K&C Phase 3 – Brief project essentials

Combined Use of SAR, InSAR and Lidar for Measuring Forest Biomass and Structure in the Northeastern United States

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Project area(s)

Use ALOS/PALSAR data for estimating forest physical characteristics of height, density and biomass. An assessment of the errors associated with these estimates is a critical part of this work. The principal remote sensing data type will be interferometric, but we are also looking at backscatter relationships as well.

The primary location for this work is the Harvard Forest, but we also have been investigating the Howland forest in Maine and the Injune Landscape Collaborative Project in Queensland, Australia.

Project objectives

The objectives of the project is to create algorithms that can be applied regionally and/or on a continental scale for estimating biomass and carbon storage. Hence, this work addresses the K&C thematic driver of **C**arbon cycle science.

Because carbon is estimated from forest structure, and forest structure can be used for characterizing forest ecology, this work also addresses the K&C thematic driver of Environmental **C**onservation.

Project schedule

Milestone 1 (March 2012). Provide lidar derived topography and vegetation height map for the Harvard Forest region to JAXA.

Milestone 2 (March 2013). Reporting of algorithm development and forest modeling effort ongoing in the Northeastern US.

Milestone 3 (March 2014). Final report for algorithm development and error assessment over the Northeastern US.

Support to JAXA's global forest mapping effort

This project will aid in JAXA's global forest mapping effort through the development of algorithms that perform forest mapping using ALOS/PALSAR data. Since JAXA's global forest mapping effort will depend primarily on PALSAR data, this work will have a direct relevance to JAXA's work.

Ground validation for the Harvard Forest will be shared. This includes ground validation data and derived products from remote sensing data from LVIS and UAVSAR.

Derived products for other forest sites in the Northeastern US can be shared as well.

Deliverables

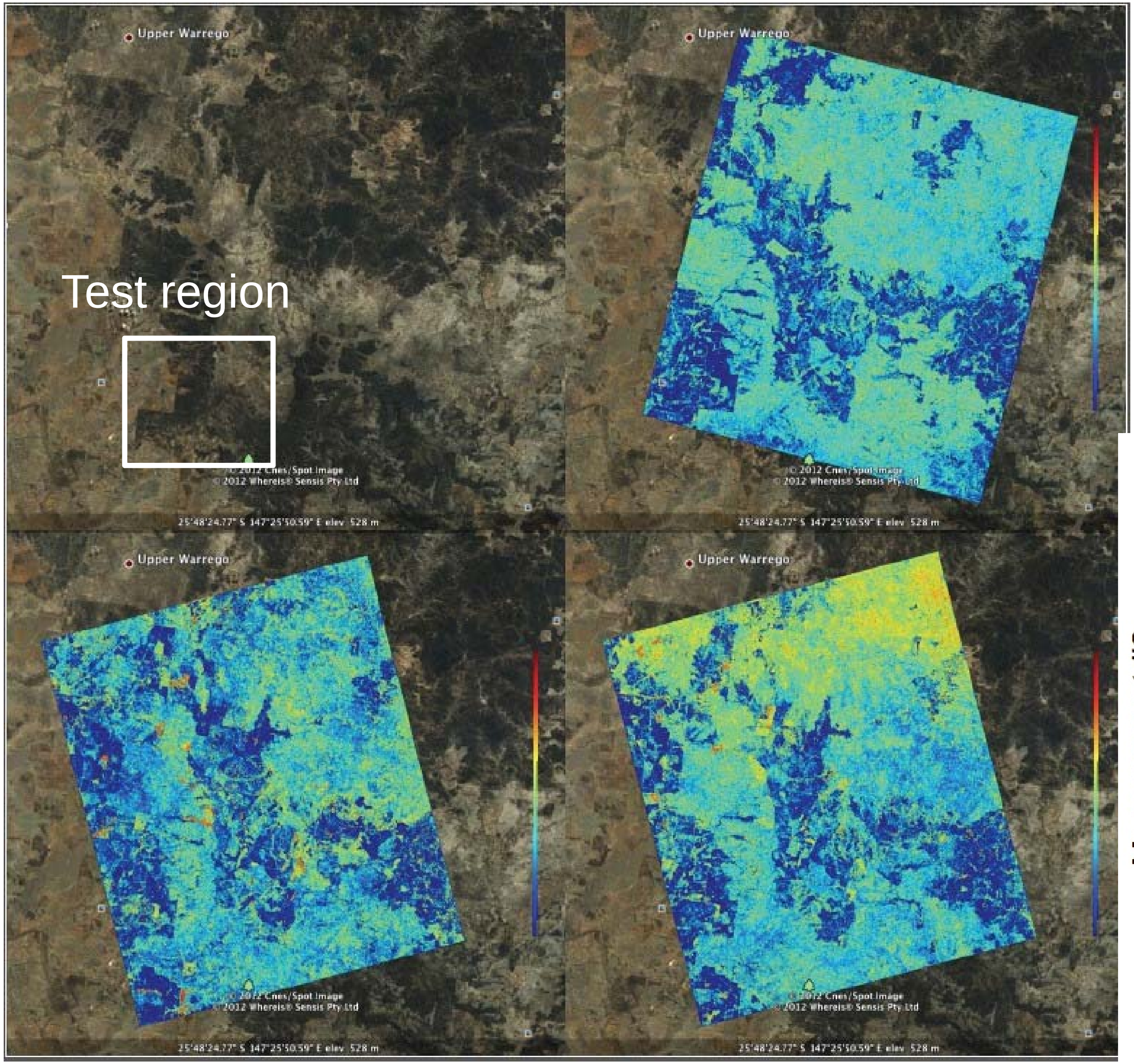
Planned output of the project:

- Lidar derived vegetation height map for the Harvard and Howland Forests (done)

- Algorithm for using interferometric correlation for estimating effective vegetation heights

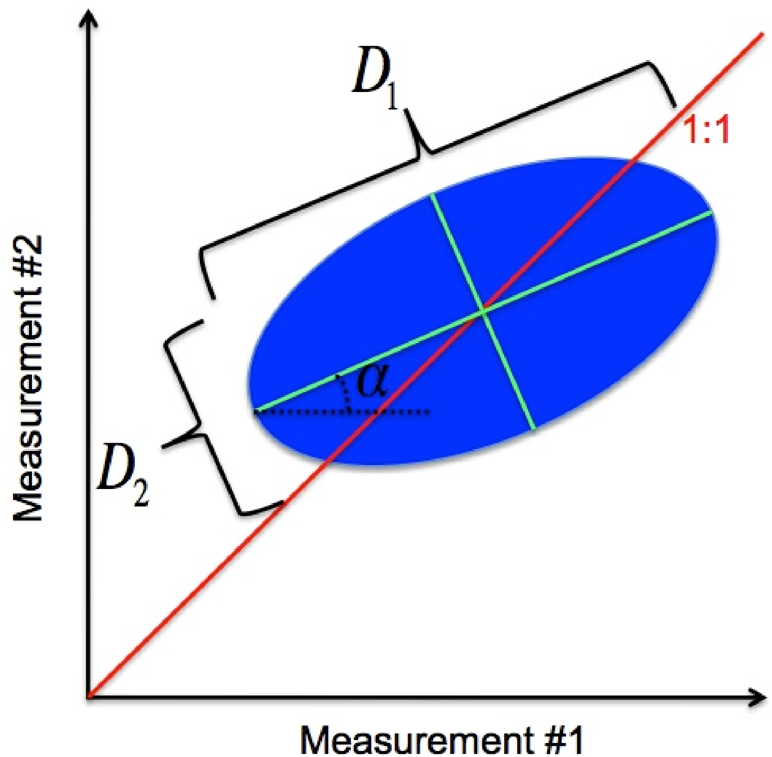
Interferometric Algorithm Development for "Forest Stand Height" (FSH)

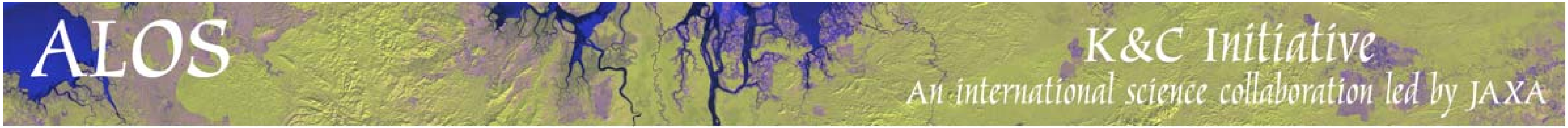
- Forest stand height (FSH) is meant to be a proxy for a combination of tree height and stand density. Metric is similar to the Lorey's height (basal area times height).
- One tree standing by itself, will have a smaller stand height than a group of trees next to one another.
- Use interferometric correlation that is corrected for
  - thermal noise effects (e.g. flat surfaces with poor SNR will have a similar decorrelation signature as a tall forest stand with good SNR)
  - temporal decorrelation (a dominant factor with a 46 day repeat observation)
- We begin with a well characterized dry savanna in Injune



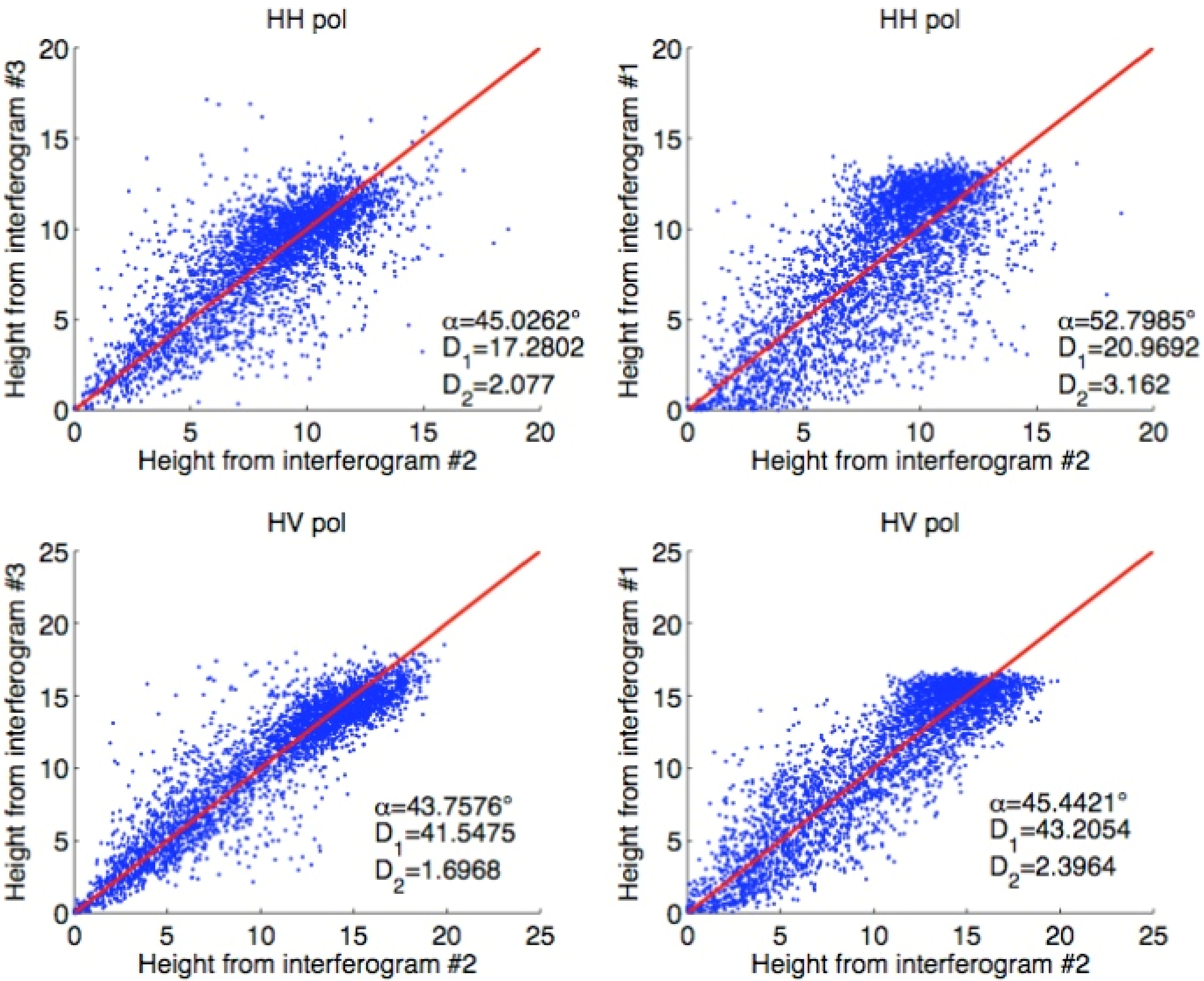
Estimate of heights between interferograms can be skewed because of temporal decorrelation effects.

Fit an ellipse to the skewed points to remove these errors





Comparison in Test region

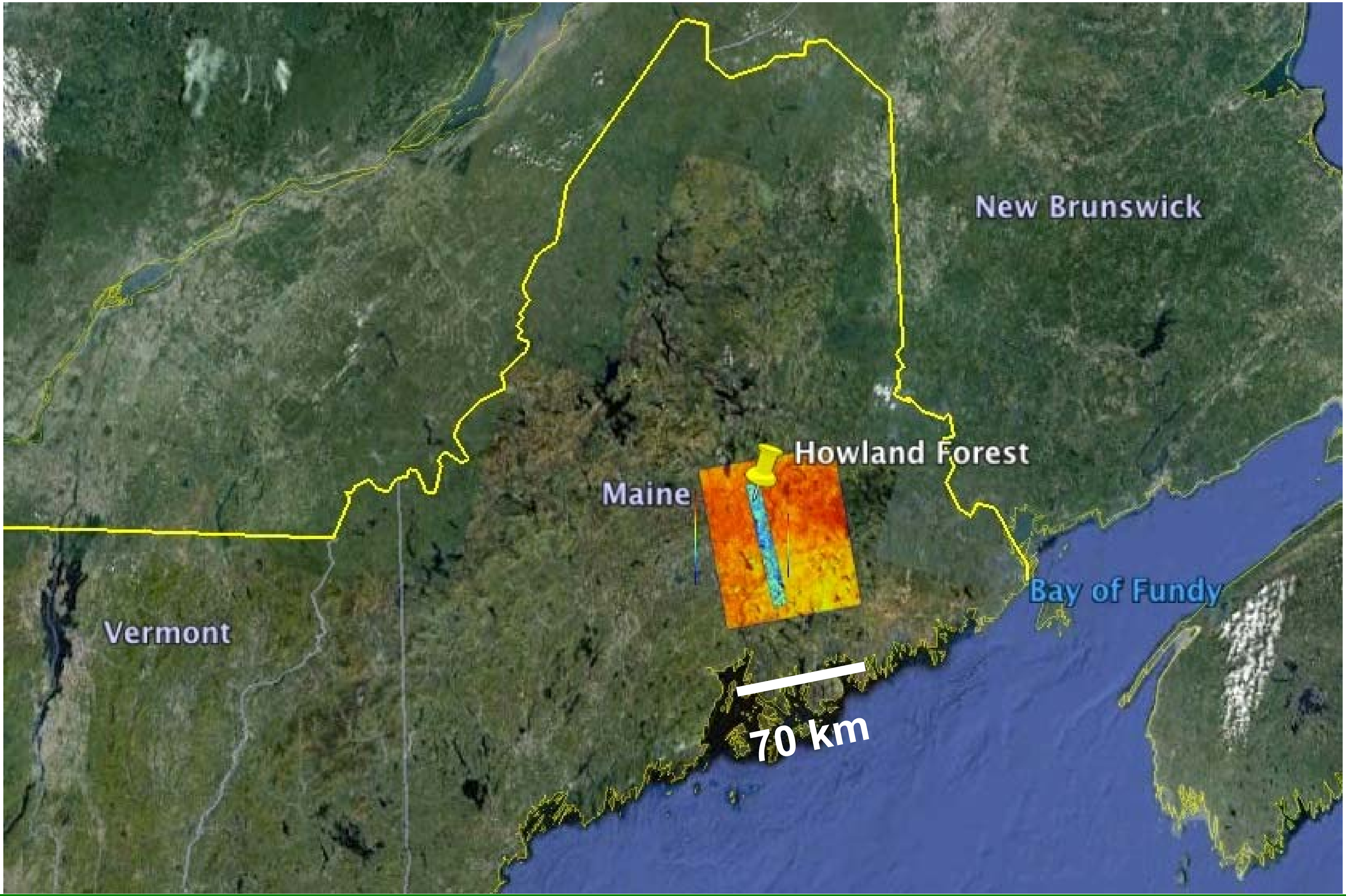


- Interferograms #1 & #2 have the least spread in estimated heights.
- Used for detecting selective logging and landcover change
- Use this mechanism as a prototype for regional mapping

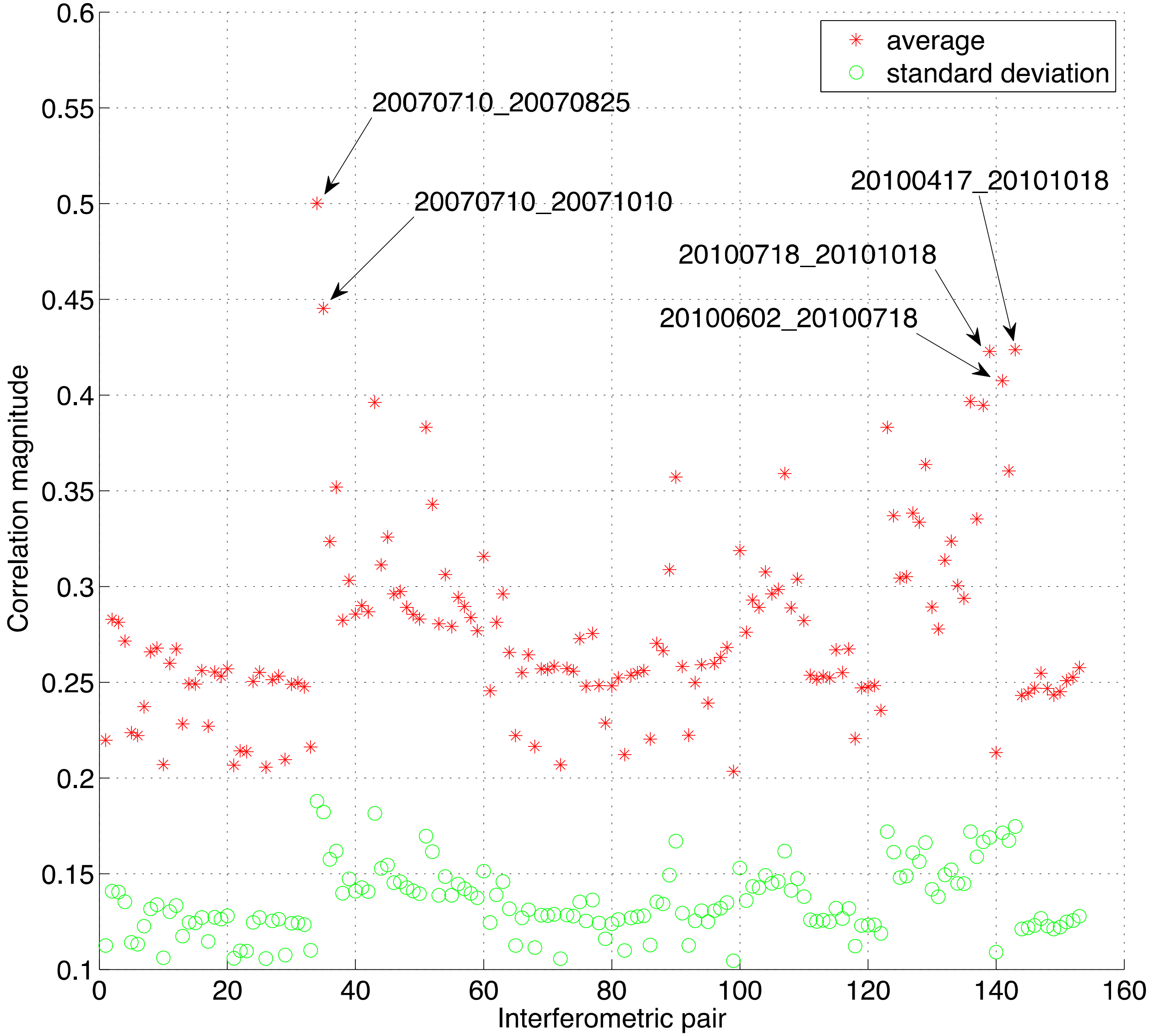
Regional Mapping

- The ILCP was initially chosen because of the relatively dry landscape and low vegetation density
- There remains a desire to expand the algorithm to a larger geographic context in order to provide large scale mapping, similar to the RCS mosaics
- The state of Maine is used as a test case because of the availability of LVIS tree height data and a large number of ALOS FBD and FBS scenes over a single area (18)

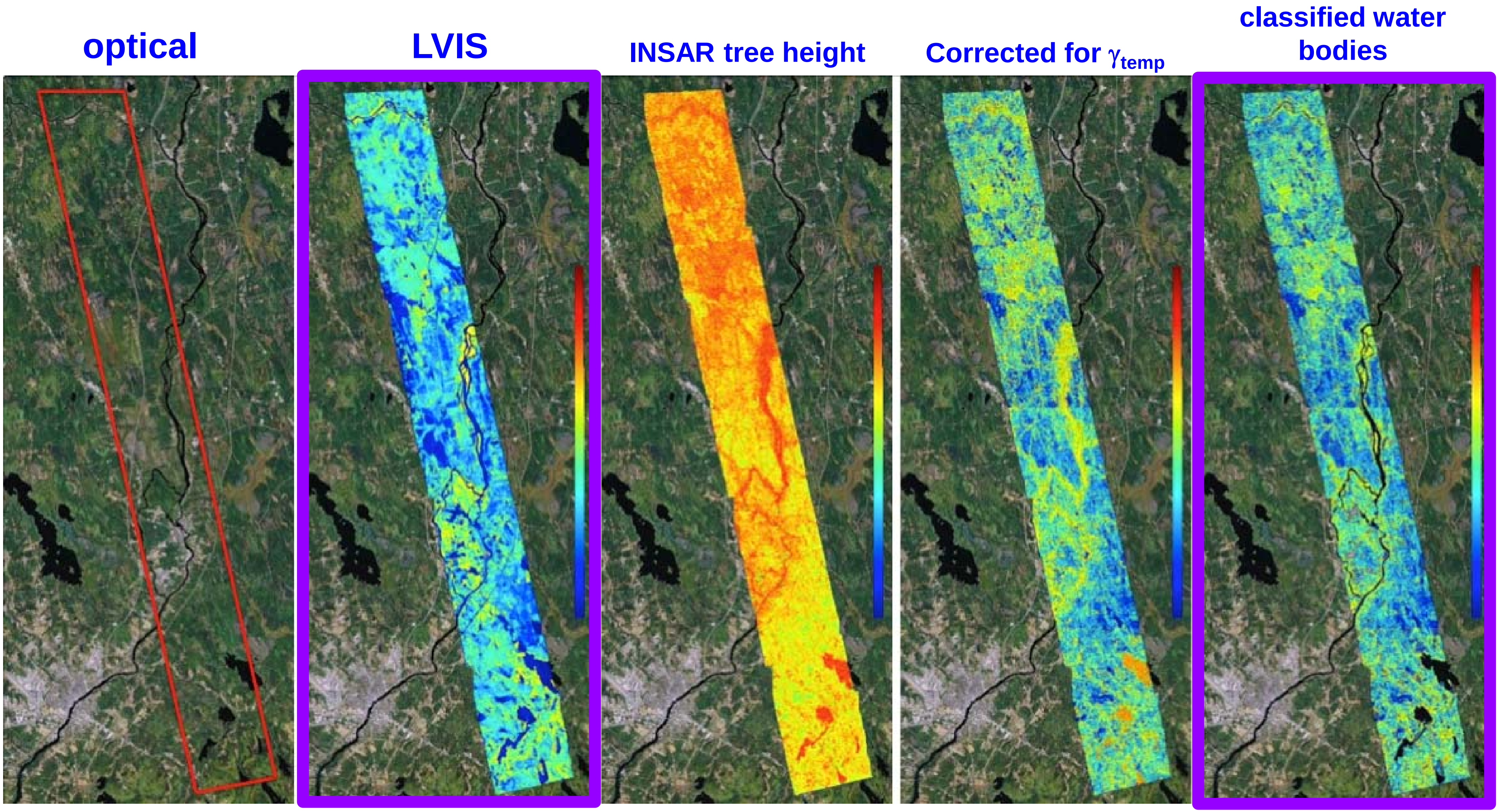
Correlation and LVIS imagery for 380_890



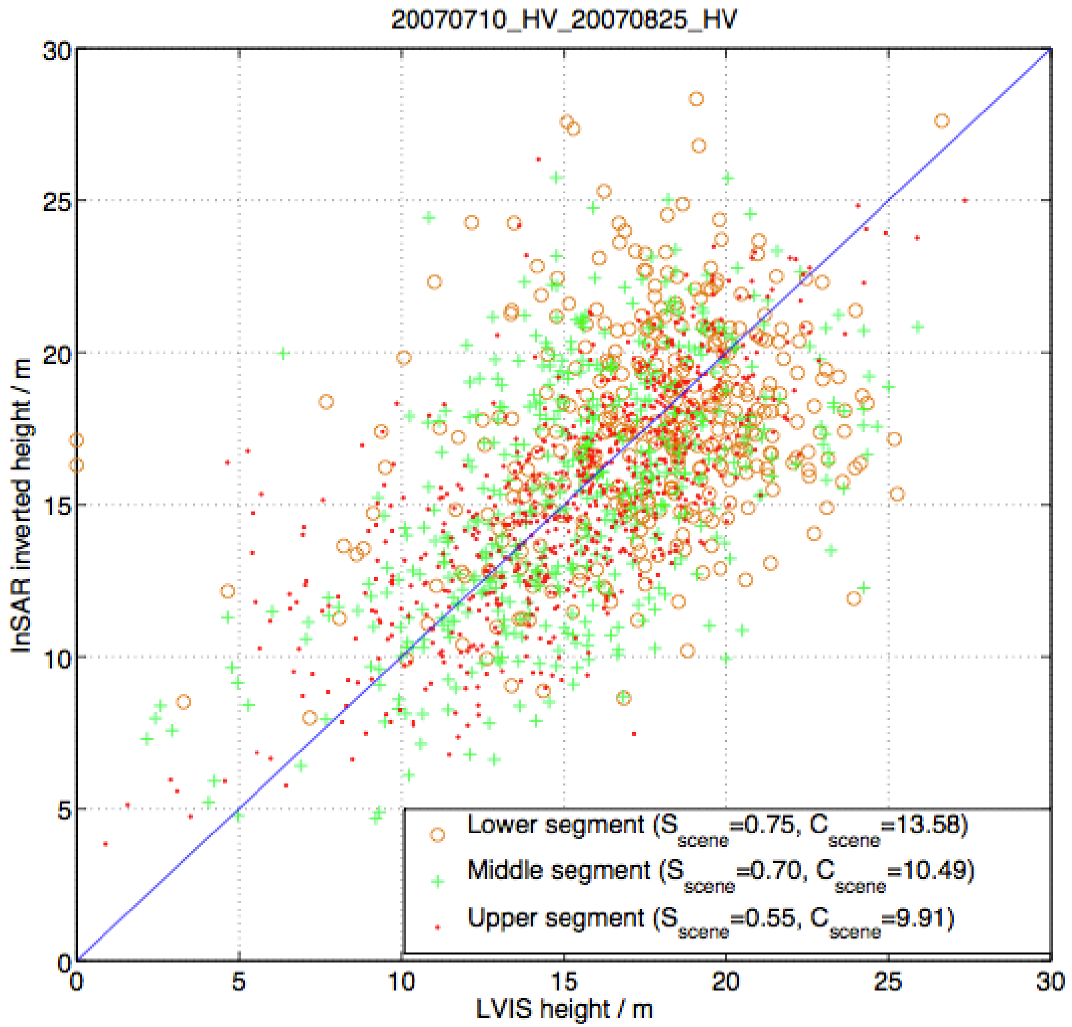
Average Correlation as a function of pair number

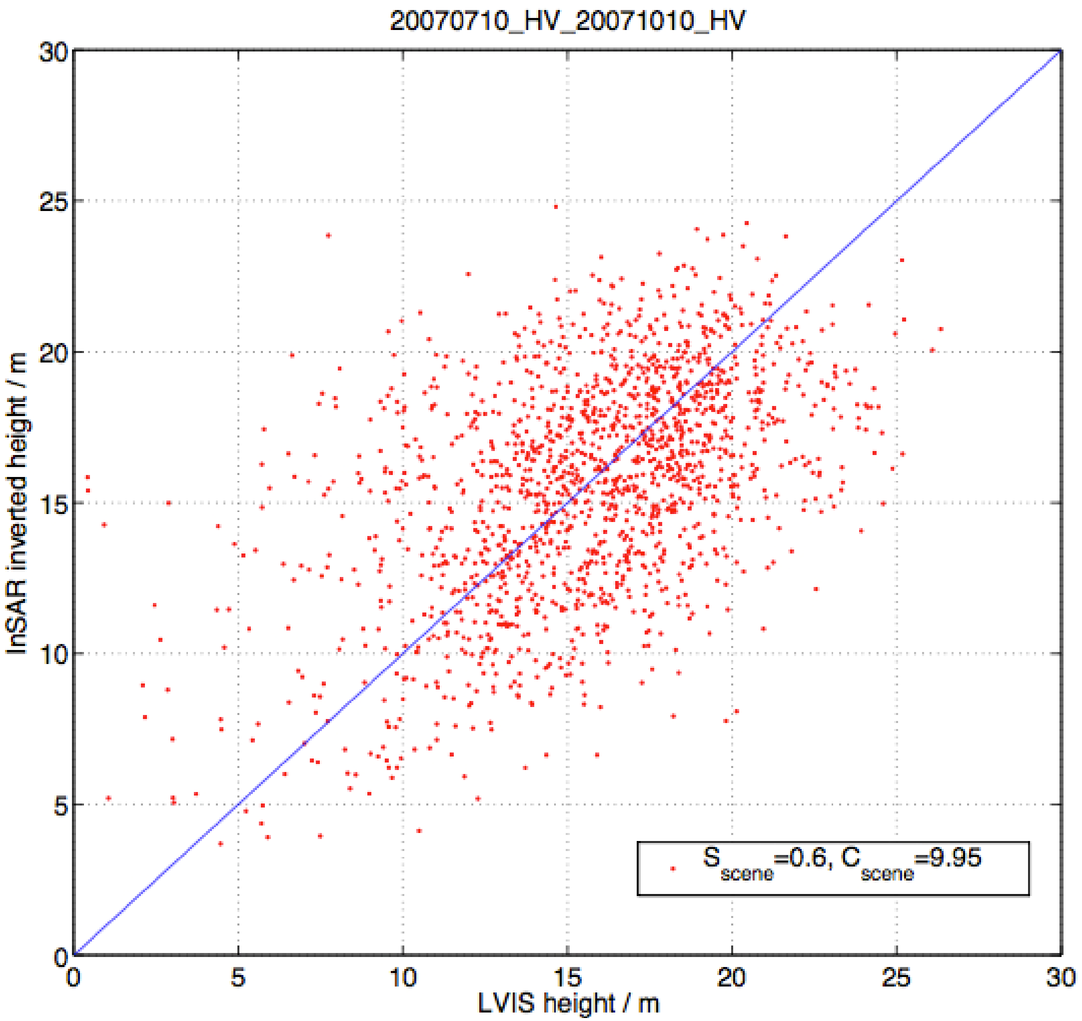


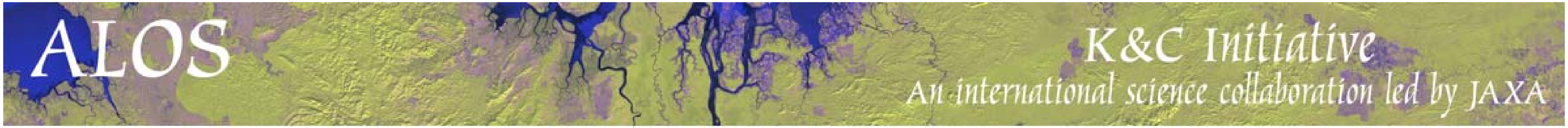
Visual comparison with LVIS heights



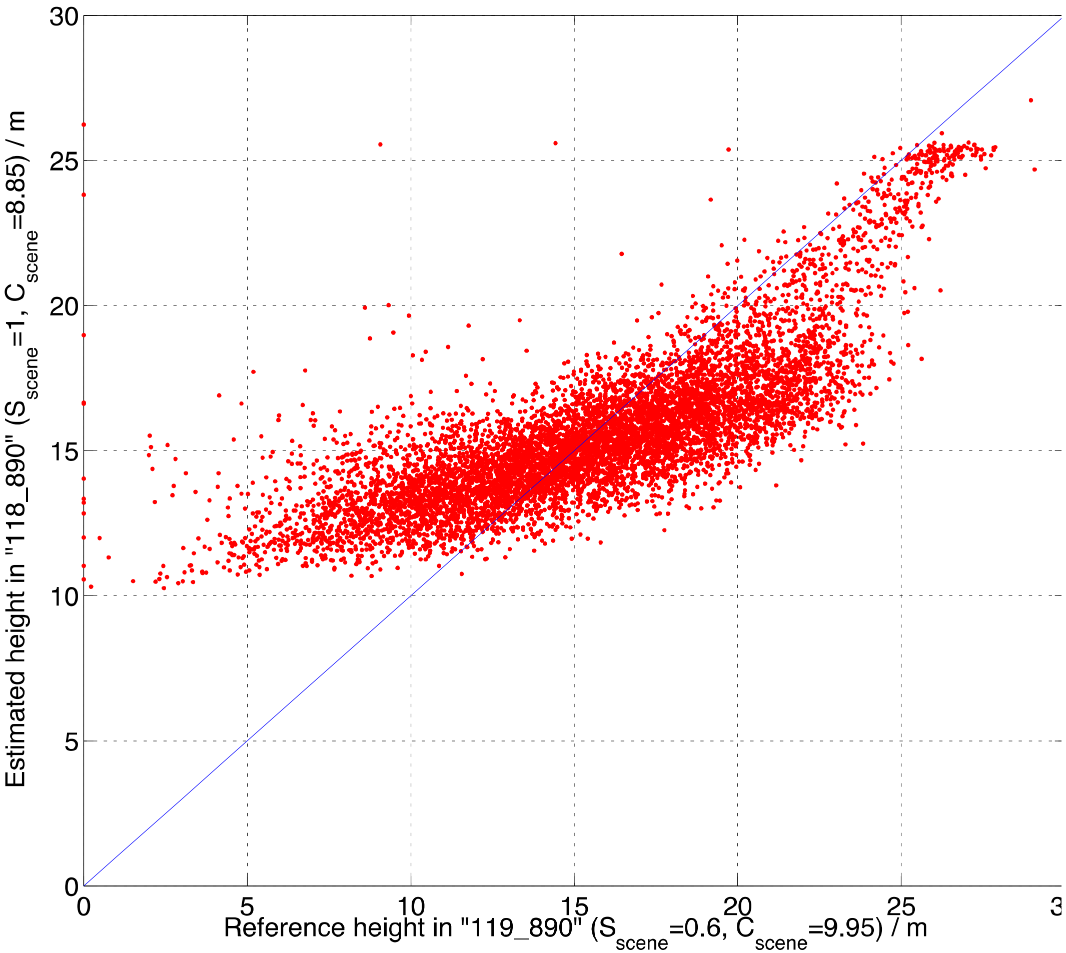
Quantitative comparison with LVIS

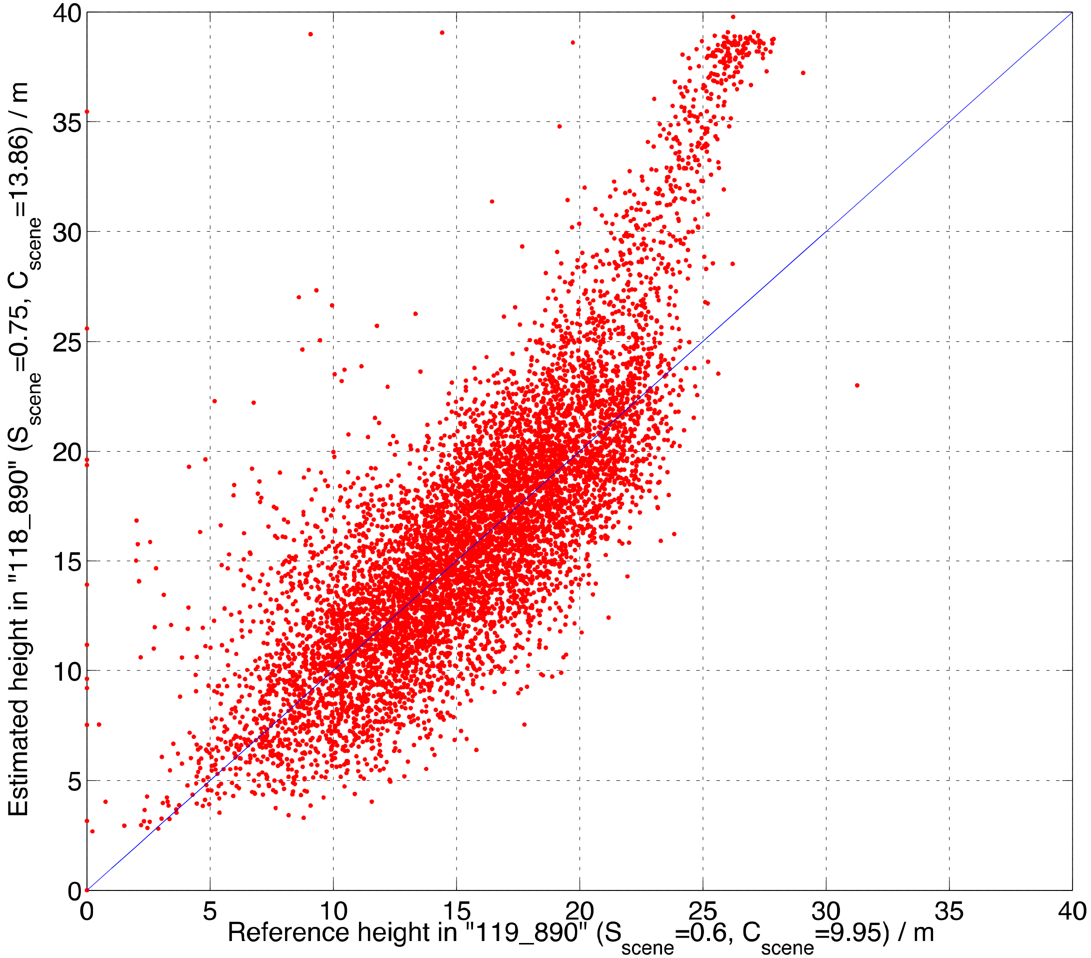




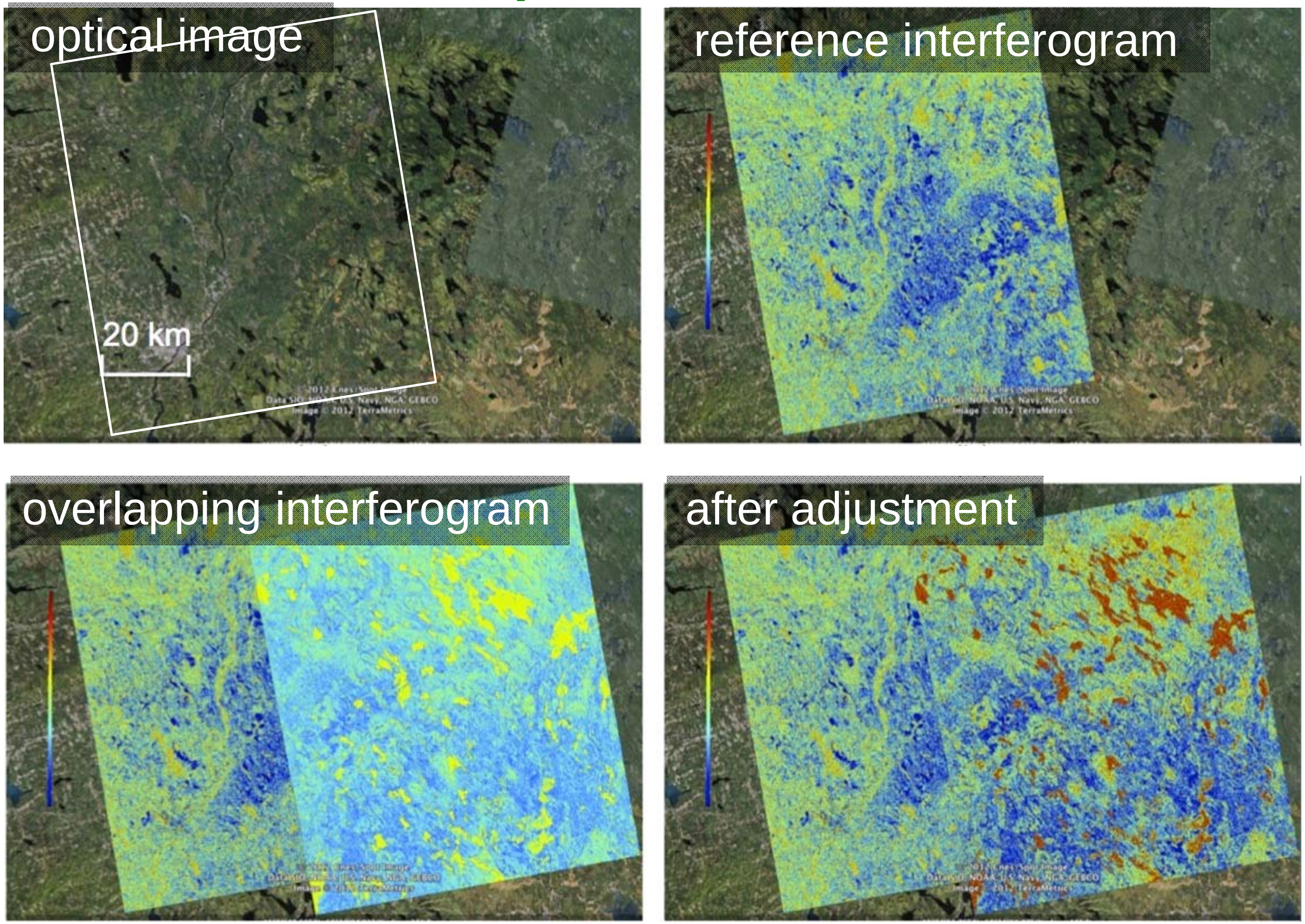


Adjustment for Temporal Decorrelation in the overlap regions

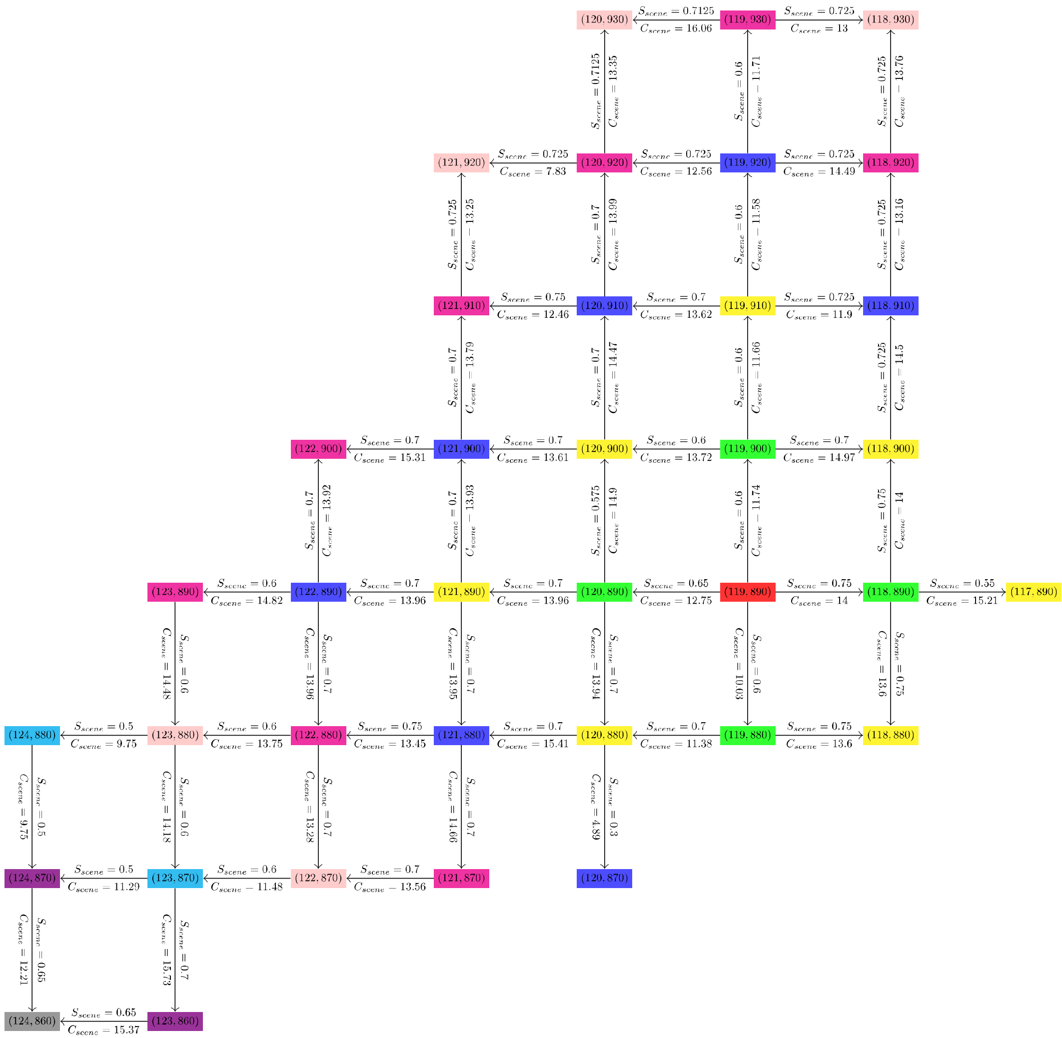


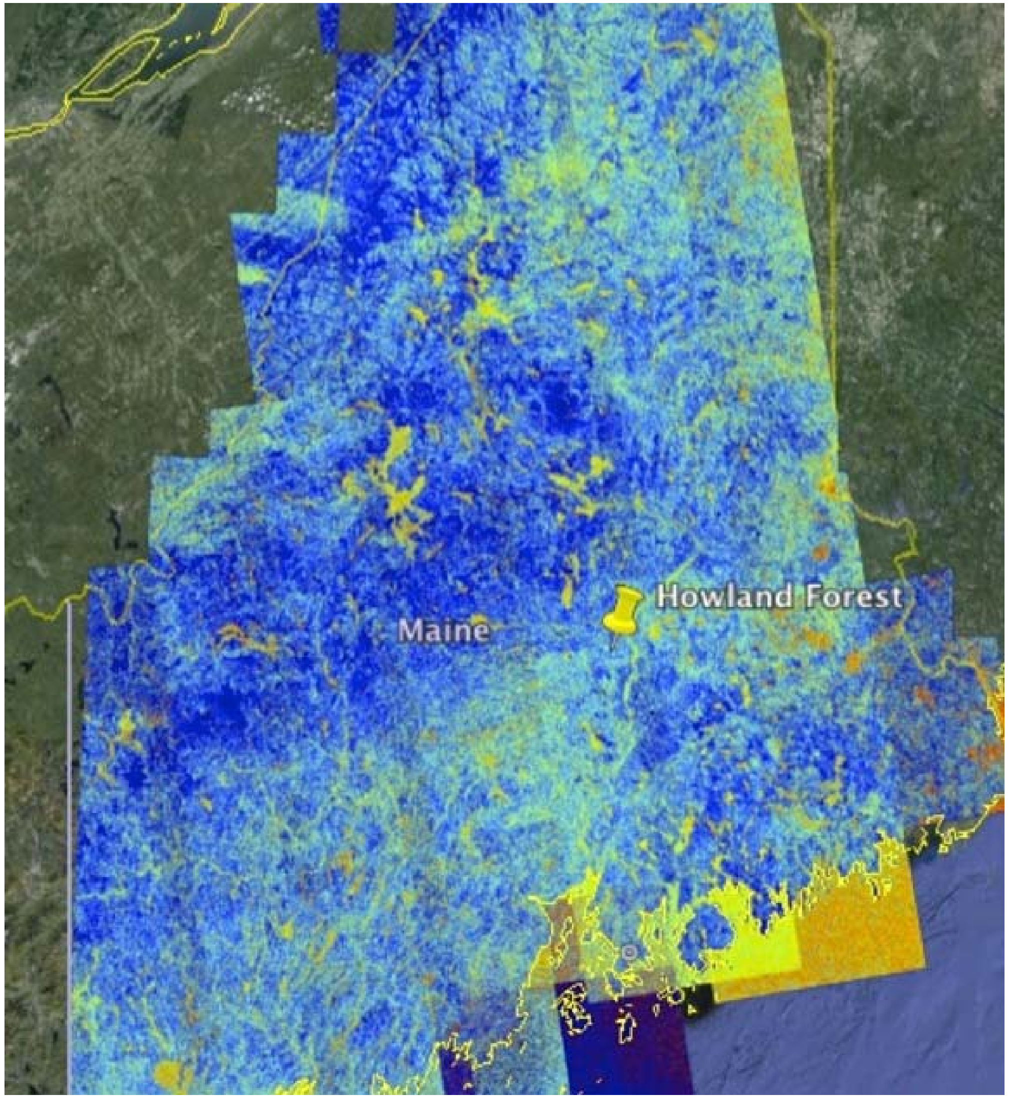


Visual comparison and adjustment for temporal decorrelation



Assembling the Mosaic





A little of the mathematics

A simple model relates the effects of motion and dielectric changes to an invertible function

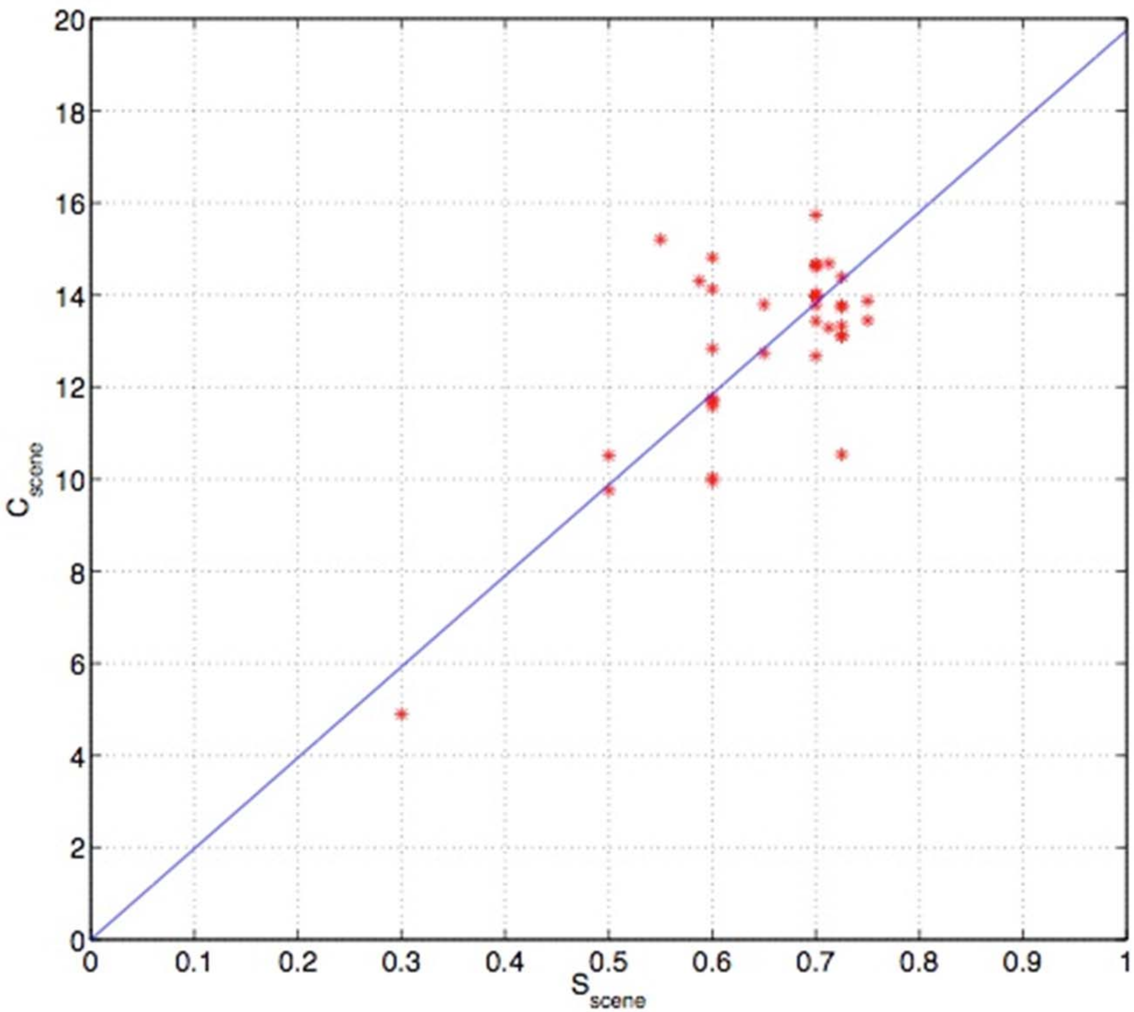
$$|\gamma_{v\&t}| \approx S_{scene} \ \mathrm{sinc}\left(\frac{h_v}{C_{scene}}\right)$$

S_{scene} is related to loss of correlation due to dielectric changes and C_{scene}, the height dependent effects of motion

$$C_{scene} \approx \frac{\lambda h_r}{2\pi^2 \sigma_r}$$

Take home message: Assuming consistency across the scene, only two coefficients need to be determined from overlap regions and ground validation

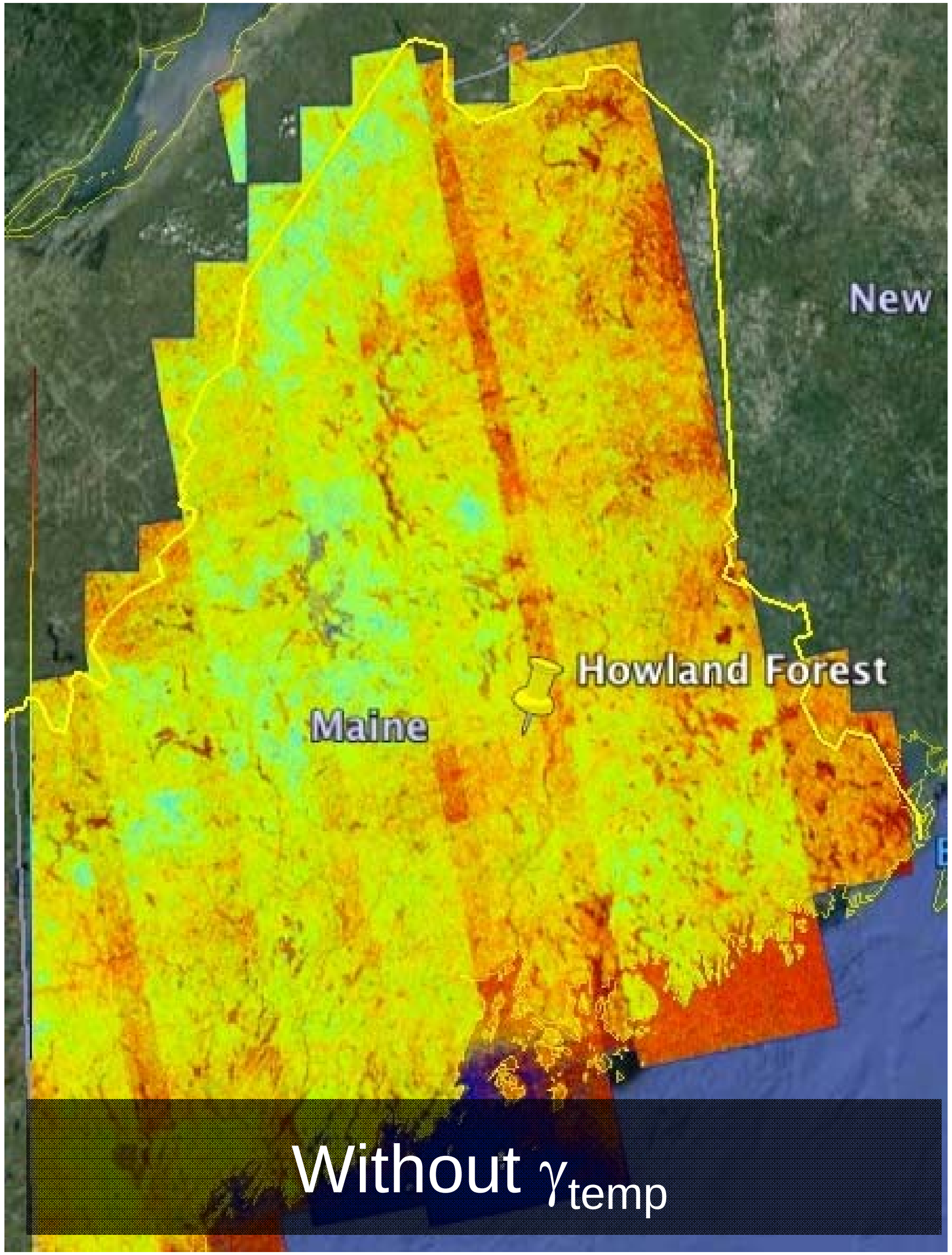
Values of C_{scene} and S_{scene} for the mosaic

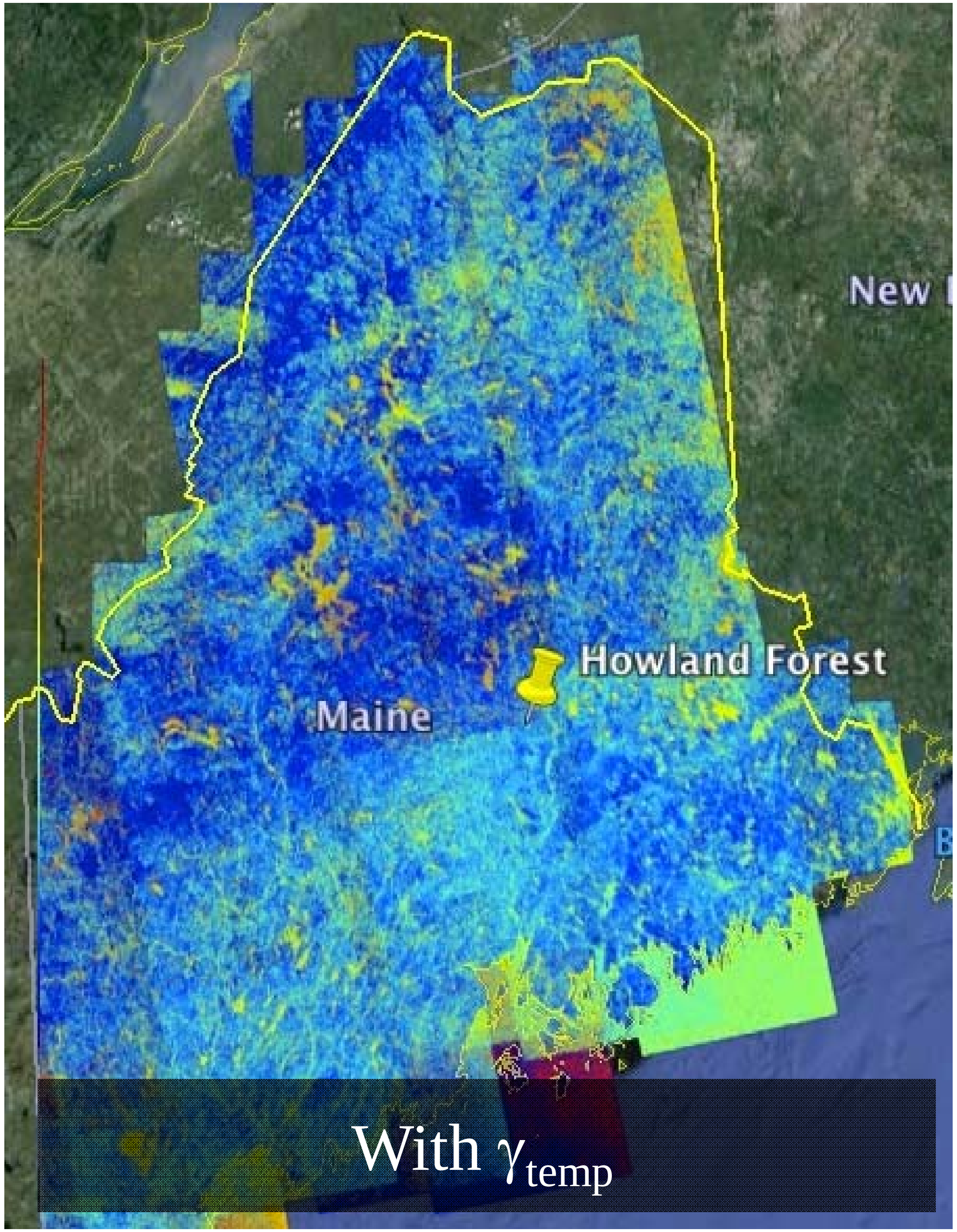


ALOS

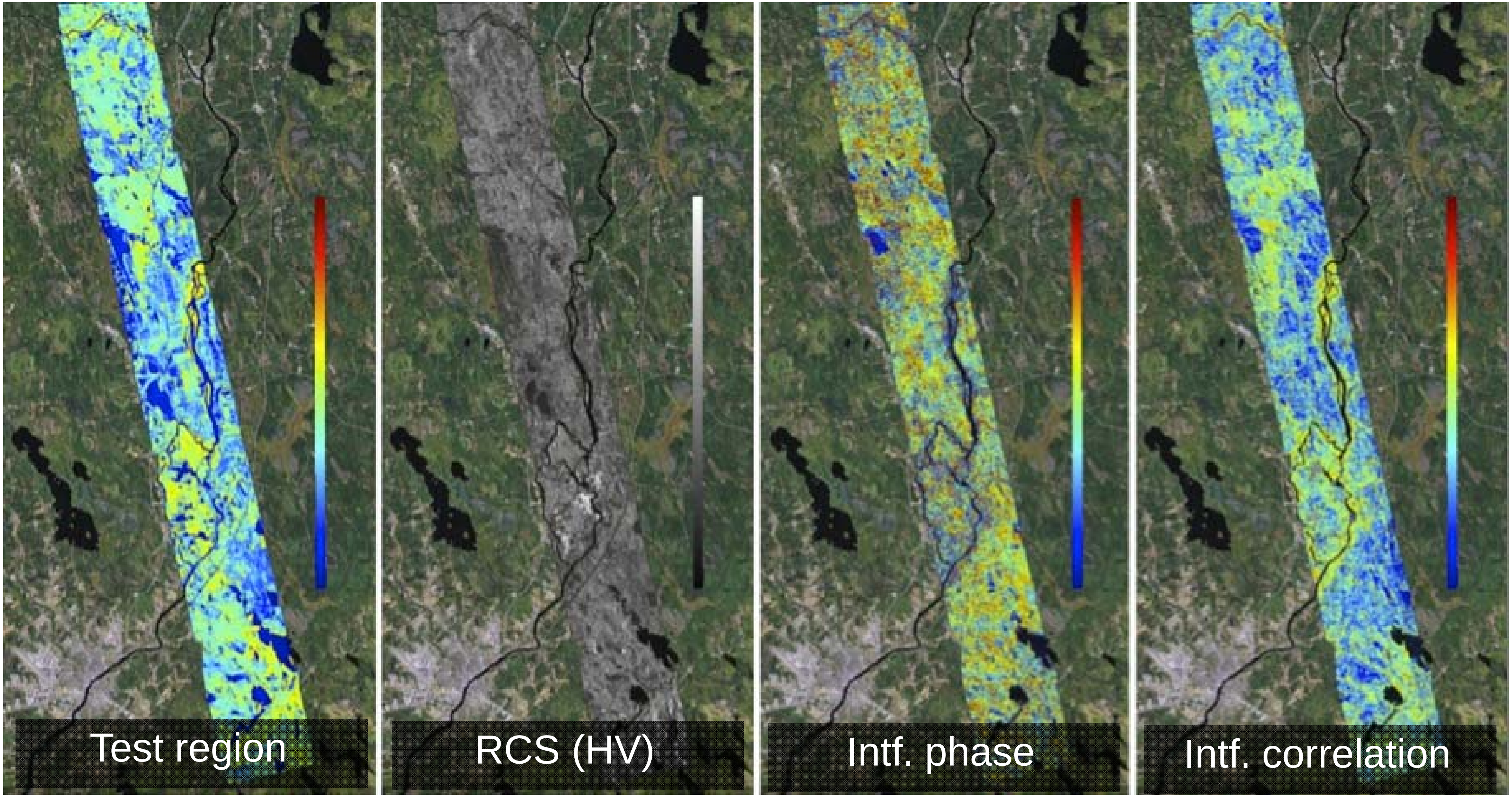
K&C Initiative

An international science collaboration led by JAXA

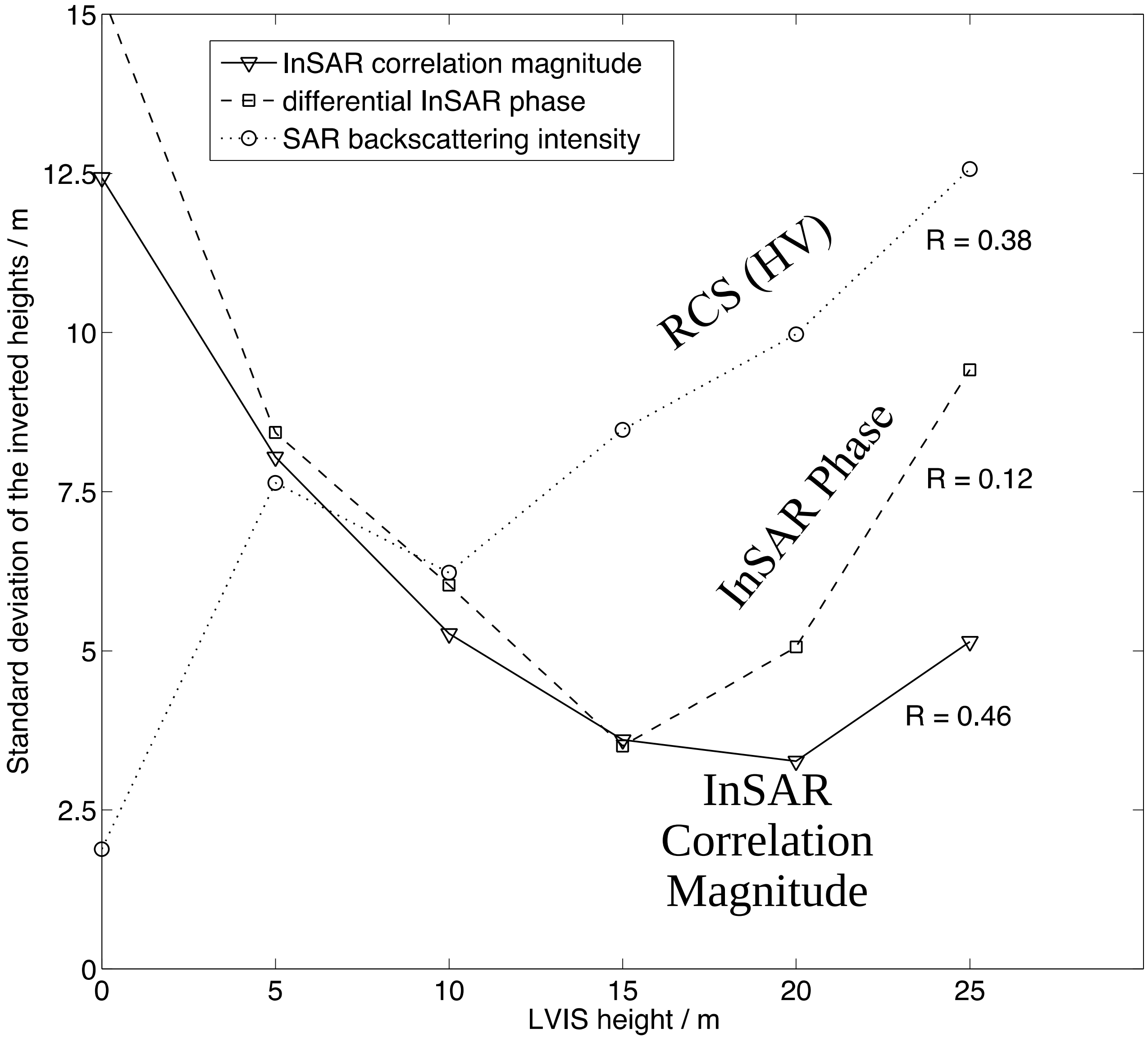




Qualitative Comparison of Methods



Quantititave comparison



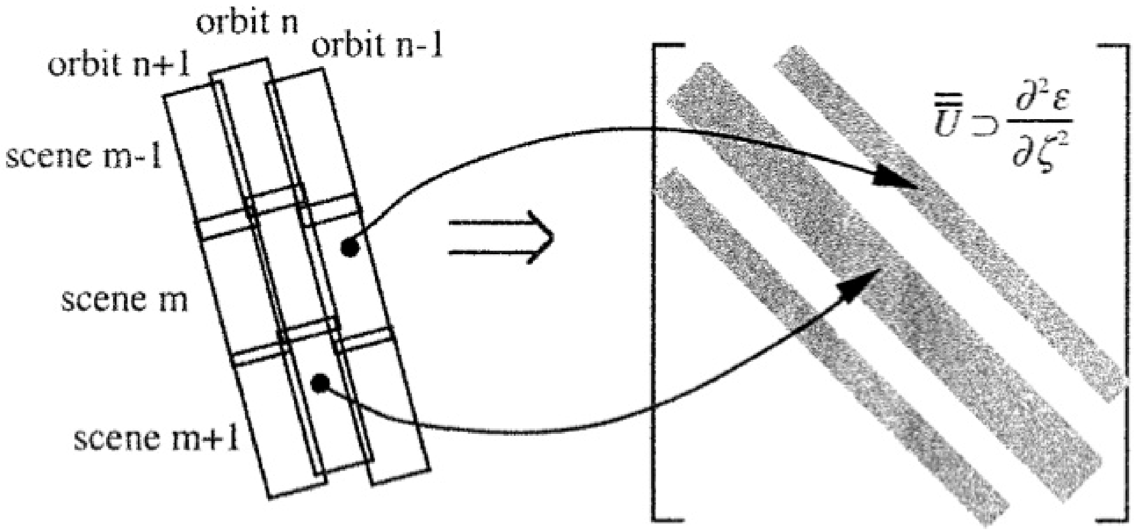
- Assuming that forest stand height (FSH) is a proxy for biomass, we can fit observations of RCS, InSAR differential height from the known DEM (phase) and the correlation magnitude height to the LVIS observed heights.
- Low heights work best with RCS.
- Large Heights have best performance with InSAR correlation magnitude

Summary

• Created an effective height map for the state of Maine

• Results compared qualitatively and quantitatively with LVIS

• Working now on automating and optimizing a method for determining fit coefficients similar to what was done for the Amazon mosaic



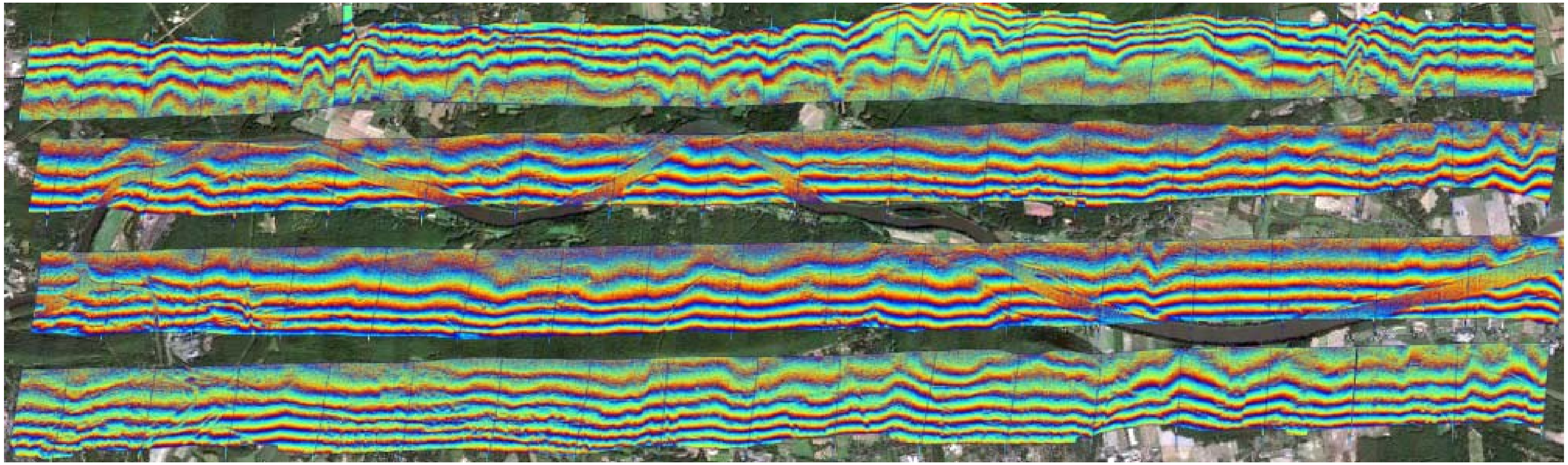
• We are working on two papers that describe the these results

East coast Ka-band

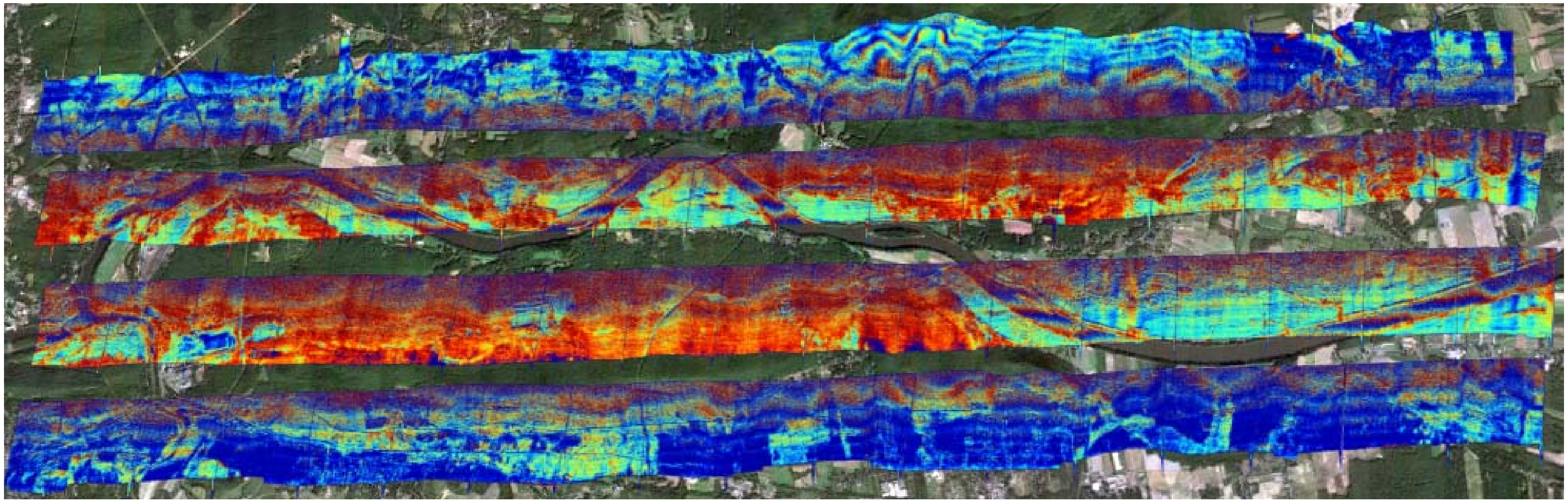
Cessna 206 Stationair

35 GHz SAR Interferometry

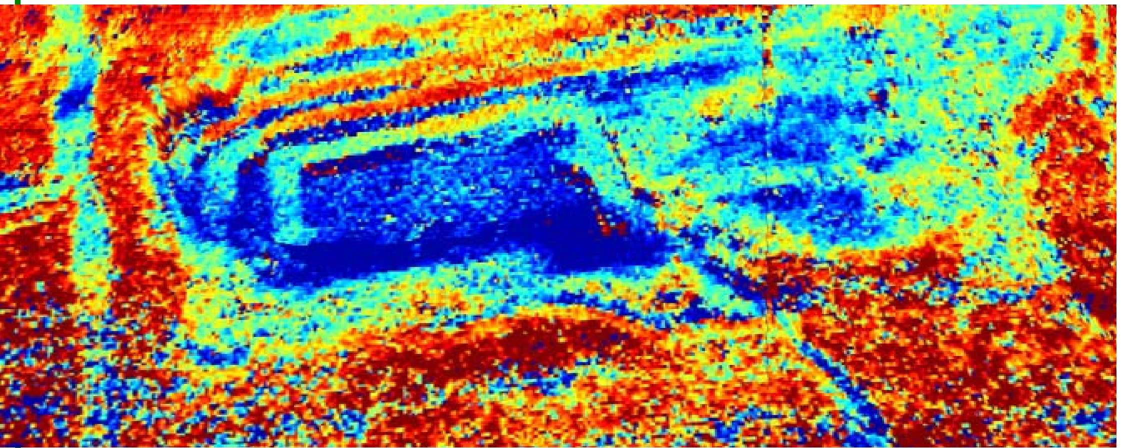
Coherence phase

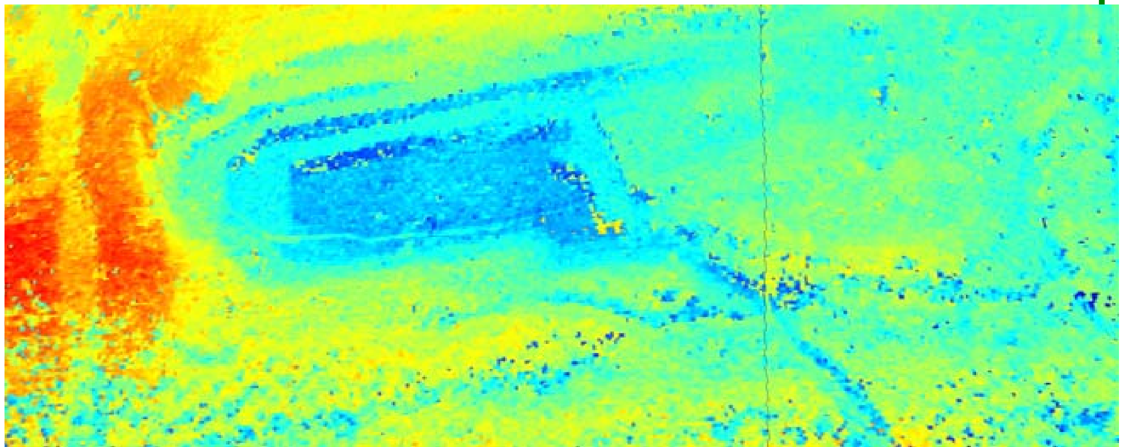


Differential Height



Differential Height Example





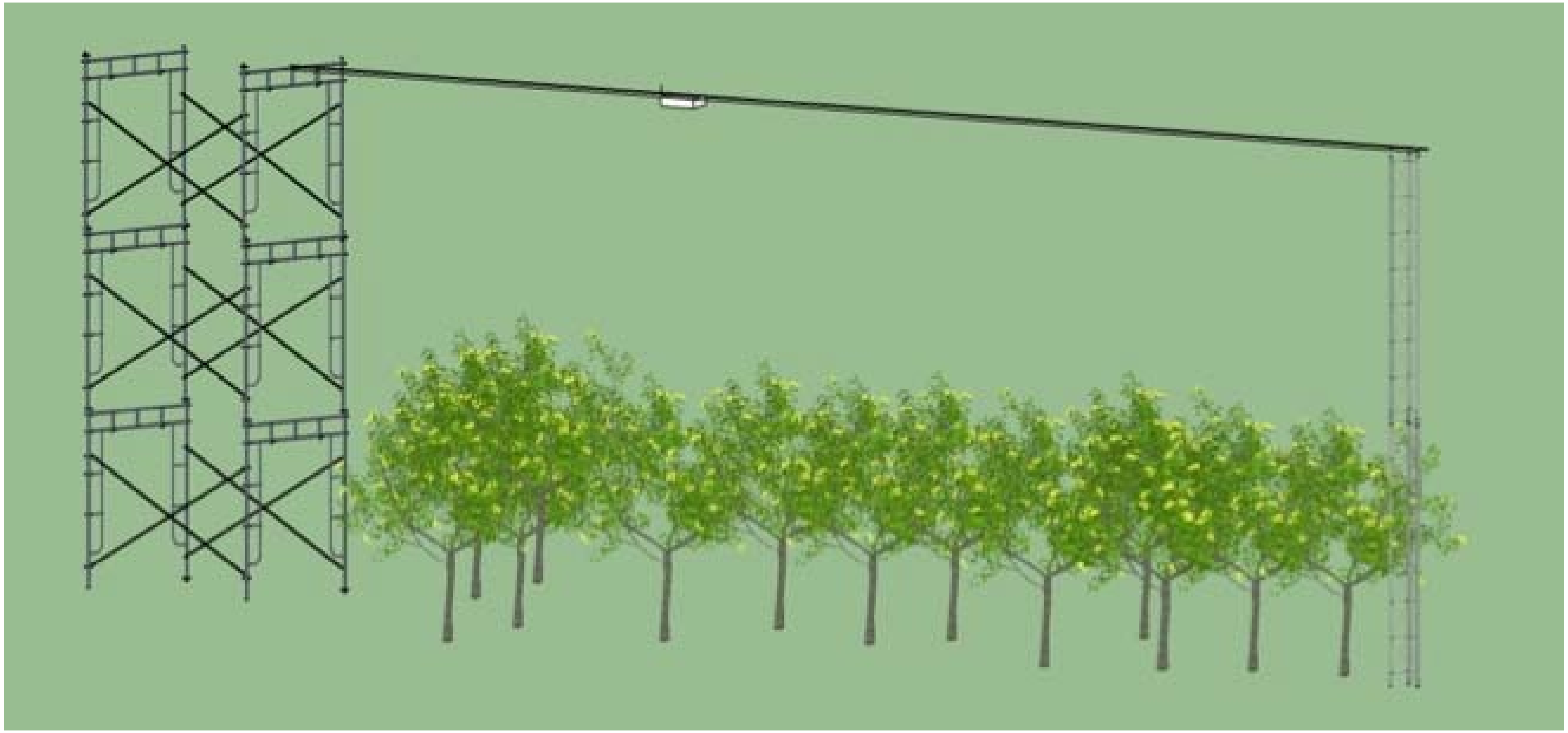
Differential Height

Final DEM

Optical (Google Earth)

Harvard Forest Above-Canopy Tram

- This summer, we will be installing an automated “tram” in one of the clearcut-regrowth plots. There will be a number of instruments on board and measurements are intended to be made on an hourly basis over a 50m length, throughout the year, daytime and nightime (possibly)



A Similar system

Sensors and computers

simple computer

infrared

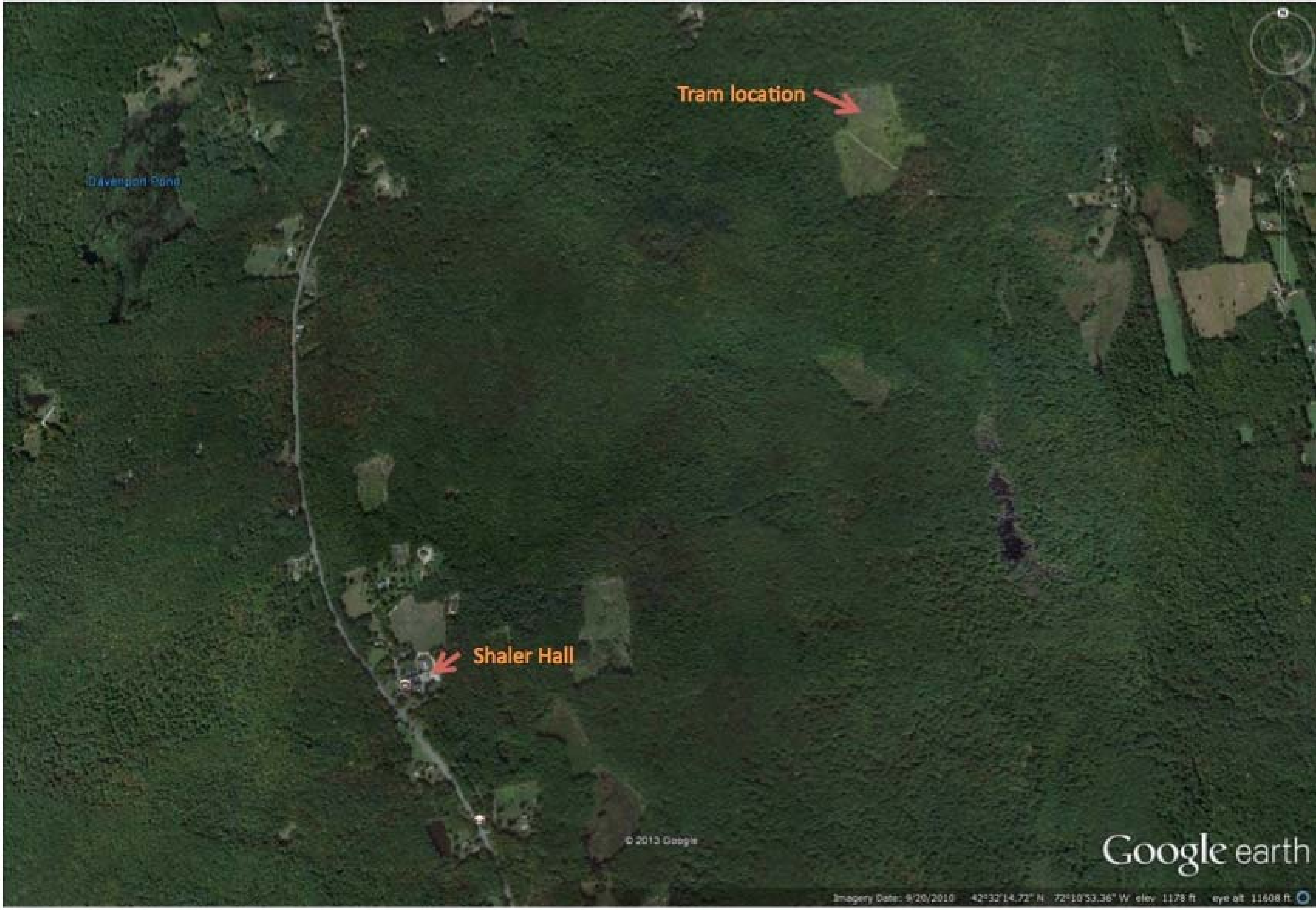
Upwelling and downwelling radiation

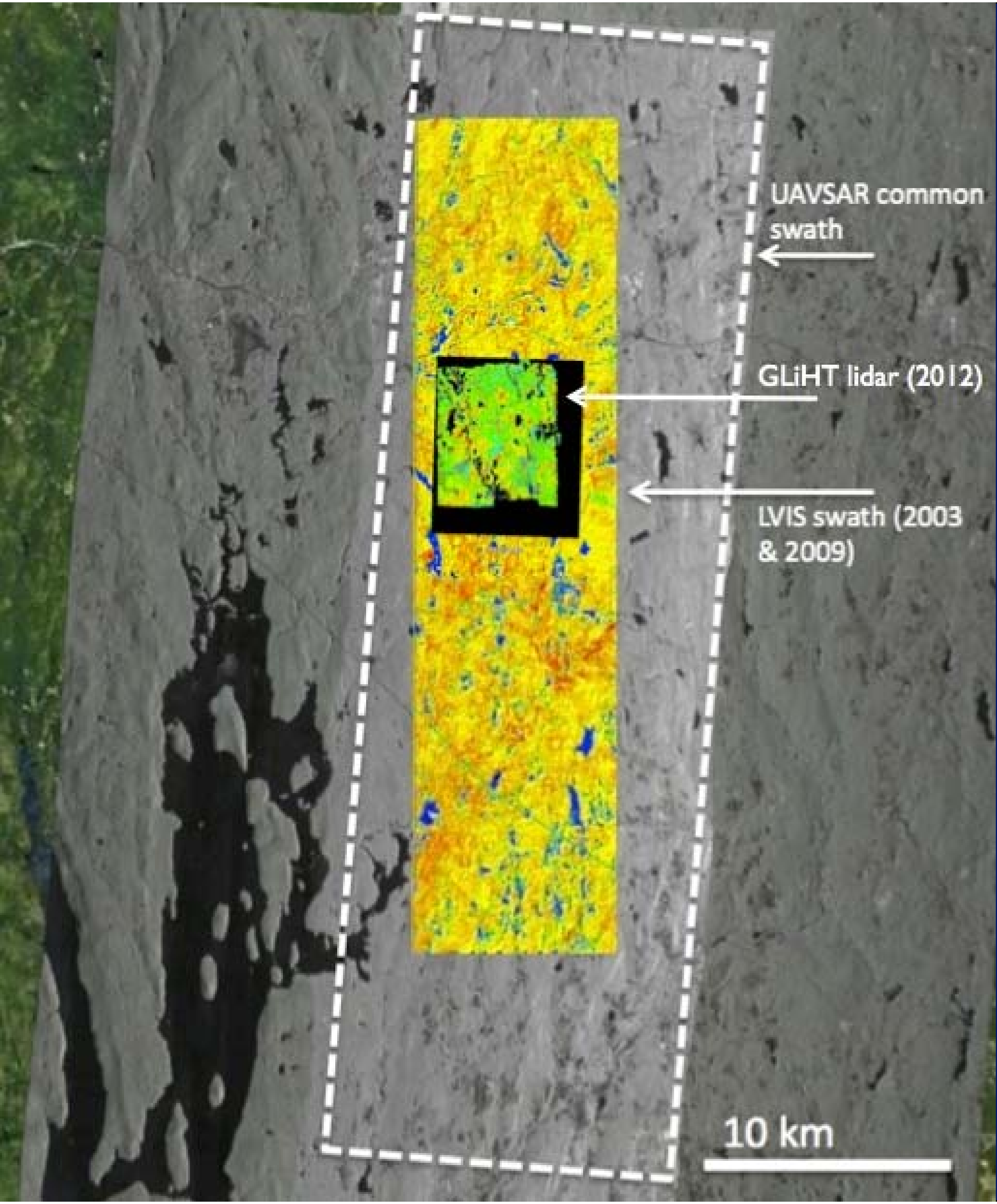
Data Logger

Spectral

Optical camera

An L-band low-power radar for measuring moisture variations (not shown)


Tram location
Davenport Pond
Shaler Hall
© 2013 Google
Google earth
Imagery Date: 9/20/2010 42°32'14.72" N 72°10'53.36" W elev 1178 ft eye alt 11608 ft



Parting thoughts

We are getting to the point where remote sensing data is plentiful, even for opportunistic airborne observations

Processing and data collection is more standardized

Questions now are more about making use of repeated coverage and multisensor observations rather than single sensor solutions