Meteorology 101

(Some) Fundamentals of Weather

Jon Nese and Jen Carfagno
The Weather Channel
February 22, 2004

Meteorology 101

Outline

- Weather and Air Quality: The Issues
- Basic Weather Concepts
- Weather Observations
- The “Models”
- Your Questions

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Weather & Air Quality:
Keys: **Air motion**, **clouds**, and **precipitation**.

Horizontal:	Wind
Vertical:	Vertical Motions, mixing

- Wind, mixing disperse Pollutants!!
- Clouds reduce sunlight and slow production of some pollutants.
- Precipitation cleanses the atmosphere.

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Questions to Answer

- How, why, when, where does the wind blow?
- What controls vertical motions?
- When and where do clouds and precipitation form?

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Geographical Terminology…

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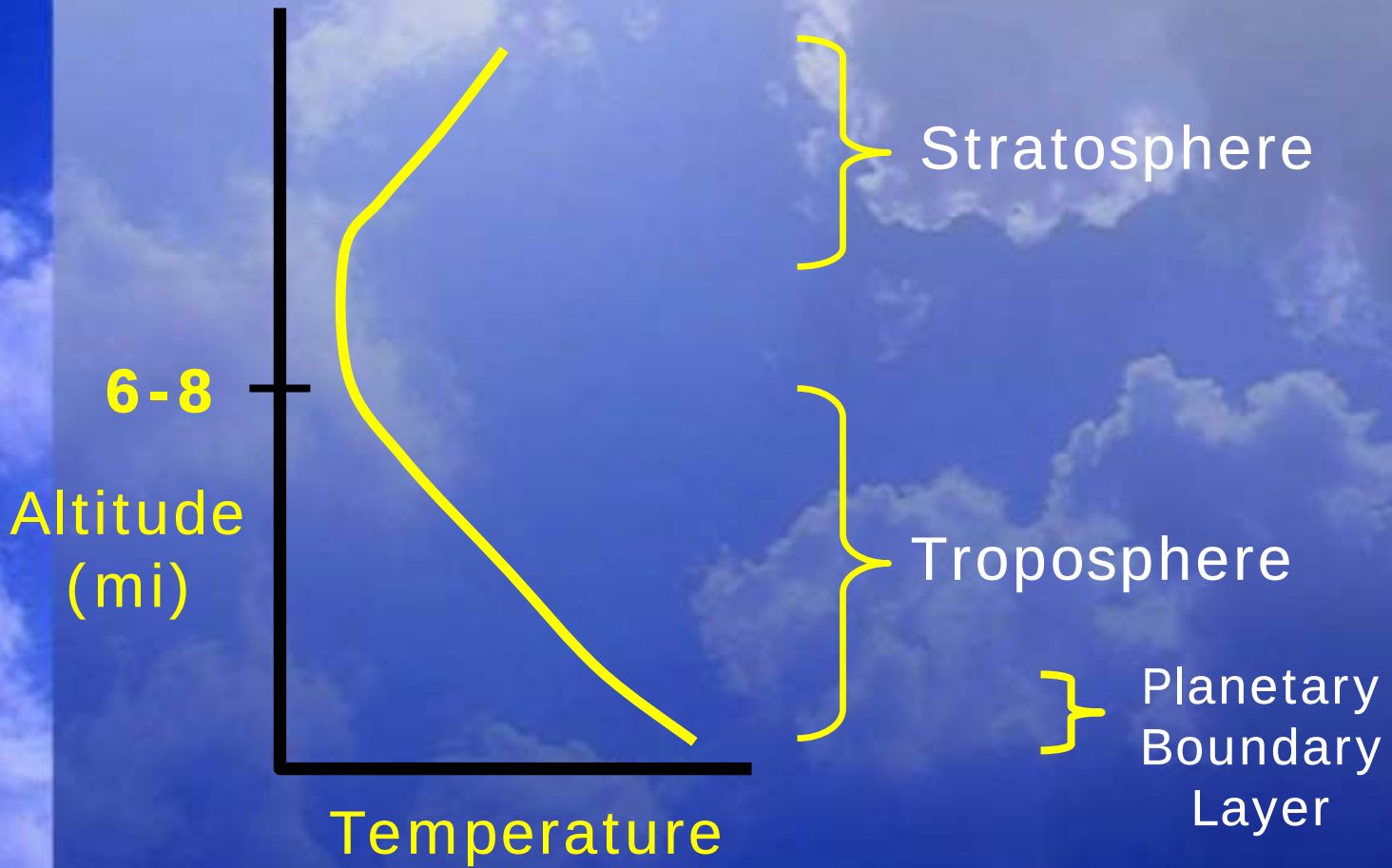
Layering of the Atmosphere



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Some Fundamentals

- Earth is heated unevenly: Tropics are warmer than the Polar Regions.
- Nature tries to try to even out temperature differences.
- Uneven heating sets atmosphere in motion and is the fundamental cause of all weather.

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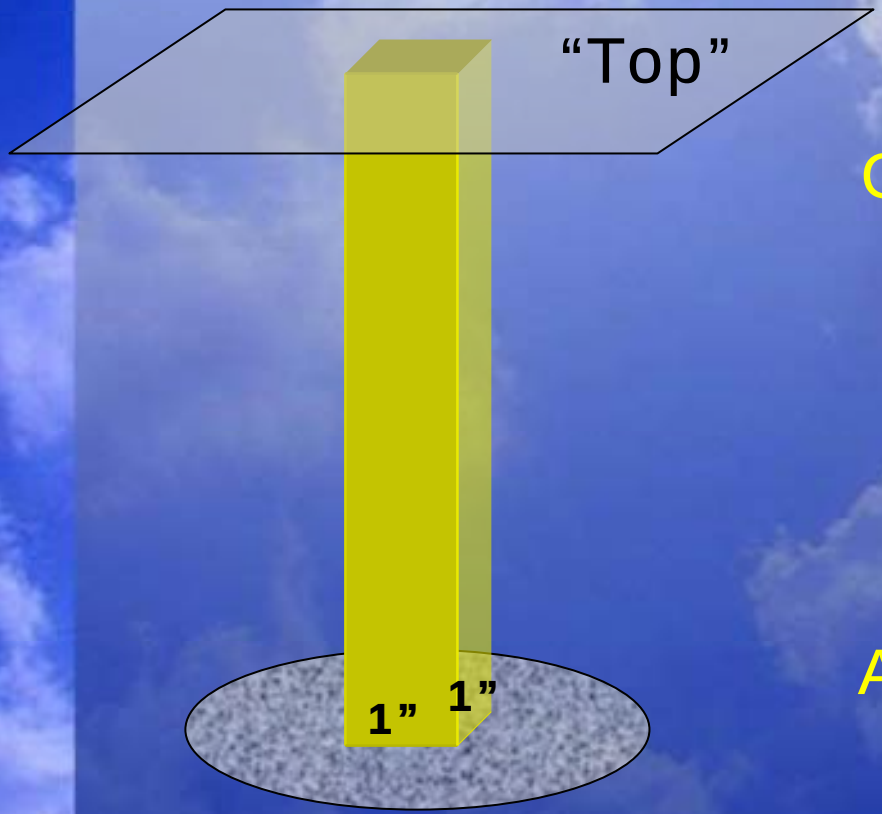
Air Pressure



On average, air weighs about 14.7 lb/in^2

14.7 lb/in^2 =29.92 "inches of mercury"

Air Pressure varies over the globe

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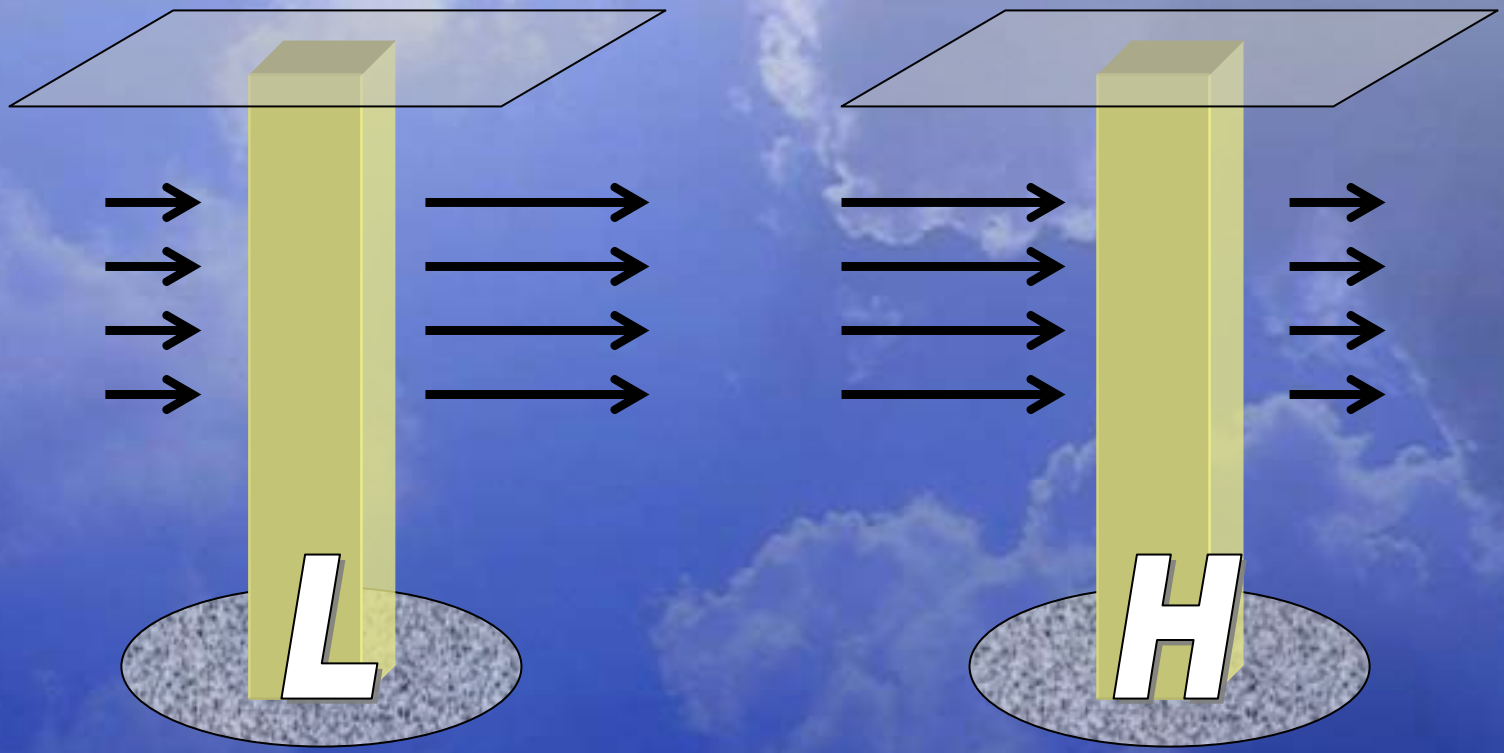
Changing Pressure - Winds



Take more out than put in – decrease pressure

Put more in than take out – increase pressure

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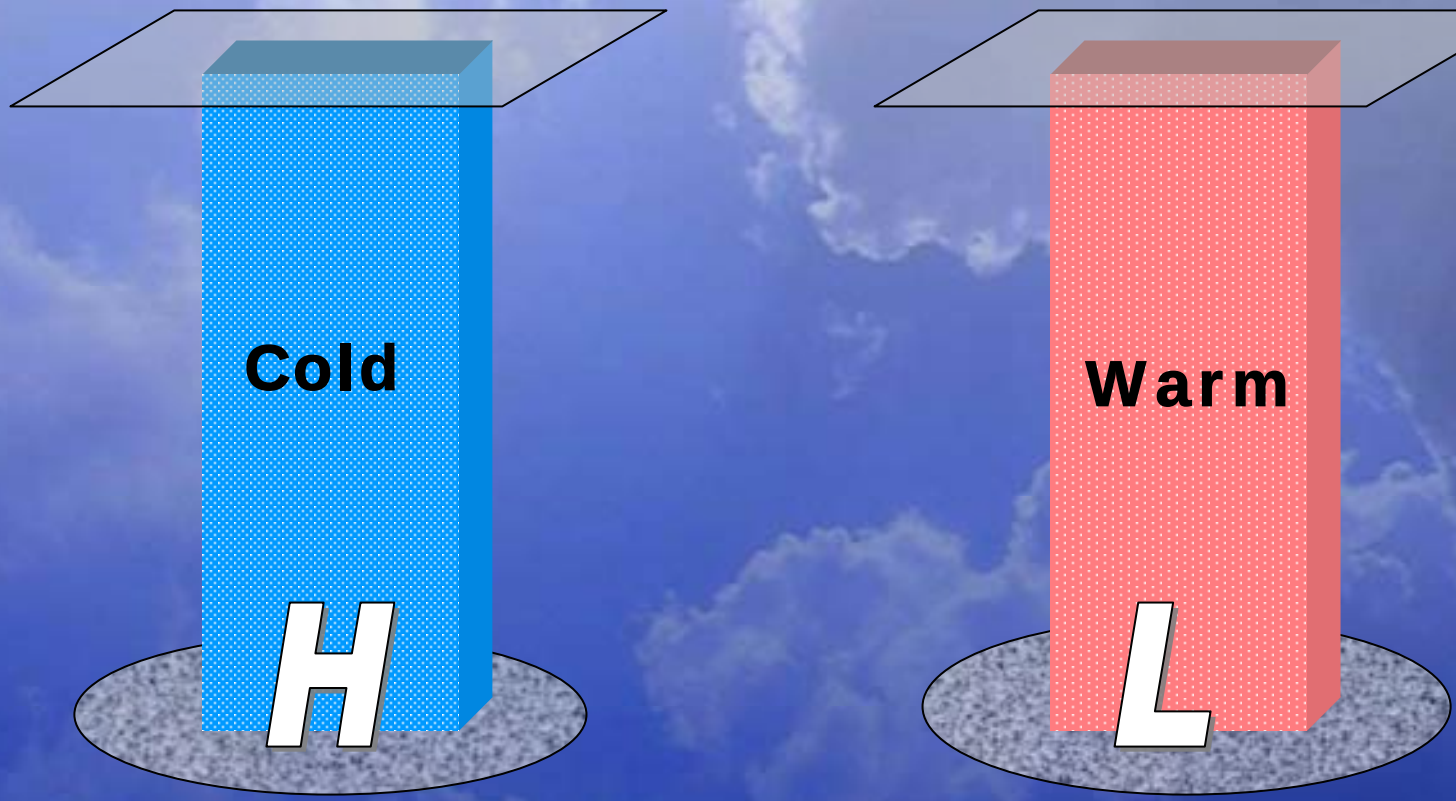
Changing Pressure - Temperature



Coldest column = highest pressure **
Warmest column = lowest pressure **

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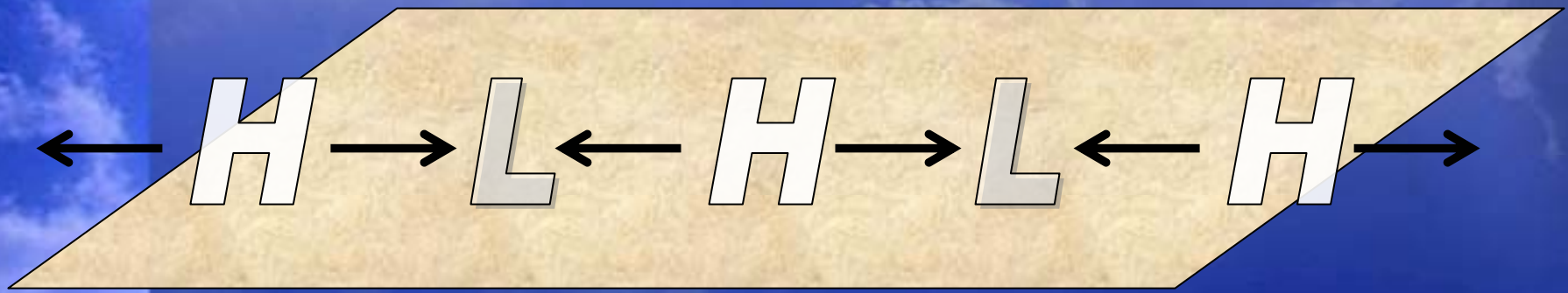
Pressure Differences Create Wind



Air moves from higher toward lower pressure

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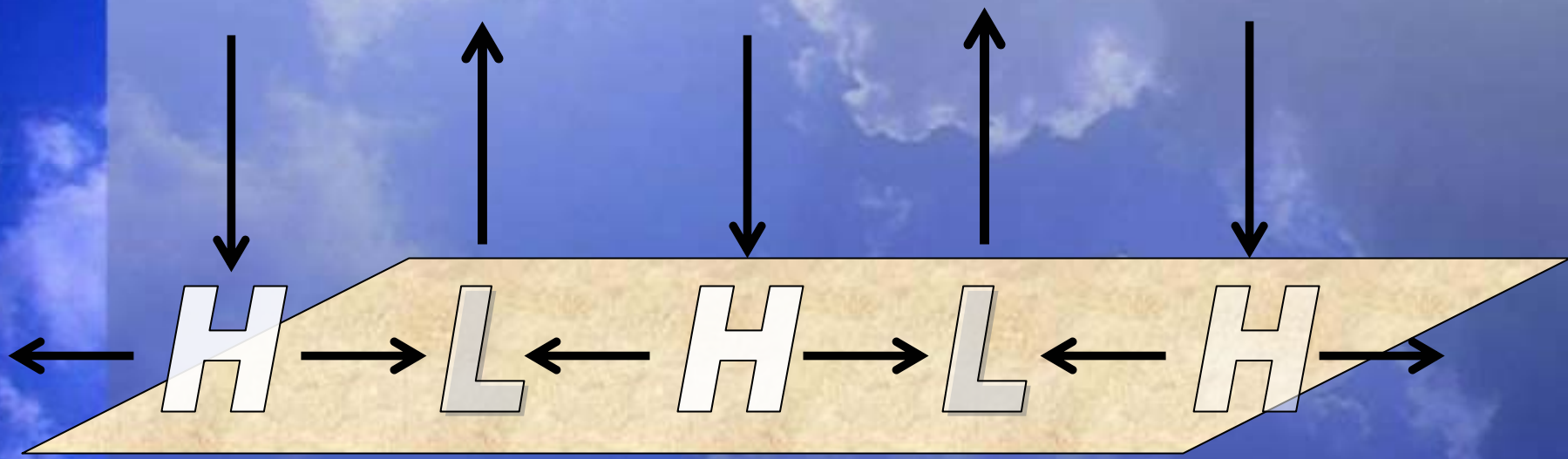
Vertical motions also occur



Air “converges” at lows, and rises.

Air “diverges” at highs, and sinks.

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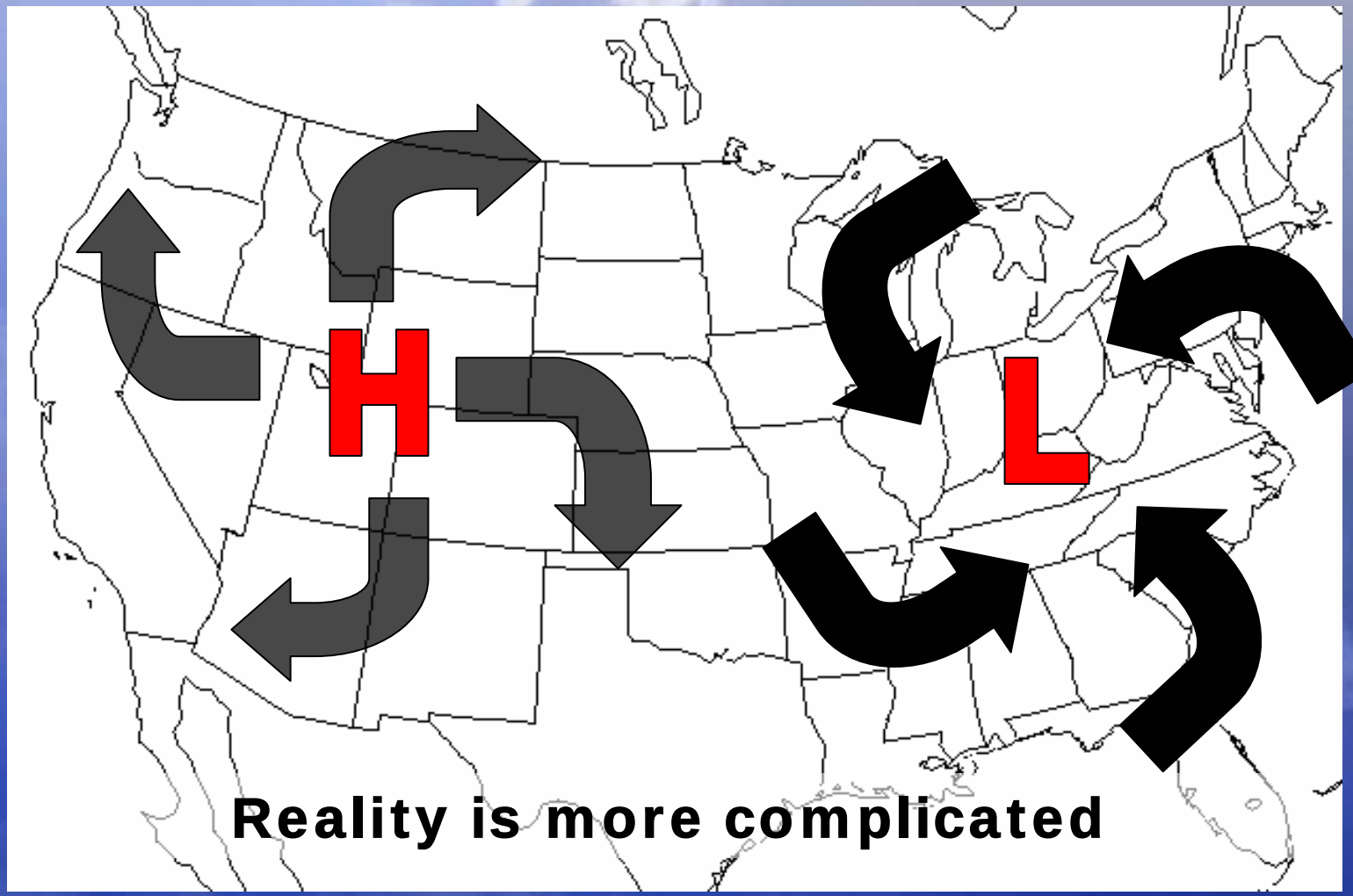

Actual winds around highs and lows

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Rising Air near Lows

- Rising air cools; water vapor in the air condenses to form clouds/precipitation
- Lows tend to bring cloudy, wet weather

Sinking air near Highs

- Sinking air warms and dries out.
- Highs tend to bring fair, dry weather.

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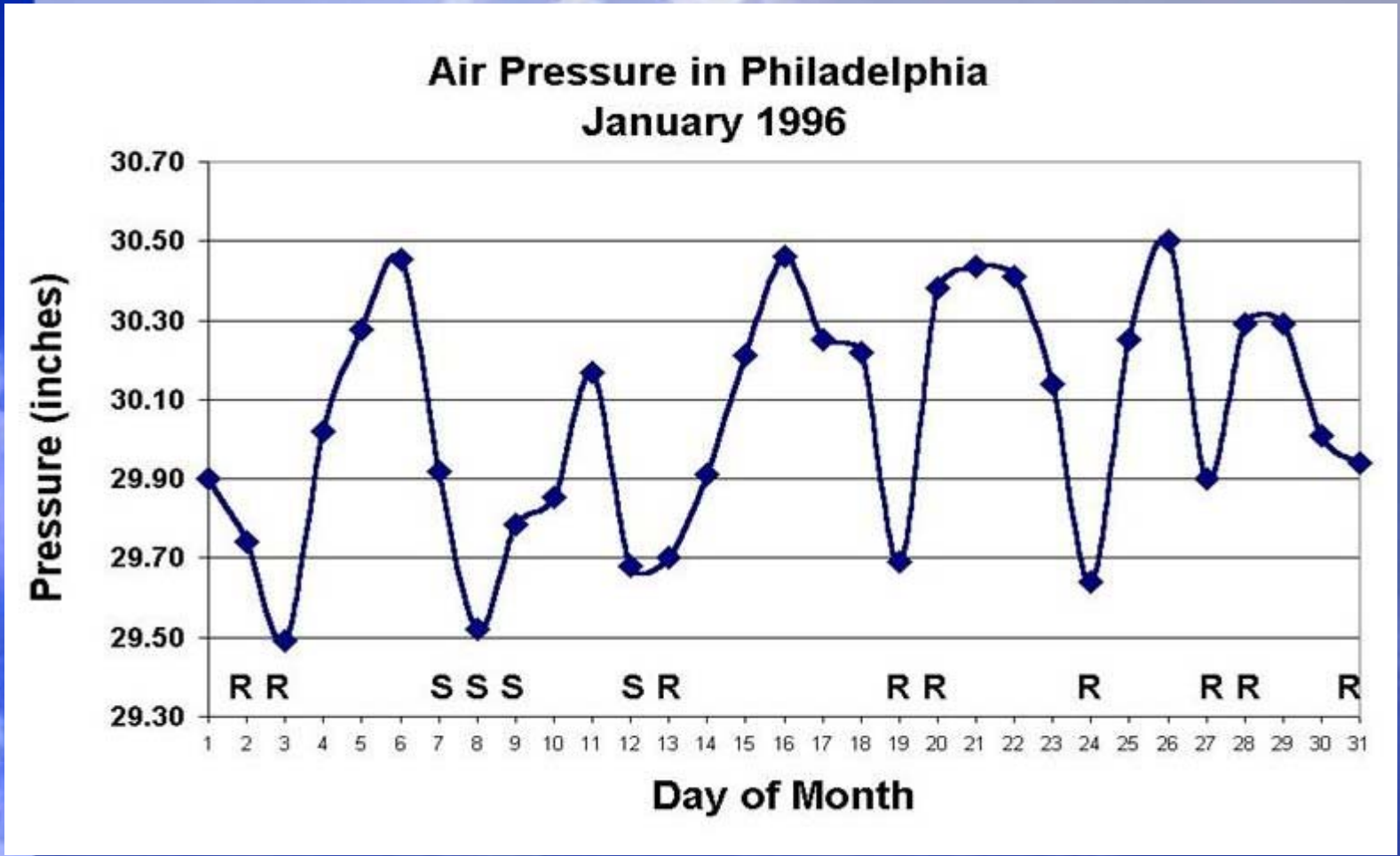

Low or lowering pressure = "Lousy" weather

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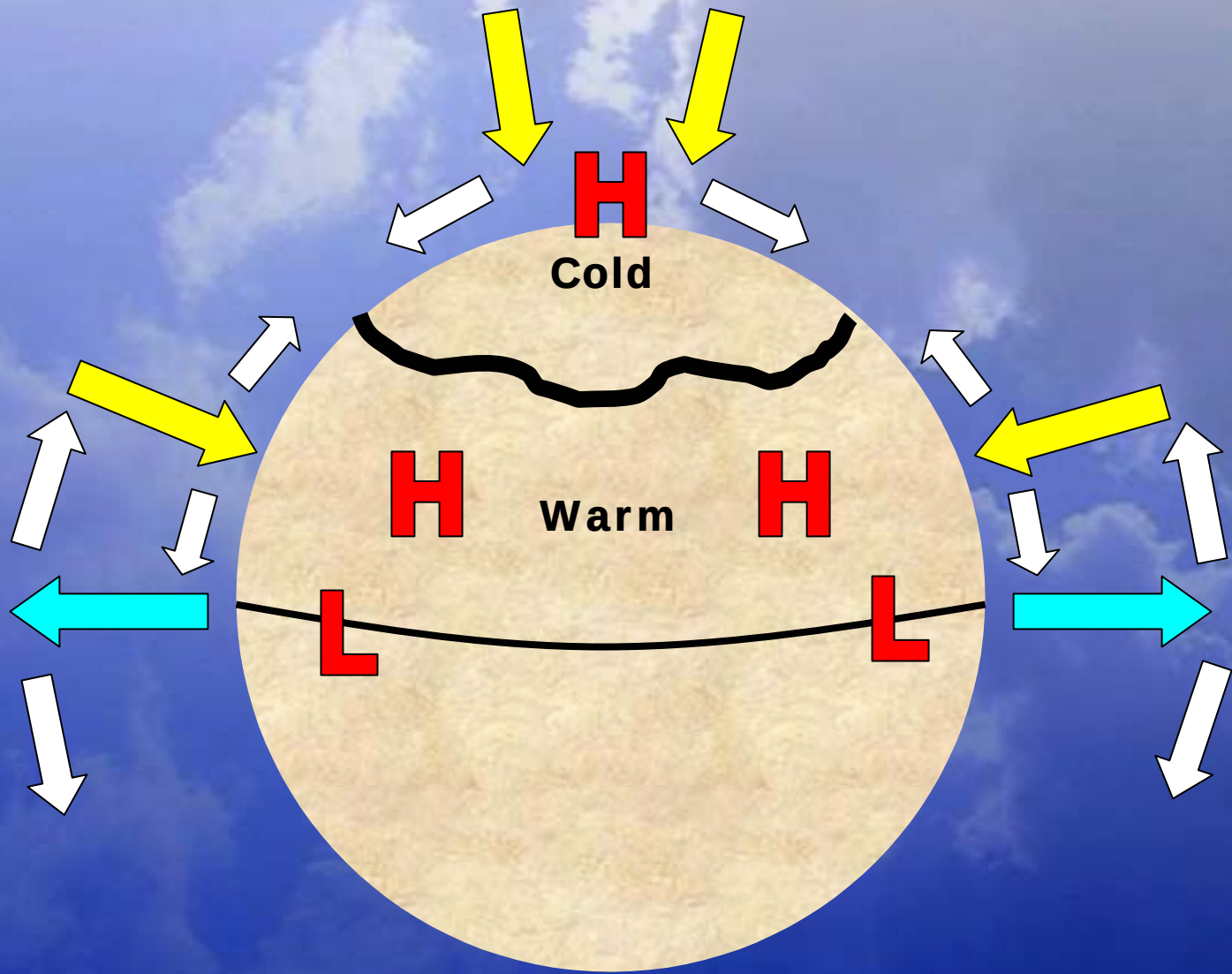

General Circulation

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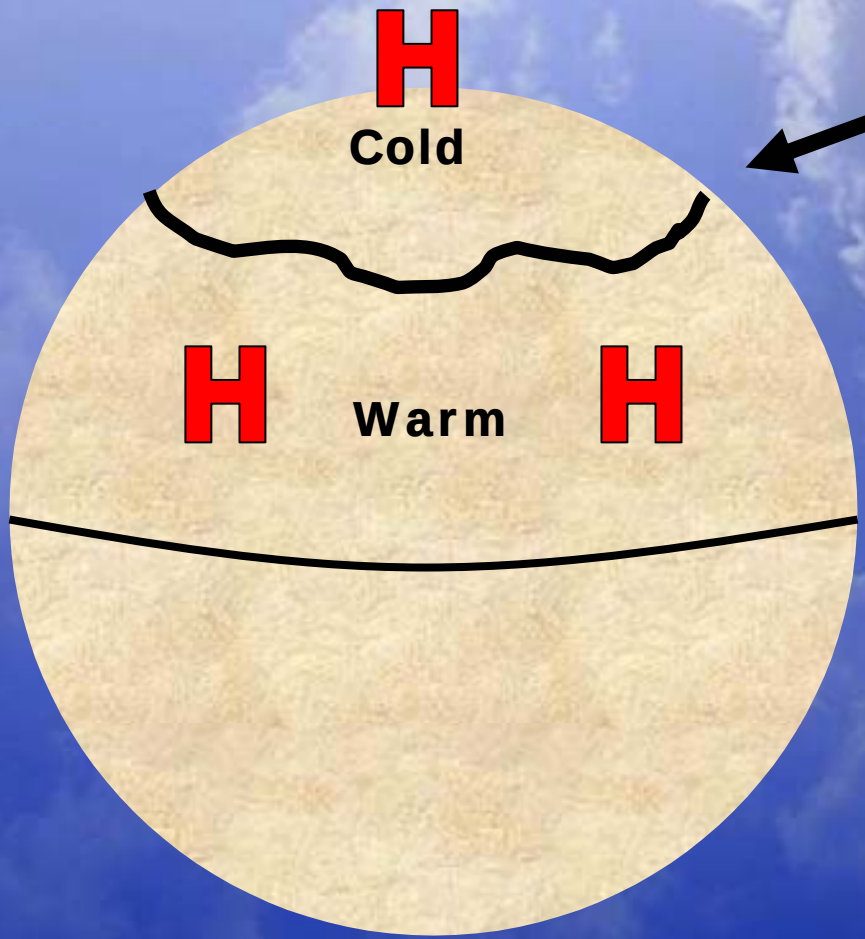

Front = Battleground of Air Masses

- Temperature differences concentrated
- Zone of lower pressure where lows (storms) often form

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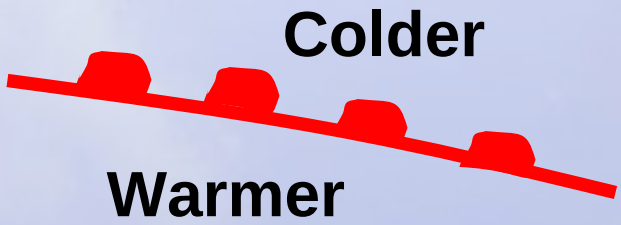
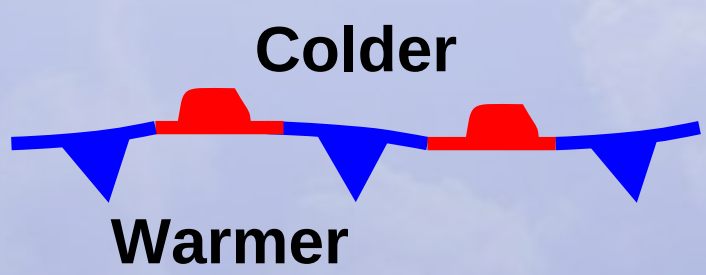
Cold Front

Cold air advances



Warm Front

Warm air advances*



Stationary Front

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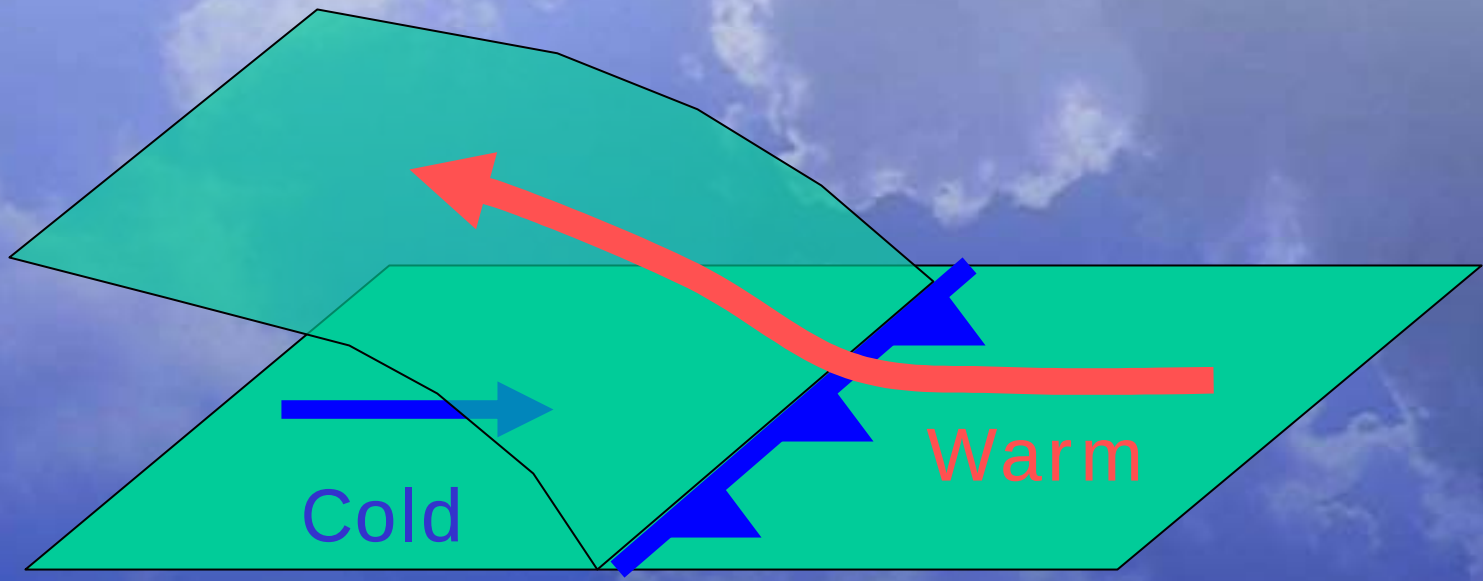
What happens when air masses meet at fronts?



Cold air lifts the warmer air.

Clouds and precipitation form.

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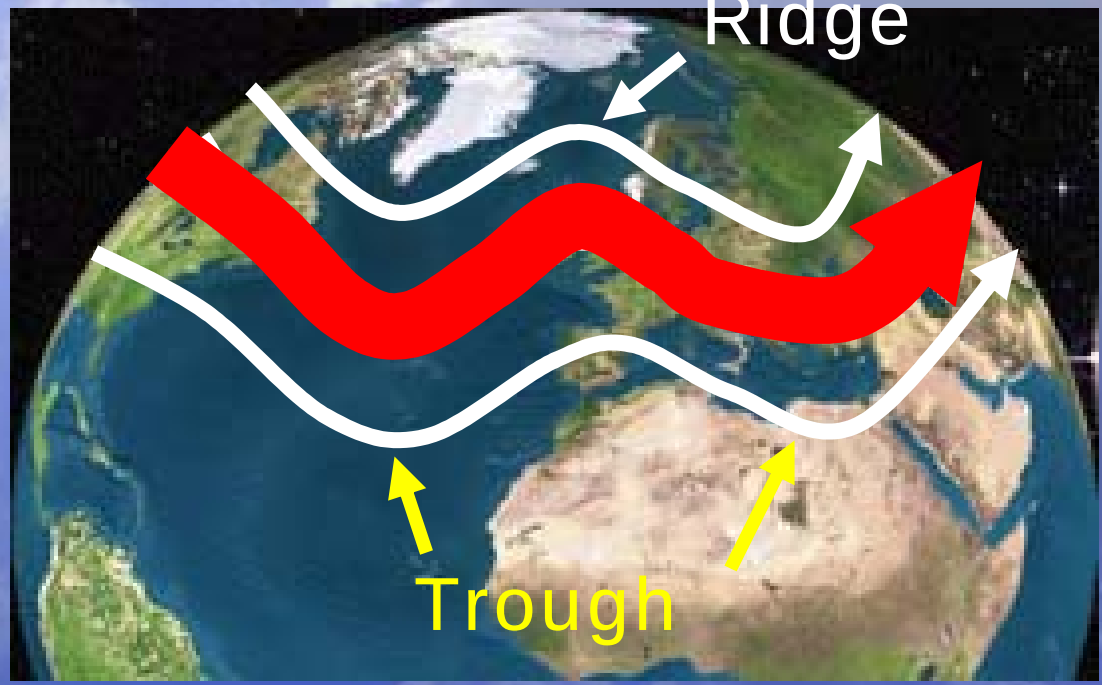
Upper-Level Features



Westerlies - High-Altitude winds blow generally west-to-east 3-6 miles above mid-latitudes.

Jet Stream – River of fastest-moving air within the westerlies.

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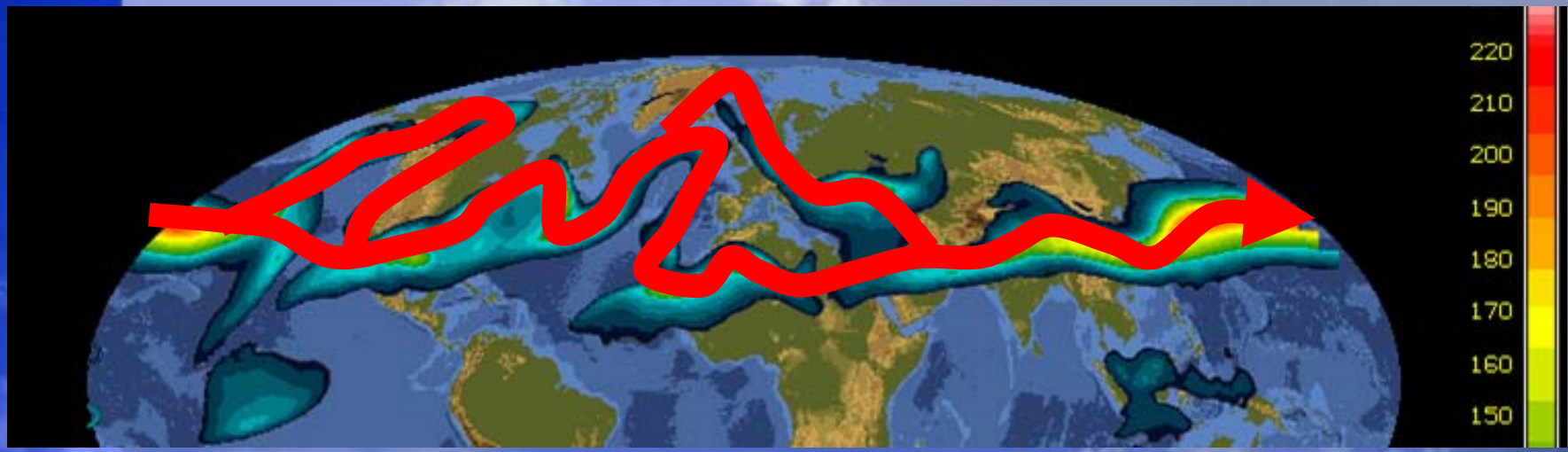

Reality is messier …

Still, highs and Lows move with the westerlies and the jet stream.

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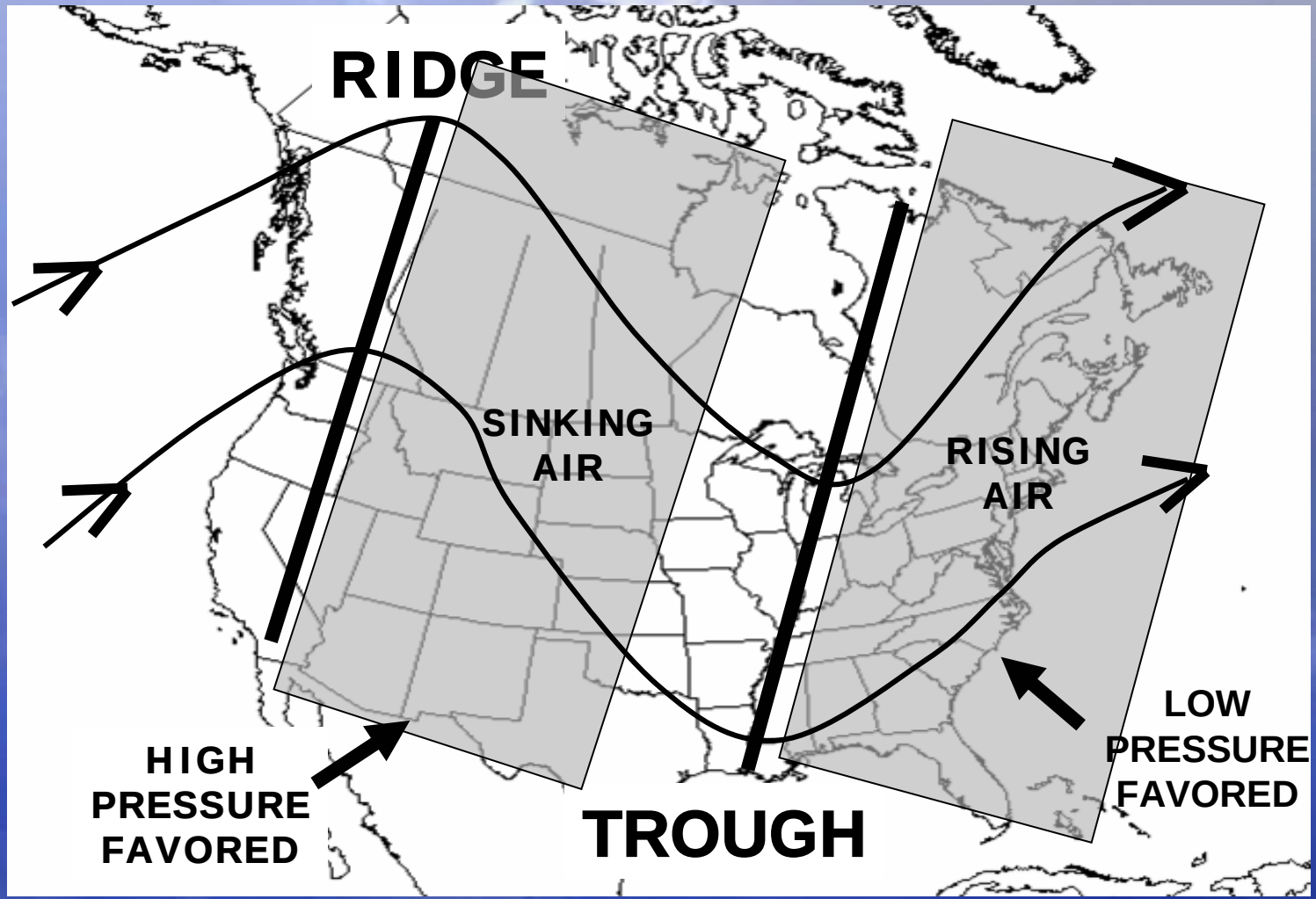

Highs and Lows form and dissipate in synch with ridges and troughs in the westerlies.

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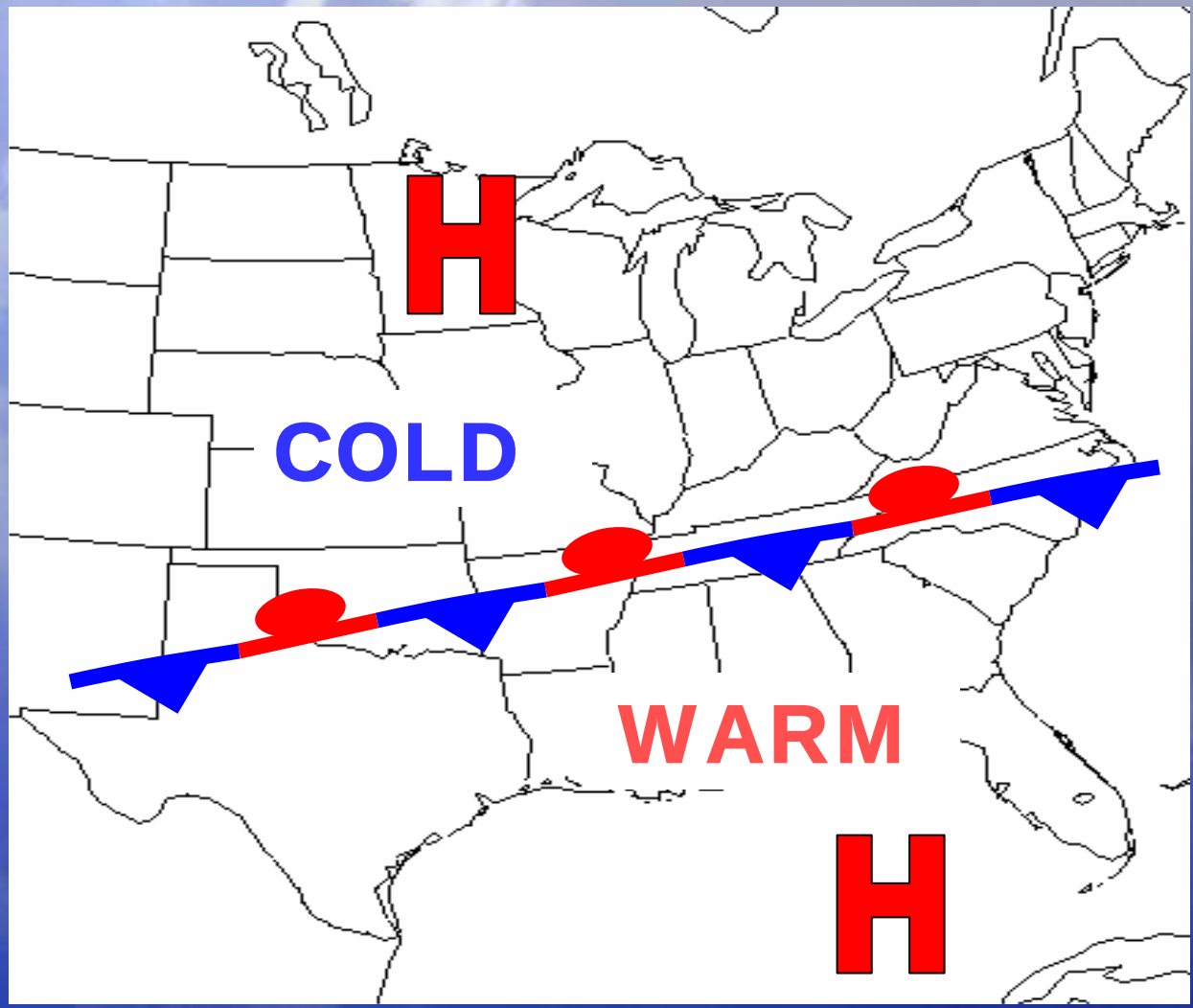
LOW

This is your life!



Stationary Front separates air masses

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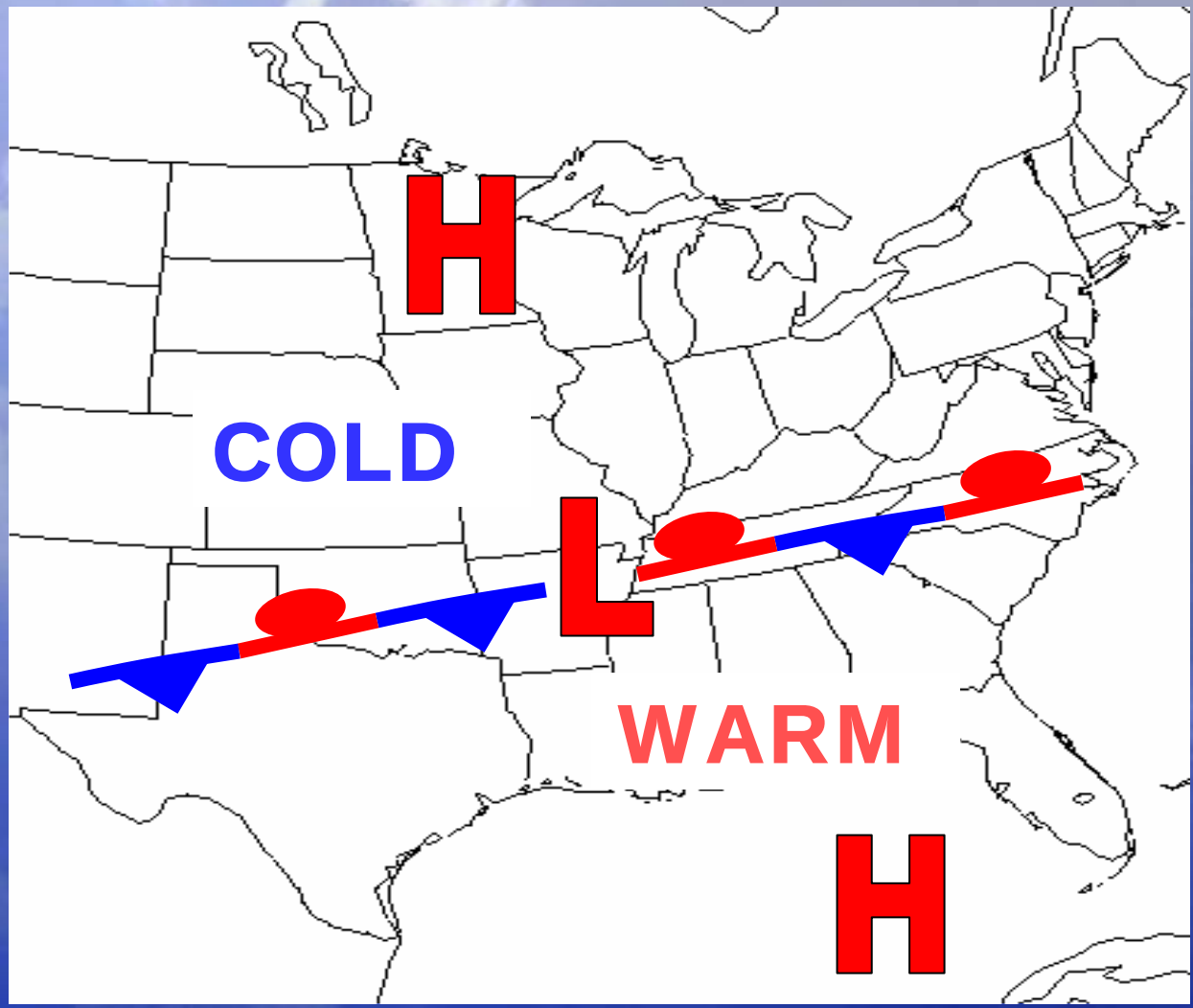
LOW

This is your life!



Area of low pressure develops along front

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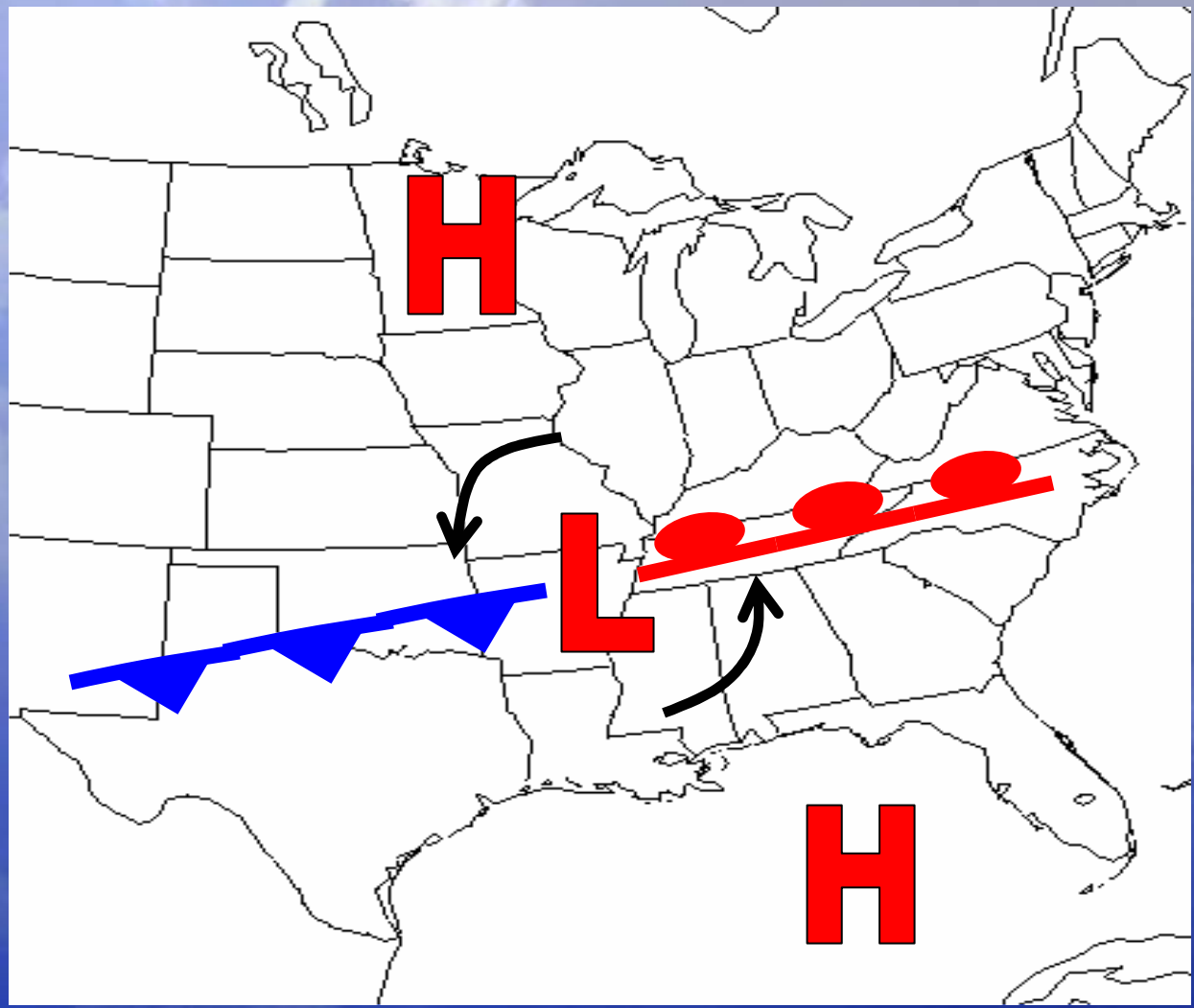
LOW

This is your life!



Circulation around low sends cold air and warm air advancing

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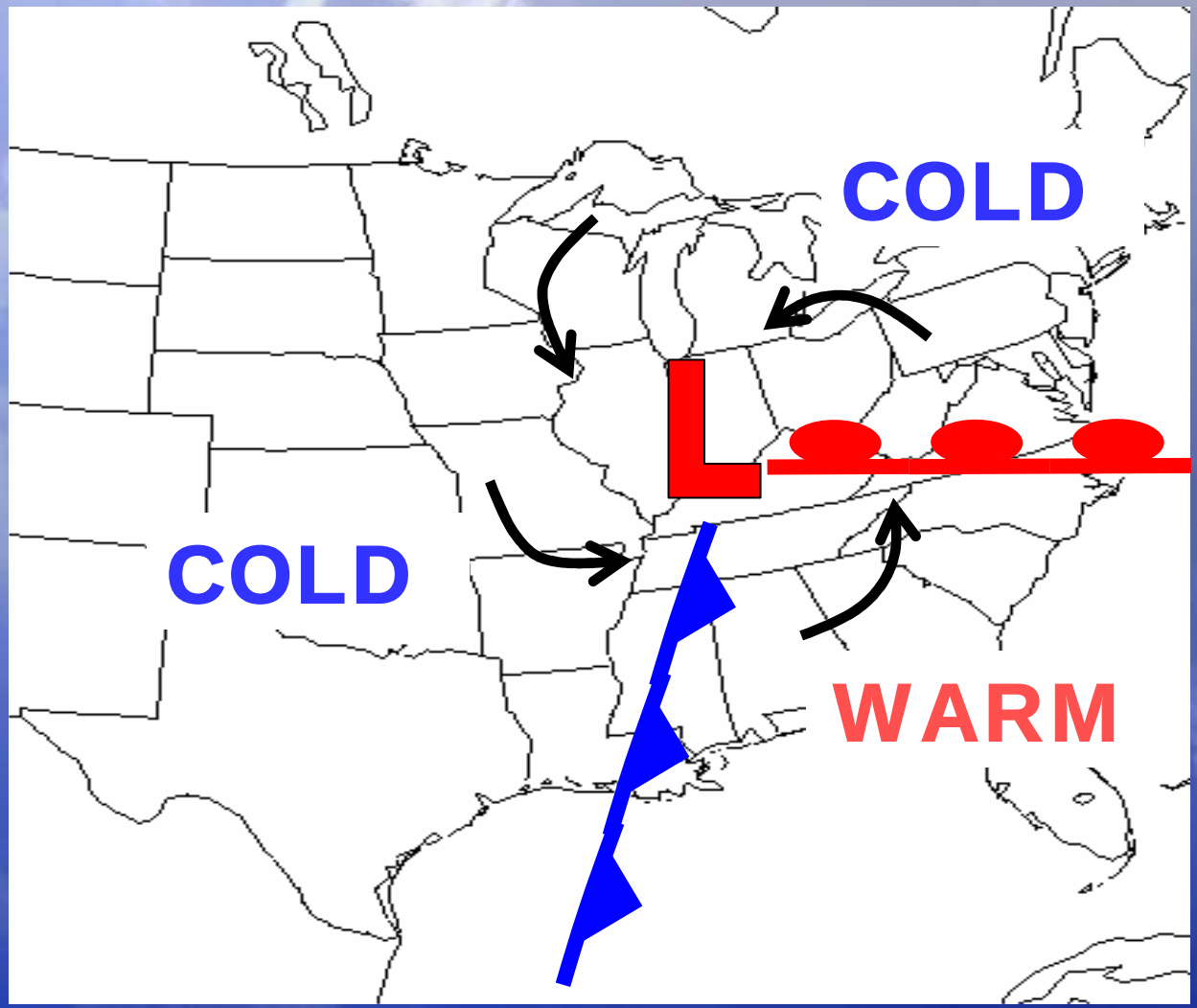
LOW

This is your life!



Low and fronts move with the upper-air westerlies while circulating low-level air

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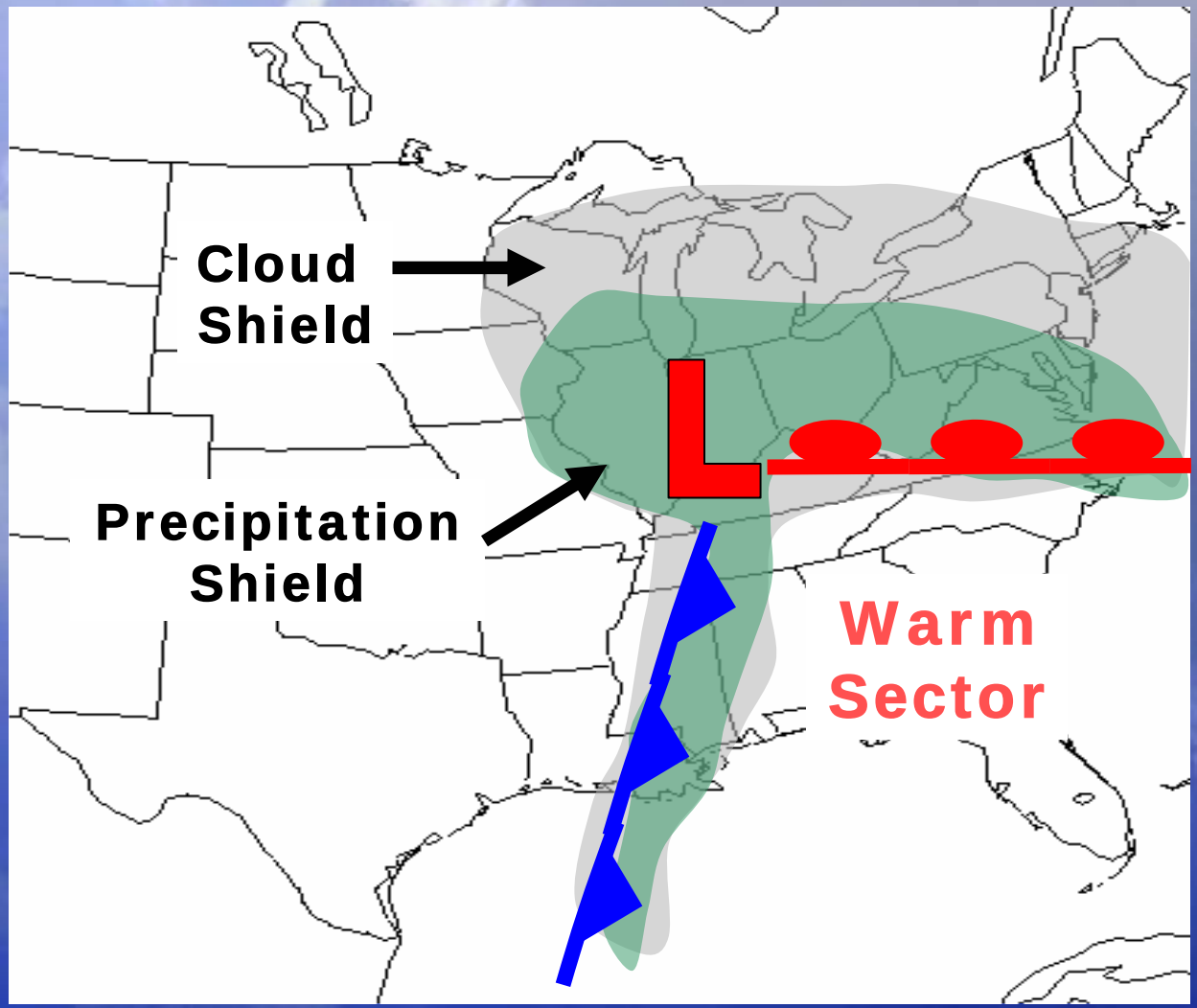
LOW

This is your life!



Typical cloud and precipitation shield of a low-pressure system and fronts

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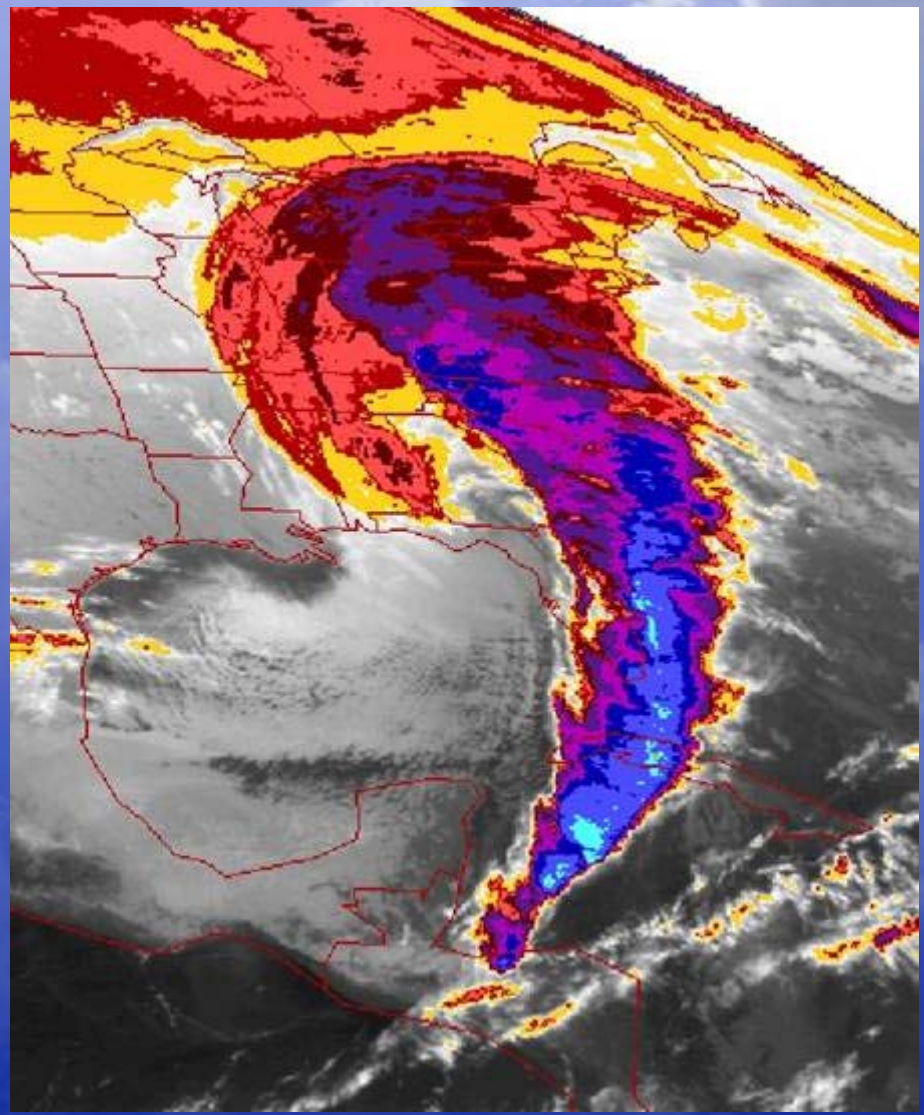

Intense lows often take on a "comma-cloud" shape when viewed from space.

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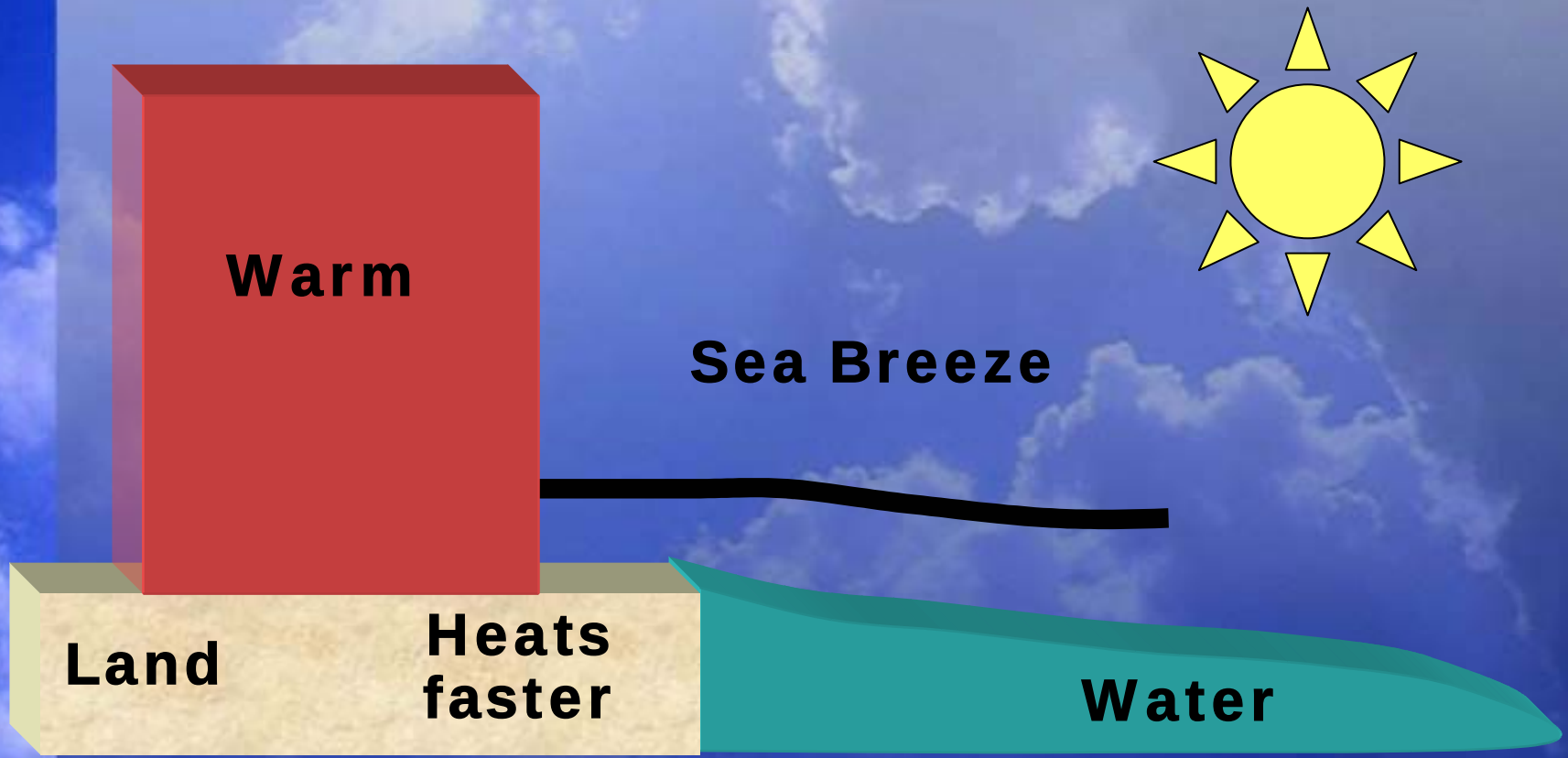
Local Winds



Uneven heating working on a smaller scale

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Another control on vertical motions

Vertical temperature structure of the atmosphere

STABLE

Inhibits Overturning

More likely to overturn

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In the Atmosphere…

- Typically, temperature decreases with altitude, so the lighter stuff (warmer air) is below the heavier stuff (colder air).

- Typically supports some overturning, especially in the boundary layer.

Cumulus clouds

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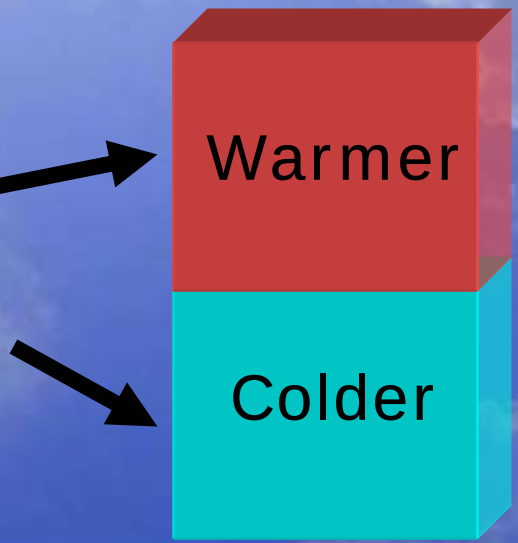
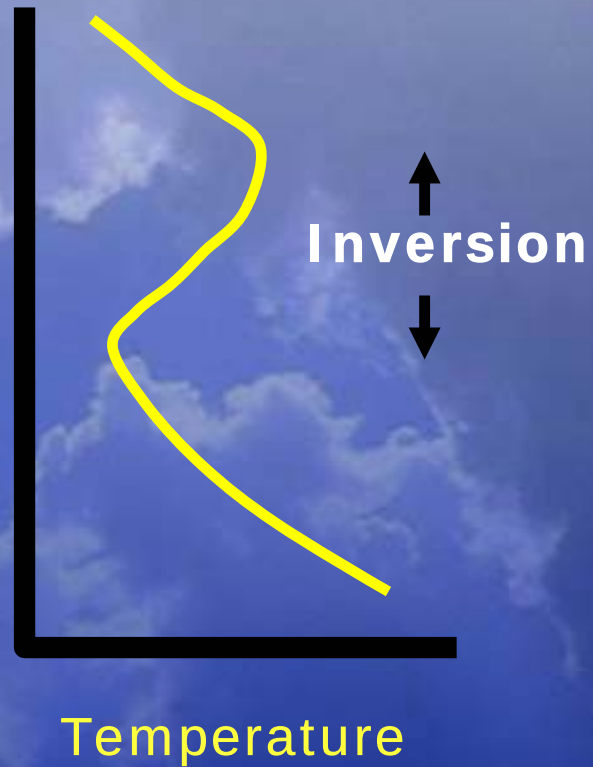
But Sometimes …

Light stuff

Heavy Stuff

"STABLE"





Inversion – A layer of the atmosphere in which temperature increases with height.

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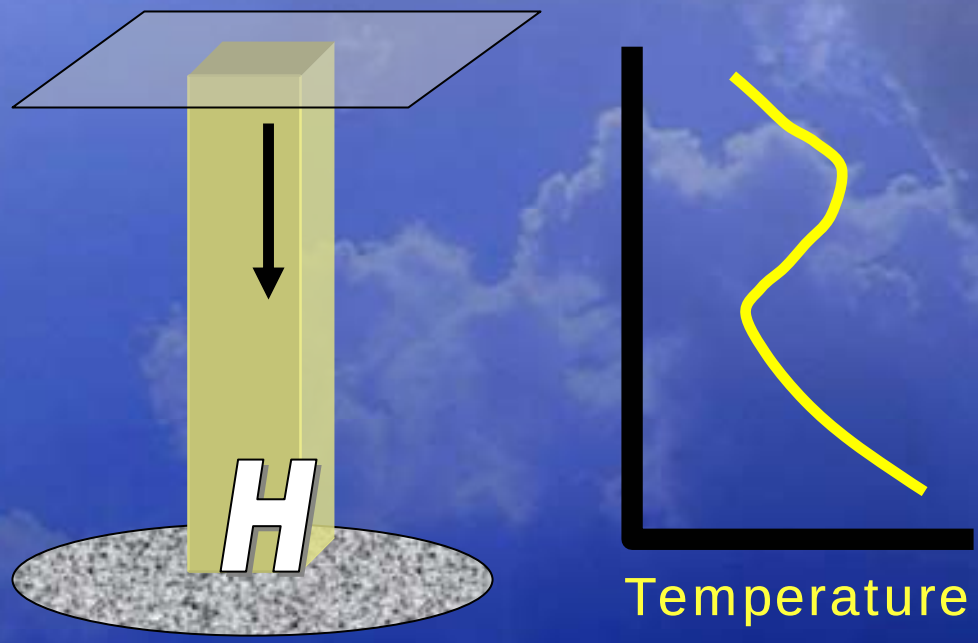
Inversions inhibit vertical mixing.

Can trap pollutants in the lower atmosphere.

Air sinks and warms near high pressure.

Creates an inversion 1000s of feet above the ground.



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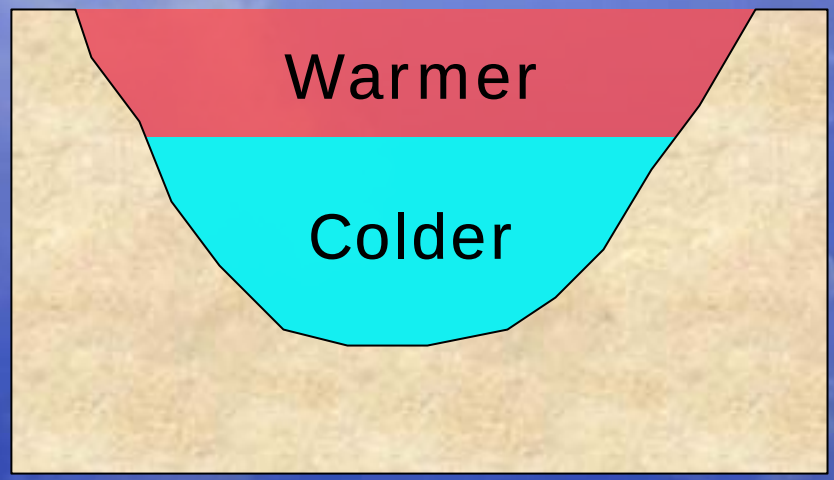

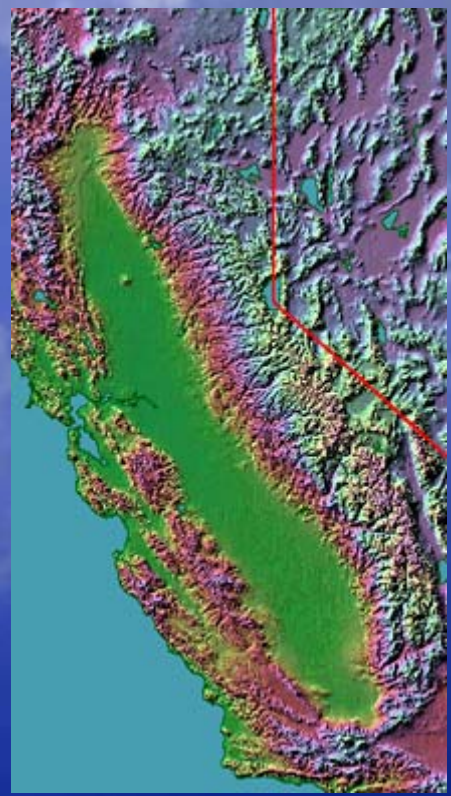

Colder, heavier air trapped in valleys.

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Key Ideas

- Wind and rising air disperse pollutants.
- When air rises, clouds/precipitation can form.
- Clouds reduce sunlight, which slows production of some pollutants; precipitation cleanses the air.
- Air rises, and winds are strongest, in the vicinity of low pressure and fronts.
- Air sinks, and winds tend to be light, in the vicinity of high pressure.

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Weather Forecasting

- **Knowledge** of how atmosphere works (e.g., high and low pressure, fronts, etc)

- **Observations, observations, observations** (surface, upper-air, satellite, radar, etc)

- **Computer guidance** (the “models”)

- **Personal experience** (“I’ve seen that before”)

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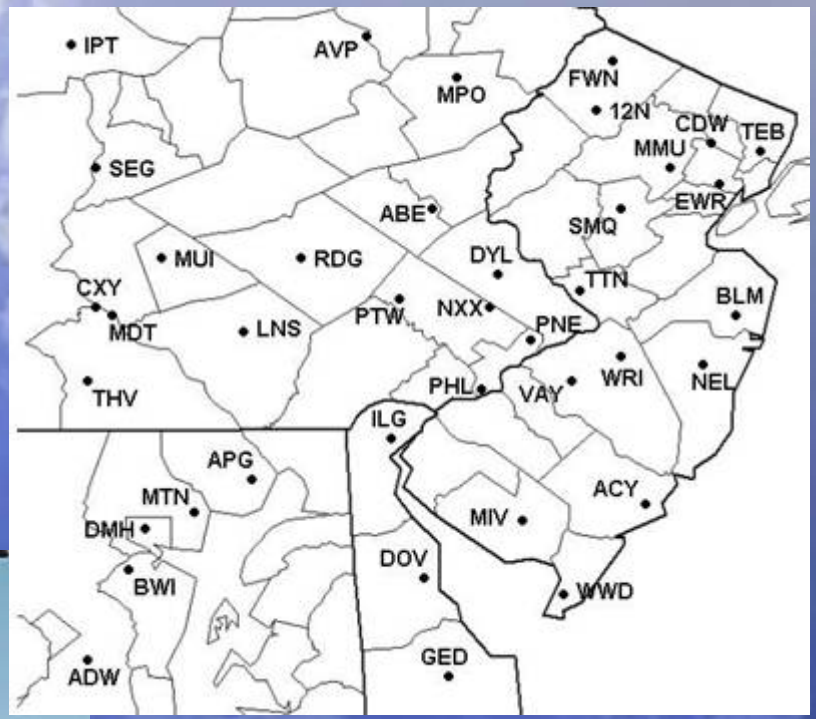

Surface observations

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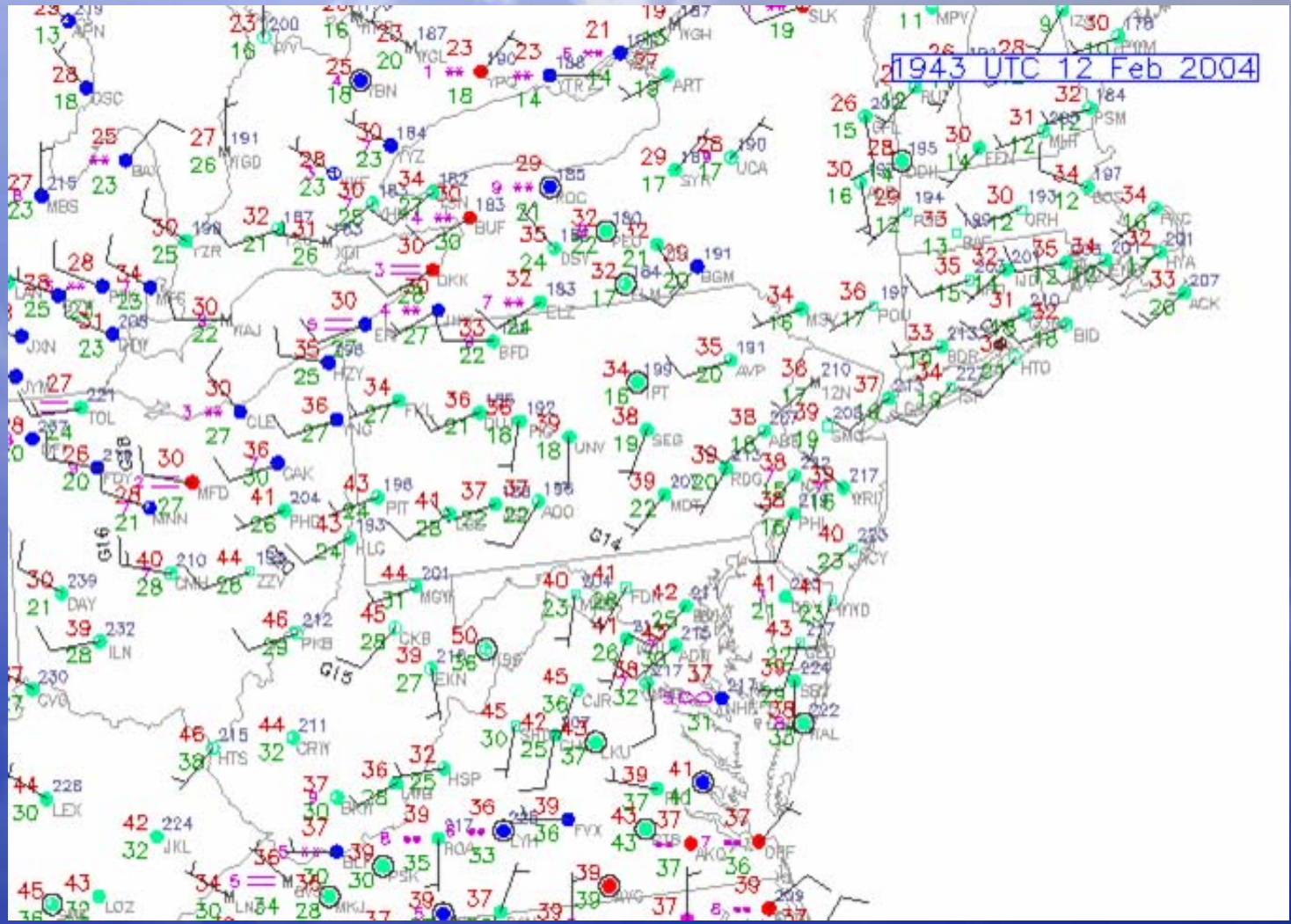

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Sources of Surface Observations

ASOS – Automated Surface Observing System

AWOS – Automated Weather Observing Station

- **ASOS** – Owned and maintained by the NWS
- Federal **AWOS** – Owned and maintained by the FAA
- Non-Federal **AWOS** – Owned and maintained by state, city, and county agencies (incl. DOT), and private airports
- Military bases – manually taken observations
- CoOp observers – NWS volunteer network, manually taken observations

*All are transmitted via FAA data lines to NWS to WSI to TWC.

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Other Sources of Surface Observations

- Private Mesonets – such as AWS (Weatherbug), etc.,
  - Owned and operated by private network
  - Not available for use by other private companies
- Public Mesonets – including RWIS, etc.
  - Owned and operated by government agencies
  - May not be centrally collected
- Academic/Research Mesonets
  - Owned and operated by universities and research institutions
  - May be available for use by private companies

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Upper-air observations

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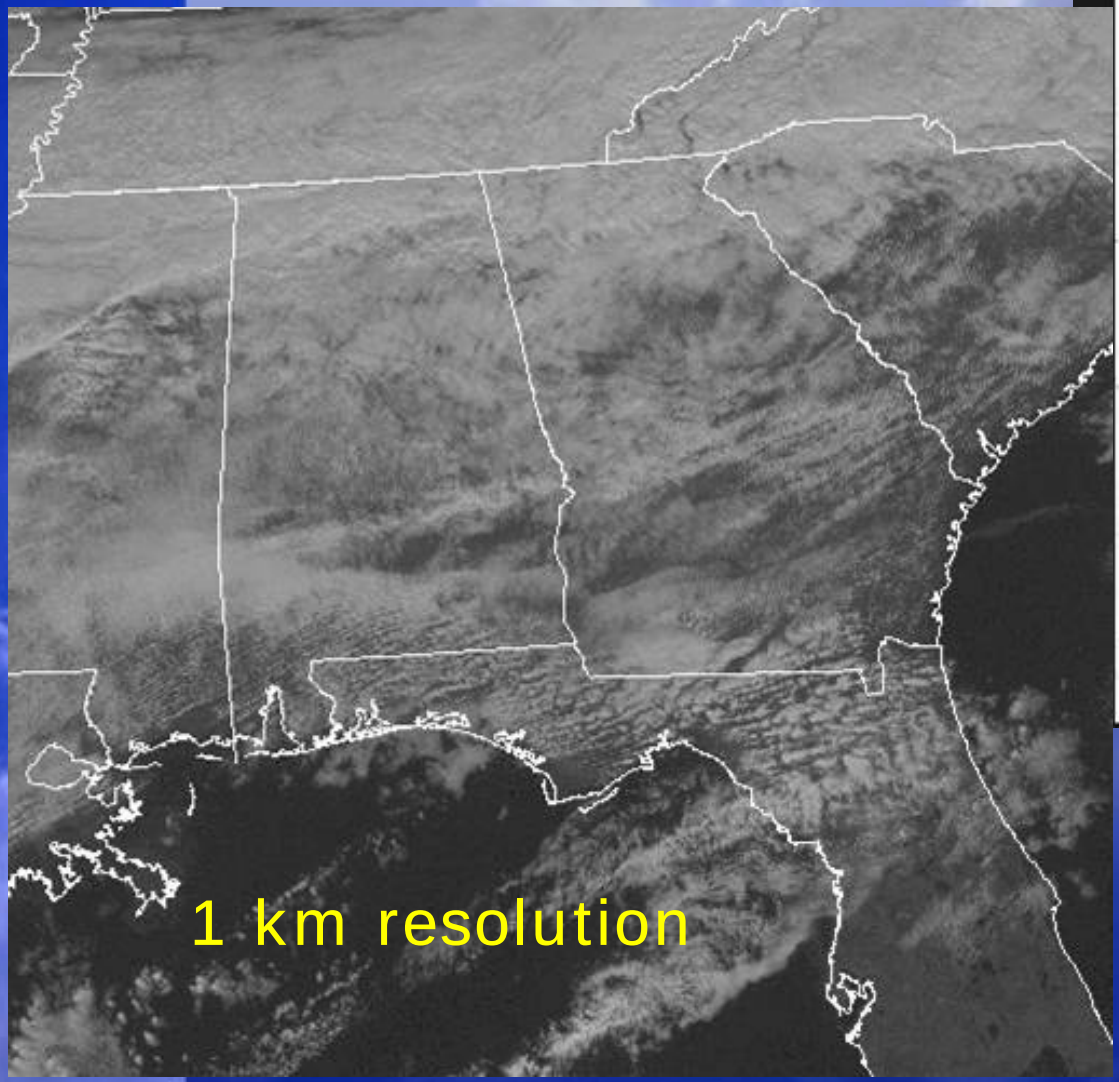

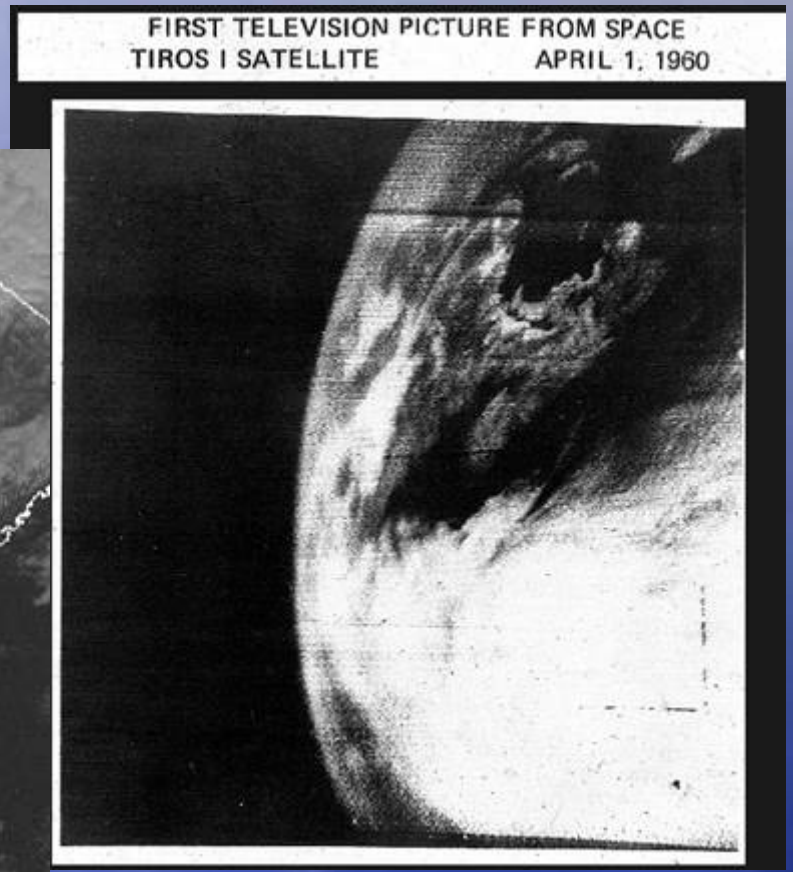

Satellite Imagery

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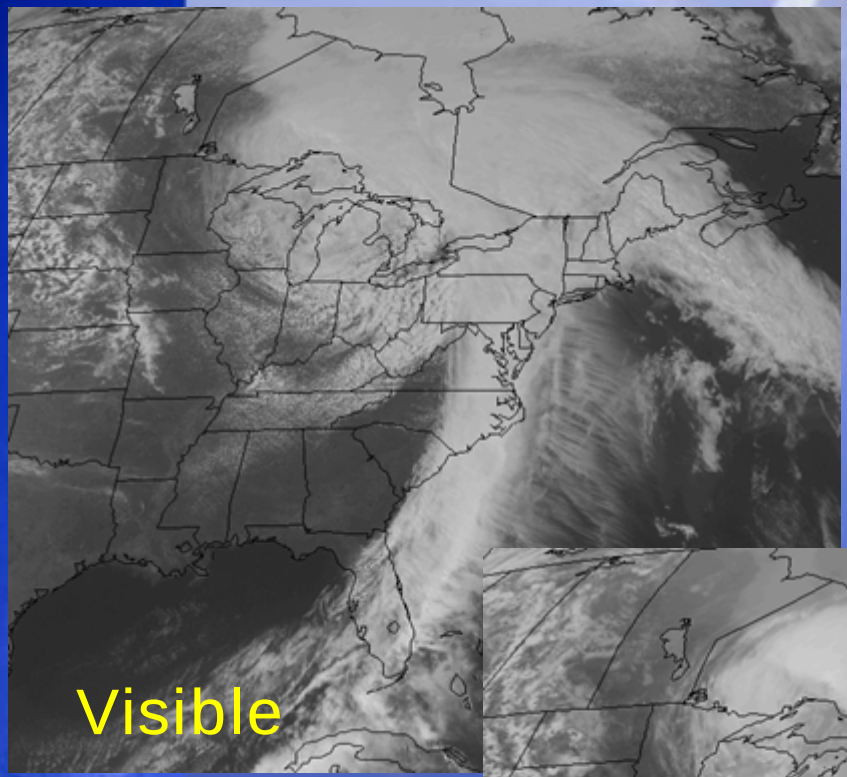

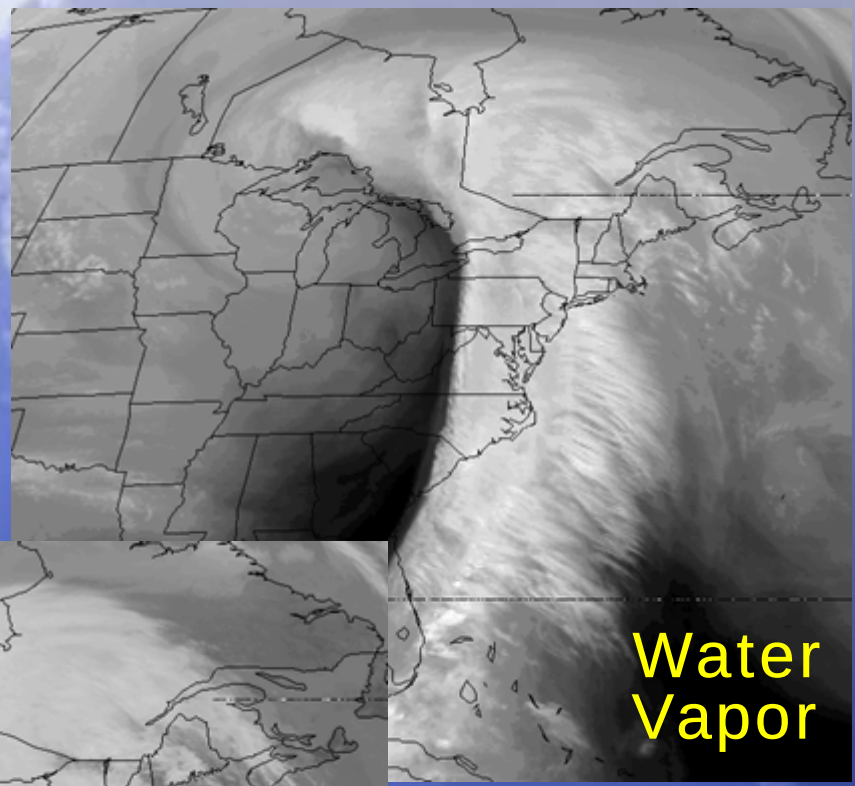

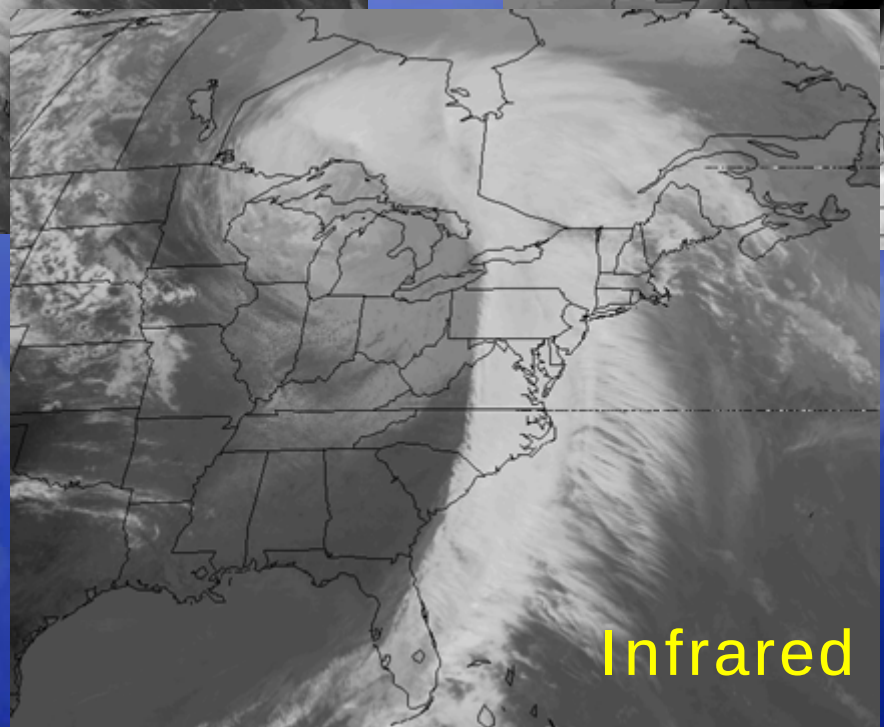

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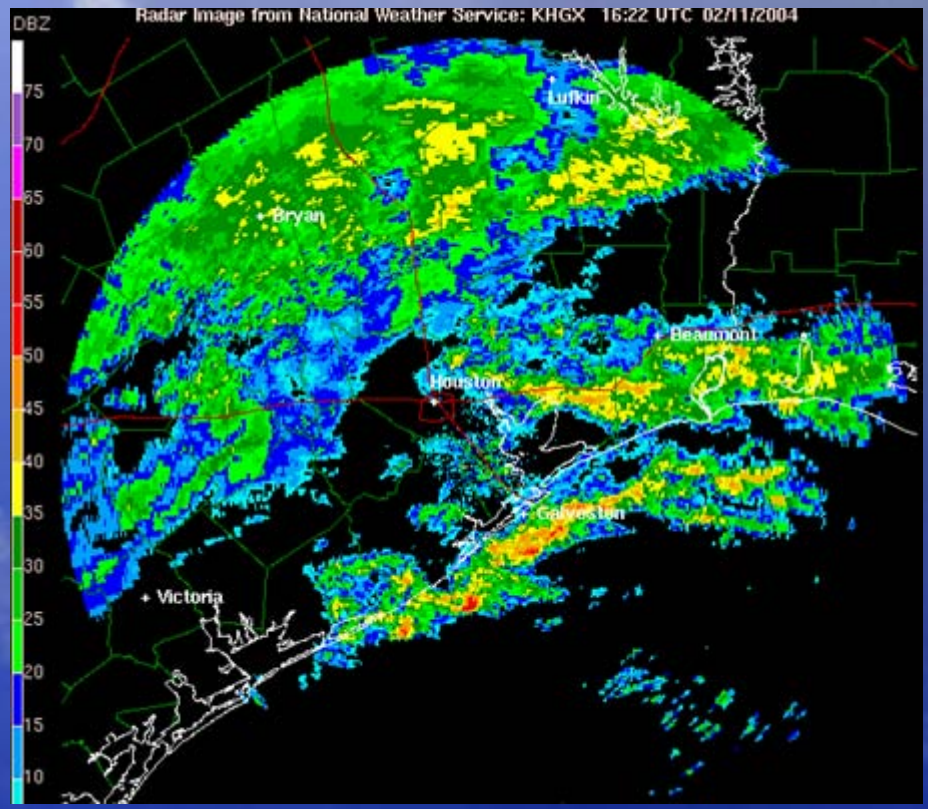
Doppler Radar



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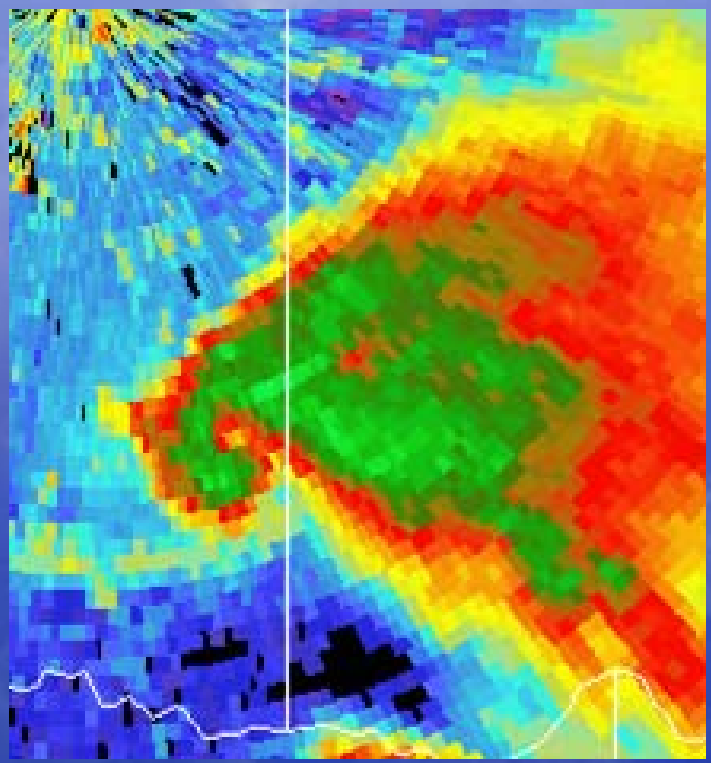
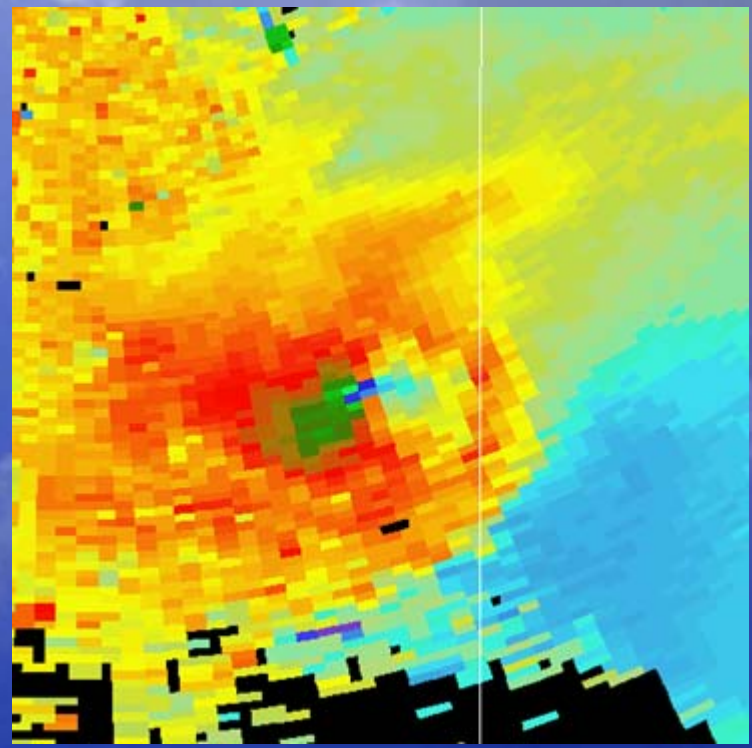
Tornado on Doppler Radar



Reflectivity



Velocity

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Doppler radar network

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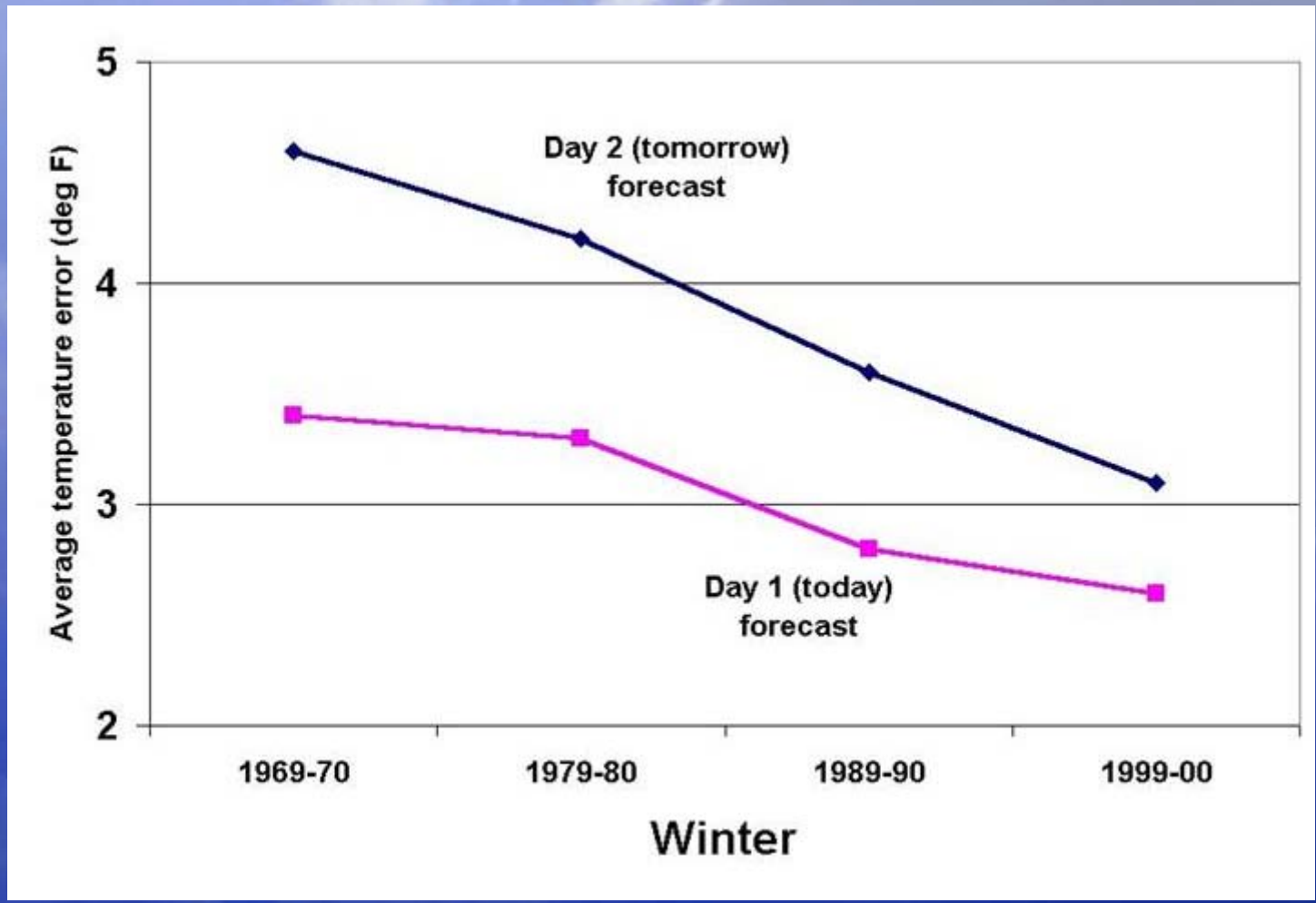

Weather forecasts have improved

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Computer Models: Numerical Weather Prediction

Temp future time = **Temp now** + **Change in Temp between now and future time**

What processes change temperature?

- Sunshine
- Wind Direction
- Evaporation
- Pressure changes
- Etc, etc, etc

Computer is programmed with mathematical representations of these processes.

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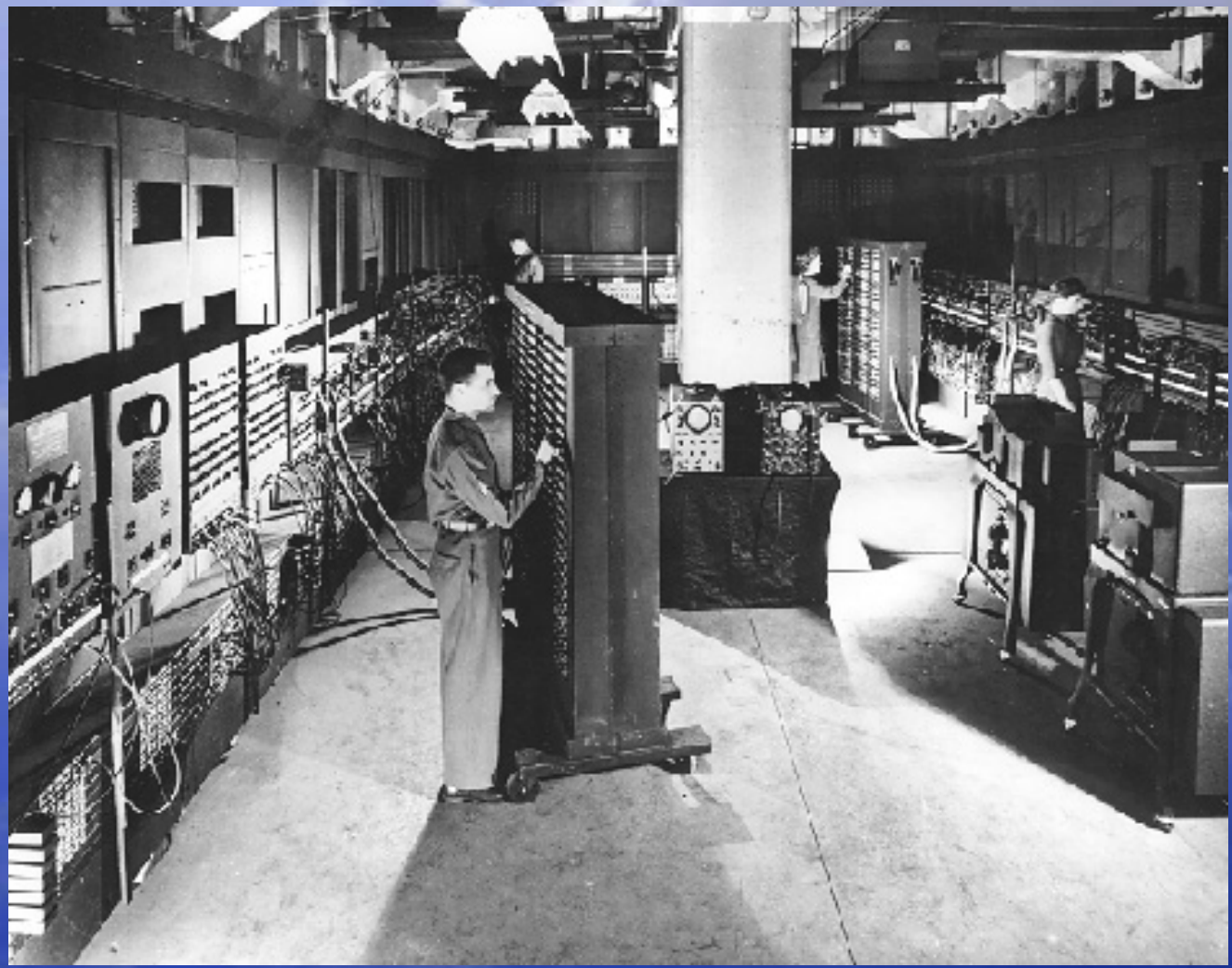

ENIAC - University of Pennsylvania, 1945

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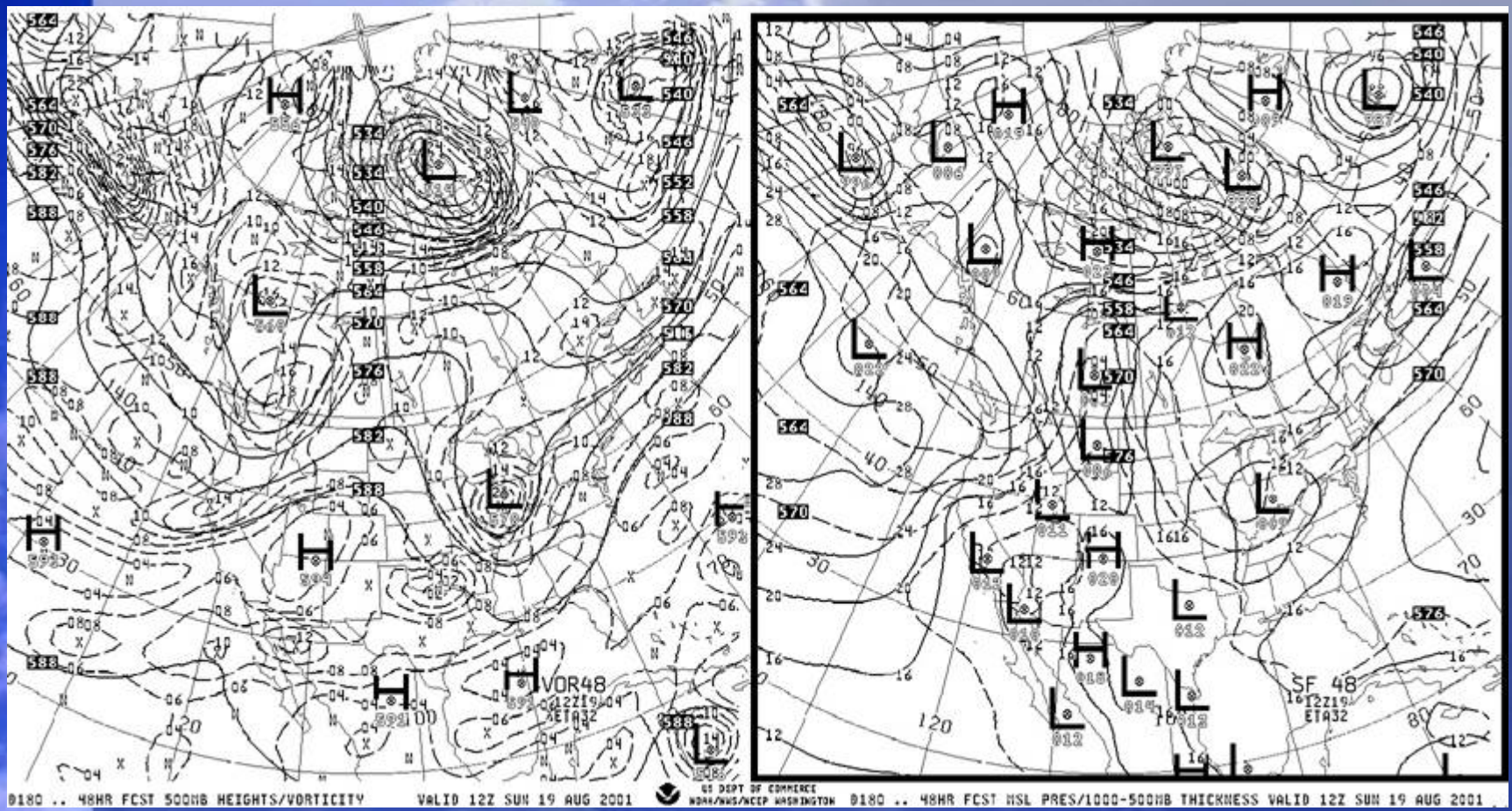

Modern Computer Model Output (map form)

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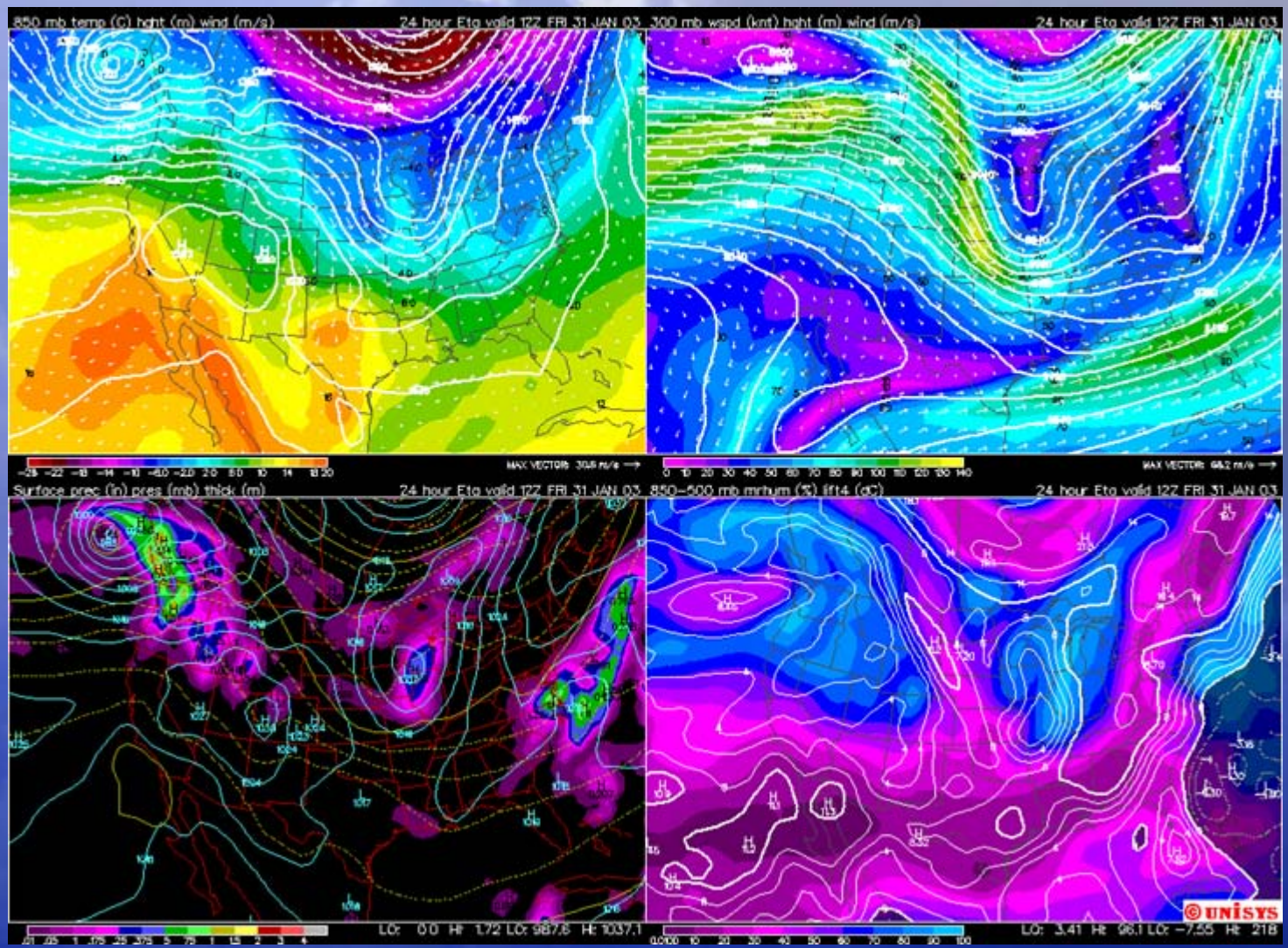

Modern Computer Model Output (map form)

THE WEATHER CHANNEL
weather.com

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```
FOUS62 KWNO 171200
OUTPUT FROM ETA 12Z FEB 17 04

TTPTTR1R2R3 VVVLI PSDDFF HHT1T3T5 TTPTTR1R2R3 VVVLI PSDDFF HHT1T3T5
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06000527423 01319 331007 34019596 06007938417 02008 310314 41030000
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18000885821 -0814 280212 32009696 18001968328 -6009 253518 39020000
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30000562608 -3115 243414 30039794 30000784707 -1612 233521 32029796
36000552244 -1619 233316 35019795 36000602016 -2418 223314 35049895
42000644246 -1316 192811 38000098 42000602335 00618 203113 40029999
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Modern Computer Model Output (tabular form)

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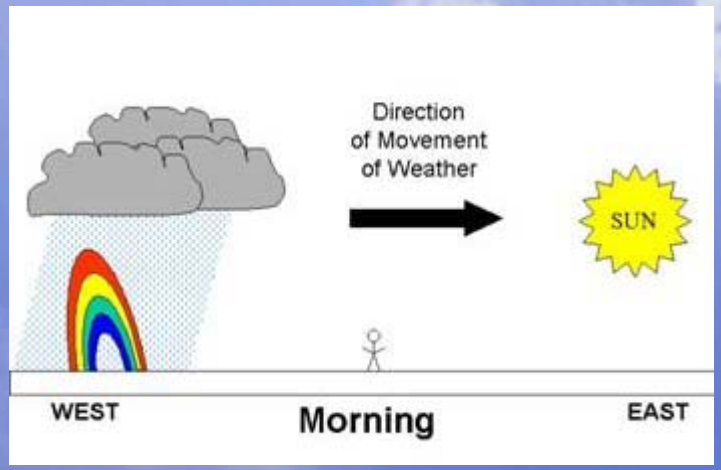

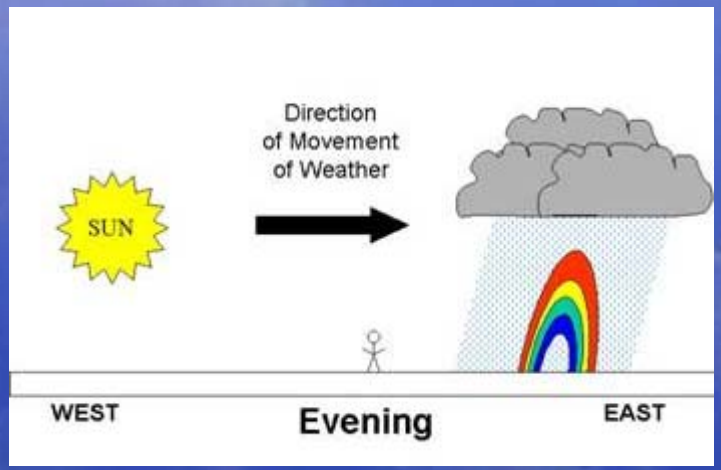

Some “folklores” are useful

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(Some) Fundamentals of Weather

Jon Nese and Jen Carfagno
The Weather Channel
February 22, 2004

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TWC Mission

Making a difference in people's lives, one forecast at a time.

- What **value** can we add (eg, experts).
- Communication of **uncertainty** - the atmosphere is a very complicated system (hurricanes, March 2001 snowstorm)
- **Educate** the public

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Operations Overview

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THE WEATHER CHANNEL
weather.com