Forest Theme:
InSAR Forest Height Retrieval

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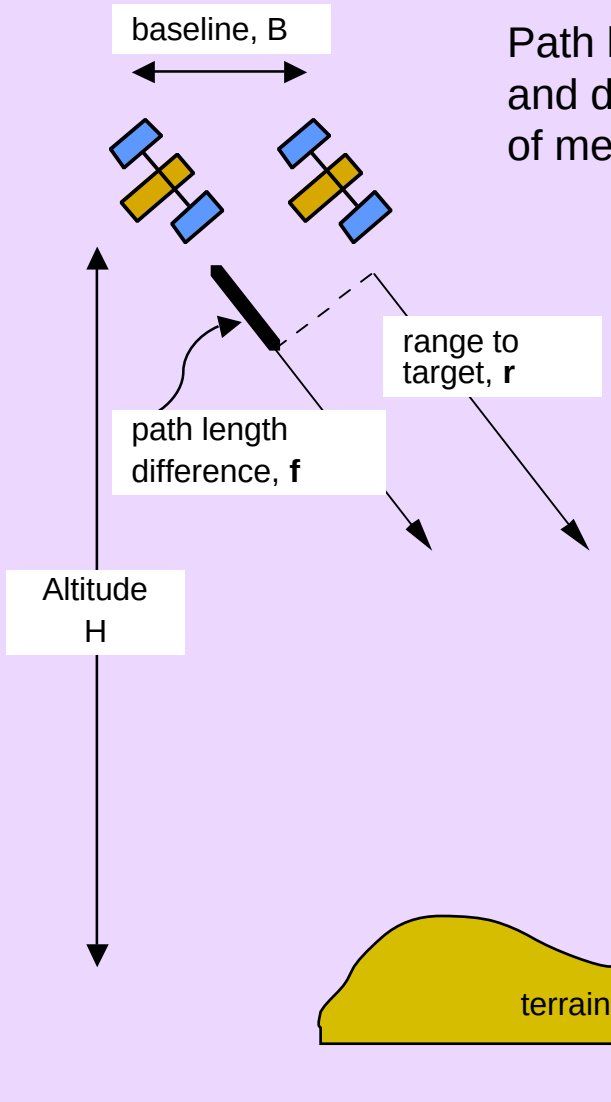
Approach

- Product Name
  - Normalized interferometric correlation
- Product Description
  - The interferometric correlation contains phase and amplitude information that is sensitive to the presence of volume scattering as well as thermal noise and temporal decorrelation. By removing these other effects through normalization, we will have something that is only sensitive to the vegetation signature that we are after. In this way, we can systematize the estimation of vegetation height/biomass
- Data
  - Working with the different modes (PLR, FBS and FBD) over well observed regions for finding candidate sites with low temporal decorrelation.
- Affiliation: UMass
- Funding Status: NASA is funding a task for characterizing temporal decorrelation using ALOS, SIR-C, Seasat and AIRSAR data. Additional funding being waited on.
- Product Status: In the final stages of creating a processing chain

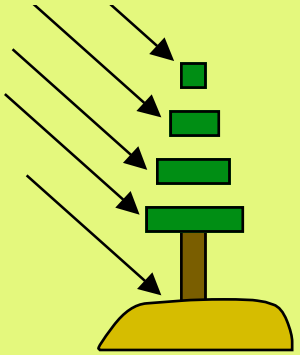
Sensitivity to Volume Scattering



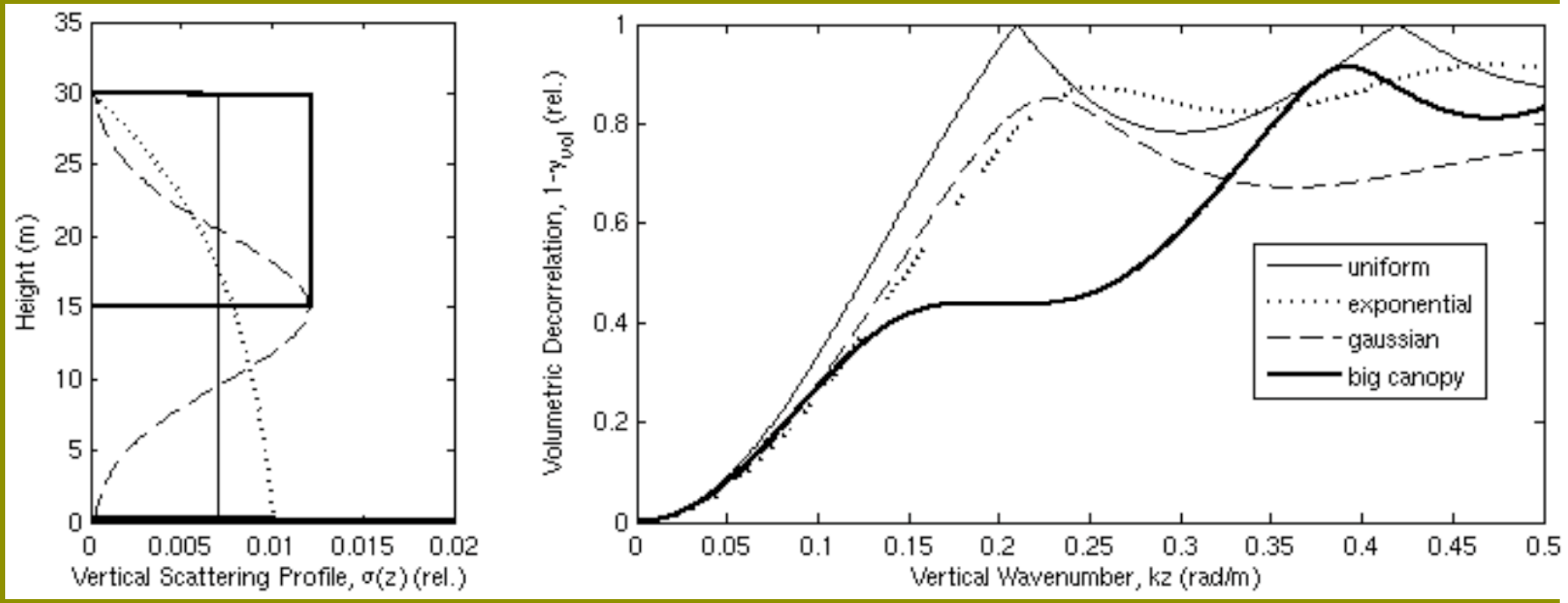
Path length difference can be used to resolve positional ambiguity and determine the height of the terrain. Accuracy is on the order of meters, with a 25m resolution

$$h = H - \rho \cos\left(\sin^{-1}\left(\frac{\lambda\phi}{4\pi B}\right)\right)$$

When the signal return comes from multiple heights, a unique signature is observed by the interferometer



Volumetric Correlation Dependence on Structure



In general: $\gamma_{vol} \le \mathrm{sinc}\left(k_z h_v / 2\right)$

random volume, no ground

Calibration

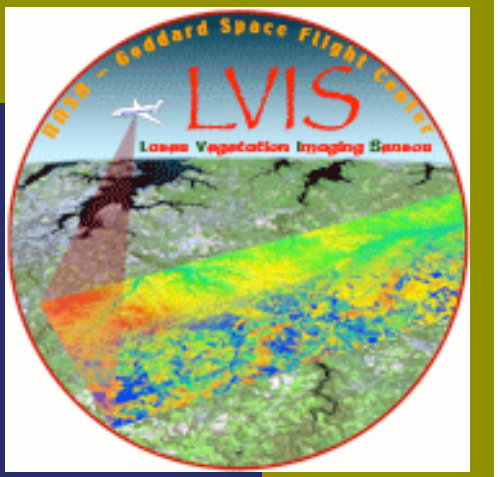
- Need for a well calibrated signal
  - understand error sources
  - provide ability to unwrap desired signature from other observational artifacts.
- Observed correlation is modeled as the combination of a variety of sources

$$\gamma_{obs} = \gamma_{vol}\gamma_{SNR}\gamma_{geom}\gamma_{temp}$$

$$\Rightarrow \quad \gamma_{vol} = \frac{\gamma_{obs}}{\gamma_{SNR}\gamma_{geom}\gamma_{temp}} = f(h_v)$$

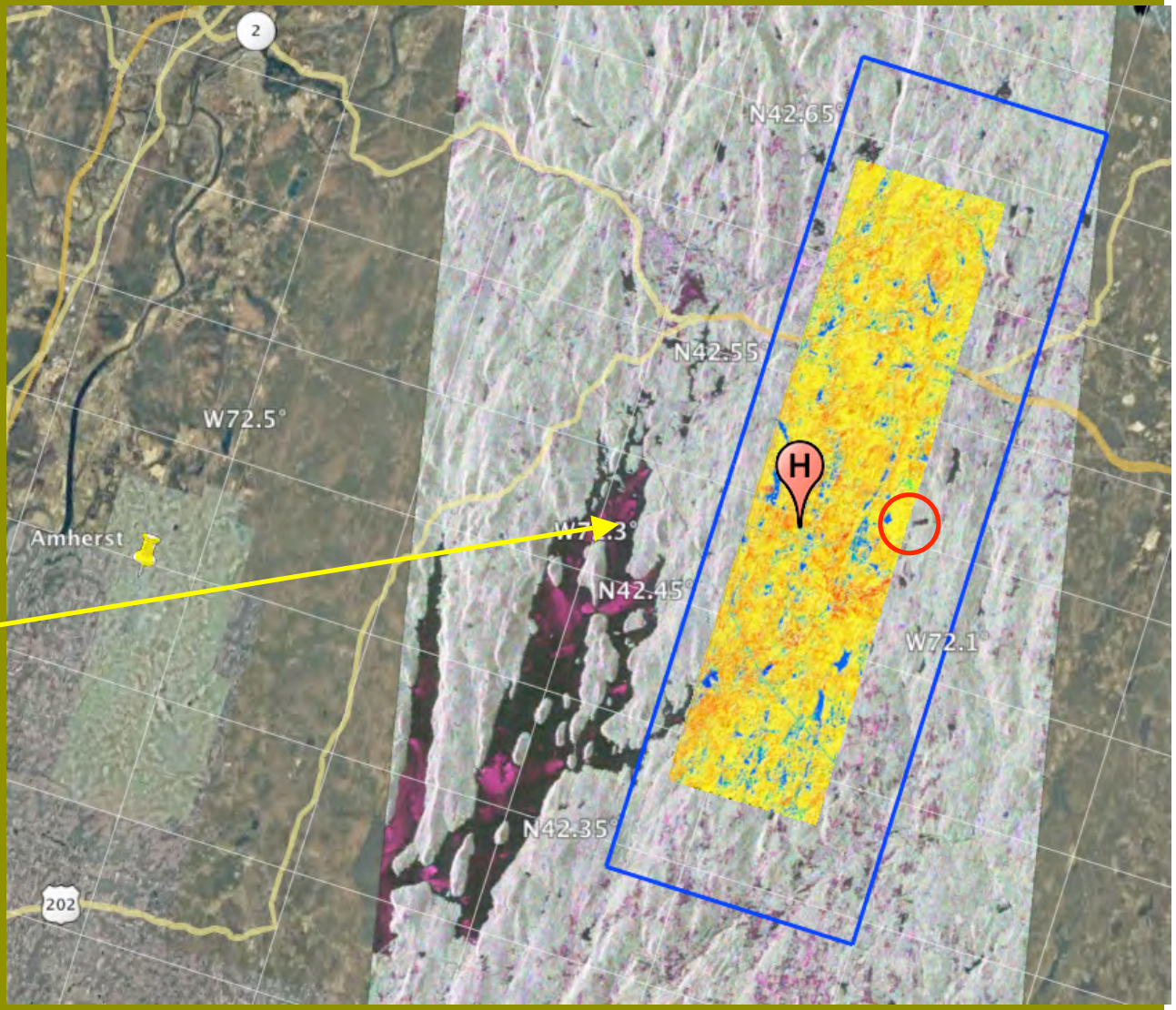
$$h_v = f^{-1}(\gamma_{vol})$$

The Harvard Forest as a Test Site



The Harvard Forest as a Test Site

The Harvard Forest, Established in1909 is used by researchers worldwide to better understand forest dynamics, forest management, ecosystems, and remote sensing



ALOS Data Collections

cal	1	27-May-06	early summer
A	2	12-Jul-06	mid summer
B	3	27-Aug-06	late summer
C	4	12-Oct-06	mid fall
D	5	27-Nov-06	early winter
E	6	12-Jan-07	mid winter
	7	27-Feb-07	mid winter
F	8	14-Apr-07	early spring
G	9	30-May-07	early summer
	10	15-Jul-07	mid summer
	11	30-Aug-07	late summer
H	12	15-Oct-07	mid fall
I	13	30-Nov-07	early winter

During its first year, ALOS/PALSAR (L-band) passed over the harvard site nine times with an incidence angle of 24 degrees and in a configuration suitable for its quad-pol observing mode. Ten of those times, the system was collecting data.

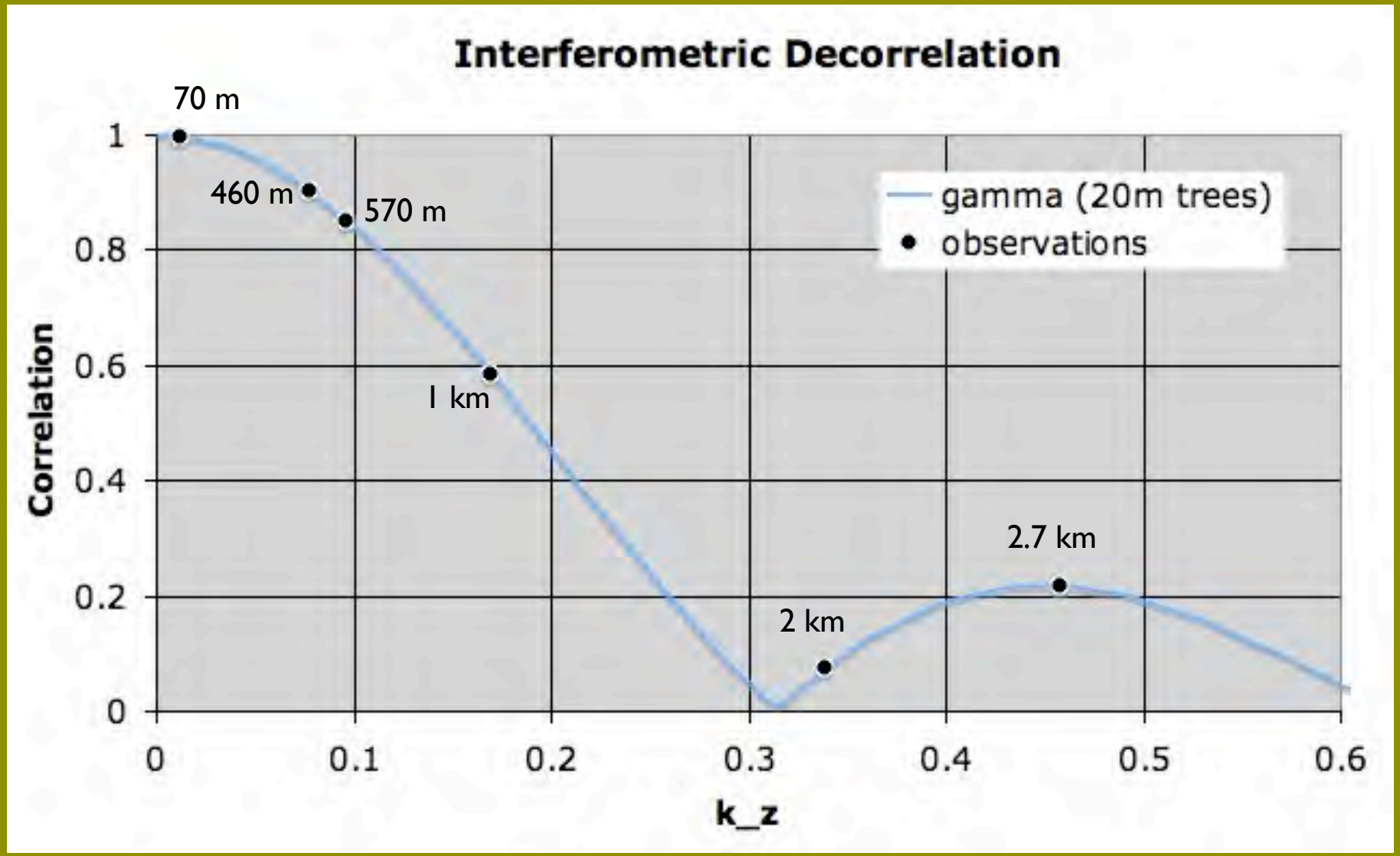
Each overpass offers an opportunity for measuring the target backscatter and polarimetric characteristics. Each pair of overpasses (every 46 days) offers a chance to perform interferometry.

Perpendicular baseline calculation for interferometric pairs

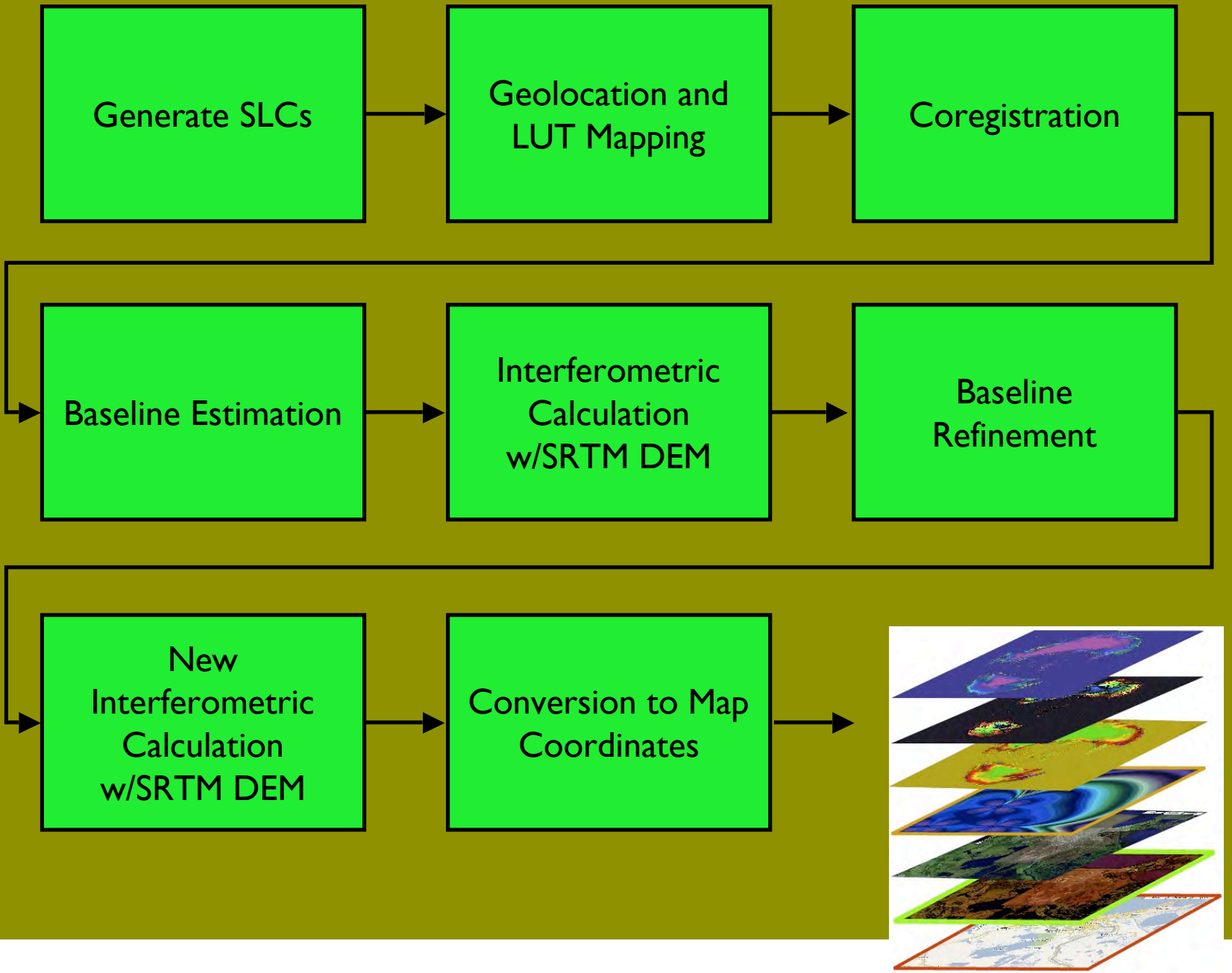
	A	B	C	D	E	F	G	H	I
A	0	4250	3800	4500	2450	5160	4600	6180	6200
B		0	460	240	1800	910	340	1900	1970
C			0	705	1350	1360	800	2380	2460
D				0	2070	660	70	1670	1720
E					0	2730	2160	3750	3800
F						0	570	1020	1080
G							0	55	1640
H								0	52
I									0

The critical baseline for this configuration is 4.5 km.

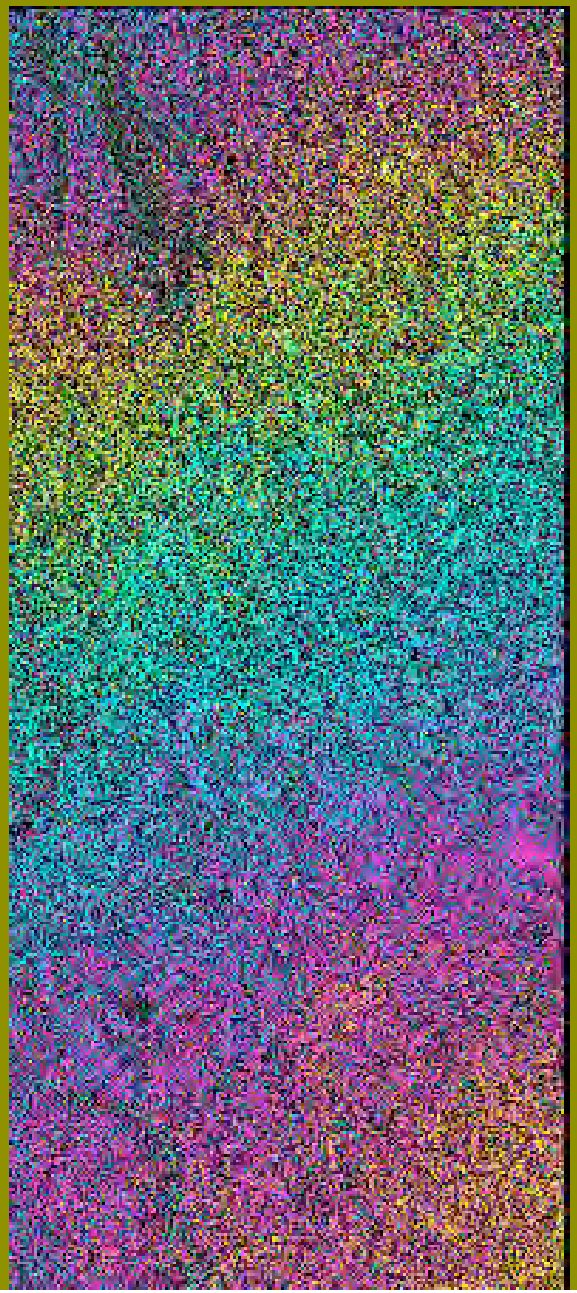
Maximum Volumetric Decorrelation



The Processing Chain

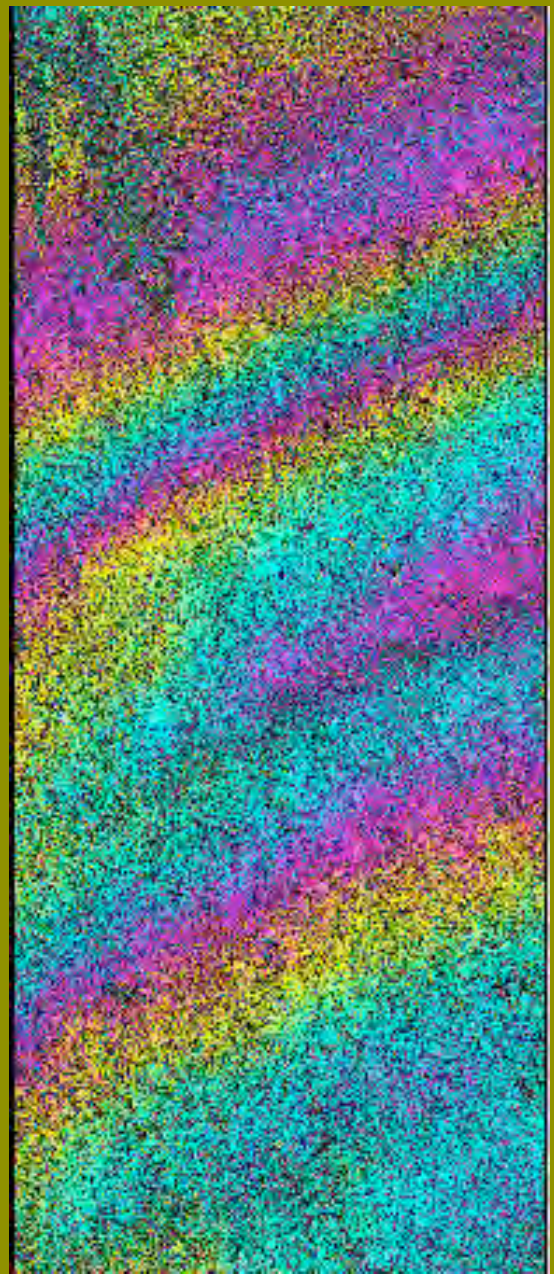


Fringes (?!)



Oct 2006 & May 2007

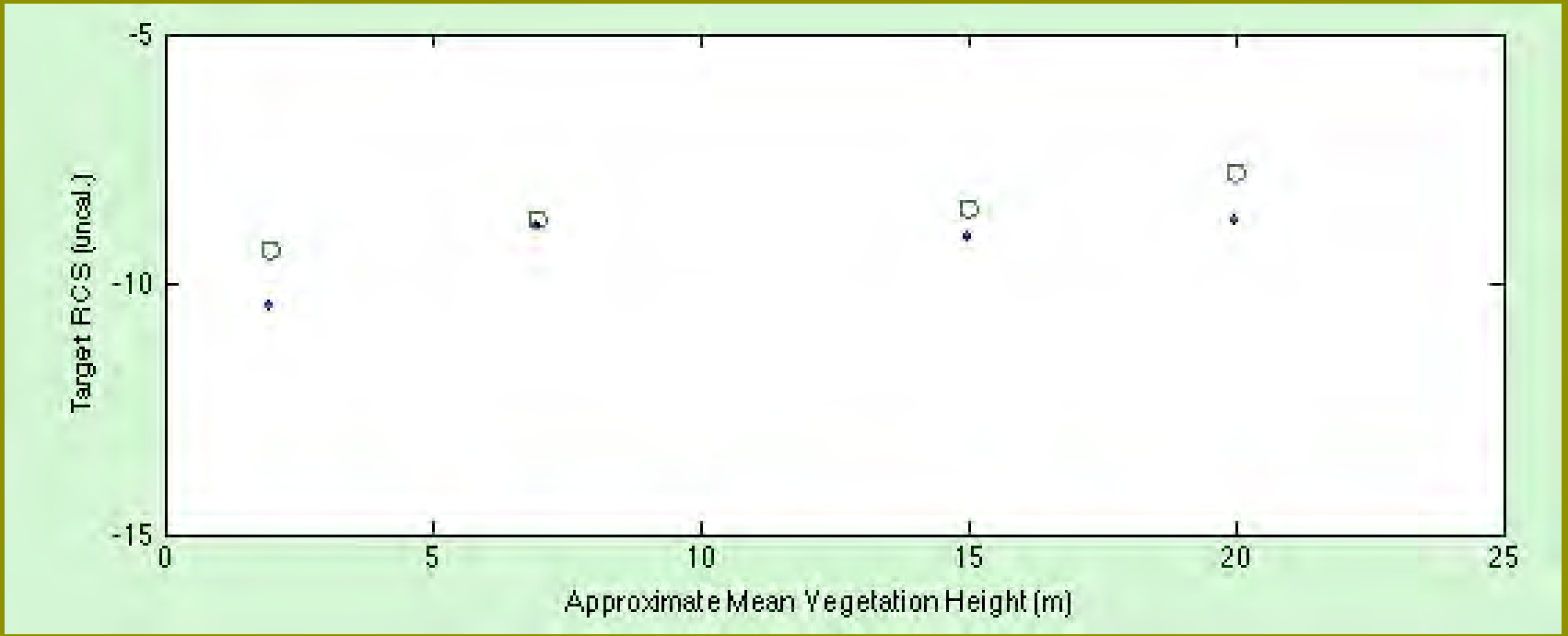
May 2007 & Oct 2007



Oct 2007 & Nov 2007

Backscatter to Vegetation Height Sensitivity

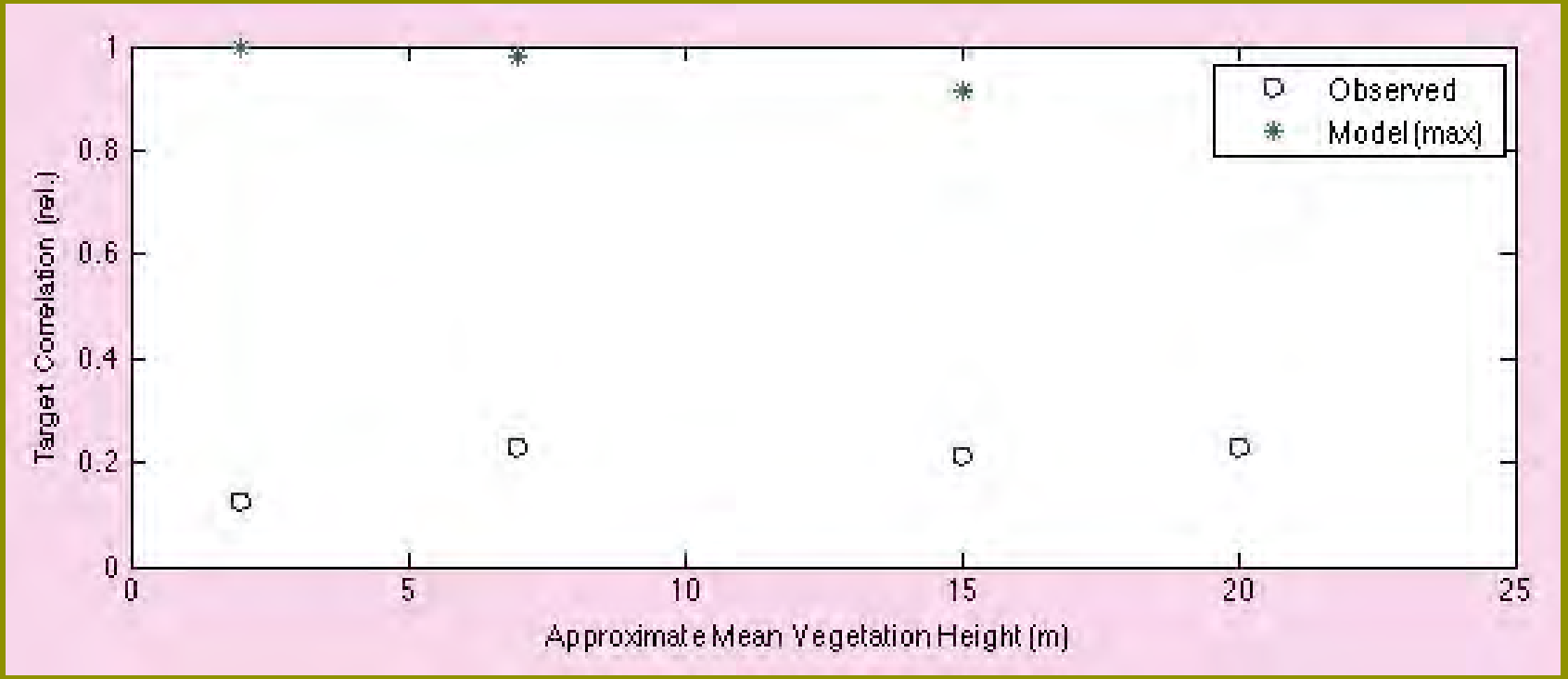
- The plot shows the target RCS as a function of the LIDAR derived vegetation height.
- Green circles indicate RCS on April 14th
- Blue dots indicate RCS on May 30th (46 days later)



Note that i.) a slight trend to slighter brightness with increasing vegetation height, and ii.) relative consistence in brightness between observations

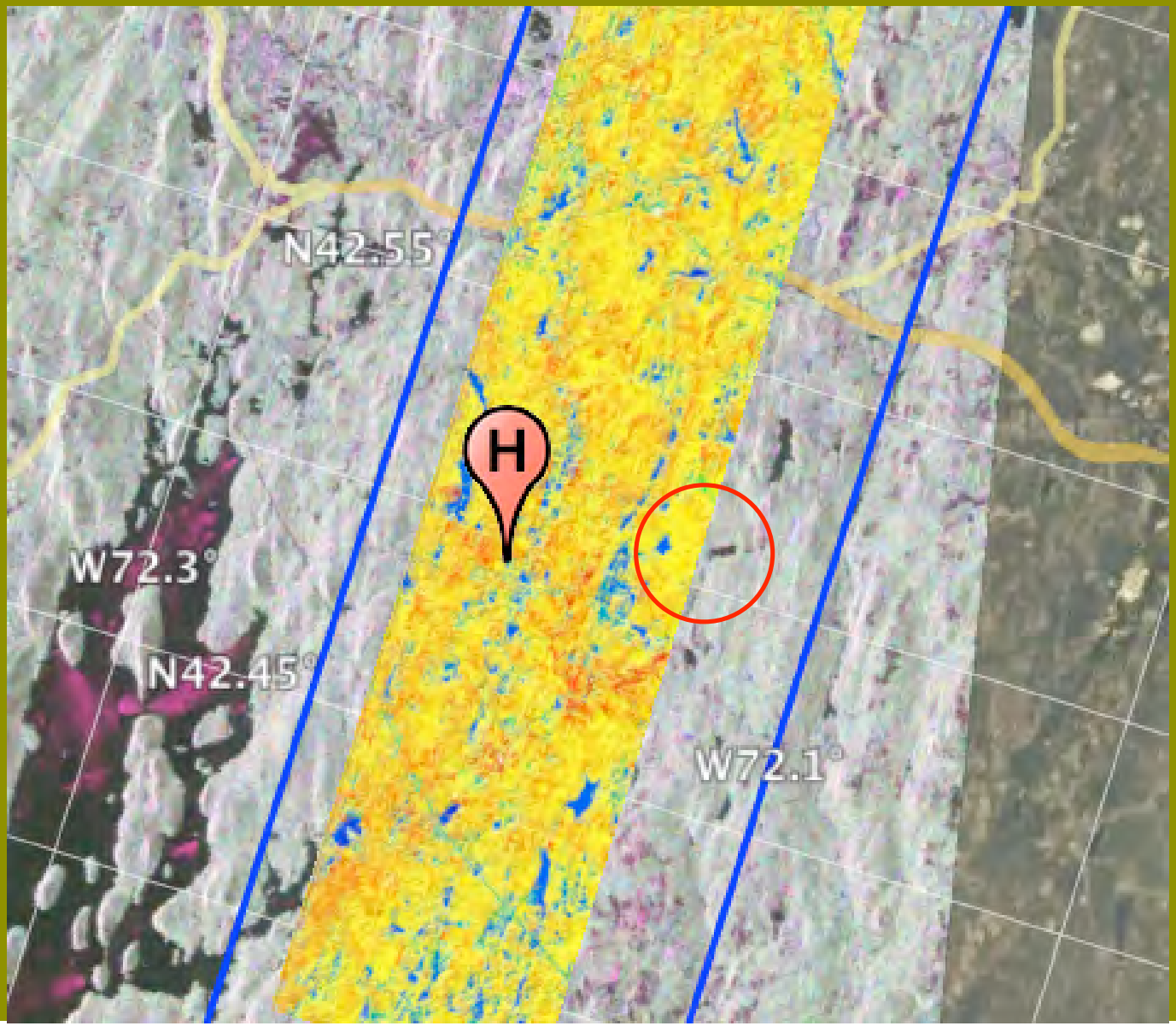
Interferometric Correlation to Height Sensitivity

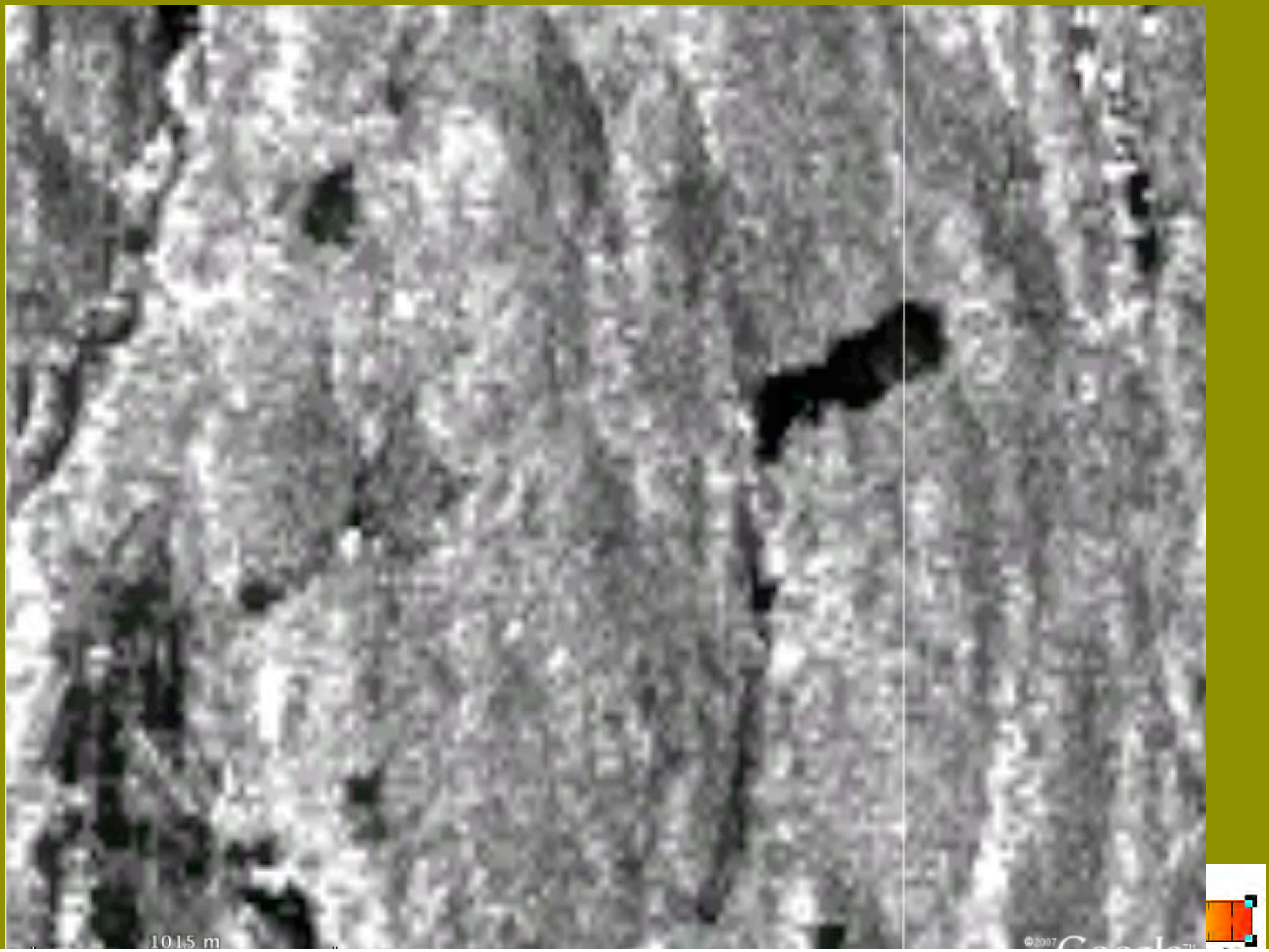
- The plot shows the interferometric correlation magnitude as a function of the LIDAR derived vegetation height.
- Blue circles indicate the observed correlation between April 14th and May 30th observations
- Green stars indicate the expected correlation using a uniform scattering model.



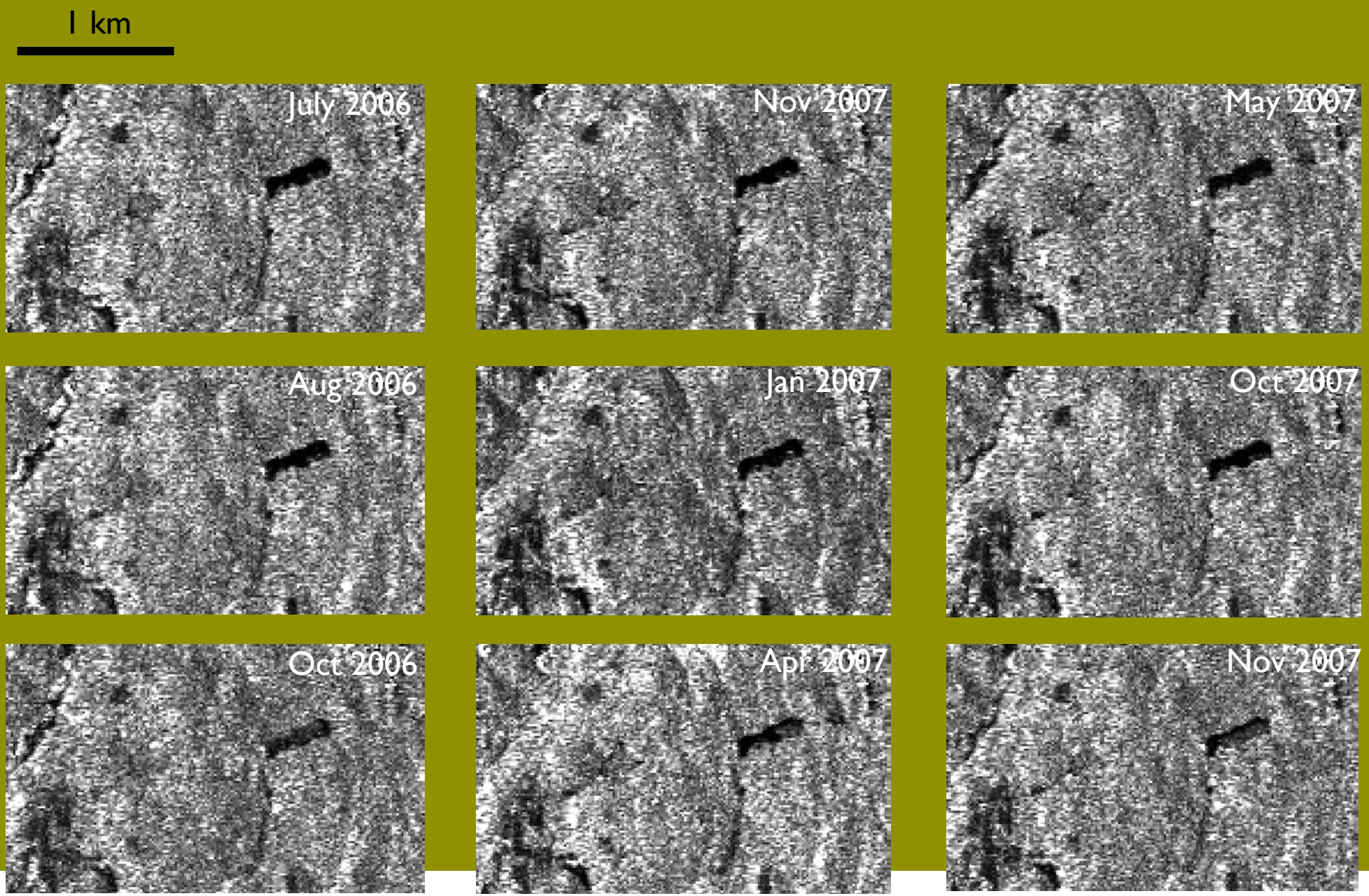
- The difference between the model and observations is likely due to the effect of temporal decorrelation.

Closeup View

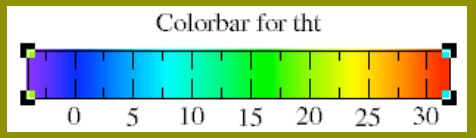


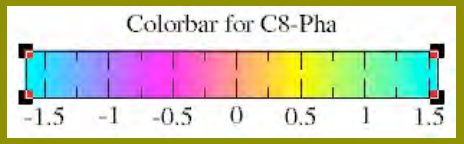

1015 m

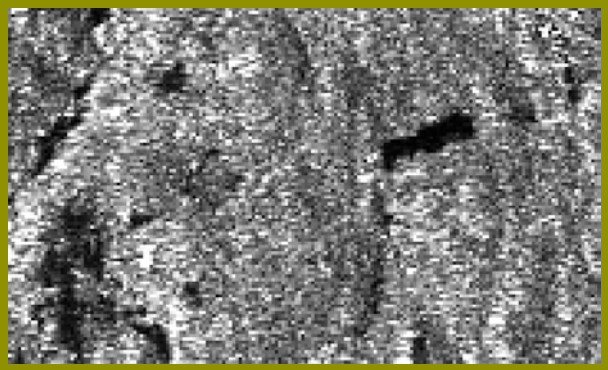
Nine Backscatter Images (HH)

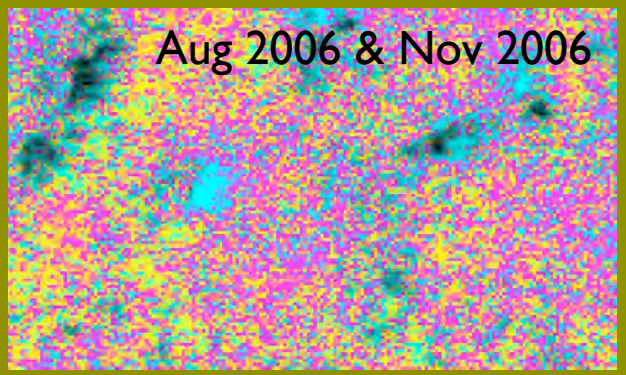


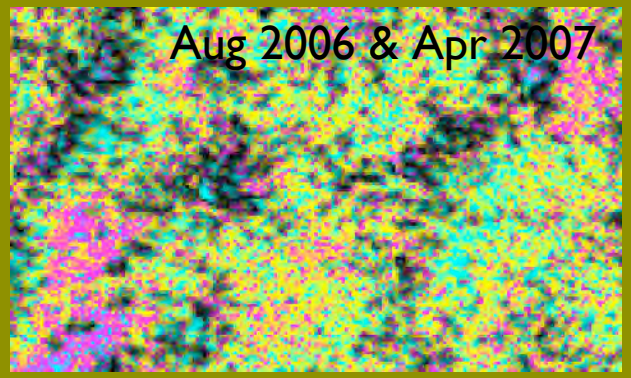
Interferometric (Differential) Results

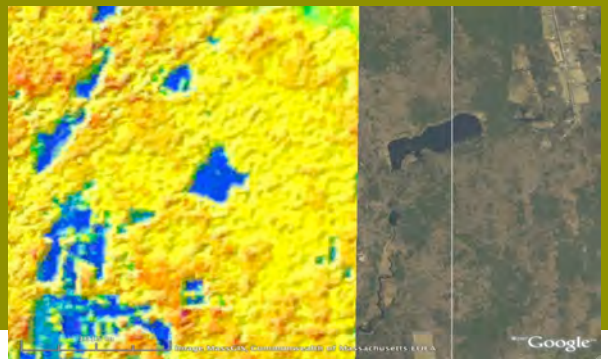


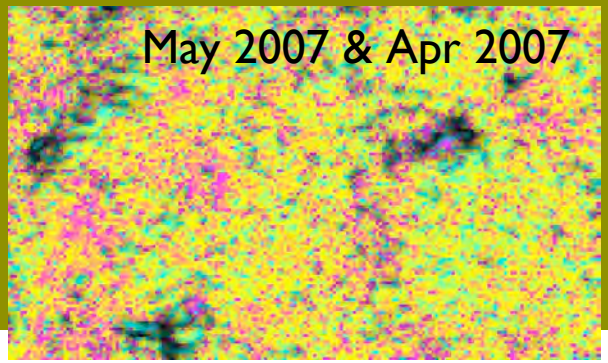


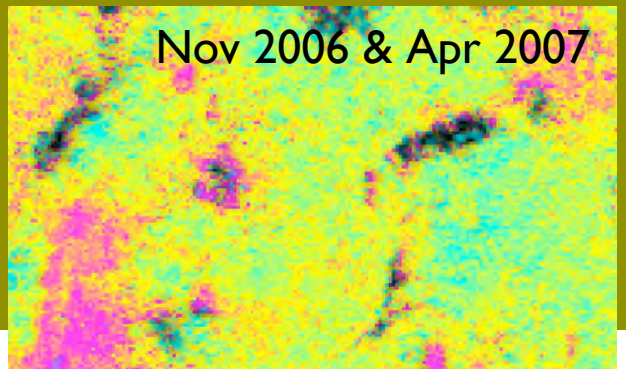








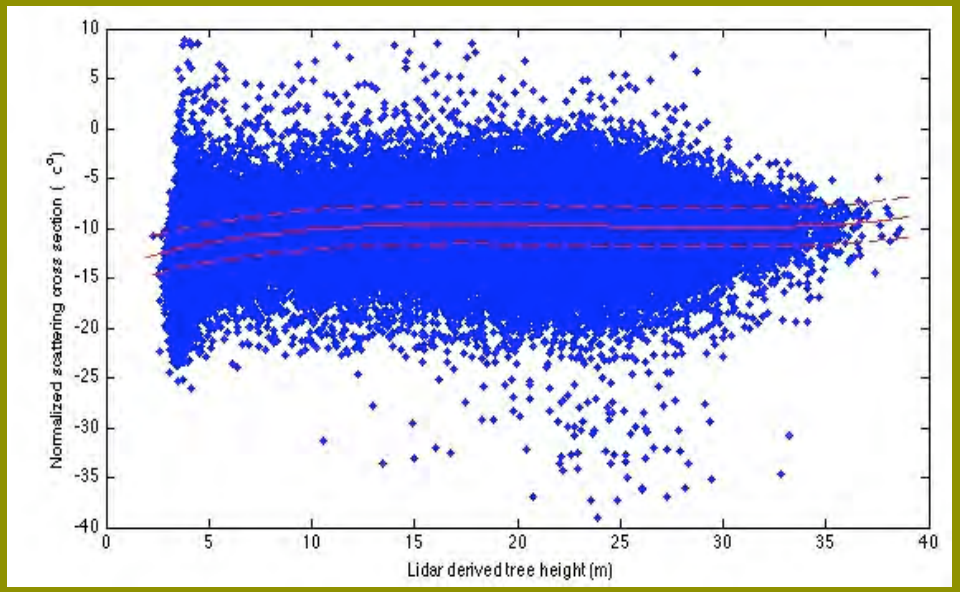




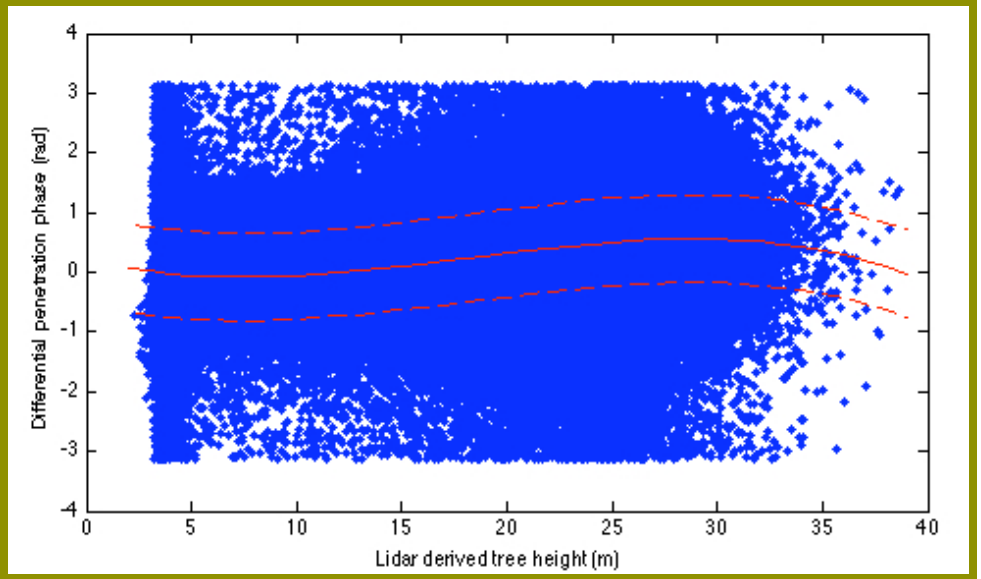
More Detailed Analysis

- Coregister the Lidar (LVIS) data with the SAR data
- Probe relationships between the SAR, InSAR and Lidar products
- Take into account
  - Ground slope on radar backscatter
  - Thermal noise on interferometric correlation
  - SRTM DEM for interferometric phase
  - Interferometric Baseline

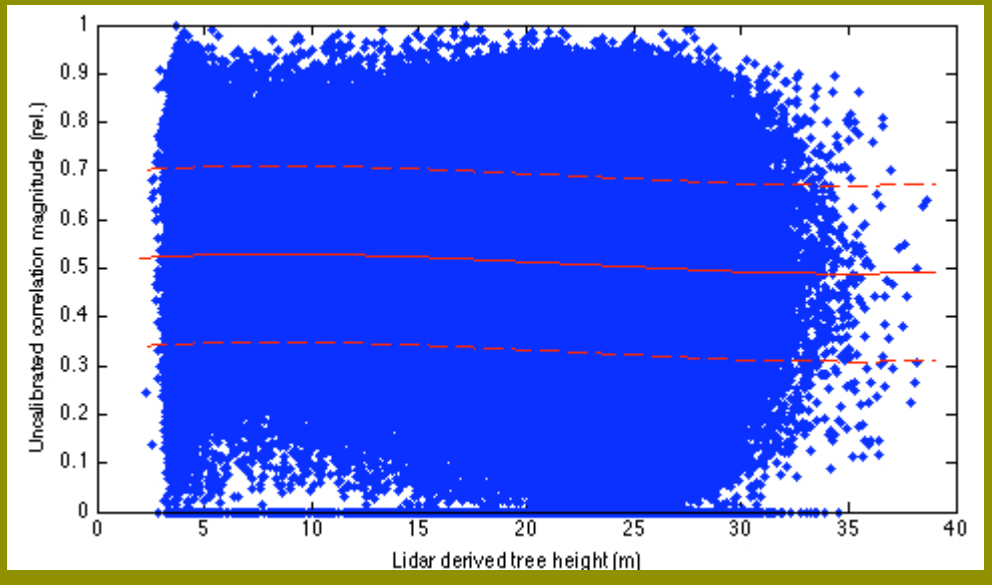
Analysis of Relationships



Backscatter to Biomass



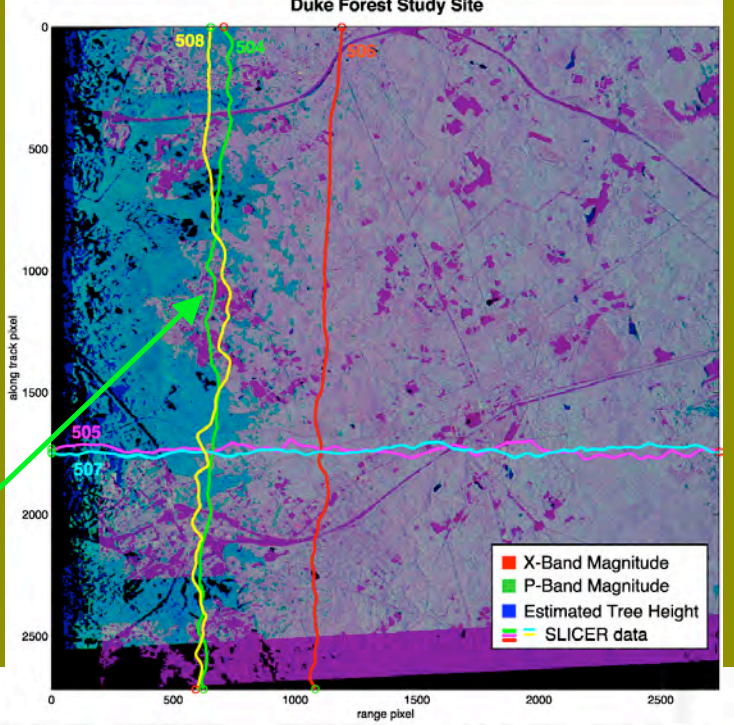
Interferometric Phase

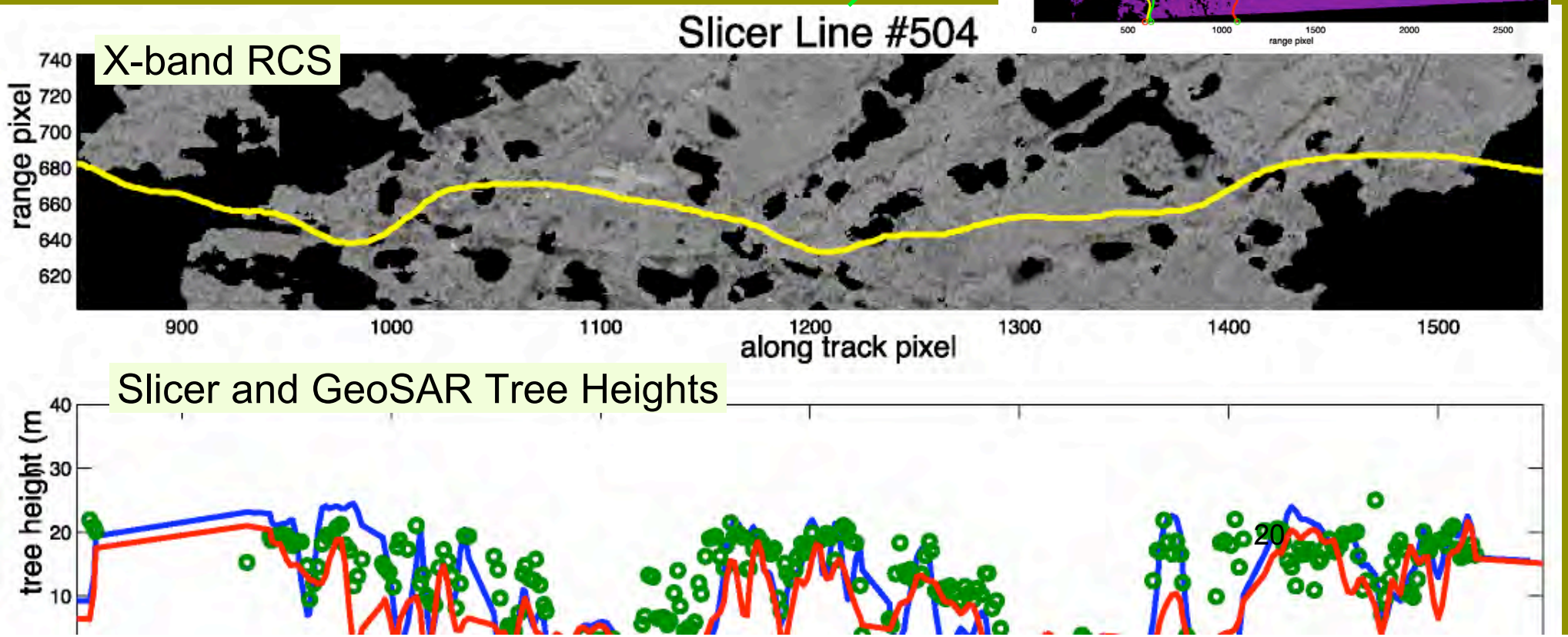


Interferometric Correlation Magnitude

No significant dependencies seen overall. A more detailed, plot by plot analysis will continue

Yes... this does really work!





What Next

- Include Polarimetric Scenes and perform PolInSAR techniques
- Work with other beam modes (FBS, FBD and maybe WB1)
- Further evaluate differential interferometry results
- Estimate temporal decorrelation on the best of the scenes
- Automate the process of scene identification and processing (would like to create a searchable database for frequently covered regions)
- Perform plot by plot analysis

Conclusion

- Temporal decorrelation is the major source of error, it remains to be seen if this is a limiting factor at the Harvard Forest
- Better orbit control would make it easier to explore the trade space
- Thank you to Gamma Remote Sensing, RESTEC and JAXA!!!!

ありがとう!