A WEB-BASED SEARCH SERVICE TO SUPPORT IMAGING SPECTROMETER INSTRUMENT OPERATIONS

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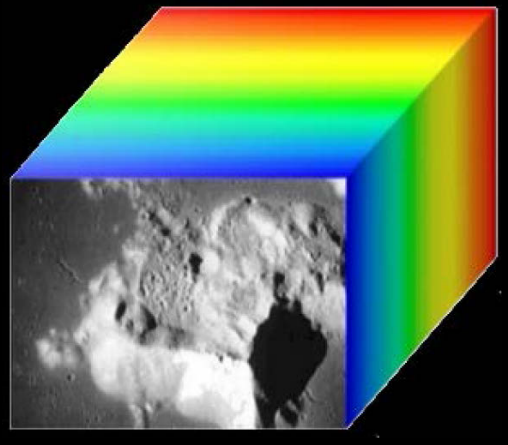

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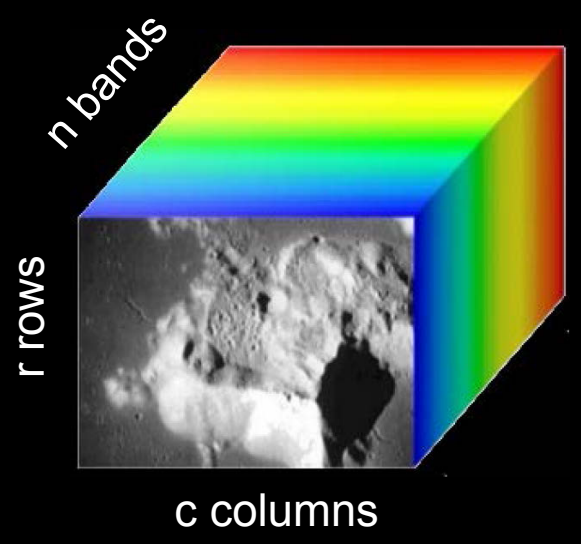
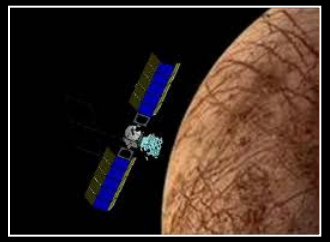
Imaging spectrometers are ubiquitous

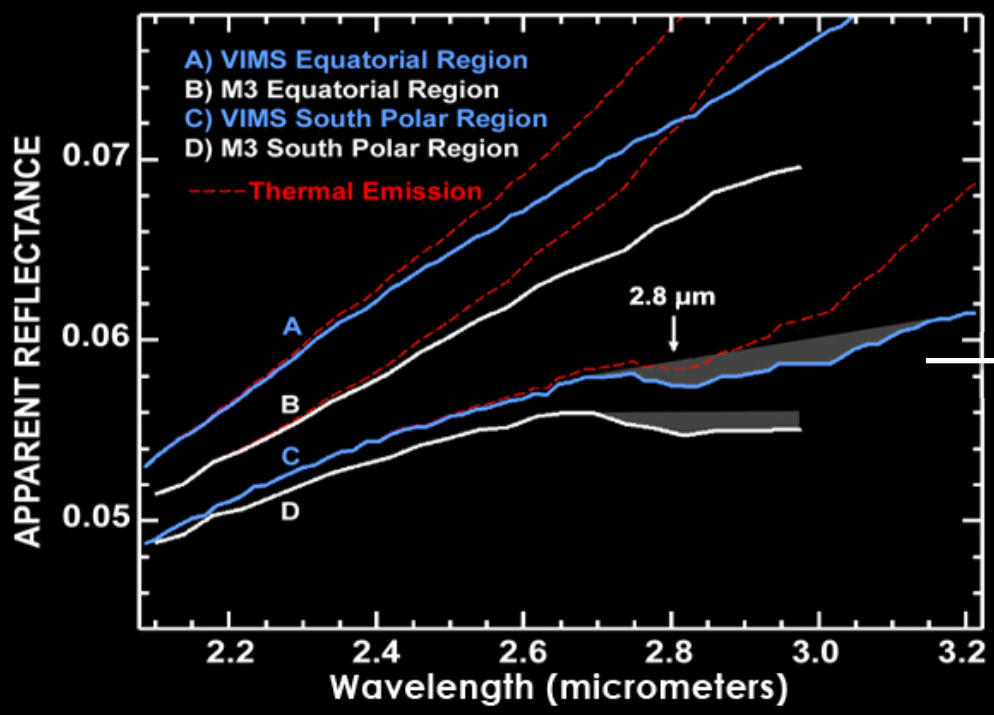
- Moon (M3)
- Mars (OMEGA, CRISM)
- Jupiter (Galileo NIMS)
- Saturn (Cassini VIMS)
- Vesta (Dawn VIR)
- Comets (Rosetta)
- In-situ
- Terrestrial applications

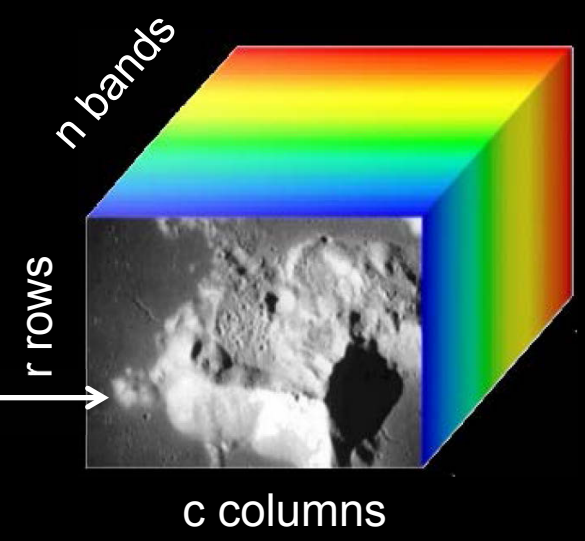




Images courtesy NASA/Brown/JPL and other missions

Imaging spectrometers are ubiquitous

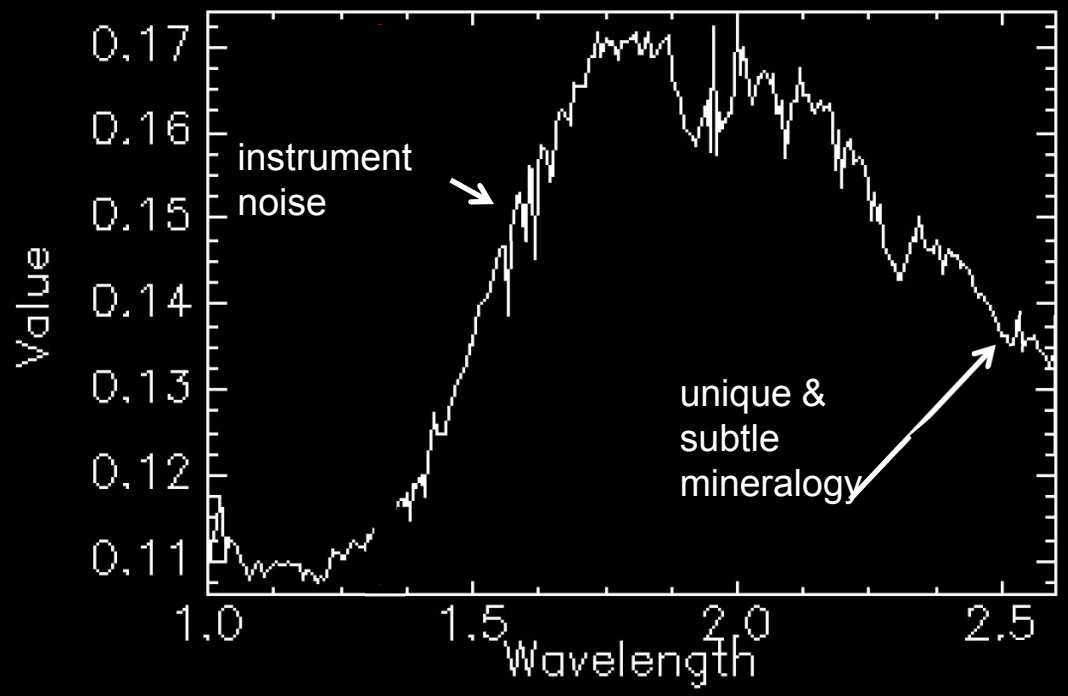




Images: NASA/ISRO/JPL-Caltech/USGS/Brown Univ.

Challenges for tactical use

1. Impossible to visualize a full image cube (non-intuitive for untrained operators)
2. Planetary spectral data can be noisy
3. Signals are subtle, difficult to interpret
4. Targets are often unknown in advance
5. Unconstrained atmospheric conditions
6. Localized features



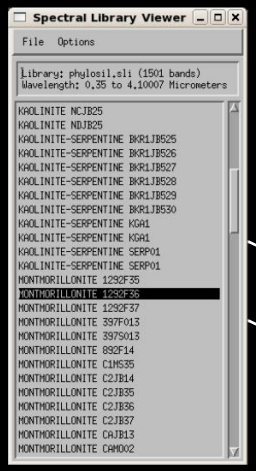
(CRISM frt3e12. Credit: NASA/UMD/Brown)

Essential capabilities for tactical instrument operations

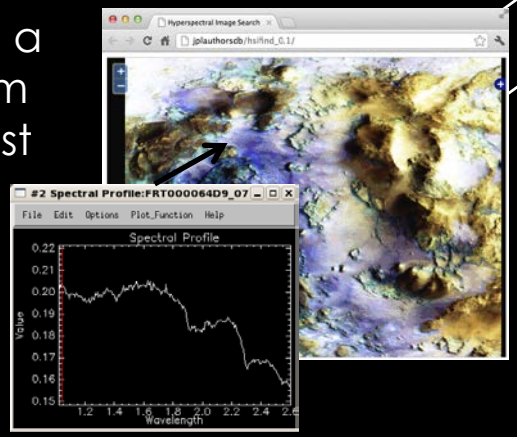
- Select and view spectra
- Build a spectral library
- Determine key constituents in a new image
- Find subtle signatures for minerals of interest

Browsing as a search problem

Case 1. user chooses a *target mineral* from laboratory catalogs or previous images

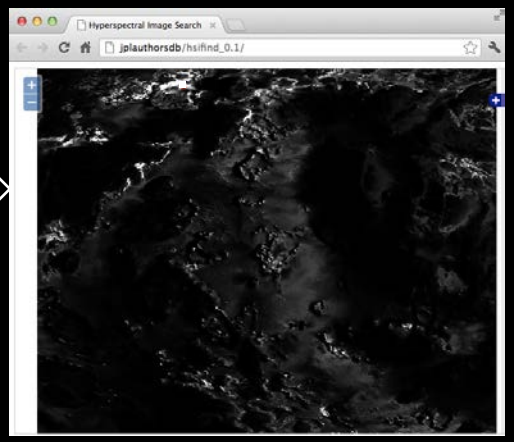


Case 2. User identifies a spectrum of interest



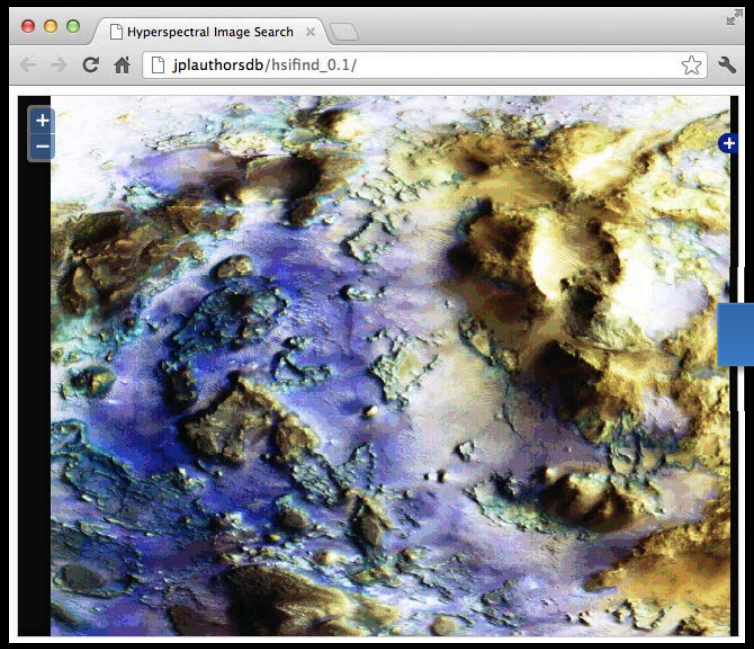
Search algorithm

Candidate matches discovered in newly downlinked scenes

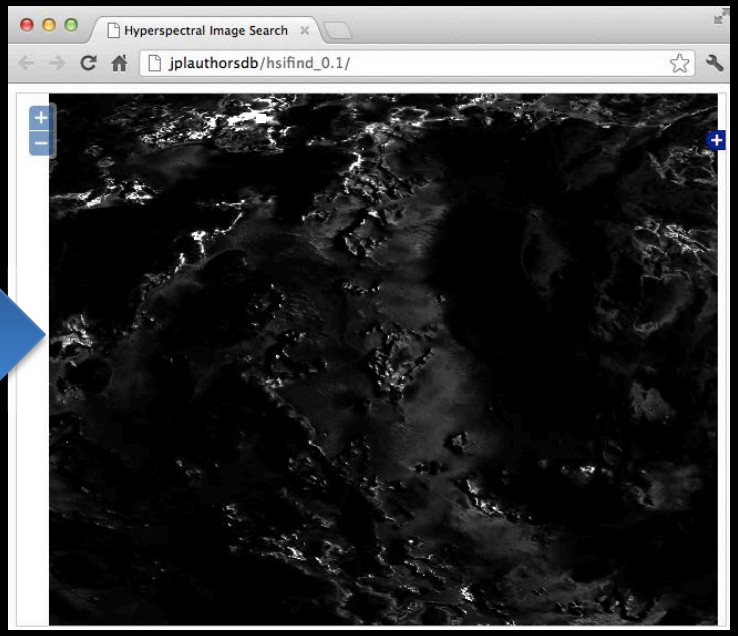


Why use a web service?

- No need to downlink full-res data cubes
- No need for expensive/complex client-side software
- Co-locate processing and data



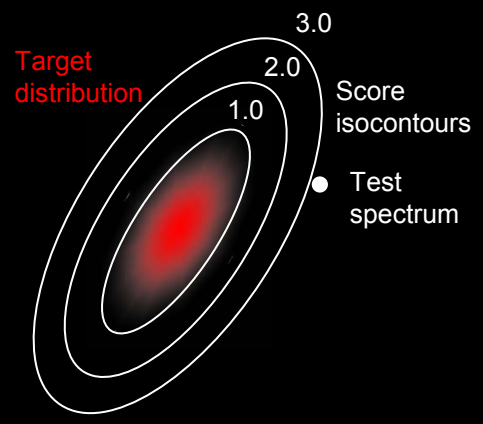
CRISM frt00003fb9



Matched filter search algorithms

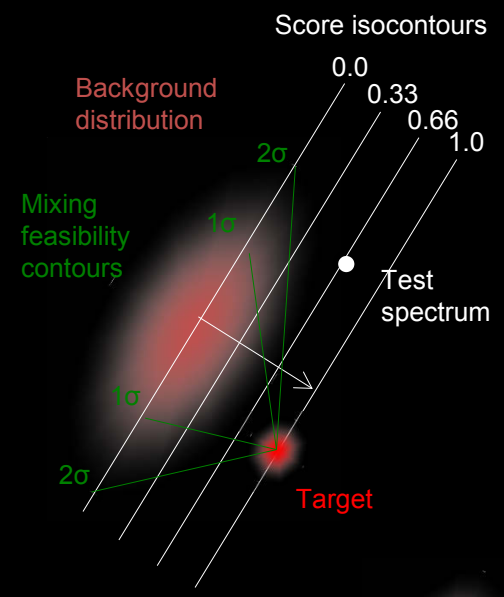
Mahalanobis distance

Measures the distance to target, along isocontours of the background distribution



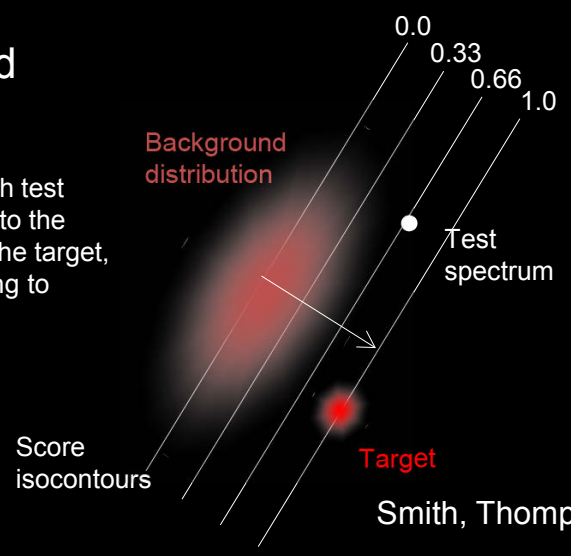
Mixture-Tuned Matched Filter

Enhances the matched filter by assessing mixing feasibility – regions that are feasible linear mixtures of the target and the background distribution. This helps reject nonphysical false positives (i.e. negative mixing ratios)



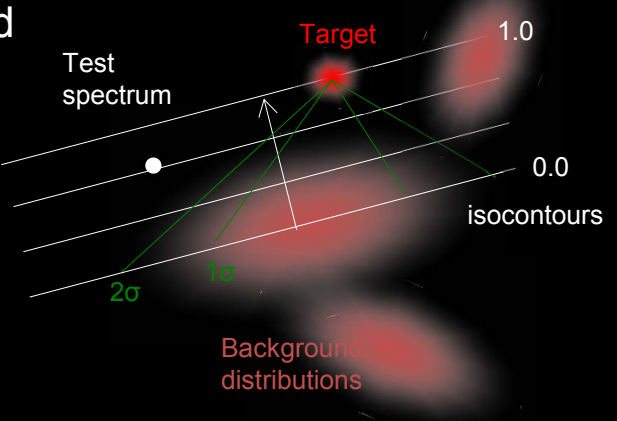
Matched Filter

Projects each test spectrum onto the direction of the target, with whitening to account for background covariance

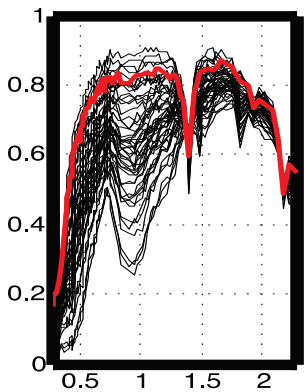


Mixture-Tuned Clutter-Matched Filter

Enhances MTMF with a more complex, multi-modal background model. We match each test spectrum using its closest background cluster.



Detection sensitivity

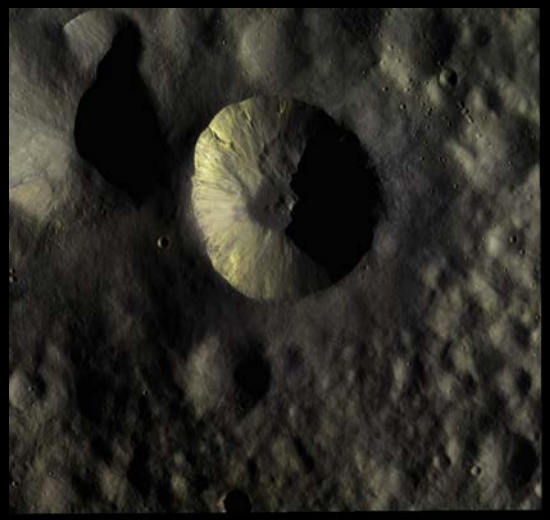


target

Matched filter score

Example: Multispectral Dawn Framing Camera

- Used multiple-filter Automatic alignment of filtered images using SIFT landmark features [Lowe, 2001]



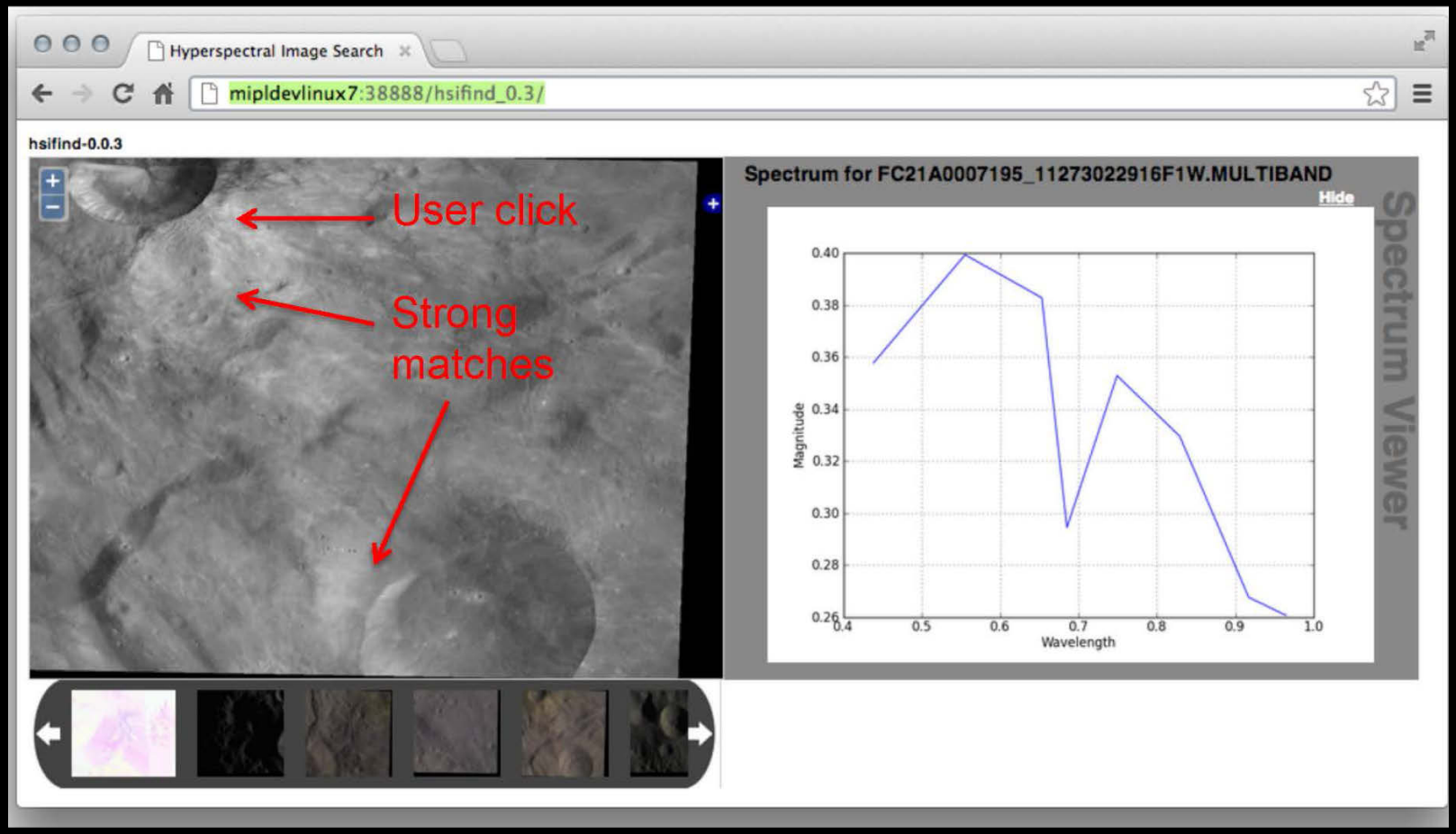
FC21A0007011_11272235916F1W (8 filters)

“Shadow” search result

“Fresh erosion” search result

Credit: NASA/JPL/DLR

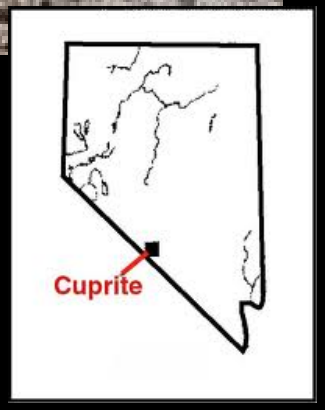
Example: Dawn Framing Camera

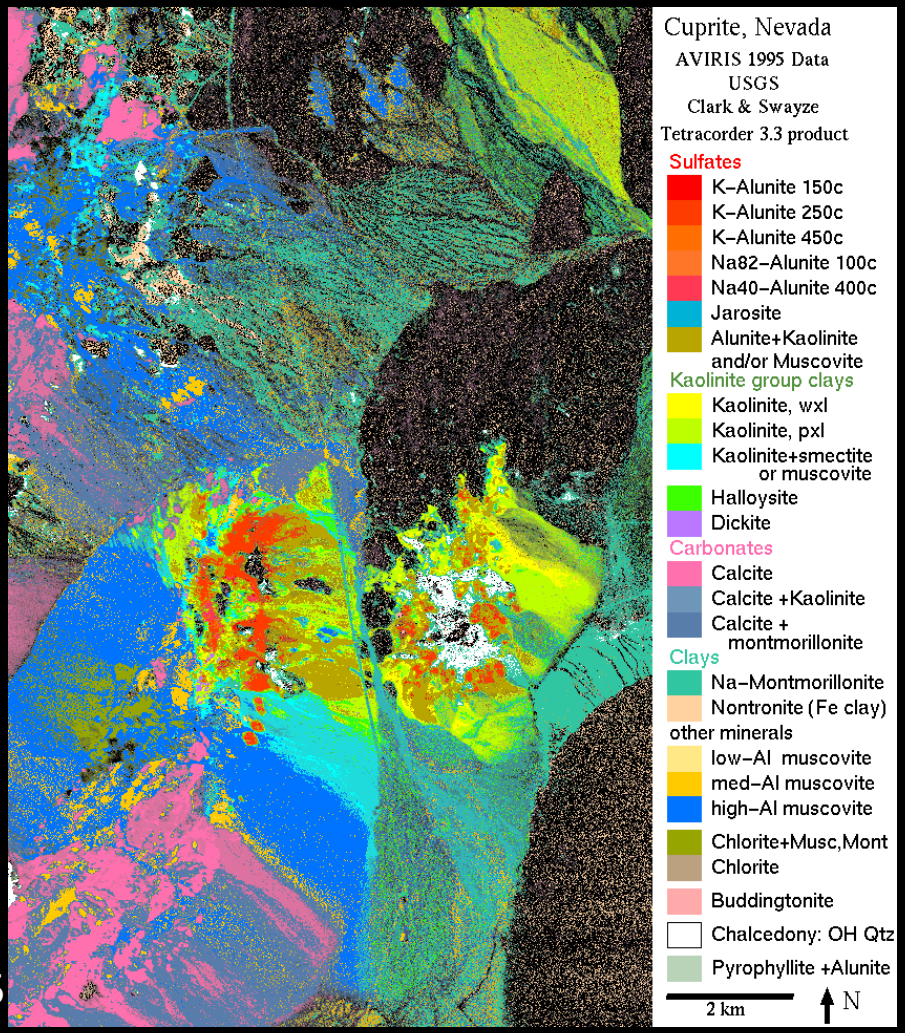


Credit: NASA/JPL/DLR

Example: AVIRIS instrument, Cuprite NV

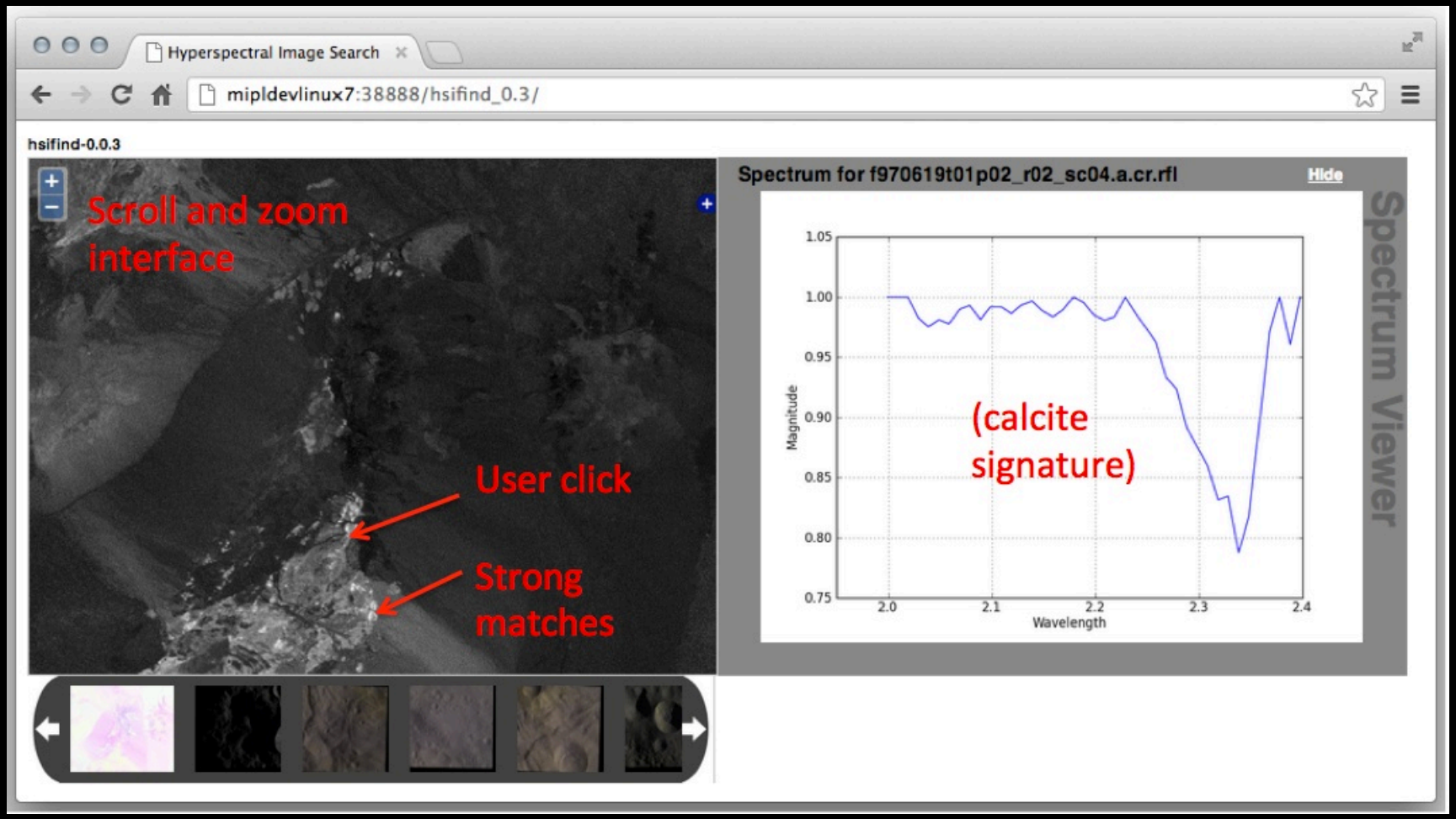
Image: USGS





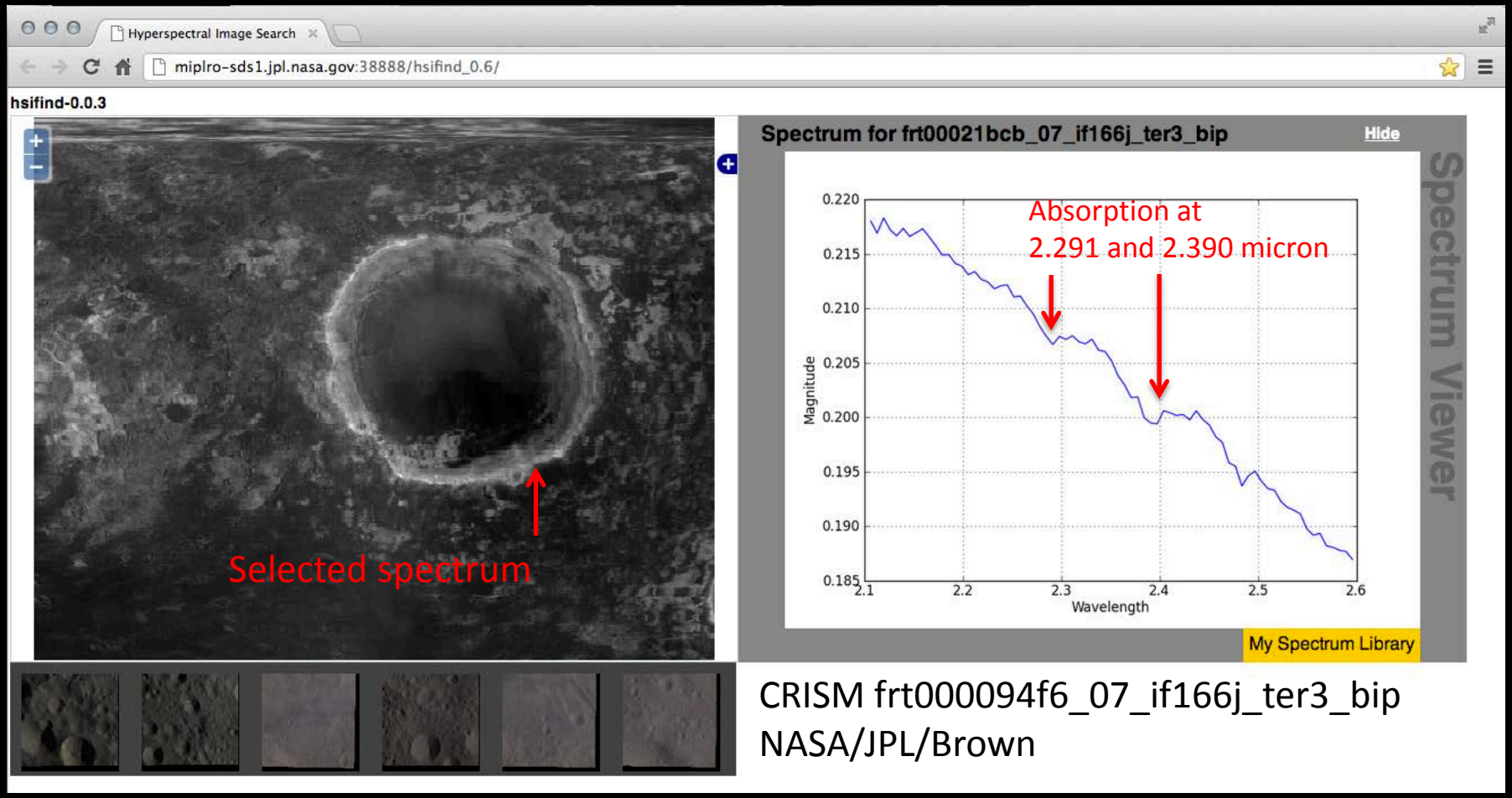
Clark & Swayze, 1995

Example: AVIRIS instrument, Cuprite NV



Credit: NASA/JPL

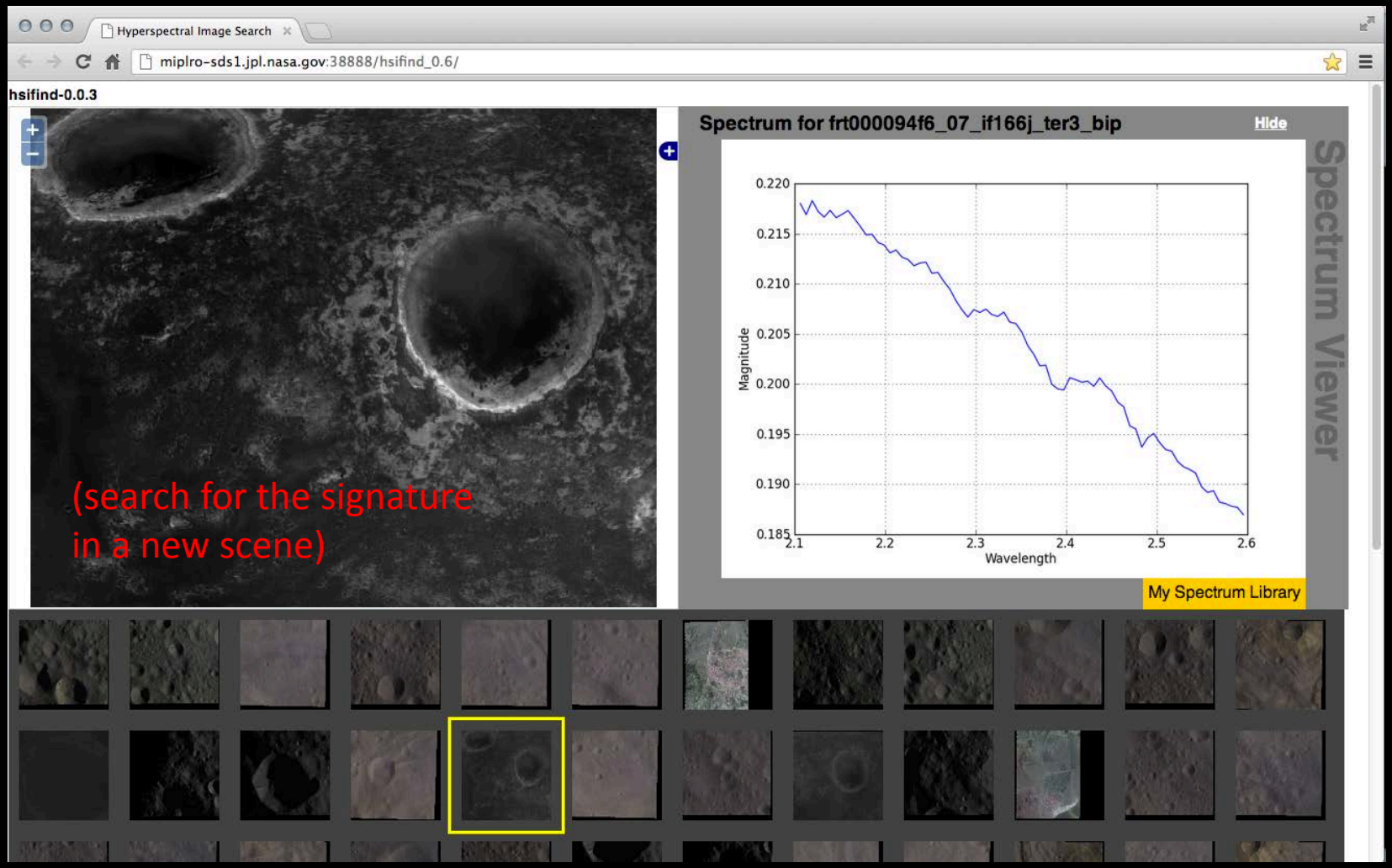
Example: CRISM MTRDRs



CRISM frt000094f6_07_if166j_ter3_bip
NASA/JPL/Brown

Credit: NASA/JPL/Brown

Example: CRISM MTRDRs



Credit: NASA/JPL/Brown

Conclusions

- Many tactical analysis tasks can be formulated as search
- “Terrestrial” matched filter target detection techniques apply equally well to planetary domains
- Server-side computation is portable, bandwidth-efficient