Global SRTM Geomorphometric Atlas

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1. Introduction

The Shuttle Radar Topography Mission (SRTM) flew on Endeavour in 2000, and created a globally consistent DEM at scales previously available only for limited areas, and generally not freely available. The orbital mechanics of the space shuttle limit coverage to regions within about 60° of the equator. North-south spacing is approximately constant, while the east-west spacing varies with latitude. Holes or data gaps represent the single significant drawback to the SRTM data. These occur in steep terrain which blocked the side-looking radar beam, and in regions with soil conditions like dry sand (Slater et al. 2006). With limited exceptions (such as the United States), comparable data sets which can be used to fill the holes do not exist, and finding a global solution to the holes issue will be a great challenge; nonetheless, for most the world, the SRTM remains the only freely available data set, and in many locations it is by far the best.

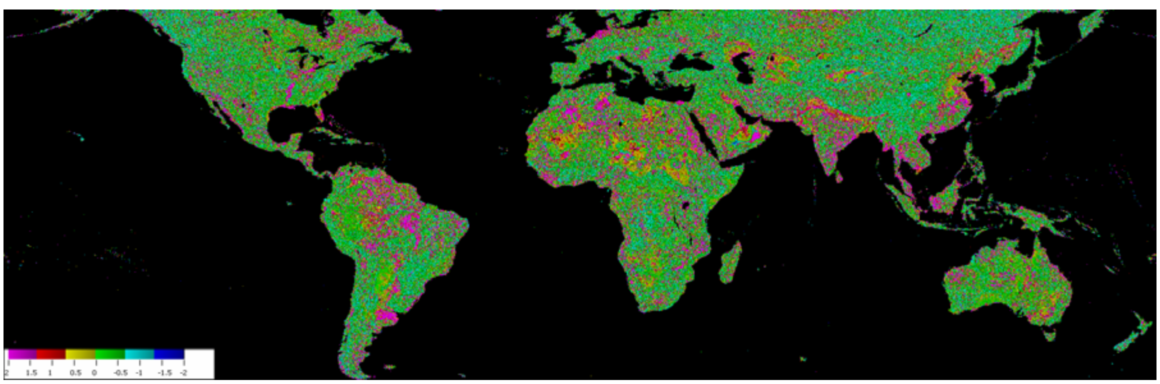

Figure 1. SRTM atlas map for ELEV_KRT, the kurtosis of the elevation distribution. At this scale only about 4% of the data points were on screen.

Geomorphometric parameters computed from DEMs include point and area statistics (Evans 1998; Pike 2001). Simple point parameters, except for elevation, require a region or neighborhood around the point. More complex point parameters, like terrain organization, require a larger neighborhood and the value of the parameter varies with the size of the neighborhood. Area parameters depend on the range or distribution of values within the selected neighborhood. Guth (2006) compared terrain statistics from the SRTM mission with the National Elevation Dataset (Gesch et al. 2006), the best cartographically derived data for the United States. We extend that study to the 3" data for the entire world and show samples of the resulting atlas and analysis possible with this data set.

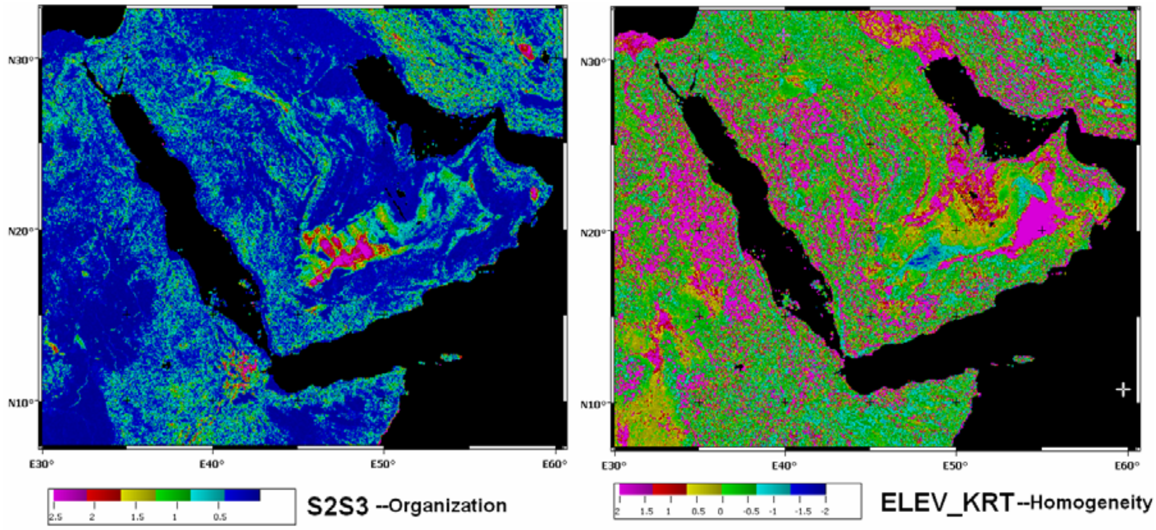

Figure 2. SRTM atlas for the Arabian peninsula at the full resolution of the data, showing two parameters.

2. Method

We divided the earth's surface between 60°N and 56°S into blocks 2.5' (arc minutes) on a side, which provides about 7.4 million regions for analysis. We store our results in data grids (two dimensional files of values, indexed by the corner coordinates and the spacing between values). This generally provides a very efficient way to store and retrieve such data. The data parameters only fill about 31% of the grid nodes because water covers 70% of earth's surface, but the files compress very well, from 5.3 GB to about 400 MB. If there were no holes or water, each block would have 2601 points, sufficient for robust statistics describing terrain. The appendix lists the computed parameters.

3. Results

Each data grid contains 8640x2784 values. Figure 1 shows a single grid, for elevation kurtosis; at the global scale, the fine detail of the atlas is not visible. Figure 2 shows the full resolution data for the Arabian peninsula, for elevation kurtosis and terrain organization. Figure 3 shows the full resolution data for two regions with different kinds of dunes, which have very different values for the two parameters shown in Figure 2.

Figure 4 shows a large portion of the Arabian peninsula from the SRTM 30 second data set. This data set has 25 data points in each of the analysis regions of the atlas, and does a good job of depicting regional topography. Figure 5 shows a filtering of the atlas data, with the points that meet set criteria colored. Values of the three parameters selected do a very good job of picking out linear dunes, with few false positives.

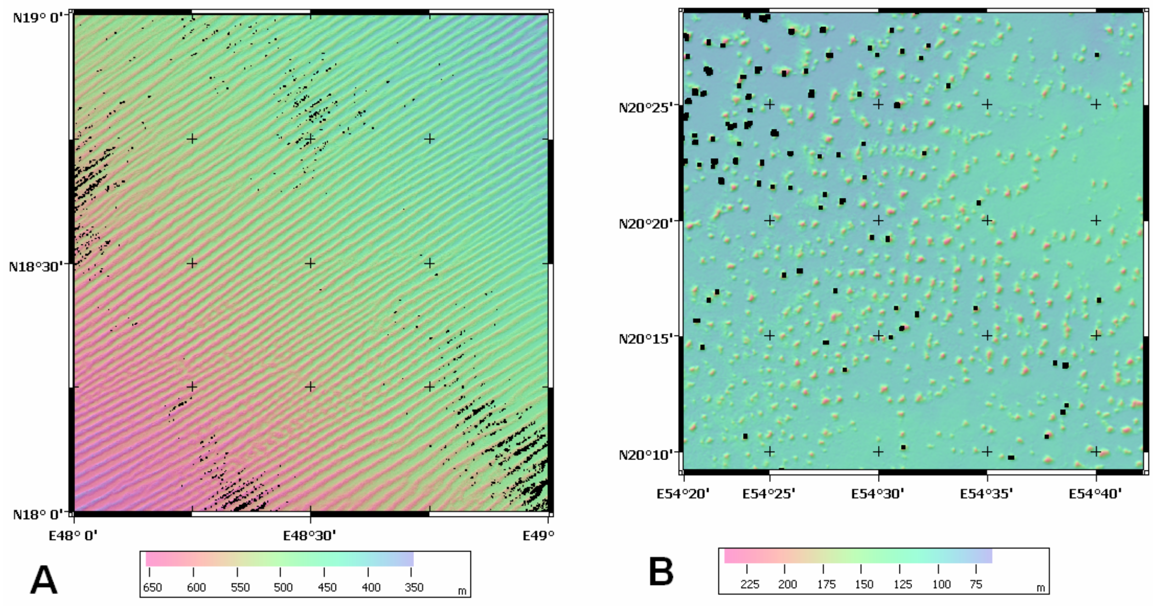

Figure 3. SRTM 3" data for two types of dunes. (A) shows linear dunes, with very high values of organization and very low values of homogeneity. (B) shows star dunes, with low values of organization and very high values of homogeneity.

4. Conclusion

Geomorphometric parameters computed from the 3 second SRTM data set capture a wealth of information about earth's landscapes. Guth (2006) showed that the restricted, nominal 1 second SRTM data set really provided information at no better than 2 second resolution, so the freely available 3 second data likely represents the best elevation data that will be available for some time. We are actively working on ways to better manipulate and visualize this data, for instance using clustering for terrain classification. The size of the data set makes this a challenging proposition, but the rewards will be significant.

5. References

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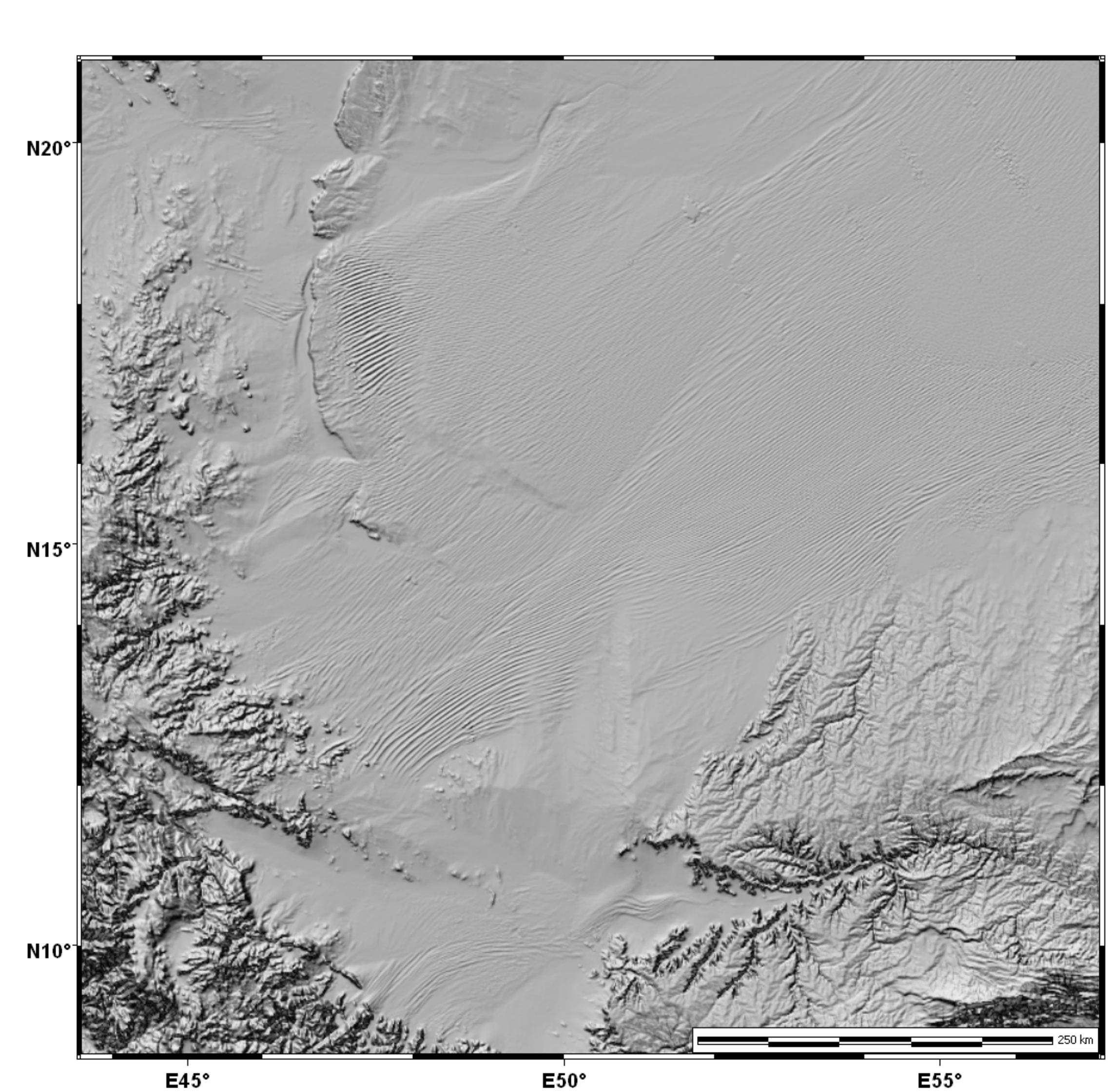

Figure 4. SRTM 30” data for a region in the southwestern portion of the Arabian peninsula. Linear dunes dominate much of the area.

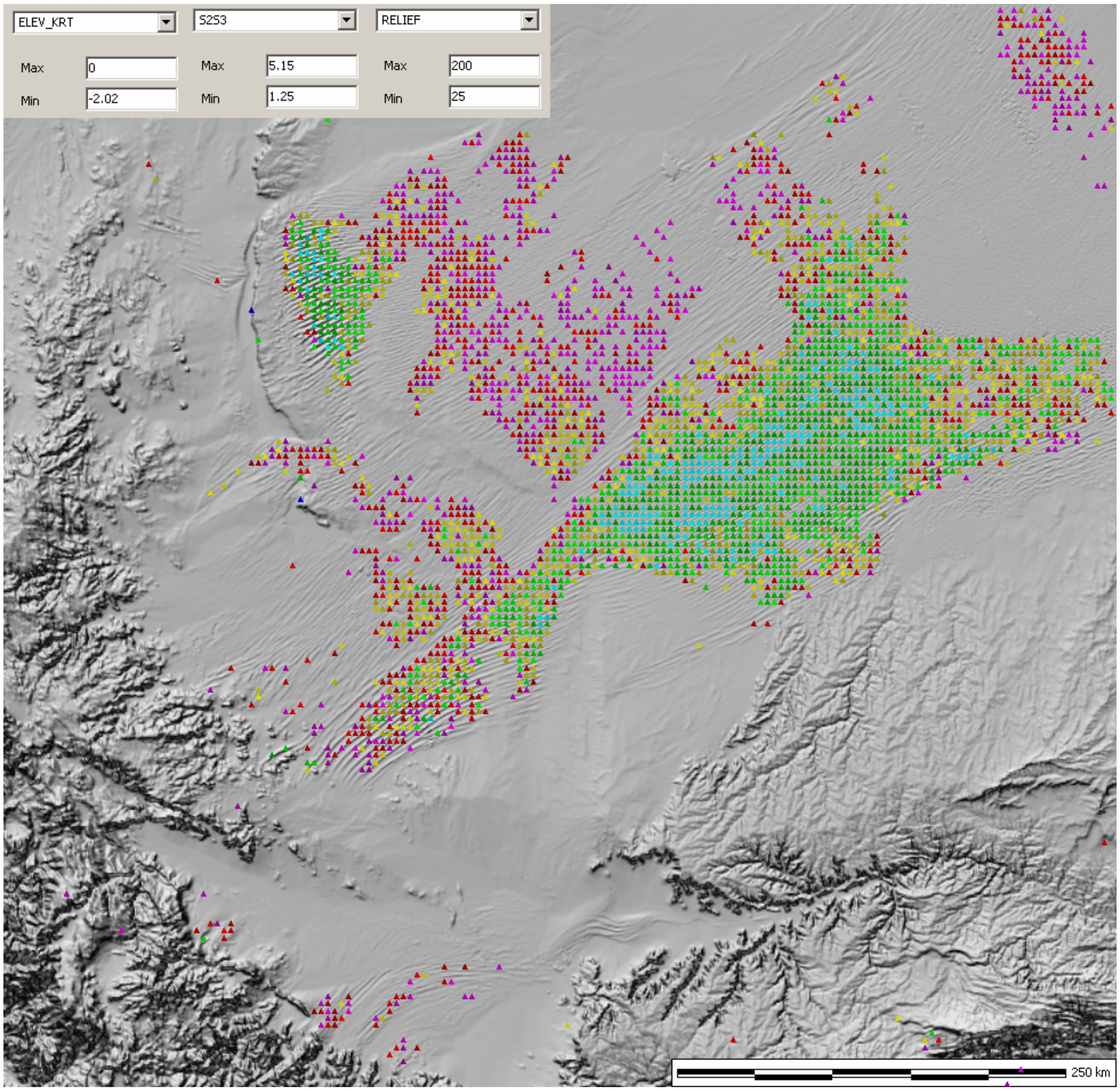

Figure 5. The region in Figure 3, with the colored points meeting specified criteria for ELEV_KRT, S2S3, and RELIEF. This set of criteria does a good job of picking out the dunes, with very few false positives. Colors based on the value of ELEV_KRT.

6. Appendix. Geomorphometric parameters in the SRTM Atlas

- **ELEV_AVG, ELEV_STD, ELEV_SKW, ELEV_KRT**: the first four moments of the elevation distribution. ELEV_STD correlates strongly with slope.
- **SLOPE_AVG, SLOPE_STD, SLOPE_SKW, SLOPE_KRT**: moments of the slope distribution in percent (100*rise/run).
- **SLOPE_MAX:** steepest slope. While this is largely of value for detecting blunders during DEM creation, it also has geomorphic significance.
- **PLANC_AVG, PLANC _STD, PLANC _SKW, PLANC _KRT**: moments of the plan curvature distribution.
- **PROFC_AVG, PROFC _STD, PROFC _SKW, PROFC _KRT**: moments of the profile curvature distribution.
- **S1S2, S2S3, FABRIC_DIR, SHAPE, STRENGTH**: Computed using logs of the three eigenvectors (S1 >> S2 > S3) of the surface normal vector distribution. S1S2 (ln(S1/S2)) measures flatness (a logarithmic inverse of slope), S2S3 (ln(S2/S3)) measures terrain organization, and FABRIC_DIR gives the dominant direction of ridges and valley. Shape = ln(S1/S2)/ln(S2/S3); Strength := ln(S1/S3) using the eigenvectors as computed above. Strength and S1S2 generally correlate closely, while S2S3 and shape correlate moderately
- **ELEV_RELF**: the elevation relief ratio ([AveZ-MinZ] / [MaxZ – MinZ]) is computed for a region and is equivalent to the coefficient of dissection.
- **SLOPE_MAX:** the largest slope (percent) in the sampling region. While this is largely of value for detecting blunders during DEM creation, it also has geomorphic significance.
- **GAMMA_NS, GAMMA_EW, GAMMA_NESW, GAMMA_NWSE**: Nugget variance, C_o, from the variogram. This is a measure of the elevation difference from each point to its nearest neighbor in four directions; smaller values reflect smooth terrain, and high values rougher terrain.
- **ROUGHNESS**: Measure correlating strongly with slope. It is defined as 1 minus the square root of the sum of the squares of direction cosines of the normal vector computed as each DEM posting in the analysis region.
- **RELIEF**: difference between the highest and lowest elevations within the sampling region.
- **TRI_PR_FR. TRI_PR_FR2:** triangular prism fractal measures using the fractal box counting method, with a second method to lessen the effects of holes.
- **MISSING**: the percentage of holes and points removed after applying the water body mask.
- **HOLES**: the percentage of holes in the SRTM data. This can be used to filter the results, and only look at statistics where missing data might bias the results.

References for the computations can be found in the MICRODEM help file (Guth 2007).