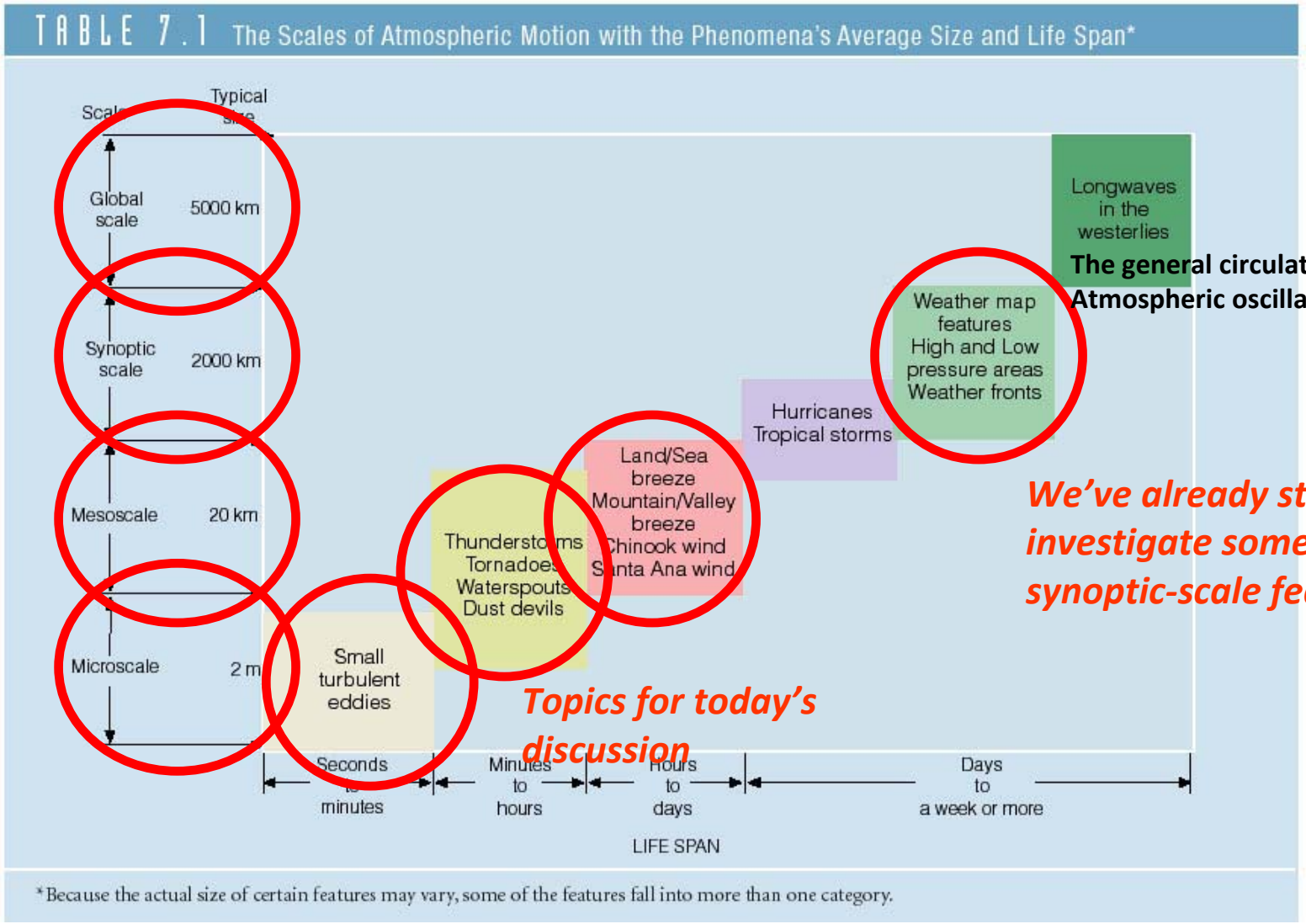
Turbulence and local winds

Scales of Atmospheric Motion vs. Lifespan



The general circulation
Atmospheric oscillations

We've already started to investigate some of the synoptic-scale features…

Topics for today's discussion

Basically here's our roadmap for the rest of the course.

The smallest type of atmospheric motion is turbulence… it is defined as small scale changes in wind speed or direction(wind shear)

It is chaotic, changes rapidly, and occurs over small distances

This makes it hard to predict…

…although we cannot predict individual gusts or eddies, we can identify some locations where turbulence usually occurs

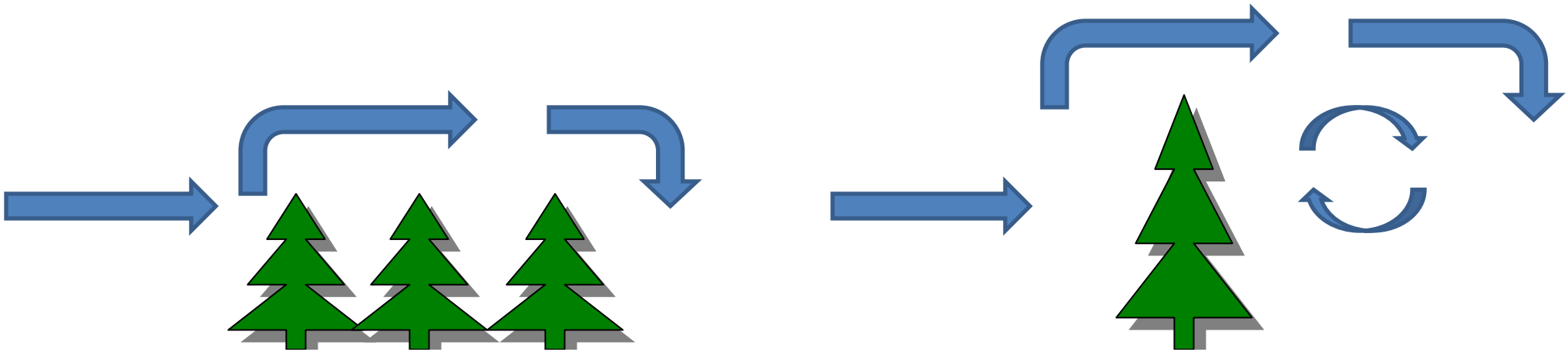

“From the flight deck… please return to your seats and fasten your seatbelts, there is a bit of weather ahead and we might get a couple bumps…”
MartinKucera.com

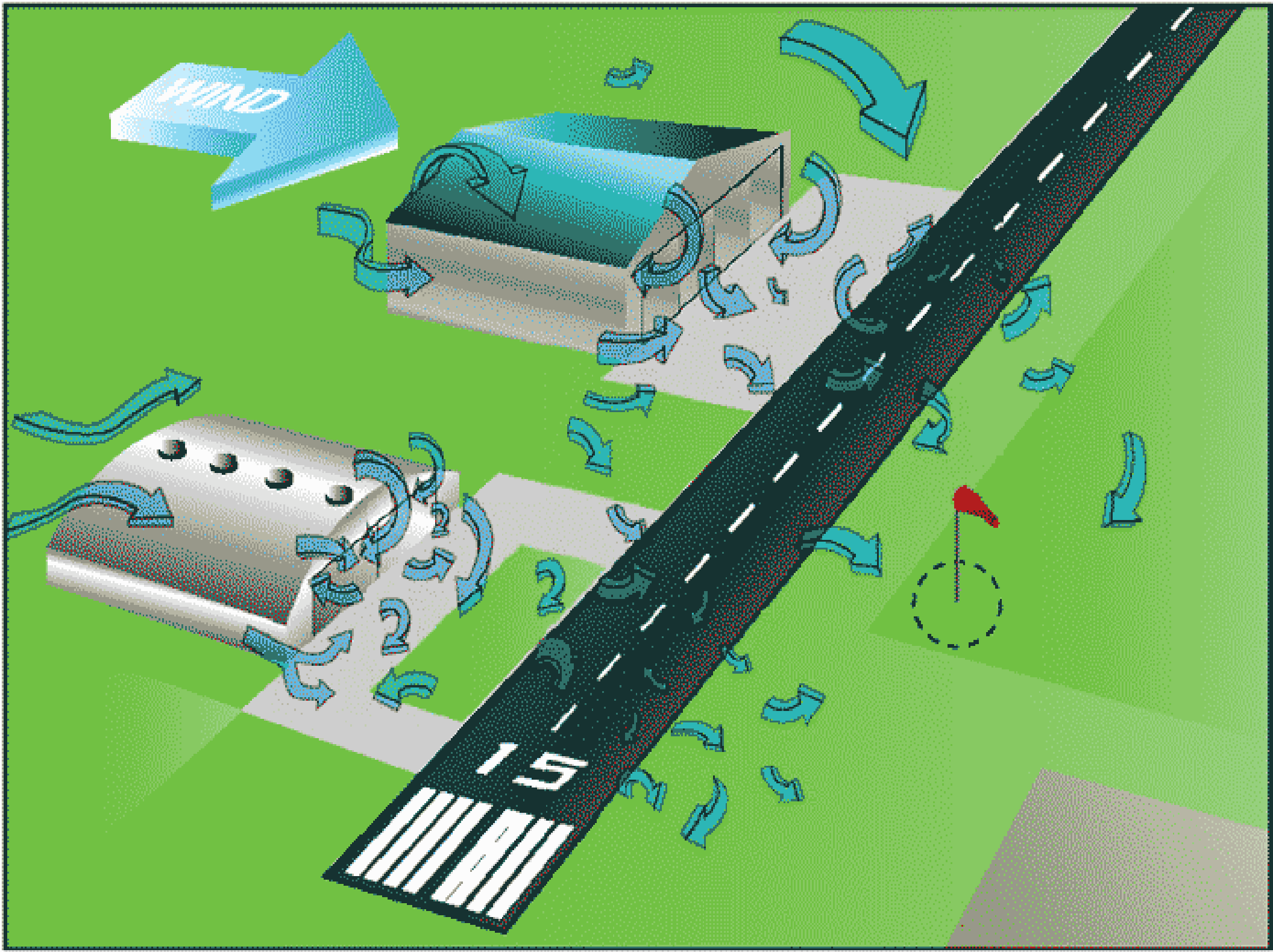
Typical types of turbulence

- Mechanical
- Mountain waves
- Convection
- Air mass boundaries(some fronts, jet stream)

Mechanical Turbulence

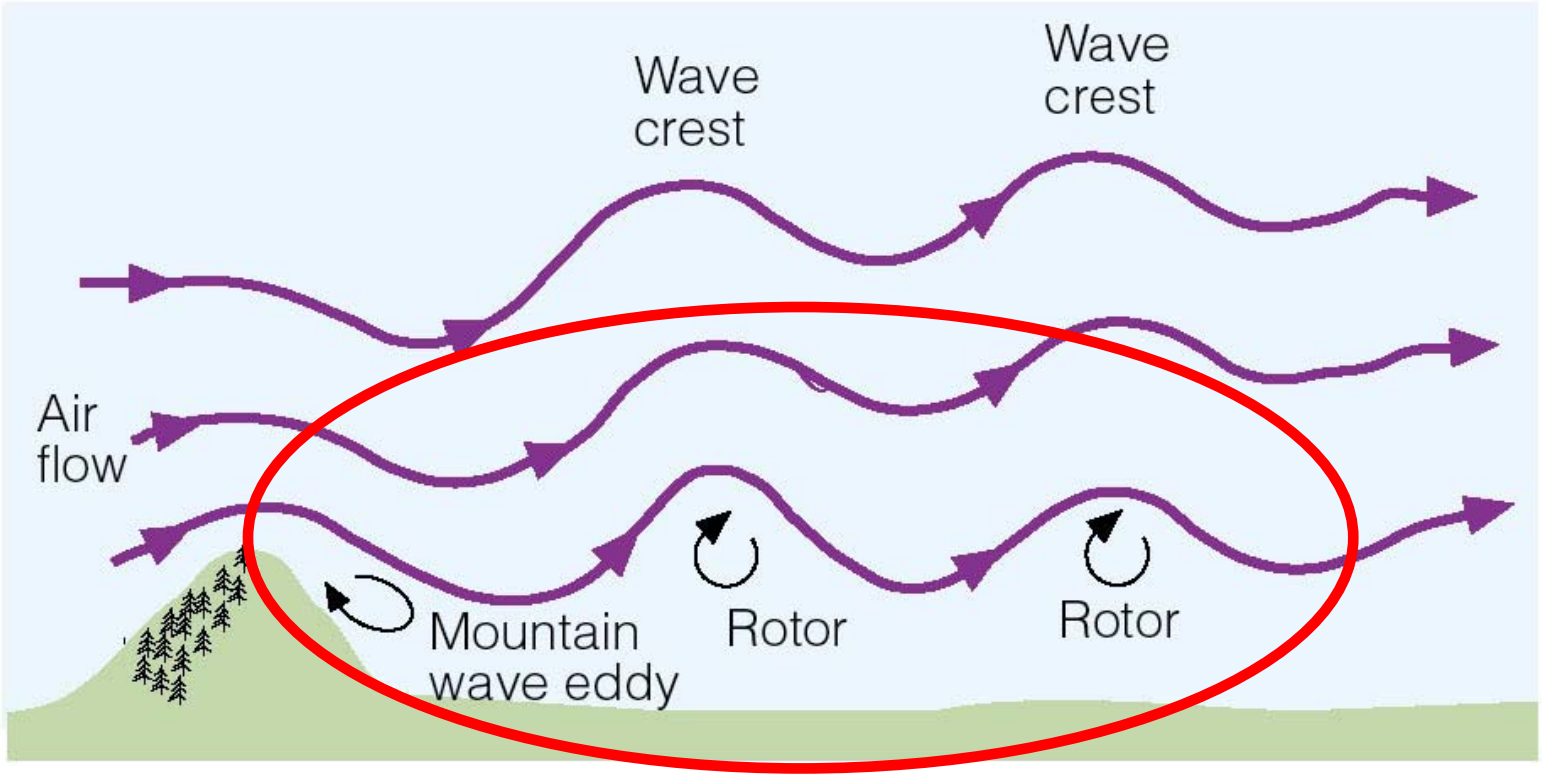
- Occurs near the surface
- Caused by friction, and obstructions to wind flow
- Obstacles include trees, buildings, and terrain.
- The stronger the wind or the larger obstruction, the stronger the turbulence

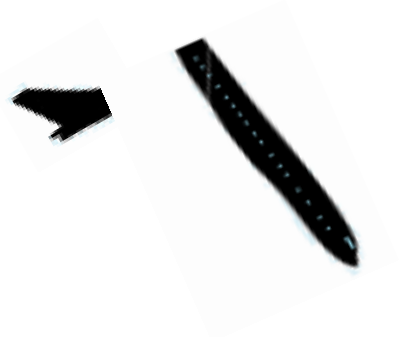



WIND
15


Add a really
large obstacle…

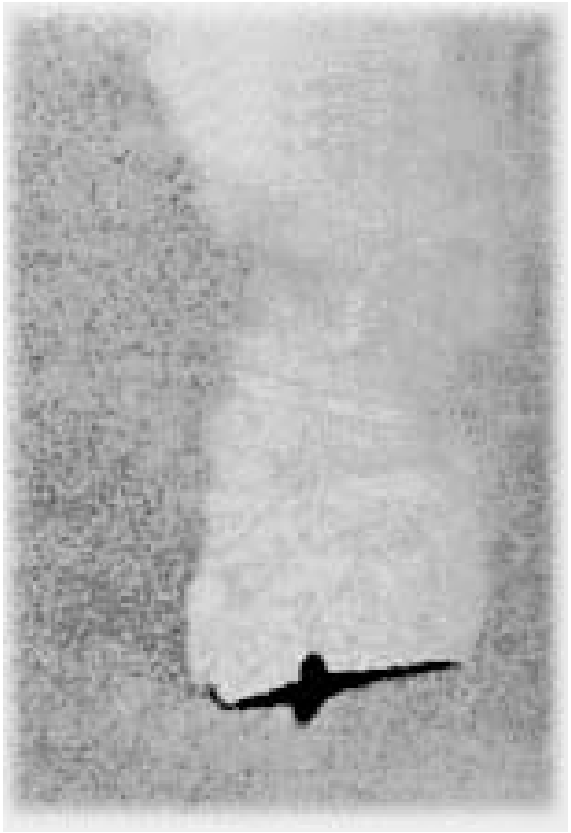
Mountain wave turbulence



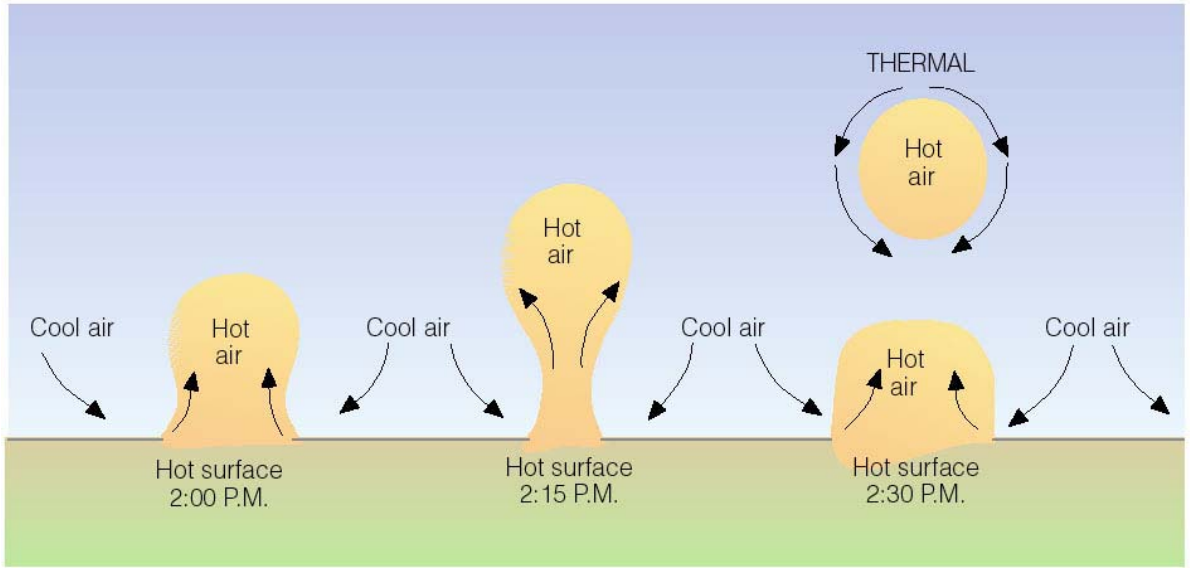


Mountain wave turbulence is amongst the strongest on earth

British Overseas Airways Flight 911, departing Tokyo, March 5 1966



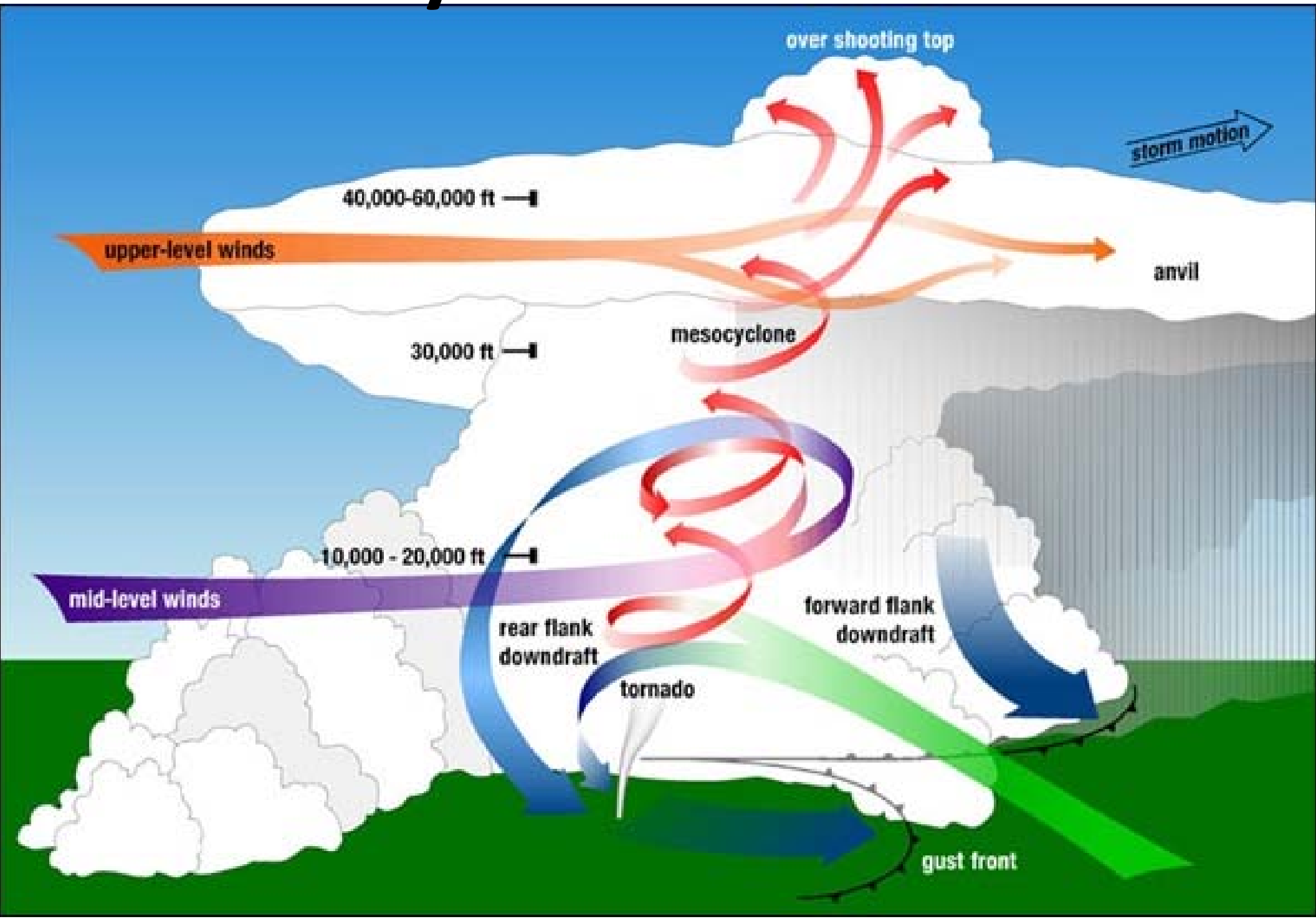
Thermal Turbulence
(Free Convection)



Formed by rising thermals due to surface heating during the day. These may form convective clouds by afternoon.

So if you want the smoothest ride, take the morning flight!

Plenty of turbulence here



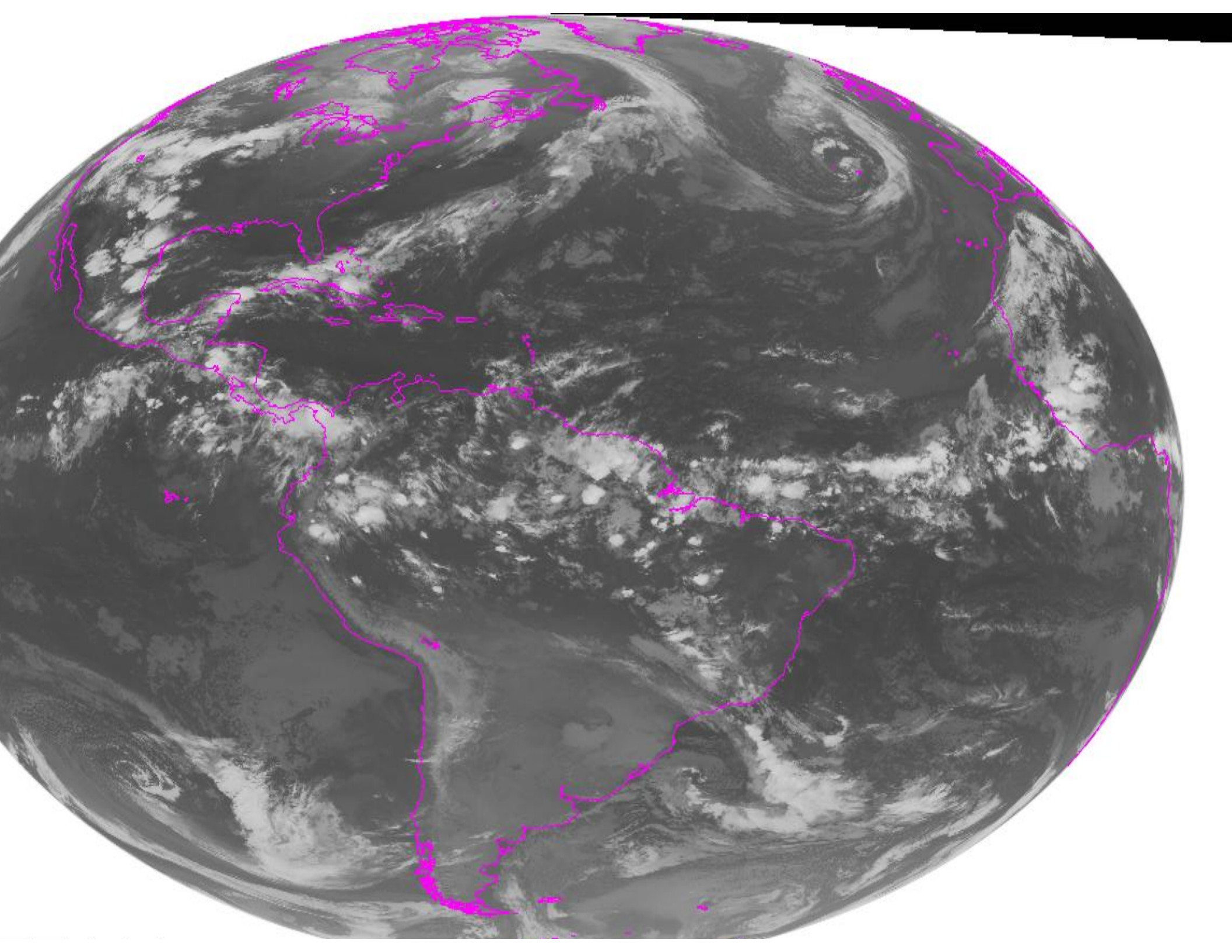
Air France 447, June 1 2009

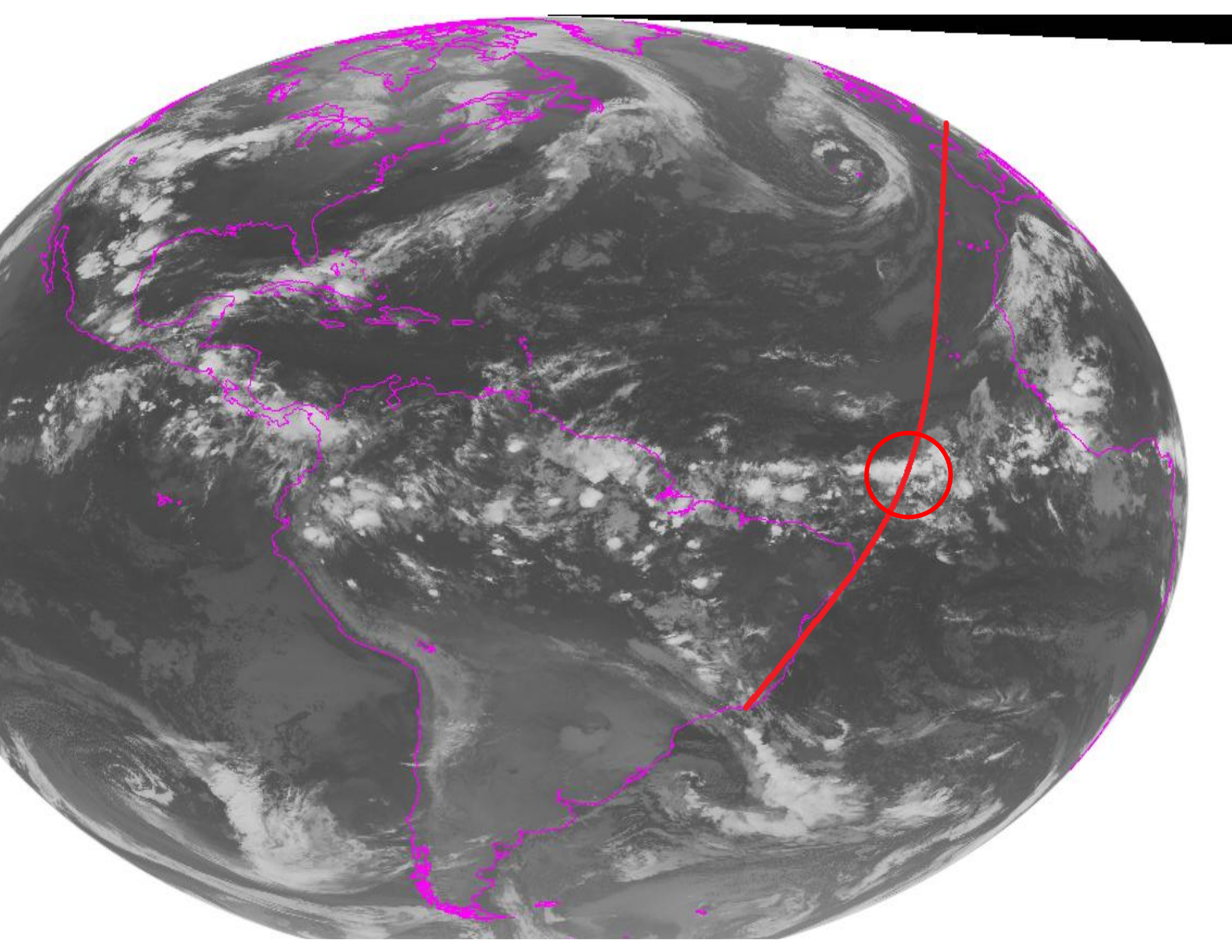
In the early morning hours of June 1 2009, Air France maintenance computers began recording a series of automated text messages from one of their aircraft on a nightly flight across the Atlantic between Rio de Janeiro and Paris.

Lasting 4 minutes, the text messages indicated a host of system failures...

After these messages ceased, no further contact with the aircraft was ever made.


LFPG
This is the most direct route between Rio and Paris. The actual route of flight would be very close to this.
SBGL



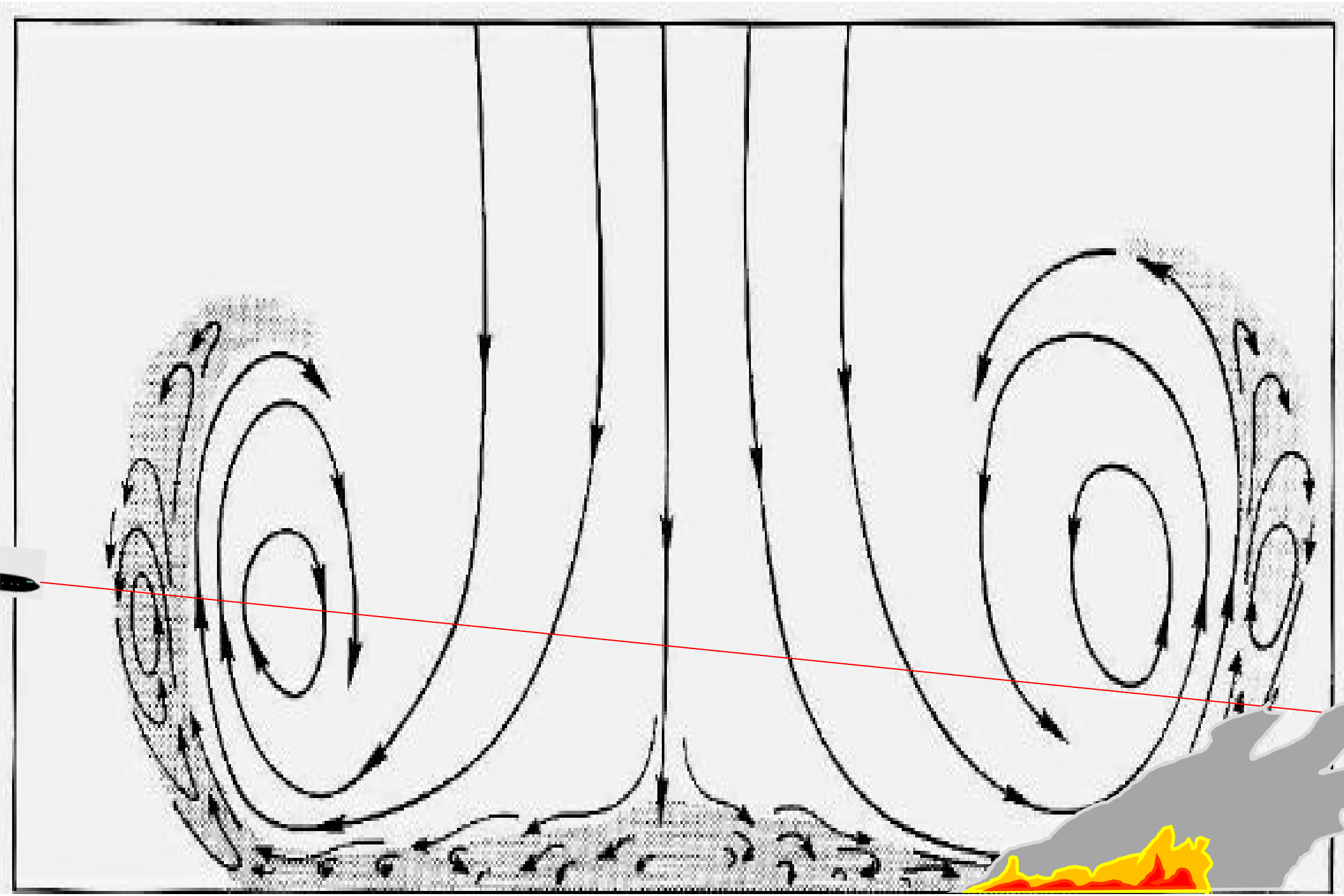


Autopilot disengage
Autothrust disengage
Flight control computers – multiple failures – resorting to alternate profile
Rudder limiter fault
TCAS fault
Flight envelope warning
Guidance 1 fault
Guidance 2 fault
Guidance 3 fault
Standby instruments 1 fault
Standby instruments 2 fault
air data computer fail
Remaining air data computers disagree
Flight management computers fault
Primary flight display fault
Secondary flight display fault
Cabin Depressurizing
>End of messages<

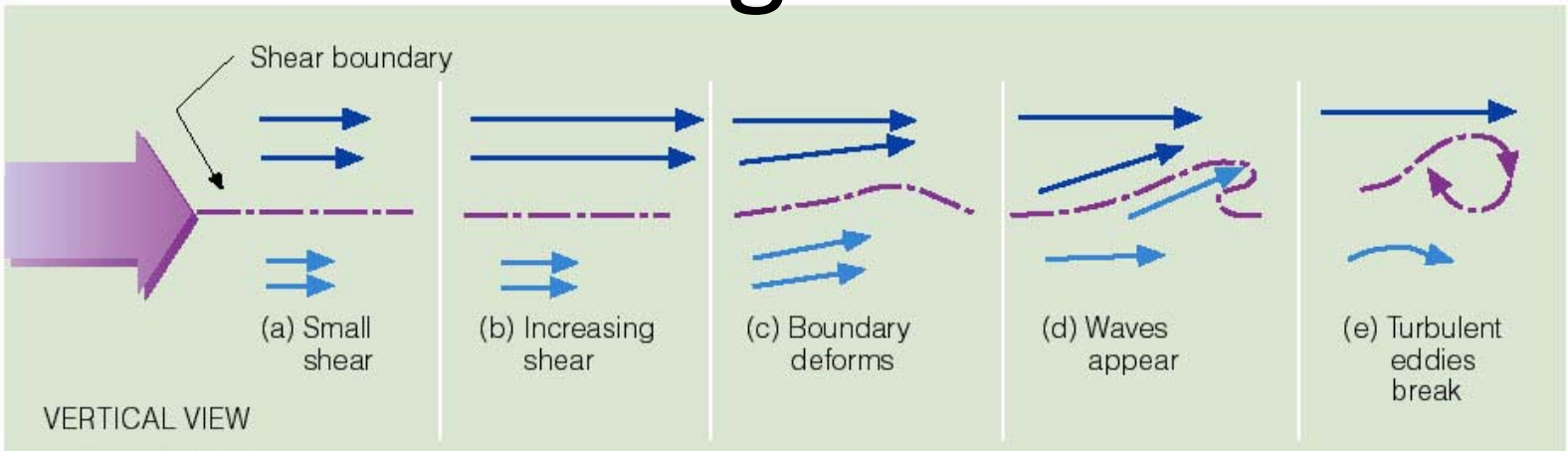
While the official investigation is ongoing, it is fairly clear that the scope of system failures indicates that following some initial shock, the aircraft is unable to be flown. Pieces of flight controls, possibly large sections of the plane, have likely detached. The final message probably indicates the fuselage is breaking up, or perhaps it is the last gasp of the failing computer

Delta 191, DFW, August 2 1985

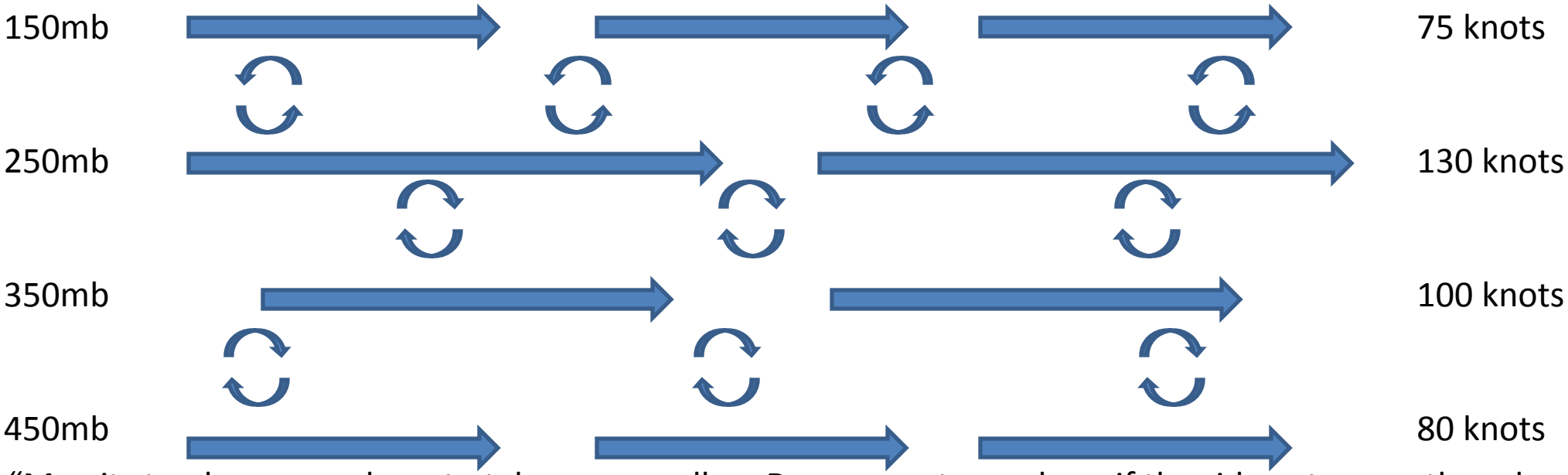
Typical microburst



Wind shear creating turbulent eddies



Sample jet stream…



"Man its too bumpy up here to take a nap, call up Denver center and see if the ride gets smoother ahead…"

"Ya, but check out this tailwind"

Turbulence Detection

Local Winds:
Sea-Land Breeze
Mountain-Valley Circulation

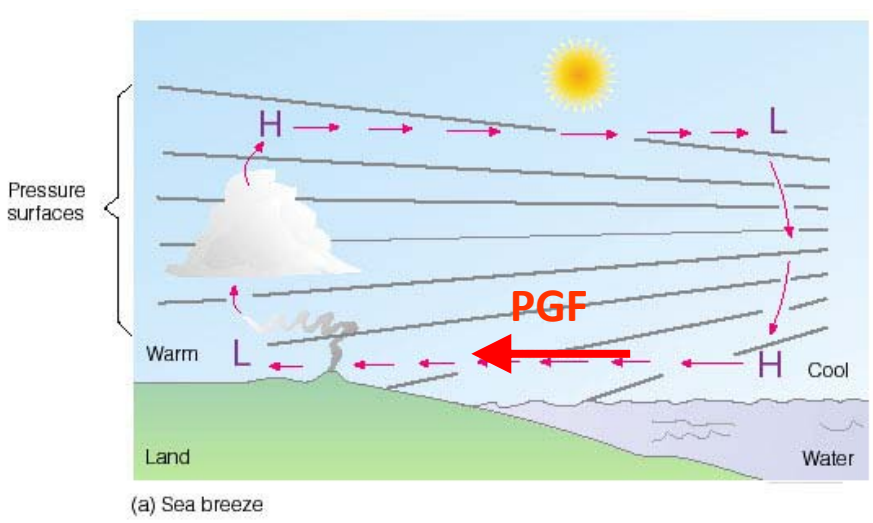
Basically the same physical idea for each one:

1. **A direct thermal circulation which occurs a small enough scale that the pressure gradient is the dominant force which drives the wind.**

2. **Driven by the diurnal cycle of solar heating.**

Sea-Land Breeze

DAYTIME



(a) Sea breeze

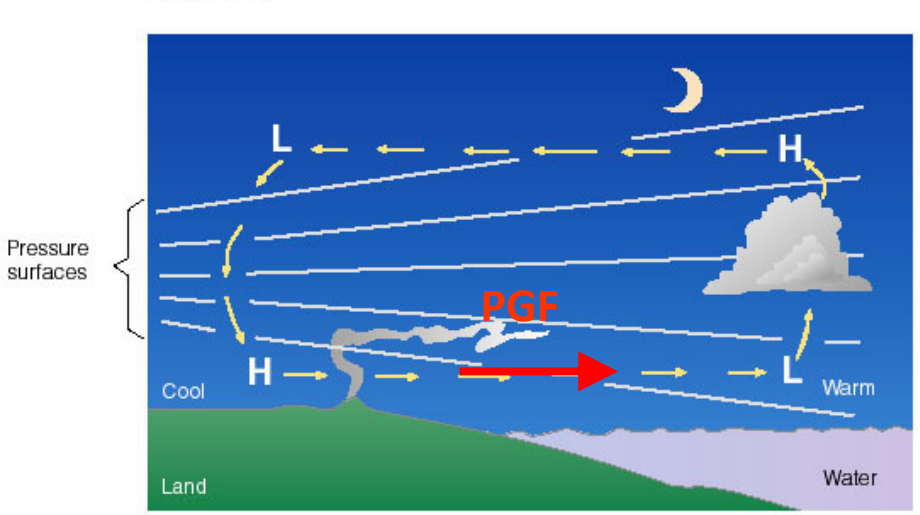
Water is relatively cool

Land is relatively warm

Onshore flow at the surface

Offshore flow aloft.

NIGHTIME



(b) Land breeze

Water is relatively warm

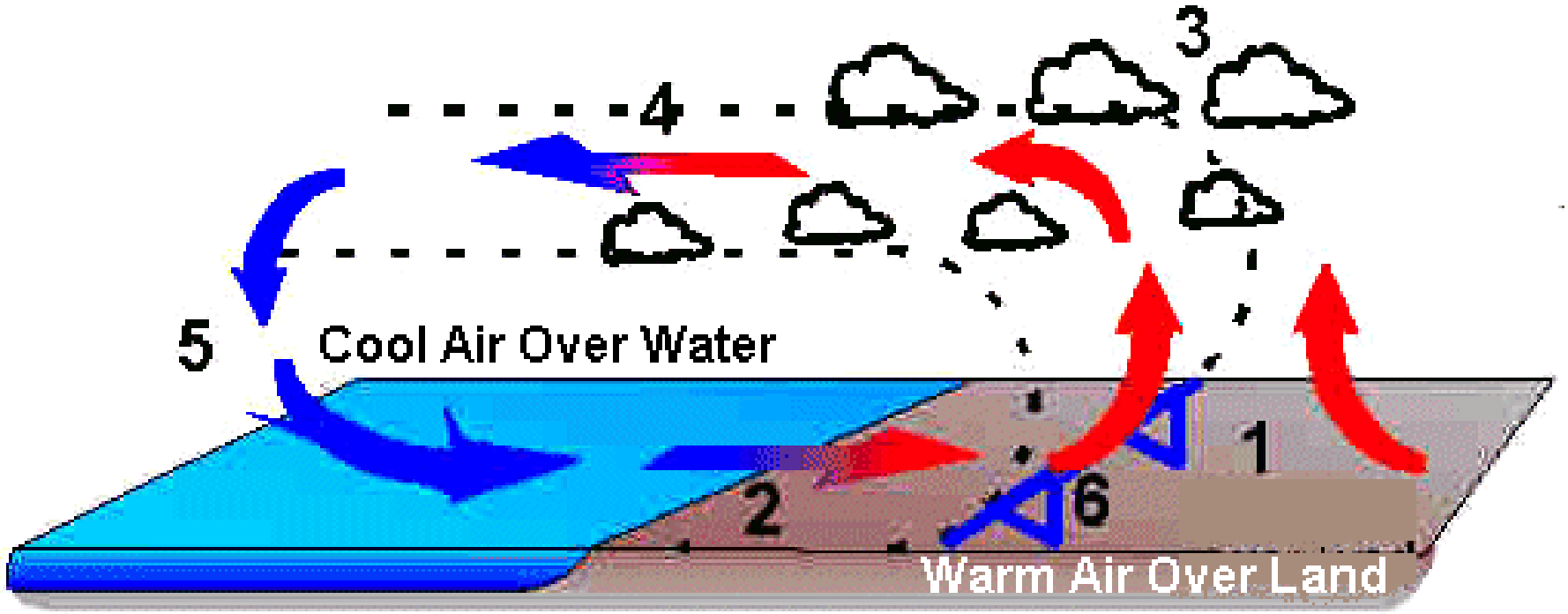
Land is relatively cool

Offshore flow at the surface

Onshore flow aloft.

Occurs because water has a high heat capacity, so it heats and cools more slowly than the land.

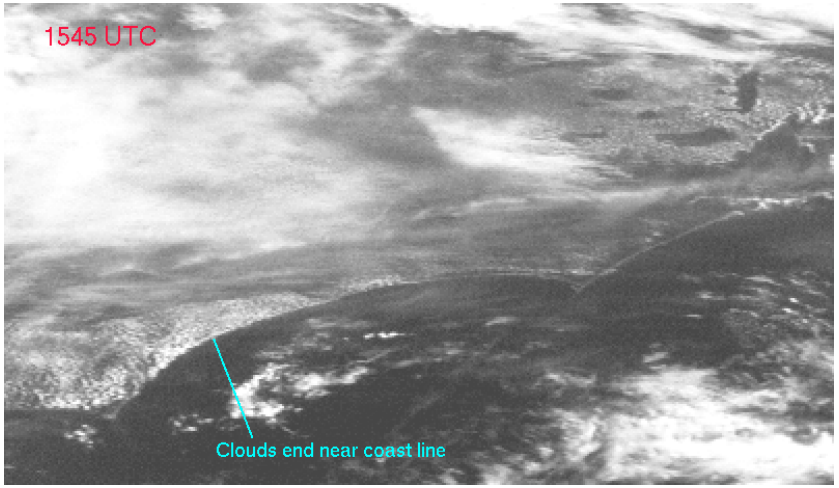
Sea Breeze Circulation and Sea Breeze Front



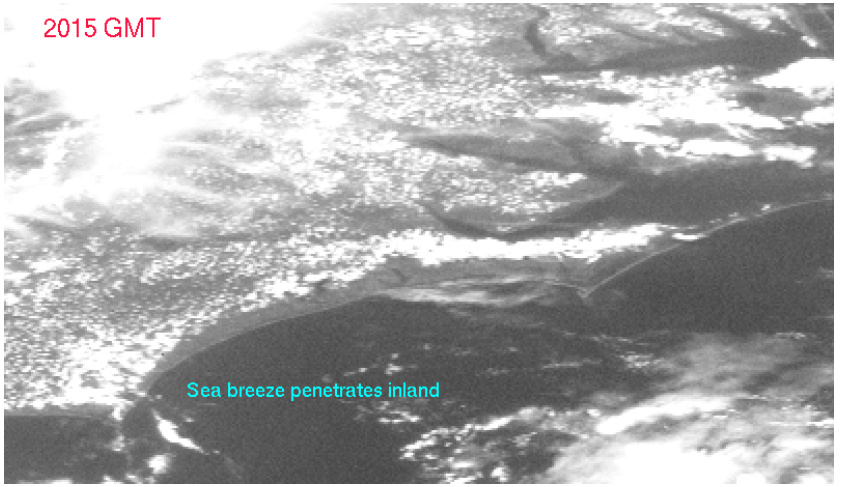
Sea breeze forces air to converge over land, leading to upward motion and formation of clouds and storms.

Sea Breeze Front: North Carolina Example

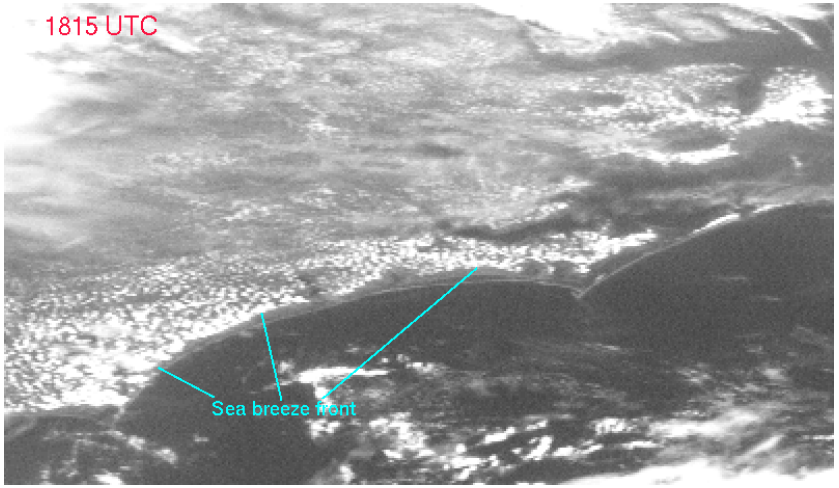
EARLY MORNING



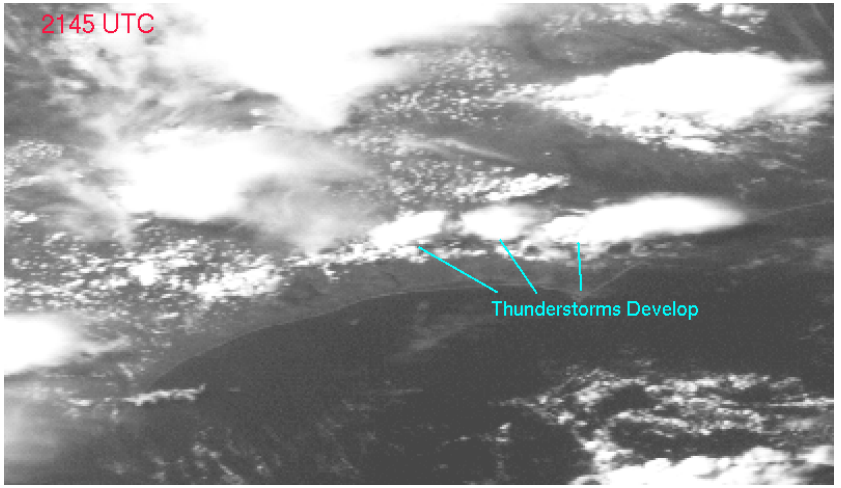
MID AFTERNOON



MID MORNING

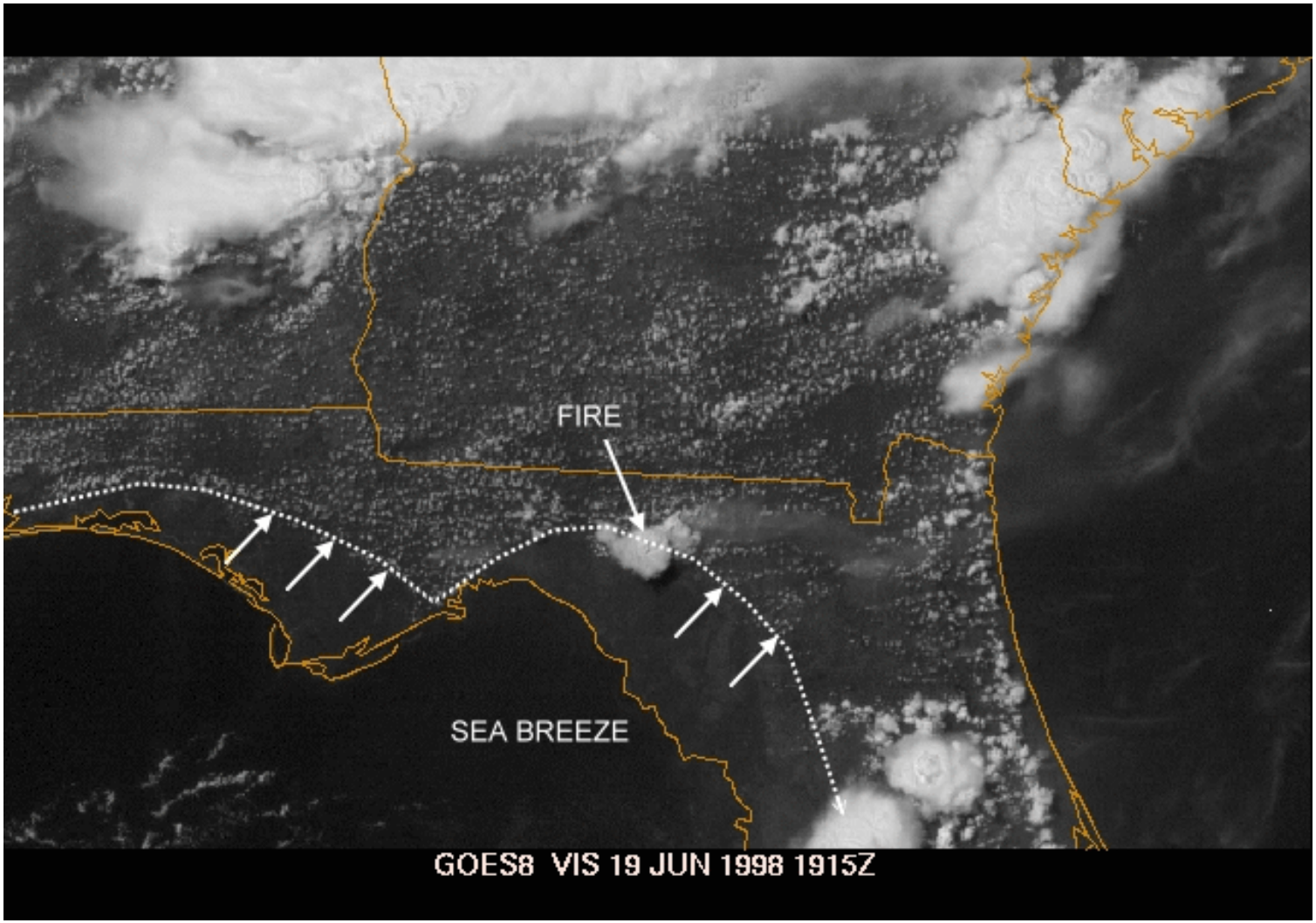


LATE AFTERNOON



(University of Wisconsin)

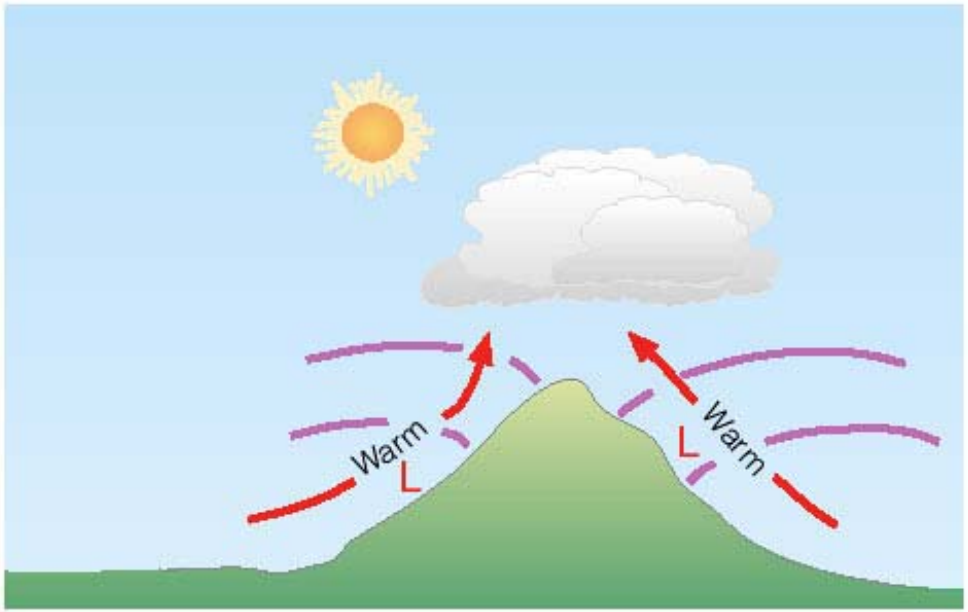
Florida Peninsula



Sea breeze is blowing the smoke from a forest file away from the Gulf of Mexico side (FL Dept. of Forestry).

Mountain-Valley Winds

DAYTIME



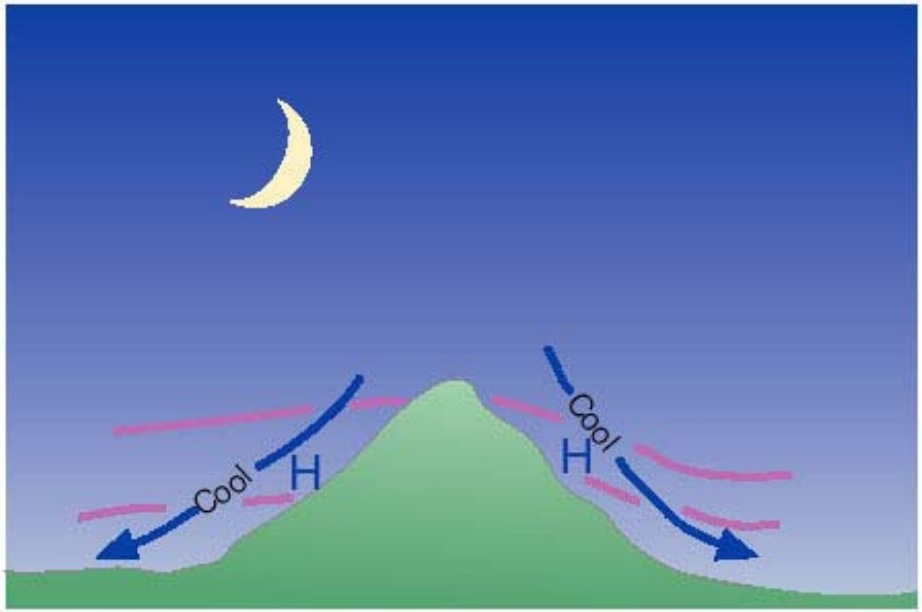
Valley Breeze

Air is heated along mountain slopes

Warmed air is locally less dense than the surrounding air above the valley.

Upslope flow.

NIGHTTIME



Mountain Breeze

Air is cooled along mountain slopes

Cooled air is locally more dense than the surrounding air above the valley.

Downslope flow.

Local Topography of Tucson, AZ

We're surrounded by mountains on three sides, so mountain valley circulations play a BIG role in our weather—especially during the monsoon!