

K&C Phase 3 – Brief project essentials

Synergetic use of ALOS PALSAR data for forest biomass retrieval and wetland classification

*Josef Kelldorfer, Oliver Cartus, Wayne Walker
The Woods Hole Research Center*

Project area(s)

Chile – Commercial Timber Lands

North-Eastern United States

Mexico

Region	Activities	04/2011 – 03/2012	04/2012 – 03/2013	04/2013 – 03/2014	04/2014 – 03/2015
Chile	SFP-Lidar based GSV/CH map production	D1.1 (<u>due</u> 31.3.2012)			
	Synergy ALOS intensity – Lidar for GSV/HT retrieval		D2.1 (<u>due</u> 31.3.2013)		
	Synergy ALOS intensity/repeat- pass coherence – Lidar for GSV/HT retrieval			D3 (<u>due</u> 31.3.2014)	
Vermont, USA	SFP-Lidar based GSV/CH map production	D1.2 (<u>due</u> 31.3.2012)			
	Synergy ALOS intensity – Lidar for GSV/HT retrieval		D2.2 (<u>due</u> 31.3.2013)		
Mexico (1)	Biomass retrieval			D4 (<u>due</u> 31.3.2014)	
	Wetland classification				D5 & D6 (<u>due</u> 31.3.2015)

(1) Originallly Congo

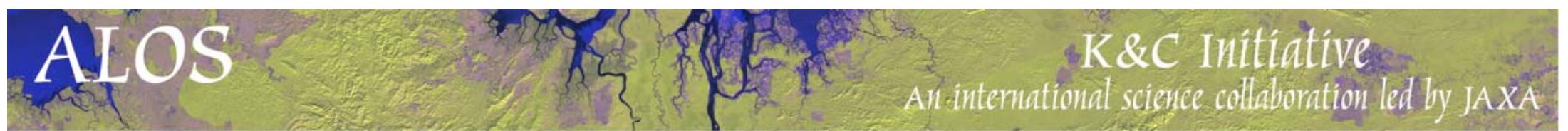
Support to JAXA' s global forest mapping effort

- Deliver regional biomass maps and algorithms to JAXA for NE United States, Chile and Mexico.
- Data sets can be used to cross-calibrate JAXA based mapping efforts for biomass.
- Reference Data Sets (Ground truth and Airborne)
 - Lidar based estimates can be used for calibration/validation purposes
 - Mexico biomass plots to be shared (in discussion with GOM)

Deliverables

Maps of biomass and forest cover

Algorithms for generating the maps (randomForest
models on calibrated data sets)

The banner features a satellite image of a river delta or coastal region with green land and blue water. The word "ALOS" is written in large, white, serif capital letters on the left side.

ALOS

K&C Initiative
An international science collaboration led by JAXA

North-Eastern US Study Site

Modeling Approach

Hypotheses:

Radar

Optical

Height = f (SRTM-NED, canopy density, cover type, ...)

↑
L-Band σ^0

↓
Biomass = f (height, density, cover type, ...)

Used a statistical approach (ensemble regression-tree algorithm) to generate the relationships, test how well height (Lorey's) and biomass could be predicted from ground measured forest survey data.

Aboveground Woody Biomass and Carbon Stock of the Conterminous United States



<http://www.whrc.org/mapping/nbcd/index.html>

http://daac.ornl.gov/NACP/guides/NBCD_2000.html

This map shows the first high-resolution (30 m resolution) map of aboveground woody biomass and carbon stock for the conterminous United States. Sample footprints are 30 m and are spatially aligned with the National Land Cover Database, 2001 (NLCD 2001) published by the United States Geological Survey.

The map was produced by integrating a year 2000 multi-sensor satellite imagery (Landsat ETM+ and Shuttle Radar Topography Mission data), bio- and geo-physical gradient data (elevation, slope, aspect, density, density, and land cover), and USDA Forest Service Forest Inventory and Analysis (FIA) field reference data. Statistical regression models were developed and applied in 30 m resolution mapping zones. Final map accuracy was performed by reclassifying the 30 m resolution biomass map. The map shows biomass as a map of predicted vegetation height, produced using a similar modeling approach and serving as a key input variable to the production of the biomass map. Aboveground woody carbon stock was estimated as 50% of the aboveground biomass production.

More Information and Data is available at:
<http://www.whrc.org/mapping/index>

Predicted Aboveground Woody Biomass and Carbon Stock



Pacific Northwest



Mid-west



Southeast



Northeast



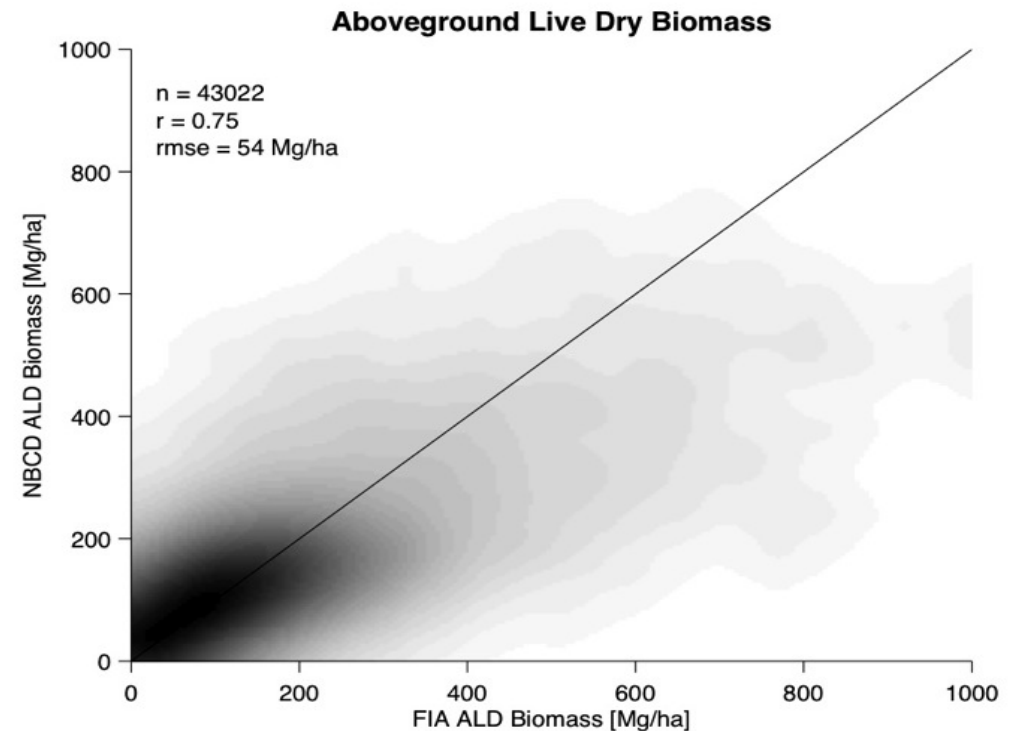
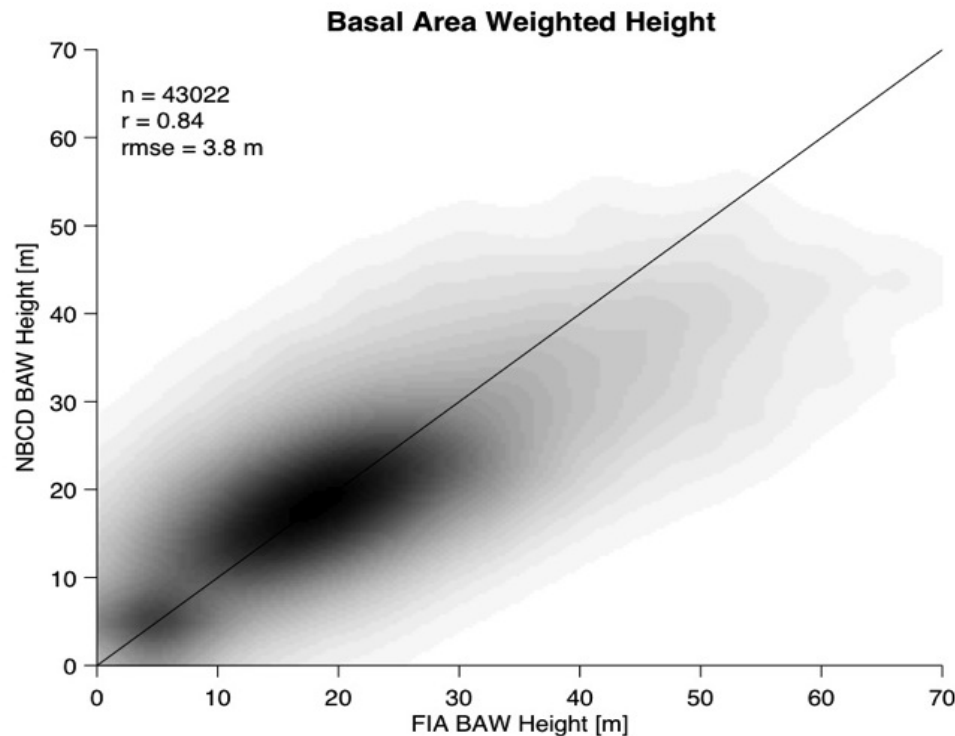
What is this? A QR (Quick Response) code which can be scanned by a mobile phone or other device to access a website or other information. To use, download a QR code reader and use your smartphone. Then, point the phone at the QR code. This will take you to the website.

Key Credits:

Map Data:
USGS National Map Accuracy Report (NMAAP) 2000
USGS National Map Accuracy Report (NMAAP) 2000
USGS National Map Accuracy Report (NMAAP) 2000
USGS National Map Accuracy Report (NMAAP) 2000



Plot Level Accuracy via Bootstrap Validation



RESULTS OF NATIONAL AND REGIONAL SCALE BAWHT AND ALD BIOMASS VALIDATION

Region	n	Height r	Height RMSE (m)	Biomass r	Biomass RMSE (Mg/ha)
<i>National</i>	43038	0.83	3.8	0.75	54.6
Pacific	5352	0.73	6.4	0.75	94.6
Interior West	8347	0.88	3.6	0.77	42.1
South	12203	0.79	3.6	0.67	51.9
Northcentral	10021	0.76	2.7	0.62	37.7
Northeast	7115	0.75	3.0	0.58	50.7

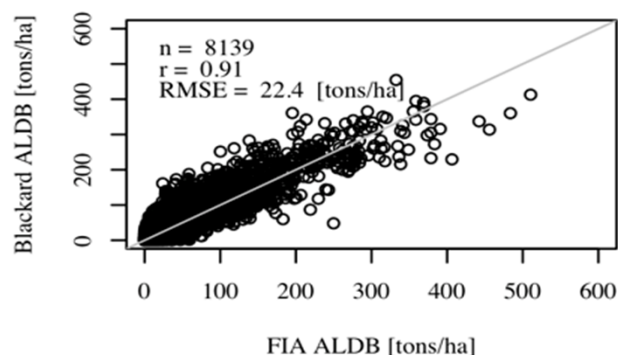
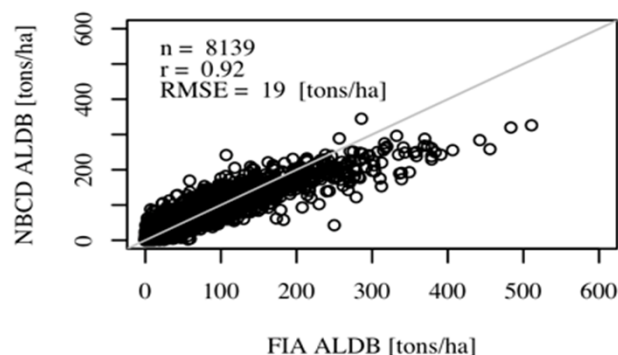
!

Multi-Scale ALDB Comparison FIA/NBCD/Blackard

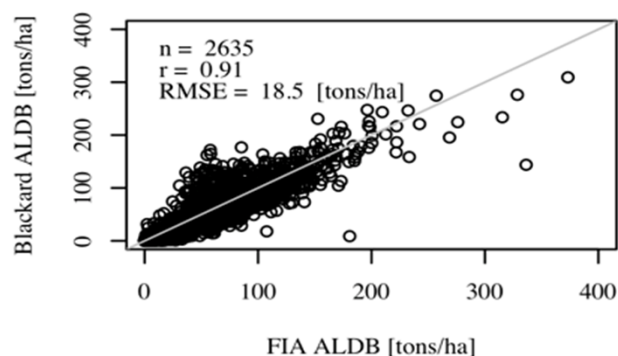
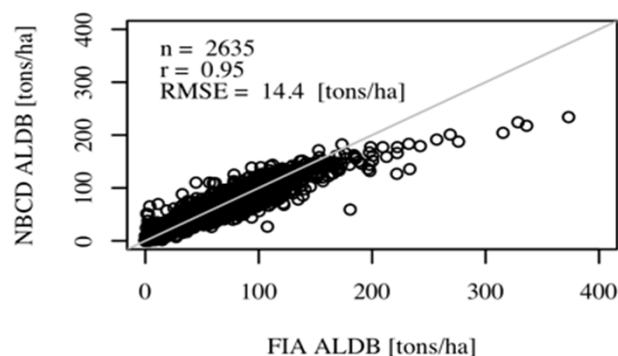
NBCD

Hexagon Scale

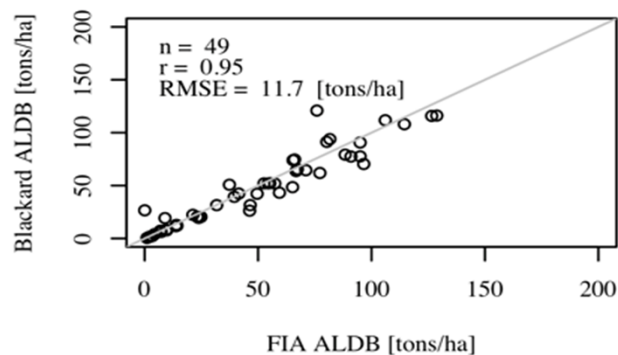
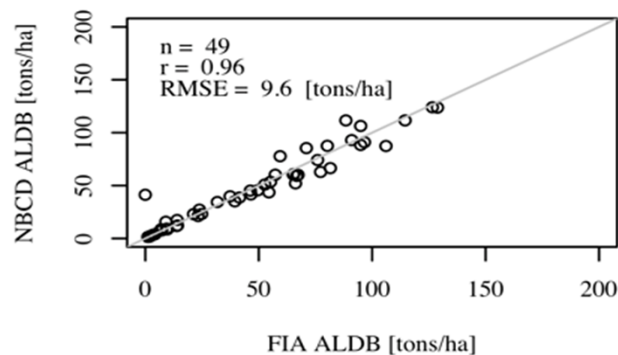
Blackard et al.



County Scale



State Scale



NBCD
multi-scale
comparison with
Blackard
et al. and FIA
biomass
estimates

Hexagon Scale

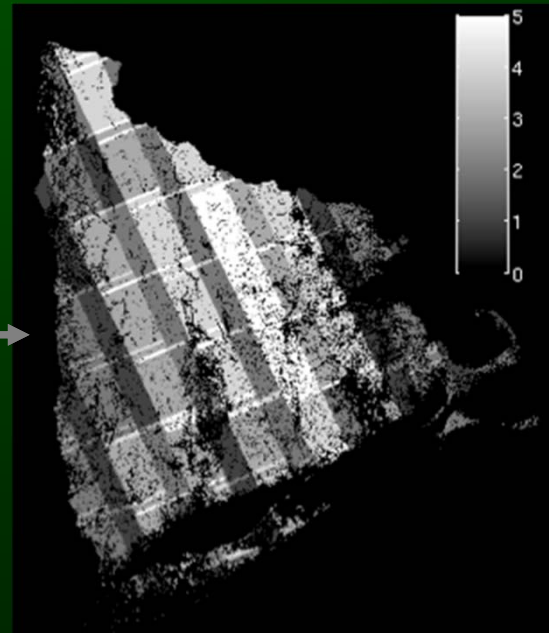
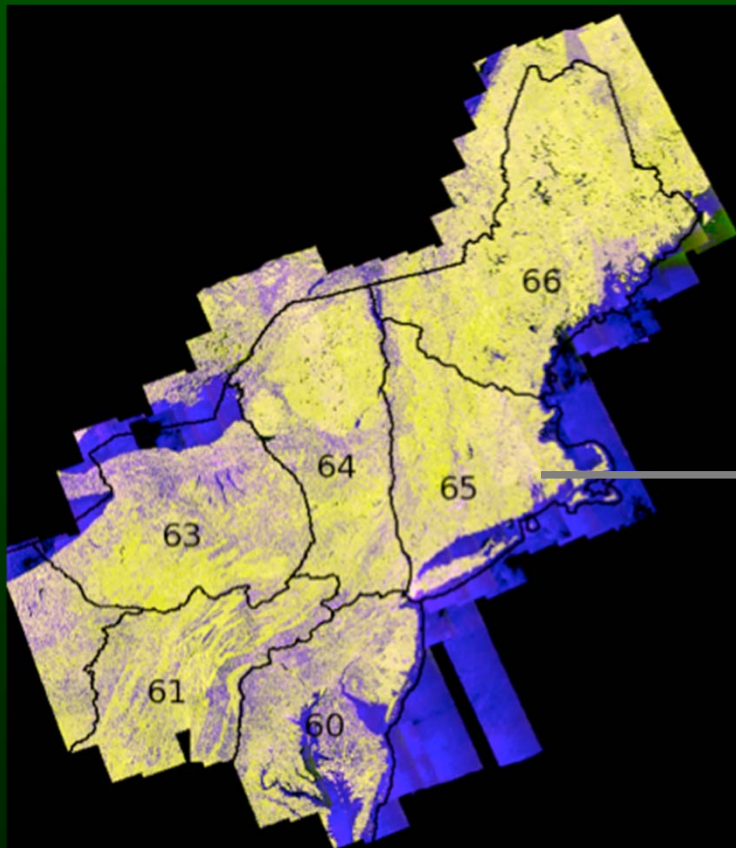
Size ~ 650 km²

~ 25 FIA plots

USDA project: Towards Spatially Explicit Quantification of Carbon Flux (2000-2007) in Northeastern U.S. Forests Linking Remote Sensing with Forest Inventory Data

Investigators: Kelndorfer, J., Cartus, O., Houghton, R. A., Walker, W. S.

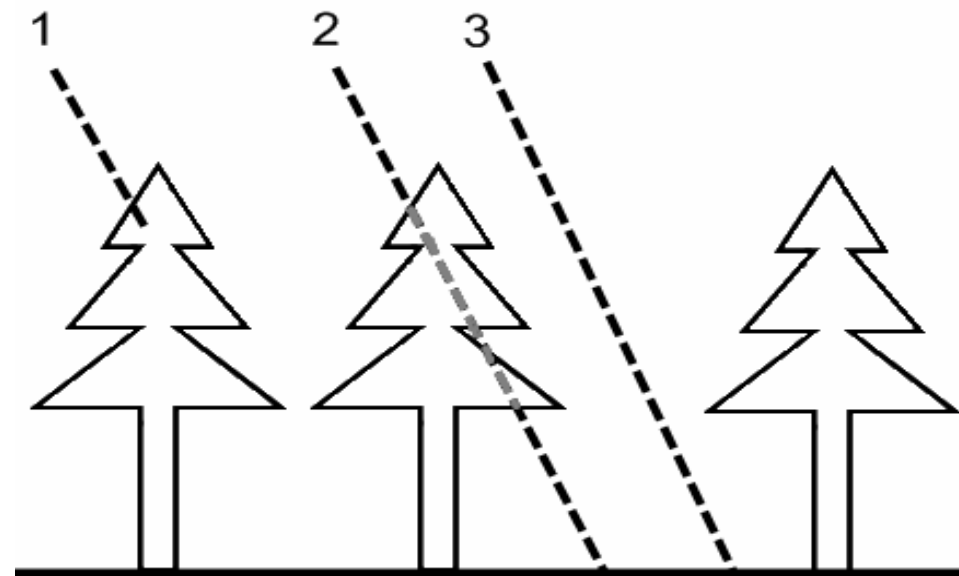
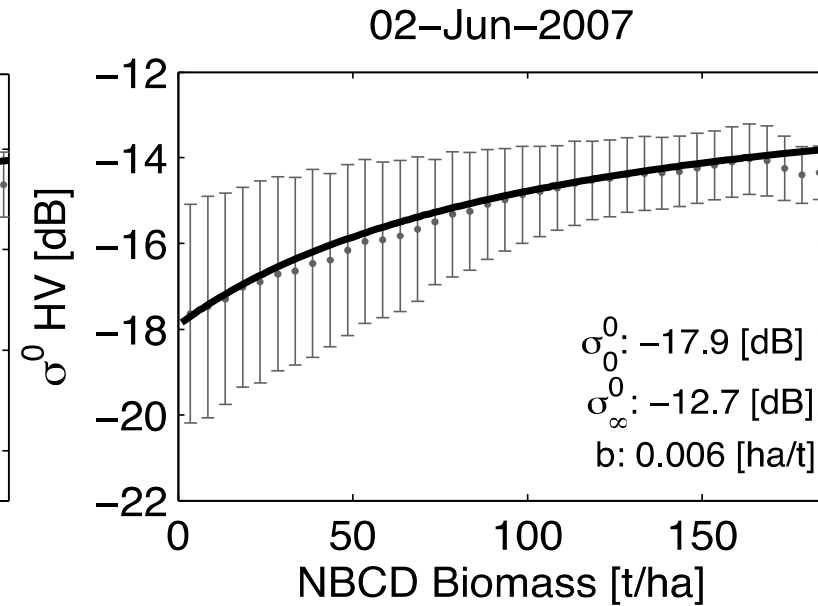
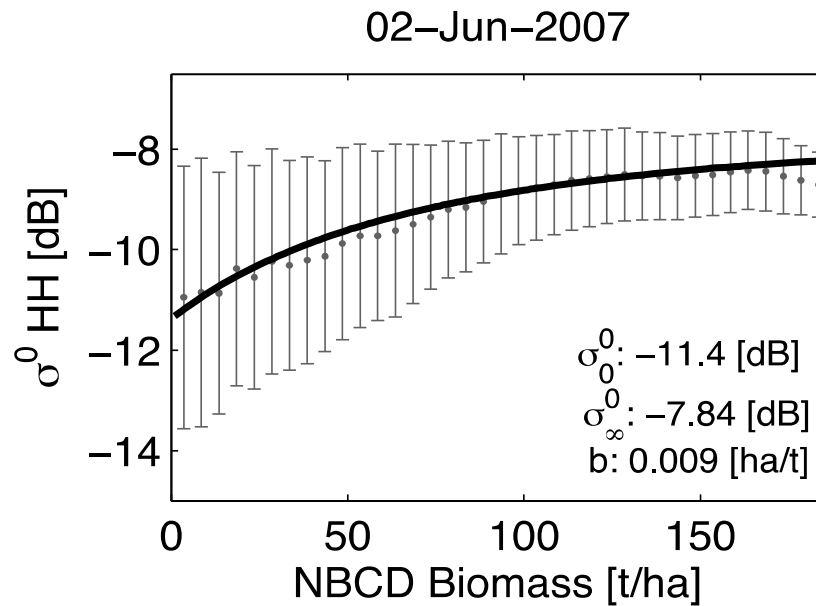
Collaboration: Maurizio Santoro, GAMMA RS



655 PALSAR FBD
images for 2007/08

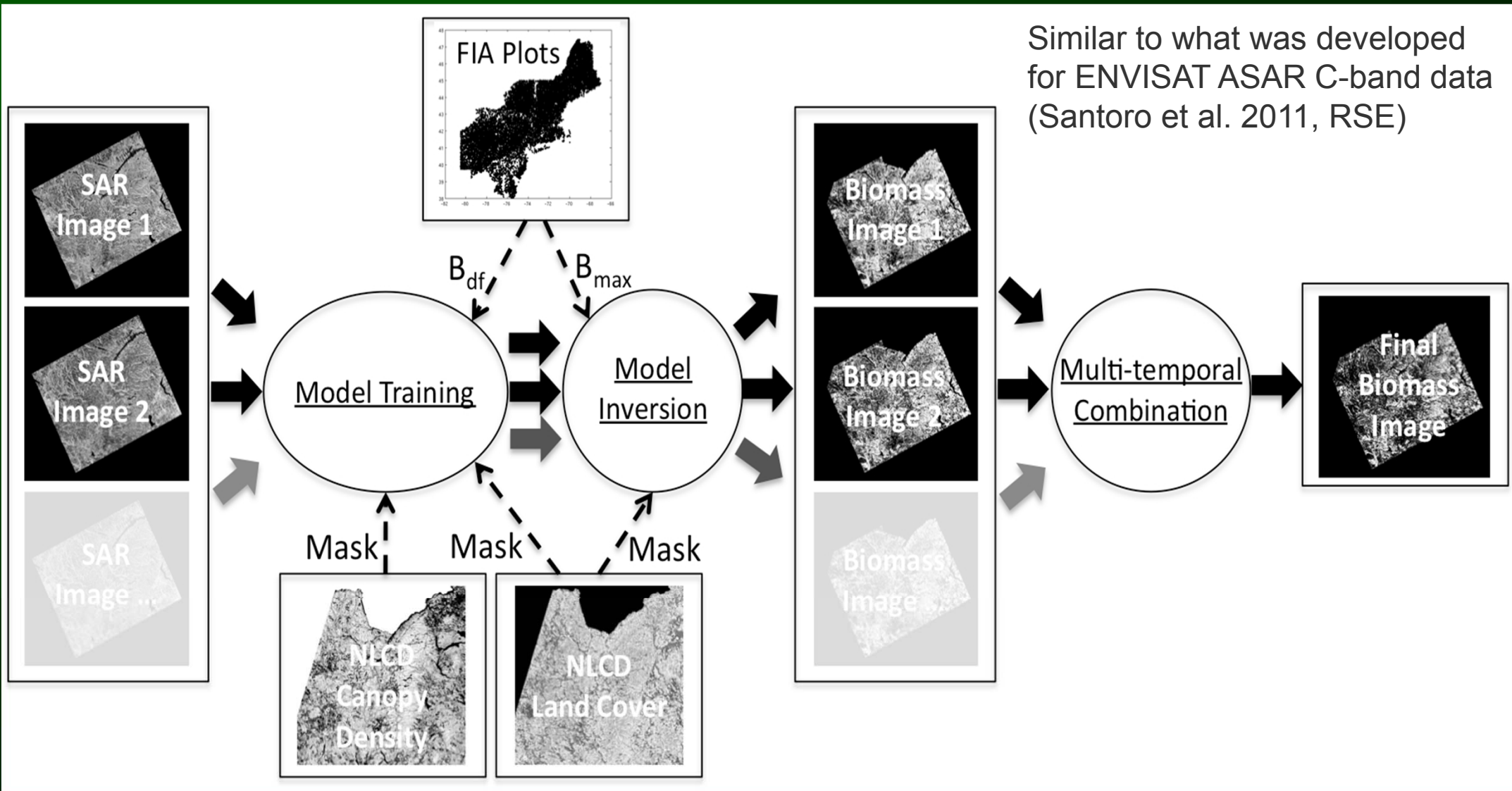
Multi-temporal
coverage: 1-5

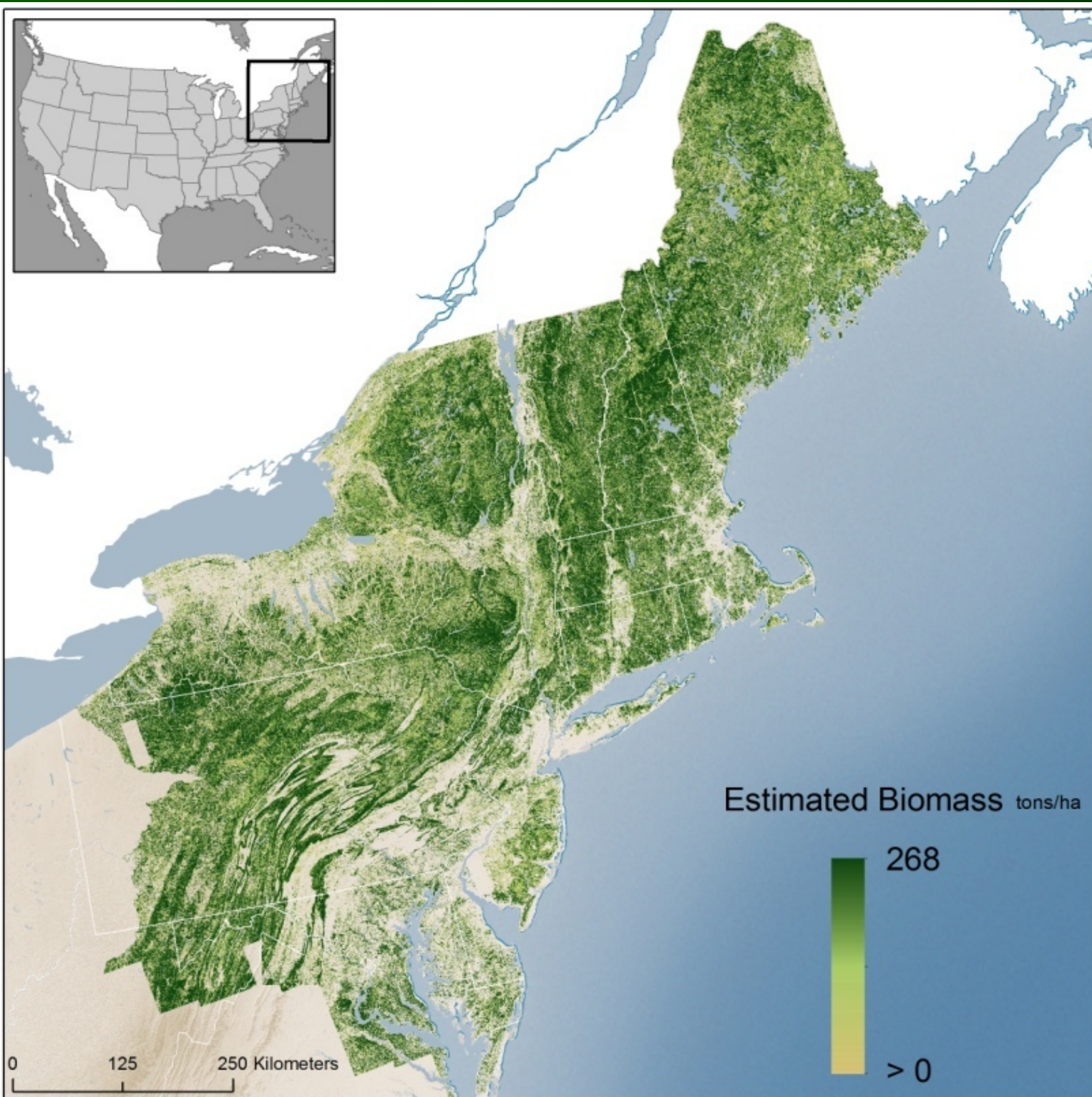
BIOMASAR (Santoro et al., 2011)



$$\sigma^0_{for} = \eta \left[\sigma^0_{veg} (1 - T_{tree}) + \sigma^0_{gr} T_{tree} \right] + (1 - \eta) \sigma^0_{gr}$$

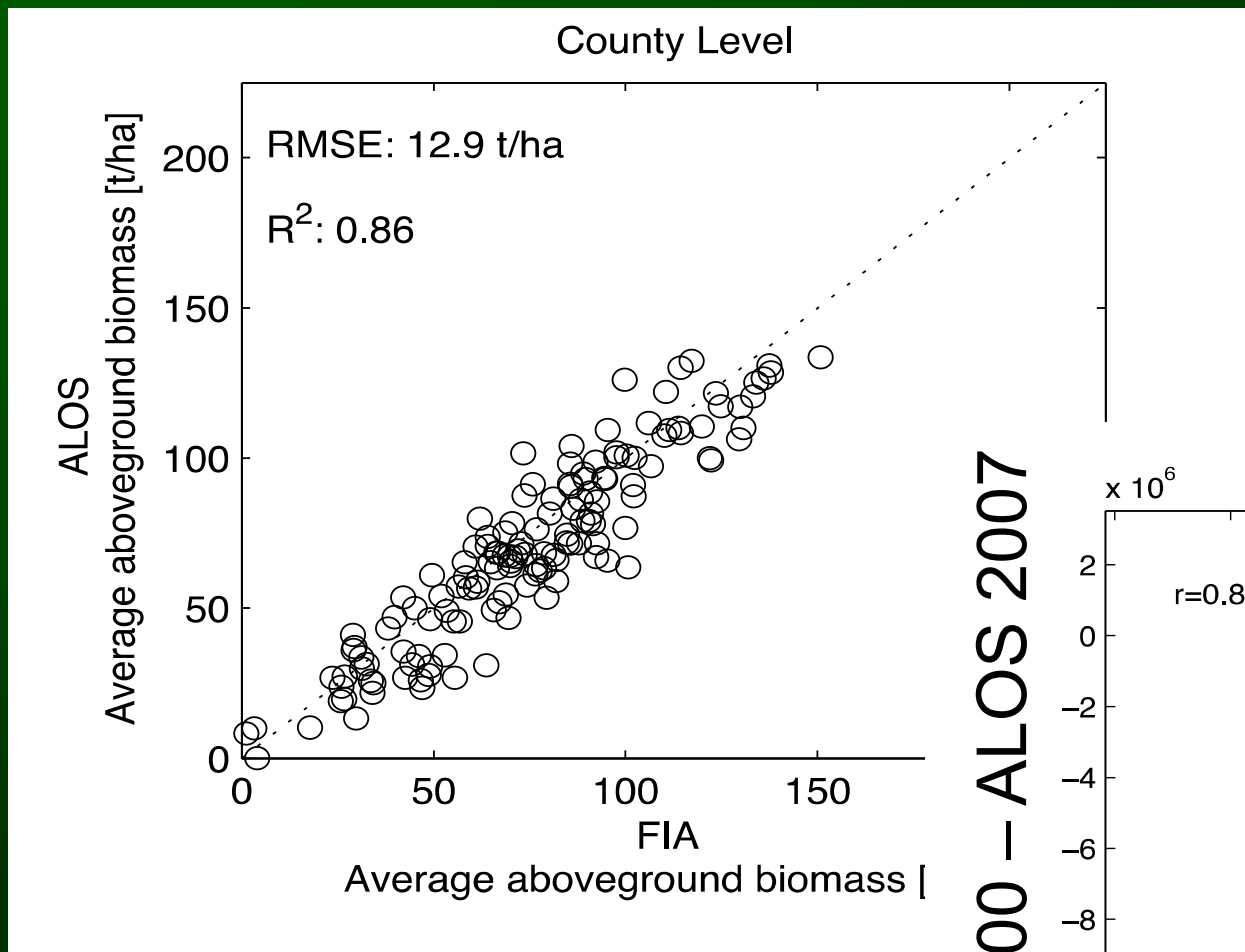
Automated Retrieval Algorithm



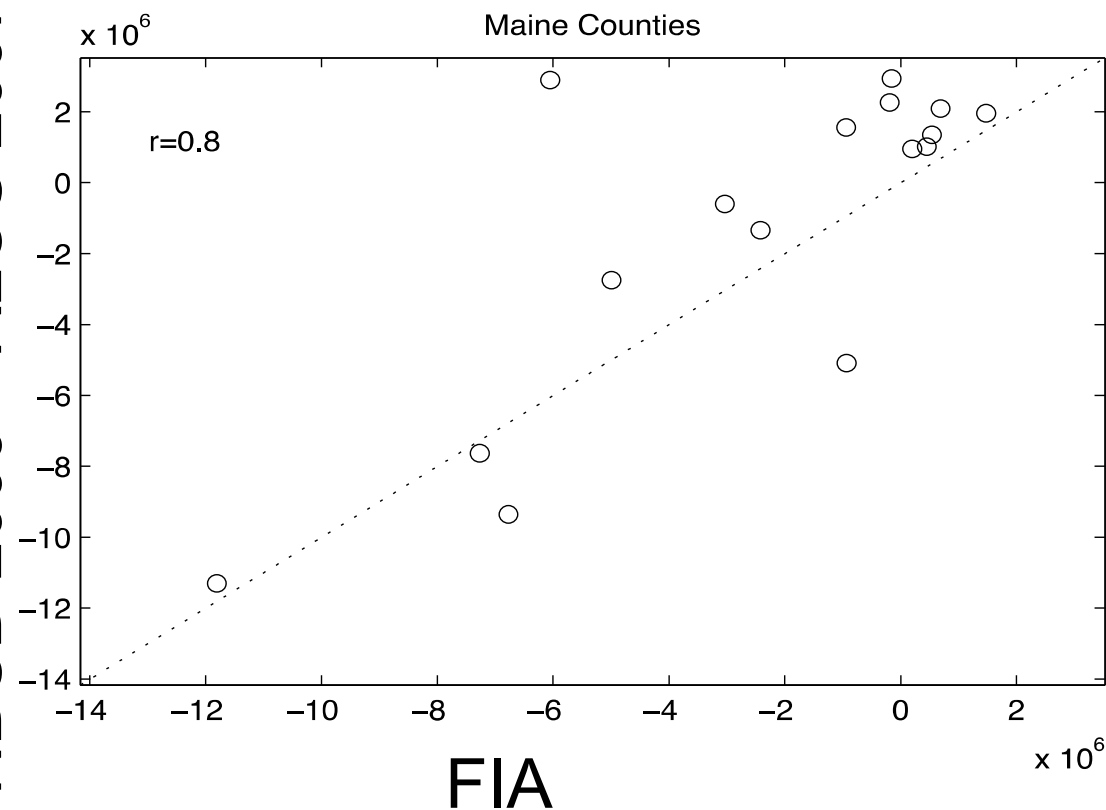


ALOS biomass
map for 2007
from 655 HH/HV
acquisitions

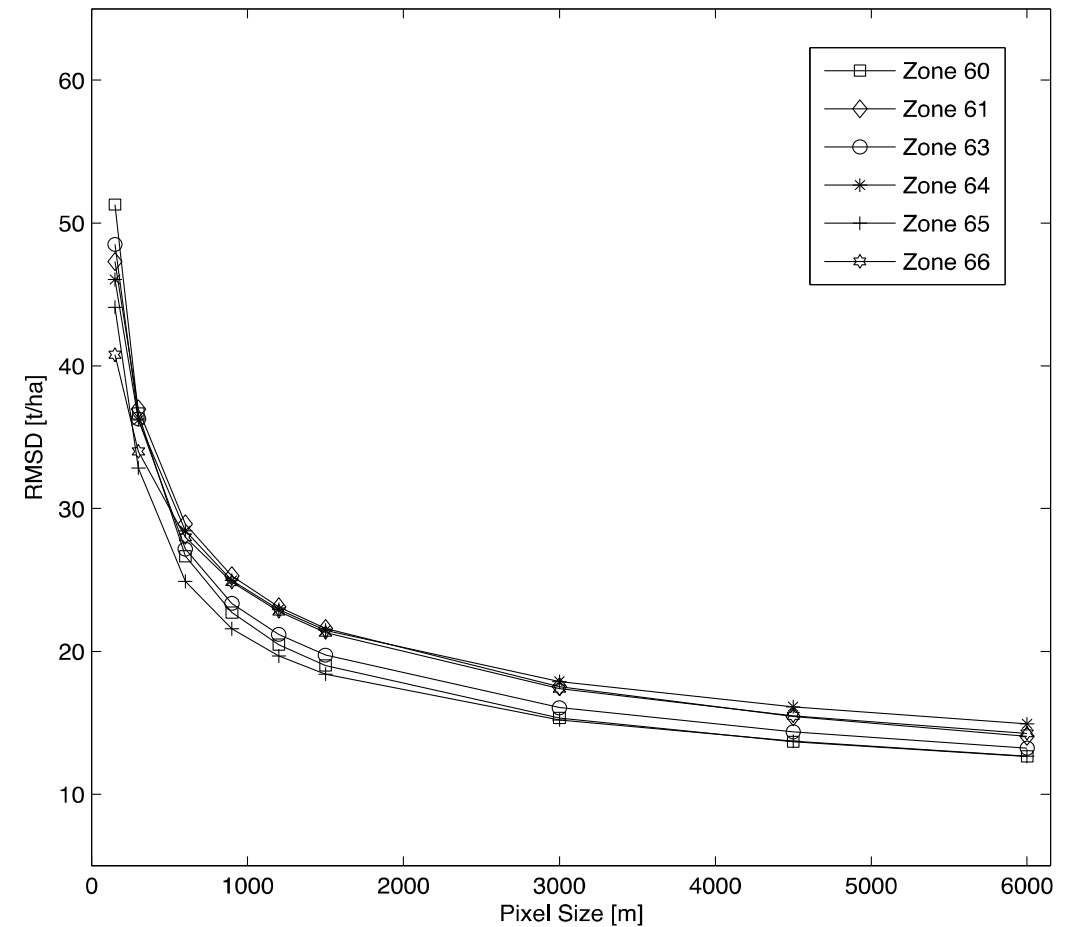
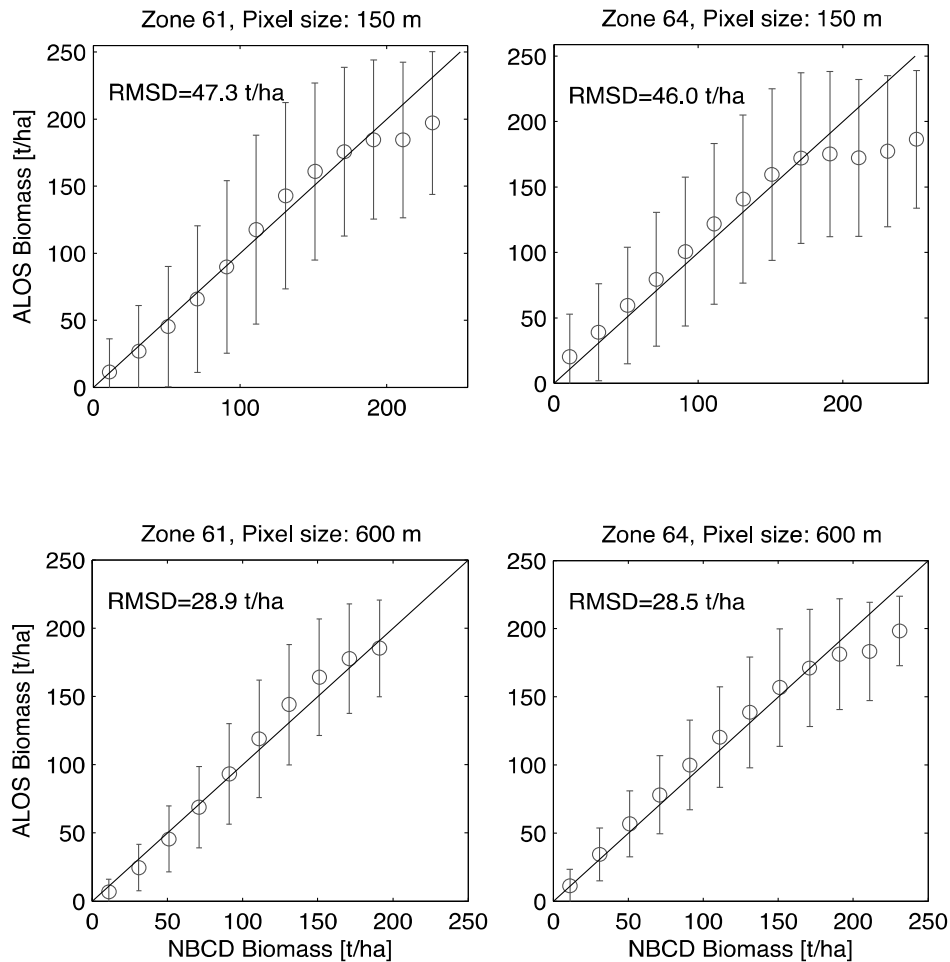
When aggregating to county scale ...



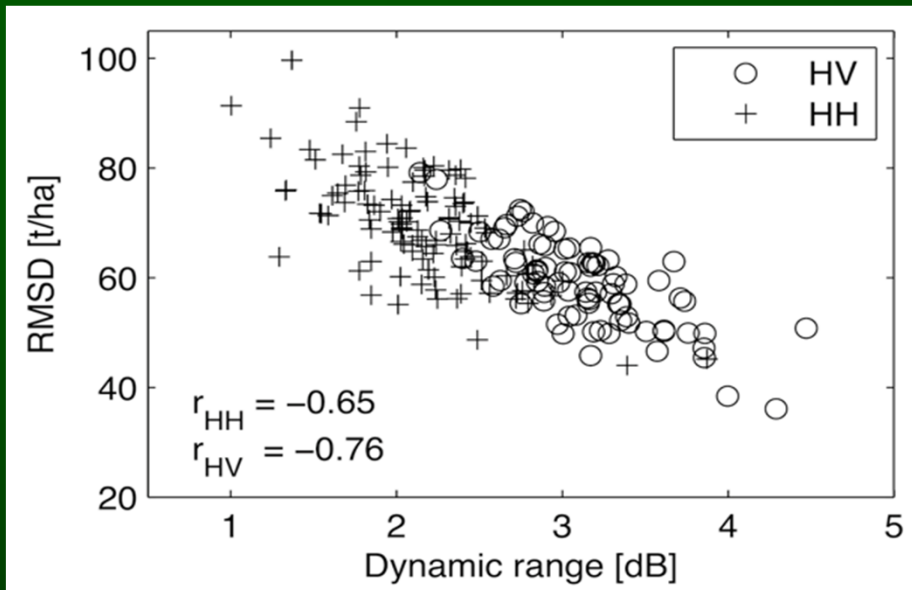
NBCD 2000 – ALOS 2007



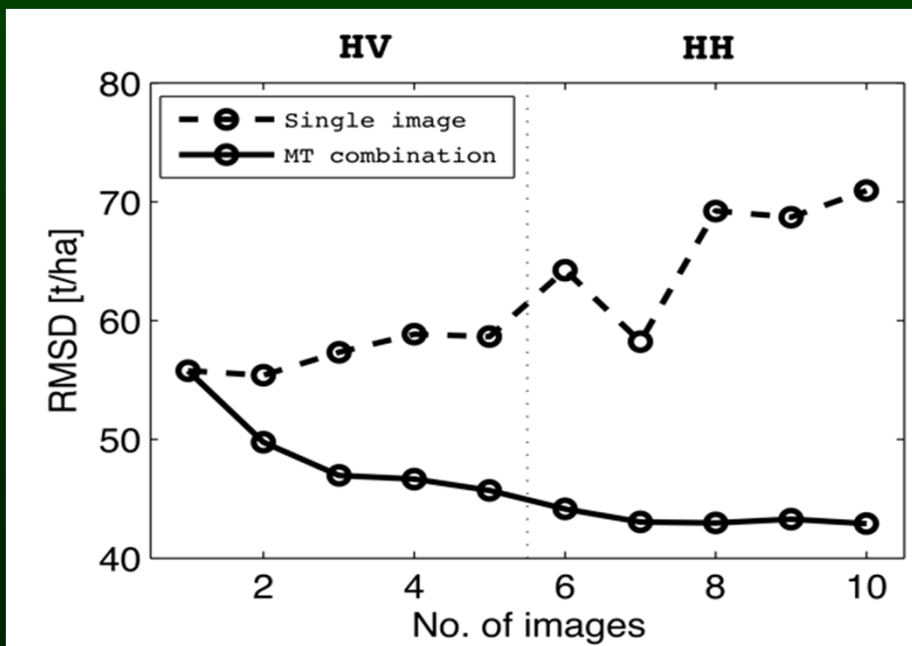
Pixel-level Comparison with NBCD



Importance of having multi-temporal data

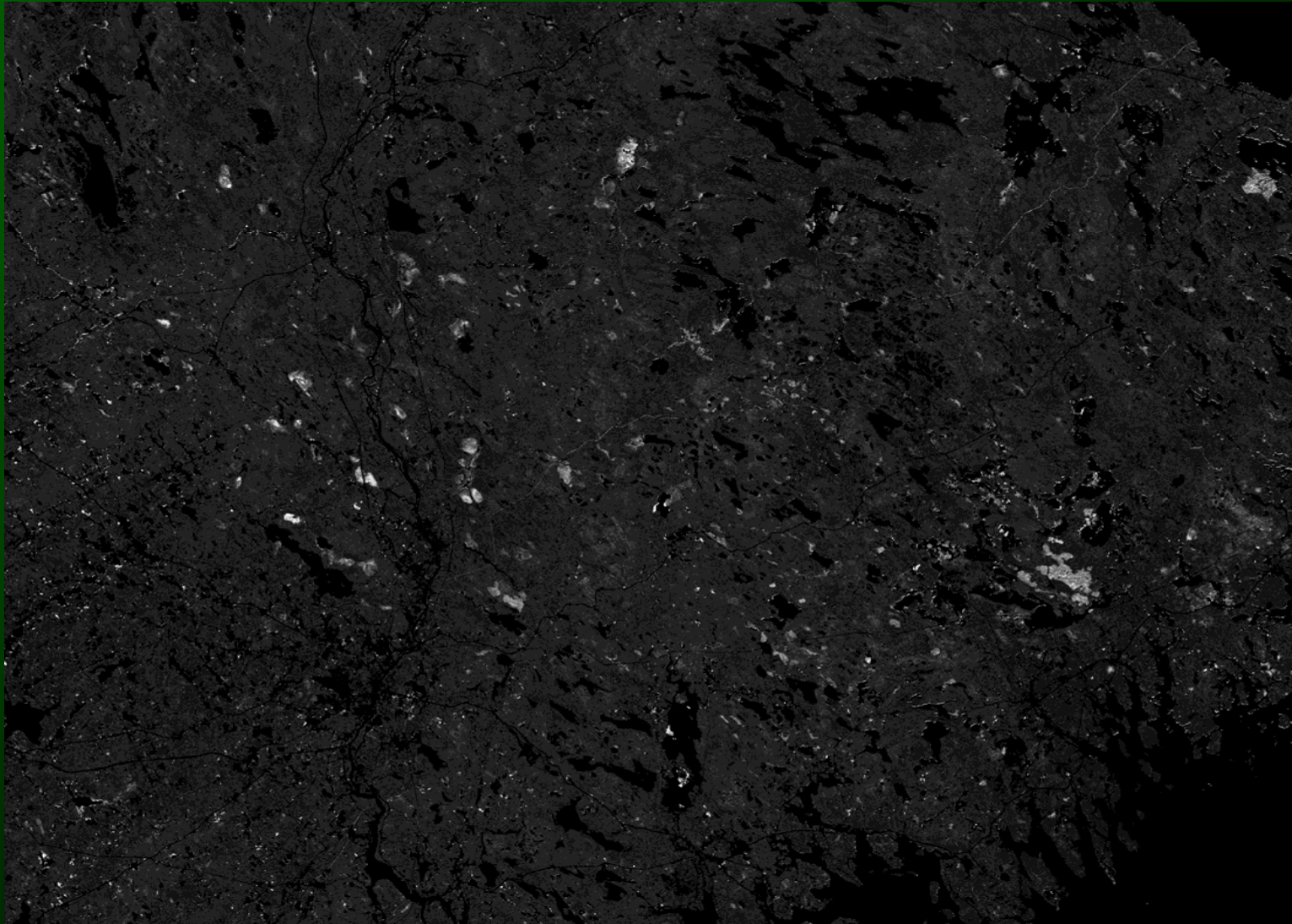


Pronounced weather effects on single image retrieval

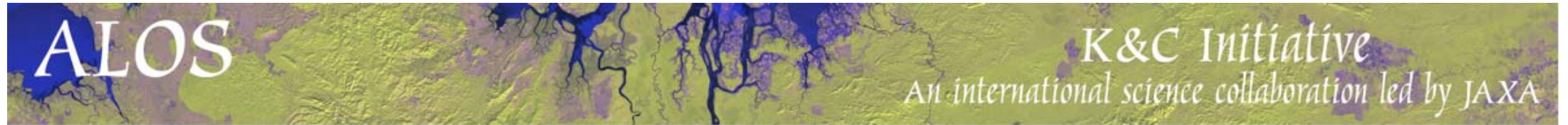


> 4 images per year (available only locally from ALOS PALSAR)

Change Signal



Difference: 1) Modeled HV Backscatter based on NBCD2000
2) ALOS PALSAR HV backscatter year 2007

The banner features a satellite image of a river delta or coastal region, with blue water and green land. The word "ALOS" is written in large, white, serif capital letters on the left side.

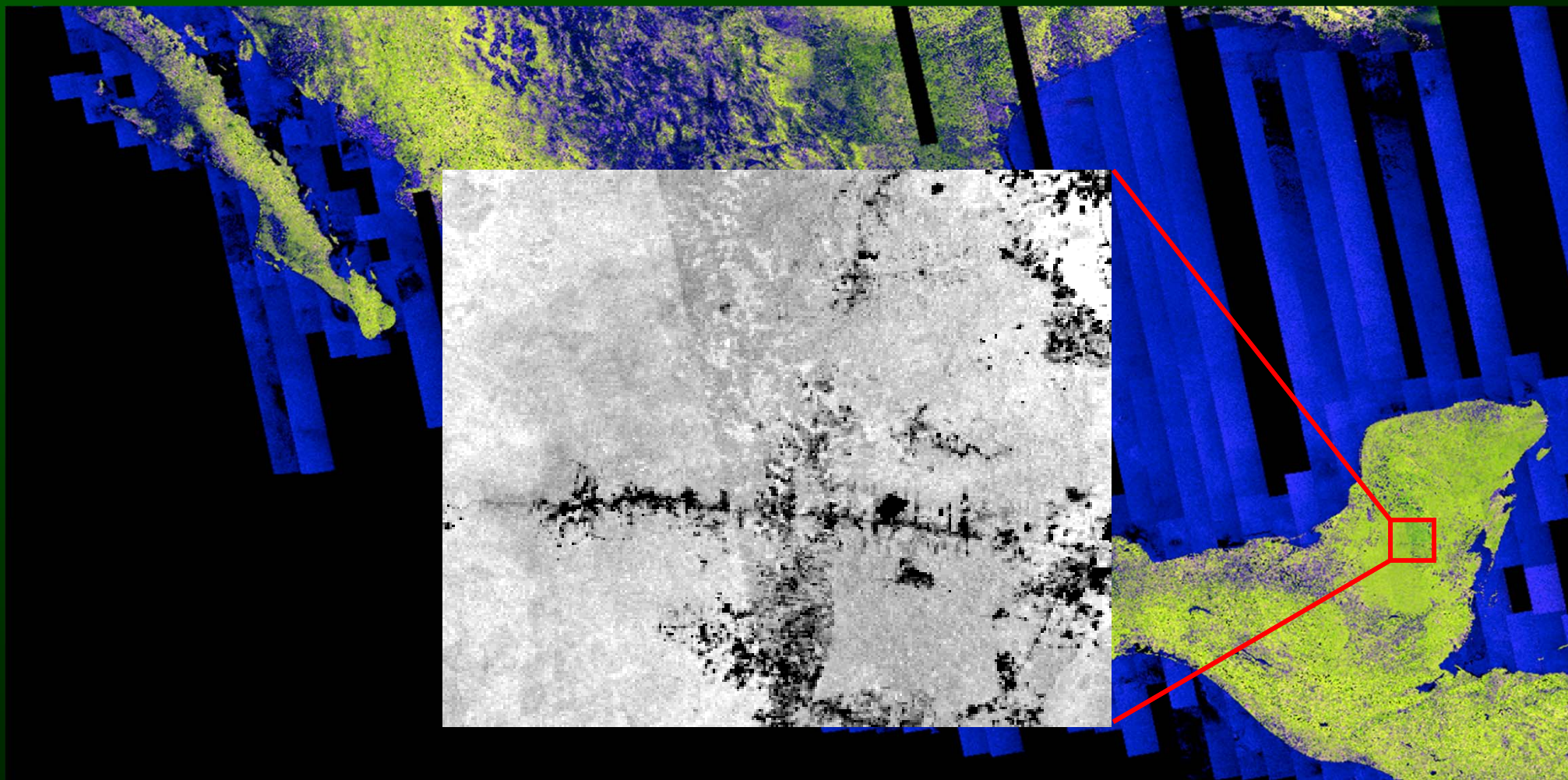
ALOS

K&C Initiative
An international science collaboration led by JAXA

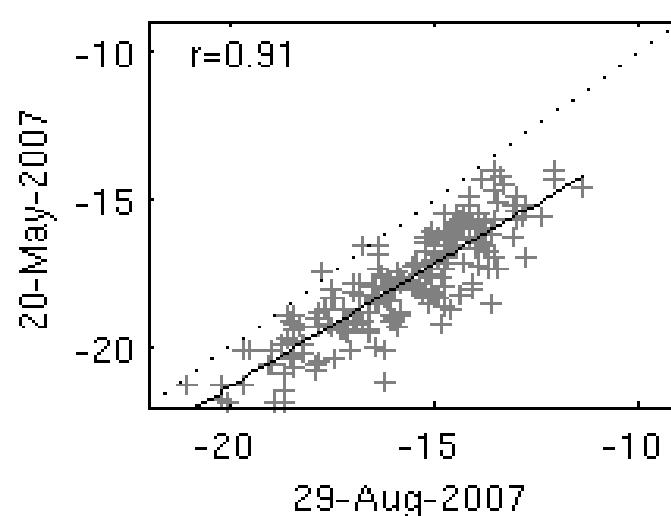
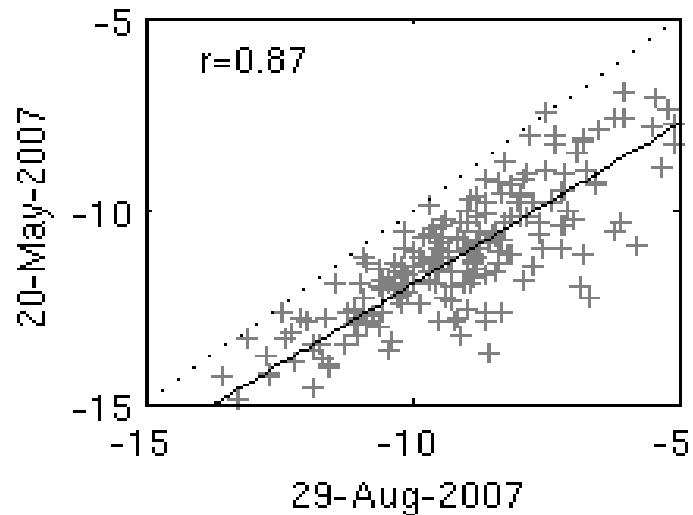
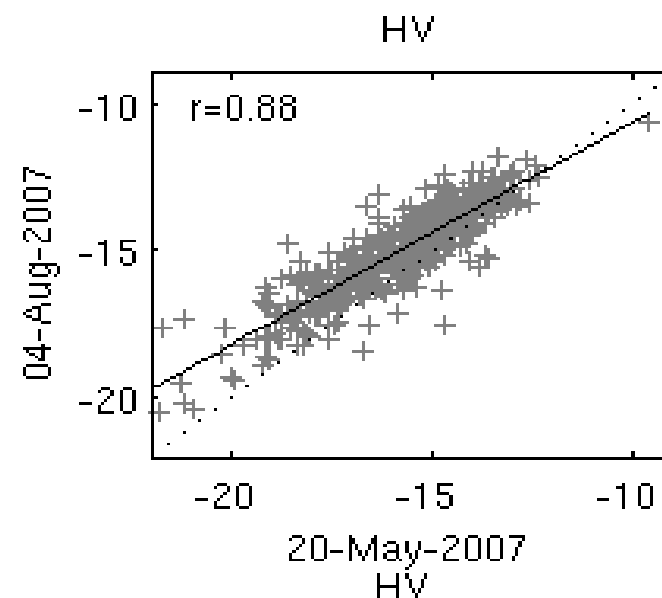
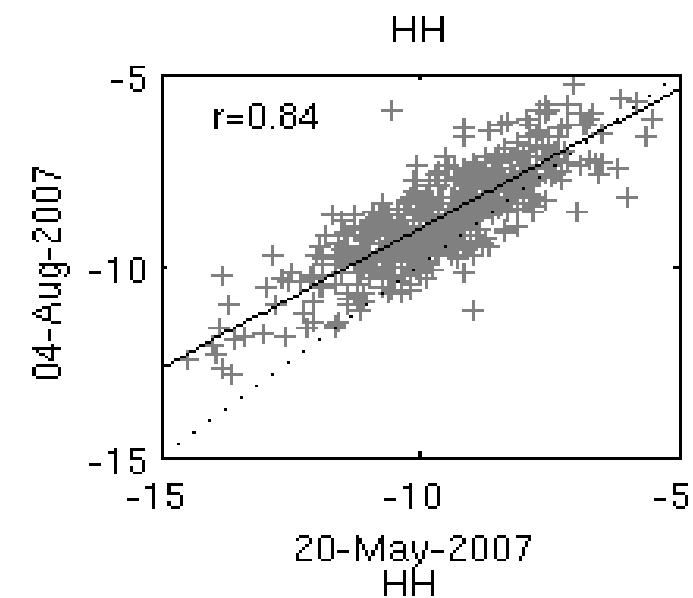
Mexico

ALOS PALSAR Mosaic

1400 FBD scenes - year 2007
Partial multi-temporal coverage

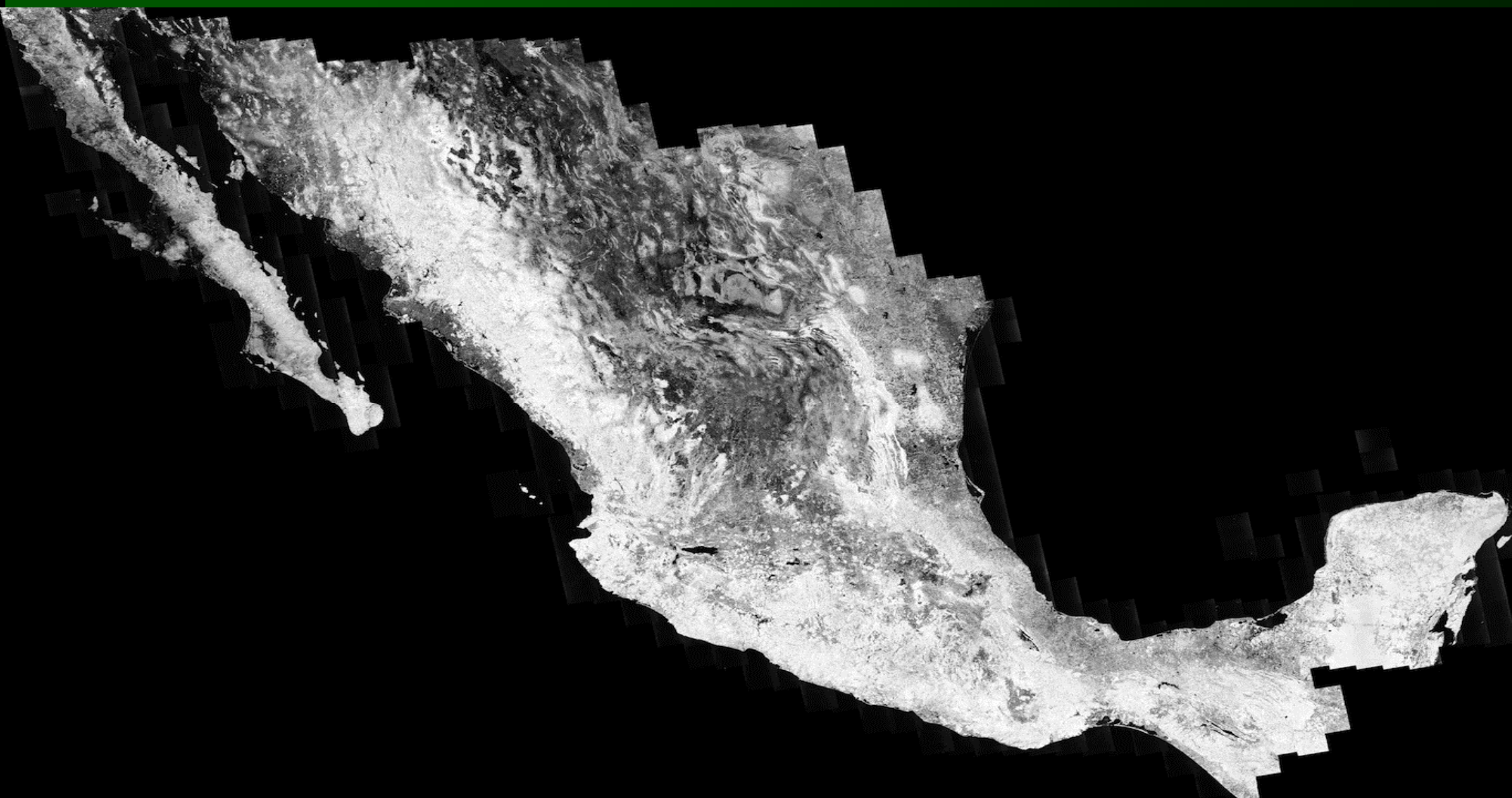


Weather Effects:

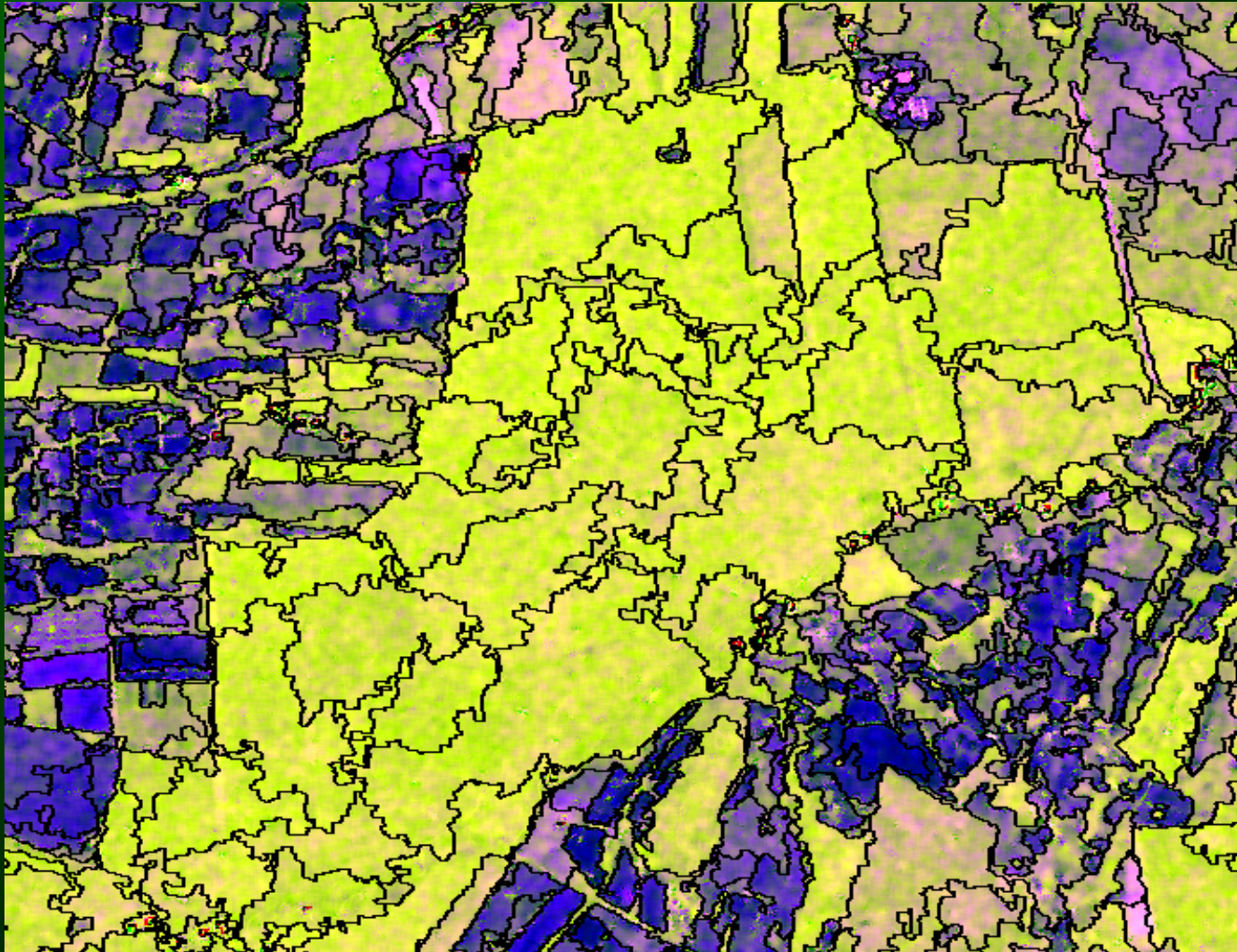


PALSAR Mosaic

- Dry conditions (low backscatter) used for mosaicking in case of multi-temporal coverage
- Otherwise: normalization of orbits acquired under wet conditions using linear functions

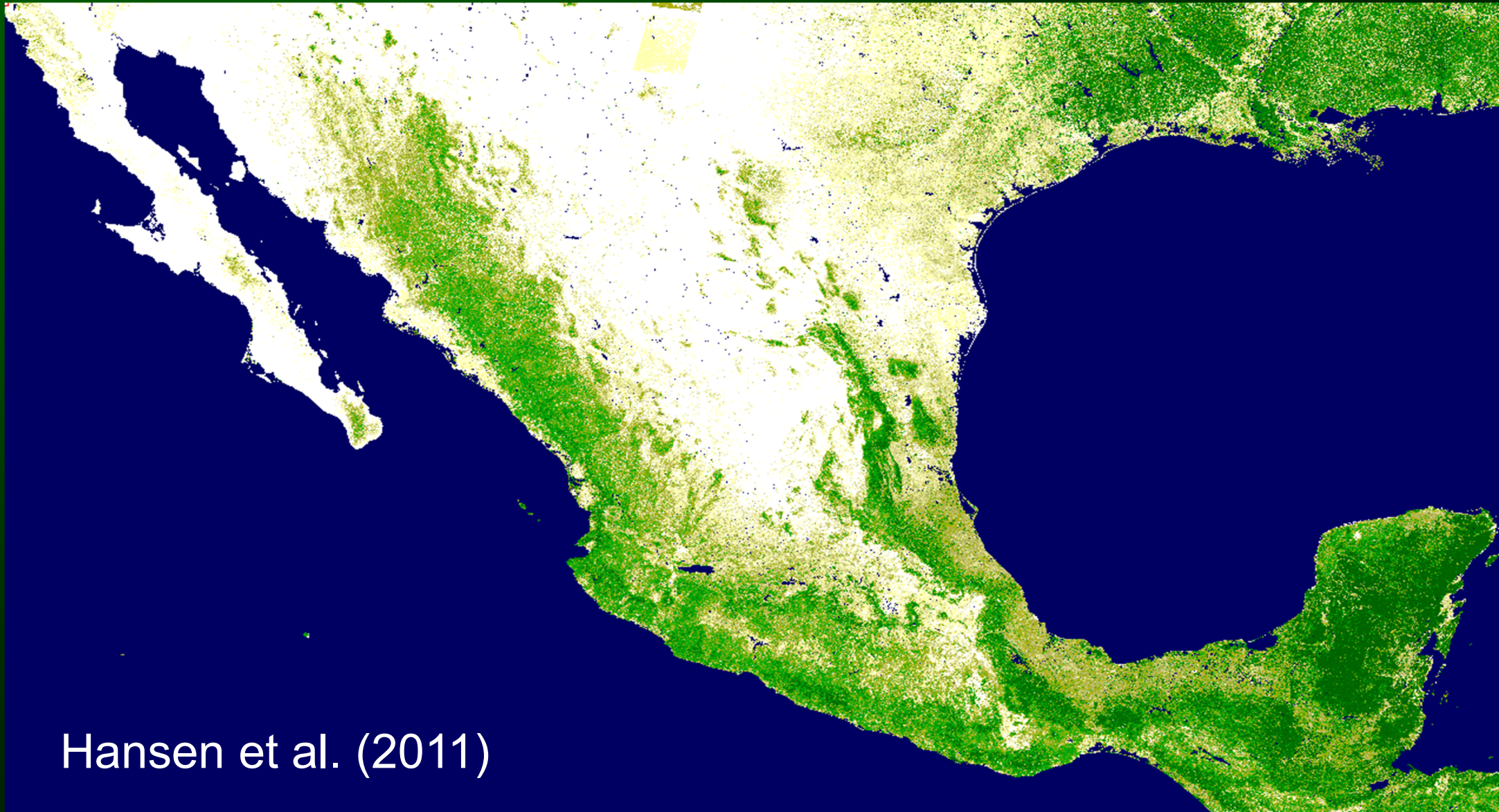


Segmentation



Further Speckle Noise reduction
Calculation of texture measures for each image object

Landsat Vegetation Continuous Field canopy cover map – 30m pixel size (2000-2004 images)

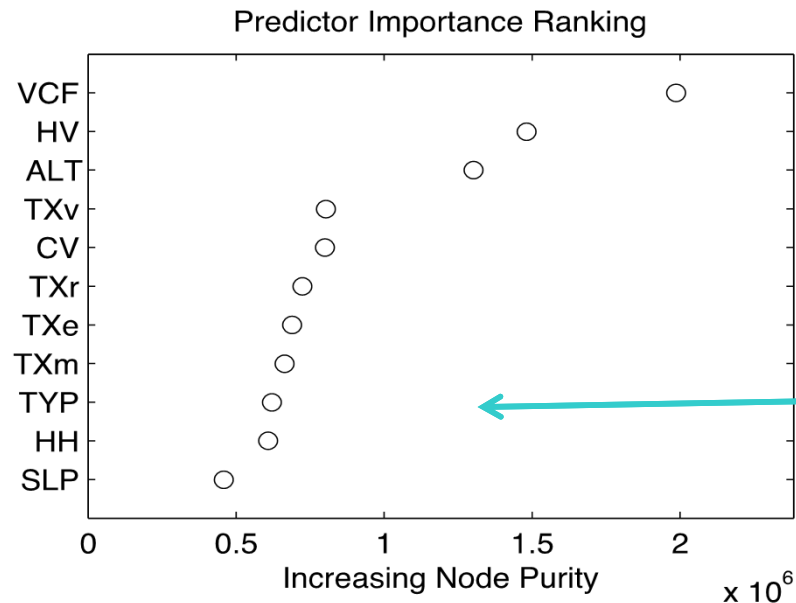
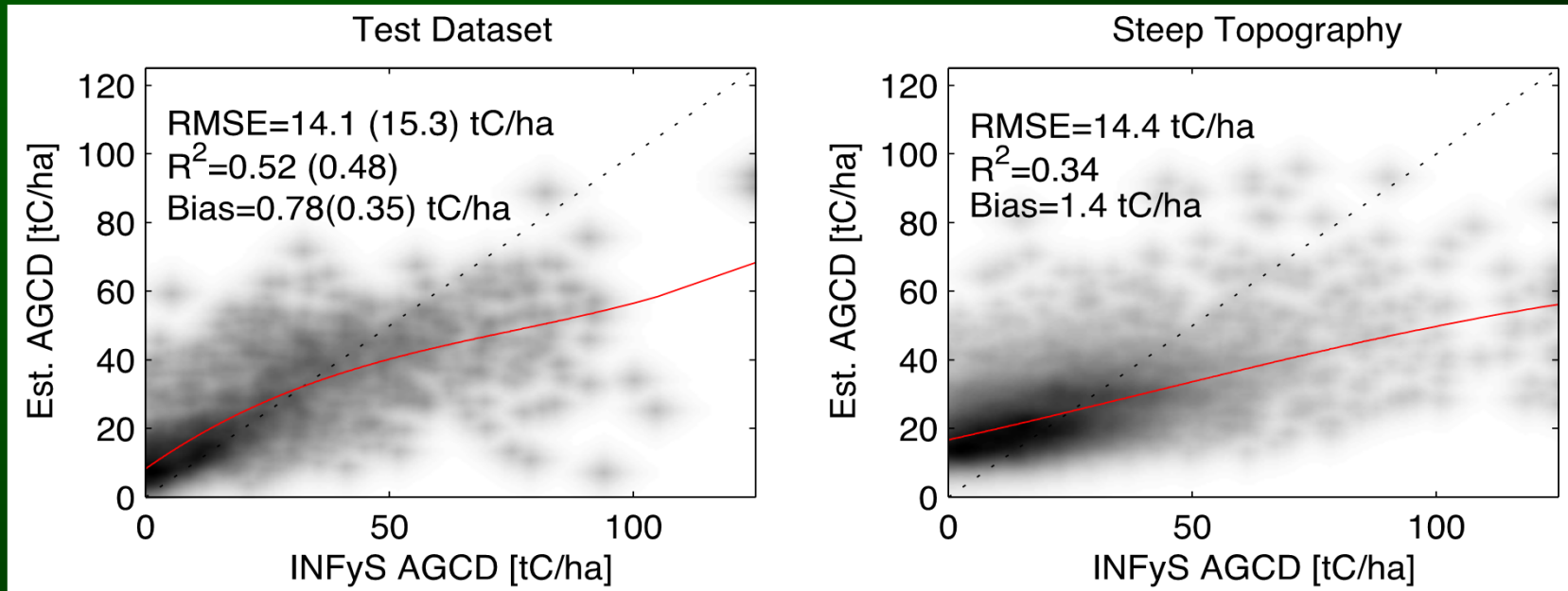


Hansen et al. (2011)

Modeling

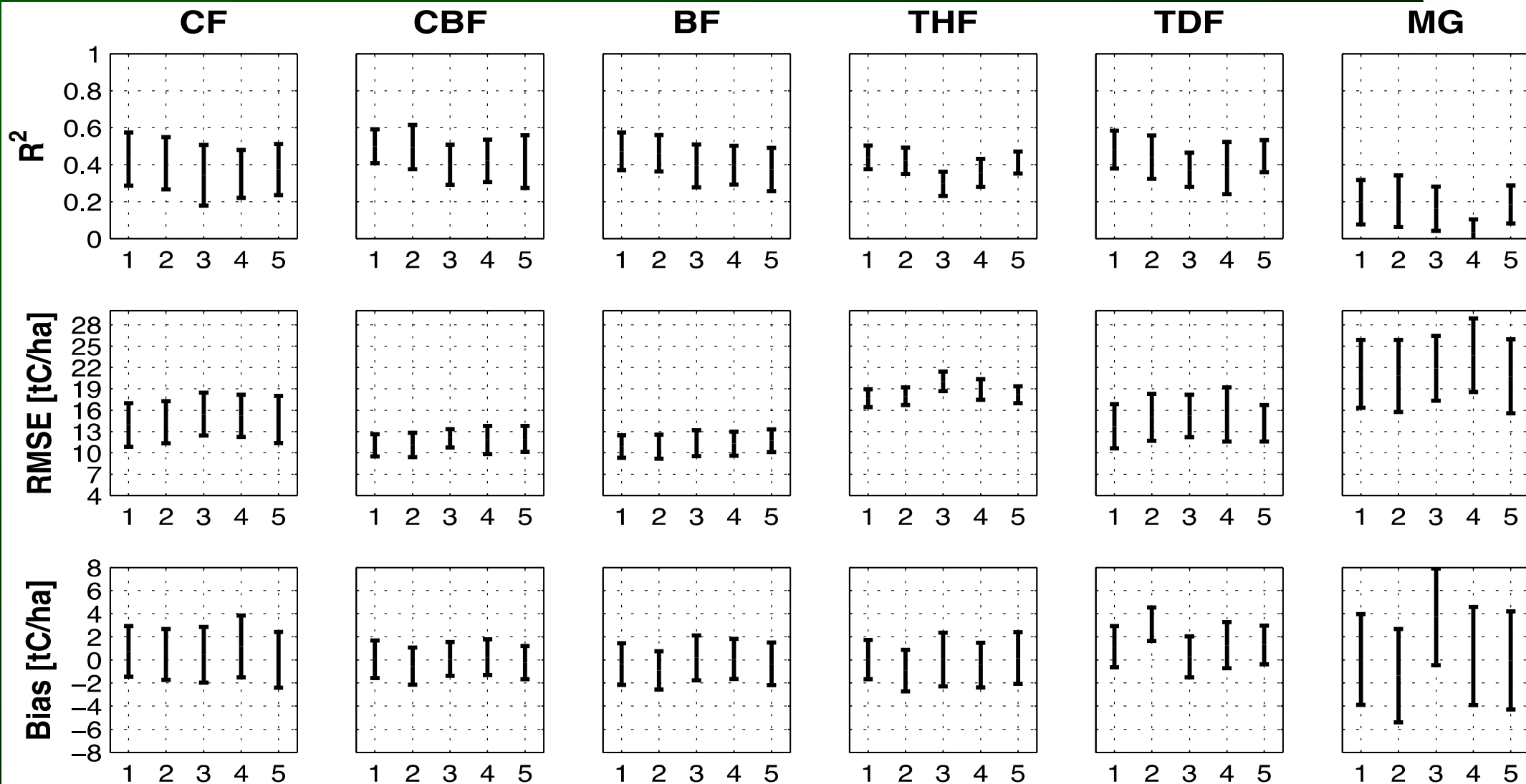
- ◆ Data mining algorithm: randomForest
- ◆ Response: INFyS aboveground biomass (tC/ha)
- ◆ Predictors:
 1. PALSAR – HH/HV backscatter and texture
 2. Landsat VCF canopy density
 3. SRTM 90m (elevation, slope)
 4. Forest Type (INFyS) → INEGI LC Series

Retrieval with randomForest



Forest Type

Forest Types



CF – Coniferous
 CBF – Conif./Broadl.
 BF – Broadleaf
 THF – Tropical humid
 TDF – Tropical Dry
 MG – Mangroves

1 – All predictors
 2 – No INFyS forest type
 3 – No Radar
 4 – No Landsat VCF
 5 – No SRTM

Densidad de Carbón de Biomasa Leñosa por Encima del Suelo de México

Carbon Density of Aboveground Woody Biomass of Mexico



Este mapa muestra la distribución de la densidad de carbono en la biomasa leñosa por encima del suelo en los bosques mexicanos. Las estimaciones (*) se realizaron a través de la integración a un modelo estadístico de aproximadamente 25,000 datos de campo del inventario del Servicio Forestal Mexicano (CONAFOR, INFyS) con observaciones de satélite óptico (Landsat) y de radar (ALOS PALSAR), así como datos de elevación y pendiente derivados del conjunto de datos de la Misión Topográfica Radar Shuttle (SRTM). El mapa fue producido a un tamaño de píxel de 30m x 30m. El carbono fue estimado para las áreas con más de 0 por ciento de cubierta de dosel tal como es definido por el producto Landsat Campos Continuos de Vegetación (VCF). La modelación fue realizada por el Woods Hole Research Center bajo el Proyecto MREDD+ financiado por la USAID.

2.2 Pg of Carbon for VCF > 0 %
1.9 Pg of Carbon for VCF > 10%
1.8 Pg INFyS

Densidad de Carbón de Biomasa Leñosa por Encima del Suelo
Carbon Density of Aboveground Woody Biomass
(Densidades de carbono por hectárea, toneladas de carbono por hectárea)



Sitios de Acción Temprana de MREDD+
MREDD+ Early Action Sites

1. Sierra de Manantlán
2. Cumbre de la Cruz (Sierra de Manantlán)
3. Volcán Nevado de Colima, Los Cuernos de El Bosque
4. Ciénaga Nacional, Continente de Maricao Forestal
5. Ciénaga Nacional de la Sierra Nevada de Chiapas
6. Sierra de Pico, Yucatán, Guatemala



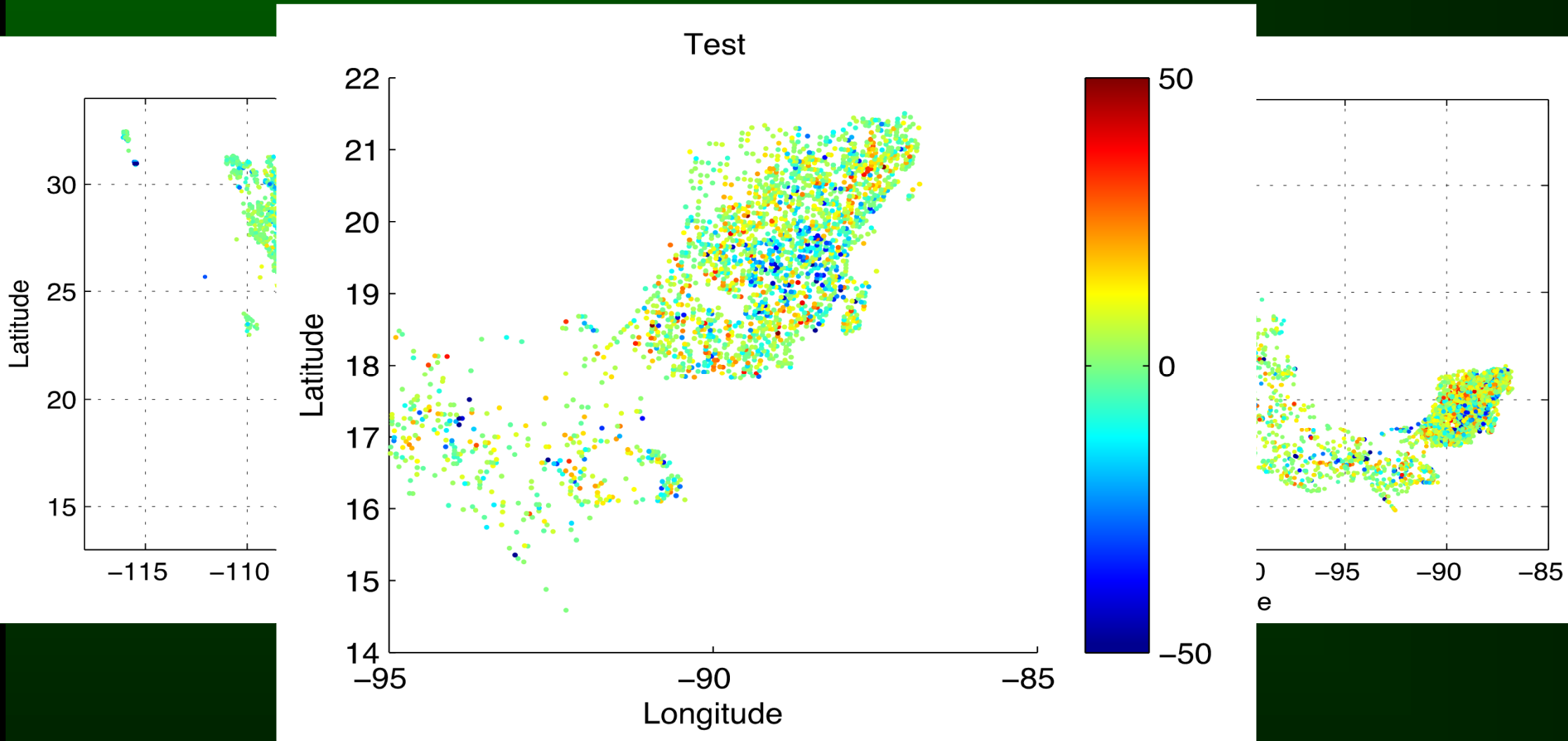
Prepared by: Woods Hole Research Center
Funded by: USAID/MREDD+ Project
Map Date: 2013

Map of Mexico showing the distribution of carbon density in aboveground woody biomass. The map uses a color scale from light yellow (low density) to dark green (high density). A legend indicates that white areas represent 'Sin Biomasa Leñosa' (No Woody Biomass). A scale bar shows distances in kilometers (0 to 300) and miles (0 to 150).

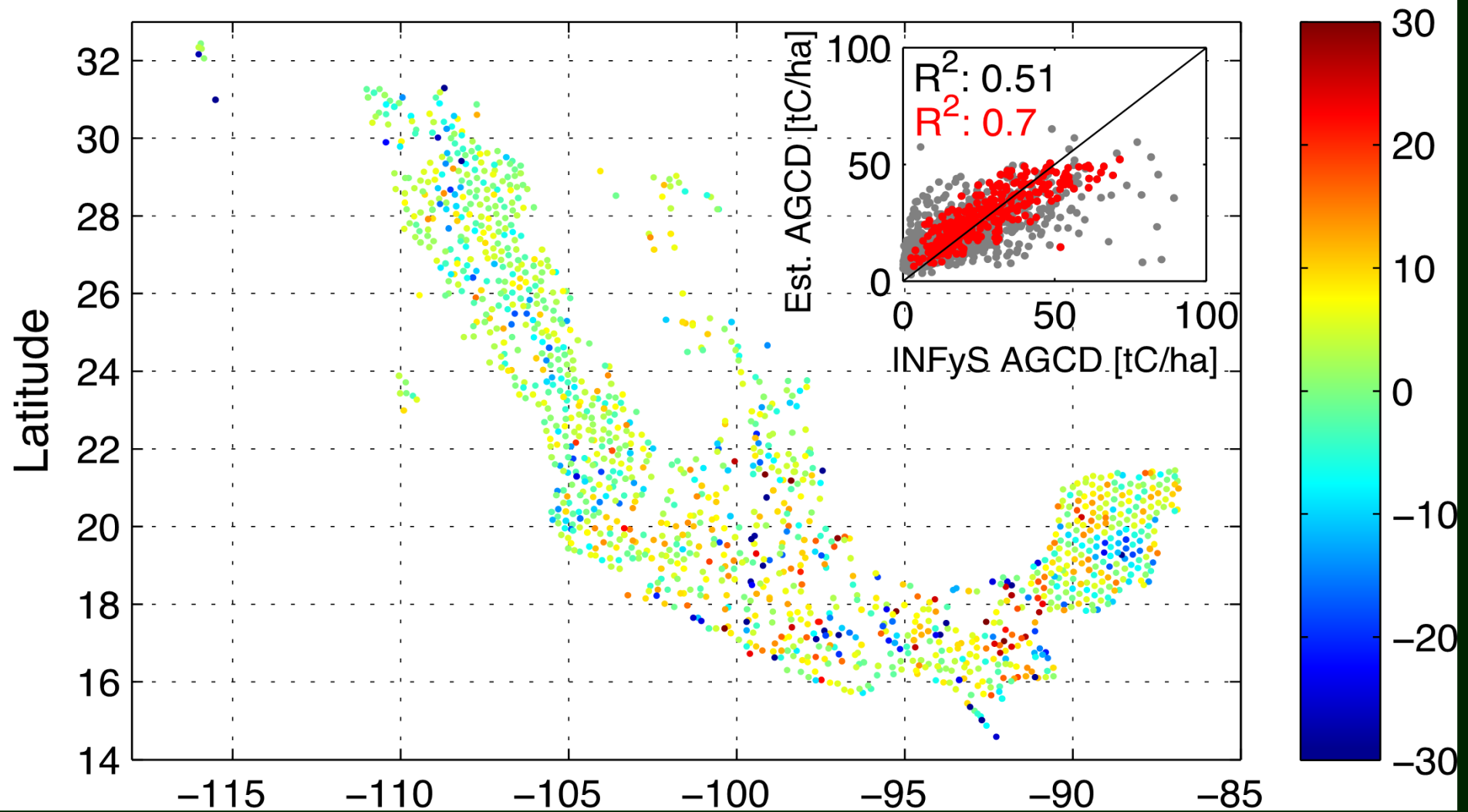
Map of Mexico showing the distribution of carbon density in aboveground woody biomass. The map uses a color scale from light yellow (low density) to dark green (high density). A legend indicates that white areas represent 'Sin Biomasa Leñosa' (No Woody Biomass). A scale bar shows distances in kilometers (0 to 300) and miles (0 to 150).

Map of Mexico showing the distribution of carbon density in aboveground woody biomass. The map uses a color scale from light yellow (low density) to dark green (high density). A legend indicates that white areas represent 'Sin Biomasa Leñosa' (No Woody Biomass). A scale bar shows distances in kilometers (0 to 300) and miles (0 to 150).

Estimates unbiased at national scale/for major forest types
Is there any systematic regional over/underestimation?



Hexagon Scale



Quick Update on Other Activities:

Pan-Tropical Effort:

- Mapping of Pan-tropical vegetation height with ALOS-PALSAR and ICESat/GLAS derived vegetation height
- Results to be reported at next meeting

NASA Carbon Monitoring System Funded Project:

- WHRC and Boston University
- Focus on GEO-FCT Sites in Mexico, Colombia, and Peru
- Time-Series Analysis of Radar/Optical data for cover change detection, uncertainty analysis and ingestion in C Flux models (Houghton et al. Book keeping model).

NASA CMS-2013 PROJECT

Time Series Fusion of Optical and Radar Imagery for Improved Monitoring of Activity Data, and Uncertainty Analysis of Emission Factors for Estimation of Forest Carbon Flux

PI: Josef Kelldorfer, WHRC

Co-Is: Curtis Woodcock, Boston University

Richard Houghton, WHRC

Pontus Olofsson, Boston University

Researchers: Oliver Cartus,, WHRC

Christopher Holden, Boston University

Collaborators:

MINAM, Peru

IDEAM, Colombia

CONABIO, Mexico



The Woods Hole
Research Center

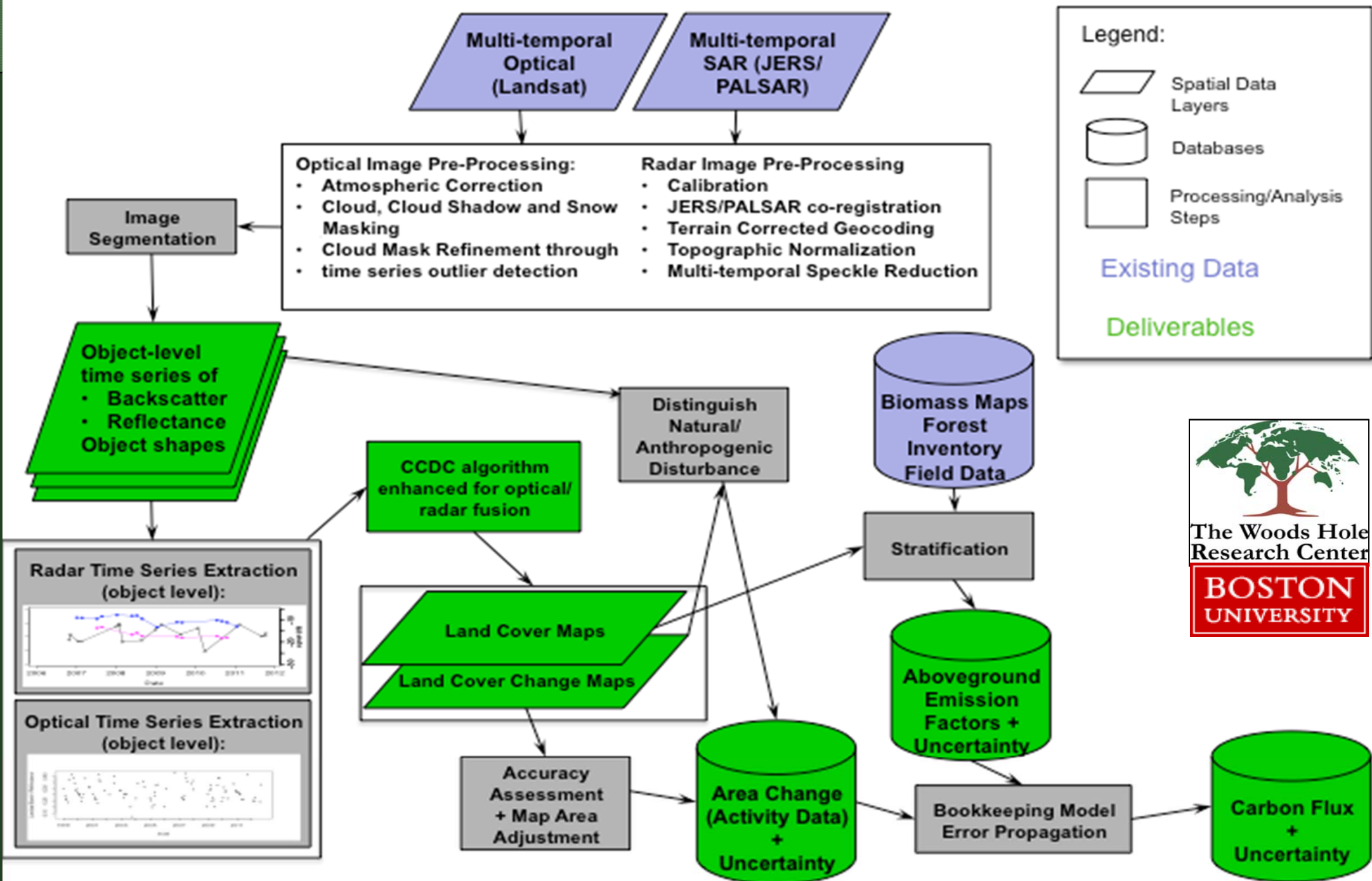
**BOSTON
UNIVERSITY**

NASA CMS SDT Meeting, November 2013

Objectives

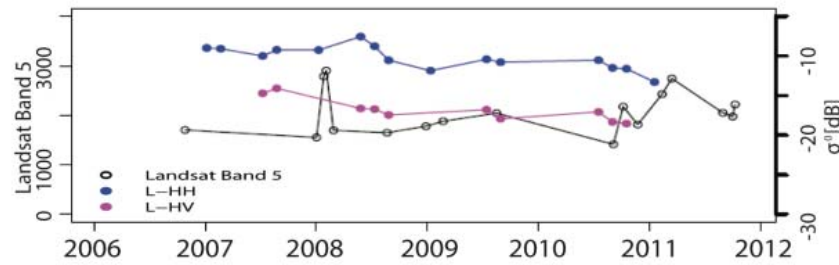
1. *Develop a Novel Method for the Generation of Activity Data*
 1. Develop an algorithm from optical and radar time series fusion to produce the most accurate assessment of deforestation, forest degradation, and forest regrowth area estimates at annual time steps or better (i.e., activity data). This includes an approach for determining the distinction of natural or anthropogenic change, and the mapping of stable (non-changing) land cover categories.
 2. Implement good practices for assessing uncertainty and accuracy of activity data estimates from the developed algorithm in (1.1).
2. *Uncertainty Analysis of Carbon Emission Estimates from Activity Data and various Sources for Emission Factors*
 1. Compile a database of country specific emission factors stratified by land cover categories (from 1.1) linked with carbon density estimates from forest inventory and existing biomass maps. The database will contain uncertainty estimates.
 2. Study impact of uncertainties in activity data and emissions factors on estimated carbon flux from a bookkeeping model in order to provide guidance to national MRV implementation.





New NASA Carbon Monitoring System Project: Time-Series Fusion Optical/Radar

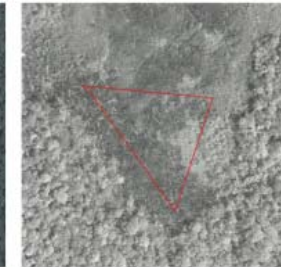
Forest to
Non-Forest



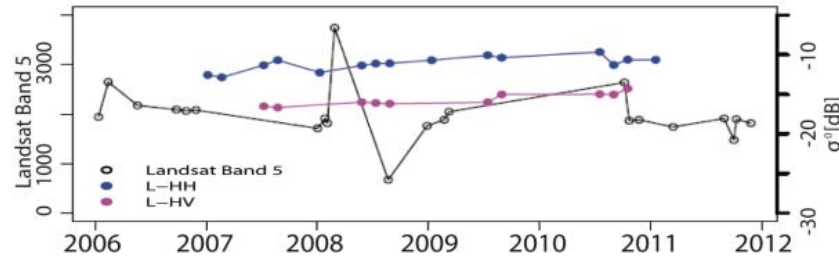
2007



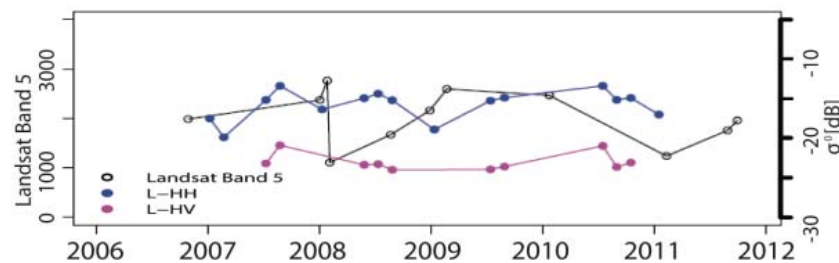
2010



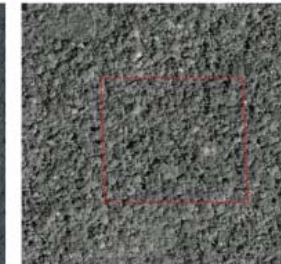
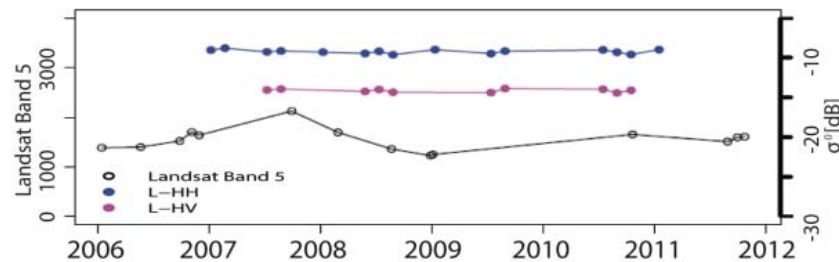
Forest
Regrowth



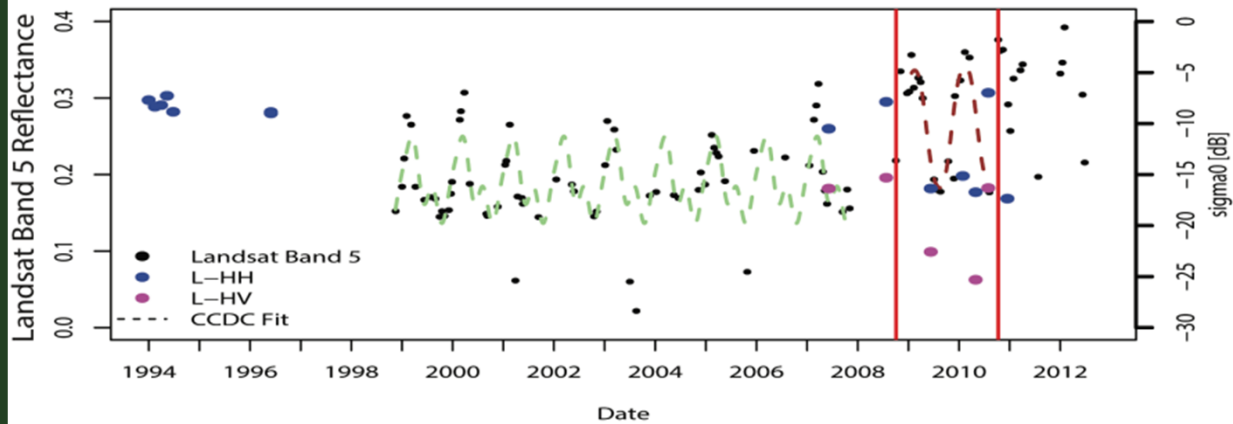
Non-Forest
to Non-
Forest



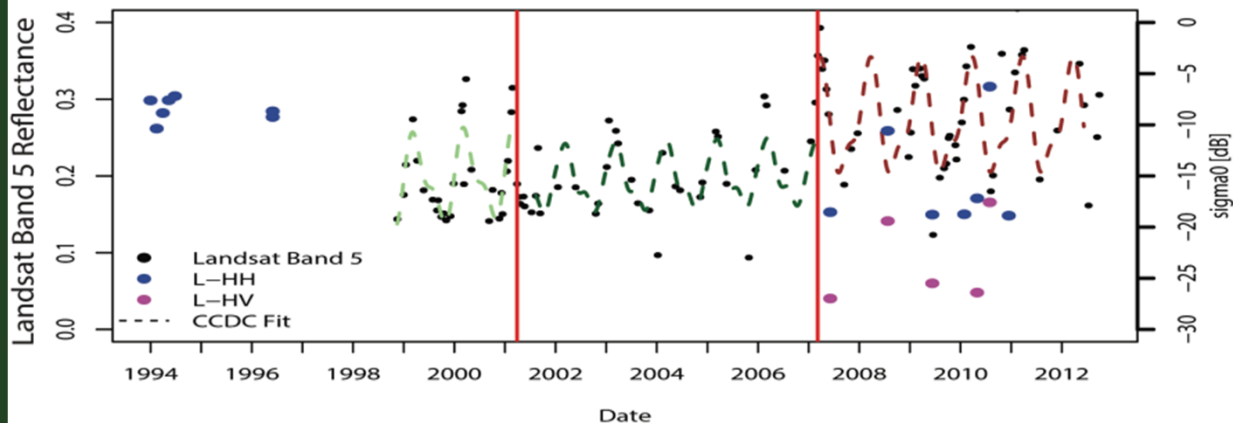
Tall Forest to
Tall Forest



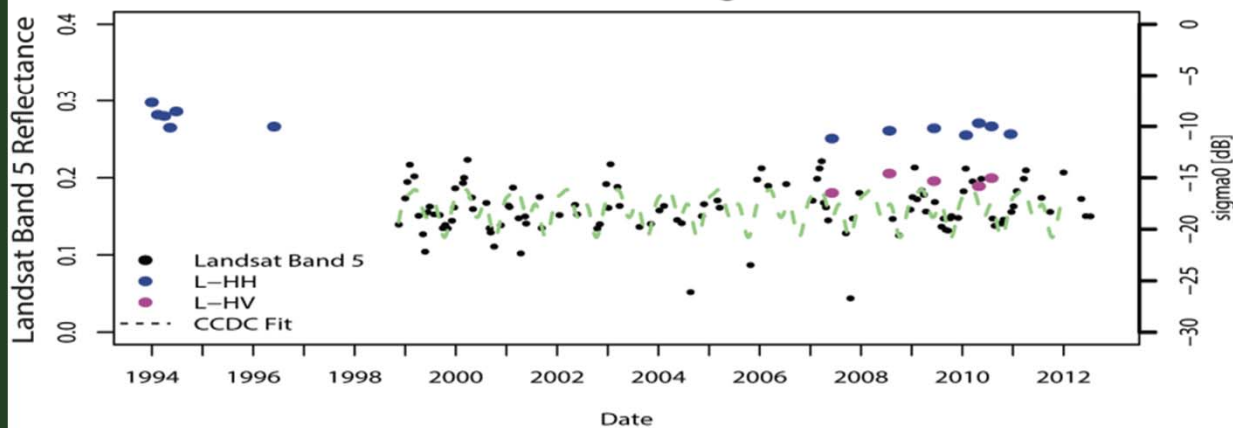
(a) Disturbance in 2008



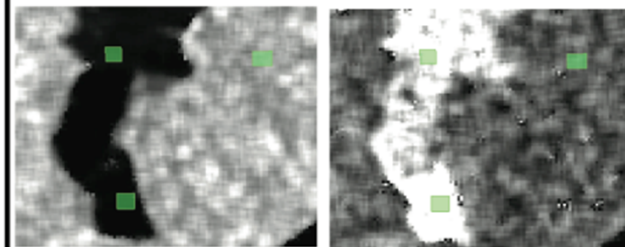
(b) Conversion to Agriculture in 2007



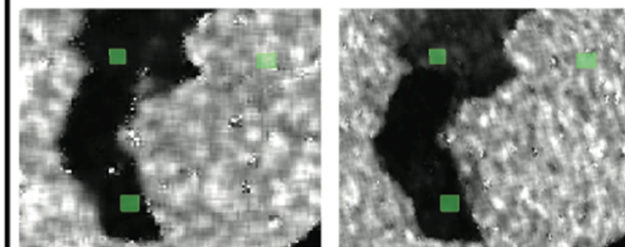
(c) Forest Remaining Forest



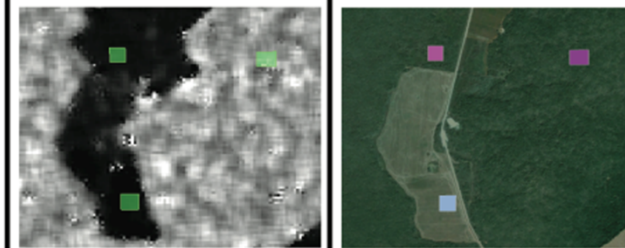
02/09/2011-ALOS 09/24/2010-ALOS



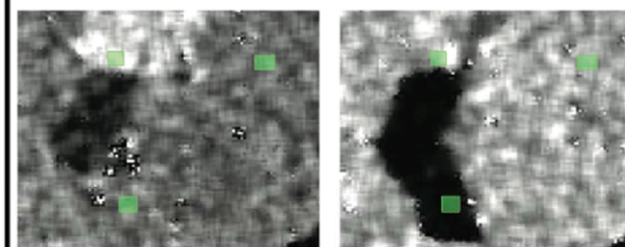
06/24/2010-ALOS 03/24/2010-ALOS



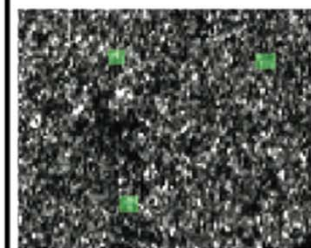
08/06/2009-ALOS 02/25/2008-Google



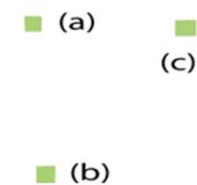
09/18/2008-ALOS 08/01/2007-ALOS



07/28/1996-JERS



Plot Sampling Location



Ticul Mexico

