# Creating a Program in MatLab to Classify CRISM Data

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#### **ABSTRACT**

The 2009-2010 undergrad Research team primary focus was to create a program using map lab that will classify CRISM data in a shorter time frame than what it will take to classify by hand. The CRISM research consisted of manually classifying images from Mars and placing them into excel's data base, downloading images and storing them into Kitoto's server so that the program can read and return results of the overall images and mineral images. These images can be classified as excellent, fair, poor, and absent. The classification of each image will show whether there is a lot, little, or no water in each kind of mineral. The five minerals are oxidized iron minerals, mafic mineralogy, hydroxylated silicates, bound water and CO2 water. The images that show the most signs of water in certain areas on Martian will be examined more closely. Currently, the CRISM team working is on creating this program in MatLab.

#### **Frequently asked questions about Mars**

- Is Mars environments suitable for life?
- If water was once present on Mars did it leave any clues"?
- If there was water on Mars, how did it affect Mars Surface?
- Can there be human exploration and colonization on Mars?
- How is Mars atmosphere different from Earths?
- When and where did the water occur?

#### Purpose

The Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) is one of NASA's high-tech Detectives seeking traces of past and present water on Martian surface." CRISM uses the saying "Follow the water" which is a method used for tracing and studying minerals that indicate liquid. By using this method of studying minerals in search for water. CRISM will be able to answer questions that many have been asking for years.

Note: Mars' liquid water may evaporate but that does not mean that it disappears. CRISM is still able to trace minerals such as iron Oxides, carbonates, Sulfates and other minerals on Mars.

### **CRISM Four Goals**

- Find the spectral finger prints of minerals that form in liquid water.
- Measure the changing amounts of water and other volatiles in the atmosphere and as polar ices.
- Map geology, composition and layering of the surface features.
- Help locate Martian resources that could provide local support for eventual human exploration and colonization.

| Common<br>Thread                | "Follow the Water"                 |                |  |  |  |
|---------------------------------|------------------------------------|----------------|--|--|--|
| W                               | Determine if Life ever Arose on Ma | ars            |  |  |  |
| A<br>T                          | Characterize the Climate of Mars   | and the second |  |  |  |
| E<br>R                          | Characterize the Geology of Mars   |                |  |  |  |
| When<br>Where<br>Form<br>Amount | Prepare for Human Exploration      | -              |  |  |  |

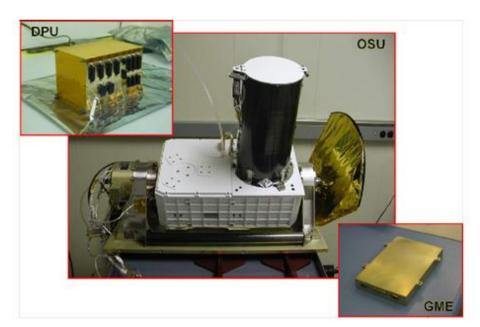
# Mentor: Dr Eric Akers

### CRISM

- scannable field of view.
- Is a Visible-infrared imaging spectrometer with a
- Covers wave lengths from 0.362 to 3.92 microns at 6.55 nanometer/channel



- •The optics, oGimbal
- •Focal planes
- •Cryocoolers
- Radiators
- •Focal plane electronics
- Gimbal Motor Electronics (GME)
- Data Processing Unit (DPU)
  - •Accepts and processes commands from the spacecraft



| $\diamond$     | В               | С             | D   | E  | F    |  |
|----------------|-----------------|---------------|---|--|------|--|
|                | Target ID (hex) | Image Quality | Eval Comment  | Observation  | Туре | Hyperlink  |
| 2              | 7532            | fair          | vnir_fem is absent, ir_maf is absent, ir_phy is absent, ir_hyd is absent, ir_ice is absent      | COORD Target - 4462 Alluvial Fan in Crater                             | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT00007 |
| 3              | 7536            | poor          | vnir_fem is absent, ir_maf is poor, ir_phy is absent, ir_hyd is absent, ir_ice is absent        | Fill - Atmospheric EPF - 5080a 4 1256096 (TOO: High TI unit and mesa)  | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT00007 |
| 4              | 753b            | poor          | vnir_fem is fair, ir_maf is poor, ir_phy is absent, ir_hyd is absent, ir_ice is absent          | S. Polar Monitoring - The Forks T1                                     | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT00007 |
| 5<br>6         | 7540            | poor          | vnir_fem is poor, ir_maf is poor, ir_phy is poor, ir_hyd is poor, ir_ice is absent              | THEMIS-VIS Greatest Hits (ID: 09695011)                                | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT00007 |
| 6              | 754c            | fair          | vnir_fem is absent, ir_maf is absent, ir_phy is absent, ir_hyd is absent, ir_ice is absent      | Fill - Atmospheric EPF - 5084a 2 1256281 (TOO: High southern latitude) | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT00007 |
| 7              | 754e            | Excellent     | vnir_fem is poor, ir_maf is fair, ir_phy is absent, ir_hyd is absent, ir_ice is absent          | Pavonis Mons eastern summit region                                     | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT00007 |
| 8              | 7558            | poor          | vnir_fem is fair, ir_maf is absent, ir_phy is fair, ir_hyd is fair, ir_ice is absent            | South Polar Layered Terrain y-shaped caverns                           | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| 9 1            | 7559            | fair          | vnir_fem is absent, ir_maf is absent, ir_phy is absent, ir_hyd is absent, ir_ice is absent      | Fill - Atmospheric EPF - 5086a 3 1256239 (TOO: SSR)                    | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| 0              | 755a            | Excellent     | vnir_fem is absent, ir_maf is absent, ir_phy is absent, ir_hyd is absent, ir_ice is absent      | Fill - Atmospheric EPF - 5086a 4 1256240 (TOO: SSR)                    | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| 9<br>10        | 7560            | Excellent     | vnir_fem is poor, ir_maf is absent, ir_phy is absent, ir_hyd is fair, ir_ice is absent          | COORD Target - Monitor changes in Richardson dune field                | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| 2              | 756a            | fair          | vnir_fem is absent, ir_maf is poor, ir_phy is absent, ir_hyd is absent, ir_ice is absent        | Fill - Atmospheric EPF - 5088a 5 1256200 (TOO: Catina)                 | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| 12<br>13<br>14 | 756e            | Excellent     | vnir_fem is poor, ir_maf is fair, ir_phy is poor, ir_hyd is poor, ir_ice is absent              | COORD Target - 11451 Basal Exposure of South Polar Layered Deposits    | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| 14             | 756f            | Excellent     | vnir_fem is absent, ir_maf is absent, ir_phy is absent, ir_hyd is poor, ir_ice is absent        | COORD Target - 360 Sample Tyrrhena Dorsa                               | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| 15 /           | 7582            | Excellent     | vnir_fem is absent, ir_maf is excellent, ir_phy is absent, ir_hyd is fair, ir_ice is absent     | Fill - Atmospheric EPF - 5092a 5 1256121 (TOO: SSR)                    | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| .6             | 7588            | Excellent     | vnir_fem is absent, ir_maf is poor, ir_phy is absent, ir_hyd is poor, ir_ice is absent          | Sisyphi Montes peak - possible ancient small highlands volcano         | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| 16<br>17       | 758d            | Excellent     | vnir_fem is poor, ir_maf is excellent, ir_phy is absent, ir_hyd is poor, ir_ice is absent       | THEMIS-VIS Greatest Hits (ID: 06317005)                                | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| 18             | 759d            | Excellent     | vnir_fem is fair, ir_maf is absent, ir_phy is absent, ir_hyd is excellent, ir_ice is absent     | 7073 Light-toned layering on plains to the south of West Candor        | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| 19             | 75a7            | Excellent     | vnir_fem is poor, ir_maf is poor, ir_phy is absent, ir_hyd is fair, ir_ice is absent            | THEMIS-VIS Greatest Hits (ID: 15831005)                                | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| 20             | 75a9            | Excellent     | vnir_fem is excellent, ir_maf is excellent, ir_phy is absent, ir_hyd is fair, ir_ice is absent  | 13064 Sample south wall of Olympus Mons Caldera                        | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT0000  |
| 20<br>21       | 75ad            | fair          | vnir_fem is absent, ir_maf is fair, ir_phy is absent, ir_hyd is absent, ir_ice is absent        | Tader Valles   | HRL  | http://crism-map.jhuapl.edu/summary.php?obs=HRL0000  |
| 22             | 75b1            | fair          | vnir_fem is excellent, ir_maf is poor, ir_phy is fair, ir_hyd is excellent, ir_ice is excellent | Fill - Atmospheric EPF - 5100d 1 1256220 (TOO: SPRC trough)            | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT00007 |
| 23<br>24       | 75b2            | poor          | vnir_fem is poor, ir_maf is absent, ir_phy is absent, ir_hyd is absent, ir_ice is absent        | Fill - Atmospheric EPF - 5100a 2 1256221 (TOO: High Southern Latitude; | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT00007 |
| 24             | 75b3            | Excellent     | vnir_fem is absent, ir_maf is poor, ir_phy is absent, ir_hyd is absent, ir_ice is absent        | Fill - Atmospheric EPF - 5100a 3 1256222 (TOO: SSR)                    | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT00007 |
| 25             | 75c0            | Excellent     | vnir_fem is poor, ir_maf is excellent, ir_phy is fair, ir_hyd is poor, ir_ice is absent         | COORD Target - 11463 Basal exposure of south polar layered deposits    | FRT  | http://crism-map.jhuapl.edu/summary.php?obs=FRT00007 |

# Undergraduate Research Experience CRISM Team 2009-2010

• This allows CRISM team to identify a broad range of minerals on the Martian surface.

### **CRISM Consist of Three Boxes**

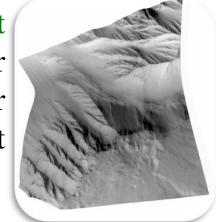
- Optical Sensor Unit (OSU)

- •Commands and powers the gimbal
- •Analyzes data from angular position encoder in
- a feedback loop
- •Accepts and processes data from the OSU and Communicates it to the spacecraft

| on Imagai | vnir_rgb   | CRISM DA<br>Viewing Features                                    |
|-----------|--|---|
| op Image: | Enhanced visible color   | BROWSE PRODUCT  |
|           | red = 592nm  | vnir_rgb  |
|           | red - 592nm  | Enhanced visible color  |
|           | green = 533 nm   | red = 592nm   |
|           | blue = 492nm   | green = 533 nm<br>blue = 492nm                                  |
|           | Downloads:<br>• <u>PNG</u><br>• <u>PNG w/ geo. grid</u><br>• <u>Map/Stretch Info</u> | Downloads:<br>• PNG<br>• PNG w/ geo. grid<br>• Map/Stretch Info |
|           |  | ir_ira  |
|           |  | IR surface brightness   |
| D - 44    | ir ira   | gray level = brightness at 1330nm.<br>Downloads:                |
| Bottom    | -  | PNG     PNG w/ geo. grid  |
| <b>T</b>  | IR surface brightness  | <ul> <li>Map/Stretch Info</li> </ul>                            |
| Image:    | gray level = brightness at 1330nm.   |   |
| 0         | Downloads:   |   |
|           | • PNG  |   |
|           | PNG w/ geo. grid     Map/Stretch Info  |   |
|           |  |   |
|           |  |   |

#### Classification

#### Excellent Fair Poor Absent



Excellent Fair Poor Absent



#### **Classifying Images (Minerals)**

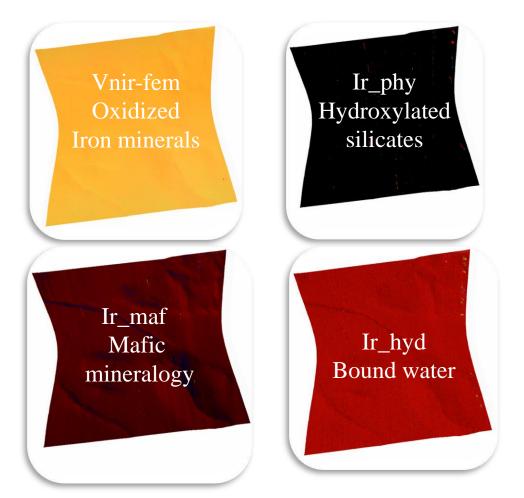
Each Image has a IR Derived Product:

- Vnir-fem Oxidized Iorn minerals
- Ir\_maf Mafic mineralogy
- Ir\_phy Hydroxylated Silicates
- Ir\_hyd
- Bound water
- Ir\_ice Water and CO2 Ice

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#### Classification





Water and CO2 Ice If all five minerals have something present other than "Absent" then the closer scientists are to finding answers regarding Mars.

#### **Downloading Images**

- Click on a link
- Guide you to the webpage
- Enlarge the picture
- Save it to a destination
- Repeat steps

# **Moving Images Into Kitoto**

Directory of saved pictures

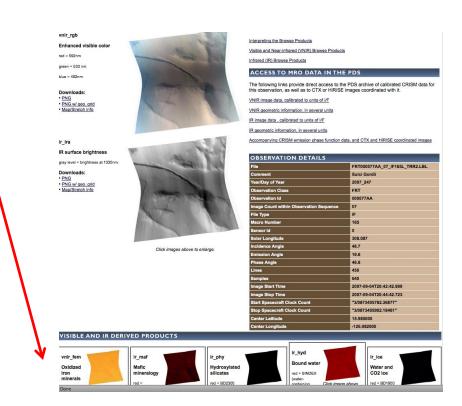
| and the second se | Name          | Date taken       | Tags  | Size            | Rating |                |                |
|---|---------------|------------------|-------|-----------------|--------|----------------|----------------|
| Fevorite Links  | a cenerpic    |                  | 1.1.2 | 30030           |        | 9. 30058 PHV1  | 8, 30109_HVD   |
| Documents   | 0, 30002      |                  |       | B. 30030        |        | 9, 30062       | 0, 30109 JCEI  |
| E Pictures  | R. 30002_FE   | ave.             |       | . 30030         |        | 8, 30062 FEM1  | 9, 30109 MA    |
| D Music   | 9. 30002 H    |                  |       | B. 30030        |        | B. 30062 HYDS  | R. 30109 PHY   |
|   | B. 30002 JC   |                  |       | 0, 30040        |        | 9, 30062 KCE1  | 9, 30119       |
| Recently Changed  | P. 30002 M    |                  |       | B. 30040        | FEMI   | R. 30062 MAF1  | 0, 30119 FEM   |
| B Searches  | 8, 30002 PH   |                  |       | 8, 30040        |        | 9, 30062 PHV1  | 9, 30119 HVD   |
| Public  | B. 30006      |                  |       | B. 30040        |        | 9, 30063       | B. 30119 ICE1  |
|   | R. 30006 FE   | IM               |       | B, 30040        |        | 9, 30063 FEML  | 9, 30119 MA    |
|   | B. 30006 H    |                  |       | 8, 30040        |        | B. 30063 HY/D1 | 8, 30119 PHY   |
|   | 9, 30006 JC   |                  |       | B. 30041        |        | 9, 30063 JCE1  | 9, 30121       |
|   | R. 30006 M    |                  |       | B. 30041        | FEMD   | 8, 30063 MAF1  | B. 30121 FEM   |
|   | 8, 30006 PH   |                  |       | 8, 30041        |        | R, 30063 PHV1  | B. 30121 HVD   |
|   | 0, 10011      |                  |       | B. 30041        |        | 9, 30082       | R. 30121 JCE1  |
|   | 8, 30011 FE   | EM1              |       | B. 30041        |        | 8. 30082 FEM1  | 9, 30121_MA    |
|   | B. 30011 H    |                  |       | 0, 30041        |        | 8, 30082 HYDS  | B, 30121 PHO   |
|   | B. 30011 K    |                  |       | 9, 30042        |        | 9, 30082 JCE1  | 301.25         |
|   | 0, 30011 M    |                  |       | 8, 30042        | FEMI   | B. 30082_MAF1  | 9, 30125 FEM   |
|   | R. 30011 PR   |                  |       | B. 30042        |        | 9, 30082 PHV1  | 9, 30125 HVT   |
|   | R. 30016      |                  |       | B, 30042        | ICE1   | B, 30088       | R. 101.25 JCE1 |
|   | 8. 30016_FE   | EMI              |       | 0, 30042        |        | 9. 30088 FEM1  | 9, 30125 MA    |
|   | B. 30016 H    | NDS              |       | 8, 30042        | PHV1   | 201/H_88006 #  | 0, 30125 PHV   |
|   | 9, 30016 K    | .E1              |       | B, 30048        |        | 9, 30088 JCE1  | 9, 30129       |
|   | 9. 30016 M    | IAF1             |       | B. 30048        | FEML   | B. 30088_MAF1  | 9, 30129_FEM   |
|   | P. 30016 Pr   | HV1              |       | B, 30048        | HYDS   | 9. 30088_PHV1  | 30129_HV0      |
|   | Re Type P     | NG Image         |       | B. 30048        | CEI    | 9, 30093       | B. 301.29 JCE1 |
|   |               | sions: 762 x 696 |       | B. 30048        | MAFI   | 9, 30093_FEML  | 30129_MAR      |
|   | R.   Size: 21 | 4 KB             |       | R. 30048        | PHIV1  | B. 30093 HYD1  | B. 30129_PHN   |
|   | 0. 30028 JC   | EL               |       | B. 30058        |        | 30093 JCE1     | B. 30130       |
|   | R. 30028 M    | IAF1             |       | B. 30058        | FEMIL  | B. 30093 MAF1  | R. 30130_FEM   |
|   | 0. 30028 PH   | HV1              |       | B, 30058        | HVD1   | B, 30093_PHIV1 | 9, 30130 HVD   |
|   | B. 30030      |                  |       | 0, 30058        | ICE1   | B. 30109       | B, 30130 JCE1  |
|   | R. 30030_FE   | DML              |       | <b>0.</b> 30058 | MAFI   | 8 30109_FEM1   | 8, 30130_MA    |
|   |               |                  |       |                 |        |                |                |

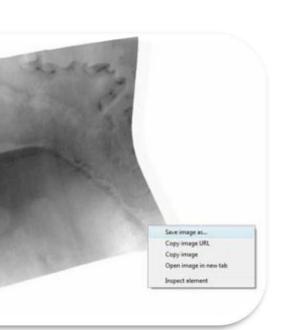
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| 30002_FEH1.png                   |                                   | 30130_PHY1.png                   | 30277_NWF1.png              | 30333_ICE1.png                   | 30391_HYD1.png                   | 30451_FEN1.png                   |
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| 30011_HYD1.png                   | 30082_FEH1.png                    | 30144 .png                       | 30299_PHY1.png              | 38347_NWF1.png                   | 30405_ICE1.png                   | 30468_HYD1.png                   |
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| 30016_NAF1.png                   | 38688_HYD1.png<br>38688_ICE1.png  | 38238_FEM1.png<br>38238_HVD1.png | 38381.png<br>38385_FEM1.png | 38354_pmt1.pmg                   | 38489 PHY1.ong                   | 30477_ICE1.png<br>30477_NWF1.png |
| 30016_PHY1.png                   | 30088_NWF1.png                    | 38238_ICE1.png                   | 38385_HYD1.png              | 38364_FEM1.png                   | 38489.png                        | 30477_PHY1.png                   |
| 30016.png                        | 30068_PHY1.png                    | 38238_NWF1.png                   | 38385_ICE1.png              | 38364_HYD1.png                   | 38426_FEM1.png                   | 30477.png                        |
| 30628_FEM1.png                   | 30068.png                         | 38238 PHY1.png                   | 30305 NAF1.ong              | 38364_ICE1.png                   | 30426 HYD1.ong                   | 38478_FEM1.png                   |
| 30628_HYD1.png                   | 30093_FEM1.png                    | 38238.png                        | 30305_PHY1.png              | 30364_NWF1.png                   | 30426_ICE1.png                   | 38478_HYD1.png                   |
| 30028_ICE1.png                   | 30093_HYD1.png                    | 30241_FEM1.png                   | 38385.png                   | 30364_PHY1.png                   | 30426_NWF1.png                   | 30478_ICE1.png                   |
| 30028_MWF1.png                   | 30093_ICE1.png                    | 38241_HYD1.png                   | 30307_FEM1.png              | 38364.png                        | 30426_PHY1.png                   | 38478_NWF1.png                   |
| 38828_PHY1.png                   | 30093_NWF1.png                    | 38241_ICE1.png                   | 38387_HYD1.png              | 38366_FEM1.png                   | 30426.png                        | 38478_PHY1.png                   |
| 30028.png                        | 30093_PHY1.png                    | 38241_NWF1.png                   | 30307_ICE1.png              | 38366_HYD1.png                   | 30427_FEM1.png                   | 38478.png                        |
| 30030_FEH1.png                   | 30093.png                         | 38241_PHY1.png                   | 38387_NWF1.png              | 38366_ICE1.png                   | 38427_HYD1.png                   | 30483_FEM1.png                   |

Excellent Fair Poor Absent



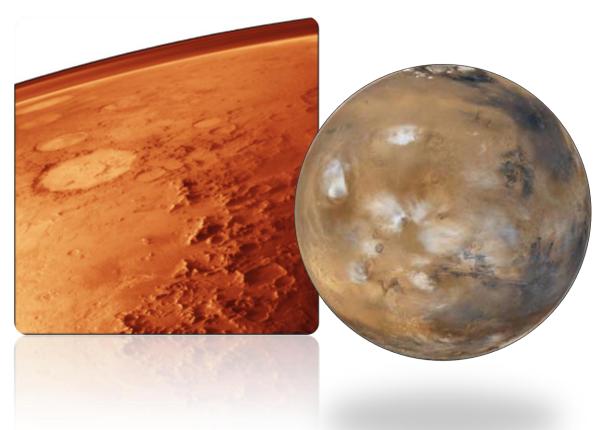
Excellent Fair Poor Absent





#### **Future Research**

- Create a program that will read the files from Kitoto and classify CRISM images automatically instead of being done by hand.
- The data that we have classified will be sent to CRISM Researchers and NASA to use in future research to understand Mars atmosphere, where and when did the water on Mars occur, if Mars is suitable for life and if there can be human exploration on Mars.



#### Logging into Kitoto

| 55                 | h  |
|--------------------|--|
| Last login: Mon M  | ar 29 13:48:08 on ttys000                                |
| -                  | t\$ ssh jdeloatch@kitoto.ecsu.edu                        |
| jdeloatch@kitoto.@ | ecsu.edu's password:                                     |
| [1]+ Stopped       | ssh jdeloatch@kitoto.ecsu.edu                            |
|                    | ssn jueroutchekitoto.ecsu.edu                            |
|                    | ecsu.edu's password:                                     |
| -                  | data; using fake authentication data for X11 forwarding. |
| -                  | ar 2 17:30:14 2010 from 10.24.61.189                     |

- •Change directory to home
- •List all files in that directory
- •Change directory to crism
- •List files in crism

a) (130, 9H/H)
a) (131, 9H/H)
a) (131, 14H/H)
a) (131, 14H/H)
a) (131, 14H/H)
a) (131, 14H/H)
a) (134, 9H/H)
a) (144, 9H/H)

Erel. K ..... 1 🕄 🕸 7.05 P

•List files in images

#### References

[1] JHU.APL Webmaster. CRISM Compact Reconnaissance Imaging Spectrometer for Mars. March 15 2010 from http://crism.jhuapl.edu/

[2] Jim Wilson. NASA http://www.nasa.gov