Workshop
Evidence from Space

ISPL ESA Study
The Use of Satellite-Derived Information as Evidence

UCL ESRC Project
on the Use of Satellite Information in Australia

Wilkins Old Refectory, UCL, Gower Street, London WC1E 6BT
Tuesday 5 October 2010

Workshop I Information Package

WORKSHOP PROGRAMME

8.15 ***Sign in –*** *Coffee and tea will be provided*

8.45 ***Welcome and Introduction*** *– Overview of Project*

Workshop Chairman: Mark Doherty

ISPL Director:	*Sa'id Mosteshar*	Key issues in use of satellite-derived information. Evaluation of previous research. New research under the Study.

8.55 ***Methodology*** *– Rules of Evidence*

Moderator: *Luc Govaert*

Presenter:	*Kevin Madders*	Relevant principles of evidence, practical issues including authentication, audit trail, processing reliability and security

9.25 ***Systems Capabilities*** *– Satellite and Data Processing Features*

Moderator: Gordon Campbell

Presenters:	*David Morten*	Satellite capabilities for land motion measurement
	Robert Gurney	Calibration and system reliability
	Marc Journel	Satellite capabilities for oil spill detection and polluter identification

10.15 **Coffee**

10.30 ***Cases using EO Information*** - *Space and Aerial Information*

Moderator: Tanja Masson-Zwaan

Presenter:	*Alessandro Ferretti*	Cases, including Rovigo
	Simon Kay	Agricultural Subsidy Claims, Verification, Fraud and Expert Evidence
	Egbert Jongsma	Cases prosecuted

11.15 ***Jurisdictional Treatment*** *– Case Reports and Regulatory Experience – Comparative Perspectives*

Moderator: *Kai-Uwe Schrogl*

Presenter:	*Sa'id Mosteshar*	UK and US
	Kevin Madders	Belgium, The Netherlands
	Lucien Rapp	France
	Johanna Symmons	Germany
	Maureen Williams	International law

12.30 **Buffet Lunch** *in the Wilkins North Cloisters*

13.30 ***UCL ESRC Project*** *- Use of satellite Information in Australia and Lessons Learned*

Moderator: *Richard Macrory*

Presenter: *Ray Purdy* Use of satellite derived information, perception and impact

14.30 **Case Study I** - *Land subsidence*

Moderator: *Luc Govaert*

Presenters: *Sa'id Mosteshar* and *Alessandro Ferretti*

15.30 **Tea**

15.45 ***Case Study II*** *– Oil Spill*

Moderator: *Gordon Campbell*

Presenter: *Kevin Madders* and *Marc Journel*

16.45 ***Questions Raised*** *– Issues Identified, Areas for Further Study, Actions and Conclusions*

Moderator: *Sa'id Mosteshar*

Panelists: *Gordon Campbell, Luc Govaert, Robert Gurney, Tanja Masson-Zwaan, Ray Purdy, Kai-Uwe Schrogl, Maureen Williams*

17.15 ***Closing report and concluding remarks*** *by the ESA Project Managers and Institute Director*

Moderators and Presenters:

Gordon Campbell	Directorate of EO Programmes, Project Manager, ESA ESRIN
Mark Doherty	Head of Exploitation Division, ESA ESRIN
Alessandro Ferretti	Chief Executive Officer, TRE
Luc Govaert	Project Manager, ESA ESRIN
Professor Robert Gurney	Director, Environmental Systems Science Centre, Reading University
Egbert Jongsma	Audit Manager, Netherlands Court of Audit
Marc Journel	Satellite Based Monitoring Services, EMSA
Dr Simon Kay	Head of Unit, Joint Research Centre, MARS
Professor Richard Macrory	Director, Centre for Law and the Environment, UCL
Professor Kevin Madders	Systemics Network International; KCL; ISPL Faculty
Tanja Masson-Zwaan	President IISL; Deputy Director, IIASL Leiden; ISPL Faculty
David Morten	Managing Director, Fugro NPA
Professor Sa'id Mosteshar	Director, ISPL
Ray Purdy	Deputy Director, Centre for Law and the Environment, UCL; ISPL Faculty
Professor Lucien Rapp	Toulouse University; ISPL Faculty
Professor Kai-Uwe Schrogl	Director ESPI; ISPL Faculty
Johanna Symmons	ISPL Researcher
Professor Maureen Williams	University of Buenos Aires/Conicet; Chair, Space Law Committee, ILA

Rapporteurs

Susan Barham	Partner, Barlow Lyde & Gilbert
Klaus Becher	Space Policy Consultant, ISPL Faculty
Dr Hervé Borrion	Science Manager, Jill Dando Institute of Crime Science, UCL
Dr Andrew Brearley	Debris Policy Specialist
Richard Graham	Senior Associate, Bird & Bird; ISPL Faculty
David Halbert	Technical Project Manager, Infoterra
Dr Stephen Hobbs	Director, Cranfield Space Research Centre, Cranfield University
Mikael Kamp Sørensen	Director, GRAS
Yeliz Korkmaz	Researcher, Leiden University
Professor Jan-Peter Muller	Image Understanding & Remote Sensing, Space & Climate Physics, UCL
Matxalen Sánchez Aranzamendi	Resident Fellow, ESPI
Neil F Stevens	General Counsel, Atrium; ISPL Faculty
Johanna Symmons	International Lawyer; ISPL Researcher
Professor Geoffrey Wadge	Chairman, Monserrat Science Committee; NERC-ESSC
Ilaria Zilioli	Contracts Officer, ESA; ISPL Faculty

PROJECT SUMMARY

1. USE OF SATELLITE-DERIVED EO INFORMATION

Satellite-derived EO information is widely used to detect and to monitor a range of activities. Many relate to environmental conditions. EO services have developed to better meet these needs and are deployed in observation of emissions, oil pollution, deforestation, land movement, use of agricultural land, geological and other changes over time and many other conditions and activities.

Satellite EO information is not limited to imagery, but spans a wide range of data, not all capable of visual representation. For example, InSAR (Interferometric Synthetic Aperture Radar) systems use reflected radar signals to make high precision measurements of differences in the levels of land surface, able to detect movements of less than one centimetre. The radar data is not necessarily visually represented.

The advantages of EO information in the context of administrative and judicial proceedings include:

1. Providing a potential source of geographic evidence allowing for a more flexible and robust response to geographical questions;

2. Improved quality and accuracy of information about temporal and spatial relationships;

3. Cost savings in gathering evidence;

4. Improved chances of prevailing in litigation; and

5. Improved implementation and enforcement of legal standards.

As EO satellite systems grow in sophistication and as their sensor resolutions improve, so does the utility of EO information as evidence.

2. OBJECTIVES

The ESA-ISPL Study explores the conditions necessary for satellite-derived EO information to be used as evidence in judicial and administrative proceedings in different jurisdictions. It has three objectives:

1. To inform the legal community about the potential uses of satellite EO information as evidence;

2. To explore the technical capabilities of EO satellite systems to meet legal needs; and

3. To identify legal and technical areas requiring further development or changes.

The Project Workshops are an important part of achieving these objectives.

3. METHOD

To inform the legal community while identifying the issues that need to be addressed, workshops will be held to engage technical experts concerned with the production of the information and lawyers and administrators who will use it in court and before tribunals. The first Workshop of the Project will cover:

1. Presentation of legal issues, covering decisions and findings in different jurisdictions;

2. Description of systems' technical capabilities and shortcomings; and

3. Discussion of the two Case Studies on Land Subsidence and Oil Pollution.

Presentations will cover the legal and technical features. There will be clarifying questions and discussion on the issues raised, with full participation by the invited guests. These participants will be asked to challenge the arguments presented in the Case Studies. They will explore the issues, exposing weaknesses in the law, and in the collection and processing of the EO information.

4. OUTCOME

The Study will arrive at an assessment of:

a) How satellite Earth observation tools relate to judicial and administrative procedures now; and

b) How they could do so in the future.

The Study Team will formulate proposals for any changes to the rules and procedures that are identified. More importantly, it will recommend actions needed to make satellite EO information more readily admissible as evidence.

Evidential Issues

1. Nature of Evidence

Evidence is the information that proves a fact. In a legal context, satellite-derived information is used for one or more purposes:

1. To monitor an activity – detection, e.g. environmental changes;
2. To verify a state of affairs – confirmation; e.g. compliance with a Treaty;
3. To establish a fact – proof; e.g. a fraudulent CAP claim.

It is used in different legal contexts:

1. International; e.g. Boundary disputes and territorial claims;
2. Regional; e.g. European Common Agricultural Policy;
3. National; e.g. Hurricane Katrina insurance claims.

2. Requirements

From a legal perspective evidence must be *admissible* and *probative* of the fact at issue. The manner and standard of proof required differ according to the legal context within which evidence is offered. Distinction is also made between *public*, *civil* and *criminal* law. Jurisdictional differences are highlighted in another paper.

3. Reliability

To be admitted, evidence must be reliable. The court must be satisfied that it is what it purports to be. Aspects of reliability are:

1. Authenticity – for instance, that an image is of the building at issue;
2. Accuracy of the data, for instance proof that a machine has been properly calibrated;
3. The chain of custody to that data – who handles it through the process to show that the source and the end product can be linked; and
4. The people involved, and the applications, the business processes and procedures applied to it. Digital data is particularly sensitive because of the ease of alteration.

To illustrate reliability and authentication of data in relation to the legal process, *In re Vee Vinhnee, debtor, American Express Travel Related Services Company Inc. v. Vee Vinhnee* (2005) the court excluded AmEx's own corporate records for lack of sufficient authentication.

4. STANDARD OF PROOF

Once admitted, evidence is judged on whether it establishes the fact at issue with a level of certainty. This level is lower in civil than in criminal cases. The former is judged 'on a balance of probability', and the latter 'beyond a reasonable doubt'. Standards in public (administrative) proceedings are less strict than these. The International Court of Justice applies a less rigidly defined standard.

Some standards exist for the authentication process. However, these are not harmonized or universally applied. Courts rely on expert witnesses to prove authenticity and to interpret the resulting information.

There are other factors that may make the evidence inadmissible, such as privacy laws and search and seizure rules.

5. NATURE OF SATELLITE-DERIVED EVIDENCE

Satellite-derived information is scientific and technical evidence. Two important evidential aspects are its digital nature, making changes difficult to detect, and the need to process it to create intelligible information. It is the processed information that is offered as evidence.

As a consequence, it may be regarded as “hearsay”. In some jurisdictions hearsay is admissible subject to specific conditions.

6. GROUND TRUTH REQUIREMENTS

Technical aspects such as resolution or inadequacy of information may limit the usefulness of satellite-derived information to a monitoring or detection function. It may be of sufficient quality only to provide corroborative evidence. This would raise the need for 'ground truth' evidence from the relevant location. In some cases there are specific legal requirements for ground truth verification.

Resolution is rapidly improving, but information may still be considered inadequate in relation to the fact to be proved. For example, cannabis is not always distinguishable from certain other crops. Oil spill is another case where there may need to be identification of specific chemical composition related to the vessel or its cargo, or other supporting information, offered in evidence.

7. EXPERT WITNESSES

In most cases satellite-derived information requires expert interpretation and validation. The normal rules for admission of expert witness testimony will apply.

JURISDICTIONAL ISSUES *

INTRODUCTION

Different standards will be applied in testing whether evidence may be admitted, depending on the jurisdiction in which the proceeding takes place. A distinction to be made is between common law and civil law systems. Broadly speaking, civil law jurisdictions use an inquisitorial system, where the judge has wide discretion to admit or reject evidence. Common law jurisdictions generally rely on an adversarial system to present and challenge evidence, under strictly defined rules of admissibility.

ADMISSIBILITY OF EVIDENCE IN THE US AND UK

The US and the UK are common law systems, and comprise more than one jurisdiction. We refer here to the laws of England and Wales ("English" law) and to US Federal law.

Both jurisdictions have shown willingness to embrace new technologies and have a reasonably permissive approach to evidence. There have been a number of cases in both jurisdictions where satellite-derived information has been admitted as evidence. However, it will be necessary to prove reliability and accuracy of the information before there is routine use of such information as evidence in judicial and administrative proceedings.

The Federal and State courts in the United States frequently admit and rely on satellite-derived information. However, there is no major authority directly dealing with admissibility of such evidence. One area of concern is often the determination of time and date on which the information was gathered.

US standards for admissibility of scientific evidence were set in the *Daubert v Merrell Dow Pharmaceuticals* ruling of the Supreme Court in 1993. It established tests that include falsifiability, known error rates and peer review. Most States use the *Daubert* ruling, which provides the following guidelines:

a. Whether the methodology has been peer reviewed;
b. Whether the methodology can be, and has been, tested;
c. What are the error metrics associated with the methodology; and
d. Whether the reasoning or methodology underlying the testimony is scientifically valid, and whether that reasoning or methodology can properly be applied to the facts in issue.

In English law, very similar tests are applied. Admissibility depends on the reliability of the evidence adduced and its probative value. It is therefore necessary to show that the evidence relates to the fact being proved, has been in safe and traceable custody without interference or inappropriate manipulation. Computer-generated evidence is now admitted and used in criminal and civil proceedings.

The potential use of satellite-derived information is recognised in legislation implementing European Commission Regulations.

ADMISSIBILITY OF EVIDENCE IN AUSTRALIA

There are a number of legislative provisions that specifically permit the admission of satellite-derived information in certain circumstances. There have also been several cases in which such information has been admitted, although there is no line of decisions that thoroughly address the conditions for admission of satellite-derived information.

In *John Nominees Pty Ltd v Dixon* (2003), the Court upheld the admission of satellite images, likening them to photographs. The Court referred to the processing of digital data according to a defined methodology, calibrated to a standard, so that they can be compared over time. The Court also referred to the need for verification or authentication of sources of satellite evidence.

ADMISSIBILITY OF EVIDENCE IN BELGIUM

The Code of Criminal Procedure summarises types of evidence in Belgium. This list is illustrative and the judge is free to accept other evidence. There is no national legislation in Belgium that prohibits the use of satellite-derived evidence in legal proceedings. Any evidence can be used to prove an illegal act.

Corroborative "ground truth," or contextual, evidence may be required to support satellite evidence. For example, Synthetic Aperture Radar (SAR) can provide information on the presence of oil at sea, but may be confused with algal growths, wind front areas and internal waves. They need to be corroborated by vessels in the neighbourhood or by surveillance airplanes.

SAR imagery combined with AIS position data could identify a polluter. However, there are no cases in Belgium where satellite data were used as evidence for illegal oil discharge by vessels at sea.

ADMISSIBILITY OF EVIDENCE IN FRANCE

To be offered as evidence, information must be contestable (Audi alteram partem) by each party; satisfy rules of admissibility (rules on proof); reliable (probative force); and must not breach privacy (European Convention on Human Rights).

To be admitted, evidence usually has to be written. Electronic records have the same probative force as traditional written forms, and must be authenticated. Requirements include:

1. Duly identified person: secure digital signature, certification by a third party;

2. Guarantee of the integrity of the record (creation and conservation).

ADMISSIBILITY OF EVIDENCE IN GERMANY

There are no specific provisions on the admissibility of satellite imagery in German law. Therefore general admissibility rules apply.

If scientific evidence carries a high margin of error, courts will often require additional supporting evidence. This requirement could apply to certain applications of satellite earth observation, such as oil spill identification, where a large number of false positives are reported.

A court may also require proof of correct functioning and state of the art processing from expert witnesses. Case law related to speed camera evidence shows that standardised devices and methods could relieve the court from having to rely on expert opinion on a regular basis. Expert opinion is still needed where a case shows specific difficulty or where inaccuracy is likely.

As electronically stored digital data can be altered without leaving any evidential trace, a court may require further evidence to authenticate the satellite-derived information, proving it comes from the original data and has not been altered.

Few reported cases mention the use of satellite data as evidence. Most are administrative law cases. Of these, the majority used the satellite-derived data to prove the location of an object or land boundaries. A second use of satellite images is assessment of character or vegetation of an area in the context of agricultural subsidies and planning law. In most cases the data was supported by additional evidence.

Satellite-derived evidence may form part of *expert opinion* or *witness testimony*, when their use is not separately recorded in the case report.

Civil Law

In civil claims, most satellite-derived information is likely to be submitted as evidence for *judicial inspection*. The court can order that one or more experts be consulted, generally appointed by the court.

Satellite images cannot be deemed *documents*, which must embody human thoughts. They therefore lack probative value of documents and are subject to the general principle of free evaluation of evidence.

Administrative Law

The inquisitorial principle applied means that the court has to investigate all facts by suitable means of evidence. However, the principle of proportionality, which is fundamental to German public law, could prevent administrative authorities from using satellite images as evidence if the cost of providing satellite imagery is significantly higher than other means of evidence supporting the same facts.

Criminal Law

The Court has discretion in assessing the probative value of evidence. Given the serious effects of its decisions, the court investigates the facts of a criminal case more thoroughly than in administrative cases, setting a higher standard of admissibility.

ADMISSIBILITY OF EVIDENCE IN THE NETHERLANDS

In the Netherlands, satellite-derived EO information, or similar material such as aerial optical pictures, are generally used and admissible in administrative and criminal proceedings, if probative.

There is however no abundance of cases, and in some instances the matter of the admissibility as such was not at stake. There is no clear precedent on the admissibility of satellite-derived information.

The Position of the Expert Witness

As in other jurisdictions, the Court relies on expert testimony and interpretation to determine the correct meaning of the evidence provided. In administrative cases it decides whether the administrative authority observed its own rules, but does not judge the quality of the expert's working methods.

Administrative Cases

Farm Subsidy

In farm subsidy cases the Court has stated that remote sensing is commonly accepted practice in the European Union. Satellite imagery has been admitted in each case. The Court has held that satellite-derived images are similar to x-rays, aerial or ultrasound pictures or DNA information.

Water Management

Satellite-derived information is frequently used in the preparation of 'environmental impact reports' to obtain permits for new water projects. An example is the planned expansion of the Tweede Maasvlakte in the Port of Rotterdam, where the Rotterdam Port Authority requires a permit from the Directorate General for Public Works and Water Management.

In preparing the Environmental Impact Report, satellite-derived EO images were extensively used by the Port Authority to verify compliance with the legal framework.

Criminal Cases

Satellite-derived Earth observation information has not been used in criminal proceedings, although aerial optical pictures have been used.

ADMISSIBILITY OF EVIDENCE IN INTERNATIONAL LAW

International law primarily covers disputes between countries. Jurisdiction rests with the International Court of Justice ("ICJ") and the International Court of Human Rights ("ICHR"), along with arbitration tribunals.

Satellite-derived information, more particularly satellite images, have been used in a number of cases before the ICJ. These include nation-to-nation boundary and maritime delimitation disputes. However, the ICJ tends to admit any evidence that the Court considers may be helpful.

RESTRICTIONS TO ADMISSION OF EVIDENCE

Hearsay

UK and US

In the UK, the rule against hearsay in civil proceedings was largely abolished in 1995, and in criminal proceedings in 2003. There were exceptions to the rule for business records and official documents, and to the extent that the common law rules still apply, some remain.

The US hearsay rule is not very different from that in English law, tending to permit rather than exclude hearsay evidence that is reliable and probative. Under Federal Rules of Evidence, the rule against hearsay remains, with exceptions that extend to some machine-generated information. Satellite-derived earth observation information may be admissible under the exception applicable to business records or to public records. Such records need to be authenticated by complying with collection and custody rules, or to meet the requirements for self-certification.

Constitutional and Other Legal Barriers: UK and US

In a number of cases remotely-sensed information, aerial or satellite-derived, have been challenged on the basis of the Fourth Amendment to the US Constitution prohibiting search without warrant. Other issues have been *privacy* and *trade secrets*. The decisions have gone both ways, depending on the facts of each case. One relevant factor often is whether there is a *reasonable* expectation of privacy.

English law also puts limits on the introduction of evidence on similar grounds. National security is also a limiting factor in both jurisdictions.

Constitutional and Other Legal Barriers: Australia

Evidence may be excluded on grounds of privacy, intellectual property rights, trade secrets, monitoring rules and national security.

Constitutional and Other Legal Barriers: Belgium

In Belgium the 1992 Privacy Act protects privacy of personal data. The independent Belgian Privacy Commission is the authority ensuring the protection of privacy during the processing of personal data.

The Privacy Commission, considering whether satellite images could be used to prosecute building offences, confirmed that satellite images are regulated by the 1992 Act. It ruled that Satellite images can be seen as information and the properties on the pictures can be identified. Data subject to the Act can only be used for the specified stated purpose. Second, it is prohibited to save the data longer then is necessary.

There are enough similarities between satellite images of building offences and those of illegal oil discharges at sea that it is likely that the Commission will give the same advice on satellite images of illegal oil discharges. This means that the gathering of satellite images of illegal oil discharges must follow the requirements of the Act.

Pro-active investigation, particularly of offences not yet committed, is only allowed for serious crimes and when there is prior written permission by the public prosecutor, which can only be given when an investigation takes place. This is not always possible with an illegal oil discharge at sea.

Constitutional and Other Legal Barriers: France

There are similar Technical and Legal Difficulties relating to Satellite Images, as apply in other jurisdictions, including possibility of mistake, reliability and accuracy of the equipment, pre-processing and processing manipulation and the need for expert interpretation. Evidence may also be excluded in the future on grounds of the right to privacy and personal data protection.

Constitutional and Other Legal Barriers: Germany

Satellite evidence could violate the right to informational self-determination contained in the German Basic Law. There are Constitutional Court decisions concerning the publication of satellite imagery and the use of automated speed camera evidence. However, this right to is not unlimited. Data is only protected if it is related to a person. The 2007 Satellite Data Security Act places restrictions on the generation and dissemination of "high-grade" satellite data. Other data protection laws regulate the dissemination of private data and access to geographical information.

In addition, if there is a prevalent public interest the right may be limited.

STANDARD OF PROOF

Standard of Proof: UK and US

There are a number of English cases in which satellite-derived information has been offered and accepted in evidence. However, this evidence is corroborative rather than primary evidence on which the decisions are based.

Standard of Proof: Belgium

There are no cases in Belgium where satellite data were used as evidence of illegal oil discharge by vessels at sea.

Standard of Proof: France

Electronic records can be considered more reliable than traditional written forms.

International Law:

The ICJ and has not articulated a standard of proof to which the evidence must conform, and approaches each case on its merits.

In the 1986 frontier dispute between Burkina Faso and Mali, the ICJ considered that maps alone could not constitute binding documents or territorial title by themselves, however accurate and technically valuable, without the parties' acceptance.

* This digest is based on reports by Yeliz Korkmaz, Professor Kevin Madders, Professor Frank Maes, Penny Martin, Tanja Masson-Zwaan, Sarah Moens, Professor Sa'id Mosteshar, Professor Lucien Rapp, David Sagar and Johanna Symmons.

CALIBRATION AND RELIABILITY *

Environmental Science and its applications are evolving rapidly as we move from description of the environment to prediction, with error bars. There are three technological catalysts of the change, advanced computation, global observations, particularly from satellites, and the computational and mathematical facilities to confront the models with the observations. Making predictions changes how the observations are used, but the methods used allow the role of observations to be quantified, along with the errors in the resultant predictions.

Some of the best-known examples of prediction are in weather forecasting and forecasting the consequences of extreme weather, such as flooding. These problems are usually classed as initial value problems, where a set of observations are used to set the initial state of a model, which is then allowed to evolve. Models are now often run many times, with slightly different initial conditions, to get estimates of the error growth in the model over time. Predictions are also assessed by comparing the predictions with observations after the event. A more recent method is data assimilation, where observations are fed into the predictive model as they are received, so that the initial and predicted fields are blended products of observations and models. These methods allow the worth of observations to be assessed, in addition to the predictions themselves. Methods of data assimilation, originally developed in control engineering, are now very common in atmospheric science, becoming more common in ocean sciences, and increasingly into the science at the land surface, including flood modelling and prediction.

A second type of prediction is so-called boundary-value prediction. Here, boundary conditions are observed, or fixed, and a model is allowed to evolve. Climate prediction is an example of this type. The model gives the general statistical description of a change with a change in boundary conditions, such as a change in greenhouse gas concentrations, but prediction of this type cannot describe the exact evolution in time of processes. This can lead to controversy, and it is important to understand the uncertainties involved in this type of prediction. Observations are again important, to set boundary conditions, and to allow comparisons between the general statistical performance of models and the general statistical description derived from the observations.

Both types of prediction have been evolving fast with better computing power, so that more processes can be modelled explicitly, and not approximated because they cannot be modelled. However, there is still controversy, both in the modelling approximations which remain and in the observations, as many of these are derived, particularly from Earth observation, and can themselves contain artefacts. The International Space Innovation Centre at Harwell, newly initiated by the UK Government, will allow the UK to investigate these observed field errors in more depth and breadth than was previously possible in the UK.

The use of observations will be illustrated by some examples. First, a key driver for weather and climate models is a good knowledge of the radiation that drives the global atmosphere and ocean system. We can now also observe this. Detailed comparisons show that the two agree to 1 - 2%, except in areas such as the Sahara where there is a lot of dust which is not well modelled. Second, the errors of weather forecast models at forecasting severe storm tracks will be shown to illustrate the growth in forecast errors in time, and to show that some predicted quantities, such as storm tracks, are better predicted than their intensity and timing. The analysis also shows the effect of adding or removing different observation fields. Third, a comparison between observed and modelled Northern hemisphere snow fields shows that while the amounts of snow are similar, they are distributed quite differently in weather and climate models, both of which differ from observations. Finally, the ways observations are being used to improve flood models will be shown.

The uncertainties increase though these examples, while the economic impact also increases. How do we handle uncertainty where there are economic benefits and therefore potentially actionable advice? The evidence from space is consistent in time and in space, but needs interpretation that introduces error. How do we handle this evidence in the presence of error?

* Professor Robert Gurney

EXPERIENCE IN EUROPEAN CAP *

Agricultural Subsidy Claims, Checks, Irregularities and Expert Evidence

Abstract

Since 1992 when remote sensing controls were introduced in EU Common Agricultural Policy legislation ("CAP"), satellite images have proven each year to be an increasingly efficient tool for checking that agricultural subsidies are correctly paid. In 2009, 690,000 farm checks were performed throughout the EU (of the approximately 8m farms in the scheme); 61% were done using remotely sensed imagery, and around 70% is expected for 2010. Very High Resolution satellites or aerial orthophotos permit the check of the size fields, their cover type and in some case cover status, thus reducing the need of physical checks on farms and thereby contributing towards a more effective and efficient management of the CAP.

Introduction

EU Member States must ensure that direct payments to farmers – worth over €44B in 2010 - are implemented correctly, thereby preventing irregularities (over-claim, or double claims for the same fields), and potentially recover amounts that are unduly paid. Member States must also ensure that farmers meet certain standards – cross compliance with EU Directives – concerning public, animal and plant health, the environment and animal welfare, and keep their land in *good agricultural and environmental condition* ("GAEC"). Member States must have a system to ensure a unique identification of farm businesses, as well as all holding's fields (the so-called Land Parcel Identification System – "LPIS") and identify animals. Each year, CAP farms make an aid application using these systems. The check of the criteria to receive subsidies works on two levels: 100% administrative cross-checks on the information provided in these applications, and through checks carried out "on-the-spot" of at least 5% of total number of farmers claiming direct subsidies, in each Member State. Currently, more than 60% of on-the-spot checks are carried out with the help of satellite imagery.

The European Commission, through the Joint Research Centre ("JRC"), currently provides EU Member States with satellite images in 24 EU countries (i.e. all except Austria, Finland and Luxembourg) for a purchasing budget of around €6.5M/yr. In 2010, 255 zones – each of around 650km^2 - were covered with High Resolution images (ground sampling distance of 5 to 10m), and 316 zones with Very High Resolution ("VHR") images (ground sampling distance of < 1m). VHR imagery representing a European-wide area of nearly 200,000 km^2. The JRC also provides a range of technical support services to European Commission's Directorate General for Agriculture and Rural Development and to Member State Administrations, by developing common specifications, standard measurement and data management tools. It validates methods to reinforce the consistency of land parcel identification and measurement across the Union and in Candidate Countries, and develops methodologies to accurately determine land cover types and status, in particular using remotely sensed data.

Methodology

The conditions under which aid is granted are verified on a sample of applications using current year remote sensing imagery. In practice this means that the claimed area, and to a certain extent the land cover or use, of each of the claimed parcels from the *Control with Remote Sensing* ("CwRS") sample is checked. Some aspects of cross compliance – in particular GAEC – may also be checked using remote sensing imagery. Each agricultural parcel is categorized separately.

The photo-interpretation of agricultural parcels is normally carried out using at least one VHR image (aerial orthophoto or satellite ortho-image with a pixel size <1m) of the current year. The area of agricultural parcels, their land use or cover wherever necessary, and cross compliance issues are checked. In addition to the VHR image, multi-temporal high resolution ("HR") images may be used.

In the case where the diagnosis may not be completed by image interpretation procedures alone, field visits are carried out to collect supplementary information on land use, area declared and/or other issues not able to be determined via the satellite image. These field visits may be carried out on all claimed parcels, for instance when only one VHR image is used, or limited to doubtful parcels, sensitive crop groups (such as crop groups receiving high payments) or specific commitments, such as payments linked to multi-annual contracts by farms.

CWRS control zones and satellite images used

Remote sensing controls of area-based agricultural subsidies are carried out using a geographically clustered sample of farmers' applications. These clustered samples are called "control zones". The zones to be controlled are selected either randomly, or on the basis of risk analysis taking account of appropriate risk factors determined by the Member States.

For each zone to be covered by a VHR satellite image provided by the Commission, an "acquisition window" is defined by the Member State (usually a 6-8 week period). Over this window, acquisition attempts are allocated by the JRC to particular VHR multi-spectral sensors, which during this year's campaign have been Ikonos, Quickbird, GeoEye-1 and Worldview 2. In a few cases, VHR Panchromatic only sensors with a ground sampling distance lower than 1m (Worldview 1 and Eros B) have been used, in conjunction with lower resolution multispectral imagery on another platform.

Area (km^2) acquired under the CwRS programme per VHR sensor

VHR satellite sensor	2008	2009	2010
IKONOS	137.000	117.000	72.400
Quickbird	30.000	12.000	18.700
GeoEye-1	n/a	45.000	81.900
WorldView2 /WorldView1	n/a	n/a	25.600 / 400
Total	167.000	174.000	199.000

* Simon Kay and Csaba Wirnhardt

USE EXPERIENCE IN AUDIT CASES *

Audit of Indian Ocean Tsunami Aid in Aceh with Geo-information

Introduction

Supreme Audit Institutions ("SAIs") have a role in safeguarding the spending of public funds by providing assurance with their audit activities: they provide assurance on the financial statements of government and public entities. Auditing also has another important function besides assurance; it is a learning tool for management that provides an assessment of weaknesses and strengths in performance.

SAIs have a role in assessing whether governments and public entities are well prepared for natural disasters (disaster preparedness and risk mitigation). They also have a role when disasters happen and government and public entities are planning, coordinating, funding and implementing disaster-relief efforts.

When the Indian Ocean Tsunami happened in 2004, the 189 members of the international organisation of SAIs ("INTOSAI") realised that this disaster would also have an effect on the SAIs from affected and and donor countries. For SAIs of affected countries, such as Indonesia and Sri Lanka, it posed a huge challenge to audit the management of disaster-related aid. But also for SAIs from major donor countries the Tsunami-disaster posed a challenge: how could the SAIs provide assurance on public funds that are mixed with other public and private funds while those funds flow from one organisation to another and from one country to another? To be able to provide assurance, an audit trail is needed to provide insight and accountability into the movement of public funds from source to final destination.

In November 2005 the Governing Board of INTOSAI decided to create a Task Force on the Accountability for and Audit of Disaster-related Aid with the aim to reconstruct an audit trail for the Tsunami-related aid flows and to learn about how to improve transparency and accountability for these flows.

The flow of disaster-related aid is a geographical movement from source to destination. Furthermore, aid (e.g. funds for education) is intended to lead to a certain output (i.e. school building and training of teachers) and finally an outcome (i.e. the education) on a specific location. Geography, therefore, plays an important role in any audit trail, but is specifically important with regard to disasters.

The INTOSAI Task Force was charged with exploring the possibilities of using geo-information in auditing disaster-related aid in order to minimize waste, competition, fraud and corruption of the aid funds. The Task Force's research question was broad: how and under what conditions can the use of geoinformation in auditing help to ensure the regularity, efficiency and effectiveness of disaster-related aid?

This paper describes the methodology and results of the INTOSAI Task Force's study into the potential use of geo-information for auditing disaster-related aid.

Detection and mapping of new houses

To study the potential role of geo-information in audit of disaster-related aid, the Task Force focused on the reconstruction of houses in the Indonesian province of Aceh (Nanggroe Aceh Darussalam, "NAD"), the most affected area of the Tsunami-hit countries, nowhere over 150,000 houses were damaged or destroyed. The interest was not only if new houses were constructed, but also where, so it could be determined if houses were constructed at the correct location.

Looking at disaster prevention and mitigation, it is also of interest whether newly constructed or reconstructed houses were built in areas that are not prone to disaster. For example, if houses were built too close to the coastline, then the risk for destruction at a next Tsunami would be high and so would the risk of aid funds being wasted. After the 2004 Tsunami, the Government of Indonesia regulated that houses should be built at least two kilometres from the coastline (in some areas the Tsunami reached two kilometres inland), therefore reducing potential risk of destruction. Accurately mapping the location of the reconstructed houses in the province would provide a mechanism to assess compliance with this Governmental requirement. It would also provide the possibility to benchmark between implementing agencies: SAIs auditees are government agencies and private entities such as non-governmental organisations ("NGOs"). In this respect, situations such as the Indian Ocean Tsunami provided SAIs with the unique possibility of benchmarking government performance against that of private entities.

The basic idea behind the proposed method [see Figure 2] is to use two maps of the objects of interest: one at the start and one at the end of the audit period and to detect the changes by applying overlay-techniques (Bijker and Sanjaya 2008). Use of decision rules for change detection limits the result to provide only the changes of interest. These changes of interest can be sorted by administrative unit when combined with an administrative map and compared to the information supplied by the institution which is being audited. Field sampling assesses the accuracy of the change detection and provides further detail on the nature and origin of the changes and the objects under study. Depending upon the required spatial resolution (i.e. sufficient to accurately locate and measure the object of interest) the maps would usually be derived from satellite images or orthorectified aerial photographs ("orthophotos"). This generic approach could be applied for all spatial objects under audit, such as forests, houses, agricultural fields, and for environmental impact assessment.

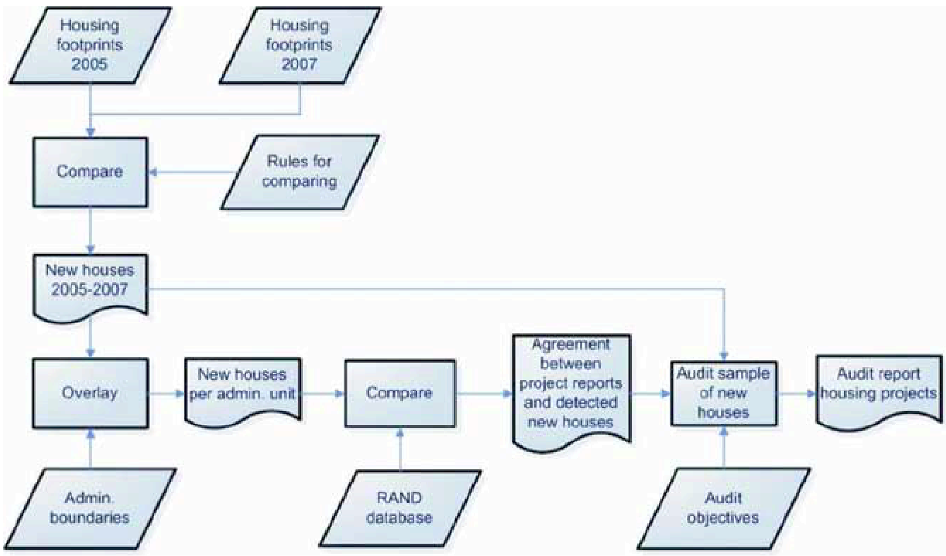

Figure 2: GIS based method for auditing housing projects

The method depends on data availability at the time of the audit. For the Aceh case study, high resolution (30cm) orthophotos, acquired in June 2005, provided by the Indonesian National Coordinating Agency for Surveys and Mapping (Bakosurtanal) via BRR's Spatial Information and Mapping Centre ("SIMCentre"), along with the panchromatic 1m KOMPSAT- 2 (Korea Multi-Purpose Satellite-2) images, donated by the Korean Aerospace Research Institute ("KARI"), acquired in May 2007 were available. Vector data (Topographic Line Map, at 1:10,000 scale) extracted from the 2005 high resolution orthophotos was also available.

Combining the 2005 map of building footprints detailing the start of the rehabilitation phase, with that of 2007 showing the current state at the time of case study, provides all the buildings constructed between clearing the Tsunami debris and the end of the reconstruction period. Overlaying the map of new houses with the map of administrative boundaries provides the number and locations of new houses per administrative unit. These numbers can be compared with the information on housing projects available through the Agency for Rehabilitation and Reconstruction of NAD and Nias ("BRR") Recovery Aceh Nias Database ("RAND") database and other project information. Lay-out plans of housing projects existed only as paper sketches.

Based on location and degree of completion, as detected by comparing the building footprint maps, the Indonesian SAI, Badan Pemeriksa Keuangan RI ("BPK") can take a stratified random or stratified systematic sample of these projects, for auditing according to its audit objective. Fraud is likely if there is a large discrepancy between the quantities of houses built according to the RAND database or project information, and the map of new houses. In such a case, the BPK field teams may want to take extra field samples to determine the reason for this discrepancy. Visualizing the spatial distribution of contractors and projects on maps shows the auditors whether there were likely to be any monopolies of building contractors in certain areas, and focus their audits accordingly. Using the map of new houses, the audit data of the houses in the sample can be extrapolated for the whole study area.

In the case of the housing audit conducted by the BPK, the results of the analysis of the KOMPSAT-2 imagery providing the housing footprints for 2007, were not ready before the field teams started their survey, so the method shown in Figure 2 was adapted [Bijker and Sanjaya 2008]. While the field teams of the BPK were conducting their survey, suitable remote sensing methods were developed to detect houses on the KOMPSAT-2 imagery and used to create the map of new houses for selected sites (Du 2008).

The field teams took copies of the 2005 orthophotos to the field and delineated the sites of the housing projects on these images. The project delineations of the field teams were digitized and combined with the map of new houses. In this way, thematic (audit) data of the housing projects could be related to the new houses mapped from the imagery.

<u>Check for compliance with risk regulation</u>

When the available Topographic Land Map and the housing data from the RAND were combined, it was possible to map all settlements within two kilometres of the coastline. A limited number of inspection sites were selected, where it was possible to collect field data including the use of a handheld Global Positioning System ("GPS") to ensure positional accuracy. To be able to provide a benchmark, inspection sites were selected from various implementing agencies. To ascertain if newly constructed houses complied with government regulations, it is a straightforward process to simply map the distance from the coast. Some of the houses were constructed within 300 metres of the coastline. Houses built by NGOs are located even closer to the coastline.

Lessons learned

From the housing audit in Aceh Indonesia, it is clear that many limitations exist concerning the availability of data. Data required for the audit do not exist or are not provided by the auditee. The combined use of GIS and remote sensing could help in resolving this problem. Data accuracy and methods to assess the accuracy of spatial (audit) data still require more attention. As with all data used by an audit institute, reliability of the data used in the audit is important for its credibility and the confidence of the general public.

GIS is a useful and cost-effective technology for the preparation and planning of an audit, and can be used to visualize where risk of fraud is highest and to limit the amount of data that has to be collected in the field, (INTOSAI Tsunami Task Force, 2008). Remote sensing can be used to acquire spatial data, which is not yet available as maps, also allowing independent verification of certain objects and processes. In the field, having the data at hand in a mobile GIS and storing the data immediately in a digital form speeds up the survey and reduces the risk of errors, and also possibly the number of samples needed. For presentation of the results of the audit, maps are very effective for summarizing information and for showing spatial relations.

The housing audit in Aceh has made INTOSAI more aware of the crucial role geography plays in compliance and performance of the public entities it audits. Using geo-information helps SAIs to understand and tackle the complexity of policy implementation in situations such as disaster areas. It also leads to more efficient and effective audits, thus enhancing the contribution of SAIs to good governance. The Netherlands Court of Audit launched a knowledge centre on GIS and Audit to further develop GIS as an audit tool: www.courtofaudit.nl/english/gisandaudit.

* Wietske Bijker (Faculty of Geo-information Science and Earth Observation (ITC), University of Twente), Egbert Jongsma, Richard A Kidd (Geospatial Consultant, Cairo, Egypt)

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LAND SUBSIDENCE CASE STUDY

THE HYPOTHETICAL SCENARIO

Property A is the site of the office and a state of the art storage warehouse owned by Four Level Ltd. (“FL”), a private defence contractor. Property B is adjacent, and is the site of the office and warehouse of Glass Suppliers Inc. (“GS”), a plate-glass manufacturing company.

In January 2009, in order to increase the capacity of its storage facility by installing a basement, FL started excavating an area close to the boundary with Property B. The excavation and subsequent building works continued until March 2009.

In April 2009, GS alleges that it observed cracks in the concrete foundations of its warehouse due to land subsidence. By September 2009, GS alleges that the degree of land movement caused damage to its stock and serious structural damage to its warehouse. GS alleges that the excavation by FL on Property A caused the land movement and claims damages.

There is satellite data available that covers both Property A and Property B. The data was processed through Permanent (or Persistent) Scatter Technique (“PSInSAR”) with a number of reference points, by a company that produces satellite images and data for commercial and legal applications. [The presentation will cover these technical details along with the details of the subsidence and the technique used to measure the relevant land movement.] Two specialists were involved in the technical analysis of the data and its interpretation.

Aerial photographs were also available. There are two sets, one dated December 2008 and another dated October 2009. These were produced by the government as part of its annual land mapping survey and made available to the public.

The ground evidence available was limited. Surveys were conducted in March 2008 for initial construction of the warehouse on Property A. No ground inspection has been carried out on Property B because FL did not consent to have surveyors on its property. However there are surveys conducted by an expert engaged by GS on Property B, who also observed Property A from Property B in October 2009.

Both the aerial and land surveys support the satellite derived information.

THE CLAIM

This case study will be presented as a civil claim by GS for damages. The Presenters are acting as Counsel for the claimant. Workshop participants will take the roles of Counsel for FL and adjudicators in the matter. Participants are also welcome to assist the claimant’s Counsel.

OIL SPILL CASE STUDY

HYPOTHETICAL SCENARIO

Despite protests by shipping and environmental interests, the port of Haven in Country A in January doubled its berthing, to manage demand.

Company MakeProfit, registered in Country B, owns the container vessel *Dark Sea*, registered in Country C. *Dark Sea* is old and poorly maintained. According to one of the crew, Nga Duc, the ship's master, Captain Salt, said he had pointed this out to MakeProfit's CEO, Shirley Doller, who had told Salt to "make do". Salt recounted that she had also instructed him to keep berthing costs "at the level they were before". The only way Salt can do this is to spend less time in port. This leaves little opportunity to evacuate properly the fuel oil waste and engine lubricant residues ("slops") that accumulate in larger than normal quantities on the vessel because of its condition.

Unusual atmospheric conditions arose in February and continued into March, when *Dark Sea* set out for Haven from Capetown. The conditions, caused by volcanic ash, left coastal surveillance aircraft grounded. Knowing that aircraft were the chief means of detecting discharges, Captain Salt apparently decided to evacuate slops directly into the sea en route to Haven. It seems this was done at night on 21 March 20 kilometres off the coast of Country E, in waters where ships frequently wait before proceeding on to Haven so as to reduce their time at berth. It is common knowledge that some ships use the waiting time to flush their tanks in this area of the sea, which lies outside Country E's territorial waters but within its declared Exclusive Economic Zone ("EEZ"). This area is regularly monitored with SAR images.

Salt then made for Haven at 14:00 on 22 March, leaving behind a patchy slick extending for 2 kilometres within the EEZ. The slick went on to beach in Countries E, F and A. Coastal fishermen from these countries are prevented from fishing in the affected area for a period of two weeks, so losing revenue.

OTHER RELEVANT FACTS

SAR and optical images from two different satellite systems are available for the period before, during and after this incident, as well as AIS data. The *Dark Sea* had left the area before any surface vessel could the affected area to investigate.

Country C disputes Country E's EEZ. Countries A and E are EU Member States. A is a civil law jurisdiction with an inquisitorial tradition, while E is a common law jurisdiction with an adversarial tradition.

THE BRIEF

The maritime surveillance authority, state prosecutor of Country E, and FishHelp (the association representing fishermen's interests of countries E, F and A) have asked you to advise on their course of action, on the basis of the evidence available. The brief for the consultation identifies the following issues:

- Surveillance means normally available and the practical value of the evidence in the circumstances

- Providers of satellite evidence and the scope, accuracy and reliability of their data, especially AIS and the two systems, SAR and optical
- Sample collection techniques for the slops and experience in similar circumstances
- Evidential law – admissibility and weight of the types of evidence concerned in relation to criminal and civil proceedings
- Authorities to be involved that are responsible for surveillance and verification under legislation based on MARPOL and European regional conventions on sea pollution
- Tribunals with jurisdiction
- Initiation of proceedings and locus standi
- Applicable substantive and procedural law

NOTES:

Port of Haven in Country A: Civil Law, EU Member, Eur
MakeProfit (owns Dark Sea) registered in Country B, Eur
Dark Sea registered in Country C: not party to MARPOL
Discharge in EEZ of Country E: Common Law, EU Member
Slick lands in A (MARPOL & Eur)
E (MARPOL)
F (MARPOL & Eur)

"Eur" denotes party to European conventions on sea pollution

ESRC UCL STUDY
USE OF SATELLITE INFORMATION IN AUSTRALIA
AND LESSONS LEARNED *

Satellite Technologies and Smart Enforcement in Environmental Legal Systems

Background

Environmental regulators across the world face a number of common challenges, which hamper their quest for effective and efficient enforcement. One of the most obvious challenges is having good information reporting systems that can both report on environmental conditions and compliance with legislation.

There have, in the last decade, been a number of publications and significant evaluations in the EU, which have looked at the potential role of satellite monitoring to the legal and regulatory sectors. These include:

- European Commission, 'APERTURE Final Report' (European Commission, Report ENV4-CT97-437, 2000).
- NPA Group, 'Applications of Earth Observation to the Legal Sector' (British National Space Centre Sector Studies Programme Report, 2001).
- 'Satellite Monitoring as a Legal Compliance Tool in the Environmental Sector' (AHRC Study, University College London, 2008).

Some of you will be familiar with these earlier studies, but for those that are not, they mainly concentrated on issues of evidence from imagery in courts, as well as identifying potential future environmental applications for the use of satellite monitoring. Understanding in Europe, as to the wider regulatory implications of using satellites to monitor regulatory regimes has never really been analysed. There will be reluctance by regulators to move from one form of obtaining evidence, to accepting a new form of technological evidence unless more substantiation is given as to whether satellite monitoring works at an operational level.

The lack of any empirical evidence on experiences, operational effectiveness and cost has meant that there has been little regulatory uptake and a poor level of the use of satellite technologies in regulatory strategies, relative to its full potential, in part, because its effectiveness has not been adequately demonstrated to regulatory bodies.

The UCL Study on Satellite Monitoring in Australia

This presentation will discuss the results of a recent UCL study, 'Smart Enforcement in Environmental Legal Systems: A Socio-Legal Analysis of Regulatory Satellite Monitoring in Australia,' which was funded by the Economic and Social Research Council in 2009/2010.

This UCL study examined whether modern satellite technologies could provide a rigorous, legally reliable, and cost effective tool in inspection and compliance regimes in environmental regulatory systems. It considers these issues in the context of relevant experience and expertise in Australia,

where State Government's have been using satellite monitoring for a decade to monitor compliance with vegetation clearing/forestry legislation. This
is the only sustained comparative example internationally where satellites have already been used to monitor an environmental law this way.

As part of this study, I spent 4 months in Australia examining the overall design, implementation and operational effectiveness of satellite monitoring programmes in 3 Australian States: South Australia, Queensland, and New South Wales. A survey of regulated farming communities in these States was also undertaken. This was to investigate the awareness and attitudes of those in Australia regulated this way, as well as to consider the impact of satellite monitoring on actual compliance with vegetation clearing legislation.

Scope of this Presentation

This presentation will provide some background information about how the satellite imagery is used by State regulators and some context as to why it is perhaps being used in Australia before other countries. It will also consider the legislation itself and whether provision for satellite monitoring was expressly included and why.
A key factor for the future use of satellite technologies is whether they can be more cost effective than what we have under current monitoring and enforcement approaches. This talk considers what imagery is being used and why, how much the imagery costs, as well as the other associated costs, which could come with operating a regulatory satellite monitoring programme.

Governments wishing to adopt a monitoring programme, which uses satellite technologies, may be required to have a far more strategic regulatory approach than other conventional land-based approaches. This presentation will discuss regulatory structures when using imagery based products and the challenges of interdisciplinary working when using satellites in a regulatory setting.

To date satellite images have been admitted as evidence in court in relatively few cases around the world. There have been many court cases in Australia where satellite imagery has been used and as a country it has an unrivalled wealth of understanding in knowing the usefulness and limitations of using it as evidence. This presentation will discuss satellite imagery in the context of admissibility as evidence, including a discussion on programmes on standardisation and best practice, which could influence its probity. I will mention the outcome of some these cases, how the judiciary in Australia have reacted to its use in the courts, and what they believe is necessary to make it more effective as an evidential tool.

There has also been little research, thus far, as to whether mere knowledge of being monitored by satellite could 'press the right buttons' in terms of having higher deterrence effect and influencing compliance behaviour. This presentation discusses whether this method of monitoring appears to have had a strong influence on the compliance behaviour of those being monitored this way. It uses the data from the surveys to give an opinion of the extent that regulated communities think they are being monitored and whether satellite monitoring might have 'nudged' some of them into compliance.

It will also consider the acceptance of satellite monitoring by regulated communities in Australia. Use of satellite technologies in a monitoring and enforcement context has the potential to polarise opinions. Although we are in an era of more pervasive technology, some regulated entities might dislike it on account of its 'Big Brother' characteristics, even though comparable data is publicly accessible on GoogleEarth. Conversely, others might embrace it and prefer it to ground-based checks, especially if it increased the opportunity for even-handedness and equal treatment in monitoring and enforcement. There has been little research to date about the attitudes of those that are monitored this way. This presentation will examine the opinions of farmers in Australia from the surveys and consider ways forward that might lead to improved co-operation and making this form of monitoring more acceptable to those being regulated using such technologies.

Finally the presentation will consider the overall impact that satellite monitoring has had in practice, in terms of compliance with the native vegetation legislation. Evidence of effectiveness and any measurable differences will be extremely important to those regulatory bodies considering using such technologies. On a basic level I will discuss whether it has worked and improved things and to what extent?

* Ray Purdy