CRISM Data Users' Workshop
Nili Fossae Data Processing Walkthrough

March 22, 2009

Frank Seelos and the CRISM Team

Walkthrough / Take Home Exercise

Blue Text: CAT/ENVI interface instructions
Green Text: Filename of source data for accompanying figure

The intermediate data processing products, derived data products, and ancillary files presented here are available online:

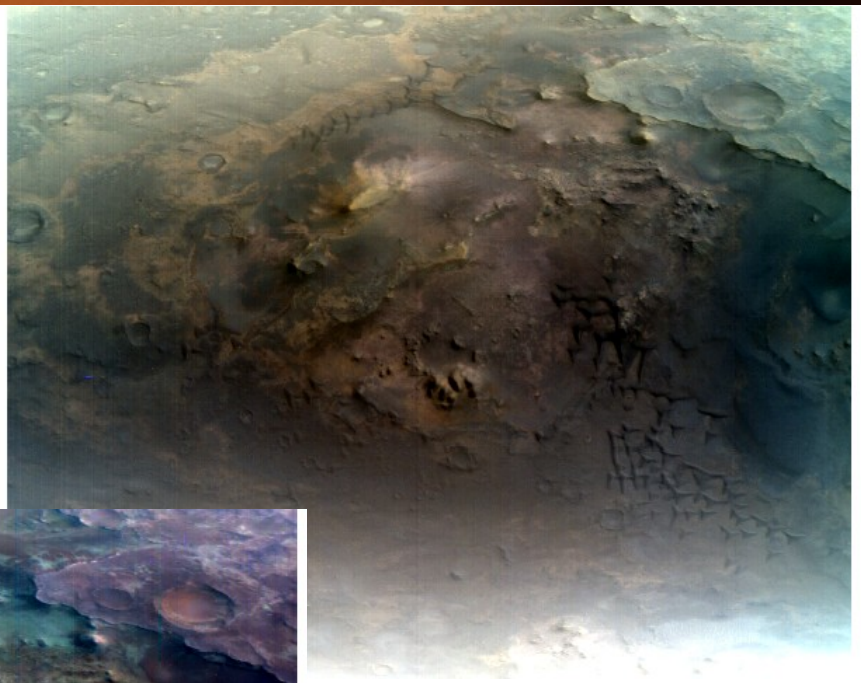
PDS Geosciences Node: http://pds-geosciences.wustl.edu/workshops/
CRISM SOC: http://crism.jhuapl.edu/CRISM_workshop_2009/

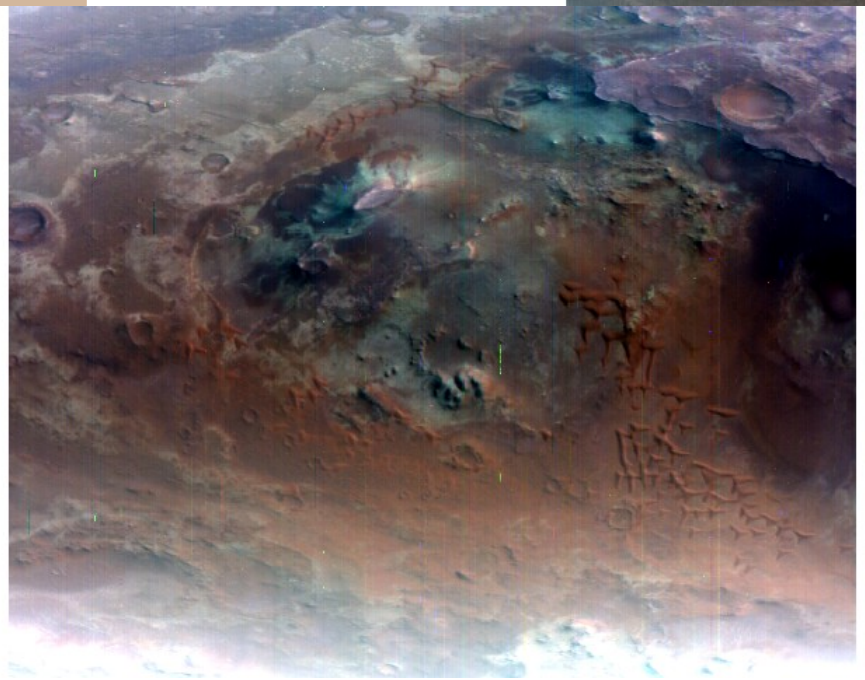
Participants in the CRISM Data Users' Workshop are encouraged to replicate the data processing and analysis presented here as a hands-on exercise

Example CRISM Observation: FRT000064D9

OBSERVATION DETAILS	
File	FRT000064D9_07_IF166S_TRR2.LBL
Comment	4001 MSL Site Need CRISM - Nili Fossae
Year/Day of Year	2007_172
Observation Class	FRT
Observation Id	000064D9
Image Count within Observation Sequence	07
File Type	IF
Macro Number	166
Sensor Id	0
Solar Longitude	261.689
Incidence Angle	62.6
Emission Angle	20.9
Phase Angle	65.2
Lines	480
Samples	640
Image Start Time	2007-06-21T06:43:02.326
Image Stop Time	2007-06-21T06:45:10.068
Start Spacecraft Clock Count	"2/0866875401.48646"
Stop Spacecraft Clock Count	"2/0866875529.31741"
Center Latitude	21.152215
Center Longitude	74.253485

VNIR RGB
R: 0.71 µm
G: 0.60 µm
B: 0.53 µm





IR RGB
R: 2.53 µm
G: 1.51 µm
B: 1.08 µm

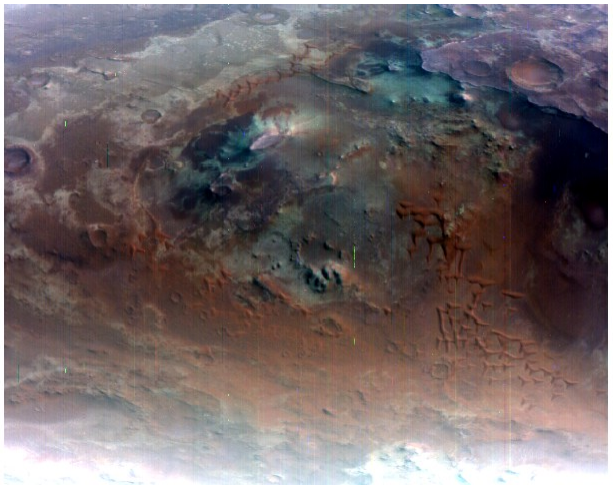
CRISM Data Processing Work Flow

- Typical CRISM data processing work flow (CAT functionality):
  - CAT: PDS to CAT conversion
  - PHT: Photometric correction [COS(i)]
  - ATM: Volcano Scan atmospheric correction (IR)
  - CLN: CIRRUS (CRISM Clean)
    - Destripe (VNIR and IR)
    - Despike (IR)
  - SUM: Summary parameter calculation

IR Progression: PDS to CAT

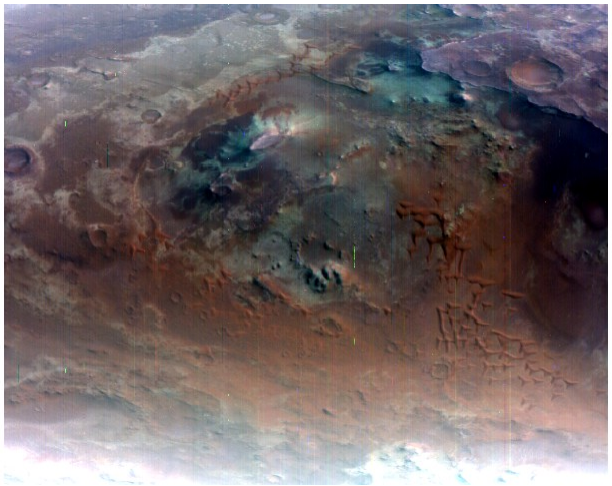
ENVI → CAT → Convert Format: PDS to CAT

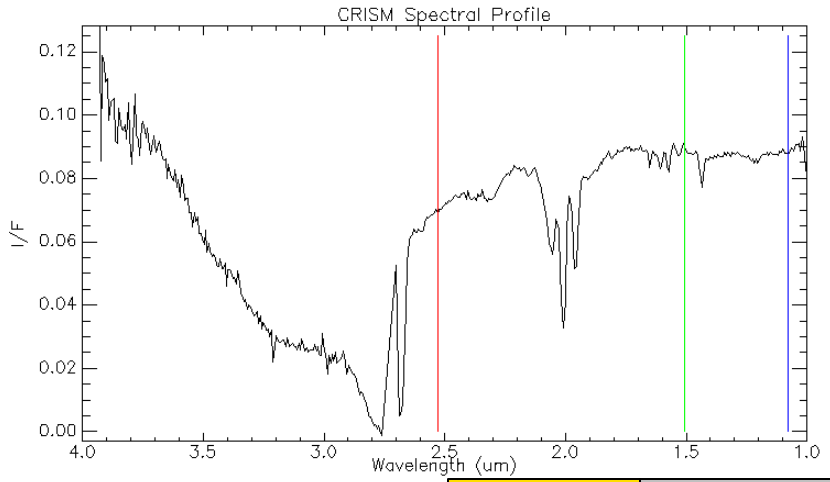
FRT000064D9_07_IF166L_TRR2.IMG

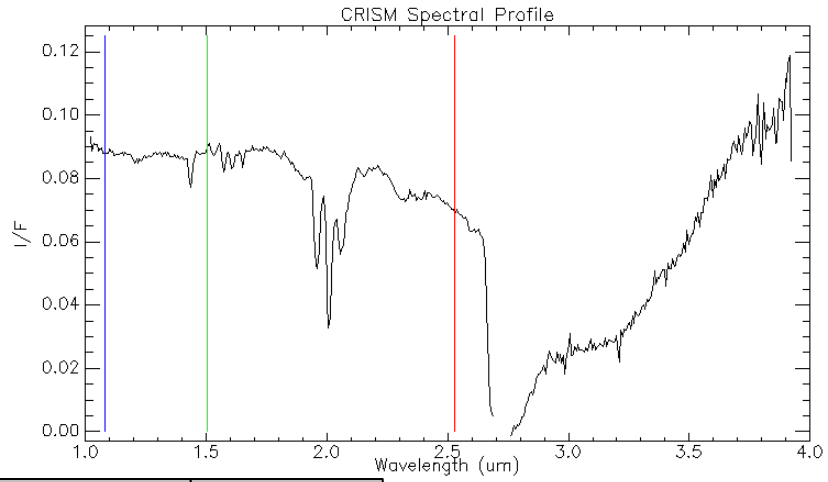


Reverses Spectral Dimension
Applies Default Bad Bands

FRT000064D9_07_IF166L_TRR2_CAT.IMG





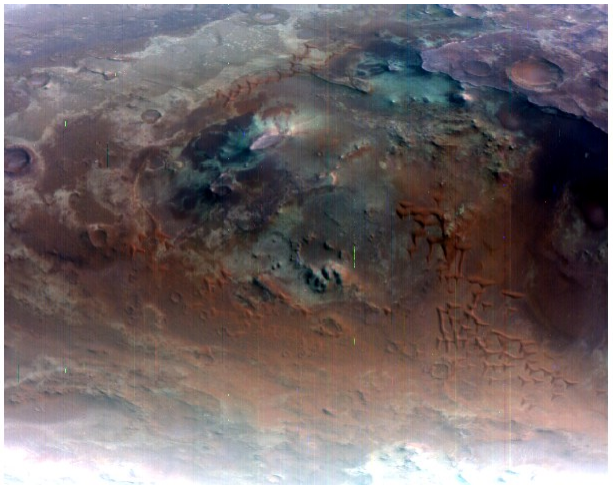


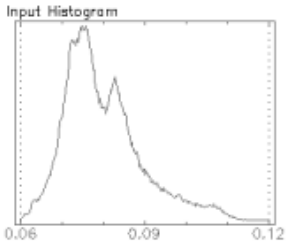
CAT | PHT | ATM | CLN | SUM

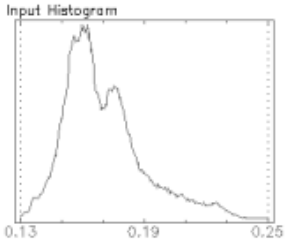
Photometric Correction [COS(i)]

ENVI → CAT → ATP Corrections → [Select File] → Photometric correction: Division by cos(i):

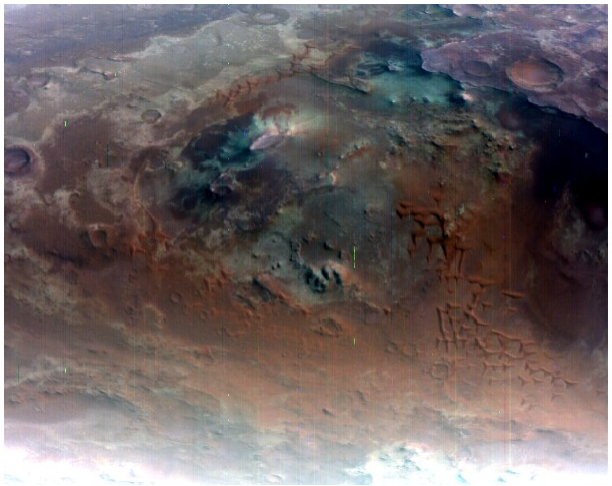
FRT000064D9_07_IF166L_TRR2_CAT.IMG

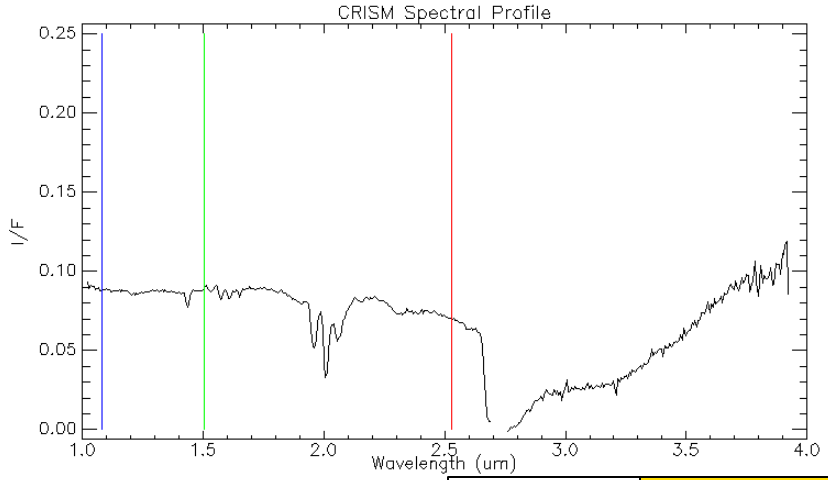


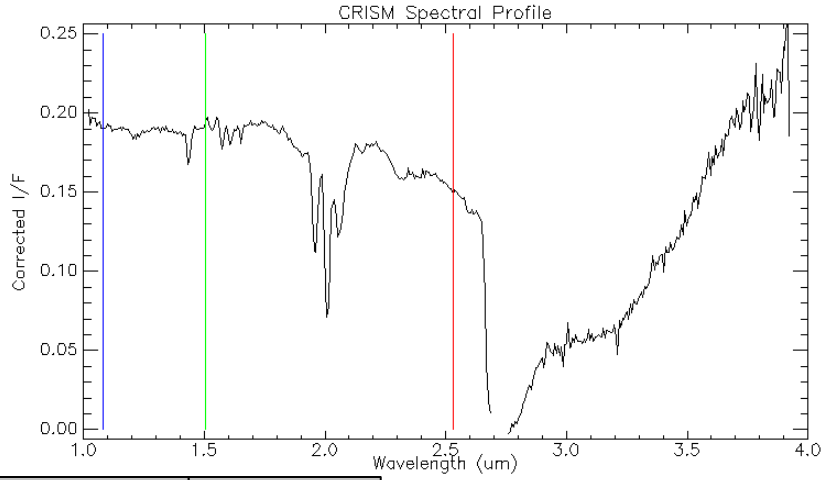




FRT000064D9_07_IF166L_TRR2_CAT_PHT.IMG





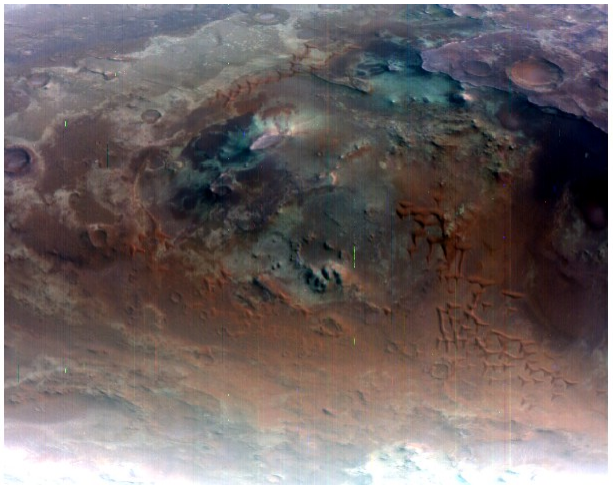


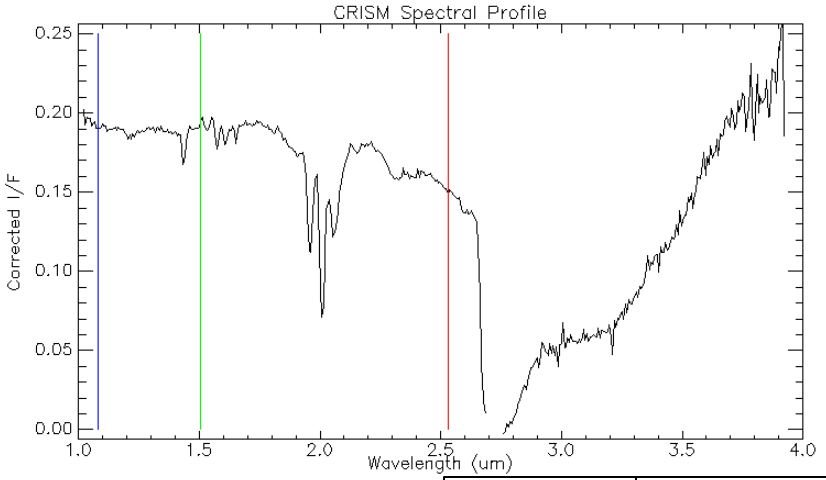
CAT | PHT | ATM | CLN | SUM

Atmospheric Correction [Volcano Scan]

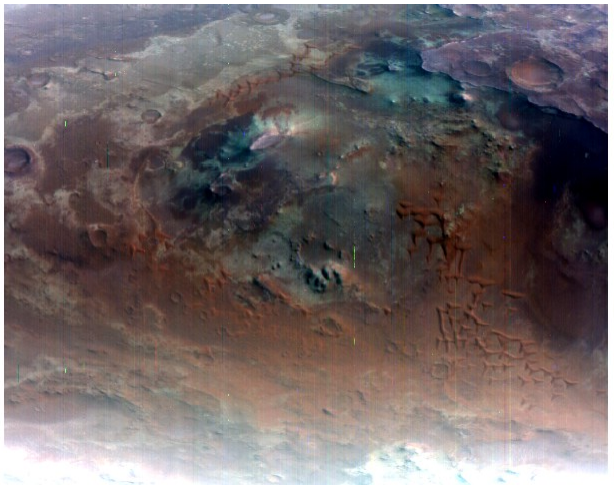
ENVI → CAT → ATP Corrections → [Select File] → Division by scaled volcano observation

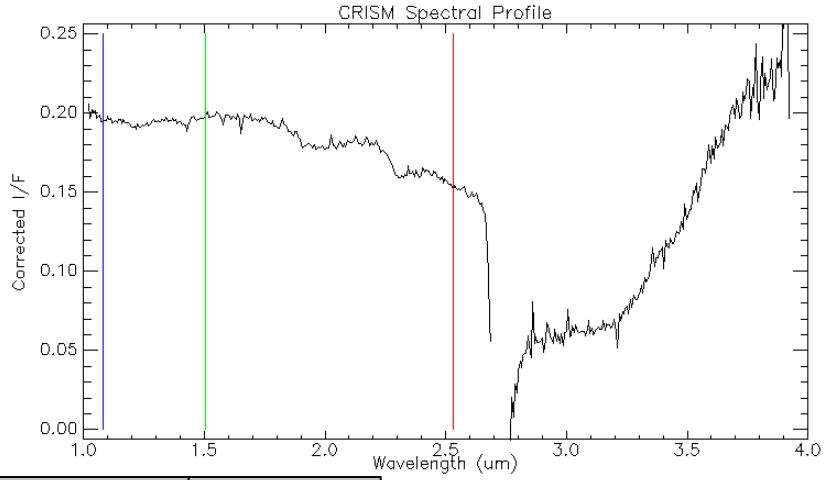
FRT000064D9_07_IF166L_TRR2_CAT_PHT.IMG





FRT000064D9_07_IF166L_TRR2_CAT_PHT_ATM.IMG



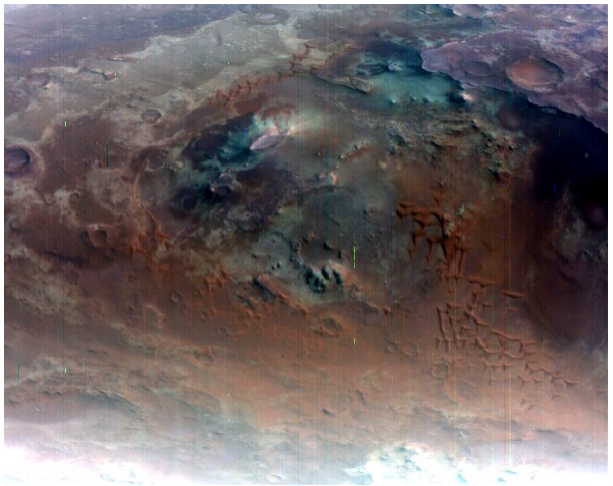


CAT	PHT	ATM	CLN	SUM

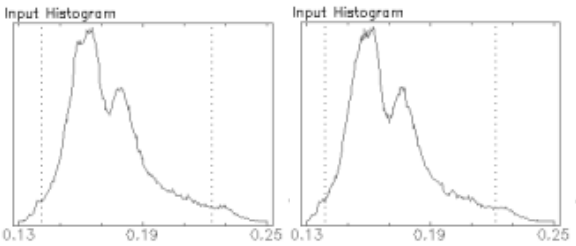
CIRRUS [CRISM Clean]

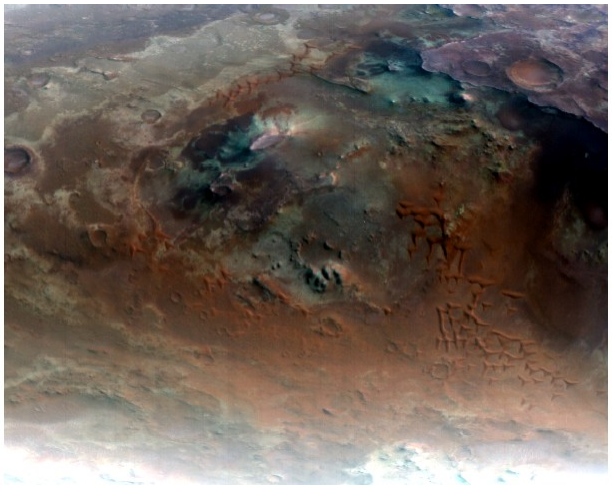
ENVI → CAT → Data Filtering → CIRRUS → Clean Spectral Cube

Select both destripe and despike for IR data

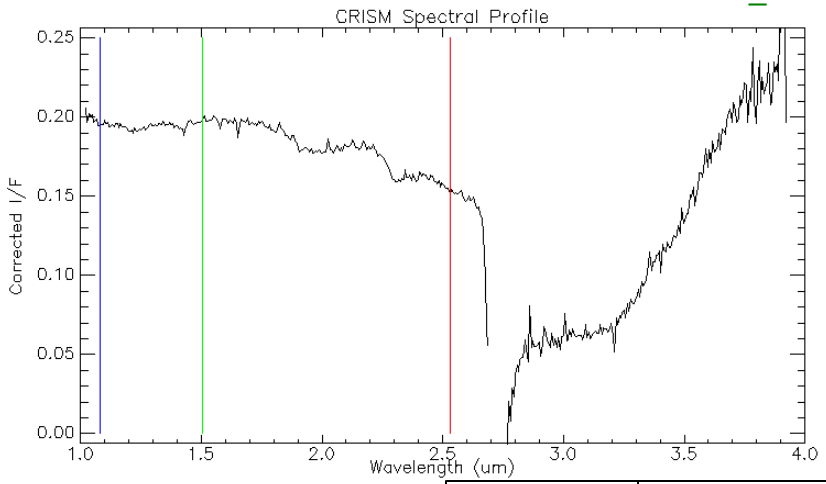


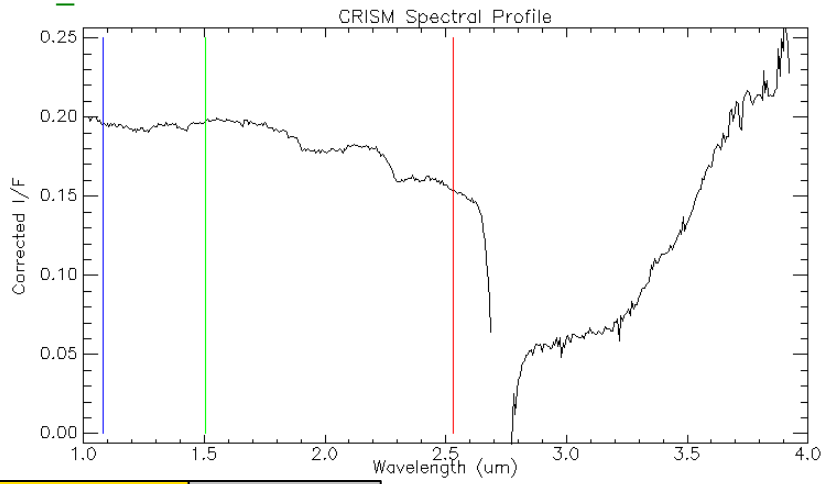
FRT000064D9_07_IF166L_TRR2...
_CAT_PHT_ATM.IMG





FRT000064D9_07_IF166L_TRR2...
_CAT_PHT_ATM_DST_DSP.IMG





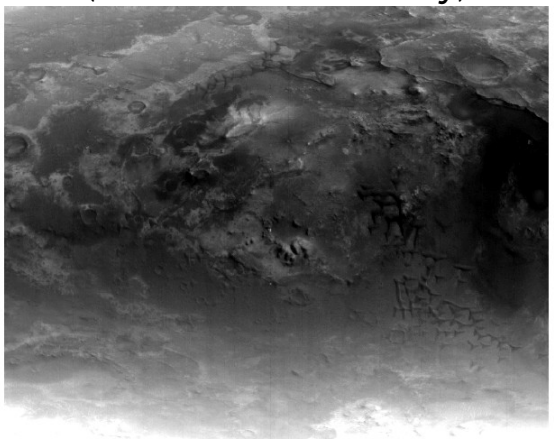
CAT	PHT	ATM	CLN	SUM

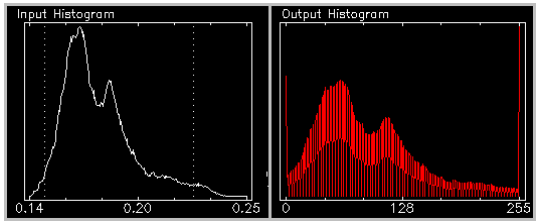
IR Spectral Summary Parameters

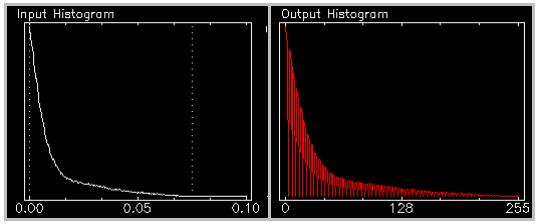
ENVI → CAT → Spectral Analysis Utilities → Spectral Summary Products → IR Data

FRT000064D9_07_IF166L_TRR2...
_CAT_PHT_ATM_DST_DSP_SUM.IMG

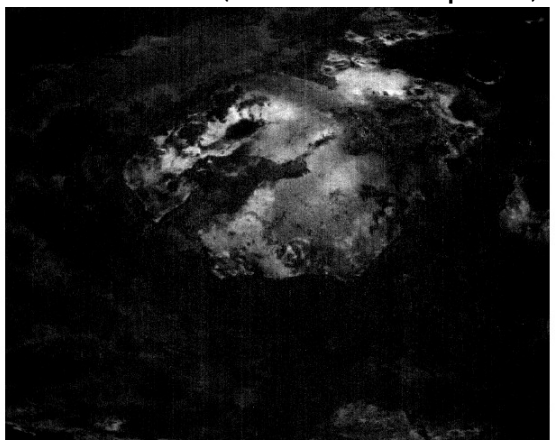
IRA (Infrared Albedo Proxy)

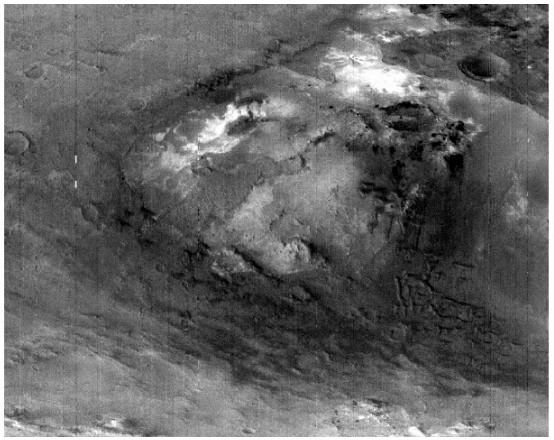


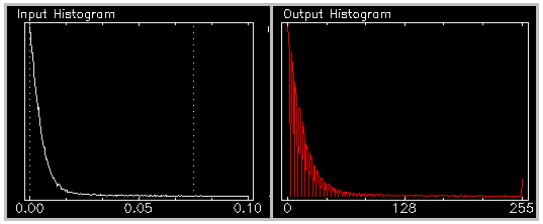


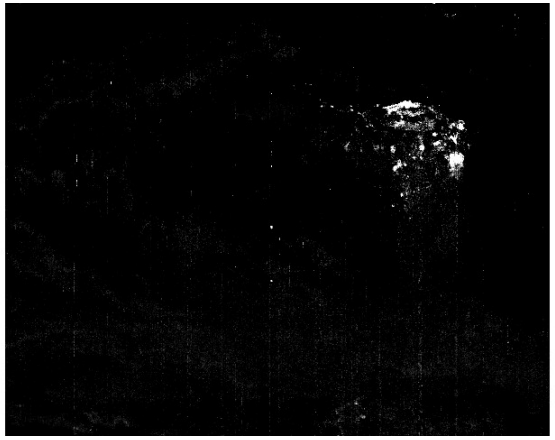


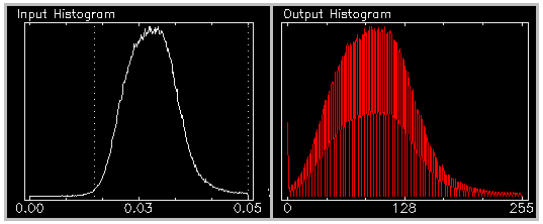
D2300 (2300 nm Drop-Off)











ISLOPE1 (1800 nm to 2500 nm Inverse Spectral Slope)

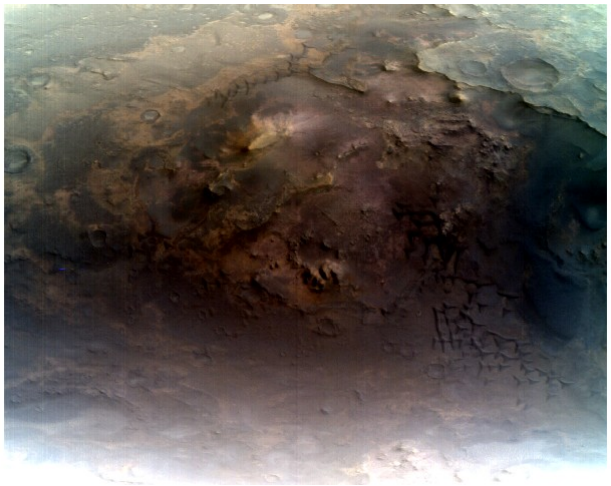
LCPINDEX (Low-Calcium Pyroxene Index)

CAT	PHT	ATM	CLN	SUM

VNIR Progression: PDS to CAT

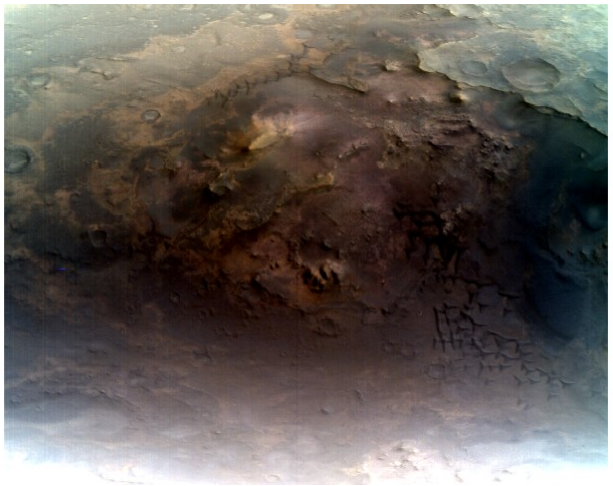
ENVI → CAT → Convert Format: PDS to CAT

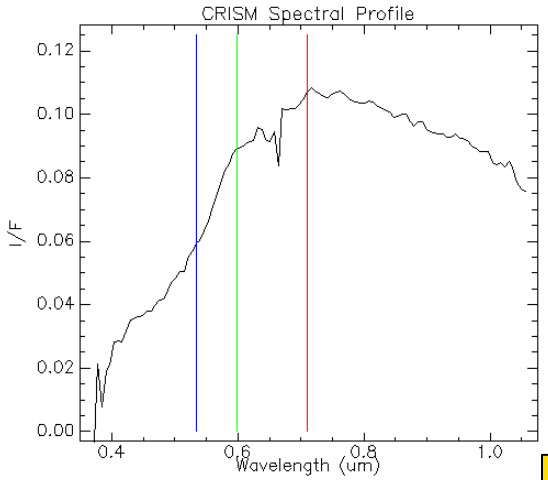
FRT000064D9_07_IF166S_TRR2.IMG

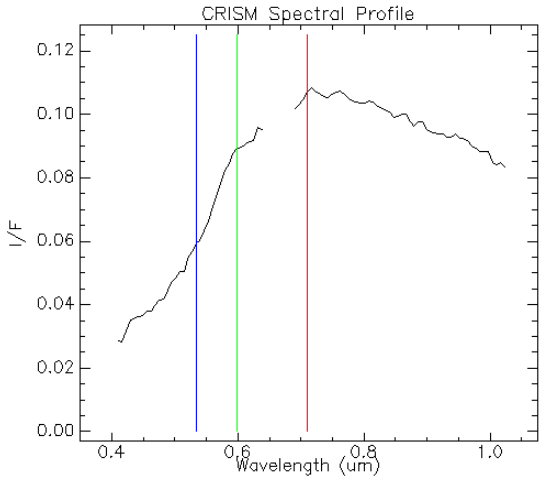


Applies Default Bad Bands

FRT000064D9_07_IF166S_TRR2_CAT.IMG





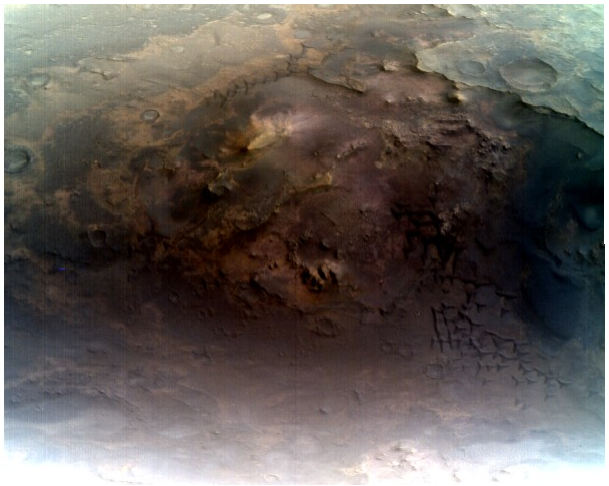


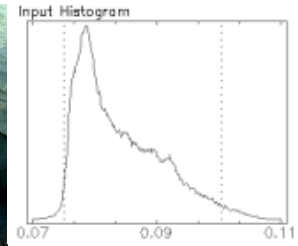
CAT | PHT | CLN | SUM

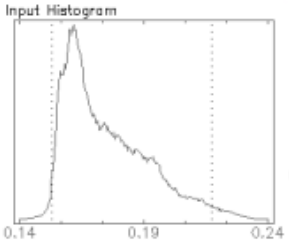
Photometric Correction [COS(i)]

ENVI → CAT → ATP Corrections → [Select File] → Photometric correction: Division by cos(i):

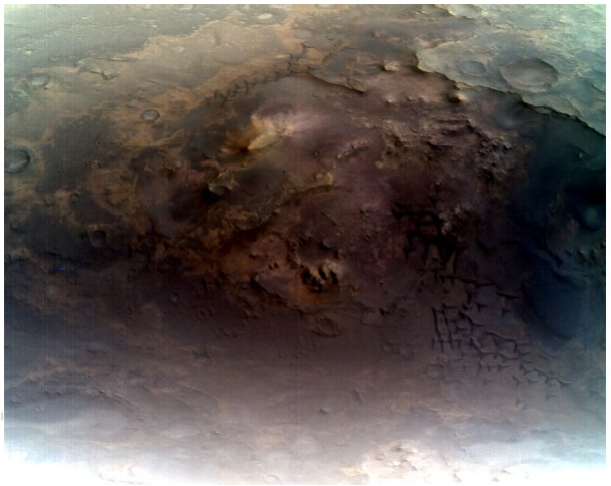
FRT000064D9_07_IF166S_TRR2_CAT.IMG

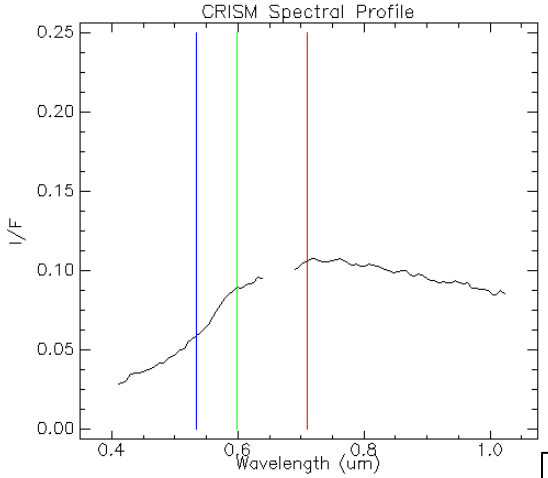


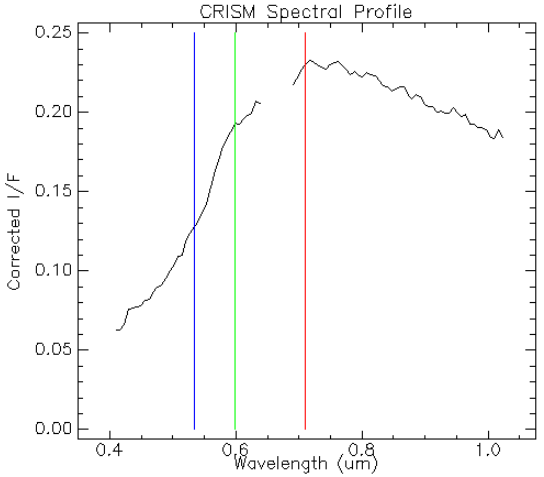




FRT000064D9_07_IF166S_TRR2_CAT_PHT.IMG







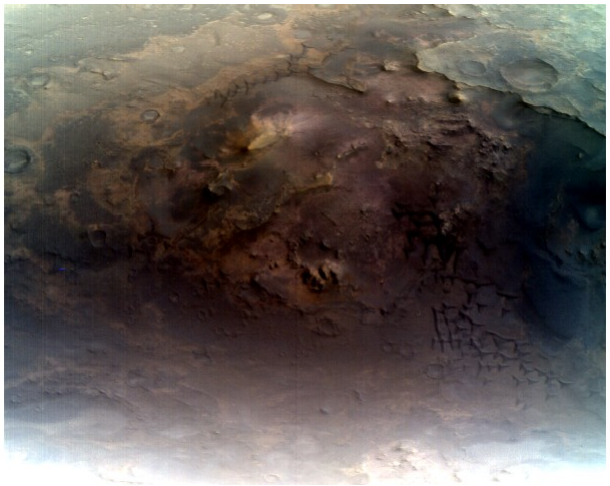
CAT | PHT | CLN | SUM

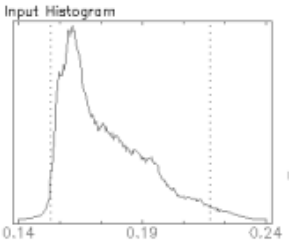
CIRRUS [CRISM Clean]

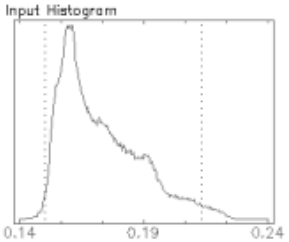
ENVI → CAT → Data Filtering → CIRRUS → Clean Spectral Cube

Select destripe for VNIR data

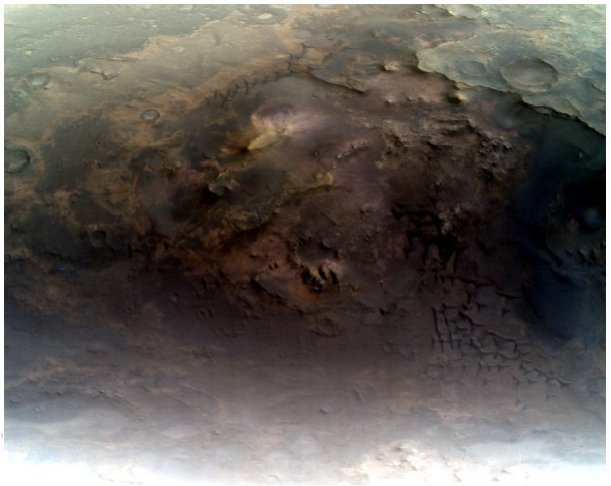
FRT000064D9_07_IF166S_TRR2_CAT_PHT.IMG

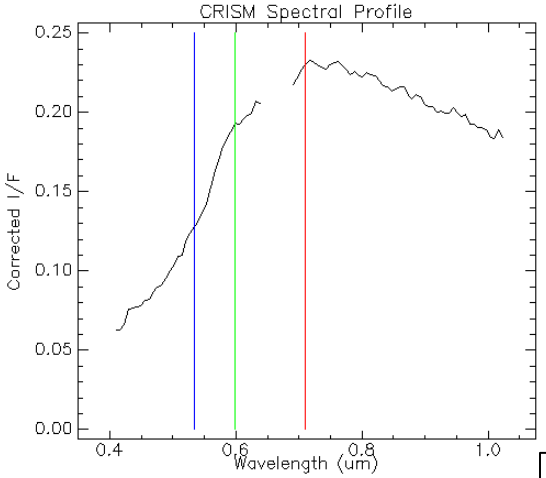


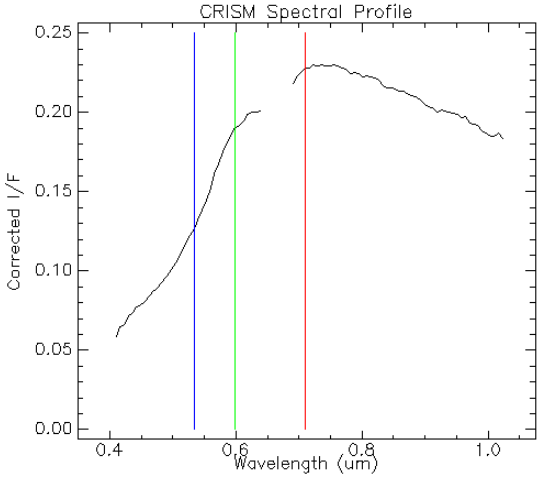




FRT000064D9_07_IF166S_TRR2_CAT_PHT_DST.IMG







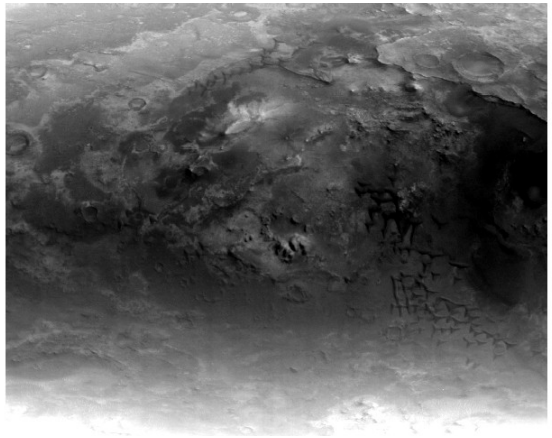
CAT	PHT	CLN	SUM

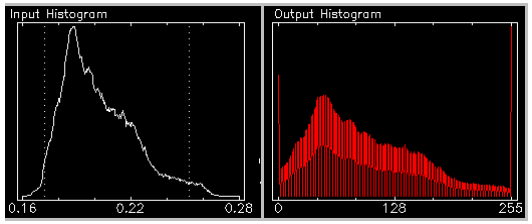
VNIR Spectral Summary Parameters

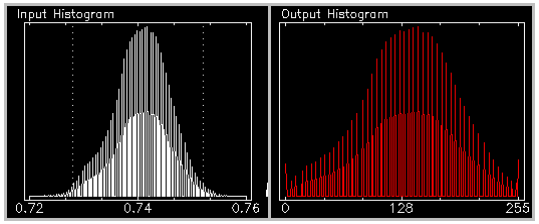
ENVI → CAT → Spectral Analysis Utilities → Spectral Summary Products → VNIR Data

FRT000064D9_07_IF166S_TRR2_CAT_PHT_DST.IMG

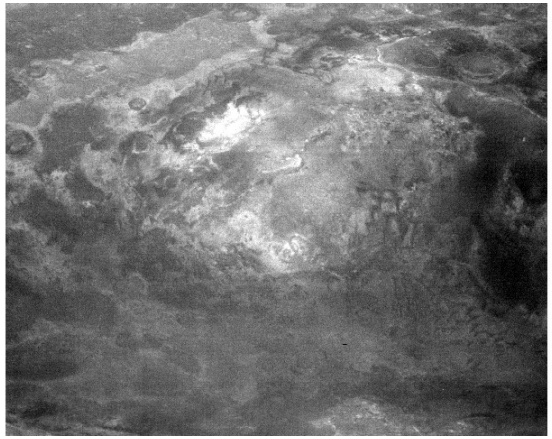
R770 (I/F @ 770 nm)

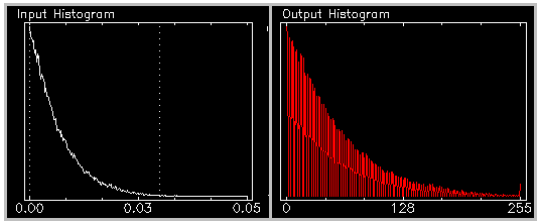


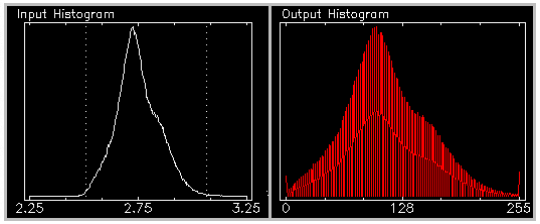


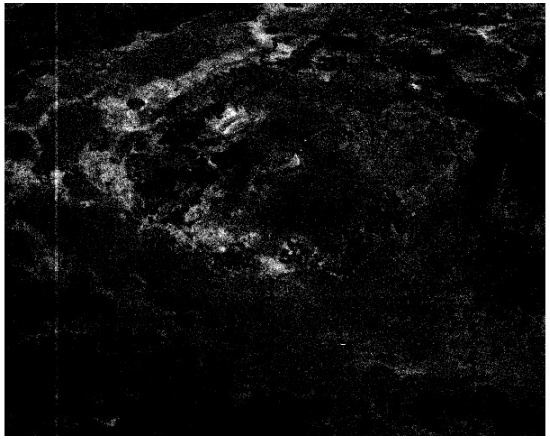


RPEAK (Wavelength of VNIR Reflectance Maximum)









RBR (Red/Blue Ratio)

BD530 (Band Depth @ 530 nm)

CAT	PHT	CLN	SUM

CRISM Data Analysis Work Flow

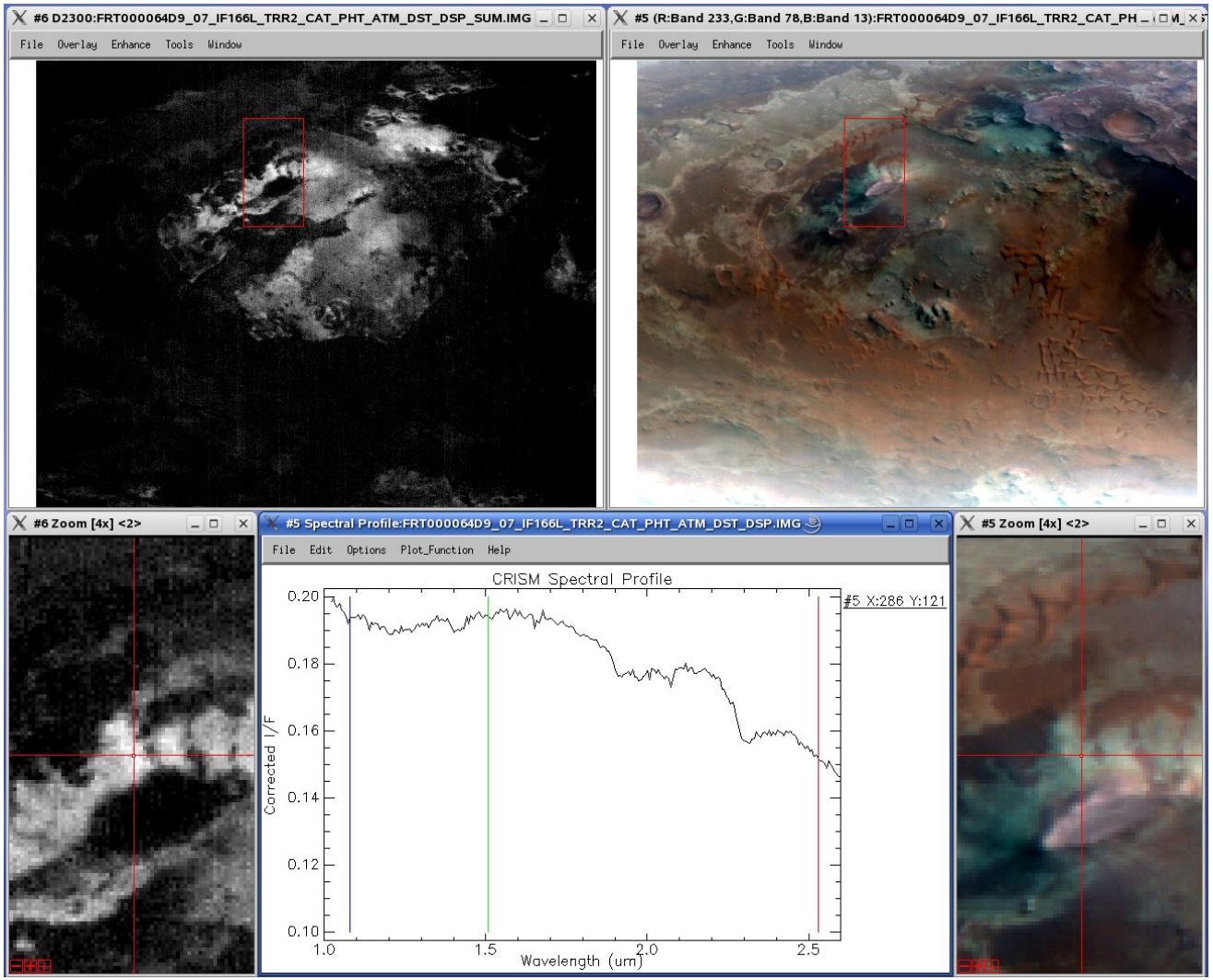
- Typical CRISM data analysis work flow (ENVI functionality):
  - Spectral unit identification
    - Guided spectral investigation
    - Link spectral data and selected spectral summary parameter(s)
  - Spectral extraction
    - Create ROIs based on linked information sources
  - Spectral ratios
  - Spectral library comparison

Spectral Unit Identification: D2300

Image → Tools → Link → Link Displays...
Select displays for pixel coordinate link

Pixel coordinate link must be done with common-detector data
VNIR/IR geographic link available after map projection

Spectral Parameter (D2300)

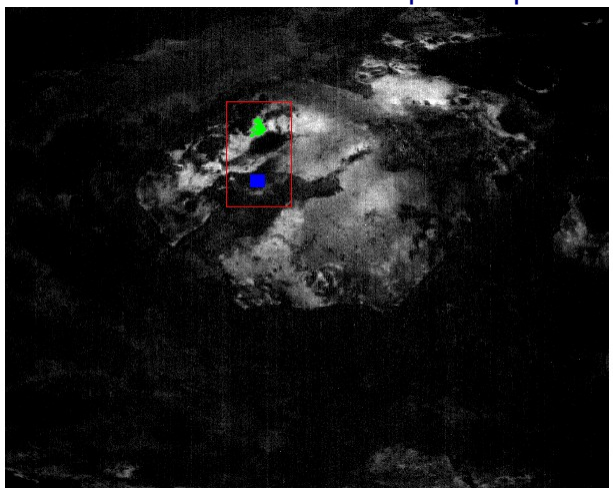
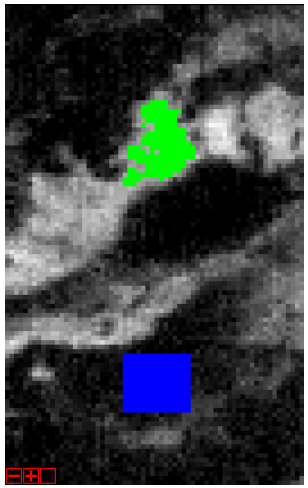
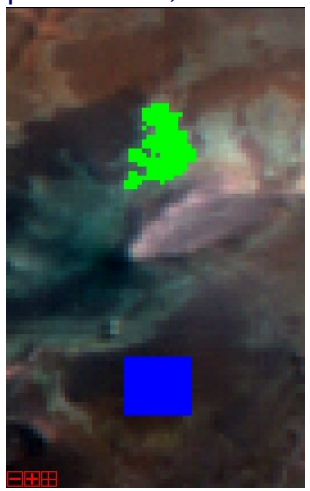
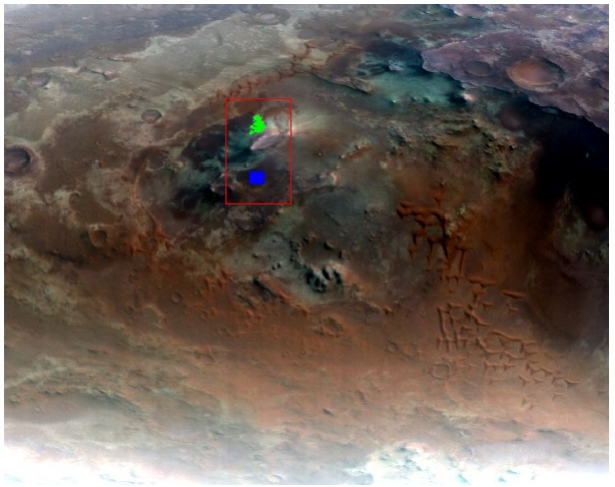


Processed Spectral Data

ROIs and Mean Spectra: D2300

Image → Overlay → Region of Interest...

Construct ROIs from spectral parameter thresholds; manual specification; ROI intersection

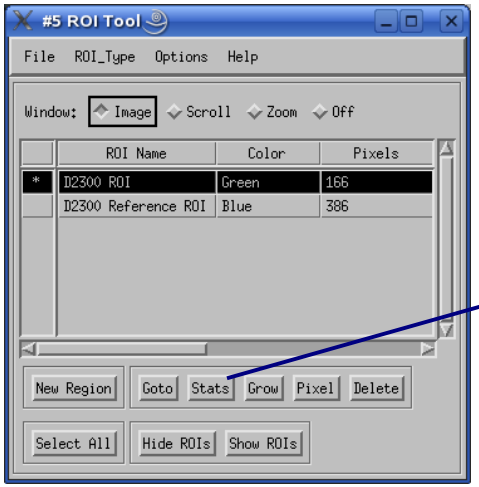





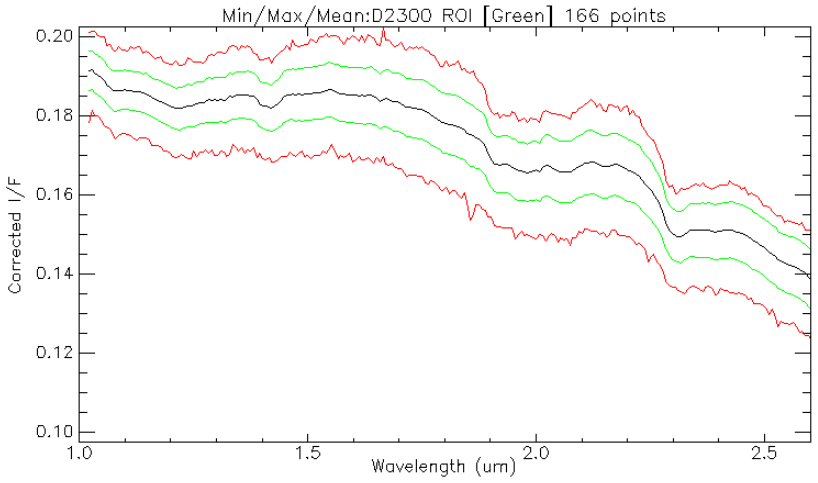
ROI Tool → Select target ROI → Stats

Compute spectral stats for spatial pixels in ROI

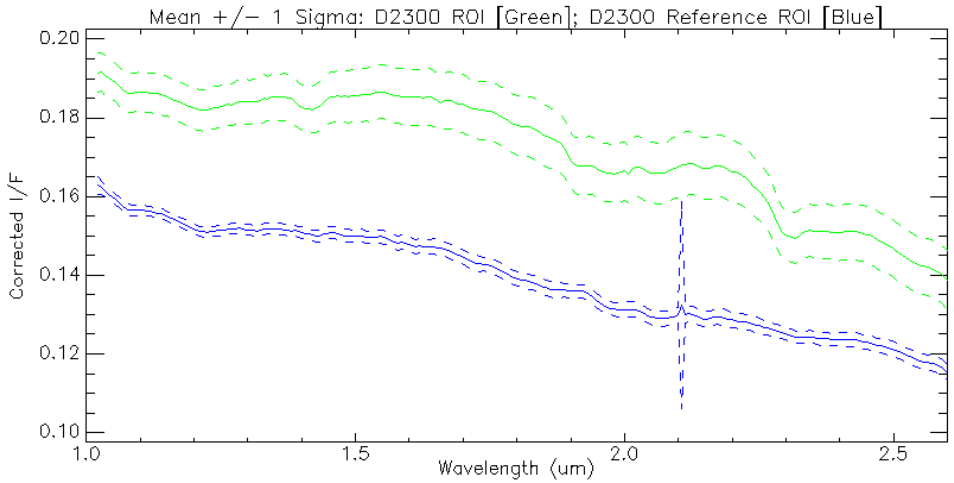
ROI file: FRT000064D9_D2300.roi

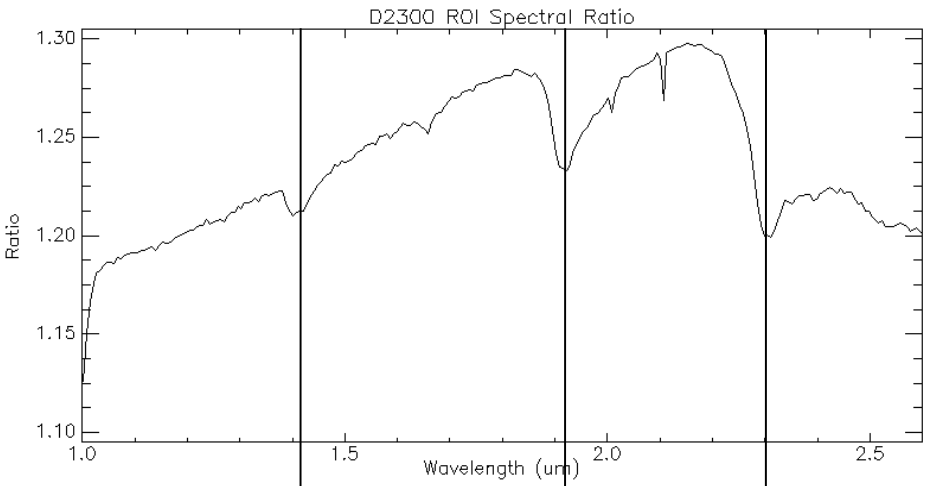
Selecting target and reference ROIs from common columns will mitigate spectral smile effects in the ratio





Ratio Spectrum and Library Comparison: D2300

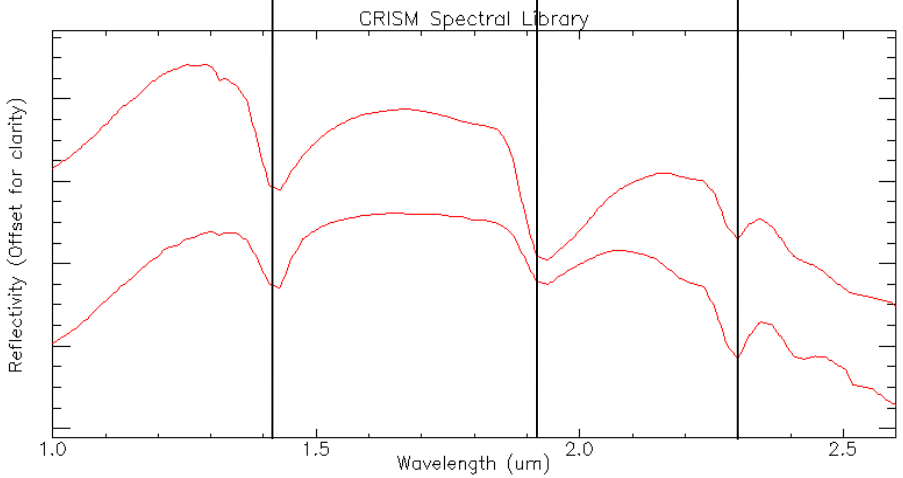




SLI file: FRT000064D9_D2300.sli

ENVI → Spectral → Spectral Math
Enter spectral math expression e.g. s1/s2
Map variables to spectra in ENVI session

ENVI → Spectral → Spectral Libraries → Spectral Library Viewer
CRISM phyllosilicate spectral library

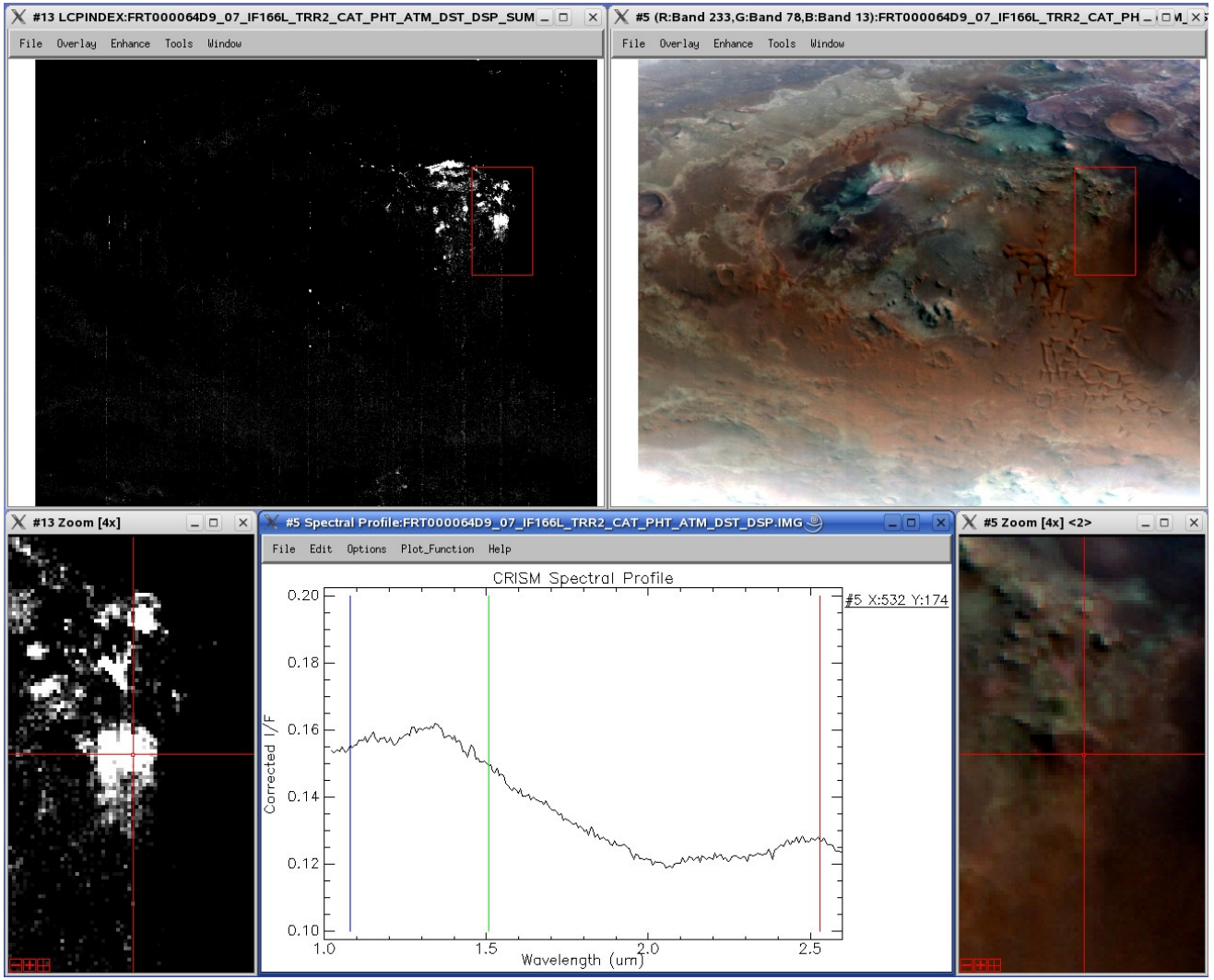


Smectite PHY07_02 [Link to Spectral Library]
Smectite PHY07 [Link to Spectral Library]

Spectral Unit Identification: LCPINDEX

Image → Tools → Link → Link Displays...
Select displays for pixel coordinate link

Spectral Parameter (LCPINDEX)

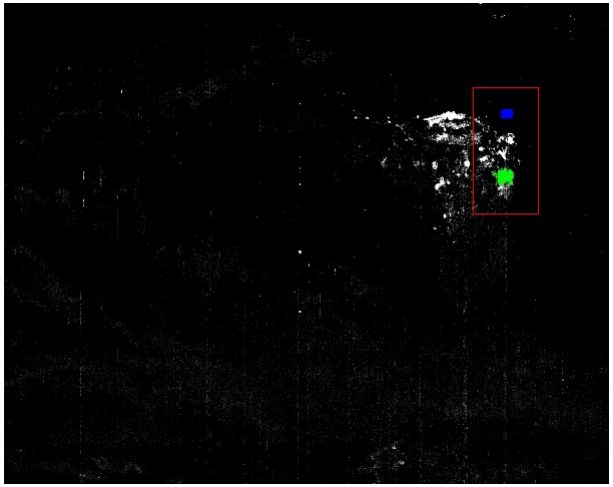


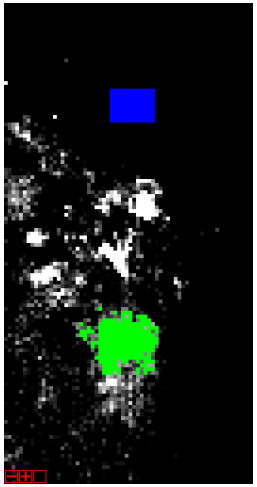
Processed Spectral Data

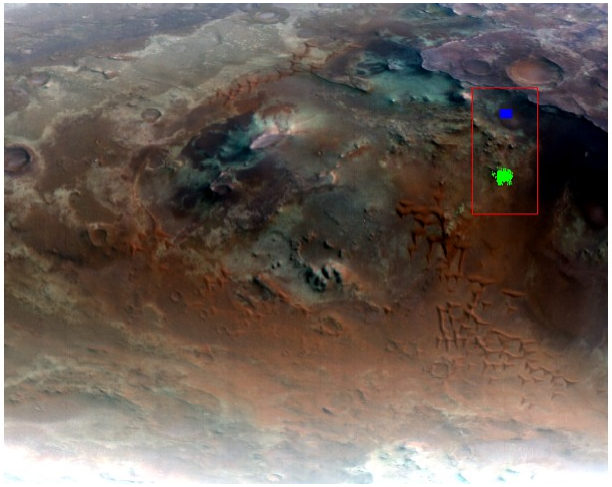
ROIs and Mean Spectra: LCPINDEX

Image → Overlay → Region of Interest...

Construct ROIs from spectral parameter thresholds; manual specification; ROI intersection



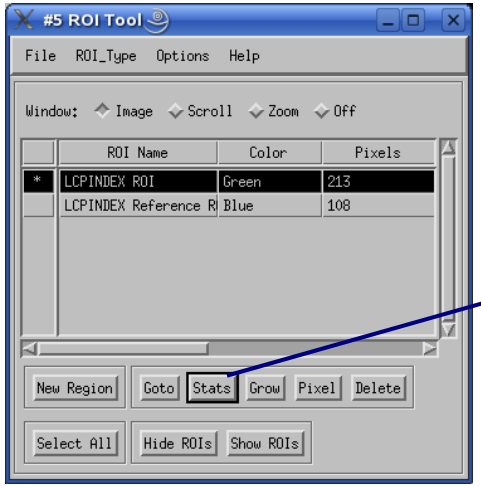


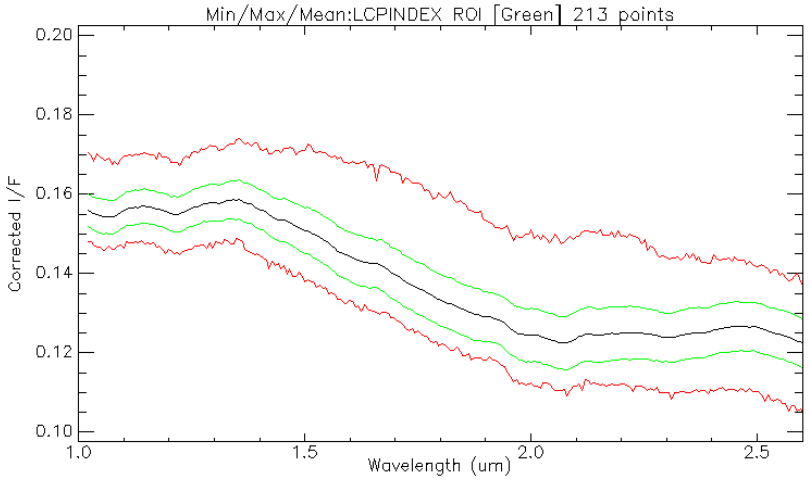


ROI Tool → Select target ROI → Stats

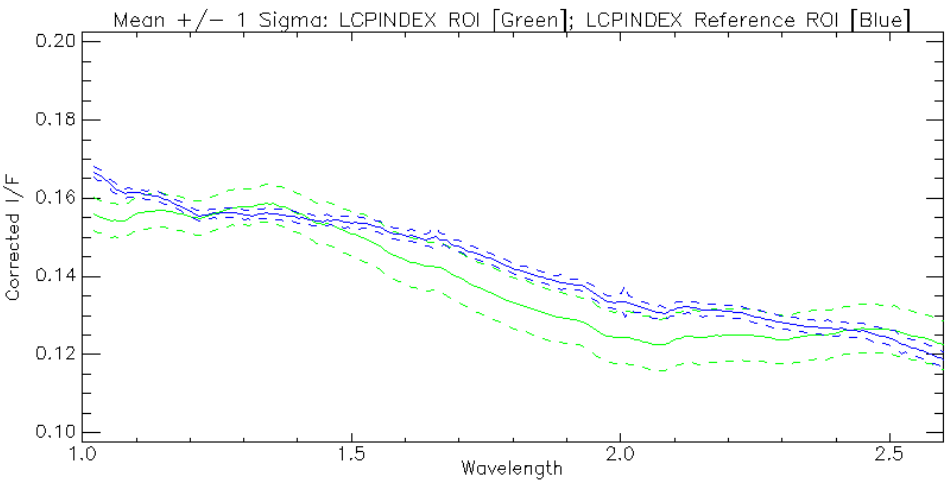
Compute spectral stats for spatial pixels in ROI

ROI file: FRT000064D9_LCPINDEX.roi

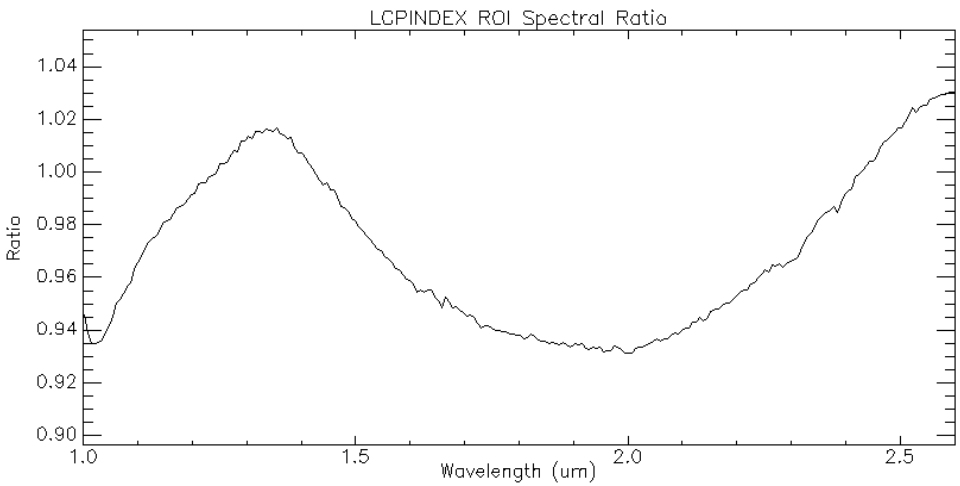




Ratio Spectrum and Library Comparison: LCPINDEX

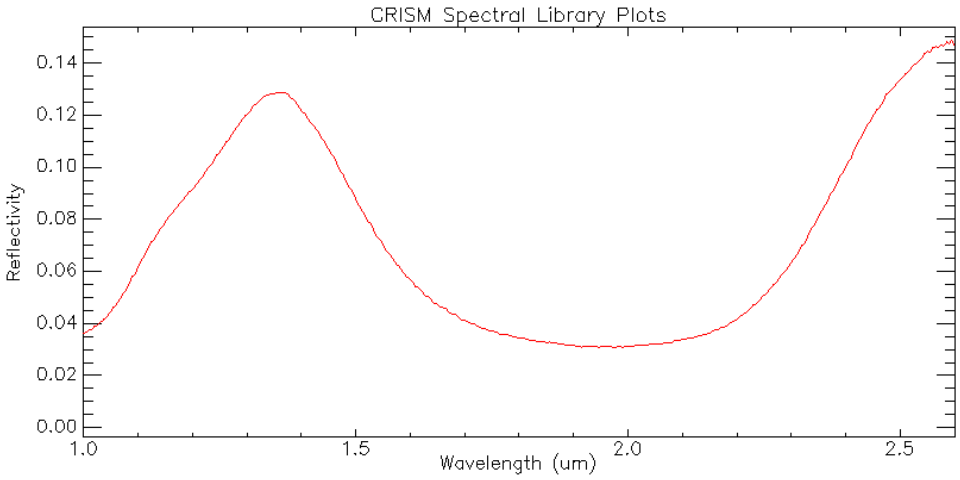


SLI file:FRT000064D9_LCPINDEX.sli



ENVI → Spectral → Spectral Math
Enter spectral math expression e.g. s1/s2
Map variables to spectra in ENVI session

ENVI → Spectral → Spectral Libraries → Spectral Library Viewer
CRISM phyllosilicate spectral library



Orthopyroxene CASB51 [Link to Spectral Library]

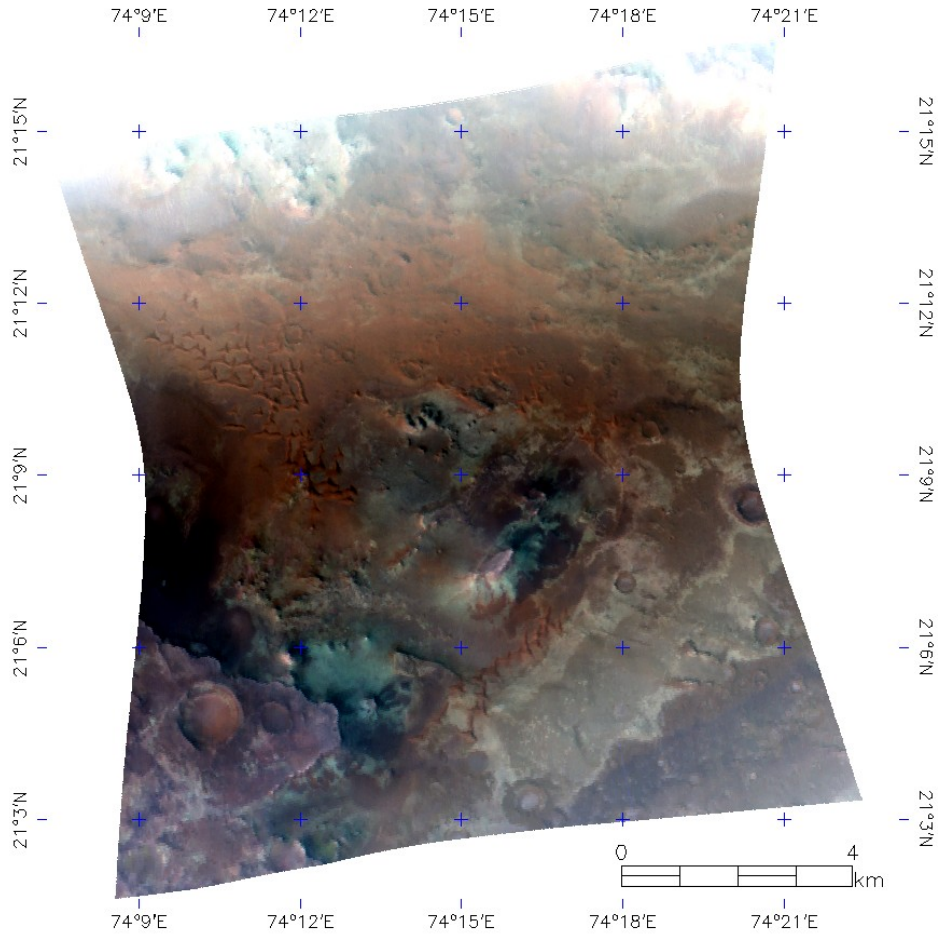
CRISM Data Registration

- Typical CRISM georeferencing procedure (CAT/ENVI functionality):
  - Project single cube (CAT)
    - MRO standard projection at native observation nadir resolution
  - Project multiple cubes to a common reference (ENVI GLT)
    - CAT or user supplied projection information
    - VNIR/IR data from common observation for layer stacking
    - Data from different observations for mosaicking
  - Layer stacking and/or mosaicking (ENVI)

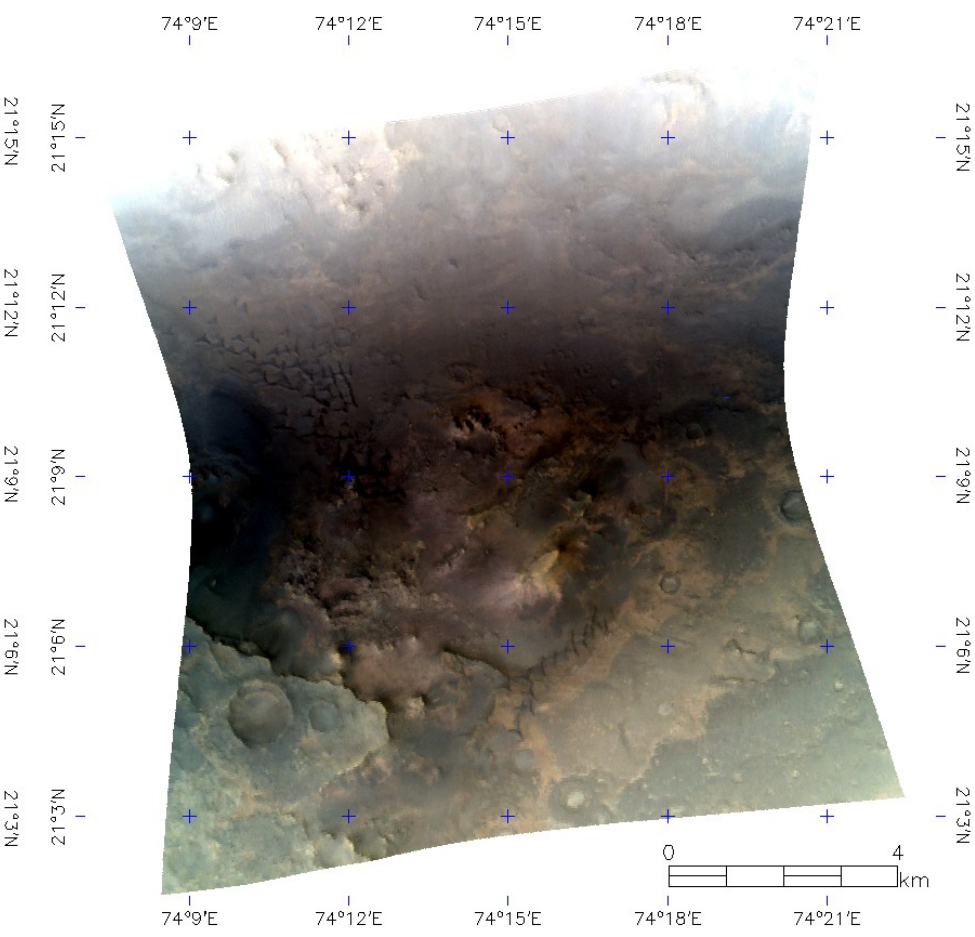
CAT Map Projection

ENVI → CAT → Map Utilities → Project Single Cube Data

Projects CRISM data to MRO standard using native nadir resolution



IR: 18.6 m/pxl



VNIR: 18.9 m/pxl

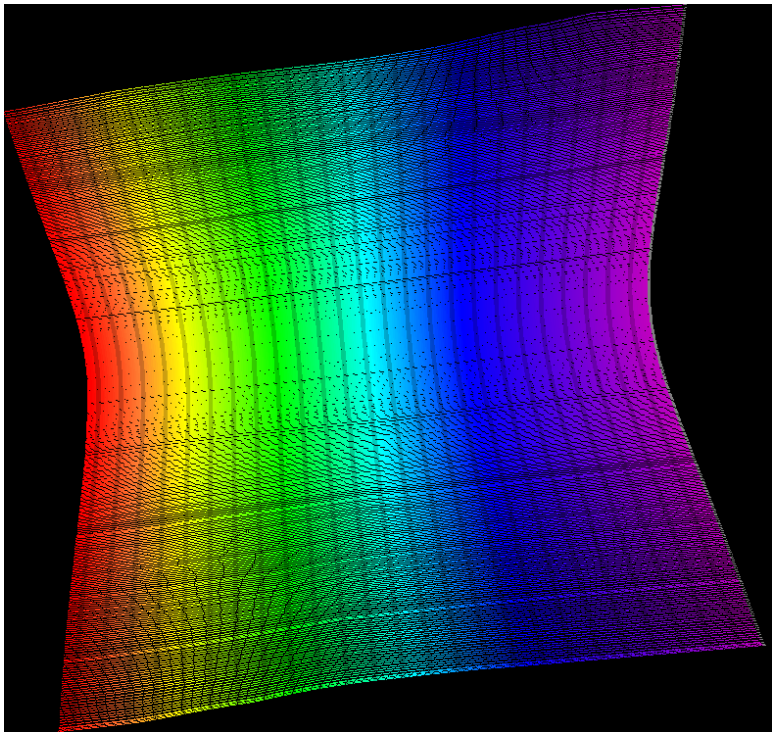
FRT000064D9_07_IF166L_TRR2_CAT_PHT_ATM_DST_DSP_PRJ.IMG

FRT000064D9_07_IF166S_TRR2_CAT_PHT_DST_PRJ.IMG

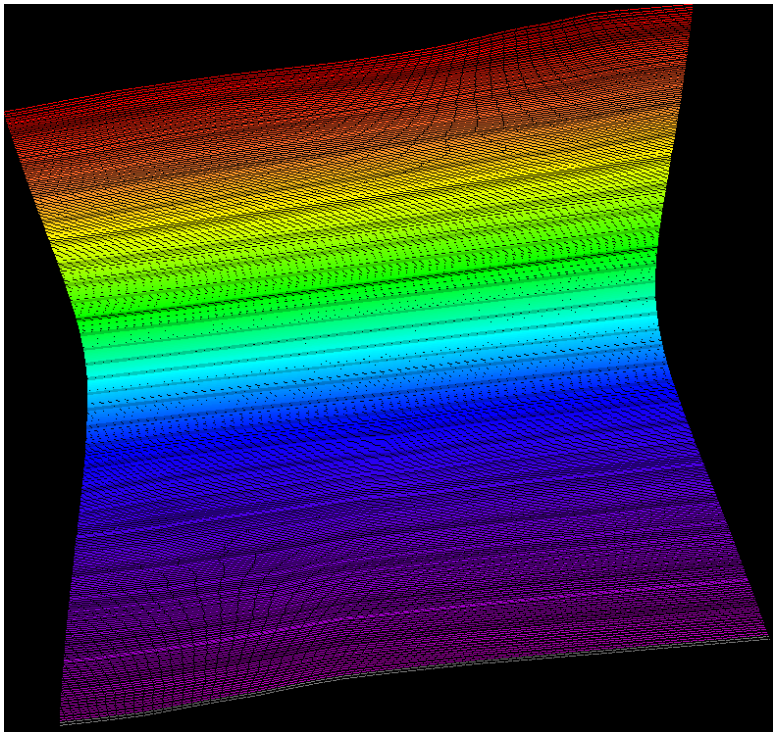
Custom Map Projection: Build GLT

ENVI → Map → Georeference from Input Geometry → Build GLT
- Input X Geometry Band: CRISM DDR Band 5 (Longitude, areocentric, deg E)
- Input Y Geometry Band: CRISM DDR Band 4 (Latitude, areocentric, deg N)
- Input Projection: Geographic Lat/Lon
- Output Projection: User Defined or Mars Default (MRO)
- Output Pixel Size: User Defined – Default is native image resolution
  - Set to consistent value for mosiacking or layer stacking
- Output Rotation: User Defined – 0 recommended in most cases

GLT: Geographic Lookup Table – A map of pixel locations relating one frame of reference to another



GLT Sample Lookup
20.0 m/pxl

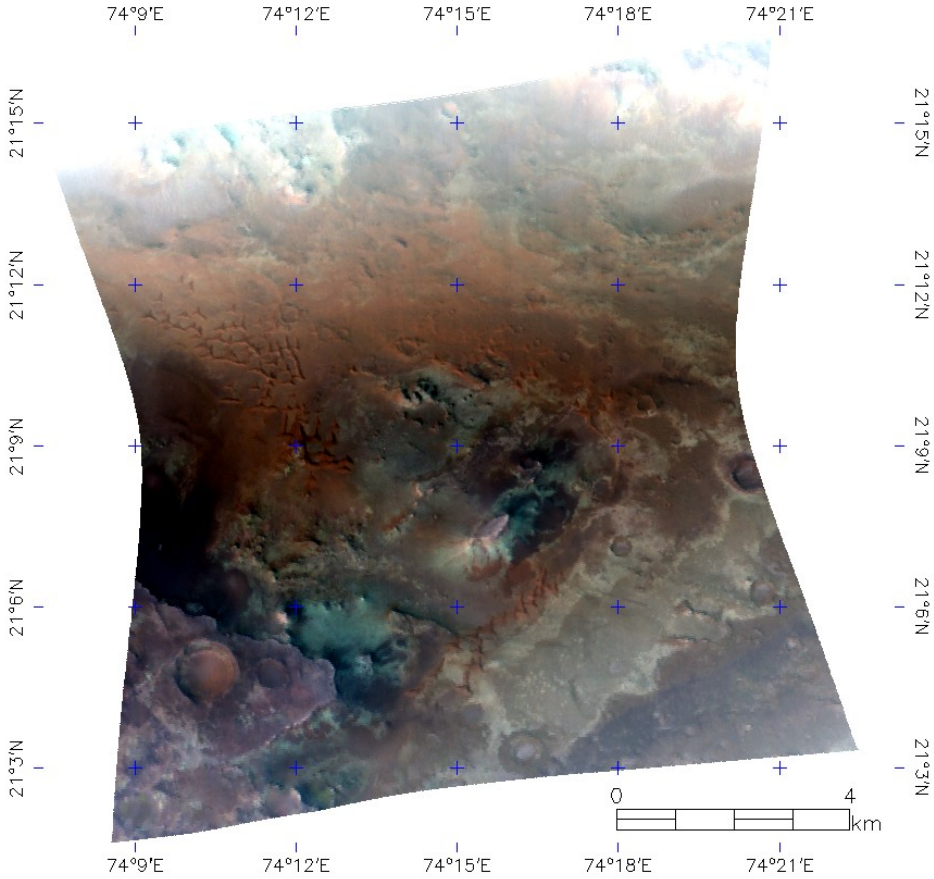


GLT Line Lookup
20.0 m/pxl

FRT000064D9_07_DE166L_DDR1_GLT.IMG

Custom Map Projection: Apply GLT

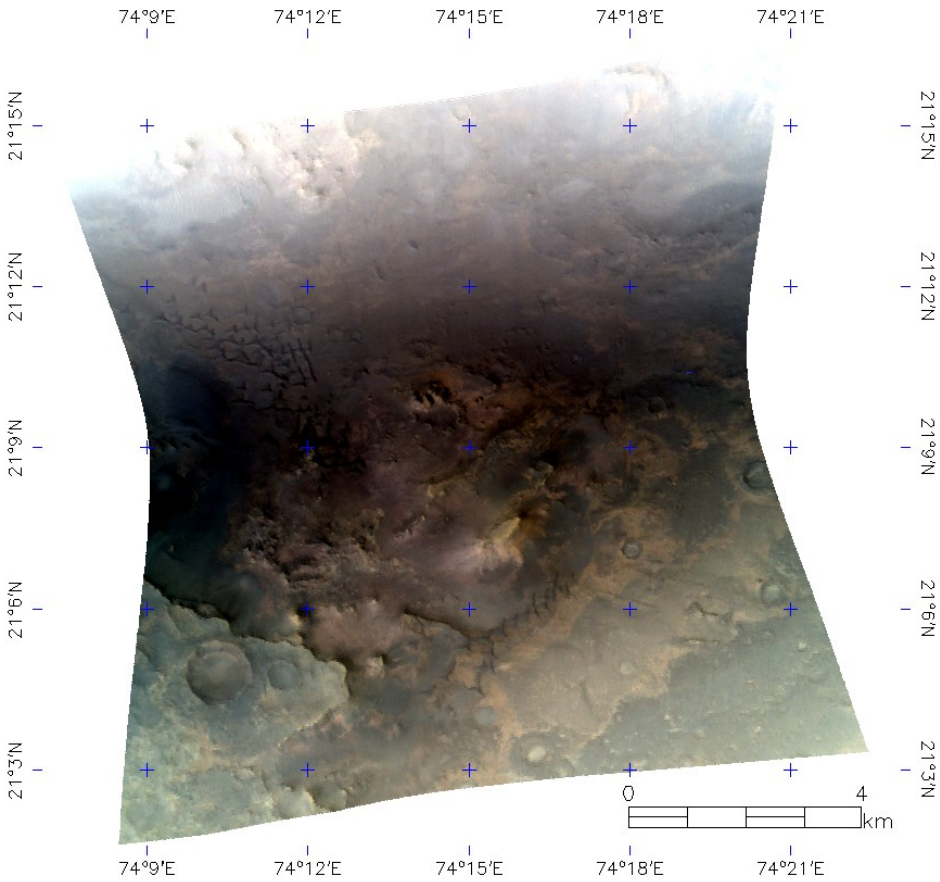
ENVI → Map → Georeference from Input Geometry → Georeference from GLT
Input Geometry Lookup File: Select GLT file
Input Data File: Select data file to project
Background Value: 65535 is CRISM NULL value



IR: 20.0 m/pxl

FRT000064D9_07_IF166L_TRR2_CAT_PHT_ATM_DST_DSP_REF.IMG

ENVI → Map → Georeference from IGM
Cascades construction and application of GLT from DDR lat/lon information



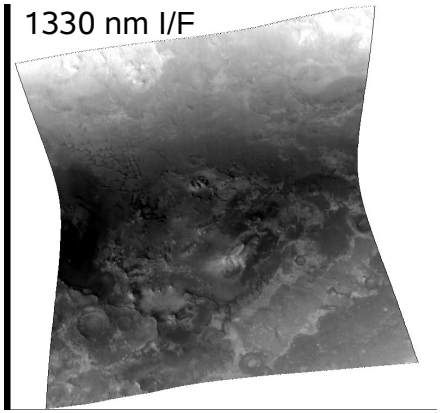
VNIR: 20.0 m/pxl

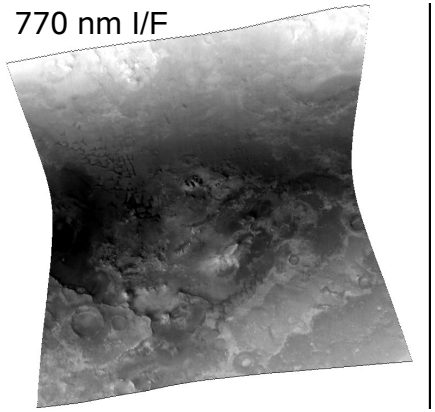
FRT000064D9_07_IF166S_TRR2_CAT_PHT_DST_REF.IMG

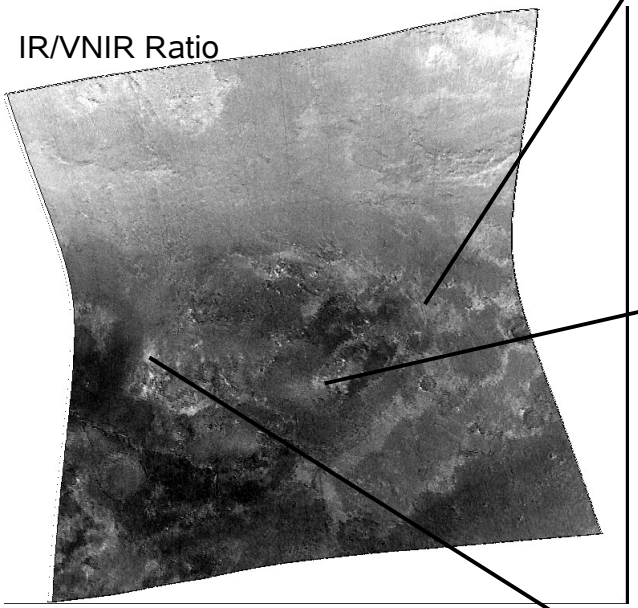
CRISM VNIR/IR Layer Stacking

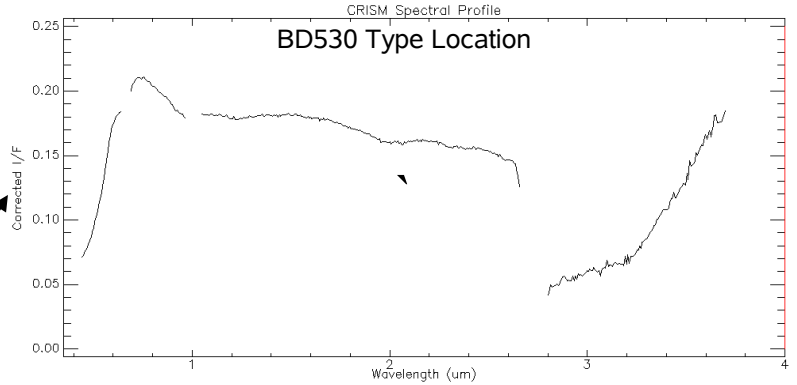
ENVI → Basic Tools → Layer Stacking
Select input layers (files) and output projection

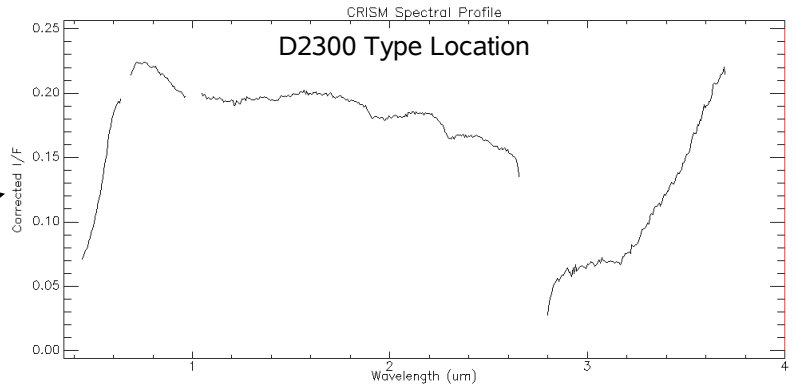
FRT000064D9_07_IF166SL_TRR2_LST.IMG

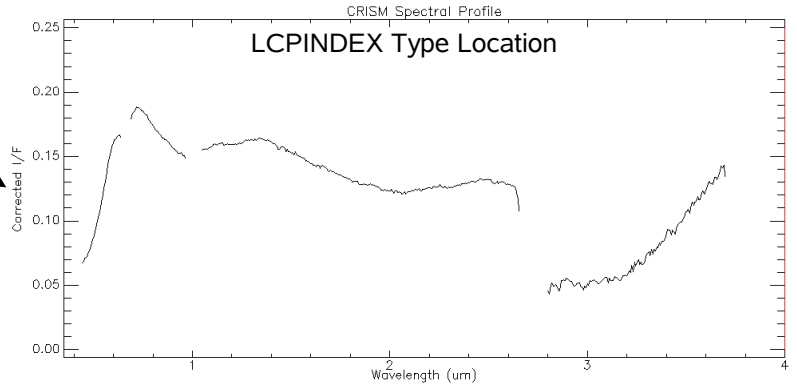












FRT000064D9_07_IF166SL_TRR2_LST_RAT.IMG

Additional Slides

Walkthrough File List (1/2)

VNIR IMG files:	
FRT000064D9_07_IF166S_TRR2.IMG	CRISM TRR2 PDS IMG file
FRT000064D9_07_DE166S_DDR1.IMG	CRISM DDR1 PDS IMG file
FRT000064D9_07_IF166S_TRR2_CAT.IMG	CAT (ENVI) format CRISM IMG data file
FRT000064D9_07_IF166S_TRR2_CAT_PHT.IMG	Photometrically corrected version of the above
FRT000064D9_07_IF166S_TRR2_CAT_PHT_DST.IMG	Destriped version of the above
FRT000064D9_07_IF166S_TRR2_CAT_PHT_DST_SUM.IMG	Spectral summary parameter cube calculated from the above
FRT000064D9_07_IF166S_TRR2_CAT_PHT_DST_PRJ.IMG	Map projected version of the processed spectral data
FRT000064D9_07_DE166S_DDR1_GLT.IMG	Custom geographic lookup table derived from the CRISM DDR
FRT000064D9_07_IF166S_TRR2_CAT_PHT_DST_REF.IMG	Custom map projected version of the processed spectral data
IR IMG files:	
FRT000064D9_07_IF166L_TRR2.IMG	CRISM TRR2 PDS IMG file
FRT000064D9_07_DE166L_DDR1.IMG	CRISM DDR1 PDS IMG file
FRT000064D9_07_IF166L_TRR2_CAT.IMG	CAT (ENVI) format CRISM IMG data file
FRT000064D9_07_IF166L_TRR2_CAT_PHT.IMG	Photometrically corrected version of the above
FRT000064D9_07_IF166L_TRR2_CAT_PHT_ATM.IMG	Atmospherically corrected version of the above
FRT000064D9_07_IF166L_TRR2_CAT_PHT_ATM_DST.IMG	Destriped version of the above
FRT000064D9_07_IF166L_TRR2_CAT_PHT_ATM_DST_DSP.IMG	Despiked version of the above
FRT000064D9_07_IF166L_TRR2_CAT_PHT_ATM_DST_DSP_SUM.IMG	Spectral summary parameter cube calculated from the above
FRT000064D9_07_IF166L_TRR2_CAT_PHT_ATM_DST_DSP_PRJ.IMG	Map projected version of the processed spectral data
FRT000064D9_07_DE166L_DDR1_GLT.IMG	Custom geographic lookup table derived from the CRISM DDR
FRT000064D9_07_IF166L_TRR2_CAT_PHT_ATM_DST_DSP_REF.IMG	Custom map projected version of the processed spectral data

CRISM PDS IMG files have accompanying label (LBL) files
CAT/ENVI IMG files have accompanying header (HDR) files

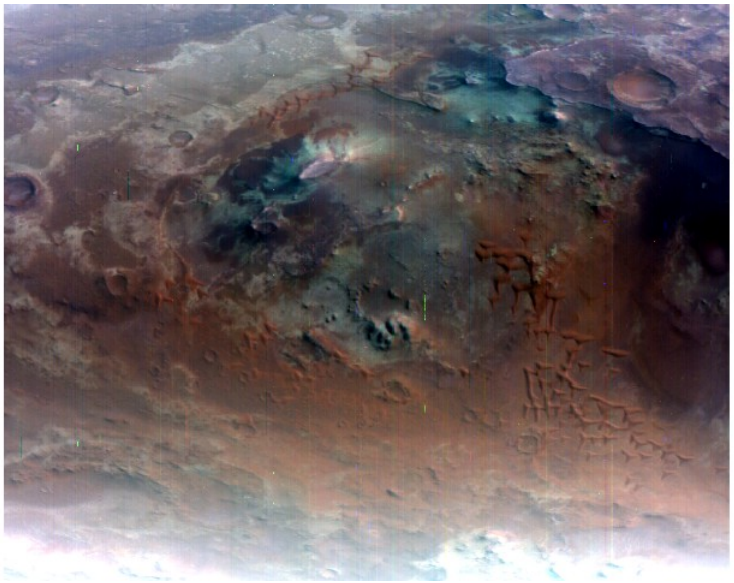
Walkthrough File List (2/2)

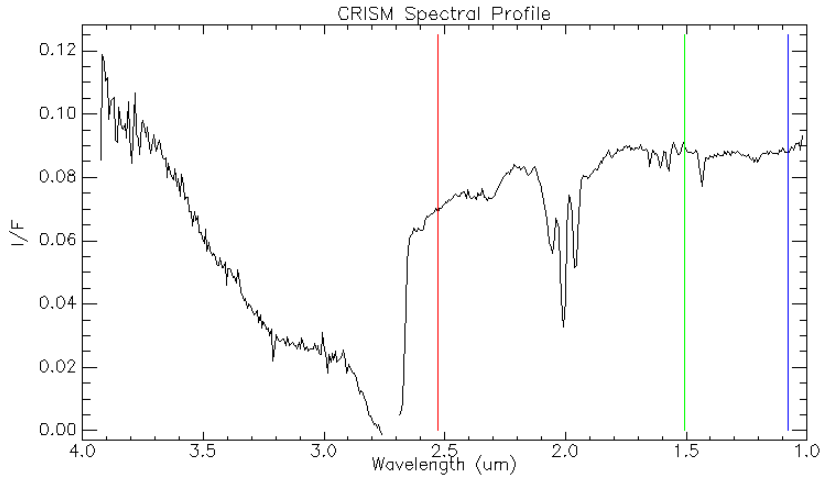
VNIR + IR IMG files:	
FRT000064D9_07_IF166SL_TRR2_LST.IMG	Merged CRISM VNIR and IR processed spectral data
FRT000064D9_07_IF166SL_TRR2_LST_RAT.IMG	IR/VNIR merged ratio parameter
Ancillary files:	
FRT000064D9_D2300.roi	Region of interest file for D2300 spectral investigation
FRT000064D9_LCPINDEX.roi	Region of interest file for LCPINDEX spectral investigation
FRT000064D9_D2300.sli	Spectral library file for D2300 spectral investigation
FRT000064D9_LCPINDEX.sli	Spectral library file for LCPINDEX spectral investigation
FRT000064D9_D2300.sta	Spectral statistics for D2300 target ROI
FRT000064D9_D2300_reference.sta	Spectral statistics for D2300 reference ROI
FRT000064D9_LCPINDEX.sta	Spectral statistics for LCPINDEX target ROI
FRT000064D9_LCPINDEX_reference.sta	Spectral statistics for LCPINDEX reference ROI
FRT000064D9_07_IF166L_TRR2.ann	Annotation file for map projected images
FRT000064D9_07_IF166L_TRR2.grd	Grid definition file for map projected images

ENVI spectral library files have accompanying header (HDR) files

CRISM TRR3 Data Filtering Preview

FRT000064D9_07_IF166L_TRR2.IMG





FRT000064D9_07_IF166L_TRR2_IKF.IMG