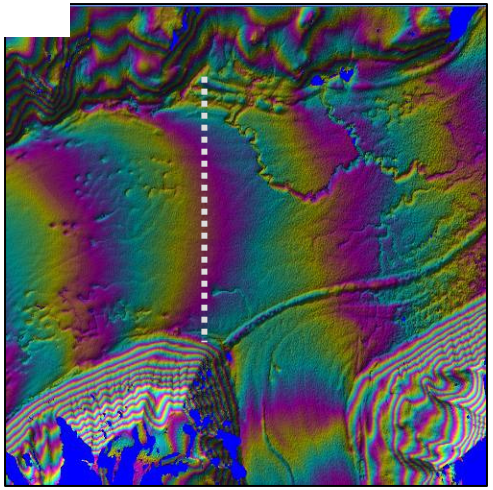
GeoSAR IFSAR Processing

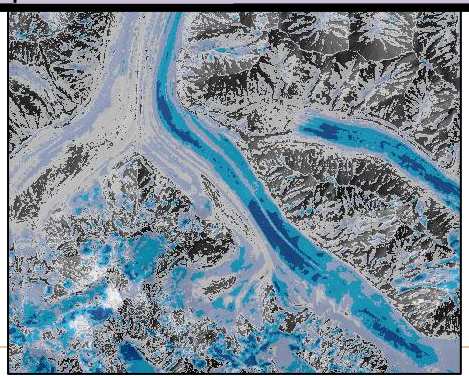
Dr. Bert Kampes
Kevin Morgan
Mark Sanford

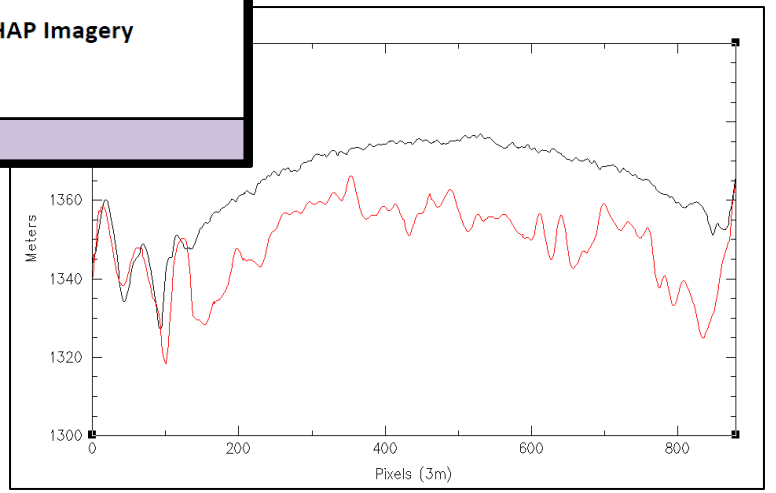
Snow and Ice Penetration @2:20PM

- See Kevin Morgan's presentation, today @2:20PM

12:00 - 1:30	LUNCH
1:30 - 2:00	Rick Guritz Moderator **Evaluation of ALOS PRISM DEM Accuracy Using a LiDAR Reference** Rick Guritz, ASF/UAF
2:00 - 2:20	**An Elevation Model for Alaska Using ALOS PRISM** Scott Arko, ASF/UAF Grant Cain, Kerri Crowder, Dan Bates, Rick Guritz, Don Atwood, Keith Cunningham
2:20 - 2:40	**Fugro GeoSAR Mapping Technology for Snow and Ice Penetration** Kevin Morgan, Fugro EarthData Bert Kampes, Megan Blaskovich, Mark Sanford - Fugro EarthData
2:40 - 3:00	**Alaska Glacier Change Observed with ALOS PRISM and AHAP Imagery** Grant Cain, ASF/UAF
3:00 - 3:30	BREAK

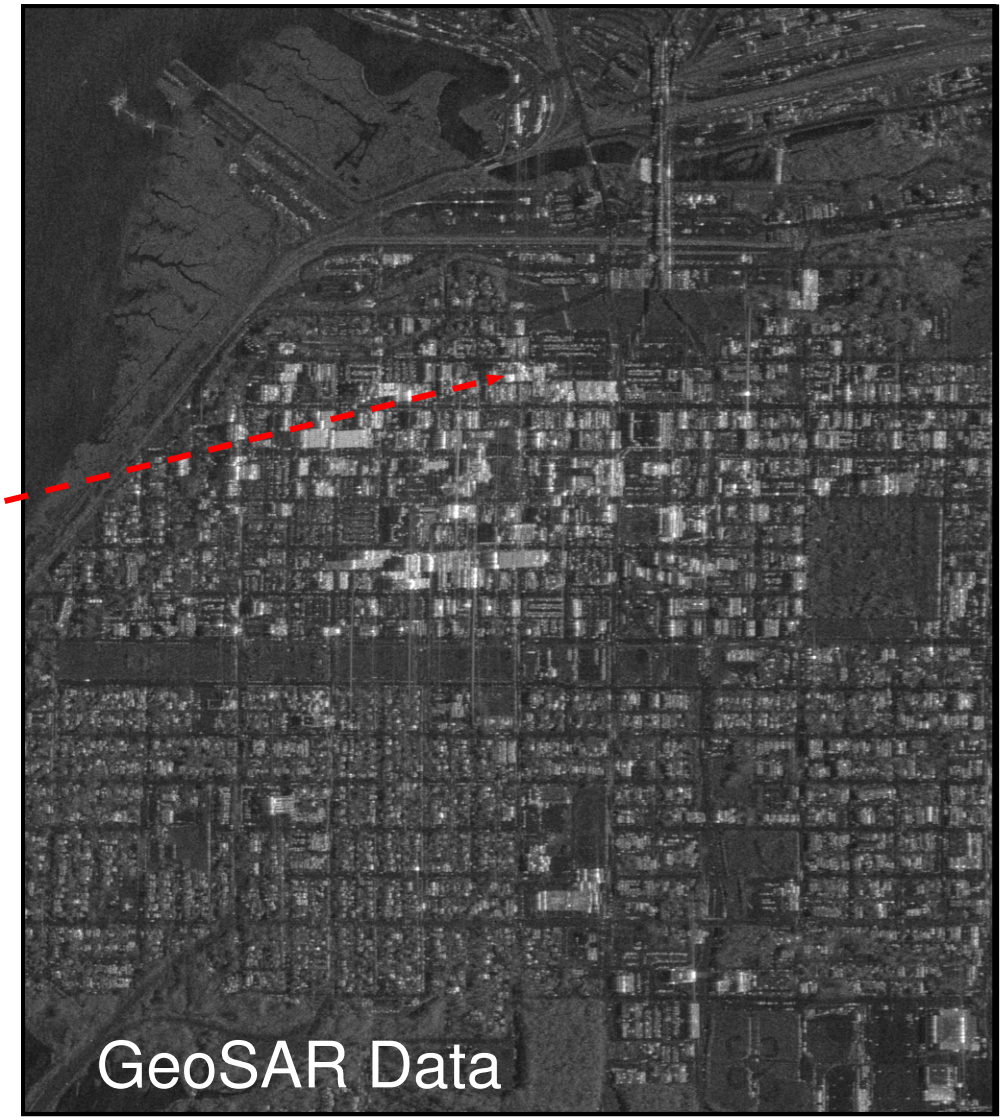




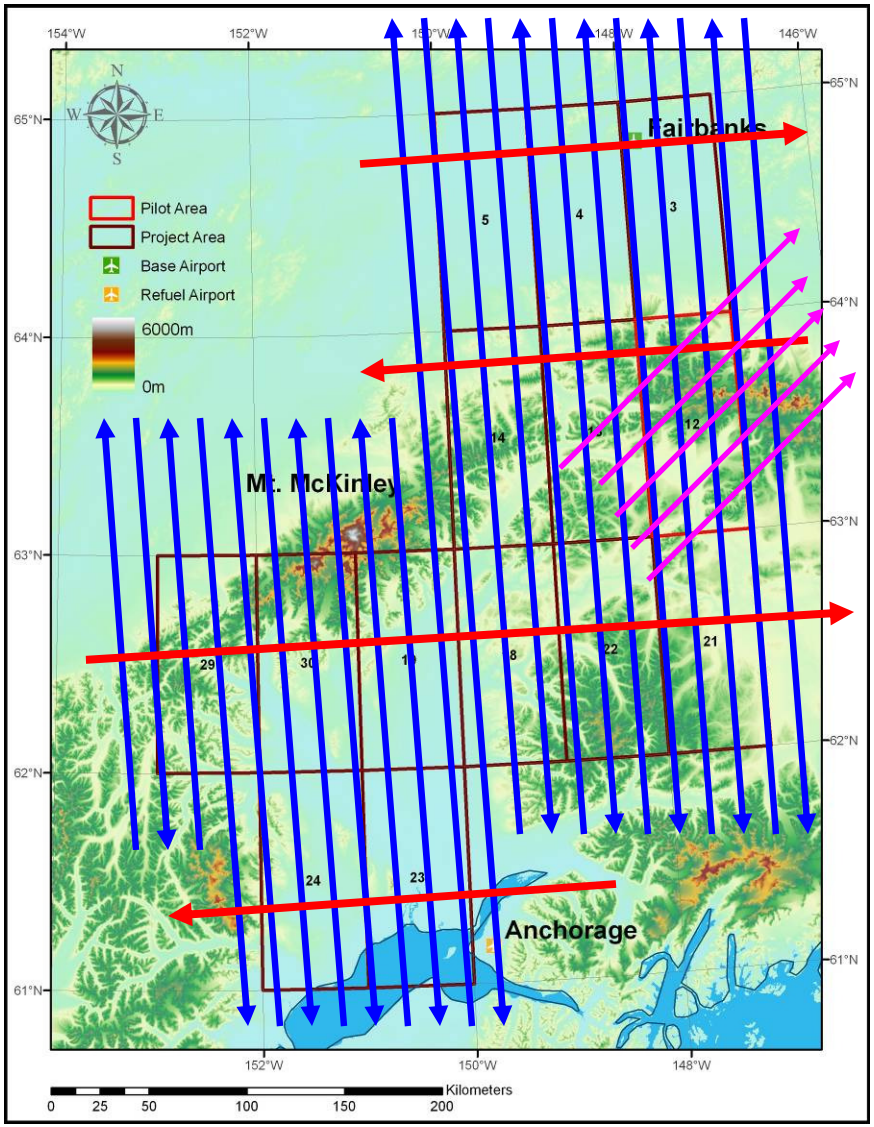


Outline

- Project Overview
- LiDAR Comparison
- Deployment Snapshots
- GeoSAR System
- Fairbanks Processed Data
- Conclusions



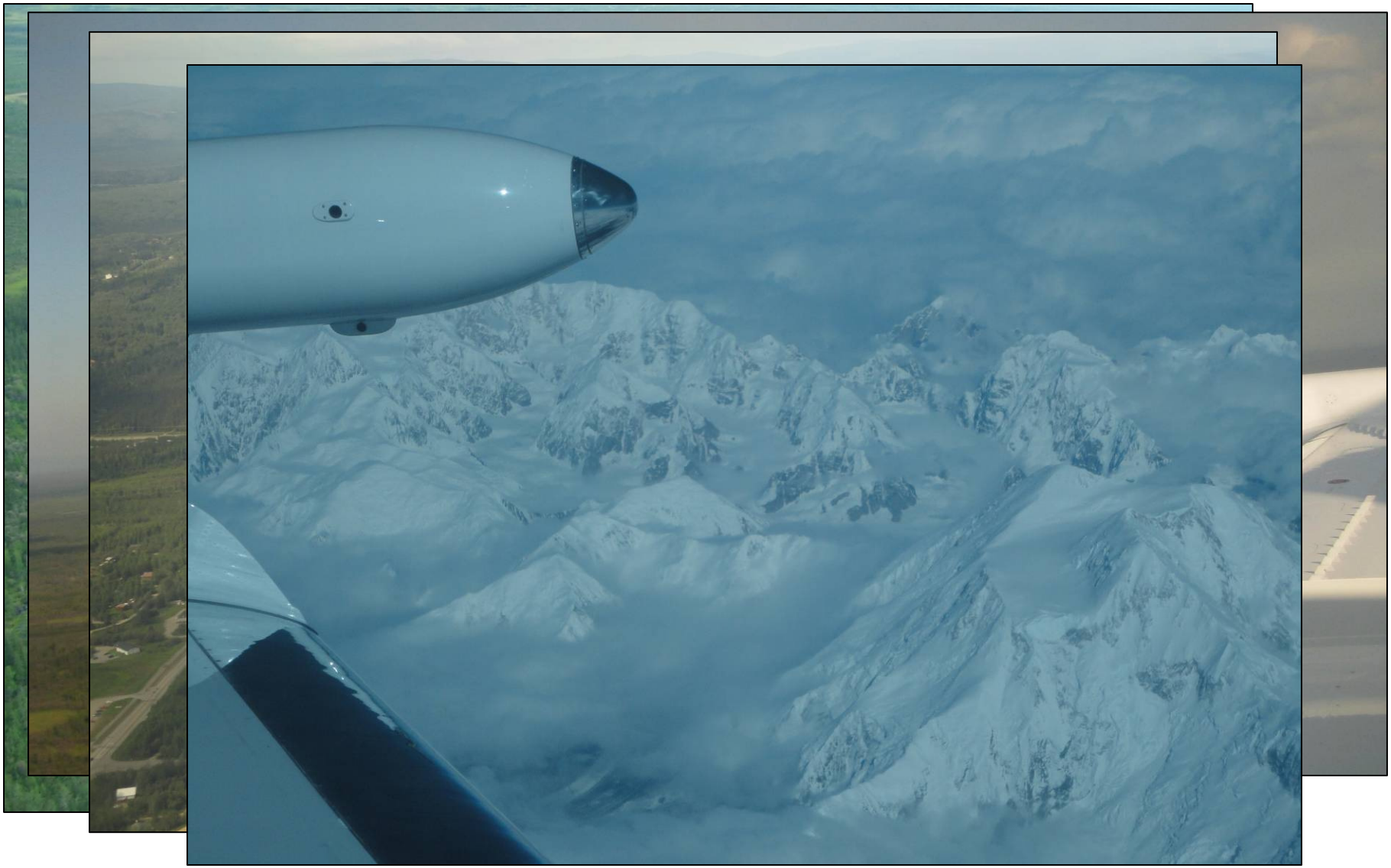
Project Overview



- Alaska Statewide Digital Mapping Initiative (SDMI)
- Fugro GeoSAR Project Area consists of 14 1^{o}x1^{o} cells between Fairbanks, Mt. McKinley (Denali) and Anchorage
- Data collected in late July 2010

- North-South Mapping Lines
- East-West Cross-Ties (Mosaick)
- Filler Lines to deal with Shadow and Layover based on ray-tracing

Extremely Varying Terrain Type

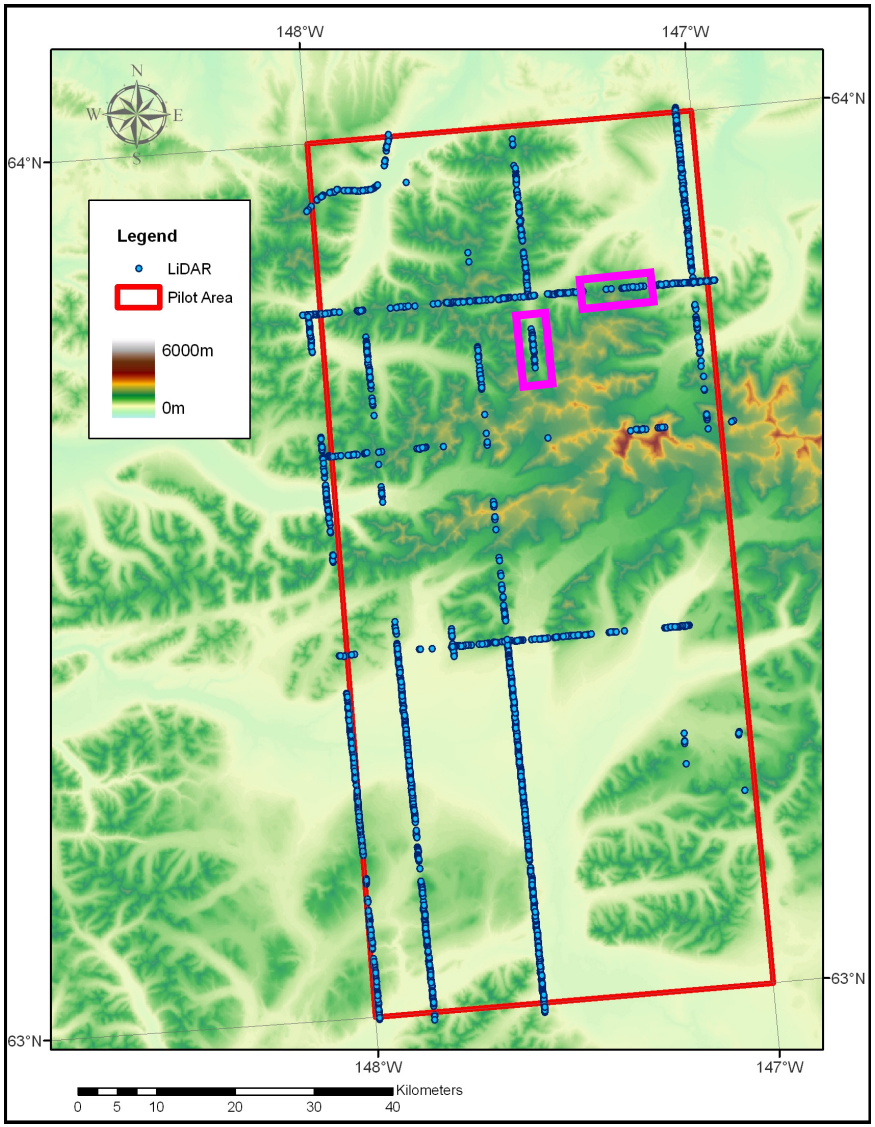


Project Deliverables

Product	Description	GeoSAR Observations
DTM	▪ Digital Terrain Model ▪ Vegetation and Buildings Removed ▪ Hydrologically Enforced	▪ P-band & X-band Interferometry ▪ Multiple Looks
DSM	▪ Digital Surface Model ▪ Hydrologically Enforced	▪ X-band Interferometry ▪ Multiple Looks
ORI	▪ Orthorectified Radar Magnitude ▪ Multiple view directions average	▪ X-band* ▪ Multiple Looks
Masks	▪ Quality Masks ▪ Hydrology, Voids, Fills, Slopes	▪ P-band & X-band
Metadata	▪ Meta Information	▪ FDGC compliant

**Hi-Res MAG, hydro; P-band MAG, and cross-pol MAG are not a deliverable.*

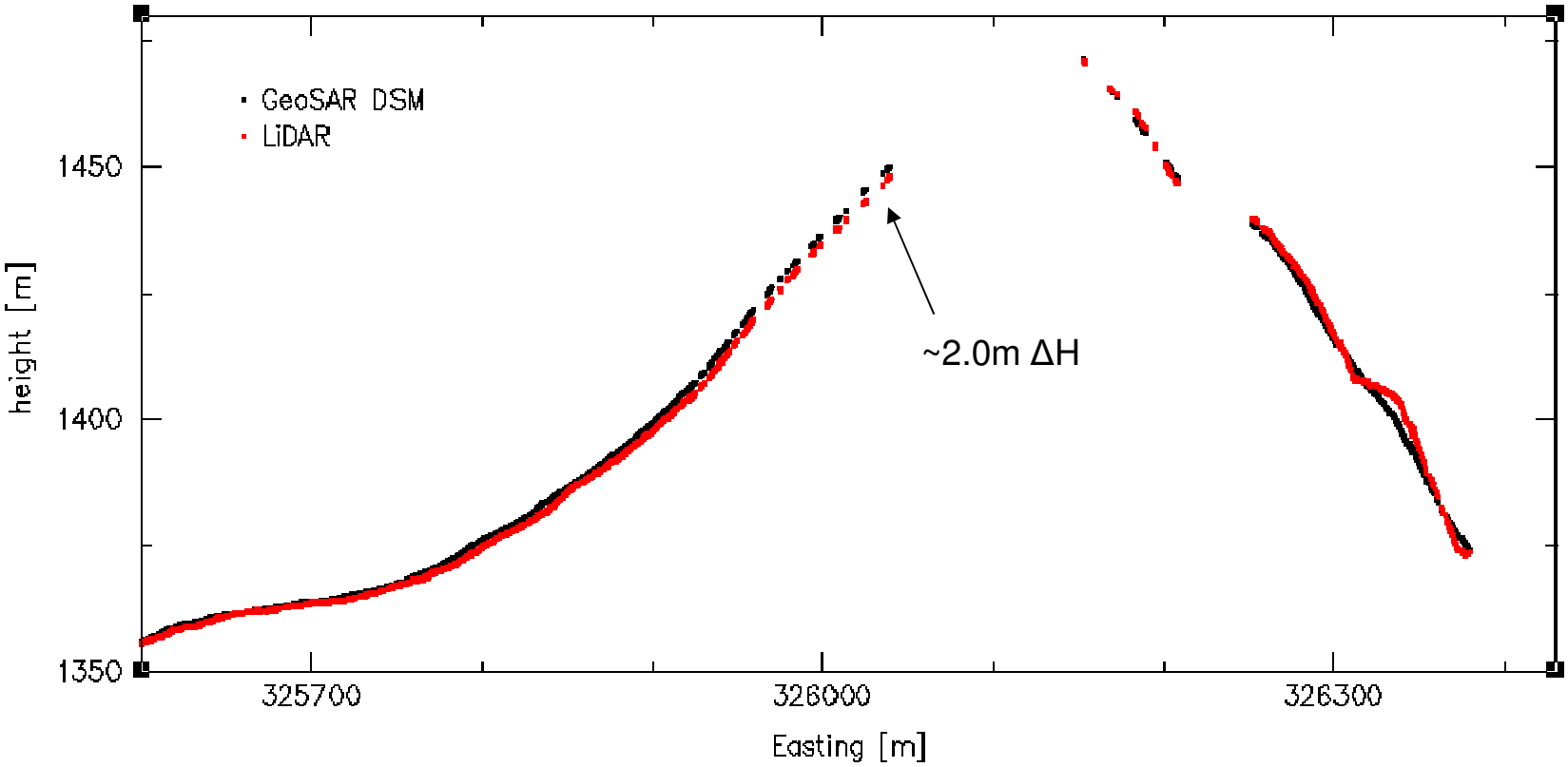
Fugro Internal Quality Assessment



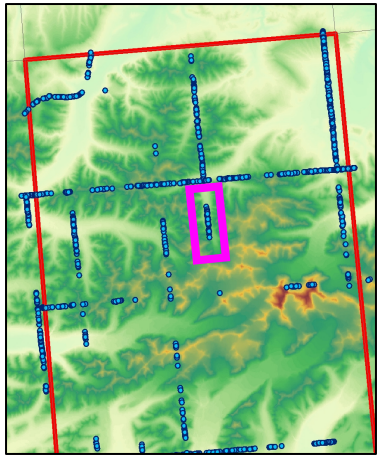
- GeoSAR is equipped with a profiling LiDAR, providing vertical ground control
- 12,628,042 usable LiDAR observations in the Pilot Area, after removing points with heights above the maximum elevation in the Pilot Area (cloud returns)
- LiDAR Points were sub-sampled by a factor 200 to have ~5m spacing between points and filtered for water body returns
- 48,433 LiDAR points remaining with RMSEz = 1.46m (not culled)

East-West LiDAR Profile Comparison

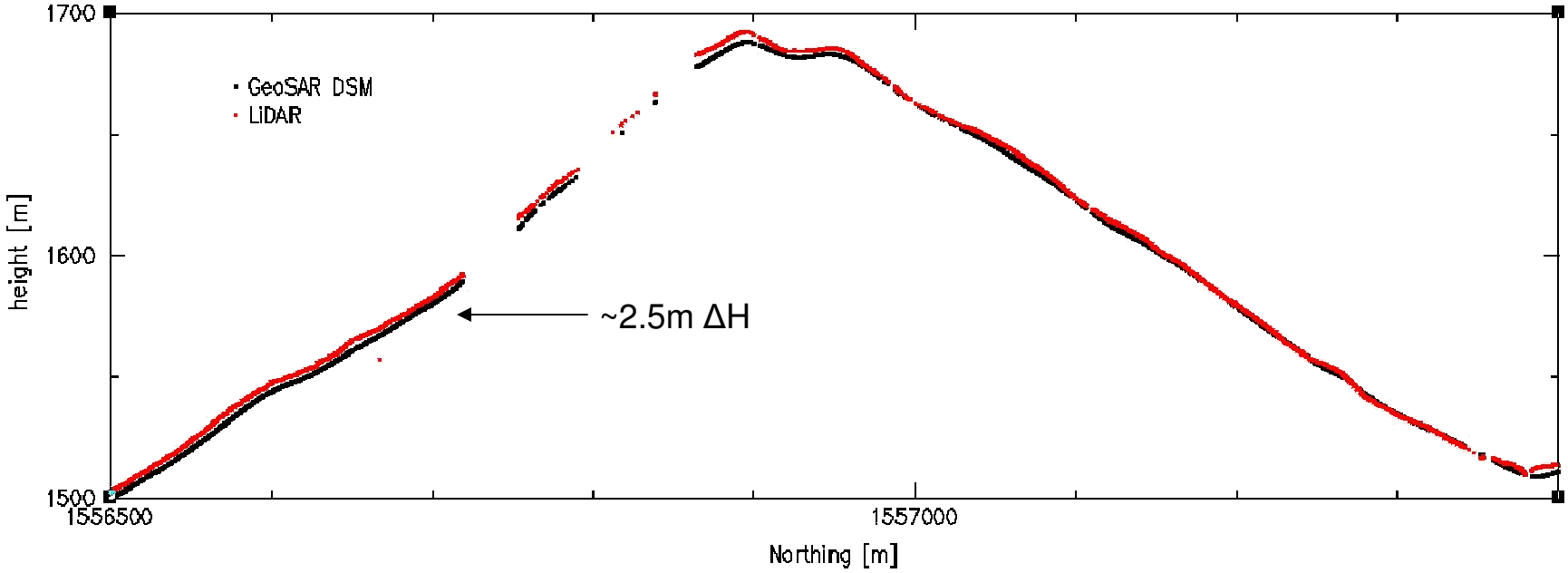
- Terrain slope ~10°-25°
- Terrain slopes located correctly in GeoSAR DEM
- Differences ~0-2m between LiDAR and DSM



North-South LiDAR Profile Comparison



- Terrain slope ~25°
- Terrain slopes located correctly in GeoSAR DEM
- Differences ~0-4m at the peak



DSM vs. LiDAR Statistics (not culled)

Slope	0° – 10°	10° – 20°	20° – 30°	30°+	Overall
Number of Points	32,184	10,358	3,856	2,035	**48,433**
Average (m)	-0.12	0.63	0.98	1.16	**0.18**
Standard Deviation (m)	1.10	1.55	1.71	3.04	**1.45**
Minimum difference (m)	-8.04	-17.90	-7.50	-52.88	**-52.88**
Maximum difference (m)	16.35	11.48	15.96	25.07	**25.07**
RMSE (m)	**1.13**	**1.64**	**1.97**	**3.25**	**1.46**

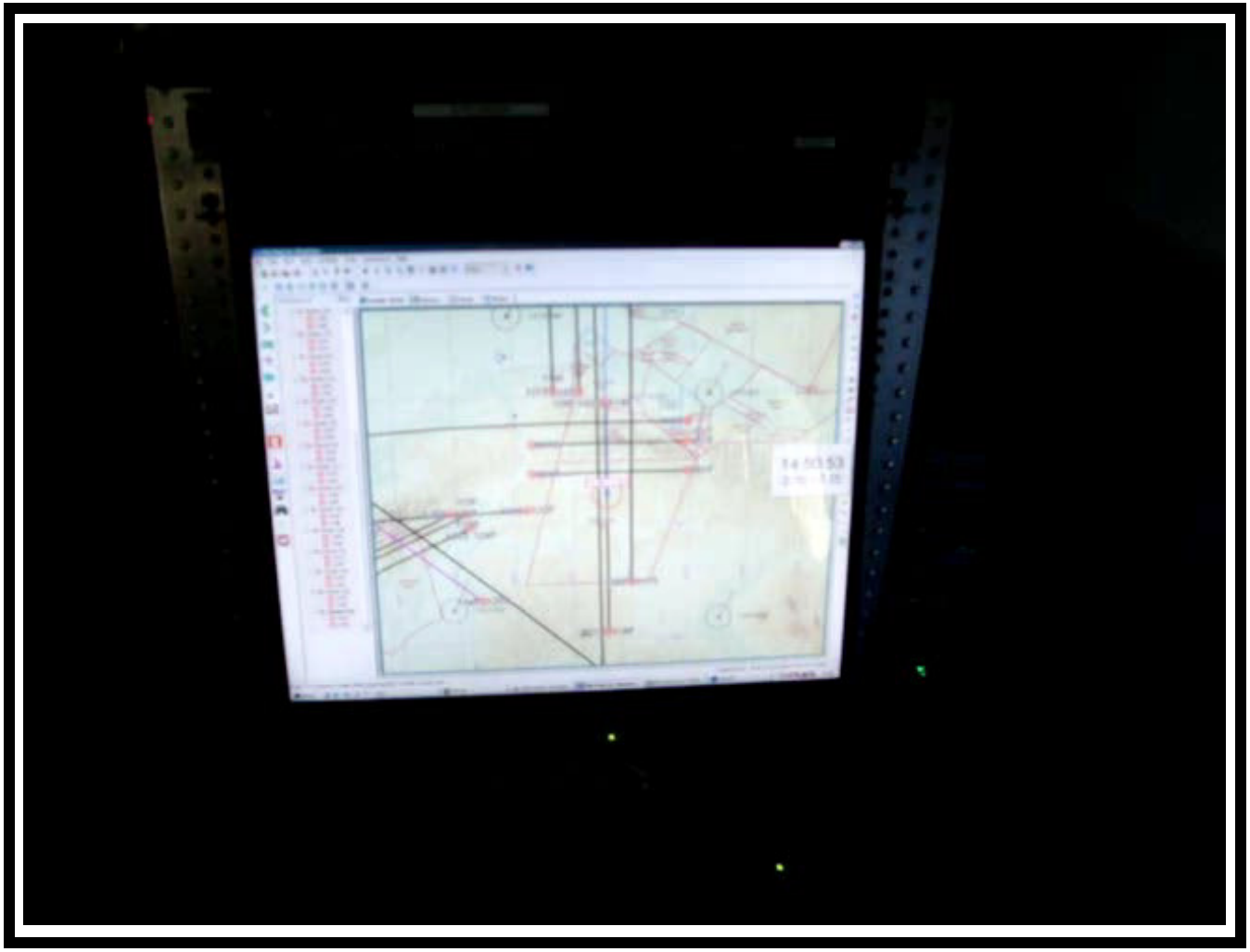
*Note: For product generation LiDAR points are automatically selected that are believed to be in flat and open, bare-earth, areas (using the terrain slope and 3 LiDAR returns). ~350 points that fulfilled these thresholds were used to determine a single z-bump of the DEM to best fit the average LiDAR elevation at these points.

GeoSAR System Overview

Movie Clip: Acquisition Take Off

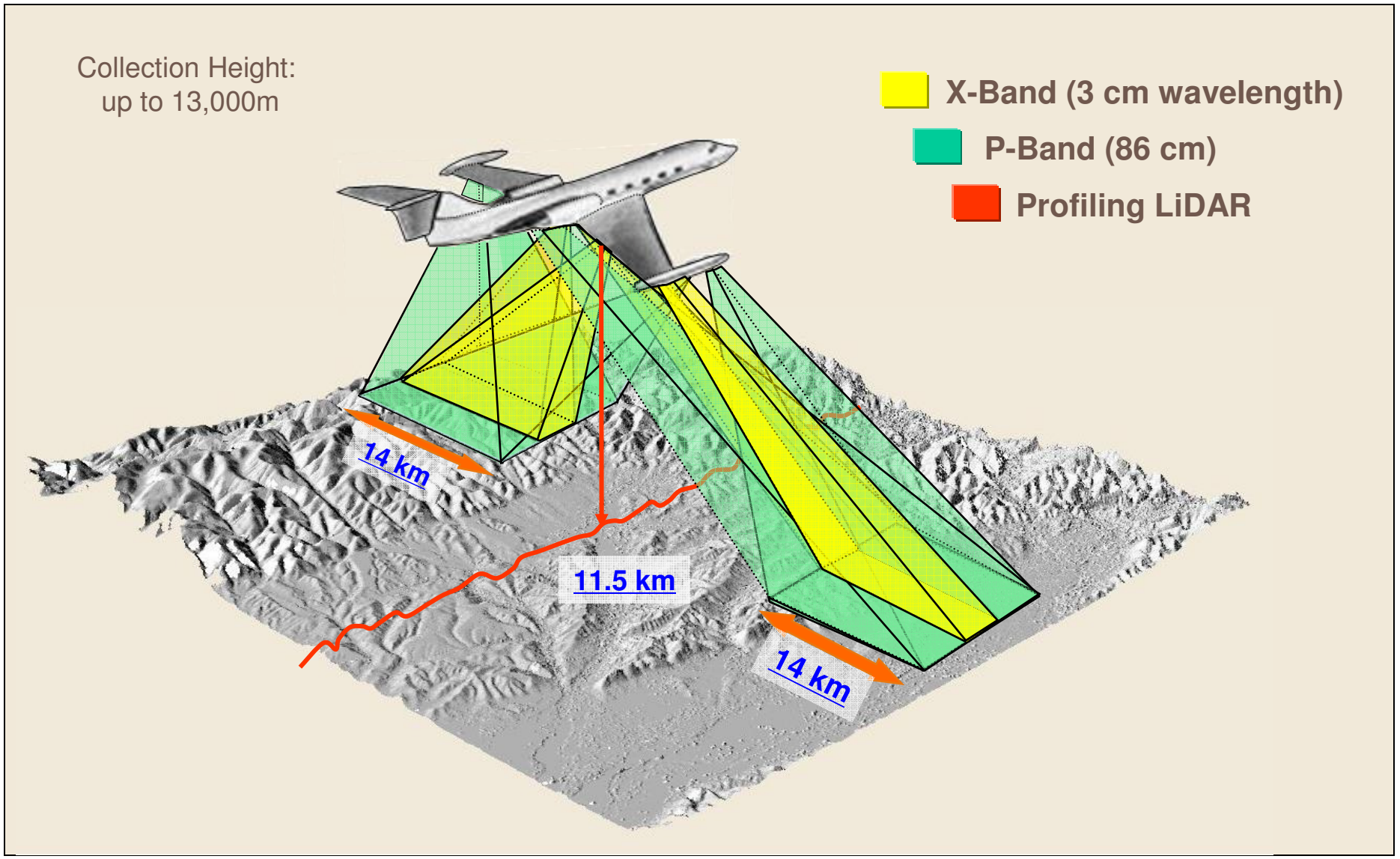
- Left Racks X-band
- Right Racks P-band
- Two radar operators
- Redundant data recording

Movie Clip: Moving Map Display

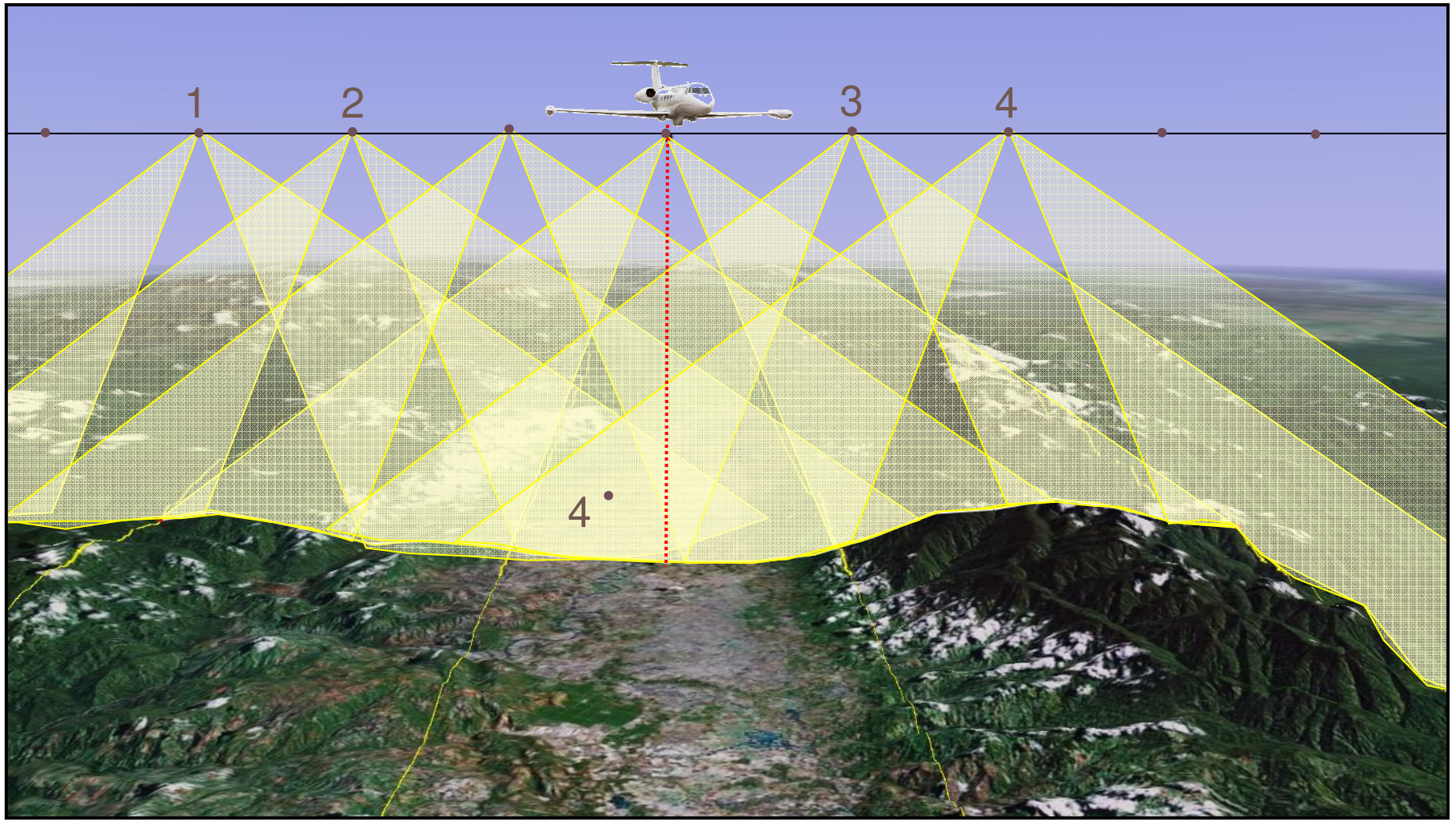


- Moving Map display
- Radar Channel Monitoring
- Wing pod P-band antenna

GeoSAR Measurements Systems



Acquisition Redundancy Improves Data Quality



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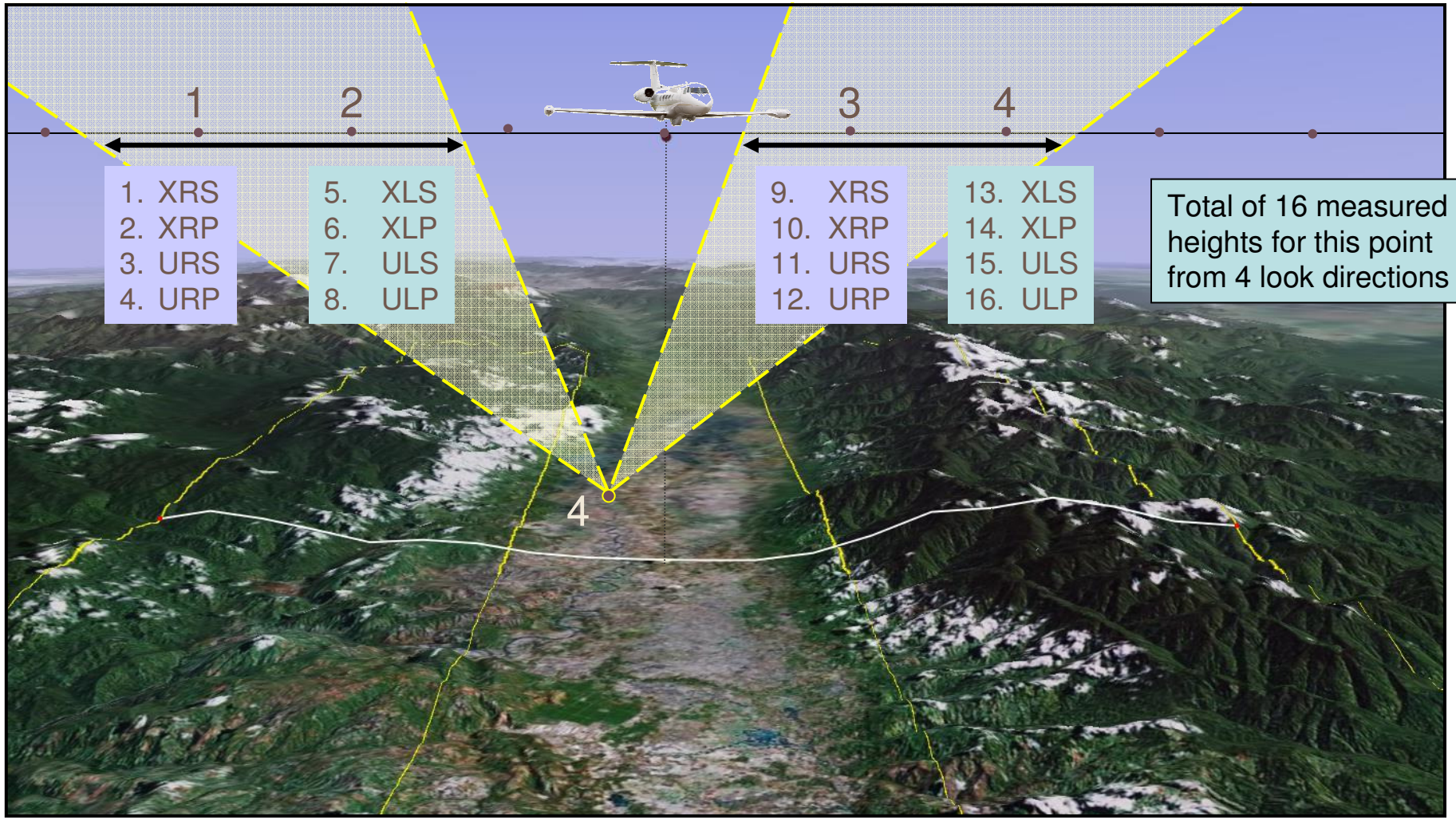
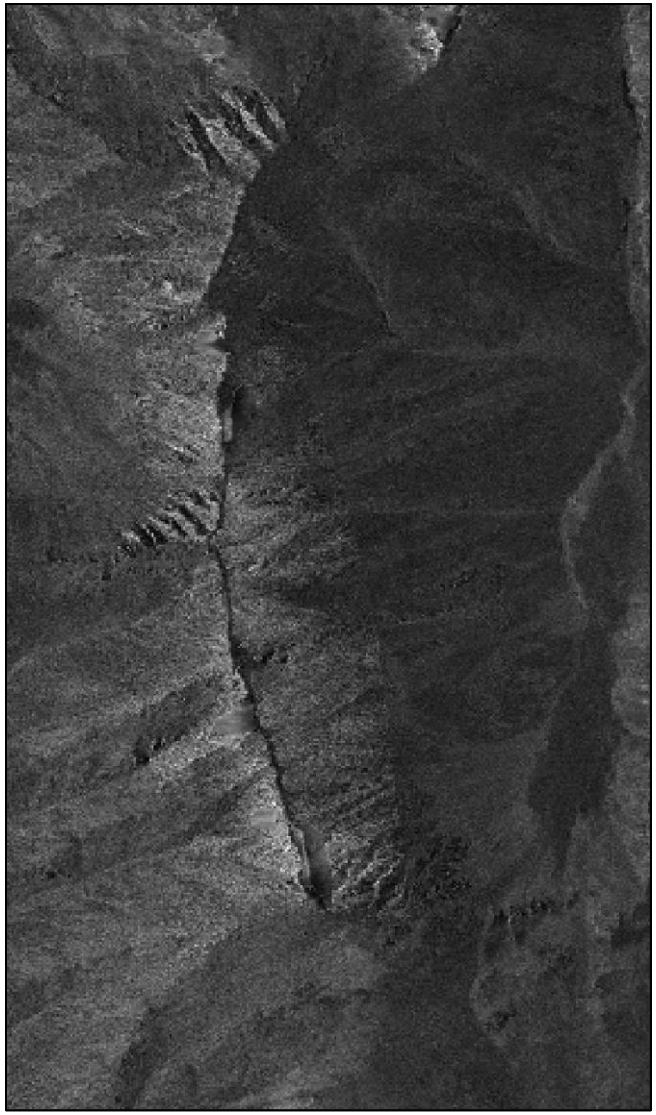
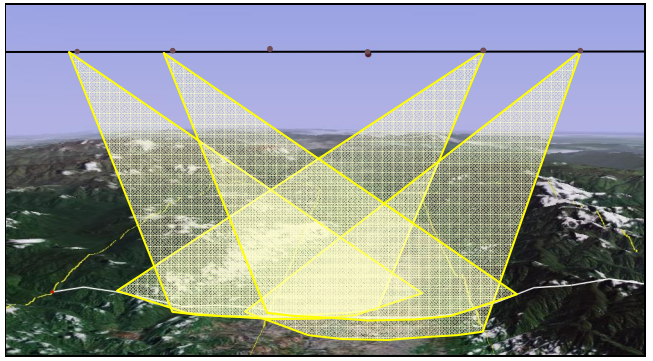


Orthorectified Radar Imagery

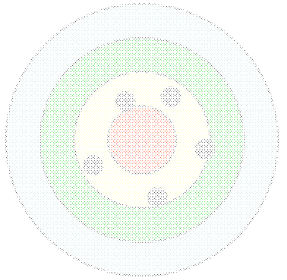




- East+West Views Average

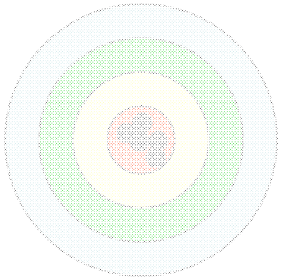
GeoSAR Accuracy, Precision and Reliability

- Accuracy (absolute location)
  - Calibration
  - P-Band Measurements through Vegetation
  - LiDAR Ground Control



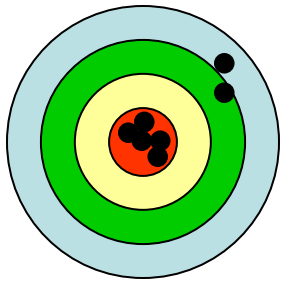
High accuracy, low precision

- Precision (relative error)
  - Airborne Interferometry
  - Multiple-Look Average



High accuracy, high precision

- **Reliability (the ability to detect errors)**
  - Redundantly Recorded Radar Data allows 16 Height Estimations for each Pixel
  - Dual-Sided Coverage

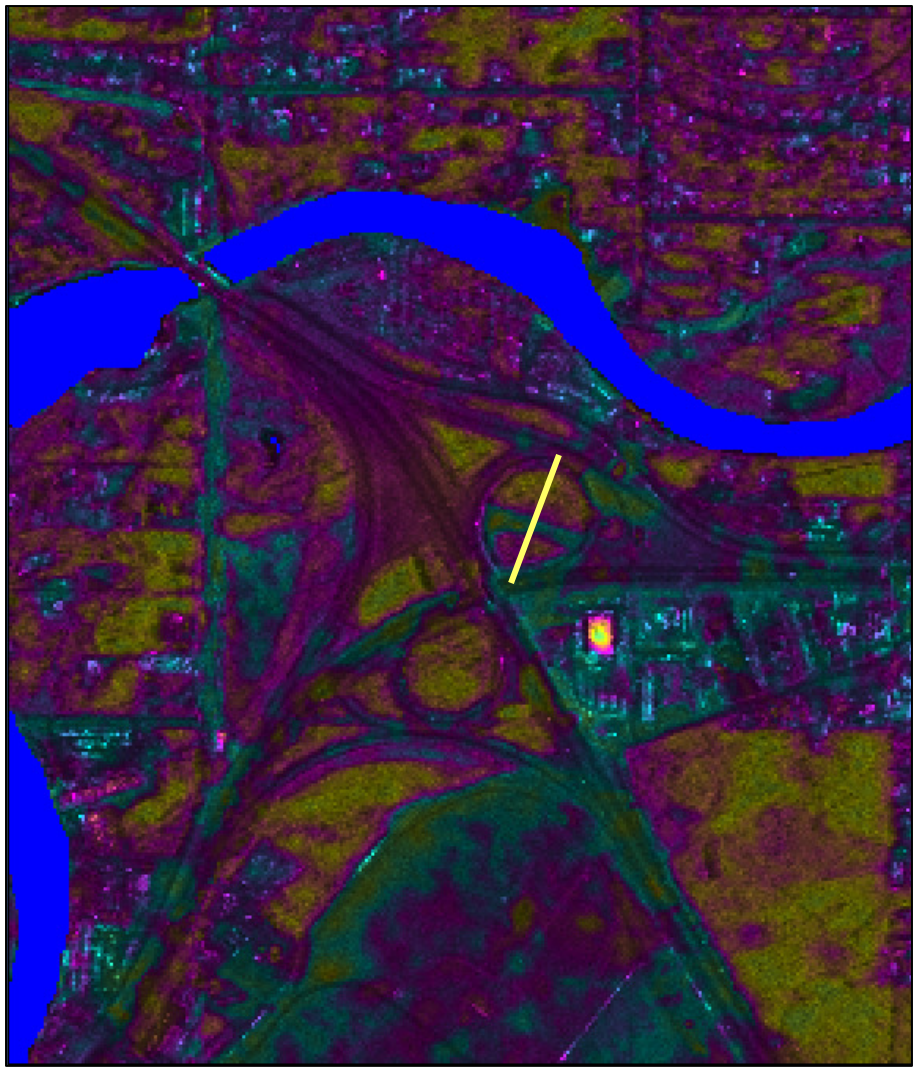


Ability to Detect Outliers

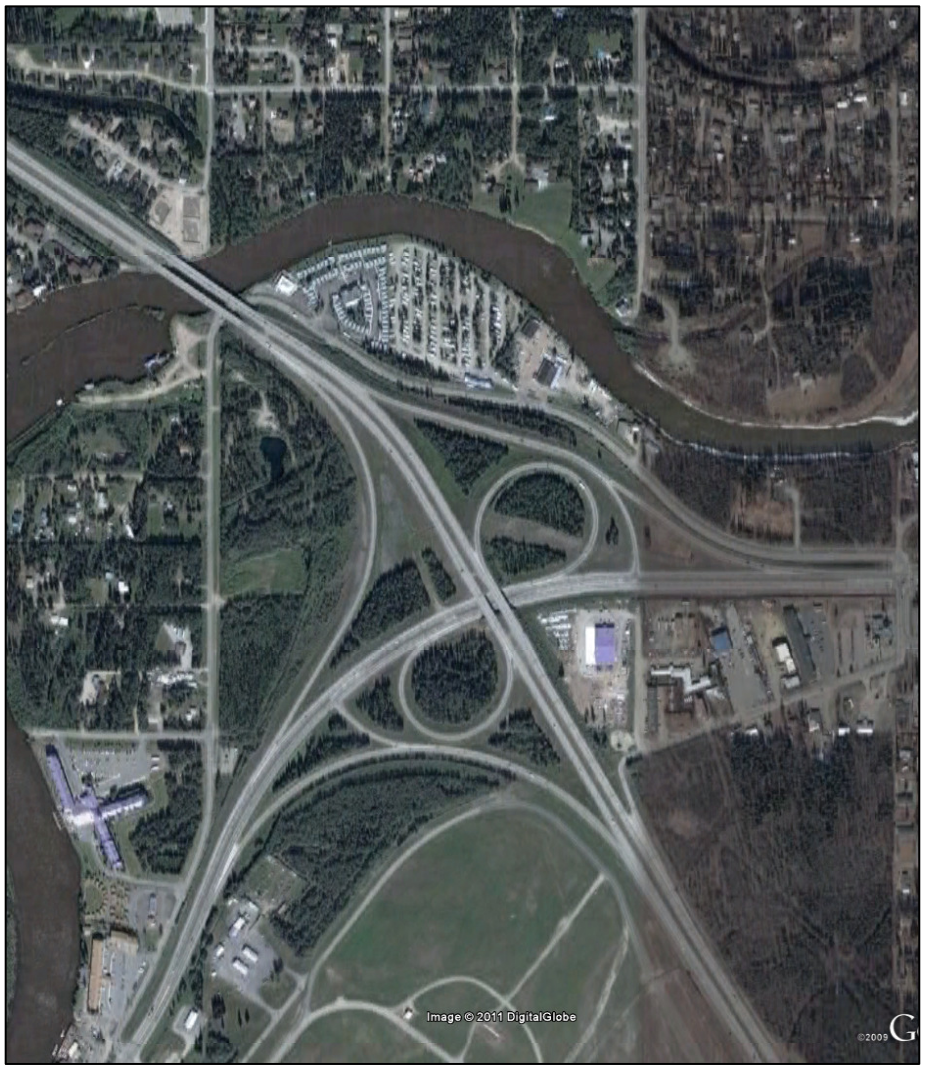
Fairbanks GeoSAR Data Example

- Map
- Optical
- X SLC
- P SLC

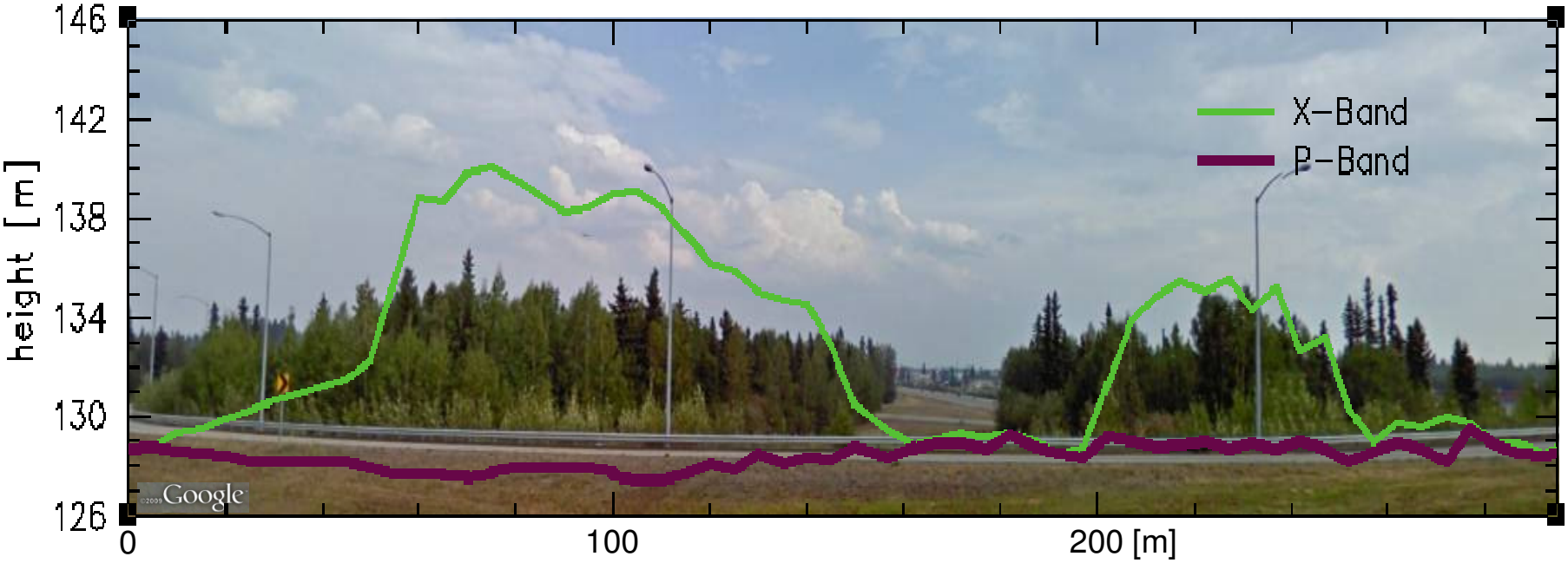
Fairbanks Vegetation X-P ~ Tree Height



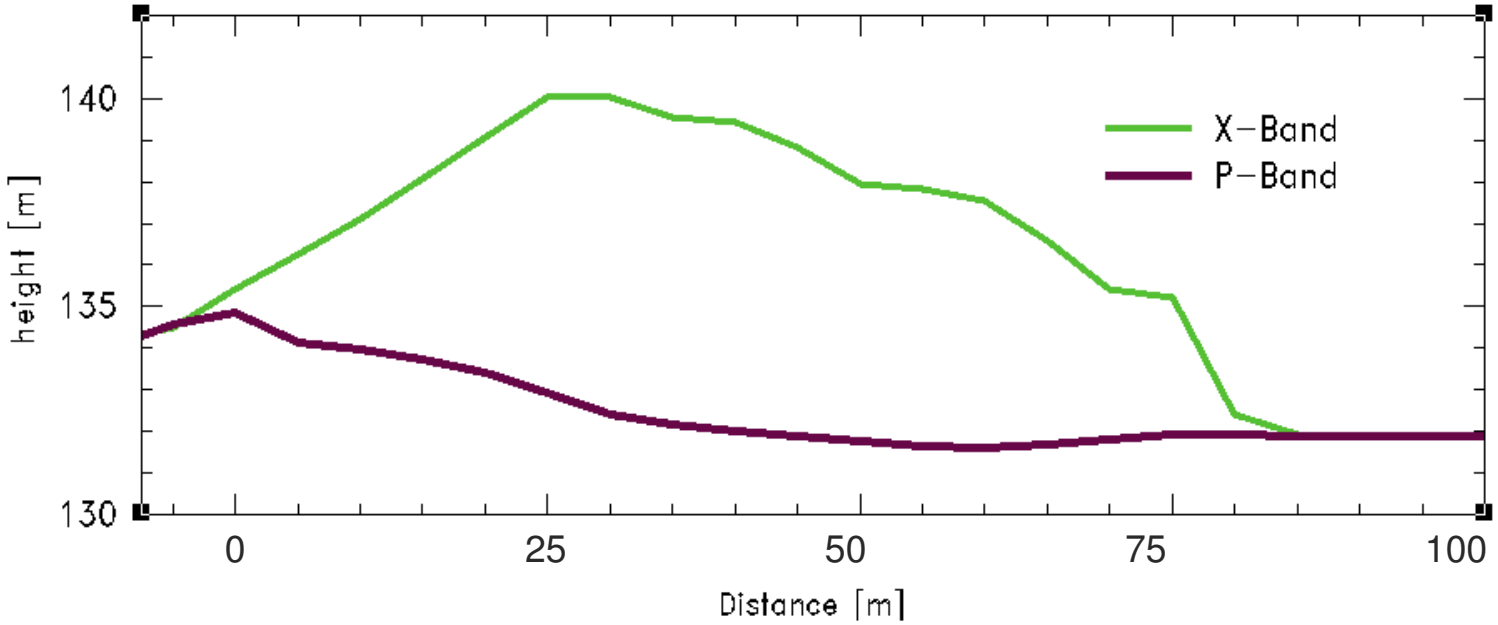
X-band – P-band Height



Fairbanks GeoSAR Data Example



Fairbanks Street View Example 2



Conclusions

- **GeoSAR IFSAR**
  - Dual-Band: X-band and P-band *at the same time*
  - Dual-Sided: Left and Right looking *at the same time*
  - Single-Pass: Interferometric data *at the same time*
  - LiDAR: Collect Ground Control *at the same time*

- **P-band Data**
  - Provide measurements through vegetation
  - P-band penetrates snow and ice: X-band for DTM
  - P-band contains information related to topographic features, hydrology, geology, and more

- **Project Area Processing Well Underway**
  - $RMSE_Z$ = 1.1m (terrain slopes 0^o-10^o; 32184 LiDAR points)
  - $RMSE_Z$ = 3.3m (terrain slopes >30^o; 2035 LiDAR points)

  - The Alaska data show many interesting things that should be applied and explored further!

Thank You