GEOMORPHOMETRY 2021
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Using lidar points cloud to evaluate global 1" and 3" DEMs

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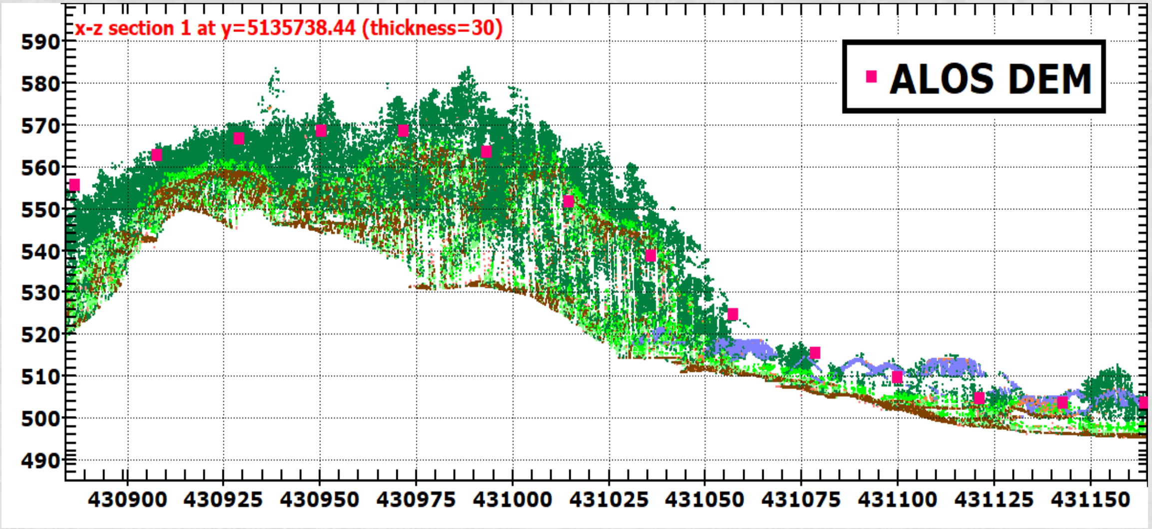


Published version

Two papers were published in the book from the 2020 conference, and then they were combined in a paper in Transactions in GIS which also incorporated the NASADEM and the Copernicus DEM that appeared after the conference papers were published, and restricted the discussion to 1” DEMs.

- **Peter L. Guth (2020) Using high-resolution lidar point clouds to evaluate 1-3 arc second global digital elevation models: in Massimiliano Alvioli, Ivan Marchesini, Laura Melelli & Peter Guth, eds., Proceedings of the Geomorphometry 2020 Conference,** https://doi:10.30437/GEOMORPHOMETRY2020_31
- Tera Geoffroy and Peter L. Guth (2020) Using high-resolution ICESat-2 point clouds to evaluate 1-3 arc second global digital elevation models: in Massimiliano Alvioli, Ivan Marchesini, Laura Melelli & Peter Guth, eds., Proceedings of the Geomorphometry 2020 Conference, https://doi:10.30437/GEOMORPHOMETRY2020_29.
- Guth, P. L., & Geoffroy, T. M. (2021). LiDAR point cloud and ICESat-2 evaluation of 1 second global digital elevation models: **Copernicus wins**. Transactions in GIS, 00, 1–17. https://doi.org/10.1111/tgis.12825. Paper as submitted in January 2021.

Quasi-Global 1” (aka 30 m DEMs)=DSMs

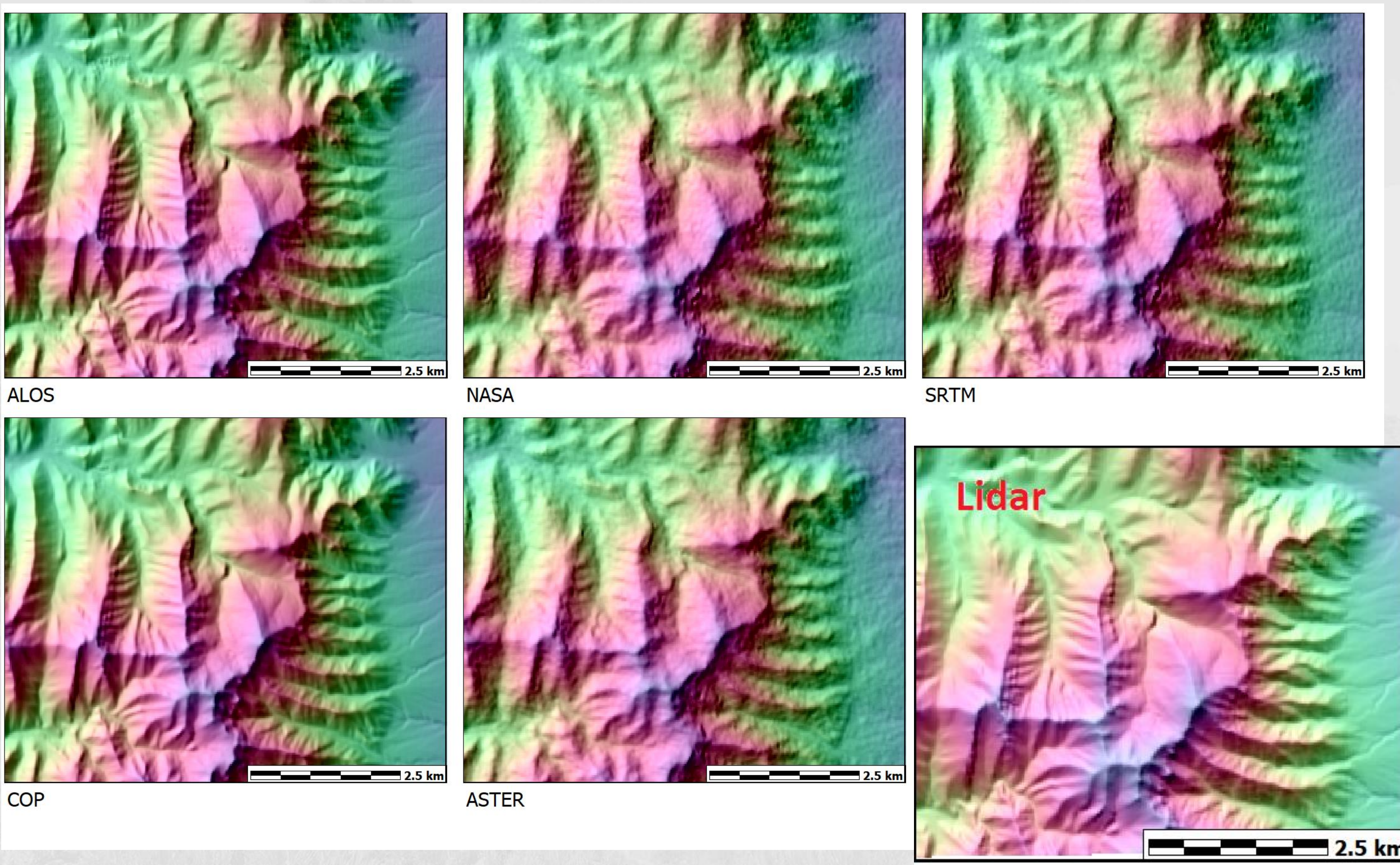
Free Global DEMs

Free Global DEM	Spacing	Primary Source	Producer	Vertical Datum	Precision	Longitudinal spacing	Acquired
SRTM (v3)	1", 3"	C band radar	NASA	Orthometric EGM96	Integer	Constant	2000 (11 days)
ASTER GDEM (v3)	1"	Stereo NIR imagery	NASA / METI	Orthometric EGM96	Integer	Constant	2000-2013
ALOS World 3D AW3D30 v3.2	1"	Stereo pan imagery	JAXA	Orthometric EGM96	Integer	Variable	2006-2011
NASDADEM	1"	Reprocessed C band radar	NASA	Orthometric EGM96	Integer or floating point	Constant	2000 (11 days)
Copernicus DEM GLO30 and GLO90	1", 3"	X band radar, Edited commercial WorldDEM	ESA/Airbus	Orthometric EGM2008	Floating point	Variable	2010-2015
Tandem_X	3"	X band radar	DLR	Ellipsoidal WGS84	Floating point	Variable	2010-2015
MERIT	3"	Radar + Stereo pan imagery	Univ. Tokyo	Orthometric EGM96	Floating point	Constant	2000-2013

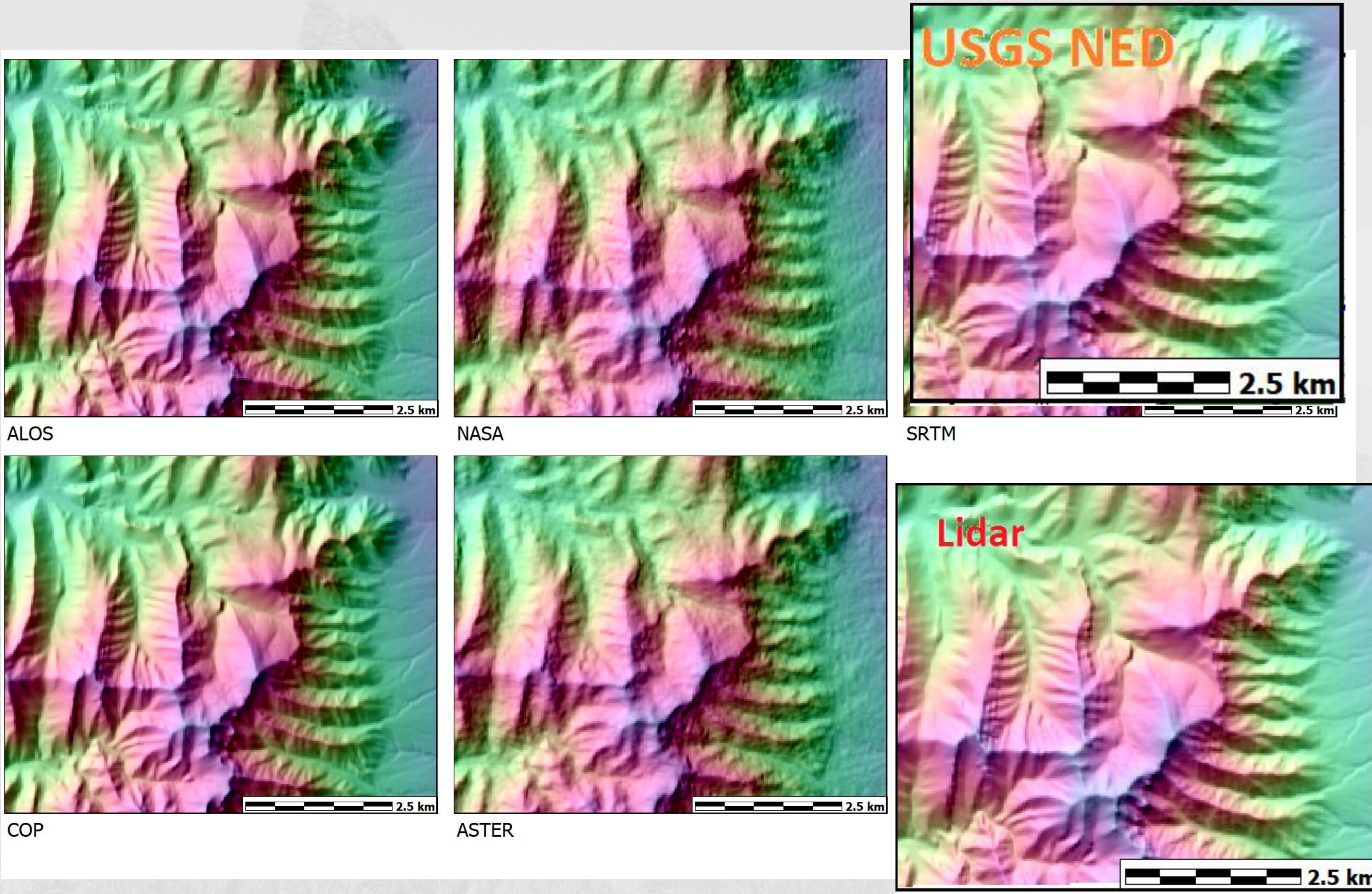
Notes:

1. All are WGS84 horizontal datum
2. All name tiles for SE corner (USGS NED/3DEP names for NW corner)

Visual comparison, 1” DEMs Utah



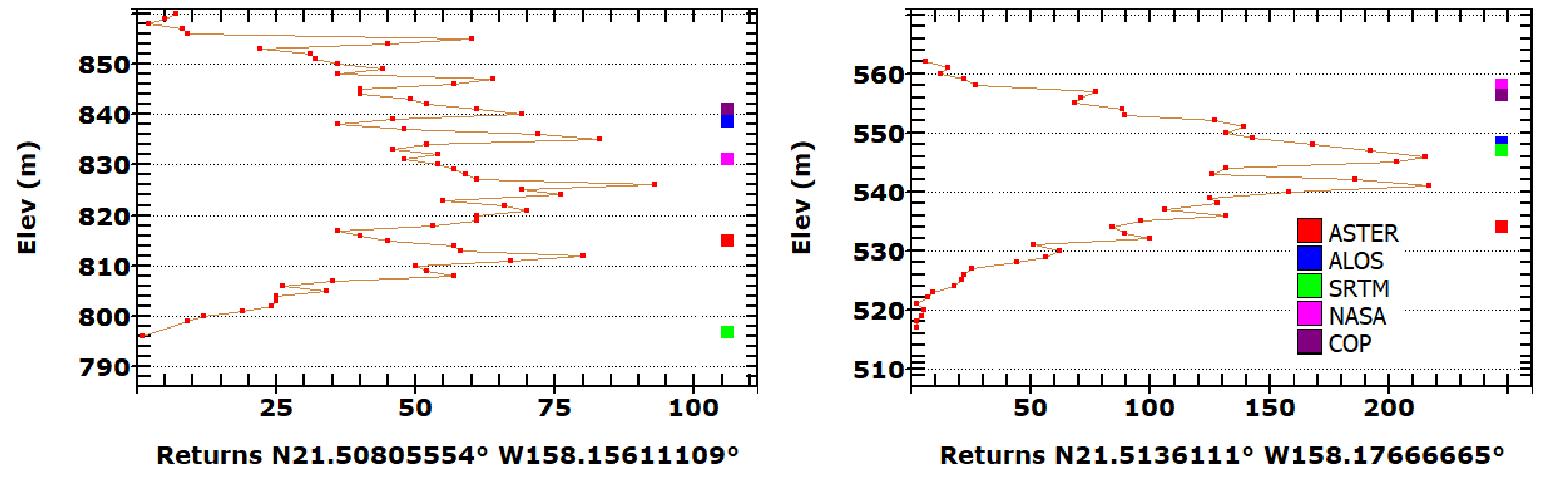
Visual comparison, 1” DEMs Utah



Final Test areas

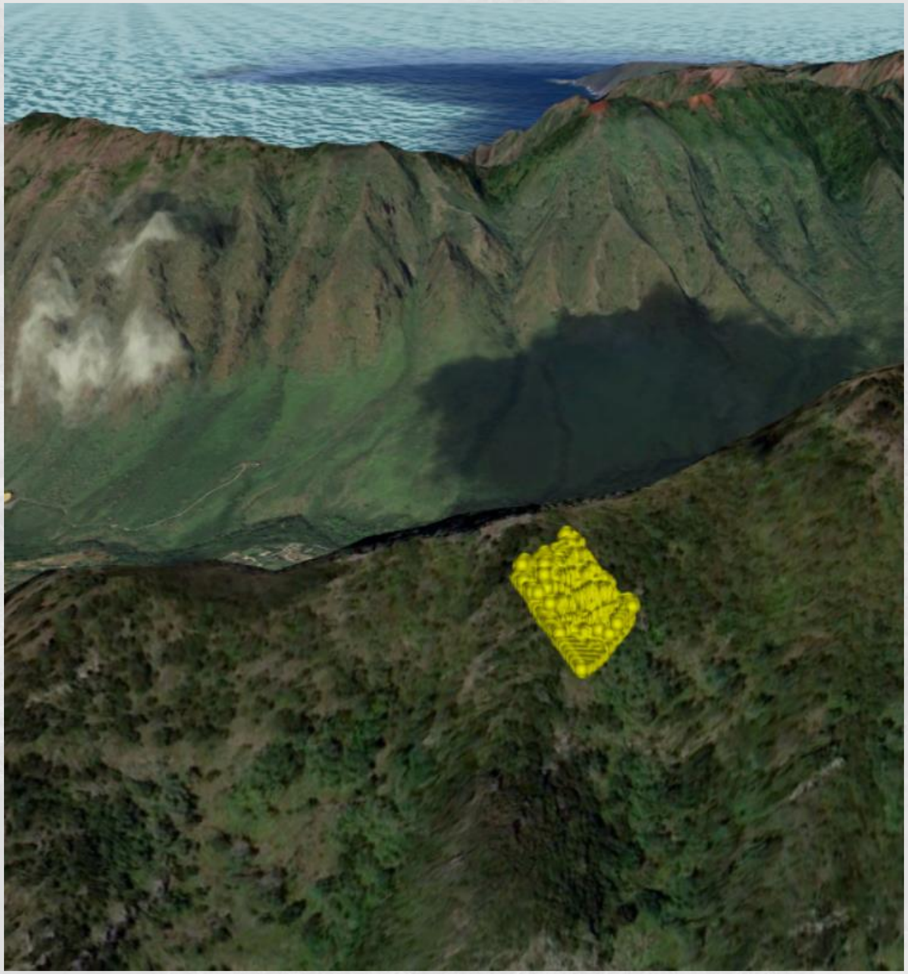
Region	Lidar 1" cells	Median lidar returns per 1" cell	Median returns per m²	Köppen classification
Kristianland, Norway N58.17° E8.02°	709428	5858	12.46	Cfb
Bled, Slovenia N46.37° E14.08°	29327	10772	18.95	Cfb
Redwoods, CA, USA N39.85° W123.77°	49728	7319	6.65	Csb
Canyon Mtns, UT, USA N39.36° W112.23°	163293	1906	3.24	Cfb/Dfb
Blue Ridge, VA USA 38.71° W78.28°	278641	4878	9.84	Cfa
Icod, Tenerife, Spain N28.37° W16.7°	33485	1221	2.09	BSh
El Hiero, Spain N27.74° W18.02°	317341	1177	1.44	BSh
Oahu, HI, USA N21.49° W158.19°	61186	1773	2.78	Am

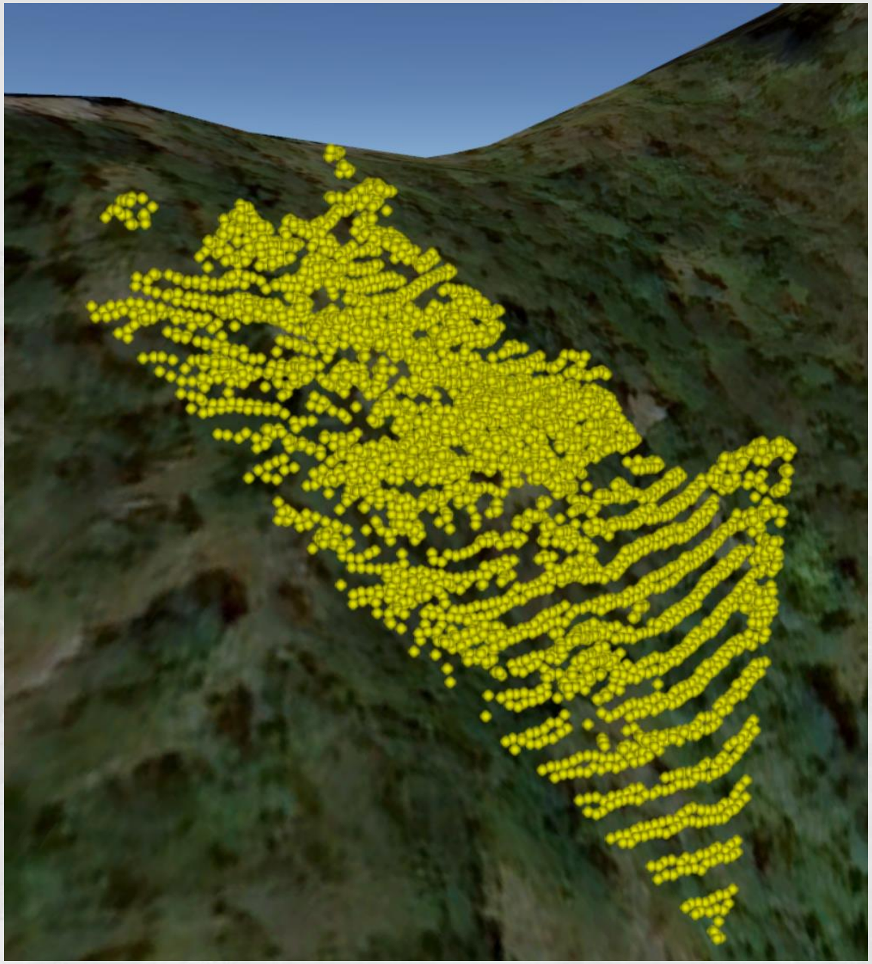
Two 1” pixels in Hawaii
1500 to 10,000 lidar returns per pixel



- Lidar provides “ground truth” for what sensor saw to create 1” DEM
- Extract returns in each 1” pixel, and determine top and bottom of “canopy”, which includes effects of sloping ground and vegetation canopy
- Actual analyses had 30,000 to 700,000 pixels in each test area

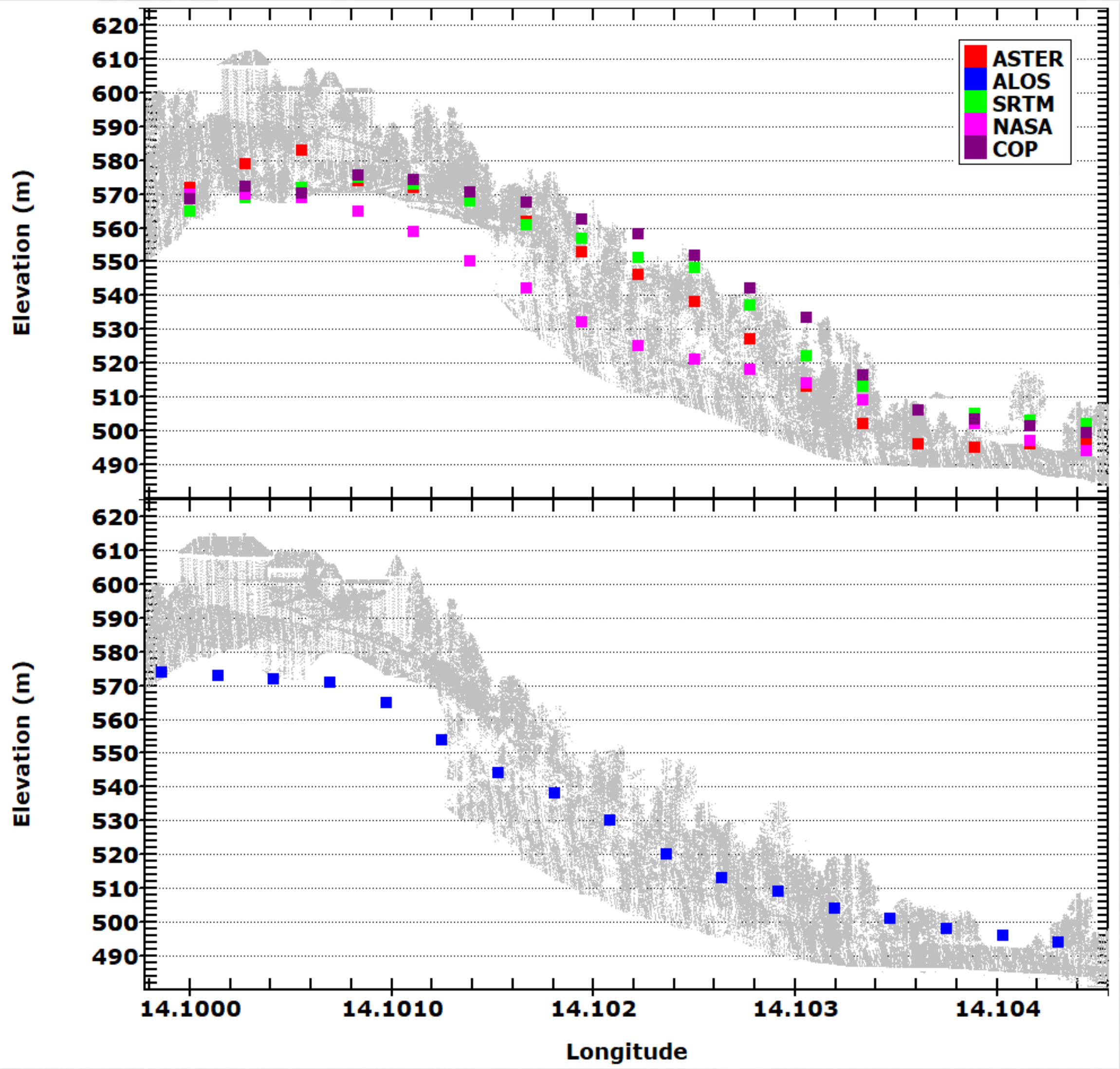
One 1”x1” pixel, 4300 lidar returns





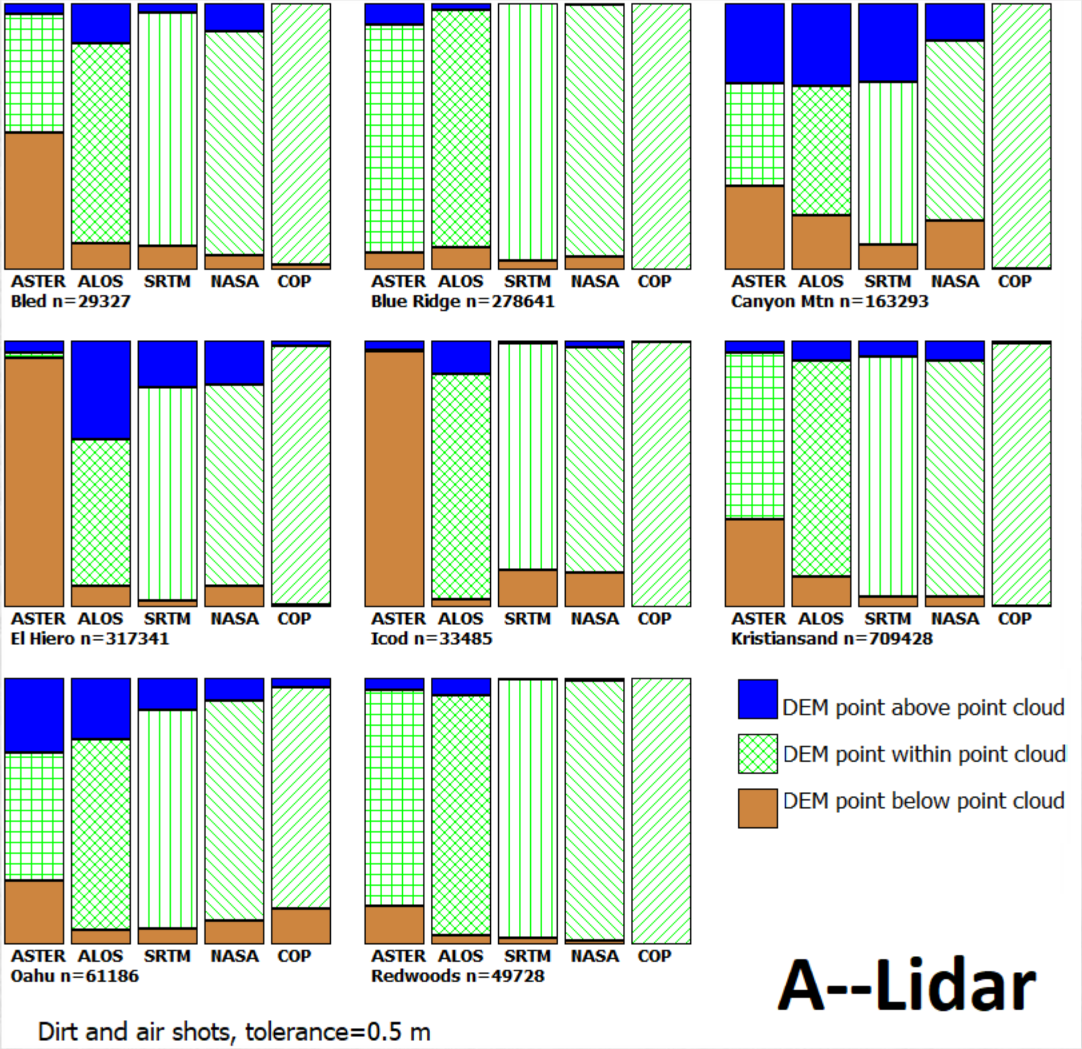
- Vegetation top of ridge to ground in valley

Bled, Slovenia

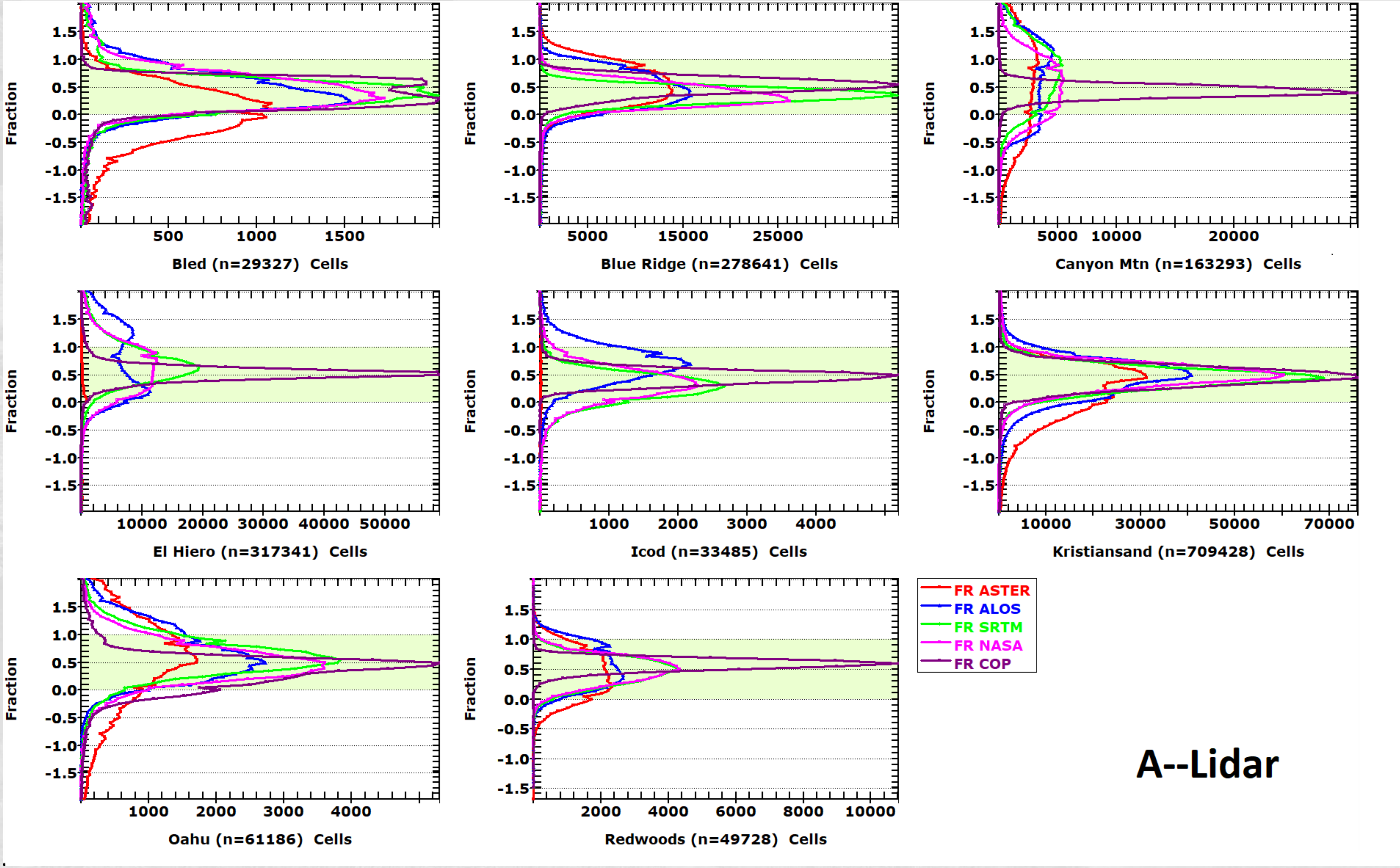


ALOS has ½ pixel offset

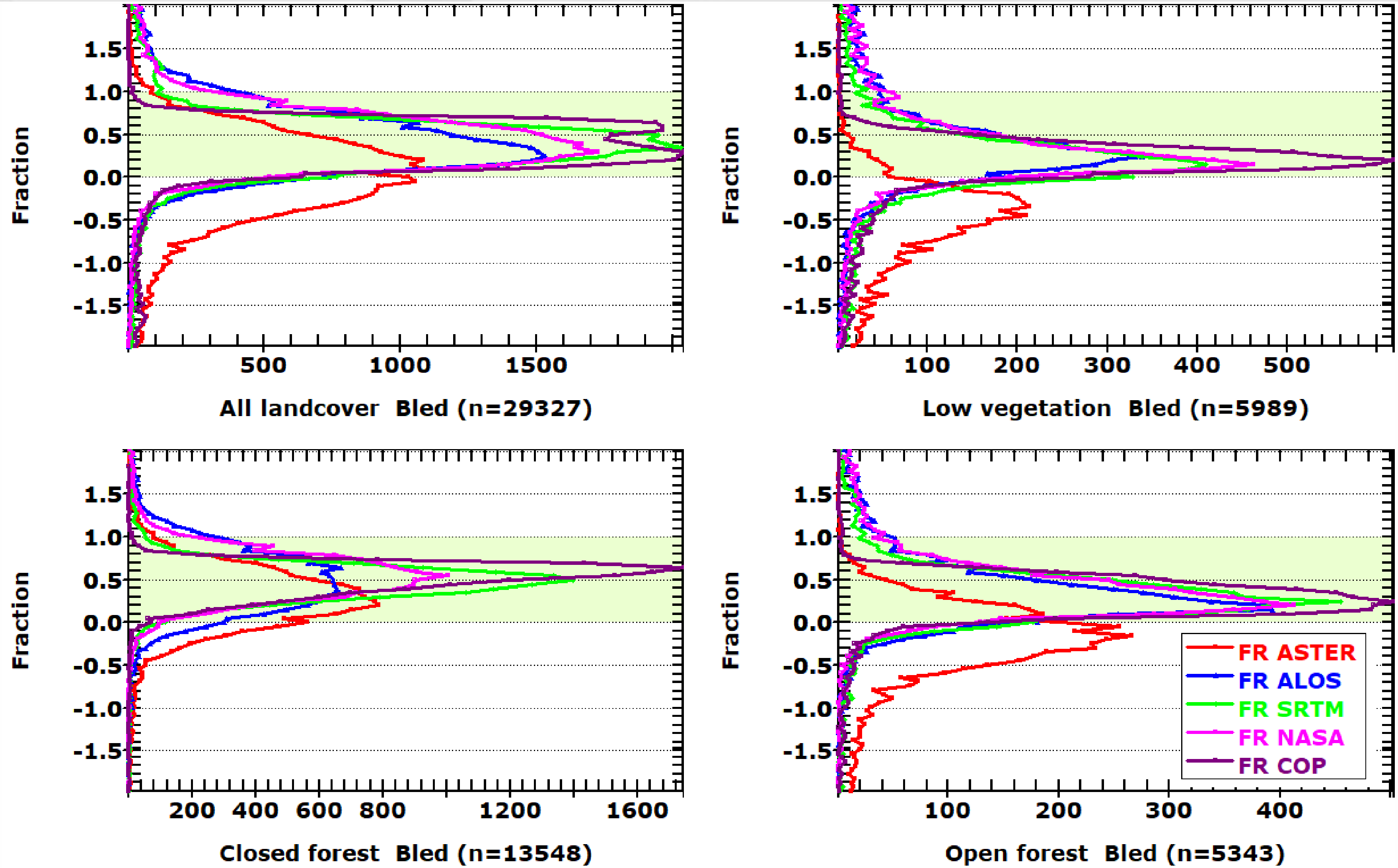
Copernicus within lidar canopy
SRTM and NASA very similar
ASTER consistently worst



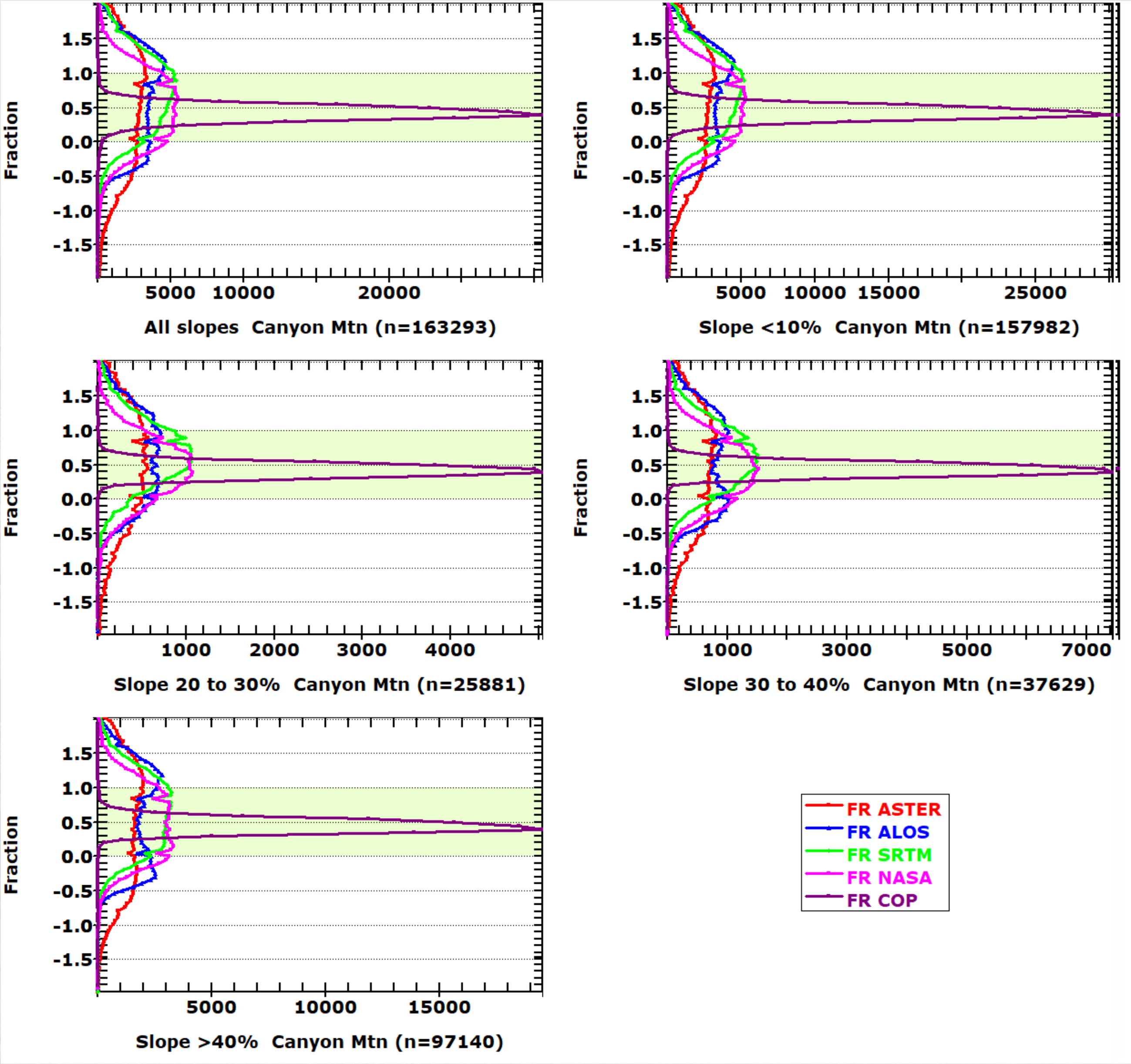
Normalize lidar "canopy" from 0 to 1
Copernicus in point cloud, near middle



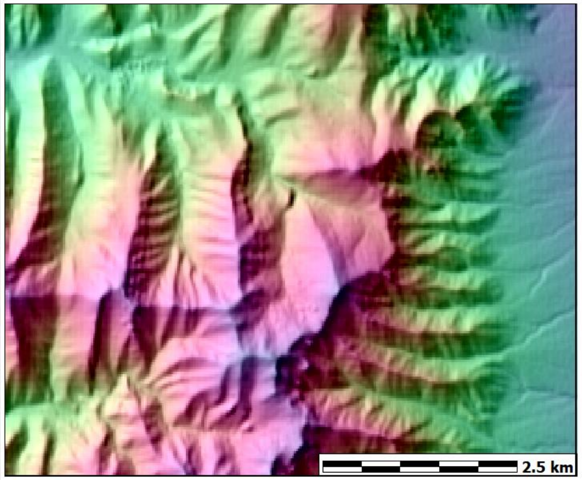
Landcover: DEMs near bottom “canopy” in open terrain



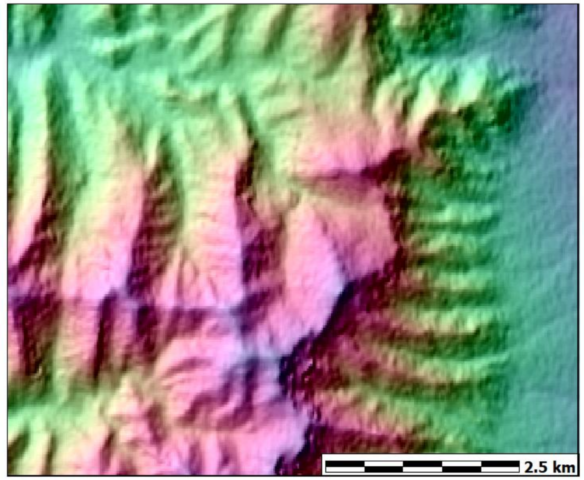
Slope categories, Canyon Mountains



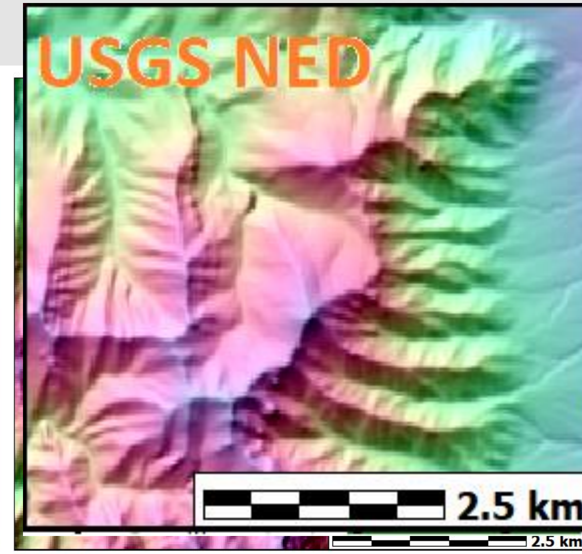
Visual comparison, 1” DEMs Utah



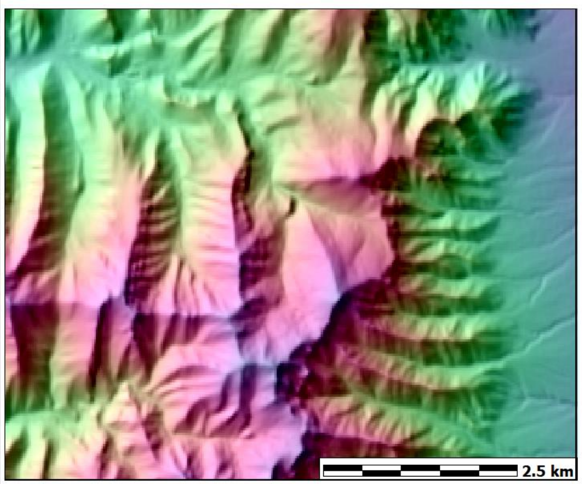
ALOS



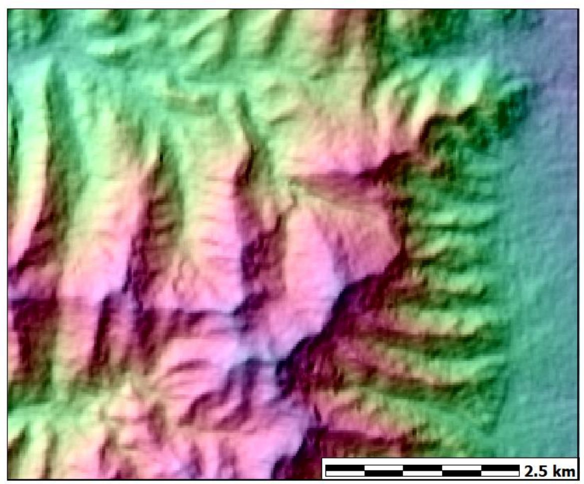
NASA



SRTM



COP



ASTER

1” DEMs Concluding thoughts

- None of the test samples are low relief
- Copernicus clearly best
- NASADEM very similar to SRTM
- ASTER clearly inferior to other 4
- Mostly within the “canopy” defined by the lidar point cloud, and thus intermediate between DSM and DTM
- What elevation do we want to represent a 1” or 3” DEM cell (min, max, median, mean, center-most)?
- We can use first, ground, or all returns