Geomorphology G322
Introduction to Aerial Photographs

I. Introduction to Air Photos

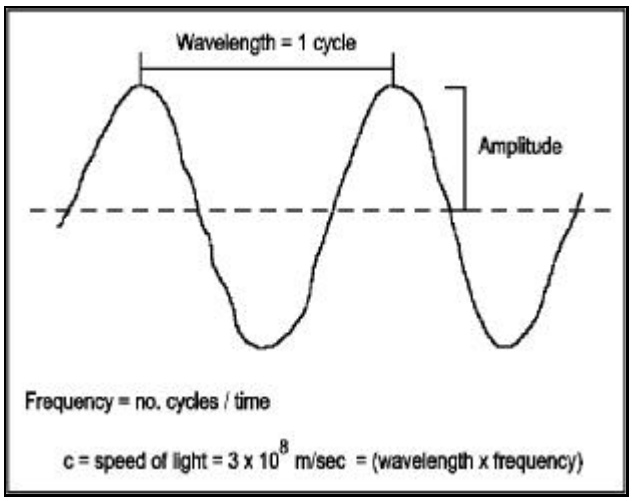
A. Aerial photographs are acquired by airpcraft especially equipped with cameras and view ports.
   1. Early Work ... Balloon-based photography during the civil war.
   2. Recent Work... Digital Cameras
   3. Most common form of airborne remote sensing

B. Uses
   1. Land-use surveys, forestry, geology, topographic / geologic mapping, soil surveys

II. Light Basics - Photographs sense reflected light

A. Electromagnetic Spectrum

1. Properties of electromagnetic radiation



a. wave length: distance from crest to crest, or trough to trough on a wave
b. frequency: no. of cycles / unit time
c. electromagnetic wave velocity = speed of light = 3×10^8 m/sec
   (1) velocity = wavelength x frequency

$$c = \lambda f$$

2. The type of radiation based on wavelength of waves (in order of increasing wavelength):
   (1) gamma rays (short wavelength:1×10^{-9} cm)
   (2) x rays (0.03-30 nm; too short to see)
   (3) ultraviolet (0.03 - 0.4 nm)
   (4) visible light (0.4 - 0.7 um; detectable by eye)

(a) violet
(b) indigo
(c) blue
(d) green
(e) yellow
(f) orange
(g) red

(5) infrared (0.7 - 14 um; too long to see)
(6) Microwave (0.1-100 cm)
(7) radio waves (>100 cm up to several km's)

** photographs record em radiation in the 0.3-0.9 um region of the spectrum (UV-visible-infrared)**

In Class Exercise

Given the following formulas and conversion factors, fill in the electromagnetic spectrum chart below.

λ = wavelength (units: km, m, cm, μm, nm)
f = frequency (units: 1 hertz = 1 hz = 1 cycle/sec = 1 sec^{-1})
c = speed of light = 3 x 10^8 m/sec
$c = \lambda f$ where λ = wavelength, *f* = frequency

Length Conversion: 1 m = 100 cm = 106 μm = 109 nm

Show all your work in the space provided.

Wavelength	Frequency (Hz)	Class of EM Radiation
2 km	_____	_____
0.5 μm	_____	_____
0.035 nm	_____	_____
20 cm	_____	_____
10 μm	_____	_____

What is the range of wavelength in centimeters, that is detected by your eye or standard camera film?

3. EM radiation interaction with the Earth's surface

a. scattered - deflected in all directions
(1) atmospheric scattering - selective scattering of certain wavelenghts of light as energy passes through the gaseous atmosphere
(a) "blue sky" = selective scattering of blue light, so that the viewer sees a "blue sky"
(b) "red sky" = selective scattering of all light, except the red portion of the spectrum, which reaches viewer

b. reflected - bounced off the earth's surface
(1) albedo = measurement of the degree of reflectiveness of earth's surface
(a) albedo = ratio of amount of reflected energy / total amount of energy
i) e.g. high albedo = snow fields
ii) e.g. low albedo = humid forest

c. absorbed - energy absorbed by earth materials, em radiation converted to heat
d. transmitted - em radiation passing through materials
(1) refraction - bending of wave energy as it passes through a medium

III. Air Photo Basics

A. Spatial Resolution

1. "resolving power" of the image-- the minimum distance between two objects that the objects still appear distinct and separate.
a. e.g. "10 m" vs "1 m" resolution

B. Film Technology
1. coated film-base with light-sensitive emulsion of silver chloride
a. photo exposure = photochemical reaction between light energy and silver chloride emulsion
2. Resolution = function of
a. camera height
b. lense quality
c. speed of film / quality of film
(1) high speed film = more sensitive to light
3. Film types
a. Black and White
b. Color
c. Infrared
d. UV photos
e. Digital Imagery
(1) Pixel Resolution

C. Scale of Photographs
1. scale of photo a function of
a. Altitude of Camera Lense
b. Focal Length of Camera (related to lense construction)

photo scale = 1 / (H/f) = 1: (H/f) where H = height of camera above surface, and f = focal length of camera (note: H and f must be in same units to determine the scale).

example problem: a camera is positioned at 6100 m above the earth's surface, the lense has a focal length of 152 mm. What will be the scale of the resulting photograph.

Answer scale = 1/ (H/f) = 1 / (6100m / 0.152 m) = 1 / 40,132 = 1:40,132

2. Common Scales
a. 1:63,360 (smaller scale)
b. Larger scale = 1:10,000 - 1:6,000

3. Standard Air Photo Size = 9" x 9"

D. Relief Displacement
1. Terms
a. relief displacement - objects in air photos appear vertically exaggerated in height and lean away from the center point of the photo
b. Principal Point - optical center of photograph, directly below the camera lense in the aircraft

(1) relief displacement increases with increasing distance away from the principal point on a photo

2. Determining the true height of an object on an air photo

h = (H x d)/r where H = height or altitude of camera above terrain, d = apparent "ground height" of object on photo as determined from photo scale, r = distance of top of object away from principal point of photo, in "ground units" as determined from photo scale.

* note: measure all components of the equation in the same lenght units (e.g. (m x m) / m = m).

Example Problem A camera is positioned 212 m above earth's surface, the apparent height of a building is measured as 40 m (as determined from air photo scale), the distance from the prinicipal point of the air photo to the top of the building is 260 m (as determined from air photo scale). What is the true height of the building?
Answer h = (H x d)/r = (212 m x 40 m) / 260 m = 32.6 m

IV. Ortho Photographs

A. aerial photographs that have been scanned into digital format and computer processed to remove all radial distortion
B. Consistent, corrected scale throughout image
    1. map be used directly as maps
        a. e.g. Soil Survey Maps

V. Stereo Pairs of Aerial Photos

A. Air photos acquired at set increments along a flight path
    1. typical flight paths = North-South

B. Stereo photograph pairs acquired with ~60% overlap between successive photos, and successive flight lines

C. Stereo Vision = "3D Viewing of Land Surface"
    1. Similar features on successive air photos separated by distance = observers eye separation (~2.5 inches)
    2. Stereoscope used to focus each eye of observer on same features of each successive photograph
        a. stereoscope causes the eyes to diverge, with each eye focused on a separate object
        b. the brain merges the two objects into 3-D
    3. Each eye focuses the image with a resulting 3-D view

D. Vertical Exaggeration of Images in Stereo Pairs
    1. Stereo images will appear to be taller than they are in reality
        a. exaggerated tree height, building height, etc.

    2. Reason: successive frames are snapped at air positions separated by 1000's of feet distance
        a. each eye in the stereoscope is focuses on the same object, but separated by thousands of feet ground distance
        b. the perceived vertical scale is greater than the horizontal scale

VI. Other Stuff
A. Satellite Imagery
B. Digital Imagery
C. Sources of Imagery
    1. USGS EROS Data Center
    2. USDA / Forest Service
    3. NASA