

# LiDAR의 산림분야 활용사례

국립산림과학원

조현국

## LiDAR의 기본원리

### ❖ LiDAR (Light Detection And Ranging)

❖ LiDAR는 레이저를 발사하고, 지상의 목표물로부터 반사되어 돌아오는 레이저의 **세기**나 **시간**을 분석하여 필요한 정보를 획득

### ❖ 레이저의 특징

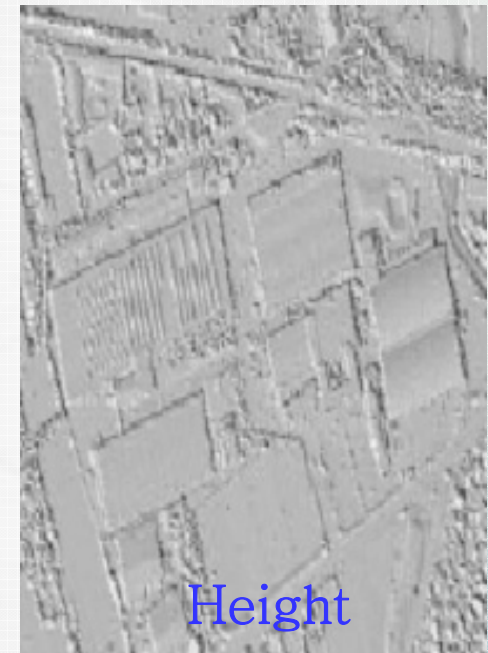
- 1) 단색성 : 한가지 파장으로 되어 있는 빛
- 2) 지향성 : 거리에 따른 빛의 세기감소 없음
- 3) 간섭성 : 산란이 일정한 빛

### ❖ 유사용어

ALS : Airborne Laser Surveying  
Airborne Laser Scanning

ALTM : Airborne Laser Terrain Mapper

ALTMS : Airborne Laser Terrain Mapping  
System

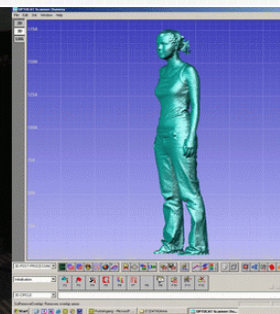
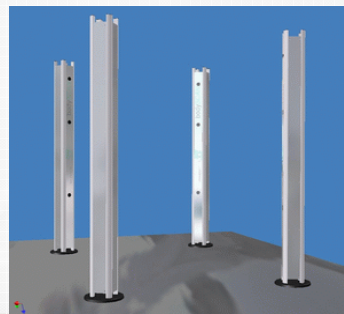
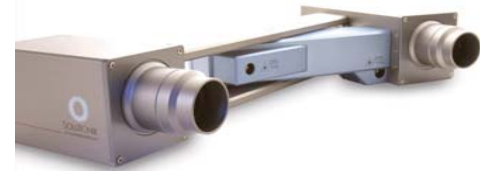
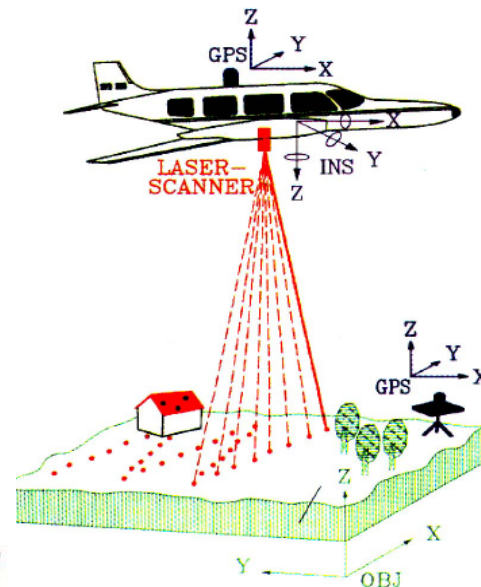


# 레이저 스캐너의 종류

- Terrestrial Scanners
- Airborne Scanners
- Distancemeters
- Industrial Scanners
- Rangefinders



LASER-SCANNING



## 항공 LiDAR의 기본원리

### 레이저거리측량장치(레이저스캐너)

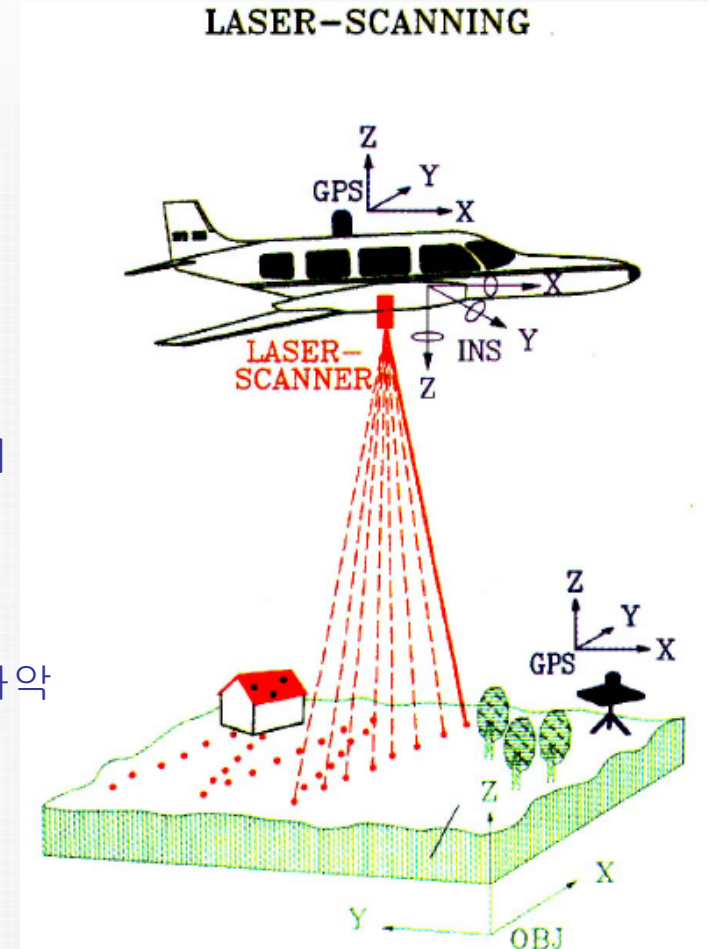
- 레이저를 송수신하여 지상의 지형, 지물까지의 거리를 구하기 위한 장치

### GPS (Global Positioning System)

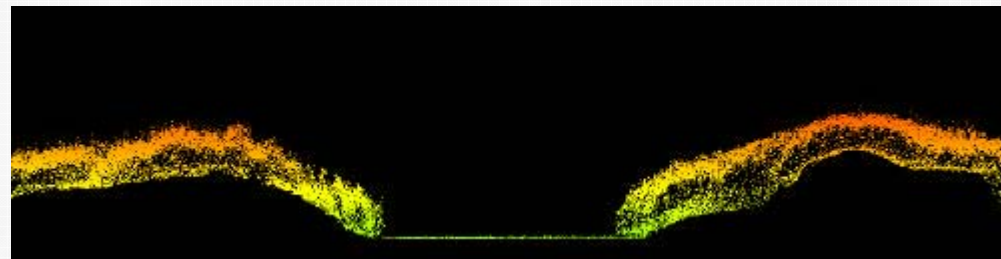
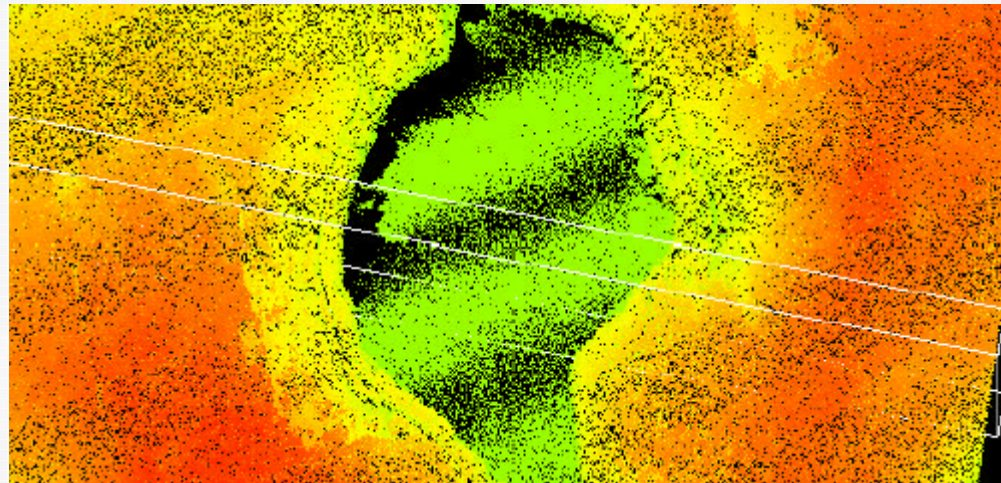
- 지상에 설치된 기준국 GPS와 항공기에 부착된 GPS에 의해 고속으로 이동하는 항공기의 위치파악

### IMU (Inertial Measurement Unit)

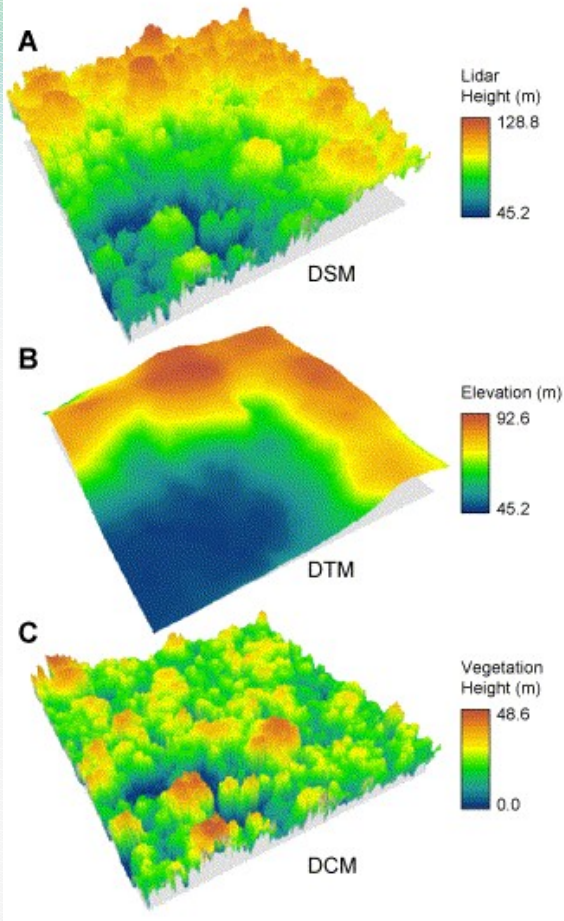
- 항공기의 수평, 수직, 좌우 회전량과 가속도를 구하기 위한 관성항법체계



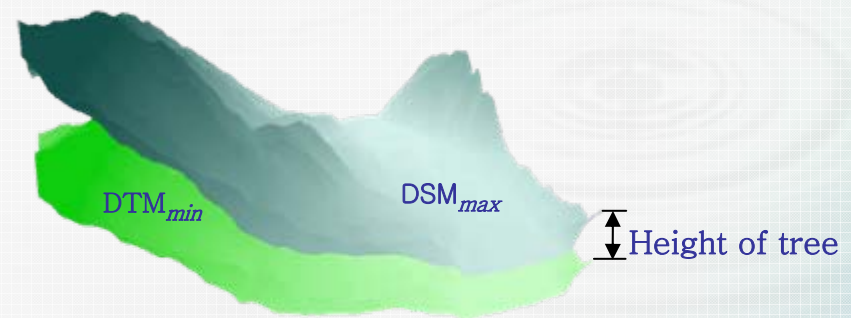
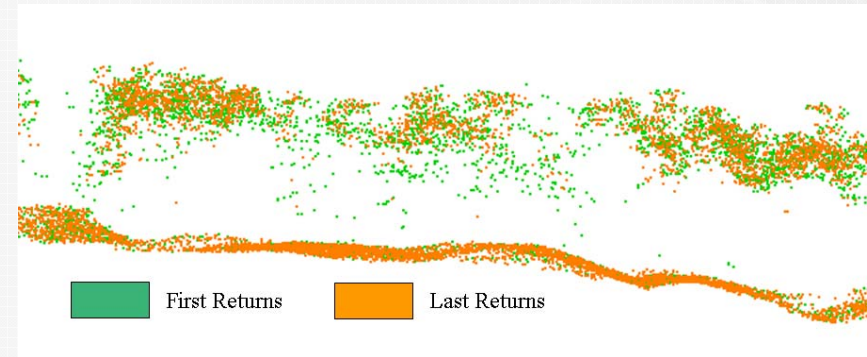
## LiDAR - Forest profile



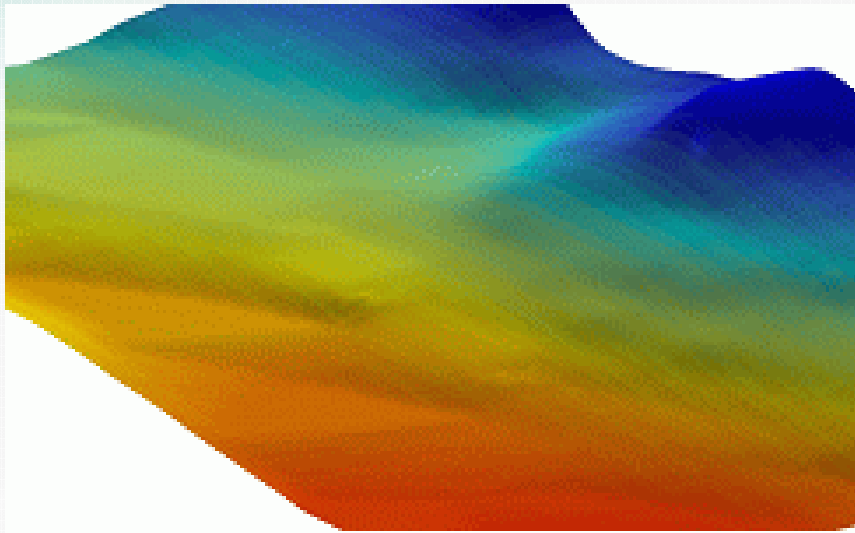
# DTM, DSM, DCM



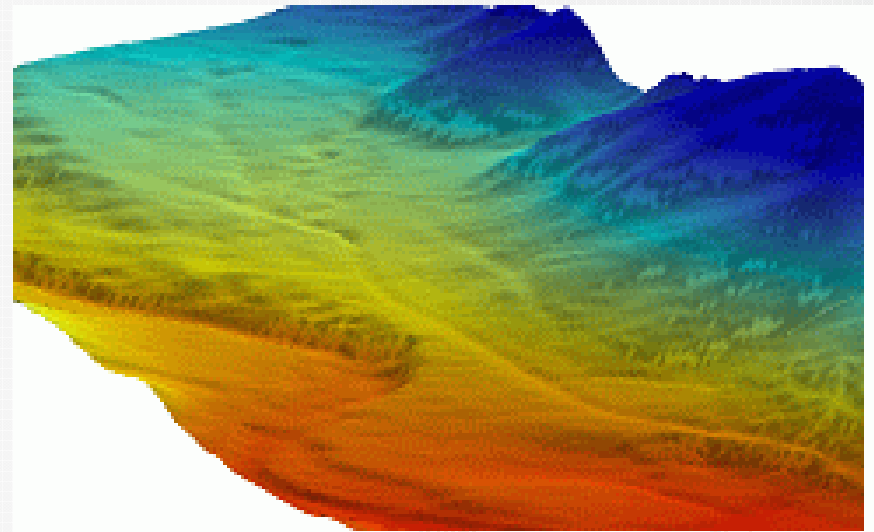
DSM : Digital Surface Model  
DTM : Digital Terrain Model  
DCM : Digital Canopy Model



## 수치지형도 DTM vs. LiDAR point DTM

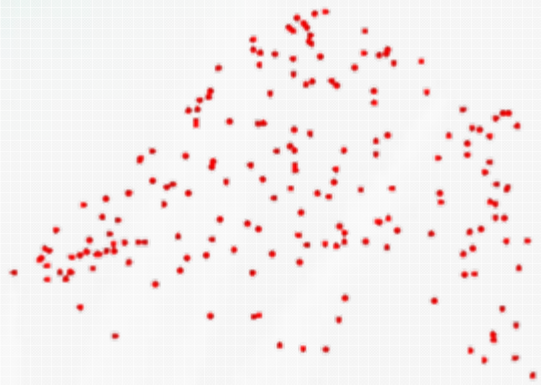


● 수치지형도 DEM

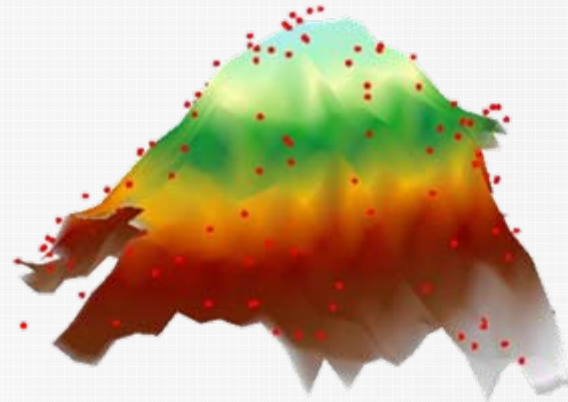


● LiDAR DEM

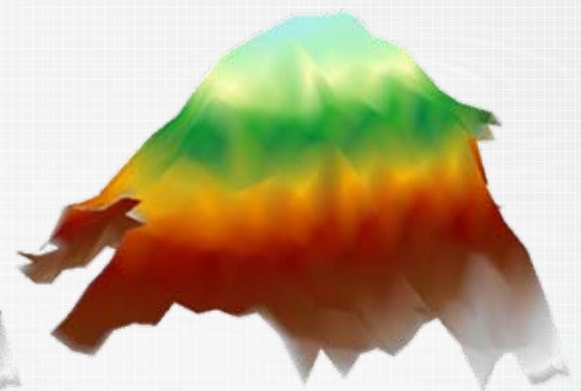
## DCM : Digital Canopy Model



(a) LiDAR point data  
reflected on crown



(b) Generating DSM with  
surface point data

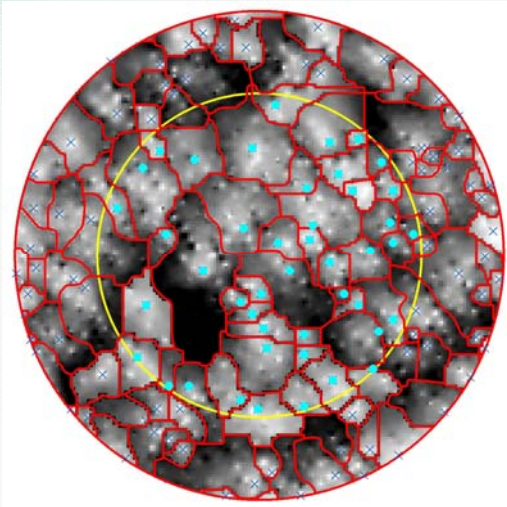


(c) Completion of DSM



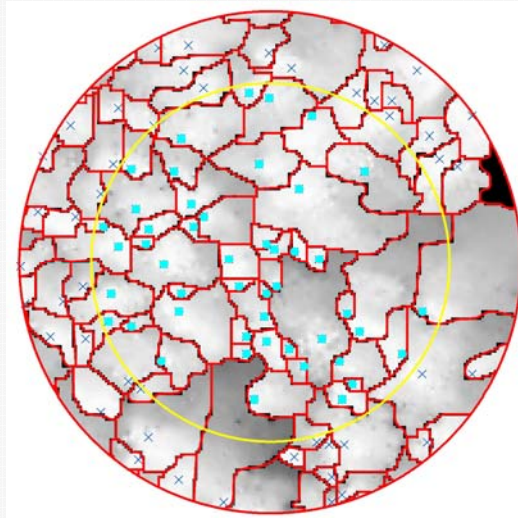
## 개별목 탐지(Segmentation)

### 잣나무



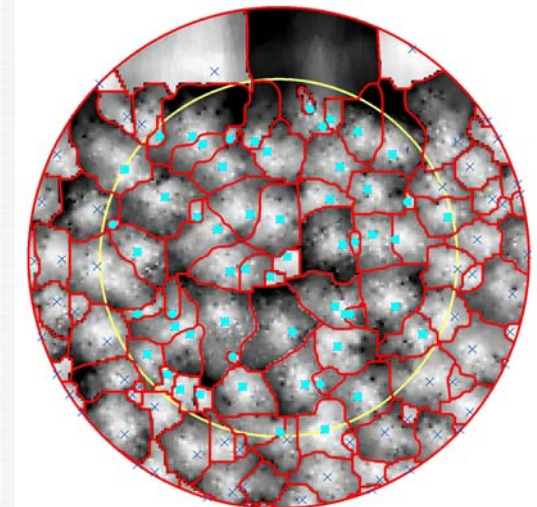
Investigated : 45  
Segmented : 45

### 소나무



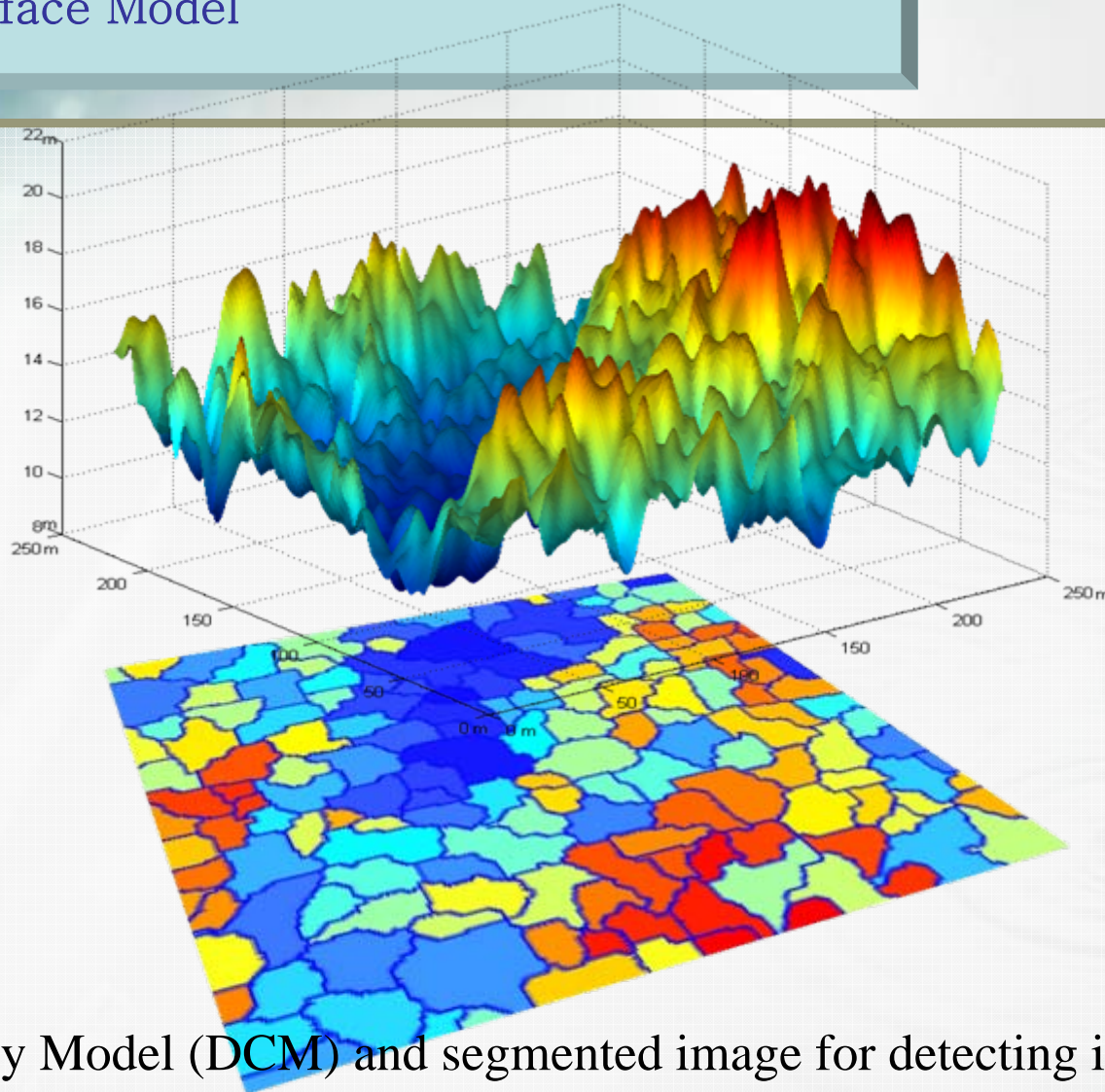
Investigated : 45  
Segmented : 47

### 전나무



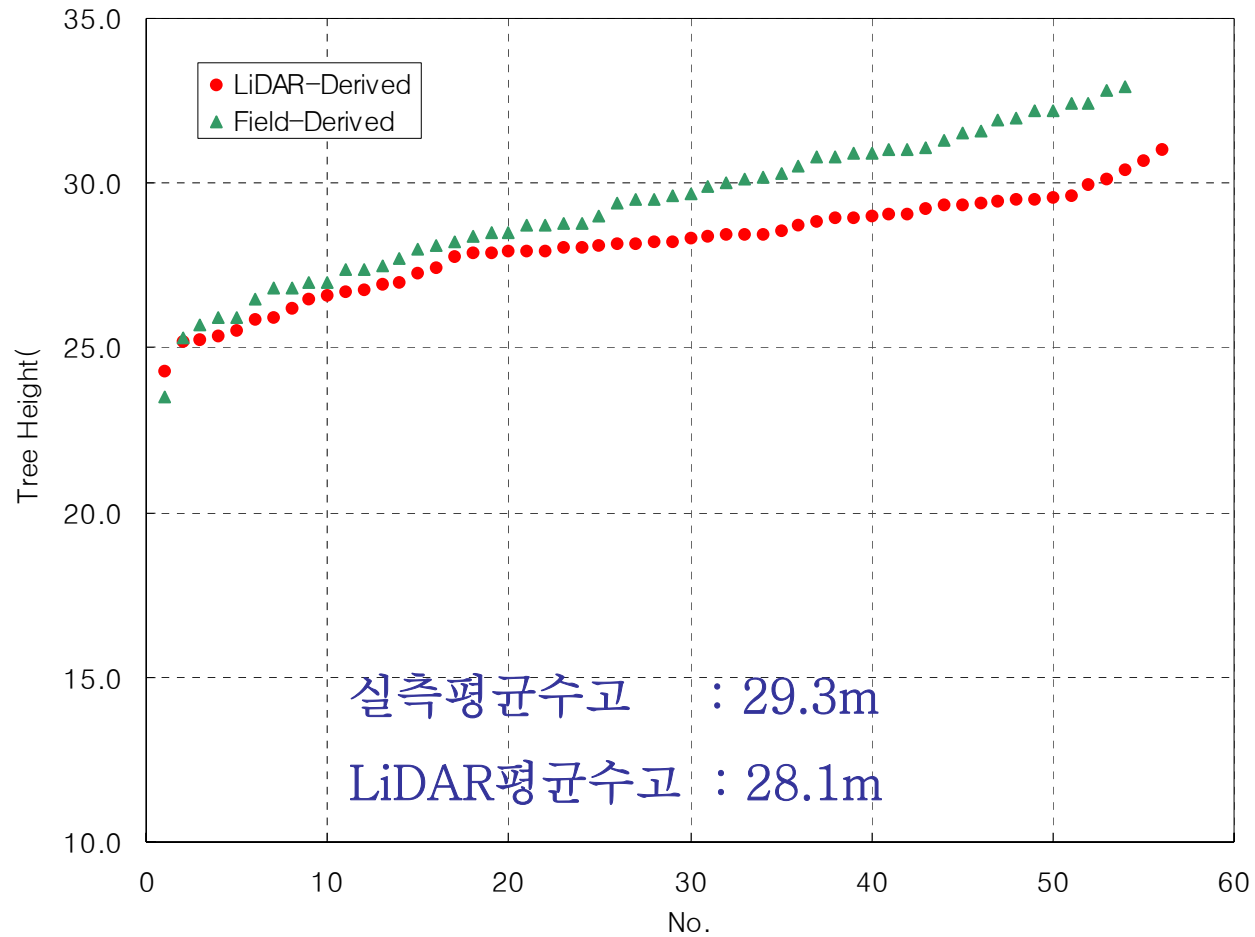
Investigated : 54  
Segmented : 56

## Canopy Surface Model



Digital Canopy Model (DCM) and segmented image for detecting individual trees

# 수고추정



Zimble et. al(2003)

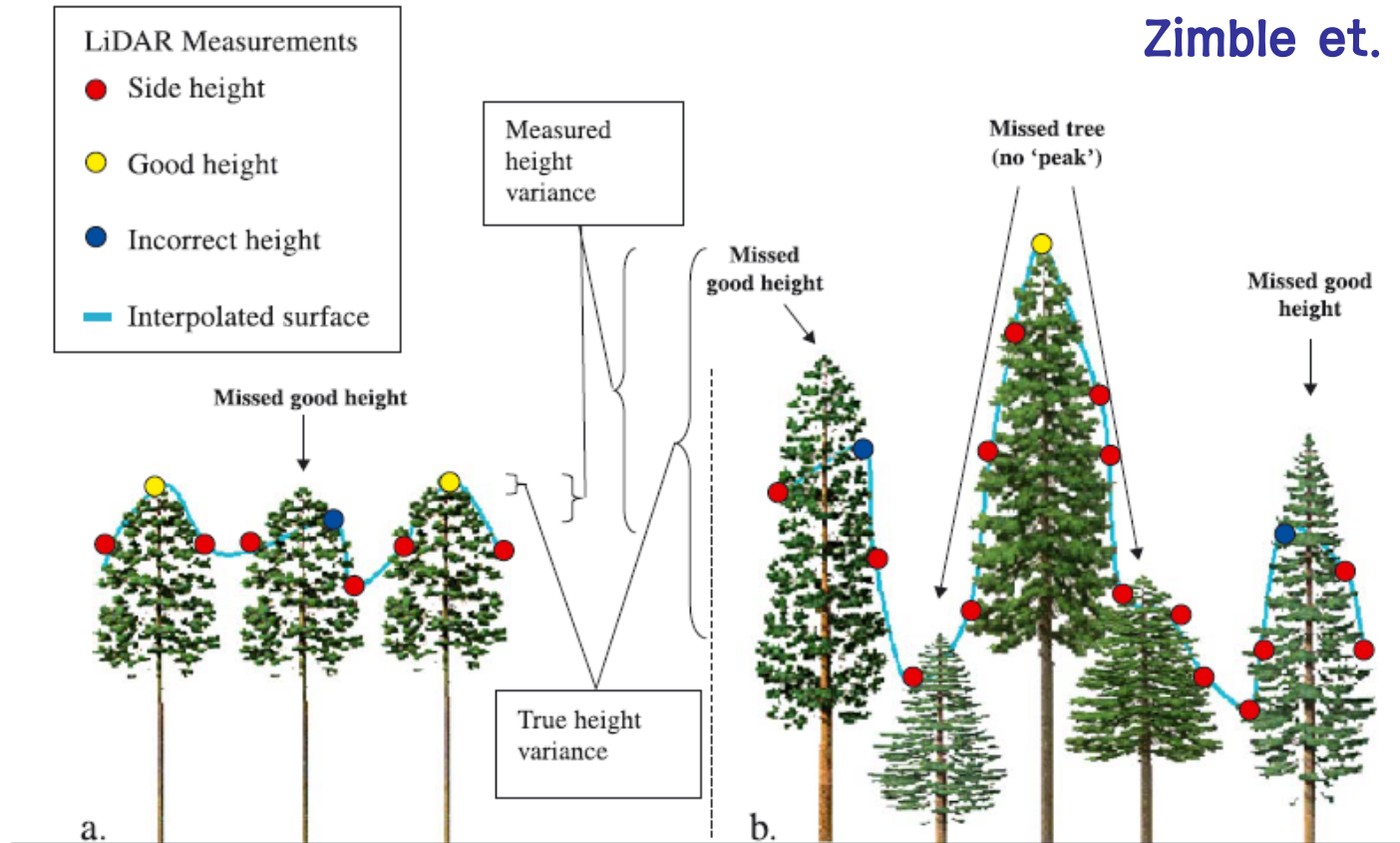


Fig. 6. Large post spacings can influence tree height variances due to incorrect tree heights within the tree height-finding model. This can still result in significant differences between single-story and multistory LiDAR plots. (a) Inflated single-story tree height variance due to incorrect tree height measurements (blue dot). (b) Reduced multistory tree height variance due to incorrect tree height measurements.

## 흉고단면적 추정

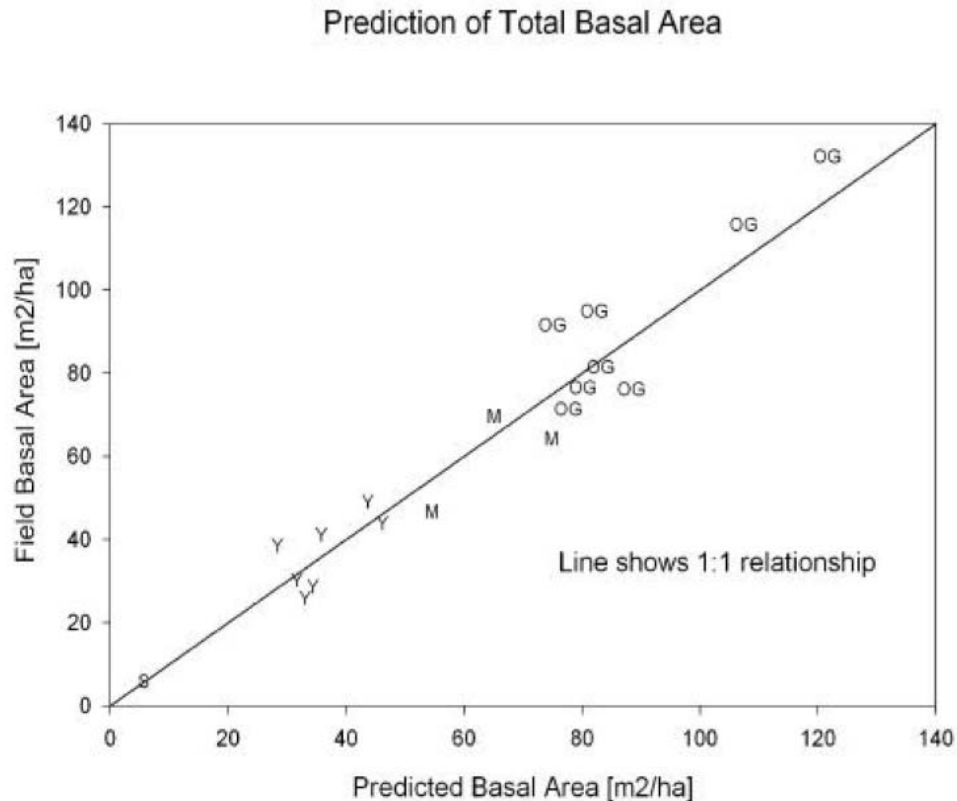


Figure 8. Prediction of Total Basal Area of Douglas-fir stands using small-footprint LIDAR data. **PRELIMINARY RESULTS ( $R^2 = .95$ )**. Seral stage codes: S = shrub-dominated, Y = young, M = mature, OG = old growth.

Renslow et al. (2000)

## LiDAR를 이용한 벌채목탐지

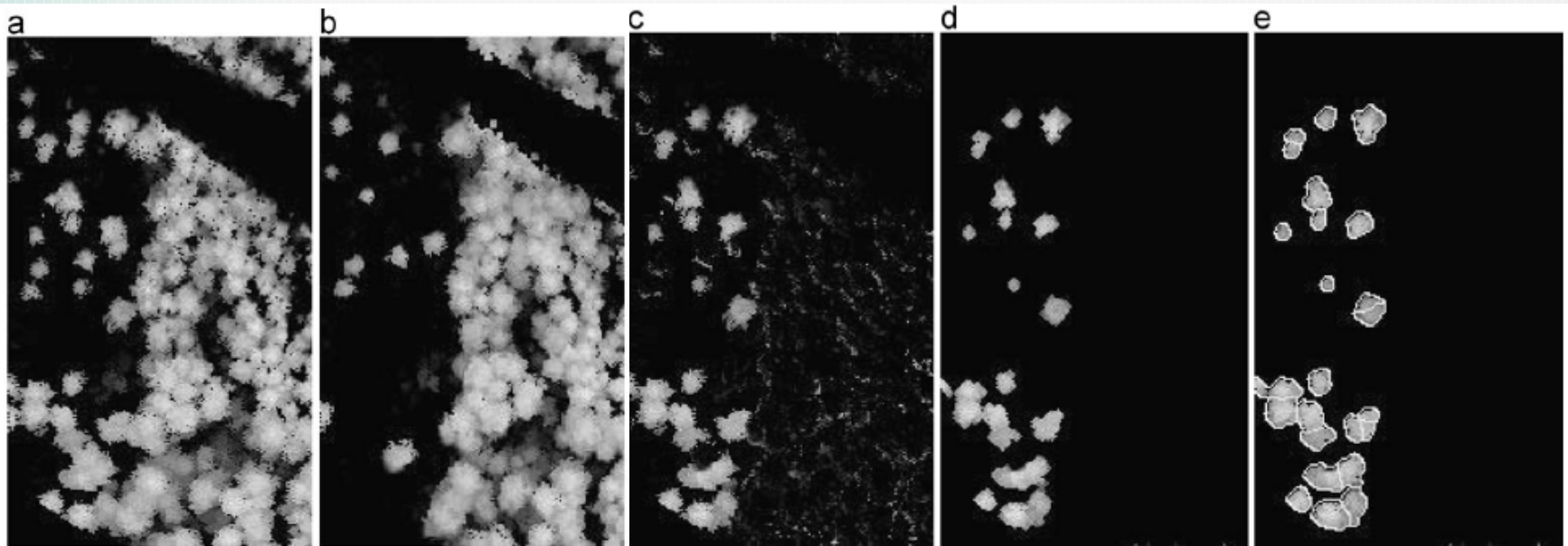
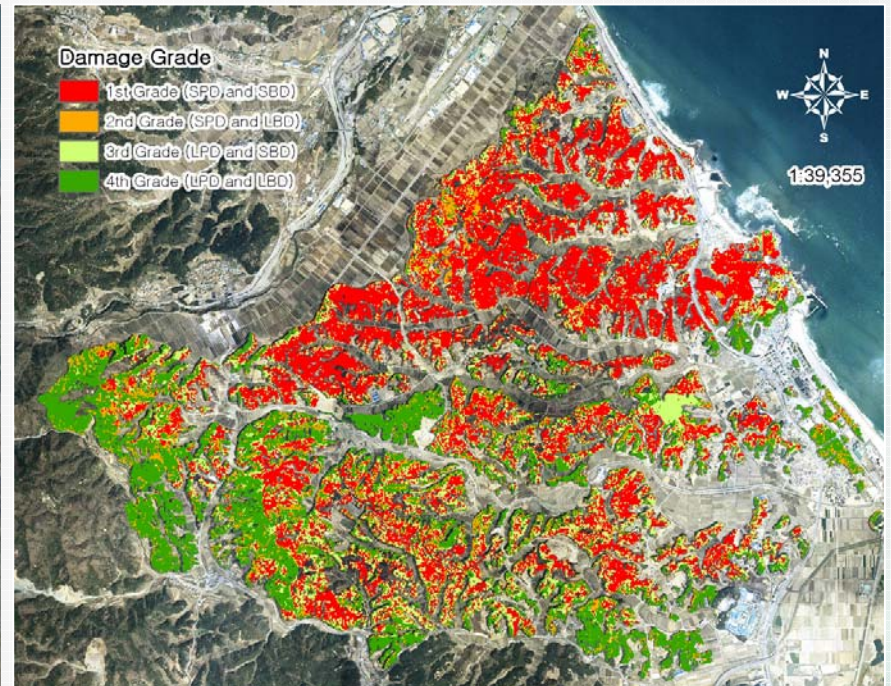


Fig. 2. An example of the automatic detection and location of harvested trees, (a) canopy height model of the 1998 data, (b) canopy height model of the 2000 data, (c) difference image, (d) image after thresholding and filtering, (e) segmented image indicating individual harvested trees.

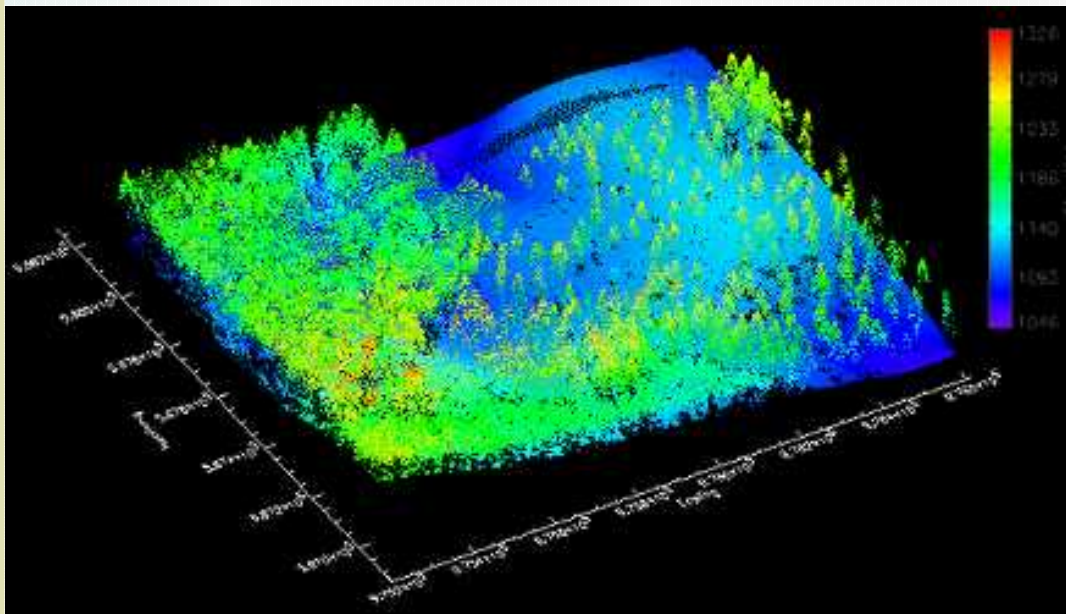
Xiaowei Yu et al. (2004)

## 산불피해지 등급화

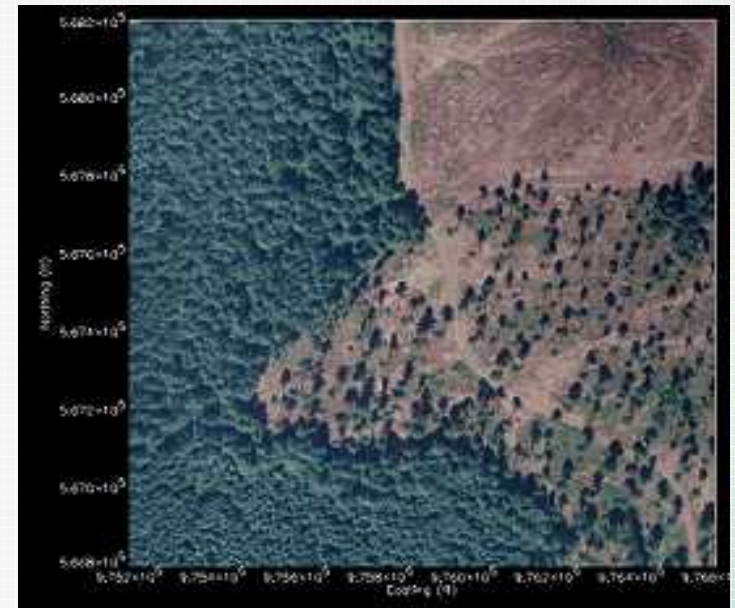


# LIDAR for forest structure analysis

High-density LIDAR data

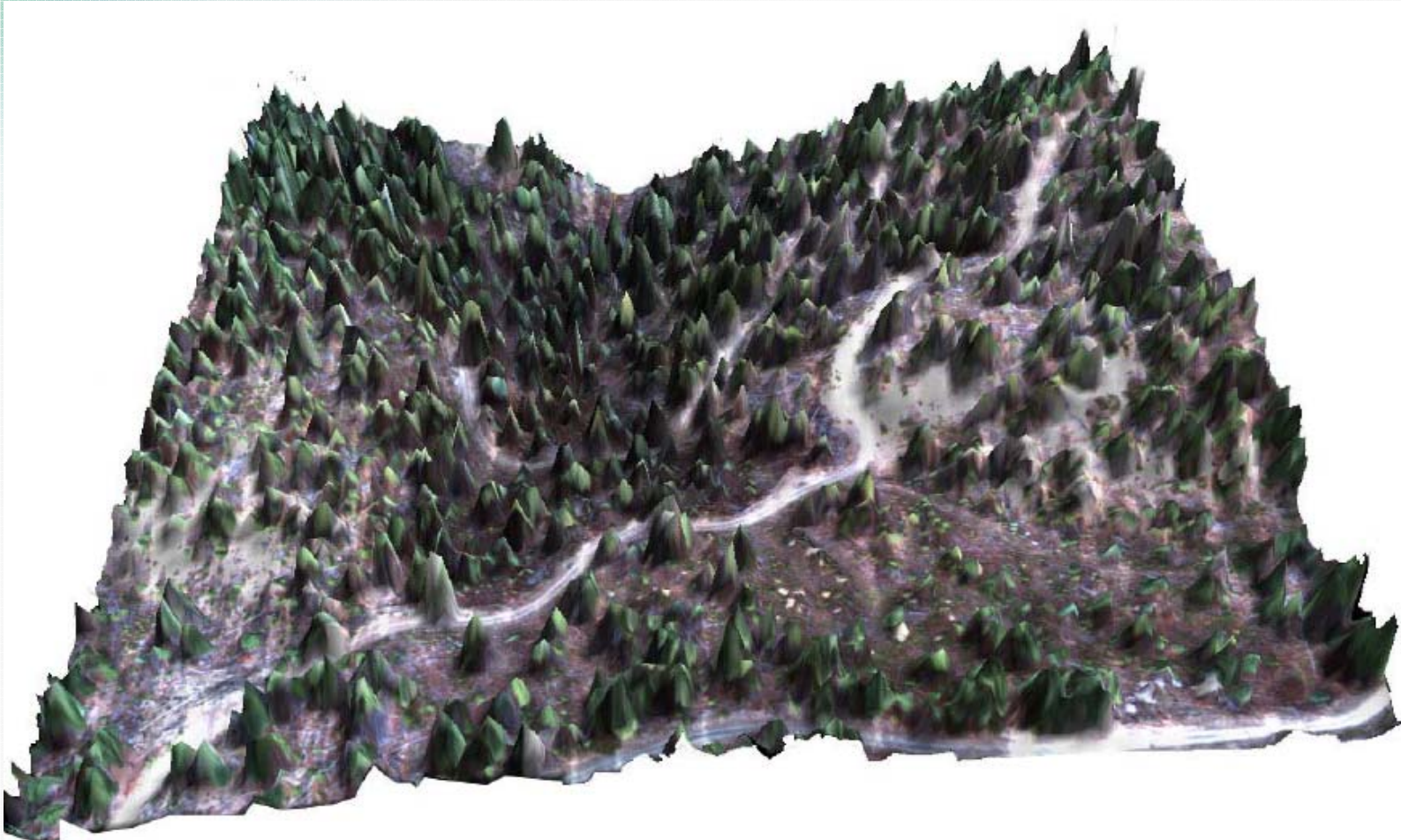


Same area in orthophoto





## Hi-Res. Multi-spectral + LiDAR



## 지상 레이저 스캐너의 종류

GS-200 (Trimble)



ILRIS-3D (Optech)



LPM-321 (RIEGL)

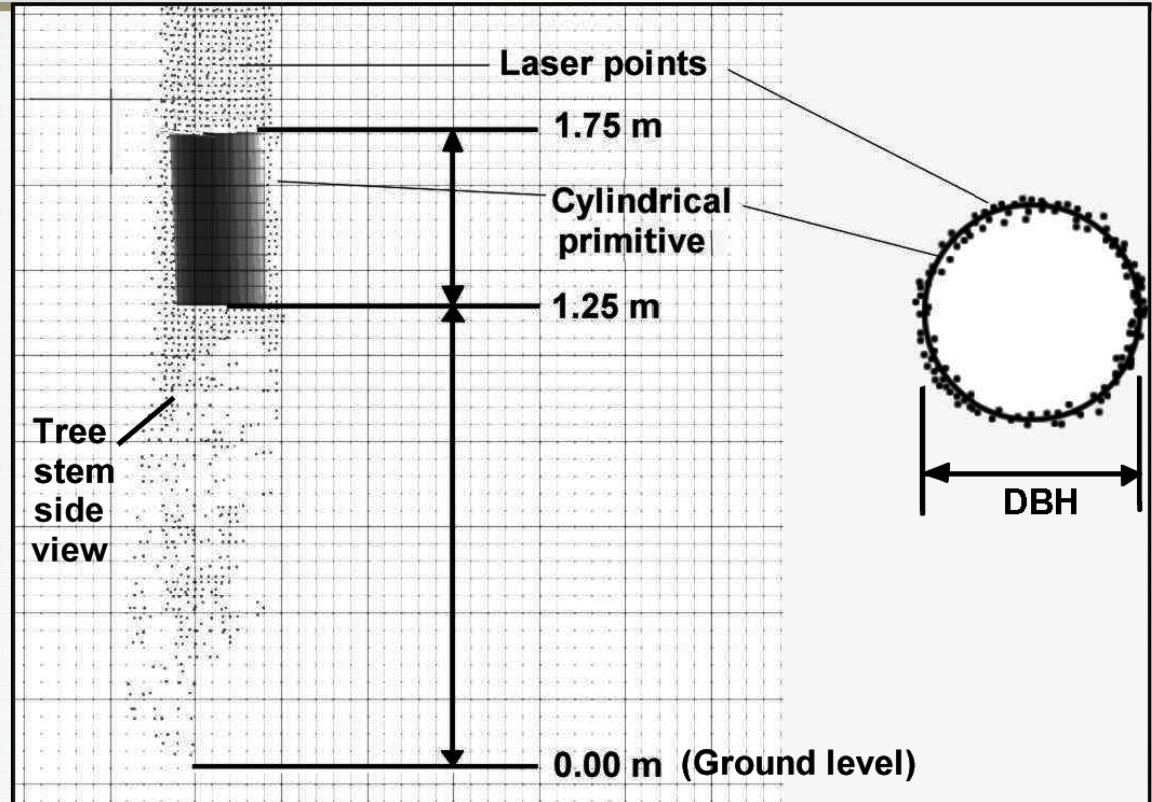
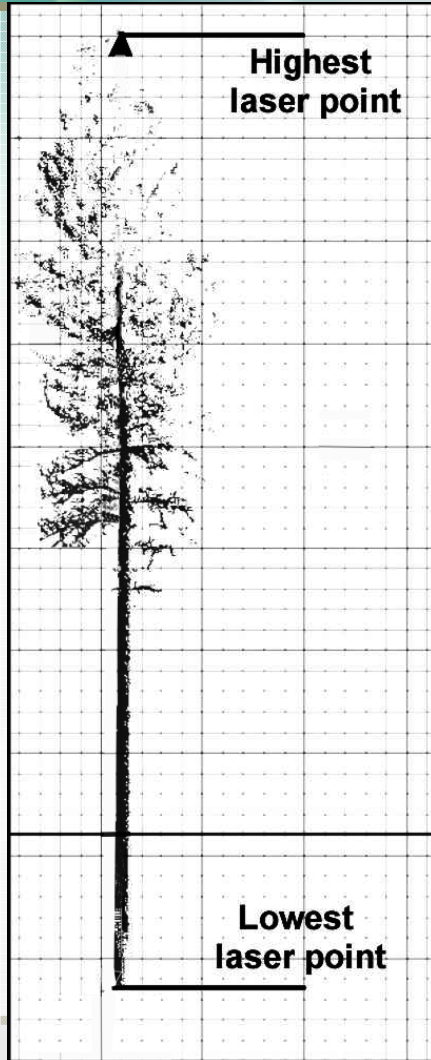


IMAGER (Zoller+Fröhlich)



# 지상레이저의 산림분야에서의 활용

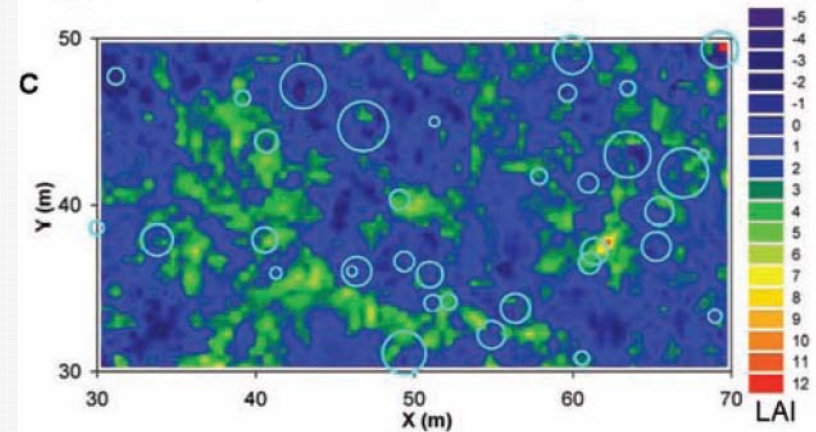
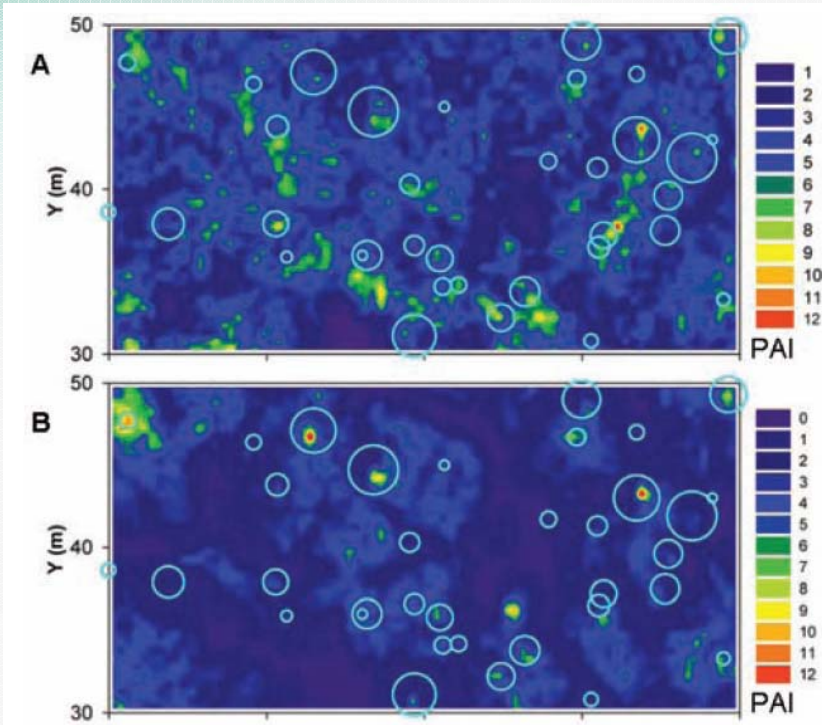
## 지상 레이저 스캐너를 이용한 산림 생장요소 측정



- ✓ 개체목의 위치, 수고, 흉고직경, 재적 그리고 임목밀도 등을 추정
- ✓ 수고측정: 가장 높은 값을 가지는 점과 가장 낮은 값을 갖는 점 사이의 값을 측정
- ✓ 흉고직경측정 : 흉고에서 가상의 원통을 이용하여 직경추정

## 산림분야에서의 활용

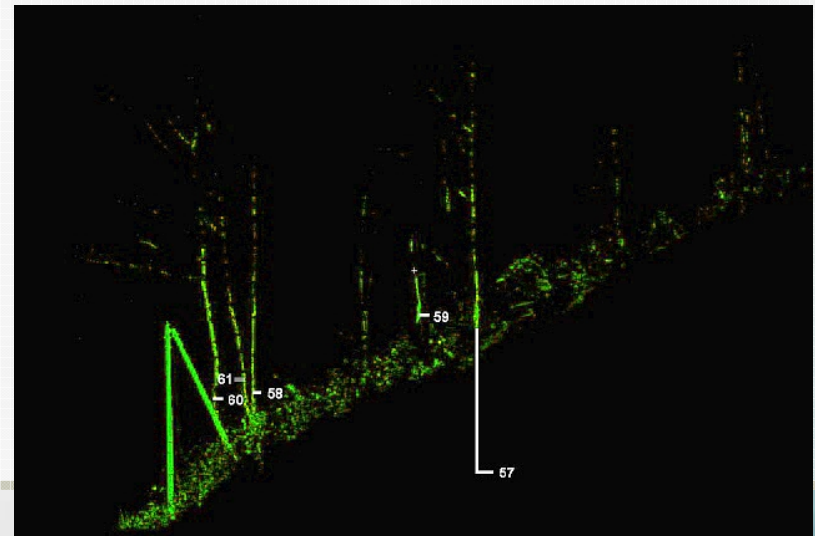
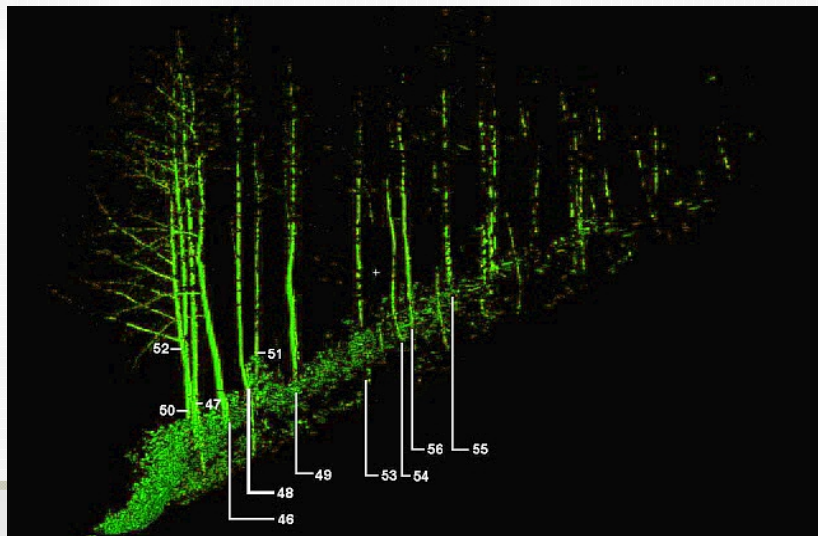
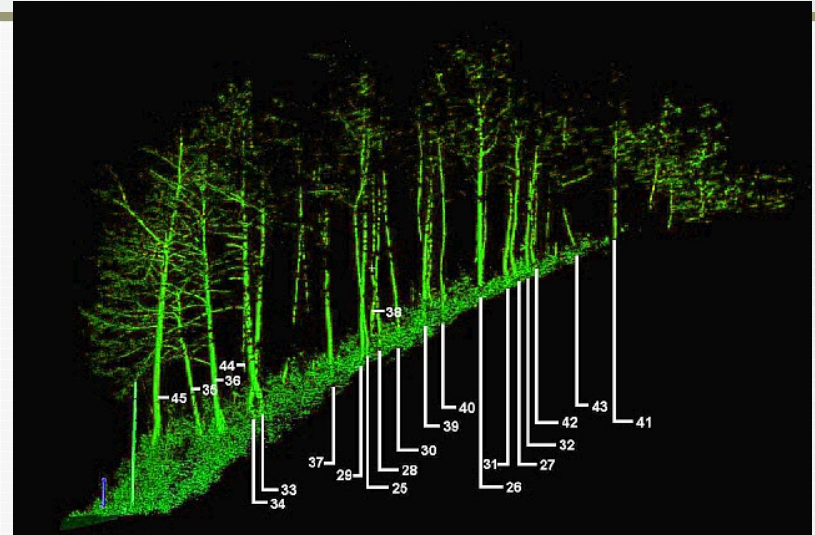
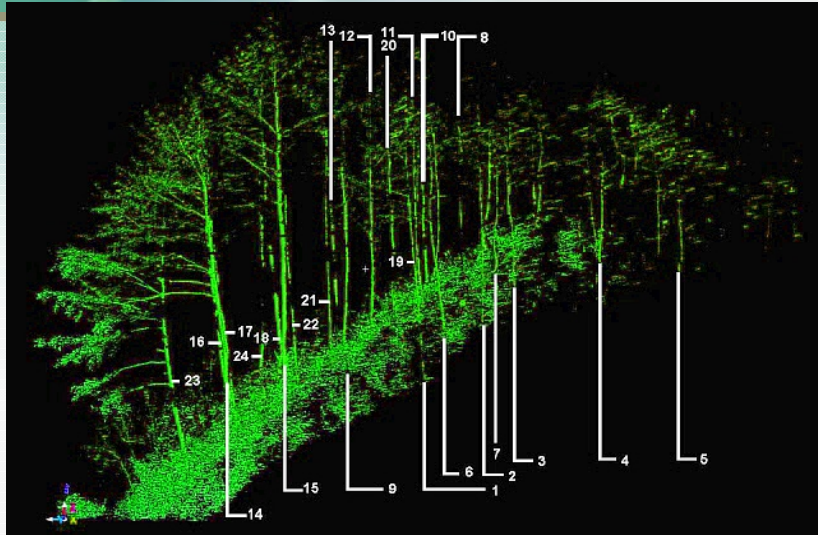
지상 레이저 스캐너를 이용한 LAI<sub>e</sub> 측정



✓ (A) Leaf-on (B) Leaf-off 의 차이를 이용한 (C) Effective LAI의 산출

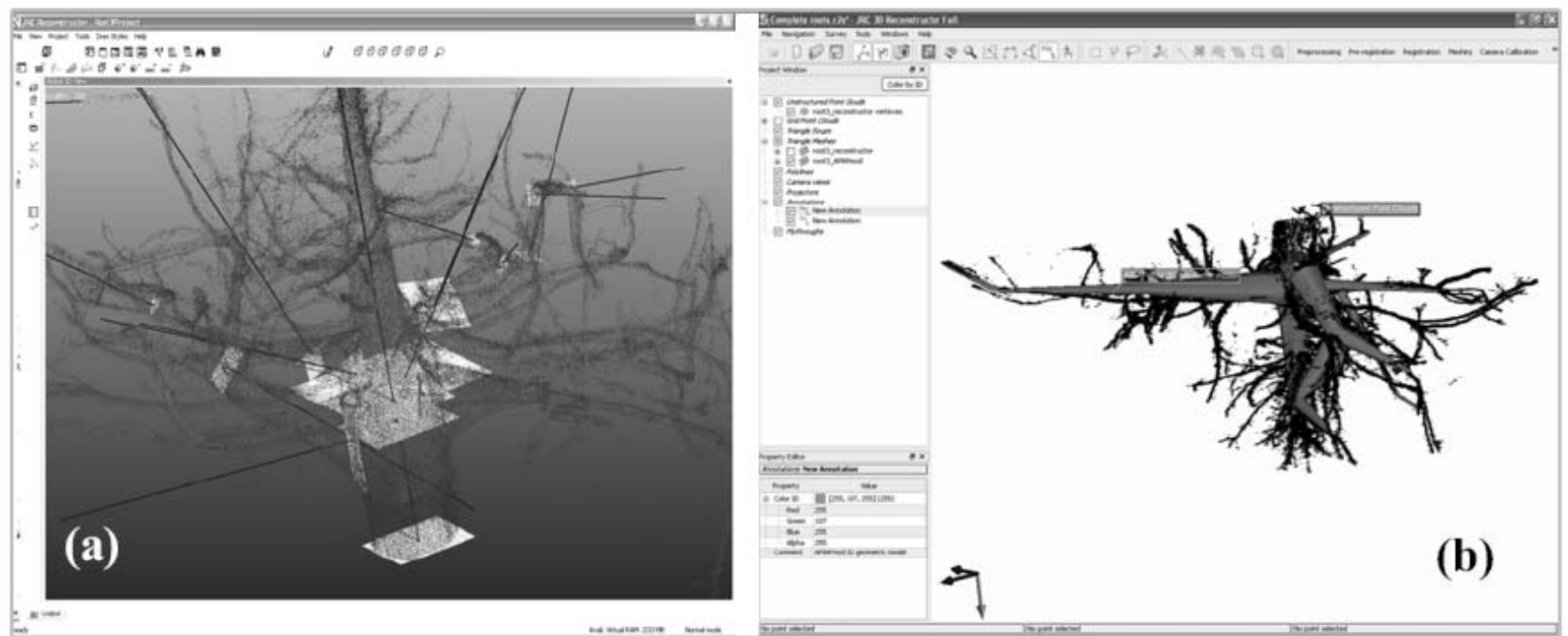
# 산림분야에서의 활용

## 산불발생지 피해분석



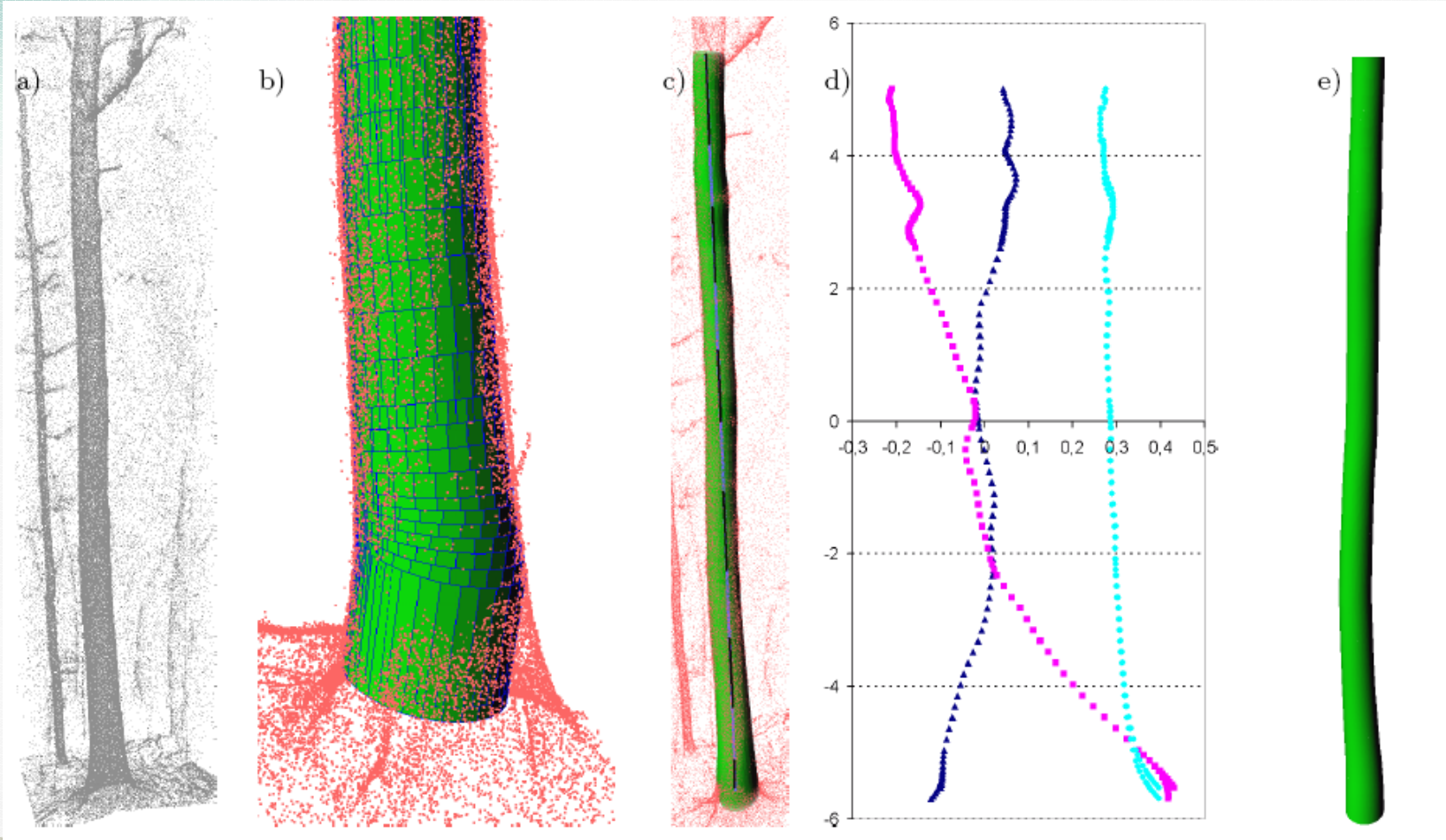
# 산림분야에서의 활용

## 뿌리 바이오매스 측정



# 산림분야에서의 활용

## 임목 모델링



# 지상 레이저 스캐너의 활용 사례

## 역공학(Reverse Engineering)

형태가 있는 제품이나 물건으로부터 설계데이터를 생성하는 기법



① Point Cloud



② Polygon Mesh



③ Curve Generation

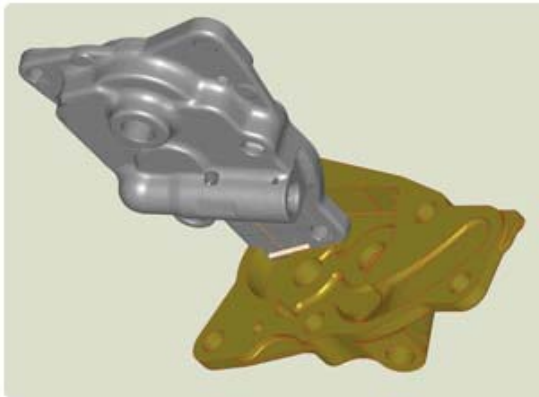


④ CAD model

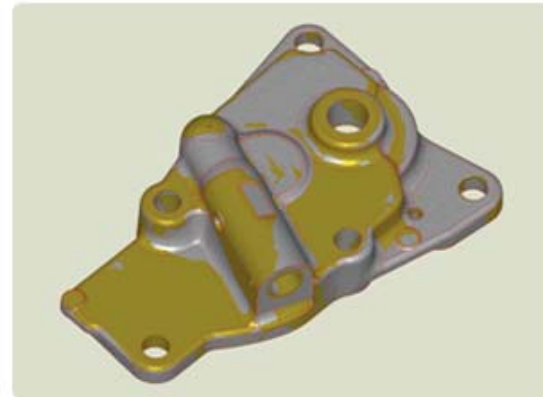


# 지상 레이저 스캐너의 활용 사례

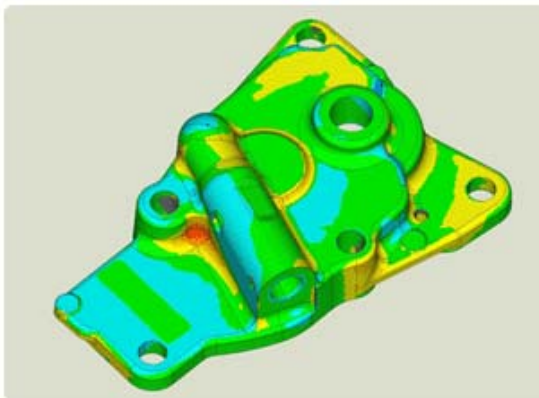
## 품질검사



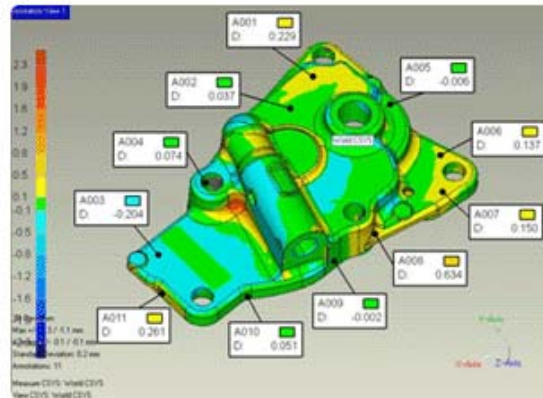
① 스캔 데이터 CAD 데이터 Import



② Best Fitting



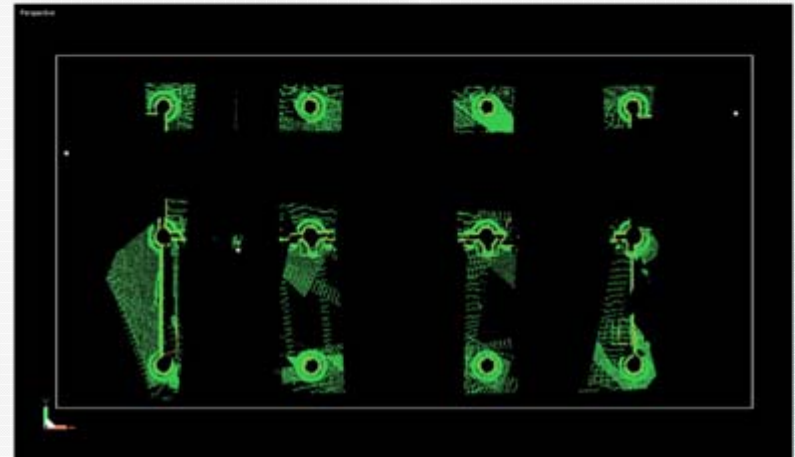
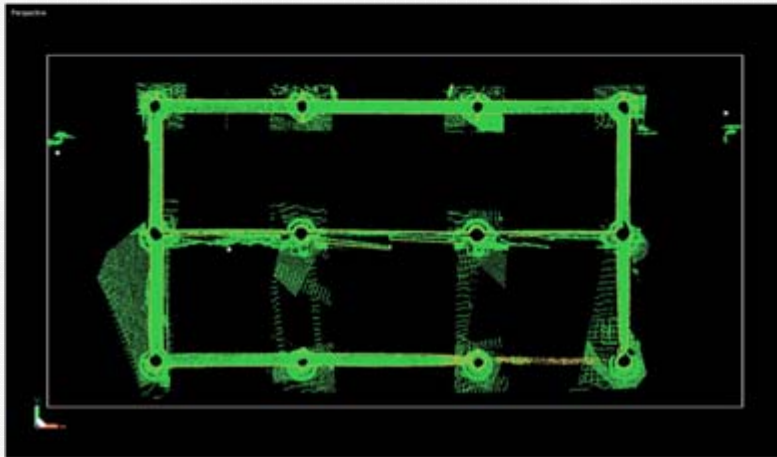
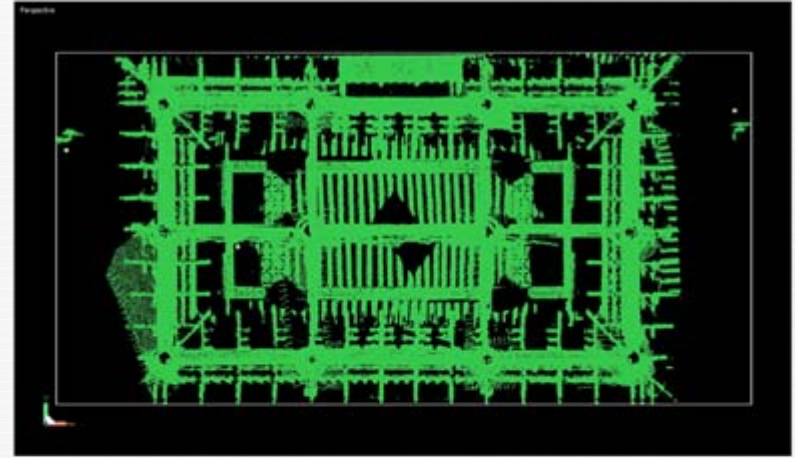
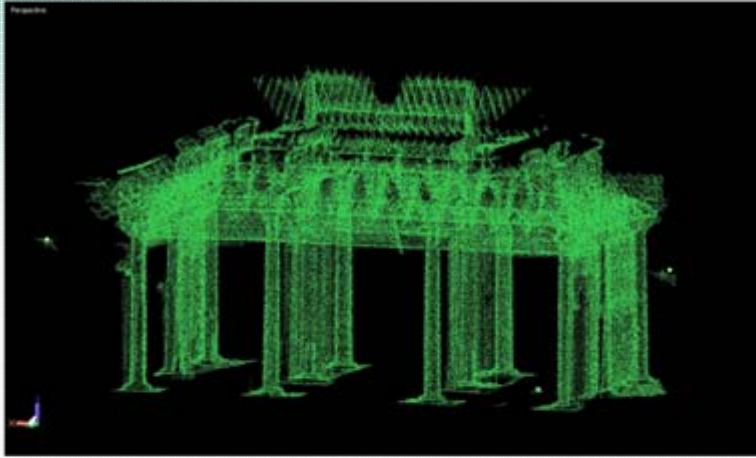
③ Deviation Map display



④ Reference Point Measurement

# 지상 레이저 스캐너의 활용 사례

문화재 정밀측량 (덕수궁 대한문 스캐닝)

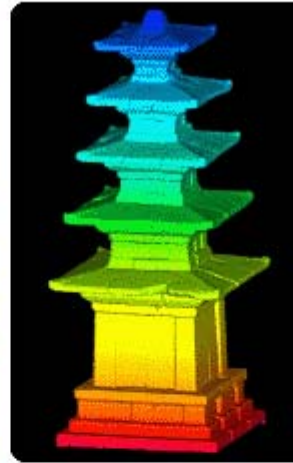


# 지상 레이저 스캐너의 활용 사례

## 문화재 정밀측량



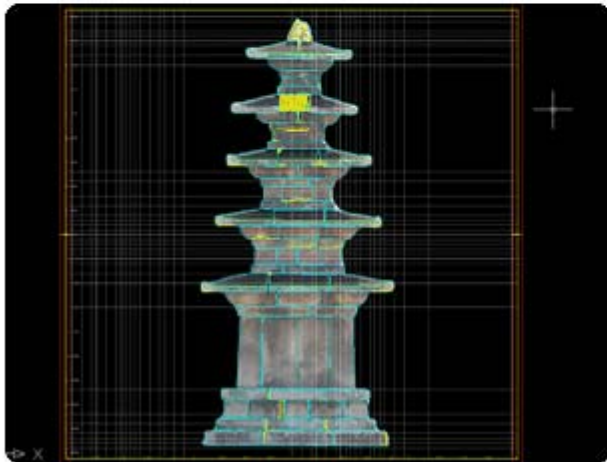
정림사지탑 실제모습



3D 폴리곤 모델



3D Section



2D Orthophoto를 이용한 2D 도면작업



완성된 2D 도면



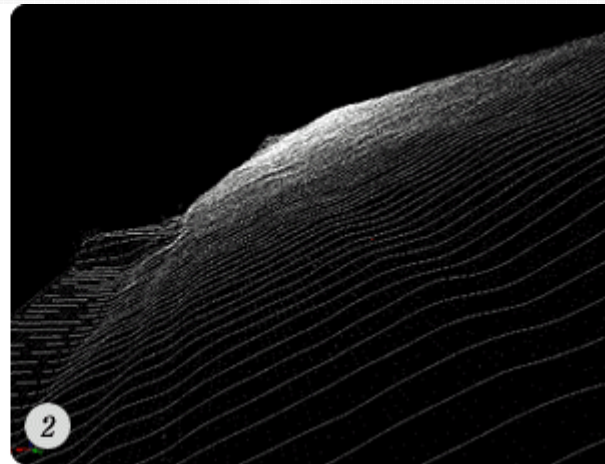
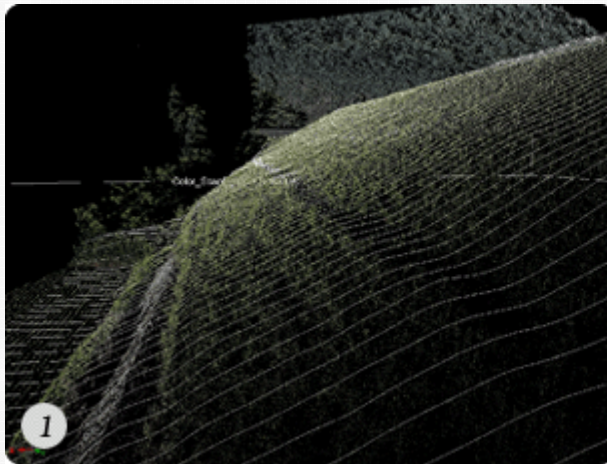
정림사지탑의 3D 텍스처 모델 완성

## 지상 레이저 스캐너의 활용 사례

### 기간경과에 따른 댐 모형 변동 데이터비교



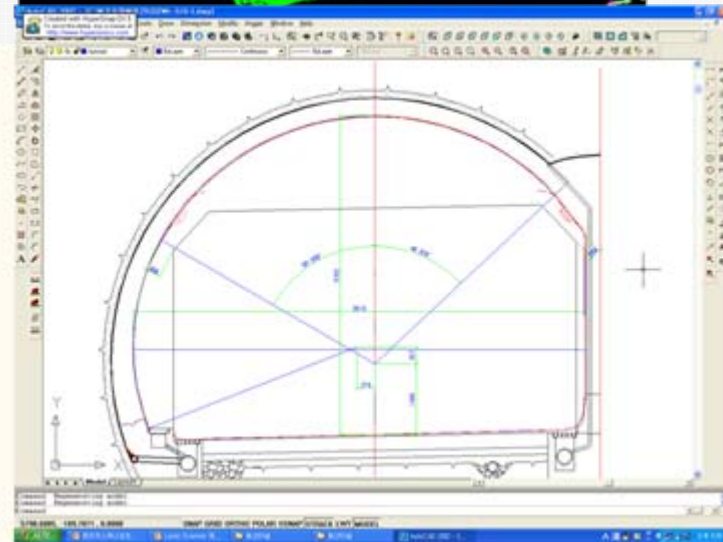
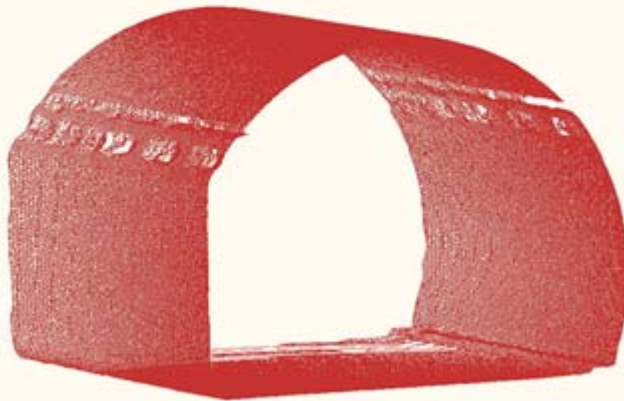
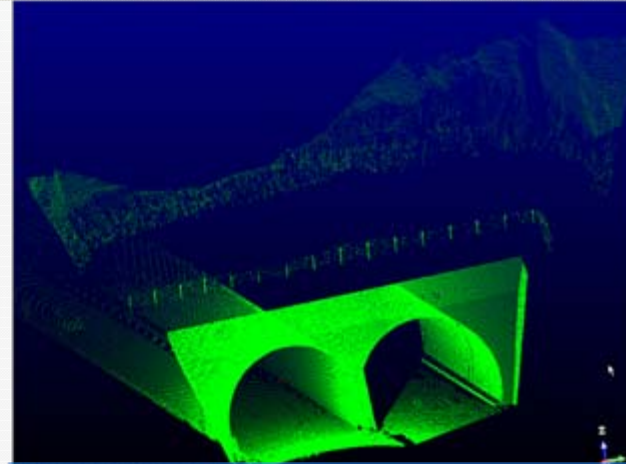
Point Cloud 데이터에 고해상도 디지털 카메라로 촬영한 이미지 데이터를 획득한 모습.  
자료상 파란색상 부분은 스캔 데이터가 없는 부분임



댐 표면 배부름 현상의 정확한 위치파악

# 지상 레이저 스캐너의 활용 사례

## 터널의 정밀 측량



# 지상 레이저 스캐너의 활용 사례

## Computer Graphics



2006년  
영화 "수"  
배우 스캔



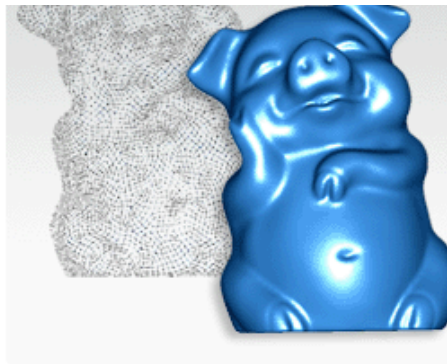
2007년  
영화 "아들"  
배우스캔



2007년  
영화 "권순분의  
납치사건"  
배우스캔



2007년  
영화 "브라보 마이  
라이프"  
배우 스캔



감사합니다

