K&C Phase 3 – Brief project essentials

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

Josef Kellndorfer, 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 (due 31.3.2012)			
	Synergy ALOS intensity – Lidar for GSV/HT retrieval		D2.1 (due 31.3.2013)		
	Synergy ALOS intensity/repeat-pass coherence – Lidar for GSV/HT retrieval			D3 (due 31.3.2014)	
Vermont, USA	SFP-Lidar based GSV/CH map production	D1.2 (due 31.3.2012)			
	Synergy ALOS intensity – Lidar for GSV/HT retrieval		D2.2 (due 31.3.2013)		
Mexico (1)	Biomass retrieval			D4 (due 31.3.2014)	
	Wetland classification				D5 & D6 (due 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

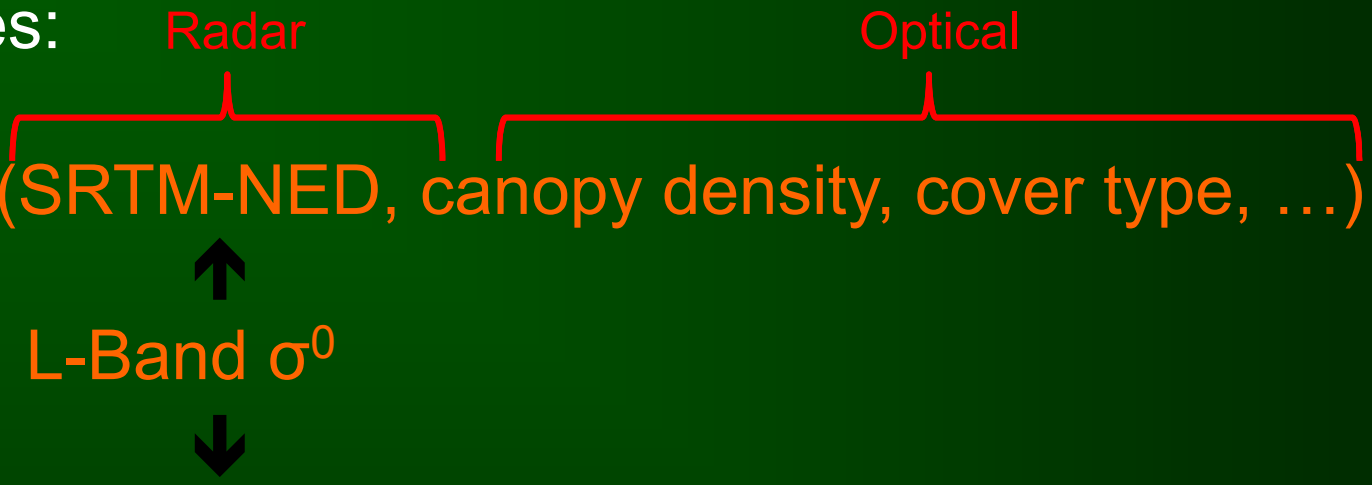
Maps of biomass and forest cover

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

North-Eastern US Study Site

Modeling Approach

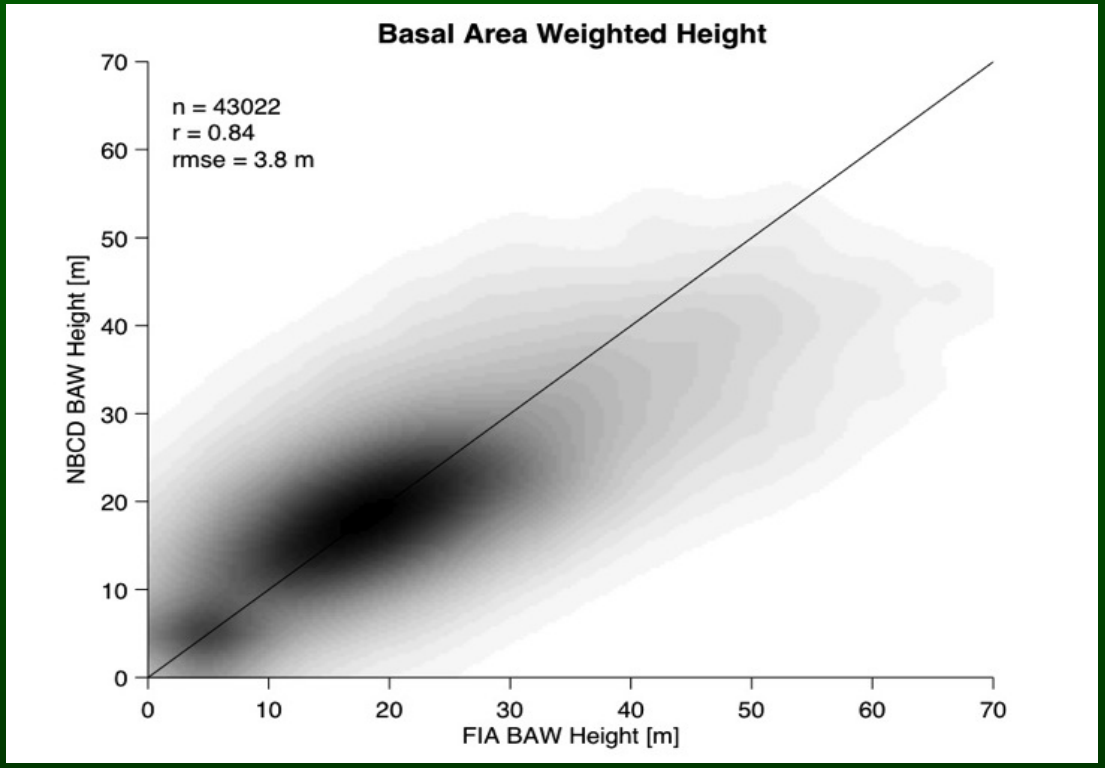
Hypotheses:

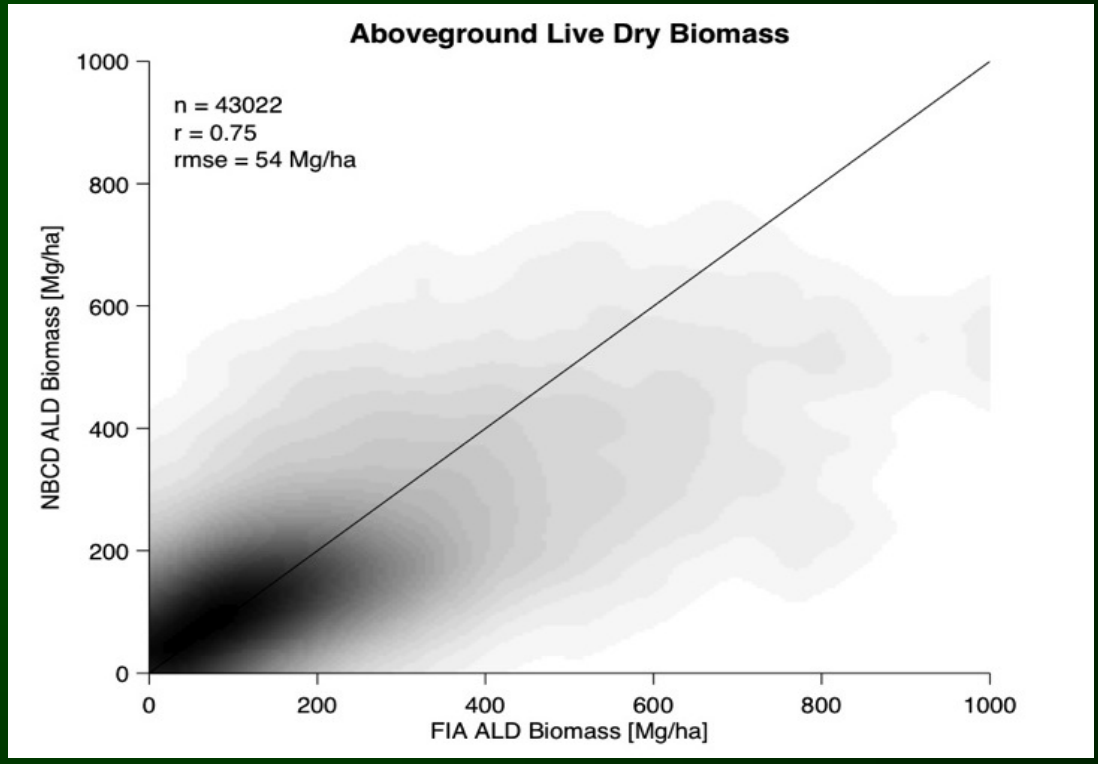


Used a statistical approach (ensemble regression-tree algorithm) to generate the relationships, test how well height (Lorey's) and biomass could be predicted from ground measured forest survey data.

Aboveground Woody Biomass and Carbon Stock of the Conterminous United States

Plot Level Accuracy via Bootstrap Validation

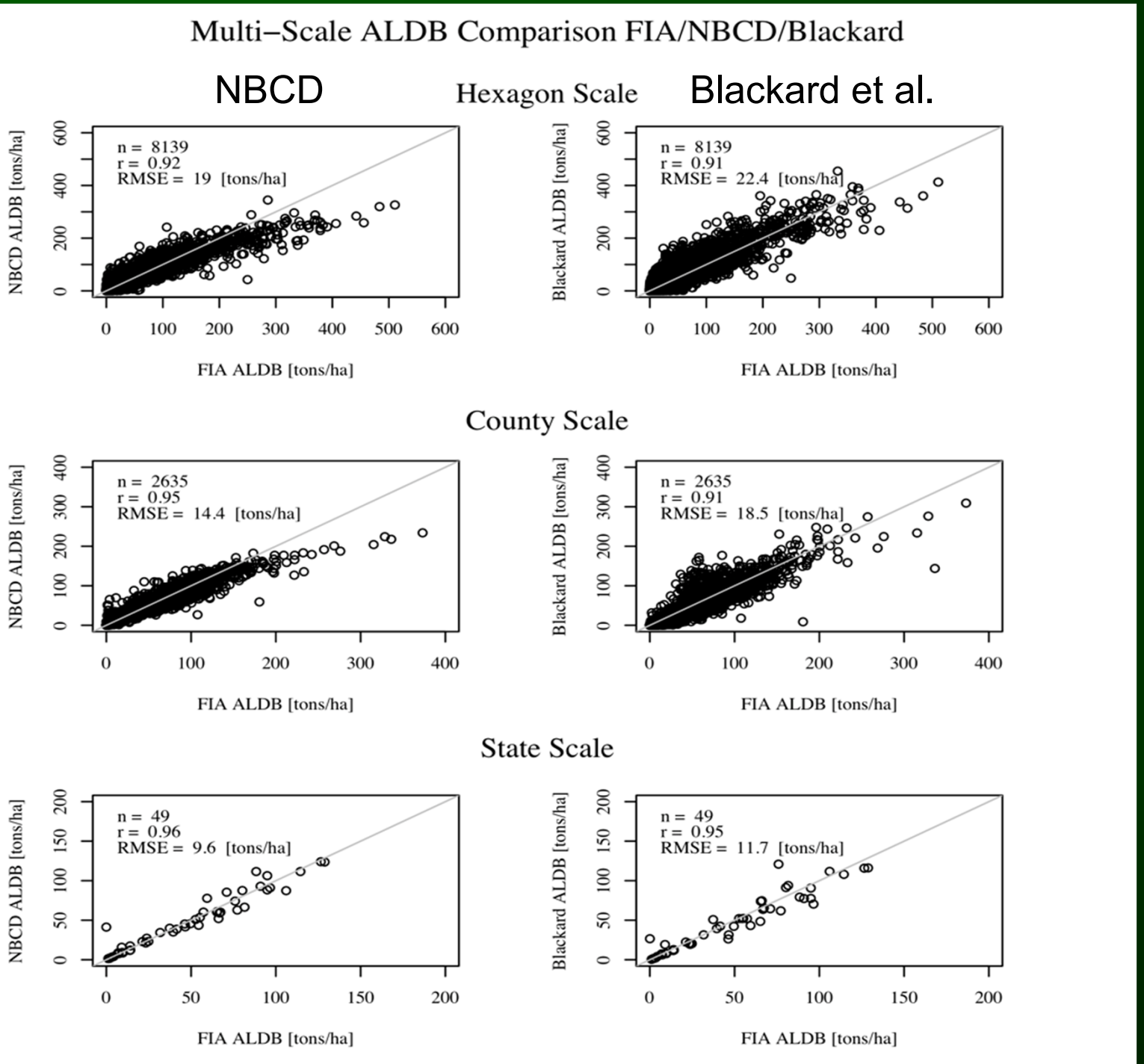




RESULTS OF NATIONAL AND REGIONAL SCALE BAWHT AND ALD BIOMASS VALIDATION

Region	n	Height r	Height RMSE (m)	Biomass r	Biomass RMSE (Mg/ha)
National	*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

!



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

Hexagon Scale

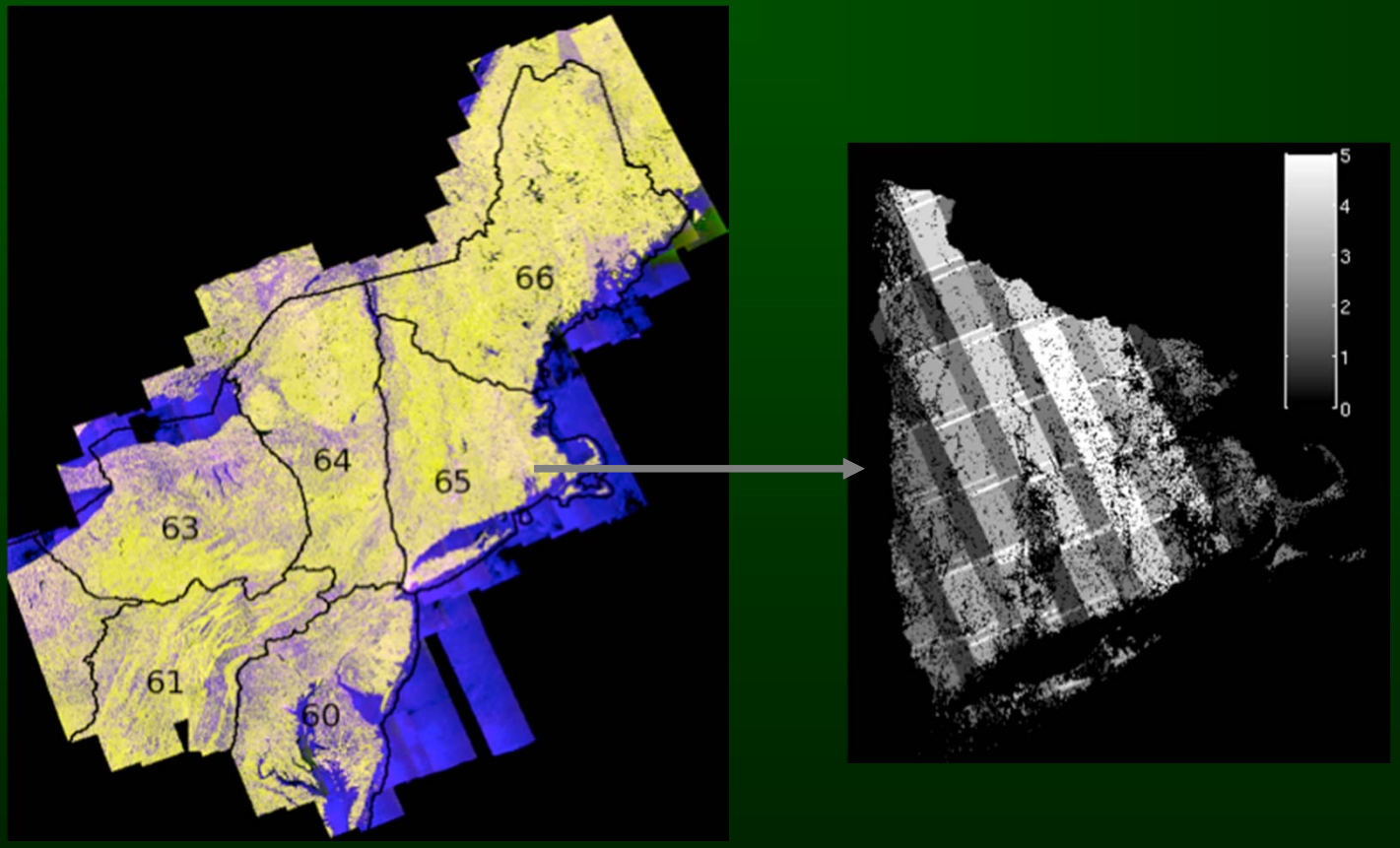
Size ~ 650 km2

~ 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: Kellndorfer, J., Cartus, O., Houghton, R. A., Walker, W. S.

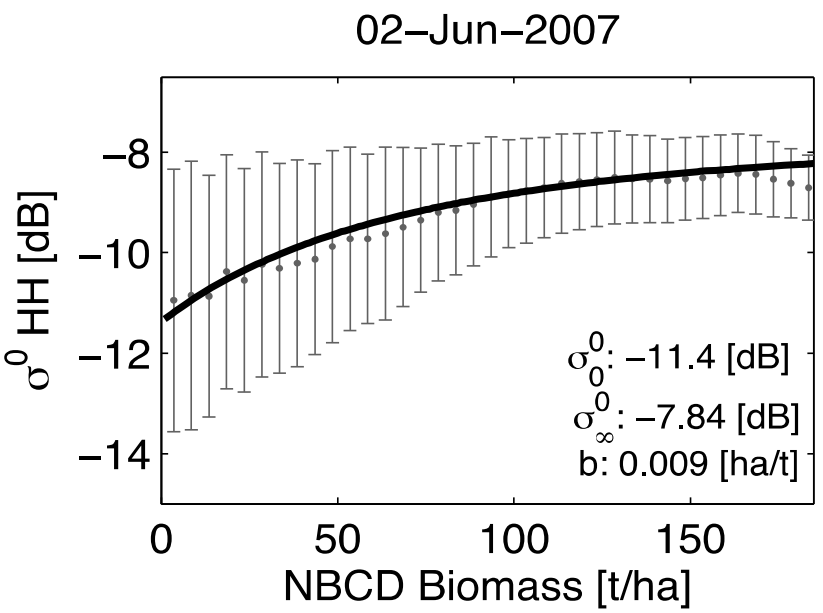
Collaboration: Maurizio Santoro, GAMMA RS

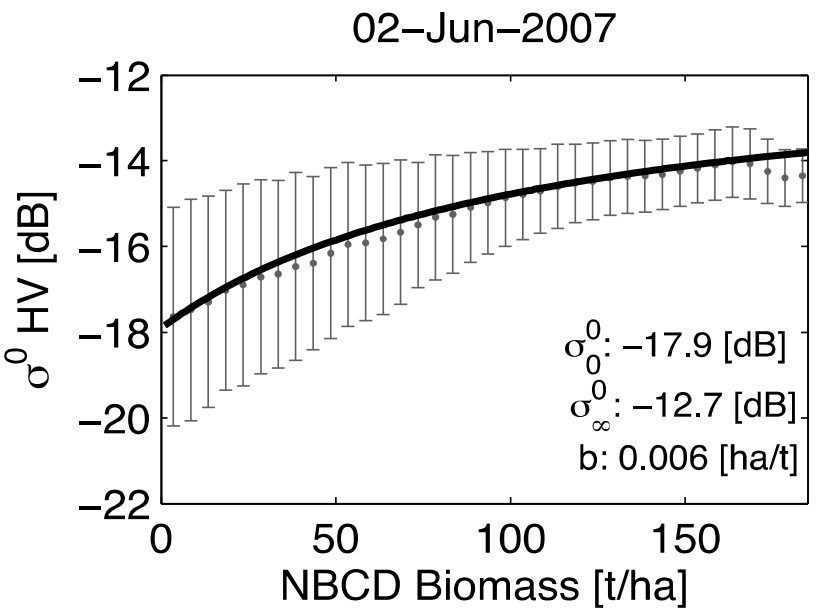


655 PALSAR FBD images for 2007/08

Multi-temporal coverage: 1-5

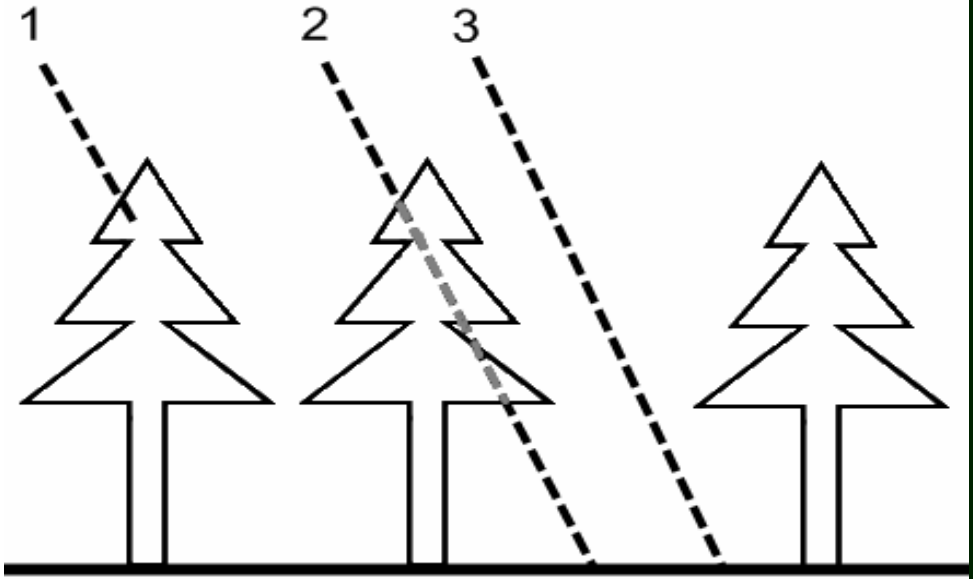
BIOMASAR (Santoro et al., 2011)



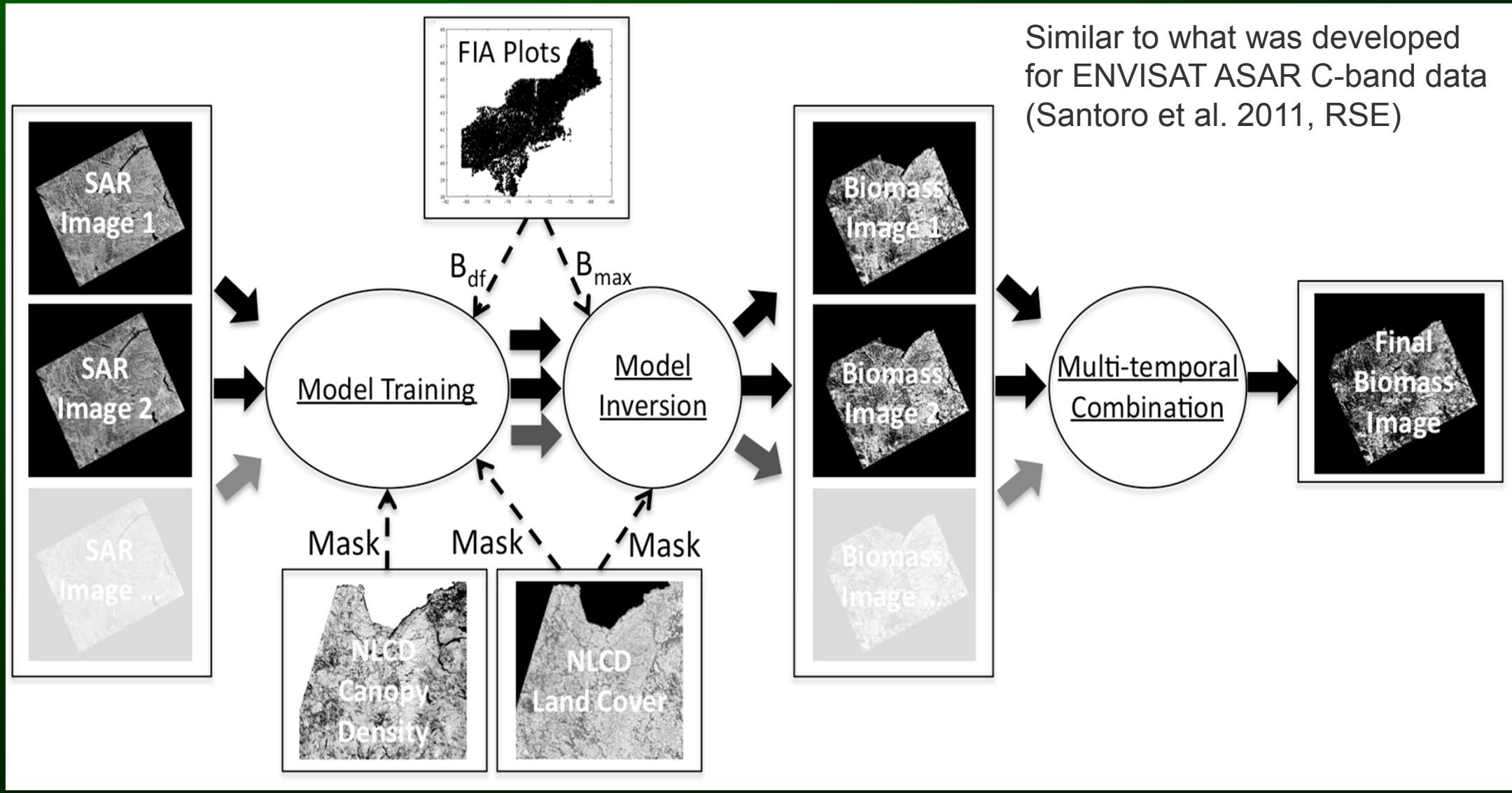


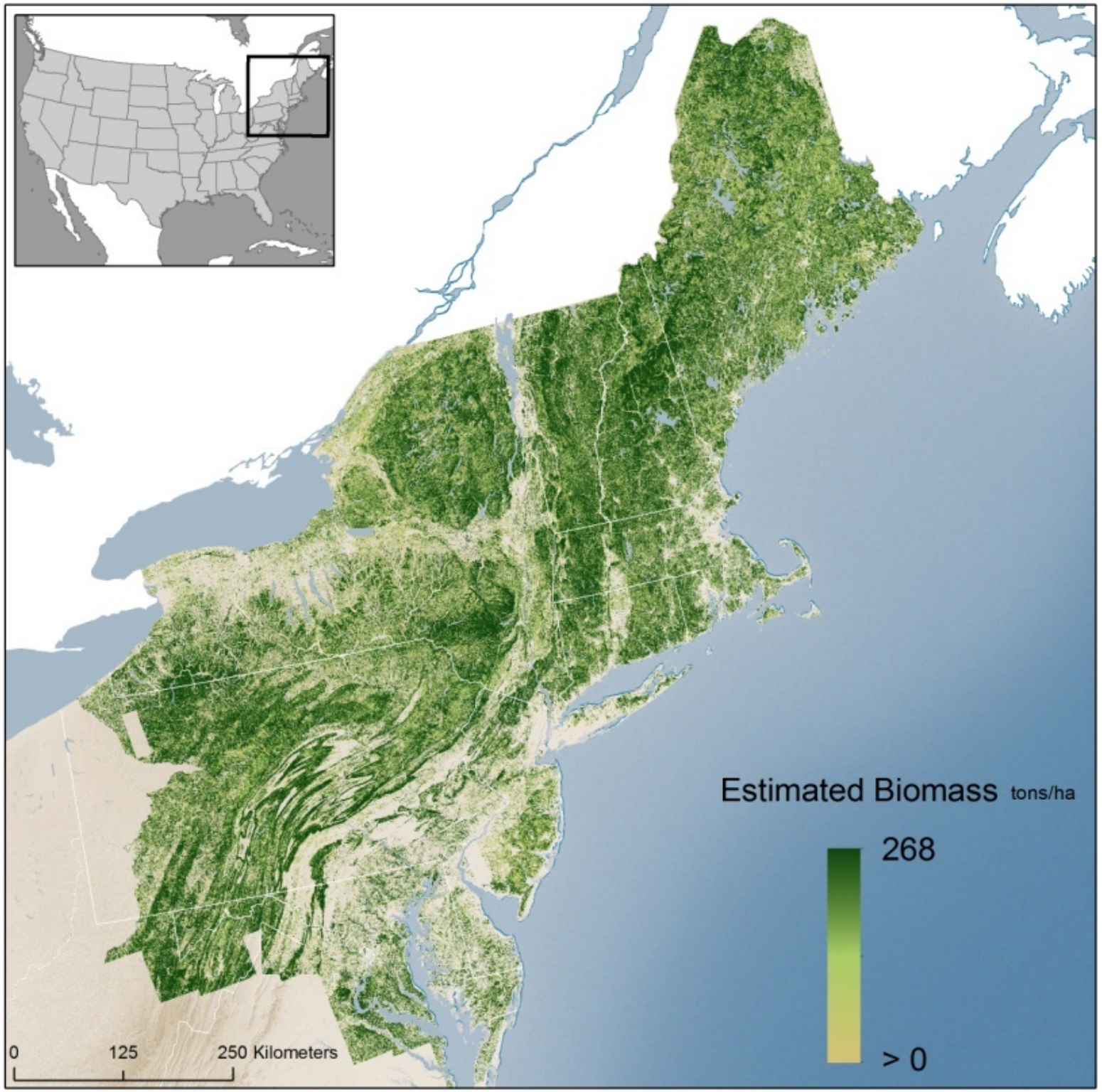
S

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



Automated Retrieval Algorithm





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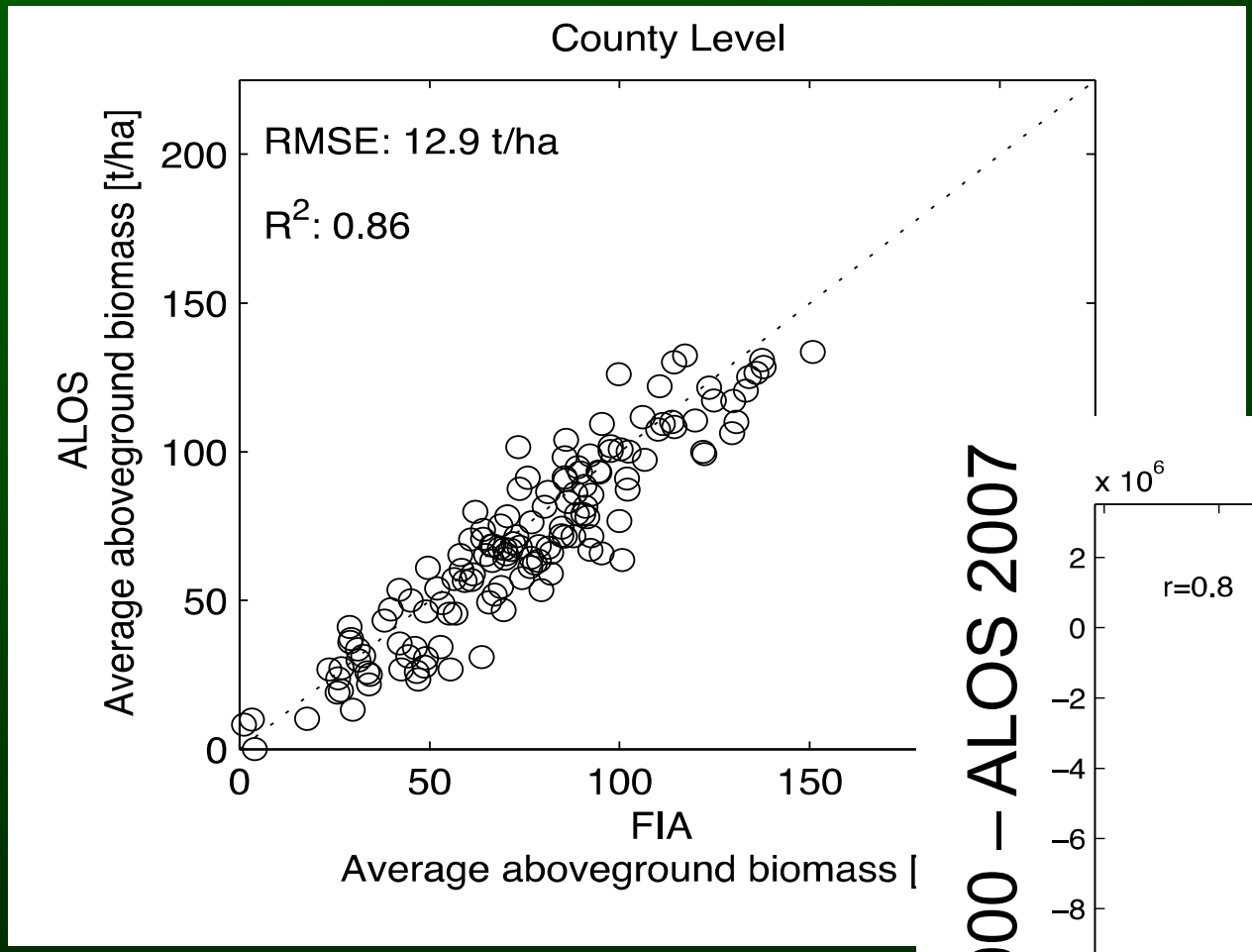
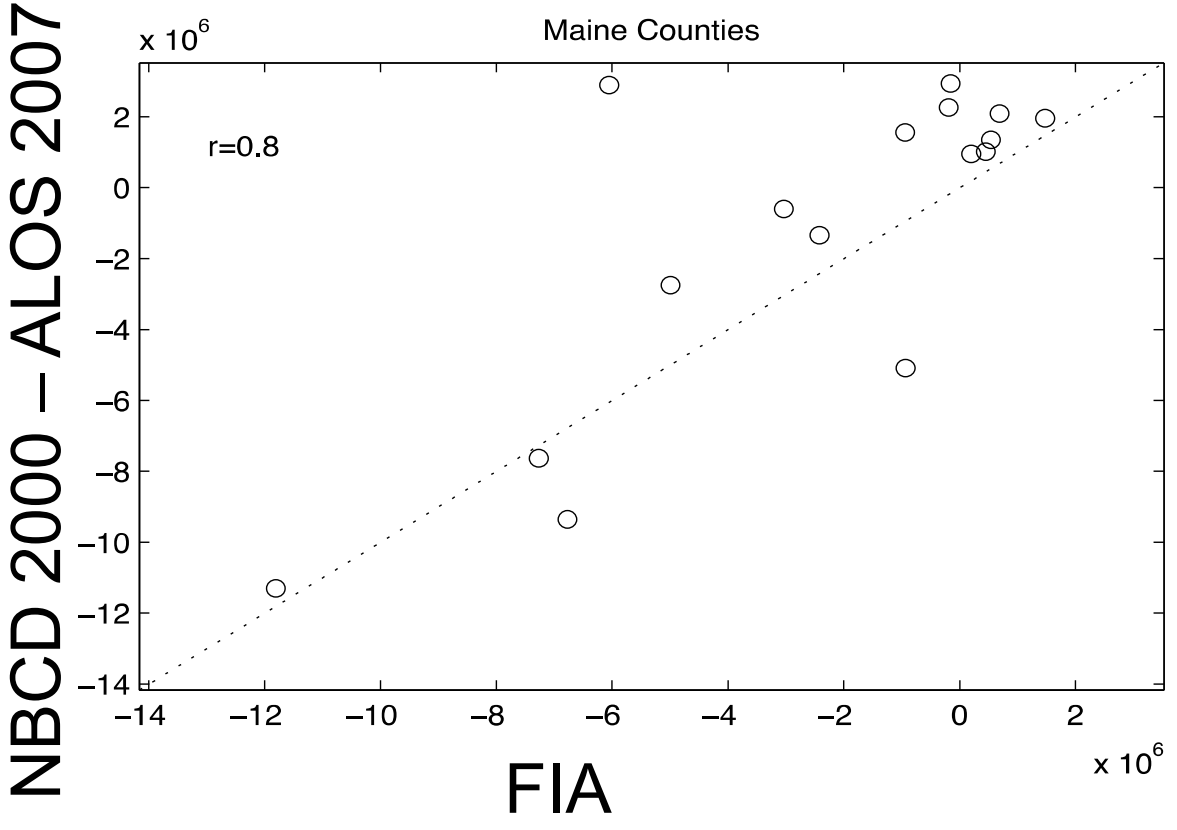
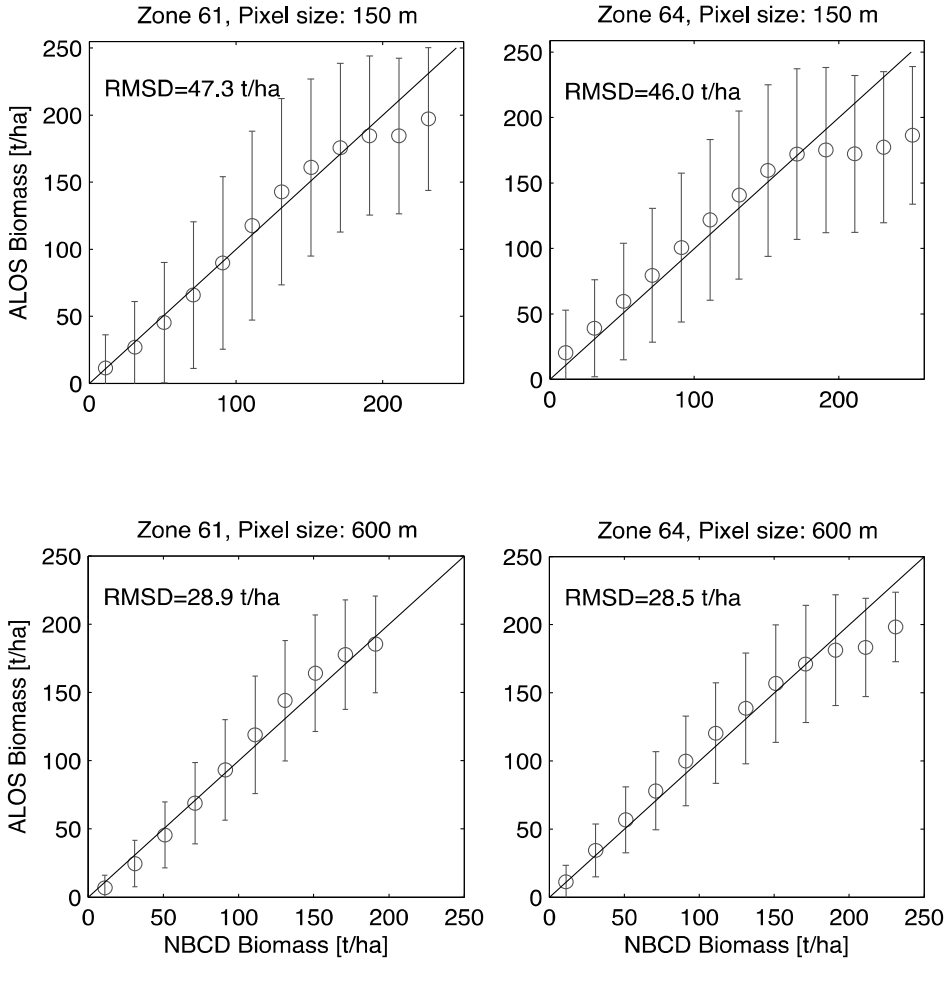
ALOS biomass map for 2007 from 655 HH/HV acquisitions

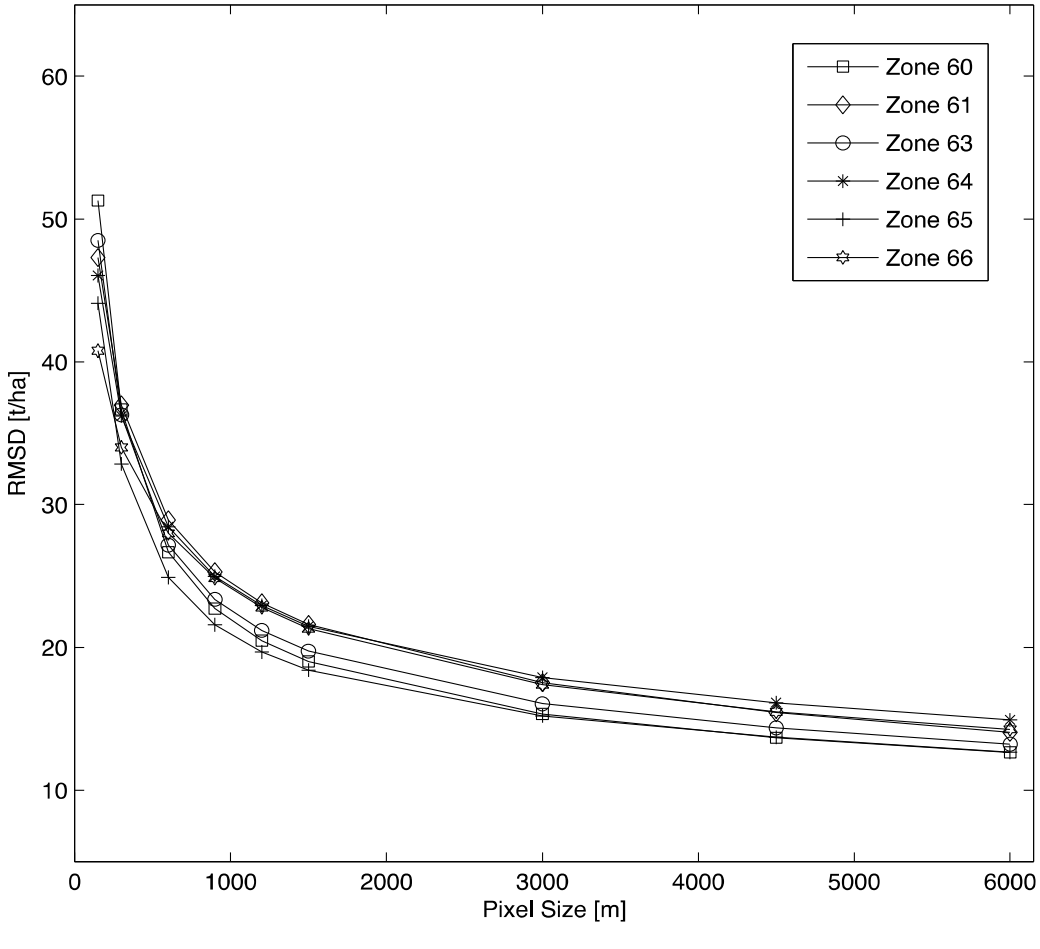
When aggregating to county scale ...



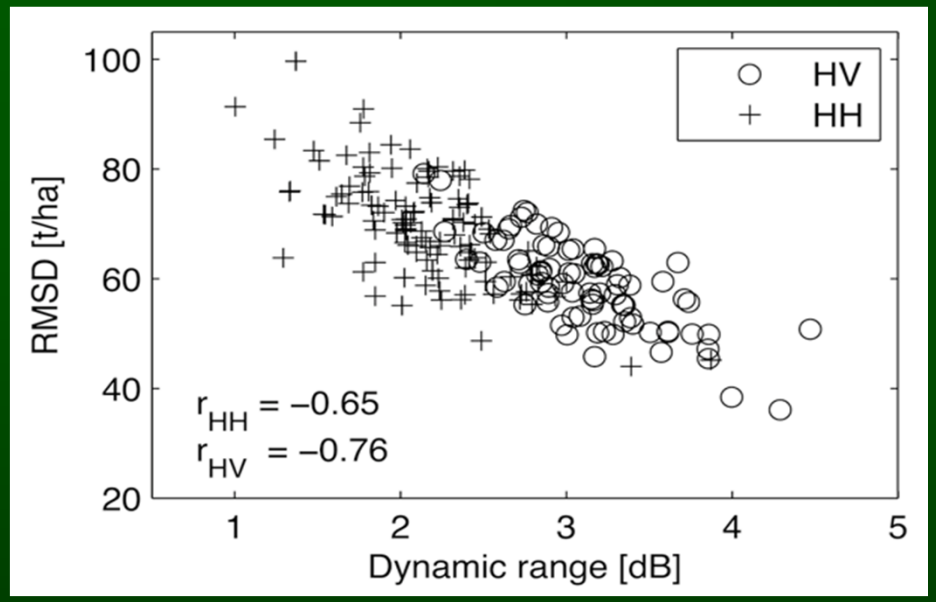


Pixel-level Comparison with NBCD

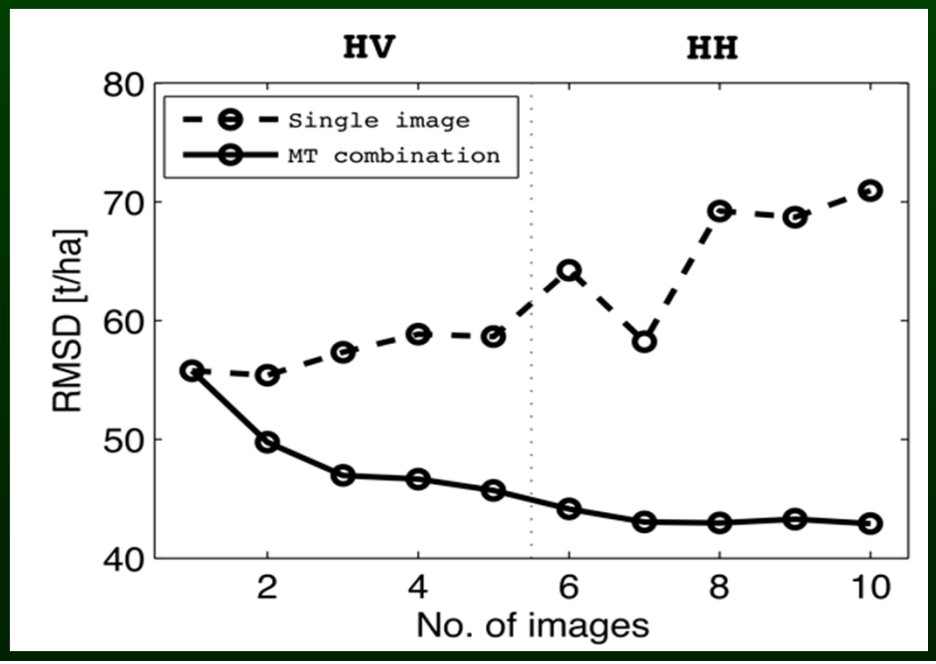




Importance of having multi-temporal data

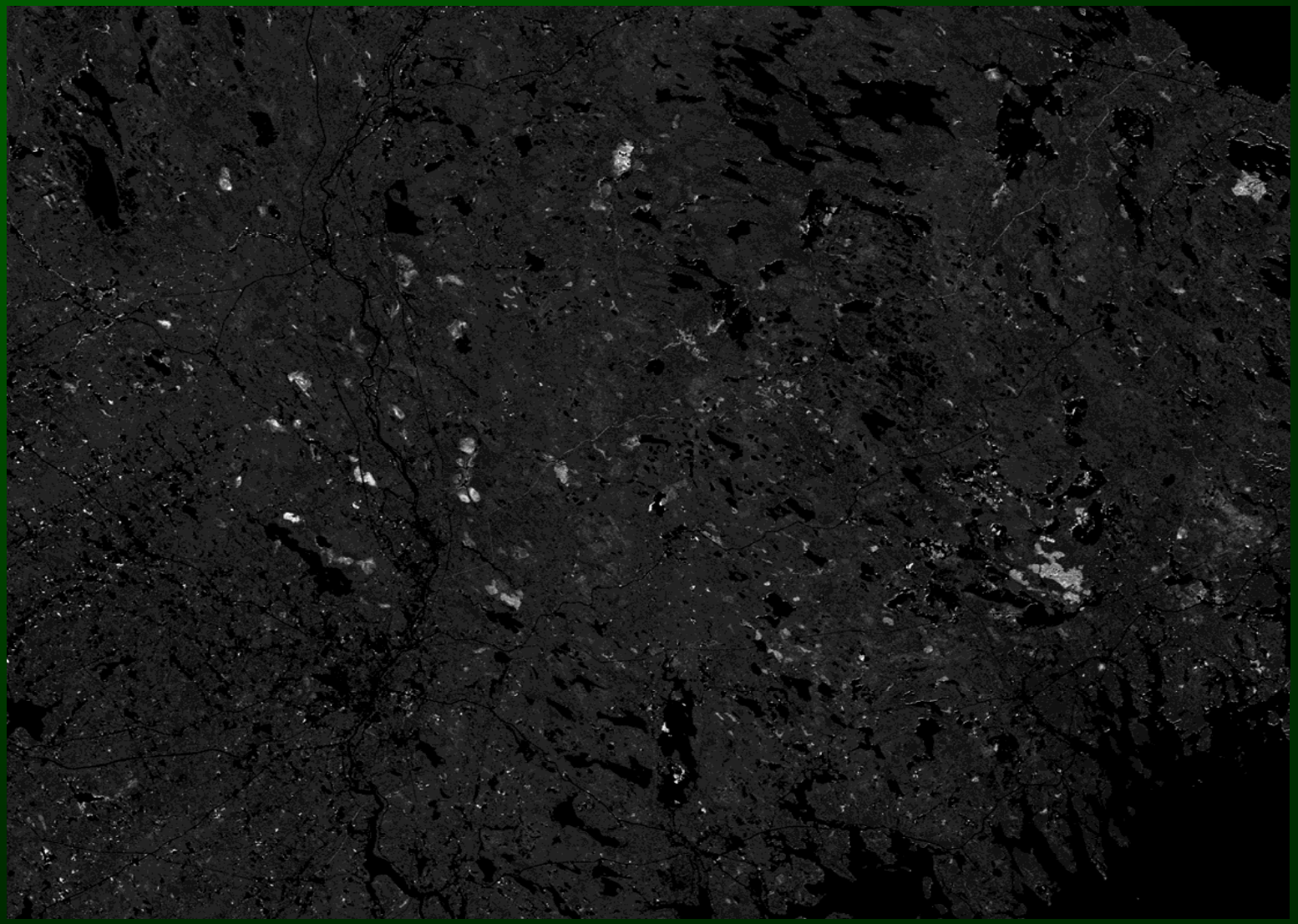


Pronounced weather effects on single image retrieval



> 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

Mexico

ALOS PALSAR Mosaic

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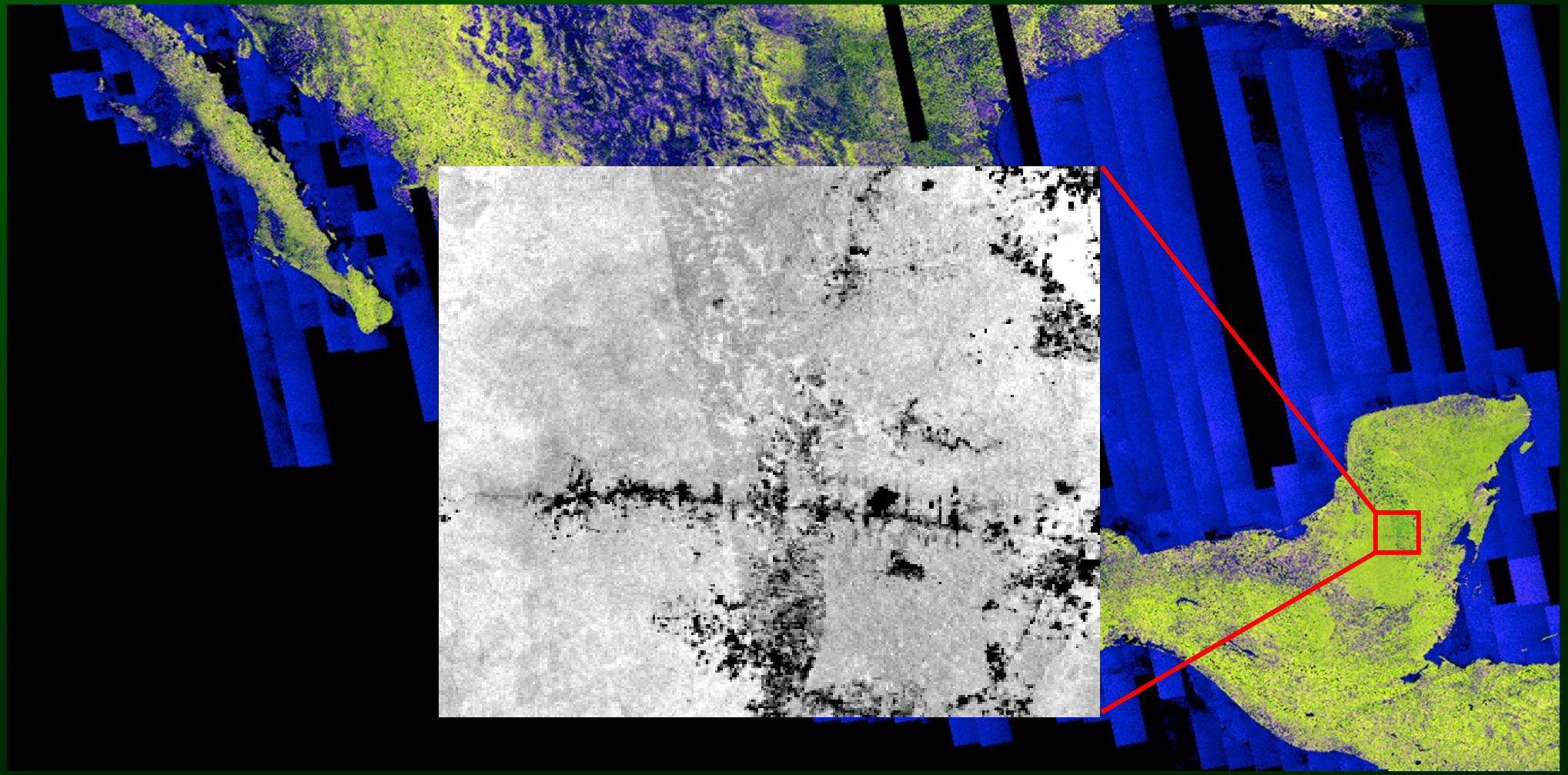
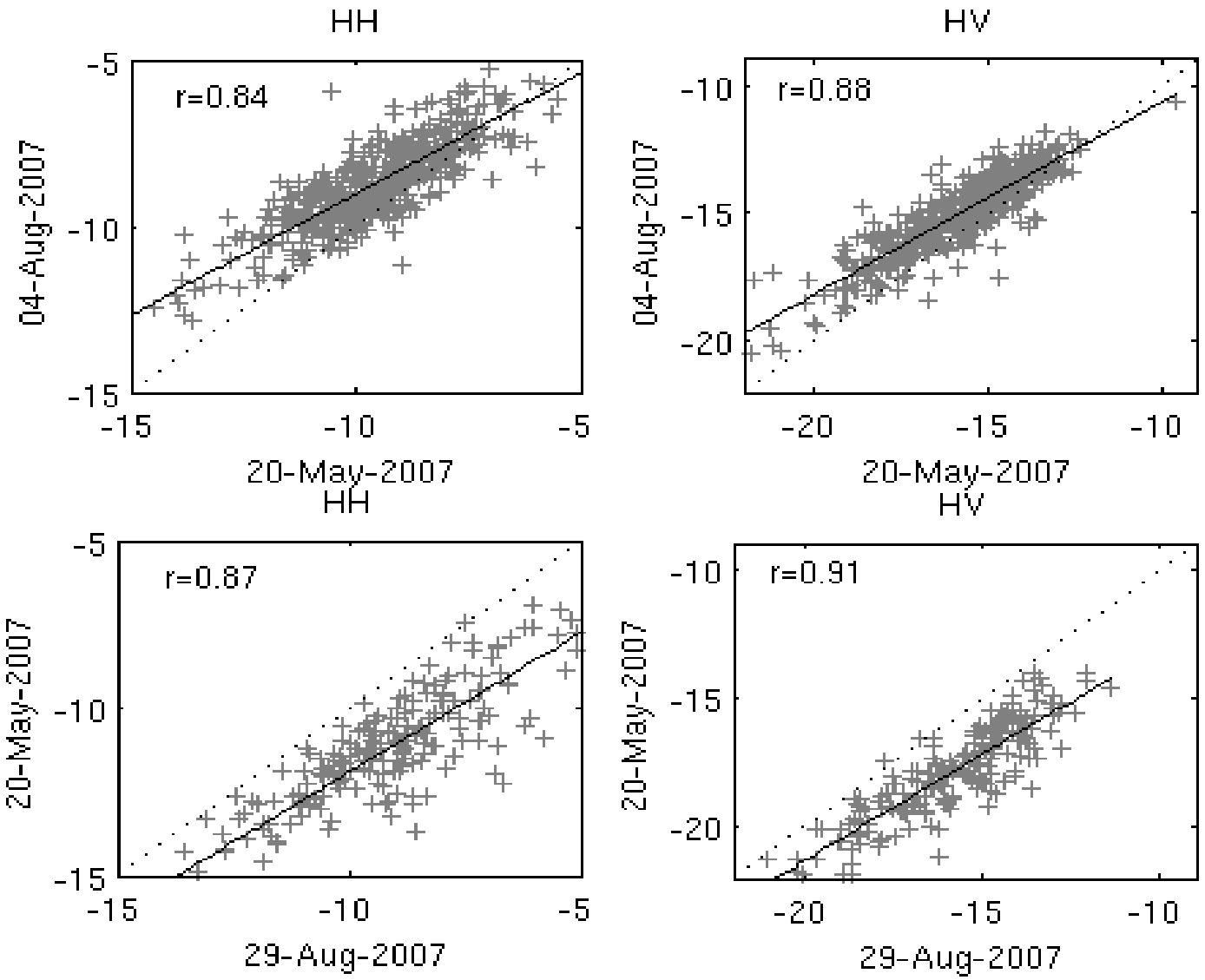
1400 FBD scenes - year 2007
Partial multi-temporal coverage

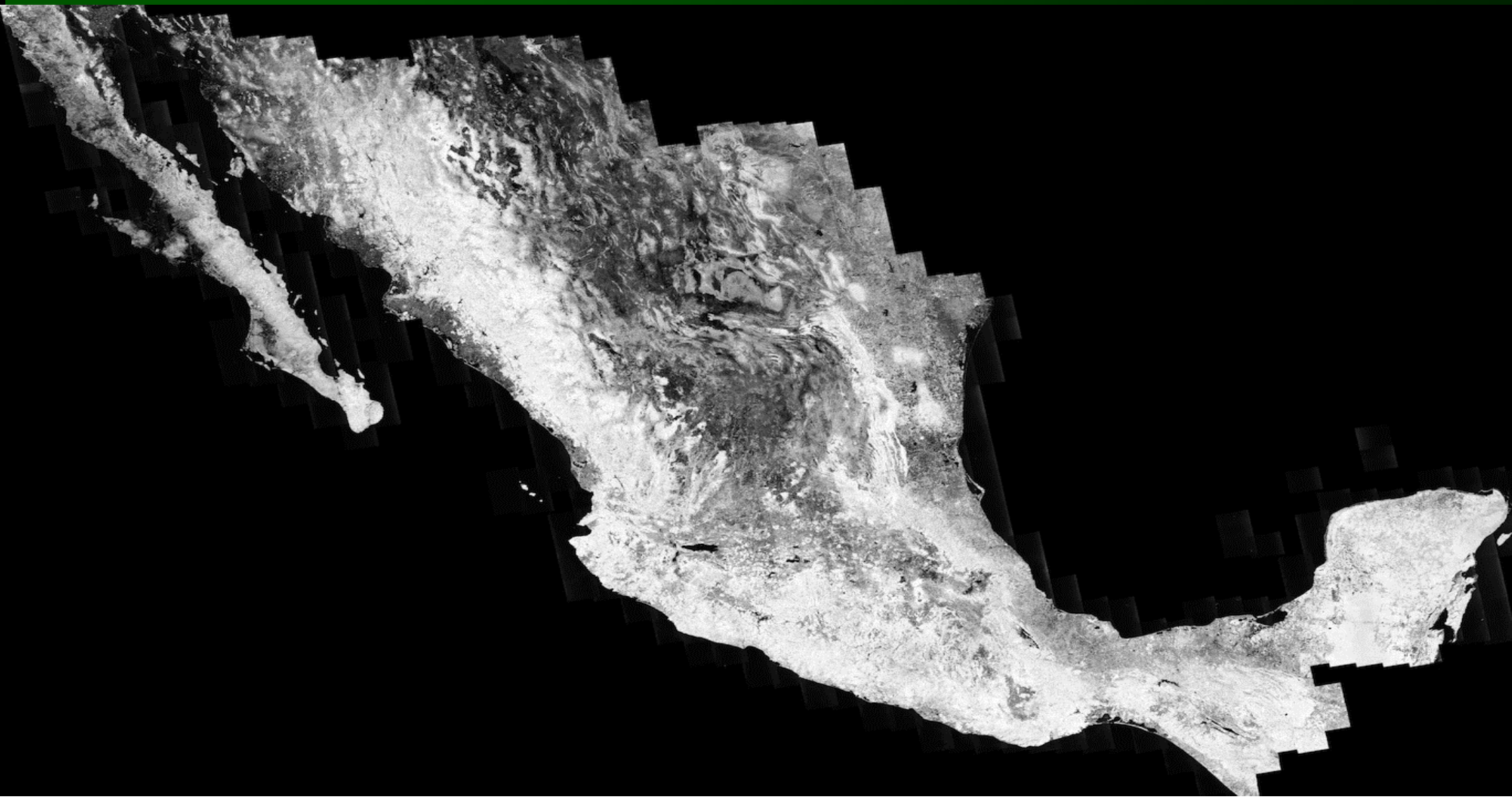


Weather Effects:

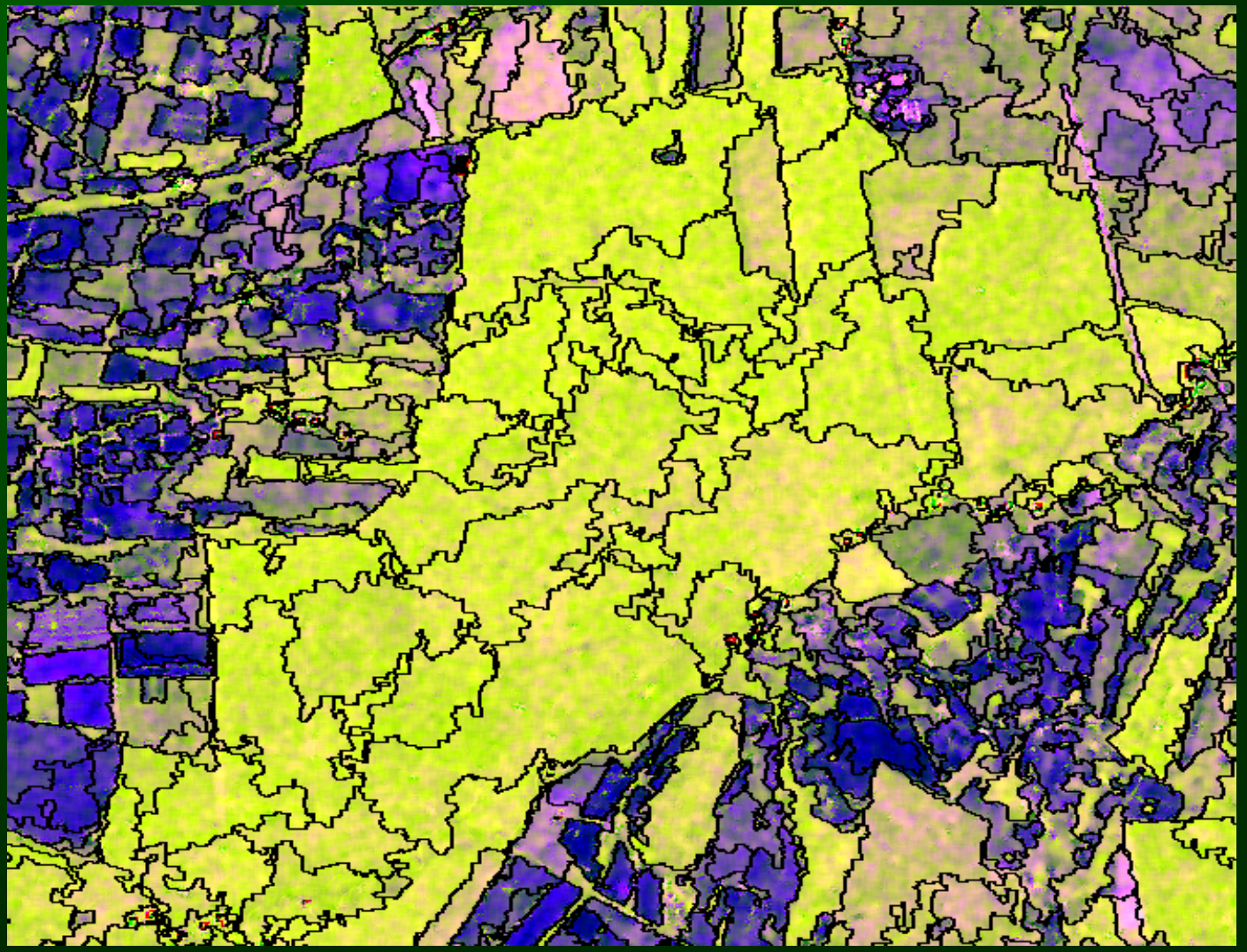


PALSAR Mosaic

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



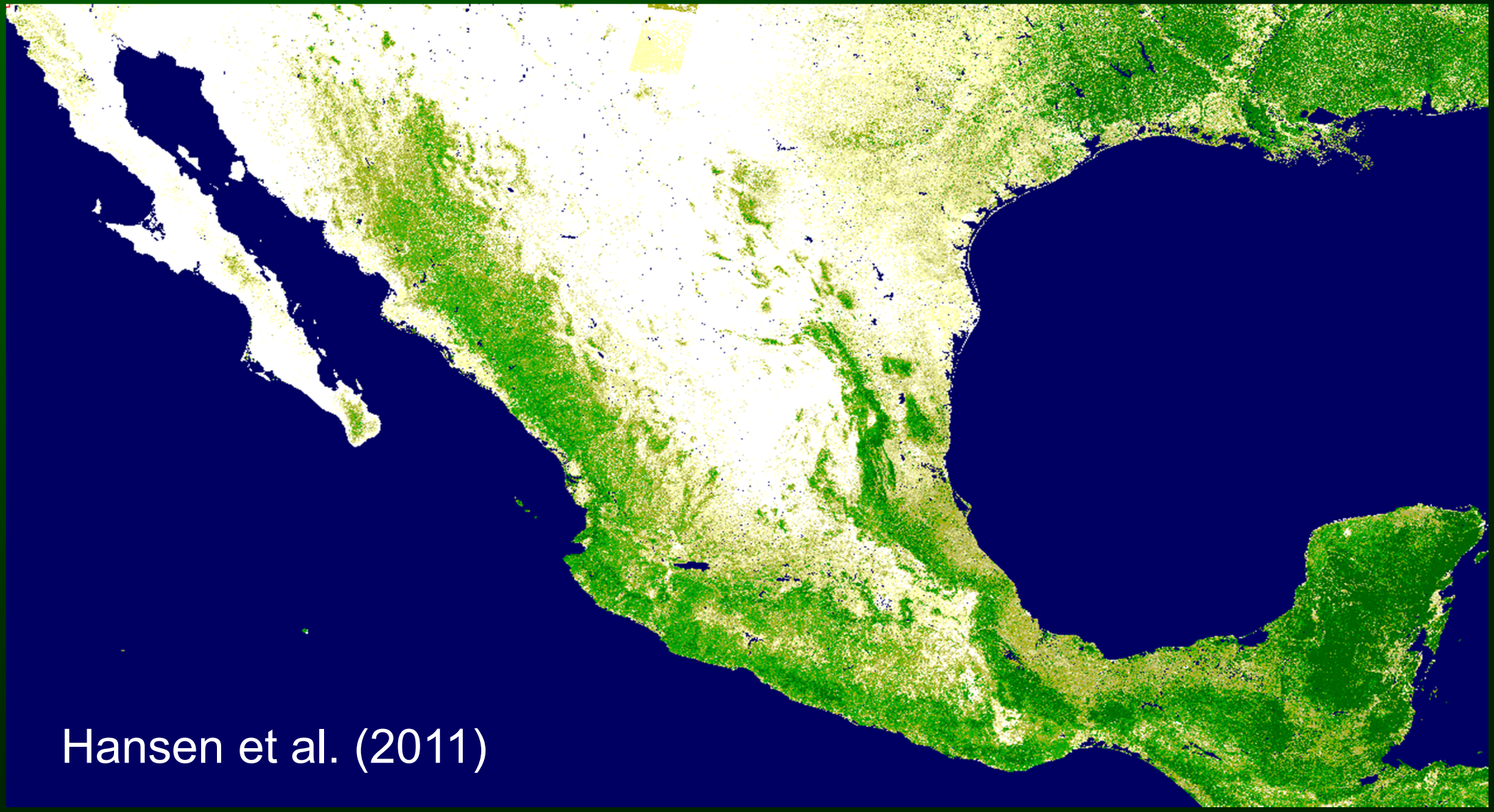
Segmentation



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)

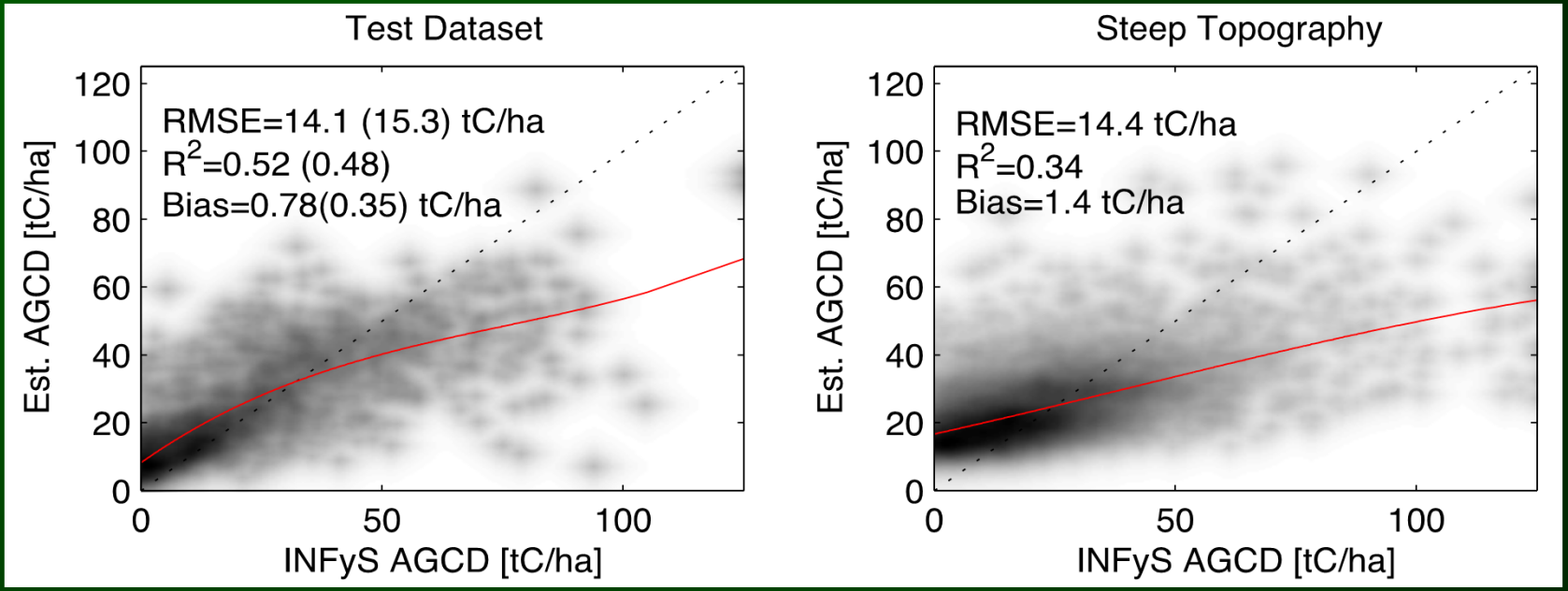


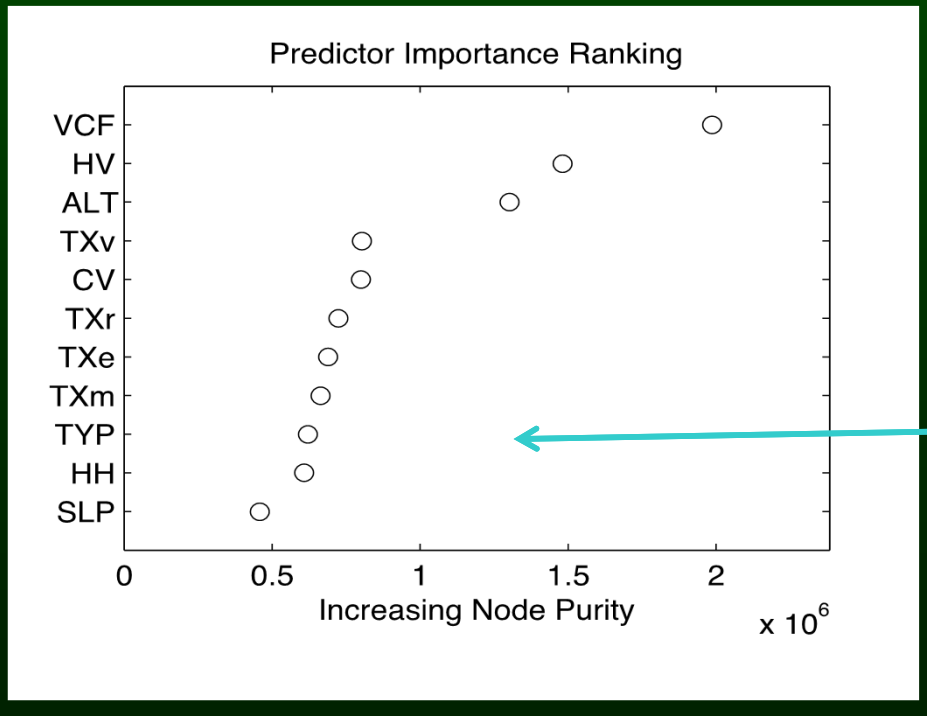
Hansen et al. (2011)

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

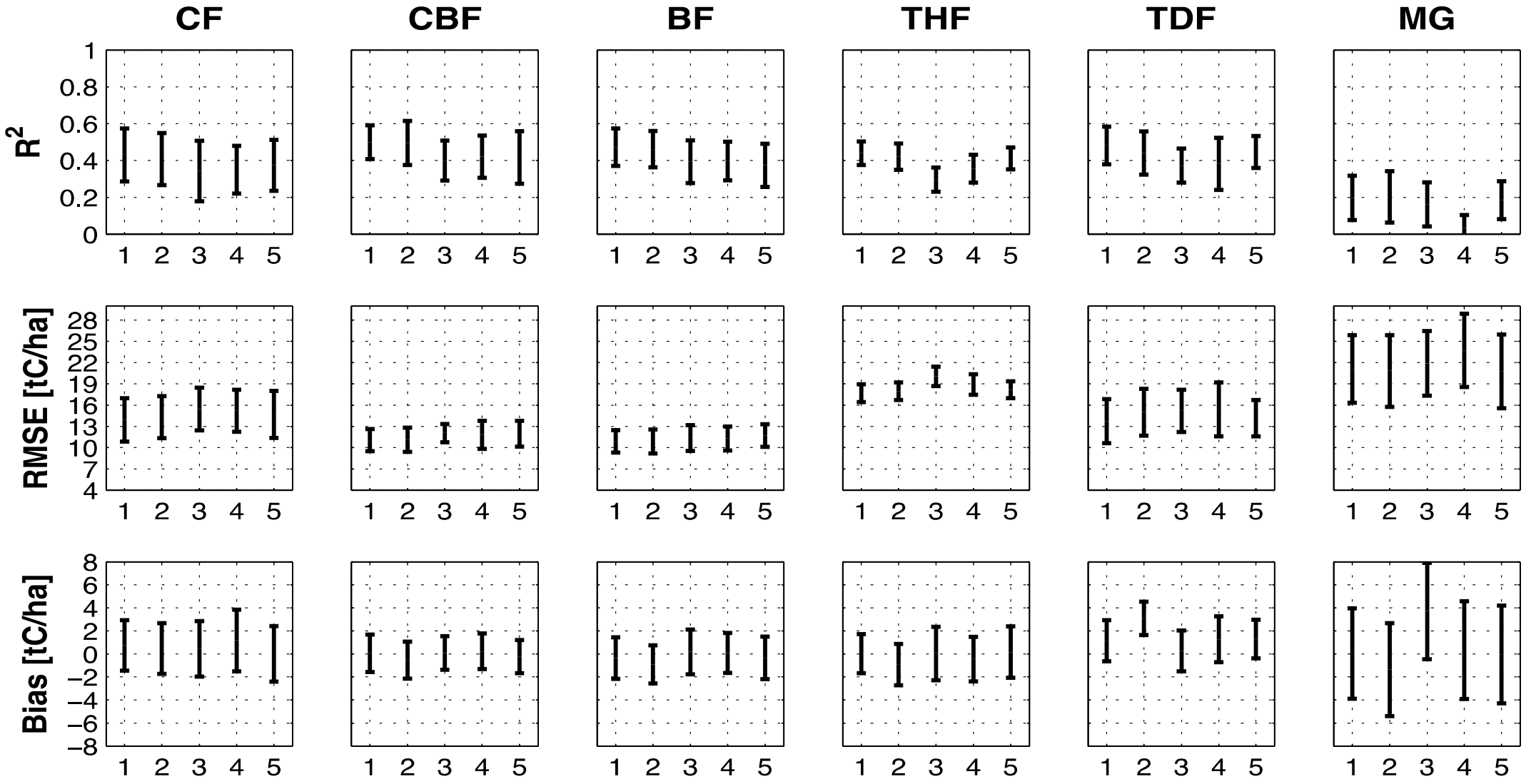
Retrieval with randomForest





Forest Type

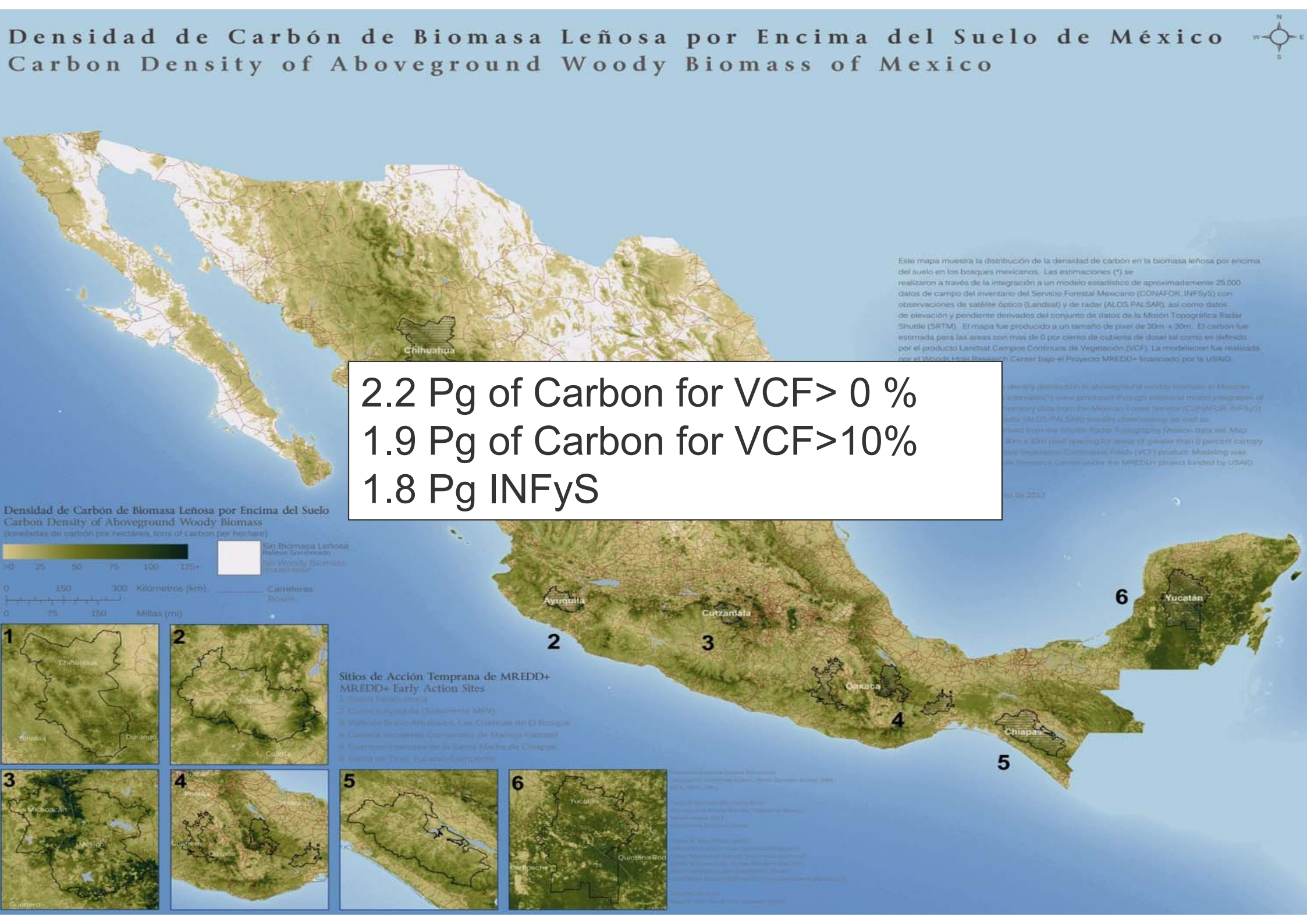
Forest Types



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

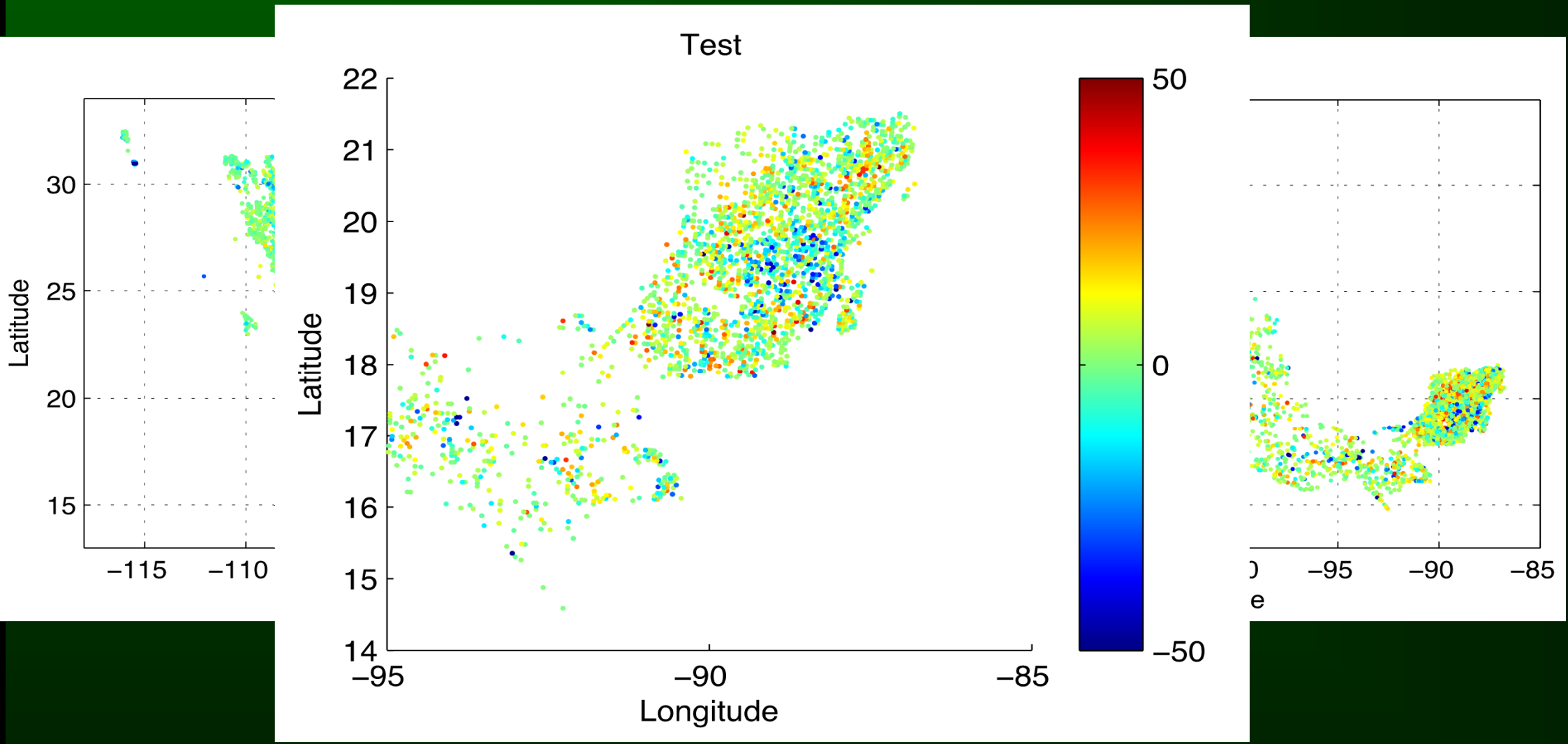
1 – All predictors
2 – No INFyS forest type
3 – No Radar
4 – No Landsat VCF
5 – No SRTM

Densidad de Carbón de Biomasa Leñosa por Encima del Suelo de México
Carbon Density of Aboveground Woody Biomass of Mexico

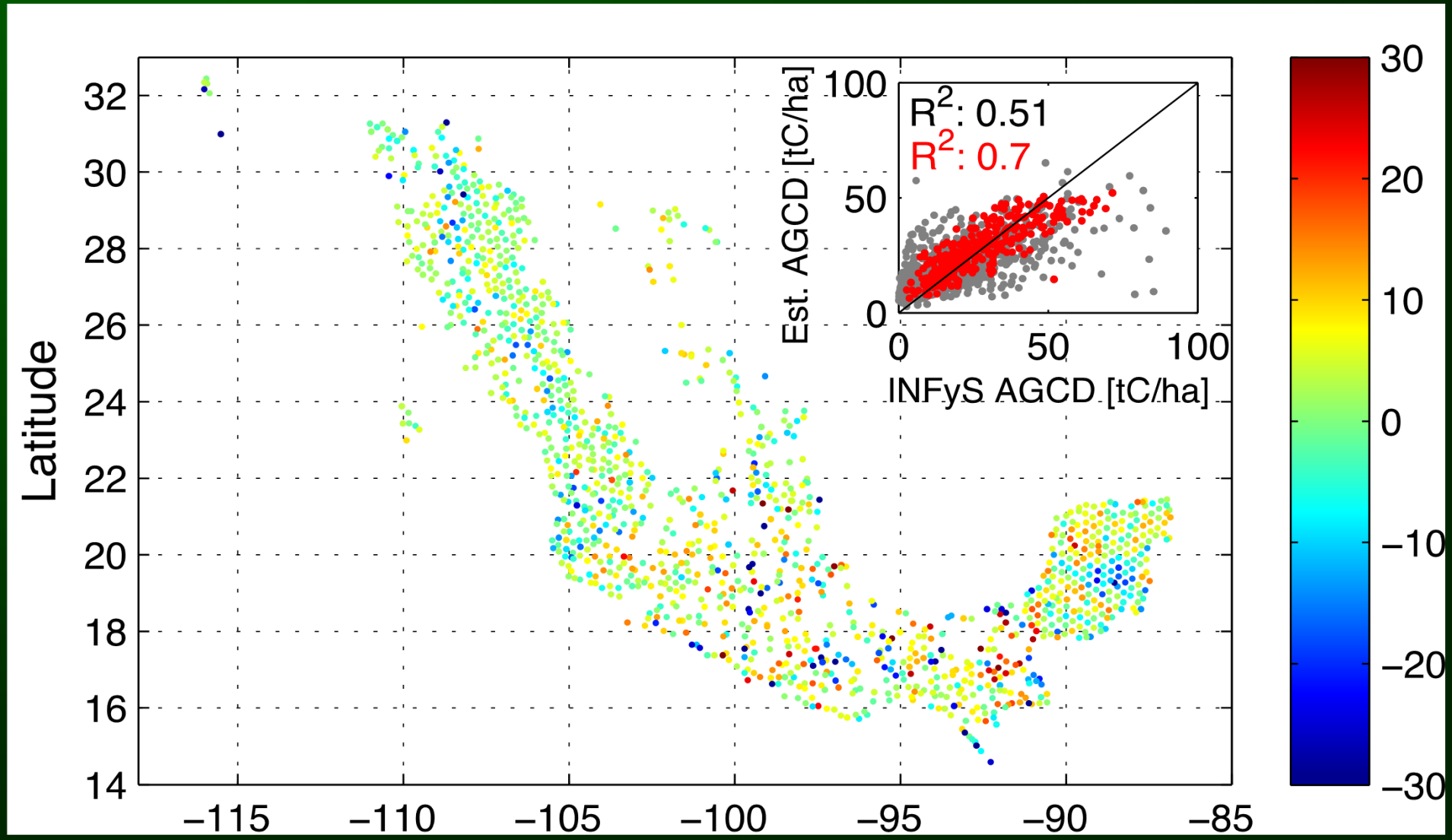


Este mapa muestra la distribución de la densidad de carbón en la biomasa leñosa por encima del suelo en los bosques mexicanos. Las estimaciones (*) se realizaron a través de la integración a un modelo estadístico de aproximadamente 25,000 datos de campo del inventario del Servicio Forestal Mexicano (CONAFOR, INFySyS) 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 pixel de 30m x 30m. El carbón fue estimada para las areas con mas de 0 por ciento de cubierta de dosel tal como es definido por el producto Landsat Campos Continuos de Vegetación (VCF). La modelacion fue realizada por el Woods Hole Research Center bajo el Proyecto MREDD+ financiado por la USAID.

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



Hexagon Scale



Quick Update on Other Acitvities:

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 Kellndorfer, 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

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BOSTON UNIVERSITY

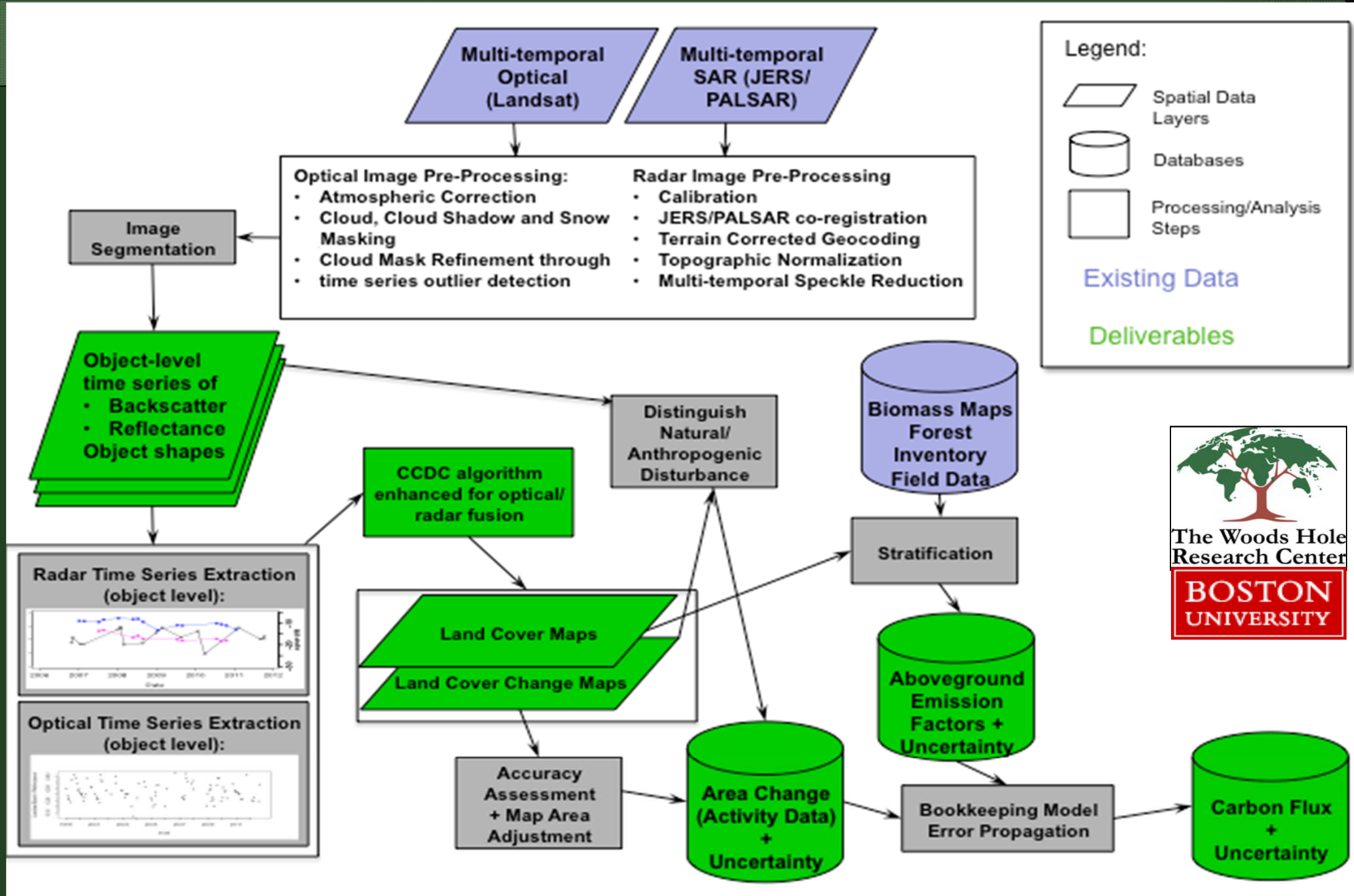
Objectives

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.

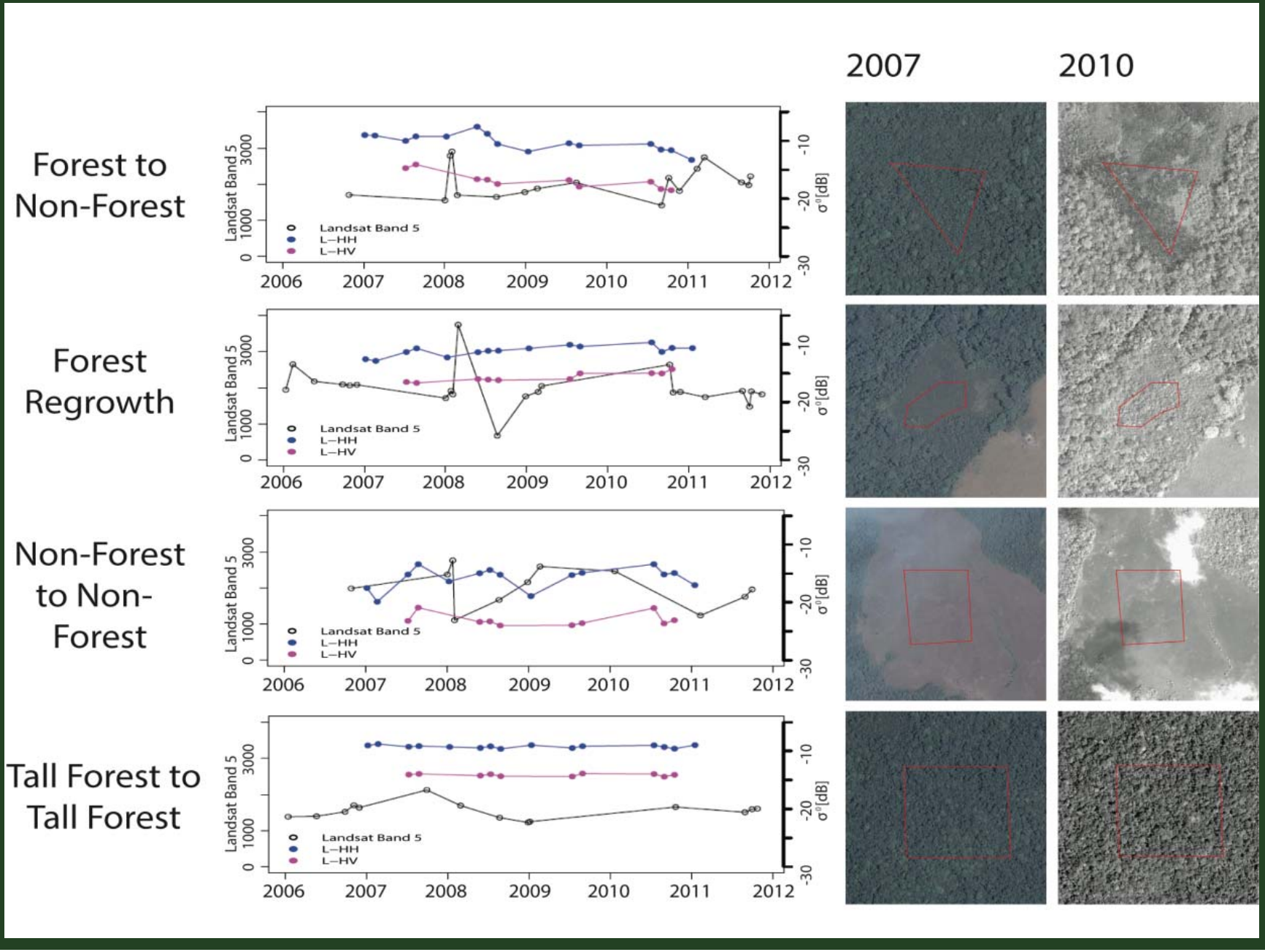
The Woods Hole Research Center

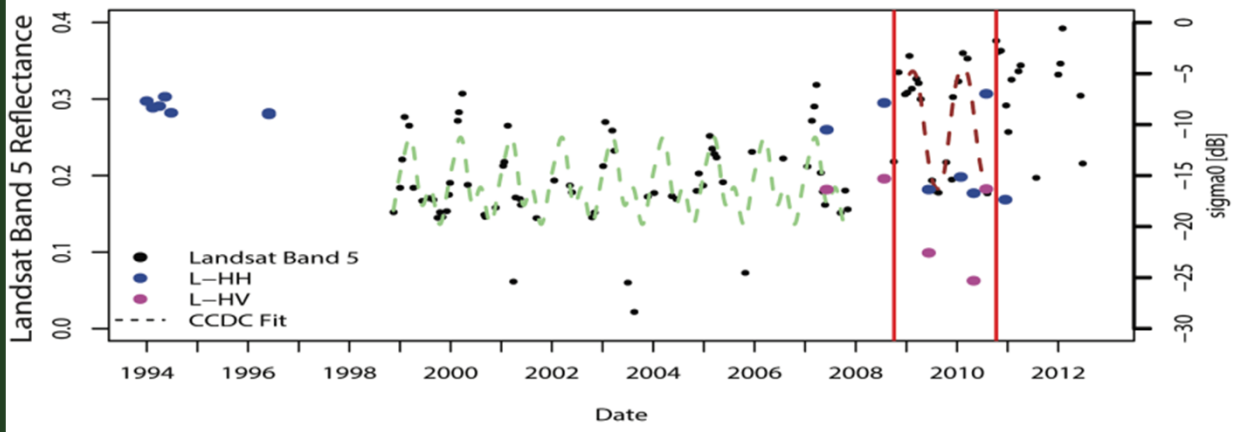
BOSTON UNIVERSITY

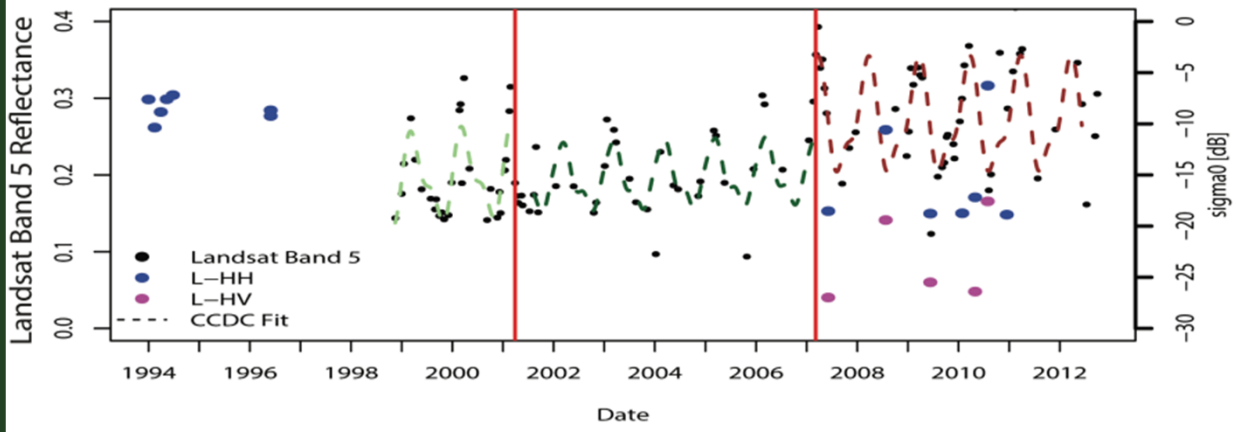


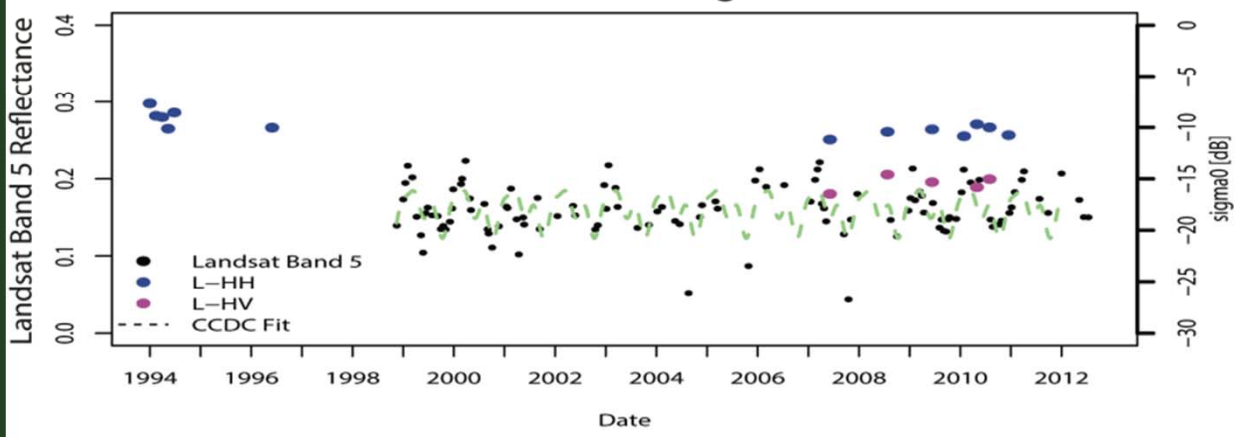
NASA CMS-2013 Project WHRC + Boston University

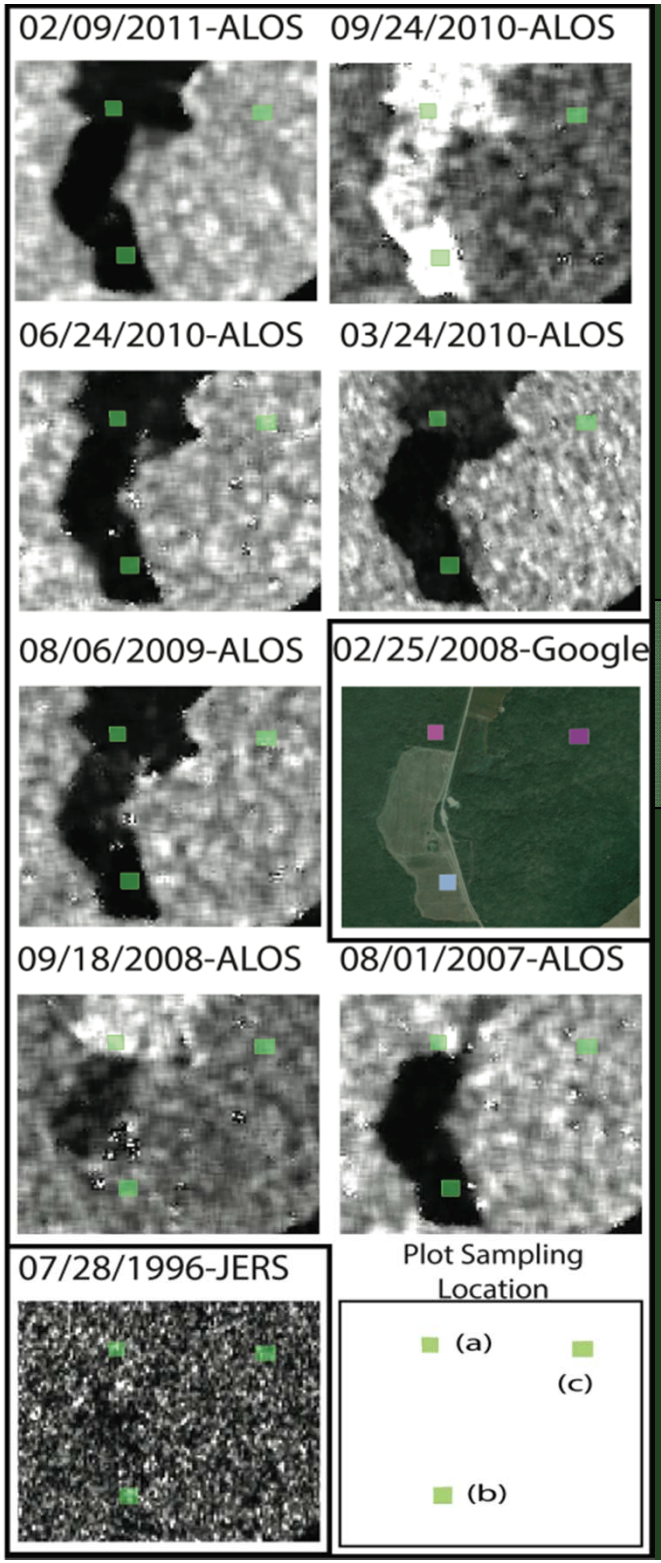
New NASA Carbon Monitoring System Project: Time-Series Fusion Optical/Radar




(a) Disturbance in 2008
Landsat Band 5 Reflectance
sigma0 [dB]
Landsat Band 5
L−HH
L−HV
CCDC Fit
Date


(b) Conversion to Agriculture in 2007
Landsat Band 5 Reflectance
sigma0 [dB]
Landsat Band 5
L−HH
L−HV
CCDC Fit
Date


(c) Forest Remaining Forest
Landsat Band 5 Reflectance
sigma0 [dB]
Landsat Band 5
L−HH
L−HV
CCDC Fit
Date


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
(a)
(c)
(b)


Ticul
Mexico