Going Forward: Extending and Exploiting the DEMIX Database With MICRODEM

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Abstract—**We show the power of the DEMIX database and the reference DEMs created to support it to analyze the properties and characteristics of 1 arc second global DEMs. This allows us to see why COPDEM and FABDEM are best, and how they improve on the others. The distributions of the differences from the reference DEMs in terms of elevation, slope, and roughness show that COPDEM and FABDEM consistently have the least bias compared the reference DEM, and the smallest standard deviations.**

I. Introduction

DEMs provide a critical base layer for almost all earth science studies. The DEMIX group is working to compare and rank 6 global DEMs: COPDEM, FABDEM, ALOS, NASADEM, SRTM, AND ASTER [1,2]. We use their database [3] and reference DEMs [4] to demonstrate preliminary results of the rich potential to mine those datasets. Two other papers at this conference have examined the ability to use qualitative evaluation of hillshade maps to rank DEMs [5], and to look at the difference maps to study the spatial patterns where ALOS and COPDEM differ [6].

II. Results

The wine contest [1] cannot use signed results because their choice of statistics requires that the values be ranked from low score (best) to high score. They commented that signed values like the mean and median provide additional context, which we will explore with Figure 1 which shows the mean, median, mode, and standard deviations of the difference distributions of elevation, slope, and roughness for all 236 tiles in the database. This summarizes the individual difference histograms for each tile. It allows the following generalizations:

- The difference distributions for COPDEM and FABDEM, and to a lesser extent ALOS, have a very sharp peak close to 0, indicating very little bias compared to the reference DTM. The other DEMs have much smaller and flatter peaks; for many it is hard to find a mode.
- NASADEM has little bias from the reference DTM only for elevation differences, where it is much better than SRTM.
- NASADEM does not improve on slope and roughness compared to SRTM.
- ASTER is clearly the worst performer.

Overall Figure 1 supports the DEM ranking from the wine contest [1], but provides insight into how the DEMs differ.

Figure 2 shows where each of 6 DEMs is tied for best, with the tiles sorted by average slope and percent forest, using three criteria of the 15 used in the wine contest [1]. Supplementary figures on Zenodo show 7 land characteristics with 6 criteria. There are 236 opinions, one per tile for each criterion with the DTM as reference and 134 opinions for the DSM as reference. There can be 1 to 6 DEMs tied, and the figure suggests where each is best:

- Fewer tiles have a DSM, which must be factored into looking at the figure.
- COPDEM and FABDEM are almost always at the top, FABDEM more often when compared to a DTM and COPDEM when compared to a DSM.
- Based on a limited number of very steep and very rough (shown on a supplementary figure) tiles, ALOS may out perform the other DEMs in that type of topography.
- NASADEM and SRTM perform best in low slope tiles, and in unforested tiles and some tiles with about 70% forests.
- ASTER is tied for first for only 6 tiles, two of which are very flat coastal DEMs in which none of the 1 arc second DEMs performs very well.

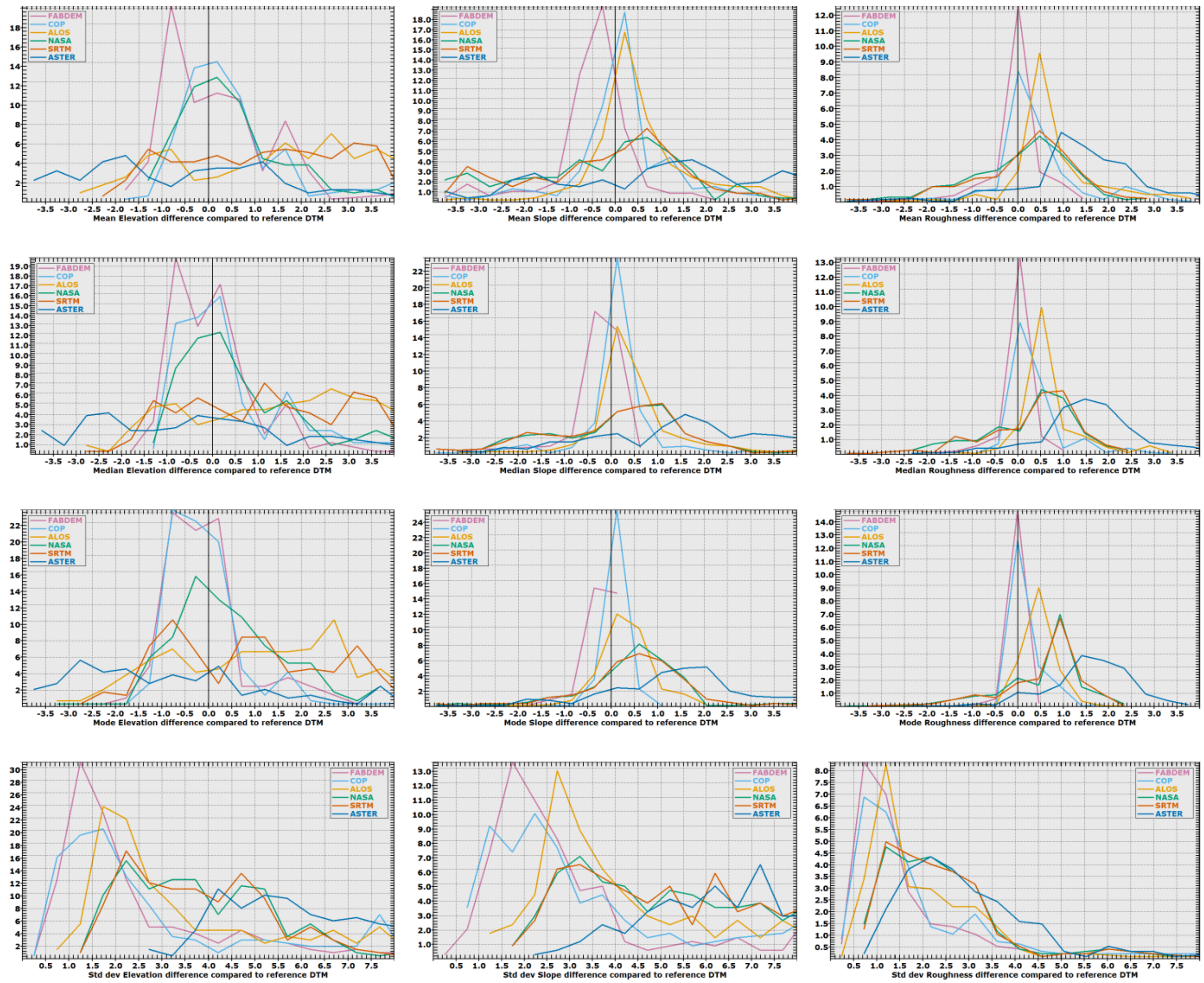

Figure 1. Summary statistics (mean, median, mode, and standard deviation) for the difference distribution compared to the reference DTM for 6 global DEMs and 236 DEMIX tiles. Graphs of the difference distributions are available online [7].

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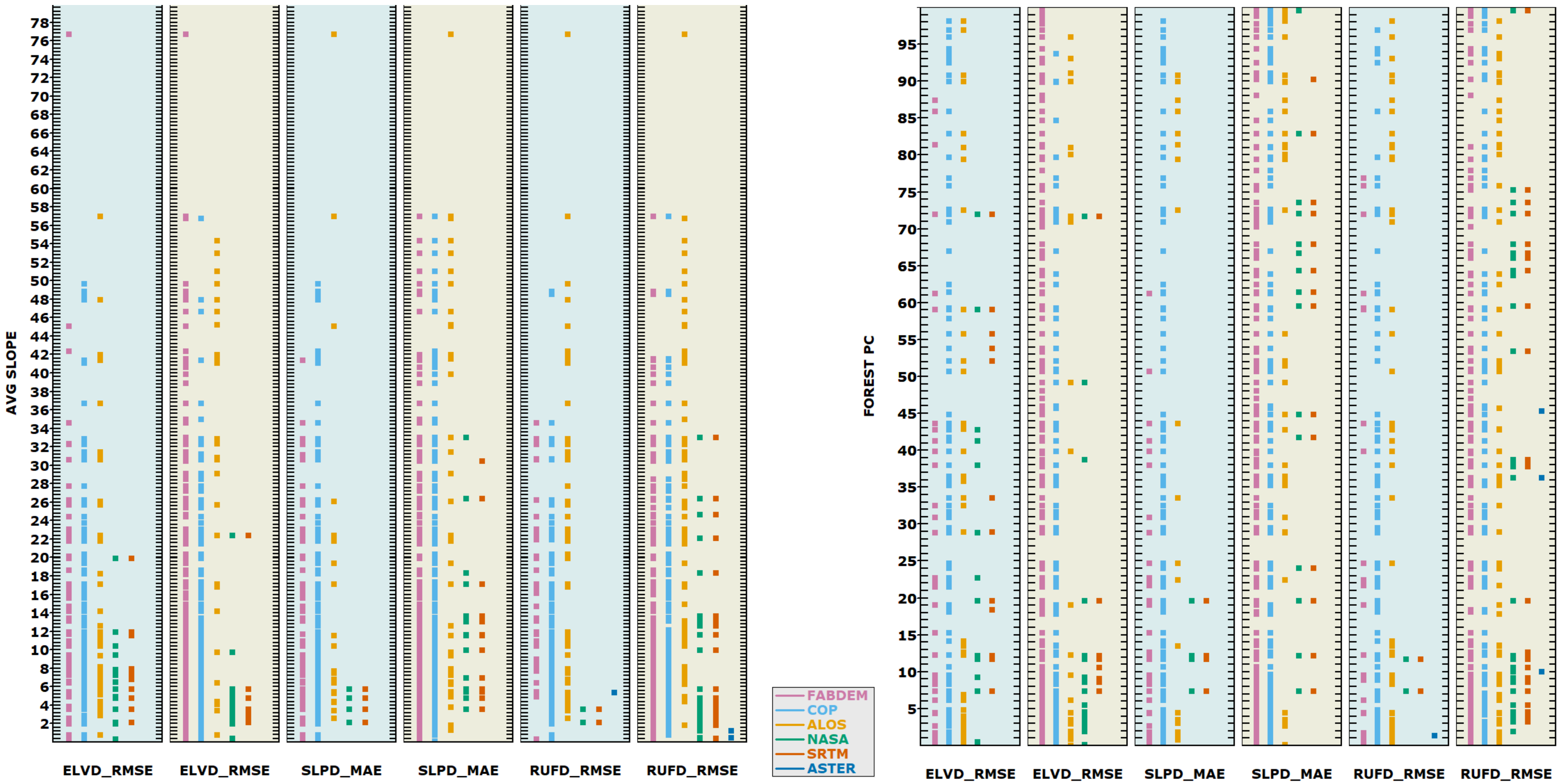

Figure 2. Tile by tile results where each DEM is ranked best within tolerance, for three parameter and both DSM (blue background) and DTM (brown background). On the left side the tiles are sorted by average slope of the tile in percent, and on the right by how much of the tile is forested. Additional results are with the paper online.

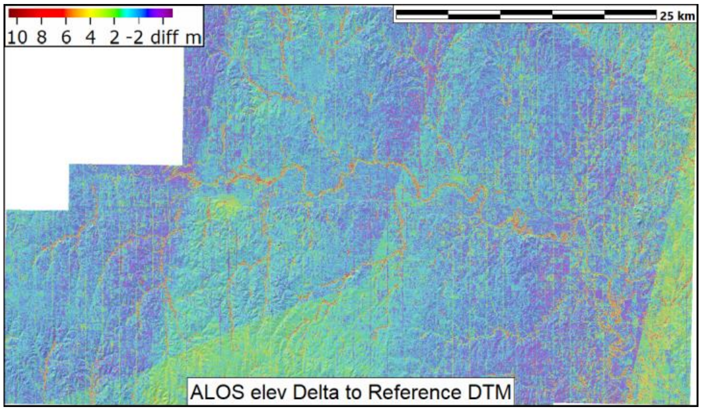

Figure 3. Elevation differences, ALOS minus reference DTM for the Republican River test area in Kansas.

Inspection of the difference maps reveals aspects of the DEMs that do not always show up in the statistics. For example, Figure 3 shows linear anomalies with the ALOS DEM showing where images were merged; we have seen the same patterns elsewhere with ALOS and notably have not seen similar artefacts with COPDEM. The scale of these anomalies makes them hard to see on individual DEMIX tiles, and is one reason we prefer to work with larger areas with many DEMIX tiles. The other, and perhaps bigger reason, is that the geographic tile boundaries do not line up well with the UTM boundaries of the source DEMs used to aggregate the reference DEMs, and it is much easier to get data for an area and then extract the individual tiles on the fly.

IV. Conclusions

We foresee several ways that the DEMIX wine contest and its associated database will be extended (1) adding more tiles, particularly in mountainous areas, (2) adding new criteria, and (3) looking beyond the numerical rankings to understand what causes the differences, and when each DEM performs best. We do not expect that the relative rankings of the DEMs will change much, but that understanding where ALOS performs best could lead to improved DEMs in areas where COPDEM underperforms; understanding the difference between optical and radar sensors might lead to better composite DEMs. All of these DEMs are composites, using additional data to fill voids, and FABDEM removed trees and buildings from COPDEM very well in creating the best (and only) DTM in the group.

V. Acknowledgments

All work done in the open source MICRODEM [8], which has source code and a 64 bit Windows executable. Larger figures and Supplementary figures available on zenodo with this paper. We thank our collaborators on the DEMIX group for stimulating discussions.

References

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