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for actions to integrate new developments (techniques / technologies / methods) into
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WORKSHOP REPORT

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PROJECT OUTLINE, WORKSHOP DESCRIPTION AND AIMS

1. USE OF SATELLITE-DERIVED EARTH OBSERVATION INFORMATION

Satellite-derived Earth Observation (EO) information is widely used to detect and to monitor a range of activities. Many uses 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 traditional imagery, but spans a wide range of data, not all of which are visual images. 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 itself an image, but is processed to produce a visual representation.

There are many advantages of EO information in the context of administrative and judicial proceedings. These include:

1. Providing a potential source of geographic evidence allowing for a 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 Study¹ explores the conditions necessary for satellite-derived EO information to be used as evidence in judicial and administrative proceedings in different jurisdictions. The Study 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 Workshop is an important part of achieving these objectives.

¹ This Project is a study conducted by the London Institute of Space Policy and Law, (ISPL), commissioned and funded by the European Space Agency, (ESA).

3. METHOD

To inform the legal community while identifying the issues that need to be addressed, the Workshop engaged technical experts concerned with the production of the information, and lawyers and administrators who use it in court and before tribunals.

The Workshop included:

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 covered the legal and technical features. Well-informed participants from the legal, administrative and technical communities discussed operational, processing and evidential aspects of satellite-derived EO information. They raised many clarifying questions and discussed the issues that arose. The arguments presented in the Case Studies were challenged, revealing strength and weaknesses in the law and in the collection and processing of the EO information.

4. OUTCOME

The Workshop threw light on:

- a) How satellite Earth observation tools are used in judicial and administrative procedures now; and
- b) Some aspects of how they could be better used in the future.

The Study Team gained insight into actions needed to make satellite EO information more readily admissible as evidence. These will be explored further in this Report and in the final phase of the Project.

BACKGROUND MATERIAL

1. INTRODUCTION

In preparation for the Workshop, summaries of matters to be covered during the Workshop and two case study scenarios were sent to participants. These and the programme provide a brief summary of the structure of the Workshop and of the issues covered.

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

1. Authenticity; e.g. that an image is a true representation of the building at issue;
2. Accuracy of the data; e.g. proof that a machine has been properly calibrated;
3. The chain of custody to that data; the chain of custody through processing, to show that the source and the end product can be linked; and
4. The people involved, the applications, the business processes and the procedures applied to it. Digital data is perceived by some to be particularly susceptible to alteration.

To illustrate reliability and authentication of data in relation to the legal process, the following case is useful: *In re Vee Vinhnee, debtor, American Express Travel Related*

Services Company Inc. v. Vee Vinhnee (2005). The court excluded corporate records of American Express 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. In addition, courts may need to rely on expert witnesses to prove authenticity and to interpret specialist technical and scientific 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. It has two important evidential aspects in this context: its digital nature, which might make changes difficult to detect; and the need to process it to create intelligible information. It is the processed information that is offered as evidence, not the original data.

As a consequence, satellite-derived information 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, a record of an on-site observation of events. In some cases there are specific legal requirements for ground truth verification.

Resolution is rapidly improving, but the detail of visual 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 other supporting offered in evidence, such as identification of specific chemical composition related to the vessel or its cargo.

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 ISSUES²

1. 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.

2. ADMISSIBILITY OF EVIDENCE IN THE US AND UK

The US and the UK are common law systems, and both of them comprise more than one jurisdiction. In this report we refer to English Law (the laws of England and Wales), not to all countries within the UK. In relation to the US, we refer mainly to US Federal law, rather than to the individual states within the US.

Both jurisdictions have shown willingness to embrace new technologies, and both 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 for admissibility:

- 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 it 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, and that it 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.

In addition, the potential use of satellite-derived information is recognised in UK legislation implementing European Commission Regulations.

² 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.

3. 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.

4. 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. However, there are no cases in Belgium where satellite data were used as evidence for illegal oil discharge by vessels at sea.

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 by 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 Automatic Identification System (AIS) position data could identify a polluter.

5. ADMISSIBILITY OF EVIDENCE IN FRANCE

To be offered as evidence, information must be contestable by each party; satisfy rules of admissibility reliable and must not breach privacy

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).

6. 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 might 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

Under the inquisitorial system operated in Germany, it is the responsibility of the court to investigate the facts. To do so the court uses all appropriate forms 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.

7. 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.

8. 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.

9. RESTRICTIONS ON 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.

Australia

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

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. It is also prohibited to save the data longer than 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.

Proactive 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.

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.

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 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.

10. STANDARD OF PROOF

Once evidence is admitted and its reliability established, it remains for the court to determine whether it proves the fact in issue with the appropriate degree of certainty. In general, in private disputes and other civil matters, a fact need be proved on a *balance of probability*. In criminal and other penal proceeding, the general standard of proof is *beyond a reasonable doubt*. The standard of proof is related to, but not the same as, reliability.

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.

Belgium

There are no cases in Belgium where satellite data were used as evidence of illegal oil discharge by vessels at sea. Other cases were not investigated.

France

Electronic records can be considered more reliable than traditional written forms. Therefore, they may be regarded as of greater weight than alternative evidence.

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.

CALIBRATION AND RELIABILITY³

Environmental Science and its applications are evolving rapidly as we move from description of the environment to prediction, which inevitably involve errors. There are three technological catalysts of the change, advanced computation, global observations, particularly from satellites, and the computational and mathematical facilities to compare and evaluate 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 is 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. Comparing the predictions with observations after the event also assesses predictions. 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 that 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

³ Professor Robert Gurney

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 through 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?

EXPERIENCE IN EUROPEAN CAP⁴

1. 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.

2. 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 650km² - 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 km². 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.

3. 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.

⁴ Simon Kay and Csaba Wirthardt

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.

4. 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 (km²) 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

USE EXPERIENCE IN AUDIT CASES⁵

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

1. 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 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.

⁵ Wietske Bijker (Faculty of Geo-information Science and Earth Observation (ITC), University of Twente), Egbert Jongma, Richard A Kidd (Geospatial Consultant, Cairo, Egypt). The authors would like to thank the Badan Pemeriksa Keuangan RI, the Indonesian Supreme Audit Institute, and the SIM-Centre, BRR for their support of the pilot study on auditing housing projects with geo-information. Furthermore, they would like to thank the KARI for providing the satellite imagery, the World Bank and the Netherlands Ministry for Development Cooperation for funding the pilot study.

2. 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 that 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 ortho-rectified 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.

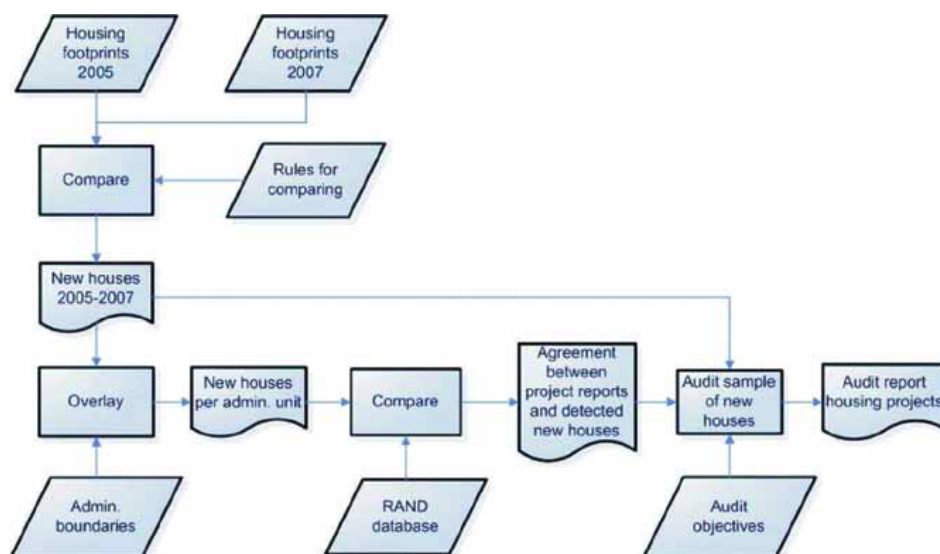


Figure 2: GIS based method for auditing housing projects

The method depends on data availability at the time of the audit. For the Aceh case study, high resolution (30 cm) 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. Layout 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.

3. CHECK FOR COMPLIANCE WITH RISK REGULATION

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.

4. 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.⁶

⁶ www.courtofaudit.nl/english/gisandaudit.

LAND SUBSIDENCE CASE STUDY

1. THE HYPOTHETICAL SCENARIO

Property A is the site of the office and a state of the art patented design warehouse owned by Four Level Ltd. (FL), a private defence contractor. Property B is adjacent to Property A and is the site of the office and warehouse of Glass Suppliers (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 as indicated in the Technical Annex. The resulting information shows subsidence in the area of the excavation. Details of the subsidence and the technique used to measure the relevant land movement are also given in the Technical Annex. Two specialists were involved in the technical analysis of the data and its interpretation.

Aerial sensed information was 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, and also observing Property A from Property B in October 2009.

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

2. TECHNICAL ANNEX

The satellite evidence was gathered from the ascending and descending orbits of the ESA satellites ERS-1 and 2 that produced satellite synthetic aperture radar (SAR)⁷ data covering the period from January 2001 - June 2010. This was processed through the Permanent (or Persistent) Scatter Technique (PSInSAR)⁸ to identify permanent scatter points on both properties that over a series of images demonstrate deformation in the level of the land and buildings. PSInSAR facilitates detection of land movement at rates as low as 1 millimetre a

⁷ Synthetic-aperture radar (SAR) is a form of radar in which multiple radar images are processed to yield higher-resolution images than would be possible by conventional means. Either a single antenna mounted on a moving platform (such as an airplane or spacecraft) is used to illuminate a target scene or many low-directivity small stationary antennae are scattered over a reception area, each imaging the target.

⁸ Interferometric synthetic aperture radar, also abbreviated InSAR or IfSAR, is a radar technique used in geodesy and remote sensing. This geodetic method uses two or more synthetic aperture radar (SAR) images to generate maps of surface deformation or digital elevation, using differences in the phase of the waves returning to the satellite. Persistent or Permanent Scatter techniques are a relatively recent development from conventional InSAR, and rely on studying pixels that remain coherent over a sequence of interferograms. In 1999, researchers at Politecnico di Milano, Italy, developed a new multi-image approach in which one searches the stack of images for objects on the ground providing consistent and stable radar reflections back to the satellite. These objects could be the size of a pixel or, more commonly, sub-pixel sized, and are present in every image in the stack. PSInSAR™ is an international trademark of Politecnico di Milano.

year, depending on the number of radar images available, the type of radar sensor used, and the phenomena under study.

Analysis of the data shows the following land movement over an area of 500 metres by 500 metres, with the boundary of Property A and B at its centre:

1. 20 measurement points were identified
2. Using measurements at two monthly intervals the rates of change per year were:

January 2008 to June 2008	Rise at 0.2 cm
June 2008 to January 2009	No change
3. Area outside immediate vicinity of boundary to June 2010 No change detected
4. At Boundary of Properties:

January 2009 to February 2009	No change
February 2009 to March 2009	Drop of 0.2 cm
March 2009 to April 2009	Drop of 0.7 cm
April 2009 to May 2009	Drop of 0.2 cm
May 2009 to June 2010	Drop of 0.3 cm

OIL SPILL CASE STUDY

1. 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.

2. 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 reach 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.

3. 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 LEARNED⁹

SATELLITE TECHNOLOGIES AND SMART ENFORCEMENT IN ENVIRONMENTAL LEGAL SYSTEMS

1. 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:

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

Some 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.

2. THE ESRC 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

⁹ Ray Purdy.

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.

3. 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?

PRESENTATIONS

1. INTRODUCTION

INTERESTS OF ESA IN THE WORKSHOP

The European Space Agency develops scientific technological systems, and puts in place operational systems to derive the utility from those technologies. Among them is earth observation, the focus of this Workshop. Typically the development cycle takes 25 to 30 years.

ESA's program is very much concerned with core science and technology, but also with engaging communities that can derive those benefits. That is the reason for this study, why ESA is very pleased to be here and to have seen the Institute for Space Policy and Law bring together leaders in science, technology and legal practice.

OVERVIEW OF PROJECT

Three very notable studies on this topic mainly concerned monitoring activity, as opposed to investigating ways in which remotely sensed information could be used as evidence. The Study by the Institute and the aim of the Workshop is to examine the criteria and conditions for evidential use of the information.

2. RULES OF EVIDENCE AND METHODOLOGY

To establish some common points of reference and introduce the technical participants to the topic, the first session addressed the broad rules of evidence. The intent was also to encourage debate on how satellite-derived EO information may satisfy the rules and what evidential issues arise because of the nature of that information.

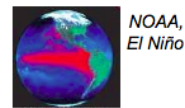
2.1 METHODOLOGY & RULES OF EVIDENCE

This presentation gives a brief description of the project, the matters investigated and the intent of the Workshop. The Primary objective is to seek the views of participants on the issues that arise in relation to the use of satellite-derived information as evidence.

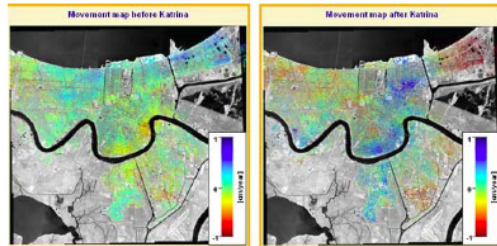
Space EO: A powerful application

- Military observation, also using civil EO data
- Spatial planning
- Operational oceanography
- Agricultural monitoring
- Resource management – forestry, water including fresh water, soil strategy
- Pollution monitoring
- Sea level and ice-cover measurement

05 October 2010



Land use – urban atlas of changes in use in Bremen



Radarsat-1 interferometric survey of soil subsidence around New Orleans before and after Hurricane Katrina 2

There are a variety of earth observation modes and uses. The information can provide evidence in a number of areas, including land use, soil subsidence, sea temperature, and military observation. GMES The European successor to the Galileo program, is very important in itself, and in driving fresh platforms and uses.

Administrative and judicial uses

- “Eyes in the sky” are thus useful for monitoring, research, service information
- But to what extent can space-derived Earth observation data validly be used also in **establishing rights and duties** and **enforcing laws**?
- Are such data *really* useful for this, or hype?



05 October 2010

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This project examines administrative and judicial uses of satellite-derived information. It addresses the extent to which space-derived data can validly be used as evidence in establishing rights and duties, and enforcing laws.

Defining the inquiry legally

- Space EO is a **transborder** activity
- What it facilitates is generation of **information** from the data
- Several legal regimes *could* benefit
- But key question is:
 - will such information **qualify** as evidence and, if so, under which **conditions**, and
 - which **variations** in such conditions must then be taken into account **internationally**, and ...
 - *how?*

05 October 2010

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Satellite-derived information has the benefit of being trans-border, but that also raises issues of jurisdiction. There are also issues of validity: what kinds of information will be useful for tribunals and administrations. In addition, a distinction may need to be drawn between “proof” as defined by lawyers and by scientists.

Proof of fact

- This implies *inquiry into means of proof* accepted in administrative and judicial systems
- Contrast these with scientific standards of proof
- Involves focusing on national procedural law
- Harmonization? In principle not within e.g. EU competences, but incursions by ECJ on basis of *effet utile* doctrine and voluntary convergence by national authorities
- Fundamental concerns exist to exclude or discount evidence if it may be “manufactured” by or on behalf of party
- Yet approaches to concerns differ nationally

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Scientific proof is reached on the basis of irrefutability, repeatability, objective states and deterministic probability, whereas there is a high degree of subjective evaluation in legal evidence.

While there has been a great deal of voluntary convergence internationally, national procedural laws have not been entirely harmonised. There are differences in approaches to reliability of evidence, processing and safeguards. One of the aims of this Study is to determine what, and how important, those differences are. With increasing ubiquity and confidence in technology, it is clearly necessary to consider its use, barriers to its use and protections that may be needed.

Options for pursuing study

- Choice: **One size fits all approach** or differentiate by jurisdiction (e.g. “civil”, “common law”)
- Choice: General abstract or **concrete** by reference to standard of trial or administrative process
- Choice: Verify such standard empirically or by **case study**
- Choice: Start with innovative or **clearly susceptible** areas
- Choice: Ex cathedra evaluation or **peer process** through interaction with communities (workshops)
- Choice: Backward or **forward-looking** (e.g. iteration of requirements, perhaps for standard)

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The study looks at abstract as well as concrete issues in the administrative and legal arena, to examine ways to achieve greater acceptability and use of satellite-derived information as evidence. It will consider whether future approaches should be tailored to different jurisdictions, or be more universal; what role standards, guidelines and legislative reform might play.

The Workshop will use presentations on land subsidence and oil pollution. Variations in approach between jurisdictions, particularly the discretion that can be used to admit evidence, will be addressed.

General initial findings on evidence

- **Judicial** standards should be preferred to administrative (higher threshold of proof, greater finality)
- Traditional difference between more inclusionary tendency of civil law system and more exclusionary tendency of common law system
- **But** relaxation in England on rules of admissibility (hearsay) mark considerable **convergence** with "civil law" approach
- **Ethical and human rights** (privacy) constraints on evidence gathering may conceivably pose problems, but unlikely that intellectual property can
- Main issue with space EO-derived information is **weight** to be assigned, which depends on **accuracy and reliability** for purposes of the applicable standard for sufficiency of proof
- Status of such evidence in any jurisdiction depends on whether **general law** of evidence applies or specific **statutory rule**; such rules may also prescribe a particular territorial jurisdiction

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It was felt that the higher standard of proof applied in courts, as opposed to administrative tribunals, would be preferable. The level of certainty to which a fact is established is higher in court than before administrative tribunals. Similarly, selecting the most restrictive jurisdiction results in the higher requirement.

To this end English law was chosen as the benchmark, for its relatively strict exclusionary rules regarding admissibility.

The weight given to evidence based on satellite-derived information will depend on its accuracy and reliability. Statutory rules on admission, and conditions to be met by such evidence, can be of benefit. Examples of such rules are found in analogous areas such as speed cameras, where type approval specifications exist. Whether such rules are relevant or desirable for these applications will be discussed.

Machine evidence

- *Witness testimony to fact* is “default”. In England reforms mean third party statements/documents are now largely admissible by principle, subject to some protections
- Reform in England includes “statements” produced by machines *involving human agency*
- Output of machines *not* involving human agency = “real” evidence
- But *collateral evidence*, generally *expert opinion*, needed as to *qualities* of machine, absent statutory provision (e.g. type approval)
- For human-dependent machine information, *proof of accuracy* or of absence of human error should be given
- N.B. Space-derived data is often *circumstantial* by nature

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In relation to machine-generated evidence, in the literature, and particularly the 2001 study by BIICL and NPA, it is said that where satellite data is involved, expert opinion is always required. This is relevant to cost and length of proceedings. There is a need to examine what approaches to the proof of accuracy may be appropriate.

Satellite data's role in providing *circumstantial* evidence

The identified vessel was the ship Fairchem Colt

The spill has been verified on the same day 3hours later (at 08:55 UTC) and Mineral oil was confirmed. Furthermore, the captain agreed they had washed the tanks And a port state control was foreseen at the CUX-harbour.

SSN: Route for last 48Hrs



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Space data is generally circumstantial rather than direct. It is indicative of an inference to be drawn.

Additional direct or circumstantial evidence: ground “truth” or “proof”

- Often required with satellite imagery
- May be supplied by aerial or surface observation and samples (circumstantial)
- May be supplied by witnesses of relevant event (direct)
- Awareness of this limitation can allow for qualified recognition of space EO data, notably in administrative contexts

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Other corroborative evidence or ground truth, perhaps in the form of extra observation, may confirm the inference drawn from the circumstantial evidence provided by satellite.

Example: Thailand

- Cadastral mapping: relies on THEOS and Worldview2 imagery (< 1m resolution) but increasingly aerial imagery
- Satellite data are corrected using ancillary datasets to a well defined mapping standard
- This aims to ensure that the geometric correction employed is accurate enough to be fit for purpose (establishing land title)

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In the example of Thailand, satellite data was not sufficient to establish land title. Ground control point verification and geometric correction were also required.

Weight: accuracy and reliability

- For space EO data, inability to show procedures do not check for and correct errors or distortions can lead to exclusion from consideration
- Audit, authenticity and monitoring therefore important as regards processing of data and information
- This indicates accepted methodolog(ies)

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Reliable, calibrated systems are needed to give sufficient accuracy and weight to evidence. Otherwise the information may be inadmissible, or may lack probative value. Audit, authenticity and monitoring are important.

Lord Chancellor's Code of Practice on the management of records issued under section 46 of the Freedom of Information Act 2000 (2009)

8.3 As part of this process [of keeping records] authorities should consider whether any of these records should be subject to particular controls so as to ensure their **evidential value** can be demonstrated if required by showing them to:

- a) Be **authentic**, that is, they are what they say they are;
- b) Be **reliable**, that is, they can be trusted as a full and accurate record;
- c) Have **integrity**, that is, they have not been altered since they were created or filed;
- d) Be **usable**, that is, they can be retrieved, read and used.

9.3 [...] Records systems should have the following characteristics: [...]

- f) They should **protect records** in digital systems from accidental or unauthorised alteration, copying, movement or deletion;
- g) They should provide **secure storage** to the **level of protection** required by the nature, contents and value of the information in them. For digital systems this includes a capacity to control **access** to particular information if necessary, for example by limiting access to named individuals or by requiring passwords. With paper files this includes a capacity to lock storage cupboards or areas and to log access to them and any withdrawal of records from them;
- h) They should enable an **audit trail** to be produced of occasions on which selected records have been **seen, used, amended and deleted**.

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There are codes of practice, guidelines and rules to ensure a good audit trail, and reliability of information.

Standards/requirements

- BS 10008:2008 Evidential Weight and legal admissibility of electronic information – Specification
- Draft BS ISO 16363 Space data and information transfer systems: Audit and certification of trustworthy digital repositories
- Other?
- Elements of fresh, specific “standard”?

05 October 2010

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Guidance might be in the form of legislation, a standard, voluntary standard, or some other statement that is applicable. Existing standards have relevance but are not specifically on point. The Study and this Workshop explore these options and related issues.

2. SYSTEMS CAPABILITIES – *Satellite and Data Processing Features*

Three presentations were given, each relating to a different application. The techniques used and the capabilities of systems measuring land motion present an interesting application. The data collection systems are not novel and much of the information used can date back several years. The innovation is the development of a technique for processing the data that can measure very small movement in land surface levels by reference to selected points. Therefore, the information reveals relative movement of land.

An important evidential facet of sensors is that the data generated be accurate. To that end, systems need to behave predictably and consistently. There is, therefore, a need for calibration and verification of system performance. This was addressed in the second presentation in the session.


Even where systems can be relied on to provide data accurately and reliably, there is a further requirement to be met. To be of evidential value, the information must relate to the specific matter being investigated. It is therefore necessary to show that the information relates to the factors that are at issues and can be relied on for that purpose. The third presentation explored this aspect of satellite systems capabilities, taking oil spill detection and polluter identification as the reference point.

2.1 SATELLITE CAPABILITIES FOR LAND MOTION MEASUREMENT

This presentation is an overview of the satellite sensor capabilities, looking at land motion measurement and some other applications.

Agenda


- Overview of Sensor Capabilities
- Application Examples including Land Motion Measurement
- Certification & Verification & Data Standards
- Current Status



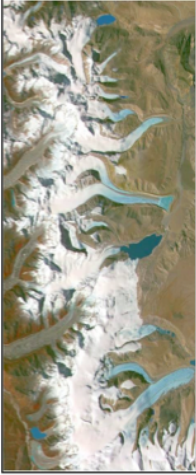
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It explores certification, verification and data standards, and issues relating to terminology and communication between scientists, technologists, academics and lawyers. Some lawyers view satellite data as electronic evidence, others as simply hearsay or circumstantial. The

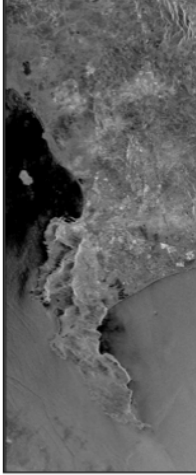
technical community needs to understand the procedural issues and the needs of the legal community.



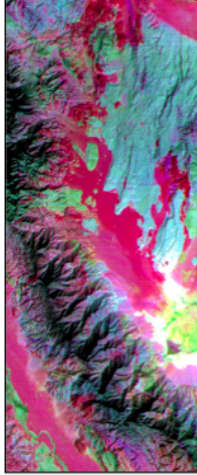
Core Sensor Capabilities




Optical



Radar




Multispectral



DEM


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There is a distinction between optical data, representing a visual image of the subject, and more complex radar data, which needs processing into a visual image. Other aspects include recording phase, change of signal phase, and the amplitude of the signal. A range of multi-spectral sensors are also used over a broad range of the electromagnetic spectrum to provide much more information, for example in the near infrared for detecting vegetation and other material and conditions. In addition, multiple passes can provide elevation models.



Imagery & Data Services

- **Range of Optical & Radar Sensors**



Landsat (ETM/TM/MSS) *Radarsat*
SPOT *ERS & ENVISAT*

and the newer generation of high resolution imagery from:

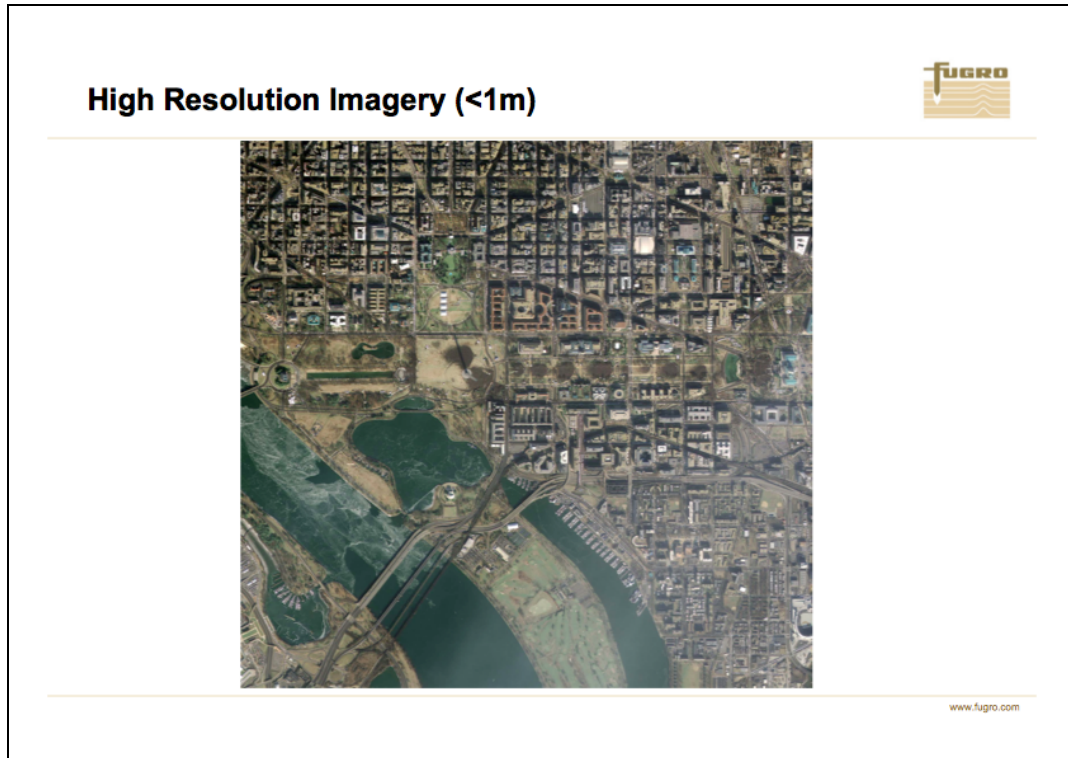
GeoEye *Worldview*
Ikonos *Quickbird*
Formosat *Kompsat*
COSMO SkyMed *TerraSAR-X*

Satellite can be complemented by airborne where higher resolution is needed.

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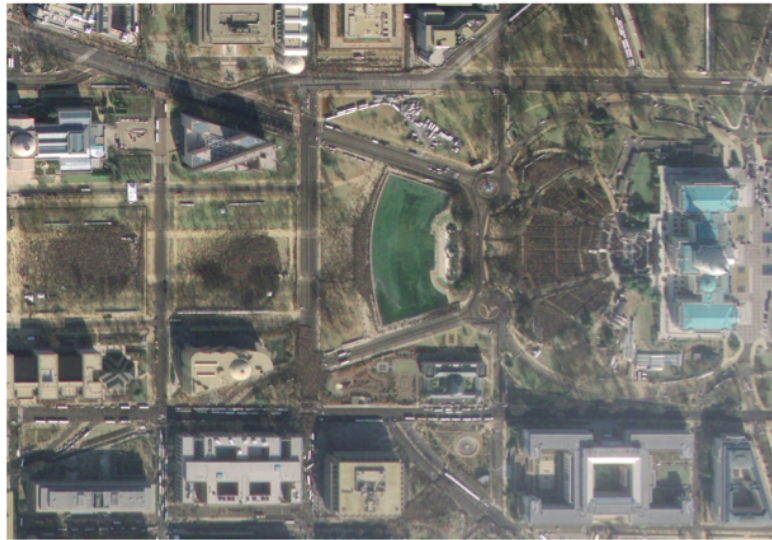
The range of sensors is maturing. Well-known traditional sensors on systems such as LandSat, RadarSat, the ESA ERS, ENVISAT, and Spot typically range in the 30 metre to 10 metre range of resolution. In the last 10 years or so, a large number of newer generation satellites have created constellations such as COSMO SkyMed, with 3 satellites, and a 4th one is on the way. These will improve the temporal separation between the data and the acquisitions.

Not all satellite missions have the same scientific and archive base. Time gaps in archives may reduce their usefulness as evidence. With increasing acquisitions, increasing coverage and daily re-visits the position is improving, but this does not resolve the historic problem.



High-resolution satellites orbiting 740 kilometres or so up, with resolutions of less than one metre, can detect numbers of people in a crowd and make estimates of attendance at an event. Movements of refugees, troops or vehicles can be observed for humanitarian or legal purposes.

High Resolution Imagery (<1m)



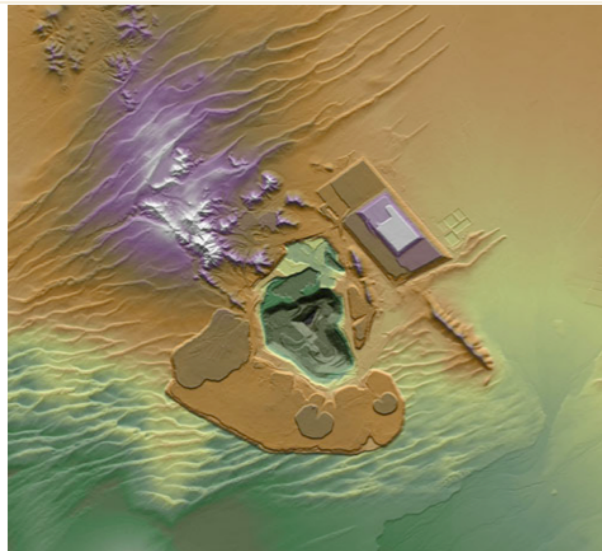
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High Resolution DEMs




SRTM : 90m

WorldView: 1m



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1 metre DEMs can now be created using DigitalGlobe and GeoEye satellites.




Applications

- Ground Motion including Settlement, Subsidence, Tectonic movement etc
- Monitoring Site Development
- Environmental Monitoring
- Change Detection – Vegetation Clearance
- Boundary Disputes
- Damage Assessments
- Pollution Monitoring
- Humanitarian – movements and migration




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Earth observation satellites can provide considerable information about ground motion and subsidence tectonic movement, as well as site development, environmental factors, site clearance, and other changes. Such observations are useful in boundary disputes and coastlines changes. Satellite data has been used in damage assessments in insurance claims, pollution monitoring, and humanitarian aid.

To detect and measure land motion as low as one millimetre, a pair of scenes and an elevation model are used.

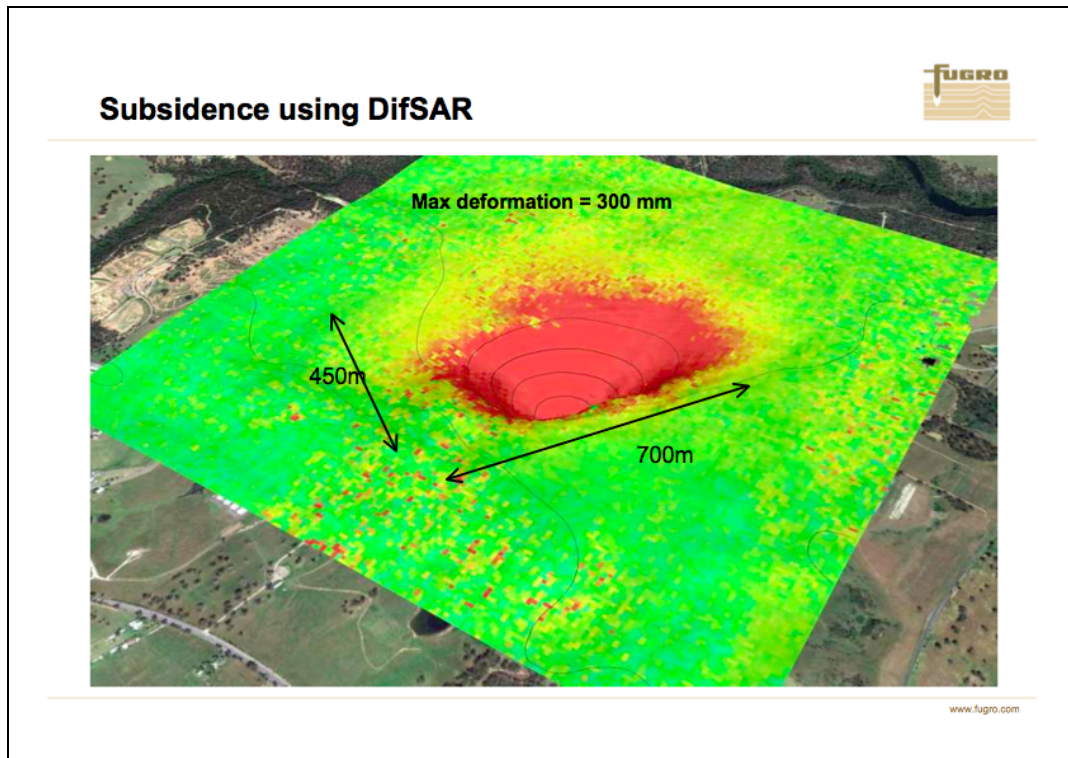


InSAR Surveying Services

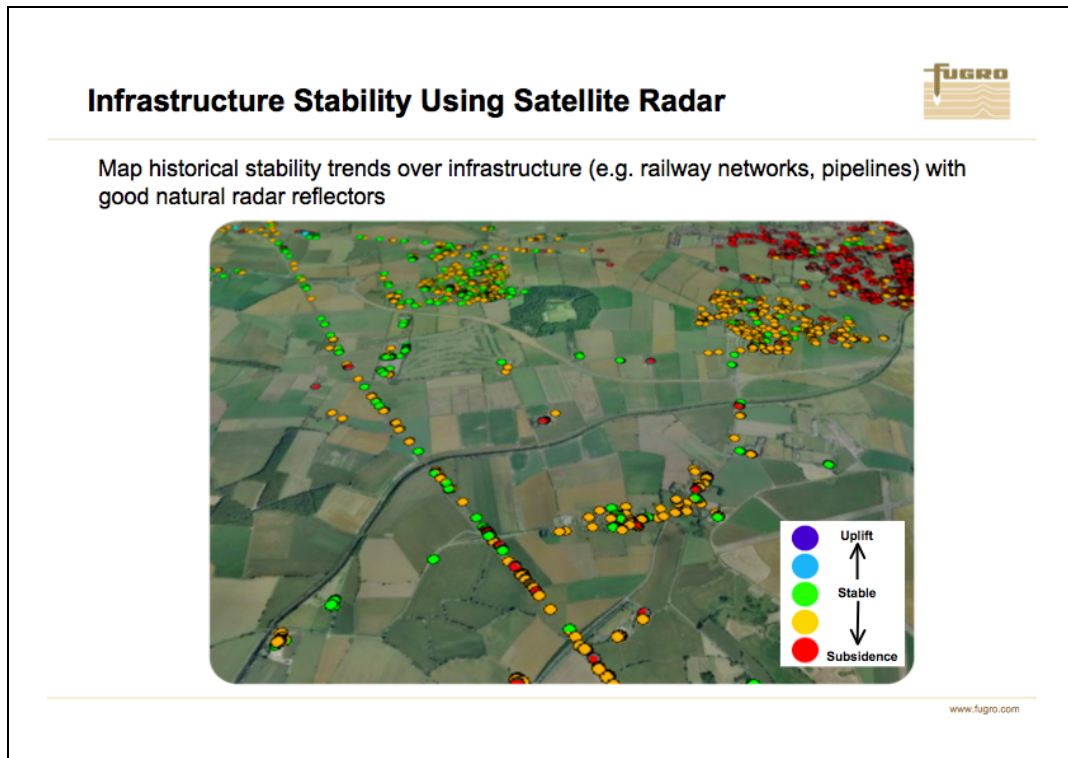
- **Differential InSAR (DifSAR):**
 - Wide area surface mapping & monitoring
- **Persistent Scatterer InSAR (PSI):**
 - Point target ground/structure motion mapping & monitoring
- **Artificial Reflector InSAR (ARInSAR):**
 - Site-/Point-specific ground/structure motion monitoring

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With a time series of data over a particular target, using more precise reflecting points -, individual buildings and features can be monitored. The above InSAR images of oil tanks in a storage reservoir enable monitoring of the stability of the whole infrastructure. The buildings act as reflectors. A passive corner reflective device reflects the radar signal, and an active device, a transponder, helps measure small changes in movement.



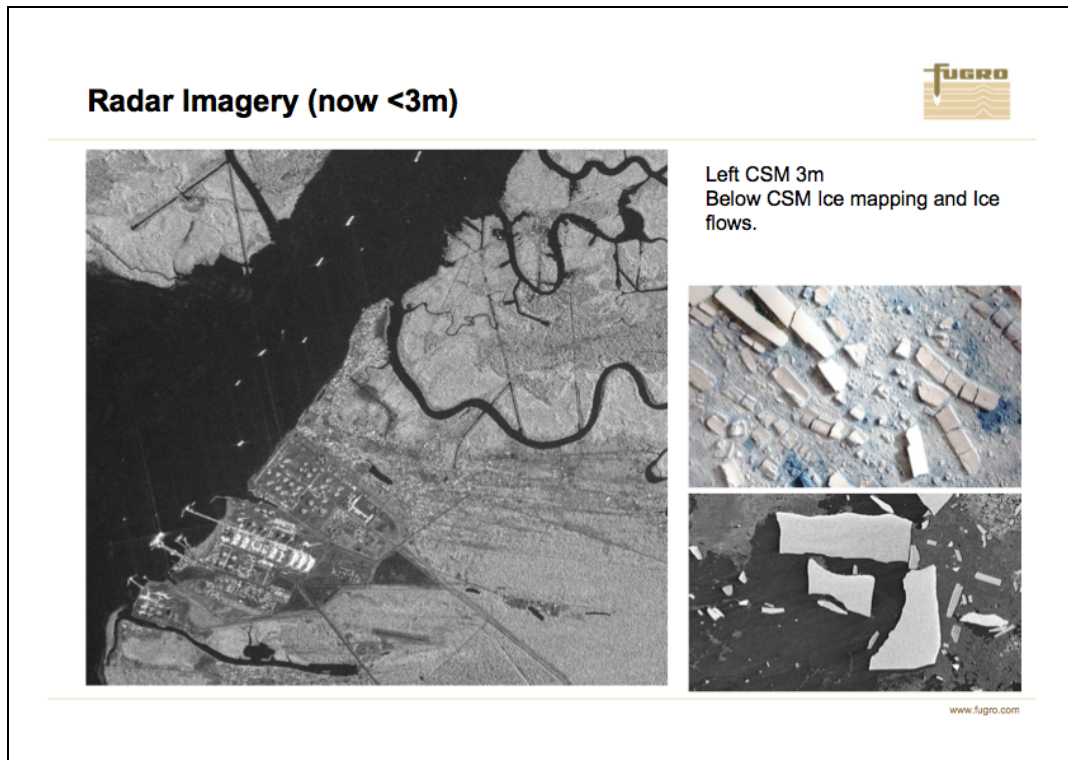
Radar imagery that may not be intuitively understood is transformed into an image, for use as a depiction of the damage and impact being observed. To be useful as evidence, it is necessary to understand how radar data from acquired scenes are processed to derive a motion image that may result in a claim.



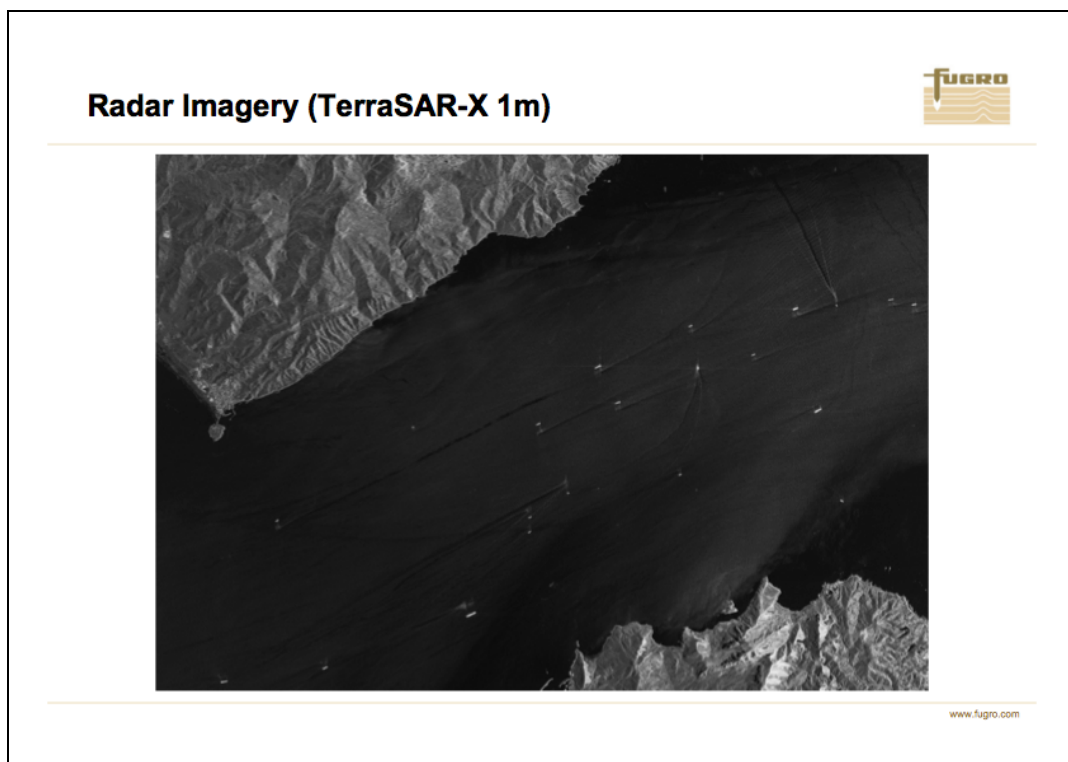
This image using the persistent scatter radar technique shows a linear feature, possibly a railway line, road or other infrastructure, and a trend of subsidence in the direction of the bottom of the image. The top right-hand corner of the image also shows an area affected by mining subsidence.



An illustration of a landslide, with corner reflectors.



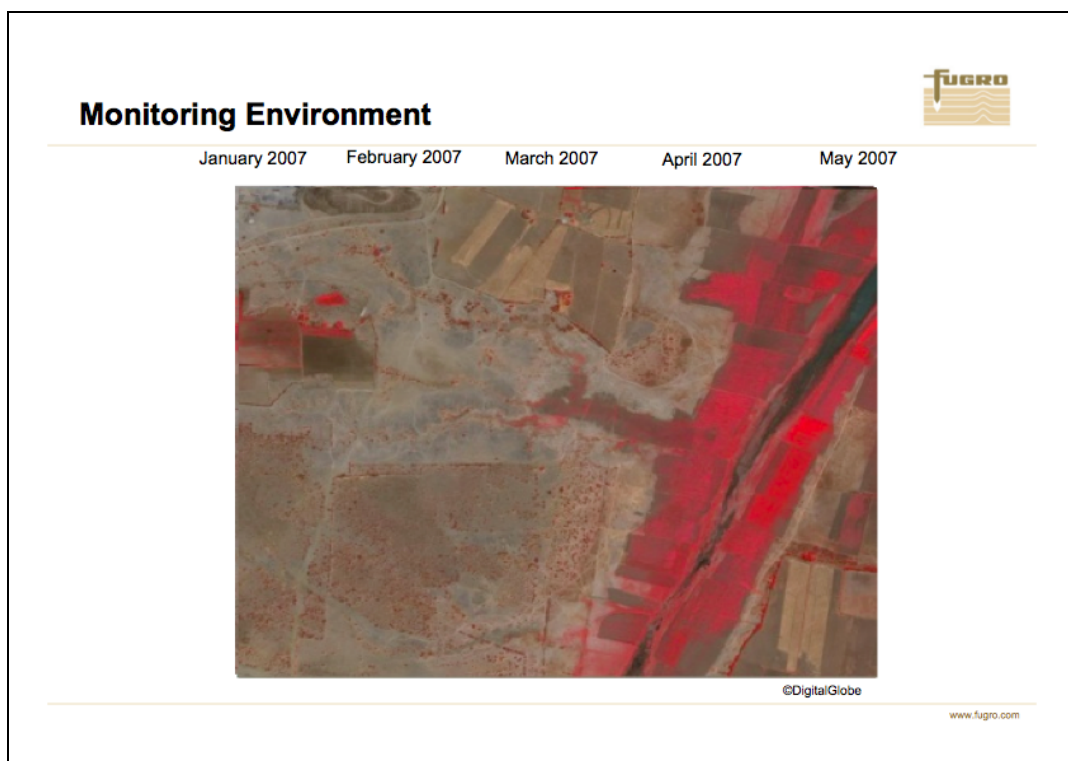
These images illustrate advances in radar from lower-resolution radar imagery, with high-resolution radar, less than 3 metres, able to pick out ships, ports and activities within those ports. Using long-track interferometry, movements between two satellites can be measured to give information about the direction of the ship. The combination of satellite imagery with other sources, such as AIS transponder information, provides a large amount of information for pollution monitoring.



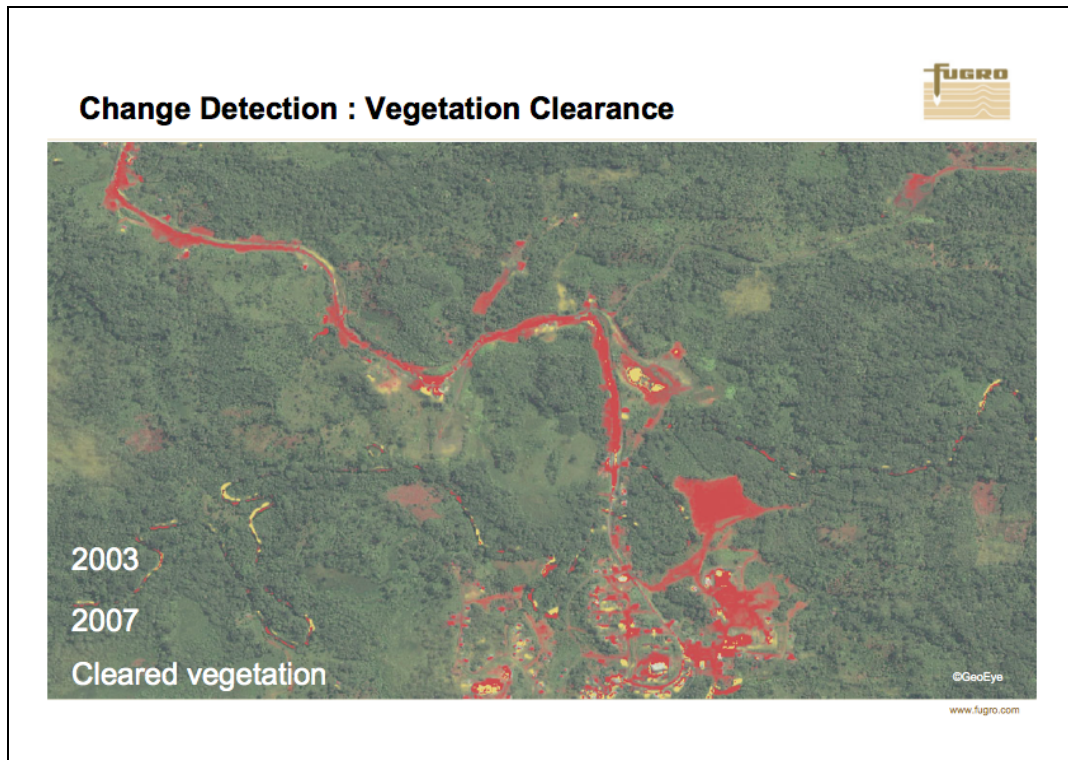
1 metre resolution of the Straits of Gibraltar reveals ship movement.



This image illustrates satellite data capability to show movement or change in a development site.




In terms of monitoring the environment, a time series can show changes, such as increasing vegetation in fields.



Another image of change detection, this time clearance.



In an insurance example, high-resolution imagery shows buildings and the extent of damage.



Certification & Data Qualification

- Processes - Certify Management Systems eg ISO 9001:2008
- People (Company) – PhD, MSc, MIET, etc plus reputation
- Techniques – Verification & Validation eg ESA GMES Terrafirma for Validation of PSInSAR
- Typical licence text as here from DigitalGlobe


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Questions are raised about certification and data qualification. Should an EO company producing data and products try to certify its management systems in terms of ISO standards? Should it focus on the credentials, qualifications and reputations of the people acting as expert witnesses? Should it validate and verify the techniques used as being ‘accepted’? Advances in the way lawyers view “electronic” evidence may overtake such questions, and whether this evidence is viewed as circumstantial or hearsay.

Most data used by EO companies come from government sources but some are from commercial companies. The data is supplied with no ‘fitness of purpose’, no warranty, and no guarantee. The above liability limitation provision is typical for most satellite data supplied.

Status : Satellite Data & Associated Parameters



- Mature (Maturing) Processes increasingly validated
- EO Specialist & Companies increasingly aware of certification & qualification issues
- Archive Data giving a potential historical record
- Global Coverage
- Accuracy of location
- Range of Resolutions (30/60m to 0.5m)
- High Resolution (several satellites now <1m)
- Cost typically upto USD14 per sq km (minimum areas plus programming)
- Growing number of EO satellites with improving data continuity

- Usually admissible as evidence
- Expert interpretation available
- Certification & verification & validation improving most importantly for radar applications

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EO products can take 30 years to come to fruition. These are a maturing set of processes. These processes are increasingly validated. For example, in the case of optical imagery, some of the simpler radar-processing techniques are generally accepted. EO companies are increasingly aware, and certainly the four companies involved in very fine radar processing for ground movement in GMES projects are aware, of the desirability of certification, including ISO 9001 certification, and validation of processes.

Satellite data provides global coverage with good accuracy. Most satellites are very well calibrated. Resolution is good, less than 1 metre. Costs vary, with some systems providing free data from the governmental and scientific communities. Commercial satellites must try to give a return to shareholders.

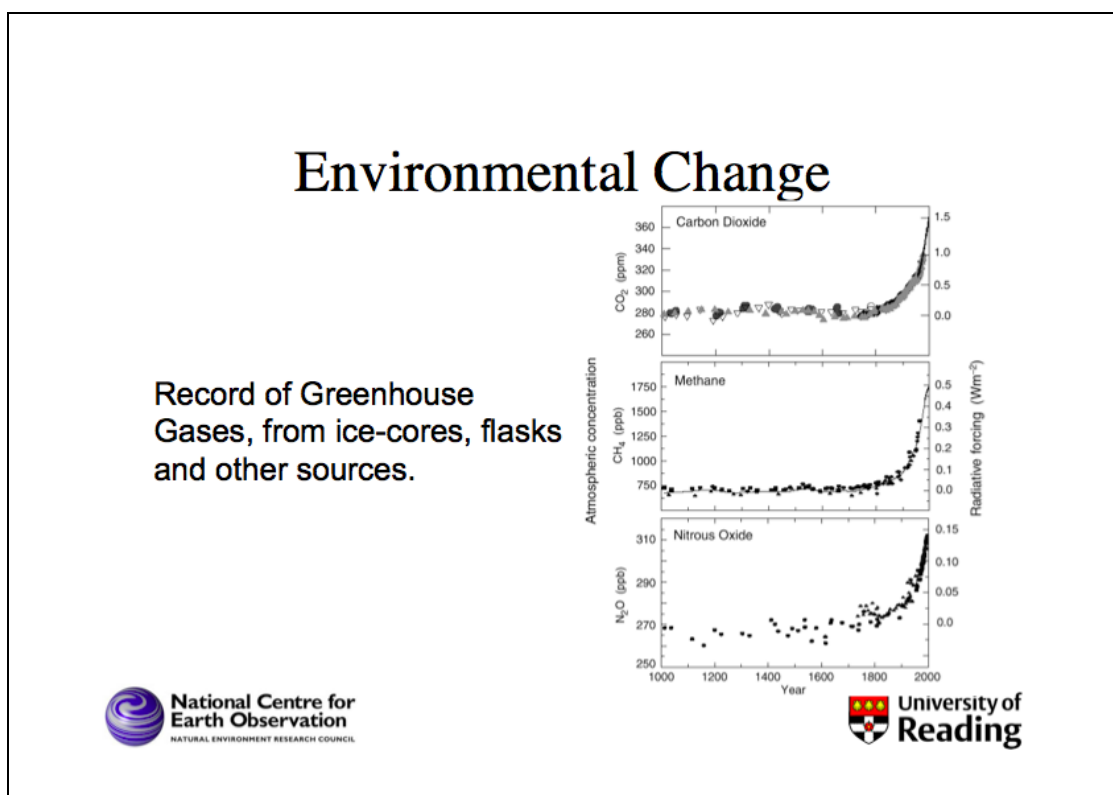
There are some questions about the admissibility of the data, and the form it has to take. It seems to be usually admissible, but this could be clarified for the value-adding EO community as a whole. Expert interpretation is widely available, but good communication and access are vital. Certification, verification and validation are key issues, particularly in radar.

2.2 CALIBRATION AND SYSTEM RELIABILITY

To examine aspects of calibration and system reliability, as well as the processing methods involved in satellite-derived information, this presentation focused on environmental and weather systems. These present some of the more challenging problems.

Environmental science is changing immensely fast. There are three catalysts for this. It is possible to bring together lots of observations, globally and regionally. These observations, particularly earth observation but other sorts of information as well, may be combined.

It is possible to solve very large sets of partial differential equations on large computers, for modelling the whole earth and bringing all this information together. Earth observation of any kind is very rarely used on its own, whether from space or any other source. It is put in context with other information.



This well-known set of data from the last 1,000 years shows the concentrations of 3 major greenhouse gases that are well mixed. This is more controversial than one might think, because it includes information from many different sources.

Obviously this data is not from remote sensing, but from other sources. There is a lot of information about calibration, differences in time, and so on, involving a lot of interpretation even in something as well known as this.

Models and Types of Prediction

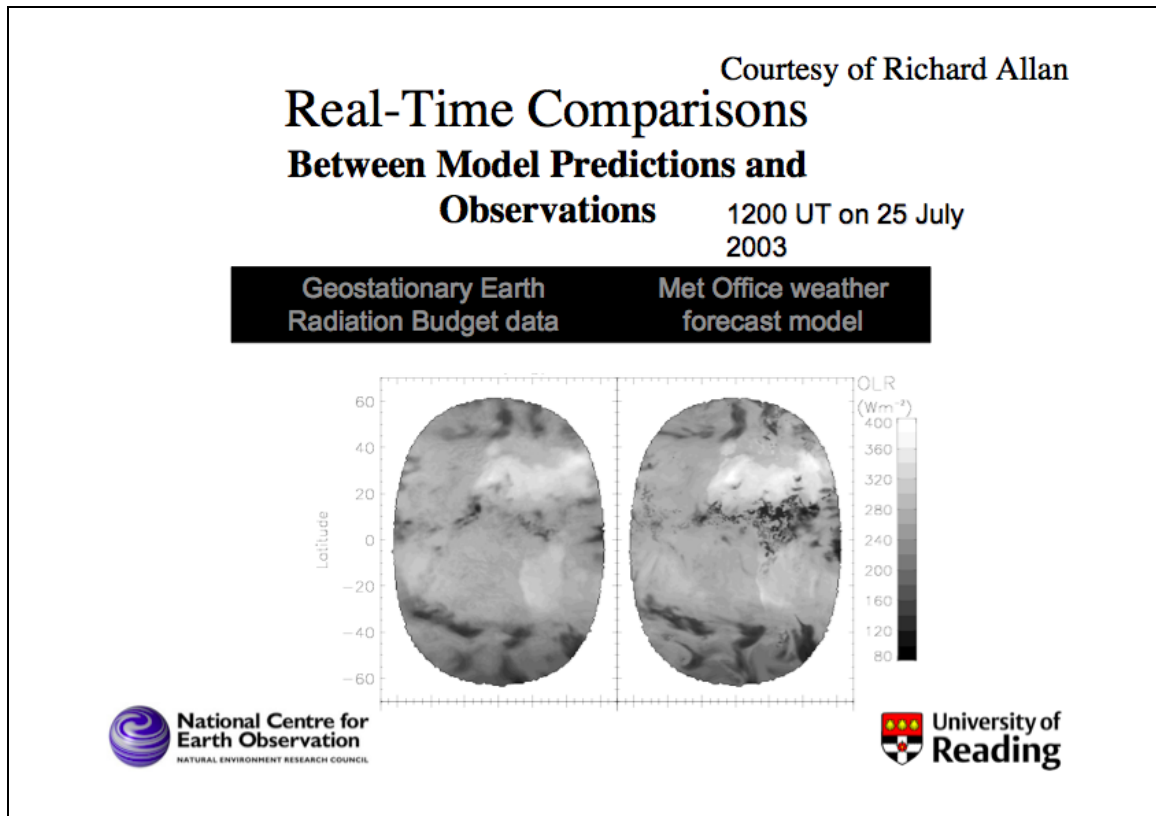
- Earth observation at an instrument is usually a potential difference measured at an instrument in space, where the potential difference is related to a radiance
- Models are required to retrieve geophysical values from most Earth observations from space
- Observations at the surface are usually of geophysical states
- Most environmental quantities required are fluxes- changes of states
- Geophysical models predict geophysical quantities that can be compared to geophysical observations, but rules are required to understand the differences between observations and models, both of which contain errors and biases. The models obey fundamental physical laws
- There are two types of geophysical prediction; the first kind evolves from an observed state; the second reproduces general statistical trends from known boundary conditions



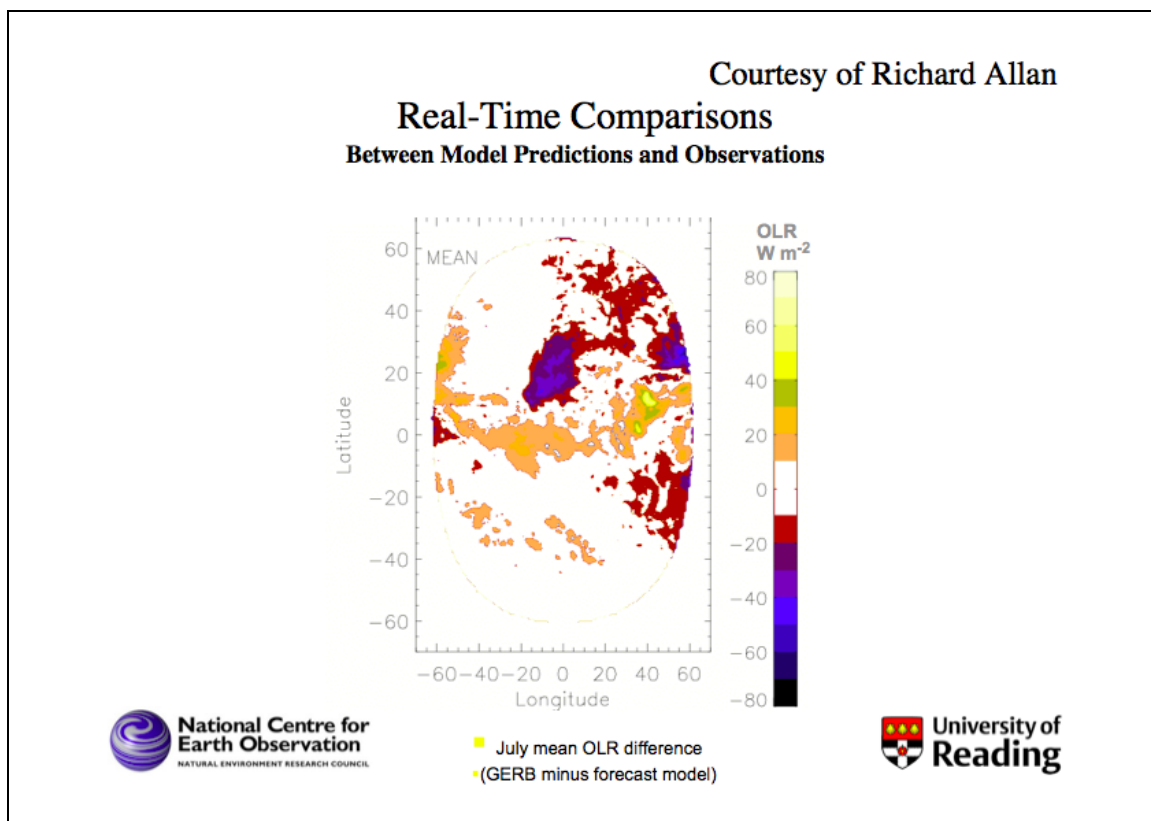
Earth observation data is almost always a voltage out of an instrument. A model is needed to convert it into a geophysical quantity, so that there is the need for expert opinion whether in the legal sense or not. Geophysical models of the planet, the climate and the weather are large, and include many different processes.

These systems combine models and observations; it is very rare to have only an observation. Usually some geophysical state is observed, and a change measured, usually a small difference between two large numbers. Errors are a concern.

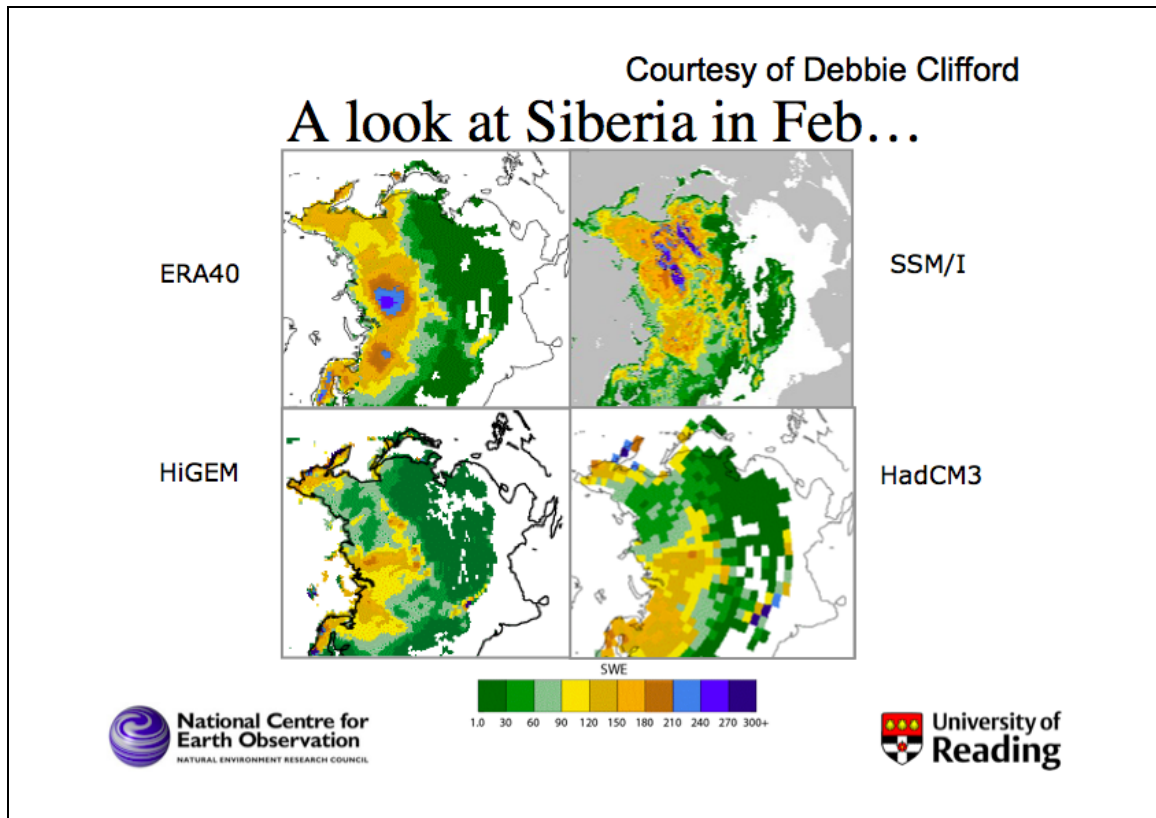
There are two kinds of prediction. One starts with a set of the measurements of the state of a process, and evolves in time. The other uses climate, with known boundary conditions, and evolves within those, but not to predict the exact state.



This classic image shows radiation over Africa, in 2003. The left is an actual observation; correct to about 3 watts a square metre, showing the outline of Africa. The right is a prediction at exactly the same time from a UK Met Office numerical weather forecast. The comparisons can be used to determine errors in the models.



Here is an average over about 5 years, of the differences of the outgoing radiation observed and modelled. The differences are extremely small except over the northwest Sahara, where atmospheric dust is present.

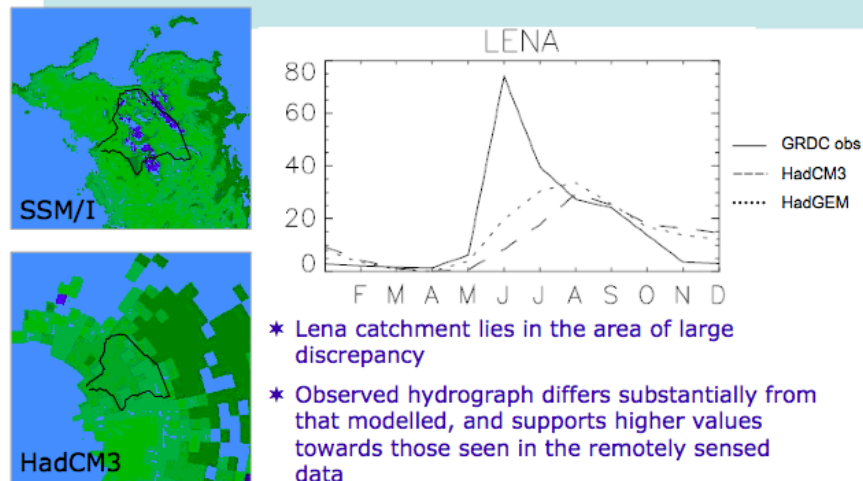


Snow is economically important for a number of reasons. This is Siberia. The top left is the European Weather Centre estimate, in average February levels over many years. The bottom two are from climate models. The top right is from the NOAA satellite series over about a 40 year period.

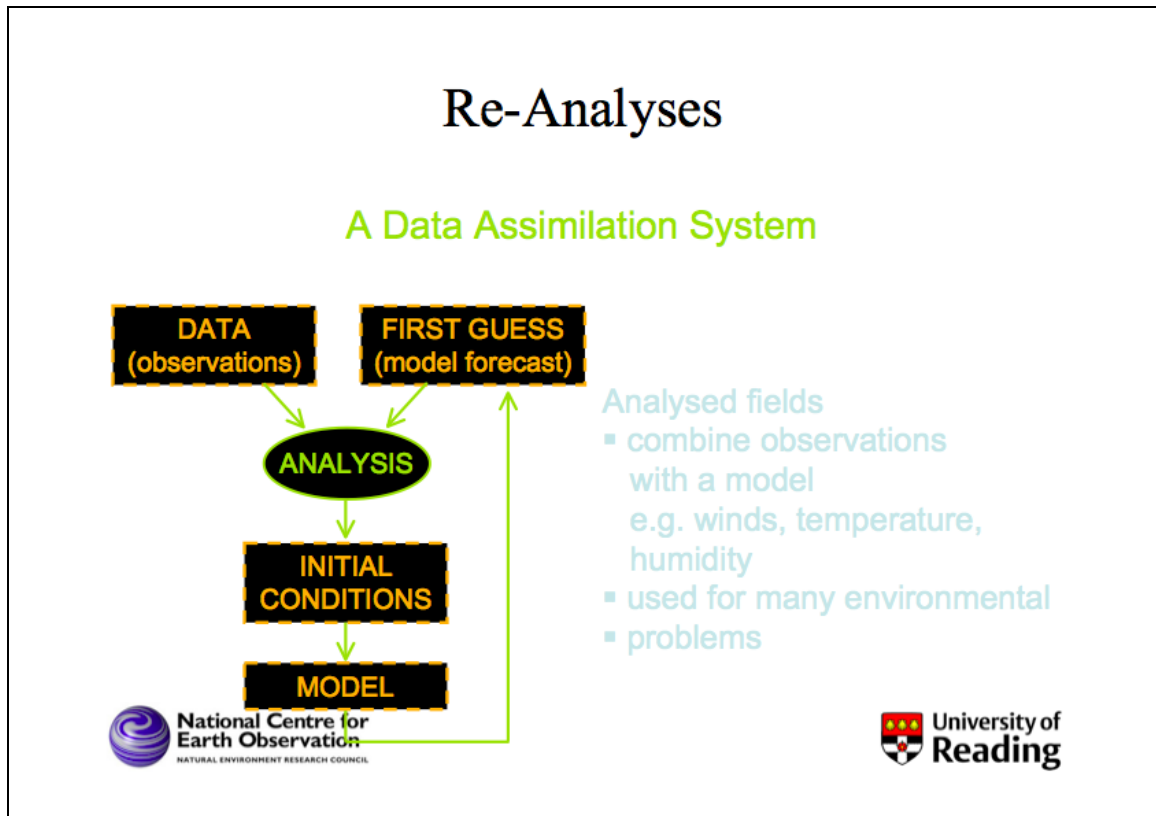
There are large differences between the model based on the satellite data, and conventional observations combined with a weather forecast model. Much more information is required in addition to the satellite data in order to interpret the data. The challenge is to design information systems able to capture enough information to be able to understand those differences.

Courtesy of Debbie Clifford

Validation - runoff?

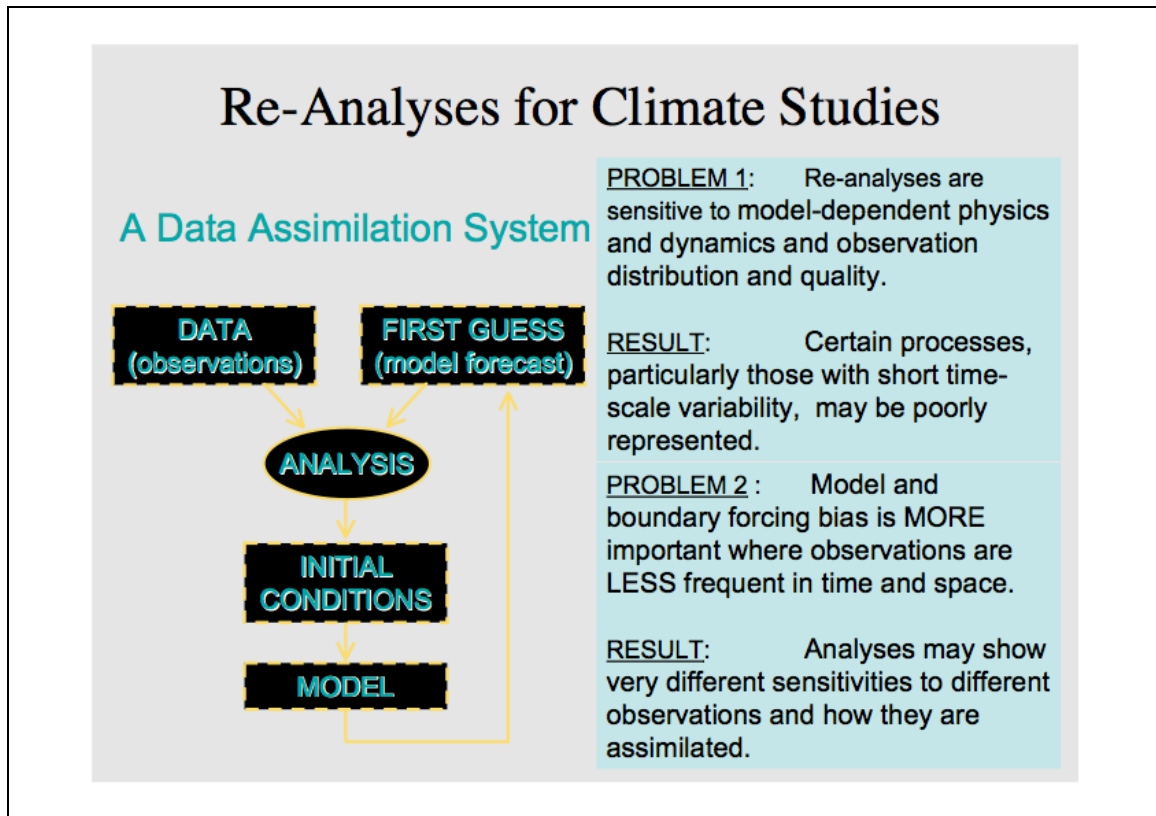


This is a catchment in eastern Siberia, with satellite data and climate model information. The solid line in the graph is the actual runoff from the catchment. The dotted and dashed lines show information from two different models. It is evident that the climate models are probably wrong in this area, and more information is needed to understand why.



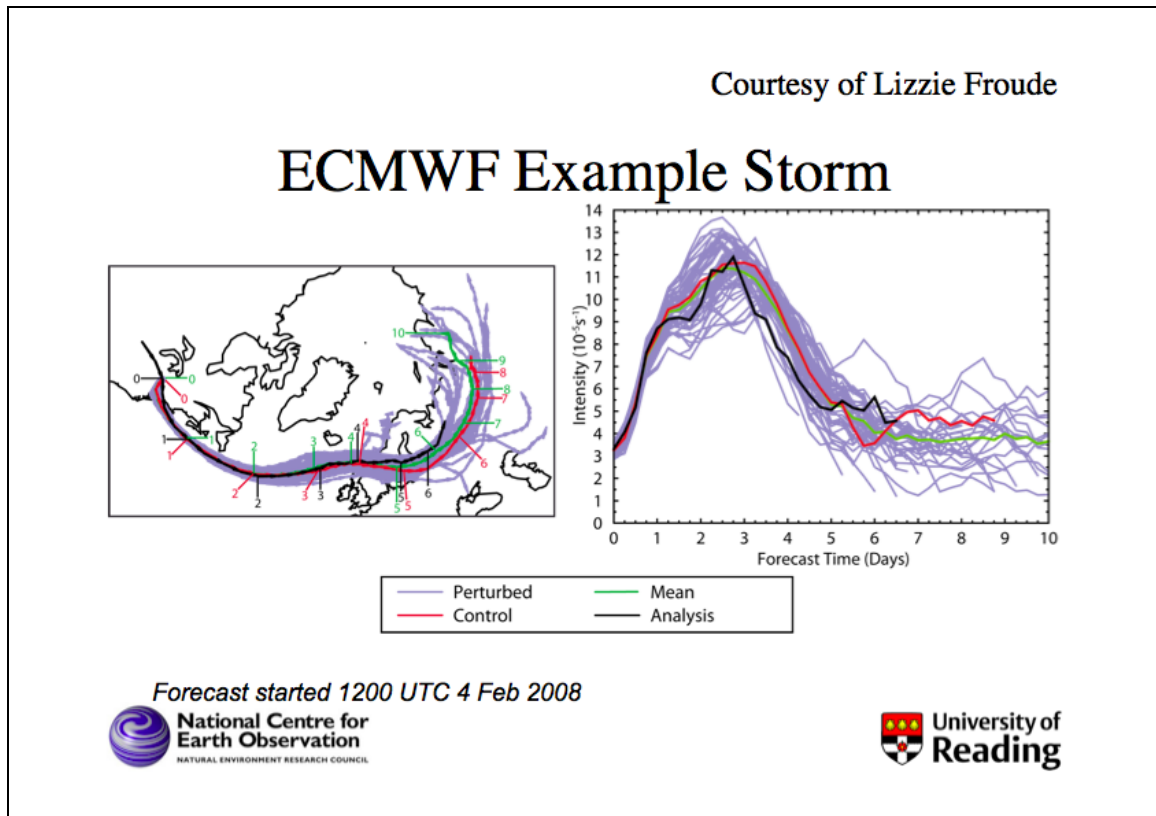
The process called data assimilation brings together observations and models. These have a lot of processes built in - conservation of energy, mass and momentum - which are true. And the observations have errors. The analysis combines the two statistically, to get a best state of the atmosphere, the ocean, and the land surface.

With this system, it is possible to work out the value of any particular piece of information, to identify errors, reduction errors that are being brought in by particular sorts of information, and also to run experiments by removing certain sorts of information and seeing the differences.



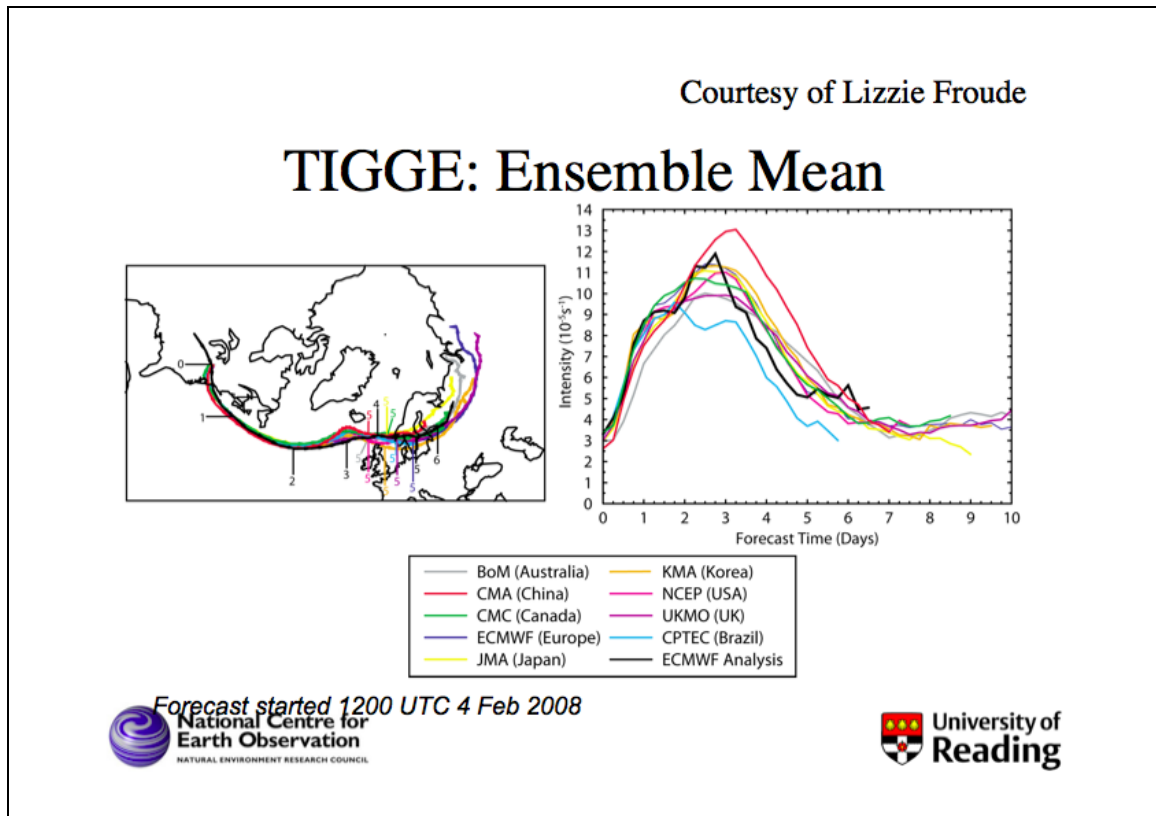
There are two problems. First, the re-analyses are sensitive to the exact models used. Certain processes are not well observed or modelled. For instance, if satellites always come across at noon and 6 pm, and it mainly rains at 4 pm, the rainfall estimate is biased.

The second problem is that where there are fewer observations in space and time, the bias becomes more important. The analyses may show different sensitivities to different observations and how they get assimilated.



The first example of weather forecasting is from the European Weather Centre. The models are run many times. Errors are investigated by running the model with slightly different physics each time. A good estimate of errors can be produced in many different processes. This is routinely done in weather forecasting, but also in other areas including ocean modelling, ice modelling, land surface flood modelling. The purple is the spread of 50 different models run with slightly different conditions, and the errors increase in time.

On the right is a graph of intensity, on the left is the track over the number of days after the initial forecast. In this example the model reproduces the storm track quite well, but the model is running too slowly, and it is probably not sufficiently intense in many cases.



It is possible to observe many storms to get average statistics, and to look across different models. These models from many countries are compared with the actual observation (in black), and the models in the different colours. They all get the storm tracks pretty well, but the intensities rather wrong.

As a legal example, if an oil rig is destroyed in a large storm, it matters which model has been used in the analysis as to whether the warning is right, as well as what observations are used. System design and calibration, error reporting and ground design system, have significant impact on the adequacy of information collected to understand what happens.

Discussion

- All Earth observations include errors and biases, which we try and reduce by combining observations with each other, and with models. Almost all “observations” already include some modelling
- Different levels of evidence need different levels of proof, and therefore different observation and calibration strategies
- The controversies around climate prediction show that different stakeholders have different views on proof and uncertainty. How should uncertainty be represented in a legal process?



All observation data, whether from space or not, include errors and biases. These must be reduced by combining different kinds of information together, and with models. Almost all so-called ‘observations’ implicitly include some modelling, to get from a voltage on the back of an instrument to a geophysical quantity that can be useful.

In the controversies in the climate community, as well as in more formal legal senses, different levels of evidence need different levels of proof, and there are different calibration strategies to adopt. The scientific community may need to examine issues of calibration in this regard.


In climate prediction, different stakeholders have very different views on proof and on uncertainty, even on the same problem. How should uncertainty be represented for legal purposes?

2.3 SATELLITE CAPABILITIES FOR OIL SPILL DETECTION AND POLLUTER IDENTIFICATION

This presentation concerns operational surveys to detect oil spills since 2007, by the European Maritime Safety Agency.

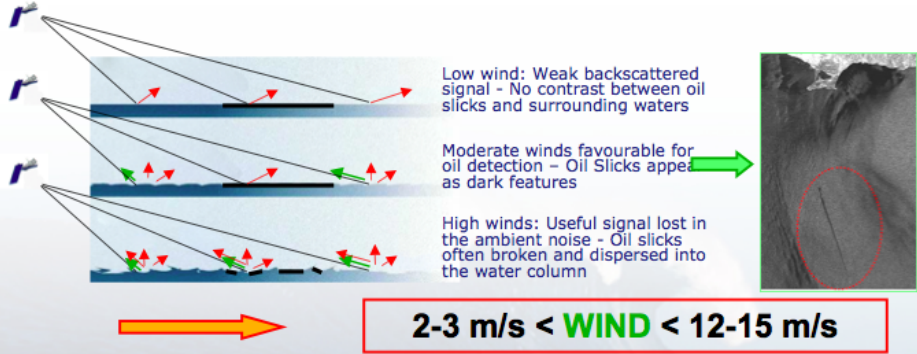


From the 1980s, the Member States wanted to monitor oil pollution at sea. They developed air and sea tools. Satellite observation dates from the mid-90s with the launch of ERS2 and RadarSat1 satellites, although few countries used SAR (Synthetic Aperture Radar) to detect oil spills.

 / European Maritime Safety Agency

Oil Slick Detection in SAR images

- SAR emits electromagnetic pulses and measures the level of the backscattered signal. Doppler history along track is used for azimuth resolution and signal modulation for range resolution.
- SAR sensors provide information on the **surface roughness** of the ocean. Ocean's roughness is **driven by the wind** which creates ripples at the sea surface.
- The presence of a **film on the sea surface damps out small waves** and **reduces the measured backscattered energy** which results in darker areas in the SAR image



Low wind: Weak backscattered signal - No contrast between oil slicks and surrounding waters

Moderate winds favourable for oil detection - Oil Slicks appear as dark features


High winds: Useful signal lost in the ambient noise - Oil slicks often broken and dispersed into the water column

2-3 m/s < WIND < 12-15 m/s

Satellite Capabilities for Oil Spill Detection and Polluter Identification London, 5 October 2010

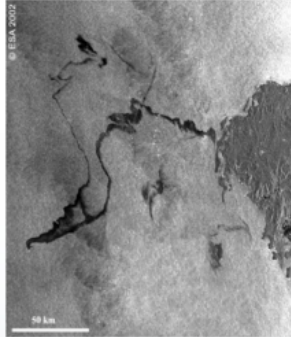
SAR emits a signal that is back-scattered to the emitter. The level of this back-scatter signal is measured. If there is no wind on the sea surface, there will be no waves and no signal coming back to the radar. If there is slight wind, there is a signal. An oil spill will smooth the sea surface, and the signal will not come back. Oil spills will appear as black features on SAR images.

In high wind, the signal is lost, and the oil slick gets broken and weathered by the natural dispersal of the water column. As an estimate, oil slick detection is done using SAR images in good wind conditions, between 2 and 3 metres per second and up to 12-15 m/s.

 / European Maritime Safety Agency

CleanSeaNet


- The European satellite oil pollution monitoring system
- Legal framework - Directive 2005/35/EC on ship sourced pollution and on the introduction for penalties for infringements
- Linked into national/regional response chain strengthening operational pollution surveillance and response for deliberate and accidental spills.
- Service operational since 16 April 2007



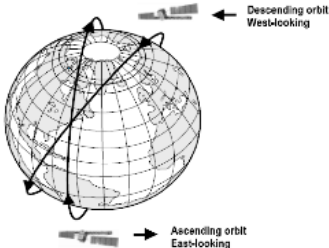
24 EU Coastal States currently users of CSN

Satellite Capabilities for Oil Spill Detection and Polluter Identification London, 5 October 2010

Directive 2005/35/EC tasked the Agency to develop and operate oil pollution detection and monitoring service. As a monitoring tool it is linked to the surveillance systems of the Member States.

 / European Maritime Safety Agency

SAR satellite and SAR products used in CSN



CONTRACTED SATELLITES:

- ENVISAT (01/03/2002*)
- RADARSAT 1 (04/11/1995*)
- RADARSAT 2 (14/12/2007*)

Table of main products used in CSN:

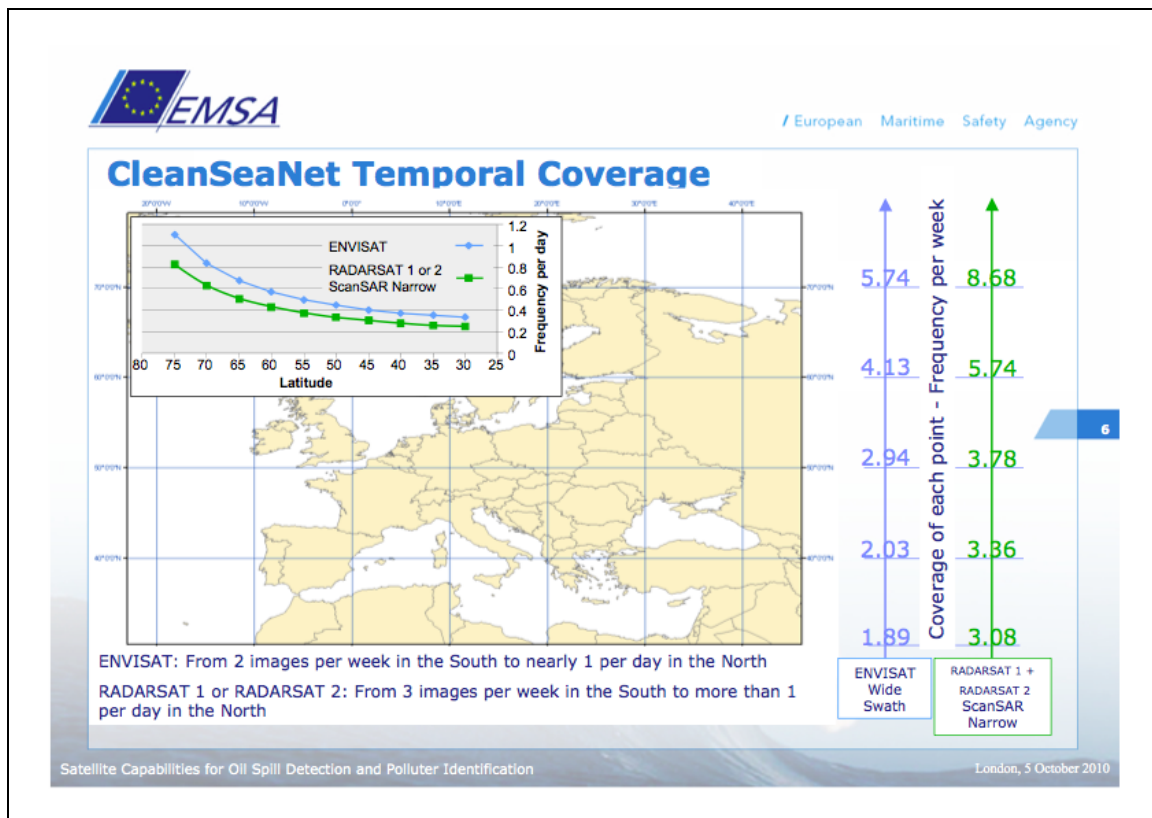
SATELLITE	PRODUCT IDENTIFICATION	Description	Resolution (Range x Azimuth, meters)	Spacing (Pixel x Line, meters)	Area Coverage (Range x Azimuth, Km)
ENVISAT	ASA_WSM_1P	Wide Swath Mode medium-resolution (VV)	150 x 150	75 x 75	405 x 405
RADARSAT-1	RS1_SNA	ScanSAR Narrow A (HH)	50 x 50	25 x 25	300 x 300
RADARSAT-2	RS2_SNA	ScanSAR Narrow (VV)	50 x 50	25 x 25	300 x 300

Occasionally, other sensors/modes can be used.

* Launch dates

Satellite Capabilities for Oil Spill Detection and Polluter Identification London, 5 October 2010

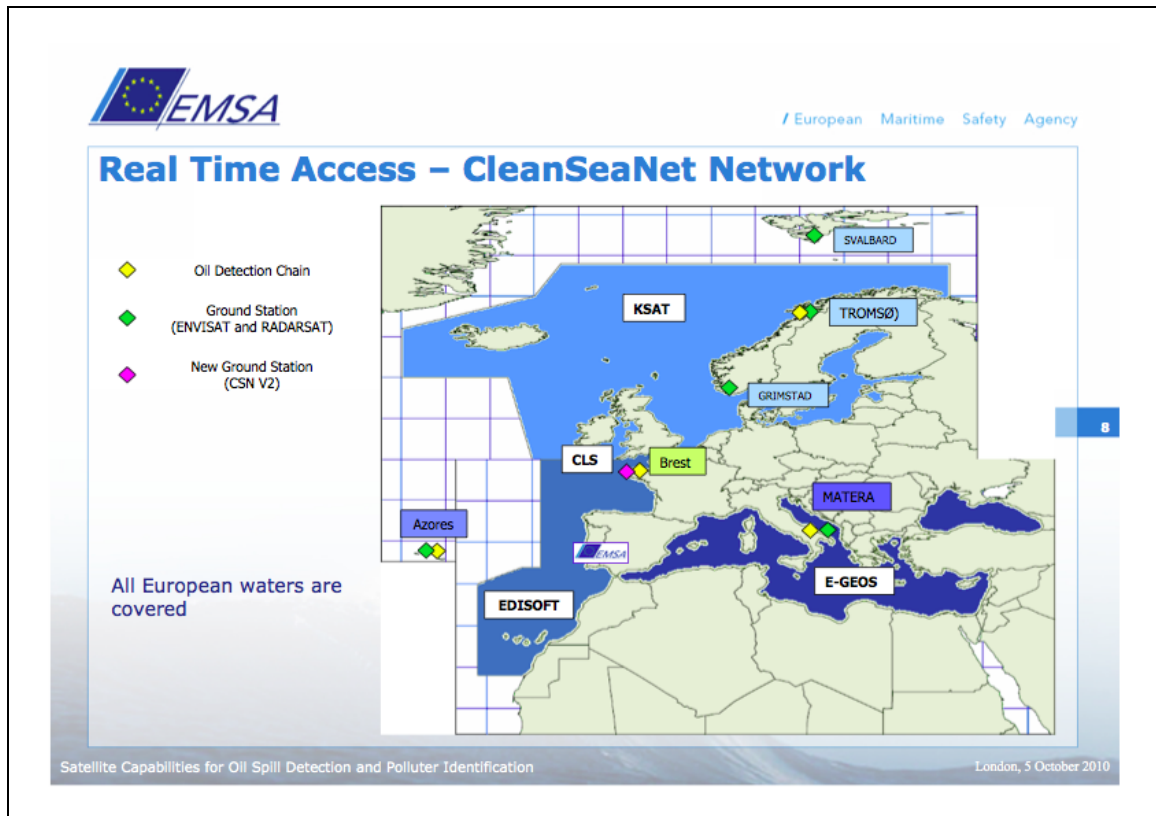
Currently there are 24 coastal States using the service which is based on ENVISAT, RADARSAT-1, RADARSAT-2 radar satellite images. High resolution is not required for oil spill detection. Therefore, satellite images present the advantage to monitor wide sea areas. Aircraft would probably be more cost effective in small areas.



Radar Satellite can monitor up to 400 kilometres wide strips looking for oil spills. An ENVISAT image covers up to 400 x 400 kilometres, and even longer, and RADARSAT covers something like 300 x 300 kilometres in one image. Satellite constraints limit temporal coverage. These polar orbiting satellites pass more often over the poles than the equator. There may be 5 images per week in the Mediterranean, with 3 satellites, but about 14 images per week in northern Norway.



Time is a crucial element to deal with illegal discharges. CleanSeaNet is a near real time service. There is less than 30 minutes between acquisition of data by the satellite, and delivery of the alert to the Member States that a possible spill may have been detected.



To meet near real time requirements, the satellite needs to be visible to the ground station while acquiring data and the oil spill analysis has to be done at the ground station. Then, the results are passed to EMSA and Member States. This requires a network of ground stations across Europe .

The current service, counts 3 service providers and 6 ground stations. CleanSeaNet 2nd generation will be progressively phased in as of December 2010. There will one additional service provider and one more ground station.

Oil Detection in SAR images – Look-alikes

SAR sensors detect all films on the sea surface that damp out small waves generated by the wind

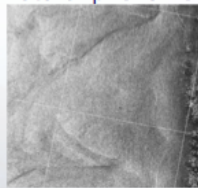
CleanSeaNet detects:

NOT "OIL SPILLS" BUT "POSSIBLE OIL SPILLS"

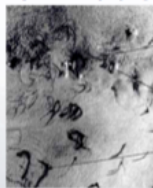
Discrimination between Oil Spills and Look-alikes require more information and most often in-situ verification.

Look-alikes:

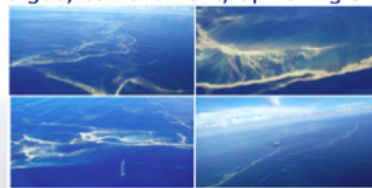
- Other man-made substances: fish or vegetable oil, chemical, sewage, other...
- Natural phenomena: low wind area, algae, current front, upwelling area...



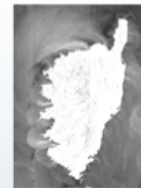
Current fronts



Low wind, rain cells
and oil seepage



Algae

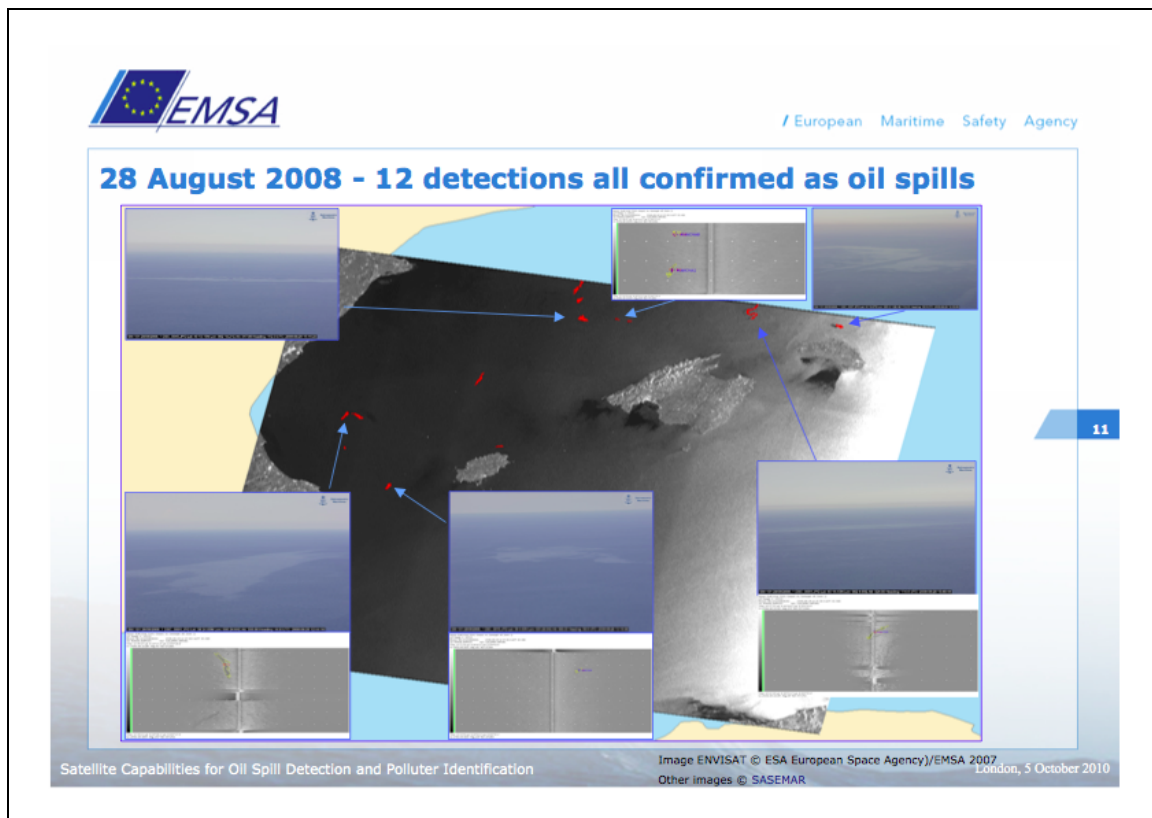


Land breeze


A SAR satellite does not detect oil spills - it detects possible oil spills. Any material that will produce the same effect as oil on the sea surface will have the same dark appearance. With experience it is possible to improve reliability and to be able to discriminate between oil spill and what we call 'look-alikes' that may be man-made, like fish or vegetable oil, chemical or natural phenomena.

Nevertheless, the system is very efficient at detecting oil spills. Oil spills are likely to be detected if there is satellite acquisition of the incident. Between the start of the service in April 2007, and December 2009, more than 7,000 spills were detected. Of almost 2,000 that were checked onsite, 542 were confirmed as mineral oil, a 27% rate of confirmation.

If the on-site verification is undertaken too late, there is a great chance that the spill will have weathered out and disappeared. By limiting the verification to aircraft and to a period of 3 hours after acquisition, the rate of confirmation increases a lot. In 2009 the confirmation rate was over 50% with an aircraft check less than 3 hours after satellite overpass. In the two past months, that rate was over 60%.

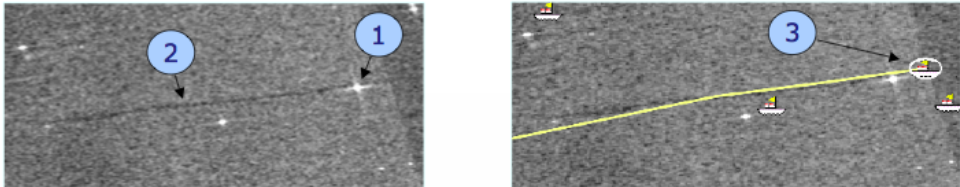


With this image 12 spills were detected and 12 were confirmed off Spain. The slide shows the SAR satellite image and for each spill the SLAR (Side Looking Airborne Radar) and optical images acquired on site by the aircraft.

 / European Maritime Safety Agency

Catching Polluters

**CleanSeaNet is able to
DETECT AND IDENTIFY DISCHARGING VESSELS**




- 1 Ship detected on SAR image (Bright Spot)
- 2 Long and linear possible spill trailing in the wake
- 3 Vessel identified

**A DISCHARGE? YES
OIL SPILL? POSSIBLE**

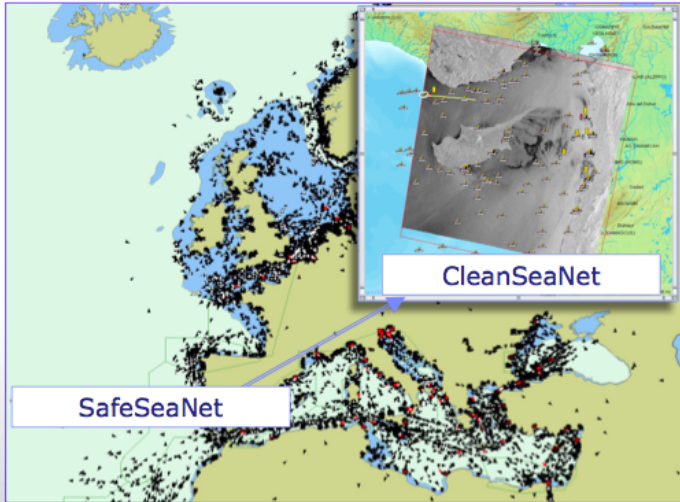
Satellite Capabilities for Oil Spill Detection and Polluter Identification London, 5 October 2010

SAR is used to detect possible spills and discharging vessels. A ship appears as a bright spot on radar. A linear trail in the wake of the vessel shows a high probability a discharge is going on. Requires additional information to determine the product spilt (oil or other substance).

 / European Maritime Safety Agency

Vessel Identification

AIS information from SafeSeaNet overlaid on SAR images




SafeSeaNet Figures

- 727 AIS coastal stations
- 2.326 data providers and 556 authorized users in 22 EU coastal states, Norway and Iceland
- 20.000 ships tracked in European waters: average of over 100.000.000 AIS positions per month

Satellite Capabilities for Oil Spill Detection and Polluter Identification London, 5 October 2010

To identify the vessel, the satellite image is overlaid with vessel traffic monitoring information from SafeSeaNet. SafeSeaNet is a European service built on the traffic monitoring systems of the Member States, with more than 700 coastal stations. Onboard AIS information passes on the position of the vessel, based on GPS.


/ European Maritime Safety Agency

Catching Polluters

In case of a discharge detected by CleanSeaNet

PROVING A MARPOL VIOLATION

REQUIRES COMPLEMENTARY EVIDENCE

Evidence can be collected on site and/or in port




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Satellite image: © CSA/MDA/EMSA 2008
 SLAR image: © Swedish Coast Guard 2008
 Photo: © Swedish Coast Guard 2008

Satellite Capabilities for Oil Spill Detection and Polluter Identification
London, 5 October 2010

It is possible to detect a discharge, but not necessarily to say if it is a violation of the MARPOL marine pollution convention. For this, complementary evidence collected on-site or in port is required.

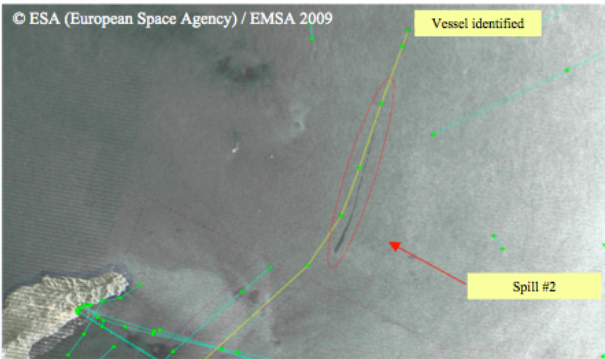
In the case illustrated below, following satellite detection, an aircraft was dispatched to the position of the satellite detection and the polluter was caught in the act.

 / European Maritime Safety Agency

Catching Polluters

On Site follow-up brings actionable evidence

© ESA (European Space Agency) / EMSA 2009



3 oil spills confirmed by aircraft:

1. 154 km long
2. 42 km long
3. 14 km long

2 polluters identified using AIS information


One polluter caught in the act (154 km long spill)

ENVISAT image acquired over the Canary Islands on 15 September 2009 by the Azores ground station

Satellite detection may serve as corroborating evidence:
Full extent of the spill – Link between spill and polluter

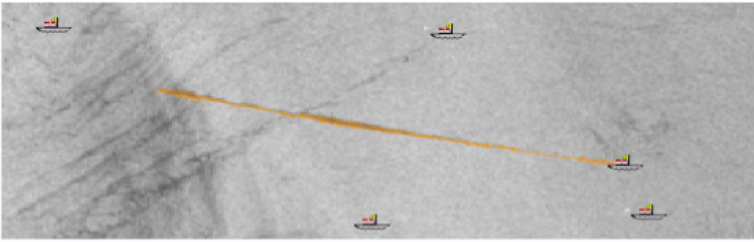
Satellite Capabilities for Oil Spill Detection and Polluter Identification London, 5 October 2010

In some Member States CleanSeaNet detection constitutes suspicion of illegal discharge. That may trigger an inspection in port on which proceedings are based.

 / European Maritime Safety Agency

Catching Polluters

CleanSeaNet detection may be considered sufficient to CONSTITUTE A SUSPICION OF AN ILLEGAL DISCHARGE




18 August 2010 – Discharge detected 45 Nautical miles off Sicily
 Inspection in the next port of call (Not Paris MoU Member)
 Evidence collected proves that the ship has been illegally discharging in the past

CleanSeaNet more and more used to TRIGGER INSPECTIONS IN PORT

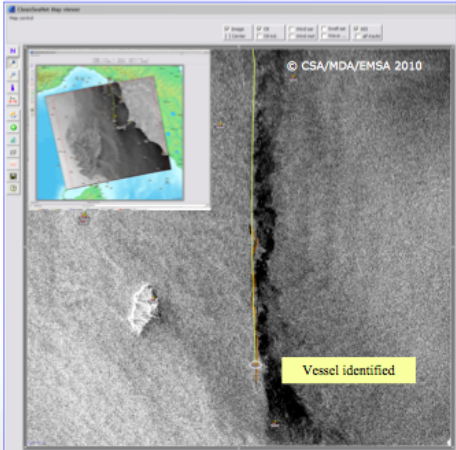
Some vessels detained or fined based on the evidence collected in port

Satellite Capabilities for Oil Spill Detection and Polluter Identification London, 5 October 2010

Here the satellite information was used to trigger the inspection in port. Evidence collected in port, shows that the vessel has illegally discharged at some time, but it would be very difficult to prove that it was this specific discharge.

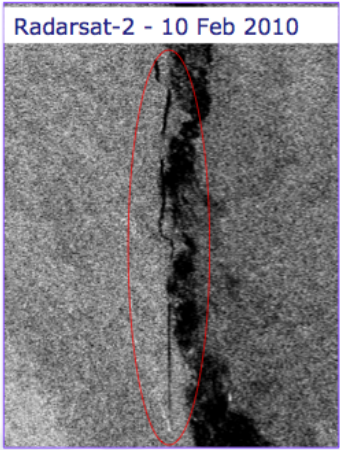

European Maritime Safety Agency

Catching Polluters



Vessel identified

Radarsat-2 - 10 Feb 2010



Vessel en-route from Italy to Lybia (Not Paris MOU member)
 A few days later, back to Italy
 Inspected and detained (oil/water separator out of order)

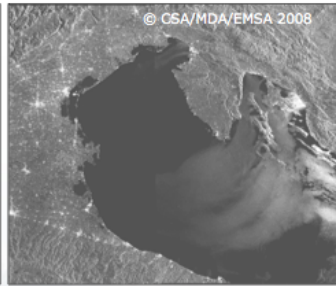
Satellite Capabilities for Oil Spill Detection and Polluter Identification
London, 5 October 2010

Satellite data can also be used as corroborating evidence to demonstrate the full extent of the spill and the link between the spill and the polluter.



/ European Maritime Safety Agency

CleanSeaNet web portal:
<http://cleanseanet.emsa.europa.eu>



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satellite coordinators@emsa.europa.eu

Satellite Capabilities for Oil Spill Detection and Polluter Identification

London, 5 October 2010

3. CASES USING EO INFORMATION - *Space and Aerial Information*

In several application areas satellite-derived EO information is already used. The experience of such use was recounted by three of the Presenters. Applications examined were those of land subsidence, agricultural subsidy claims and audits of international aid provided by the Netherlands.

The technique known as Permanent Scatter InSAR, developed by an Italian team, provides the means to measure land movement. It has been used in one decided case in Italy, relating to the subsidence damage caused to a historical monument in Rovigo. This was a penal proceeding, requiring a reasonably high standard of proof.

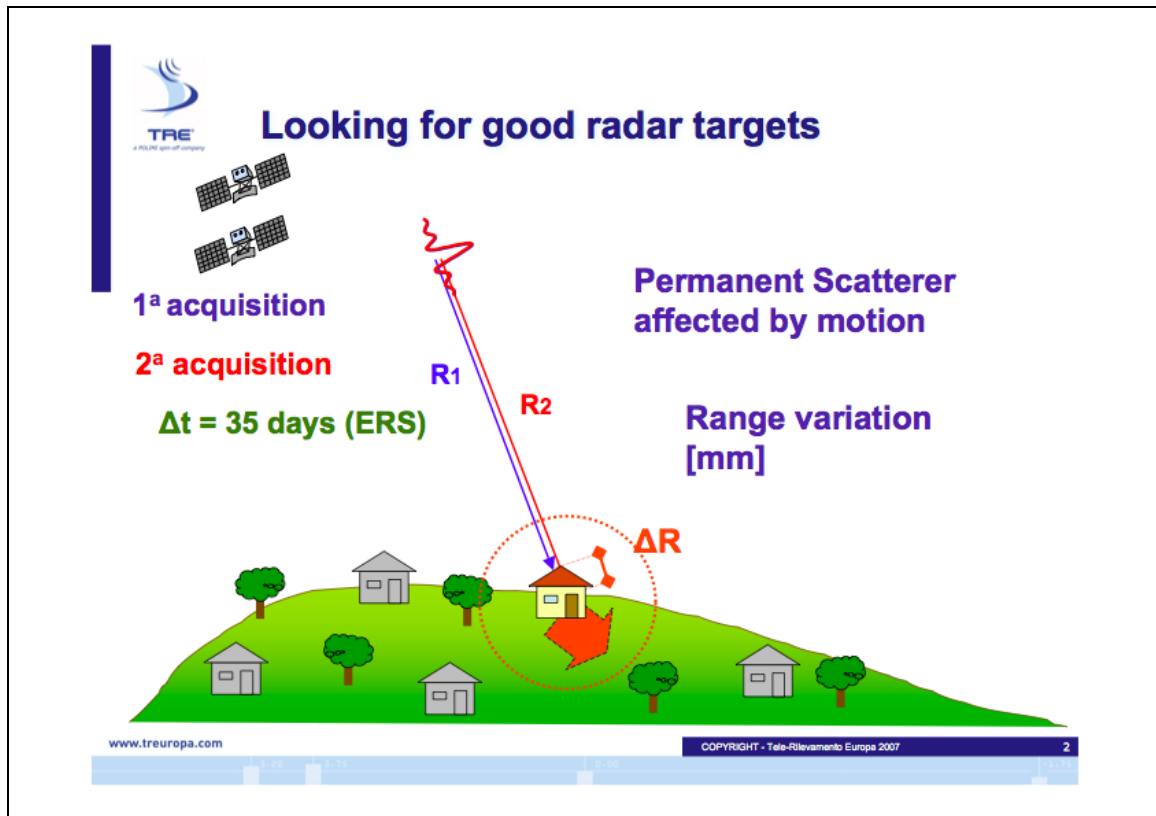
Satellite-derived EO is used to verify agricultural subsidy claims under the European Common Agricultural Policy from time to time. There are many grounds on which subsidy can be claimed. This provides a reasonably varied range of scenarios against which to assess evidential issues.

Another area of verification is presented by assessment of the flow and effectiveness of disaster aid from government funds. Satellite-derived information has been used for this purpose by the Netherlands. This presentation highlighted the importance of reliability and accuracy in audit applications.


This session deals with cases using earth observation information, focusing both on space and aerial information.

3.1 LAND SUBSIDENCE CASES, INCLUDING ROVIGO

Radar allows measurement of the distance between the radar sensor and the radar target. It is possible to compare acquisitions at two different times for the detection of possible surface deformation, in particular the displacement of individual buildings or structures.



The radar data can be subjected to analysis by different techniques. PSInSAR (Permanent Scatter Interferometric Synthetic Aperture Radar) is a technique developed by the Polytechnic University of Milan, particularly useful in measuring small land surface movement over time.



Accuracy (PSInSAR™ data)


Typical values @ < 1 km from the reference point
>40 images – ERS and ENVISAT satellites (C-band)

<u>Displacement (LOS)</u>	Average Displacement Rate	Single Measurement
Precision (1s)	<1 mm/yr	<5 mm

<u>Positioning</u>	E - W	N - S	Height
Precision (1s)	6 m	2 m	1,5 m


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The displacement rate can be as precise as 1mm per year. On a single measurement better than 5 mm is possible. These are differential measurements common to other geodetic networks.



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TELE RILEVAMENTO EUROPA

Rovigo Case Study



- **In 1994, three different churches in the centre of Rovigo were affected by severe damages caused by terrain settlement**
- **In the same period, a major excavation area was present about 100-120m apart from the churches**
- **A legal action started quite soon, but after 6 years was still unclear whether or not the excavation work could have caused terrain settlement more than 100m apart**
- **Experts appointed by the company in charge of the excavation claimed that the settlement influence zone could not affect the monuments, due to the distance of the churches from the excavation area**

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In 1994, three churches in the centre of Rovigo, all national monuments, were damaged by subsidence, at the same time that there was a major excavation about 100 metres away. In the legal action that followed, the excavating companies claimed that the damage pre-dated the excavation. Experts were appointed, and it was not at all easy to find a solution.



Rovigo: excavation and damages





Excavation of an underground parking in the centre of Rovigo, Italy in 1994-1995. The intensive water pumping lowered the piezometric level of more than 3 m during the excavation works and subsequent activities.

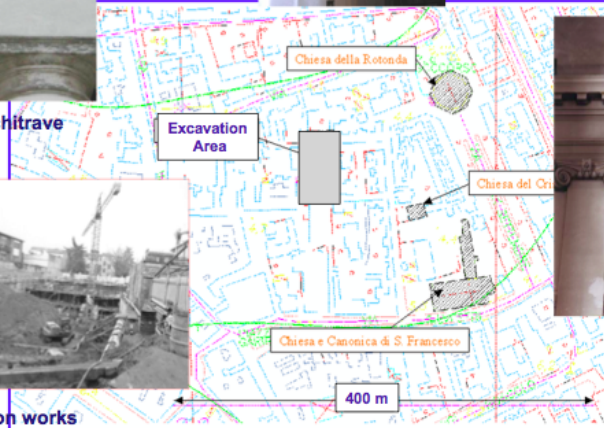
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The damage was serious, and relates both to the size and the technique used for excavation.



Rovigo



Plaster peeling off the walls

Cracks on the architrave

1994: excavation works


Church of S. Francesco: fissures and cracks on the walls

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Fissures and cracks appeared in the walls of the Church of San Francesco. Plaster was peeling from the walls of the Chiesa del Christo. Cracks appeared on the architrave of the Chiesa della Rotonda. The map shows the excavation area at centre of the area where many buildings were affected. The difficulty was that there was some distance between the excavation area and the buildings.



TRE
a POLIMI spin-off company

Satellite Radar Data

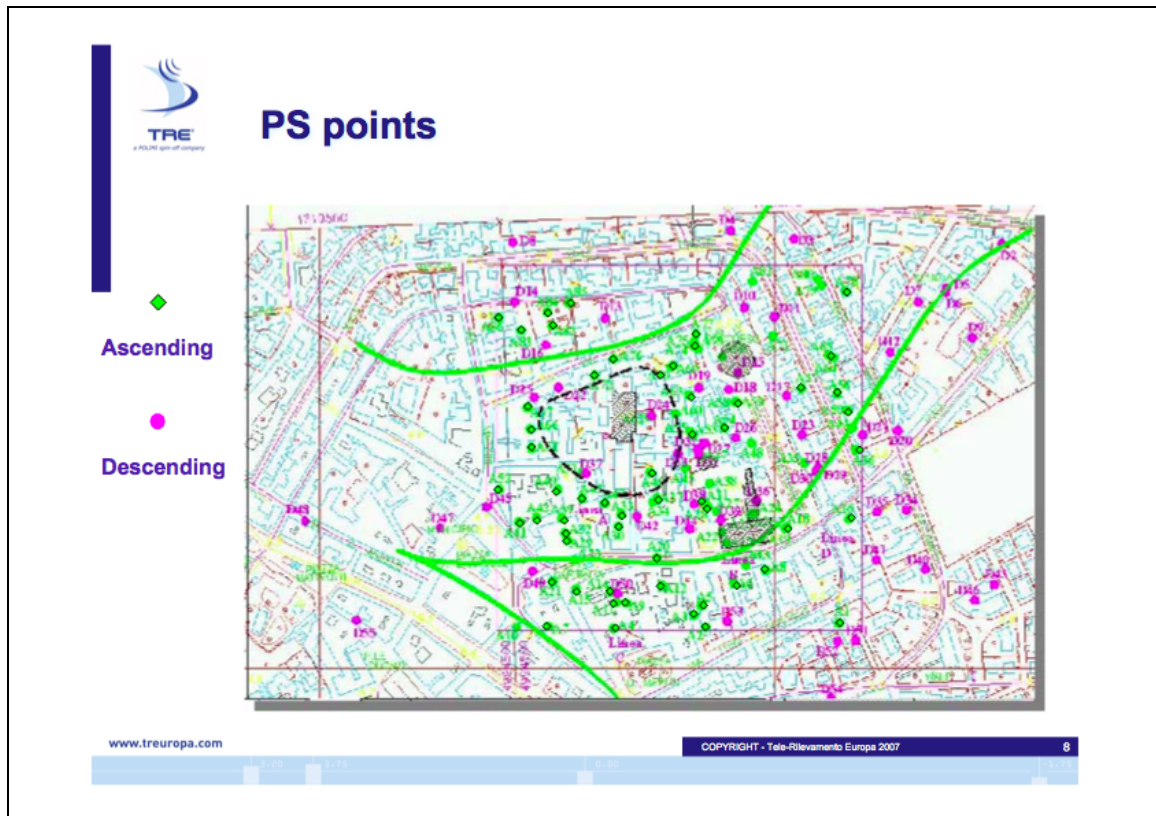


- **In 2001, Lorenzo Jurina, POLIMI professor, involved in the trial as expert by the Italian Ministry of Historical Heritage, contacted TRE to assess whether or not satellite radar data could show any evidence of terrain deformation in 1994.**
- **2 data-sets were identified, acquired over Rovigo from 1992 to 2000 by the ERS-1/2 satellites, operated by ESA. One data-set was acquired along ascending satellite orbits, while the other was a “descending” data-set.**
- **2 independent PSInSAR™ analyses were carried out over an area of about 20 km² centred on the excavation area**
- **The area of major interest was a 400x400m area where 145 measurement points were identified (from both data-sets)**

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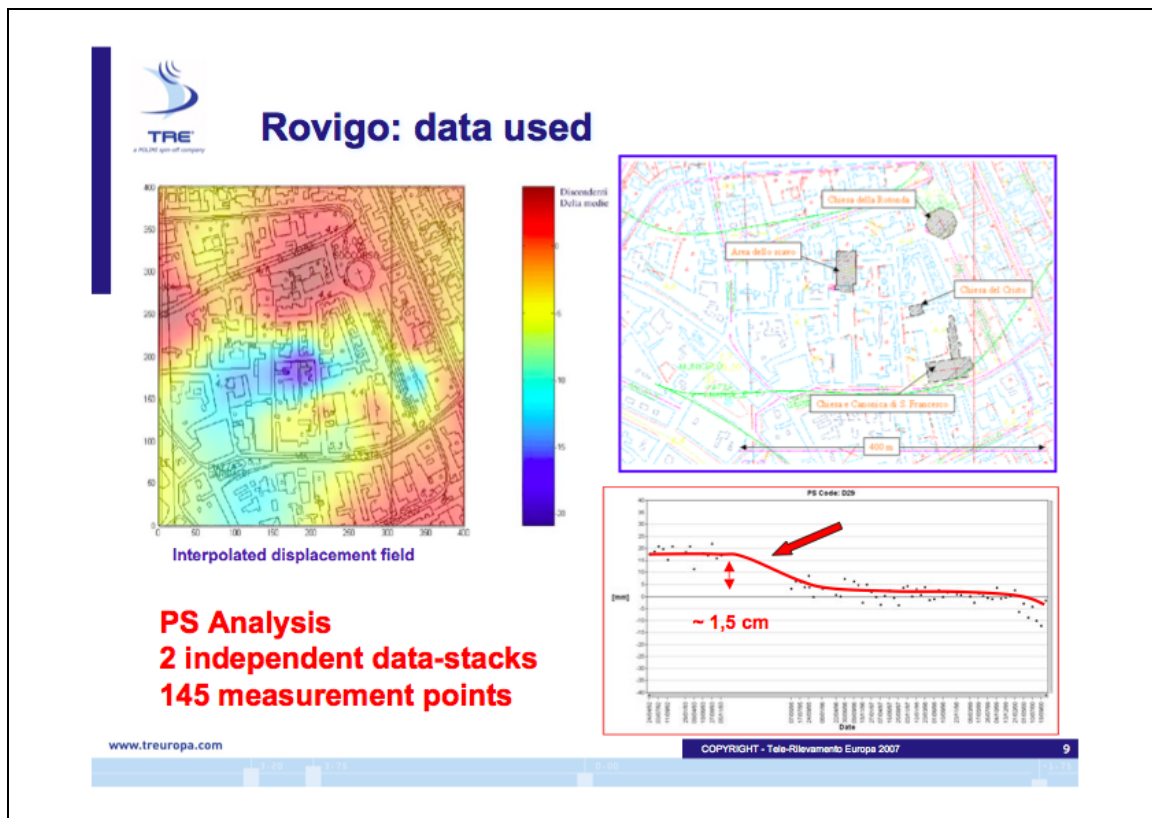
Many expert geophysicists, geologists, and structural engineers considered it unlikely that damage could have resulted 100 or 150 metres from an excavation. The Italian Ministry of Historical Heritage and the municipality of Rovigo then engaged a new expert, Lorenzo Jurina at the Polytechnic. He asked TRE to process all the data available, to investigate when the churches suffered from subsidence.

The ESA archive contained two independent data sets covering the relevant area of Rovigo. It was also possible to carry out PSInSar analysis to identify more than 140 measurement points distributed over the area of interest.




This is the area of interest containing the three churches and the excavation area. It illustrates the estimated maximum area that could be affected by the excavation works, based on geological data available.

The coloured dots correspond to the permanent or persistent scatter of targets on roofs of buildings, or balconies, which can be detected by the radar systems onboard the ERS satellite.

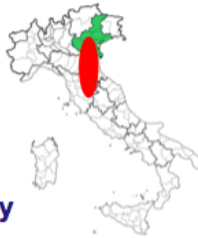


More than 70 measurement points were measured, 30 of one data set, and 40 of an independent data set, showing there was indeed a drop of more than 1.5 centimetres in 1994. The area affected by the deformation was much larger than expected.



TRE
a PSInSAR spin-off company

“Ground Truth”




- **It is well known that the area of Rovigo is affected by subsidence phenomena due to soft terrain.**
- **Subsidence rates of about 2 mm/yr have been measured using optical leveling surveys about 1 km apart from the area of interest for the trial**
- **The 2 PSInSAR™ data-sets both confirmed this well-known phenomenon with high accuracy.**
- **Confirmation of PSInSAR™ data using *in situ* observations allowed a sort of calibration and ground truth assessment of remote sensing data**

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This is a new technique. It was important to calibrate the data with ground truth, as indeed was requested by the experts from the other side. It was possible to compare PSInSAR data with data from optical levelling surveys carried out over Rovigo, and in an area close to the excavation area. Exactly the same surface displacement rates were found in both independent SAR data sets, in agreement with the optical levelling surveys. The two PSInSAR data sets confirmed the phenomenon with high accuracy, better than 1 millimetre per year. The confirmation of PSInSAR data and situ information allowed a sort of calibration and ground-truthing.



TRE
a POLITECNICO company

Evidence



- **Confirmation of a well-known phenomenon was very important**
- **Cross-validation was even more important: two independent data-sets processed independently showed the same picture: terrain settlement happened in 1994 and the area affected by subsidence was centred in the excavation area**
- **Satellite data were not the only data used in the trial (geological models, reports on the age of the damages and the techniques used during the excavation, etc. were all taken into account), but - for sure – radar interferometric data were the only *measurements* available**

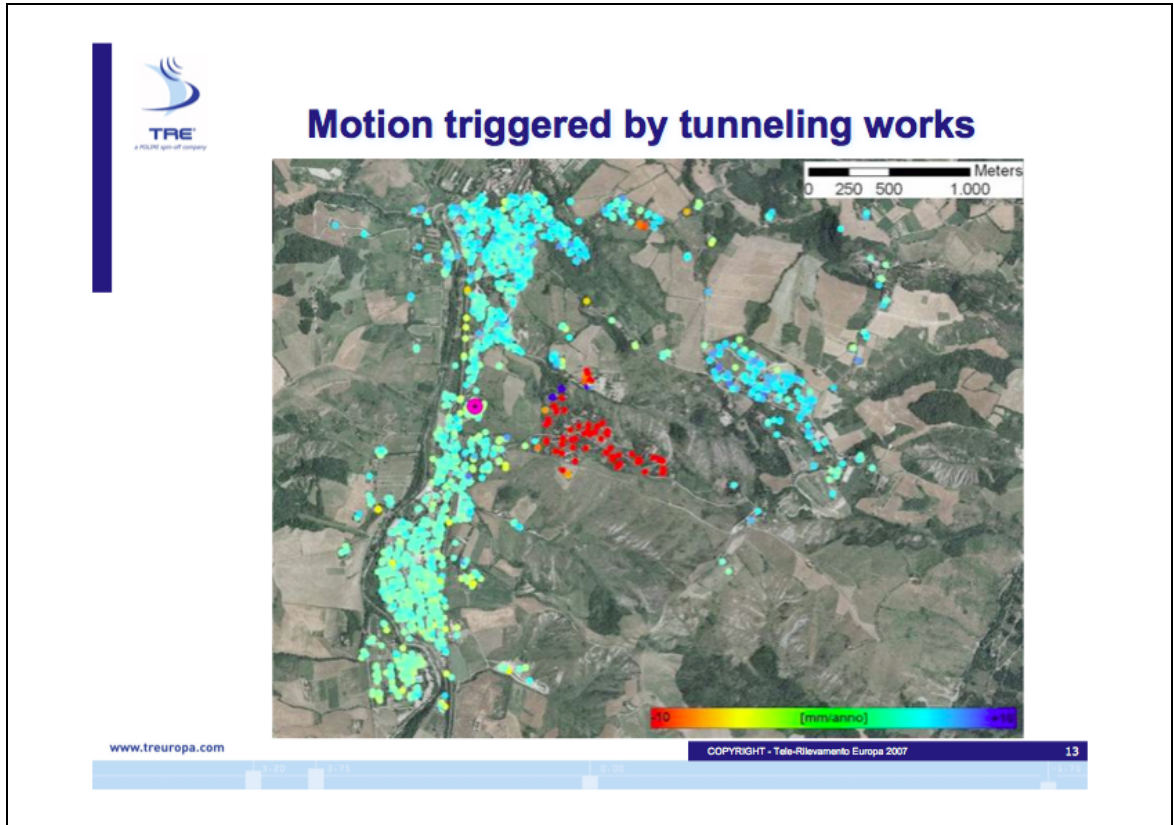
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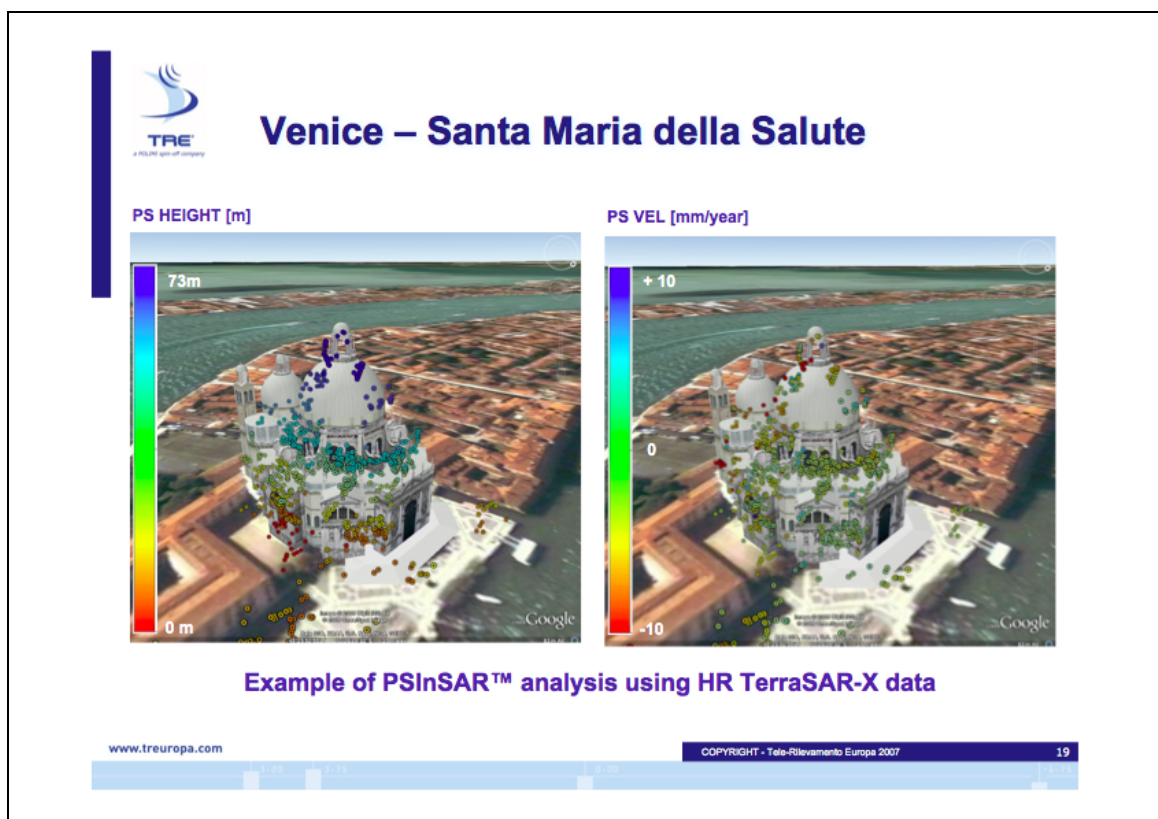
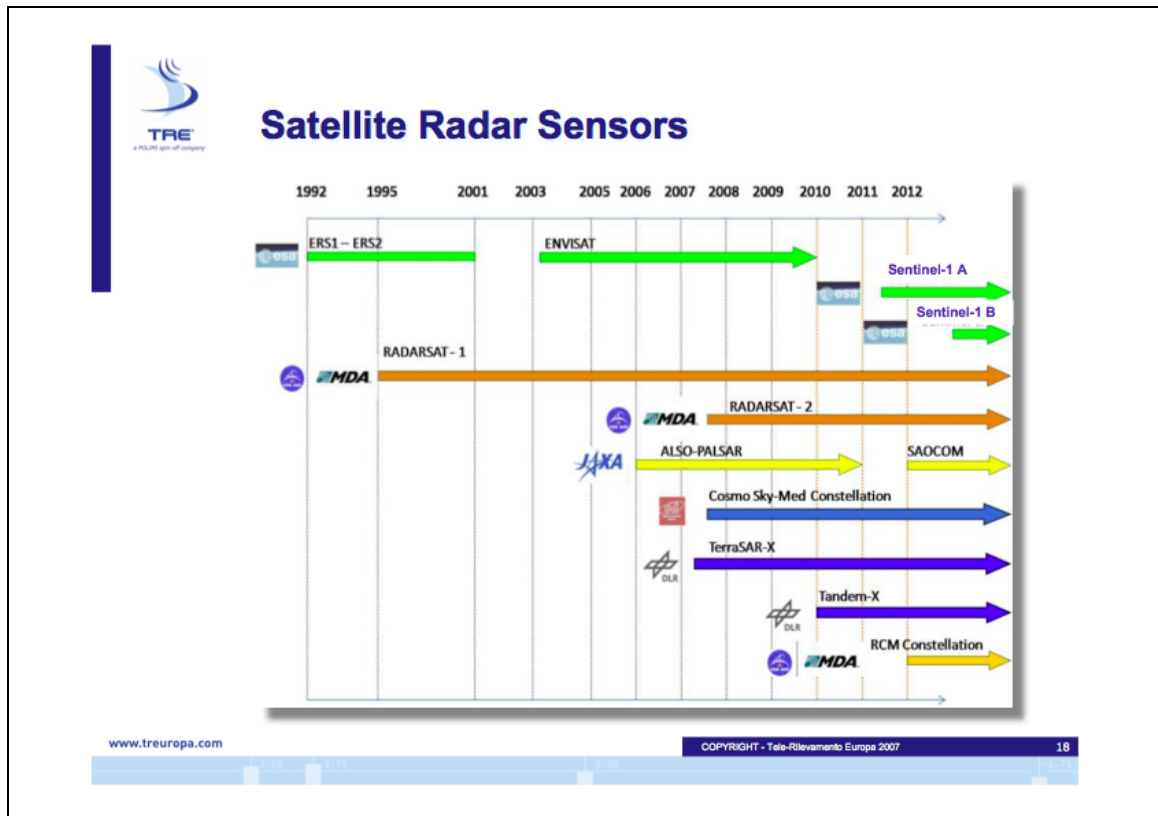
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For the first time it was possible to confirm the settlement, after years of experts saying it was not possible based on geological models. This kind of data will become more and more common in litigation.

[Note: The following slides, 12 to 24, were not presented at the Workshop, but may be of interest.]








Conclusions

- **SAR data** can be extremely useful to assess whether an area or an individual building was affected by terrain compaction or subsidence
- **Advantages:** high precision; quantitative and reliable data; fast data processing; regular updates; cost-effective.
- **Historical archives** of radar data are available since 1992
- **Limitations:** not all radar targets are good PS. Artificial reflectors should be installed to allow the monitoring of individual structures where no PS is present.
- In the **future** more and more satellite data will be available and SAR measurements will become a standard monitoring tool.


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3.2 AGRICULTURAL SUBSIDY CLAIMS: VERIFICATION, FRAUD AND EXPERT EVIDENCE

Farmers in the European Union receive subsidies under the Common Agricultural Policy, CAP, by filing claim under various farming provisions. To avoid excessive or unjustified claims, sample claims and those that appear wrong are verified. Earth observation plays an important role in this process.



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MARS
Monitoring Agricultural Resources

Joint Research Centre of the EC?

- **JRC Mission:**
 - **"The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies.**
 - As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union.
 - Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national."

JRC is part of the European Commission, and provides technical support for Commission policy.



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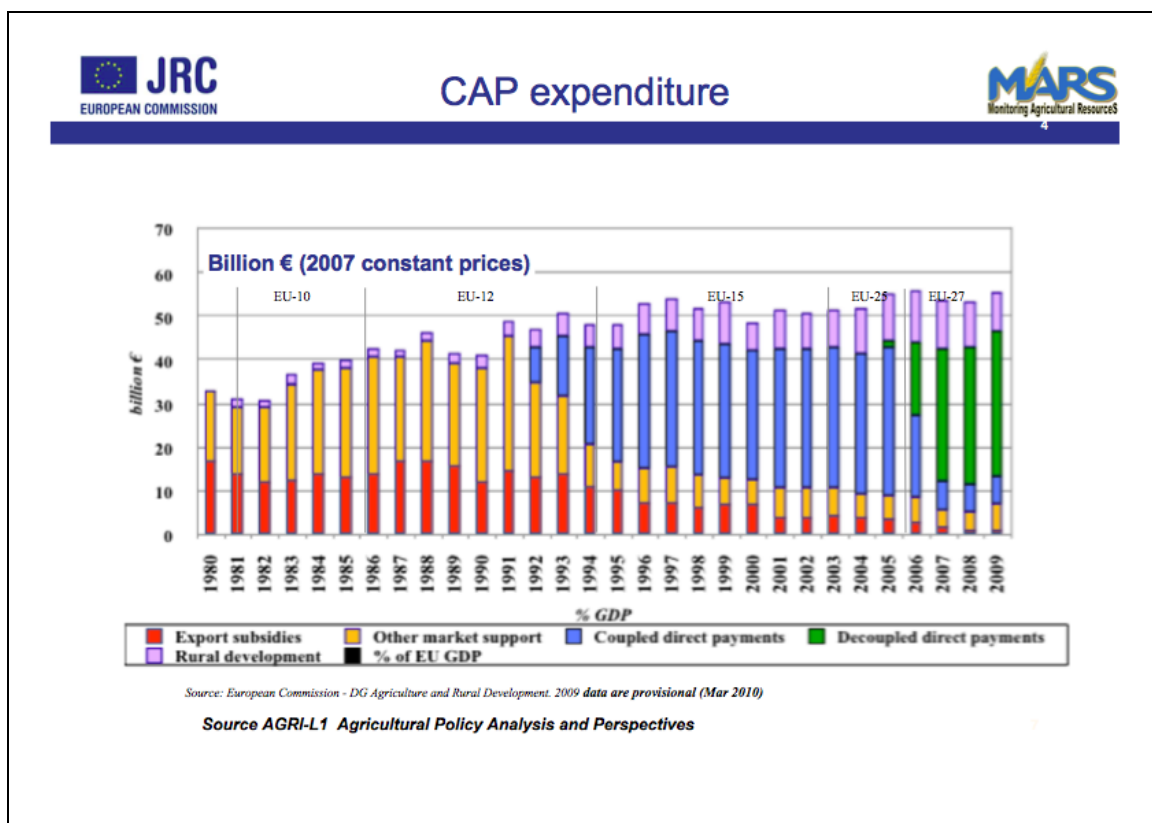


MARS
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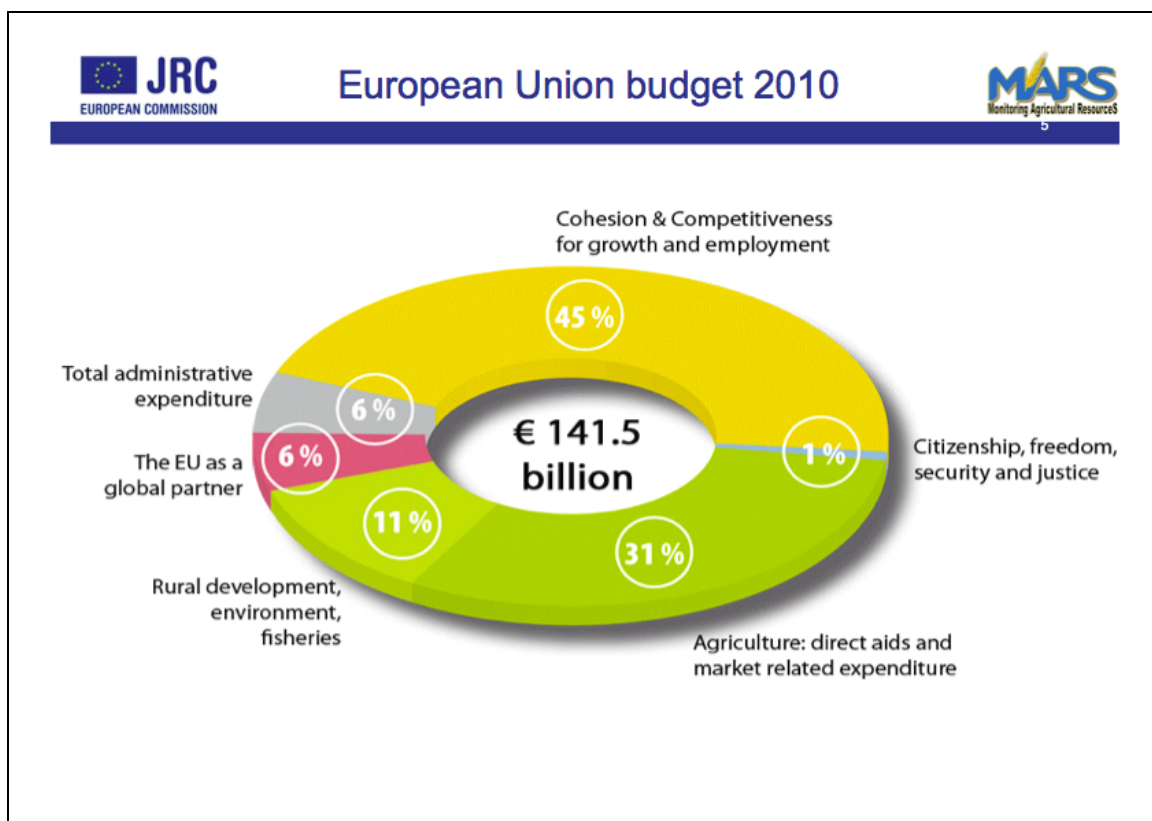


The screenshot shows the MARS Unit website with the following content:


- European Commission Joint Research Centre MARS**
- The Monitoring Agricultural Resources (MARS) Unit Mission**: We provide scientific and technical support on EU Agriculture and Food Security policies.
 - In Europe, the Unit addresses key issues related to the management and control of the Common Agriculture Policy; Independent crop yield forecasts, agricultural insurances, standard control methods of area based subsidies, compliance with environment, and effect of climate change. It supports EU projects related to Land Administration, the enlargement process, and the GMES Space Component.
 - In developing countries, assistance is given to the EU Food Security Thematic Program with special emphasis on Africa, and to providing building blocks for an European capacity for Global Agriculture Monitoring. The activities of the Unit are based on expertise in agro-meteorological crop modelling, sampling methods, econometric, geomatics (GIS, GPS and ICT), and satellite & airborne remote sensing (the Unit manages the EC Framework Contracts for the provision of Satellite Remote Sensing data and manages the access/dissemination of EU map data archives).
- Latest News & Events**:
 - WikICAP now available to everyone for reading. We are pleased to announce that our WikICAP platform is now available to everybody for reading. You can find it at http://marwiki.jrc.ec.europa.eu/wikicap/index.php/Main_Page. Please not...
 - 2009 GAEC workshop: GAEC Implementation after the Health Check adjustment. This year the workshop is organized jointly by the Irish Department of Agriculture, Fisheries and Food (DAFF) and the MARS Unit of the JRC. It is dedicated to the changes of the GAEC after the Health Check.
 - LPIS 2009 Workshop, Tallinn, October 6th-8th
 - 15th GeoCAP Conference - Taormina ITALY 18-20 November 2009. The 2009 GeoCAP annual conference - the fifteen of the series - is jointly organized by the GeoCAP Action of the MARS Unit and the Italian Agenzia per le Erogazioni in Agricoltura (AGEA). The conference, entitled "Geomatics in support of the CAP", will take place from 18 to 20 November...
 - New distribution system for ECMWF derived metadata available. MARS FOODSE has replaced the previous system for ECMWF derived meta data downloads with a new one. The new system includes real time data and Era-Interim data at a 0.25 degree resolution, in addition to the 1 degree resolution data distributed previously.
- Latest Bulletins & Publications**:
 - MARS Bulletin Europe - Forecast Update - 01.09.2009 Vol. F12009 No. 2




Approximately €56 billion a year goes to farmers.



This year direct payments are about €43 billion to manage land, and about €12-15 billion for various improvements on that land.

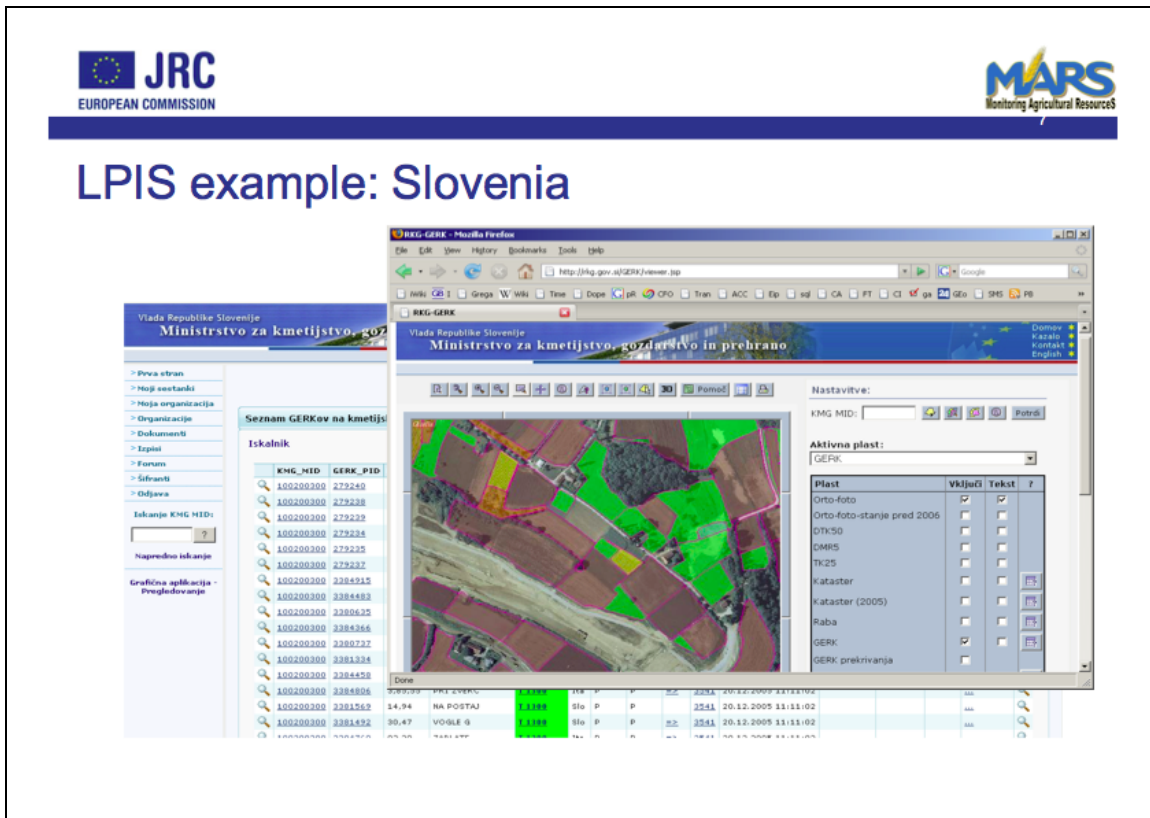

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The CAP today – the basics

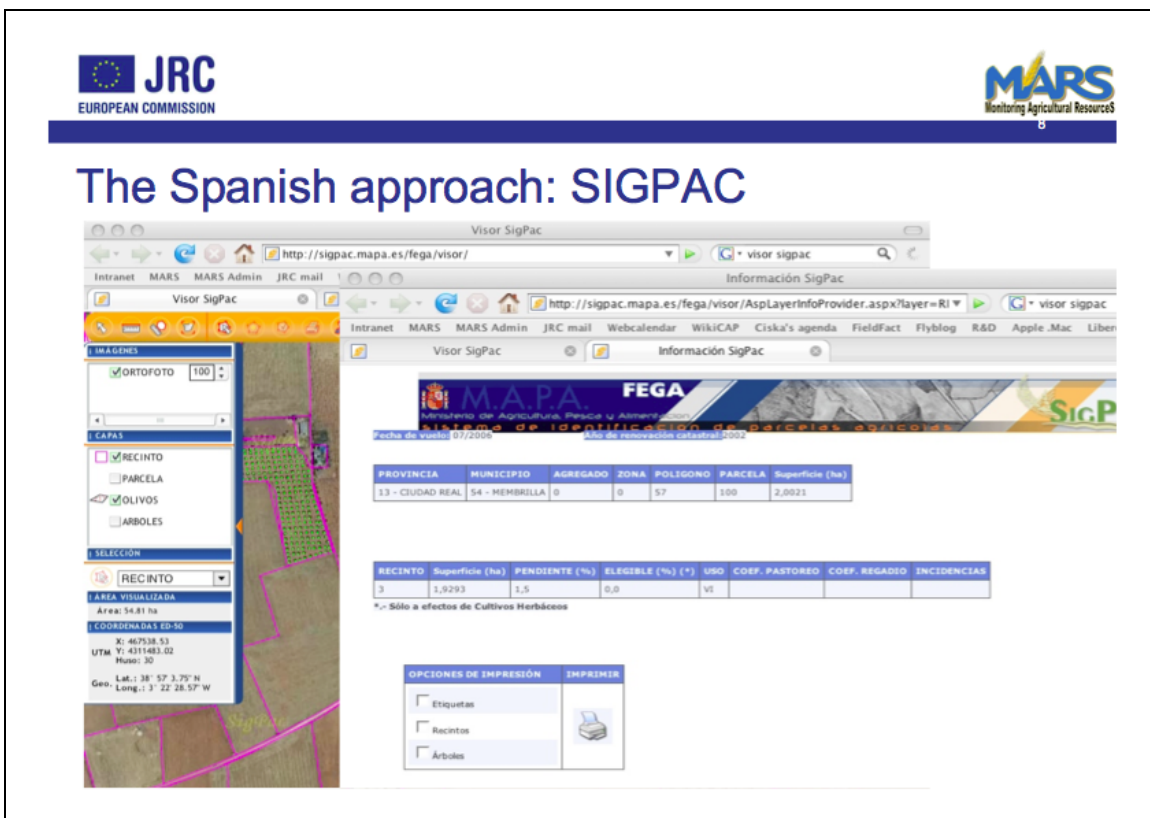

Monitoring Agricultural Resources

- Since 2005, the majority of aid to farmers is paid *independently* of production – **Direct Payments (€43B in 2010)**
 - Other payments are made under the **Rural Development** program
- In addition, farmers have to respect environmental, food safety, phytosanitary and animal welfare standards.
 - **Cross Compliance** - Farmers who fail to do this will face reductions in their direct payments

Farmers are not being paid for crops, but are effectively paid to take care of the land. They are required to do cross compliance, which relates to environmental and other Directives in European legislation that have been implemented in national law.



Behind this is a remote sensing-based information framework, the Land Parcel Identification System.



This example from Spain is based on aerial photographs taken about every 5 years (but several member states use satellite imagery). Each field managed by a farmer is actually located, like a cadastral system focused on the land that the farmer uses. There are 138 million European fields mapped. Farmers have to input into a database used to process their claims.

The slide shows how precise these photographs can be, with detail including olive trees, on the left, which were the subject of subsidies at the time.

ANNEX III		
Good agricultural and environmental condition referred to in Article 6		
Issue	Compulsory standards	Optional standards
Soil erosion: Protect soil through appropriate measures	— Minimum soil cover	— Retain terraces
	— Minimum land management reflecting site-specific conditions	
Soil organic matter: Maintain soil organic matter levels through appropriate practices	— Arable stubble management	— Standards for crop rotations
Soil structure: Maintain soil structure through appropriate measures		— Appropriate machinery use
Minimum level of maintenance: Ensure a minimum level of maintenance and avoid the deterioration of habitats	— Retention of landscape features, including, where appropriate, hedges, ponds, ditches, trees in line, in group or isolated and field margins	— Minimum livestock stocking rates or/and appropriate regimes
	— Avoiding the encroachment of unwanted vegetation on agricultural land	— Establishment and/or retention of habitats
Protection and management of water: Protect water against pollution and run-off, and manage the use of water	— Protection of permanent pasture	— Prohibition of the grubbing up of olive trees
	— Establishment of buffer strips along water courses (*)	— Maintenance of olive groves and vines in good vegetative condition
	— Where use of water for irrigation is subject to authorisation, compliance with authorisation procedures	

Council Reg 1122/2009

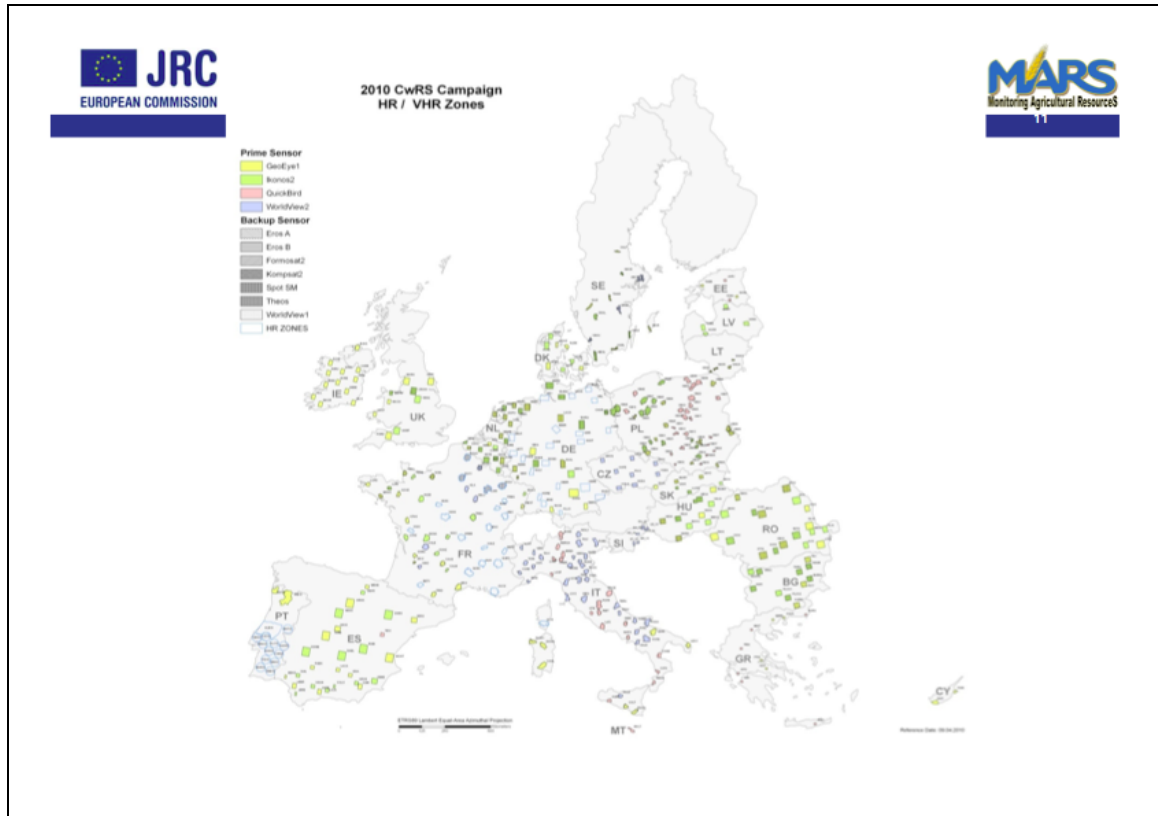
(*) Note: The GAEC buffer strips must respect, both within and outside vulnerable zones designated pursuant to Article 3(2) of Directive 91/676/EEC, at least the requirements relating to the conditions for land application of fertiliser near water courses, referred to in point A.4 of Annex II to Directive 91/676/EEC to be applied in accordance with the action programmes of Member States established under Article 5(4) of Directive 91/676/EEC.

The basis for the system is legislation that has been in place for about 18 years. The latest version is Council Regulation 1122/2009, which includes the cross-compliance requirements.


The slide details areas of monitoring, such as soil erosion, and landscape features like hedgerows.



This example of an auditor in a field illustrates how expensive it would be to audit 138 million fields by sending a person to collect direct evidence. This is of course administrative management rather than specifically legal, but the collection of the evidence is fundamental.




About 5-7% of farms are checked yearly, in the order of 5 to 10 million fields. This year's satellite acquisition campaign is shown, covering more than 200,000 square kilometres of earth observation imagery. The approach has evolved into this pattern, showing imagery with detail of about one half to one square metre.

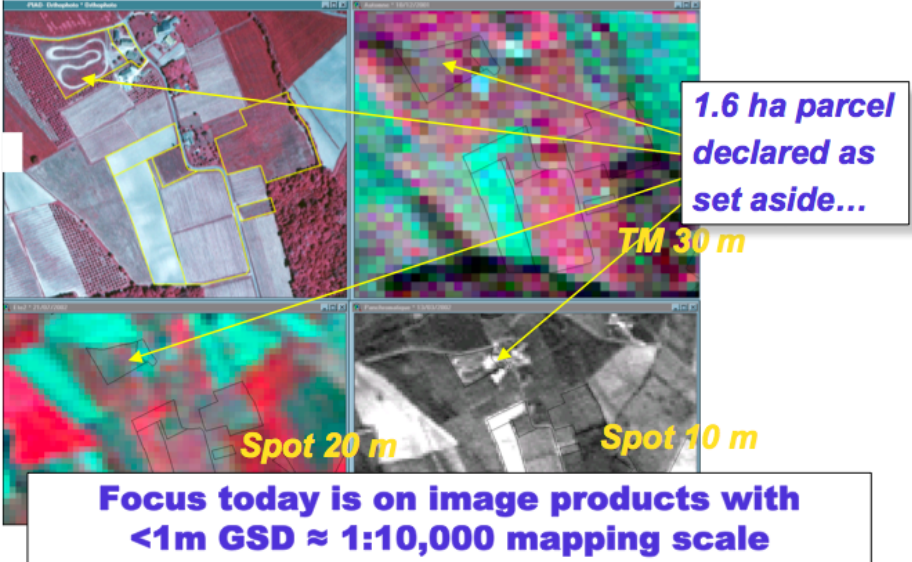


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Subsidy checks in the CAP



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1.6 ha parcel declared as set aside...

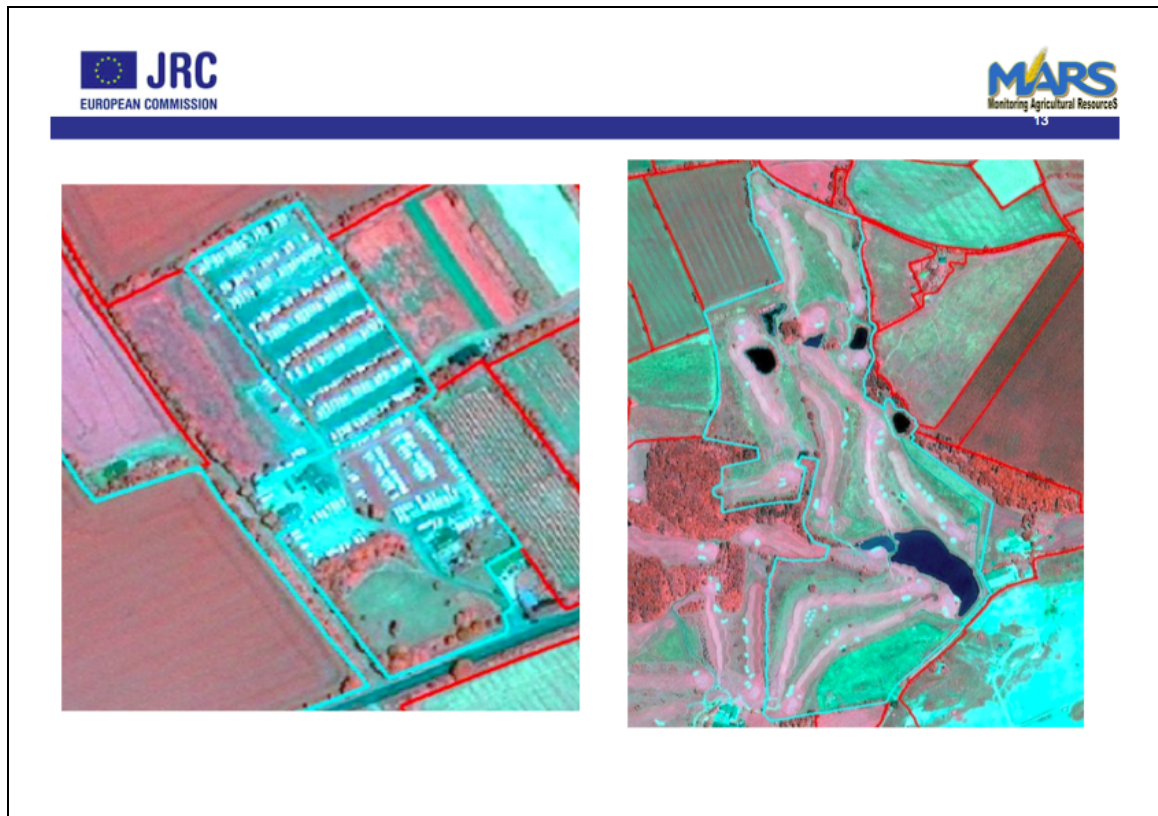
TM 30 m

Spot 20 m


Spot 10 m


Focus today is on image products with <1m GSD \approx 1:10,000 mapping scale

Imagery is complemented by multiple data. The system is widely used, with 24 Member States employing this approach in 2010. The European Commission pays for the imagery, this year €6.5 million, but the cost of processing and analysis of the information for use by the Member States is probably about €40 million a year.



The outlined areas in this slide are fields in the land parcel information system, the left one showing use as a caravan park, and the right one as a golf course. Neither of these is eligible for payments. It is the exception, but irregularities need to be filtered out of the farmers' claims.


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2007 application on
2005 orthophoto and LPIS


— Farmer's sketch 2007


Farmer claims that the
road was built **after** he
submitted his application
(i.e. after 15/05/2007)



VHR satellite
20/06/2007

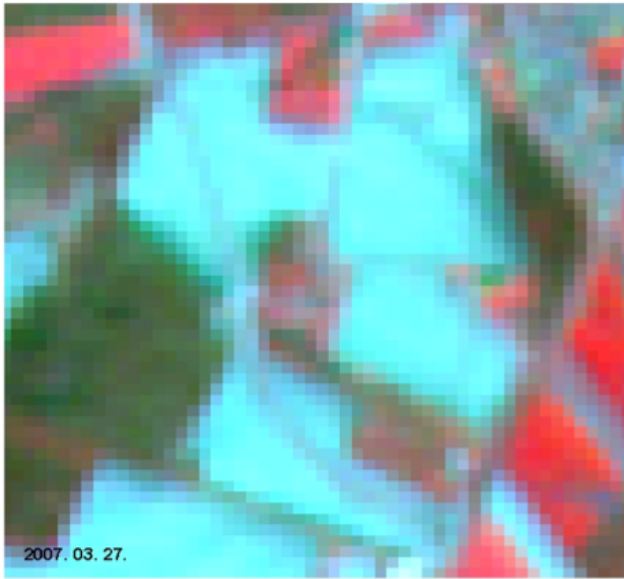
This slide illustrates another case where satellite imagery proved that a claim was false. The outlines drawn on the 2005 photograph show the fields that the farmer is declaring for subsidies, in his claim in April or early May 2007. It also shows a road that had been built through the field.

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Farmer claims that the road was built **after** he submitted his application (i.e. after 15/05/2007)

Road construction has started well before the application was submitted: It can already be detected on High Resolution satellite images early 2006



2007. 03. 27.



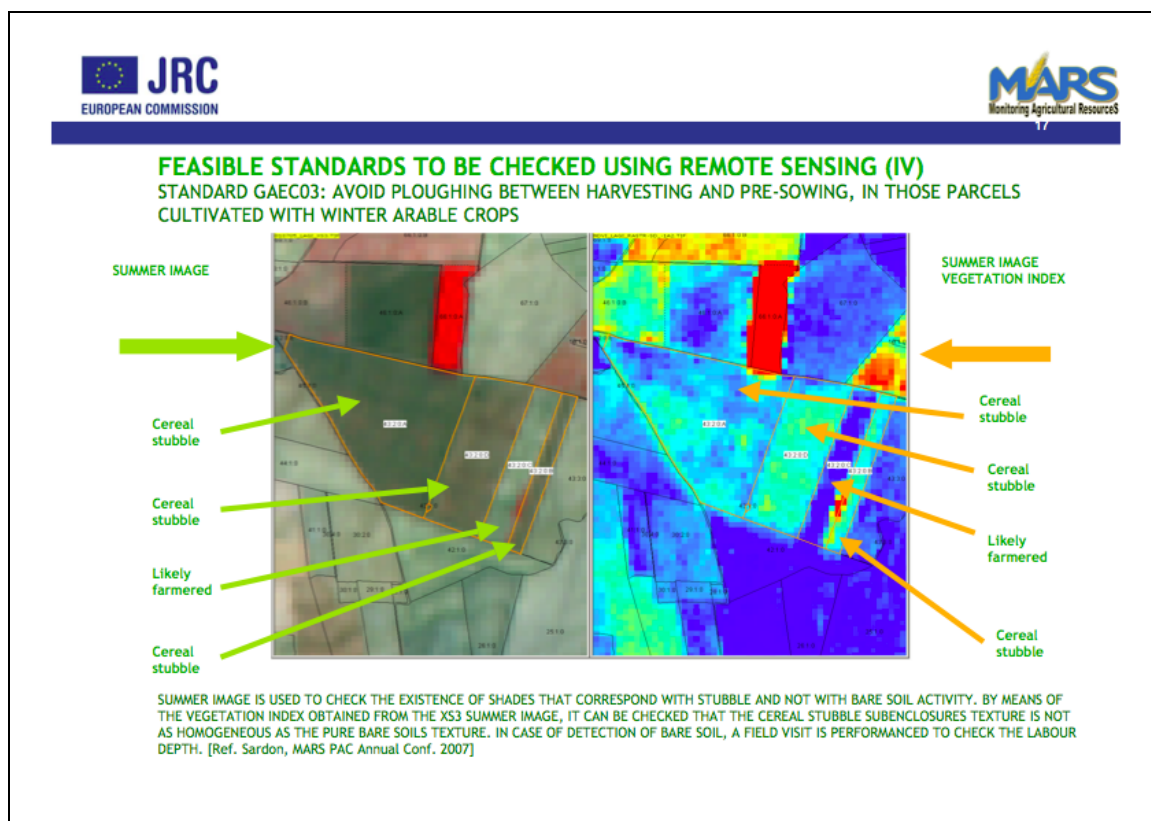
The farmer claimed that the road was built after his claim was submitted. However, the Member State was able to refer to earlier images, with coarser resolution but nevertheless confirming that the road was constructed earlier, probably between September 2005 and May 2006. The satellite data provided the only clear evidence that the claim made by the farmer was irregular.

FEASIBLE STANDARDS TO BE CHECKED USING REMOTE SENSING (IX)
STANDARD GAEC08: MAINTENANCE OF RETAIN TERRACES, KEEPING THEIR DRAINAGE CAPACITY AND AVOIDING THE RISK OF SILTING UP AND GULLY FORMATION

The figure consists of two side-by-side images of a rural landscape. The left image is labeled 'ARCHIVE ORTHOPHOTO' and shows a winding river with distinct terraced banks. The right image is labeled 'VHR IMAGE OF THE CURRENT YEAR' and shows the same area, but the terraced banks have been removed, replaced by a smoother, more uniform surface. Two black rectangular boxes are overlaid on both images to highlight the same area, showing the change in the riverbank structure. Green arrows point from the text labels to their respective images.

NON ELIMINATION OF TERRACES, BOUNDARIES, ETC IS CHECKED BY COMPARISON BETWEEN THE ORTHOPHOTO AND THE VHR IMAGE
 [Ref. Sardon, MARS PAC Annual Conf. 2007]

The legislated standards include quite specific requirements. In this case a satellite-derived image reveals that the farmer removed terracing previously visible in the archived photograph, in breach of the standard.



This crop rotation case imagery illustrates a case requiring more expertise to interpret. Using non-visible data such as infrared channels might be specific to a particular season. Expertise is required both on the remote sensing instrument, and on the agronomic conditions of the land management in order to assess whether the land is being managed to standard.

In summary, remote sensing has become a major tool for Member States, not necessarily for prosecuting farmers, but as a support to the subsidy claim phase, as a deterrent, reducing the number of false claims and helping farmers to make good claims. The rate of irregularities in most Member States is down to around 1% or 1 ½% of payment value much lower than before this technology was used.

4. JURISDICTIONAL TREATMENT – *Case Reports and Regulatory Experience* – *Comparative Perspectives*

There are numerous factors that govern the admission and use of evidence. These differ among jurisdictions and according to the nature of the judicial or administrative process and of the applicable substantive and procedural laws and rules. The possible permutations make any general assessment or approach an enormous task.

To make the task manageable and to establish common grounds, this session examined a number of jurisdictions to arrive at points of similarity and of difference. The underlying proposition is that if any rules or guidelines conform to the strictest set of requirements, compliant evidence will be admissible in all jurisdictions.

This session is a comparative look at various cases and law in the UK, US, Belgium, Netherlands, France, Germany, and international law. The order is the jurisdiction considered least rigorous to the most rigorous. The topics will include admissibility of evidence, restrictions on admission of evidence and standard of proof.

4.1 INTERNATIONAL JURISDICTIONAL TREATMENT

This presentation summarizes the major issues involved in the production of satellite imagery as evidence in court, focusing on the International Court of Justice, international arbitrations and other related examples. There is also reference to the views of lawyers, judges and scientists about satellite data in international litigation. Its use is growing. Satellite data is nowadays used as evidence in various fields of science, such as biology. Awareness of its use is spreading in Latin America.

A number of these questions and ensuing difficulties were clearly outlined in the Report prepared by the BIICL, concluded in 2001 recommending, *inter alia*, the need to create awareness and the importance of capacity building in this field. It observed, in rather worrying terms, that it was not the satellite data that judges were using in court but, rather, the opinion of the expert interpreting the image. This situation left judges and arbitrators particularly uneasy.

The problem is, in fact, that even though satellite images, as evidence in court, allow little margin for human error in the production of the image, there is scope for manipulation during the interpretation stage by the expert. Glaring examples in the nineties were the boundary disputes between Nigeria and Cameroon, Qatar-Bahrain and Botswana-Namibia, within the ICJ, and Yemen-Eritrea in the field of international arbitration.

Briefly, Nigeria had used a recent satellite image to show the location of a certain area. The image was interpreted differently by the parties and, instead of helping, caused even more confusion. The net result was that, whereas Nigeria considered the satellite data as a very clear way to clarify a point to the Court, once interpreted, it had the opposite effect.

More recently, the award from the Eritrea-Ethiopia Claims Commission (2009) is illustrative. This Commission was called to decide, by means of binding arbitration, all claims for loss, damage or injury related to the violation of International Humanitarian Law. In other countries, the Terrero case decided by the Supreme Court of Argentina in 2002 marked the first stages of the use of satellite data as evidence in court in that country.

From the very outset it was perceived that the issue of evidence from space was particularly sensitive in cases of boundary disputes on the international front where questions of sovereignty over land and water were disputed. The essential issue, doubtless, is the legal value of EOS data, a result of a long chain of interpretations from the moment raw data is collected by the satellite until it is submitted to court.

One of the first landmarks, noteworthy for its implications, was the Frontier Dispute case, in 1986, between Burkina Faso and Mali, where the ICJ considered that maps could not constitute a binding document or territorial title by themselves, whatever their accuracy and their technical value, unless the parties concerned had expressed their acceptance.

Twenty-four years on, however, the advances of science and technology have led to a completely different international context that indicates the need for further studies on the topic. This would provide useful pillars for drawing up international standards and give a more precise legal framework for the use of satellite data in court. The prevailing opinion is that higher precision is not the only difference between satellite data as evidence in court and that supplied by more traditional means (aerial or terrestrial). The difficulties, rather, concern the very nature of satellite imagery that mainly consists of data and not photographs proper. This point is essential where evidence is concerned. The falsification of a conventional photograph could be detected at a later stage. This is not the case when dealing with

numbered images which are merely a list of data that can be modified without possibility of detection and the modification of which are invisible to the human eye.

In short, satellite data should be viewed in more positive light. This is the general opinion. International standards should be agreed on the authentication of data, and reliable mechanisms for the production of satellite imagery in court should be enforced controlling the whole process of data collection.

4.2 GERMAN JURISDICTIONAL TREATMENT

Germany is a civil law jurisdiction, so is somewhat different from other jurisdictions discussed. There are some very precise legal provisions in the codes, but there are no specific provisions on the admissibility of satellite imagery.

The German evidential code defines several categories of evidence. These include judicial inspection, witness evidence, expert opinion, documents, and interrogation of parties. Most satellite images are likely to be submitted as evidence for judicial inspection. The court can order that one or more experts be consulted at the time of judicial inspection. The court will rely on, and either accept or reject, expert witnesses, and the satellite information they use as visual aids becomes incorporated into the expert's opinion.

Courts enquire into the technical quality of the evidence that is produced, and will require supporting additional corroborative evidence if the margin of error in the system is unacceptably large. However, with some evidence, such as speed cameras, there is reliance on standard devices and methods of generating the end product, and decisions may be made without hearing any expert evidence.

In terms of limitations and restrictions on using evidence in Germany, there is a constitutional right to informational self-determination. The 2007 Satellite Data Security Act imposes restrictions on the use of, and particularly the dissemination of, high-grade satellite data if it impinges on personal privacy.

There are very few reported cases in Germany. Most are administrative, and the majority deal with the location of an object, or land boundary disputes. Frequently, issues of admissibility of the evidence generated from the satellite information are not articulated in the decisions. This has been a recurring theme in the Project to date.

4.3 FRENCH JURISDICTIONAL TREATMENT

Difficult questions arise in relation to the use of space imagery. It is an unusual type of evidence because it is costly, complex, and questionable. It needs corrections and human intervention, which could lead to challenges to the evidence.

Content of Today's Presentation

- Preliminary remarks
- Overview of Proof under French Law
- Focus on Electronic Records
- Technical and Legal Difficulties relating to Satellite Images
- Case Law Review
- Proposals
- Speaker profile

Preliminary Remarks

- > **An unusual piece of evidence in judicial proceedings...**
 - **Costly** : satellite in operation or acquisition of images
 - **Complex** : technical processing
 - **Questionable** : corrections, treatments
- > **... which needs to comply with the fundamental rights of the parties**
 - **Contestability** (*Audi alteram partem*)
 - **Admissibility** (Rules on proof)
 - **Reliability** (Probative force)
 - **Privacy** (ECHR, 2010)

In France, as well as many other countries, there are fundamental human rights to consider. Evidence must be contestable, so that the other party could challenge it. It must be admissible

and reliable. This relates to burden of proof and the probative force of the evidence. Evidence must also comply with protection of human rights, especially with privacy, since September 2010.

Watson, Farley & Williams

Overview of Proof under French Law

> Principles

- Proof has to be made via an *instrument in writing* (Civil Code, Article 1341)
- **Electronic records** can also be used *under specific conditions* (Act No. 2000-230 of 13 March 2000 ; Civil Code, Articles 1316-1 to 1316-4)

> Parties are sometimes exceptionally allowed to provide evidence using any other means

- In case of *prima facie evidence* (*commencement de preuve*) : a written document from the opposed party attesting to the existence of an alleged contract (Civil Code, Article 1347)
- Before of a *Commercial Court* (Commercial Code, Article L. 110-3)
- In some circumstances, eg. *when a party cannot provide written evidence* (Civil Code, Article 1348)

> Parties can also be exonerated from providing evidence

- If they benefit from a *presumption* (Civil Code, Articles 1349 to 1353)

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Under French law, there are principles, and exceptions to these principles. First, any piece of evidence has to be provided by a written instrument. The March 2000 Act authorized the use in France, as in some other countries in the world, of electronic records as evidence.

Exceptionally, other parties may provide other evidence. Prima facie evidence might be presented. In a commercial court, there are other means of proof. The Civil Code, allows other means of proof if there is no written evidence, for instance, if documents have been destroyed in a fire.

In some cases, parties can also be exonerated from providing evidence, where there is a presumption.

Focus on Electronic Records (Articles 1316-1 to 1316-4 of the Civil Code)

> Establishment of an authentication process for electronic records

– Legal requirements (Act No. 2000-230 of 13 March 2000; Civil Code, Article 1316-1):

1. **Duly identified person**: secure digital signature, certification by a third party
(Decree No. 2001-272 of 30 March 2001; Decree No. 2002-535 of 18 April 2002)

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

> Consequences regarding the proof of electronic records

– **Presumption of reliability** of electronic records (Civil Code, Article 1316-4 para. 2)

– **Same probative force** as traditional written forms (Civil Code, Article 1316-3)

– Electronic records **can be considered more reliable** than traditional written forms
(Civil Code, Article 1316-2)

The Act authorizes the use of electronic records, providing that there is a duly identified person, and integrity of the record can be shown. There is a presumption of reliability of electronic records, which have the same probative value as written evidence.

Technical and Legal Difficulties relating to Satellite Images

- > **Admissibility of satellite images** when parties can prove by any means of evidence
- > **Authenticity and accuracy would raise some issues**
 - **Step 1: Image acquisition:** possibility of mistakes related to the **accuracy and reliability of the equipment**
 - **Step 2: Pre-processing and processing**
 - Removal of errors introduced during image acquisition, colour adjustment, removal of certain objects from the image
 - Very **dependent upon the processing operator**
 - **Step 3: Image interpretation:** a judge could find it difficult to interpret satellite images **depending on their precision**
- > **Issues might also arise in the future regarding of the right to privacy and personal data protection**

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Precedents

- > **Aerial photography**
 - Admissibility of the **evidence of a breach of the law** on maritime navigation and fishing provided by an aerial photography (CA Bastia, 15 April 1992; CA Poitiers, 2 April 1993)
- > **Space data case law**
 - **GPS surveillance** of a crime suspect, although interfering with the individual's right to privacy, **can be justified if implemented in accordance with the law** (ECHR, 2 September 2010, *Uzun v. Germany*)
 - **GPS surveillance of employees** interferes with the individual's right to privacy if not implemented **with respect to data protection regulation** (CNIL, Decision of 16 March 2006; Cass. soc., 26 November 2002, *Ms X v. Société Wieth-Lederlé*)
- > **DNA evidence legislation** (Act No. 94-653 of 29 July 1994; Civil Code, Articles 16-10 to 16-13)
 - Requirements for the admission of DNA evidence:
 - **Filiation** litigation
 - **Consent** of the person
 - Carried out by an **authorised expert**

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Several cases might be of interest. First, there are precedents from aerial photography although there are differences between aerial photography and satellite-derived imagery.

Aerial photographic evidence has been admitted as proof of breach of law. Two particular cases are cited.

There is no case law regarding space data, but there is on GPS. The case concerns remotely-gathered personal information and privacy protection. The European Court of Human Rights ruled that the use of GPS surveillance could be admissible in some circumstances.

DNA evidence, which is only used to prove any affiliation, or any element relating to the family, requires the consent of the person, and must be carried out by an authorized expert.

Watson, Farley & Williams

Proposals

Issue	Proposal
<ul style="list-style-type: none"> > Data source authentication 	<ul style="list-style-type: none"> > <i>Legal modification</i> expressly authorising and setting the requirements for the recognition of satellite images as judicial evidence > Adoption of standards by a trusted body (possibly at a European level)
<ul style="list-style-type: none"> > Data integrity 	<ul style="list-style-type: none"> > Use of a <i>certification process</i> for the original image > Storage of the original image on a <i>secure medium</i>
<ul style="list-style-type: none"> > Confidentiality and protection against unauthorised access 	<ul style="list-style-type: none"> > Use of <i>digital signatures</i> for the original image > Assessment of the <i>level of trust of people</i> who can access and/or process the image

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In conclusion, several steps should be taken if space imagery as evidence is to be used more extensively, at least in France. First, legal modification is needed, which might take the form of a new Act recognizing satellite imagery as evidence. Second, there should be standards issued by a trusted body, if possible at the European level, and a certification process. Third, a secure medium is required for storage of satellite-derived information. Fourth, in relation to confidentiality and protection against unauthorized access, digital signatures may be useful. Finally, there should be assessment of the qualifications of the people who have access to, or process, the data.

4.4 BELGIAN AND THE NETHERLANDS JURISDICTIONAL TREATMENT

This presentation focuses on Belgian criminal law. The Criminal Code is a permissive regime in principle, with no specific barrier to the use of space earth observation data under Belgian law generally. There are issues of admissibility in relation to civil law, particularly where violation of private life is concerned.

Belgium (U. Ghent)

- No barrier in principle to use of space EO data
- Focus on criminal law especially oil spills); no satellite EO cases yet
- Interviews with coastal authorities
- Law of 06.04.1995 on prevention of oil pollution from ships: all means of proof open, thus eyewitness, pictures, videos (Art. 5bis); satellite not specified
- Aircraft photos and videos accepted 2003 case (Court Appeal, Ghent)
- Advantage of aircraft over satellite images: agents of observing state institute (MUMM) act to corroborate to counter problem of look-alikes
- Privacy Commission advice 26/2006 qualified satellite imagery as subject to Data Protection Act 1992 requirements. As such, processing of PII can only be performed by an authorized person where any form of litigation is involved.
- Proactive investigation prohibited unless for serious crimes with authorization of public prosecutor

Interviews with coastal authorities, particularly in relation to MARPOL in its implementing legislation, resulted in the view that all means of proof are open, including eye-witnesses, pictures, video. Satellite is not specifically mentioned. Related case law concerned aerial photographs and videos. The authorities prefer aircraft data to satellite data, because the agents are able to observe, and therefore to exclude look-alikes.

Two points may be fruitful areas for further investigation. First, advice given by the Belgian Privacy Commission in 2006 specifically on satellite imagery was that it is unequivocally subject to the Data Protection Act of 1992 concerning personally identifiable information ('PII'). The implication was that PII can only be processed by an authorized person where any form of litigation is involved.

Second, proactive investigation is prohibited in Belgium unless for serious crimes, and then only with the authorization of the public prosecutor.

Netherlands (IIASL)

- No barrier in principle to use of space EO data
- Focus on use of EO information products in agriculture, water management
- Interviews with agencies, companies, judges, counsel
- Administrative proceedings: analysis of doctrine and evidential requirements
- 2002 agricultural subsidy case. Satellite images accepted as "common and accepted" system in EU for evidence (that crop different than subsidy claimed for), but with expert witness
- Satellite EO images treated on par with x-rays, etc.
- Court did *not* investigate quality of expert (Georas) evidence – only if minister correctly exercising powers
- Quality of local EO processor nevertheless checked by JRC
- Issues of procedural equality regarding access to expertise; need for independent source of expert advice?
- Privacy – Special Powers of Investigation Act: constraints on gathering data but court held thermal camera no violation
- Proactive investigation prohibited unless for serious crimes with authorization of public prosecutor

In The Netherlands, there is no barrier in principle to use of space observation data, exactly as in Belgium. This report looks at agriculture, water management and cannabis production.

There were interviews with administrative agencies, companies, judges, counsel and legal academics interested in evidence and civil procedure, related to administrative proceedings. There was analysis of the doctrine and evidential requirements, with the standard for sufficiency of proof at about 60% as compared to a standard of about 90% for criminal prosecution.

In relation to case law, there was a 2002 agricultural subsidy case in which satellite images were accepted, on the basis that they are a common and accepted form of evidence within the European Union. The expert witness was from the company holding the current contract from the Ministry.

The case had two notable features. First, satellite earth observation images were treated as on a par with x-rays. Second, the court did not investigate the quality of the expert, only if the minister was correctly exercising his or her powers. This is significant in The Netherlands, where technical experts are appointed by tender by the Ministry, and therefore are not independent of government. This is obviously noteworthy when it is not the practice for both sides to present independent experts.

The authorities would like to be able to use the potential of this type of technology.

4.5 UK AND US JURISDICTIONAL TREATMENT

This presentation describes and compare the UK and US evidential rules.

Introduction

- Both US & UK more than one jurisdiction
- Common law adversarial
- High water-mark

Both the US and UK are multi-jurisdictional. The United Kingdom comprises 3 jurisdictions and the United States 51, the States and the Federal system. Both are adversarial common law systems, where evidence is not extracted and weighed by the court itself, but the opponents who will try to keep each other in line and to the point.

Digital Data

- Space-derived information is its digital
- Needs processing to be intelligible
- Open to undetected manipulation
- Greater need to authenticate and interpret
- Analogous to other machine generated information

Space-derived information is digital, and must be processed. It can be manipulated, so there is a need for authentication and interpretation. It is analogous to other machine-generated evidence and information.

Hearsay

- Automatic generation without human intervention - real evidence; camera
- Processed through a number of steps regarded as hearsay
- Less weight

Automatically-generated intelligible information, such as that from speed cameras, is real evidence, a record of what actually happened. The issue of hearsay doesn't arise, because there is no intervention aside from writing the software and processing through a number of steps. That obviously affects the weight that is given to any particular evidence.

English Law

- Admissibility depends on reliability and probative value
- Show evidence relates to fact being proved
- Safe and traceable custody
- No inappropriate interference or manipulation
- Hearsay 1995 and 2003 Acts; Business records and official documents
- European Regulation

Evidence in the English system is admissible if it goes to establish the fact, or is capable of establishing the fact, and is reliable. In the case of satellite data, one of the important issues is the audit trail, whether it has been in safe custody through the various stages.

Hearsay was a major preoccupation in the past, but in England the 1995 Civil Evidence Act, and the 2003 Criminal Justice Act, have largely done away with the issue. The court rules on the reliability of evidence, and its usefulness as proof.

In terms of satellite information, there are regulations and Directives of the European Union that have been given statutory and regulatory recognition in England. These are mainly environmental and agricultural, frequently concerned with monitoring illegal fishing, fisheries, and verification of compliance with agricultural requirements.

English Cases

- Satellite-derived information has been offered and accepted in evidence
- Corroborative rather than primary evidence

There are many cases in which satellite-derived information has been offered and accepted in evidence. There are no direct decisions on the issue of admissibility, or the reasons why it was admitted or rejected. It is mainly used as corroborative evidence rather than primary evidence.

US Federal Law

- Satellite-derived information is scientific and technical evidence
- *Daubert v Merrell Dow Pharmaceuticals* 1993 Supreme Court ruling established tests that include falsifiability, known error rates and peer review
- Reasoning or methodology underlying testimony to be scientifically valid

Turning to the US system, many of the State jurisdictions have very similar rules. Satellite-derived information is treated in the same class as scientific and technical evidence, and there are tests for whether or not it would be admissible.

Formerly, it had to be generally accepted by the relevant scientific community. The Supreme Court in 1993 decided that instead it was necessary to inspect whether evidence can be falsified, error rates, peer review of the methods used, and whether evidence was regarded as acceptable by the relevant community, or a good sector of it.

US Constitution

- Fourth Amendment prohibits search without warrant
- *Privacy and trade secrets* decisions gone both ways depending on facts
- Reasonable expectation of privacy

The American system is much better at keeping things out of court than the English. They rely on their Constitution. In both of the following areas decisions have varied, depending on the facts of the case. The first area relates to the search and seizure provision of the Fourth Amendment. There have been a number of relevant cases, particularly in detecting cannabis growth in buildings, with thermal imaging where illegal activity is suspected.

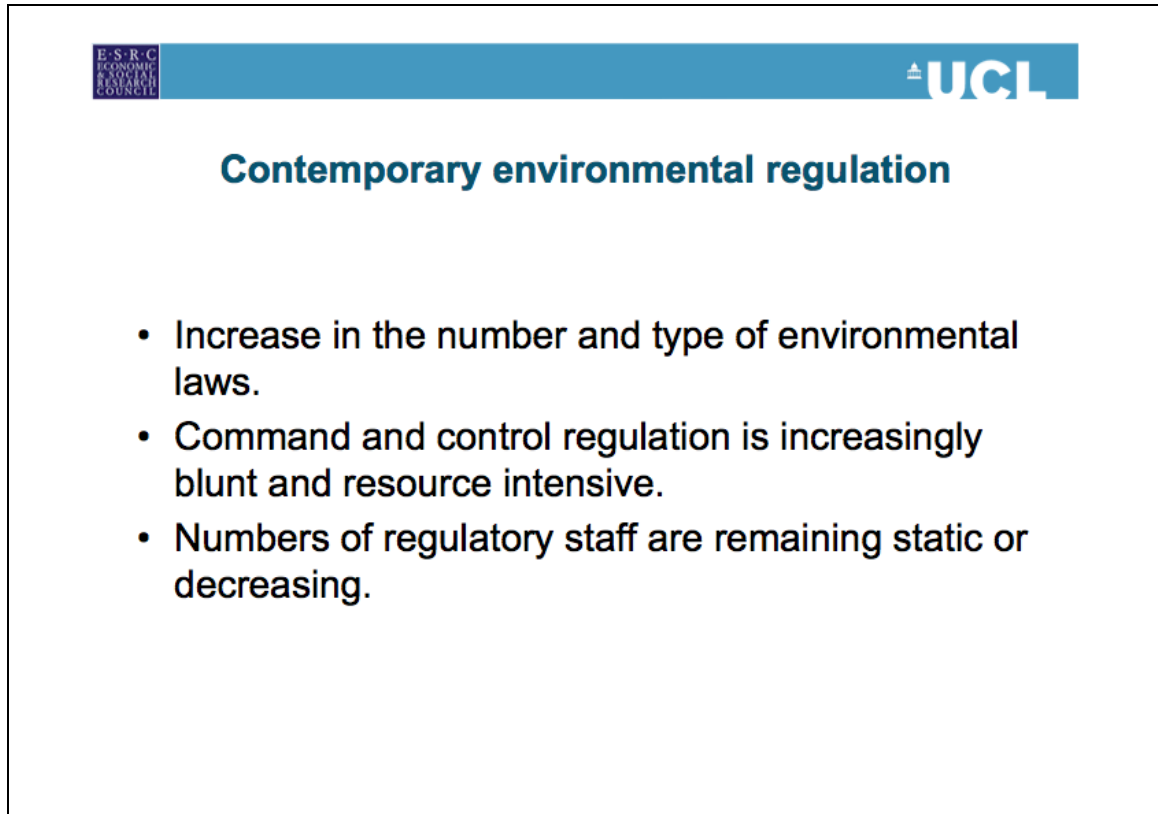
The other area involves trade secrets. Cases have been pursued, and the test is generally whether there is a reasonable expectation of privacy. It may be that there is a slightly exaggerated sense of the intrusion into privacy by satellite detection.

In conclusion, in the UK and the US courts frequently admit and rely on satellite-derived information. There is no direct authority dealing with admissibility itself. Judges, particularly in the US, seem to be concerned about the reliability of dating the information.

5. UCL ESRC PROJECT – *Use of Satellite Information in Australia and Lessons Learned*

Because of its large land mass and low population density, Australia is ideal for satellite-based monitoring and has one of the largest bodies of legislation and decided cases in which satellite-derived EO information has been used in evidence. [*Professor Richard Macrory*]

Please note: The contents of the following PowerPoint presentation are from a UCL ESRC sponsored project: 'Smart Enforcement in Environmental Legal Systems: A Socio-Legal Analysis of Regulatory Satellite Monitoring in Australia.' Nothing in this PowerPoint can be used or reproduced without the author's permission.



The screenshot shows a PowerPoint slide with a blue header bar. On the left of the header is the ESRC logo (Economic and Social Research Council) and on the right is the UCL logo. The title of the slide is 'Contemporary environmental regulation'. Below the title is a bulleted list of three points:

- Increase in the number and type of environmental laws.
- Command and control regulation is increasingly blunt and resource intensive.
- Numbers of regulatory staff are remaining static or decreasing.

Step changes in the technology

1970's	79 metres
1980's	30 metres
1990's	10 metres
2000	1 metre
2001	60 cm
2007	41 cm

Potential drivers for satellite monitoring

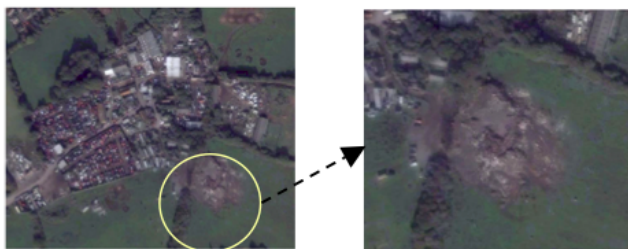
- If they have advantages over existing monitoring approaches (e.g. quicker, more accurate).
- If they can monitor something which could not be monitored by conventional means before, or where this was problematic to monitor.
- If its use can save money whilst protecting the quality of front-line services.

Legal research on satellite monitoring

- European Commission, 'APERTURE Final Report' (European Commission, 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).

Using archived imagery to identify offences

- October 2005



- June 2004



- Offence was between May 2005 and January 2006.

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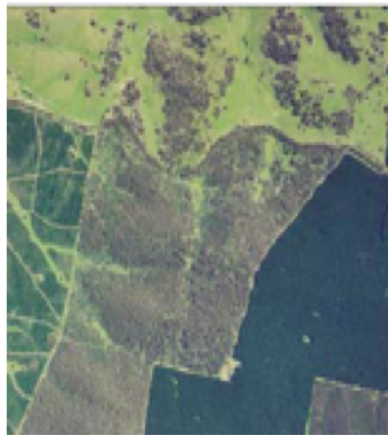
An Examination of Australia.

- first international example where satellites have been systematically used to monitor compliance with a specific environmental law.
- it has a wealth of understanding in knowing how to make satellite imagery 'game-fit' for court.
- there have been many lessons learnt, over a sustained period, that could be useful for regulatory agencies in other countries.

Remit of the ESRC study

- to consider the operational effectiveness and cost of existing Australian State satellite monitoring programmes and any constraints affecting their use.
- to investigate the awareness and attitudes of those regulated this way and to see if this has had an impact on their compliance behaviour.
- to analyse whether those regulated see it as a more/less desirable method of regulation than conventional forms of regulatory monitoring.

Imagery of illegal vegetation clearing



Aerial Photograph
1 June 1999



IKONOS
26 April 2002



How much does the satellite monitoring approximately cost?

Imagery

- Low resolution imagery (statewide) – free / cover processing costs, \$50,000.
- High resolution imagery (scene) - \$2000.
- High resolution imagery (statewide) - \$2.5 million

Programme

- New South Wales - \$6.5 million.
- South Australia - \$600,000.

Why is Australia spending money on this?

- There was practically no monitoring before this programme. It was impossible to adequately monitor vegetation clearance before satellites.
- In the time it takes inspectors to survey 20 hectares on the ground in Queensland, the remote sensing team can look at 2.5 million hectares using satellite imagery in the same period.

Queensland – reversal of burden of proof

- The equipment used is deemed to be accurate and precise and to have been used by an appropriately qualified person.
- A statement of any of the following matters in a certificate or report is evidence of the matters stated in the absence of evidence to the contrary: (a) the person's qualifications; (b) that it is a remotely sensed image of a stated area; (c) the date on which it was produced; (d) the person's stated conclusions drawn from a stated remotely sensed image; (e) the location of the stated area; (f) whether vegetation in a stated area has been cleared;
- If a party wishes to challenge any of the above they have to give the other side 20 days of this and state the detailed grounds on which they rely.

Regulatory changes?

- Could potentially have more offences to investigation! Can't investigate all of these so have to prioritise how they are dealt with.
- Have to adopt more strategic approaches with interdisciplinary teams.
- Need for training and communication.

What is under attack in court?

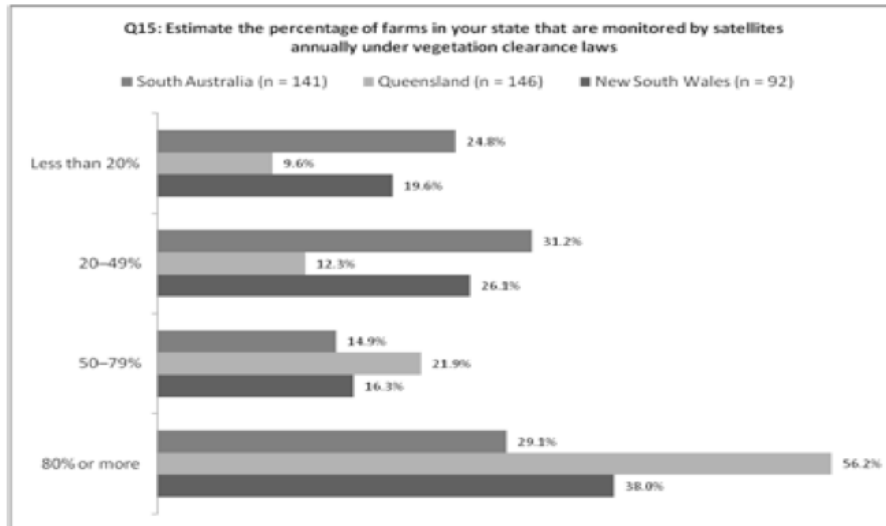
- potential for data changing of the imagery.
- the quality and accuracy of the imagery.
- whether the satellite was working correctly – was it even switched on?
- the experts interpretation of the imagery.
- the credentials of the Government expert working on the imagery.

...but mainly legal procedure.

Standards – as to best practice

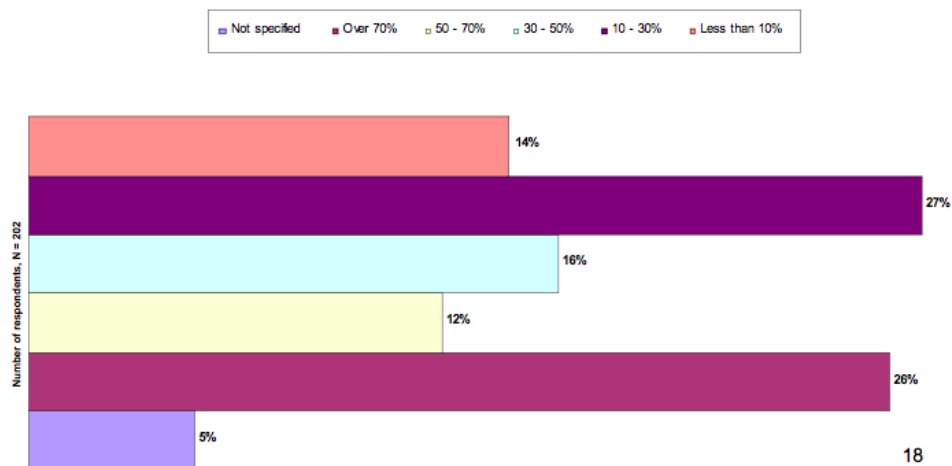
- British Standards Institution, '*Evidential weight and legal admissibility of electronic information*', BS 10008:2008 (2008).
- American National Standards Institute and Association for Information and Image Management, '*Legal acceptance of records produced by information technology systems*', ANSI/AIIM TR31-2004 (2004).
- International Organization for Standardization, '*Document management – information stored electronically – recommendations for trustworthiness and reliability*', ISO/TR 15801, 2nd ed. (2009).

Deterrent: % monitored annually in Australia



Deterrent: % monitored annually in UK

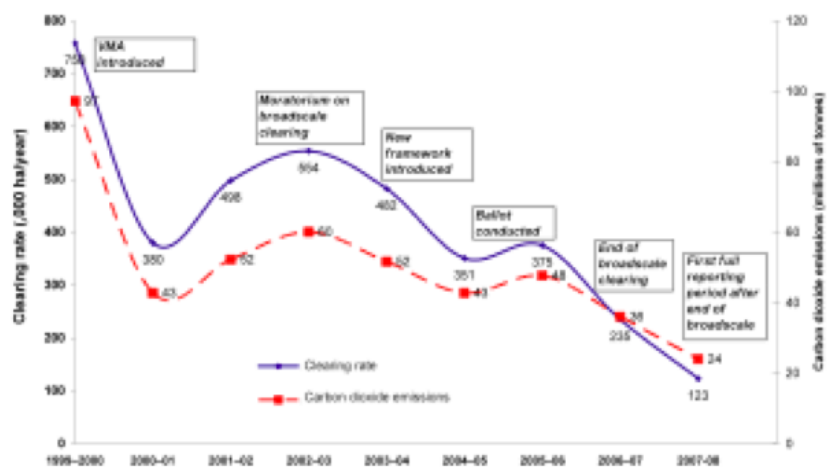
What percentage of farms in the UK are monitored by satellite annually?



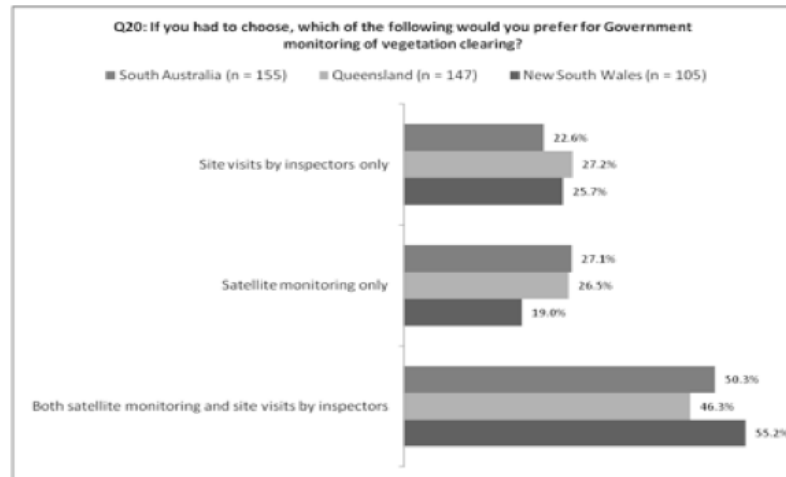
Deterrent impact in Australia



Measuring impact in Queensland



Preferred method of monitoring



What did they like about satellite monitoring?

- It stopped dishonest people in the farming industry giving the law abiding majority a bad name (73%)
- It allowed them to operate on a fairer and more equal basis, assuming every farm was monitored (50%).
- It was a more consistent and accurate method than other means of checking (54%).

What concerns did they have?

- Not being given information on this (70%)
- Invasion of privacy (58%)
- That they weren't informed when they were monitored / 'Big-Brother' (84%)
- Data handling / trust in government (36%)

Extending satellite monitoring to new areas

- Laws on the disposal of waste (52% in favour, 23% against).
- Laws on climate change (28% in favour, 39% against)
- Laws on irrigation and water use (57% in favour, 21% against)
- Laws on water pollution (69% in favour, 15% against)
- Laws on nature conservation (41% in favour, 21% against)

What they wanted if satellite monitoring was extended.

- Reduction in ground inspections (46%)
- Access to the satellite imagery (96%)
- Assurances of data security (93%)

5 Key recommendations

- 1) Satellite providers having better support and communication networks to Government.
- 2) Establishment of Government body to coordinate championing, purchasing and cataloguing.
- 3) Planning how interdisciplinary cooperation and regulatory structures might work from start.
- 4) Having a national/international standards regime and evidentiary support provisions
- 5) Get those monitored on-side, by emphasising 'supports' and look to offer incentives.

6. CASE STUDY I – *Land Subsidence*

Interaction between the technical and legal experts is a critical aspect of greater use of satellite-derived EO information as evidence. Further, the evidential requirements to be met by such information are fundamental to its use. To achieve both the desired interaction and to put the evidence to the test, a land subsidence scenario was devised and presented in a moot setting. The legal and technical arguments were separately presented and participants were invited to act as opposing counsel, expert or judge.

The scenario and the issues arising from them are as presented in the pre-workshop papers. While it is similar to the Rovigo case, it is not identical. Note that legal facts are not absolute facts, as was perhaps suggested this morning. It's all about assessing the margin of error.

The Scenario

- Property A owned by FL
- Adjacent Property B owned by GS
- FL excavation on A close to B from January 2009 to March 2009
- April 2009 cracks in foundation of B
- September 2009 damage to warehouse B and glass stock

Property A is owned by Four Level Limited (FL). It is adjacent to Property B, owned by Glass Suppliers (GS).

FL excavates on its own land, but close to the boundary with Property B, between January and March 2009. In April 2009, cracks are discovered in the foundations of Property B's glass storage facility. By September 2009, there is damage to the warehouse and the glass stock in the warehouse.

GS Claim

- Cracks in April 2009 due to excavation
- Land movement continued to September 2009 also due to excavation
- Subsidence caused damage to warehouse B and stock of GS

GS claims that there were cracks in the foundation in April 2009. Counsel asserts that this was due to the excavation of Property A that caused the land movement, resulting in damage to the warehouse and stock of GS.

Available Information

- SAR data 500 by 500 metres; 20 Reference points; boundary of A and B at its centre
- Data for period January 2008 to June 2010
- PSInSAR used to process the information
- Government aerial data for Dec. 2008 and October 2009
- Ground survey Mar 2008; Oct 2009 from B

SAR radar data was analysed. It is asserted that it shows movement in the land, greater at the boundary of the two properties than in the area 500 metres by 500 metres surrounding it.

Data has been analysed from January 2008 until June of 2010. It shows an increase in the rate of subsidence just after the excavation. Further support for this contention comes from government aerial data obtained in December 2008 and October 2009. This is provided as corroborative evidence. GS's case is that the satellite evidence is sufficient.

There is also a ground survey in March 2008 FL, prior to excavation of their land. Finally, there is a land survey of October 2009, only from Property B because FL would not allow access.

Evidence Adduced

- Proven cracks and damage due to subsidence
- Raw SAR data from EO Provider
- PSInSAR analysis by Expert E1 and E2
- System security and custody
- Calibration and accuracy of system

The evidence submitted is that the cracks are due to subsidence. GS's case is that subsidence occurred because of FL's excavation and for no other external reason.

The case is supported by SAR data. The providers will present their permanent scatter analysis. It is comparable to the data obtainable on other systems, with a good chain of custody. It has gone from one computer system to another.

If calibration and accuracy of the system is in issue, there is a certificate from an organisation that has developed a standard. It is not an internationally accepted one but the organisation is in the business of calibrating and determining the accuracy of satellite systems.

System

- Certification of satellite system
- British Standard BS10008 covers:
Management of the availability of electronic information over time;
- Electronic identity verification, including use of electronic signatures, and linking electronic identity to particular electronic information.
- It does **not** cover processes used to evaluate the authenticity of information prior to it being captured in the system.

Standard BS10008, which covers the management availability of electronic information over a period of time, was not used.

Processing and Storage

- Objective measurement of the trustworthiness of their repository.
- Draft ISO 16363: The repository's written standard operating procedures and actual practices to ensure digital objects are obtained from the expected depositor. Examples of a Producer include persons, organizations, corporate entities, or harvesting processes.

The draft ISO touches on processing, but it was not adopted for this case. The case is that the certification is adequate.

Experts

- Establish education, knowledge, skill and experience
- Identify minimum qualifications
- Describe methodology, peer review, scientific credibility
- How technique distinguishes level over time

There is no system for identifying minimum qualifications. However, the education, knowledge, background, skill and experience of our experts have been established. The method has been peer reviewed. Methodology will be explained by the expert witness, who will also give an indication of how the technique distinguishes a level of movement over a period of time.

Satellite-Derived Information

Admission

- **Collection:**
 1. Satellite system accuracy, reliability; communication network; sensor calibration
 2. Storage security and reliability
- **Processing:**
 1. System and storage security and reliability
 2. Acceptable method
 3. Historical information storage and retrieval

Participants are asked to consider challenging on several grounds. On admissibility, are system accuracy, calibration, storage and security adequate? Does the processing follow an acceptable method? What is an acceptable method?

The case differs from Rovigo to the extent that in Rovigo there was historical data going back 10 years. Here, there are about 2 years. Is that sufficient to show the stability of the ground prior to the excavation?

Satellite-Derived Information Proof

- **Must prove:**
 1. **Damage caused by subsidence - Surveyor**
 2. **Subsidence occurred - Historical comparison**
 3. **Time and location - combine GPS & date stamp**
 4. **Location identification and scale - Notice to admit**
 5. **Alternative to 4, Surveyor**
 6. **2, 3 & 4 combined could give time, location & subsidence**
 7. **System and technique certified - or expert**

To succeed we must prove these facts. The surveyors' reports indicate that the damage was caused by subsidence. The 2 years of historical data is sufficient to show that the subsidence occurred because of the excavation, and for no other reason. There is time and location evidence.

The burden of proof might be reversed. A Notice to Admit that the system is accurate and that the land movement is as indicated by the satellite, might be served.

Evidence from surveyors and land measurements might be offered, as an alternative to proffering the satellite information. However, GS was not given access to Property A to do a proper survey of the land level.

Next, the expert witness will present the case: the evidence and why the historical data is sufficient.

Typically 2 years is not enough. It depends on the quality of the measurement points. In an urban area, there would be about 400 measurement points per square kilometre, and here, in just 500 x 500 metres, we have 20. This is sufficient in this case because the very best points were selected.

It is important to note that there are two independent data sets. One is acquired along ascending orbits, and one along descending orbits. The combination of the motion of the earth and of the satellite makes it possible for an area to be imaged by two independent acquisition geometries. If the measurements are exactly the same, using two independent data stacks, it's like having two companies in charge of optical levelling surveys finding exactly the same displacements over the very same area of interest.

Another important point is that the dates of the acquisitions are beyond any reasonable doubt, because ESA confirms the time of the radar image. Typically a measurement point is characterised during a period when no event is occurring. The error and the number of points

outside that threshold may be relevant.

In this case there are three images indicating movement. With two independent acquisitions and a typical error rate, to have the same results by accident is unlikely (in the order of 10^{-2}).

There are five points within the area of interest, showing almost exactly, the same. The expert opinion is that the probability that these kinds of results are generated by random noise is really extremely low, beyond 10^{-6} , so 1 in 1 million. The data are evidence of the fact that the displacement occurred in 2009.

7. CASE STUDY II – *Oil Spill*

A second hypothetical scenario concerning oil spills was devised for discussion from the perspective of different parties enforcing anti-pollution laws, or who suffered damages due to the spills. This session explored the use of satellite-derived information as evidence in different circumstances and for different purposes.

This case study looks at oil spill, using satellite-derived information. The technical expert is Marc Journal from the European Maritime Safety Agency.

An oil spill incident has occurred at sea. Represented here are a prosecutor in a victim state, and fishermen who have suffered as a result of the spill. A technical expert is assisting. Participants are asked to act as lawyers and technical experts in a consultation, to define strategy. Whether there is a case to take to court and if so, to which court, with which chances of success, and using what evidence. Criminal as well as civil proceedings are foreseen.

Case scenario

- Haven berthing charges → *Dark Sea* dilemma
- Captain “makes do”, discharge of slops
- Aircraft monitoring systems disabled (ash)
- Jurisdiction with respect to incident
- Effects in E, F and A with economic loss
- MARPOL and other conventions
- SAR and optical images, AIS data
- Samples?
- Bases of action: criminal and civil

The Port of Haven has raised its berthing charges. The captain of the *Dark Sea*, Captain Salt decides, given the ship owners’ financial concerns, to discharge slops at sea. If satellite data is

the primary form of evidence, will it be sufficient? Will additional evidence be needed?

There are several points to consider. During this period volcanic ash made observation flight impossible. Because this is a sea incident, and by nature international, here may be jurisdictional aspects. The MARPOL convention is relevant, and perhaps others. There is satellite technology employed, along with AIS tracking data. Sampling of the spill is to be considered.

Jurisdictional analysis (Marpol)

- **Coast state can generally prosecute if spill occurs in its territory.**
- **But if not – evidence produced by coast state accepted by flag state?**
- **Is ground proof corroborative evidence necessary under rules of prosecuting state?**

Under MARPOL there are various rules of jurisdiction.

Choosing jurisdiction(s)

	A	B	C	[D]	E	F
UNCLOS	Port; Coastal		Flag		Coastal	Coastal
MARPOL	Port; Coastal				Coastal	
Further Euro conventions	Eur	Eur				Eur
EU	EU				EU	
IMO, ILO etc.				[IMO; Nationality]		
Civil	Civil; Victims	Owner			Common; Victims	Victims

N.B. Refer to Case Study II exercise sheet for explanations and abbreviation references.

Where will proceedings be initiated? Participants are invited to address three areas. The first is strategy, choice of forum. The second relates to evidential issues, and the third to enforcement, and how the economic loss can be recovered.

Evidential analysis

- Which means of surveillance are normally used, and how, in conjunction?
- Ground proof corroboration indispensable? Which? Cf. Normal aircraft corroboration not available in this scenario
- Variations in civil/administrative and criminal proceedings?
- Authorities to involve and risks?
- Other showstoppers?

The first question is which is the best place to take proceedings.

DISCUSSION

1. RULES OF EVIDENCE

The presentation covered various aspect of evidence and the range of rules that govern its use in judicial and administrative settings. The state of the rule against hearsay was considered as was authenticity and reliability.

Comment: The relevant characteristic of satellite-derived EO information is that it is electronic. Therefore, the issues are the same as for any electronic evidence. Further, lawyers and judges do not understand electronic evidence.

Response: The quality of expert evidence can be critical. Courts can err by relying on their own judgment in the face of expert evidence. This is further examined when considering the jurisdictional issues in the Netherlands.

2. SYSTEMS CAPABILITIES – *Satellite and Data Processing Features*

The three presentations in this session covered the technical capabilities, including processing techniques for satellite data. The first presentation focused on sensors and processing techniques in general and for land motion measurement. Issues relating to standards, reliability and accuracy were mentioned. The need for better understanding and greater communication between lawyers and technicians, scientists and administrators was highlighted.

The second paper covered calibration as well as factors relevant to the combination of earth observation data with other information such as geographic and time. Modelling and its impact on the information generated were addressed.

Detection of oil spills was the main theme of third presentation, which covered the techniques used to monitor and identify polluters. The impact of environmental factors on satellite observation systems was considered.

Comment: While there is great value in climate models, they are predictive. But, the legal community is many steps away from being able to use predictive model data in the courtroom. The predictive method treats observations as ‘truth’, against which the models are measured. The legal community has yet to take a standardised observation, and consider it ‘truth’ that can be considered as evidence in court.

Response: Even the so-called ‘observations’ have a model built into them, so one is really comparing model with model, which is not true in classical scientific terms. The scientific method involves reproduction of a result many times in the laboratory. There is only one Earth, and one realisation. The scientific method is used as closely as possible, but it is hard. On an oil slick, a model can be run many times to work out what the errors are. Whether they have been used or not is a different case.

Comment: When using something off a computer as the ‘facts’ of what was contained in the presentation, somebody actually put that in, the actual software is irrelevant, because those words are ‘fact.’ This is where the hearsay point is relevant. Where the software is controlling how the information is assessed and produced, then the original software and its affect on the information has to be considered. Otherwise it cannot be determined whether or not the assessment coming out of the software is correct. That is the crucial legal issue.

Response: That is a good illustration of how one designs the ground system. The requirements of this community will drive the requirements of the system.

Comment: Some data, eg from GeoEye, is optical and its interpretation depends on the human eye. Others, like SAR data and subsidence of the land, are not. Similar Japanese radar data produce different results, depending on how they are analysed. There is no human involved in that, with the exception of the point about the software involving a human element. But it is produced from a data production chain. How does the law deal with different interpretations of the same data, either done by eye or done by computers?

Response: Before the legal community can be expected to answer that question, technicians have to tell them what uncertainties are associated with the information that's being provided. One of the things expected out of this discussion is clarity in how the information is qualified.

Comment: A typical problem, for example in oil spills, is not to prove that the vessel was there. It is to correlate the vessel with the SAR image. This evidence is not accepted right now in Italy, it is not understood. Legally a human being is needed to inspect the ship and make a validation in situ.

Comment: In the international climate change negotiations, there is discussion of using remote sensing data to measure changes in land use and forestry, in particular deforestation. Is there any methodology in place to look into the uncertainties that are linked to the use of remote sensing data?

Response: Yes. There is starting to be methods developed to model the whole system out and understand what all the different errors are, or how you combine the observations. There is a need to understand what the legal community needs in terms of what the errors are, and what information has to be included.

3. CASES USING EO INFORMATION - *Space and Aerial Information*

This session was devoted to practical experience in the use of satellite earth observation information. These related to evidence of land subsidence causing damage to a historic monument in Italy, monitoring and verifying CAP subsidy claims by European farmers, and audit of foreign aid and disaster aid grants by the government of the Netherlands.

Comment: It was stated that satellite remote sensing monitoring for CAP verification this year covered about 5%–7% of the total area. It implies that farms in a large area can get away with inflated subsidy claims this year. A second related question is how to determine which areas are monitored. In Britain and the Netherlands there is a risk-based approach, focusing on where there are likely to be breaches. Is that going on with CAP monitoring, concentrating on likely problem areas?

Response: Legislation requires a minimum of 5% controls, bearing in mind that of the information collected from the farmers, 100% is already given an administrative check through the system. This creates a scatter-shot of places across Europe. There is a requirement that $\frac{3}{4}$ of the checks be made on the basis of some kind of risk analysis, using the database of farmers and the types of declarations they have made. Member States decide on higher probability of risk in terms of where they locate their checks. Freedom of information obligations requires release of sensor location, but maps are too small-scale for individuals to assume they would not be monitored by earth observation. The locations are released after the fact, i.e. not made available before the monitoring process starts. Areas surveyed are published at the end of the year.

Comment: How do you make sure that the regulation meets the desired aims and is not adapted to what is measured? In other words, to do it by biodiversity or water quality or things of that sort, that is efficacious in some way.

Response: The actual checking part is not necessarily directly linked to what the policy is trying to get, but the checking has to go in step with policy. Policy is not driven by what is checked, it is driven by political goals. Technological solutions are sought at the same time to enable that to actually be deployed directly. Both the regulations and technology have been changing.

Comment: The Rovigo case was very clear, but in many respects it was too clear to be interesting. What happens when the actual signal gets so low that it can be challenged in court? Also, the other issue with PSInSAR technique is that a long time series is needed. What happens when people try to force you into a statement about whether something is happening now rather than having happened many years before?

Response: In such a case no data can be given. A very noisy time series may contain a measurement point that is perfect for the client. If the false alarm rate is really high, it cannot be used before a tribunal. Typically, it is not so easy even to find the number. The false alarm rate is 10^{-5} , 10^{-6} . It is sometimes possible to use the Monte Carlo simulation, but not always. Sometimes a measurement point may be not on the roof of the building, but just at the basement level, and can be interpreted to say almost anything about the tilt of the structure. So, it's still a matter of the expertise of the people in charge of the processing, who should be able to say "Yes, I can tell you." It's really almost impossible that this kind of time series is generated completely randomly. Of course, the more data we have, the better.

Comment: In all three cases it seems that satellite data is not easy to use in a self-standing manner without supporting information, but it is used effectively. Also, you always need interpretation.

4. JURISDICTIONAL TREATMENT – *Case Reports, Regulatory Experience* – *Comparative Perspectives*

Evidential rules of a number of jurisdictions were examined, comparing their provisions and their history of using satellite and aerial Earth Observation information as evidence.

Comment: It seems that for each topic, each use of satellite evidence, a methodology needs to be defined and the situation analysed in detail. It would be very beneficial for everybody if as an outcome of the Study a more or less agreed analysis is produced of what is needed to be studied to deal with a specific problem.

Response: A primary object of the Study is to identify areas that need further investigation. We certainly do not imagine we can come up with all the answers in this Project.

Comment: On the central issue of authentication, what is lacking is awareness of multi-national satellites. First, there are many countries, with equally capable orbiting satellites, from which information could be drawn. There appears to be focus on just a narrow band of European satellites. Use of information from those others may help overcome the authentication problem. A uniform international processing system can overcome some of these difficulties. Secondly, other kinds of applications of remote sensing should also be

considered. For example, as far as international law is concerned, satellites are routinely used to ensure compliance with international arms control treaties.

Response: Using alternative systems is a great way to achieve authentication and verification, or at least to get an indication of the range of requirements for authentication, and to assess where error margins may be. The International Standards Organisation is developing some standards looking at satellite-derived information. This is largely focussed on storage and handling, as opposed to authenticating or validating the processing, which is the other element that is needed for reliable evidence. International treaties invoke international relations and the diplomatic arena that is somewhat different from the legal and administrative fora of concern here. Not the same degree of certainty is needed.

Response: Regional standards may be accepted, in Europe, in other regions, South Pacific, but not internationally. Developing international norms in this area is a very high priority.

Comment: Introduction of digital signatures, created for the banking environment, into the earth observation chain was discussed and demonstrated under an ES study of a year ago. There is no need for something completely new. Digital signatures, under the Digital Signature Act signed by the European Commission, can be used to sign the data, follow up the complete processing chain, to authenticate all the data and all the information that is coming from satellites.

5. UCL ESRC PROJECT – *Use of Satellite Information in Australia and Lessons Learned*

Australia has the most extensive regulation and use of satellite-derived information as evidence. In this session the findings of a study funded by the ESRC were presented. The regulations and precedents provided a point of comparison, particularly for monitoring and verification. Surveys of farmers and administrators also shed some light on attitudes to satellite monitoring.

Comment: At the UK Environment Agency detection is part of a bigger picture. About 30,000 environmental incidents are detected in the various disciplines. Around 1,000 infringers are prosecuted or cautioned, thus partially addressing the problem. Greater deterrence through prosecutions would be a real positive move. Use of satellites might create greater deterrence. Together with GPS and SatNav systems, this sort of evidence can work very well. This kind of evidence can be useful in some of the bigger landfill cases, where landfill sites are hidden away or filled surreptitiously over a long period of time. Satellite-derived information may be used not only as evidence in cases, but a really good deterrent, getting the message out that the satellites are there, and the Agency is able to use the evidence that comes from them.

Comment: Today much has been said about the ease of manipulating digital, which applies equally in the terrestrial environment. Has this had any effect in court proceedings?

Response: The chain of custody and what has actually happened is not generally under attack. In Australia the interpretation is often challenged, but not so much an original image that's been maliciously altered. That is quite a serious accusation to make against Government, and needs to be backed up with strong evidence. In Queensland, with the reverse burden of proof, to raise manipulation there must be some evidence of wrongdoing.

Comment: There is a very interesting article in the current edition of the Journal of Environmental Law, by Elizabeth Fisher, looking at environmental modelling. It addresses

the extent to which environmental models are accepted on face value, despite all the underlying assumptions. It is beginning to explore why this hasn't been looked at before.

Comment: It should be noted that the Australian Government and the Information Privacy Commissioner considered privacy. They reported to the Department of the Environment that resolution of 3 cm was an acceptable monitoring level by satellite. Obviously systems are nowhere near that.

6. CASE STUDY I – *Land subsidence*

Comment: Accepting that the damage has been caused by subsidence, there can be many causes of subsidence such as hot weather or trees growing nearby. We need to know that there are no other reasonable causes of subsidence. That would be a very important part of the evidence.

Response: That point is covered by the choice of reference points. These reference points are the points in comparison to which the area of interest has moved. The five points are fixed, and the observations reveal that the movement has occurred at the boundary between the two properties. The only difference there is that the excavation took place, leaving no other rational explanation is subsidence at the boundary due to excavation, because the surrounding land did not move.

Comment: Water extraction could cause the subsidence. There is no proof this particular property was not extracting water from its water table immediately below the property in that period alone, and hence the signal would have appeared.

Response: The party alleging the cause is water extraction must adduce evidence of that fact. The expert witness is not giving evidence of the cause; merely that there was subsidence in this amount on the boundary of these two properties.

Response: In this hypothetical scenario, determination of the cause will depend very much on the spatial distribution of the measurement points. Where there are 3 on property A and 2 on property B, and the time series show exactly the same behaviour so that there is indeed correlation, there is just one phenomenon rather than two independent phenomena taking place. Radar specialists provide the very best measurements to geologists, to geophysicists or structural engineers. But they are not the experts who can say a word about the reason for the subsidence.

Comment: How many data sets were used? Would it not be nice to have a longer period before it happened, to exclude a general movement that is not caused by the excavation? And a question is, how accurate is your measurement?

Response: The question is about the number of images. 20 images were used in this hypothetical scenario, but typically in real cases all available radar data are always used, no matter the numbers. For Rovigo, there were 120, and in another there were 300. For example, to decide to evacuate a section of a village where, say, 200 people live (and that's a real case), the information needs to be very reliable. In that case 3 independent data sets were used, showing exactly the same amount of motion in all 3 independent data sets. It is then up to the authorities to decide whether or not people can stay there. This is something that happened 6 months ago, and probably there will be litigation, because people don't want to leave their own houses.

Comment: Is there a minimum number of reference points that need to be present?

Response: The rule of thumb is 30, but it really depends on the area of interest and the quality of the measurement points. There also needs to be a reasonable data archive over time. It is important that there be regular acquisition over the whole of Europe and creation of a data archive.

Comment: What makes this case difficult to take seriously is the lack of ancillary information, present in real world cases. In a subsidence case one would expect information about the weather, because a long period of dry weather could lead to subsidence. And it might be preferential, under one particular property for all sorts of reasons, due to geology, or due to construction techniques, or seismic information would be another. To present a case that only relies on satellite data is so different from the real world, where satellite data is always just a part of the evidence base.

Response: This point goes to causation, in other words, is it that the excavation is cause of damage. The satellite information is being accepted as evidence that there was subsidence. That is the area being explored in this Case Study. There was a discussion this morning about error margins, and maybe that aspect can be discussed.

Comment: The court needs to be convinced about atmospheric effects and how they have been taken care of, and reassured that there is nothing peculiar about the local topography that might give rise to these sort of features just as artefacts.

Response: In this case the problem is very local, so the area of interest is very small, just a couple of hectares, and as reported in the literature, atmospheric effects are very well spatially correlated. The double difference between the point of interest and the reference points outside of the area of interest were considered. And this typically is enough, at least for a very local area, to get rid of atmospheric effects.

Comment: The software program raises questions about how the figures that come out of the raw data are produced.

Response: The processing chain is very complex, involving some 1 million C code lines, certified to the extent possible, including under ISO 9000. The key question here is that at least in principle, for small areas, it's possible to re-generate the same results even if you don't run the 1 million line C code processing chain. That's an important fact.

Comment: Agreeing there is no fault-free software available, the aircraft industry for can be used as a model. In that industry, two separate softwares do the same analysis. If both come to the same result then it is okay. Otherwise the software is not fault-free.

Response: PSInSAR will probably become a standard tool, but it is not yet a commodity. Data is obtained from ESA, and processed using two independent processing chains developed by two research groups. If exactly the same results are produced, one can rely on the result. It is a problem when the two results tell two very different stories.

Comment: To establish tort liability there must be, first, a causal link between the fault of the Defendant and the damage. The causal link here has been based on exclusion, because there was no other event in the relevant period. Some doubt was expressed because no other

potential causes were considered. Second, the extent of the damage should be shown. The technique here does not do so. Third, the responsibility of Company A is to be established.

Comment: None of the measurements have an error associated with them. In the absence of that evidence, it is difficult to know what the numbers mean. The method used has a certain heritage, but when does it work and when does it not work? And is this method being applied under conditions when it's absolutely known to work, and how close are the limits of it working? One would need to be able to make clear statements about those elements.

Response: It's very important to put in writing the level of reliability and the probability of false alarm you have in any measurement. Usually a report in litigation is based on more than 5 measurements. So this is a very hard situation.

Comment: The causal components have been questioned. But, using some slightly wider-area techniques would eliminate some of those objections. For example, with water extraction, or mining, or some geological fault, if the area beyond the 500 metres boundary or the locale of the buildings was stable in the perimeters, the causal connection is strengthened.

Response: That is why for example in Rovigo a 20 sq km area was used.

7. CASE STUDY II – Oil Spill

Extensive discussion of jurisdiction and forum shopping took place. The issues raised are of significance in any claim or prosecution. However, they are not the focus of the present Study that is concerned with evidential issues. These do vary from jurisdiction to jurisdiction and further examination of these variations will be of value, as indicated elsewhere in this Report.

Comment: The ship has arrived in Country A, therefore best to proceed in Country A, and bring civil and criminal proceedings. Bring criminal action against the Master for ordering the chief engineer to open the slop tanks. There is also an environmental crime because the slops have arrived on the beach. Automatic Identification System, (AIS), data and the SAR image can identify and potentially link the vessel to the spill.

Response: It is not so simple because A is the port State, but where did the pollution occur? That information is needed first. Also, the flag State always has precedence for prosecution, under United Nations Convention on the Law of the Sea, (UNCLOS). So there is a competition for jurisdiction, but proceedings can be started in A.

Comment: The flag State must be informed of action against the vessel. The slick went on the land in countries E, F and A. Country A can take its own action, and need only inform the flag State, which can take other action.

Comment: Pollution occurred 20 km off Country E, while the ship was en route to Country A. The country affected in the first place is not A, but E. The oil has been drifting towards A and F. When the oil reaches A, the ship may already be in A, or have called in A and left. The first question is, where is the spill and what are the consequences. The other facts to be determined are whether Dark Sea is the source of the oil and what damage is caused.

Comment: A central question is the how to collect and proffer the evidence on damage and link to the vessel. Evidence is needed to show the slick discharged off E is the same oil as reached the coast.

Comment: The slops were discharged at night, on 21st of March, when optical data is not

useful. The boat makes for Haven at 14.00 on the 22nd of March, so sometime in the morning of the 22nd of March, it is possible to think about optical data. There is no indication of the period of time for the discharge.

SAR data will probably be the major evidence base. It is useful for oil slick detection only at a relatively narrow window of wind speeds, and wave conditions. If it is very smooth, the oil spill cannot be detected, nor can it be in high waves. Therefore, wind information is necessary, which may be available from coastal and meteorological stations. Instruments on ESA satellites, and on other satellites can give wave and wind information at the sea surface. The spatial resolution of that data is not nearly as good as optical imagery. But other satellite data can provide some of the wind and wave characteristics, to allow the SAR data to be used. The combination of data is fundamental to this case.

The scenario states that there were unusual atmospheric conditions from February to March. Radar data are dramatically affected by the state of the atmosphere. Jan-Peter Muller did many studies on the impact of the atmosphere on radar and where there are false activities. The unusual atmospheric conditions would distort and could make SAR data are absolutely unusable.

Response: The image to use is the SAR image. The scenario states there are SAR images and optical images before, during and after the incident. Optical images are not used for routine monitoring. An optical image from ESA or other archive is obtained if there is activity detected. Its use is complementary.

There are suitable wind conditions for detection. This is not a narrow window; in most cases there are good detection conditions. If there is a low wind area, and close to it a little bit more wind, which is very often the case, then if the spill starts in the windy area it can still be seen in the low wind area. In high wind conditions, very heavy fuels remain, even with storms of 25 m/sec, which is 15 knots. SAR is not that limited and a SAR image is a very good detection tool.

If atmospheric conditions have affected the SAR image the quality of the image can be assessed. The vessel is seen as a bright spot, and the coastline is very clear. Images can be processed to optimise how they look. That is not manipulation but treatment.

Look-alikes, such as algae, are a problem. With an oil slick what is observed is smooth water. All that can be said is that there is smooth water detection algorithm. The point about look-alikes and false positives, is the shape of the images. A bright spot at the front followed by a long line behind is unlikely to be from anything other than a ship with a trail of oil. [Note: Causal link established by exclusion - see discussion following Case Study I.]

Response: In this example, there is a question whether the ship was stationary or en route when the spill occurred. The image would look different in each case. Also when oil spill stops drifting, it has a special appearance, and a course predictable using oil drift modelling tools. The great advantage of SAR images is the wide coverage area, not high-resolution. The location and movement of the spill are of interest. At 20 km from the coast additional information may be obtained by inspection and samples of the spill. The satellite provides a full picture of the extent of the spill, (not the volume, for which more information is needed), and whether it was a discharge from the vessel. Some questions remain, like the source of the spill, which may need additional evidence.

Comment: Here the ship is not moving when it creates the spill. Is SAR the only evidence available?

Response: There will be the Automatic Identification System (AIS), Long Range Identification and Tracking, (LRIT), or vessel monitoring system of a coastal state, using a radar station. What's important is any type of vessel traffic information. The type of information is not important, as long as the vessel and its route can be monitored, tracked and identified. The vessel can also be linked to spillage using back-tracking modelling, to connect the echo of the vessel to the spill.

Comment: Satellite information is insufficient to tie the particular oil spill to the ship. That would need some in situ chemical analysis. A witness is needed to show that it came from the particular ship.

Response: Chemical analysis is very complex. The spill is bilge water, a mixture of oil, lubricants, and possibly other substances. It will be very difficult to have a clear answer. In an accidental spill, like Erika [tanker spill off France, December 1999], there is a product that is clearly identified, and the spill and the sample products can be shown to be similar. This is the same type of product. It is difficult to identify them as the same product.

There is a network called Bonn-OSINET (The Bonn Agreement Oil Spill Identification Network of Experts), with specialised laboratories. There is also CEDRE in France, (Centre of Documentation, Research and Experimentation on Accidental Water Pollution), and organisations that know how to do the spectral analysis of the product and to tell if it matches or not. If pollution occurs in port, in some cases it works. But when there is pollution on the high seas, it is more difficult to show the sample is taken from the spill.

Comment: Slops are a mix of several products. It is quite difficult and very expensive to make the chemical analysis. If samples are taken on the beach, the link with the vessel is harder to establish. There have been several precedents in the UK with sampling, and every vessel has been released with no convictions, because the proof with sampling has not worked.

Comment: Is there a spectral technique that analyses the chemical composition of the spill? Once it starts to move, the spill will mix with other oil, and therefore becomes corrupted.

Response: There is a remote sensing technique that is being operationally applied by oil companies. It was developed in the 1980s, called fluorescence spectroscopy. It uses laser that can operate in day and night, and it can differentiate between oil and algae and different types of oil.

8. QUESTIONS RAISED

In the course of the Workshop a number of issues were identified that had not been previously contemplated, as well as some that the Study had anticipated. This session brought together the major themes that had emerged during the day.

Comment: A major theme has been that irrespective of jurisdictional difference in admissibility and rules for establishing a fact, all require that evidence be reliable and accurate. The question remains how a process, structure, rules or code of conduct can be constructed to meet those requirements that are universally applicable and to make satellite-derived information more readily useable as evidence internationally.

Response: There appears to be a distinction between different interpretations of the same imagery. Deliberate alteration of images rarely occurs, it is usually easily detected, and is not of great concern. But there will be cases where experts reach different conclusions,

irrespective of what an audit trail shows. The tribunal will decide which expert's method is more convincing.

Having codes of practice is very sensible. It guides the court, and judges want to know if best practice is followed or not. There is merit in codes at the European, international level, or national level. Much of the work is already done, because most of the codes that exist are quite relevant.

Comment: Education and communication among disciplines has been a recurring theme. The lack of a common language and understanding may be because this is an emerging area. The question is how quickly chartering may emerge in this field. In more established areas, chartering has an important role in determining standards of behaviour and what gets done.

Comment: To take a step back, data integrity is the issue. What is needed is to assure the digital data is original. This is also important for archives. A quality seal could be provided to the archive, so that a judge can say, 'Well, this data, this information derived or comes from an archive which has this European quality seal, so that we can be sure that there is no manipulation, or that we can trace back to a kind of original.' This idea was recently developed in a workshop co-organised by the European Space Policy Institute, International Institute of Space Law, and the International Society for Photogrammetry and Remote Sensing.

Comment: There may be too much emphasis on the data itself. Although it would be desirable to certify the data by a central organisation, the discussion today has been about the information derived from the data. It is the information that is challenged. There has not been any indication of doubt about the date, the timing or the authenticity of the data itself. Questions arise at the level of the information service, as in the land subsidence case, such as how it is processed, what kind of software is used for the processing, and so on. What has emerged is the need to have the information services standardised, or certified.

Comment: At EMSA the practice is to give service providers access to the data, which is retained by EMSA. In the next generation system EMSA will add MD5 signatures to all files delivered. If necessary it can compare the original with the files sent by the service provider. The only potential weak point in the chain is when a private ground station acquires the data. However, there is a certification process, ensuring a level of quality.

Comment: There is a risk that not everyone will accept regional or national standards. Any standard must be international.

Comment: Compliance with obligations under the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation (REDD) can most effectively be verified by remote sensing information. There are plans to set up a REDD mechanism, including requirements for measuring, reporting and verification of emissions from forests. That will need data systems that can facilitate comparing emissions over time. It will be difficult to measure reductions in those countries where there are no data archives in place. In designing the system, the broader perspective in an international context has to be considered, recognising not all countries are in a position to develop the systems.

Comment: There appears to be a progression in use of earth observation data, and the legal environment seems to be the most demanding where evidence is presented. The regulatory framework may be failing in a prosecution situation. Australia appears to have a more favourable framework for the use of satellite-derived information as evidence. This suggests that the regulatory regime in which the data is used is a natural precursor to its use in the judicial context. The CAP regime appears to support that proposition.

The situation with EMSA is equally interesting. EMSA exists because of several directives, and it is using satellite data because it is written into the Directive. It wasn't something that people in EMSA decided to do on its own merits. With GMES, regulations have to be developed hand in hand with the technology and the methodology to get it accepted. Acceptance comes about by communities working together. Availability is another contributing factor to acceptance, as in the case of Google Earth.

Agreed best practice [guidelines] will promote use of satellite-derived information as evidence. Some treaties and regulations are unenforceable because the principles are agreed without verifying the means to implement them.

The starting point is to have a commonly accepted source of data that is universally trusted. It need not be perfect and not useable as evidence, but provides a common basis for testing other measurements and reference point for questions. Probably the first place in the international framework where earth observation data will come to play, even before its use as a tool for verification, is as a common table that is understood and accepted and available. That is the starting point for all these things that later lead to acceptance in the judicial framework.

Comment: The International Research on Permanent Authentic Records in Electronic Systems, (InterPARES), is an international project developing standards for the preservation of electronically stored data. Standards continue to be tested in court by cross-examination.

Response: Standards are similar to established business practices and overcome any issue related to admissibility. Once a standard is established, the lawyer's task is to show the data does not conform to the standard. It will be a difficult task to establish the standard is wrong.

Comment: Standards are useful not only for court, but to guide best practice to improve evidence. What is clear about some of the things looked at today is that satellites do not provide a perfect form of evidence. Corroborative evidence is needed in most cases.

Comment: One main conclusion is that there is more space activity than the man in the street or the detached observer is aware of, and there's less legal knowledge than desirable. Therefore, it is important to draw up some kind of guidelines on the state of evidence and the production of satellite images in courts, mainly to help the judges, who are asking for this.

Comment: Different experts can interpret satellite evidence differently. There should be examination of what conditions could lead to greater consistency and whether the tribunal should appoint expert witnesses.

Two aspects that have not been addressed in depth today, are cost-benefit analysis and privacy. It will greatly help convince users and increase use if space data if it is shown to be an economic alternative to aerial photographs, ground inspection or radar images.

In US cases, thermal images have been found by many courts not to invade privacy. However, the issue is gaining importance, particularly where individuals are concerned.

ISSUES IDENTIFIED

1. INTRODUCTION

In the course of the Workshop and further discussions, certain issues that need greater study or resolution were identified. The following list is not necessarily exhaustive, but provides an indication of the major concerns expressed. Comments in relation to each are intended to provoke further discussion and reflection. Some proposals that relate to a number of the identified issues are covered under the section Plans for Further Action Research and Study.

2. EDUCATION AND REDUCTION OF TECHNOLOGY GAP

There is a need to understand and clarify different perceptions of the nature of the data. Satellite-derived data was characterised by some lawyers as “electronic evidence.” This is such a broad term that it is unhelpful. It may be a reference to a matter that is detected by an electromagnetic process. An example may be radar detection of speed. Evidentially this is direct evidence, much as the reading on a speedometer, not subjected to any process. Apart from showing the correct operation and calibration of the instrument, nothing more is needed.

Another example would be a reference used as a synonym for “digital,” raising issues of undetectable alteration. Depending on the nature of the data and the information sought, varying degrees of processing can be necessary to generate intelligible information from the data. This too may introduce errors that need to be taken into account.

An important task of the Study is to focus discussion on relevant issues and facilitate understanding between and among technicians and lawyers, better understanding of the technology and awareness of different perceptions.

3. ESTABLISHING A COMMON LANGUAGE

On a related topic, there is no common language between and among technical and legal participants. For example, it was pointed out that highly scientific technical people might be a bemused to hear that some of the data they produce is simply *hearsay* or *circumstantial*.

The hearsay rule that operates to exclude second-hand information as evidence is largely a common law concept. The rule is all but abolished in the US and UK. What is important is the relevance of information and whether it can contribute to establishing a fact in issue.

A common language will help avoid misunderstandings and encourage greater communication between specialists in the different disciplines. This may be achieved by producing a glossary or dictionary of terms accessible both to scientists and lawyers.

4. NEED AND PROCEDURES

There is also a lack of sufficient appreciation of capabilities and requirements of each group between scientists, academics, commercial earth observation system operators, data suppliers, lawyers and clients. An understanding of the process in which each discipline is engaged is also absent. Some of the proposals for future action will alleviate these shortcomings.

5. SUBJECT OF CERTIFICATION

The features or matters that need to be certified from an evidential perspective are not generally clear to suppliers of data and processed information. These include management systems (some addressed by ISO standards), credentials and qualifications of those who might act as expert witnesses to the techniques used in collection and processing data. There is also uncertainty about the method and relevance of verification and validation. For example whether it is sufficient or necessary to show techniques are “accepted” within the relevant technical community, and what impact such validation has on treatment of the information as circumstantial or hearsay evidence.

Such questions highlight the need for better and clearer communication of the needs of lawyers to the technical community.

6. VERIFICATION, VALIDATION AND CERTIFICATION

The technical community in particular regard verification, validation and certification as key to establishing reliability of information. This is particularly relevant in less transparent cases such as radar, where the meaning of the information is not immediately clear.

The need to interpret the data poses other questions. For example, whether there is need for several data sets, or for additional means of verification. Ease of manipulation and change of data need to be examined. Accuracy and timing may be important, as may be time stamping data. The need for ground truth to compare satellite data is a further aspect of verification and validation that must be considered. It may also be desirable to have a certification process or standard qualifications for experts.

There continues to be a strong argument for investigation of alternative methods of certification, verification and data standards, outlining merits and drawbacks. Any standards or certification systems need to be at an international level, not least to facilitate use of data from different systems for validation purposes.

7. QUALIFICATION OF INFORMATION

Processed information, such as that being discussed here, will generally carry certain qualifications. Different systems may generate slightly different results and processes can also have inherent errors. There must be clarity on how information is qualified, for example in relation to differences in results due to analysis techniques used, what errors may be present and their impact on the information.

8. DIFFERENCES IN APPLICATIONS AND SYSTEMS

Difference in the applications for which the information is generated and used must be accommodated. There is likely to be a need to set criteria for different applications, eg the number of reference points for PSInSAR for subsidence, comparison with analysis using different techniques, how many data sets should be used.

ADDITIONAL ISSUES TO BE EXAMINED

INTRODUCTION

Certain themes emerged during the Workshop, pointing to areas that would benefit from additional study. These will be further considered and issues examined to add value to our Final Report. Not all can be covered as a part of this Study, but will indicate the direction for further studies. The following summarises some potential areas for further examination.

1. RELIABILITY

Technical Systems

A central requirement for the use of satellite-derived information as evidence is that the information be reliable. A number of factors affect reliability, and a tribunal needs to be satisfied on each. These range from calibration to functional characteristics of sensors. One approach to ensuring and demonstrating reliability would be to establish a certification regime with specific criteria to be met.

In all evidential applications information needs to be date and time stamped. Either the system or the collection process should provide this information.

Transfer and Storage

Both the communication system and storage arrangements should be secure and free of elements that may alter or lose the data and information collected. Standards and audit procedures can provide the necessary assurance. There is currently a Draft ISO¹⁰ standard dealing with storage of data being reviewed.

Processing

An expert witness usually presents the method and results of processing. Although in many circumstances expert evidence remains necessary, its scope and focus can be reduced. Any criteria established for processing data into useful information and evidence will be dependent on the application to which it relates. Differences between the characteristics of applications can point to necessary variations in criteria to be met in each class of case.

2. RULES OF EVIDENCE

Jurisdictions differ in their evidential rules and laws. Analysis of such rules in a large number of jurisdictions will better facilitate the development of rules and criteria applicable internationally. A question arises whether one or a number of standards or guidelines will best serve the greater use of satellite-derived information as evidence.

3. APPLICATIONS

Common principles apply to the use of satellite-derived information as evidence, irrespective of the application. However, both in terms of the technical capabilities and processes used and the character of the facts to be established, different applications have specific characteristics that need to be accommodated. This feature became evident in the course of the Workshop and on discussion of the Case Studies. Therefore, at this stage of development of techniques and the law, it is likely to be more productive to examine the requirements of particular applications.

¹⁰ ISO 10008.

POSSIBILITIES FOR FURTHER ACTION, RESEARCH AND STUDY

1. AWARENESS

From the outset the Study Team and ESA were conscious of the need to create awareness of the potential for use of satellite-derived Earth Observation information as evidence among lawyers, and to make the technical community familiar with the needs of lawyers and courts. The Workshop not only confirmed this need, but also helped identify the particular nature of the needs of each group.

1.1 OPPORTUNITY TO EXCHANGE INFORMATION

There appeared to be strong support for further opportunities to exchange information and continue the dialogue. It is certainly the intention to do so and to devise effective methods for this to take place. The case study format may work well, perhaps with tighter direction focusing on limited issues to be explored in depth.

A series of seminars can also be useful to identify topics and to develop a common language. This will facilitate better understanding of the capabilities and needs of each group, thus fostering greater awareness of what is desirable and what can be achieved.

1.2 COMMON LANGUAGE

An important aspect of creating awareness is the ability to understand and communicate the current position and future needs. It rapidly became clear that there are few concept on which there is shared understanding between the groups and, at times, within each group.

As exchanges between the groups increase a more uniform use of expressions will emerge. However, this will take time and a more concerted and formal approach may be desirable. There are several glossaries that include EO terminology and expressions as well as acronyms, mainly aimed at technicians.¹¹ The development of glossaries giving definitions useful to technicians and lawyers alike can be a worthwhile exercise to undertake.

2. NATURE AND COMPONENTS OF EVIDENCE

2.1 EVIDENCE AND ERROR

In the course of the Workshop it became apparent that there are some misconceptions about the nature of evidence and of the legal process of establishing a claim or a crime. Evidence is the set of facts that need to be established to support a claim or prosecution. The process of establishing those facts is commonly referred to as “proof.”

However, the term “proof” may be misleading. In legal proceedings, irrespective of jurisdiction, two stages are involved. First, evidence is given of the facts necessary to establish the claim, or the occurrence of the crime. No legal system requires that the underlying facts be shown to be incontrovertible. In other words, it is not necessary to show the fact to be true. At most it has to be shown that the event, action or circumstance occurred “beyond a reasonable doubt.” This is less than the level of certainty required for “truth.”

¹¹ See for example, ESA Earthnet Online: <http://envisat.esa.int/earth/www/object/index.cfm?fobjectid=1397>; International Astronomical Federation: <http://www.iafastro.com/index.html?title=Glossary>; NASA Earth Observatory: <http://earthobservatory.nasa.gov/Glossary/?mode=all>; Natural Resources Canada: http://www.ccrs.nrcan.gc.ca/glossary/index_e.php?term=Tech&choice=B

It follows that lawyers do not deal in “truth,” but an approximation of the truth, depending on whether they are involved in civil or criminal litigation. Each fact is established subject to a level of error, albeit not readily quantifiable. The task of the court is to determine whether the evidence offered meets the requisite level of certainty. To this extent, the task is no different from that of the scientist in dealing with error in data. However, the scientist has a method of quantifying the error, whereas the court, with non-scientific evidence, has no quantitative method for assessing evidence.

The second stage of the legal process is to demonstrate that the fact established was the cause of the occurrence that gives rise to the relevant legal right or liability. Causation may be shown by expert evidence, ie opinion of a specialist in the relevant field, by natural inference or other means.

To enable technicians to supply useful information to the legal community, an understanding of these concepts and distinctions is important. Again, interaction between the groups as well as seminars and workshops can be valuable tools in gaining such understanding.

2.2 COMBINATION OF SATELLITE-DERIVED INFORMATION

The Workshop underlined the desirability of a holistic approach to satellite-derived EO information as a source of evidence. Data from Geographic Positioning Systems (GPS) and time-stamping data may be vital elements in authenticating evidence. This aspect of legal relevance and the technical means of generating and combining reliable information need to be investigated. A question that arises is how to treat information that may be regarded as machine-generated reliable evidence, when combined with information that is processed and is subject to interpretation by an expert. If they are discrete, each establishing a different relevant fact, no difficulty should arise. The problem will only become relevant where together they are evidence of one fact.

Examination of situations and matters in which such combination of information takes place would be a useful exercise.

3. QUALITY OF EVIDENCE

To be of value, evidence must be relevant and reliable. In the context of satellite-derived EO information, each element involved in the collection, transmission, storage and processing of the data must be reliable. The information must faithfully represent what is observed.

The Workshop deliberations support the proposition that the way forward to creating the conditions for the use of satellite-derived information as evidence lies in the establishment of criteria for the collection, storage, handling and processing of satellite-gathered data. It is contended that an international code will be most generally accepted and used.

An approach that may be taken is to investigate the criteria to ensure admission and probative value. This can be done in the course of establishing standards applicable to satellite Earth observation data. To facilitate use as evidence, such standard will need to address reliability and security of the data and its processing.

3.1 STANDARDS AND CERTIFICATION

One means of ensuring reliability is to have a set of standards to which the data and the processes conform. Groups within and outside ESA are already working on standards. Any additional work done in this area will complement the activities of those groups and ensure that the development of any standards takes account of legal requirements for the use of satellite-derived information products as evidence.

Areas of focus will include identifying the core criteria to be met in the collection, storage (which may include compliance with ISO/DIS 16363), handling and processing of data from inception to the end product as evidence.

Collection covers sensor reliability and accuracy, involving calibration and system error assessment;

Storage covers security, including stability, of the systems and media and custody procedures of the depository;

Handling covers access to the data, passwords, transfer and tracking of custody and manipulation; and

Processing covers the changes and manipulations to which the data is subjected, the algorithms used and the qualifications and experience of operators responsible for processing the data.

An ideal position will be to establish an internationally recognised and accepted body with defined procedures to certify conformity with the relevant standards.

3.2 EXPERT WITNESSES

Greater use of satellite-derived evidence may be further facilitated by identification and definition of core qualifications of experts. These will be individuals with the minimum skills and knowledge needed to interpret satellite-derived information. A first step would be to determine whether such core qualifications can be identified to apply to all experts, with additional specialised skills for each area of application.

3.3 RISK OF ALTERATION

The ease with which satellite-derived information might be deliberately falsified needs careful consideration. The risk of such manipulation should be assessed both at the raw data level and during processing.

4. APPLICATIONS

The Workshop considered two different applications as Case Studies, namely land subsidence and oil spill. It was evident that not only the technical capabilities required for each, but also the nature of the facts to be established, differed widely. From a technical perspective the land subsidence case study required analysis of historical data, as well as observations using a specific technique. The oil spill case study relied on frequent contemporaneous observations and an ability to distinguish look-alikes.

In Case Study I, the underlying fact to be established, subsidence, was readily observable and measured by satellite. In Case Study II an important fact, the identification of the oil and its link to the vessel, necessary for establishing liability, is not yet observable by satellite. It may, therefore, be more productive to focus on specific applications that more readily lend themselves to the use of satellite-derived information as evidence.

Applications that may be considered further include water rights, geotechnical information used in urban planning and major construction projects and wetland management. Other applications that may be considered are detection of activities by warlords, illegal diamond mining and environmental security, such as compliance with requirements for REDD.



**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 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 Journal 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

<i>Moderator:</i>	<i>Kai-Uwe Schrogl</i>	
<i>Presenter:</i>	<i>Sa'id Mosteshar</i>	UK and US
	<i>Kevin Madders</i>	Belgium, The Netherlands
	<i>Lucien Rapp</i>	France
	<i>Johanna Symmons</i>	Germany
	<i>Maureen Williams</i>	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

<i>Moderator:</i>	<i>Richard Macrory</i>	
<i>Presenter:</i>	<i>Ray Purdy</i>	Use of satellite derived information, perceptions and impact

14.30 Case Study I – Land subsidence

<i>Moderator:</i>	<i>Luc Govaert</i>
<i>Presenters:</i>	<i>Sa'id Mosteshar and Alessandro Ferretti</i>

15.30 Tea

15.45 Case Study II – Oil Spill

<i>Moderator:</i>	<i>Gordon Campbell</i>
<i>Presenter:</i>	<i>Kevin Madders and Marc Journal</i>

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

<i>Moderator:</i>	<i>Sa'id Mosteshar</i>
<i>Panelists:</i>	<i>Gordon Campbell, Luc Govaert, Robert Gurney, Tanja Masson-Zwaan, Ray Purdy, Kai-Uwe Schrogl, Maureen Williams</i>

17.15 Closing report and concluding remarks - ESA Project Managers and Institute Director

ATTENDANCE LIST

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 Jongma	Audit Manager, Netherlands Court of Audit
Marc Journal	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
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 Borrión	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
Professor Geoffrey Wadge	Chairman, Monserrat Science Committee; NERC-ESSC
Ilaria Zilioli	Contracts Officer, ESA; ISPL Faculty

Participants

Maria Adams	Head of Future Missions, UK Space Agency
Jonathan Amos	Science Correspondent, BBC News
Philip Annetts	Department for Environment Food & Rural Affairs, DEFRA
Tony Ballard	Partner, Harbottle & Lewis, ISPL Trustee
Cristina Barreau	Environmental Lawyer, Surfrider Foundation Europe
Darcy Beamer-Downie	General Counsel, Airclaims Ltd
Dr Ulrike Bohlmann	Legal Administrator, ESA
Rasmus Borgstrøm	Geographic Resource Analysis & Science Ltd., GRAS
Ann Brosnan	Head of Serious Casework, Environment Agency UK
Alan Brunstrom	Integrated Applications Promotion IAP, ESA
Giovanni Cannizzaro	Business Development, Telespazio
Marco Cattadori	Booz & Co
Dario Cau	Captain, Italian Coastguard ITCG
Antidia Citores	Law and Lobbying Coordinator, Surfrider Foundation Europe
Robin Cleverly	Law of the Sea Consultant, UK Hydrographic Office
Vivian Contin-Williams	International Lawyer
Willibald Croi	Project Manager, Applications, LuxSpace
Dr J Phillip Dann	ISPL Faculty
Julien Delanoë	ESA Climate Office
Martin Ditter	Project Manager, ESA Harwell Centre
Samantha Duckett	Helical Bar
Ruth Eldon	ISPL Workshop Administrator
Yanal Abul Failat	Student, Kingston University
Chris Forsyth	Partner, Freshfields Bruckhaus Deringer
His Honour Simon Goldstein	ISPL Trustee
Caroline Grace	Grace & Co, ISPL Trustee
Geoffrey Hall	Principal & Director, Moreton Hall Associates
Lars Boye Hansen	Geographic Resource Analysis & Science Ltd., GRAS
Professor Ray Harris	Emeritus Professor of Geography, UCL
Elizabeth Hiester	Solicitor, former Partner, Clifford Chance
Dr Richard Hilton	Business Development Manager, Space Services, Infoterra Ltd
DS Steve Hubbard	Deputy Project Manager, Op Javelin, Metropolitan Police
Sam Hutchinson	Helical Bar
Professor Bhupendra Jasani	Visiting Professor, Department of War Studies, King's College London
Dr Shaída Johnston	Science & Technology Policy, Law Department, George Washington University
Professor Rónán Kennedy	Faculty of Law, National University of Ireland, Galway
Daniel Lawrence	Of Counsel, Environment, Regulatory & Planning, Freshfields Bruckhaus Deringer
Dr George Leloudas	Gates and Partners
Christian Lindqvist	Telenor
Harold Linke	Manager Software and ICT, HITEC Luxembourg

Stephen Mason	Barrister, Visiting Fellow, BIICL
Florent Mazurelle	European Security Policy Administrator, ESA
Mr Justice Sir Richard McCombe	
DCI Mick Neville	Project Manager, Op Javelin, Metropolitan Police
Sekai Ngarize	Senior Science and Policy Advisor, DECC
Pat Norris	Logica
Rolf S Olofsson	Partner, White & Case
Chetan Pradhan	Vice-Chairman / Account Manager, Earth Observation, Logica
Mads Olanders Rasmussen	Geographic Resource Analysis & Science Ltd., GRAS
David Slater	Cambrensis Environmental Consultancy
Chiara Spina	PhD Candidate, University of Rome 'La Sapienza'
Dr Jerry Stanley	Director, Rondle Ltd
Dr Jill Stuart	Department of Government, Politics of Outer Space, London School of Economics
Christian Tøttrup	Geographic Resource Analysis & Science Ltd., GRAS
Wouter Veening	Chairman & President, Institute for Environmental Security
Robert Volterra	Partner, Latham & Watkins
Luc Willems	Deputy Secretary-General – Benelux, Telindus
Michael Williams	External Relations Manager - Group on Earth Observations, GEO Secretariat