Taiwan's Earth Observations
&
International Societal Benefits

Taiwan Integrated Earth Observation System

2015 HIGHLIGHT

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&
International Societal Benefits

Contents

04 **Introduction of Taiwan**

05 **Taiwan's Earth Observation Satellites**

08 **International Societal Benefits**

- Disaster Risk Management
- Climate Change
- Food Security
- Scientific Research

17 **Way Forward**

Introduction of Taiwan

Located in the Western Pacific, Taiwan is a beautiful subtropical island with a population of 23 million people. It is also situated in the plate-boundary zone between the Eurasia plate and the Philippine Sea plate, therefore, more than 200 mountain peaks higher than 3,000 meters above sea level. Over the past several decades, an “economic miracle” has brought its people an annual per capita income of over US$20,930. Meanwhile, a flourishing democratic political system was established, with active participation by all citizens. Taiwan ranked 15th place in the Global Competitiveness Report 2015 – 2016, according to the World Economic Forum. As Taiwan has realized the importance to integrate social and environmental sustainability into the making of economic policies, Taiwan has been pursuing sustainable development for more than ten years and has gained a wealth of experience. In June 2015, Taiwan sets a milestone by passing the Greenhouse Gas Reduction and Management Act.

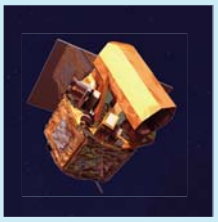
Formosat-2 Taiwan mosaic image

Taiwan's Earth Observation Satellites

The Global Earth Observation System of Systems (GEOSS) is being built by the Group on Earth Observations (GEO) to provide decision-support tools to a wide variety of users. GEOSS 10-Year Implementation Plan was adopted at the third Earth Observation Summit on 16 February 2005 in Brussels, Belgium. In accordance with these documents, the purpose of GEOSS is to achieve comprehensive, coordinated observations of the Earth system in order to improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behavior of the Earth system. The initial topics of interest include: natural disaster, health, energy, climate, water, weather, ecosystems, agriculture, and biodiversity. We believe Taiwan is an essential and crucial segment to fulfilling global observation needs. Taiwan anticipates to taking one step forward by actively participating in GEO's efforts and supporting the GEO Strategic Plan 2016-2025: Implementing GEOSS. And we are ready to commit to working with global community to contribute continuing endeavors in the next decade.

Since 1991 Taiwan has established sustainable space infrastructure, including successful deployment and operations of 3 Earth observation satellite programs: Formosat-1, Formosat-2, and Formosat-3.

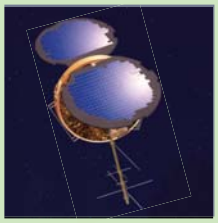
Taiwan's satellite programs



Formosat-2

Formosat-2

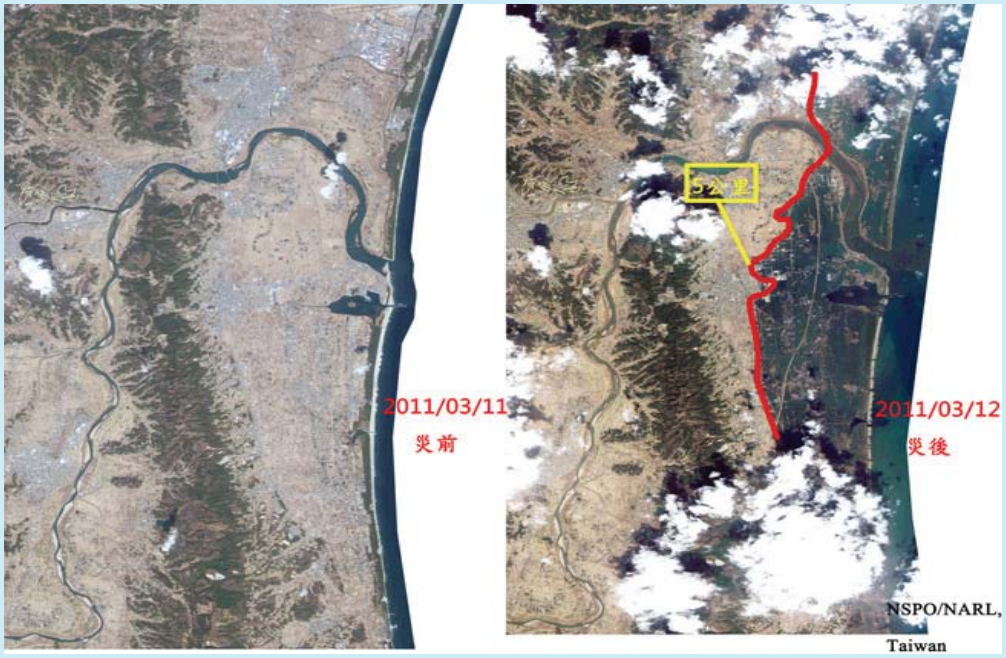
Formosat-2, Taiwan's first remote sensing satellite, was successfully launched in May of 2004 into the Sun-synchronous orbit at 891 km of altitude. Its major payload is a high-resolution electric-optical type remote sensing Instrument with ground resolution of 2-m Panchromatic (PAN, black & white) and 8-m Multi-Spectral (MS, color). Images taken by Formosat-2 not only fulfill Taiwan civilian needs on land utilization, agricultural and forest planning, disaster assessments, and environmental monitoring, but are also being distributed to international users for specific applications. Over 11 years, the footprints Formosat-2 has covered amounted to a surface area of 1,200,000,000 km^2, which is approximately 8 times the entire surface area of the world's land.



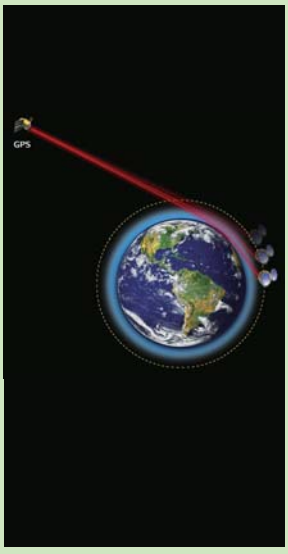
Formosat-3

Formosat-3

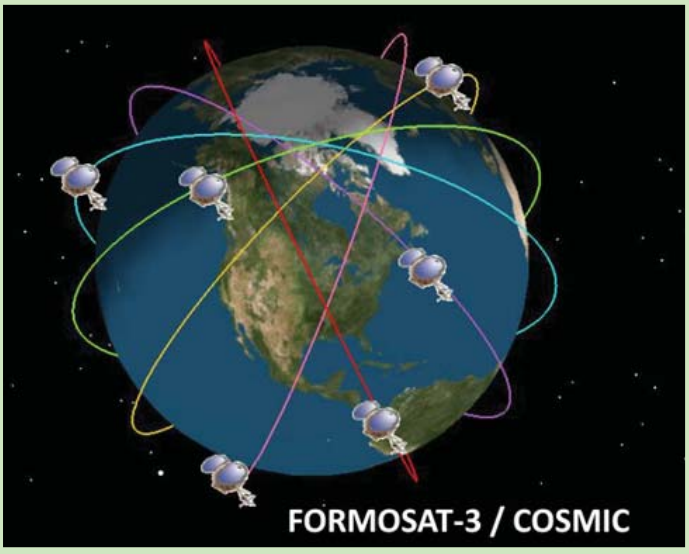
Formosat-3/COSMIC (Constellation Observing System for Meteorology, Ionosphere, and Climate) is an international collaborative project between NSPO and UCAR (University Corporation for Atmospheric Research). Following the successful deployment in April 2006, the six-satellite constellation system started to collect around 2000 atmospheric sounding data per day by utilizing radio occultation technique to retrieve the GPS signals. The retrieved atmospheric and ionospheric data in vertical profiles are widely used for operational weather forecasts, research, and related applications. The results of the Formosat-3 mission have shown a significant and positive impact to the global weather forecast system and reported in many important science articles, such as Nature and Science. Formosat-3 is praised as the most accurate and stable Earth's thermometer in the space. As of August 2014, the total accumulated volume of Formosat-3 data is approximately 84TB for both ionospheric and atmospheric profiles.



Formosat-2 in support of 311 Great East Japan Earthquake



The Formosat-3 mission/principle of GPS radio occultation



Formosat-3 constellation

International Societal Benefits

Disaster Risk Management

In average, Taiwan is influenced by 4 typhoons per year with approximate US$640M of property loss per typhoon. In addition, Taiwan is situated in the plate boundary, which resulted in highly active seismic activities, rapid crust deformations, and numerous active faults in and around Taiwan. On September 21, 1999, an earthquake with magnitude 7.3 on the Richter scale has caused heavy casualties and damage to buildings in Taiwan. Situating in this environment, Taiwan has accumulated abundant data and experience, and developed associated disaster reduction technologies, including advanced monitoring and early warning systems.

HIGHLIGHT

1. Support to countries in 236 events of major disaster reliefs

2. Support international organizations in response to disasters

image source: http://nepal-quake.colife.org.tw/

Application of Formosat-2 to Disaster Reduction

With Formosat-2's unique daily revisit capability and global coverage, it is capable to get rapid access to disaster areas and provide near real time monitoring information for rescue planning. Since 2006 Taiwan has been providing free Formosat-2 images for humanitarian applications through international organizations including International Charter Space & Major Disasters (IDC), UNOOSA/UN-SPIDER (UN Office for Outer Space Affairs/Space-based Information for Disaster Management and Emergency Response), UNITAR/UNOSAT (UN Institute for Training and Research/Operational Satellite Applications Programme) and Planet Action Initiative (since 2008). In 2010 Taiwan joined the Sentinel Asia, Formosat-2 has since then worked with other nations and contributed to fight against natural disasters in Asia-Pacific region. The supports include Sichuan Earthquake (2008), Great East Japan Earthquake (2011), Haiyen Typhoon (2014), and Nepal Earthquake (2015). Currently, Formosat-2 has aided 57 countries in 236 events of major disaster reliefs.

Based on the image data of Formosat-2, Taiwan is implementing a 3D High-resolution GEO lab dedicating for decision support to natural disaster prevention and environmental monitoring.

Formosat-2 applications for disaster reduction.

Climate Change

Taiwan has been actively participating in a global trans-boundary greenhouse gas (GHG) monitoring network for decades and has established a domestic GHG inventory database since 1990. In addition, Taiwan has announced emission reduction targets, aiming to cut its CO_2 emissions to 2005 levels by 2020, returning to 2000 levels by 2025, and returning to 50% of 2000 levels by 2050. To better understand the trends and impact of the increasing atmospheric increasing atmospheric GHG, industry, government and academic resources were integrated to enable regular monitoring of atmospheric CO_2 levels, and associated changes in climate.

HIGHLIGHT

1. **Support with 4547 image segments in polar region monitoring**
2. **Support in Latin America to monitor environment and dynamic changes of territory**

Formosat-3 improves the forecast accuracy of typhoon track (image source: Central Weather Bureau)

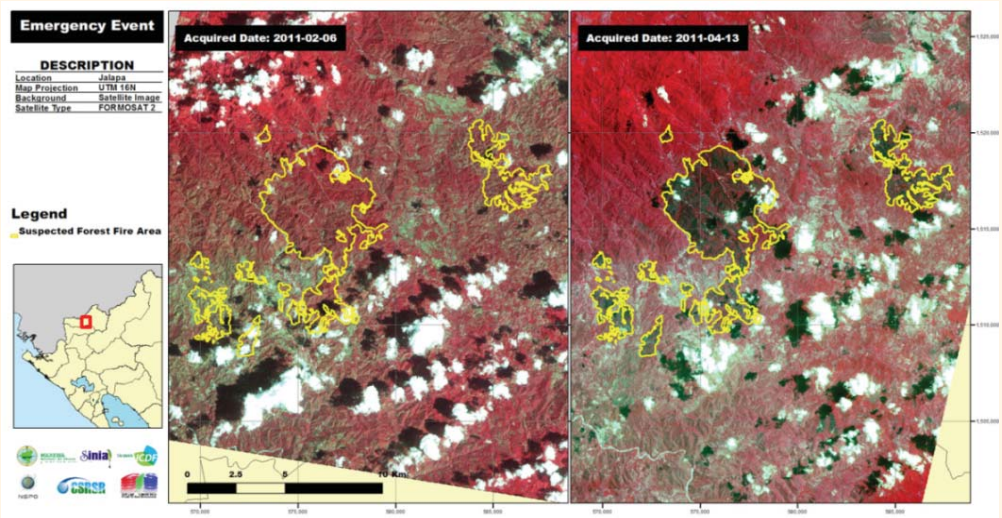
Forest Monitoring – REDD+

According to IPCC report, global deforestation accounts for approximately 20% of all CO_2 emissions, and reducing emissions from tropical deforestation is critical to slow down global warming. Formosat-2 can periodically provide information of the areas, types and changes of forests. In May 2011, Taiwan has engaged in several cooperation projects with diplomatic allies in Latin America, including Honduras, Nicaragua and El Salvador, by applying Formosat-2 satellite imagery and GIS technique for resource management and natural disasters.

Honduras has participated in REDD+ initiative (Reducing Emissions from Deforestation and Forest Degradation) since 2013, and Formosat-2 images are included as one of her MRV (Measurement, Reporting and Verification) system to monitor the dynamics of change in forest coverage. In the future, Formosat-2 along with Formosat-5 has potential to expand the application in the global climate network by active participation in international program such as REDD+ and 20/20 initiatives.

UN-REDD PROGRAMME

GFOI Global Forest Observations Initiative

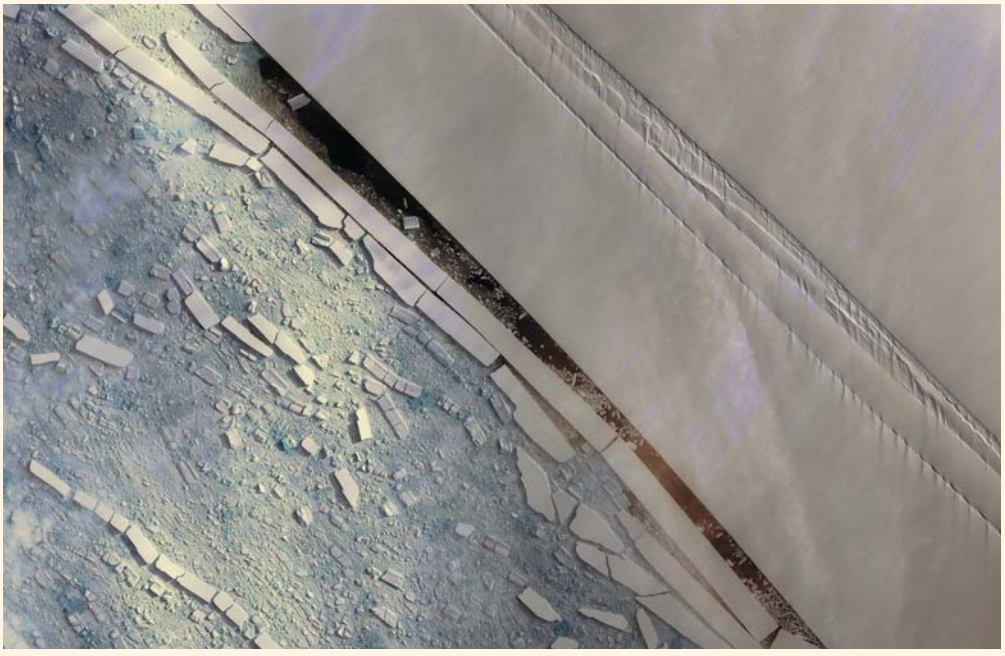


Formosat-2 supports for monitoring forest fire in Nicaragua.
(image source: Center for Space and Remote Sensing Research, National Central University)

Polar Region Monitoring – IPY

For several decades, surface air temperature in Artic region has increased at approximately twice the global rate due to the GHG emission. The International Polar Year (IPY), organized by the International Council for Science (ICSU) and the World Meteorological Organization (WMO), is a large-scale international cooperative scientific program focused on the Arctic and the Antarctic from March 2007 to March 2009 in which a wide range of physical, biological, and social research topics will be examined. The GEO 2007-2009 work plan calls for coordinating with the IPY to enhance the utilization of Earth observations in all appropriate realms as well.

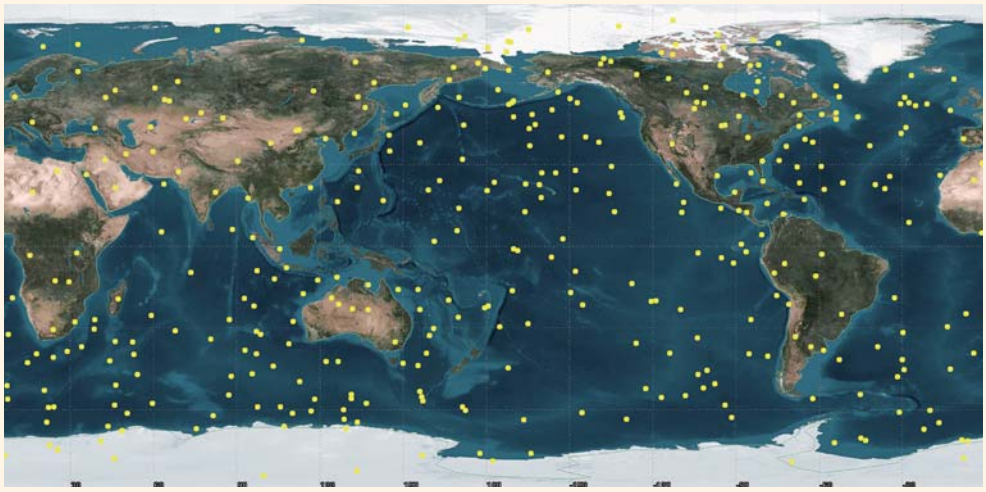
Formosat-2, operating in a high inclination orbit, is particularly useful for high latitude observation of the polar ice sheets and sea ice over the Arctic and Antarctic regions on the study of global warming phenomena. For supporting the IPY, Formosat-2 established a polar archive consists of 4547 image segments. With a high resolution of imagery, Formosat-2 can reveal the surface signatures, as well as the ice shelf disintegration over entire Arctic and Antarctic in great detail for further scientific and applied analysis of ice mass, ice shelf breaking modeling and its physical indication.



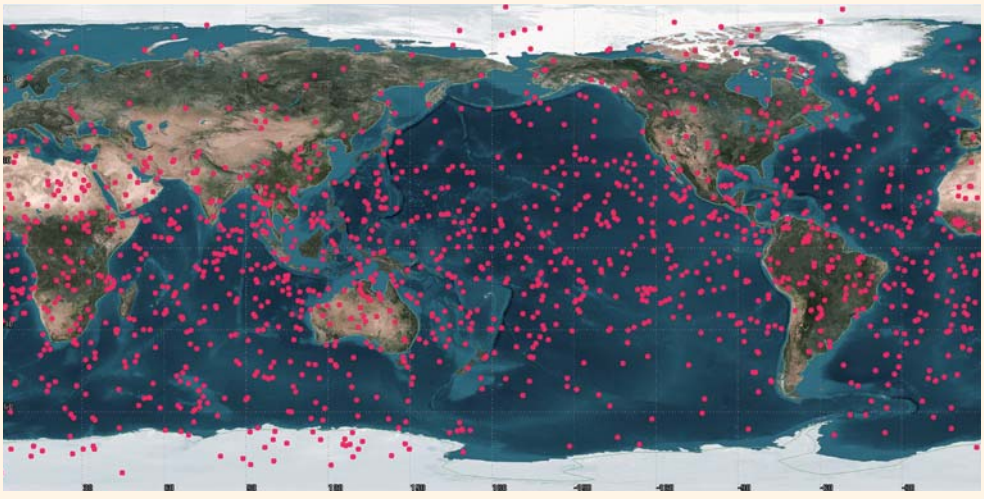
Wilkins Ice Shelf disintegrated due to rising temperature on the Earth.(image source: Formosat-2)

Extreme Weather Forecast

A study conducted in 2012 by the ECMWF (European Center for Medium-Range Weather Forecasts) indicated that the GPS (Global Positioning System) RO (Radio Occultation) data consists of 2~3% of the total data used, and has an average impact of approximately 10% Forecast Error Correction to the Numerical Weather Prediction. In the area of natural disasters, the assimilation of soundings can contribute to the improved forecast of typhoon track and heavy precipitation associated with the Mei-yu front, minimizing the costs and loss of life due to natural disasters. Taiwan has been sharing significant resources to allow the extraction and provision of occultation measurements in near-real-time to continuously serve global users. The global data user community of Formosat-3 has grown to 2693 registered users from 74 nations in 2015.



Formosat-3 occultations-3 hrs coverage



Formosat-7 occultations-3 hrs coverage

Food Security

For the past few years, due to frequent natural disaster caused by global climate change, food prices have been escalating, and food security has become a critical subject. Taiwan is joining in the efforts to contribute to challenge the global food security issue. According to the report from FFTC (Food & Fertilizer Technology for the Asian and Pacific Region), a target has been set to have 40% of food self-sufficiency rate for Taiwan in 2020. In order to achieve the target, the Council of Agriculture of Taiwan has established a GIS-based soil resources and agricultural land cover database by combining space, aerial observations, and ground truth survey as a means to increase competitiveness of intensive land-use agricultural production.

GEOGLAM
Global Agricultural Monitoring

Formosat-2 satellite image of Tainan's farmland

In recent years GEO Global Agricultural Monitoring (GEOGLAM) initiative is designed to enhance worldwide agricultural crop yield estimates through crop area monitoring. Joint Experiment for Crop Assessment and Monitoring (JECAM) is the Research and Development portion of the GEOGLAM, its results are important for the development and sharing of best practices in agricultural monitoring. In 2013 we joined JECAM with a test site in central Taiwan. In response to JECAM minimum data set requirement, whose objective is to build a common data set of satellite and in situ observations to support research and methods benchmarking activities across JECAM sites, Formosat-2 has become one of the Fine/Very Fine Optical image provider. The imagery is currently being used in France and Taiwan test site.

While GEOGLAM evolves as a system of systems, consistent with the overall approach of GEO in developing the GEOSS, Asia-RiCE is regional rice crop estimation and monitoring component for GEOGLAM. Under this framework, Taiwan is establishing her rice crop maps and yield estimates.

Asia-RiCE
Crop Estimation and Monitoring

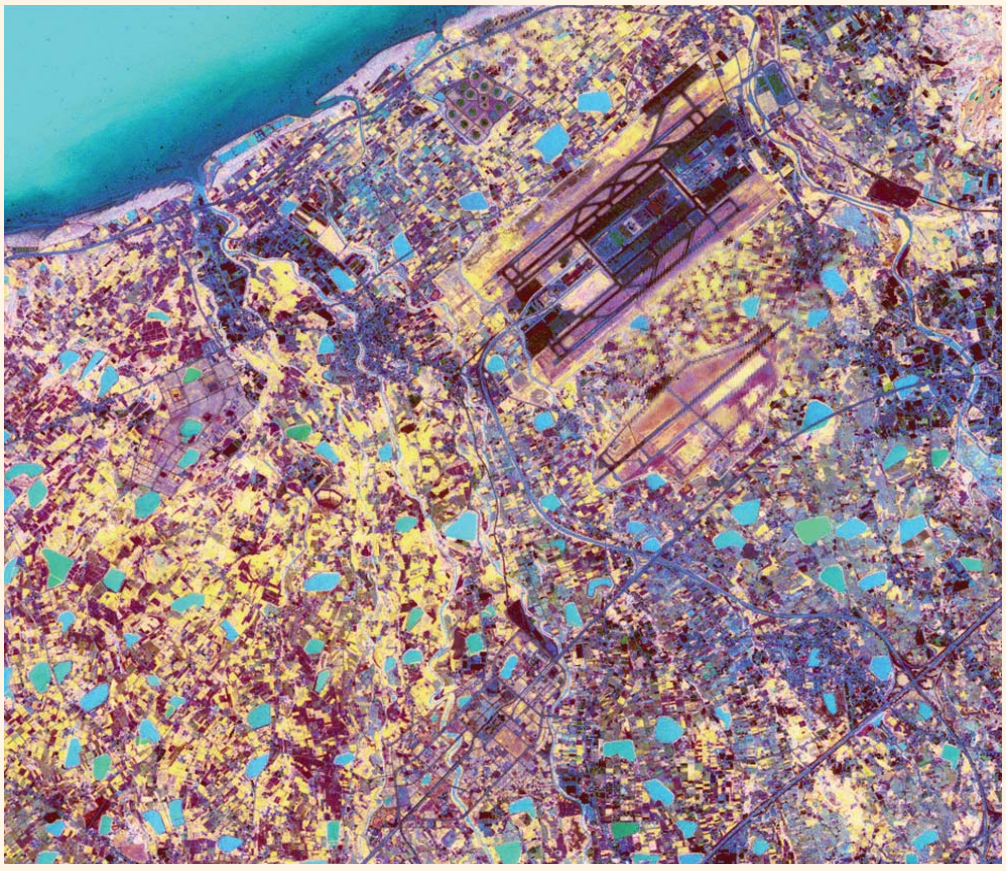
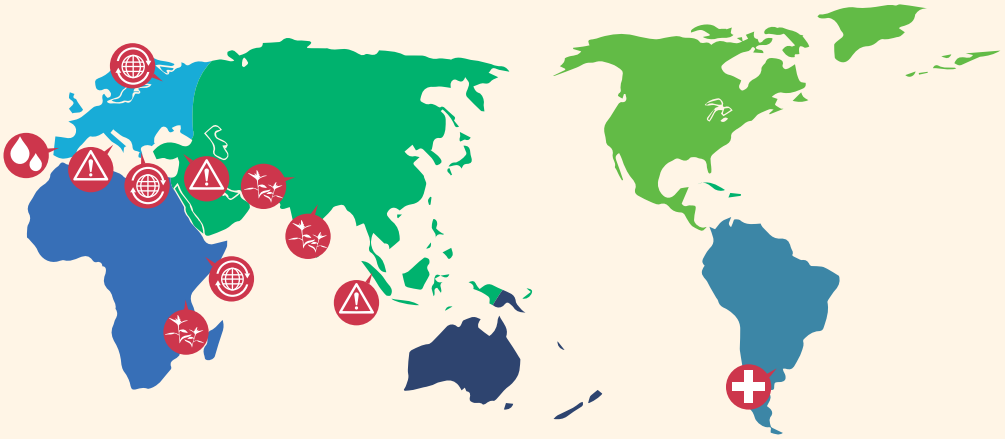


Image classification in Taiwan's farmland

Scientific Research

In 2014, in the 10th anniversary of services, Formosat-2 celebrated this milestone with the International Society for Photogrammetry and Remote Sensing (ISPRS) by providing free archive and newly acquired images to the science community. This activity facilitates opportunity for researchers to conduct advanced researches related to 9 Societal Beneficial Areas advocated by GEO/GEOSS. The call for proposal received responses from investigators in Europe, Asia, Africa, and America with applications to disaster, land utilization, archaeology, agriculture, health and ecology. This joint initiative provides a successful demonstration in promoting remote sensing applications to increase societal benefit.



Collaboration with ISPRS

Way Forward

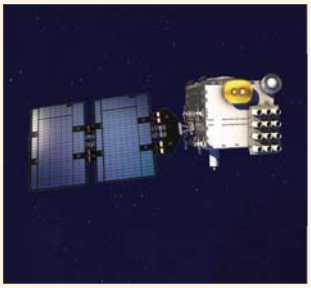
Formosat-5

Formosat-5 is the successor to Formosat-2. It is the first indigenous Remote Sensing Satellite of Taiwan, which is scheduled to launch in 2016. It will operate in a Sun-synchronous orbit at 720 km of altitude and revisit the same place in every 2 days. The optical Remote Sensing Instrument (RSI) is equipped with an innovative five-band multi-SOC CMOS sensor that provides 2-m resolution of panchromatic and 4-m resolution of multi-spectral imagery. Formosat-5 is capable of high agility maneuver, which enables asynchronous images tasking such as along the coast line or longitude.

Formosat-7

In viewing the need of the constellational global GPS-RO data to continue the enhancement of the weather predictions and the climate observations,NSPO and NOAA (National Oceanic and Atmospheric Administration) cooperate to implement the next RO constellation program, Formosat-7. The constellation calls for 12 mission-specific-orientated satellites plus one NSPO-Built satellite. Formosat-7 constellation will provide 8000 sounding data per day. It is anticipated that the deployment of Formosat-7 will continue to contribute to international meteorological community and further increase weather forecast capabilities.

Formosat-5



Formosat-7

other global issues…there is much more we can do…

Health

The geomedicine idea has recently gained global attention. Numerous evidences show that the use of geographic information has caused dramatic impact on human health. With satellite remote sensing data derived geographic information and environmental ground facts, correlation can be found for disease such as heart attack, dengue fever and lung cancer. Formosat-2 optical imagery can support geomedical research, including estimating multiplication of mosquitos, planning ambulance traffic flow, etc. An example in 2014, Formosat-2 supports to respond to Ebola crisis by tasking the West Africa area to help better understand the status and immediate environment of locations of the Ebola Treatment Centers.

Ecosystem

Coastal ecosystems such as wetlands, estuaries, and coral reefs are particularly vulnerable to climate change, but they are also the most biologically productive environments in the world. Taiwan has contributed in conducting multi-temporal monitoring of mangrove and corals along Taiwan's coast lines by using Formosat-2 monitoring. International cooperation projects are being extended to other countries in Southeast Asia and Latin America.

Water

Fresh water is vital for the living of human being. Although annual rainfall in Taiwan is over 2500 mm, the steep mountains and short rivers make rainwater storage a major challenge. Formosat-2 multi-spectral scenes can be used to monitor the dynamic changes in reservoir water quality including the concentrations of Chlorophyll-a and suspended solids. Formosat-2 optical imagery data can also be used to monitor the long-term coastline change and to estimate the sea-level rise due to the climate change impact.

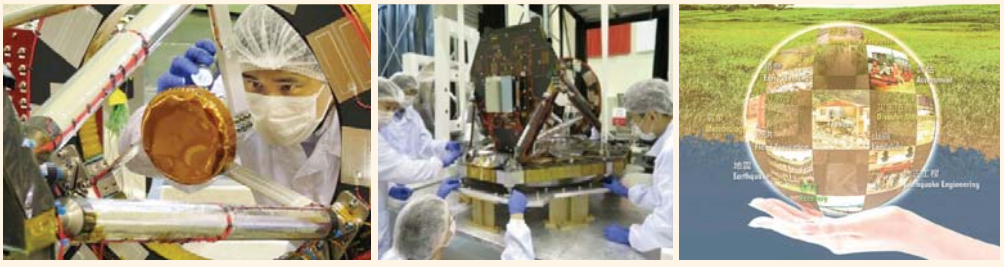
Taiwan's pursuit of sustainable development

Disaster Management Information Platform

Pursuit of sustainable development is one of the ultimate visions of the government in Taiwan. In Earth observation technology, Taiwan has accumulated enormous achievements from R&D. To synergize Earth observation related resources, the Ministry Of Science and Technology (MOST) initiated Program on Applying Science and Technology for Disaster Reduction (ASTDR) to ensure that technological innovations can be effectively and efficiently applied to practical disaster reduction applications. The overall objective of this program was to establish a Disaster Management Information Platform (DMIP) to enhance the effectiveness of disaster response operations, improve related systems, strengthen the disaster-management information-sharing platform, and promote relevant knowledge dissemination and communication. Under the framework of advanced cyber infrastructure, the core technologies include data warehousing, 3D visualization, cloud computing, collaborative technology, and disaster reduction technology.

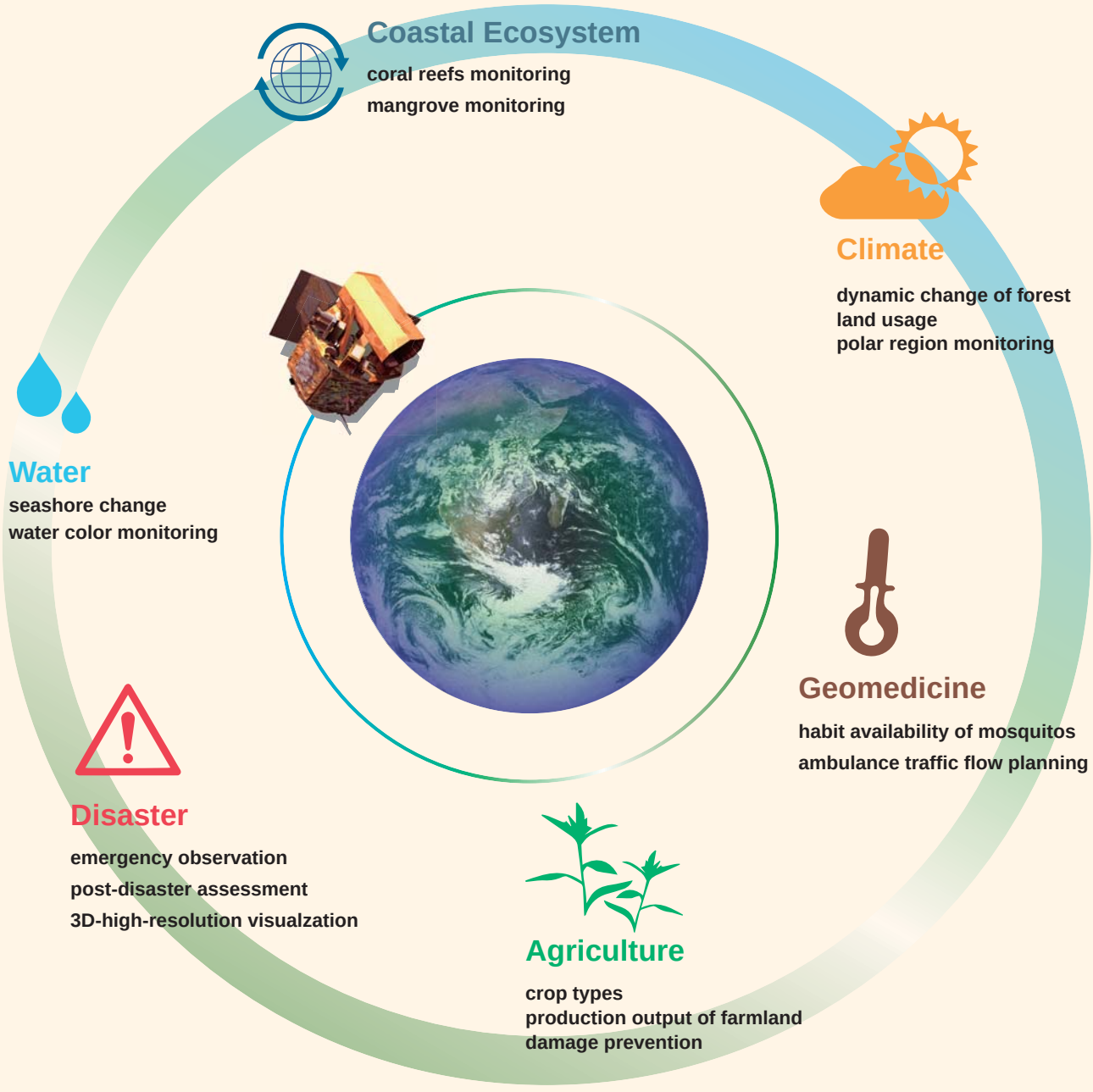
Earth Science Observation Knowledgebase

Earth Science Observation Knowledgebase (ESOK), also supported by the MOST, is a petascale database that incorporates observation data from space, atmosphere, land, and ocean. ESOK is a synergy of Taiwan's elite researchers in Earth science, featuring big data including Formosat-2 images; Formosat-3 RO and ionosphere science data; Earthquake shock wave data; atmospheric temperature/humidity data; HF radar data for ocean current measurement, and etc. It is believed that ESOK has potential to play an important role in expanding our understanding of the ever-changing land which we live in.



Formosat-5 under development

As a member of the global village, Taiwan should, and would like to take part in the Group on Earth Observations (GEO) to work with all members in the endeavors to protect the Earth and her natural resources. Taiwan is currently official member of international organizations such as World Trade Organization (WTO) and the Asia Pacific Economic Cooperation (APEC), and thus she should join the orchestration of the World. Taiwan has also demonstrated achievements and capabilities in Earth observation related sciences and technologies. Taiwan is committed to becoming a significant and effective contributor to the 9 Societal Benefit Areas under the GEO cooperation framework. We believe that we all live in the same Earth and all humans should help to protect our planet. Taiwan is willing and ready to fulfill its duty as a member of the global village in realizing the goal of sustainable development.


Coastal Ecosystem
coral reefs monitoring
mangrove monitoring
Climate
dynamic change of forest
land usage
polar region monitoring
Water
seashore change
water color monitoring
Geomedicine
habit availability of mosquitos
ambulance traffic flow planning
Disaster
emergency observation
post-disaster assessment
3D-high-resolution visualzation
Agriculture
crop types
production output of farmland
damage prevention

Editor/ National Space Organization, NARLabs

Contributing Organizations/

Aerial Survey Office, Forestry Bureau, Council of Agriculture

Central Weather Bureau, Ministry of Transportation and Communications

Center for Space and Remote Sensing Research, National Central University

Digital Earth Research Center, Chinese Culture University

Environmental Protection Administration

GIS Research Center, Feng Chia University

Information Center, Ministry of Interior

Ministry of Science and Technology

Ministry of Foreign Affairs

National Applied Research Laboratories (NARLabs)

- National Center for High-Performance Computing
- National Center for Research on Earthquake Engineering
- Taiwan Ocean Research Institute

National Science and Technology Center for Disaster Reduction

Research Center for Humanities and Social Sciences, Academia Sinica

School of Forestry and Resource Conservation, National Taiwan University

Taiwan Agricultural Research Institute, Council of Agriculture

Taiwan GIS Center

Taiwan Integrated Earth Observation System

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