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Multi-scale Visualization of Remote Sensing and Topographic Data of the Amazon Rain Forest

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Multi-scale Visualization of Remote Sensing and Topographic Data of the Amazon Rain Forest for Environmental Monitoring of the Petroleum Industry.

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Figure 1) Location map of the study area.

ABSTRACT

PETROBRAS (the Brazilian national oil company) built a pipeline to transport crude oil from the Urucu River region to a terminal in the vicinities of Coari, a city located in the right margin of the Solimoes River. The oil is then shipped by tankers to another terminal in Manaus, capital city of the Amazonas state. At the city of Coari, changes in water level between dry and wet seasons reach up to 14 meters. This strong seasonal character of the Amazonian climate gives rise to four distinct scenarios in the annual hydrological cycle: low water, high water, receding water, and rising water. These scenarios constitute the main reference for the definition of oil spill response planning in the region, since flooded forests and flooded vegetation are the most sensitive fluvial environments to oil spills. This study focuses on improving information about oil spill environmental sensitivity in Western Amazon by using 3D visualization techniques to help the analysis and interpretation of remote sensing and digital topographic data, as follows: (a) 1995 low flood and 1996 high flood JERS-1 SAR mosaics, band LHH, 100m pixel; (b) 2000 low flood and 2001 high flood RADARSAT-1 W1 images, band CHH, 30m pixel; (c) 2002 high flood airborne SAR images from the SIVAM project (System for Surveillance of the Amazon), band LHH, 3m pixel and band XHH, 6m pixel; (d) GTOPO30 digital elevation model, 30' resolution; (e) Digital elevation model derived from topographic information acquired during seismic surveys, 25m resolution; (f) panoramic views obtained from low altitude helicopter flights.

The methodology applied includes image processing, cartographic conversion and generation of value-added product using 3D visualization. A semivariogram textural classification was applied to the SAR images in order to identify areas of flooded forest and flooded vegetation. The digital elevation models were color shaded to highlight subtle topographic features. Both datasets were then converted to the same cartographic projection and inserted into the Fledermaus 3D visualization environment. 3D visualization proved to be an important aid in understanding the spatial distribution pattern of the environmentally sensitive vegetation cover. The dynamics of the hydrological cycle was depicted in a basin-wide scale, revealing new geomorphic information relevant to assess the environmental risk of oil spills. Results demonstrate that pipelines constitute an environmentally saver option for oil transportation in the region when compared to fluvial tanker routes.

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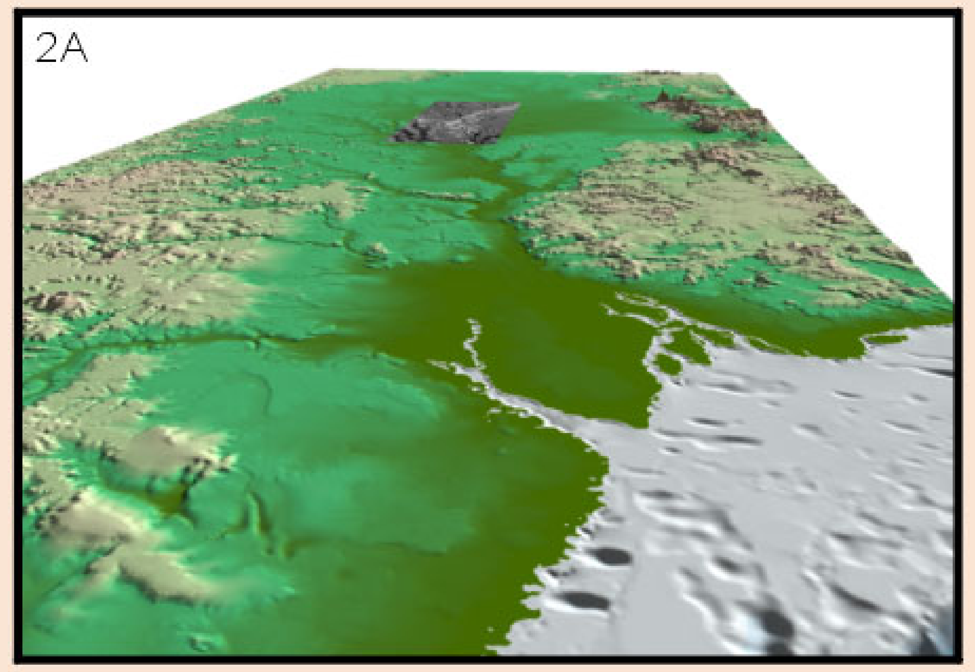


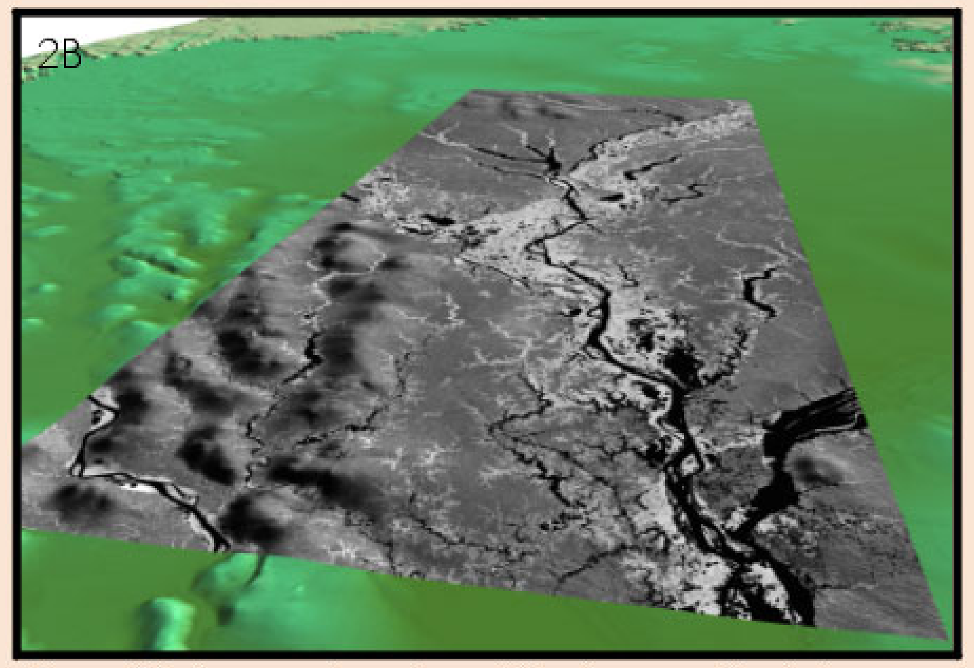


Figure 2) Perspective view of the Amazon Basin from east to west.
A) Regional view including the Continental Shelf and Slope. The mouth of the Amazon River is situated in the background. The area potentially affected by the oil production and transport is highlighted in the background.
B) Detail of the potentially affected area.

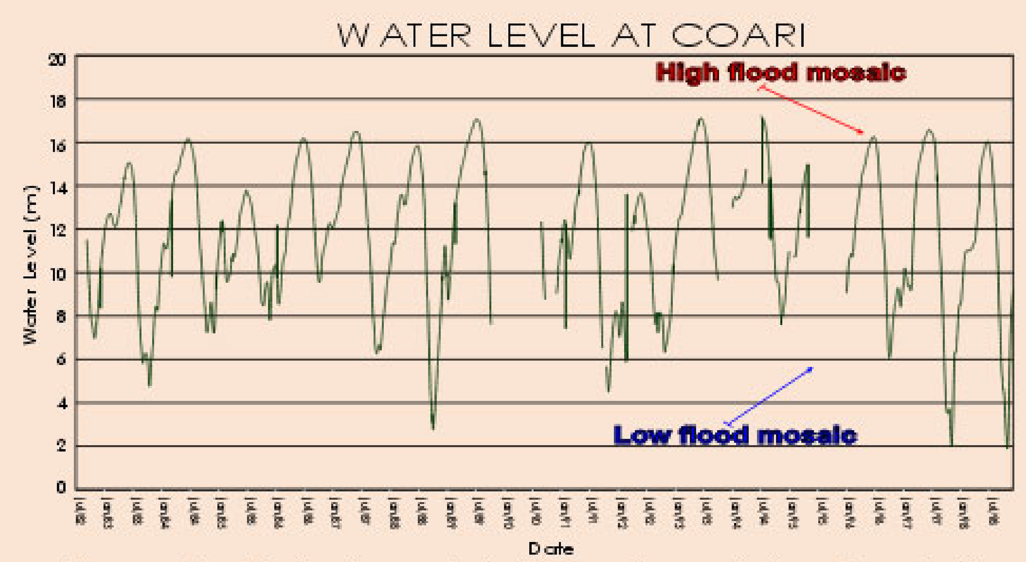


Figure 3) Daily stage height readings at the Coari city.

ESI RANKING	HABITATS
1	Manmade structures
2	Exposed rocky platform or outcrop
3	Rapid / waterfall
4	Scarp / cliff
5	Exposed sand / gravel beach or bank
6	Sheltered sand / gravel beach or bank
7	Exposed mud beach or bank
8	Sheltered mud beach or bank
9	Confluence of rivers and lakes
10a	Aquatic vegetation bank (macrophytes)
10b	Flooded vegetation (igapós, várzea, chavascal, campo)

Table 1) Oil spill environment sensitivity index for fluvial regions of the Amazon region. Source: Araújo et al (2002).

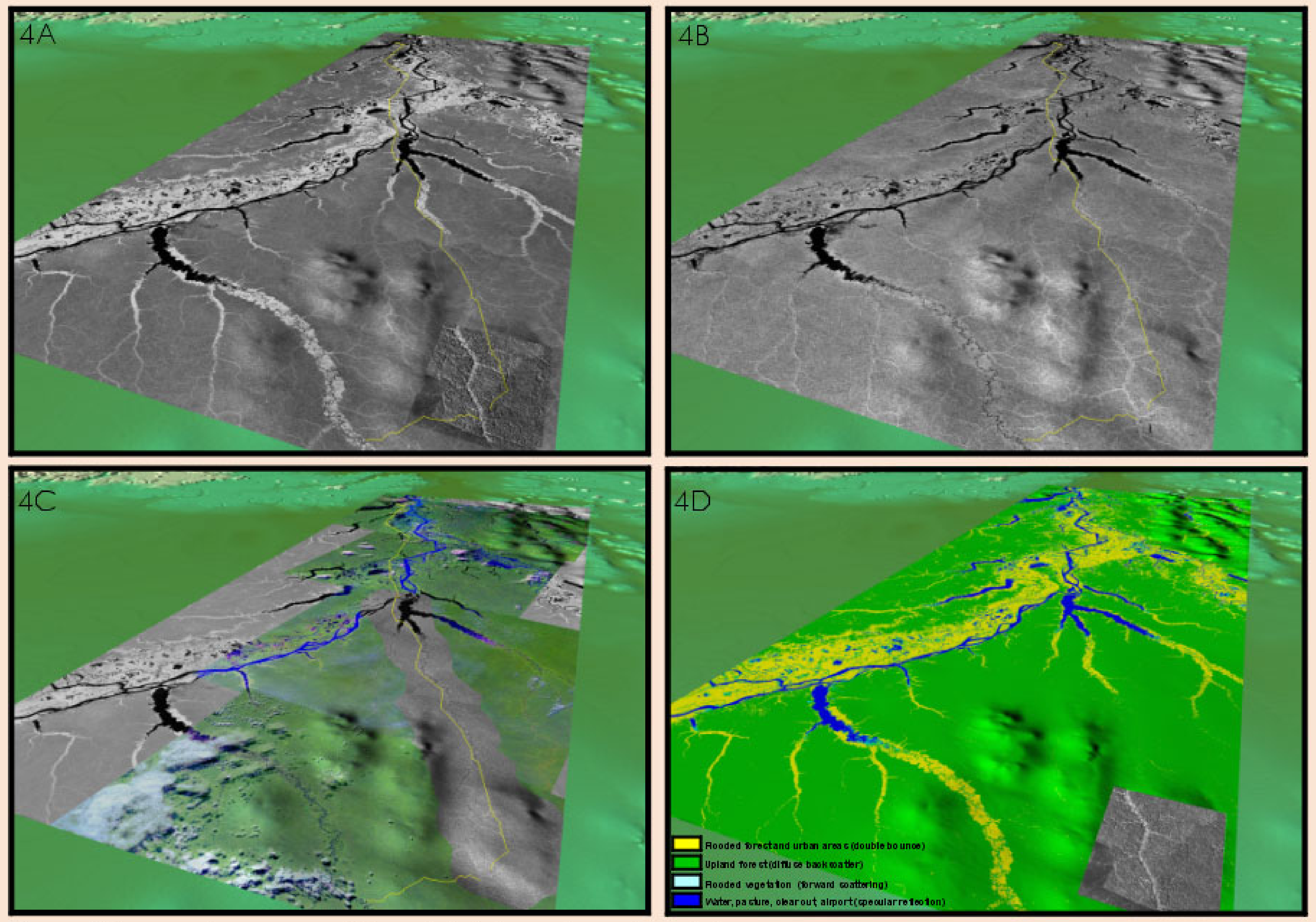


Figure 4) Comparison among different orbital remote sensing data.
A) 1996 high flood JERS-1 SAR mosaic, LHH, 100m pixel, acquired for the Global Rain Forest Mapping Project, draped over the GTOPO 30 digital elevation model. Flooded alluvial plains are represented by bright areas of strong radar backscatter (double bounce effect).
B) 1995 low flood JERS-1 SAR mosaic, LHH, 100m pixel. Notice the lack of double bounce effect during the low water season.
C) Landsat-5 TM 341 (RGB) mosaic and 2001 high flood RADARSAT-1 W1 mosaic, CHH, 30m pixel, of the Urucu river flood plain.. The spectral signature in the Landsat image is strongly dominated by the response of the uppermost canopy level. Data acquisition is limited by cloud cover in the western portion of the mosaic. The backscatter in the Radarsat image is dominated by the upper levels of the canopy, due to the limited penetration of the C band when compared to the L band.
D) Semivariogram textural classification applied to the high flood JERS-1 SAR mosaic.

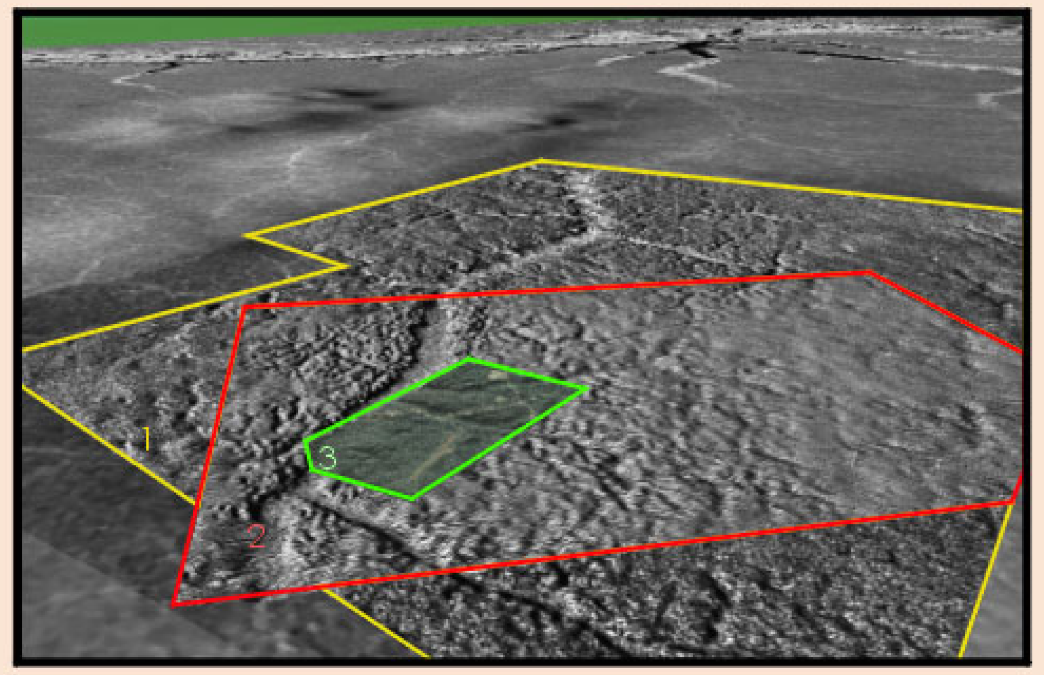
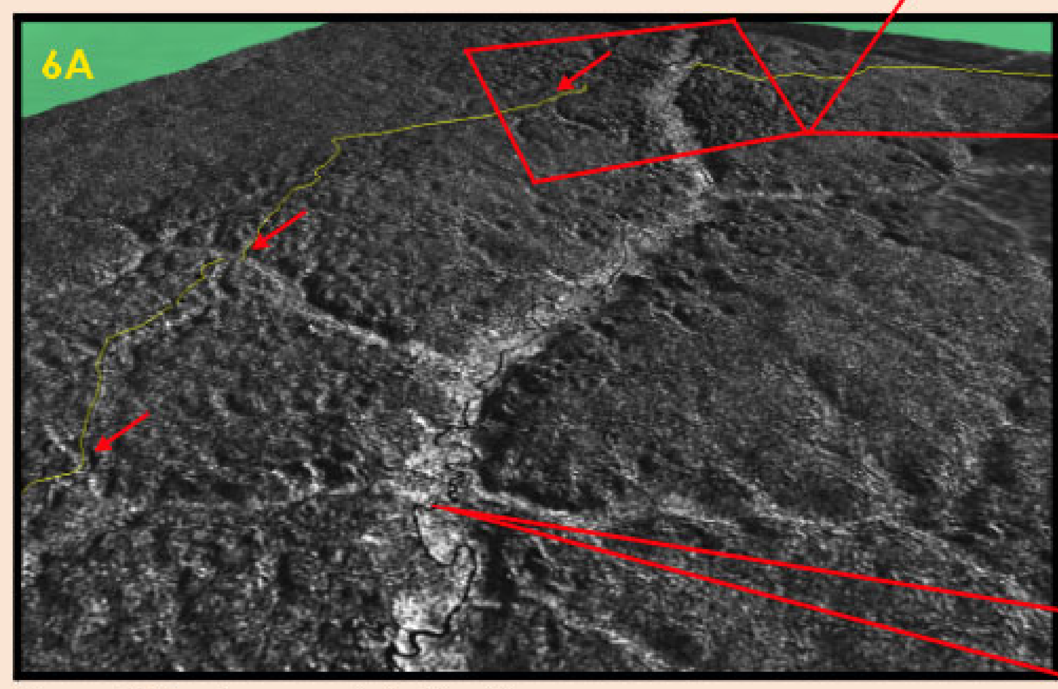
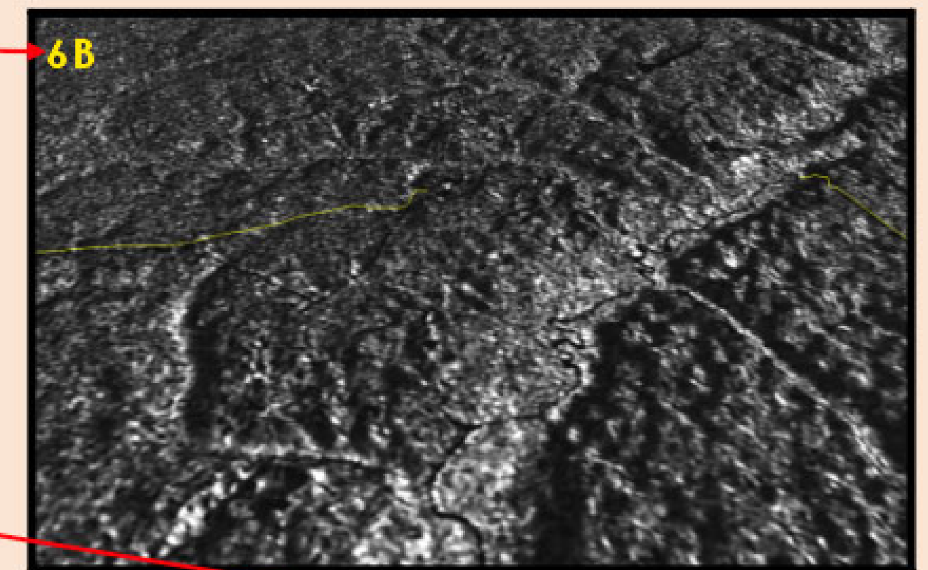


Figure 5) Urucu river oil and gas production area. Topographic data of the terrain were acquired during seismic surveys. In the Amazon forest, digital elevation models are normally generated using standard photogrammetry, therefore reconstructing the surface of the top of the canopy, and not the terrain. The following remote sensing data are draped over detailed ground topography: 1) 1996 high flood JERS-1 SAR mosaic, 30m pixel 2) 2002 high flood SIVAM airborne SAR images, LHH, 3m pixel. 3) 2000 Ikonos image, true color, 1m pixel.





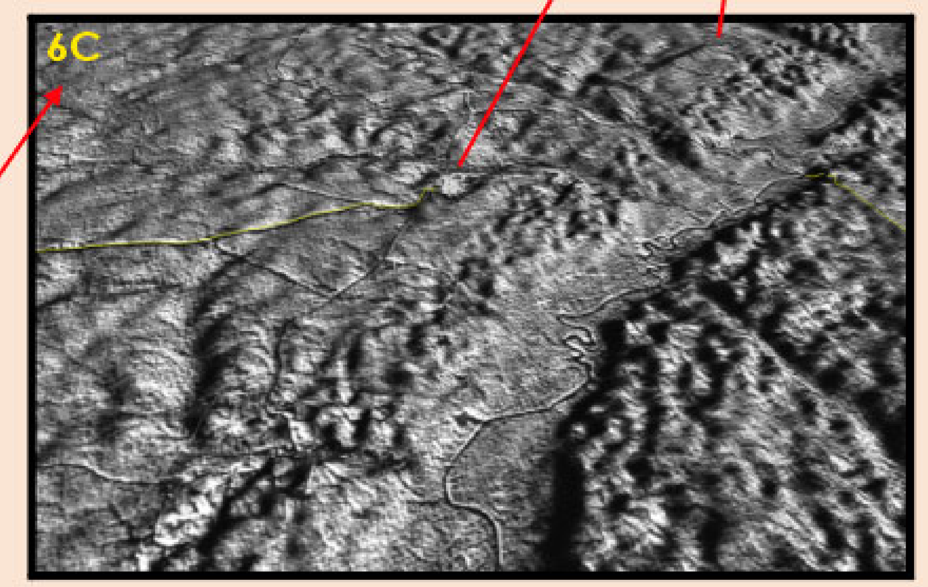


Figure 6) Environmental high-risk areas.
A) High flood JERS-1 SAR showing the flood plain with high backscatter, and the oil pipeline highlighted in yellow. Notice the tributaries of the right margin of the Urucu river (red arrows).
B) Detail of a high-risk area (red box in figure 6A) close to the Arara processing plant and the Urucu airport.
C) High-resolution SIVAM airborne SAR image covering the same area. The double bounce effect is not well expressed in the airborne SAR image due to the large incidence angles (40° in the near-range).

Figure 7) Ikonos image draped over detailed topography.
A) Urucu airport.
B) Arara processing plant.

Figure 8) Ground truth.
A) Aerial view of Urucu River and the Urucu-Coari pipeline.
B) Photograph of flooded vegetation.