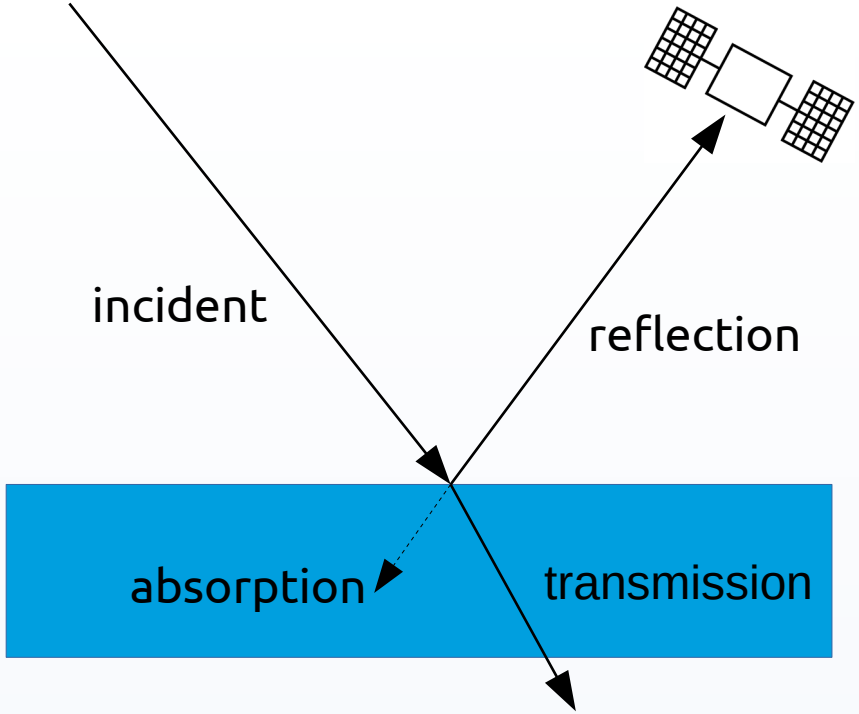
EGM703 – Advanced Active and Passive Remote Sensing

Week 1, Part 5: Atmospheric Correction

Atmospheric effects

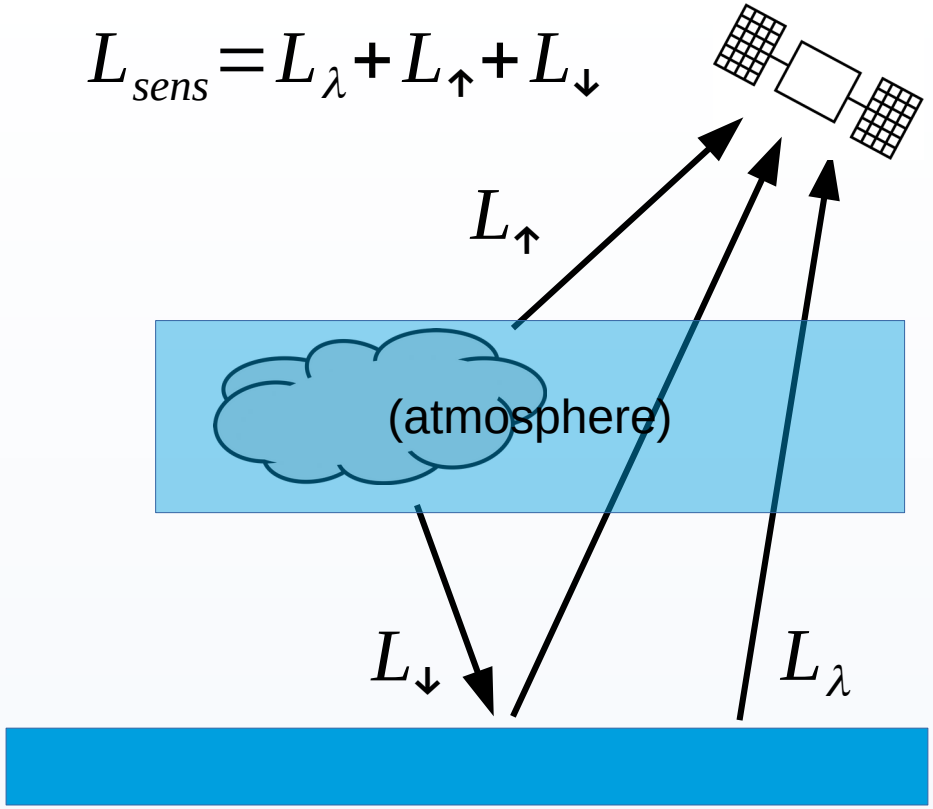
- Recall: the atmosphere is also made up of atoms/molecules
  - This changes what we measure at sensor
- Molecules:
  - Absorb (↓ L_λ, estimated T)
  - Emit (↑ L_λ, estimated T)
  - Transmit
- Creates a bias, or shift, in the measurement
- Varies based on conditions at acquisition



$$\Phi_i = \Phi_r + \Phi_a + \Phi_t$$

So what does the sensor see?

- Not much incident radiation in thermal infrared → little reflection
- Large λ → little scattering
- Signal recorded (L_{sens}) consists of:
  - Radiation emitted by the surface, L_{λ}, modified by atmosphere
  - Reflected downwelling radiation, $L_{\downarrow}$
  - Upwelling radiation (emitted by atmosphere), $L_{\uparrow}$



Radiative transfer

- A simplified version of the radiative transfer equation:

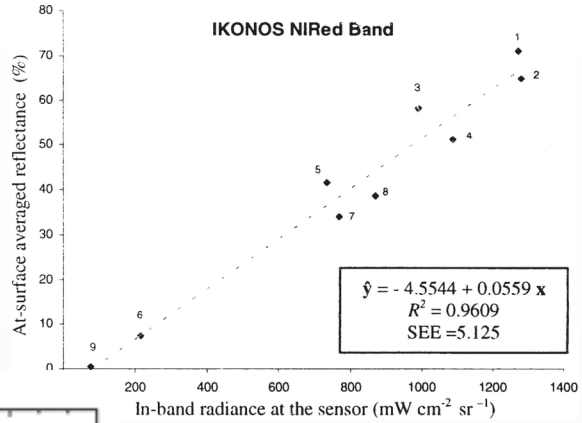
$$L_i = \left[\varepsilon_i B_i(T_s) + (1-\varepsilon_i) S_i^{\downarrow}\right] \tau_i + S_i^{\uparrow}$$

Emitted by surface
Emitted at bottom of atmosphere
Emitted at top of atmosphere

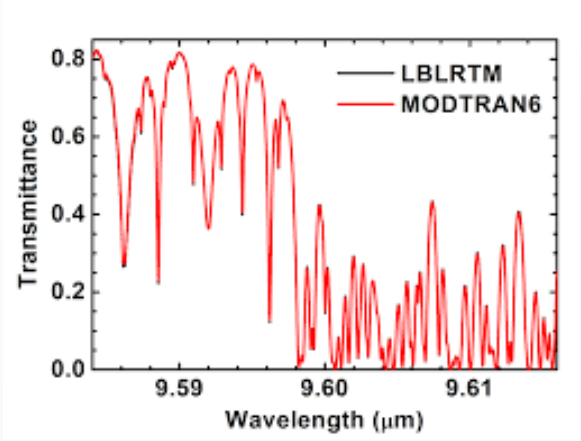
  - $B_i(T_s)$: blackbody radiance for temperature T_s
  - $S_i^{\downarrow}$: atmospheric irradiance
  - $S_i^{\uparrow}$: atmospheric radiance
- Key parameters:
  - Surface emissivity
  - Transmittance (depends on atmospheric composition)
  - Atmospheric temperature

Atmospheric correction

- Empirical Line Method (ELM)
  - Linear regression against in-situ measurements
  - Downside: requires in-situ measurements
- Radiative Transfer Model
  - Attempt to model atmospheric conditions
  - e.g., MODTRAN (Berk et al., 1987, 2014), TES (Gillespie et al., 1998)

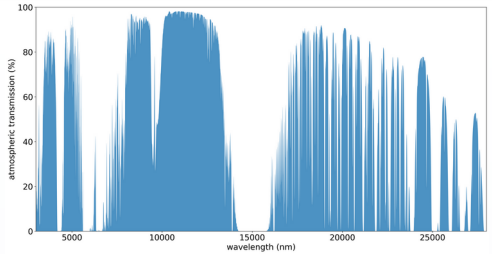


Karpouzli & Malthus, 2003



modtran.spectral.com

Split-window methods



- Recall: L_λ, ε_λ are dependent on λ
- The same is true for atmospheric transmittance, τ
- Observations at two λ ("split window" or "two-channel"):
  - estimate atmospheric components
  - recover surface brightness temperature
  - can also estimate emissivity
- After some math(s) occurs, T_s is estimated as a linear combination of T in different bands

Summary

- The atmosphere exists, which is mostly a good thing.
- Sensor measures both ground and atmospheric components of radiance
- To correct (remove) atmospheric component:
  - Use in-situ data;
  - Model atmospheric parameters;
  - Or use observations at multiple wavelengths

Additional resources

- Lillesand, Kiefer & Chipman – Chapter 7.2
- Campbell & Wynne – Chapter 2.5, 11.2, 11.3
- Jensen – Chapter 6
- Berk et al., 1987 [Spectral Sciences, Inc.]
- Berk et al., 2014 [WHISPERS]
- Gillespie et al., 1998 [IEEE Trans. Geosci. Rem. Sens.]
- Karpouzli and Malthus, 2003 [Int. J. Rem. Sens.]