Homework #3

SOLUTION

Geology 4113 (Remote Sensing)

Assigned Feb. 9, 2018

Due February 16, 2018

Sabins #3.06: (10 points) The oscillating mirror of the TM completes 14 scans each second. Calculate the dwell time for each ground resolution cell.

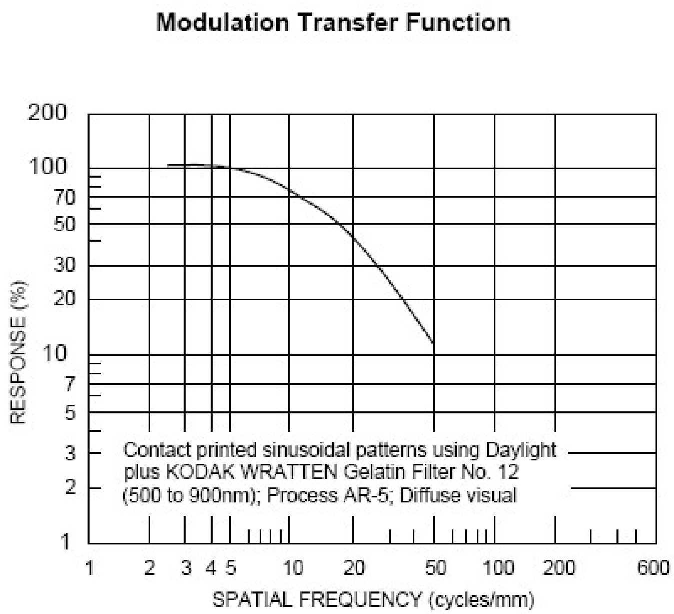
From Table 3-2 TM has a swath width of 185 km, and a resolution of 30 m (in the visible and reflected IR). That means it has (185,000 m/swath) / (30 m/pixel) = 6167 pixels per swath. If it covers those in 1/14 second then the dwell time per pixel is (1/14 s) / (6167 pixels) = 1.16×10^{-5} *s/pixel = 11.6 μs/pixel.*

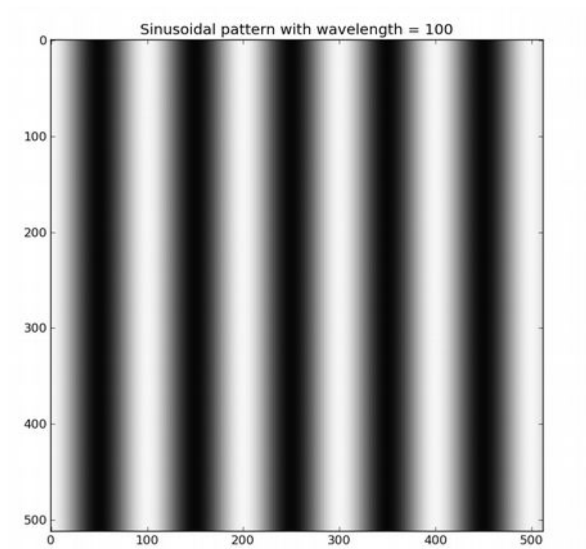
Sabins #3.08: (15 points) The northern portion of the TM mosaic of the Central Arabian Arch (Plate 4) covers parts of two major sand seas, shown by bright orange-yellow signatures. There are two distinctly different patterns of sand dunes. Describe each of the dune patterns, including the shape, alignment, and size (of individual dunes). *(RRH note: This will require a short paragraph. You should be as specific as possible in describing terms such as size and shape. Give sizes in km, list azimuths (if relevant) in degrees E of N.) Although you don't need to read it to answer this question, in case you are interested there is a more detailed discussion of the geology of the region on pages 346 – 357. We will cover that later in the semester)*

The northeast dune field consists of long linear dunes. They are spaced a distance of ~1.2 mm apart, which from the scale at the bottom corresponds to 1.2 mm × (100km / 32 mm) = 1.2 mm × 3,120,000 = 3.7 km. They are more-or-less parallel, oriented with the long axis at 115^o *(E of N), or equivalently,* 295^o*, which is parallel to the edge of the mountains. The longest ones extend for at least 60 mm ⇒ 187 km, with the NW edge cut off the picture. The dune structure appears to die out near the NE corner of the one frame, but may reappear after a gap, in a frame further to the east. Although less distinct, the dunes in that eastern frame appear of similar character, but their orientation has been shifting to follow the mountains, and are oriented at approximately* 140^o*. Including the region on this other frame, the length of the dune field is over 400 km, and its width (again, partially cut off), is almost 100 km.*

A second type of dunes appears in two parallel bands of sand running NNW to SSE within the bedrock exposures. These dunes are much smaller and NOT organized into linear patterns. Rather the individual dunes have roughly equal dimensions in different directions, approximately 0.5 to 1.0 mm on the map, or 1.5 to 3 km in the field. While some subtle patterns exist in their positions, the pattern they form is much more randomly than with the linear dunes.

1) **(Modulation Transfer Function (MTF) 15 points)** The following is the MTF which Kodak publishes in their film information sheet for AEROCHROME III Infrared Film 1443, used for aerial photograph. Rather than being calibrated in cycles/radian, because this applies to film, it is calibrated in cycles per millimeter. It shows how higher and higher frequency (smaller and smaller spacing) light-and-dark sine waves patterns will blur out when recorded on that film.





a) Find the frequency (given in cycles per millimeter) at which the response drops to 50%.

The MTF of Aerochrome III IR film 1443 declines to 50% when the spatial frequency is about 18 cycles per millimeter. Note that as used in the later parts, the distance between crests of the pattern will be (1/18) mm. Mathematically, L'_{film} *or* $\lambda_{film} = 1 / \upsilon_{film}$
where λ_{film} *is the spatial wavelength at the resolution limit, i.e. the distance between peaks in the sinusoidal resolution pattern, and* υ_{film} *is the spatial frequency which corresponds to that pattern.*

b) Assume this film is used with a "perfect" camera lens which has a focal length of 0.25 meter. What spatial frequency given in cycles per radian, corresponds to that 50% point?
When used with an f=0.25 meter focal length lens the angle which corresponds to a focal plane distance of $L' = (1/18)$ *mm will be* $\theta = (L' / f) = (1/18)\text{mm} / 250\text{ mm} = (1/4{,}500)$ *radians. (I've used the approximation* $\tan(\theta) = \theta$ *for small angles like this. Now we want to describe the resolution of the camera (film+lens) system in terms of cycles per radian, that is the number of cycles of the pattern which fit in a full radian. If the spacing between crests of the pattern in*

(1/4,500) radians, there will be $\upsilon_{camera} =$ *4,500 cycles per radian which could also be written as* $\upsilon_{camera} = (f / L') = f \times \upsilon_{film}$.

c) Assume the camera is being used from an aircraft flying at 5,000 meters. What distance on the ground corresponds to this spatial wavelength? That is, suppose you wanted to draw a light-and-dark sine-wave pattern on the ground which would be "blurred" just enough to reduce its apparent contrast by 50% How big would that sine-wave pattern be as measured by its wavelength – the distance between one bright band and the next bright band? (Note. We're talking about wavelengths of the light and dark pattern, <u>not</u> wavelengths or frequencies of the light itself.)

The spacing on the ground between peaks of the pattern, a distance H = 5,000 m away from the lense will simply be $L = \theta \times H$ *= (1/4,500) radians × 5,000 m = 1.11 m. This could also be written* $L = H / \upsilon_{cameram}$ *or using the equations discussed earlier for scale,*
$L = L' \times H / f$.