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INSTITUTE OF
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High Quality Visualizations and Analyses of the Mars Surface

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Content

The I.P.F. and Mars

Developing a Topographic Mars Information System (TMIS)

Dealing with Large Topographic Data

SCOP++: A software for interpolation, management, application and visualization of nationwide digital terrain data

Automated Error Elimination on MOLA Data

Using robust methods to automatically eliminate errors down to a RMS of 20 m

Raster Analyses of DTMs using SCOP++

Hydrological and mathematical analyses of digital terrain models

Visualizations of Mars Surface

Perspective views, Panoramic views, lakes, rivers, names, ...

Abstract

The I.P.F. (Institut für Photogrammetrie und Fernerkundung) is Co-Investigator at ESAs HRSC on Mars Express project. Its main task is the development of an information system for HRSC data (High Resolution Stereo Camera) that should be the main interface for data exchange between the Co-Investigators of this project. Further on it can be used as a presentation web portal to act as data source for the whole mars scientists community. This can be realized easily, because the information system is designed as web application using XML (eXtensible Markup Language) related technologies.

Besides the institute uses its experience in handling large topographic data on the MOLA-2-Dataset. It uses SCOP, a software for interpolation, management, application and visualization of digital terrain data, which was implemented in cooperation of the I.P.F., Vienna and INPHO GmbH, Stuttgart.

Current results are

- a global Digital Terrain Model (DTM) of Mars (Resolution: 4500 m) which was calculated in one job
- automated error elimination of track referencing errors and computation of a high resolution DTM of Vallis Marineris (Resolution: 330 m)
- the ability to apply this automated error elimination method (based on robust estimation) on the global MOLA-2-Dataset

Furthermore derived products are computed from such DTMs. Special focus is set in hydrological analysis using rain simulation and in visualizations such as perspective views, VRML (3D) models, ... that can be visualized using any kind of raster overlay (MOC images, shadings, height codings, ...). As volcanoes are very interesting regions from a topographic point of view, lots of them are already visualized.

A new extension of SCOP allows to compute 360° panorama views of an area. So it allows to do a landing site simulation, long time before the lander has touched the surface of Mars.

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Exploring Mars Surface and its Earth Analogues

Sicily and Mount Etna
September 23-25, 2002

The I.P.F. and Mars

The I.P.F. is Co-Investigator at ESAs *HRSC on Mars Express* project.



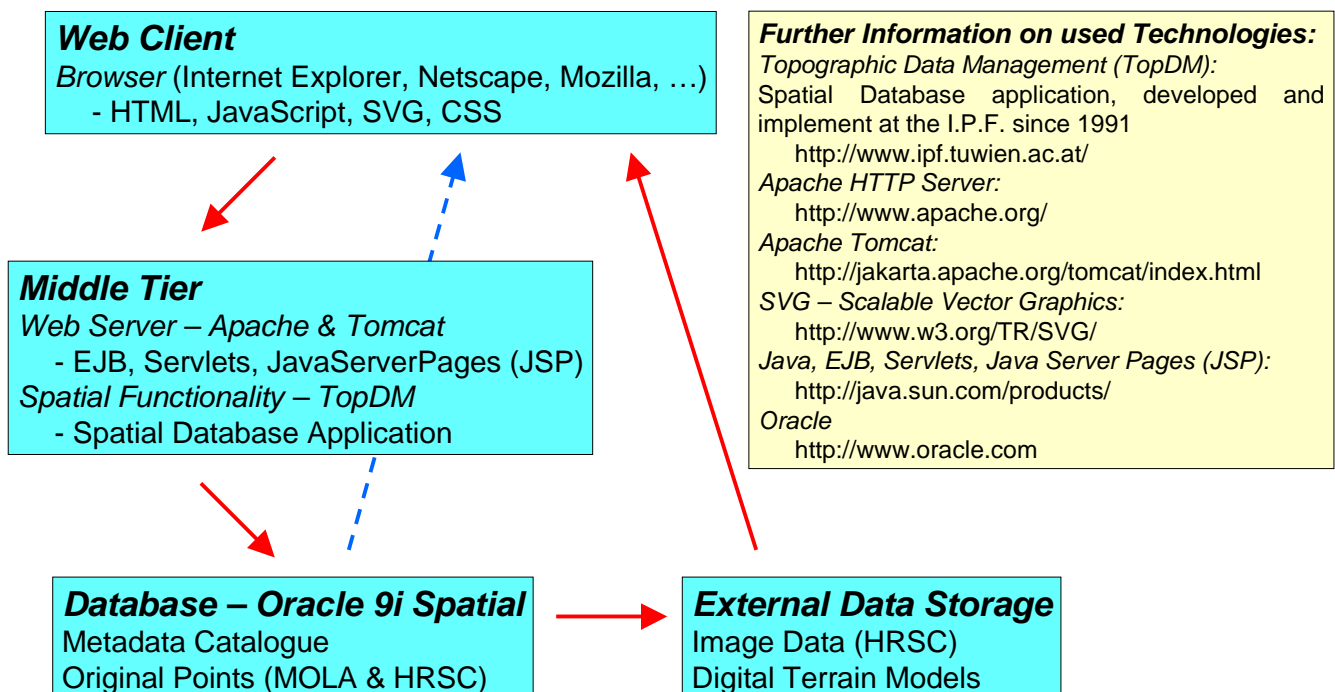
Main Task:

- development of an **information system** for HRSC data (High Resolution Stereo Camera) as
 - interface for **data exchange** between the Co-Investigators of the project
 - presentation web portal - **data source** for the whole mars scientists community

Realization:

- **web application** based on *Oracle 9i* database using *Oracle Spatial* extension
- uses **XML** (eXtensible Markup Language) related technologies:
 - **GML** (Geography Markup Language): Data interchange and validation
 - **SVG** (Scalable Vector Graphics): Data interchange and visualization

Topographic Mars Information System (TMIS) – A Schematic Overview



Dealing with large Topographic Data

The application **SCOP++** is designed for *interpolation, management, application and visualization* of nationwide digital terrain data. It has been developed and continuously improved over the last 30 years in cooperation of Institute of Photogrammetry and Remote Sensing (I.P.F.), Vienna, and INPHO GmbH, Stuttgart.

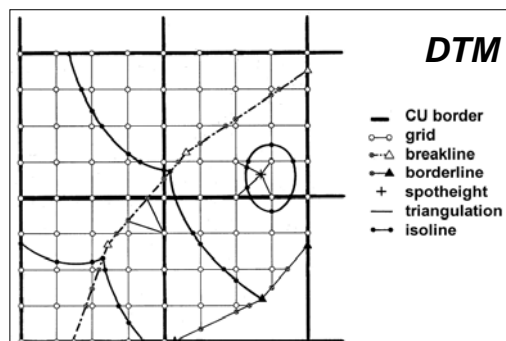
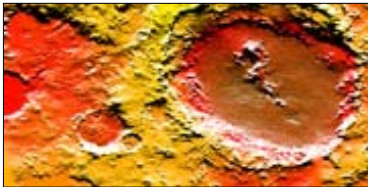
Currently SCOP++ is provided to the Co-Investigators of the HRSC on Mars Express project to use it within the project's context.

Main parts:

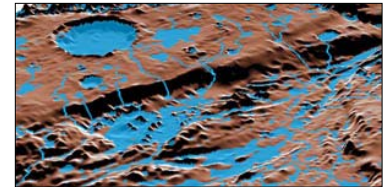
- data preprocessing and editing
- interpolation of digital terrain models (DTM)
- computation of derived products

Overview of SCOP++ results:

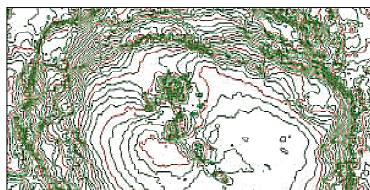
Shadings
Height codings



Hydrological Studies



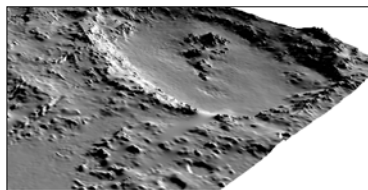
Isolines



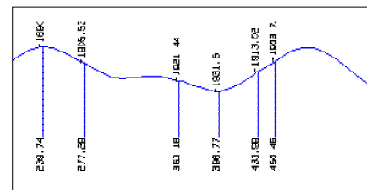
Further Functionality

- Elevation maps
- Animations (VRML)
- DTM intersections
- Visibility studies
- ...

Perspective views



Profiles



SCOP++

Automated Error Elimination on MOLA Data

Method – Robust Estimation

- **line segments** are compared to the terrain model
- points of marked lines are reinserted if correct
- Surface is strongly deformed by gross errors \Rightarrow **3 iterations**
RMS = 200 m \Rightarrow RMS = 75 m \Rightarrow RMS = 20 m
RMS ... root mean square error

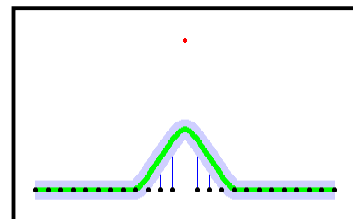
Result

- **Original Points**
- points with gross errors are excluded

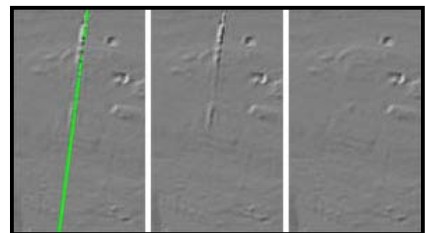
Advantages of automated vs. visual error elimination

	automated – SCOP	visual – MOLA Team
eliminated Points	~ 3 % corresponds to 23 tracks	1 error \Rightarrow whole track is eliminated (800.000 pts)
error level	RMS > 20 m	RMS > 75 m
Homogeneity	granted	according to the user

Influence of a gross error (red dot)
blue band: RMS acceptance limit



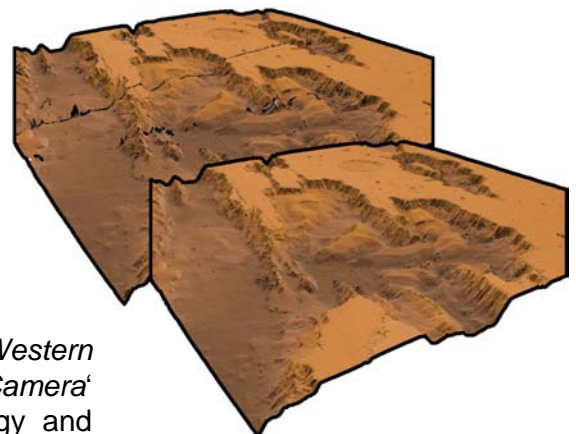
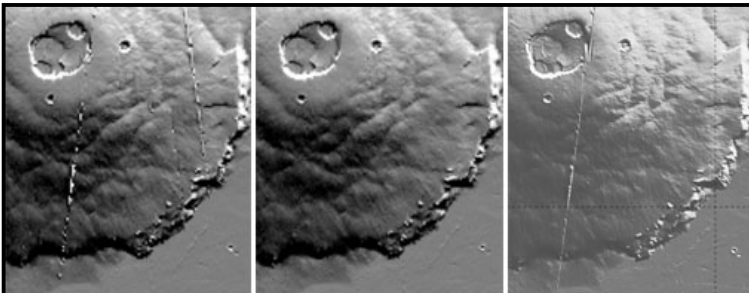
Track recovers



Error Elimination using SCOP

MOLA Team *

Example area within the Valles Marineris
before and after automated error elimination



* Image source: http://ftpwww.gsfc.nasa.gov/tharsis/mars_quads.html

Current Result:

DTM for 'A new digital Orthoimage Map of the Martian Western Hemisphere using Data obtained from the Mars Orbiter Camera'
M. Wählisch et al., DLR Institute of Space Technology and Planetary Exploration, Berlin, Germany

Poster at 33rd Lunar and Planetary Science Conference March 2002, Houston, Texas, USA

Raster Analyses of DTMs using SCOP++

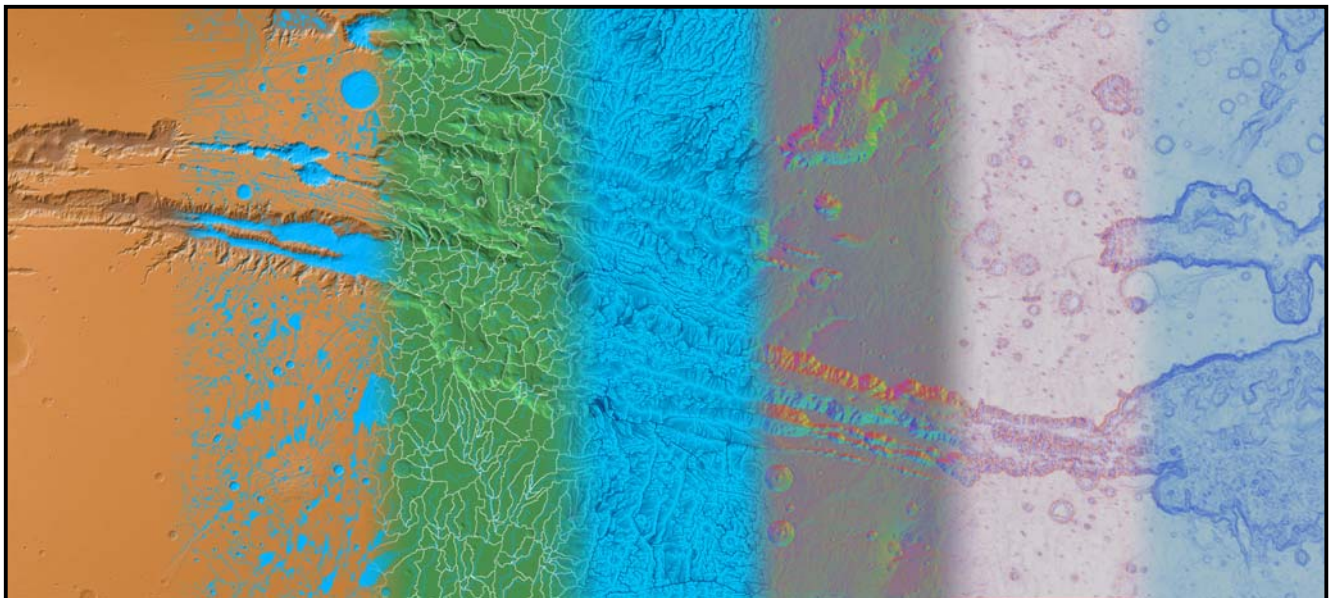
The module **Matrix** allows SCOP++ for raster analyses of DTM data. To do this, the area is discretized according to a given grid step.

Two groups of raster analyses methods are available:

- **Hydrological Analyses:** Based on rain simulation, visualizations such as depressions, drainage behavior, rivers (according to given minimal catchment area size and river length), and catchment boundaries, can be derived. The results are available as TIF-Images. Some are available in vector format, too.
- **Mathematical Analyses:** Curvature, exposition and raster slope maps can be derived. They are available in TIF.

All resulting images can be combined with others. For example shading, height coding, depressions and rivers can be displayed in one combined image to give an impression of rain behavior of an area. Further on orthophotos such as MOC images can be combined with these visualizations.

Valles Marineris: DTM Resolution = 500 m/Pixel



Height Coding
Shading

Depressions
Rivers

Catchment
Rivers

Drainage

Exposition

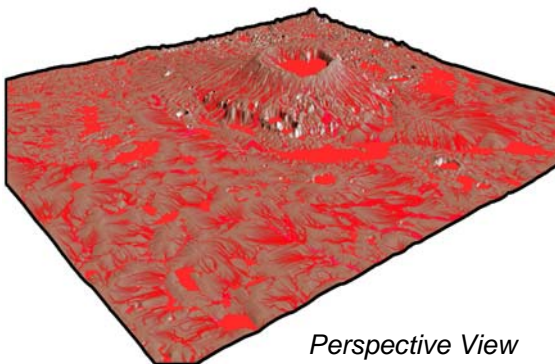
Curvature

Slope

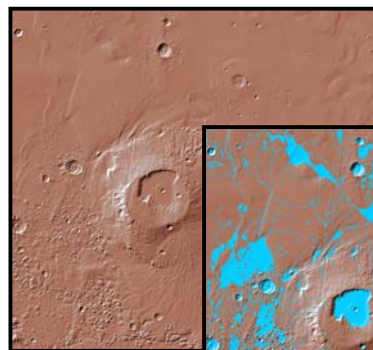
Visualizations of Mars Surface

Apollinaris Patera:

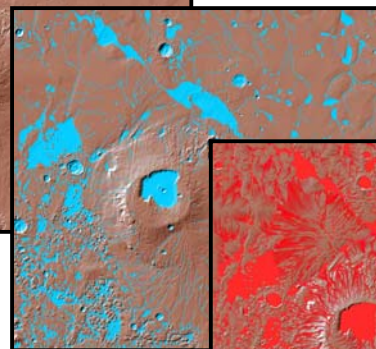
DTM resolution: 500 m / Pixel



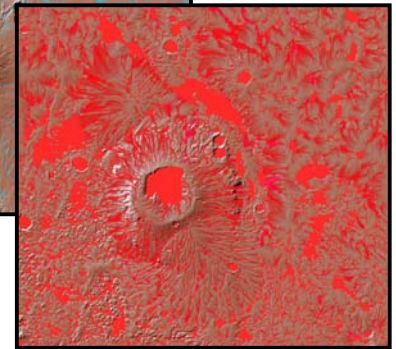
Perspective View



Surface



Depressions
Rivers



Depressions, Drainages

Hydrological Analyses of Mars Volcanoes

As volcanoes are very interesting from a topographical point of view, the I.P.F. computed high quality DTMs and derived several raster image visualizations using rain simulation algorithms.

Considering that lava spreads like water on Mars surface, the resulting lakes and rivers are colored red to simulate supposable streams of lava.

Creation of the presented Visualizations

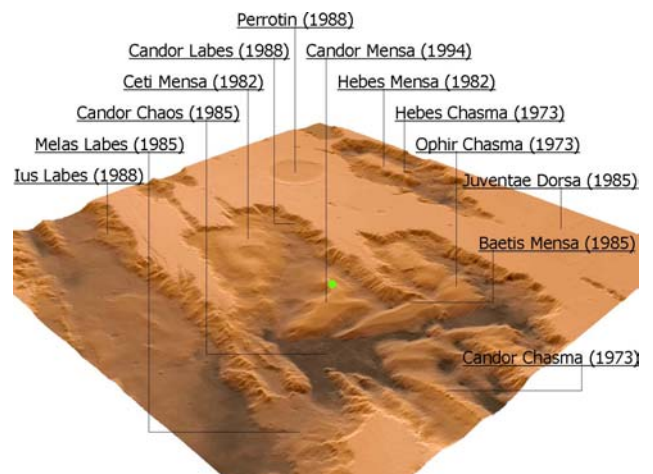
All presented results are derived from the MOLA-2-Dataset from NASA's Mars Global Surveyor (MGS).

Based on a DTM and a geo referenced raster image overlay, SCOP++ allows for the computation of many different visualizations such as *Perspective and Panoramic Views, VRML-Models, and so forth* and also for combination of raster images using image processing algorithms.

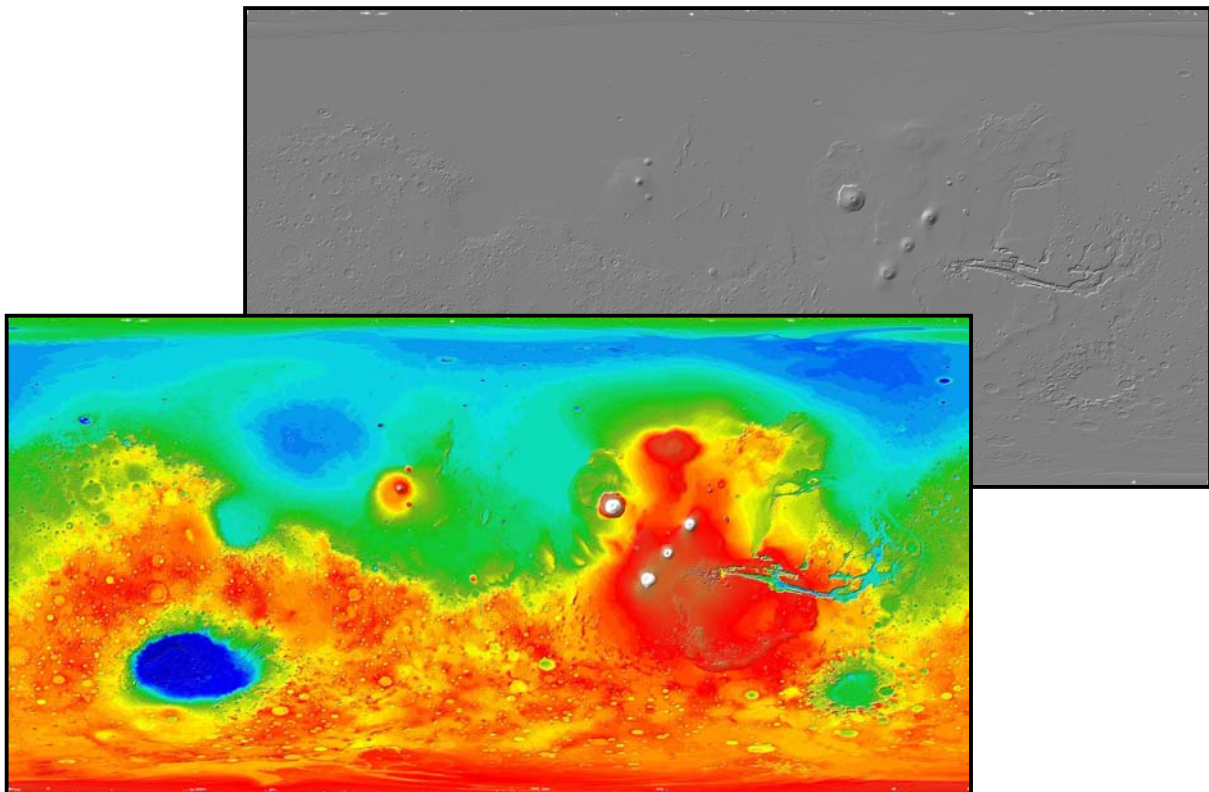
Some of the presented images are further processed using commercial image processing software.

Perspective View of Valles Marineris

Green dot: View point of panoramic view (following page)
Nomenclature source: <http://planetarynames.wr.usgs.gov/>



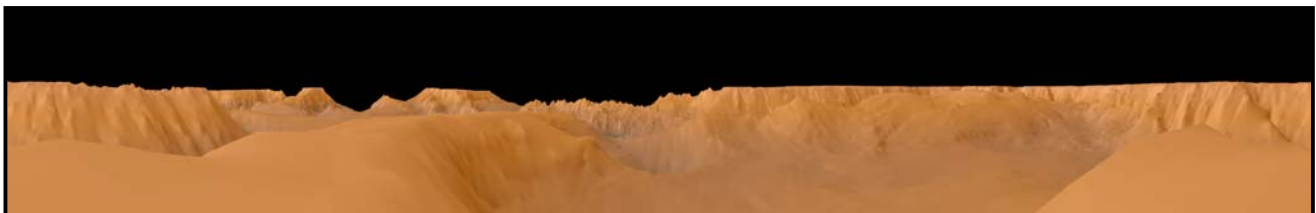
Visualizations of Mars Surface



Global DTM of Mars Surface:

Computation was done in one job. Every 10th points was taken \Rightarrow 60 million points

Resolution: 4500 m / Pixel



360° Panoramic View within the Valles Marineris:

DTM resolution: 500 m / Pixel; Raster Overlay: Combination of height coding and shading