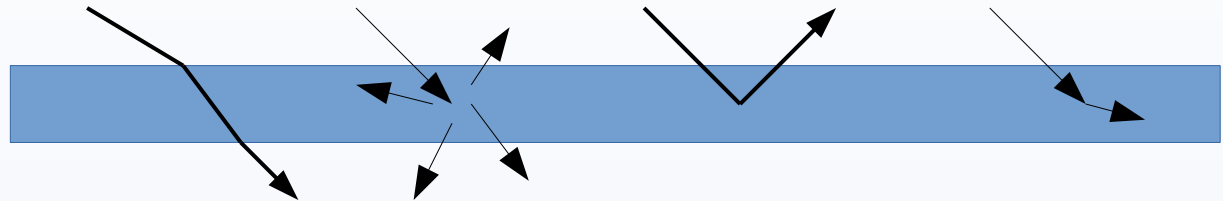
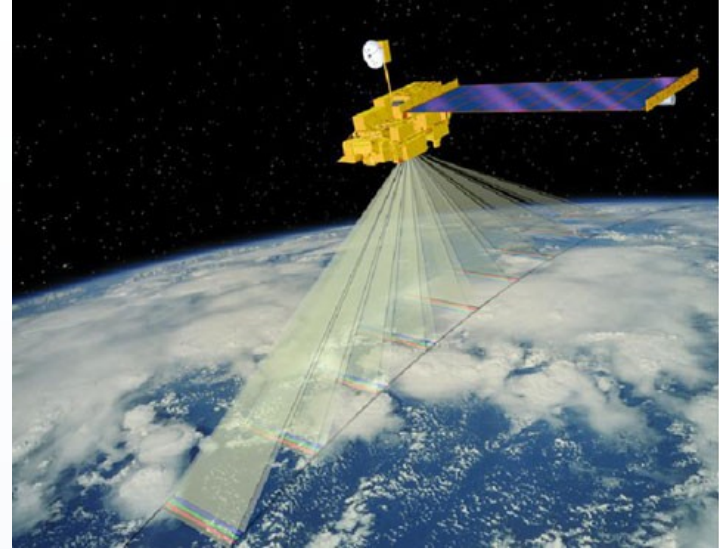


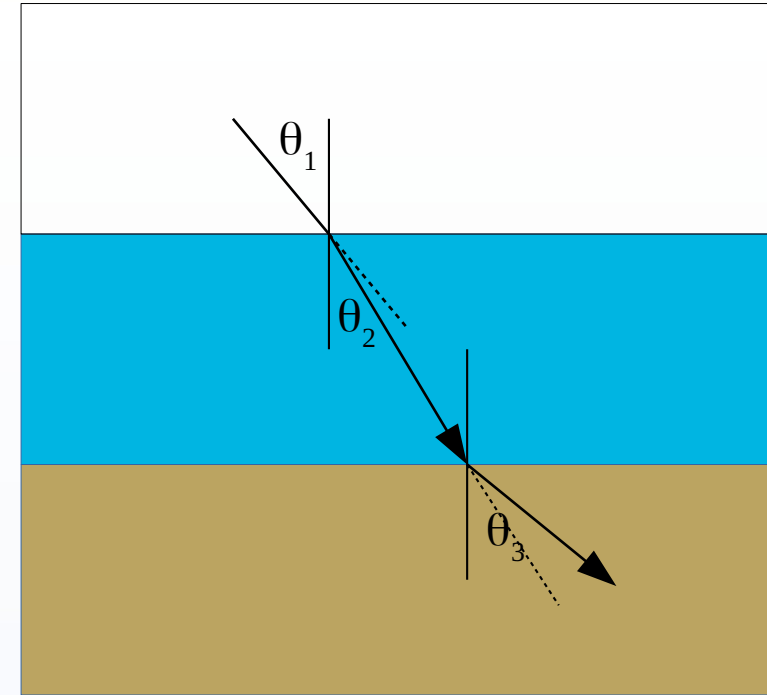
EGM310 – Remote Sensing and GIS

Week 9, Part 3: Interaction with the Atmosphere

- Earth has an atmosphere.
 - Between target and sensor
 - ⇒ EMR has to go through the atmosphere
- Interaction can go one of four ways:
 - Refraction
 - Scattering
 - Reflection
 - Absorption



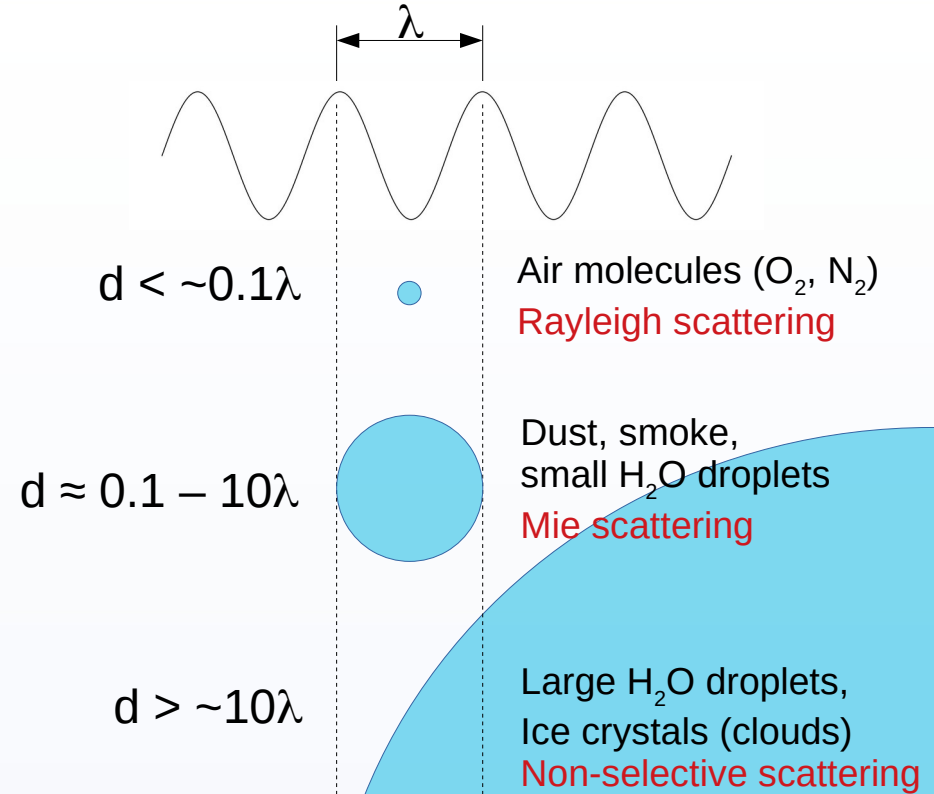
- **Recall:** traveling between two substances changes the speed of light
 - Depends on temp., air pressure, humidity/vapor pressure, λ
 - This changes the travel time for the signal
 - ⇒ Causes an apparent displacement of object
- The **refraction index** $n_i > 1$ depends on the density of the substance
- The larger the incidence angle, the more influence refraction has
 - Think sunsets/moonrises, mirages
- Becomes more of a problem with high-resolution images (~ 1 m)



$$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$$

$$n_i = \frac{c_0}{c_i}$$

- **Diffusion** of EMR by atmospheric particles with **unpredictable direction**:
 - Absorption + re-emission (small-diameter particles)
 - Physical scattering (large-diameter)
- Three main types, depending on particle size



Rayleigh scattering

- Particle is much smaller than λ
- Depends on:
 - Refraction index
 - Density of air
 - Wavelength
- Amount of scattering: $\sim \lambda^{-4}$
 - ⇒ Blue light scatters ~5 times more than red light

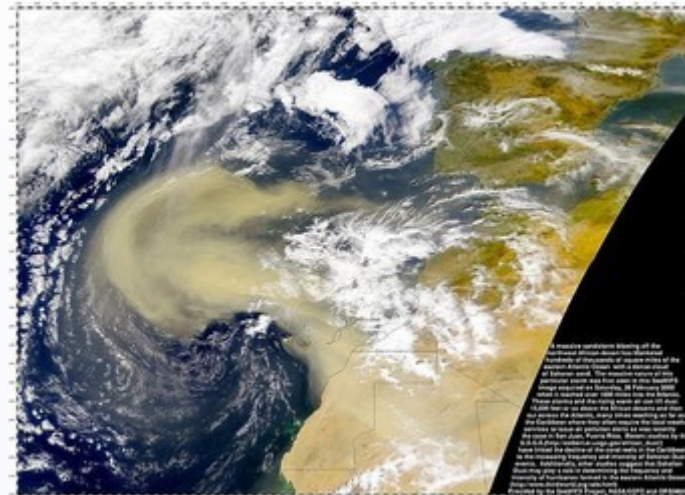


Mie scattering

- Particle is about the same size as wavelength
- Stronger than Rayleigh scattering (less light goes through)
- Less of a difference with λ :
 - Amount of scattering: $\sim \lambda^{-1}$
- Primarily smoke, pollution, dust particles
- Also smaller water droplets

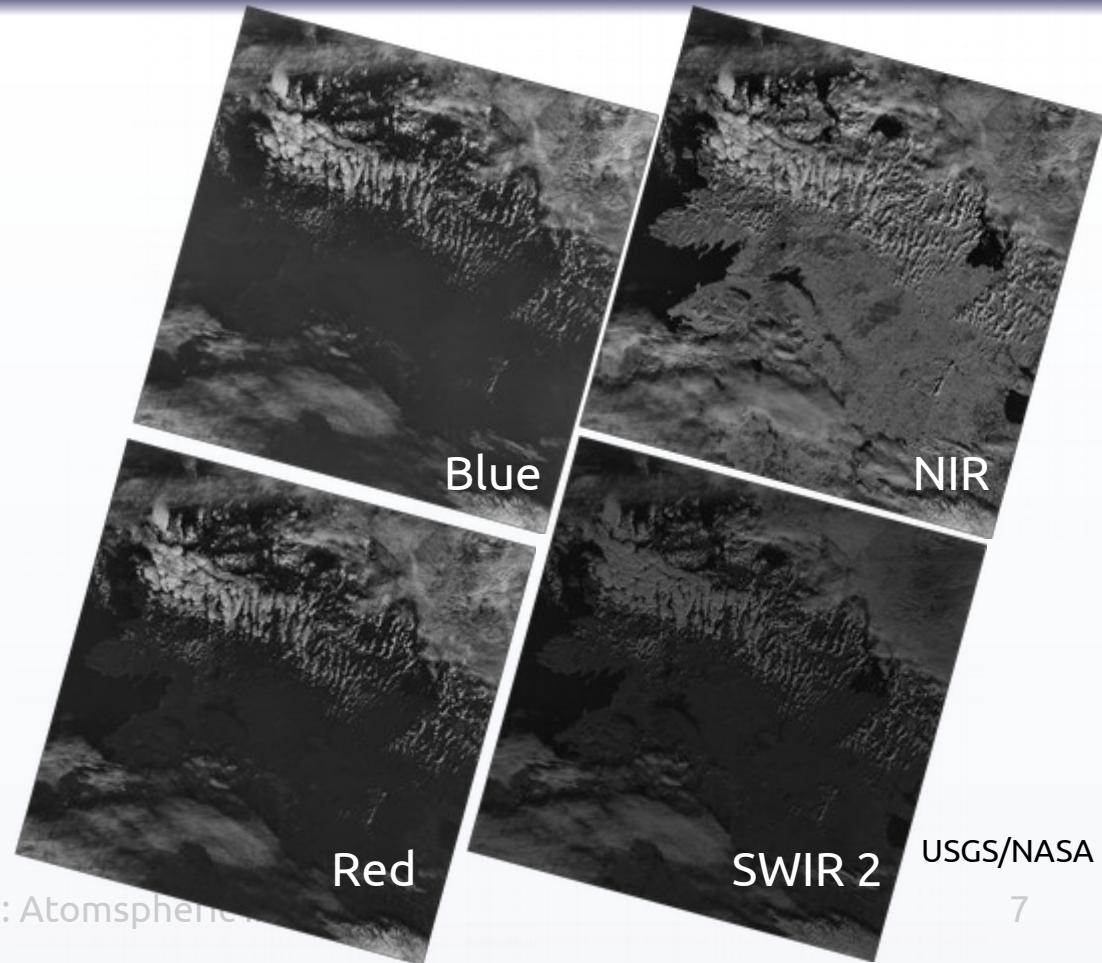


@PettyCommaAngie



Non-selective scattering

- Particle is much larger than wavelength
- Does not depend on λ
 - All λ scattered equally
- Primarily large water droplets, dust particles
- Examples:
 - Clouds
 - Fog



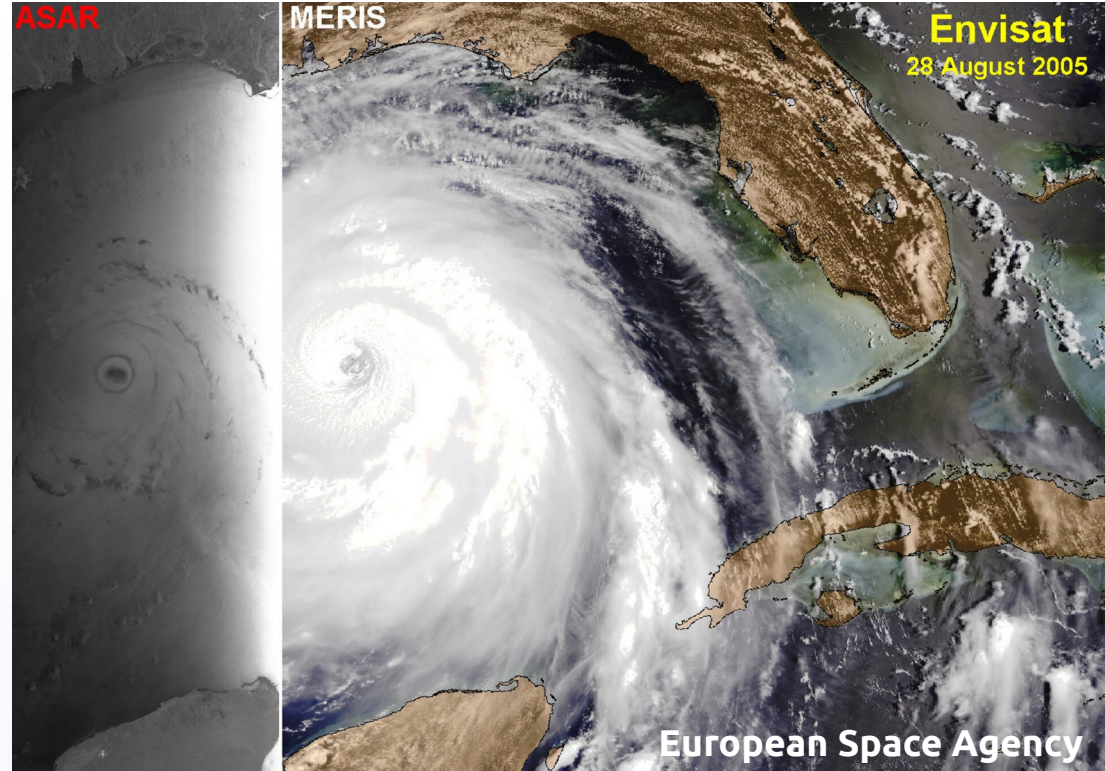
Effects of scattering

- Shadows aren't completely dark
- Atmospheric perspective
- UV not normally used for remote sensing
- Radiation from outside field of view reaches sensor
- Decreased contrast

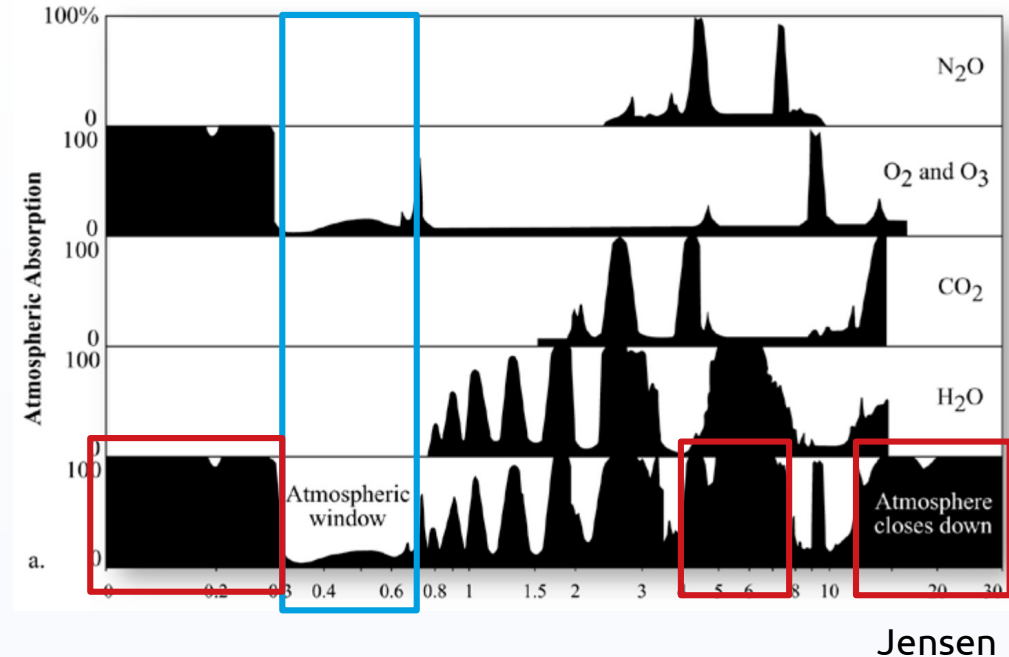


Joaquim Alves Gaspar, CC BY-SA 2.5 via Wikimedia Commons

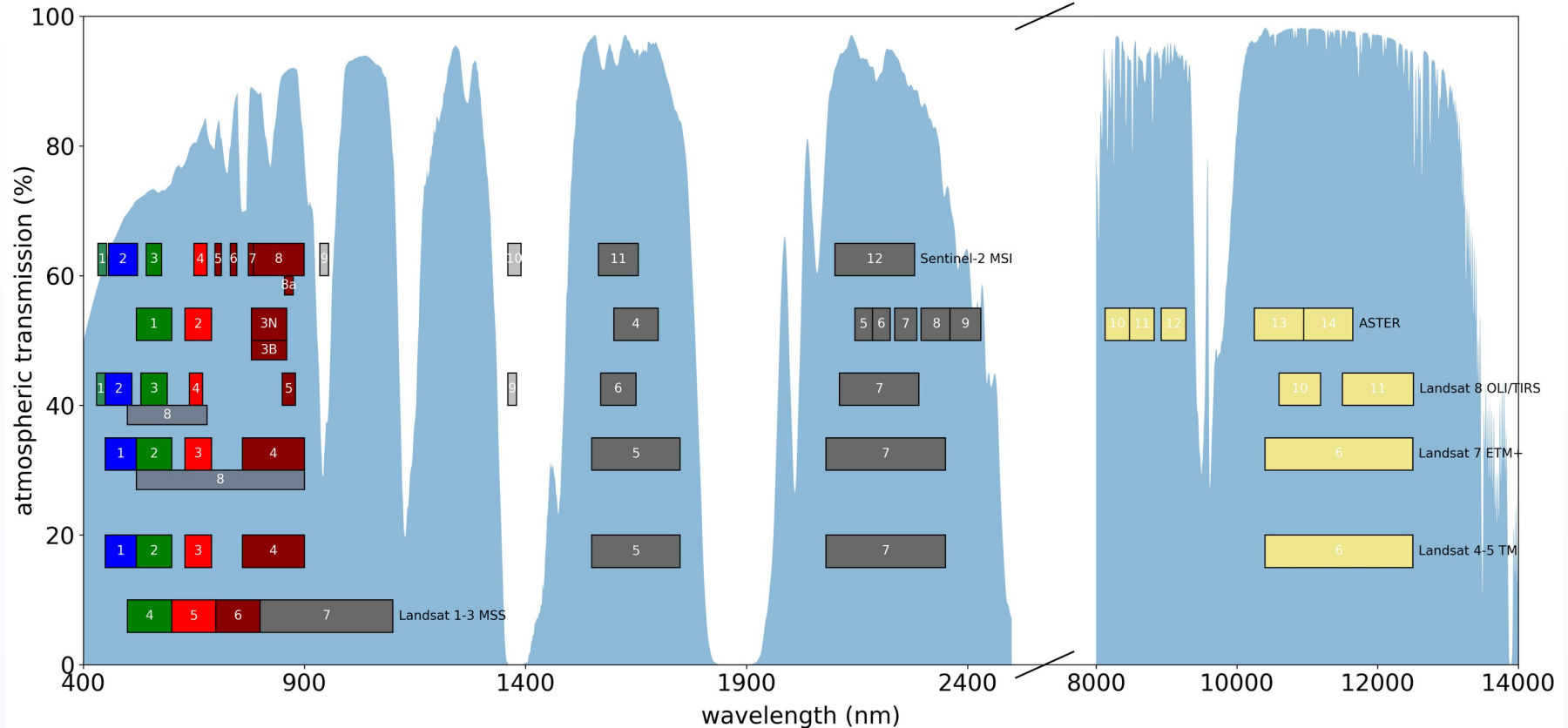
- Either:
 - Absorption and re-emission of EMR
 - Physical scattering directed away from surface, toward sensor
- Mostly clouds



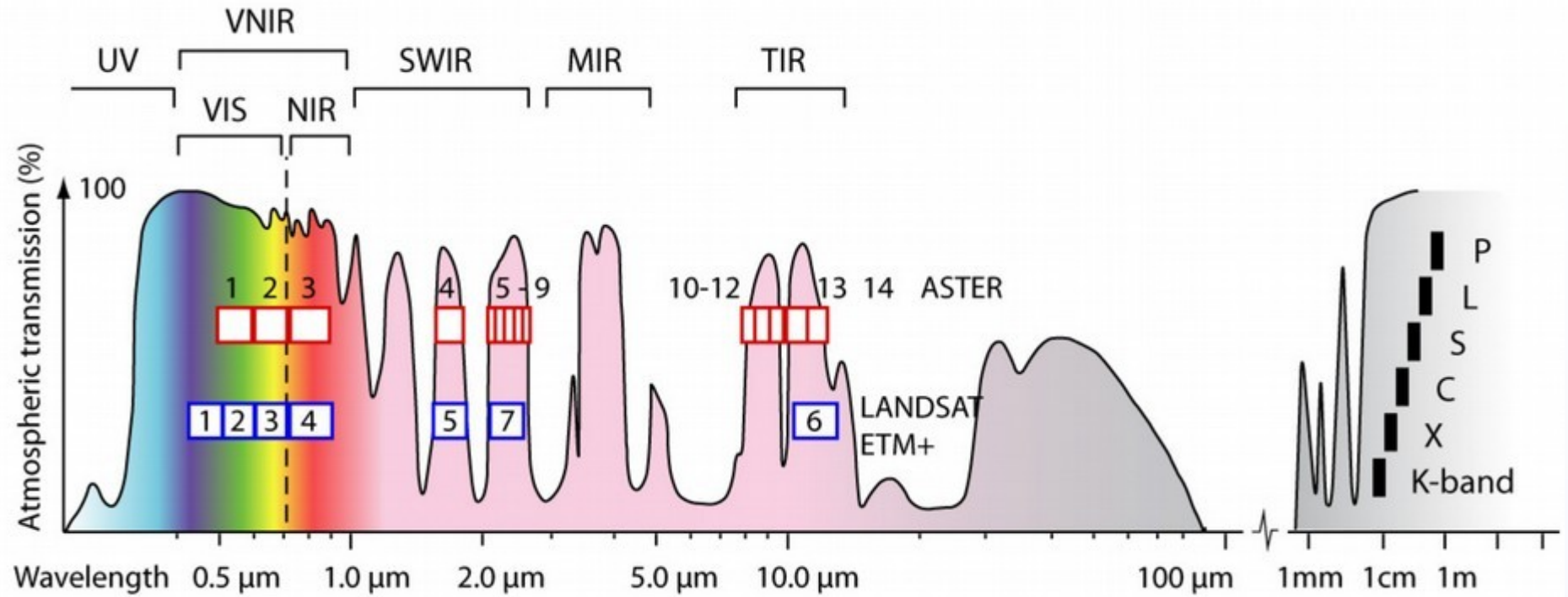
- Energy also absorbed, transformed, re-emitted by particles in atmosphere
- Depends on wavelength, molecule
- Relatively little absorption in visible range
- Near-total absorption in UV, parts of IR



Absorption bands/windows



Absorption bands/windows



A. Kääb

- The Atmosphere: good for life, tricky for remote sensing
- Incoming EMR can either refract, scatter, reflect, or be absorbed by atmosphere
 - Depends on properties of EMR, atmosphere
- We design satellite sensors to make use of “windows” in the atmosphere

- Lillesand, Kiefer & Chipman – Chapter 1
- Campbell & Wynne – Chapter 2
- Natural Resources Canada [Remote Sensing Tutorials](#)
- Why the sky is blue [[How&Why](#)]