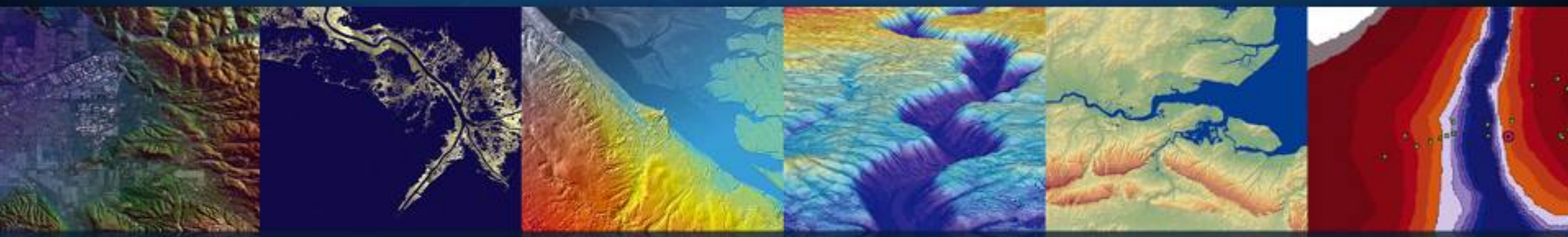

Empirical Assessment of X/C-Band InSAR and L-Band PolInSAR Elevation Data: Implications for Canopy Height and Vegetation Cover Mapping

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Introduction

- Surface models derived from InSAR data do not provide good tree heights due partial penetration into the canopy.
  - i.e. the scattering phase centre is below the top of the canopy.

- Scattering phase centre height is wavelength dependent (Treuhaft *et al.,* 1996; Sun *et al.,* 2003; Dall, 2007, Walker *et al.,* 2007).

- Published studies suggest ~85 % of a tree's height is captured with X-band InSAR (Dall *et al.,* 2001; Rignot *et al.,* 2001; Williams and Greely, 2001; and Varekamp and Hoekman, 2002; Dall *et al.,* 2007).

- Need better estimates of vegetation canopy height for use in a variety of applications

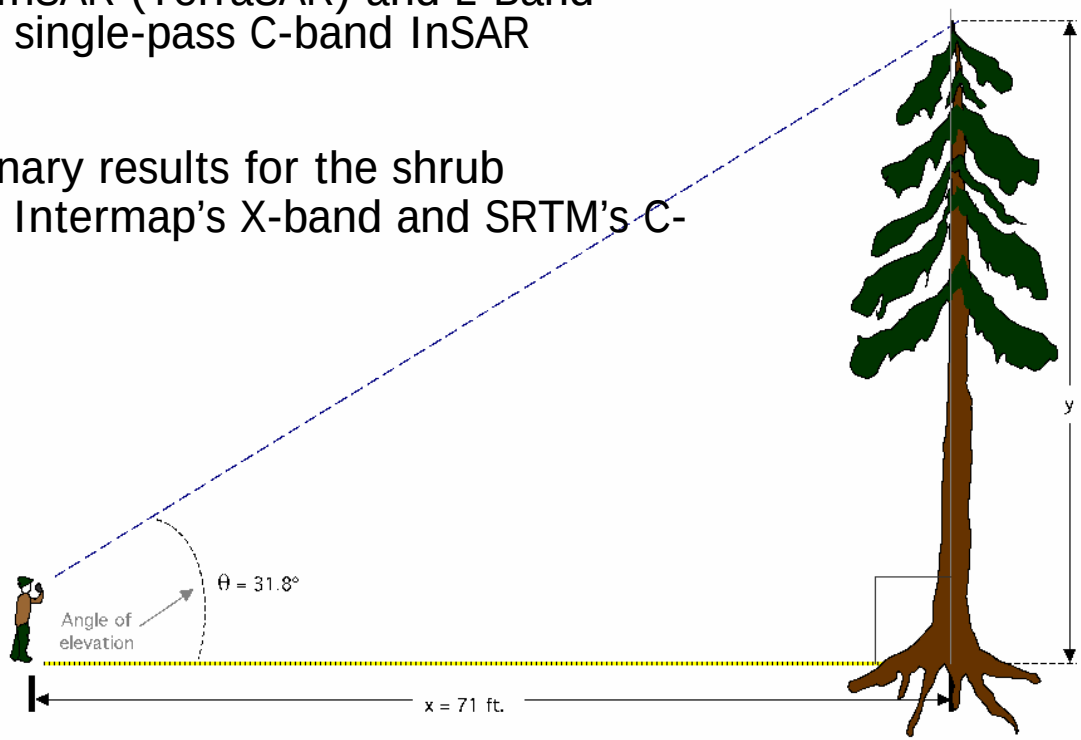
- This research focusses on the analysis of first surface feature heights derived from X/L/C-band airborne/spaceborne InSAR/PolInSAR data.

Research Motivation

- Evaluate the relationship between the scattering phase centre heights of airborne X-band InSAR and L-Band PolInSAR, spaceborne X-band InSAR and C-Band InSAR and field collected heights .
  - Determine under which assumptions the relation holds and use it to derive a true canopy height model.

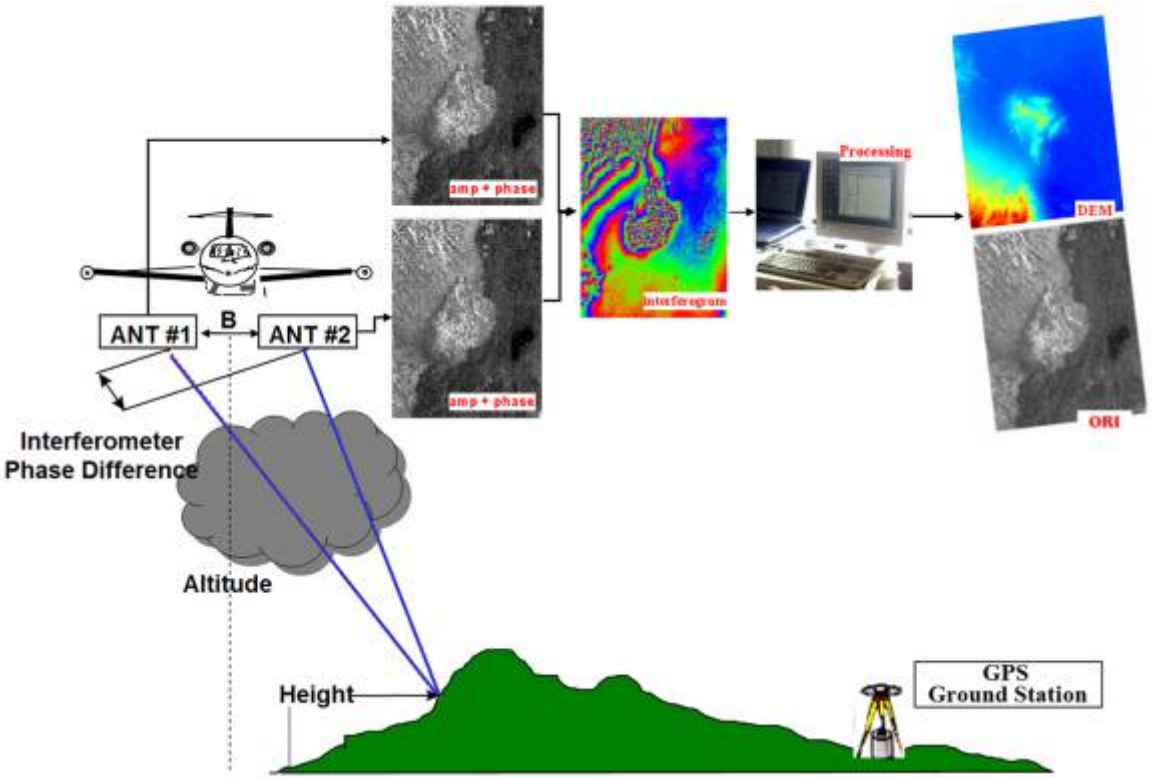
- Test using scattering phase centre heights posted at 1.25 m and 5m for the airborne single-pass X-band InSAR, 1.25 m posts for the repeat-pass spaceborne X-band InSAR (TerraSAR) and L-Band PolInSAR and 30 m posts for the single-pass C-band InSAR (SRTM).

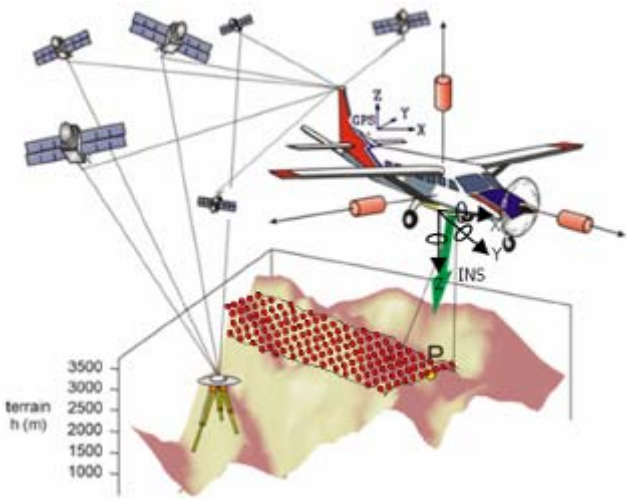
- This presentation reports preliminary results for the shrub vegetation class in Arizona using Intermap's X-band and SRTM's C-band InSAR.



What is InSAR?

- InSAR: Interferometric Synthetic Aperture Radar (also known as IFSAR)
- Radar-based remote sensing technique that provides X, Y, and Z coordinates of a location imaged by a radar beam at high accuracy.

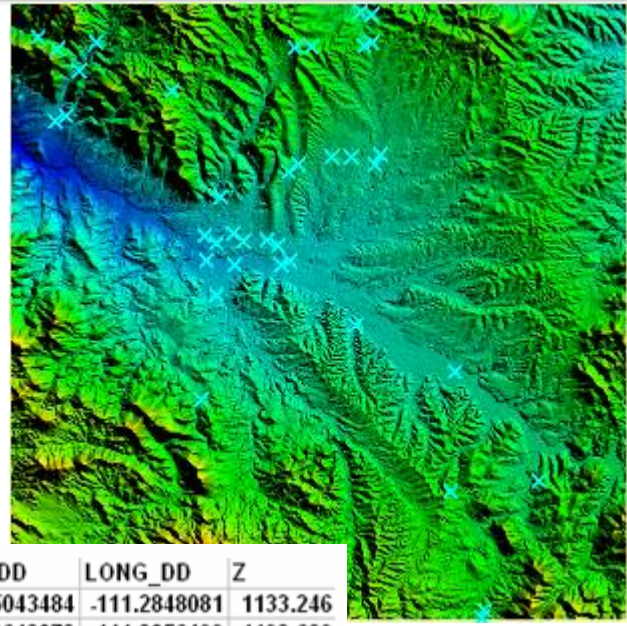




Data Sets – Study Location

- Lat/Long: 31° 37' 30.00" - 31° 30' 00.00" N; -111° 22' 30.00" - -111° 15' 00.00" W
- Min/Max Elevation: 1073.642 m, 1633.651 m
- Approximate Area 169.2 km^2; Semi-arid Environment

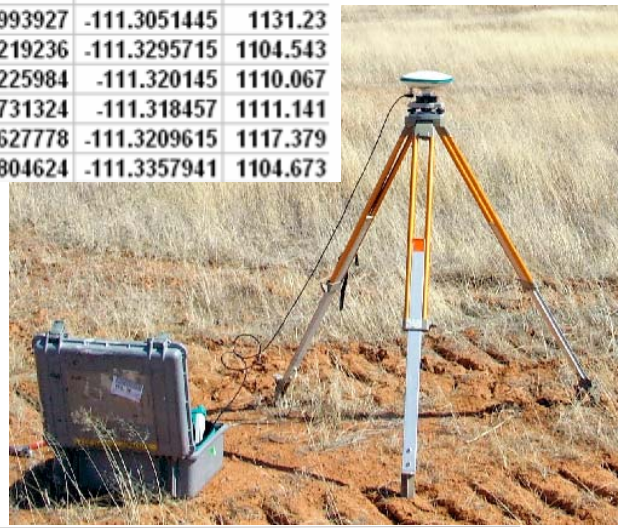
- 31 base station (X) were collected and DCPG post processed to obtain an independent bare earth elevation data set with a 10 cm vertical accuracy.



NEXTMap InSAR	Parameter	Specification
	Microwave Band	X
	Polarization	HH
	Baseline	1 m
	InSAR	Single Pass
	Data	DEM, Imagery
	Resolution	5 m posting
	Accuracy	Absolute 1 m RMSE
	Provider	Intermap Technologies

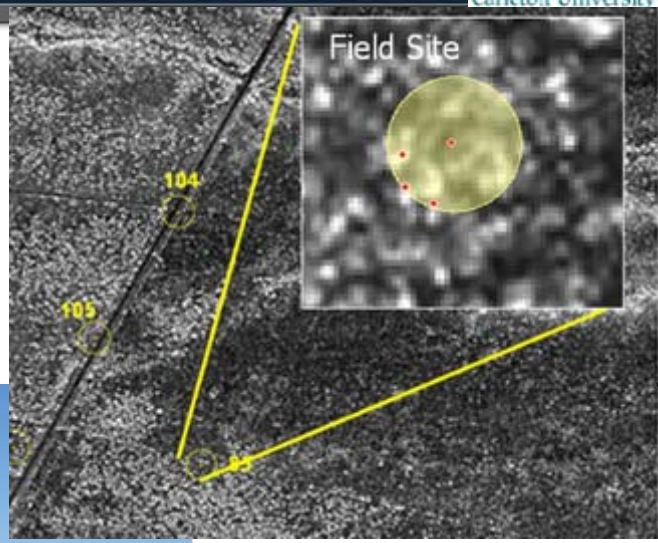
SRTM	Parameter	Specification
	Microwave Band	C
	Polarization	VV
	Baseline	60 m
	InSAR	Single Pass
	Data	DEM
	Resolution	30 m posting
	Accuracy	Absolute 16 m RMSE
	Provider	USGS

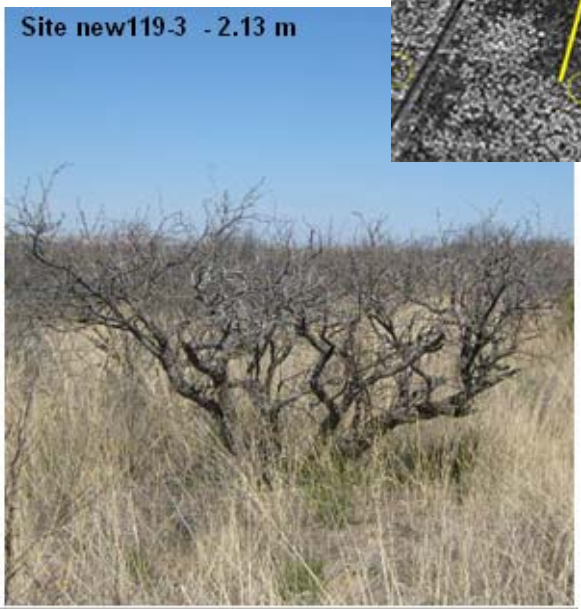
Site	LAT_DD	LONG_DD	Z
37	31.55043484	-111.2848081	1133.246
38	31.52613073	-111.2856499	1193.689
123	31.50047019	-111.2794334	1194.287
129	31.55993927	-111.3051445	1131.23
131	31.57219236	-111.3295715	1104.543
133	31.57225984	-111.320145	1110.067
132	31.5731324	-111.318457	1111.141
137	31.57627778	-111.3209615	1117.379
138	31.57804624	-111.3357941	1104.673

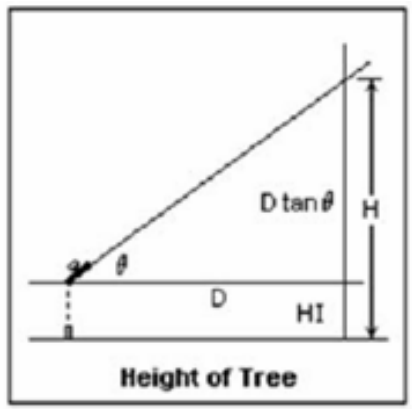


Field Data Measurements: Bare Ground

- Sample area at each base station = 100 foot radius
- Number of shrubs counted within the circle
- Three dominant tree heights measured







Site #	Photo #	Site Location (x, y, z geographic coordinates)			Site Type	Number of trees within site (circular with a 100 ft radius)	Height (ft)	Height (M)	θ (degrees)	H1 (cm)	D (cm)
		Latitude	Longitude	Base Station Height							
new119	n/a	31.54489812	-111.33657	**1157.904**	Base Station	124	na	na	na	na	na
	119-1	31.54481639	-111.33677	n/a	Shrub		8	2.44	na	na	na
	119-2	31.54479947	-111.33679	n/a	Shrub		8	2.44	na	na	na
	119-3	31.54518881	-111.33659	n/a	Shrub		7	2.13	na	na	na

Results: How Good is the X-band InSAR DTM?

- Compared Intermap DTM (1m RMSE) with to 10 cm RMSE base station data. The NEXTMap Data 1 m RMSE specification was satisfied.

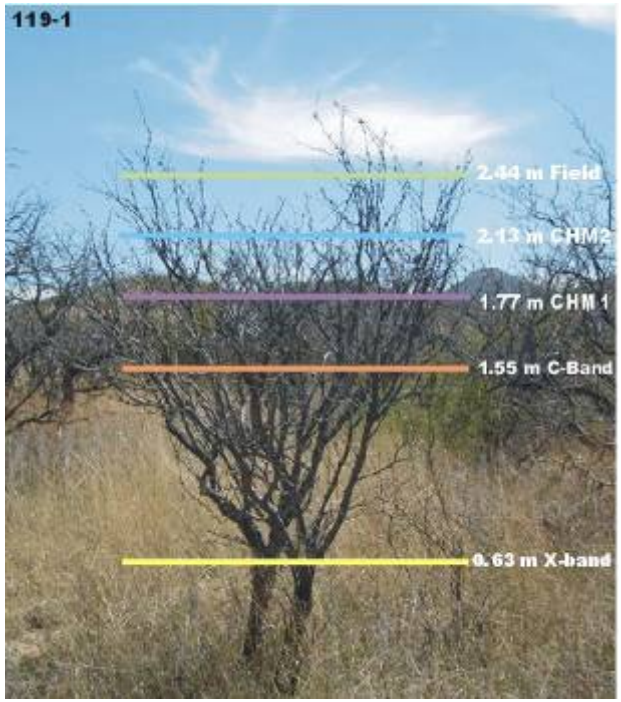
- Compared the two shrub canopy height models with the field collected tree heights. Both models obtained a 1 m RMSE.

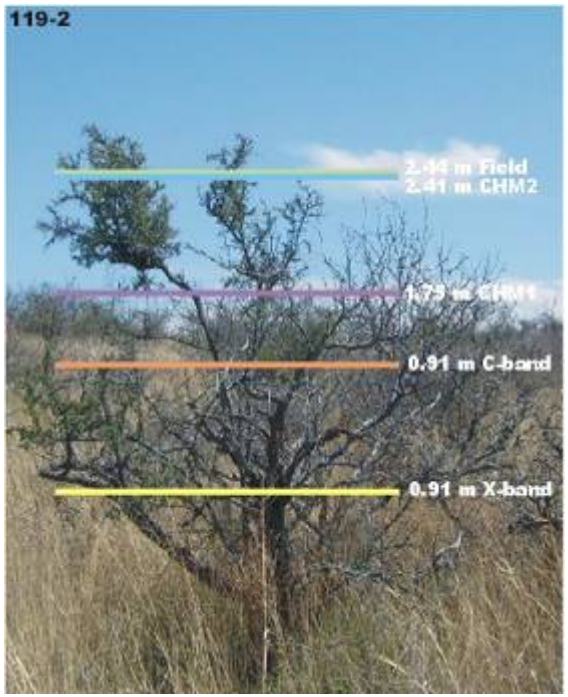
Bare Earth Points	DTM	NED10
Number of VCPs	31	31
Excluded points	0	0
Included VCPs	31	31
Mean	0.18	-2.65
Max +	2.73	1.85
Max -	-0.61	-9.03
Std dev	0.71	2.21
RMSE	0.72	3.43
95 Percentile	1.37	5.47
Blunder (3x Std dev)	2.12	6.64

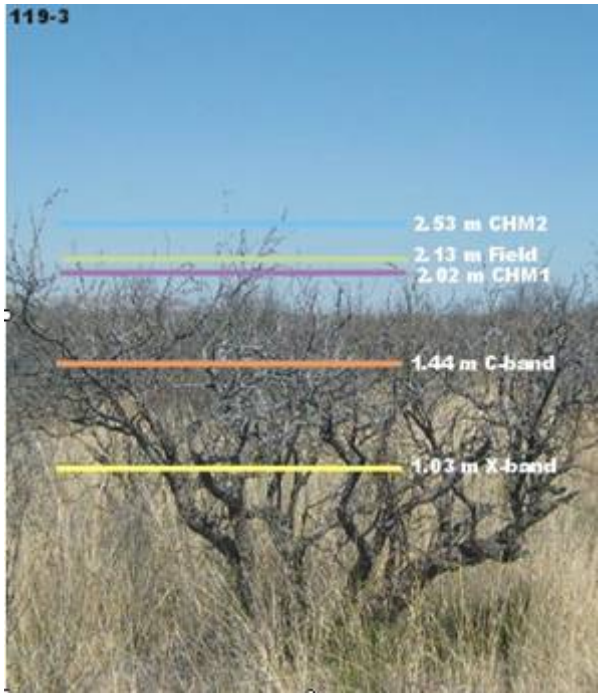
Tree Heights m	X Band Trees CHM1	X-Band Trees CHM2
Number of VCPs	72	72
Excluded points	0	0
Included VCPs	72	72
Mean	-0.43	0.32
Max +	2.34	2.64
Max -	-1.56	-0.66
Std dev	0.93	0.78
RMSE	1.00	0.82
95 Percentile	1.72	1.43
Blunder (3x Std dev)	2.78	2.34

Results: Bias Calculations

- Downward bias calculations were derived and utilized with land cover and InSAR SPC heights to create two Canopy Height Models (CHM1 & CHM2). The CHMs were compared to known tree heights. One sample site is presented here.

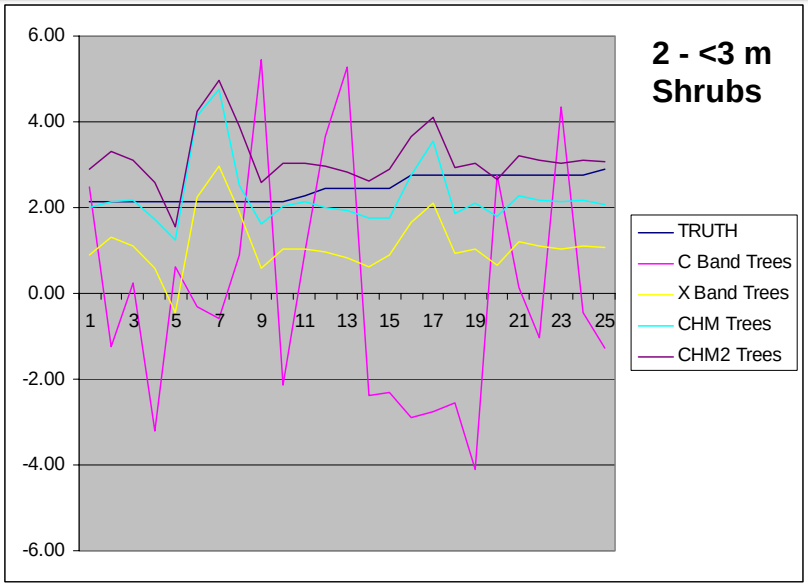


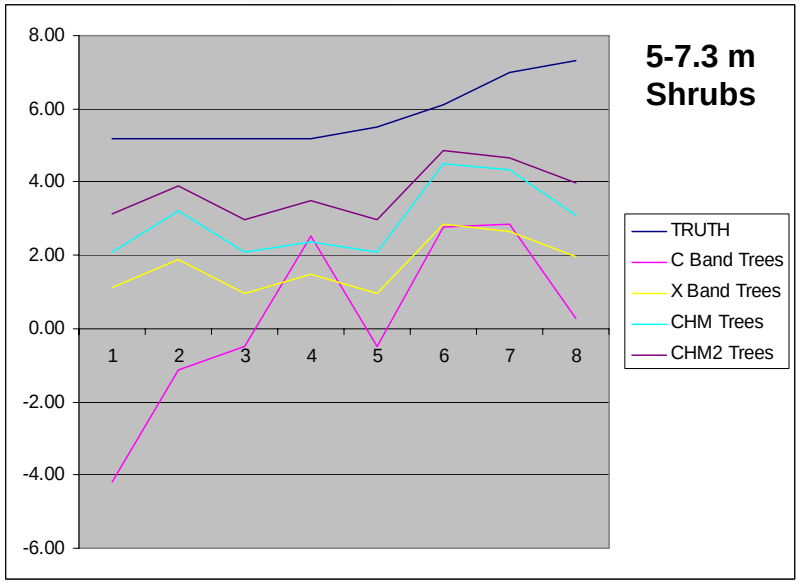


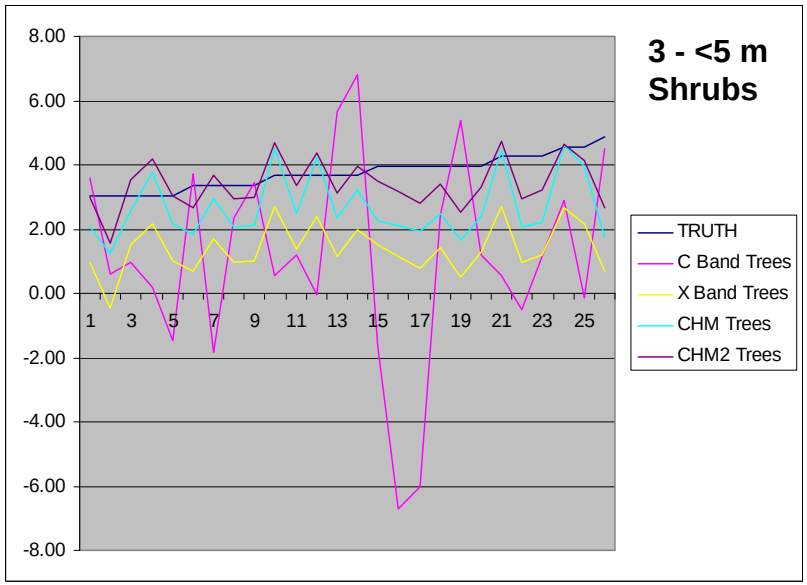


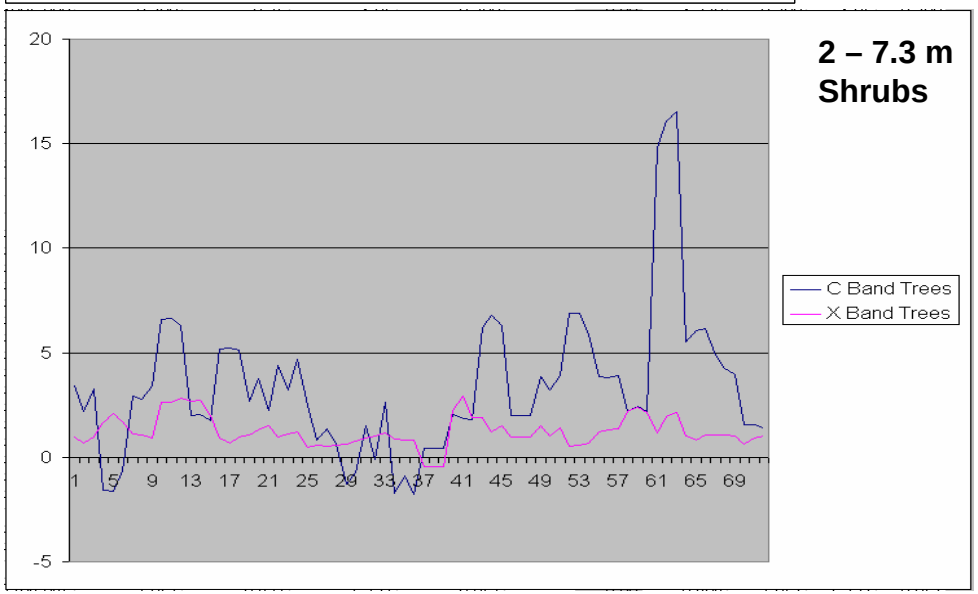
Site #	Photo #	Site Location (x, y, z geographic coordinates)			Site Type	# Trees 100" Radius Circle	Field Height (ft)	Field Height (m)	DSM-DTM (m)	DSM-DTM (m)	X-band BIAS	C-band BIAS	X-Band Canopy Models		Delta CHM1 - DSM	Delta CHM1 - DSM
		Latitude	Longitude	Height									CHM1	CHM2		
new119	n/a	31.54489812	-111.336571	**1157.9**	Base Station	124	na	na								
	119-1	31.54481639	-111.336773	n/a	Shrub		8	2.44	0.63	1.55	25.94%	63.52%	1.77	2.13	0.67	0.31
	119-2	31.54479947	-111.33679	n/a	Shrub		8	2.44	0.91	1.56	37.34%	63.93%	1.75	2.41	0.69	0.03
	119-3	31.54518881	-111.336587	n/a	Shrub		7	2.13	1.03	1.44	48.50%	67.61%	2.02	2.53	0.11	-0.40

Results: Sample Bias









Ongoing Research

- Create/validate the CHM2 model for dense forest canopies.
- Calculate the mean tree canopy height over a 10 m posted DEM.
- The model needs to be tested over a variety of topographic conditions (NEXTMap USA).
- Test model using TerraSAR X data.
- Continue to analyze the field data and CHM2 model results against slope and vegetation density.
- Continue analysis described previously for different data types and land cover types.