

>>> Nouragues nature reserve/Guyana Amazonian park

Using remote sensing to combat illegal gold washing

Innovative methods overcome the difficulties of accessing certain regions

Managing Guyana's forest massif, and especially the protected areas, calls for the use of innovative methods to overcome difficult access and the sheer immensity of the areas. Faced with the pressure of illegal gold washing, which is seriously affecting two major French protected species, the government has set up a rapid-response surveillance system. Remote sensing (which uses high-resolution satellite data) is proving to be an effective solution.

The project was developed against an increasingly alarming backdrop on the Guyana plateau. Steadily rising international gold prices have accelerated the development of illegal gold washing: since the 1990s, the area devoted to mining activities has increased more than fivefold. Moreover, because gold washing is alluvial, its impact is located along water courses and many natural habitats are directly affected, not to mention mercury pollution of the food chain and increased concentrations of substances in suspension.

Government agencies, and in particular the ONF (national forest agency) in charge of the State's forests and the regional environment department, raised the alert and developed a tool to monitor this activity. This alert system was brought into use in 2005 at two particularly hard-hit pilot sites (see map opposite). The first of these is the Nouragues national nature reserve¹ (the north-east of the reserve, a zone with high gold-bearing potential, has recently been struck by a spate of small-scale illegal mining operations). The second is the Sikini river, in the north-east of the Guyana Amazonian park². For some years now, this sector has seen a dramatic increase in illegal gold mining, which has now spread over vast areas. Because the Brazilian border is so close, the «garimpeiros», or gold-washers, are especially active here.

The growth of mining operations. To begin with, remote sensing was used to establish an annual tally of the sectors affected and quantify the areas deforested between 1990 and 2000. The methodology was developed by Cirad (the French agricultural research centre working for international development), using Landsat satellite images (30 m resolution), in

cooperation with the ONF, which has a geographical information system applied to the surveillance of mining activity. The procedure was subsequently improved by using data from the Spot-5 satellite³ (2.5 m and 10 m resolution) to track changes in the mining operations.

The current system can be used to characterise two phenomena that are directly observable by the satellite.

- Deforestation operations. Because these are clearly visible, they make it possible to pinpoint the sectors being worked. The spectral signature of deforestation operations, on the other hand, is not discriminatory (strong nebulosity, cloud fringes and misty clouds can yield the same response when processed automatically). These

objects are therefore analysed when the soil is exposed, by directly digitising their contours and using photo interpretation.

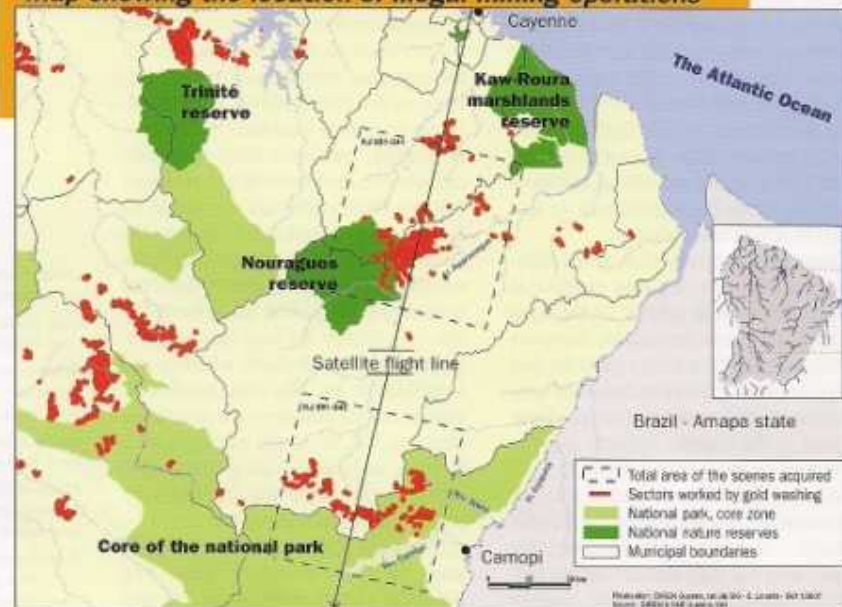
- Water turbidity and pollution. The type of gold mining practised in Guyana – small-scale washing of the soil – releases large quantities of substances in suspension into Guyana's water courses. Turbid waters have a very distinctive spectral signature that is far more discriminatory, so automatic processing is quite possible. The phenomenon of water turbidity and pollution encompasses two distinct cases:

- For small operations carried out under cover of the forest – as in the Nouragues reserve – pollution is observed only downstream, on stretches that are at least ten metres wide. The actual mining operations are situated upstream of the signal detected.

- In zones that are worked over extensive areas, the «baranques» (settling pits holding the water used to wash the soil) are large enough to be observed by the satellite and can be distinguished in the images.



Map showing the location of illegal mining operations



The processing applied to analyse turbidity can be broken down into six phases:

1. Calibration of the Spot images. Differences in sunlight and camera angles are corrected.

2. Calculation of three indices: water (NDWI), vegetation (NDVI) and turbidity/cloud (NDCI). These indices are based on the four channels provided by Spot-5 (namely the medium infrared, which is sensitive to leaves' water content, the near infrared, which is sensitive to leaf structure, the red channel, which is sensitive to leaves' absorption of chlorophyll, and the green channel, which is sensitive to water content in the atmosphere).

3. Application of processing algorithms. These are filters which, for each of the four channels and three indices, retain only the pixels that match the spectral characteristics of the search object.

4. Signal recombination. Only the pixels common to the filters developed from the seven selection criteria (the three indices and four channels) are retained.

5. Validation and manual cleaning of the artefacts¹.

6. Vectorisation of the result for integration into the ONF's geographical information system.

An effective system. On two separate occasions, helicopter reconnaissance missions conducted by the ONF or the police have validated the results. Today the processing system is operational and a system of alert can be introduced. The twofold benefit of this approach lies, firstly, in the quality of the processing systems developed by Cirad and the ONF, and secondly, in the regularity and rapidity of satellite coverage. The Spot-5 satellite has proved particularly responsive in this respect: over a full year of monitoring, it captured scenes every eleven days, on average. Additionally, the presence of the SEAS station in Guyana means that data is received almost instantaneously (and free of charge, thanks to an agreement between the government and the satellite operator, Spot image).

The automatic detection and alert tool can now pinpoint each active gold mining site. This gives government agencies fast, reliable information on gold washing and helps them optimise their mission as an environmental watchdog. The police forces can then undertake operations to destroy the mining operations. In addition, because the Spot-5 data has better resolution, the land-use assessment of the areas being mined has also been improved.

Outlook. This remote sensing tool will be incorporated into the Observatory of mining activity in Guyana (an inter-departmental data-centralisation platform under the responsibility of the regional prefecture and whose operational use has been entrusted to the ONF). Under these arrangements, the alert system will be extended to the whole of the area concerned by mining, which is equivalent to one third of Guyana. The tools may also

be extrapolated to monitor other phenomena related to deforestation or water course pollution, such as assessing the turbidity of water, as part of new research programmes. ■

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1. France's largest terrestrial reserve, covering 100 000 hectares of tropical forest and managed by the ONF since 2008.

2. National park created in 2007.

3. This data is acquired directly in Cayenne from the new SEAS receiver station (for satellite-assisted surveillance of the Amazonian environment) in Guyana.

4. Technical anomalies stemming from automatic processing.

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TYPICAL
ILLEGAL GOLD
WASHING
OPERATION.

AERIAL VIEW
OF A GOLD
WASHING
OPERATION.

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