MEASUREMENT OF STRIKE AND DIP OF GEOLOGIC LAYERS FROM REMOTE SENSING DATA – NEW SOFTWARE TOOL FOR ARCGIS. T. Kneissl, S. van Gasselt and G. Neukum, Institute of Geosciences, Planetary Sciences and Remote Sensing, Freie Universitaet Berlin, 12249 Berlin, Germany, thomas.kneissl@fu-berlin.de.

Introduction: Strike and dip measurements, i.e., layer attitudes, are very simple but important geological methods for structural and stratigraphic analysis in geological sciences. The dip value of a geological layer is defined as the amount this layer is tilted from the horizontal in decimal degrees. The strike value is the direction along the horizontal line of this geological layer. Another notation to describe the orientation of a layer is the dip direction value instead of the strike value. Generally, these measurements are done in the field directly at the outcrop of a geological layer. In planetary sciences this kind of field measurement is not possible for obvious reasons. Therefore the only way to get information about the spatial position of geologic layers is the use of remote sensing data. For such measurements on remote sensing data, a terrain model describing the z-extent and image data for the xy extent of a geological surface is needed. A layer can be interpolated using at least three discrete measurement points on a layer's outcrop.

ESRI's ArcGIS provides a basic function to interpolate simple planes out of a set of xyz-values containing measurement points. However, this *trend* function is rather limited, as for example the extent of the interpolated surface is limited to the extent of the envelope defined by the input measurement points. Furthermore, the input points have to be stored internally in a featureclass with which it is not possible to have an easy interactive measurement process.

Methodology: In remote-sensing data the intersection of geological layers, faults, contacts or fractures with the original topographic relief do not necessarily appear as a linear line. By using intersection lines with a known elevation, it is possible to determine the attitude of a layer. The positions and elevations of different measurement points along the observed line allow the construction of planes describing the surface of the geologic layer of interest (figure 1). In this respect, three measurement points exactly define a plane. Using more than three points, in order to reach higher accuracy, the best-fitting plane has to be computed using a polynomial fit. The regression equation is $z = ax + by + c$, where x and y are coordinates in a projected reference system, z is the elevation above a given datum, and a, b and c are the fit coefficients (e.g., [1]).

ArcGIS generally provides the possibility to interpolate simple planes out of a point shapefile containing z-values. However, this procedure is very cumbersome and therefore the measuring of strike and dip for more than one layer is very inefficient. The developed ArcGIS extension uses the described basic ArcGIS function '*trend'* and provides a more user-friendly interface for measuring many geological layers. Furthermore, this tool enables the user to access many more functionalities when compared to the basic *trend analysis* of ArcGIS.

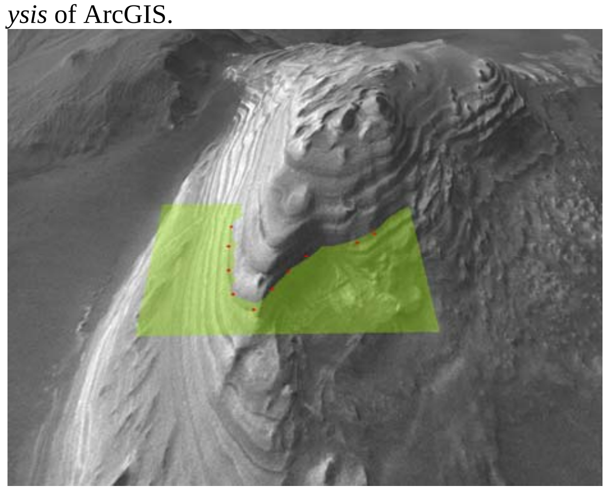

Figure 1: Interpolation of plane (transparent green) using z-values containing measurement points (red dots).

Workflow in ArcGIS: In order to measure the dip and dip-direction of a layer the user has to manually sample measurement points along the outcrop of a layer/structure. The software interpolates the layer surface using the *trend* function of ArcGIS. During this step, the software also performs an intersection of the original digital terrain model with the interpolated raster layer and defines the theoretical extent of the measured layer as a polygon (see figure 2). The software automatically provides the properties of the interpolated layer: the layer dip[°], dip direction[°] and the RMS error. The theoretical extent of the interpolated layer, the outcrop polyline feature as well as the geological strike/dip label rotated by the calculated dip direction are displayed in the current data frame. Additionally, the individual errors of the measurement points are displayed to enable the user to adjust specific measurements manually, within the constraints of the observed layer outcrop, in order to interpolate a layer surface with a RMS error as small as possible. If the individual layer measurement is finished, this layer can be accepted and all visible graphic objects (layer extent, outcrop line, geolog. label, and the original measurement points) are stored internally in the *layer* *list* dialog (see figure 3). Additionally, the interpolated raster layers are stored within an internal multi-band raster datasets. The user may create topographic profiles containing the original surface as well as the interpolated layer surfaces in the subsurface.

If all layer measurements of interest are finished, measurements can be exported as shapefiles. During this step a maximum number of four shapefiles are created: a point shapefile for all measurement points of individual layer interpolations, a polygon shapefile containing the maximal extents of these layers, a polyline shapefile for the outcrop lines, and a second point shapefile with the geological strike and dip symbols. The layer properties (dip, dip direction, and RMS error) are stored as attributes of the respective features. Additionally, the geological strike-dip symbols are automatically rotated to the dip direction and become labeled with the respective dip value.

This tool is free for academic/educational use. System requirements: ArcGIS 9.3 and ESRI's Spatial Analyst extension. For more information, please contact thomas.kneissl@fu-berlin.

Acknowledgement: This research was partly supported by the German Science Foundation (DFG) through the Priority Program Mars and the Terrestrial Planets (DFG-SPP 1115, Project: Chronostratigraphy of Mars, grant: NE 212/8-3), the Helmholtz Association through the research alliance "Planetary Evolution and Life", and the German Space Agency (DLR), grant 50QM0301 (HRSC on Mars Express).

References: [1] Davis J.C. (1986) Wiley, New York.

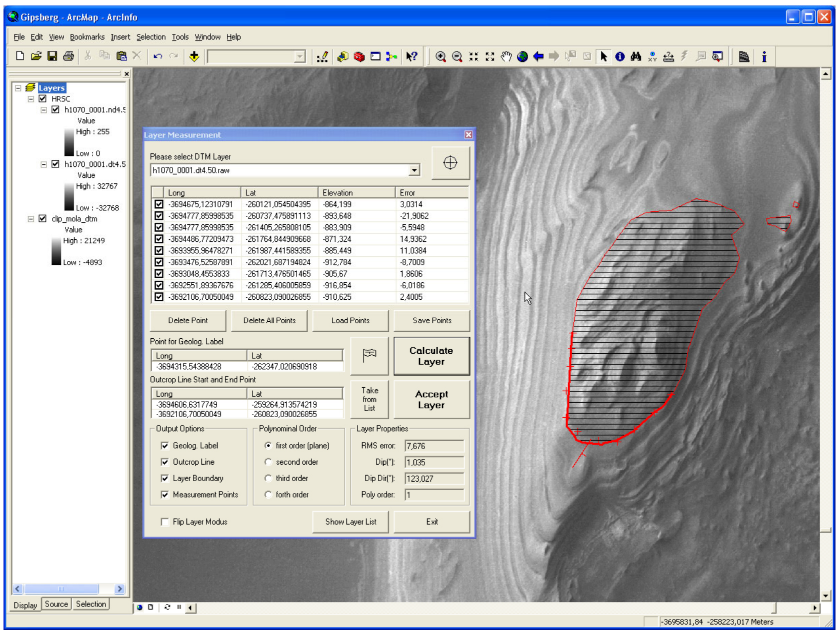

Figure 1: Measurement of strike and dip using the *LayerTools* extension in ArcGIS.

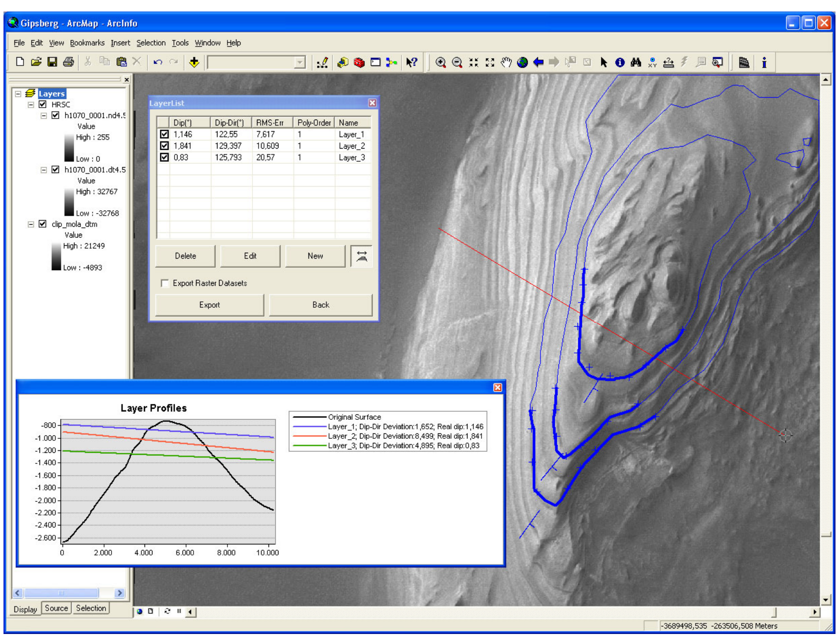

Figure 2: *Layer-List* dialog containing several layer measurements. Topographic profile shows the attitudes of the interpolated layers.