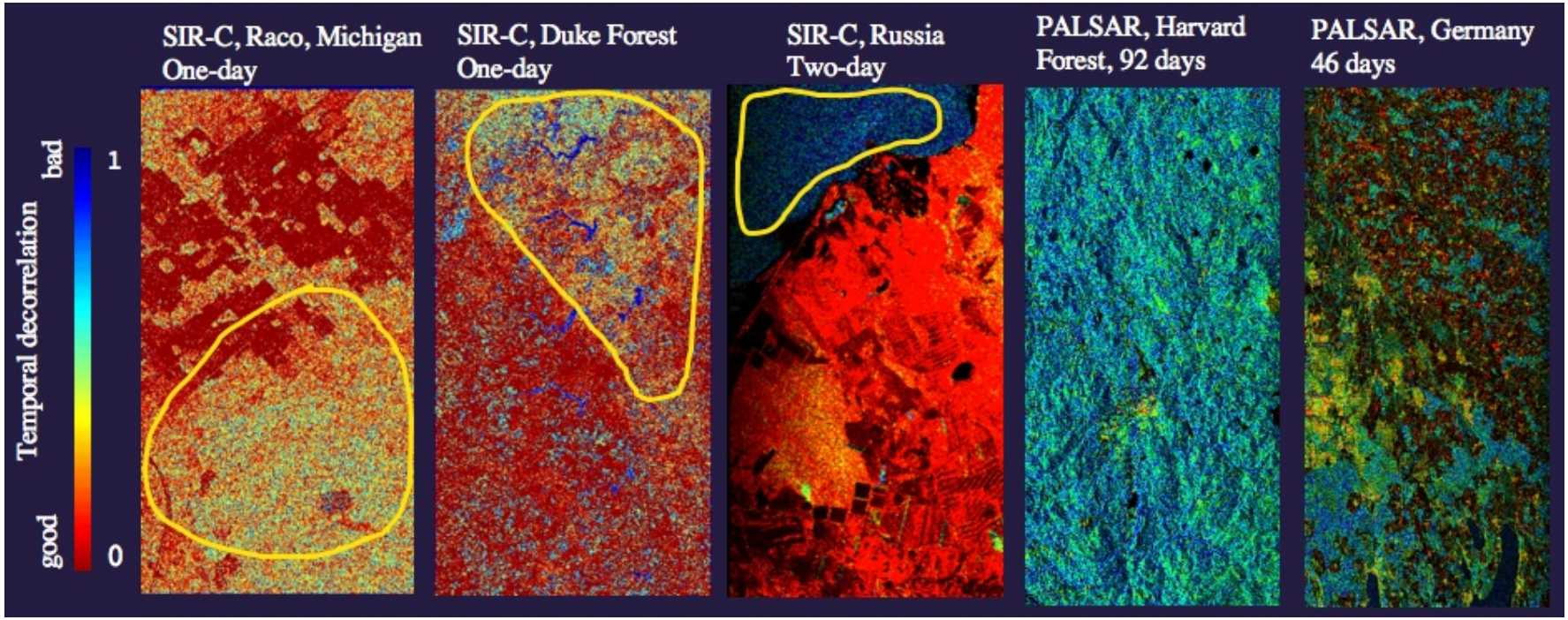
Completion of work from Phase 1

- **Forest Biophysical Parameter Estimation from InSAR; Determination of Calibrated Coherence**
  - InSAR can be used for estimating vegetation height if error sources such as temporal decorrelation can be controlled
  - Present status: completed by demonstrating that temporal decorrelation is a dominant error source
  - Updated data requirement: request to continue InSAR acquisitions as possible
  - Deliverables: algorithms for estimating temporal decorrelation have been presented in K&C meetings, public conferences, and in a paper submitted to RSE

Paul Siqueira
University of Massachusetts, Amherst

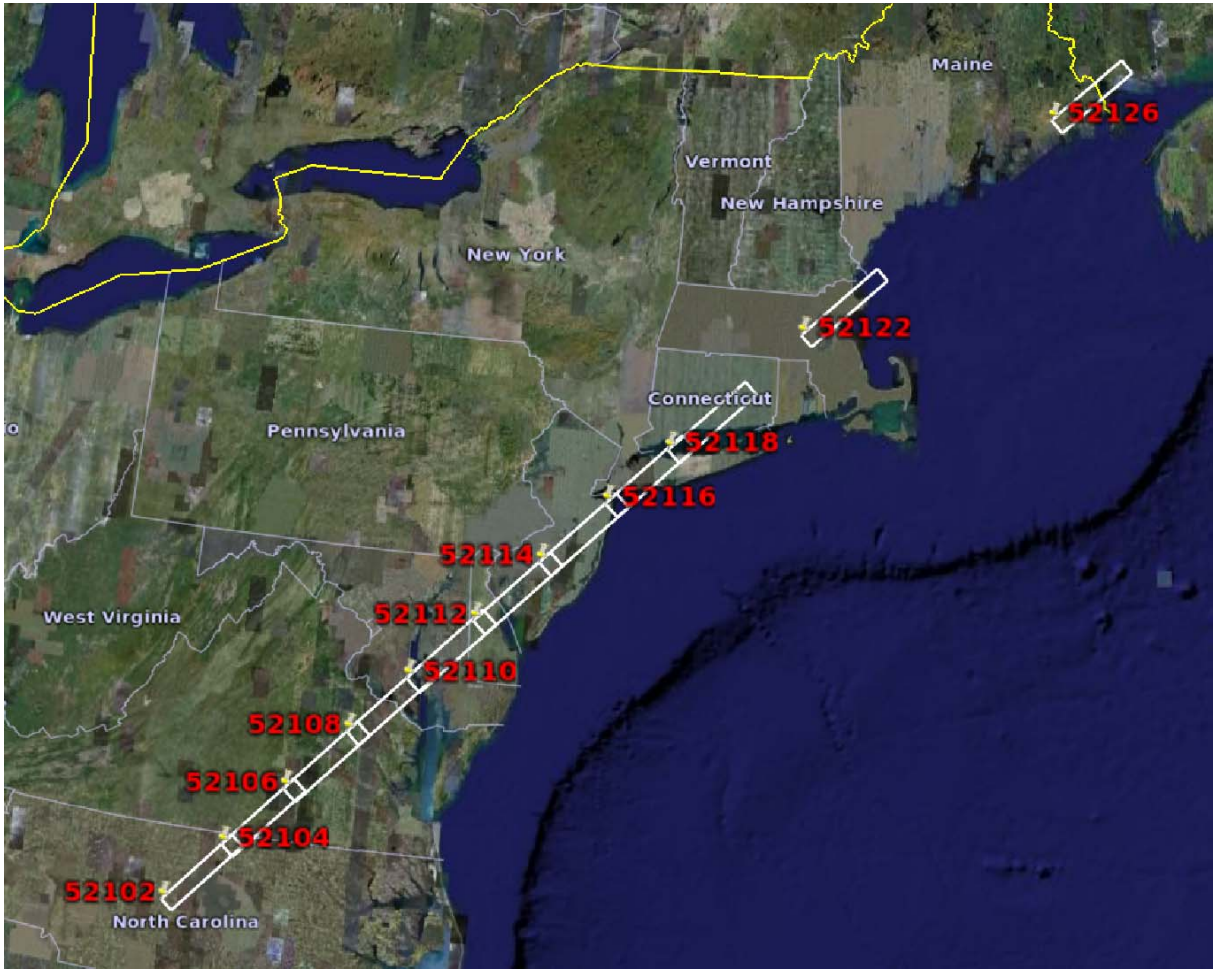
Techniqes developed for calibrating the interferometric correlation signal

- Estimates of temporal correlation made for a variety of scene pairs
- Some degree of temporal decorrelation seen in <u>all</u> data. Even one day repeat-pass from SIR-C



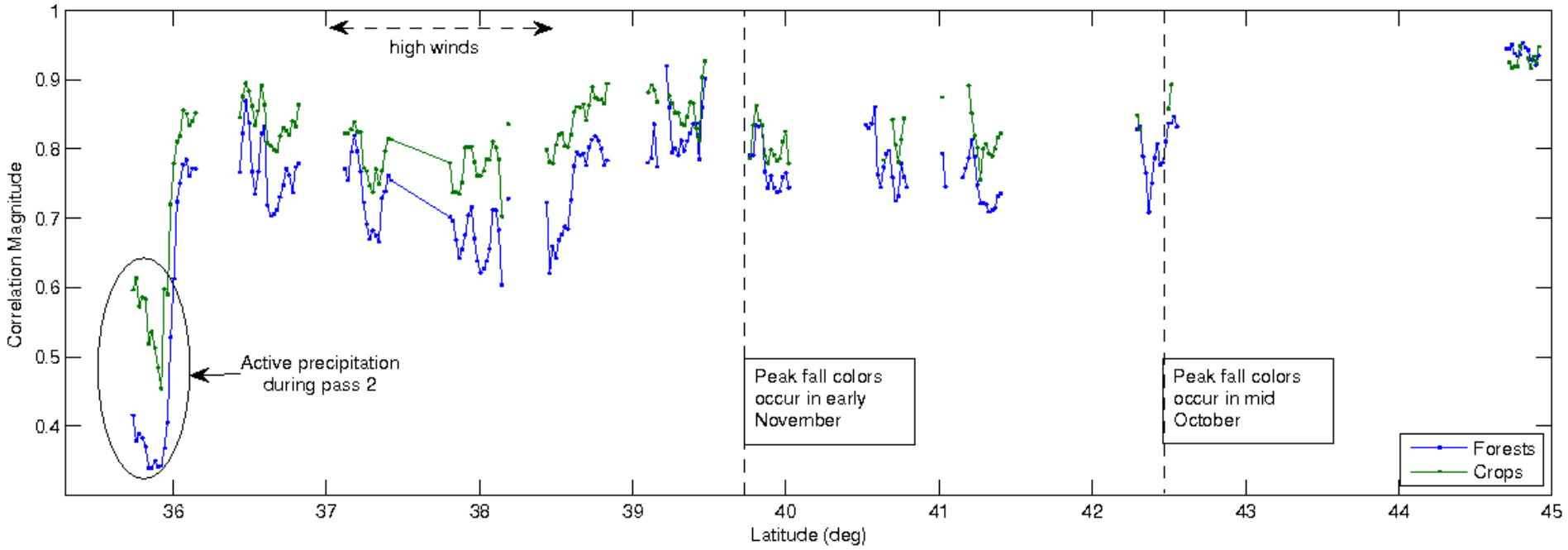
Detailed temporal decorrelation study

- Near zero baseline, one day repeat pass from SIR-C (1994) analyzed
- National Land Cover Dataset (1992) used to determine target classes
- More than 1 million hectares analyzed



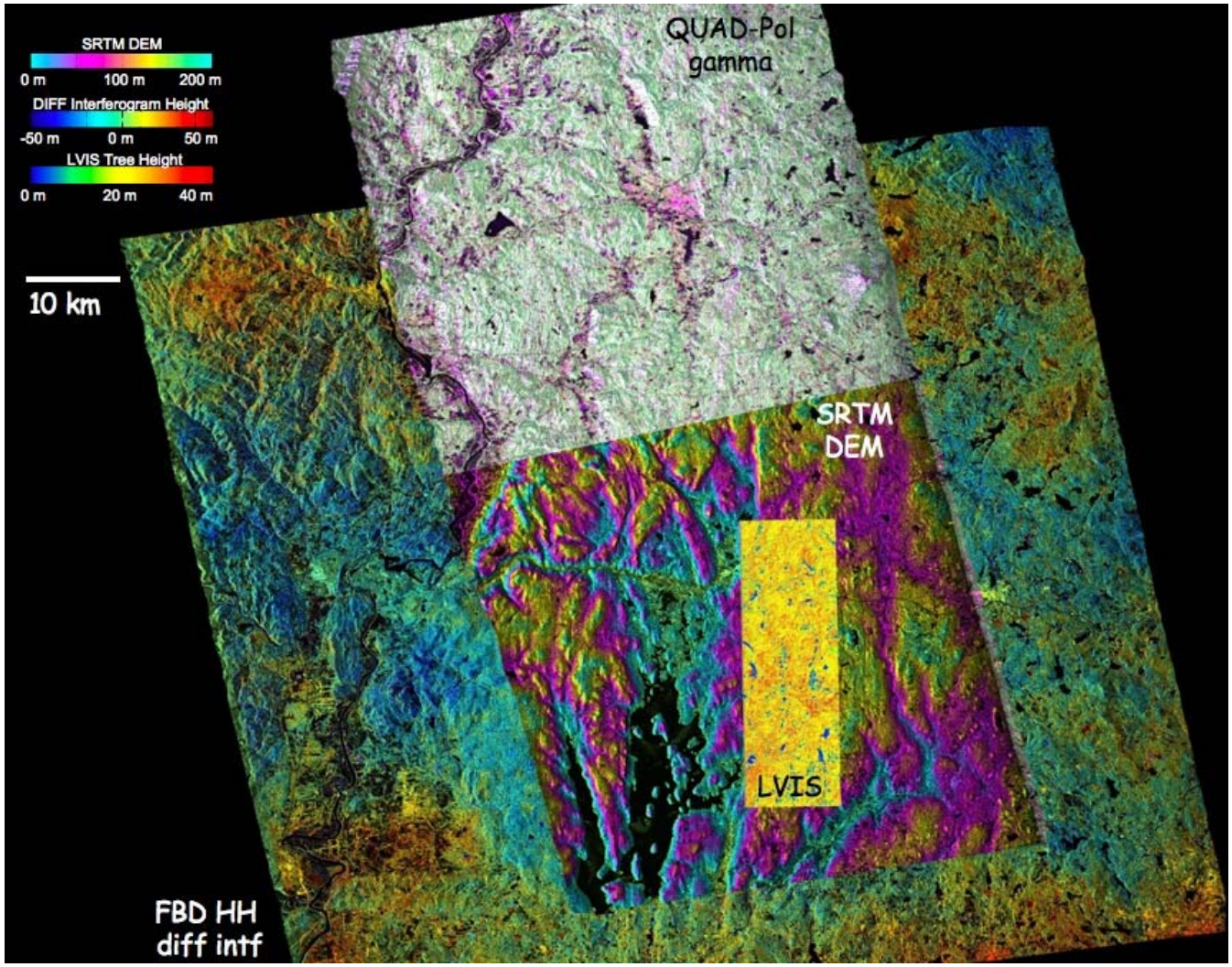
One-day repeat, zero baseline from SIR-C results

- Some degree of temporal decorrelation is always present
- Dependent on phenology and weather (rain and wind)
- Dependent on target type as well (crops: green; forests: blue)



Extensive Work Accomplished over the Harvard Forest

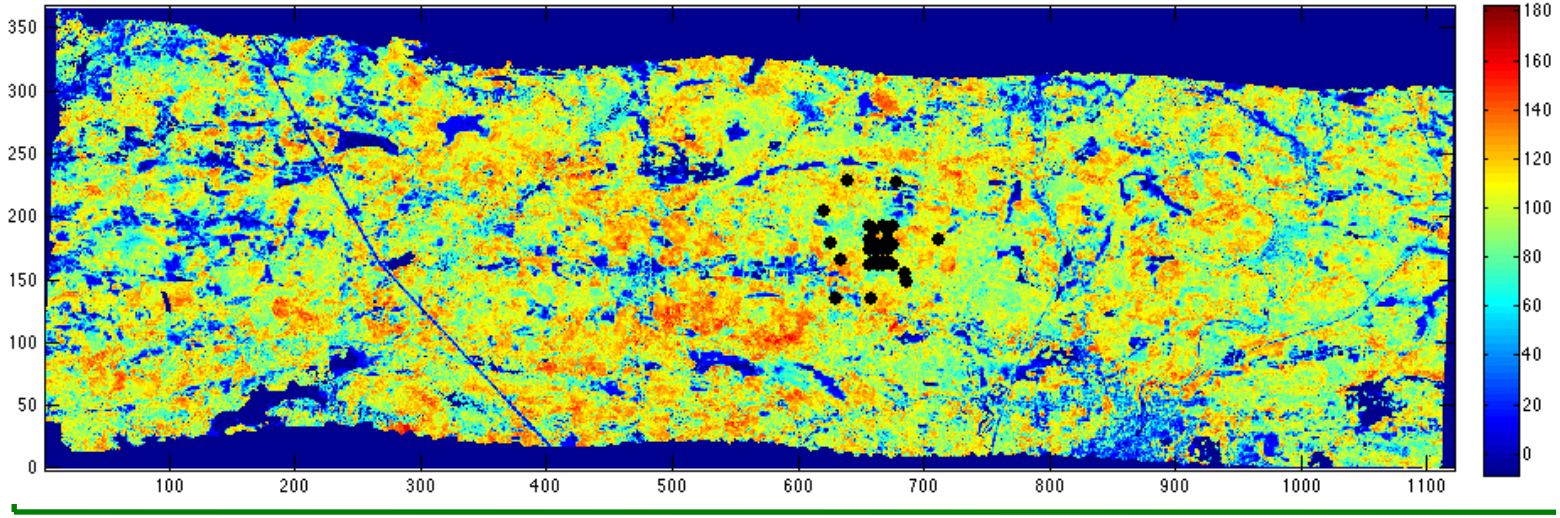
- A concentrated test site was developed for algorithm development
- Full waveform lidar collected by LVIS in 2001
- Lidar data, combined with ground validation data, converted to biomass
- Will be imaged this spring by UAVSAR
- Calibration targets to be deployed



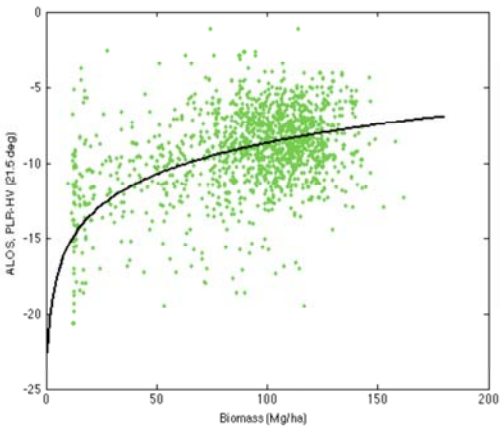
Biomass Estimates from lidar and LHV

- Ground validation combined with full waveform lidar moments used to estimate biomass across the LVIS swath
- Lidar data coregistered with PALSAR SAR/InSAR data in the slant range, on a pixlel-by-pixel basis using lookup tables and simulated SAR image from DEM
- Lidar nadir-track compared to radar backscatter. Errors may be due to lidar ground reflection detection and the "random" association of selected biomass sites

Biomass map derived from full waveform lidar data



RCS biomass estimates



σ^{o}_{hv} = -22.5 + 3.0 ln AGB

ALOS

K&C Initiative
An international science collaboration led by JAXA

Extension Phase Proposal:
LiDAR/SAR/InSAR data fusion using a segmentation approach

A SEGMENTATION APPROACH FOR COMBINING RADAR BACKSCATTER, INSAR AND LIDAR MEASUREMENTS TO DETERMINE VEGETATION 3D STRUCTURE AND BIOMASS FROM SPACE

SUBMITTED IN RESPONSE TO
NASA RESEARCH ANNOUNCEMENT
NNH08ZDA001N-TE
TERRESTRIAL ECOLOGY

Paul Siqueira
University of Massachusetts, Amherst

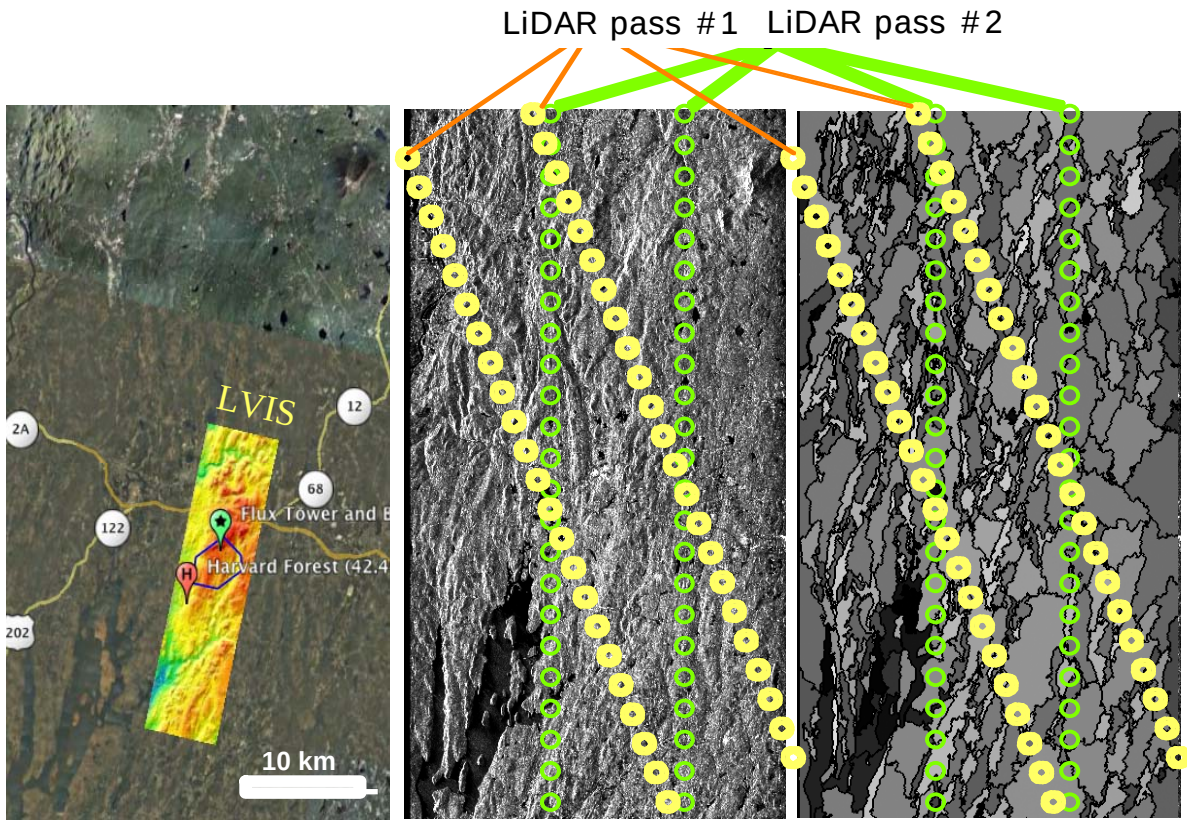
UNIVERSITY OF MASSACHUSETTS
M I R S L
MICROWAVE REMOTE SENSING LABORATORY

Project Objectives

- In the absence of a Tandem mission (excepting TanDEM-X and possibly TanDEM-L), temporal decorrelation will dominate the interferometric signature. Hence, an alternative methodology will be necessary.
- Develop a robust method of estimating forest biophysical parameters over geographically extensive regions
- Utilize SAR/InSAR data for their mapping capabilities
- Utilzie Lidar for its 'direct' measurement of vegetatation structure
- Perform an error analysis for varying SAR/InSAR configurations

Segmentation Approach

- **Backscatter power, texture and polarimetry utilzed in segmentation**
- **Aggregate regionsof like resonse via an image segmentation**
- **Utilize coincident Lidar on a scene by scene basis to assign values of interest to the segmented SAR image**



Optical plus full-waveform lidar (LVIS) coverage

SAR backscatter image

Segmented SAR

Project Team (for proposal)

- Paul Siqueira (PI; algorithms and processing)
- Bruce Chapman (co-I, gadfly; algorithm development and extension of work to mosaicked products)
- Kathleen Bergen (co-I; ecology applications and science lead for 3D structure requirements)
- Richard Lucas (collaborator; segmentation, forest applications, and ground validation for Queensland sites)
- William Munger (collaborator; provide Harvard forest ground validation inputs)
- Kyle McDonald (collaborator; data distribution & interface to MEaSUREs task)
- Scott Hensley (collaborator; UAVSAR overflights and processing)

Project Plan

- **Split into 5 technical threads**
  - **Algorithm development**
    - Feature selection
    - Segmentation development
    - Error assessments
  - **Injune/Queensland dataset development**
  - **Harvard Forest dataset development**
  - **NASA Carbon Cycle and Ecosystems dataset development**
    - Other sites located in California, the East Coast, and in Central America
    - More sites are welcome
  - **Large-scale swath dataset development**
    - Coincident with Injune/Queensland, the Harvard Forest and the Carbon Cycle and Ecosystems (DESDynI) sites

Project Plan

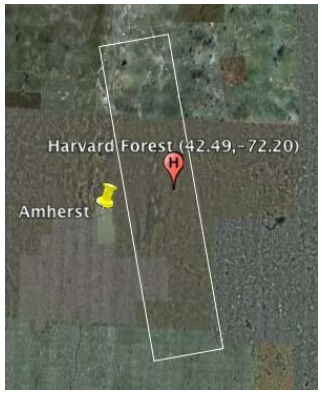
- **Algorithm development over selected test sites**
  - **Combine SAR, LiDAR and InSAR data**
    - Segmentation of orthorectified and slope corrected SAR/InSAR data
    - Full waveform Lidar data (LVIS) used to determine statistics over a subset of segmented regions
    - Regions that are not covered by Lidar that belong to simiar SAR/InSAR class types will be assigned lidar waveform moments measured for regions that are covered by the lidar.
  - **Accuracy Assessment made over selected test sites**
    - "best" accuracy to be determined by including all available data types
    - Study performed to understand the impact on error metrics of reducing the total observation vector (e.g. quad-pol vs. dual-pol vs. single-pol).
  - **Repeat-pass UAVSAR data processed to**
    - Cross-calibrate ALOS/PALSAR data
    - Provide interferomtric observables of coherence and height that will be useful for intepretting data and expanding its extent
- **Algorithms and error assessment extended over regional scales (~9 PALSAR scenes)**
  - **Include ICESAT waveform data.**
- **Algorithms and error assessment extended over large scale regions, similar to ALOS/PALSAR masks**

Project Map (current)

- Two primary regions for initial work in first year
- To be expanded to additional NASA Carbon Cycle and Ecosystem sites in second year
- Regional assessments to be based on initail regions and CCE sites
- Additional sites of interest (lidar data and ground validation required)

Injune, Queensland

Harvard Forest and New England



Duke Forest

La Selva, Costa Rica

Time Schedule

- **Project Threads broken into tasks discretized into 3 month pieces**
- **Project anticipated to formally start in April, 2009.**

Project Milestones	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Project Start and Reviews	◇				◇				◇			◇
Thread 1: Algorithm Development												
Dual-pol segmentation algorithm	■											
Quad-pol segmentation algorithm		■		■								
Interferometric segmentation algorithm			■									
Specification of vegetation structural characteristics		■	■									
Analysis of ICESAT data			■	■								
Error formulation and analysis		■	■	■								
Thread 2: Injune, Queensland dataset												
Aggregation of data resources	■											
Application of segmentation algorithms		■	■	■								
Evaluation of ICESAT data over the region			■	■								
Error analysis			■	■	■							
Thread 3: Harvad Forest, MA dataset												
Derivation of biomass from available LVIS data	■											
Application of segmentation algorithms		■	■	■								
Estimation of vegetation characteristics			■	■	■							
Evaluation of ICESAT data over the region			■	■								
Error analysis			■	■	■							
UAVSAR data collection												
Thread 4: NASA CCE dataset development												
Participation in data collections		■	■	■								
Comparison of updated LVIS/UAVSAR data with existing data				■	■	■	■	■				
Application of segmentation algorithms						■	■	■	■			
Evaluation of ICESAT data over the CCE sites							■	■	■			
Error analysis							■	■	■	■		
Thread 5: Inclusion of large-scale data from ALOS/PALSAR												
Identification of relevant data				■	■	■						
Application of segmentation algorithms						■	■	■	■			
Error analysis							■	■	■	■		
Evaluation of ICESAT and land classification data over the region								■	■	■	■	
Final Summary and Report											■	■

Data Requirements

- **Differentiation between data requirements and data desires**

- **Data Requirements**
  - **FBD and PLR over selected sites**
    - **Quad-pol benefits by a deeper observation vector, yet suffers from smaller swath and steep incidence angle**
    - **Dual-pol more limited observations but has larger swath and better incidence angles**
  - **Would like to ask that the current agreement with JAXA be continued**

- **Data Desires**
  - **Coincident ALOS/PALSAR observations with UAVSAR overflights**
  - **Concentrated time series data over selected sites**

- **Processing Requirements**
  - **We prefer level 1.0 data; Utilize gamma software for processing**

- **We would be interested in sites from KC team that has lidar, PALSAR (at least FBD) and ground validation data available for use.**

Definition of Deliverables

- Ground validation data and algorithms to be publically made available
- Harvard and Queenslad results to be presented at K&C meeting; preferably KC13 next January (2010)
- Additional NASA CCE test sites by KC15 (2011)
- Application of algorithms to regional scales KC17 (2012)?