

Mars Reconnaissance Orbiter CRISM Hyperspectral Data Sets and Analysis Tools

Ray Arvidson

Washington University in Saint Louis

52nd DPS (Virtual Meeting)

Zoom Tutorial

10/26/20

2:30 to 3:30 PM, EDT

To enter a tutorial session, click on “Let’s talk” at the **PDS Exhibitor Booth** at the DPS web site.

Tutorials

MRO CRISM Hyperspectral Data Sets and Analysis Tools

*Monday, October 26
2:30 to 3:30 PM EDT*

Mars Rover In Situ X-ray Compositional Data Sets and Analysis Tools

*Tuesday, October 27
3:00 to 4:00 PM EDT*

Content and Use of PDS Geosciences Node Orbital Data Explorers

• *Wednesday, October 28
4:00 to 5:00 PM EDT*

Content and Use of PDS Geosciences Node Landed Mission Analyst Notebooks

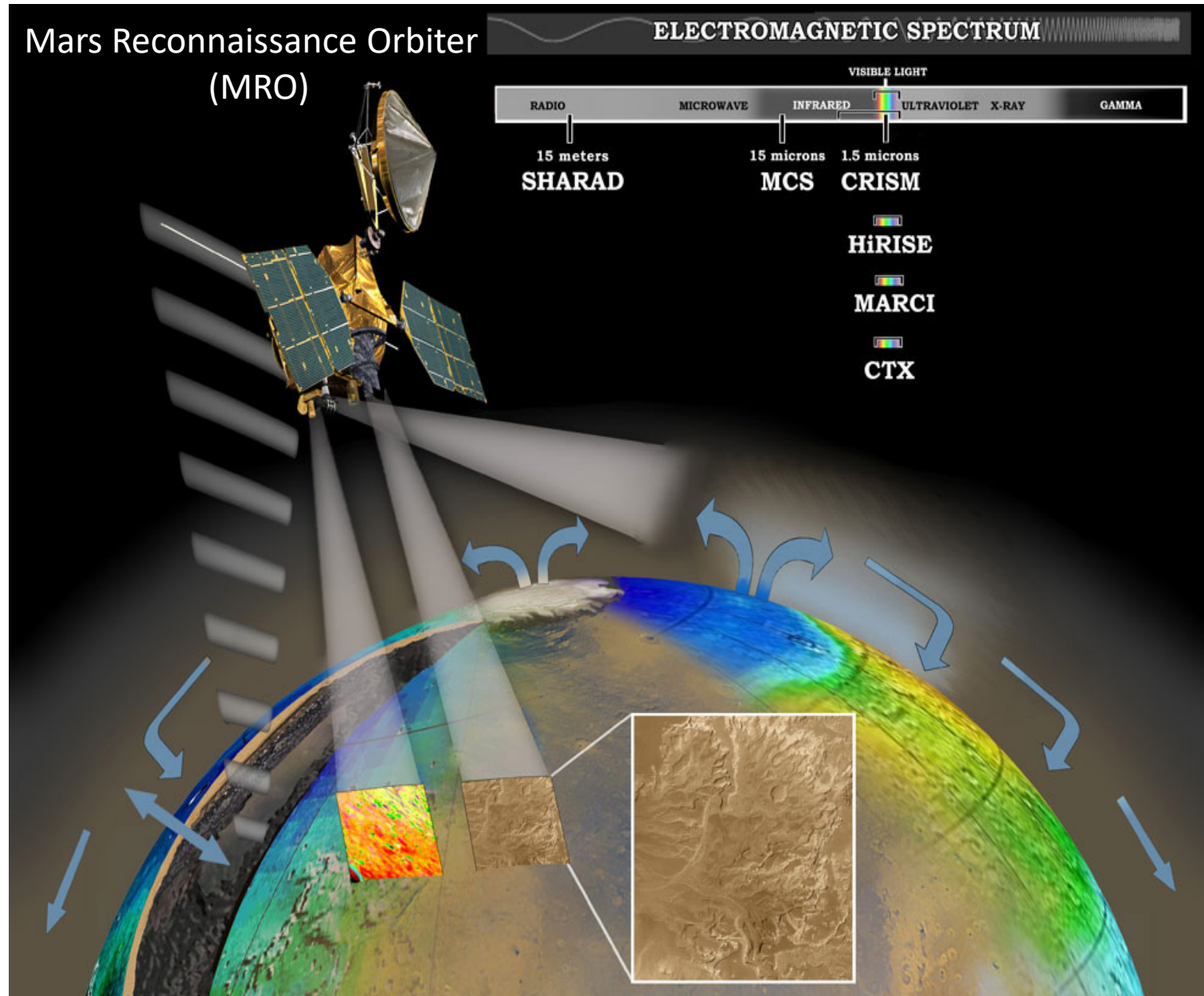
*Thursday, October 29
3:00 to 4:00 PM EDT*

Webinars

Introduction to PDS Geosciences Node Data Sets and Analysis Tools
*Monday, October 26
12:00 to 12:30 PM EDT*

Introduction to PDS Geosciences Node Orbital Data Explorers and Landed Mission Analyst Notebooks
*Wednesday, October 28
2:00 to 2:30 PM EDT*

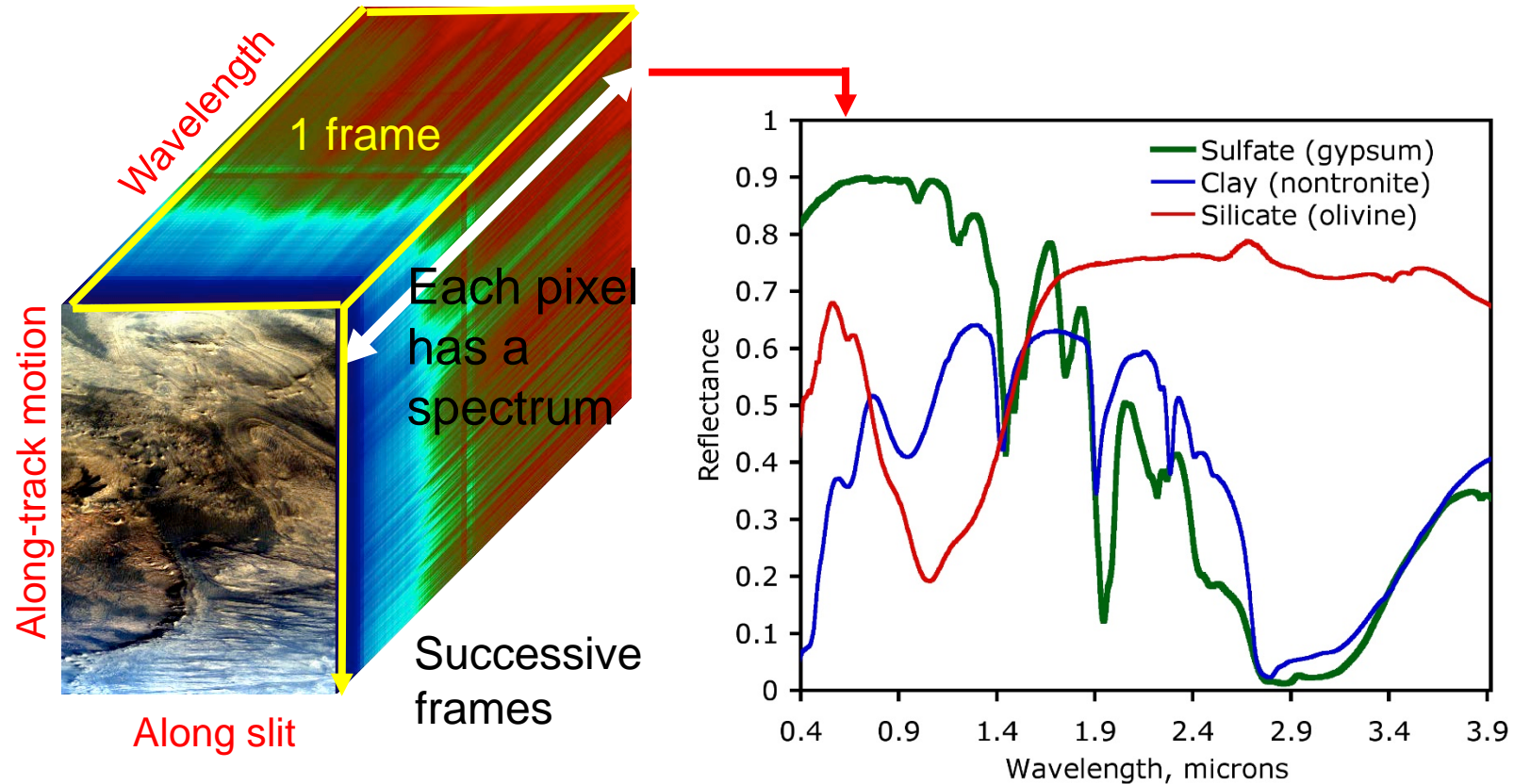
Compact Reconnaissance Imaging Spectrometer for Mars (CRISM)



- CRISM*, HiRISE, and CTX synergistically characterize surface geologic features
- MARCI, MCS, and CRISM track spatial and seasonal variations in the atmosphere
- CRISM S and L Data: 0.362–3.920 μm at 6.55 nm per band
- Full Resolution Targeted Mode (FRT) 18 m/pixel

*Murchie et al., 2007, JGR-Planets, DOI: 10.1029/2006JE002682

CRISM: Basic Structure of the Data is a Cube Composed of Successive Frames Acquired Along Orbital Track



Each readout of the detector is one line of a spatial image. An image is acquired as MRO moves along its ground track, thereby collecting adjacent lines.

Each pixel has a spectrum whose absorptions can be compared with minerals

CRISM Operational Modes

- CRISM has many operational modes, producing an array of data products.
- This tutorial will focus on use of the CRISM Analysis Tool (CAT) for processing and analysis of a single Half Resolution (HRL) VNIR and IR data set covering Jezero crater and delta (i.e., Perseverance rover landing site).
- Will use CAT implemented in ENVI5.5.3, although there is also an open source Java version (JCAT). (ENVI and Java CAT versions are available on the PDS Geosciences Node web site.)

AN ILLUSTRATED GUIDE TO CRISM OBSERVING MODES

Summary of Observing Modes and Characteristics

Mode	Description	Surface Tracking		Spectral Sampling (# channels)		Spatial Resolution (m/pix)				Primary Science Function			Acquisition Dates (DOY)	ID Range (Hex)	
		Gimbaled	Push-broom	VNIR	IR	20	40	100	200	Footprint Size (km)	Targeted	Mapping			Atmospheric
FRT	Full Resolution Targeted	•		107	438*								-10x10	start: 2006_270 end: 2012_146	2782 252AB
HRL	Half Resolution Targeted	•		107	438*								-10x20	start: 2006_273 end: 2012_146	2820 252A3
HRS	Half Resolution Short	•		107	438*								-10x6	start: 2006_273 end: 2012_144	2847 252A8
EPF	Emission Phase Function	•		107	438*					variable				start: 2006_273 end: 2012_146	2778 252A9
FRS	Full Resolution Short	•		107	438*								-10x3	start: 2012_275	26050
MSV	Multispectral Window		•	19	55								-10x45, 10x180, 10x540	start: 2006_272 end: 2006_072	2776 A609
HSV	Multispectral VNIR		•	90	0*								-10x45, 10x180, 10x540	start: 2012_013	22678
MSP	Multispectral Survey		•	19	55								-10x45, 10x180, 10x540	start: 2006_270	27DC
HSP	Hyperspectral Mapping		•	107	154								-10x45, 10x180, 10x540	start: 2011_142	1E328
HSV	Hyperspectral VNIR		•	107	0*								-10x45, 10x180, 10x540	start: 2009_174	1358A
ATO*	Along-Track Oversampled		•	107	438*	non-square pixels: up to ~3 m/pix down-track, 20 m/pix cross-track								start: 2011_079 end: 2012_142*	1D678 251D4 27195
ATU	Along-Track Undersampled		•	107	438*	non-square pixels: ~40 m/pix down-track, 20 m/pix cross-track								start: 2012_293	2715A
LMB	Limb Scan		•	107	438	non-square pixels				N/A				start: 2009_191	289C
TOD	Tracking Optical Depth		•	107	438	non-square pixels								start: 2007_217	6F28
FFC	Flat Field Calibration		•	varies by type	varies by type	non-square pixels								start: 2006_274	2856

*Most gimbaled observing modes including FRT, HRL, HRS, EPF, FRS, ATO, and ATU can be commanded as VNIR-only. MSV and HSV are VNIR-only by definition. LMB, TOD, and FFCs cannot be commanded as VNIR-only. (From DOY 2011_079 to 2012_142, ATO mode was a variation of FRT and labeled as "FRT" in the PDS archive. Beginning again on 2012_293 and ongoing, ATOs are labeled as "ATU" in the archive. These two periods also correspond to a change in the way that ATOs were acquired, resulting in a difference in footprint size and shape.)

Gimbaled, Hyperspectral Modes

Emission Phase Functions

- All gimbaled observations acquired prior to 2012_146 have associated incoming and outgoing EPF segments.
- In "EPF" mode, the central scan is 10x binned, 200 m/pix.

Spatial Characteristics

- Gimbaled observation examples have been scaled proportionally to their native (cross-track) spatial resolution.
- All CRISM images are ~10 km wide at their narrowest.
- Different binning modes result in different pixel sizes: 1x=20 m/pix, 2x=40 m/pix, 5x=100 m/pix, 10x=200 m/pix.
- Modified gimbal scan rates result in non-square pixels in the along-track direction, as in ATO and ATUs.

Summary of Observing Modes and Characteristics

CRISM: Two Instruments in One

- **Visible and Near Infrared (VNIR) Detector:** 107 channels (6nm sampling) from 0.3646 to 1.0560 μm .
- **Near Infrared (IR) Detector:** 438 channels (6nm sampling) from 1.0013 to 3.9368 μm .
- The VNIR detector can acquire data when the cryosystem that cools the IR detector is turned off. This results in VNIR-only modes, such as HSV and MSV. All gimbaled modes can also be acquired with just the VNIR portion of the spectral data.

Pushbroom Modes

Mapping Modes

- CRISM pushbroom, or mapping, observations all have either 100 or 200 m/pix spatial resolution, and so appear similar to one of two form factors when map projected.
- The difference in hyperspectral and multispectral mapping modes is illustrated in the graph below.

• Not pictured here are TOD and FFC observations, which are smeared out in the along-track direction.

Atmospheric Observations

- During limb scans the MRO spacecraft pitches forward or backward so that CRISM can observe the vertical structure of the atmosphere.

Comparison of Wavelength Sampling

MSV, MSV

MSV, HSP, HSV

CRISM Background Reading

- For details about the instrument, operations, and an overview of early data products see: Murchie, S. L. et al., CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) on MRO (Mars Reconnaissance Orbiter), *J. Geophys. Res.*, 112, E05S03, doi: 10.1029/2006JE002682
- CRISM SIS is the “Master Manual” for details about CRISM data products in the PDS Geosciences Node.

Mars Reconnaissance Orbiter

CRISM DATA PRODUCT SOFTWARE INTERFACE SPECIFICATION

Version 1.3.7.4

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Steps Needed to Get Ready for Processing

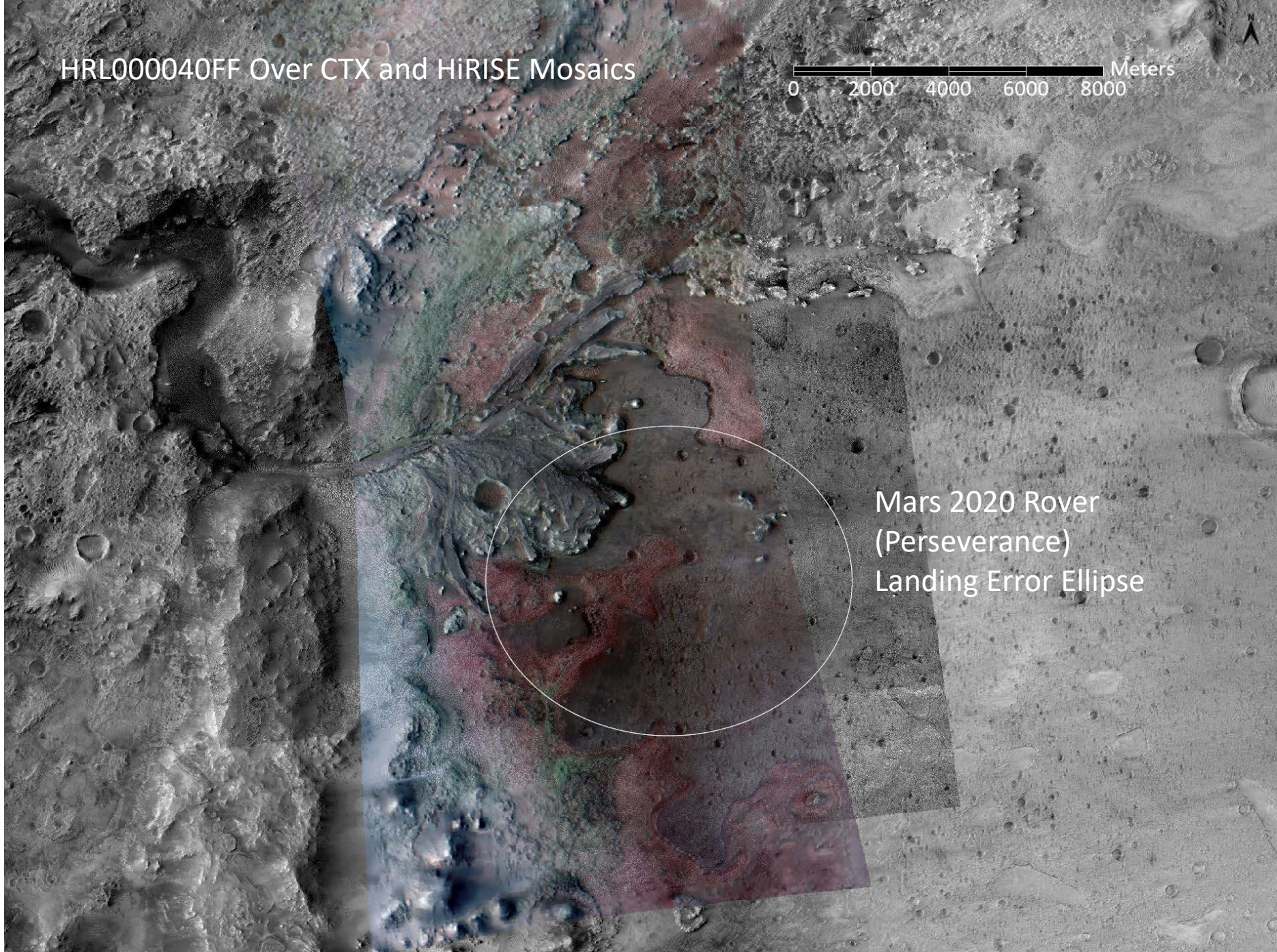
- Use the Geosciences Node Mars Orbital Data Explorer to search for CRISM data sets covering Jezero crater. Chose HRL000040FF because of rich mineral and geologic associations.
- Download the S and L I/F and/or radiance cubes and associated Digital Data Records (all in sensor space).
(See ODE/AN webinar and ODE tutorial session at the DPS meeting.)
- Have CAT installed on ENVI5.X (Geosciences Node help is available to do this installation, if needed. chow@wunder.wustl.edu Feng Zhou)
- Now let's go to the tutorial screens showing ENVI5.5.3 and CAT processing of the data sets:
 - Examine file structures
 - Read CRISM files
 - Do atmospheric correction using "volcano scan" method
 - Generate spectral parameters and flatten
 - Map project data
 - Conduct some initial analyses

Interactive Tutorial Showing ENVI5.6 Screen

HRL000040FF Over CTX and HiRISE Mosaics

0 2000 4000 6000 8000 Meters

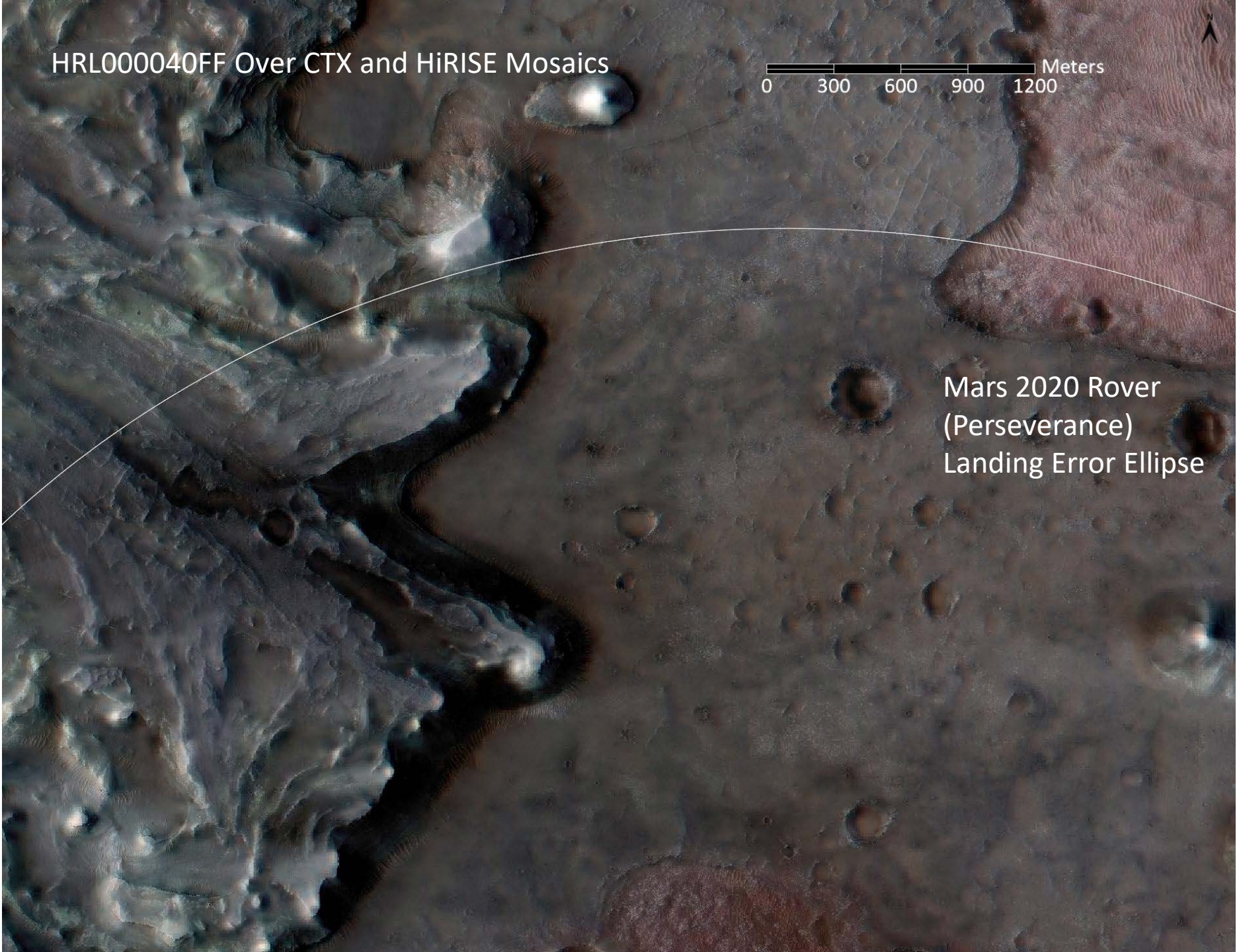
Mars 2020 Rover
(Perseverance)
Landing Error Ellipse



HRL000040FF Over CTX and HiRISE Mosaics



Mars 2020 Rover
(Perseverance)
Landing Error Ellipse



Questions or Comments?