A. How can you identify the flood water extent from SAR intensity/ coherence images? What is the principle of the methods? [/4 marks]

Method and principle to identify SAR intensity [/2 marks]
Method and principle to identify SAR coherence [/2 marks]

SAR intensity method needs to SAR images in the same area which are taken before and immediately after the flood. the reflection of dry land is a diffuse reflection before the flood and will be changed to specular reflection after flooding. The detail shows in figure 1. Because of this change, the water zones can be detected by comparing these two images.

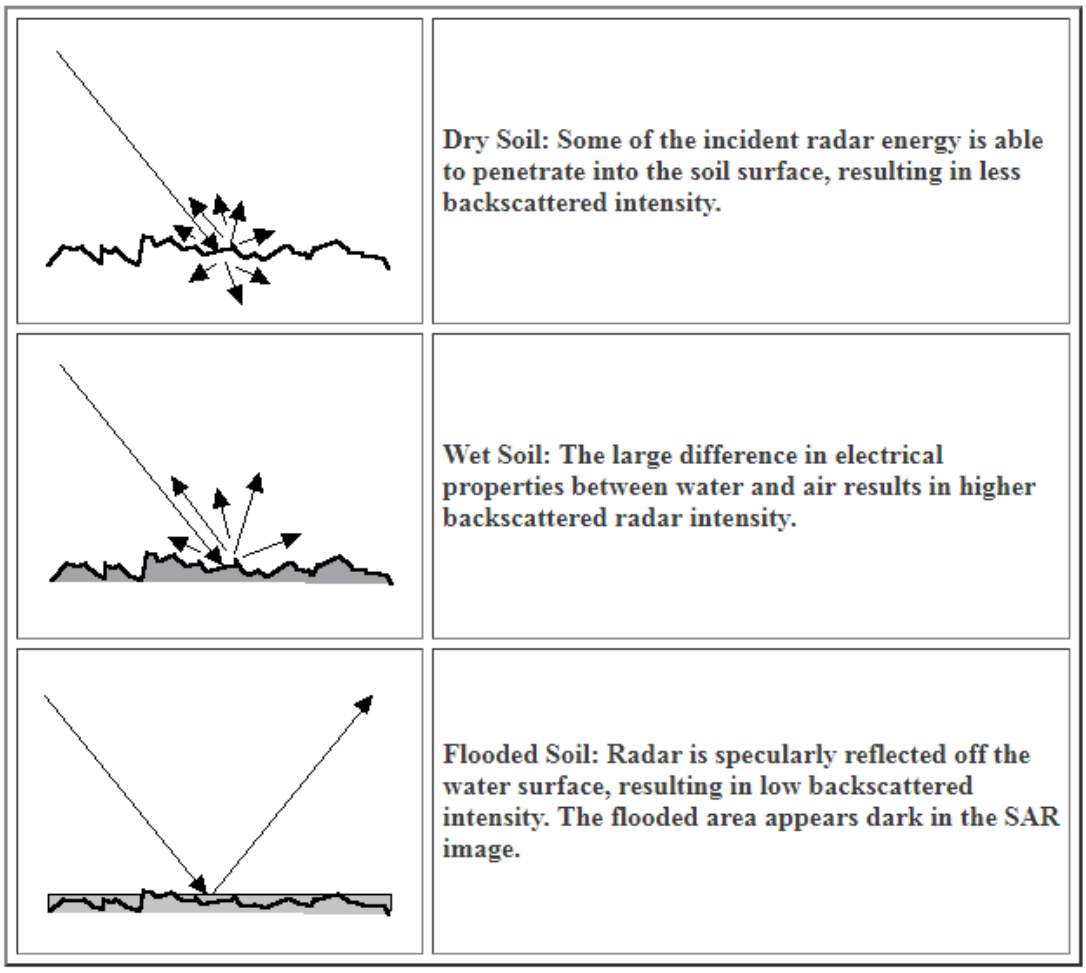


Figure 1 Reflection of dry land and flood area

The value between 0-80 is identified to be the water area (blue area in figure 2); the value between 80-180 is identified to be the land (white area in figure 2), and the value larger than 180 is assumed as the flooding water (red area in figure 2). The value is closer to 1 means the coherence is higher. Therefore, in figure 7, the value between 0-0.3 shown as black means there is likely water zone and the value between 0.3-0.914589703 shown as white is much more like the land area.

B. Produce SAR intensity images and SAR intensity difference image. Compare the SAR intensity images and the SAR intensity difference image. What do the negative intensity difference and positive intensity difference represent? [Please include the SAR intensity difference image to answer this question] [/6 marks]

Discuss about positive and negative intensity difference [/2 marks]
Include SAR intensity images [/2 marks]
Include SAR intensity difference image [/2 marks]

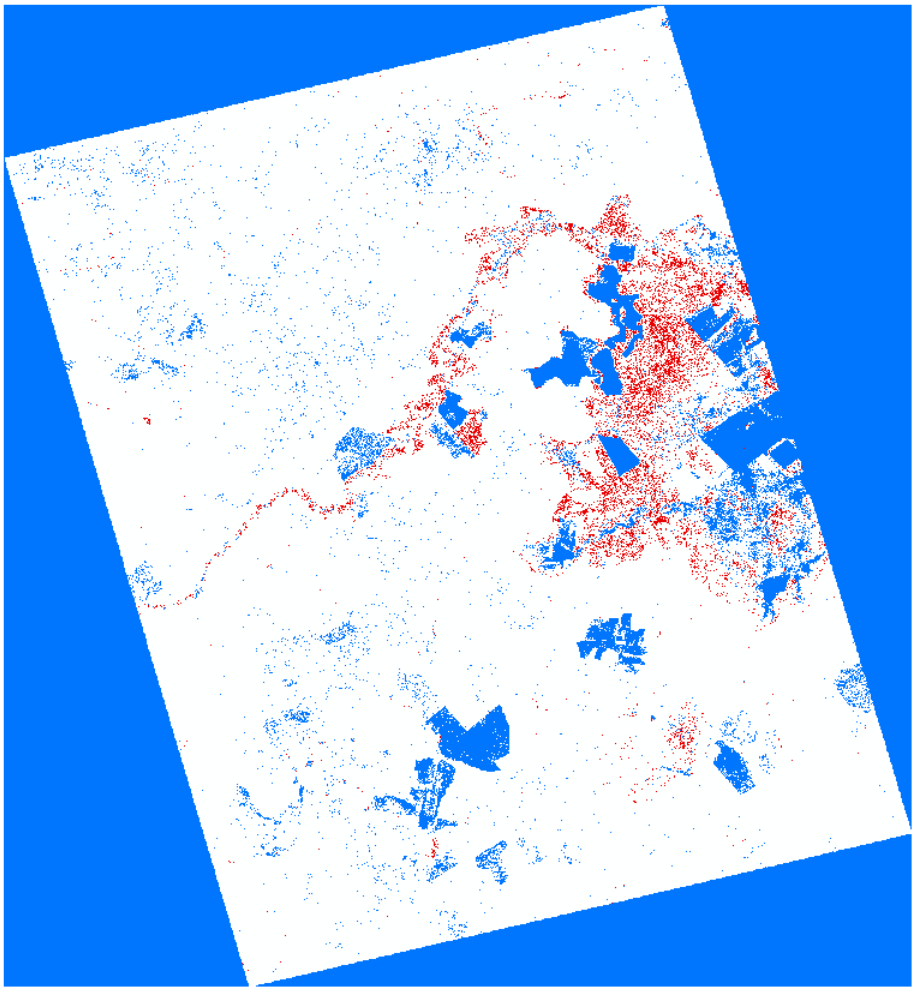


Figure 2 CSK-intensity-20110319

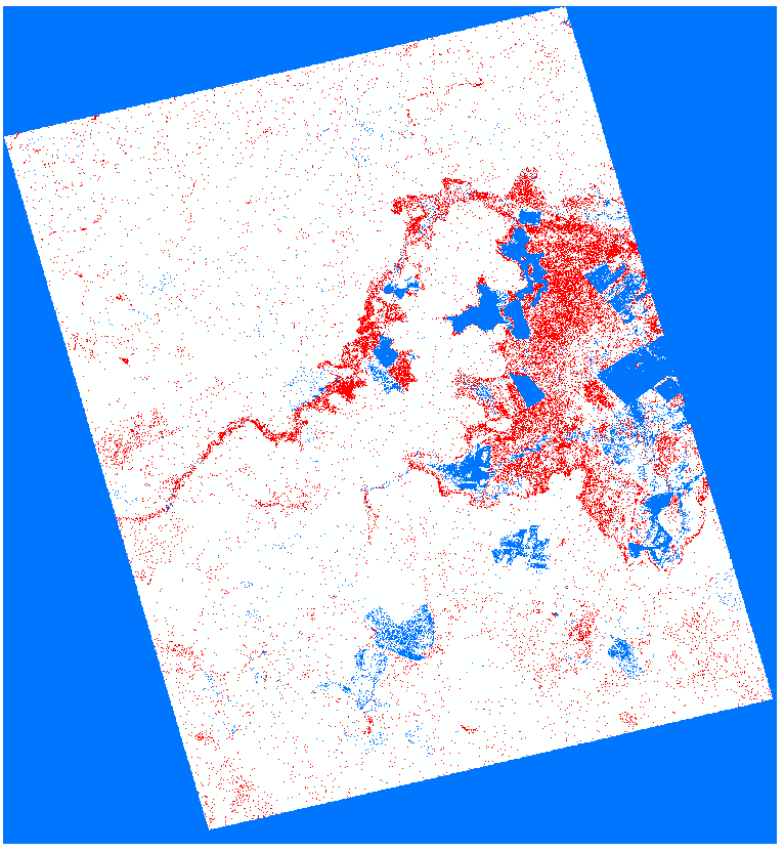


Figure 3 CSK-intensity-20110320

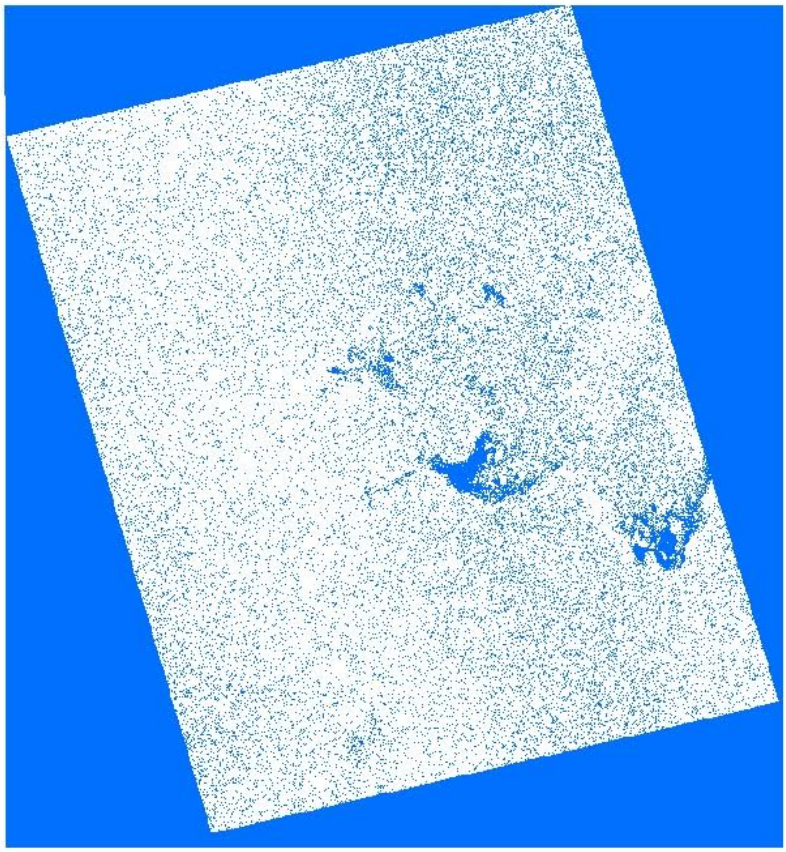


Figure 4 SAR intensity difference image

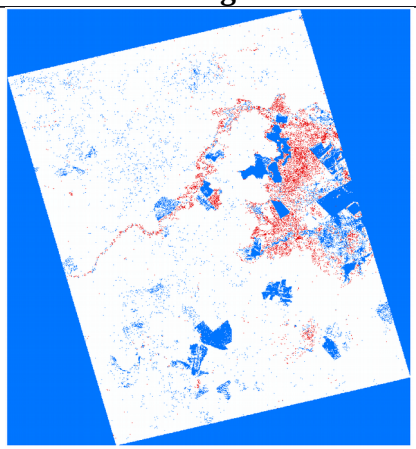
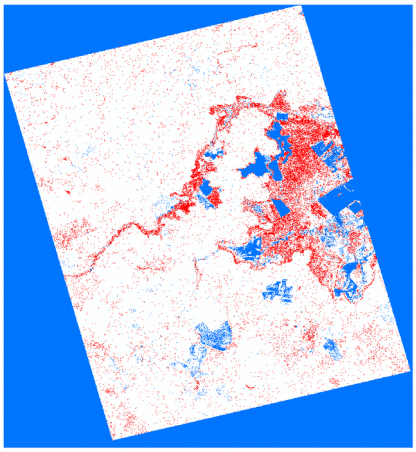
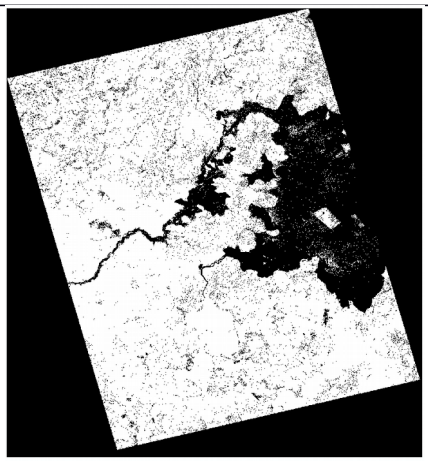
Table 1 Positive and Negative intensity difference

Change types	20110319	20110320	Represent
Positive	0-80	80-180	This may mean that the water is gone and changed into the land area.
Positive	0-80	>180	This may means that the water level is rising, and the still water is changed into the flood water
Positive	80-180	>180	This may shows that the water level is rising and the land is changed into the flooding area.
Negative	80-180	0-80	This may represent that the water level is rising, and the land is changed into still water
Negative	>180	0-80	This may represent that the flooding water changed into still water.
Negative	>180	80-180	This may represent that the water is gone, and the flowing water is changed into the land.

C. Compare the SAR intensity analysis and SAR coherence analysis. Discuss the pros and cons of these methods in a table. [/6 marks]

A table including:
Pros and Cons for SAR intensity analysis [/2 marks]
Pros and Cons for SAR coherence analysis [/2 marks]
With images to back up the answers [/2 marks]

Table 2 Pros and Cons of SAR intensity images and SAR Coherence images

Images types	Pros	Cons	Images
SAR intensity	More accurate to show to flooding area; Cloud or vegetation does not influence the results; Show the density of the flood; Positive and negative changes can be presented; Can be analysed by computer;	Cannot show the boundaries of flood; Based on pure colour, not real colour	 Figure 5 CSK-intensity-20110319  Figure 6 CSK-intensity-20110320
SAR coherence	Can shows the flood boundaries; Can be analysed by computer	positive or negative changes cannot be presented , and also Cannot show as true colour	 Figure 7 CSK-coherence-20110319-20110320

D. Compare the SAR images and optical images. What are the radar intensity and coherence values for the pixels over different surfaces, such as still water, flooded forest, bare soil, farm land, forest and buildings? Are these values reasonable? [Hint: Utilise the optical images] [/6 marks]

Still water [/1 marks]
Flooded forest [/1 marks]
Bare soil [/1 marks]
Farm land [/1 marks]
Non-flooded Forest [/1 marks]
Buildings [/1 marks]

These features can be identified by comparing the SAR intensity or coherence images with the optical images
First, changing the properties of image "CSK-intensity-20110320.img" and the image "CSK-coherence-20110319-20110320.img" into 32 classes, then compared with the image "NewAngledoolFlood-2010-03-20cm.ecw" and the image "NewAngledoolFlood-2010-03-20cm-cir.ecw". The results show in table 3.

Table 3 values of selected features in SAR intensity images and Coherence images

	SAR intensity images	**SAR coherence images**
Still water	26-77.6	0-0.31
Flood forest	154-242	0.06-0.31
Bare soil	77-131	0.58-0.67
Farm land	102-193	0.06-0.65
Non-flooded forest	111-183	0.06-0.63
buildings	193-227	0.31-0.51

According to the results shown on table 3, the values may not be reasonable. It may caused by SAR images as value overlap, which leads to difficulty of objects identification. Meanwhile SAR images do not have good visualisation with true colour.

E. Try different threshold values for mapping flood water extent from the SAR intensity and coherence images [i.e. m*odify the value in the colour table*]. What are the best threshold values for the generation of water extent map from the SAR intensity and coherence images? [Please include water extent maps generated from the SAR intensity/coherence images to answer this question] [/6 marks]

Reasonable threshold values for SAR intensity image 1 and water extent map [/2 marks]
Reasonable threshold values for SAR intensity image 2 and water extent map [/2 marks]
Reasonable threshold values for SAR coherence image and water extent map [/2 marks]

In order to select a reasonable threshold values for SAR intensity images, first it need to open the properties of the image, and then find the histogram in the classification. Two peaks in the histogram can be found and choose the bottom between these two peaks as the first reasonable threshold value. The best threshold value is obtained by

the principle of symmetry. The best threshold value for CSK-intensity-20110319 is 55 and 185 (figure 8 and 9). Meanwhile, the best threshold values for CSK-intensity-20110320 are 67 and 200 (figure 10 and 11). The best threshold value for CSK-coherence-20110319-20110320 is 0.23 but do not need to select the second threshold value (figure 12 and 13).

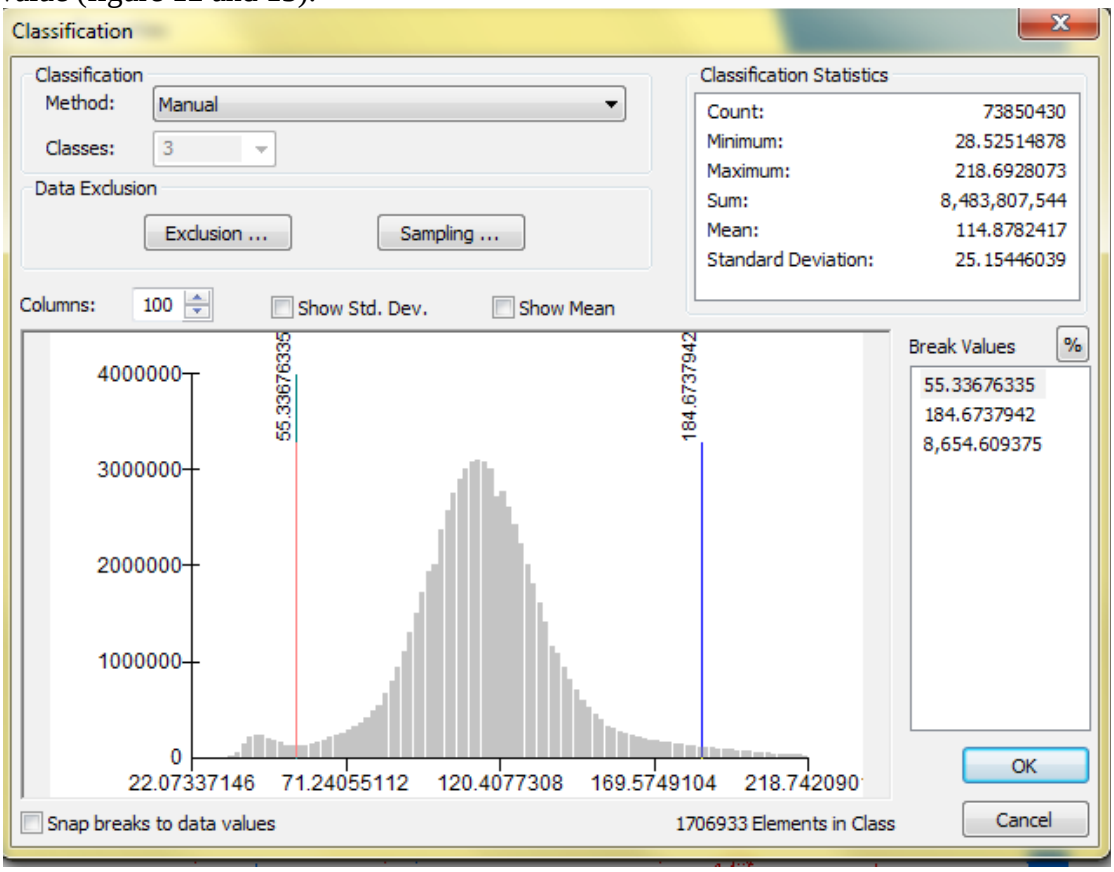


Figure 8 the histogram of CSK-intensity-20110319

Figure 9 CSK-intensity-20110319 images with flood extent images opened in Google

Earth

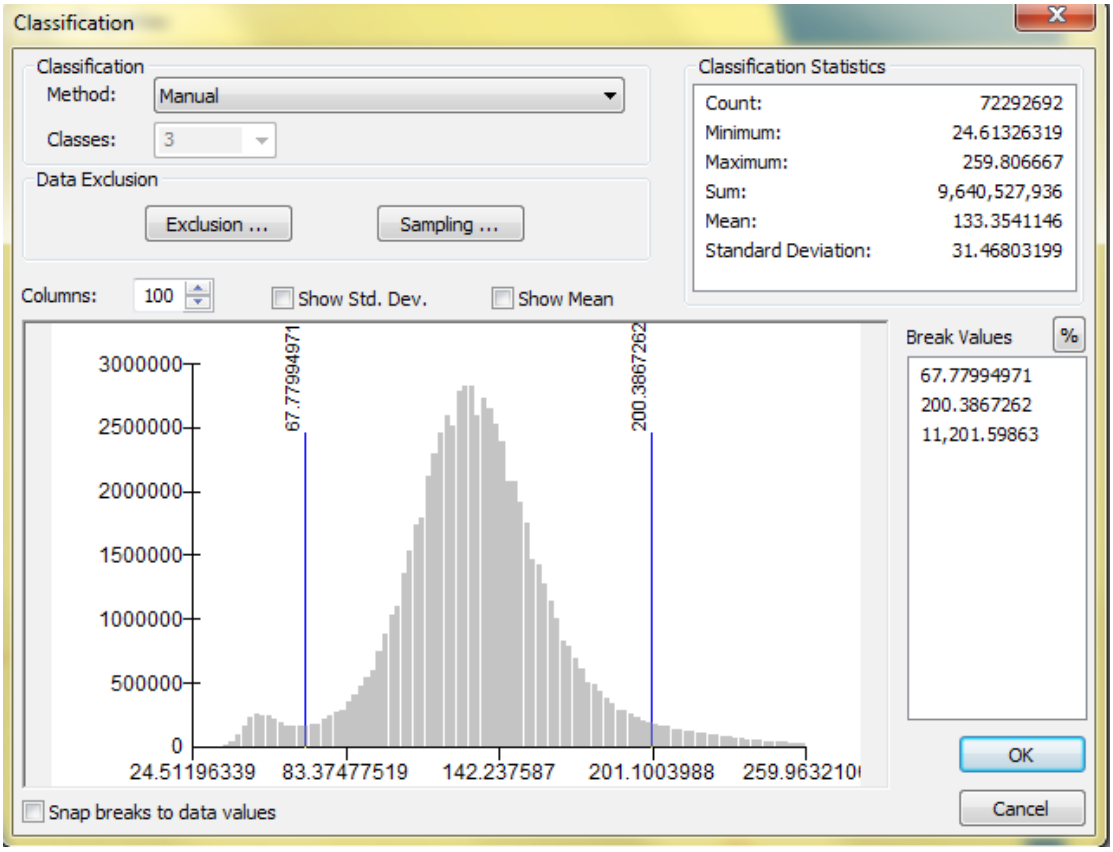


Figure 10 the histogram of CSK-intensity-20110320

Figure 11 CSK-intensity-20110319 images with flood extent images opened in Google Earth

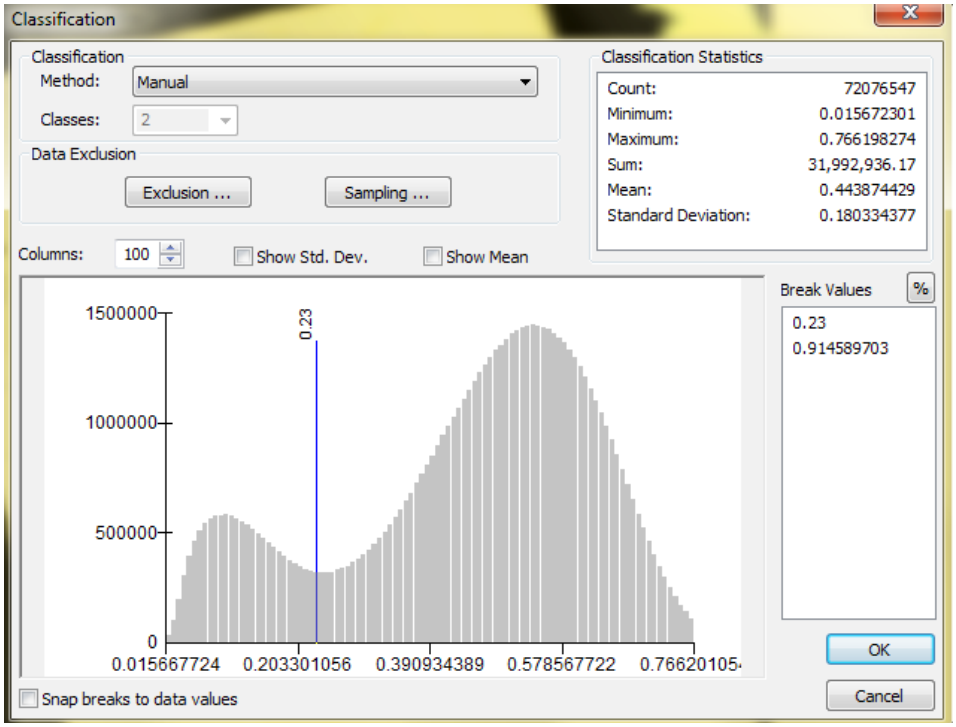


Figure 12 the histogram of CSK-coherence-20110319-20110320

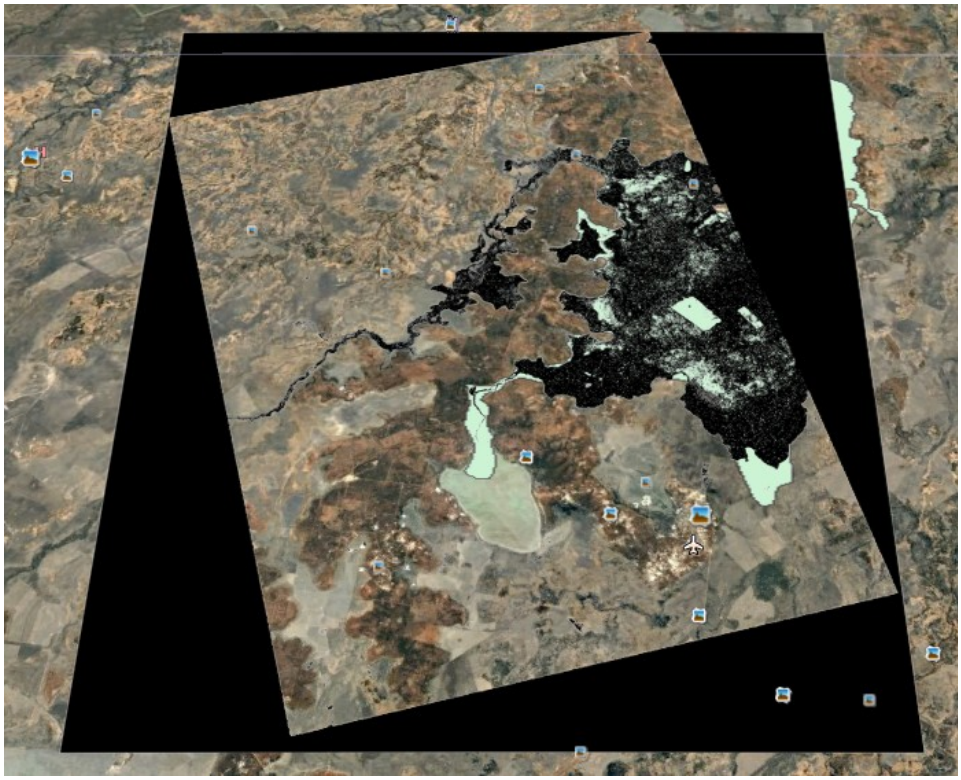


Figure 13 CSK-coherence-20110319-20110320 images with flood extent images opened in Google Earth

G. Compare the SAR images, the optical images and the flood extent map from SES (State Emergency Service). Discuss the pros and cons of these methods with illustrations. [/6 marks]

Discuss about the accessibility [/1 marks]

Discuss about the cost [/1 marks]
Discuss about the spatial extent [/1 marks]
Discuss about the temporal extent [/1 marks]
Discuss about the resolution [/1 marks]
Discuss about the accuracy [/1 marks]

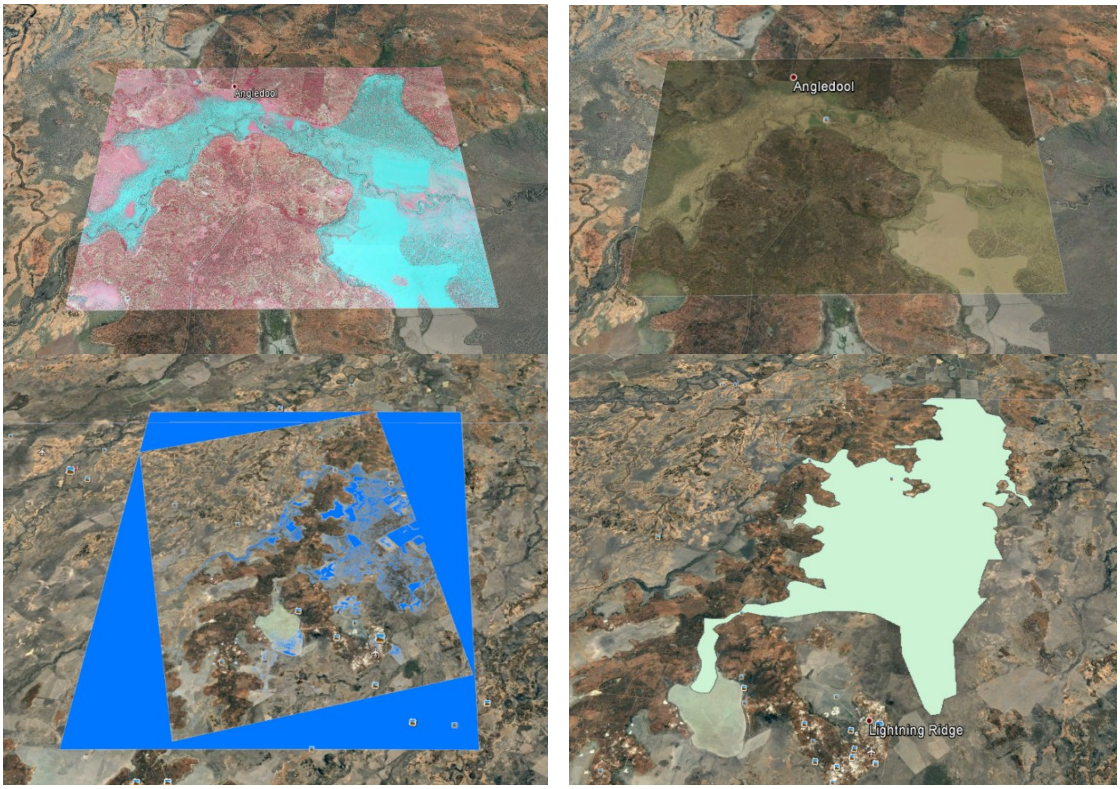


Figure 14. Flood map in Google Earth

Figure 14 shows 3 different flooding maps in google earth. Top left is infrared image; top right is true colour image; bottom left is the SRA intensity image and bottom right, is the SES image.

Discuss about the accessibility [/1 marks]

SAR system is not limited by weather but highly rely on an applicable satellite revisiting time. However, optical images are highly influenced by weather because it is produced by airborne. SES can do both air observation and land observation, which is a fast mapping method.

Discuss about the cost [/1 marks]

Compared with the SAR system, the operating costs on the aerial platform and SES are high.

Discuss about the spatial extent [/1 marks]

SAR images are the largest spatial extent in this three method as the high monitoring level. Optical images system may be in the second, which depends on the aerial platform. However, due to the SES is depended on both air platform and land-based techniques, the spatial extent is critical, so, it hard to decide which one is larger. In this case, SES seems larger than the optical images. Detail is shown on figure 15.

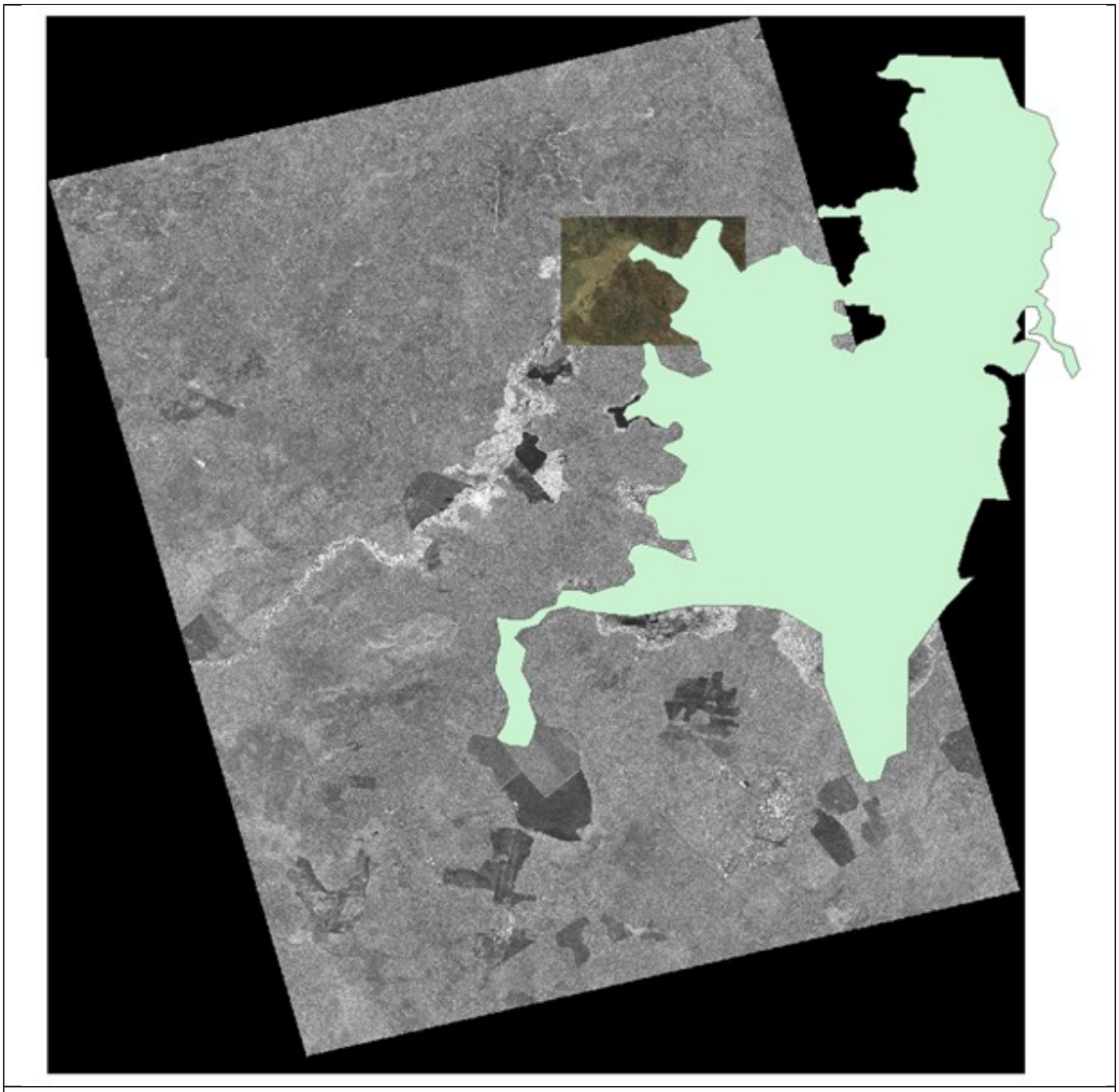


Figure 15 the special extent of SAR, SES and optical images

Discuss about the temporal extent [/1 marks]

The temporal extent of optical images and the SES may be the same if weather allowed.

Discuss about the resolution [/1 marks]

optical images are the best in resolution, and second is SAR images. SES has lowest resolution because it is only able to show flood boundaries but not to show the non-flood area.

Discuss about the accuracy [/1 marks]

The SAR images show the flood extents accurately. The optical images show the floodwater extent correctly but cannot show the flood underneath vegetation. The SES only shows the flood boundaries but cannot show the non-flooded areas in between.

Reference

Nico, G., Pappalepore, M., Pasquariello, G., Refice, A., & Samarelli, S. (2000).

Comparison of SAR amplitude vs. coherence flood detection methods - a GIS application. *International Journal of Remote Sensing*, *21*(8), 1619–1631. https://doi.org/10.1080/014311600209931

End of lab exercise.