Atmospheric Optical Phenomena

Atmospheric Optical Phenomena are produced by the reflection, refraction, dispersion and scattering / diffusion of rays of sunlight.

These principles in physics explain commonly asked questions as

1. Why is the sky blue?
2. Why are some clouds white and others dark?
3. How are rainbows formed?
4. Why are rainbows at different locations at different times of the day?

The following optical phenomena are presented with brief formation processes.

Blue Skies and White Clouds

- Nitrogen in the atmosphere is a selective scatterer and scatters shorter wavelengths of visible light (violet, blue and green) more efficiently than longer wavelengths (yellow, orange and red).
- Our eyes are more sensitive to blue light, so the sky appears blue.
- Hazy atmosphere occurs when small particles (dust and sea salt) are suspended in the atmosphere. These particles scatter light and we see a whitish tinge instead of clear blue.
- The more particles that are suspended in the atmosphere, the whiter the sky appears.
- Clouds appear white because countless numbers of cloud droplets scatter all the wavelengths of visible light in all directions. The light penetrates the cloud through to the base of the cloud.
- Dark clouds are seen when the cloud grows thicker, larger and taller and the very little light penetrates through to the base of the cloud. The raindrops at the cloud base also are so large that they cannot scatter efficiently but rather absorb the energy.

Red Suns and Blue Moons

- Near sunrise or sunset, the angle of the sun's rays strike the atmosphere at a lower angle than during the day. Thus the light penetrated a deeper layer of atmosphere and most of the shorter wavelength of visible light have been scattered away. Therefore, when the light finally reaches our eyes, we see the longer wavelengths (orange-yellow).
- Bright yellow-orange sunsets occur when the atmosphere is fairly clean. A more polluted atmosphere gives a **red sunrise / sunset**. Eg. Volcanic sunsets

- **Blue moons** occur when relatively large particles (0.01 -1.0 µm) particles scatter longer wavelengths of visible light (red, orange, yellow) and the shorter wavelengths reaches our eyes. Thus we see a blue moon.

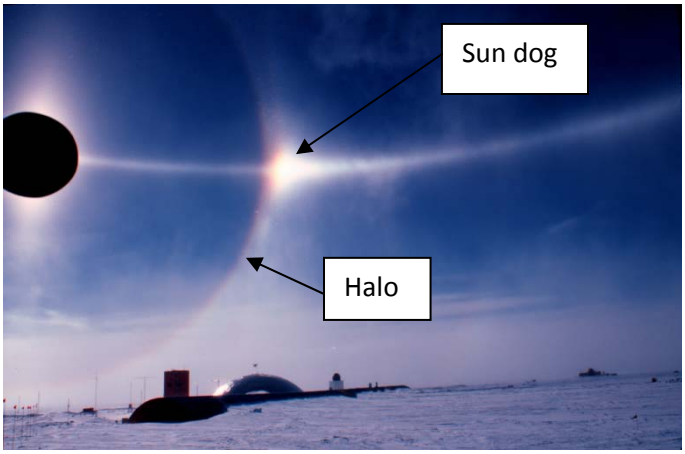
Mirages

- **Mirages** are formed when light is bent as it passes through the atmosphere having varying densities.
- When the sun heats the earth's surface the air closer to the ground is warmer and less dense than layers of air higher in the atmosphere.
- As light travels from a less dense medium to a denser medium at an angle, the light is bent toward the normal.
- As light travels from a dense medium to a less dense medium at an angle, the light is bent away from the normal.
- We see mirages as shimmering or watery spots on hot surfaces, inverted reflections of distant objects, and other objects appear taller than they really are.

Rainbow

- A **rainbow** is visible light broken into what we see as seven colors: red, orange, yellow, green, blue, indigo and violet. They always appear in the same order, with red on top and violet on the bottom, in a main rainbow.
- In a secondary rainbow, they appear in the opposite order.
- Rainbows are light. You can't touch them. You can't reach around behind them. They exist only in the eyes and sometimes the photographs of the people who see them.
- **Three** things must happen for you to see a rainbow's colors. **First**, the sun must be shining. **Second**, the sun must be behind you, and **third**, there must be water drops in the air in front of you. Sunlight shines into the water drops, which act as tiny prisms that bend or "refract" the light and separate it into colors.
- Each drop reflects only one color of light, so there must be many water drops to make a full rainbow. You'll see the brightest rainbows when the water drops are large, usually right after a rain shower.
- Often you can see a second rainbow above a brighter one. This is caused by extra reflection inside the raindrops. Because the secondary rainbow is formed from two reflections instead of one, it has a wider radius than the first rainbow and its colors are reversed, with red on the bottom and indigo on the top.
- Because rainbows are light and because light rays strike everyone's eyes a little differently, the rainbow you see will be a little different from the one someone else sees, even if he or she is standing right beside you. Someone else a short distance away or looking from a different angle may see a much different rainbow -- or no rainbow at all.

Halo and Sun Dogs



- **A halo** is an optical phenomenon produced by ice crystals creating a single ring of color around the sun or moon. It occurs more frequently than a rainbow.
- They are produced by the ice crystals in cirrus clouds high (5–10 km, or 3–6 miles) in the upper troposphere.
- The shape and orientation of the crystals is responsible for the type of halo observed. Six-sided ice crystals that make up those clouds act as the prisms that separate the sun's light into colours.
- The light is reflected and refracted by the ice crystals and split up into colours by dispersion. The crystals behave like prisms and mirrors, refracting and reflecting sunlight between their faces, sending shafts of light in particular directions.
- Atmospheric phenomena such as halos were used as part of weather lore as an empirical means of weather forecasting before meteorology was developed.
- To see a halo, don't look directly into the sun. Instead, block the sun from your view with your hand, so you can just see the clouds around it. Sunglasses also may help you see a halo -- but even with sunglasses, you'll need to block the sun from your eyes.
- **Sun dogs** or parhelia are atmospheric phenomena that create bright spots of light in the sky, often on a luminous ring or halo on either side of the sun.
- When light refracts through flat horizontal ice crystals, you might see bright spots of light along the right and left sides of a halo.
- Sundogs may also appear as a coloured patch of light to the left or right of the sun. They can be seen anywhere in the world during any season, but they are not always obvious or bright. Sundogs are best seen and are most conspicuous when the sun is low.

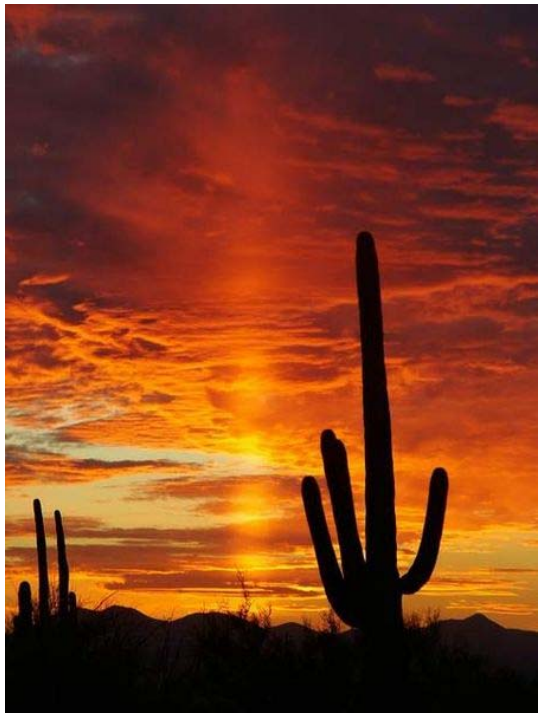
Corona

- They are similar to halos but are formed from a cloud's water drops rather than from ice crystals.
- Light shines through cloud droplets, curves around the circular drops and gets diffracted. This means it spreads out, creating an area of light larger than the sun or moon. This "crown" of milky light around the sun or moon is the **corona**.
- When all the cloud droplets are about the same size, the diffracted light can make the corona separate into colors. These colors may repeat themselves.
- Commonly seen in recently formed altostratus and altocumulus.

Irisation / Cloud Iridescence

- **Cloud iridescence** is the occurrence of colours in a cloud and is similar to irisation.
- It is a fairly uncommon phenomenon and is usually observed in altocumulus, cirrocumulus and lenticular clouds.
- The colours are usually pastel shades.
- Iridescence is most frequently seen near to the sun with the sun's glare masking it. It is most easily seen by hiding the sun behind a tree or building. Other aids are dark glasses or observing the sky by its reflection in a convex mirror or in a pool of water.
- Iridescent clouds are a diffraction phenomenon. Small water droplets or even small ice crystals in clouds individually scatter light.
- Large ice crystals produce halos, which are refraction phenomena rather than iridescence. Iridescence should similarly be distinguished from the refraction in larger raindrops that gives a rainbow.
- The cloud must be optically thin so that most rays encounter only a single droplet. Iridescence is therefore mostly seen at cloud edges or in semi-transparent clouds.

Sun / Light Pillars



- **Sun Pillars** appear most often at sunrise and sunset as a vertical shaft of light extending upward or downward from the sun.
- They are formed by reflection of sunlight through ice crystals.
- **Pillars** can also form when hexagonal plate-like ice crystals fall with their flat bases oriented horizontally. As they fall, they tilt from side to side and reflect the light off the tipped surfaces of the crystals. A bright area is then produced above or below the sun.

Crepuscular Rays

- **Crepuscular rays** are rays of sunlight that appear to radiate from a single point in the sky.

- These rays, which stream through gaps in clouds or between other objects, are columns of sunlit air separated by darker cloud-shadowed regions.

- The name comes from their frequent occurrences during crepuscular hours (those around dawn and dusk), when the contrasts between light and dark are the most obvious.

Lightning

- Lightning is the discharge of electricity that occurs in a mature thunderstorm (cumulonimbus cloud).

Auroral Lights

- An **aurora** is a natural light display in the sky, particularly in the polar regions, caused by the collision of charged particles directed by the Earth's magnetic field.

- An aurora is usually observed at night and typically occurs in the ionosphere.

Glory

- A **glory** is an optical phenomenon, appearing much like an iconic Saint's halo about the head of the observer, produced by light backscattered (a combination of diffraction, reflection and refraction) towards its source by a cloud of uniformly-sized water droplets.

Sources

http://en.wikipedia.org

Duncan, Tom and Deniz Önaç, Physics for the Caribbean – A CXC Course

Ahrens, C. Donald, Meteorology Today

Wallace, J. M. and Peter Hobbs, Atmospheric Science

Compiled by Paula Wellington

For the Trinidad and Tobago Meteorological Services

2011

Trinidad and Tobago Meteorological Services

Rawinsonde Building, Piarco International Airport,

Piarco

Website: www.metoffice.gov.tt

Email: dirmet@tstt.net.tt

Telephone: 669-5465

Fax: 669-4009