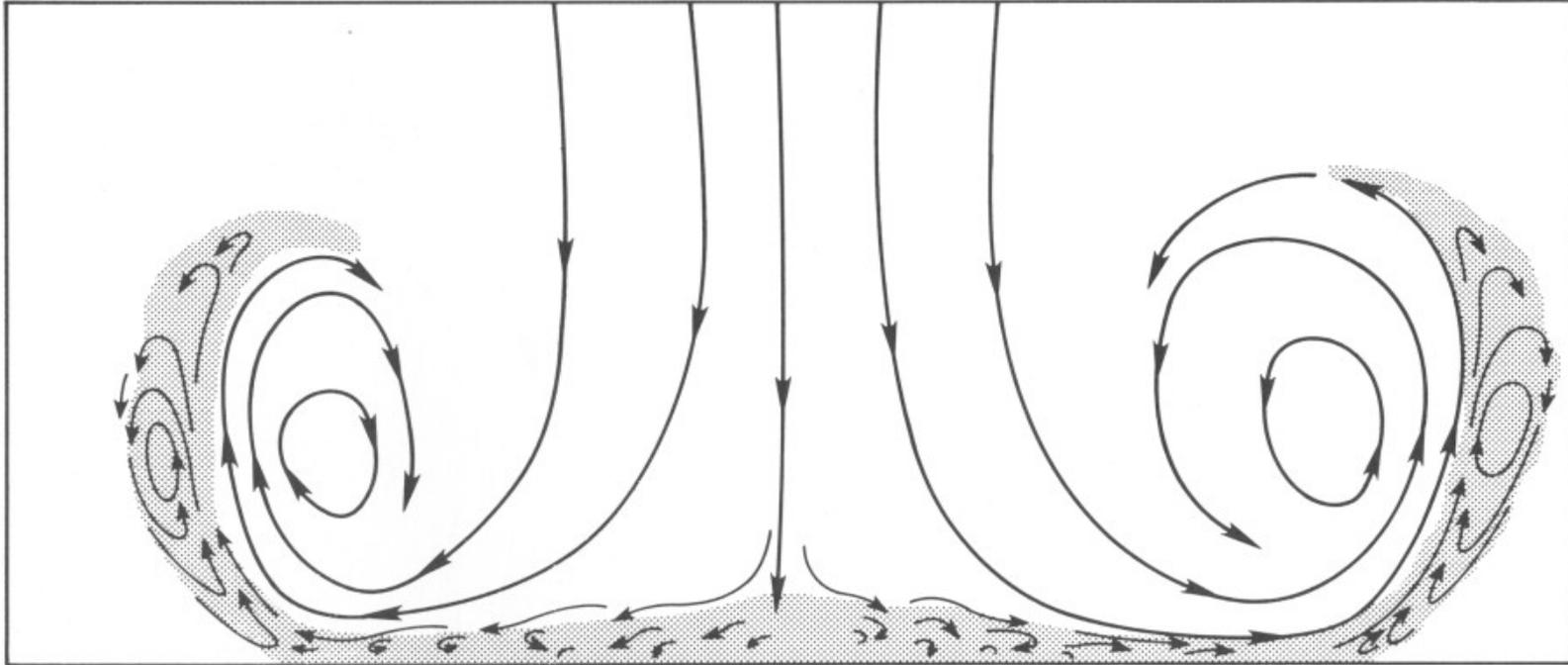
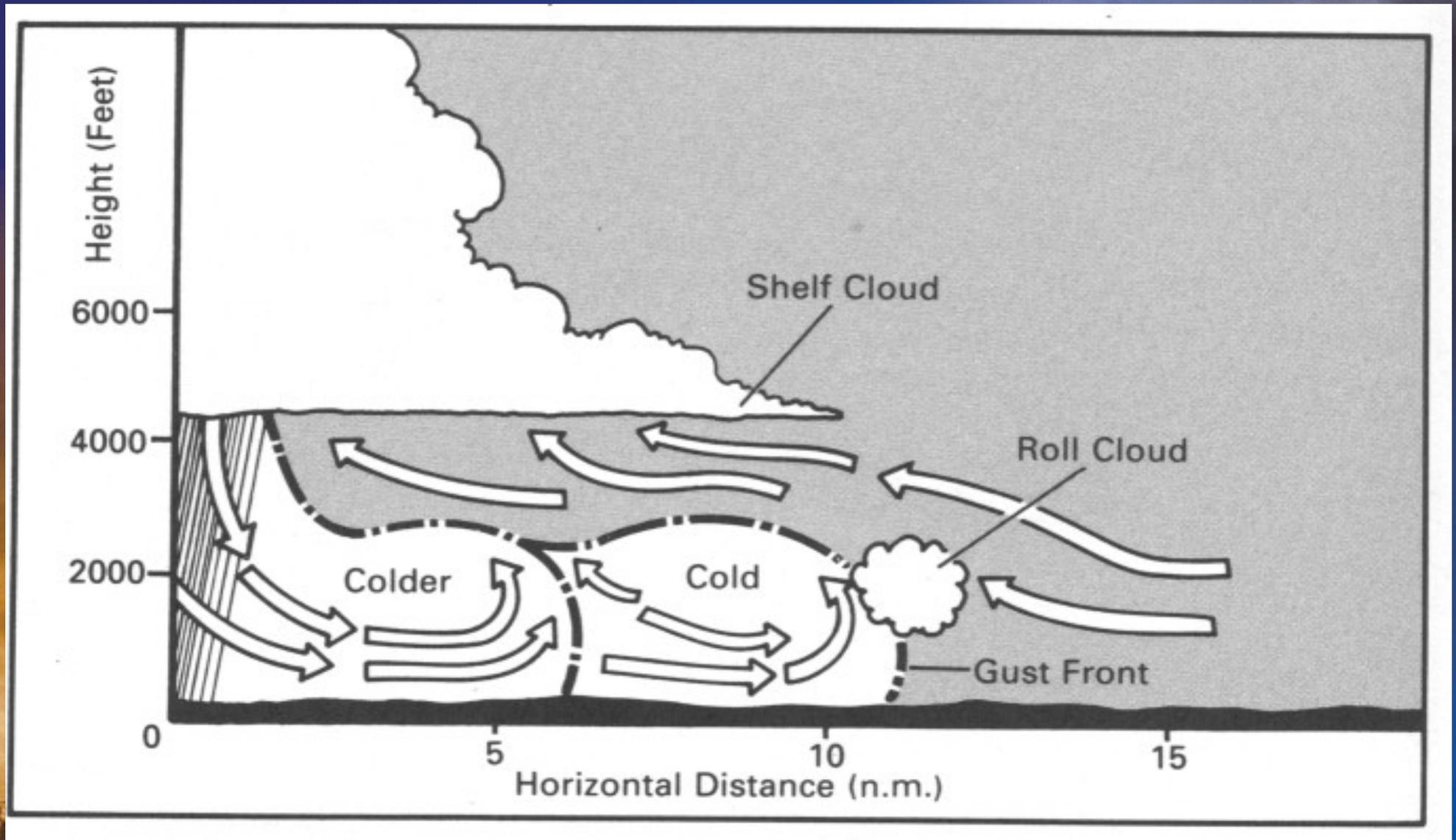


Figure 4. Cross section of a conceptual vortex ring model of a microburst (Caracena, 1982; 1987). The shaded portion is the friction boundary layer that contains vorticity opposite to that of the descending ring.

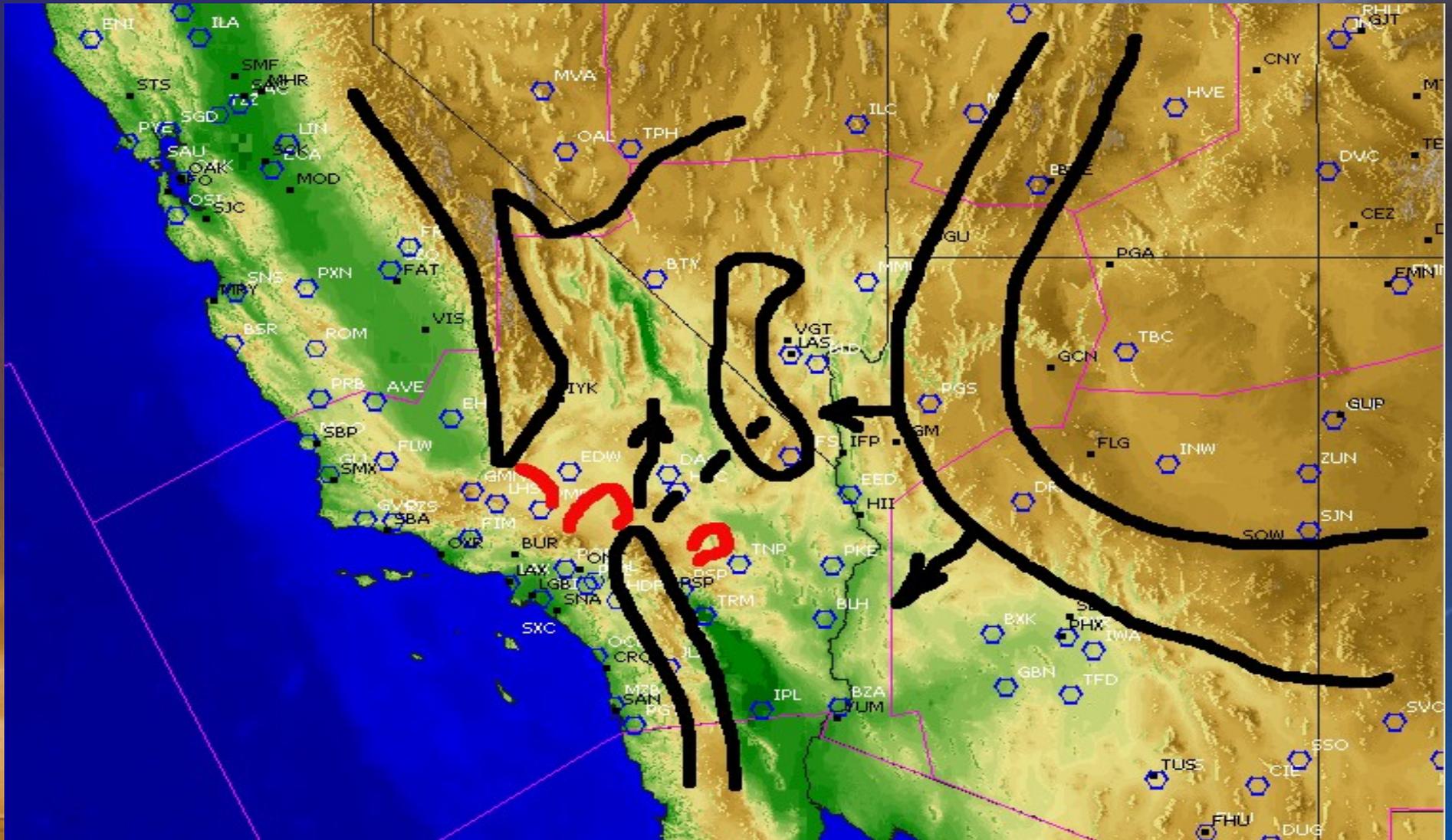


Gust Fronts



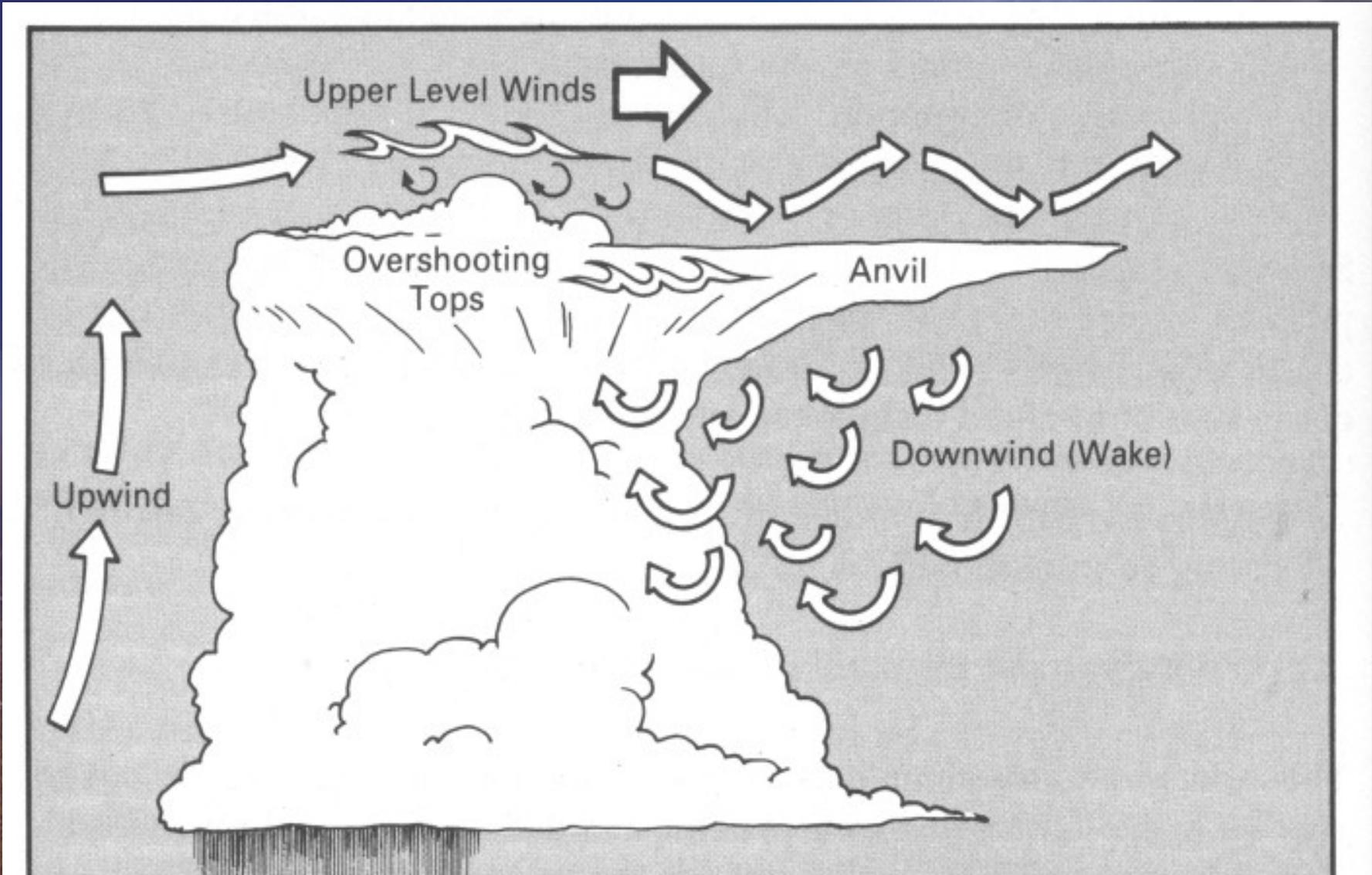


Thunderstorm Regions – Southwestern U.S.





Lee and Anvil Related Turbulence around



Pilots Eye View of Severe Thunderstorm

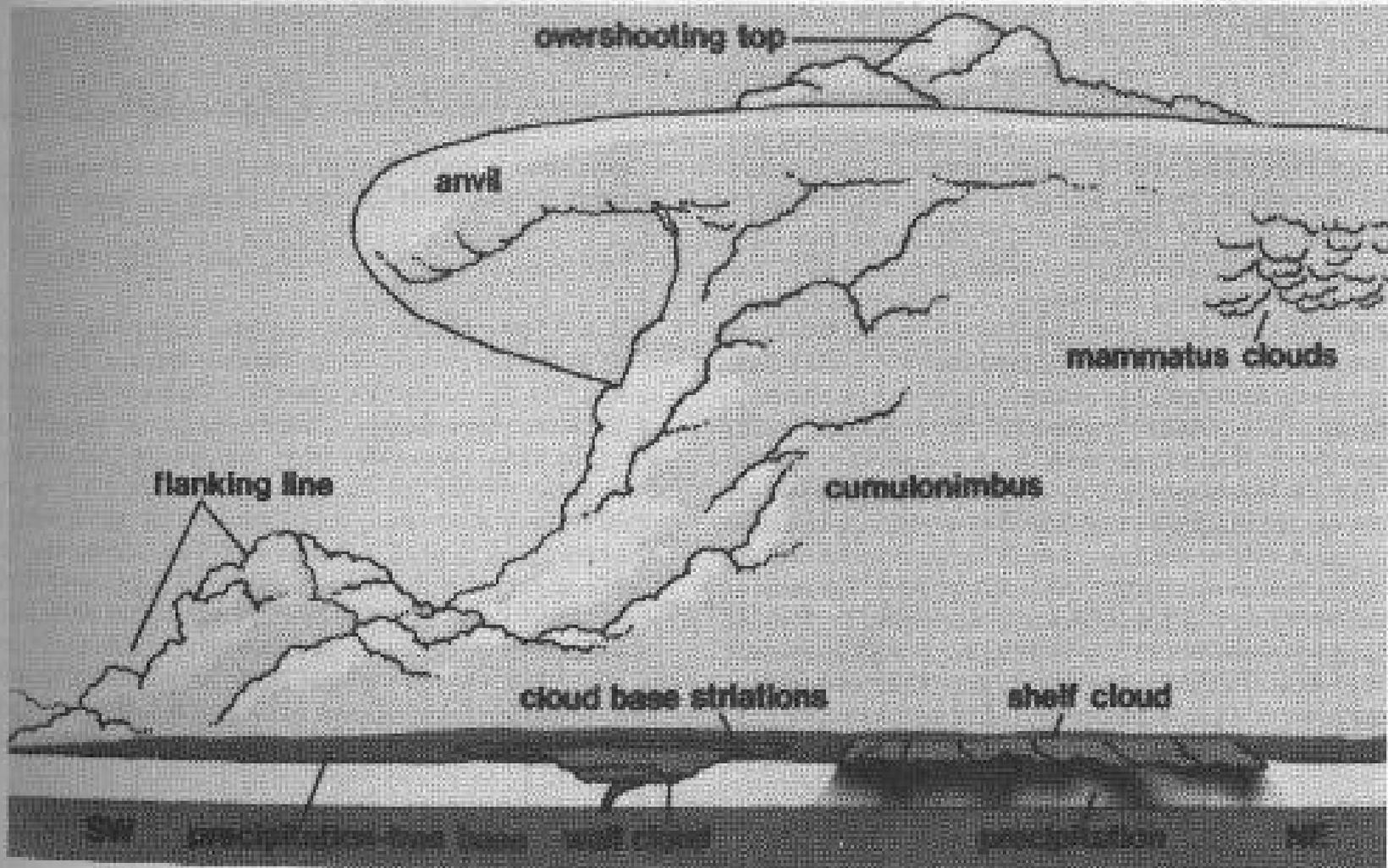


Figure 10.4. Composite view of a typical tornado-producing cumulonimbus as seen from the southeast. The horizontal scale is compressed (diagram by C. Doswell and B. Dittman).



Lee Wave Phenomena

- Mountain Wave Structure Discussion
- Lower Turbulent Zone – Rotor
- Distinction between Trapped and Vertically Propagating Waves
- Higher layer Breaking Wave region
- Strategies for encountering strong Lee Wave downdrafts

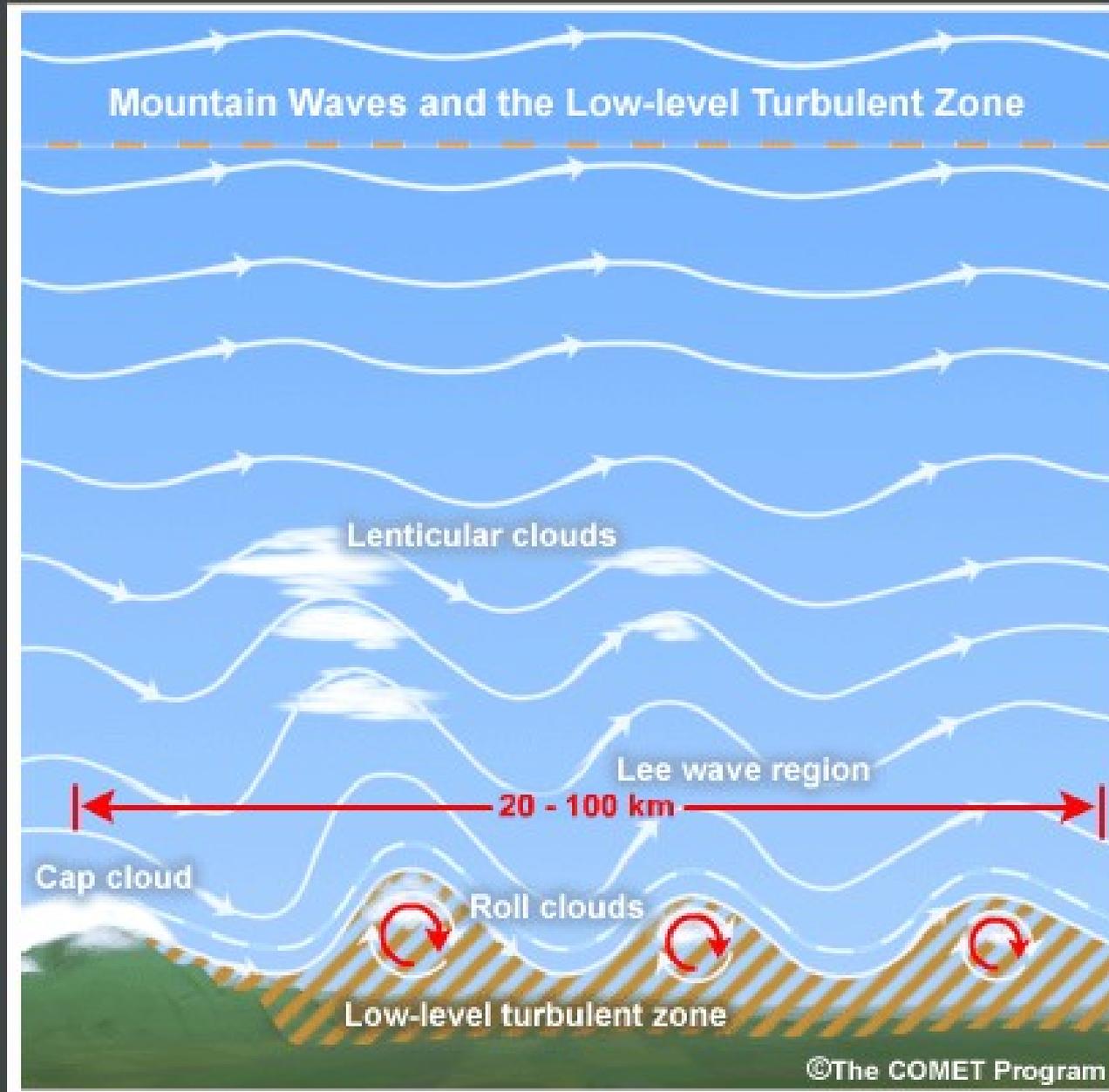


Mountain Wave Clouds Altostratus Standing Lenticular (ACSL)



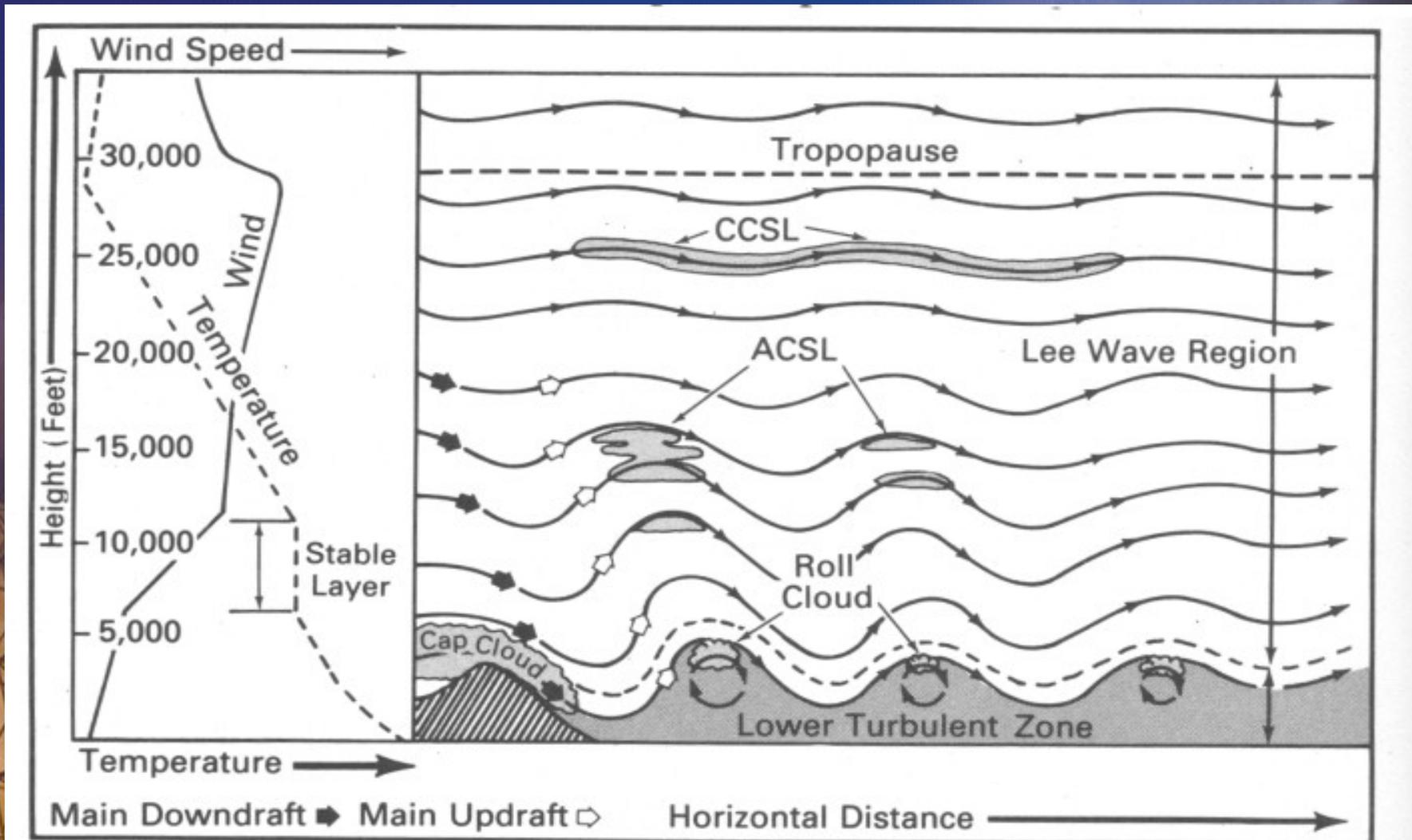
Mountain Waves

Characteristics





Schematic – Key Features of Mountain Wave System





Severe Owens Valley Mountain Wave



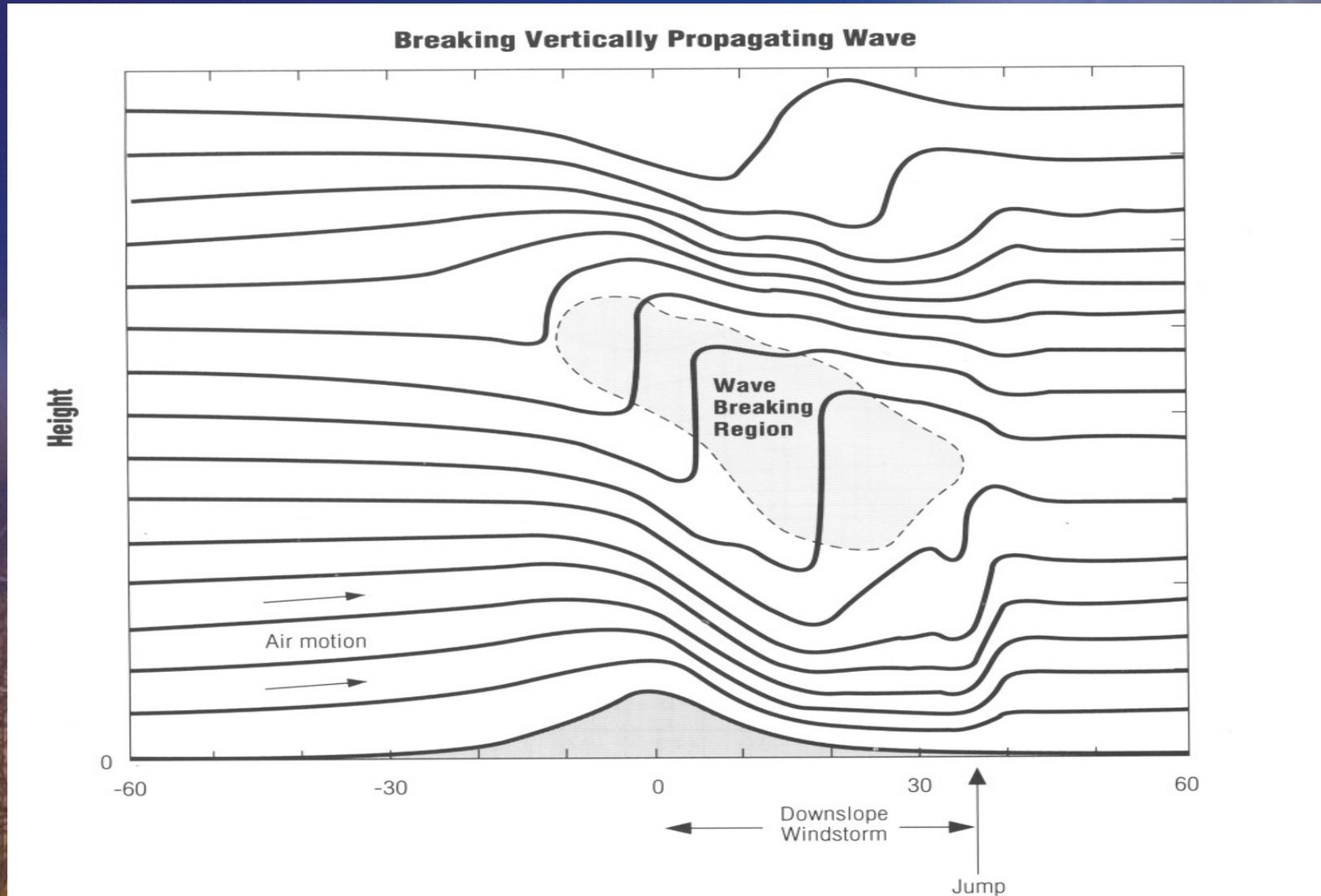
Downslope Windstorm along the Eastern Sierra Nevada and Owens Valley, CA



Photo by Robert Symons

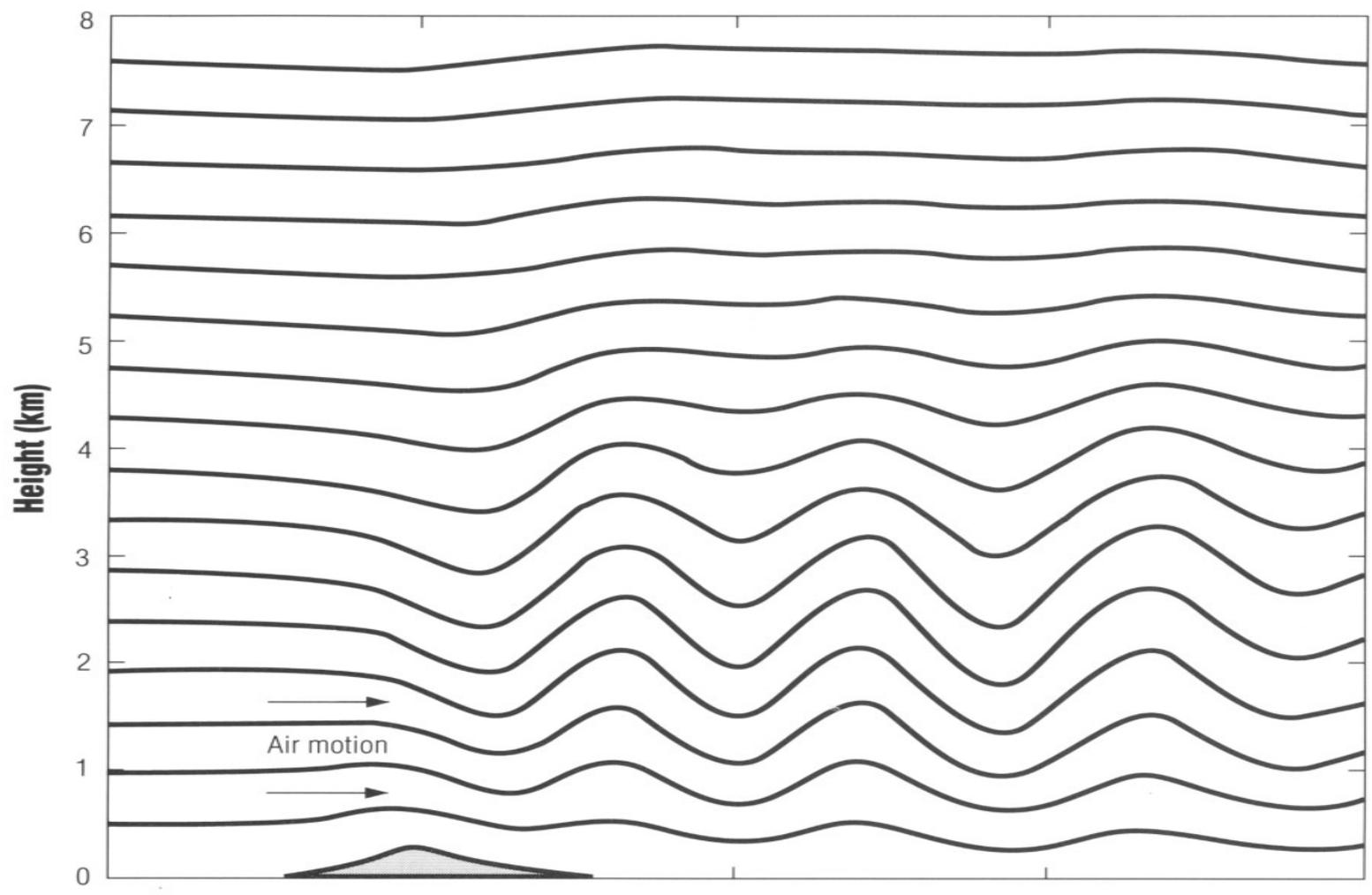


Vertically Propagating – Breaking Wave





Trapped Lee Waves





Thank you very much for
coming....

