



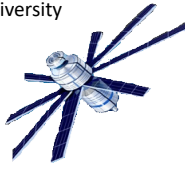
遙測衛星的生活應用

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What is remote sensing?

- RS is the acquisition of information about an **object or phenomenon without making physical contact** with the object and thus in contrast to on site observation.
-Wikipedia
- RS is the science of obtaining information about objects or areas from a distance, **typically from aircraft or satellites**.
-US. NOAA
- RS is the science of **acquiring, processing and interpreting images** that record the interaction between electromagnetic **energy** and matter.

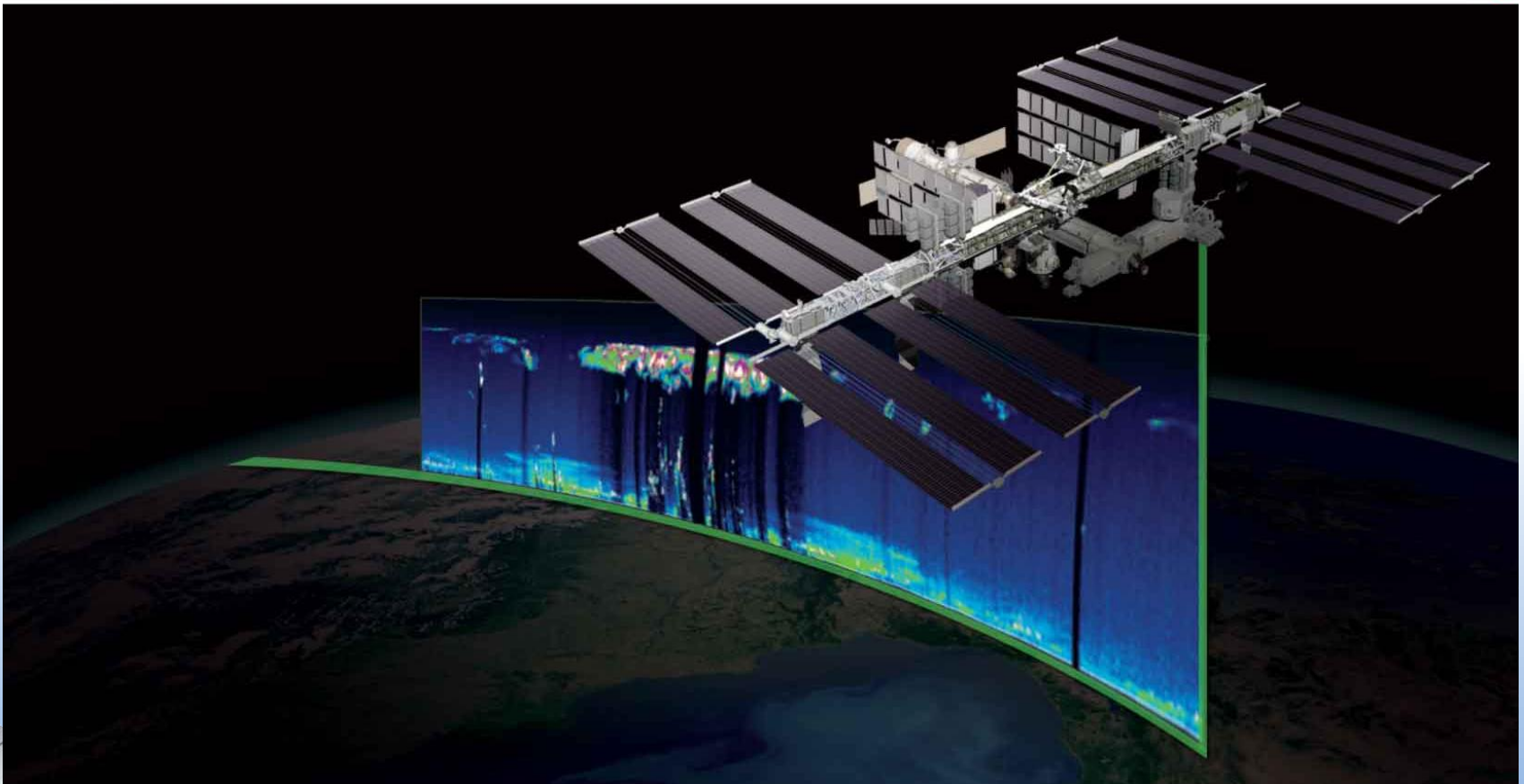
-Sabins Jr., & Lulla, K. (1987). Remote sensing: Principles and interpretation



Remote sensing in international societies

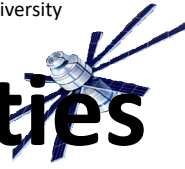
- NASA, U.S.

https://www.nasa.gov/sites/default/files/thumbnails/image/edu_remote_sensing_large.jpg

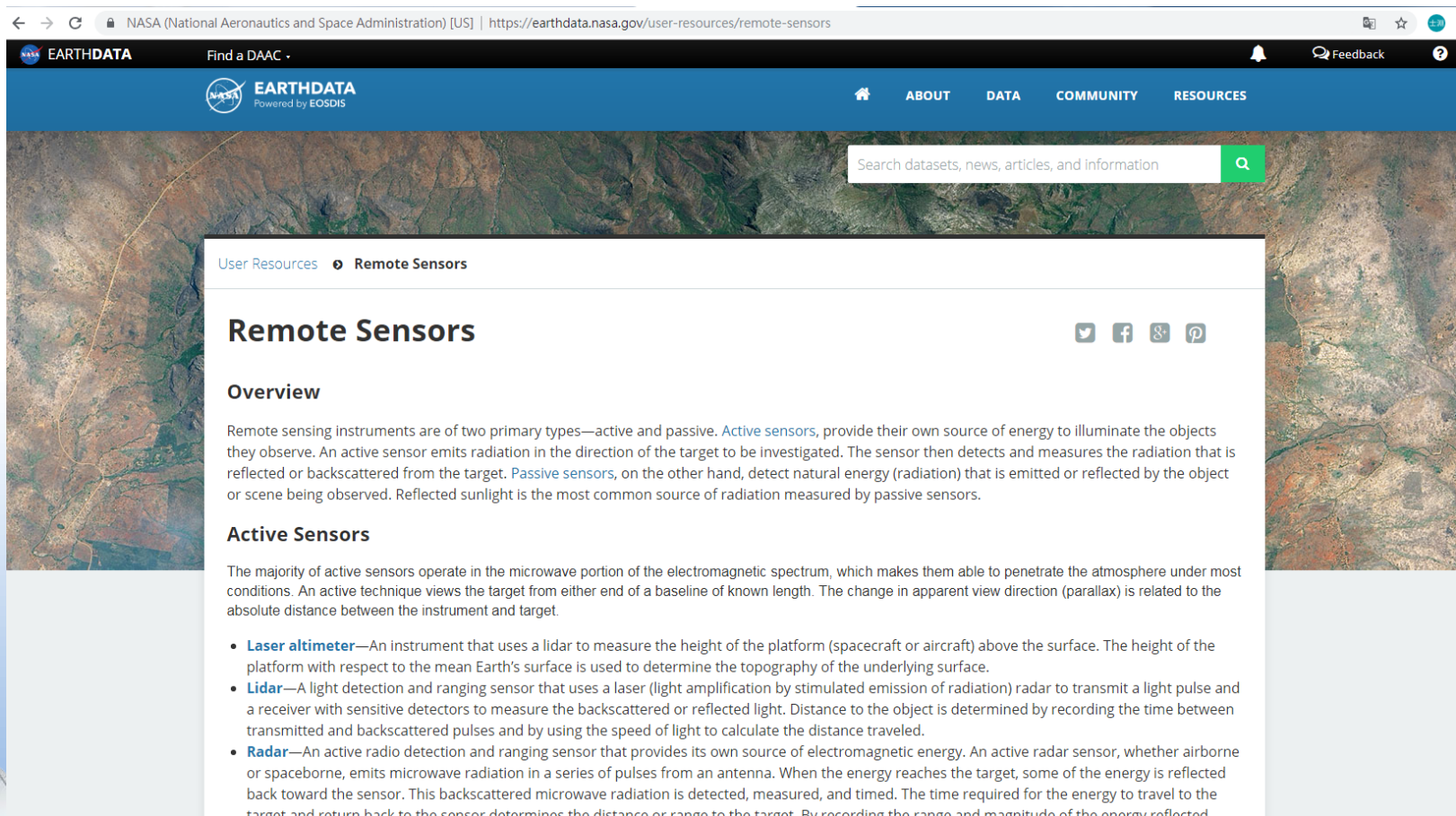




Remote sensing in international societies



- NASA, U.S.



The screenshot shows the NASA EarthData website's 'Remote Sensors' page. The page features a blue header with the NASA logo and 'EARTHDATA Powered by EOSDIS'. A search bar is present. The main content area is titled 'Remote Sensors' and includes an 'Overview' section and an 'Active Sensors' section. The 'Overview' section explains that remote sensing instruments are either active or passive. Active sensors emit their own energy, while passive sensors detect natural energy. The 'Active Sensors' section lists three types: Laser altimeter, Lidar, and Radar, each with a brief description of how they work.

← → ↻ 🔒 NASA (National Aeronautics and Space Administration) [US] | https://earthdata.nasa.gov/user-resources/remote-sensors

EARTHDATA Find a DAAC

EARTHDATA Powered by EOSDIS

ABOUT DATA COMMUNITY RESOURCES

Search datasets, news, articles, and information

User Resources Remote Sensors

Remote Sensors

Twitter Facebook Google+ Pinterest

Overview

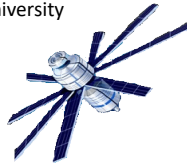
Remote sensing instruments are of two primary types—active and passive. **Active sensors**, provide their own source of energy to illuminate the objects they observe. An active sensor emits radiation in the direction of the target to be investigated. The sensor then detects and measures the radiation that is reflected or backscattered from the target. **Passive sensors**, on the other hand, detect natural energy (radiation) that is emitted or reflected by the object or scene being observed. Reflected sunlight is the most common source of radiation measured by passive sensors.

Active Sensors

The majority of active sensors operate in the microwave portion of the electromagnetic spectrum, which makes them able to penetrate the atmosphere under most conditions. An active technique views the target from either end of a baseline of known length. The change in apparent view direction (parallax) is related to the absolute distance between the instrument and target.

- **Laser altimeter**—An instrument that uses a lidar to measure the height of the platform (spacecraft or aircraft) above the surface. The height of the platform with respect to the mean Earth's surface is used to determine the topography of the underlying surface.
- **Lidar**—A light detection and ranging sensor that uses a laser (light amplification by stimulated emission of radiation) radar to transmit a light pulse and a receiver with sensitive detectors to measure the backscattered or reflected light. Distance to the object is determined by recording the time between transmitted and backscattered pulses and by using the speed of light to calculate the distance traveled.
- **Radar**—An active radio detection and ranging sensor that provides its own source of electromagnetic energy. An active radar sensor, whether airborne or spaceborne, emits microwave radiation in a series of pulses from an antenna. When the energy reaches the target, some of the energy is reflected back toward the sensor. This backscattered microwave radiation is detected, measured, and timed. The time required for the energy to travel to the target and return back to the sensor determines the distance or range to the target. By recording the range and magnitude of the energy reflected





• European Space Agency (ESA)



COPERNICUS AND ITS SENTINELS

European Earth Observation Programme Copernicus: observing our planet for a safer world

-  Known as GMES until 2012, Global Monitoring for Environment and Security
-  30 Public and Private missions are also contributing data
-  16 years of development and testing
-  Sentinel-Missions at the heart of the space component
-  Civil Security: Allowing early warning and crisis prevention in conflict and disaster areas
-  Emergency Management: Accurate and timely data for emergency plans and rescue for disaster management
-  Land Surface Monitoring: Geographical information on land cover, related variables and urban development
-  Marine Environmental Monitoring: Observations and forecasts on the state of the physical oceans and regional seas
-  Climate Change Monitoring: Helps to understand the reasons for climate change, rising sea levels and melting ice caps
-  Earth Atmosphere Monitoring: Daily information on the global atmospheric composition and when Sentinel-4 is in service this will be hourly

SENTINEL-1



- All-weather, day-and-night radar imaging satellite for land and ocean services
- Able to "see" through clouds and rain
- Data delivery within 1 hour of acquisition
- Airbus Defence and Space developed C-band radar instrument

SENTINEL-2



- Medium Res Multispectral optical satellite for observation of land, vegetation and water
- 13 spectral bands with 10, 20 or 60 m resolution and 290 km swath width
- Global coverage of the Earth's land surface every 5 days
- Airbus Defence and Space prime contractor for satellites and instruments

SENTINEL-3



- Measures sea-surface topography with a resolution of 300 m, sea and land surface temperature and colour with a resolution of 1 km
- Measures water vapour, cloud water content and thermal radiation emitted by the Earth
- Determines global sea surface temperatures with an accuracy greater than 0.3 K
- Airbus Defence and Space supplies Microwave Radiometer

SENTINEL-5P



- Global observation of key atmospheric constituents, including ozone, nitrogen dioxide, sulphur dioxide and other environmental pollutants
- Improves climate models and weather forecasts
- Provides data continuously during five-year gap between the retirement of Envisat and the launch of Sentinel-5
- Airbus Defence and Space prime contractor for satellite and TROPOMI instrument

SENTINEL-4



- Provides hourly updates on air quality with data on atmospheric aerosol and trace gas concentrations
- Spatial sampling is 8 km and spectral resolution between 0.12 nm and 0.5 nm
- Airbus Defence and Space prime contractor for spectrometer
- Carried aboard EUMETSAT's Meteosat Third Generation (MTG) satellites

SENTINEL-5



- Measures air quality and solar radiation, monitors stratospheric ozone and the climate
- Global coverage of Earth's atmosphere with an unprecedented spatial resolution
- Airbus Defence and Space prime contractor for instrument
- Carried aboard EUMETSAT's MetOp Second Generation satellites

SENTINEL-6



- Observes changes in sea surface height with an accuracy of a few centimeters
- Global mapping of the sea surface topography every 10 days
- Enables precise observation of ocean currents and ocean heat storage, vital for predicting rises in sea levels
- Airbus Defence and Space prime contractor for satellite

2014

2020





Remote sensing in international societies

- JAXA, Japan



Japan Aerospace Exploration Agency

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[Missions](#)

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[Topics in Your Area](#)

Satellites and Spacecraft

Topics

[Home](#) > [Missions](#) > [Project Topics](#)

Topics List

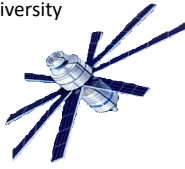
Oct. 29, 2018 Updated

Successful Launch, H-IIA Launch Vehicle No. 40 Encapsulating "IBUKI-2"(GOSAT-2) and KhalifaSat

The H-IIA Launch Vehicle No. 40 with the Greenhouse gases Observing SATellite-2 "IBUKI-2" (GOSAT-2) and KhalifaSat, a remote sensing Earth observation satellite onboard lifted off at 13:08:00 p.m. on October 29, 2018 (Japan Standard Time) from the Tanegashima Space Center. The launch and flight of H-IIA F40 proceeded as planned. So did the separation of GOSAT-2 and KhalifaSat, which was confirmed respectively at approximately 16 minutes and 09 seconds and 24 minutes and 15 seconds after liftoff.

[> Press Release \(10/29\)](#)





Remote sensing in Taiwan

- National Space Organization (NSPO, 國家太空中心)
— 福爾摩沙衛星二號 (福衛二號)



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FB粉絲專頁

認識NSPO 太空計畫 動態訊息 多媒體藝文

福衛五號影像精選 • 福衛二號影像精選 • NSPO放映室 • 相片集錦

福爾摩沙衛星七號

福爾摩沙衛星五號

福爾摩沙衛星三號

福爾摩沙衛星二號

計畫簡介

衛星特性

酬載儀器

國產元件

發射系統

地面系統

任務成果

福爾摩沙衛星一號

探空火箭計畫

其他計畫



福爾摩沙衛星二號 | 任務成果

我國自主擁有的第一枚遙測衛星

福衛二號發射至今，持續執行既定的遙測與科學任務，衛星本體與酬載正常運作，尤其遙測與科學酬載狀況一直運作良好，衛星姿態由反應輪及磁矩棒控制，不須燃燒燃料，太陽能電力供應也足夠衛星的正常運作。

福衛二號從2004年6月4日開始密集照相任務，已攝得許多國內外有價值的遙測圖片，同年7月4日開始進行科學觀測，也攝取許多紅色精靈與大氣輝光等科學影像，在國際營運展開後，順利打入國際遙測市場，更充分發揮其功能。該年夏天國內發生多次水災，12月26日南亞更發生強烈地震與巨大海嘯，造成嚴重災害，福衛二號及時對災區進行照相，這些相片對於救災與重建工作有相當大的幫助，成功發揮福衛二號的功能。

以下為數張福衛二號遙測酬載觀測的影像：圖1為敏督利颱風過後，水災影響的彩色影像，解析度8米；圖2為中正紀念堂，解析度2米；圖3為新竹科學園區，解析度2米。(解析度指影像內每一個pixel點代表的長度)



▲ 敏督利颱風後，七二水災草埔公路影像(解析度8米)

土地利用

- 對台灣現有土地運用之規劃提供最新的參考資料，應用領域包括大面積之區域發展規劃、縣市綜合開發規劃、土地使用分類與變化之監控...等。
- 提供最新地形地貌資料，供地圖製作使用。
- 提供地理資訊系統(GIS)之基本圖檔資料。



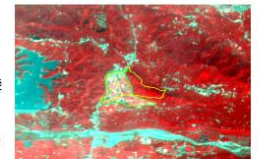
農林規劃

- 定期提供台灣內陸農作物與林木生長面積，及種類與變化情形，並預估產量。
- 國有林地的變化與防火巷的維護；並監控台灣山地之使用變化，如開墾、坍塌、墾植...等。
- 定期對農作物、林木生長狀況與健康情形提供最新資料，以供分析與預防之用。



環境監控

- 定期監控水源區、水庫、河川之蓄水量及污染狀況，以掌握台灣水資源供應狀況。
- 定期監控國家公園、自然生態環境保護區之環境變遷。
- 定期監控垃圾、工業廢棄物、廢土...的棄置狀況。



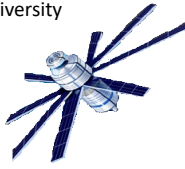
災害評估

- 於災害發生後，對台灣陸地受災面積的發現與受災程度提供快速與直接的分析資料，以進行災後評估與復建的參考，包括風災、水災、火災、地震等。



(<https://www.nspo.narl.org.tw/tw2015/projects/FORMOSAT-2/achievements.html>)





Remote sensing in Taiwan

- National Space Organization (NSPO, 國家太空中心)
 - 福爾摩沙衛星五號 (福衛五號)



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[福衛五號影像精選](#) • [福衛二號影像精選](#) • [NSPO放映室](#) • [相片集錦](#)

福爾摩沙衛星五號，2017年8月25日在美國范登堡基地成功發射，歷經近半年的元件調校、軌道操作及影像處理，已成功執行全球電離層觀測及遙測取像任務，衛星遙測影像品質也符合各項預定需求。

目前福衛五號運行於高度720公里的太陽同步軌道，約99分鐘繞行地球一週，每兩日通過台灣一次，所提供的高解析度光學影像可涵蓋全球，將應用於政府施政、防災勘災、國土安全、環境監控及學術研究等。此外，福衛五號搭載的「先進電離層探測儀」科學酬載，可進行電離層觀測及地震前兆研究，目前每兩日可合成一張全球電離層電漿參數分布圖，有效地監控全球電離層的變異性。

福衛五號拍攝之台灣全圖及先進電離層探測儀之多軌合成離子濃度分布圖如下所示：



▲ 福衛五號拍攝之台灣全圖



福爾摩沙衛星五號 | 計畫簡介

光學遙測酬載儀器自主發展能力，發展關鍵元件與技術

福爾摩沙衛星五號發展與發射



福爾摩沙衛星五號計畫(簡稱福衛五號)，係「第二期國家太空科技發展長程計畫」所提出「遙測衛星計畫」中之第一枚衛星計畫，本計畫之目標說明如下：

- 建立衛星本體自主發展能力及傳承設計，掌握核心元件設計與製造能量。
- 建立光學遙測酬載儀器自主發展能力及傳承設計，發展關鍵元件與技術。
- 落實衛星遙測技術與應用，延續服務福衛二號國內外遙測影像使用者族群。
- 推廣太空科學任務，支援學術研究。

福爾摩沙衛星七號

福爾摩沙衛星五號

計畫簡介

執行現況

衛星特性

酬載儀器

自主發展關鍵元件

發射載具

影像處理

衛星操控

福爾摩沙衛星三號

福爾摩沙衛星二號

福爾摩沙衛星一號

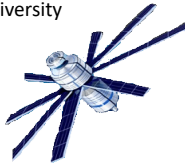
探空火箭計畫

其他計畫



***CO₂ flux estimation in local city based on
GIS and high-resolution multispectral
satellite imagery***

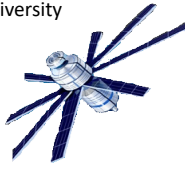




Introduction

- In order to control the greenhouse gas (GHG) emissions, the CO₂ reduction obligation for developed countries was outlined in the Kyoto Protocol adopted in 1997.
- Since then, the allocation of emission reduction was discussed continuously in the subsequent Conferences of Parties (COP) arranged by the United Nations Framework Convention on Climate Change (UNFCCC).
 - It is believed that the pledges for countries to submit emissions reduction targets will be introduced world widely in the near future.

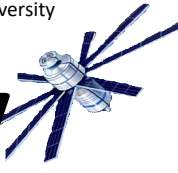




Study Site

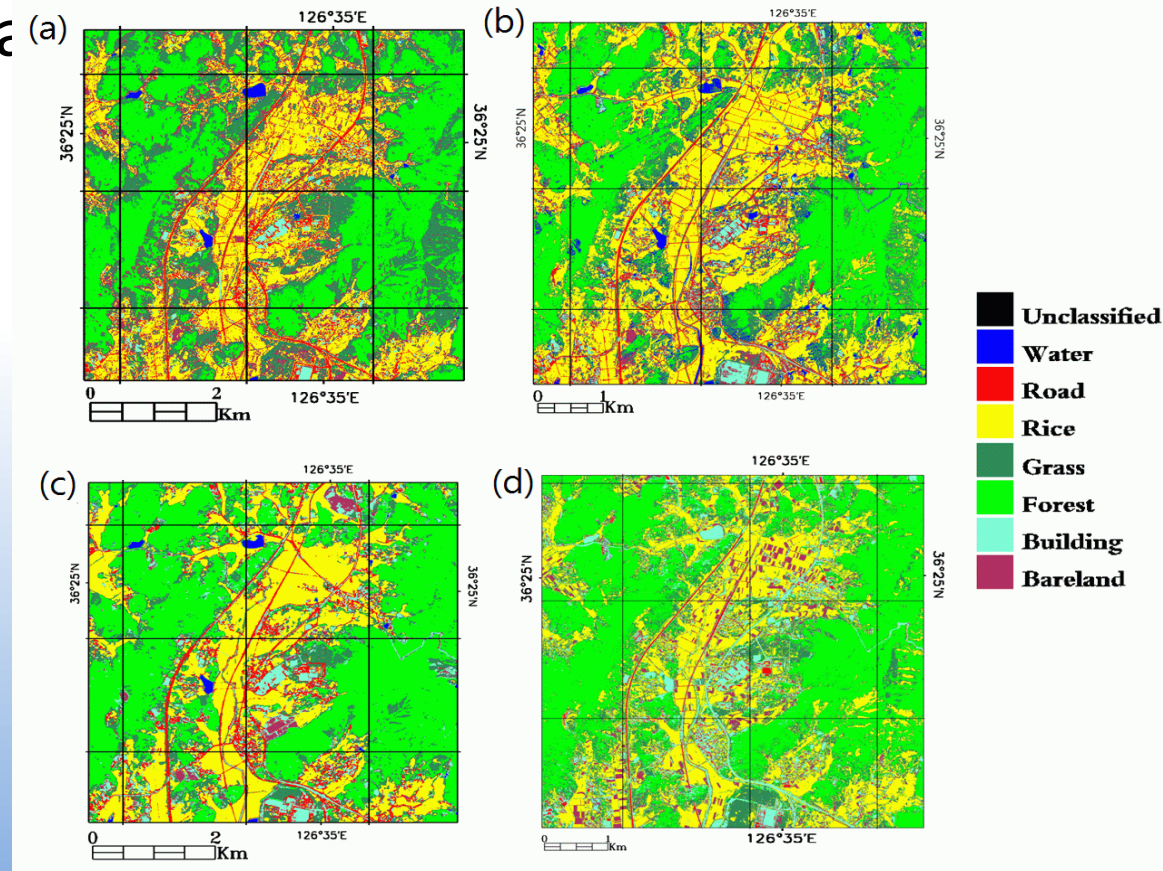
- The study area included various land cover types, for example vegetation canopy, sandy beach, water, cultivated area mainly rice paddy and dense urban



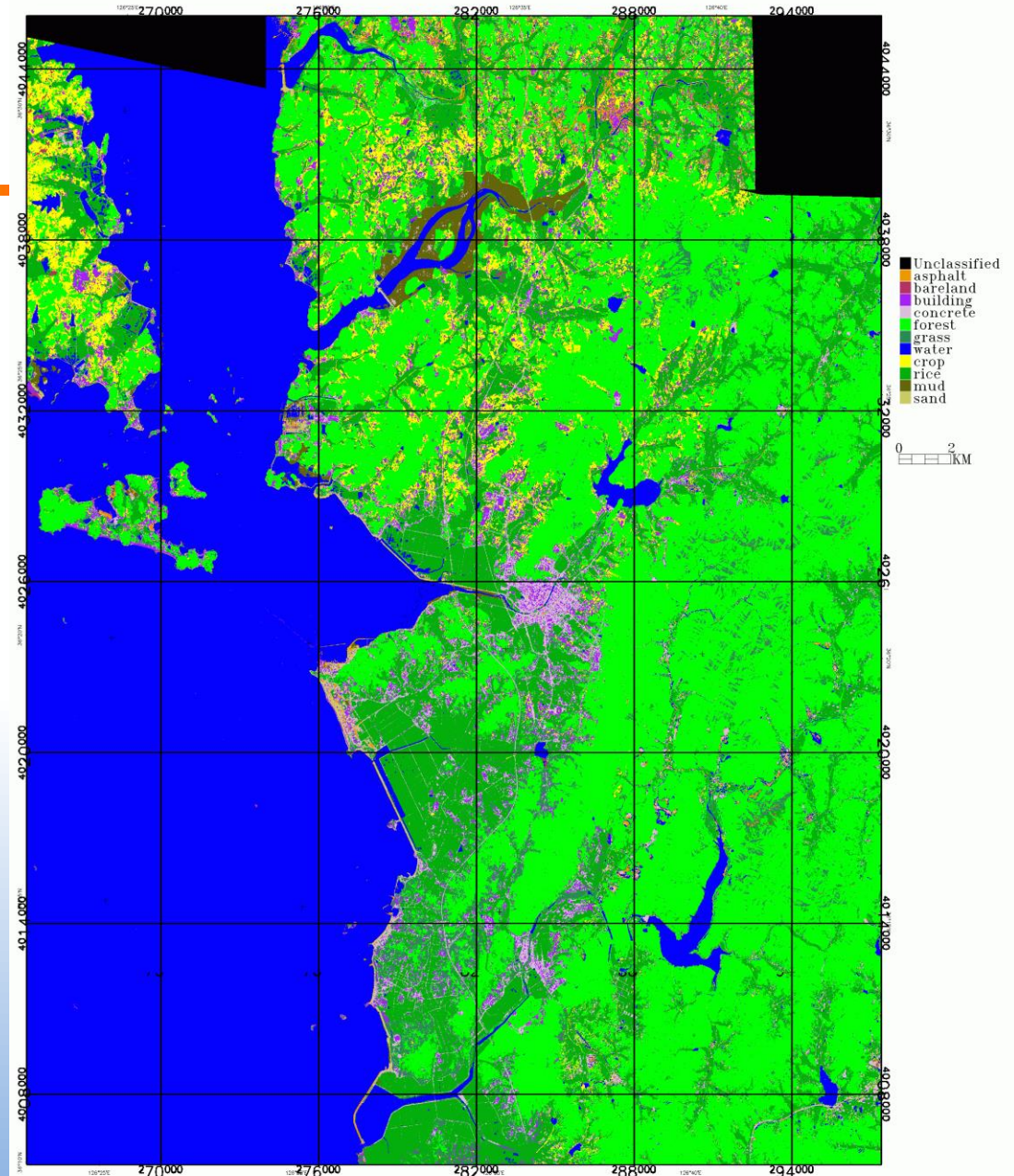


Dataset – Multispectral Imagery

- The land cover classification results employing (a) FORMOSAT, (b) KOMPSAT, (c) Rapideye, (d) SPOT with the m_2



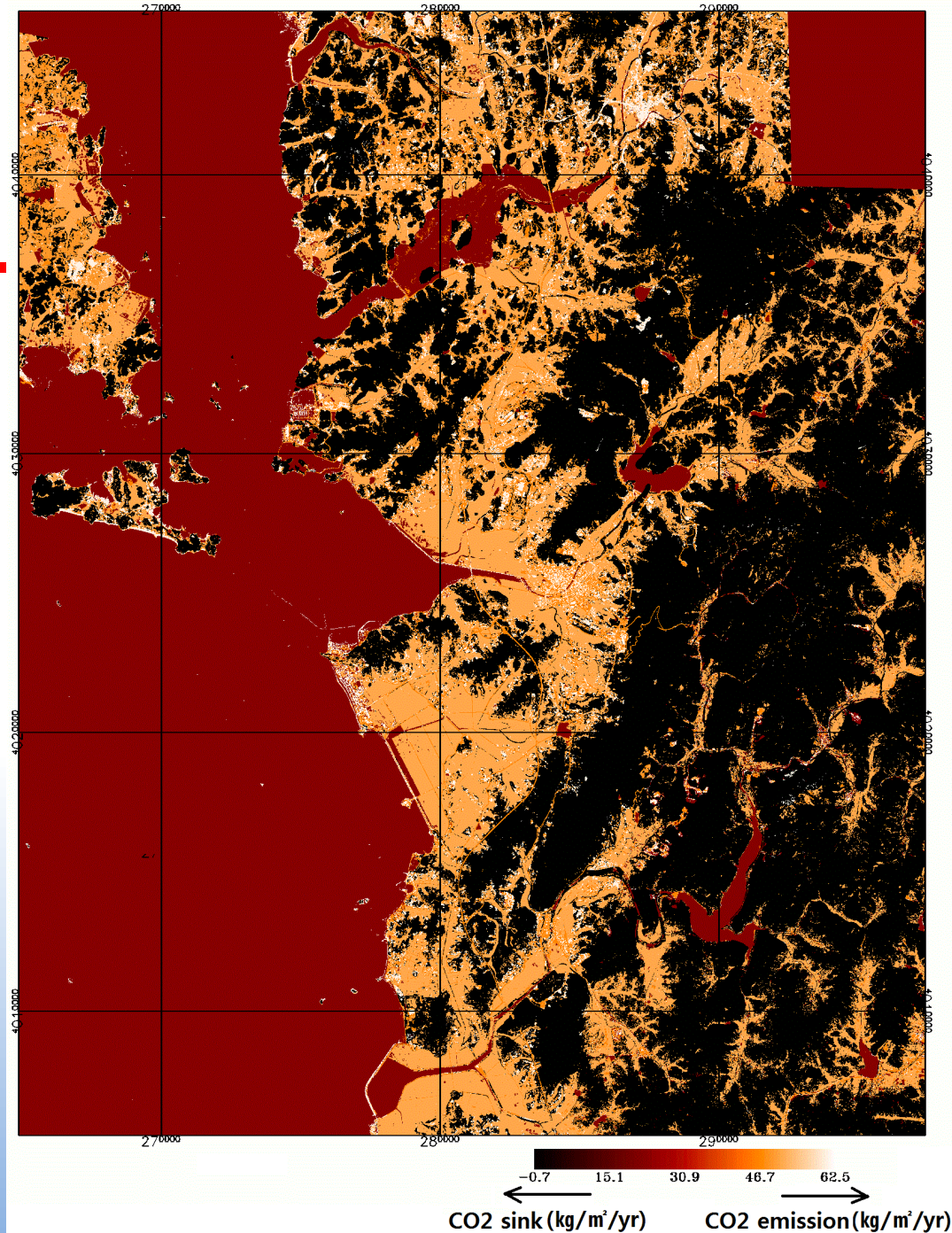
Results – Land cover map (Boryeong)



Results

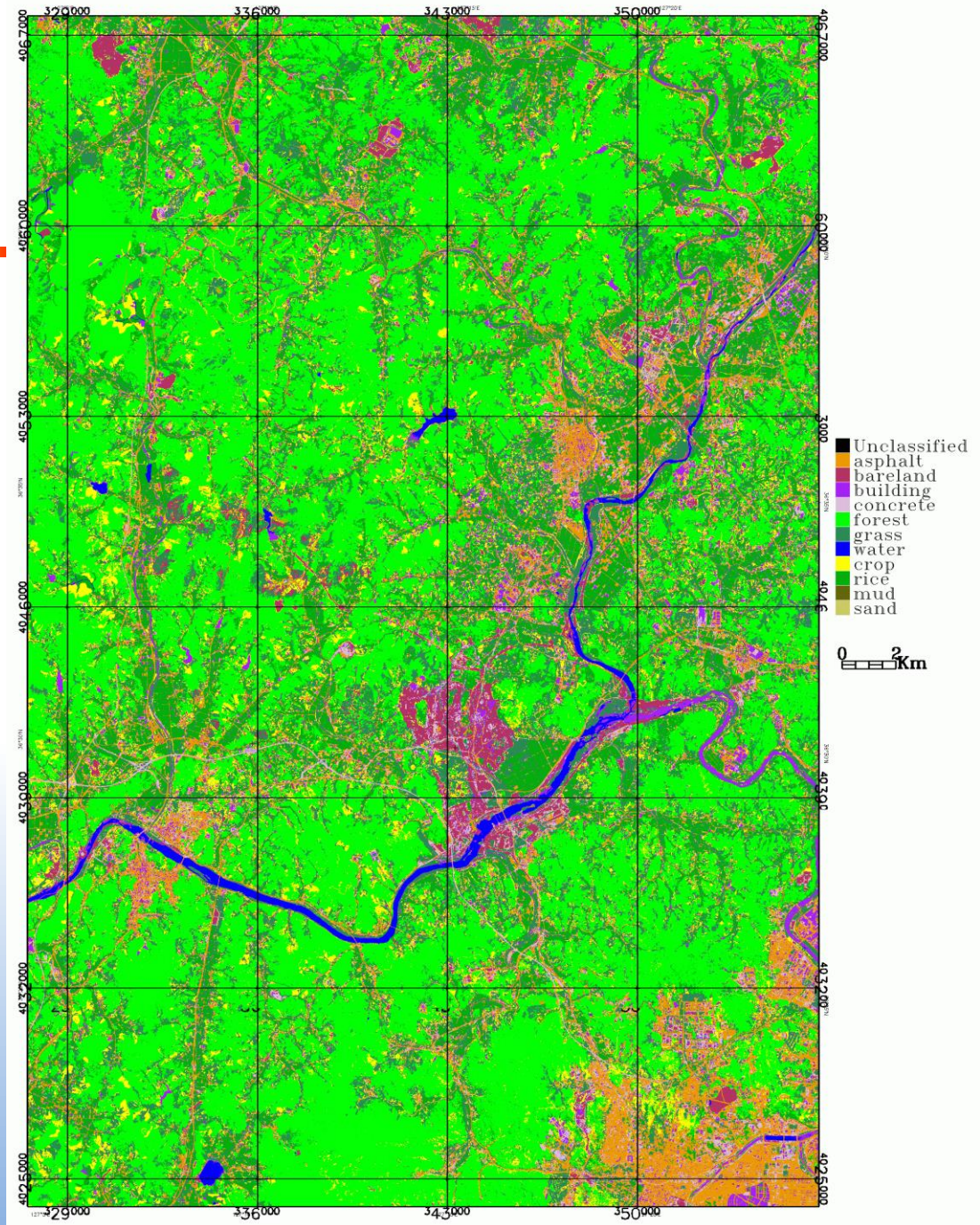
CO₂ Emission map (Boryeong)

- Total CO₂ flux over Boryeong is 3.609e+9 Kg /year.



Results

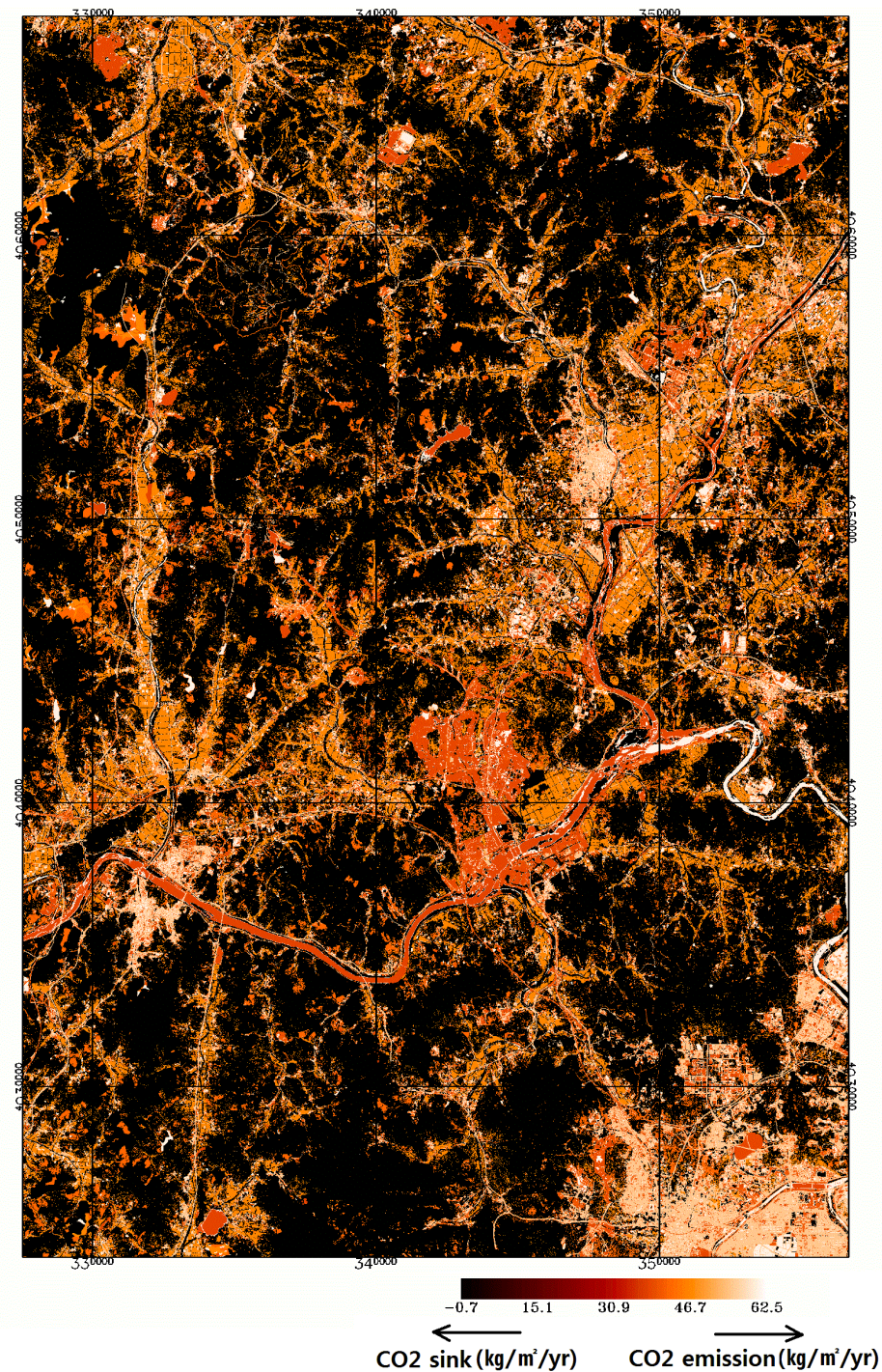
Land cover map (Yeongi City)



Results

CO₂ Emission map (Yeongi City)

- Total CO₂ flux over Yeongi is 7.387×10^9 Kg /year.





Estimation of Green Water Footprint of Rice Paddies



Introduction



a recently developed **indicator** to identify the usage and distribution of the fresh water resource

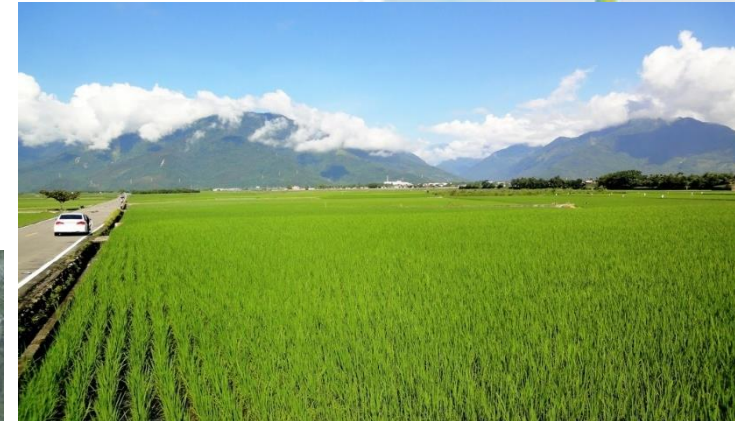


- **Crop** is a type of product needs large amount of water.
- Only blue water can be estimated clearly, **green water** contributed for crop growth was **ignored**.
- Because **green water is hidden in products** or **hard to measure in evapotranspiration (ET)**.
- It's critical to identify the amount of green water of crop.



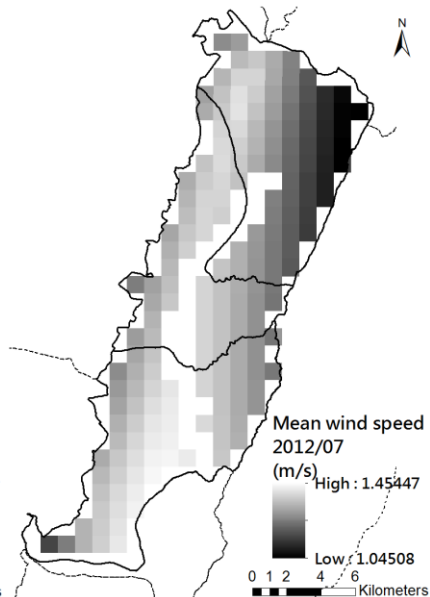
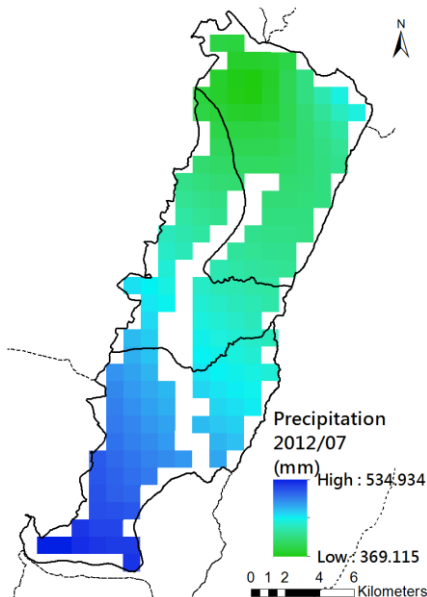
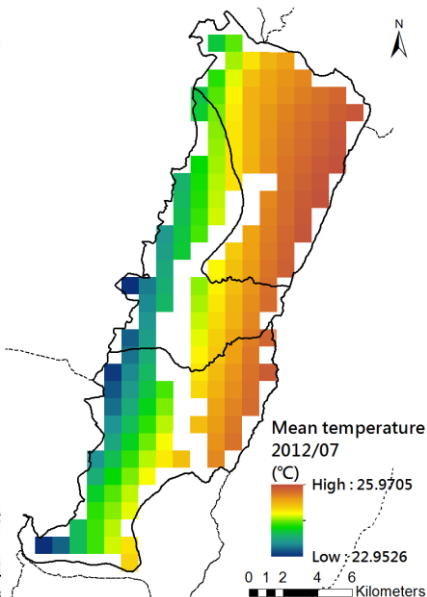
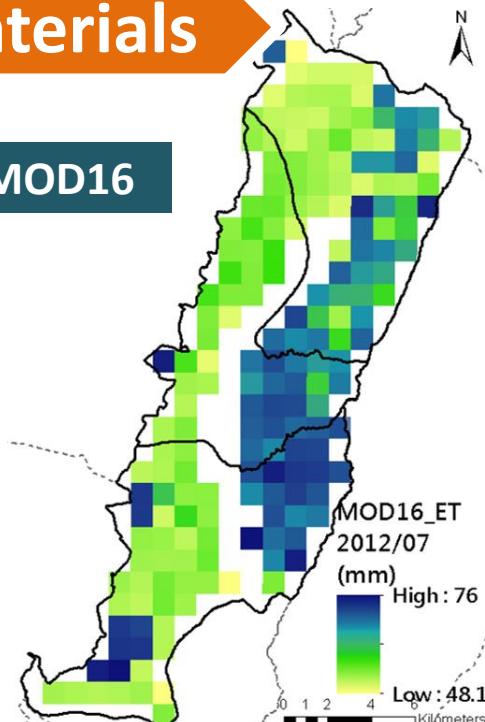
Study Area

- ✓ the southeast of Taiwan
- ✓ Rice paddies: 6,500 – 7,000 ha

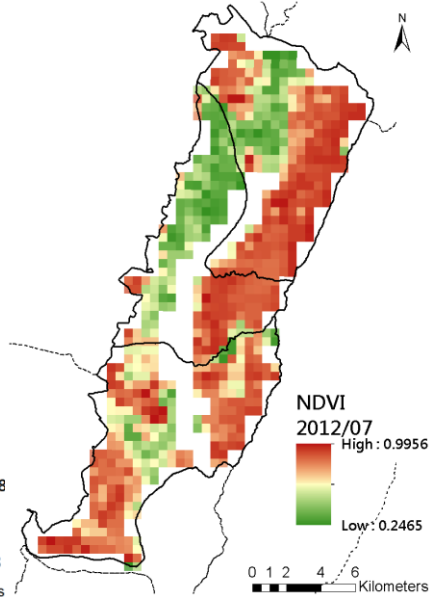
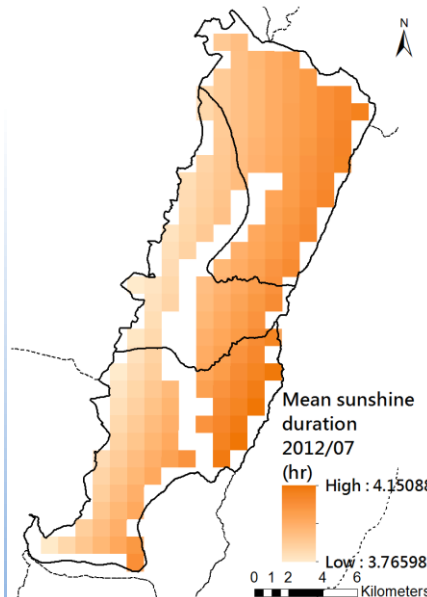
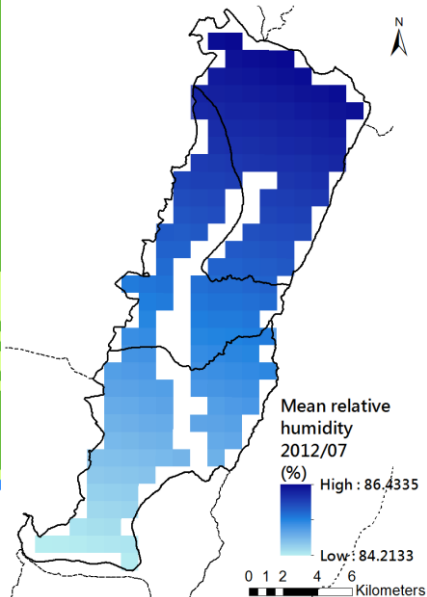
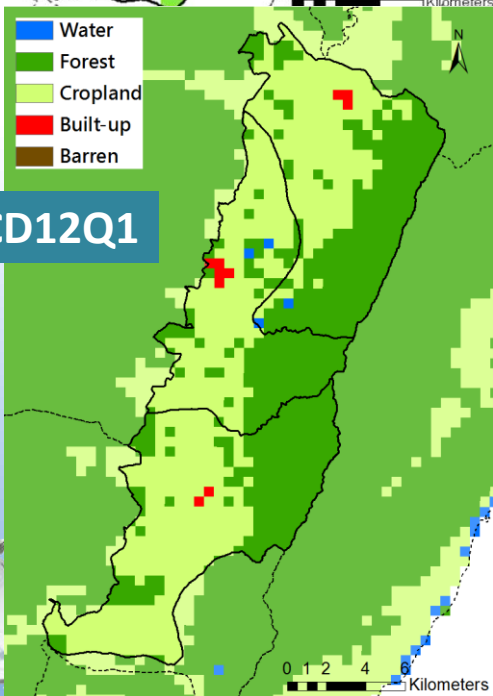


Materials

MOD16



MCD12Q1



MOD13Q1

◆ Stepwise Regression for ET

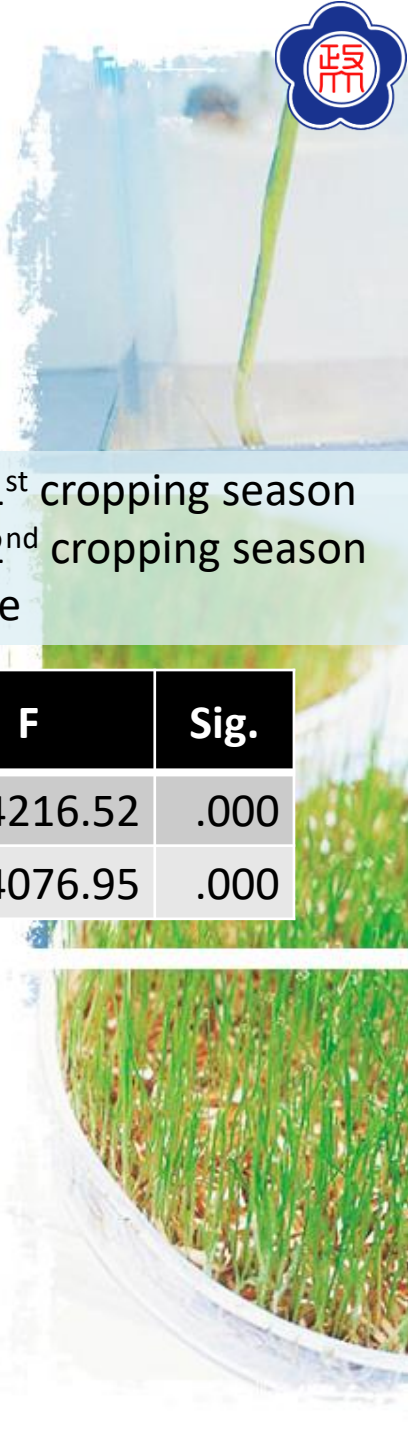
- Data covered the period: 2003 – 2012
- Number of samples: 4,200

$$ET_1 = -24.731 + 4.887 \times T + 22.821 \times NDVI$$

$$ET_2 = -56.149 + 5.704 \times T + 29.813 \times NDVI$$

ET1: ET over 1st cropping season
 ET2: ET over 2nd cropping season
 T: temperature

Model	R	R ²	adjusted R ²	Std. Error of the estimate	F	Sig.
1 st Cropping Season	.80	.65	.65	14.50	4216.52	.000
2 nd Cropping Season	.80	.64	.64	16.07	4076.95	.000



◆ Results of Out-of-sample Forecasting

- Number of out-of-samples: 48
- Period: 2003 – 2012

Model	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Avg.
1 st crop	0.89	0.88	0.88	0.87	0.88	0.87	0.88	0.75	0.80	0.89	0.86
2 nd crop	0.85	0.86	0.85	0.85	0.86	0.89	0.87	0.83	0.79	0.88	0.85

- Period: 2013 - 2014

Model	2013	2014	Avg.
1 st crop	0.85	0.89	0.87
2 nd crop	0.85	0.86	0.86

- ✓ The developed models could provide **highly accurate** ET predictions
- ✓ This result demonstrated **the applicability** of our regression models



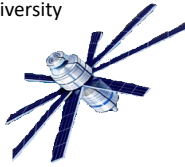


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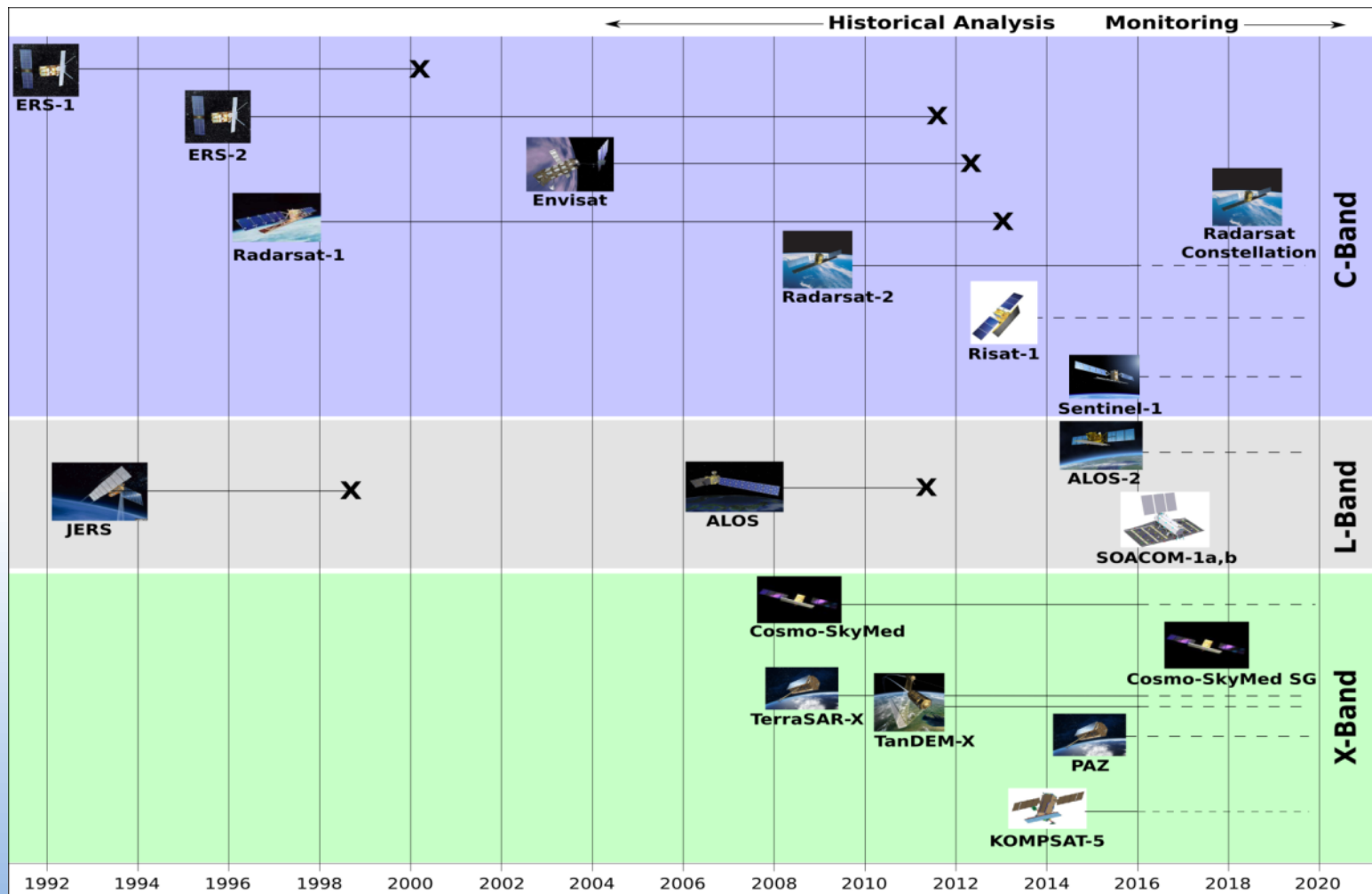
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Interferometric Synthetic Aperture Radar (InSAR) Applications



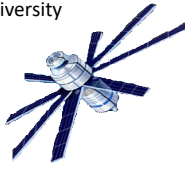


SAR Missions



<https://winsar.unavco.org/portal/wiki/Satellite%20Information/>





Interferometric SAR (InSAR)

- InSAR use the **phase** information stored in two SAR image snapped at **different time** for same location to make **Digital Elevation Model (DEM)**.
- In 1969, the first application of radar interferometry in Earth-based observations of **Venus**
- In 1974, used to Earth topographic mapping.
- Airborne and spaceborne InSAR systems were applied to Earth observation in 1986 and 1988, respectively.

Rosen, P. A., Hensley, S., Joughin, I. R., Li, F. K., Madsen, S. N., Rodriguez, E., & Goldstein, R. M. (2000). Synthetic aperture radar interferometry. *Proceedings of the IEEE*, 88(3), 333-382.

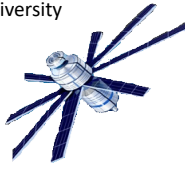
Rogers, A.E.; Ingalls, R.P. *Venus: Mapping the surface reflectivity by radar interferometry*. *Science*. 1969, 165, 797-799.

Graham, L.C. *Synthesis interferometric radar for topographic mapping*. *Proc. IEEE* 1974, 62, 763-768.

Zebker, H.A.; Goldstein, R.M. *Topographic mapping from Interferometric Synthetic Aperture Radar Observations*. *J. Geophys. Res.* 1986, 91, 4993-4999.

Goldstein, R.M.; Zebker, H.A.; Werner, C.L. *Satellite radar interferometry: Two-dimensional phase unwrapping*. *Radio Sci.* 1988, 23, 713-720.





Differential-InSAR (D-InSAR)

- DInSAR is the technique to **extract displacement** signature from a SAR interferogram over the acquisition period.
- In 1989, the first demonstrated the potential of DInSAR for **sub-centimeter** level surface deformation mapping over a large area.

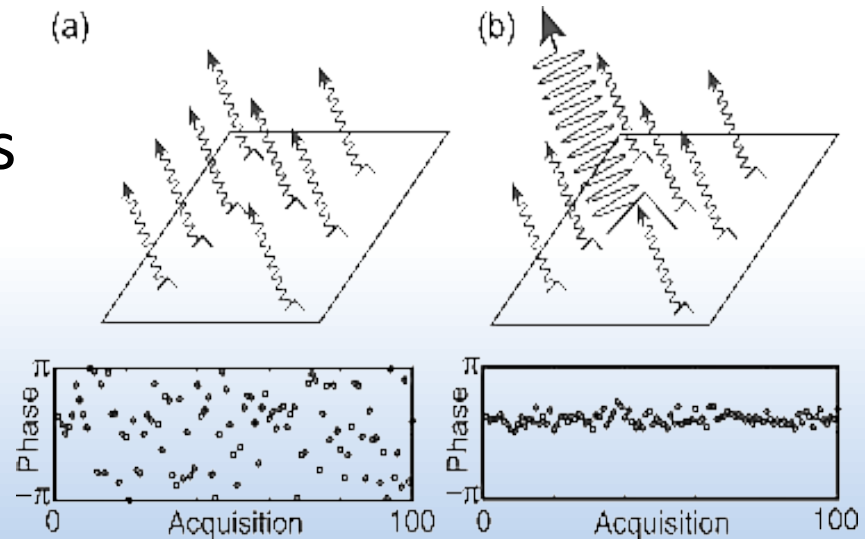
Gabriel, A.K.; Goldstein, R.M.; Zebker, H.A. Mapping small elevation changes over large areas: differential radar interferometry. J. Geophys. Res. 1989, 94, 9183–9191.

Li, Z.W.; Ding, X.L.; Liu, G.X.; Huang, C. Atmospheric Effects on InSAR Measurements - A Review. Geom. Res. Austr. 2003, 79, 43–58.



Persistent Scatterer InSAR (PS-InSAR)

- PS-InSAR developed in 2000 offers a systematic processing strategy, capable of utilizing all archived SAR image and creating a **stack of D-InSAR** that have a common master image.
- The phase of isolated points (PS) with **strong and stable** radar returns is analyzed as a function of time, baseline, and space.



Ferretti, A.; Prati, C.; Rocca, F. Nonlinear subsidence rate estimation using permanent scatterers in differential SAR interferometry. *IEEE Trans. Geosci. Remote Sens* 2000, 38, 2202–2212.

Ferretti, A.; Prati, C.; Rocca, F. Permanent scatterers in SAR interferometry. *IEEE Trans. Geosci. Remote Sens* 2001, 39, 8–20.

Hilley, G.E.; Bergmann, R.; Ferretti, A.; Novali, F.; Rocca, F. Dynamics of slow-moving landslides from permanent scatter analysis. *Science* 2004, 304, 1952–1955.

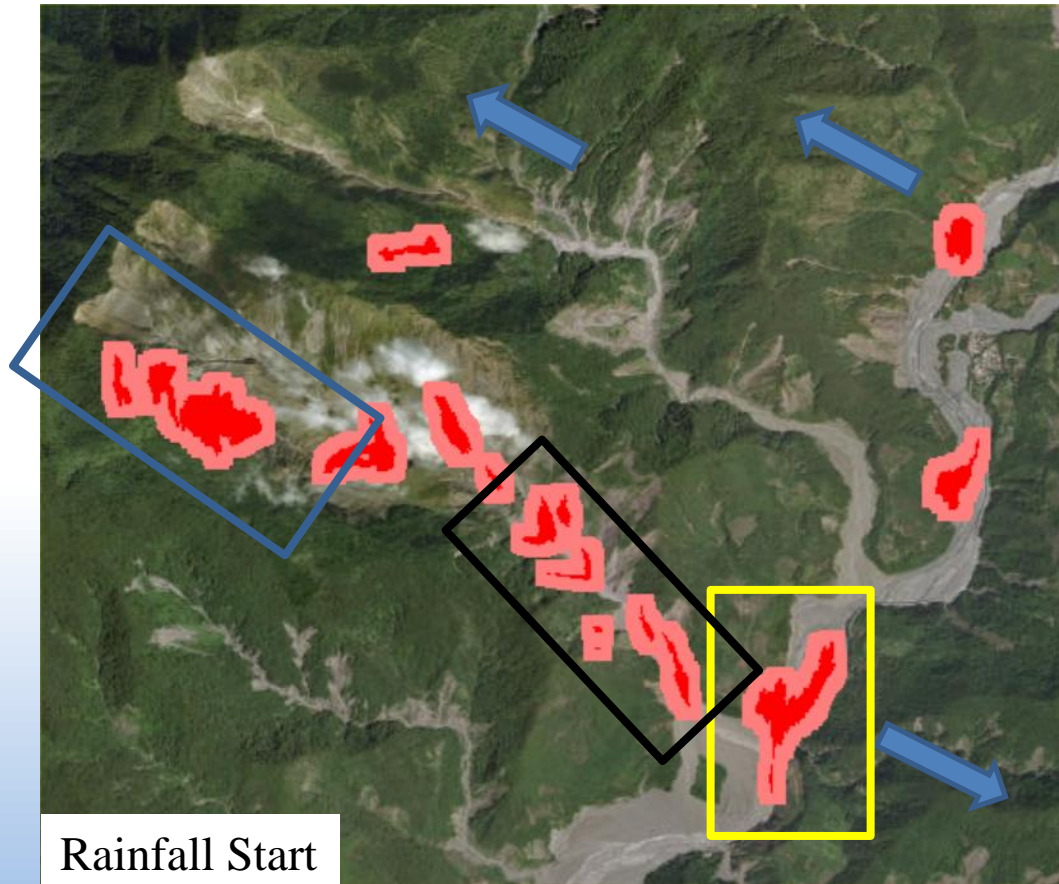
Hooper, A.; Segall, P.; & Zebker, H. (2007). Persistent scatterer interferometric synthetic aperture radar for crustal deformation analysis, with application to Volcán Alcedo, Galápagos.

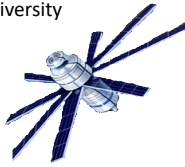
Journal of Geophysical Research: Solid Earth (1978–2012), 112(B7).

Hooper, A.; Zebker, H.; Segall, P.; Kampes, B. A new method for measuring deformation on volcanoes and other natural terrains using InSAR persistent scatterers. *Geophys. Res. Lett.* 2004, 31, L23611.

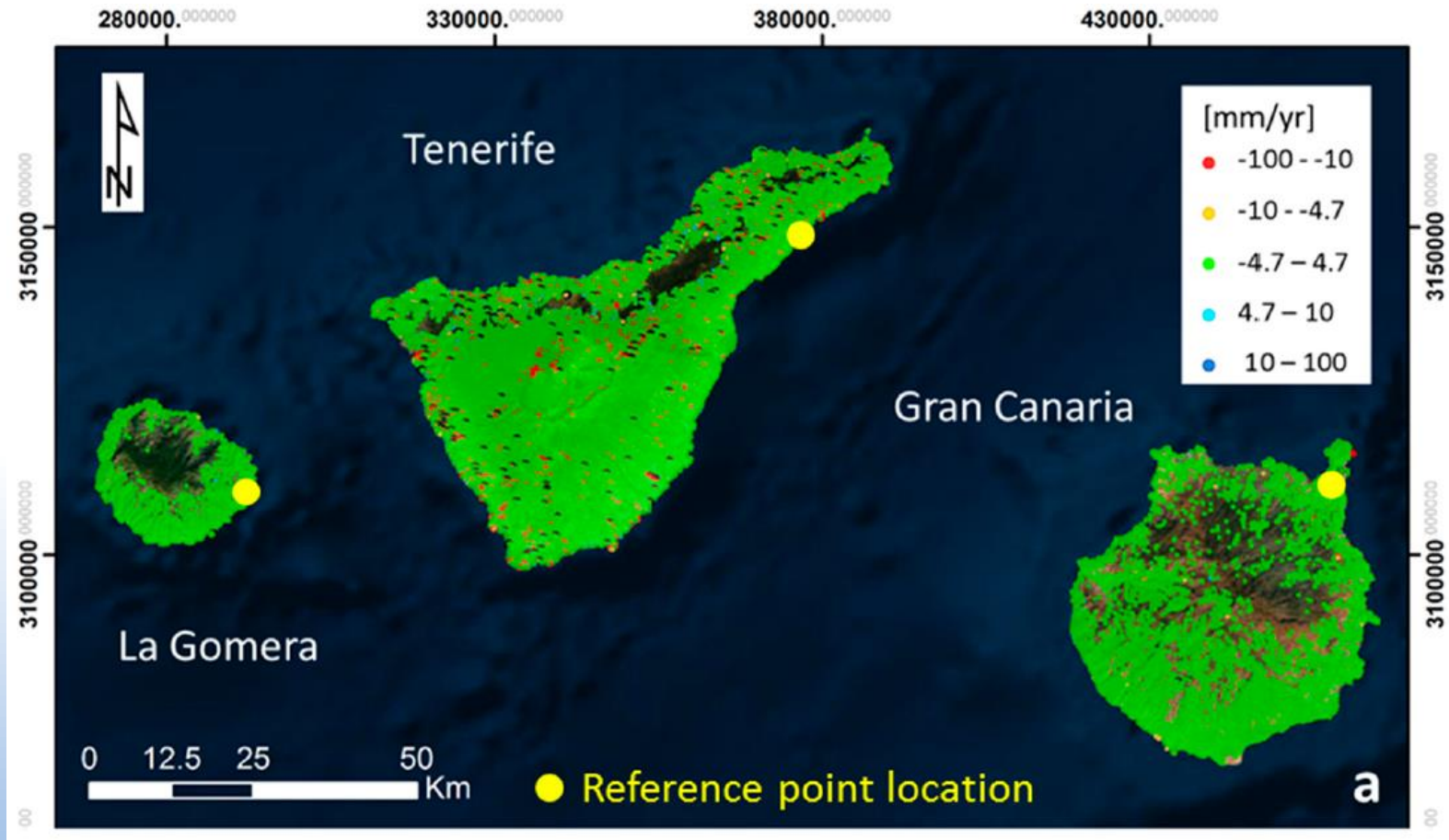


Amplitude Change - Landslides





PS InSAR Processing



Barra, A. et al., 2017. A Methodology to Detect and Update Active Deformation Areas Based on Sentinel-1 SAR Images. Remote Sensing, 9(1002).





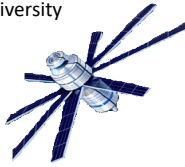
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Creation of MOLA, HRSC, CTX and HiRISE Mars DTM



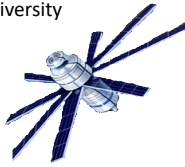
Introduction



- Mars orbiters and sensors

 - Active sensor
 - NASA's Mars Global Surveyor (MGS)
 - Mars Orbiter Laser Altimeter (MOLA)
 - The first comprehensive Mars topography map was produced based on MOLA data in 2001
 - Passive (optical) sensor
 - ESA's Mars Express
 - High Resolution Stereo Camera Experiment (HRSC)
 - NASA's Mars Reconnaissance Orbiter (MRO)
 - Context Imager (CTX)
 - High-Resolution Imaging Science Experiment (HiRISE)



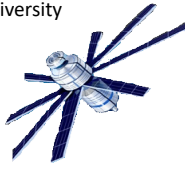


- HRSC image
- 12.5 m/pixel
- 65 x 500 km

- CTX image
- 6 m/pixel
- 30 x 86 km

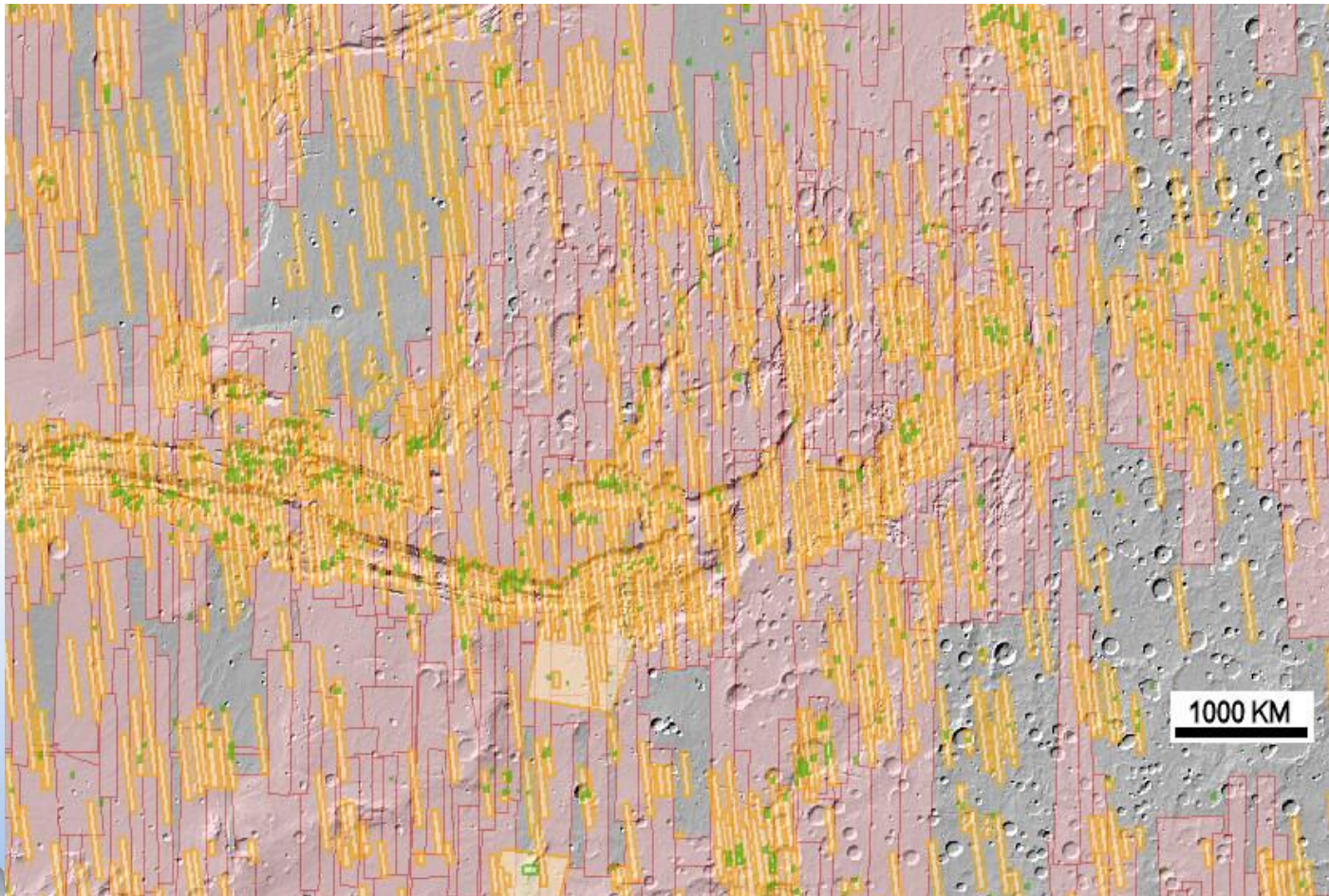
- HiRISE image
- 0.25 m/pixel
- 0.5 x 1.3 km





Introduction

- Coverage of HRSC, CTX and HiRISE imagery



Red: HRSC

Yellow: CTX

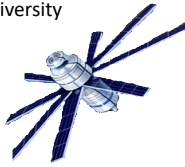
Green: HiRISE



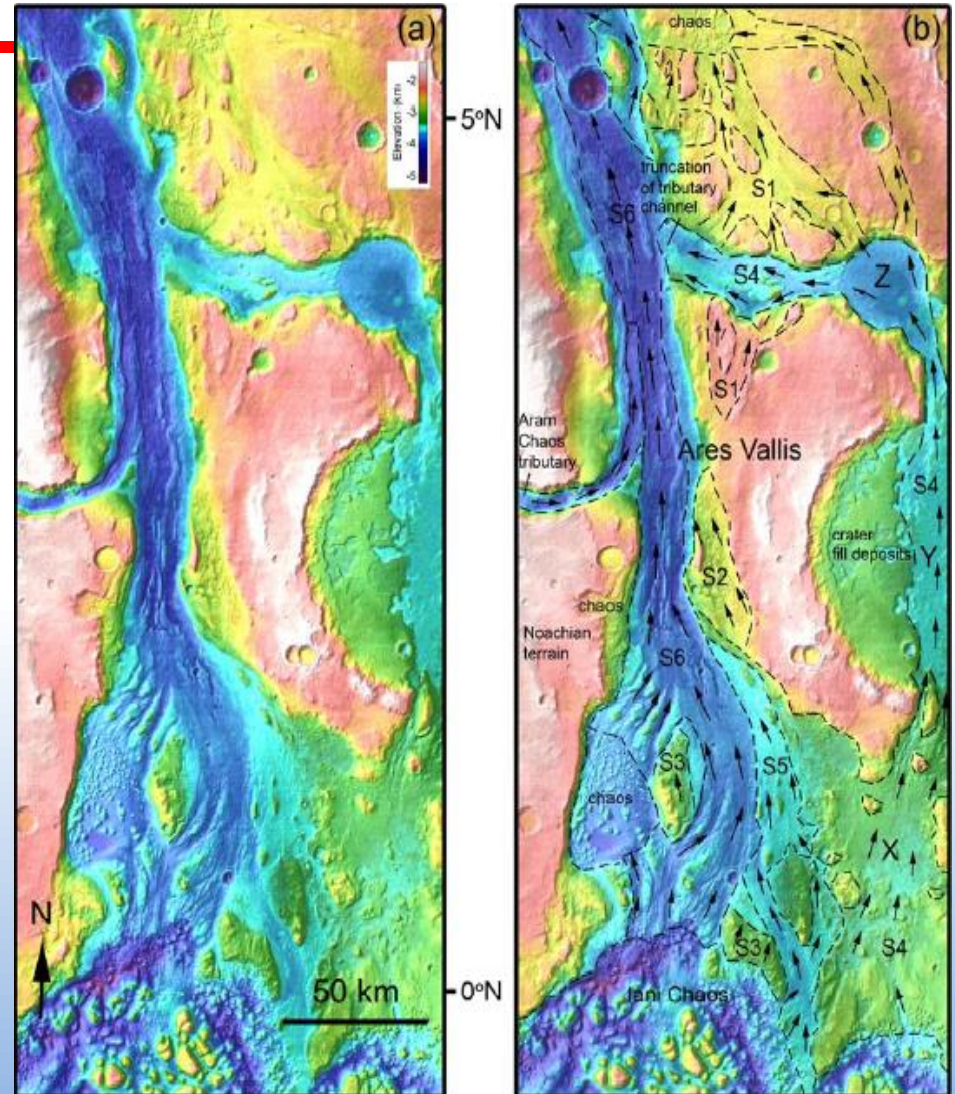
HRSC DTM



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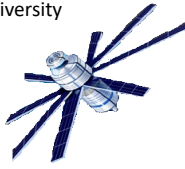
- A refined chronology of catastrophic outflow events in Ares Vallis, Mars



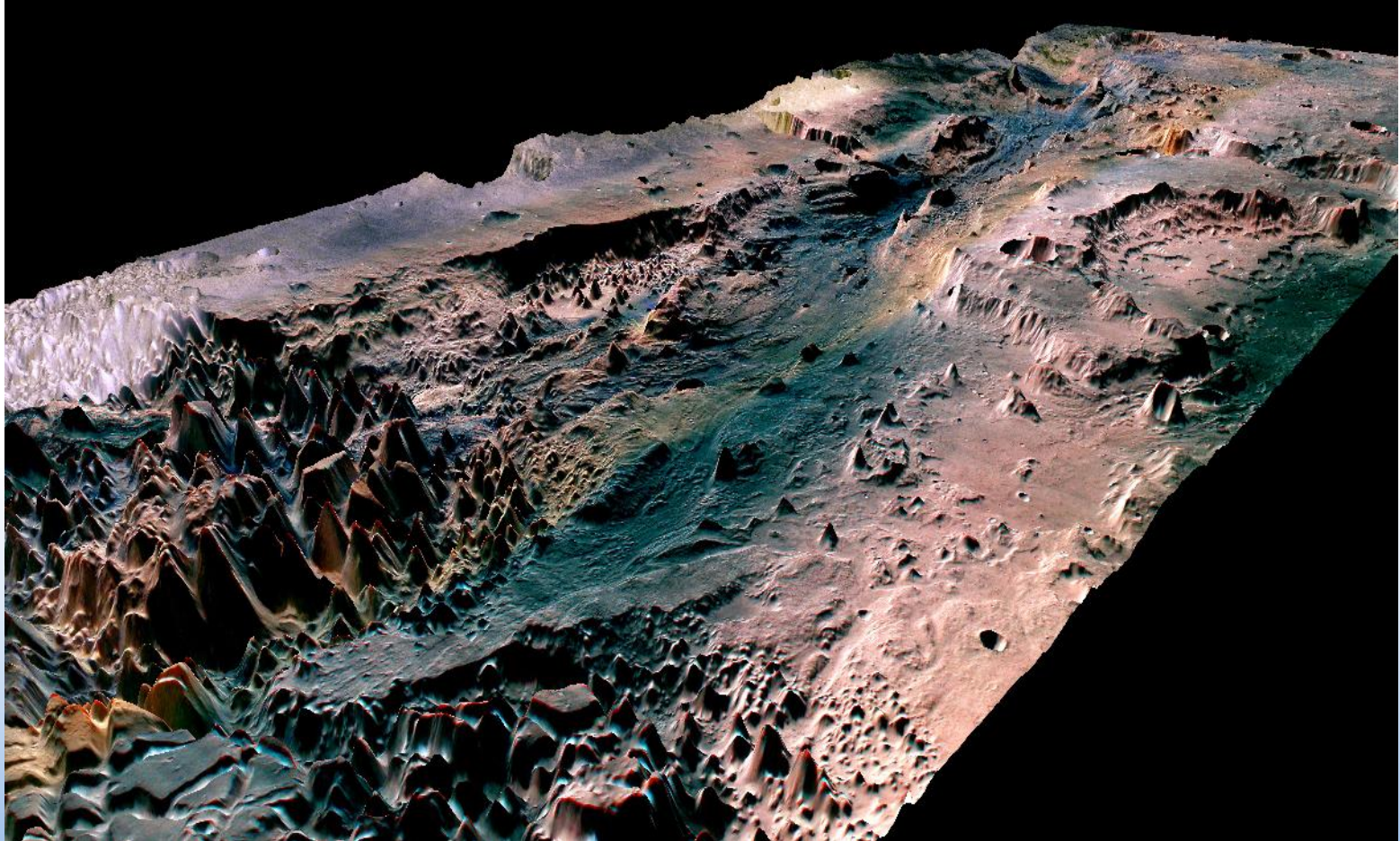
HRSC DTM



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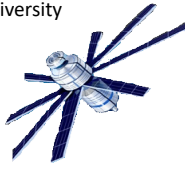
- Ares Vallis



Thermokarst



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CTX DTM

- CTX DTM of thermokarst-like depressions
 - Topography data illustrate that channels form networks connecting depressions of different base elevation.

