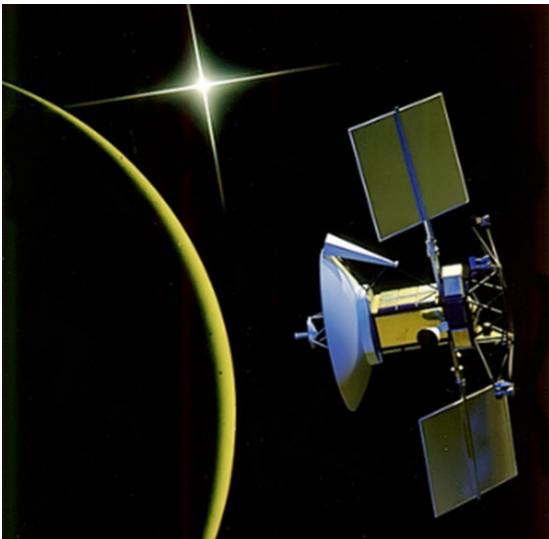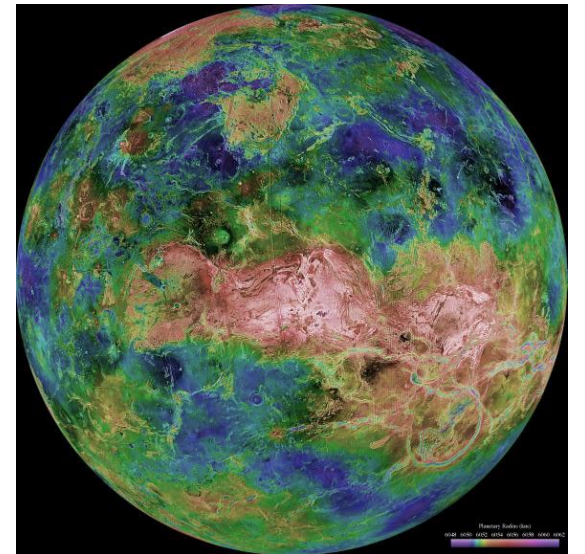# Updating Magellan Venus Data to PDS4 Archiving Standards

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Introduction

- The PDS Geosciences Node has about 750 Gbytes in 12 datasets of Venus data collected by the Magellan mission.
  - The Imaging Node also has a collection called F-Maps, which is not part of this project.
- Most of these datasets were acquired and delivered to the PDS while PDS archiving standards were initially being developed.
  - This was even before PDS3 standards.
- The Geosciences Node is updating its Magellan data archives to the PDS4 standards.
  - As will be discussed in this presentation, the project will improve the Magellan archives by correcting several archive technology limitations that were available in the 1990s.

# *Importance of Magellan Dataset to Future Venus Exploration*

- We feel it is important to update the Magellan datasets because of the renewed emphasis on Venus exploration.
- Three missions have recently been selected to further the exploration of Venus.
  - NASA's VERITAS and DAVINCI missions and ESA's EnVision mission.
  - Data from these missions will be collected in the late 2020s and early 2030s.
  - VERITAS and EnVision will have radar instruments that are much improved over the Magellan SAR instrument.
- Updating the Magellan datasets would support these missions by:
  - Providing use in mission operations for targeting.
  - Providing a baseline for detecting changes on the surface of Venus possibly due to erosion, impact cratering or volcanism.

Magellan Mission to Venus

- The Magellan Mission used radar imaging and altimetry, and radio tracking to map the Venusian surface and interior from 1990 to 1994.

- Mission phases at Venus were divided into 243 Earth day long mapping cycles.

- SAR, altimetry and radiometry data were acquired during the first three mapping cycles.
  - Cycle 1 collected left-looking SAR and radiometry data and nadir altimetry data.
  - Cycle 2 acquired data to fill in data gaps and coverage of the south polar area, using right-looking geometry.
  - Cycle 3 focused on stereo imaging with left-looking images acquired at incidence angles different from cycle 1.

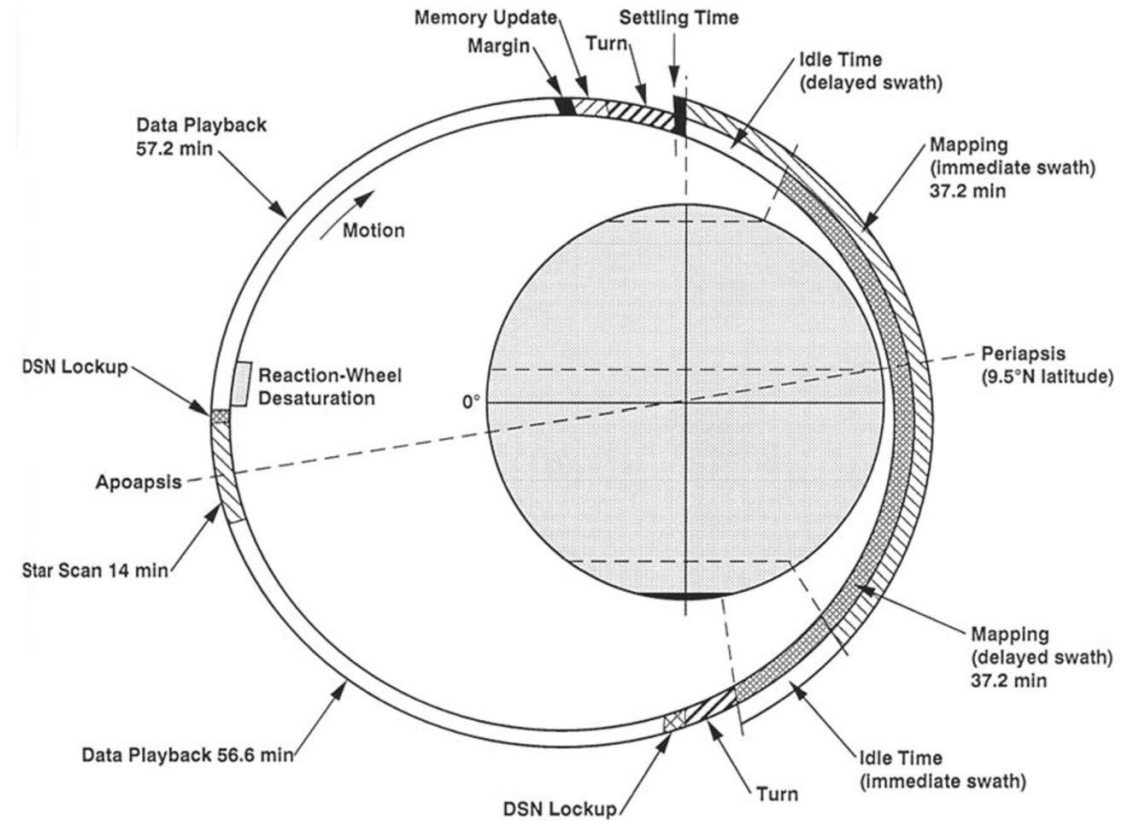- Cycles 4 and 5 were dedicated to mapping the gravity field of Venus.

How Magellan Radar Acquired Data
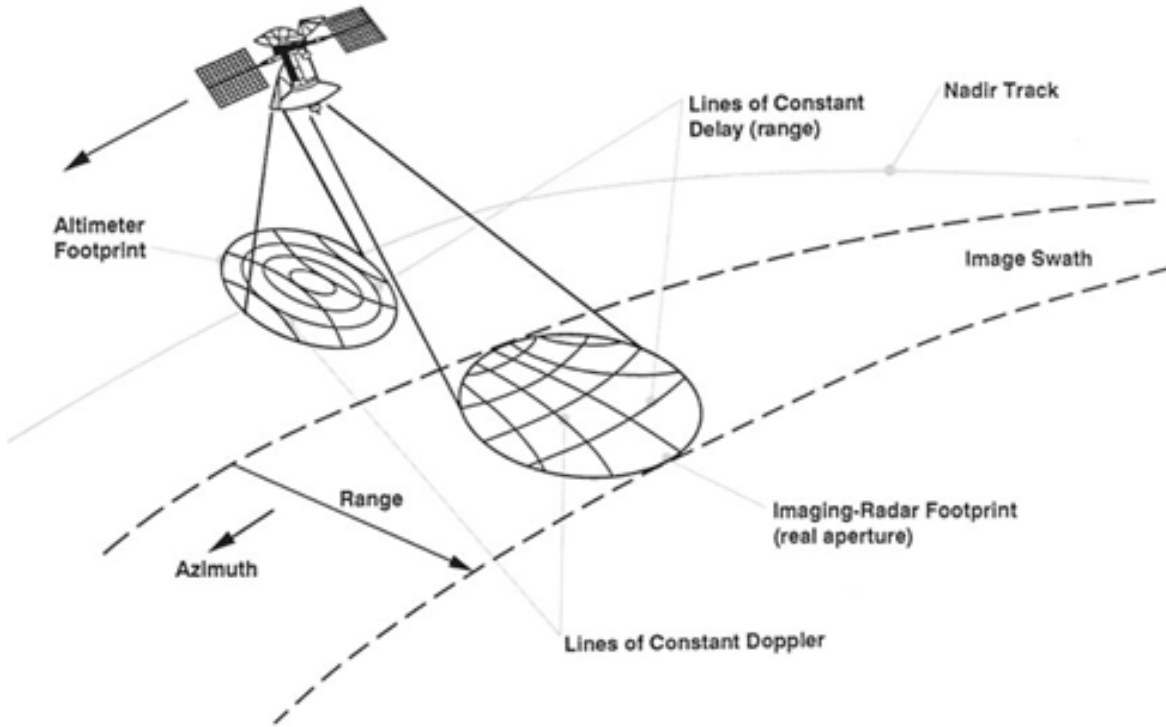
Alternating transmitter bursts were used to collect SAR and altimetry data. Passive radiometry data were collected in between altimetry and SAR bursts.
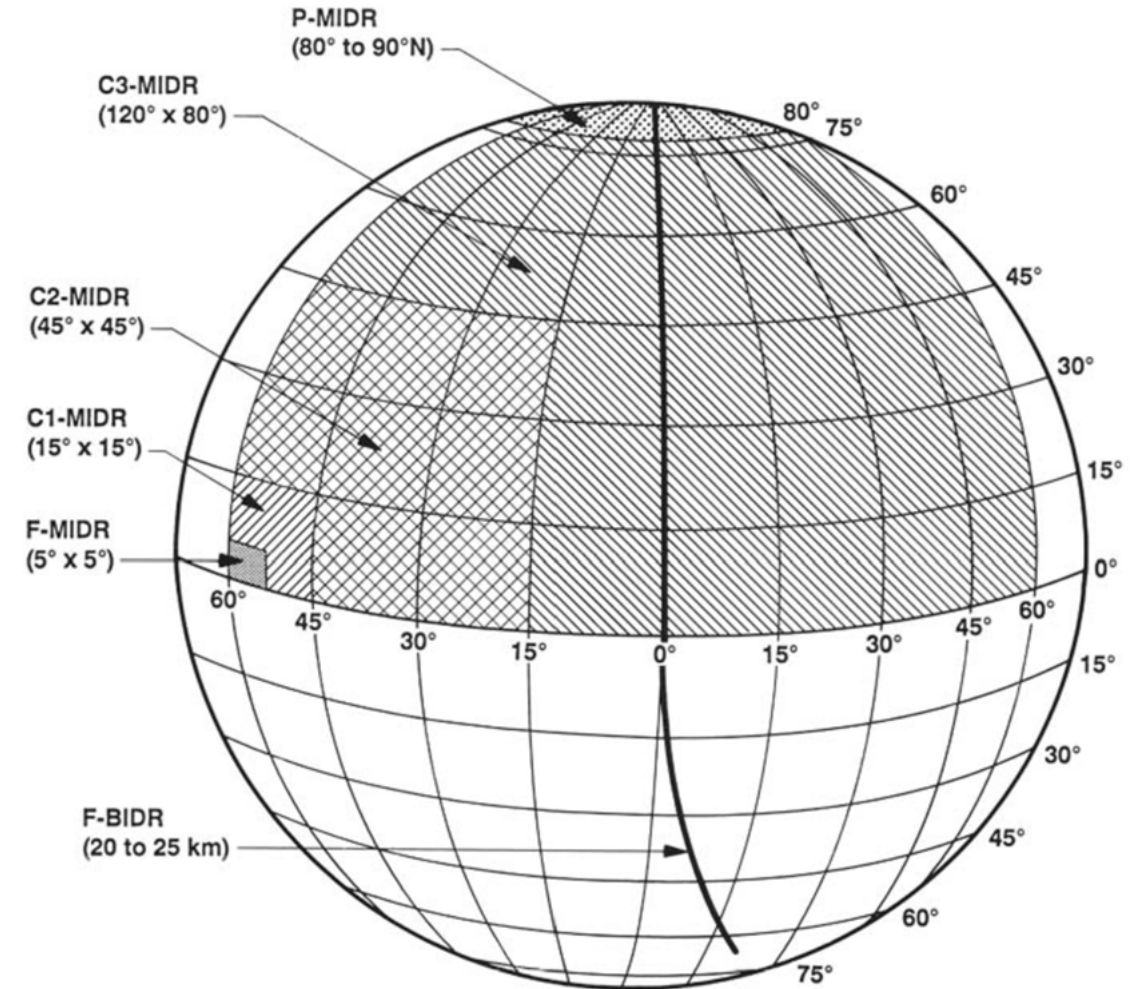
Orbit period was about 3.25 hours. Radar wavelength was 12.6 cm.

Magellan SAR Images

- The primary SAR product is the F-BIDR (Basic Image Data Record).
  - Pixel size of 75 m; typically 20 km wide and 17,000 km long.
  - More than 4000 F-BIDRs delivered the PDS on magnetic tape.
- BIDRs combined in mosaics called MIDRs – F-MIDR, Cx-MIDR and P-MIDR.
  - Mosaicked Image Data Record.
  - F = full resolution and Cx = compressed.
  - F-MIDRs only created for a small fraction of the planet.
  - About 1270 MIDRs delivered on CD-ROMs.
- DN values proportional to radar backscatter cross-section.

P-MIDR (80° to 90°N)

C3-MIDR (120° x 80°)

C2-MIDR (45° x 45°)

C1-MIDR (15° x 15°)

F-MIDR (5° x 5°)

F-BIDR (20 to 25 km)

F-BIDR	Full-Resolution Basic Image Data Record
F-MIDR	Full-Resolution Mosaicked Image Data Record
C1-MIDR	Compressed-Once Mosaicked Image Data Record
C2-MIDR	Compressed-Twice Mosaicked Image Data Record
C3-MIDR	Compressed-Thrice Mosaicked Image Data Record
P-MIDR	Polar Mosaicked Image Data Record

Existing Magellan data at the Geosciences Node

- Table lists all Magellan datasets at the Geosciences Node, along with the data type and dataset size.

- While we plan to restore all Magellan datasets, we have assigned priorities for the work.
  - Priority 1 datasets will be restored first.

- Currently, working on the F-BIDR, MIDR, GxDR, and ARCDR datasets.

Table 1: Geosciences Node Magellan Datasets pds-geosciences.wustl.edu/missions/magellan				
Dataset	**Description**	**Data Type**	**Size, GB**	**Restoration Priority**
F-BIDR	Along track SAR and Radiometry	Image; Table	480.70	1
C-BIDR	Compressed SAR	Image; Table	77.25	2
F-; Cx-MIDR	Mosaicked SAR	Image Mosaic	75.45	1
ALT-EDR	Raw Altimetry	Table	43.32	4
ARCDR	Altimetry and Emissivity	Table	8.34	1
GxDR	Global Mosaics	Image Mosaic	0.51	1
SCVDR	Surface Properties	Table	29.66	3
GVDR	Global Properties	Table	0.57	3
BSR	Bistatic Radar	Table	7.02	4
LOSAPDR	Line of Sight Acceleration	Table	1.06	2
Gravity Models	Spherical Harmonics	Image; Table	0.88	1
Raw Radio Science	Spacecraft Tracking	Table	9.29	5
Restoration Priorities: 1 = highest; 5 = lowest. Total archive size is ~750 GB.				

Issues with Original Magellan Data Archive

- The existing Magellan data archives have several issues related to 1990s technology that make their use with modern computing environments difficult.
  For example:
  - Binary data in several datasets are stored using VAX floating point format, which is no longer in wide use and requires software to convert the format.
  - In order to accommodate image display technology available at the time of the mission, large mosaics were divided into many small framelets, which required piecing the framelets together to view an entire mosaic.
  - Much of the documentation about data processing and formats is in paper form and not readily available to researchers.

- Upgrading to PDS4 standards has been an exercise in "data archeology", which is the science of recovering data in obsolete formats and from obsolete media.

F-BIDR Dataset

- F-BIDR data were delivered to PDS on 9-track magnetic tape.
  - Geosciences Node copied each tape to CD-WO media and at a later time copied the CD-WO versions to the Node's online repository.
  - Some tapes were completely or partially unreadable. Where possible replacement tapes were provided by the Magellan project.
  - A processing log file is associated with each F-BIDR tape copied to CD-WO.

- Each F-BIDR contains one or two image files and a number of ancillary and engineering data files.
  - SAR data are stored as a Sinusoidal map projection. A second image file is present for polar data and stored in an Oblique Sinusoidal projection.
  - F-BIDR images are 512 pixels wide and up to about 200,000 pixels long.
 - F-BIDR tapes also contain a raw radiometry data file.

F-BIDR Plan

- The existing F-BIDR image format is not compatible with PDS4 standards because of the interlaced line prefix data.
    - The long images are also divided into small blocks that begin with a Standard Format Data Unit (SFDU).
    - Each block is spatially offset from the next.
    - Thus, each F-BIDR image will be reformatted to meet PDS4 standards.
- The updated dataset will focus on the image files as the ancillary and engineering data are not likely to be of interest to most data users.
    - These files will be preserved in the existing dataset.
- The Geosciences Node plans to develop and make available code to assemble individual F-BIDRs into custom mosaics.
    - The aspect ratio of F-BIDRs make them awkward to work with.
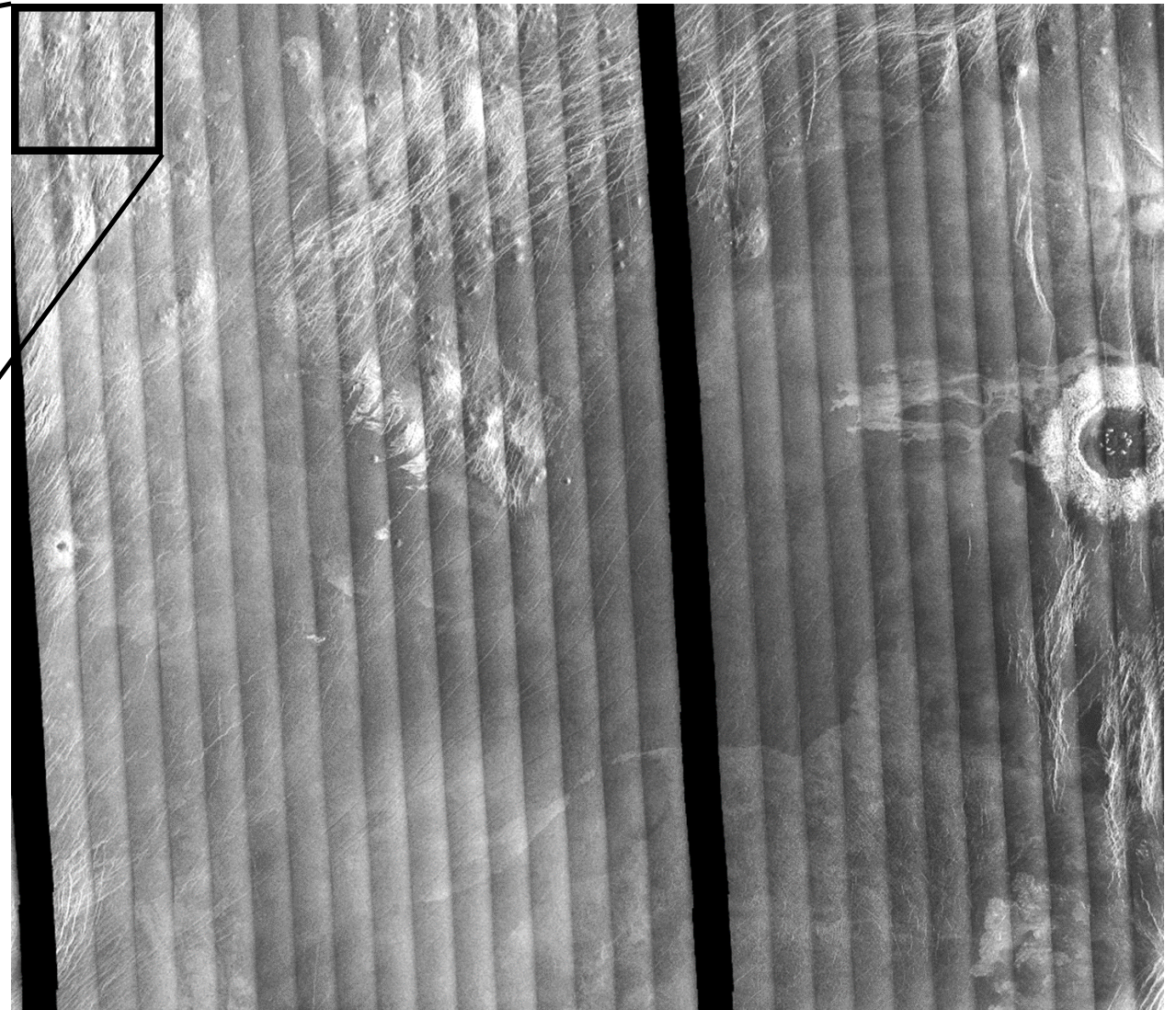
MIDR Dataset

- F-BIDRs were combined into mosaics call MIDRs by the Magellan project because of the F-BIDR aspect ratio.
  - MIDRs exist in full resolution and in reduced resolution.
  - Each mosaic was originally subdivided in smaller images for archiving and to account for available display devices at the time of the mission.

- Each MIDR will be reconstructed into a single image in the updated dataset from the small frames in the original dataset.

- Errors in the original PDS labels will be corrected and additional metadata parameters will be added to the PDS4 labels.

- A browse version will be generated for each mosaic that has been contrast enhanced and stored as a JPEG file for easy display.

Example MIDR

F-MIDR Mosaic
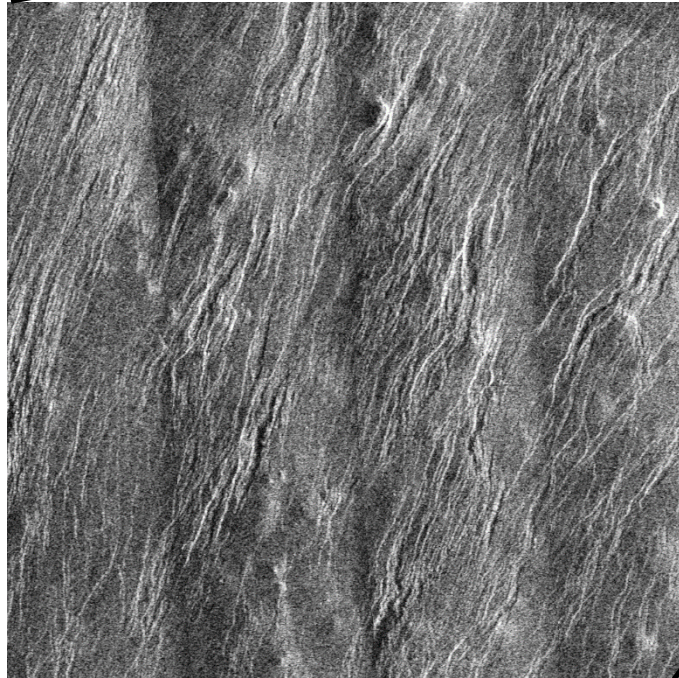
Single F-MIDR Frame

Each mosaic has 56 frames.

GxDR Dataset

- Altimetry and Radiometry data were processed into four global gridded maps (GxDR).
  - Topography (radius), slope, emissivity, and Fresnel reflectivity.
- Each map type exists in four map projections.
  - Sinusoidal, Mercator, North and South Polar Stereographic.
- Maps were originally subdivided into small frames, as for MIDRs, for delivery to PDS.
- Each map will be reconstructed into a single image file and browse image generated, as for the updated MIDRs.
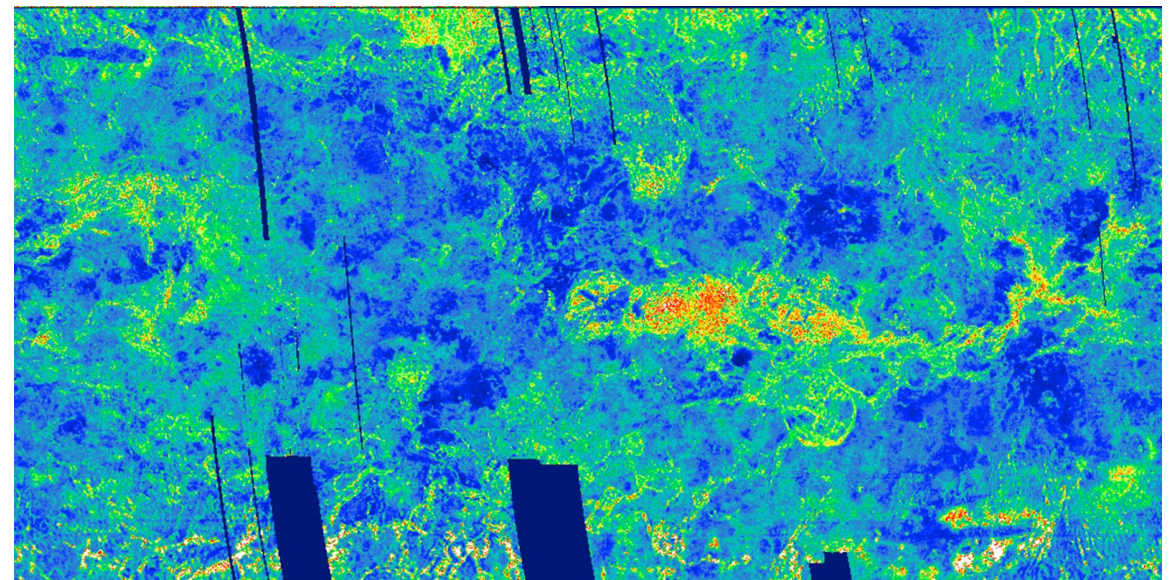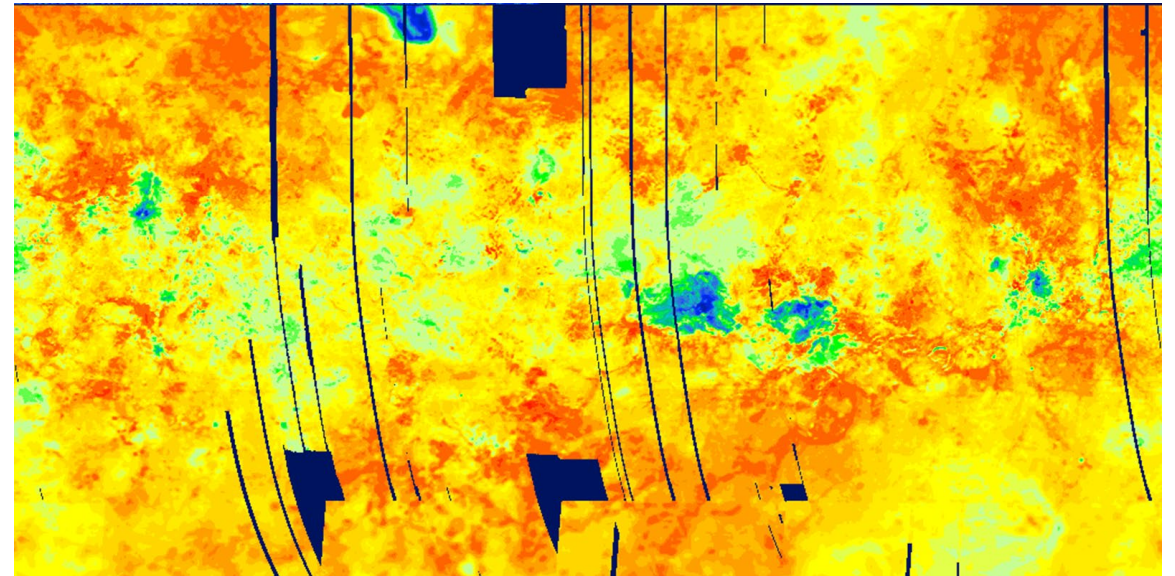
Global Emissivity (top) and Slope (bottom) Mercator maps

MIDR and GxDR Status

- Test PDS4 bundles for the MIDR and GxDR datasets are nearly complete.
    - User guides describing the PDS4 datasets are being written.
    - Once test bundles are complete, a full PDS peer review will be started because the data have been reformatted.
    - After the review is complete and any revisions made, full production will begin.
- Expect that these datasets will be ready for release by the end of 2022.
- The updated datasets will be ingested into the Geosciences Node ODE tool to support search, browse viewing, product footprint plotting on a Venus base map, and downloading of the data.

ARCDR Dataset and Status

- Magellan altimetry and radiometry data were delivered PDS as individual points along the orbit track in the Altimeter and Radiometry Composite Data Record (ARCDR) dataset.

- An altimetry and a radiometry file exists for each Magellan orbit where these data were acquired.
  - The data are stored in binary tables using VAX format for floating-point values.

- We have developed scripts to read the ARCDR files, convert the VAX formats to IEEE, create PDS4 compatible binary tables and PDS4 labels.

- We will also plot a several ARCDR parameters versus latitude and save these plots as JPEG files for browse products.

ARCDR Example

Venus Radius: adf01152_3

Venus Emissivity: rdf01152_2

Venus Reflectivity: adf01152_3
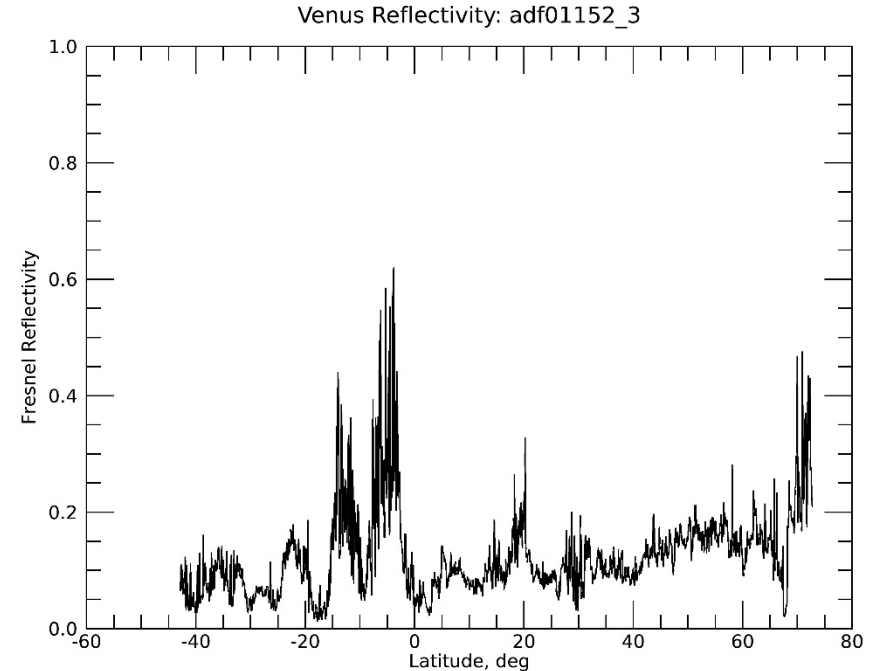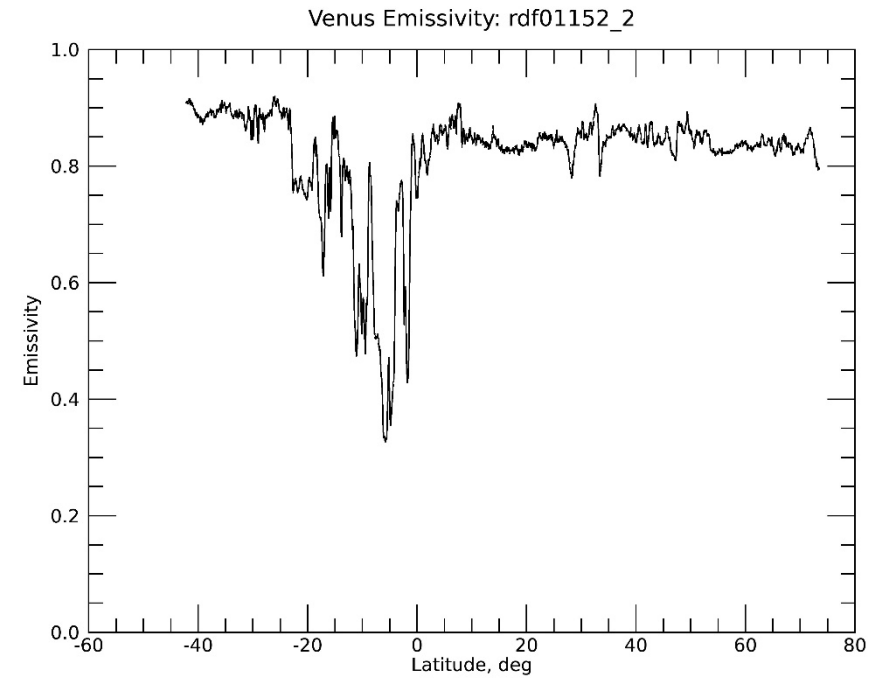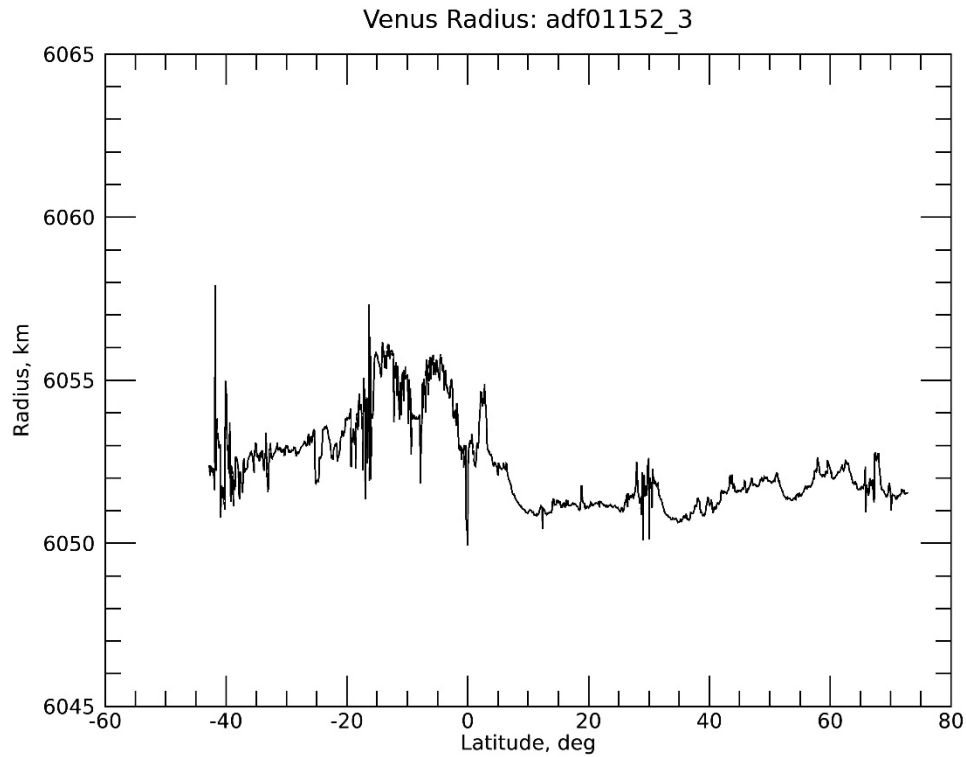
Example ARCDR data for orbit 1152. Note the radius and Fresnel reflectivity data are co-located, but the emissivity data are not. Altimetry and reflectivity data are derived from nadir looking pulses, whereas the emissivity data are located off to the side where the SAR data were pointed.

Conclusions

- This project will result in Magellan datasets that are more compatible with future Venus data.

- Magellan datasets will have improved metadata using PDS4 labels and most will have easily viewable browse products.

- Geosciences Node Venus ODE tool (ode.rsl.wustl.edu/venus) will support search and download of these updated datasets.

- Updated Magellan MIDR, GxDR, and F-BIDR image datasets will be completed and released by end of 2022.
  - Updating of the remaining Magellan datasets should be complete by end of 2023.