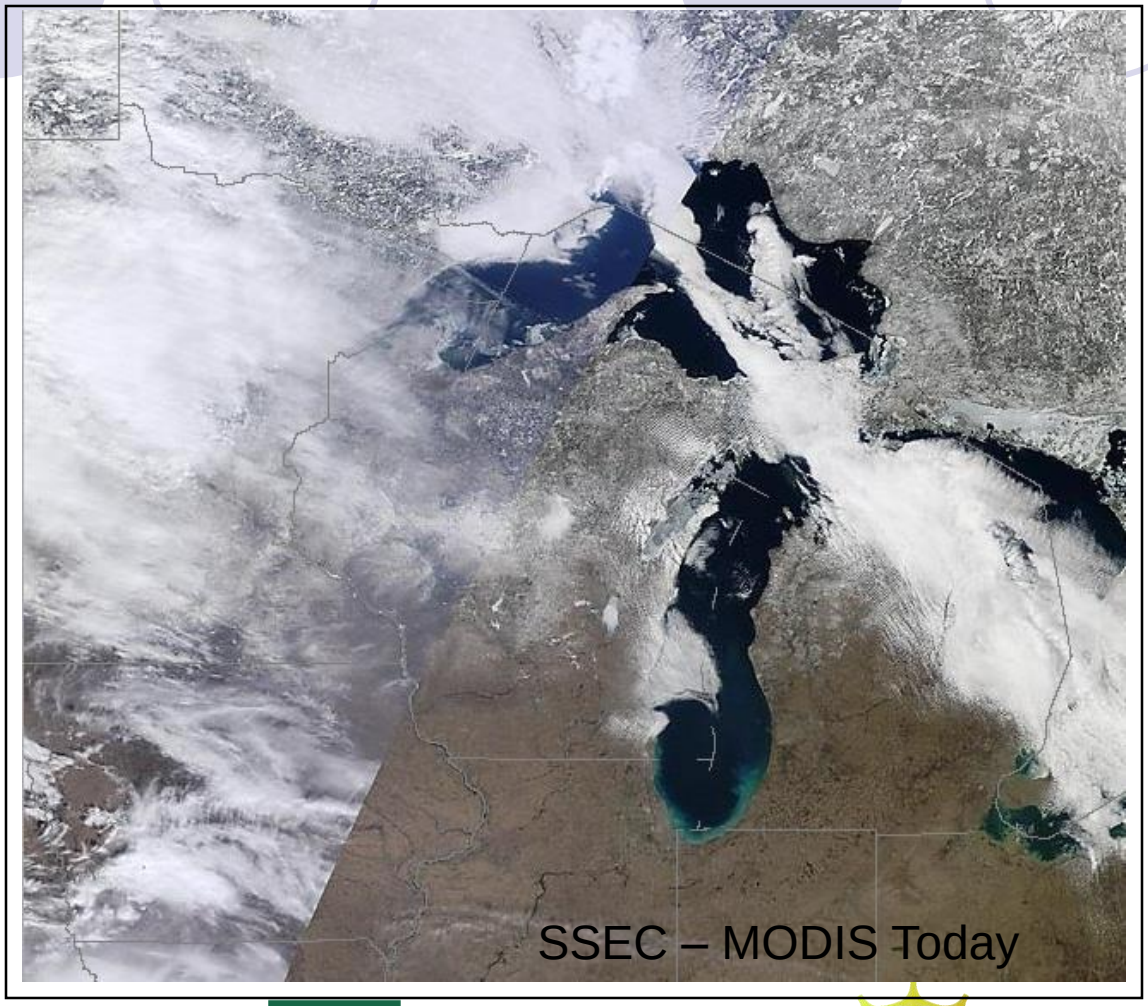
Satellites, Weather and Climate Module 2b:

Cloud identification & classification



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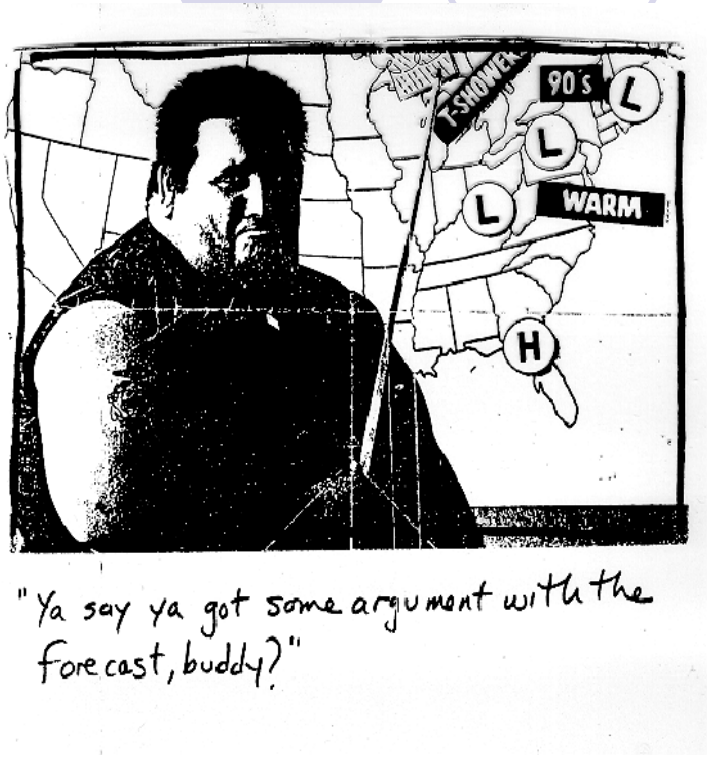
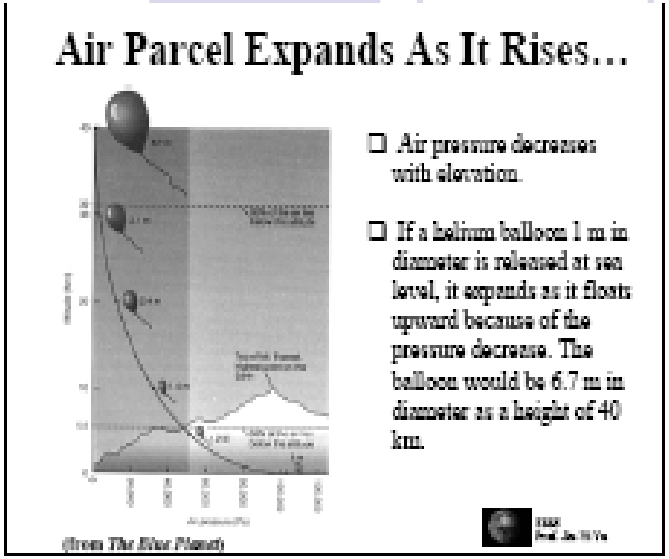
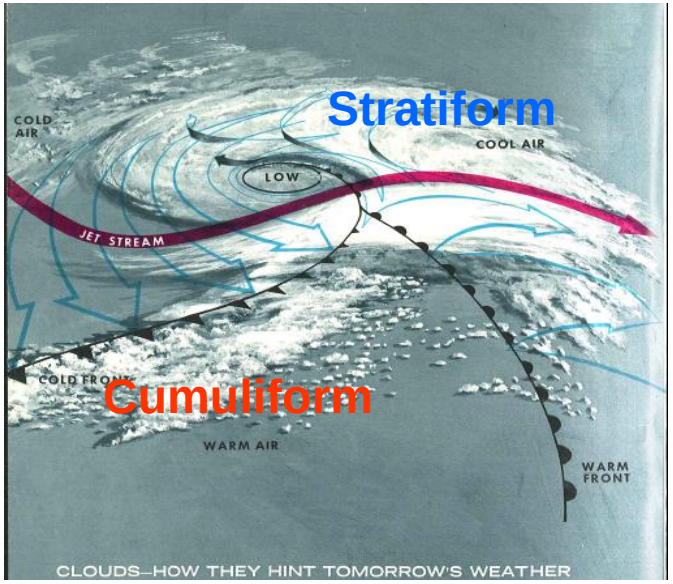
Our Cloud Watching and Identification Goals



- describe cloud classification system used by meteorologists
- relate this classification to cloud formation processes
- real-time cloud watching exercise
- review the importance of cloud study

Cloud formation - review





- recall -- rising air cools followed by condensation and cloud formation
- stable or layered clouds generally form ahead of a warm front and low pressure system
- convective clouds form ahead of the cold front and in warm air

Cloud classification - Introduction

- First formally accepted cloud classification system developed by Luke Howard 1802-1803

- This system is used today, although it has been expanded and modified through the years
- Cloud classification is agreed upon and under the auspices of the UN World Meteorological Organization (WMO)

- Understanding that multiple cloud types and formation processes do overlap (i.e. stratocumulus)
- Meteorologists or climatologists in one country are able to understand cloud observations from another country (International)

Cloud classification is based on…

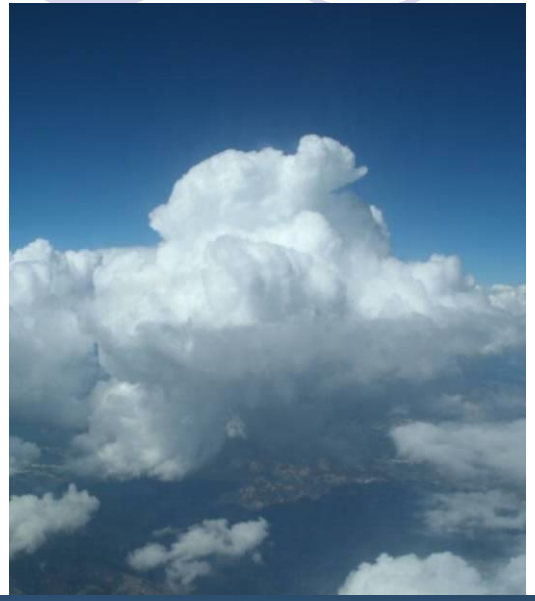
Cloud appearance, physical processes and height above ground

- ***appearance and physical formation process*** :
  - Flat layers, sheets or stratiform clouds
  - Heaps or billowy clouds (cumuloform)
  - Fibrous or wispy (cirroform)

- ***height***
  - Processes may occur at all altitudes (i.e. stratus, altostratus or cirrostratus)

- Processes may overlap
  - ***For example…stratocumulus*** involve layering of billowy clouds

Cloud characteristics

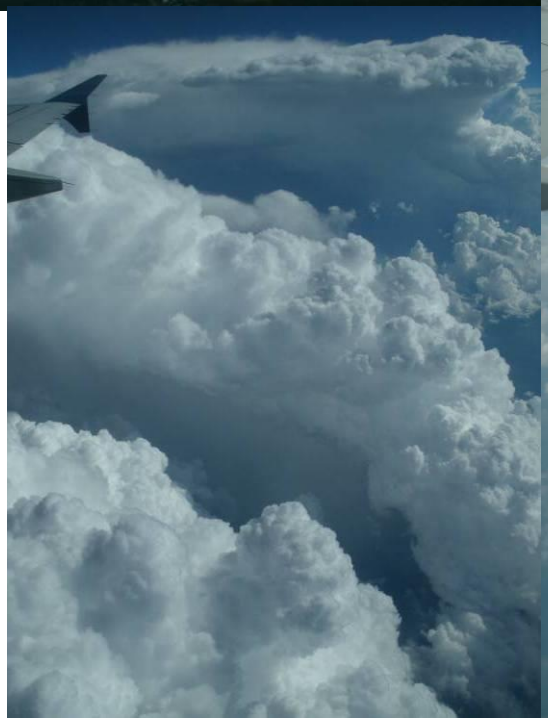


- shape
  - air motion
- texture
  - cloud composition (ice crystals / water drops)
- brightness
  - number & size of water droplets/ ice crystals
  - relative position of sun, cloud, observer

Photos: L.-A. Dupigny-Giroux

Clouds

- appearance
  - cirro = ice
  - strat = layer (Roman)
  - cumu = heap/puffy
  - nimbus = rain
- altitude
  - high
  - middle (alt)
  - low (stratiform)
  - vertical development
    - Cumulus (Cu)
    - Cumulonimbus (Cb)

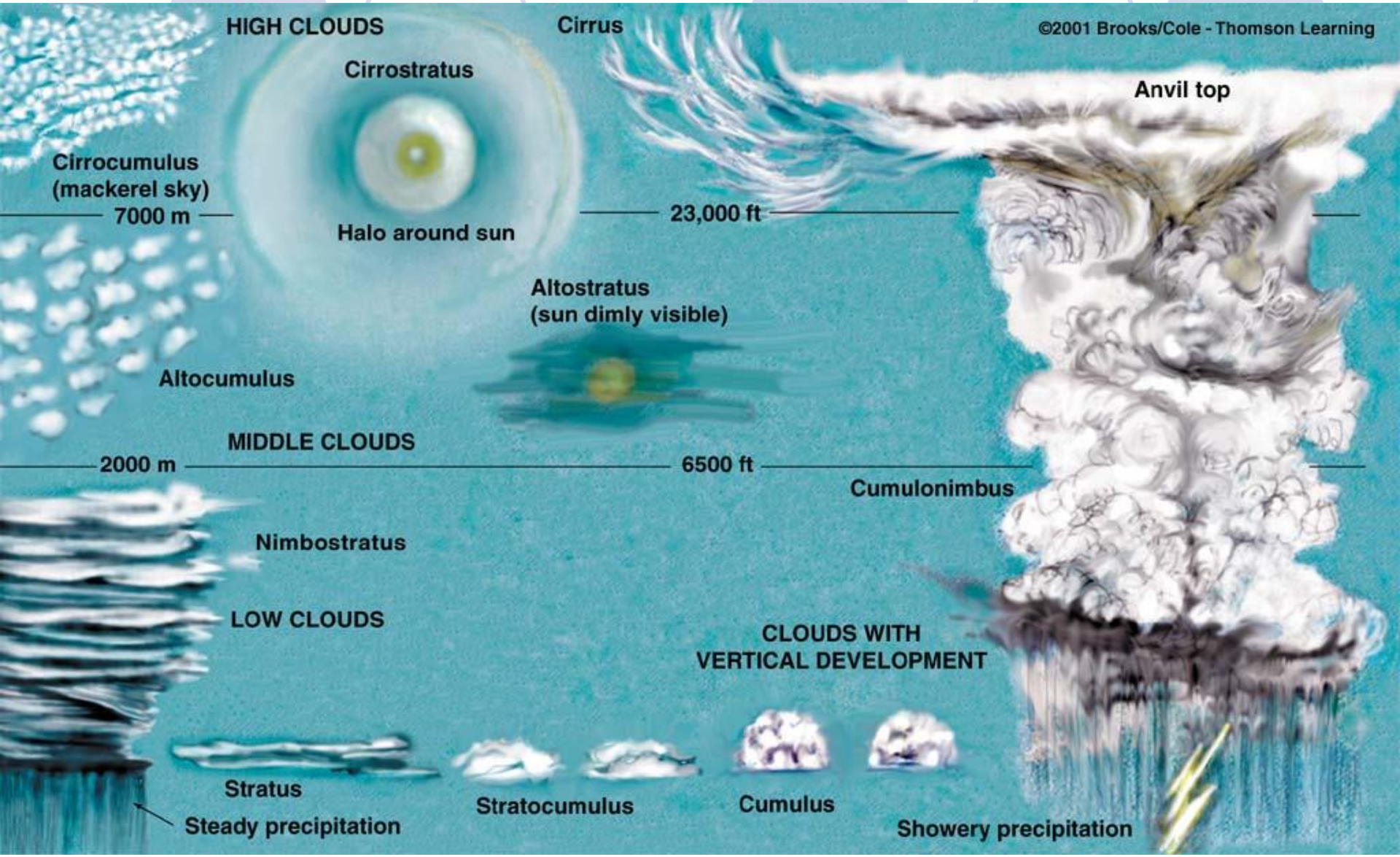


Photos: L-A. Dupigny-Giroux

Latin derivation of cloud classification

Latin Root	***Translation***	***Example***
Cirrus	**Curl of hair**	**Cirrus, Cirrostratus**
Stratus	**Layer, stratified**	**Altostratus, Stratus**
Cumulus	**Heap, accumulate**	**Fair weather cumulus**
Nimbus	**Rain**	**Cumulonimbus, Nimbostratus**

The prefix – Alto - is latin for High…so think of altostratus as higher stratus clouds…in meteorology the term "alto" is applied to middle level clouds.


HIGH CLOUDS
Cirrus
©2001 Brooks/Cole - Thomson Learning
Cirrostratus
Anvil top
Cirrocumulus
(mackerel sky)
7000 m
23,000 ft
Halo around sun
Altostratus
(sun dimly visible)
Altocumulus
MIDDLE CLOUDS
2000 m
6500 ft
Cumulonimbus
Nimbostratus
LOW CLOUDS
CLOUDS WITH
VERTICAL DEVELOPMENT
Stratus
Steady precipitation
Stratocumulus
Cumulus
Showery precipitation

Cloud Identification

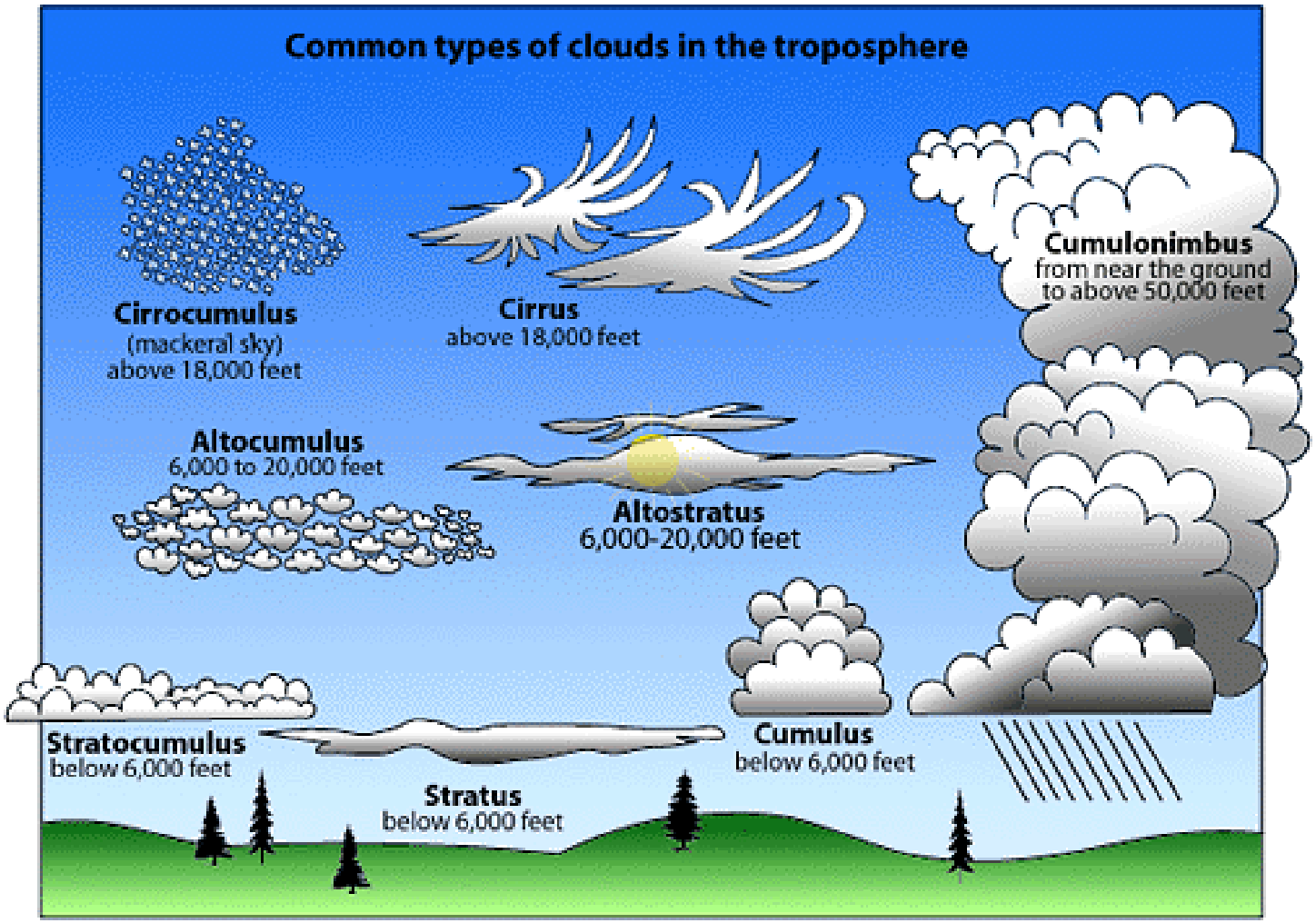
Family	***Cloud Type or Genera***			***Cloud base height***
High Cloud family	**Cirrus**	**Cirrostratus**	**Cirrocumulus**	**> 18,000 ft (> 5487 m)**
Mid cloud family		**Altostratus**	**Altocumulus**	**6500 - 18,000 ft (1981- 5487 m)**
Low cloud family	**Stratus**	***Nimbostratus***	**Stratocumulus**	**< 6500 ft (< 1981 m)**
Clouds Vertically developed	**Cumulus**	***Cumulonimbus*** (*thunderstorms*) **tops >50,000 ft (15244 m)**		**< 6500 ft (< 1981 m)**

1 meter = 3.28 ft

Visual relationship of cloud height (family) and formation process and appearance (types)

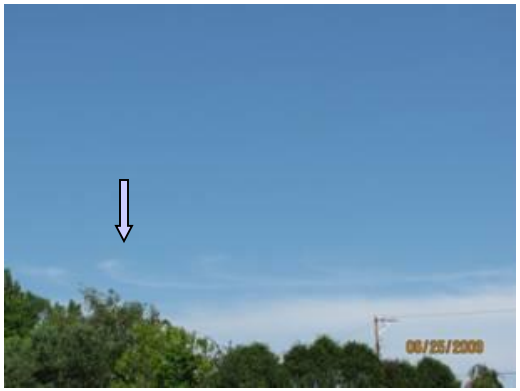
Ice Crystals

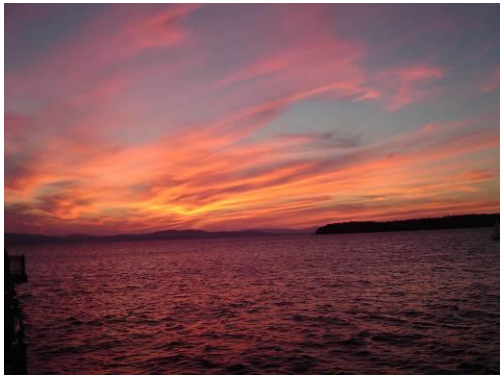
Liquid water



High cloud family

Cirrus (Ci) or High Ice Clouds





- composed of ice crystals
- delicate fibrous or wispy cloud
- generally in detached bands or lines and may form hooks or mares' tails in middle photo
- normally very thin although appear thickest toward horizon
- normally white although yellow, orange and red at sunset/sunrise

Cirrus debris from decaying cumulonimbus cloud

- sometimes referred to as false cirrus when Cumulonimbus (Cb) tops become glaciated with ice crystals
- this type of cirrus is much more dense then usual cirrus clouds
- blow-off cirrus from dissipating Cb which developed over Adirondacks and moved across northern Lake Champlain

Cirrostratus (Cs) clouds

- composed of ice crystals which frequently refracts sunlight and causes halo (middle photo).
- it's the only cloud that results in halo (extensive coverage and all ice)
- milky white veil of cloud usually occurs with cirrus
- thickens and lowers into Altostratus if associated with advancing low pressure or warm front heralding weather change

Cirrostratus

Photo: L-A. Dupigny-Giroux

Cirrocumulus (Cc) Clouds

- least frequently observed of the cirrus family. Usually occurs with other cirrus clouds
- delicate with no shadow effect within cloud
- generally noted in patches and usually as globular, waves or ripples
- top photo small delicate globular structure (left center)
- bottom photo clouds exhibit delicate wave structure

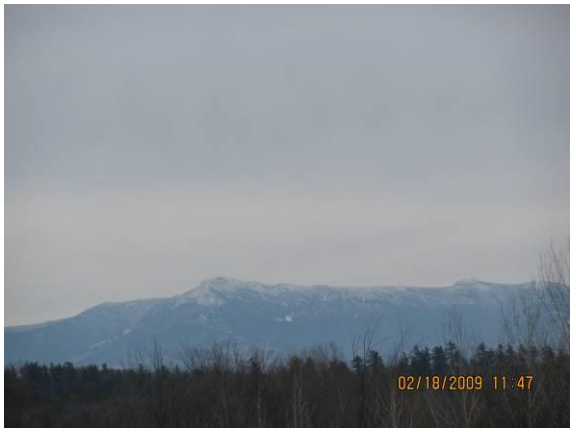
Mid-level cloud family

Altostratus (As) frequently evolve into Nimbostratus (Ns)

- **Top left: smooth gray As with a few Sc evolve into ragged Nimbostratus (bottom left)**
- **Bottom right: Altostratus in winter with sun appearing as through frosted glass with no shadows on ground**
- **Frosted glass appearance due to precipitation evaporating into dry low levels (virga)**

Dull gray Altostratus clouds

- Altostratus (As) are generally a uniform dull gray or bluish gray. They are thicker than Cs and usually hide the sun.



- top 2 photos fairly smooth As and bottom photo As with striations or banding.

Typical views of Altocumulus (Ac)

- top photo: Altocumulus cloud above lower stratocumulus
- lower photo bands of Ac cloud (rising air) separated by clearing with downward motion
- larger than Cirrocumulus
- may evolve into As and Ns.
- if left over from overnight convection may limit surface heating thus inhibit thunderstorm development.
- may also indicate instability aloft and support thunderstorms

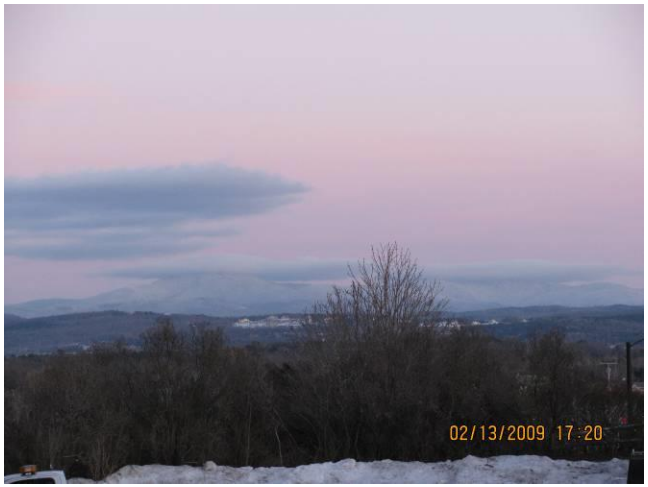
Different varieties of Altocumulus (Ac) clouds

- top photo: mid level band of Ac exhibiting some convective development (unstable) may indicate thunderstorm potential

- bottom photo…unusual Altocumulus lenticular clouds with thick Cs and As

Low cloud family

Cold air stratocumulus (Sc)



- Stratocumulus are layered convective clouds in the low level
- they range from very dark to light gray…but exhibit thin and thick spots depending upon vertical motion
- top photo: cold air stratocumulus
- bottom photo: evening Sc wrapping around Green Mountains

More Stratocumulus (Sc)

- Sc have weak convection thus are generally not a very thick cloud thus generally support only sprinkles or flurries
- top photo: typical wave or undulation pattern with thickest clouds in updraft
- bottom photo: patch or quilt-like pattern with clear spots indicative of downward motion

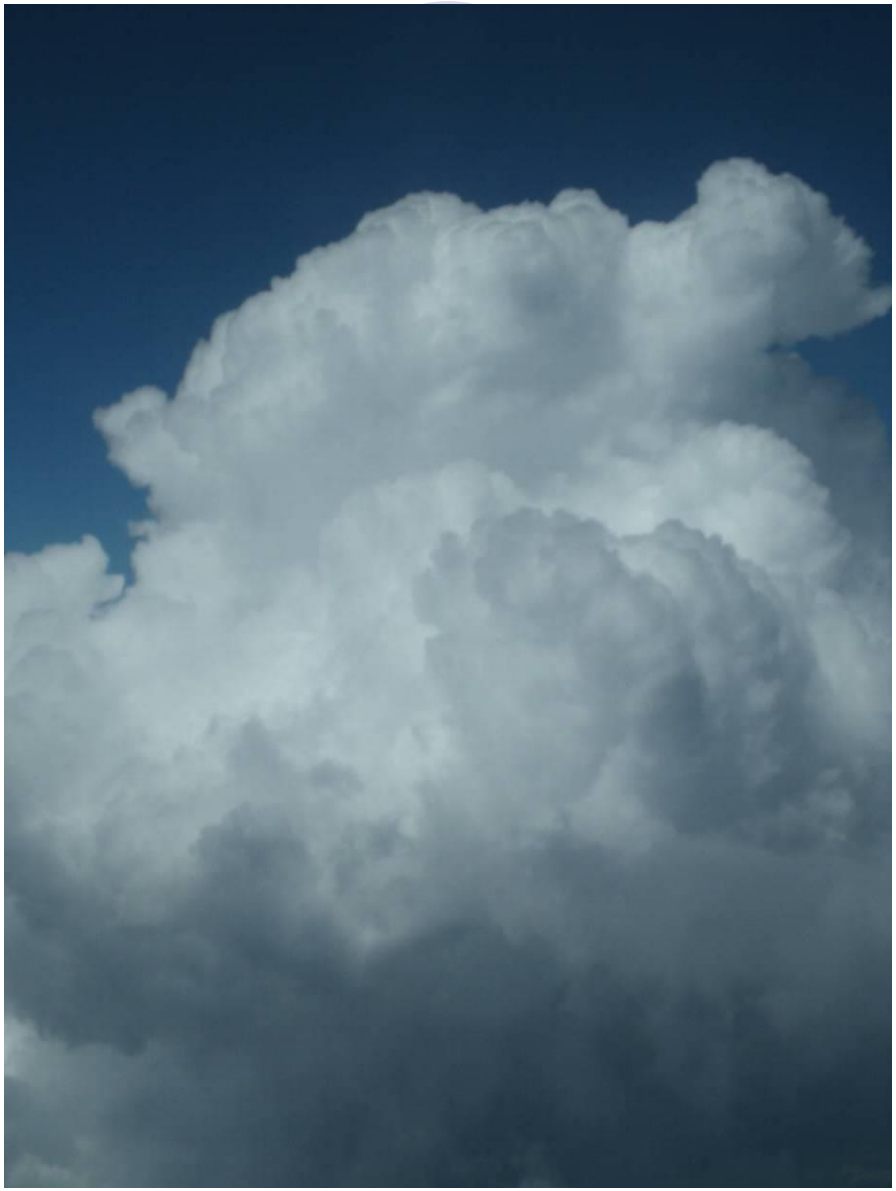
Nimbostratus (Ns) and Stratus (St)

- Ns (top) are layered to greater heights (thick) and result in steady precipitation

- darker than St and may have ragged bases

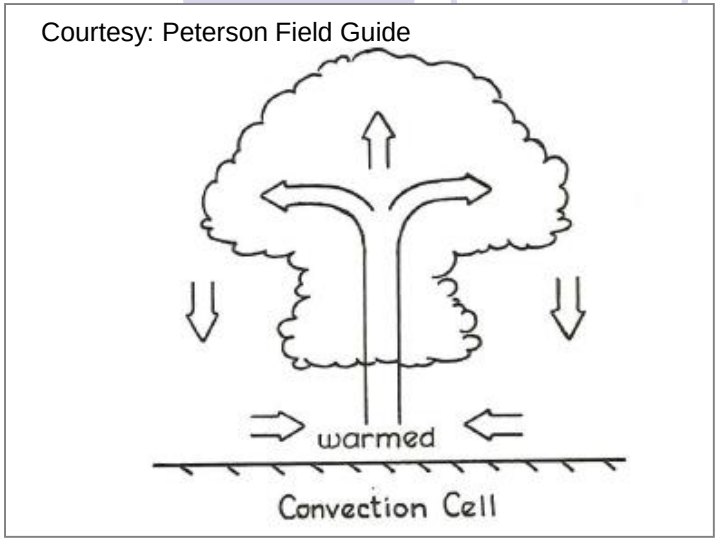
- Stratus are fairly uniform and lighter gray than NS. Only sprinkles or drizzle occur. Morning fog may lift into St

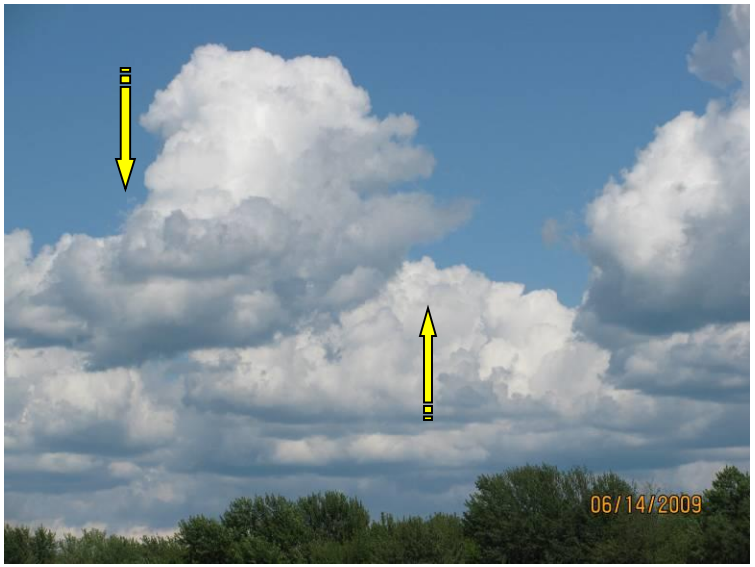
Clouds of Vertical Development



Photos: L-A. Dupigny-Giroux

Cumulus convection process





- sun heats the earth which in turn heats the air
- heated air rises replaced by sinking cooler air from aloft
- rising air expands and cools to the condensation point with formation of cumulus clouds with flat bases at Lifting Condensation Level
- domed tops where air eventually becomes non buoyant
- evaporating cloud elements on cloud edges in downward moving air

Cumulus (humilis) clouds *August 9, 2008*

- fair weather cumulus of limited vertical growth. Clouds form in upward convective current and resemble cotton balls or sheep.

- flat bases of clouds form at about the same level which represents the lifting condensation level

- bottom photo shows cumulus dissipating into stratocumulus

Cumulus congestus or Towering Cu

- Cumulus congestus developing due to orographic forced ascent up over the Green Mountains
- note bubbling appearance of cloud similar to pot of boiling water
- Cumulus repeatedly developing over foothill west of Lake Champlain and dissipated as it moved over the lake.

Orographic Towering Cumulus *May 31 2009*

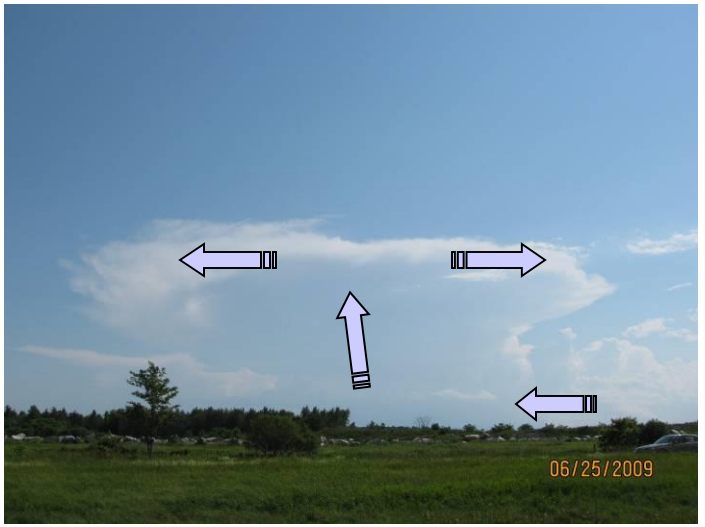
- line of towering cumulus (TCU) over the spine of the Green Mountains
- note flat bases at lifted condensation level
- building clouds are following by rain shafts and virga in bottom photo eventually reaching the ground

Evening towering cumulus June 3 2009

Cumulus cloud tops illuminated by setting sun…while lower clouds and bases appear dark

Cumulonimbus (Cb) - thunderhead

- large vertically developed cloud
- can be single cell thunderstorm or may form in clusters or lines
- top photo still developing and very active bubbles or cells. No tilt to cloud so will be short lived (30 mins)
- bottom photo thunderstorm Cb in mature stage. Sharp sides and glaciated cirrus blow-off anvil top with storm tilting slightly
- cumulus clouds to right indicate low level moisture inflow with Ci blow-off upper left



Cumulonimbus – up close

- Dark threatening cloud resembles nimbostratus when viewed up close overhead.
- Turbulent nature noted by roll cloud beneath parent cloud indicative of strong low level winds
- Note circular rotation of entire cloud

NAME THAT CLOUD…