Spatial Resolution and Satellite Scene Swath

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Geog 581

What is Resolution??

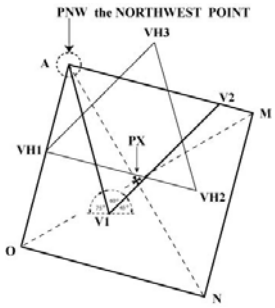
Resolution Criteria

Resolution is…

1. Based on the geometrical properties of the system
2. Ability to distinguish between points
3. Ability to measure the periodicity of repetitive targets
4. Ability to measure the spectral properties of small targets

1st Criterion

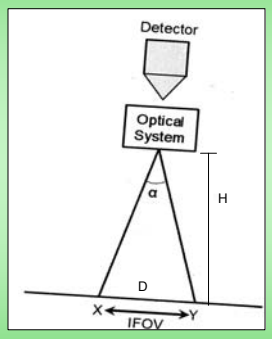
Geometry



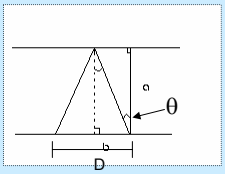
Instantaneous Field of View

- IFOV= The area on the ground that is viewed by the instrument from a given altitude at any time.

$$\alpha = \frac{D}{H}$$



Proof of IFOV Geometry



$$2\tan\theta = \frac{b}{a}$$

$$\theta = \tan^{-1}\left(\frac{b}{2a}\right) \qquad \theta \to 0$$

$$\theta = \frac{b}{2a} \qquad 2b=D$$

$$\theta = \frac{D}{a}$$

$$\theta = \frac{D}{H} \qquad H = a = \text{altitude}$$

IFOV

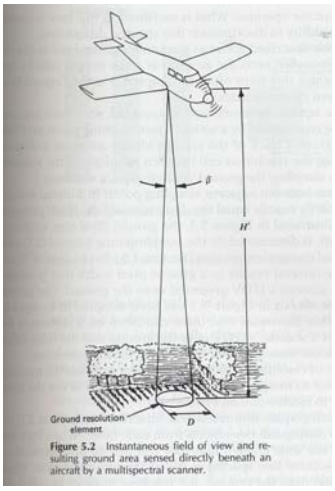
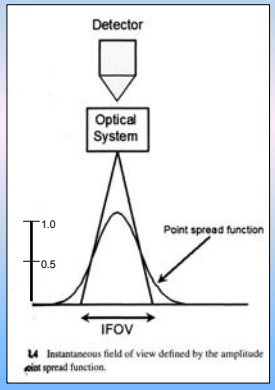


Figure 5.2 Instantaneous field of view and resulting ground area sensed directly beneath an aircraft by a multispectral scanner.

2nd Criterion

Point Sources

2 Dimensional Plot of the Point Spread Function



Instantaneous field of view defined by the amplitude point spread function.

Point Spread Function (3D)

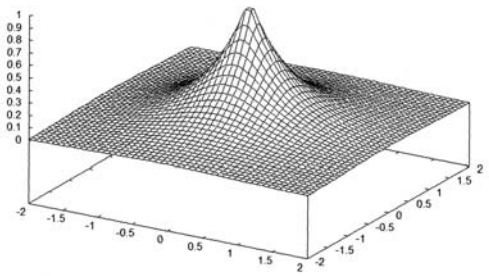
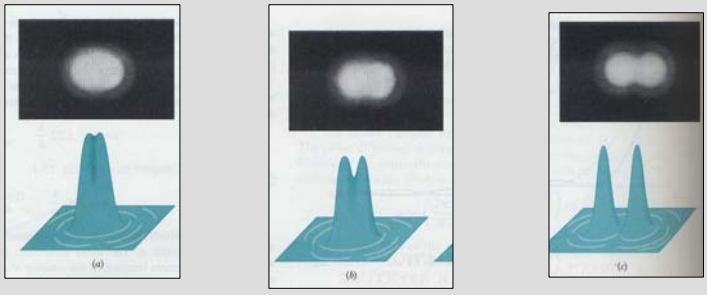


Figure 2.3 Point spread function. The area of the pixel being imaged runs from $-0.5 \leq x \leq 0.5$ and $-0.5 \leq y \leq 0.5$, i.e. centred at (0,0,) but the energy collected by the sensor is nonzero outside this range. The ideal point spread function would be a square box centred at (0,0) with a side length of 1.0.

Resolving Point Sources



Diffraction Pattern

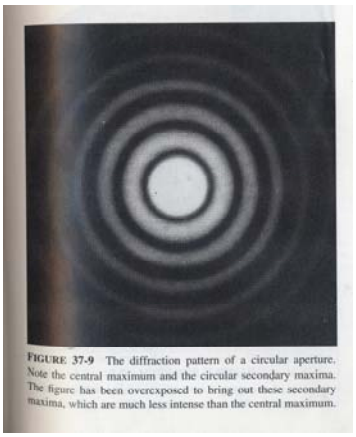


FIGURE 37-9 The diffraction pattern of a circular aperture. Note the central maximum and the circular secondary maxima. The figure has been overexposed to bring out these secondary maxima, which are much less intense than the central maximum.

Rayleigh's Criterion

$$\theta_R = 1.22 \frac{\lambda}{d}$$

λ = wavelength

d = diameter of circular aperture opening

IFOV deficiencies

- Based solely upon geometry and neglects spectral properties of the target
- Point sources are difficult to distinguish

ERE

- **Effective Resolution Element**— ”the size of an area for which a single radiance value can be assigned with reasonable assurance that the response is within 5% of the value representing the actual relative radiance”.

Modulation

- The ratio of maximum and minimum radiance values recorded over a given area.

$$M = \frac{E_{\max} - E_{\min}}{E_{\max} + E_{\min}}$$

Pixels

- A digital image is an ordered set of numeric values and is not necessarily related to IFOV.
- Pixels are more than an average of reflected radiance.

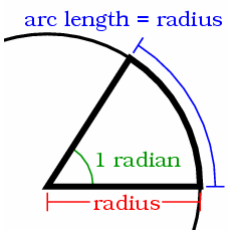
IFOV for AVHRR

Table 3.0.1-1. Spectral band widths (micrometers) of the AVHRR.

Channel #	TIROS-N	NOAA-6,-8, -10	NOAA-7,-9, -11,-12,-14	NOAA-13	IFOV (mr)
1	0.55-0.90	0.58-0.68	0.58-0.68	0.58-0.68	1.39
2	0.725-1.10	0.725-1.10	0.725-1.10	0.725-1.0	1.41
3	3.55-3.93	3.55-3.93	3.55-3.93	3.55-3.93	1.51
4	10.5-11.5	10.5-11.5	10.3-11.3	10.3-11.3	1.41
5	Channel 4 repeated	Channel 4 repeated	11.5-12.5	11.4-12.4	1.30

http://www2.ncdc.noaa.gov/docs/podug/html/c3/sec3-0.htm

Definition of Radian



Ground Swath for AVHRR

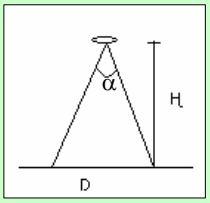
The IFOV for the AVHRR is 1.4 mrad, its altitude is 833 km.

Solve for *D* using the equation: $\alpha = \frac{D}{H}$

1.4 mrad = D/833 km

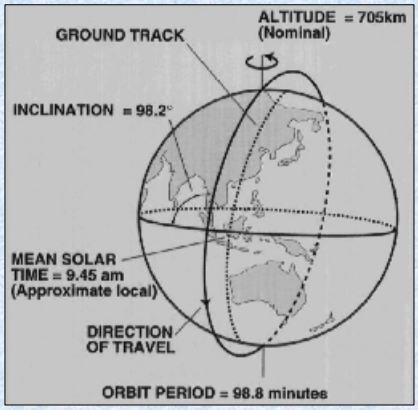
0.0014 rad = D/833 km

D = 1.1 km



3rd Criterion

Periodicity



Period of a Satellite

$$T_0 = 2\pi(R_p + H')\sqrt{\frac{R_p + H'}{gR_p^2}}$$

T_0= orbital period, sec.

R_p= planet radius, km (6380km for earth)

H'= orbital altitude, km

g_s = acceleration due to gravity (9.81m/s^2)

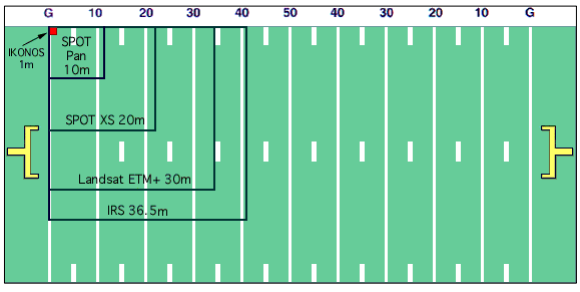
Orbital Period for AVHRR

- $T_0=2\pi(6380+833)\sqrt{[(6380+833)/(0.0098*6380^2)]}$

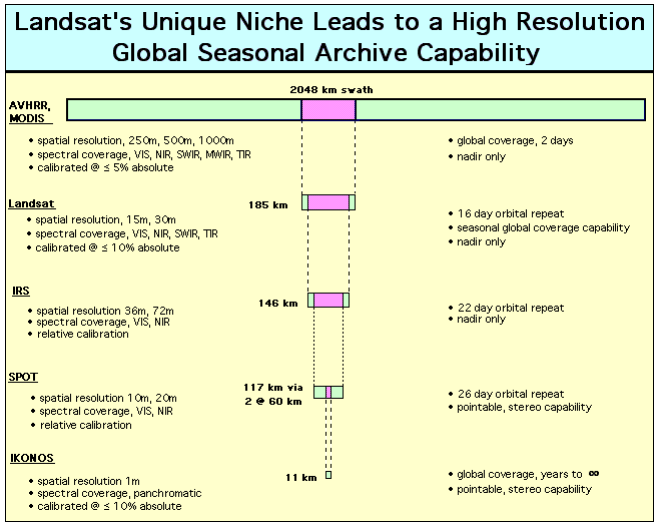
- T_0 = 6091.1sec
- T_0= 1.7hr

- Therefore, The AVHRR orbits earth ~14.1 times per day.

Comparison of Satellite Sampling Resolutions



http://landsathandbook.gsfc.nasa.gov/handbook/handbook_htmls/chapter6/chapter6.html



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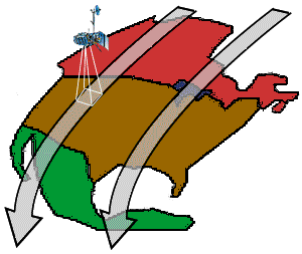
Ground Swath



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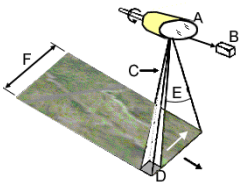
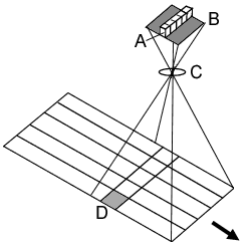
Satellite Sensors

Across Track Scanner

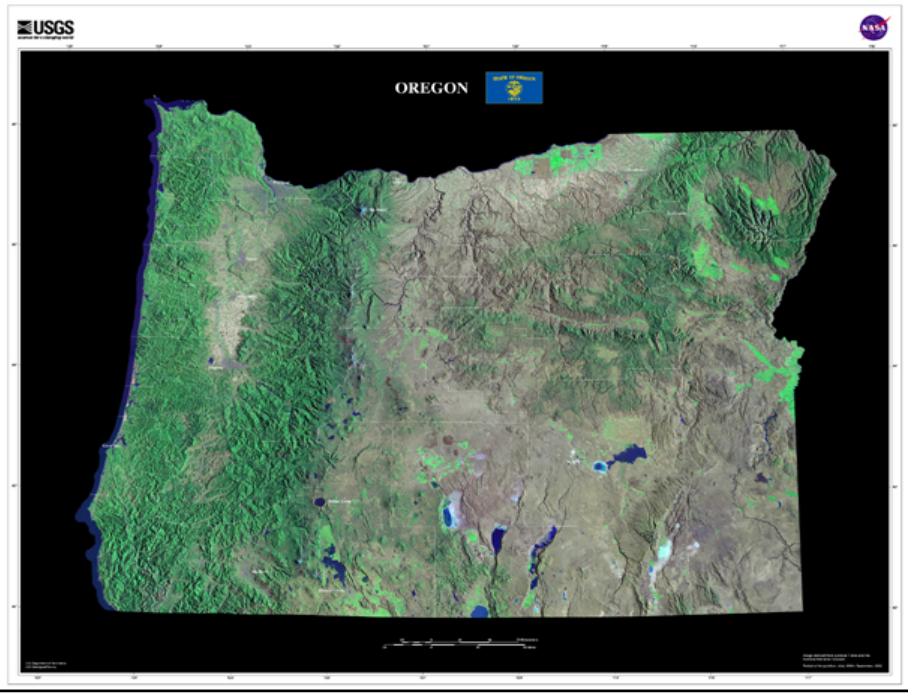


A: Rotating Mirror
B: Detectors
C: Instantaneous Field of View
D: Ground Resolution Cell
E: Angular Field of View
F: Swath

Along Track Scanner



A: Linear Array of Detectors
B: Focal Plane of Image
C: Lense
D: Ground Resolution Cell
Advantages over across track
- no moving parts
- finer spatial resolution
- finer spectral resolution
- better signal/noise ratio
- simplifies image construction



Ground Swath