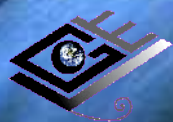


遙測在考古應用初探

蔡富安
國立中央大學
太空及遙測研究中心 暨
土木工程學系
ftsai@csrsr.ncu.edu.tw



GeoComputing
Laboratory



國立中央大學太空及遙測研究中心

大綱

- 遙測簡介
- 光學遙測考古應用
- 微波遙測考古應用
- 特殊遙測考古應用
- 結論

遙測之定義

To learn *something* about *something*
without touching it.

以非接觸式方式獲取目標物之資訊

- 方式：透過感測器
- 媒介：電磁波、聲波…
- 對象：物體表面物理特性（溫度、溼度、粗糙度、顏色等）、幾何資訊（位置、方向、大小、形狀、速度）、或目標區的各種現象 (phenomena)

遙測之目的與定位

To learn *more, more quickly, or more economically.*

- 遙測的目的非取代地面或傳統量測
- 輔助資料
 - 更多
 - 更快
 - 更廣
 - 更經濟

遙測之類別

■ 以感測器 (sensor) 類別區分

□ 主動式遙測

- 遙測儀器發射電磁波或其他感測媒介，並接收目標物反射回波
- 例如：合成孔徑雷達影像、氣象雷達、光達 (LiDAR)、多普勒雷達等

□ 被動式遙測

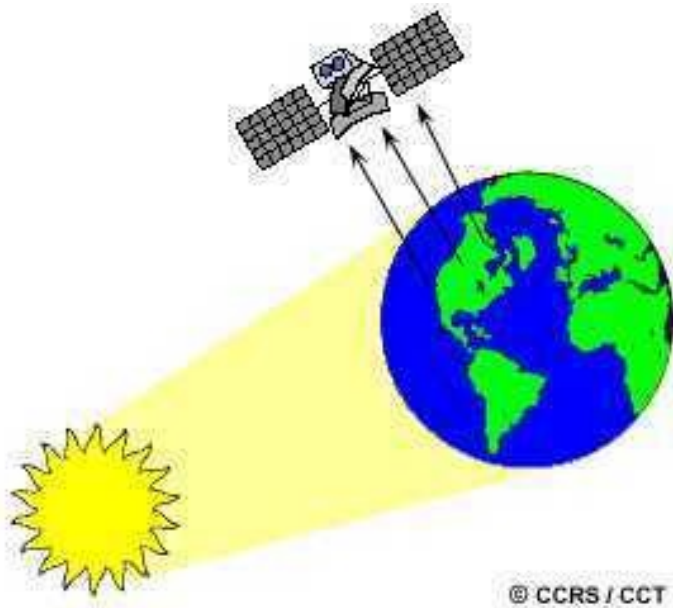
- 遙測儀器並不發射電磁波，能量來自目標物本身放出的電磁波或目標物對其他能量來源的反射
- 例如：光學衛星影像、航空攝影測量等

遙測之類別

- 以載具 (platform) 類別區分
 - 衛載 (space-borne)：衛星
 - 空載 (airborne)：飛機、直昇機、氣球、無人載具 (UAV)
 - 地面遙測 (ground-based)：車、船、手持式、固定式...

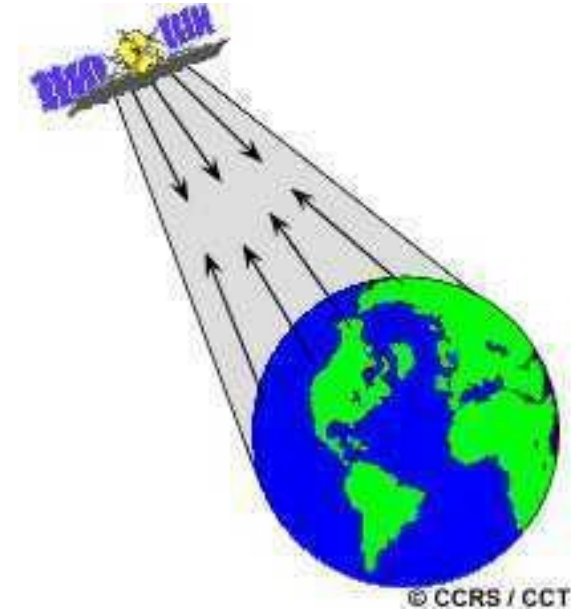
■ 被動式 (Passive)

- 電磁波能量來自太陽
- SPOT
- FORMOSAT-2

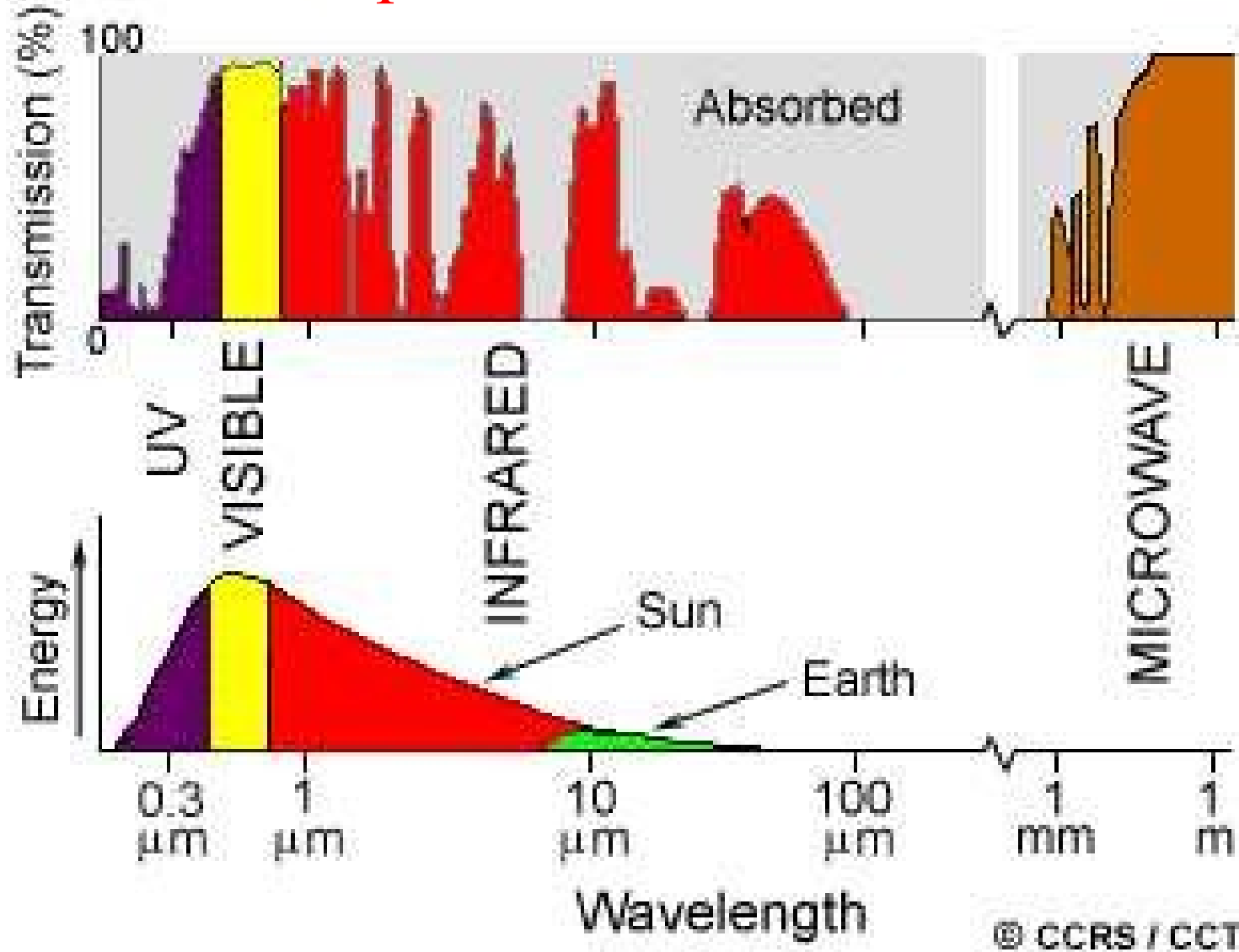


■ 主動式 (Active)

- 電磁波能量來自載體本身
- ERS
- Radarsat



Solar EM Spectrum



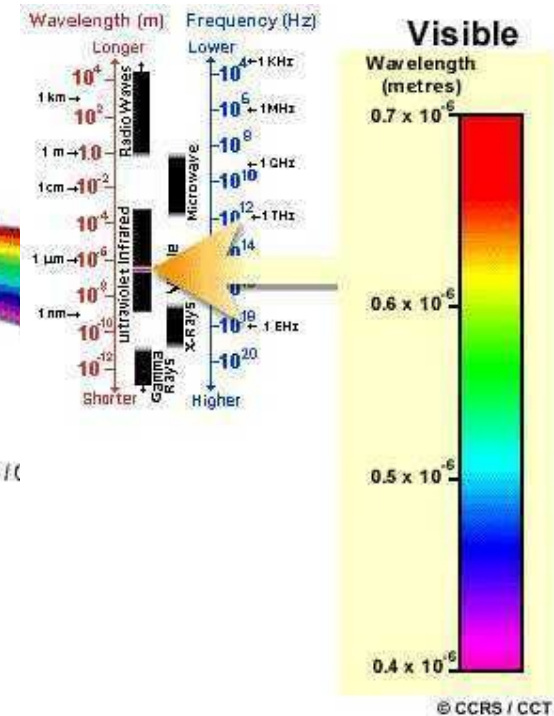
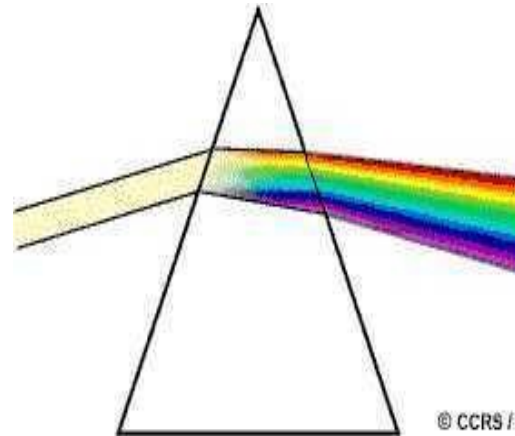
A. 電磁波譜

■ 紫外線 (Ultraviolet or UV)

- 岩石、礦石等在紫外線照射下會發出螢光 (近可見光)

■ 可見光 (Visible)

- 0.4-0.7 μm
 - 紫 \rightarrow 紅



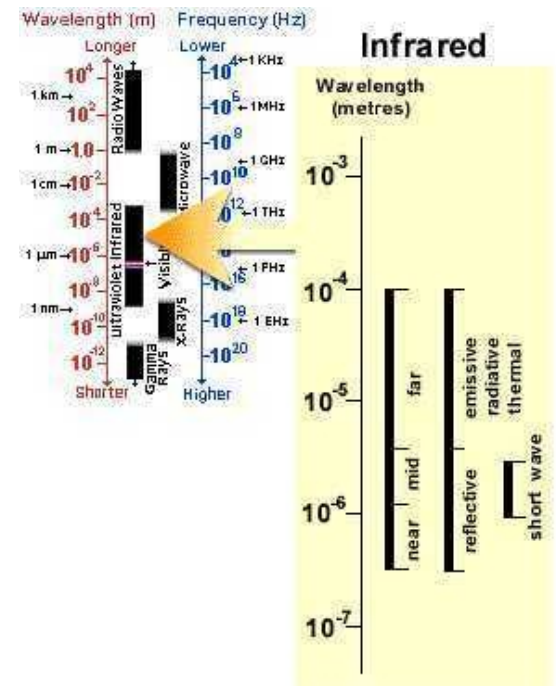
A. 電磁波譜

■ 紅外光 (Infrared, IR)

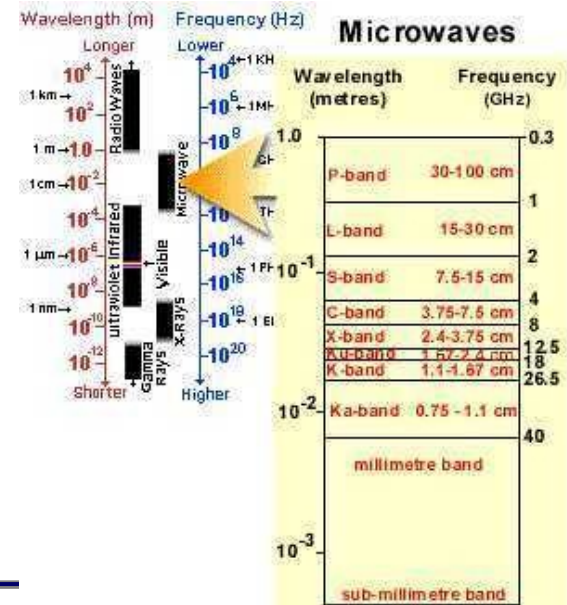
- 反射性 NIR-SWIR(0.7-3 μm)
- 輻射性 Thermal-IR(熱紅外光, 3-100 μm)
 - 由地物本身所輻射出之熱能

■ 微波 (Microwaves)

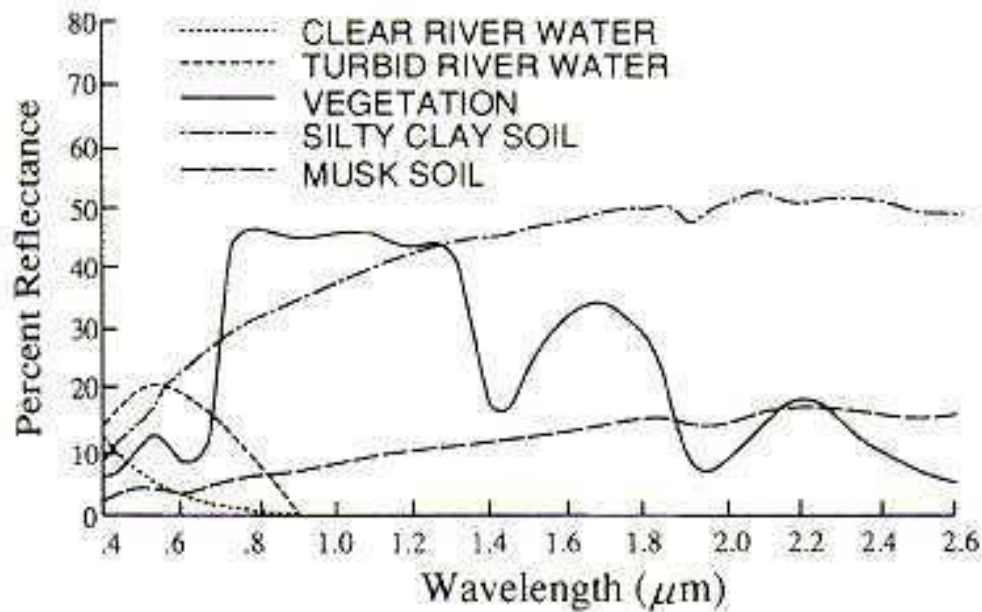
- 1mm-1m



© CCRS / CCT



地物光譜反射特性

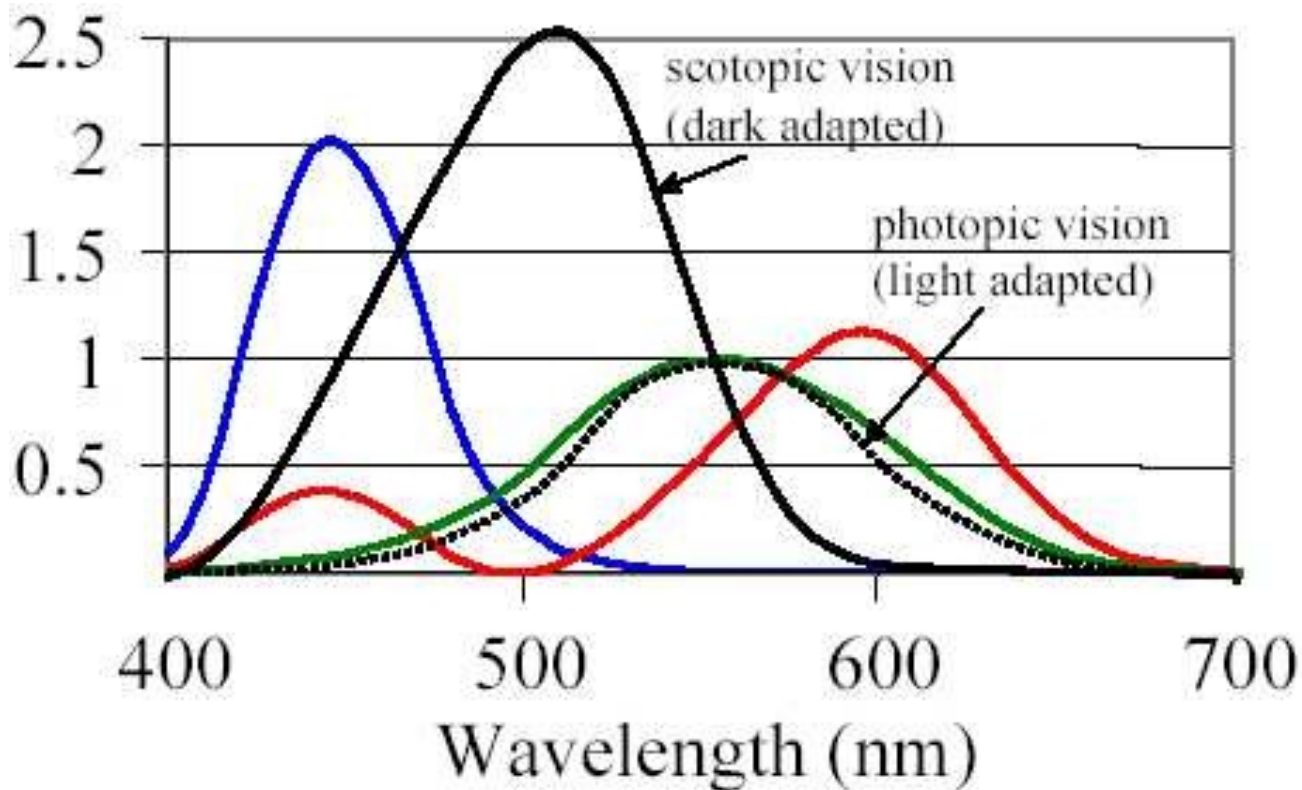


**Spectral reflectance of
vegetation, soil and water**

©JARS

人眼視覺系統限制

- 僅能感應 0.4~0.7 μm
- 僅有 3 個顏色（波長）接收器 (color receptors)



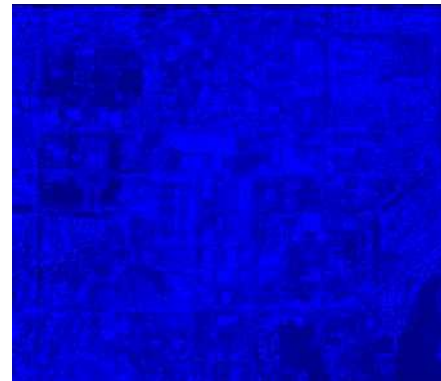
■ 數位影像色彩

◆ True color

Formosat-2 image



61
55
57
58
61
58
59
62
61
59
60
59
60
58
48
65
73
74
72
73
75
77
75
74
77
75
75
77
77
79
69
67
80
87
104
99
100
102
105
102
103
103
103
103
103
105
100
96
94
107
106



74
73
71
79
70
75
73
79
82
94
52
68
57
65
67
64
60
91
90
90
90
86
88
65
95
95
108
105
84
75
81
83
79
74
117
118
111
115
106
115
117
118
123
136
137
116
99
105
111
106
104

Red-Red

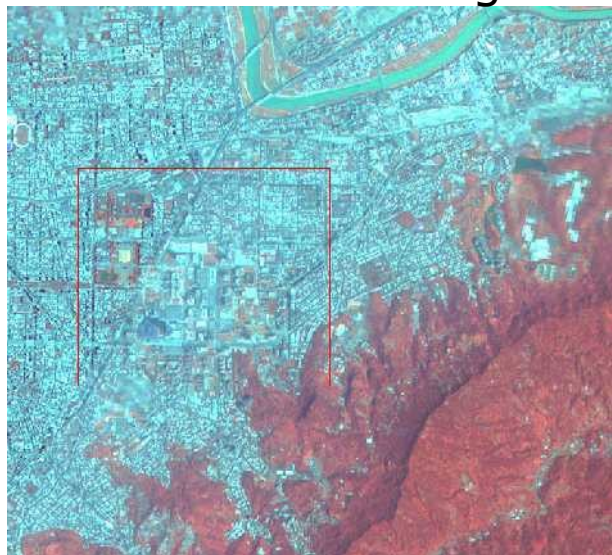
Green-Green

Blue-Blue

■ 數位影像色彩

◆ False color

Formosat-2 image



64
67
67
67
68
72
70
73
66
66
68
64
58
68
85
84
82

74
72
73
75
77
75
74
77
75
75
77
77
79
69
67
80
87

104
99
100
102
105
102
103
103
103
103
103
105
100
96
94
107
106



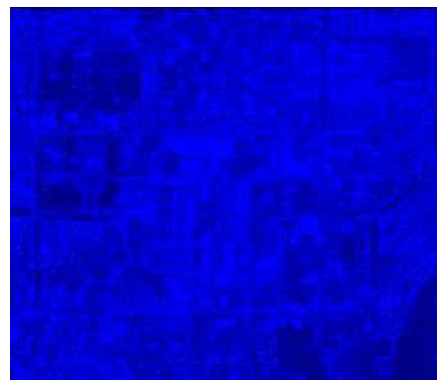
81
80
76
74
80
81
84
90
92
85
74
72
68
65
66
66
63

Red-NIR



91
90
90
90
86
88
85
95
95
108
105
84
75
81
83
79
74

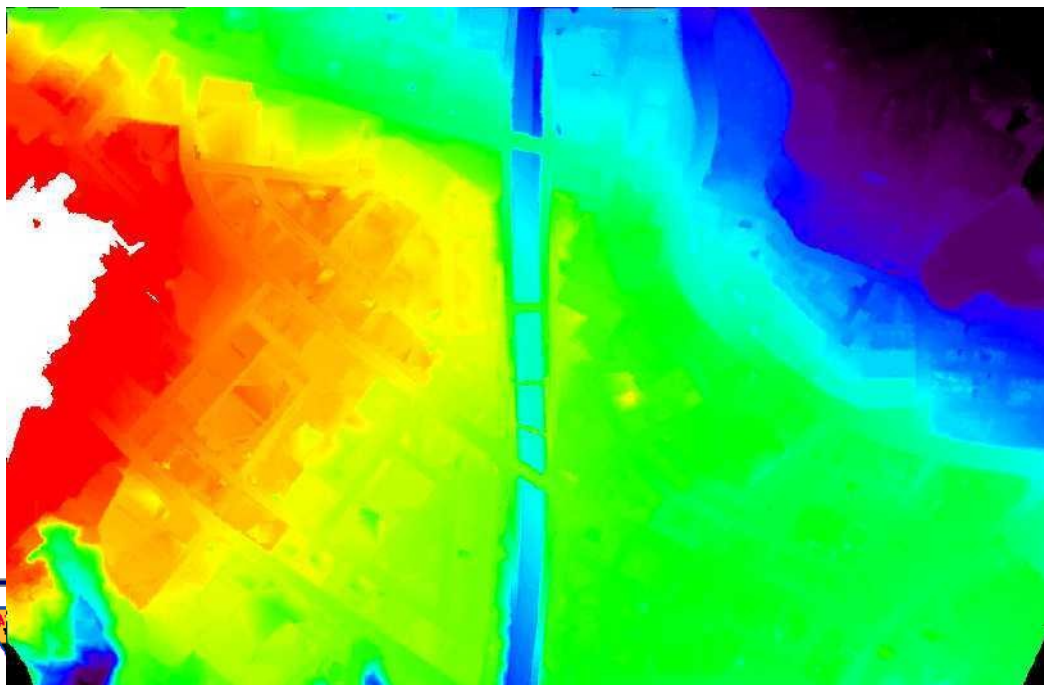
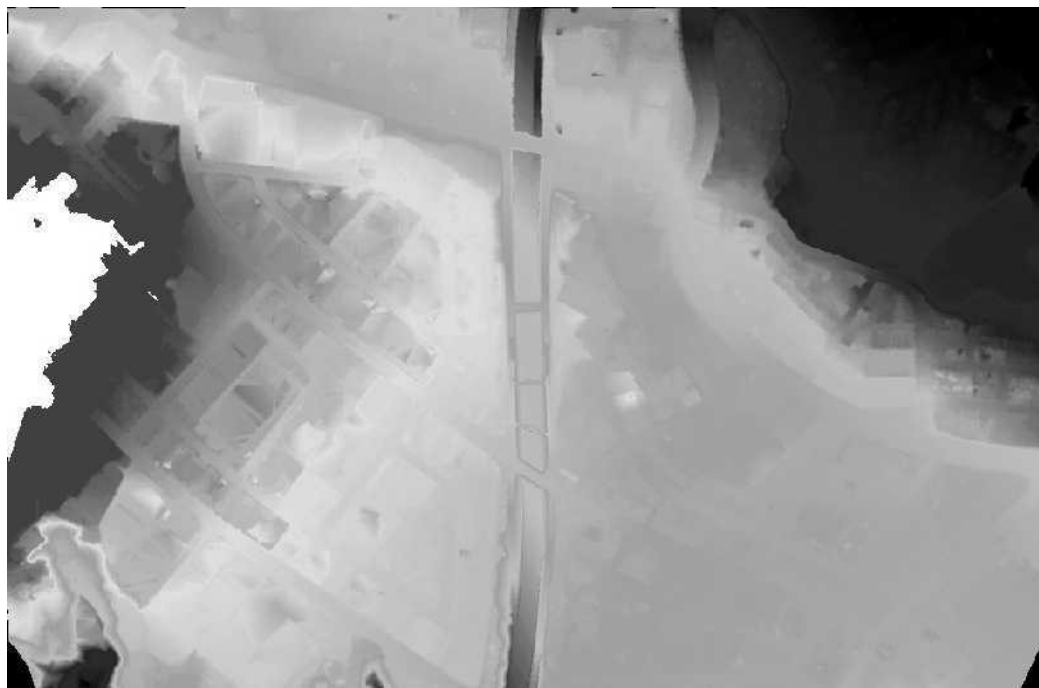
Green-Green



117
118
111
115
106
115
117
118
123
136
137
116
99
105
111
106
104

Blue-Blue

- 數位影像色彩
 - ◆ Pseudo color

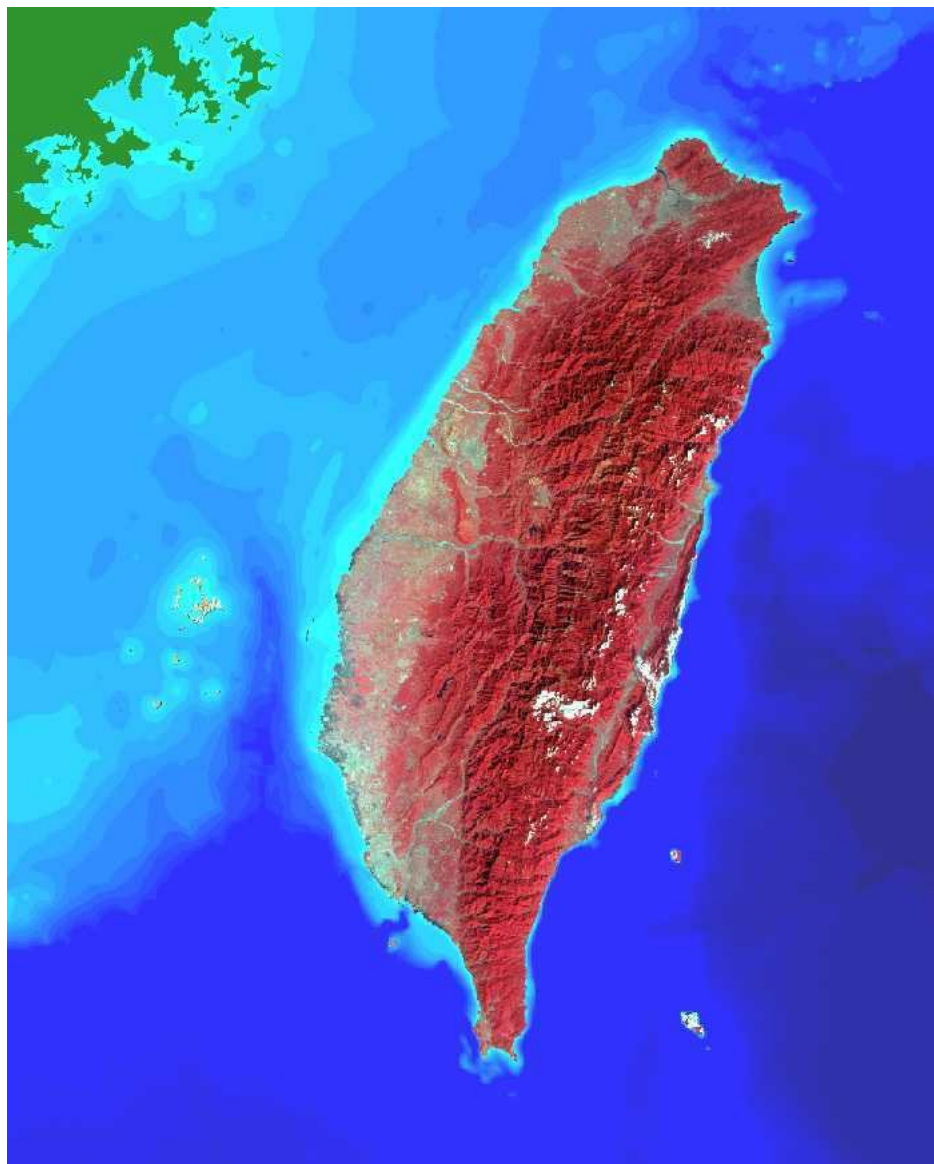


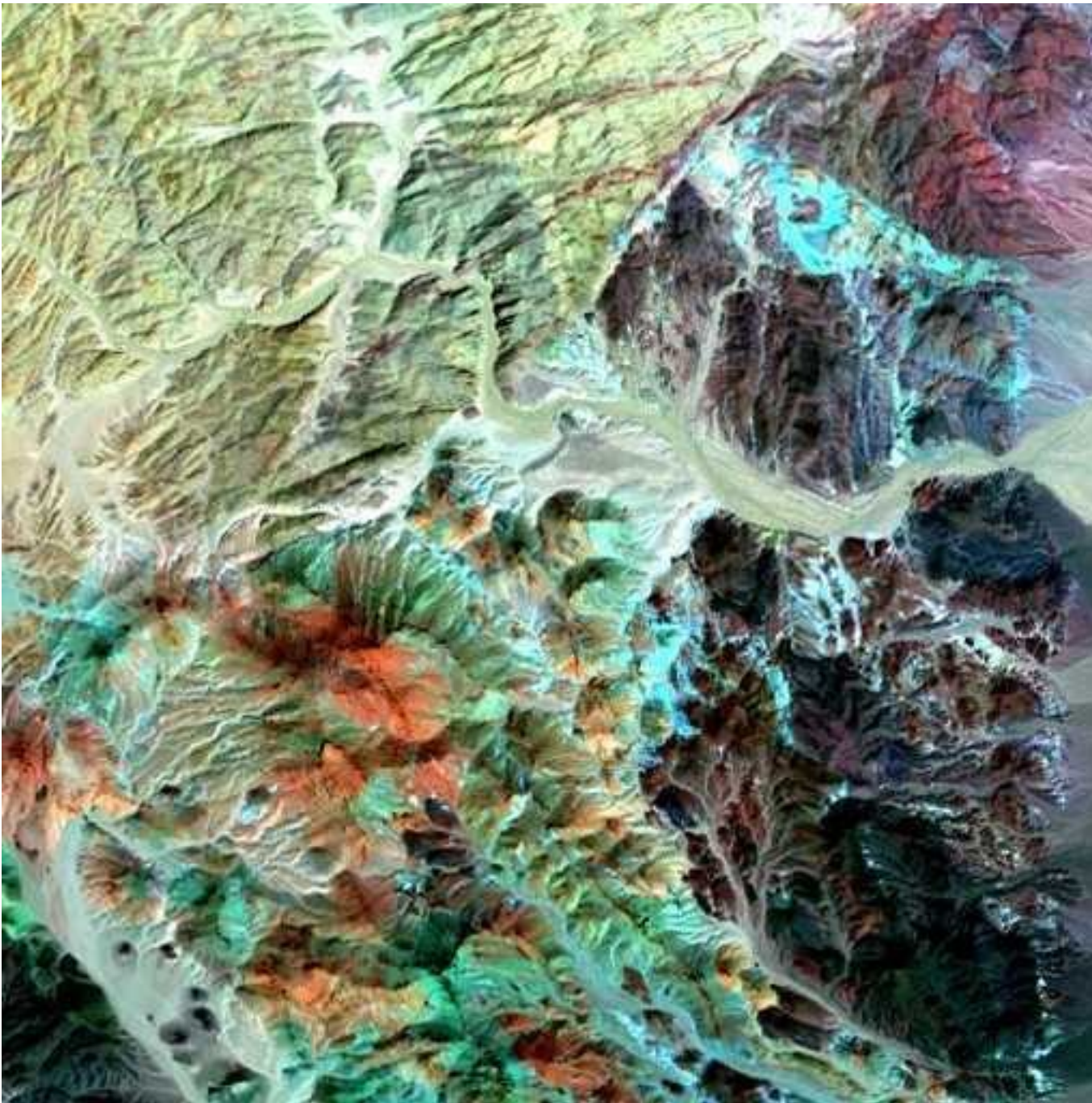
R+G+B



IR+R+G

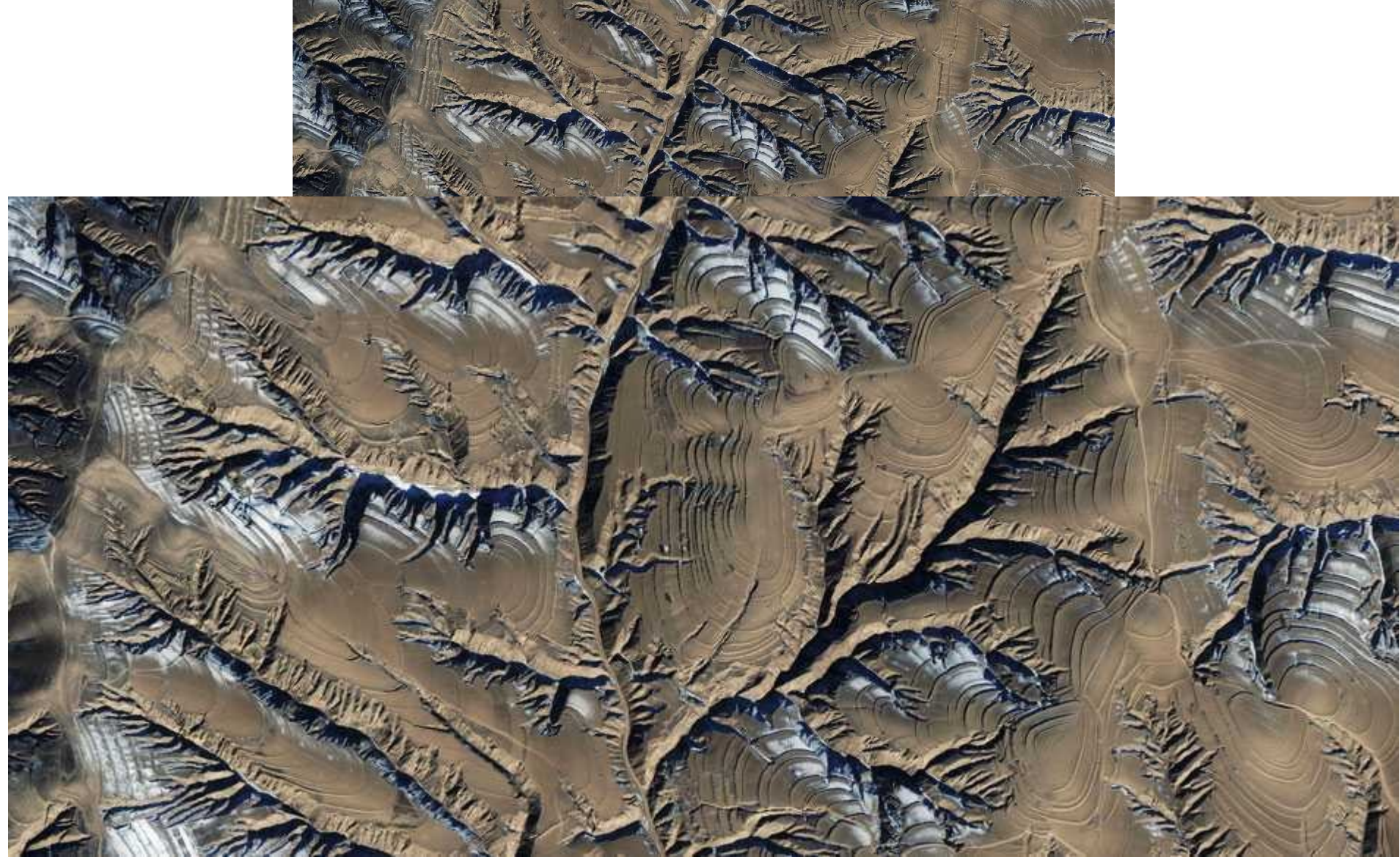






Gobi Desert,
Mongolia

© HyVISTA Co.



山西峒嵐

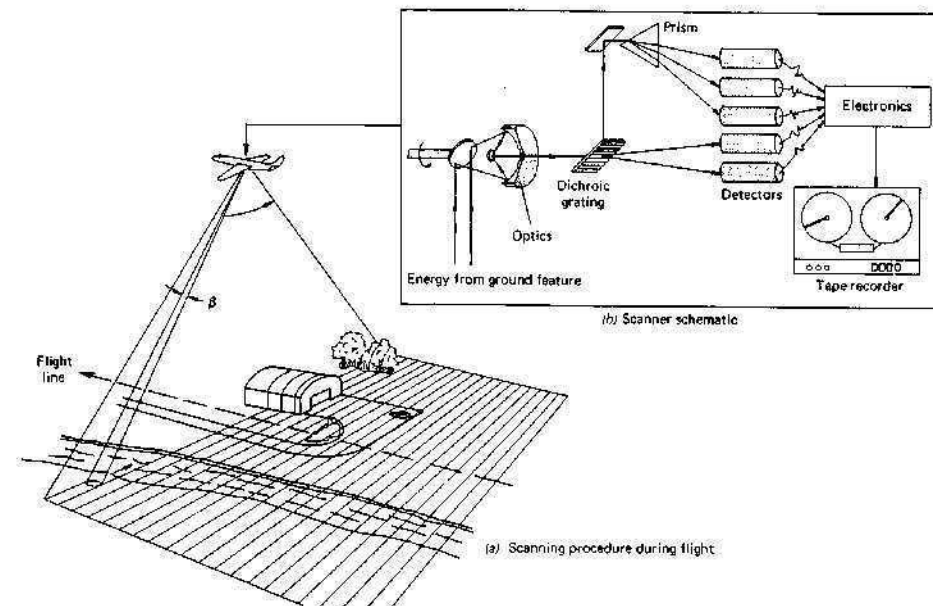


© GeoEye

光學感測器

跨徑掃描儀 (Across-Track, 或 Wisk-broom Scanner)

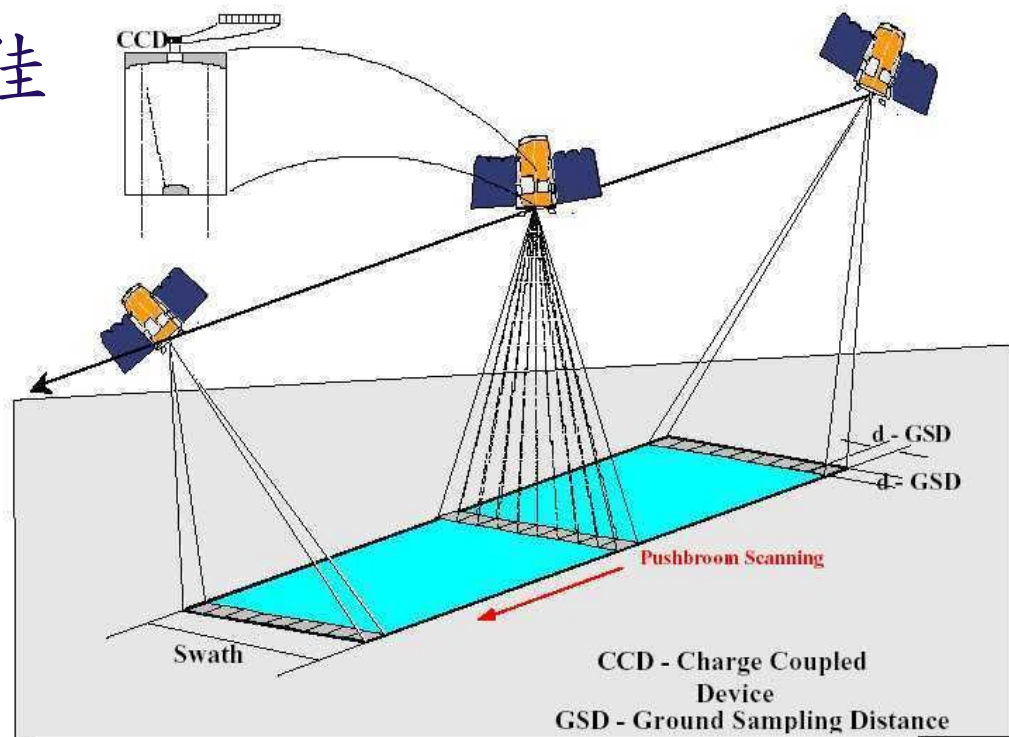
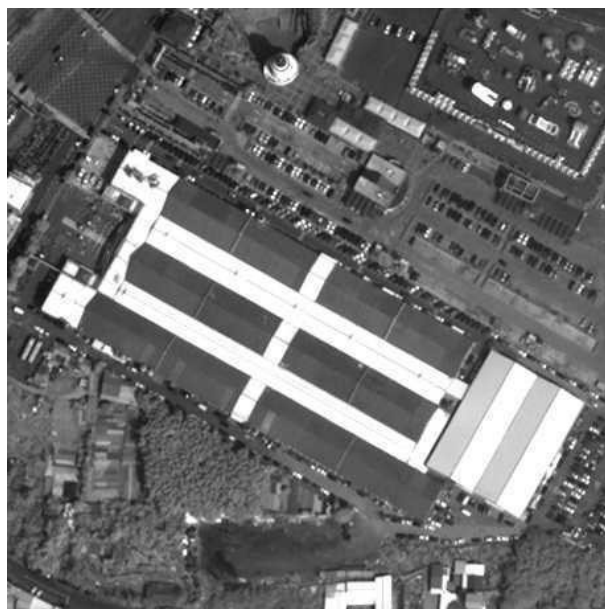
- 垂直於飛行方向掃描
- 探測元件多樣化
- 影像幾何品質較差

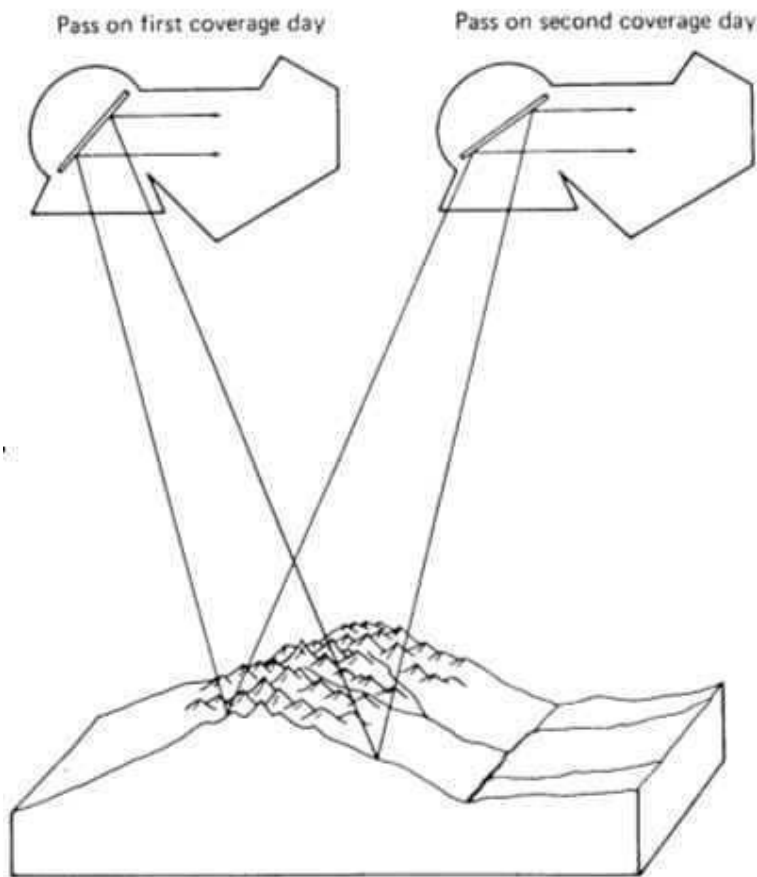


光學感測器

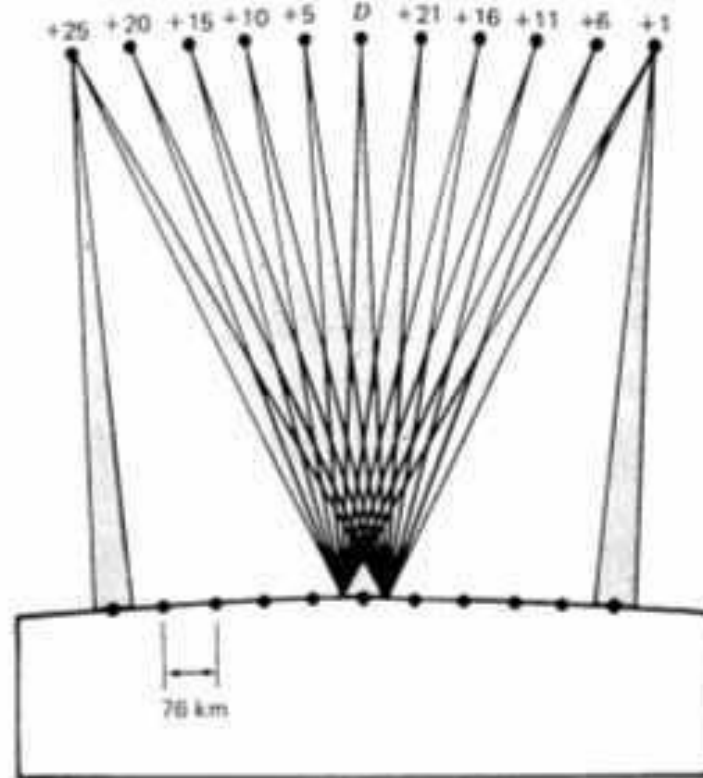
沿徑掃描儀 (Along-Track 或 Push-broom Scanner)

- 一系列探測元件同時沿飛行方向掃描
- 探測波段較受限制
- 影像幾何品質較佳



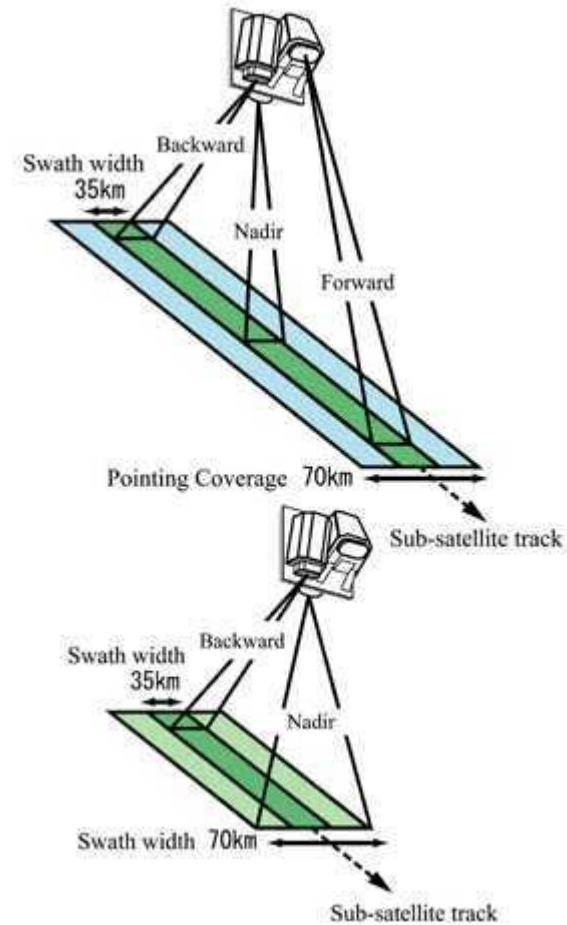
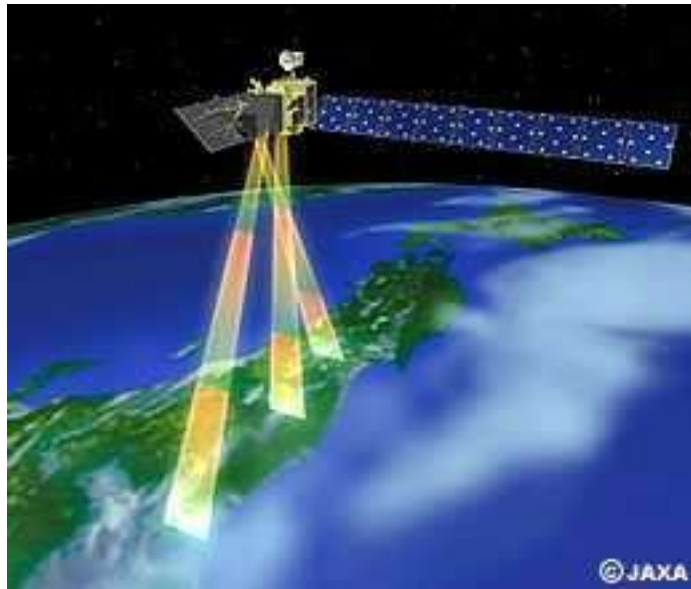


立體觀測

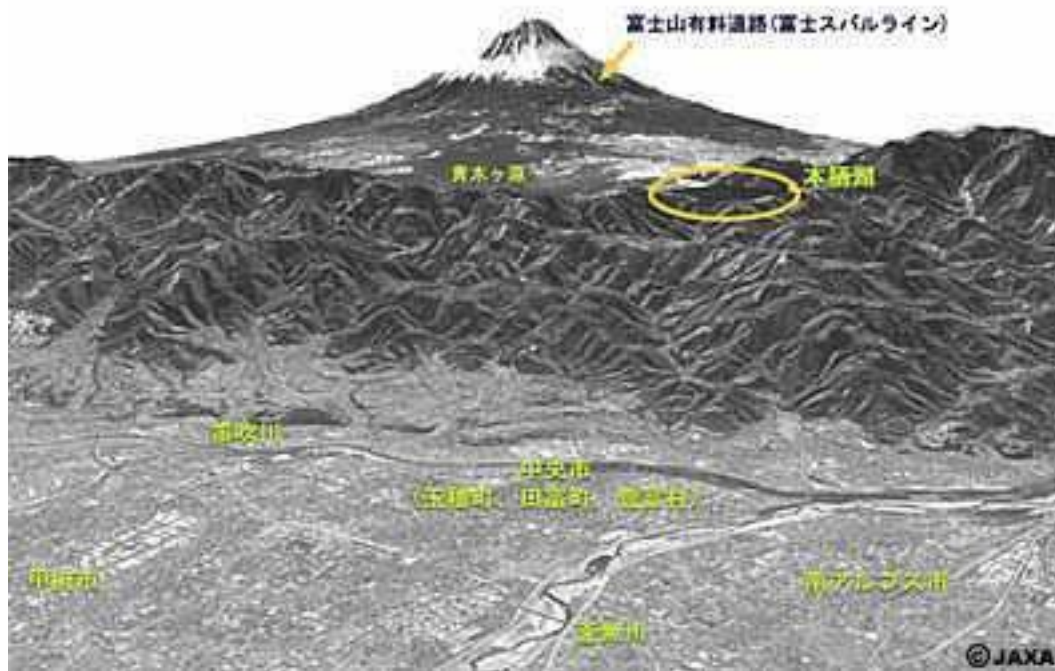


提升時間解析度

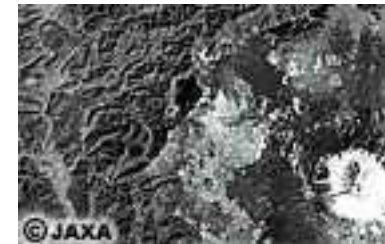
ALOS-PRISM: 三視掃瞄立體像對



ALOS-PRISM: 三視掃瞄立體像對



Backward Image



Nadir Image

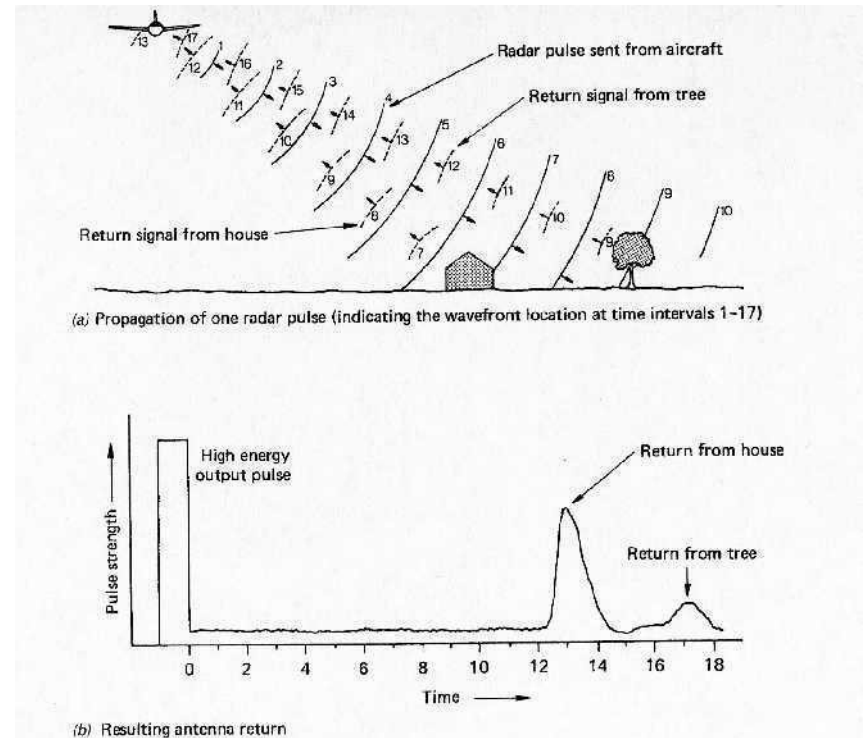


Forward Image

雷達感測器

■ 真實孔徑雷達 (Real Aperture Radar, RAR)

- 天線直徑較大
- 資料處理較簡

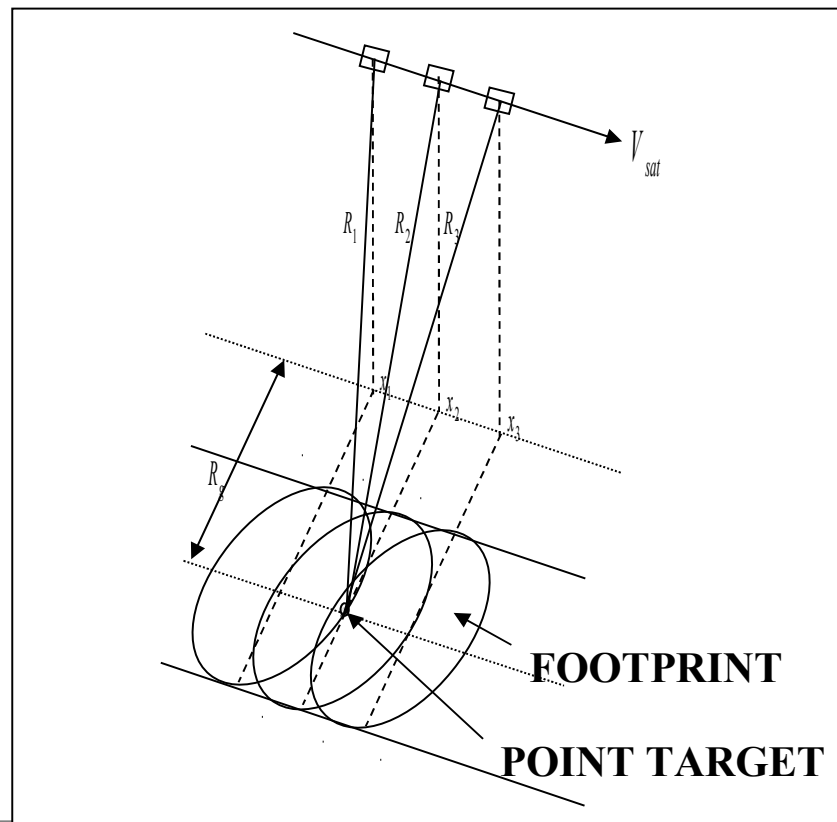


雷達操作示意圖

雷達感測器

■ 合成孔徑雷達 (Synthetic Aperture Radar, SAR)

- 天線直徑較小
- 資料處理較繁



光學影像與雷達影像之比較



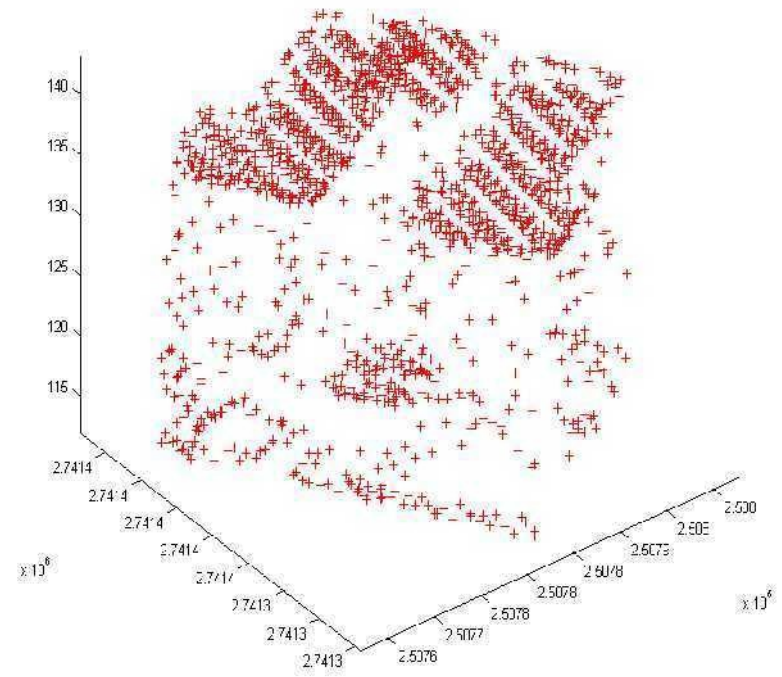
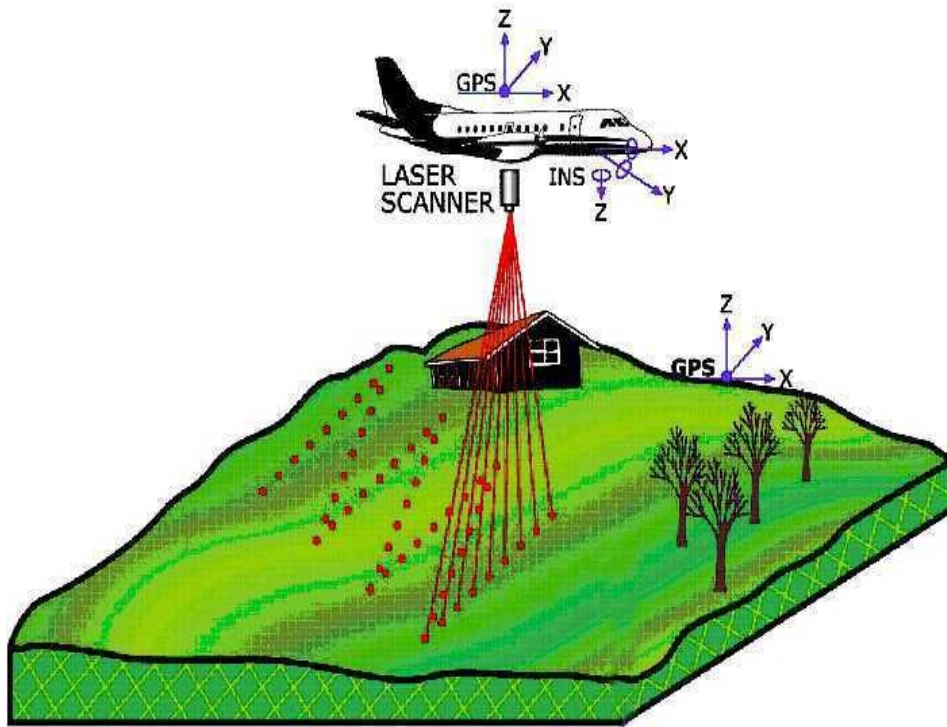
SPOT



Radarsat

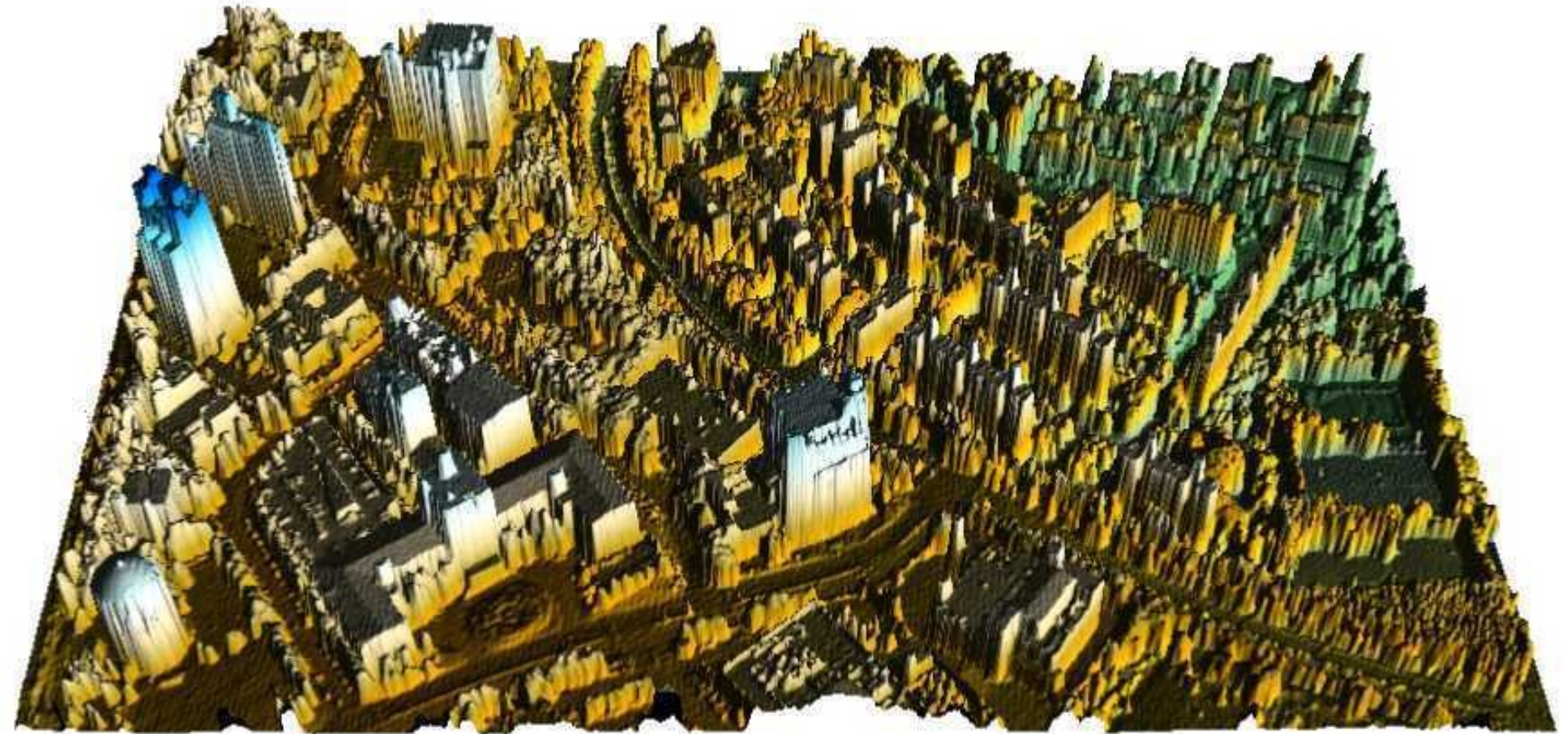
Light Detection And Ranging

LASER SCANNING



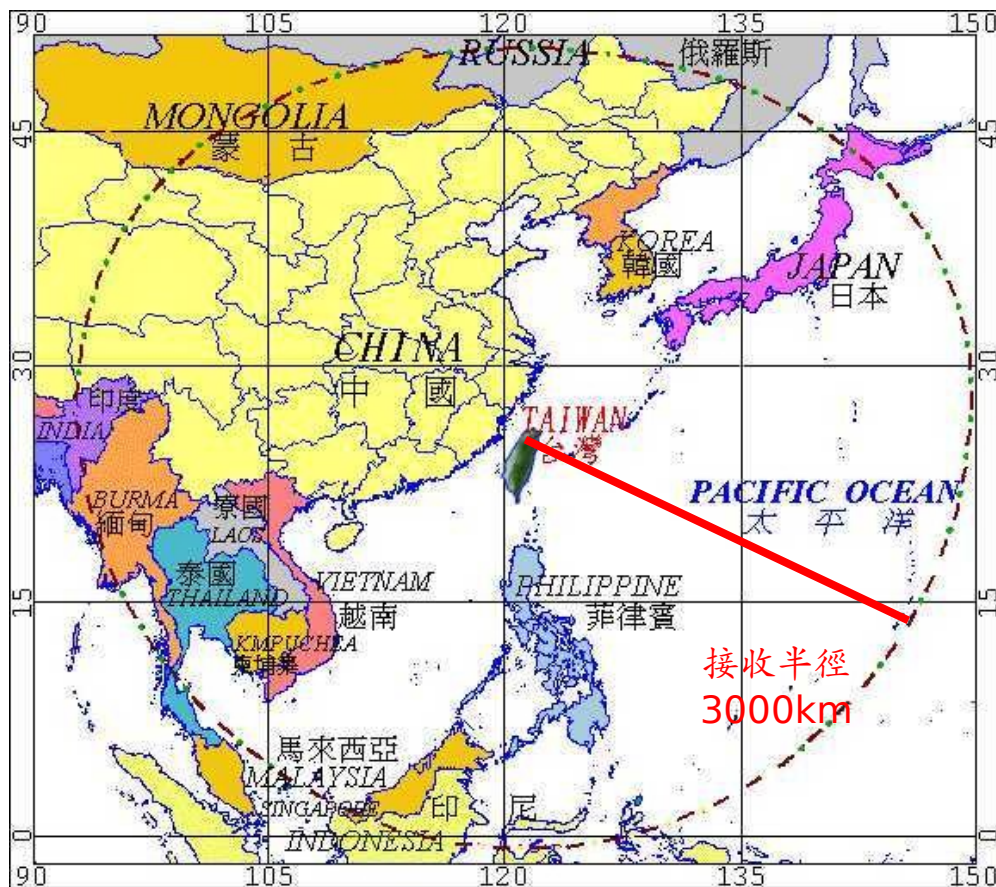
取自：Leica

Airborne LIDAR



新竹科學園區數值地表模型 (DSM)₂₉

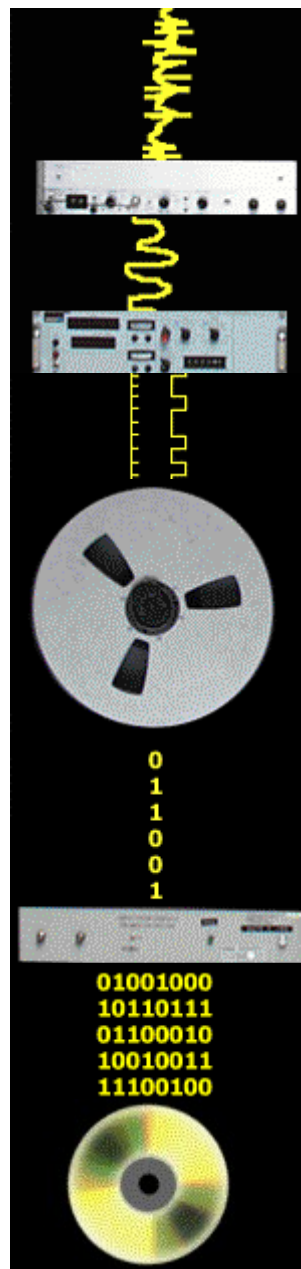
中央大學太遙中心資源衛星接收站



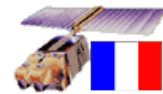
Satellite Remote Sensing Data Acquisition and Processing



Copyright CCRS



SPOT 2,4,5



ERS-2

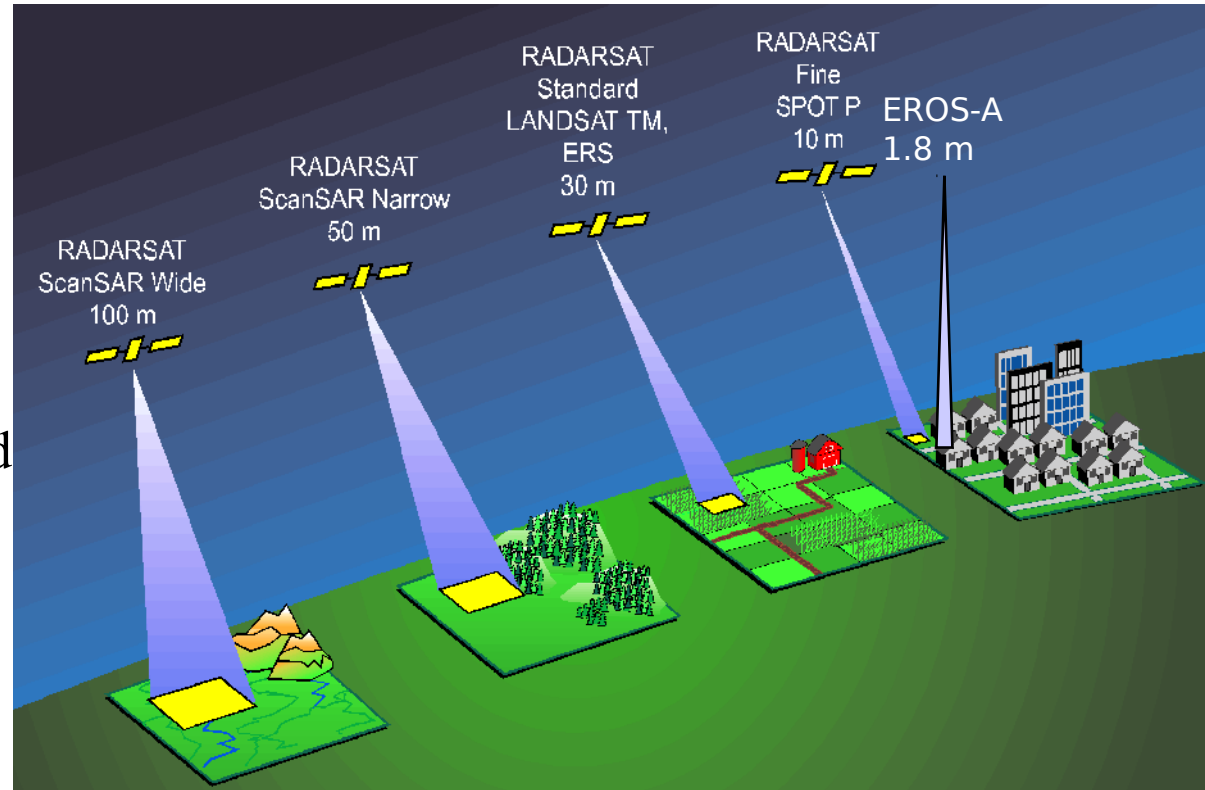


EROS-A



Earth Resources Satellite Receiving Station

Comparison of image resolutions



@RSI

TERRA, AQUA

Formosat-2

Major products

- Standard products : bulk, system & orthorectified
- Value-added products : 6.25 m/1.8 m color images, 3D perspective view, flight simulation

Aerial Archaeology



© Aerial Archaeology Newsletter & T. Baker

Aerial Archaeology



Neolithic house (ca 6500 BC)



Paleoriver



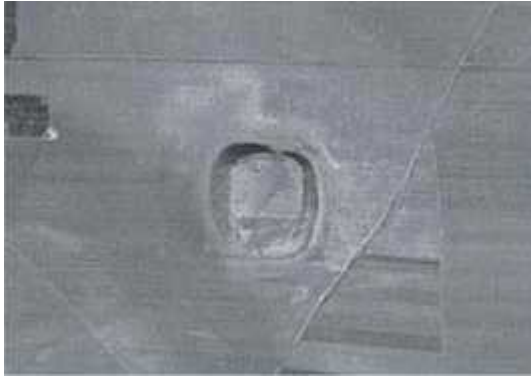
Frohsdorf (8th century AD)



Ditches from middle Neolithic

© Aerial Archive, Universität Wien

衛載遙測應用



Corona KH-4B (2m)



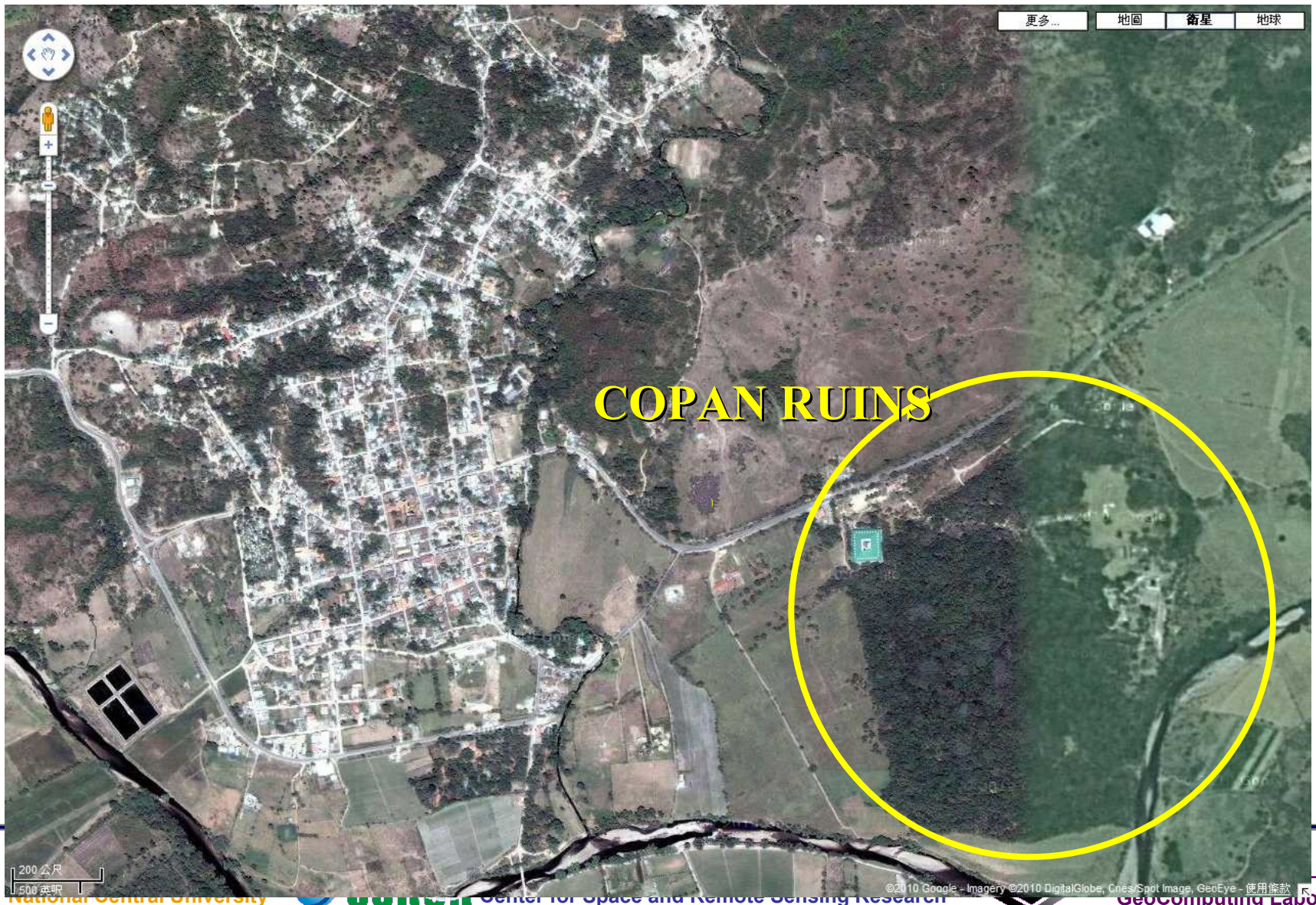
IKONOS (1m)



Landsat (30m)

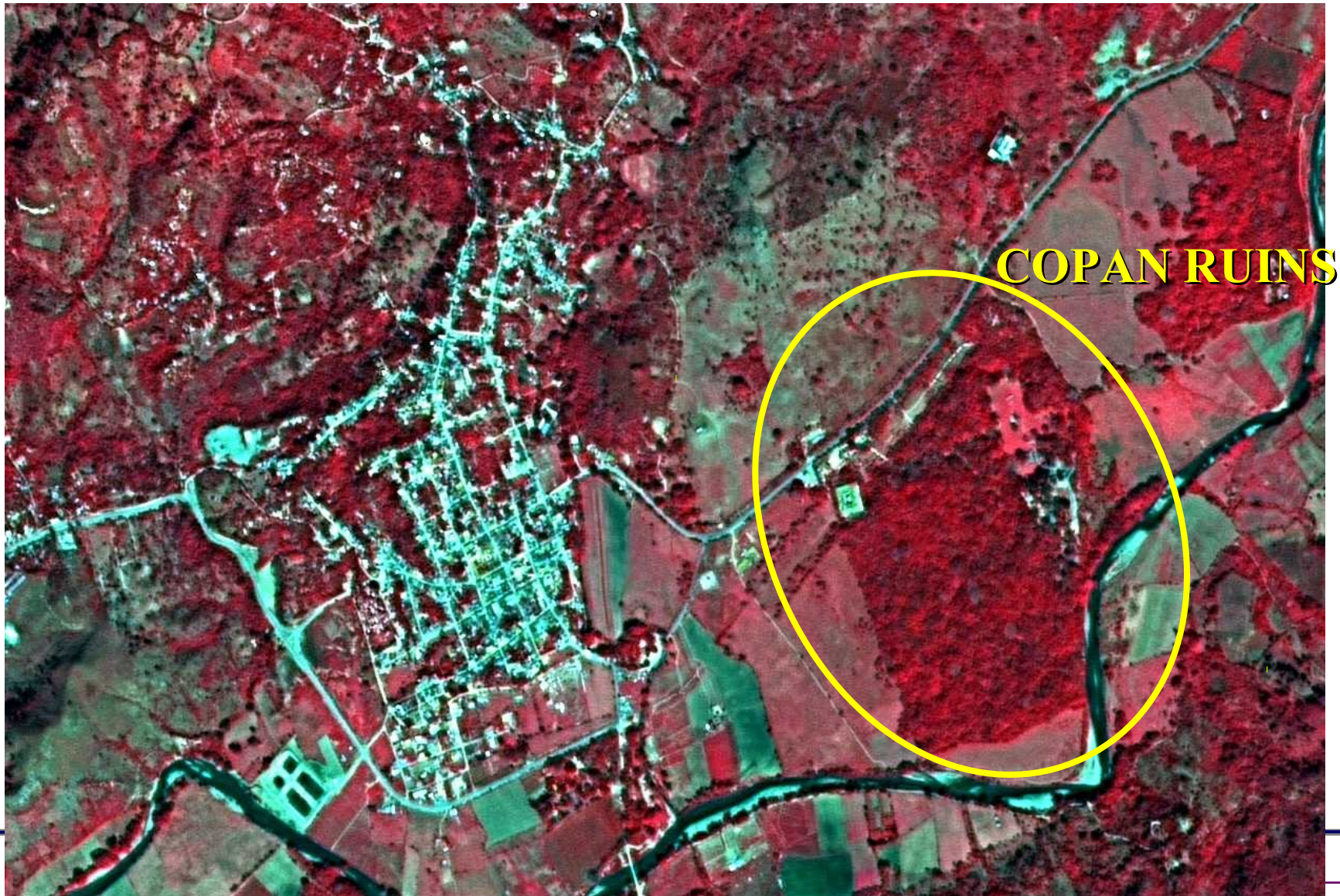
(Source: Beck et al., 2006)

COPAN, HONDURAS GOOGLE MAP



COPAN, HONDURAS

SPOT-5 Fused Image (Resolution: 2.5m), 01/25/2004



COPAN RUINS



ASTER
VNIR-TIR
15~90m







© GeoEye



© GeoEye

Machu Picchu, Peru



© GeoEye



© GeoEye



國立中央大學
National Central University

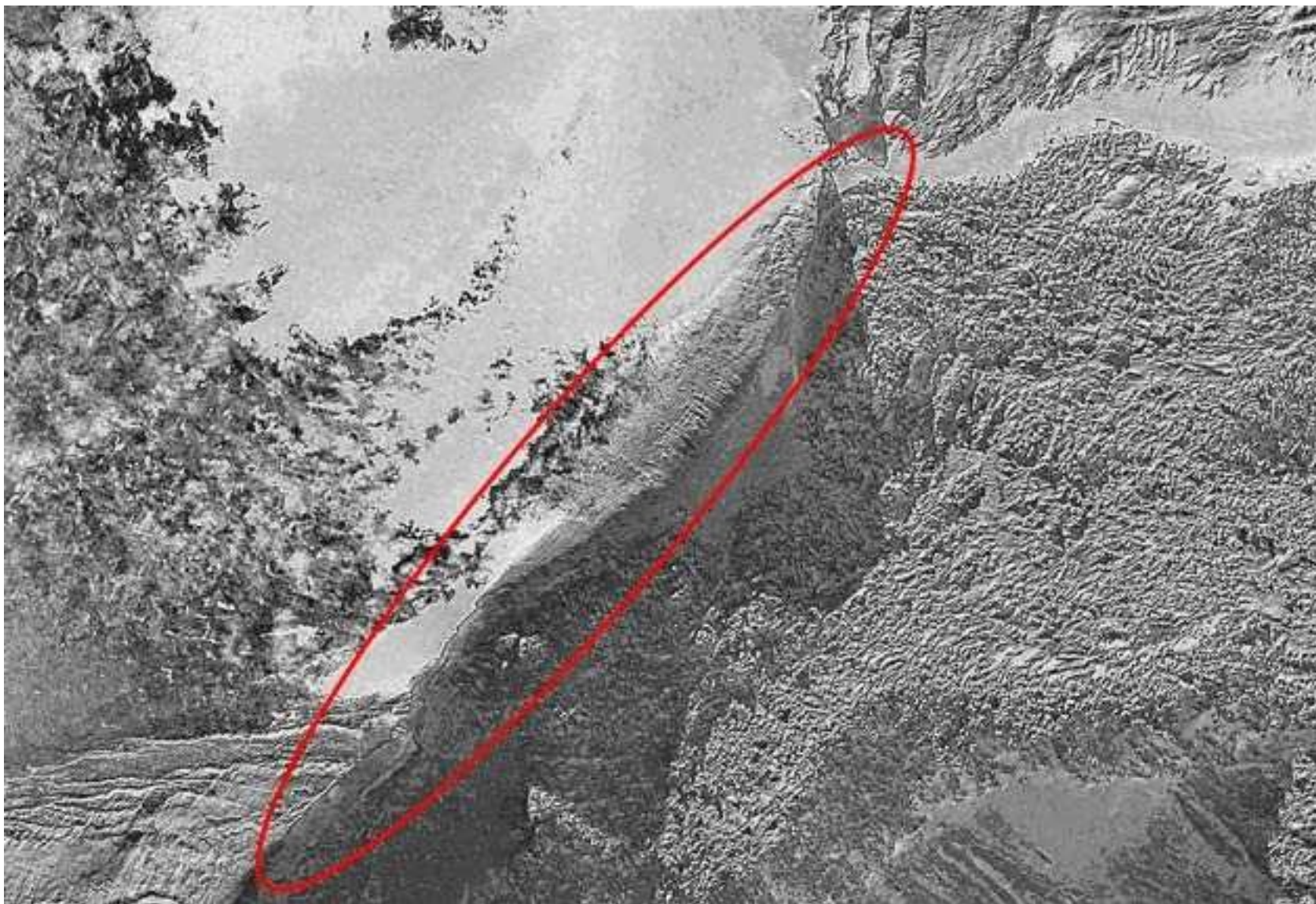


太空及遙測研究中心
Center for Space and Remote Sensing Research



空間運算實驗室
GeoComputing Laboratory





非可見光遙測應用



Color Infrared Photograph showing suspected road.

非可見光遙測應用



墓園

CIR 影像

溫泉

© NASA

48



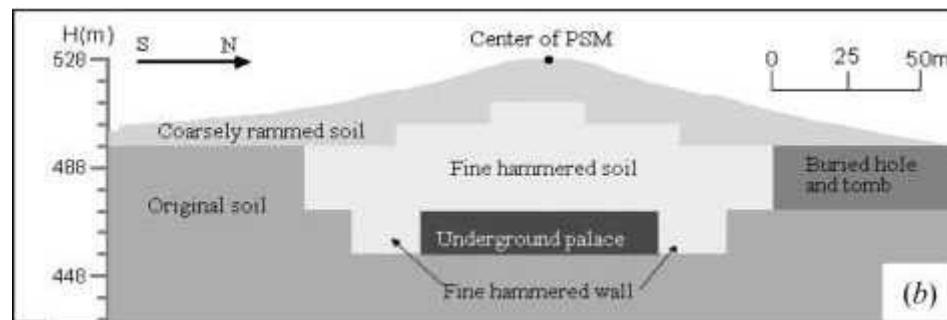
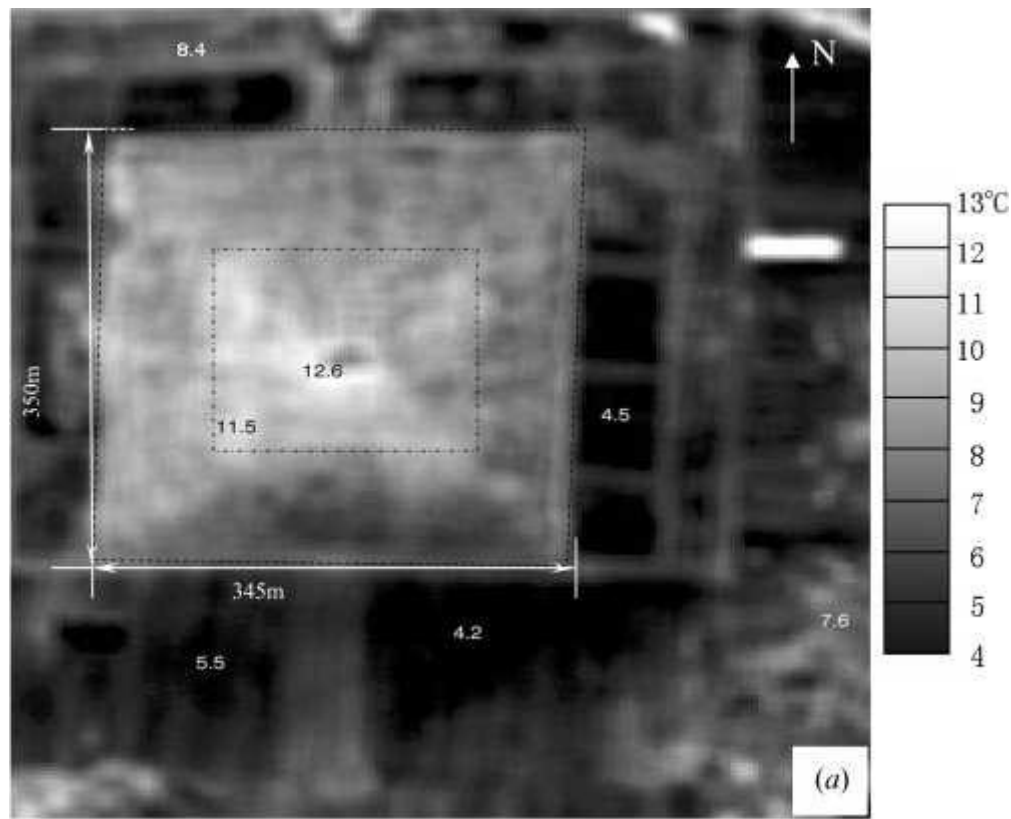
TMIR



CHACO CANYON

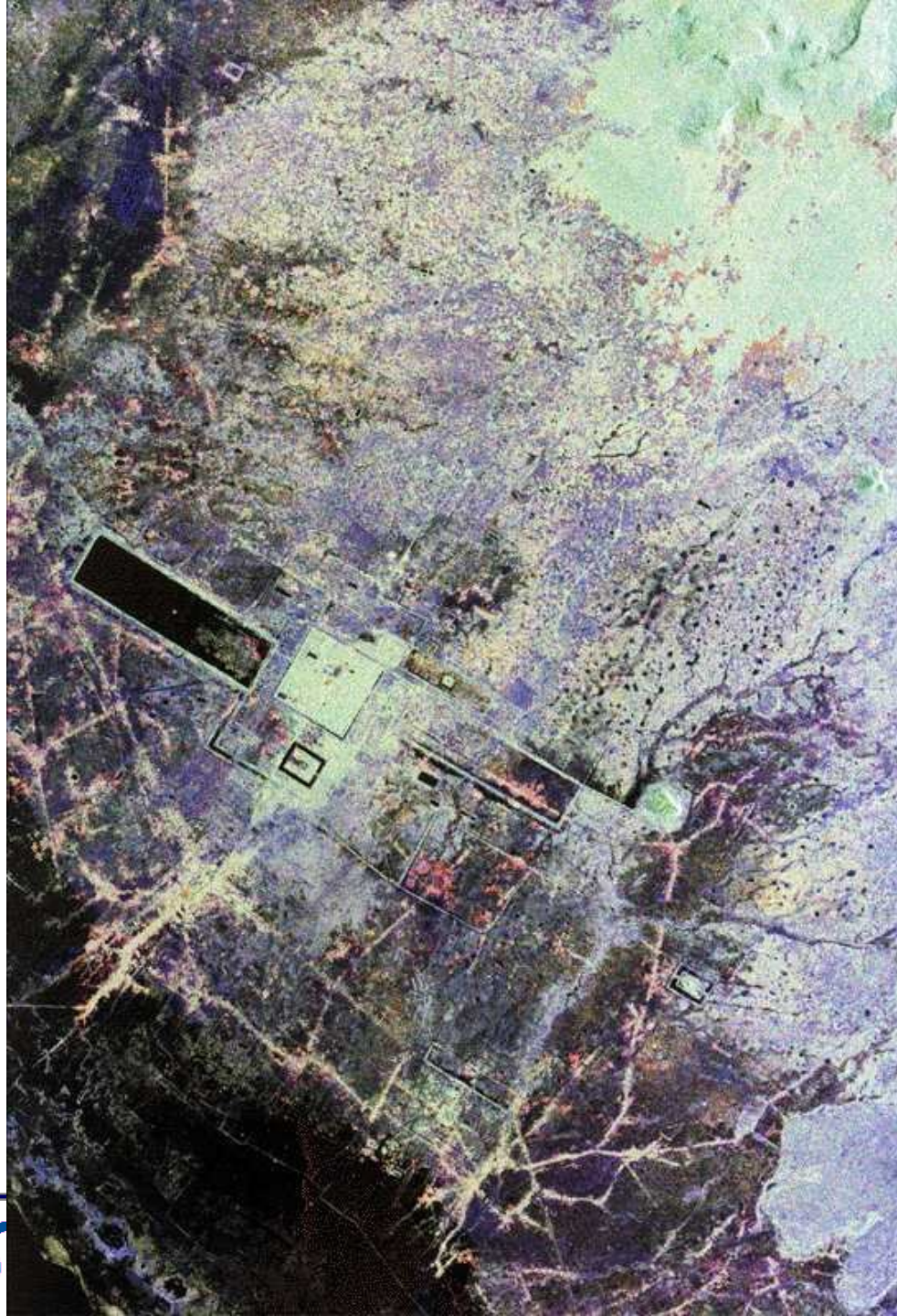
LOOKING SOUTHEAST

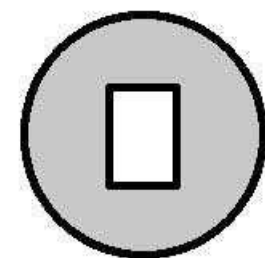
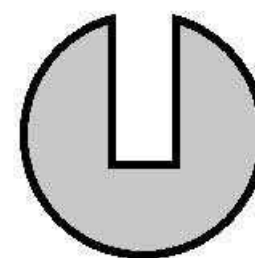
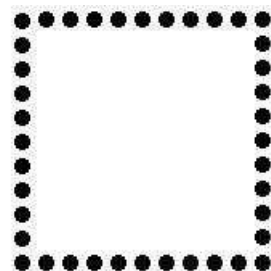
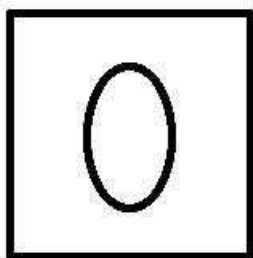
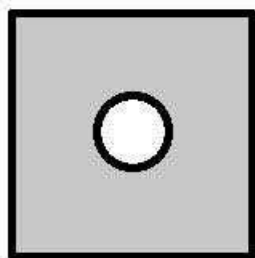
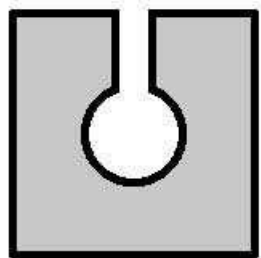
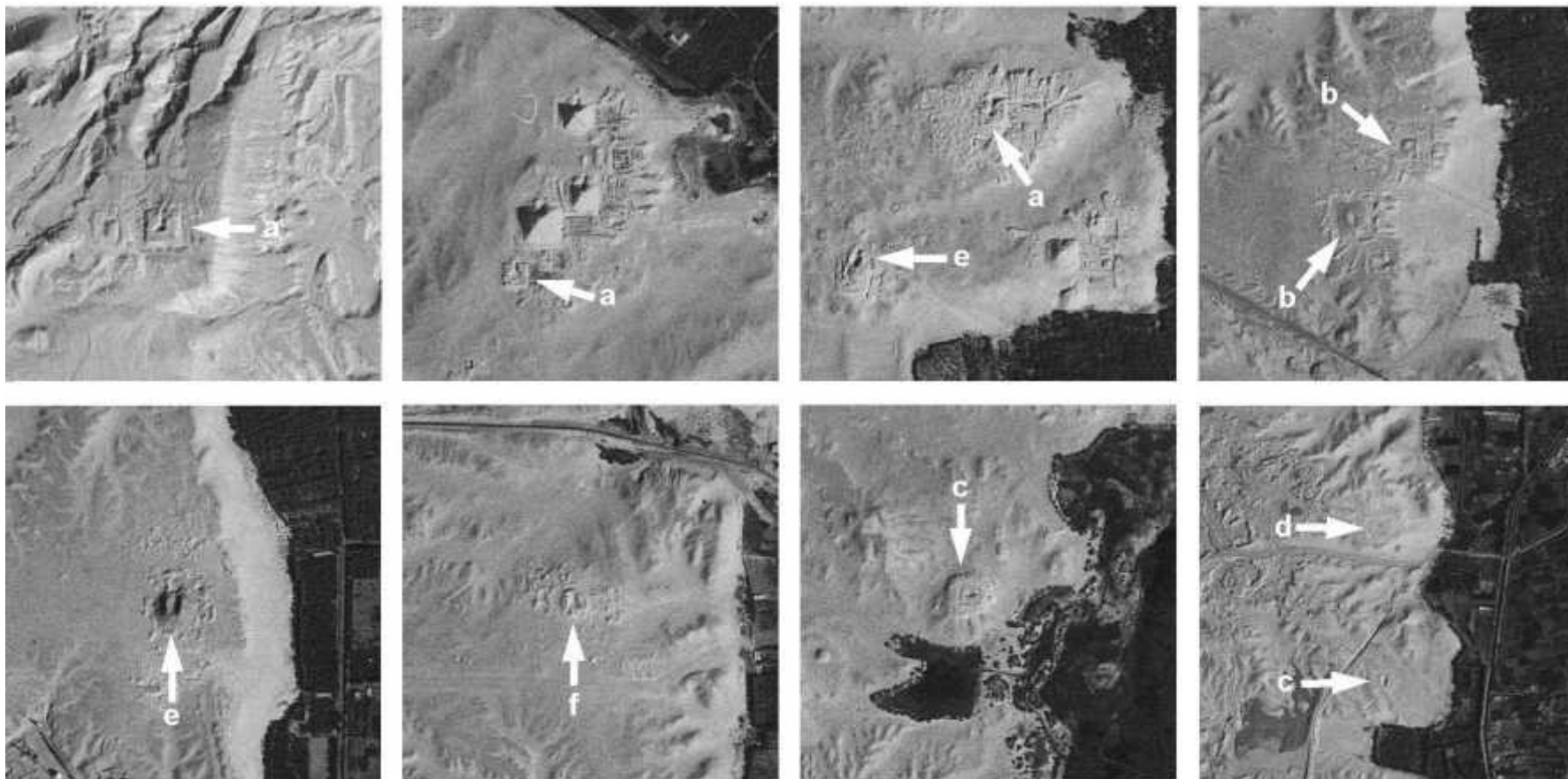




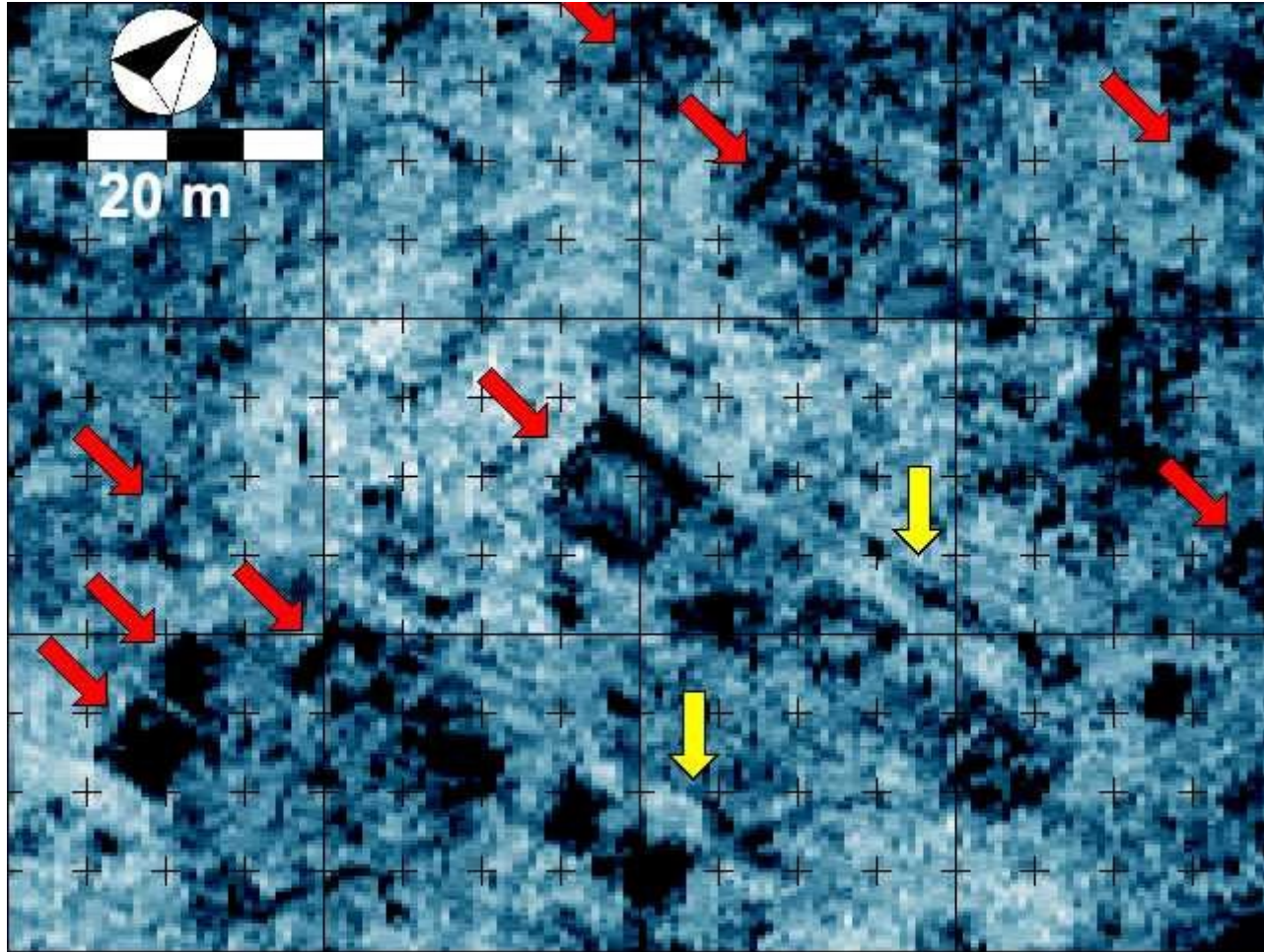
(Source: Tan et al., 2006)

測遙達雷 應用



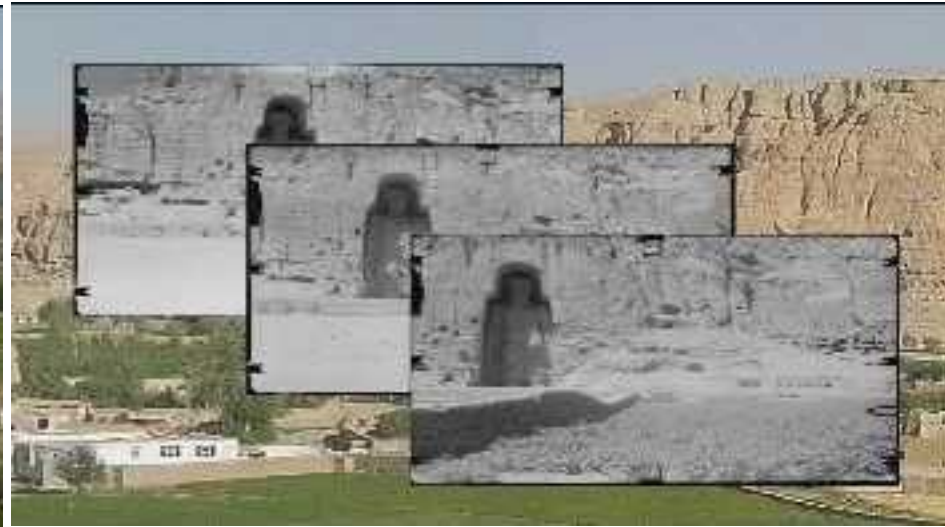


透地雷達影像



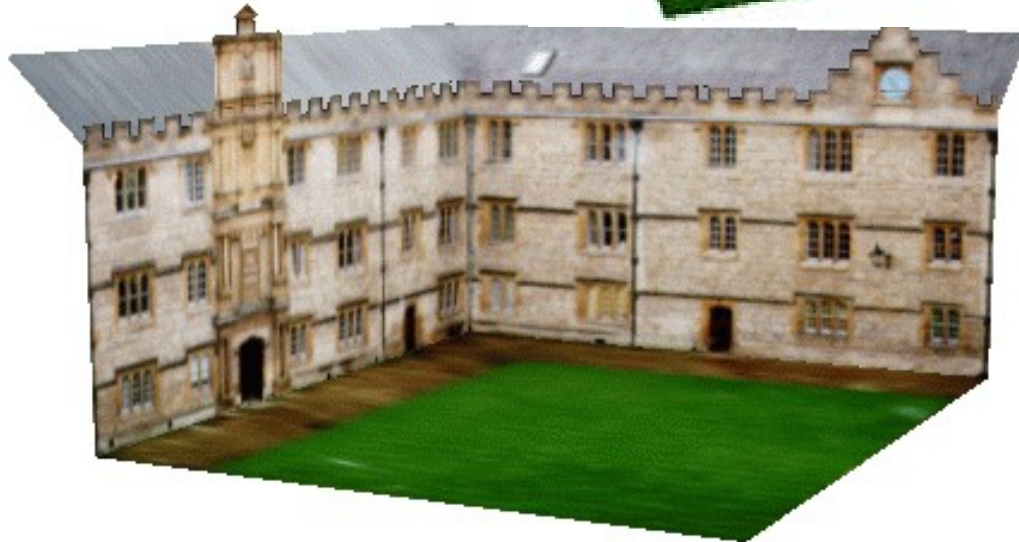
(Source: Kvamme et al., 2006)

非典型遙測技術應用



單視角影像三維重建





(Leibowitz et al., 1999)



地面光達



59

取自 .OPTECH



國立中央大學
National Central University



太空及遙測研究中心
Center for Space and Remote Sensing Research



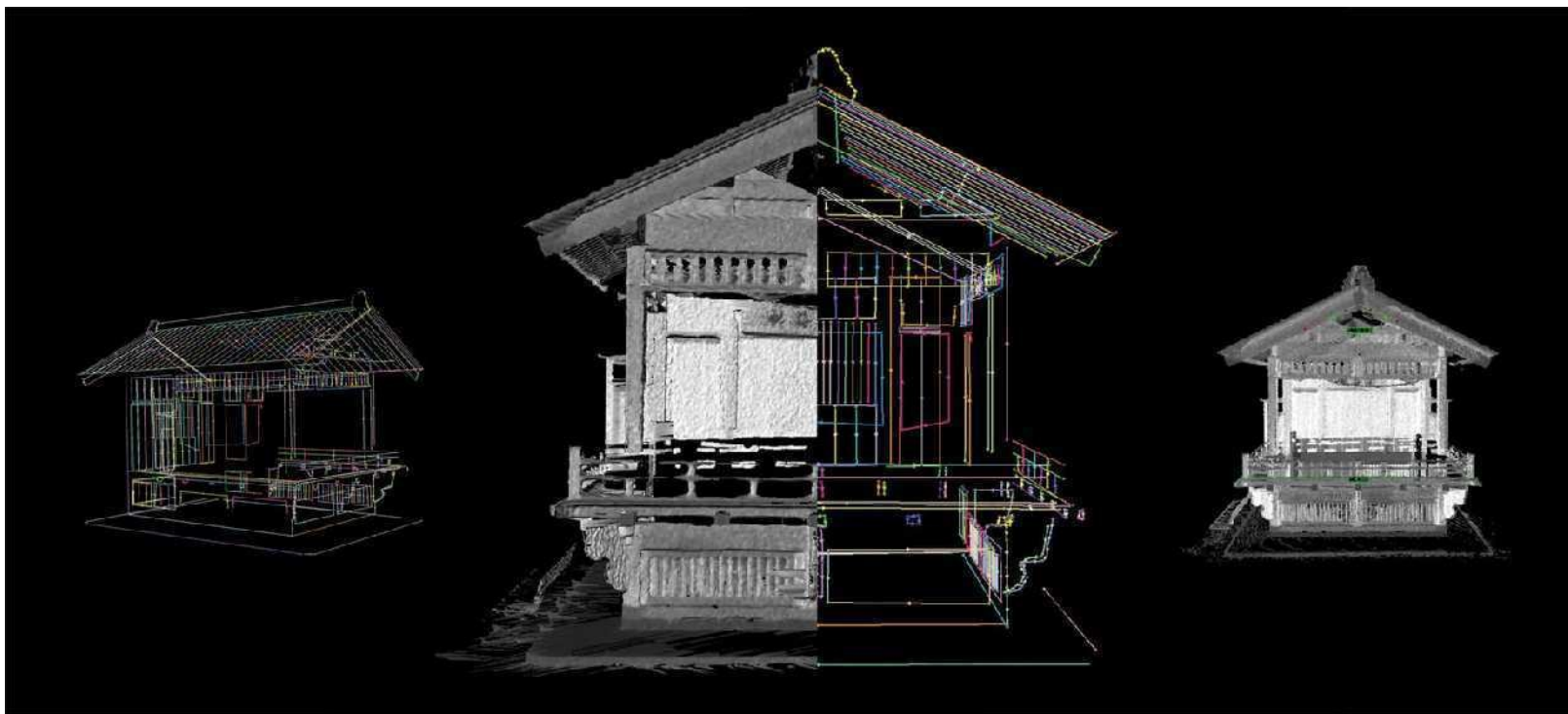
空間運算實驗室
GeoComputing Laboratory

地面光達



© Optech

地面光達

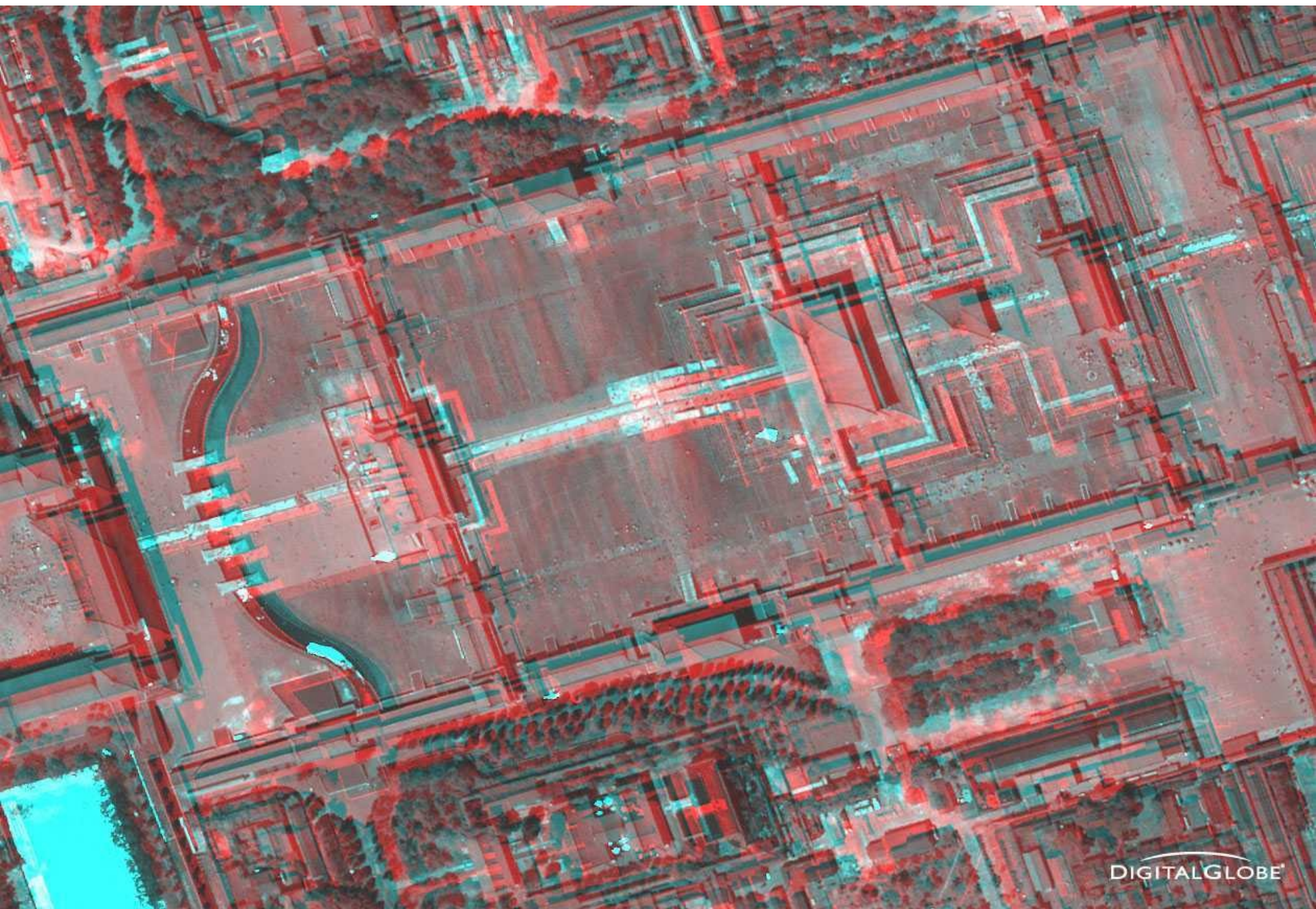


Wireframe Model of Japanese House, with CAD Sections Extracted from Model

取自 :OPTECH

地面光達





DIGITALGLOBE



National Central University

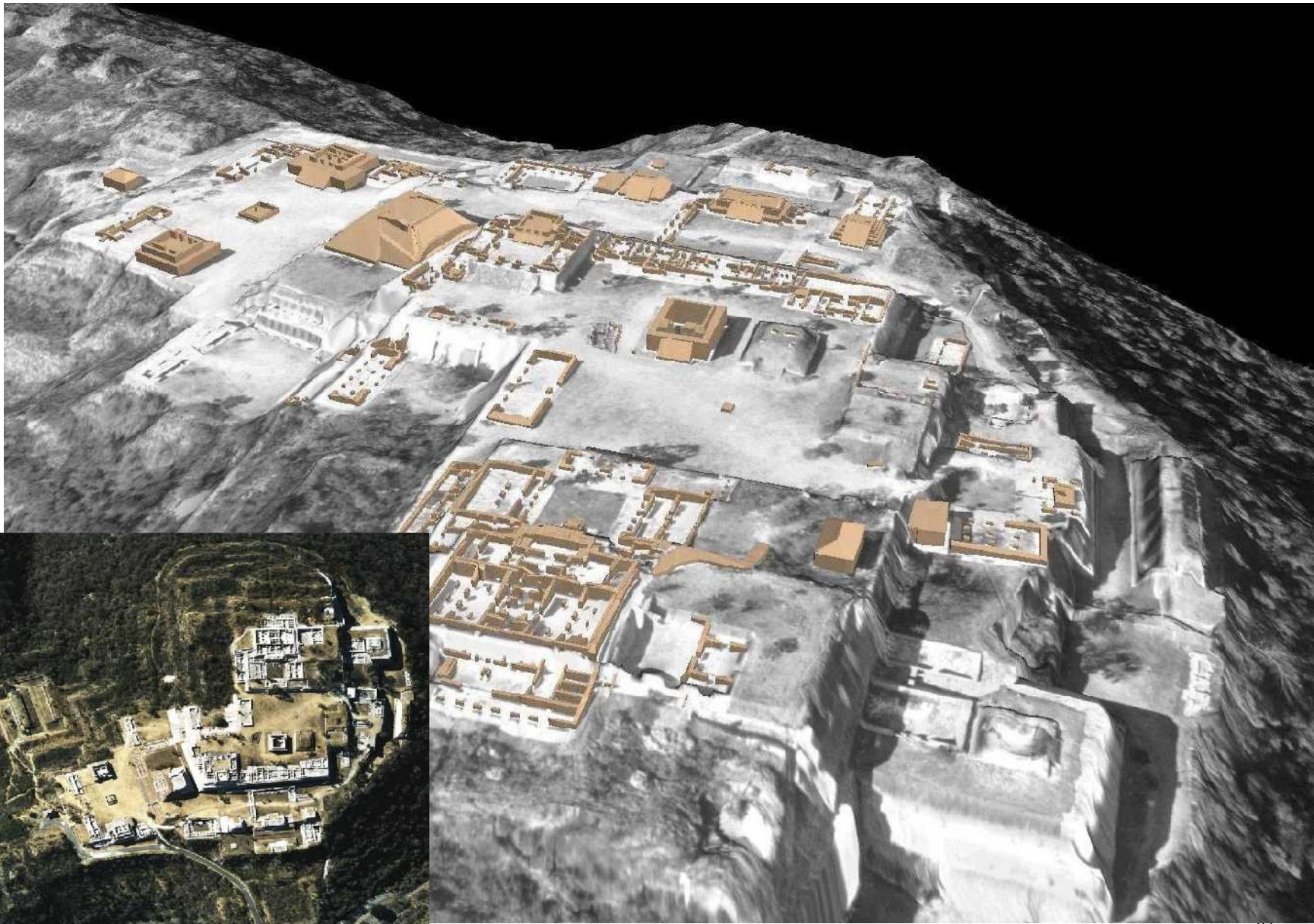


Center for Space and Remote Sensing Research



GeoComputing Laboratory

© ETH



國立中央大學
National Central University



太空及遙測研究中心
Center for Space and Remote Sensing Research



空間運算實驗室
GeoComputing Laboratory

三維重建



© ETH



國立中央大學
National Central University



太空及遙測研究中心
Center for Space and Remote Sensing Research



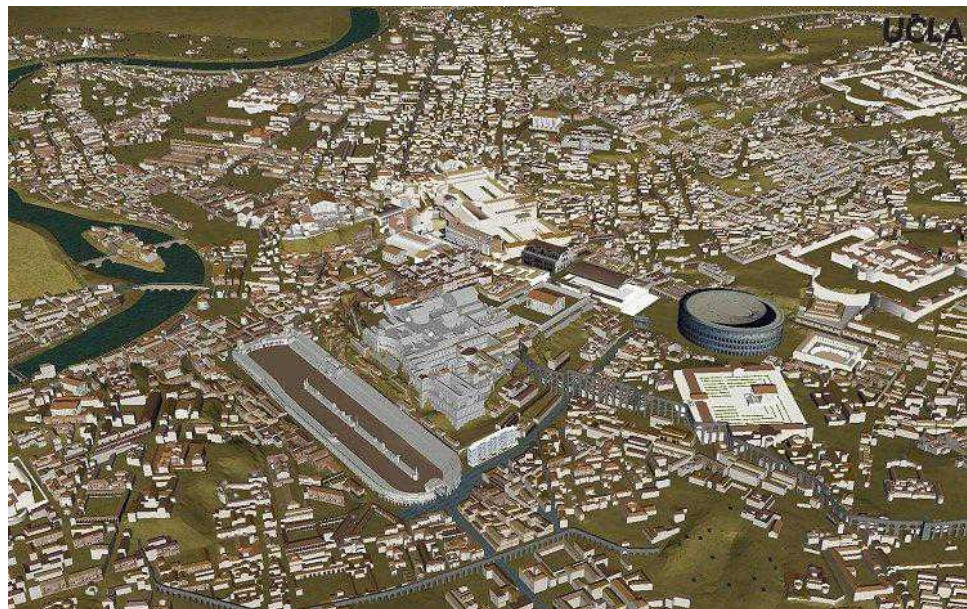
空間運算實驗室
GeoComputing Laboratory



© ETH



歷史模擬重建



© ETH



結論：遙測考古應用

- 新地點之發現
- 現場之探索
- 發掘等之評估
- 更經濟的方式
- 非破壞性之檢測
- 領域知識之結合

參考資料

- Beck, A., G. Philip, M. Abdulkarim, D. Donoghue, “Evaluation of Corona and Ikonos high resolution satellite imagery for archaeological prospection in western Syria”, *Antiquity.*, 81 (311). pp. 161-175, 2007.
- Cavalli, R. M., F. Colosi, A. Palombo, S. Pignatti, M. Poscolieri, “Remote hyperspectral imagery as a support to archaeological prospection”, *Journal of Cultural Heritage*, 8, pp. 272-283, 2007.
- Kucukkaya, A. G., “Photogrammetry and remote sensing in archeology”, *Journal of Quantitative Spectroscopy & Radiative Transfer*, 88, pp. 83–88, 2004.
- Kvamme, K, E. Ernenwein, M. Hargrave, T. Sever, D. Harmon, F. Limp, “New Approaches to the Use and Integration of Multi-Sensor Remote Sensing for Historic Resource Identification and Evaluation”, SERDP Project SI-1263, University of Arkansas, 65 pps, 2006.
- Rowlands, R., A. Sarris, “Detection of exposed and subsurface archaeological remains using multi-sensor remote sensing”, *Journal of Archaeological Science*, 34, pp. 795-803, 2007.
- Tan, K., Y. Wan; X. Zhou; D. Song; Q. Duan, “The application of remote sensing technology in the archaeological study of the Mausoleum of Emperor Qinshihuang”, *Int'l J. Remote Sensing*, 16(20), pp. 3347-3363, 2006.