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www.gov.uk/government/organisations/uk-space-agency

The UK Space Agency leads the UK efforts to explore and benefit from space. It works to ensure that our investments in science and technology bring about real benefits to the UK and to our everyday lives. The agency is responsible for all strategic decisions on the UK civil space programme. As part of the Department for Business, Energy and Industrial Strategy, the UK Space Agency helps realise the government's ambition to grow our industry's share of the global space market to 10% by 2030..

The UK Space Agency:

- supports the work of the UK space sector, raising the profile of space activities at home and abroad
- helps increase understanding of our place in the universe, through science and exploration and its practical benefits
- inspires the next generation of UK scientists and engineers
- regulates and licences the launch and operation of UK spacecraft, launch operators and spaceports
- promotes co-operation and participation in the European Space Agency and with our international partners

International Partnership Programme

www.gov.uk/government/collections/international-partnership-programme

The International Partnership Programme (IPP) is a five-year, £152 million programme run by the UK Space Agency. IPP focuses strongly on using the UK space sector's research and innovation strengths to deliver a sustainable economic or societal benefit to emerging and developing economies around the world.

IPP is part of and is funded from the Department for Business, Energy and Industrial Strategy's Global Challenges Research Fund. This is a £1.5 billion fund announced by the UK government to support cutting-edge research and innovation on global issues affecting developing countries.



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Bridging the space and development worlds with governments, space agencies, development agencies and private sector space companies.

David Taverner (author)

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- Ecometrica Platform (Ecometrica)
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- Service4EO (Deimos Space UK)

Climate and Disaster Resilience

Assess the risk of when, where and how severe a weather-based disaster, e.g. cyclones and floods, will be

- CommonSensing (UNITAR)
- Coastal Risk Information Service (C-RISe) (National Oceanography Centre)
- Flood Risk Management Systems and Data (Ambiental Risk Analytics)
- Shoreline Mapping and Change Detection (National Oceanography Centre)

Assess the risk of when, where and how severe other disasters, e.g. fires, earthquakes and volcanoes, will be

- Exposure and Multi-hazard Data for Disaster Risk Management (British Geological Survey)
- FireSat (Clyde Space)
- Forest and Wild Fire Monitoring (eOsphere)

Monitoring of disaster-impacted regions when disaster strikes to improve coordination of response teams and assets

- EASOS Data Discovery Hub (Geocento)
- Rapid Flood Mapping Service (RFMS) (Telespazio VEGA UK)
- Humanitarian Rapid Mapping Service (UNOSAT)

Identify and value assets for insurance, including buildings, infrastructure and agriculture/livestock

- SIBELIUs (eOsphere)

Communications (voice, messaging and internet) when networks are damaged or absent

- SatComms for Climate and Disaster Resilience (Avanti)
- SatComms for Natural Disasters (Inmarsat)

Agriculture

Forecast weather, including flood and drought, and monitor crops, to improve agricultural decisions for increased yields

- Crop Observation, Management & Production Analysis Services System (COMPASS) (Rezatec)
- Drought and Flood Mitigation System (DFMS) (RHEA)
- Earth Observation for Flood and Drought Resilience (Airbus Defence and Space)
- Ecological Production Management Information System (EcoProMIS) (Agricompas)
- Grape Production Climate Resilience (Rothamsted Research)

Assess risk of outbreak and spread of pests

- Advanced Coffee Crop Optimisation for Rural Development (ACCORD) (Earth-i)
- Pest Risk Information Service (PRISE) (CABI)
- Pest Prediction (CABI)
- WeatherSafe Platform (WeatherSafe)

Forecasting agricultural productivity to improve agricultural supply chains

- Agriculture Simulations (Sensonomic)
- Agri-track (Environment Systems)
- Land Resource Evaluation Service for Agricultural Activity and Production (Booker Tate)
- Land Cover® plus Crops (Remote Sensing Applications Consultants)

Forestry and Land Use

Identify sites of potential illegal logging and provide enforcement agencies with information to interdict illegal loggers

- Forest Change Mapping (Telespazio VEGA UK)
- Forest Disturbance Early Warning System (FDEWS) (Remote Sensing Applications Consultants)

Measure social and economic value of forests and forest products

- Forests 2020 & ForestWatch Optical Change Detection (University of Leicester)

Monitor carbon stocks within forests

- Carbon Data Model Framework (CARDAMOM) (University of Edinburgh)

Observations of tropical peatland condition, as input to peatland management and restoration

- Peatland Monitoring (CGI)
- Surface Motion Monitoring (ISBAS) (GVL)

Map what land is used for at present, and what it could be converted to for greater economic or social benefit

- Land Cover Mapping (Remote Sensing Applications Consultants)
- Deforestation prevention using land use monitoring and valuation (Vivid Economics)

Monitor land and coastal environments for degradation

- Pixalytics Portal (Pixalytics)

Demonstrate opportunities for better use or management of land for economic, societal and environmental benefit

- SENCE (Environment Systems)

Maritime

Management of fisheries and aquaculture

- Marine Environment Monitoring (eOsphere)

Identify and analyse unusual maritime behaviour to enable agencies to stop illegal fishing

- Innovative SatComms for Inclusive and Sustainable Fishing (Inmarsat)

Find fishing boats at sea for safety, search & rescue

- C-RISe Near Real Time Marine Information Service (Satellite Oceanographic Consultants Limited)
- exactTrax - Safety and Tracking Initiative for Small Vessels (OASIS-TU / MSIS-TU) (exactEarth Europe Limited)

Health

Communications (voice, messaging and internet) for rural health workers and clinics

- SatComms for Rural Health Services (Inmarsat)

Assess risk of outbreak and spread of disease

- Dengue MOsquito Simulation from Satellites (D-MOSS) (HR Wallingford)

Education

Communications (voice, messaging and internet) for rural schools

- iKnowledge (Avanti)

Water & Sanitation

Improve infrastructure for provision of clean water and sanitation

- Watershed Management (Rezatec)

Identify existing water sources (previously unmapped watering holes)

- Water Availability (Pixalytics)

Energy

Accurately plan, design and monitor solar, wind and hydropower systems, based on insolation, wind and rainfall, for countries, companies or communities

- Renewable Energy Space Analytics Tool (RE-SAT) (Institute for Environmental Analytics)

Mining and Industrial

Minimise environmental damage from mining and industry

- Dam Monitoring from SATellites (DAMSAT) (HR Wallingford)

Monitor the development of large infrastructure projects

- Satellite-Structural Health Monitoring (S-SHM) & Satellite Ultra-Precise Motion Monitoring Integrated Technology (SUMMIT) (Telespazio VEGA UK)

Urban and Transport

Monitor the development of large infrastructure projects

- Satellite Image Analysis for Maintenance of Property Databases (Airbus Defence and Space)
- CRUST: Climate Resilient Urban Simulation Tool

Monitor cultural buildings and heritage

- Cultural Heritage Protection Service (UNOSAT)

Communications and Connectivity

Communications (voice, messaging and internet) for communities and businesses

- Every Community Online (ECO) (Avanti)
- SCYTALE Suite (GRC)

Annex A: Organisation Contact Details

Background

This report is produced under the International Partnership Programme (IPP), a five-year, £152 million programme run by the UK Space Agency. IPP uses the UK space sector's research and innovation strengths to deliver a sustainable, economic and societal benefit to undeveloped nations and developing economies. Projects within IPP span themes including: improving agricultural development, enhancing disaster response, increasing resilience to climate change, reducing maritime pollution and illegal fishing, and reducing deforestation.

IPP is part of the Department for Business, Energy and Industrial Strategy's (BEIS) Global Challenges Research Fund (GCRF), a £1.5 billion Official Development Assistance (ODA) fund which supports cutting-edge research and innovation on global issues affecting developing countries. ODA-funded activity focuses on outcomes that promote long-term sustainable development and growth of developing countries on the OECD Development Assistance Committee (DAC) list. IPP is fully ODA compliant, being delivered in alignment with UK aid strategy and the United Nations' (UN) Sustainable Development Goals (SDGs).

This document is a catalogue of solutions from the space sector that address a range of use cases across 11 sectors. This catalogue will initially have a focus on solutions for developing countries and at a later date may expand to be global in focus.

The objective is to raise awareness and interest in the usage of space solutions in developing countries. The primary audience is potential users and customers of these space solutions, including government, private sector, donors, NGOs and others.

It is structured according to sectors e.g. disaster resilience and there is also a section for General Solutions that are cross-sectoral. Each sector is subdivided into use cases and the solutions are aligned to those. Organisation contact details are in Annex A so that potential users/customers can contact the organisations directly.

The sectors currently covered by solutions in this catalogue are:

General Solutions

Climate and Disaster Resilience

Agriculture

Forestry and Land Use

Maritime

Health

Education

Water and Sanitation

Energy

Mining and Industrial

Urban and Transport

Communications and Connectivity



General Solutions



General Solutions

The following products address use cases across multiple sectors.

- **Earth and Sea Observation System (EASOS)**
(Satellite Applications Catapult)
- **Ecometrica Platform (Ecometrica)**
- **Satellite Data Services: Near Real Time Imagery**
(Environment Systems)
- **Service4EO (Deimos Space UK)**



Earth and Sea Observation System (EASOS) (Satellite Applications Catapult)

Overview

EASOS is a platform designed to provide high value decision support to tackle country specific environmental, security, and human challenges. Through its intelligent way of fusing data from terrestrial and satellite sources, EASOS provides knowledge on a wide variety of topics to different government departments on a local, regional, and international scale. Currently the system has three live services: EASOS Flood Watch, Forest Watch, and Marine Watch.

www.easos.org.uk

Solution benefits

- Rapid and cost-effective creation of applications to meet key environmental, societal, and disaster management challenges.
- Flexible allowing automatic connection and ingestion of multiple forms of data including satellite imagery, mapping layers, live telemetry from the field, environmental and weather forecast data.
- Scalable from local to regional and national scale and capable of deploying globally.
- Integrates the very best of British innovation from multiple UK commercial and academic organisations.
- Development paths underway looking at solutions for agriculture, mining, air quality and other applications.
- EASOS Flood Watch 
 - Provide warning of flooding up to 7 days in advance
 - Enable preventative action to be taken prior to a disaster event

- Enable the Disaster Management committee to coordinate all agencies, and take preventative measures acting on consistent, reliable information
- Achieve over 90% accuracy for flood alerts with a 12-hour lead time
- EASOS Marine Watch 
 - Reduction in financial impact of marine pollution
 - Early warning of impact to environmentally sensitive coastline
 - Decision support for containment and cleaning efforts
 - Reduce loss of habitat and damage to marine life by deterring ships from pumping bilges off the coastline
- EASOS Forest Watch 
 - Regional level detection and monitoring of logging activities
 - Enables enforcement of forestry legislation and management practices
 - Help protect the endangered species threatened by their diminishing habitat

Key technical features

- EASOS Flood Watch
 - Provide warning of flooding up to 7 days in advance
 - Forecasts the impact of rainfall
 - Continuously monitors river and rain gauge state
 - Locate and visualise forecasted flood impact on key infrastructure such as roads, evacuation centres, medical facilities
 - Assess human and financial impact of forecasted flooding
 - Flood planning for 1 in 5 to 1 in 10,000 year scenarios

- EASOS Marine Watch
 - Detect potential oil pollution incidents on the surface of the ocean
 - Forecast pollution dispersal for the next 84 hours
 - Automatic alerts based on areas of interest, oil detection size and forecasted coastal impact
 - AIS data integration to help identify vessels which could be responsible
 - Model what-if scenarios for oil spills and model the impact of boom deployment
 - Rapidly identify nearby vessels which can assist with oil slick assessment
- EASOS Forest Watch
 - Identify change to the forest canopy in protected areas
 - Automatic alerts based on areas of interest, detection size and trends
 - Hotspot monitoring using high resolution Radar data.

Case studies

The EASOS solution is currently deployed in Malaysia with three services – Flood Watch, Marine Watch, and Forest Watch, delivering high-value decision support through a series of applications, the system is almost entirely automated, reducing cost and mitigating delays.

EASOS automatically provides flood forecasts every 6 hours (4 times a day), has detected over 3,000 hectares of deforestation in two areas of interest and successfully stopped oil hitting the Malaysian coastline on multiple occasions. One example featured extensively in the Malaysian media is shown below.

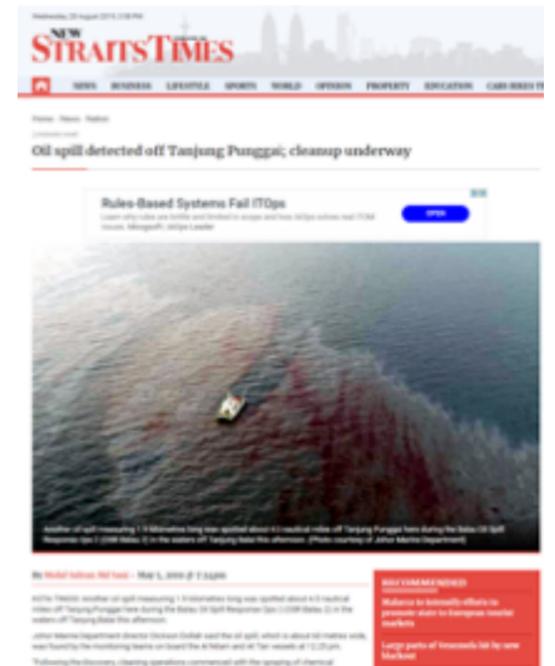


Figure 1: May 2 2019: EASOS Marine Watch detected an oil spill and alerted the Malaysian Maritime Dept who successfully contained the spill averting damage to 13km of coastline and estimated cleanup costs of \$1.6m

Organisation overview

The Satellite Applications Catapult is an independent innovation and technology company, created by Innovate UK to drive economic growth through the exploitation of space. We work with businesses of all sizes to realise their potential from space infrastructure and its applications. Based in Harwell, Oxfordshire, the Catapult was established in May 2013 as one of a network of centres to accelerate the take-up of emerging technologies and drive economic impact for the UK. We are a not-for-profit research organisation which is registered as a private company limited by guarantee and controlled by its Board.

Ecometrica Platform (Ecometrica)

Overview

The Ecometrica Platform brings together Earth observation (EO) 'big data' and turns it into strategic, geo-analytical insights for use by businesses and governments worldwide. An easy to use web interface enables non-experts to easily interact with and rapidly analyse large, complex environmental datasets - from forest protection to disaster response, sustainability metrics to full global supply chain intelligence.

www.ecometrica.com

Solution benefits

- Offers a complete view of fast-changing environmental information, and rapid, critical decision-making tools on local, regional, national or supranational scales.
- Easy to use interface enables non-experts to easily interact with and rapidly analyse large, complex environmental datasets.
- Product is used by governments and donors globally to monitor impact: identifying ecosystems at risk, tracking progress with roll out activities, monitoring outcomes of investments, policies and progress and analysing the spatial distribution of results.
- Platform is fully hosted and supported by experts with deep subject matter expertise.
- Platform has capability to manage terabytes of EO data using cost effective cloud storage solutions.
- Enables clients to make sense of complex EO data, assess risk to land assets or populations from natural disasters, prove compliance and sustainability of new venture.

Key technical features

- 'Off the shelf' products: include measuring avoided forest loss, impact monitoring and environmental risk mapping across agriculture, forests, biodiversity and water.
- Areas of Interest (AOI): Enables end users to run complicated data models on specific geographic areas.
- Time series: It can perform time-series analysis with historical results, querying large quantities of data in seconds.
- Results and reports: Areas of Interest (AOIs) are used to run queries on key geographic areas - results appear instantly on screen and can be downloaded as spreadsheets or PDF reports.
- Data agnostic - Ecometrica has partnerships with various EO data providers; providing our own content, plus content from others - similar to the Netflix approach.
- The platform can combine EO data from various sources such as free optical data from Sentinel-2, Landsat and MODIS; high resolution optical data; or radar from Sentinel-1.
- Ecometrica works with end users to identify their user requirements, to bring the most appropriate data to answer those specific questions.
- The Ecometrica Platform is ready to use with no user IT infrastructure beyond a desktop/laptop computer and internet connection.

Case studies

The UK Government has been using the Ecometrica Platform to monitor the International Climate Fund (ICF)'s forest investments. The Ecometrica Platform is used to report against Key Performance Indicators (KPIs), and the Hectares Indicator is used to measure avoided forest loss because of UK investment. Hectares Indicator uses a combination of EO data to develop risk maps to determine expected loss (and where that will happen), as well as to look at actual loss over the investment period.

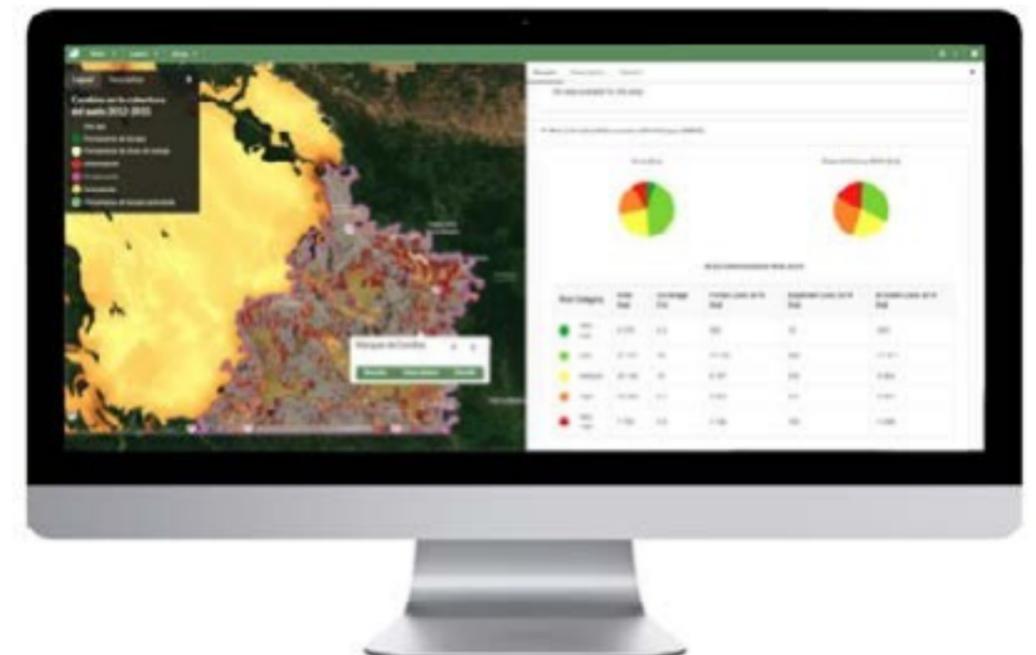
Forests 2020 is an IPP supported project using EO imagery to improve forest monitoring across six partner countries: Mexico, Colombia, Brazil, Ghana, Kenya and Indonesia. It addresses some of the technical barriers to effectively using EO for forest monitoring such as timeliness and accuracy of data. The Ecometrica Platform has been established in each country to support curation and analysis of data to ensure new national data products are accessible to those who need it for policy and management decisions.

Organisation overview

Ecometrica is a global leader in downstream space and sustainability reporting. We turn vast and growing streams of observation data from space, air and land into actionable insights for business, government and society. From forest protection to disaster response, sustainability reporting software to full global supply chain intelligence, Ecometrica's technology uses machine learning and world-class human innovation and expertise to provide our public and private sector customers with a complete view of fast-changing information, and rapid, critical decision-making tools on local, regional, national or supranational scales.

For more details on our range of products please visit our website: www.ecometrica.com

Figure 2: Platform interface showing results of the Hectares Indicator (HI) in Mexico



Satellite Data Services: Near Real Time Imagery (Environment Systems)

Overview

Satellite Data Services is a cloud-based service delivering access to near-real time analysis-ready satellite imagery and derived products from the Sentinel-1 and 2 satellites. We handle pre-processing and associated costs, so you do not have to. Low cost monthly or annual subscriptions give users access to analysis ready satellite data under an open data licence for applications to help detect, monitor and measure land-based activity and change over time.

<https://data.envsys.co.uk>

Solution benefits

- A low cost, easy to use subscription service of ready to use imagery and data products from optical and radar Sentinel satellites.
- On demand access to processed, ready to use, global Earth observation (EO) imagery for your key geographic areas of interest.
- On demand analytics of land and water to give you current state of agriculture and environment from field to farm, to national coverage.
- Analyse historic agricultural and environmental metrics and identify trends from satellite indices, such as crop performance, natural resource management and risk management.
- Satellite Data Services products are a key input for modelling, monitoring, land management, and policy formulation.
- Metrics collection in all-weather, including night time and cloudy conditions, from radar satellites.
- Access your data directly for repeated delivery.
- Data published under open data licence giving you freedom to use our data for commercial and non-commercial purposes.

- Technical support including webinars, use of open source GIS software, bespoke solutions (consultancy, email and phone).
- Interactive demonstrator to showcase uses (<https://data.envsys.co.uk/demonstrator>).

Key technical features

- Processes Sentinel-1 and Sentinel-2 imagery: 10 metre resolution on a 6-12-day image refresh cycle.
- Georeferenced and atmospherically corrected data, on a per-tile basis, based upon Sentinel-2 tiling grid to enable consistent analysis and easy integration with other georeferenced data.
- Customised automatic optical imagery cloud detection routine to support your analysis planning.
- Terrain flattened imagery as standard to give you more spatially consistent data into your analysis.
- Operated within a cloud-based infrastructure, which is accessible via a browser or application programming interface (API).
- OpenAPI compliant with the Swagger/YAML standard to help you rapidly connect your system to the data services programmatically.
- Standards-based data file formats e.g. TIFF for easy use in the widest range of GIS and business intelligence systems.
- Open data licence (CC-BY-SA-4.0) which gives you complete flexibility in using and sharing the data how you need to.
- ISO19139 compliant metadata which gives you standards-based descriptions of the data services products, so you know exactly what you are getting.

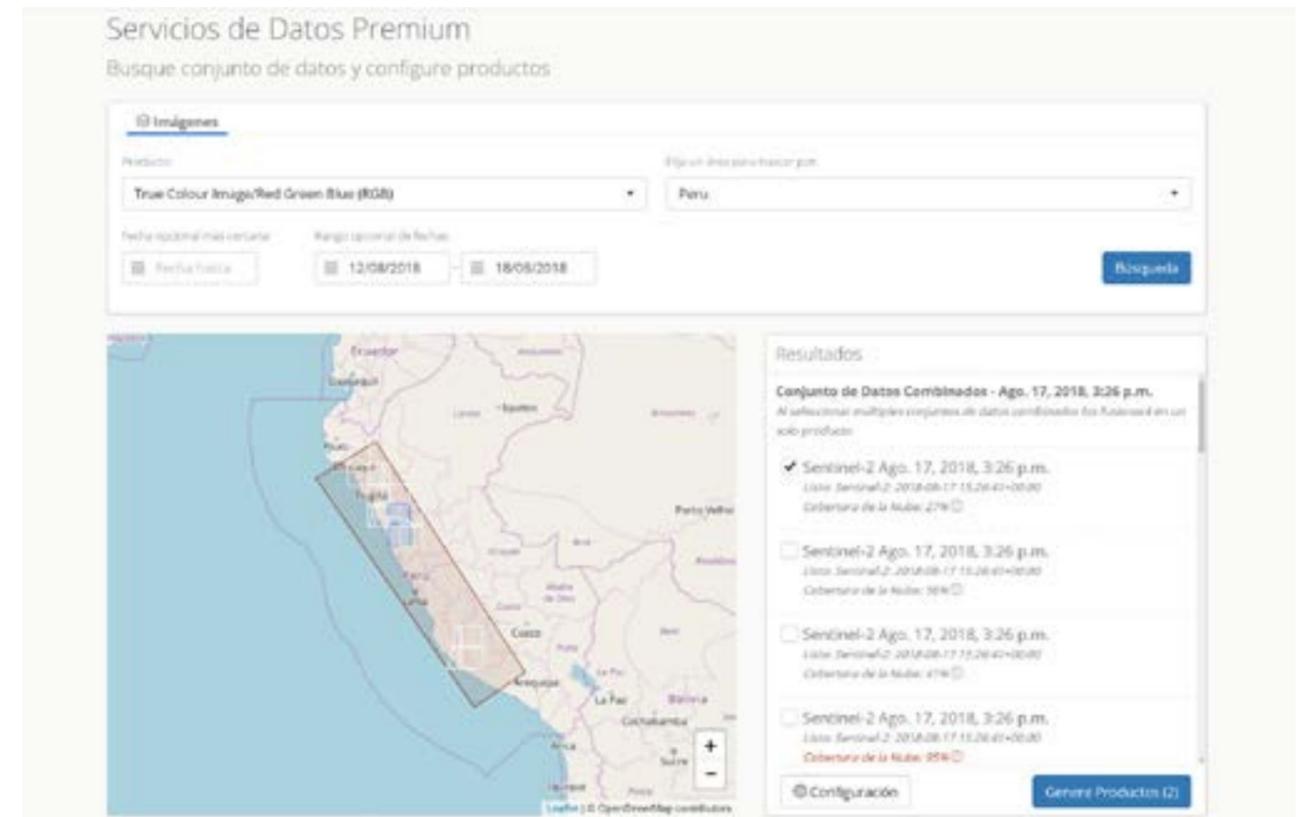
Case studies

Deployed with Tecbaco a leading international banana exporter in Colombia. Tecbaco are leaders in technology adoption and use a crop management system to manage operations, such as irrigation scheduling. Tecbaco are integrating imagery and metrics from the Environment Services Data Services, gaining valuable insights: to target agronomy checks, inform investment and management decisions, regional understanding of crops distribution and change, supply chain transparency, and support sustainable use of natural resources.

Organisation overview

Environment Systems is an established environmental and agricultural data company, providing trusted evidence and insight to governments and industry across the world since 2003. The consultancy delivers bespoke advice and solutions for land management, monitoring and policy for ecosystems, natural capital evaluation, agricultural trials and agricultural supply chains. The company's satellite data services deliver always-on, accessible open data insights from satellite EO analytics.

Figure 3: Extract from Satellite Data Services portal, available in both English and Spanish



Service4EO (Deimos Space UK)

Overview

Service4EO is a back-end platform that delivers Earth observation (EO) products to applications that address a range of problems in developing countries. It collects and ingests EO data from satellites and drones combined with data from ground sources and processes the data to applications for sectors such as agriculture, urban mapping, forestry and coastal management. Service4EO targets organisations which want to develop applications using EO data from different sources without having to manage the complexity of integrating and processing the EO data.

www.elecnor-deimos.com/delegacion/deimos-space-uk

Solution benefits

- Service4EO targets organisations which want to develop applications using EO data from different sources without having to manage the complexity of integrating and processing the EO data.
- It offers an easy integration and access to EO data from free and commercial satellites, for non-experts.
- It is ideal for applications which need to monitor multiple small geographic Areas of Interest (AOI) with different sensors for different environmental conditions, with near real time delivery.
- Service4EO has a cost-effective design to provide data at minimum cost.
- Service4EO is based on the latest Artificial Intelligence techniques

Key technical features

- It ingests and integrates both satellite and unmanned aerial vehicle (UAV)/drone imagery provided by end users.
- Service4EO uses machine learning and advanced neural network algorithms (forms of artificial intelligence) to extract insights from imagery.
- A subscription application programming interface (API) is available to define the areas of interest, the acquisition plans and the services to subscribe. Service4EO will automatically deliver the required products to the application based on subscriptions.
- Currently supports a range of EO sources including Sentinel 1-2, Landsat 8, RapidEye, Deimos 1-2, Worldview 1-3, PlanetScope, Supersview, Gaofen1-3 and others, down to a resolution of 30 centimetre.
- This range of EO sources provide a temporal resolution of several images per day to one image per year (depending on the acquisition plan for the targeted application).
- Processing of UAV imagery to generate mosaics and digital elevation models and other products down to a resolution of 1 centimetre.
- Service4EO has a library of services/products from vegetation index (chlorophyll content index and soil reflectance adjusted index) to advanced object detection (car counting, building extraction, plants detection and forest fire scars).
- Service4EO can be hosted in a scalable cloud (e.g. Amazon Web Service) or a local secured infrastructure. It can be operated by Deimos or any third-party.

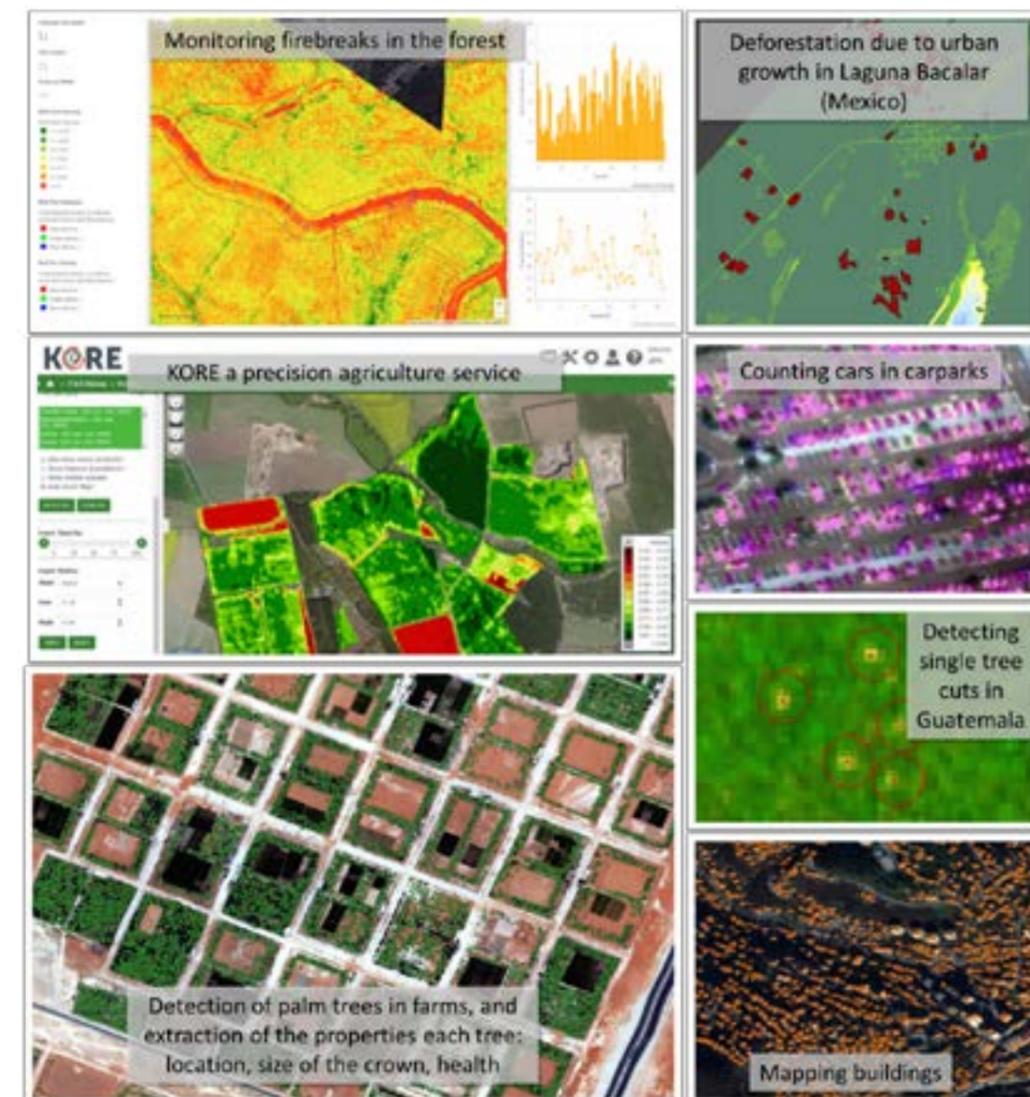
Case studies

Part of the eOsphere SIBELIUS project in Mongolia, supported by IPP, to help the herders to get a better insurance policy for livestock losses due to severe weather conditions and to find grass or shelters during drought or heavy snow.

Organisation overview

Deimos Space UK was created in 2013 as a branch of Elecnor Deimos to address the UK and UK-export market for space systems, services and applications. The company offers expertise in flight systems, ground segment systems, space situational awareness, satellite navigation, applications and services. The knowledge of satellites, data systems and location-based services puts the company in a unique position when developing satellite applications.

Figure 4: Examples of Service4EO products and applications



Climate and Disaster Resilience



Climate and Disaster Resilience

Natural disasters – cyclones and hurricanes¹, floods, droughts, earthquakes and volcanoes – have impacted 3.5 billion people totalling an estimated US\$1.9 trillion in economic losses since 2000.² Developing countries are disproportionately impacted by disasters. The average annual damage from 1980 to 2015 was 1.5% of GDP in developing countries, compared to 0.3% of GDP in developed countries and the average share of affected population over the same period was 3.0% in developing countries, compared to 0.4% in developed economies.³

The space sector is well placed to contribute new types of information to form part of the solution to the major challenges facing the disaster resilience sector today, in both developed and developing countries. The unique benefit that space solutions provide is global, repeatable, scalable data that can deliver high value insights about our dynamic planet, especially within developing countries where existing data and insight is poor.

The Sendai framework articulates four critical action areas which space solutions support:⁴

- **Understanding disaster risk:** for example, Earth observation (EO) improves accuracy of disaster forecasts
- **Strengthening disaster risk governance:** for example, EO improves government's planning and prioritisation of disaster response
- **Investing in disaster risk resilience:** for example, EO supports a robust insurance market through improved calculation of risk

- **Enhancing disaster preparedness for effective response:** for example, satellites provide critical national communications infrastructure, particularly when terrestrial networks are damaged or absent in remote regions

See also UK Space Agency International Partnership Programme report **Space for Disaster Resilience in Developing Countries**.⁵

The space sector provides the following solutions for climate and disaster resilience use cases:

Assess the risk of when, where and how severe a weather-based disaster, e.g. cyclones and floods, will be

- **CommonSensing (UNITAR)**
- **Coastal Risk Information Service (C-RISe) (National Oceanography Centre)**
- **Flood Risk Management Systems and Data (Ambiental Risk Analytics)**
- **Shoreline Mapping and Change Detection (National Oceanography Centre)**

Assess the risk of when, where and how severe other disasters, e.g. fires, earthquakes and volcanoes, will be

- **Exposure and Multi-hazard Data for Disaster Risk Management (British Geological Survey)**
- **FireSat (Clyde Space)**
- **Forest and Wild Fire Monitoring (eOsphere)**

Monitoring of disaster-impacted regions when disaster strikes to improve coordination of response teams and assets

- **EASOS Data Discovery Hub (Geocento)**
- **Rapid Flood Mapping Service (RFMS) (Telespazio VEGA UK)**
- **Humanitarian Rapid Mapping Service (UNOSAT)**

Identify and value assets for insurance, including buildings, infrastructure and agriculture/livestock

- **SIBELIUs (eOsphere)**

Communications (voice, messaging and internet) when networks are damaged or absent

- **SatComms for Climate and Disaster Resilience (Avanti)**
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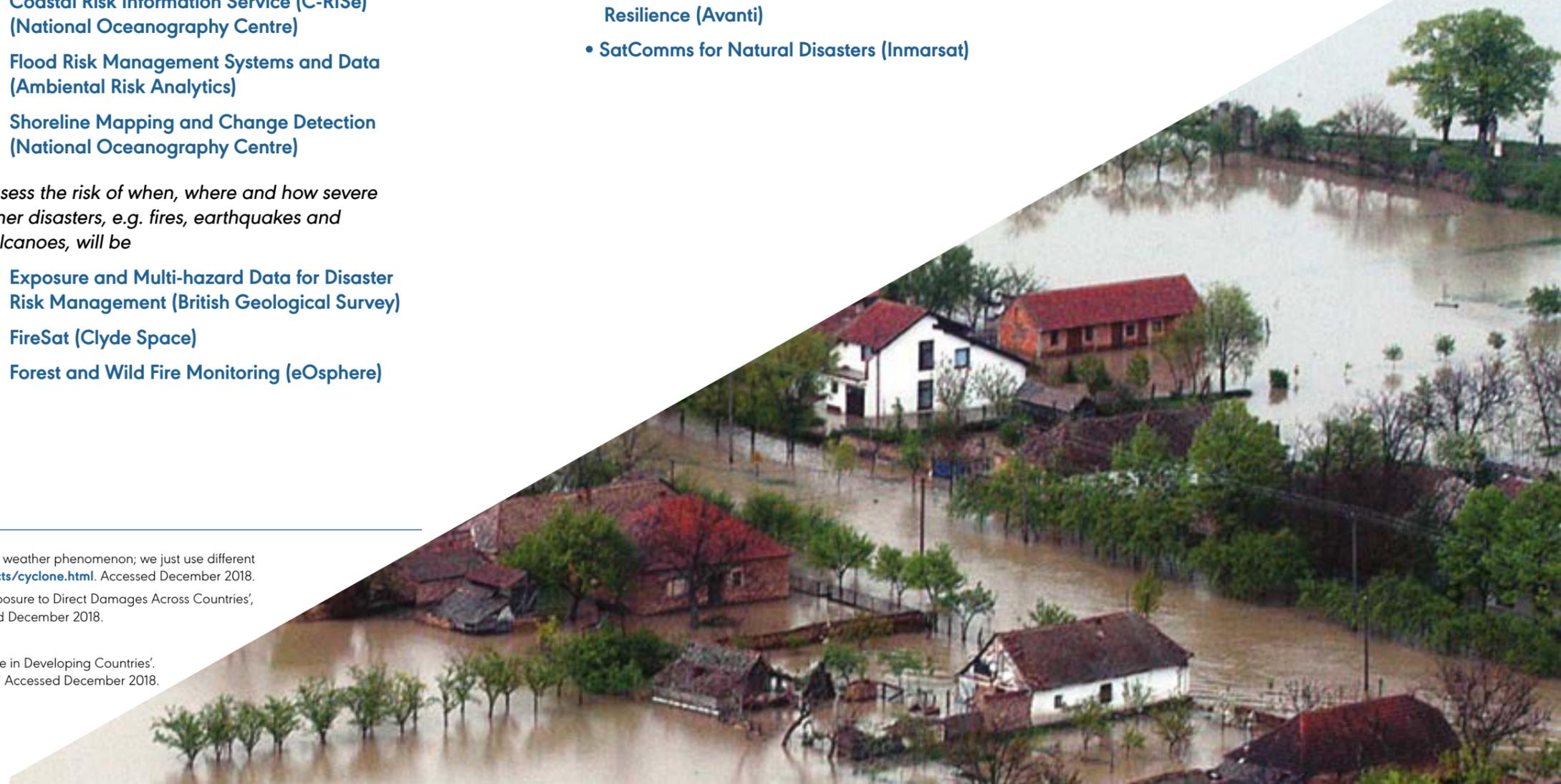
1 National Ocean Service. 'Hurricanes, cyclones, and typhoons are all the same weather phenomenon; we just use different names for these storms in different places', <https://oceanservice.noaa.gov/facts/cyclone.html>. Accessed December 2018.

2 Moody's Investor Services. 'Understanding the Impact of Natural Disasters: Exposure to Direct Damages Across Countries', https://www.eenews.net/assets/2016/11/30/document_cw_01.pdf. Accessed December 2018.

3 Same as above

4 UK Space Agency & Caribou Space. 'Space for Climate and Disaster Resilience in Developing Countries', <https://www.spacefordevelopment.org/library/space-for-disaster-resilience/> Accessed December 2018.

5 Same as above



CommonSensing (UNITAR)

Overview

The overall aim of CommonSensing is to improve national resilience towards climate change, including disaster risk reduction, and contribute to sustainable development in Small Island Developing States (SIDS), through the use of satellite Earth observation (EO). This is done by assessing climate predictions, coupled with hazard mapping and food security analysis to provide countries capacity to better access climate funds and thus become more resilient to climate change.

www.unitar.org/unosat

Solution benefits

- Strengthens national and regional technical capacity towards applying and reporting for climate funds and informing climate action policy.
- Reduced impact and improved risk management of disasters generated by hydro-meteorological e.g. hurricanes and geophysical e.g. earthquakes.
- Enhanced sustainable development in main economic sectors at a national level.

Case studies

CommonSensing is currently being developed with the governments of Fiji, the Solomon Islands and Vanuatu, supported by IPP.

Organisation overview

An autonomous UN body established in 1963, the United Nations Institute for Training and Research (UNITAR) is a training arm of the United Nations System and has the mandate to enhance the effectiveness of the UN through diplomatic training, and to increase the impact of national actions through public awareness-raising, education and training of public policy officials.

UNITAR's Operational Satellite Applications Programme (UNOSAT) is the lead agency for CommonSensing and a technology-intensive programme delivering imagery analysis and satellite solutions to relief and development organisations within and outside the UN system to help make a difference in critical areas such as humanitarian relief, human security, strategic territorial and development planning.

Figure 5: CommonSensing for climate resilience



Assess the risk of when, where and how severe a weather-based disaster, e.g. cyclones and floods, will be

Coastal Risk Information Service (C-RISe) (National Oceanography Centre)

Overview

Coastal Risk Information Service (C-RISe) delivers access to satellite-derived data on sea level, wind speed and wave heights; enabling stakeholders to use this information to improve socio-economic resilience to coastal hazards such as inundation, floods, storm damage, wetland loss, habitat change, coastal erosion and saltwater intrusion.

www.satoc.eu/projects/c-rise

Solution benefits

- Sea level information is critical for improving socio-economic resilience to coastal hazards such as inundation, floods, storm damage, wetland loss, habitat change, coastal erosion and saltwater intrusion.
- C-RISe delivers new sea level and met-ocean data to address a gap in Earth observation (EO) data available to the country partners to monitor coastal risks.
- Provides analysis of historical changes in sea level, alongside met-ocean data on winds and waves, revealing trends and rates of change.
- Collaborative approach to local data validation and interpretation builds human and institutional capacity to deliver information on coastal risks.
- A number of use cases have been developed that combine C-RISe data with local expertise from the region.
- The alternative to C-RISe is use of long-term tide gauge records which are not available in many areas of the world.

Key technical features

- C-RISe is based on the application of freely available radar altimetry data (ERS-1, ERS-2, Envisat, Topex, Jason-1,2,3), analysed using methods developed at the National Oceanography Centre.

- Variable spatial and temporal resolution depending on source of satellite data.
- A 16-year coastal sea level data set for the South West Indian Ocean region has been generated with the NOC ALES processor. These data and analyses are being provided, with wave and wind climatologies and near real-time wave and wind data, to local users, through a bespoke data portal.
- A python software package has been written to allow regional partners to validate the C-RISe altimeter sea level data against locally available tide gauge data.
- Processed data sets are accessible/downloadable via a web portal and can be used off-line (<https://eo.meraka.csir.co.za/crise/>).

Case studies

Service focused initially on Mozambique, Madagascar and South African coastlines supported by IPP. The service was extended to Mauritius in 2019. Case studies will be made available on the project website when completed.

Organisation overview

The National Oceanography Centre (NOC) conducts Satellite Oceanography research concerned with measuring exchanges between the atmosphere, ocean, and marine biosphere to predict the response of the marine system to climate change. This includes measurement of variability and change in sea level, wind and waves which, combined with in situ observations and models, can be used to inform hazard assessments. We contribute towards developing cost-effective observations of global and coastal oceans to deliver state-of-the-art operational oceanography and environmental monitoring. We contribute towards developing cost-effective observations of global and coastal oceans to deliver state-of-the-art operational oceanography and environmental monitoring.

Flood Risk Management Systems and Data (Ambiental Risk Analytics)

Overview

Effective flood risk management requires clear and current information to make informed decisions. Ambiental produces high precision flood data in the form of hazard maps and flood risk analysis quantifications. Using a systems approach enables end users in government, disaster response, insurance and the private sector to better prepare for and respond to flood emergencies.

www.ambientalrisk.com

Solution benefits

- Easily visualise data, share insights and configure alerting protocols through the use of intuitive, web-based dashboard applications.
- A worldwide flood forecasting capability for advanced warning of flood events, based on dynamic modelling of live data feeds such as rainfall radar, forecast models and hydromet telemetry.

- An automated end-to-end workflow solution with powerful geospatial tools for customising views of data layers and analysing flood impacts.
- Flexible and highly scalable deployment option which can be deployed on enterprise systems or delivered as a cloud-hosted service.

Key technical features

- Digital flood risk products underpinned by Ambiental's Flowroute modelling technology - tried and tested by governments and insurers worldwide.
- Flood forecasting capability delivered using Ambiental's FloodWatch software - full catchment continuous 2D coupled hydrological/hydraulic simulation of floods up to 7 days in advance.
- Able to ingest a range of data types, including WMS and API feeds - systems can incorporate remotely sensed data of land use, topography and satellite weather monitoring.
- Uses high performance computing for rapid results and machine learning for automated calibration - to ensure long warning lead times and improved predictive accuracy.
- Solution delivered through a range of front-end visualisation technologies and back-end processing servers - software delivered as a service and tailored to a client's budget and requirements.

Case studies

A high-resolution pluvial flood forecasting system and risk visualisation platform was developed for Greater London. The system provides flood hazard predictions, risk quantifications and alerting tools. Met Office rainfall forecasts are processed and flood risk is quantified through live impact forecasting to a range of asset types. Working with stakeholders at The Greater London Authority and Transport for London flood risk to the transport network is calculated and visualised. In this project remotely sensed data was processed and visualised to detect changes in greenspace. Also, natural language processing is used to extract contextual information on flooding from social media feeds.

Organisation overview

Ambiental is a global specialist in flood risk assessment and risk management. A company of Royal HaskoningDHV, Ambiental provides flood forecasting systems using flood modelling techniques that support better decision-making around flood risk management by predicting the location and severity of flooding, preventing damage, and protecting people, property and assets. The company produces flood maps, data sets, catastrophe models, flood forecasting products and environmental reports internationally. Ambiental conducts both rapid assessments and in-depth research that support better decision-making around flood risk management.

Figure 6: Ambiental Risk Analytics Dashboard System designed to forecast floods and quantify risk impacts for Greater London, UK



Shoreline Mapping and Change Detection (National Oceanography Centre)

Overview

This service delivers coastline, and, where relevant intertidal maps. The coastline method works by identifying land-water boundaries in time series of SAR data and high-resolution optical images. Tidal corrections are applied in order to establish locations for high and low water shorelines, and the location of mean sea level. Tidal corrections are based on available tidal models, supplemented with available tide gauge data and sea level measurements from coastal altimetry.

Multiple coastline maps produced on e.g. an annual (or more frequent) basis can be used to identify locations of shoreline change due to coastal erosion or sediment deposition. The maps can therefore be used to monitor regions that are known to suffer rapid shoreline change, for example to establish annual erosion/deposition rates, and also to identify new locations where shoreline changes occur.

This service is being delivered as one of several services under the ESA EO4SD initiative: <http://eo4sd-marine.eu/>

Solution benefits

- Informed planning of coastal defences.
- Improved safety of coastal populations & coastal navigation.
- Reduced risk to buildings, business and infrastructure.
- Monitoring of coastal erosion that can cause flooding, rock falls, landslides, loss of land and damage to infrastructure.
- Monitoring of sediment deposition and moving sandbanks obstruct port inlets and reduce maritime safety.

Key technical features

- Shoreline maps at 10m resolution for selected locations, with estimated locations for high and low water lines.
- 10m resolution for up to 100km coverage per map.
- In areas with flat topography, maps of intertidal bathymetry can be produced.
- Uses Sentinel-1 SAR and Sentinel-2 MSI data.
- Uses sea level data from altimetry and tide gauges.
- Tidal model outputs.

Organisation overview

The National Oceanography Centre (NOC) conducts Satellite Oceanography research concerned with measuring exchanges between the atmosphere, ocean, and marine biosphere to predict the response of the marine system to climate change. This includes measurement of variability and change in sea level, wind and waves which, combined with in situ observations and models, can be used to inform hazard assessments. We contribute towards developing cost-effective observations of global and coastal oceans to deliver state-of-the-art operational oceanography and environmental monitoring.

Exposure and Multi-hazard Data for Disaster Risk Management (British Geological Survey)

Overview

The overall aim of METEOR is to provide robust national-scale exposure and multi-hazard information based on Earth observation (EO) data. Consistent, reliable information on exposure (building location and construction type) along with multi-hazard knowledge (i.e. how hazards such as earthquakes and landslides occur and interact) is vital when building resilience to hazards and contributing to sustainable development in countries on the OECD list.

<https://meteor-project.org/>

Solution benefits

- National-scale robust exposure data providing consistent and validated information on building type and construction for disaster risk management.
- National-scale hazard and multi-hazard data covering earthquakes, floods, landslides and volcanic events.
- Protocols outlining how the outputs are derived is freely available to ensure confidence in the results and replicability/updates in the future.
- Outputs are freely distributed for use by a wide range of stakeholders across policy, technical and NGO sectors.
- Co-designed and co-developed with stakeholders to ensure outputs are fit-for-purpose, understood and used.
- Strengthened national and regional awareness and technical capacity when planning for and responding to disasters such as earthquakes, floods, landslides and volcanic eruptions.

Key technical features

- The solution is based on day- and night-time optical satellite imagery; synthetic aperture radar (SAR) data and digital terrain models validated by ground data.
- EO data provides a reliable and cost-effective way to deliver outputs in potentially data-poor areas and those that are difficult to access.
- Outputs are formatted to integrate into existing and prototype national Disaster Information Management Systems.

Case studies

METEOR is currently being developed with international partners, supported by IPP.

Nepal is represented by the National Society for Earthquake Technology (NSET). Nepal is a multi-hazard prone country. NSET maintains a database of 29 types of disaster that have affected Nepal since 1971. In 2015 the Gorkha earthquake and associated landslides caused over 9000 fatalities, injured nearly 22,000 people and destroyed over 470,000 buildings. In Nepal, METEOR is focussing on national exposure data with earthquake, landslide and flood multi-hazard analyses.

Assess the risk of when, where and how severe other disasters, e.g. fires, earthquakes and volcanoes, will be

Tanzania is represented by the Department for Disaster Management, Prime Minister's Office. The average annual loss from multi-hazard events in Tanzania is estimated at nearly US\$64M¹. The hazard contribution is 60% from flooding and 40% from earthquakes while there is an estimated 2.5 million people living within 30km of a volcano. In Tanzania METEOR is focussing on delivering national exposure data with earthquake, flood and volcanic multi-hazard analyses.

METEOR will also deliver national exposure data for the remaining 47 Least Developed Countries (LDC's) on the DAC list of ODA recipients.

Organisation overview

METEOR is led by the British Geological Survey (BGS) (<http://www.bgs.ac.uk>). BGS is a component organisation of UK Research and Innovation (UKRI) which is the UK's leading body for basic, strategic

and applied research. BGS was founded in 1835 and is the world's longest established national geological survey. The 'Geodesy and Earth Observation' area has a mixed funding portfolio including projects funded via ESA/EU, NERC (UK), World Bank, Innovate UK (UK) and DFID (UK). BGS addresses a number of different challenges including 'Decarbonisation and Resource Management', 'Environmental Change Adaptation' and 'Multi-hazards and Resilience'.

METEOR consists of several components led by expert organisations in their fields:

- Exposure development - ImageCAT Inc
- Landslide and volcanic hazard - British Geological Survey
- Seismic hazard - Global Earthquake Model Foundation
- Flood hazard - Fathom Ltd
- Multi-hazard modelling - British Geological Survey
- Field data collection - Humanitarian OpenStreetMap Team
- Monitoring and Evaluation - Oxford Policy Management

FireSat (Clyde Space)

Overview

FireSat adds considerable value to existing fire detection assets. The solution uses nanosatellites to provide targeted coverage of Africa with improved temporal and spatial resolution than offered by existing satellite remote sensing of fires. The system intends to enable a step-change in the detection of smaller fires, down to 90m² allowing earlier intervention to keep fires under control.

www.clyde.space

Solution benefits

- Supports wild fire detection in Africa where 75% of worldwide wild fires occur.
- Increases detection of fires by up to 50% compared to existing methods such as fire towers and operational satellites.
- Decreases notification time of wild fires for land owners and governmental agencies.
- Supplements the existing Advanced Fire Identification System (AFIS) capability.
- Over a 12 months period the FireSat constellation monitors a larger area than the satellites that currently feed information into AFIS.
- Cost of operating constellation is 1% of other existing space-based solutions.

Key technical features

- Operates in sun-synchronous orbit, which provides a higher revisit rate for a satellite in the constellation.
- Employs medium resolution imager to detect fires.
- Detects fires as small as 90m².
- Revisit rate of five days with 3-satellite constellation - comparable with existing solutions.
- Revisit rate increased with each satellite added to constellation.

Case studies

The technology that the FireSat constellation will use is being deployed on an in-orbit demonstration mission called ZACube-2, which is supported by IPP. Deployment will occur in December 2018 with the technology live and tested by April 2019. The full Firesat constellation is expected to commence manufacture in 2019 and be operating on-orbit in 2020.

Organisation overview

Clyde Space offers a wide range of services and products including; off-the-shelf platforms, individual subsystems and ground segment solutions, all available at the click of a button; custom solutions designed to our customers' requirements ranging from tailor-made subsystems to turnkey mission solutions; and services including mission consultancy, training and operations.

Figure 7: ZACube-2 in launch configuration



Forest and Wild Fire Monitoring (eOsphere)

Overview

eOsphere satellite ground receiving stations have been installed in countries worldwide (including Malaysia, Vietnam, Indonesia, Greece, Mongolia and Cuba) to allow government agencies to detect and monitor forest and wild fires using medium resolution thermal infrared and visible satellite data in near real time. As well as detecting and monitoring fires, the product also detects burn scar area, smoke, aerosol and air quality, volcanic eruptions and ash.

www.eosphere.co.uk

Solution benefits

- Forest and wildfires can be detected and monitored in near real time.
- With multiple satellites, multiple overpasses each day from each satellite and wide satellite ground swaths, forest and wild fires can be detected over large areas and monitored many times each day.
- As well as detecting and monitoring fires the product also detects burn scar area, smoke, aerosol and air quality, volcanic eruptions and ash.

Key technical features

- Using the short wave and thermal infrared channels on polar orbiting meteorological satellites such as EOS Terra & Aqua and Suomi-NPP & NOAA 20.
- The eOsphere satellite ground station typically includes a 2.4 to 3.0 metre tracking antenna with X-band (or dual X-/L-band) front end, satellites receivers, high specification ingest and processing systems for automated scheduling, real-time reception, ingestion and processing of the direct broadcast downlinks from the EOS Terra & Aqua (MODIS), Suomi-NPP & NOAA-20 (VIIRS), NOAA & MetOp (AVHRR) meteorological satellites.

- The satellites used are all free-to-air (i.e. no licensing costs), providing the multiple medium resolution (250 metre to 1 kilometre), visible, near-, shortwave- and thermal-infrared imaging radiometre channels required for routinely detecting forest and wild fires.
- Typically, four to six satellite overpasses per day from four satellites, with swath widths of between 2,300km and 3,000km, are used to detect and monitor fires multiple times every day within ~3,000km of the satellite ground station.
- Forest and wild fire products include maps of radiative power, burn scar, aerosol concentrations, smoke / ash and textual information of the detected fires in text, Shapefile and other GIS formats.
- Is used to deliver many other medium resolution environment products including cloud mask, type and optical properties, vegetation indices, aerosols, atmospheric vertical profiles, land and sea surface temperature, land use classification, snow and sea ice and ocean colour.
- The solution is a complete standalone automated end-to-end system from scheduling for reception of satellite overpasses to delivery of forest and wild fire detection products to geospatial databases and web-sites.
- The solution includes a fully featured visualisation system for display of satellite imagery and products, along with tools for re-projection, re-sampling, aggregation, re-formatting and delivery of products.
- eOsphere offers a complete solution including requirements specification, delivery, installation and commissioning of all equipment, full integration with end-user's infrastructure, training and ongoing maintenance and support. The user does not need existing or additional IT infrastructure.

Case studies

National Observatory of Athens (NOA), Athens, Greece - as part of the EU Project BEYOND: Building a Centre of Excellence for Earth Observation Based Monitoring of Natural Disasters, in 2014. The system is now used as part of the European Forest Fire Information System (EFFIS), a component of the Copernicus Emergency Management Service Risk and Recovery Mapping, routinely delivering forest fire products covering Central and Eastern Europe, the Mediterranean, Middle East and North Africa to the EFFIS system.

Supplied to the Centre for Multidisciplinary Integrated Technologies for Field Monitoring (FIMO) at the University of Engineering and Technology (UET), Vietnam National University (VNU), Hanoi, Vietnam, in 2014. FIMO is a university teaching

and research department specialising in field monitoring techniques, including remote sensing, with particular emphasis on forest fire and air pollution monitoring, as part of the national disaster monitoring system.

Organisation overview

eOsphere was established in 2001 and is strongly focused on solving real remote sensing problems for a range of customers and end users. Key application areas include the provision of affordable satellite ground receiving stations for environmental and hazard monitoring.

Figure 8: The eOsphere satellite ground system, installed at the National Observatory of Athens



EASOS Data Discovery Hub (Geocento)

Overview

EASOS Data Discovery Hub is a user friendly, one stop shop, web platform that can be used to discover, select, order, receive, visualise and download Earth observation (EO) data, with convenient filtering tools. It provides efficient and independent access to imagery from the range of image suppliers to help monitor and assess areas of concern to authorities in terms of illegal activity, accidents and natural disasters.

www.geocento.com

Solution benefits

- Ongoing access to EO data collected by all the major image suppliers, including free EO data, providing flexibility in covering events and locations with the most appropriate EO data. For example, EO data that can be tasked to identify oil spills through cloud, to data that can monitor deforestation.
- User friendly, one stop shop, web platform that can be used to discover, select, order, receive, visualise and download EO data, with convenient filtering tools.
- Subscription based service that allows access to EO data from multiple sources, without the need to select in advance, avoiding tie in to single supplier solutions.

Key technical features

- The platform has information on over 56 million existing EO images, a multi-mission planning engine that provides details on future imaging opportunities for image tasking and access to free imagery from Copernicus and Landsat.
- Standalone, cloud-based web platform that can be white labelled, powered by an application programming interface (API) from Geocento.
- EO data, including optical and radar, ranging from 30 metre resolution down to 25 centimetre resolution.
- Combines both free EO data and commercial EO data, including optical and radar, ranging from 30 metre resolution down to 25 centimetre resolution.
- Scans image supplier catalogues multiple times a day to create "meta-catalogue" of existing EO data that is then made discoverable via API. The Geocento online service (API) underpinning the platform receives 4500 search requests for imagery per day.
- Includes multi-mission planning for satellite imaging opportunities and planning constraints for forward planning of new acquisitions, plus includes (where published) image acquisition plans.
- Includes order management application for image purchases, and direct download of non-commercial imagery, along with e-commerce for PAYG.
- Image hosting, full resolution viewing and download, as well as an image sample server that provides access to example imagery before you buy.
- Hosting for image processing algorithms is supported.

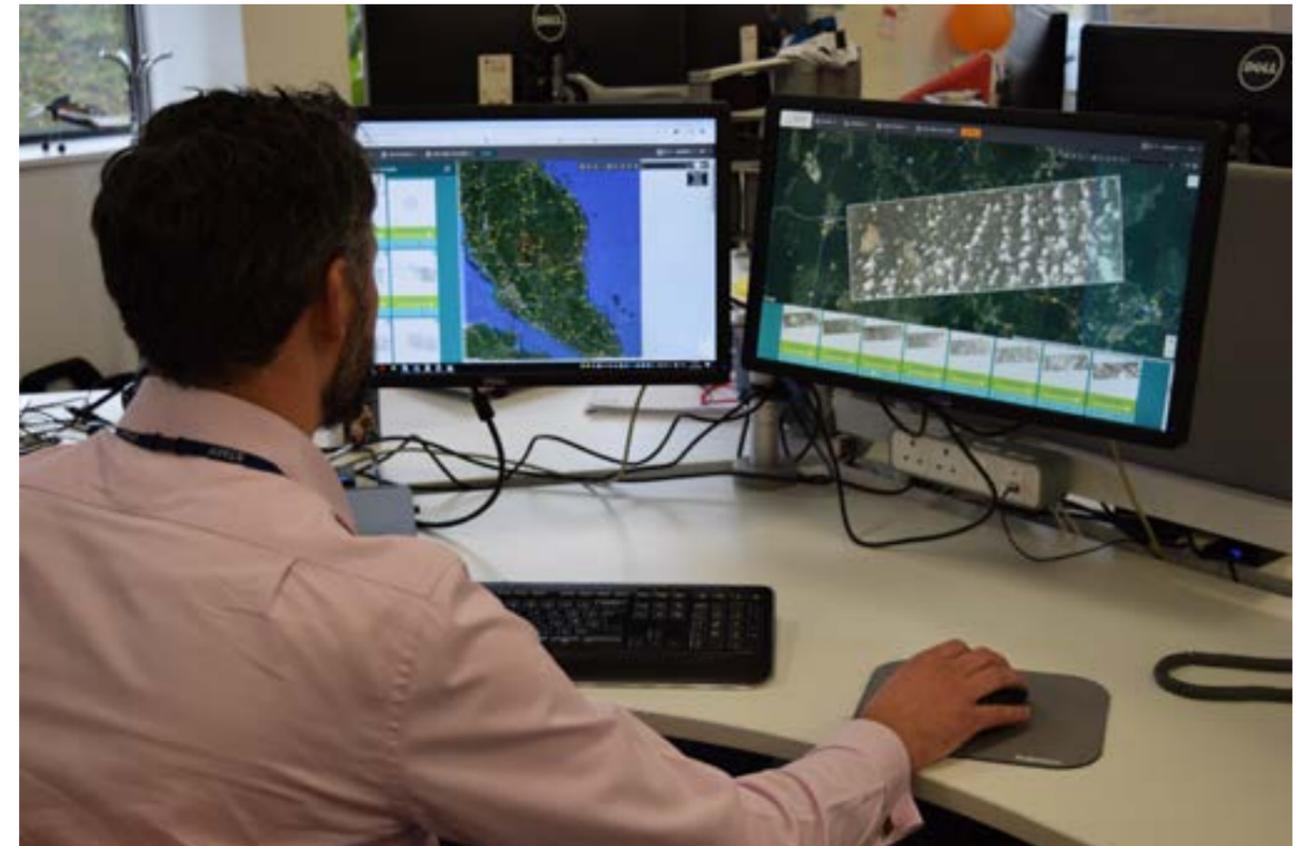
Case studies

Geocento is used as the platform for planning and accessing EO data in the EASOS project in Malaysia supported by IPP. The project aids the government across the forestry, marine pollution and disaster resilience (flooding) domains. The platform was used recently to identify suitable imagery related to deforestation in Malaysia, with one result being the detection of an illicit timber processing shed.

Organisation overview

Geocento's mission is to "make imagery accessible". It has pursued this goal by developing web-based technologies to access imagery (currently used under license by several industry leading EO companies), developing a wide network of satellite (and also airborne) image suppliers, and using digital marketing to create a rapidly growing pipeline of imaging opportunities around the globe. The company is based in Harwell with a subsidiary in Villafranca del Castillo, Spain.

Figure 9: The Geocento EarthImages platform, showing Malé Maldives, courtesy of Airbus



Rapid Flood Mapping Service (RFMS) (Telespazio VEGA UK)

Overview

Rapid Flood Mapping Service (RFMS) provides a quick response in mapping flooded areas in the immediate lead up - and during - a severe weather event e.g. torrential rainfall. Targeted at national disaster resilience agencies and the first responder community, RFMS utilises high-resolution radar data that is unaffected by clouds and is capable of delivery of actual observed flood extent data every 12 hours. Provides maps of the true distribution of visible flood water, enabling quick and efficient response, recovery and relief.

<http://telespazio-vega.com/>

Solution benefits

- Near-real time mapping of flood extents with possibility of updates every 12 hours. Depending on ground station availability, flood extent layers can be produced within four to five hours of image acquisition by the satellite.
- Reacts to compatible automatic alerts from national weather agencies or an instruction from a customer.
- Works in most weather conditions including cloud.
- Can be enabled over rural and urban areas.
- Use of the COSMO-SkyMed constellation of four satellites means that flood maps derived from the satellite images can be available the day after an alert of impending flood is received.
- Accurately maps the true distribution of visible flood water, enabling quick and efficient response, recovery and relief.

Key technical features

- Satellite derived spatial dataset that highlights the true distribution of visible flood water in both vector and raster formats.
- Uses radar which works at night and can penetrate clouds.
- Uses tasked high-resolution commercial COSMO-SkyMed radar data, in either Spotlight (1 metre) or StripMap (3 metre) modes to match customers' needs.
- Sentinel-1 data can also be used for flood mapping when available (Sentinel satellites cannot be tasked specifically by the user).
- Can be used as a standalone product with datasets being delivered through a web platform. Alternative methods to match customers delivery needs can also be used e.g. File Transfer Protocol (FTP) and Geoserver.
- High to medium precision mapping can be produced using various Digital Terrain Models (DTM) to match customers' needs and budget.

Case studies

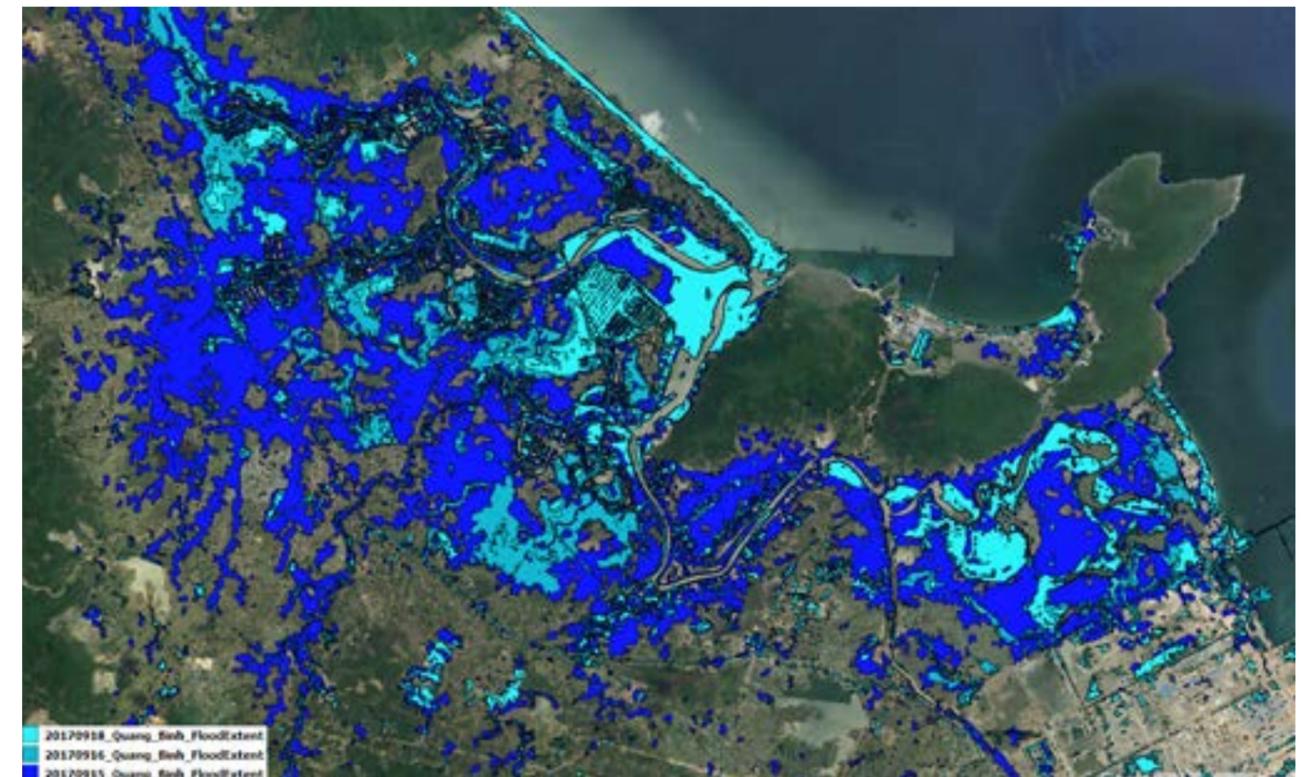
Telespazio developed the capability via the UK Space Agency's Space for Smarter Government programme and adapted it to provide data and value-add services for two IPP projects. In Vietnam, flood waters were monitored in Quang Binh (see figure), and the system is ready to respond to further flood events during the 2019 wet season. The aim is to react to typhoon alerts in Vietnam and map the flood events that follow. Also implemented in Earth and Sea Observation System (EASOS) Floodwatch with Satellite Applications Catapult for Malaysia.

Organisation overview

Telespazio VEGA UK Ltd (TVUK) is a highly experienced consulting, technology and engineering services business, which supports satellite operators and manufacturers worldwide and helps other organisations benefit from space

data and services. Based in the UK, it is a wholly owned subsidiary of Telespazio SpA, and employs approximately 140 highly qualified staff with a wide experience in Science, Earth Observation, Geo-Information, Navigation and Telecoms Projects.

Figure 10: Flood extent map for Quang Binh, Vietnam, over three dates



Monitoring of disaster-impacted regions when disaster strikes to improve coordination of response teams and assets

Humanitarian Rapid Mapping Service (UNOSAT)

Overview

UNOSAT provides rapid satellite imagery analysis during natural and environmental disasters to improve situational awareness and support relief efforts. Our staff is able to process requests on a 24/7 basis year-round. Output products include maps, GIS-ready data, statistics and reports. They are shared with governments, UN agencies and other actors.

www.unitar.org/unosat

Solution benefits

- Enhanced situational awareness - know how various areas are affected by the disaster as well as who and what is at risk to ensure an efficient disaster response.
- Wide range of products - assess and map the impact of many types of disaster including floods, fires, chemical waste, oil spills, earthquakes, storms, landslides and volcano eruptions.
- All disaster stages - rapid risk assessments to rapid damage estimation, humanitarian access and reconstruction monitoring.
- Rapidity - a plan scheduling imagery collection and analysis is sent within a few hours, and our first maps are usually shared within three days, 24/7 year-round.
- Continuous follow-up - sharing of additional products as the situation evolves and as new information from the field allows for data refinement.
- Access hard-to-reach areas - satellite imagery provides information about areas that would normally be too dangerous or too costly to access.
- Clear and objective information - as part of the United Nations, UNOSAT strives to provide unbiased and unambiguous information.
- Coordinated approach - to prevent redundancy, mapping efforts are coordinated with other

organisations providing satellite analysis through the Global Disaster Alert and Coordination System (GDACS) Satellite Mapping Coordination System (SMCS).

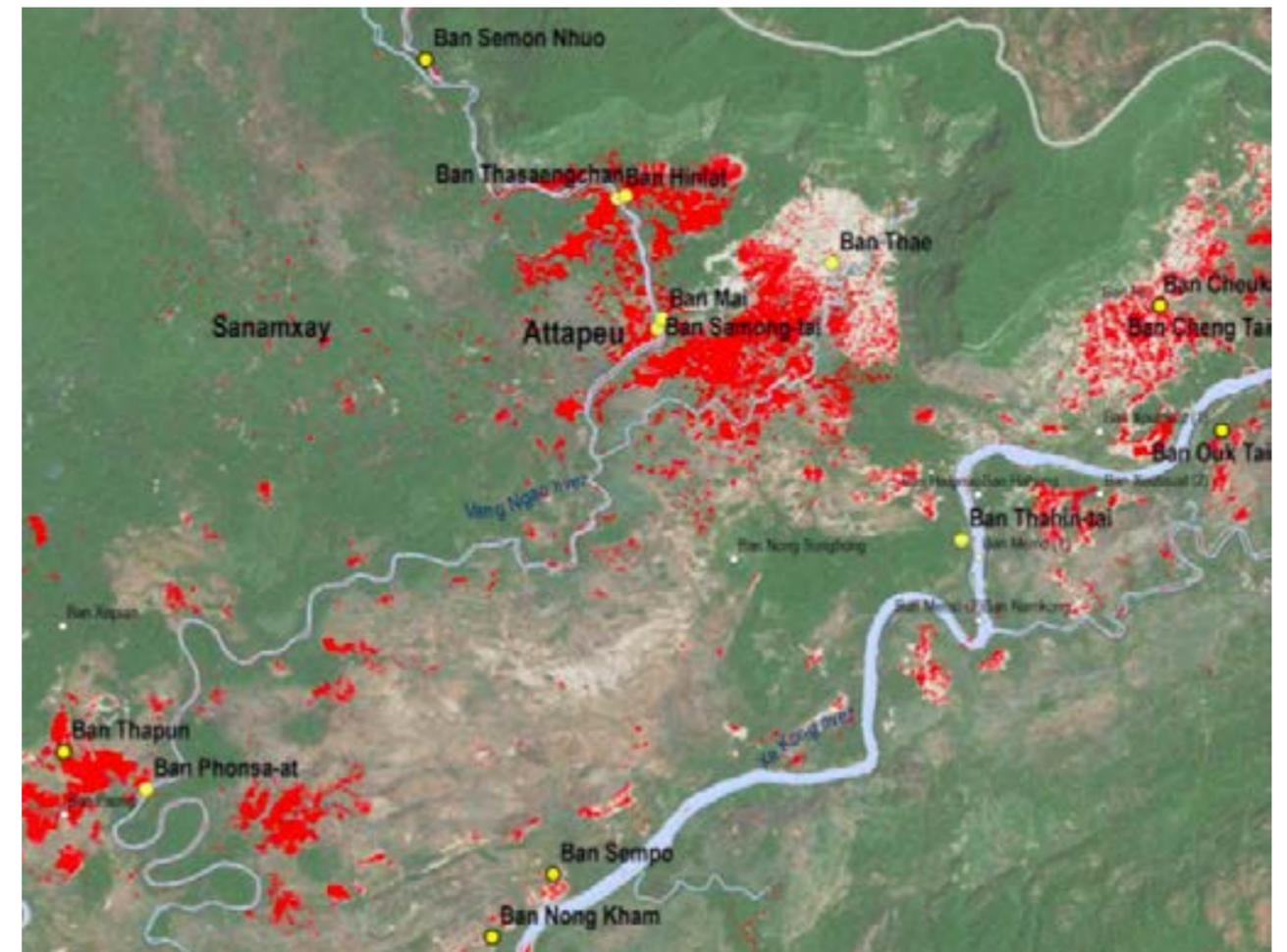
Key technical features

- Free - this service is free of charge for UN Agencies, UN Member States and NGOs.
- Multiple data sources - uses optical and radar imagery ranging from very high resolution (~30 centimetre) data from commercial providers, to medium resolution (~30 metre) data from Landsat, depending on needs.
- Privileged access to imagery - able to obtain imagery using the International Charter: Space and Major Disasters, as well as commercial imagery using in-kind contributions.
- High update frequency - uses the most recent data available and updates the products accordingly, providing at best same-day imagery.
- Multiple levels of detail - products can cover territories at the regional scale, national scale and local scale to answer needs.
- Flexible formats - depending on the nature of the disaster and the capacities of the targeted audience, we can provide simple maps and reports accessible from a web browser, raw GIS data and online live maps reflecting the evolution of the situation.
- Strong link with the field - the UN-Adaptive System for Image Communication over Global Networks app (UN-ASIGN) to allow users to directly upload field photos on our live maps.
- Cutting-edge infrastructures - UNOSAT is hosted at the European Organisation for Nuclear Research (CERN) in Geneva and benefits from its outstanding IT infrastructures to store imagery and host online live maps.

Case studies

On 23 July 2018, Saddle Dam D collapsed in Lao PDR, causing flash floods in nearby areas. The next day the World Food Programme (WFP) requested UNOSAT to provide satellite imagery analysis and support the humanitarian response. On the same date, UNOSAT triggered the collection of radar imagery over the area of interest and started to analyse the situation. UNOSAT continuously provided details on the increase in inundated areas and the potential impact on villages.

Figure 11: Satellite-detected flood waters in Lao



Organisation overview

UNOSAT is a centre of excellence for satellite imagery and geospatial analysis within the UN system. We focus on the provision of satellite imagery analysis and adaptive geospatial solutions to both UN sister agencies, and those non-governmental and international organisation active in mainstream international endeavours such as humanitarian assistance, human rights, and development in general. As a part of UNITAR, we undertake training and research activities.

SIBELIUs (eOsphere)

Overview

Improved severe-weather resilience for herding communities using satellite Earth observation (EO). The solution provides improved capacity for distributing new and upgraded environmental information products. Solution provides information regarding pasture, snow and drought, including absolute regional averages, anomalies and trends, to stakeholders supporting herding communities including the insurance sector, government agencies coordinating livestock and land use, and directly to the herders through text messaging.

www.eosphere.co.uk

Solution benefits

- Solution provides information regarding pasture, snow and drought, including absolute regional averages, anomalies and trends.
- Improved products will have complete country coverage, provided more frequently, for longer periods of the year, more accurately and with improved spatial resolution.
- Benefits for the herding community will be achieved by using improved environmental information through three main channels: (1) the insurance sector, (2) government agencies coordinating livestock and land use, (3) directly to the herders through text messaging.
- Applicable for environmental monitoring especially for pasture, snow and drought in countries with herding communities.

Key technical features

- A Mongolian Open Data Cube will form a key component of the SIBELIUs infrastructure which will allow time series of EO data and derived products to be queried by staff at the country's Meteorological Institute and other Government agencies.
- The SIBELIUs solution makes use of free and open EO data making it sustainable, in particular Sentinel-2 and Landsat 8.
- The SIBELIUs solution is aiming to update environmental products every two weeks, which meets requirements for relatively slowly evolving conditions such as pasture.

Case studies

SIBELIUs, supported by IPP, will deliver greater severe weather resilience for herders by providing new EO derived environmental products to key stakeholders supporting herding communities in Mongolia. SIBELIUs is building capacity at Mongolia's National Meteorology Institute (NAMEM) to provide new and enhanced environmental products. SIBELIUs will channel its benefits through three existing networks:

- developing new insurance products for herders
- support for government agencies for managing reserve regions
- distributing products via a mobile phone text messaging service

Organisation overview

eOsphere was established in 2001 and is strongly focused on solving real remote sensing problems for a range of customers and end users. Key application areas include the provision of affordable satellite ground receiving stations for environmental and hazard monitoring.

Figure 12: Mongolian pastoralist



Identify and value assets for insurance, including buildings, infrastructure and agriculture/livestock

SatComms for Climate and Disaster Resilience (Avanti)

Overview

Communication between emergency services, disaster responders and the public is critical in delivering fast, meaningful responses during emergencies or disasters. Avanti supplies high throughput fixed and mobile satellite connectivity providing secure, reliable, always-on voice and data communications in emergency situations.

www.avantiplc.com

Solution benefits

- Satellite communications provide a secure, reliable, always-on communications infrastructure.
- Supports governments and public safety services to maintain command & control, situational awareness and continuity of operations in chaotic emergency situations.
- Supports operations where terrestrial communications are absent or compromised due to damage by natural disasters.
- Offers rapid deployment to emergency scenes with man-portable or vehicle communications.
- Augments the coverage, capacity & resilience of land radio networks.
- Provides resilient backbone communications to headquarters & critical sites.
- Supports fast network restoration post-emergency.

Key technical features

- Avanti's HYLAS satellite fleet exclusively utilises Ka-band High Throughput Satellite (HTS) technology delivering capability across Europe, Africa and the Middle East with many operational advantages over legacy very small aperture terminal (VSAT) systems.
- Increased throughputs with speeds in excess of 50Mbps down and 10Mbps up.
- High spectral efficiency dramatically reducing bandwidth cost for users.
- Local Wi-Fi and cellular (mobile) breakouts.
- Support for multiple users, devices and rich data applications such as voice-over-IP, video conferencing and situational awareness platforms.
- A range of VSAT terminal solutions for fixed, deployable and mobile communications.
- Small form factor terminals (<70cm diameter) with rapid deploy and self-install features offering high capability to field teams on short notice.
- SatComms for emergency vehicles enabling communication on-the-pause and on-the-move.
- Full national coverage no matter how remote the location.
- Interconnection for widely distributed sites and interoperability for disparate networks.
- Simple to use systems that IT technicians can be trained to install, operate and support.
- Provision of engineering services for solution design and delivery, installation, training, maintenance and integration with existing IT infrastructure.

Case studies

Avanti Communications is leading the Satellite Enablement for Disaster Risk Reduction in Kenya ("SatDRR Kenya") project, supported by IPP. The project supports the Kenyan Ministry of Interior, Red Cross Society and other agencies by providing secure fixed and mobile satellite communications via Avanti's Ka-band satellite, HYLAS 2, for emergency situations such as conflict, famine, floods and disease outbreaks. The SatDRR Kenya satellite communications network enables emergency responders and humanitarian organisations to act quickly and effectively on the ground. The project also provides Earth observation (EO) data to improve Kenya's pre- and post-disaster strategy and planning, as well as capacity building and knowledge transfer services for users.

Consortium members include: Torchlight Group Limited, Airbus Defence and Space & Global Radiodata Communications.

Organisation overview

Avanti has invested US\$1.2 billion in the latest Ka-band satellite technology and shaped it to meet our customers' aspirations:

- governments that want to empower their digital economies
- mobile operators that wish to bring ubiquitous coverage to their customers
- enterprises that want to grow through digital productivity
- security forces wishing to protect their sovereignty
- people and communities that want to cross the digital divide

Through our HYLAS satellite fleet, Avanti have extensive coverage of the UK, Europe, Middle East and Africa. With market-leading products, Avanti work with local and international service providers to connect homes, grow businesses, extend mobile networks and work closely with governments.

Figure 13: Avanti HYLAS satellite fleet combined coverage



*Communications
(voice, messaging and internet)
when networks are damaged or absent*

SatComms for Natural Disasters (Inmarsat)

Overview

Inmarsat provides in-situ powerful but easily deployable equipment, including Inmarsat's new Global Xpress (GX) satellite equipment during disaster response scenarios. Global Xpress (GX) terminals allow communications at speeds not previously possible for emergency response teams and mobile BGANs allow responders to provide in situ impact assessments. Rapid deployment at the disaster area provides the national coordinating authority with the infrastructure to run national and local disaster response communications, at scale.

www.inmarsat.com

Solution benefits

- For natural disaster affected areas communications are frequently severely damaged, and impact assessment and response are predominantly paper based.
- Inmarsat and its partners have been working closely with governments to enable urgent communications deployment to affected areas.
- Dramatic improvements in the efficiency of data collection, benefits distribution as well as command and control processes.

Key technical features

- Global Xpress (GX) terminals allow communications at speeds not previously possible for emergency response teams and therefore provide a step change for disaster response.
- Mobile BGANs allow responders to provide in situ impact assessments enabling faster responses and support to affected inhabitants.

- An innovation around Global Xpress allows advanced bandwidth management to improve usage efficiency and thereby keep costs to reasonable levels.
- Bandwidth management of the SatComms solution is critical as there could be some users wasting capacity with heavy video downloads and other bandwidth consuming apps.

Case studies

Working with the Philippines Governments Department of Social Welfare and Development, that co-chairs the National Disaster Reduction and Response Council that coordinates government inter agency responses following a disaster event, in the Philippines, supported by IPP. This provides the Philippine government with a resilient capability to rapidly restore communications and increase command and control of recovery operations within 24 hours of occurrence of a disaster.

Organisation overview

As the pioneer and world leader in mobile satellite communications, Inmarsat has been powering global connectivity for nearly four decades. We provide governments, commercial enterprises and humanitarian organisations with mission-critical voice and high-speed data communications land, at sea and in the air.



Agriculture

Agriculture

The global agriculture sector faces many challenges today, many of which are more acute in developing countries. Low agricultural production remains a major issue for the agriculture sector in developing countries and is a contributing factor to on-going hunger and malnutrition in these countries. Concurrently, the growing demand for food and decreasing availability of land for farming caused by global population growth is a major issue. Unpredictable and extreme weather patterns, loss of land and changes in growing conditions caused by climate change presents significant challenges for the agriculture industry globally. Access to natural resources such as land and water is under increasing pressure and the unsustainable use of such resources is a major challenge for the agriculture industry.

The space sector is well placed to contribute new types of information and tools to form part of the solution to the major challenges facing the agriculture sector today, in both developed and developing countries. The unique benefit that space solutions provide is global, repeatable, accurate and scalable data that can be used to deliver high value insights, cost effectively, about how issues are impacting our planet. This allows action to be taken to make a positive impact in many different areas and this represents a significant opportunity for developing countries.

Space solutions support increased production through Earth observation (EO) improving the accuracy and relevance of decision support tools and affordability of credit products. EO enables supply chain optimisation to reduce losses. EO improves the range of decision support tools to

ensure sustainable management of environmental resources and supply chain traceability. EO also improves the accuracy of disaster early warning systems and affordability of insurance.⁶

See also UK Space Agency International Partnership Programme's report **Space for Agriculture in Developing Countries**.⁷

The space sector provides the following solutions for agriculture use cases:

Forecast weather, including flood and drought, and monitor crops, to improve agricultural decisions for increased yields

- **Crop Observation, Management & Production Analysis Services System (COMPASS) (Rezatec)**
- **Drought and Flood Mitigation System (DFMS) (RHEA)**
- **Earth Observation for Flood and Drought Resilience (Airbus Defence and Space)**
- **Ecological Production Management Information System (EcoProMIS) (Agricompass)**
- **Grape Production Climate Resilience (Rothamsted Research)**

Assess risk of outbreak and spread of pests

- **Advanced Coffee Crop Optimisation for Rural Development (ACCORD) (Earth-i)**
- **Pest Risk Information Service (PRISE) (CABI)**
- **Pest Prediction (CABI)**
- **WeatherSafe Platform (WeatherSafe)**

Forecasting agricultural productivity to improve agricultural supply chains

- **Agriculture Simulations (Sensonomic)**
- **Agri-track (Environment Systems)**
- **Land Resource Evaluation Service for Agricultural Activity and Production (Booker Tate)**
- **Land Cover® plus Crops (Remote Sensing Applications Consultants)**

⁶ UK Space Agency & Caribou Space. 'Space for Agriculture in Developing Countries'. <https://www.spacefordevelopment.org/library/space-for-agriculture-in-developing-countries/>. Accessed December 2018.

⁷ Same as above



Crop Observation, Management & Production Analysis Services System (COMPASS) (Rezatec)

Overview

The Crop Observation, Management and Production Analysis Services System (COMPASS) uses satellite Earth observation (EO) data to help smallholder farmers manage their sugar cane and wheat agriculture. It helps optimise crop productivity by identifying factors that cause the yield gap between crop potential and actual field performance. It also provides agronomic support to advisory services, agribusiness, farmer co-operatives, crop insurers and governments.

www.rezatec.com/resources/projects/mexican-compass/

Solution benefits

- Improved productivity for wheat and sugar cane smallholder farmers.
- Improved resource use efficiency and hence lower emissions of fertiliser nitrogen and greenhouse gases (GHGs) to the environment.
- Improved market function as farmers, traders, government and other stakeholders will have improved information on likely crop yields, allowing much better planning of crop marketing, which helps to stabilise incomes.
- Regular updates with greater accuracy of crops status than can be achieved on the ground for thousands of farms.

- Crop progress effectively benchmarked against comparator farms and local and regional averages to give farmers the information they need to improve performance.
- Crop growth map covering all the crops in the area supports industries to plan marketing of crops and for insurance companies and government to plan insurance cover.
- Assist farmers in crop management activities, including optimum sowing period and optimum irrigation schedule.
- Irrigation bodies, processors and crop insurance companies gather agricultural data through COMPASS, saving costs spent on third party surveyors to gather this information manually.
- Assist crop insurance companies to monitor each customer's (farmer) crop management activities and through satellite's crop health status thereby help assessing appropriate discount rates to individual farmers based on their crop management performance.
- Assist crop insurance companies with updates on associated farms and review historical data during claims.
- Assist wheat processors with expected yield from the associated farmers within the supply chain for plant production/process optimisation.
- Assist irrigation bodies to evaluate and map supply demand to the associated farm lands and optimise operation with accurate information provided by the farmers through the Compass mobile app.

Key technical features

- Uses Sentinel-2 EO data, in combination with commercial EO data.
- Uses Sentinel-2 multi-spectral data, with 12 spectral bands, at 10 metre resolution. This data has a five-day revisit period, which makes it ideal for monitoring crop yield.
- EO data is combined with 30 site-specific parameters grouped by soil, management, inputs and environment that determine the production efficiency of wheat and sugar cane crops, e.g. soil type, harvest date, disease control and temperature.
- Assist the wheat and sugarcane farmers to monitor their crop health every week with satellite and crop model data analysis.
- Advises farmers of the potential gap in their crops forecast yield versus maximum potential yield, optimal sowing and irrigation dates.
- Provides a log of crop management activities and reminders from sowing until harvest.

- Farmers just require a mobile phone or desktop plus an internet connection. No other IT infrastructure is required.

Case studies

Rezatec is providing COMPASS in Mexico to help smallholder farmers growing sugar cane and wheat to improve crop management, in partnership with CIMMYT and COLPOS. Mexican farmers need to improve crop productivity and stabilise their incomes to facilitate rural community economic development.

Organisation overview

Rezatec helps businesses improve the management of their land-based assets by providing intelligent insight based on analysing a complex array of geospatial information, including advanced EO data. High-value landscape insights are provided to clients via our web portal giving exclusive access to pre-packaged and custom-built landscape intelligence products. Through custom dashboards, users can upload, download, add or edit data modelling and manipulate the visualized map with show/hide data layers.

Figure 14: COMPASS farmers app showing a wheat farmer's crop health status (left) and advising optimum sowing dates with expected yield range in tonnes/hectare (right)



Forecast weather, including flood and drought, and monitor crops, to improve agricultural decisions for increased yields

Drought and Flood Mitigation Service (DFMS) (RHEA)

Overview

The Drought and Flood Mitigation Service (DFMS) provides robust meteorological, hydrological, and other Earth observation (EO) information as observations, forecasts, and data archives. Products for monitoring, near and long-term planning, and historical analysis are provided through an on-line portal to users in the government, commercial agriculture, and development sectors. Focussed on reducing the impact of drought and floods, DFMS enables improved agricultural management and preparing for weather conditions in general.

www.dfms.co.uk

Solution benefits

- DFMS delivers reliable and actionable weather and crop data where up to now it has been unavailable, inaccessible, or of varying quality.
- As a service, using DFMS only requires an internet-connected device, removing the need for capital investment and expert maintenance & development skills.
- DFMS empowers those who cover last mile agriculture with the information to plan and execute their actions better, e.g. with DFMS managers of outgrowing schemes can direct their smallholders to plant, spray, and harvest under optimum weather conditions.
- Weather and hydrological forecasts on two, seven, and 90-day time scales.
- Space-based monitoring of crop health, water extent and surface temperature and more, at spatial resolutions down to 10 metre.
- Access to monitoring data and forecast archives, going back up to 30 years.

- Includes customisable threshold alarms, for example rainfall levels or drought risks.
- Based on a highly scalable and replicable cloud-based platform.

Key technical features

- No software to install - on-line access via web browser.
- Customisable user interface - users select the maps and charts they want to see.
- Meteorological forecast provided by the UK Met Office using MOGREPS and GloSea.
- Hydrological baseflow, runoff, evapotranspiration, and soil moisture deficit forecasts and associated drought and flood risk indices.
- Normalized difference vegetation index (NDVI) and burned area index (BAI) at 10 metre spatial resolution. Soil moisture and water extent and height at 20 metre resolution and land surface temperature at one km.
- Input data sources include SMOS, MODIS and Sentinel-1 and 2.
- Based on Open Data Cube technology, the open source software to manage satellite data, backed by CEOS, USGS, and the UK's Satellite Applications Catapult.
- Underlying platform uses any type of EO data (open or commercial; in-situ or remote; optical, radar, LIDAR, etc.) and can host processing algorithms and models.

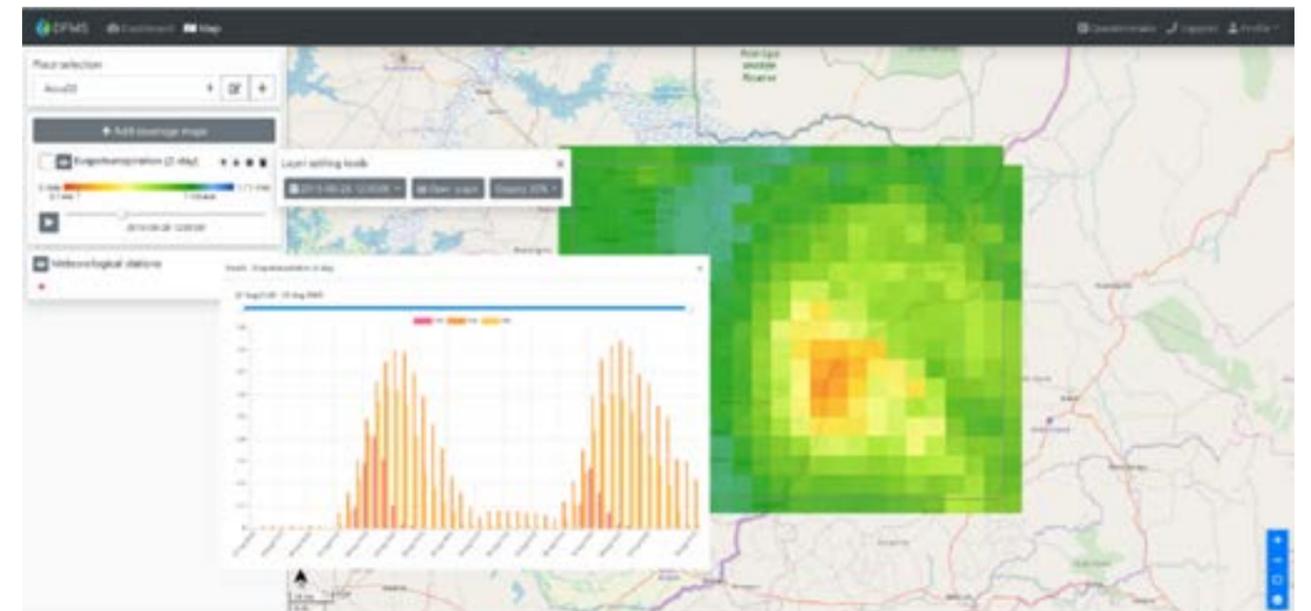
Case studies

DFMS will be provided as a service to the Ugandan Government. It will enable government officials to provide the Ugandan people with practical information that will help them respond to the effects of climate change. The aim is to use satellite and ground-based data, combined with drought and flood models, to help people respond to effects on agriculture. The initial development of DFMS was supported by IPP.

Organisation overview

RHEA Group is a professional engineering and solutions company, providing bespoke engineering solutions, system development and security services to space sector and other critical national infrastructure organisations. RHEA employs over 400 staff, located globally across 11 countries. RHEA operates DFMS from the UK, supported by a consortium of UK organisations, and markets and supports DFMS in Uganda through a local agent.

Figure 15: DFMS showing a 2-day evapotranspiration forecast for the Mount Elgon area



Earth Observation for Flood and Drought Resilience (Airbus Defence and Space)

Overview

Earth Observation for Flood and Drought Resilience focuses on alleviating poverty for farmers that currently have little or no access to insurance by demonstrating the efficacy of Earth observation (EO) data for the micro-insurance market. It also focuses on building social and economic resilience to drought and flood by providing economic impact decision-support information at a national level about where best to make infrastructure investments or land use changes.

www.intelligence-airbusds.com/land-administration

Solution benefits

- The information provided will support decision making and the development of improved insurance products that pay out to people in greatest need at the required time, using indices that more accurately reflect the incidence of flood and drought than current measures provide.
- Reasonable payouts in due time will prevent farmers from selling animal stock to subsidise their incomes from crop failure due to drought or flood.
- These improved insurance products, once successfully demonstrated, shall increase the overall take-up of insurance, allowing micro-insurance companies to spread risks and reduce costs.
- The product is an independent, verifiable information source, thus free from corruption or bribery, which are significant factors restricting the development of this sector due to reluctance of both insurers and customers.
- The solution provides granular information on the likelihood of flood or drought and supports the assessment of the socio-economic impacts of these events thus assisting policy makers targeting resilient economic development.

- The information enriches understanding of vulnerability, by using new information to explain how floods and droughts impact upon people.
- This enhances the value of existing information, both meteorological and socio-economic, providing independent verification of flood and drought events and situational awareness of impacts on the ground.

Key technical features

- The solution uses multiple low to medium resolution optical satellite EO data sources including Airbus commercial DMC data, combined with free Landsat, MODIS and Sentinel data.
- The product delivery frequency is every 10 days, with a product resolution of 20 metre.
- The solution provides the ability to view index-based drought impact products relevant to different insurance companies or end users (farmers). This includes analysis of drought characteristics, the nature and extent of historical events and projected future scenarios of climate and land cover change.
- The Future Flood Explorer (FFE) model enables results to be interpolated for different policy responses and climate scenarios.
- The Computational General Equilibrium (CGE) model is used as the primary tool to understand the economic impacts of decreases in crop production.

Case studies

This solution will be further tested during 2019, in Kenya, for both the micro-insurance market and for providing economic impact decision-support information at a national level.

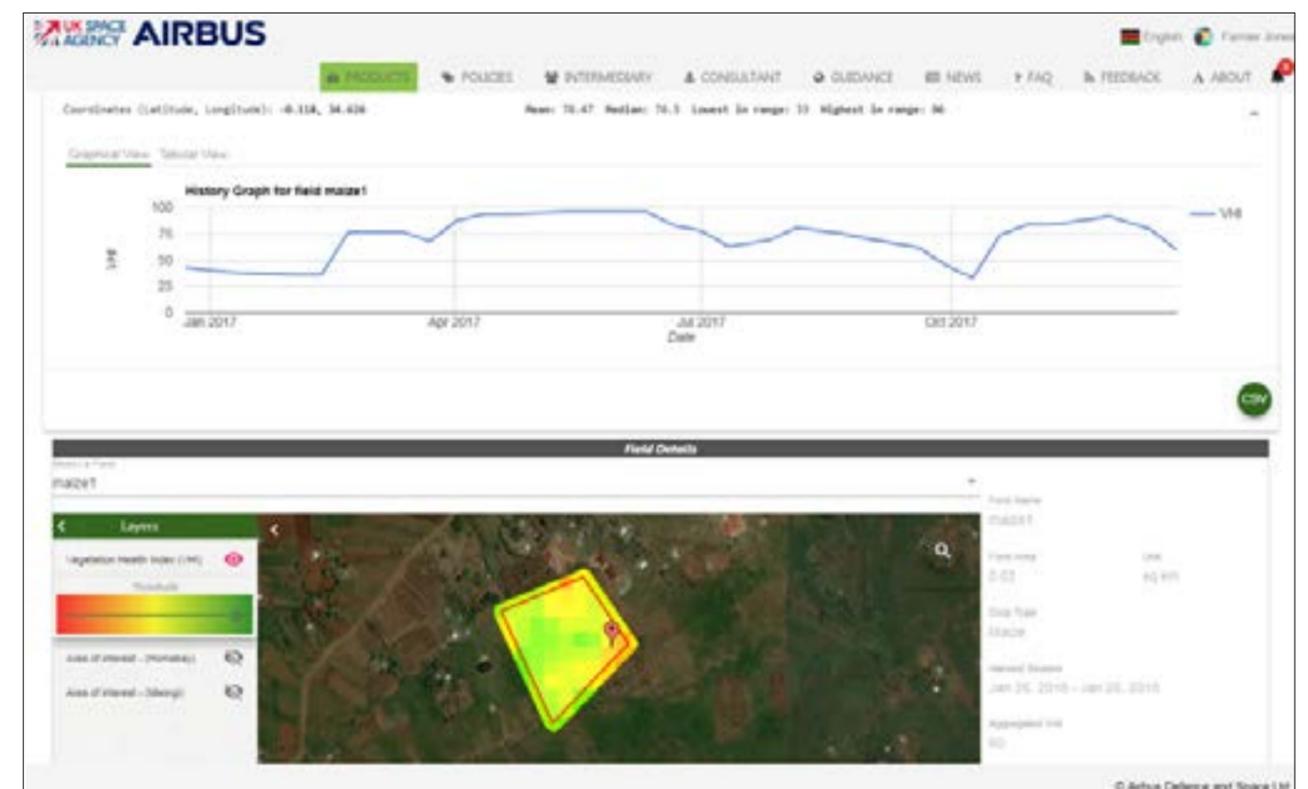
Organisation overview

Airbus Defence and Space - Intelligence UK, provides satellite image acquisition and timely processing, interpretation, analysis and management, as well as hosting of geospatial

data and consultancy services for many sectors including: central and local government, land administration, agriculture, forestry and environment. Products and services delivered from our four UK offices provide solutions for our customer base around the globe.

Consortium members include: Vivid Economics, Sayers and Partners Ltd, Oxford University - School of Geography and the Environment and Machine Learning Group.

Figure 16: Vegetation Health Index (VHI) for a selected farmland over a one-year period⁸



⁸ The bottom panel displays the VHI values as a heat-map with 20 metre square resolution at the end of the year. The graph on the top panel shows how the index has changed over the year indicating different levels of vegetation health. The value is low at the start of the year when the crop had just been planted. As the crop season progresses, the vegetation index value rises and peaks during the May and June months.

Ecological Production Management Information System (EcoProMIS) (Agricompas)

Overview

The EcoProMIS platform is developed per crop and country to address the economical, technical and environmental challenges faced by a wide range of agricultural stakeholders. By combining satellite Earth observation (EO) with comprehensive crop production data we create in near real-time valuable knowledge services for growers and a range of eight commercial decision support services for the entire value chain.

www.agricompas.com

Solution benefits

- Integrating EO in the EcoProMIS platform provides accurate, timely and affordable information on crop conditions on a large geographic scale.
- User agreements with growers, affordable and tested data collection technology, clever algorithms and a solid IT infrastructure secures reliable, detailed, timely and comprehensive crop production data.
- Growers are provided with advice regarding crop management, inputs, soil and environmental information to improve decision making.
- Decision support modules target various challenges, e.g. climate change and mitigation, competitiveness, pollution and socio-economic inequality.
- These modules are: Productivity, Insurance, Finance, Supply Chain, Food Security, Environment, R&D and Data Mining.
- Growers sign user agreements for access to free crop production knowledge in return for collecting and sharing part of the required data.
- Highly scalable to other crops and geographies.
- Improving gross margins as data collection tools

get better and additional services are marketed.

Key technical features

- Continuous collection of grower data including soil, inputs, management and biotic environmental data, during the crop production cycles.
- Near-real time processing of crop production data and crop performance data with crop modelling, machine learning and artificial intelligence.
- Real time collection of weather station data per grower and production unit (i.e. field) including: camera traps can be used for monitoring wildlife, eddy covariance flux systems to measure carbon dioxide and methane emissions, and static chambers to measure nitrogenous oxides emissions.
- The platform is cloud based and is designed on Microsoft Azure ICT infrastructure and does not require the user to have IT infrastructure e.g. servers. It is accessible via desktop/laptop and mobile devices via a web portal and via alerts and reports.
- Uses free EO data from Sentinel and commercial EO data depending on the level of service provided.
- Uses optical data Sentinel-2, radar for cloudy and night time from Sentinel-1, Sentinel-5 data for atmospheric composition, and unmanned aerial vehicle (UAV) drone data.

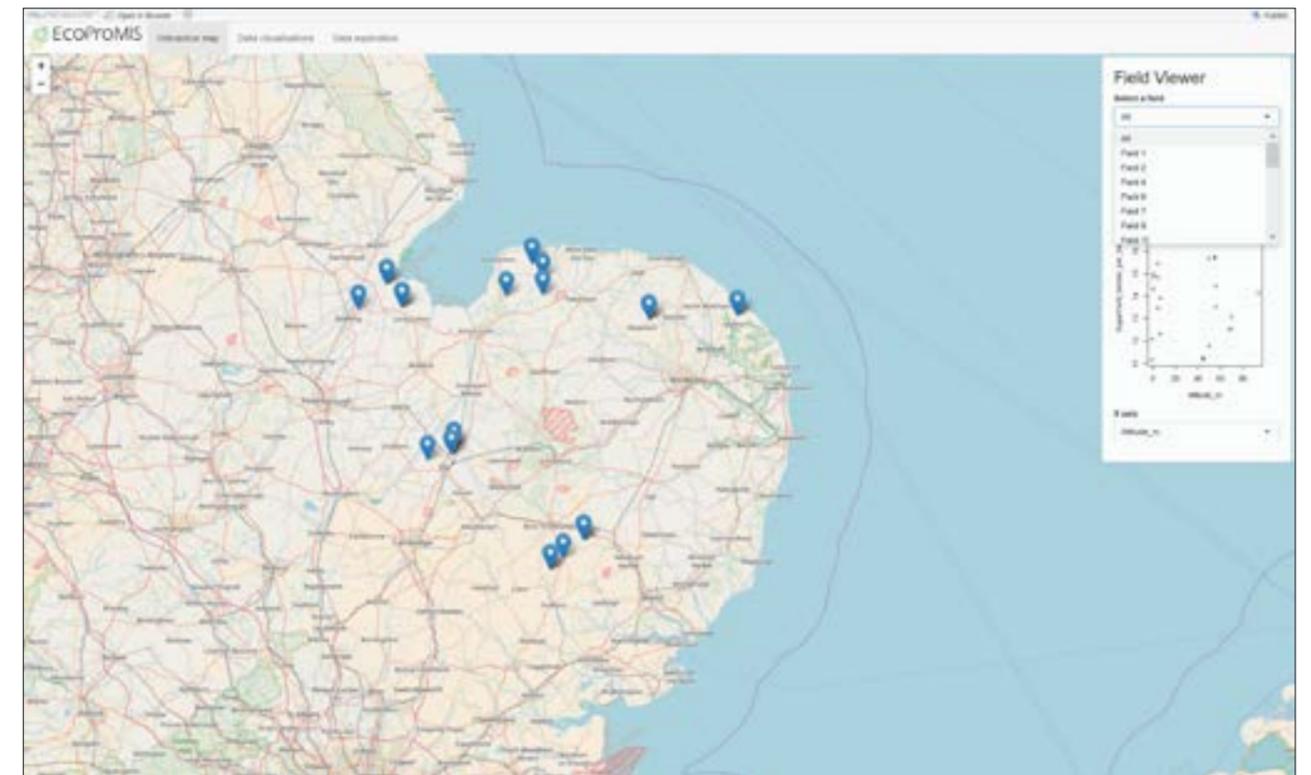
Case studies

The EcoProMIS platform is being used in Colombia, supported by IPP. It will collect weather, greenhouse gases, and crop performance data (e.g. with satellite and UAV), while growers will provide data on inputs, management and soil. The data is processed with modelling, machine learning and artificial intelligence, into knowledge and insights for growers to produce better crops and into decision support services for users e.g. insurance firms.

Organisation overview

Agricompas is a specialist in agricultural data analytics. We build data analytics platforms for cropping systems worldwide and provide knowledge and decision support services to a wide range of stakeholders. In Colombia we develop platforms for oil palm, rice and cacao with the growers and their federations. Our objective is to create sustainable agriculture by increasing productivity and profitability while minimising environmental impact, protecting biodiversity and improving the socio-economic conditions of stakeholders.

Figure 17: Sugar beet production monitoring per individual field in East Anglia, UK (which is being adapted to Colombia)



Grape Production Climate Resilience (Rothamsted Research)

Overview

Making grape production more resilient to weather and climate using Earth observation (EO) and smart sensors.

www.agritechinchina.org

Solution benefits

Exploits satellite EO data and smart sensor technology (for soil, weather, crop conditions) and GIS modelling to:

- reduce water inputs, and improve frost and disease management
- identify suitable regions for new vineyard development
- improve sustainability and security of the viticulture sector and the economic development of low-income rural regions

Key technical features

- Combines environmental data and weather data (both from remote sensing and on-site sensors), to support decision making, such as for frost protection or targeted irrigation.
- Allows forecasting of irrigation needs in pilot vineyards driven by soil moisture data.

Case studies

Funded by UK Newton Fund, this is a partnership between UK based company Climate Wine Consulting (CWC Ltd) and China's Northwest University of Agriculture and Forestry (NWUAF). Focused on three vineyards in the Helan Mountain region of China, it shows huge potential for the use of environmental data from remote sensing and smart sensors to make Chinese viticulture more weather resilient, efficient and sustainable.

Organisation overview

Rothamsted Research is a world-leading, non-profit research centre that focuses on strategic agricultural science to the benefit of farmers and society worldwide.

Figure 18: Frost damage is one of the risks faced by vineyards in the Helan Mountain region



Advanced Coffee Crop Optimisation for Rural Development (ACCORD) (Earth-i)

Overview

Advanced Coffee Crop Optimisation for Rural Development (ACCORD) provides proactive, targeted crop management information to improve the livelihoods and incomes of smallholder coffee farmers in Rwanda and Kenya. The crop management advice, which is delivered via a mobile app, is derived from satellite Earth observation (EO) and advanced micro-climate information. The information helps to make significant improvements to coffee crop quality and yield, allowing farmers to achieve higher incomes for their work and improve the quality of life for their families.

www.earthi.space

Solution benefits

- Proactive, customised, geo-targeted advice aimed at improving yields and the quality of coffee produced by small-holder coffee farmers in Kenya and Rwanda.
- Crop health monitoring and detailed, short-term, farm-targeted weather forecasts for coffee smallholders.
- Automated pest and disease warnings enabling farmers to take both preventative measures and more accurate reactive measures when dealing with coffee pests and diseases.
- Alert system enabling agronomists and farmers to communicate with each other.
- Improving the quality and yield of the coffee crop will help to secure higher prices allowing farmers to achieve higher incomes and improving the quality of life for their families.

Key technical features

- The ACCORD mobile app delivers targeted crop management information, utilising a unique mixture of multi-spectrum satellite EO imagery with highly localised and accurate weather data and pest & disease alert models.
- The custom weather model uses a mixture of historical data, and live data to provide geo-targeted, highly accurate weather forecasts.
- EO data provides a reliable, independent and cost-effective way to monitor the Normalized Difference Vegetation Index (NDVI) of crop health and is used to detect the early warning signs of deterioration and the presence of pests or diseases.
- ACCORD uses a combination of optical satellites, such as Sentinel and the DMC3/TripleSat constellation, to ensure the correct resolution of data is being acquired and balanced with cost effectiveness.
- Spatial resolution varies from free sources such as Sentinel's 20 metre, to commercial imagery ranging from 5 metre to 0.8 metre depending on the specific use.
- The ACCORD solution will use a cloud-based web platform to display data and mobile app for use in the field via their mobile. Information is delivered by a mobile phone app or SMS. A farmer will require a mobile network to receive an SMS, but not necessarily data.

Assess risk of outbreak and spread of pests

Pest Risk Information Service (PRISE) (CABI)

Case studies

Coffee is one of the world's premium quality crops, but farmers lack access to timely and accurate weather data to help them improve their yield and farming practices. The initial core service is currently in test across farms in Kenya and Rwanda. First harvest results are expected to demonstrate the positive impact of the ACCORD product.

Organisation overview

Earth-i is a British company providing satellite imagery, analytics and insights to clients across global geographies and diverse industries, NGO and governmental sectors including Agriculture, Urban Management and Environmental & Disaster Response. Earth-i's head office is situated on the Surrey Research Park, Europe's largest academic space campus.

Figure 19: Sorters at a coffee washing station in Embu County, Kenya



Overview

Pest Risk Information Service (PRISE) is an innovative crop pest and disease risk forecasting product designed for smallholders and commercial producers in developing countries. Bringing together a broad range of stakeholders, including plant protection authorities, space experts, private sector companies, and the farmers themselves, PRISE uses state-of-the-art crop and pest modelling techniques to provide users with advanced warning of a damaging outbreak and appropriate advice to mitigate crop losses.

www.cabi.org

Solution benefits

- Create an early warning system to warn of the risk of pest outbreaks using cutting-edge space infrastructure.
- Earth observation (EO) data and state-of-the-art modelling techniques allows risk assessment of pest outbreaks over wide, remote rural areas.
- Establish expansive, novel crowdsourcing observations to strengthen and validate the system.
- Integrate risk forecasts into existing plant health systems, leveraging your existing current programmes and projects.
- Deliver alerts and advice to farmers at scale.
- Develop and sustain the service by building in-country technical capacity and engage the private sector (e.g. agro-dealers and insurance companies).
- Encourage countries to develop policies to strengthen crop protection by demonstrating that effective pest forecasting can be scaled to national and regional levels.

Key technical features

- PRISE uses static and dynamic data sources to drive pest risk models of insects and pathogens life cycles which are driven primarily by environmental factors. These sources include:
 - external data products from existing sources such as: land surface temperature, precipitation, humidity and land cover
 - EO data processed to provide customised information used in the project, such as downscaled surface specific temperature and vegetation state
 - data collected by existing projects, particularly CABI's Plantwise programme, including pest lifecycle data, crowdsourced pest presence/absence data and pest management advice data
 - data collected and processed in the project is stored in an AgroMet Data Cube which supports efficient access to a multi-temporal, multi-parameter dataset which is used within the project for pest risk modelling and is also available to project partners externally
- The pest risk modelling component uses data in the AgroMet Data Cube to derive pest lifestage and risk indicators. This information is communicated to users via a pest risk Bot in the Telegram messaging system which is used by Plantwise plant doctors.
- The system driving PRISE is modular and can be implemented in a distributed or centralised arrangement, using cloud processing. Users access the system outputs via a website or application programming interface (API). The system is currently hosted by the Centre for Environmental Data Analysis (CEDA), a partner in the project.

Pest Prediction (CABI)

Case studies

The product has been deployed in Ghana, Zambia, Kenya and soon in Malawi and Rwanda, supported by IPP. This is with the partners Plant Protection & Regulatory Services Directorate (PPRS, Ghana), Kenya Agricultural & Livestock Research Organisation (KALRO), Kenya Ministry of Agriculture, Livestock and Fisheries (MOALF, Zambia), Department for Agricultural Extension Services Malawi (DAES) and the Rwanda Agricultural Board (RAB).

Organisation overview

CABI is an international not-for-profit organisation that improves people's lives worldwide by providing information and applying scientific expertise to solve problems in agriculture and the environment. We put information, skills and tools into people's hands. CABI's 49-member countries guide and influence our work which is delivered by scientific staff based in our global network of centres.

PRISE project partners working with CABI include Assimila, CEDA and Kings College London.

Overview

Pest Prediction aims to produce cutting edge research to provide pest and disease monitoring and forecast information, integrating multiple sources of data, Earth observation (EO), meteorological and vertical looking radar, to support decision making in the sustainable management of insect pests and diseases. Predictive models on wheat rust severity that are passed to government agencies so that they can decide if a coordinated action is required at national or province level.

www.cabi.org

Solution benefits

- Predictive models on wheat rust severity that are passed to governments so that they can decide if a coordinated action is required at national or province level.
- Developing locust development models and biopesticide suitability models to help governments to decide a) where to send resources for locust control and b) if biopesticides can be effective in controlling the locusts in those current climatic conditions.
- Modelling helps the government to decide when is suitable to spray and hence have better informed pesticide application.

Key technical features

- Predictive models for wheat rust severity are based on EO algorithms using MODIS data and ancillary information such as weather and crop data that can be updated every 16 days at a resolution of 500 metre.
- The results of the monitoring models for wheat diseases and pests are automatically delivered in an online platform with free access from computers or mobile devices.

- Monthly reports of disease severity for wheat are delivered to key stakeholders (e.g. plant protection organisation and researchers) who interpret the results.
- The locust development model predicts the temporal progression of locust generations from hatching to adulthood based on accumulated temperature using Numerical Weather Prediction, reanalysis and EO temperature data (e.g. ECMWF Re-Analysis climate data and the Global Forecast System from NOAA). A similar approach is used to estimate the efficiency of biopesticide (time to kill locusts at a given period of spraying).

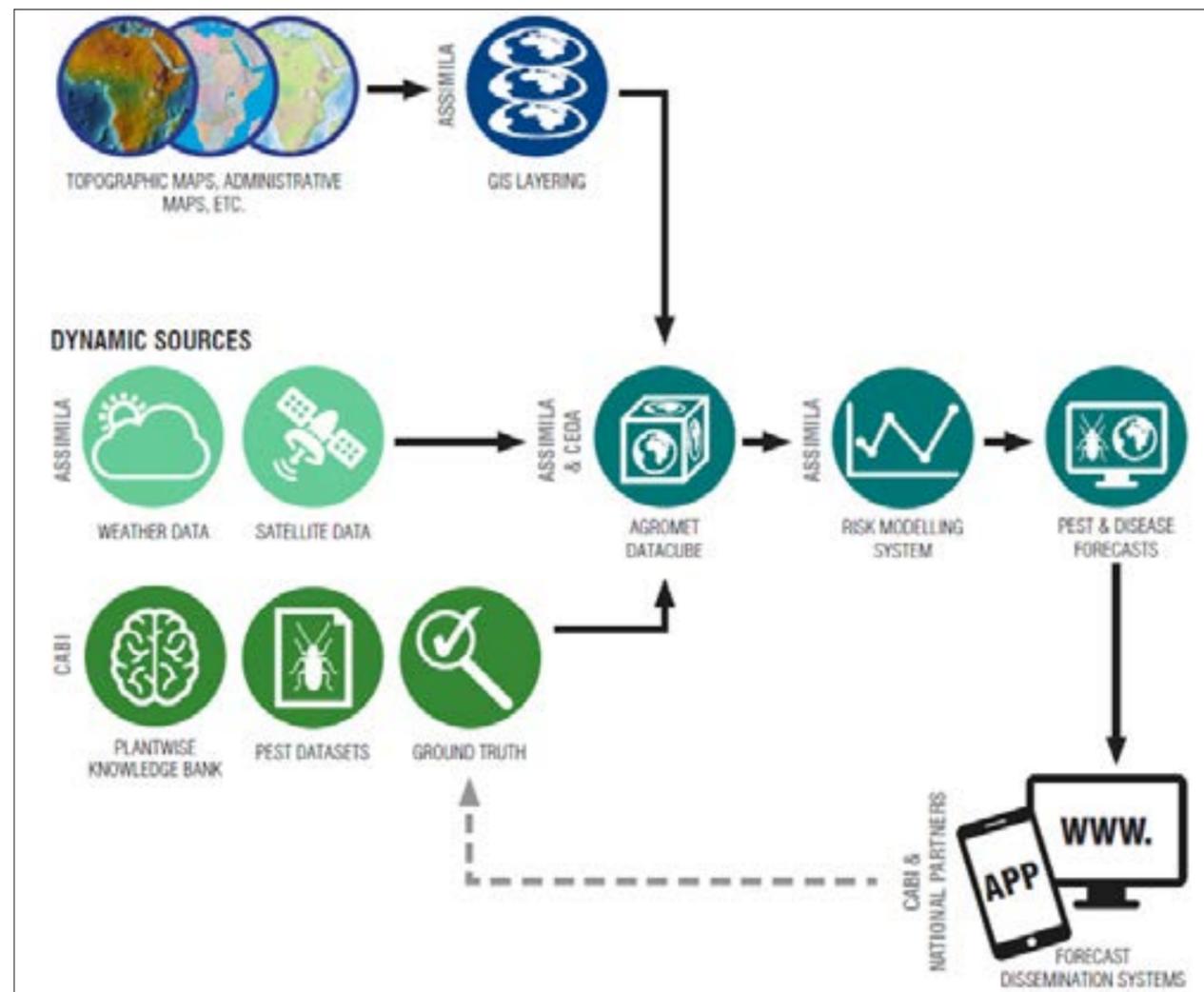
Case studies

Predictive models for wheat rust severity in China have been developed by the Institute of Remote Sensing and Digital Earth Institute (RADI) under the Chinese Academy of Sciences (CAS). The wheat rust forecasting service has been adopted by the Ministry of Agriculture (MoA) in China to estimate potential damage to wheat crop. Forecasts are reviewed by experts before publication in monthly reports. This information helps MoA officials to plan their crop protection activities and if needed, mobilise resources across China.

Organisation overview

CABI (Centre for Agriculture and Biosciences International) is an international not-for-profit organisation that improves people's lives worldwide by providing information and applying scientific expertise to solve problems in agriculture and the environment. The solutions described here are the result of the Sino-UK project "Integrating Advanced Earth Observation and Environmental Information for Sustainable Management of Crop Pests and Diseases" integrated by Remote Sensing and Digital Earth Institute (RADI), CABI, Assimila Ltd, King's College London, Institute of Plant Protection (IPP-CAAS), Zhejiang University and Rothamsted Research.

Figure 20: A schematic of the PRISE system



WeatherSafe Platform (WeatherSafe)

Overview

The WeatherSafe platform provides field specific advice for coffee farmers. This is generated from satellite Earth observation (EO) data and bespoke weather forecasts, offering early warnings for pest and disease, supporting agronomist and farmer decisions making, helping farmers make faster, better choices which directly impact both the quality and quantity of coffee produced.

www.weathersafe.co.uk

Solution benefits

- Field specific seven-day weather forecasts to give coffee farmers time to prepare for key weather events, such as the start of the rainy season.
- Field specific automated pest and disease warnings enabling farmers to take both preventative measures and more accurate reactive measures when dealing with coffee pests and diseases.
- Field specific health monitoring enabling coffee agronomists to view a list of their designated farmers and fields prioritised in order of those requiring the most attention.
- Alert system enabling agronomists and farmers to communicate with each other.

Key technical features

- WeatherSafe is a standalone cloud-based solution with a web platform and accompanying mobile device application.
- Employs commercial, paid for, EO data.
- High precision optical images of targeted fields with a two metre multispectral resolution, which corresponds to the crown of a coffee tree.
- Weekly imagery across each field utilising red/green/blue/near-infrared spectral bands.
- The cloud-based service means access to the product is possible via smart phone or laptop with an internet connection, or via SMS.

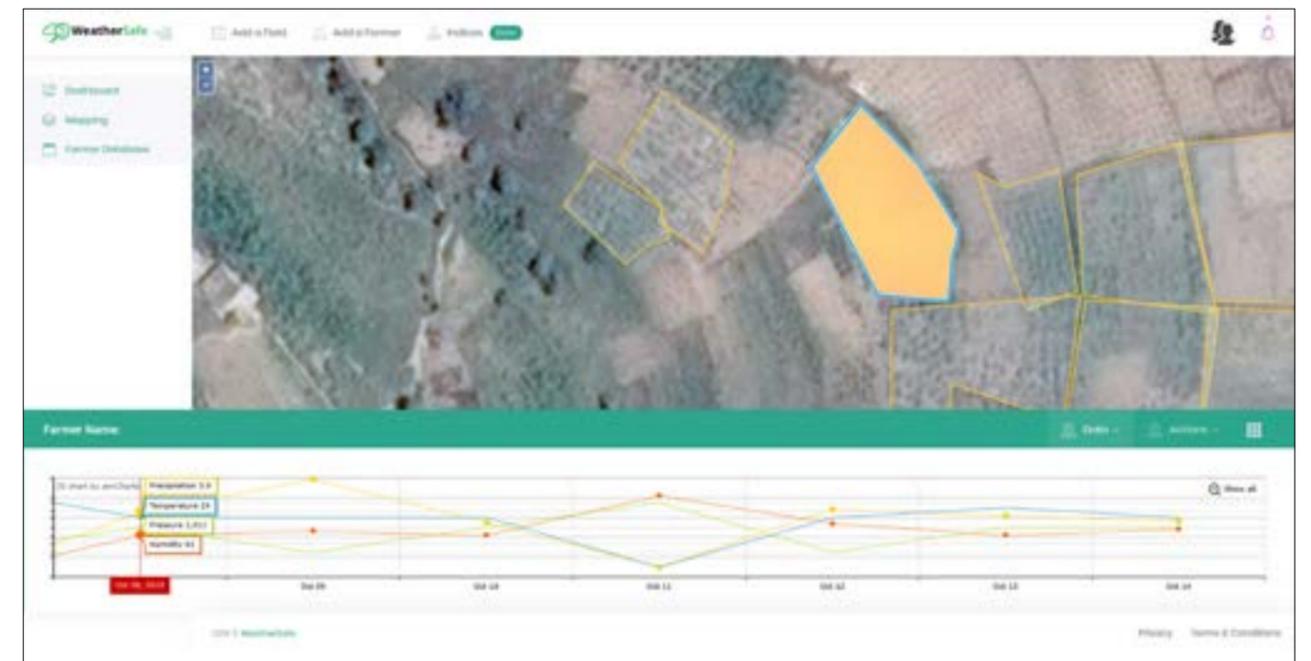
Case studies

Kinini Coffee, who are based in Rulindo, Rwanda, use the WeatherSafe platform to help their agronomists give better advice to their coffee farmers. The WeatherSafe platform has changed farming practice from traditional to a tech-based precision agriculture, for example, by farmers knowing when to use pesticides and having the ability to verify if fertiliser is being applied properly.

Organisation overview

At WeatherSafe, we develop solutions to one of the greatest challenges facing humankind - leadership in data science, the next breakthrough area of agriculture. Together, we will provide new time critical insights and help farmers and government with the decisions they make every season, generating new growth opportunities.

Figure 21: WeatherSafe platform, showing a mapped coffee field which has had the normalized difference vegetation index (NDVI) heatmap applied, and a bespoke seven-day weather forecast



Agriculture Simulations (Sensonomic)

Overview

Agriculture Simulations makes use of Earth observation (EO) data to solve challenges for agricultural planning, harvesting, logistics and long-term food systems resilience in a changing climate. It gives dynamic insight into complex human and natural systems by combining computational simulations and EO data. It enables both short-term operational and long-term strategic decision-making by actors in the food chain – from independent farmers wanting to know where to harvest, to large traders needing to know who to buy sustainable produce from and governments and NGOs looking to optimise strategic infrastructure investments.

www.sensonomic.com

Solution benefits

- **Yield prediction** – Through combining advanced data analytics with standard EO products we can predict future yield.
- **Harvest planning** – Produce ripens within a short time frame, and often farmers have limited access to labour and equipment. We optimise dynamic resource allocation to increase yield capture and value.
- **Logistics and operations** – After harvesting high value produce must be processed, stored, and distributed. Our simulation tool provides daily advice to optimise first-mile logistics and operations.

- **Investments** – Aggregating inputs from the products above we offer a robust and dynamic investment model, which can be updated regularly as new data is made available. This ensures an improved understanding of where and when to allocate capital.
- It provides daily insights into unintended consequences on agricultural system as a whole, and creates insight into what consequences an agronomic, economic or social policy decision can lead to.
- It captures how decisions influence both humans and nature through thousands of simulations in a digitised version of the clients' agricultural landscape.

Key technical features

- It is a rules-based computational simulation approach for analysing input from multiple EO data sources, in a changing environment.
- All simulations are carried out in a digitised version of reality, in which EO data layers makes up the components of the 'simulated world'.
- Our solution is delivered via a web-based Software-as-a-Service.
- It can be integrated with other systems through an application programming interface (API).
- It consumes both open and commercial EO data – with optical EO being the main data source.
- The data is refreshed from daily to every month, dependent on data source.

- The resolution of imagery used is between 10-15 metre for systems understanding of large geographies, and down to 50 centimetre for individual farms where object identification may be necessary.
- Some input generation such as yield, and harvest timing requires local inputs through handheld devices to ground-truth estimates derived from EO.

Case studies

Sensonomic is assisting the International Fund for Agricultural Development (IFAD) and the countries of Senegal, Mali and Cameroon to optimise their investment in agricultural infrastructure in rural areas. The product's simulations show which roads to upgrade and where to invest in storage facilities

to support agricultural intensification under different scenarios of climate change and population growth.

Yield prediction for tropical agriculture – working across multiple crops we provide large plantation producers with improved yield prediction services. In Malaysia, Fiji, Vanuatu, Solomon Islands, Burkina Faso, Portugal. With the following crops: sugar, oil palm & olives.

Organisation overview

Our UK operation is headquartered in London's Canary Wharf, at Level39. Our diverse team is comprised of geographers, technologists, biologists, product developers, and economists. We have a strong research collaboration with leading academics from the University of Oxford.

Figure 22: A systems approach with the clients' operations front and centre



Forecasting agricultural productivity
to improve agricultural supply chains

Agri-track (Environment Systems)

Overview

Agri-track enables agri-businesses to receive up-to-date crop monitoring and forecasting information in formats they are familiar with (data, alerts, maps) that are compatible with their own corporate or crop management systems, enabling them to make near-real time decisions based on crop intelligence that scales from the field to countrywide. Crop-specific monitoring and forecasting data includes yield estimates, growth stage, harvest timing and field-level leaf stress estimates.

www.envsys.co.uk/agriculture

Solution benefits

- Agri-track provides ready to use, near real time, crop-specific monitoring and forecasting data for a wide variety of crops around the world.
- Crop-specific monitoring and forecasting data for production status: yield estimates, growth stage, harvest timing and field-level leaf stress estimates.
- Multiple scales of information: field, farm, regional and countrywide, including regional estimates of area and yield.
- Regional crop maps showing inter-seasonal change.
- Receive regular crop production data regardless of the weather for key commercial crops in developing countries for growers and crop traders.
- Regional and national crop mapping for market intelligence and food security planning for crop traders, NGOs and government.
- Up-to-date intelligence informs planning and management bringing many benefits in agronomy, management and crop intelligence.

- Aggregated data (e.g. from multiple farms) for effective decision making at board and senior management levels.
- Automated capture of field boundaries at farm to regional scale, bringing opportunities for improved data capture and management in developing countries.

Key technical features

- Data can be directly fed to existing crop management systems or bespoke client platforms from Agri-track.
- Crop specific data is provided as a GIS map layers, alerts and/or spreadsheets.
- Standalone cloud-based subscription service accessible via desktop and mobile devices. Broadband connection speed is required.
- Updates of crop production analytics: every 6 to 12 days using Sentinel-1 and Sentinel-2 satellite imagery, commercial EO data can be incorporated if required.
- Spatial resolution of 10 metre.
- Training and support provided to ensure successful adoption by users.
- Support organisations to find open source solutions if needed.
- Ready to use crop production analytics are available on Agri Track, approximately 48 hours after the satellite imagery becomes available from ESA.

Case studies

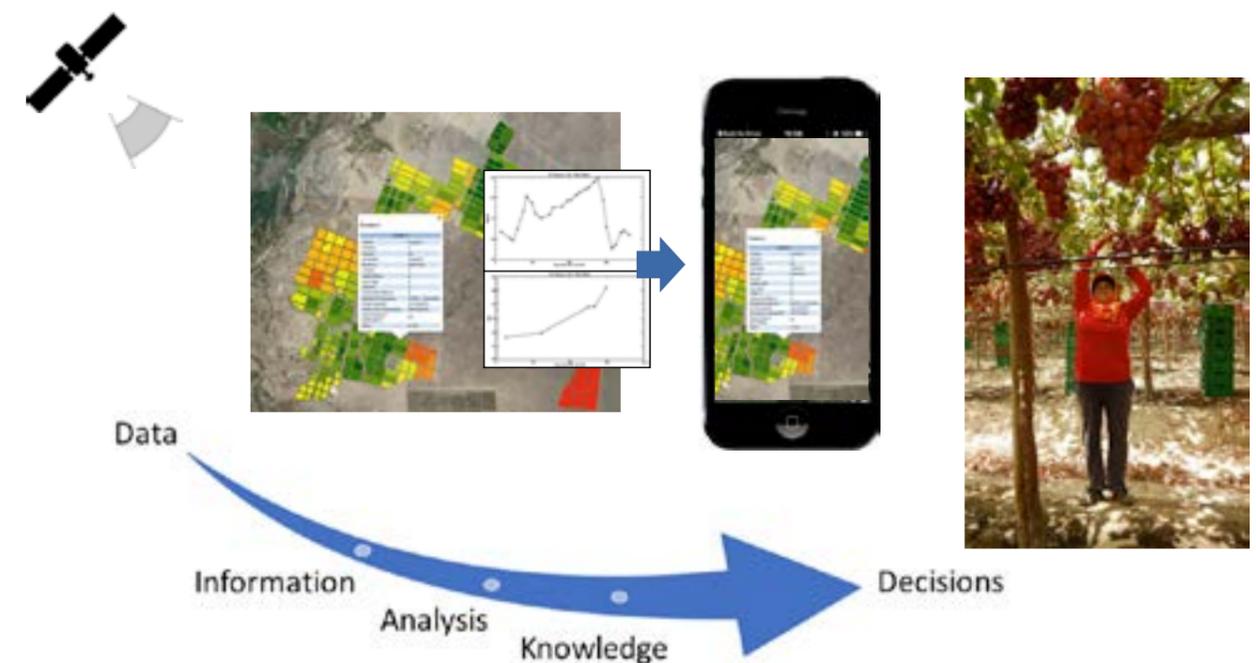
Monitoring and estimating/forecasting asparagus production with Danper, Peru, supported by IPP. Danper is the largest exporter of fresh asparagus in Peru. As a partner in EO4cultivar, Danper regularly upload data from the Environment Systems data services to their crop management system for an area of over 1750 hectares of asparagus. The system combines satellite derived data with other management and agronomy data. Field managers consult the system to guide field visits saving time and money.

Organisation overview

Environment Systems is an established environmental and agricultural data company, providing trusted evidence and insight to governments and industry across the world since 2003.

The consultancy delivers bespoke advice and solutions for land management, monitoring and policy for ecosystems, natural capital evaluation, agricultural trials and agricultural supply chains. The company's satellite data services (<https://data.envsys.co.uk/>) deliver always-on, accessible open data insights from satellite Earth observations (EO) analytics.

Figure 23: Using EO data for tracking and forecasting agricultural production to improve decision making in agricultural supply chains



Land Resource Evaluation Service for Agricultural Activity and Production (Booker Tate)

Overview

High resolution Earth observation (EO) imagery and digital surface models are used to provide rapid assessment of land resources for defining Areas of Interest (AOI) for more specific ground truthing via detailed topographical, soil and geotechnical surveys to assess land agriculture potential. This gives a rapid assessment of land potential for agriculture by survey teams precisely targeting potential agricultural productive zones and discounting areas of obvious unsuitability or ecological sensitivity.

www.booker-tate.co.uk

Solution benefits

- Provides cost-effective and rapid assessment of land resources for agricultural use.
- Provides current information on land resources, for example detailed contour information.
- Low cost compared to ground-based approaches, for example survey teams, for land assessment.
- Allows rapid identification of the most productive areas for agricultural development.

Key technical features

- Provides topographical, soil and geotechnical information to assess land potential.
- Forms part of a more comprehensive land resource assessment system.
- Can use free EO data e.g. Google Earth, QGIS, Sentinel-2, and also costed data provided as a pay-for service e.g. LIDAR, unmanned aerial vehicle (UAV) imagery.

- Spatial resolution is tailored to the level of study, for example, reconnaissance or detailed feasibility study.
- Data obtained and updated as and when required by the project, such as weekly crop observation imagery from Sentinel.
- Data analysis performed on local computing infrastructure and/or utilisation of the cloud environment.

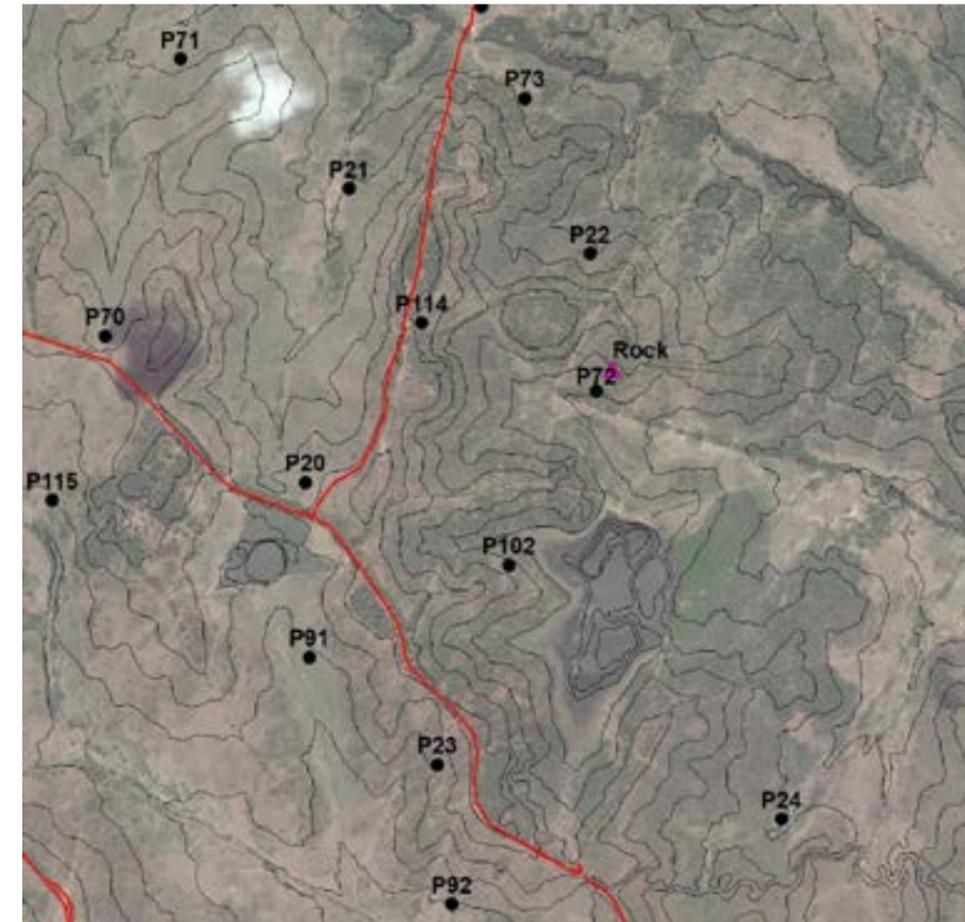
Case studies

The use of high-resolution EO imagery and digital surface models is employed in Booker Tate's studies to assess the agriculture potential of green field or brown field sites, primarily for the cultivation of sugarcane and associated crops. Such techniques are particularly valuable where irrigation is to be used and therefore a highly accurate level of surface contouring is required. However, in most cases the assessment of drainage requirements and capacity are also of high importance in estate or lands planning. Recent land assessments have been carried out for clients in Mozambique, Nigeria and Indonesia. Current clients include the Royal Swaziland Sugar Corporation in Eswatini, IFC with the Government of Ethiopia, Rezatec Ltd in the UK and two on-going projects in Indonesia.

Organisation overview

Booker Tate is a leading international agricultural production and processing consultancy that supports clients to bring new agricultural projects to realisation, and helps clients achieve performance improvements within existing projects in an environmentally, socially and economically sustainable manner.

Figure 24: Detailed one metre interval contour map, created from a mosaic of LIDAR imagery, for land use planning in Sri Lanka



Land Cover® plus Crops (Remote Sensing Applications Consultants)

Overview

Land Cover plus Crops is a solution developed by Remote Sensing Applications Consultants (RSAC) to provide detailed annually updated crop maps of Great Britain. It provides parcel-level information derived from Earth observation (EO) data for every field in the country. It is now being applied in developing countries to offer improved understanding of agricultural land use and farming practices and allow prediction of production and prescription of appropriate interventions to ensure food security.

www.ceh.ac.uk/crops2015

Solution benefits

- Detailed parcel-level crop map that provides information for every individual field.
- Operationally produced on an annual basis for Great Britain since 2015 (~2 million parcels) in the framework of the national land cover map produced by the UKRI Centre for Ecology & Hydrology (CEH).
- It is also transferable to the developing world to offer improved understanding of agricultural land use and farming practices.
- Temporal series of products allows analysis of crop rotations and cropping trends (e.g. in Great Britain, four years' data available to date).
- Combined with RSAC's radar-derived measures of crop growth (separate product), allows prediction of production, and prescription of appropriate agricultural interventions to ensure food security and adaptation to climate change.

Key technical features

- Based on time series of free Sentinel-1 radar and Sentinel-2 optical satellite data.
- Maps the main arable crops such as winter and spring wheat, winter and spring barley, oilseed rape, field beans, potatoes, sugar beet and maize, plus improved grassland (but not vegetables).
- All cropping units larger than two hectares mapped.
- Multiple crops within the same field separately mapped.
- Classification accuracy of 90-97% for cereals and oilseed rape.
- Finalised maps available soon after harvest (some crop classes available earlier).
- Rapid massive data processing enabled by cloud processing facilities.
- Delivered as vector data (parcel outline polygons attributed with crop information) for ease of use in geographic information systems (GIS).

Case studies

Land Cover plus Crops has been demonstrated in Mongolia to provide crop identification and crop productivity information to support a number of different government regulatory, policy, planning and protection functions. Maps and statistics on the location, extent, type, and variability of crops will help the Mongolian Ministries of Agriculture and Environment to facilitate adaptation to climate change and maintain levels of food security nationally.

Organisation overview

RSAC is an SME with 30 years of experience providing specialist services to developers and users of Earth Observation. The company has considerable expertise in the use of satellite optical and radar data for land applications worldwide, particularly in the field of agriculture. The company is involved in a range of research, development and operational activities, playing a leading role in agricultural applications of remote sensing in the UK and heading up several international development projects.

Land Cover plus Crops was originally developed in conjunction with Anglian Water. Water companies require detailed agricultural data for improved catchment modelling in the context of water quality. Land Cover plus Crops products are used to allow more accurate modelling of pesticide sources and transport pathways within catchments. Land Cover plus Crops enhances the current Drinking Water Safety Planning approach for diffuse agricultural sources of contamination in terms of hazard identification, risk assessment and management.

Figure 25: RSAC's Land Cover® plus Crops 2016 for Great Britain - overview, detail and legend (the solution is also being implemented in various developing countries)





Forestry and Land Use

Forestry and Land Use

The global forestry sector faces many challenges, many of which are more acute in developing countries. These nations have some of the most valuable forests in terms of timber and ecosystems, but their sustainability is increasingly under threat. Rapidly growing human populations require more land for agriculture, while increased exposure to international markets for commodities like timber, soy, and palm oil are driving deforestation and forest degradation. These processes are entirely legal but developing country forestry is also troubled by illegal deforestation. These processes cause huge carbon emissions – around one-sixth of the emissions from all human sources – and are driving climate change. Additionally, the clearance of tropical forests is the largest driver of tropical biodiversity loss and also deprives forest dependent communities of their livelihoods.

Space solutions address forestry challenges in developing countries by improving the monitoring of deforestation and forest degradation, improving mapping and conservation of forest carbon and biodiversity, and also improving commercial forest management and optimising land use planning.⁹

See also UK Space Agency International Partnership Programme's report [Space for Forestry in Developing Countries](#).¹⁰

The space sector provides the following solutions for forestry use cases:

Identify sites of potential illegal logging and provide enforcement agencies with information to interdict illegal loggers

- **Forest Change Mapping (Telespazio VEGA UK)**
- **Forest Disturbance Early Warning System (FDEWS) (Remote Sensing Applications Consultants)**

Measure social and economic value of forests and forest products.

- **Forests 2020 & ForestWatch Optical Change Detection (University of Leicester)**

Monitor carbon stocks within forests

- **Carbon Data Model Framework (CARDAMOM) (University of Edinburgh)**

Observations of tropical peatland condition, as input to peatland management and restoration

- **Peatland Monitoring (CGI)**
- **Surface Motion Monitoring (ISBAS) (GVL)**

Map what land is used for at present, and what it could be converted to for greater economic or social benefit

- **Land Cover Mapping (Remote Sensing Applications Consultants)**
- **IMAGES (Vivid Economics)**

Monitor land and coastal environments for degradation

- **Pixalytics Portal (Pixalytics)**

Demonstrate opportunities for better use or management of land for economic, societal and environmental benefit

- **SENCE (Environment Systems)**

⁹ UK UK Space Agency & Caribou Space. 'Space for Forestry in Developing Countries'. <https://www.spacefordevelopment.org/library/space-for-forestry-in-developing-countries/>. Accessed December 2018.

¹⁰ Same as above



Forest Change Mapping (Telespazio VEGA UK)

Overview

Designed to facilitate better management of tropical forests and find illegal logging in near real time, Forest Change Mapping highlights areas of change. Targeted at government users, and state level actors, interested in tropical forests, the forest change mapping service utilises high resolution radar data that is unaffected by clouds which often plague the use of optical Earth observation (EO) data in tropical and/or cloudy regions.

<http://telespazio-vega.com/>

Solution benefits

- High resolution forest change mapping.
- Find where and when illegal logging occurs in near real time.
- Use the changes to create alerts and prioritise regions of action.
- Can provide mapping in night time and cloudy conditions which is vital for the conditions of the tropics.

Key technical features

- X-/C-band spaceborne radar forest canopy change mapping.
- Demonstrated delivery times in six hours following the satellite overpass.
- Detect logging events that are smaller than 100 square metres.¹¹
- Configurable to use COSMO-SkyMed or Sentinel-1 radar data.

- COSMO-SkyMed can acquire four repeat scenes of an Area of Interest (AOI) within a 16 day window.
- Sentinel-1 has a repeat frequency of 6-12 days depending on the country location.
- Configurable for different coverage and resolution requirements.
- Large area coverage utilising the full Interferometric Wide Sentinel-1 250km swath, or a targeted, very high-resolution service at 40km or 10km swath, utilising the Stripmap or Spotlight COSMO-SkyMed acquisition modes.
- Can be utilised either on local IT infrastructure and servers or cloud based.

Case studies

Malaysia - Telespazio VEGA UK is the forestry domain lead on the EASOS project in Malaysia, supported by IPP, and has gained significant knowledge in the area of tropical forest monitoring. Potentially illegal deforestation alerts are currently being produced and served in a visualisation tool (developed by the Satellite Applications Catapult) to the Forestry Department of Peninsular Malaysia (FDPM). Several hundred hectares of suspected illegal logging in Malaysian tropical forests have been detected and alerted to Malaysian stakeholders.

Organisation overview

Telespazio VEGA UK Ltd (TVUK) is a highly experienced consulting, technology and engineering services business, which supports satellite operators and manufacturers worldwide and helps other organisations benefit from space

data and services. Based in the UK, it is a wholly owned subsidiary of Telespazio SpA, and employs approximately 140 highly qualified staff with a wide experience in Science, Earth Observation, Geo-Information, Navigation and Telecoms Projects.

Figure 26: An area of deforestation detected in Peninsula Malaysia - with tree cutting in orange in the EASOS portal



Identify sites of potential illegal logging and provide enforcement agencies with information to interdict illegal loggers

¹¹ When using the 1m resolution COSMO-SkyMed SPOTLIGHT mode. Free Landsat-based alerts, such as the one implemented by the University of Maryland have a minimum area greater than 900m²

Forests 2020 & ForestWatch Optical Change Detection (University of Leicester)

Overview

Forests 2020 and ForestWatch-Optical (two separate products) deliver land cover and forest cover change information gathered from satellite Earth observation (EO) optical and radar data to end users at least every five days to monitor large land areas across the globe using custom-made solutions.

<https://le.ac.uk>

Solution benefits

- High frequency and large area mapping of land cover changes using EO data.
- Highly accurate deforestation alert system.
- Tailored to suit the end-user's requirements.
- Highly scalable solution i.e. new Areas of Interest (AOI) can easily be added, and land cover monitoring areas.

Key technical features

- Uses free EO data from the Sentinel-1 and 2.
- Sentinel-2 is a multispectral satellite constellation imaging in the visible to infrared spectrum. Sentinel-2 carries 13 bands with three different spatial resolutions: 10 metre, 20 metre and 60 metre and a combined revisit time of five days.
- Sentinel-1 is a C-band radar providing information day and night, and under cloud cover condition. Sentinel-1 has a combined revisit time of six days.
- The satellite images are processed and analysed using state-of-art open source software and machine learning.
- The ForestWatch-Optical solution is hosted by EASOS.

Case studies

Forests 2020 works in areas in Brazil, Mexico, Colombia, Ghana, Kenya and Indonesia monitoring forest cover change using optical and radar imagery, supported by IPP.

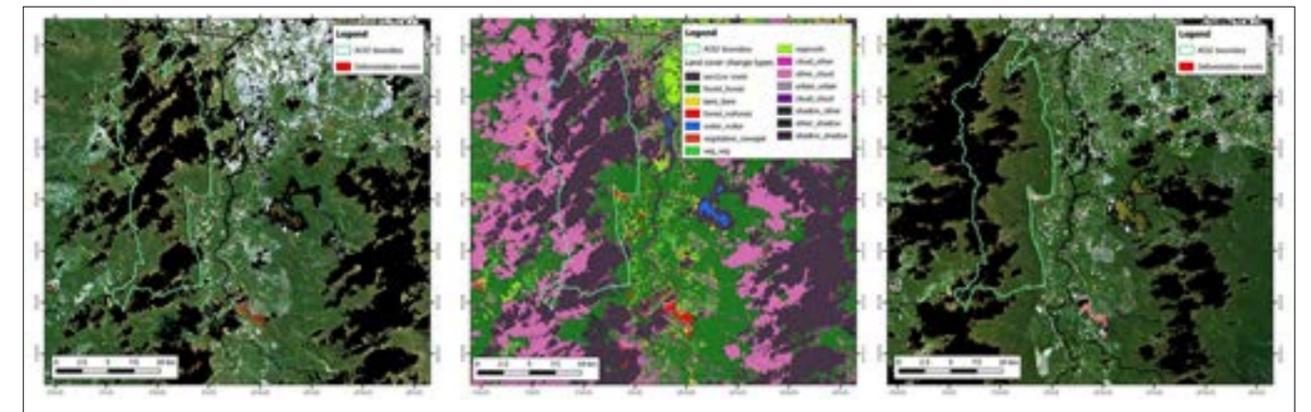
ForestWatch-Optical is operational over two sites in the Malaysian peninsula, monitoring forest areas of potentially illegal logging activities, as part of the EASOS project, supported by IPP.

Organisation overview

The University of Leicester has a track record of excellent research into Earth Observation science and applications, building on over 50 years of space research. Professor Heiko Balzter, director of the Centre for Landscape and Climate Research, is

an accomplished research professor with over 20 years research experience, 90 journal publications, over 3300 citations (h-index = 30), and over €14 million research income.

Figure 28: Forest change detection interfaces



Carbon Data Model Framework (CARDAMOM) (University of Edinburgh)

Overview

CARDAMOM provides robust analysis of forest carbon stocks and their dynamics. By combining a range of Earth observation (EO) data with a model that provides a forecast capability for forest fire risk, climate sensitivity, and carbon sequestration capacity.

www.geos.ed.ac.uk/homes/mwilliam/CARDAMOM.html

Solution benefits

- Provides a full assessment of the forest carbon and water balance, stocks and fluxes, at variable grid resolution across the study domain.
- Products are consistent with climate, soils, and forest observations.
- Combines strengths of EO data (supports spatial mapping) with process model understanding (which allows for forecast capacity) and can be updated dependent on new data availability.
- Risk of forest fire is estimated based on analysed forest state and soil moisture linked to observations of burned area.
- Model allows for exploration of scenarios of afforestation, reforestation, climate sensitivity of carbon cycling (source and sinks estimates) and fire risk likelihoods.
- Users can evaluate alternate land cover scenarios to scope effects of reforestation, afforestation, fire risk.

- Current forest biomass can be related to potential biomass under current and future climates to identify optimal areas for carbon sequestration (i.e. carbon storage).
- Modelling predicts time scales of forest response to changes in management, disturbance and/or climate.

Key technical features

- Assimilates information on canopy phenology (EO optical data), climate, soils, biomass (EO radar data, Light Detection and Ranging (LIDAR) derived) to generate a carbon cycle analysis using free data.
- Spatial resolution depends on Area of Interest (AOI) and resolution of EO input from one kilometre to 100 kilometre.
- Temporal resolution of the initial analysis is available from 2000-present in most cases (era of available EO data).
- Clear confidence intervals attached to all products.
- Outputs are shared via online tools of Ecometrica's EO Labs, a customisable web-based application.
- The analysis is undertaken using supercomputing capacity at Edinburgh. Model forecasting will be undertaken using online tools currently under development.

Case studies

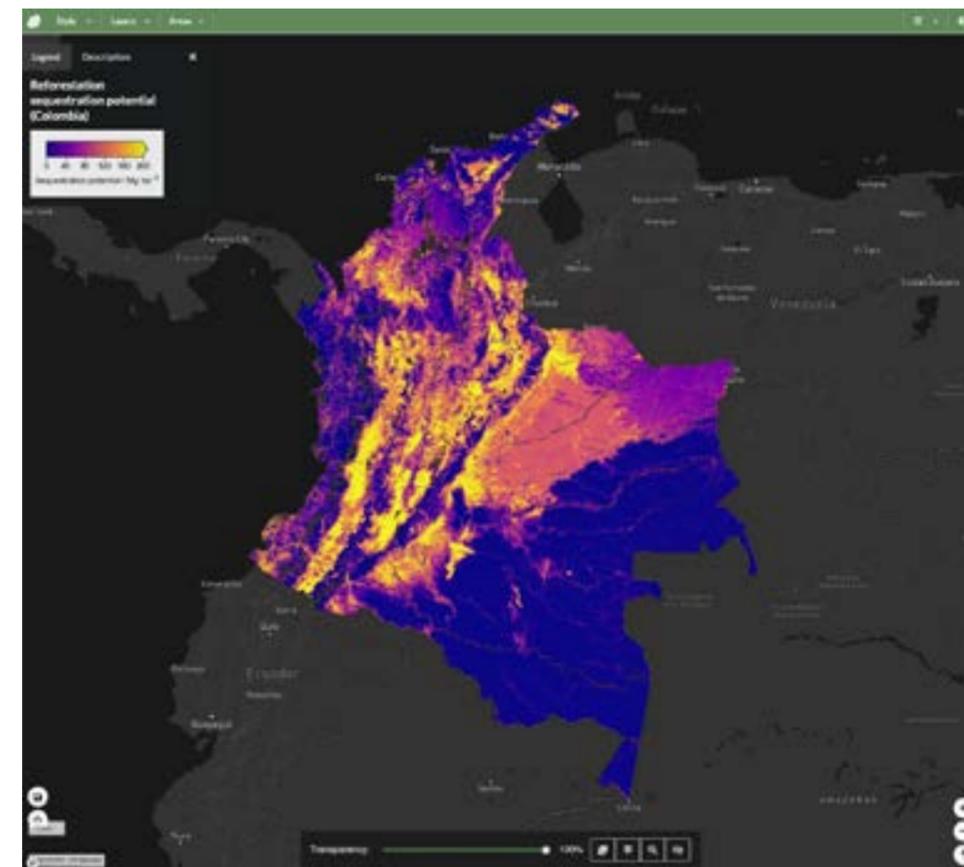
Potential biomass mapping of Columbia and Ghana to evaluate potential for carbon sequestration, timing of forest growth, and its climate sensitivity.

Continued training of Brazil's Instituto Nacional de Pesquisas Espaciais (INPE) and Kenya's Kenya Forest Service (KFS) partners to construct bespoke country specific CARDAMOM carbon cycle analyses. The development of in country capacity allows for utilising unique country specific datasets to address local forest management challenges identifying risks and opportunities in response to changing climate (e.g. development of drought) and ecosystem disturbance (e.g. fire and logging).

Organisation overview

The University of Edinburgh is a globally significant research and education establishment, with over 35,000 students and 4,000 academic staff. It is ranked in the top 20 in world universities and has an annual income of £900M in 2016-17. Its School of GeoSciences is rated as the most powerful in the UK by a recent assessment, and includes major strength in geodatascience, remote sensing, Earth observation, forest ecology and modelling. In 2018 the University launched its Centre for Sustainable Forests and Landscapes to focus its strength in natural and social science on addressing major challenges related to global forests.

Figure 29: Map of the deficit between current and potential above ground biomass (AGB) across Colombia identifies the opportunity for landscapes to sequester carbon



Peatland Monitoring (CGI)

Overview

Peatland Assessment in SE Asia by Satellite (PASSES) – provides two satellite-derived products: PeatMotion and PeatCover. PeatMotion provides landscape scale observations of peat surface motion. PeatCover provides a characterisation of the landscape which aids in interpretation of the PeatMotion.

PASSES products inform low carbon development programmes, enhanced peatland restoration planning and assessment, plantation-scale water management strategies and plantation-scale evidence of sustainability compliance.

www.cgi-group.co.uk

Solution benefits

- PeatMotion and PeatCover products offer a cost effective option for routine monitoring over very wide, often inaccessible areas of tropical peatland.
- PeatMotion observations provide regional-scale insights into peatland condition, enabling better planning and prioritisation of restoration interventions.
- PeatMotion products provide proxy observations for water table depth:
 - Routine monitoring of water table depth contributes to an improved capability for determining regulatory compliance.

- Wide area monitoring of water table depth enables assessment of the effectiveness of restoration interventions.
- Maintaining appropriate water table depth balances productivity with CO2 emissions and fire risk.

- PeatCover products provide landscape context which aid with interpretation of the PeatMotion.
- Routine observations of peat surface motion in remote, vegetated areas from satellite is highly innovative and for peatland, is unique to PASSES.

Key technical features

- PeatMotion and PeatCover are derived from Sentinel-1 radar imagery. Radar is unaffected by cloud, ensuring reliable observations and consistent monitoring.
- Sentinel-1 imagery is available free and open, contributing to a cost effective monitoring capability.
- PeatMotion products are imagery intensive, requiring substantial volumes of satellite data. PASSES is enabled on a state-of-the-art cloud-hosted processing platform optimising overall production efficiency.
- PASSES monitoring can be systematic, requiring minimal operator intervention.
- PeatMotion products are currently produced at 50m resolution.

- PeatMotion products currently provide average peat surface motion, and are updated every 12 months
- PeatCover products are produced at 20m resolution and are also updated every 12 months.
- PASSES products are available for discovery and download via a web interface for subscribed users. Users require a connection to the internet to access PASSES products.

Case studies

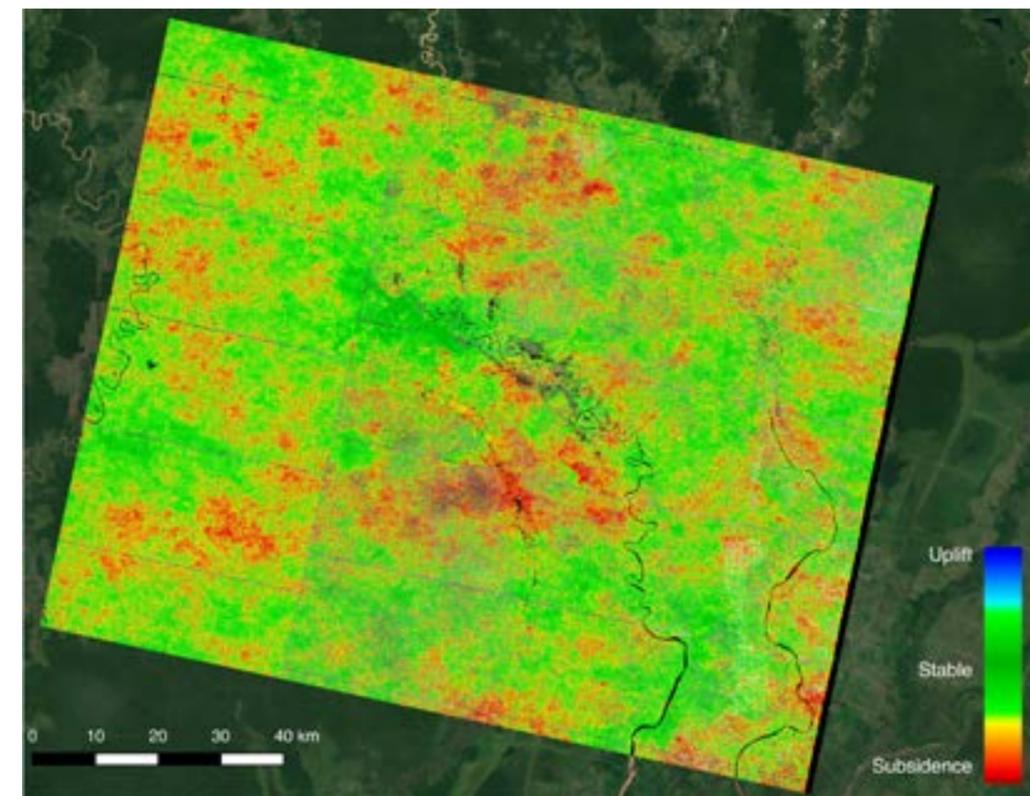
PASSES has successfully demonstrated the capability to generate preliminary products. These preliminary products are now being refined and utility demonstrated through a number of use cases.

These will include: informing certifications for Verified Sourcing Areas, informing environmental profiling for Landscape Approach analyses, informing Peatland Restoration Intervention assessments and plantation-scale water management programmes and drainability assessment.

Organisation overview

CGI is the 5th largest IT services company in the world operating across a broad range of industries, including over 40 years' heritage in the space industry. CGI builds and delivers complex, mission-critical space systems. Our solutions are secure, often in complex technical environments, proven to work first time, every time, ultra-reliable and delivered on time to avoid costly delays.

Figure 30: Prototype products showing land uplift or subsidence in Palankaraya, Indonesia



Observations of tropical peatland condition, as input to peatland management and restoration

Surface Motion Monitoring (ISBAS) (GVL)

Overview

Surface Motion Monitoring (ISBAS) uses satellite radar data to provide comprehensive land surface motion monitoring that can be used to assess the health of tropical peatland and also provide geospatial intelligence on issues related to long term environmental land motion including mining, deforestation, urbanisation and surface water management. Any land-class can be remotely monitored without the need for ground control; including remote, forested and urban areas.

www.geomaticventures.com

Solution benefits

- Provision of information on the status of peatland and how they respond to land use change, management and ecosystem rehabilitation measures.
- Provision of wide area full coverage survey maps of precise millimetre rates of land motion i.e. subsidence, uplift and lateral motion.
- Uses satellite Earth observation (EO) and requires no ground-based infrastructure.
- Can be imported as a layer into any GIS software (e.g. ArcGIS and QGIS).
- Underpins more effective allocation and management of public and private sector resources for land/peatland restoration and management.
- Provides a monitoring system to assist in reduction in rates of land motion and greenhouse gas emissions.

Key technical features

- ISBAS utilises Sentinel-1 radar data which is collected routinely every 6-12 days and processed at 20 metre resolution.
- Exploiting the patent pending Intermittent Small Baseline Subset (ISBAS) satellite radar data processing system that uses sequences of radar images to measure subsidence data over tropical peatlands over long periods of time.
- Ability to measure millimetric rates of land subsidence and uplift.
- Can be correlated with existing datasets collected in-situ with EO data collected from satellites.
- Provision of average land velocity measurements per pixel, where the pixel resolution/spacing is 20m through the GeoMoves suite of products.
- Provision of time series data per pixel through the GeoDynamics suite of products.
- Provision per pixel periodic monthly updates on surface motion.

Case studies

ISBAS is a key technology solution as part of the PASSES (Peatland Assessment In South East Asia by Satellite) that is working to prove that peatland monitoring is a cost effective way to reduce forest fires, in Indonesia and Malaysia, supported by IPP.

The British Geological Survey have used the technique to monitor rates of surface ground motion over gas extraction sites in the UK.

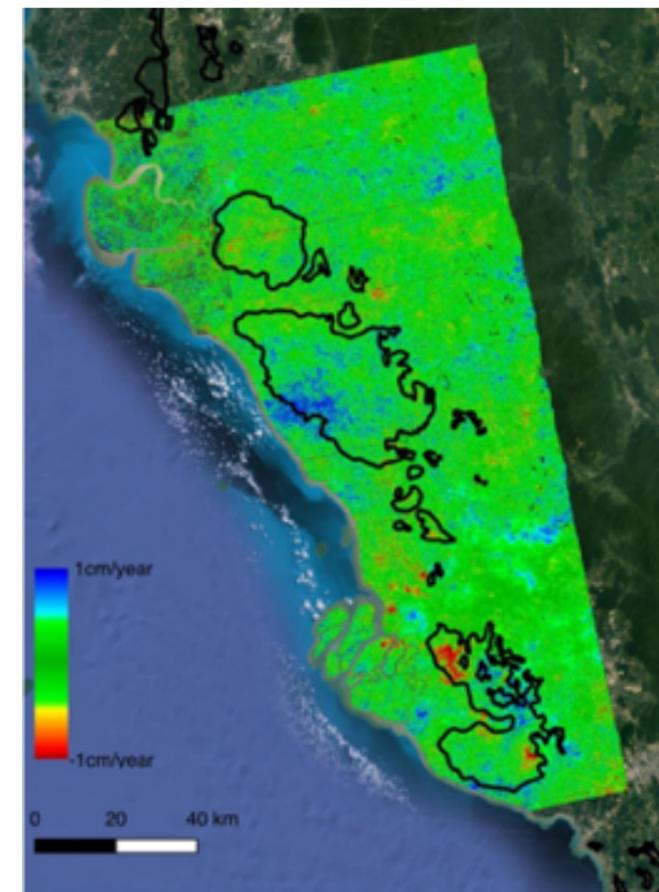
The University of Nottingham use the technique to assist in the development of models to measure the health of peatland bogs in Scotland.

Organisation overview

GVL provide satellite data-based ground motion surveys for environmental safety and security. Our surveys provide very precise rates of surface ground motion over large areas.

These surveys can be used to give early warnings regarding land subsidence benefitting a range of industries including land & property, infrastructure owners and operators, utilities, onshore mineral & oil and gas, government and regulators and environmental management.

Figure 31: Land subsidence over Johor, Malaysia from 1995 to 2005



Land Cover Mapping (Remote Sensing Applications Consultants)

Overview

Remote Sensing Applications Consultants (RSAC) offers bespoke land cover and land use mapping services based on Sentinel and commercial high-resolution satellite Earth observation (EO) data.

Present day and historical output maps are suitable for development planning, including site suitability analysis relating to REDD+ afforestation projects, and input to natural capital valuation systems.

www.rsac.co.uk

Solution benefits

- Bespoke land cover and land use mapping services.
- Present day and historical maps.
- Outputs are suitable for development planning, including site suitability analysis (e.g. for afforestation), and input to natural capital valuation systems.
- Repeat mapping provides information to the land use, land use change and forestry sector on changes and the drivers of change to improve reporting, for example, on carbon emissions.

Key technical features

- Standalone solution, though outputs can be usefully integrated with other layers in a geographic information system (GIS).
- Uses free Sentinel data and other commercial high-resolution satellite data, depending on the user/customer needs.
- Outputs are suitable for development planning, including site suitability analysis (e.g. for afforestation), and input to natural capital valuation systems.
- Uses large volumes of multi-temporal radar and optical data processed in a cloud environment.
- Classification accuracy varies depending on terrain mapped, typically around 85%.
- Spatial resolution of 10 metre.
- Update frequency according to user needs, typically 1-10 years.
- Outputs delivered as vector or raster layers for incorporation into a GIS.

Case studies

In the San Martín Region of Peru, a baseline inventory of land use has been produced from Sentinel-1 and Sentinel-2 satellite imagery as the basis for natural capital valuation activities, in an IPP-supported project with Vivid Economics. The overall accuracy of the classification, which in this case included 10 land use classes, was independently determined to be 88%. The information is being used by the regional government to improve its understanding of changes driven by coffee and cocoa cultivation.

To support World Bank activities to promote sustainable economic development in Mozambique, RSAC supplied land cover and land use maps from very high-resolution satellite data for three historical time periods. The maps provided information required to assess candidate sites for pulpwood plantation development, including

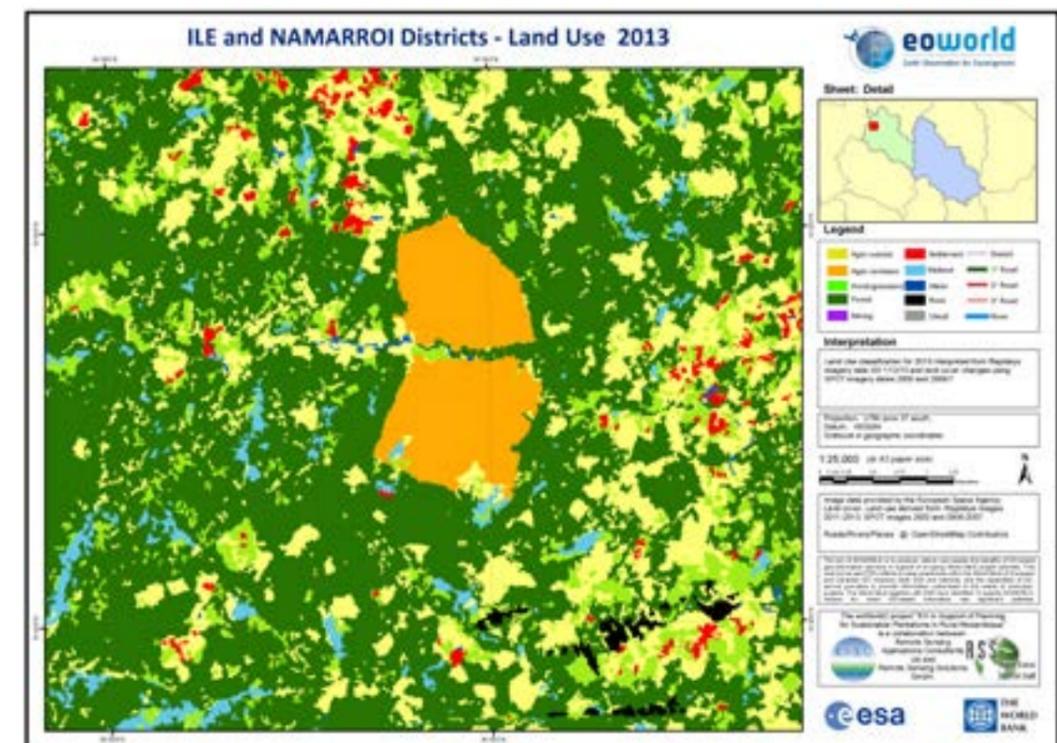
the physical suitability of land for growing trees and its capacity to meet sustainability criteria, which include impact of developments on local communities and the ecosystem.

Organisation overview

RSAC is an SME with 30 years of experience providing specialist services to developers and users of Earth Observation. The company has considerable expertise in the use of satellite optical and radar data for land applications worldwide, particularly in the field of agriculture.

The company is involved in a range of research, development and operational activities, playing a leading role in agricultural applications of remote sensing in the UK and heading up several international development projects.

Figure 32: Land use map produced by RSAC Ltd to support assessment of candidate sites for pulpwood plantation development in Mozambique (within the ESA-World Bank eoworld initiative)



Map what land is used for at present, and what it could be converted to for greater economic or social benefit

Deforestation prevention using land use monitoring and valuation (Vivid Economics)

Overview

By estimating the value of alternative land uses, predicting forest loss and detecting it in near-real time, IMAGES helps land managers and policymakers understand and prioritise trade-offs in unprecedented spatial, temporal and economic detail.

www.vivideconomics.com

Solution benefits

- Analyses land use change scenarios to understand implications of agricultural and forestry policy interventions compared to a business-as-usual case.
- Supports the design of land-use zoning rules and regulations, including high level agricultural, forestry, or climate change targets.
- Helps government enforcement agencies allocate scarce resources to minimise deforestation by identifying times and locations that forests are most at risk of loss or degradation.
- Allows policymakers to quantify, value and visualise the valuable ecosystem services forests produce to better inform investment planning.
- Enables the issuance of zero-deforestation conditional land titles through very high-resolution plot-level mapping.
- An easy-to use web-based platform enables interactive user analysis for non-experts, and access to all of the project's data layers for expert users.

Key technical features

- Combines static land use classification rasters constructed using Sentinel-2 optical EO data with Sentinel-1 radar EO data based forest disturbance information to generate a historic time-series of land use since 2016 at a 10 metre spatial and 2 week temporal resolution.
- Creates predictive modelling based on econometric and machine learning techniques to understand likely paths for land use change over a 10+ year time horizon.
- Uses natural capital valuation techniques to quantify and value a series of ecosystem services including water provision, water filtration, sediment retention, ecotourism and carbon sequestration.
- Can be flexibly adapted for use with any land use classification raster, making it applicable to a wide variety of locations and resolutions.
- Available as a standalone web interface but can be integrated into solutions hosted by other platforms as economic modelling layers able to utilise a wide variety of land use rasters.

Case studies

Ivory Coast: Vivid Economics, supported by IPP, is working closely with the UN REDD+ Secretariat and the Ministry of Water and Forests, as well as other parties in Ivory Coast to use IMAGES to inform policy choices in the country.

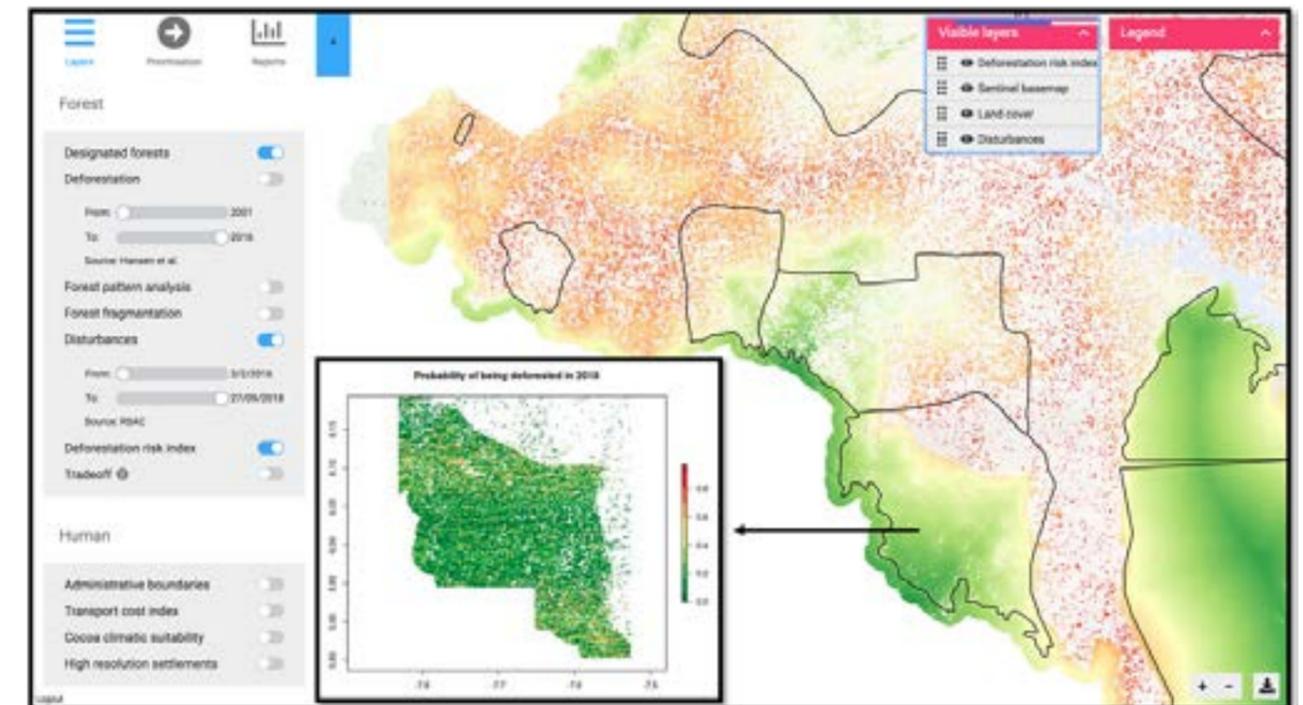
Peru: Vivid Economics, supported by IPP, is using IMAGES to support the national and regional government's planning and implementation of land-use zoning, productive investments, and 'conditional land titling' in the San Martin region of Peru.

Organisation overview

Vivid Economics is a leading economics strategy consultancy with global reach. Specialising in cities, climate change, economic development, energy, finance and natural resources, we advise on the most critical and complex policy and commercial questions facing clients, both in government and the private sector, around the world.

Central to our work is robust, evidence-based analysis communicated effectively. We have wide-ranging expertise and skills in commercial strategy, public policy design, economy-wide and market modelling, econometrics and spatial analysis. Our experience is demonstrated in a track record in delivering first-of-a-kind, custom solutions with solid economic foundations.

Figure 33: Deforestation risk index and forest cover loss between 2016 and 2019 on IMAGES



Pixalytics Portal (Pixalytics)

Overview

Pixalytics Portal provides automated Earth observation (EO) products to potential customers without the need for specialist knowledge of EO. Currently, it includes floodwater mapping, water extent/saturated ground mapping, ocean colour water quality and turbidity mapping. The user chooses their product and select the geographical area on a map they prefer. Then, once they have paid, the portal automatically processes the data and provides the output in a GIS-friendly format.

www.pixalytics.com

Solution benefits

- Affordable and cost-effective EO products to enhance the opportunity for satellite data to be used by the wider community of non-experts.
- Automated processing allows the products to be generated almost instantly for the geographic areas currently offered; worldwide versions of the product are available on request.
- Offers costs savings over an individual user spending their time downloading and processing the data.
- Combines the latest cutting-edge scientific algorithms with EO data to provide an up-to-date picture of what is happening on the planet.

Key technical features

- Uses free data from the Sentinel missions and the United States (NASA/NOAA/USGS) missions including Landsat.
- Uses EO data at a variety of spatial resolutions, down to 10 metre for the flood and water extent mapping products.
- The temporal resolution of the data is limited by the availability of satellite acquisitions, which for the UK is normally every 5-6 days for both Sentinel-1 and 2.
- Offers products using both optical and radar EO data - in particular, the radar data is used for the flood and water extent products that are subsequently not affected by cloudy conditions.

Case studies

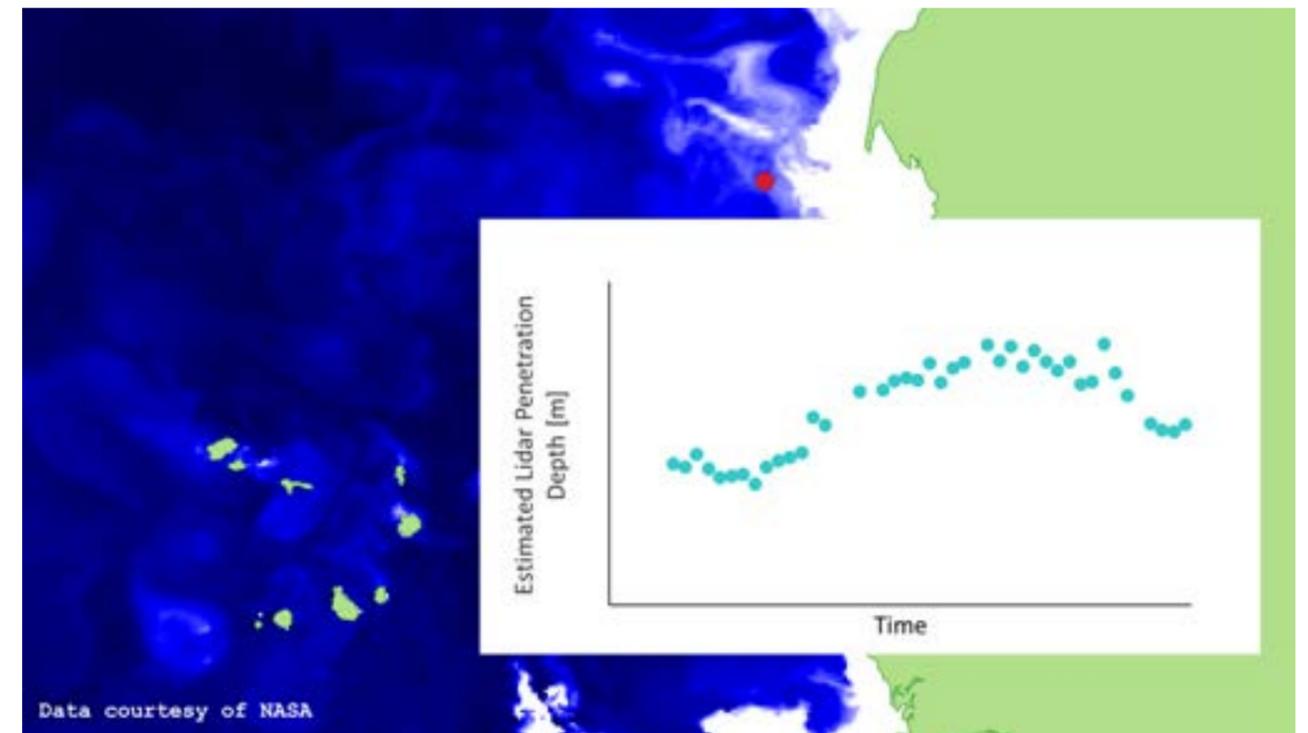
The portal itself is currently in beta test format, although the water extent product is already in near real-time use across Uganda as part of the Drought and Flood Mitigation Service (DFMS), supported by IPP. It allows non-expert users to choose their geographical Areas of Interest (AOI), and then download constantly updated datasets in a GIS-friendly format.

Organisation overview

Pixalytics is a trusted independent Earth observation consultancy. We combine cutting-edge scientific knowledge with satellite and airborne data to provide answers to questions about our planet's resources and behaviour. Our services include scientific consultancy, spatial analyses & data

management, training, research and development services across both marine and terrestrial remote sensing. We offer some unique Earth observations products through our Pixalytics Portal and collaborations with other organisations linked to IPP projects and other activities.

Figure 34: Variability in the turbidity of the coastal ocean off Africa, with a plot of the LIDAR penetration depth over time for a specific location



SENCE (Environment Systems)

Overview

Natural capital is those elements of the natural environment which provide valuable goods and services to people. SENCE provides maps of natural capital stocks to show how well areas of land are able to support ecosystem services such as: food provision, flood protection, pollination, carbon storage, diversity of plants and animals. Decision-makers can monitor natural capital, visualise and estimate the impact of scenarios of change, plan and deliver land management action for long-term sustainable development.

www.envsys.co.uk

Solution benefits

- Natural capital is those elements of the natural environment which provide valuable goods and services to people. SENCE provides maps of natural capital stocks to show how well areas of land are able to support ecosystem services such as: food provision, flood protection, pollination, carbon storage, diversity of plants and animals.
- Assess risks to ecosystem services such as from soil erosion, flood risk, storm surge, climate change; model and map how and where these risks can affect people.
- Identify the best places in the landscape to invest to improve natural assets, for example where to plant natural vegetation to reduce erosion, slow water flow to reduce flooding, reduce the effects of storm surges or store carbon.

- Address business or policy needs with new information to produce strategies and plans to deliver resilient land management action, adaptation and long-term sustainable development.
- Demonstrate the value of natural capital to society and identify where investment in natural assets, enhances these for the benefit of people, wildlife and the economy.
- Working closely with stakeholders to demonstrate the benefits of natural capital to deliver community benefits such as cleaner water, more reliable water supply, ecotourism and resilience into the future.
- Scenario modelling shows how natural assets change in response to differing policy futures or land management strategies.

Key technical features

- Satellite optical and radar data is used to map land use, landform, habitat and vegetation structure, delivering vital new environmental information in places that are remote, dangerous and expensive to survey by fieldwork.
- Works from the field or habitat scale up to catchments, regions and countries.
- Supports natural capital valuation, where techniques are used to frame sustainability issues in terms of our main global indicator of value, which is money.
- Uses freely available Sentinel-1 and 2 satellite imagery (10 metre) or other commercially available higher resolution imagery, providing a range of spatial resolution, typically from 5 to 10 metre.

- Works in conjunction with field survey and existing datasets.
- Modelling handles differing scales and types of input data and can incorporate existing non-satellite environmental, cultural and land-use data.
- The method allows for participatory approaches, such as workshops, to engage stakeholders so that their needs, knowledge and values can then be represented.
- Outputs as GIS map layers including KML, data services, reports.
- Underpinned by the SENCE Ecosystem Reference Database which provides the scientific evidence to support the mapping and modelling based upon studies from over 500 peer reviewed journals.

Case studies

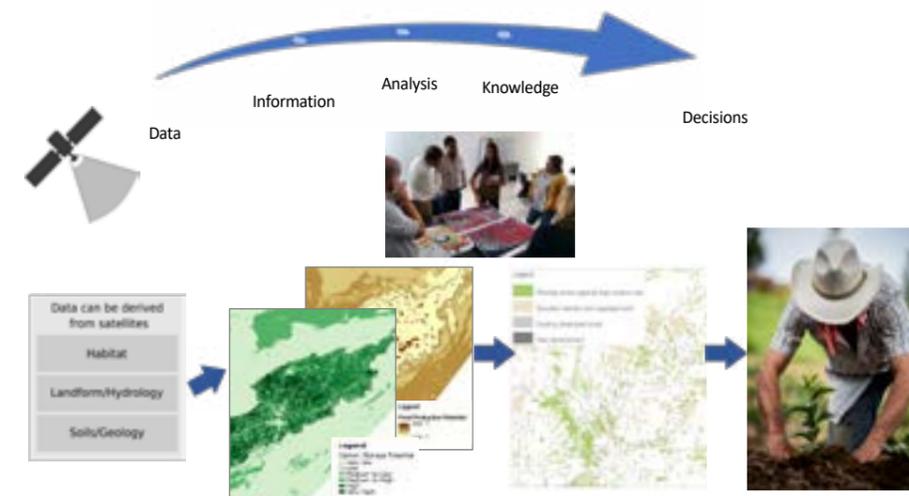
Vulnerability mapping in the UK Overseas Territories with Joint Nature Conservation Committee (JNCC) in Anguilla NEA. The SENCE model assessed

vulnerability to human life from storm surge and flooding for five UK Overseas Territories. Mapping terrain, coastal water depth and terrestrial vegetation from optical and radar imagery produced a storm surge risk model. Coral reef and mangroves demonstrated an important role in counteracting wave energy and reducing storm impact, informing policy and governance, providing practical solutions, such as siting evacuation areas and informing restoration priorities.

Organisation overview

Environment Systems is an established environmental and agricultural data company, providing trusted evidence and insight to governments and industry across the world since 2003. The consultancy delivers bespoke advice and solutions for land management, monitoring and policy for ecosystems, natural capital evaluation, agricultural trials and agricultural supply chains. The company's satellite data services (<https://data.envsys.co.uk/>) deliver always-on, accessible open data insights from satellite earth observations analytics.

Figure 35: Use of satellite data for decision-making for sustainable management of resources using the SENCE approach



Demonstrate opportunities for better use or management of land for economic, societal and environmental benefit

Maritime



Maritime

The world's oceans and coastlines are an essential and valuable resource. The shipping industry, fisheries, tourism, the oil and gas sector all depend on the long-term sustainable development of the marine environment. 'Blue Growth' strategies to enable these sectors to thrive and support new opportunities in aquaculture, marine biotechnology and renewable energy must also protect this vital habitat.

In this vast ocean terrain, satellite services underpin the intelligence gathering requirements to support Blue Growth and are the critical infrastructure to deliver global connectivity. Satellites provide surveillance and communication capabilities for maritime operations and fisheries, and environmental data to support development and enable us to monitor the impact of these activities on marine habitats.

The space sector provides the following solutions for maritime use cases:

Management of fisheries and aquaculture

- **Marine Environment Monitoring (eOsphere)**

Identify and analyse unusual maritime behaviour to enable agencies to stop illegal fishing

- **Innovative SatComms for Inclusive and Sustainable Fishing (Inmarsat)**

Find fishing boats at sea for safety, search & rescue

- **C-RISe Near Real Time Marine Information Service (Satellite Oceanographic Consultants Limited)**
- **exactTrax – Safety and Tracking Initiative for Small Vessels (OASIS-TU / MSIS-TU) (exactEarth Europe Limited)**



Marine Environment Monitoring (eOsphere)

Overview

eOsphere satellite ground receiving stations are installed in countries worldwide (including Indonesia, China, Ecuador and Malaysia) allowing agencies to detect and monitor the marine environment using medium resolution visible and thermal-infrared Earth observation (EO) imagery to determine ocean water quality and sea surface temperature. These EO derived ocean products can be used to monitor the health and productivity of marine habitats, increasingly under pressure from human activity and climate change, by detecting oil slicks, algal blooms, high chlorophyll and suspended matter concentrations and ocean fronts.

www.eosphere.co.uk

Solution benefits

- Ocean water quality measures such as chlorophyll, suspended matter and sea surface temperature can be measured.
- These EO derived ocean products can be used to monitor the health and productivity of marine habitats, increasingly under pressure from human activity and climate change, by detecting oil slicks, algal blooms, high chlorophyll and suspended matter concentrations and ocean fronts.
- The satellite ground station provides automated reception and processing of EO data to enable ocean quality products to be generated in near real time, typically within a few minutes of each satellite overpass.

- Large areas can be monitored many times each day in all but the cloudiest conditions or can be used to generate daily, weekly or longer aggregated cloud free datasets for climate data records.

Key technical features

- The satellite ground station typically includes a 2.4 to 3.0 metre tracking antenna with X-band front end, satellites receiver, high specification ingest and processing systems for automated scheduling, real-time reception, ingestion and processing of the direct broadcast downlinks from the EOS Terra & Aqua (MODIS), Suomi-NPP & NOAA-20 (VIIRS) and Feng Yun 3 (MERSI) meteorological satellites.
- Narrow optical channels on polar orbiting meteorological satellites such as EOS Terra & Aqua and Suomi-NPP & NOAA 20.
- Sea surface temperature measured using multiple thermal infrared channels.
- The satellites used are all free-to-air (i.e. no licensing costs), providing the multiple medium resolution (250 metre to 1 kilometre), visible and thermal-infrared imaging radiometre channels required for routinely monitoring ocean water quality.
- Typically, 4-6 satellite overpasses per day from four satellites, with swath widths of between 2,300 kilometres and 3,000 kilometres, are used to detect and monitor ocean water quality multiple times every day within ~3,000 kilometres of the satellite ground station.

- Ocean water quality products include maps of water leaving radiances, angstrom coefficients, chlorophyll-a concentration, K490 index, coloured dissolved organic matter, particular organic and inorganic carbon, total suspended matter, fluorescence and sea surface temperature.
- In addition to ocean water quality products the eOsphere solution can be used to deliver many other medium resolution environment products including cloud mask, type and optical properties, vegetation indices, aerosols, atmospheric vertical profiles, land and sea surface temperature, land use classification, hot spot detection, snow and sea ice.
- The eOsphere solution is a complete standalone automated end-to-end system from scheduling for reception of satellite overpasses to delivery of ocean water quality products to geospatial databases and web-sites.
- The eOsphere solution includes a fully featured visualisation system for display of satellite imagery and products, along with tools for re-projection, re-sampling, aggregation, re-formatting and delivery of products.
- eOsphere offers a complete solution including requirements specification, delivery, installation and commissioning of all equipment, full integration with end-user's infrastructure, training and ongoing maintenance and support. The user does not need existing or additional IT infrastructure.

Case studies

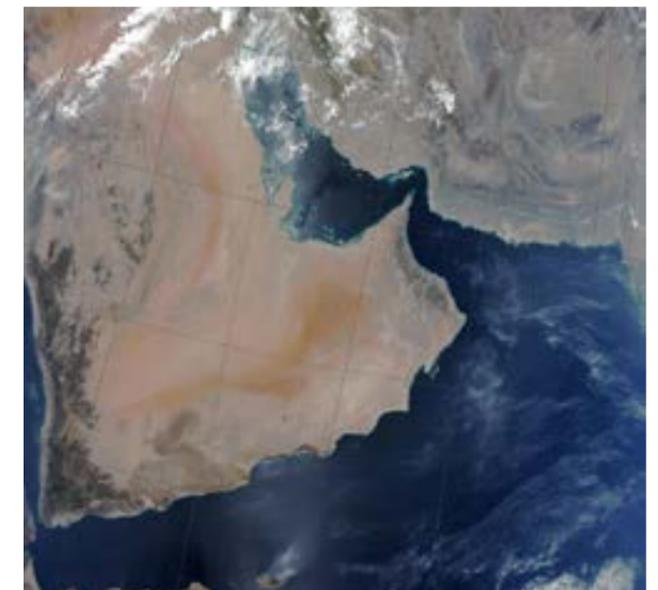
Regional Organisation for Protection of Marine Environment (ROPME) - The eOsphere Marine Environment Monitoring system was supplied to them in 2018. ROPME is a multi-national organisation established to monitor the marine environment in the Arabian Gulf and around the Arabian Peninsular.

Shanghai Ocean University (SHOU) - The eOsphere Marine Environment Monitoring system was supplied to them in 2007, upgraded for reception of new polar orbiting and geostationary satellites in 2013 and 2015 and technology refreshed in 2018. The system is used as a teaching tool for ocean remote sensing and undertakes research into the marine environment of the Chinese sea areas.

Organisation overview

eOsphere was established in 2001 and is strongly focused on solving real remote sensing problems for a range of customers and end users. Key application areas include the provision of affordable satellite ground receiving stations for environmental and hazard monitoring.

Figure 36: Suomi-NPP VIIRS false colour composite swath image of the ROPME sea region, received and processing at ROPME, Kuwait



Innovative SatComms for Inclusive and Sustainable Fishing (Inmarsat)

Overview

Environmentally unsustainable fishing, including illegal and unreported fishing, harms the entire value chain, as well as introducing safety and security challenges. This solution uses fishing Vessel Monitoring Systems (VMS), whereby equipment that is installed on fishing vessels provides information about the vessels' position and activity.

www.inmarsat.com

Solution benefits

- Provision of communications for vessel captains and fishermen at sea to families and for emergencies.
- Enables new operational protocols for policing and fisheries management.
- Improve the policing of illegal fishing and conservation areas via a geo fencing capability.

Key technical features

- This project uses fishing satellite VMS, whereby equipment that is installed on fishing vessels provides information about the vessels' position and activity.
- Inmarsat L-band satellites provide highly reliable global coverage of vessels at sea.
- The Inmarsat-4 constellation offers two connectivity services IsatData Pro and Fleet One.

- IsatData Pro (IDP) is an Internet of Things (IoT) messaging system capable of delivering location tracking and basic two-way communications such as text messaging, emergency alerts, and form submission (e.g. electronic catch reports) for a very low-cost.
- Fleet One enables a richer application environment for productivity tools, including voice capabilities and standardised safety services.

Case studies

Implemented in Indonesia with the Ministry of Marine Affairs and Fisheries (KKP), supported by IPP. Working with the Indonesian Ministry of Fisheries and commercial fishing boat owners, the programme is running two pilots. The first is a pilot of 200 vessels under 30 gross tonnes that has demonstrated the benefits of on board SatComms systems saving 20 lives in the first year of operation. It has also improved the ability for fisher folk to communicate with their families as well as changing the manner in which the vessels operate when at sea.

The second pilot is of vessels over 30 gross tonnes using a feature rich FleetOne device, with aims to improve reporting and prove to be a useful tool for reducing Illegal, Unreported and Unregulated (IUU) fishing.

Organisation overview

As the pioneer and world leader in mobile satellite communications, Inmarsat has been powering global connectivity for nearly four decades. We provide governments, commercial enterprises and humanitarian organisations with mission-critical voice and high-speed data communications on land, at sea and in the air.

Identify and analyse unusual maritime behaviour to enable agencies to stop illegal fishing

C-RISe Near Real Time Marine Information Service (Satellite Oceanographic Consultants Limited)

Overview

C-RISe Near Real Time Marine Information Service – provides hourly updated satellite derived information on marine weather conditions, to provide the latest information on waves and winds, supporting planning of marine operations and warning of severe conditions as they approach. Satellite Earth observation (EO) data provide a valuable source of information on marine conditions, especially for fast moving intense weather systems during the tropical cyclone season.

www.satoc.eu/projects/c-rise

Solution benefits

- In situ data on marine conditions are sparse in the South-West Indian Ocean, and there is limited availability of local marine forecasts.
- Satellite EO provides a valuable source of information on marine conditions, especially for fast moving intense weather systems during the tropical cyclone season (November – May).
- C-RISe provides the latest satellite measurements of ocean winds and waves, overlaid on a model forecast, in an easy to use web format.
- These data can then be used in a range of applications including: maritime safety through search and rescue support and operational planning for illegal logging, smuggling, pollution.
- Improved tropical storm information.

Key technical features

- Sources of satellite ocean wind and wave data are polled every 10 minutes to identify new measurements in the South-West Indian Ocean region.
- New data are identified, processed and loaded onto data tables, and presented on an interactive web interface that can be panned, zoomed and queried.
- These data are presented along-side the latest US NOAA WaveWatch3 model forecast for the region.
- The source data can be accessed directly for integration onto local presentation systems.
- The data provided are open access, provided that the source is acknowledged in any application.
- The satellite data are:
 - satellite altimeter (Jason-2, Jason-3): significant wave height, wind speed, along track, seven kilometre interval. Irregular sampling due to satellite orbit, typically 10-15 passes per day in the region
 - satellite scatterometer (Metop /ASCAT): wind speed and direction 550 kilometre wide swath, 25 kilometre grid resolution, twice daily passes
 - surface current speed and direction from the ESA Globwave project, on a global 11 kilometre grid, updated daily

Find fishing boats at sea for safety, search & rescue

- The model forecast data:

- include US NOAA Wavewatch3 model, wind speed and direction, wave height, period and direction. Global 0.5° model (55 kilometre grid at the equator), updated every six hours
- can be viewed on any computer or smart phone with an internet connection and web-browser. No further local computing capacity is necessary

Case studies

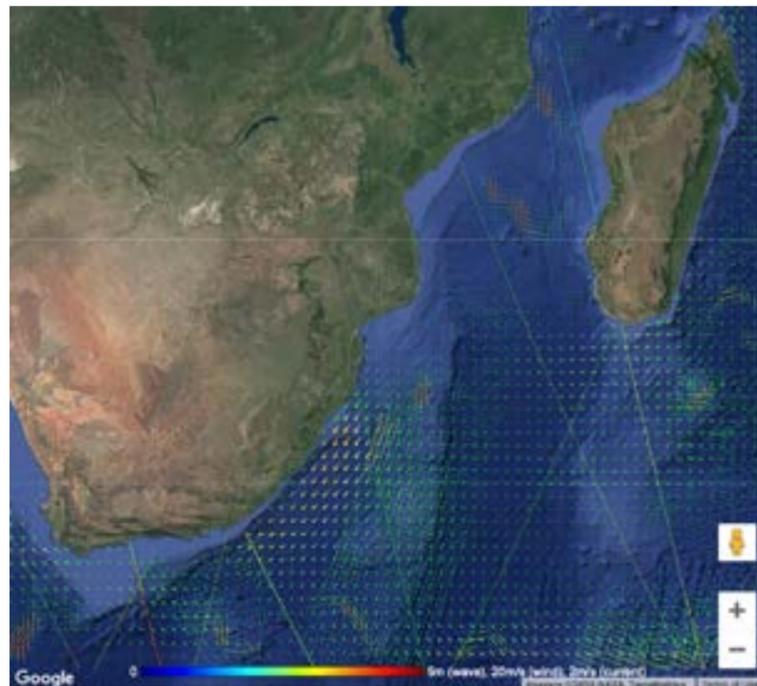
C-RISe is being implemented, with Mozambique, Madagascar and South Africa to provide satellite-based information on sea level rise, storm surges, extreme wind speeds and wave heights, supported by IPP. The goal is to enable local stakeholders to use this information to reduce the social and economic impact of coastal hazards and increasingly variable weather patterns. This is with international partners: Mozambique National

Meteorological Office (INAM); the Mozambique National Maritime and Coastguard Agency (INAMAR); the Madagascar Meteorological Office (DGM); and the Madagascar National Centre for Maritime Information (CFIM).

Organisation overview

Satellite Oceanographic Consultants Limited (SatOC) is an SME, founded in 2008, with the aim to develop and promote practical applications of satellite oceanography, working with industry, the research community and commercial and institutional end users. Our principal technical expertise is on satellite measurements of ocean winds, waves and currents. We also have close association with specialists on satellite optical, infrared and synthetic aperture radar (SAR) imagery from which information on sea surface temperature, water quality parameters and other oceanographic features can be obtained. This gives us a full understanding of all techniques and applications of satellite oceanography.

Figure 37: C-RISe near real time marine weather service web page



exactTrax – Safety and Tracking Initiative for Small Vessels (OASIS-TU/MSIS-TU) (exactEarth Europe Limited)

Overview

Loss of life from small boats at sea, particularly fishing vessels, is a persistent and extensive global problem. Small-scale fisheries are also under threat in many areas of the world from global warming and over / illegal fishing. Small vessels also make up significant proportions of many nations' overall boat populations, but can often be involved in illegal activities such as smuggling of people, arms, drugs and resources.

exactTrax supports the real-time, highly cost-effective, satellite tracking of small vessels equipped with simple-to-deploy transponders. Being standards-based, exactTrax also supports collision avoidance with bigger vessels, and improved maritime safety through a transponder's in-built alert mode.

www.exactearth.com/products/exacttrax

Solution benefits

- Improved safety of life for small boat operators and crew, regardless of whether operating inshore or offshore / open ocean.
- Improved small-scale / artisanal fisheries management.
- Improved maritime awareness / maritime security via small vessel tracking.
- Easy to deploy: on-board transponders applicable to any size / type of boat - from a sail-powered wooden pirogue with no on-board infrastructure to an industrial fishing vessel.
- Very cost effective both in terms of transponder costs and satellite airtime.
- Attractive low-cost alternative to satellite-based Vessel Monitoring System (VMS) for small-scale / artisanal fishing boats.
- Global transponder tracking and safety alert information provided in real-time via exactEarth's 60+ satellite Automatic Identification System (AIS) constellation.

Key technical features

- A wide range of exactTrax-enabled transponders are available; all are battery operated and designed to be deployed on boats with little or no on-board infrastructure. In-line battery charging is via solar-power or on-board DC power if available, or batteries can be charged off-line via mains power.
- Each transponder provides regular position information that can be detected in real-time by exactEarth's satellite AIS constellation, terrestrial AIS networks (if available), and any neighbouring ship equipped with an AIS transceiver.
- Each transponder contains a safety alert function, which can be activated by the crew in the event of an incident at sea. Transmitted alert information can be detected in real-time by exactEarth's satellite AIS constellation, terrestrial AIS networks (if available), and any neighbouring ship equipped with an AIS transceiver.
- Transmitted location and safety alert data is standards based - based on the IMO's international AIS standard.
- Tracking and safety alert data is provided to end users via web browser, SMS and smartphone applications.
- Transponders can be deployed and detected in any part of the world, including polar latitudes.
- Tracking and safety alert data can be provided to organisational users via NMEA feeds and/or OGC-based web services; transmitted transponder data integrates automatically into existing terrestrial AIS networks.
- exactTrax uses a combination of AIS and ASM VHF frequency transmissions; the latter means that satellite detection rates remain good in areas of the world where shipping densities and/or the terrestrial radio noise floor are high.

Case studies

Under the UK Space Agency's International Partnership Programme (IPP), exactTrax has been operationally implemented in South Africa in collaboration with the South African Maritime Safety Authority (SAMSA), the National Sea Rescue Institute (NSRI) and Marine Data Solutions (MDSol). With the support of SAMSA, exactTrax has also been operationally adopted by Ovenstone Agencies (PTY) Ltd for its lobster fishing concession in Tristan da Cunha.

Under a new IPP extension, exactTrax is now being operationally deployed in Madagascar in collaboration with two commercial companies - Stone Three Communications (South Africa) and Ibonia (Madagascar), and a number of Madagascar government departments including the CFIM (Le Centre de Fusion d'Informations Maritimes); the APMF (l'Agence Portuaire, Maritime et Fluviale); ARTEC (L'Autorité de Régulation des Technologies de Communication); COFONA (Le Commandement des Forces Navales); and the CSP (Le Centre de Surveillance des Pêches).

Pilot trials of exactTrax, again with the support of the IPP and SAMSA, have also been successfully run in Namibia, Mozambique, Mauritius, Tanzania, the Gambia and Senegal, with the Gambia the first of these to subsequently adopt the technology operationally on some of its semi-industrial fishing boats. A pilot trial with Project Abalobi (abalobi.info) in South Africa is also ongoing.

Organisation overview

exactEarth Europe (eEE), with its parent company exactEarth (eE), is a satellite AIS (S-AIS) data services SME, providing the most advanced information on global maritime traffic available today and delivering an unrivalled view of the maritime picture at a global scale. Offering fully secure data in a variety of industry standard formats and delivery methods, eEE's data provides real value for a wide range of maritime applications delivering operational efficiencies, enhancing security, safeguarding the environment and assisting in saving lives.

eEE has specific responsibility within the wider eE group to innovate (develop, market and sell) new services based on exploiting satellite AIS; this includes small vessel tracking (exactTrax) and mobile maritime data communications (exactSeNS).

Figure 38: exactTrax transponders deployed in Africa on a fishing vessel



Health



Health

In many countries there are still large health coverage gaps, in particular for poor and marginalised communities. Half the world's population cannot access needed health services, while 100 million people are pushed into extreme poverty each year because of health expenses, shows World Bank Group and World Health Organisation (WHO) research from 2017. In addition, 800 million people spend at least 10 percent or more of their household budget on healthcare expenses, often forcing them to choose between their health and other needed expenses for their family. Even if health services are available, countries at all incomes levels often struggle to ensure quality in health services.¹²

Satellite communications can provide voice and internet communications services for health centres and health workers in rural areas that lack mobile phone signal and internet access. Earth observation (EO) is used to identify areas where there are the right environmental conditions, e.g. humidity and standing water, for certain diseases to spread.

The space sector provides the following solutions for health use cases:

Communications (voice, messaging and internet) for rural health workers and clinics

- **SatComms for Rural Health Services (Inmarsat)**

Assess risk of outbreak and spread of disease

- **Dengue MOsquito Simulation from Satellites (D-MOSS) (HR Wallingford)**

¹² World Bank. 'Health'. <https://www.worldbank.org/en/topic/health/overview>. Accessed December 2018.



SatComms for Rural Health Services (Inmarsat)

Overview

Extending the reach of basic medical services into remote areas, without mobile coverage or internet access. By delivering professional training, data collection and disease monitoring using Inmarsat's Broadband Global Area Network (BGAN) satellite communications technology.

www.inmarsat.com

Solution benefits

- Extension of basic medical services into remote areas of the country that lack mobile coverage.
- Video-based health worker training, improved health systems management and governance using an information system application and improved disease surveillance capabilities.
- Improved health systems management and governance using an information system application connected to the internet.

Key technical features

- Satellite connectivity will be provided by BGAN, accessed by a local tablet with a patient record application (Clinipak) and a medical healthcare video training application (VTR).
- A local Wi-Fi network is installed with access to a variety of Wi-Fi-enabled devices such as smartphones, tablets and laptops.
- Works across many device types including Wi-Fi-enabled feature phones, smartphones, tablets, PCs and laptops.

Case studies

Deployed in Nigeria, supported by IPP, across 75 sites in Kano, Lagos and Ondo states as well as the Federal Capital Territory, bringing the national standards and tools of healthcare to the most remote areas. The solution includes a digital patient record system (Clinipak) and video-based training application (VTR) available in connected parts of the country but in this case enabled by Inmarsat communications technology. The solution helps to close the challenge of the digital divide to improve healthcare at the last mile. It also enables health workers to better support their patients and support state and national government health objectives.

Organisation overview

As the pioneer and world leader in mobile satellite communications, Inmarsat has been powering global connectivity for nearly four decades. We provide governments, commercial enterprises and humanitarian organisations with mission-critical voice and high-speed data communications on land, at sea and in the air.

Communications (voice, messaging and internet) for rural health workers and clinics

Dengue MOsquito Simulation from Satellites (D-MOSS) (HR Wallingford)

Overview

The Dengue MOdel forecasting Satellite-based System (D-MOSS) project is developing a dengue fever early warning system. The tool generates several months advance warning of likely dengue outbreaks. One of the key components is a water assessment module that provides the additional benefit of improving water management in transboundary river basins.

www.hrwallingford.com

Solution benefits

- Probabilistic forecasts of dengue outbreaks issued every month, up to seven months in advance at a district level, covering an entire country.
- Seasonal forecasts (six months) of water availability, covering the whole of the country at a catchment scale.
- Graphical and tabular portrayal of forecasted number of dengue cases, disease incidence, transmission months, probability of exceeding outbreak thresholds and water availability indicators presented in both English and the local language.
- Supporting information on recommended actions to be taken, provided by the decision makers, such as the Ministry of Health and Ministry of Natural Resources and Environment, and based on the forecasts and associated uncertainty.

Key technical features

- Incorporation of a variety of Earth observation (EO) data products ranging from historical observations to the latest state-of-the-art missions.
- Hydro-meteorological and societal parameters are analysed in order to infer dengue fever outbreaks.
- Use of a common spatio-temporal analysis 'grid' with a 'Polygon Series' structure to integrate historical stressor datasets with each other and with historical dengue fever incidents. These are then input into a statistical model which provides forecasts based on future seasonal forecasts of these stressors.
- Accesses the UK Met Office seasonal forecasts (six-months lead time), a set of freely available optical and radar EO data from GPM (NASA/JAXA), Sentinel and SMOS (ESA), SMAP, Aqua and Terra (NASA) such as rainfall, temperature, humidity, soil moisture, land use, population density. This is used to forecast dengue outbreaks and water availability.

Assess risk of outbreak and spread of disease

- Solution architecture relying on open and non-proprietary software and on flexible deployment into platforms including cloud-based virtual storage and application processing.
- Web-based portrayal system and numerical model forecasting engine deployed on commercial cloud services which can be accessed via desktop/laptop devices with an internet connection.
- Open-source solutions are employed where possible together with widely known development languages and tools.
- Built in capability to replicate anywhere in the world and for a variety of other diseases.

Case studies

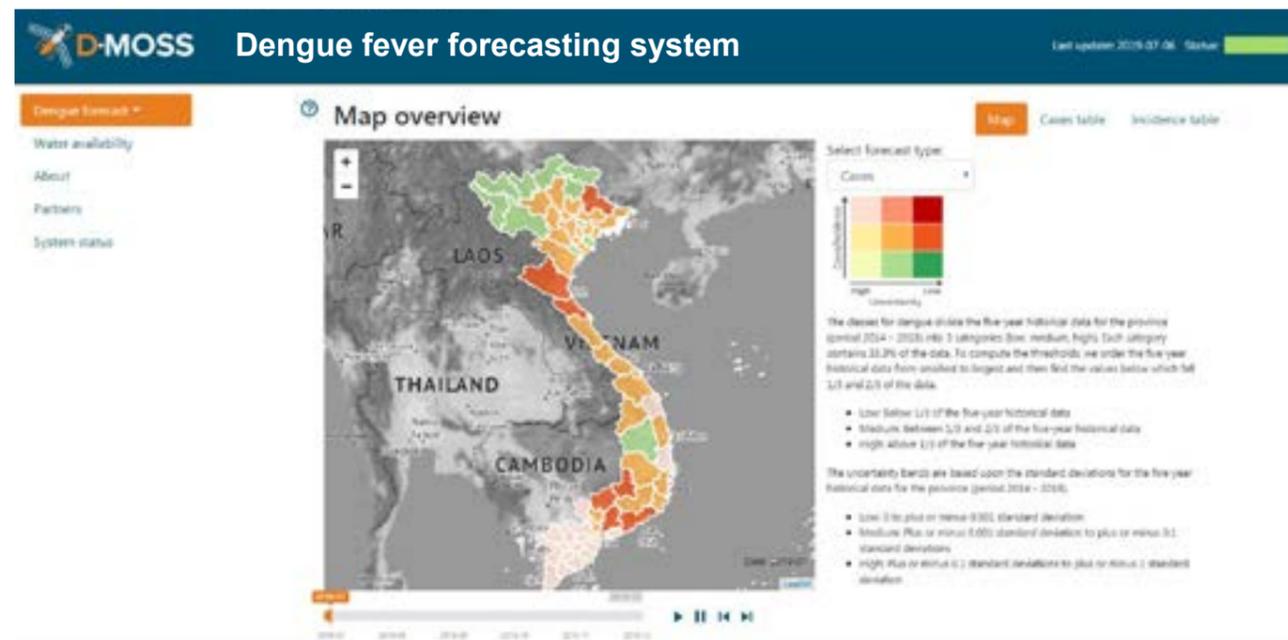
The D-MOSS dengue forecasting system is being implemented in Vietnam, supported by IPP. Considering the current trends in dengue epidemics, the D-MOSS dengue forecasting system will assist the Vietnamese Ministry of Health to put timely dengue

control and prevention measures in place. The project will also estimate the likelihood and severity of future dengue outbreaks under a range of climate change, land-use and water management scenarios. This will allow the Vietnamese Ministry of Health to formulate appropriate interventions and policies. D-MOSS will soon be expanding into another six countries in the region (Cambodia, Laos, Malaysia, Philippines, Sri Lanka and Thailand).

Organisation overview

HR Wallingford with headquarters in Wallingford in the UK, is a not-for-profit, independent research organisation, formed in 1947. HR Wallingford specialises in research and consultancy which includes early warning systems, water resources and climate change adaptation. HR Wallingford works closely with government and non-governmental organisations worldwide to provide the evidence-based tools to support decision making related to water availability and climate change adaptation across a range of sectors.

Figure 39: Designs of the D-MOSS dashboard (currently being built)



Education



Education

Education is a human right, a powerful driver of development and one of the strongest instruments for reducing poverty and improving health, gender equality, peace, and stability. Education delivers large, consistent returns in terms of income and is the most important factor to ensure equality of opportunities. For individuals, it promotes employment, earnings, health, and poverty reduction. Globally, there is a 9% increase in hourly earnings for one extra year of schooling. For societies, it drives long-term economic growth, spurs innovation, strengthens institutions, and fosters social cohesion. Indeed, making smart and effective investments in people is critical for developing the human capital that will end extreme poverty.¹³

Developing countries have made tremendous progress in getting children into the classroom and more children worldwide are now in school.

But learning is not guaranteed, as the 2018 World Development Report (WDR) stresses. For about half of students, schooling is not learning. Hundreds of millions of children cannot read or write despite having attended school. In Sub-Saharan Africa, almost 90% of students do not have the minimum skills in reading and maths. And not even all children are in school – some 260 million children are still out of primary and secondary school.¹⁴

Satellite communications can provide voice and internet connectivity to schools in rural areas to facilitate teaching and learning.

The space sector provides the following solutions for education use cases:

Communications (voice, messaging and internet) for rural schools

- **iKnowledge (Avanti)**

¹³ World Bank. 'Education'. <http://www.worldbank.org/en/topic/education/overview>. Accessed December 2018.

¹⁴ Same as above



iKnowledge (Avanti)

Overview

iKnowledge provides high speed broadband from Avanti's HYLAS 2 Ka band satellite, to provide internet access to hundreds of rural schools in developing countries, using a very small aperture terminal (VSAT) satellite terminal receiver installed at the school. Classrooms are fitted with high speed satellite internet with fully-equipped Information and Communications Technology (ICT) Lab of laptops and projectors, to support the ICT curriculum for students. This is combined with ICT and leadership training for teachers in 100 schools to improve their ability to provide the ICT curriculum to the schools and the community.

www.iknowledge.co.tz

Solution benefits

- Classrooms are fitted with high speed satellite internet with fully-equipped ICT Lab of laptops and projectors, to support the ICT curriculum for students.
- School staff now have the ability to communicate more efficiently with Ministry of Education and district educational offices using the internet.
- Children benefit from learning through the latest audio-visual content to improve their learning experience, which is particularly important for schools that do not have enough text books.
- Solar power for schools without grid electricity.
- Schools that cannot afford a monthly subscription of satellite bandwidth have the ability to buy satellite internet on a pay as you go basis.

- Teacher retention is higher for schools with iKnowledge as teachers have benefits of personal development and easier communication with friends and family.
- Training curriculums provided to teachers include:
 - training teachers how to use ICT facilities in the provision of ICT teaching with the Skill Builder Module
 - providing leadership skills to head teachers and local government bodies on ICT policy and managing ICT in school curriculums with the Leadership Module
 - providing a 'train the trainer' module to ensure the teachers and school administrators pass the ICT skills and leadership training to other teachers, schools and communities with the Academy Management Module

Key technical features

- High speed satellite internet with 15Mbps downlink and 2Mbps uplink.
- Satellite multicast to deliver multimedia rich video and audio content to schools makes efficient use of available satellite bandwidth.
- M-Pesa mobile payment system integrated with a smartphone app, on any internet browser allows teachers, students and the local community to buy internet bandwidth.
- A local cached server stores educational content for teachers to access whenever needed, reducing the need for satellite bandwidth.
- Access Controller with Content Logic provides secure control interface for many teachers to log into the internet, and to protect students, from accessing unsolicited websites and content.

Case studies

iKnowledge, supported by IPP, has been deployed to over 300 schools across 25 regions in Tanzania, including:

Zeze Secondary School - In rural Western Tanzania, there is a lack of network infrastructure and electricity and as a result, teachers and students are unable to access the most up-to-date online educational content, hindering the pupils' learning opportunities and future employability. iKnowledge provided high speed, reliable broadband connectivity to the school and an inexpensive solar solution for electricity.

Science for Marginalised Girls - Many young girls in rural Tanzania have aspirations to become doctors, teachers, and lawyers and are anxious to continue their education but there is a nationwide shortage of science teachers. A school in Kagera proposed a solution to bring high speed, reliable satellite broadband connectivity to the school to enable the marginalised girls to access educational content online and continue their studies.

Organisation overview

Avanti has invested US\$1.2 billion in the latest Ka-band satellite technology and shaped it to meet our customers' aspirations:

- governments that want to empower their digital economies
- mobile operators that wish to bring ubiquitous coverage to their customers
- enterprises that want to grow through digital productivity
- security forces wishing to protect their sovereignty
- people and communities that want to cross the digital divide

Through our HYLAS satellite fleet, we have extensive coverage of the UK, Europe, Middle East and Africa. With market-leading products, we work with local and international service providers to connect homes, grow businesses, extend mobile networks and work closely with governments.

Figure 40: iKnowledge ICT equipment being used in rural Tanzania



An aerial photograph of a winding river with vibrant blue water, flowing through a lush green landscape. The river meanders through various islands and peninsulas covered in dense vegetation. In the upper right, a residential area with small houses is visible through the trees. A red diagonal graphic element is present in the top left corner of the image.

Water & Sanitation

Water & Sanitation

Today, most countries are placing unprecedented pressure on water resources. The global population is growing fast, and estimates show that with current practices, the world will face a 40% shortfall between forecast demand and available supply of water by 2030. Feeding nine billion people by 2050 will require a 60% increase in agricultural production (which consumes 70% of the resource today) and a 15% increase in water withdrawals. Besides this increasing demand, the resource is already scarce in many parts of the world. Estimates indicate that 40% of the world population live in water scarce areas, and approximately one quarter of world's GDP is exposed to this challenge.¹⁵

Climate change will worsen the situation by altering hydrological cycles, making water more unpredictable and increasing the frequency and intensity of floods and droughts. Water security is a major - and often growing - challenge for many countries today. It is a transboundary issue with 276 transboundary basins, shared by 148 countries, and 300 aquifers systems are transboundary.¹⁶

Globally 2.3 billion people live without access to a basic sanitation service: almost 892 million of these people practice open defecation. Despite significant gains, over 2.2 billion people gained access to improved toilets or latrines since 1990, sanitation was one of the most off-track Millennium Development Goals (MDGs) globally.¹⁷

Earth observation (EO) aids the planning of infrastructure for provision of clean water and sanitation. It also supports the identification of existing water sources, for example unmapped watering holes, and identify new potential sites for water exploration.

The space sector provides the following solutions for water and sanitation use cases:

Improve infrastructure for provision of clean water and sanitation

- **Watershed Management (Rezatec)**

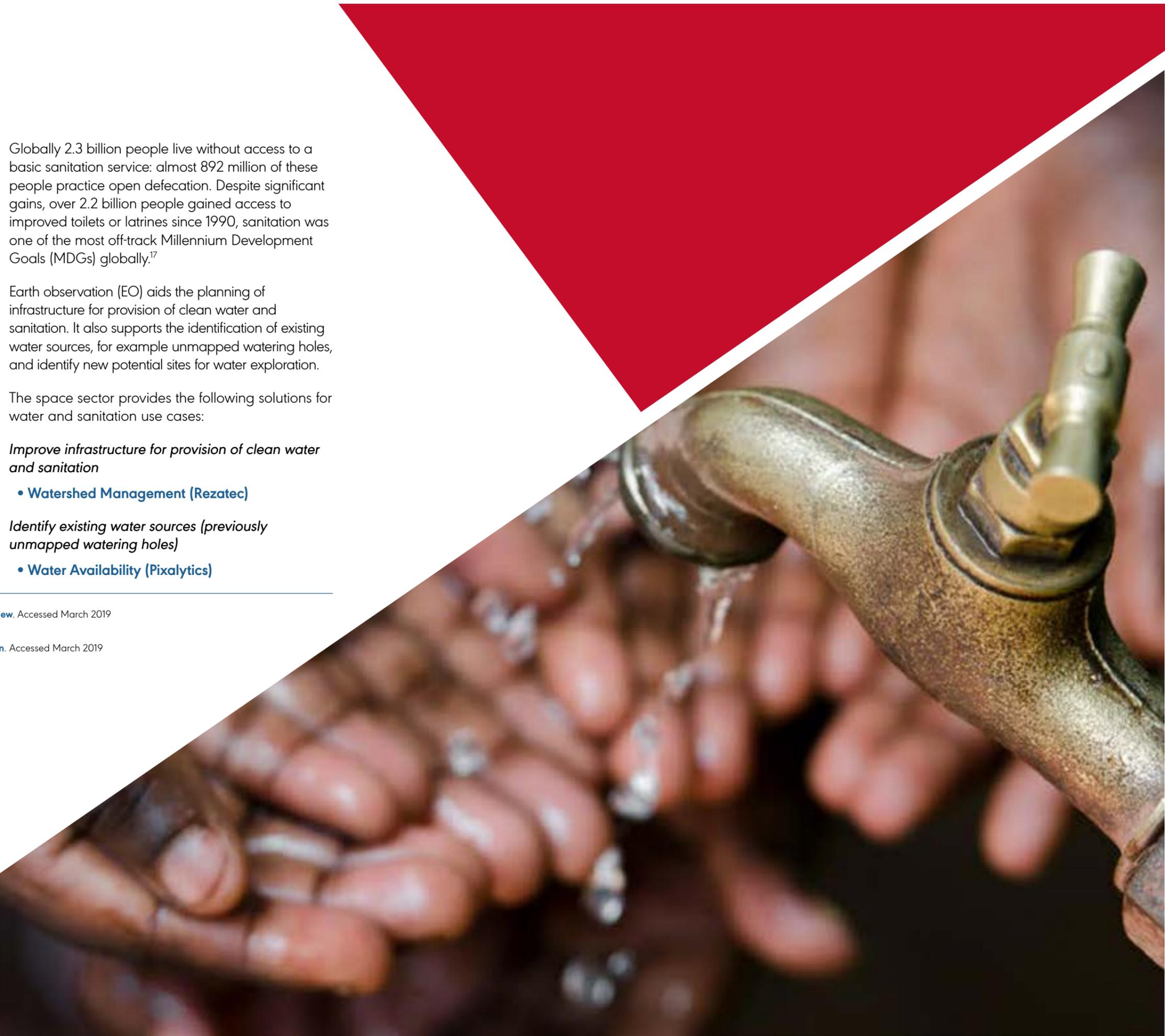
Identify existing water sources (previously unmapped watering holes)

- **Water Availability (Pixalytics)**

¹⁵ World Bank. 'Water'. <http://www.worldbank.org/en/topic/water/overview>. Accessed March 2019

¹⁶ Same as above

¹⁷ World Bank. 'Sanitation'. <http://www.worldbank.org/en/topic/sanitation>. Accessed March 2019



Watershed Management (Rezatec)

Overview

Effective catchment management is vital for water companies to achieve water quality without having to undertake expensive treatment downstream. This means mapping, measuring, monitoring and predicting change across landscapes within catchments in order to better understand the relationship between land use and water quality. Until now, water companies have found it difficult to achieve this level of insight across large catchments with any frequency without a heavy reliance on costly ground resources. The product provides regularly updated Earth observation (EO) based analytics to understand land use and engage with local land owners, meet regulatory compliance, and reduce water treatment costs.

<https://www.rezatec.com/services/water-management/water-quality/>

Solution benefits

- Use regularly updated analytics to understand land use and engage with local land owners, meet regulatory compliance, and reduce water treatment costs.
- Map agricultural land use at field level across a large area to identify hotspots of agricultural pollution polluting the water catchment.

- Predict future diffuse pollution based on the crop growth cycle and other agricultural uses.
- Improve management of water abstraction by predicting changes in diffuse pollution based on precipitation and water flow.
- Communicate easy-to-interpret information to a wide range of water quality stakeholders and land owners to support engagement programmes that reduce the need for costly water purification.
- Analytics delivered via web-based portal or integrated into existing GIS systems.

Key technical features

- Multi-spectral Sentinel satellite EO data combined with proprietary algorithms allows identification of crop types with a high level of accuracy.
- Monthly updates allow for both summer and winter land use mapping and crop identification.
- It allows monitoring of large water catchment areas and identification of sources of pollution not currently identified.

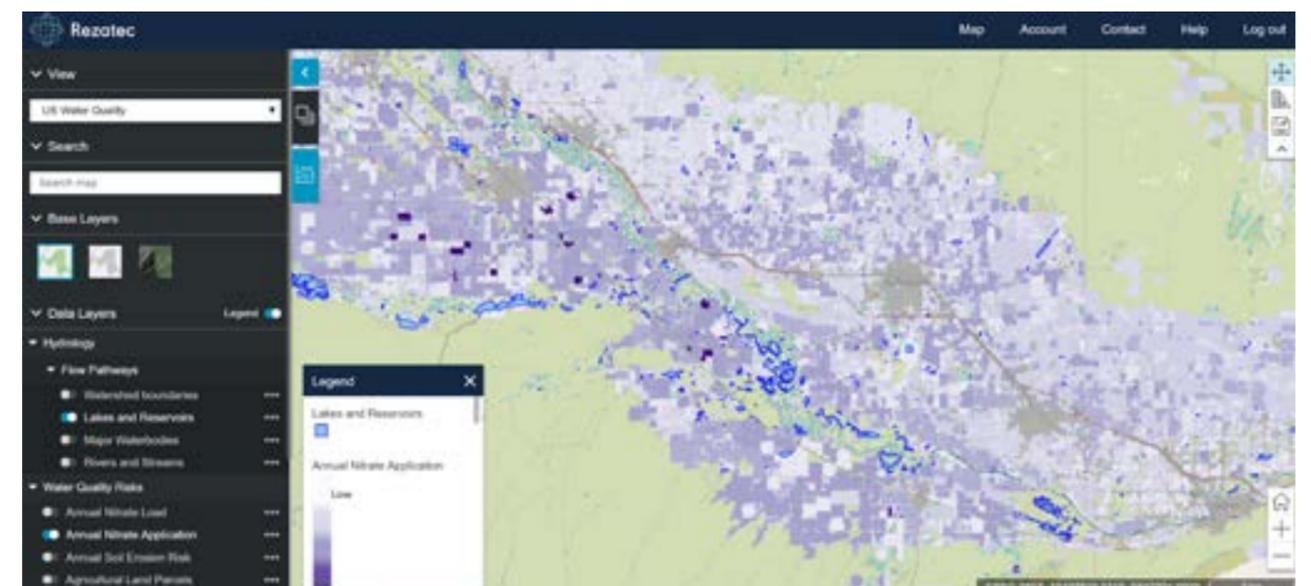
Case studies

Working with Metro Pacific Water to improve the availability of drinking water in the metropolitan city of Manila in the Philippines. Using pioneering EO data processing techniques and proprietary algorithms, Rezatec analysed agricultural and urban land use and modelled the natural hydrology around Laguna Lake - the largest lake in the Philippines - to produce a land-use map to identify diffuse sources of urban, industrial and agricultural pollution, hydrological attributes and rainfall run-off models.

Organisation overview

Rezatec applies data science to satellite imagery and geospatial data to deliver sophisticated, cloud-based analytics to customers owning and operating high value, distributed land-based assets. Rezatec data services enable improved margins, enhanced competitive advantage and optimised asset management for its customers. Rezatec customers cover the globe and are leaders in their respective industries in the water, agriculture, infrastructure and forestry sectors.

Figure 41: Annual nitrate load per field shown in the Rezatec portal



Improve infrastructure for provision of clean water and sanitation

Water Availability (Pixalytics)

Overview

Pixalytics has derived soil moisture content, water body height and water extent - which includes both water bodies and saturated ground - information using microwave data from Earth observation (EO) satellites that can be used to identify and map water sources. Microwave EO data has the benefit of not being affected by cloud, and when combined with other data sources provides an invaluable and practical way to monitor water sources over wide areas and in countries where similar information is often sparse.

www.pixalytics.com

Solution benefits

- Time savings in monitoring water sources through easier data availability, and financial savings by not having to maintain physical equipment or record in situ measurements.
- EO has advantages over ground-based measurements for mapping large areas in developing countries.
- Comparisons of satellite-derived water extents over time can show areas of diminishing open water with variations of water height for larger water bodies, for example, crops planted around the margins of lakes can encroach over time.
- Soil moisture can indicate the availability of water for crops.
- Allows the processing of historical data for new sites to see trends in water sources over time.

Key technical features

- Pixalytics product uses satellite EO data with a variety of spatial resolutions, including the whole of the country down to 10 metre resolution.
- Primarily uses free-to-access Sentinels and other space agency satellite missions, such as those operated by NASA and NOAA.
- Based on microwave data that provides information in cloudy conditions.
- Combines the power of different satellite-based instruments and processing techniques to understand a more comprehensive picture of water availability.
- The water extent product is running in near real time and is updated every time one of the Sentinel-1 satellites passes over Uganda, allowing an updated map of the full country to be generated every month. Whereas, the water height product is point values over specific water bodies.
- Runs within a cloud-based computing system with the outputs integrated into the specific platforms being developed for the DFMS system for Uganda and the EcoProMIS project in Colombia.
- Also available via a web-portal for other customers who only need a device and internet connection.

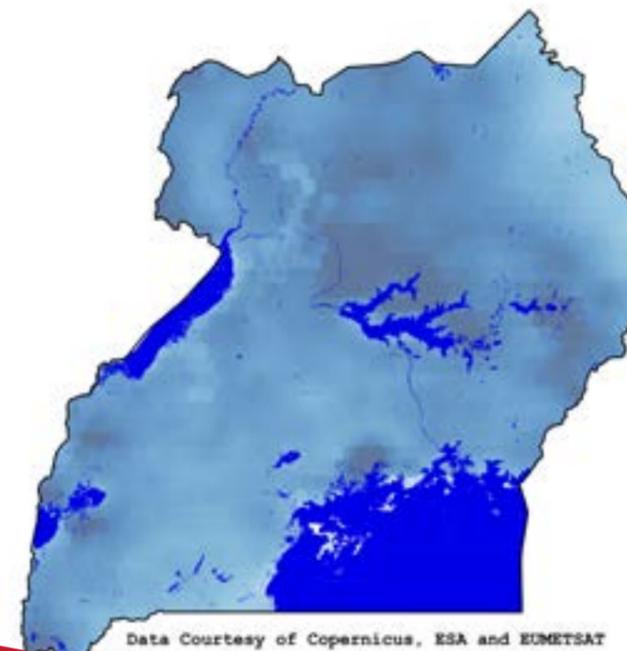
Case studies

As part of the Ugandan Drought and Flood Mitigation Service (DFMS), funded within IPP, Pixalytics has developed a suite of water-focused EO products that support the Ugandan government alongside a wider range of DFMS individual users in understanding water availability. The EO products are being combined with ground-based and modelling inputs from other project partners within DFMS, to support an early warning system for future potential floods and droughts enabling national and local organisations to provide advice to farmers to enable them to take actions to reduce the risk from these events.

Within the EcoProMIS project, which started in 2018, Pixalytics is initially developing a series of vegetation monitoring products specifically tuned to rice and oil palm. However, water availability is a key concern for sustainability, and so we will be investigating these products for their applicability to Colombia.

Organisation overview

Figure 42: Multi-year average of the soil moisture during September (darker as wetter) overlaid with the September 2018 water extent data that shows primarily open water



Pixalytics is a trusted independent Earth observation consultancy. We combine cutting-edge scientific knowledge with satellite and airborne data to provide answers to questions about our planet's resources and behaviour. Our services include scientific consultancy, spatial analyses & data management, training, research and development services across both marine and terrestrial remote sensing. We offer some unique Earth observations products through our Pixalytics Portal and collaborations with other organisations linked to IPP projects and other activities.

*Identify existing water sources
(previously unmapped watering holes)*



Energy

Energy

Energy is at the heart of development. Without energy, communities live in darkness, essential services such as clinics and schools suffer, and businesses operate under crippling constraints. Energy makes possible the investments, innovations and new industries that are the engines of jobs and growth for entire economies. Universal access to affordable, reliable and sustainable energy, Sustainable Development Goal (SDG) 7, is essential to reach other SDGs and is at the centre of efforts to tackle climate change.¹⁸

Today, about one billion people still live without electricity, while hundreds of millions more live with insufficient or unreliable access to it. At the same time, nearly three billion people cook or heat their homes with polluting fuels like wood or other biomass, resulting in indoor and outdoor air pollution that cause widespread health impacts.¹⁹

Earth observation (EO) can be used to define the best mix of energy sources for a country, company or community and to improve the planning and design of renewable energy systems through accurate assessment of insolation, wind and rainfall.

The space sector provides the following solutions for energy use cases:

Accurately plan, design and monitor solar, wind and hydropower systems, based on insolation, wind and rainfall, for countries, companies or communities

- **Renewable Energy Space Analytics Tool (RE-SAT) (Institute for Environmental Analytics)**

¹⁸ World Bank. 'Energy'. <http://www.worldbank.org/en/topic/energy/overview>. Accessed December 2018.

¹⁹ Same as above



Renewable Energy Space Analytics Tool (RE-SAT) (Institute for Environmental Analytics)

Overview

RE-SAT provides advanced data analytics to help energy planners and investors to locate renewable energy generators in order to optimise the amount of renewable energy generated, minimise their environmental impact and maximise the return on investment.

www.the-iaea.org

Solution benefits

- Improve renewable energy planning through high-resolution estimates of power availability from renewable sources.
- Increase the chance of investment in new renewable energy infrastructure through more accurate energy projections.
- Optimise the requirement for spare capacity, such as spinning reserves or battery storage, to balance intermittent renewable energy production.
- Optimise the location of renewable energy infrastructure by integrating GIS layers such as protected areas, proximity to the existing energy infrastructure and road networks.

- Increase productivity through collaborative working using the online data repository to share relevant energy documentation with key stakeholders, such as policy makers, energy planners, utility companies and regulators.
- Save time and money on lengthy natural resource field surveys through access to high-resolution computer simulated data.

Key technical features

- A web-enabled, cloud-based application allows centralised application maintenance for geographically distributed users.
- No requirement to install local software or maintain the platform.
- Best-in-class resource data - accuracy of one square kilometre and 10-minute time variability.
- Ability to model a range of renewable energy resources including solar, wind and wave devices.
- The Scenario Builder application enables users to define a collection of renewable energy installations, producing a detailed energy performance analysis per generator and for the scenario as a whole.
- Allows for uploading GIS layers directly onto the platform.
- Easy-to-use data repository with specific user access through password protected, secure logins, allows quick access to resource assessments and relevant national energy information.

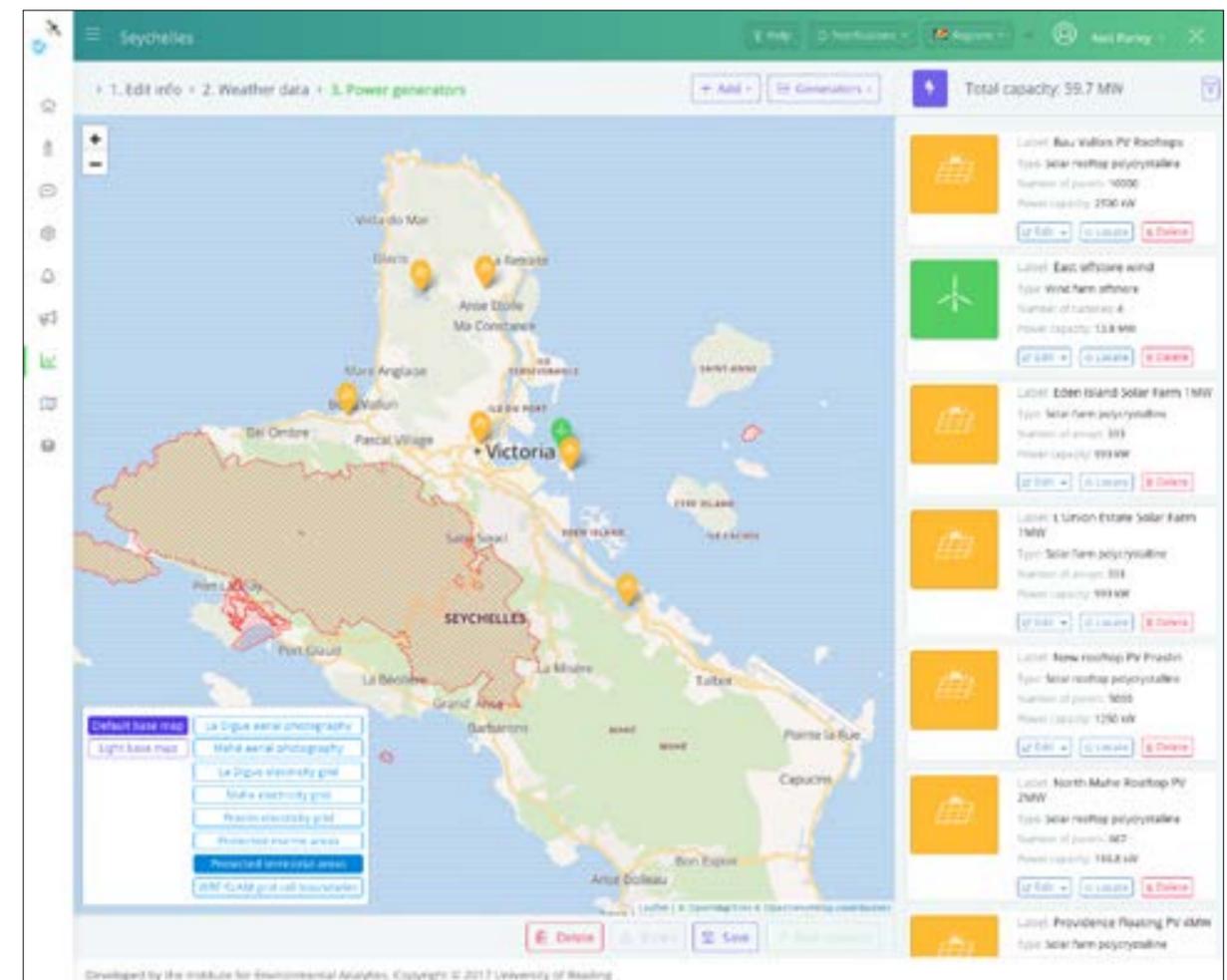
Case studies

RE-SAT has been used by the Government of Seychelles to explore the target of achieving 15% of renewable electricity generation by 2030. This was the first attempt for the government of Seychelles to model a potential scenario to reach that target. By using RE-SAT they realised that to achieve the target they needed to increase the type of generators as the target could not be achieved with just solar energy due to the lack of available area. RE-SAT is now being deployed across six other Small Island Developing States (SIDS).

Organisation overview

Founded in 2015, the Institute for Environmental Analytics (IEA) is one of the world's leading centres for big data analytics in the environmental field. The IEA specialises in turning large scale, global environmental data into easy-to-use products for clients in the energy, agriculture and infrastructure markets.

Figure 43: RE-SAT energy planning application showing the location of generators that the user has selected for that particular scenario



Accurately plan, design and monitor solar, wind and hydropower systems, based on insolation, wind and rainfall, for countries, companies or communities

Mining and Industrial



Mining and Industrial

Natural resources play a dominant social, economic, and political role in 81 countries, accounting for a quarter of global GDP and half the world's population. Africa alone is home to about 30% of the world's mineral reserves, 10% of the world's oil, and 8% of the world's natural gas. But all too often these natural resources have become a source of conflict rather than opportunity. Many resource-rich countries also suffer from poverty, corruption, and conflict stemming from weak governance.²⁰

Earth observation (EO) and Global Navigation Satellite System (GNSS) can be used to monitor large scale mining and industrial infrastructure from space for structural movement and weakness – enabling improved maintenance and prevention of structural damage or failure.

The space sector provides the following solutions for mining and industrial use cases:

Minimise environmental damage from mining and industry

- **Dam Monitoring from SATellites (DAMSAT) (HR Wallingford)**

Monitor the development of large infrastructure projects

- **Satellite-Structural Health Monitoring (S-SHM) & Satellite Ultra-Precise Motion Monitoring Integrated Technology (SUMMIT) (Telespazio VEGA UK)**

20 World Bank. 'Extractive Industries'. <http://www.worldbank.org/en/topic/extractiveindustries/overview>. Accessed December 2018.



Dam Monitoring from SATellites (DAMSAT) (HR Wallingford)

Overview

Dam Monitoring from SATellites (DAMSAT) uses satellite technology to remotely monitor water and tailings dams and other tailings deposit areas. The system will help authorities take preventative action and thus reduce the risk of failure of water and tailings storage facilities and the consequent damage to population and ecosystem services downstream.

<https://damsat.org/>

Solution benefits

- Increased monitoring capacity by providing frequent monitoring information over wide areas and across remote locations.
- Action timely preventative interventions to reduce the risk of failure and damage to population and ecosystems downstream by receiving abnormal behaviour and weather forecast alerts.
- Consistent monitoring across sites regardless of the relative inaccessibility and hazardous nature of the terrain.
- The wide area coverage allows detecting issues in areas where it might not be expected, areas that are not currently monitored or that are difficult to access.
- More efficient use of resources and improved planning and prioritisation of site visits thanks to available performance information for the sites.

- High- or low-resolution solutions depending on the accuracy and frequency needs.
- Assessment of consequences of dams failures that informs about risk.

Key technical features

- Browser map-based interface with graphical portrayal of data, providing data analysis and a variety of alert management options. Including traffic light status indicators for infrastructure sites of interest.
- Wide area movement monitoring based on Interferometric Synthetic Aperture Radar (InSAR) data using high resolution COSMO-SkyMed Himaq and low resolution Sentinel-1 with quarterly and biweekly updates
- Real-time movement detection for specific infrastructures using in-situ Global Navigation Satellite Systems (GNSS) receivers, with millimetre precision and at five minute intervals.
- Rainfall, water level and overtopping forecast alerts for storage facilities based on hydrological modelling and weather forecast data from the European Centre for Medium-Range Weather Forecasts (ECMWF) and the National Oceanic and Atmospheric Administration (NOAA).
- ECMFW's forecast comprises high resolution global deterministic forecast to be produced at nine kilometre grid resolution with a lead time of up to 10 days.
- NOAA freely available GFS forecast data has a resolution up to 30 kilometers with four forecasts per day and a lead time of 16 days.

- Pollution monitoring based on satellite Earth observation (EO) optical data analysis from Landsat, Sentinel and potentially other high-resolution sources.
- Overlays of dam failure flood outlines and consequences based on two-dimensional hydraulic modelling.
- Cloud platform-based solution running on Siemen's MindSphere, which provides state of the art security framework compliant with industry standards.

Case studies

The approach is being tested on a number of water and tailings dams as well as operational, closed and abandoned tailings storage facilities in the mining regions of Cajamarca and Cerro de Pasco in Peru, supported by IPP. This is in collaboration with multinational mining companies and local and

national authorities including the Ministry of Energy and Mines and the National Water Authority. The solution will help the authorities and companies to effectively monitor the large number of existing tailings dams and storage facilities, especially those in remote locations, and allow them to take proactive actions.

Organisation overview

HR Wallingford with headquarters in Wallingford in the UK, is a not-for-profit, independent research organisation founded in 1947 specialising in research and consultancy including dams, hydraulics and hydrology and flood risk. HR Wallingford works closely with government and non-governmental organisations worldwide to provide evidence-based tools to support decision making related to dam and flood defence failures and flood risk impacts.

Figure 44: A tailings dam in Peru



Satellite-Structural Health Monitoring (S-SHM) & Satellite Ultra-Precise Motion Monitoring Integrated Technology (SUMMIT) (Telespazio VEGA UK)

Overview

Satellite-Structural Health Monitoring (S-SHM™): Innovative use of satellite technologies in ground motion based structural engineering monitoring. It is a highly scalable solution from that can monitor a single piece of infrastructure up to city-scale survey – to detect structural and ground motions.

Satellite Ultra-Precise Motion Monitoring Integrated Technology (SUMMIT): Monitoring of ground motion of specific infrastructure using Global Navigation Satellite Systems (GNSS).

<http://telespazio-vega.com/>

Solution benefits

Satellite-Structural Health Monitoring (S-SHM™):

- Allows infrastructure asset managers to assess specific structures such as bridges, dams, flyovers, buildings for ground movement impact on the structure.
- Provides a three-dimensional view of infrastructure asset health by monitoring ground movements.
- Allows long term preventive maintenance of the infrastructure asset.
- Works in most weather conditions including cloud.
- Precise structural and ground motion detected in order of 2-3 millimetres.

- No in-situ equipment or site access required over large areas.
- Multiple infrastructure assets can be monitored simultaneously.

Satellite Ultra-Precise Motion Monitoring Integrated Technology (SUMMIT):

- Remote monitoring of strategically targeted infrastructure assets in real time.

Key technical features

Satellite-Structural Health Monitoring (S-SHM™):

- Uses radar that works in cloudy conditions.
- Combines Interferometric SAR (InSAR) derived point cloud data and three-dimensional models of the infrastructure.
- Uses high resolution commercial COSMO-SkyMed SAR data, in either Spotlight (one metre) or StripMap (three metre) modes to match customers' needs.
- An innovative InSAR method using Persistent Scatterer Interferometry (PSI) is applied.
- Utilises solid points on buildings, rock and poles to build a picture of up to 300,000 points per image to monitor ground movement.
- InSAR combined with three-dimensional Building Information Modelling (BIM) to map structure and ground motion.
- Colour indexed point data for each PSI visualises the amount of movement that has been observed.

- A standalone solution implemented on Telespazio's computing infrastructure; a user with an asset management portal can access the output of the S-SHM tool via JSON format.

Satellite Ultra-Precise Motion Monitoring Integrated Technology (SUMMIT):

- In house developed software and GNSS hardware to provide real time GNSS measurements of ground movement.
- Data generated every minute and updated to the server every five minutes.

Case studies

S-SHM™: Satellite Structural Health Monitoring – was developed under InnovateUK funding to provide structural specific assessment based upon the use of Persistent Scatterer InSAR (PSI) data. This supported an assessment of Transport for London's (TfL) East India and Canning Town stations and showed displacement movements.

Figure 45: Left: SUMMIT interface with motion vectors displayed over the site map. Right: SHM view of East India & Canning Town



SUMMIT applied to Tailing Dams monitoring – SUMMIT is being used in the IPP supported project 'Space-based dam monitoring' in Peru with HR Wallingford. Two targeted tailing dams will be monitored with both the SUMMIT system and the InSAR S-SHM™; one dam site is abandoned with potential risk of leakage and the other is an active tailing dam.

Organisation overview

Telespazio VEGA UK Ltd (TVUK) is a highly experienced consulting, technology and engineering services business, which supports satellite operators and manufacturers worldwide and helps other organisations benefit from space data and services. Based in the UK, it is a wholly owned subsidiary of Telespazio SpA, and employs approximately 140 highly qualified staff with a wide experience in Science, Earth Observation, Geo-Information, Navigation and Telecoms Projects.



Monitor the development of large infrastructure projects

An aerial photograph of a vast, densely populated city, likely Tokyo, showing a grid of streets and numerous skyscrapers. In the background, a range of mountains is visible under a hazy sky. The top-left corner of the image is obscured by a dark purple, curved graphic element.

Urban and Transport

Urban and Transport

Globally, 55% of the population lives in urban areas today, and this trend is expected to continue – by 2045, the number of people living in cities will increase by 1.5 times to six billion, adding two billion more urban residents. By 2050, 68% of the world's population will be urban. With more than 80% of global GDP generated in cities, urbanisation can contribute to sustainable growth if managed well by increasing productivity, allowing innovation and new ideas to emerge.²¹

However, the speed and scale of urbanisation brings challenges, including meeting accelerated demand for affordable housing, well-connected transport systems, and other infrastructure, basic services, as well as jobs, particularly for the nearly one billion urban poor who live in informal settlements to be near opportunities.

Building cities that “work” – being inclusive, safe, resilient, and sustainable – requires intensive policy

coordination and investment choices,²² supported by consistent, accurate and up-to-date information on the status and development of the built environment.

Earth observation (EO) offers great capabilities for the monitoring, inventory and analyses of urban areas and transportation systems.

The space sector provides the following solutions for urban and transport use cases:

Monitoring and planning urban environments

- **Satellite Image Analysis for Maintenance of Property Databases (Airbus Defence and Space)**
- **CRUST: Climate Resilient Urban Simulation Tool (Vivid Economics)**

Monitoring cultural buildings and heritage

- **Cultural Heritage Protection Service (UNOSAT)**

²¹ World Bank. 'Urban Development'. <https://www.worldbank.org/en/topic/urbandevelopment/>. Accessed December 2018.

²² Same as above



Satellite Image Analysis for Maintenance of Property Databases (Airbus Defence and Space)

Overview

Airbus has developed a solution for monitoring changes to buildings in urban and rural environment through the analysis of three-dimensional satellite data. The focus of this solution is that property records can be kept up to date to enable equitable property taxation to raise much needed funds for developing cities.

www.intelligence-airbusds.com/land-administration

Solution benefits

- Use of very high-resolution satellite Earth observation (EO) to monitor detailed change in the urban environment.
- Identifies buildings and land parcels that have changed and directs fieldwork assessment for detailed property data collection.
- Updated property details allow valuations to be kept aligned and remain current.
- This valuation information feeds property taxation and enabling revenue to be collected by the national tax authorities.
- Ensuring the property database is maintained and kept up to date, maximises revenue potential for benefit of local authority through the increased funding of local public services.
- An up to date and equitable tax base linked to service development increases the willingness to pay amongst property owners.
- This innovative technique to data updates has been shown to be more efficient and cost effective than purely a manual, fieldwork-based approach.

Key technical features

- Airbus commercial Pleiades satellite imagery used in tri-stereo mode allowing Digital Surface Models (DSM) to be created.
- Land parcel maps created using open source GIS software and manual image interpretation with the work carried out by local teams trained by Airbus staff.
- The land parcels created represent the base units that undergo change detection.
- Change detection process identifies both two-dimensional and three-dimensional changes permitting the recognition of potential increases in the number of storeys.
- Change process deployed as a web application on Airbus servers accessible anywhere with an internet connection.
- Change results uploaded to mobile application on Android tablets for follow up field work.
- Once field work is complete, updated property details are synchronised with central property database, allowing updated details to be used for valuation calculations.

Case studies

Airbus has deployed this solution in the Senegalese capital Dakar, supported by IPP. It can be applied to other cities in Senegal and globally. A team of local staff working for Airbus' partner have created a land parcel map for the majority of the city. Key areas have then undergone the change detection process using multiple epochs of imagery, typically six months apart. The change results were verified in the field using a mobile tablet application, and property details collected enabling valuation calculations to be made and provided to the revenue authority.

Organisation overview

Airbus Defence and Space - Intelligence UK, provides satellite image acquisition and timely processing, interpretation, analysis and management, as well as hosting of geospatial data and consultancy services for many sectors including: central and local government, land administration, agriculture, forestry and the environment. Products and services delivered from our four UK offices provide solutions for our customer base around the globe.

New Africa Consulting (NAC) is a specialist in developing public-private partnership in Senegal. It was created as part of a commitment to the implementation of Africa's key development strategies.

Figure 46: GIS representation, by colour and vertical extent, of the property values for individual land parcels in Dakar



CRUST: Climate Resilient Urban Simulation Tool (Vivid Economics)

Overview

Sustainable urban growth requires adequate planning. The current urban footprint and its potential future growth are important factors that affect a city's ability to become sustainable and improve the quality of life of its citizens. The climate resilient urban simulation tool helps facilitate the analysis of different growth scenarios that allows cities to estimate the future land needs, infrastructure costs, vulnerability profiles and GHG emissions associated with different options.

www.vivideconomics.com

Solution benefits

- Combines satellite imagery with volunteered geographic information data to generate automated urban growth and land use inventories which can be further enriched with local data.
- Urban growth simulation tool framework that helps urban planners and policy-makers with visually & spatially-explicit scenarios of future urban growth.
- Simulation framework integrates climate resilience focusing on floods, conservation planning and compact growth to help land use planners to create best use of land plans.
- Allows policymakers to identify future hotspots of development where infrastructure provision is a priority, vulnerable areas which need to be protected from future growth.

- Land allocation tool as part of the framework allows housing departments to identify best consolidated land parcels for low income housing schemes.
- Urban growth monitoring tool as part of the framework helps local governments to monitor the growth of illegal settlements in sensitive areas.

Key technical features

- Automated built environment monitoring using open access multitemporal Landsat and Sentinel imagery which can be combined with high resolution imagery such as Worldview to create detailed land use inventories for a city.
- Uses econometric techniques to estimate future housing demand taking into account future shocks.
- Machine learning based simulation tool which identifies potential drivers of urban growth to spatially allocate future residential, commercial and industrial demand at 30m resolution.
- Can be flexibly adapted for use with any land use classification raster, making it applicable to a wide variety of locations and resolutions.
- Can be coupled with a catastrophic model to integrate present and future hazards and exposure and vulnerability assessments for different scenarios.

Case studies

Georgetown, Guyana: Vivid Economics, supported by Inter-American Development Bank, is working closely with the Ministry of Housing, Central Housing and Planning Authority as well as other parties in Guyana to use the tool to inform flood-resilient land development choices in the capital city of Georgetown.

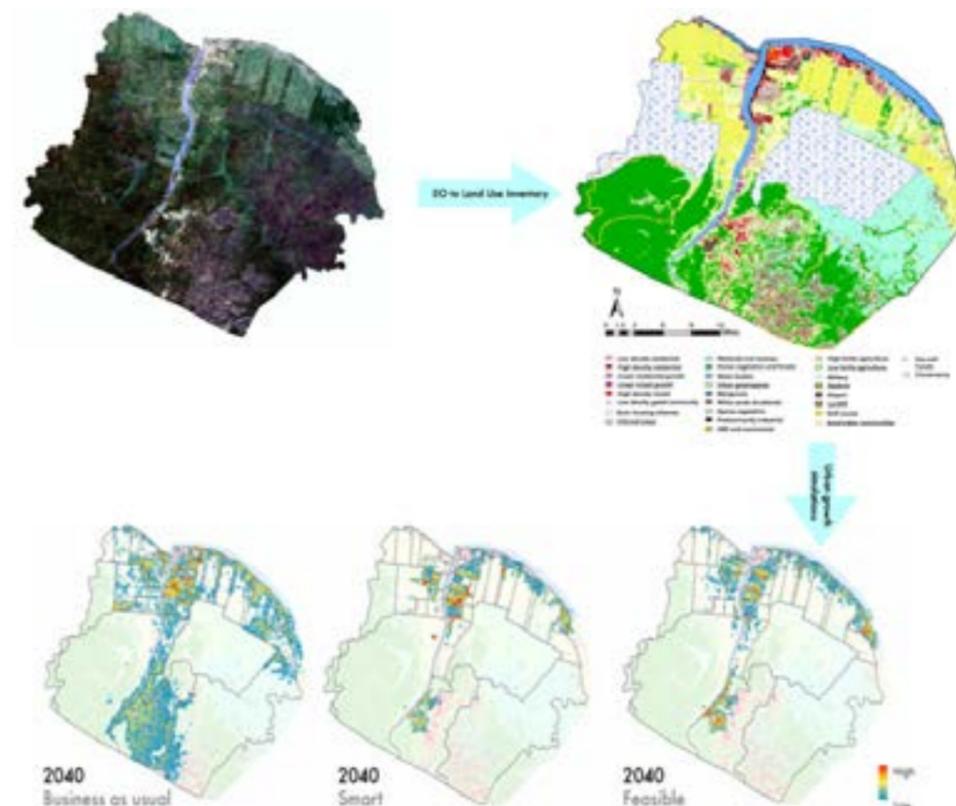
Addis Ababa, Ethiopia: Vivid Economics, supported by IPP, is using tool to help the National Planning Commission plan for climate-adaptive scenarios for future urban growth.

Organisation overview

Vivid Economics is a leading economics strategy consultancy with global reach. Specialising in cities, climate change, economic development, energy, finance and natural resources, we advise on the most critical and complex policy and commercial questions facing clients, both in government and the private sector, around the world.

Central to our work is robust, evidence-based analysis communicated effectively. We have wide-ranging expertise and skills in commercial strategy, public policy design, economy-wide and market modelling, econometrics and spatial analysis. Our experience is demonstrated in a track record in delivering first-of-a-kind, custom solutions with solid economic foundations.

Figure 47: Application of the tool for planning flood-resilient urban growth in Georgetown, Guyana



Cultural Heritage Protection Service (UNOSAT)

Overview

Cultural property is of great importance for humanity and cultural heritage sites in the Middle East and North Africa (MENA) regions are being deliberately targeted in recent armed conflicts, resulting in damage, looting and in some cases total destruction. In addition, natural heritage sites nowadays are under constant myriad of threats ranging from climate change, construction of infrastructure and housing to mining and quarrying.

The use of modern technologies has proven extremely valuable, not only to keep track of events, but also in view of providing communities with sufficient documentation that could help dealing with the inflicted trauma and to contribute to future reconstruction efforts.

www.unitar.org/unosat

Solution benefits

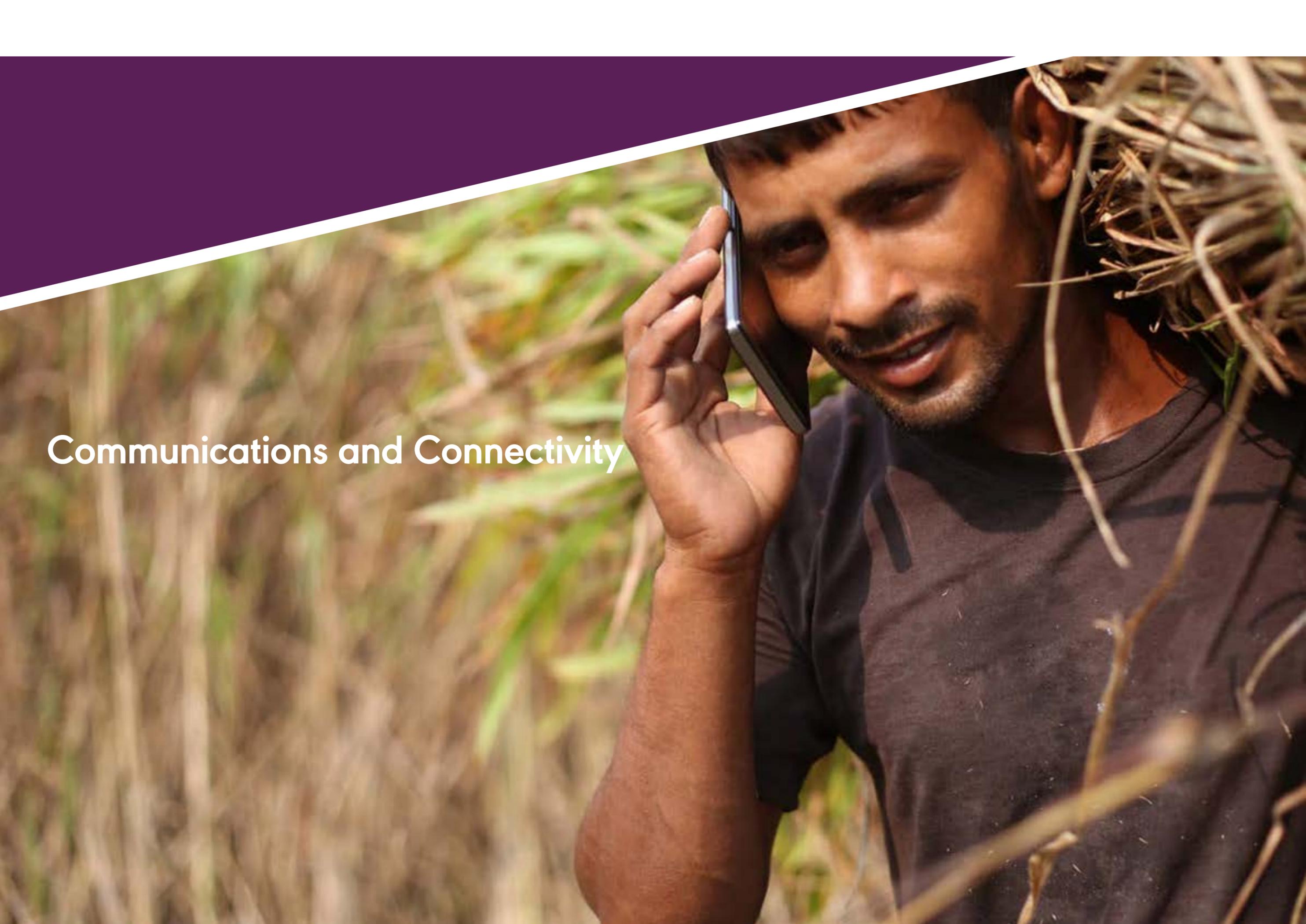
- Place cultural heritage sites under regular monitoring through the use of satellite imagery to produce periodic reports.
- Systematic monitoring will help document historic events and damages, which will be very important in view of justice, and possible recovery, reconstruction and determent.
- Regular monitoring of sites can also help in devising preventive conservation measures and set risk management mechanisms as a documentation tool of urban and territorial modifications through time.

Key technical features

- Development of a number of change detection algorithms to provide an output of changes or more precisely, changes on surface brightness levels given an input two or more images acquired at different times over the same cultural significant area.

Case studies

In 2018, UNOSAT conducted a series of tests to develop the change detection algorithm with the cooperation of CERN openlab. The result was the development of a change detection system that accurately detected damaged structures in the World Heritage Site of Palmyra in Syria between August and September 2015 using high-resolution satellite images.

A photograph of a man in a rural setting, carrying a large bundle of sticks on his back. He is wearing a dark t-shirt and is talking on a mobile phone. The background is a field of tall grasses. The image is partially covered by a purple diagonal shape in the top-left corner.

Communications and Connectivity

Communications and Connectivity

The so-called Fourth Industrial Revolution is a digital revolution that requires universal and reliable internet access; without it, many developing countries will not be able to fully participate in an increasingly mobile and digital-based economy. 95% of the global population now live in an area that is covered by a mobile-cellular network. More than half of Tanzanians living on less than US\$2 a day have access to mobile technology.²³

But even though the digital revolution is a global phenomenon, there are still huge disparities between and within countries when it comes to the penetration, affordability, and performance of digital services. While almost half of the world's population in 2016 had access to the internet, the penetration rate in the least developed countries was only 15%, or one in seven individuals. One contributing factor is that access to the internet through mobile or fixed broadband remains prohibitively expensive in many developing

countries, where lack of digital infrastructure and regulatory bottlenecks hamper broadband development. The speed of broadband services also varies. Fixed-broadband speeds of 10 Mbps and higher are common in developed countries; by contrast, in the LDCs, only 7% of fixed-broadband services reach 10 Mbps.²⁴

Satellite communications provides voice and internet connectivity in rural and remote regions that lack mobile coverage.

The space sector provides the following solutions for communications and connectivity use cases:

Communications (voice, messaging and internet) for communities and businesses

- **Every Community Online (ECO) (Avanti)**
- **SCYTALE Suite (GRC)**

²³ World Bank. 'Digital Development'. <https://www.worldbank.org/en/topic/digitaldevelopment>. Accessed December 2018.

²⁴ Same as above



Every Community Online (ECO) (Avanti)

Overview

To address the digital divide, provide connectivity and promote economic growth, Avanti developed ECO, an end-to-end internet hotspot solution for rural Africa. It provides a reliable and integrated Wi-Fi hotspot solution that enables broadband satellite internet access for communities, schools, clinics and businesses.

www.avantiplc.com

Solution benefits

- A reliable and integrated Wi-Fi hotspot solution that enables broadband satellite internet access for communities, schools, clinics and businesses.
- Shared access via Wi-Fi hotspots dramatically reduces the cost for providing connections to individuals - the ECO service is price benchmarked against local mobile services.
- Substantial data rate performance over 3G services.
- Services can be offered across Avanti's footprint in Africa and the Middle-East.
- Provides governments, businesses and communities a way to address the digital divide and promote economic growth via connectivity.
- Self-sustainable as the operational costs can be offset using the revenue generated from the sale of ECO credits.
- Flexible platform enables multiple commercial models and white-labelling for customers.

Key technical features

- High throughput very small aperture terminal (VSAT) delivering broadband internet of up to 50 Mbps downlink and 4 Mbps uplink.
- Long range Wi-Fi capability for up to 400 metres with line of sight that can be shared by over 30 users simultaneously.
- Accessible from any device that supports Wi-Fi including low cost smartphones commonly used in Africa.
- Resilient power system protected against unstable AC power, brown-outs and indirect lightning strikes.
- Solar powered version for stand-alone off-grid operation.
- Easy installation through pre-wired components, comprehensive step-by-step user manuals and a mobile application to support the installation and commissioning process.
- Weather proofed locked cabinet for electronic components.
- Remote monitoring, configuration, updates of the main terminal components enabling easy troubleshooting.
- A user-friendly ECO mobile application, allowing the user to purchase credits via credit card or mobile money.
- A billing platform providing safe and secure way to manage user details and payments.
- The ECO dashboard provides a simple web interface showing statistics on site specific usage and financial transactions.

Case studies

- The ECO solution has been deployed to 50 Tanzanian schools, as part of the project called iKnowledge, supported by IPP. Here, the solution provides internet to the school for free allowing teachers and students to access the most up-to-date online educational content but also enables the surrounding community to connect to the internet by purchasing credits on the ECO app using M-Pesa mobile payment.
- ECO is also being trialled in South Africa where a variety of applications are being addressed including: school connectivity projects, Corporate Social Responsibility (CSR) programs delivering Wi-Fi at retail points of sale (kiosks) and with internet service providers looking to deliver Wi-Fi Hotspots to communities lacking internet access. Avanti is also providing similar satellite Wi-Fi solutions in Kenyan primary schools and community business incubation hubs.

Organisation overview

- Avanti has invested US\$1.2 billion in the latest Ka-band satellite technology and shaped it to meet our customers' aspirations:
- governments that want to empower their digital economies
- mobile operators that wish to bring ubiquitous coverage to their customers
- enterprises that want to grow through digital productivity
- security forces wishing to protect their sovereignty
- people and communities that want to cross the digital divide
- Through our HYLAS satellite fleet, we have extensive coverage of the UK, Europe, Middle East and Africa. With market-leading products, we work with local and international service providers to connect homes, grow businesses, extend mobile networks and work closely with governments.

Figure 48: ECO mobile application



SCYTALE Suite (GRC)

Overview

SCYTALE is a lightweight, man portable satellite communications solution equipped with a satellite terminal that can provide 'office type' communications, including telephony, email, internet, video conferencing and wi-fi. Commercial Off the Shelf (COTS) and can be carried by one or two persons depending on requirements. It does not rely on terrestrial mobile network infrastructure which is often lacking in rural areas or might be damaged during a disaster. Self-configuring and setup time in under 10 minutes to actual use of communications.

www.grcltd.net

Solution benefits

- Does not rely on terrestrial mobile network infrastructure which is often lacking in rural areas or might be damaged during a disaster.
- Global coverage so can be operated anywhere.
- A scaleable system that can be for the first responders, up to a medium sized deployable headquarters, communities, relief camps and field hospitals.
- Simple setup so the user does not need to be a communications engineer to setup or use the system.
- Full 24 hours per day, all year round support and helpdesk available via email and phone.
- Procure or lease options available to minimise upfront costs.
- Wide range of airtime services available such as from Inmarsat, Avanti and Intelsat etc.
- A complete end to end solution that includes: terminal-baseband-airtime-support and training.
- Fully portable - so can be established on the

ground, in a vehicle or a building.

Key technical features

- System can be configured to operate with the user's network which can be global.
- Variable uplink and downlink speed from 0.5Mbps up to 20Mbps (synchronous or asynchronous).
- Satellite terminals no larger than 65 centimetre.
- Voice over Internet Protocol (VOIP) telephones.
- Ethernet connectivity for internet access.
- Optional PICOCELL (2G GSM) module to enable GSM capability in the field via SCYTALE.
- GSM 'bubble' at the deployed location.
- Battery or mains operated.
- WAN and LAN interfaces allows end user to connect their own devices.
- Shared bandwidth between many users and devices.
- Communications can be secured by end user crypto devices.
- IP Rated 65.
- CE Marked.

Case studies

SatDRR is a disaster resilience project in Kenya with Avanti, supported by IPP. With GRC providing deployable systems with corresponding satellite terminals for disaster relief operations.

Five systems deployed in three central African countries for mining and mineral exploration.

Organisation overview

GRC Ltd is an independent UK SME Telecoms and Engineering company that designs and delivers RF and Satellite solutions for UK Defence, Government and Commercial sectors. Using COTS technology, the systems are able to be delivered quickly and can be supported in country or remotely via a 24/7 helpdesk. The capabilities are ideally suited for Aid Agencies, first responders and contingency operations where fast setup, reliable, deployable communications are needed.

Figure 49: SCYTALE satellite communications equipment



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