No.102

EnMAP for Food Security and Sustainable Agriculture

Earth Observation (EO) through remote sensing from space is the most feasible way to acquire site specific crop properties. The ESA-sponsored and DLR-supported project TalkingFields (www.talkingfields.de) demonstrates how a close combination of agro-ecological crop growth and management models with data from existing and future remote sensing sources (Sentinel, LANDSAT, RapidEye, TerraSAR-X, EnMAP) can be used to support farmers in increasing efficiency of farm management.

Problem

Global biomass demand for food, energy and biomaterials is expected to roughly double from 2005 to 2050. At the same time most global land suitable for agriculture is already in use. Sustainable efficiency gains and increasing yields on today's cropland are therefore essential to ensure food security even with future demands. Today's crop management is field based and limited in efficiently using fertilizer because it is based on a "one size fits all" approach. 'Precision farming' employs data from space and ground assets to optimize the use of resources for maximum agricultural output. TalkingFields is a valuable service for sustainable and cost-effective agriculture by combining Earth observation and navigation satellites' input with information from ground sensors to help farmers decide how, when and where to allocate resources for the best results. The service attracted customers from across Europe.

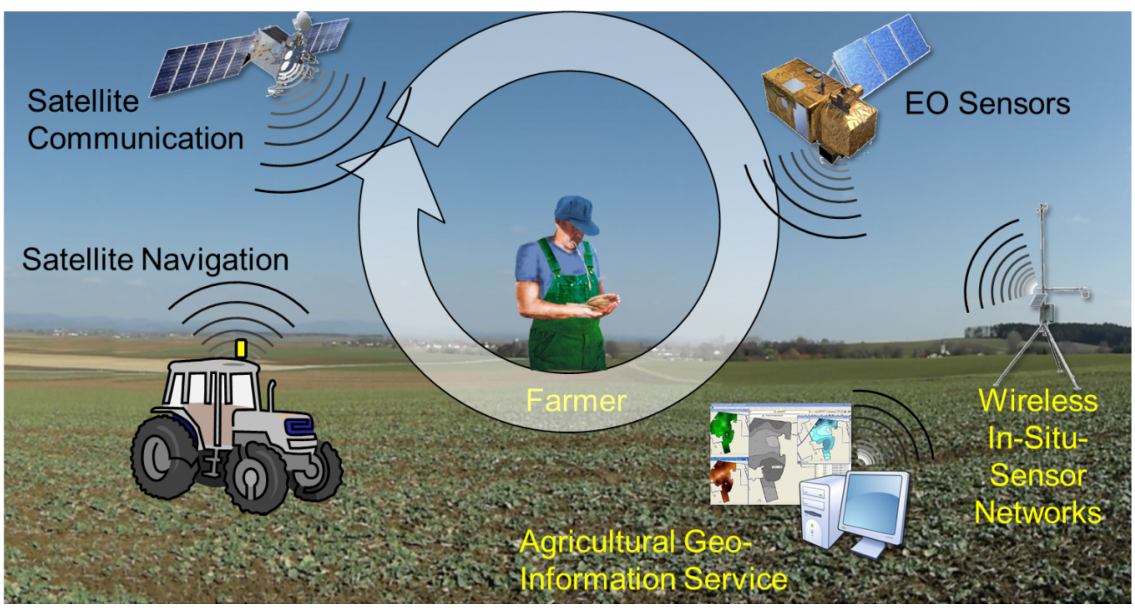

Fig. 1: In TalkingFields, the farmer is in the focus. He is assisted by all available technology, including several space components (mainly GNSS and EO)

Satellite Earth Observation Data Application

The TalkingFields service is produced by three German organisations: the satellite remote sensing company VISTA, the agricultural service provider PC Agrar, and the Ludwig-Maximilians-University of Munich, who developed the crop growth model. Combined, their expertise has resulted in an integrated service that can provide farmers with all the elements they need to make educated decisions on how to manage their crops.

This combination of services means TalkingFields can use the Earth observation sensors Sentinel, LANDSAT, RapidEye, TerraSAR-X and in the future EnMAP to supply data on individual zones' soil fertility and disease risk by analyzing biomass distribution, while its software element calculates the economic returns of different precision farming strategies. Farmers are also supplied with yield reports, covering both past output and future estimates of up to four weeks in advance. Navigation satellites provide accurate geo-location information to enable farmers to apply the advised measures exactly where needed.

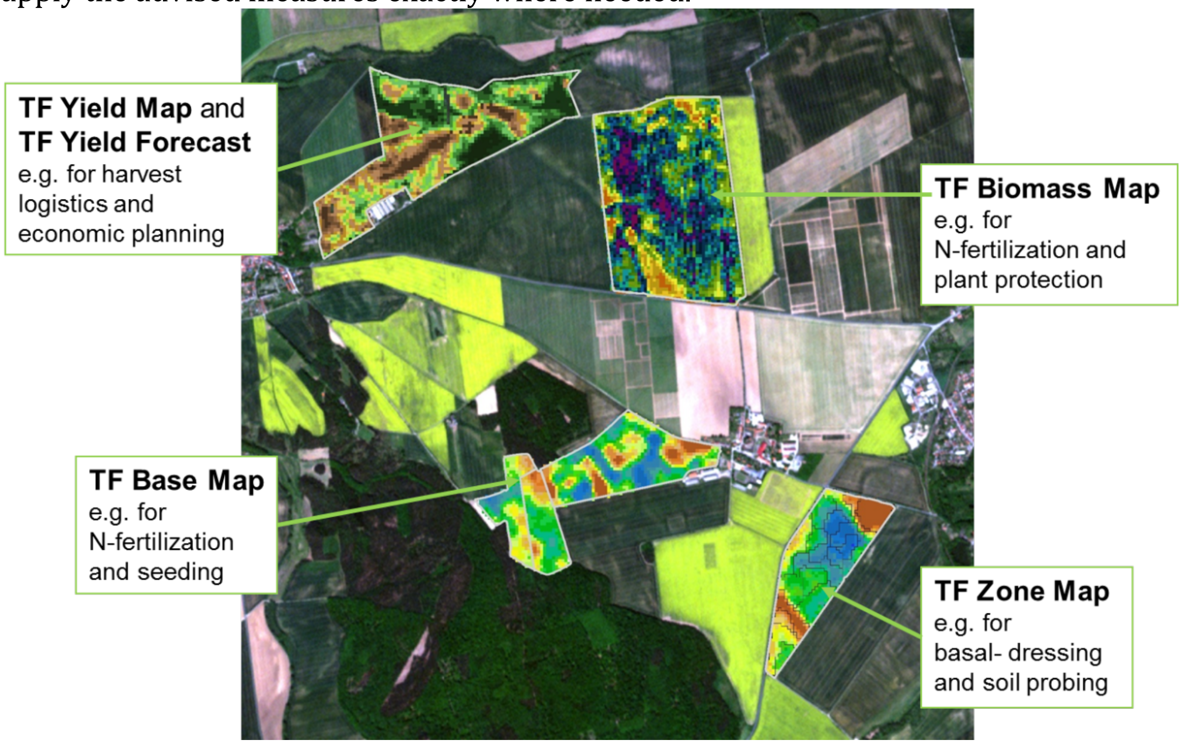

Fig.2: The TalkingFields products.

TalkingFields (TF) uses remote sensing data of a whole palette of sensors to provide services in the form of TF Yield Maps, TF Yield Forecasts, TF Base Maps for managing site specific fertilizer application or seeding, TF Zone Maps for zoning and probing and TF Biomass Maps e.g. for plant protection. They allow the farmer to more accurately apply seeding, fertilizing, pesticide application and planning of harvest dates. More accuracy means lower production costs, as resources such as water and fertilizer are not wasted. More accurately also means more yield per fertilizer used. This benefits not only farmers, but also agricultural stakeholders such as drinking water protection agencies, resulting in both successful commercial business and as well as environmental gains.

An important characteristic of the TF services is that they are not bound to one specific Earth Observation source. Instead, a multi-mission concept is applied, that allows the use of all optical satellite sensors with a high spatial resolution (resampled to a standard grid size of 20m). Landsat-8 OLI data has been integrated in the processing and used for growth analyses in 2013. The use of Sentinel-2 data is being prepared, so that also this important data source can be used as soon as it becomes available. EnMAP as the expected first imaging spectrometer in space will strongly enhance the TalkingField services by using the full spectral information to completely derive the TF services from remote sensing data without ground truth.

The up-to-date services on biomass and yield estimation rely on the fast and reliable availability of EO data. Practical experience about the temporal sampling of EO data shows that 4 optical satellite images per harvest year are necessary for best results.

Improved site characterization is used to quantify the spatial distribution of yield potential within a field by analyzing multi-year satellite observations. Fig. 3 shows a result: the TF Base Map for a farm in Eastern Germany. In opposition to other approaches that usually use the average of different vegetation indices over several years, the approach used by TalkingFields applies a geo-statistical processing that filters out patterns in the field that are observable over multiple years. These patterns are usually bound to site-characteristics, e.g. the water holding capacity of the soils. They do not necessarily show up every year, but they show up persistently. In Fig. 3 elongated features that span several fields and have lower persistent biomass values are visible. These are lime-ridges that have a lower water holding capacity than the soils around them.

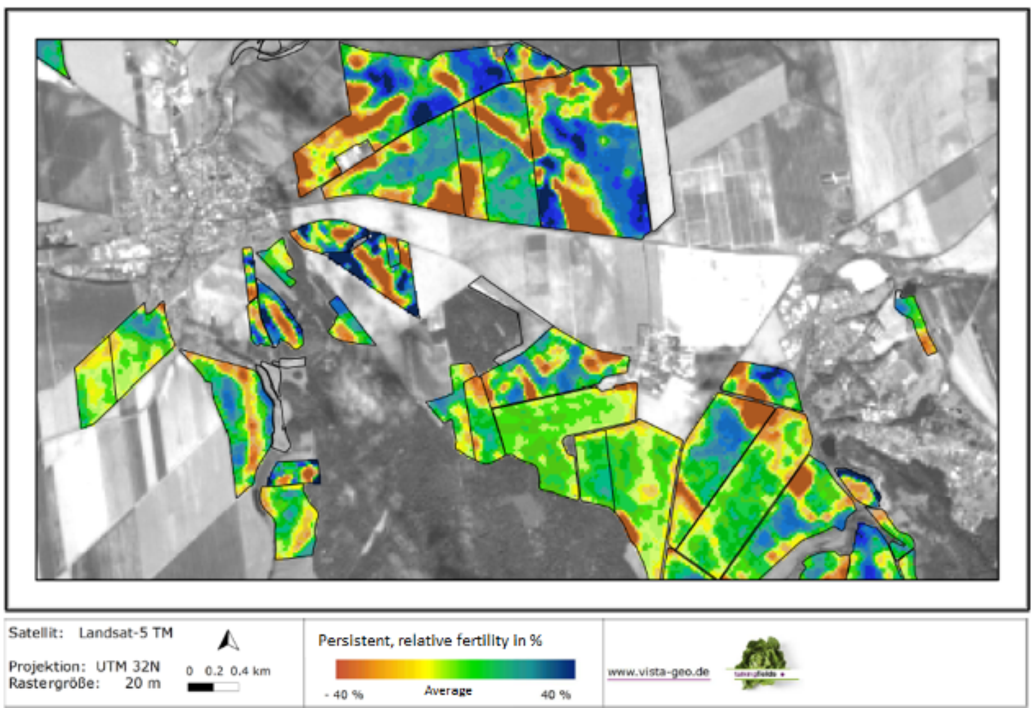

Fig.3: TF Base Map as calculated for a farm in Eastern Germany

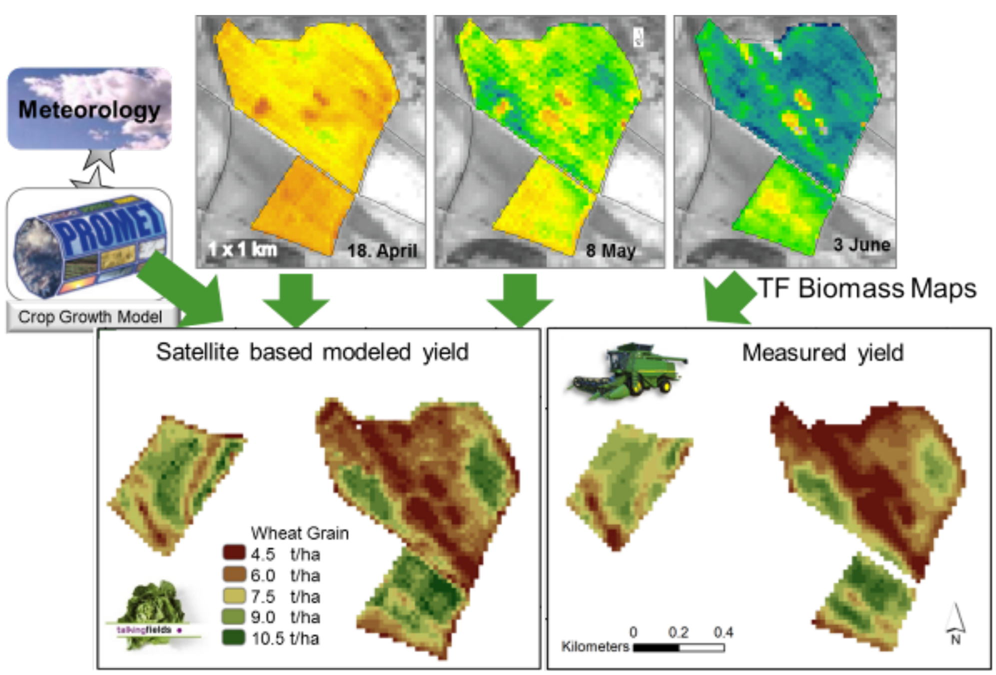

Fig.4: Comparison of the TalkingFields Yield Maps using the PROMET crop growth model and EO data with measured yields during harvests. Satellite data: RapidEye.

At the same time TF Yield Maps deliver yields that are determined by combining a plant growth model with time series of multi-sensor EO data. A comparison between TF Yield Maps and at-harvest measurements is shown in Fig.4.

TalkingFields has successfully concluded its Demonstration Phase in April 2014 and is now a commercial service. It has been supported through the Integrated Applications Promotion (IAP) programme of ESA's Telecommunications and Integrated Applications Directorate and by DLR within its EnMAP scientific preparation programme.

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Use of SAR data to map and quantify eruptive deposits for lahar assessment

Radar images can be acquired at night and in cloudy conditions, which represents a significative advantage when using SAR data for volcano monitoring rather than optical and infrared sensors. Variation in InSAR coherence and amplitude evolution can be used to map eruptive deposits, which is a key information for assessing volcanic hazards. Based on the 2010 Merapi volcano eruption case, we developed a supervised classification method applied to dual-polarization ALOS data in order to map the pyroclastic deposits. This method will be used by the Center for Volcanology and Geological Hazard Mitigation (CVGHM) for lahar assessment in Indonesia.

Problem

When non-consolidated volcanic deposits are emplaced during an explosive eruption, they can rapidly be remobilized by rain water to form lahars. Such lahars are mixtures of water and rock fragments flowing down the slope of a volcano and represent an important risk in Indonesia because they can damage and destroy infrastructures (road, bridges, villages…) and cause fatalities. After an eruptive event, it is thus essential to rapidly estimate the volume and location of eruptive material emplaced, such parameters being the inputs of lahar models used to produce maps of areas potentially affected. Mapping eruptive deposits based on field observations takes time and is not always possible because some difficulties or dangers might prevent the access to the field area. Alternatively remote sensing data represent a useful tool to quickly map eruptive deposits after an eruption without requirement to access the field thus reducing the risk and duration of investigations.

Satellite Earth Observation Data Application

Optical data present the advantage of the high resolution with sub-metric image pixels however they cannot provide any information in presence of clouds. In contrast, Synthetic Aperture Radar (SAR) data can bring information during day or night, independent of the meteorological conditions, such providing useful information in humid tropical environments where volcanoes are covered by clouds. The radar echo is sensitive to any change in the distribution of scatterers at the ground. As a result, the emplacement of eruptive deposits can easily be detected through multi-temporal SAR images. Detection can be based, either on evolution of reflectivity, i.e. the amplitude of the radar images, or on the temporal decorrelation of the signal.

We recently developed a new method allowing to map eruptive deposits in a semi-automatic way rapidly after an eruptive event based on dual-polarization SAR data (Solikhin et al, 2015). This method takes advantage of both the ground reflectivity evolution and the decorrelation induced by deposits emplacement. It has been tested on eruptive deposits emplaced after the 2010 VEI 4 Merapi eruption in Indonesia.

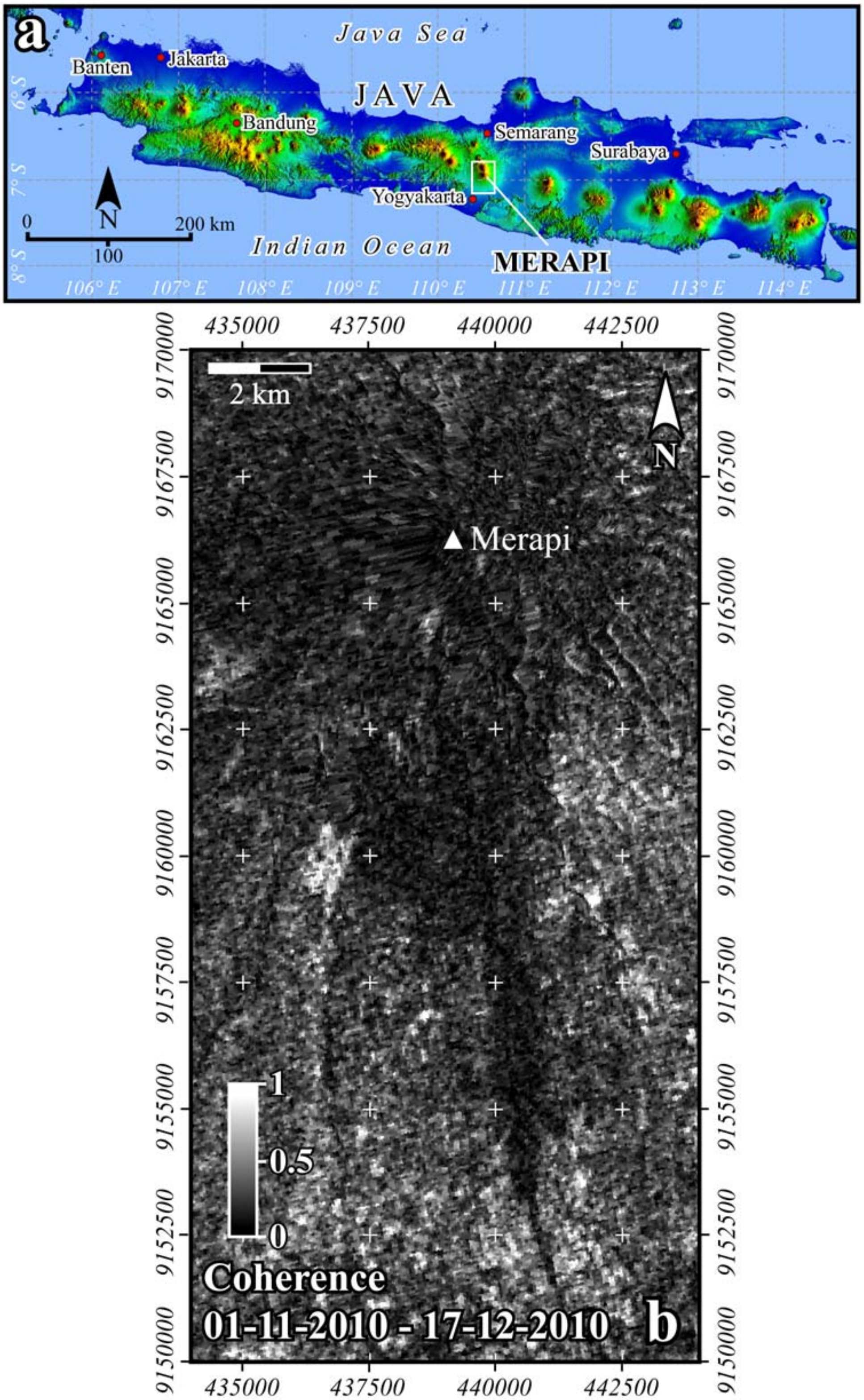
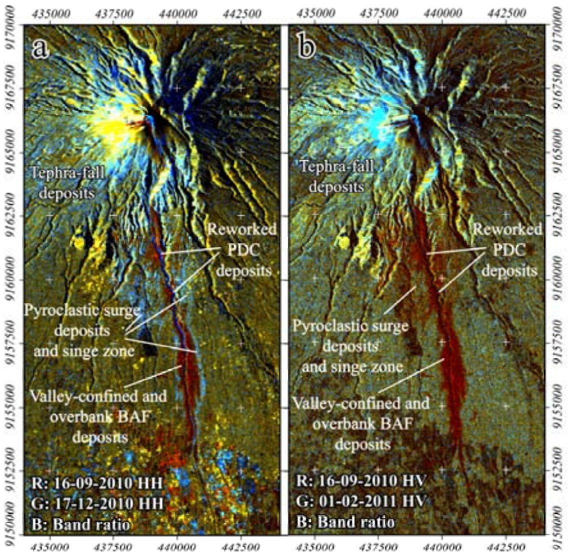


Figure 1*: Application of SAR data to map the eruptive deposits of the 2010 VEI 4 eruption of Merapi volcano a) Location of Merapi volcano in the central part of Java island (the white box corresponds to the area covered in part b and in figure 2. B Coherence image obtained when forming the interferogram between two descending ALOS/PALSAR images acquired before the main eruptive phase (on 1November 2010) and after (on 17 December 2010). The area covered by eruptive deposits is characterized by a strong decorrelation and appears dark.*

First a coherence image (Figure 1) is produced using a SAR image acquired just before the eruption and another one acquired after eruptive deposits emplacement. On this image, deposits are characterized by a loss of coherence and appear as dark. Then we use four amplitude images corresponding to acquisitions performed respectively before and after the eruption in two different polarizations (co-polarized, HH, and cross-polarized, HV, data) in order to distinguish the various deposits. As shown on figure 2, each type of deposits is characterized by a given evolution of the backscattering when considering both polarizations. Radar amplitudes in direct (HH) and cross (HV) polarizations decrease where the valley-confined and overbank block-and-ash flow (BAF) deposits (D1) are emplaced. Rainfall- and runoff-reworked PDC deposits (D2) are characterized by an increase in ground backscattering for HH polarization and a decrease for HV polarization. Ground backscattering transiently increases in both polarizations after tephra fall (D4) deposition. This specific behaviour is expected to be strongly dependent on the wavelength of the radar data but the important point is that it can characterize a given type of eruptive deposits when considering both co and cross-polarized data.



c) Deposits

- D1: Channel-confined and overbank BAF deposits
- D2: Reworked PDC deposits
- D3: Pyroclastic surge deposits
- D4: Tephra-fall deposits

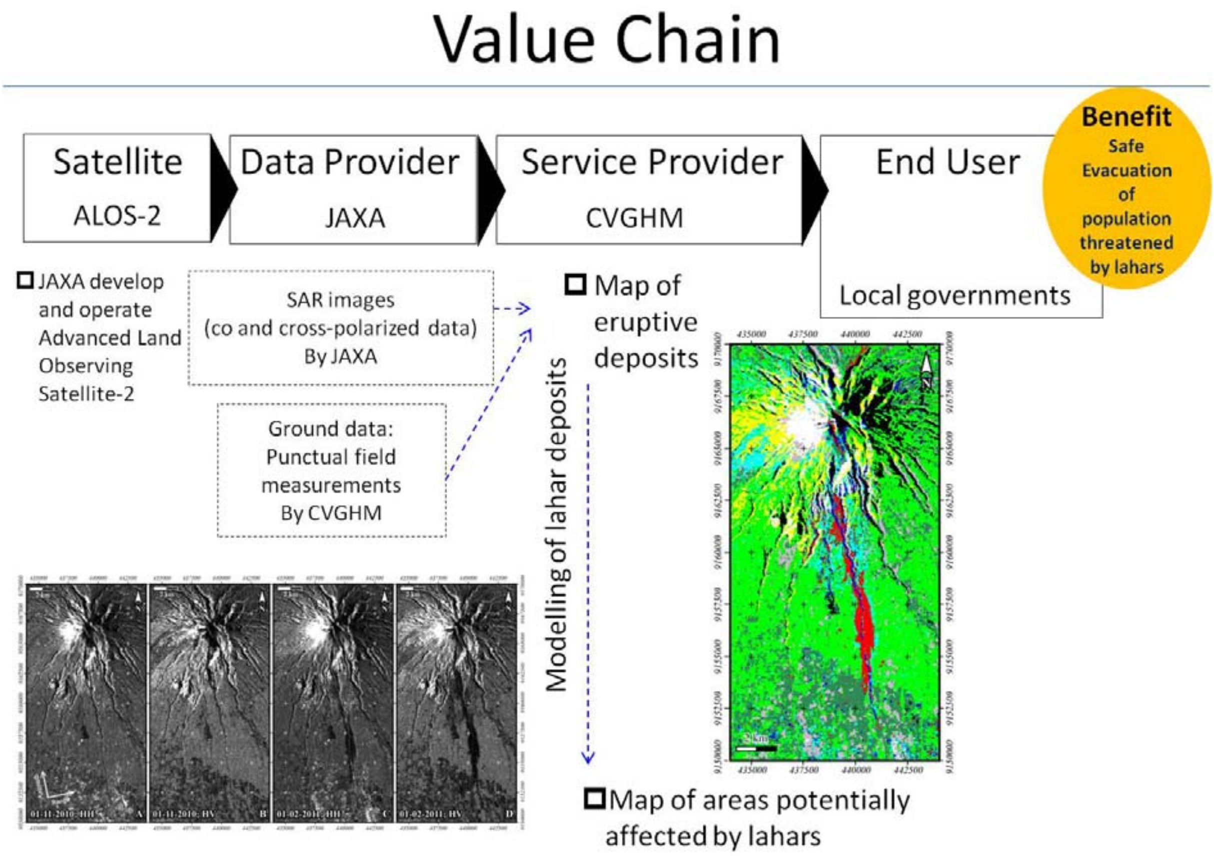
	HH	HV
D1	↓ 6.4 dB	↓ 7.5 dB
D2	↑ 4.6 dB	↓ 2.8 dB
D3	↑ 2.4 dB	↓ 0.4 dB
D4	↑ 2.0 dB	↑ 1.7 dB

Figure 2) ALOS-PALSAR amplitude-change image of Merapi's southern flank. The false-color composite (R: earlier image; G: later image; B: ratio of the second image divided by the first image) is obtained using pairs of amplitude images acquired in before the eruption and after the event). Deposit characteristics are known from field observations and optical imagery a) HH polarization (first image acquired on 16 september 2010, second image acquired on 17 december 2010) b) HV polarization (first image acquired on 16 september 2010, second image acquired on 1 february 2011). C) Amplitude evolution for the various types of deposits.

We then combine the information from the coherence image with those from the four amplitude images using a supervised classification method based on maximum likelihood to map the deposits. Classification derived from ALOS-PALSAR images using the maximum likelihood classification provides a result with 70% classification accuracy for deposits overall. We verified that the results derived based on this method are similar to the one produced from high-resolution satellite optical imagery and field-based data.

In the future, this new method will be used by CVGHM to rapidly map eruptive deposits based on SAR data in order to update risk assessment for lahars.

Value Chain



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Reference:

A. Solikhin, **V. Pinel**, J. Vandemeulebrouck, J.-C. Thouret, M. Hendrasto, Mapping the 2010 Merapi pyroclastic deposits using dual-polarization Synthetic Aperture Radar (SAR) data, Remote Sensing of Environment, http://dx.doi.org/10.1016/j.rse.2014.11.002, 180-192, 2015.

#105

Prevention of Illegal Logging in Amazon Forest using ALOS/PALSAR

Problem

Brazil has been struggling with deforestation in the Amazon rainforest since 1970's. As big projects for mining development caused deforestation during 70's and 80's, the main reason of deforestation in the Amazon since 90's is illegal logging. A report[i] by a Brazilian commission said that 80% of all logging in the Amazon was illegal during the late 90's.

Brazilian National Institute for Space Research (INPE) developed and has been operating the near real time forest monitoring system "DETER" since 2004 to support surveillance and control of deforestation by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA). DETER uses data obtained by MODIS (MODerate resolution Imaging Spectroradiometer) on NASA's satellites and can detect a deforestation area over 6.25hectares. DETER contributed to prevention of illegal logging, but it can't monitor deforestation during cloudy weather because MODIS can't observe the ground under cloud. This is a crucial problem in such a tropical rainforest area as the Amazon where covered by cloud in rany season almost five months a year. Loggers were able to cut many trees during rainy season without any investigation by the government.

Satellite Earth Observation Data Application

On the other hand, the Japan Aerospace Exploration Agency (JAXA) developed and launched the Advanced Land Observing Satellite (ALOS) in 2006 with three sensors on board. One of them was the Phased Array L-band Synthetic Aperture Radar (PALSAR). Radar sensors can monitor ground surface even when it is cloudy because its radiowave penetrates cloud and reaches ground surface. In addition, L-band type radiowave is very sensitive to forest and PALSAR was one of the best space tools for monitoring deforestation.

IBAMA took an interest in PALSAR data when they sent an engineer to a remote sensing training course in Japan hosted by the Japan International Cooperation Agency (JICA). In order to obtaion the data observed by PALSAR over Amazaon, IBAMA made an agreement with JAXA in 2007. However Brazil had a long history and much experience of monitoring forest by optical satellite sensor, their knowledge and technology for using Radar sensor were not matured. Therfore, they sent an official request to Japanese Government to transfer the technology of Japanese Radar satellite to detect deforestation in the Amazon. When JICA received the request from Brazil, they established a three yeas project in 2009 with IBAMA and the Federal Police Department (DPF). Then, JICA appointed the Remote Sensing Technlogy Center of Japan (RESTEC) to implement the project.

JAXA provided PALSAR “ScanSAR” data over the Amazon for IBAMA almost every five days during the project according to the agreement. “ScanSAR” is one of PALSAR observation modes which can cover 350km wide at once with 100m ground resolution. 100m resolution is much lower than “Fine Beam” observation mode of which ground resolution is 10m, but “Fine Beam” can cover only 70km which is not enough to monitor whole area. The size of logged areas was very large and “ScanSAR” was able to detect it.

Original PALSAR data shows a balck and white image with patterns according to the conditions of ground surface. If a certain area is very smooth - lake, river, paved road for instance, the area is shown as a black or dark gray color while a rough area - forest, grass field, and so on - is shown as a light gray color with patterns. In fact, if you compare forest and deforested areas, deforestad areas are shown darker than forest areas in PALSAR image. By using this principle, after recieving observation data from JAXA, IBAMA overlaied multitemporal sets of the data and produced a color composite image to detect deforestation areas. The color composite image helps IBAMA identify deforested areas shown as a dark color in the middle of forest shown as bright. If a deforested area is as large as 2ha at minimum, it can be detected.

Several interpreters of IBAMA and DPF who trained by RESTEC manually found dark colored suspected logging areas and created polygons in the color composite images (see figure 1). The image can be saved as GeoTIFF format and the interpreters can easily overlay the images on the other optical satellite images on their own GIS or even using Google Earth. It helps the interpreters estimate the position of the suspected logging areas. In 2010, they created and provided 1,007 polygons for DPF officials. DPF flew helicopters to the suspected logging areas and if loggers were indeed cutting trees there, the officials prevented further illegal logging and protected the forest.

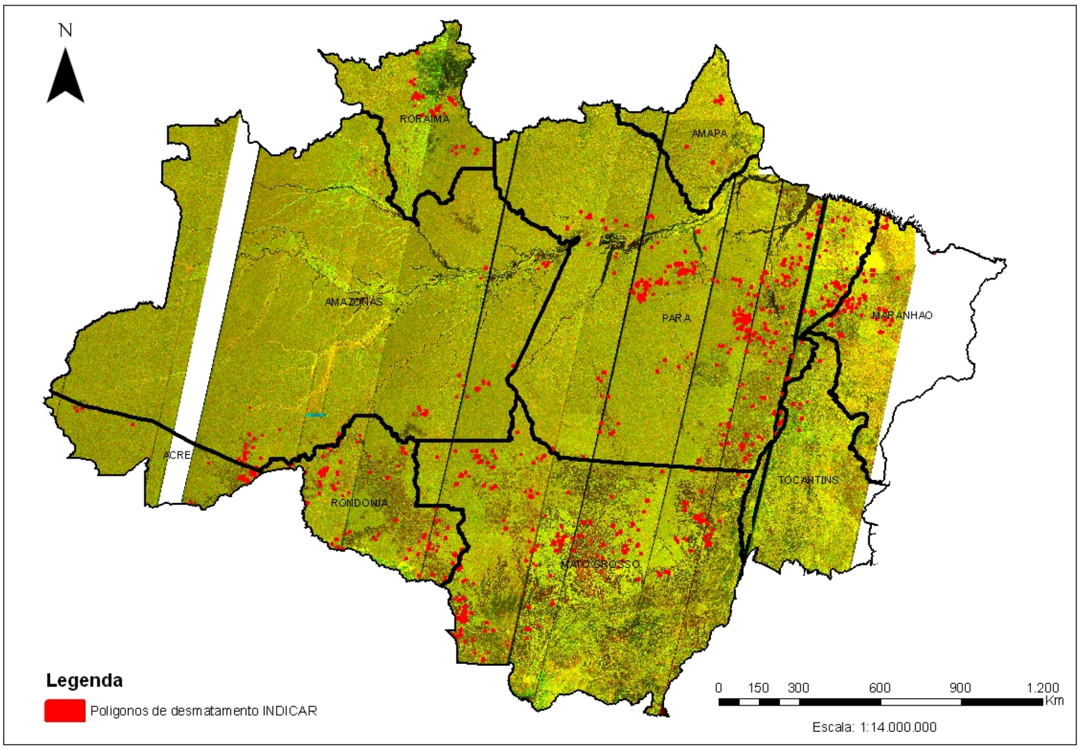


Figure 1. Mosaicked Color Composite Image and Polygons

The rapid delivery of polygons created from PALSAR data was the key to preventing illegal logging since the loggers were cutting trees rapidly. By using the software developed by RESTEC helps IBAMA easily create the color composite images and the suspected logging polygons. The cooperation between IBAMA and DPF was also the key to the success and it was efficient indeed. Another big challenge was very wide target area - the entire Amazon. ScanSAR mode of PALSAR can observe 350km width at once and the target area was covered within several days. Although its ground resolution was very low, we put higher priorities on speed of information delivery and the extent of coverage.

Figure 2 shows the annual rate of deforestation in the Amazon since 2001. The number is released by INPE at their website. The deforestation area has been decreasing since 2005 rihgt after INPE started operation of DETER. PALSAR contributed to decreasing since 2009.

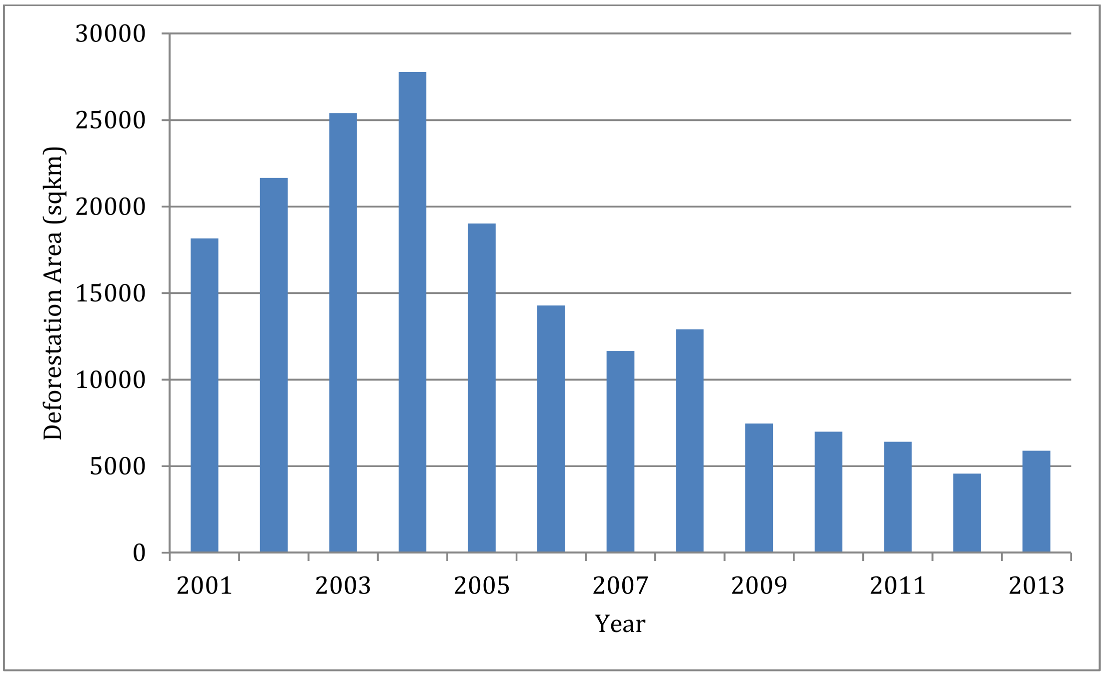
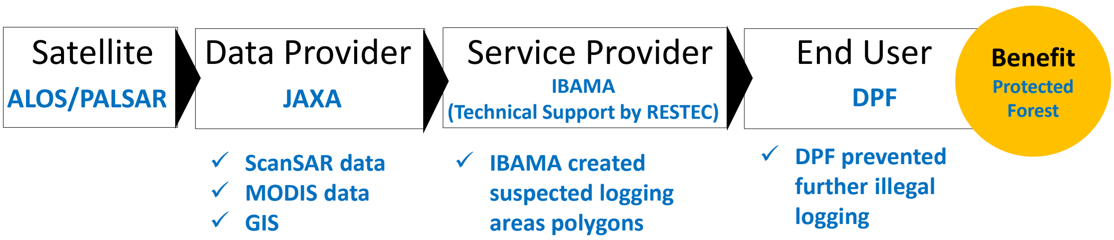


Figure 2. Annual Rate of Deforestation in the Amazon

Value Chain



JAXA provides PALSAR (ScanSAR mode) data for IBAMA who creates color composite images and detects suspected logging areas. IBAMA also creates polygons when they find the suspected areas. DPF flies to the area and prevent further illegal logging when they receive the polygon information.

More Information

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Affiliated Agencies: DPF, IBAMA, JAXA, JICA, RESTEC

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[i] Viana, G. 1998. Report of the External Commission of the Chamber of Deputies Destined to Investigate the Acquisition of Wood, Lumber Mills and Extensive Portions of Land in the Amazon by Asian Loggers. Brasilia, Brazil.

Entomological Rift valley fever risk in Senegal: a high spatio-temporal resolution risk mapping from remote sensing

Murielle Lafaye (CNES), Cécile Vignolles (Cnes), Baba Sall (Directorate of veterinary services of Senegal), Mawlouth Diallo (Dakar Pasteur Institute), Jacques-André Ndione (Centre de Suivi Ecologique de Dakar), Jean-Pierre Lacaux (Laboratory of Aerology of Midi-Pyrénées Observatory)

The results presented here is the outcomes of a franco-senegalese project gathering the Centre de Suivi Ecologique, the Dakar Pasteur Institute, the Direction of Veterinarian Services, Météo-France, and CNES. It addresses the Rift Valley Fever, a viral disease that occurs essentially in Africa, causing very serious economic losses in livestock. A brand new EO satellite-based decision-aid tool for a better management of animal health with the aim of a better adaptive strategy is presented. It is based on SPOT-5 images and designed for local health users.

Context

The emergence and re-emergence of infectious diseases with high epidemic potential, such as the Rift Valley Fever, encourage public health actors to adapt their strategy of management concerning human and veterinarian health. This adaptation requires the development of new means of risk prediction. In this context, the study of vector borne infectious diseases requires the knowledge of factors conducive to the emergence and spread of the disease. The first step in risk prediction is to identify areas of vector proliferation. This knowledge enables the identification of areas at risk for human and animal populations. It enables also to model and to prevent the occurrence of diseases by setting up early operational warning systems (SAP). Linkages between infectious diseases, environment and climate variability do not have to be spelled out anymore. Nevertheless, providing users with forecast data and risks maps, at a local scale, on "*where and when*" a risk for the emergence of given diseases vectors remains quite a challenge. Such risk maps will key contributing elements towards adaptive control strategies of the public heath actors.

Satellite Earth Observation Data Application

Some epidemics (malaria, Rift Valley fever, dengue ...) depend on climatic and / or environmental factors, some of which can be identified by remote sensing and entered in biomathematics models to assess the risk of emergence and propagation of disease vectors. In this context, the Centre National d'Etudes Spatiales (CNES) has developed with its partners a conceptual approach based on the study of climate-environment-health relationships and an original appropriate spatial offer. This multidisciplinary research approach known as tele-epidemiology, combining the physical and biological sciences to define the determinants for the emergence and spread of the disease studied. Earth Observation Satellite data do not provide information directly related to pathogens (viruses, bacteria, parasites) causing the disease, but on their environment (geographical, meteorological, hydrological ...) and in particular on the habitats favorable to the development and proliferation of vectors. Therefore, satellite imagery contributes to the measurement of environmental factors favorable (or not) for the emergence of these diseases vectors. This methodological approach has been successfully applied to Rift Valley fever (RVF) in the Ferlo region of Senegal leading to the development of a dynamic mapping of Zones Potentially Occupied by Mosquitoes (ZPOMs).

The abundance of the main RVF vectors in the Ferlo region (*Aedes vexans* and *Culex poicilipes*) is directly linked to ponds' dynamics. The latter is associated with the spatiotemporal variability of rainfall events. Rainfall distribution and its spatial heterogeneity, is thus a key parameter for the emergence of the main vectors of the RVF. The goal of this applied project was to use specific Geographical Information System (GIS) tools and remote-sensing (RS) images and data to detect potential ponds as breeding sites, and evaluate the risk for cattle for being exposed to vectors bites. Subsequently a risk for mosquito's emergence has been modelled and validated using in-situ entomological measurement campaigns. It should be acknowledged that a risk is a result of hazard and vulnerability. If hazard is represented by the mosquitoes presence (entomological risk called also vector hazard), vulnerability is represented by parked animals and migrating livestock.

Three steps have been necessary to achieve the goal:

- Set-up brand-new index for detecting of small and temporary ponds using high-spatial SPOT-5 images. Satellite remote sensing has provided a global view for the dynamics of the ~ 1300 ponds, potential breeding sites for hazards to happen in the Barkédji area
- Modelling dynamic ZPOM combining mechanisms linking rainfall variability, dynamic of ponds and density of aggressive vectors. Remotely-sensed environmental data (Spot-5 images) and meteorological information (from in-situ and satellite data such as TRMM, GSMaP, RFE, CMORPH, PERSIANN) were used to fit a model with hydrological and entomological components, in order to produce dynamic high resolution maps (10-m spatial resolution, daily temporal resolution) to predict the entomological risk for Rift Valley fever in the Ferlo region of Senegal (see figure1)

- Crossing dynamic ZPOM (vector hazard) and cattle park localization (hosts vulnerability) to evaluate the environmental risk (i.e risk for being exposed to vector bites). The integration of dynamic modelling on mosquitoes proliferation and the positioning of the livestock parks into a geographic information system, allows providing every week the Directorate of veterinary services of Senegal with forecasting bulletins of the zones under risks for the following 10 days.

The Directorate of veterinary services is then able to integrate this information into its adaptation strategy of animal health management. This strategy includes:

- park livestock away from zones at risks: warnings in local language have been installed near the ponds to inform breeders to park their animals at least 500m away from the ponds;
- organize anti-larval control: with these bulletins, the Pasteur Institute of Dakar should be able to organize efficient larval and vector control actions;
- organize RVF vaccination: with these bulletins, the Directorate of veterinary services of Senegal could optimize vaccination campaigns in the most risky zones;
- organize the communication strategy: by integrating the forecasted risks bulletins in the National Information System of Surveillance of Epidemics that feeds the Ministry of livestock in Senegal, the headquarters of the Directorate of veterinary services of Senegal and its local representatives in rural districts. It is planned to broadcast advertising messages in local language through local radio stations to facilitate comprehension and acceptance levels

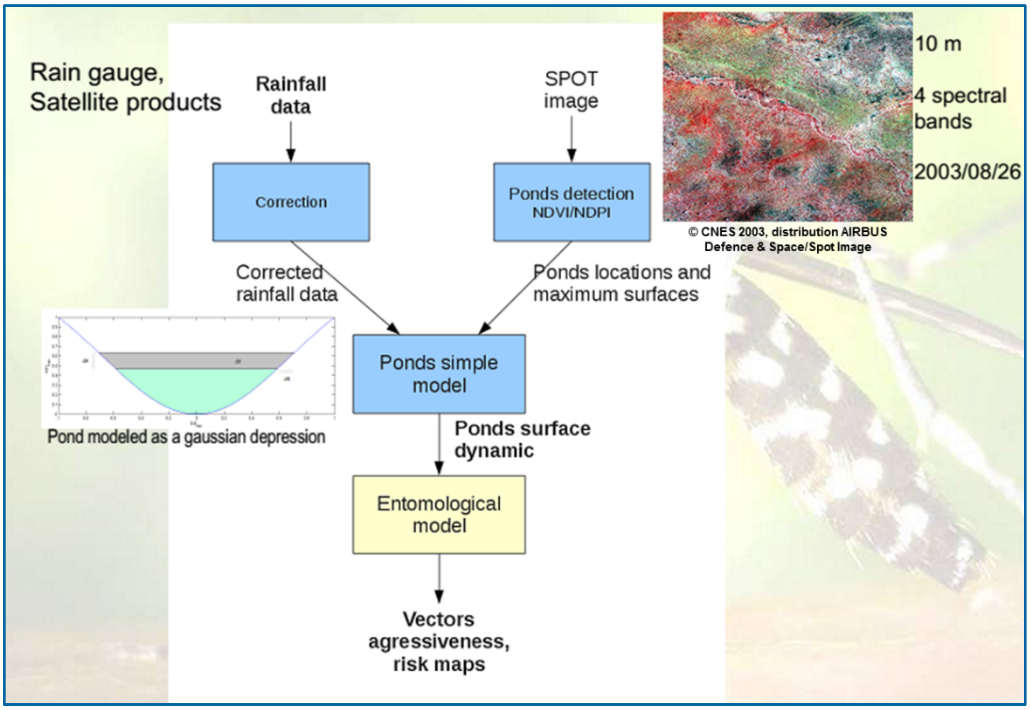

Figure 1 :The Rift valley fever entomological risk modelling

Value Chain

See the PowerPoint

More Information

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Value Chain Template

Satellites	Data Provider	Service Provider	End User
		Centre de Suivi Ecologique de Dakar	Directorate of Veterinary services of Senegal

Benefit
better management of animal health

SPOT-5 ---> **Optical image**
By Airbus Defense and Space

TRMM
GPM-core
GCOM-W-AMSR2
DSMP-SSMI
NOAA-AQUA
NOAA-AMSU
METOP-AMSU
GOES-8
GOES-10
Meteosat-6,
Meteosat-7

---> **Satellite rainfall estimates**

- TMPA (TRMM Multisatellite Precipitation Analysis) by NASA/ JAXA
- GSMaP (Global Satellite Mapping of Precipitation) products by JAXA-CREST
- RFE (African Rainfall Estimation) by NOAA-CPC
- PERSIANN (Precipitation Estimation from Remotely Sensed Information Using Artificial Neural Networks) by the CHRS, University of California
- CMORPH product from the DMSP, NOAA,Aqua, and TRMM satellites by NOAA-CPC

Ground Data

- Entomological data by the Dakar Pasteur Institute
- Meteorological data from in situ gauge

Service Provider:

- ☐ small and temporary ponds mapping at 10m resolution
- ☐ Dynamic high resolution maps (10-m spatial resolution, daily temporal resolution) predicting the entomological risk for Rift Valley fever (presence of mosquitoes)
- ☐ Forecasting bulletins of the zones under risks for cattle for being exposed to mosquitoes bites

End User:

- ☐ End user adapts and optimizes its strategy of animal health management

#110

Monitoring Sea Ice to Provide Support for the Safe Travel of Ships

In 1970, there was a large maritime accident by drift ice in Hitokappu Bay, Etorofu Island. This accident triggered the establishment of "Ice Information Center, JAPAN" in the 1st Regional Coast Guard Headquarters,Japan Coast Guard (JCG). JCG operates Ice Information Center only during winter every year to produce and distribute "Sea Ice Condition Chart".

The Sea Ice Condition Chart indicates the distribution of sea ice around Hokkaido. It is effectively utilized for safe navigation of vessels including fishing boats, merchant vessels and tourist ships, aiming to prevent a maritime accident in sea ice areas around Hokkaido such as in the Sea of Okhotsk.

Problem

Ice Information Center, JAPAN（海氷情報センターの略語？IIC？以下同） produces the Sea Ice Condition Chart everyday, and distributes it to users through the Internet and by fax during winter. The Sea Ice Condition Chart is produced based on information from various institutions and partners, including satellite data.

They, however, face a problem that it is difficult to get the precise information about sea iceunder cloud, because most of informationis acquired in the band of visible or infra-red.

Therefore, to address this problem, Ice Information Center cooperates with the Japan Aerospace Exploration Agency (JAXA) to produce the Sea Ice Condition Chart precisely and completely using SAR data regardless of weather conditions.

Satellite Earth Observation Data Application

Ice Information Center, JAPAN collects information from various institutions and partners to produce the Sea Ice Condition Chart. The collected information is analyzed to calculate the Sea Ice Condition Chart through the Internet and by fax at 17:00 (JST) every day. Figure 1 shows the work flow of Ice Information Center including the type of information from Japan Coast Guard, cooperating institutions and partners, and the provision of ice information

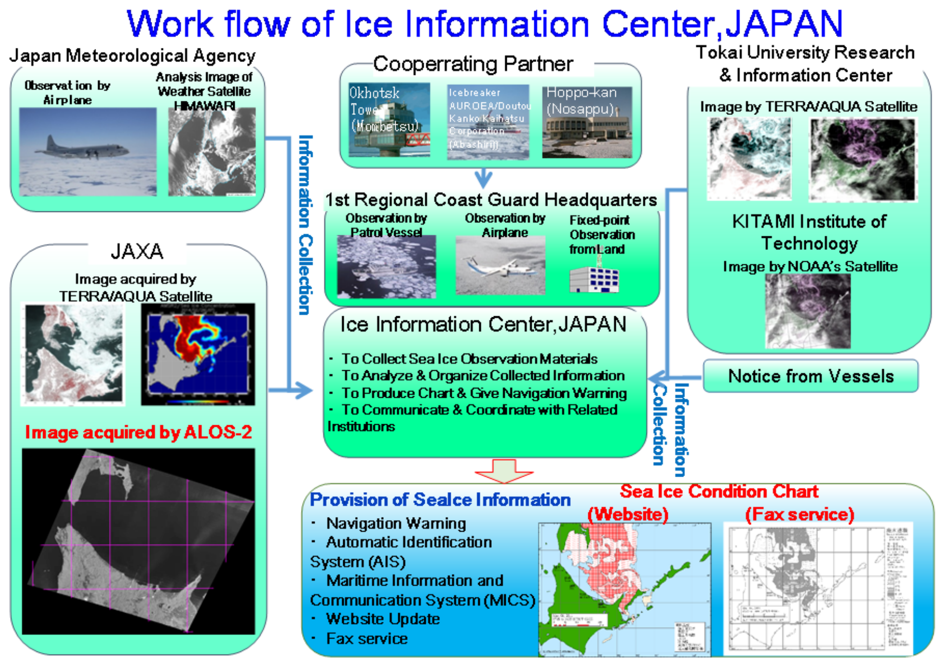


Figure 1: Work Flow of Ice Information Center

Ice Information Center, JAPAN produces the Sea Ice Condition Chart integrating various information such as observation data by satellites, airplanes and vessels, visual observation from the land, analysis information by the Japan Meteorological Agency and notices from vessels. From this season, it became possible to acquire complete information even in cloudy area by adding data of JAXA's satellite, Advanced Land Observing Satellite-2 (ALOS-2) to existing types of information after about three and a half years, because SAR sensor onboard ALOS-2 can observe penetrating through clouds. Actually the observation under the cloudy area was possible by Advanced Land Observing Satellite (ALOS, former satellite) , but furthermore ALOS-2 allowed to increase the number of observation near the center of the Sea of Okhotsk by utilizing its performance of a variable incident angle.

Since Hokkaido area has a lot of bad weather in winter, it is often the case that the Sea Ice Condition Chart included some intervals due to no data in cloudy areas where it was difficult to obtain sea ice information. By adding ALOS-2 data available under all weather to information source, Ice Information Center became to be able to produce and provide complete information even in cloudy days again. These effective information contribute to prevention of maritime accidents for vessels that are forced to fish during heavy weather.

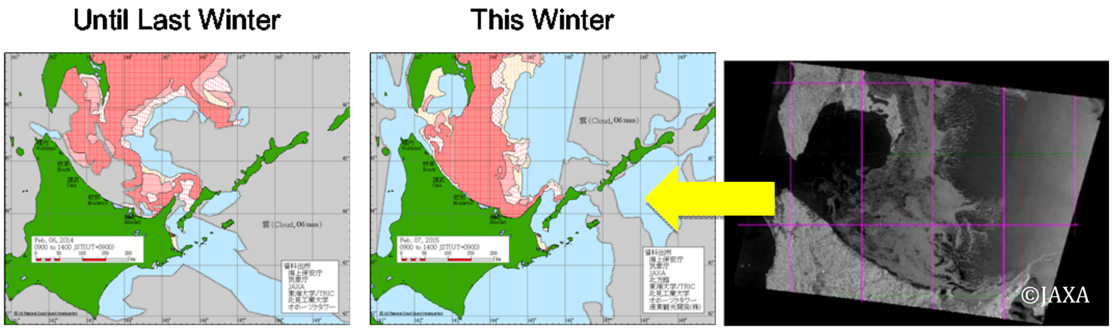
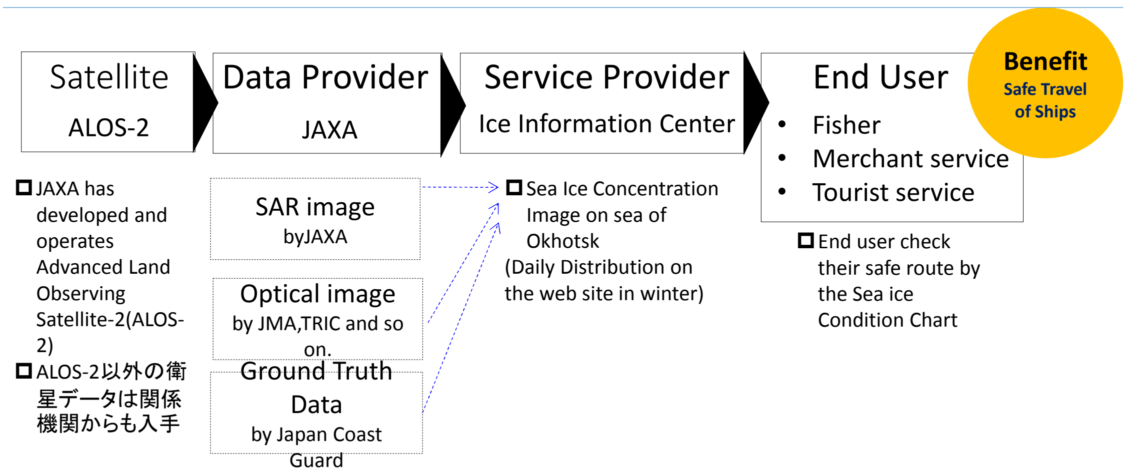


Figure 2. Sea Ice Concentration Image
(Left) Released on 6 February, 2014
(Middle) Released on 7 February, 2015
(Right) Satellite image by ALOS-2 on 7 February, 2015

Value Chain



Ice Infromation Center, JAPAN URL:
http://www1.kaiho.mlit.go.jp/KAN1/drift_ice/eng.html

More Information

For more information, please feel free to contact:

Name
Organization
Email
Phone

No.111

Title :

Monitoring of water quality and water level of rivers and lakes in Brazil: towards a remote sensing-based operational monitoring application at the Brazilian National Water Agency.

Jean-Michel Martinez[1], Dhalton Tosetto Ventura[2], Gérard Cochonneau[1], Eurides de Oliveira[2], Rita Cerqueira Piscoya[2], Valdemar Santos Guimarães[2]

[1]GET Laboratory, IRD/CNRS/Université Toulouse 3, 14 Avenue Edouard Belin, 31400 Toulouse, France.

[2]Brazilian National Water Agency, Setor Policial Sul, Área 5, Quadra 3, Bloco L, Brasília – DF Brazil

Short Summary :

A remote-sensing based application called HIDROSAT is operated by the hydrological department at the Brazilian National Water Agency (ANA) to deliver suspended sediment concentration, chlorophyll-a concentration and water level estimates of rivers and lakes from different satellites. The remote sensing data improves the conventional monitoring capacity by increasing the number of stations and the frequency of data collection.

Problem

The Brazilian Water Agency (ANA) coordinates the national hydrometeorological network, being responsible for approximately 2900 stations distributed all over the Brazil, most of them comprising, at least, water level and rainfall monitoring. Suspended particulate matter (SPM) sampling is run, along with discharge measurement, at 488 stations. Water level is recorded daily or hourly. SPM and water quality data are collected every four months. Considered the country size and the importance of water resources for environmental and economical purposes, both the network's spatial coverage and SPM sampling frequency should be considered as insufficient. Furthermore, water quality monitoring in lakes are under responsibility of other institutions and lacks homogeneity. The improvement of monitoring capacity would necessarily raise significantly the operational cost of the national hydrological network but is seen as crucial. As a result, alternative techniques to conventional monitoring methods based on field measurement must be evaluated.

Satellite Earth Observation Data Application

Recently, ANA and the French Research Institute for the Development (IRD), through a research agreement with the Brazilian Cooperation Agency (ABC), have developed the MEG-HIBAM project that aims at incorporating the spatial remote sensing data into a global monitoring strategy for hydrological processes. The project seeks to integrate both conventional and remote sensing based technics for the improvement of the operational monitoring capacities in the Brazilian largest catchments. A web-based interface operated by the ANA was developed in order to deliver remote sensing-based hydrological data, called Hidrosat (www.ana.gov.br/hidrosat).

Optical remote sensing can be efficiently used for the monitoring of the water color, e.g. its spectral behavior. The water color is linked to the presence of optically active components within the water column. Three main components alter the water optical properties in the visible and infrared wavelength range: colored dissolved organic matter (CDOM), surface particulate matter (SPM) (either organic or inorganic) and photosynthetic pigments of microalgae such as the chlorophyll-a

(Chl-a). The presence of each optically active component as well as its concentration controls the light absorption and scattering processes, making possible to derive algorithm to infer some water quality parameters from the analysis of the upwelling light emerging from a water body.

Altimetry satellites determine the distance from the satellite to a water body by measuring the transmission/scattering time of a radar pulse. The altimeter emits a radar wave and analyses the return signal that bounces off the surface. To obtain fine water level estimates of river and lakes different complex corrections are calculated to take into account satellite exact orbital position, atmospheric interferences and earth's geoid. The altimeter visits the same point on the globe every 35 to 10 days depending on the satellite configuration.

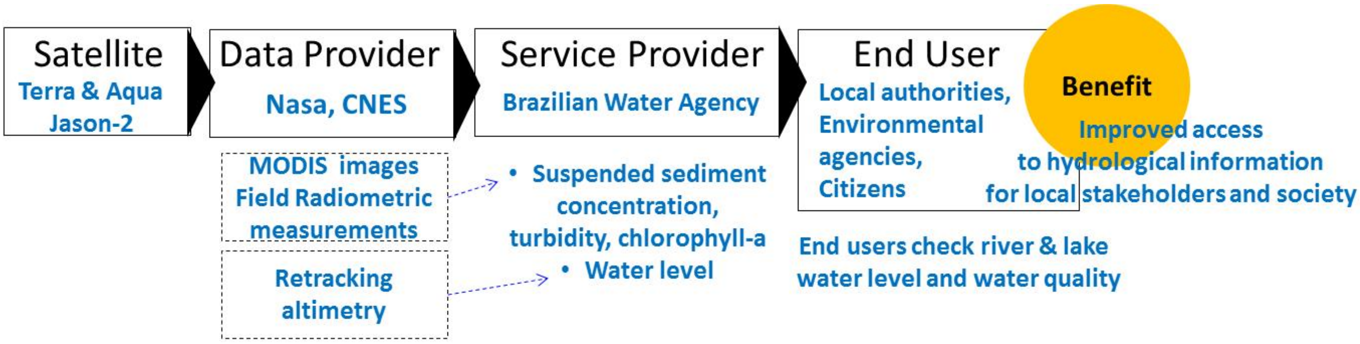
The Hidrosat application aims at providing hydrological parameters either related to water quantity (water level) or water quality (SPM, Chl-a) in rivers and lakes of some ungauged or poorly gauged basins. The applications consider three main topics / areas ranging from water resources monitoring to health risk assessment and socio-economic impacts :

- Monitoring river water level and sedimentary fluxes in the Amazon River basin. The largest river basin in the world is facing increasing hydrological extremes and modification of sediment fluxes through construction of dams. Remote sensing data allow to complete and to extend the field-based monitoring capacity that is hampered by the ANA network's low density in the Amazon basin and the difficulty to operate in a large transboundary basin.

- Eutrophication pollution in Nordeste semi-arid region. Uncontrolled growth of alga (mostly cyanobacteria) results in a decreasing of oxygen content of the water, and a diffusion of toxins. Those processes raise the cost for water treatment, cause fish mortality and increase disease prevalence in the local population. Hidrosat represent the first monitoring system of the eutrophication level of several reservoirs (through Chl-a proxy) delivering satellite-based estimates within 15 days.

- Sedimentation processes in cascade of dams used for electric power generation. Brazil's economy relies largely over hydroelectricity, which accounts for 85 % of the country electricity generation. However, hydropower efficiency and dam life expectancy is directly impacted by sediment trapping which need to be monitored independently. Hidrosat allows to monitor upstream/downstream water turbidity variations and to analyze the impacts of the different impoundments in the Parana River catchment.

The remote sensing derived data makes possible to increase the number of monitoring stations and the data acquisition frequency. The use of MODIS images makes possible to deliver 8-day estimates of the different water quality parameters while satellite altimetry is delivered every 10 days using Jason-2 data. This delay represents a step forward, especially for the water quality monitoring, where data originating from the conventional network are usually updated every four months.



Value Chain

The IRD teams developed the satellite data processing chains for both altimetry and water color. For several years, the end user has been trained to run the different processing softwares and to the different remote sensing techniques. A specific database has been built at ANA that is interconnected to the national hydrologic database maintained by the agency. Jason-2 data are processed automatically using VALS software to deliver water level estimates each 10 days with a 2-day delay. Water quality parameters are assessed from MODIS sensors onboard Terra and Aqua satellites. MODIS products considered are surface reflectance 8-day composites at 250-meter and 500-meter spatial resolution (e.g. MOD/MYD09 Q1/A1 products). Water quality parameter retrieval is based on algorithms calculated from field radiometric measurements realized by ANA and IRD/GET teams. The Hidrosat application delivers, depending on the catchment, time series of either suspended sediment concentration, chlorophyll-a concentration or water turbidity. Those data are used to increase knowledge about water resources, for definition of environmental policies such as aquaculture licensing or for flood forecasting.

More Information

For more information, please feel free to contact:

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Website URL : www.ana.gov.br /hidrosat

IRD Institut de recherche pour le développement

ANA AGÊNCIA NACIONAL DE ÁGUAS

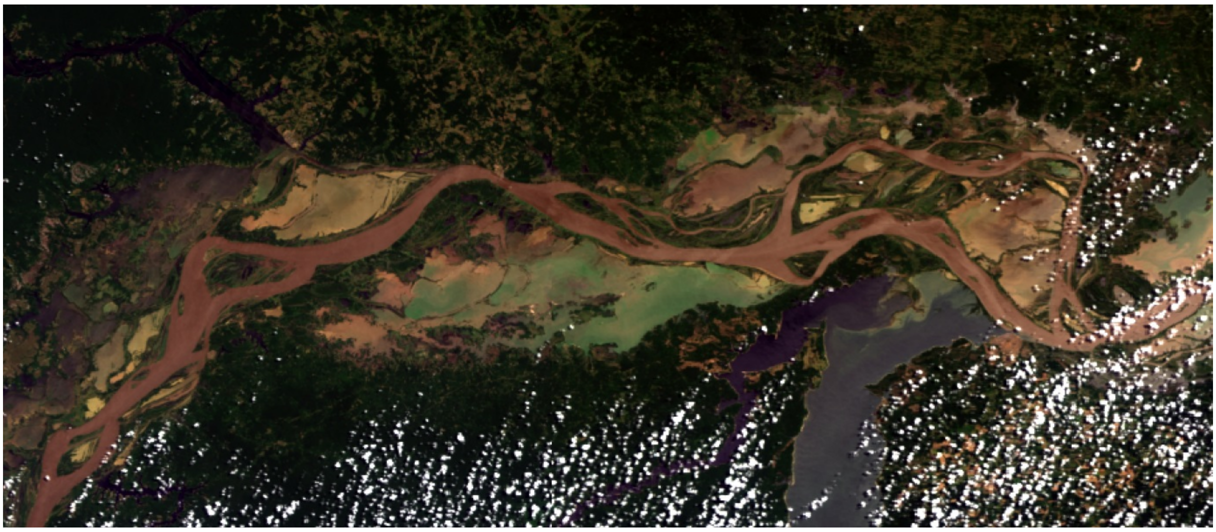


Figure 1 : Satellite image of the Amazon River and of its floodplain. The different water colors are related to different biophysical processes that drive water quality and that can be monitored from space.

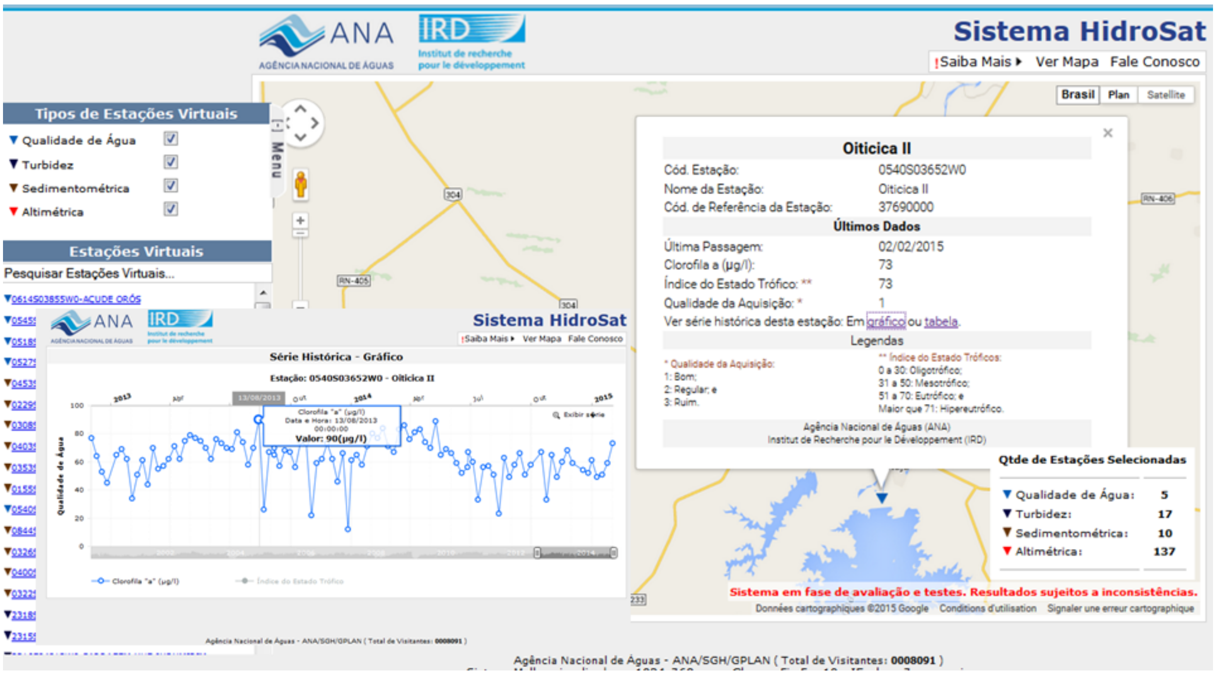


Figure 2 : Hidrosat online interface hosted by the Brazilian National Water Agency delivering hydrological parameters assessed from satellite data, including water level and water quality of rivers and lakes in Brazil.

ADB's Technical Assistance project: Applying Remote Sensing Technology in River Basin Management（Bangladesh, the Philippines, and Viet Nam）

1)Yusuke Muraki, Infrastructure Specialist (Space Technology), Sector Advisory Service Division,
Regional and Sustainable Development Department
Asian Development Bank
2) JAXA ADB Project Team

Context

Many countries in Asia and the Pacific have suffered from water-related disasters such as floods caused by typhoons and heavy rains. As one of the most powerful nonstructural measures to guard against water-related disasters, monitoring and warning systems have been implemented in Asia and the Pacific. However, there is still insufficient latency, frequency, and coverage of observation data; and inadequate dissemination of warnings to local communities. The titled ADB's technical assistance project has been conducted from April 2012 to March 2015, which is helping Bangladesh, the Philippines, and Viet Nam improve monitoring and warning systems on flood risk management at a reasonable cost and based on practical knowledge by applying space-based technology and information and communication technology. Target agencies are assisted with advisory services and financial support in formulating and implementing the following: (i) extending flood warning lead times by 1 day - 2 days in the Jamuna River basin in Bangladesh by collecting precipitation data publicly available from satellites and ground observation systems, (ii) developing existing flood analysis models in the Red-Thai Bin River basin in Viet Nam by collecting satellite precipitation data, (iii) developing a system in the Cagayan River basin in the Philippines to provide satellite-based precipitation data and transfer it to the existing flood analysis model, and (iv) developing flood warning dissemination and disaster monitoring systems using web-based GIS and cellular phones in Bangladesh and Viet Nam. JAXA is collaborating with ADB in this project as the implementing agency, supporting project management and providing technical advice.

Contribution of Space Technology and Geographic Information Systems

Global Satellite Mapping of Precipitation (GSMaP) is an hourly global rainfall map in near real time, available 4 hours after observation with a 0.1 degree (about 10 kilometers [km]) grid over a global area (60N–60S), using the JAXA Global Rainfall Watch System. JAXA and the consultant team have been developing methodologies and systems to calibrate and validate GSMaP with ground rainfall data in the pilot area of each country. The calibrated GSMaP is used as input data for flood models in the target river basin for more effective and efficient flood forecasting. These models include the Integrated Flood Analysis System in the Philippines, which was developed by the International Centre for Water Hazard and Risk Management, and the Water and Energy Budget-Based Distributed Hydrological Model, developed by Professor T. Koike, University of Tokyo.

http://sharaku.eorc.jaxa.jp/GSMaP/

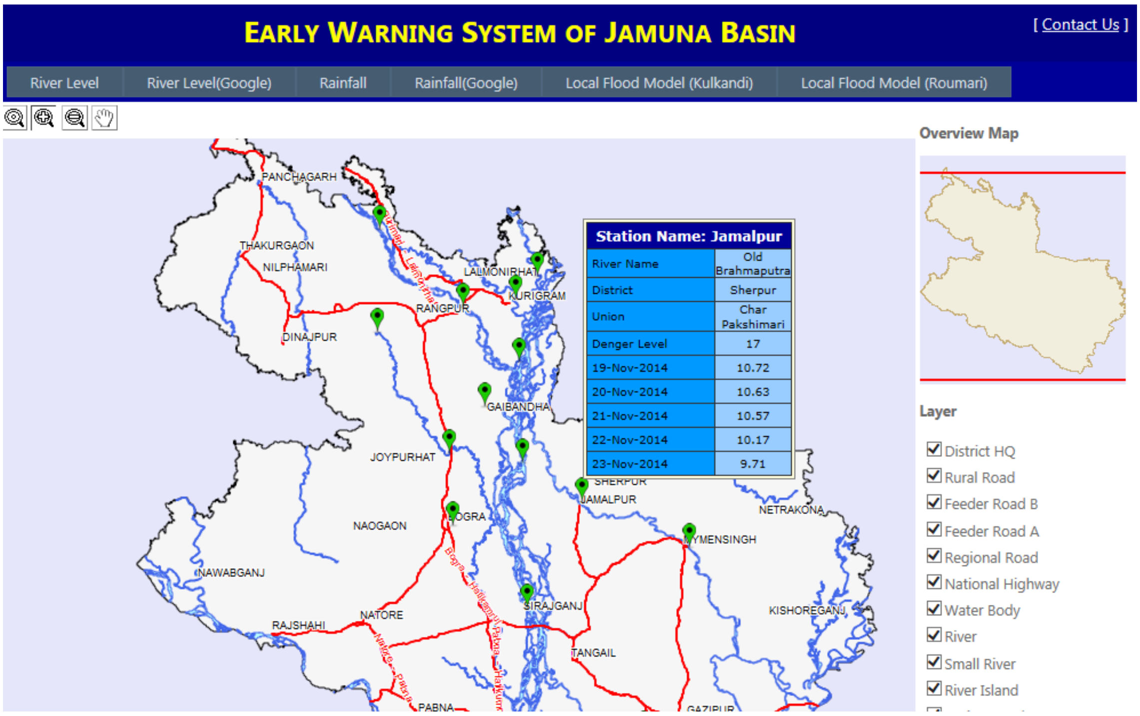
High-quality, satellite-based topographical information (digital elevation model [DEM] or digital surface model [DSM]) obtained from the Advanced Land Observing Satellite (ALOS) was used to study the effectiveness of its use for the local flood model to make an inundation map in the pilot area as an alternate source of geographic data to those obtained from spot survey. ALOS imagery and map data for the pilot area of the local flood model were used for the background layer of the web-based GIS developed under this technical assistance project.

Web-based GIS was also developed for flood warning information sharing in the pilot areas in Bangladesh and Viet Nam.

Current Status

The project has been completed end of March 2015 and operational use of the developed systems are expected in coming flood season in 2015.

<The Developed Web-GIS for Bangladesh>


EARLY WARNING SYSTEM OF JAMUNA BASIN
[Contact Us]
River Level
River Level(Google)
Rainfall
Rainfall(Google)
Local Flood Model (Kulkandi)
Local Flood Model (Roumari)
Overview Map
Station Name: Jamalpur
River Name | Old Brahmaputra
District | Sherpur
Union | Char Pakshimari
Denger Level | 17
19-Nov-2014 | 10.72
20-Nov-2014 | 10.63
21-Nov-2014 | 10.57
22-Nov-2014 | 10.17
23-Nov-2014 | 9.71
PANCHAGARH
THAKURGAON
NILPHAMARI
LALMONIRHAT
KURIGRAM
RANGPUR
DINAJPUR
GAIBANDHA
JOYPURHAT
SHERPUR
JAMALPUR
NETRAKONA
NAOGAON
BOGRA
MYMENSINGH
NAWABGANJ
SIRAJGANJ
KISHOREGANJ
RAJSHAHI
NATORE
TANGAIL
PABNA
GAZIPUR
Layer
District HQ
Rural Road
Feeder Road B
Feeder Road A
Regional Road
National Highway
Water Body
River
Small River
River Island

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SENTINEL ASIA SUCCESS STORY

1) Dr. Arturo Daag, Chief, Geology, Geophysics Research & Development Division (GGRDD), PHIVOLCS

2) JAXA Sentinel Asia Project Office, Satellite Application Promotion Center(SPAC), JAXA

Sentinel Asia Success Story (SASS) is an activity aimed at:

- Cooperation for disaster risk reduction (DRR) in the mitigation/preparedness phase
- Regional cooperation including end-users
- Local awareness and knowledge transfer through capacity building
- Human resources and human network development

Content

The Sentinel Asia (SA) initiative is a voluntary, grass-roots collaboration based on best efforts between regional space agencies and disaster management institutions for regional humanitarian purposes. SA applies remote sensing and Web-GIS technologies to assist disaster management efforts in the Asia-Pacific. Sentinel Asia (SA)'s target is to provide the disaster information to end-users who are fighting against disasters and help them utilize it more. Furthermore, SA's final target is to become a community-operated system in each country or region. Some activities including more case-studies with end-users focusing on a specific country and region are requested. In this context, SA has started SASS in the Philippines. These kinds of activities should be expanded to other countries and regions. Through these end-users-oriented activities, with enthusiastic cooperation from each country and region, SA could be operated as a community system.

(1) JAXA has been implementing the SASS in the Philippines since 2009 (see Figure 1). By using Advanced Land Observing Satellite (ALOS) pansharpened imagery and a Digital Surface Model (DSM), hazard maps for lahars near Mt. Mayon, floods in Iloilo city and landslides in Antique province were created by the Philippine Institute of Volcanology and Seismology (PHIVOLCS), the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), and the Mines and Geoscience Bureau (MGB), respectively. This mapping occurred in the first phase, from the beginning of 2009 to March 2010. In the second phase, beginning in April 2010, an application of GSMaP has been used to track landslide warning in Albay;

interferometry has likewise been used to monitor land subsidence in the Manila area and earthquake/volcanic eruptions at Mt. Mayon, Mt. Taal, and Valley Fault.

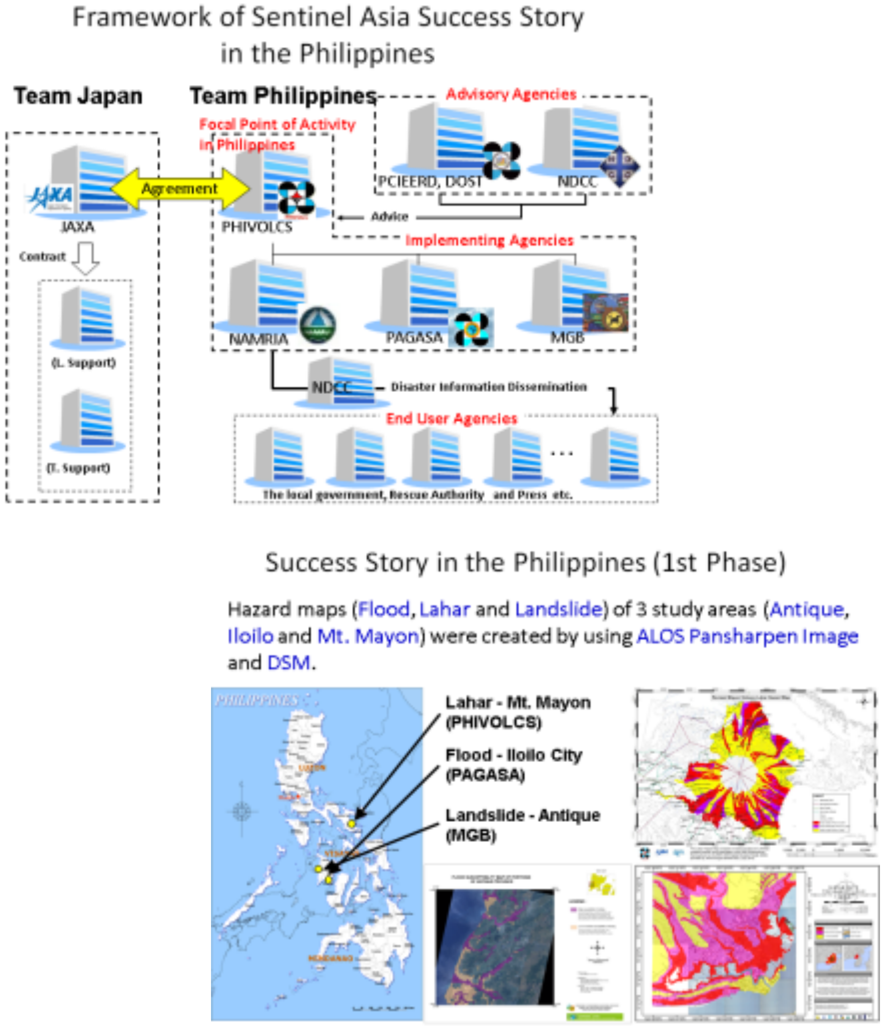


Figure 1. Framework and activities of Sentinel Asia Success Story in the Philippines

Mt. Mayon in Luzon, the Philippines, recorded volcanic activity beginning on 14 December 2009, and the lava that flowed out from the crater was confirmed on 20 December. About 47 thousand people living near the Mayon Volcano evacuated according to warnings issued by the Province government. JAXA made emergency observations with PRISM/AVNIR-2 aboard ALOS on 25 December 2009, at the request of PHIVOLCS through Sentinel Asia, and provided observed data to PHIVOLCS. PHIVOLCS created a lava deposit map of the eruption using such ALOS imagery and other sources, which was used to understand the situation and inform the decisions of the National Disaster Coordinating Council (NDCC). A lava flow hazard map and lahar hazard map had been prepared beforehand using ALOS DEM, and with cooperation from JAXA and PHIVOLCS, which may be supplemented by updating lava deposit data during eruption emergencies as shown in Figure 2.

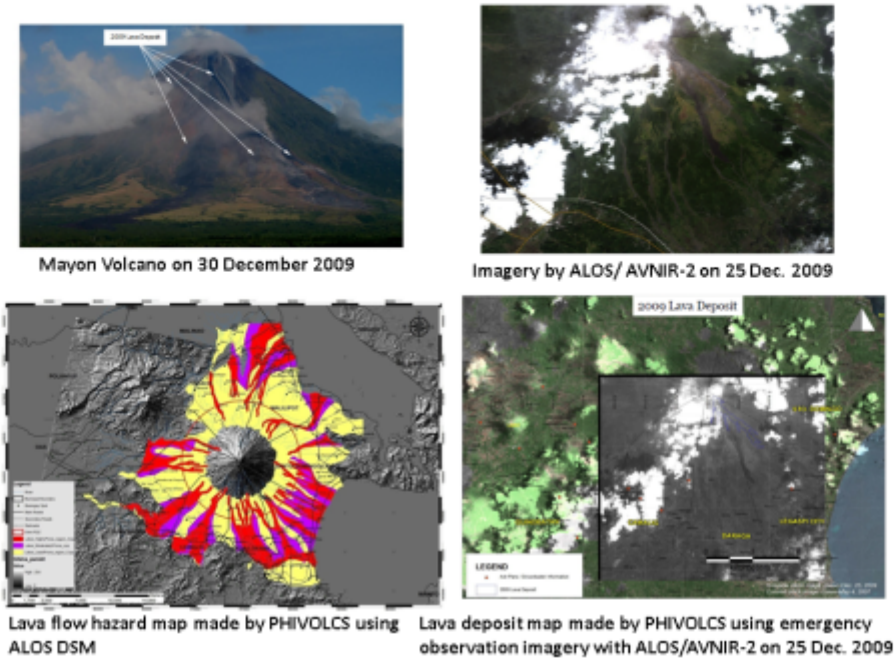
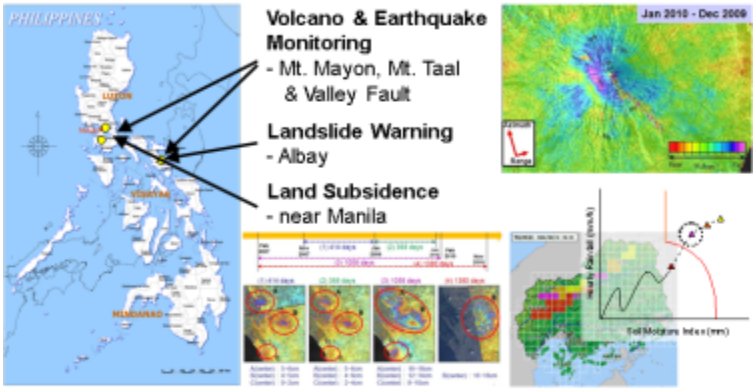


Figure 2. Eruption of Mayon Volcano in the Philippines in December 2009

(2) From 2010 to 2012, 2nd Phase was implemented. In this phase, application of GSMaP for Lnadsliges Warning and Interferometry for monitoring of Land Subsidence and Earthquake/Volcanic Eruption have been studied. The activities include: 1) To develop a prototype system of Landslise/Flood Early Warning System for Albay, 2) To apply DSInSAR technique to monitor Land Subsidence around Metro Manila and Land Deformation at Volcanos(Mt. Taal, Mt. Mayon and Negros Island), and 3) To hold technical traning for 1) and 2).

Success Story in the Philippines (2nd Phase)

Application of GSMaP for Landslide Warning, and Interferometry for monitoring of Land Subsidence and Earthquake/Volcanic Eruption have been studied.



Technical Training

Summary from 2009-2011	Trainings	No. of Participants
2009	Remote Sensing	9 ++
2009	Multi-spectral and Radar Image Processing	22
2010	InSAR Processing	35
2010	Satellite-based Rainfall Precipitation	34
2011	Differential Interferrometry	27
2011	Landslide Modelling and Warning Using Satellite-based Rainfall Data	28

(3) From 2013, 3rd Phase has been started. In this phase, the Landslides/Flood Early Warning System for whole the Philippines was developed. Also, PSInSAR technique was demonstrated to monitor subsidence in the metro Manila and Volcanic area in addition to DSInSAR. The prototype early warning sysytem will be continuouly demonstrated in the coming flood season and be validated for its effectivity. InSAR technicque by using ALOS-2 data is expected to demonstrate for monitoring Subsidence.

THE CHALLENGE TO USE EO PRODUCTS FOR EARTHQUAKE-RELATED CIVIL PROTECTION ACTIVITIES IN ITALY

BY

Anna Rita Pisani (ASI), Roberta Giuliani (DPC), Stefano Salvi (INGV), Daniela Di Bucci (DPC), Simona Zoffoli (ASI).

Satellite Earth Observation (EO) products, integrated with ground-based data, can effectively support seismic risk management activities. They contribute in particular to the hazard assessment, by providing important information on ground deformation rates, and to emergency response, by providing information needed to understand the phenomenon and to manage the response actions. This report aims at showing the contribution of EO-based scientific products, generated during the 2009 L'Aquila and 2012 Emilia earthquakes in Italy, to the emergency response managed by the Italian Department of Civil Protection (DPC).

PROBLEM

In Italy, DPC coordinates the response of the National Service of Civil Protection to disasters (e.g., earthquakes, landslides, floods, volcanic eruptions, fires). DPC activities are supported by a network of national Centres of Competence (CC), that are research institutions and academies that integrate technological and scientific advancements in risk prediction (when possible) and prevention, risk mitigation and emergency response. Among the national CC there is also the Italian Space Agency.

Currently, the DPC use of radar satellite data is in a pre-operational phase. Since 2009, during earthquake emergencies, still not official procedures have been tested and EO data contributions have been exploited providing useful results for DPC activities, in particular for event scenarios and situational awareness.

SATELLITE EARTH OBSERVATION DATA APPLICATION

In case of severe earthquakes in Italy, satellite products do contribute to the emergency response. For example geodetic GPS and InSAR imaging data (ERS, ENVISAT, ALOS, COSMO-SkyMed, TerraSAR X, Sentinel-1) are used to generate maps of ground deformation, caused by fault motion, measured in a very precise way (few mm) and at high resolution (pixel size up to few square meters). These maps are then employed to generate an accurate estimate of the earthquake source location and parameters, which are essential elements of the event scenario. Other useful information conveyed by the co-seismic ground deformation concerns the (re)activation of large landslides, collapse of sinkholes, shallow caves or mines, passive mobilization of old fault planes. All these phenomena may imply an added hazard for the considered area, and their identification contributes to the situational awareness.

Further important information that can be extracted from the high resolution InSAR images concerns the diffuse effects of the seismic shaking on the natural and built environment. The abrupt change of the surface properties caused, for instance, by building collapses, seismically induced soil landslides, soil fractures or soil liquefaction episodes, can be detected, and its spatial extent precisely and rapidly mapped.

These maps can be generated in near real time, being the images availability the limiting factor, since the processing, modeling, and interpretation phases require only few hours, while normally the first post-event images are obtained after 1-4 days.

Since 2009, in a joint effort including the Italian Space Agency (ASI), the National Institute for Geophysics and Volcanology (INGV) and DPC, applications of satellite EO data during seismic emergencies have been carried out through specific projects.
The SIGRIS project (www.sigris.it), in particular, was mostly focused on exploiting the capacity of the COSMO-SkyMed constellation, a dual-use, 4-satellite X-band system devoted to civilian and defense uses, which is managed by ASI, and which guarantees the shortest possible global revisit time among all EO SAR satellites (down to 1 day for interferometric acquisitions).
The activation of COSMO-SkyMed image acquisition for a seismic emergency in Italy takes place shortly after the occurrence of moderate to large magnitude earthquakes (> 5.0). The Council of Ministers, depending on the severity of the damages and consequences caused by the event, decides whether to declare the national state of emergency, which involves the entire National Service of Civil Protection under the DPC coordination. This prompts the CC activation for, among the others, the generation of EO-based science products. ASI turns COSMO-SkyMed in the state of highest priority, to monitor the crisis area with all available observational resources. Then the archive is examined, and a new acquisition plan is formulated to acquire post-event images matching the pre-event ones (a requirement for InSAR processing). The plan is devised and implemented by ASI, taking into account the requirements (geographic location and timing of acquisition) of the CC scientific teams. The latter process the images provided and generate added-value products: InSAR interferograms, maps of co-seismic ground displacement, maps of the impact on the built environment, seismic source model, etc. These products are cross-validated by the CC and then provided to the DPC and the National Service of Civil Protection for their institutional use.
Two examples of InSAR derived products are shown in Figures 1 and 2.

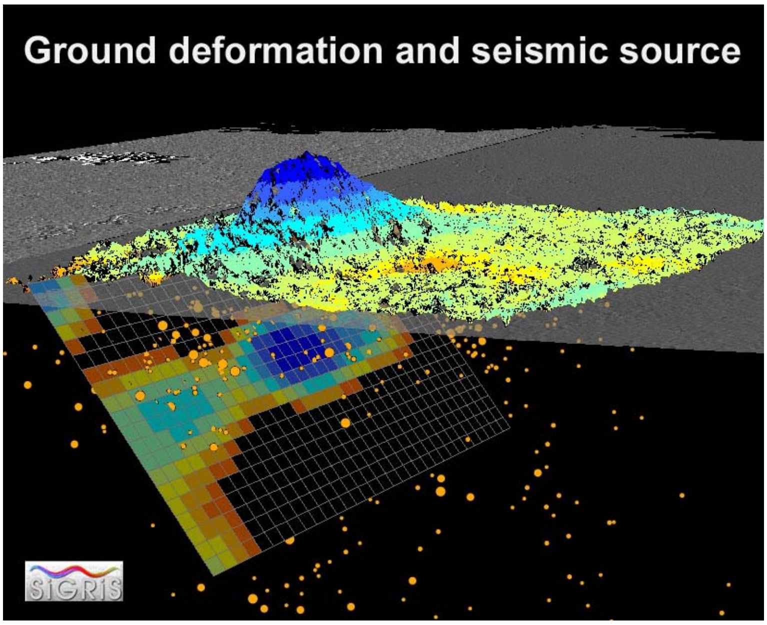


Figure 1 - Ground deformation map and earthquake source model generated for a magnitude 5.8 earthquake on May 29th, 2012 in the Emilia region in Northern Italy. The post-event image was acquired 5 days after the earthquake, and the source model was generated in 2 hours and validated using seismological and GPS data. These products can be used to define the event scenario.

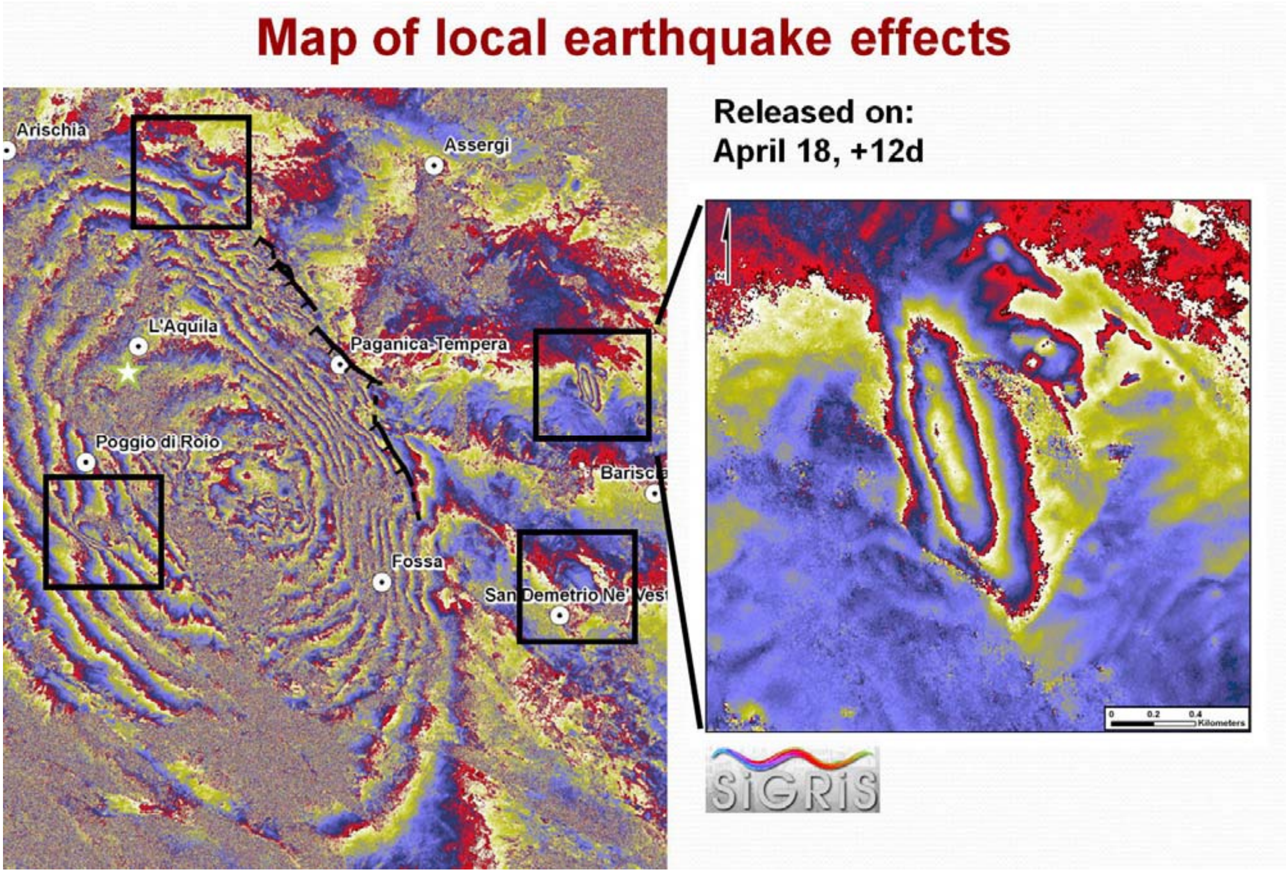
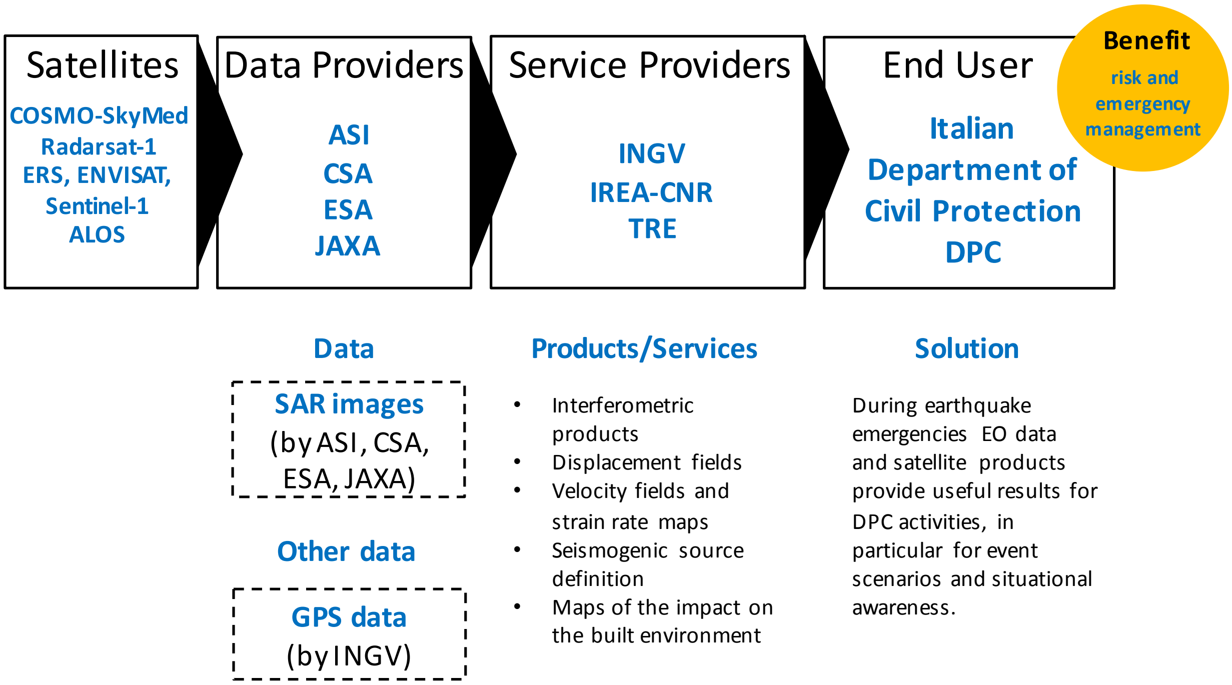


Figure 2 - Products generated for the April 6th 2009, Mw 6.3, L'Aquila earthquake (Central Italy). Left image: map of co-seismic ground displacement, where local environmental effects of earthquake are highlighted (reactivated fault scarps and slow moving landslides). Right image: detailed map of ground deformation triggered by the seismic shaking on a preexisting landslide. The first useful COSMO-SkyMed post-event image was acquired 6 days after the earthquake, the first version of the ground deformation map was generated in 4 hours later, and updated versions in the following days. The product here shown was generated several days after the earthquake, since field validation was deemed necessary.

Value Chain



More Information

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Phone: +39 06 8567 622

Provide URL's for relevant websites and affiliated Agencies. Include Agency logos here too.

www.asi.it

http://www.protezionecivile.gov.it

www.ingv.it

www.sigris.it

agenzia spaziale italiana

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

#120

Enhancing the national carbon accounting and reporting capability using data from the latest EO missions

[1]Shanti Reddy, Elizabeth Farmer, Katherine Green, Zulfiquar Khwaja and Mark Bradley

[2]Peter Caccetta, Suzanne Furby and Drew Devereux

The Department of the Environment developed a fully integrated Carbon Accounting Model (FullCAM) for estimating biomass, litter and soil carbon pools in forest and agricultural systems in Australia. The model is used for tracking the greenhouse gas (GHG) emissions estimates and stock changes associated with land use and management in the Australian national inventory. FullCAM is driven by land cover change data from Landsat series of satellites starting from 1972 to the present. In 2014, the land cover change programme (LCCP) has undergone significant improvements incorporating the surface reflectance data collected by the Landsat 8 satellite, extending the forest monitoring capability to support the second commitment period of the Kyoto Protocol. Increased automation, combined with time series data analysis, has led to significant efficiency gains and additional capability to implement new UNFCCC rules and accounting consistent with the IPCC guidelines.

Problem

Estimation of GHG emissions and removals from the land sector is a critical component of the national inventory reporting (NIR) under the United Nations Framework Convention on Climate Change (UNFCCC). The land sector is responsible for about 19 per cent of global carbon dioxide emissions since 1960 (IPCC, 2014). From 2015, most countries will be required to submit biennial update reports to the UNFCCC. International guidance on national greenhouse gas inventories prepared by the IPCC suggests several ways to estimate GHG emissions and removals from the land sector including use of field measurements, remote sensing techniques, ecosystem models or a combination of these methods.

Integrating models with field measurements and remotely sensed satellite data is a cost effective method to generate the national carbon accounts and also to support domestic climate change policies promoting project level carbon sequestration activities.

An important consideration in using the satellite data is to ensure time series consistency of national inventory estimates when data from different sensors or satellites is used over a period of time. The following case study demonstrates the approach Australia has taken in using the latest surface reflectance data from the Operational Land Imager (OLI) on-board the Landsat 8 satellite.

Satellite Earth Observation Data Application

Australia has pioneered the application of time series analysis of Landsat data to detect four decades of land cover history, which underpins the national inventory system (DoE, 2014). For this purpose, an operational satellite data processing system has been developed using path oriented products

[1] Department of the Environment (DoE), Australian Government
[2] Commonwealth Scientific and Industrial Research Organisation (CSIRO)

from the MSS, TM and ETM+ sensors (Furby, 2002). Whilst the existing methodology served the purpose very effectively, it required modifications to ingest improved quality surface reflectance products from the OLI sensor.

Geoscience Australia, the Landsat ground station operator in Australia, released a new product in 2013 - the Australian Reflectance Grid (ARG25). ARG25 is ready-to-use data fully corrected for geometric distortions and calibrated as an absolute surface reflectance (Figure 1). The specification of this new product is quite different to the previous Landsat 5 and 7 data products used for the national inventory Land Cover Change Programme (LCCP). To ensure time series consistency and compatibility with the existing LCCP, a detailed technical assessment was undertaken to assess the geometric and radiometric consistency and interoperability between these two products.

First, the geometric consistency was assessed by matching about 13,300 ground control points (GCP) drawn from the LCCP scenes held in the national inventory data library and the corresponding ARG25 scenes. This analysis showed that whilst the temporal geometric accuracy of ARG25 products is highly consistent, several GCPs had residual matching errors ranging from 1, 2 and greater than 2 pixels compared to the LCCP products. This result stems from the two series compiled from slightly difference geometric references. The mis-registration, if not accounted for, would result in false change being reported. To resolve this, the mean residual vector for each GCP was calculated and applied to the LCCP scenes to align with the ARG25 product base. The scene specific transformation coefficients ensured that the two products are aligned and consistent to within a pixel for the entire country.

The second step in the process was to assess the radiometric consistency between the ARG25 and LCCP products using a total of 339 image pairs. The two products were paired up based on the Landsat path and row, and image acquisition date. For each band, a gain, offset and correlation values were calculated. The gain and offset values for converting LCCP pixel values into ARG25 pixel values can be expressed as -

$$\text{ARG25} = \text{gain} * \text{LCCP pixel value} + \text{offset}$$

The relatively high correlations confirm that there is a strong linear relationship, across all bands, between the LCCP values and the equivalent ARG25 image values. Based on this study, scene specific, linear transformation coefficients for each band have been calculated to convert the LCCP calibrated pixel values to be consistent with the ARG25 surface reflectance values (Devereux, *et al*. 2013). The time series consistency of this method was also assessed for selected sites using eight years of surface reflectance data.

Following the above steps, the 2014 Landsat 8 surface reflectance data and the existing LCCP data have been processed to a consistent standard for further processing - mosaicking and classification. Mosaicking of the individually calibrated surface reflectance images into 1:1,000,000 map sheet tiles forms a seamless base for image classification using thresholds applied to linear discriminant functions (Furby, 2002). This is to identify areas of forest and non-forest, consistent with Australia's definition of a forest.

The next step is a Conditional Probability Network (CPN) analysis (Kiiveri, *et al.* 2001) to strengthen confidence in the 'forest' or 'non-forest' classification of a pixel by considering the previous and subsequent images in the time sequence to resolve any uncertainty in the classification (forest/non-forest) of a particular image. This comparative analysis of the same land unit over time was made possible by the accurate and consistent geographic registration and spectral calibration of the image sequences, providing the ability to 'drill' through time on a pixel-by-pixel basis.

The final step in the analysis was to attribute the cause of the forest cover loss either due to (a) permanent change in land use, or (b) temporary loss of forest cover, for example, as a result of harvesting (Figure 2). The attributed land cover change data forms a key input into the FullCAM to estimate emissions and removals for a given change event.

Figure 1. Landsat 8 surface reflectance image of Australia - 2014

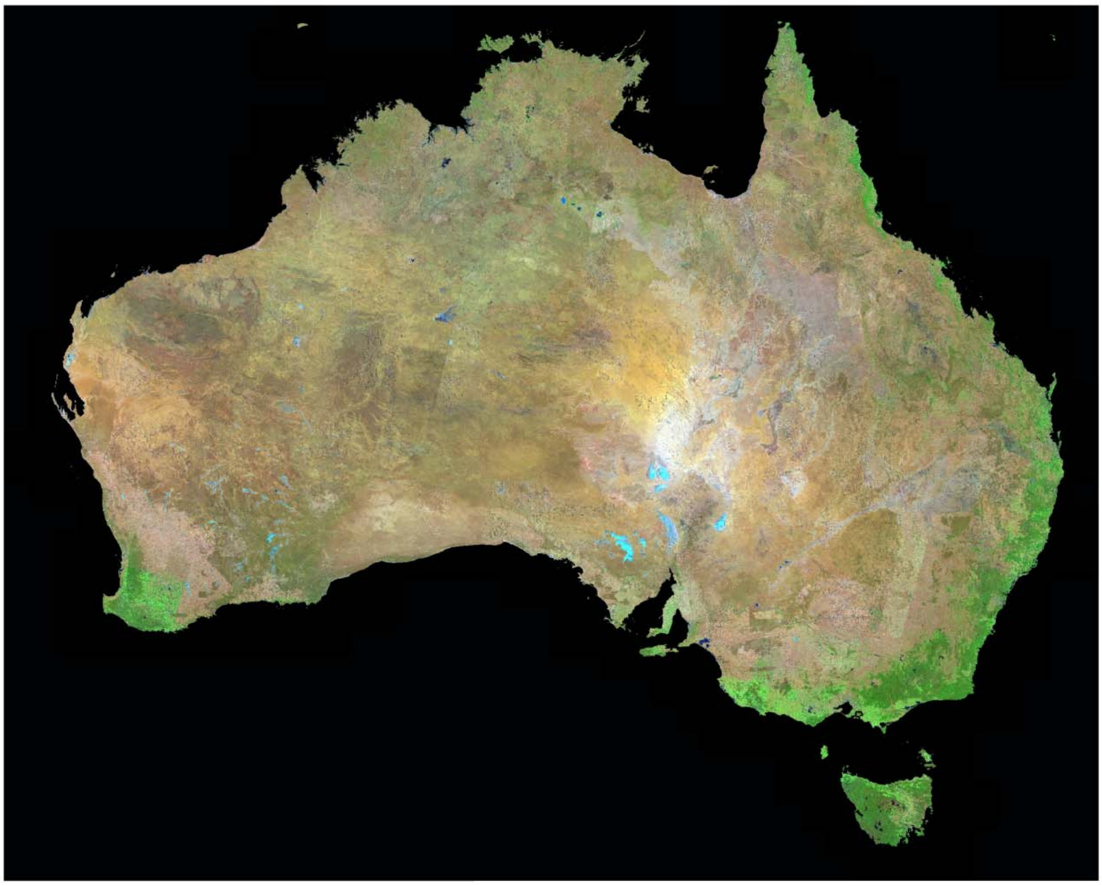
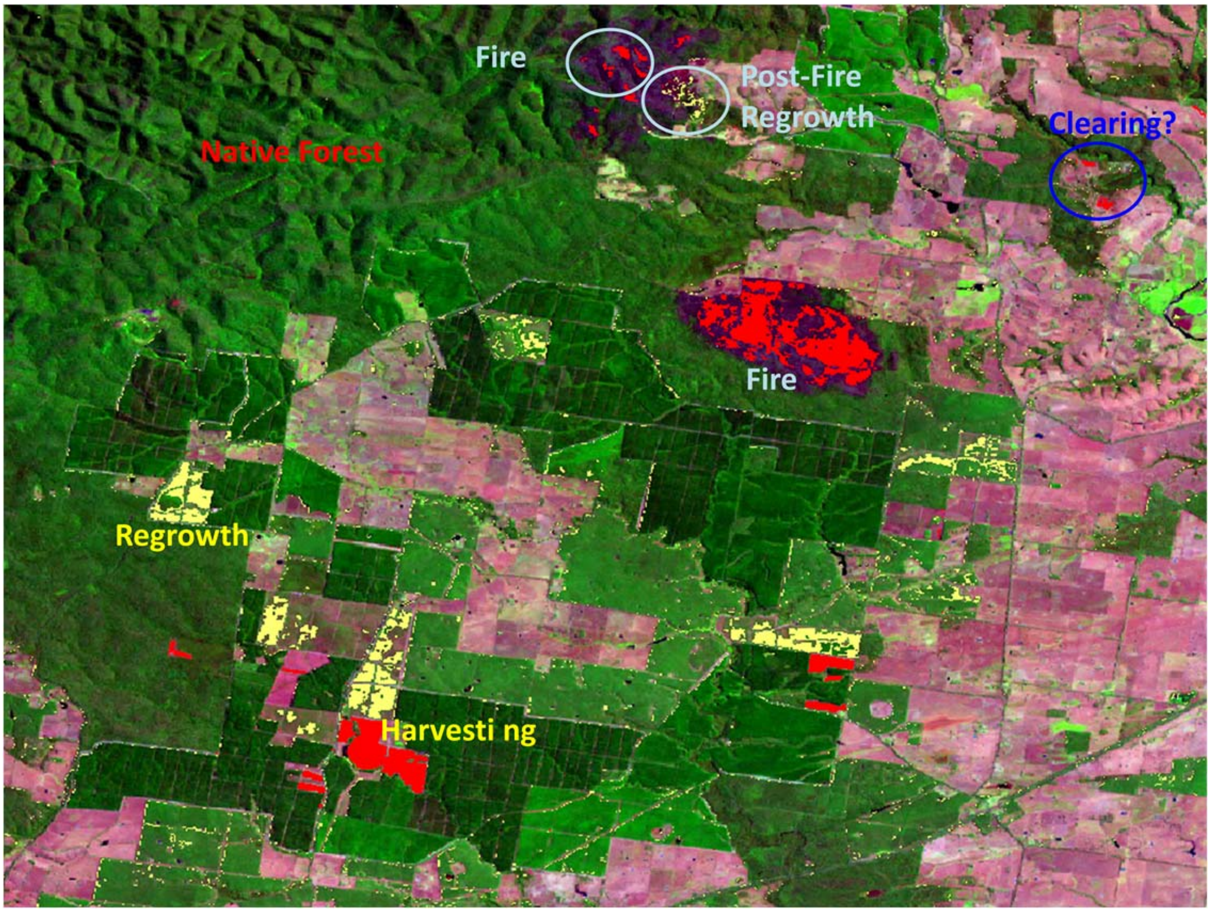
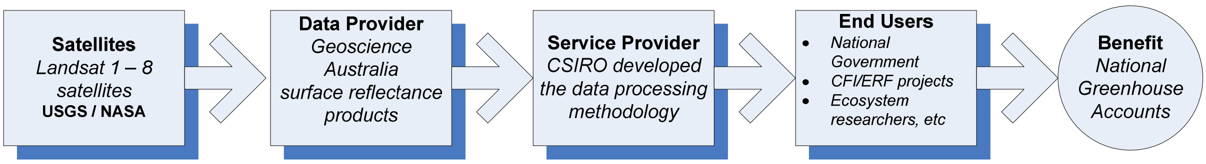


Figure 2. Landsat satellites detect land cover changes such as regrowth (yellow), harvesting (red), forest fires (red), and potential land clearing (blue).



Value Chain

Figure 3. Key components of the Australian land cover change programme value chain.



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Ocean fronts helping to define marine protected areas

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Descriptions

A front is the interface between contrasting water masses, often a hotspot for marine animals such as fish, seabirds and basking sharks. Satellite tools for mapping ocean fronts have been developed and applied as a proxy for the abundance and diversity of marine animals, to assist the planning of UK marine protected areas, and delineation of significant areas in the high seas. This has generated impact in the implementation of conservation policy, which will lead to societal benefit; and could also expedite the planning of marine renewable energy installations. These novel algorithms are applied to EO data from NOAA, NASA and ESA.

Challenges

A thermal front is the boundary between water masses that differ in temperature and are often sites of high productivity. Many pelagic biodiversity hotspots are related to fronts and provide important feeding areas for seabirds and a range of iconic species, for example cetaceans and basking sharks around the Isle of Man, Hebrides and Cornwall (Scales et al., 2014a).

The UK policy context of this research was driven by the need to establish an ecologically coherent network of marine conservation zones (MCZs) by 2012. Networks of such marine protected areas are required for conservation of critical marine habitats within Europe, but knowledge of the abundance and diversity of pelagic animals is scarce. All EU countries and more worldwide are required to define MPAs in order to halt the declining environmental status of their seas.

The Convention on Biological Diversity (CBD) has adopted criteria for the identification of Ecologically or Biologically Significant Areas (EBSAs) in the high seas globally, but at present these are based on fixed, benthic features.

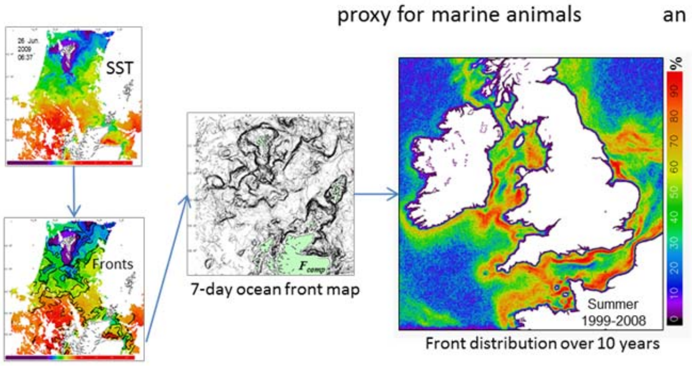
Applications/Solutions

Satellite tools for mapping ocean fronts have been developed and applied as a proxy for the abundance and diversity of marine animals, to assist the planning of marine protected areas (MPAs). Frequent locations of thermal fronts in UK shelf seas were identified using an archive of 30,000 satellite images acquired between 1999 and 2008, using techniques developed at PML (Miller and Christodoulou, 2014). We have published many studies on the distribution of different marine animals in relation to fronts, e.g. seabirds (Scales et al., 2014b) and basking sharks (Miller et al., 2015). This increases the evidence-base to underpin applications and impacts.

Value Chain (including end-users)

Current end users include: Defra (UK Gov dept); Scottish Natural Heritage; Marine Conservation Zones regional projects; Wildlife Trusts; Convention on Biological Diversity (CBD); UK National Centre for Earth Observation (NCEO).

Satellite	Data Provider	Service Provider	End User	Benefit
NOAA, Aqua, Senintel-3	NOAA, NASA, ESA	Plymouth Marine Laboratory	UK government departments and agencies	Cost-effective guidance on marine protected areas
	Sea-surface temperature and colour data from AVHRR, MODIS, OLCI sensors	Oceanic front detection and aggregation into front frequency maps: used as proxy for marine animals	This was a widely applied dataset in helping to define MPAs, hence had an impact on UK policy	



Outcomes/Benefits

These front frequency maps were applied as a proxy for the abundance and diversity of pelagic marine animals, in a Defra-funded MPA Data Layers project. The front maps were an important factor in recommending at least 11 of the 46 offshore MPAs for UK, indicating that this was among the most widely applied datasets. Hence this research has had an impact on UK policy, and once the MPAs are designated will provide benefit to the environment, society and economy through the conservation of commercial fisheries and charismatic fauna.

The techniques were then applied globally within a US-funded project to identify key habitat areas in the open ocean. The front maps influenced the boundaries of several EBSAs in the Pacific Ocean agreed at a CBD regional workshop in August 2012: "*frontal probability maps were used to help identify a boundary for the Carnegie Ridge and Equatorial front EBSA… Also to pull out how the Humboldt current went offshore in Northern Peru - the boundary mimicked a bird migration route from the Galapagos.*".

A further potential market is to expedite the planning process for offshore marine renewable energy installations by selecting sites to minimise adverse impacts.

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#124

Energy and Earth Observation Applications: Assessment and Mitigation of Geohazard Sites Along Strategic Transportation and Energy Corridors in Canada

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Descriptions

Over the last decade, the Canadian Space Agency (CSA) has been involved in the support of scientific initiatives, demonstration projects and operational implementation activities related to disasters and security management. Through the Government Related Initiatives Program (GRIP), the CSA and its public and private sector partners have fostered the development of Earth Observation (EO) information and services related to geohazards. This article highlights the success of the CSA and its partners from Natural Resources Canada and the Alberta Geological Survey, which developed new InSAR methods and techniques. These techniques demonstrate the potential of RADARSAT-1 and 2 to improve the assessment and mitigation of geohazards, such as ground subsidence and landslides, in Canada. This initiative is directly linked with the Global Earth Observation System of Systems (GEOSS) Implementation Plan and contributes to the GEO Work Plan.

Challenges

The Canadian Space Agency (CSA) understands the tremendous role and value that space-based Earth Observation (EO) systems and information have regarding disaster management, mitigation, response and its environmental and socio-economic impacts and benefits. Security, which includes disaster and geohazard management, is one of the three pillars of the CSA EO strategy. Our vision is for Canada to be an internationally recognized leader in the development and use of EO applications in support of national priorities. We recognize that threats to our environment are a clear danger in the context of climate change and we believe that action is needed now to ensure our quality of life, particularly for those most vulnerable to health threats from environmental and technological disasters. The security area is not only defined by disaster management, but by a wide variety of events that could affect the environment and health of the population. Not being prepared is costly. In the past, Canada has experienced multiple catastrophic events (i.e. Spanish flu pandemic, Tseax river cone eruption, Saint-Jean-Vianney mudslide, Red River floods, Okanagan valley fires, Ocean Ranger oil platform sinking, etc.). In 1998, the ice storm in Quebec cost the country $1.2 billion and the droughts of the last decade in our prairies cost Canada's economy over $3 billion. We now can add glacier and permafrost melting in the Canadian Arctic to the list of hazards which are expected to have a negative impact on our environment and economy. Our need for EO applications to predict severe environmental and man-made disasters has never been greater. As technologies mature, they yield more benefits and applications. Canada's government understands how crucial science, technologies and their applications are to building a strong economy. This article gives an example of one of the Canadian EO success stories in geohazard monitoring using InSAR technologies.

Figure 1. Landslide and soil instability in Alberta Canada. Source: AGS/NRCAN.

This initiative is directly linked with the Global Earth Observation System of System (GEOSS) Implementation Plan (section 4.1.1. Disasters: loss of life and property from natural and human-induced disasters) and contributes to the GEO Work Plans (i.e. DI-06-03: Integration of InSAR Technology). It also supports Canadian government priorities to secure our energy future, preserve Canada's environment, keep Canadians safe, contribute to global security and build stronger institutions. The CSA, through the GRIP Program, has worked with the Canada Center for Remote Sensing (CCRS) on a project involving the application of InSAR technology to map and characterize ground hazards in Western Canada. The project involves characterizing subsidence over abandoned coal mine workings, movements along active faults and slope movement for landslides in the Rocky Mountains, Alberta Plains and in Canada's arctic. All sites chosen for this study are located along strategic transportation and energy corridors. This project is not only meant to demonstrate the application of InSAR monitoring along Canada strategic energy and transportation corridors but also to build InSAR monitoring capacity within NRCAN's Earth sciences sector and the Alberta Geological Survey, part of the Alberta Energy Regulator. InSAR deformation monitoring as a routine hazard assessment method is in its early stage of development in Canada. There is a need to develop convincing case studies at difficult high-risk sites that will be used to establish an InSAR monitoring baseline for continuous integrated monitoring along Canada's strategic transportation and energy corridors.

Applications/Solutions

The project objectives are: (1) to produce InSAR products of active landslide areas along strategic transportation and energy corridors, and of selective seismically active areas in Canada; (2) produce an InSAR image archive of selected active geohazard areas in Canada. The areas selected for this investigation include: large and small active vegetated landslides along strategic energy and transportation corridors (Trans Canada Highway in the Rockies, Mackenzie Valley Pipeline, the Town of Peace River/Highway 2 Corridor, and Highway 49 Crossing of the Little Smoky Highway River, Alberta); and the seismically active Leach River fault affecting the city of Victoria. Multi-temporal InSAR maps have provided an input for modeling the seasonal motion behaviour and predictability of these hazard sites in order to develop the mitigation strategies for these high-risk areas. As some of these geohazard sites are vegetated and wet, which results in non coherent targets, the installation of corner reflectors as coherent targets is a significant part of this integrated InSAR monitoring development strategy. The results of the project are: the successful integration of field-installed corner reflector technology and InSAR analysis to monitor gradual motion at high risk geohazard sites.

<u>Crowsnest Pass/Highway 3, Alberta</u>

The Crowsnest Pass in Southwestern Alberta is an important trade corridor. Both provincial Highway 3 and CP Rail transport people and goods from eastern Canada into British Columbia and ports on the Pacific Ocean. Much of the settlement in the corridor occurred in the early 1900s when coal mining in the region led to many decades of mining of underground coal seams in the area. Perhaps the most memorable event from this time period was the 1903 Frank Slide, Canada's deadliest landslide which killed over 80 people when it buried a portion of the mining town of Frank. The legacy of the coal mining rush in the region is a series of abandoned underground coal mines that underlay modern-day infrastructure and urban development.

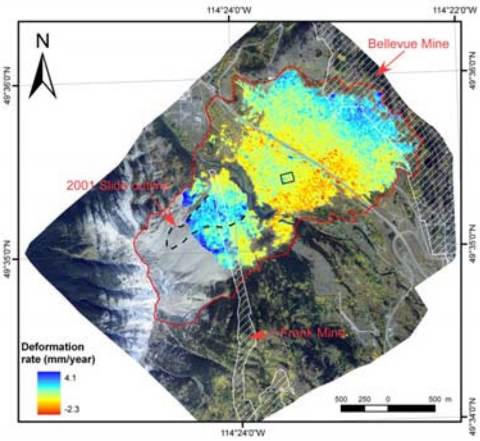


Figure 2. Crowsnest Pass. In conjunction with studies being undertaken by the Alberta Geological Survey (AGS) on unstable slopes on Turtle Mountain, site of the Frank Slide, InSAR technology was utilized to map subsidence of the ground overlying the abandoned coal mine workings. By utilizing Radarsat-1 Fine beam data from fall 2004 to summer 2006, many thousands of coherent targets were identified above the mines and a map was produced showing the rates and patterns of deformations.

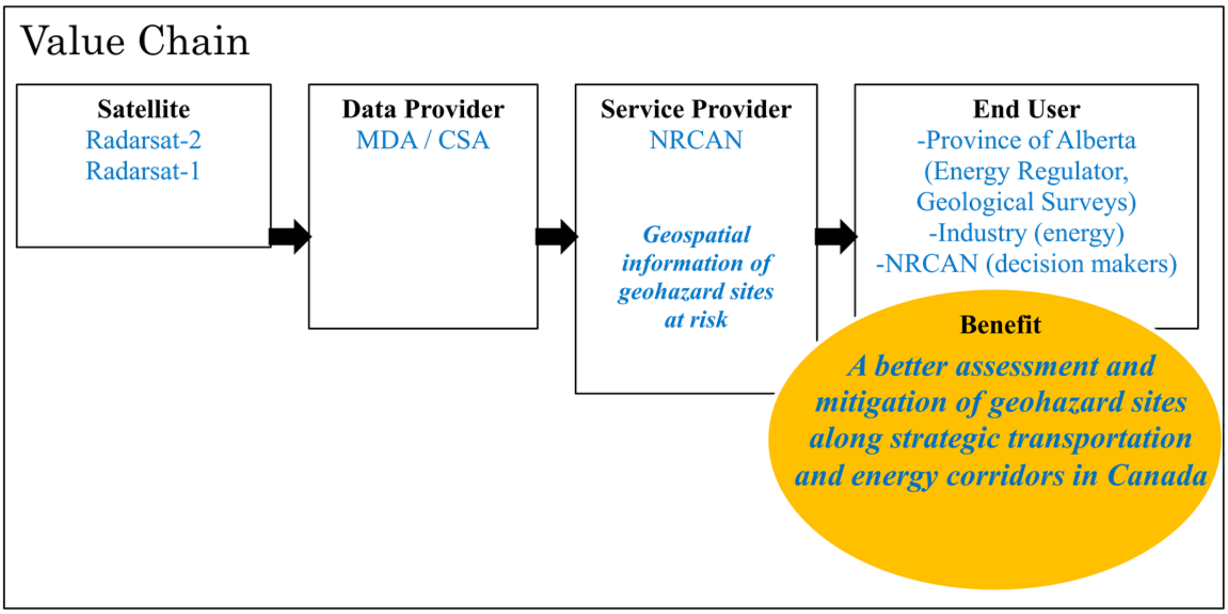
Highway 49/Little Smoky River Crossing, Alberta

The Little Smoky River bridge and approach roads were completed in 1957. Since that time there has been ongoing valley slope instability that has impacted the highway and west bridge abutment, resulting in ongoing costly maintenance issues. As the repairs to the highway, a major trade route for north western Alberta, cost the Alberta government many hundreds of thousands of dollars per year, studies are underway to provide a viable long-term solution to mitigate the impacts of this slope movement on the highway. Options were considered for stabilization of the slide, and for highway realignment away from the area of greatest instability. All options are costly and limited information is available to confirm the viability of each option due to the very deep slide plane. As there are significant decisions to be made by Alberta Transportation (AT) with very little data on the valley walls, the use of InSAR with corner reflectors was considered to be an exciting option for acquiring a wide array of data. In October 2006, an array of eighteen small areas was cleared of vegetation and corner reflectors were installed by personnel from AGS, AT, CCRS and the University of Alberta. Each reflector, in the shape of a four-sided pyramid, was aimed so that the large open end was oriented to be directly perpendicular to the direction of radar pulses emitted from the orbiting Radarsat-1 satellite, which obtains results over the site every 24 days. The reflectors are used to provide an amplified signal back to the satellite, when compared to the heavily vegetated surrounding areas. As of November 2008, a set of 28 readings was obtained for each reflector and the results processed at the CCRS offices in Ottawa. The processed results have been taken by AGS Geological Hazards staff and compared against conventional geotechnical instrumentation on the site (slope inclinometers) and visual interpretations of the complex slope movements on the site. A set of GPS readings was also taken by AGS, AT and CCRS staff during the summer of 2008. Results were passed on to AT to aid in making future decisions as to managing landslide risks along the highway corridor in the future..

Highway 2 Corridor/Town of Peace River, Alberta

The Town of Peace River is located along the floodplain and valley walls of the Peace River in north western Alberta. Although aesthetically pleasing, a large portion of its urban footprint and transportation infrastructure is built either on the flood plain or on the unstable valley walls of the Peace River Valley. Beginning in 2006, a study was initiated to characterize the extent, rates and style of the large scale landslides in and around the municipality and assess their impacts on the highways, gas transmission and distribution pipeline networks, and urban infrastructure. As the glacial history is complex and landslides originate in various settings, the initial components of the study are the development of a three dimensional geological model and completion of an inventory of documented landslides in order to determine logical groupings for landslide types. In order to develop an understanding of the historical movement rates and extents, an InSAR study will review deformation trends between 1992 and 2006 and compare these results to deformations recorded using conventional instrumentation over this time period. This work is currently underway and involves collaboration between AGS, CCRS and the University of Tromsø (Norway). It is expected that the results of the InSAR will be a key component of the hazard analysis and aid in decision making as to mitigation and future land use planning.

Value Chain (including end-users)



Outcomes/Benefits: A better assessment and mitigation of geohazard sites along strategic transportation and energy corridors in Canada

It is clear from these examples and the published results, RADARSAT InSAR monitoring of selected high risk landslide sites affecting transportation routes is providing convincing case studies and guidelines for other users to apply. Over the duration of the InSAR Canadian Space Agency GRIP project, the Alberta Geological Survey and Natural Resource Canada have increased their uses of InSAR techniques, which are now becoming routine in monitoring high – risk sites. A large archive of InSAR data for these sites is now available, and will be used for future long term integrated monitoring of these unstable slopes that are affecting our transportation routes and energy corridors.

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#125

Public Health and Earth Observation Applications: Risk Assessment of Infectious Diseases in Canada

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Descriptions

In the UN resolution entitled "The Space Millennium: Vienna Declaration on Space and Human Development", the participating States recognized the importance of space science and space applications for progress in fundamental knowledge of the universe such as health, environmental monitoring, management of natural resources, disaster management as well as the major contribution that space science and applications make to the well-being of humanity and specifically to economic, social and cultural development. The States also identified an action "to improve public health"[1].

In the context of the prevention and control of various emerging diseases and chronic conditions, the management of key public health issues requires solid evidence-based knowledge. Earth observation (EO) images can provide a contribution by deriving data from population and environmental determinants of health over the large Canadian territory. The Public Health Agency of Canada (PHAC) has recently completed a successful project via the Canadian Space Agency (CSA) Government Related Initiatives Program (GRIP). To assess the average contamination level of recreational beaches in southern Quebec, Earth Observation (EO)-based methodologies and measures were introduced into statistical models. The initiatives allowed the PHAC and their partners to identify farming and urban activities as having a major influence on the microbiological quality of recreational waters in terms of fecal contamination levels and possible foodborne pathogens and were able to identify beaches at high risk of contamination.

Also, risk mapping for vector-borne and emerging infectious diseases, and intelligence synthesis for emergency preparedness were identified by PHAC as areas needing immediate attention. In most of these cases, EO is used to supplement current process and data; in some cases, it is foreseen as being able to replace some of our current requirements for extensive field data sampling. The public health experts in Canada are starting to use EO images in a systematic way.

Challenges

In today's fast changing world, public health is facing many challenges in the prevention and the control of various emerging diseases and chronic conditions. Many of these health conditions arise from a sustained interaction between evolving human populations (change in demography, migrations and travels) and the environment. Zoonotic diseases are infections that can be acquired through contact between animals and humans. According to World Health Organization, at least 61 percent of all human pathogens are zoonotic, and have represented 75 percent of all emerging pathogens during the past decade [2, 3]. The emergence of zoonotic diseases, such as avian influenza (H5N1, H1N1, H7N9), new coronavirus (MERS-Cov), the West Nile virus, Lyme disease, Ebola virus, and malaria, is ranking high among the public health issues that the World Health Organization (WHO), the World Organization for Animal Health (OIE) as well as numerous national organizations, companies and universities are attempting to address. In order to mitigate these types of health risks they are adopting a multi-sectorial approach of collaboration known as the One Health approach [4].

The understanding of inherent mechanisms of infectious diseases transmission is challenged by global and environmental changes. Governments and the public have a need of a better understanding of ecosystems and their health. Also, evidence-based knowledge is required for the management of key public health issues. However, obtaining the necessary data on environmental health determinants constitutes a major challenge because of the large territory to cover. In fact, obtaining those data from field campaigns requires an unreasonable amount of resources. Fortunately, this is where Earth Observation (EO) images can step in and provide a contribution. Data from population or environmental determinants may be derived from EO images, particularly in regard to the impact of natural or anthropogenic ecosystem changes. Operationally, EO images have demonstrated their usefulness in the prevention and control of persistent and new diseases. They provide important wide and near-range geo-spatial information that can fuel research, improve monitoring and risk assessment for public health and guide intervention measures and disease control; they can also be useful in the preparation and response to emergencies; and they can help improve health security by reducing risks concerning the introduction of infectious disease (e.g., new avian influenza). Thus, the EO satellite data and products can be advantageous in several ways, including availability of different scales and wide-spread coverage, monitoring capability and rapid acquisition, costs effectiveness, as well as data quality and data continuity.

In Canada, EO has an opportunity to enhance public health-related knowledge and capacity to investigate diseases across a vast territory of more than 10 million square kilometers, including in the North. In doing so, the Canadian government can rely on access to RADARSAT-2 images through the CSA. Since the 1990s, space-based EO technologies have been integrated into epidemiology and public health domains [5,6]. EO can play an important role in the decision-making process in public health, and the recent methodological approach resulting from this integration is valued by experts working on emerging and re-emerging infectious diseases in Canada. This approach is now known as tele-epidemiology.

Applications/Solutions

Tele-epidemiology is a recent discipline combining epidemiology and space technology applied to human and animal health. It allows the spatial and the temporal study of events affecting the health or disease processes. It involves the monitoring and the assessment of the distribution of animal and human illnesses strongly linked to climatic and environmental variations [5].

Tele-epidemiology is particularly interesting for the study and monitoring of emerging and re-emerging vector-borne diseases, since these involve the transmission of viruses or bacteria by vectors (insects, invertebrates, and mammals) whose population and movements are often influenced by environmental characteristics. Tele-epidemiology is then used to model the spread of disease and map the associated risks from vector-ecology knowledge affected by and following environmental changes (e.g., Lyme, Malaria, Eastern Equine Encephalitis, etc.). The analysis of EO images allows rapid identification of specific sites that can be used for field validation of the presence of a vector infected by a disease and the enhancement of active disease surveillance, as is the case for Lyme disease in Canada [6].

Tele-epidemiology also has recently found usefulness in the study of bacteria contaminating lakes and thus representing a risk to bathers. PHAC has recently completed a project through the CSA Government Related Initiatives Program (GRIP) to assess the benefit and usefulness of satellite data for monitoring and managing foodborne pathogens associated with recreational waters. EO-based methods and measurements were integrated into statistical models to assess the average contamination level of recreational beaches in southern Quebec [10, 12]. Data from various EO satellites, such as RADARSAT-2, Envisat/MERIS, Landsat-5, MODIS, AVHRR, SPOT-5, GeoEye-1 and Worldview-2 were used in order to better characterize the surrounding land use and environmental determinants. The project allowed PHAC to identify farming and urban activities as having the main influence on the microbiological quality of recreational waters in terms of fecal contamination levels and possible foodborne pathogens [7, 8].

Since 2000, the Earth Observation Applications and Utilizations division of the CSA has managed EO-specific programs and projects. Efforts to date have focused on the utilization of radar and optical EO data, and on integrating the satellite data into environmental information systems related to water, agriculture, energy, climate, weather, ecosystems, biodiversity, security, and others. The CSA has worked with other government departments, with industry and with research institutions across Canada to develop and implement a number of health- and environment-related monitoring activities.

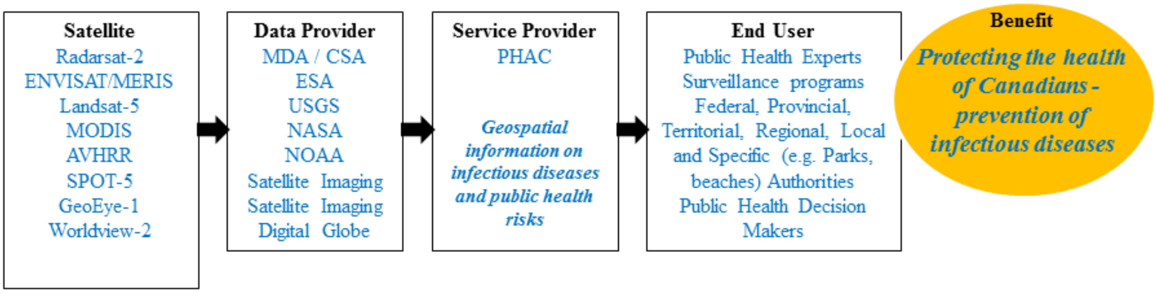
PHAC and the health community are exploring new initiatives with national and international partners, such as the CSA, the World Health Organization (WHO) and the United Nations (UN). These partnerships are advancing the application of EO, monitoring and forecasting systems to health decision-making processes. In particular, they provide a solid base for the (1) development of tele-epidemiology EO applications (i.e., infectious and vector-borne diseases, ecology and behavior, water and air quality); (2) understanding of ecosystems changes that can lead to the emergence of diseases; and (3) integration and fusion of geospatial, medical and socio-economic data for health care decision support systems [9].

Information is at the core of public health, as it can lead to better decision-making in the prevention and control of diseases. Although EO images are widely available, there is further investment required to produce results or spatial information timely, repeatedly and accurately. In Canada, the public health sector is starting to utilize and exploit EO images in a more systematic way. Research and development of tele-epidemiology requires expert training, education, and knowledge transfer from science to operations. In addition, the enhanced development of risk-assessment models and the early warning of infectious diseases by tele-epidemiology could have an impact on current surveillance methods, intervention and controls and will call for adoption of this new approach.

Global and environmental changes challenge our understanding of the inherent mechanisms of zoonotic disease transmission. A better understanding of ecosystems and their health is needed. The EO images offer the opportunity to gather essential information on environmental determinants of health, from coast-to-coast including the Canadian Northern region and other remote communities. Several new EO satellite missions will be launched in the coming years. Satellite systems like the RADARSAT Constellation, the European Sentinels, SMAP, and other future sources of information will increase the benefits for the health sector.

CSA's EO applications programs have focused on user needs and helped facilitate the implementation of tele-epidemiology activities at PHAC, fitting well within a One Health approach promoted internationally. In a world where satellite-based EO play a key role in the stewardship of land, ocean and atmospheric features, it could do the same by helping to manage emerging public health issues at the interface between humans, animals and the environment.

Value Chain (including end-users)



Outcomes/Benefits: Protecting the health of Canadians (prevention of infectious disease)

The prevention and control of persistent and emerging infectious diseases require solid evidence-based knowledge from population and environmental determinants of health. EO offers innovative datasets based on constant evolving geospatial approaches and applications. EO improves our knowledge on diseases by addressing the need for new sources of evidence-based data and intelligence on the determinants of health and their interactions. For example, the use of geospatial technologies and EO images is useful to characterize the spatial and temporal variability of environmental determinants involved in microbial contamination of recreational lakes. Even if bacteria are invisible to the human eye and to satellites, it is possible from space to characterize the sources of contamination and the determinants involved in transport and transmission (agriculture, urban areas, etc.). This risk assessment is feasible with the use of geospatial tools and through the integration of factors involved in microbial contamination, providing the information necessary for decision-making, management of public health surveillance, and control of diseases [8, 10].

EO provide new information and then enhance current control and prevention programs designed for protecting Canadians against infectious diseases providing up-to-date environmental data and land features pertinent for public health actions such as risk mapping, risk communication and identification of vulnerable populations. Also, EO images contribute to the epidemiological intelligence to support decision by enhancing the current understanding of the spatial progression and speed of distribution of vectors, direction of progression, seasonality, impact on climate change on vector-borne diseases emergence in the coming years.

EO provide wide near-range of geo-spatial information that can guide intervention measures or preparation and response to emergencies; can help improve health security for reducing risk concerning the introduction of human pathogens and toxins in the environment. It also contributes to public health response mechanisms with early warning detection of transboundary infectious diseases. EO enhances public health-related knowledge and capacity to investigate diseases across a vast territory of more than 10 millions square kilometers, including the North. It can play a role in decision-making process and the recent methodological approach is valued by experts working on emerging and re-emerging infectious diseases in Canada.

The core benefit of EO is to move one step ahead on an agenda of gaining tactical advantage and efficiency by investing in a useful technology applicable to a whole range of public health issues, both in peace and in peak times.

EO is solid, sustainable and innovative avenue enabling better decision making at different authoritative levels and increasing the efficiency of many preventive, preparedness and response actions.

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Agence de la santé publique du Canada   Public Health Agency of Canada

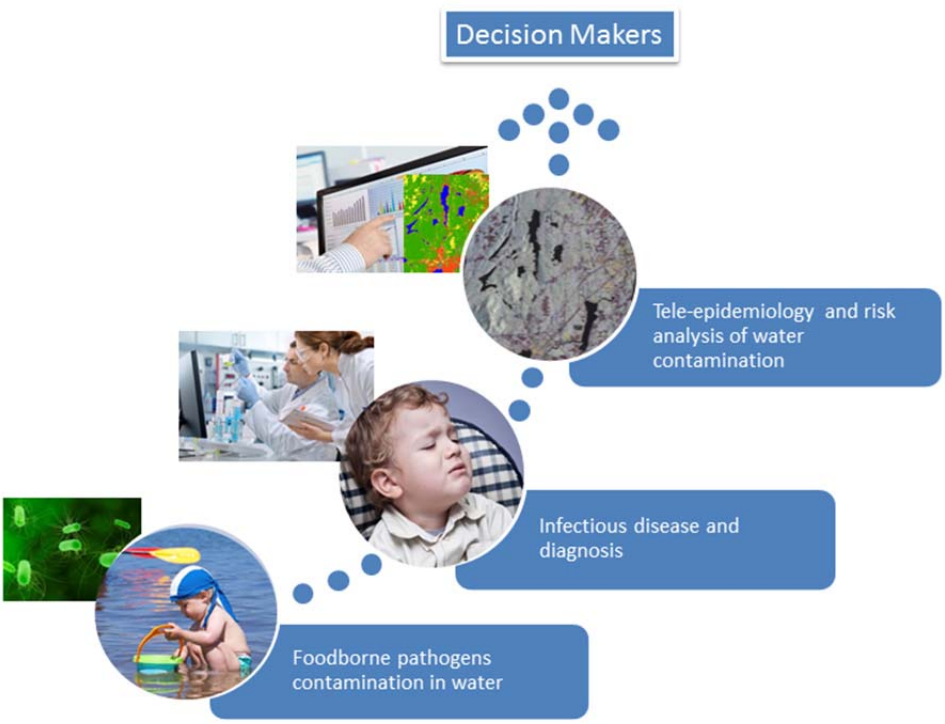

Figure 1: Tracking foodborne pathogens contamination in water from the source with EO images. Source: PHAC.

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#126

Use of Satellites for Disasters in Southern Africa

The CEOS Working Group on Disasters is working with research partners to develop capabilities for monitoring floods and with end-users to build and sustain the capacity to use these capabilities in real-time disaster management. One of the focus areas of this effort is in southern Africa, where several ongoing projects are being leveraged and coordinated to provide a "one-stop shop" for satellite information pertinent to flood risk.

Problem

Accurate, reliable information is critical for responding to natural disasters, but information from traditional in-situ sources (e.g., rain and streamflow gauges) is typically sparse and often not available to decision-makers in a timely manner, particularly in less developed countries. In addition, those who might be affected by flooding need to be convinced of the threat if they are going to heed the warnings—as an example, in 2008 Namibia endured its worst flooding in decades, but many chose not to heed the warnings given because they had not experienced floods in recent memory. Satellites can address both of these needs by providing real-time information with excellent spatial resolution and coverage as well as analyses of risk based on previous flood events. However, decision-makers are often unable to take advantage of this information because they are unaware of satellite data, do not have immediate access to it, or are not trained in how to use it. To bridge this gap, connections need to be made between these users and the data providers, including making the data available in a format that is easy to use and interpret and providing the training that ensures that the data will be used.

Satellite Earth Observation Data Application

In response to this problem, the CEOS Working Group on Disasters was formed in 2013 to coordinate existing efforts in satellite remote sensing of floods, volcanoes, and earthquakes and connect them with decision-makers in the affected areas. For floods, three pilot areas were selected: the Caribbean (with a focus on Haiti), southern Africa (with a focus on Namibia), and the Mekong Delta, and a global pilot has also been initiated to provide satellite products that are produced on a global rather than a regional scale.

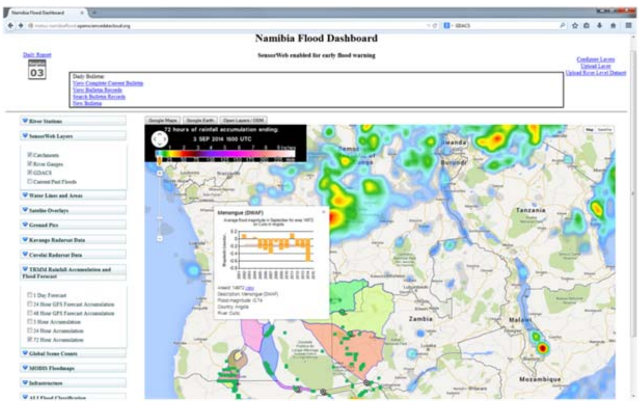

Figure 1. Sample image from the Southern Africa Flood Dashboard, illustrating some of the available imagery overlays and point data.

The centerpiece of each pilot project is the "Flood Dashboard": a Web site that allows the user to overlay various relevant satellite products on a map and also to access available in-situ data by clicking on a gauge point (Fig. 1). These satellite products include real-time inundation maps (Fig. 2), flood risk as determined from analyses of previous flood events, current and expected rainfall, and predicted water elevation from flood models that use the satellite data as input. The Dashboard is at http://matsu-namibiaflood.opensciencedatacloud.org/ and is fully open-access. Many of the projects contributing data to this Pilot also have a training component, such as the European Space Agency's TIGER initiative, and the pilot is leveraging this training to the benefit of other Pilot users not directly affiliated with TIGER.

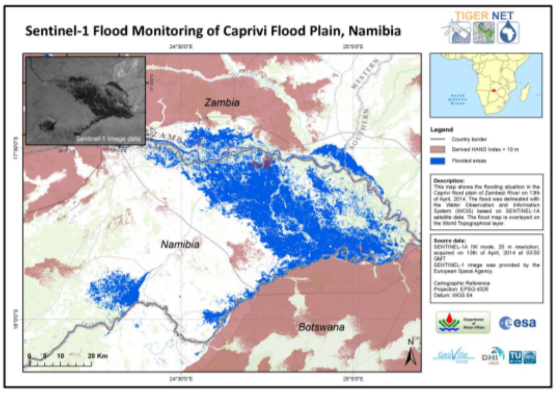

Figure 2. Sample flood image over Namibia from Sentinel-1a on 13 April 2014 created by TIGER-NET. Copyright EAS/TigerNet/Department of Water Affairs/GeoVille/DHI/TU Vienna/GEO. Used by permission.

Value Chain

The pilot project uses data from multiple satellites across many space agencies, such as the Canadian Space Agency's (CSA) Radarsat-2, the European Space Agency's (ESA) Sentinel-1, the German Aerospace Center's (DLR) TerraSar-X (TSX), the Japanese Aerospace Exploration Agency's (JAXA) Advanced Land Observation Satellite (ALOS-2), the National Aeronautics and Space Administration's NASA Earth Observing satellite (EO-1), and the United States Geological Survey's (USGS) Landsat-8. The raw data from these satellites are converted to flood extent and flood hazard maps by value-added partners such as the Lippmann Institute, Deltares, the United Nations Institute for Training and Research (UNITAR) Operational Satellite Applications Programme (UNOSAT), and the NASA Jet Propulsion Laboratory (JPL). Many of these data sets are not routinely made available for free, so the Flood Pilot has entered into agreements with the appropriate space agencies to request a limited amount of data whenever flood events occur. This information is then made available by NASA at the Flood Dashboard, which is then used by entities like the Namibian Department of Water Affairs and Forestry and the National Water Resources Authorities, and the Regional Centre for Mapping of Resources for Development (RCMRD). As previously noted, the Flood Pilot is also leveraging training efforts in order to build capacity to use these data by the decision-makers.

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The Copernicus Sentinels Benefitting Society and Environment: first examples using Sentinel-1A

Europe's Copernicus programme provides key data and information services to improve environment management, help mitigate the effects of climate change and safeguard everyday lives. The Programme is based on a new family of Sentinel satellites that supply accurate data in a sustained, operational way. The first, Sentinel-1, is already routinely providing all-weather, day-and-night radar imagery in support to several applications and notably to those applications requiring continuous monitoring of large areas at sea. Operational supply chains are expected to be progressively integrated with Sentinel-1: a first one, providing ice monitoring services in near-real time, is already up and running while another one is planned to be activated soon in support to oil spill monitoring.

Problem

Oceans not only represent a key ecosystem influencing life on Earth, but also an enormous reservoir of potential resources. They are theatre to ever increasing exploitation activities and growing marine traffic. In European waters alone, more than 20.000 ships are tracked everyday[1], carrying passengers but also oil, gas and other goods. In order to support safe and secure activities while always protecting the environment, enhanced monitoring capabilities are needed. For instance, to support navigation in the Northern seas - which are hazardous in winter due to the presence of ice - or to face spills from vessels, offshore platforms and oil pipelines - which may severely pollute marine and coastal habitats and cause enormous damage to the natural environment and to the economy. Aircrafts could be used to monitor such areas, but over very large surfaces they are time-consuming and expensive, and usually not a feasible option for private companies nor for public authorities.

Satellite Earth Observation Data Application

Earth observing satellites have a demonstrated capability to provide an effective and efficient solution to continuously monitor very large areas at sea. Satellite-borne radar imagers are capable of distinguishing different targets like ships, oil slicks and floating ice. They can even distinguish between the thinner, more navigable first-year ice and the hazardous, much thicker multiyear ice. The satellite images can be used, together with other kinds of data, to produce high-resolution

[1] Source: European Maritime Safety Agency (EMSA)

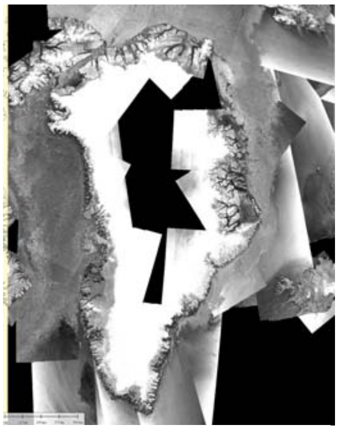

Figure 1: Satellite borne radar images from Sentinel-1 mosaicked by the Copernicus Marine Environment Monitoring Service,. Credits: ©Copernicus Data(2015)

ice charts and forecast ice conditions such as motion, concentration, thickness and ridges. The maps and forecasts, continously updated, are delivered to ships and local authorities that use them to plan their routes and update the planned ones as needed. Examples of satellite maps and of derived ice charts are shown in Figs. 1 and 2.

To support environmental policy applications, satellite images can be screened via semi-automated techniques to quickly detect oil slicks and vessels. If correlated with identification signals emitted by all "regular" vessels, they can help identifying potential polluters and help tracking illegal releases. Thus this application helps to strengthen operational responses to accidental and deliberate discharges, and assist local authorities in their follow-up actions for the areas under their jurisdiction.

Nevertheless, in order for satellite images to be exploited in operational services by civil authorities and commercial companies, a sufficiently frequent coverage over the areas of interest must be guaranteed and the information made available as quickly as possible. In addition, long-term sustained and reliable data delivery must be ensured. Copernicus Sentinel-1 mission has been designed to meet such requirements and, with its focus on reliability, operational stability, global coverage and quick data delivery, is expected to make a step change in several operational applications. The satellite is capable of imaging up to 4 million sqkm per orbit, ensuring a revisit time in the North pole of up to several times per day. In 2016 a second satellite of the same type, Sentinel 1B, will be launched with a complementary orbit, doubling the coverage performances.

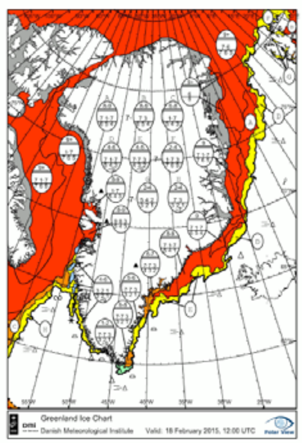

Figure 2: Greenland ice chart, as derived from Sentinel-1 data on Feb. 18, 2015. Credits: DMI, PolarView.

Value Chain

Sentinel-1 acquires in a pre-programmed conflict-free operation mode, imaging global landmasses, coastal zones, sea‑ice, polar areas, and shipping routes at high resolution. The data are systematically downlinked, processed and made available to users. The Copernicus Services exploit satellite data and combine them with other types of data (e.g. from other satellites, numerical models and/or in-situ sensors) to derive value-added information for various types of uses. One of these Services, the *Copernicus Marine Environment Monitoring Service*, provides – among other products - operational forecasts for sea ice, thereby supporting ship routing and search & rescue activities in the Northern seas. Since the end of the satellite *In-Orbit Commissioning* in October 2014, an average of ~ 15 acquisitions per day are performed over the Northern seas (namely over Eurartic, Baltic, Greenland waters, Davis strait and Labrador sea*)* and products are made available via a dedicated dissemination line within 3 hours from acquisition. A total of more than 20.000 cumulative products have been made available to date. Based on these data, the partners within the *Copernicus Marine Environment Monitoring Service* produce daily ice charts, iceberg density maps and maps of sea ice drift and deformation for several types of users, as schematically represented in Fig. 3.

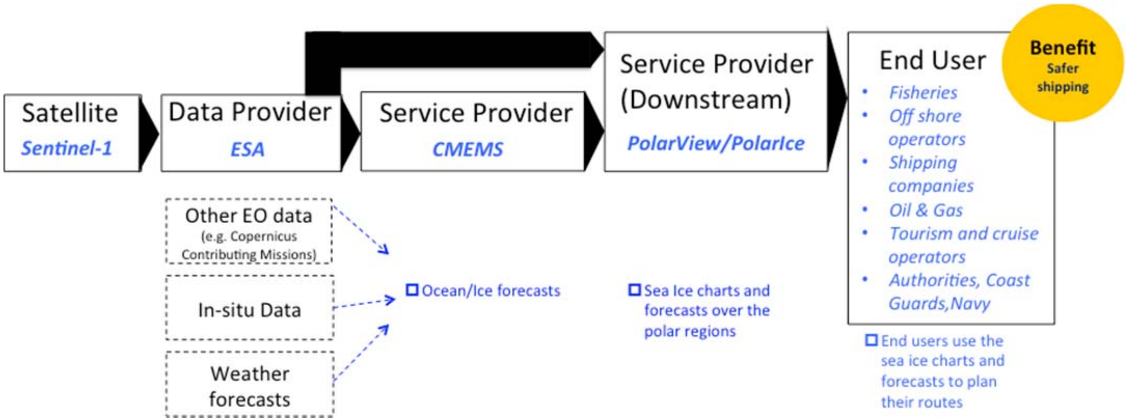

Figure 3: Graphical representation of the ice monitoring value chain, from Sentinel-1 via the Copernicus Marine Environment Monitoring Service (CMEMS) and the downstream service provider PolarView.

Another operational chain to be soon activated is the one to support the maritime surveillance activities within the *Copernicus Security Service* portfolio. ESA is currently discussing with the European Maritime Safety Agency (EMSA) to set-up a dedicated interface to incorporate Sentinel-1A data within the EMSA CleanSeaNet oil spill monitoring and vessel detection service. This service is already integrated into European national and regional pollution response chains, whereby national contact points are notified about detected possible oil spills within 30 minutes of the satellite overpass. Today, approximately 2.500 satellite images are processed and analysed by EMSA every year, but it is expected that Sentinel-1A will be capable to boost the service providing a much higher repetition for EU waters.

Sentinel-1 data are available for all users at http://scihub.esa.int under a free and open data policy. Products and alerts from the *EMSA CleanSeaNet Service* are made available freely to authorized users in Europe at https://portal.emsa.europa.eu. Forecast and other data from the *Copernicus Marine Environment Monitoring Service* are freely available at http://marine.copernicus.eu. Free and open access to Copernicus data and information is expected to stimulate the take-up of EO for commercial use and to play an important role in European research, thereby boosting innovation and economic growth.

More Information

For general information about Copernicus, please visit: http://copernicus.eu

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EUMETSAT Future Systems: Continuity and Innovation

Geostationary Systems: Meteosat Third Generation (MTG)

EUMETSAT is currently developing the Meteosat Third Generation programme together with ESA, who is responsible for the space-segment development. The six satellites of the MTG System will be based on three-axis stabilized platforms. The operational configuration of the MTG system will be a system of two imaging satellites (MTG-I), to form an in orbit backup system and allow rapid scan services, and one sounding satellite (MTG-S). The first imaging satellite is currently scheduled for launch early 2019 and the first sounding satellite roughly two years later. The Programme lifetime is 20 years. The imaging satellites will continue and improve the capabilities of the SEVIRI (Spinning Enhanced Visible and Infrared Imager) services of the current MSG (Meteosat Second generation) system. The MTG Flexible Combined Imager (FCI) has 16 channels with a sampling distance of 1-2 km and a repeat rate of 10 minutes for the full disk (FDHSI = Full Disk High spectral Resolution Imagery) in support of the full disk scanning service (FCI-FDSS). Fast imaging services over Europe to monitor severe weather and provide Nowcasting support can be delivered every 2.5 minutes in 4 channels with an improved resolution by a factor of two (HRFI = High Resolution Fast Imagery) in support of the rapid scan service (FCI-RSS). A new Lightning Imager (LI) will allow the continuous detection of lightning discharges at a sampling of about 10 km within the field of view in support of severe weather monitoring and warning as well as Nowcasting.

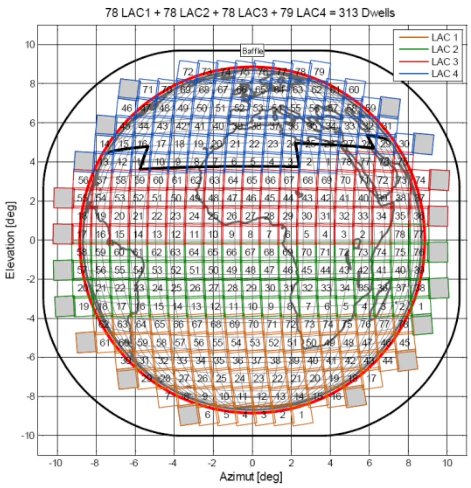

Figure 1. Meteosat Third Generation Infrared Sounder (IRS) coverage of 313 Dwells, grouped into four Local Area Coverage areas (LAC). The coverage over Europe (LAC-4) is provided every 30 minutes. The coverage of the whole disk takes one hour.

The sounding satellite will bring two new instruments in heritage from polar orbiting instruments into geostationary orbit and will allow the three dimensional mapping of water vapor, temperature and ozone every hour and also air quality monitoring and support to atmospheric chemistry. The Infrared Sounder (IRS) will implement Fourier Transform Spectrometry, i.e. hyper spectral sounding into geostationary orbit. It will provide IR hyper spectral images in two bands (long wave infrared (680-1210 cm^{-1}) and Mid wave infrared (1600-2250 cm^{-1})) for 313 elementary „Dwells" of 160 x 160 samples, at a sampling distance of around 4 km (i.e. 640 x 640 km^2), sampling time 10 s, for a theoretical complete disk coverage within one hour. The IRS field of view is distinguished into four Local Area Coverage areas (LAC), observed in 15 minutes; see Figure 1. It is envisaged that LAC-4, covering Europe, is observed every 30 minutes. The spectral resolution of IRS is 0.625 cm^{-1}. The IRS observations will be complemented by an Ultraviolet, Visible and Near-Infrared spectrometer (UVN), providing UVN spectra at a horizontal resolution of about 8 km. The spectral coverage is provided in three spectral bands (UV: 305 - 400 nm; VIS: 400 - 500 nm, NIR: 750 - 775 nm). This will allow air quality monitoring at city level over Europe every hour. This mission is implemented through the Copernicus Sentinel-4 instrument. The designed lifetime of the satellites will be 7.5 years.

Data Collection Service (DCS) and Search and Rescue (SAR) are embarked as well.

Polar Systems: EUMETSAT Polar System - Second Generation (EPS-SG)

The system to provide continuity and innovation to the EUMETSAT Polar System, the Second Generation of EPS (EPS-SG) is currently being prepared by EUMETSAT, jointly with the partners ESA (developing the Metop-SG satellites), NOAA, CNES and DLR. The currently assumed need date for the first satellite is end of 2020. The agreed missions will improve and extend the current EPS services. To implement them a two satellite system (Metop-SG-A and Metop-SG-B) is required. The new Metop-SG satellites are currently developed by ESA. Metop-SG-A will carry the imaging and sounding instruments and a radio-occultation mission. Instruments comprise an improved hyper spectral sounding instrument, the IASI Nouvelle Generation (IASI-NG, four bands in the 3.62 – 15.5 µm range), provided by CNES in the frame of a co-operation agreement, with the performance of half of the IASI instrument noise and doubled IASI spectral resolution. Furthermore an improved imager MetImage, provided by DLR, will introduce MODIS/VIIRS class imagery for cloud, aerosol, precipitation and surface analysis, and also in support to the sounding mission at a horizontal resolution of 250 – 500 m, with 20 channels in the visible and infrared spectral region. In addition a new microwave sounder will provide all weather sounding capabilities (MWS), in heritage of AMSU/MHS, in an extended spectral region between 23 and 229 GHz at 40 to 17 km spatial resolution. UV/VIS/NIR and SWIR Sounding (UVNS) capabilities at 7 km resolution will be implemented through the Copernicus Sentinel-5 mission. It will provide observations in heritage to the GOME-2 mission at a spectral resolution of 0.06 to 1 nm in the range of 0.27 – 2.4 µm. The Multi-viewing, Multi-Channel, Multi Polarization imager (3MI) allows to measure polarized radiances in the visible and infrared spectral domain. Metop-SG-B, the second satellite, will carry the continuity mission for scatterometry (SCA, 5.3 GHz, 25 km resolution and dual polarization) and two new missions, the ice cloud imager (ICI, 183 – 664 GHz at 15 km spatial resolution), as well as a microwave imager in heritage of SSMIS (MWI, 18.7 – 183 GHz at 10 – 50 km spatial sampling, from highest to lowest frequencies).

Table 1. Metop-SG payload: a) Metop-SG-A, b) Metop-SG-B.

a) Metop-SG Satellite-A Payload	**METimage**	***VIS-NIR-IR Imaging***
	IASI-NG	***Hyperspectral IR Sounding***
	MWS	***Microwave Sounding***
	3MI	***Polarimetric Imaging***
	Sentinel-5	***UVVIS Sounding***
	RO	***Radio-Occultation***

b) Metop-SG Satellite-B Payload	**SCA**	***Scatterometry***
	MWI	***Microwave Imaging***
	ICI	***Ice Cloud Imaging***
	ARGOS-4	***Data Collection***
	RO	***Radio-Occultation***

Global Data are provided in Ka band downlink, but also in direct broadcast via X-band.

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Title: Collaborative EO Application Development for Understanding and Managing Australia's Environment

Authors: Phinn, S.R, Held, A.A., Scarth, P., Gill, T., Paget, M., Nethery, N., Johansen, K. and Ross, J.

Australia's Terrestrial Ecosystem Research Network (www.tern.org.au), and its remote sensing facility AusCover (www.auscover.org.au) have developed and implemented a unique program that has enabled collaboration across multiple levels of state and national government and research institutions to deliver new, continentally consistent, validated time series of satellite EO based biophysical property maps. The mapping products are all based on a combination of field calibration-validation data and validated algorithms. The mapped products include vegetation structure estimates (cover, height, above-ground biomass, phenology), vegetation indices, burnt area and history, and meteorological parameters. All of the field data, algorithms and time-series are published through the TERN AusCover portal. The data are published with context appropriate and rich meta-data and licensing. The meta-data enables experienced EO data users and other ecosystem scientists to determine if the data are suitable for their purposes and how to process it. The licences are in a slightly modified form of the "Creative Commons By Attribution" license as required under the Australian Government's Data Licensing Legislation. This ensures users of the data are legally bound to cite the data source, so that data producers and their institutions receive formal and measureable recognition of their work output and its use. This enables measurement in the Data-Citation index as well as publishing indexes. This approach enables and promotes the transition of our government, research and academic EO activities to an open-data and open-science culture. All of these agencies in Australia, and the overseas agencies we build EO applications with, benefit from improved access to data, rich meta-data and algorithms, which reduces duplication and enables collaboration and cooperation.

Problem:

Development of continental scale biophysical map products, that are derived from EO data and are required on daily, weekly, monthly, seasonal or annual bases require significant and sustained investment in EO data collection, along with continental field data collection, and appropriately skilled personnel and processing, storage and distribution capabilities. In most of the world's continents this is a major challenge due to multiple nations making up continents, and in some cases such as Australia and North America, with multiple states making up continents. Developing and maintaining operational EO programs at these levels is a challenge in itself, let alone having scope for EO research to determine how to build new continental EO based biophysical map products, or to determine how to use new sensors and field data collection technologies and techniques. Australia's Terrestrial Ecosystem Research Network was constructed specifically to address this type of challenge across multiple ecosystem science areas, including EO. AusCover is TERN's EO facility which brings together universities, research institutions, state agencies and national agencies to build and validate continental scale biophysical map products as a research activity – the resultant data sets and programs are described at www.auscover.org.au (Figure 1). The key premise of this activity and other TERN facilities is that it explicitly recognised what has been done previously, and attempts to build on this to develop a continental approach and product, and to improve the process and product where possible so all those contributing will benefit.

Satellite Earth Observation Data Application:

The application addressed is public use: Supporting an informed and secure society

The lack of collaboration, sharing and cooperation across EO agencies was addressed directly by establishing a three year program, which identified essential biophysical data sets at state and national levels required for environmental monitoring and management, and embarking on a set of activities that would establish what image and field data had been collected across each agency, what algorithms were being used and their applicability and accuracy across jurisdictions. This was used to define how these could be hosted, documented and combined to build more accurate mapping algorithms at a continental scale that all users would benefit from. This was done for vegetation structural properties (cover, height, above round biomass, phenology), vegetation indices, burnt area and history, and meteorological parameters. The algorithm and product development and delivery were only possible due to the multi-jurisdictional “level playing field” approach provided by TERN AusCover, where the agencies could share their data collection infrastructure, staff, data and algorithms. In some cases, e.g. fractional cover and biomass, collaborative new projects, such as with the JAXA’s K&C program, were used to help drive research activities. As a result algorithms were built and validated across all major ecosystems, from sandy deserts, through shrubland, savannah, eucalypt woodlands and forests, to dense tropical and temperate rainforests. All of the field data, resultant algorithms and time-series are published through the TERN AusCover portal with context appropriate and rich meta-data and licensing.

Figure 1: AusCover facility structure

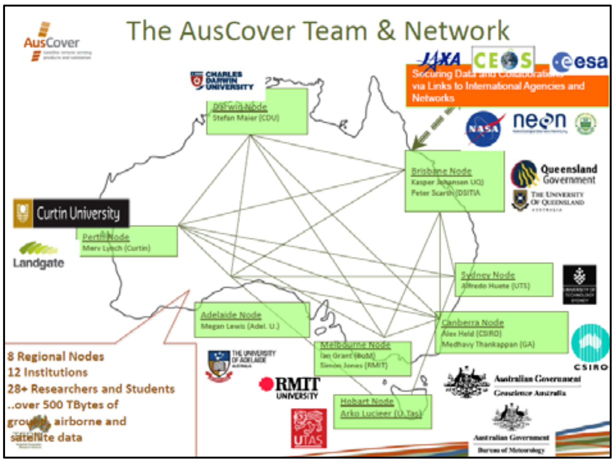
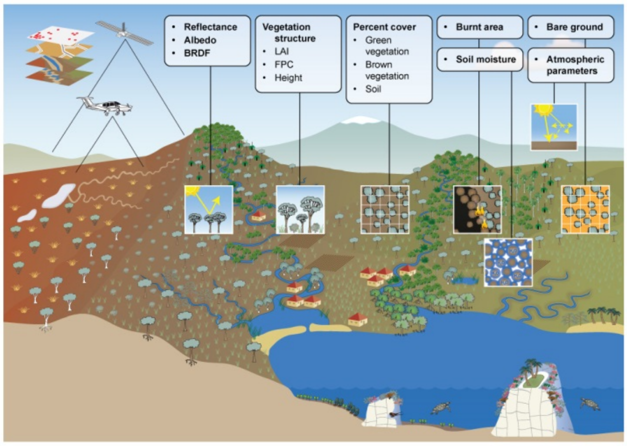


Figure 2: AusCover data products



Value Chain – see following page

The data products on the TERN AusCover portal are derived from a range of EO data sources. For satellite image data this includes the USGS Landsat archive, NASA’s MODIS, Hyperion and ICESAT archives, NOAA’s AVHRR archives, and JAXA’s ALOS 2 PALSAR archive. Airborne LiDAR and hyperspectral data are collected and provided by Airborne Research Australia (www.airborneresearch.com.au) and Hyvista Corporation (www.hyvista.com). Field based terrestrial laser scanner data were provided by collaborating state agencies and universities using Riegl instruments. The latter instrument program also enabled an international TLS inter-comparison to occur at several of the AusCover field sites – the data and summaries of this activity are at http://128.197.168.195/?page_id=466.
All of the AusCover products can be freely accessed from http://www.auscover.org.au/data/product-list.

More Information

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Value Chain- Monitoring changes in Australia's ecosystems to support government monitoring and management

Satellite

Landsat series
TERRA.AQUA
Hyperion
ICESAT
AVHRR
PALSAR

Data Provider

USGS
NASA
NOAA
JAXA

Service Provider

Various State Governments - Australia

End User

- All other state agencies
- National agencies
- Scientists
- Students
- International Agencies

Benefit

Improved EO product development and capacity for all of Australia's EO agencies

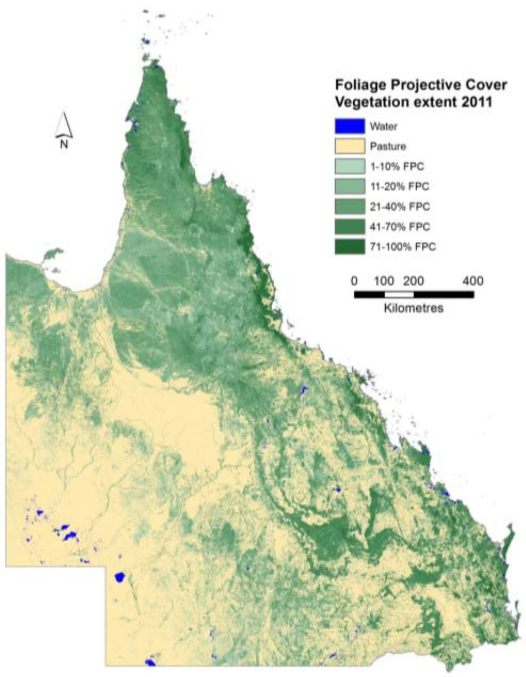
Title: Monitoring changes in Australia's ecosystems to support government monitoring and management

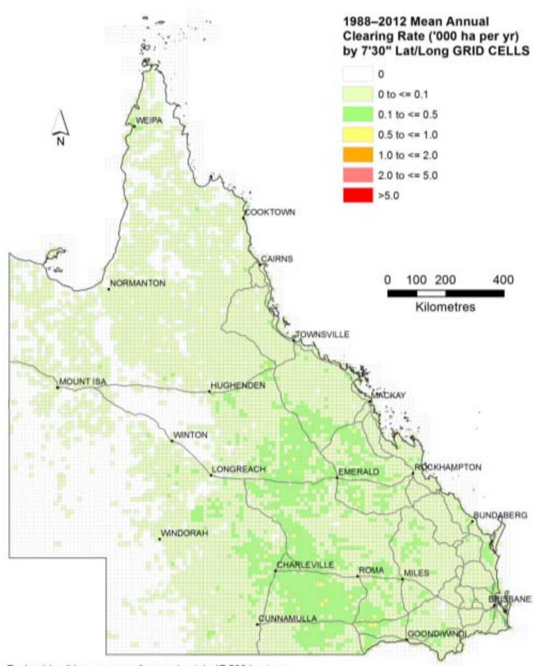
Authors: Phinn, S.R, Scarth, P., Witte, CV., Tindall, D., Danaher, T., Hicks, R., Gill, T., Mellor, A. and Johansen, K.

The legislated monitoring and on-ground management of Australia's environmental resources, atmosphere, vegetation, soils, water bodies and benthos, are conducted by state government agencies. State agencies are Australia's largest and longest term users of satellite EO data, as well as our largest employers of EO specialists. This paper outlines a specific range of legislated activities in Australia that are fully supported by EO data, for baseline mapping, monitoring and modelling. Mapping the percentage of a pixel covered by vegetation and its change on an annual basis is a common legislated requirement across Australia's states. The Landsat image archive and extensive field data are used with an established and secure processing system to deliver annually updated maps of vegetation cover and their change at state and national levels. The project driving these applications has been established for over 20 years (see www.qld.gov.au/environment/land/vegetation/mapping/slats). A slightly different approach has been taken to continental scale vegetation cover mapping, with national research infrastructure used to link state collections of field surveys of vegetation cover, to development of a common method for processing and delivery at national scales.

Problem:
Woody vegetation cover mapping is a basis for vegetation mapping and monitoring across several states and nationally. The mapping of woody vegetation cover is linked to several state vegetation management acts and is required on an annual basis (Figure 1). Accurate mapping must work from semi-arid grassland, across savannah woodland, temperate woodlands, to coastal forest and rainforest and cannot be done from field or aerial photography. Landsat Thematic Mapper and field based approaches were developed in 1990s in association with vegetation dependent industries in one state (Queensland), which also paralleled development of national land use maps. As the method and access to Landsat data improved, mapping went from once every five years to annual in 2000, and then moved to use the full Landsat TM/ETM+ archive when it was made available by USGS. The method was initiated in Queensland, and has since been adopted/modified in New South Wales , Northern Territory and Tasmania, and most recently to a more advanced nationally applicable product – persistent green vegetation fraction and fractional cover (Figure 2). These products are used across state governments for a range of applications, including compliance assessment for vegetation clearing permits, recognised as global best practice (Evidence from Earth Observation Satellites. Emerging Legal Issues, December 2012, Brill / Martinus Nijhoff , ISBN 978-9004194434, 498p (Ray Purdy, editor With Denise Leung)).

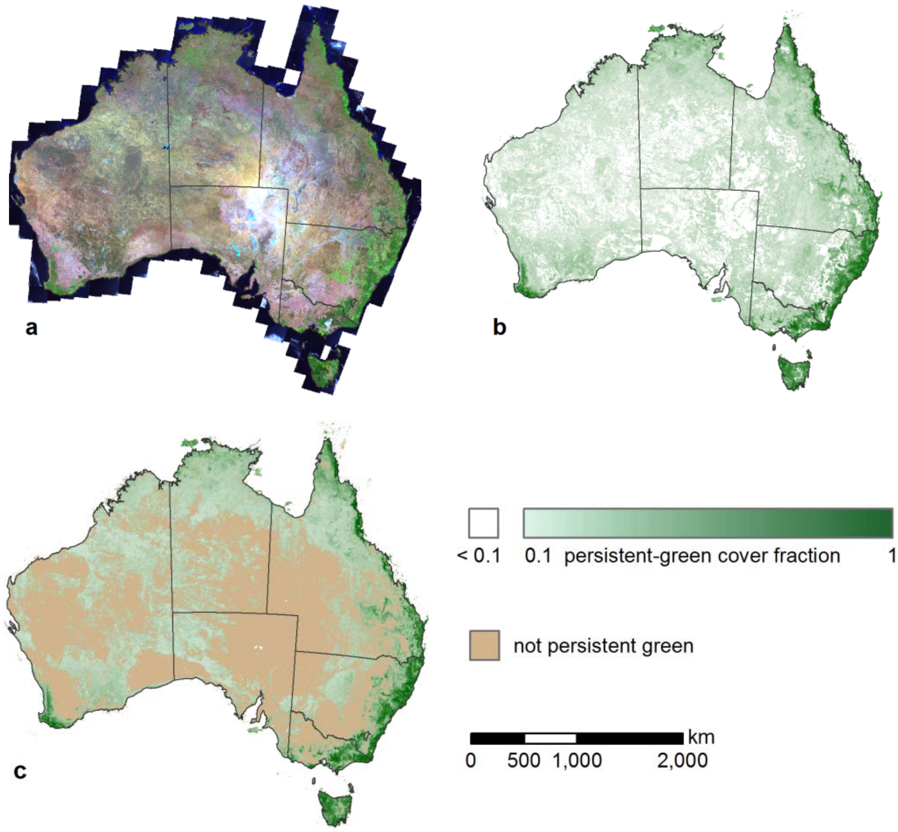
Figure 1: The Statewide Land Cover and Trees Study, woody foliage projective cover mapping results (https://publications.qld.gov.au/storage/f/2014-09-11T02%3A11%3A13.856Z/slats-report-2011-12.pdf)





Each grid cell has an area of approximately 17,500 hectares.

Figure 2: National persistent green vegetation fraction product, base Landsat scenes and product.
(www.auscover.org.au/xwiki/bin/view/Product+pages/Persistent+Green-Vegetation+Fraction)



Satellite Earth Observation Data Application:
The application addressed is public use: Supporting an informed and secure society
The problems identified here, in mapping vegetation, were addressed by combining extensive field survey programs, with extensively tested satellite image geometric and radiometric correction programs and well supported and maintained project teams to develop programs that accurately map vegetation structural properties. The approaches used are fully documented and published in peer reviewed literature, and the code, approaches and data are available through publicly accessible portals.
The foliage projective cover data sets are available from:
www.qld.gov.au/environment/land/vegetation/mapping/slats/ and
qldspatial.information.qld.gov.au/catalogue/custom/index.page
The national vegetation fractional cover and persistent green vegetation fraction data, supporting documentation and field calibration data are available from: www.auscover.org.au/data/product-list

Value Chain – see following page
The woody fractional cover and other fractional cover products are produced using the USGS Landsat Thematic Mapper, Enhanced Thematic Mapper and Advanced Land Imager archives and SPOT 4 and 5 data. Field data are collected by Queensland, New South Wales, Victorian, Tasmanian and Northern Territory Governments. Data are used by all state agencies, general public, land-holders, research agencies and private companies.

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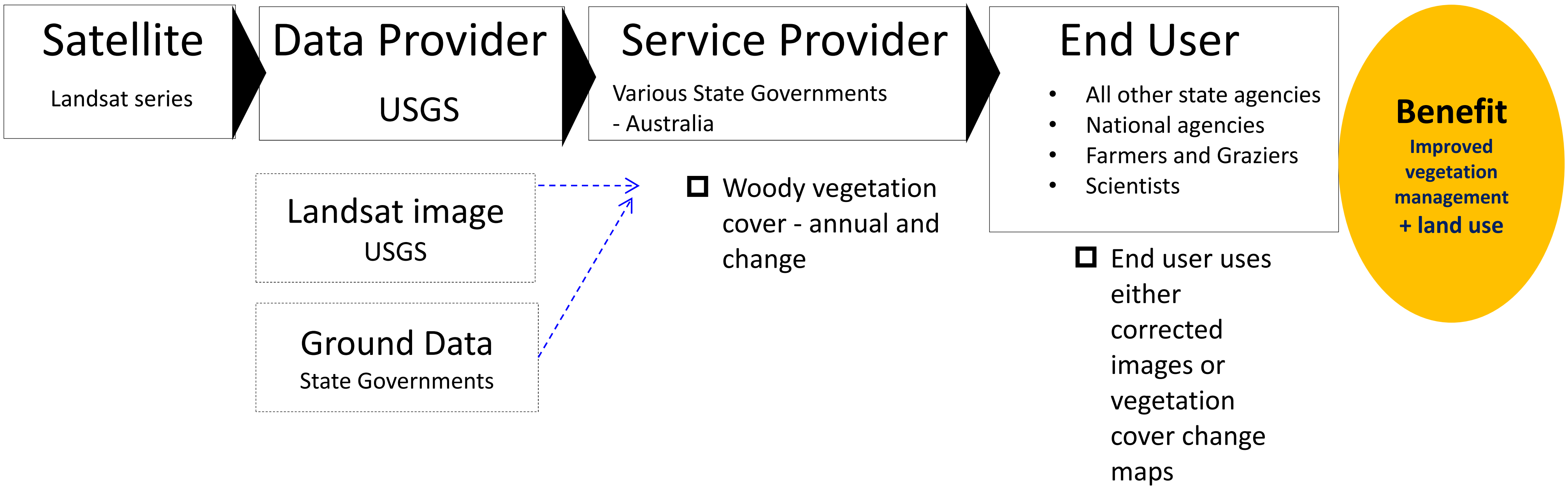
Value Chain- Monitoring changes in Australia's ecosystems to support government monitoring and management



#202

Earth Observation for Mine Waste Characterization from Multispectral and Hyperspectral Spaceborne Sensors.

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Earth Observation for mine waste characterization may prove as an important documentation and monitoring tool in the near future for countries with a long mining history such as South Africa. In this rapidly developing country a proof of concept study was carried out to demonstrate the use of data products from multispectral and hyperspectral spaceborne sensors for mapping and monitoring rapidly changing mining landscapes. Here a cost effective monitoring system would have to rely on spaceborne data because of the need for rapid, repetitive and area-wide monitoring. Anticipated end-users of such an application would be state entities (e.g. Department of Mines and Mineral Affairs, Department of Water Affairs, Geological Surveys) and private companies such as big mining houses as well as their operating subsidiaries.

Motivation

South Africa is a country with a long mining history due to the historic discoveries of gold and platinum. Figure 1 shows a part of the spatial extent of these areas where the mining for platinum group elements (PGE) and gold is carried out. Gold is mined in the central part from the Witwatersrand “conglomerate reefs”, which are coarse-grained clastic sediments. Platinum mining is concentrated along the Bushveld Complex, with its prominent Rustenburg Section shown in the northern part of figure 1. Many large tailings dams and mineral processing sites, which contain the residue from mineral processing (gold and platinum extraction) are located next to densely populated urban areas, such as the Gauteng metropolitan area around Johannesburg and around Rustenburg and its associated towns in the North West Province. Here problems may arise from the dissemination of tailings material into the environment e.g. by dust plumes. The generation of acid mine drainage and the potential of metal dissolution (Cr, Ni, As, Pb, U) is another important factor in an area where fresh water resources for an ever growing population are becoming scarce [1]. Continuous, area-wide monitoring of active and abandoned tailings and mineral processing sites by standard methods, such as field surveying or by airborne data takes, is not cost effective for such a large area.

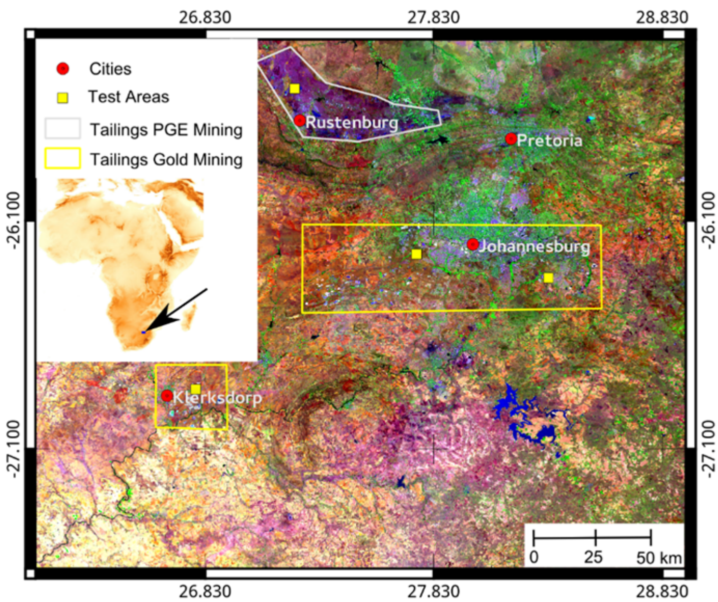

Fig. 1: Landsat 8 composite (R: 2200 nm, G: 860 nm, B: 550 nm) of areas affected by gold and platinum mining and associated tailings sites around the greater Johannesburg and Gauteng area, after Mielke et al., 2014. ETOPO-1 inset map (data courtesy NOAA) for reference. Please note that only the future Sentinel-2 will have a swath large enough to cover the whole area in one data acquisition. Whilst the here presented composite is a mosaic of four Landsat-8 scenes.

Spaceborne Monitoring of Mine Waste Sites in South Africa

Only data from multispectral mapping missions can cover the area shown in figure 1 in a rapid, repetitive, effective and continuous way. Landsat-8 OLI [2] is a sensor from such a mission capable of mapping mine waste through the broad iron absorption feature around 900 nm of primary and secondary iron bearing minerals, which are characteristic for mine waste from gold and platinum mining. A robust, area-wide characterization and mapping of mine waste material is only possible via the synergetic use of multispectral data from large-scale mapper missions such as Landsat-8 OLI in combination with a hyperspectral spaceborne sensor such as EO-1 Hyperion [3], which offers the potential of material identification via expert systems such as the USGS Tetracorder [4] and the material identification and characterization algorithm (MICA) [5]. This synergetic use is demonstrated in figure 2 at the Impala platinum mines to the north of Rustenburg where the spatial distribution of tailings and mining related material can be seen in the iron feature depth image (right image in figure 2), which matches the spatial distribution of iron bearing pyroxene (left image in figure 2). This absorption feature based relationship could now be exploited to map mine waste material in the larger Rustenburg area [6]. Next generation multispectral and hyperspectral sensors have the potential to improve the results shown in figure 2, due to an enhanced spectral and multi-temporal resolution. Such a perfect sensor pairing would be EnMAP [7] and Sentinel-2 [8], which have already shown their potential for the detection of secondary iron bearing minerals from simulated data [9].

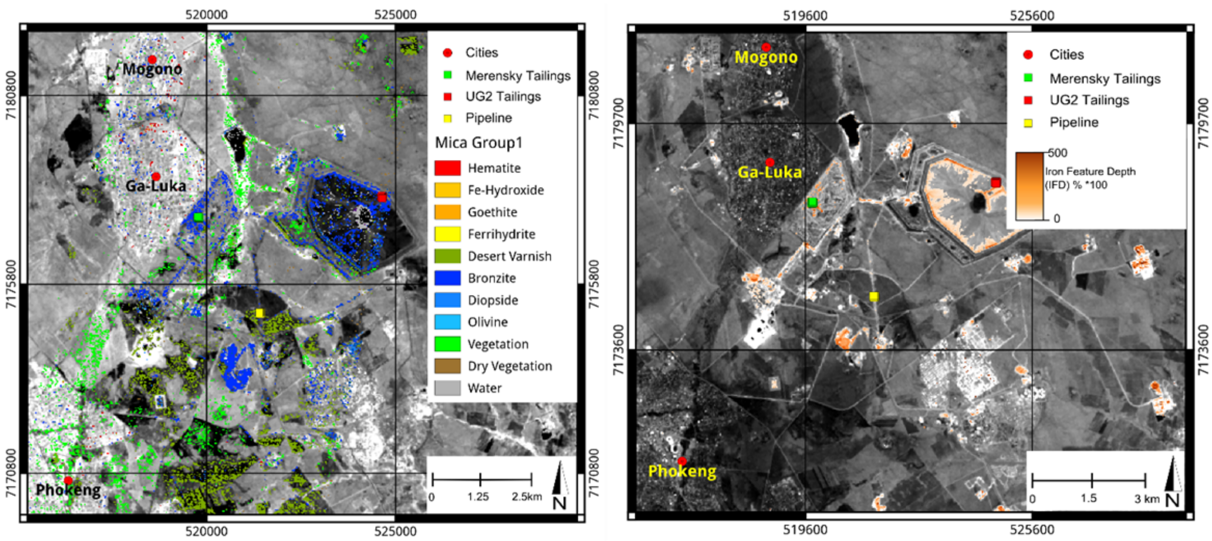

Fig. 2: Mineral Analysis from hyperspectral EO-1 Hyperion data (left) using the USGS Material Identification and Characterization Algorithm (MICA) overlain over the near infrared channel of Landsat-8 OLI, from Kokaly 2012 and Iron Feature Depth (IFD) calculated from multispectral Landsat-8 data, after Mielke et al. 2014. With the help of the IFD the mine waste material distribution can be mapped with the large swath of Landsat-8 OLI (right), whilst the narrow swath of EO-1 Hyperion provides the spectral accuracy to calibrate and validate the IFD result from the multispectral OLI sensor.

The here demonstrated technological potential of current and future multispectral (e.g. Sentinel-2) and hyperspectral (e.g. HISUI, EnMAP and HyspIRI) spaceborne instruments could be integrated into an automated mine waste monitoring system for areas, which are affected by large tailings facilities, as shown in figure 1. This is demonstrated in figure 3, which proposes a value chain of such a system. The backbone of such an integrated system would be the level-1 and level-2 data, which are provided by the entities, which are operating the spaceborne sensors, for example by ESA for the Sentinel fleet, by DLR for EnMAP, by JAXA for HISUI and by NASA for EO-1, Landsat-8 and HyspIRI. This data now serves as input for the mine waste monitoring system, which could be designed and operated through a research and development partnership between public research, institutes private companies and state entities (e.g. geological surveys). The here generated level-3 and 4 datasets (e.g. actual maps of the spatial distribution of mine waste material, the change in its spatial distribution over time and derived pollution hazard maps) could then be used by end users such as public legislative and governing bodies and institutions to prevent and mitigate hazards that may arise from a dissemination of mine waste into adjacent areas. The use of an open data principle, which is already implemented for Landsat-8 and for EO-1 by NASA and which is anticipated for ESAs Sentinel-2 and for the German EnMAP mission, will further facilitate the use of multispectral and hyperspectral spaceborne data especially in developing countries such as South Africa. This enables the establishment of a valid and up-to date inventory of active and abandoned mine waste and mining sites in a cost-effective way, ensuring a better protection of local communities in the area by constant, area-wide monitoring.

Fig. 3: Proposed model for a potential mine waste monitoring value chain that exploits the complementary strengths of multispectral and hyperspectral spaceborne data in a synergetic way. Hyperspectral data can offer a precise material identification (e.g. through a mineral map), whilst multispectral data can deliver an area wide overview on the spatial distribution of mine waste with a high temporal frequency. This synergetic use is based on the physics based absorption feature of iron that can also be resolved by modern multispectral sensors such as Landsat-8 OLI and Sentinel-2.

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#203

Satellite based maritime surveillance to increase safety, security and efficiency of ship traffic

Authors

Susanne Lehner, Egbert Schwarz, Michael Nyenhuis – German Aerospace Center (DLR)

With 90% of all goods being transported on sea routes an efficient, internationally competitive maritime industry is of high overall economic significance. The global exchange of goods is rising steadily causing an increase of ship traffic. New fuel efficient and safe routes are being discussed. In addition, tourism plays an increasingly important economic role at sea. To increase safety, security and efficiency of shipping and to protect the oceans, global data that provide reliable information about storms and sea state, sea ice cover, environmental pollution and ship locations are of paramount importance. This article demonstrates the use of the two German high resolution X-band radar satellites TerraSAR-X and TanDEM-X to develop maritime surveillance products, including ship detection and traffic monitoring or wind and sea-state information. The products are generated independently of weather conditions and in near-real-time and are delivered to operational users.

Problem

The monitoring of ship traffic is currently executed on the basis of data collected from radio communication systems like terrestrial AIS or LRIT and onboard ship or coastal radar. As these systems were originally established to support collision avoidance, their application to generate global maritime domain awareness is limited: Coastal radar and communication systems only provide local shipping information usually at a radius of about 30nm. Using satellites with radar or AIS sensors may overcome this limitation of range. The quality of AIS data from the communication systems can be affected though by human interference like counterfeiting and negligence as it is a cooperative system. There are further systematic technical limitations like message collisions, which happen for the wide acquisition areas of satellite AIS and thus the need of confirmation by Earth observation data.

Additionally high resolution measurements of wind and sea state fields are essential for maritime domain awareness are and frequently requested by shipping and offshore construction and maintenance. The usage of buoy data is restricted to local coverage and weather forecast systems can be improved by better quality of wind field input including frontal development and resolution of underwater topography. Using SAR data is a promising approach to integrate model and in situ data and their use provides the ability to monitor spacious ocean areas in all weather and sunlight illumination conditions.

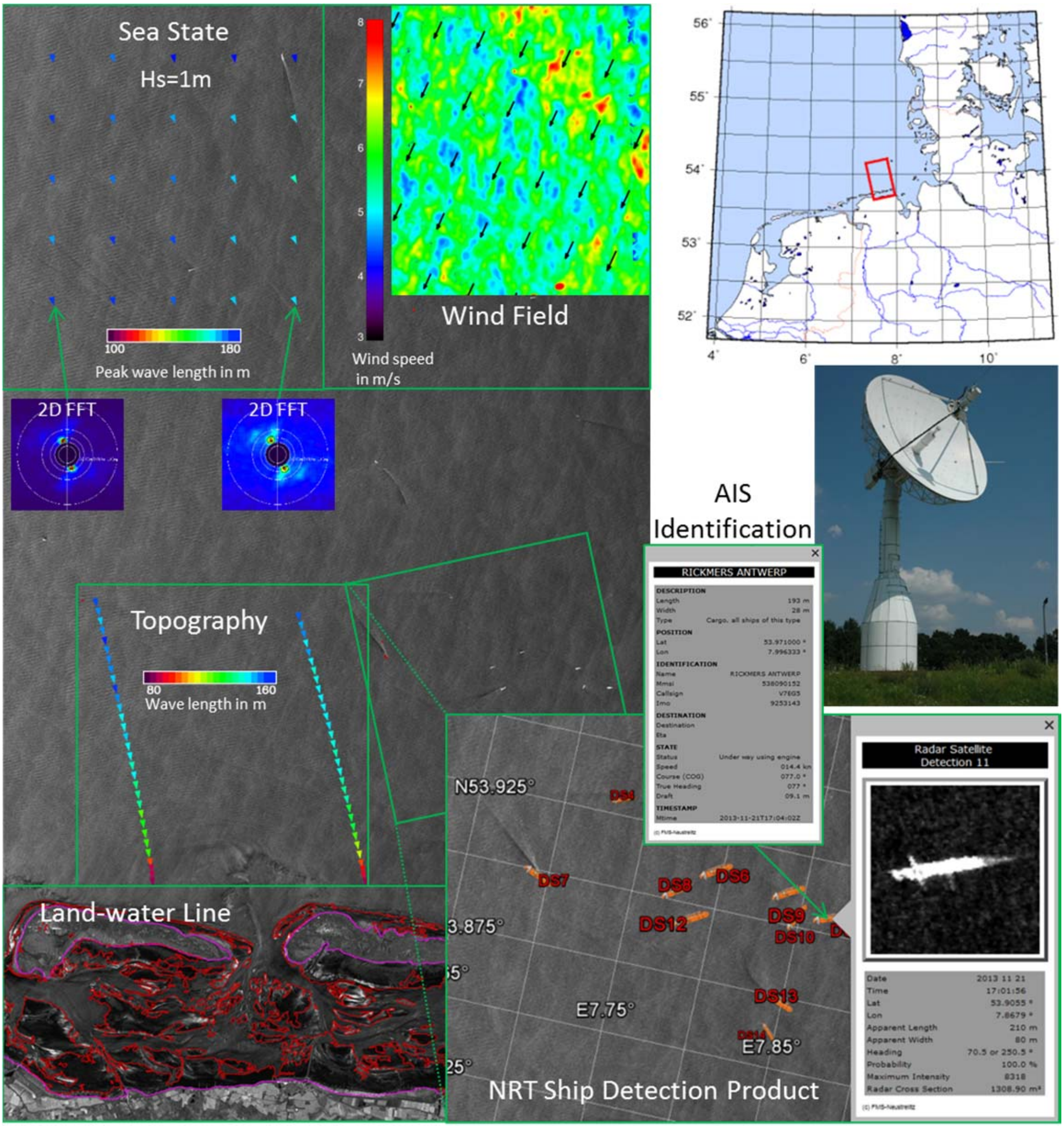

Figure 1: TerraSAR-X Stripmap scene with results provided by maritime NRT-value-adding-processors. Shown are wind field, sea state map (here swell from a different direction to wind), topography retrieval, ship detection results and land-waterlines (date: November 21, 2013) at the German North Sea Coast, © DLR 2013, Visualization of ship detection in Google Earth.

Maritime TerraSAR-X Applications

We investigated how maritime domain awareness can be achieved using high resolution X-Band radar data from the TerraSAR-X mission in NRT. The use of large-scale and high-resolution Earth observation data provides the ability to localize, identify and track ships in coastal areas or the open sea. The derivation of wind and sea state parameters supports the planning and maintenance of offshore construction. Radar images and the value-adding products can be delivered to ship bridges and coordination centers within near real time, supporting Search and Rescue missions, Weather Services and pursuit of piracy, smuggling, illegal fishing and environmental crime.

Value-Adding Chain

DLR developed a near-real-time processing chain for TerraSAR ship detection, wind field and sea state derivation, oil spill and iceberg detection within the TerraSAR-X Payload Ground segment. The acquisition circle of the ground station in Neustrelitz using an elevation of five degrees allows a coverage, e.g., towards the South, up to the Mediterranean Sea. Delivery of TerraSAR-X images and value-adding products can be accomplished within 15 minutes. The ship detection products are automatically overlaid by AIS information in order to provide vessel identification and anomaly detection possibilities. Operator interaction is only required for quality assurance.

The wind field and sea state products are delivered to weather centers and used up to now for validation purposes of high resolution coastal models. Assimilation and thus model improvement is a further issue.

While a fast delivery is already possible in the framework of campaigns the goal is to achieve a 24/7 service connecting to the technical environment of the individual user at affordable data cost.

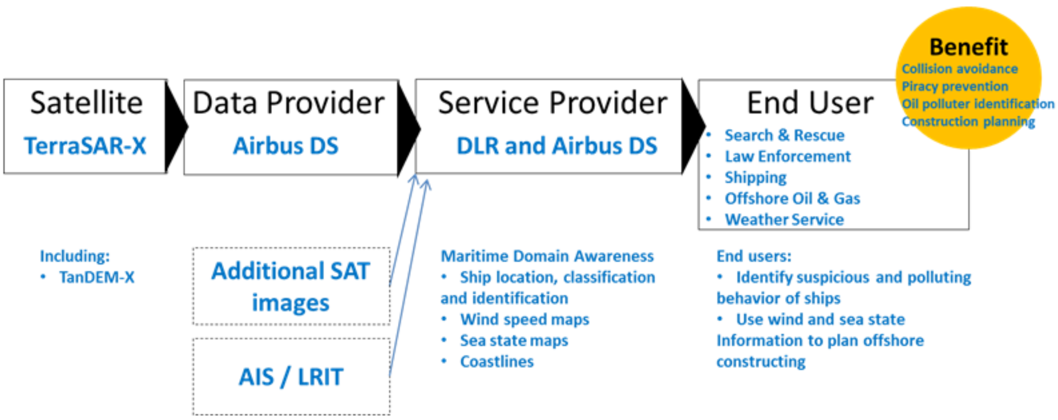

Figure 2: Value-adding chain

More Information

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Use of Earth Observations satellites for maritime downstream applications

CLS (Collecte Localisation Satellite), France

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Tel: +33 (0)5 61 39 37 45

Since a few years now, ocean-observing satellites entered an operational era and naturally occupy a major place in the development of products and services designed to manage and predict ocean and climate change for the benefit of maritime applications.

Earth-Observation (EO) satellite requires a long experience in the processing, validation, distribution and exploitation of satellite data. Derived from these Earth Observations, remote sensing products are now setup and distributed in real time:

- Sea level heights and ocean currents are derived from altimetric satellites (such as Jason-2, HY-2, Saral/AltiKa and the future generation of Sentinel European satellites).
- Sea surface temperature is derived from optical satellites (such as AVHRR sensors on NOAA satellites, AMSR-E on Aqua, TMI on TRMM...).
- Ocean colour is also derived from optical satellites (such as MODIS sensor on Aqua, VIIRS sensor on Suomi...).
- Sea surface salinity is derived from specific satellites (such as SMOS...)
- Sea state, detection of oil spills, detection of iceberg, and detection of vessels at sea are derived from synthetic aperture radars (such as RadarSat-2, TerraSar-X, CosmoSkyMed, Sentinel-1...).

The development of operational oceanography systems benefits from EO data. These systems integrate composites of remote sensing data with in-situ data and ocean models to provide a real time description and prediction of the ocean state. By broadening the use of EO data to the validation and the calibration of operational oceanography systems, real-time products and services for operational oceanography applications are available for various downstream users.

In this technological context, the use of satellite Earth-Observation (EO) data, provided by up-to-date remote sensing techniques, has been shown to be extremely valuable for different industrial applications at sea. Today, the combination of different remote sensing techniques and operational oceanography systems affords integrated products for downstream maritime applications such as the management of pelagic fisheries and the safety of offshore oil and gas operation at sea.

The distribution of marine resources (fish stocks) in deep ocean is mainly driven by the intrinsic characteristics of oceanic waters. Indeed the presence of fishes is the consequence of the ocean currents, the temperature, the salinity, the phytoplankton content of the oceanic waters. These characteristics are depicted by EO maps on surface and operational oceanographic systems in depth. Making the correlation between ocean characteristics and pelagic fish resources provides relevant information on the presence of fishes. This information is crucial for the protection of marine resources especially in deep ocean where information is sparse. EO satellite and numerical modelling provide operational tools for the integrated management of marine resources in deep ocean.

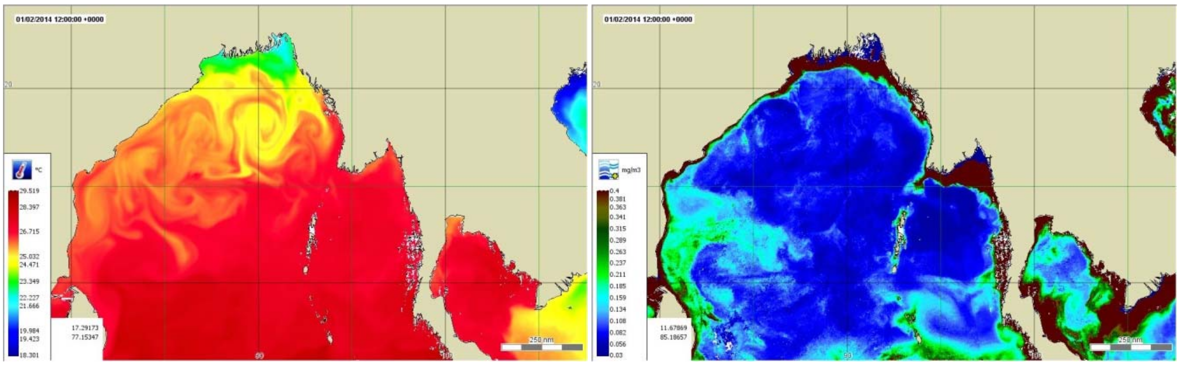

Figure 1: Map of Sea Surface Temperature (left, colours from blue, low temperature, to red, warm temperature) and map of Phytoplankton content (left, colours from blue, low concentration to brown, high concentration). Maps are derived from Earth-Observation data. Information is provided to fish stock managers for fishery regulation.

Recently, the exploration and exploitation of oil and gas industry has moved from coastal to offshore areas where the ocean conditions are extreme: currents are stronger, bathymetry is deeper (more than 1000 meters) and wave and wind environment is rougher. In these conditions, how to design the most robust equipment and ensure the safety of day-to-day operations? The role of EO satellite data became increasingly important for offshore applications especially far away from the coasts. By combining EO data, in situ data, and ocean modelling capabilities, crucial real-time ocean information and environmental studies are provided to the oil and gas industry. They are key-elements to optimize the design of equipment at sea, to support decision makers who are responsible for safety at sea during daily and critical operations and to help the offshore oil and gas community to protect the environment.

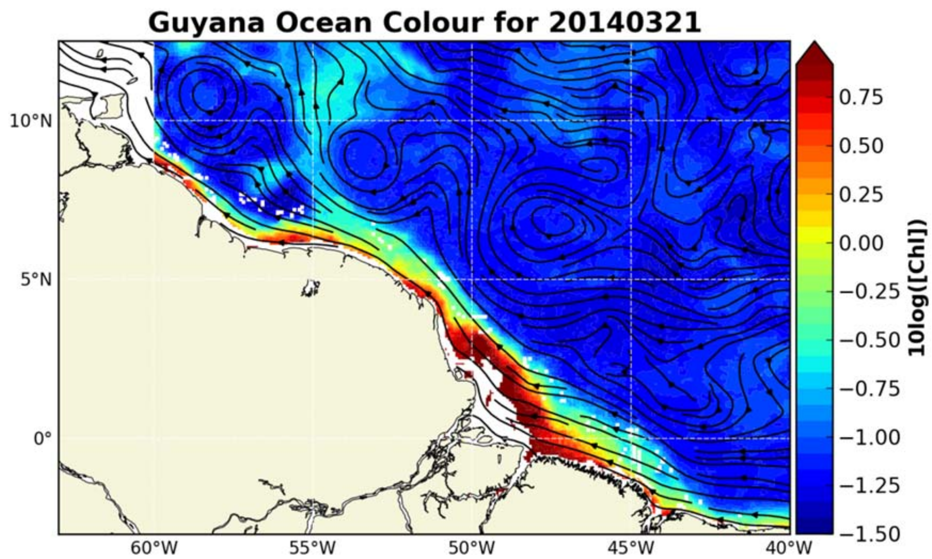

Figure 2: Map of Phytoplankton content (colours from blue to red) and Surface Ocean Currents (curved arrows). Maps are derived from Earth-Observation data and numerical modelling. Information is provided to oil rig safety managers for safety operations at sea.

#206

Radar Satellite based sea ice and iceberg monitoring

Authors

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As a consequence of climate change the sea ice conditions in the Arctic during the summer months become increasingly attractive for commercial shipping. Timely variable ice conditions require continuous and frequent monitoring to ensure safe, ecofriendly and economic routing of vessels. This article describes the use of X-Band synthetic aperture radar (SAR) earth observation data for the derivation of tactical iceberg information. High resolution SAR data can substantially enhance the situational awareness of the local sea-ice conditions and thus is expected contribute to marine safety as well as to the optimized planning of commercial operations in Arctic waters.

Problem

In polar regions pack-ice and iceberg drift show a dynamic nature, with wide deviations in its extent depending on changing oceanographic and meteorological phenomena. Shipping routes in the Arctic north remain therefore affected through ice and icebergs. Increased exploration activities in Arctic waters also increases the demand for maritime domain awareness as offshore operations are conducted within the vast and remote areas towards the poles. Operations involve offshore surveying as well as constructing and maintenance of installation far from terrestrial infrastructure. There is a need for integrated situational awareness services combining large scale ice condition maps with detailed tactical information. Radar remote sensing has the potential to provide the source data for such an integrated service.

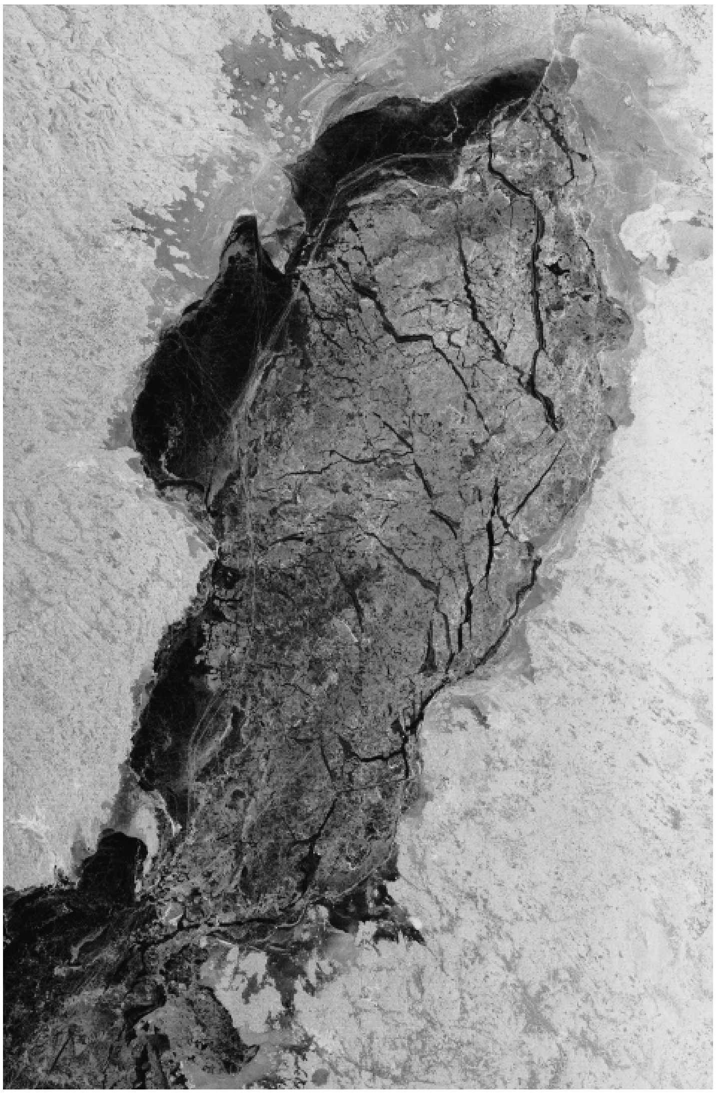

Figure 1: TerraSAR-X Wide ScanSAR scene with heavy sea-ice conditions at Bay of Bothnia (date: March 17, 2013), © DLR e.V. 2013, Distribution Airbus DS

Satellite Earth Observation Data Application

Airbus Defence and Space (Airbus DS) and the German Aerospace Center (DLR) investigated to support tactical ship routing with high resolution X-Band radar data from the TerraSAR-X mission. As a baseline, wide area SAR modes from C-Band missions are used to gather information for strategic ice information. In order to complement the situational awareness, the entities mentioned above were jointly developing and investigating tactical information content from TerraSAR-X imagery. A high level of scene details and provision in a timely manner is a key element for tactical maritime information. The synergistic use of large-scale and high-resolution Earth Observation sensors improves the situational awareness without limiting the observation capacities of a single system.

DLR has developed automatic near-real-time vessel and iceberg detection algorithms for TerraSAR-X imagery. This processing capacity has been evaluated and further complemented by an operator component by Airbus DS. Figure 2 shows an example of an integrated vessel/iceberg detection product.

Earth observation based information layers increase the awareness of the present sea-ice situation beyond the visibility of on-board systems and therefore supports Search & Rescue operations and the avoidance of collisions for vessel operations in maritime areas prone to ice hazards.

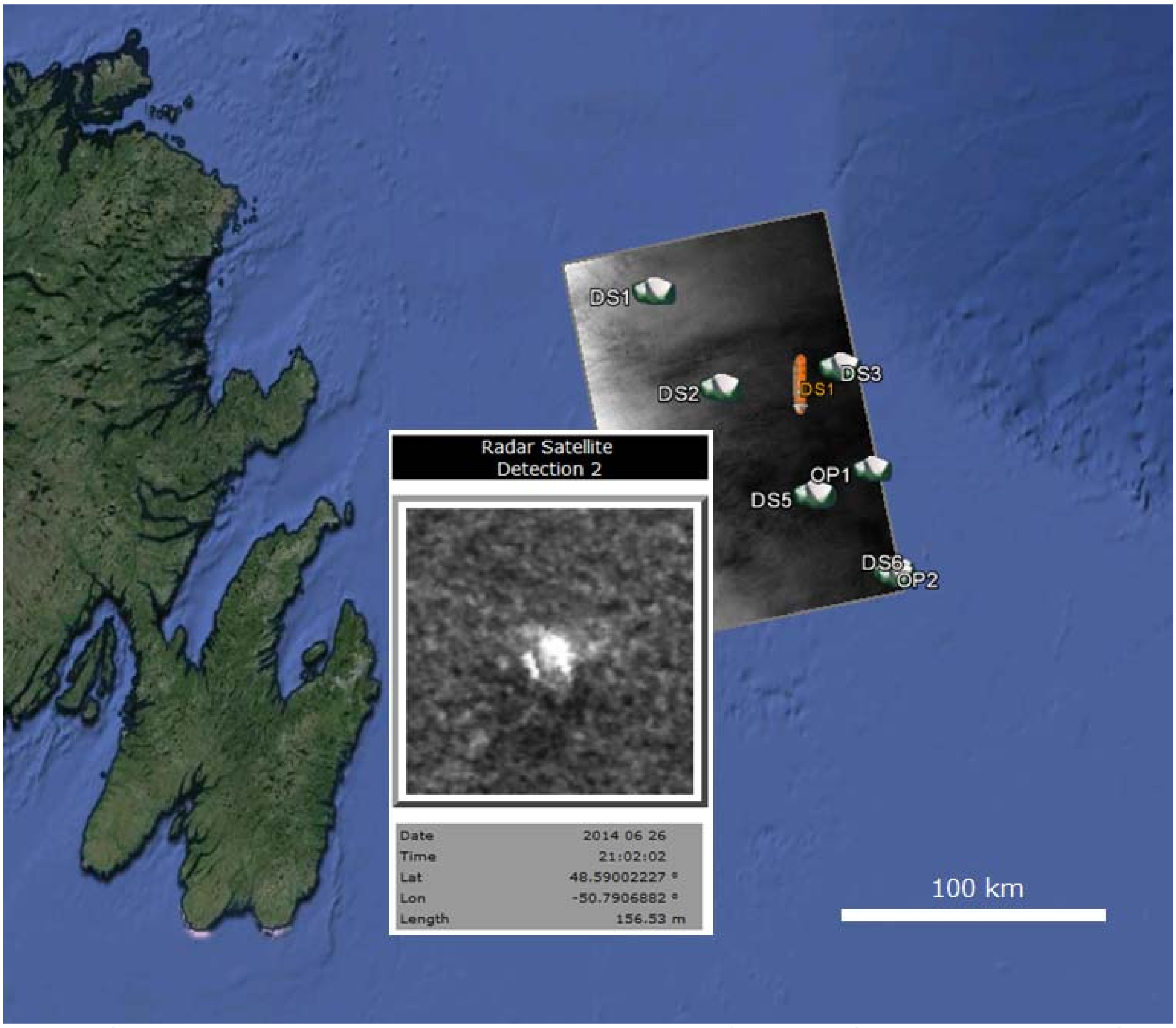

Figure 2: Semi-automatic iceberg/vessel detection report (near Neufoundland, Canada), based on TerraSAR-X (date June 26, 2015), © DLR e.V. 2014, Distribution Airbus DS. Visualization in Google Earth.

Value Chain

X-Band data from the TerraSAR-X mission is well suited for tactical ship routing due to the sensor's high resolution modes its largely independency of cloud cover and sunlight. The Spanish PAZ satellite (owner and operator: Hisdesat) will be launched in 2015 into the same orbit as TerraSAR-X and TanDEM-X. A near-real-time processing chain has been developed for the detection of vessels and icebergs within a scene. DLR is presently preparing a near-real-time production of an ice classification map. In areas where a satellite data reception facility is available, imagery and automated detection products are available within 30 minutes after the acquisition.

A subsequent operator based quality assurance (QA) step ensures reliable detection product and allows for the discrimination between icebergs and vessels by correlation with AIS (Automatic Identification System) information in combination with a visual analysis.

The resulting tactical iceberg / vessel detection product is finally either fused into a more general situation report or alternatively directly used by the end-user.

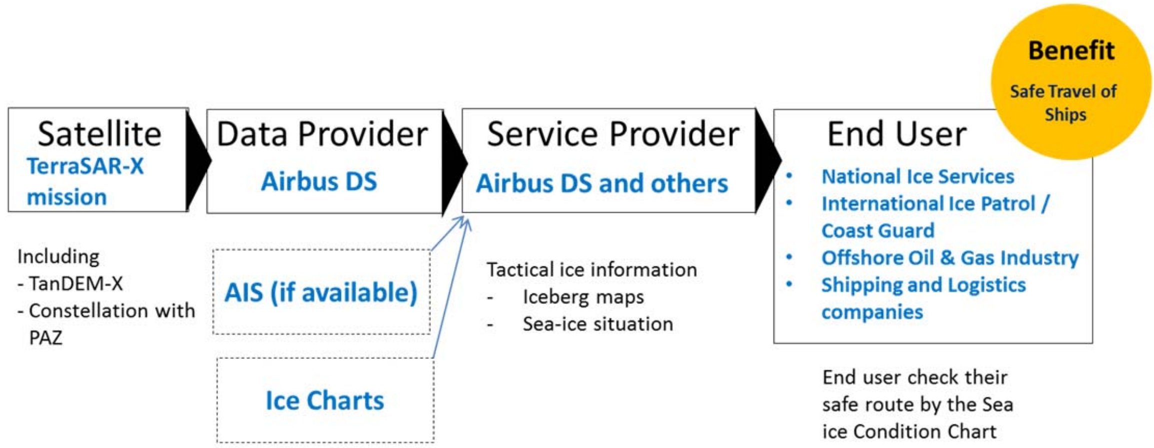

Figure 3: Value Chain for tactical sea-ice information

More Information

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AIRBUS DEFENCE & SPACE

#207

SPOT monitors the evolution of the Serbian territory

IGIS project is a cooperation between the Serbian Republic Geodetic Authority (RGA) and the French consortium IGN FI - Airbus DS. It is aimed at setting up a National Spatial Data Infrastructure and a Remote Sensing Centre for the Republic of Serbia. SPOT satellites have been triggered to demonstrate their capacity to face this challenge, and provide an in-depth agricultural land cover over the entire country.

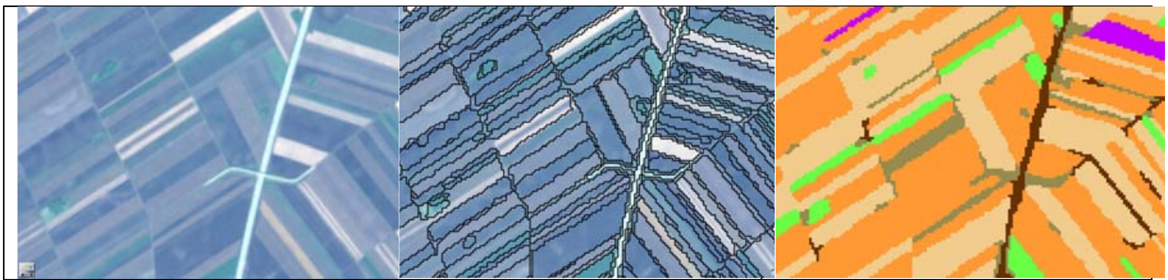
Problem

Creating a map of land coverage on a national scale without prior information and ground measurements is a big challenge as it implies access of multitemporal data series to discriminate vegetation types.
To do so, 4 to 6 SPOT complete multispectral coverages are required within a year, each coverage to be collected at relevant periods of the cultural cycles in order to discriminate the various types of crops.

Satellite Earth Observation Data Application

The SPOT 6/7 systems tasking capacity and the efficient management of cloud coverage, thanks to the 6 tasking plans per day, were essential for agriculture monitoring as timeframe for acquisitions are usually very short.

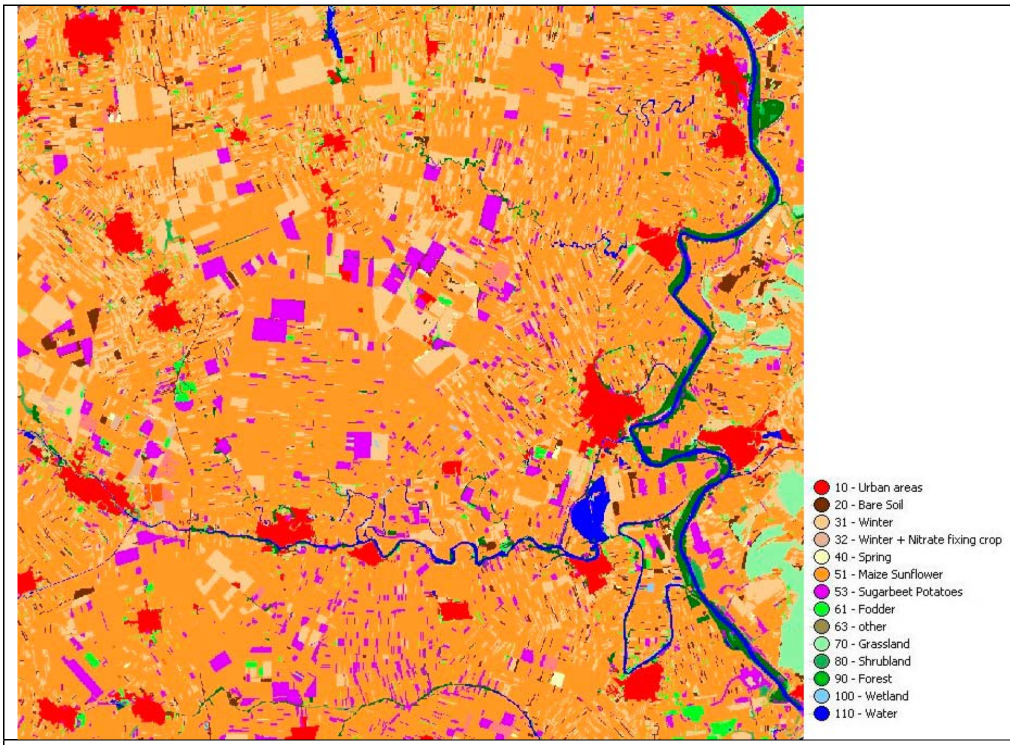
After images collections, a 2-step post-processing is defined as illustrated in the the figure below.



SPOT 6 Image	Segmentation	Classification

The classification stage provides discrimination of crops variety. It can only be achieved by monitoring plants growth profiles and cycles. We used the Overland™

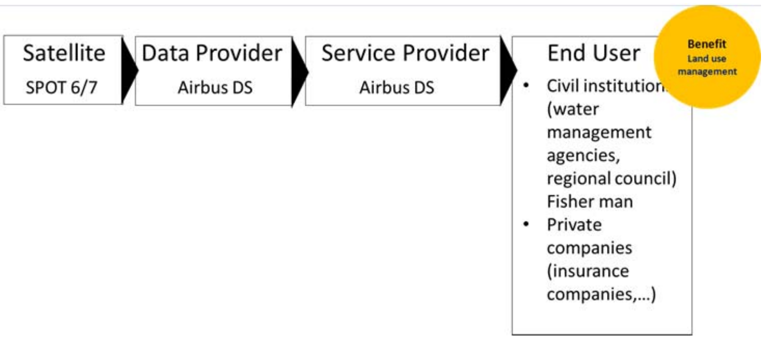
processing suite to generate biophysical parameters layers, such as green or brown cover fractions, and canopy shadow factor.
These layers are used as input data for the classification tool, which is based on a decision-tree approach.
The SPOT 6/7 spectral resolution (1.5m Pan-sharpened and 6m Multispectral) and 12-bit image coding are assets to reach a high-level accuracy in a very fragmented agricultural landscape, such as in Serbia, and increase the quality of the segmentation stage.



Example of large scale 14-class land cover map generated

A 14-class land cover map has been generated over the whole territory of Serbia.

Value Chain



The key benefits of the SPOT solution in the frame of the land cover project are:

- High resolution allows access to intra-field information even for small parcels (<0.05ha)
- The reactive tasking is key for acquisitions at the right period of the cultural cycle
- The blue band of SPOT 6/7 improved discrimination of the crops
- The biophysical parameters extracted from the SPOT 6/7 images allow accurate characterization of the cultural conditions independently from the acquisitions conditions.

More Information

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#210

Using SPOT and Pléiades Data To Plan a Pipeline Settlement

ILF Consulting Engineers provides consulting services to help customers to execute complex infrastructure projects. In the frame of the SCPFX project (South Caspian Pipeline), the company needed a set of geographic information to assess the best routing options for a pipeline corridor in Azerbaijan and Georgia.

Problem

ILF Consulting Engineers needed information to calculate which route would guarantee the fastest and the most cost effective settlement for the pipeline, in two areas in Georgia and Azerbaijan. Leading a survey to assess best routing of a cross border infrastructure settlement can be long and expensive:

- Ground survey suppose the cost and time to send expert people in the fields for a long period – the longer the pipeline, the longer the survey;
- Airborne imagery campaigns also require administrative clearance to get flight authorization from each countries involved by the infrastructure route.

Satellite imagery sounded like a perfect solution for this situation, saving the time and effort associated to organize a ground or an airborne campaign in remote, cross-border locations. However, ILF Consulting Engineers had a double requirement: get data immediately at the start of the project and reach a final accuracy of 1m RMS.

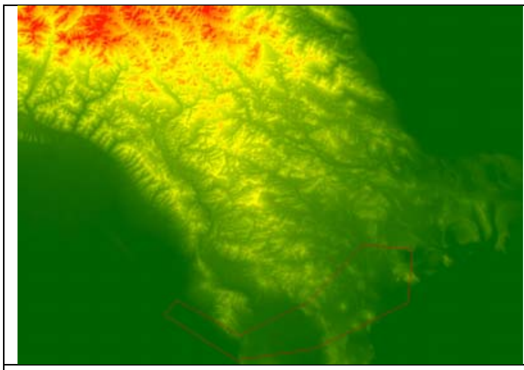
Satellite Earth Observation Data Application

Airbus Defence and Space's constellation capacity contributed to provide a variety of datasets covering a total area of 2,189km^2 along the pipeline corridor, in order to comply with the customer's double requirements (immediate availability, 1m final accuracy)

1. SPOTMaps and Elevation30 data were delivered promptly, as they are off-the-shelf, ready-to-use data sets derived from SPOT satellites imagery.

- SPOTMaps are country-wide mosaics, featuring 1,5 or 2,5m resolution in natural color, available over more than 110 countries to date.
- Elevation30 is a 3D medium resolution model, available off-the-shelf for more than 75m sq.km.

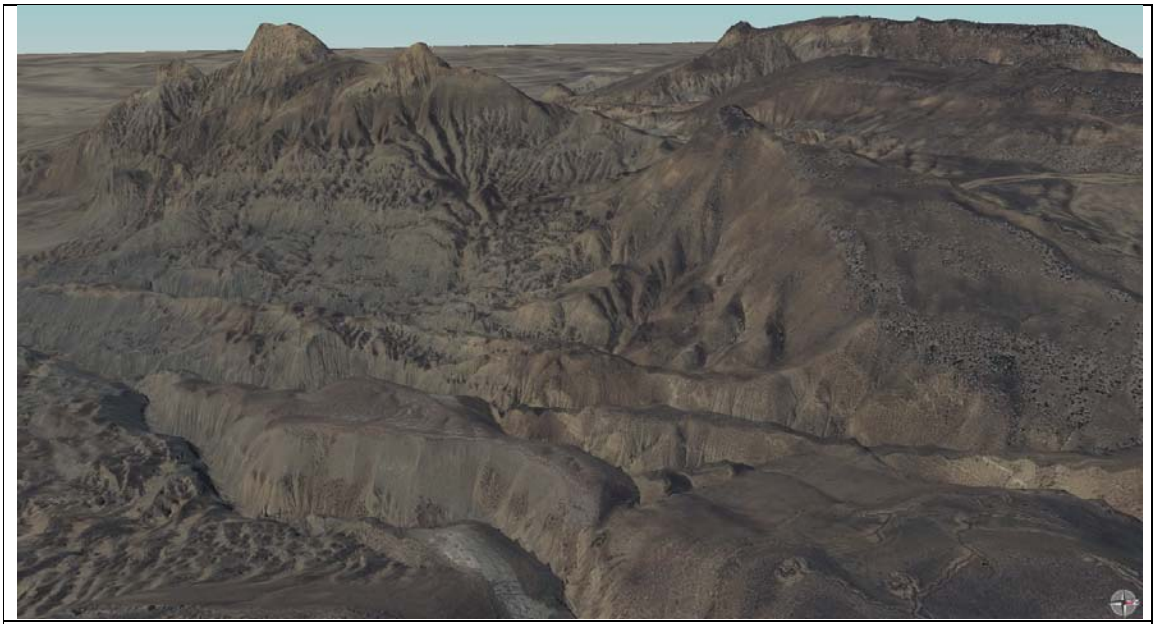
These 2 datasets supported a rapid preparatory study of the pipeline corridor, to analyse and correct the early routing.



▲ **For Early Morphological Analysis: Elevation30**
30m resolution 3D Model
6 to 10m LE 90 – Off-the-shelf
(in red, the customer's area of interest)

▲ **To Adjust Pre-Routing : SPOTMaps**
Off-the-shelf, seamless, country-wide mosaic

2. Then, 50cm Orthophotos, as well as 1m Elevation1 Digital Terrain Models were provided for the Area of Interest. Ground Control Points (GCPs) were captured and used to increase absolute accuracy in planimetry and elevation to help define the final plans of the pipeline project. For a subset of the corridor, 3D vector maps of topographic features along the pipeline were extracted in stereo with a scale of 1:5,000. All these datasets were derived from VHR stereo imagery acquired by the Pléiades Constellation.



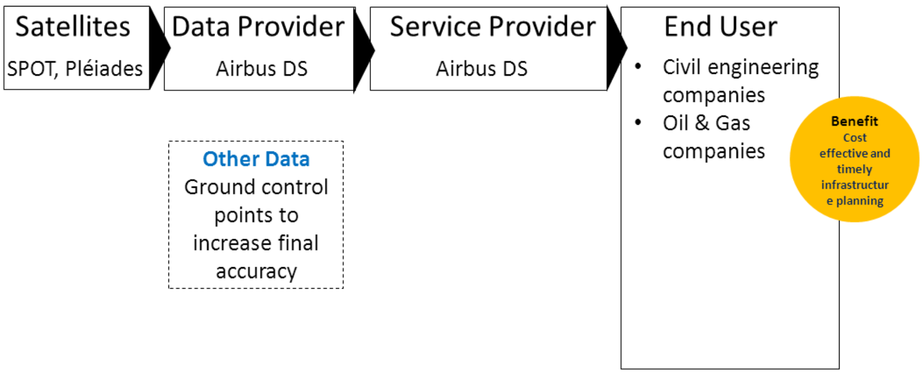
▲ **For 3D In-detail Modelling of the Pipeline Route: Elevation 1 DTM**
Precise 3D Model representing ground elevation along the final pipeline route

▲ **3D Vector Map**
Topographic feature extraction at 1/5,000 scale

The accuracy of all Airbus Defence and Space products delivered exceeded the customer's specifications and expectations:
"We would like to express our satisfaction concerning the products received from Airbus Defence and Space in the frame of the SCPFX project (South Caspian Pipeline). […] SPOT and Pléiades deliverables were compared with highly precise terrestrial in-situ measurements. For over 80% of the evaluated areas, all products (DTM, Orthophoto and VectorMaps) were far better than the requested specifications, showing an RMS of 50cm to 60cm in the elevation component. Whereas the RMS of the remaining 20% was around 1m, always staying within the project's specifications."

ILF Consulting

Value Chain



The key benefits of Airbus Defence and Space's satellite constellation for civil engineering and energy industry are:

- Ideal combination between **coverage** and **resolution**
- From **local insight** (1 / 5,000) to **nation-wide mapping**
- From **detection** up to **identification**
- Cost and time **efficiency**

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#211

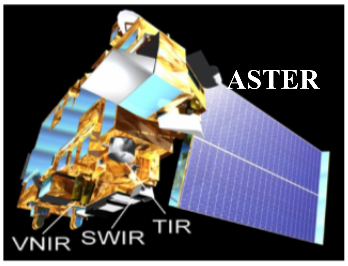
Title： ASTER Data Used to Identify Copper Potential Regions

Problem： The mining licenses for large-scale promising areas (alteration zones) and easily

accessible small-scale promising areas have been kept maintained by the metal majors in Northern Chile, while chances for Japanese companies were limited in early 1990’s.

Basement rocks were covered by Quaternary sediments and volcanic rocks in the area. Even if large-scale alteration zones existed, they were covered by overburdens, and their exposure was limited in small scale. Their potentials were not evaluated sufficiently.

Satellite Earth Observation Data Application

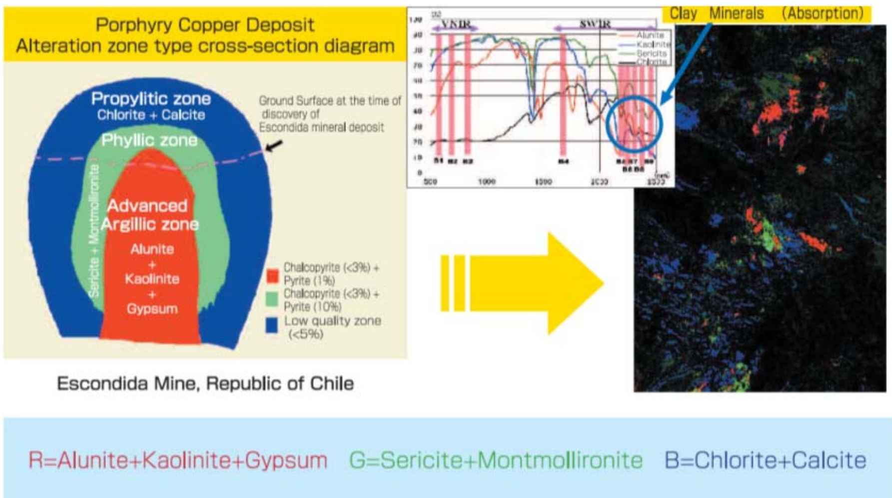


The Advanced Space-borne Thermal Emission and Reflection Radiometer () is a 15-channel imaging instrument operating on NASA’s Earth Observing Terra morning orbital platform since1999 (Yamaguchi et al., 1998). By the joint project between the U.S. National Aeronautics and Space Administration and Japan’s Ministry of Economy, Trade, and Industry, ASTER has been acquiring data for 15 years, since March 2000.

Having more excellent space and spectral resolution than previous satellite sensors (Landsat Thematic Mapper with 80m of space resolution), ASTER can not only extract small scale alteration zones, but also analyze mineral phase on pixel basis and create alteration zones maps.

These analyses enable to evaluate small scale promising areas (alteration zones) in mountainous remote areas being hard to access.

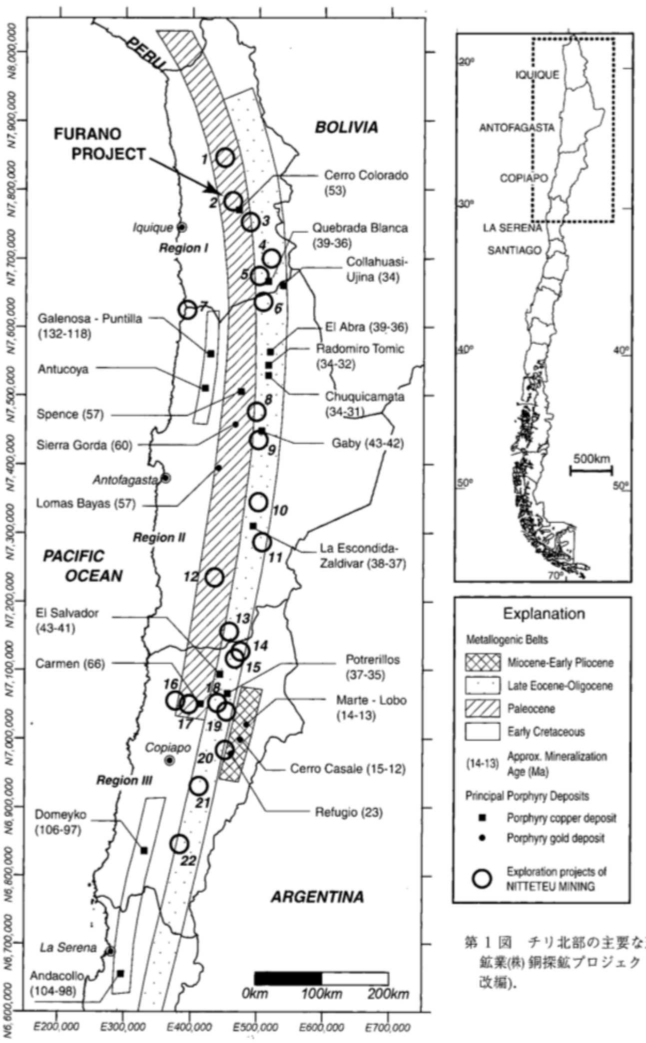
By taking advantage of ASTER sensor's identification capability of mineral phase, sericite alteration zones indicating the center of the porphyry copper mineralization are exposed partially or totally and are extracted as promising areas.



Value Chain

Japanese companies applied for mining licenses in promising areas and acquired them. Those areas had been evaluated as worthless to keep mining license by metal majors.

Japanese company extracted promising areas through the study of mineralization model, taking into consideration mineral deposit types, and the analysis of ASTER data with high resolution multi sensors made it possible to extract altered minerals. Then they reviewed the availability of mining licenses periodically and applied for mining licenses at the time when promising areas were released as open areas for mining licenses, and they carried out development study sequentially.



1～22の番号は以下のプロジェクト名に対応.
1：Monbetsu,
2：Furano,
3：Kitami,
4：Otaru,
5：Sapporo-N,
6：Sapporo-S,
7：Tokachi,
8：Esashi,
9：Tsugaru,
10：Odate,
11：Oga,
12：Kamioka,
13：Shinyo,
14：Zaou-N,
15：Zaou-S,
16：Tadami-W,
17：Tadami-E,
18：Nazu,
19：Shirracawa,
20：Iwaki,
21：Hitachi,
22：Choushi.
座標系はUTMゾーン19(WGS84)を使用.

第 1 図　チリ北部の主要な斑岩銅－金鉱床ベルトと日鉄鉱業(株) 銅探鉱プロジェクト(Camus and Dilles, 2001を改編).

More Information

They started nationwide project to extract promising areas over the country using ASTER data. They applied mining licenses for promising areas and started comprehensive survey consisting of geological, geophysical, geochemical and drilling survey steadily, and screened out the promising areas. METI, JOGMEC and Japan space systems encouraged researchers and engineers engaged in mining industry to develop the leading technology to extract promising areas using ASTER and other satellite data. Their efforts led to acquisition of their own mining lease or joint mining development projects.

The teamwork among those Japanese companies has helped to secure stable supply of mineral resources for Japan.

Satellite monitoring of harmful algal blooms (HABs) to protect the aquaculture industry

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Descriptions

Harmful algal blooms (HABs) can cause sudden and considerable losses to fish farms, for example 500,000 salmon during one bloom in Shetland, and also present a threat to human health. Early warning allows the industry to take protective measures. PML's satellite monitoring of HABs is now funded by the Scottish aquaculture industry. The service involves processing EO ocean colour data from NASA and ESA in near-real time, and applying novel techniques for discriminating certain harmful blooms from harmless algae. Within the AQUA-USERS project we are extending this capability to further HAB species within several European countries.

Challenges

In Scotland alone the aquaculture industry (mostly farmed salmon) is worth around £600 million per year; UK wide, shellfish culture contributes a further £33 million per year . Harmful algal blooms (HABs) can cause sudden and considerable losses to fish farms, for example 500,000 salmon during one bloom in Shetland, and 350 tonnes of salmon during a HAB event in Norway, HABs are estimated to cost the US aquaculture industry about £82 million per year. HABs can also present a threat to human health. Early warning of HABs allows the industry to take protective measures.

Applications/Solutions

Earth observation (EO) ocean colour data has been processed in near-real time to provide bulletins to the Scottish aquaculture industry. This service involves novel techniques developed at PML for discriminating certain harmful blooms from harmless algae (Kurekin *et al.*, 2014), and operational processing systems designed to provide timely information on water quality (Shutler *et al.*, 2015). The Linear Discriminant Analysis (LDA) classifier was trained using the full spectrum of water leaving radiances, absorption and backscattering; and false alarms are minimised by labelling as ‘unknown’ any data that cannot be reliably classified (Kurekin *et al.*, 2014). By comparison with *in situ* measurements, the method has been validated for *Karenia mikimotoi* and *Phaeocystis* HAB risk discrimination (Figure 1), though it is only applicable to high-biomass bloom-forming species that cause a characteristic colouring of the ocean.

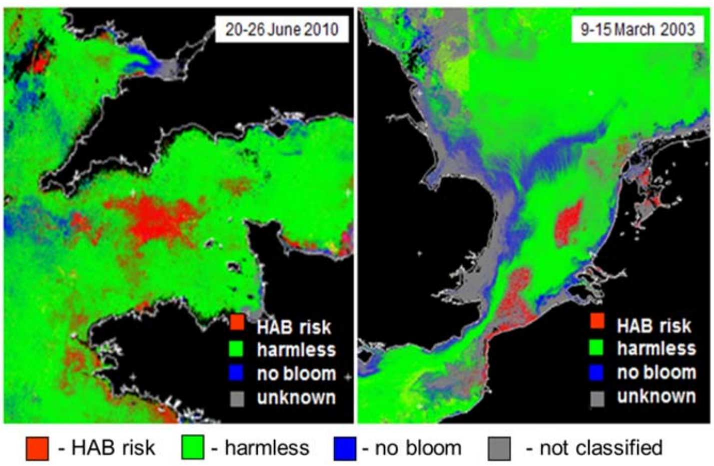
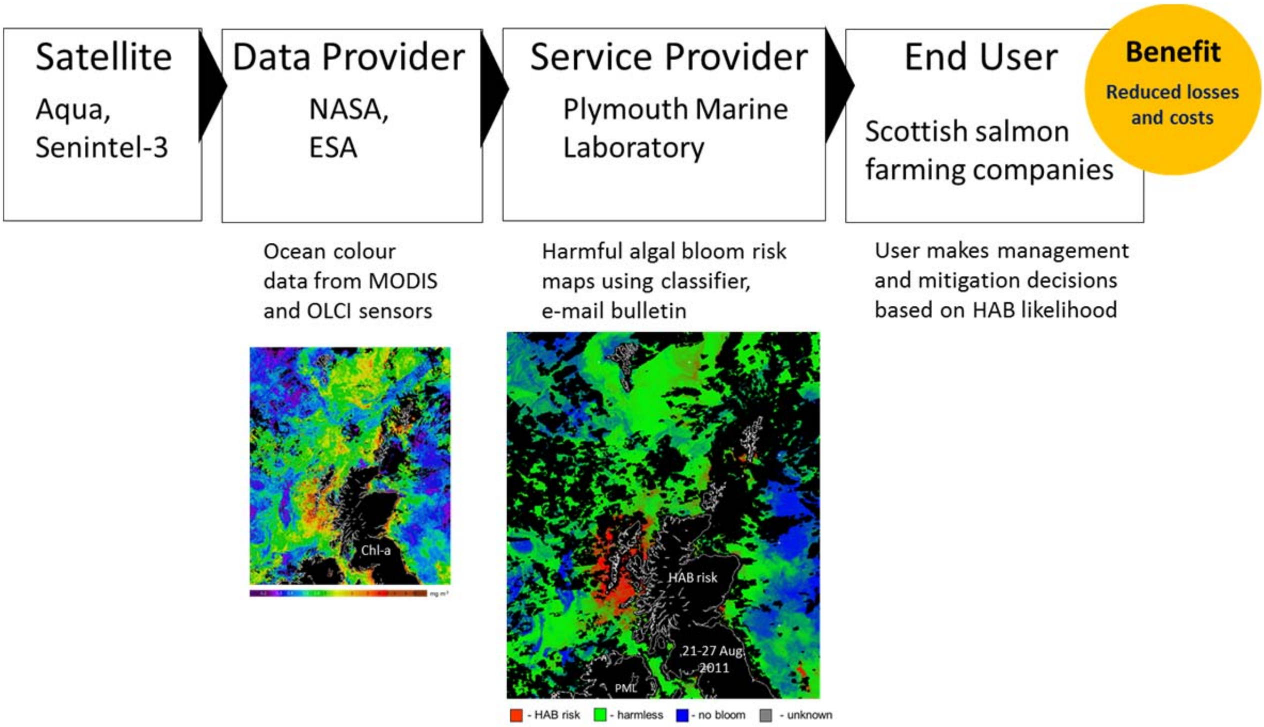


Figure 1. Harmful algal bloom risk maps using EO ocean colour discrimination: *Karenia mikimotoi* bloom in the Western English Channel in summer 2010, and *Phaeocystis globosa* bloom in the Southern North Sea in spring 2003

Value Chain (including end-users)



The end users include the Scottish Salmon Producers' Organisation which represents the interests of the individual fish farming companies. Other potential end users include the marine insurance industry, Crown Estate, and fish farming and aquaculture companies in other countries.

Outcomes/Benefits

The service to monitor for HABs has been running successfully for several years funded by the aquaculture industry. Quotes from the industry: "*Allowed us to put the farms on 'alert' a few days before a bloom came…We are convinced that this prevented us from suffering loses.*" "*I would not feel secure enough to go blind in future; we need this information*".

Within the EC AQUA-USERS project we are further developing the HAB classifiers to improve the capability to discriminate HABs in near-real time, and exploring commercial opportunities for European services.

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PML | Plymouth Marine Laboratory

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

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Shutler, J.D., Warren, M.A., Miller, P.I., Barciela, R., Mahdon, R., Land, P.E., Edwards, K., Wither, A., Jonas, P., Murdoch, N., Roast, S.D., Clements, O. & Kurekin, A. (2015) Operational monitoring and forecasting of bathing water quality through exploiting satellite Earth observation and models: The AlgaRisk demonstration service. *Computers & Geosciences,* 77, 87-96. doi: 10.1016/j.cageo.2015.01.010

#213

Use of AW3D within Mineral Exploration

By Greg Madden, Geoimage Pty Ltd and Alex Farrar, First Quantum Minerals Ltd

Abstract

Performing mineral exploration operations within remote, mountainous areas is always difficult, expensive and time consuming. This case study highlights an example where a high quality Digital Elevation Model (DEM), derived from satellite imagery, is an extremely effective tool to use within these operations. The study area is located in the Andes Mountains in Southern Peru. The large elevation range and the remoteness of the area justified the use of a high resolution DEM as part of the exploration process. The 5-metre resolution ALOS World 3D (AW3D) topographic data was identified as a superior solution to off-the-shelf medium resolution DEMs. The use of AW3D within the exploration process has resulted in significant time savings in the crucial interpretation and planning stages, improving the ability of field teams to access the highest priority targets first. This data will continue to add value throughout the exploration stages of the projects including accurate siting of drill pads and 3D modelling of other datasets. This case study provides a good example of how a high quality satellite derived dataset, such as AW3D, can be employed within the mineral exploration phase of a mining operation.

Introduction

Mining operations within remote areas can often provide a number of challenges, requiring innovative ideas or solutions to optimise efficiency. In areas such as the Andes mountains these problems need to be overcome very early on in the exploration phase. The use of remote sensing datasets, such as ALOS World 3D (AW3D) Digital Elevation Model (DEM) within the mineral exploration phase of the mining life-cycle is an example of such innovation. The AW3D dataset, when combined with Very High Resolution satellite imagery can provide a wealth of information for a number of phases, particularly during exploration and planning.

Challenges

The Project Area is 678sqkm in size, located within the Andes Mountain Range in Southern Peru and is mountainous with elevations ranging from 1809m to 4791m and slopes ranging between 0 to 81 degrees. Such steep terrain means that vehicular access within the region is limited, due to a multitude of un-crossable steep sided valleys that cut through the project area. Navigating within these steep sided creek valleys on foot provides the best means to map the project, due to the fact that they incise geology and provide good geologic exposures. However, navigating around the creek valleys is also necessary for accessing the further afield regions of the project, as well as for the purposes of taking gridded samples for analysis and for less detailed surface geologic mapping.

Therefore consultation of 3-dimensional terrain models and imagery is vital before going into the field. Such consultation allows large savings in time and energy that otherwise would have been used in the field walking down dead ends. This is especially important in locations like the Andes, where high altitude walking exacerbates energy and effort spent.

Figure 1: 3D Visualisation WorldView-2 over AW3D DEM
(©NTT Data, RESTEC/Included©JAXA and ©DigitalGlobe 2015)

Applications/Solutions

During the early exploration phase of the project, freeware such as Google Earth was sufficient to use for basic navigational mapping purposes. However as it became clear that the project would advance beyond the generative exploration phase, the decision to invest in high resolution satellite imagery and terrain models became compelling.

The large size and remoteness of the project area lent itself to the utilisation of imagery and DEM derived from satellite imagery. Complete imagery coverage over the area was available from DigitalGlobe's extensive, very high resolution imagery archive. However, only monoscopic imagery was available. The lack of archive, stereo data meant that a decision regarding the DEM dataset was required.

The option of acquiring very high resolution, stereo data was considered and was rejected for the following reasons:

- The possibility of cloud, and cloud shadow being present within the fresh capture imagery. Any portions of the stereo data that contains cloud, or cloud shadow, preclude the production of elevation values. The resultant "holes" would require infilling with low resolution datasets such as Shuttle Radar Topography Mission (SRTM) 90m data, or ASTER GDEM 30m data;

- Very High Resolution satellites typically acquire data, including stereo captures, at off-nadir angles that were deemed undesirable over the project area. Given the topography throughout the area, there was a high risk of no stereo data due to occlusion, particularly over the steep creek valleys. Again, these "holes" would require infilling with SRTM or GDEM data; and

- The overall requirement did not necessarily dictate that an expensive 1m DEM dataset was necessary.

Once the decision was made to reject a 1m DEM dataset, AW3D was then considered. When considering suitability for this particular area, AW3D was found to have the following benefits:

- AW3D is generated from the large archive of triplet mode imagery acquired by the Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) sensor on the Japanese ALOS satellite. The dataset is produced by using numerous triplet datasets, which serves to either reduce or totally remove cloud and smoke effected areas. In our case, a dataset was available over the area that had no cloud effected area, and therefore fully covered with 5m elevation data;

- The PRISM Triplet dataset involves a forward-looking, backward-looking and nadir sensors. Of further benefit, ALOS typically acquired data with minimal off-nadir capture angles. The triplet configuration, combined with direct overflight of the satellite meant that there was a significant reduction of occlusion holes, caused by slope;

- Because the AW3D is produced as an "off-the-shelf" product, there was minimal delivery time of the product, this combined with a relatively low expense, meant that the data could be quickly incorporated within the exploration operations; and

- The 5m resolution was considered more than adequate to support operations.

Overall, the AW3D solution was considered a suitable option for use within the project. The dataset provided a consistent and complete terrain model which when combined with very high resolution imagery, such as DigitalGlobe's 50cm resolution WorldView-2 imagery, improved efficiency in planning and decision making processes.

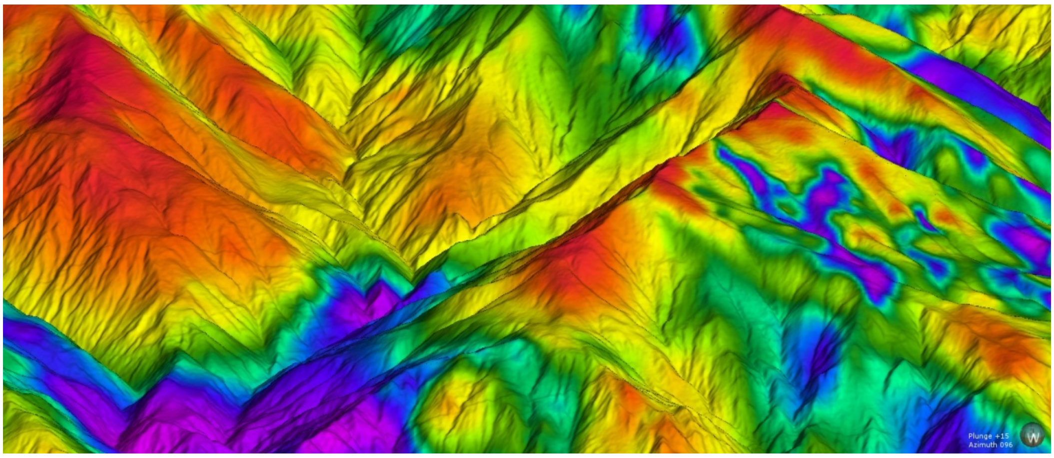

Figure 2: Analytic Signal Vertical Integral (ASVI) Airborne Magnetics draped over AW3D- Shaded Relief (©NTT Data, RESTEC/Included©JAXA)

Outcomes/Benefits

The 5m DEM and high resolution satellite imagery are now vital parts of the 3D geologic model. Interpretation of geochemical and geophysical data using the 3D terrain model is essential in such rugged terrain. The DEM and imagery also assists with drill hole and environmental planning as well as a higher resolution dataset to examine for terrain accessibility. Importantly the satellite imagery is a few years more recent than the Google earth, as such it has more updated roads and infrastructure information. The purchase of the detailed satellite imagery has the added importance of having a dated image showing the environment before any invasive exploration or mining activity has been initiated; therefore providing a baseline of the undisturbed land that can be used as part of any environmental permitting that may take place in the future.

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FIRST QUANTUM
MINERALS LTD.

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#214 GLOBAL MAPPING OF THE EARTH'S LAND SURFACE COMPOSITION

Minerals are fundamental to the formation of the Earth and its dynamic processes though Earth scientists have not had access to continental-scale maps of the land surface composition. To help address this gap, a team of twenty organisations led by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), generated a suite of mineral products of the Australian continent from a unique satellite imaging system called the Advanced Spaceborne Emission and Reflection Radiometer or ASTER. The main driver being to empower the mineral exploration community with free, publicly-accessible, digital, scalable (prospect to regional scales) mineral products that would enable them to more efficiently make decisions regards a given area's economic prospectivity (deposit discovery) but with less environmental impact. The Japanese designed and built ASTER sensor was launched in December 1999 as part of a multi-sensor payload onboard the USA's Terra platform for servicing NASA's "Earth Science Enterprise". ASTER is a polar-orbiting (<83° latitude) imaging system with a 60 km swath and sensing 14 spectral bands at a pixel resolution between 15 and 90 m. These bands include six in the shortwave infrared (SWIR, 1-2.5 µm) wavelength region, where clay minerals have diagnostic absorption features, and five in the thermal infrared (TIR, 8-12 µm) wavelength region, where other silicate minerals like quartz have diagnostic features.

Seventeen ASTER mineral maps of Australia were publicly released in August 2012 (http://www.ga.gov.au/scientific-topics/earth-obs/satellites-and-sensors/aster-radiometer/national-aster-maps). These mineral products were designed to help map rock types and the effects of superimposed alteration (footprints to mineralisation) and regolith processes (weathering, erosion and deposition). Thousands of mineral maps were subsequently downloaded over the web by users from over 40 countries or obtained via external drive (~1 Terrabyte for a complete set of products) provided by the government geoscience agencies across Australia. This demonstrates how access to new geoscience data can attract interest and investment into a country like Australia, which is reliant on the health of its resources sector. Importantly, these digital ASTER mineral maps are easily integrated with other geospatial data allowing for improved understanding of geological processes. For example, Figure 1 shows a link between the surface clay mineral composition from ASTER, the thickness of the crust (MOHO) and seismic activity. That is, thin crust is associated with deposition and the surface accumulation of illite/montmorillonite clay, while a thick, stable crust produces kaolinite (given a history of humid conditions). Contrasting zones of crustal thickness are associated with increased seismic activity, presumably because of isostatic re-adjustments to erosion/deposition (Fig. 1).

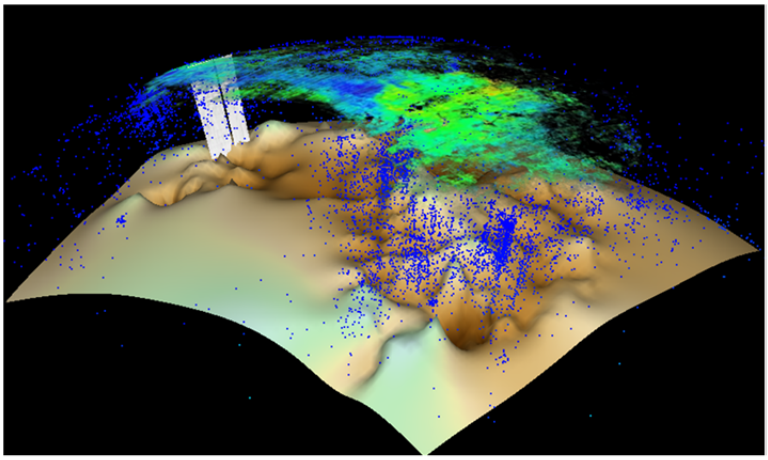


Figure 1: 3D oblique view of the Australian crust that combines the surface clay mineral composition from ASTER (warmer colours are illite-montmorillonite and cooler colours are kaolinite) with the base of crust (MOHO) and seismic activity (blue dots). http://www.ga.gov.au/data-pubs/interactive-3d-models/world-wind-3d-data-viewer

The first gold discovery using the Australian ASTER minerals maps was announced by Kentor Gold on the Australian Stock Exchange soon after the public release of the satellite products (Fig. 2). Many other exploration successes have since been achieved such that ASTER is now valued and used routinely by the mineral resources sector. This paradigm shift by the community also helps them prepare for the arrival of even more precise mineral information offered by future satellite hyperspectral systems.

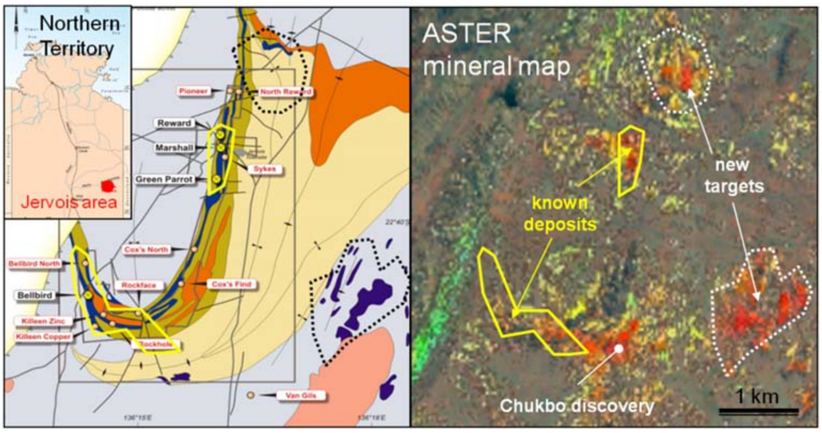
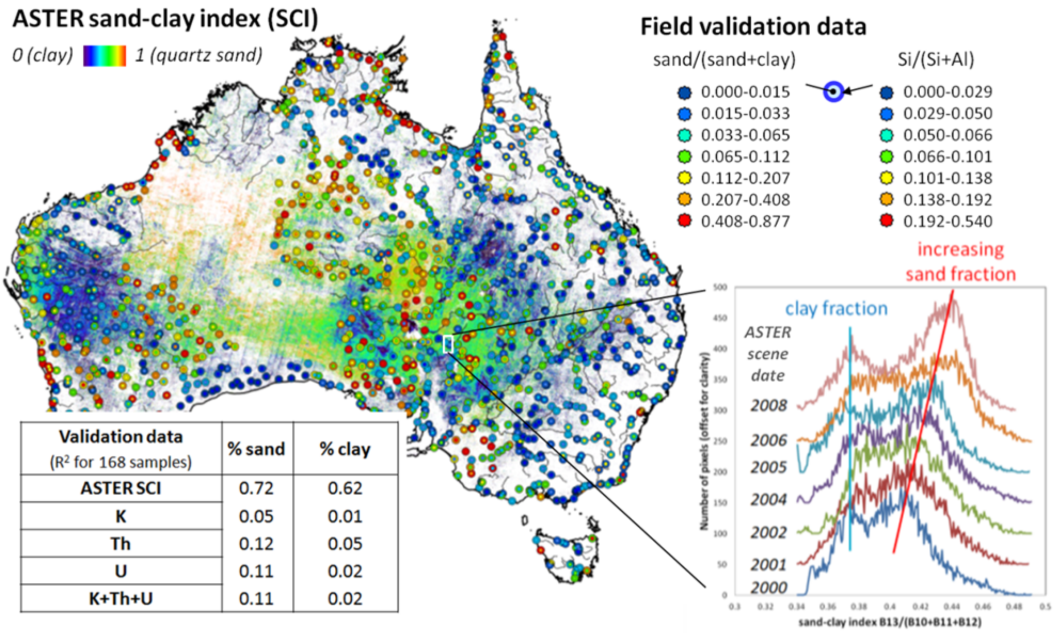


Figure 2. (left) published geology and mineral occurrences in the Jervois area, Northern Territory (from Kentor Gold); and (right) propyllitic alteration of the Jervois area mapped using ASTER, which was critical in the discovery of Chukbo Au and base metal mineralisation.

ASTER is also being tested for environmental applications, including baseline mapping and monitoring the proportion of sand versus clay size fractions as a means for assessing the process of desertification on the world's drylands (Fig. 3). Importantly, results to date show that ASTER provides superior measurement of this information compared to other methods (e.g. airborne radiometric K, U, Th data) and that there appears to be sufficient resolution with ASTER to track annual changes. However, the loss of ASTER's full functionality in 2008 means future monitoring will require the launch of new sensors with mineral-sensitive SWIR-TIR spectral bands, such as NASA's proposed HyspIRI.



Validation data (R² for 168 samples)	% sand	% clay
ASTER SCI	0.72	0.62
K	0.05	0.01
Th	0.12	0.05
U	0.11	0.02
K+Th+U	0.11	0.02

Figure 3. ASTER map of the proportion of sand to clay size material (SCI) validated using field sample analyses of particle size and Si and Al geochemistry. Table (bottom left) provides regression statistics for field samples. Histograms (bottom right) of the ASTER SCI for the period between 2000 and 2008 for an area near Lake Eyre. Note the increasing sand size component with time, presumably related to continued wind erosion.

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#301

GDM: the Ground Deformation Monitoring French infrastructure for scientific applications

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As part of a national Solid Earth thematic center deployment, several French institutions are implementing a scientific service dedicated to ground deformation monitoring. This service will be based on a CNES computing infrastructure hosting Sentinels products, and will offer catalogue access, HPC facilities and thematic computation services on InSAR and optical imagery. Computation services will give scientists access to DTM, displacement map time series, quality indicators and processing and modelling tools. GDM is aimed at serving a wide panel of scientific fields, such as earthquake cycle studies, tectonics, volcanism, erosion dynamics, or anthropogenic deformations.

State of the art

The recent and forthcoming Earth observation satellite missions open a new era characterized by both a massive data dump and a need to go beyond the frontiers of the Earth components in order to get the full picture of processes acting in the Earth system at various time and spatial scales. This especially holds for the monitoring of ground deformation, a fundamental information for many processes including earthquake cycle, natural and anthropogenic hazards, and global isostatic adjustments.

Access to satellite and complementary in-situ data is provided by dedicated services. Over the last few years, several notable initiatives have been developed to provide Solid Earth sciences with efficient research e-infrastructures (European Plate Observing System, Virtual Earthquake and Seismology Research Community in Europe -VERCE-, ESA GTEP project - Geohazards Thematic Exploitation Platform- …). French infrastructures for data acquisition and distribution are organized around National Observation Services (in situ data), scientific services participating to International associations data centers and wider research infrastructures such as the *Réseau Sismologique et géodésique Français (RESIF*) that is the major French contribution to EPOS.

However there is still a need to fill the gap between the raw data and its scientific use, either for technical reasons (big data issues) or due to the need for a better support in term of expertise on the data, of software availability, or of data cost. Therefore the need for thematic cooperative platforms aimed to largely broaden the scientific use of data has been underlined over the last years.

The Sentinel missions launched by ESA will provide a large volume of high quality data. For the first time, it will be possible to access, free of charge, multi scales and high quality multi sensor data. The data volume will represent around 13To/day or around 5 Po/year, which is 50 times the data volume of the ENVISAT satellite. It is thus necessary to implement dedicated structures for archiving, accessing and managing such large data volume and to develop appropriate tools adapted to these new data in order to exploit them for scientific applications.

Sentinel 1 was launched on April 3rd 2014 and S2 and S3 will be launched in 2015. There are urgent needs concerning the access and storage of the Sentinel products, as well as the development and availability of tools for data processing and exploitation. Several complementary initiatives have been thus developed by ESA or national agencies for this purpose.

In France, a national thematic center project named ForM@Ter, interconnected with the CNES infrastructure PEPS (*Platform for Exploiting Products from Sentinels*), proposes the GDM (Ground Deformation Monitoring) service to facilitate access and exploitation of the Sentinel data for ground deformation monitoring applications.

Satellite Earth Observation Data Application

a) Stakeholders

The GDM service is proposed as one component of the ForM@Ter project.
ForM@Ter is a French Solid Earth thematic data pole project launched in 2012 by the French national space agency (CNES), and the National Centre for Scientific Research (CNRS). It relies on the contributions of scientists from more than 20 French Earth sciences institutions and laboratories. Its goal, designed with the scientific community, focuses on the determination of the shape and movements of the Earth surface with the objective to contribute to a wide variety of scientific areas (earthquake cycle, tectonics, morphogenesis, volcanism, erosion dynamics, geodynamic, geodesy) and to offer many interfaces with other disciplines, such as climatology or glaciology. Tools and products provided by ForM@Ter result from the scientific communities needs and wishes.
The PEPS platform is currently under development supported by CNES and will open its first services for a first test phase during the 1st semester of 2015. The PEPS platform is multi-thematic and is designed to provide to Sentinel data users increased efficient access to high volumes of Sentinel data, as well as:

- processing capacities,
- processing means to reduce the data volume which must be downloaded,
- sharing of tools and pooling ressources,
- validation, awareness and training.

b) Services offered, use and end users

The Ground Deformation Monitoring (GDM) service will mostly use SAR and optical satellite data for quantifying ground displacements for various scientific applications. To this end, it will provide a national cooperative platform with a unified access to relevant space based imagery and products (meta-catalogue accessing) to ease access to data, tools, and qualified products for non-expert users.

GDM will provide:

- storage of Sentinel 1-2-3 data and products,
- catalogue ingestion and facilities (search and retrieval),
- hosted computing and HPC facilities including massive data processing applications, and thematic computational chain hosting.
- displacements data quality evaluation tools

A user interface will be implemented on the ForM@Ter website (www.poleterresolide.fr). It will then be possible to access to the catalog and query remote catalogs such as the PEPS catalog. From this interface, it will be possible to download data, access and use processing tools, make thematic and intermediary products. It will also be possible to use or contribute to web services for data/product visualization and metadata discovering or have possibility to work on Single-Sign-On.

The target audience of this service is:

- Scientists: for research in tectonics; earthquake cycle volcanology (mapping of volcanic deposits and faults, determinations of topography and its evolution, quantification of the deformation…); erosion dynamic; geodynamics etc.

  The service will contribute to the ESFRI EPOS research infrastructure implementation.

- Private sector (local authorities, insurance companies…): for societal needs (land management, risk assessment).

<u>Figure1</u>: *The GDM service, interaction between users and stakeholders, and example of applications.*

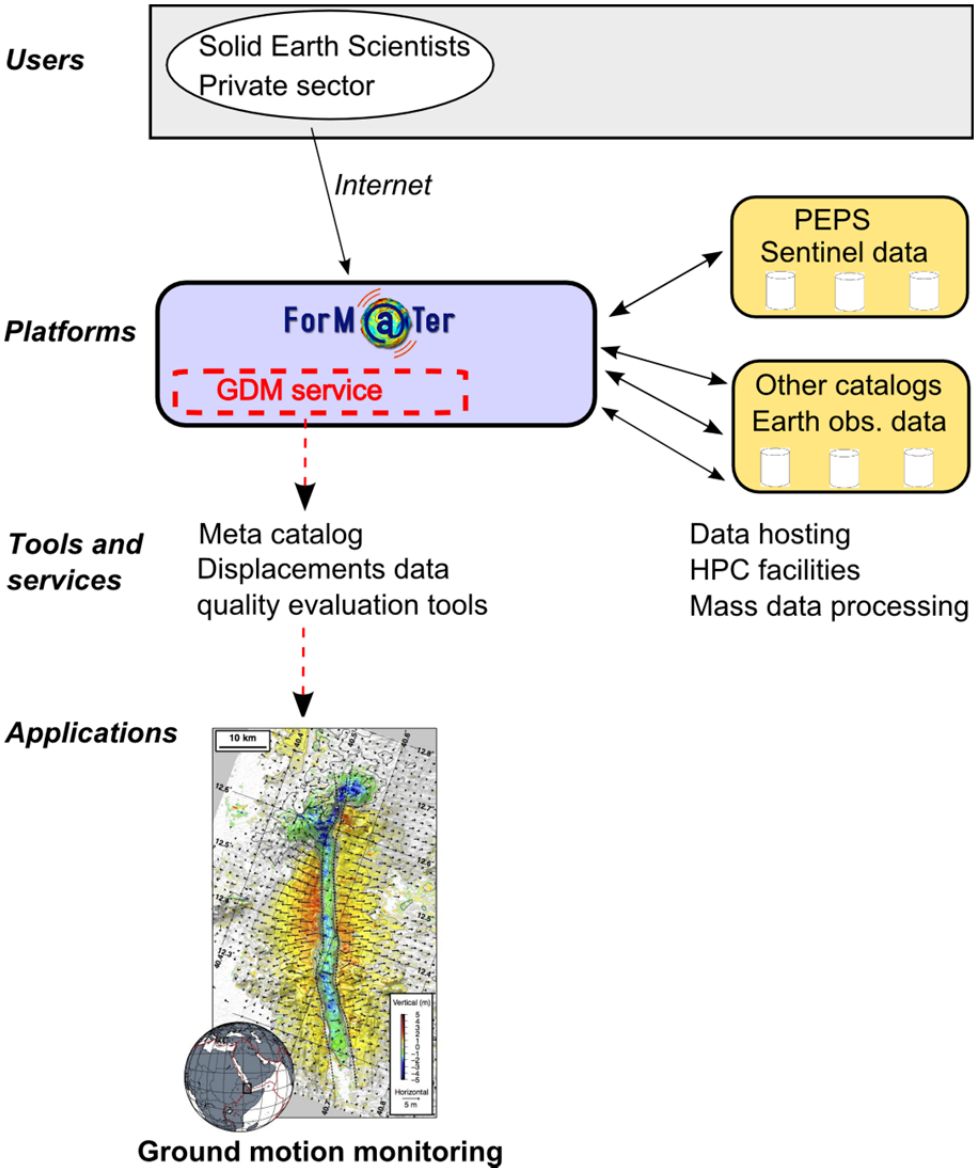
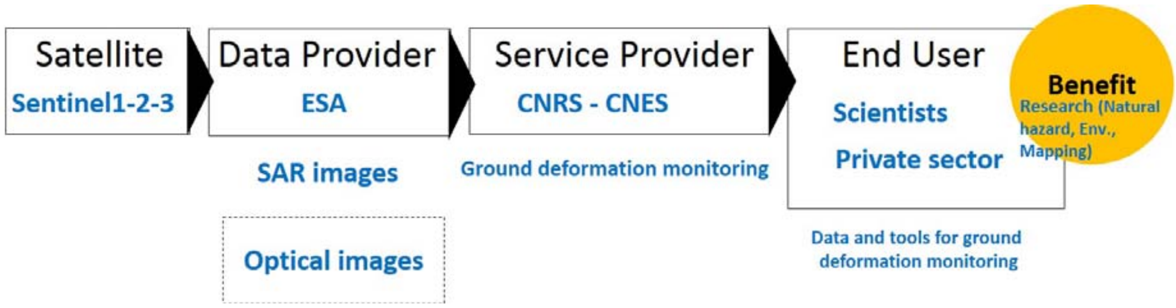


Figure 2 : *Value chain*



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#302

GOSAT data since 2009 and its application

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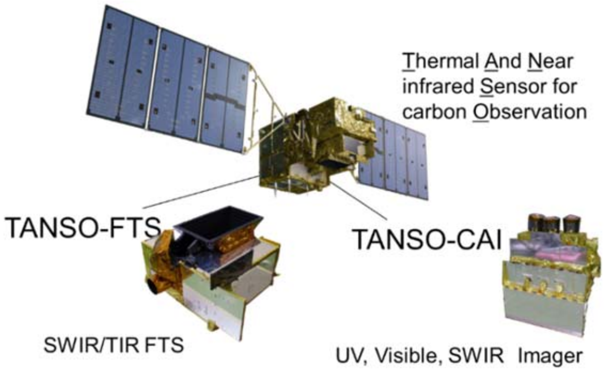
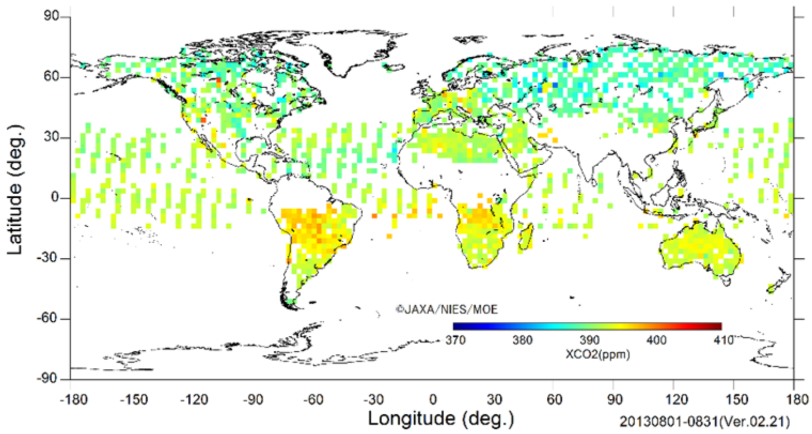
Tatsuya Yokota, the National Institute for Environmental Studies

Description: Japan's GOSAT, whose project is promoted by the Japan Aerospace Exploration Agency (JAXA), Ministry of the Environment (MOE) Japan and the National Institute for Environmental Studies (NIES), is the world's first mission to monitor two major greenhouse gases: carbon dioxide (CO_2) and methane (CH_4).



TANSO-FTS and CAI photos and design view of the GOSAT satellite on-orbit.

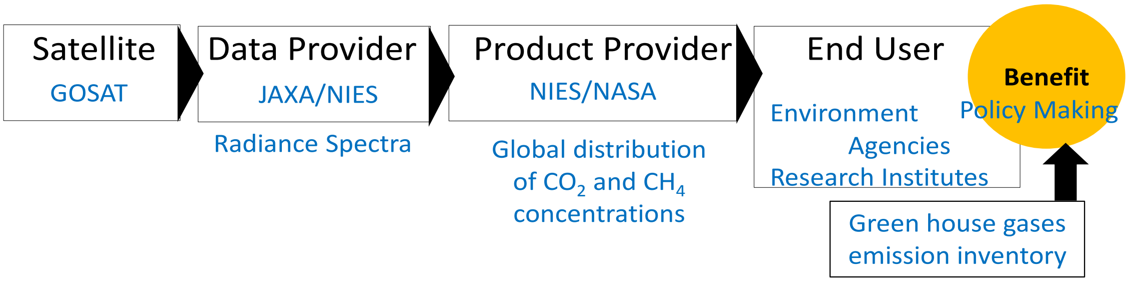
Challenges: The high resolution spectra dataset of CO_2 and CH_4 absorption band has been well-calibrated and distributed to space agencies and research institutes by JAXA since 2009. Multiple teams from more than 10 countries have been working on independent CO_2 retrievals with relative errors < 2 ppm over most regions of the globe. These datasets not only reduced uncertainty of regional CO_2-fluxes globally, but also demonstrated point-source emission monitoring such as CO_2 from mega-cities and CH_4 from oil fields and livestock. Furthermore, it has been revealed that the first high resolution GOSAT spectra of vegetation fluorescence presented patterns of gross primary productivity and opened a new viewpoint on the carbon cycle.



Monthly Global Map of Column concentration of CO_2. August 2013

Applications/Solutions: After its 5-year designed life nominal operation, GOSAT has enough propellant for orbit control to extend its operation and no significant degradation has been detected in both the satellite-bus systems and mission instruments. During the first 5-year operation in orbit, GOSAT has demonstrated the effectiveness of satellite greenhouse gas (GHG) observation with precise calibration and validation. The homogeneous GHG spatial scale is relatively large. But the emission source is not equally distributed. GOSAT has an agile pointing system, permitting a large number of custom targets per orbit. Now, in addition to regular grid observation, the pattern has been modified and optimized for monitoring regional emissions qualitatively that are only possible with satellite measurements.

Value Chain (including end-users): The spectral data acquired by GOSAT are provided from http://data.gosat.nies.go.jp/GosatUserInterfaceGateway (GUIG) to general users. The gas retrieved results are available also from GUIG and other independent gas retrieved product providers from GOSAT spectral data such as http://mirador.gsfc.nasa.gov/. Researchers of world-wide institutes and universities have presented outcomes on carbon fluxes and long term trend of GHGs using the GOSAT gas retrieved results



Outcomes/Benefits: The satellite observation is a very powerful method for monitoring GHGs because a long term and frequent global observations can be done by using a single instrument. GOSAT has made full use of this advantage. The GOSAT data have been constraining the CO_2 and CH_4 emissions in several existing tracer transport models. Environment agencies could use these results as a reference facts for policy making. Even though the outcomes from GOSAT data are not matured yet, outcomes in near future would useful for policy makers to seek effective reduction method of GHG emissions. The surface observation of GHGs data are limited in developing mega cities. The GOSAT footprint of 10.5 km will cover regions surrounding entire emission sources. GOSAT will demonstrate cost-effective and quantitatively useful GHG monitoring from space.

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NEODAAS: Providing satellite data for efficient research

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Neil Lonie, Steve Parkes: University of Dundee

The NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS) provides a central point of Earth Observation (EO) satellite data access and expertise for UK researchers. The service is tailored to individual users' requirements to ensure that researchers can focus effort on their science, rather than struggling with correct use of unfamiliar satellite data.

Problem

Satellite EO data are a powerful tool of benefit in many fields of research: many important research and societal questions, such as the rate at which particular areas of the Earth are warming due to climate change, can be answered in no other way because no other mechanism exists for obtaining such wide-scale observations. However, the understanding of EO data is an active research field in itself and, therefore, researchers in fields that may benefit from its use often do not have the requisite training or experience to find, process and critically evaluate available EO data, meaning that it often cannot be applied effectively.

Satellite EO Data Application

NEODAAS is a facility funded by the UK government to provide a central repository of EO data and expertise to the UK research community. It was formed from the merger of Dundee Satellite Receiving Station (DSRS) with the Remote Sensing Data Analysis Service at Plymouth Marine Laboratory (PML) in 2006. Data are received and disseminated from a number of satellites primarily operated by NASA, NOAA, ESA and EUMETSAT.

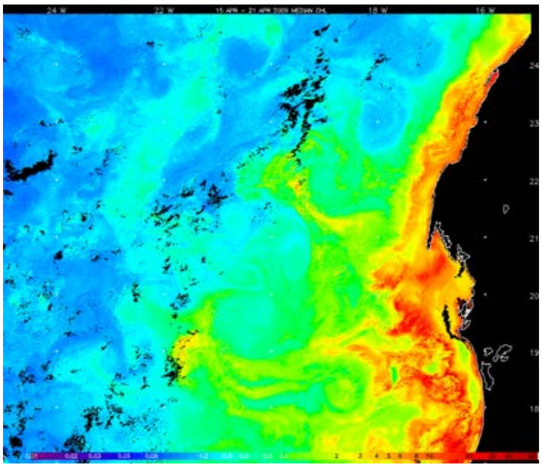


Figure 1: Aqua MODIS Chlorophyll composite for part of SOLAS-ICON cruise

NEODAAS differs from the data products disseminated directly by the space agencies in that NEODAAS tailors its outputs to each specific user, as well as providing data products developed in-house, such as thermal front maps. Researchers may request datasets for a particular region and time period of interest from NEODAAS. This means that users require little or no expertise of their own in order to make immediate effective use of the data, since NEODAAS will have provided data selected for their specific application and are available to provide support in use.

NEODAAS frequently provides pro-active near-real time satellite support for field research campaigns, with NEODAAS staff emailing a daily bulletin to the field site (often a ship at sea). Where such support is provided there is often a significant efficiency improvement as satellite data permit targeting of sampling effort on specific features of interest, thereby ensuring either sampling can be completed more quickly or more samples can be collected. The direct reception capability at Dundee allows NEODAAS to make images available more quickly than they would be if data were obtained from other sources.

As an example, Fig. 1 shows a NEODAAS chlorophyll map of the area studied by the 2009 SOLAS-ICON research expedition. SOLAS-ICON was investigating gas exchange between the ocean and atmosphere in the highly variable Mauretanian upwelling zone off West Africa, and followed two transient filaments of water moving off the coast. They relied on NEODAAS satellite data to allow them to find these filaments in order to inform their sampling strategy.

Another example is the Aerosol-Cloud Coupling and Climate Interactions in the Arctic (ACCACIA) project which investigates the processes that control the properties of low-level clouds in the Arctic. The interactions between atmospheric aerosols and clouds in the Arctic are poorly understood, and this is reflected by the poor performance of climate models when modelling Arctic clouds. The Arctic is warming much faster than the rest of the world and this is, therefore, crucial for predictions of climate change

Two field campaigns were undertaken in 2013 involving both cloud sampling from aircraft and marine investigations from ships. NEODAAS provided near-real-time imagery such as showed in Fig. 2 to inform sampling strategy of the research ships and permit planning of the research aircraft involved so that the science could be accomplished.

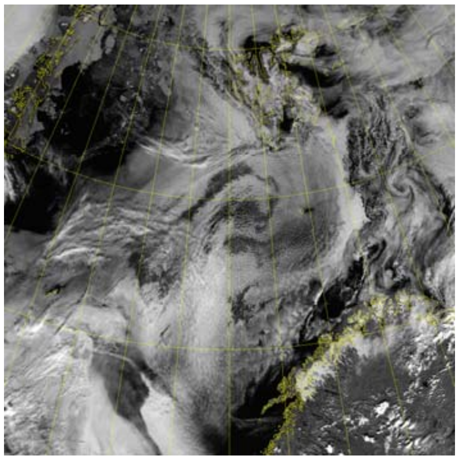
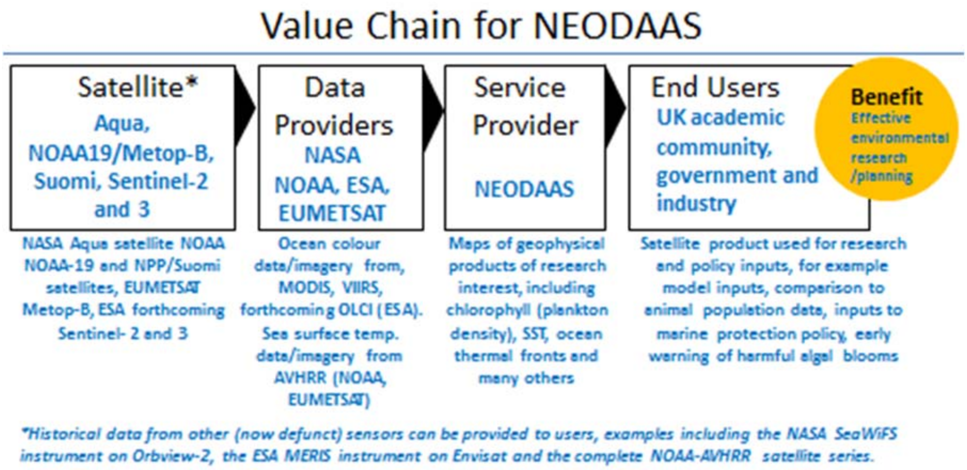


Figure 2: AVHRR channel 2 image received at NEODAAS-Dundee used for ACCACIA project flight planning

NEODAAS provides a direct economic benefit to the UK research sector by permitting researchers to spend their time on their science. It provides a further economic benefit by maximising use of assets such as research ships that are expensive to run – NEODAAS usage costs only a fraction of one day's science time on board a research vessel and, therefore, where NEODAAS data enables effective experimental design it results in a significant cost saving.

NEODAAS can provide assistance for scientific applications: please email info@neodaas.ac.uk to discuss your requirements. Use is likely to be free for UK academic purposes, though a charge may be made for commercial use.



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#304

The crucial and unique role of Earth Observation data within the 2014 Cephalonia (Greece) seismic crisis

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Summary

A magnitude 6 earthquake in Jan. 2014, followed a week later by a magnitude 5.9 event, caused extensive damage on the Greek island of Cephalonia. The timely acquisition of satellite radar imagery by the Italian COSMO-SkyMed and the German TerraSAR-X satellite constellations, provided a unique tool to map the 3D surface displacement associated with the second event and model its causative faults. These were located onshore Cephalonia, rather than off its western coast, as expected from seismogenic fault catalogs. This exemplifies the crucial role of Earth Observation data in improving our understanding of regional tectonics and the assessment of seismic hazard.

Problem

The monitoring of tectonic deformation plays a crucial role in improving our understanding of earthquake processes as well as our capability of assessing seismic hazard. To this end, techniques based on satellite remote sensing are particularly cost-effective, and can complement other technologies, which require deployment and maintenance of ground instrumentation (e.g. GPS), particularly in areas of the planet, which are difficult to access for geographical or political reasons. Furthermore, from the numerical modelling of surface deformation measurements, it is possible to infer the causative faults of large earthquakes, and describe their properties (geometric and kinematic). This complements the results based on the analysis of seismological data, especially in regions where the latter are scarce or of difficult interpretation.

Below we discuss the application of satellite Earth Observation data to the study of a magnitude 5.9 earthquake, occurred on Feb. 3, 2014 on the island of Cephalonia, Greece (Fig. 1). This is a plate boundary region with a high density of active faults, where seismological analyses are complicated by an instrumentation gap towards west and south-west, due to a large stretch of sea, and by the varying thickness of the underlying Earth crust. It is also an area where permanent GPS stations are few, and thus can provide only a partial picture of complex surface deformation patterns. For these reasons, Earth Observation data can provide a unique contribution to the understanding of the tectonic activity in this region.

Satellite Earth Observation Data Application

On Jan. 26, 2014 a magnitude 6.0 earthquake struck the island of Cephalonia, Greece, followed by a magnitude 5.9 event on Feb. 3, 2014, causing extensive structural damages and inducing widespread environmental effects. Following the first mainshock, acquisition of satellite imagery was planned from descending passes of the Italian Space Agency (ASI) COSMO-SkyMed satellites in the framework of the CEOS Disaster Risk Management Seismic Pilot and from ascending passes of the German Space Agency (DLR) TanDEM-X satellite. This enabled researchers at the Italian National Geophysics and Vulcanology Institute (INGV) and at the National Observatory of Athens (NOA), funded respectively by the ASI-INGV MUSA project, and by the FP7 EU project BEYOND (GA 316210), to measure the 3D permanent coseismic deformation field of the Feb. 3, 2014 event. The high resolution and timely acquisition of the satellite imagery allowed the application of a combination of advanced processing techniques, namely Differential Synthetic Aperture Radar Interferometry (DInSAR), Intensity cross-correlation and Spectral Diversity (also known as Multi Aperture Interferometry), which in turn allowed the full 3D deformation field to be mapped. Relative deformations as high as 35 cm were observed in the north-south direction, as well as an uplift of about 20 cm of the whole of the Paliki peninsula with respect to the rest of the island (Fig. 2A).

A numerical modelling of the deformation measurements was then carried out (Fig. 2B), which suggests the earthquake was mainly due to the rupture of a 20 km long ~N-S oriented fault, running almost parallel to the east coast of the Paliki peninsula. A second NE-SW oriented structure, ~10 km in length, located in the south of Paliki is also likely to have been activated. These results are somewhat unexpected, since they clearly indicate that sources with a main north-south displacement component (right-lateral mechanism) and a lesser vertical one (reverse component) are also located onshore Cephalonia, and not only off its western coast as previously believed.

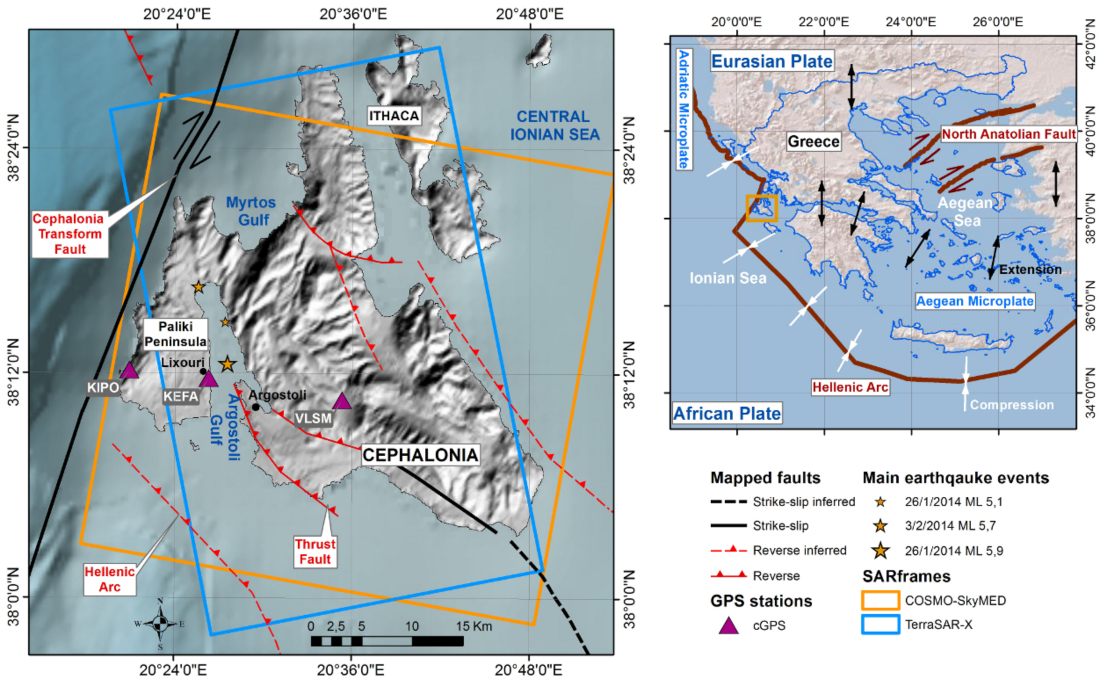

Fig. 1 Tectonic context of the Aegean Sea and the main known active faults on the island of Cephalonia. Rectangles indicate the coverage of the satellite radar images. Magenta triangles represent permanent GPS stations. Yellow stars indicate the epicenters of the three largest events of the 2014 sequence.

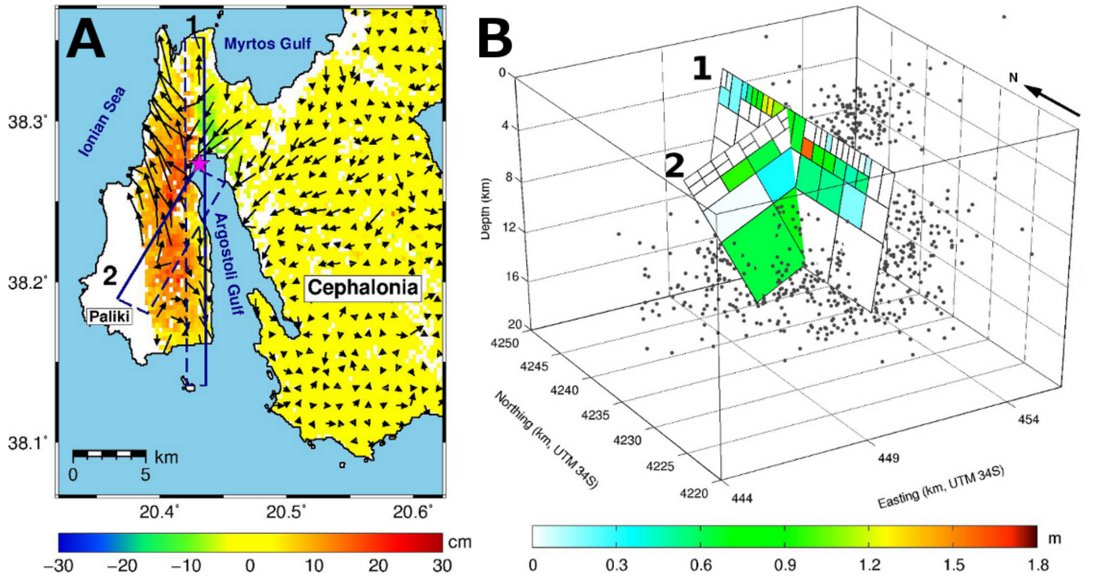

Fig. 2 (A) Vertical (colour scale) and horizontal deformation (arrow field) associated with the Feb. 3, 2014 Cephalonia earthquake. Rectangles indicate the surface projection of the causative fault planes with solid lines representing the intersection with the surface. The star represents the relocated earthquake epicentre. **(B)** 3D view from SW of the estimated motion (slip) on the causative fault planes. The grey dots represent smaller earthquakes (aftershocks) recorded in the month following the main events.

Value Chain

This application used radar imagery from the COSMO-SkyMed and the TerraSAR-X constellations of satellites, operated by the Italian Space Agency (ASI) and by the German Space Agency (DLR) respectively.

The imagery was processed by the National Earthquake Centre department of the Italian Istituto Nazionale di Geofisica e Vulcanologia (INGV), and by two institutes within the National Observatory of Athens (NOA), namely the Institute of Astronomy, Astrophysics, Space Applications and Remote Sensing, and the Istitute of Geodynamics. The output of the processing was a 3D map of the permanent surface deformation associated with the magnitude 5.9 Feb. 3, 2014 earthquake (Fig. 2A) and a numerical model of its causative faults (Fig. 2B).

The end users, which could benefit from this application include Greek national bodies, whose institutional tasks include geological survey and mapping, such as the Institute of Geology and Mineral Exploration (IGME), civil protection, such as the Earthquake Planning and Protection Organisation (EPPO) and research working groups, such as the Greek Database of Seismogenic Sources. (GreDaSS).

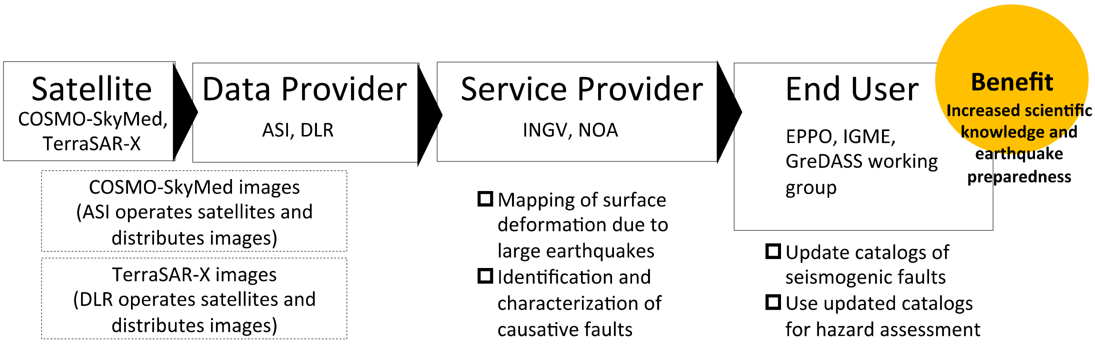

Fig. 3 Value chain diagram

More Information

For more information and/or to access the results of our surface deformation measurements and numerical modelling, please feel free to contact:

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Further technical information can also be found in the following journal article:
http://srl.geoscienceworld.org/content/86/1/124.full.pdf+html

Service provider URLs:
http://www.ingv.it
http://www.noa.gr

End user URLs:
http://www.oasp.gr/
http://portal.igme.gr
http://gredass.unife.it/