Atmospheric Optics

The amazing variety of optical phenomena observed in the atmosphere can be explained by four physical mechanisms.

- Scattering
- Reflection
- Refraction
- Diffraction

Things to look for
- Blue Sky
- White Clouds
- Blue Smoke
- Red Sunsets
- Crepuscular Rays
- Heiligenschein
Scattering

Light is scattered by the air molecules, cloud droplets, and aerosols.

The resulting optics depend on the size of the scatterer.

Rayleigh Scattering

Small objects such as air molecules and fine smoke particles most effectively scatter blue light.

Scattering by Air Molecules

Scattering of blue light by air molecules is more than 9 times greater than scattering of red light.
Scattering by Air Molecules

Mie Scattering
Larger objects such as cloud droplets and ice crystals scatter all visible light equally well.

Mie scattering is greatest parallel to incident light.

Scattering
Rayleigh Scattering  Mie Scattering  Mie Scattering, larger particles

Mie scattering is greatest parallel to incident light. Rayleigh scatter is nearly equal in all direction.
Rayleigh and Mie Scattering

Mie scattering results in white clouds and the glare around the sun. Blue sky is the result of Rayleigh scattering.

Scattering by Smoke

Larger particles appear brown and smaller particles scatter blue.

Scattering by Cloud Droplets

Rayleigh scattering results in white clouds, with black bottoms if they are thick enough.
When all visible light is scattered away by cloud drops the cloud turns black.

Avoid exposed places during thunderstorms.

Most of the blue light is scattered out, leaving red light, which is scattered toward the observer by clouds.
When the sun sets or rises, the sunlight passes through a long path of air. Most of the blue light is scattered out, leaving red light, which is scattered toward the observer by clouds.
Scattering by Cloud Droplets

Shadows cast by clouds or trees on hazy days result in crepuscular rays, also known as Jacob’s ladders.

Mountain’s Shadow
Anti-crepuscular Rays

Reflection
The Law of Reflection
The angle a) of incident light equals the angle b) of reflected light.

Reflection
- Sun Pillars
- Circumhorizontal Arcs

Reflection by Water
Sunlight reflecting off of the ocean can produce a sun pillar.

The Law of Reflection

The angle a) of incident light equals the angle b) of reflected light.

Sun Pillars
Sunlight reflecting off of plate-shaped ice crystals can produce a sun pillar.

Sun pillars commonly occur beneath an altostratus cloud just after sunset.
Sun pillars commonly occur beneath an altostratus cloud just after sunset.

Reflection by Ice Crystals

Reflection and Scattering by Dew Drops

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Questions?