K&C Phase 4 – Status report

Use of short-period ALOS-2 observations for vegetation characterization and classification

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Project outline and objectives

To characterize the RCS (co- and cross-polarization) of stable and changing targets over time. These are important components for the development of segmentation and detection algorithms necessary for change detection and target identification.

These would be done over:

1. the northeastern US, (done)
2. regions in South America where ground validation data is available (done)
3. agricultural regions in the US and elsewhere (done)

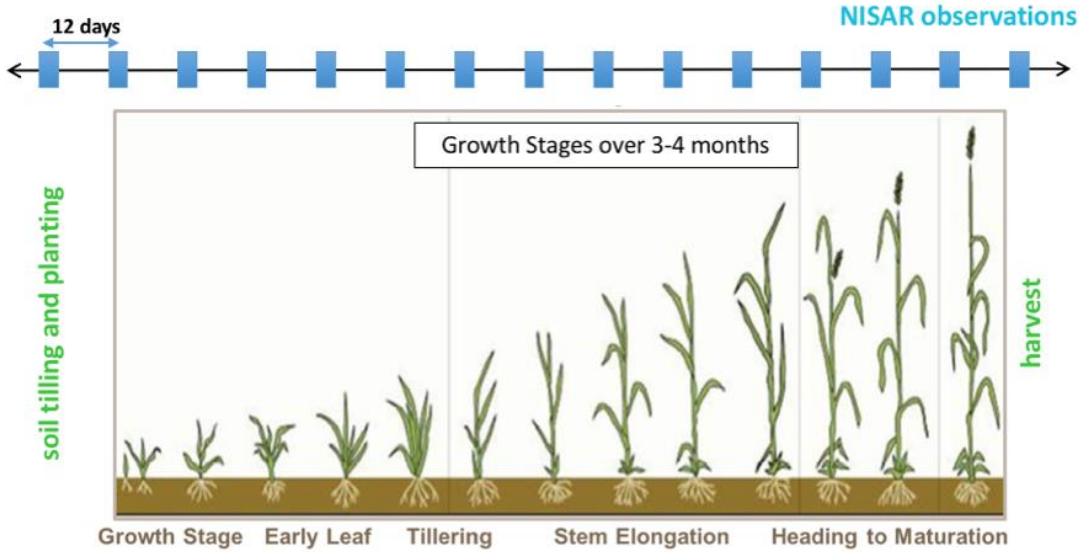
- To characterize temporal decorrelation related to interferometry; an important error source for deformation studies that the use of volumetric decorrelation for estimating forest vertical structure (especially for multi-baseline observations). This will be done for forested and bare-surface regions over the geographic areas detailed above
- Develop a methodology for using time series observations over short-repeat periods for the characterization of agriculture and inundated regions, for the geographic areas detailed above.

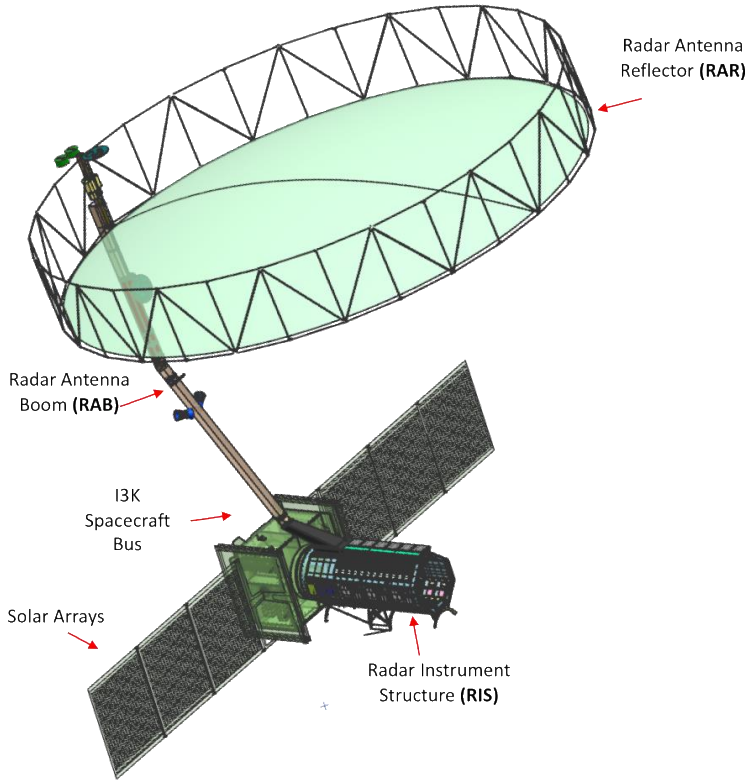
This work supports *the 4 K&C thematic drivers of* **C**arbon cycle science, the GEO initiative for global agricultural monitoring (GEOGLAM & JECAM) and Environmental **C**onservation as it applies to permanent land cover conversion.

NISAR Development: Ecosystems

- Biomass
- Disturbance
- Inundation
- Agriculture

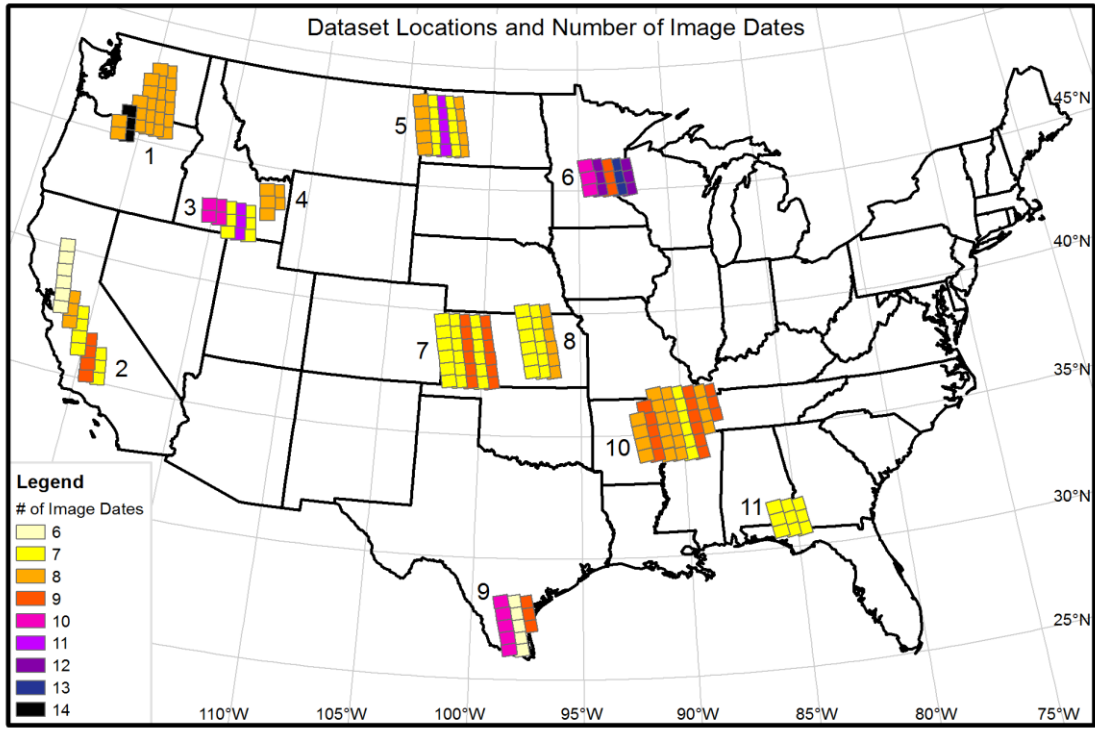
Dense-time series of L-band data (dual-pol)

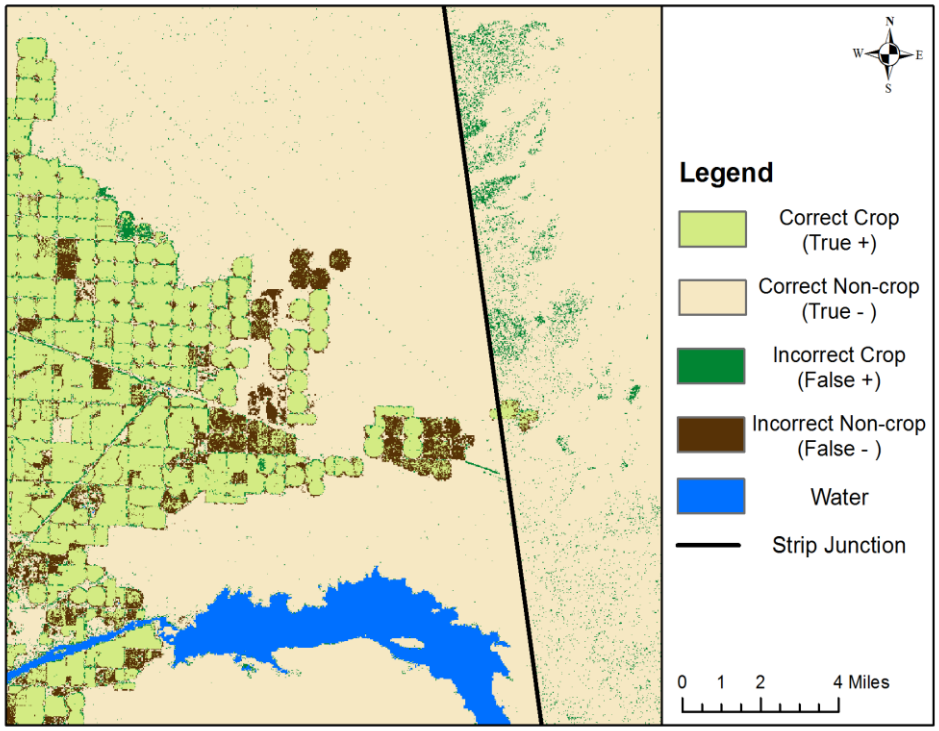




Crop Area Determination

- Use coefficient of variation and a simple threshold to detect regions of land management
- ALOS-1 archive used to sample geographically disperse regions in the US where ground validation (USDA's CropScape) is available

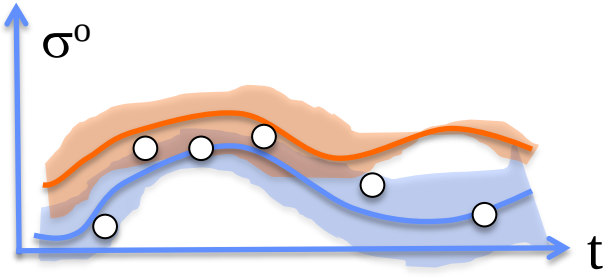


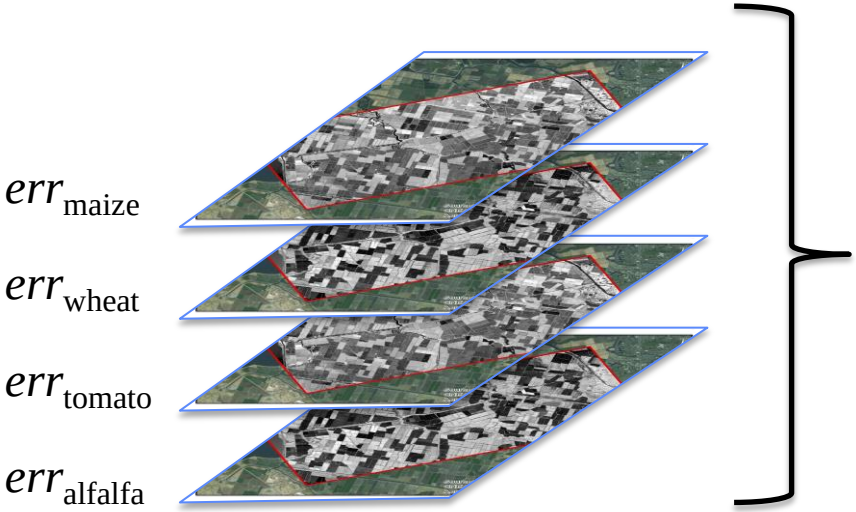


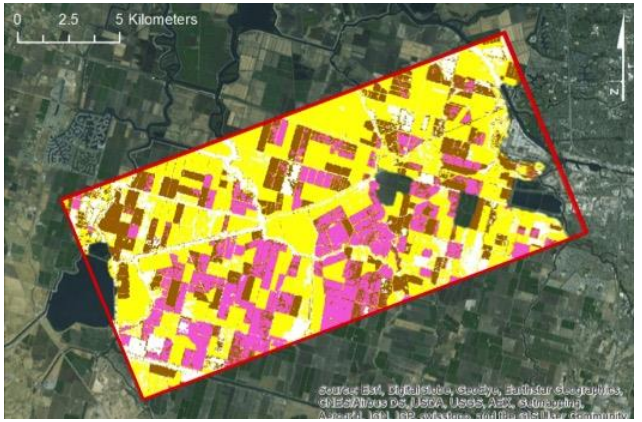
Whelen, T. and P. Siqueira, "Coefficient of variation for use in crop area classification across multiple climates," Int. J. Appl. Earth. Obs. & Geoinf., 18 pp., 2018

A Simple Time-Series Classifier

$$err_{class} = \sum_{j} \frac{\left(s^{\circ}_{\text{obs}}(t_j) - s^{\circ}_{\text{model-class}}(t_j)\right)^2}{\text{var}\left(s^{\circ}_{\text{model-class}}(t_j)\right)}$$





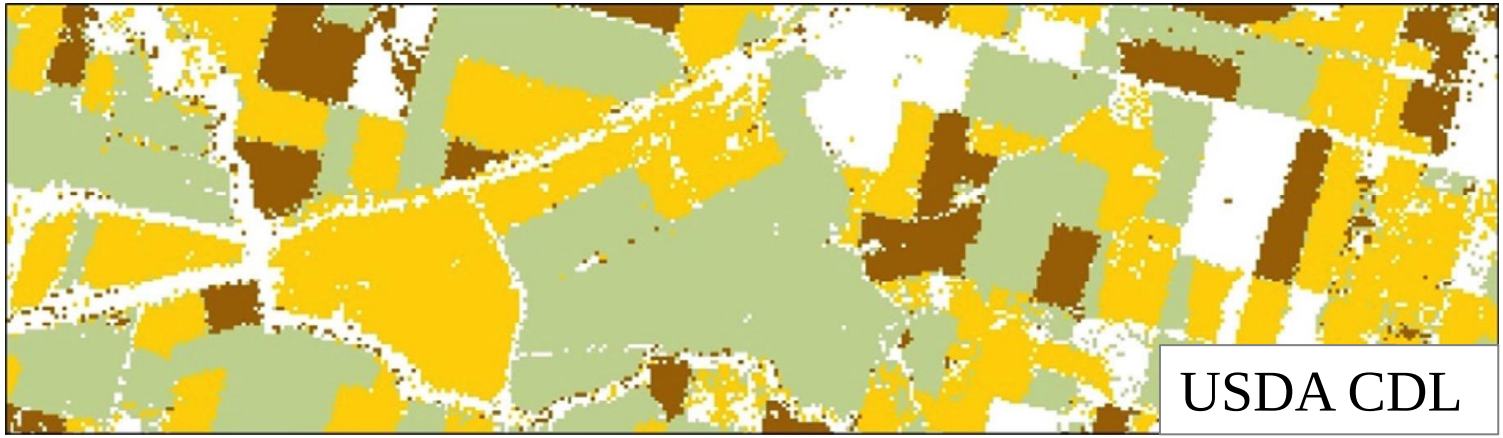


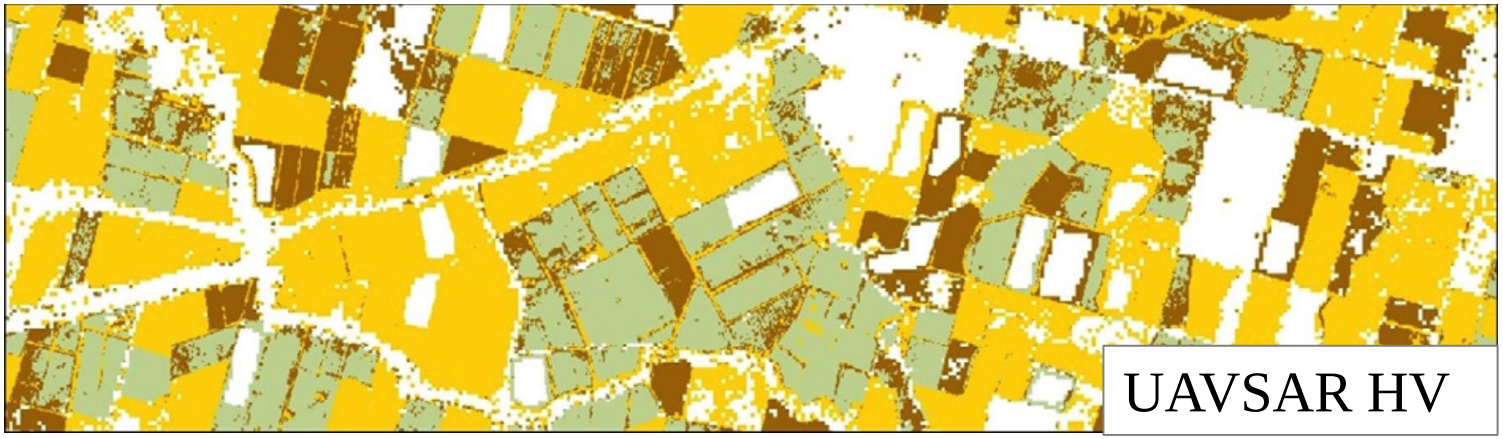
83% Classification accuracy using HV time series alone (no additional data layers included in processing)

See also: 1.) Whelen & Siqueira, Remote Sensing of the Environment, 2017 (L-band)
2.) Whelen & Siqueira, Remote Sensing Letters, 2018 (C-band)

RMSE / Mahalanobis Distance pixel-level classifier

- A measure of the probability for a multi-dimensional observation
- In this case, time and polarization combination, are the dimensions.



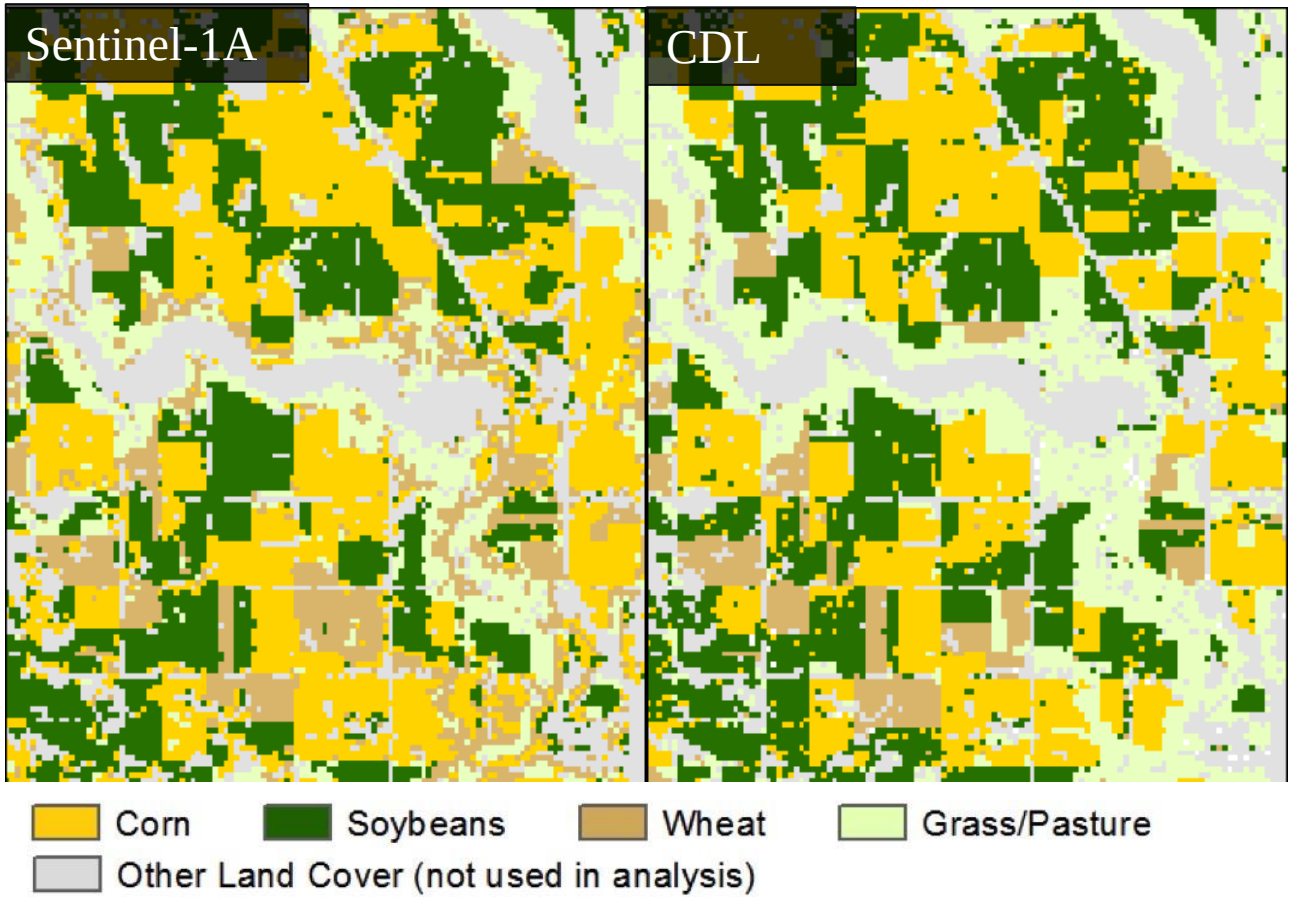


Alfalfa
Corn
Winter Wheat
Other Landcover

Blank regions in HV-classification indicate fields used for model development

Use of time-series for classification

- 16 Sentinel 1-A images in North Dakota
- April through November time series, approximately 12-day repeat
- VV, VH and VV+VH combination



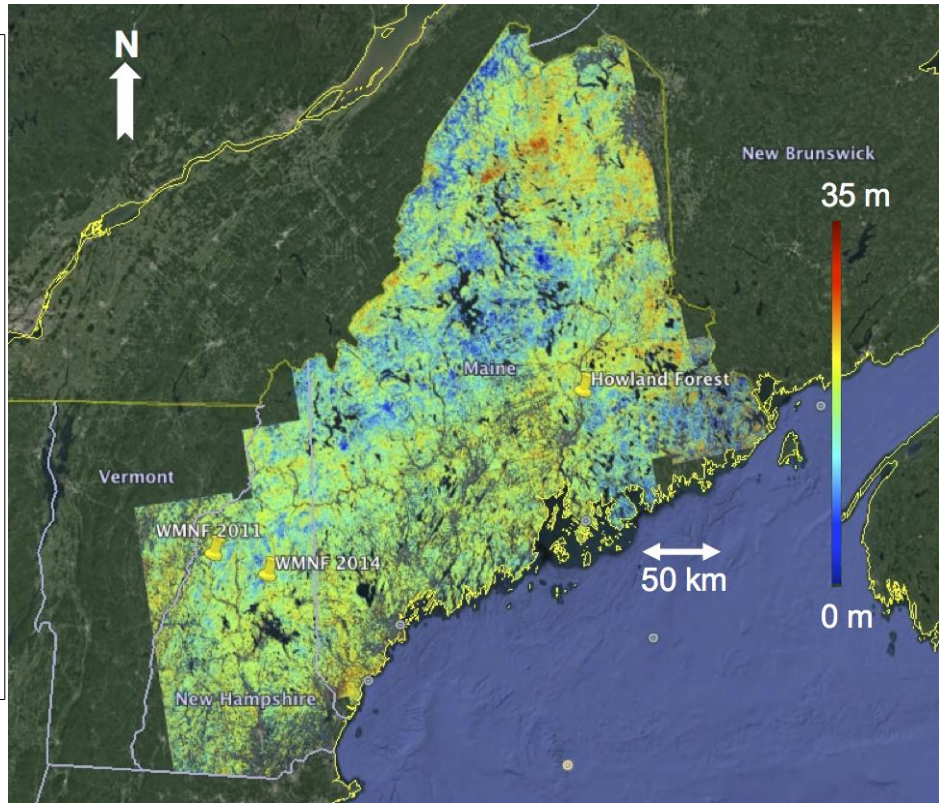
Repeat-Pass Forest Stand Height

Repeat-Pass Temporal Decorrelation used to indicate FSH

One-state increased to two states. Also incorporates independent lidar measures of FSH

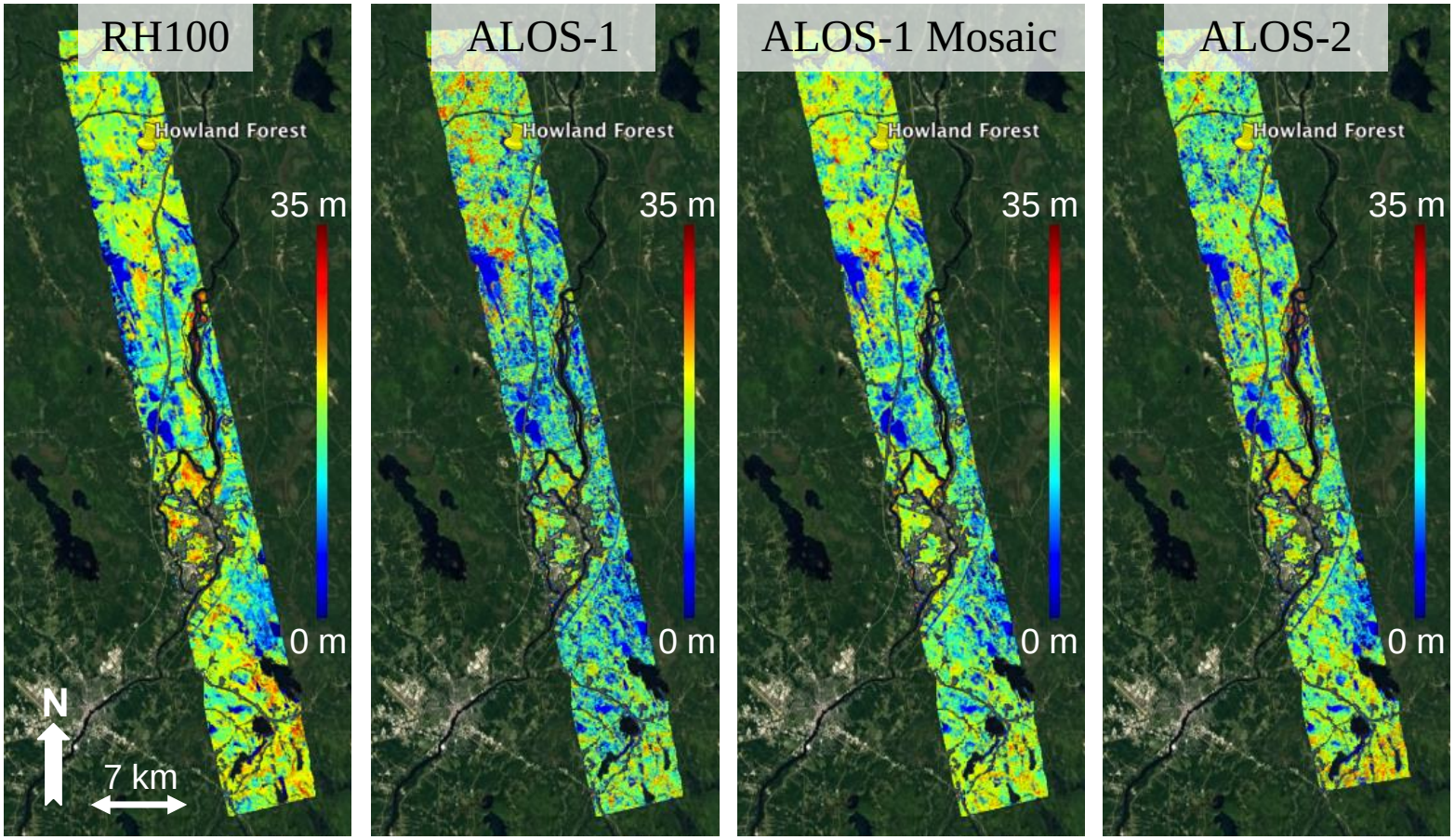
Data sets

Two-state mosaic



Application to ALOS-2

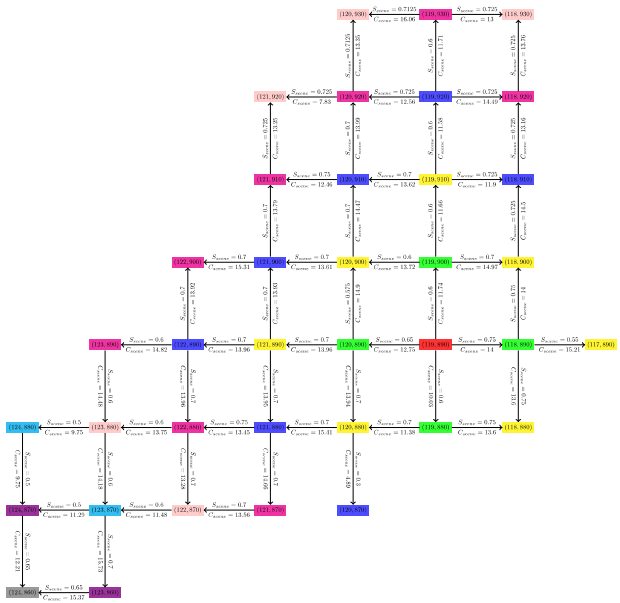
- The same algorithm, exercised over repeat-periods of 46+ days for ALOS-1 has been applied to ALOS-2 14-day data with successful results

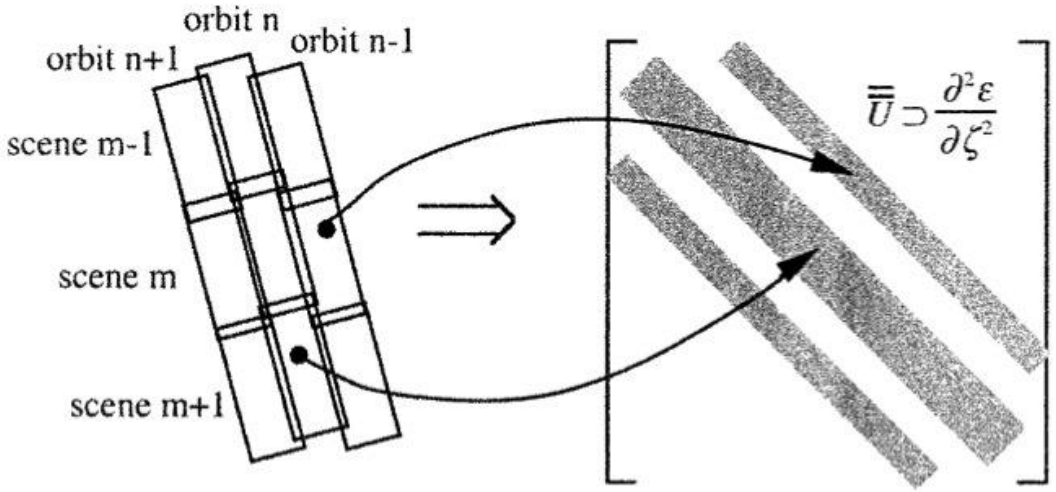


Use of Mosaicking

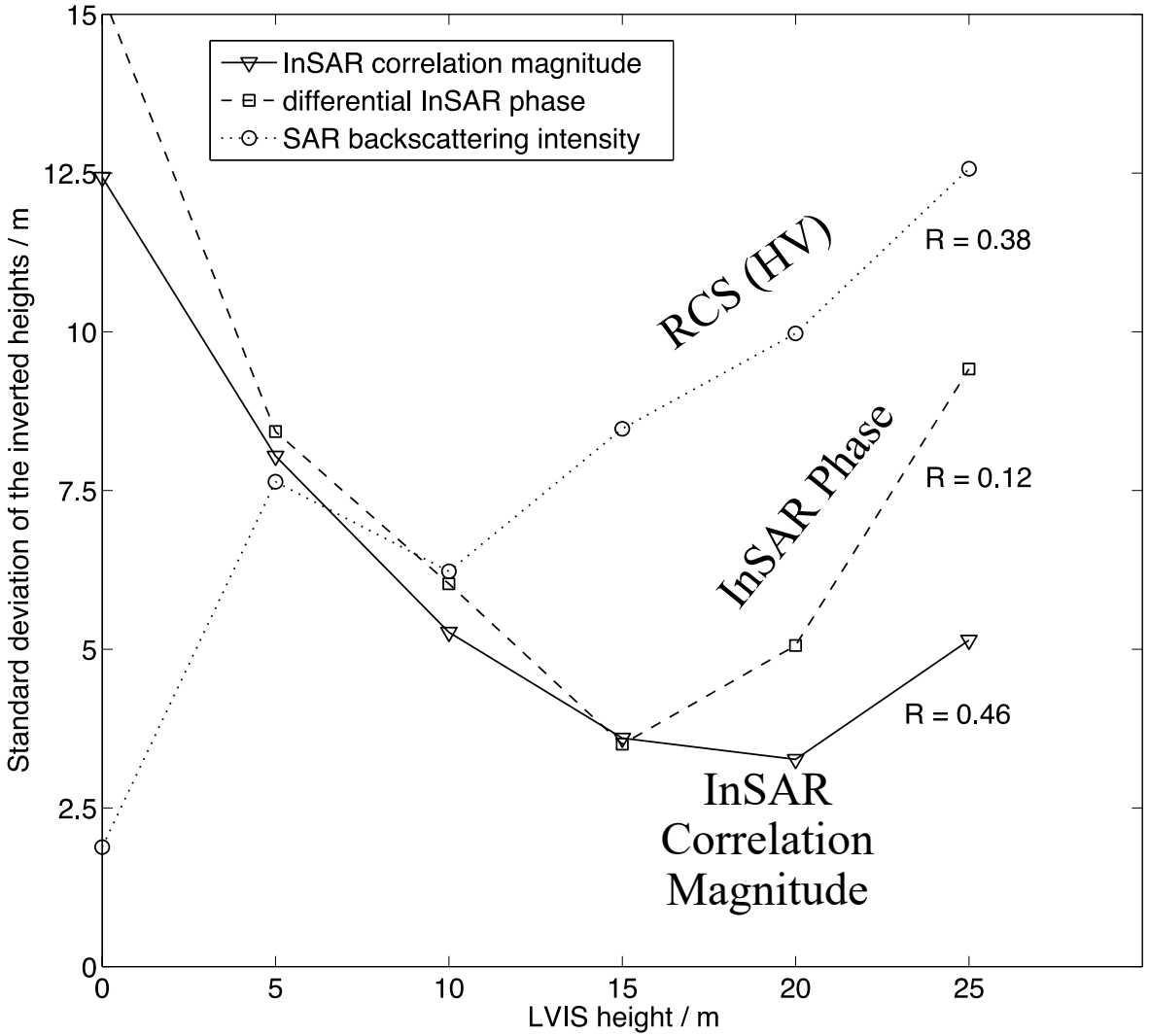
- Until recently, determination of scaling coefficients, Sscene and Cscene, have been done by scene-by-scene estimation using overlap regions

- We have developed a method for determining fit coefficients similar to what was done for the Amazon mosaic

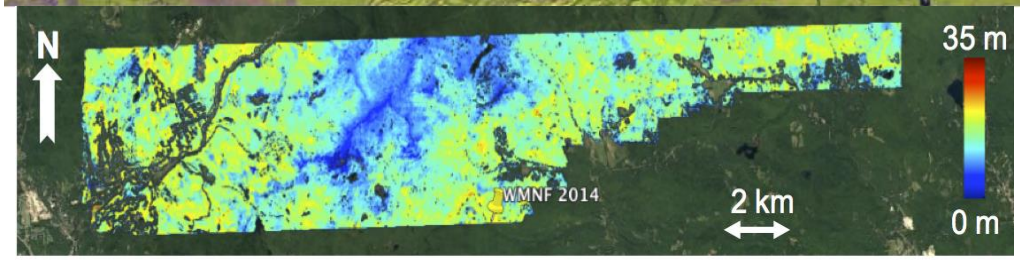




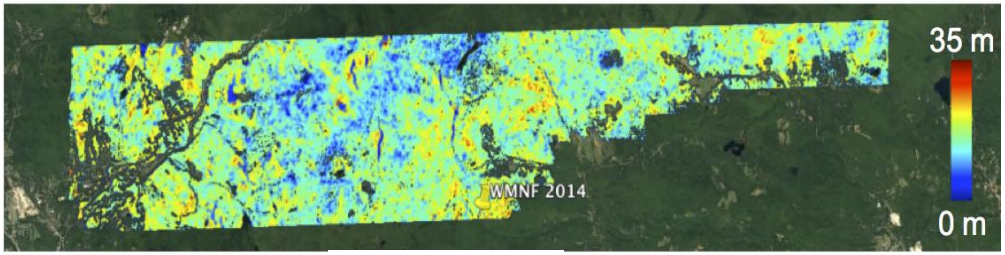
Quantititave comparison



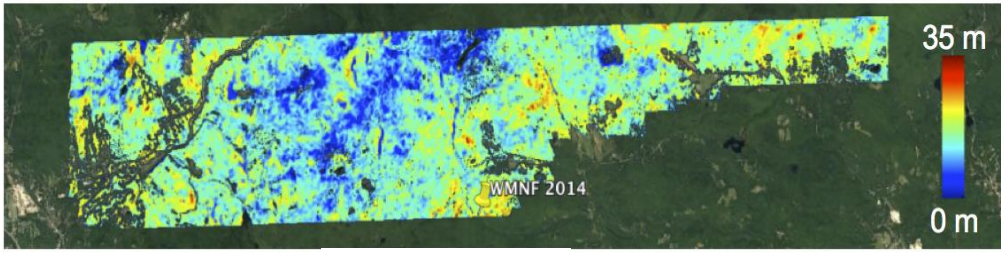
- Assuming that forest stand height (FSH) is a proxy for biomass, we can fit observations of RCS, InSAR differential height from the known DEM (phase) and the correlation magnitude height to the LVIS observed heights.
- Low heights work best with RCS.
- Large Heights have best performance with InSAR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



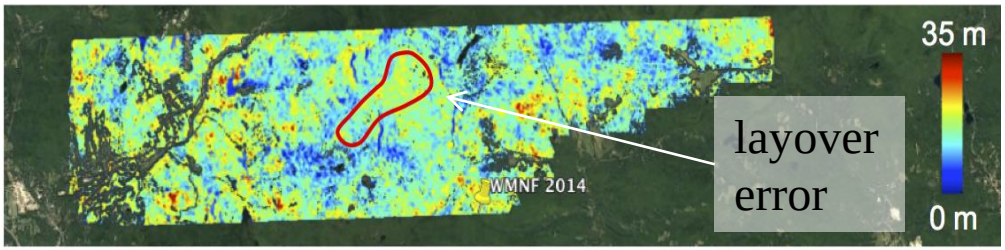
Lidar RH100



ALOS-1 single



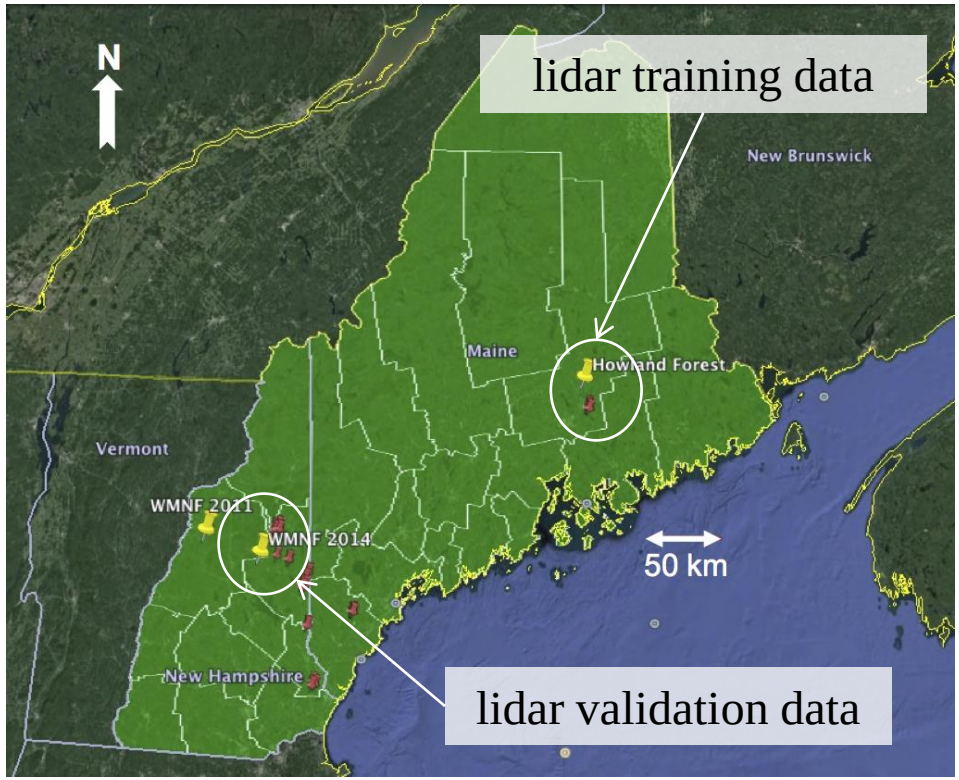
ALOS-1 mosaic



ALOS-2 single

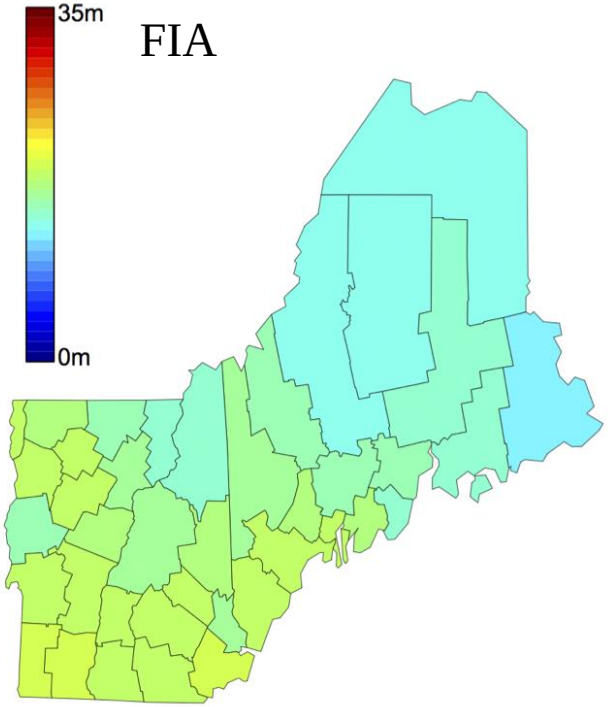
Work with AGS & Mark Ducey

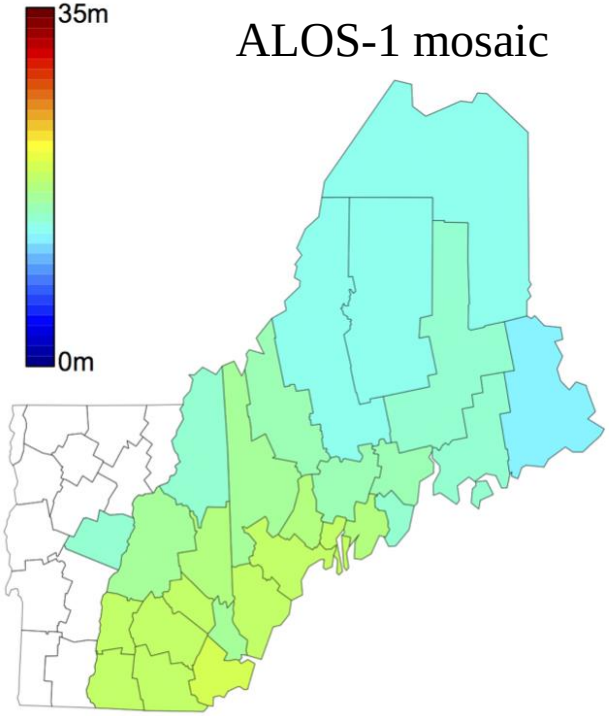
- RH100 lidar data over the Howland Forest and ALOS-1 correlation w/mosaicking used to propagate FSH parameters to lidar validation site, some 300 km away
- Compare results with single-scene FSH estimation from ALOS-1 and ALOS-2

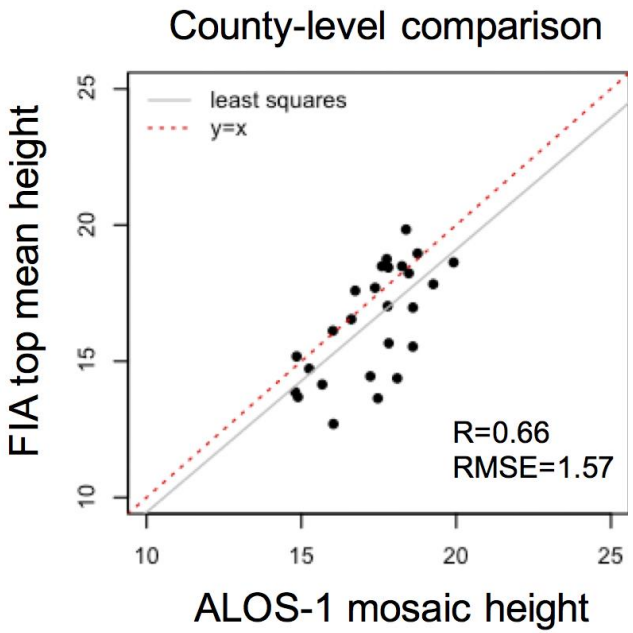


FSH at the County Level

- County-level accuracy (RMSE) is 1.6 m, comparable to FIA accuracy

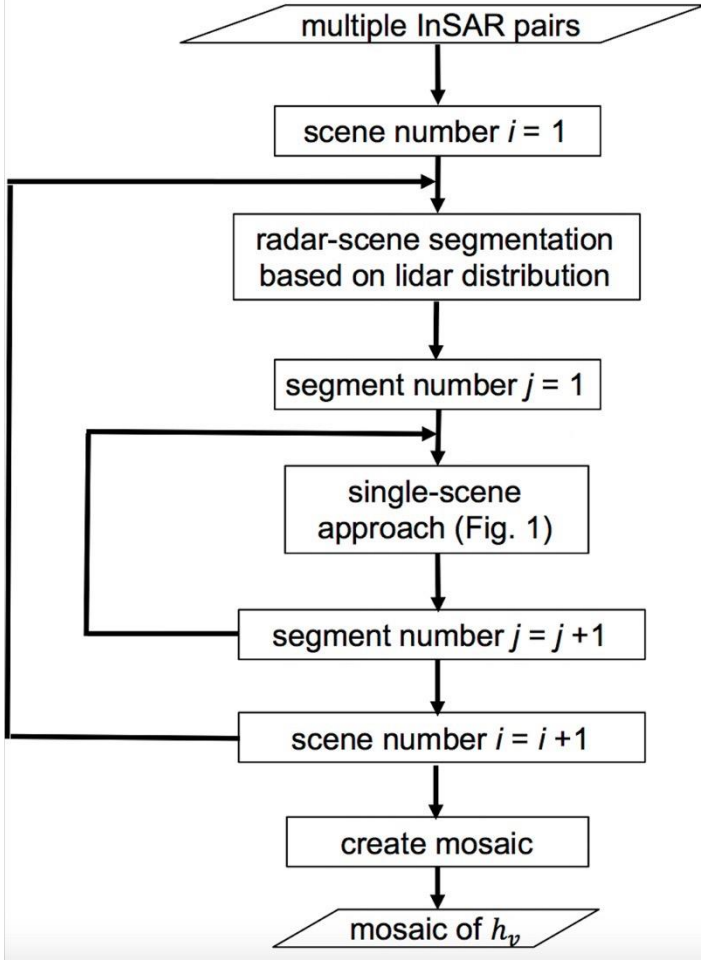






FSH Algorithm

- Algorithm is automated using Python
- Available at github/leiyangleon/FSH



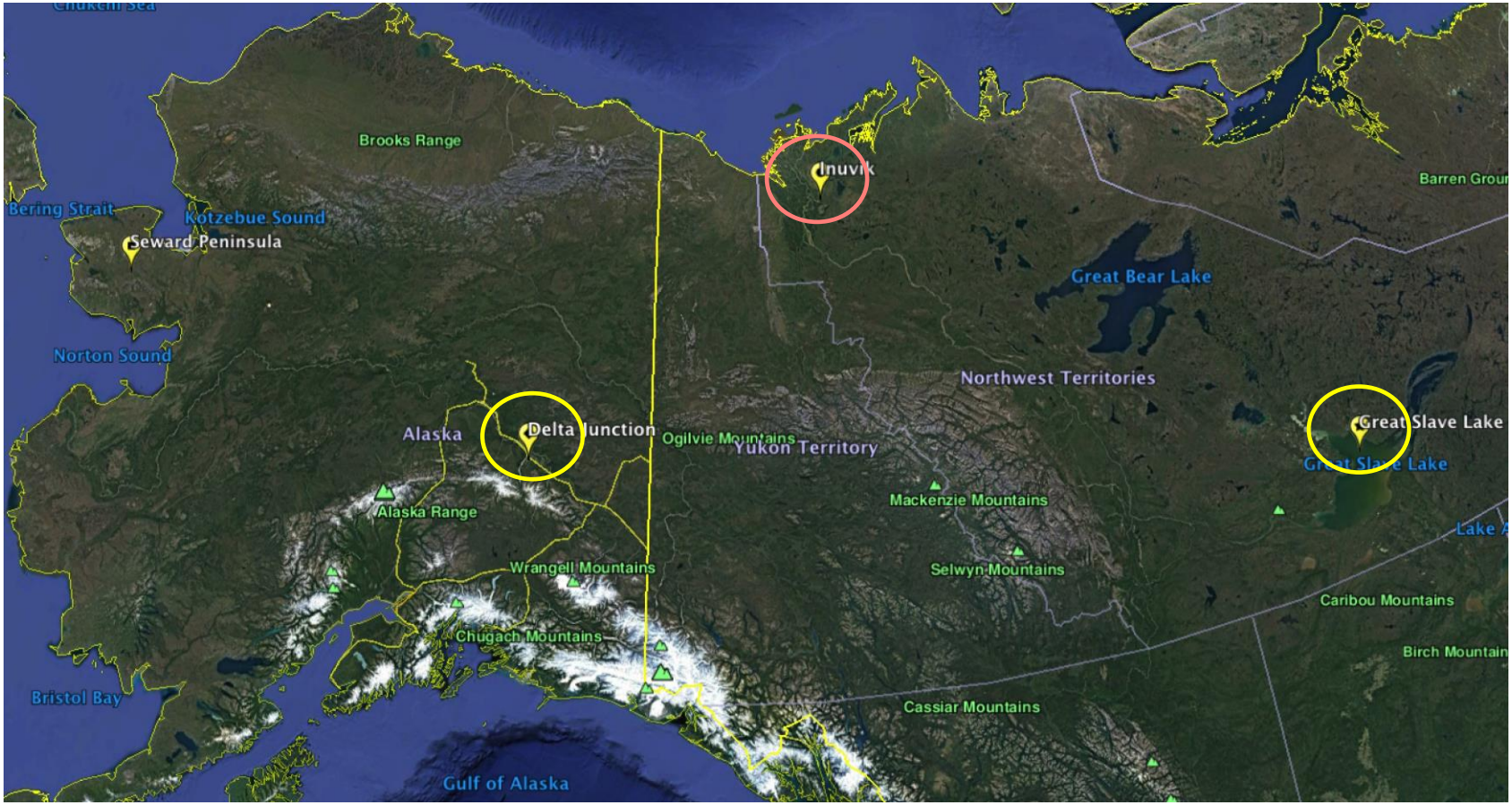
- Lei, Y. and Siqueira, P., 2014. Estimation of forest height using spaceborne repeat-pass L-Band InSAR correlation magnitude over the US State of Maine. Remote Sensing, 6(11), pp.10252-10285.
- Lei, Y. and Siqueira, P., 2015. An automatic mosaicking algorithm for the generation of a large-scale forest height map using spaceborne repeat-pass InSAR correlation magnitude. Remote Sensing, 7(5), pp.5639-5659.

ALOS-2 & ABoVE

- NASA is in the midst of the Arctic Boreal Vulnerability Experimeht (ABoVE) intended to study the ecologic consequences of climate change in the boreal region in Alaska and Canada
- Research focus areas on
  - Hydrology
  - Disturbance (fire, insect)
  - Disturbance History (biological succession)
  - Permafrost & Landscape effects
  - Habitat changes and effects on wildlife

Some study sites in ABoVE

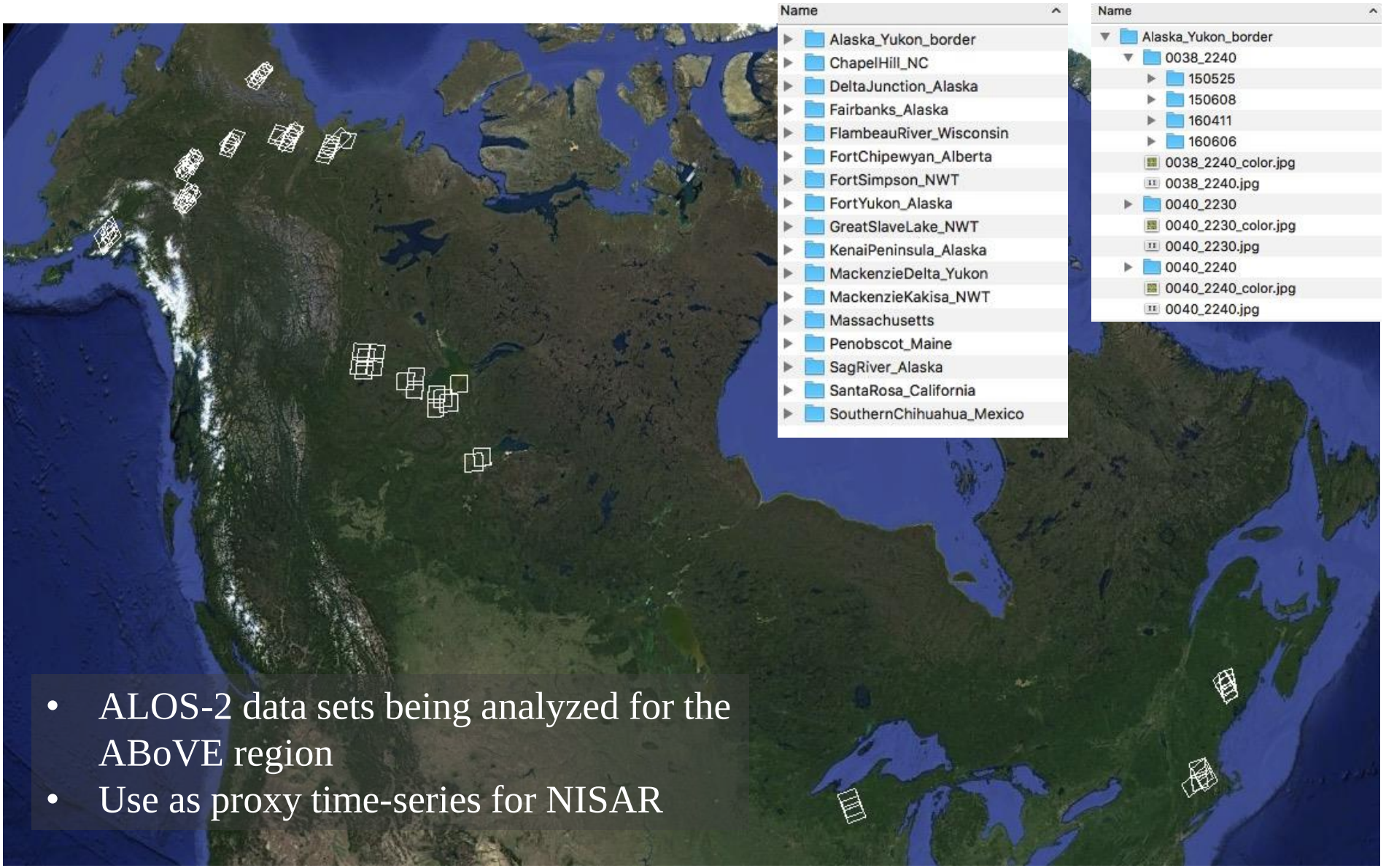
- Intensive air campaign in the ABoVE region in summer 2017
- Snow characterization at Inuvik in March 2018



ALOS

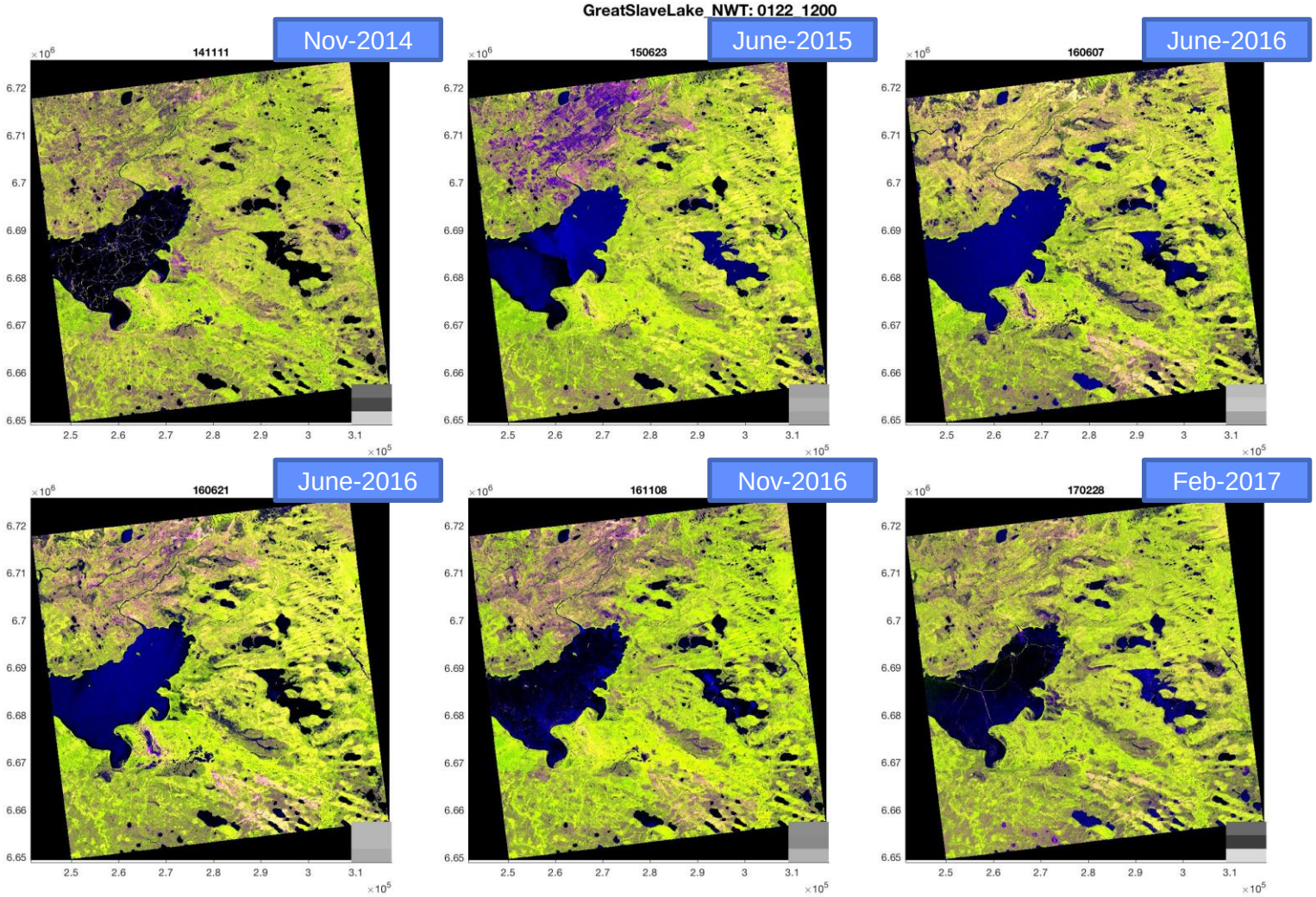
K&C Initiative

An international science collaboration led by JAXA



- ALOS-2 data sets being analyzed for the ABoVE region
- Use as proxy time-series for NISAR

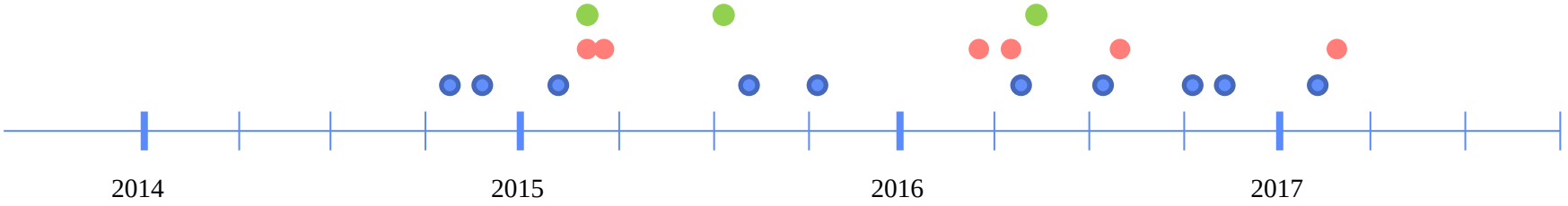
Example of ALOS-2 time series

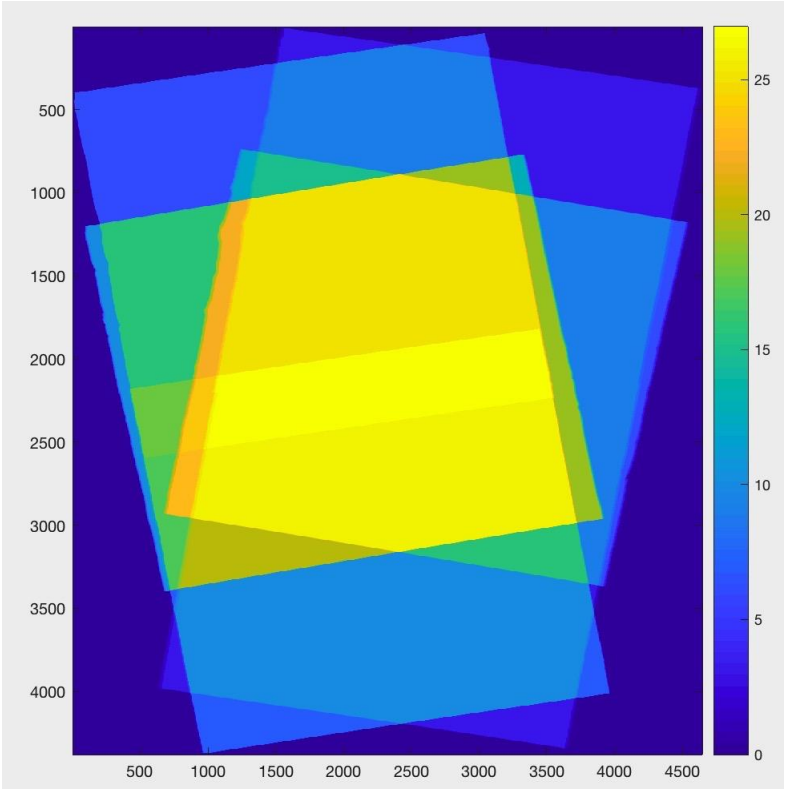


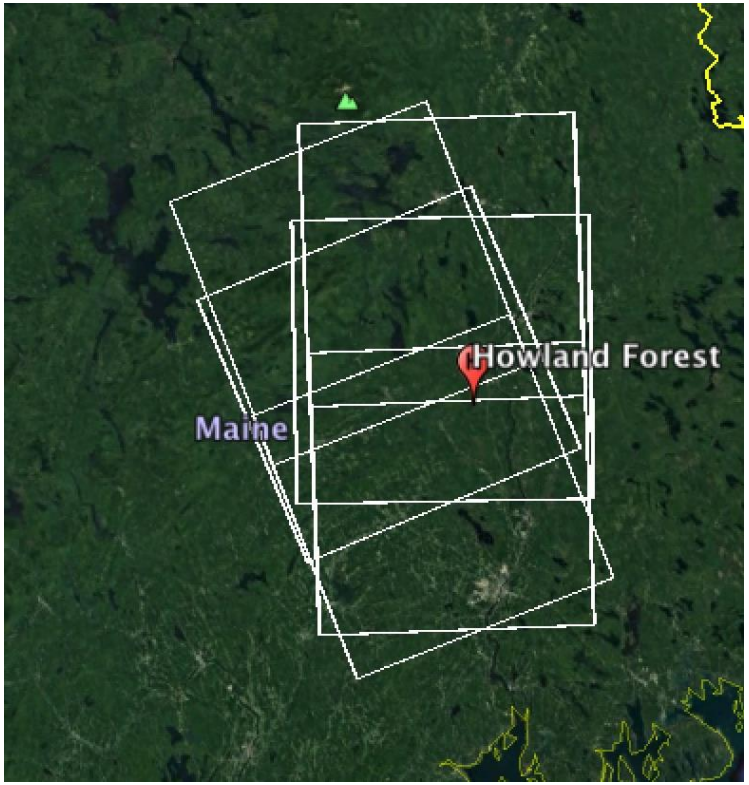
Dates
11-11-2014
06-23-2015
06-07-2016
06-21-2016
11-08-2016
02-28-2017

HH HV
HH/HV

ALOS-2 Observations at Howland/Penobscot

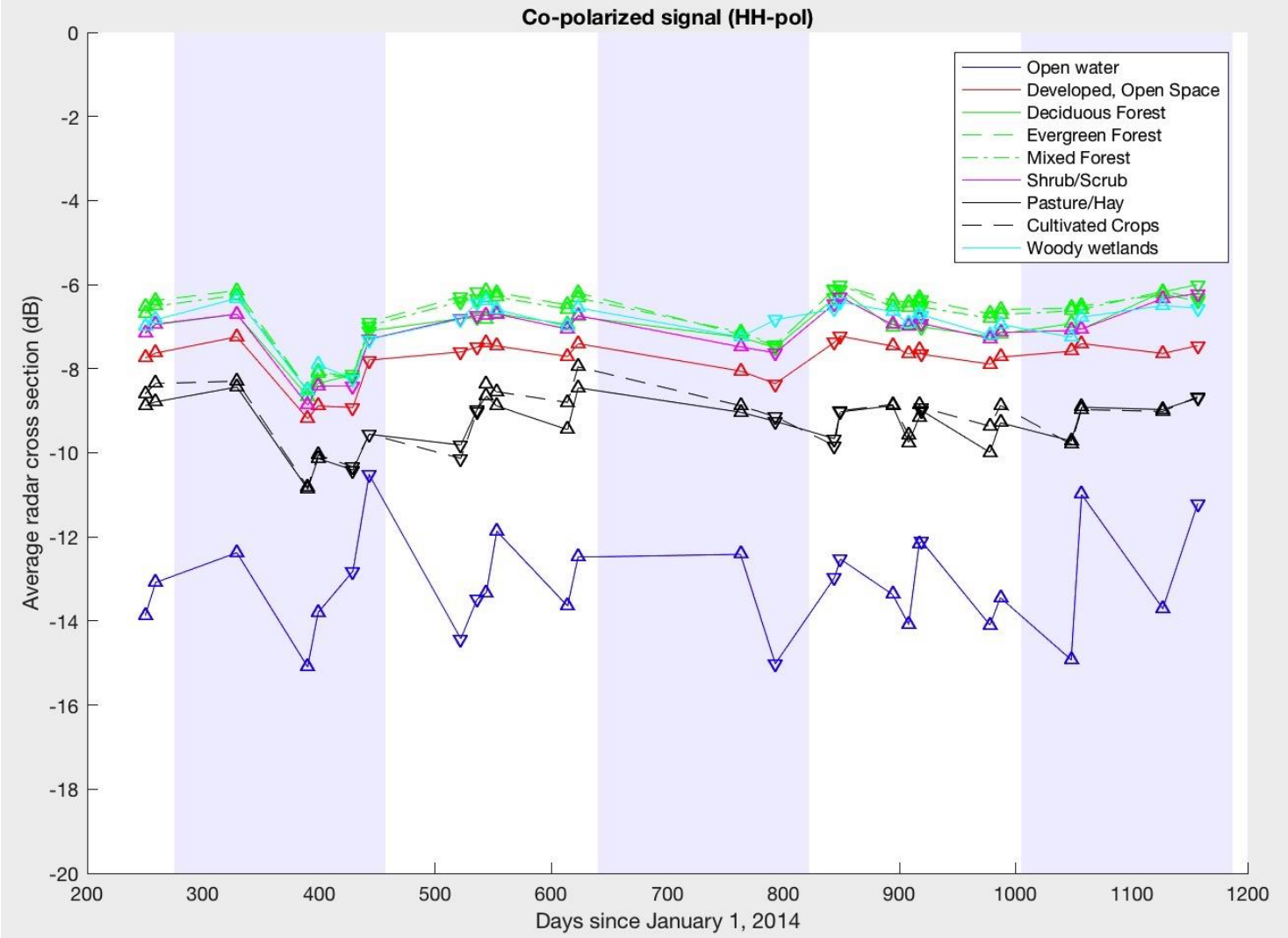






- FBD Descending
- FBD Ascending
- FBS Ascending

Compare HH and HV RCS for different landcovers



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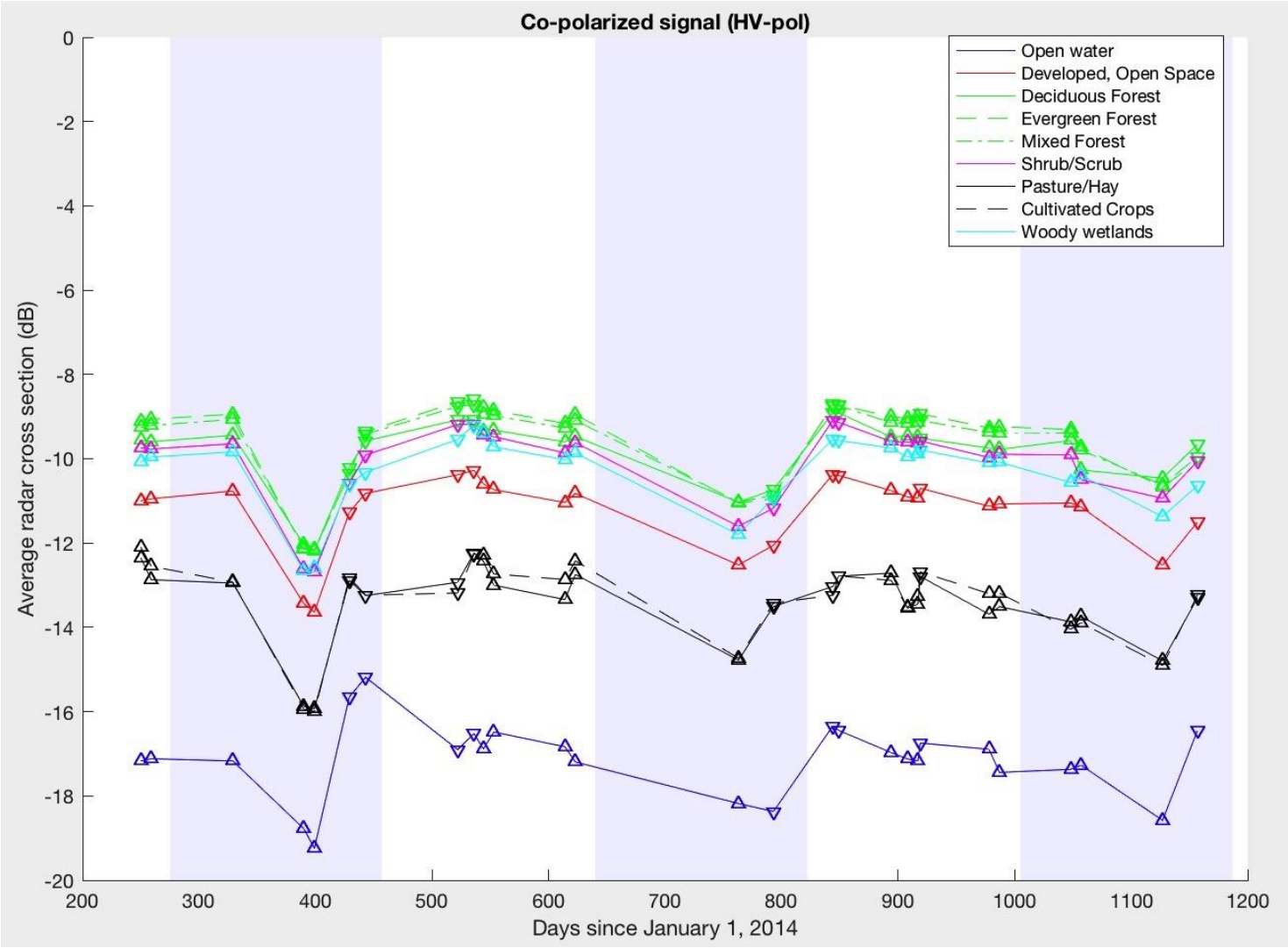

Deliverables & Milestones

- 2 papers written on FSH (Remote Sensing) in 2014 & 2015, including K&C acknowledgement; 2 others written on the theory
- ALOS-1 derived FSH map for Maine and New Hampshire
- Lack of significant L-band coverage over Maine, and limitation of scenes prevents application of ALOS-2 data for FSH
- Coefficient of variation paper (RSE) in 2018
- Lack of consistent L-band data set other than UAVSAR prevents study for crop-classification work
- Will provide phase 4 report
- Will request 1-year extension, topic to analyze ALOS-2 data in the ABoVE and Northeastern US regions

Other K&C relevant publications

An Error Model For Mapping Forest Cover And Forest Cover Change Using L-Band SAR

Oliver Cartus, Paul Siqueira, and Josef Kellndorfer

(acknowledgements include Maurizio & Johan)