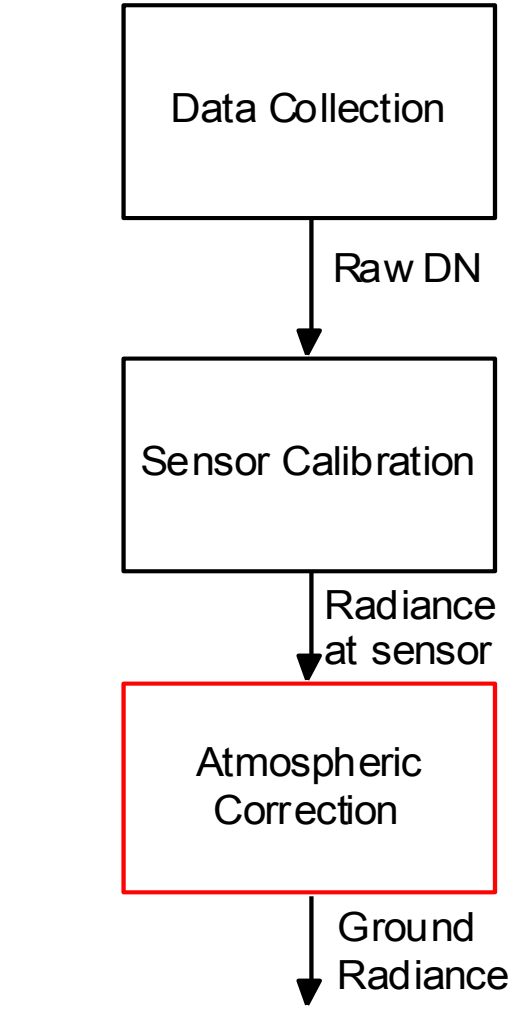
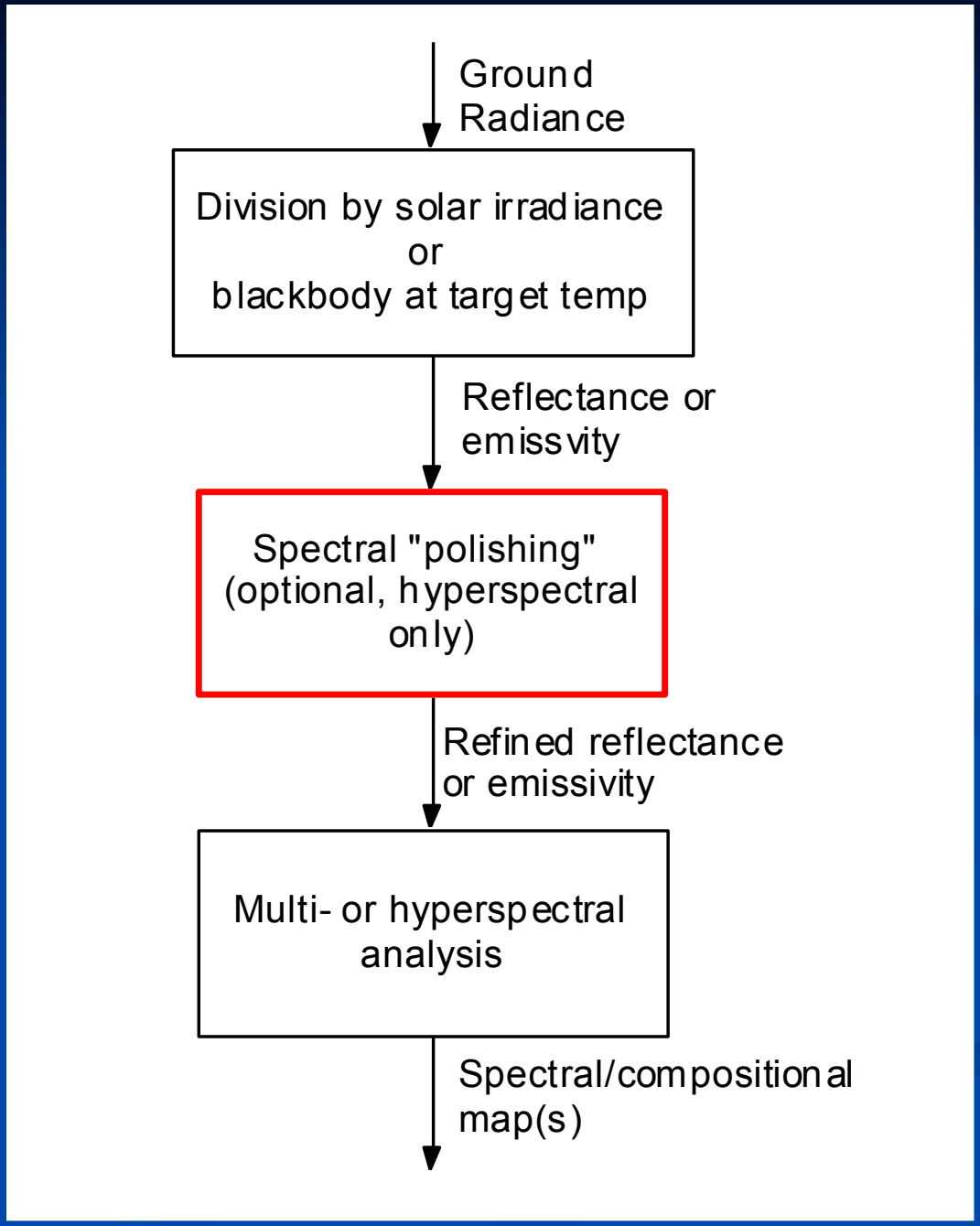
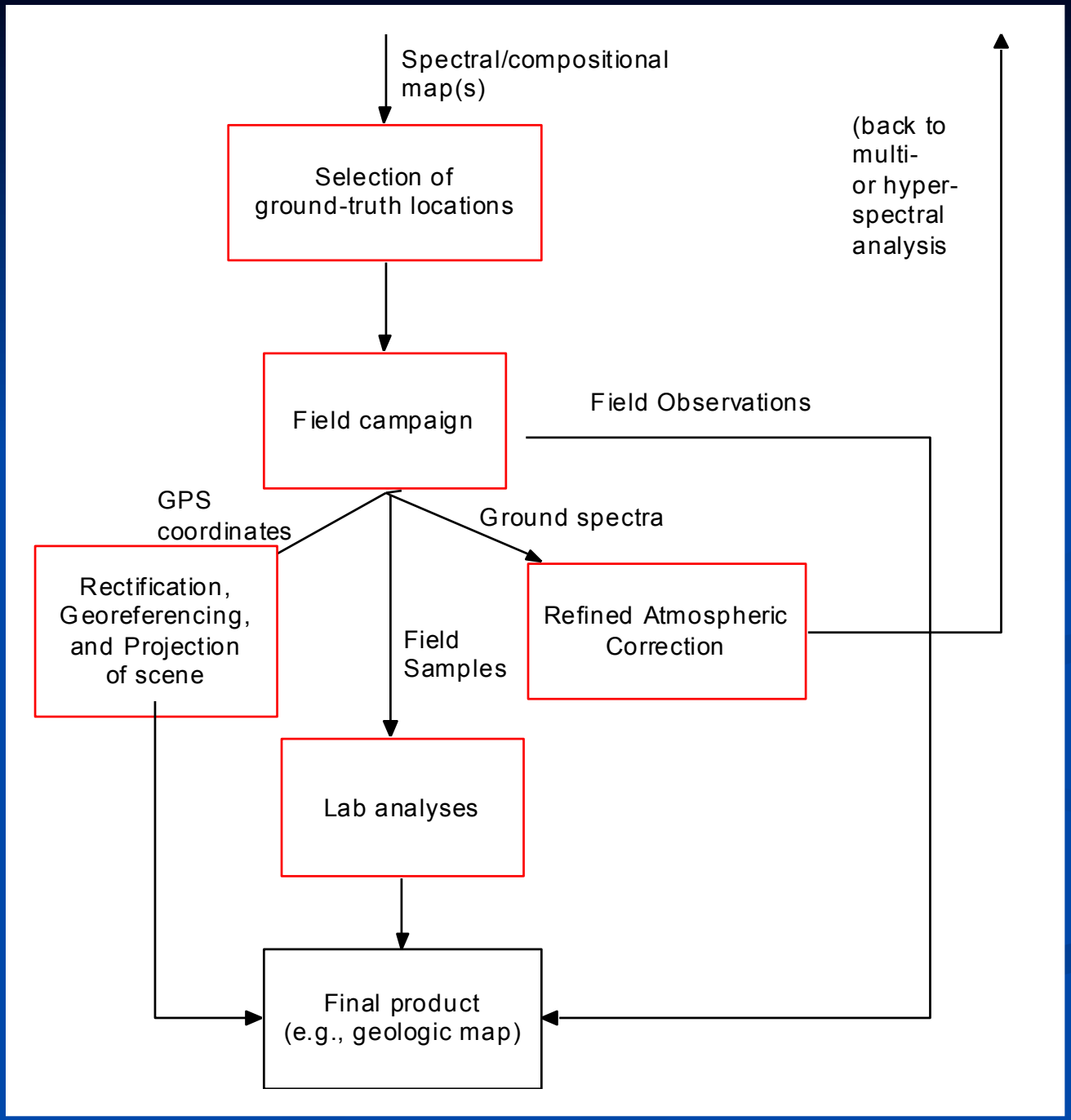
Putting It All Together: A Typical Flowchart for Remote Sensing Projects



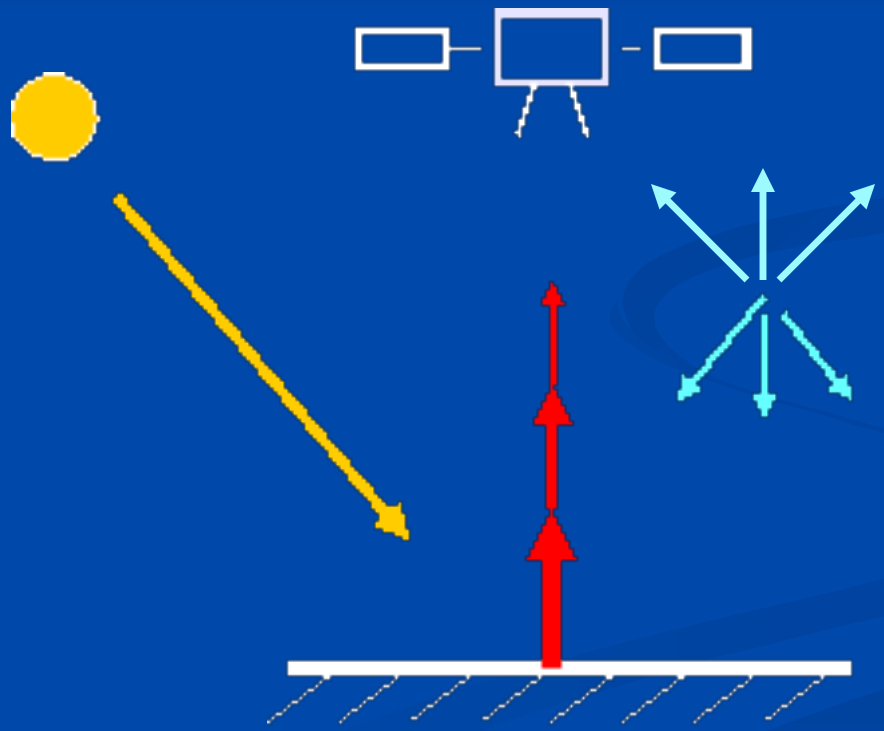

Ground Radiance
Division by solar irradiance or blackbody at target temp
Reflectance or emissvity
Spectral "polishing" (optional, hyperspectral only)
Refined reflectance or emissivity
Multi- or hyperspectral analysis
Spectral/compositional map(s)


Spectral/compositional map(s)
Selection of ground-truth locations
(back to multi- or hyper-spectral analysis
Field campaign
Field Observations
GPS coordinates
Ground spectra
Rectification, Georeferencing, and Projection of scene
Field Samples
Refined Atmospheric Correction
Lab analyses
Final product (e.g., geologic map)

Atmospheric Effects

For measurements of reflected sunlight (Vis/NIR):

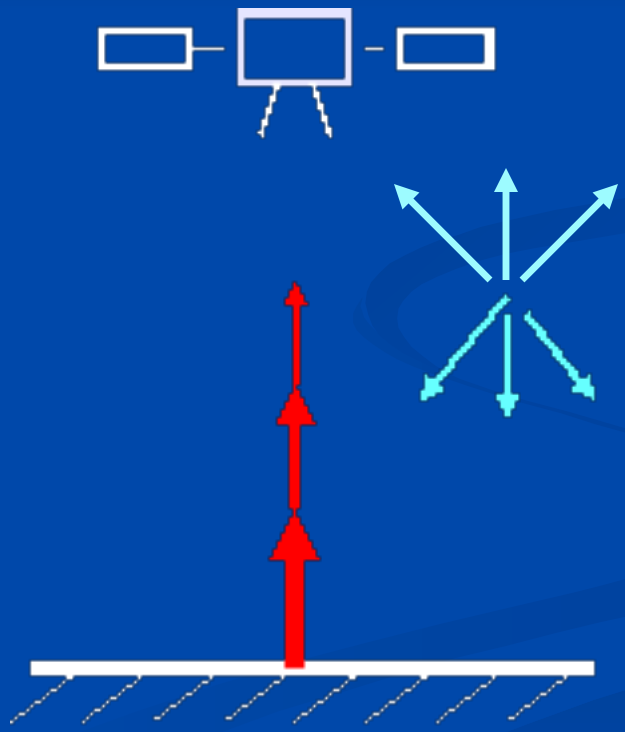
$$I_{sensor} = \left[RJ_{sun} + RL_{atm\_down} \right](1 - 2\tau_{atm}) + L_{atm\_up}$$



Atmospheric Effects

For measurements of self-emitted light (TIR):

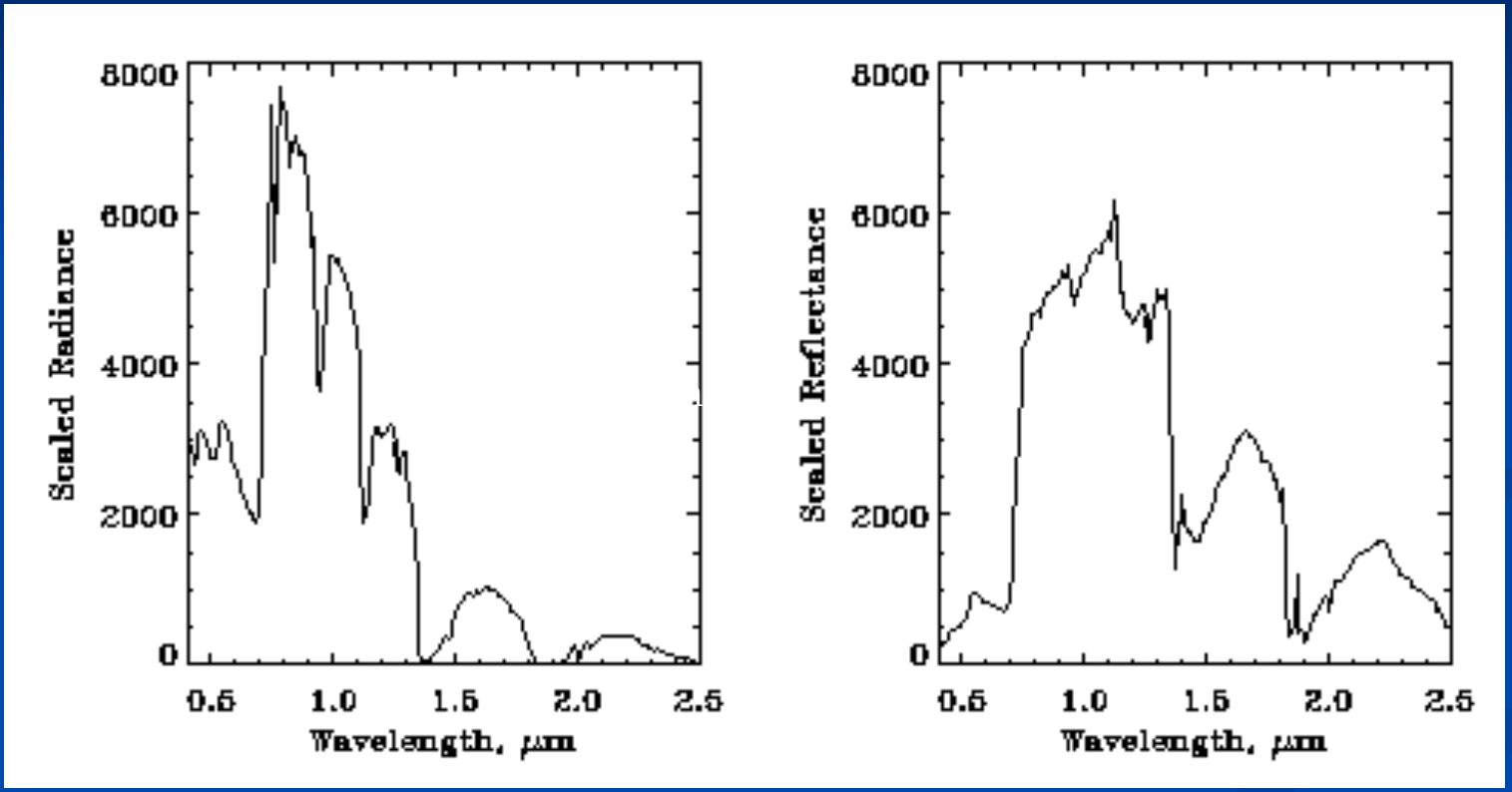
$$I_{sensor} = \left[\varepsilon B_{surface} + RL_{atm\_down}\right](1-\tau_{atm}) + L_{atm\_up}$$



Atmospheric Correction

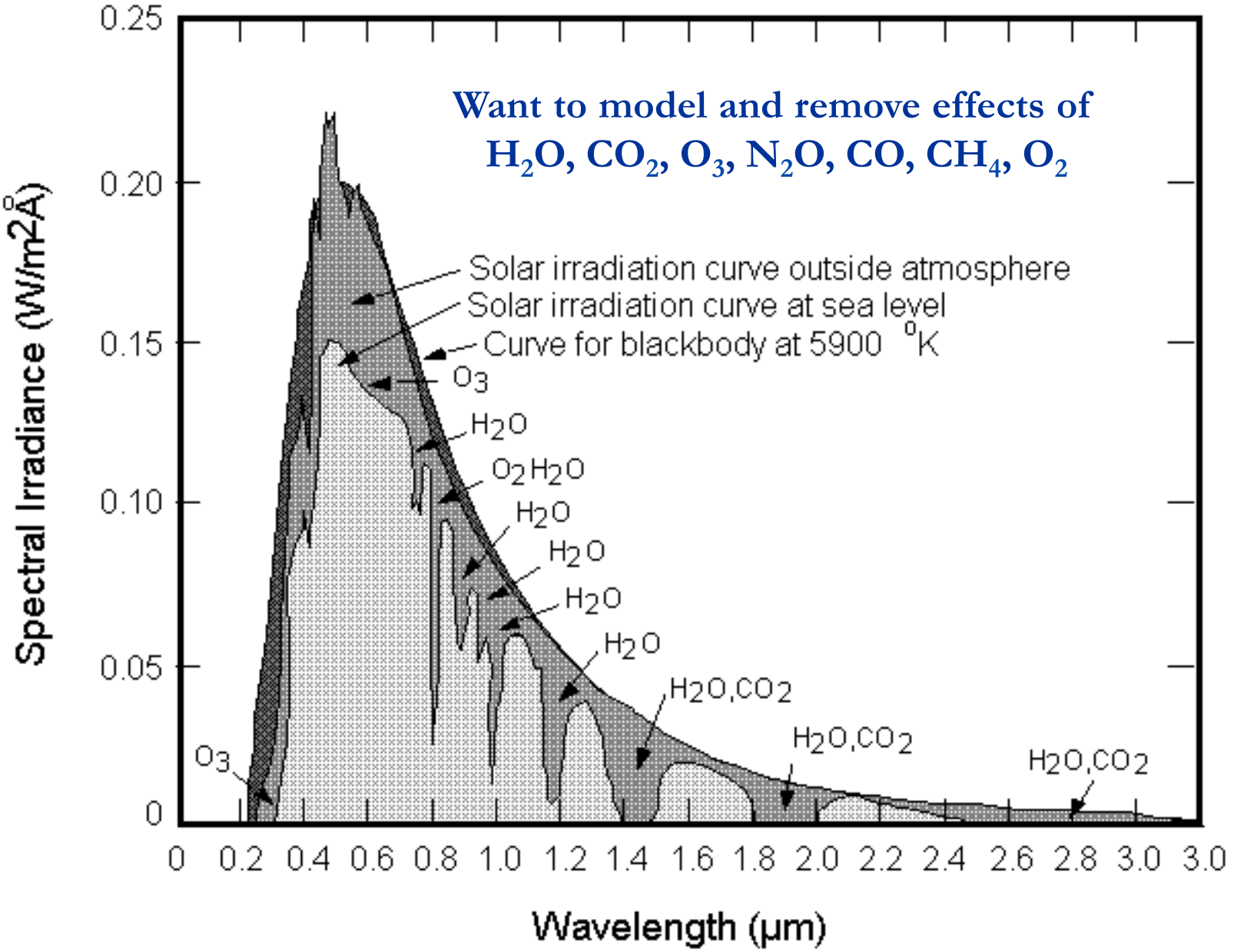
Model-based corrections:

- Goal is to remove effects of absorption, emission, and scattering of photons by the atmosphere
- For the geologic remote sensing analyst, typically involves use of one of several "black boxes", e.g. MODTRAN or ATREM.



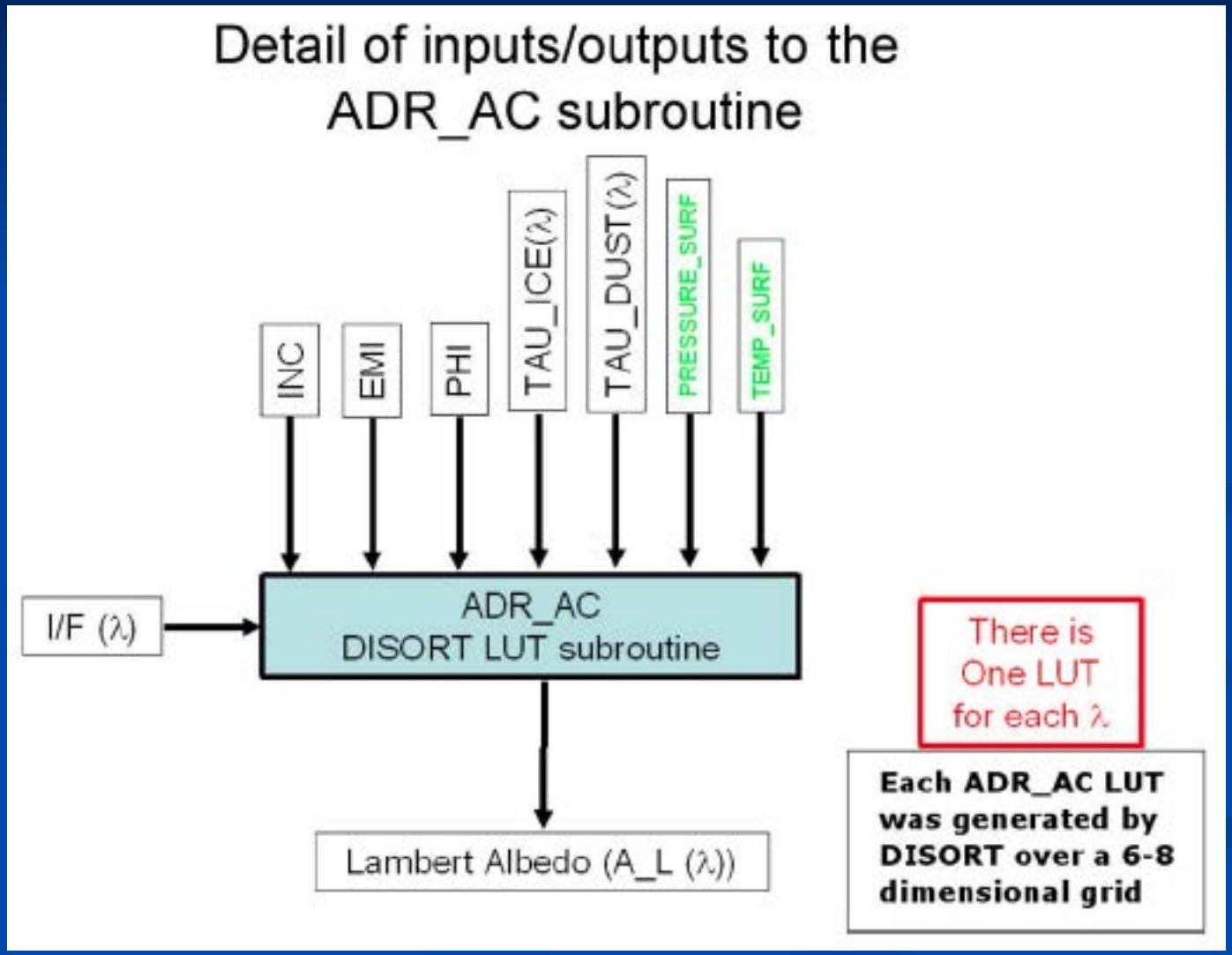
ATREM input

ATREM output



Solar Spectrum with Atmospheric Absorbtions

DIScrete Ordinates Radiative Transfer (DISORT)



McGuire et al. (2008)

Other types of atmospheric correction:

- IARR (Internal Average Relative Reflectance): Calculates the reflectance of every pixel in the scene relative to the average of all pixels in the scene averaged together.

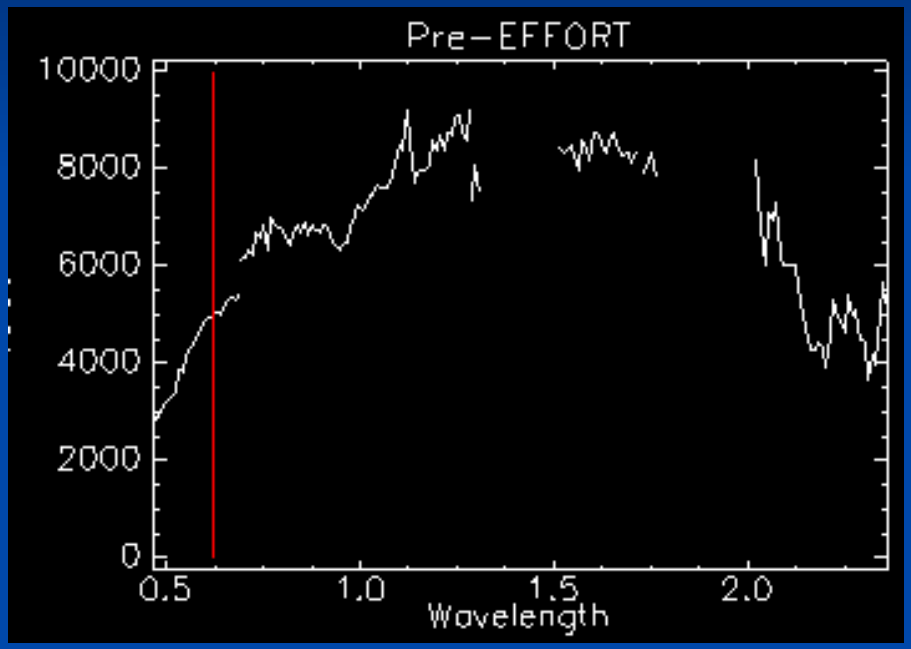
  - Works best when there are a wide variety of mineralogies in scene, but not great with vegetation.
  - Useful when nothing is known about the scene – e.g., no ground truth spectra, and no model-based atmospheric correction available.
  - Will mute the spectral contrast of components present in a large fraction of the scene.

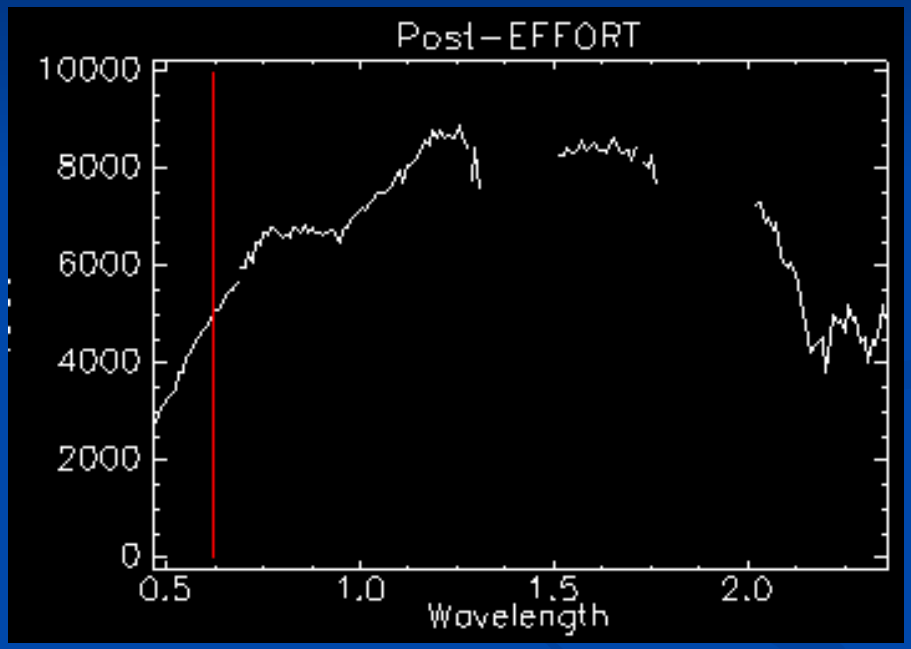
Other types of atmospheric correction:

- Empirical Line Calibration
  - Employs spectra collected on the ground from known locations in the scene.
  - By comparing pre-correction remote spectrum to ground spectrum from same location, correction values are derived for each wavelength.
  - Works best when multiple locations used, especially if some have low overall reflectance and others have high overall reflectance.
  - Similar in some ways to *volcano scan* technique used on Mars (divide by "atmospheric spectrum" derived from comparing summit and flank of dusty Olympus Mons)

Spectral Polishing

- Goal is to remove any residual atmospheric effects in the spectra
- EFFORT: Empirical Flat Field Optimized Reflectance Transformation:
  - A purely mathematical technique – no physics or geology used.
  - Takes advantage of fact that residual atmospheric effects are usually narrow spectral features, whereas mineralogic features are usually somewhat wider.
  - Fits n-degree polynomial model to spectra from all pixels. For each channel, calculate linear regression of correction factor between data and model. Average correction factors from all pixels


Pre-EFFORT
10000
8000
6000
4000
2000
0
0.5
1.0
1.5
2.0
Wavelength


Post-EFFORT
10000
8000
6000
4000
2000
0
0.5
1.0
1.5
2.0
Wavelength