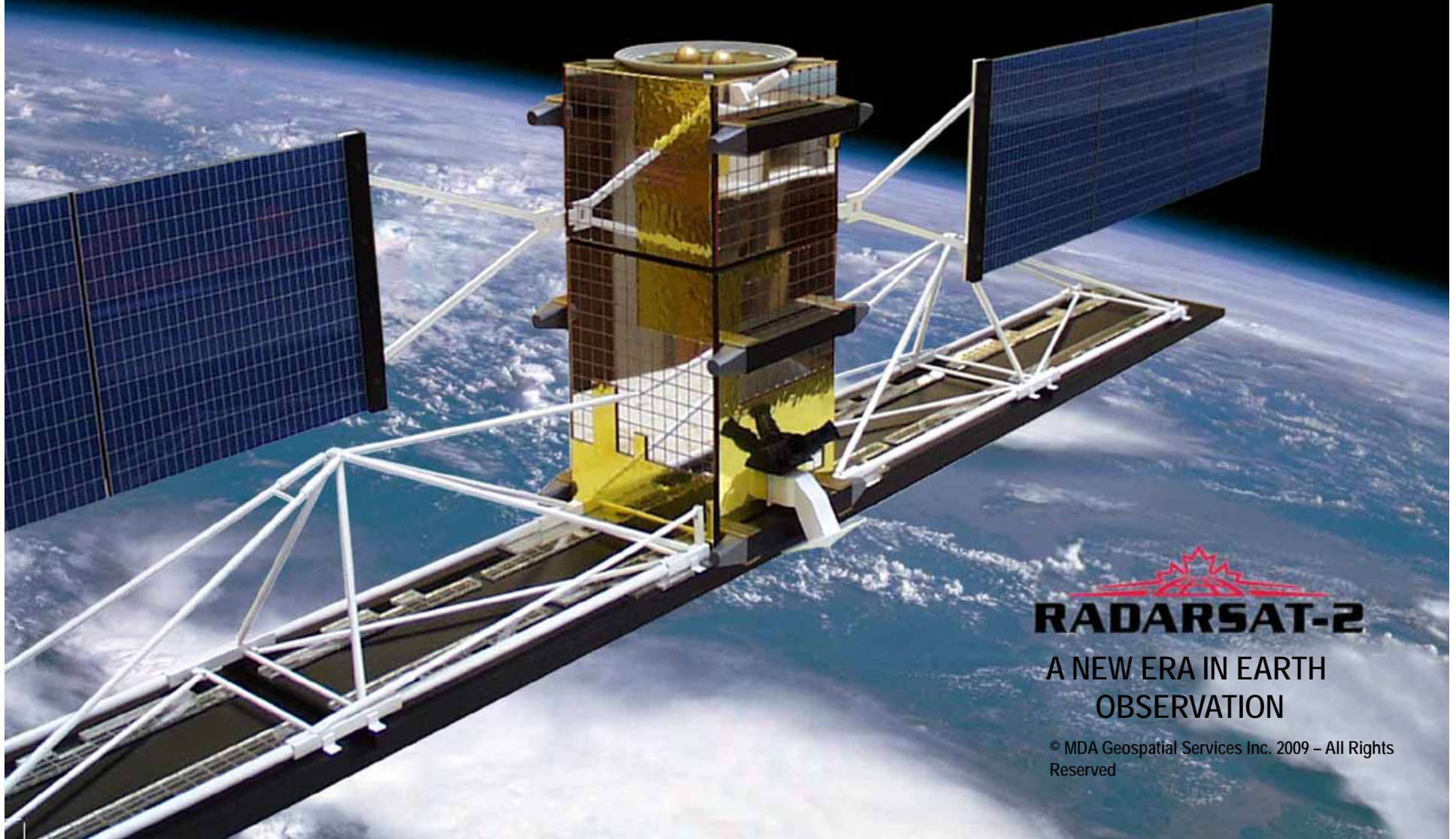


Use of C-band SAR for Global Forest Monitoring?... Yes!!

Marco van der Kooij, MDA
SDCG, March 6, 2012
mvanderkooij@mdacorporation.com




RADARSAT-2

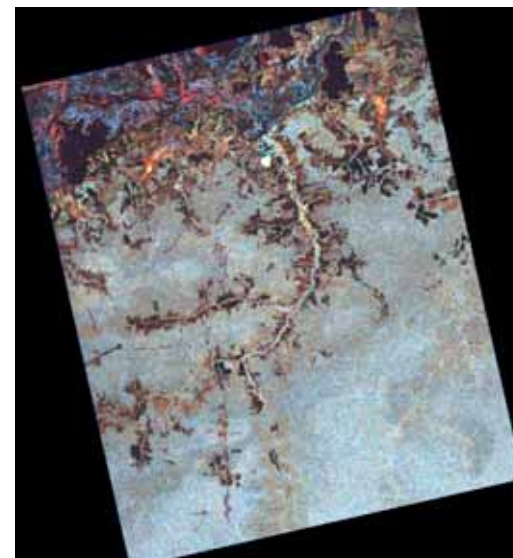
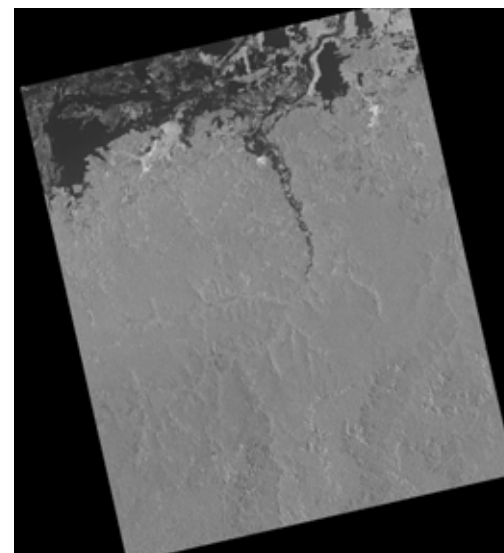
A NEW ERA IN EARTH
OBSERVATION

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Reserved

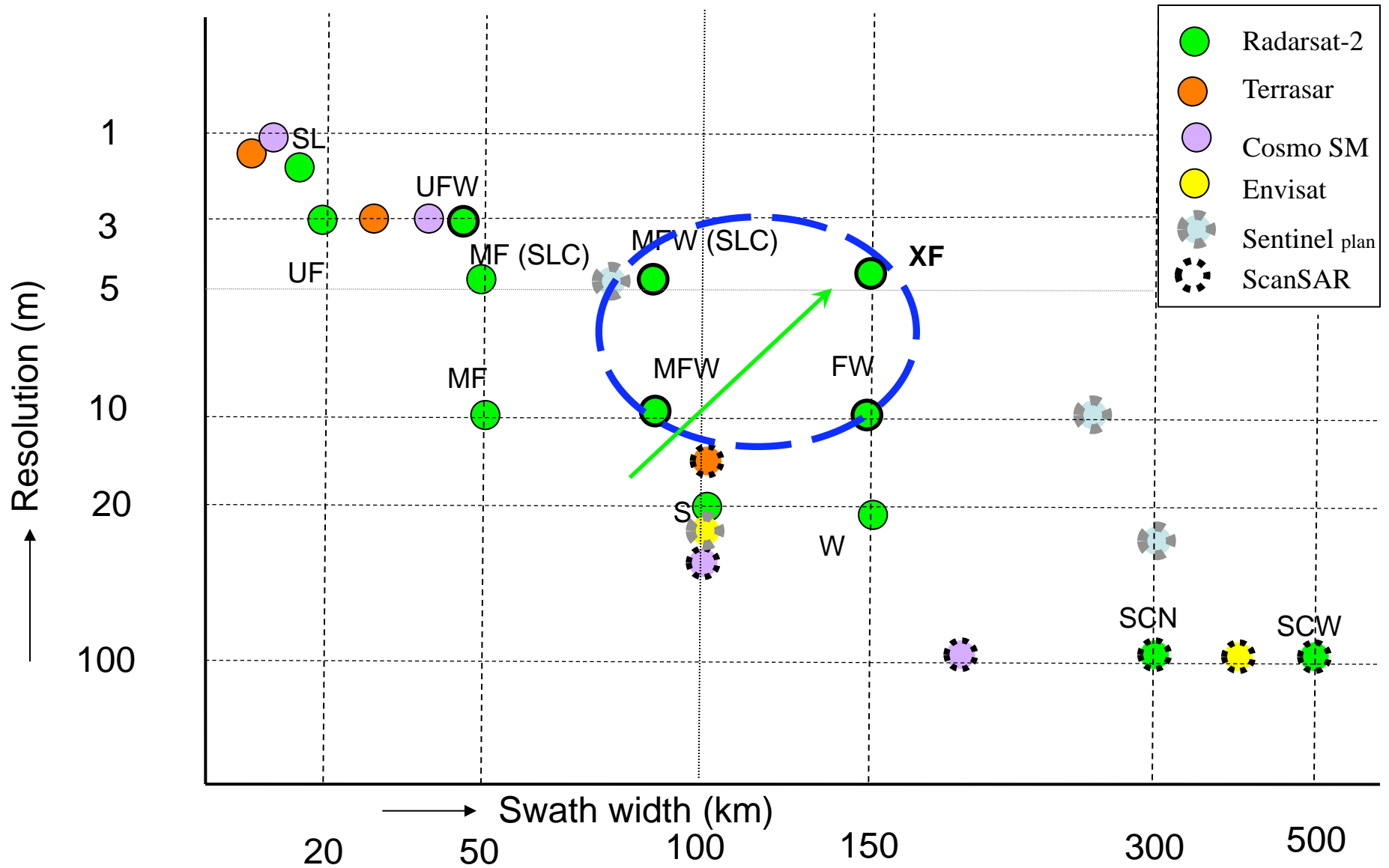
Content



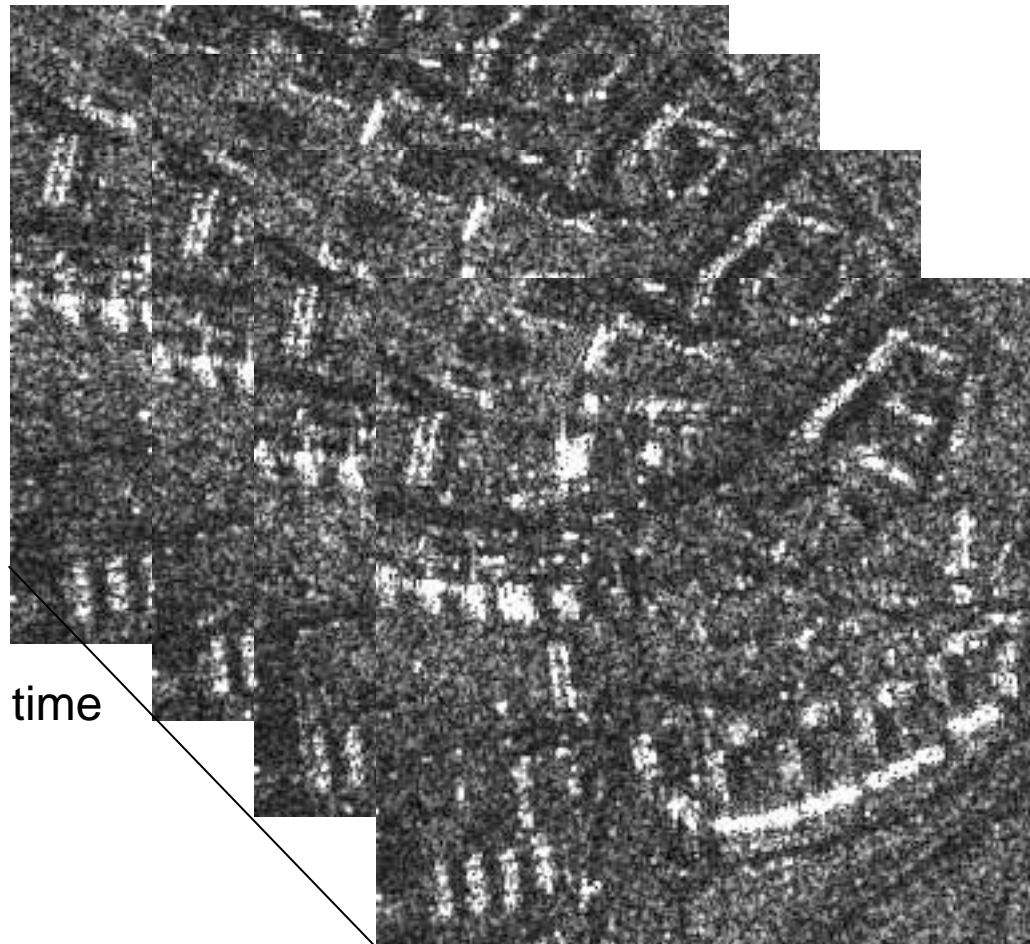
- **SAR and C-Band SAR for forest applications: limited benefit?**
- **Approach for extracting change and canopy texture information**
 - **Use of exactly repeated SAR acquisition geometries**
 - **Use of stack processing methods**
 - **Powerful change detection methods**
- **Examples Brazil**
- **RADARSAT-2 new wide swath (up to 180 km) high/medium resolution (3-10 m) image modes and capacity**
- **“The Change Detection Machine”: frequent high resolution monitoring of forests**



The importance of the combination of wide swath and high to medium resolution



Stacking... Exactly repeated SAR images

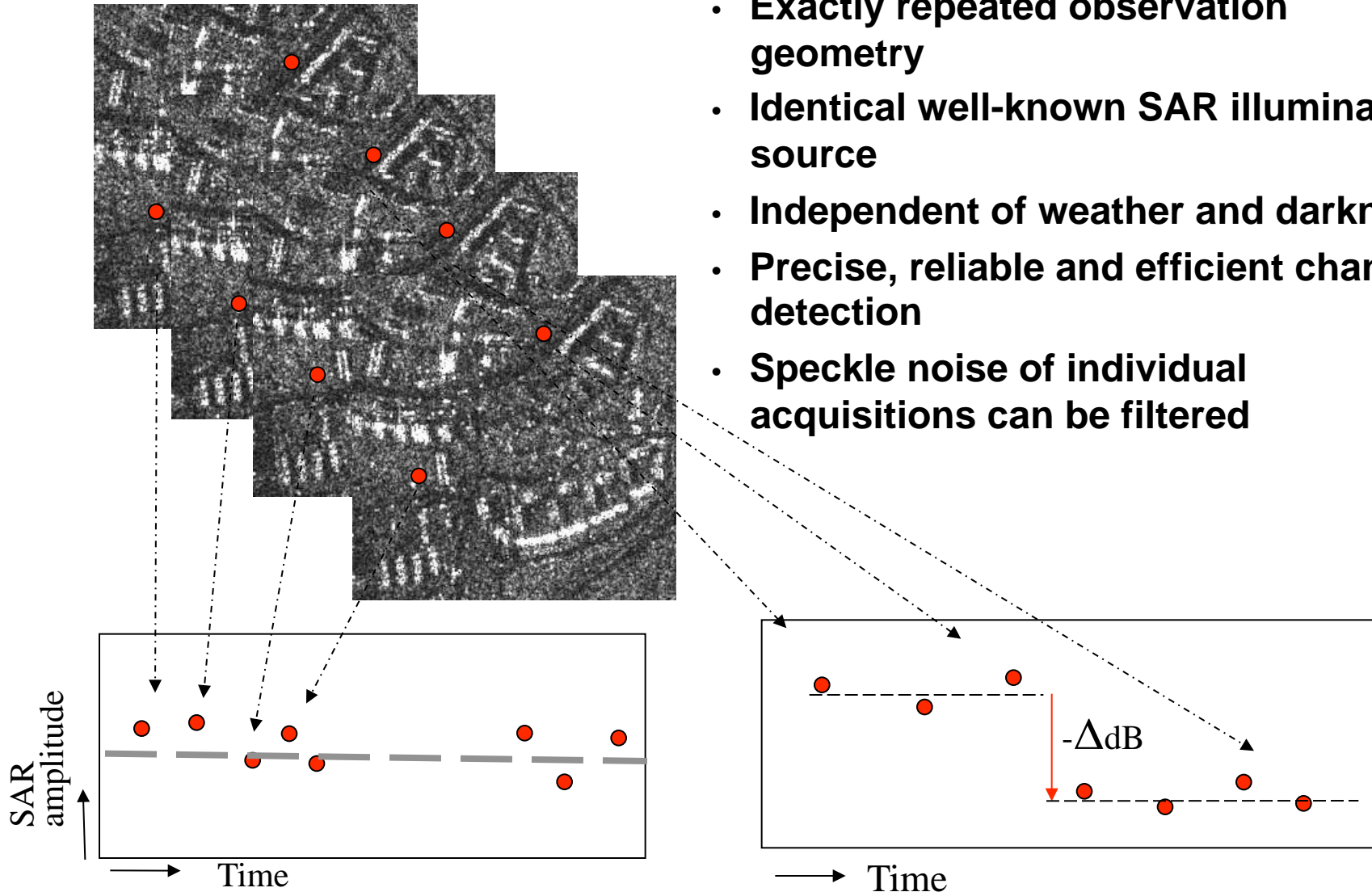


time

SAR Stacking... How and Why...



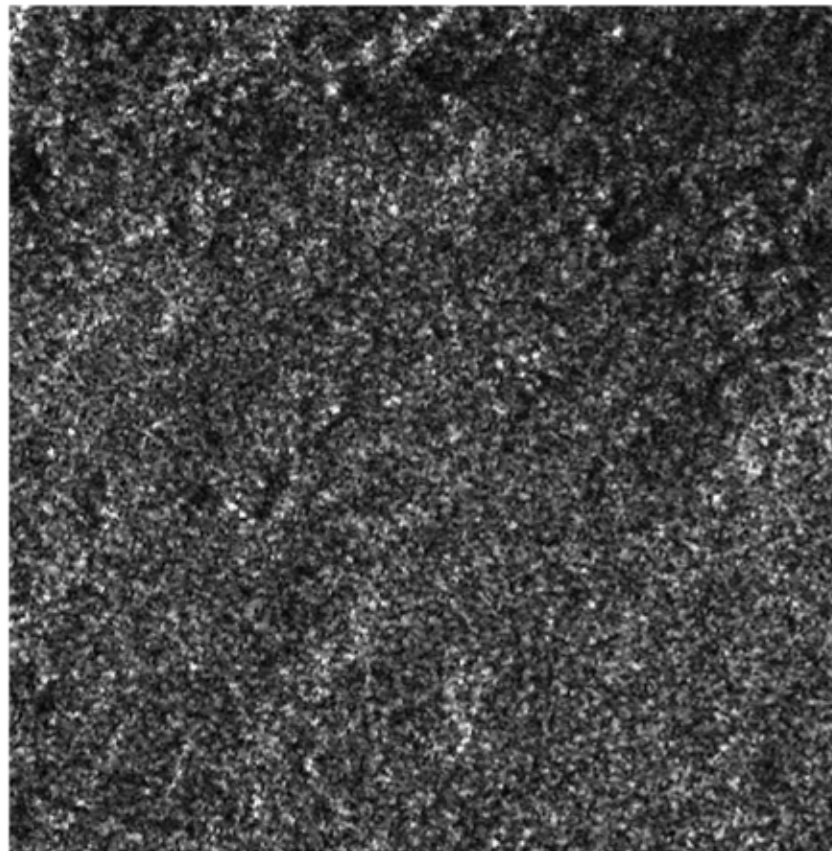
- Exactly repeated observation geometry
- Identical well-known SAR illumination source
- Independent of weather and darkness
- Precise, reliable and efficient change detection
- Speckle noise of individual acquisitions can be filtered



The challenge of using single SAR images

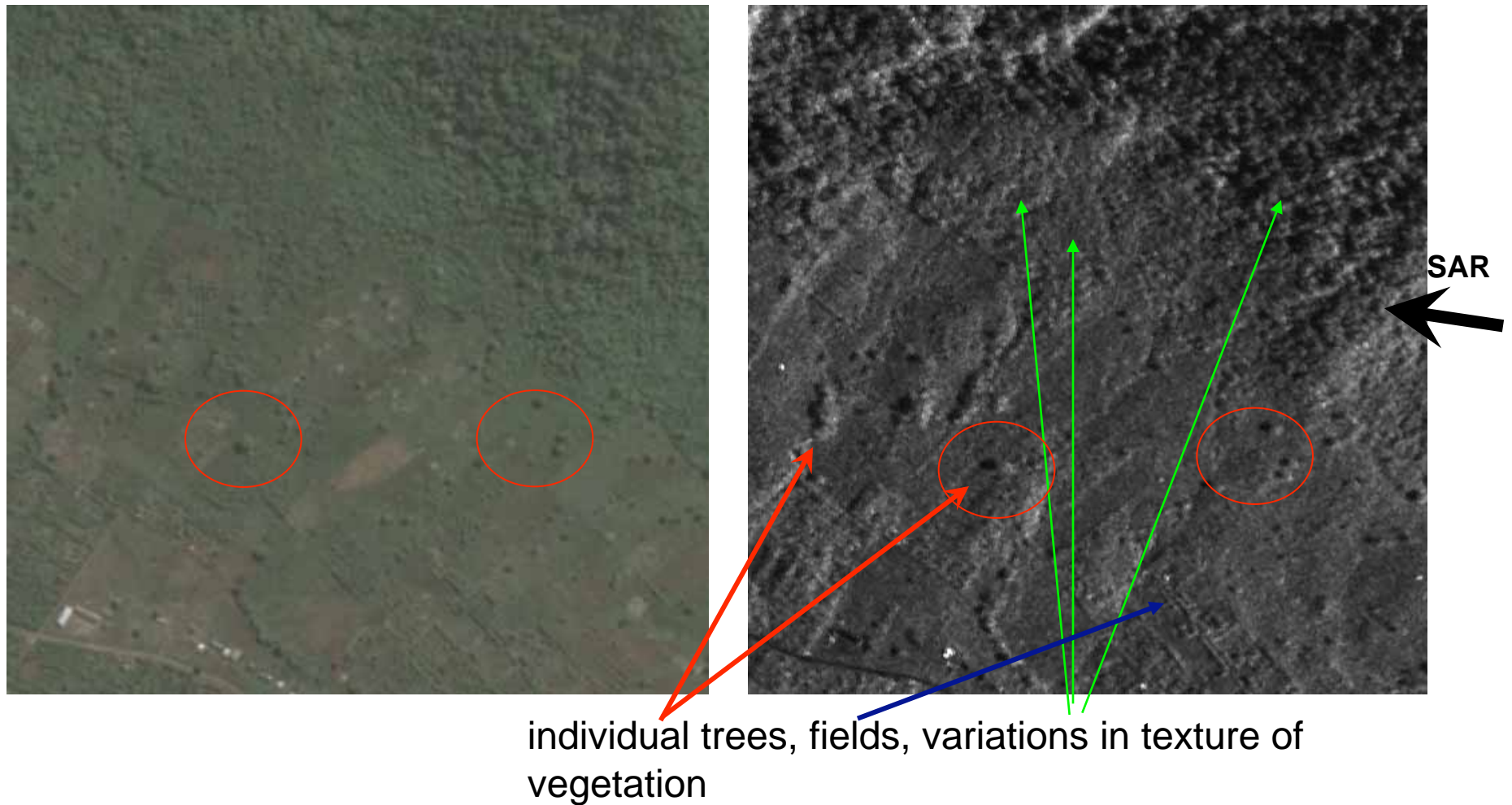


approx 1 x 1 km typical forested terrain (SAR image RADARSAT-2 MF, 5 m resolution)

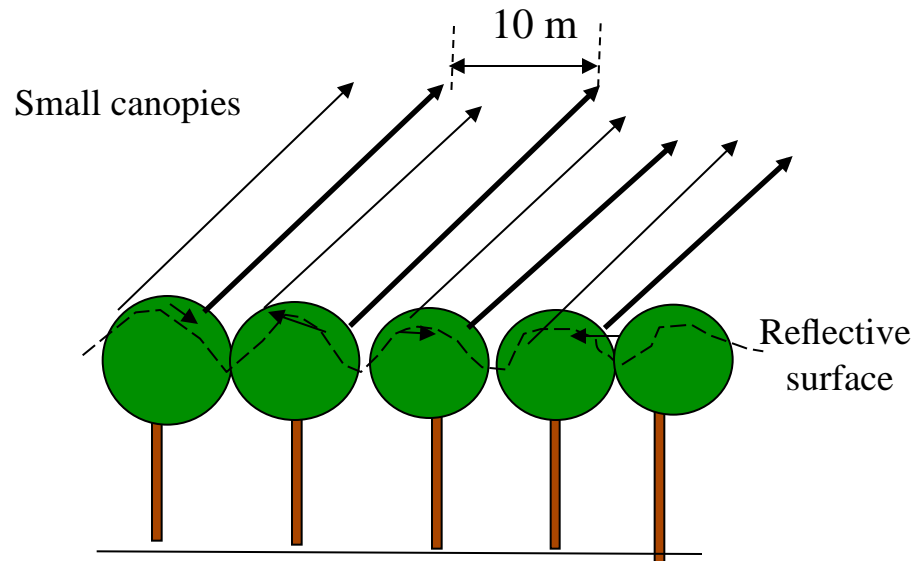


The benefit of stack-based archive imagery

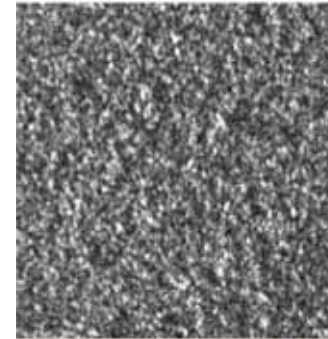
an example of use of ~20 archive scenes at 5 m resolution



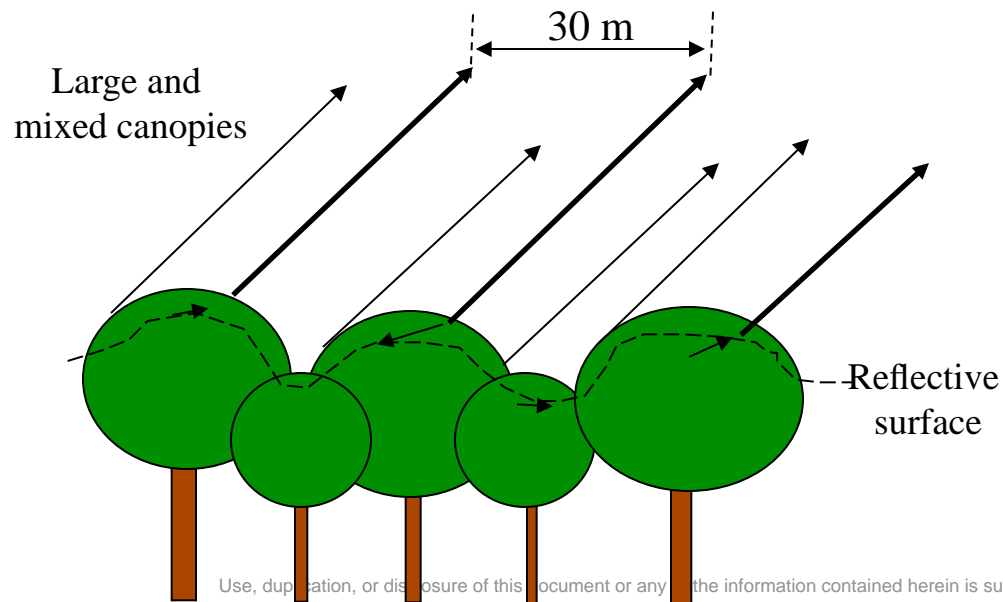
Canopy texture in stacked C-band SAR images



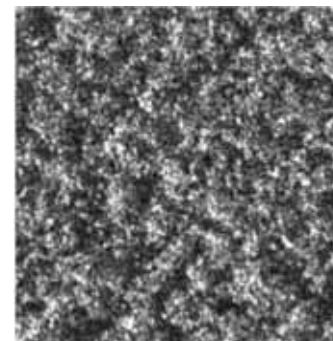
Approx. 300 x
300 m



Rough but short
spatial distances
(say 10 m)



Approx. 300 x
300 m

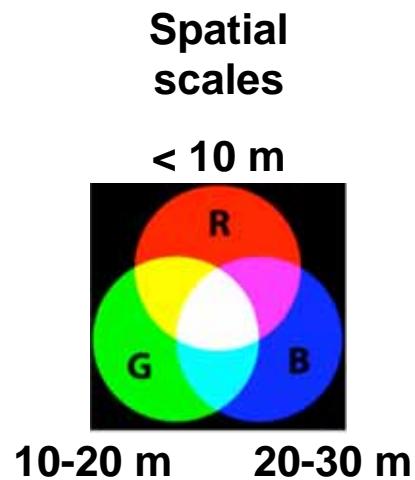


Rough and many
spatial structures
(say up to 30 m)

Measuring and visualizing canopy roughness at different spatial scales



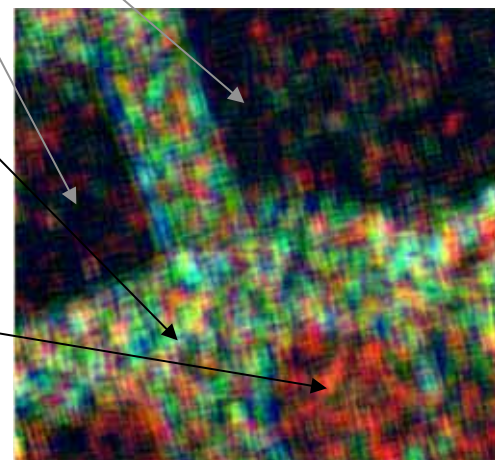
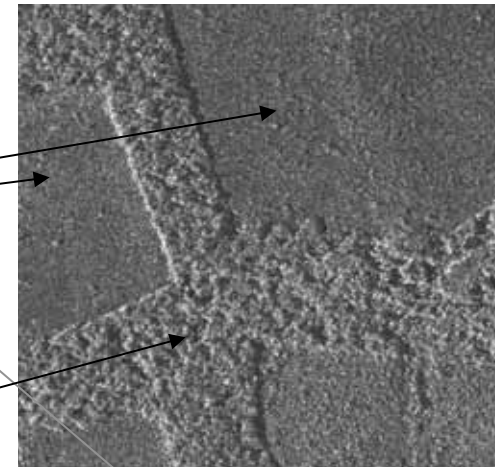
- Use spatial band-pass filter to obtain 3 channels (e.g. 0-10 m, 10-20, 20-30)
- Use colour addition approach



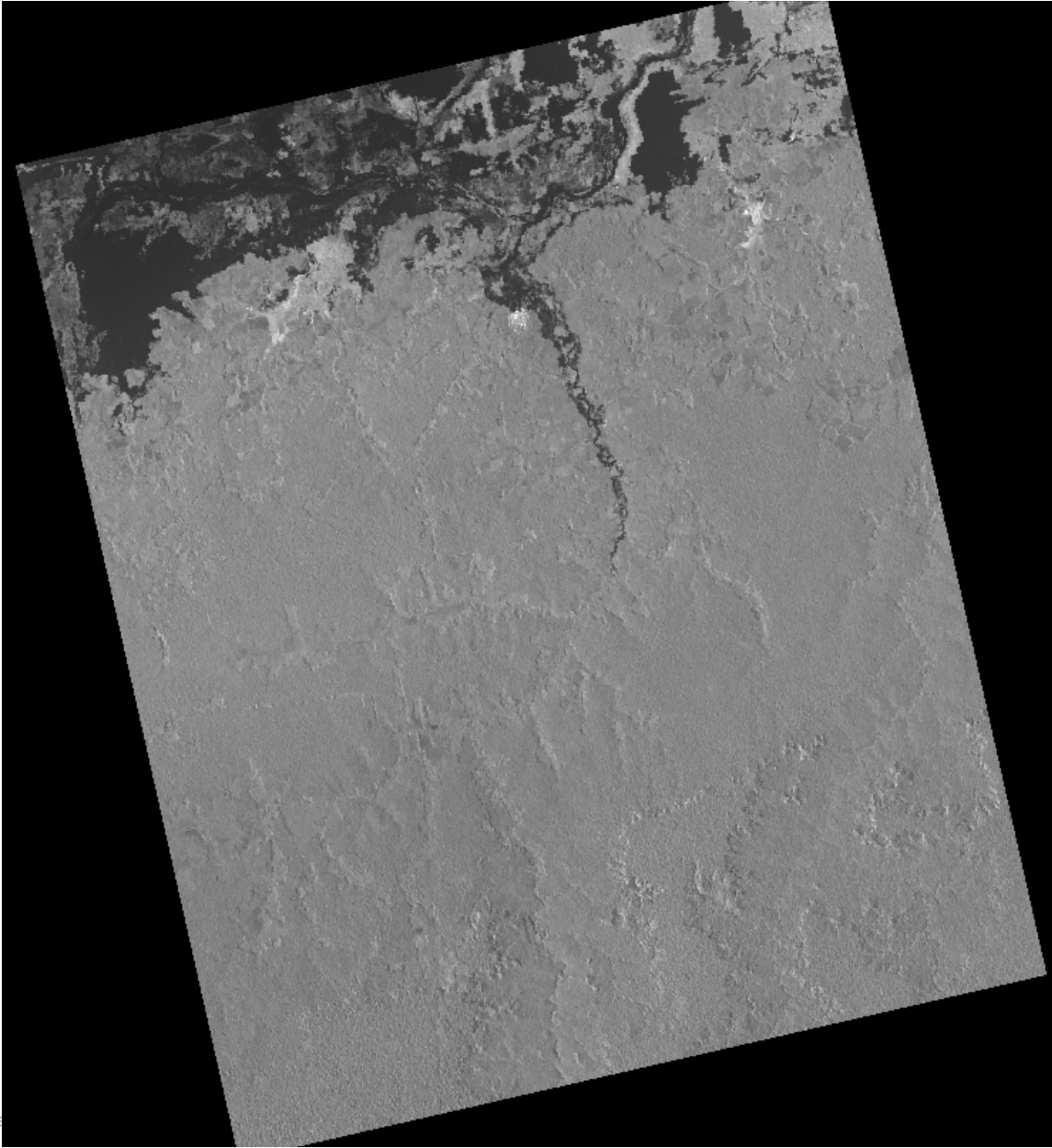
Smooth fields =
black

Mixed forest, rough
= white

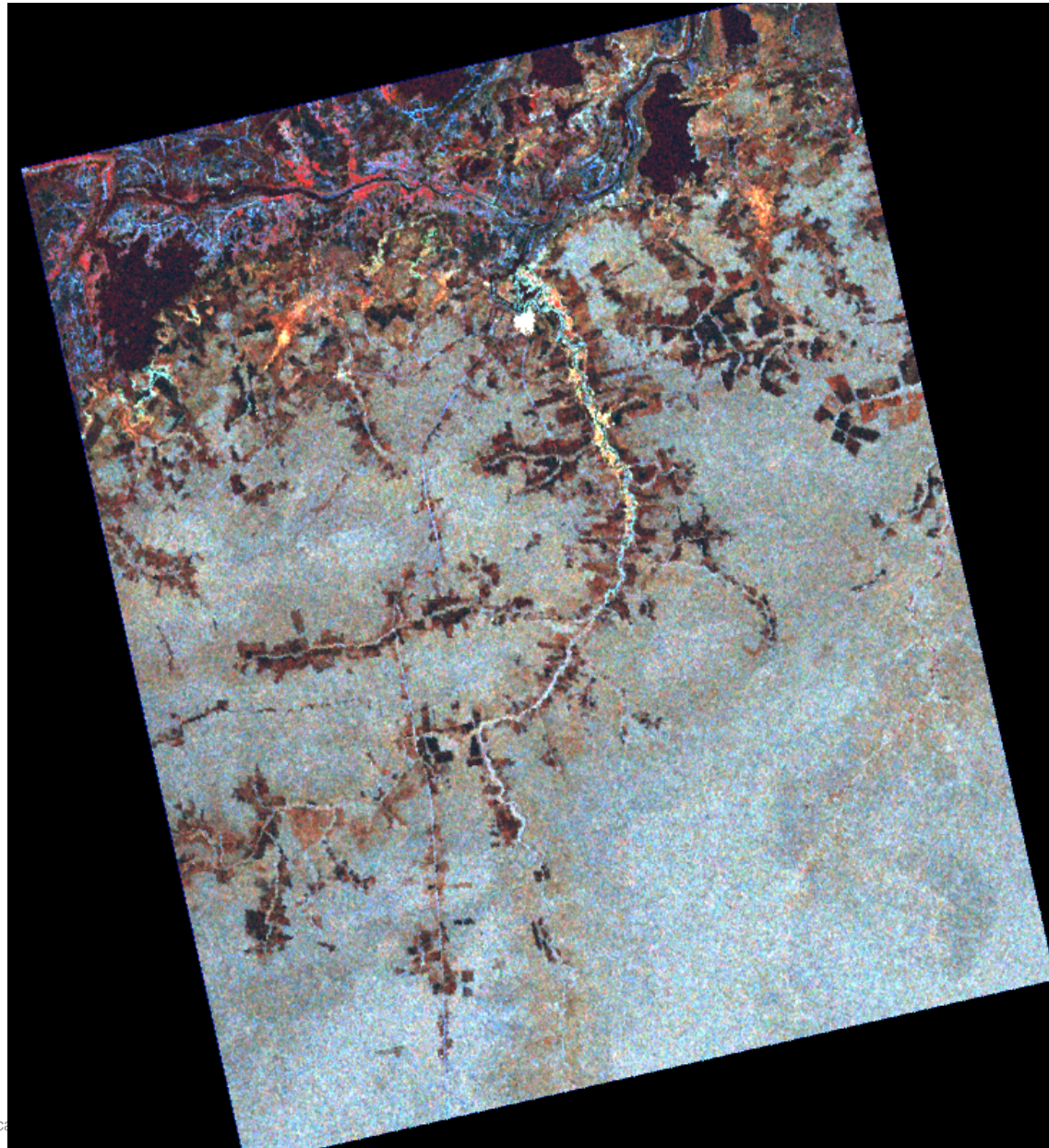
Small trees, rough =
red



UFW, HH, Feb 17, 2012 (45 km swath, 3 m resolution)

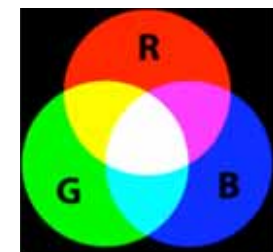


Texture (from 2 scenes of UFW)



**Spatial
scales**

< 10 m



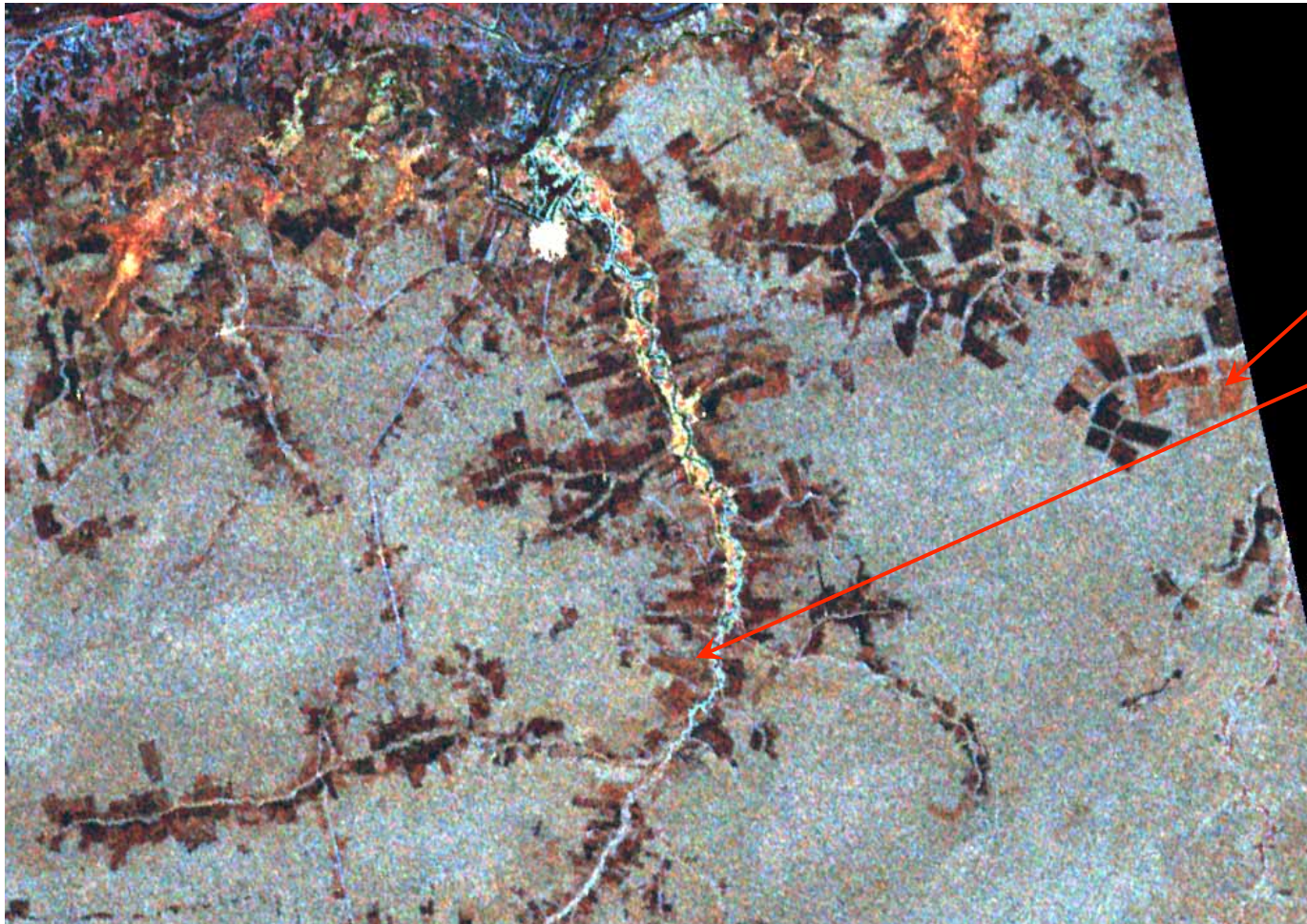
10-20 m

20-40 m

Spatial texture map from SAR



Quality depends on spatial and radiometric resolution

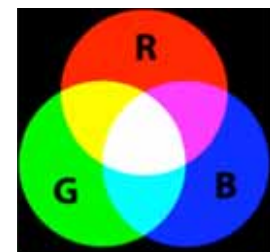


Temporal average of 2 scenes UFW
Source resolution 3m
Texture map res: 50 m

Areas of re-growth?

Spatial scales

< 10 m

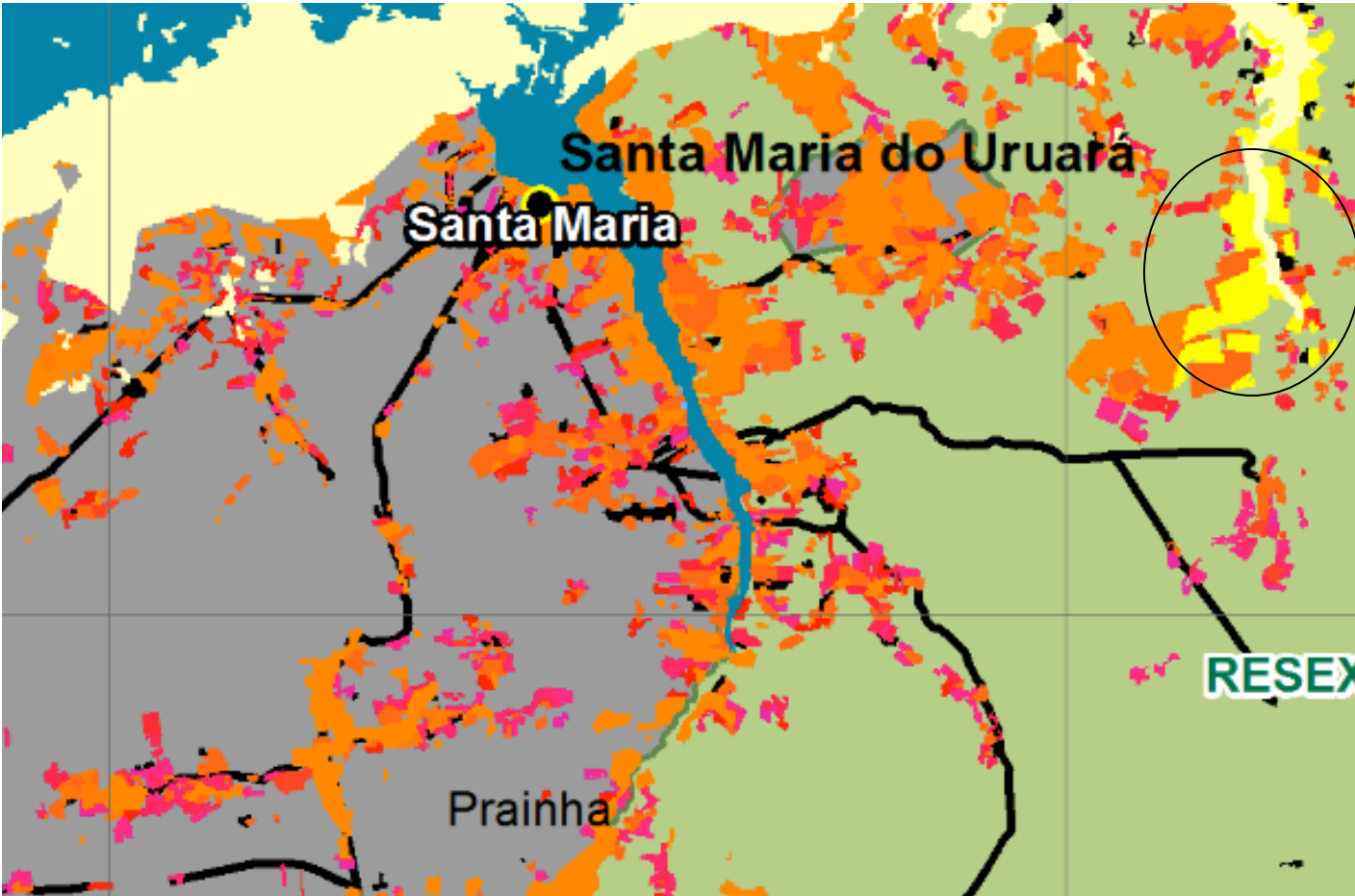


10-20 m

20-40 m

Deforestation vector database

timing of deforestation by year

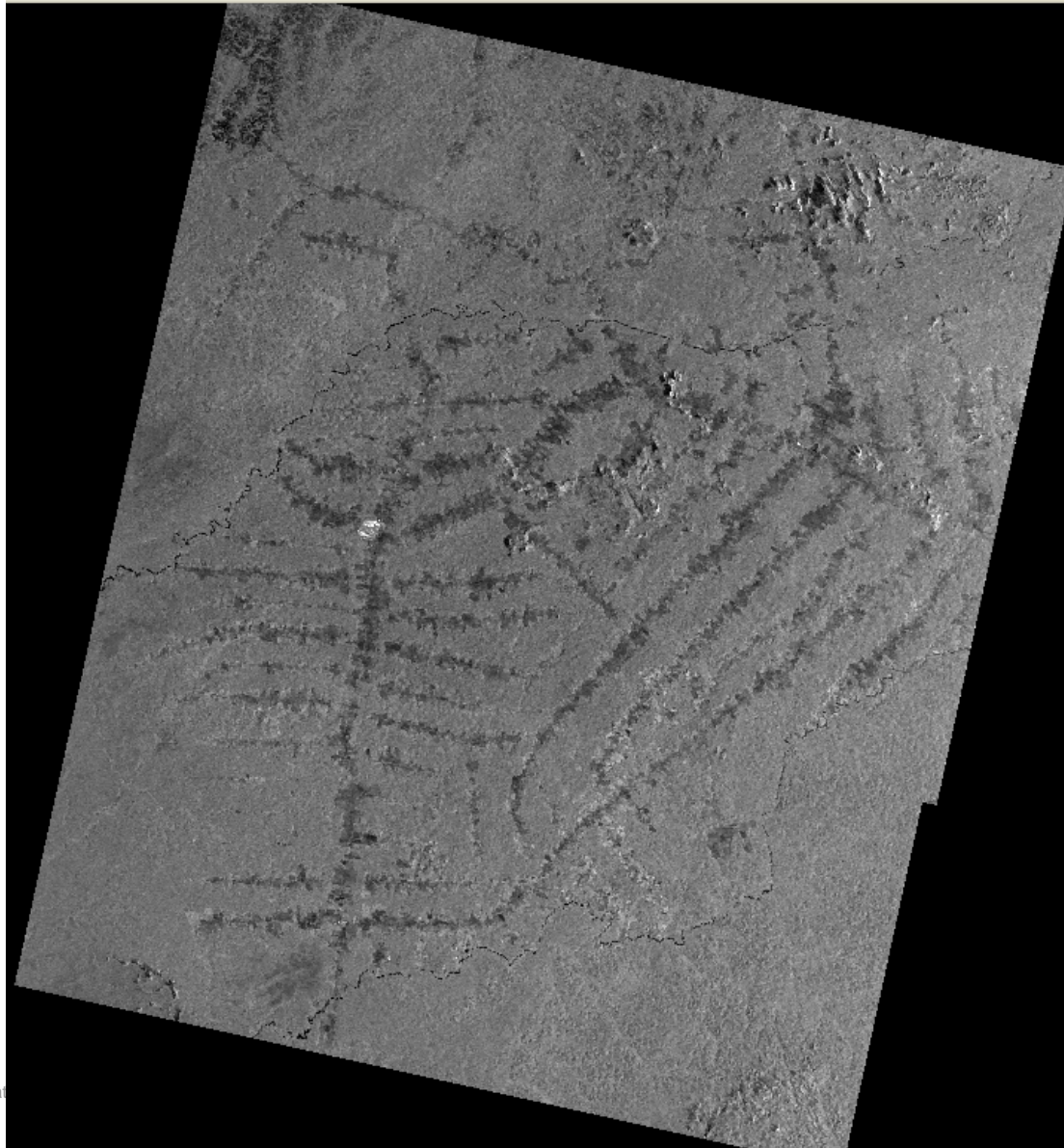


Older clearings

Rorainopolis (Northern Brazil)



Dec 27 2011, Jan 20 + Feb 13, 2012, MFW22, HH, res: 5 m, swath: 90 km

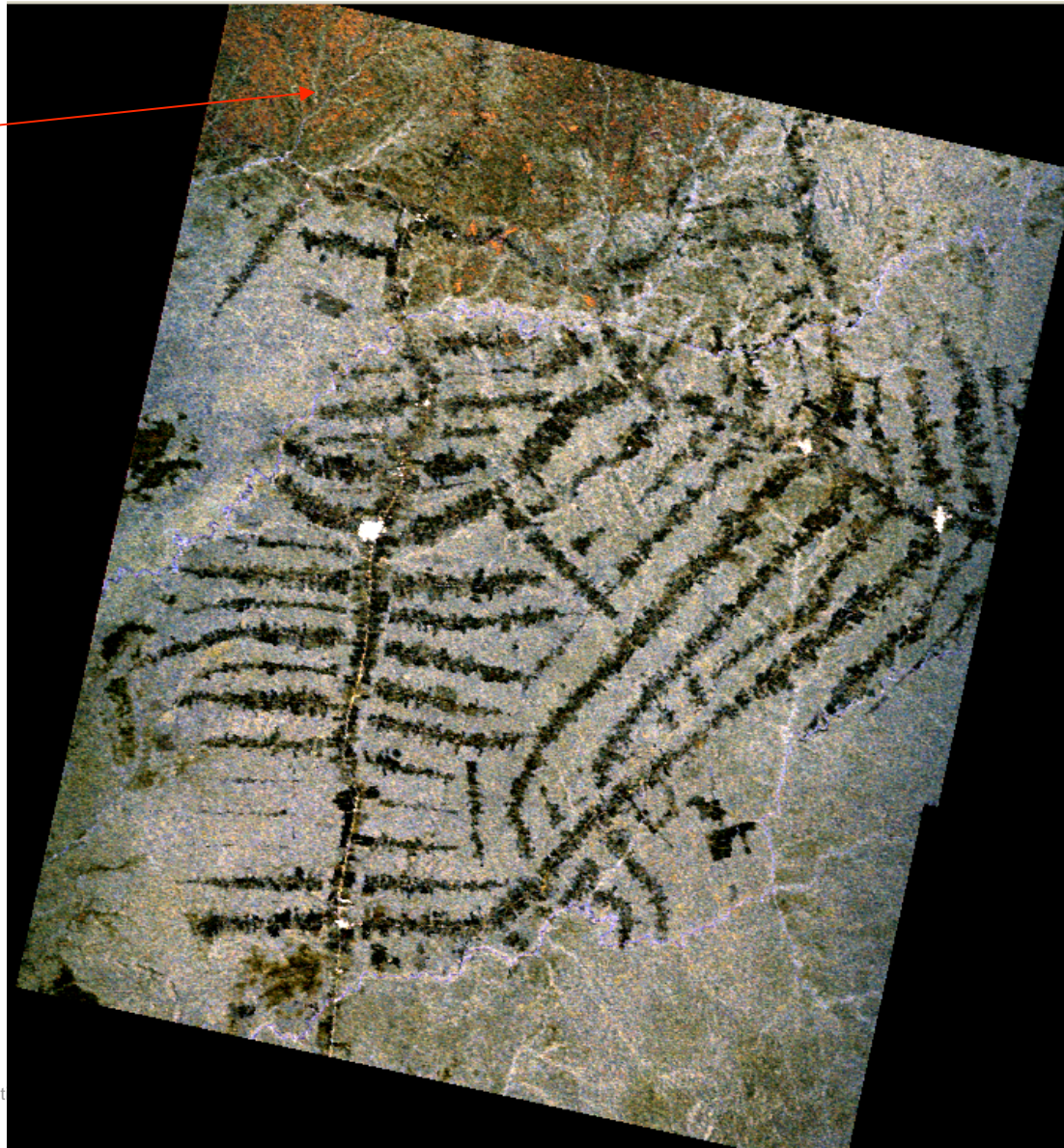


Use of Spatial texture



Mapping of clearings and natural terrain

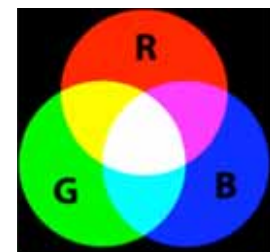
Savannas and wetlands



Temporal average of 3 scenes MFW (5 m resolution)

Spatial scales

< 9 m

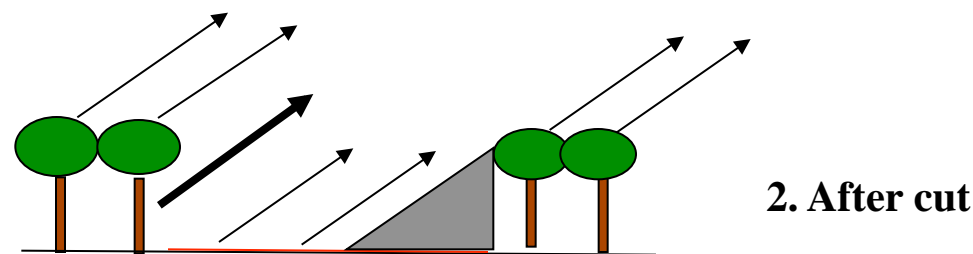
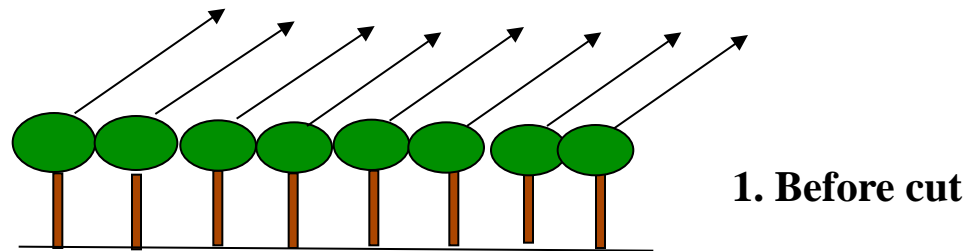


9-15 m

15-30 m

SAR Stack-based Forest Change Detection

- Repeat of identical or nearly identical geometry



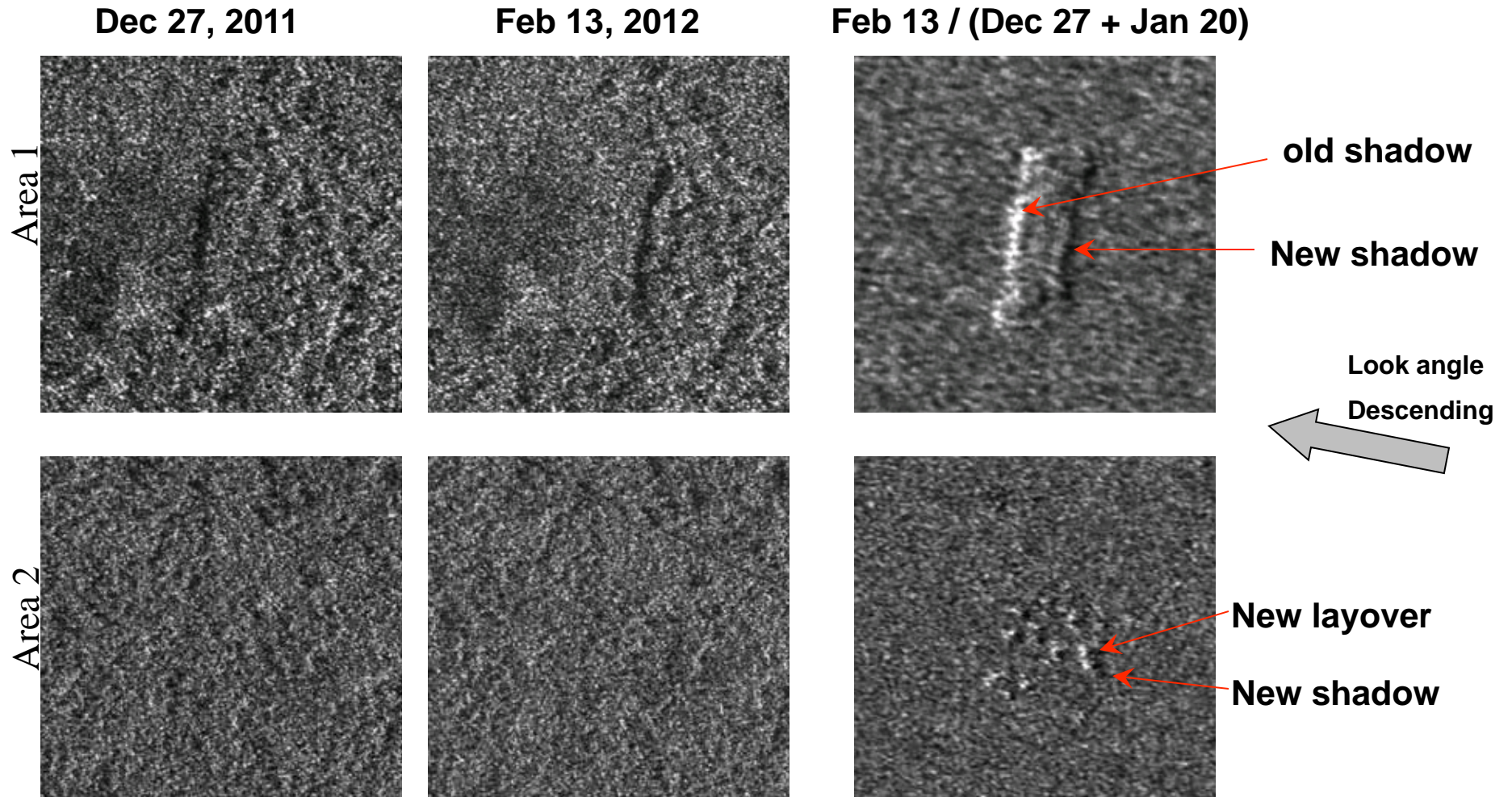
**Increase of
reflection**

**Shadow,
decrease of
reflection**

Examples of change detection MFW 5 m resolution



“punched holes” in the forest



Examples of change detection MFW 5 m resolution



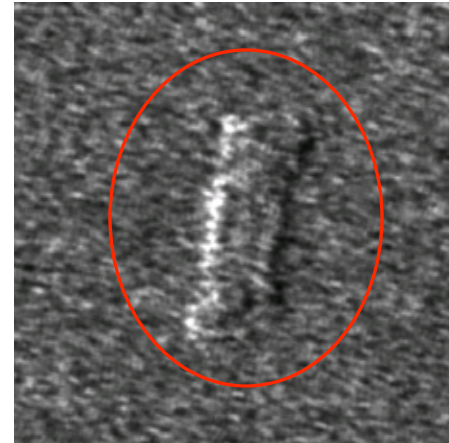
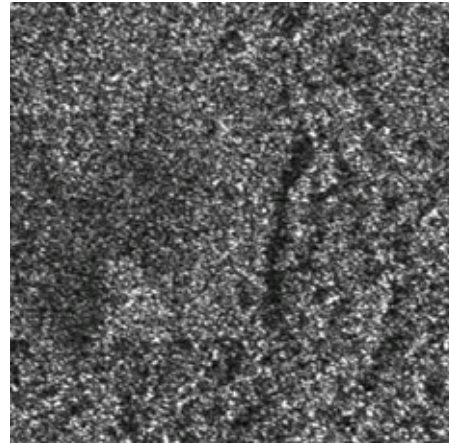
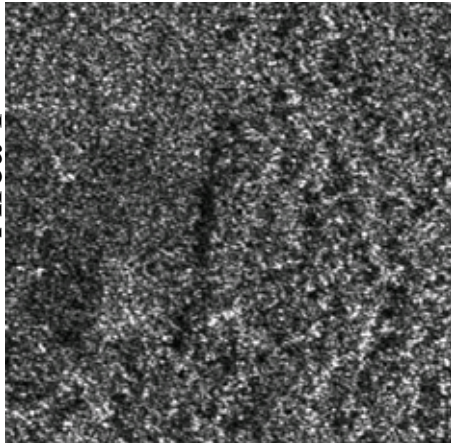
“punched holes” in the forest

Dec 27, 2011

Feb 13, 2012

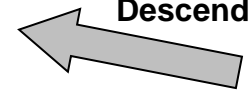
Feb 13 / (Dec 27 + Jan 20)

Area 1

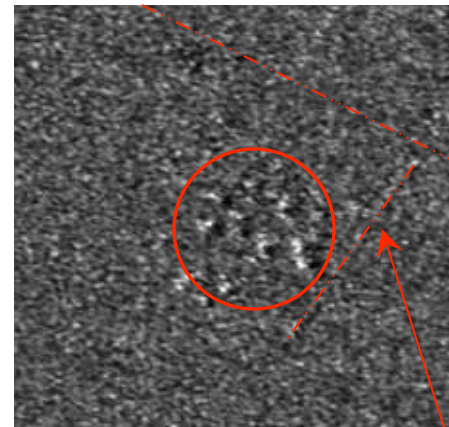
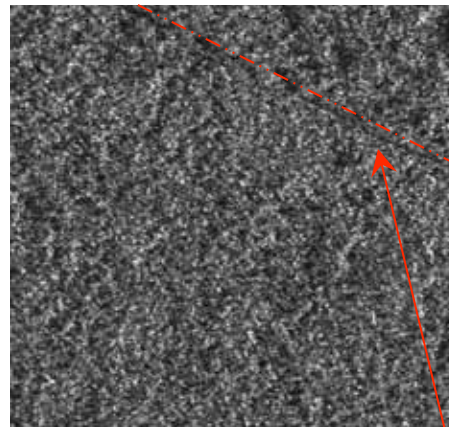
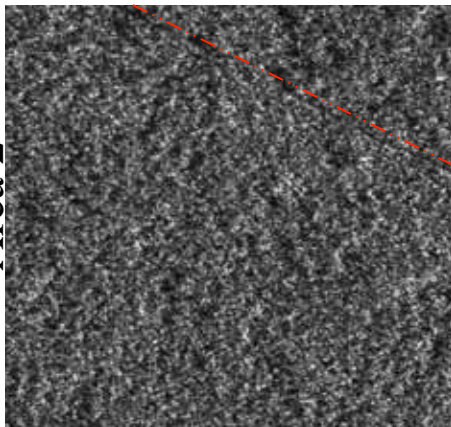


Clearcut
150 x 500 m

Look angle
Descending



Area 2



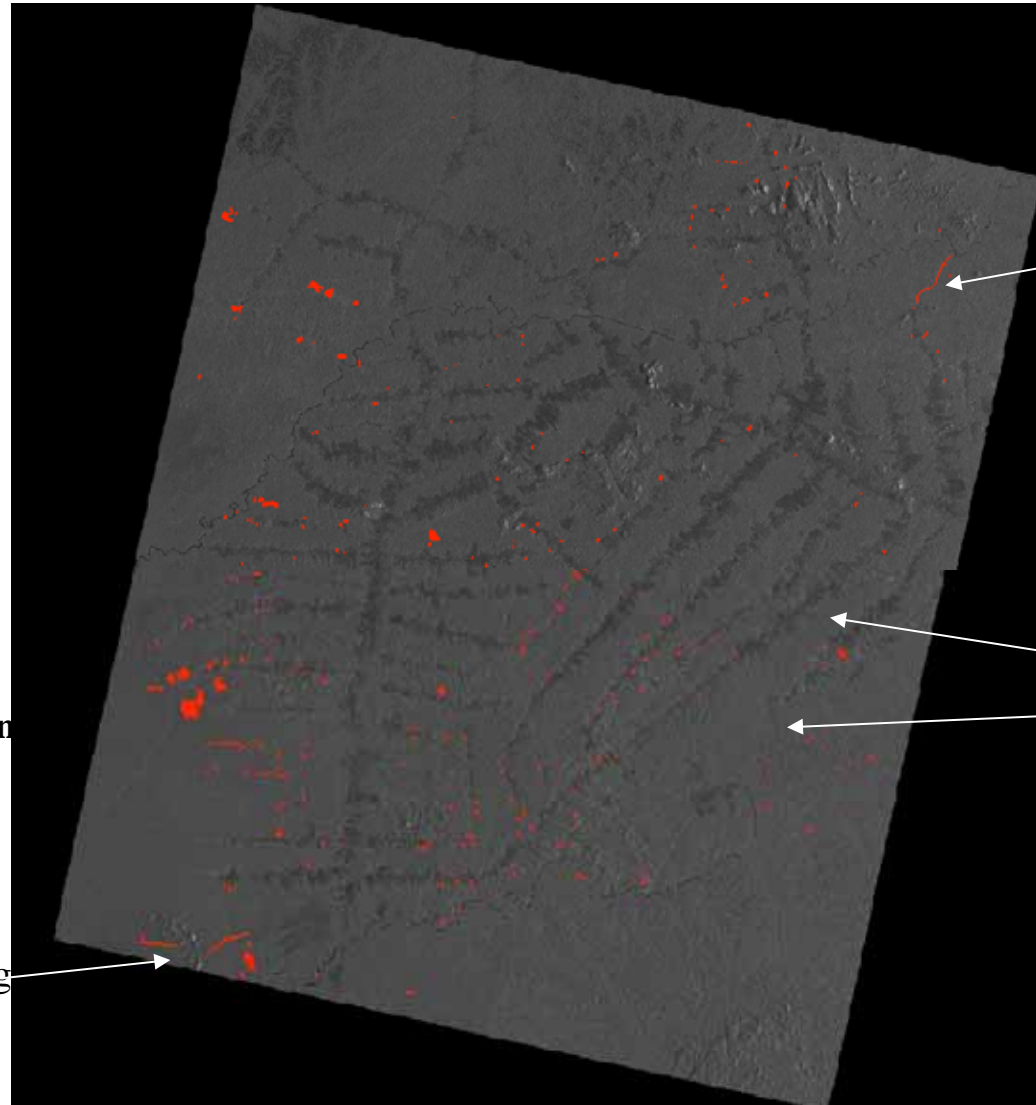
Selective logging
400 x 400 m

Existing road

**Connection to
Existing road?**

Overview of cuts

December 27, 2011 – February 13, 2012



Construction or widening of logging road

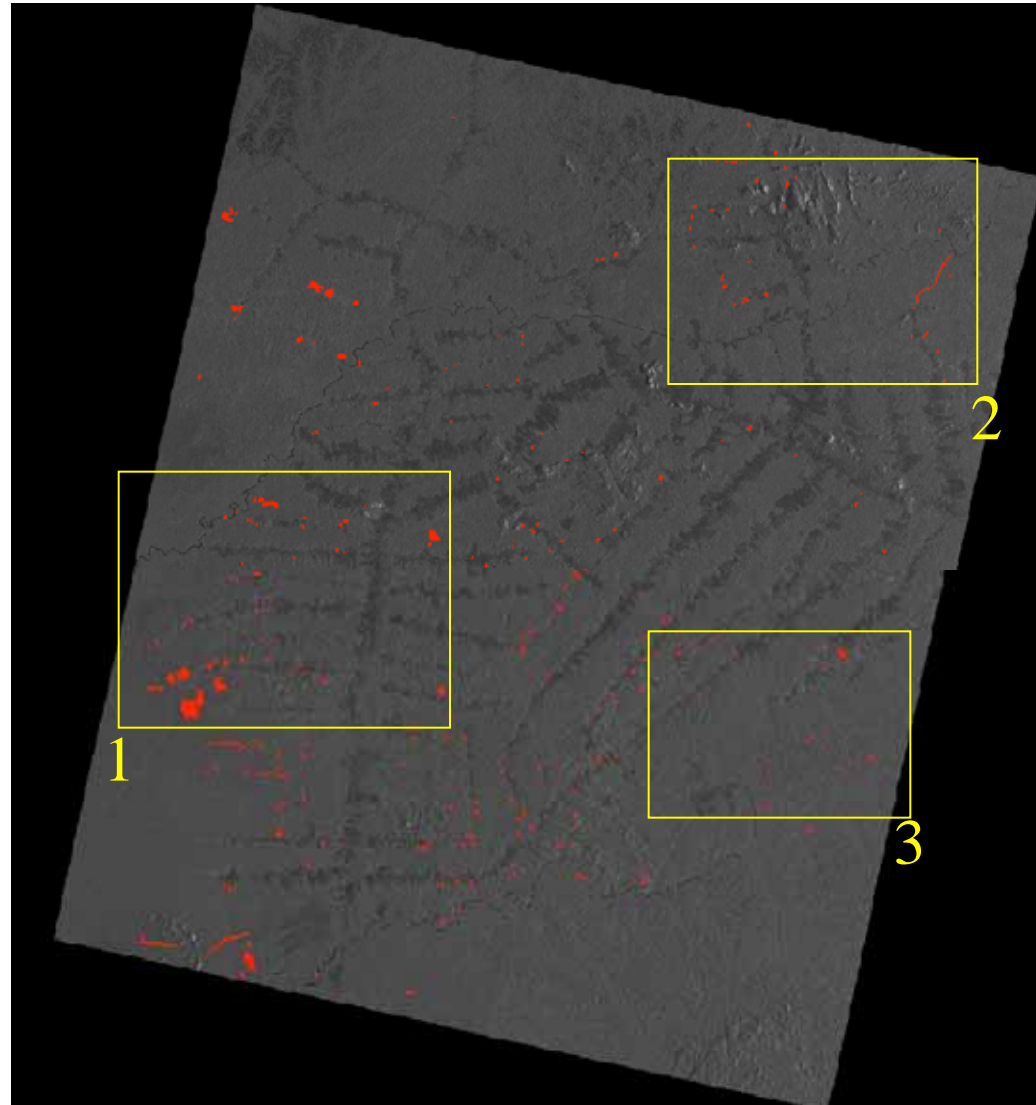
Very many small cuts that are close to or **below modis detection limit**

Large recent clearcuts **difficult to detect in rain season with modis**

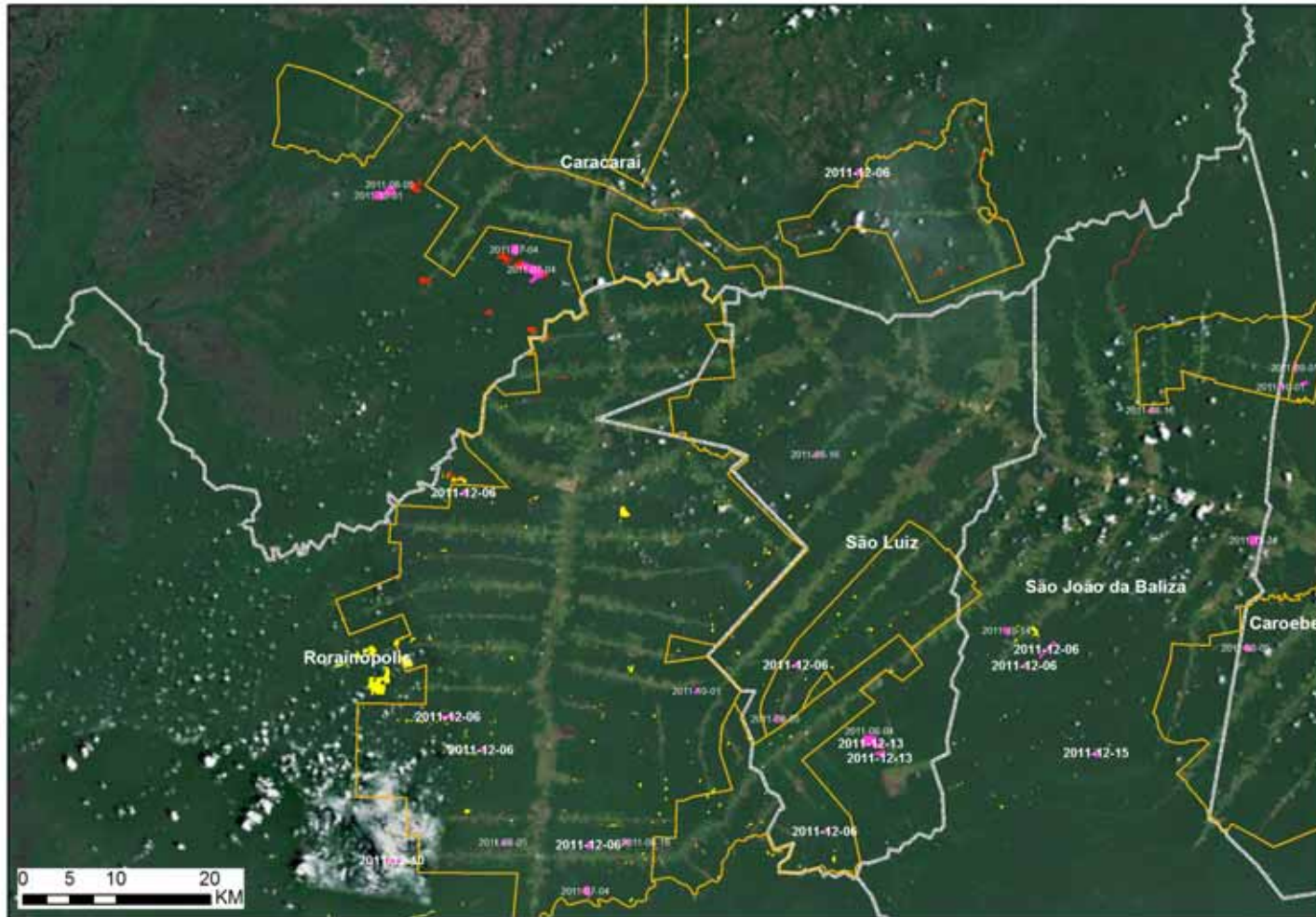
Construction or widening of logging road

Overview of cuts

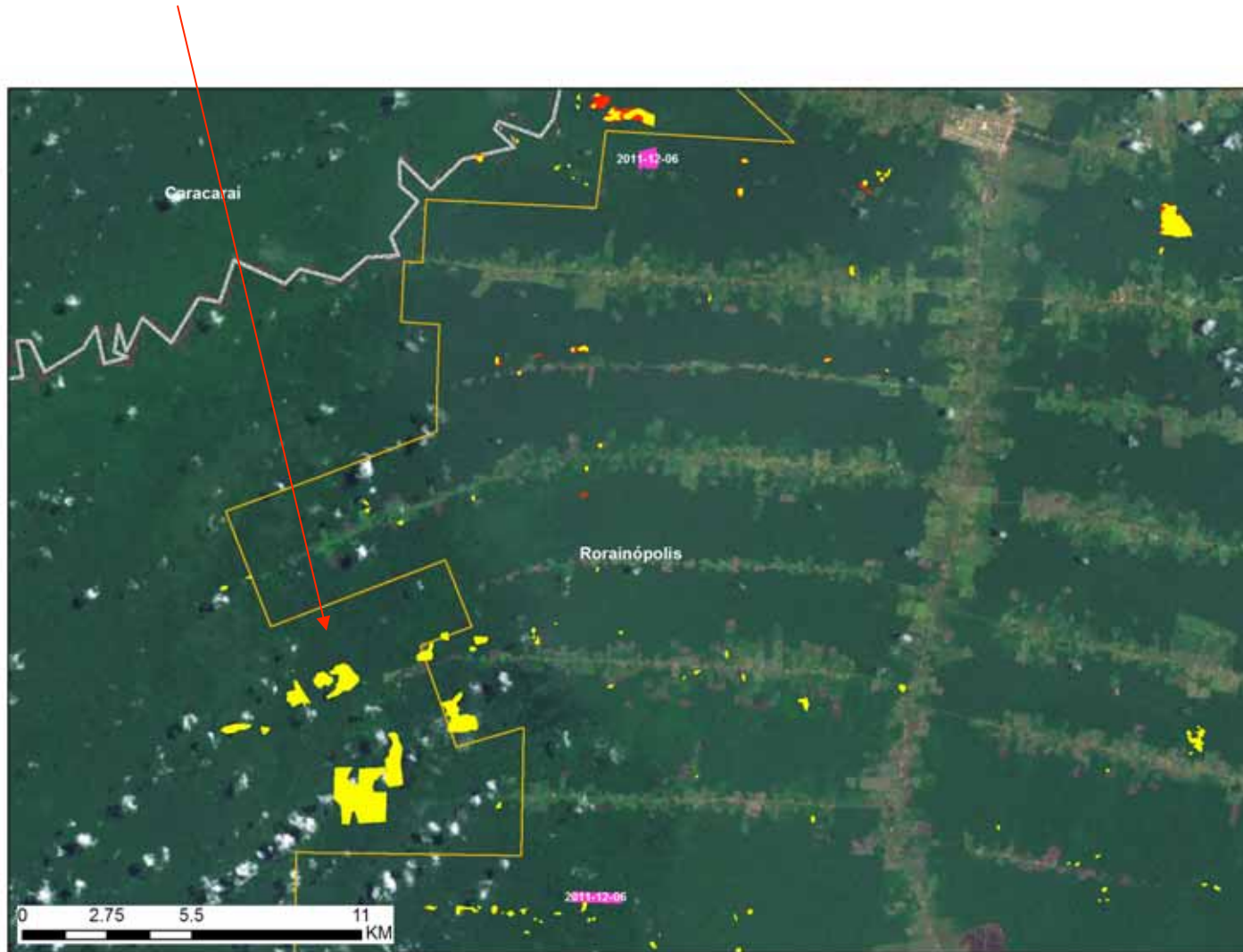
December 27, 2011 – February 13, 2012



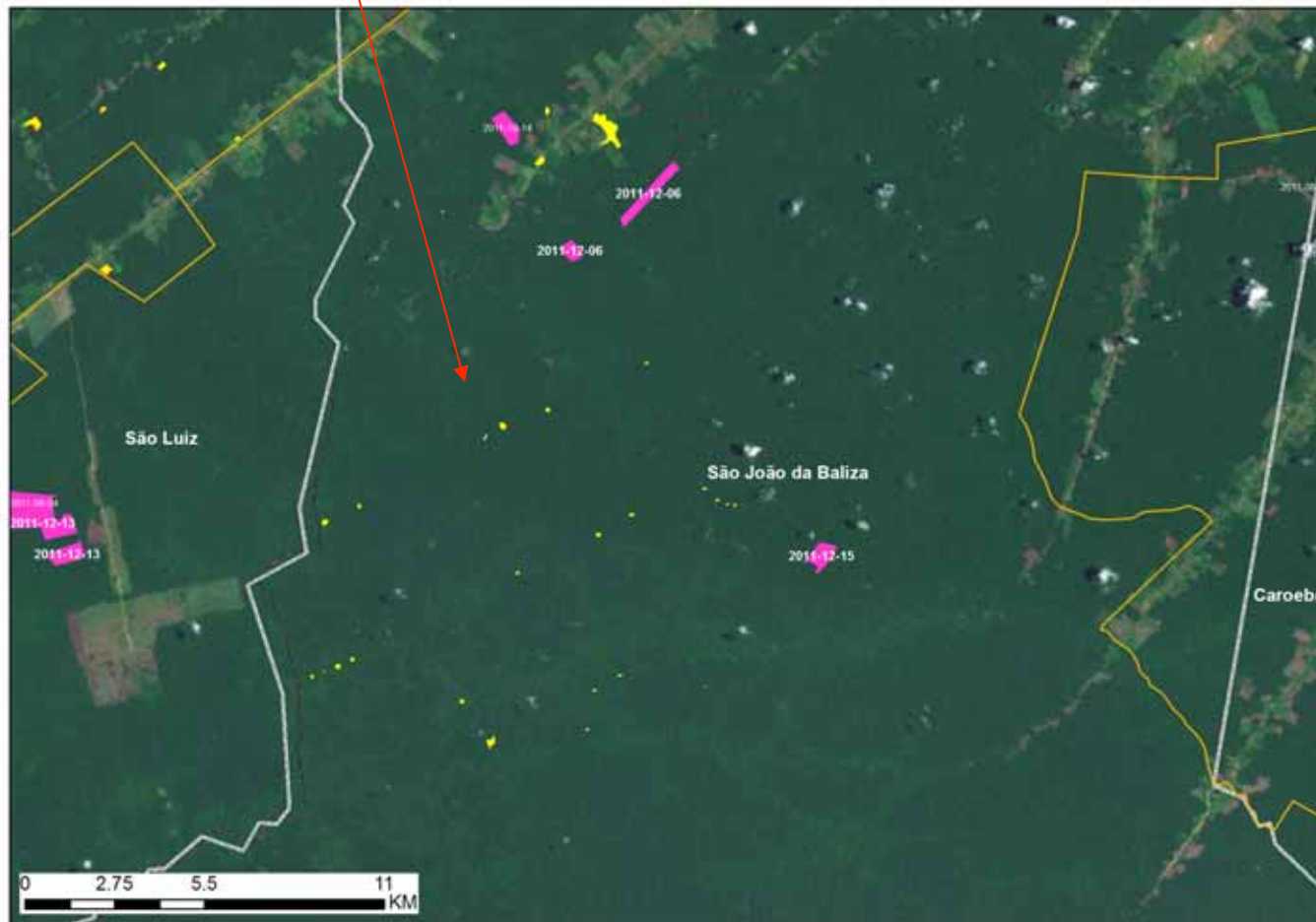
Combined visualization with vector data bases (rural and municipal boundaries, DETER alerts (pink, Modis))



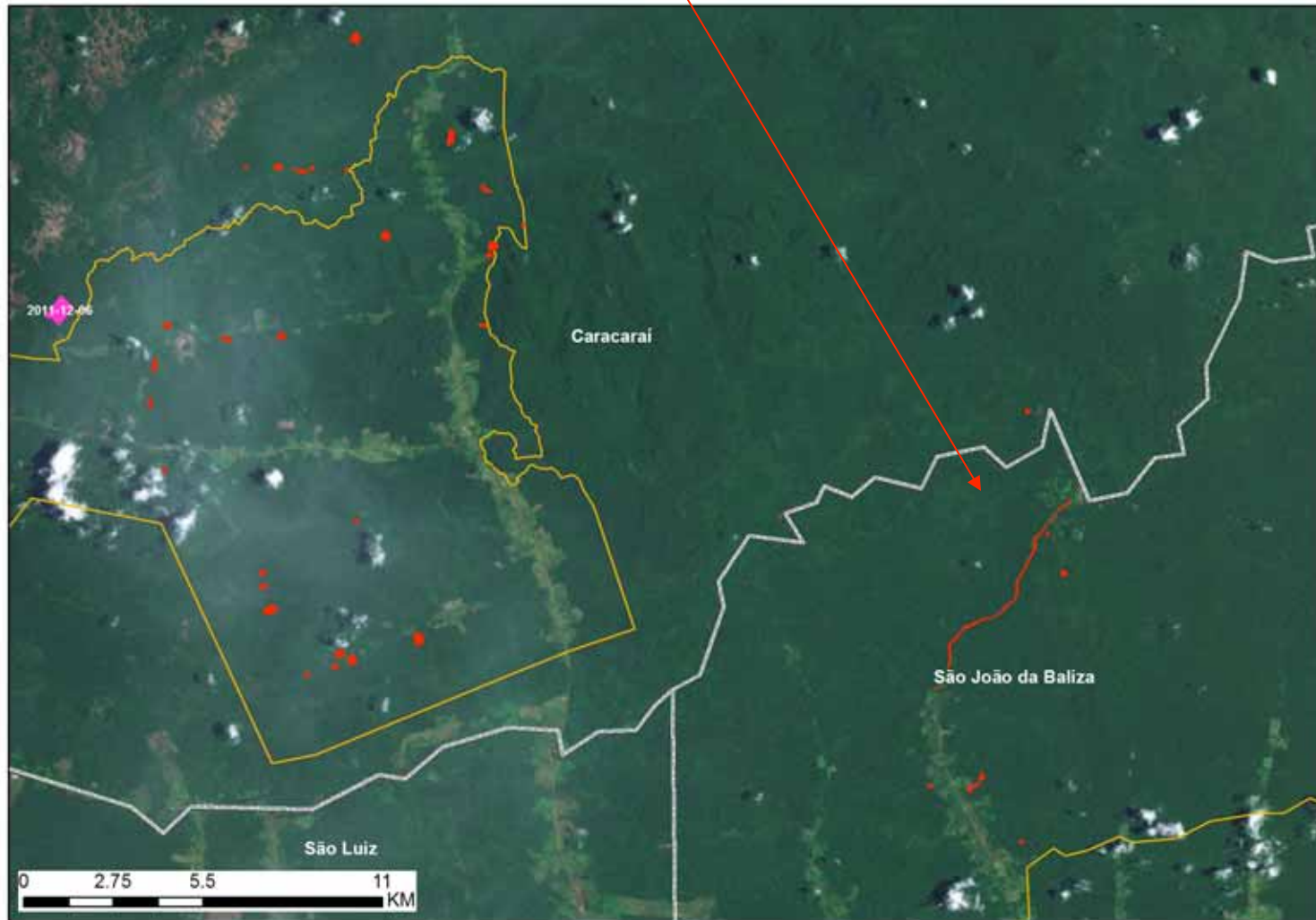
Sub-area 1, example of large recent cuts



Sub-area 2, example of detection of patterns of small-scale activity



Sub-area 3, example of new road (or widening of road) to nearby creek



RADARSAT-2, new wide image modes



Summary of New image modes introduced in 2011

	Resolution	New Swath Width
Wide Ultra-Fine	3 m	38-54 km (from 20 km)
Wide Multi-Look Fine	5 or 10 m (1 or 4 looks)	90 km (from 50)
Wide Fine	10 m	120-180 km (from 50 km)
Wide Fine Quad-Pol	10 m	50 km (from 25 km)
Wide Standard Quad-Pol	20 m	50 km (from 25 km)

New XF (Extra Fine) image mode: 24 day repeat complete coverage (ascending + descending) of very large areas: to be released in June 2012

	Resolution	New Swath Width
XF-1, 2, 3, 4 Inc. angles 20°- 50°	5 m (1 look)	110-180 km

Great acquisition capacity for RADAR monitoring



An example at 5 m resolution

Performance measure = km² / day

Satellite	Resolution	Swath width	Estimated Maximum Commercial Capacity	Performance measure (km ² / orbit)	Performance measure (km ² / day)
RADARSAT-2 XF (SLC)	5.0 m	150 km	24.5 minutes/orbit	1,540,000 km ²	22,100,000 km ²

RADARSAT-2 has excellent coverage performance and is suitable for large area repeat monitoring

Conclusions



- **C-band SAR is excellent and suitable for forest monitoring by using stack-based acquisition, processing and detection methods**
- **RADARSAT-2 high resolution (5 m) wide swath (150 km) modes are an EO breakthrough**
- **Wall-to-wall texture maps of the forest canopy might be obtained e.g. on a yearly basis for purpose of land use, forest regeneration mapping at resolutions of 25-50 m.**
- **Precise forest change detection can be obtained frequently and reliably (e.g. 1/month) for forest cut alerts.**
 - **Resolutions (MMU 0.1 to 1.0 Ha) are 1 to 2 orders of magnitude better than current systems**
 - **Wall-to-wall change detection and data mining**
- **R-2 capacity sufficient for wall-to-wall monitoring at 5 m. Local downlink capacity required**