Good Morning ☺ 1.17.14

- **Lab 6-4 Wrap-up !**
- **Atmos. Moist. Wksht. Part D #1-5 Cloud Types PPT**
- **Air Masses Notes – fill in air mass ditto**
- **Fronts Ditto Fill in**
- **Lab 6-5 Proc. E, next week**
- **HW: PART G**

Cloud: *A visible aggregate of minute droplets of water, or tiny crystals of ice, or a mixture of both*

Classification of Clouds

Generally, clouds are classified on the basis of two criteria: ***height*** and ***form***.

- **High-level clouds (bases above 6,000 m)**
- **Mid-level clouds (bases 2,000 – 6,000 m)**
- **Low-level clouds (bases below 2,000 m)**
- **Vertically developed clouds (span more than one height range)**

Three Basic Clouds Forms

- **Cirrus:**
  - From the Latin root meaning “curl” or “filament”
- **Cumulus**
  - From the Latin root meaning “heap”
- **Stratus**
  - Sheets or layers. From the Latin root meaning layer.

High Clouds

- **Form above 6,000 m (20,000 ft.)**
- **Primarily composed of ice crystals**
- **Typically thin and white in appearance**
- **Can have a magnificent array of colors when the sun is low on the horizon**
- **Includes *cirrus* and *cirrostratus***

High Level Clouds: Cirrus

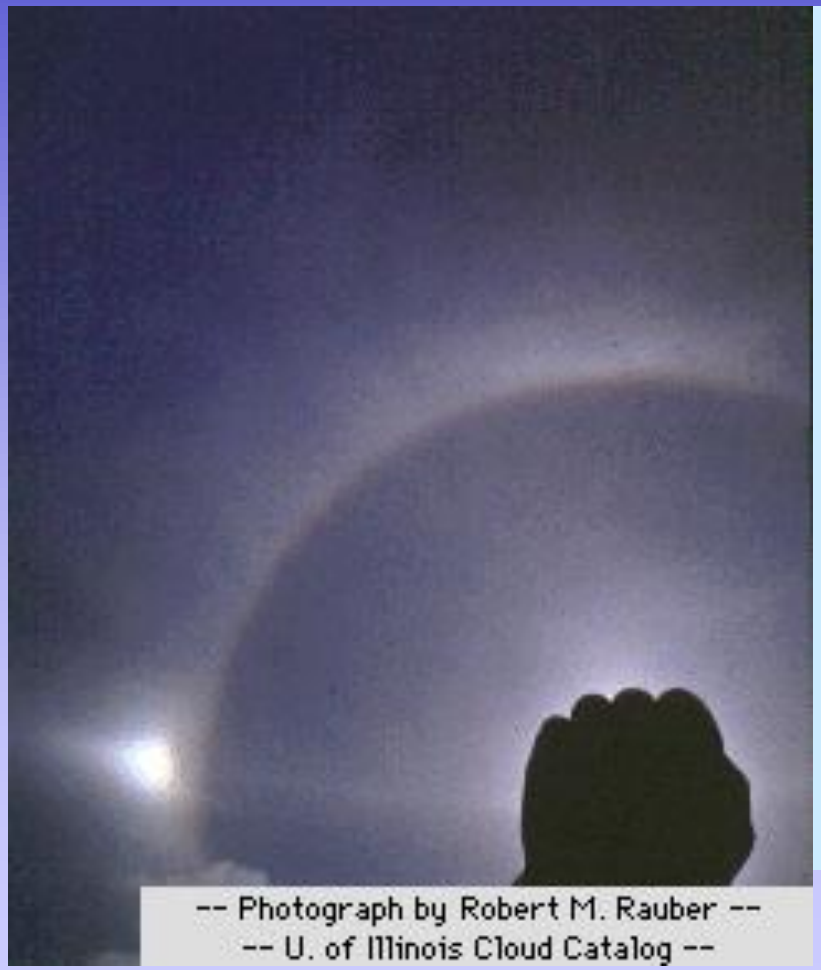
- Most common high level clouds
- Occur in fair weather
- Point in the direction of air motion at their elevation
- Fall streaks are caused by slowly falling snowflakes and ice crystals and change of wind with height

High level clouds: cirrus

High level clouds: cirrus

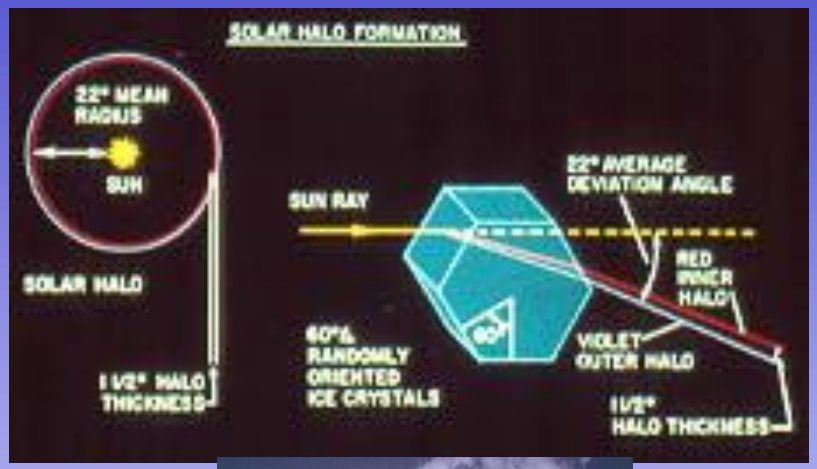
High level clouds: cirrus

High Level Clouds: Cirrostratus



- **Sheet-like; covers much of the sky**
- **A transparent, whitish cloud veil**
- **Can be so thin that the sky may not appear to have clouds**
- **Produces a *halo* around the Sun or Moon**
- **Indicates an approaching warm front**

Cirrostratus Clouds Produce a "Halo" Effect



- ✓ Six-sided ice crystals are randomly oriented
- ✓ Amount of dispersion changes as angle of light striking the crystal surface changes
- ✓ More light is scattered in one direction than in another (max is 22º)

Cirrostratus Halo

High level clouds: cirrocumulus

- **Appear as white patches made of small cells or ripples.**
- **Commonly called a "*mackerel sky*"**
- **Foretells stormy weather**
- ***Mackerel scales and mares'tails make lofty ships carry low sails.***

Middle level clouds

- Altitude range of 2,000 to 6000 m (6,500 ft to 20,000 ft)
- Composed primarily of liquid water droplets but can be ice crystals when temperature is low
- The prefix *alto* is part of the cloud name.
- Two types: *altocumulus* and *altostratus*

Middle level clouds: altostratus

- Layer of cloudy air, sometimes thick and preceding rain
- Sun seen as if shining through glazed glass
- Distinguished from cirrostratus by lack of a “halo”

Middle level clouds: altocumulus

- Rounded masses or parallel bands
- Individual cells usually are shaded with distinct outlines
- Formed from gradual lifting of air in advance of a cold front

Low level clouds

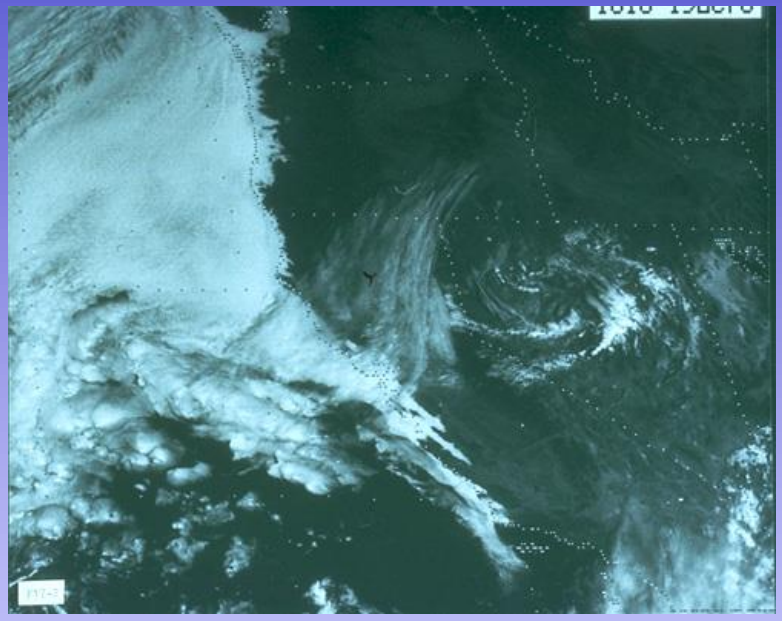
- Generally below 2,000 m (6,500 ft)
- Mostly composed of liquid water droplets but will have ice particles and snow at low temperatures
- Inlcudes:
  - ✓ *stratus*
  - ✓ *Stratocumulus*
  - ✓ *nimbostratus*

Low level clouds: stratus

- Uniform layer
- Frequently covers much of the sky
- May produce light precipitation

Low level clouds: stratus

Low level clouds: stratus



Low level clouds: stratocumulus

- Bottom resembles long parallel rolls
- May appear as rounded masses with breaks of clear sky in between
- Color may vary from light to dark gray

Low level clouds: nimbostratus

- Low and dark - The sun is not visible
- Accompanied by precipitation
- Name is from Latin:
  - ✓*nimbus* for rain cloud
  - ✓*Stratus* for layered
- No clear cloud base due to precipitation and fog

Vertically Developed Clouds

- **Associated with unstable air (rising air)**
- **Most commonly formed through *thermal convection* or *frontal lifting*.**
- **Heights can reach above 12,000 meters**
- **Two types:**
  - ✓ ***cumulus***
  - ✓ ***cumulonimbus***

Fair weather cumulus clouds

- Form on clear days when unequal surface heating causes parcels of air to rise above lifting condensation level
- Flat base and distinct outlines
- Appear as “floating cotton”

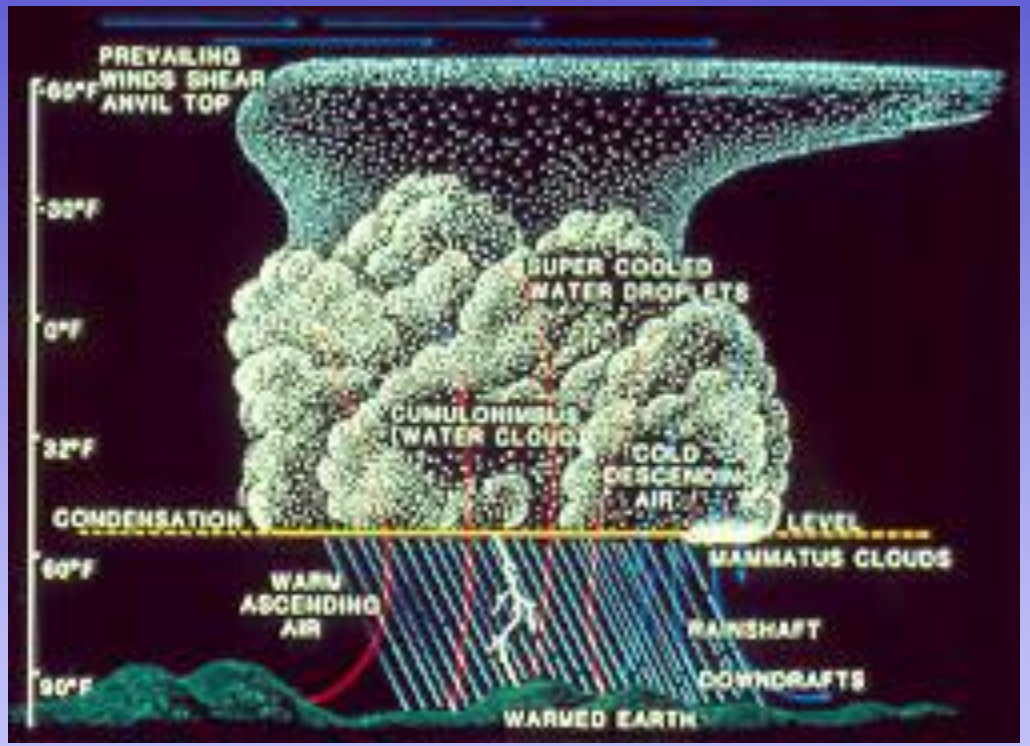
Cumulus Clouds

Cumulus congestus clouds

- As the cumulus rises, its top leaves the low height range
- Top > 7,000 m ; Base 1-2,000 m
- Very active separated heaps with flat bottoms and growing towers

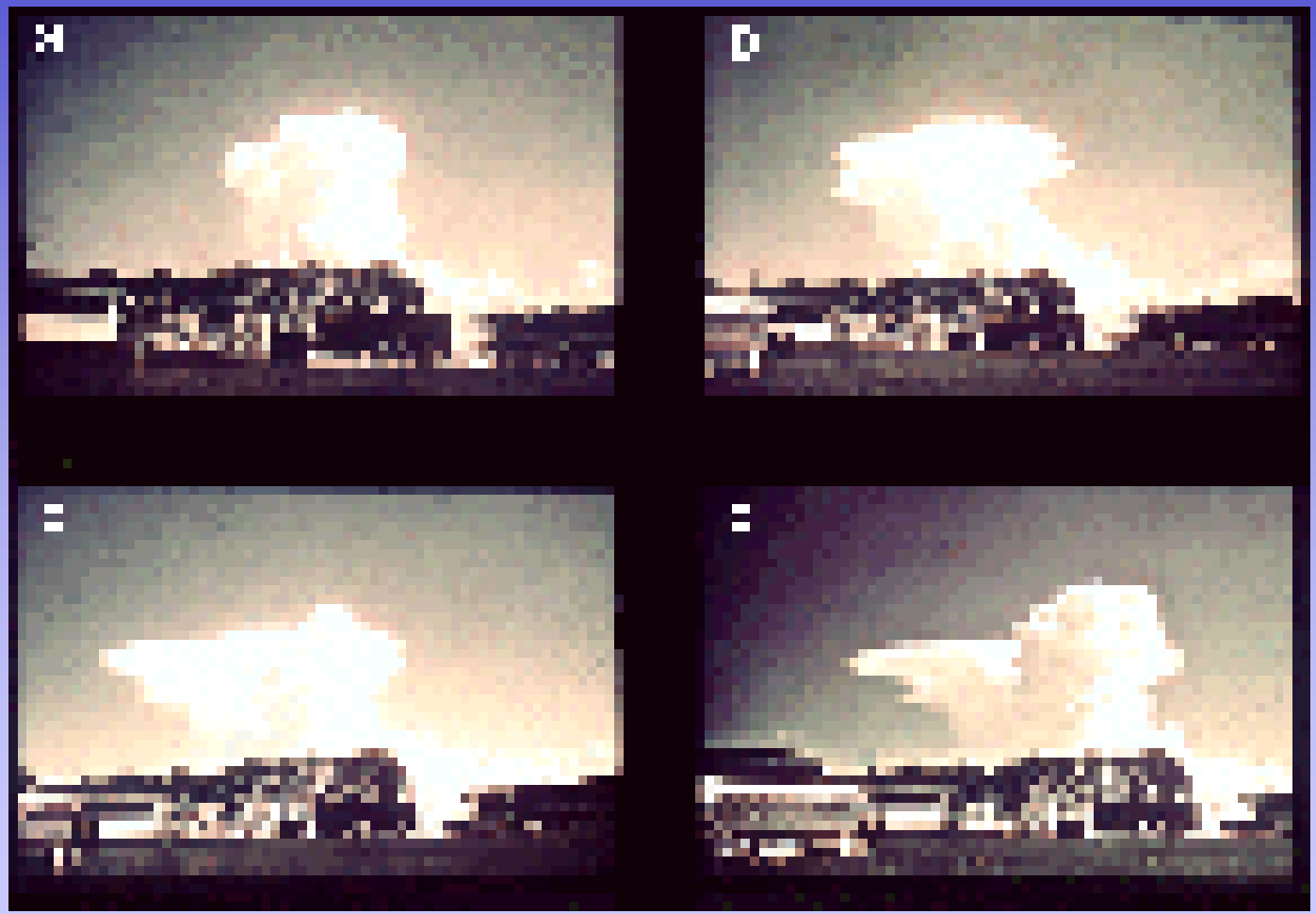
Cumulonimbus Clouds

- Source of lightning, thunder, and hail
- Exist as individual towers, or a line of towers
- Strong updrafts
- In later stages, the upper part turns to ice and spreads out in the shape of an anvil
- Tops can be > 12 km



Cumulonimbus Clouds

Cumulonimbus Cloud Development Series



Cumulonimbus Clouds

Cumulonimbus Clouds (Supercells)

Other Cloud Types

- **Mammatus clouds**
- **Lenticular Clouds**
- **Contrails**

Mammatus Clouds

- Clouds have rounded bulges on bottom surfaces
- May resemble udders of cows
- Associated with severe weather and cumulonimbus clouds
- Formed by sinking precipitation particles

Mammatus Clouds

Lenticular Clouds

- Lens-shaped
- Turbulent flow over mountains
- Often on the leeward side

Lenticular Clouds
(Mt. St. Helens)

Lenticular Clouds
(Mauna Kea, Hawaii)

Contrails (condensation trails)

- Cirrus-like trail aircraft exhaust
- Condensed water droplets freeze before evaporation
- Indicates high moisture in upper Troposphere

Sheared Contrails

- ✓ **Wind effect**
- ✓ **Contrail becomes sheet-like**

The end

Billow Clouds

- Formed from vertical shear and weak thermal layering
- Called *Kelvin-Helmholtz* instability
- Visible signal to aviation of dangerous turbulence

Contrail Funnel

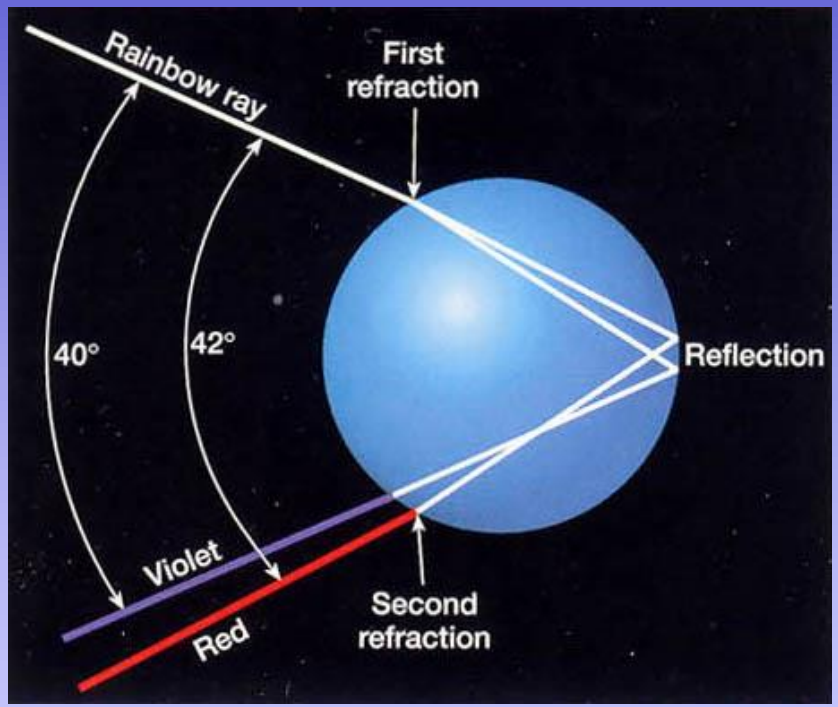
- Flaps cause lateral airflow under the wing
- Air recombines with air flowing over the wing backwards
- Low pressure and rotational shearing causes the cloud
- Extends several tens of meters behind the aircraft
- Causes extreme turbulence

Other Optical Effects

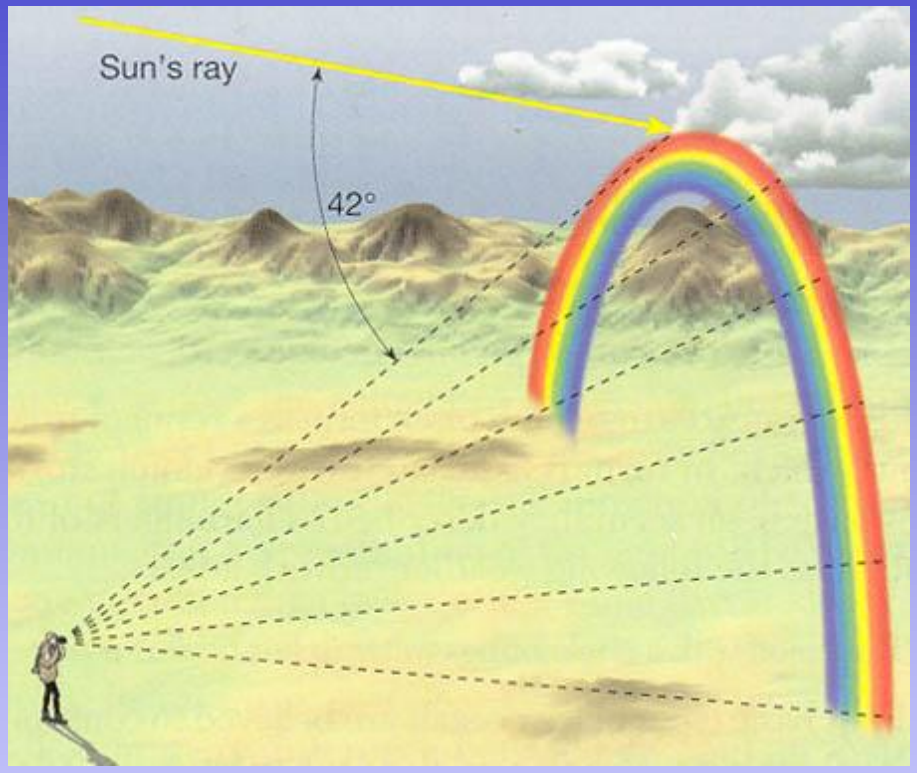
- Rainbows
- The “Glory”
- Crepuscular Rays
- Iridescent Clouds
- Sun Pillars

Rainbows

- Water drops acts as prisms
- Light is refracted upon entering the droplet
- Rays are reflected when leaving on the other side

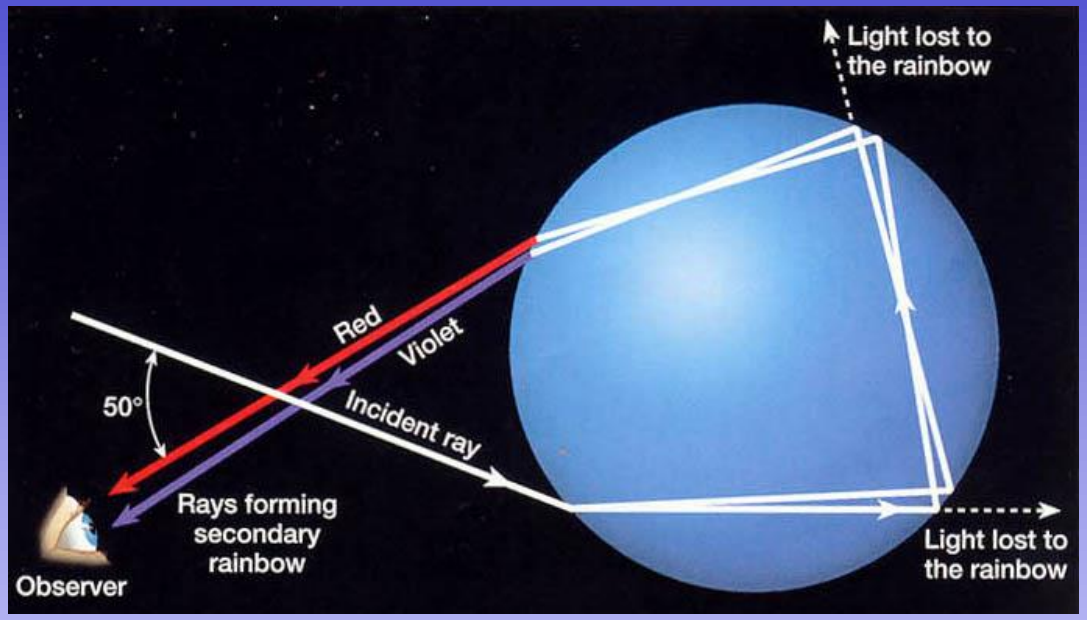


Curved Shape of Rainbows



- Rainbow rays travel towards an observer at 42 degrees from the path of sunlight

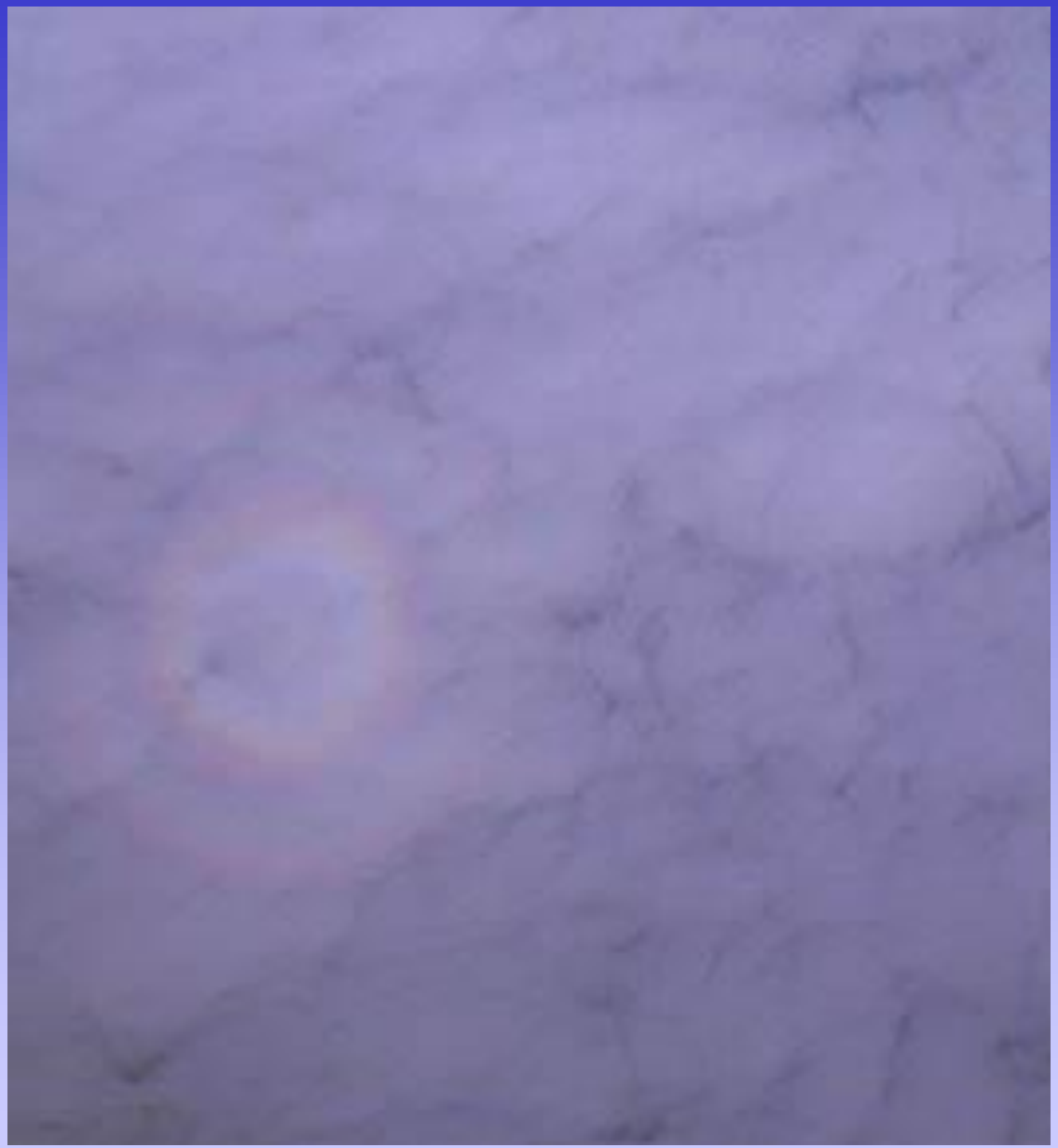
Secondary Rainbows



- Formed by dispersion similar to the primary rainbow
- Caused by an additional reflection
- Colors are reversed

The Glory

- Viewed from above
- Airplane shadow surrounded by colored rings



Crepuscular Rays

Crepuscular Rays

- ✓ Breaks in clouds
- ✓ Scattering of light by dust and water vapor
- ✓ "Path" of light is visible
- ✓ Rays are parallel but appear to radiate due to perspective

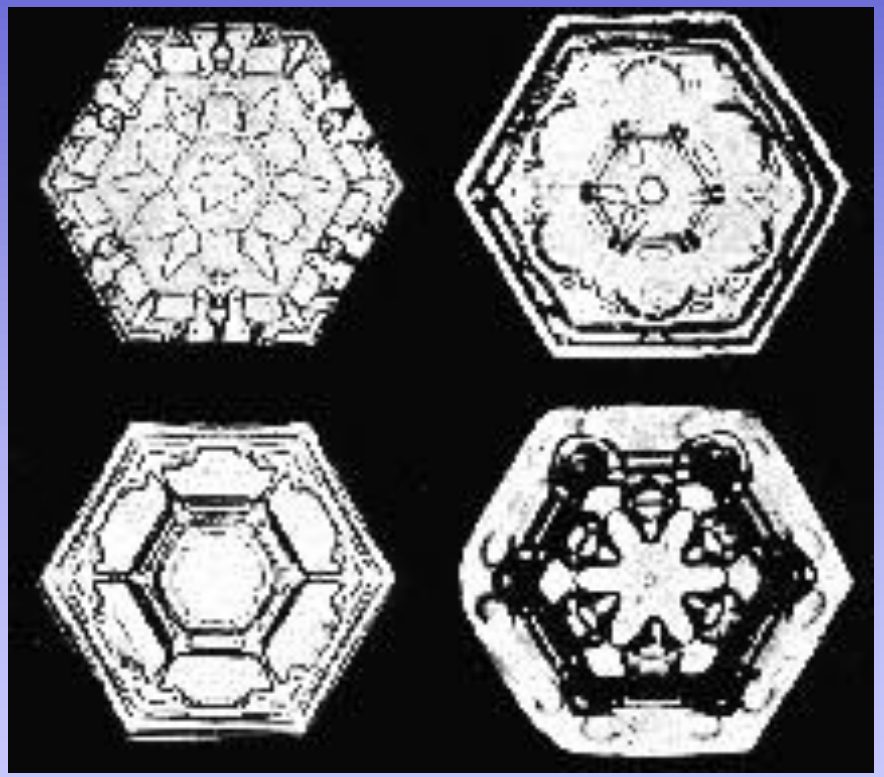
Iridescent Clouds

- Areas of bright colors
- Generally violet, pink, and green
- Diffraction by small droplets or ice crystals
- Particles must be small and uniform in size

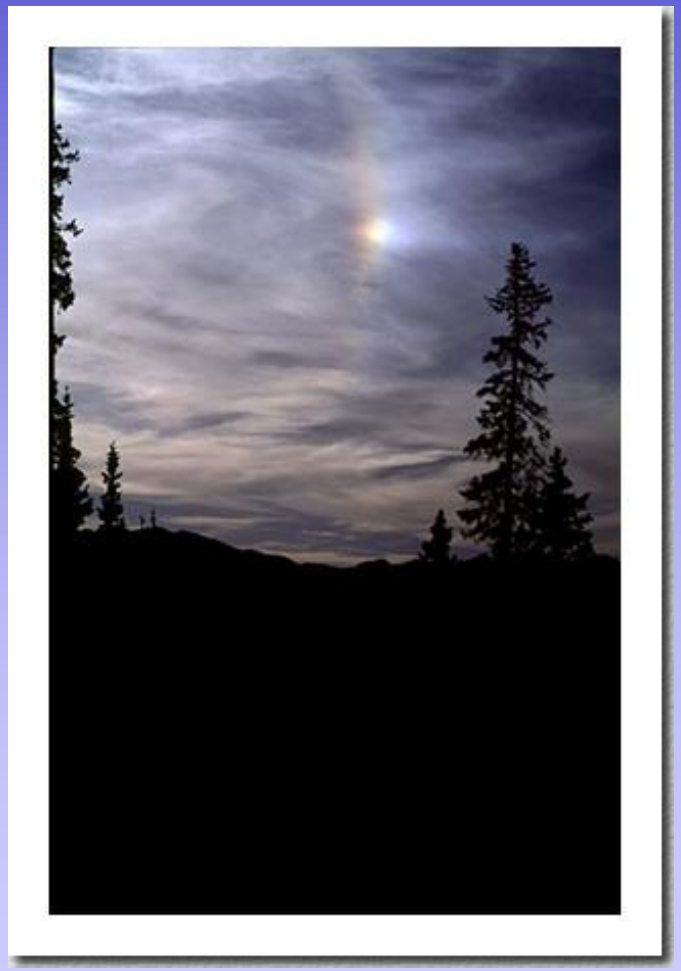
Sun Pillars

Sun Pillars

- ✓ Vertical shafts of light
- ✓ Hexagonal plate-like ice crystals
- ✓ Fall with horizontal orientation
- ✓ Sunlight reflects off ice



Sun Dogs or Parhelia ("beside the sun")



- "Mock Sun's" seen adjacent to the 22^{o} halo
- Results from vertically oriented ice crystals
- Results from slowly descending ice crystals

As the crystals sink through the air they become vertically aligned, so sunlight is refracted horizontally — in this case, sundogs are seen.