

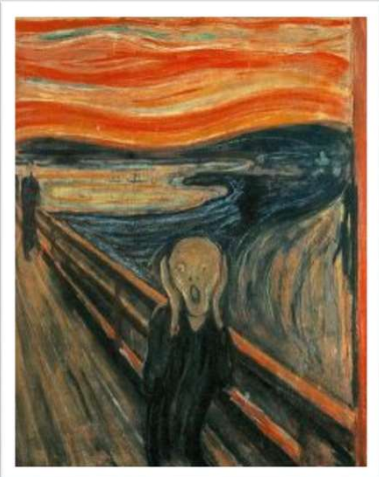


# **ATMO 102 Pacific Climates and Cultures**

**Lecture: Atmospheric Optics  
Introduction**

# Red and other Colored Sunsets

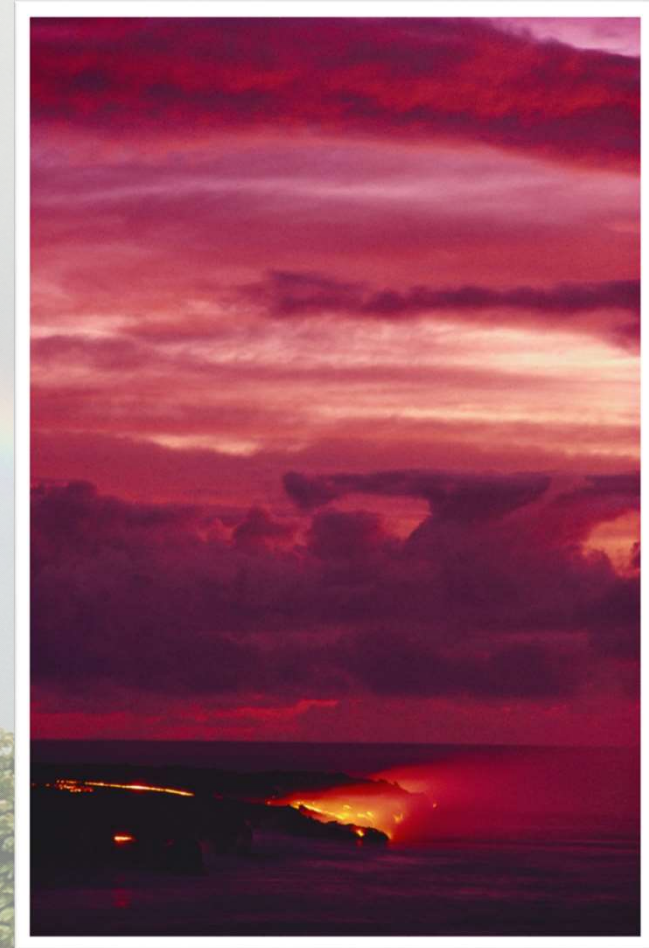
- Most **spectacular Sunsets** occur when there are lots of fine particles in the atmosphere...
  - Dust
  - Volcanic Ash
  - Vog



**Volcanic sunsets** depicted in Munch's The Scream  
1883 eruption of Krakatoa



**Spectacular sunsets** from the Sarychev volcanic eruption June 2009 from the International Space Station



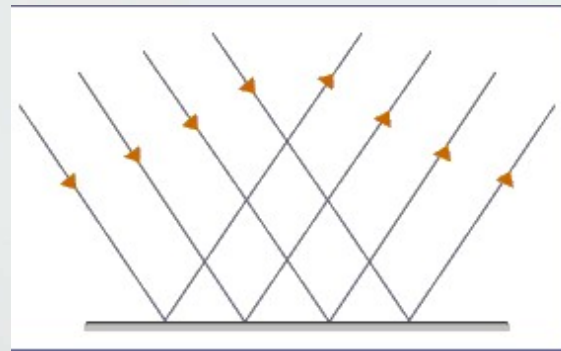
**Purple Sunset off Big Island**  
Date unknown



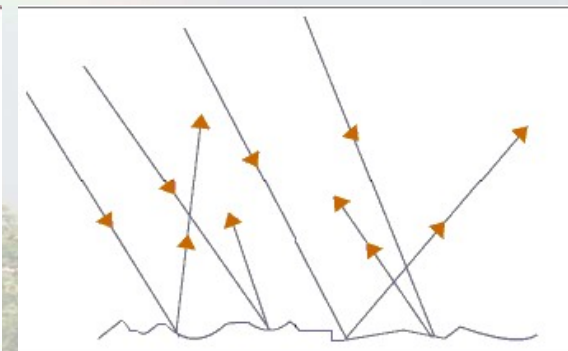
# White Light & The Nature of Light

- **The Law of Reflection**

- Light rays always bounce off the reflecting surface at the same angle at which they meet at that surface.



On a **SMOOTH** surface you can easily see that the angles are the same.



On a **ROUGH** surface light will strike (and reflect) at different angles.

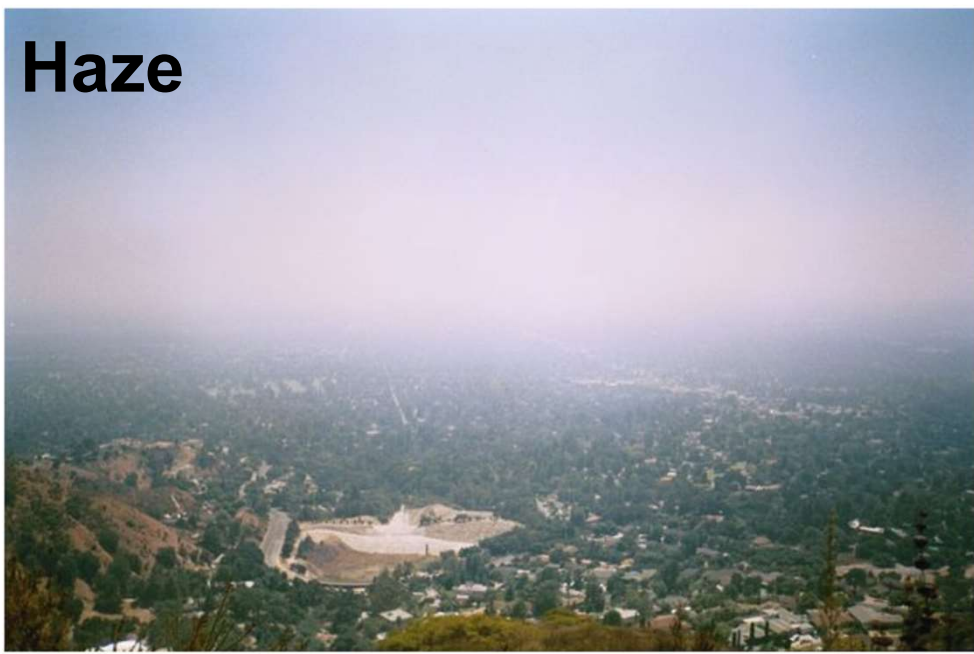
- **White light is composed of many wavelengths**

- Atmospheric gases, clouds and particles interact differently with these wavelengths
- Sky Color
- Optical Phenomena

# White Skies – Hazy, Fog and SMOG

- **Fog, haze** or **smog** scatter light more equally in all wavelengths so the resulting sky looks white

Haze



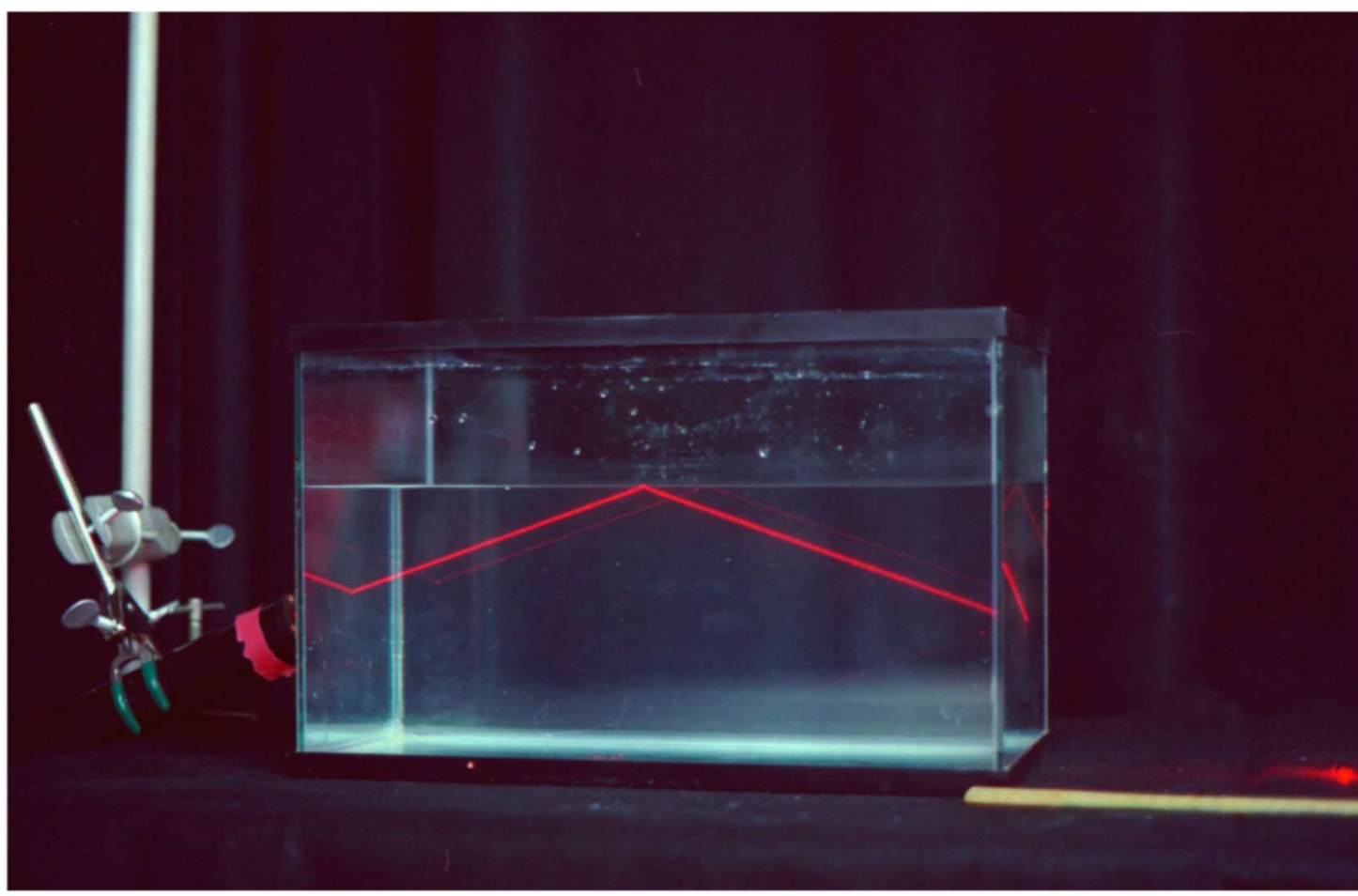
Fog



Smog



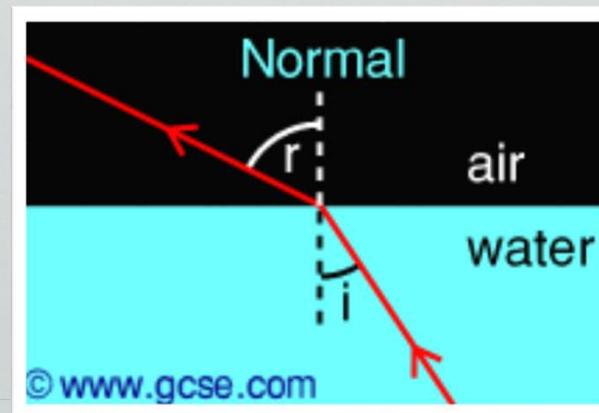
# Nature of Light – Internal Reflection



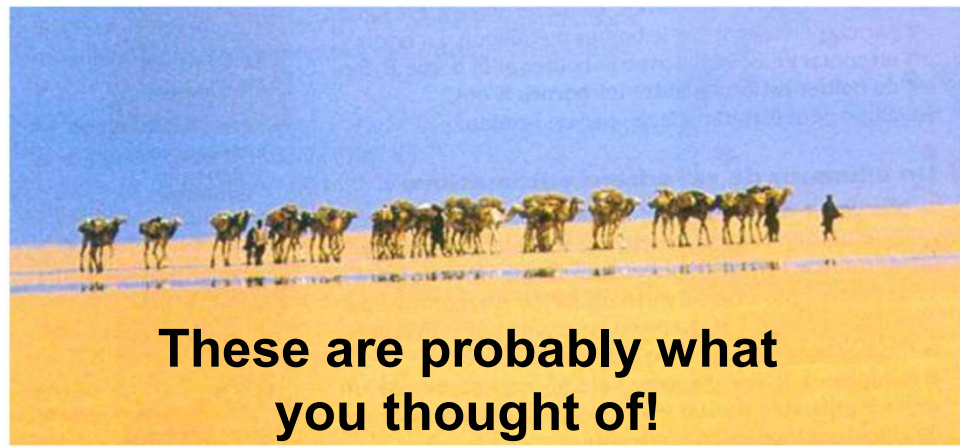
- Occurs when light that is traveling through a transparent material (like water) reaches the opposite surface and is reflected back into the transparent material.

# Nature of Light – Refraction

- Some rays are not reflected
- **Refraction** is the bending of light as it passes obliquely (not at 90 deg) from one transparent medium to another.
  - The velocity of light varies depending on the medium.
  - It is slower in water or ice than in a vacuum.



- What do you think of when you think of the word “Mirage?”



**These are probably what you thought of!**

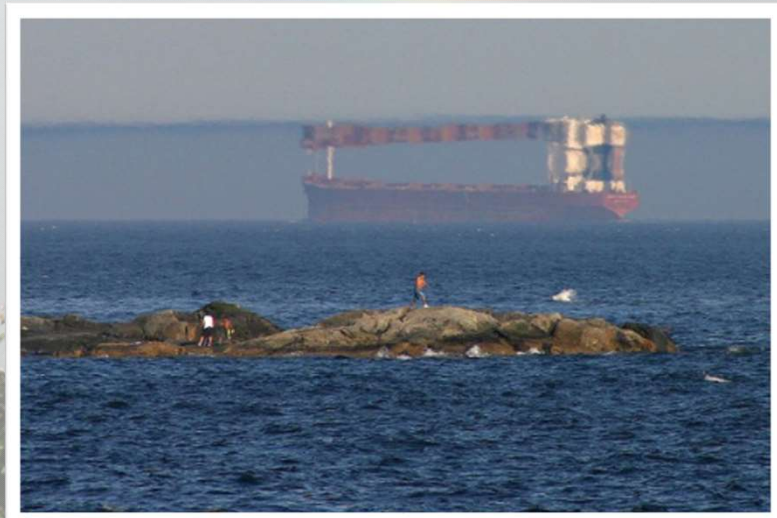
## **Mirages**

**These are still mirages!  
What's going on here?**



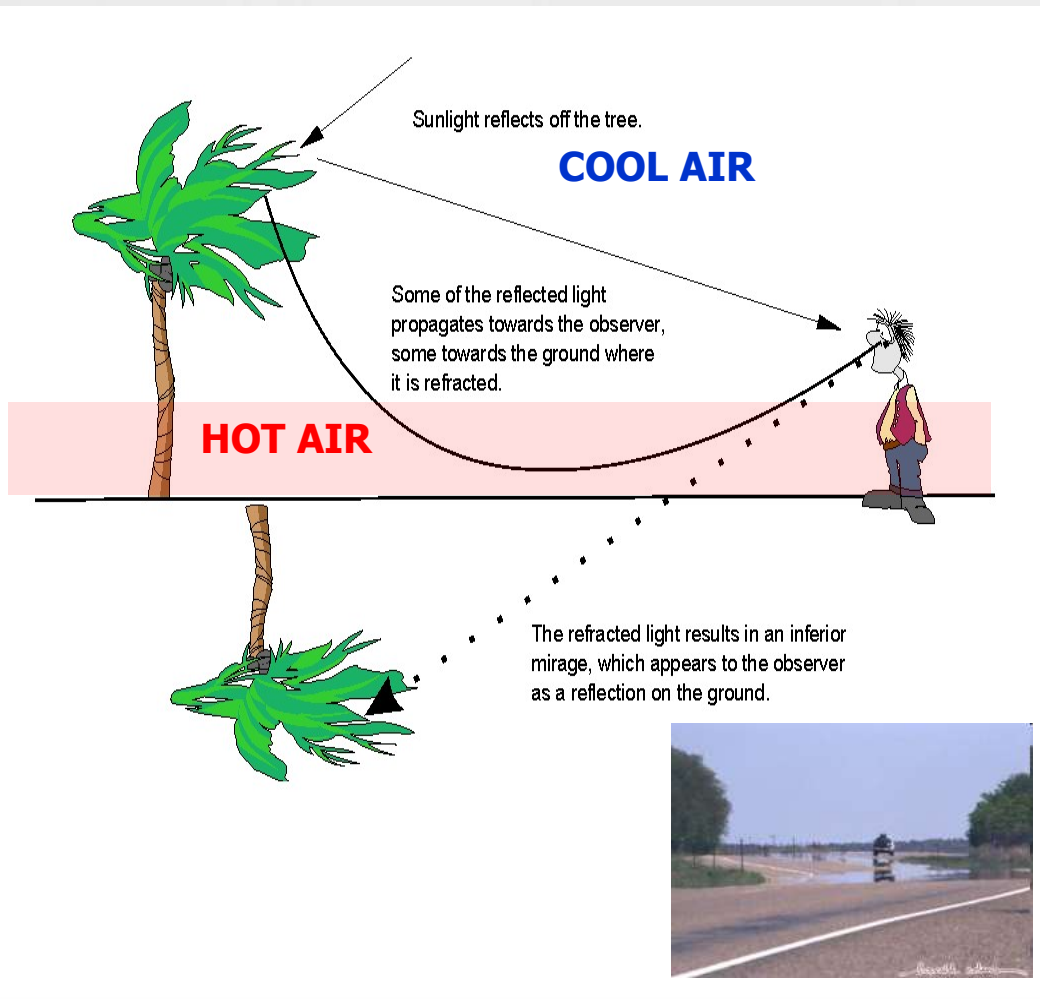
# Mirages

- Usually associated with **desert regions**
- **Can happen anywhere**
  - Related to air of **different densities**
- **Different types**
  - 1. Inferior Mirage**
    - The image is **BELOW** the true location of the object
    - Usually warm air below, cold above
  - 2. Superior Mirage**
    - The image is **ABOVE** the true location of the object
    - Usually warm air above, cold below





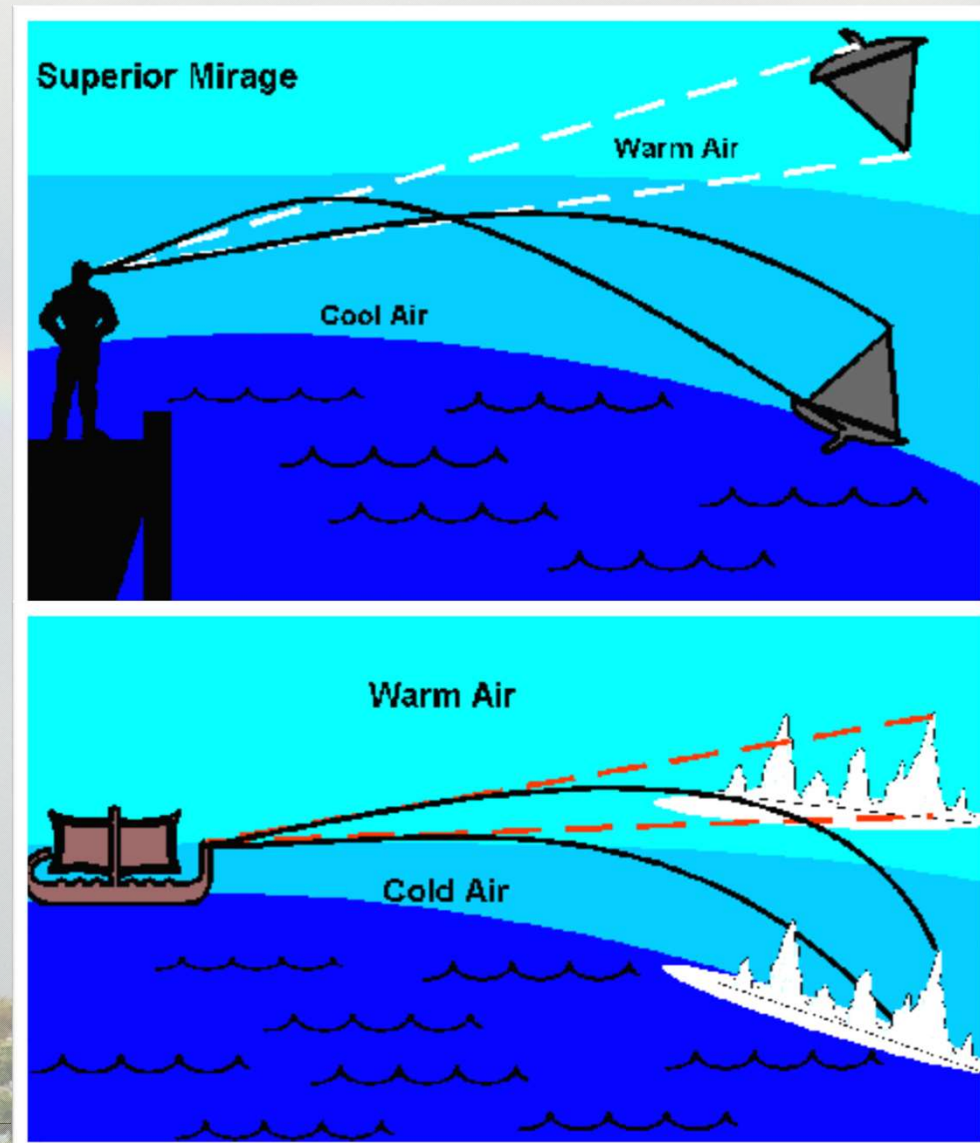
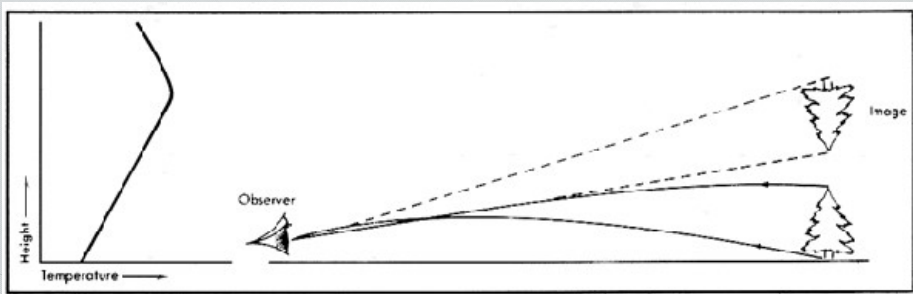
# How inferior mirages work....



- **Change in air density** = gradual bending of light rays
- Near the earth's surface light traveling through less dense air develops a **curvature in a direction OPPOSITE to the Earth's Curvature**.
- When light rays pass from hotter to colder, they **bend toward the direction of the cooler** air.
- Makes objects appear below (or above) where they are, often inverted (upside down).
- **Human brain perceives light as traveling in a straight line.**

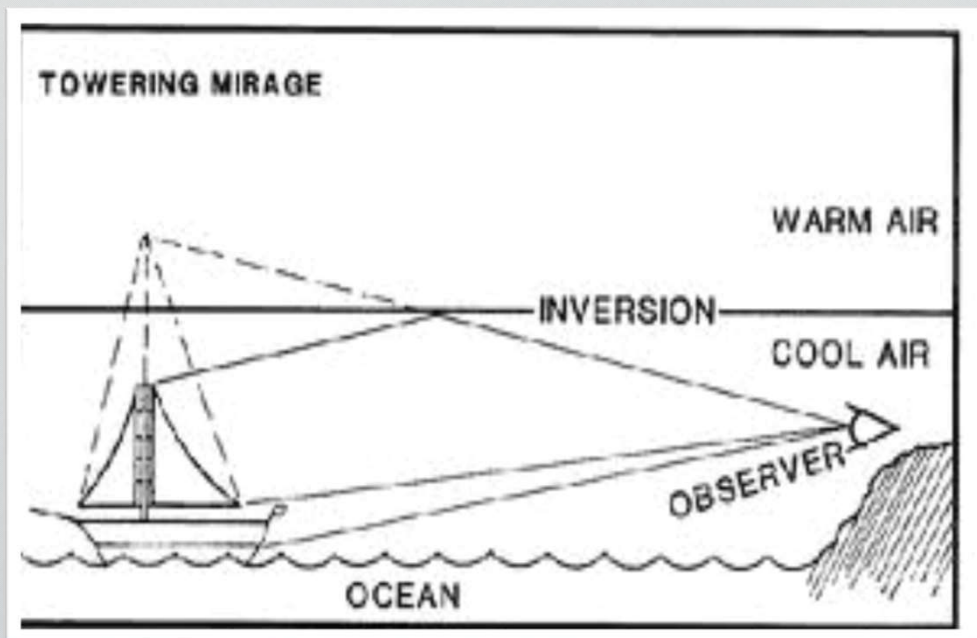
# Superior Mirages

- The air close to the surface must be **much colder** than the air above it.
- This condition is common over **snow, ice and cold water surfaces**.
- When very cold air lies below warm air, light rays are bent downward toward the surface, thus tricking our eyes into thinking an object is located higher or is taller in appearance than it actually is.



# Superior Mirages

- **Towering:** changes in the apparent size of an object



- **Looming:** Makes it appear object is suspended over the horizon.



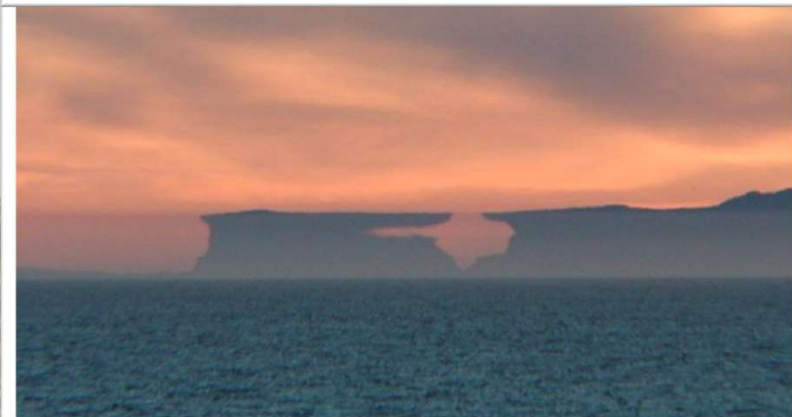
# Fata Morgana

- Named after the sister of King Arthur
- a.k.a Morgan La Fey –An evil witch, rival of Merlyn.
- Credited with the ability to create towering castles out of thin air.



# Fata Morgana

- A complex mirage in which distant objects are **distorted as well as elongated vertically**.
- For example, a relatively flat shoreline may appear to have tall cliffs, columns, and pedestals.
- The phenomenon occurs under much the same meteorological conditions as the **superior mirage** with inversion, and **contains features of both towering and inversion**.



# Glory

- Colored rings surrounding the shadow of the airplane
- Named after the “halo” it produces around a person’s shadow
- Can be see at the surface if the observer is located such that:
  - Above a layer of fog
  - Sun at his or her back
- The shadow on the ground the glory will enshroud the observer’s head.



- Not usually seen when the observer is on the ground ... Easier to see when in an airplane



# Corona

- Appears as a bright whitish disk centered on the Moon or Sun. **But mostly the MOON!**
- Sometimes colors are seen, but are rare
  - Red outer band, blue in the middle
- Produced when a thin **layer of water-laden clouds** (usually altostratus) cover the Moon (or the Sun)
- The **Corona is due to the BENDING of light around the EDGES** of the drops causing them to collide and interfere with each other.
  - **Diffraction** – The bending of light around sharp edges.
  - **Interference** – Occurs when light rays of different frequencies (colors) meet.

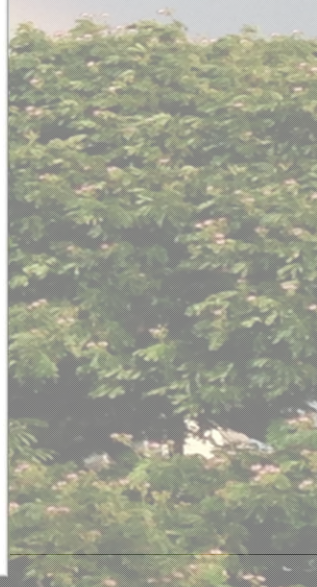
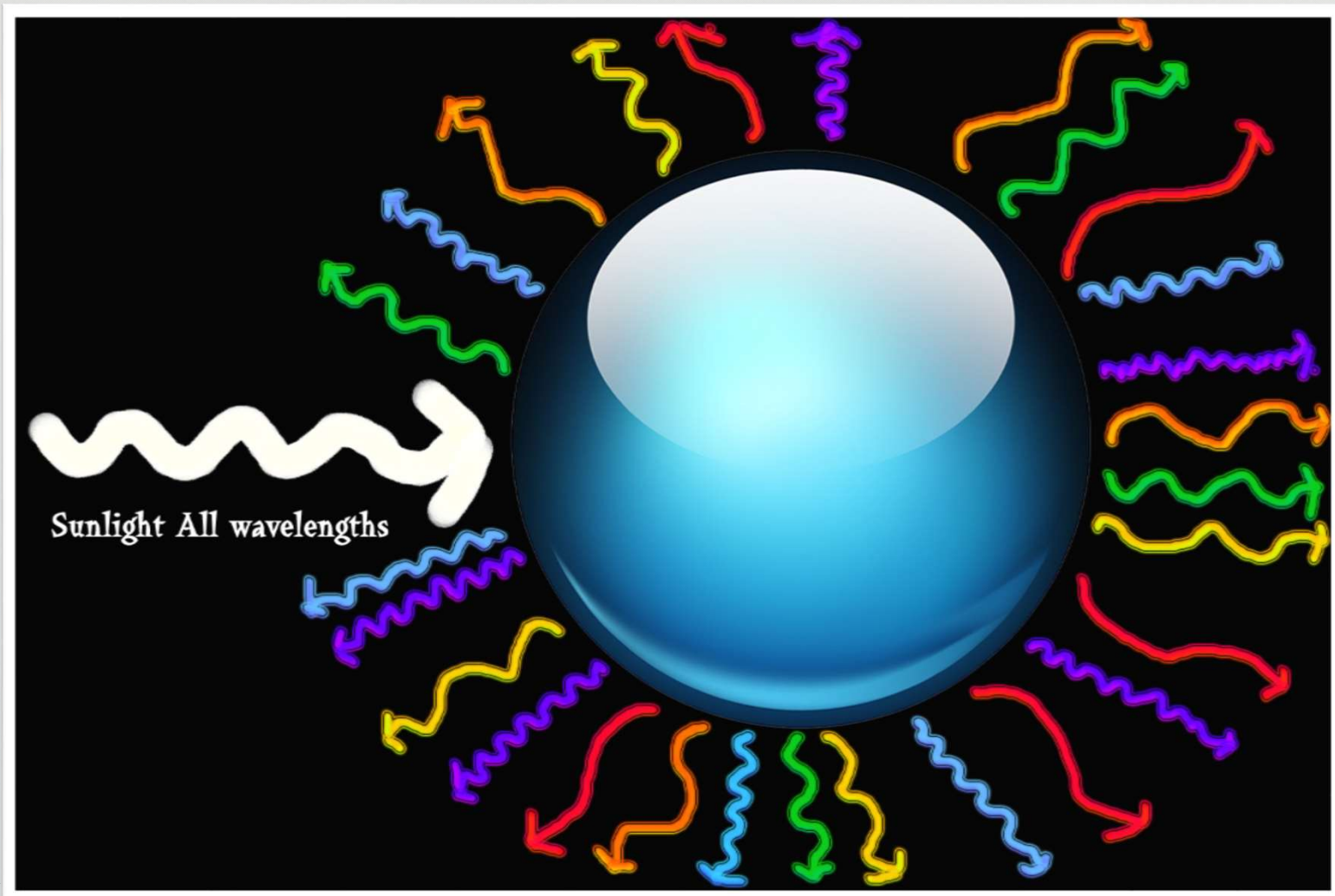


# Rainbows

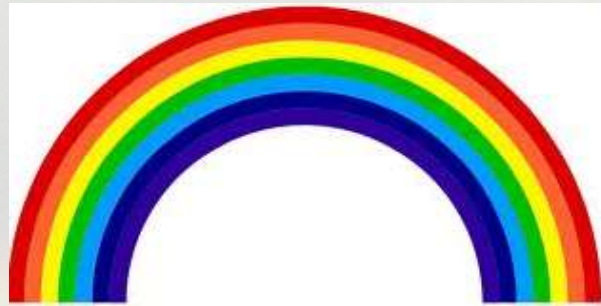




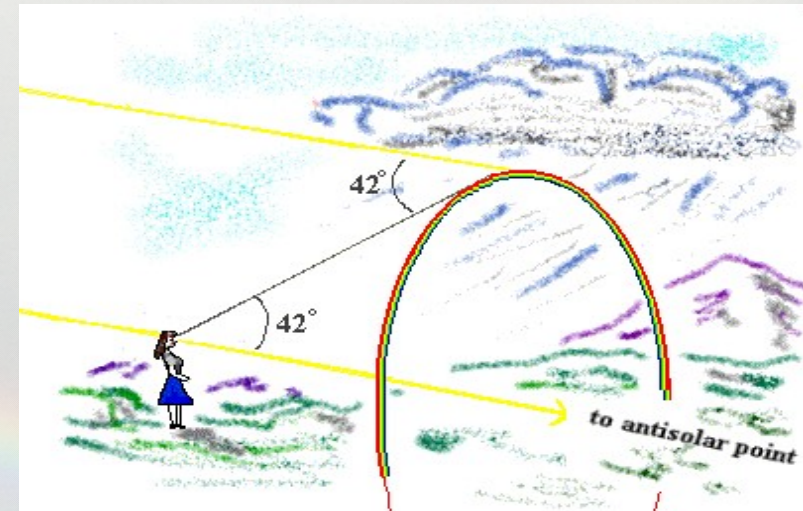
# Cloud drops scatter white light



# Rainbows

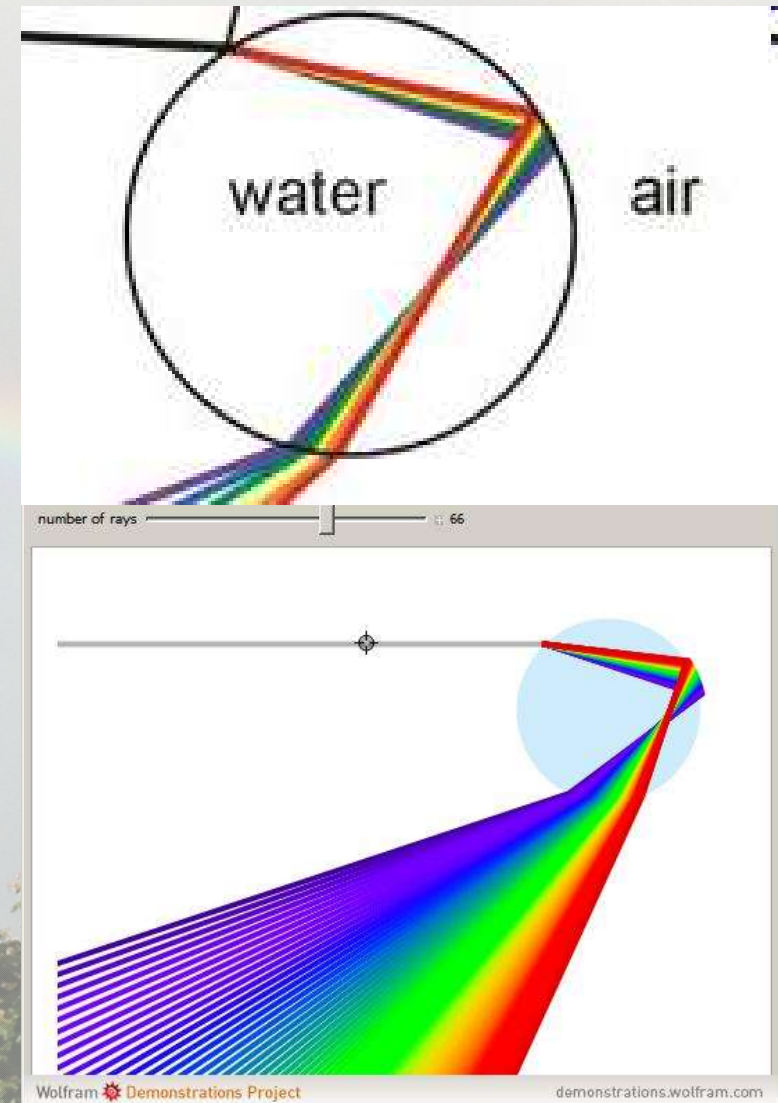


- Clarity of color varies
- Outermost band is always **RED**
- Innermost band is always **VIOLET**
- Usually see SIX Colors
  - Red, Orange, Yellow, Green, Blue, Violet
- Usually seen when the observer has the **Sun on one side** and a **rain shower on the opposite side**.
  - i.e. Sun at your back, facing the rain
- Fine mists from waterfalls and sprinklers can generate mini-rainbows.



# Rainbow Formation

- Need three things:
  - 1) Sunlight
  - 2) Water droplets
  - 3) An observer in between the rain and the sun
- Refraction
  - As light travels through water it is bent
  - Different colors travel at different speed in water
    - Each color is then bent at a different angle
    - Violet is refracted and bent the most
    - Red is refracted and bent the least



# Rainbow Formation

- The angle between sunlight and the dispersed color is always:
  - **42° for red**
  - **40° for violet**
- The curved shape results from the fact that the light always travels at 42° from the path of sunlight
- An observer will only see one color from each raindrop
- **Each observer sees their OWN rainbow!**

