GRAD590F Homework 1
Satellite Camera Radiometry
Spring 2008

Design an 0.25 meter GSD (S), panchromatic satellite camera for low earth orbit (400-2000 km). Give recommendation for the following and show how you arrived at your values:

- Altitude
- Focal length
- Aperture diameter
- Cycle time (line rate) and exposure time

Use three of Kodak KLI 8811 linear arrays to obtain an effective cross track sampling of 24,000 pixels. We want to obtain a nominally square scene (24k x 24k pixels). Ensure that each scene is acquired in maximum 10 seconds. Accommodate scene elements with 70% reflectance (albedo). Use quantum efficiency of 40% and noise factor K = 0.7 (30% loss). Assume that this sensor can be configured with 32 TDI stages. After selecting a value for H, knowing the detector size d, and knowing S, compute focal length by $d/S = f/H$

Steps:

- Integrate planck function over visible wavelengths (0.4 to 0.7 micrometers) to get solar radiance, L_s
- Use $M_s = \pi L_s \varepsilon$, to get emittance of sun, use 0.99 for emissivity (ε)
- Use area of sun surface to get total flux emitted in the visible $\Phi = 4\pi R_s^2 M_s$
- Get E_e irradiance at earth (top of atmosphere) by total flux divided by area of sphere at sun-earth distance $E_e = \Phi/(4\pi D^2)$
- M_e apparent emittance of brightest scene element by multiplying the prior E_e by 70% max reflectance and by 2x atmospheric attenuation factor 0.64^2
- Get radiance of that scene element by $L = M_e/\pi$
- Use green light (550 nm=0.55 micrometer) to obtain energy per photon ($h\nu$) and use the full well (saturation) level to get max energy per detector (Q)
- Use max scan time to get line rate, get T_e and extended T_{ee} via TDI stages.
- Use the design equation $Q = q_e k L \pi R_a^2 \frac{1}{H^2} T_{ee} S^2$ to make a table of possible aperture and altitude values. Choose the smallest aperture as the solution.

References

- IRIS tutorial on course web page
- Rees, W.G., 2001, *Physical Principals of Remote Sensing*, Cambridge Univ. Press
- Elachi, C., 1987, *Introduction to the Physics and Techniques of Remote Sensing*, John Wiley & sons
- www.kodak.com / all businesses / image sensor solutions / products / linear CCD / KLI 8811 / specifications / product summary & data sheet