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付録 1: 基礎研修マテリアル

付録 2: 上級研修マテリアル

付録 3: WebGIS 研修マテリアル

付録 4: 第 5 回 JCC 議事録

付録 5: ソフトウェアマニュアル

付録 6: ALOS データ処理用ツール[Windows7/XP 用プログラム最新版(DVD 版のみ付属)]

Hand Book on PALSAR Image Interpretation

October 2010

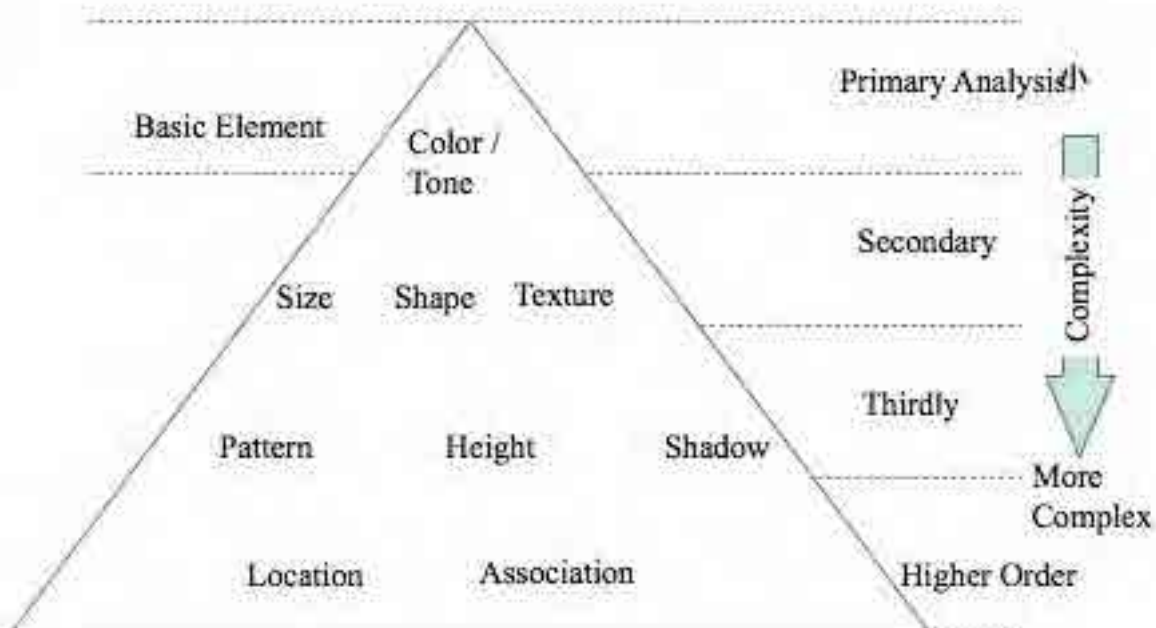
M. Ono, Remote Sensing technology Center of Japan

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PALSAR Image Interpretation Manual

Remote Sensing Technology Center of Japan

Distribution of Image Interpretation Key



Tone / Color

- Tone, in the gray scale image, and Color and Chroma (hue and saturation) in the color image, provide image interpreter with the most amount of information if it is within his comprehension.
- Almost all interpretation case, target appears in the image has different tone or color from its the back ground or other objects. If it is not the case, you can not recognize the target
- In a aerial photo image interpretation, tone shows reflected energy level. But in the recent sensor systems, tone shows not only a reflected energy but also radiation, conduction and scattered energy level.

Shape and Size

- Most of the ground based object can be primarily interpreted by its size and shape. In the stereo image 3D image provide more easy recognition even if the size information is not provided.
- Vegetable garden and rice paddy often polygon or rectangle but former is sometimes inclined in a 3D image and easy to distinguish. There are many signals to discriminate each others. In PALSAR system stereo pair is not available, so inclination information comes from dem used for orthographic conversion of the image.
- In a afforested area, average size of tree crown shows diameter of trees and age of it.

Shadow and Shade

- Building height evaluation or tree kind discrimination can be done by shadow and shade. In a high resolution SAR image, foreshortening value will provide building height.
- Main role of shade is to provide texture and pattern information.
- Texture represents detailed surface information which can not be recognized as individual surface detail.
- Texture, which is the information on a object whether it has rough surface or smooth surface, is an important element to conduct image interpretation.

Texture

- Texture in image is created by tonal repetition in groups of objects that are often too small to be discriminated as individual objects. Texture shows the impression of surface like smooth or rough and is very important in differentiating various various classes of environmental phenomena in SAR image.
- For novice interpreter, texture recognition is sometimes difficult.
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Pattern

- If it is compared with a cloth, texture is an expression of manner of weaving, while pattern is a image drawn on the cloth.
- Interpretation of shape is conducted in smaller scale but pattern is interpreted in more larger scale.
- For example, a rice paddy is usually square or rectangular and a group of rice paddy make a grid or strip pattern.
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meaning of roughness
- Feature, flatness definition, incident angle response
- Meaning of Polarization
- Tools for analysis
- More detailed knowledge on PALSAR can be obtained from a presentation material prepared by Dr. Humberto of IBAMA.

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Tools and approach for General image interpretation about forest

- Tool: PALSAR Viewer
- Tool: Google Earth
- Tool: General remote sensing analysis tools
- Approach: Recommended approach to establish image interpretation key is to use PALSAR_Viewer to cut polygon and put on to Google Earth to compare target with optical image.
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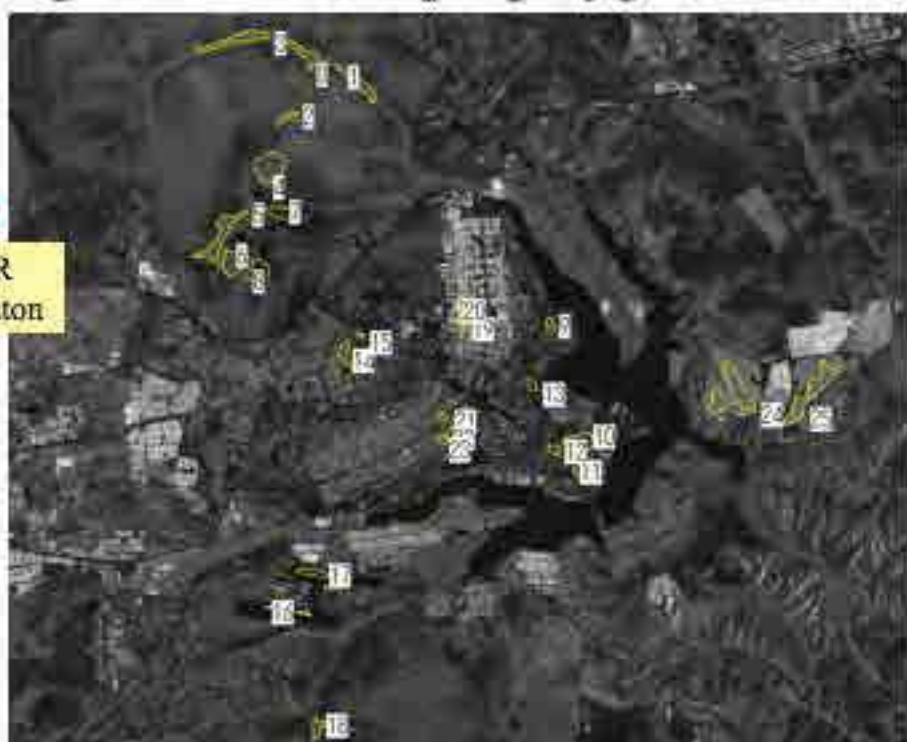
Single Image analysis

- Surface flatness effect appears in L band forest area.
- This means forest area shows higher brightness than non forest flat area.
- It is also indicated that forest area response is relatively flat.
- Next pages show a result by PALSAR image and Google comparison for forest area in Brasilia.

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Target site and sample polygon allocation

 PALSAR Illumination



SceneID="ALPSRP163666860", FBS HH pol. Lev.1.5, Acq. date 2009.8.07

Polygon 0



optical

 Radar



Palsar

Location		
Lat	15:41:47'S	
Long	-47:57:58'W	
Shape	Indeterministic	
Size	narrow side width, 150m	
ROI	-8.085	
std dev	2.551	
Texture	Fine	
Description	Depict forest with small trees. Fore edge of the forest to face radar illumination shows a little bit higher brightness (a) while back side shows a shadow (b).	

Polygon 1



optical



Radar

Palsar

Location			
Lat	15:42:08"S		
Long	47:56:37"W		
Shape	Indeterministic		
Size	narrow side width 150m		
[M]	-8.422		
std dev	2.604		
Texture	Fine		
Description	Depict forest with small trees. Fore edge of the forest to face radar illumination shows a little bit higher bright ness (a) while back side shows a shadow (b).		

Polygon 2



Radar

Location			
Lat	15:43:9"S		
Long	47:57:54"W		
Shape	Geometric shaped are		
Size	horizontal width of polygon is 810m		
[M]	-7.621		
std dev	2.746		
Texture	Fine		
Description	Forest is well recognized by its brightness, texture and fore edge and back edge of the forest.		

Polygon 3



optical

Location			
Lat	15:41'55"S		
Long	47:59'23"W		
Shape	Indeterministic		
Size	narrow side width 150m		
[RF]	-8.069		
std dev	2.686		
Texture	Fine		
Description	Depict forest with small trees. Edge is not clear but forest boundary is easily recognized.		

Radar



Palsar

Polygon 4



optical

Location			
Lat	15:44'12"S		
Long	47:58'1"W		
Shape	Indeterministic		
Size	radius of round is almost 500m		
[RF]	-8.066		
std dev	2.602		
Texture	Smooth		
Description	Roundly marked grass or unvegetated area.		

Radar



Palsar

This is non forest area

Polygon 5



→
Radar



Palsar



optical

Location		
Lat	15:45:46"S	
Long	47:58:40"W	
Shape	Indeterministic	
Size	narrowest width of polygon is 180m	
RFI	-8.482	
std dev	2.721	
Texture	Fine	
Description	Fore boundary and aft boundary is easy to recognize.	

Polygon 6



→
Radar



Palsar



Optical

Location		
Lat	15:46:12"S	
Long	47:58:18"W	
Shape	Geometric shaped area	
Size	horizontal width of polygon is 750m	
RFI	-8.651	
std dev	2.514	
Texture	Fine	
Description	Low discrete trees, bare soil and grass area is shown in very low contrast.	

This is non forest rough area

Polygon 7



Optical



Radar

Palsar

Location			
Lat	15:45:11"S		
Long	47:57:37"W		
Shape	Geometric shaped area		
Size	Horizontal width of polygon is 810m		
(N)	-15.947		
std dev	2.58		
Texture	Smooth		
Description	Low discrete trees, bare soil and grass area is shown in very low contrast.		

This is non forest area

Polygon 8



Optical



Radar

Palsar

Location			
Lat	15:46:16"S		
Long	47:57:43"W		
Shape	Geometric shaped area		
Size	horizontal width of polygon is 750m		
(N)	-14.897		
std dev	3.293		
Texture	Fine		
Description	Flat area is shown as dark pixels. Individual trees are recognized as bright dot.		

This is non forest area

Discrimination forest and non forest from single HH pol image (FBS)

- FBS image is not so easy to discriminate forest and non forest area, because reflectance value and surface texture is not unique for forest area when you compared the data with non forest area.
- Large scale discrimination of forest from non forest may possible.

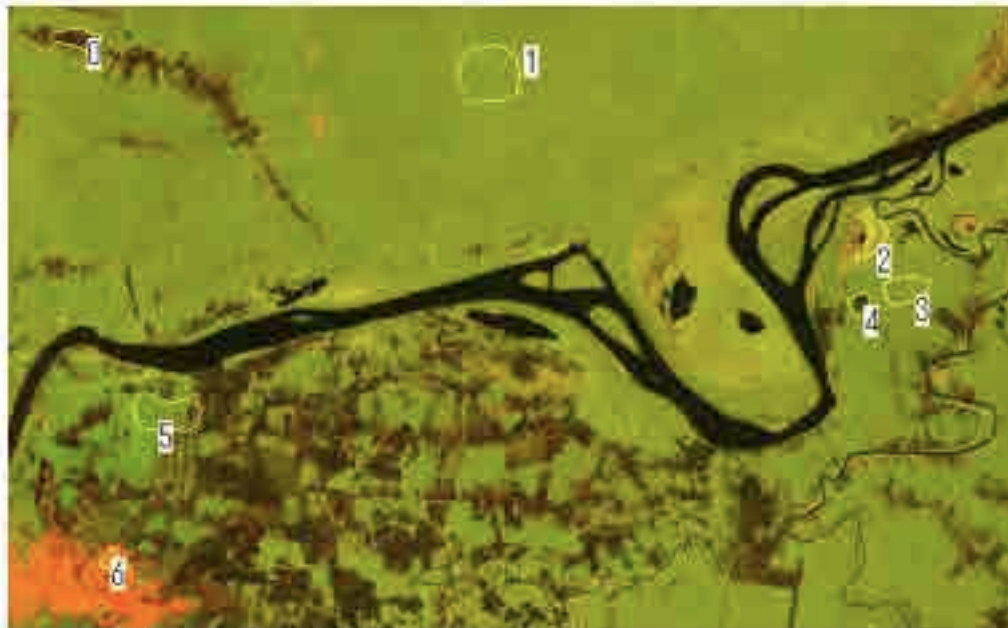
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Discrimination of forest from non forest area (dual Pol.)

- PALSAR FBD provides us with dual polarization image.
- Copolarization (HH or VV) is basically the same with FBS data except data sampling space (6.25m FBS and 12.5m FBD).
- Cross polarization component reflect object structure and higher level in volume scattering, which often shows higher response in forest image.
- Use color composite of FBD to conduct interpretation.
- From next pages a mixed area of Amazon forest and non forest mixture in Rondonia.

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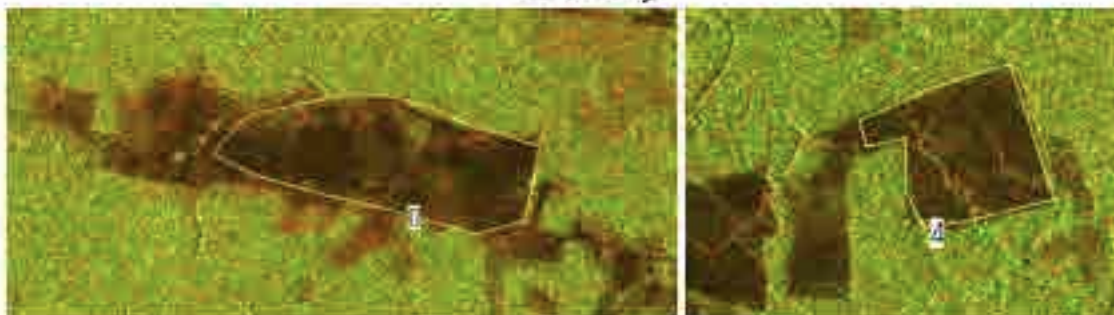
Image interpretation by dual pol. SAR



Test area (Rondonia Brazil)

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Statistics of Polygon 0 and 4 (deforested area)

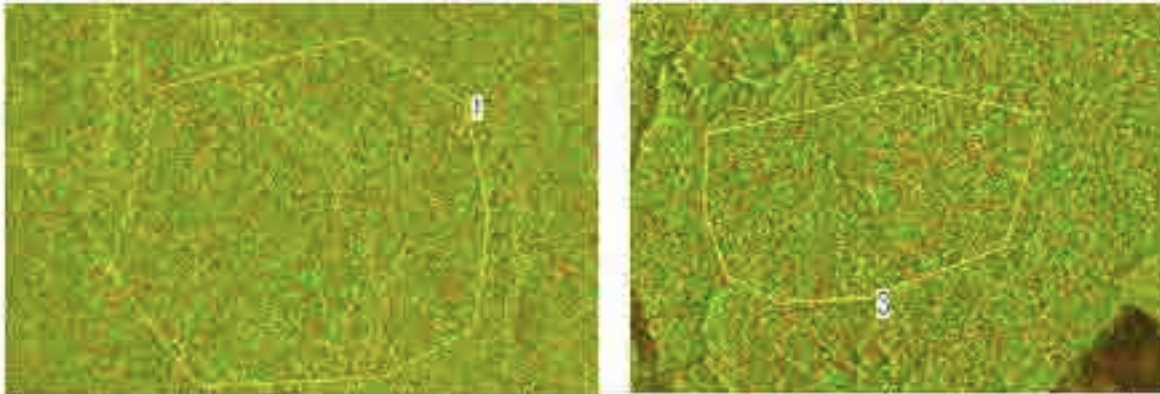


Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	- 13.124	3.479	- 22.101	3.592	deforestation
1	- 8.164	2.718	- 13.235	2.716	forest
2	- 5.579	2.812	- 12.307	2.715	grass or low tree
3	- 8.427	2.704	- 13.52	2.779	forest
4	- 13.384	3.342	- 21.375	3.165	deforestation
5	- 9.726	3.352	- 14.767	3.944	forest and load
6	2.778	4.749	- 15.692	3.437	city

Sigma naught distribution (in dB)

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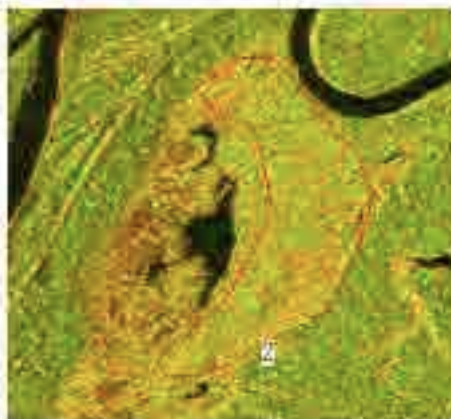
Polygon 1, 3(forest)



Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	-13.124	3.479	-22.101	3.592	deforestation
1	-8.164	2.718	-13.235	2.716	forest
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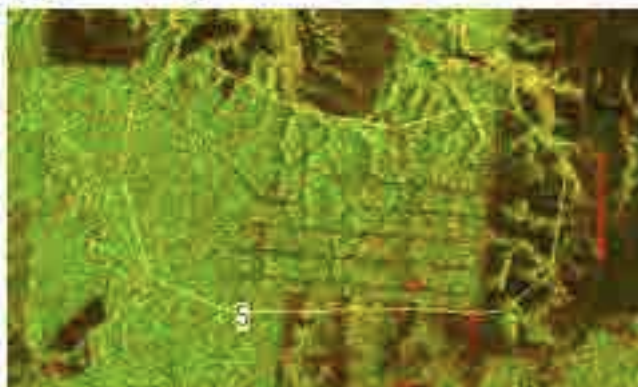
Polygon 2 (Grass or low tree)



Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	-13.124	3.479	-22.101	3.592	deforestation
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2	-5.579	2.812	-12.307	2.715	grass or low tree
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Polygon 5 (forest and access road)



Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	-13.124	3.479	-22.101	3.592	deforestation
1	-8.164	2.718	-13.235	2.716	forest
2	-5.579	2.812	-12.307	2.715	grass or low tree
3	-8.427	2.704	-13.52	2.779	forest
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22

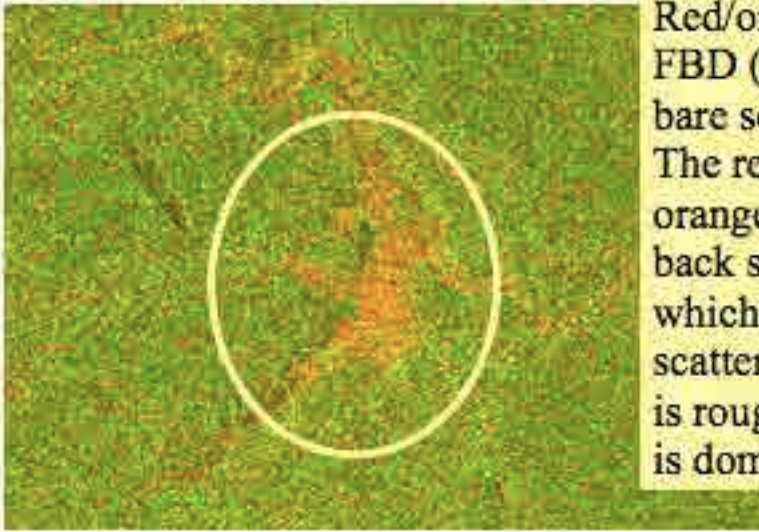
Polygon 6 (Resident area)



Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	-13.124	3.479	-22.101	3.592	deforestation
1	-8.164	2.718	-13.235	2.716	forest
2	-5.579	2.812	-12.307	2.715	grass or low tree
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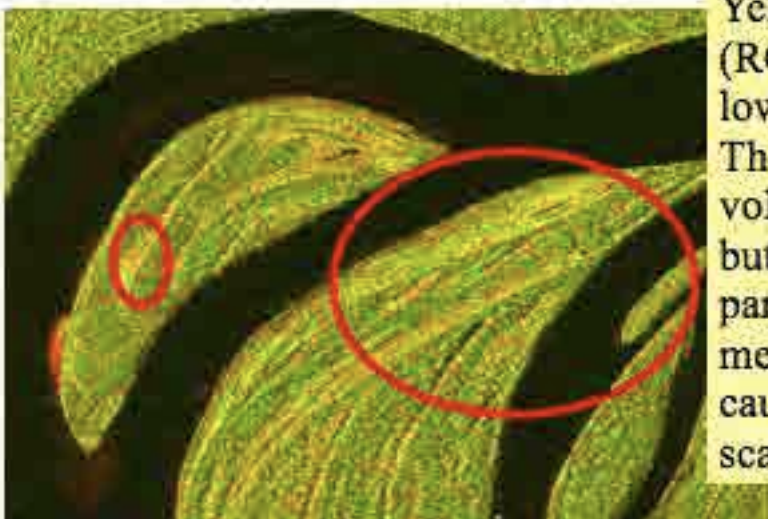
Red/Orange in a forest



Red/orange area appears in FBD (RG=HH,HV) image, is bare soil or manmade object. The reason is that red to orange means relatively weak back scatter in HV component, which means volume scattering is low. Thus the area is rough but surface reflection is dominant.

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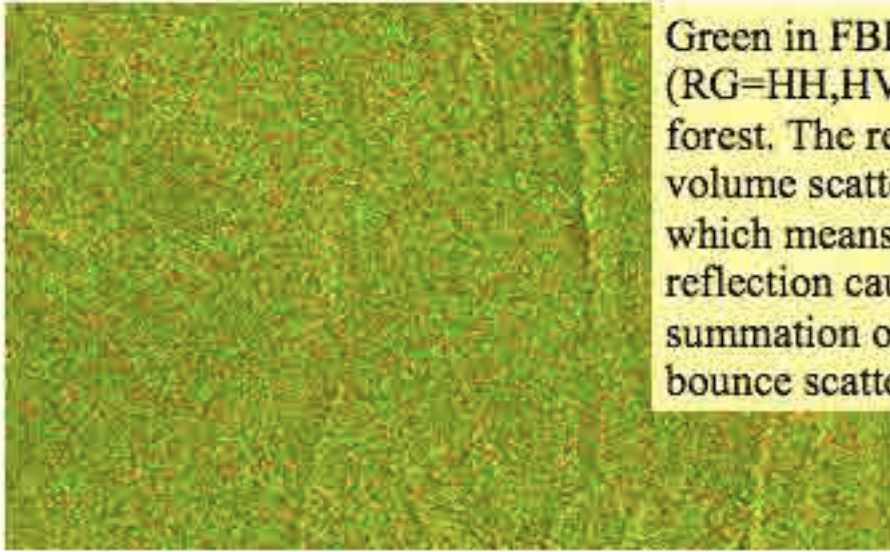
Yellow in forest area



Yellow in FBD (RG=HH,HV) image is low tree or grass land. The reason is that volume scattering exists but the value is low compared with forest, that means low tree or grass causes weak volume scattering.

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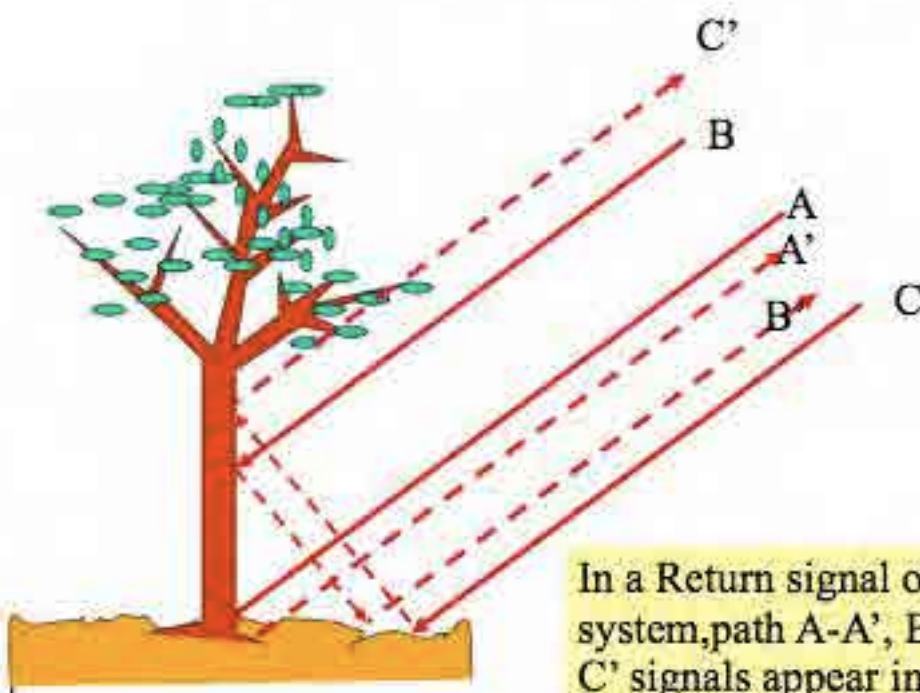
Green in FBD image



Green in FBD (RG=HH,HV) image is forest. The reason is that volume scattering is high, which means stronger reflection caused by summation of double bounce scattering by trees.

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Reflection by trees



In a Return signal of a SAR system, path A-A', B-B', and C-C' signals appear in the same pixel.

Conclusion Forest and non forest discrimination by FBD

- PALSAR FBD is relatively sensitive to discriminate forest area from image.
- Some possibility to classify forest exists but not conducted yet.
- More statistical analysis is necessary to conduct automated classification.

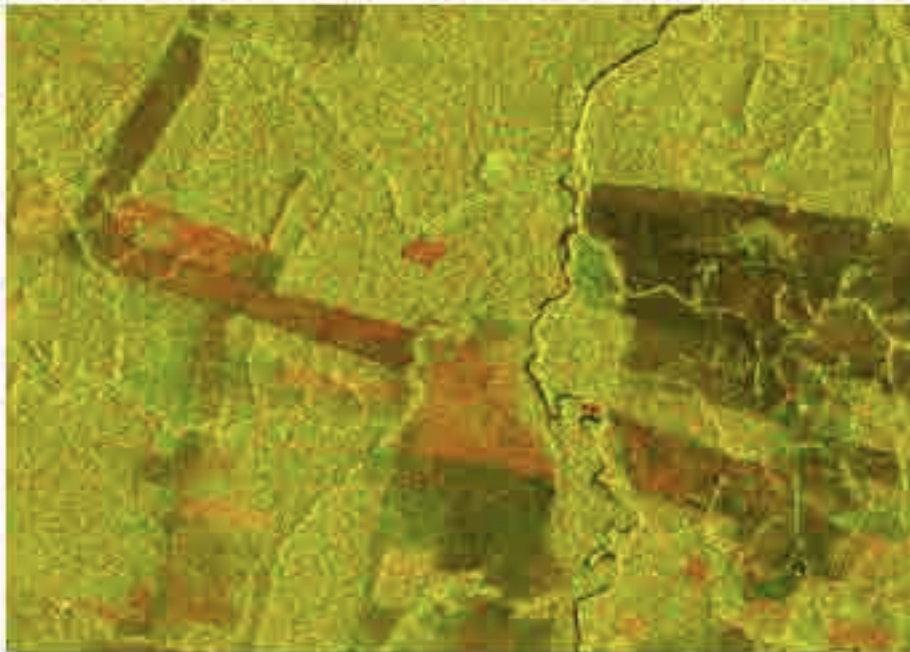
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Change detection and find new deforestation

- The effect of deforestation is surface roughness change and diminish of volume scattering, which causes difference of back scattering.
- Time series analysis is a good method to detect deforestation.
- Multi temporal color composite of same parameter SAR data and Multi temporal switching comparison will be a good method to identify newly happened deforestation.

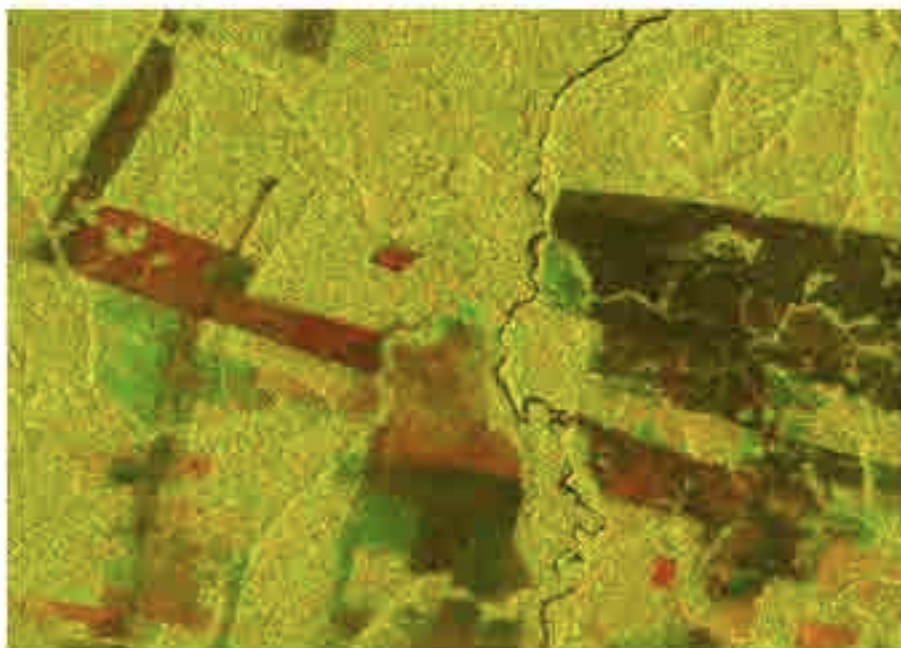
29

Multi temporal color composite (HH-HH)



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Multi temporal color composite (HV-HV)



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Image interpretation of multi temporal composite image



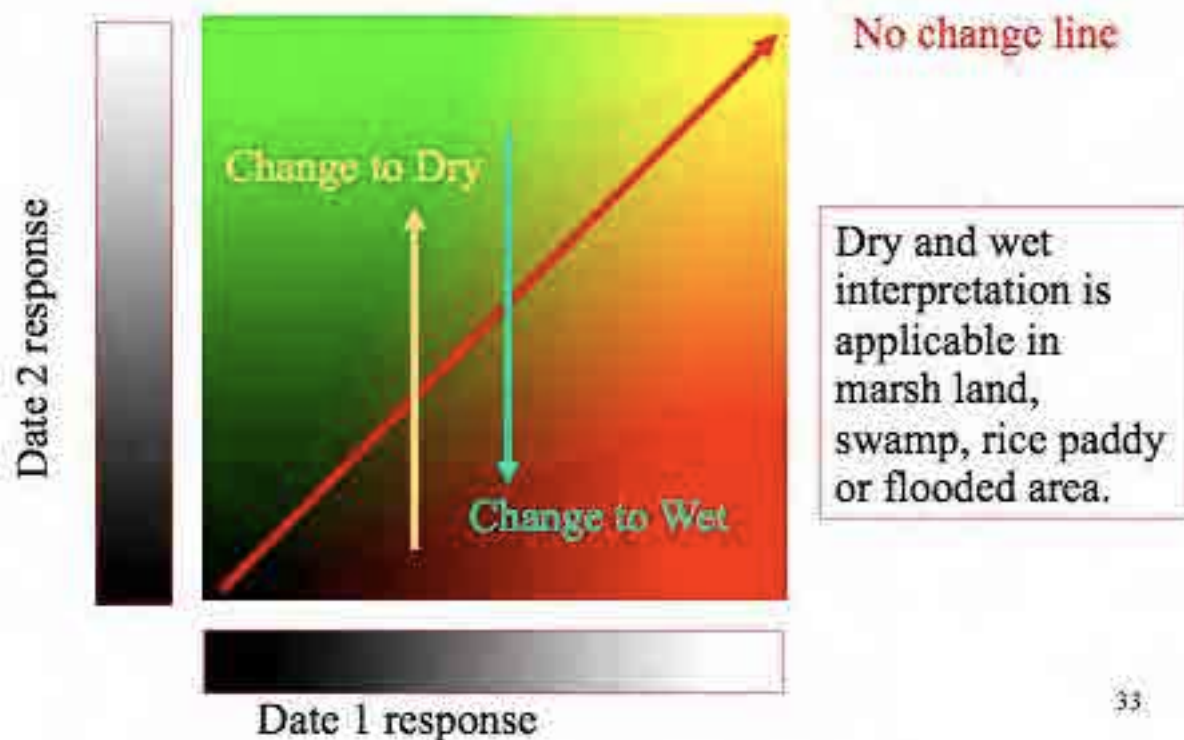
In a PALSAR image intensity varies from dark to bright depending on the surface condition of target.

In general, flat surface shows dark reflectance. And flat surface is often made by still water or wet surface.

In this context, dark area can be a flat surface or still water covered area and bright area is rough or dry area.

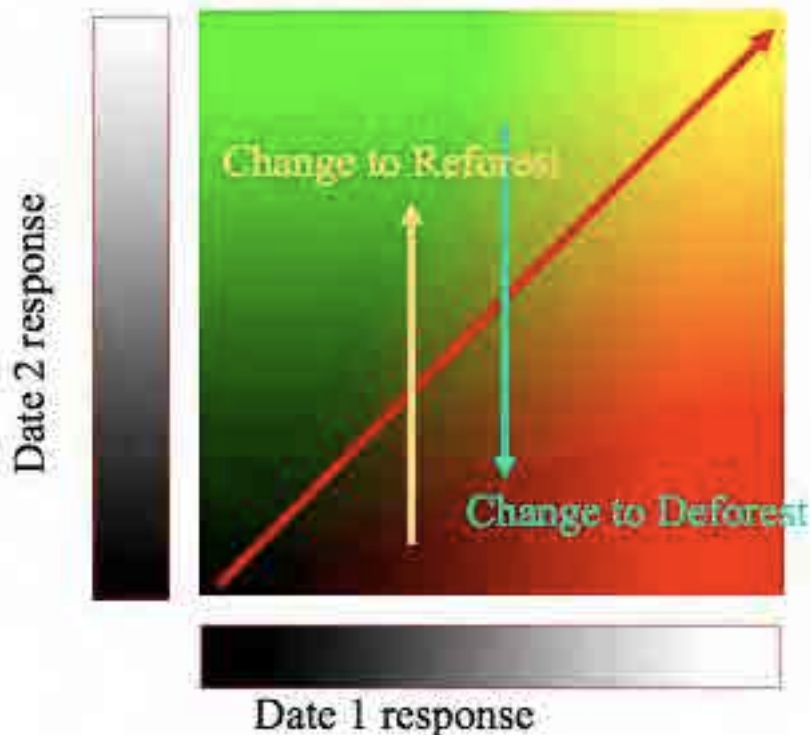
32

Two date color composite (Dry Wet interpretation)



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Two date color composite (Deforest Reforest interpretation)



No change line

Flat surface is often caused by tree cut in forest area.
So, dual date composite can be interpreted as deforest or reforest in forest area.

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Evaluation of deforestation

- Yellow part is no change during two observation date.
- Red (bright or dark) is new deforested or degraded forest or vegetation.
- Green is reforested or increased forest or vegetation.
- HV composite is higher contrast and easy to recognize the changes.
- This is due to the sensible response of vegetation on HV volume scattering.

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Multi temporal FBD switching

By pressing “v” key after opening dual FBD image observed in different date, you can recognize changed area in the image.



New



Old

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Note on same area covered data

- In multi temporal data analysis, you must obtain data covers same area in different data observation.
- Conditions to cover a same area can be checked from filename itself in default mode PALSAR data.
- First 5 digit of filename numerical code (red character below) shows cycle number of orbit. Every 671 cycles the satellite comes back to the same place.
- The second 4 characters (blue character below) shows frame position in oncycle orbit.
- Thus **XXXXX+671*N** means same orbit and same **YYYY** covers the same area.

IMG-HH-ALPSR**12345****6789**L1.5....

Higher level analysis of change detection

- Differential interferometry is a promising tool to detect changes sensitively.
- There is a possibility to identify selective cutting or mining activities by detecting surface change precisely.
- The application is beyond the scope of this hand book.
- This will be discussed in advanced SAR courses.

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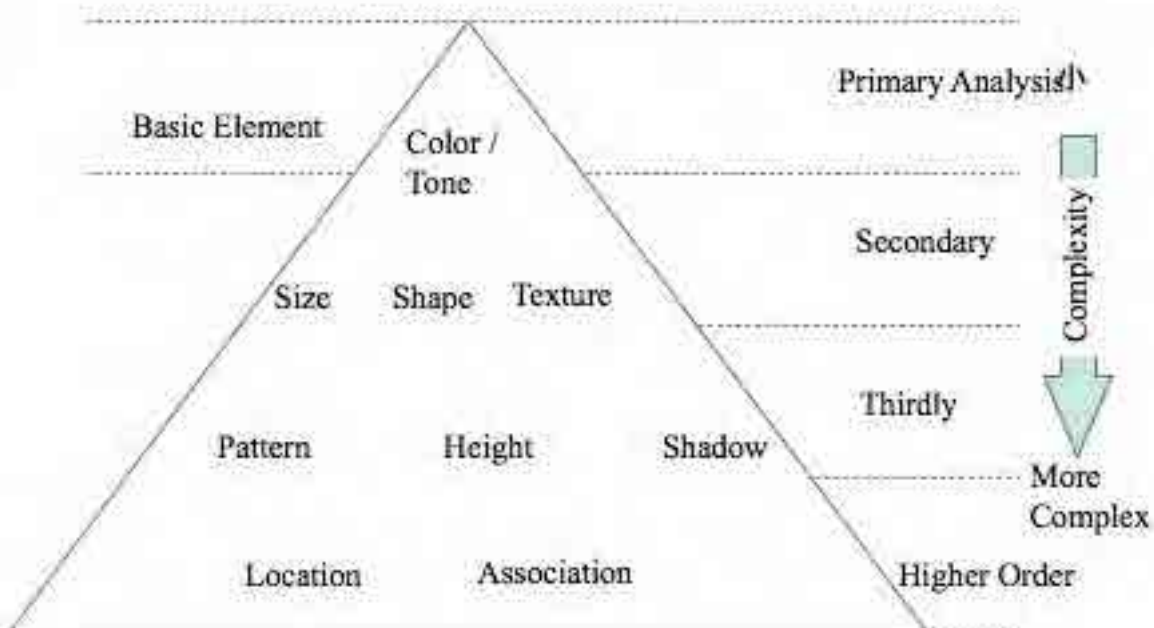
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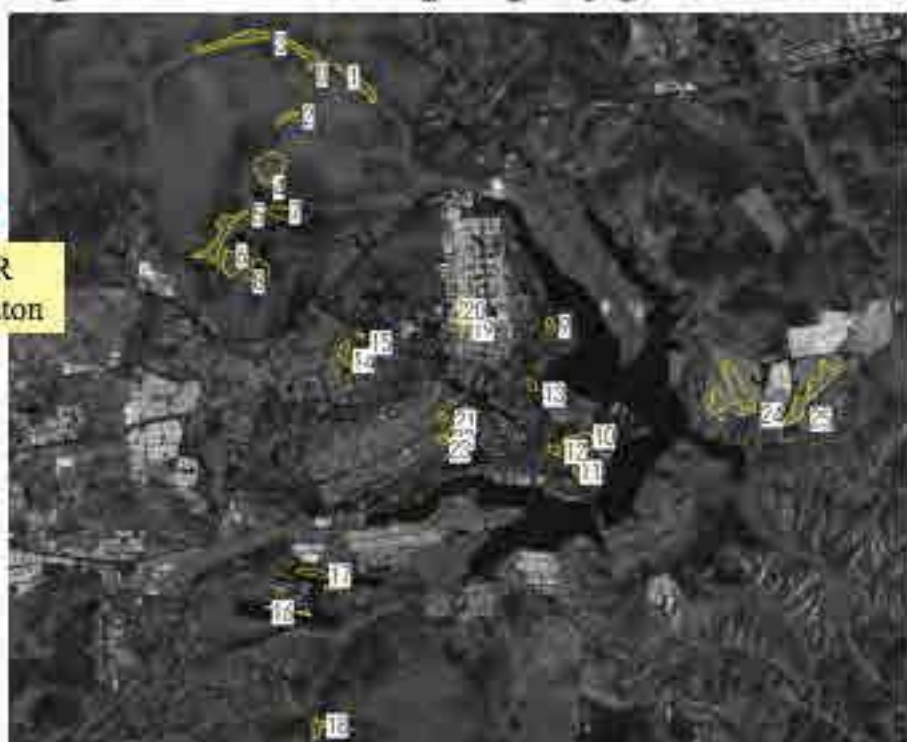
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- Surface flatness effect appears in L band forest area.
- This means forest area shows higher brightness than non forest flat area.
- It is also indicated that forest area response is relatively flat.
- Next pages show a result by PALSAR image and Google comparison for forest area in Brasilia.

5

Target site and sample polygon allocation

PALSAR
Illumination



SceneID="ALPSRP163666860", FBS HH pol. Lev.1.5, Acq. date 2009.8.07

Polygon 0



optical

Radar



Palsar

Location		
Lat	15:41:47'S	
Long	47:57:58'W	
Shape	Indeterministic	
Size	narrow side width, 150m	
ROI	-8.085	
std dev	2.551	
Texture	Fine	
Description	Depict forest with small trees. Fore edge of the forest to face radar illumination shows a little bit higher brightness (a) while back side shows a shadow (b).	

Polygon 1



optical



Radar

Palsar

Location			
Lat	15:42:08"S		
Long	47:56:37"W		
Shape	Indeterministic		
Size	narrow side width 150m		
[M]	-8.422		
std dev	2.604		
Texture	Fine		
Description	Depict forest with small trees. Fore edge of the forest to face radar illumination shows a little bit higher bright ness (a) while back side shows a shadow (b).		

Polygon 2



Radar

Location			
Lat	15:43:9"S		
Long	47:57:54"W		
Shape	Geometric shaped are		
Size	horizontal width of polygon is 810m		
[M]	-7.621		
std dev	2.746		
Texture	Fine		
Description	Forest is well recognized by its brightness, texture and fore edge and back edge of the forest.		

Polygon 3



optical

Location			
Lat	15:41'55"S		
Long	47:59'23"W		
Shape	Indeterministic		
Size	narrow side width 150m		
[RF]	-8.069		
std dev	2.686		
Texture	Fine		
Description	Depict forest with small trees. Edge is not clear but forest boundary is easily recognized.		

Radar



Palsar

Polygon 4



optical

Location			
Lat	15:44'12"S		
Long	47:58'1"W		
Shape	Indeterministic		
Size	radius of round is almost 500m		
[RF]	-8.066		
std dev	2.602		
Texture	Smooth		
Description	Roundly marked grass or unvegetated area.		

Radar



Palsar

This is non forest area

Polygon 5



optical

→
Radar



Palsar

Location		
Lat	15:45:46"S	
Long	47:58:40"W	
Shape	Indeterministic	
Size	narrowest width of polygon is 180m	
RFI	-8.482	
std dev	2.721	
Texture	Fine	
Description	Fore boundary and aft boundary is easy to recognize.	

Polygon 6



Optical

→
Radar



Palsar

Location		
Lat	15:46:12"S	
Long	47:58:18"W	
Shape	Geometric shaped area	
Size	horizontal width of polygon is 750m	
RFI	-8.651	
std dev	2.514	
Texture	Fine	
Description	Low discrete trees, bare soil and grass area is shown in very low contrast.	

This is non forest rough area

Polygon 7



Optical



Radar

Palsar

Location			
Lat	15:45'1"S		
Long	47:57'37"W		
Shape	Geometric shaped area		
Size	Horizontal width of polygon is 810m		
(VV)	-15.947		
std dev	2.58		
Texture	Smooth		
Description	Low discrete trees, bare soil and grass area is shown in very low contrast.		

This is non forest area

Polygon 8



Optical



Radar

Palsar

Location			
Lat	15:46'16"S		
Long	47:57'43"W		
Shape	Geometric shaped area		
Size	horizontal width of polygon is 750m		
(VV)	-14.697		
std dev	3.293		
Texture	Fine		
Description	Past area is shown as dark pixels. Individual trees are recognized as bright dot.		

This is non forest area

Discrimination forest and non forest from single HH pol image (FBS)

- FBS image is not so easy to discriminate forest and non forest area, because reflectance value and surface texture is not unique for forest area when you compared the data with non forest area.
- Large scale discrimination of forest from non forest may possible.

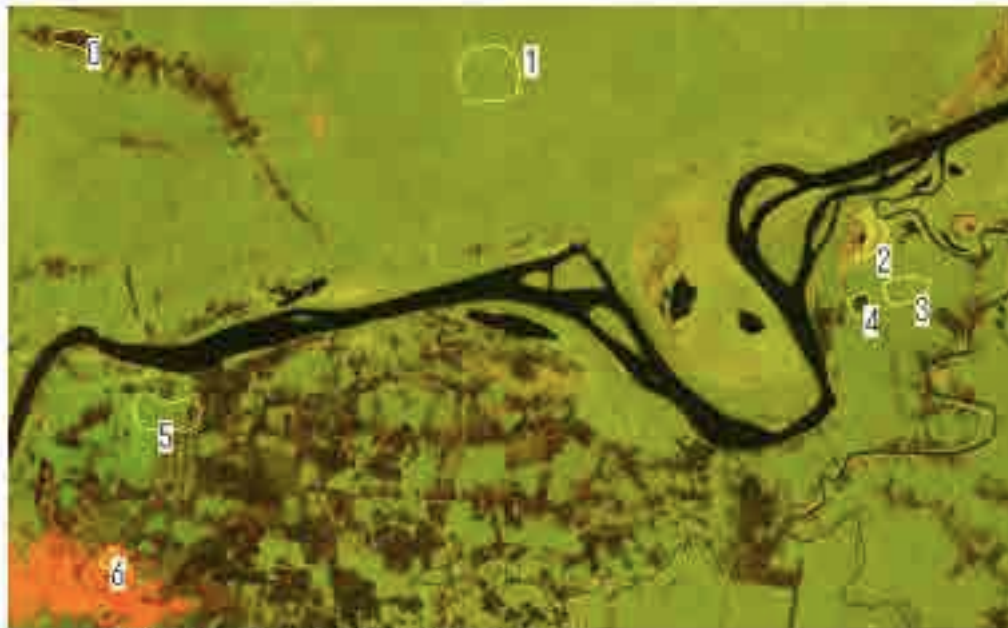
16

Discrimination of forest from non forest area (dual Pol.)

- PALSAR FBD provides us with dual polarization image.
- Copolarization (HH or VV) is basically the same with FBS data except data sampling space (6.25m FBS and 12.5m FBD).
- Cross polarization component reflect object structure and higher level in volume scattering, which often shows higher response in forest image.
- Use color composite of FBD to conduct interpretation.
- From next pages a mixed area of Amazon forest and non forest mixture in Rondonia.

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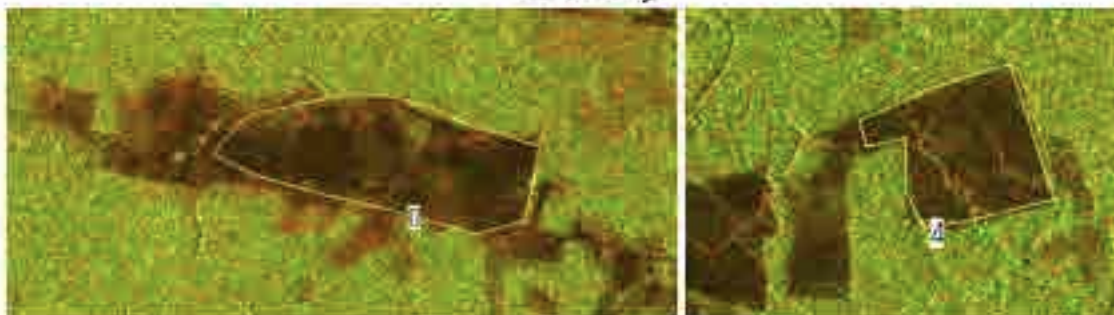
Image interpretation by dual pol. SAR



Test area (Rondonia Brazil)

18

Statistics of Polygon 0 and 4 (deforested area)

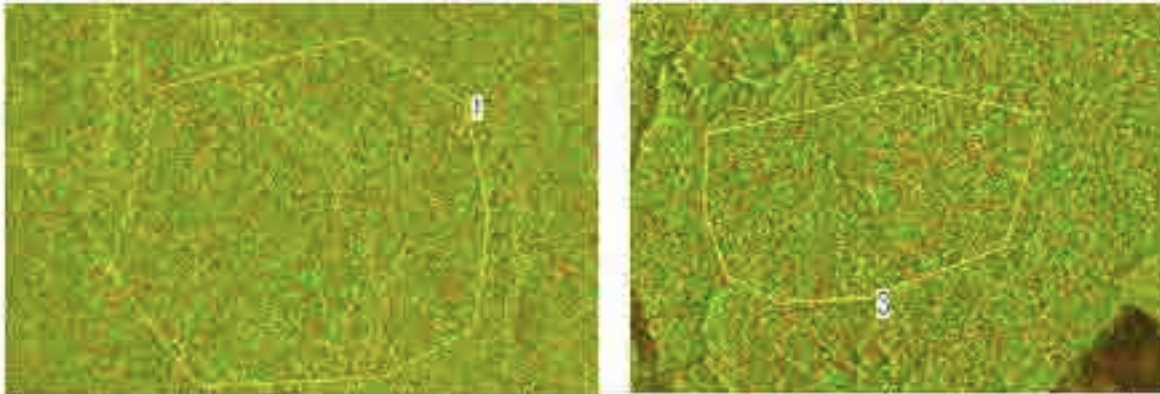


Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	- 13.124	3.479	- 22.101	3.592	deforestation
1	- 8.164	2.718	- 13.235	2.716	forest
2	- 5.579	2.812	- 12.307	2.715	grass or low tree
3	- 8.427	2.704	- 13.52	2.779	forest
4	- 13.384	3.342	- 21.375	3.165	deforestation
5	- 9.726	3.352	- 14.767	3.944	forest and load
6	2.778	4.749	- 15.692	3.437	city

Sigma naught distribution (in dB)

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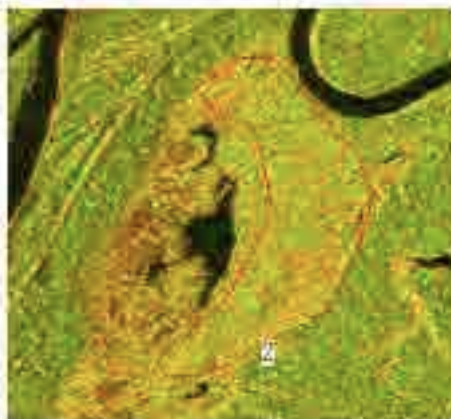
Polygon 1, 3(forest)



Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	-13.124	3.479	-22.101	3.592	deforestation
1	-8.164	2.718	-13.235	2.716	forest
2	-5.579	2.812	-12.307	2.715	grass or low tree
3	-8.427	2.704	-13.52	2.779	forest
4	-13.384	3.342	-21.375	3.165	deforestation
5	-9.726	3.352	-14.767	3.944	forest and load
6	2.778	4.749	-15.692	3.437	city

20

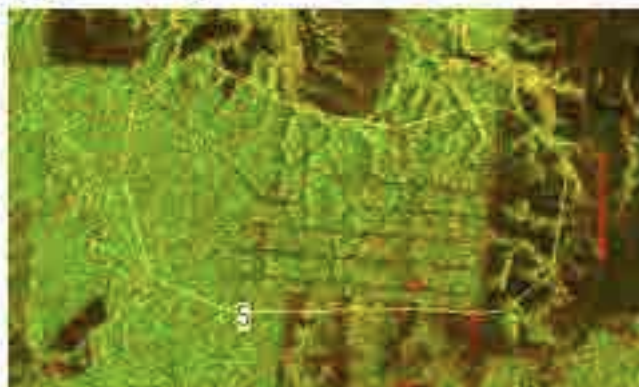
Polygon 2 (Grass or low tree)



Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	-13.124	3.479	-22.101	3.592	deforestation
1	-8.164	2.718	-13.235	2.716	forest
2	-5.579	2.812	-12.307	2.715	grass or low tree
3	-8.427	2.704	-13.52	2.779	forest
4	-13.384	3.342	-21.375	3.165	deforestation
5	-9.726	3.352	-14.767	3.944	forest and load
6	2.778	4.749	-15.692	3.437	city

21

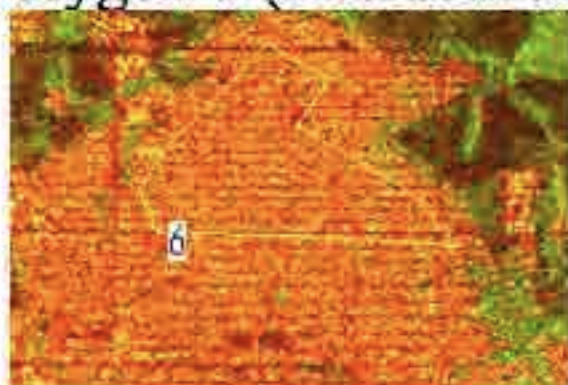
Polygon 5 (forest and access road)



Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	-13.124	3.479	-22.101	3.592	deforestation
1	-8.164	2.718	-13.235	2.716	forest
2	-5.579	2.812	-12.307	2.715	grass or low tree
3	-8.427	2.704	-13.52	2.779	forest
4	-13.384	3.342	-21.375	3.165	deforestation
5	-9.726	3.352	-14.767	3.944	forest and load
6	2.778	4.749	-15.692	3.437	city

22

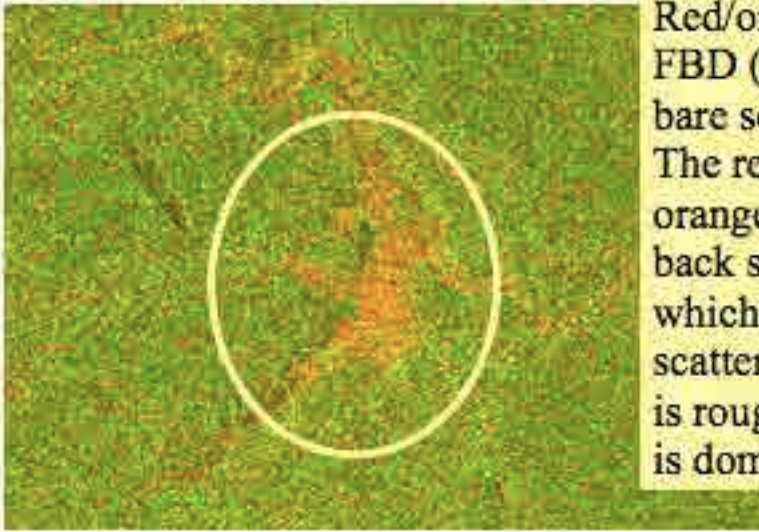
Polygon 6 (Resident area)



Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	-13.124	3.479	-22.101	3.592	deforestation
1	-8.164	2.718	-13.235	2.716	forest
2	-5.579	2.812	-12.307	2.715	grass or low tree
3	-8.427	2.704	-13.52	2.779	forest
4	-13.384	3.342	-21.375	3.165	deforestation
5	-9.726	3.352	-14.767	3.944	forest and load
6	2.778	4.749	-15.692	3.437	city

23

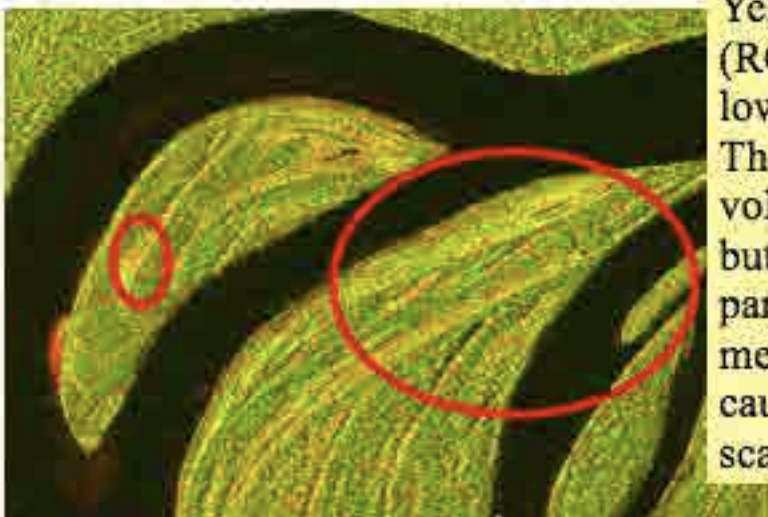
Red/Orange in a forest



Red/orange area appears in FBD (RG=HH,HV) image, is bare soil or manmade object. The reason is that red to orange means relatively weak back scatter in HV component, which means volume scattering is low. Thus the area is rough but surface reflection is dominant.

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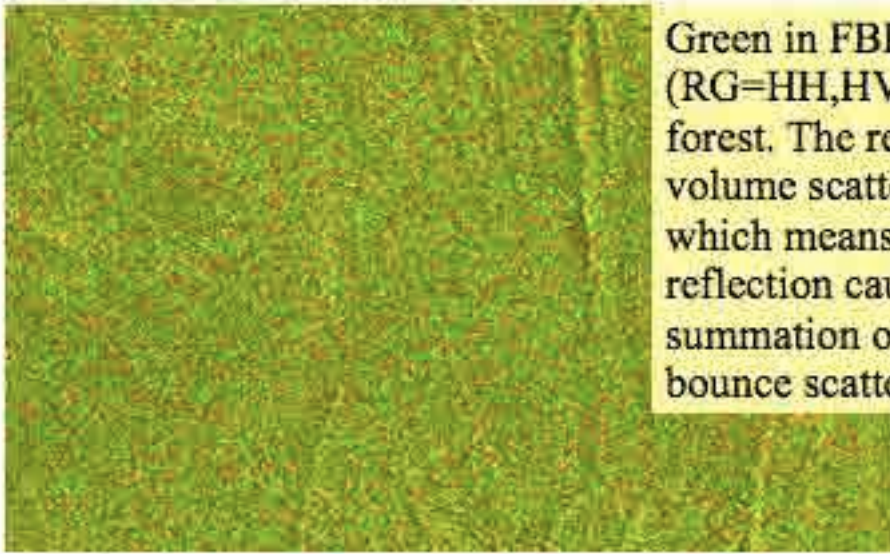
Yellow in forest area



Yellow in FBD (RG=HH,HV) image is low tree or grass land. The reason is that volume scattering exists but the value is low compared with forest, that means low tree or grass causes weak volume scattering.

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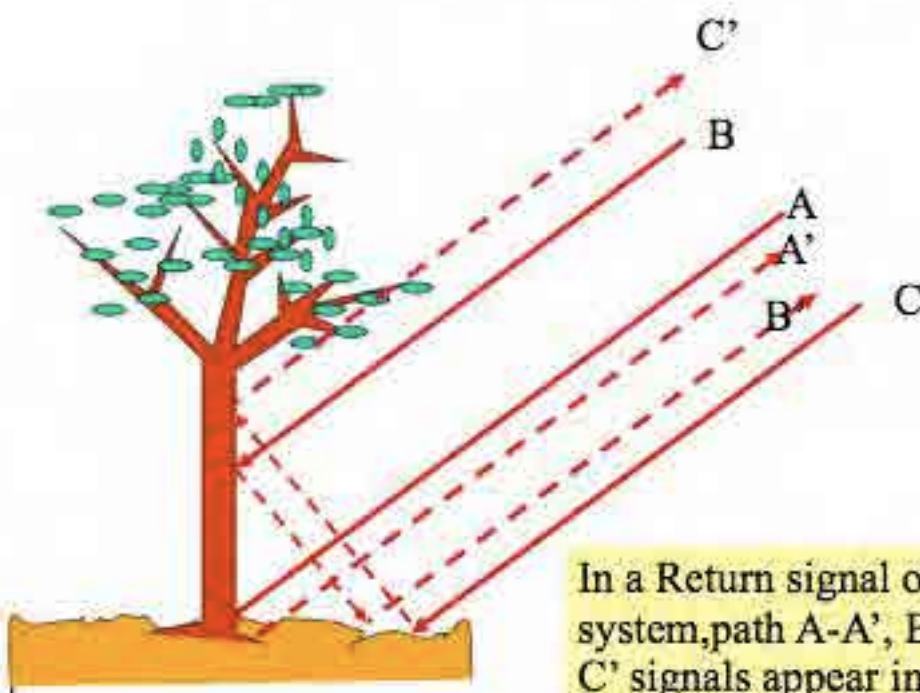
Green in FBD image



Green in FBD (RG=HH,HV) image is forest. The reason is that volume scattering is high, which means stronger reflection caused by summation of double bounce scattering by trees.

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Reflection by trees



In a Return signal of a SAR system, path A-A', B-B', and C-C' signals appear in the same pixel.

Conclusion Forest and non forest discrimination by FBD

- PALSAR FBD is relatively sensitive to discriminate forest area from image.
- Some possibility to classify forest exists but not conducted yet.
- More statistical analysis is necessary to conduct automated classification.

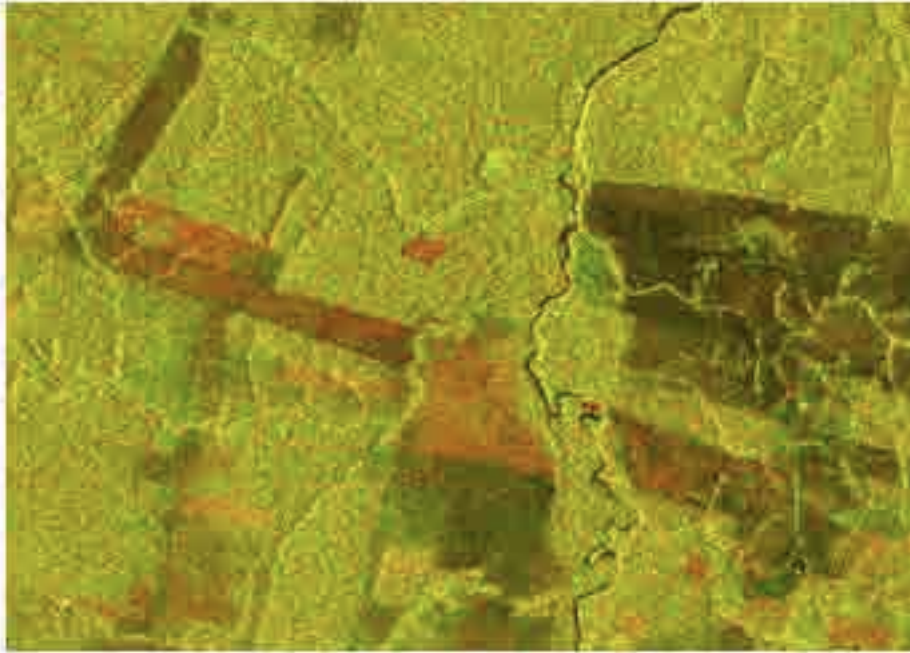
28

Change detection and find new deforestation

- The effect of deforestation is surface roughness change and diminish of volume scattering, which causes difference of back scattering.
- Time series analysis is a good method to detect deforestation.
- Multi temporal color composite of same parameter SAR data and Multi temporal switching comparison will be a good method to identify newly happened deforestation.

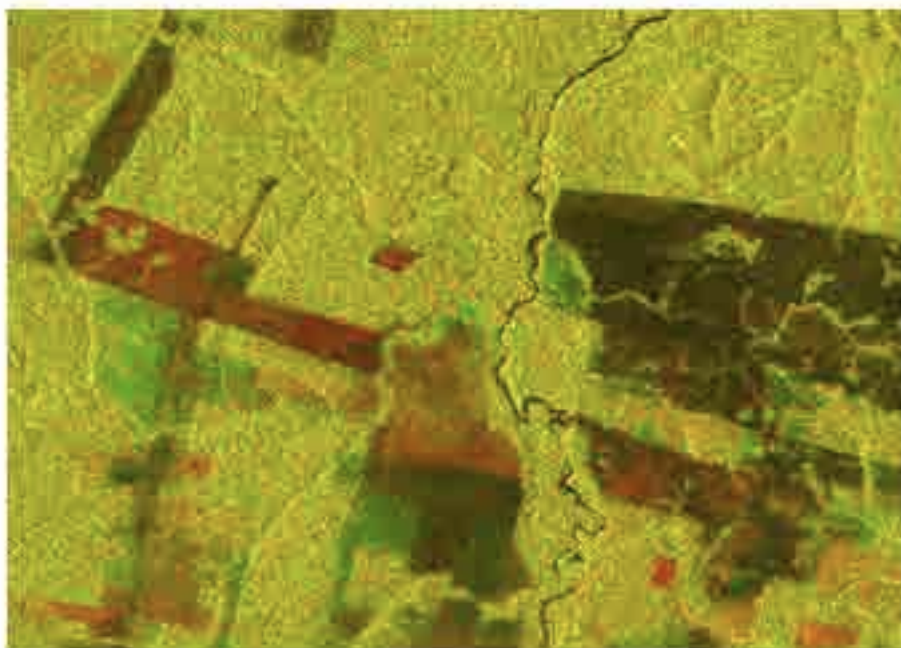
29

Multi temporal color composite (HH-HH)



30

Multi temporal color composite (HV-HV)



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Image interpretation of multi temporal composite image



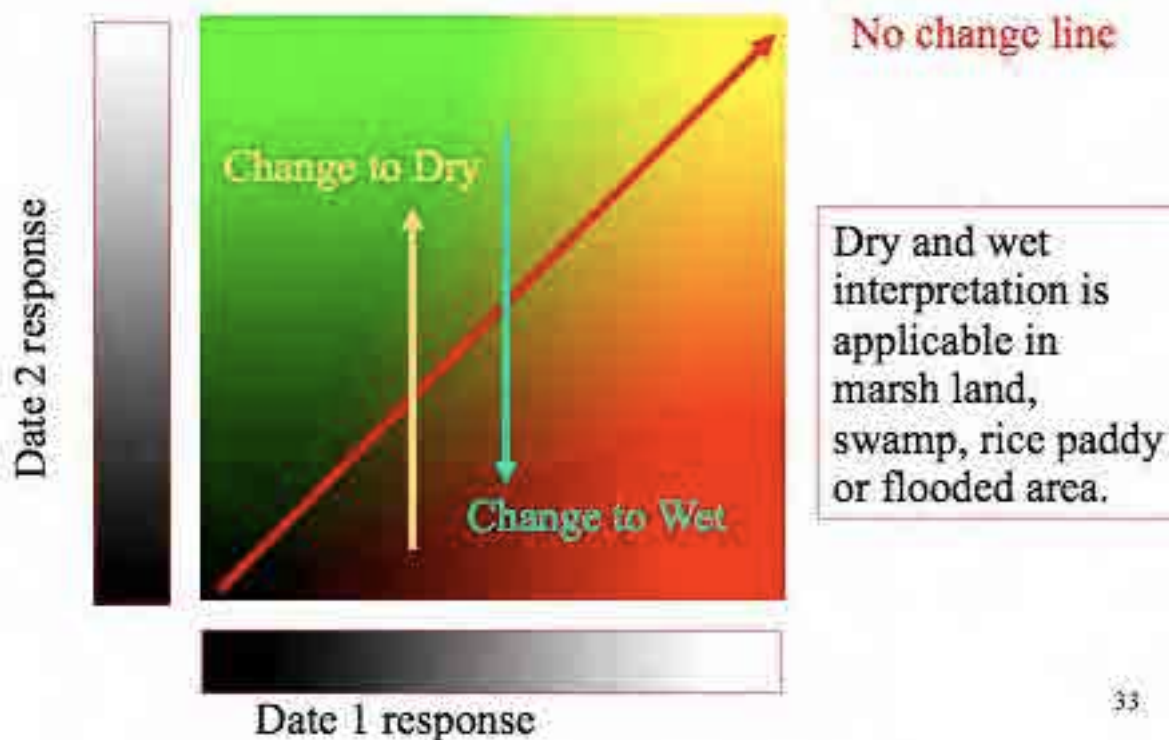
In a PALSAR image intensity varies from dark to bright depending on the surface condition of target.

In general, flat surface shows dark reflectance. And flat surface is often made by still water or wet surface.

In this context, dark area can be a flat surface or still water covered area and bright area is rough or dry area.

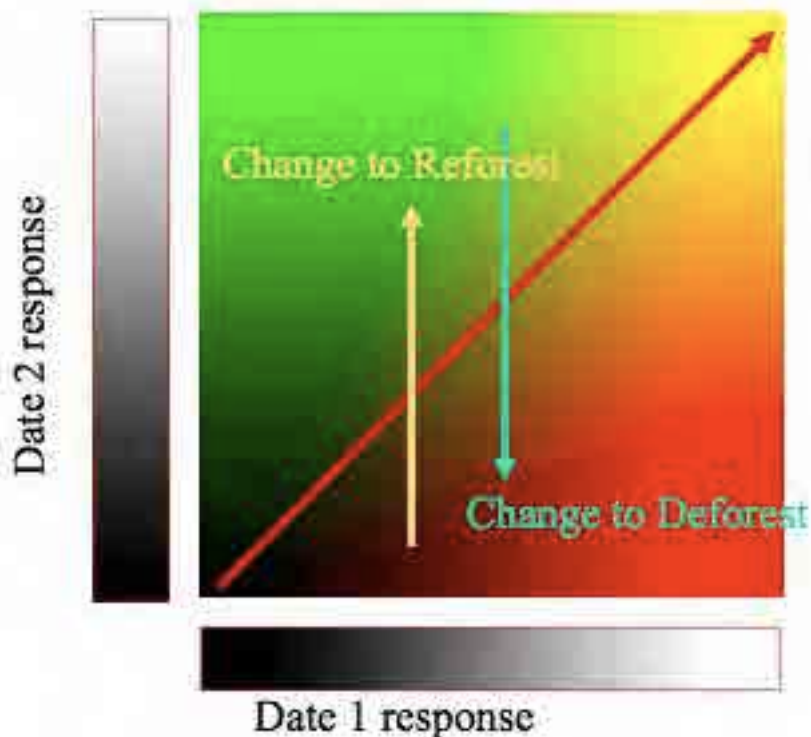
32

Two date color composite (Dry Wet interpretation)



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Two date color composite (Deforest Reforest interpretation)



No change line

Flat surface is often caused by tree cut in forest area.
So, dual date composite can be interpreted as deforest or reforest in forest area.

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Evaluation of deforestation

- Yellow part is no change during two observation date.
- Red (bright or dark) is new deforested or degraded forest or vegetation.
- Green is reforested or increased forest or vegetation.
- HV composite is higher contrast and easy to recognize the changes.
- This is due to the sensible response of vegetation on HV volume scattering.

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Multi temporal FBD switching

By pressing “v” key after opening dual FBD image observed in different date, you can recognize changed area in the image.



New



Old

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Note on same area covered data

- In multi temporal data analysis, you must obtain data covers same area in different data observation.
- Conditions to cover a same area can be checked from filename itself in default mode PALSAR data.
- First 5 digit of filename numerical code (red character below) shows cycle number of orbit. Every 671 cycles the satellite comes back to the same place.
- The second 4 characters (blue character below) shows frame position in oncycle orbit.
- Thus **XXXXX+671*N** means same orbit and same **YYYY** covers the same area.

IMG-HH-ALPSR**12345****6789**L1.5....

Higher level analysis of change detection

- Differential interferometry is a promising tool to detect changes sensitively.
- There is a possibility to identify selective cutting or mining activities by detecting surface change precisely.
- The application is beyond the scope of this hand book.
- This will be discussed in advanced SAR courses.

VISUAL IDENTIFICATION OF NEW DEFORESTATION USING SCANSAR IMAGES

INDICAR works with ScanSAR color composite images for different dates in 90 days, provided by the Japanese Aerospace Agency (JAXA).

To identify new deforestation initially we excluded the deforestation already identified by the official systems. We created a *mask* that aggregates PRODES polygons (the latest), DETER (YTD) and index (polygons identified above)

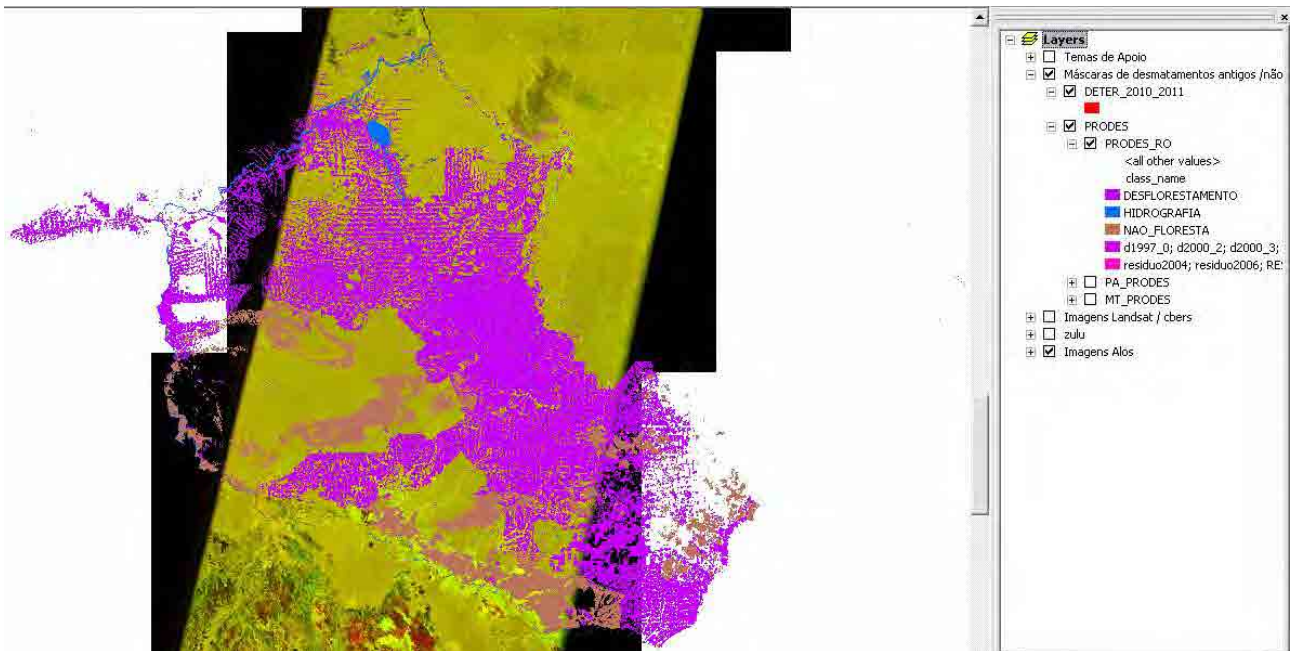
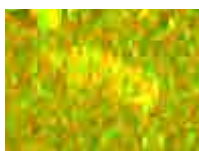


Figure 01: Masks of Rondonia State.

We proceeded to the visual identification of deforestation, observing brightness and shape of polygons. The process is conducted at 1:150,000 scale, allowing the definition of areas of at least 25 hectares.

In the case of recent deforestation, search anthropic polygons (regular, which indicates a good chance of being a human intervention), denoting a non-natural transformation. We believe that recent deforestation present this pattern of brightness due to the whole soil surface moisture (dielectric constant) + dirt resulting from deforestation (Double bounce and volume scattering), and the geometric pattern.

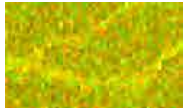


Deforestation: High brightness, polygonal defined.

There are many other patterns found in the ScanSAR compositions, and the main are:



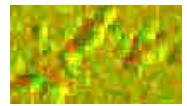
Forest: characterized by the diffusion of waves, does not present a defined pattern.



Gallery Forest: presents more intense brightness than forest. The fact of going around the water courses allows the recognition due to the unusual shape



Old deforestation: Low intensity of brightness caused by specular reflection because the targets act as smooth surfaces.



Rugged topography, has regions with high brightness however there are regions near blackened and following a pattern of direction due to shadows generated by sensor's position to the target



Wetlands: bright, easily confused with deforestation, distinguished by shape and seasonality.

In the following example we have identified the following features

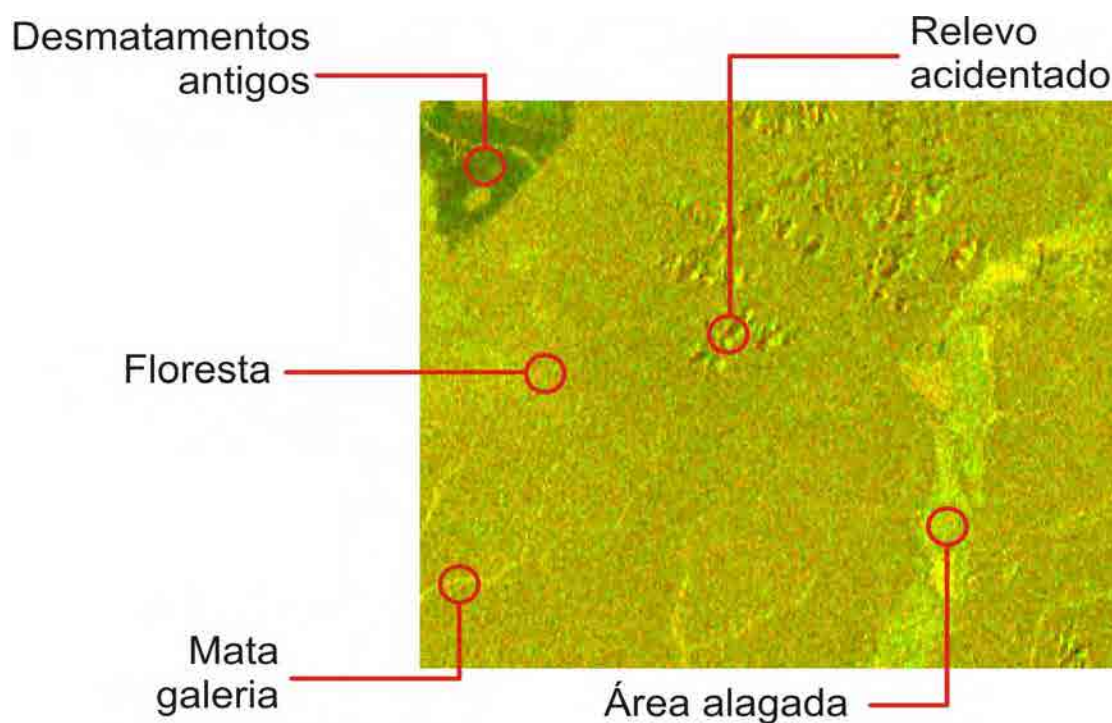


Figure 2: features visually identified in the composition of cycles 41 and 39 in Rondônia State

The masks simplify a visual identification of feature because of decreases of areas that will be supervised and avoid the repeated detection of polygons.

Other subjective coefficient are taken in consideration and delineation of a deforestation or not, as the following

- Proximity of ancient deforestation defined by PRODES;
- Proximity to recent deforestation, defined by DETER and INDICAR;
- Proximity to roads.

Factors that create doubts in the delineation of polygons:

- Proximity to gallery forests and waterways;
- Proximity to areas of "non forest" defined PRODES;
- Proximity to rugged relief;
- Polygon Non-regular format.

In the following example, we have an area identified as deforestation, closer to old deforestation and a large area classified as "non-forest" by PRODES system:

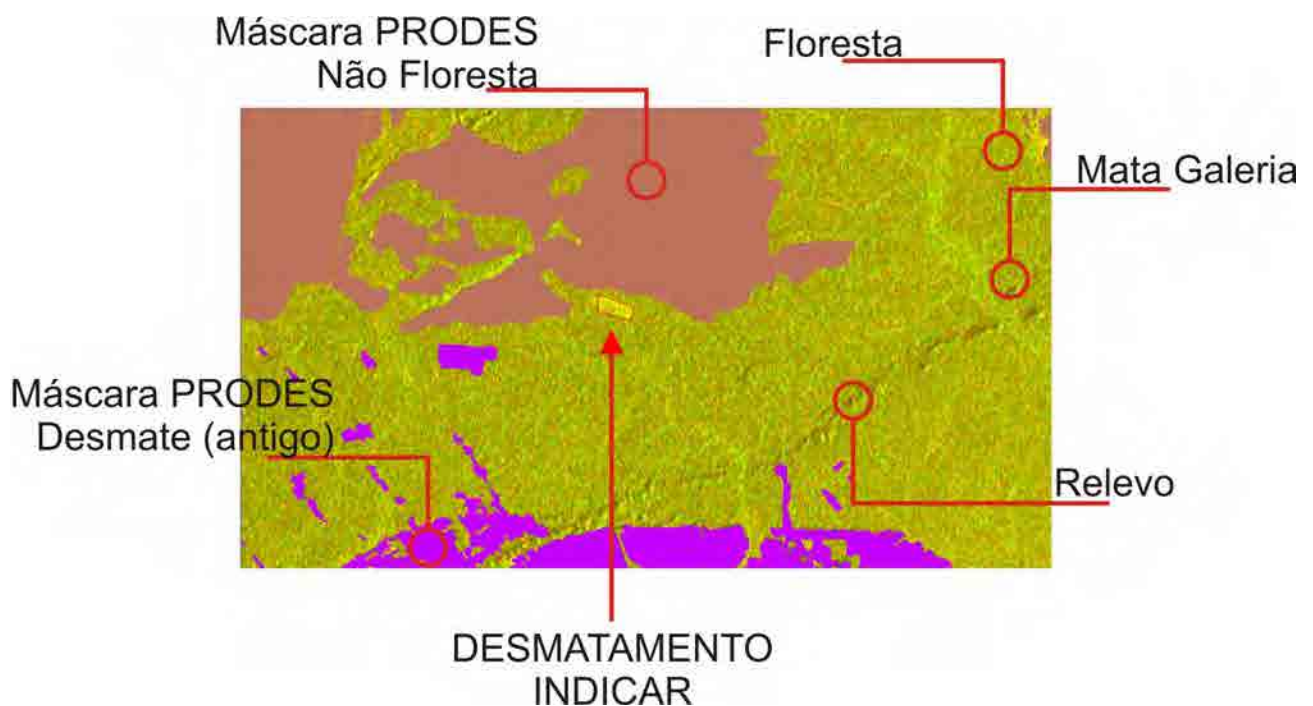


Figure 03: identification of deforestation in the ScanSAR images composition.

As noted, the methodology is based on visual concepts and subjective definition for deforestation, still had a high success rate in the validation made by the CSR and the field work carried out by inspectors.

Manual de Monitoramento do Desmatamento na Amazonia

Editor M. Ono (JICA Expert)

Objetivo do Manual

Introduzir a metodologia e critérios básicos de avaliação para monitorar o desmatamento utilizando dados ALOS PALSAR

Fornecer apontamentos para o processo sistemático para uso PALSAR no aplicativo atual e futura extensão do processo para outra área de aplicação

Deixar as experiências obtidas no projeto atual para futuro analista ou desenvolvedor de software.

Metodologia

A metodologia de uso está resumida abaixo. Você deve selecionar ou usar vários métodos em associação a realização de detecção de desmatamento.

- Interpretação visual de imagens SAR
- Detecção de mudanças por composição Multi temporal
- FBD switch
- A análise estatística / classificação FBD
- Detecção automática ou semi-automática de desmatamento (Classificação dual pol., classificação textural, classificação sigma base zero). Está em projeto, ainda não está pronto.
- Comparação de imagens ópticas por sobreposição KML

Informações gerais sobre a natureza da imagem PALSAR

PALSAR utiliza banda L, com comprimento de onda de 23 cm.

Ondas de rádio dessa frequência penetram a cobertura florestal. Algumas acertam a superfície terrestre e outras são espalhadas devido ao volume de ramos e folhas da árvore, causando **componete** polarizada cruzada que aparece nos sinais recebidos.

No corte raso da floresta, a superfície da terra aparece nua nas imagens que parecem planas neste comprimento de onda, causando reflexo, o que reduz ondas retroespalhadas para receptor de satélite. Na área de corte raso, a imagem fica escura devido a redução de retroespalhamento.

Além disso, devido ao espalhamento do volume de uma floresta, a recepção polarizada dupla (FBD) mostra reflexão relativamente forte na componente polarizada cruzada.

Para mais detalhes na natureza da imagem de radar, há muitas referências de livros e documentos. Consulte os documentos listados se você tiver mais interesse sobre esta matéria. (Appendix. Ia, Ib, Ic)

Monitoramento do Desmatamento

Um modelo de reflexão de radar de detecção do desmatamento é a utilização de mudanças e alterações de rugosidade superficial espalhamento do volume devido ao desmatamento.

Pelo desmatamento, a rugosidade da superfície afeta o retorno da onda ao radar, o que torna a componente de espalhamento suave e reduz o volume. Assim, a área desmatada da imagem torna-se escura em dados de banda L PALSAR.

Como várias pesquisas relataram, o brilho da componente HH na área desmatada aos poucos recupera o tempo decorrido após a ocorrência de desmatamento. Enquanto o componente HV é estável após desmatamento.

Isto sugere que a rugosidade superficial recupera gradualmente após o desmatamento, mas a recuperação do crescimento de árvores ocorre mais lentamente. Mas este efeito ainda não foi verificado.

Existe a possibilidade de usar a detecção de mudança de altura usando interferograma diferencial, mas isto não é verificado ainda.

Detecção de Corte Raso

Efeito do corte raso na reflexão de radar é a diminuição da rugosidade da superfície. Na imagem PALSAR o corte raso se torna escuro, tanto na componente HH e no componente HV. Como mostrado na página anterior, componente HH têm uma tendência para recuperar o brilho em relativamente curto espaço de tempo decorrido (de vários meses a um ano de experiência PALSAR).

No modo ScanSAR, o monitoramento contínuo é necessário para detectar alterações em relação a recuperação do brilho.

Efeito sobre a componente de polarização cruzada é diminuir o volume do componente de dispersão, devido ao desmatamento. Isso é relativamente estável durante o tempo decorrido após o desmatamento.

Pensando na natureza do tempo de dependência da área de corte raso, o monitoramento

de desmatamento mais preferível é usar o componente HV PALSAR no caso

Tempo de Dependência

Corte raso, primeiro mostra efeito claro sobre a resposta do radar. Esse efeito gradualmente diminui ou torna-se vago após um ou dois ciclos de tempo decorrido.

A redução do sinal de rastreamento (fade away) é mais significativa para a reflexão co-polarizada (HH no FBS e FBD) do que para a reflexão polarizada cruzada (HV em FBD). Esse resultado sugere que parece melhor usar HV para detectar o desmatamento.

O efeito (fade away) pode ser o resultado de uma secagem dos solos superficiais ou grama crescendo na área de corte raso.

The effect must be checked through field survey and be confirmed which model is adequate.

O efeito deve ser verificado através de levantamento de campo e ser confirmado que o modelo é adequado.

○ :Possible △ :May be x impossible

Detecção de corte seletivo de madeira

Detecção de corte seletivo de árvores é um tema muito difícil. Há apenas uma possibilidade de utilizar alguns dados PALSAR para detectar o corte seletivo. A possibilidade será verificada nas atividades do ano anterior.

Verificação

Para monitorar o desmatamento utilizando PALSAR, é imprescindível realizar pesquisa de campo ou observação local equivalente a fim de verificar o processo.

Muitas vezes, usar o Google Earth no local da imagem é adequado, porque a nossa área alvo atrai o interesse de todo o mundo e com frequência o Google atualiza a área de cobertura com imagens de alta resolução óptica.

Em alguns casos, você pode verificar os resultados analisados pela sobreposição de imagens PALSAR divididas em partes menores de áreas-alvo no Google Earth.

Tenha cuidado com o pensamento da frequência de atualização das imagens de fundo do Google Earth. Verificações devem ser limitadas para estabelecer metodologia. Não utilizar para a análise de alvo real.

Nova detecção de desmatamento em PALSAR Wide Beam

Detecção usando compostos coloridos multi temporais de digitalização de imagens SAR mostra novos desmatamentos ou algum desmatamento falso com mudança de cor.

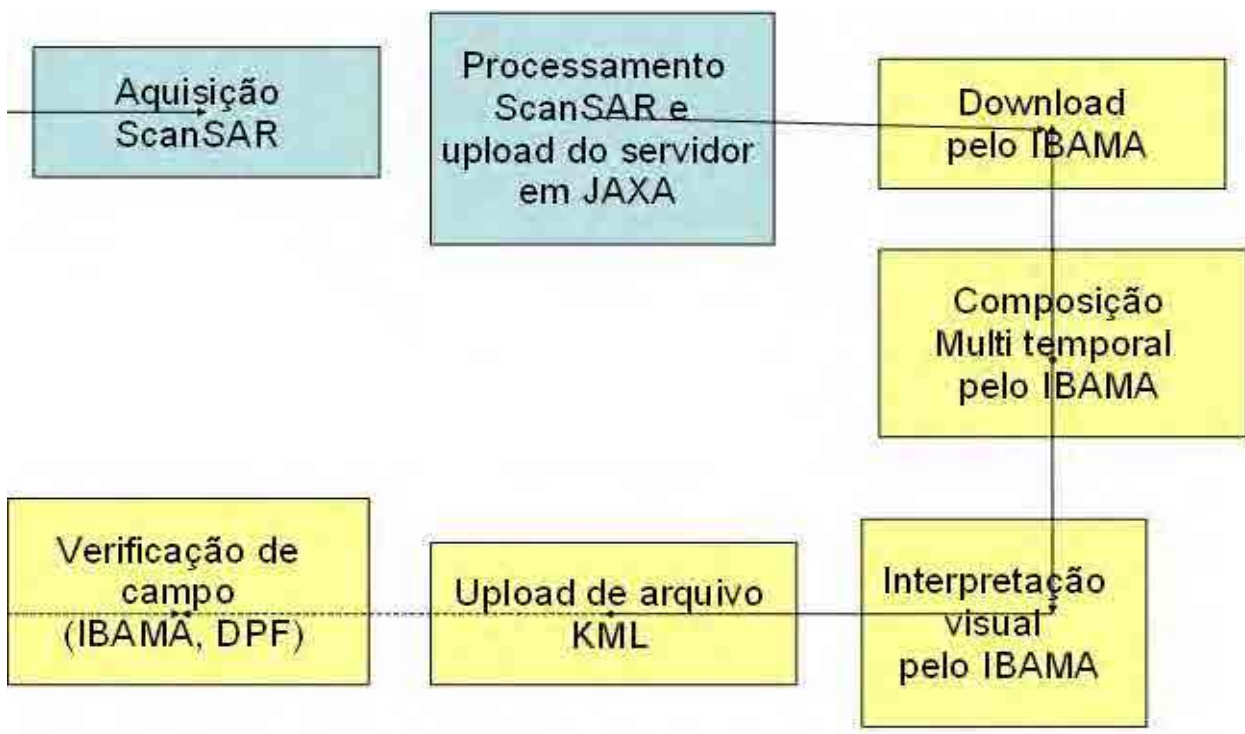
Toda mudança na reflectância de radar entre as datas 2 ou 3 de observação aparece como colorida na imagem composta, enquanto menos mudança é exibida como o amarelo (2 datas) e cinza (3 datas).

Alguns são devido ao desmatamento, alguns são efeito da variação sazonal da superfície do solo (umidade do solo), alguns são as alterações ambientais naturais (inundações ou secas) ou efeito do crescimento da vegetação. mo

Para discriminar o desmatamento entre as mudanças na imagem, a decisão empírica é importante.

Devido à resolução do wide beam mode (100m), o desmatamento é detectado a partir de 4 hectares.

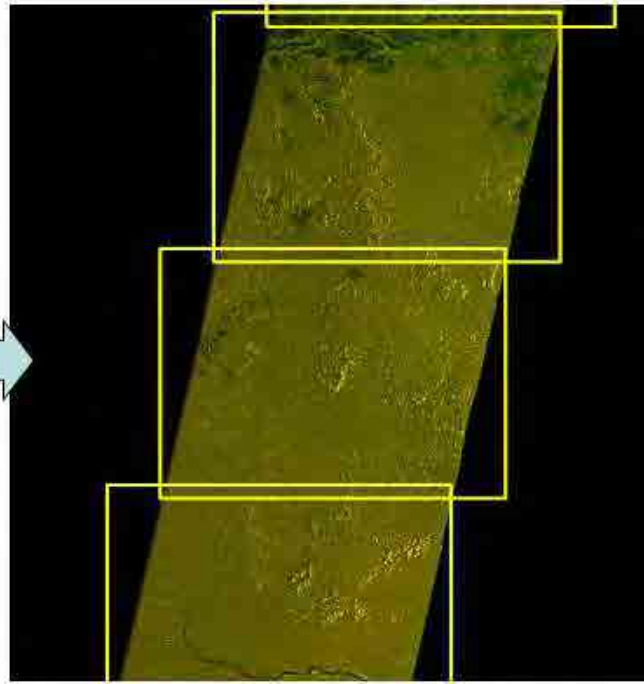
Rápido processo de detecção pelo PALSAR ScanMode



Pré-processamento de ScanSar

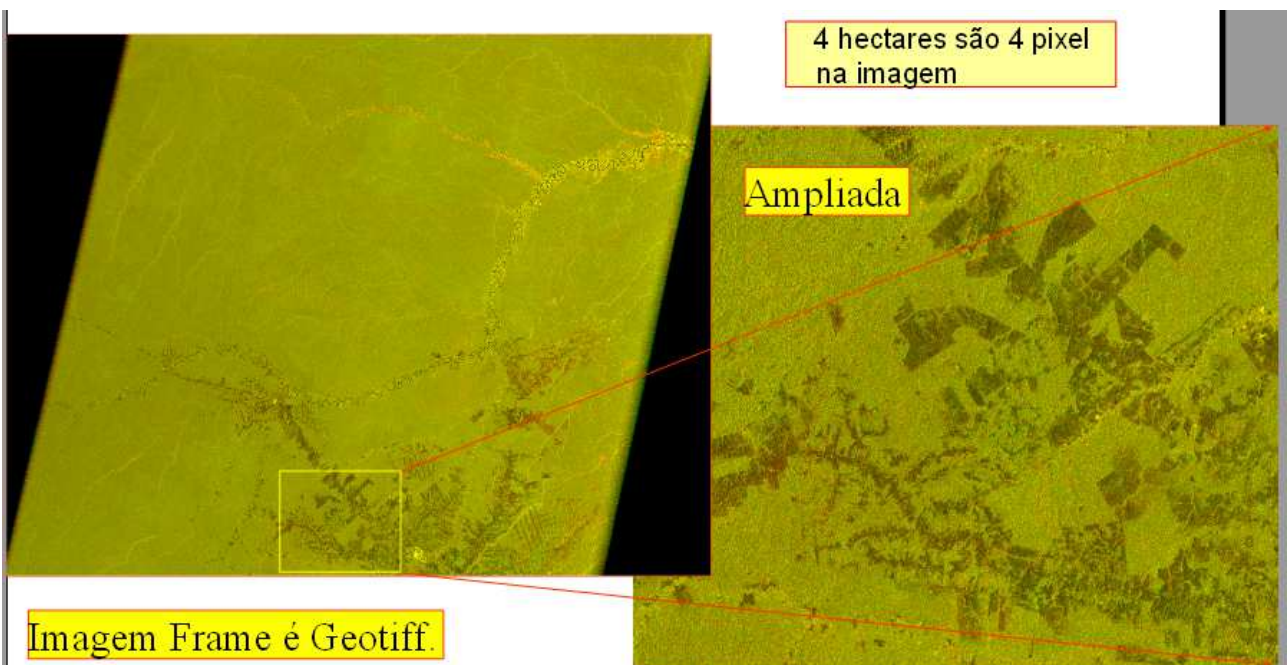


Composição de 2-3 cenas temporais de cor



Enquadramento pelo parâmetro de entrada (Framing by input parameter)

Imagem Frame de composição 2 datas



Exemplo de monitoramento por PALSAR FBS

As páginas a seguir mostram alguns exemplos de imagens PALSAR para mostrar itens em floresta do Parque Nacional de Brasília (mata de Cerrado) por PALSAR modo FBS (espaçamento de pixel é 6.25m).

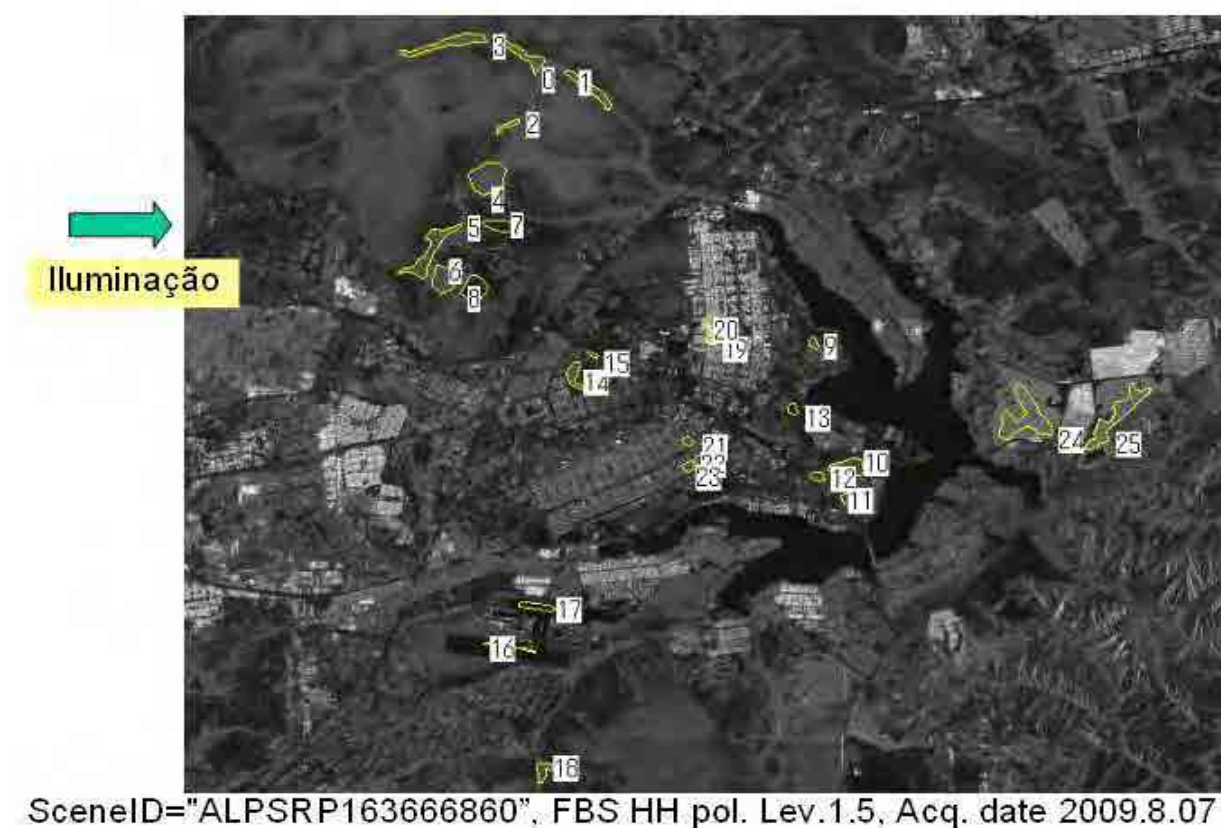
Sigma valor zero é uma indicação para discriminar C.

Neste exemplo, a correção de inclinação não é aplicada mas para discriminar o alvo com maior precisão, recomenda-se aplicar antes a correção de inclinação.

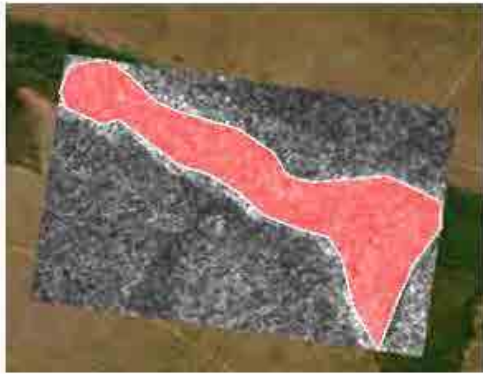
Nesta amostra, considere sigma zero para haver possibilidade de discriminar a floresta de outros objetos.

Imagens da superfície do solo são retiradas do Google Earth, que é fácil de identificar objetos em imagens.

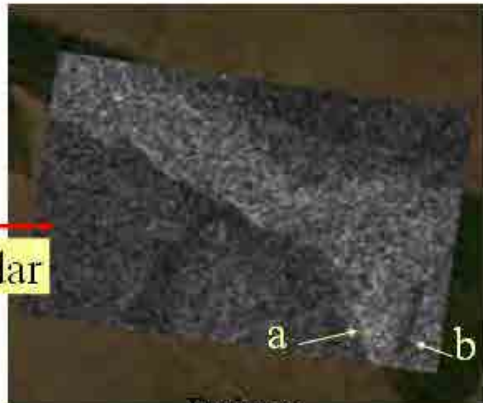
Local alvo e amostra do polígono de alocação



Polígono 0



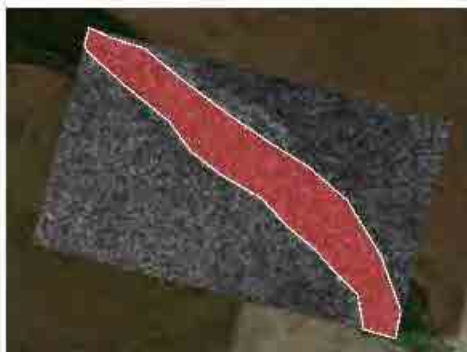
ótica



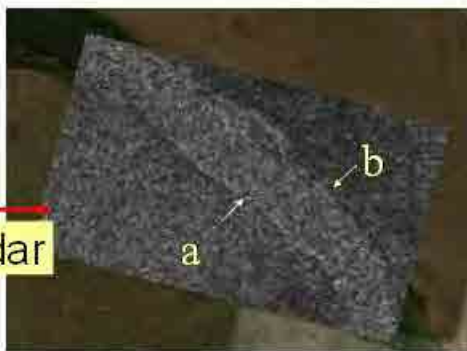
Radar

Palsar

Location			
Lat	15:41'47"S		
Long	47:57'58"W		
Shape	Indeterministic		
Size	narrow side width 150m		
[M]	-8.065		
std dev	2.651		
Texture	Fine		
Description	Depict forest with small trees. Fore edge of the forest to face radar illumination shows a little bit higher bright ness (a) while back side shows a shadow (b).		



ótica



Radar

Palsar

Location			
Lat	15:42'08"S		
Long	47:56'37"W		
Shape	Indeterministic		
Size	narrow side width 150m		
[M]	-8.422		
std dev	2.604		
Texture	Fine		
Description	Depict forest with small trees. Fore edge of the forest to face radar illumination shows a little bit higher bright ness (a) while back side shows a shadow (b).		

Polígono 1

Polígono 2



Radar

Location			
Lat	15:43'9"S		
Long	47:57'54"W		
Shape	Geometric shaped are		
Size	horizontal width of polygon is 810m		
AV	-7.621		
std dev	2.746		
Texture	Fine		
Description	Forest is well recognized by its brightness, tecture and fore edge and back edge of the forest..		

Polígono 3

Polígono 4



ótica



Radar

Palsar

Location			
Lat	15:44'12"S		
Long	47:58'1"W		
Shape	Indeterministic		
Size	radius of round is almost 500m		
[M]	-9.066		
std dev	2.602		
Texture	Smooth		
Description	Roundly marked grass or unvegetated area.		

Polígono 5



óptica

→
Radar



Palsar

Location			
Lat	15.45'46"S		
Long	47.58'40"W		
Shape	Indeterministic		
Size	narrowest width of polygon is 180m		
[M]	- 8.482		
std dev	2.721		
Texture	Fine		
Description	Fore boundary and aft boundary is easy to recognize.		

Polígono 6



ótica



→
Radar

Palsar

Location			
Lat	15:46'12"S		
Long	47:58'18"W		
Shape	Geometric shaped are		
Size	horizontal width of polygon is 750m		
ME	- 8.651		
std dev	2.514		
Texture	Fine		
Description	Low discrete trees, bare soil and grass area is shown in very low contrast.		

Polígono 7



ótica



Radar

Palsar

Location			
Lat	15:45'1"S		
Long	47:57'37"W		
Shape	Geometric shaped are		
Size	horizontal width of polygon is 810m		
3D	-15.947		
std dev	2.58		
Texture	Smooth		
Description	Low discrete trees, bare soil and grass area is shown in very low contrast.		

Polígono 8



ótica



Radar

Palsar

Location:			
Lat	15:46'16"S		
Long	47:57'43"W		
Shape	Geometric shaped area		
Size	horizontal width of polygon is 750m		
[M]	-14.697		
std dev	3.293		
Texture	Fine		
Description	Flat area is shown as dark pixels. Individual trees are recognized as bright dot.		

Monitoramento da Floresta / Desmatamento de área PALSAR FBS

As páginas seguintes são exemplos de partes de Rondônia pelo PALSAR FBD (15m de amostragem espacial de imagens dupla polarização: HH e HV).

Estatísticas Sigma zero mostram a distinção de florestas típicas / não-florestas, mas a cor nesta cena típica nos ajuda a compreender as diferenças de destino.

Existe a possibilidade de aplicar os dados estatísticos para a classificação da floresta e não floresta, bem como a classificação automática do desmatamento....

Interpretação de composição FBD



Vermelho: reflexão da superfície do solo, nua ou com uso humano

Amarelo: superfície aleatória ou árvores baixas ou pasto

Verde: floresta

Preto : água parada ou superfície lisa

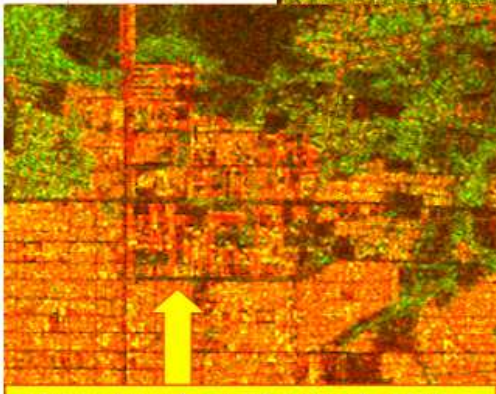
Escuro na área florestal: corte raso ou corte seletivo

Exemplo de monitoramento florestal

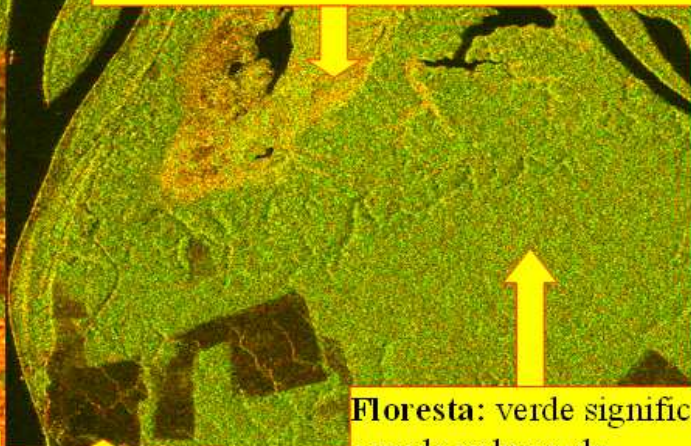
Composição de cor HH-HV

Rio: Baixa reflexão HH e HV significa superfície plana como a superfície da água

Gramma ou campo de árvores de baixo: Baixa reflexão HH significa nivelamento da média, enquanto reflexão HV relativamente alta significa converter polarização do objeto como galhos inclinados de árvores baixas....



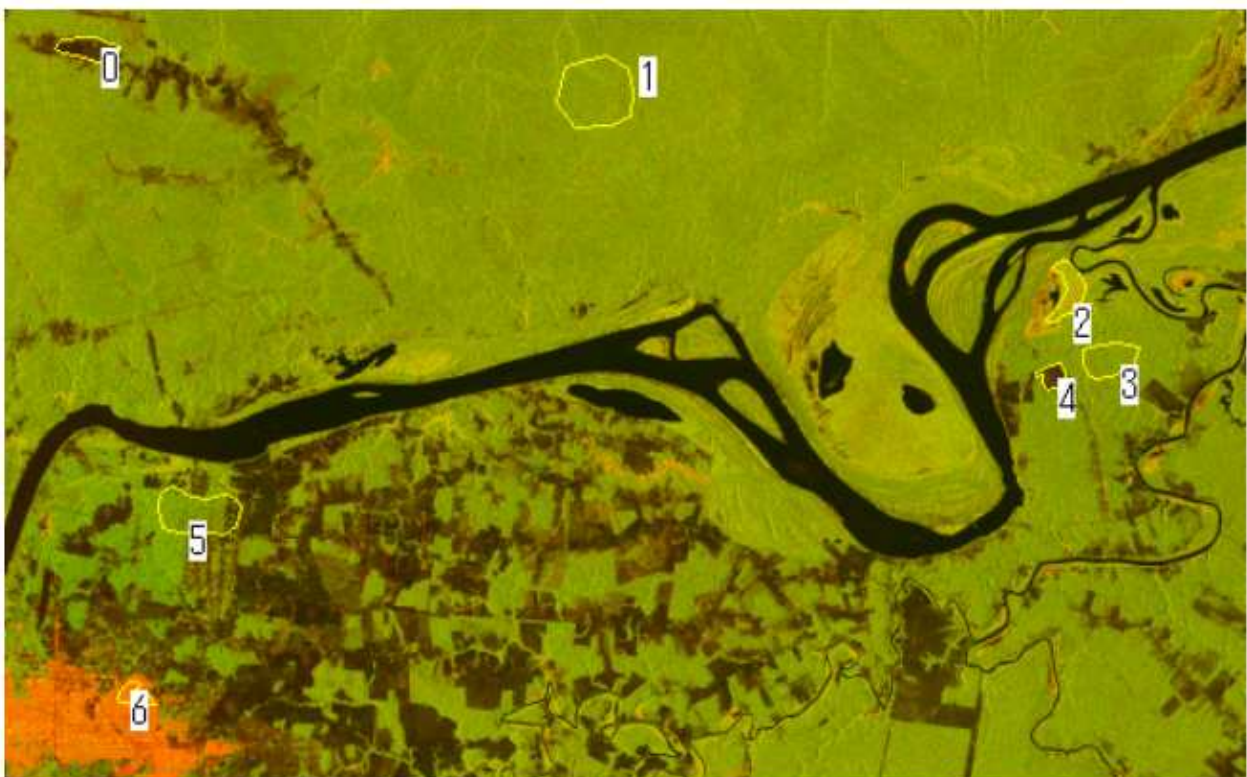
Cidade: alta reflexão de HH significa uma combinação de objetos geométricos simples.



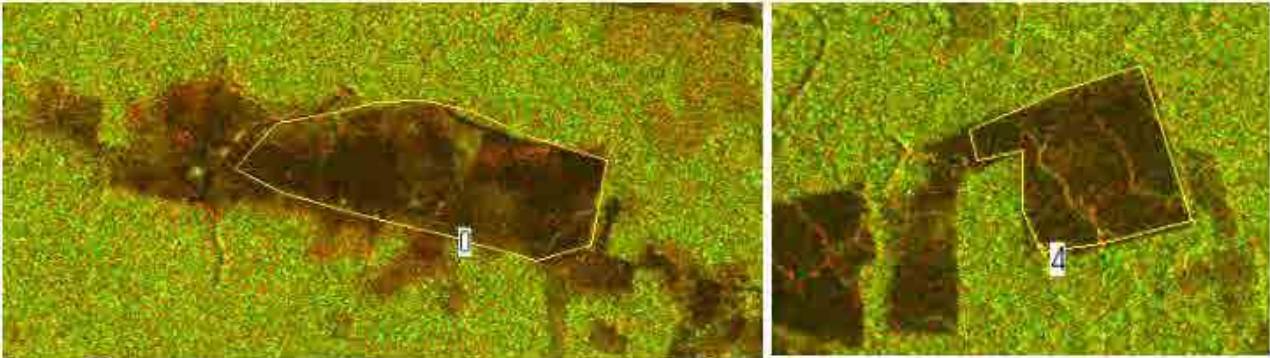
Desmatamento

Floresta: verde significa grande volume de espalhamento por causa das árvores altas.

Área Teste

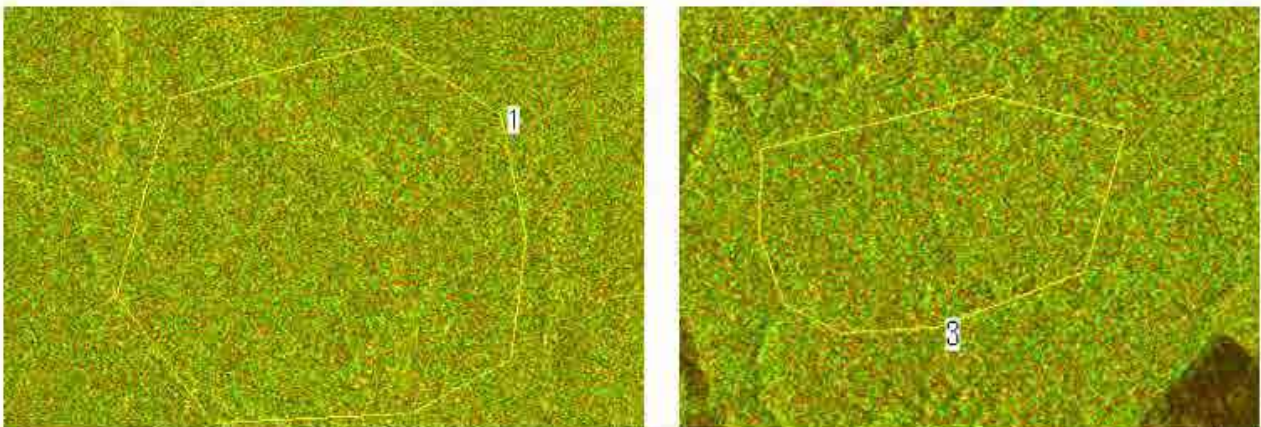


Polígono 0 e 4 (área desmatada)



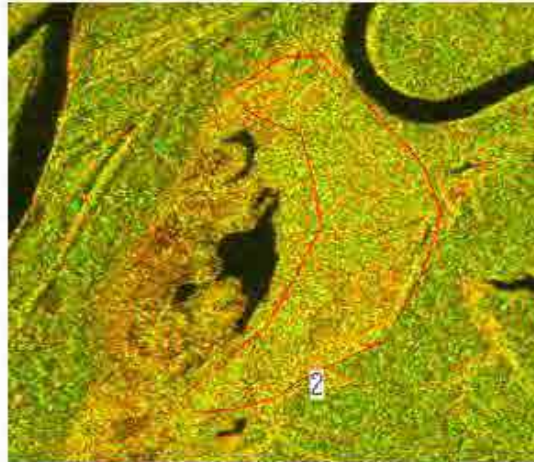
Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	- 13.124	3.479	- 22.101	3.592	deforestation
1	- 8.164	2.718	- 13.235	2.716	forest
2	- 5.579	2.812	- 12.307	2.715	grass or low tree
3	- 8.427	2.704	- 13.52	2.779	forest
4	- 13.384	3.342	- 21.375	3.165	deforestation
5	- 9.726	3.352	- 14.767	3.944	forest and load
6	2.778	4.749	- 15.692	3.437	city

Polígono 1 e 3(Floresta)



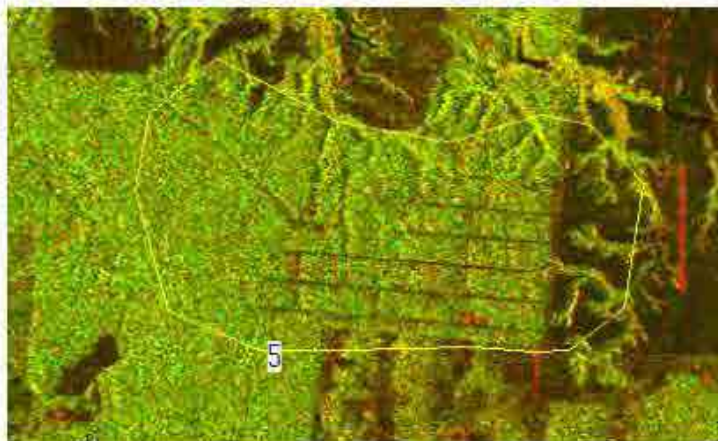
Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	- 13.124	3.479	- 22.101	3.592	deforestation
1	- 8.164	2.718	- 13.235	2.716	forest
2	- 5.579	2.812	- 12.307	2.715	grass or low tree
3	- 8.427	2.704	- 13.52	2.779	forest
4	- 13.384	3.342	- 21.375	3.165	deforestation
5	- 9.726	3.352	- 14.767	3.944	forest and load
6	2.778	4.749	- 15.692	3.437	city

Polígono 2 (Campo ou árvores baixas)



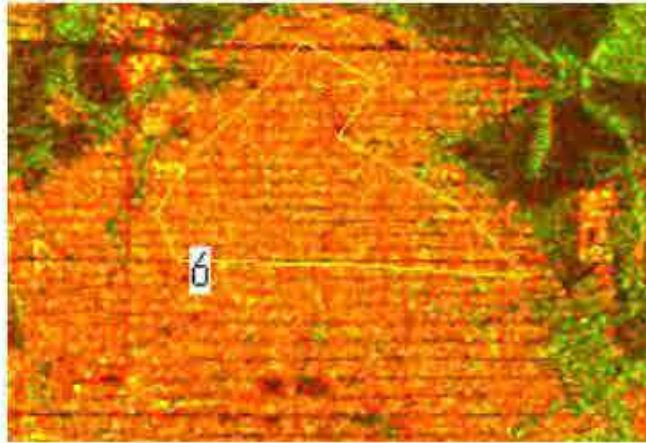
Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	- 13.124	3.479	- 22.101	3.592	deforestation
1	- 8.164	2.718	- 13.235	2.716	forest
2	- 5.579	2.812	- 12.307	2.715	grass or low tree
3	- 8.427	2.704	- 13.52	2.779	forest
4	- 13.384	3.342	- 21.375	3.165	deforestation
5	- 9.726	3.352	- 14.767	3.944	forest and load
6	2.778	4.749	- 15.692	3.437	city

Polígono 5(Floresta e entrada de acesso)



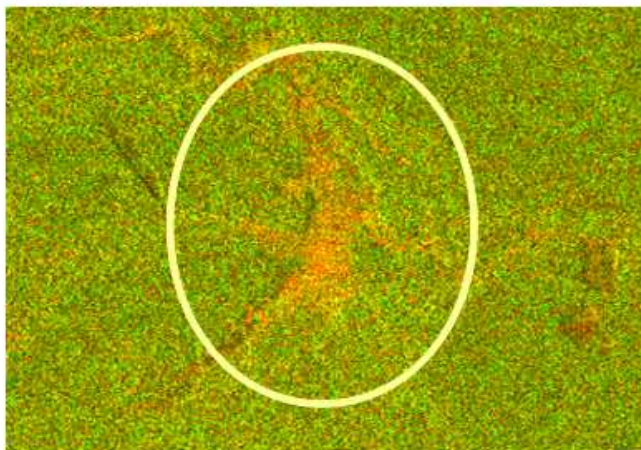
Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	- 13.124	3.479	- 22.101	3.592	deforestation
1	- 8.164	2.718	- 13.235	2.716	forest
2	- 5.579	2.812	- 12.307	2.715	grass or low tree
3	- 8.427	2.704	- 13.52	2.779	forest
4	- 13.384	3.342	- 21.375	3.165	deforestation
5	- 9.726	3.352	- 14.767	3.944	forest and load
6	2.778	4.749	- 15.692	3.437	city

Polígono 6 (Área Residencial)



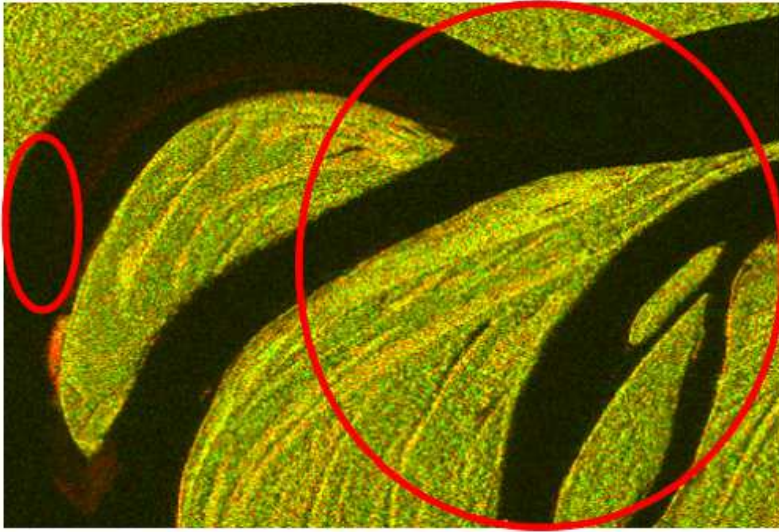
Polygon	HH- s0	HH- stdDev	HV- s0	HV- stdDev	Description
0	- 13.124	3.479	- 22.101	3.592	deforestation
1	- 8.164	2.718	- 13.235	2.716	forest
2	- 5.579	2.812	- 12.307	2.715	grass or low tree
3	- 8.427	2.704	- 13.52	2.779	forest
4	- 13.384	3.342	- 21.375	3.165	deforestation
5	- 9.726	3.352	- 14.767	3.944	forest and load
6	2.778	4.749	- 15.692	3.437	city

Vermelho/Laranja na floresta



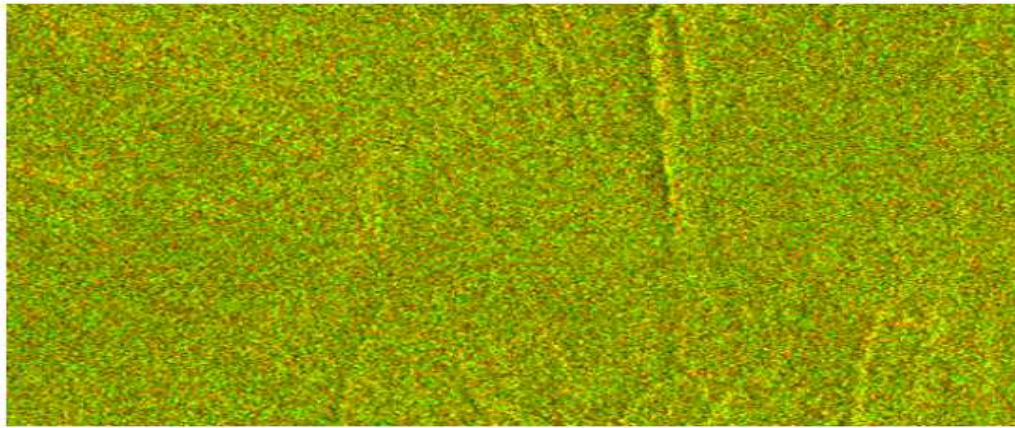
Área vermelha/alaranjada que aparece nas imagens FBD (RG=HH,HV) , é um solo nu ou que sofreu uso do homem. A razão dessa coloração é que houve dispersão relativamente fraca para trás do componente HV, o que significa que o volume de espalhamento está baixo. Assim, a área é rugosa mas a reflexão da superfície é dominante.

Amarelo em área de floresta



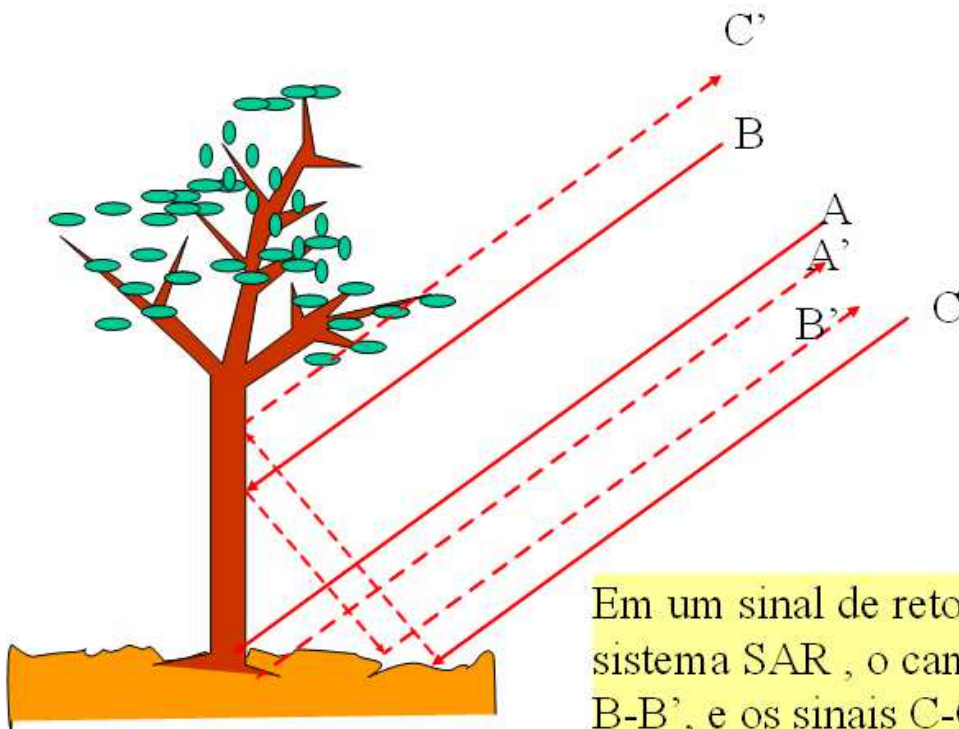
Amarelo em imagem FBD (RG=HH,HV) é campo ou árvores baixas. A razão é que o volume de espalhamento existe mas o valor é baixo comparado com o da floresta, o que significa que árvores baixas e campos causam redução do volume de espalhamento.

Verde em imagem FBD



Verde em imagem FBD (RG=HH,HV) é floresta. A razão é que o volume de espalhamento é alto, o que significa reflexão forte causada pela soma do duplo salto de espalhamento pelas árvores.

Reflexão pelas árvores



Em um sinal de retorno de um sistema SAR, o caminho A-A', B-B', e os sinais C-C' aparecem no mesmo pixel.

Conclusão da discriminação de florestas e não florestas pela FBD

PALSAR FBD é relativamente sensível à reconhecer áreas florestais na imagem.

Alguma possibilidade de classificar floresta existe, mas não é realizado ainda.

É necessária uma análise mais estatística para realizar uma classificação automática.

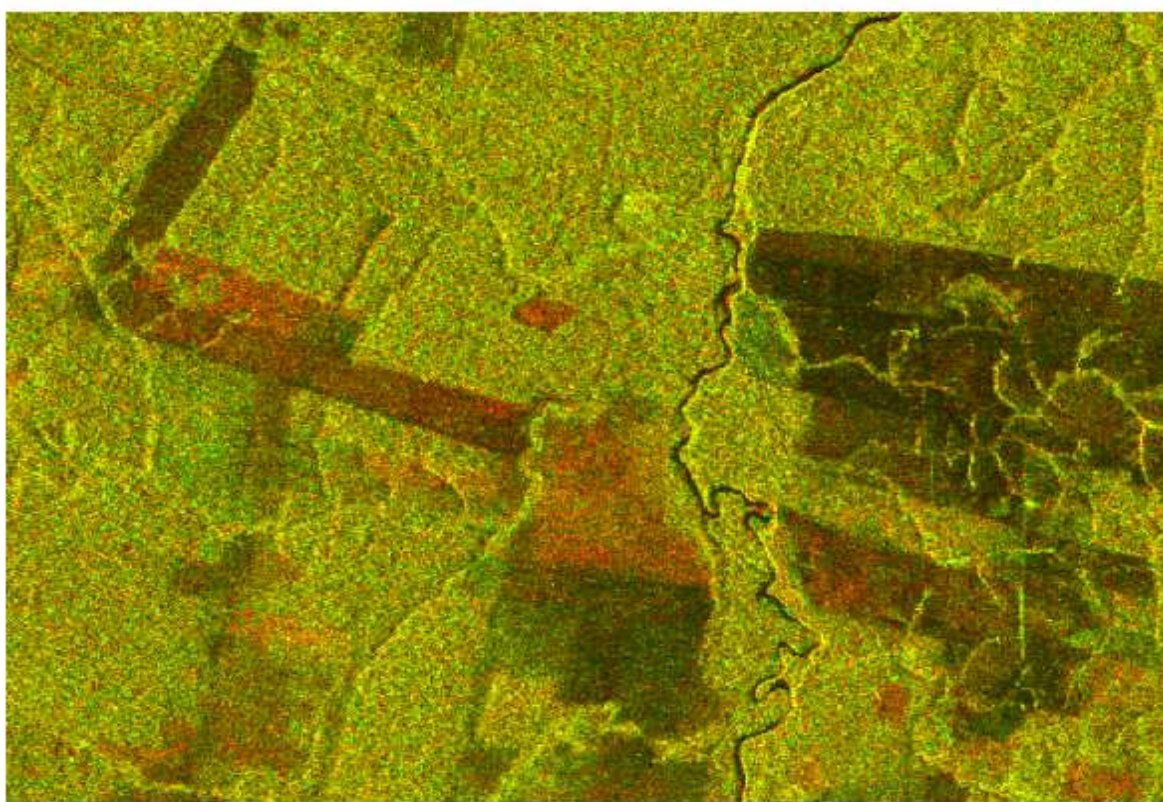
Deteção de mudança e encontrar novos desmatamentos

O efeito do desmatamento é a alteração de rugosidade superficial e a diminuição do volume de dispersão, o que provoca diferença no retroespalhamento.

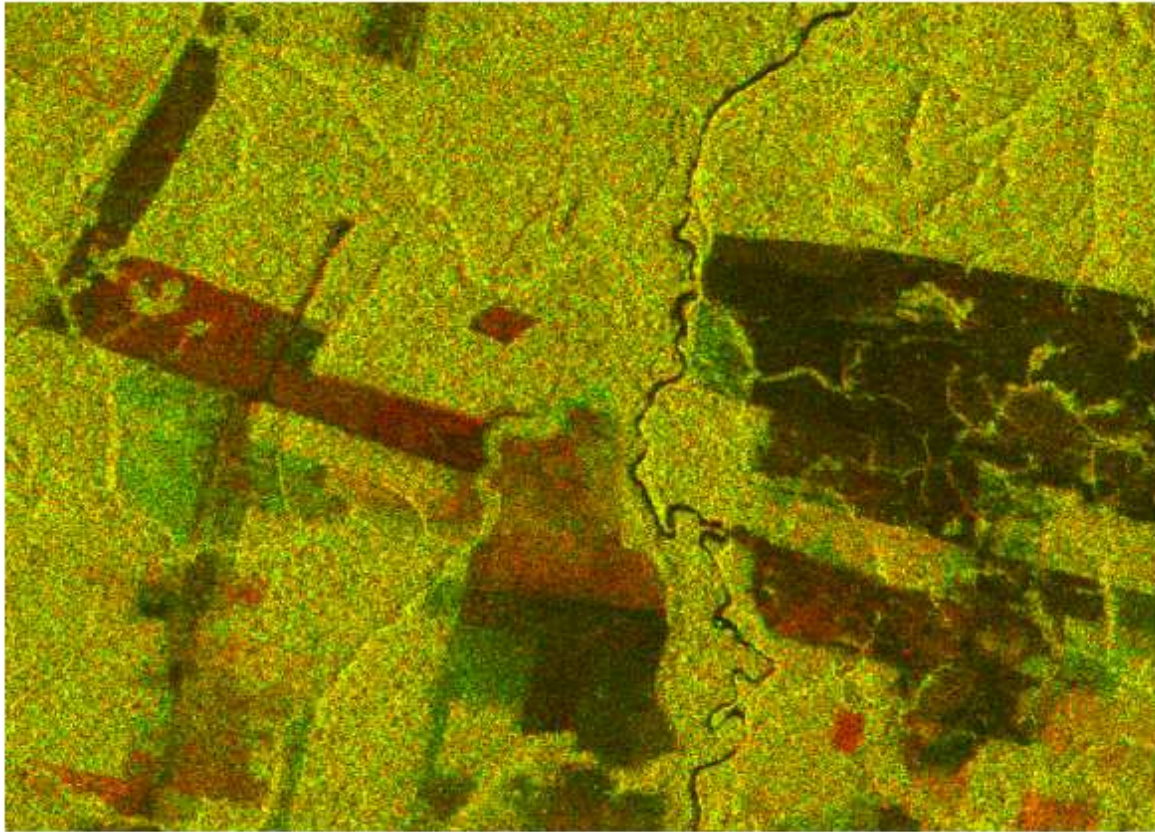
Análise de séries temporais é um bom método para detectar o desmatamento.

Composição Multi temporal colorida com o mesmo parâmetro de dados SAR e comparação da mudança Multi temporal será um bom método para identificar desmatamentos recentes.

Composição Multi temporal colorida (HH-HH)



Composição Multi temporal colorida (HV-HV)



Interpretação de imagem da composição de imagens Multi temporais



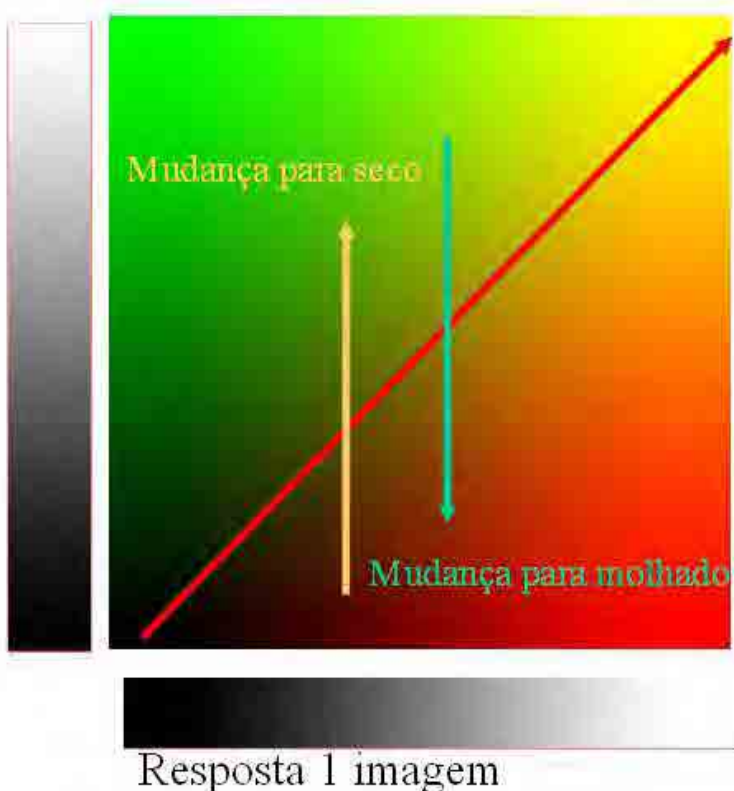
Em uma imagem PALSAR a intensidade varia de escuro para claro, dependendo da condição da superfície do alvo.

Em geral, uma superfície plana mostra reflectância escuro. E uma superfície plana é geralmente feita por água parada ou superfície molhada.

Neste contexto, a área escura pode ser uma superfície plana, ou ainda área coberta de água e área iluminada é a área áspera ou seca.

Composição colorida de duas imagens (Interpretação seco-molhado)

Resposta 2 imagens

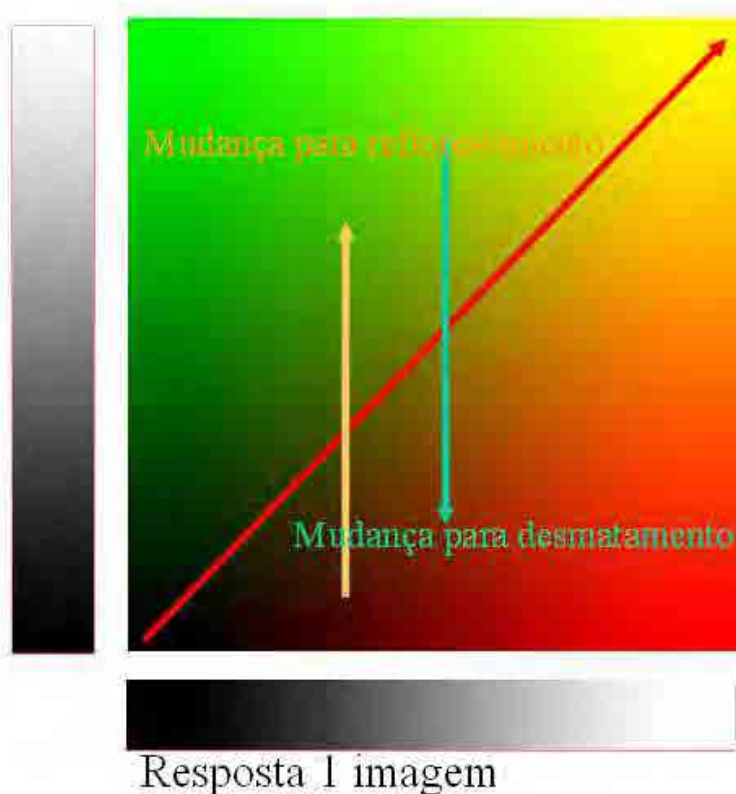


Nenhuma linha de mudança

A interpretação de secos e molhados é aplicável no pantanal, brejo, plantação de arroz ou área inundada.

Composição de duas imagens (Interpretação de Reflorestamento e Desmatamento)

Resposta 2 imagens



Nenhuma linha de mudança

Uma superfície plana é geralmente causada por corte de árvores na área florestal. Então, na composição de 2 imagens uma área pode ser interpretada como desmatamento ou reflorestamento em área de floresta.

Avaliação do desmatamento

Parte Amarela: nenhuma mudança durante dois períodos de observação.

Vermelho (claro ou escuro): novos desmatamentos ou áreas degradadas ou vegetação.

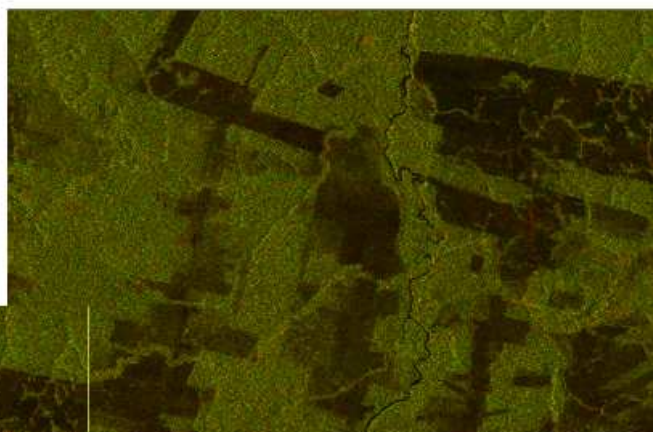
Verde: área reflorestada ou aumento de floresta ou vegetação.

Composição HV: maior contraste e fácil de reconhecer as mudanças

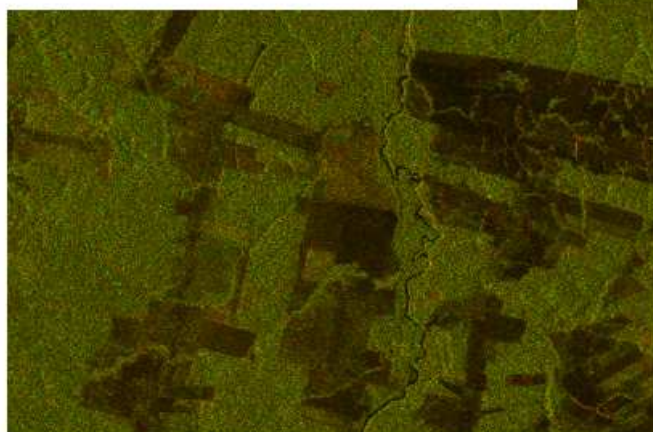
Isto é devido à resposta sensível da vegetação no volume de espalhamento HV.

Mudança Multi temporal FBD

Ao pressionar a chave “v” após a abertura da imagem dupla FBD observada em diferentes datas, você pode reconhecer se mudou alguma área da imagem.



Nova



Antiga

IDENTIFICAÇÃO VISUAL DE NOVOS DESMATAMENTOS NAS IMAGENS SCANSAR.

O INDICAR trabalha com a composição colorida de imagens ScanSAR cedidas pela Agência Aeroespacial Japonesa (JAXA) de datas distintas em aproximadamente 90 dias.

Para identificar os novos desmatamentos inicialmente excluimos os desmatamentos já identificados pelos sistemas oficiais. Foi criada uma máscara que agrega os polígonos PRODES (o mais recente), DETER (acumulado no ano) e INDICAR (polígonos identificados anteriormente)

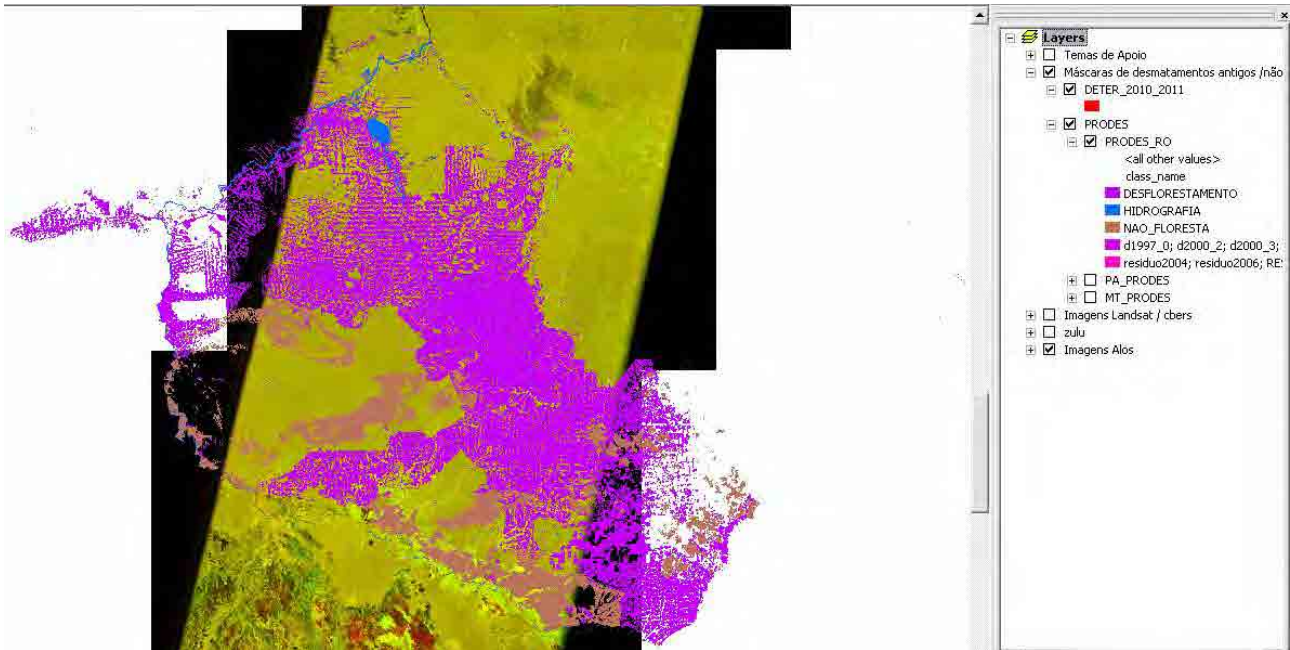
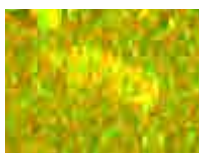


Figura 01: Máscaras de Rondônia.

Partimos então para a identificação visual dos desmatamentos, levando em consideração o brilho e a forma dos polígonos. O processo é realizado na escala 1:150.000, permitindo a definição de áreas de no mínimo 40 hectares.

No caso dos desmatamentos recentes procuramos polígonos com formas antropizadas (regulares, o que indica grande chance de ter sido uma intervenção humana), denotando uma transformação não-natural. Acreditamos que os desmatamentos recentes apresentem este padrão de brilho devido ao conjunto solo com umidade superficial (constante dielétrica) + sujeira resultante do desmatamento (Double bounce e volume scattering), e o padrão geométrico ocorre



Desmatamento: Brilho elevado, poligonal definida.

Existem outros padrões encontrados em grande numero nas composições ScanSAR, sendo os principais:



Floresta: caracterizado pela difusão das ondas, não apresenta um padrão definido.



Mata Galeria: Apresenta intensidade de brilho mais intensa que a floresta. O fato de circundar os cursos d'água permite o reconhecimento devido ao formato incomum.



Desmatamento antigo: Pouca intensidade de brilho causado pela reflexão especular, pois os alvos agem como superfícies lisas.



Relevo acidentado: apresenta regiões com alto brilho porem próximo existem regiões escurecidas e seguem um padrão de direcionamento devido as sombras geradas pela posição do sensor em relação ao alvo



Áreas alagadas: brilho intenso, facilmente confundido com desmatamentos, distinguindo-se pela forma e sazonalidade.

No exemplo a seguir identificamos as seguintes feições:

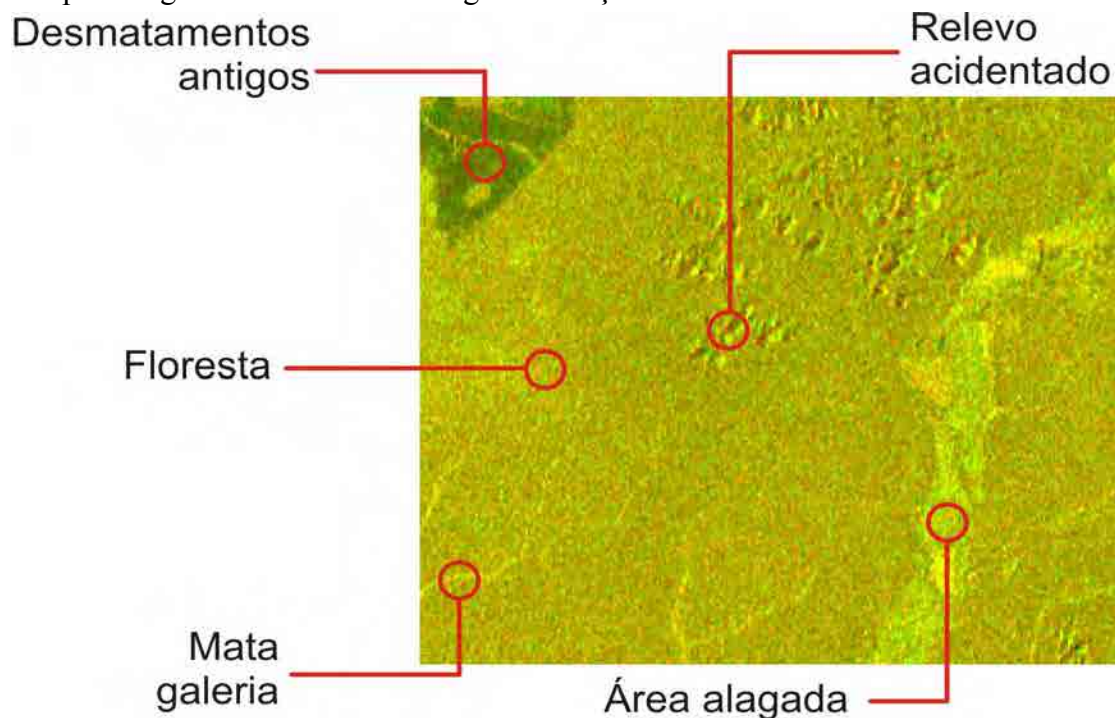


Figura 2: feições identificadas visualmente na composição dos ciclos 41 e 39 em Rondônia.

Com a ajuda das máscaras simplificamos a identificação visual das feições, pois a área a ser supervisionada diminui sensivelmente e evitamos a detecção repetida de polígonos.

Outros fatores subjetivos são levados em consideração na delimitação ou não de um desmatamento.

Fatores que confirmam um desmate são os seguintes:

- Proximidade de desmatamentos antigos, definidos pelo PRODES;
- Proximidade de desmatamentos recentes, definidos pelo DETER e INDICAR;
- Proximidade a estradas.

Fatores que geram dúvidas na delimitação de polígonos:

- Proximidade a matas galeria e cursos d'água;
- Proximidade a áreas de “não floresta” definidas pelo PRODES.
- Proximidade a relevos acidentados;
- Formato não regular do polígono.

No exemplo a seguir, temos uma área identificada como desmate, próximo a desmatamentos antigos e uma grande área classificada como “não floresta” pelo sistema PRODES:

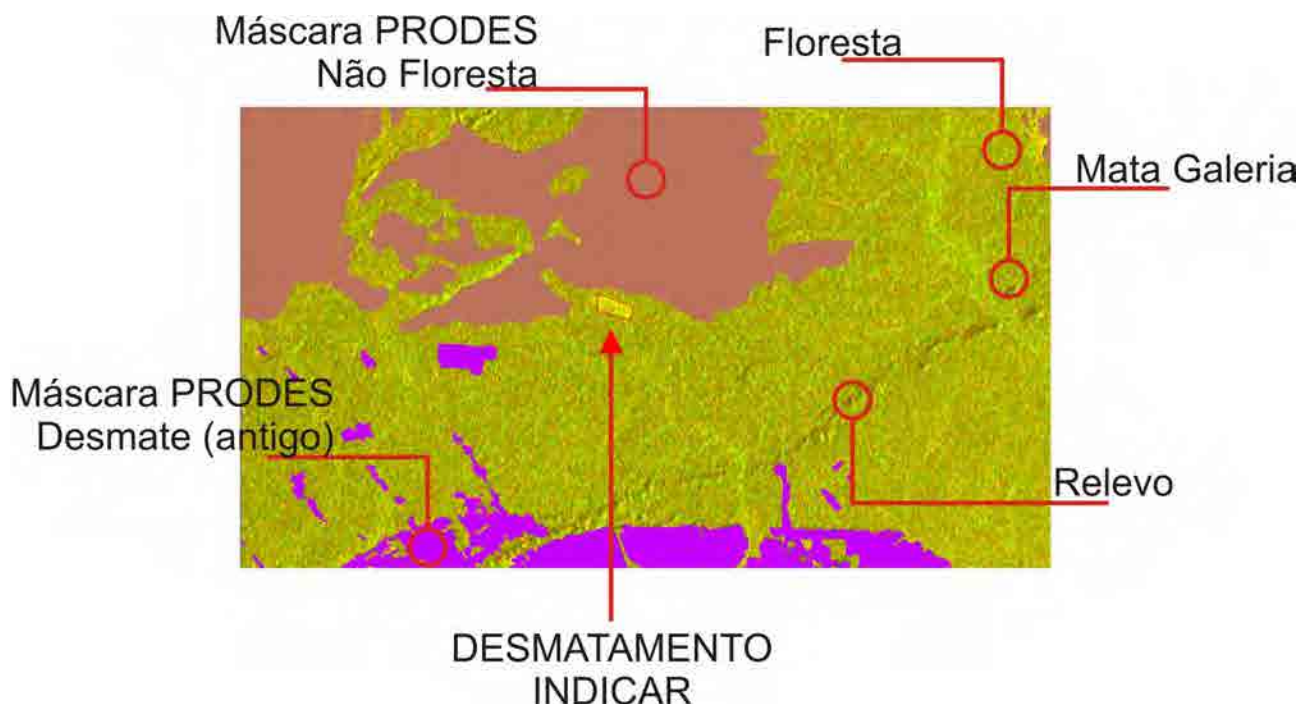


Figura 03: identificação de desmatamento na composição de imagens ScanSAR.

Como podemos notar, a metodologia é baseada em conceitos visuais e subjetivos para definição do desmatamento, ainda assim apresentou alto índice de acerto nas validações feitas pelo CSR e no trabalho de campo desenvolvido pela fiscalização.

Nota sobre a mesma área que cobre os dados

Em várias análises de dados temporais, é necessário obter dados que cobrem a mesma área na observação de dados diferente.

Condições para cobrir uma mesma área pode ser verificada no próprio nome do arquivo de dados padrão modo PALSAR.

5 primeiros dígitos do nome código numérico (caracter vermelho abaixo) mostra o número do ciclo de órbita. Todos os 671 ciclos do satélite voltam ao mesmo lugar.

A segunda de 4 caracteres (caracter azul abaixo) mostra a posição do frame em órbita sobre o ciclo.

Assim **XXXXX+671*N** significa mesma órbita e a mesma **YYYY** cobrindo a mesma área.



IMG-HH-ALPSR123456789L1.5

Análise mais profunda de detecção de mudança

Interferometria Diferencial é uma ferramenta promissora para detectar sensíveis mudanças.

Existe a possibilidade de identificar o corte seletivo ou atividades mineiras detectando as alterações de superfície com precisão.

A aplicação está além do escopo deste manual.

Isto será discutido em cursos avançados SAR.

2011

Manual de Utilização de Imagens SAR/ALOS



ÁREA DE PERÍCIAS EM MEIO AMBIENTE
DEPARTAMENTO DE POLÍCIA FEDERAL
06/05/2011

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1. Breve explicação sobre imagens de radar

As imagens de radar são resultado do registro da radiação eletromagnética no intervalo das micro-ondas (figura 1). Essas imagens possuem algumas vantagens em relação a imagens que captam a radiação no intervalo do espectro do visível e infravermelho devido a:

- i) alta transmissibilidade das micro-ondas na atmosfera;
- ii) a independência em relação à iluminação solar, permitindo imageamento noturno;
- iii) a capacidade das micro-ondas de atravessar nuvens, chuva e poeira.

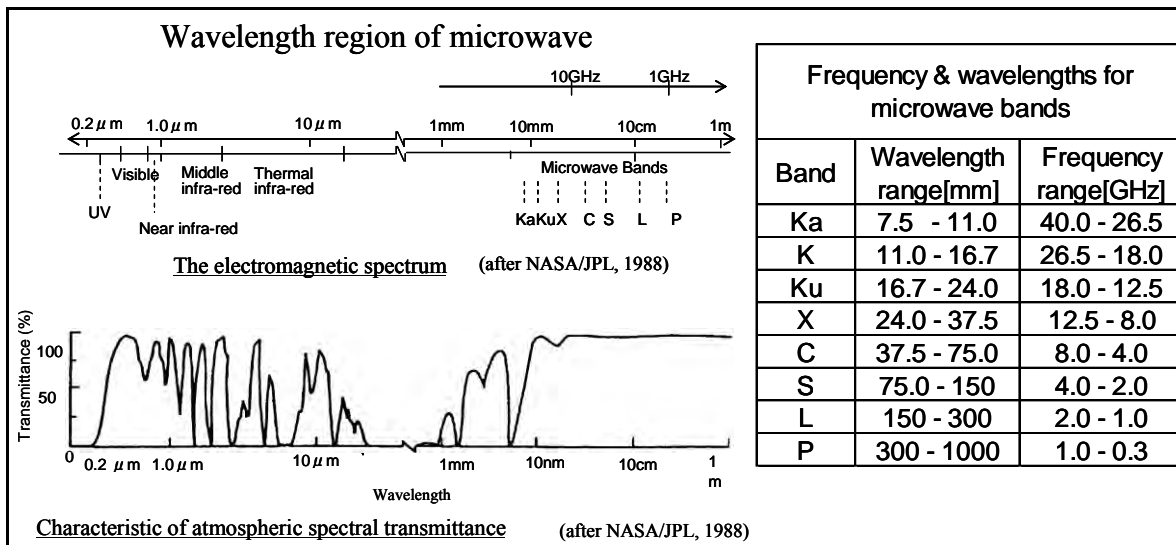


Figura 1 – Espectro da radiação eletromagnética com ênfase para a região das micro-ondas.

O sensor utilizado para obtenção das imagens de radar é um instrumento que fica acoplado a uma plataforma que pode ser uma aeronave ou um satélite. O processo de imageamento é ativo, pois a antena do sensor emite e capta pulsos de radiação eletromagnética no intervalo do comprimento de onda das micro-ondas (1 cm a 1 m, cuja frequência corresponde a faixa de 0,3 GHz a 30 GHz) que retornam à antena após interação com a superfície terrestre. Atualmente o principal sistema de radar imageador é o Radar de Abertura Sintética (SAR), cujo funcionamento será explicado adiante.

Os pulsos emitidos pela antena dos radares imageadores costumam estar entre as frequências de 1 a 2 GHz, correspondente a banda L das micro-ondas. Na superfície terrestre esses pulsos são retroespalhados em várias direções, sendo parte deles refletidos de volta para a antena do radar. Os pulsos retroespalhados atingem a antena do radar na forma de ecos enfraquecidos em relação aos pulsos emitidos e são recebidos com uma polarização específica, horizontal ou vertical, não tendo necessariamente a mesma polarização dos pulsos emitidos. Os ecos captados são convertidos em sinais digitais que posteriormente são processados para compor a imagem de radar.

Cada pixel da imagem de radar representa o retroespalhamento das micro-ondas para uma determinada área na superfície terrestre. Áreas escuras na imagem de radar representam baixo retroespalhamento das micro-ondas, enquanto que áreas claras indicam o contrário, ou seja, significam que grande parte da energia das micro-ondas foi refletida na direção da antena do radar.

O retroespalhamento para um determinado comprimento de onda das micro-ondas varia, basicamente, conforme o tamanho dos objetos na superfície terrestre, a diversidade dos objetos, a polarização dos pulsos, o ângulo de incidência dos pulsos e a direção dos corpos na superfície terrestre. Áreas que possuem objetos com tamanho similar ao comprimento de onda utilizado pelo radar (15 a 30 cm no caso da banda L) tendem a aparecer mais claras nas imagens devido ao maior retroespalhamento, enquanto que as áreas onde ocorrem objetos menores que o comprimento de onda aparecem escuras.

Portanto, quanto maior o retroespalhamento das micro-ondas numa dada região, mais clara será essa área na imagem de radar, correspondendo a uma superfície mais áspera/rugosa. A vegetação, por exemplo, geralmente se comporta como uma superfície áspera em relação aos comprimentos de onda utilizados pela maioria dos radares e aparecem em cinza ou cinza claro nas imagens de radar.

As superfícies planas que refletem pouca radiação para a antena do radar aparecerão mais escuras nas imagens de radar como, por exemplo, as estradas. As edificações que não estão orientadas de forma a refletir a radiação diretamente para o radar aparecerão em tons de cinza claro, como se fossem superfícies ásperas. Outra situação comum é quando a radiação refletida nas ruas se soma à radiação refletida pelas edificações devido à orientação espacial desses objetos e retorna direto para a antena do radar, o que resulta em tons muito claros (branco) nas imagens de radar.

Superfícies inclinadas na direção do radar serão mais claras nas imagens por terem um retroespalhamento maior do que aquelas superfícies que não são atingidas pelas micro-ondas do radar por estarem situadas, por exemplo, atrás de uma montanha.

Outro fator que influencia no retroespalhamento da radiação são as propriedades elétricas dos alvos, incluindo o teor de água. Objetos úmidos aparecem mais claros, enquanto que objetos secos aparecem escuros nas imagens. Entretanto, corpos d'água com superfície lisa (sem marolas) irão refletir a radiação para longe da antena do radar (ângulo de incidência = ângulo de reflexão) e serão escuros na imagem.

O ângulo de incidência da radiação emitida pelo radar também influencia no retroespalhamento. Quanto mais perpendicular à superfície maior o retroespalhamento, que tende a diminuir com o aumento do ângulo de incidência.

Por fim, o retroespalhamento também varia conforme a polarização da radiação emitida. Alguns radares do tipo SAR emitem radiação micro-ondas tanto com a polarização horizontal (H) quanto vertical (V) e recebem os pulsos refletidos com polarização H ou V. Logo, temos as seguintes possíveis combinações HH (emissão H, recepção H), VV, HV e VH.

2. O Satélite ALOS

O termo ALOS vem do inglês *Advanced Land Observing Satellite* ou Satélite Avançado de Observação da Terra. Em japonês seu nome é DAICHI. O satélite foi lançado em 24/01/2006 do Centro Espacial de Tanegashima no Japão com o foguete H-IIA. Foi projetado para funcionar por um período de três a cinco anos.

Compõe o grupo dos satélites japoneses de observação dos continentes, sucedendo os satélites JERS-1 (*Japanese Earth Resources Satellite – 1*) e o ADEOS (*Advanced Earth Observing Satellite*). Foi criado para ser usado para cartografia, monitoramento e exploração de recursos naturais e monitoramento de desastres (figura 2).

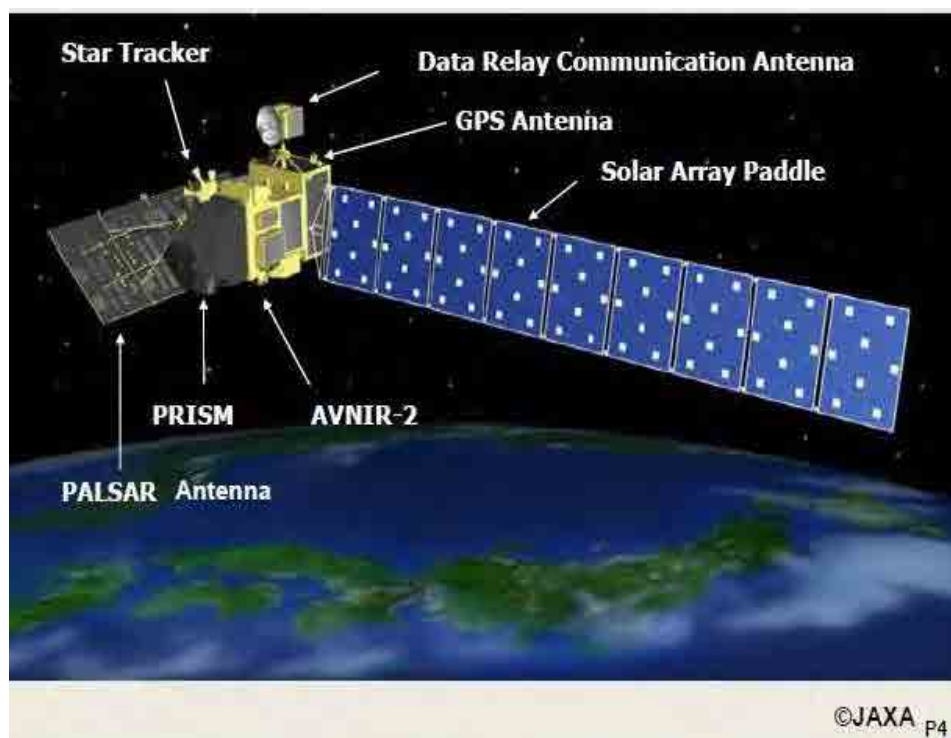


Figura 2: Satélite Avançado de Observação da Terra - ALOS. Fonte: JAXA

O ALOS é um dos maiores satélites de observação da Terra. Tem peso de aproximadamente 4 toneladas e tamanho de 3,5 metros de largura, 4,5 metros de comprimento e 6,5 metros de altura e o seu painel solar mede 22 x 3 metros. A velocidade de transmissão de dados é de 240 Mbps por DRTS (*Data Relay Test Satellite*) ou de 120 Mbps por transmissão direta da estação. Em 22/04/2011, o satélite ALOS parou de funcionar, encerrando seu ciclo de vida útil. Há a previsão de lançamento do satélite ALOS2 até 2013.

O satélite possui órbita heliossíncrona e funciona a uma altitude de 691,65km na linha do Equador a uma inclinação de 98,16 graus. Sua resolução temporal é de 46 dias, com subciclos de dois dias. Assim, a cada ciclo de 46 dias o satélite passa por 671 órbitas, compondo assim oito ciclos por ano. No primeiro ano, os primeiros ciclos (1 e 2) serviram para a realização de testes de avaliação

do satélite, os ciclos 3 a 6 serviram para testes de calibração e validação e, a partir do 7º ciclo foram iniciadas as aquisições de imagens de acordo com a estratégia de observação da JAXA.

O satélite tem três instrumentos de sensoriamento remoto, sendo dois sensores ópticos (PRISM e AVNIR2) e uma antena PALSAR.

2.1 O Sensor PRISM

O instrumento PRISM – *Panchromatic Remote-sensing Instrument for Stereo Mapping* ou Instrumento de Sensoriamento Remoto Pancromático para Mapeamento Estéreo consiste em um conjunto de três telescópios pancromáticos de 2,5 metros de resolução espacial. Tem capacidade de visada dianteira, traseira e nadir, utilizadas para criação de pares estereoscópicos e modelos numéricos de terreno de alta precisão. O telescópio que imageia em nadir cobre uma faixa de 70 km ao passo que os demais cobrem faixas de 35 km de largura cada. O comprimento de onda deste instrumento é de 0.52~0.77 micrometros e a codificação é de 8 bits.

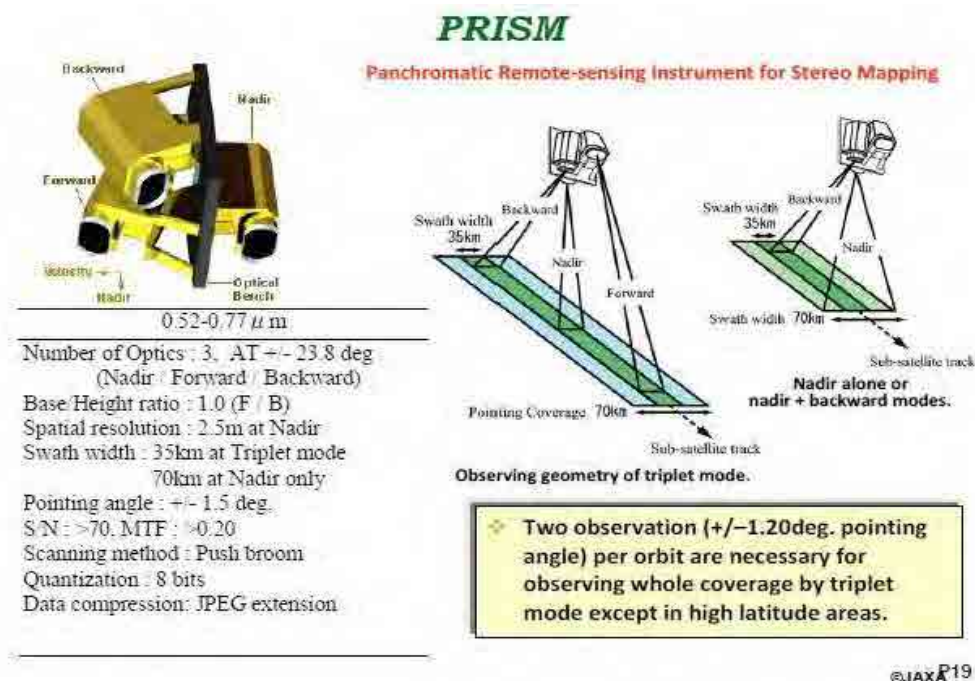


Figura 3: Características do PRISM - Instrumento de Sensoriamento Remoto Pancromático para mapeamento estéreo. Fonte: JAXA

2.2 O Sensor AVNIR

O instrumento AVNIR2 – *Advanced Visible and Near Infrared Radiometer type 2* ou Radiômetro Avançado para Regiões do Visível e Infravermelho Próximo Tipo 2, possui 4 bandas com os seguintes comprimentos de onda: B1=0.42~0.5 mm (Azul), B2=0.52~0.60 mm (Verde), B3=0.61~0.69 mm (Vermelho), B4=0.76~0.89 mm (Infravermelho próximo). Torna possível a produção de imagens multiespectrais coloridas clássicas, como as do LANDSAT e SPOT, com resolução espacial de 10 metros. A faixa imageada é de 70 km em nadir e o sensor pode ser dirigido para imagear faixas laterais a sua órbita quando necessário. Sua codificação, assim como o PRISM, é de 8 bits.

AVNIR-2

Advanced Visible and Near Infrared Radiometer type 2

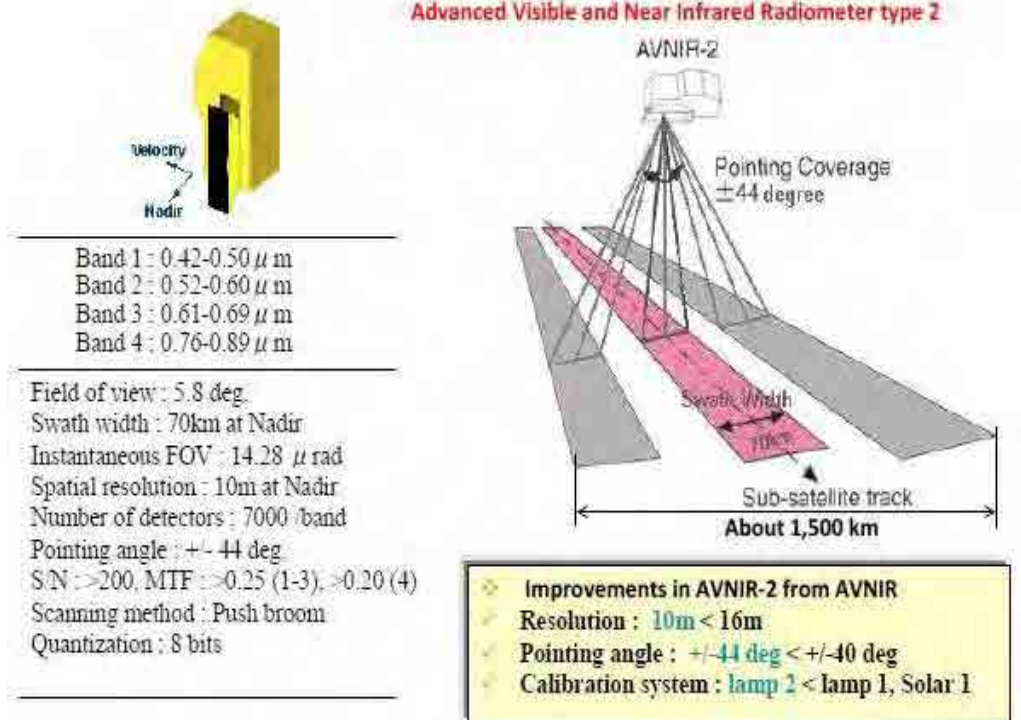


Figura 4: Características do sensor AVNIR-2 - Radiômetro Avançado para Regiões do Visível e Infravermelho Próximo Tipo 2. Fonte: JAXA

2.3 O Sensor PALSAR

O instrumento PALSAR – *Phased Array type L-band Synthetic Aperture Radar* é um radar de abertura sintética (SAR) que opera em banda L, com resolução de 10 a 100 metros. Pode produzir imagens em três modos: Fine Resolution Mode, ScanSAR Mode e Polarimetric Mode.

No modo ScanSAR a faixa de imageamento é de 250 a 300 km, 3 a 5 vezes mais larga do que instrumentos SAR convencionais. Já nos modos Fine e Polarimetric as faixas são de 40 a 70 km e 20 a 65 km respectivamente. A resolução espacial pode variar de 7 a 88 metros no modo Fine, de 24 a 89 metros no modo Polarimetric e tem 100 metros no modo ScanSAR. Além disso, a polarização é diferente para os três modos: I) no ScanSAR a polarização pode ser HH ou VV, II) no modo Fine pode ser HH ou VV ou HH+HV ou VV+HV e III) no modo Polarimetric, o mais completo nesse quesito, a polarização pode ser HH+HV+VH+VV.

PALSAR

Phased Array type L-band Synthetic Aperture Radar

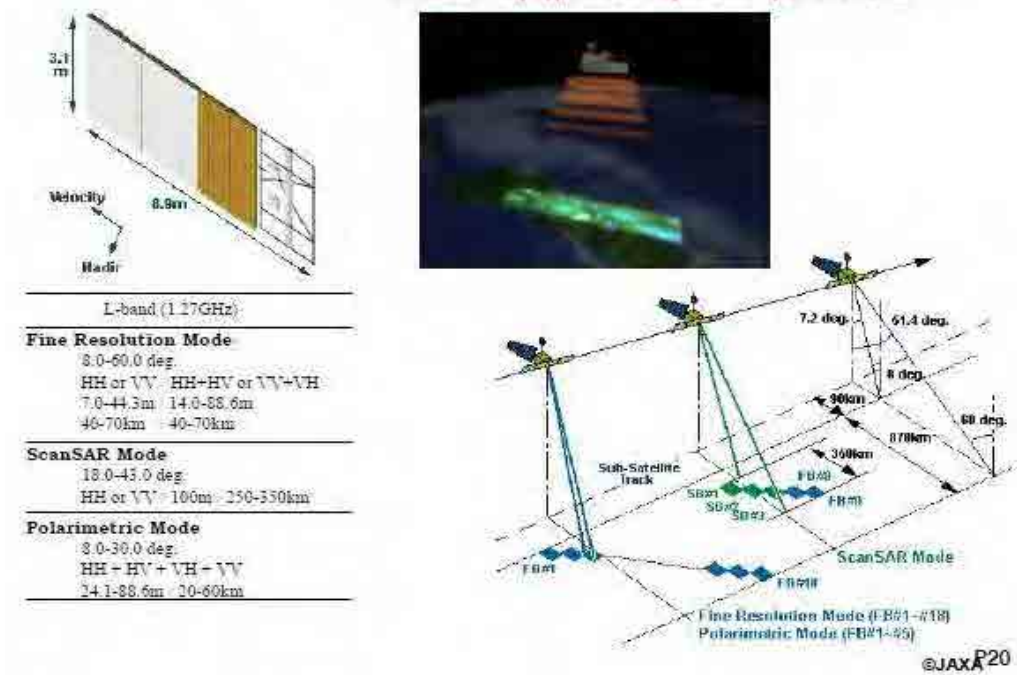


Figura 5: Características do sensor PALSAR-2 - Radar de abertura sintética que opera em banda L. Fonte: JAXA

3. Introdução a Polarimetria

3.1 Polarização

A polarização é definida como “a orientação segundo a qual oscila, no tempo, o vetor campo elétrico (E) da onda eletromagnética” (Correia *et al.*,). Já a polarimetria de radar aplicado em sensoriamento remoto é definida como “o controle das propriedades polarimétricas (comportamento da direção elétrica de campo) de ondas de radar e a extração de suas propriedades de destino a partir do comportamento de espalhamento (refletido) de ondas de um alvo” (Boerner *et al.*, 1998).

A polarização pode ser classificada em três formas de transmissão: linear, circular e elipsoidal.

A transmissão é dita linear quando a orientação do campo elétrico (E_z) varia segundo um único plano, que pode ainda ser horizontal ou vertical. A onda eletromagnética é dita horizontalmente polarizada quando o vetor do campo elétrico é perpendicular ao plano de incidência da onda (plano que contém o vetor normal à superfície e o vetor de propagação da onda) ou de maneira geral, quando o vetor do campo elétrico é paralelo à superfície imageada (figura 6).

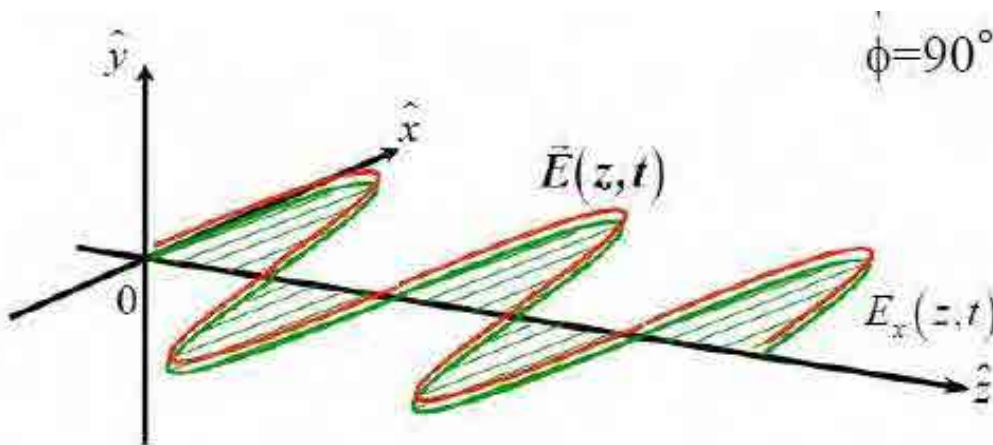


Figura 6: Polarização do tipo linear e horizontal em relação ao campo elétrico (E_z) e ao tempo (t). Fonte: RESTEC

Para uma onda plana, o comprimento do vetor campo elétrico (E_z) define a amplitude da onda; a velocidade de rotação estabelece a frequência da onda, enquanto que a orientação e a forma geométrica traçada pela ponta desse vetor determinam a polarização da onda.

Uma onda eletromagnética pode ser polarizada (uma senóide monocromática com frequência constante e amplitude estável caracteriza uma onda totalmente polarizada), despolarizada (com polarização aleatória) ou, ainda, apresentar um comportamento intermediário entre esses dois extremos, caracterizado por certo grau de polarização.

Para as ondas circulares e elípticas, o vetor campo elétrico (E) trabalha em forma de rotações (horário ou anti-horário), variando pelo ângulo de orientação (Ψ) e a elipsidade (χ).

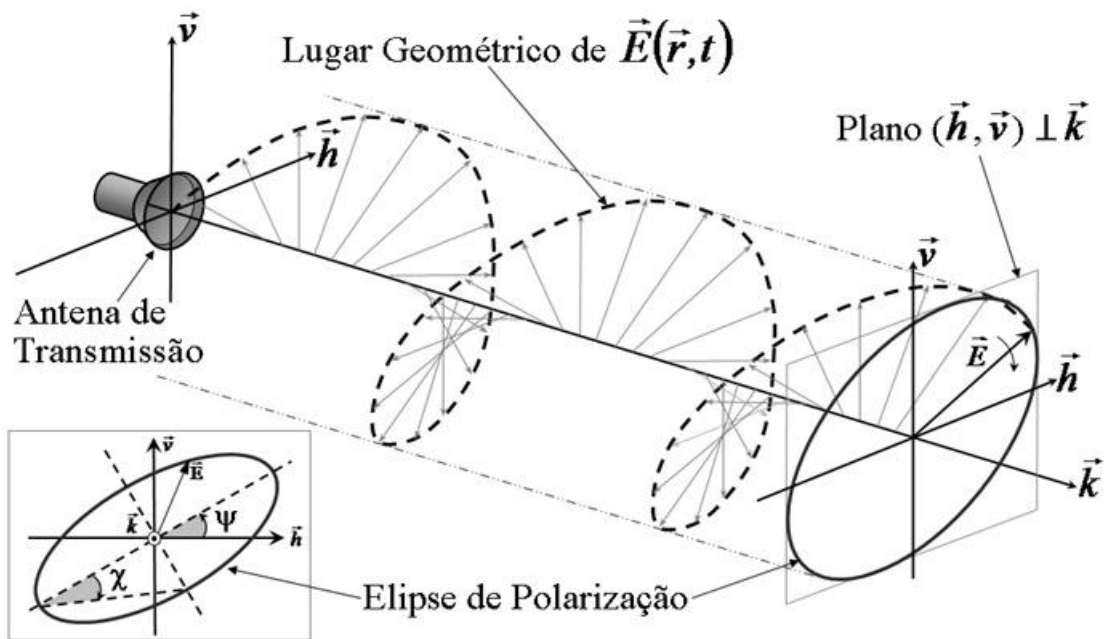


Figura 7: Polarização circular (figura maior) e em elipse (figura menor). Fonte: Correia, 2008.

Segundo Andrade *et al.* (2007), os radares transmitem micro-ondas polarizadas horizontal ou verticalmente que geram ondas retroespalhadas com uma variedade de polarizações. As polarizações podem ser sintetizadas a partir da combinação adequada de componentes vertical e horizontal, podendo existir quatro tipos de combinações de polarizações transmitidas e recebidas:

- HH – recepção e transmissão horizontal;
- VV – recepção e transmissão vertical;
- HV – transmissão horizontal e recepção vertical e;
- VH – transmissão vertical e recepção horizontal.

A interação dos objetos na superfície terrestre com as micro-ondas tem relação direta com a polarização incidente (Kuplich, 2003). Se os objetos em questão possuem uma orientação vertical (ex.: plantios de cana de açúcar), a interação com micro-ondas na polarização vertical será maior, assim como o eco gerado (coeficiente de retroespalhamento = σ).

Entretanto, os objetos ou superfícies espalhadoras podem ter a capacidade de despolarizar a onda incidente e gerar um eco numa polarização distinta à enviada, isto graças aos mecanismos de espalhamento (grau de penetração da onda, ângulo de incidência) e fatores que alteram o comportamento do objeto.

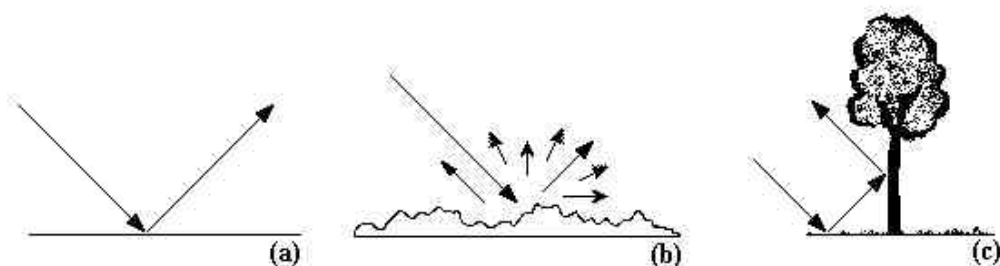


Figura 8: Tipos de superfície que alteram o coeficiente de retroespalhamento (*backscatter*): (a) liso ou especular, (b) rugosa ou difuso, (c) lisas e reflexão de canto (*double-bounce*). Adaptado de Kuplich, 2003.

3.2 Fatores que influenciam o coeficiente de retroespalhamento (σ)

Mecanismos de espalhamento;

Orientação dos elementos difusores do dossel;

Em relação ao alvo:

constante dielétrica do alvo (ex.: umidade),

tamanho,

forma,

Orientação do alvo (ex.: Orientação da folha);

Em relação à superfície:

a rugosidade,

constante dielétrica da superfície (características do solo, no caso do estudo da vegetação – figura 8). Solos mais úmidos apresentam maior coeficiente de retroespalhamento,

geometria de distribuição dos elementos difusores (no caso de um dossel agrícola - direção e espaçamento das linhas de plantio da cultura, porcentagem de cobertura, altura da planta, etc – figura 9).

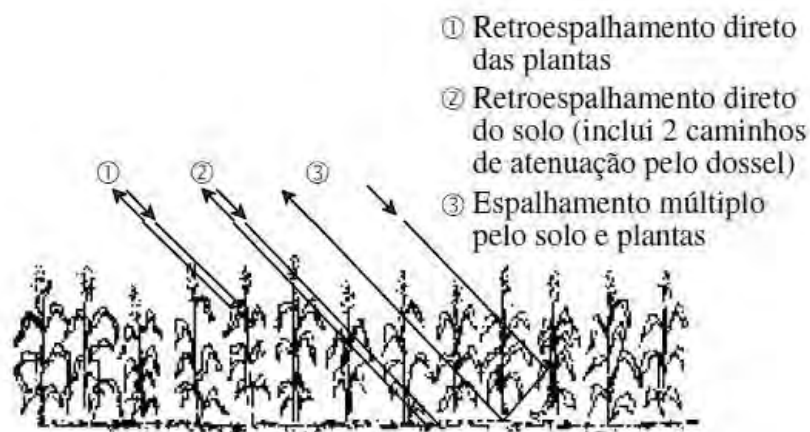


Figura 9: Fatores que alteram o coeficiente de retroespalhamento do objeto em questão (plantação de milho). Fonte: Correia, 2008.

3.3 Potencial de Uso de Imagens Polarimétricas em Exames Periciais

Atualmente, o uso de imagens ALOS-PALSAR pelos Peritos é aplicado principalmente na detecção de desmatamentos de forma complementar aos sensores ópticos (LANDSAT, CBERS). As perícias em desflorestamentos têm foco na análise visual em áreas restritas, especialmente durante a estação chuvosa.

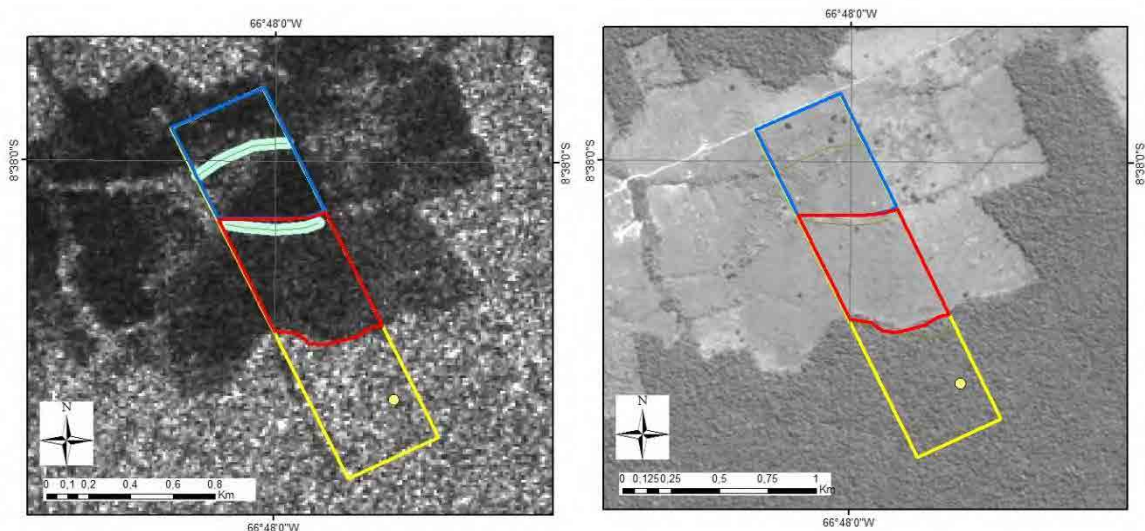


Figura 10: Comparação do desflorestamento utilizando imagem ALOS-PALSAR, polarização HV (figura da esquerda) e imagem CBERS 2B, sensor HRC (figura da direita), em uma propriedade rural localizado no Município de Lábrea-AM. (Laudo nº 329/2011 - INC/ DITEC/DPF), ambas de 2008. Em estudos mais complexos, a diferença de comprimento de ondas entre as Bandas X (comprimento de onda entre 3,75 a 2,40 cm) e P (comprimento de onda entre 136 a 77 cm) é utilizado para estimar, quantitativamente, a biomassa da Floresta Amazônica (<http://www.cartografia.org.br/boletim/Boletim62.pdf>).



Figura 11: Apresentação do Exército detalhando o mapeamento cartográfico da Amazônia com o uso de sensores de radar nas Bandas X e P, possibilitando a estimativa da biomassa (Disponível em: <http://www.cartografia.org.br/boletim/Boletim62.pdf>).

De acordo com Soler (2000), imagens de radar (Satélite RADARSAT-1, banda-C, polarização HH) foram utilizadas para detectar manchas de petróleo no oceano, obtendo bons resultados (figura 12).

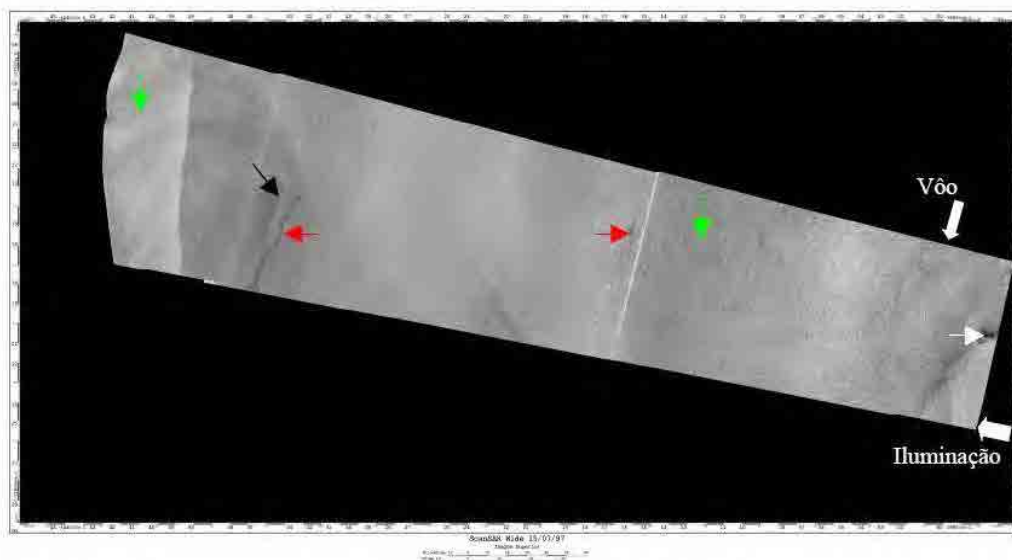


Fig. 5.12 – Recorte da imagem *ScanSAR Wide* de 15/07/97 original (superior), onde as cores das setas estão relacionadas às seguintes classes: vermelho – óleo, verde – água, branco – baixa de vento e preto – embarcação/plataforma.

Figura 12: Identificação de manchas de óleo no oceano utilizando sensores de radar. Imagem extraída de Soler(2000).

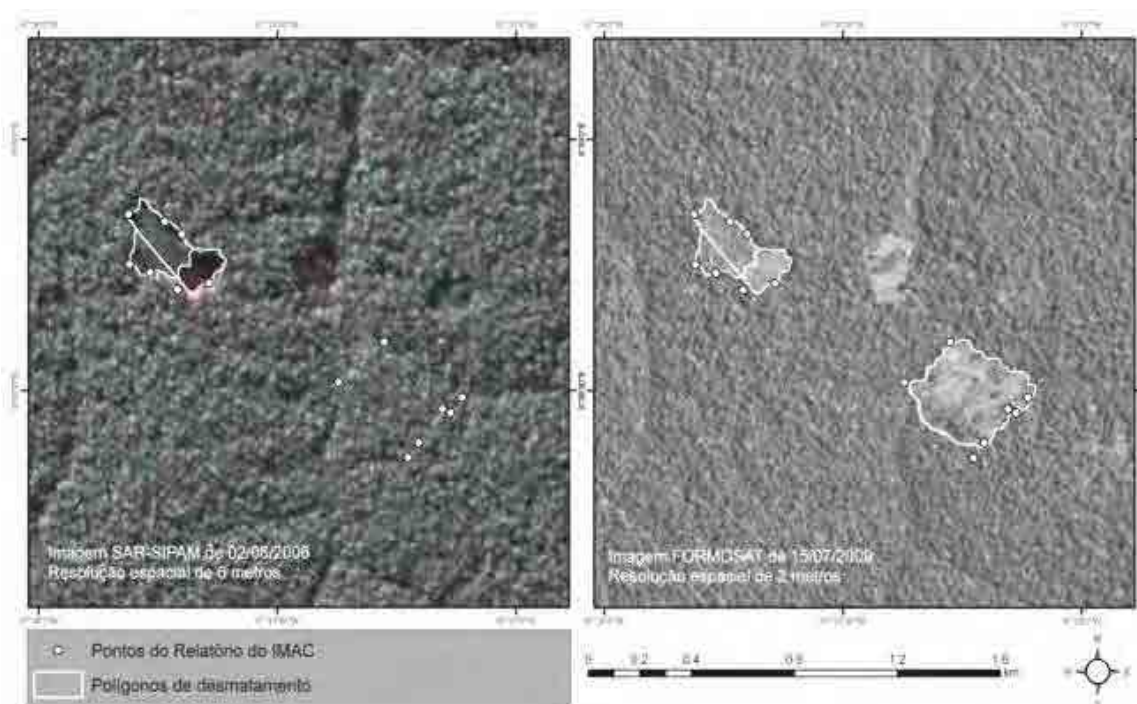


Figura 13: Utilização de imagens de alta resolução para delimitação de polígonos de desmatamento - à esquerda imagem SAR utilizando polarimetria (R:HH, G:HV, B:VV) do sensor aerotransportado (R-99B) do SIPAM e à direita imagem ótica do satélite FORMOSAT. Imagens extraídas do Laudo Pericial Criminal nº 188/2011 – SETEC/SR/DPF/AC.

4. Programa PALSAR Viewer V 1.8.3

4.1 Apresentação

O *programa* PALSAR Viewer foi desenvolvido pelo Engenheiro Makoto Ono, Perito Sênior do convênio DPF/IBAMA/JICA que atua junto ao *Remote Sensing Technology Center of Japan - RESTEC* (www.restec.or.jp).

Este *programa* é utilizado para manipulação de dados PALSAR. É possível identificar, mensurar e analisar os valores de pixel (estatísticas), retificar a imagem utilizando dados SRTM (ortorretificação), delinear polígonos e exportá-los para o formato KML (*Google Earth*), bem como, realizar interpretação preliminar dos dados PALSAR.

Neste manual haverá direcionamento para a identificação e download de imagens ALOS, em específico as imagens ALOS PALSAR nível 1.5 de processamento. A maioria das imagens ALOS obtidas por meio do Projeto de Cooperação DPF/IBAMA/JICA possuem este nível de processamento e são de áreas da Amazônia Legal.

Com este Manual, espera-se, familiarizar os Peritos Criminais Federais com informações espaciais desta natureza para aplicação nas Perícias Criminais executadas pelo Departamento de Polícia Federal. A versão do *programa* referenciada neste Manual é a 1.8.3.

4.2 Obtenção de Imagens ALOS PALSAR

Atualmente existem diferentes fontes oficiais das imagens ALOS PALSAR. Neste manual será descrita a forma de obtenção destas imagens via INTELIGEO, <http://www.inteligeo.ditec.dpf.gov.br/portal/>, conforme ilustrado na figura 14.



Figura 14. Imagem ilustrativa da página inicial do sítio eletrônico do INTELIGEO.

Este Manual não abordará todas as ferramentas disponíveis no INTELIGEO que serão objeto de produto específico. No contexto deste manual concentraremos os detalhes apenas nas imagens ALOS.

Clicando-se no link “Mapa principal” na página inicial do INTELIGEO, acessa-se a interface gráfica do sistema ilustrada na figura 15.



Figura 15. Imagem ilustrativa da interface gráfica do INTELIGEO.

4.3 Utilizando o INTELIGEO

O mapa do Brasil ilustrado na página inicial do INTELIGEO traz algumas informações padrão como, por exemplo: a imagem utilizada como fundo, os limites estaduais, as unidades de criminalística (INC, SETC, NUTEC e UTEC), além das unidades do DPF.

No canto superior direito da tela há um conjunto de palavras, tecnicamente nominadas “map switcher”, que permitem alterar a imagem de fundo do INTELIGEO e saber quais são as camadas disponíveis para visualização, bem como, ativar/desativar estas camadas. Entre as diferentes imagens de fundo disponíveis, há um mapa com informações altimétricas. Passando-se o ponteiro do mouse sobre a palavra “Mais”, é apresentada a lista de pastas que contém camadas que podem ser ativadas/visualizadas pelo usuário. A figura 16 ilustra estas informações ressaltadas pela seta vermelha.

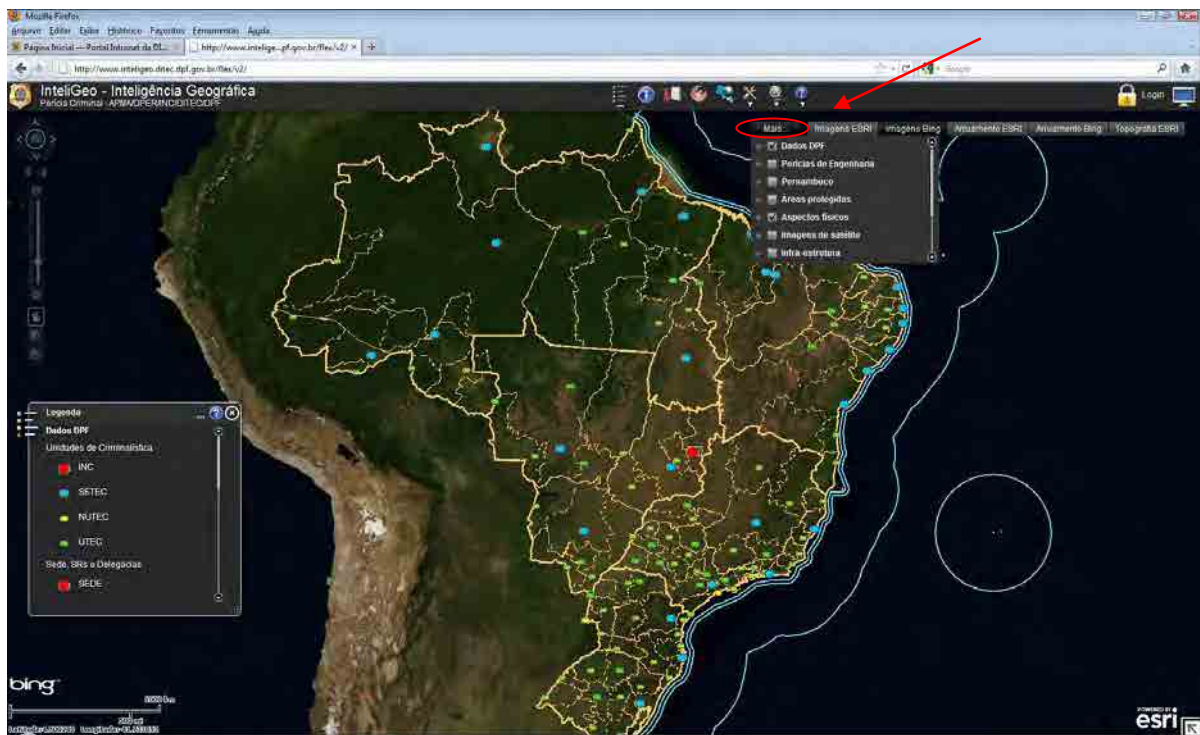


Figura 16. Imagem ilustrativa das pastas existentes no menu “Mais”.

Atualmente, as pastas disponíveis para visualização são: **Dados DPF**, Perícias de Engenharia, Pernambuco, Áreas protegidas, **Aspectos físicos**, Imagens de satélite, Infra-estrutura, **Limites e cidades**, Propriedades rurais. As pastas que contém camadas visíveis por padrão estão em negrito. A figura 17 ilustra esta informação.

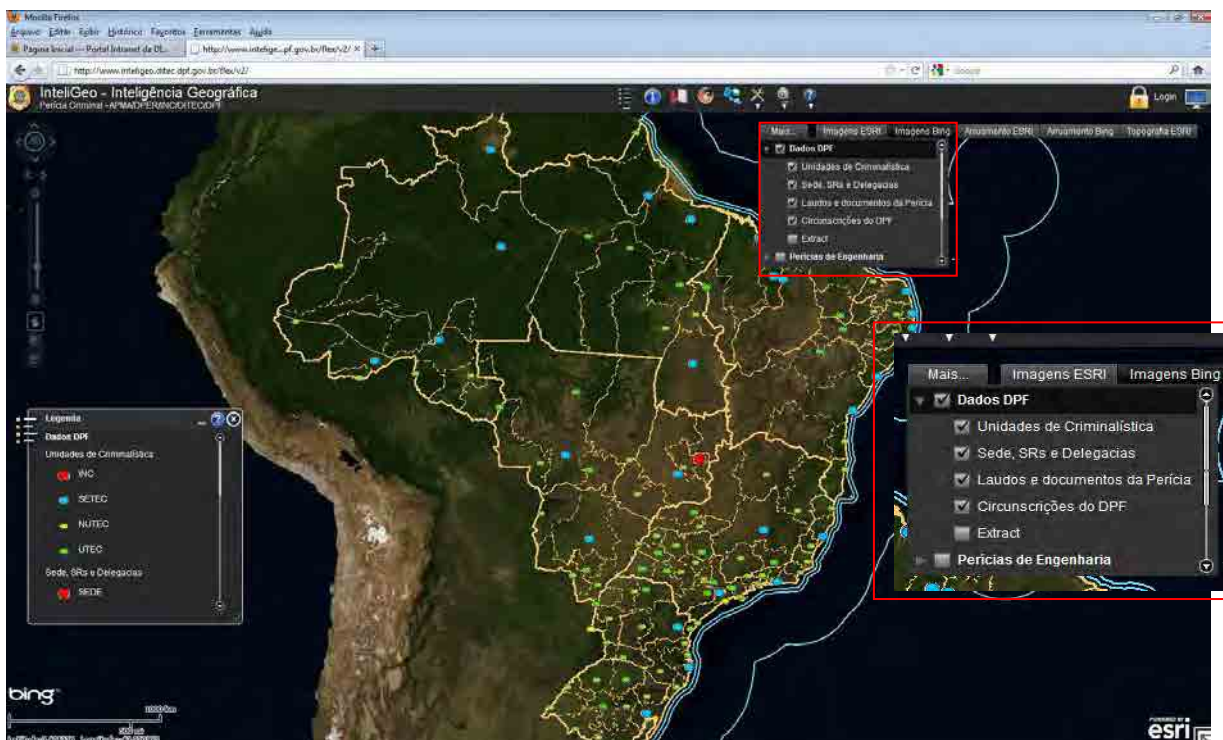


Figura 17. Imagem ilustrativa das camadas existentes na pasta Dados DPF.

4.4 Identificando e baixando Imagens PALSAR

Inicialmente, para identificar quais imagens estão disponíveis no INTELIGEO, é preciso habilitar a pasta “Imagens de satélite” no menu “Mais”. Feito isso, pode-se expandir esta pasta, tornando visível o conteúdo da mesma. Está disponível para visualização e download grande acervo de imagens de diversos sensores. A figura 18 ilustra estas informações.

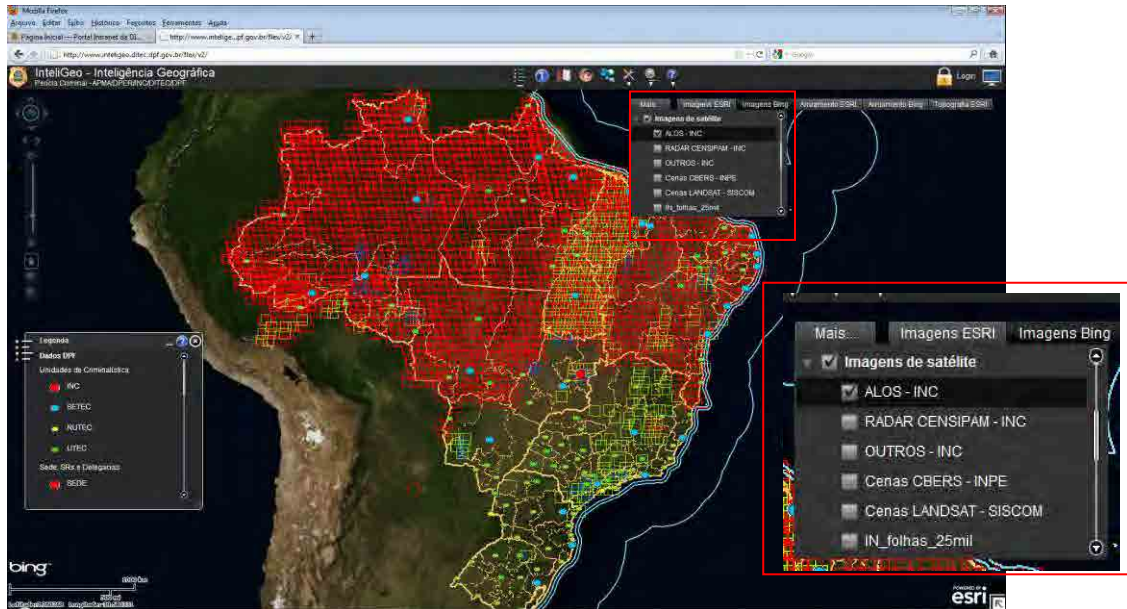



Figura 18. Imagem ilustrativa das camadas existentes na pasta Dados DPF.

Para visualizar quais imagens estão disponíveis basta alterar o zoom, por meio do menu de zoom localizado na porção superior à esquerda da página e/ou por meio do botão de rolagem do mouse. Para identificar as feições, imagem de satélite, deve-se utilizar a ferramenta localizada na porção superior da página: . Clicando no ícone retro mencionado, habilita-se a caixa de ferramentas “Identificar” que possibilita a identificação por feição: ponto, linha, retângulo e polígono. A figura 19 ilustra estas informações, ressaltadas pela elipse amarela.

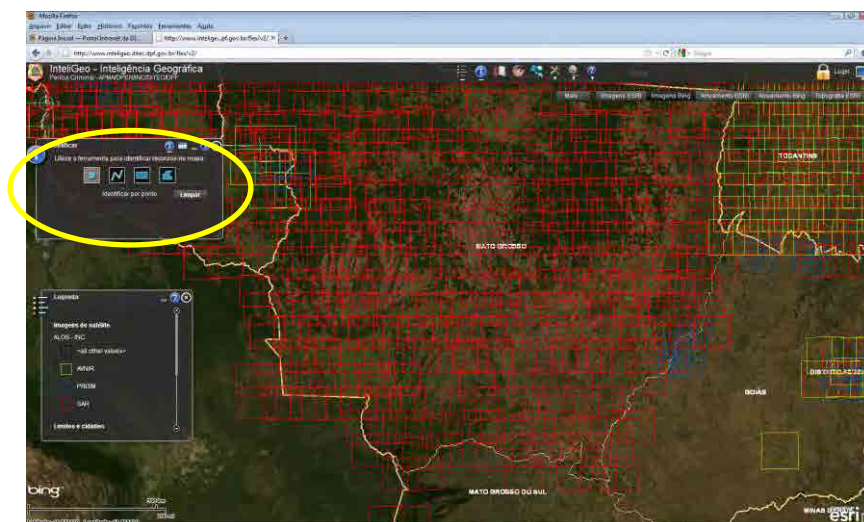


Figura 19. Imagem ilustrativa da ferramenta para identificação das imagens ALOS disponíveis.

Selecionando-se com qual feição deseja-se proceder à identificação e deve-se clicar sobre a imagem que recobre a região de interesse. O conjunto de informações, metadados da imagem selecionada, inclusive o link para download, é apresentado na própria caixa de ferramentas “Identificar”. A figura 20 ilustra estas informações, ressaltadas pela elipse amarela.

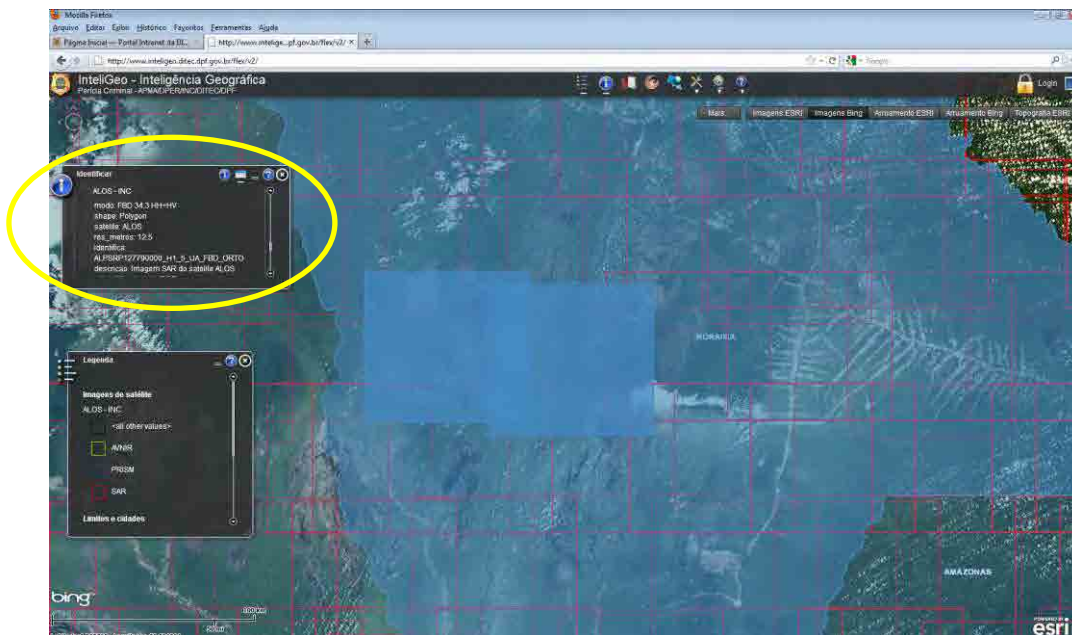


Figura 20. Imagem ilustrativa dos metadados da imagem selecionada na caixa de ferramentas “Identificar”.

Além dos resultados, metadados, apresentados na caixa de ferramentas “Identificar”, pode-se encontrar o nome da imagem, a fonte, a data de obtenção, a polarimetria, a resolução, o nível de correção (georreferenciamento), além do já citado link para download em janela adicional no centro da página do INTELIGEO. A figura 21 ilustra estas informações, ressaltadas pela elipse amarela.

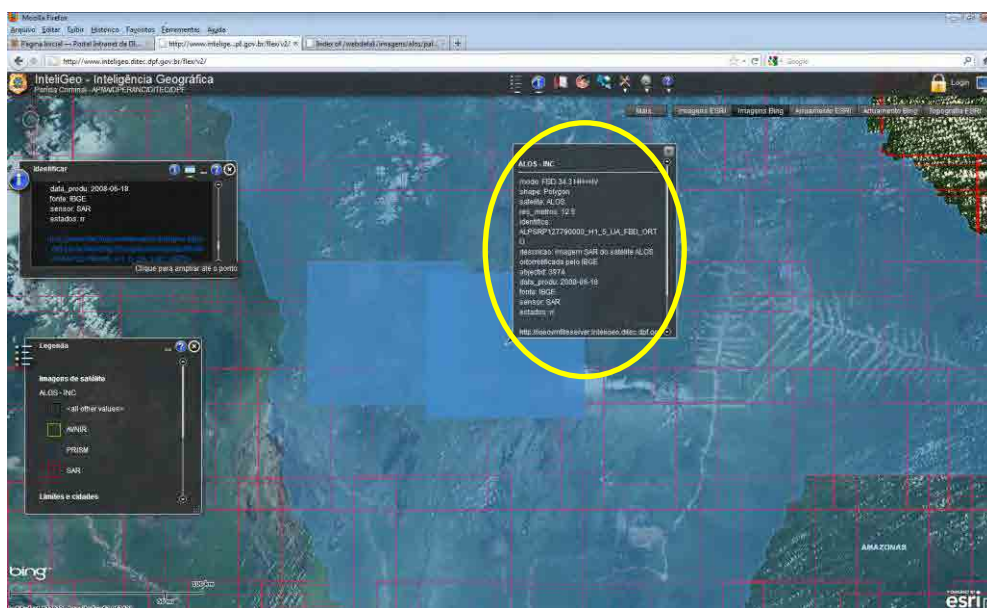


Figura 21. Imagem ilustrativa da janela aberta para apresentação dos metadados da imagem selecionada.

Clicando-se no link para download abre-se uma nova janela/aba do navegador utilizado apresentando os dados referentes à cena selecionada disponíveis para download. Nesta página, o usuário deve selecionar para download e processamento no software PALSAR Viewer a imagem original que está gravada em formato compactado (*.zip). O arquivo deve ser salvo preferencialmente em uma pasta criada diretamente na raiz C:\. A figura 22 ilustra esta informação.

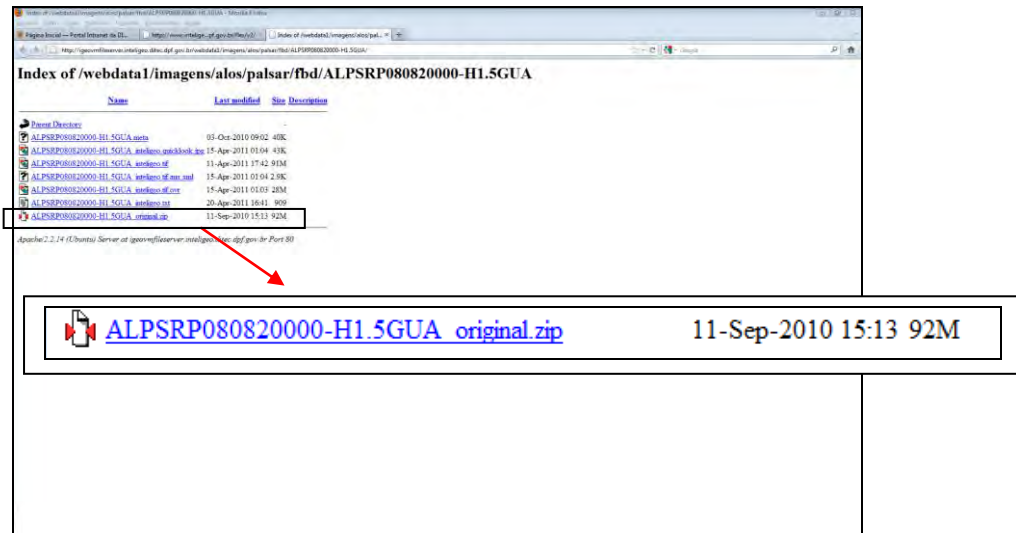


Figura 22. Imagem ilustrativa da página onde são apresentadas as informações disponíveis para download.

4.5 Iniciando o PALSAR Viewer

O programa PALSAR Viewer não necessita ser instalado. Para iniciar a utilização recomenda-se que seja criada uma pasta na raiz do C do computador. Esta pasta deve conter o aplicativo conforme ilustra a figura 23.

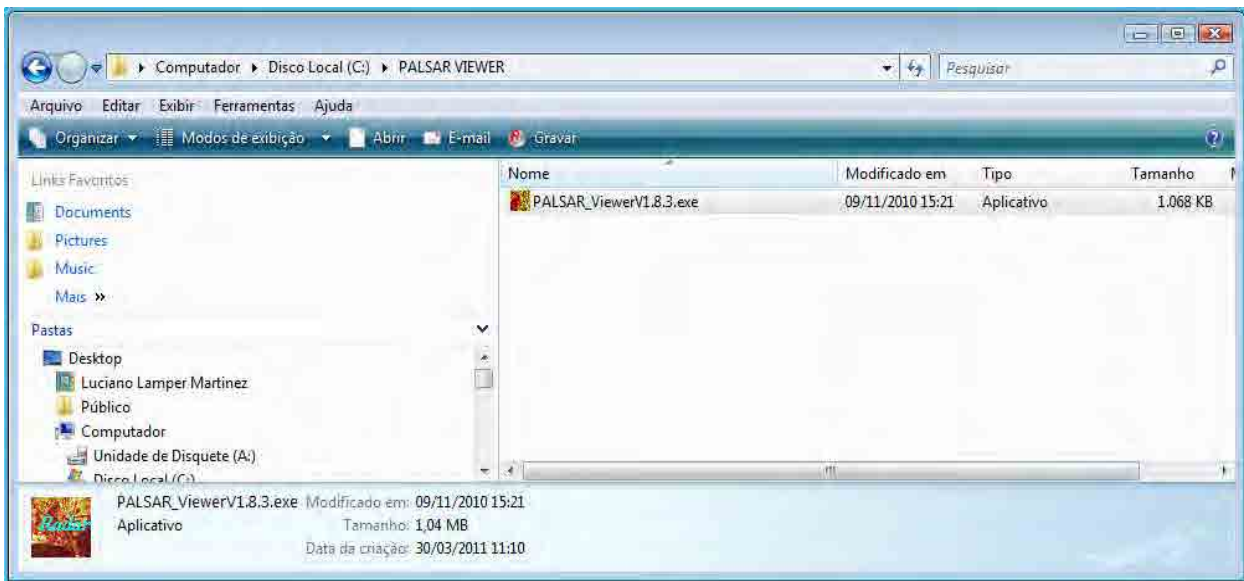


Figura 23. Imagem ilustrativa da pasta criada contendo o aplicativo PALSAR Viewer.

Para iniciar o aplicativo, basta clicar duas vezes no ícone do mesmo (PALSAR_ViewerV1.8.3.exe). Surgirá então a janela ilustrada na figura 24.



Figura 24. Imagem ilustrativa da janela de abertura do programa PALSAR Viewer.

Clicando em “Click me” surgirá a janela inicial ilustrada na figura 25:

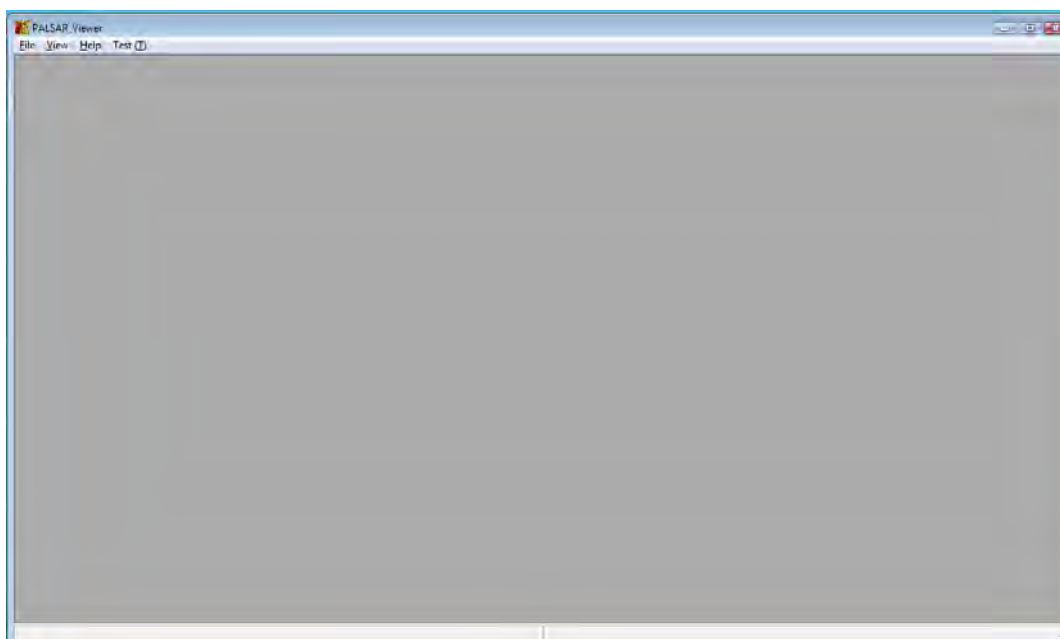


Figura 25. Imagem ilustrativa da janela inicial do programa PALSAR Viewer.

4.6 Abrindo imagens PALSAR

O programa PALSAR Viewer é utilizado para abertura, análise e correção geométrica de imagens ALOS PALSAR nível 1.5, tanto de polarimetria simples quanto multipolarimétrica.

Para abrir a imagem PALSAR, clicar no Menu File > Open Palsar L1.5 File (figura 26):

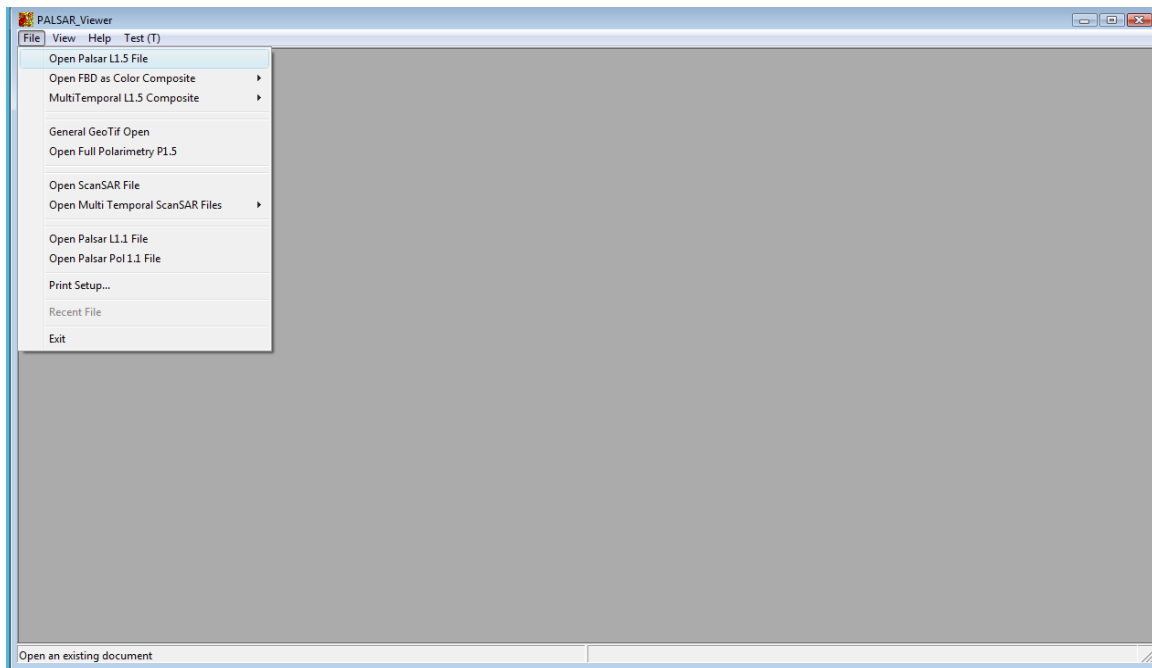


Figura 26. Imagem ilustrativa da janela de abertura da imagem PALSAR.

Surgirá uma janela onde a imagem desejada deve ser selecionada conforme ilustra a figura 27:

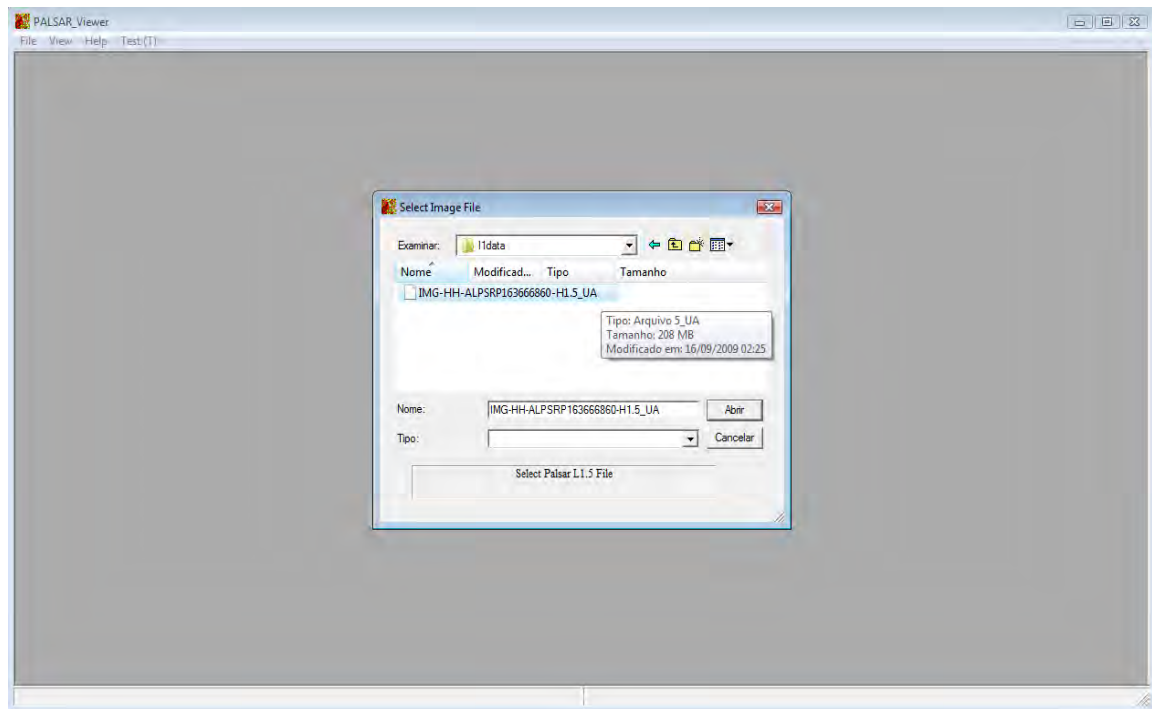


Figura 27. Imagem ilustrativa da janela para seleção da imagem PALSAR.

4.7 Alterando o Zoom da imagem

Clicando no Menu View > Image Scale pode-se alterar o zoom da imagem (figura 28):

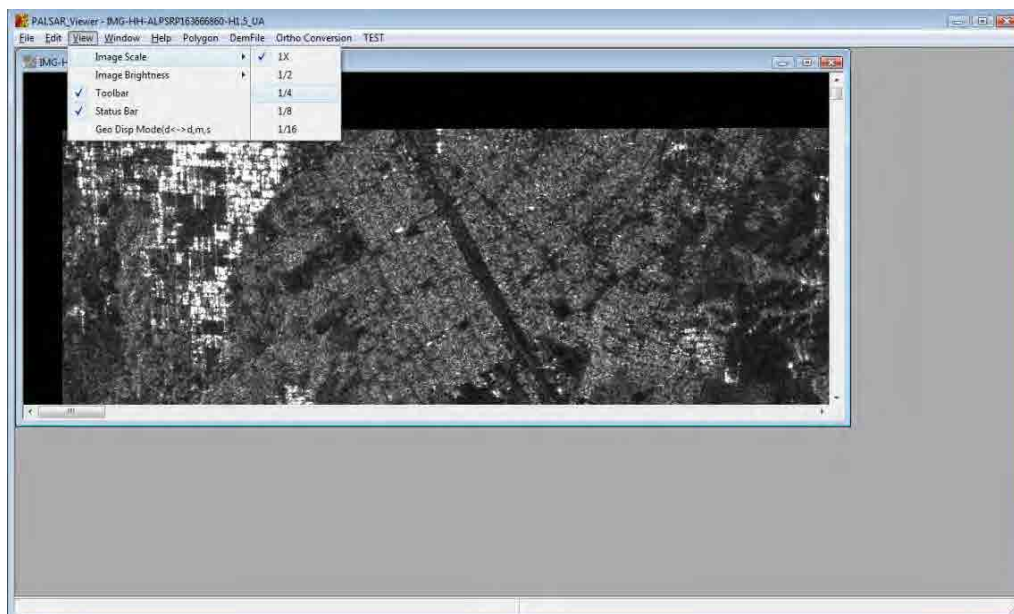


Figura 28. Imagem ilustrativa da janela de alteração do *zoom* da imagem Palsar.

4.8 Localização do Pixel e Estatísticas

Clicando com o mouse em qualquer ponto da imagem são exibidos na barra de status inferior as seguintes informações: Endereço do pixel (Pixel Address), Valor digital do pixel (Pixel Digital Number), Sigma₀ e Coordenadas Geográficas (No Menu View, a opção Geo Disp Model (d<->d,m,s) deve ser marcada para exibição da coordenada em d°m's'', figura 29).

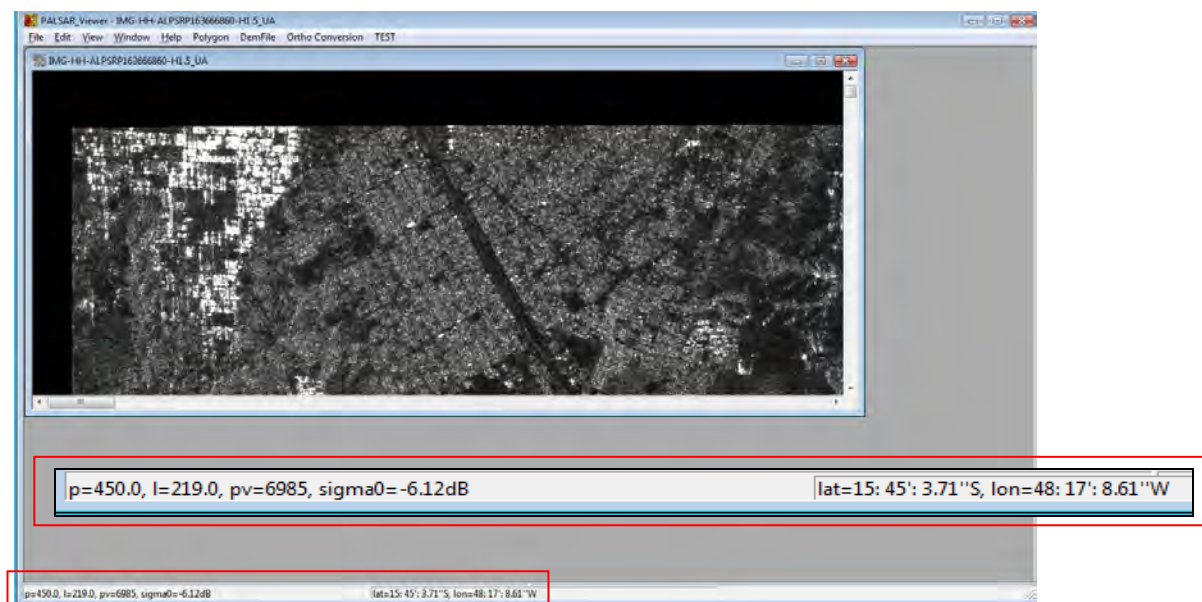


Figura 29. Imagem ilustrativa da localização do pixel e estatísticas.

4.9 Alteração do Brilho da Imagem

No Menu View > Image Brightness > Set Intensity, pode-se alterar o brilho da imagem (figura 30):



Figura 30. Imagem ilustrativa da alteração de brilho da imagem.

4.10 Menu Polygon

Clicando no Menu Polygon visualiza-se as diferentes opções disponíveis: exibição do identificador do polígono, exclusão de um ou todos polígonos, exportação de polígonos, conversão (exportação) para KML, estatísticas da região do polígono, geração de tabela, exportação e importação de geopolígonos (figura 31).

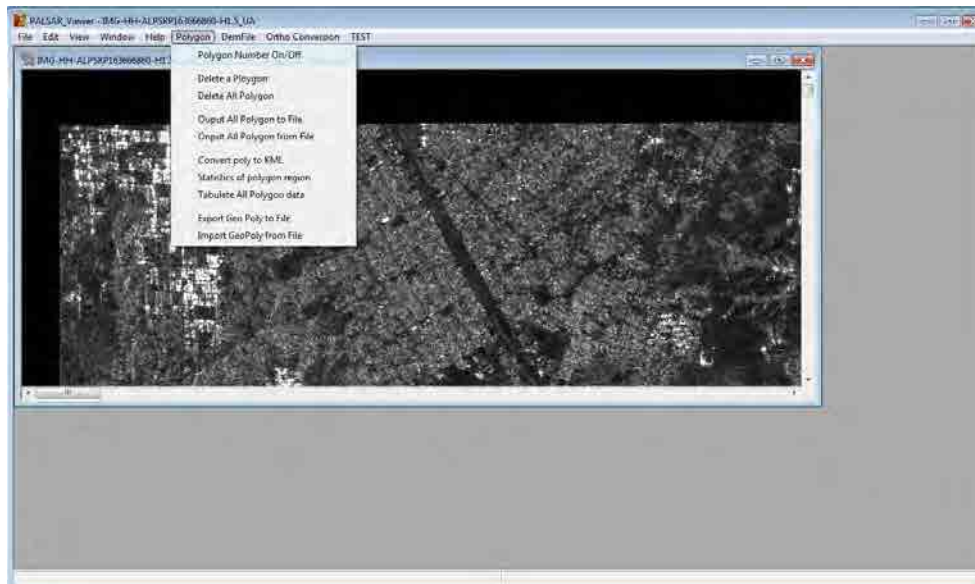


Figura 31. Imagem ilustrativa das opções disponíveis no Menu Polygon.

4.11 Delimitação de Polígonos

Para delimitar polígonos, basta manter pressionada a tecla “t” e desenhar com o mouse, limite vermelho, conforme ilustrado na figura 32.



Figura 32. Imagem ilustrativa do delineamento de polígonos.

Para fechar o polígono pressionar a tecla “r”. O limite ficará amarelo (figura 33).



Figura 33. Imagem ilustrativa do fechamento de polígonos.

4.12 Ativar/Desativar Polígonos

Para tornar um polígono inativo (amarelo) em um ativo (vermelho), ou vice-versa, basta manter pressionada a tecla “a” e clicar no interior do mesmo (figura 34).

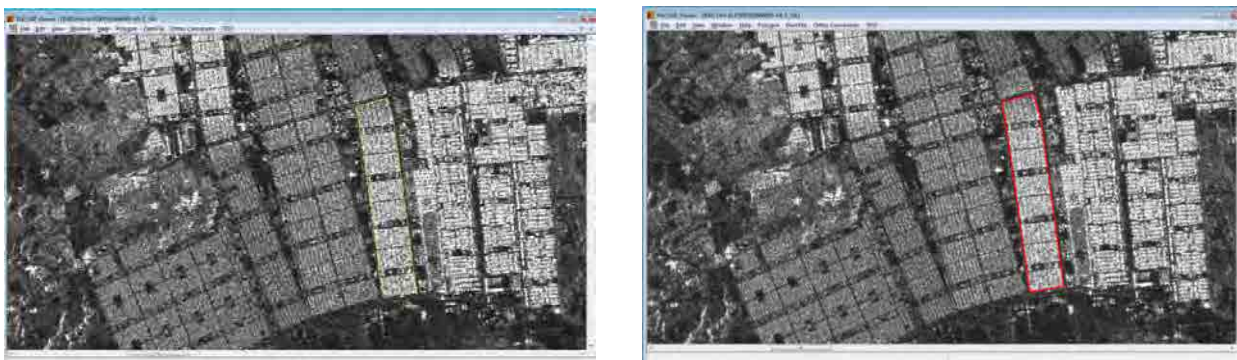


Figura 34. Imagens ilustrativas da ativação e desativação de polígonos.

4.13 Estatísticas de Polígonos

No Menu Polygon > Statistics of polygon region, pode-se visualizar o valor médio, Sigma0, dos “pixels” contidos no(s) polígono(s) ativo(s) e o desvio padrão. O(s) polígono(s) precisa(m) estar ativo(s), ou seja, vermelho(s). Esta opção está ilustrada na figura 35.



Figura 35. Imagem ilustrativa do fechamento de polígonos.

Os valores calculados são exibidos na barra de status inferior (figura 36).



Figura 36. Imagem ilustrativa das estatísticas da região do polígono ativo.

4.14 Conversão (exportação) de Polígonos para KML

No Menu Polygon > Convert poly to KML é possível converter o(s) polígono(s) criado(s) para o formato KML do Google Earth (figura 37).



Figura 37. Imagem ilustrativa da conversão/exportação de polígonos para KML.

4.15 Visualização de Polígonos, formato KML

No aplicativo Google Earth é possível visualizar o arquivo KML exportado.

É importante salientar que este arquivo KML, assim como as imagens PALSAR nível 1.5, estão apenas georreferenciados. Ao visualizar o arquivo KML no Google Earth será notório o deslocamento deste em relação à imagem referência deste aplicativo. Este deslocamento é devido à distorção, foreshortening = encurtamento, da imagem PALSAR (figura 38).

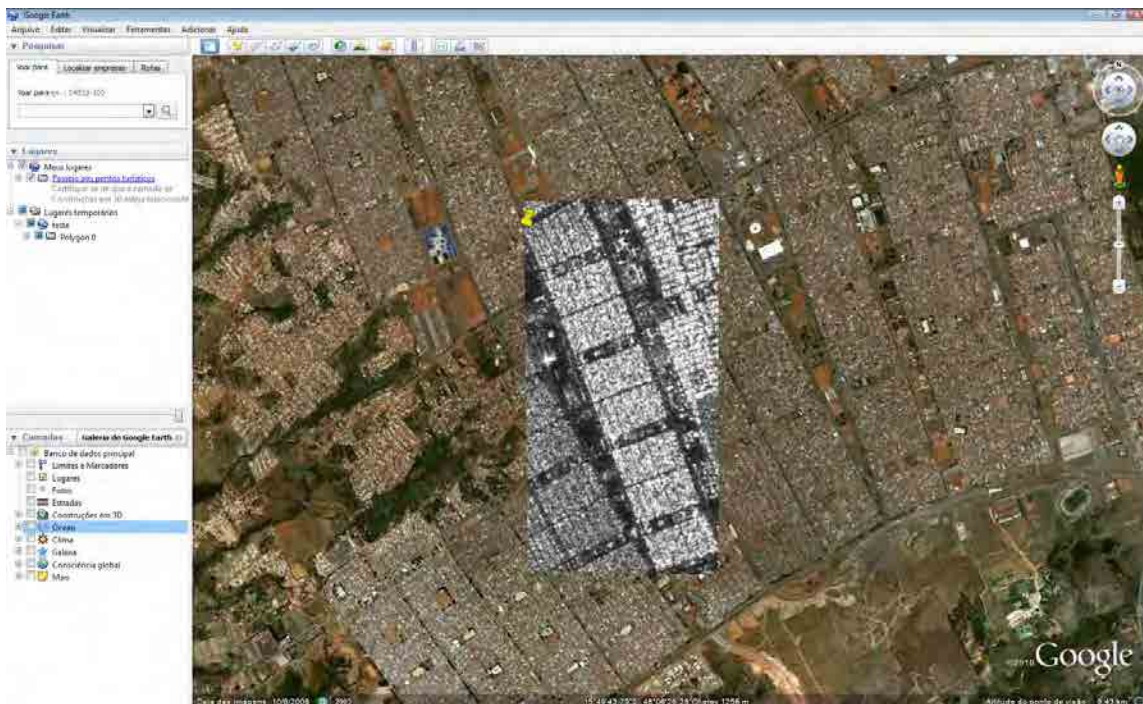


Figura 38. Imagem ilustrativa da visualização do polígono exportado, KML, no aplicativo Google Earth.

4.16 Ortorretificação (correção do foreshortening) utilizando dados SRTM

No programa PALSAR Viewer é possível ortorretificar as imagens PALSAR (correção de distorção, foreshortening) utilizando DEM - Digital Elevation Model (Modelo Digital de Elevação), em específico dados SRTM (Shuttle Radar Topographic Mission).

No Menu DemFile > Show Dem List verifica-se quais arquivos SRTM e Geoid Data File são necessários para execução desta ação (figura 39).



Figura 39. Imagem ilustrativa dos arquivos SRTM e Geoid Data File necessários para ortorretificação.

4.17 Obtenção dos arquivos SRTM necessários para Ortorretificação

O programa PALSAR_Verwer V1.8.3 permite a manipulação dos dados SRTM mais atualizados, dados SRTM versão 4, na qual, os erros de imageamento relacionados ao relevo já foram corrigidos. Estes dados SRTM podem ser obtidos no sítio eletrônico (figura 40):

<http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp>

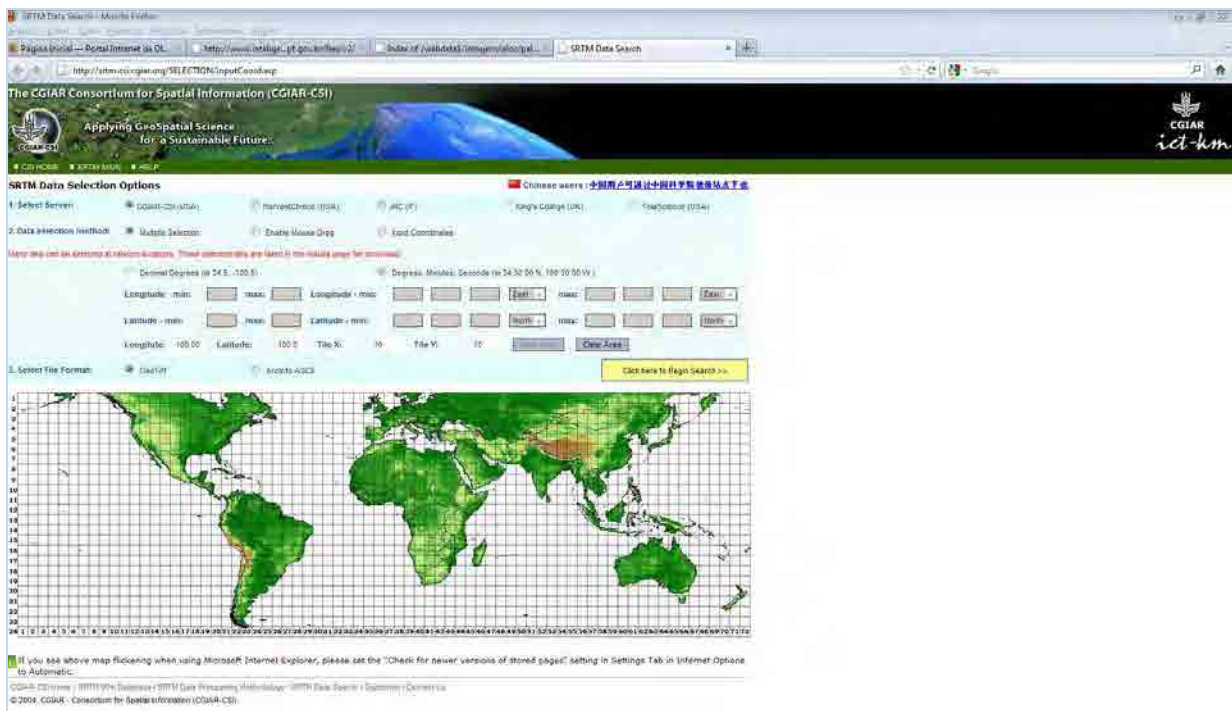


Figura 40. Imagem ilustrativa da página utilizada para obtenção dos arquivos SRTM.

Nesta página é possível realizar buscas e downloads de duas formas:

1. Inserindo coordenadas geográficas (DDD ou DMS);
2. Selecionando a área de interesse no mapa.

Como os dados SRTM cobrem grandes extensões territoriais, sugere-se a seleção visual no mapa conforme ilustrado na figura 41 e ressaltado pela seta vermelha.

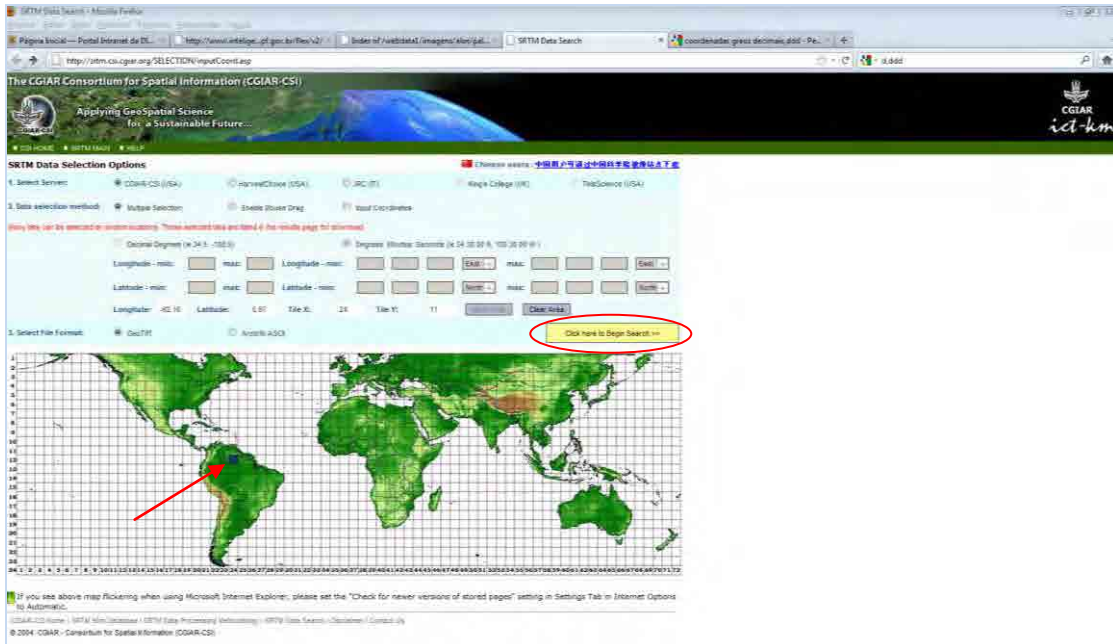


Figura 41. Imagem ilustrativa dos arquivos SRTM necessários para ortorretificação.

Após a seleção da área que recobre a localização da imagem a ser ortorretificada, deve-se clicar no botão amarelo, “Click here to Begin Search”, ressaltado pela elipse vermelha na figura 41. Após o processamento surgirá a página ilustrada pela figura 42. Na porção inferior desta página são apresentadas as opções de download dos dados SRTM, conforme ilustra a figura 42 destacadas pelas elipses vermelhas.



Figura 42. Imagem ilustrativa das opções de download dos arquivos SRTM.

4.19 Processo de Ortorretificação

O Menu DemFile > SRTMV4 > 1 deg Unit dem do PALSAR Viewer, utilizado anteriormente para conferir se o arquivo SRTM selecionado é mesmo àquele necessário para ortorretificação, será utilizado agora para converter os dados SRTMV4 para SRTM de primeiro grau (figura 45). Após clicar no Menu indicado, surgirá uma janela onde deve-se apontar para o diretório onde o arquivo SRTM foi descompactado.

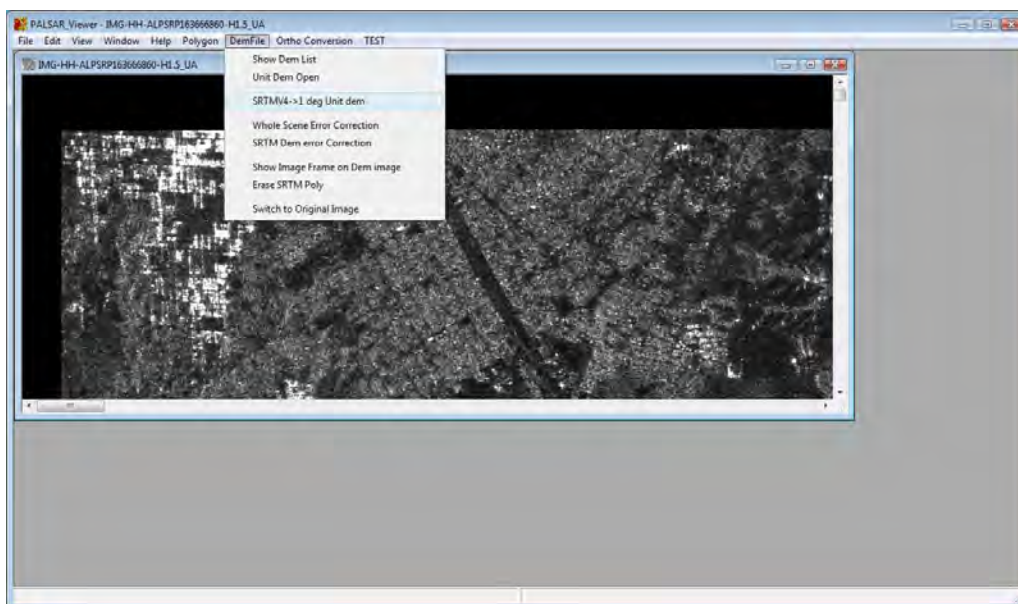


Figura 45. Imagem ilustrativa da conversão de arquivos SRTM.

Em seguida, no Menu Ortho Conversion > Palsar Lev1.5 to Ortho inicia-se o processo de correção do foreshortening, ortorretificação (figura 46).

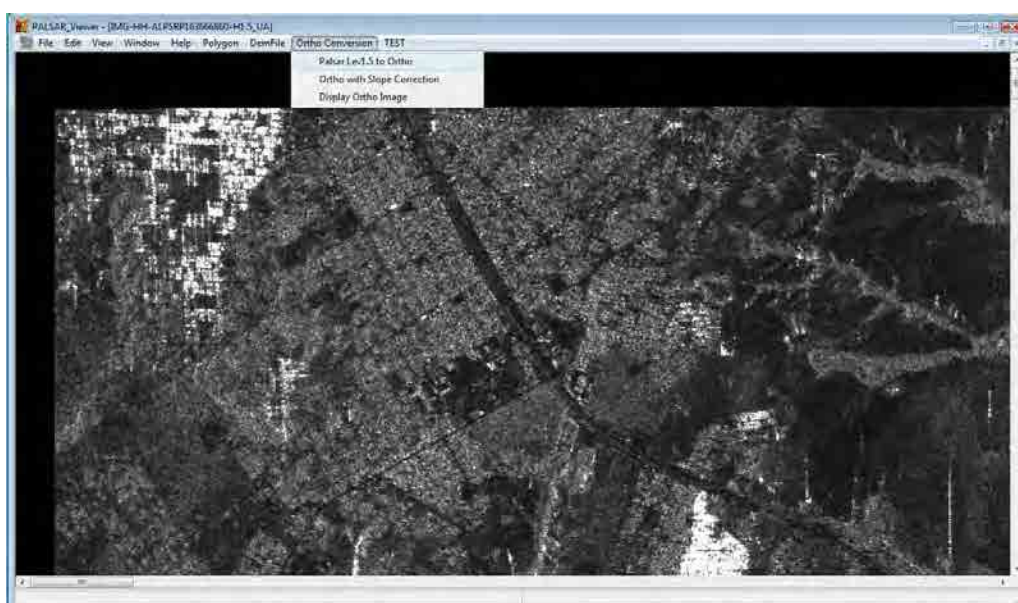


Figura 46. Imagem ilustrativa do início do processo de ortorretificação.

Na janela seguinte escolhe-se o nome do arquivo e a pasta de destino para geração da imagem ortorretificada. O formato neste processo é o geotiff (figura 47).

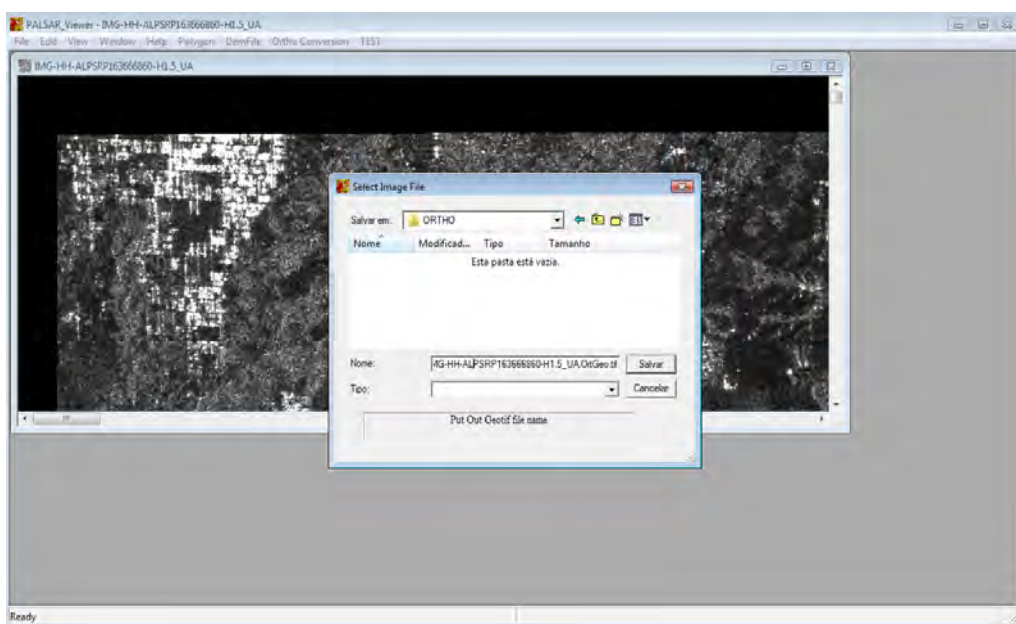


Figura 47. Imagem ilustrativa da janela onde é definido o nome e destino do arquivo ortorretificado.

Na próxima janela que surgir, basta selecionar, um a um, os arquivos “*.hgt” (SRTM) e “*.dac” (geóide) solicitados (estes arquivos devem ter sido previamente obtidos nos sítios eletrônicos supracitados, seguindo-se os procedimentos anteriores a este 4.17 e 4.18) (figura 48).

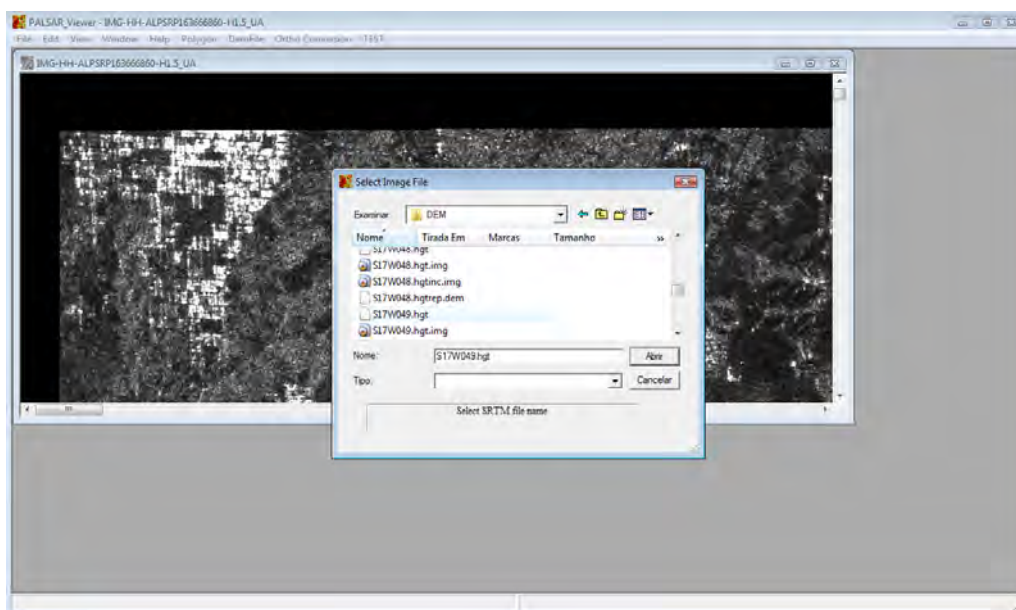


Figura 48. Imagem ilustrativa da janela onde são selecionados os arquivos “*.hgt” e “*.dac”.

O processamento iniciará automaticamente e pode ser acompanhado na barra de status inferior. Terminado o processamento, pode-se carregar a imagem ortorretificada a partir do Menu File > Open Pair Geo Tif (figura 49).

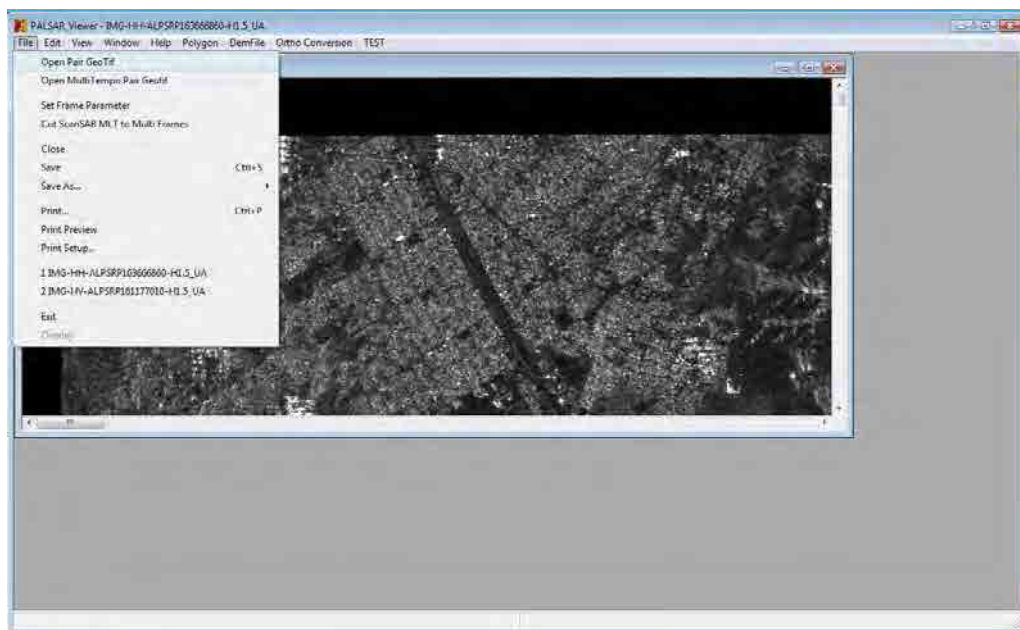


Figura 49. Imagem ilustrativa do procedimento para abertura da imagem ortorretificada.

A tecla “v” permite alterar entre a imagem original, georreferenciada e a imagem ortorretificada. Executando os procedimentos anteriormente descritos para delimitação de polígonos e exportação para KML, pode-se verificar o perfeito ajuste entre a imagem ortorretificada e a imagem utilizada pelo aplicativo Google Earth (figura 50).

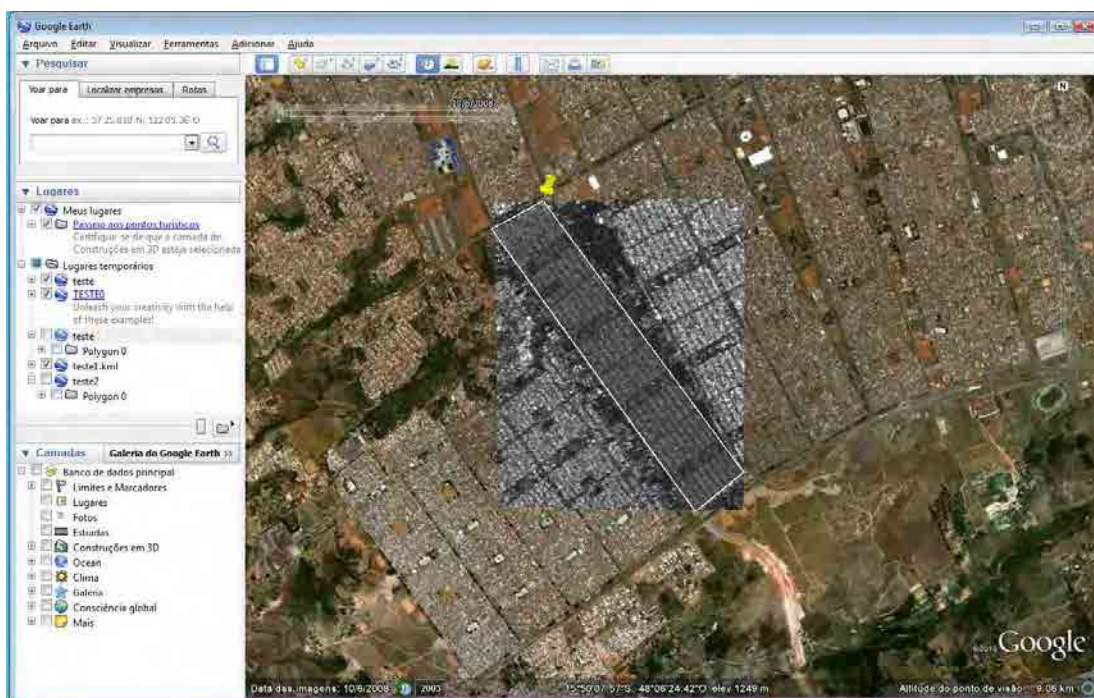


Figura 50. Imagem ilustrativa da visualização do polígono exportado, KML, no aplicativo Google Earth.

4.20 Composição Polarimétrica

Quando há disponibilidade de imagens de mais de uma polarimetria; HH, HV, VV; pode-se carregar as bandas nos canais R (Red) e G (Green) e gerar uma imagem em composição colorida. Este procedimento é executado clicando-se no Menu File > Open FBD as Color Composite > New Composite (figura 51).

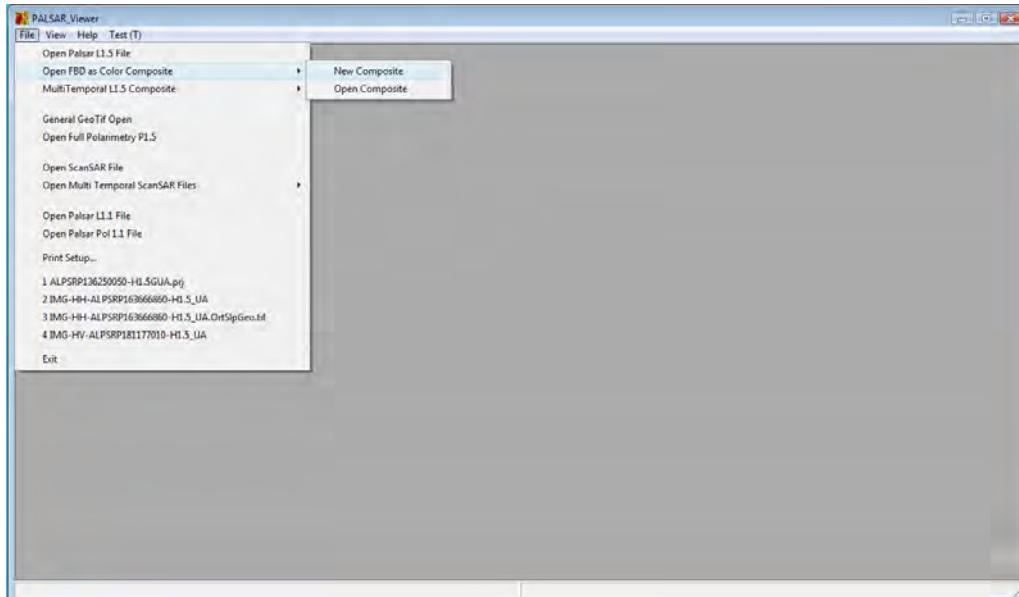


Figura 51. Imagem ilustrativa da abertura de imagens multipolarimétricas.

Na janela escolhe-se qual das polarimetrias estará no canal R e no canal G (figura 52).

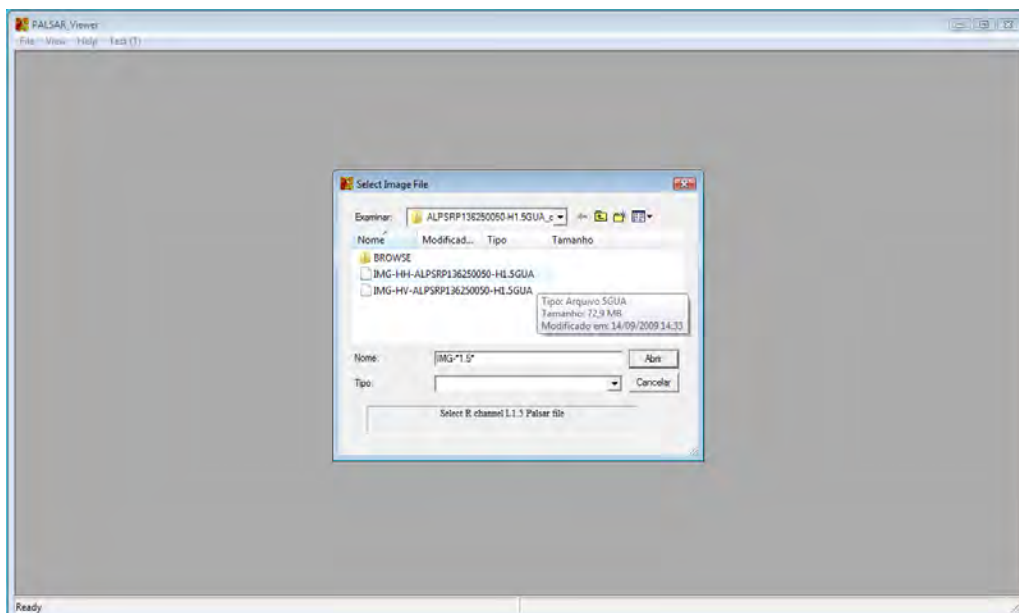


Figura 52. Imagem ilustrativa da seleção da polarimetria/canal R e G.

O resultado apresentado é semelhante a este ilustrado na figura 53:

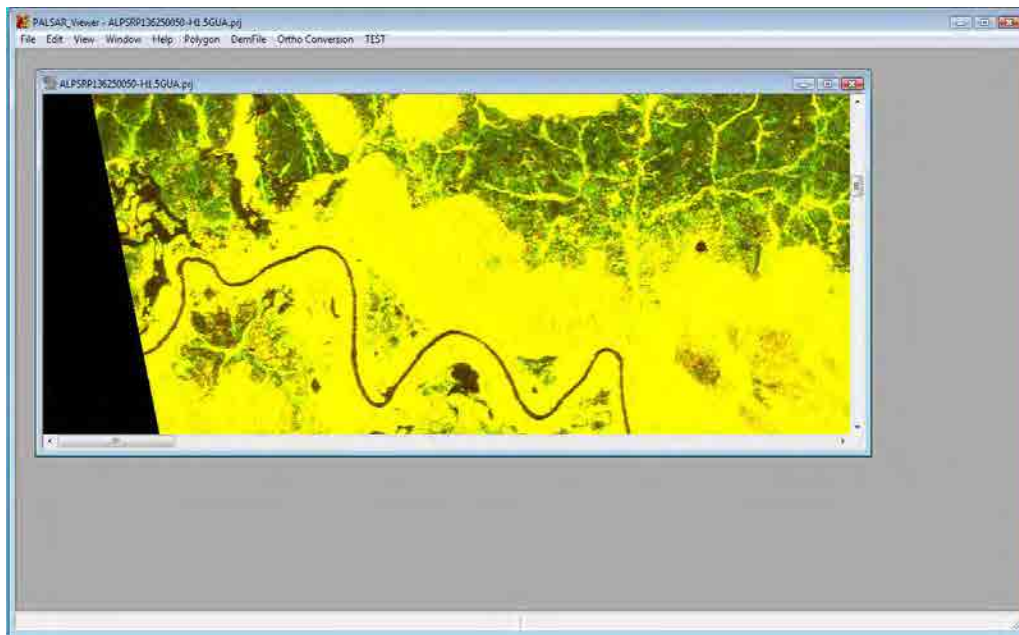


Figura 53. Imagem ilustrativa da composição colorida HH/Red e HV/Green.

Após a geração da composição colorida, os Menus funcionam da mesma forma que a imagem de apenas uma polarimetria, inclusive a correção utilizando o DEM.

4.21 Interpretação de dados PALSAR

Em dados PALSAR, a intensidade da imagem varia de escuro a claro dependendo da condição da superfície dos alvos. Em geral, superfícies planas apresentam reflectância escura. Normalmente, as superfícies planas são água parada ou superfícies úmidas.

Neste contexto, áreas escuras podem ser superfícies planas ou áreas cobertas por água e áreas brilhantes podem ser áreas de cobertura áspera ou áreas secas (figura 54).

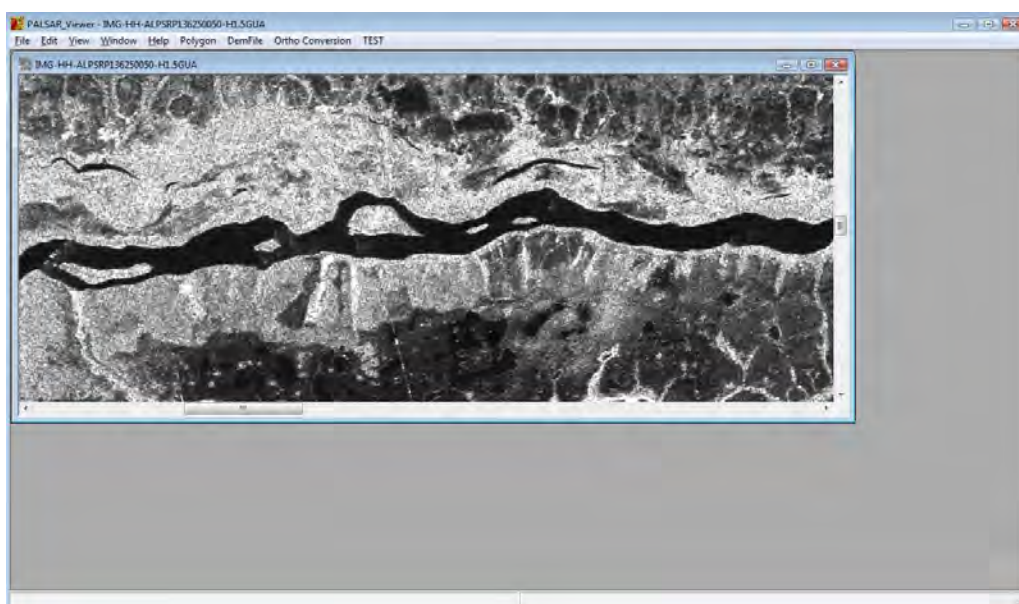


Figura 54. Imagem ilustrativa das características dos alvos em imagens PALSAR.

Superfícies planas, escuras, também podem ser originadas a partir do corte de árvores em áreas de floresta que normalmente apresentam-se brilhantes.

Sugere-se que a interpretação de dados PALSAR seja, quando possível, validada em outras imagens de sensores ópticos.

4.22 Considerações Finais

Todas as informações dispostas neste Manual têm como referência o material didático disponibilizado pelo Perito Sênior Sr. Makoto Ono, durante os cursos de capacitação promovidos no âmbito do convênio DPF/IBAMA/JICA, para os Peritos Criminais Federais do DPF e Analistas Ambientais do IBAMA. Quaisquer dúvidas podem ser tiradas junto à Equipe Técnica do citado convênio.

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Boerner, W. M, Mott, H., Luneburg, E., Livingstone, C., Brisco, B., Brown, R. J, Paterson, J. S. Polarimetry in Radar Remote Sensing: Basic and Applied Concepts. *Principles & Applications of Imaging Radar. Manual of Remote Sensing*. Third Edition Volume 2. 1998.

Correia, A. H. Freitas, C. C, Sant'anna, S. J. S, Rennó, C. D. Utilização de Radar de Abertura Sintética na Classificação de Uso e Ocupação de Solo. Disponível Em: <<http://www.dpi.inpe.br/ofigeo.pdf>>. Acesso em 28/3/2011.

Correia, A. H. Fundamentos da Polarimetria e da Calibração SAR. Disponível em http://www.dpi.inpe.br/cursos/ser410/basic_sar_polarimetric_and_calibration_tutorial.pdf. Acesso em 28/3/2011.

Kuplich, T. M. Estudos Florestais Com Imagens de Radar. Disponível em <http://vsites.unb.br/ih/novo_portal/portal_gea/lsie/revista/arquivos/volume_6_numero_1_2003/e_g_2003_v6_n1_071_096_kuplich.pdf>. Acesso em 28/3/2011.

RESTEC. Apresentação de Palestra.

Soler, L S. S. Detecção de Manchas de Óleo na Superfície do Mar por Meio de Técnicas de Classificação Textural de Imagens de Radar de Abertura Sintética (Radarsat-1). Inpe. Dissertação de Mestrado. Disponível em < www.obt.inpe.br/pgsere/Soler-L-S-2000/homepage.pdf>. 2000. 167 fls.

Fontes:

<http://southport.jpl.nasa.gov/>

<http://www.dpi.inpe.br/spring/teoria/radar/radar.htm>

Fonte:

Textbook on ALOS PALSAR (RESTEC)

<http://www.alos-restec.jp/>

<http://www.jaxa.jp/projects/sat/alos>

<http://engesat.com.br/>

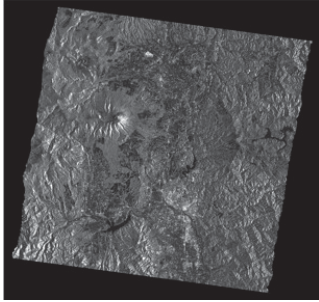
Definition of Products –PALSAR (2/2)

High Level Products : will be generated at EORC.

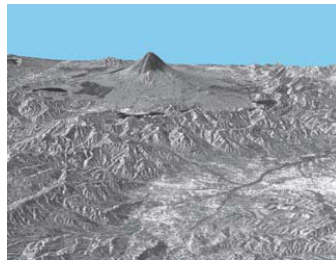
PALSAR : DEM by InSAR (2,500 scenes/y, 50m), and Ortho-rectified image

Research Products (tentative) : will be produced at EORC.

- Forest and biomass map, Surface deformation, sea-ice, soil moisture, and snow parameter products using PALSAR data



Ortho-rectified image.



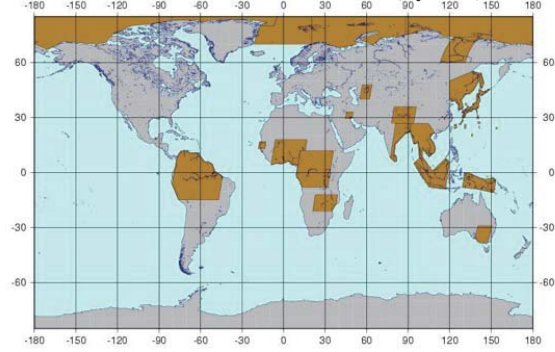
Interferometric SAR DEM of Mt. Fuji derived from JERS-1/SAR.

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ALOS Observation Strategy

--- PALSAR Observation Plans (Cycle 20)---



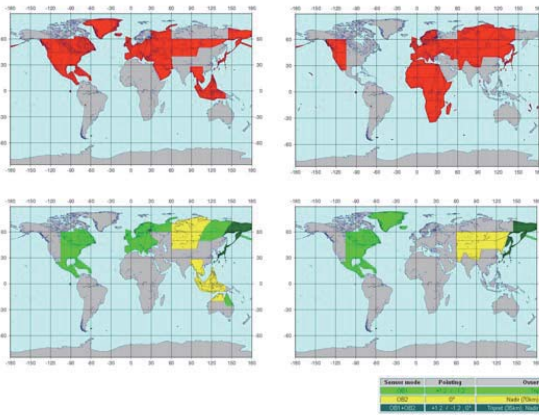
Mode	Off-nadir	Polarization
ScanSAR 5-beam short burst (120 Mbps)	20.1° - 36.5°	HH
Fine Beam	34.3°	HH

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ALOS Observation Strategy

--- The PRISM and AVNIR-2 Observation Plans (Cycle 20-21)---



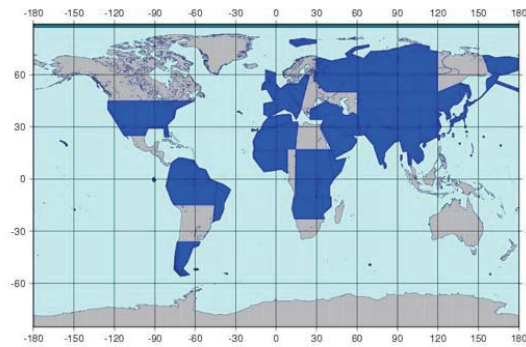
Sensor mode	Polarization	Observation tracks
PRISM	HH	Nadir (0km) + Backward (0km)
AVNIR-2	HH	Nadir (0km) + Backward (0km)

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ALOS Observation Strategy

--- PALSAR Observation Plans (Cycle 20)---



Sensor mode	Off-nadir	Polarization
Fine Beam	41.5°	HH
Fine Beam	21.5°	HH+HV
Fine Beam	31.5°	HH+HV+VH+VV
Fine Beam	34.3°	HH
Fine Beam	21.5°	HH
Fine Beam	49.0°	HH+HV

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ALOS Observation Strategy

--- The PALSAR Observation Plan ---

Sensor mode	Polarization	Off-nadir angle	Pass designation	Coverage	Time window	Observation frequency
Fine Beam Single pol.	HH	34.3°	Ascending	Global	Dec-Feb	1-2 obs/year
Fine Beam Dual pol.	HH+HV	34.3°	Ascending	Global	May-Sep	1-4 obs/year
Fine Beam Polarimetry	HH+HV+VH+VV	21.5°	Ascending	Regional	Mar-May	2 obs/2 year
ScanSAR 5-beam short burst	HH	20.1° - 36.5°	Descending	(a) Global (b) Regional	Jan-Dec	(a) 1 obs/year (b) 8 obs/1 year
Fine Beam Dual pol.	HH+HV	49.0°	Ascending	the Arctic Circle	Jun-Oct	1-3 obs/year

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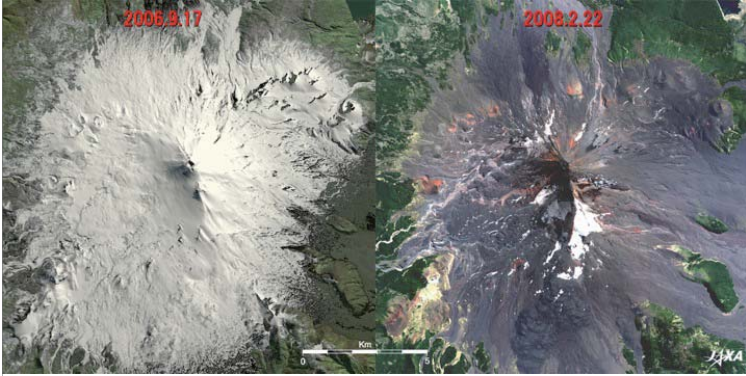
Chapter 3. Examples

- ✓ Volcano
- ✓ Glacial lakes
- ✓ Satellite topographical map
- ✓ Land-slide
- ✓ Flood
- ✓ Earthquake
- ✓ 3-D viewing
- ✓ Deforestation
- ✓ ScanSAR
- ✓ Polarimetric observation

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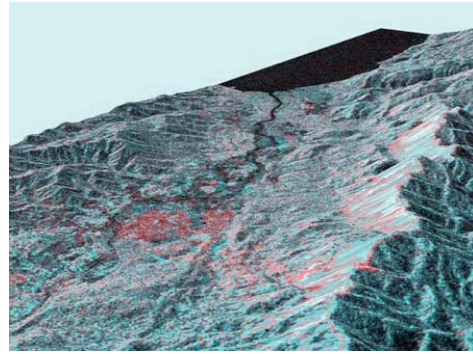
Volcano : Araucania's Volcanoes with Glaciers in Southern Chile



The 3,125-m-high Llama Volcano :
 A double-peaked volcano with the higher peak having a 350-m-diameter crater and one of the largest and the most active volcanoes in Chile.
 On New Year's Day 2008, the volcano ended a 13-year dormant period going back to 1994. ©JAXA p

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North-west view of landslide area in Leyte Island, Philippines



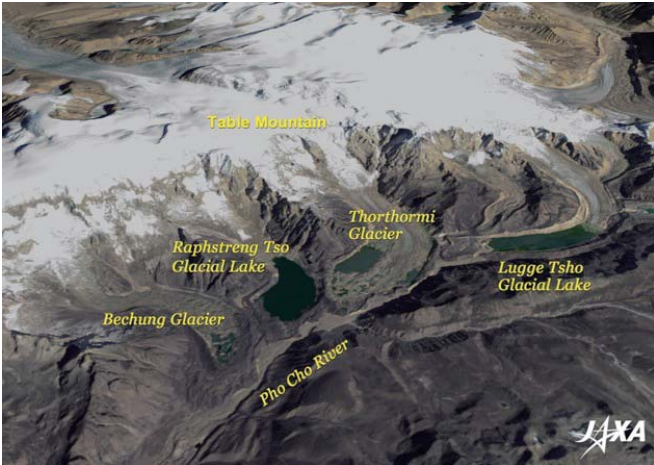
ALOS/PALSAR observation: Feb. 24, 2006 (JST)
 JERS-1/SAR observation: Feb. 2, 1996 (JST)
 Longitude and latitude around the landslide stricken area
 Around 10°20' N, 125°5' E

Bird's eye view of the landslide stricken area
 Color composite image with observation data by the PALSAR and JERS-1/SAR (R: PALSAR, G and B: SAR)
 The area circled by yellow dots is estimated as a disaster stricken area based on the color composite image.

©JAXA http://www.eorc.jaxa.jp/ALOS/img_up/disaster_060225.htm

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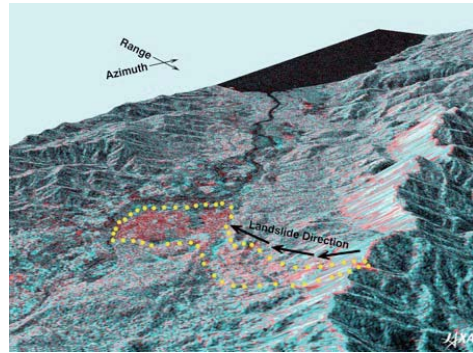
Glacial lakes in Bhutan Himalayas



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North-west view of landslide area in Leyte Island, Philippines



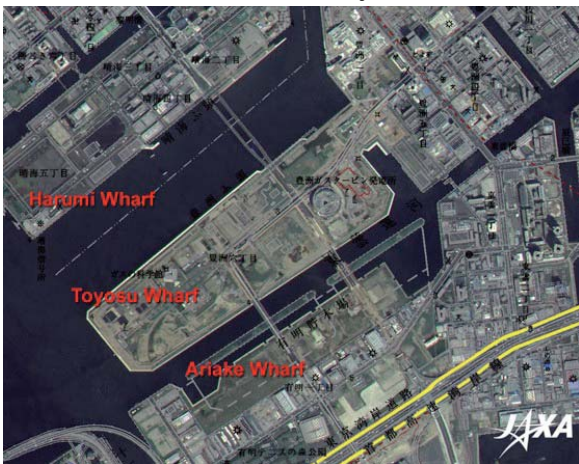
ALOS/PALSAR observation: Feb. 24, 2006 (JST)
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©JAXA http://www.eorc.jaxa.jp/ALOS/img_up/disaster_060225.htm

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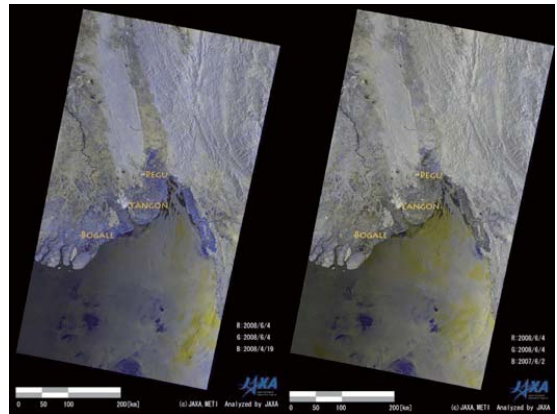
1/25,000 Scale Satellite Topographical Map, Southern Tokyo



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Flood

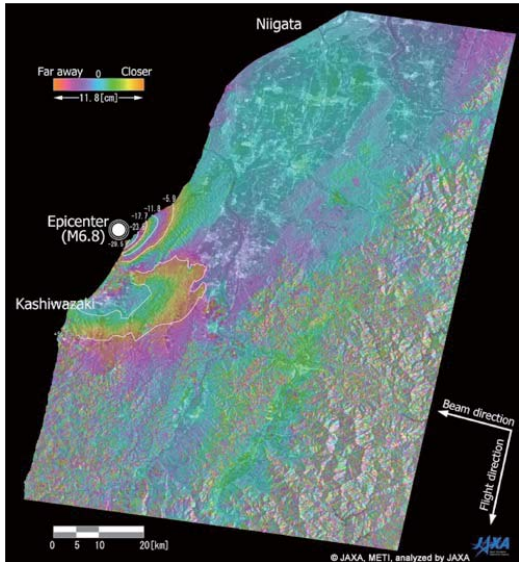


Myanmar was heavily flooded from May 2 to May 3, 2008, due to Cyclone Nargis.

BLUE color in the figure shows the flooded area expected and it spread out 20-100km inland from the coasts.

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Earthquake

Diastrophism in Chuetsu Region, Niigata

-11.8 cm indicates that the distance between the Daichi and the land got closer (shrunken) or diastrophism with a rise took place.

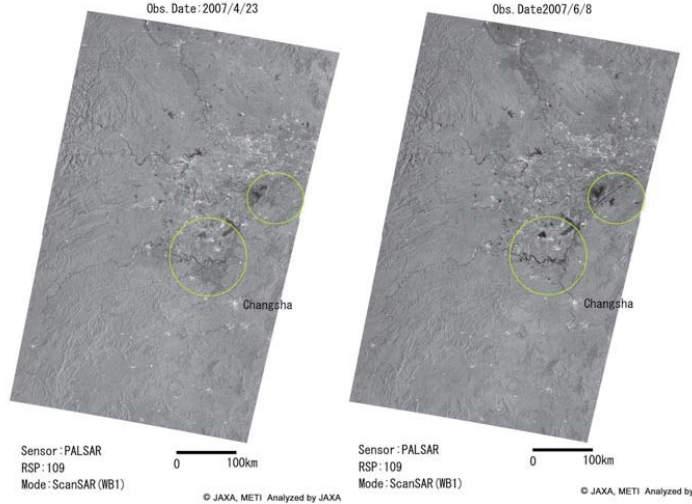
+11.8 cm indicates that the distance between the Daichi and the land got further (longer) or diastrophism with a subsidence took place.

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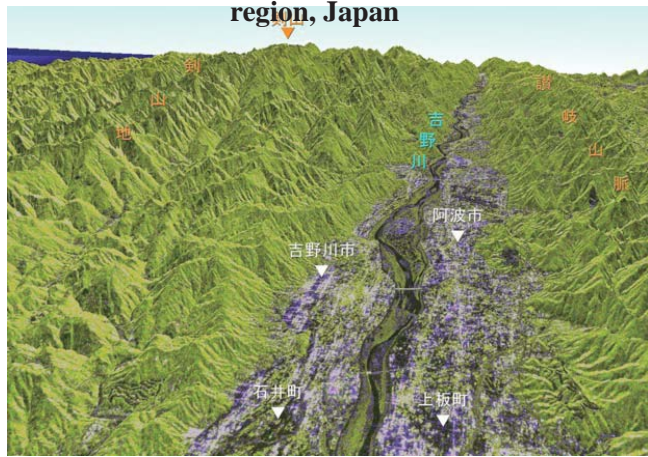
terça-feira, 13 de outubro de 2009

SCANSAR : South of China Flood observation by PALSAR(SCANSAR)



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3-D viewing of the vicinity of Yoshino River, Shikoku region, Japan

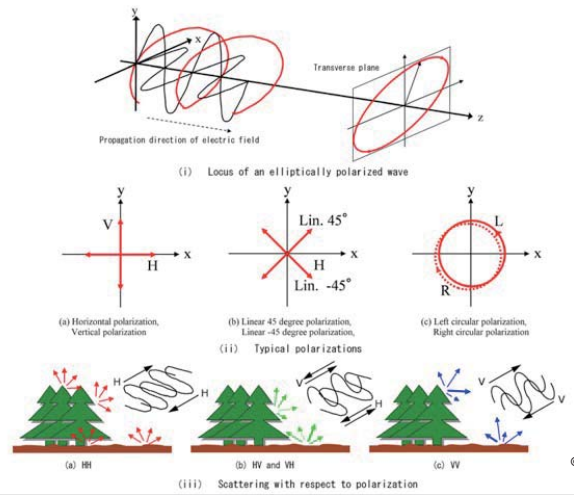


Processed by M. Shimada (JAXA) and K. Isono (RESTEC)

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Polarimetric observation by PALSAR



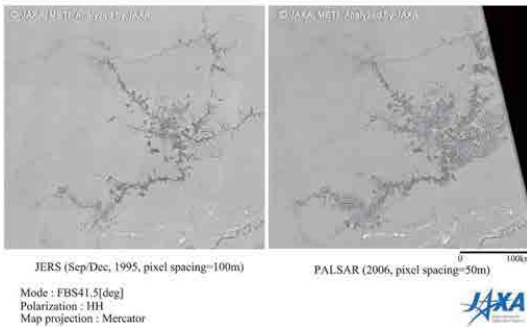
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Deforestation

Amazon mosaic (Rondonia area)



Deforestation at the West Rondonia during eleven years. Left is the JERS-1 SAR mosaic in 1995, right is the PALSAR mosaic in 2006.

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Around Kita-kyusyu-shi, Japan

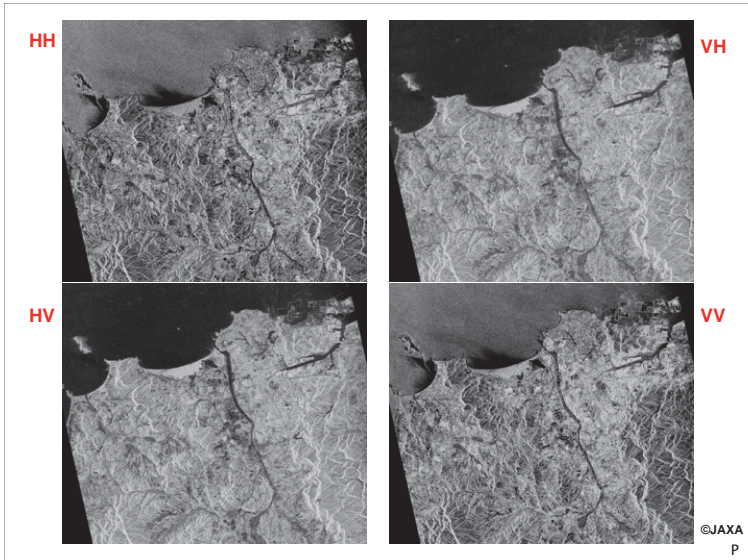
Left image observed by PALSAR (Polarimetric) on May 16, 2006

Right image observed by Landsat-5/TM on Jan. 10, 1994.

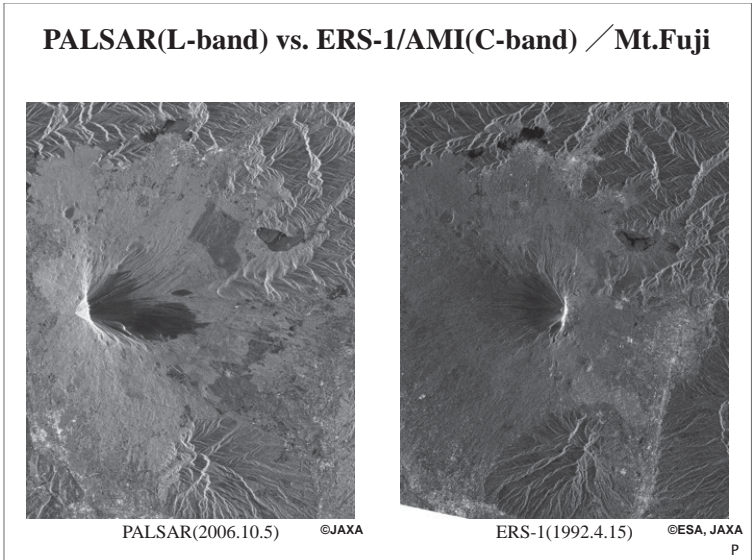
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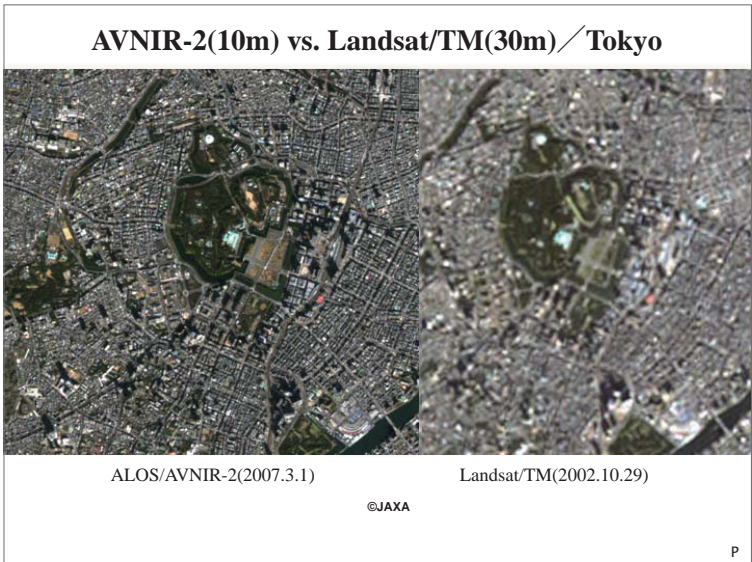
terça-feira, 13 de outubro de 2009

Chapter 4. Comparison with the other satellites

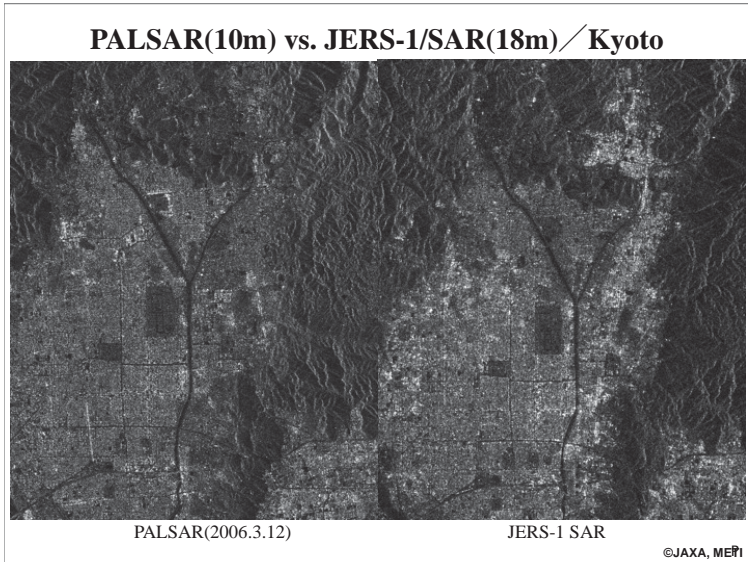
- ✓ PALSAR vs. JERS-1/SAR
- ✓ PALSAR vs. ERS-a/AMI
- ✓ AVNIR-2 vs. Landsat/TM
- ✓ AVNIR-2 vs. IKONOS/Mul
- ✓ PRISM vs. IKONOS/Mul
- ✓ PRISM vs. IKONOS/Pan

©JAXA P

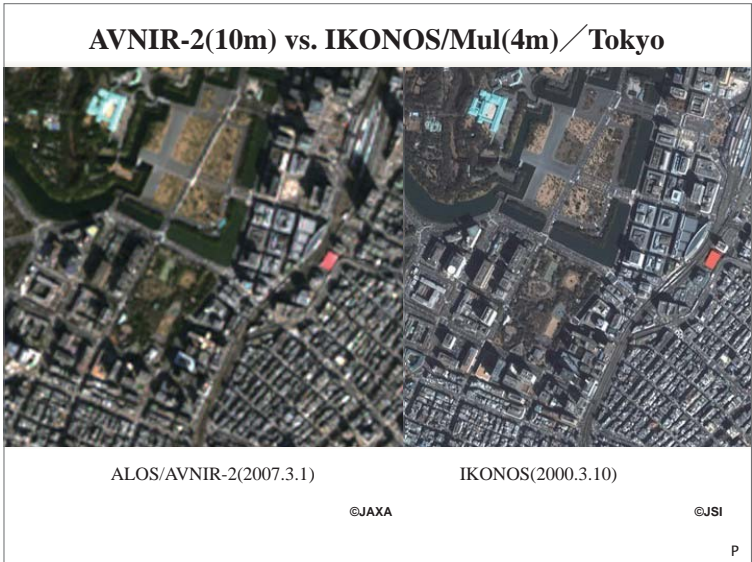
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PRISM(2.5m) vs. IKONOS/Mul(4m) / Tokyo



ALOS/PRISM(2007.3.1)

IKONOS(2000.3.10)

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Contents

1. Geometry of SAR image
 - 1.1 Mapping on Slant range and Ground range
 - 1.2 Fore shortening
 - 1.3 Lay over
 - 1.4 Shadow
2. Radiometric Property of SAR image
 - 2.1 System defined parameter
 - a) Wavelength
 - b) Incident angle
 - c) Polarization
 - d) Illumination orientation
 - e) Speckle noise
 - 2.2 Target depend parameter
 - a) Surface roughness
 - b) Dielectric constant
 - c) Shape of target
 - Specular reflection
 - Double bounce
 - Volume scattering
3. Radiometric Calibration
4. SAR specific analysis technology
 - 4.1 Inteeferometry(InSAR)
 - 4.2 Polarimetry
 - 4.3 Coherence
 - 4.4 SAR stereo

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PRISM(2.5m) vs. IKONOS/Pan(1m) / Tokyo



ALOS/PRISM(2007.3.1)

IKONOS/PAN(2000.3.10)

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1. Geometric Distortion of SAR

In the SAR image reconstruction process, cross track pixel sampling is originally done using range (from satellite to target distance) information. Usually equal range spaced image (referred as slant range image) is created initially. Due to the side looking geometry, equal range spacing causes unequal ground range spacing.

Also, due to the image mapping process, pixel position distortion appears depending on the local land feature measured from a reference plane. This distortion happens both in slant range image and in ground range image.

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The Project for utilization of ALOS images to support the protection of the Brazilian Amazon Forest and combat against illegal deforestation.
Basic training course 2009

SAR Image Characteristics

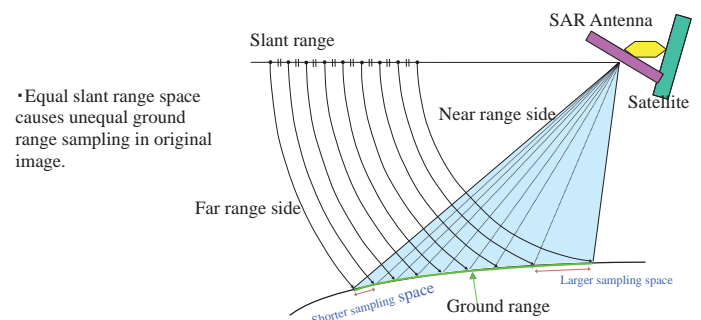


REMOTE SENSING TECHNOLOGY CENTER OF JAPAN
TOKYO, JAPAN

terça-feira, 13 de outubro de 2009

1. Geometrical Characteristics of SAR

1.1 Ground range distortion by equal range sampling



• Equal slant range space causes unequal ground range sampling in original image.

- In PALSAR image products, georeferenced and geocoded data is resampled to equal ground sampling space.
- SLC data is usually slant range image to keep original phase information.

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1. Geometrical Characteristics of SAR

1.1 Difference between Slant range image and Ground range image



Slant range image



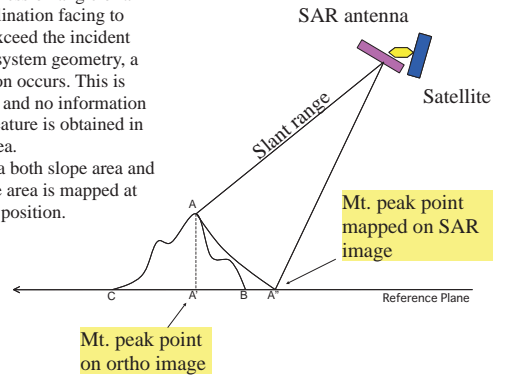
Ground range image

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1. Geometrical Characteristics of SAR

1.3 Lay Over

In case the depression angle of a local slope inclination facing to SAR system exceed the incident angle of SAR system geometry, a severe distortion occurs. This is called lay over and no information on the target feature is obtained in the lay over area. In lay over area both slope area and moderate slope area is mapped at the same pixel position.

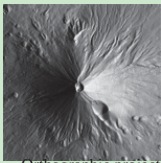


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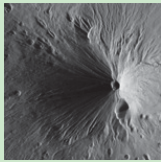
1. Geometrical Characteristics of SAR

1.2 Image Distortion due to local land feature and satellite geometry

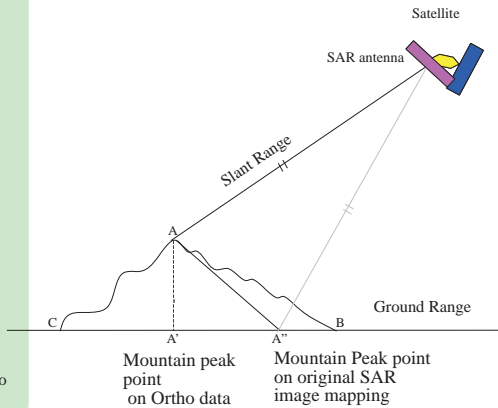
Simulated SAR image



Orthographic projection



Slant range image (re-sampled to equal ground range space)

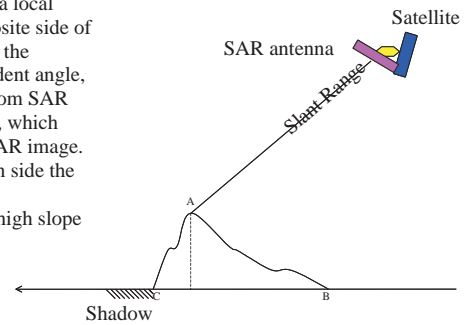


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1. Geometrical Characteristics of SAR

1.4 Radar Shadow

If the inclination of a local slope facing to opposite side of SAR system exceed the complement of incident angle, the slope is hidden from SAR system illumination, which causes shadow in SAR image. Shadow continues in side the blanket area of the illumination by the high slope object.

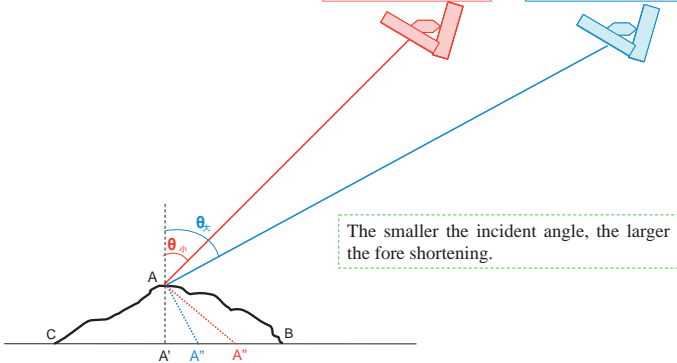


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1. Geometrical Characteristics of SAR

1.2 Fore Shortening

Small incident angel Large incident angle

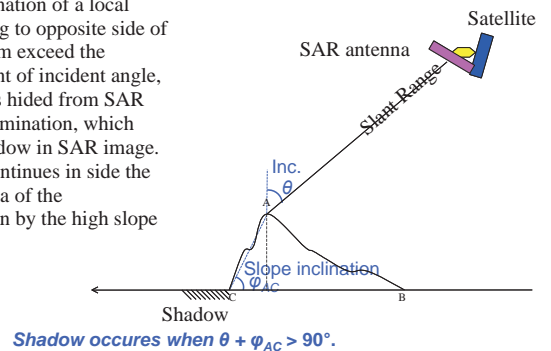


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1. Geometrical Characteristics of SAR

1.4 Radar Shadow

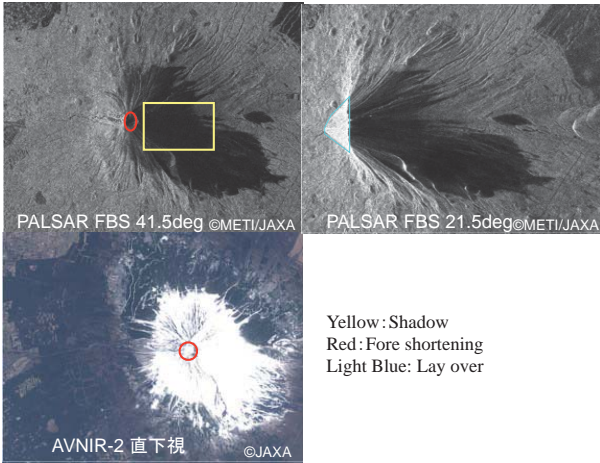
If the inclination of a local slope facing to opposite side of SAR system exceed the complement of incident angle, the slope is hidden from SAR system illumination, which causes shadow in SAR image. Shadow continues in side the blanket area of the illumination by the high slope object.



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1. Geometrical Characteristics of SAR

Examples



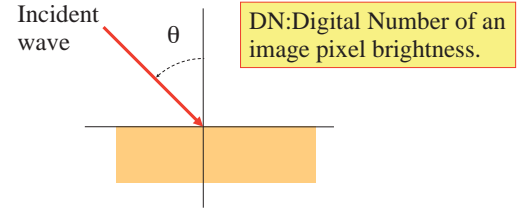
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Concept of σ

Radar back scattering cross section(RCS)= return energy within a beam width and range bin. (Wikipedia)

$$\sigma = DN \sin(\theta) \text{ (normalized by pulse illuminated area)}$$

$$\gamma = \sigma / \cos(\theta) \text{ (normalized value to perpendicular incident energy)}$$



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2. Radiometric Characteristics of SAR

2.1 SAR system Element to affect intensity

- a wavelength
- b incident angle
- c polarization
- d illumination orientation
- e speckle noise

2.2 Target Element to affect intensity

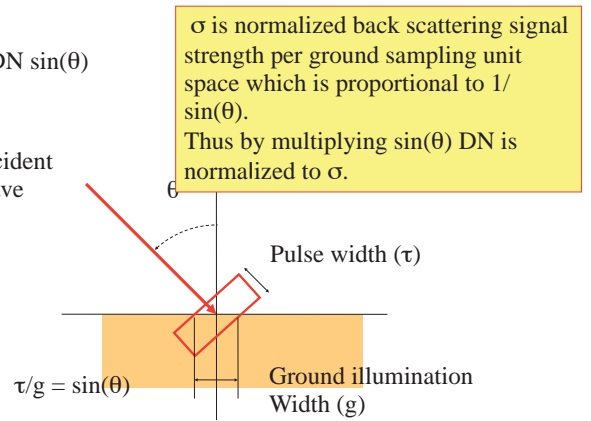
- a electromagnetic parameter (dielectric/magnetic constants)
- b surface texture
- c surface pattern
- Mirror, Dihedral, Trihedral, Bragg scattering

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Value of σ in RADAR image

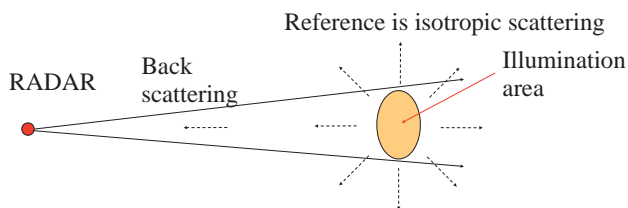
$$\sigma = DN \sin(\theta)$$

Incident wave



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Digital Number of SAR image



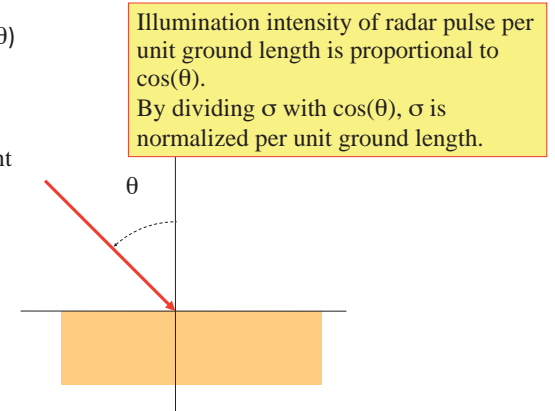
DN is a digitized back scattering signal strength normalized by Radar illumination strength.

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Concept of γ

$$\gamma = \sigma / \cos(\theta)$$

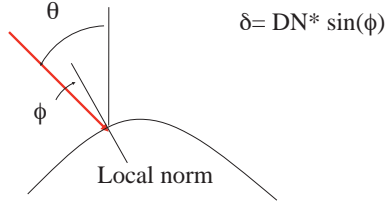
Incident wave



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Slope Correction

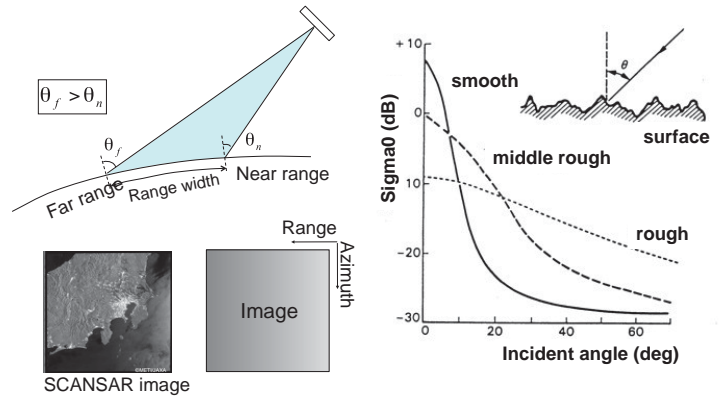
- In the derivation of S , $\sin(\alpha)$ is multiplied to DN. In standard processing α is counted as angle of incident wave direction (opposite direction) and normal vector on flat earth surface.
- If incident angle relative to slope of local feature is taken



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2. Radiometric Characteristics of SAR

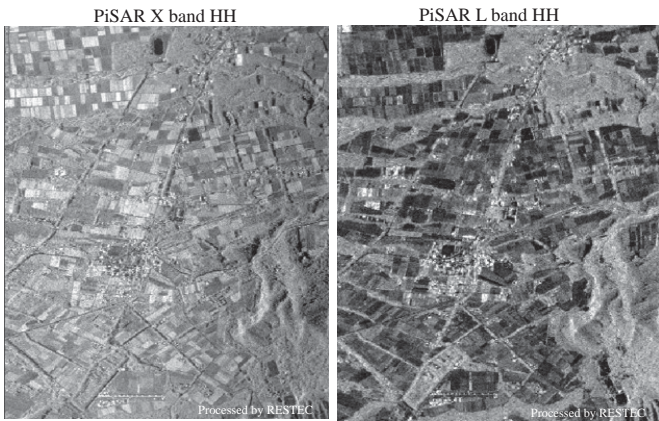
-2.1 Effect of Incident angle



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2. Radiometric Characteristics of SAR

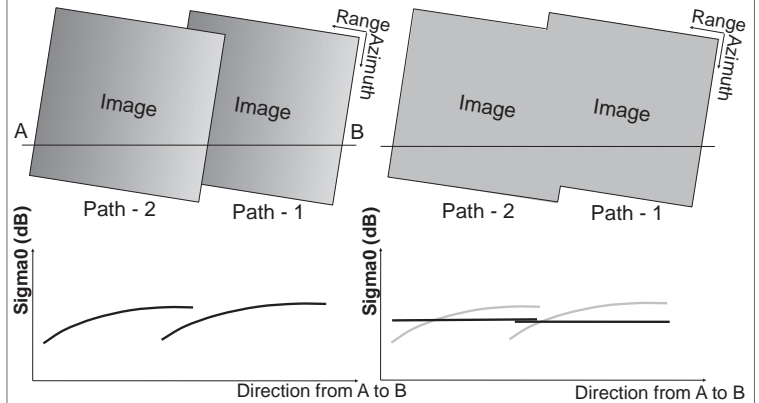
2.1 System parameter effect of wavelength



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2. Radiometric Characteristics of SAR

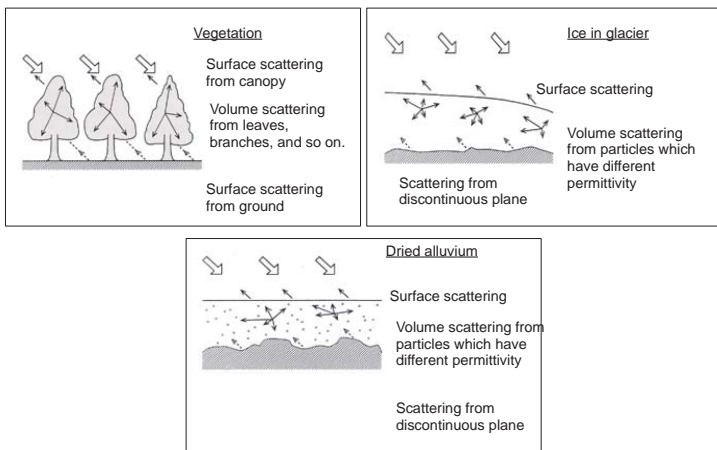
2.1 Image discontinuity due to the effect of incident angle



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2. Radiometric Characteristics of SAR

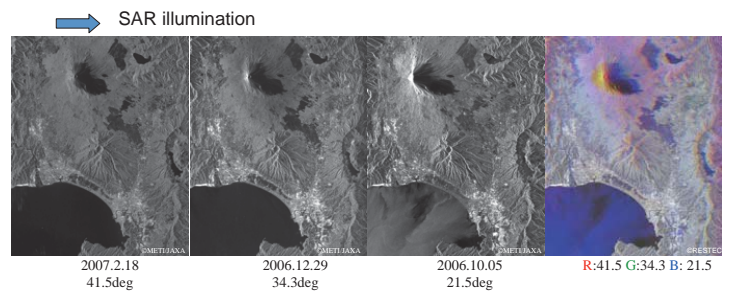
2.1 Effect of wavelength



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2. Radiometric Characteristics of SAR

2.1 Example of incident angle difference

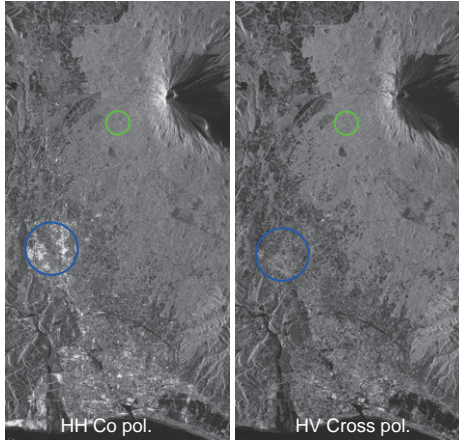


- Check !
- Difference in fore slope
 - Difference in local slope effect
 - Difference of Sea surface

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2. Radiometric Characteristics of SAR

2.1 Effect of polarization

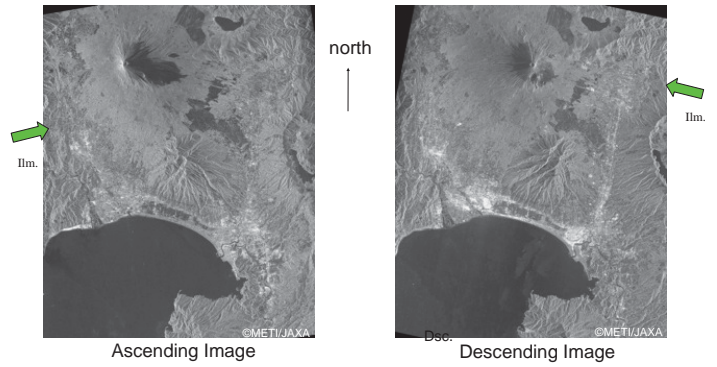


Dual polarization reception in PALSAR (copol. And cross pol.) provides additional surface information from the SAR image pair. Urban area usually causes weak reflection in cross pol. While it causes bright reflection (blue circle). On the contrary, forested area the difference between co pol. And cross pol. Is small (green circle)

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2. Radiometric Characteristics of SAR

2.1 Example of Ascending observation and Descending observation



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2. Radiometric Characteristics of SAR

2.1 Effect of polarization

Pi SAR X band

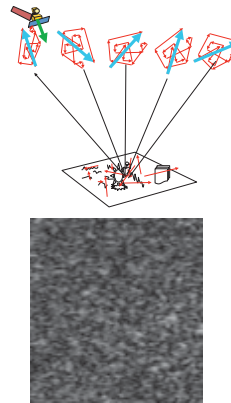


Airborne PiSAR Xband Image (2004.8.4) Grow stage indication of vegetable field appears in the color difference of the agriculture fields.

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2. Radiometric Characteristics of SAR

2.1 Speckle Noise



A unit cell (pixel) contains many reflecting objects in the cell. Even if each object in the cell reflects radar wave isotropically, over all summation of reflected electro-magnetic wave varies depending on the observation direction due to the variation of relative phase.

Radar reflectance is a measure to evaluate power reflection ratio to incident power.

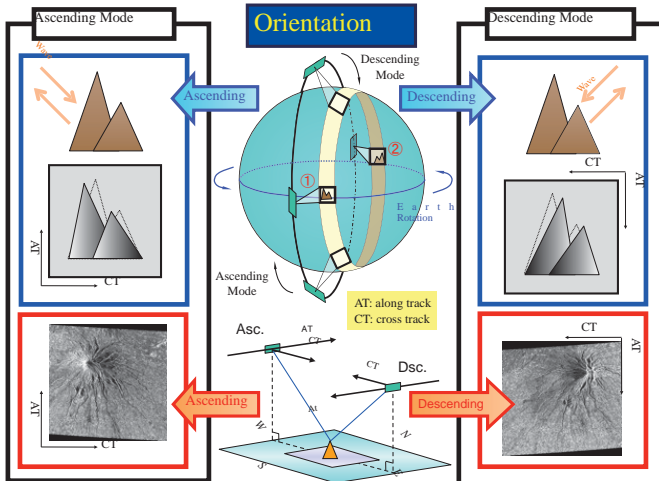
But in the SAR image processing, amplitude summation from individual object with various reflectance is calculated as pixel value. Thus statistic expectation of the vector summation (complex pixel value) is zero (summation of random complex number) while the statistic expectation of the variance is the Radar reflectance.

Difference of the two value appears as speckle noise which is multiplicative nature. Thus the noise looks significant compared with the thermal noise in optical images.

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2. Radiometric Characteristics of SAR

2.1 Effect of illumination orientation (Ascending and Descending)



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2. Radiometric Characteristics of SAR

2.1 Speckle noise reduction

- From the basic SAR process nature, speckle noise reduction can be done in various ways.
- Using a statistic theory, one effective way is to obtain many samples showing a pixel and non coherently averaging the data to evaluate Radar reflectance.
- This is called multi look processing.
- By sacrificing resolution, several independent pixel value can be obtained from an original image, which can be averaged to reduce speckle noise.

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Radiometric Characteristics of SAR

2.2 Target depend elements

Following 3 element affect intensity level of SAR image.

- Surface roughness
- Dielectric constants
- Surface pattern and texture

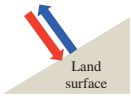
Discrimination of surface roughness and dielectric constants

Use of dual polarization or polarimetry may provide solution.

Shape and pattern/texture:

depending on the target shape, location pattern and texture causes various kind scattering as: Bragg, specular, volume, multiple bounce scattering.

Specular reflection



Single bounce



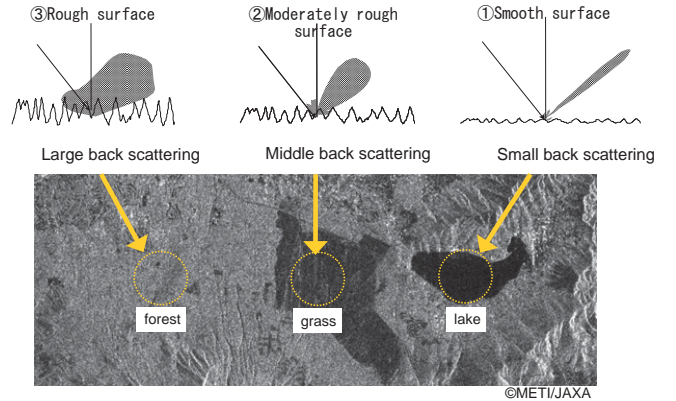
Dual bounce



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Radiometric Characteristics of SAR

2.2 Surface roughness: Typical sample



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Radiometric Characteristics of SAR

2.2 Surface roughness

Rayleigh's condition

$$h \leq \frac{\lambda}{8 \cos(\theta)} \quad \text{:smooth limit}$$

(h : rms of height variation, λ : wavelength, θ : incident angle)

In the case of ALOS/PALSAR/JERS-1, $\theta=38^\circ$, $\lambda=0.23\text{m}$ then;

Smooth limit is $h \leq 3.65\text{cm}$

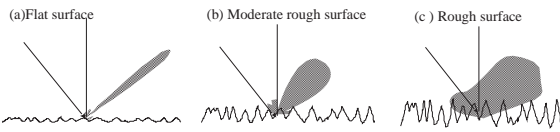


Image of scattering directivity relative to surface condition.

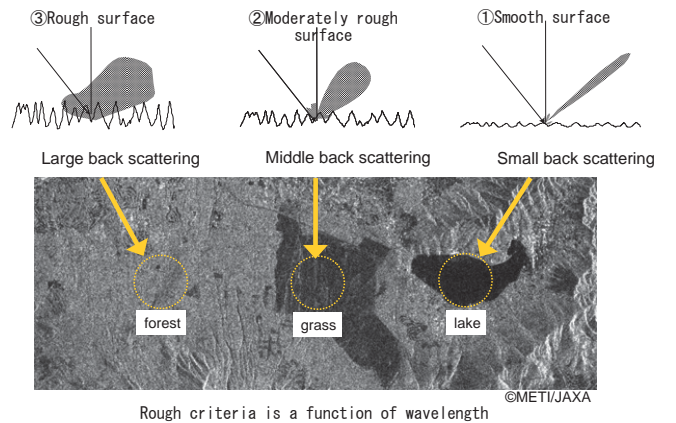
Spatial distribution of surface roughness must also be counted. If the spatial frequency is less than wavelength, rough surface looks like a some smooth dielectric body sheath.

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Radiometric Characteristics of SAR

2.2 Surface roughness: Typical sample

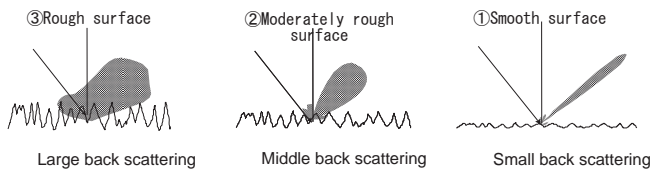


Rough criteria is a function of wavelength

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Radiometric Characteristics of SAR

2.2 Surface roughness: Typical sample



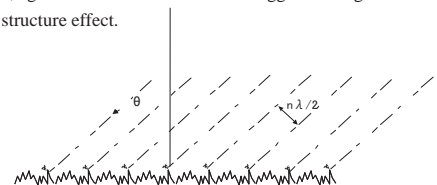
Radiometric Characteristics of SAR

2.2 Surface roughness

•Bragg scattering

repeated pattern of local random surface causes a strong reflection to specific directions. This phenomena are called Bragg scattering and used in various analysis in physics. In the radar remote sensing this is often used to analyze sea surface observations.

In land observation, agriculture field often causes Bragg scattering to show some directive periodic structure effect.



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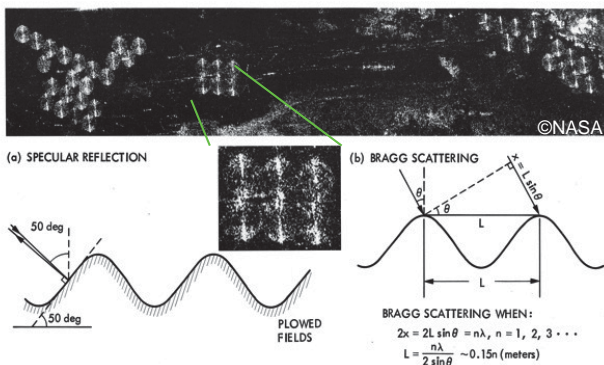
terça-feira, 13 de outubro de 2009

terça-feira, 13 de outubro de 2009

2. Radiometric characteristics of SAR

2.2 Pattern

Specular reflection, Bragg scattering



リビアのセンターピボット式灌漑農業地帯のSIR-A画像

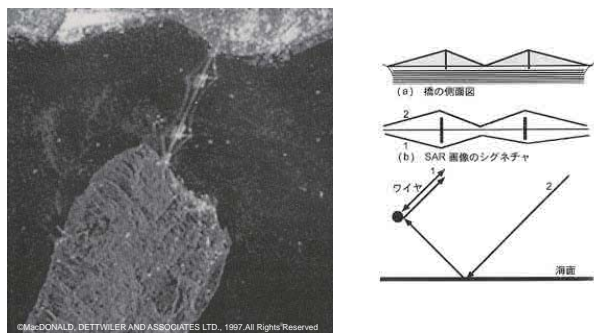
32

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2. Radiometric characteristics of SAR

2.2 Shape / location

Multiple reflection by a bridge and water surface

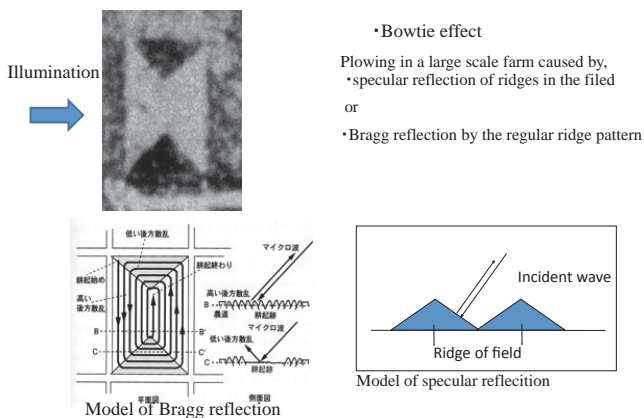


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2. Radiometric characteristics of SAR

2.2 Pattern and shape



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3. Calibration of Reflectance

2. Radiometric characteristics of SAR

2.2 Shape and location

Cardinal Effect



Strong back scattering in urban area from buildings inside. Reflection from building face to wave incidence causes strongest back scattering.

Dihedral or trihedral reflection and multiple reflection by its combination is the main reason of the reflection.

Parallel structure to wave incidence direction is almost dark in the image.

L band :Purple
X band :Green

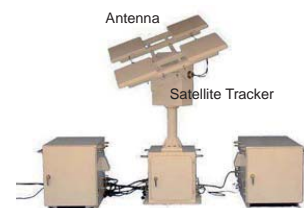


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3.1 Conversion to back scattering coefficient

- Back scattering coefficient σ^0 : Ratio of return signal power over incident power.
- In a SAR system, theoretical beam width after image processing and its illumination power density distribution is necessary to evaluate the value.
- Calibration using known reflectance object appears in the image is easier than theoretical dedication.
- Passive or active corner reflector is used as reference reflection source.

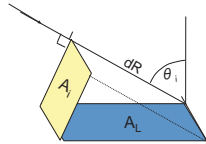


Active Radar Calibrator (ARC)

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3.1 Conversion to back scattering coefficient

Calculation of back scattering:
Set a corner reflector with known back scattering coefficient to be appears in the processed SAR image and use the value in the image as reference back scattering.



ALOS/PALSAR (L1.5)

$$\sigma^0 = 10 \log_{10} \langle |I|^2 \rangle + CF \text{ (dB)}$$

- I: Digital number of a pixel in SAR image
- CF: calibration constant derived from processed corner reflector pixel value in SAR image.
- CF is written in the leader file of PALSAR image products.
- If the signal processing parameter or equation is modified the CF may be changed.



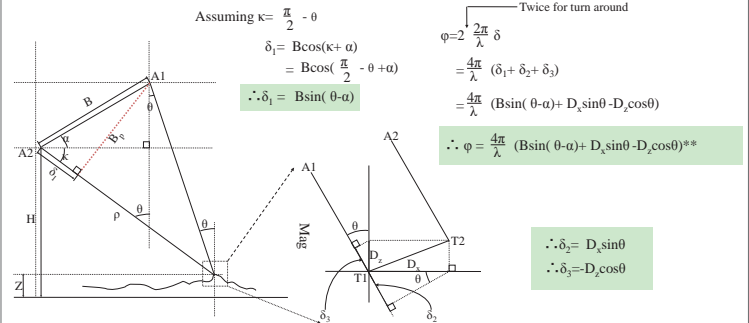
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4. SAR data analysis technology

4.1 SAR Interferometry

Geometry of SAR interferometry

Assume δ as slant range difference between observation A1 and A2 and phase difference ϕ following equations stand as;



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4. SAR Image Analysis Technology

4.1 Interferometry

4.2 Polarimetry

4.3 StereoSAR

terça-feira, 13 de outubro de 2009

4. SAR data analysis technology

4.1 SAR Interferometry

Reduction of basic equation

Phase component

In the image of previous page, an equation to show relations among $Z, \rho,$ and θ as;

$$Z = H - \rho \cos \theta$$

Calculate total differentia of f using equation in

$$d\phi = \frac{\partial \phi}{\partial \rho} d\rho + \frac{\partial \phi}{\partial z} dz + \frac{\partial \phi}{\partial Dx} dDx + \frac{\partial \phi}{\partial Dz} dDz$$

(a) (b) (c) (d)

where (a) : Orbit fringe
(b) : Land feature fringe
(c) ,(d) : Variance fringe

Since (a) doesn't contain land feature information, it is eliminated in post processing. Other items are used in various way.

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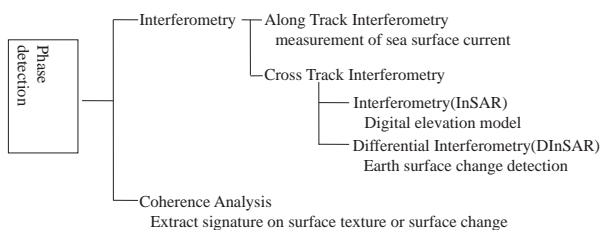
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4. SAR data analysis technology

4.1 SAR interferometry

• SAR Interferometry

Using precision return phase preservation nature of SAR signal processing, interferometer is realize from a pair of images.

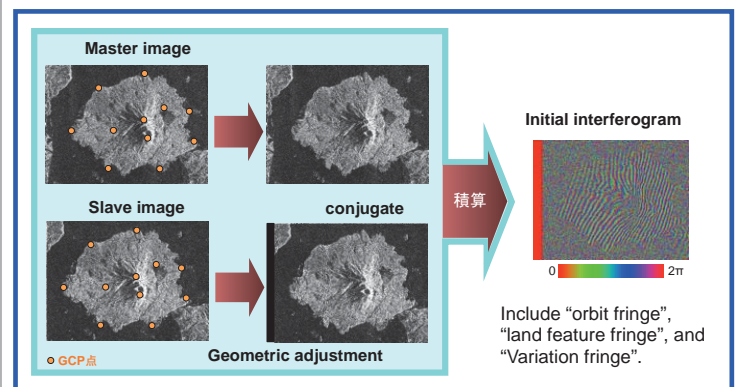


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4. SAR data analysis technology

4.1 SAR Interferometry process flow

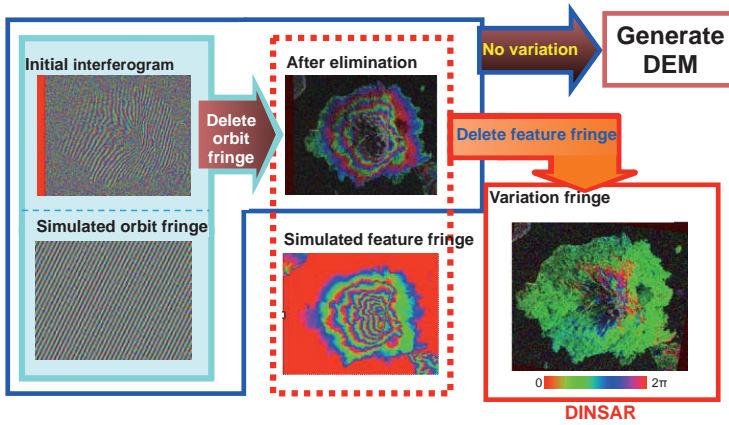


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4. SAR data analysis technology

4.1 SAR Interferometry process flow

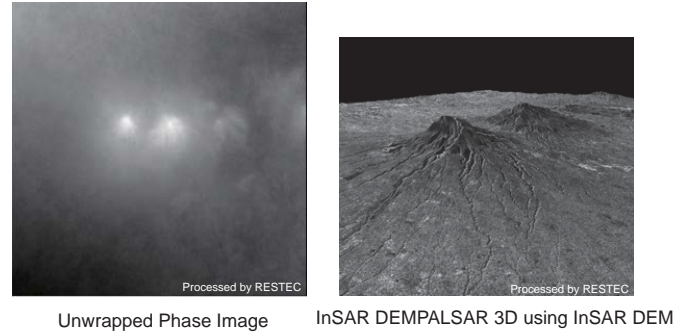


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4. SAR data analysis technology

4.1 SAR Interferometry: Digital elevation model



Unwrapped Phase Image

InSAR DEMPALSAR 3D using InSAR DEM

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4. SAR data analysis technology

4.1 SAR Interferometry

2. Land feature fringe

$$\frac{\partial \phi}{\partial z} = \frac{4\pi B \cos(\theta - \alpha)}{\lambda \rho \sin \theta} = \frac{4\pi B \rho}{\lambda \rho \sin \theta} = \frac{1}{\cos \theta} \frac{\partial \phi}{\partial \rho}$$

Above equation indicates countability of digital elevation mode. In the case of JERS-1, assumin Bp of 500m 1 cycle fringe is equivalent to 100m elevation. By assumin no variation between 2 observation, height difference is proportional to phase difference as,

$$\frac{\partial \phi}{\partial z} = \frac{4\pi B \rho}{\lambda \rho \sin \theta}$$

3. Variation fringe

$$\frac{\partial \phi}{\partial Dx} = \frac{4\pi}{\lambda} \sin \theta$$

Dx:horizontal variation

$$\frac{\partial \phi}{\partial Dz} = -\frac{4\pi}{\lambda} \cos \theta$$

Dz:vertical variation

By removing feature fringe, variation happens in between two observation can be detected. It is very sensitive to change even a half wavelength displacement can be detected.

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4. SAR data analysis technology

4.1 SAR Interferometry

coherence : a measure for phase stability in a pair of Single Look Complex image(SLC). (Coherence) The value is calculated as covariance of two conjugate pixel values.

$$\rho_c = \frac{|E(c_1 c_2^*)|}{[E(c_1 c_1^*) E(c_2 c_2^*)]^2}$$

$c_1 c_2$ is conjugate 2 pixel values in the two SAR images

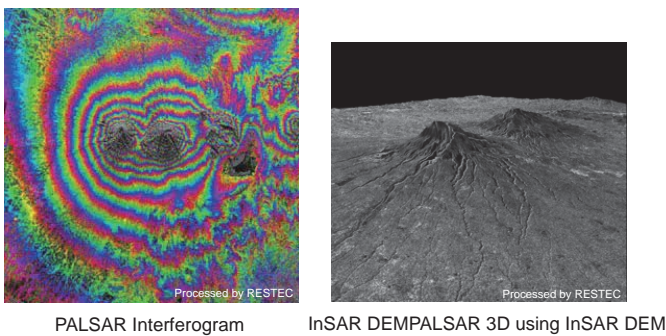
*means conjugate of a complex number, E() is an expectation of the component.

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4. SAR data analysis technology

4.1 SAR Interferometry: Digital elevation model



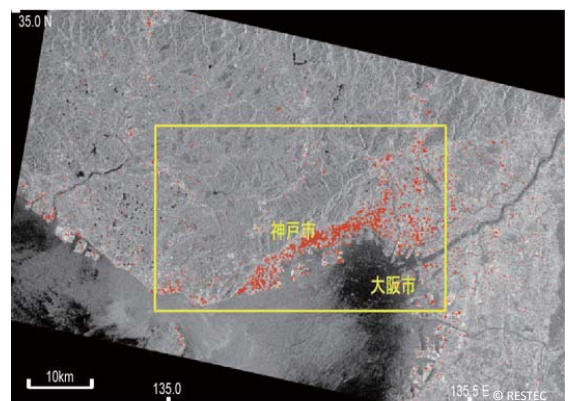
PALSAR Interferogram

InSAR DEMPALSAR 3D using InSAR DEM

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4. SAR data analysis technology

4.1 SAR Interferometry : Damage analysis



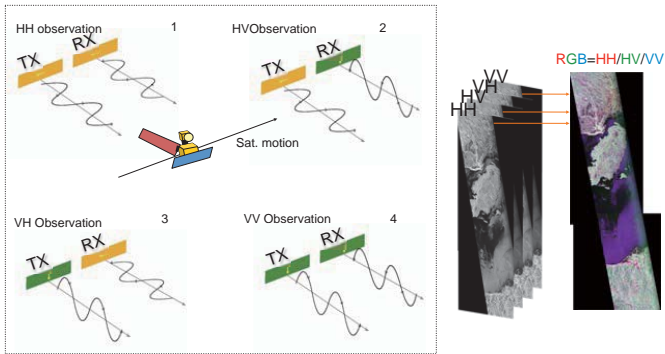
SAR image pair before and after an Earthquake ERS-1 SAR, coherence was calculated to detect damage by the earthquake.

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4. SAR data analysis technology

4.1 SAR Polarimetry

- 4 independent data are acquired from the SAR system.
- Pixel value is stored as complex number to preserve phase delay between TX and RX, which make a scattering matrix.



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4. SAR data analysis technology

4.1 SAR Polarimetry

Scattering Matrix

In a polarimetric SAR image each pixel consists of a scattering matrix of 2 by 2 complex numbers.

$$[S(HV)] = \begin{bmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{bmatrix}$$

In the linear stable system $S_{HV} = S_{VH}$ by the reciprocity theorem of Electromagnetism.

The advantage of the matrix is its flexibility that the matrix can be converted in various basis like circular polarization, ellipsoidal polarization, etc.

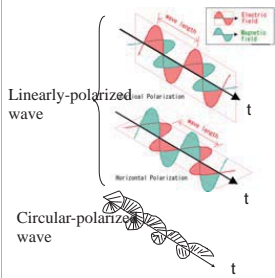
Circular polarization base

$$[S(RL)] = \begin{bmatrix} S_{RR} & S_{RL} \\ S_{LR} & S_{LL} \end{bmatrix} \quad \begin{aligned} S_{RR} &= (S_{HH} - S_{VV} - 2jS_{HV})/2 \\ S_{LL} &= (S_{VV} - S_{HH} - 2jS_{HV})/2 \\ S_{RL} &= S_{LR} = -j(S_{HH} + S_{VV})/2 \end{aligned}$$

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4. SAR data analysis technology

4.1 SAR Polarimetry



Circular polarized wave : spirally rotated polarization
Linearly polarized wave : Horizontal Polarization
Vertical Polarization

In the field of Satellite, H and V polarizations are defined as below:

(H)orizontal pol. : Parallel to satellite's orbital direction
(V)ertical pol. : Vertical to satellite's orbital direction

Case of SAR sensor :

JERS-1 : Emit H pol. and receive H pol. (HH)
ERS-1 : Emit V pol. And receive V pol. (VV)

If we obtain 4 component as phase preserved image data, this is a unique component to express RADAR reflectance. Any transmission and reception mode can be numerically realized from the 4 component. In free space operation only the 3 component is independent upon the reciprocity theorem in electromagnetic theory.

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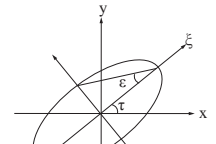
4. SAR data analysis technology

4.1 SAR Polarimetry

Polarization signature

This is an expression of response between Transmission and reception by taking incident wave source with ellipsoidal expression by Tilt angle and ellipticity angle and reception by the same wave source.

The response often shows characteristic pattern depending on the target structure.

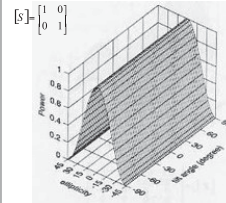


Parameter to express elliptically polarized wave.

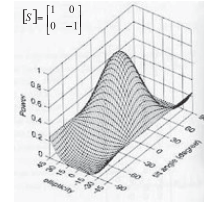
τ : Tilt angle ($-90 \leq \tau \leq 90$)

ϵ : Ellipticity angle ($-45 \leq \epsilon \leq 45$)

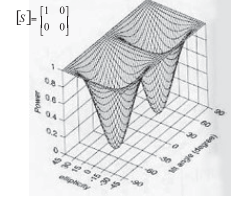
Polarization signature



Flat plane



2面コーナーリフレクタ



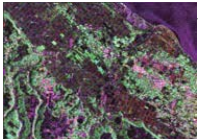
水平ワイヤ

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4. SAR data analysis technology

4.1 SAR Polarimetry

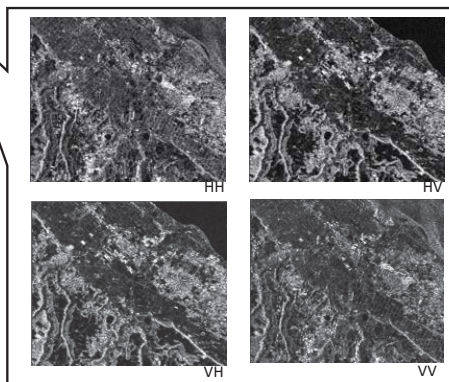
Example polarimetric images



Pi-SAR, L-band, RGB = HH+HV+VV (2004.8.11)



QuickBird, Pansharpen, True Color (2004.8.18)



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4. SAR data analysis technology

4.1 SAR Polarimetry

Instead of scattering matrix, several pre processed matrix is often used. All the matrix is derived from scattering matrix component.

$$\text{Covariance Matrix } \langle C \rangle = \begin{bmatrix} \langle S_{HH} S_{HH}^* \rangle & \sqrt{2} \langle S_{HH} S_{HV}^* \rangle & \langle S_{HH} S_{VV}^* \rangle \\ \sqrt{2} \langle S_{HV} S_{HH}^* \rangle & 2 \langle S_{HV} S_{HV}^* \rangle & \sqrt{2} \langle S_{HV} S_{VV}^* \rangle \\ \langle S_{VV} S_{HH}^* \rangle & \sqrt{2} \langle S_{VV} S_{HV}^* \rangle & \langle S_{VV} S_{VV}^* \rangle \end{bmatrix}$$

Correlation coefficient

$$\text{Cor}(XY, AB) = \frac{\langle S_{xy} S_{ab}^* \rangle}{\sqrt{\langle S_{xy} S_{xy}^* \rangle \langle S_{ab} S_{ab}^* \rangle}}$$

XY, AB means polarization combination of transmission and reception.

In linearly pol. : HH, HV, VH, VV,

In circular: RR, RL, LR, LL.

Covariance vector, Coherency vector

$$\kappa_p = \frac{1}{\sqrt{2}} \begin{bmatrix} S_{HH} + S_{VV} \\ S_{HH} - S_{VV} \\ 2S_{HV} \end{bmatrix} \quad [T] = \kappa_p \kappa_p^* = \begin{bmatrix} \frac{|S_{HH} + S_{VV}|^2}{2} & (S_{HH} + S_{VV})(S_{HH} - S_{VV})^* & (S_{HH} + S_{VV})S_{HV}^* \\ (S_{HH} - S_{VV})(S_{HH} + S_{VV})^* & \frac{|S_{HH} - S_{VV}|^2}{2} & (S_{HH} - S_{VV})S_{HV}^* \\ S_{HV}(S_{HH} + S_{VV})^* & S_{HV}(S_{HH} - S_{VV})^* & 2|S_{HV}|^2 \end{bmatrix}$$

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4. SAR data analysis technology

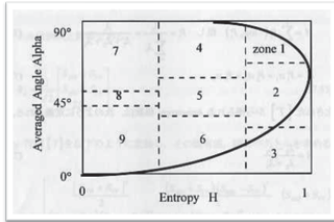
4.1 SAR Polarimetry

Entropy alpha plane

From eigenvalue 1 of Coherency matrix and Angle α of Eigen vector, entropy H and α is defined.

Entropy H (0~1) index for randomness of scattering.
 H=0: surface scattering only
 H=1: 3 kind of scattering is mixed (total randomness)

Angle α (0°~90°) index for polarization dependency
 0°: plate, 45°: wire, 90°: Corner reflector



エントロピとアルファ平面[9]

Using entropy and alpha scattering index is divided into several region, which segment the target category.

Left 9 zone is commonly used to define region on H-A plane.

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4. SAR data analysis technology

4.3 SAR Stereo: Aanallyph

Parallax equation of same side stereo pair of SAR image.

$$p = |\cot\theta_1 - \cot\theta_2| \cdot h$$

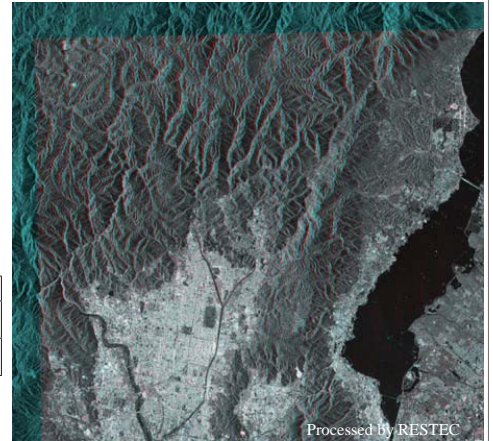
(same illumination direction)

$$p = |\cot\theta_1 + \cot\theta_2| \cdot h$$

(opposite illumination direction)

Image parameter

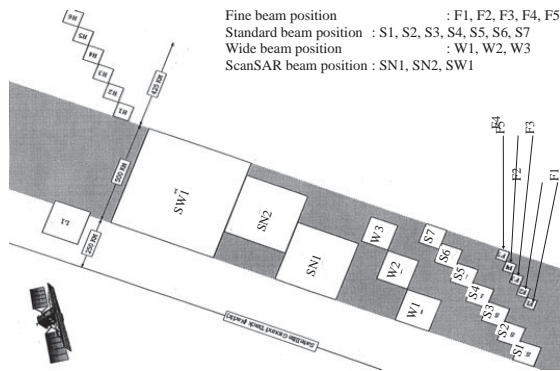
SAR	Mode	Date	Inc.
RADA R	F1	1997.3.17	37.6°
RADA R	F5	1997.3.27	47.5°



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4. SAR data analysis technology

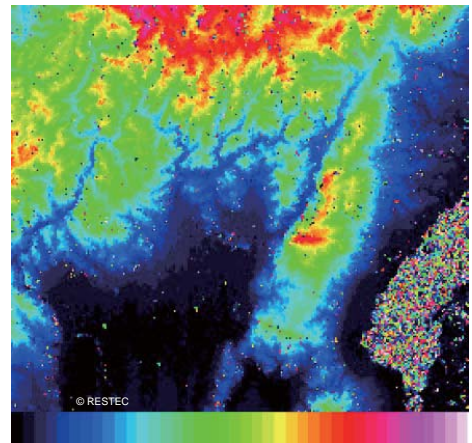
4.1 SAR Stereo



Fine beam position : F1, F2, F3, F4, F5
 Standard beam position : S1, S2, S3, S4, S5, S6, S7
 Wide beam position : W1, W2, W3
 ScanSAR beam position : SN1, SN2, SW1

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DEM from SAR stereo

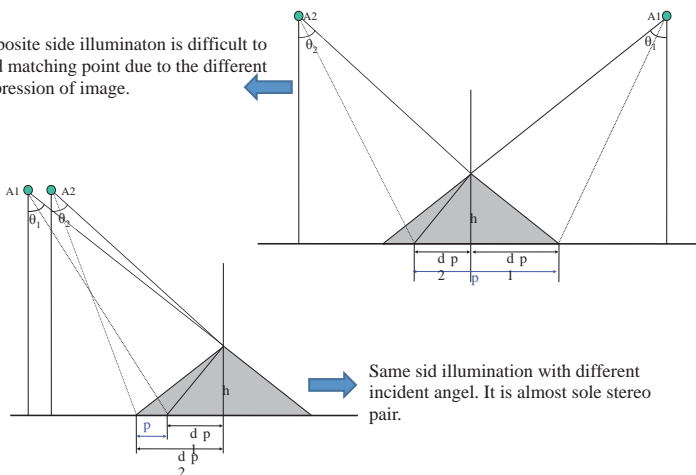


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4. SAR data analysis technology

4.1 SAR Stereo

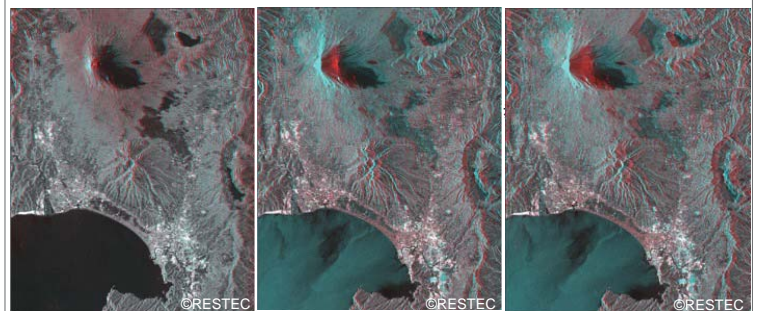
Opposite side illumination is difficult to find matching point due to the different impression of image.



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4. SAR data analysis technology

4.3 SAR Stereo: Aanallyph



①R/G/B:41.5/34.3/34.3

②R/G/B:34.3/21.5/21.5

③R/G/B:41.5/21.5/21.5

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Access and Open ALOS Images



REMOTE SENSING TECHNOLOGY CENTER OF JAPAN
TOKYO, JAPAN

terça-feira, 13 de outubro de 2009

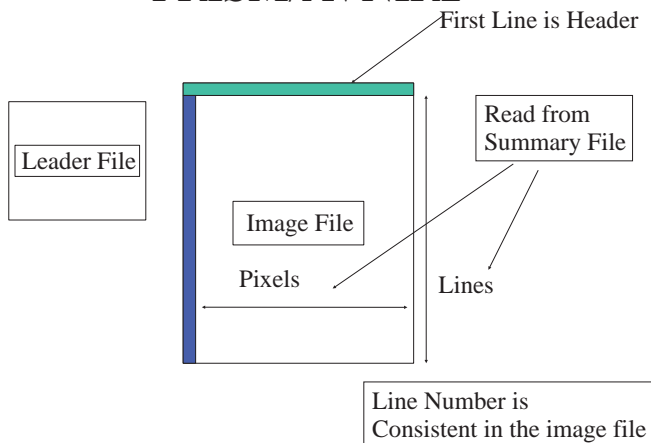
Naming of Image Files

- Image starts with “IMG-”
- PRISM: IMG-ALPSM*****1B2-UN
- AVNIR2 IMG-B1-ALAV”*****1B2R

**** is orbit turn number from launch (5digit)+process code

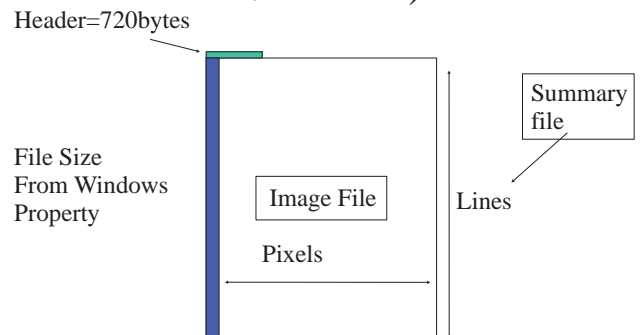
terça-feira, 13 de outubro de 2009

PRISM/AVNIR2



terça-feira, 13 de outubro de 2009

PALSAR Image File Structure (Lev. 1.5)



terça-feira, 13 de outubro de 2009

Getting Parameter

1. Read Summary text to find line number
2. Find file size from windows property
3. Calculate apparent pixel number

$$\text{Pixels} = \text{File_size} / (\text{line} + 1)$$

$$\text{Header} = \text{Pixels}(\text{number shown above})$$

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Find PALSAR Parameter(Lev 1.5)

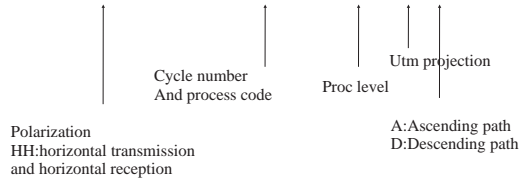
$$\text{Pixel} = (\text{FileSize} - 720) / (\text{Line} \times 2)$$

Byte Order: UNIX format (High byte first order) byte swap is required in the Intel systems.

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Naming of PALSAR(Lev 1.5)

- IMG-HH-ALPSR****-H1.5-UA



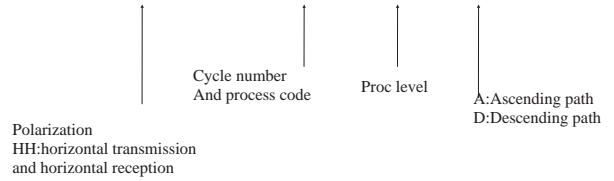
VV:vertical trans. /vertical rec.

HV: horizontal trans./vertical rec.

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Naming of PALSAR(Lev 1.1)

- IMG-HH-ALPSR****-H1.1__A

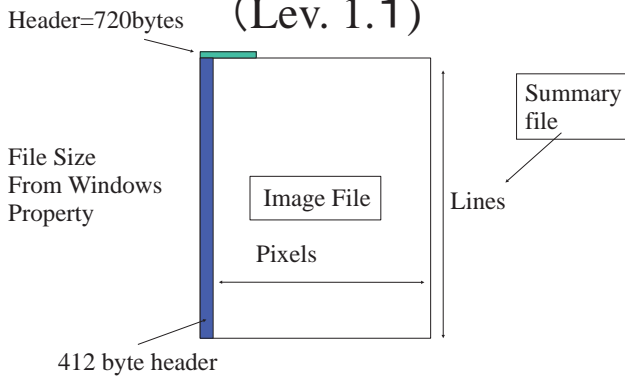


VV:vertical trans. /vertical rec.

HV: horizontal trans./vertical rec.

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PALSAR Image File Structure (Lev. 1.1)



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Access to AUIG

<https://auig.eoc.jaxa.jp/auigs/top/TOP1000LoginLang.do>

AUIG 3.0
ALOS User Interface Gateway

Services for Members

User ID: GUEST999

Password: ●●●●●●●●

Login

[Guest ID / Password]
GUEST999 / AuigV3.0

User Registration

Access above site and login using indicated Guest ID and Password
ID: GUEST999
PW: AuigV3.0

[2009.09.02] System main
2009 11:30 (UT)

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Find PALSAR Parameter(Lev 1.1)

$$\text{Pixel} = ((\text{FileSize} - 720) / \text{Lines} - 412) / 8$$

Byte Order: UNIX format (High byte first order) byte swap is required in the Intel systems.

terça-feira, 13 de outubro de 2009

Login and Order

AUIG 3.0
ALOS User Interface Gateway

Login Status

2009/10/09 22:24
User: GuestUser

Logout

Services for Members

Order and Obs. Requests

Tool Download

Information for Login User

ALOS Information

After Login, select "Order and Obs. Request".

4:00 (UT)

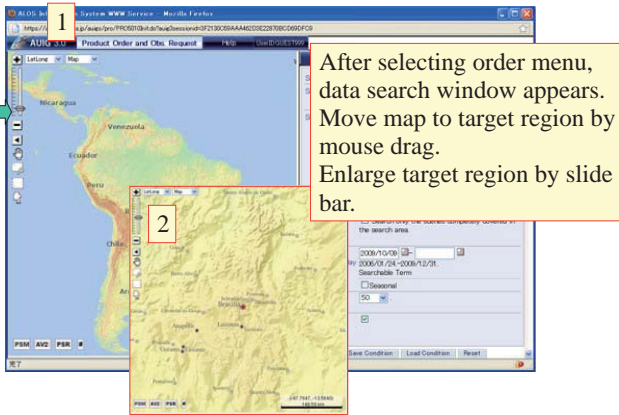
[2009.10.02] System
11:30 (UT)

[2009.09.18] System
2009 7:30 (UT)

[2009.09.02] System
2009 11:30 (UT)

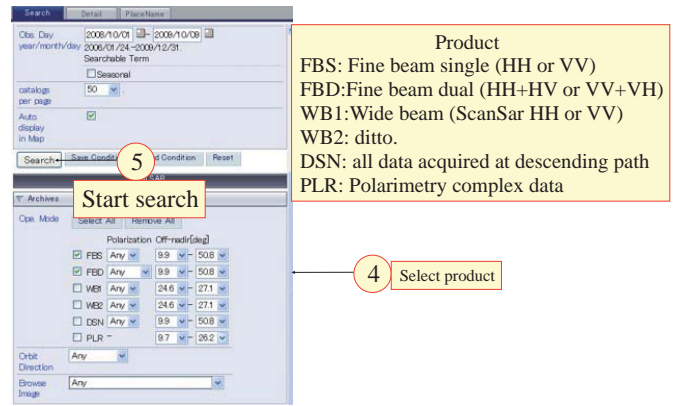
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Data search window



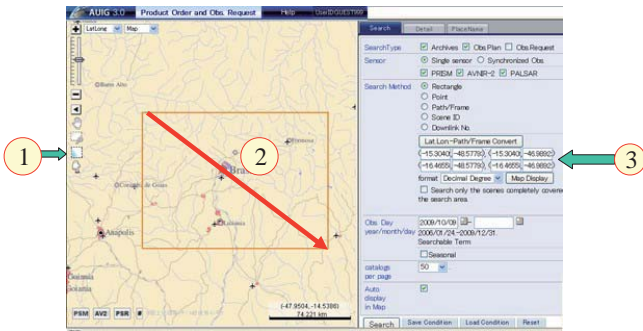
terça-feira, 13 de outubro de 2009

Select search conditions (1 PALSAR)



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Set search rectangle

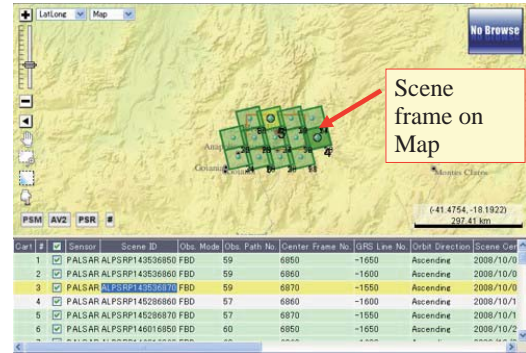


Select rectangle tool and drag mouse from top left to bottom right. 4 corner geo information appears on right hand dialog.

Alternately, you can directly specify the value in the right dialog

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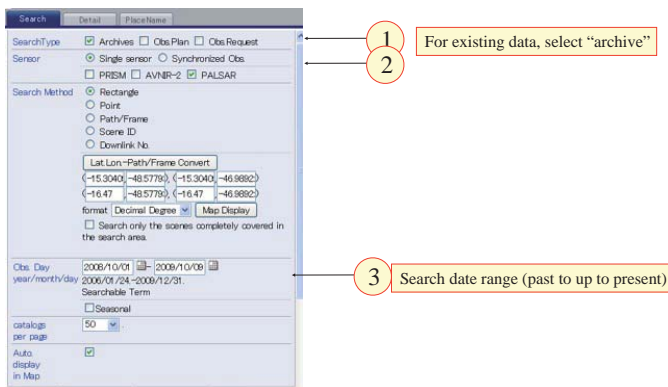
Search result



In PALSAR image search, no browse data exist because there is no need of check because of cloud free.

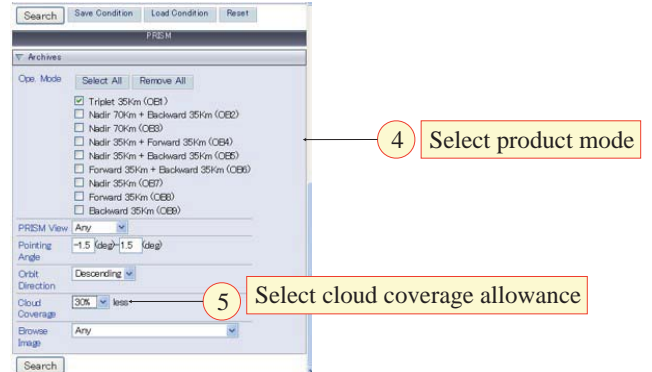
terça-feira, 13 de outubro de 2009

Select search conditions (1 PALSAR)



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Case of PRISM



terça-feira, 13 de outubro de 2009

Search result

PSM	AVZ	PSR	No.	Scene ID	Operation Mode	Scene Center Day	Obs. Number	Center Frame Number	Cloud Coverage (Scene)	Nadir View Extraction Position of Image (Pointing Angle)	Pointing Angle	Off-nadir angle	Data Quality	Downlink Seq. Number	Orbit Direction	Ground Station Code	Calibration File	Orbit Data	Forward View Extraction Position of Image (Pointing Angle)	Backward View Extraction Position of Image (Pointing Angle)	Pointing Change Flag	Level II Status	Table Number
2	PSM	ALPSMW184223920	OBI	2009/09/16	396	3920																	
3	PSM	ALPSMW184223976	OBI	2009/09/16	396	3976																	
4	PSM	ALPSMW185033920	OBI	2009/07/15	396	3920																	
5	PSM	ALPSMW187513915	OBI	2009/08/01	396	3915																	
6	PSM	ALPSMW187513976	OBI	2009/08/01	396	3976																	
7	PSM	ALPSMW187513920	OBI	2009/08/01	396	3920																	
8	PSM	ALPSMW187513976	OBI	2009/08/01	396	3976																	
9	PSM	ALPSMW191743920	OBI	2009/08/30	396	3920																	

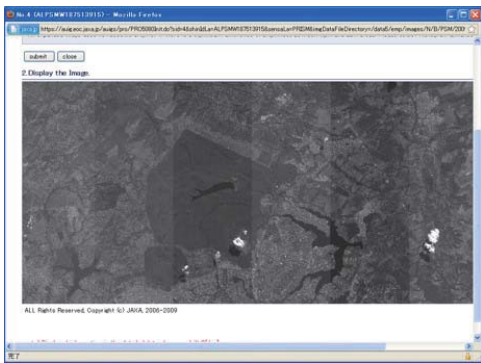
terça-feira, 13 de outubro de 2009

Enlarged thumb nail image



terça-feira, 13 de outubro de 2009

Enlarged thumb nail image



terça-feira, 13 de outubro de 2009

Case of AVNIR2

PSM	AVZ	PSR	No.	Scene ID	Operation Mode	Scene Center Day	Obs. Number	Center Frame Number	Cloud Coverage (Scene)	Nadir View Extraction Position of Image (Pointing Angle)	Pointing Angle	Off-nadir angle	Data Quality	Downlink Seq. Number	Orbit Direction	Ground Station Code	Calibration File	Orbit Data	Forward View Extraction Position of Image (Pointing Angle)	Backward View Extraction Position of Image (Pointing Angle)	Pointing Change Flag	Level II Status	Table Number
1	AVNIR-2	ALAGAH182000100	OBI	2009/07/20	396	3920																	
2	AVNIR-2	ALAGAH180003916	OBI	2009/08/16	396	3916																	
3	AVNIR-2	ALAGAH180003920	OBI	2009/08/16	396	3920																	
4	AVNIR-2	ALAGAH187513915	OBI	2009/08/01	396	3915																	
5	AVNIR-2	ALAGAH187513920	OBI	2009/08/01	396	3920																	
6	AVNIR-2	ALAGAH184223916	OBI	2009/09/16	396	3916																	
7	AVNIR-2	ALAGAH184223920	OBI	2009/09/16	396	3920																	

terça-feira, 13 de outubro de 2009

Search result

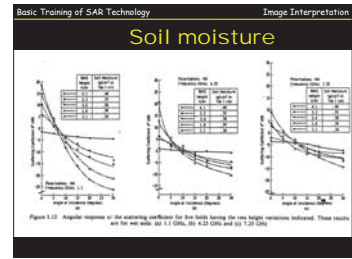
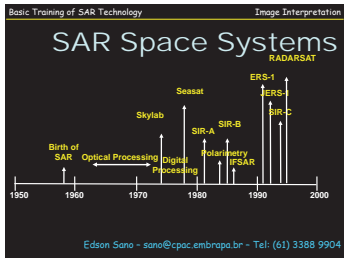
PSM	AVZ	PSR	No.	Scene ID	Operation Mode	Scene Center Day	Obs. Number	Center Frame Number	Cloud Coverage (Scene)	Nadir View Extraction Position of Image (Pointing Angle)	Pointing Angle	Off-nadir angle	Data Quality	Downlink Seq. Number	Orbit Direction	Ground Station Code	Calibration File	Orbit Data	Forward View Extraction Position of Image (Pointing Angle)	Backward View Extraction Position of Image (Pointing Angle)	Pointing Change Flag	Level II Status	Table Number
EM	PSM	ALPSMW184223920	OBI	2009/09/16	396	3920																	
EM	PSM	ALPSMW184223976	OBI	2009/09/16	396	3976																	
EM	PSM	ALPSMW185033920	OBI	2009/07/15	396	3920																	
EM	PSM	ALPSMW187513915	OBI	2009/08/01	396	3915																	
EM	PSM	ALPSMW187513976	OBI	2009/08/01	396	3976																	
EM	PSM	ALPSMW187513920	OBI	2009/08/01	396	3920																	
EM	PSM	ALPSMW187513976	OBI	2009/08/01	396	3976																	
EM	PSM	ALPSMW191743920	OBI	2009/08/30	396	3920																	

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Enlarged thumb nail image



terça-feira, 13 de outubro de 2009



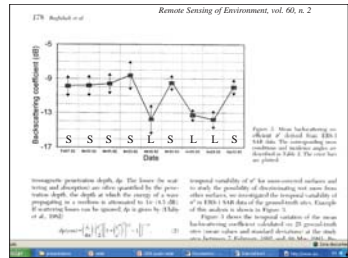
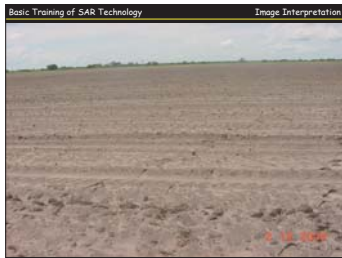
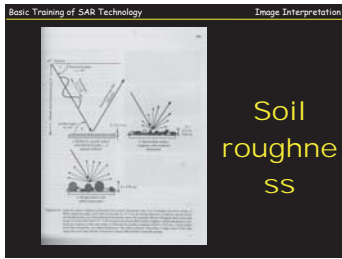
Basic Training of SAR Technology Image Interpretation

Sensor configuration:
 Frequency
 Polarization
 Incidence angle

Terrain:
 Dielectric constant
 Soil roughness & slope
 Canopy structure

Artifact:
 Speckle





The Landers earthquake occurred on June 28, 1992.
 The ERS-1 data was taken on April 24, July 3 and August 7, 1992, while the satellite was in a 35-day repeat orbit.
 The pixel spacing is 30 m and the image size is 90 x 113 Km.
 This data has been processed extensively by Dr. Didier Massonnet and his group at CNES in France, and by Howard Zebker, Paul Rosen, Richard Goldstein, Andrew Gabriel and Charles Werner of the Jet Propulsion Lab in California.





Basic Training of SAR Technology Image Interpretation

Ondas refletidas por dois alvos próximos em do eixo são altamente coerentes. Isso é, há uma relação regular ou sistemática entre suas amplitudes.

A Interferência provocada pelas ondas coerentes refletidas faz com que a imagem grossa pode algumas vezes causar cancelamento do sinal recebido dos dois alvos. O efeito é uma aparência granular do tipo sal e pimenta.

original filtro adaptativo
 filtro de Frost filtro Frost modificado

Basic Training of SAR Technology Image Interpretation

Figure 3. Interferometric SAR image for 10 days at 70cm.

Basic Training of SAR Technology Image Interpretation

Basic Training of SAR Technology Image Interpretation

Speckle

Ondas coerentes de radar

Interferência construtiva

Interferência destrutiva

Exemplo de alvo homogêneo

Interferência construtiva

Interferência destrutiva

Resultado

Resultado

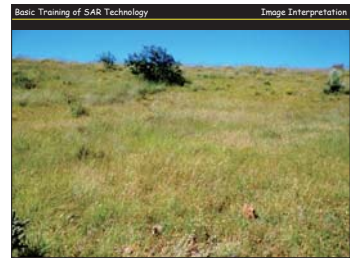
Grava variadas de interferência (entre construtiva e destrutiva)

Basic Training of SAR Technology Image Interpretation

Walnut Creek Watershed
Tumbelon, AZ

ERS-1 SAR coherency image
December 20, 1992

Study case: SAR image interpretation for soil moisture



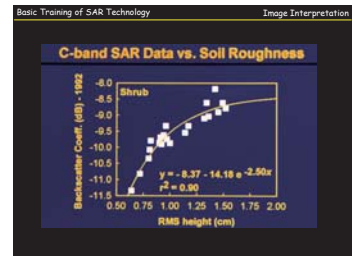
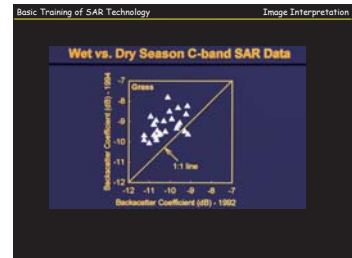
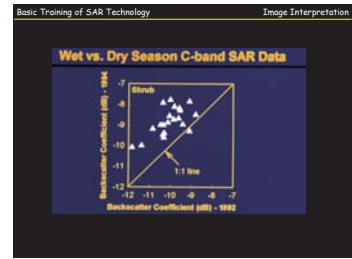
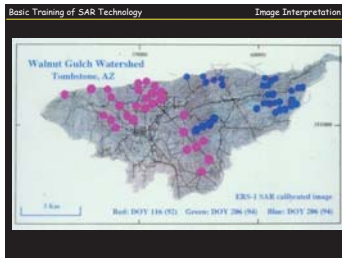
Basic Training of SAR Technology Image Interpretation

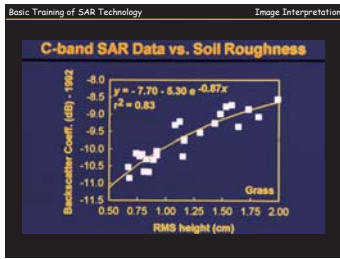
Sensitivity Analysis of C-band Synthetic Aperture Radar Data to the Soil Moisture Content in a Semiarid Region

Edson E. Sano
Advisor: Dr. Alfredo Huete

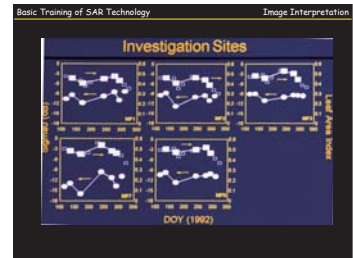
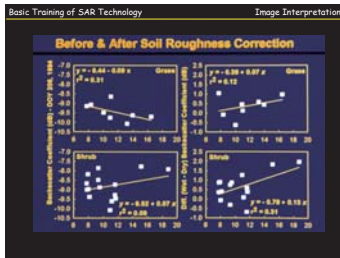
The University of Arizona
1997







- Basic Training of SAR Technology Image Interpretation
- ### CONCLUSIONS # 1
1. Improved relation between SAR and Mv after roughness correction
 2. Relatively poor r^2
 3. Possible explanation: vegetation influence



Basic Training of SAR Technology Image Interpretation

CORRECTING ROUGHNESS EFFECTS

Technique: σ^0 (wet - dry) (dB)

Assumptions: roughness stable over the time
dry season SAR image is function only of roughness

Basic Training of SAR Technology Image Interpretation

ADDITIONAL CORRECTION

Residual σ^0 for vegetation correction

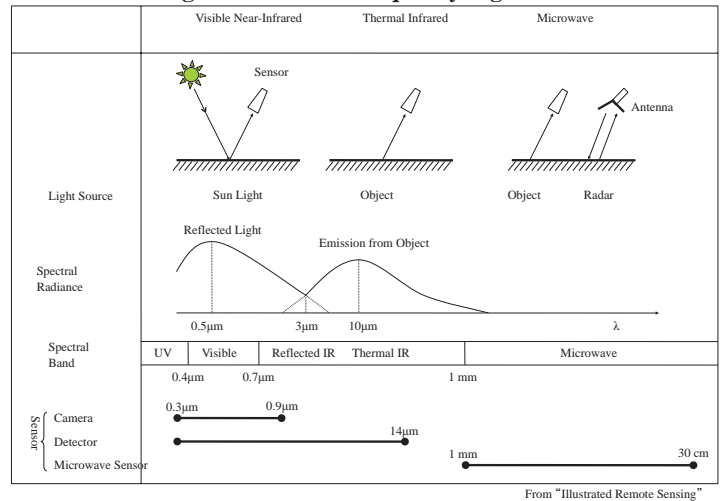
Introduction to Remote Sensing



REMOTE SENSING TECHNOLOGY CENTER OF JAPAN
TOKYO, JAPAN

terça-feira, 13 de outubro de 2009

Remote Sensing in 3 Different Frequency region



terça-feira, 13 de outubro de 2009

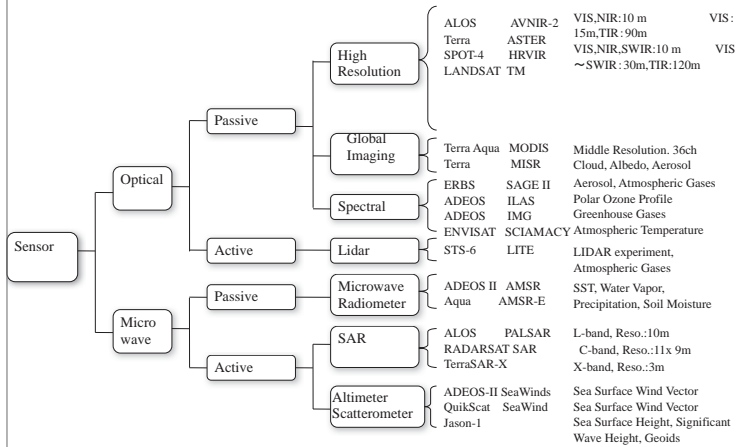
Introduction to Remote Sensing

Toshiro SUGIMURA, Ph.D.
Research Department
Remote Sensing Technology Center of Japan

Table of contents

- Chapter 1. Principal, Overview of Remote Sensing
- Chapter 2. Global Observation
- Chapter 3. Future Earth Observation

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Variety of Remote Sensors

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Essential of Remote Sensing

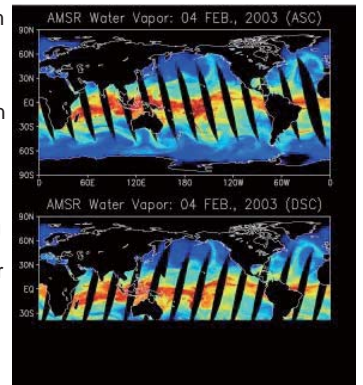
Sensing and Processing

1. Measurement by sensors:
To provide measurement data on physical parameter of objects.
2. Data Processing and Analysis:
To retrieve quantitative or qualitative information from measurement data.

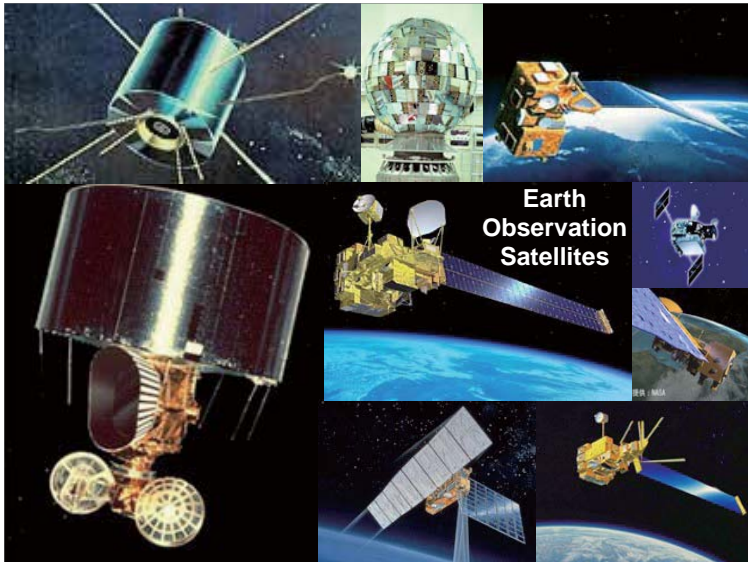
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Data Processing and Analysis

- Image data is reproduced from bit stream sensor data.
- Quality and accuracy of information is characterized and upgraded using calibration and validation result.
- Physical parameters and attributes of object are retrieved using algorithms, models of emission, scattering and radiation transfer mechanism and knowledge for interpretation.



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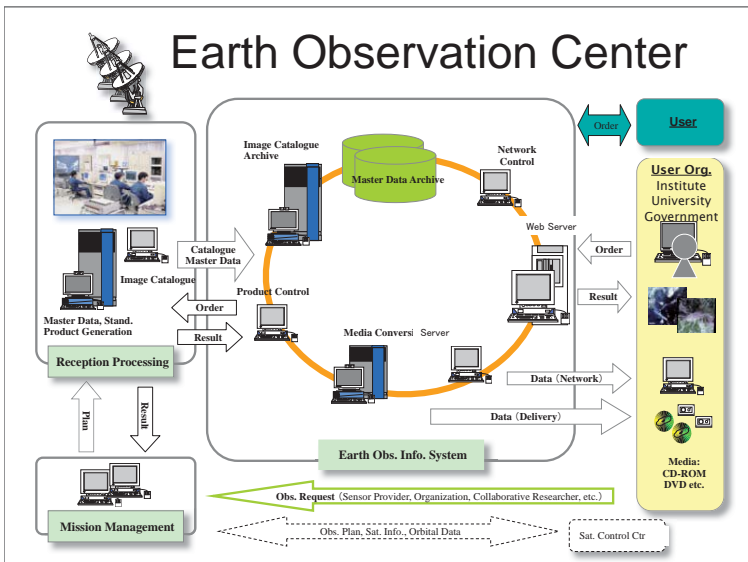


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Essential of System Design

- Starting from requirements for observation and data use, then R&D of technologies to realize them are important.
- Quality of output data and information are depending on the function and performance of sensors, satellites, ground systems.
- Characterization, calibration and validation are also important for evaluation and improvement of data quality.
- Total system optimization based on the trade off study on user needs and provider's resources is necessary.

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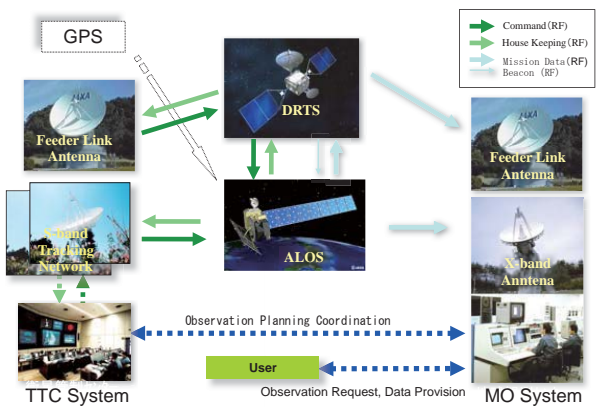
terça-feira, 13 de outubro de 2009

Japanese Satellites

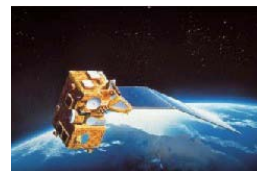
Satellite	Sensor	Band	Operation	Alt.	Recurrency	Resolution	Swath
MOS-1, 1b	MESSR	MULTI	4	87.2-96.4	909km	50m	100x90km
	VTIR	MULTI	4				
JERS-1	MSR	MICRO WAVE	MICRO WAVE	92.9-98.10	568km	18m	75x75km
	VNIR	MULTI	4				
ADEOS	AVNIR-Mu	MULTI	4	96.10-97.6	797km	16m	80x80km
	AVNIR-Pa	PANCR0	13				
TRMM	TMI	MICRO WAVE	MICRO WAVE	97.11-	402.5km	3	6-50km
	PR	MICRO WAVE	MICRO WAVE				
AQUA(USA)	AMS-E	MICRO WAVE	MICRO WAVE 6	02.5-	705km	1	3.5-43km
	AMS-R	MICRO WAVE	MICRO WAVE 8+2				
ADEOS-II	GLI	MULTI	23	02.12-03.10	803km	250m, 1km	1600km
	VNIR	MULTI	6				
ALOS	AVNIR-2	MULTI	4	06.01-	691.65km	2.5m	35km, 70km
	PALSAR	RADAR	Fine ScanSAR				

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Network: Satellite - Ground Station



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Momo-1 (MOS-1), Japan's first marine observation satellite, was launched in 1987

VTIR : Visible and Thermal Infrared Radiometer
 Wave length 0.5-0.7, 6.0-7.0, 10.5-11.5, 11.5-12.5 μm
 Resolution 900m(Visible)-2700m(Thermal)
 Swath width 1500km

Main Characteristics	
Launch Date	2/19/1987
Momo-1 (MOS-1) Launch Vehicle	N-II Launch Vehicle (N16F)
Launch Site	Tanegashima Space Center
Momo-1b (MOS-1b) Launch Date	2/7/1990
Momo-1b (MOS-1b) Launch Vehicle	H-I Launch Vehicle (H21F)
Momo-1b (MOS-1b) Launch Site	Tanegashima Space Center
Weight	Approx 740kg (at lift off)
Shap	Box type with expanding type solar paddle (one wing)
Mission Life	2 years
Attitude Control	Three-axis stabilized (controled bias momentum)

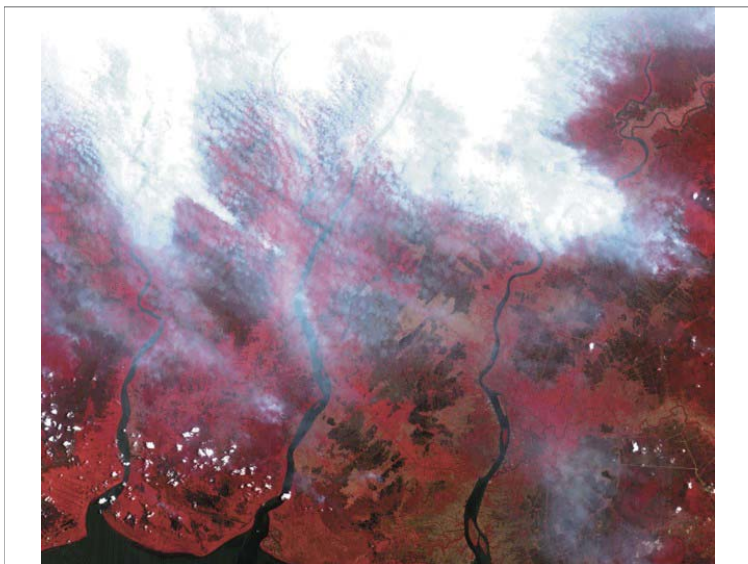
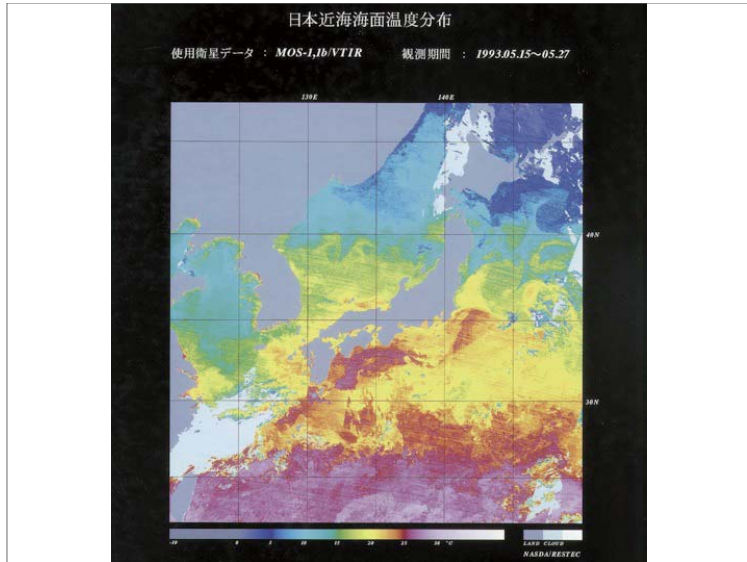
MESSR : Multispectral Electronic Self-Scanning Radiometer
 Wave length 0.51-0.59, 0.61-0.69, 0.72-0.80, 0.80-1.10μm
 Resolution 50m
 Swath width 100km
 Detector band Linear array CCD, 2048 elements/band

MSR : Microwave Scanning Radiometer
 Wave length 23.8GHz, 31.4GHz
 Resolution 32km (23.8GHz), 23km (31.4GHz)
 Swath width 370km
 Brightness temperature 30-300K (1K step)

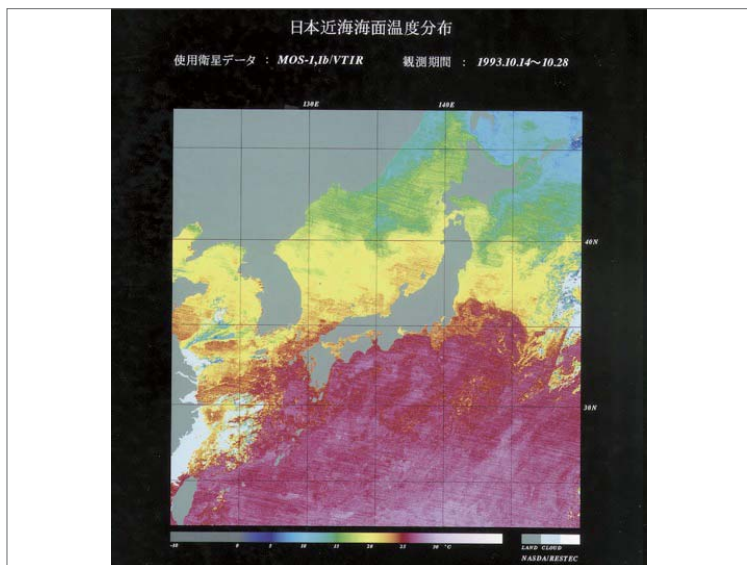
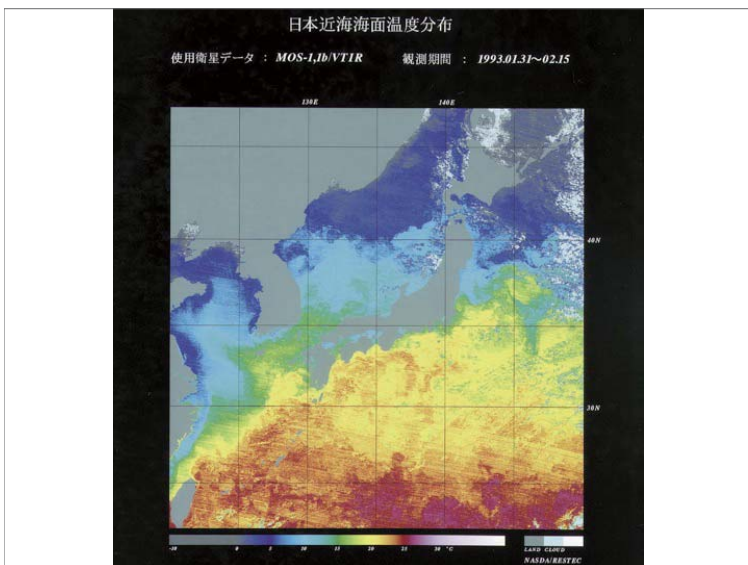
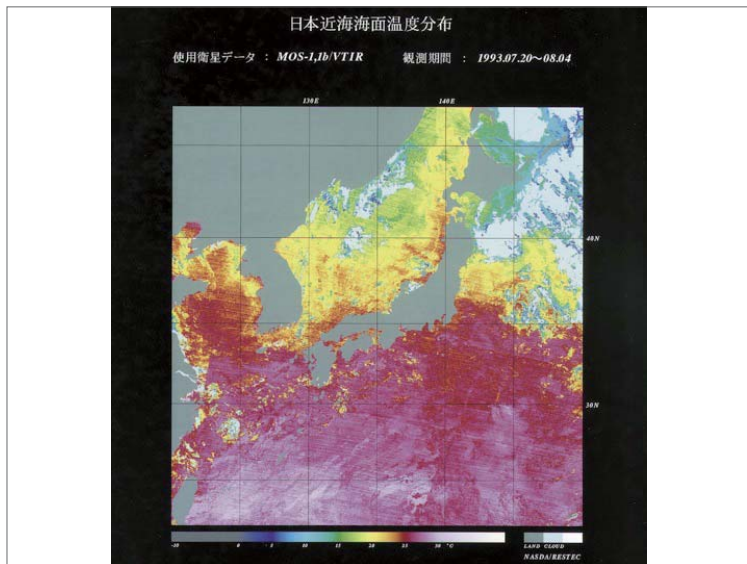
terça-feira, 13 de outubro de 2009



terça-feira, 13 de outubro de 2009



terça-feira, 13 de outubro de 2009





FUYO-1(JERS-1) is an earth observation satellite whose primary objective is to gather data on global land masses while conducting observation for land surveys, agricultural-forestry-fisheries, environmental protection, disaster prevention and coastal surveillance, with emphasis on locating natural resources

Main Characteristics

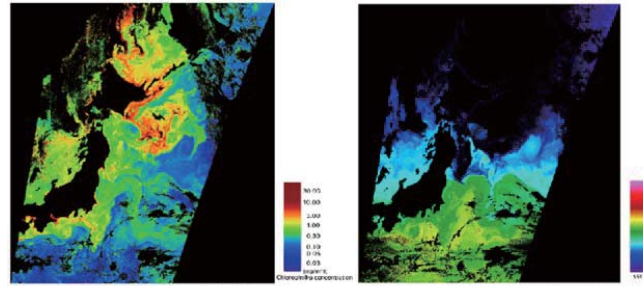
Launch Date	2/11/1992
Launch Vehicle	H-I Launch Vehicle (H24F)
Launch Site	Tanegashima Space Center
Weight	1,400kg
Shape	Structure Box type Approx. 1m x 1.8m x 3.1m Synthetic aperture radar Approx. 12m x 2.5m Solar cell paddle Approx. 8m x 3.4m
Design Life	2 years
Attitude Control	Three-axis stabilized (zero momentum)

SAR : Synthetic Aperture Radar
 Frequency 1.275GHz (L band)
 Polarization HH
 Off-nadir observation 35
 Resolution 18m (range)x18m (azimuth at 3 looks)
 Observation area 75km

OPS : Optical Sensor
 wave length
 VNIR 0.52—0.60, 0.63—0.69, 0.76—0.86, 0.63—0.69μm (FWW)
 SWIR 1.60—1.71, 2.01—2.12, 2.13—2.25, 2.27—2.40μm
 Resolution 18.3m (range)x24.2m (azimuth)
 Swath width 75km
 Stereo angle 15.3 (with band 3 and 4) (B/H=0.3)

terça-feira, 13 de outubro de 2009

Application for Ocean Monitoring
 -Chlorophyll concentration and sea surface temperature-



OCTS Chlorophyll-a concentration image [Apr. 26, 1997 1:37 UT/Around Japan]
 Chlorophyll concentration by ADEOS/OCTS

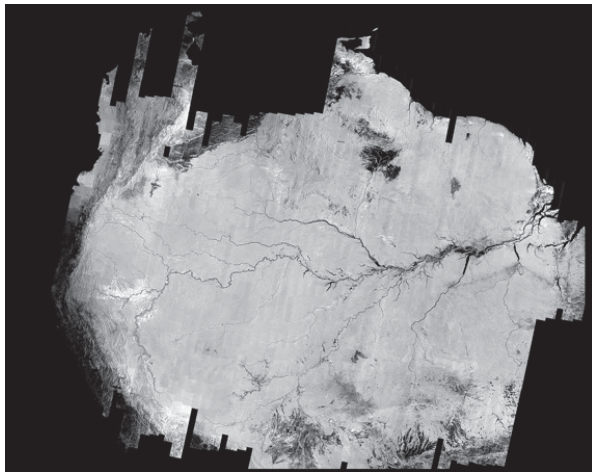
OCTS Sea Surface Temperature image [Apr. 26, 1997 1:37 UT/Around Japan]
 Sea surface temperature by ADEOS/OCTS

This images show the chlorophyll concentration and sea surface temperature obtained around Japan by ADEOS/OCTS

©JAXA

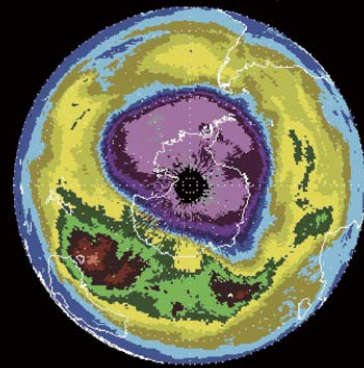
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terça-feira, 13 de outubro de 2009

ADEOS TOMS Total Ozone for September 12, 1996



125, 175, 225, 275, 325, 375, 425, 475, 525
 Dobson Units

NASDA/NASA

terça-feira, 13 de outubro de 2009



ADEOS was launched on August 1996 and provided a large volume of data containing valuable information about our environment atmosphere, ocean and land for about 10 months.

Major Specifications

International Designation Code	1996-046A
Launch Date	8/17/1996 10:53(JST)
Launch Vehicle	H-II Launch Vehicle 4F
Launch Site	Tanegashima Space Center
Shape	Module type with deployable solar paddle (one wing) Body: Approx. 4x4x5(m) (mission, bus module) Solar Paddle: Approx. 3x26(m)
Weight	Approx. 3,560kg
Orbit Type	Sun Synchronous Subrecurrent
Altitude	Approx 800km
Inclination	Approx. 98.8deg
Period	Approx. 101min
Recurrent Period	41days
Attitude Control	Three-axis stabilized (zero-momentum)

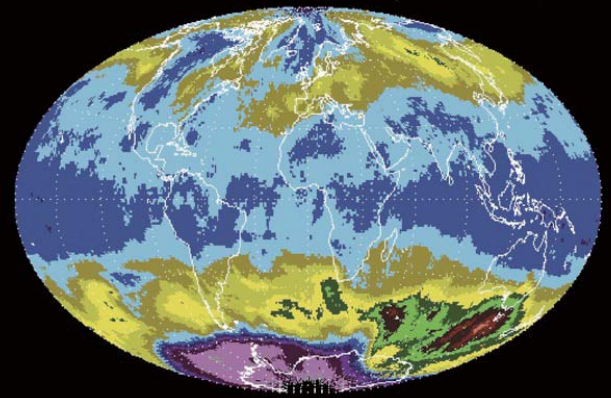
OCTS : Ocean Color and Temperature Scanner
 wave length 0.402—0.422, 0.433—0.453, 0.480—0.500, 0.510—0.530, 0.555—0.575, 0.660—0.680, 0.745—0.785, 0.845—0.885, 10.30—11.40μm, 11.40—12.50μm
 Resolution 700m (nadir)
 Swath width 1,400km

AVNIR : Advanced Visible and Near-Infrared Radiometer
 Wave length
 Multi spectral (Mu) 0.42—0.50, 0.52—0.60, 0.61—0.69, 0.76—0.89μm
 Panchromatic (Pa) 0.52—0.69μm
 resolution 16m(Mu), 6m(Pa)
 Swath width 80km

TOMS : Total Ozone Mapping Spectrometer
 Wave length 308.6, 312.5, 317.5, 332.3, 331.2, 360.0nm
 Resolution 40km (at nadir)
 Swath width 2,800km

terça-feira, 13 de outubro de 2009

ADEOS TOMS Total Ozone for September 12, 1996



125, 175, 225, 275, 325, 375, 425, 475, 525
 Dobson Units

NASDA/NASA

terça-feira, 13 de outubro de 2009



TRMM is an Earth-observation satellite that diagnoses conditions on Earth by measuring precipitation in tropical and subtropical areas.

Major Specifications

International Designation Code	1996-046A
Launch Date	8/17/1996 10:53(JST)
Launch Vehicle	H-II Launch Vehicle 4F
Launch Site	Tanegashima Space Center
Shape	Module type with deployable solar paddle (one wing) Body: Approx. 4×4×5(m) (mission, bus module) Solar Paddle: Approx. 3×26(m)
Weight	Approx. 3,560kg
Orbit Type	Sun Synchronous Subrecurrent
Altitude	Approx 800km
Inclination	Approx. 98.6deg
Period	Approx. 101min
Recurrent Period	41days
Attitude Control	Three-axis stabilized (zero-momentum)

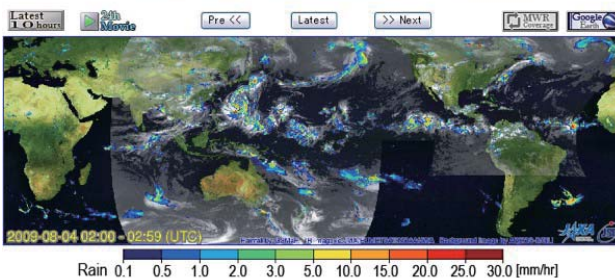
terça-feira, 13 de outubro de 2009

<http://sharaku.eorc.jaxa.jp/GSMaP/index.htm>

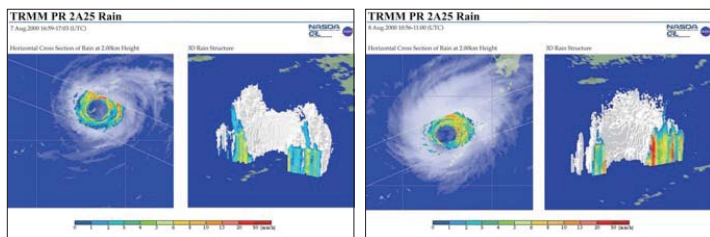
Global Rainfall Map
in Near Real Time

>> [Members Page](#)
>> [Japanese](#) Last up date: 2009/Aug/04 07:00:08 UTC

Date: 2009 / Aug / 4 02:00-02:59 UTC Submit



terça-feira, 13 de outubro de 2009

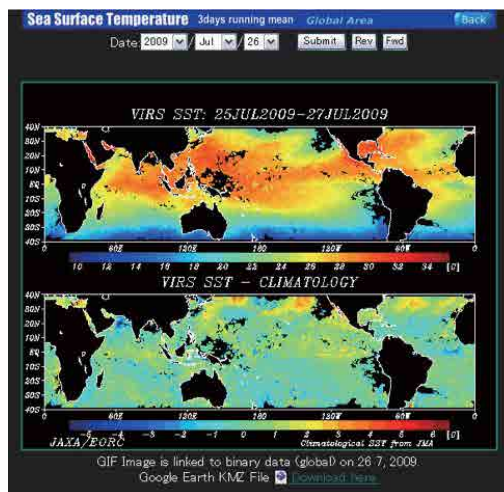


This images shows horizontal cross sections of rain and 3D rain structures of typhoons obtained by TRMM/PR.

Satellite data contributes to enhance the accuracy of weather forecast.

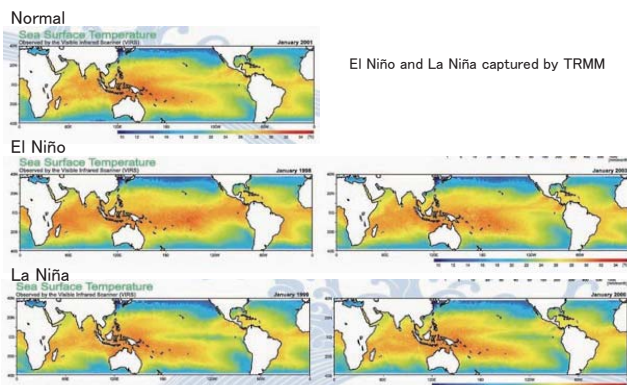
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Application for Ocean Monitoring
-El Niño and La Niña-



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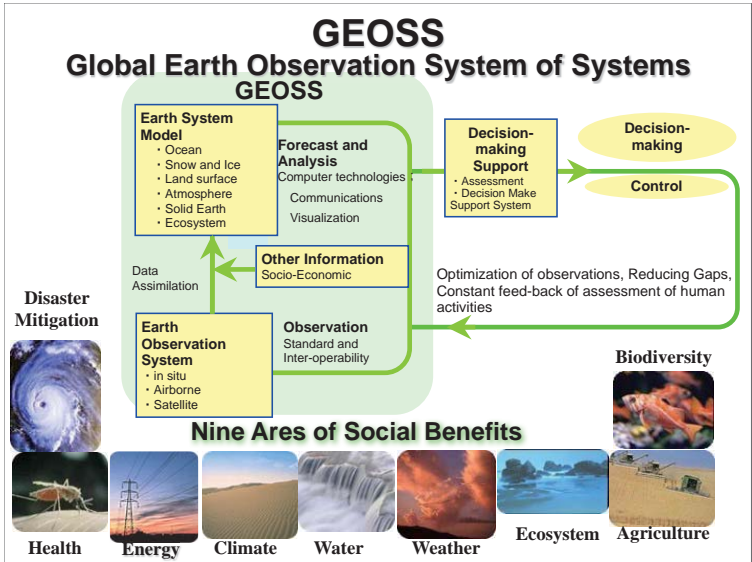


The Advanced Earth Observing Satellite-II "Midori II"(ADEOS-II) was launched in December 14, 2002.

Main Characteristics

Momo-1 (MOS-1)	Launch Date	2/19/1987
	Launch Vehicle	N-II Launch Vehicle (N16F)
Momo-1b (MOS-1b)	Launch Date	2/7/1990
	Launch Vehicle	H-I Launch Vehicle (H21F)
	Launch Site	Tanegashima Space Center
	Weight	Approx 740kg (at lift off)
	Shap	Box type with expanding type solar paddle (one wing)
	Mission Life	2 years
	Attitude Control	Three-axis stabilized (controlled bias momentum)

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Advantages of Satellite Based Remote Sensing

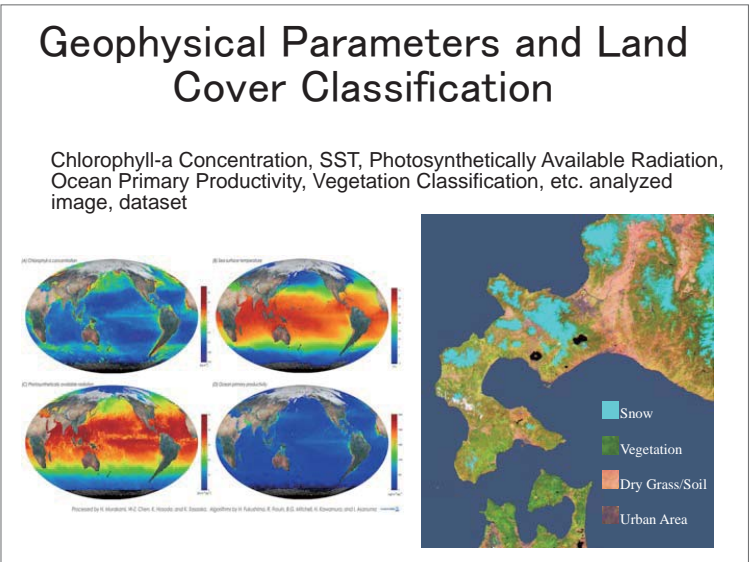
- Wide coverage and simultaneous observation
- Operational continuous observation
- Global homogeneous observation data
- Temporal and spatial sampling
- Analysis of spatial distribution pattern and temporal change on physical parameters describing phenomena
- Integrated use with data sets, models, knowledge data, and their integration (4 Dimensional Data Assimilation, Validation of Model, Relational Data Use on GIS)

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Earth Observation System

- **Observation System**: for global observation data acquisition, information derived from data, utilization of data.
- **Objectives, necessity**: to support decision making of measures against issues on environment, resource, disaster, etc. providing scientific bases.
- **Integrated system**: “analysis and synthesis” of trans-disciplinary science and engineering enable complementary approach.

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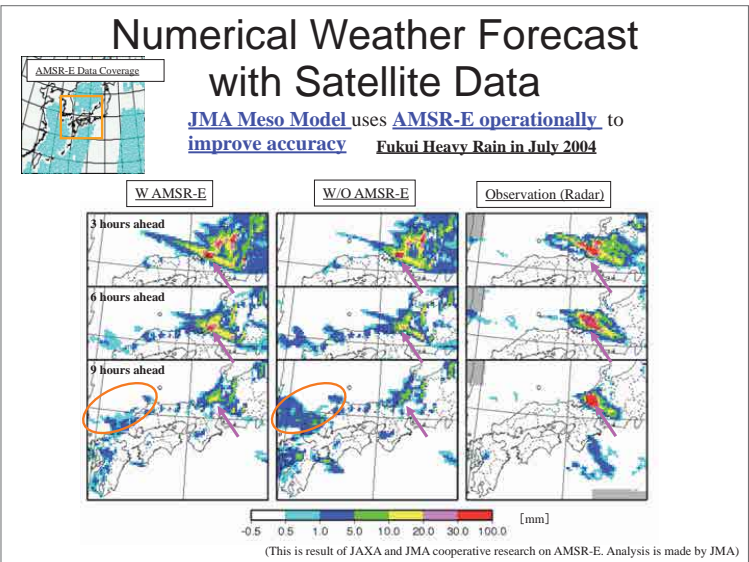


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Expected Role of Satellite based Remote Sensing in GEOSS

1. To monitor global change.
2. To bring awareness of problem in relationship between global change such as global warming and human activity.
3. To grasp the real, understand the process to drive change, elucidate mechanism, take preventive measures based on the forecast.
4. To solve issues on environment, resource, disaster, etc.

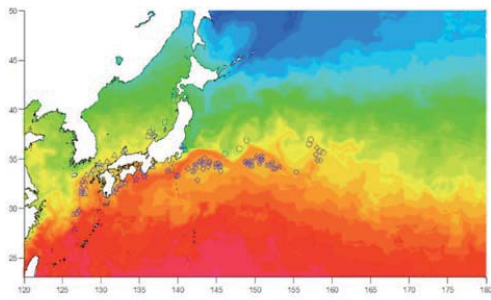
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Contribution to Fishery Information

All weather SST product from AMSR-E is produced for information service at higher rate of daily basis from weekly basis by JAFIC to improve the fishery efficiency of fishing boats



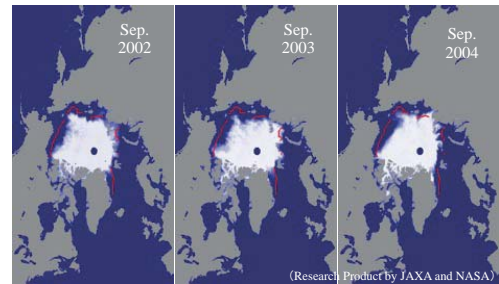
◇ かつお, ○ まぐろ, □ いか, △ あじ

SST map produced with AMSR-E and location plot of fishing grounds (by JAFIC)

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Climate Change Detection

Monitoring of the progress of global warming is started by the continuing observation of cryosphere. In summers of these years, shrink of sea ice area have been observed by AMSR-E.



(Produced by US National Snow and Ice Data Center)

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Visualization and Quantification using Image Data

- Visual recognition of physical parameters by color and pattern in distribution map.
- Investigation of relationship in regional events apart in time and place by visualizing wide coverage area.

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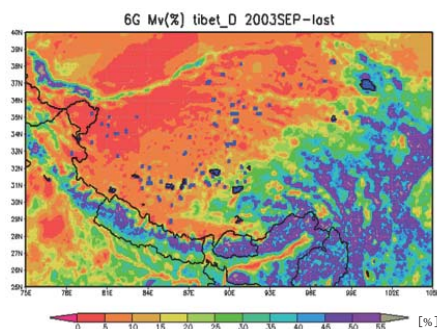
Environmental Monitoring and Disaster Applications

- Climate Change Monitoring → Precursor Detection, Assessment.
- Mapped Information of Weather, Fishery, Sea Ice were operationally used.
- Data use for resources management, disaster mitigation → Example Images are available from EORC Website.
<http://www.eorc.jaxa.jp/>
- Earth Observation System: Integrated use of observation data and models → Social Benefits (disaster mitigation, health, energy, climate, water, weather, ecosystem, agriculture, biodiversity)

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Soil Moisture Distribution Measurement

Quantified soil moisture distribution using AMSR-E



Product of cooperative research by JAXA and The University of Tokyo

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Summary of EO System

- Key of Earth Observation System Construction
 - ❑ Definition of essential geophysical parameter, interpretation key in accordance with objective.
 - ❑ Development of recognition method by visualization and quantization.
 - ❑ Development of synergetic use of image and quantitative information.
- Possible effect of integrated knowledge by trans-disciplinary cooperation.
 - ❑ Effect of gap filling and bridging between each specialized area by trans-disciplinary exchange of knowledge.
 - ❑ Continuous improvement based on the feedback from operational use.
 - ❑ Circulatory interactive effect by users and providers.

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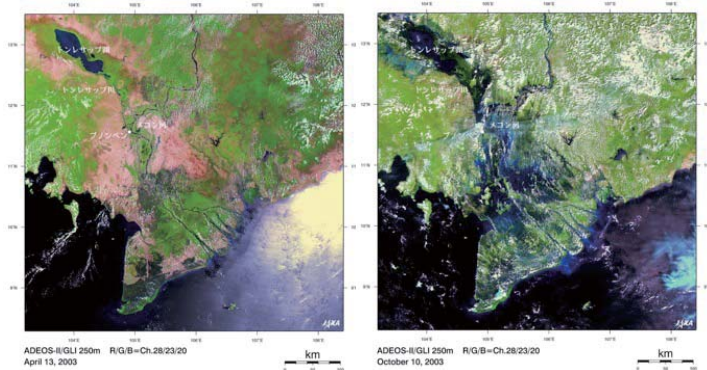
Introduction to ADEOS-II/GLI

- More than 5 years passed since launch of ADEOS-II in Dec. 2002 and EOS-Aqua in May 2002, and then the result of science and demonstration of practical operational applications come out.
- As the results of science, we had the first standard products in the world such as soil moisture measured by AMSR/AMSR-E, images of wide field of view 1km and 250m medium resolution multi-spectral, and global images of aerosol over land observed by UV channel of GLI, etc..
- Review of research results on the global data of GLI onboard ADEOS-II is provided.

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Seasonal Change in Tonle Sap Lake

Left: Dry Season (April, 2003),
Right: Wet Season (October, 2003)



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Sensors onboard ADEOS-II

GLI (Global Imager, JAXA)

Chlorophyll, Vegetation, Sea Surface Temperature, Cloud, Aerosol, etc.

AMSR and AMSR-E (Advanced Microwave Scanning Radiometer, JAXA)

Water Vapor, Precipitation, Sea Surface Temperature, Sea Surface Wind, etc.

ILAS-II (Improved Limb Atmospheric Spectrometer-II, MOE)

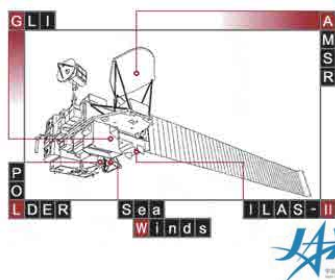
Atmospheric Trace Gases (O₃, HNO₃, CH₄ etc.)

SeaWinds (Wind Scatterometer, NASA/JPL)

Sea Surface Wind (Direction, Speed)

POLDER (Polarization and Directionality of Earth's Reflectances, CNES)

Aerosol, cloud, vegetation, etc.

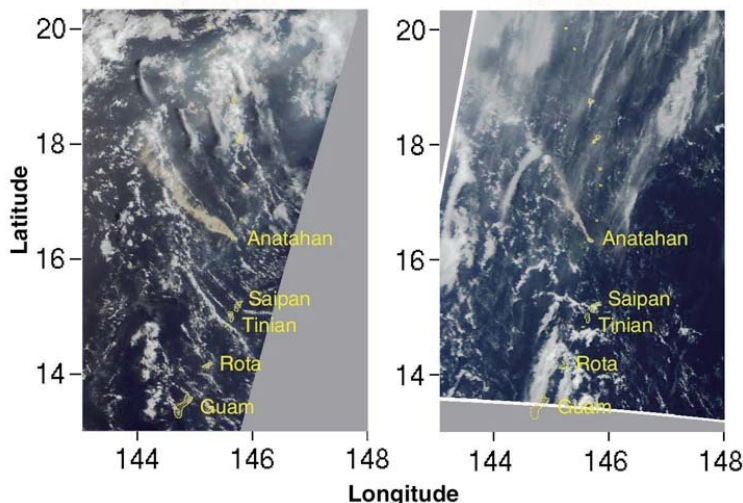


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Volcanic Plumes from Anatahan Island

May 28th, 2003

May 30th, 2003



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Cloud-free global land-surface image from GLI

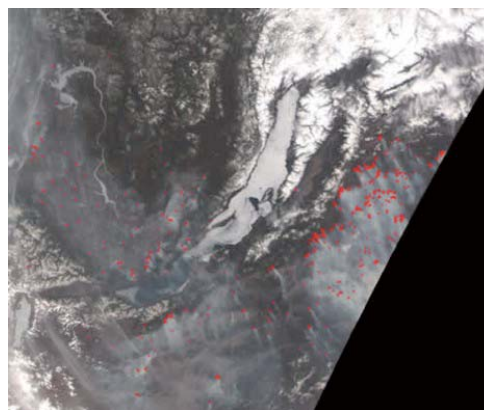
ADEOS-II Global Imager (GLI)



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Hot Spots and Smokes from Forest Fires in Siberia Observed by GLI

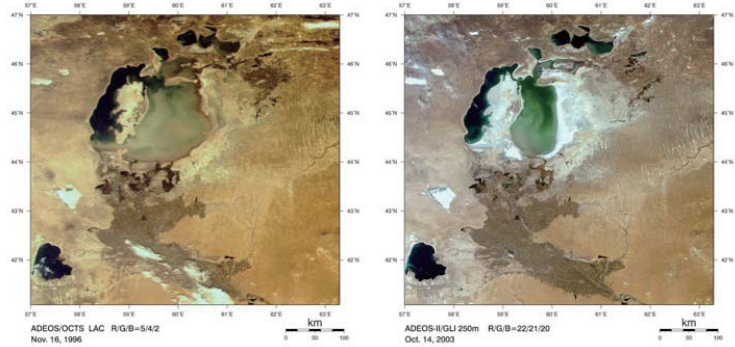
28 May 2003



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Hydrological Change in Aral Sea

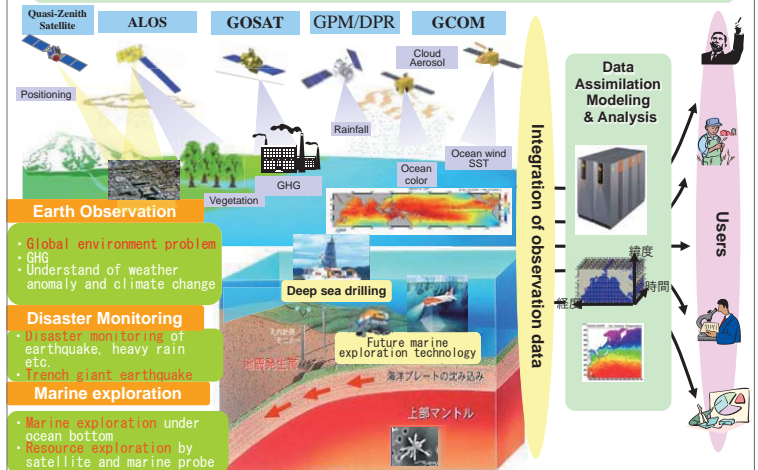
Left: November, 1996, OCTS
Right: October, 2003, GLI



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"Integrated Marine Exploration and Earth Observation System"

Establishment of a fundamental system for Earth observation, disaster monitoring and marine exploration system as a national key technology for Japanese national security



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Conclusions

Global Observation of ADEOS-II

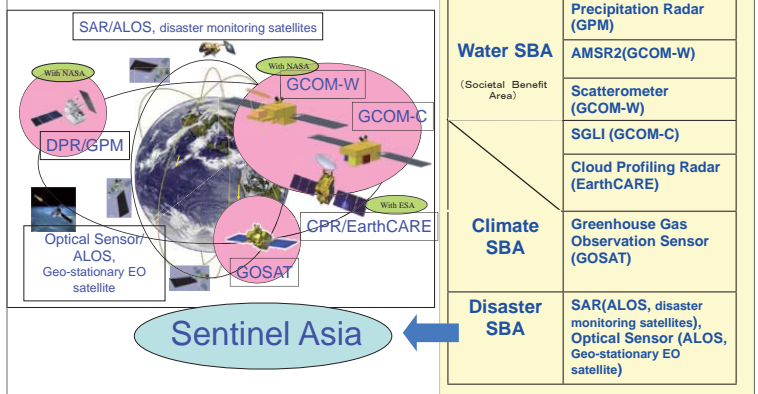
- Medium resolution sensors; AMSR/AMSR-E and GLI onboard ADEOS-II (Midori-2) and EOS-Aqua provide global products in every 4 days, so that large-scale disaster monitoring have been demonstrated.
- GLI and AMSR/AMSR-E are relatively high resolution compared with former medium resolution sensors, and disasters and environmental information from regional to global scale have been obtained successfully.
- Data transmission from Ground Station to users; JMA, JAFIC in near-real-time basis has been explored and validated.

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JAXA's Earth Observation Program for GEOSS

To develop and operate an Earth Observation System for GEOSS

A plan of advanced low Earth orbit satellites



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Basic Strategy of Earth Observation

Council for Science & Technology Policy
(March 2006) endorsed

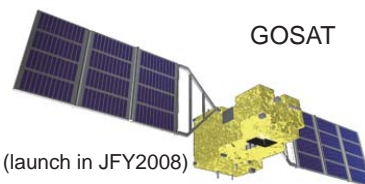
- Establishment of Integrated Marine Exploration & Earth Observation System by coordinating with satellites, aircrafts, ships, buoys, and ground based measurements
- Establishment of Inter-usable data access and sharing platform for all archive data and information to achieve GEOSS goal (Water management, Climate,,,,,)

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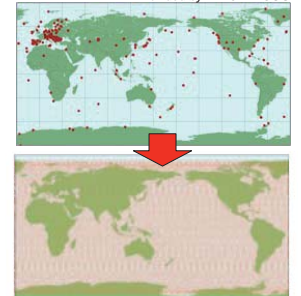
Greenhouse Gases Observing Satellite <GOSAT>

Number and distribution of ground-based greenhouse gases monitoring stations is not enough. GOSAT enables global (with 56,000 points) and frequent (at 3 days) monitoring.

Current Ground-based Observation Points (320pts)
Provided by WMO WDCGG



(launch in JFY2008)



Increase of Observation Points using GOSAT (56,000pts)

Objectives

- (1) To observe CO₂ and CH₄ column density
 - at 100-1000km spatial scale (with scanning mechanical)
 - with relative accuracy of 0.3-1% for CO₂ (1-4ppmv, 3 month average).
- (2) To reduce sub-continental scale CO₂ annual flux estimation errors by half
 - 0.54GtC/yr → 0.27GtC/yr

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Global Precipitation Measurement <GPM>

GPM is a follow-on and expanded mission of the current on-going TRMM



Core Satellite
Dual-frequency precipitation radar (DPR)
Microwave radiometer (GMI)
•Precipitation with high precision
•Discrimination between rain and snow
(launch in 2013)

8 Constellation Satellites
Microwave radiometer
•Global precipitation every 3 hours
(launch around 2013)

- Improve the accuracy of both long-term and short-term weather forecasts
- Improve water resource management in river control and irrigation systems for agriculture

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Greenhouse Gases Observing Satellite "IBUKI" (GOSAT)

The Japan Aerospace Exploration Agency (JAXA) would like to announce that we successfully acquired the "First Light" by the Greenhouse Gases Observing Satellite "IBUKI" (GOSAT) during the course of its initial functional check. The data was acquired by the onboard sensors of the IBUKI, the Fourier Transform Spectrometer (TANSO-FTS) and the Cloud and Aerosol Imager (TANSO-CAI), which were just activated. The IBUKI was launched by JAXA at 12:54 p.m. on January 23, 2009, (Japan Standard Time, JST) from the Tanegashima Space Center. Its initial functional check, including checking the attitude control system and communication system, has been carried out on schedule, and the satellite is in good condition.

The attached diagrams and images show the observation results by the TANSO FTS and TANSO-CAI when the IBUKI passed over Japan at around 1:00 p.m. on February 7, 2009 (JST).

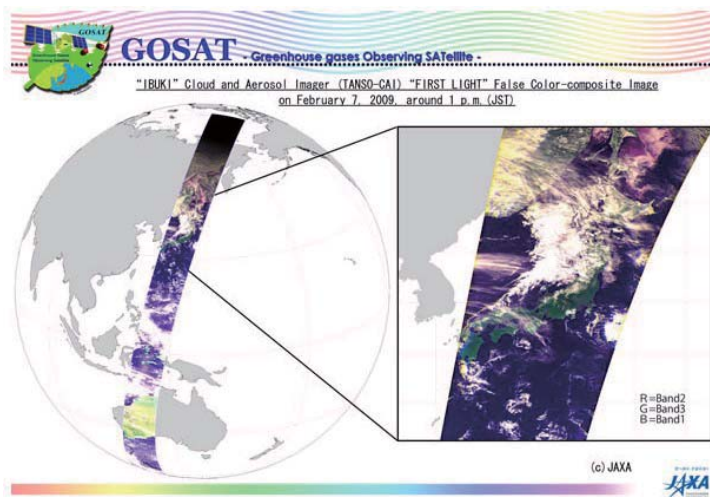
We will continue to carry out the initial functional check, which is scheduled to be completed in three months after its launch. JAXA, the National Institute for Environmental Studies (NIES), and the Ministry of the Environment (MOE) will then cooperatively carry out the initial calibration and validation operations including comparing IBUKI data and data acquired on the ground, confirming the data accuracy, and making compensations based on the data.

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Global Change Observation Mission <GCOM>

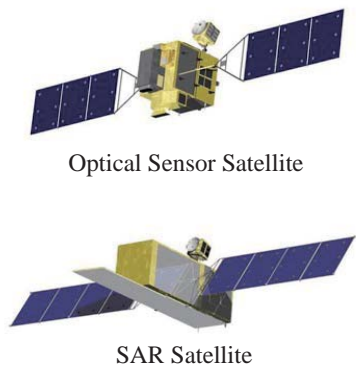
	GCOM-W	GCOM-C
Orbit	Type : Sun-synchronous, sub-recurrent Altitude : 699.6 km Inclination : 98.19 degrees Local time of ascending node : 13:30	Type : Sun-synchronous, sub-recurrent Altitude : 798 km Inclination : 99.36 degrees Local time of ascending node : 10:30
Satellite overview		
Mission life	5 years	
Launch vehicle	H2A launch vehicle	
Mass	2000kg (AMSR follow-on 340 kg and SeaWinds 240 kg included)	1800 kg (SGLI 460 kg included)
Instrument	•AMSR follow-on instrument	•Global Imager follow-on instrument (SGLI)
Launch (target)	JFY 2010	JFY 2011

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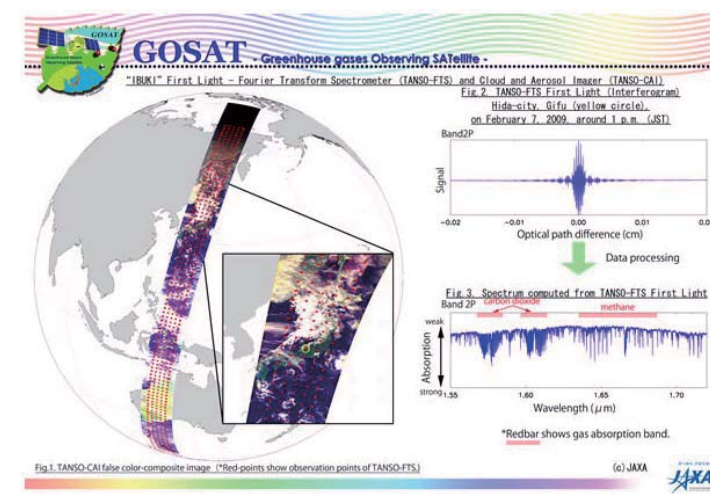
Proposed ALOS Follow-on Missions Constellation of Satellites of Optical Sensor and SAR



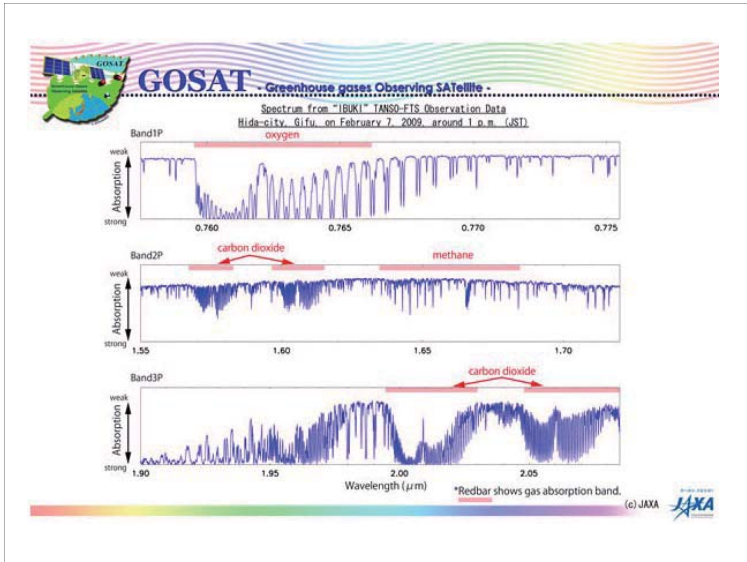
Optical Sensor Satellite

SAR Satellite

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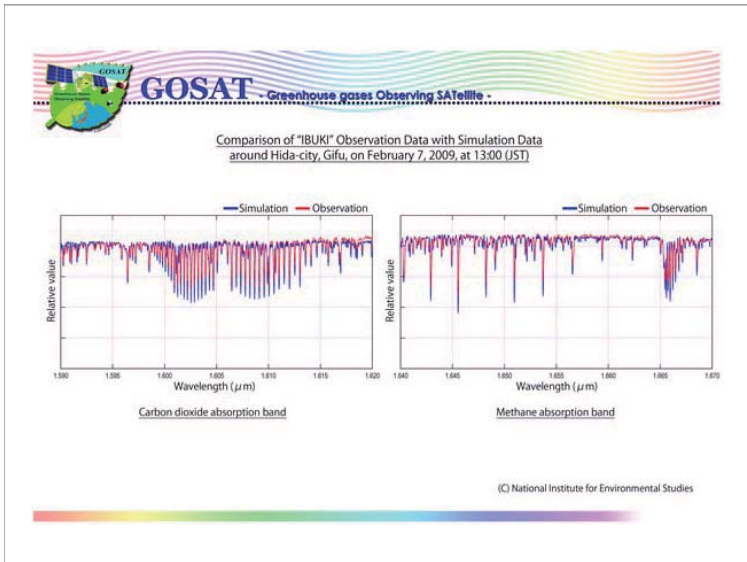


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1. Microwave

- Microwave is a spectrum range of electromagnetic wave.
- The spectrum range is used for most of present communication, earth observation, navigation, and even for cooking.
- Space traveling nature of electromagnetic wave is fundamental of remote sensing in both observation and communication.

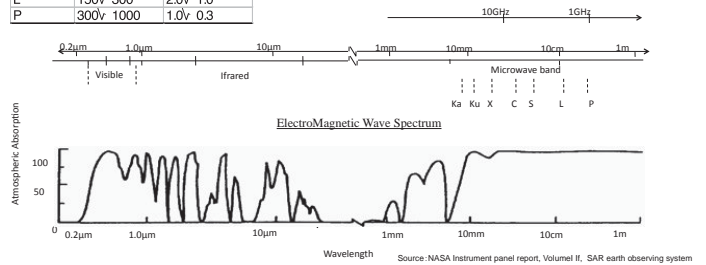
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1.1 Microwave Frequency

Band	WL(mm)	Frq(GHz)
Ka	7.5v 11.0	40.0v 26.5
K	11.0v 16.7	26.5v 18.0
Ku	16.7v 24.0	18.0v 12.5
X	24.0v 37.5	12.5v 8.0
C	37.5v 75.0	8.0v 4.0
S	75.0v 150	4.0v 2.0
L	150v 300	2.0v 1.0
P	300v 1000	1.0v 0.3



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The Project for utilization of ALOS images to support the protection of the Brazilian Amazon Forest and combat against illegal deforestation.
Basic training course 2009

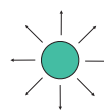
1.2 Introduction to Microwave Remote Sensing

RETEC REMOTE SENSING TECHNOLOGY CENTER OF JAPAN
TOKYO, JAPAN

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1.2 Microwave Emission(1)

- Every object emit microwaves from its surface proportional to its absolute temperature. This value becomes a noise limit of radar system.



Thermal noise = $k T B$ (watt)

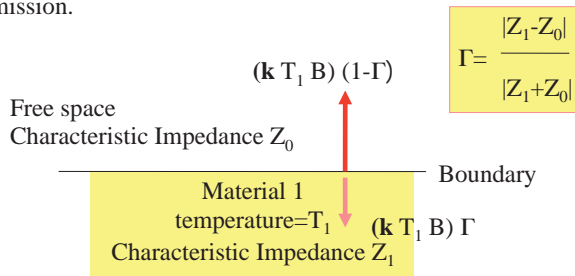
$k: 1.3806503 \times 10^{-23} \text{ m}^2 \text{ kg s}^{-2} \text{ K}^{-1}$
B: Spectral Bandwidth

Object (temperature = T Kelvin)

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1.2 Microwave Emission(2)

Monitoring surface and subsurface conditions from microwave emission.



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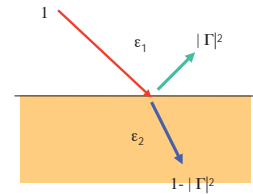
Scattering and reflection

(reflection and refraction at smooth surface)

- $Z_0 = \sqrt{\mu/\epsilon}$ (ϵ is permeability, μ is magnetic permeability)
- $\Gamma = (Z_2 - Z_1)/(Z_2 + Z_1) = (\sqrt{\epsilon_1} - \sqrt{\epsilon_2})/(\sqrt{\epsilon_1} + \sqrt{\epsilon_2})$: Assuming $\mu = \text{constant}$
- Return Power ratio = $|\Gamma|^2$

Refractive index = $\sqrt{\epsilon}$

$\sqrt{\mu_0 \epsilon_0} = 1/c$
(c: Light Speed)



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1.3 Microwave Scattering

- Coherent Scattering**
Reflection from a plate, dihedral, trihedral structures and its combination.
- Non Coherent Scattering**
Reflection from rough surface or multiple reflection from randomly located group of objects.
- Semi Coherent Scattering**
random reflection objects are located periodically.

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Dielectric Constant of Various Materials

Material	ϵ_r	Material	ϵ_r
Aluminium (1 kHz)	$-1300 + i1.3 \times 10^{14}$ [2]	Graphite	10-15
Silver (1 kHz)	$-85 + i8 \times 10^{12}$ [2]	Silicon	11.68
Vacuum	1 (by definition)		
Air	0.00000050	Ammonia (C)	26, 22, 20, 17
Teflon	[3]	Methanol	30
Polyethylene	2.1	Furfural	42
Polystyrene	2.25		
Carbon disulfide	2.4-2.7	Glycerol	41.2, 47, 42.5 (0, 20, 25 °C)
Paper	2.6		
polymers	2-12	Water (C)	34.5
Silicon dioxide	3.5	Hydrofluoric acid	83.6 (0 °C)
Concrete	4.5	Formamide	84.0 (20 °C)
Pyrex (Glass)	4.7 (3.7-10)		
Rubber	7	Sulfuric acid (20-25 °C)	84-100
Diamond	5.5-10		
Salt	3-15	Hydrogen peroxide (-30-25 °C)	128 at -60

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1.3 Microwave Scattering

Scattering Reference:

- To express surface condition by scattered amount of electromagnetic value, ratio of scattered wave strength vs. illuminating wave strength is a key.
- As a reference of scattering coefficient, a sphere made of perfect conductor is used.
- Compare the scattering wave strength with the scattered strength from a sphere intercept the same solid angle from incident wave direction.
- In a RADAR system, this amount is called (back) scattering coefficient and often use a symbol: σ_0 (sigma naught).
- Using the concept, RADAR cross section is often used as a reflection measure.

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Magnetic Permeability

- Most of non magnetic materials, relative magnetic permeability is 1.0.
- Magnetic materials like iron, nickel or cobalt have a large relative magnetic permeability of 1000-10000.
- In the radar reflection analysis, we can assume the value as constant 1.0.

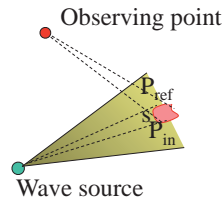
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Concept of scattering constant σ

- σ is a ratio of reflected Eelectro Magnetic (EM) power to incident EM.
- For a specific point it is expressed as;

$$\sigma = \lim_{s \rightarrow 0} (P_{ref}[s]/P_{in}[s])$$

where s is solid angle, P_{in} and P_{ref} is incident and reflected EM power, respectively.



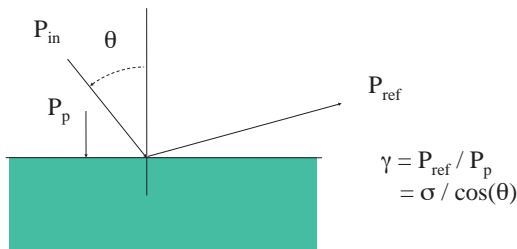
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Scattering under various conditions

- Incident angle
- Surface roughness
- Material structure
- Material allocation pattern

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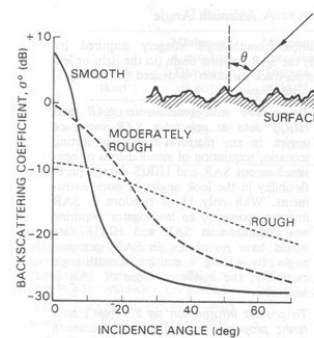
Concept of scattering constant γ



γ is a normalization concept to make reflection constant independent of input incident angle by scaling to unit vertical incidence of EM wave P_p . In a pulse radar system, one more item, range gate or pulse width, must be taken into account. This will be discussed in SAR radiometric part.

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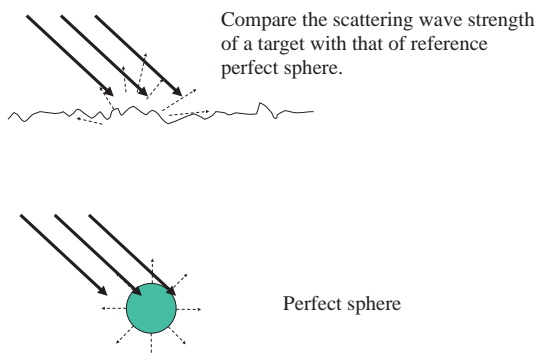
Effect of surface roughness and incident angle



Schematic diagram showing the effect of the surface roughness and incidence angle (θ) on backscatter (after NASA/JPL, 1988).

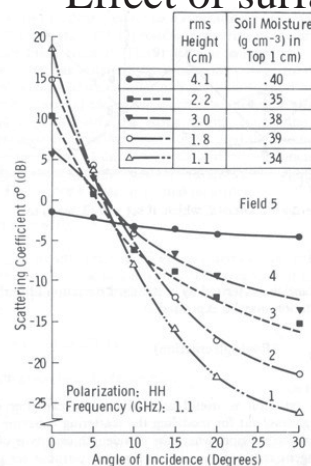
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Scattering reference



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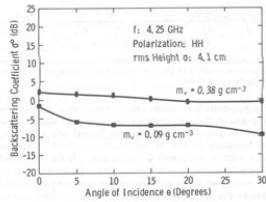
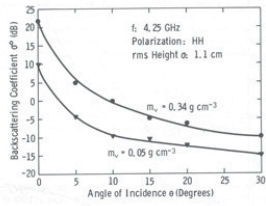
Effect of surface roughness



Scattering coefficients for bare-soil fields with different surface roughness (after Ulaby et al., 1982).

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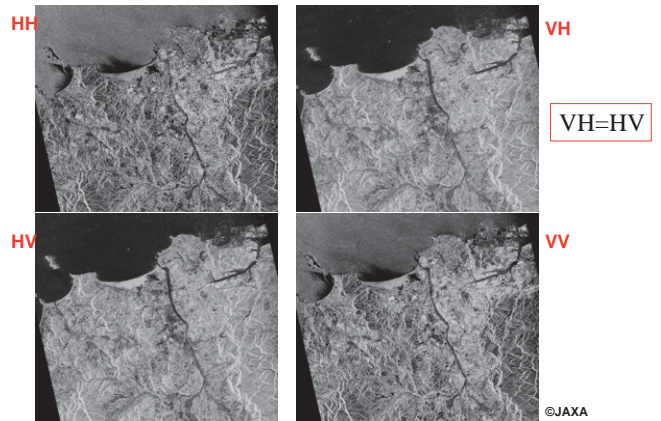
Effect of surface roughness



Comparison of the backscatter for wet and dry soil for a smooth surface (top) and a rough surface (bottom) (after Ulaby et al., 1982).

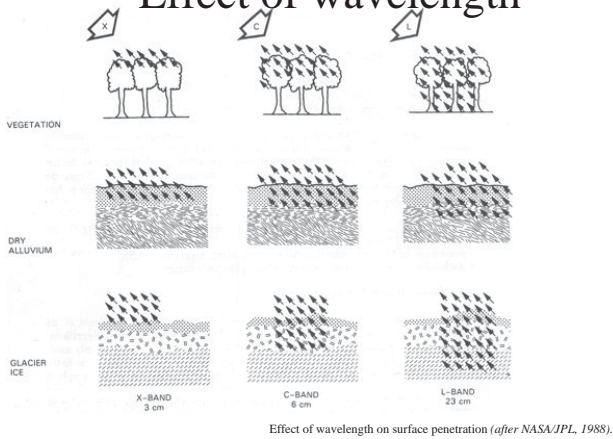
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Effect of polarization



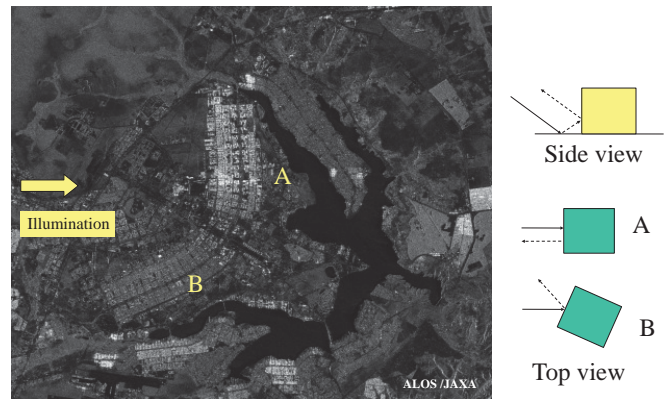
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Effect of wavelength



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Effect of orientation of structure



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Effect of polarization



Color composite

(RGB=VV,VH,HH)

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Reference

- 1) NASA/JPL, Synthetic Aperture Radar, Technical Report, NASA Earth Observation System, Instrument Panel Report, Vol. III, 1988.
- 2) Ulaby F., Moore, R. and A. Fung, *Microwave Remote Sensing*, Vol. 2, Artec House, Norwood, MA, 1982.

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Principle of Synthetic Aperture Radar



REMOTE SENSING TECHNOLOGY CENTER OF JAPAN
TOKYO, JAPAN



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RADAR



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- (2) SAR Image processing
- (3) Characteristics of SAR image
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 - II. Geometric characteristics
 - III. Difference of Microwave bands
 - IV. Descending and Ascending image
- (4) SAR specific analysis method
 - I. Stereo SAR
 - II. Polarimetric SAR
 - III. Interferometric SAR
- (5) Appendix
 - Introduction of ALOS value-added products



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SAR and its strong point(1)

SAR:

Abbreviation of Synthetic Aperture Radar
Sensor itself transmit a microwave on the ground
and receive the reflection from ground (backscatter)

Preferable target for SAR observation

- Ice, Ocean waves
- Soil moisture, vegetation mass
- Man-made objects, e.g. buildings
- Geological structures



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(1) Introduction



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SAR and its strong point(2)

Strong point of SAR

- Can observe under all-weather condition
- Can work day-and-night observation
- Can observe polarimetric observation
- Have the Coherency information

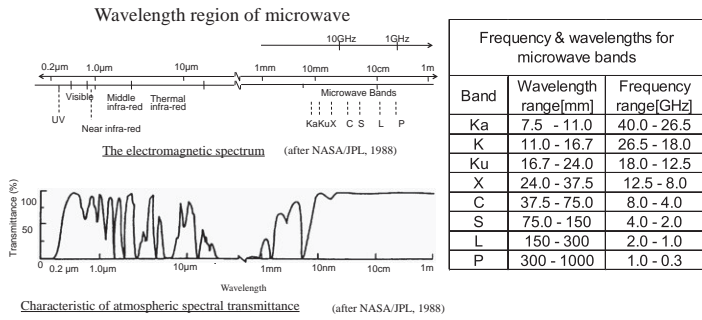
Weak point of SAR

- Difficulty of image interpretation
(Characteristics of microwave image)
- Geometric Distortion due to observation system
(Foreshortening, Layover, Radarshadow)



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What's microwave?



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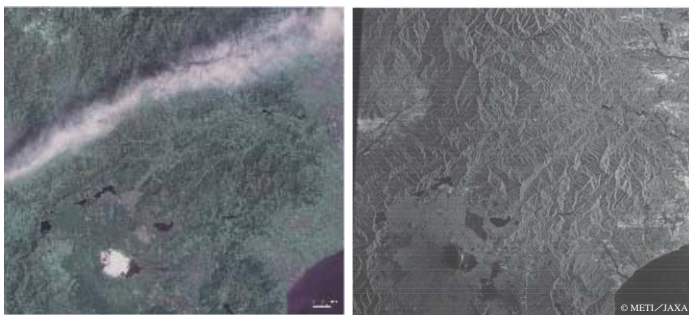
Important parameters for SAR system

- Incidence angle
- Wavelength
- Polarization
- Spatial Resolution
- Repeat cycle

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Optical and Microwave sensor



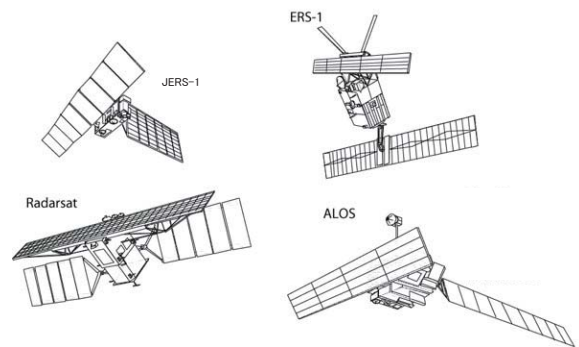
LANDSAT TM (23 Apr. 1992)

JERS-1 SAR (23 Apr. 1992)

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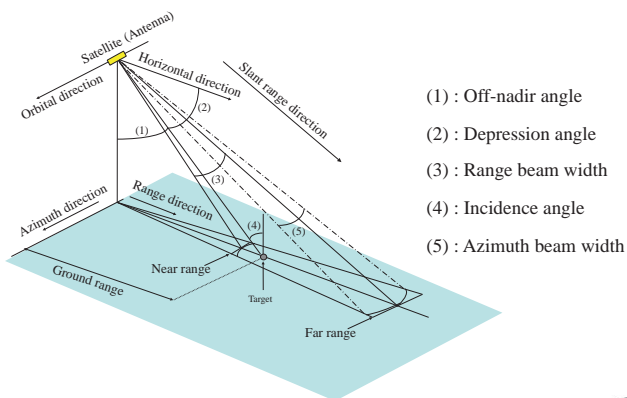
SAR Satellites



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Observation geometry of SAR



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SAR satellites

Characteristics and parameters of SAR on board satellites					
	ERS-1	JERS-1	RADARSAT	ENVISAT	ALOS
Launch	Apr. 1991	Feb. 1992	Nov. 1995	Mar. 2002	Jan. 2006
Orbital altitude	785km	568km	793 - 821km	799.8km	691.65km
Orbital inclination	98.5 deg.	97.7 deg.	98.6 deg.	98.55 deg.	98.16 deg.
Frequency	5.3GHz (C-band)	1.275GHz (L-band)	5.3GHz (C-band)	5.331GHz(C-band)	1.270GHz(L-band)
Wavelength	5.7cm	23.5cm	5.7cm	5.6cm	23.6cm
Polarization	WV	HH	HH	HH, WV, HH+VW, VV+VH, HH+HV	HH, W, HH+HV, VV+VH, HH+VW+HV+VH
Off-nadir angle	20 deg.	35 deg.	9 - 48 deg.	13.5 - 39 deg.	10 - 51 deg.
Incidence angle	23 deg.	36.7 deg.	10 - 60 deg.	15 - 45.2 deg.	8 - 60 deg.
Swath width	100km	75km	50 - 500km	56.5 - 104.8km	20 - 350km
Azimuth resolution	30m	18m (stack)	9 - 147m	30 - 1000m	10 - 100m (stack)
Range resolution	30m	18m	6~147m		
Peak power	4.8kW	325W (designed as 1.3kV5kW)	1.4kW (average)	2.3kW	2.3kW
Bandwidth	19MHz	15MHz	11.6/17.3/30.0	8.48-16MHz	14MHz/28MHz
Antenna size	1 x 10m	2.2 x 12m	1.5 x 15m	1.3 x 10m	3.1 x 8.9m

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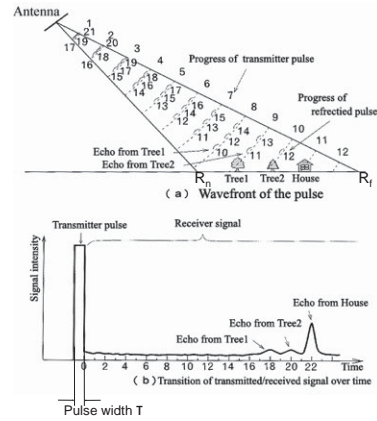


SAR Image Processing

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Pulse radar



SAR illuminate the microwave to the ground and observes the "backscatter" from the ground.

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Processing level

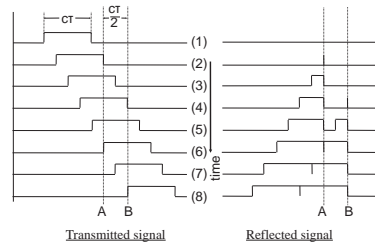
- 1 RAW data : Raw signal data. Before the image reconstruction of SAR image
- 2 SLC data : SLC means Single Look Complex. This data has phase and amplitude information in complex style
- 3 Image data : Each pixels are consist of real value (usually 2byte short integer). No phase information

To create from data1 to 2 or 3, It is necessary to process range compression and azimuth compression

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Range Resolution (1) Range resolution without range compression



When the distance between two objects is less than $c\tau/2$, these objects can not be distinguished in the image.

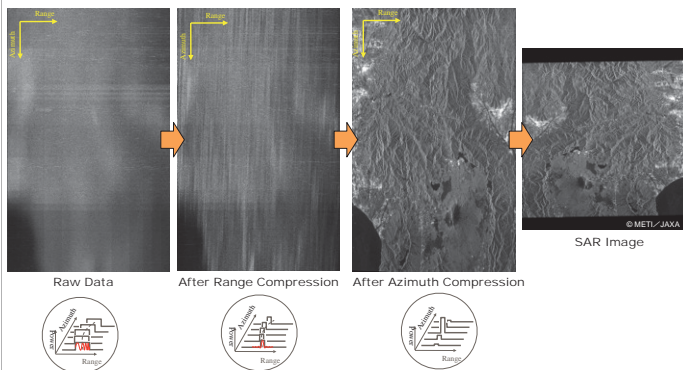
i.e. JERS-1/SAR:
The pulse width is 35 μ m, therefore the range resolution Δx is as below.
 $\Delta x = c\tau/2 = 3.0 \times 10^8 \times 35 \times 10^{-6} / 2 = 5250\text{m}$ (in slant range)

The more narrow the pulse width is, the more higher the resolution is.

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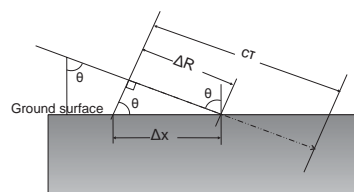
SAR image processing



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Range Resolution (2) Slant range resolution and ground range resolution



The relationship between the ground range Δx and the slant range ΔR is expressed as below with the incident angle θ .

$$\Delta x = \Delta R / \sin\theta = \frac{c\tau}{2 \sin\theta}$$

Hence, the ground resolution Δx is lower than the slant range resolution ΔR .

Hence, the resolution is higher at the far range side than that at near range side.

i.e. JERS-1:

$$\Delta x = c\tau / 2 \sin\theta = 3.0 \times 10^8 \times 35 \times 10^{-6} / (2.0 \times \sin 35^\circ) = 9153\text{m}$$

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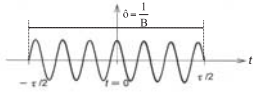


Range Resolution (3) Characteristics of pulse and resolution

S/N in SAR image : Depends on the transmission power.
 Transmission power = (Pulse width) x (Injection power)
 Resolution of SAR image : Depends on the band width. High resolution needs sharp pulse width, but shallow pulse width leads to the deterioration of S/N.

It is difficult to realize the pulse signal which has both sharp pulse width and high transmission power.

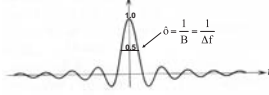
Increase the band width without the modulation of pulse width. → Chirp compression



In the case of sine wave and rectangular wave,

$$\text{Band width : } B = \frac{1}{\tau}$$

$$\text{Resolution : } \Delta R = \frac{c\tau}{2} = \frac{c}{2B}$$



In the case of chirp-compressed wave,

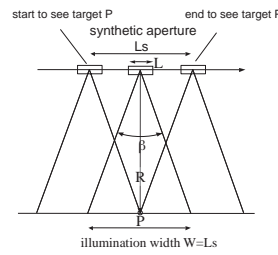
$$\text{Band width : } B = \frac{1}{\tau} \Delta f \quad (\text{After detection})$$

$$\text{Resolution : } \Delta R = \frac{c\tau}{2} = \frac{c}{2B} = \frac{c}{2\Delta f} \quad (\text{After detection})$$

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Azimuth resolution(2) ~Spatial resolution of azimuth direction (Aperture Synthesis)~



antenna beam width of real aperture $\beta = \lambda / L$
 illumination width of real aperture $W = bR = R/L$
 length of synthetic aperture $L_s = W$
 antenna beam width of synthetic aperture $b_s = \lambda / (2L_s)$
 count phase difference two times to and from satellite
 spatial resolution in azimuth direction is;
 $r_s = b_s R = R / (2L_s) = R / (2 R / L) = L / 2$

∴ Maximum spatial resolution in azimuth direction is $L/2$ independent of distance and wavelength.

***Maximum spatial resolution do not depend on wavelength or distance to target**

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Range resolution(4) ~Chirp Modulation~

Chirp modulation:
 Changing a frequency of wave in proportion to changes in time

frequency $f = f_0 + \alpha t$ (α : constant)
 Output waveform $g_s(t) = \exp[2\pi(f_0 + \alpha t)t]$

In the case of JERS-1:

$$f_0 = 1275 \text{ MHz}$$

$$\Delta f = 15 \text{ MHz}$$

$$1267.5 \leq f \leq 1282.5$$

Bandwidth after phase detection:

$$B = \Delta f$$

In the case of JERS-1, pulse width and spatial resolution after chirp compression is following:

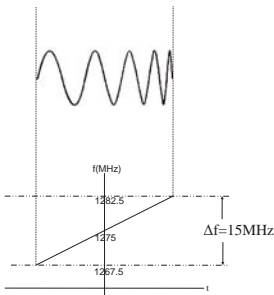
$$\text{Pulse width } \tau_{mc} = 1 / \Delta f = 6.67 \times 10^{-8} \text{ (s)}$$

$$\text{Spatial resolution on slant range:}$$

$$\Delta R = c \tau_{mc} / 2.0 = 10 \text{ m}$$

$$\text{Spatial resolution on ground range:}$$

$$\Delta X = \Delta R / \sin 35^\circ \approx 17.4 \text{ m}$$



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Look processing (For reducing the effect of speckle noise)

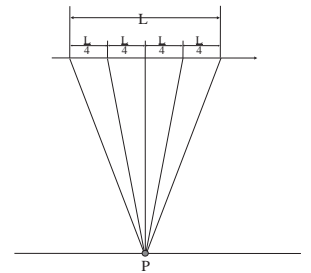
Multi-Look processing:
 Virtually separate the synthesized antenna and average the image which made by each small separated antenna
 Its purpose is to reduce the effect of speckle noise.

Note spatial resolution of full synthesized antenna is r_A , after multi look processing is r_{Am}

$$\rho_{Am} = \rho_A \cdot L / (L/4)$$

$$= 4 \rho_A$$

spatial resolution is inversely proportional to look number



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Azimuth resolution(1) ~Azimuth resolution without azimuth compression~

• Set spatial resolution of azimuth direction as δ and slant range length R , spatial resolution of azimuth direction is estimated following equation:

$$\text{Half bandwidth } \beta = \lambda / L \text{ (rad)}$$

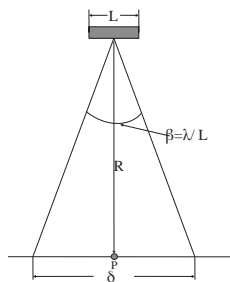
(L: azimuth antenna width)

$$\delta = \beta R = \lambda R / L$$

In the case of JERS-1;

$$\lambda = 23 \text{ cm}, R = 700 \text{ km}, L = 12 \text{ m},$$

$$\delta = 0.23 \times 7 \times 10^5 / 12.0 = 13400 \text{ m}$$



Spatial resolution in azimuth direction = 13km → almost no use!!! (Low resolution)

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Spatial resolution of SAR image (Summary)

- Spatial resolution on ground range is getting higher to go to far range side.
- Range compression, Azimuth compression → execute for the improvement of the spatial resolution
- The narrower the illuminating pulse width, the higher spatial resolution of image
- Maximum azimuth resolution is decided by the real antenna size and it is a half of real antenna width.
- Azimuth resolution is finally decided by the number of look number

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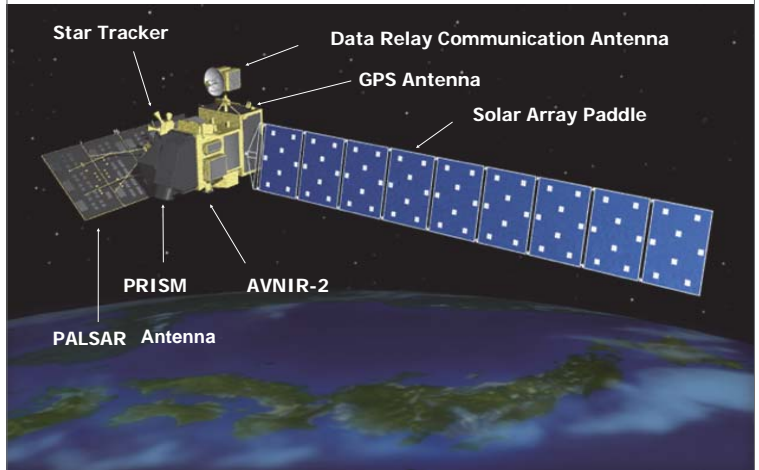


ALOS System



REMOTE SENSING TECHNOLOGY CENTER OF JAPAN
TOKYO, JAPAN

On orbit configuration



ALOS System

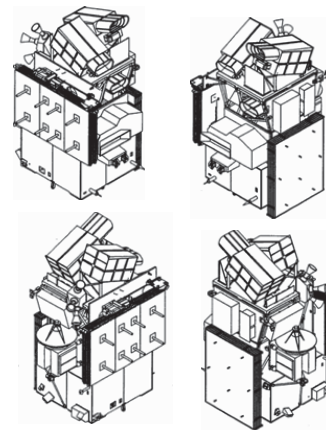
Masaharu TAKAMATSU
Akira MUKAIDA

Research Department/Tsukuba Office
Remote Sensing Technology Center of Japan

Table of contents

- Chapter 1. Bus Technology
- Chapter 2. Observation and products
- Chapter 3. Examples
- Chapter 4. Comparison with the other satellites

Lift-off configuration



Bus Subsystems

- Position/Attitude control Subsystem
- Thermal Control Subsystem
- Communication Subsystem
- Data Processing Subsystem
- Structure Subsystem
- Electric Power/Solar Array Subsystem
- Integration Subsystem

Chapter 1. Bus Technology

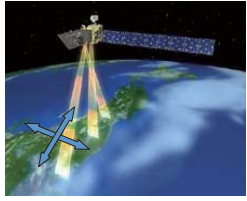
- ✓ On orbit configuration
- ✓ Lift-off configuration
- ✓ Bus technologies to support the missions
- ✓ Integration and Test

Bus technologies to support missions

Mission Items	Requirements	Technology / Orbit
(1) Cartography	(1) Accurate positioning and Attitude control	(1) Positioning/Attitude control subsystem (2) Thermal control subsystem
(2) Disaster Monitoring	(2) Land Observation (3) Timely data transfer (4) 3 sensors & huge data	Orbit, Swath widths Communication subsystem Data processing subsystem Data processing subsystem
(3) Regional Observation (4) Resources Survey	3 sensors & huge data 3 sensors & huge data	Data processing subsystem
Satellite system Large scale structure Large electric power consumption	(5) Light weight & Low temperature strain (6) Light weight & Large electric generation	(1) Structure subsystem (2) Thermal control subsystem Solar array subsystem

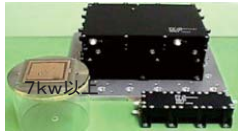
Accurate positioning & Attitude control

(1) Positioning / Attitude control subsystem



(1)-1 Positioning : inaccurate satellite position
 → inaccurate observed area
 ⇒ ranging by laser reflector

• Position is determined by 2 waves of GPS



L1, L2 wave receiving antenna



Satellite equipped laser reflector

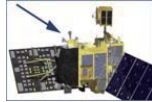
(1)-2 Attitude : inaccurate satellite attitude

→ inaccurate observed area

area

Satellite attitude is determined by the star tracker referring to the on board stars catalogue

star tracker



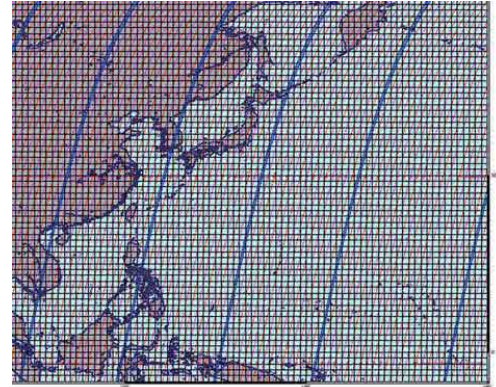
Observed area is determined without the ground control point.

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All Land Observation

Orbit and sensor view width



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equator

Distance between the adjacent orbit on the equator is 60km. Recurrent cycle is 46 days. Using the AVNIR-2 pointing mechanism, sub-cycle is 2 days.

P

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Accurate positioning & Attitude control

(2) Thermal control subsystem

• To avoid the criterion axis deformation, the star tracker is covered by hood with multi layer insulation to keep temperature constant under the

• To avoid the criterion axis deformation, PRISM is housed in the box with multi layer insulation to keep temperature constant under the hot and cold condition of space.



PRISM(1unite)



star tracker

Observed area is directly obtained at the determined position and attitude.

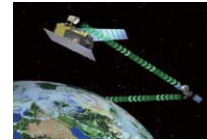
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Timely data transfer

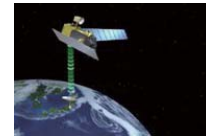
Communication subsystem

• via Ka band Data Relay Test Satellite (DRTS) transfer : 240Mbps



• Direct X-band transfer

: 120Mbps



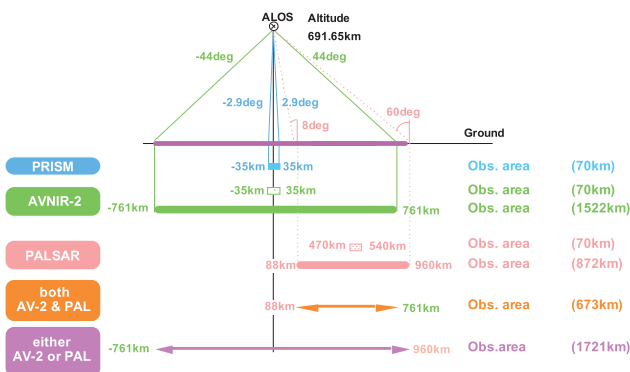
via DRTS : always when link is established > Direct : about ten minutes when the satellite passes over the receiving station, Hatoyama

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All Land Observation

Orbit and sensor view width



All land observation with view width ± 35 km (70 km)
 → Distance between the adjacent orbit on the equator 60 km < 70 km

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Three sensors & huge data

Data processing subsystem

• Acquired data amount

PRISM : 960 Mbps (total of 3 line sensors)

AVNIR-2 : 160 Mbps

PALSAR : 240 Mbps / 120 Mbps

• Acquired data amount > data transfer capacity

↓

• Data compression

PRISM : discrete cosine transfer (lossy)

Solid state recorder 96GB

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Light weight & Low temperature strain

Structure subsystem

- Light weight : Truss structure
- Low temp. strain : Use CFRP (carbon fiber reinforced plastic) to cancel the temperature strain of joint metallic coupler by truss structure material+



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Chapter 2. Observation and products

- ✓ ALOS sensors
- ✓ PALSAR operation modes
- ✓ Data processing
- ✓ Observation strategy

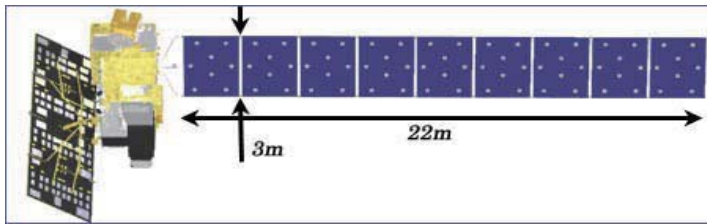
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Light weight & Large electric power generation

Solar array subsystem

The solar cells are fixed on the aluminum honeycomb and CFRP face sheet sandwich panel

Electric power generation > 7kw

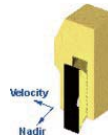


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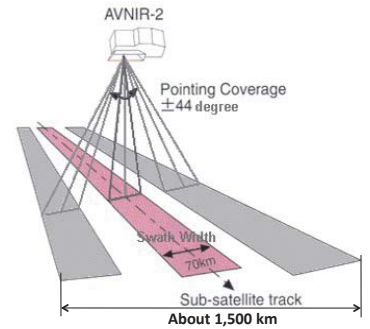
AVNIR-2

Advanced Visible and Near Infrared Radiometer type 2



Band 1 : 0.42-0.50 μ m
 Band 2 : 0.52-0.60 μ m
 Band 3 : 0.61-0.69 μ m
 Band 4 : 0.76-0.89 μ m

Field of view : 5.8 deg.
 Swath width : 70km at Nadir
 Instantaneous FOV : 14.28 μ rad
 Spatial resolution : 10m at Nadir
 Number of detectors : 7000 /band
 Pointing angle : +/- 44 deg.
 S/N : >200, MTF : >0.25 (1-3), >0.20 (4)
 Scanning method : Push broom
 Quantization : 8 bits

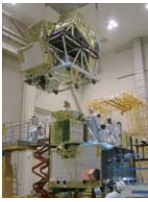


- ✦ Improvements in AVNIR-2 from AVNIR
- ✓ Resolution : 10m < 16m
- ✓ Pointing angle : +/-44 deg < +/-40 deg
- ✓ Calibration system : lamp 2 < lamp 1, Solar 1

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Integration and Test



Assembled PRISM on the satellite bus



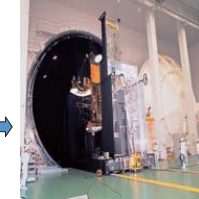
Installed PALSAR antenna



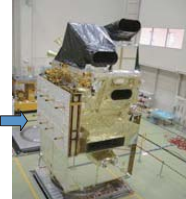
Vibration tests



Acoustic test



Thermal test in space chamber

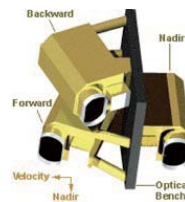


completion ©JAXA P

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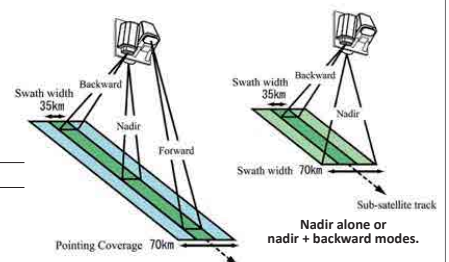
PRISM

Panchromatic Remote-sensing Instrument for Stereo Mapping



0.52-0.77 μ m

Number of Optics : 3, AT +/- 23.8 deg (Nadir / Forward / Backward)
 Base/Height ratio : 1.0 (F / B)
 Spatial resolution : 2.5m at Nadir
 Swath width : 35km at Triplet mode
 70km at Nadir only
 Pointing angle : +/- 1.5 deg.
 S/N : >70, MTF : >0.20
 Scanning method : Push broom
 Quantization : 8 bits
 Data compression: JPEG extension



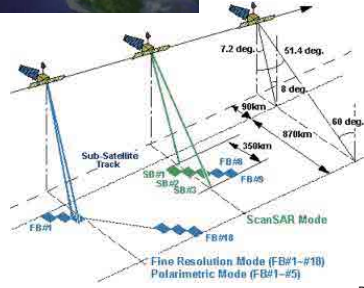
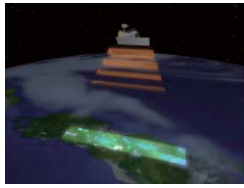
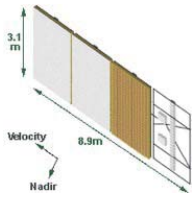
- ✦ Two observation (+/-1.20deg. pointing angle) per orbit are necessary for observing whole coverage by triplet mode except in high latitude areas.

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PALSAR

Phased Array type L-band Synthetic Aperture Radar



L-band (1.27GHz)

Fine Resolution Mode
8.0-60.0 deg.
HH or VV / HH+HV or VV+VH
7.0-44.3m / 14.0-88.6m
40-70km / 40-70km
ScanSAR Mode
18.0-43.0 deg.
HH or VV / 100m / 250-350km
Polarimetric Mode
8.0-30.0 deg.
HH + HV + VH + VV
24.1-88.6m / 20-60km

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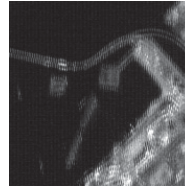
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Definition of Products PRISM & AVNIR-2

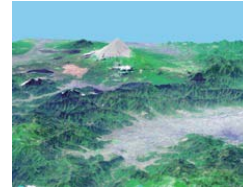
Standard Products : processed in JAXA Earth Observation Center (EOC)
 AVNIR-2, **PRISM** – 1A : Uncorrected image, scene unit (Raw data)
 1B1 : Radiometrically corrected image
 1B2 : Geometrically corrected image, R/G

High Level Products : will be generated at EORC.
PRISM : Digital Surface Model (DSM) and Ortho image (500 scenes/year)
 AVNIR-2 : Ortho-rectified image

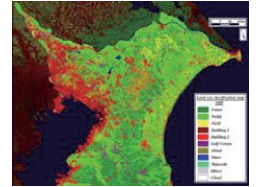
Research Products (tentative) : will be produced at EORC.
 - LULC classification and vegetation, Albedo, Mountain and Glacier, Pan-sharpened image using AVNIR-2 and **PRISM**, and Scene-DSM by **PRISM**



Example of AVNIR-2 1A. (Stagger arrange)



Mt. Fuji's DSM derived by JERS-1/OPS stereo.



Example of land-cover classification using Landsat/TM image. ©JAXA

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PALSAR Operation Modes

* Total: 132 modes

Mode	Fine Resolution		Direct Downlink (DT)	ScanSAR	Polarimetry
	Single-Pol. (FBS)	Dual-Pol. (FBD)			
Frequency	L-band (1270 MHz)				
Chirp Bandwidth	28 MHz	14 MHz	14 MHz	14/28 MHz	14 MHz
Polarization	HH or VV	HH/HV or VV/VH	HH or VV	HH or VV	HH+HV +VH+VV
Incidence Angle	8-60 deg (typ 39 deg)	8-60 deg (typ 39 deg)	8-60 deg (typ 39 deg)	18-43 deg	8-30 deg (typ 24 deg)
Range Resolution	7-44 m	14-88 m	14-88 m	100 m	24-89 m
Swath Width	10m@39deg	20m@39deg	20m@39deg	(Multi-look)	30m@24deg
Bit Length	40-70 km	40-70 km	40-70 km	250-350 km	20-65 km
Data Rate	5 bits	5 bits	3/5 bits	5 bits	3/5 bits
	240 Mbps	240 Mbps	120 Mbps	120/240 Mbps	240 Mbps

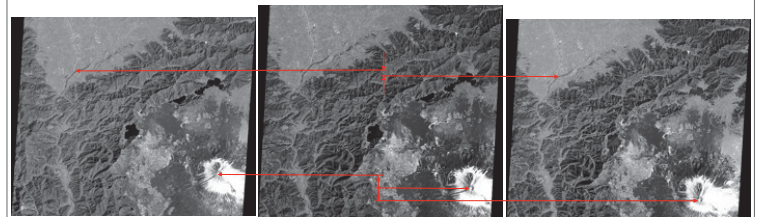
Major operation modes: 6 (9) modes

Mode	FBS	FBD	(DT)	ScanSAR	Polarimetry
Off-nadir angle (deg)	21, 34, 41	41	21, 34, 41	5 SCAN (17-43)	21
Polarization	HH	HH+HV	HH	HH	HH+HV +VH+VV

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Example of images observed from different angles



Velocity Direction ↓

Position error occurs depending on the altitude

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Data Processing

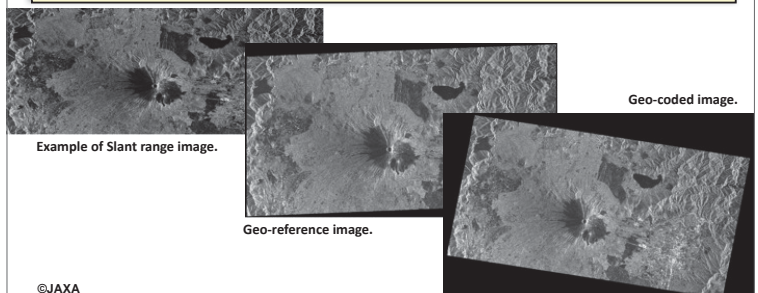
Processing Level	Definition	
Level 0 only for ERSDAC GSI EORC Data nodes	AVNIR-2 Level 0 data for distribution (including TT&C, AOCS, PCD telemetry)	
	PRISM Level 0 data for distribution (including TT&C, AOCS, PRISM mission telemetry)	
	PALSAR Level 0 data for distribution (including TT&C, AOCS, PALSAR mission telemetry)	
Level 1 (Processed data)	AVNIR-2, PRISM	
	1A	Uncorrected image, Scene unit (Uncompressed)
	1B1	Radiometrically calibrated image
	1B2	Geometrically corrected image
	PALSAR	
	1.0	Uncorrected image, Scene Unit
1.1	Single look complex data on slant range	
1.5	Multi look processed image	

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Definition of Products -PALSAR (1/2)

Standard Products : Processed at JAXA Earth Observation Center (EOC)
 PALSAR – 1.0 : Uncorrected image, scene unit
 Raw data + Orbit + Telemetry (384-847MB)
 1.1 : Single-Look Complex data on slant range (SLC)
 4 bytes IEEE (I+Q) + Ancillary
 1.5 : Multi look processed image (Amplitude, Georeference/Geocode)
 2 bytes Int + Ancillary (160-280MB@6.25m, 40-71MB@12.5m)



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