Some Musings On Current Evolutionary Trends In The Space Business

CubeSat Workshop
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Tom Chrien
tchrien@raytheon.com

Some Formidable Lizards

- **Space-Based InfraRed Systems- High (SBIRS-High)**
- **National Polar-orbiting Operational Environmental Satellite System (NPOESS)**
- **Geostationary Operational Environmental Satellite (GOES)**
- **Transformational Communications Satellite (TSAT)**
- **Global Positioning System (GPS)**

…and their environmental niches

Missile Warning
SIGINT
Space Control
Meteorology
Communication
Planetary Science
Environmental Monitoring

IMINT
MASINT
Mapping
Navigation
TV/Radio
Earth Science
Astronomy

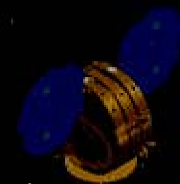
Punctuated Equilibria

Large, stable, central populations exert a strong homogenizing influence. New and favorable mutations are diluted by the sheer bulk of the populations through which they must spread. They build slowly in frequency, but changing environments usually cancel their selective value long before they reach fixation. Thus, phyletic transformations in large populations should be very rare…

But small, peripherally isolated groups are cut off from their parental stock. They live as tiny populations in the geographic corners of the ancestral range. Selective pressures are usually intense because peripheries mark the edge of ecological tolerance for ancestral forms. Favorable variations spread quickly. Small peripheral isolates are a laboratory for evolutionary change.

Gould, Panda’s Thumb, New York, WW Norton pp. 182-184

Operationally Responsive Space



…. space technology context is changing, making possible a movement to an additional business model and an expanded business base for space. Cost per kilogram on orbit is still a problem. But, capability per kilogram is soaring due to advances in information technology. This makes the alternative feasible. The door for small, micro and nanosatellites is open, allowing us to redefine cost and mission criticality curves, increase transaction and learning rates and the ability to assume risk.

Adm. Arthur K Cebrowski

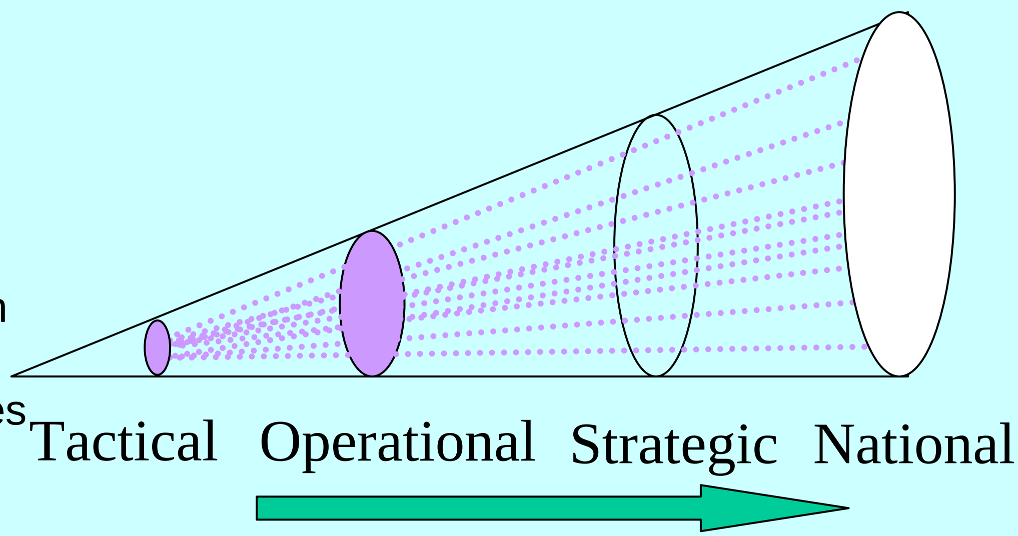
March 2004 US Senate Testimony

Evolving Meaning of *Operational*

Original Context From Cebrowski

Operational

Demand Driven
Military Capability
Autonomous
Integrated
Decentralized Control
Reduced Classification
Broadened User Base
Decreased Cycle Times
Risk Tolerant



Evolving Context: So important that it cannot fail

Some Advice I Received Early In My Career

…Pick a entirely new field of study and figure it out

before long, you will be a world expert

(i.e. find your own niche)

H. G. Wells, The Outline of History, 1922

"The telescope has released the human imagination as no other implement has ever done. If there is any other apparatus worthy to be compared to its enlarging influence, it is the spectroscope, which was developed after the discoveries of Fraunhofer, the glass-worker, in 1814. Since man has lived on earth he has seen rainbows, but who could have told him that those bands of colour held in them a promise that one day he should be able to analyze the stars? But the spectroscope receives the rays from any luminous source, passes them through prisms and breaks them up into rainbow-like bands. These bands reveal under examination transverse lines of brightness and darkness which vary with the heat and the chemical composition of the source of light and of any intervening vapour. So that men can now sit in observatories and learn the composition and take the temperature of stars incalculable billions of miles away."

Spectroscopic View Of Planet Earth

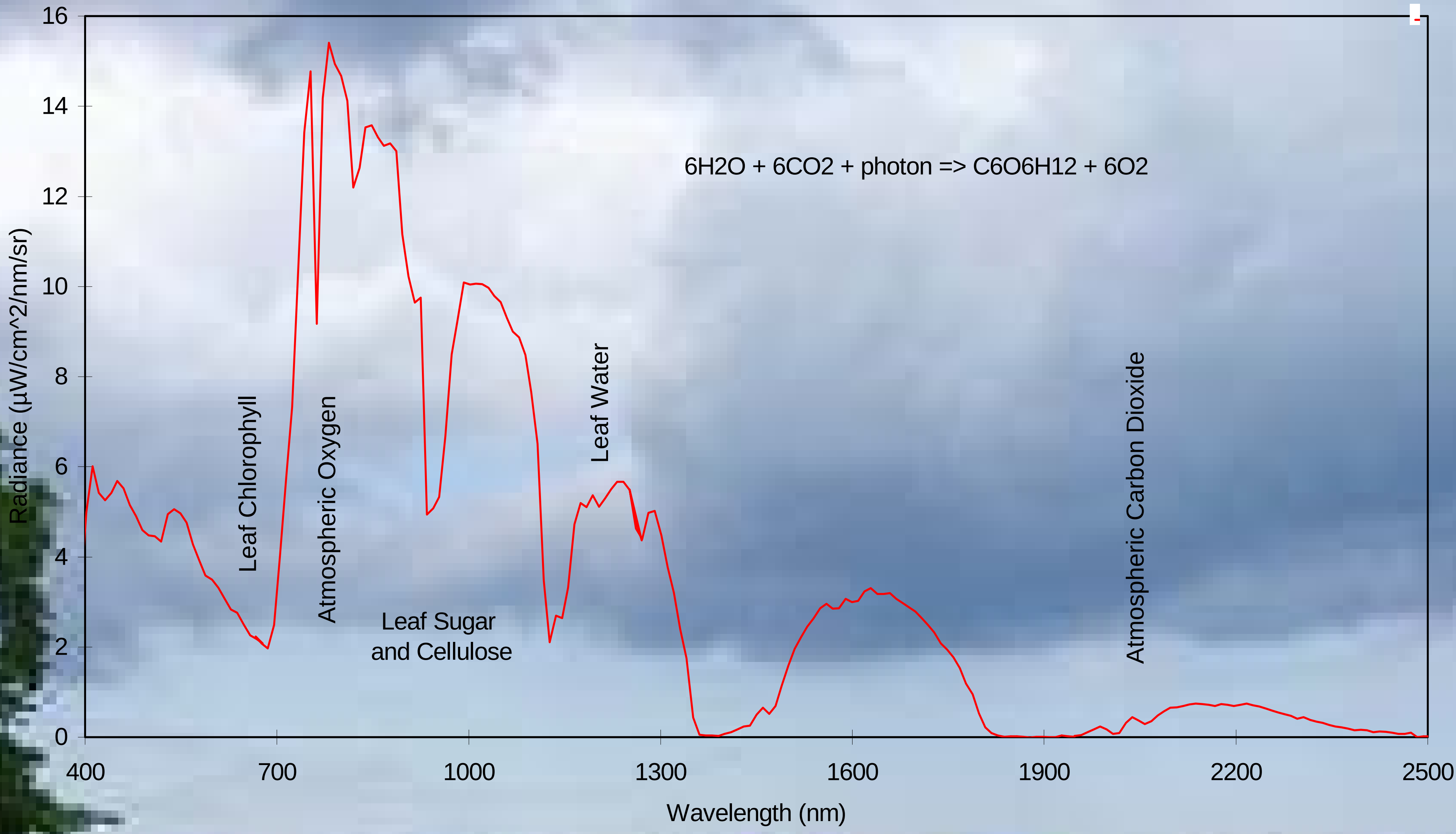
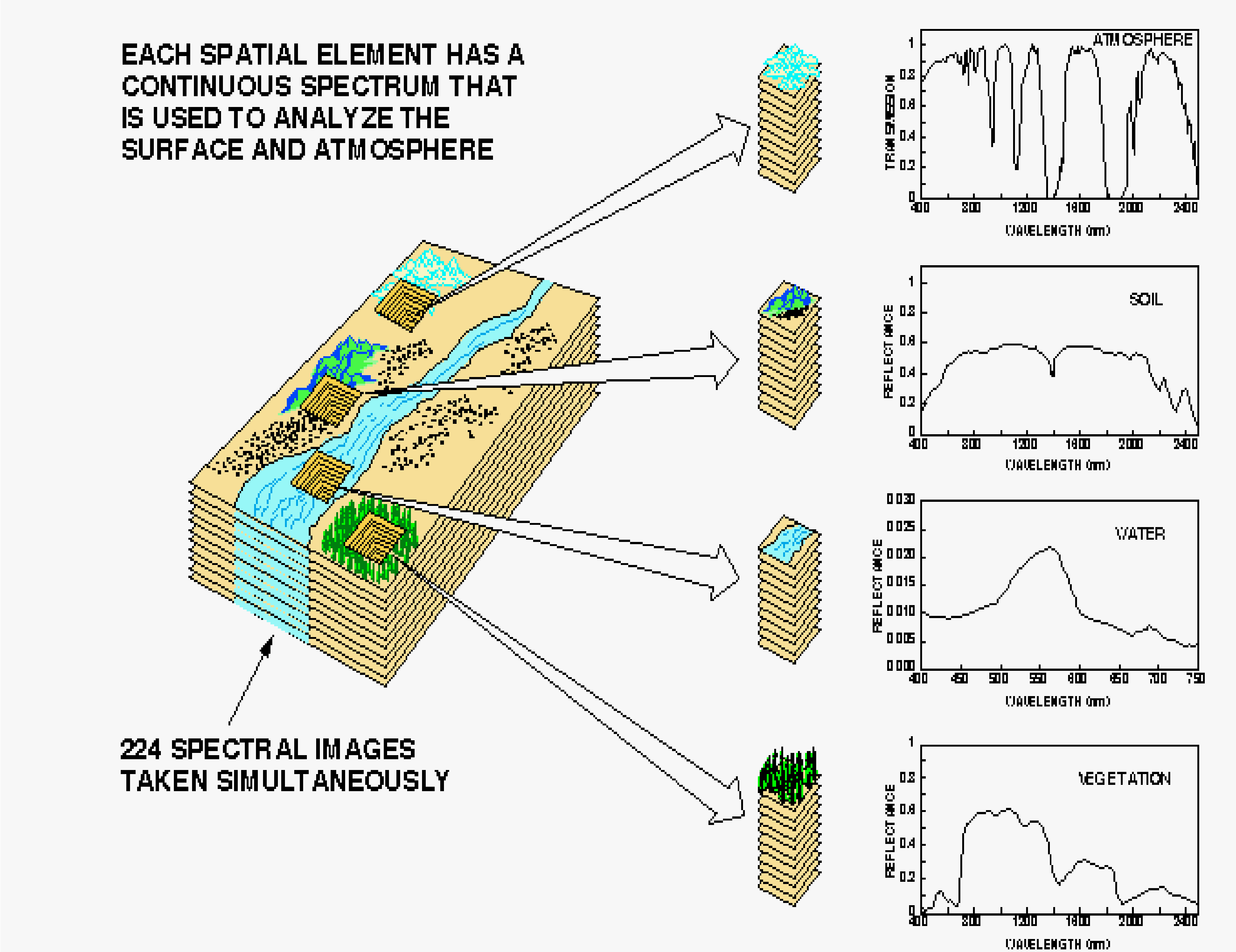
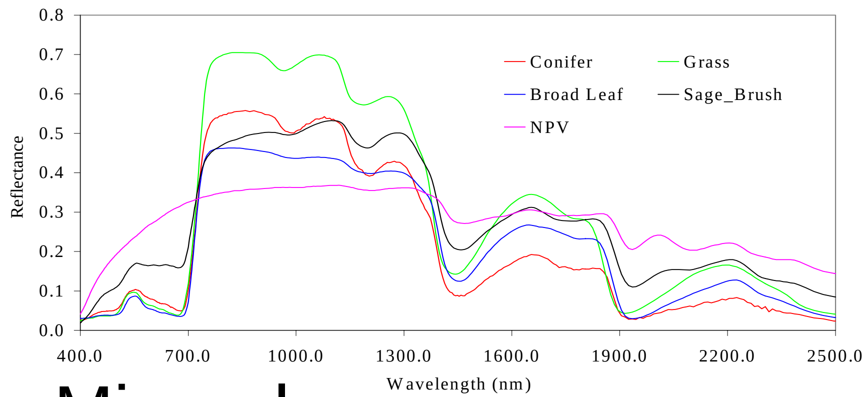


Image Cube Concept

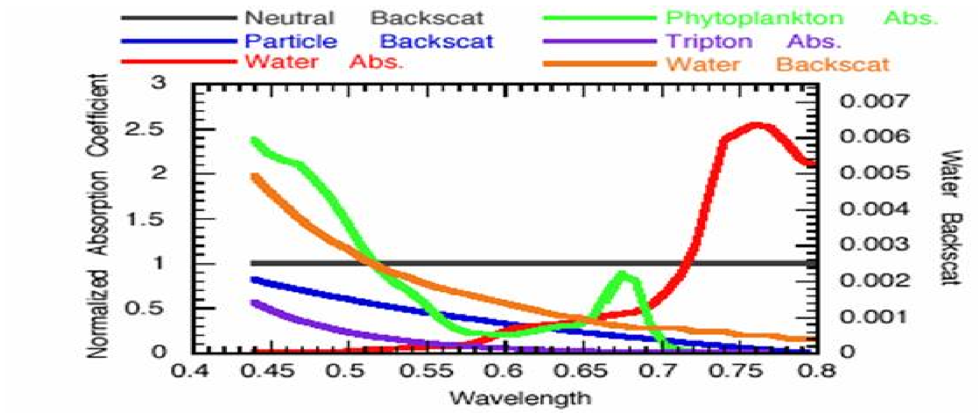


Earth Spectra

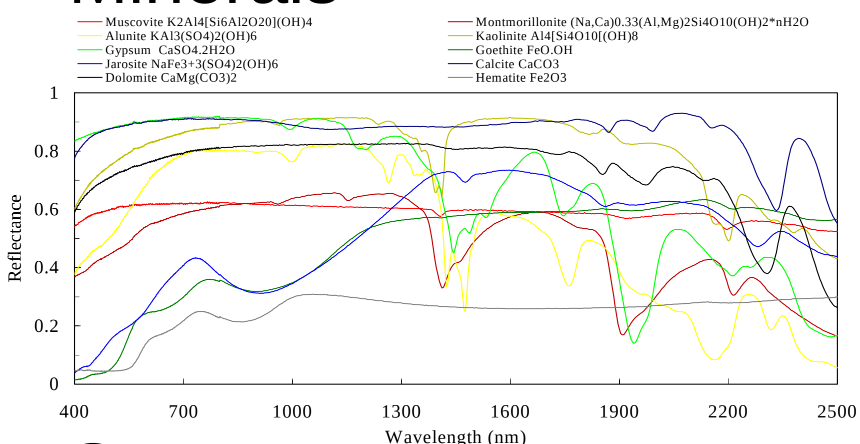
Vegetation



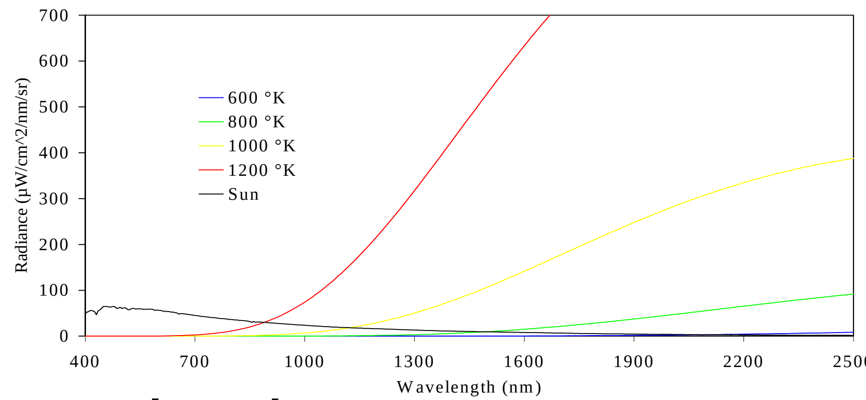
Water



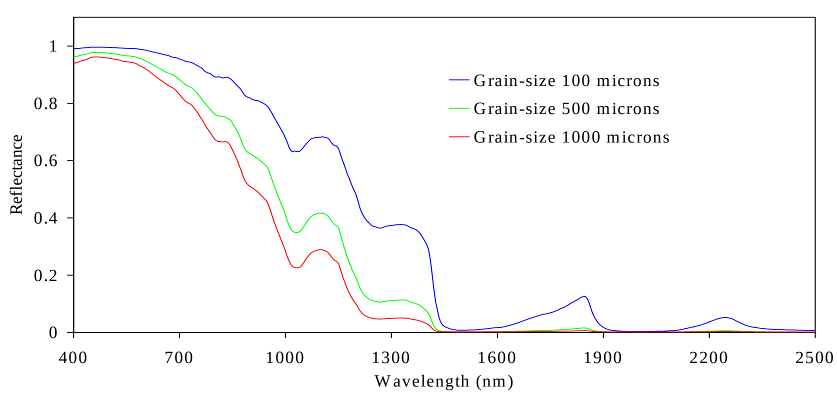
Minerals



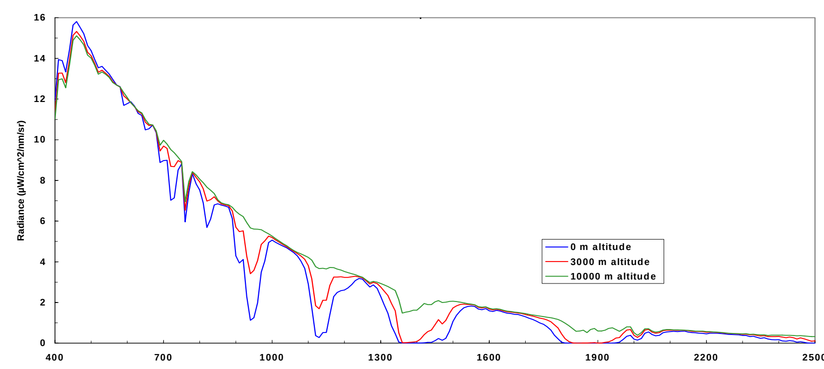
Fire



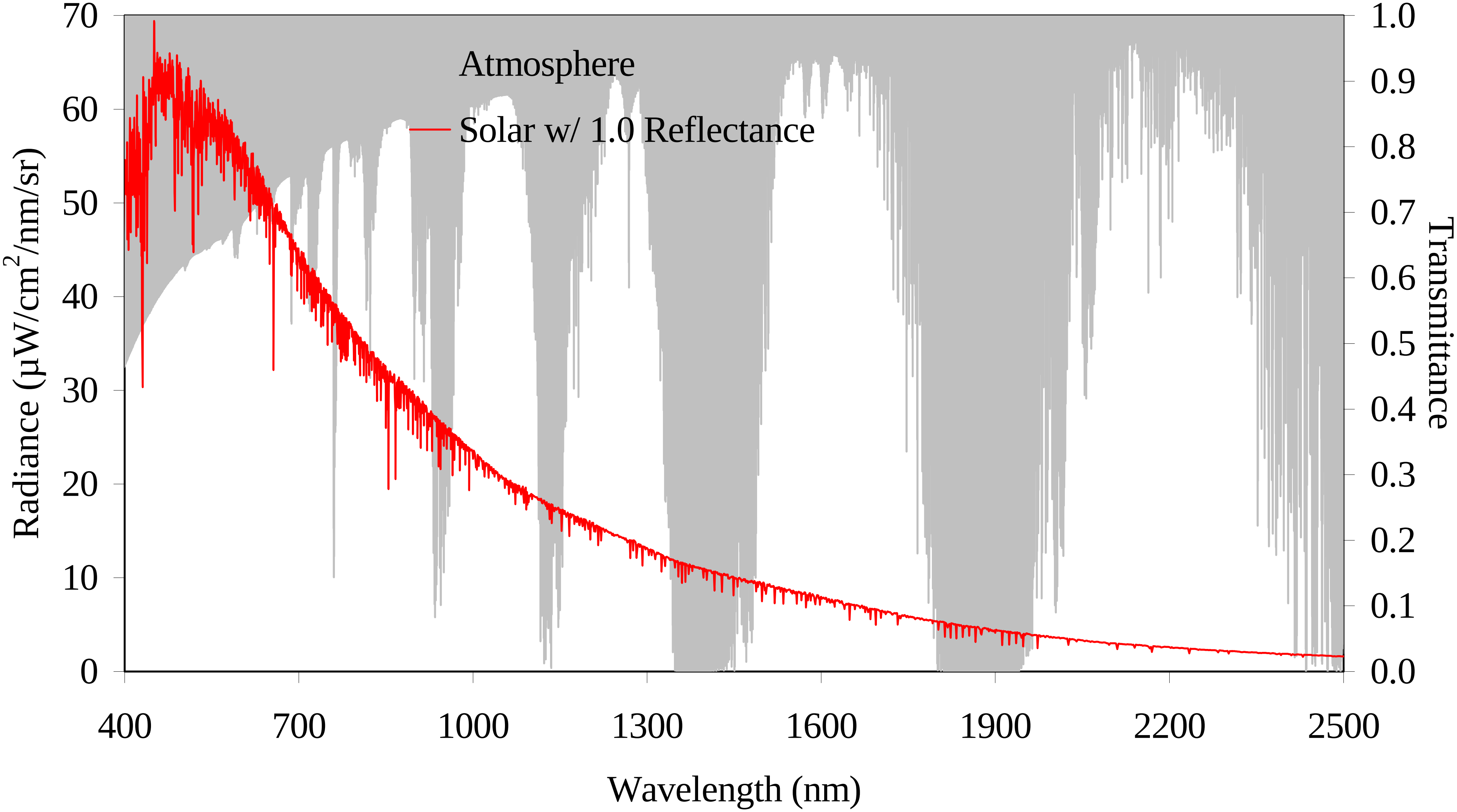
Snow



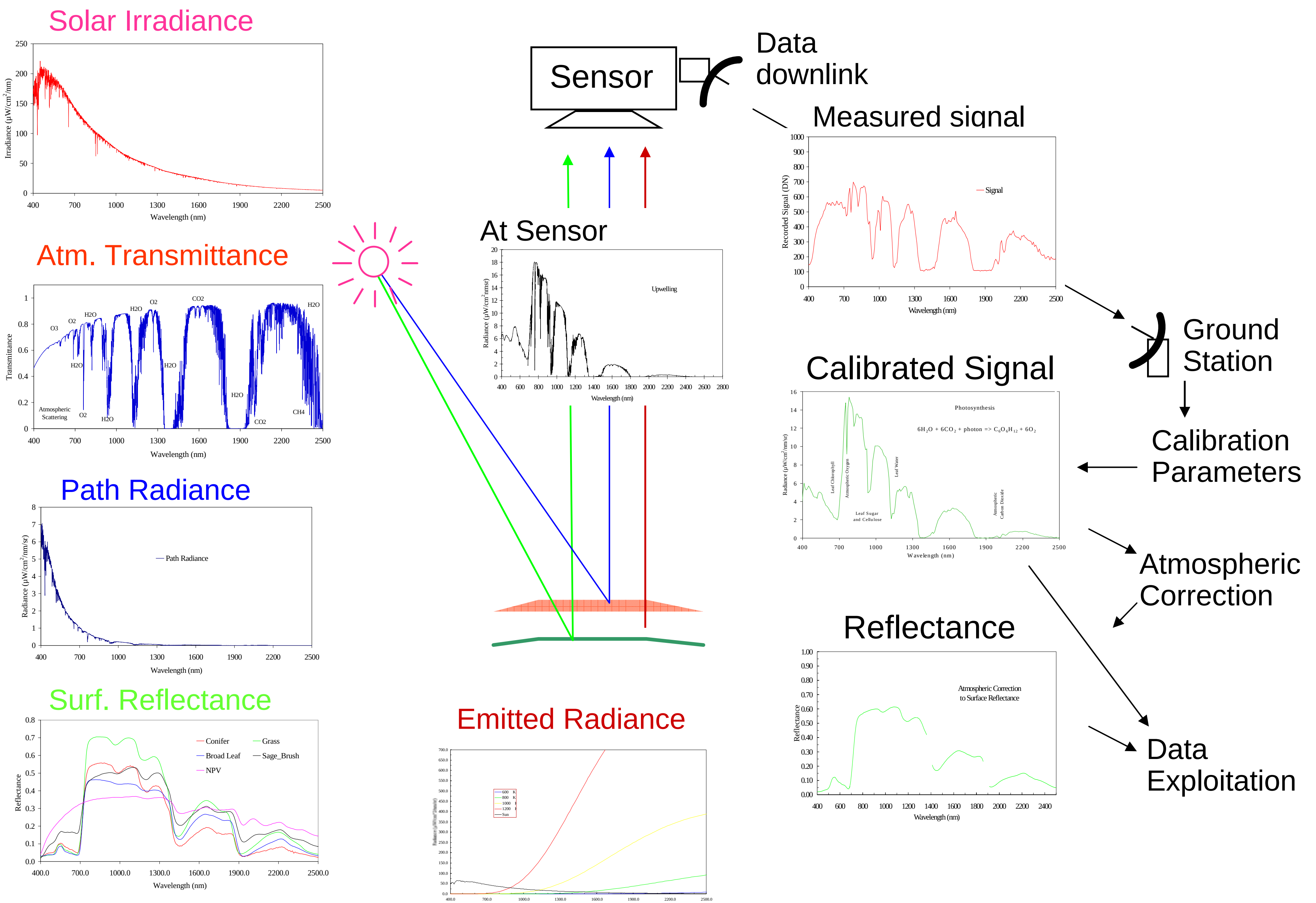
Clouds



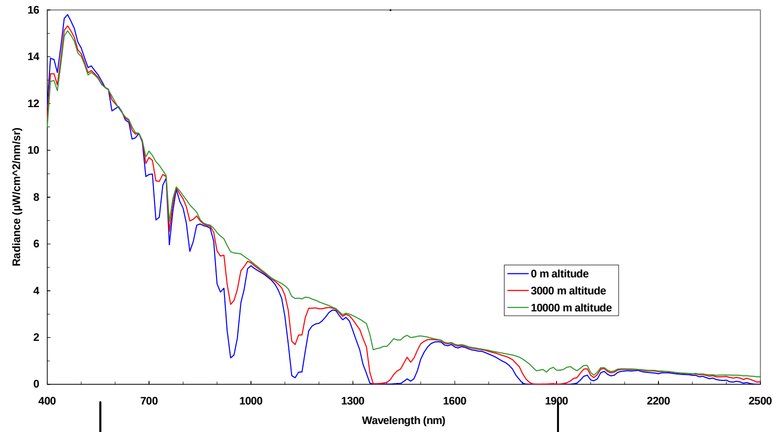
Solar Signal and Transmittance of the Atmosphere



Imaging Spectroscopy Overview



Cirrus Cloud Detection Over Mojave Desert



Visible Image

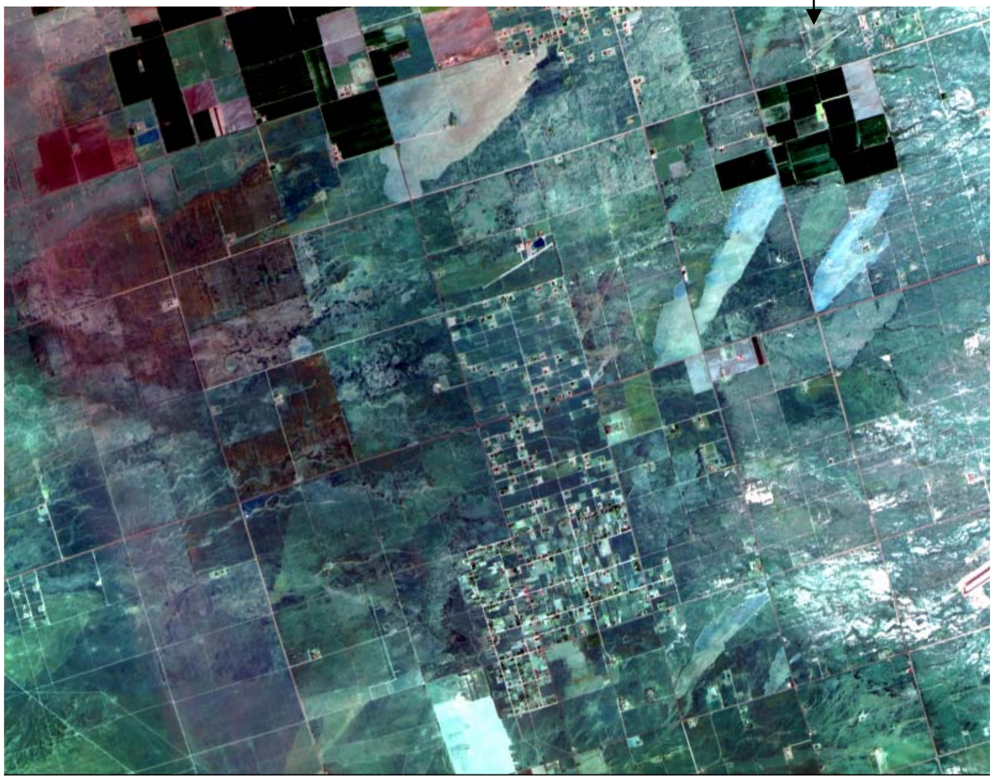
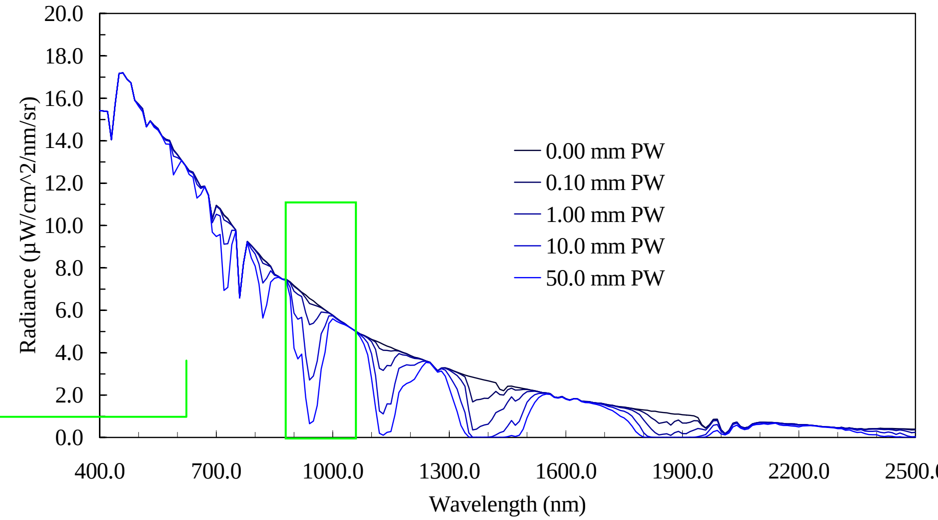


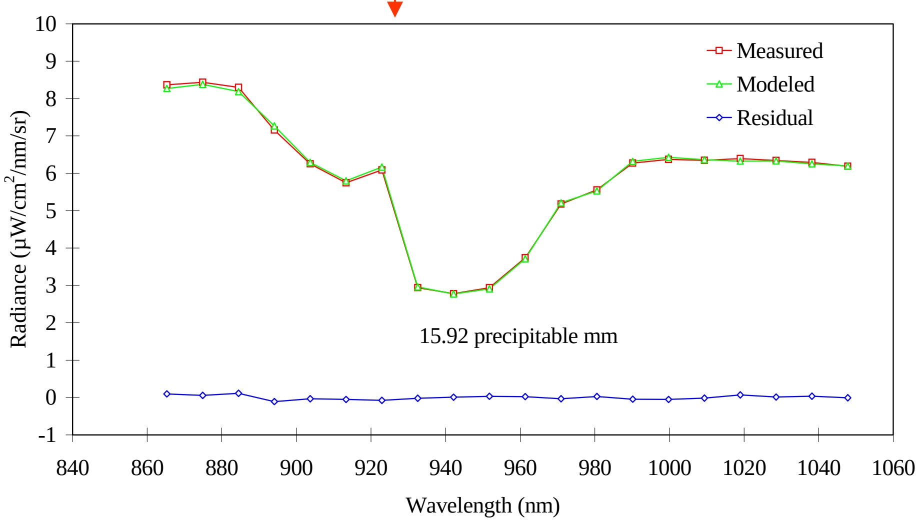
Image from 1380 nm

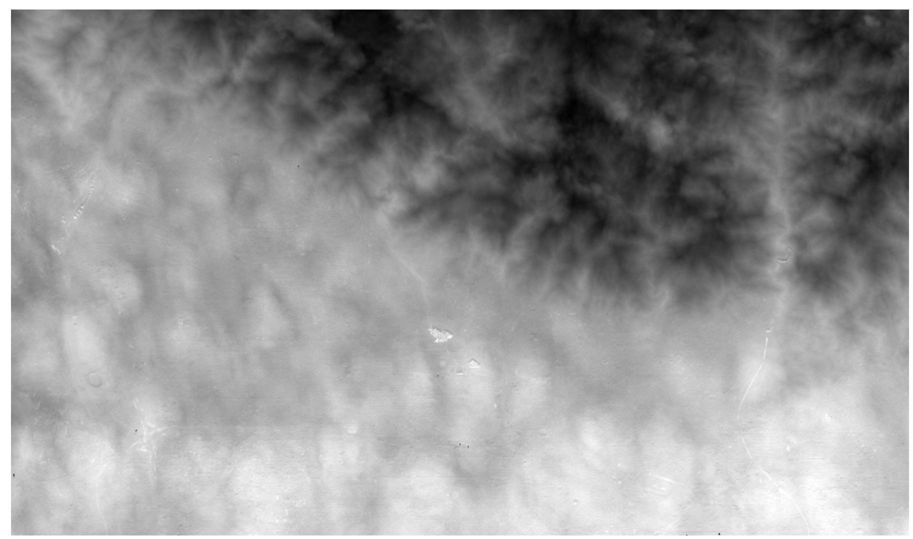
Accounting For Water Vapor



Modeled

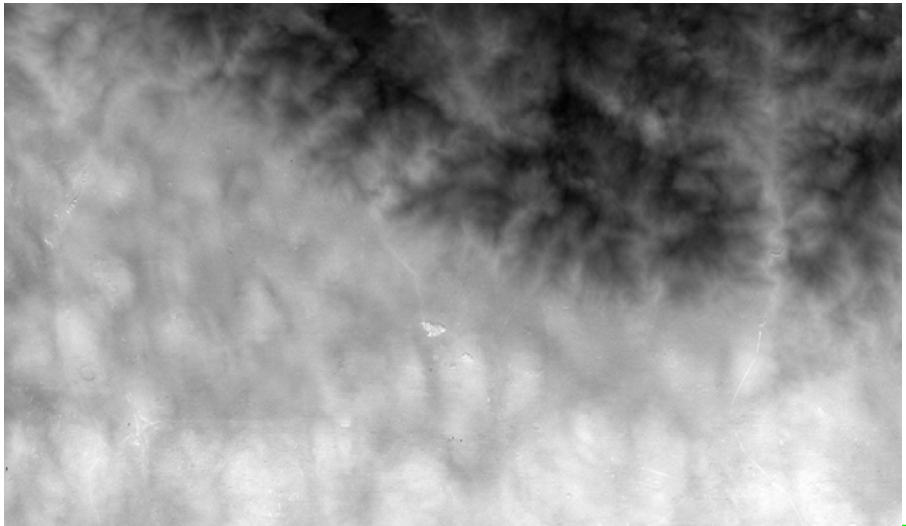
Measured

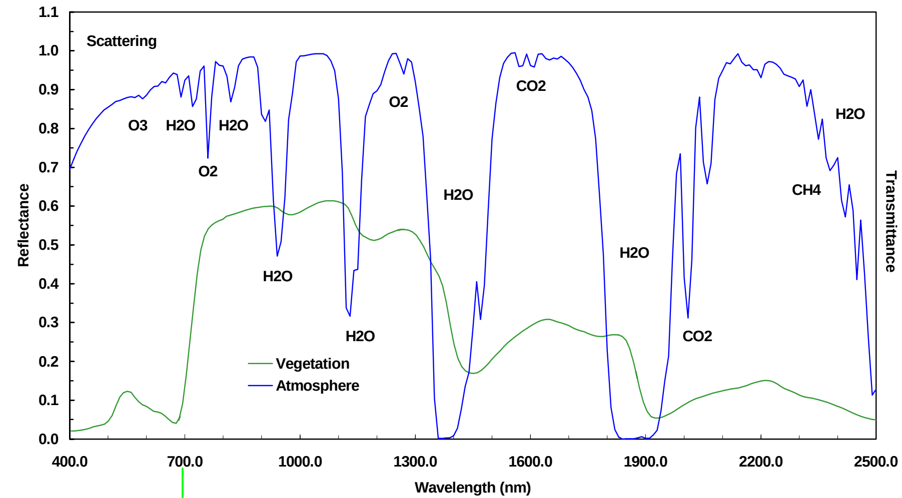




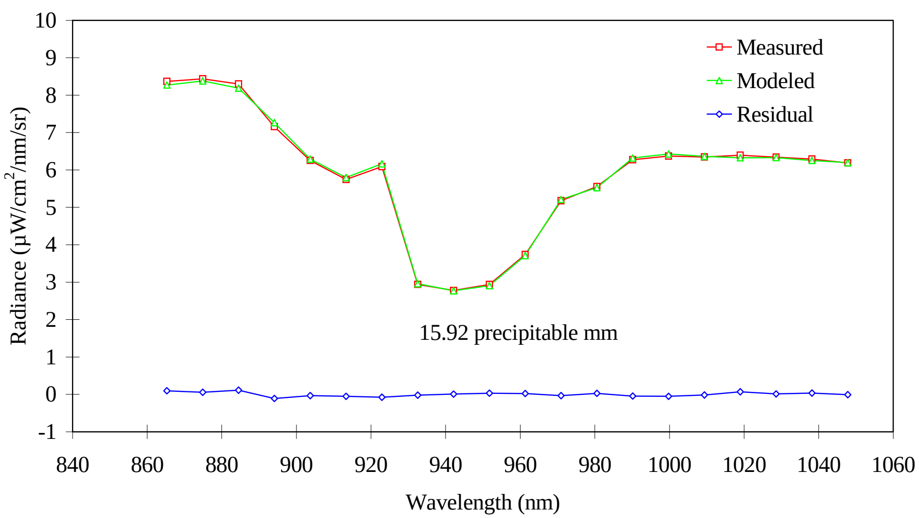
Water Vapor
Parameter map

Accounting For Liquid Water

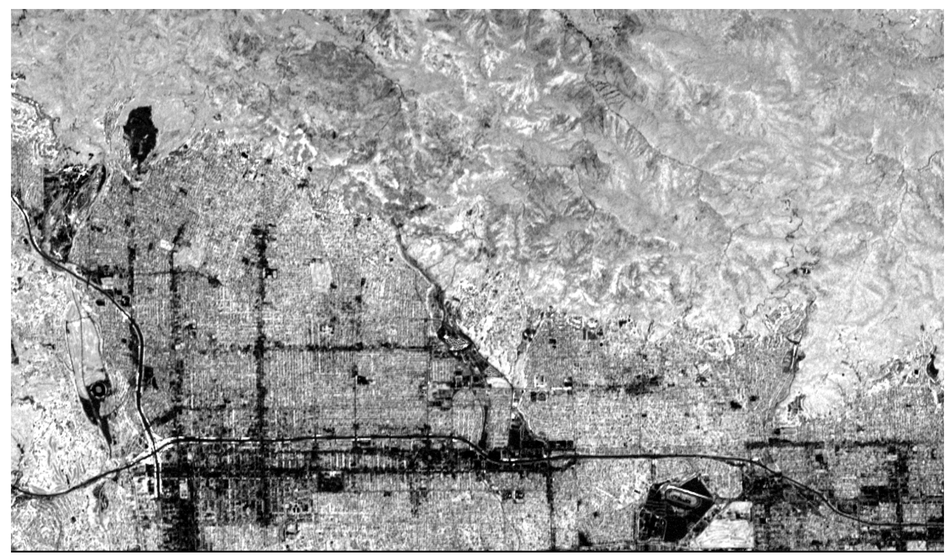




Vapor and Liquid Modeled



Liquid Water
Parameter map



Radiance To Reflectance Inversion

- $Lt = \mu F_0 \rho_a / \pi + \mu F_0 T_d \rho_s T_u / \pi$

Lt is the at sensor radiance

μ is the cosine of the solar zenith angle

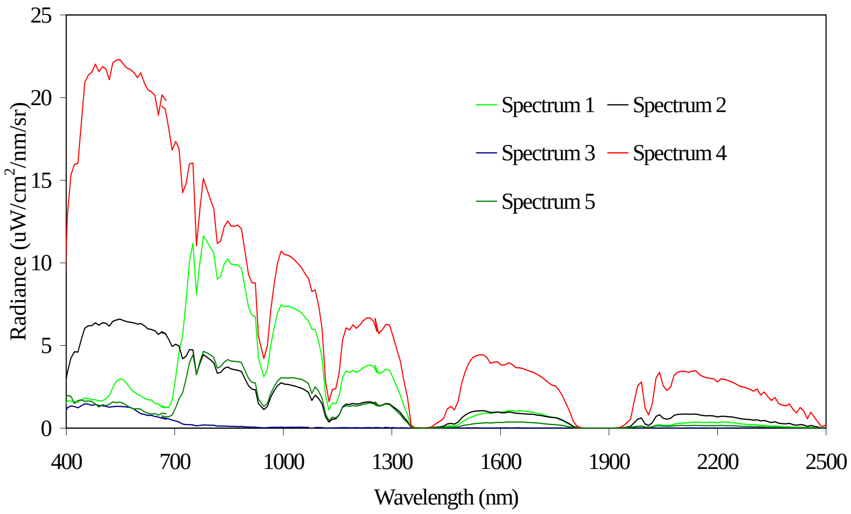
F_0 is the exo atmospheric irradiance

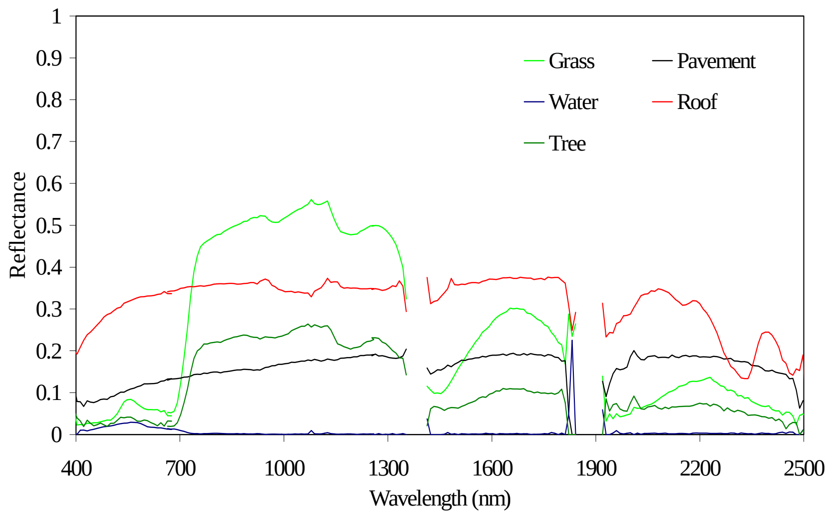
ρ_a is the upward reflectance of the atmosphere

T_d is the downward transmittance

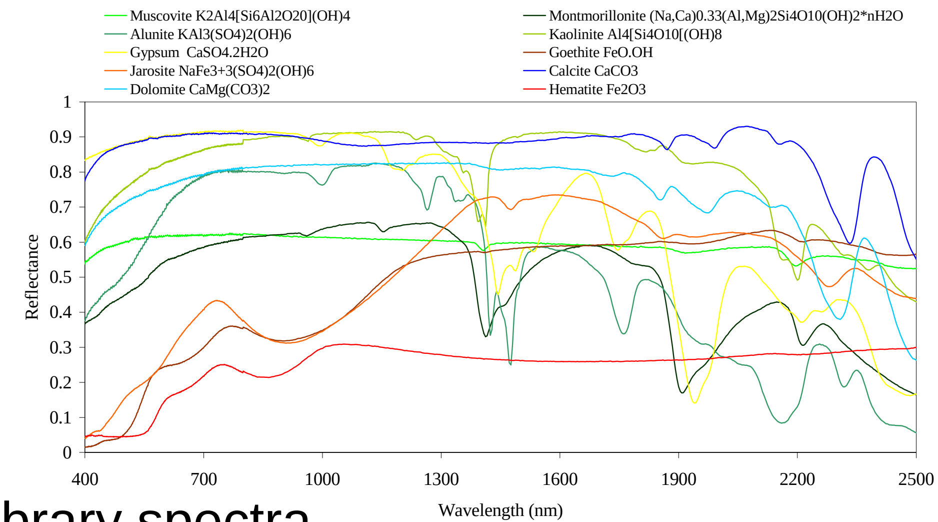
ρ_s is the reflectance of the surface

T_u is the upward transmittance of the atmosphere



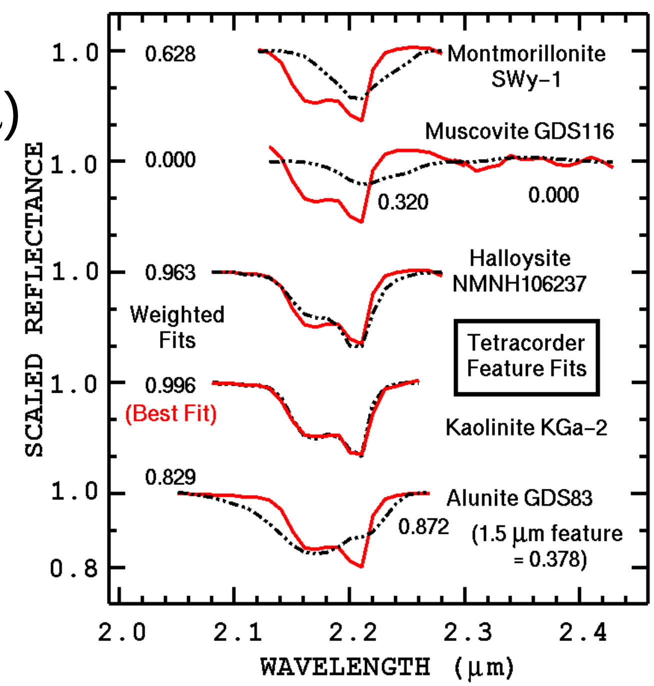


Mineral Mapping With USGS's Tetracorder

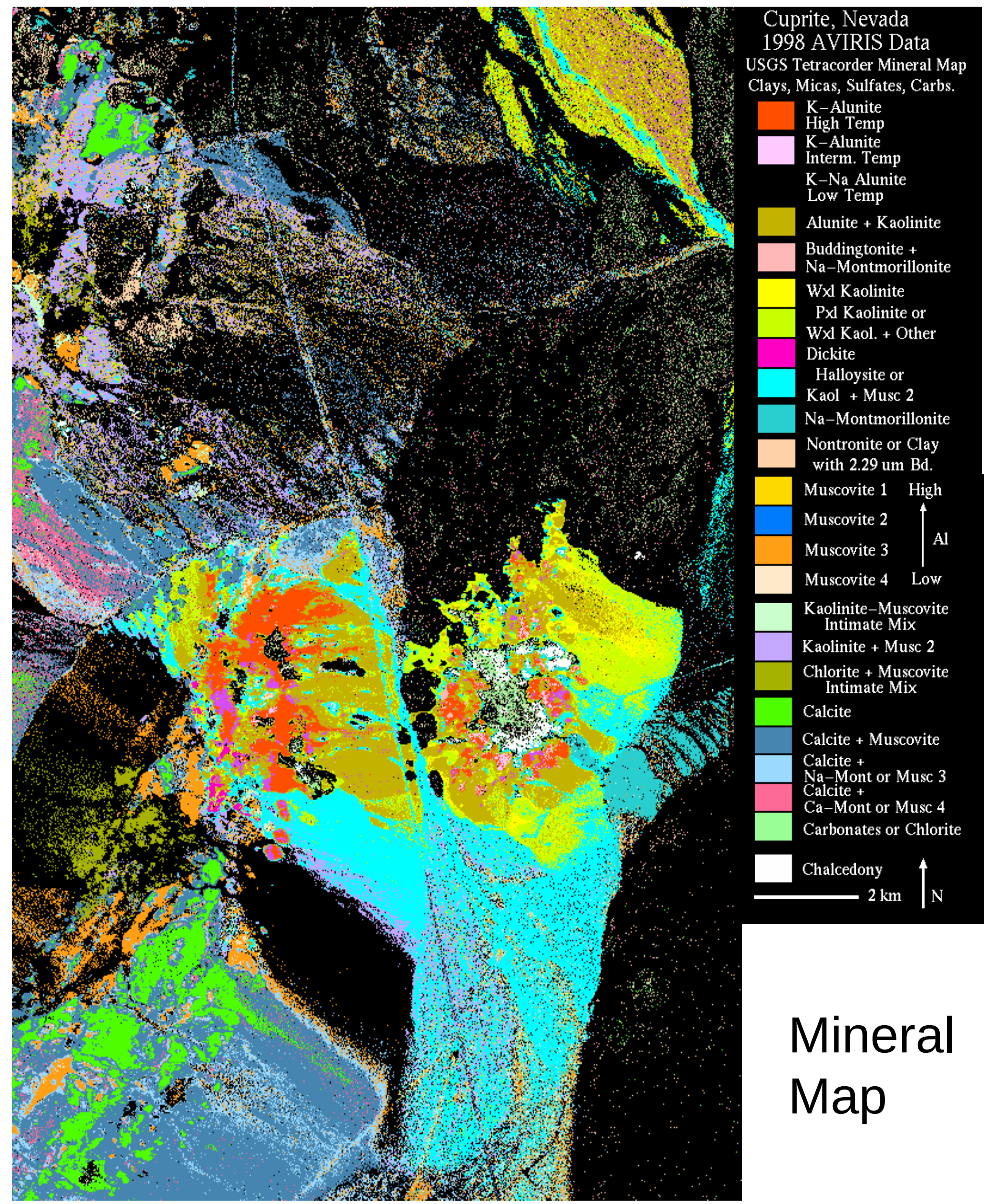


Library spectra

R(λ)



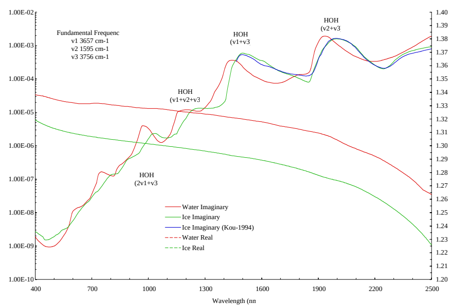
Best Match



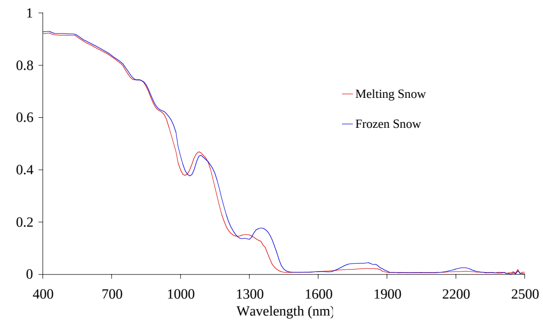
Mineral Map

Snow and Ice Model Matching

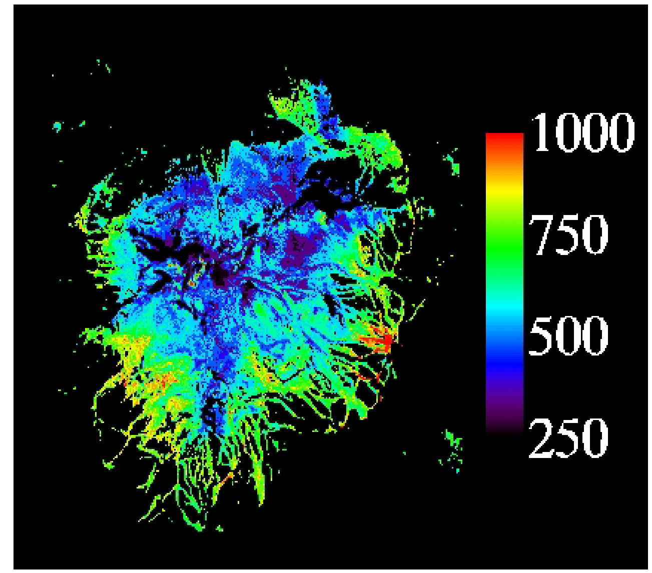
Complex refractive
Index of water and ice



Physical model of
Snow spectral reflectance

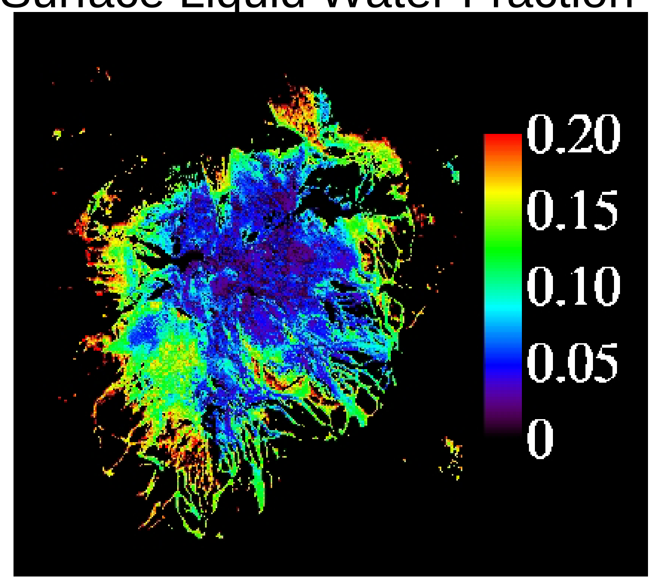


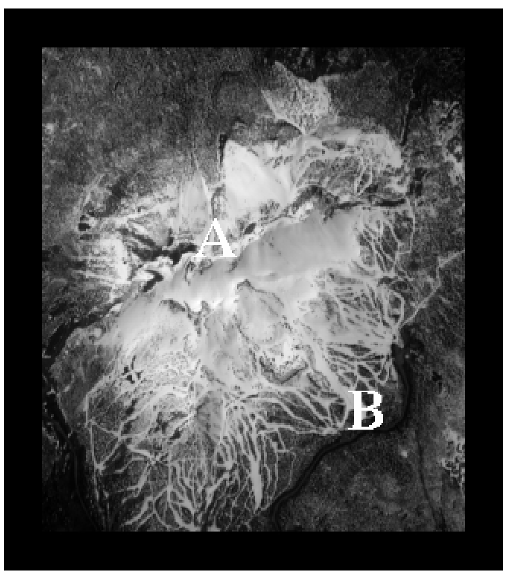
Surface Grain Size [μm]



Nonlinear least square
Model matching

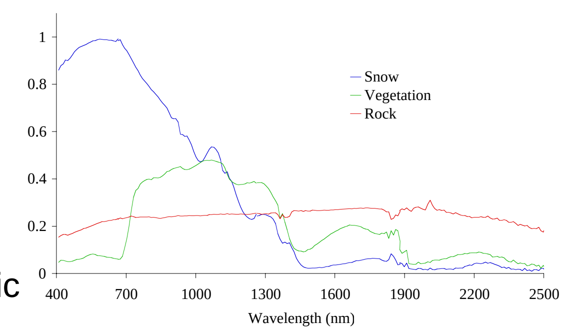
Surface Liquid Water Fraction





Calibrated Radiance

Atmospheric
Correction

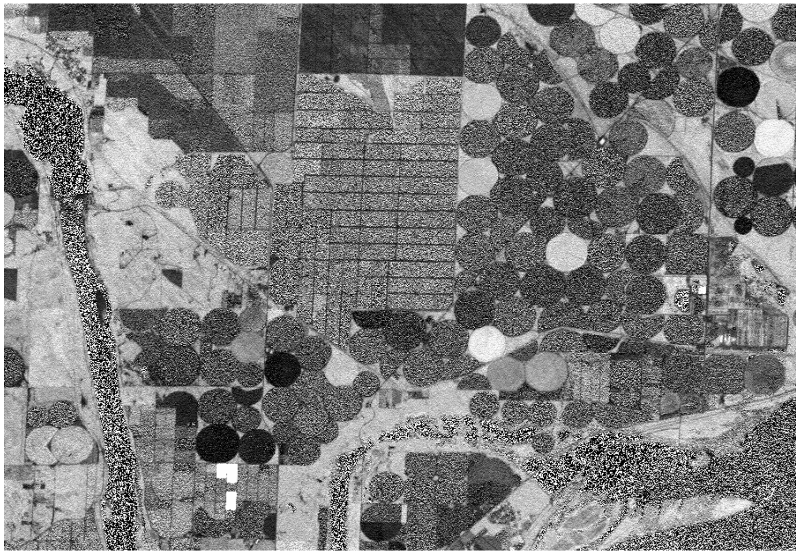


Reflectance Spectra

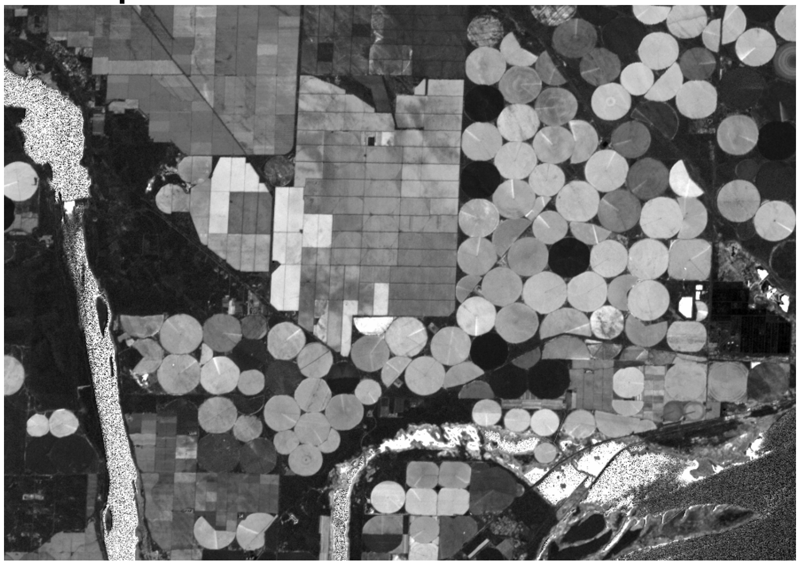
Vegetation Parameter Over Wallula, WA

False Color

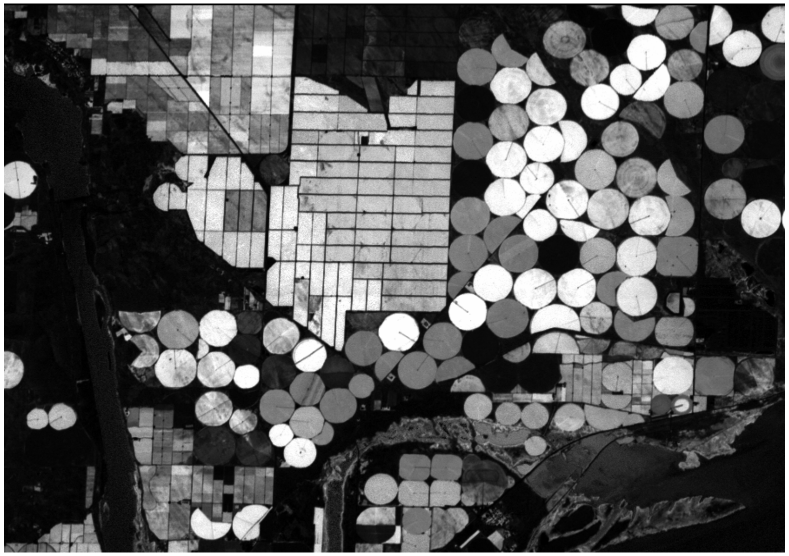
Cellulose



Liquid Water

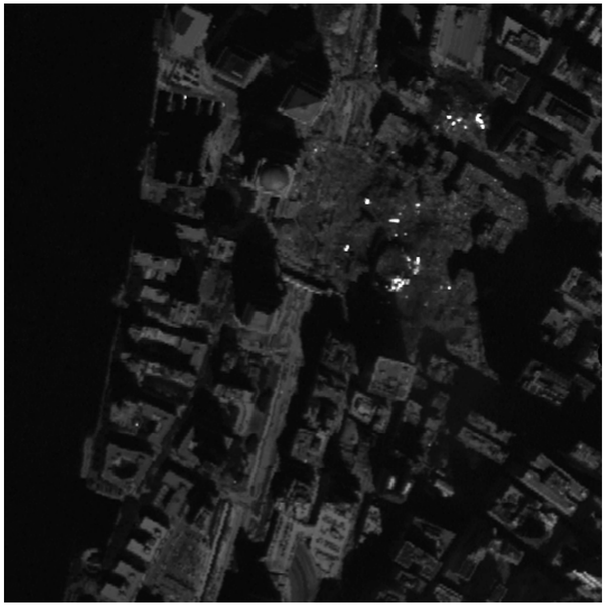


Chlorophyll



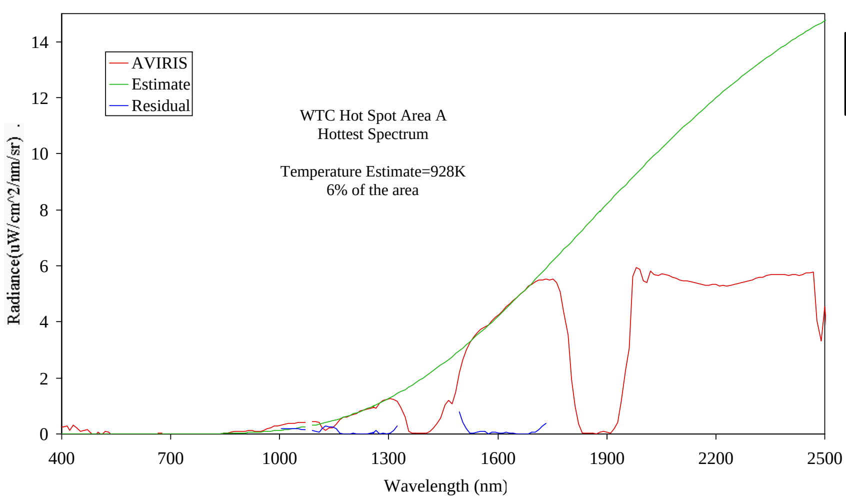
World Trade Center Hot Spot Mapping

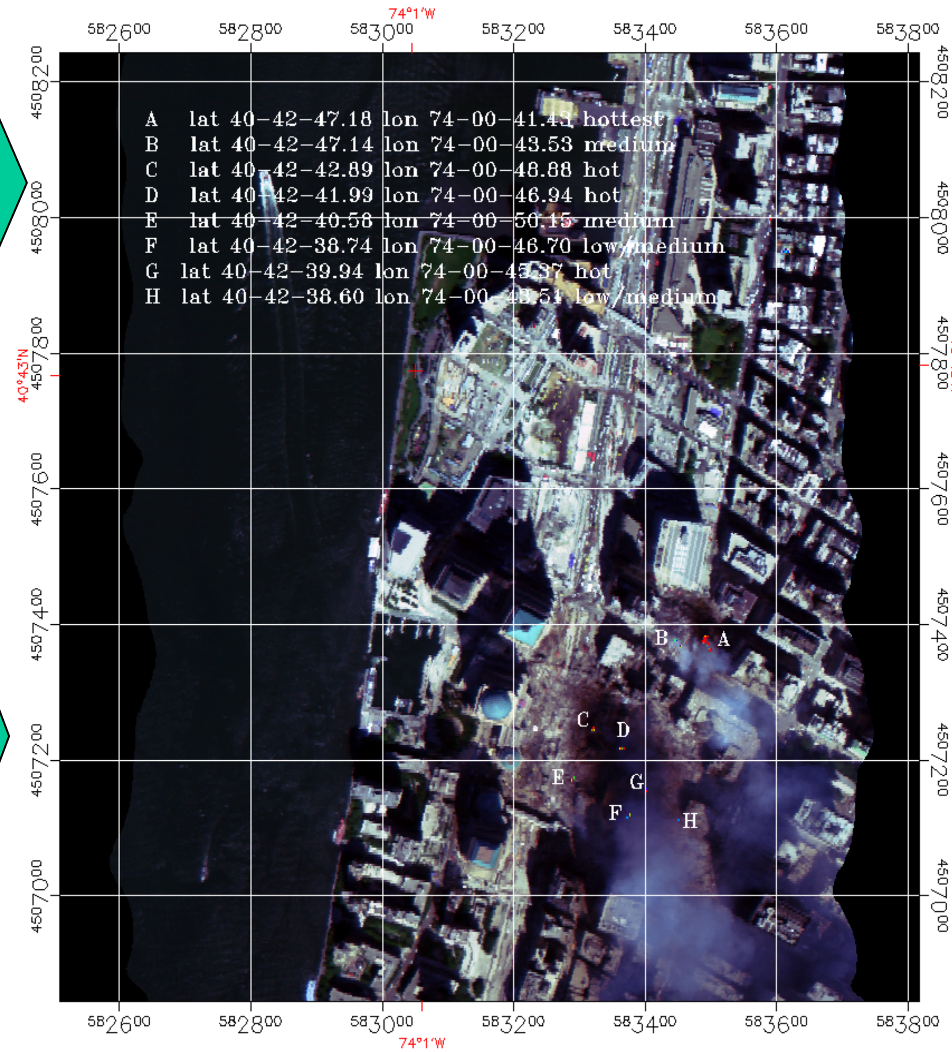
Radiance Image Cube (SWIR)



GPS/INS data

Model Matching to Planck Blackbody





Fraction, temperature, and lattitude, Longitude coordinates for each hot spot

World Trade Center Asbestos Mapping

Library Spectra

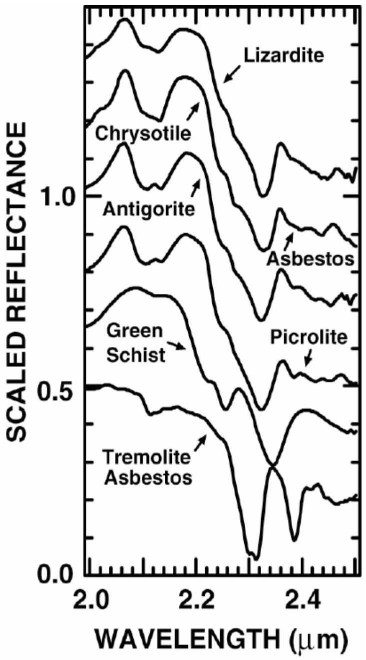
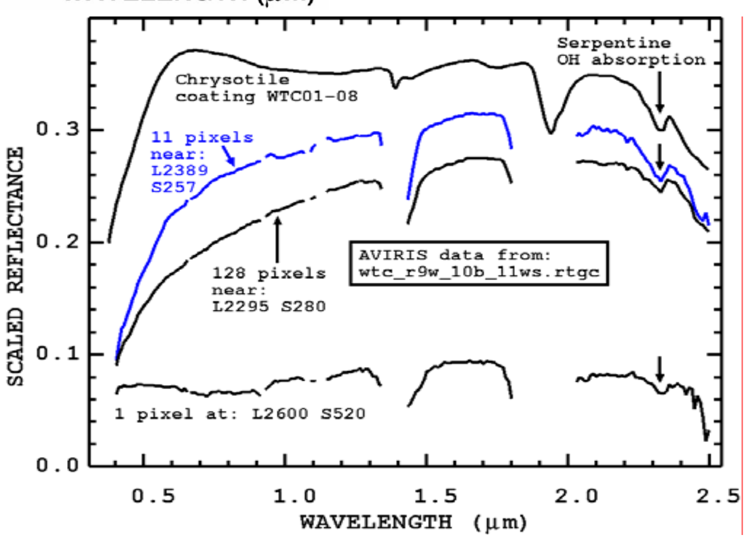


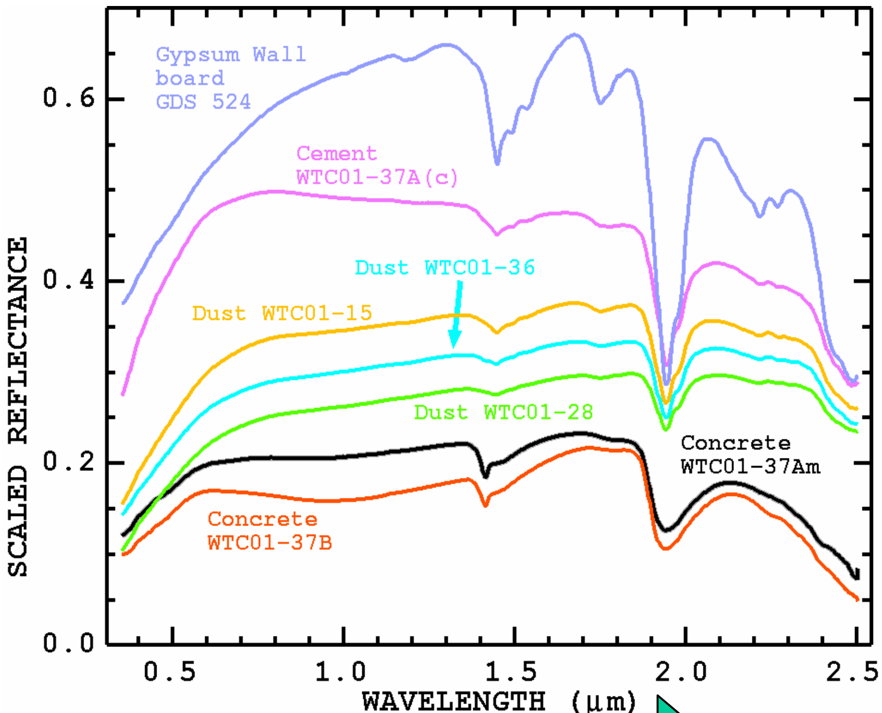
Image map Of match to Crysotile

Match to measured spectra



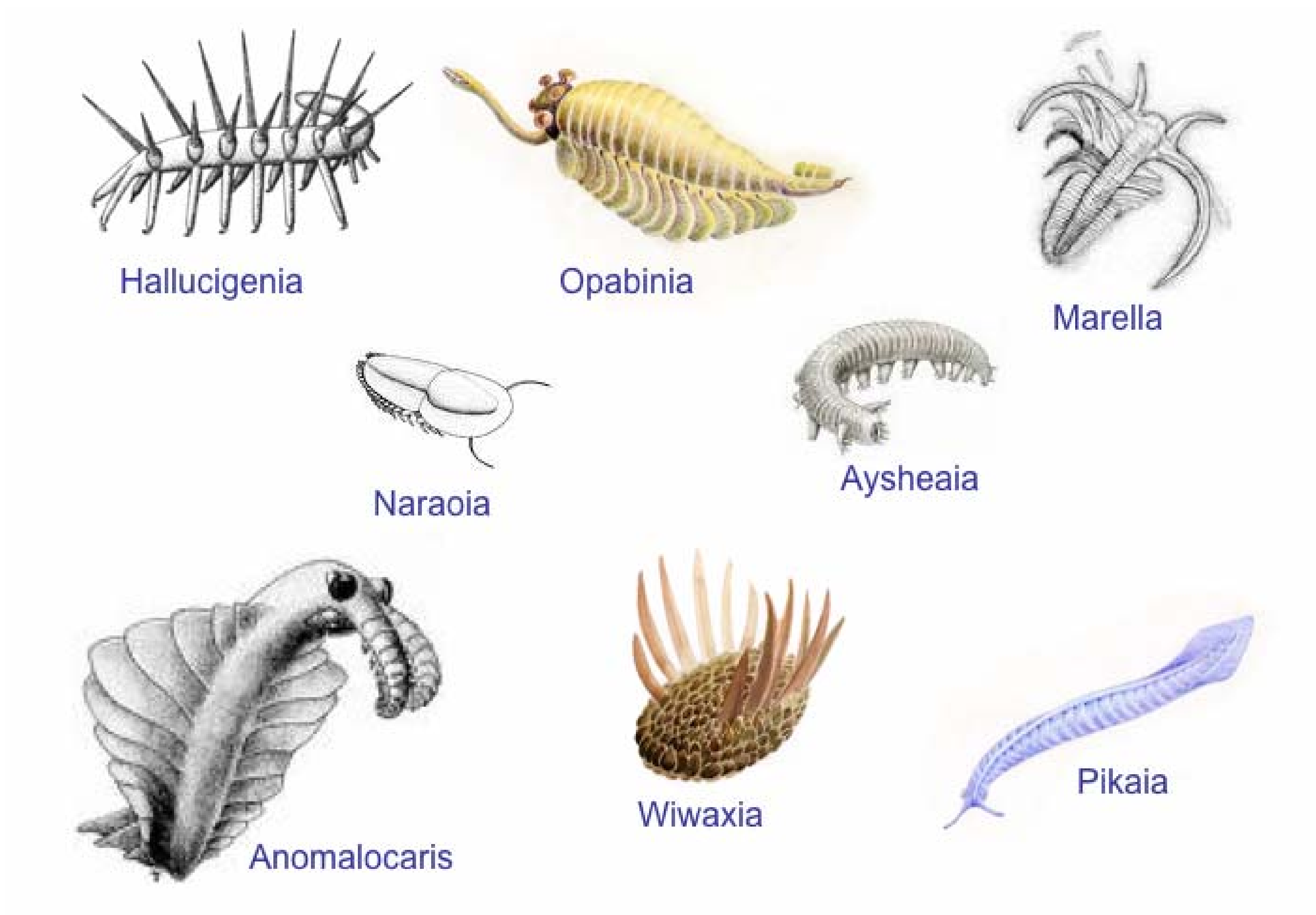
World Trade Center Debris Identification

Site-specific spectral library



Feature Matching to Reflectance spectra

Guess the Genetic Survivors of the Burgess Shale which one are we most closely related to?



Dominant Form of Life On Earth?