Product Delivery Report for K&C Phase 2

SAR Backscatter, InSAR and Lidar Studies for Measuring Vegetation Structure Over the Harvard Forest Region

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Science Team meeting #15
JAXA TKSC/RESTEC HQ, Tsukuba/Tokyo, January 24-28, 2011

K&C deliverables

Papers and Reports

1. Published

- K&C Phase-1 and Phase-2 reports
- One “contribution” to the K&C Booklet (SAR, InSAR and Lidar Studies for MeasuringVegetation Structure Over the Harvard Forest Region)
- *Ahmed, R., P. Siqueira, K. Bergen, B. Chapman and S. Hensley, “A biomass estimate over the harvard forest using field measurements with radar and lidar data,” IEEE GRSS Proc., 4pp., Honolulu, 2010.*
- *Ahmed, R., P. Siqueira, S. Hensley, B. Chapman, K. Bergen, “Temporal decorrelation studies for vegetation parameter estimation with spaceborne radars,” IEEE GRSS Proc., 481-484, Boston 2008.*
- *Ahmed, R., P. Siqueira, S. Hensley, B. Chapman and K. Bergen, “A survey of temporal decorrelation from spaceborne repeat-pass InSAR,” Rem. Sens. Env., 9pp, accepted for publication, April 2010*

2. Submitted/in preparation

- *Expect to submit at least one paper, based on the K&C phase-2 report, to the RSE special issue.*

K&C deliverables

Data sets and Thematic products (mosaics, classification maps etc.)

This project has been about process development and error analysis. Deliverables have been in the form of methodology and technique comparison

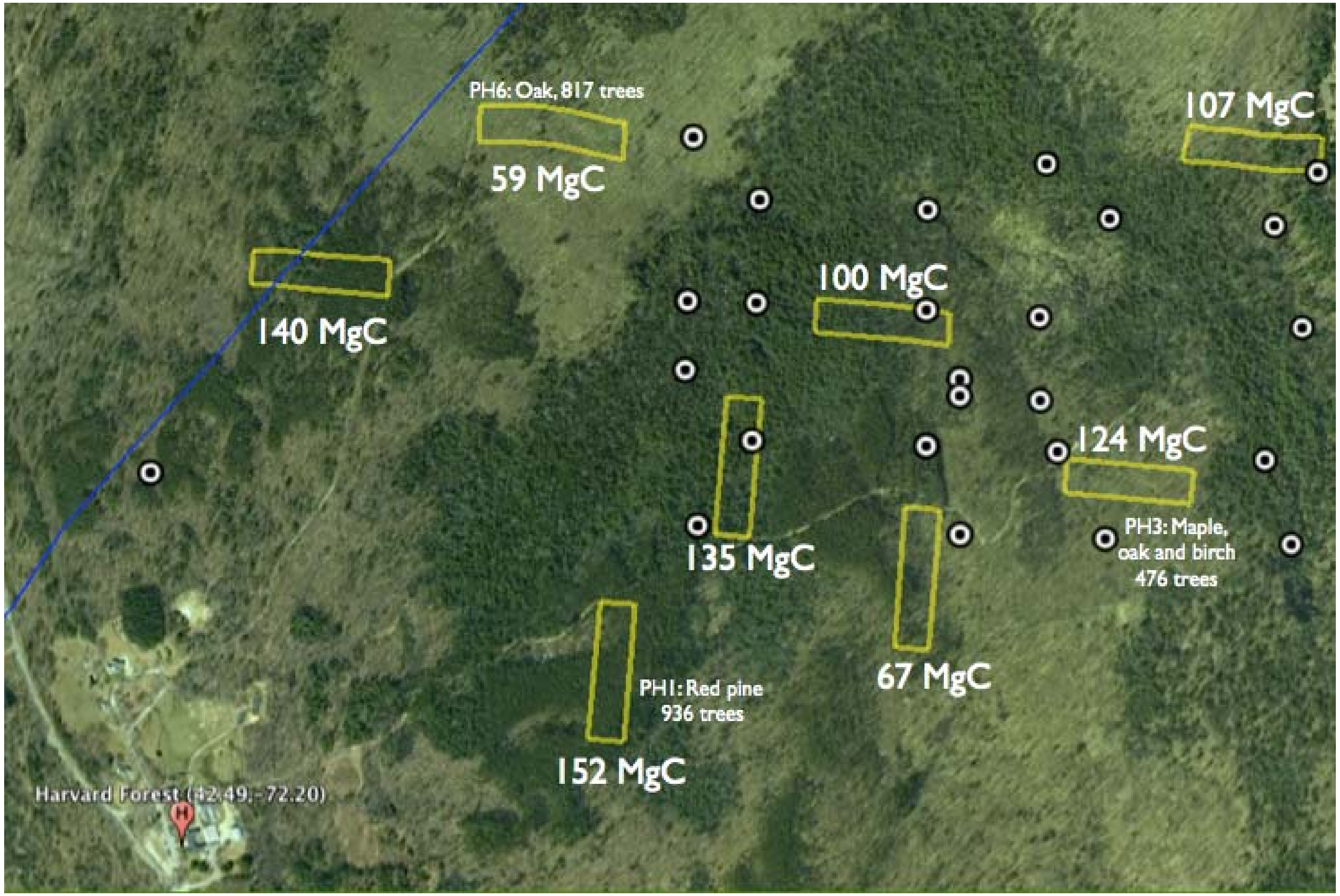
<u>Ground Validation data over the Harvard Forest and Northeast can be made available to the K&C project</u>

We would like to work with JAXA on the validation and refinement of the global forest and biomass map.

The Harvard Forest as a Test Site

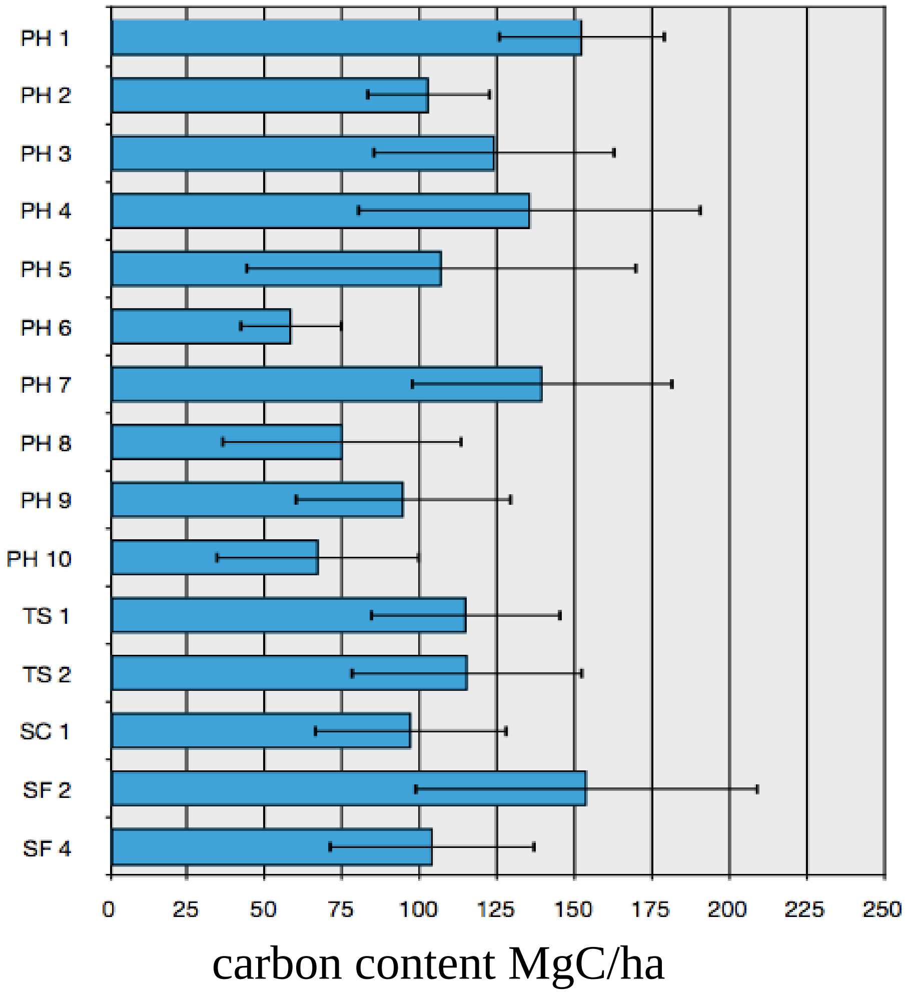
- **The Harvard Forest in Western Massachusetts is being used to develop scalable algroithms that can be applied world-wide. The target variety, terrain flatness and history of observation makes it an appealing remote sensing target for calibration/validation and vegetation studies.**

Ground Validation



- In all, over 10,000 trees were catalogued over 15 one hectare regions, 225 25x25m subplots, for species, dbh, and live-or-dead

Ground Validation Summary



Within the 15 one hectare validation sites, DBH, species and number density were recorded. These are converted into Biomass and carbon content via allometric equations. The reange of biomasses are from 120 to 310 tons per hectare.

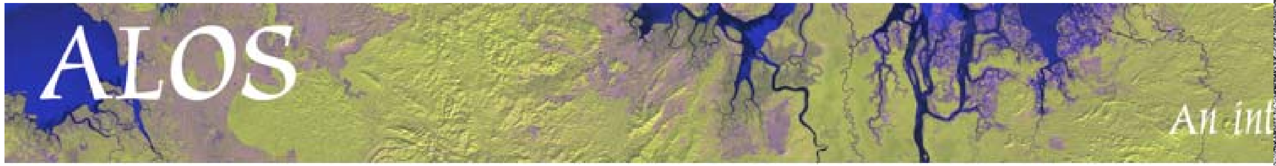
1	2	3	4	5	6	7	8
16	15	14	13	12	11	10	9

ALOS/PALSAR DATA

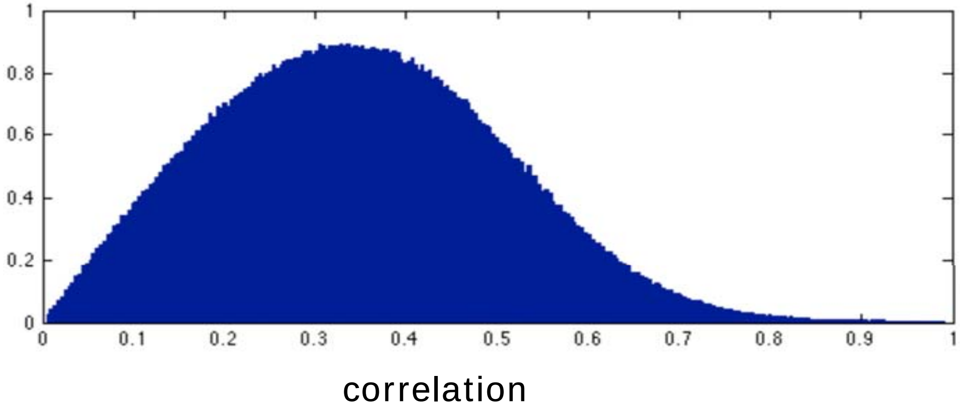
ALOS/PALSAR
- 48 FBS Scenes
- 20 FBD Scenes
- 30 PLR Scenes
- 46 day repeat

Data has been processed interferometrically, but suffers from temporal decorrelation

Parameter	Value		
Center Frequency	1270MHz		
Modes	FBS	FBD	PLR
Bandwidth	28MHz	14MHz	14MHz
Polarization	HH	HH, HV	HH, HV, VH, VV
Resolutions	4.6x3.5m	9.3x3.5m	9.3x3.5m

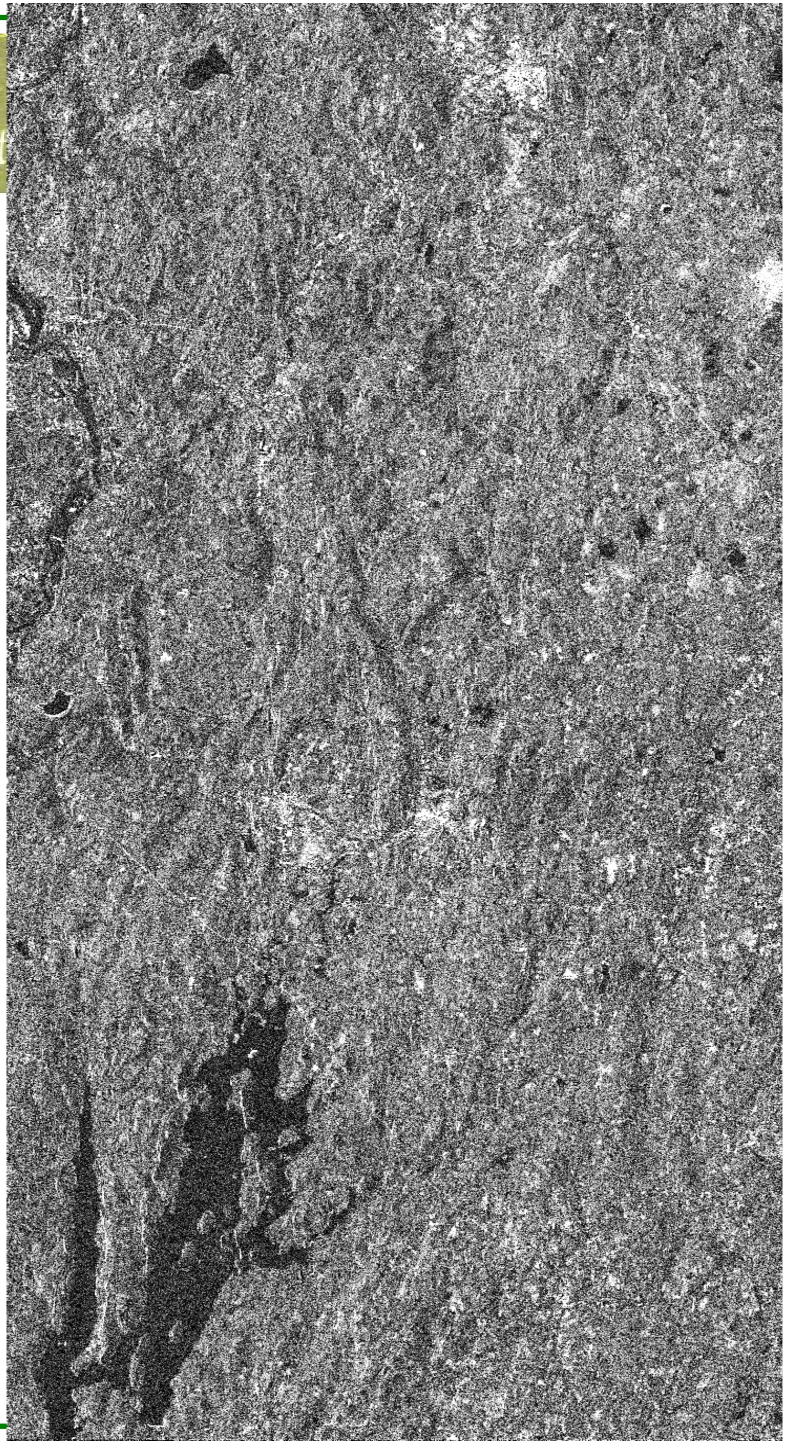


Correlation (uncorrected)



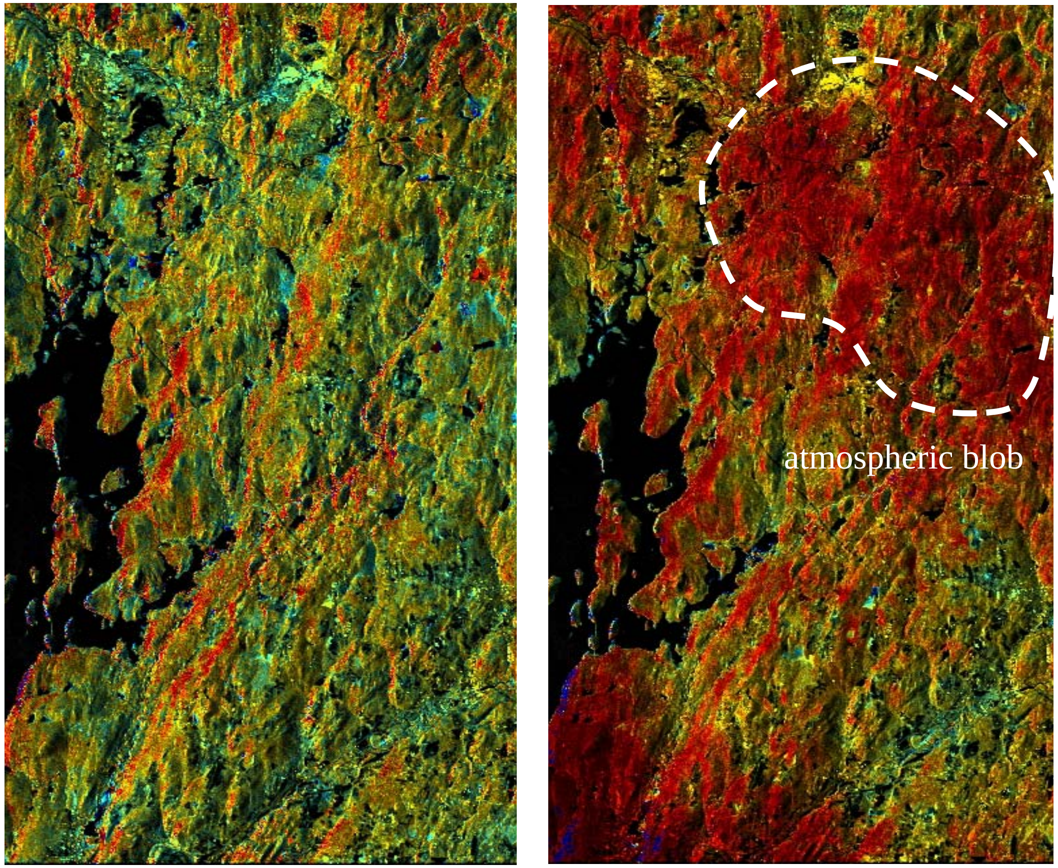
As reported by many, a 46-day repeat period causes problems in terms of using the interferometric coherence for InSAR and PolInSAR for quantitative estimation of vegetation characteristics.

Use of coherence may still be suitable for forest/non-forest classification.



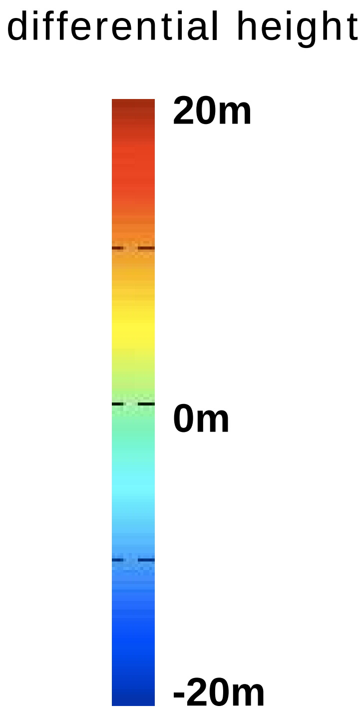
Differential Interferometry?

- A C-band DEM and PALSAR interferometric pairs could, in principal, be used to measure differential penetration
- Initial results show that the signature is dominated by atmospheric effects



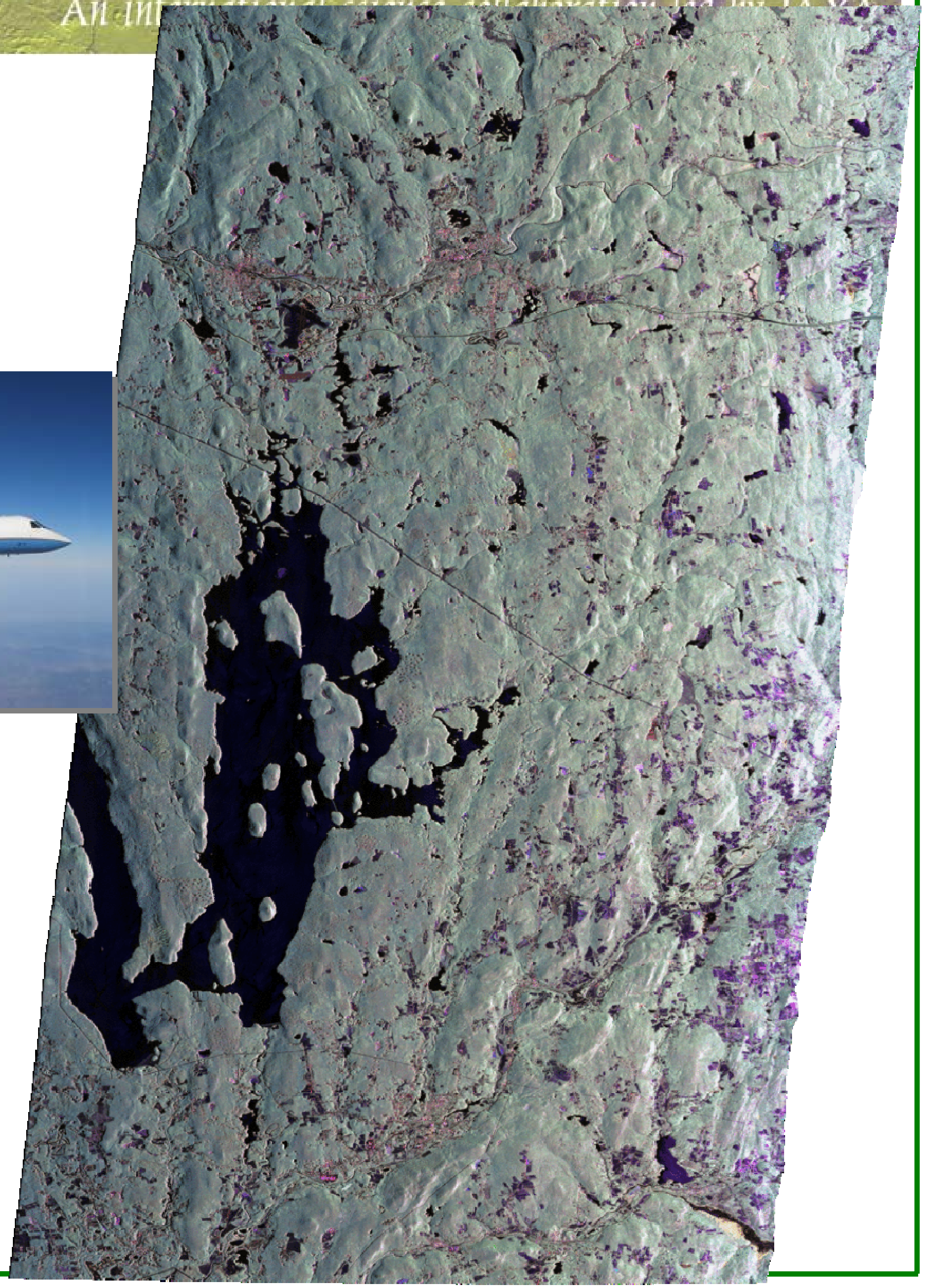
PALSAR, PLR HH
11/06 - 12/06 Diff. Hgt.

PALSAR, PLR HH
12/06 - 4/07 Diff. Hgt.



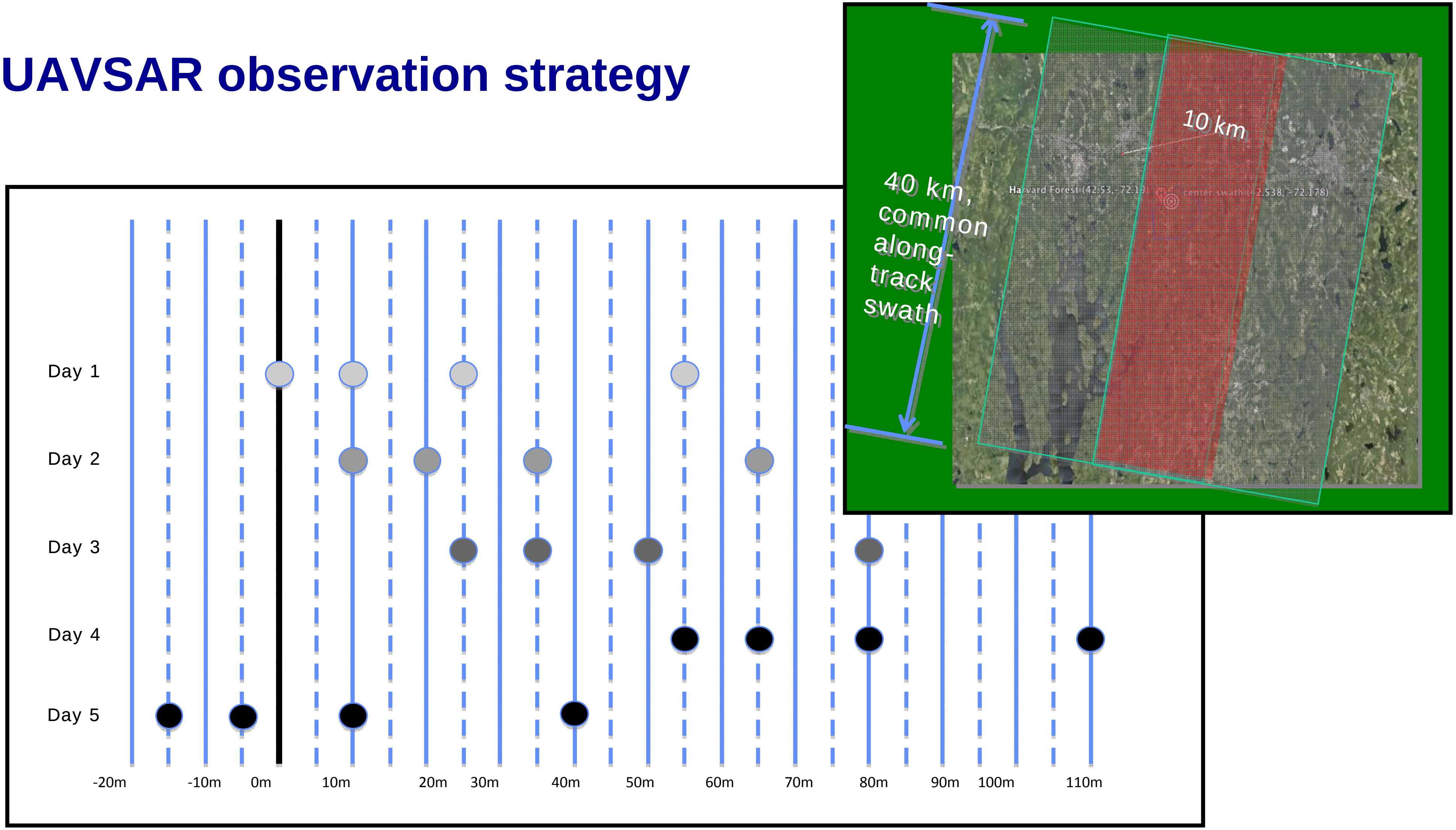
UAVSAR DATA

Between August 4 – 15, 2009, UAVSAR flew over the Harvard region in a repeat-pass, racetrack configuration

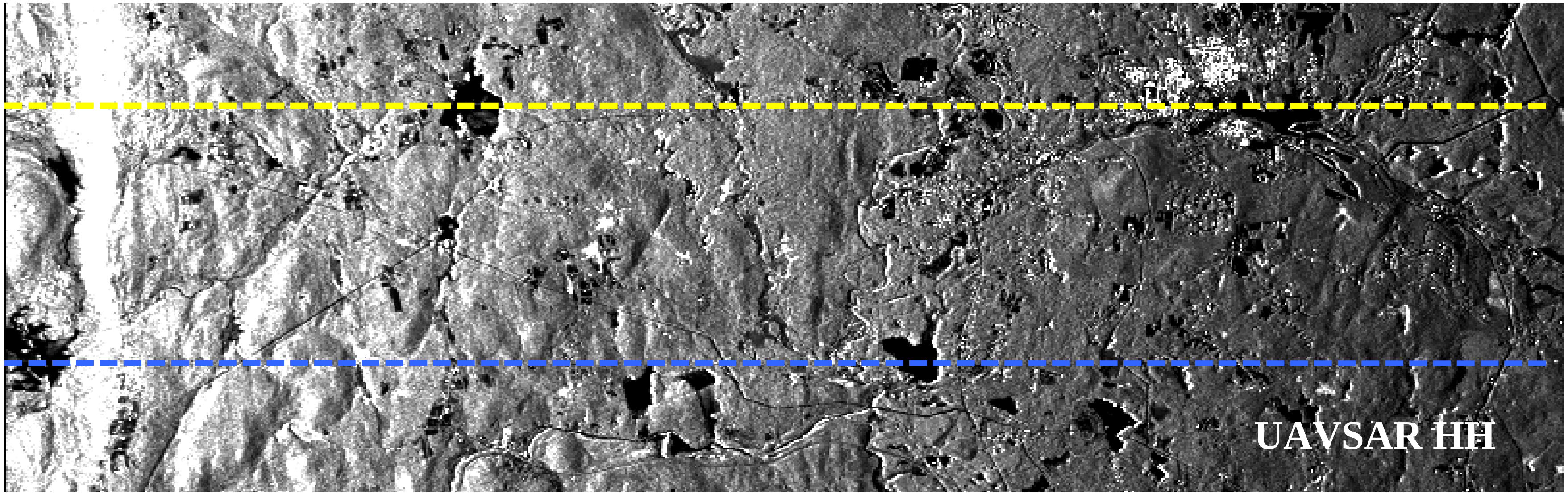


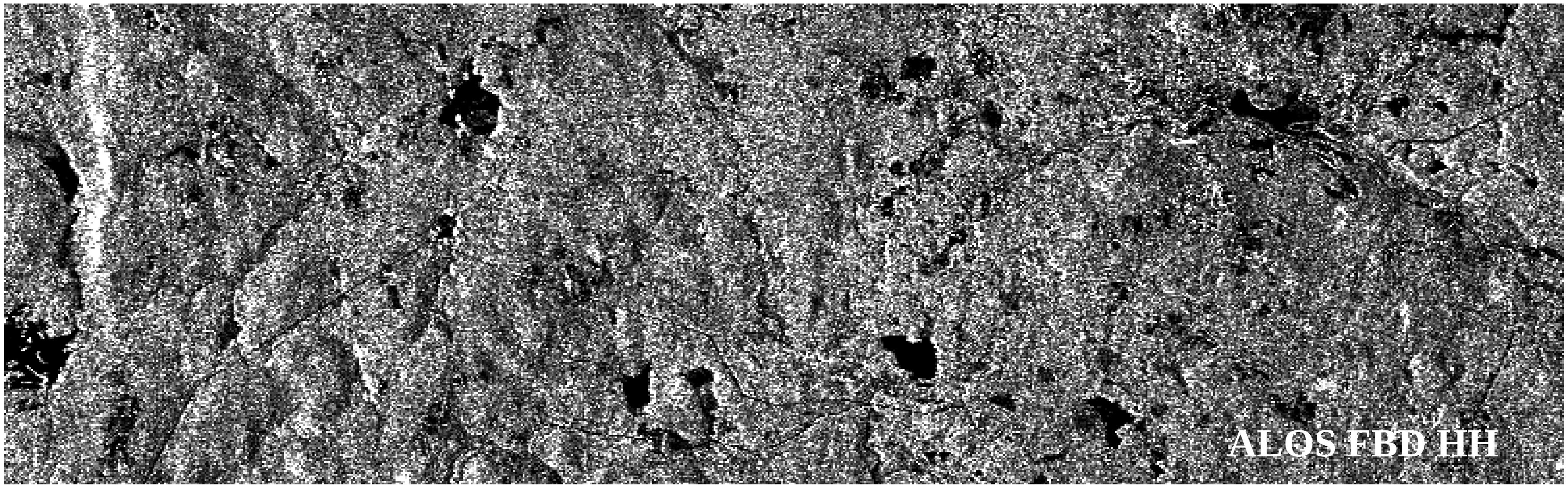
Parameter	Value
Frequency	1.26GHz
Bandwidth	80MHz
Polarization	HH, HV, VH, VV
Look Angles	25 - 65 degrees
Resolution	1.6 x 0.66 m

UAVSAR observation strategy



All passes occur at same altitude (12.5 km), with a 40 degree look angle to center swath


UAVSAR HH


ALOS FBD HH

ALOS

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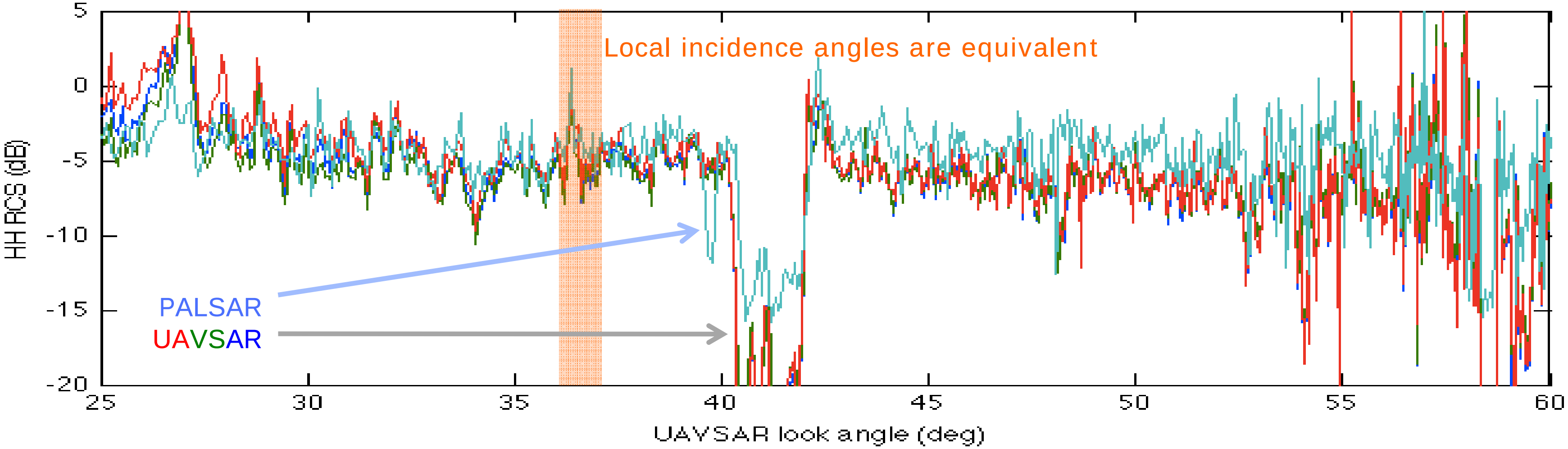
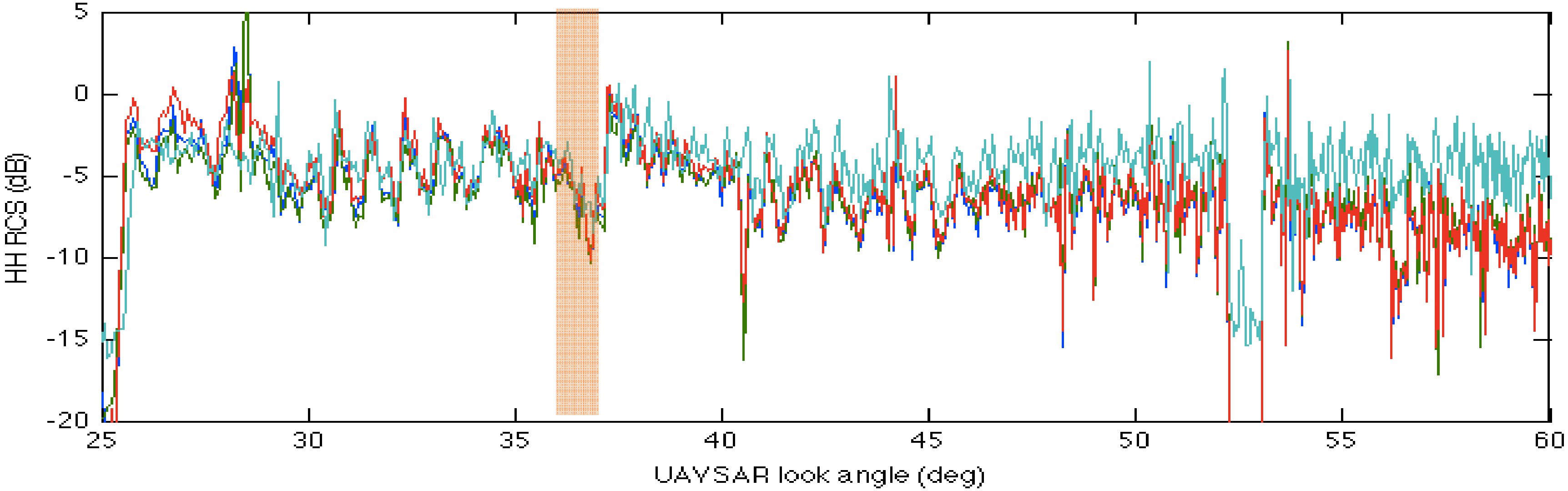
UAVSAR and ALOS Backscatter Comparison





Data selected for comparison and analysis

$$\gamma_0 = \frac{\sigma^0}{\cos(\vartheta_i)}$$

ALOS/PALSAR

- 8 FBD scenes (9.5 x 3.5m resolution)
- The acquisition dates range from 2006 to 2009
- All scenes acquired between the months of July and October
- Backscatter data has been compensated for area projection and local incidence angle variations using 30m SRTM DEM

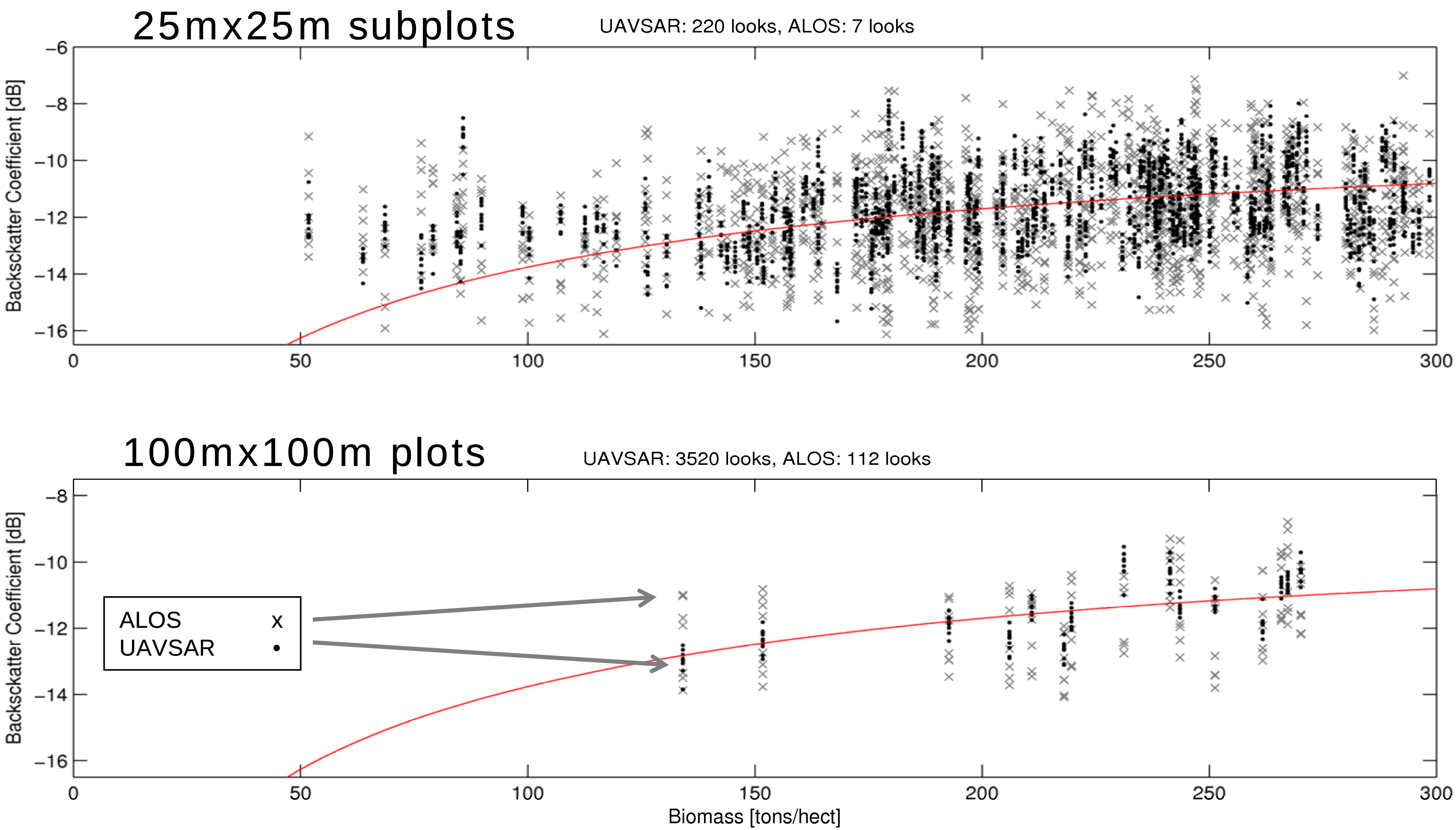
UAVSAR

- 10 scenes (1.6 x 0.66m) from 5° heading
- Data acquired on three days; August, 6th, 8th and 16th of 2009.
- Projection area and incidence angle variations compensated for using 30m SRTM DEM

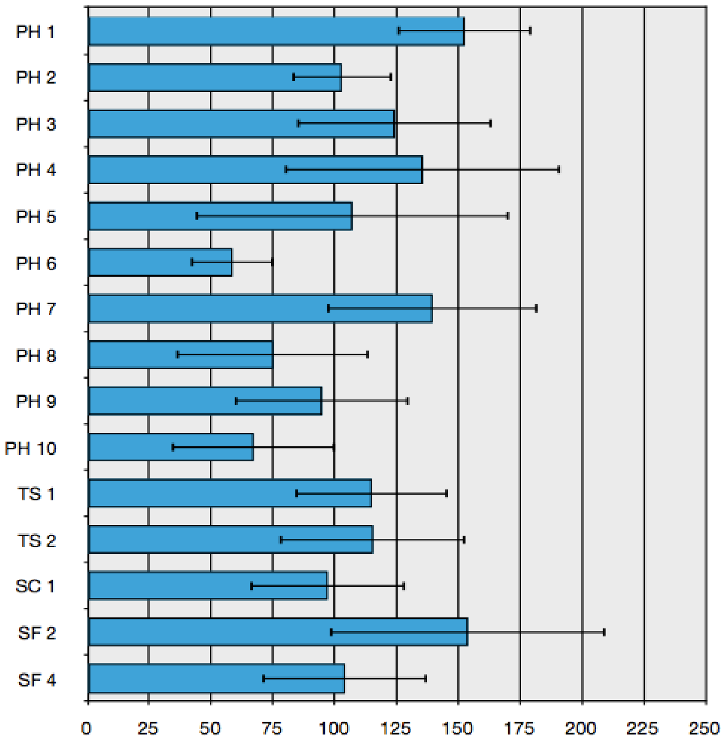
Ground Validation

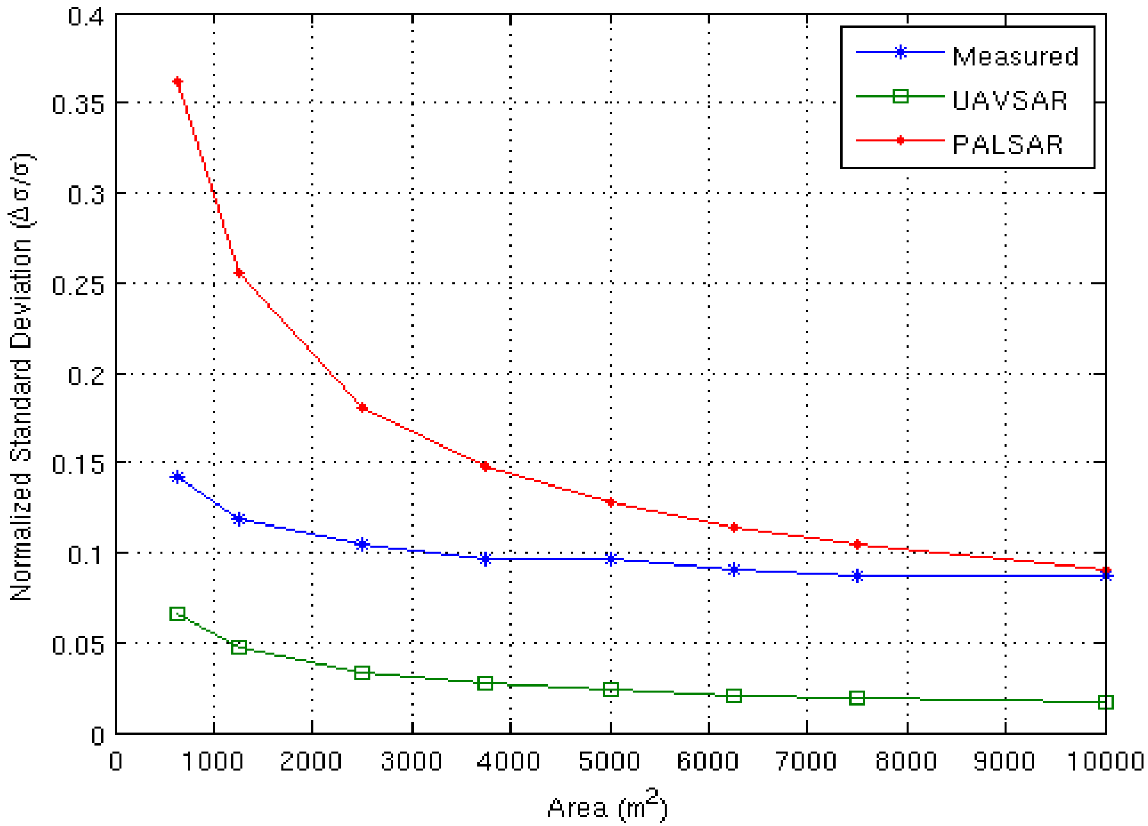
- Biomass estimates from 240 survey locations (subplots)

Backscatter (HV) and biomass

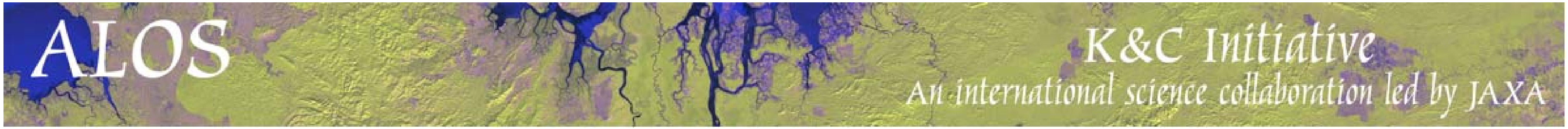


Relative error as a function of area





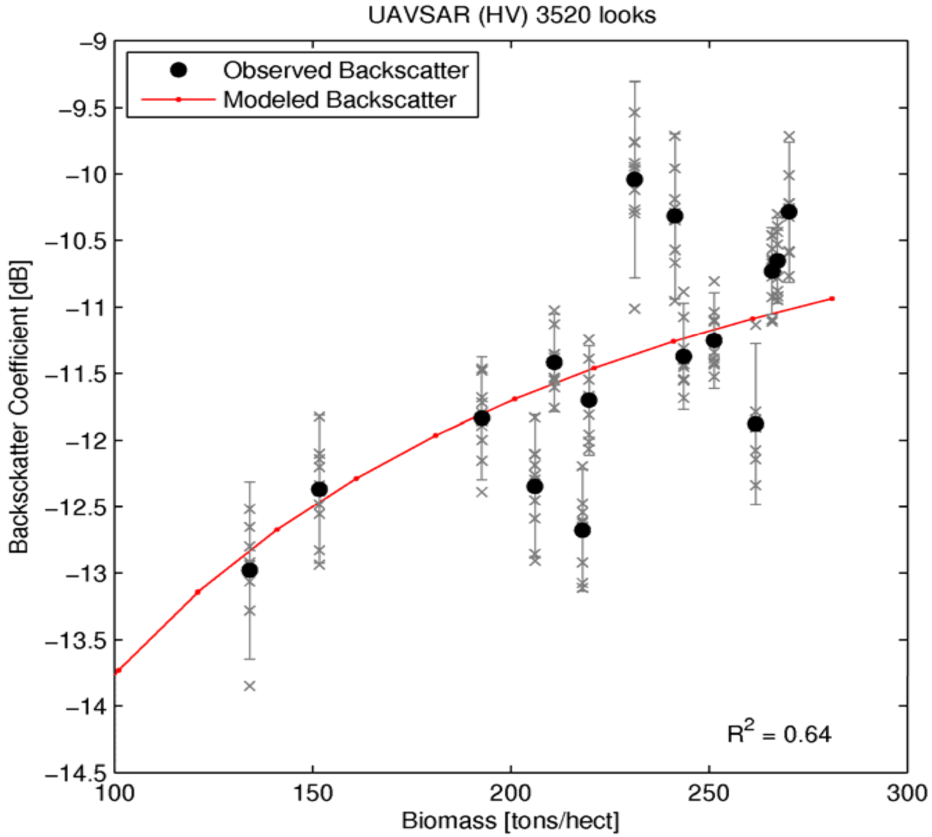
$$\sigma = A\left(1 - e^{-Bb}\right) + Cb^{\alpha}e^{-Bb} \qquad \frac{\Delta\sigma}{\sigma} = \frac{1}{\sqrt{N}}\left(1 + \frac{1}{SNR}\right)$$

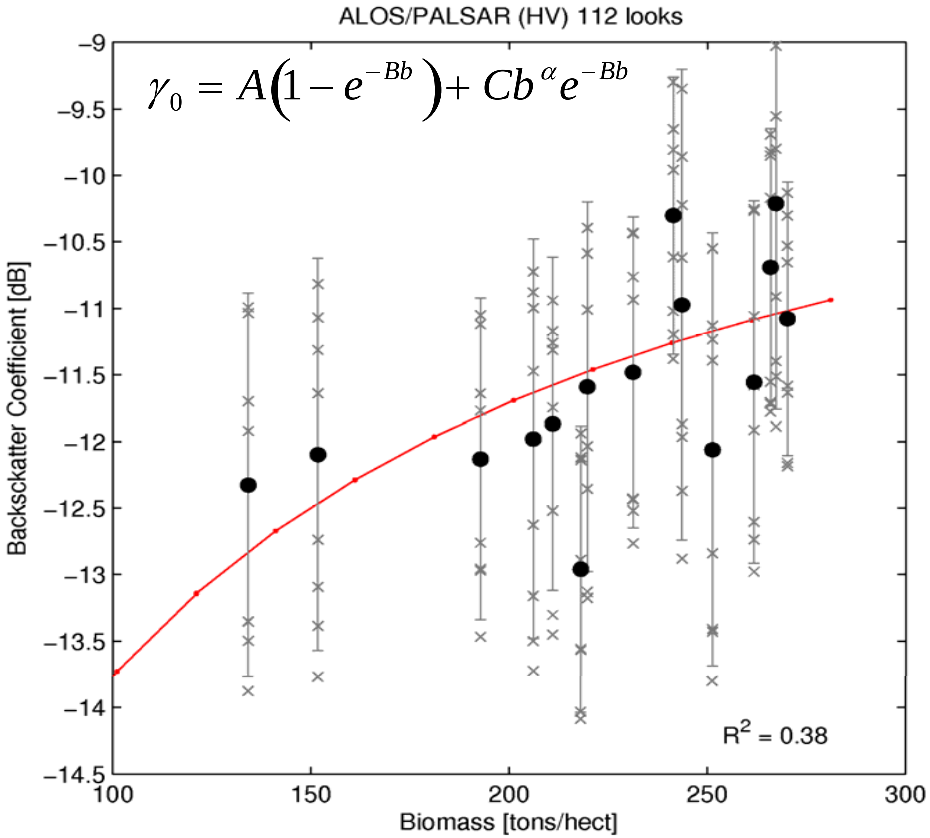


Hectare scale estimates

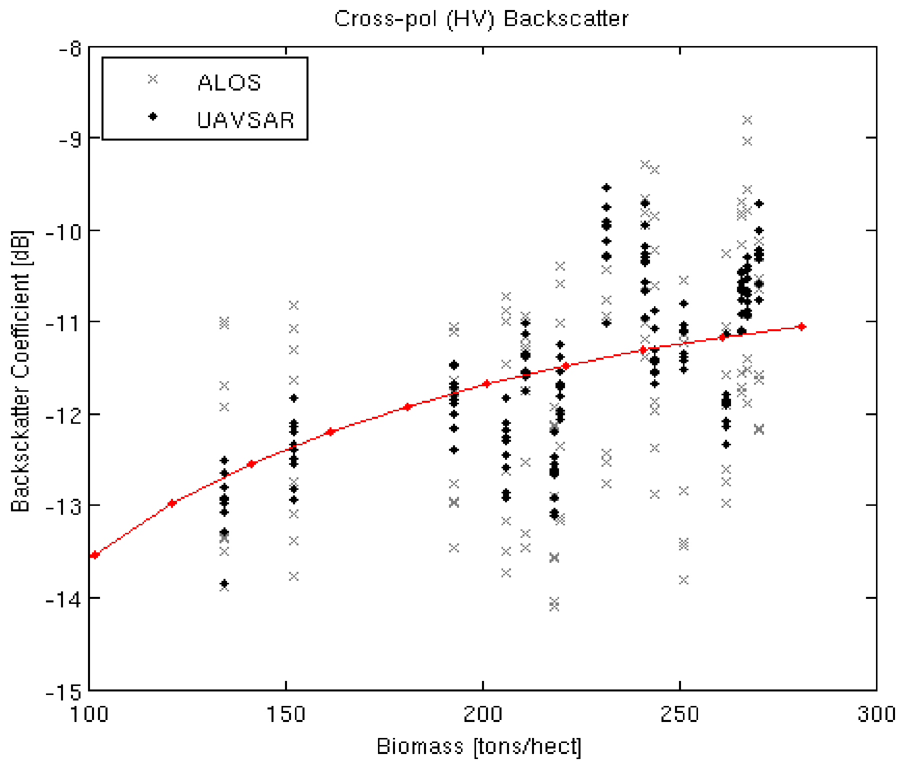
Over one-hectare sized plots, the variance is significantly reduced, thus improving the ability for making biomass estimates from backscatter observations.

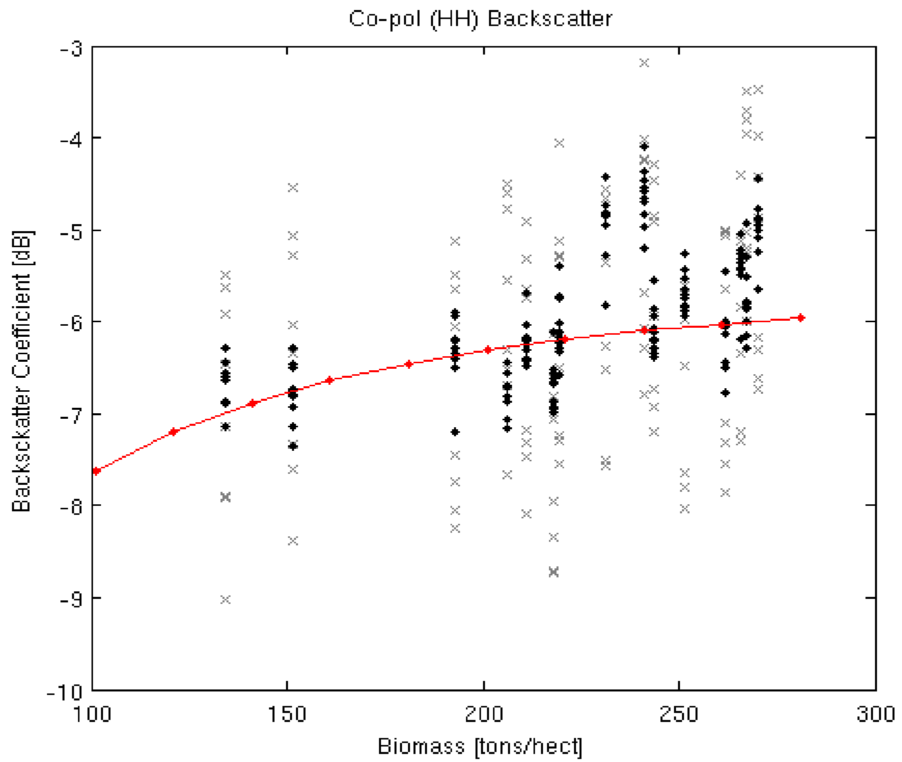
This is a strong argument for increased bandwidth. A difficult quantity to come by.





Polarization dependence





The oberved relationship is not a strong function of polarization, but a “bias” between co-pol and cross-pol is evident in the data as expected

Saturation does appear to occur at lower biomass levels for co-pol compared to cross-pol

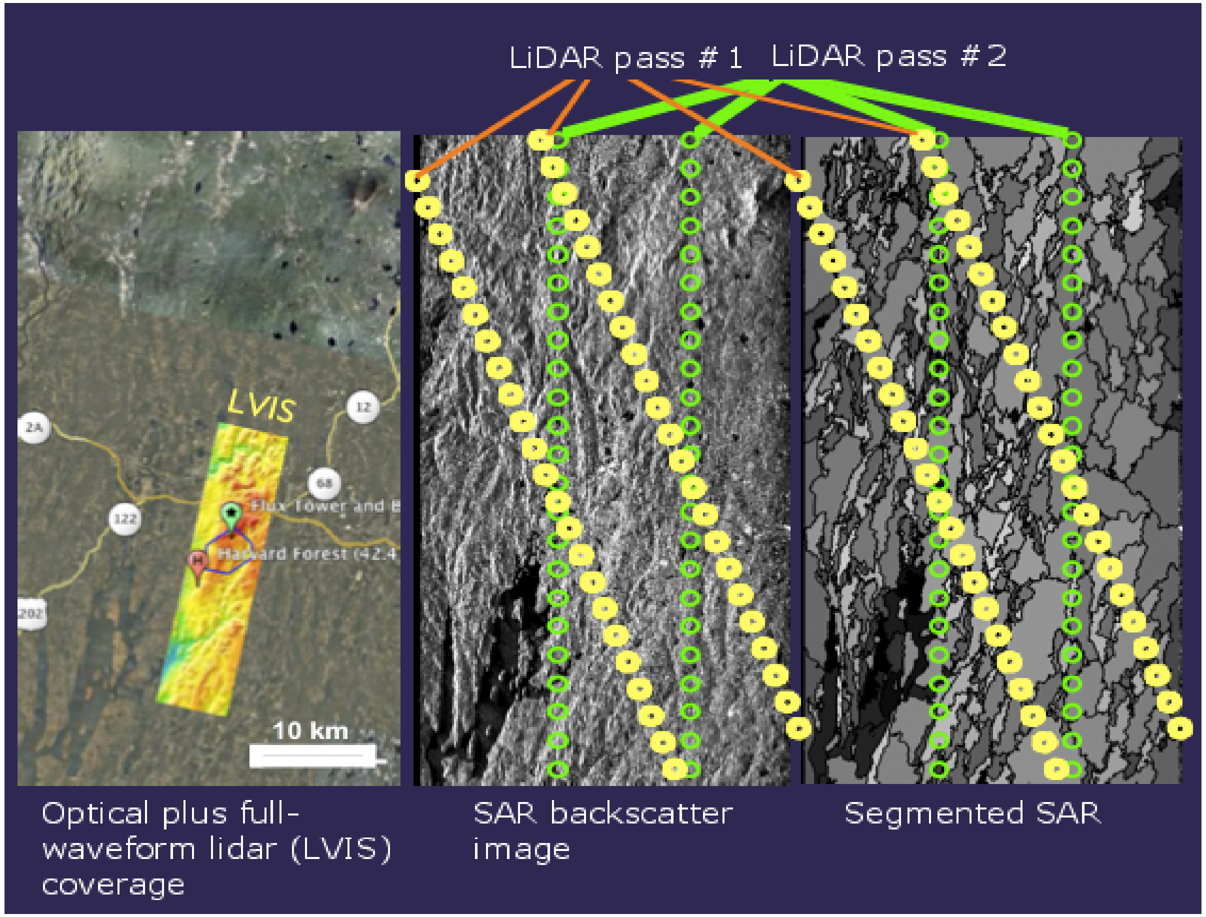
Segmentation Approach

- Due to difficulties in measuring structure from backscatter and repeat-pass interferometry, an alternate approach to structure estimatation is being investigated.

  - Relies on the fundamental sensitivity of SAR backscatter power, texture and polarimetry to varying ground cover.

  - Aggregate regions of a like response via an image segmentation

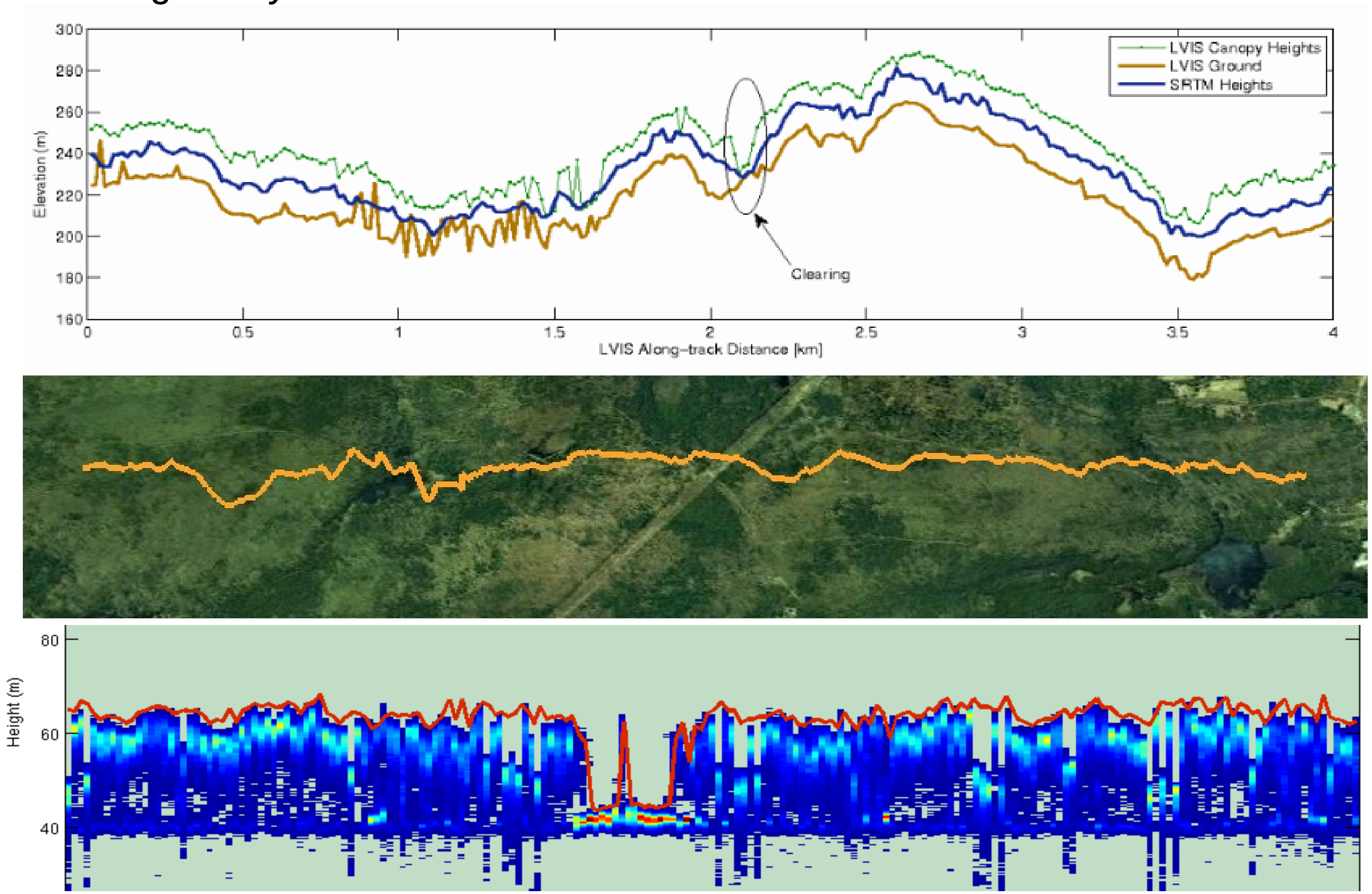
  - Utilize coicident LiDAR observations on a scene by scene basis to assign values of interest to the segmented RaDAR image.

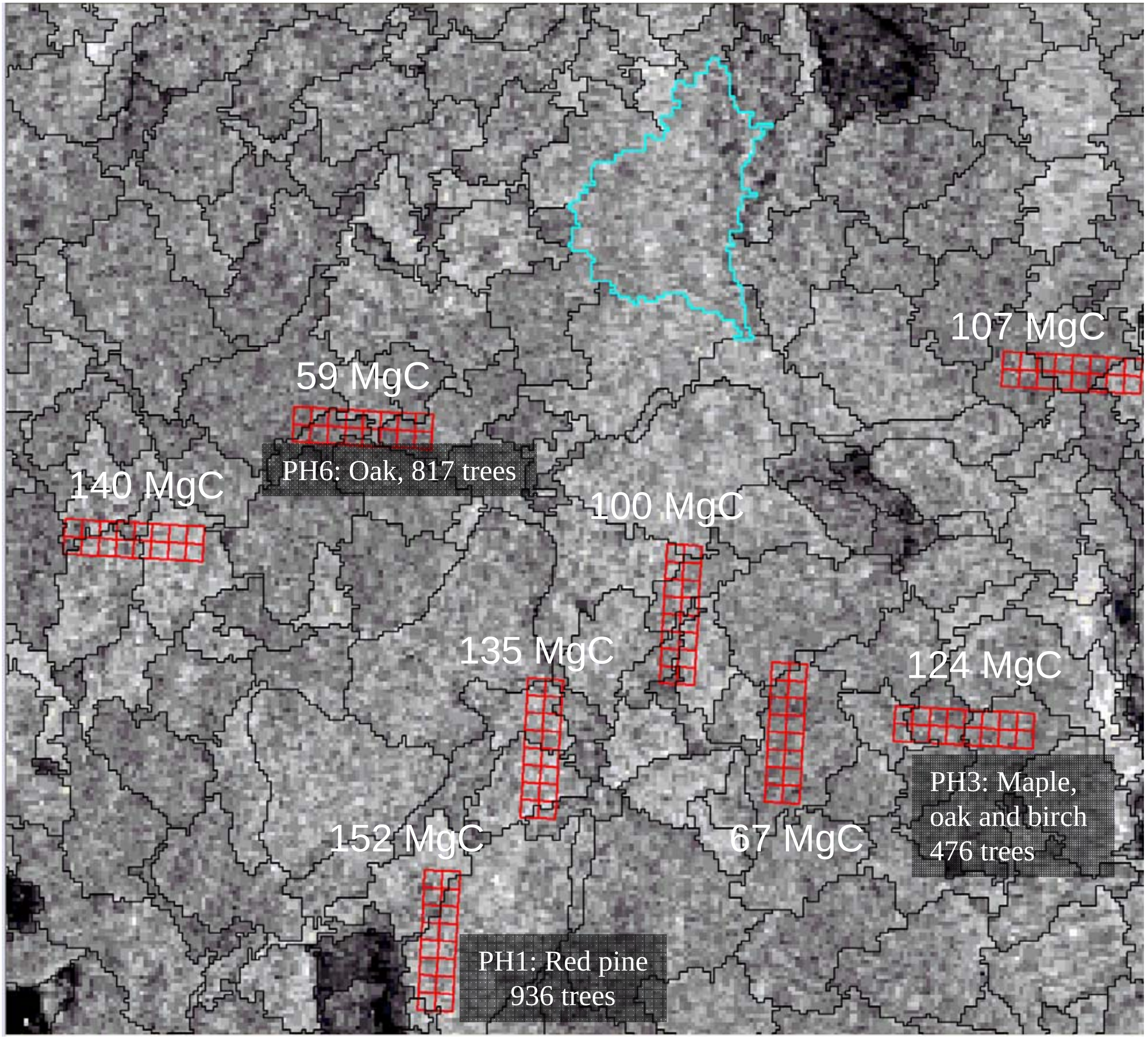


LVIS - Full Waveform Lidar

Collected full waveform data during a campaign over the Harvard Forest Region in 2003, and again in 2009.

data are being analyzed.



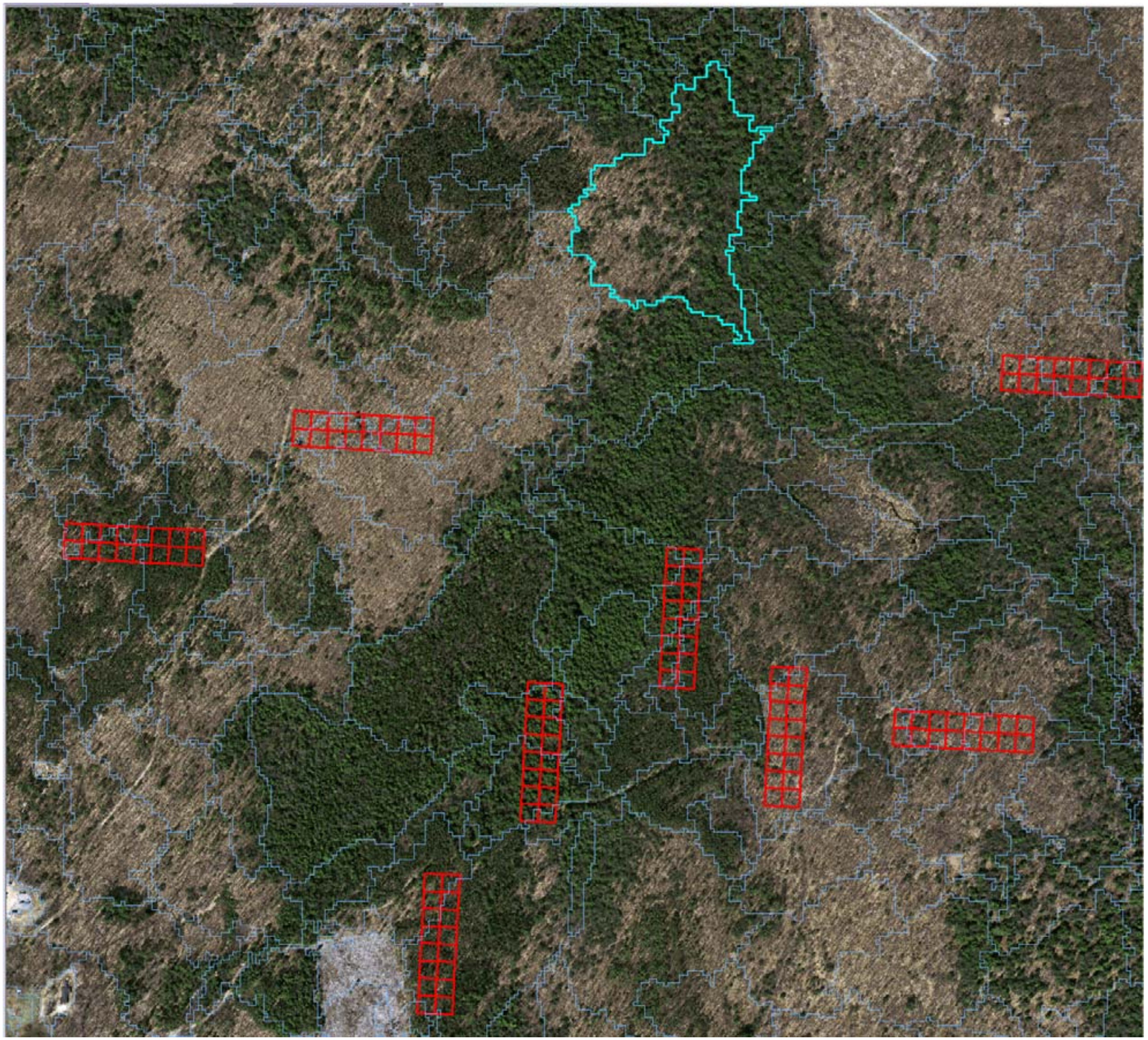


Backscatter (HV)

Orthophoto (1m)

Rh100

Land use map



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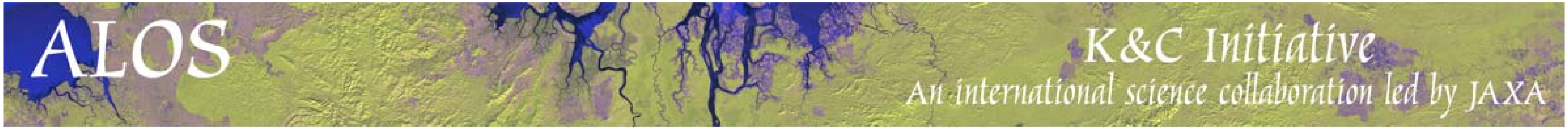
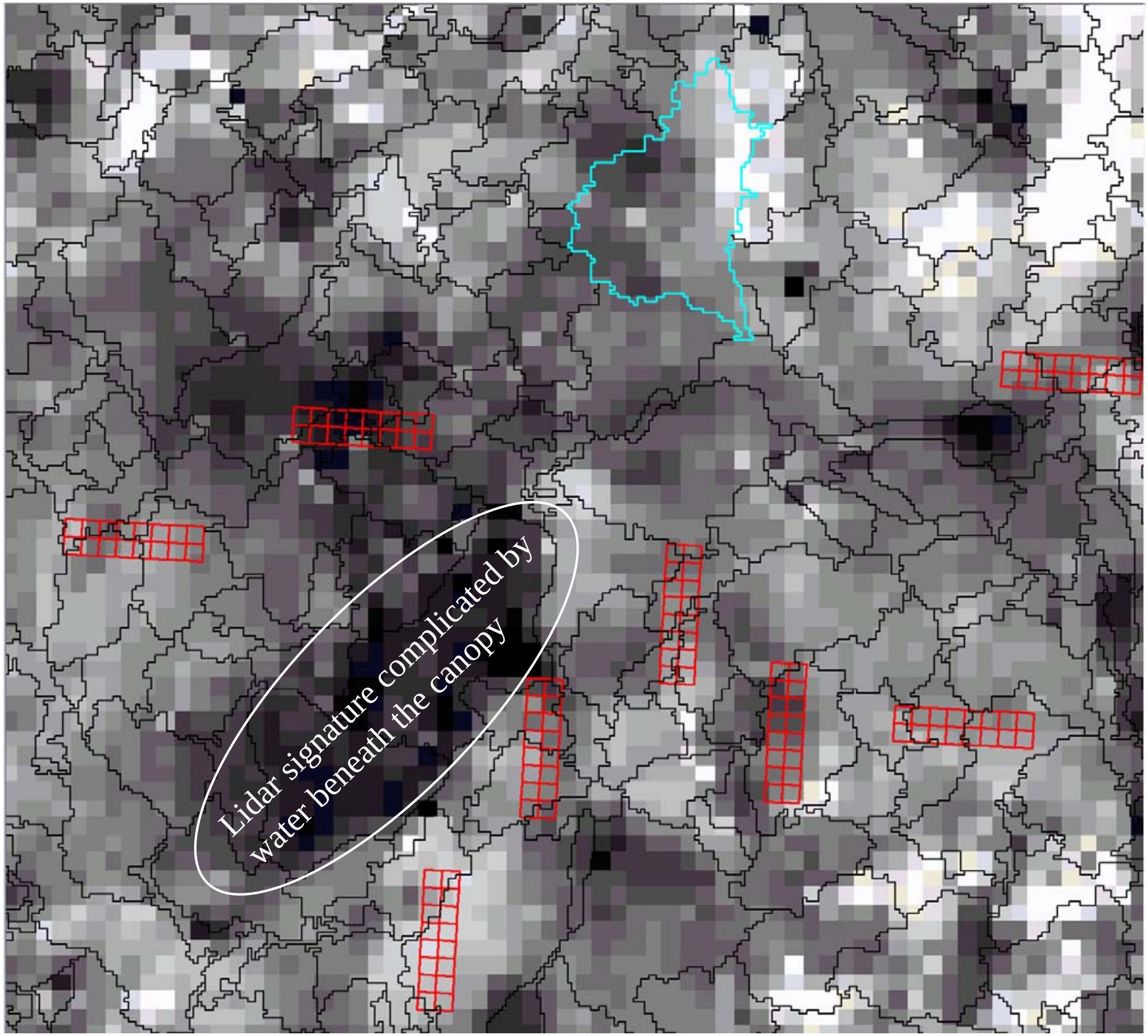
Orthophoto (1m)

Rh100

Land use map





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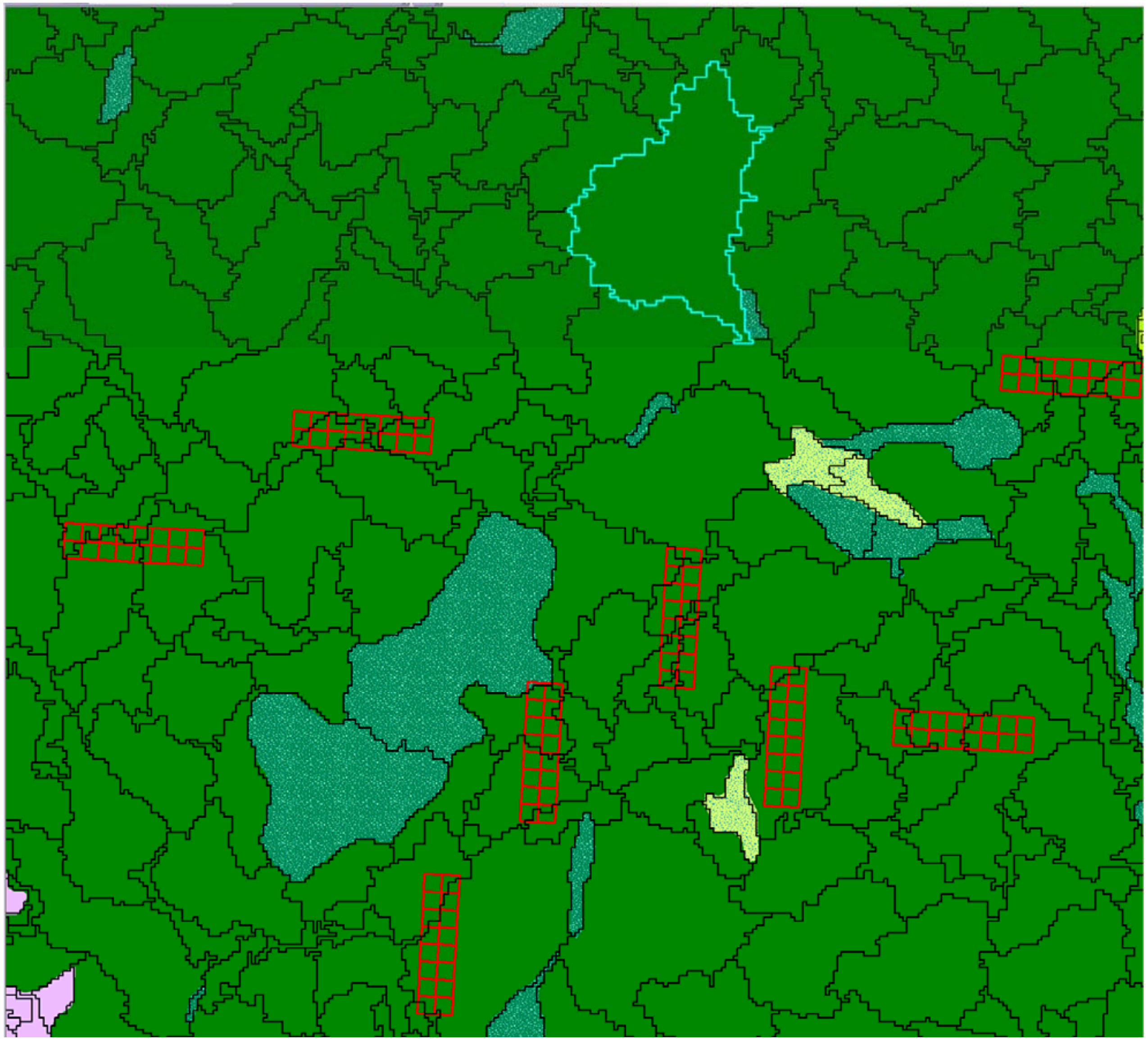

Backscatter (HV)

Orthophoto (1m)

Rh100

Land use map

Conclusions

- **Biomass data from 15 hectares in the Harvard Forest was collected during a field campaign in summer of 2009.**
- **The biomass data was analyzed with Spaceborne (ALOS/PALSAR) and Airborne (UAVSAR) HH, and HV radar backscatter data.**
- **Cross-polarized (HV) backscatter data appears to have a relationship with ground measured biomass even at the high biomass levels prevalent in the Harvard Forest. More polarimetric analysis is ongoing.**
- **A large number of independent looks are required for estimating biomass from radar backscatter. Work is underway to determine the minimum number of necessary looks. THIS MEANS LARGE BANDWIDTH IS CRITICAL FOR BACKSCATTER TO BIOMASS ALGORITHMS.**
- **full waveform lidar data from 2003 and 2009 are being analyzed. Work is underway to establish height to biomass relationships using LVIS and ground measured heights.**
- **Segmentation approach is just now being explored**
- **Interferometric analysis indicates that temporal decorrelation dominates any signature that may be related to the forest structure.**

ALOS

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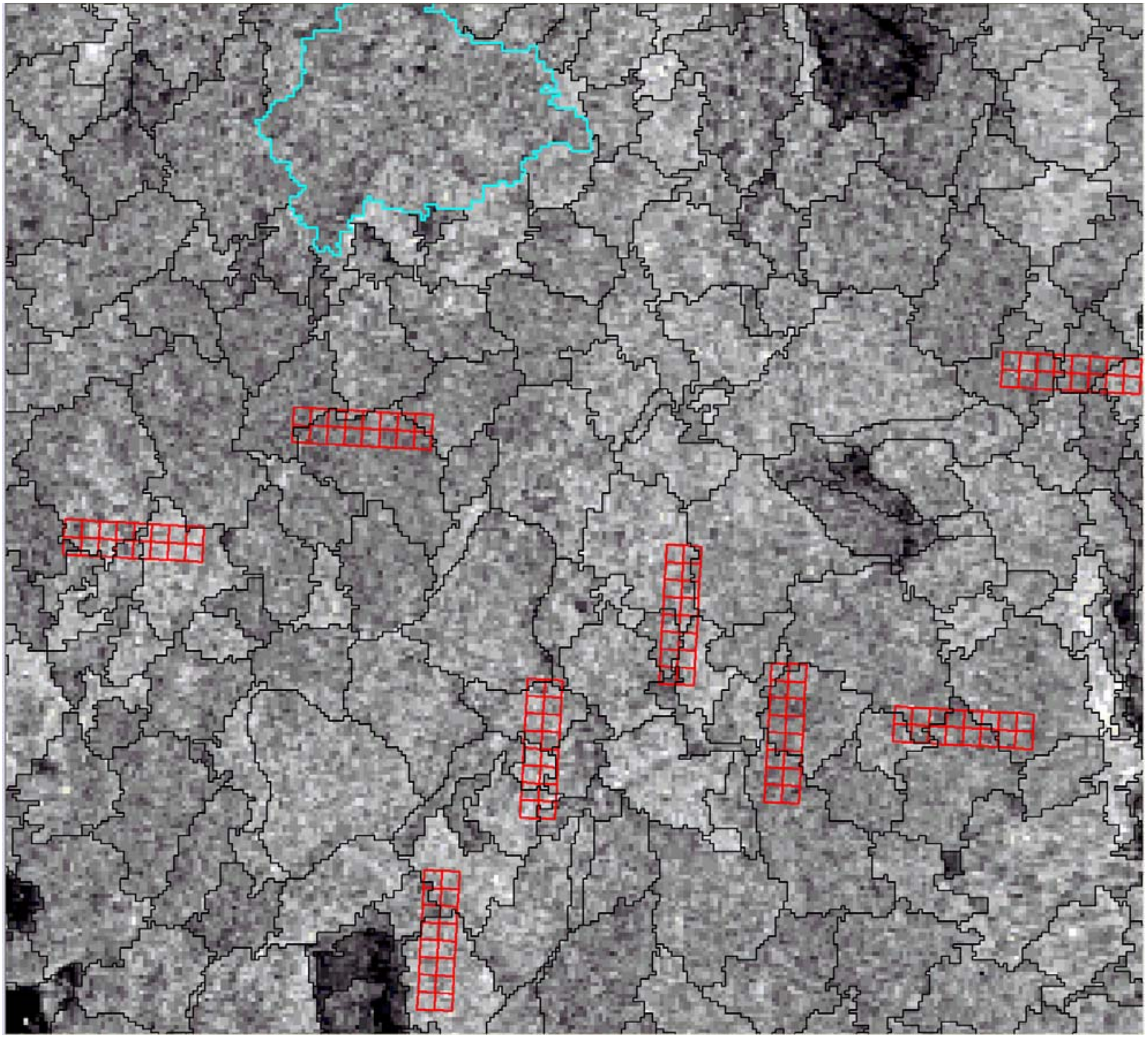

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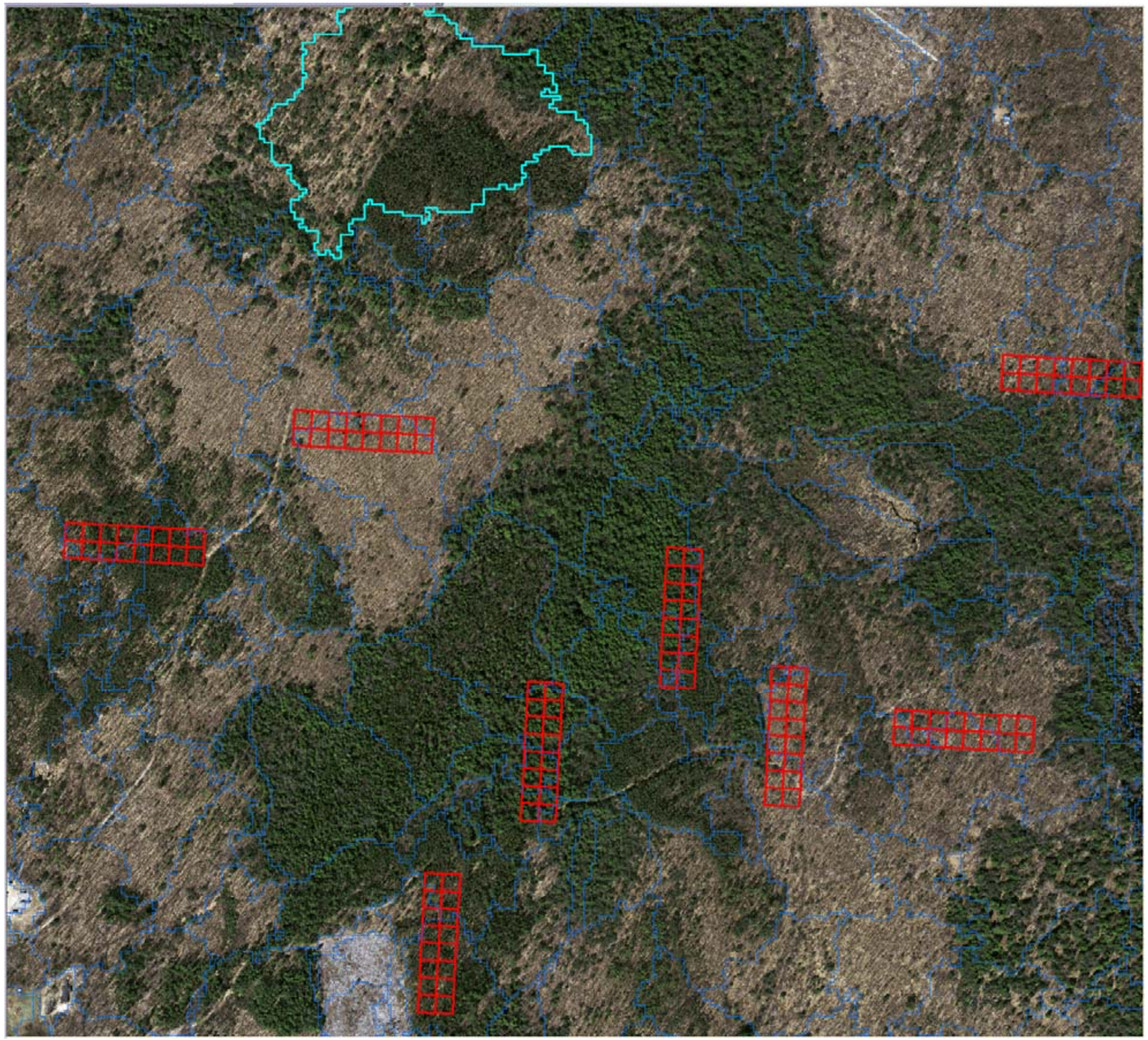
Orthophoto (1m)

Rh100

Land use map



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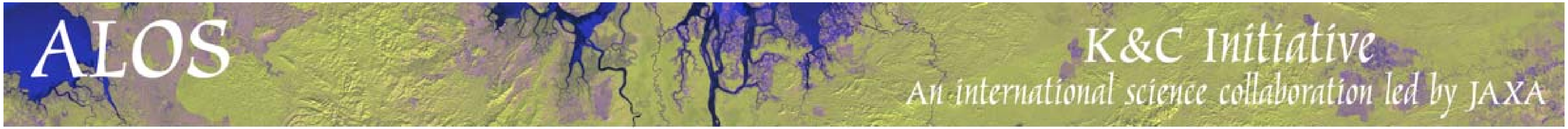

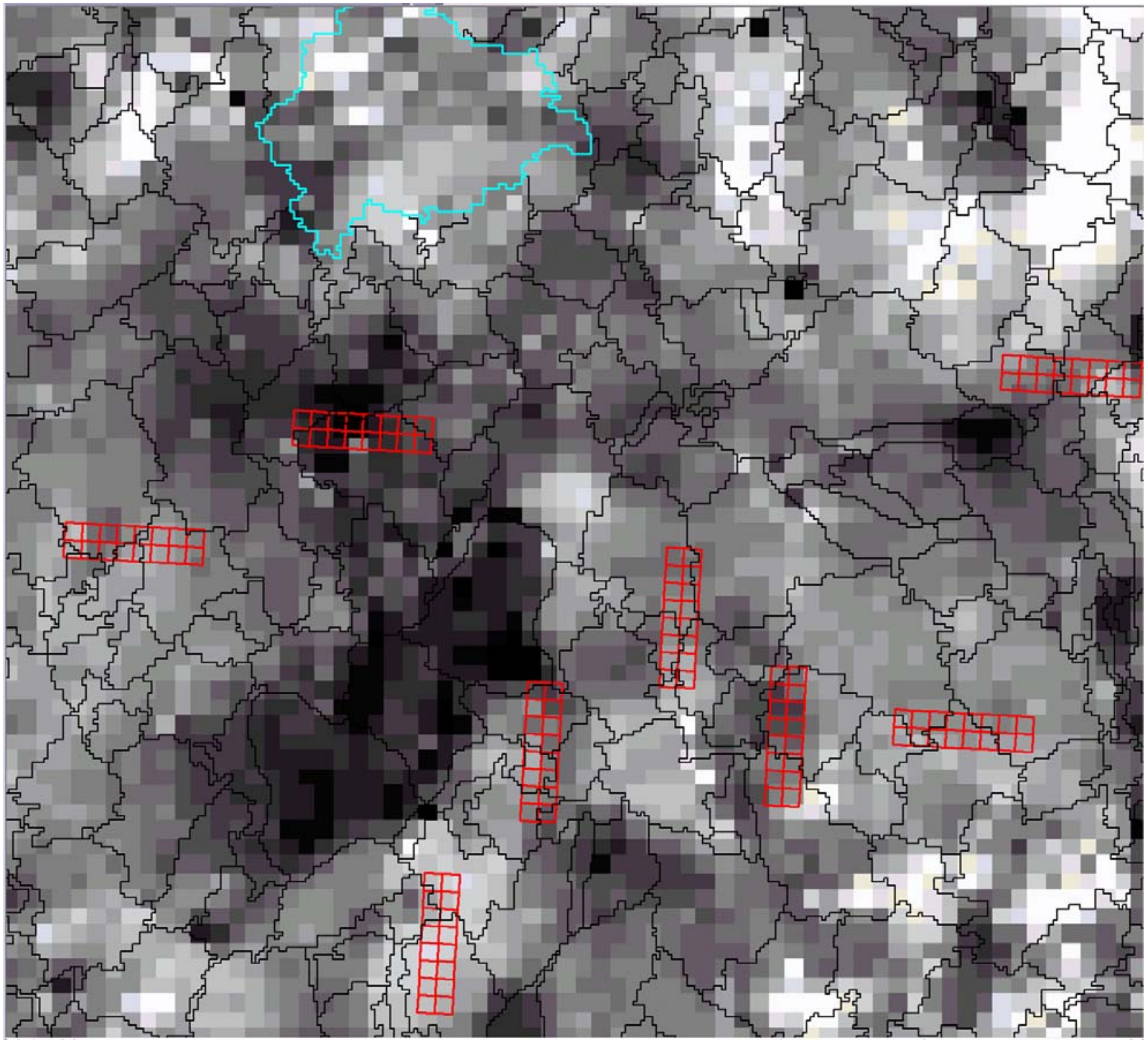

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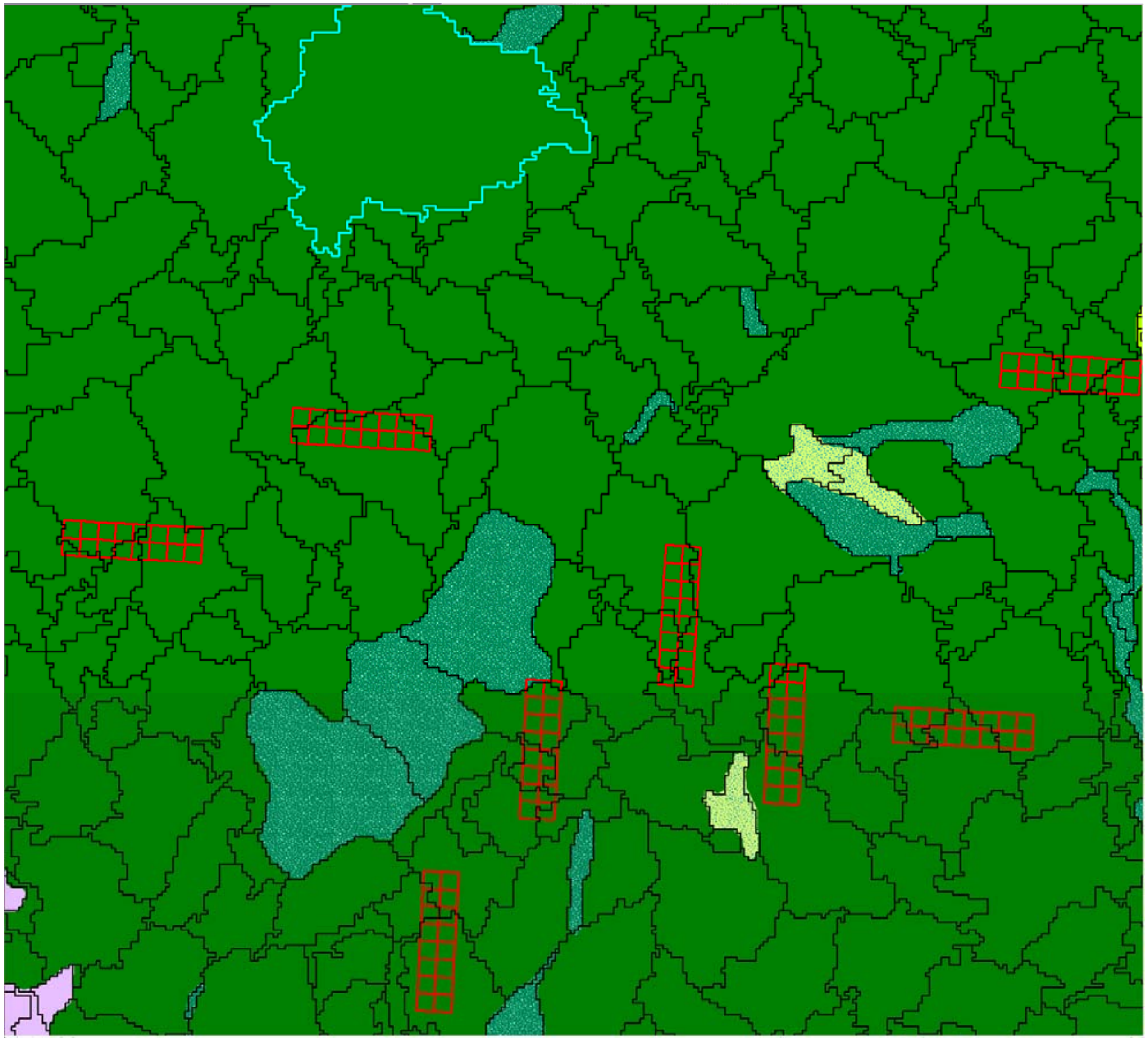

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