MAPPING INVASIVE PLANT SPECIES IN TROPICAL RAINFOREST USING POLARIMETRIC RADARSAT-2 AND PALSAR DATA

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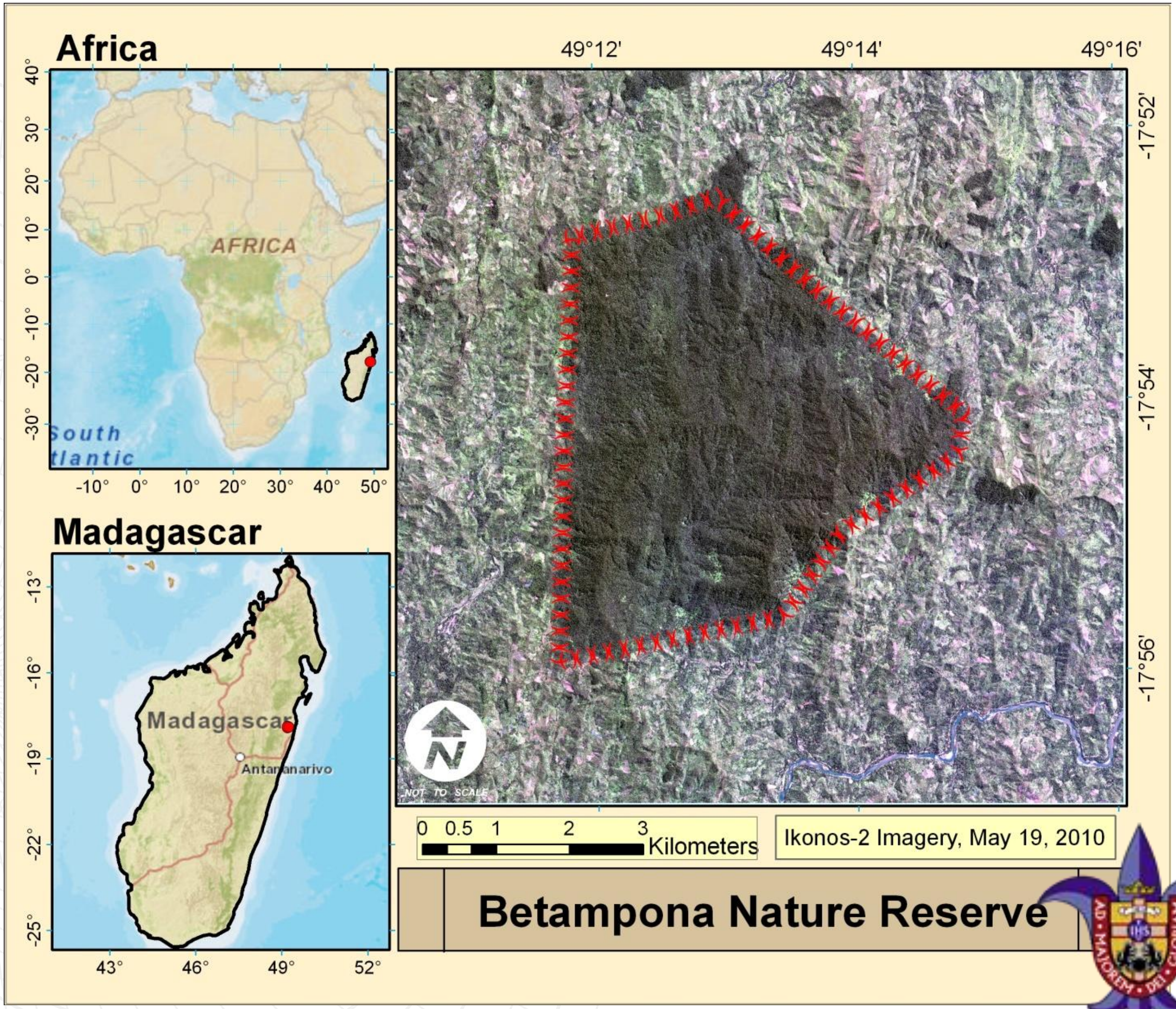
IGARSS

24-29 July, Vancouver, Canada

Study area

- Area: 68 sq km
- one of the last remnants of intact lowland rainforest in Madagascar
- a sanctuary for a vast diversity of flora and fauna



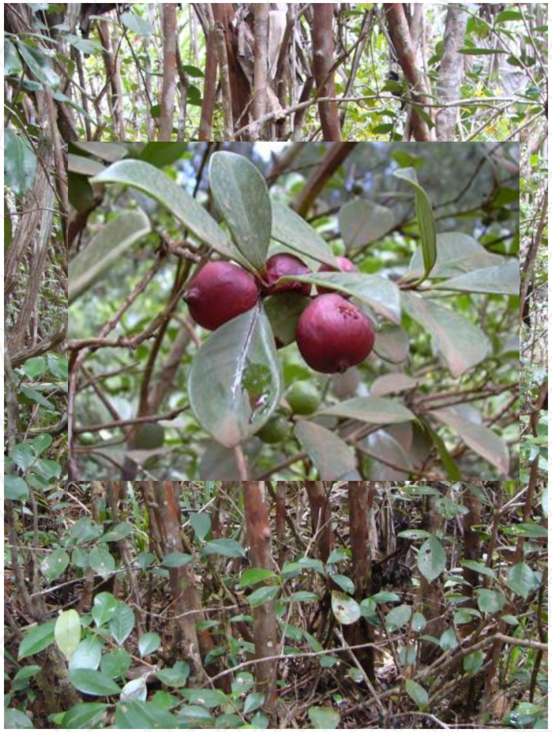
Study area - Tropical Rainforest

Why Invasive Species?

- An indication of eco-system degradation
- Introduced through anthropogenic activities such as illegal logging and urbanization, and climate change
- Animal and plant species diversity in the reserve has become critically endangered through forest degradation and the introduction of invasive species

Invasive Species

Guava (P. cattleianum)



Piste Principale

Wild ginger (A. angustifolium)

Invasive plant species differ in canopy structure than native forest

Invasive Species

Rubus – a type of invasive raspberry

Longoza

http://ca.wikipedia.org/wiki/Fitxer:Aframomum_angustifolium_fruit.jpg

AFRAMOMUM ALBOVIOLACEUM (RIDL.) K.SCHUM

http://www.westafricanplants.senckenberg.de

Invasive plant species differ in canopy structure than native forest

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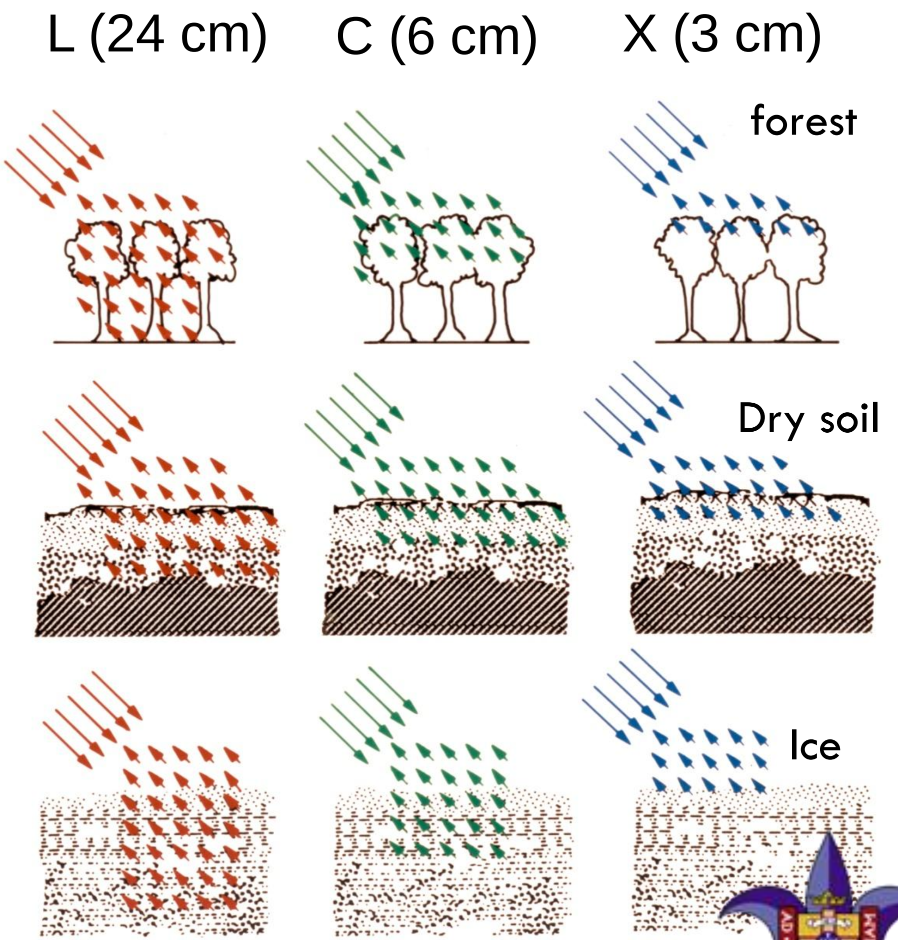
Our goal

- to explore the capabilities of Radarsat-2 quad-pol data (C band) and both dual and quad-pol PALSAR in mapping invasive plant species and forest degradation in Betampona Natural Reserve

- assess native forest health and diversity to monitor the effectiveness of in-situ conservation efforts

Hypothesis

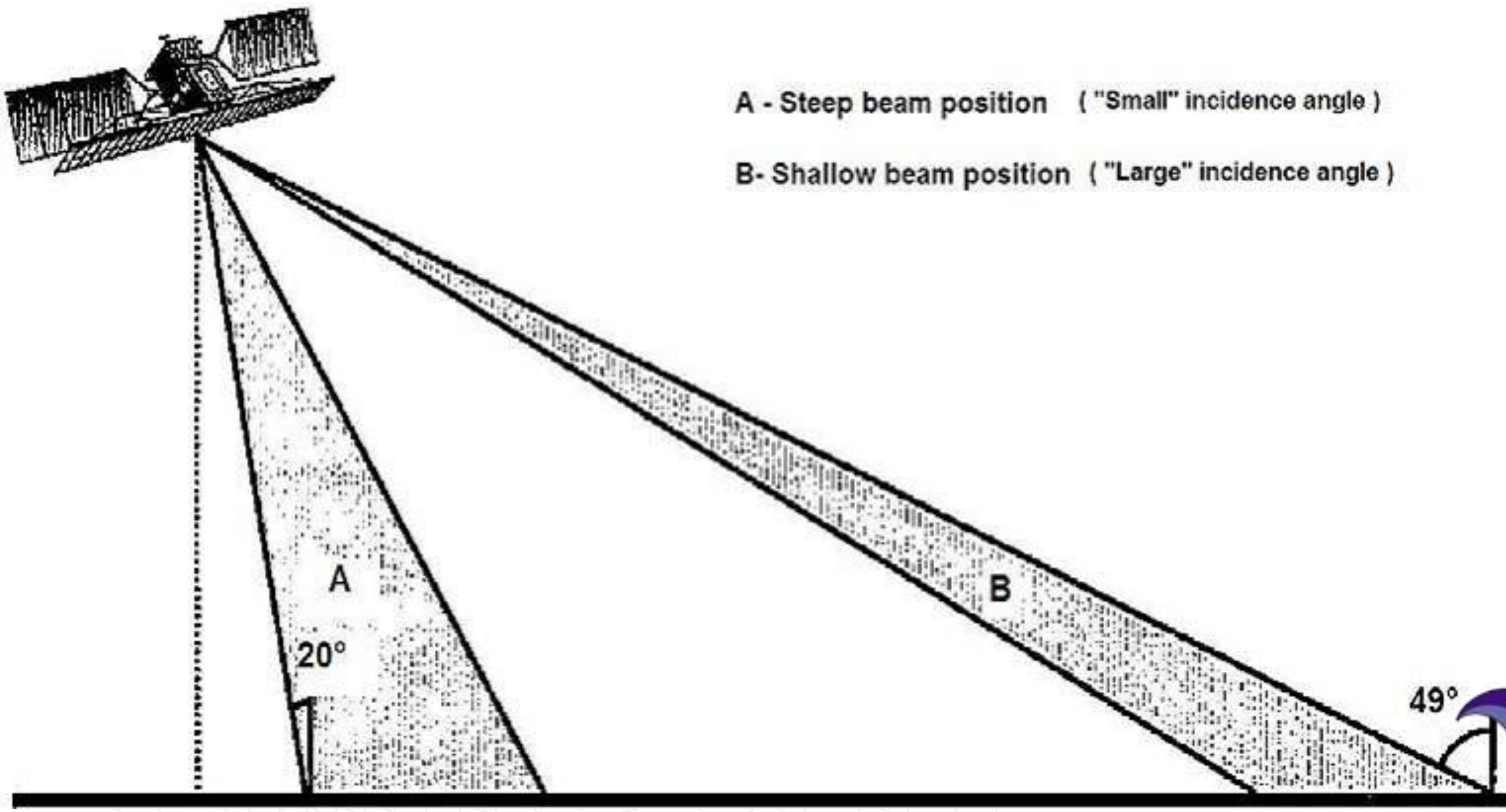
- Leaves reflect shorter (e.g., C) but not longer wavelengths (e.g., L)
- Reflections from bare forest floor may introduce some noise in longer wavelengths
- C band (5.6 cm) have a limited ability to penetrate to the forest understory and floor, and therefore, may be more useful in mapping plant species in forest canopies or sub-canopies?



Credit: Rosen, JPL

Hypothesis

Steeper incidence angle is better to map invasives?



Datasets

- Shallow incidence angles
  - useful for delineation of land use activities, e.g. illegal logging
- Steep (small) incidence angles:
  - may be more useful for vegetation type mapping

Sensor	Product	Orbit/ Path	Frame	Acquisition date	Off-nadir angle	Spatial Resolution	Orbit direction
Radarsat-2	FQ10 /L1.1	36-71D		05/18/2010	29.32^o	8 m	Descending
PALSAR	PLR/L1.0	474	620	05/18/2008	21.5^o	12.5 m	Ascending
PALSAR	FBD/L1.1	550	6820	07/23/2007	34.3^o	12.5 m	Ascending

Methodology: Polarimetric Features

- Polarimetric Features
  - Co-pol correlation coefficient

$$\frac{\langle S_{HH} S_{VV}^{*} \rangle}{\sqrt{|S_{HH}|^2 |S_{VV}|^2}}$$

Rodriguez & Martin, 1992

  - Co-Polarization ratio (HH/VV)

$$\frac{\langle S_{HH} S_{HH}^{*} \rangle}{\langle S_{VV} S_{VV}^{*} \rangle}$$

Drinkwater, et al, 1992

  - Polarimetric phase difference (HH-VV) in radians

$$\arg(\langle S_{HH} S_{VV}^{*} \rangle)$$

Shriever, et al, 2003

  - Linear depolarization ratio (in dB)

$$LDR(dB) = 10 \cdot \log_{10}\left(\frac{\langle S_{HV} S_{HV}^{*} \rangle}{\langle S_{VV} S_{VV}^{*} \rangle}\right)$$

Kennedy, et al., 2001

Methodology: target decomposition theorems

- Pauli Basis

$$k_P = \frac{1}{\sqrt{2}}\begin{bmatrix} S_{hh}+S_{vv} \\ S_{hh}-S_{vv} \\ 2S_{hv} \end{bmatrix}$$

$S_{hh}+S_{vv}$ → *Direct scattering*

$S_{hh}-S_{vv}$ → *Double bounce*

$2S_{hv}$ → *Multiple scattering*

- coherency matrix

$$= \frac{1}{2}\left\langle\begin{bmatrix} \langle |S_{hh}+S_{vv}|^2\rangle & \langle (S_{hh}+S_{vv})(S_{hh}-S_{vv})^*\rangle & 2\langle (S_{hh}+S_{vv})S_{hv}^*\rangle \\ \langle (S_{hh}-S_{vv})(S_{hh}+S_{vv})^*\rangle & \langle |S_{hh}-S_{vv}|^2\rangle & 2\langle (S_{hh}-S_{vv})S_{hv}^*\rangle \\ 2\langle S_{hv}(S_{hh}+S_{vv})^*\rangle & 2\langle S_{hv}(S_{hh}-S_{vv})^*\rangle & 4\langle |S_{hv}|^2\rangle \end{bmatrix}\right\rangle$$

T_{11}=single bounce

T_{22}=double bounce

T_{33}=volume scattering

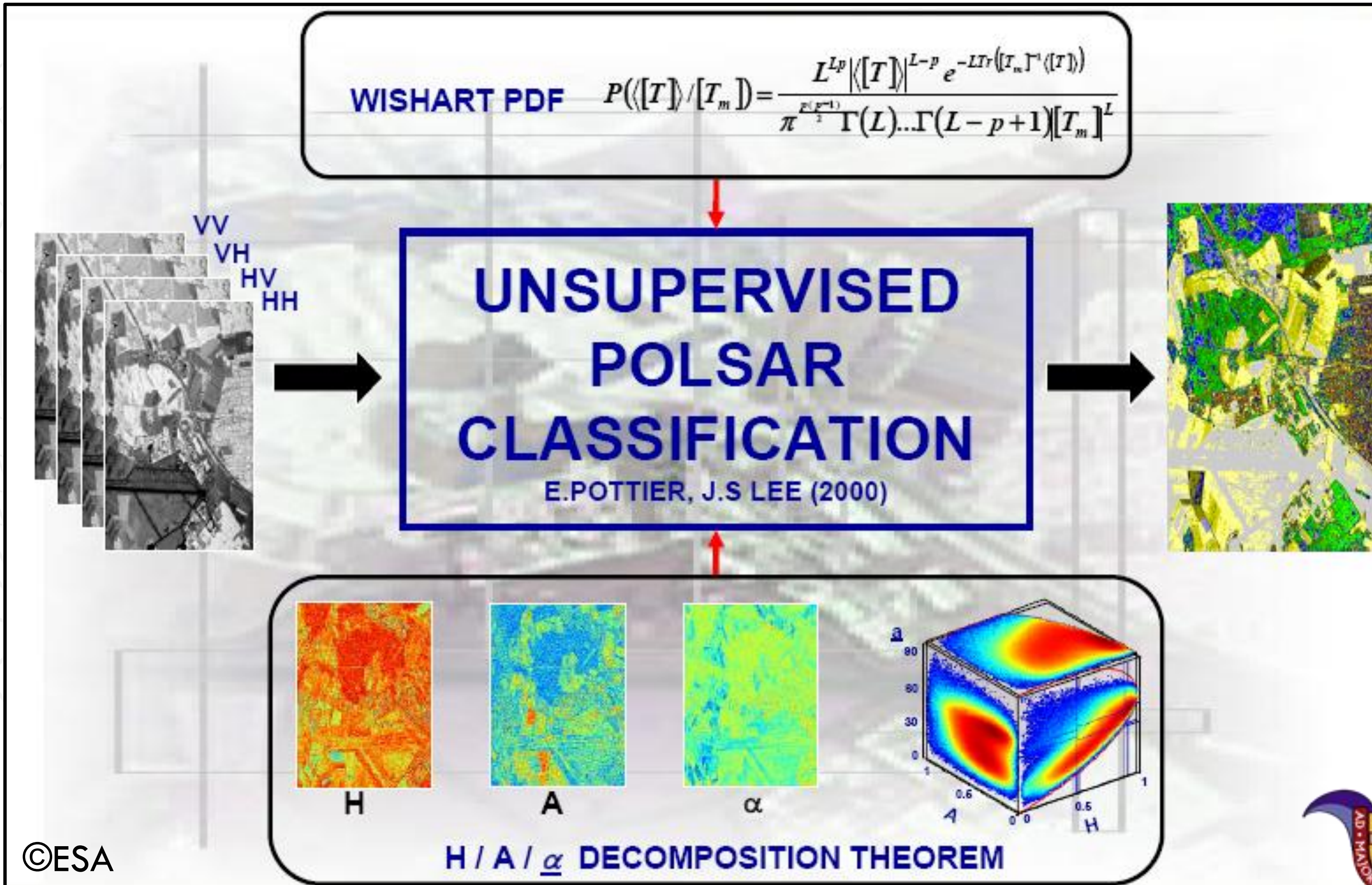
- Freeman-Durden model based decomposition

Freeman and Durden, 1998

- Cloud-Pottier eigenvalue-eigenvector decomposition

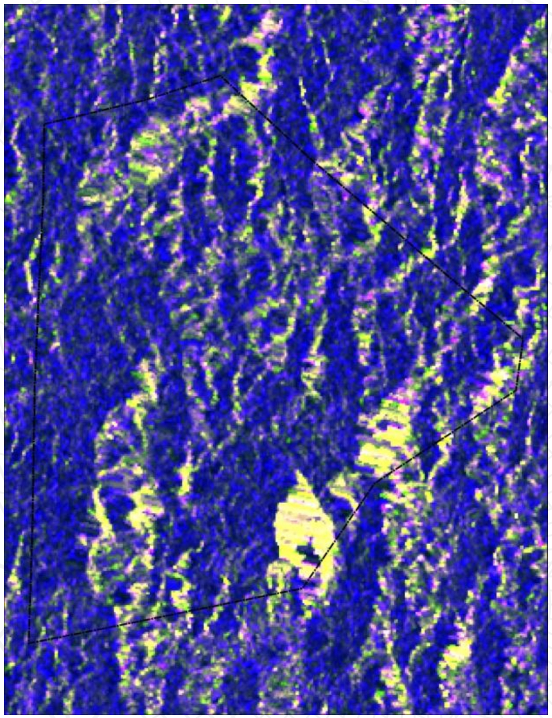
Cloude and Pottier, 1997

Methodology: Wishart Classfication



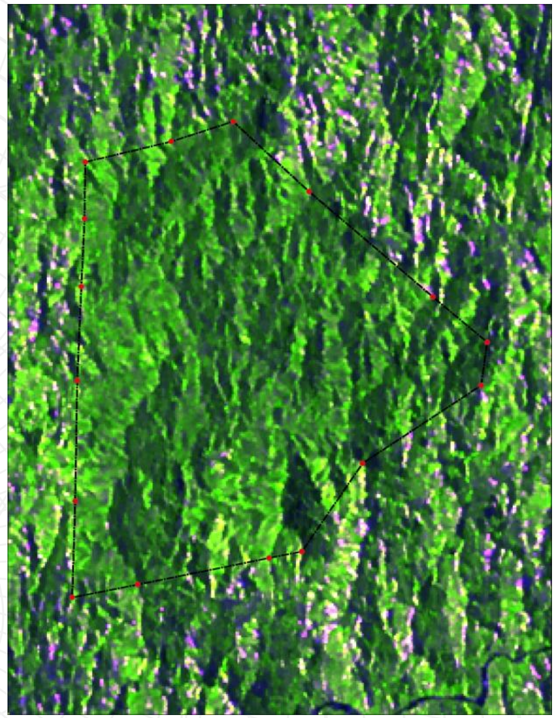
Results: Polarimetric Features - pol-ratio, linear depol ratio

Radarsat-2



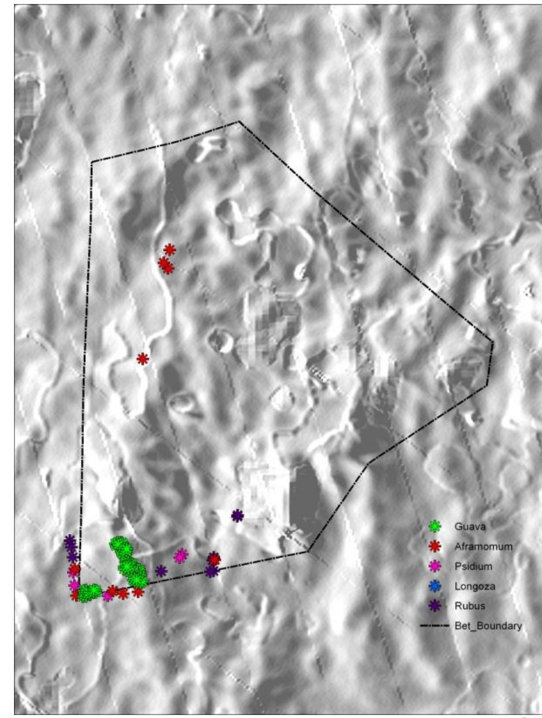
HH, HV, HH/VV

PALSAR FBD



HH, HV, HH/HV

Ground truthing



PALSAR FBD campsite gives better results.

PALSAR PLR pol ratio and LDR are noisy!!!

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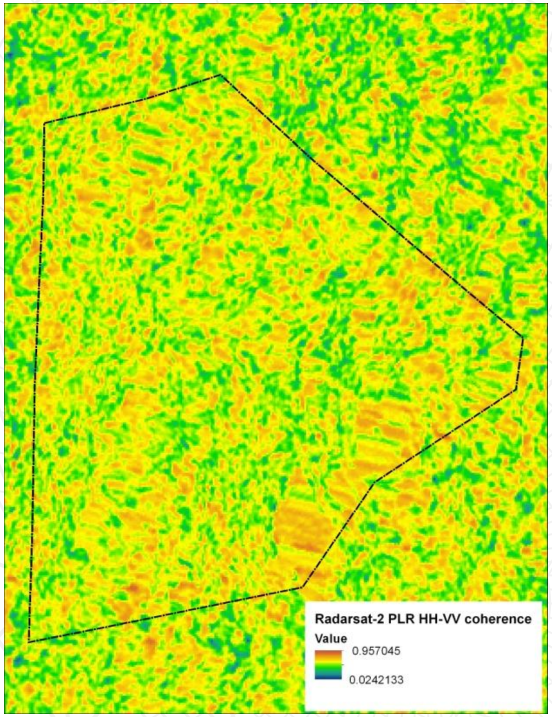
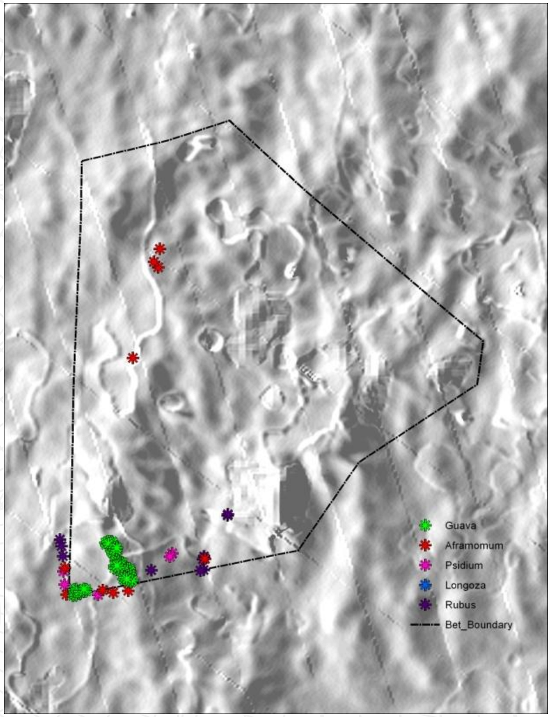
Results: Polarimetric Features – phase differences/coherences

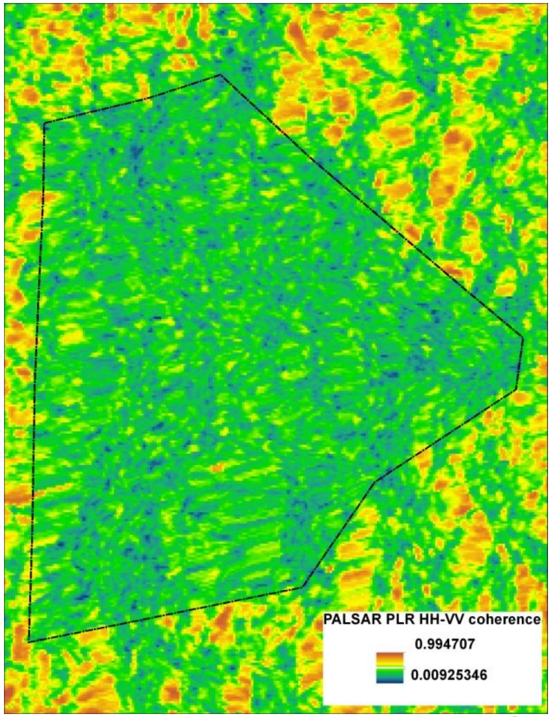
Radarsat-2



Ground truthing



PALSAR PLR



PolInSAR → HH-VV Phase Difference (PPD) → Coherences

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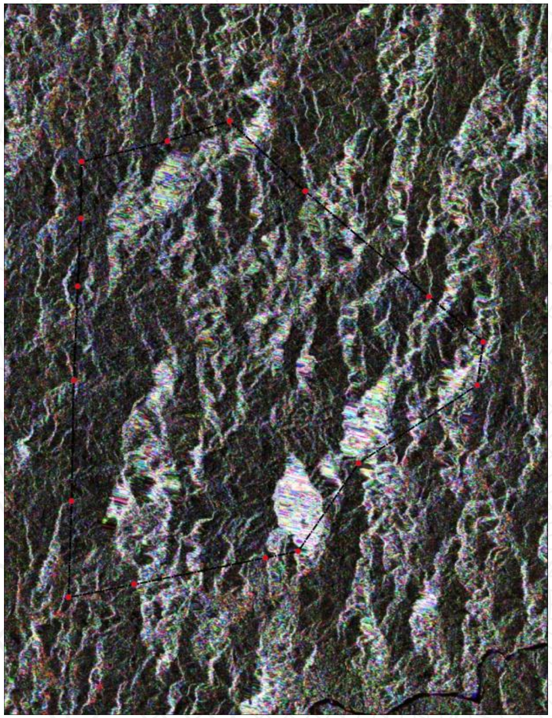
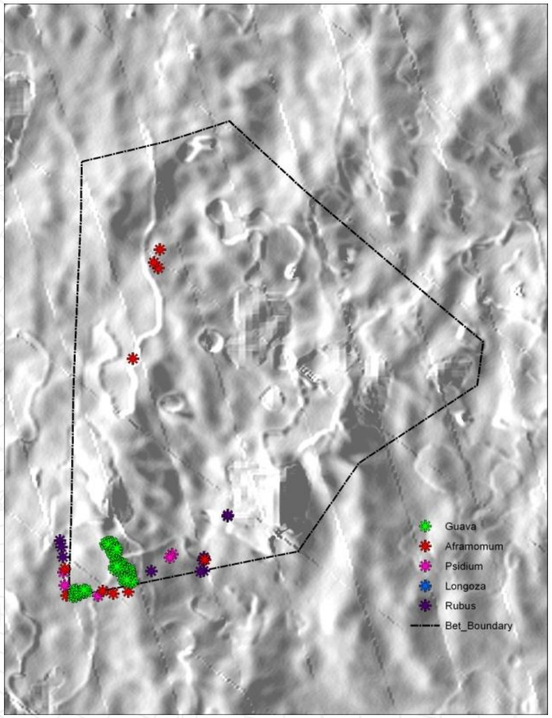
Results: Pauli Decomposition

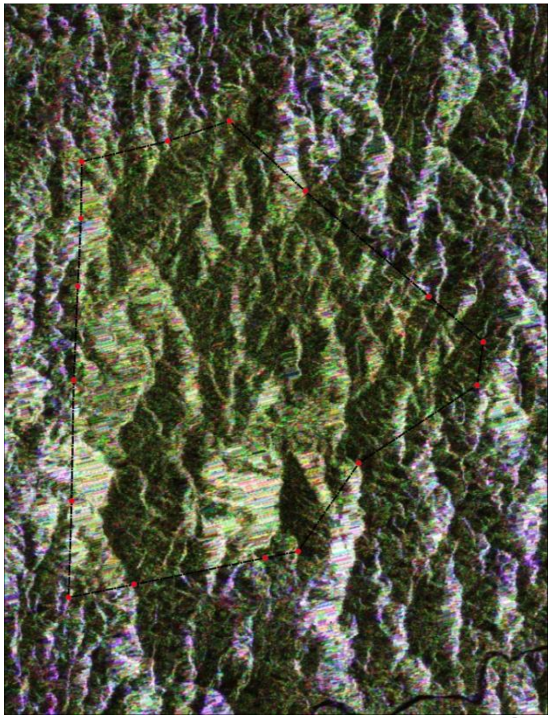
Radarsat-2



Ground truthing



PALSAR PLR



PALSAR FBD campsite gives better results!!!

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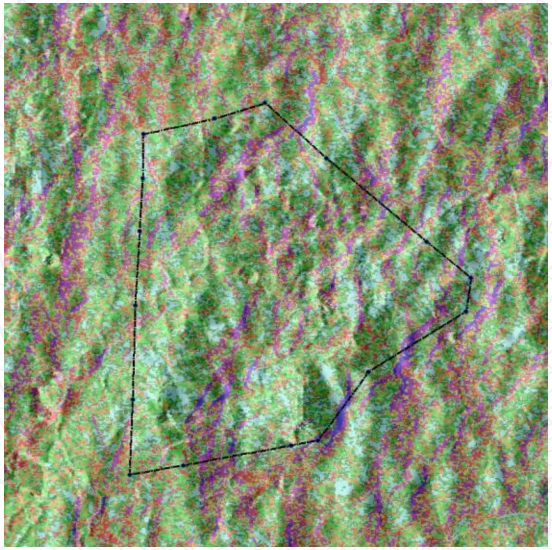
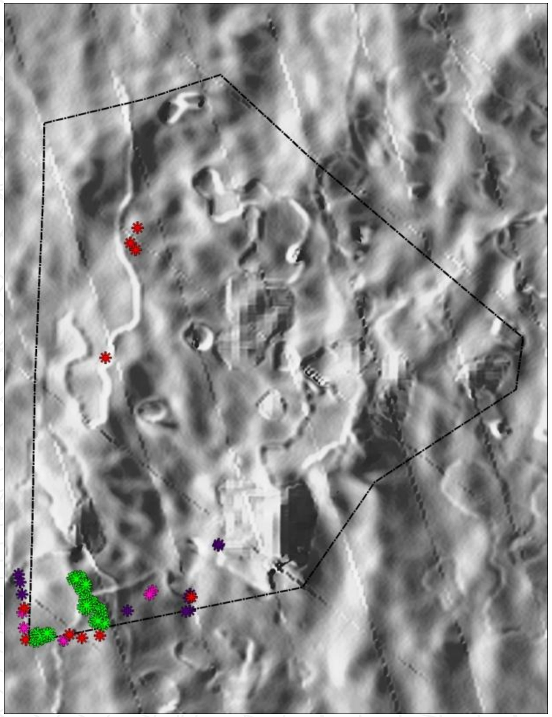
Results: EAA Decomposition/Wishart Classifications

Radarsat-2
Wishart Classification

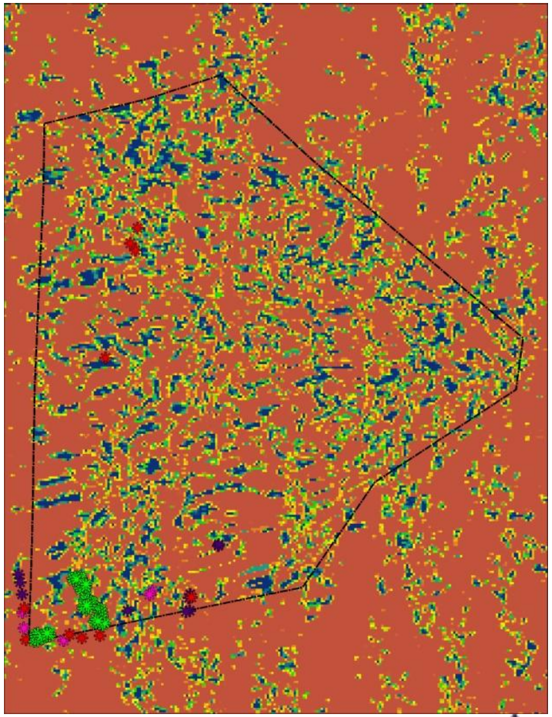


EAA classification → Clustering

Ground truthing



PALSAR PLR EAA Classes



Embarrassing resutls???

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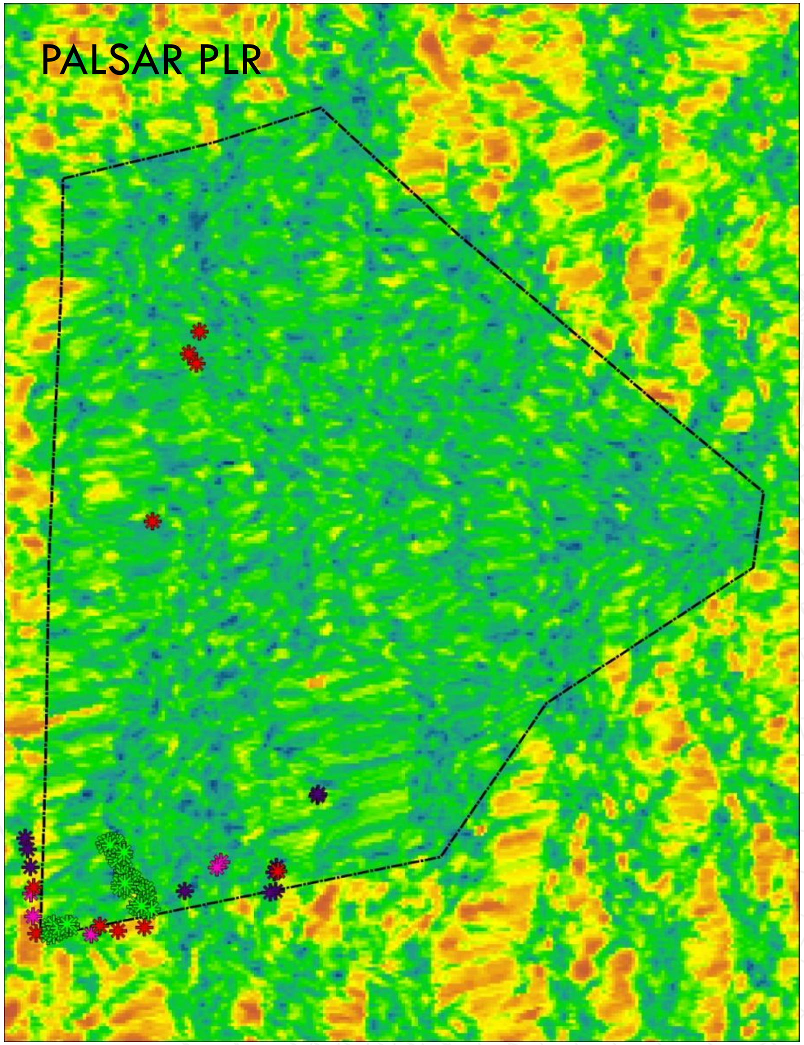
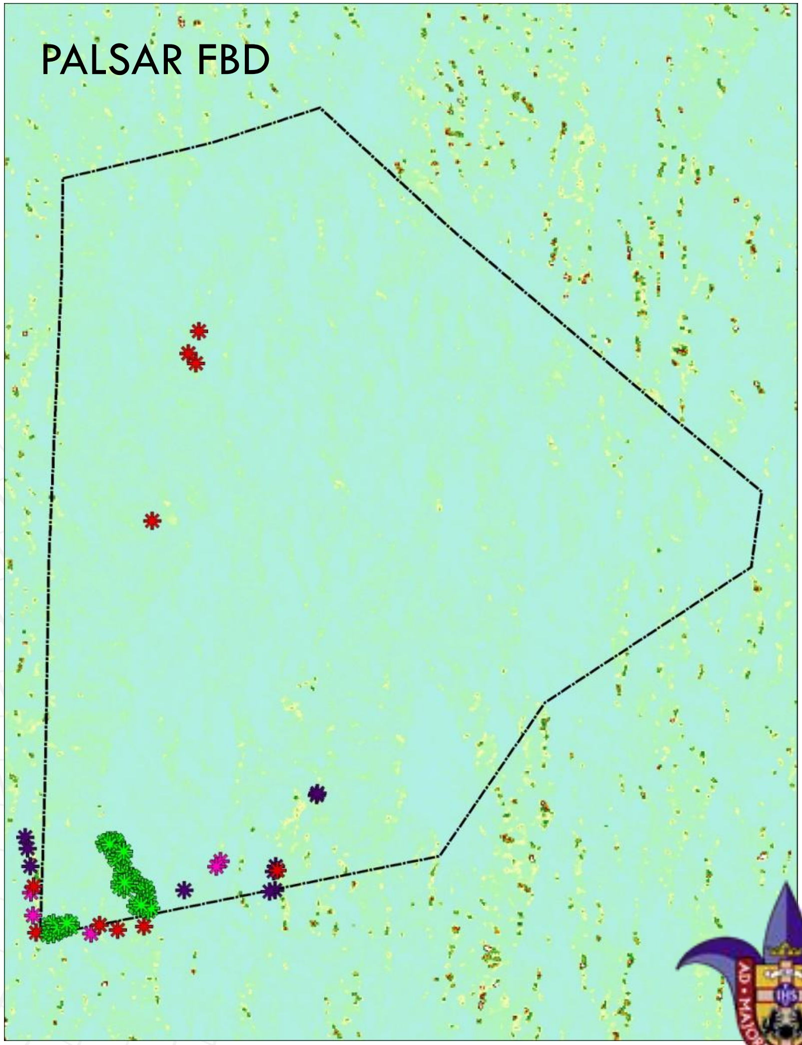
Results: PALSAR PLR w/ FBD





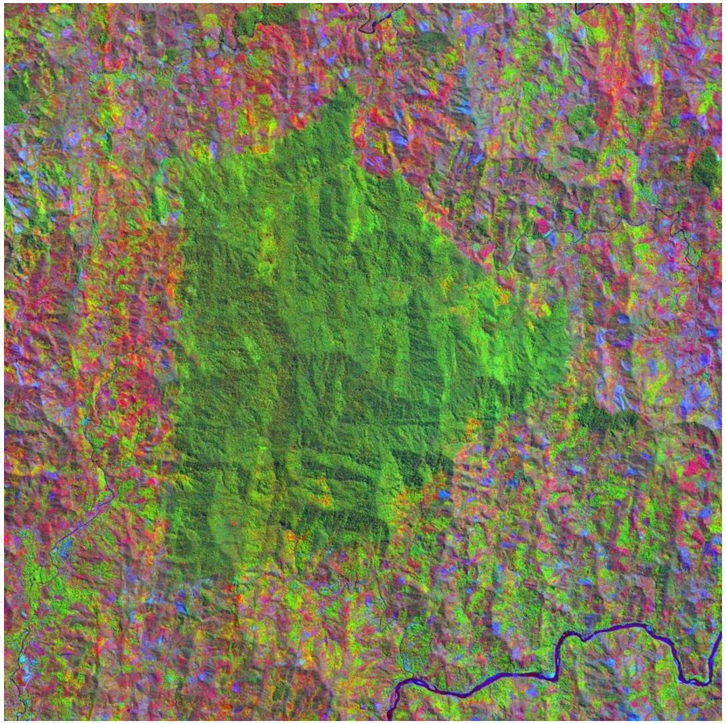
Greater exposed bare soil (21.9 incidence angle)

HH, HV, HH/HV

Conclusion

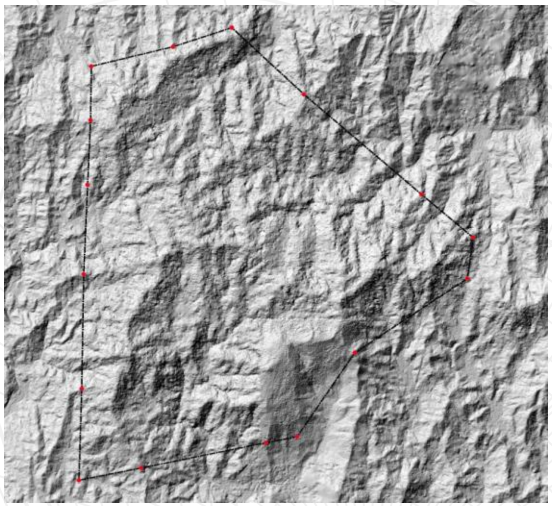
- PALSAR polarimetric data are superior for inventorying invasive forest species in rainy forest
- Phase information is **crucial**, e.g., HH and VV, HH and HV phase differences, and polarimetric coherences should be exploited
- RADARSAT-2 data did not perform well, perhaps a steeper incidence angle may useful
- PALSAR FBD **HH**, **HV**, **HH/HV** composite is equally impressive as PLR results

Ikonos-2 4m PCA

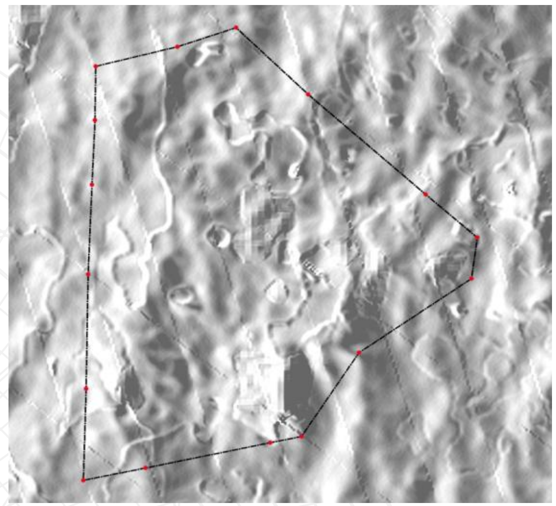


Hillshade vs. Local Incidence angels

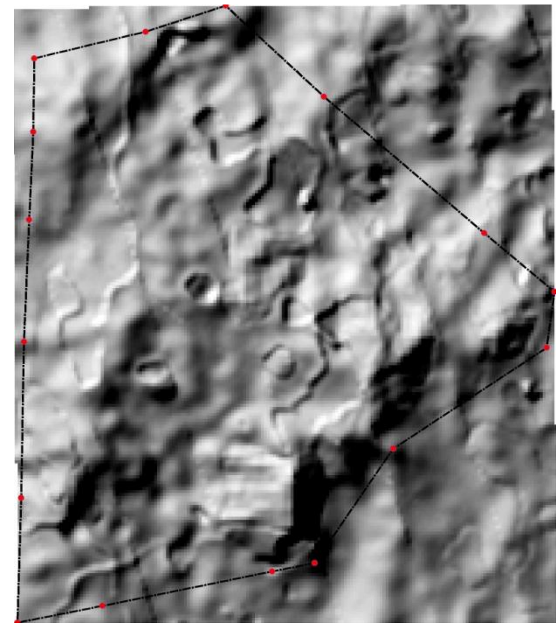
2m DTM from GeoEye Stereo

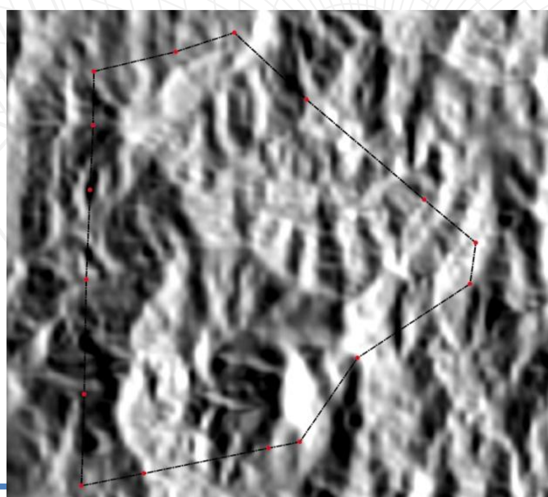


Radarsat-2 LIA



ASTER 30 m GDEM





ASTER and Radarsat-2 represent surface elevation while PALSAR and DTEM showing the terrain1

PALSAR FBD LIA

Questions, comments Please!!!

Future work