UNIVERSITY OF TWENTE.

Training Course

Remote Sensing – Basic Theory & Image Processing Methods

19 – 23 September 2011

DIGITAL TERRAIN MODELS

Introduction

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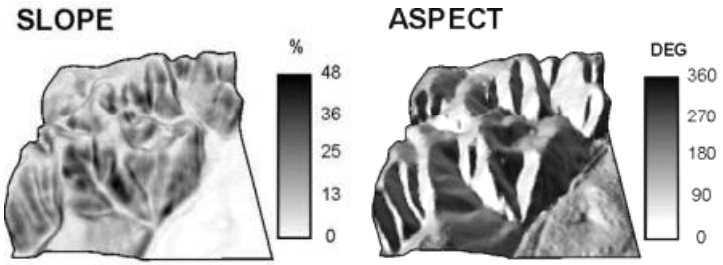
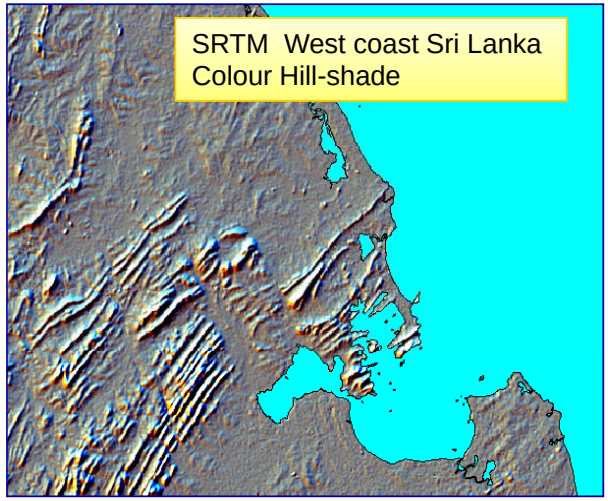
Digital Elevation and Terrain Models

A Digital Terrain Model (DTM) is a quantified representation of terrain made from a Digital Elevation Model (DEM)

- **Examples of terrain variables derived from a DEM:**
  - **Terrain elevation**
  - **Slope steepness**
  - **Slope length & slope form**
  - **Slope & aspect**

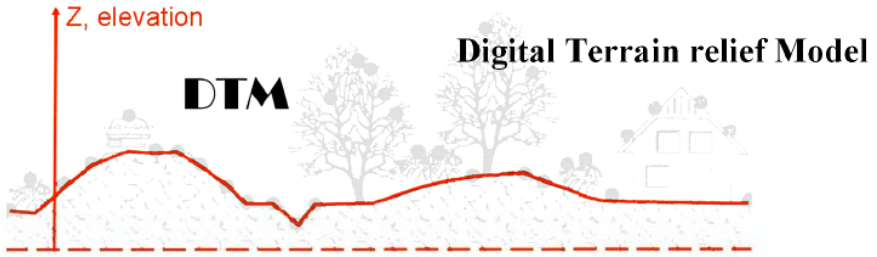




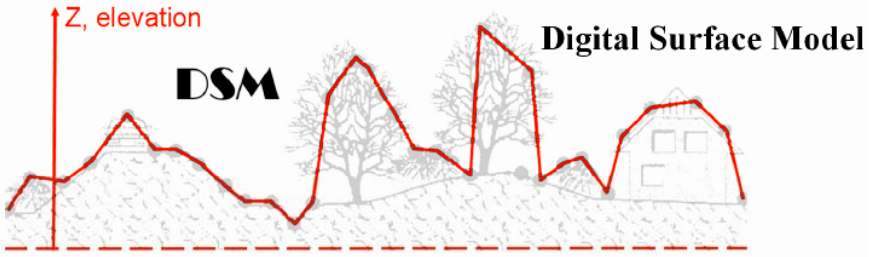
- A **Digital Surface Model** includes also features like vegetation, buildings, etc.

Digital Elevation (surface) and Terrain Models

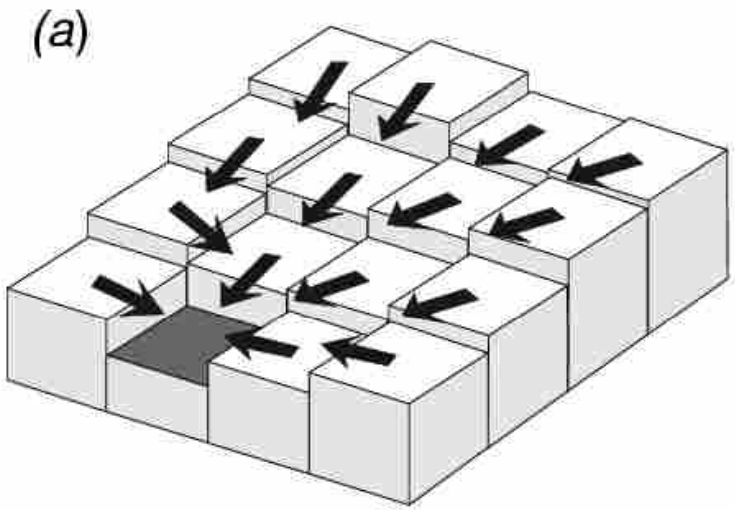
Digital Terrain relief Model (DTM): **model of the shape of the ground surface**

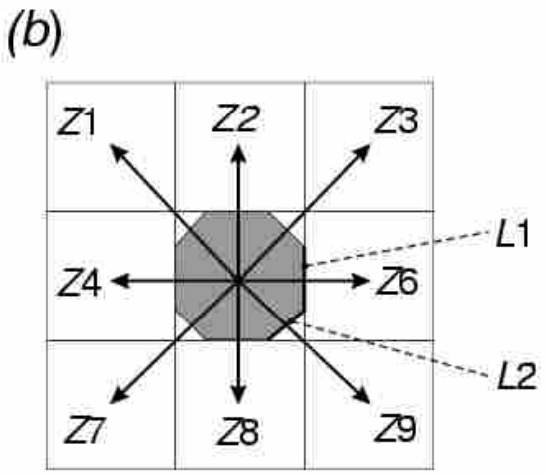


Digital Surface Model (DSM): **model of shape of the surface including vegetation, infra-structure, etc.**



Digital Elevation and flow accumulation



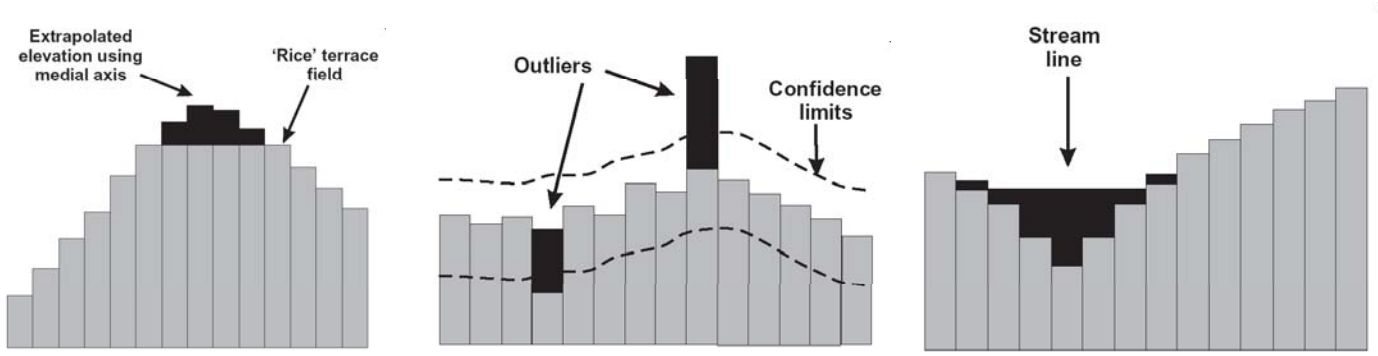


(a) Contributing cells at observed location

(b) Effective contour lengths at cardinal and diagonal directions (L1 and L2) in a 3*3 window

Digital Elevation Model – Removal of errors

- ✓ **Reduction of obvious artefacts**
- ✓ **Reduction of local outliers**
- ✓ **Adjustment of DEM elevation by incorporating additional information**

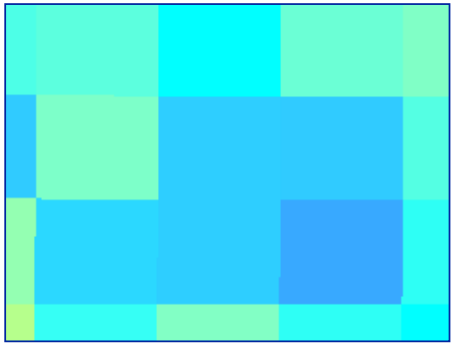


(Source: Hengl et al, 2004)

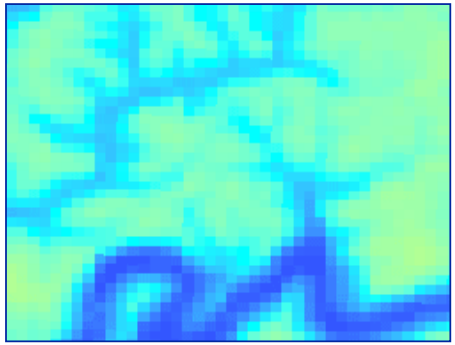
Digital Elevation Model

Cell size of DEM

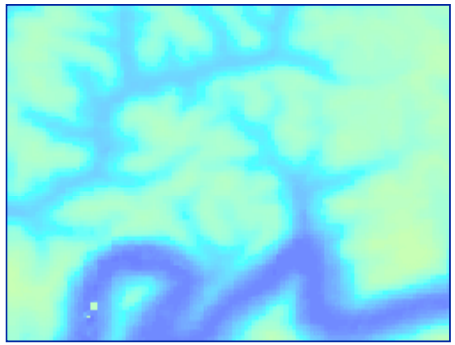
GLOBEDEM
1 km



SRTM Global
90 m



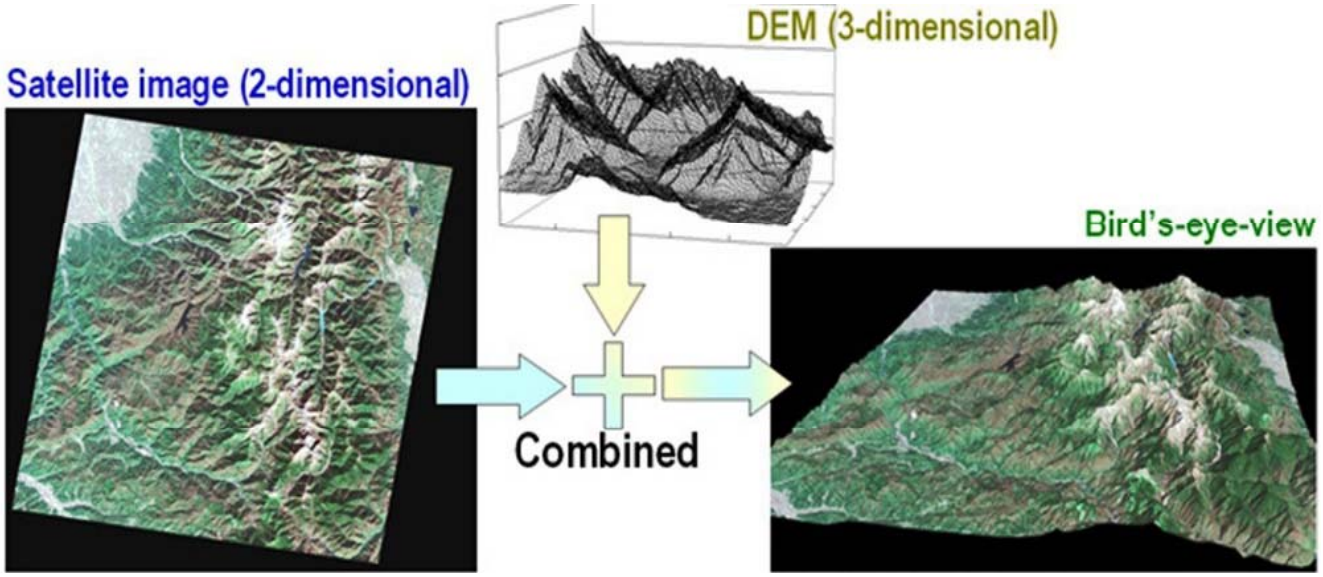
ASTER
30 m



Figures: USGS SRTM Website

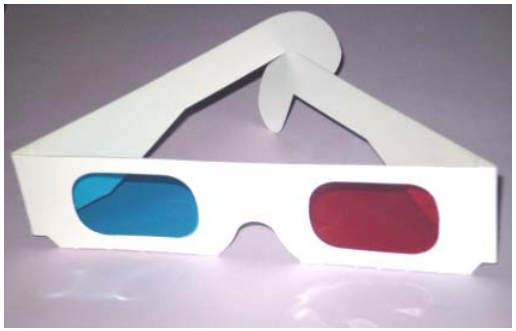
Digital Terrain Models (DEM)

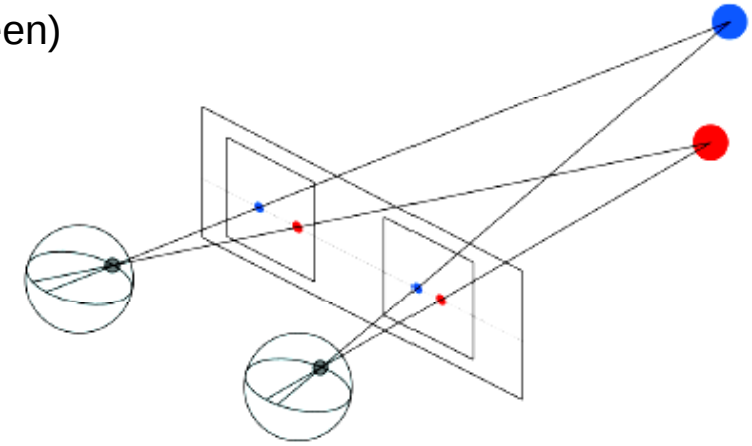
DEM combined with satellite image



Stereoscopy: Anaglyph vision

- Science of producing three-dimensional (3D) visual models
- Basic requirements: images of the same object from two different positions
- Can be viewed at the computer screen
- Anaglyph : red & blue (or green)

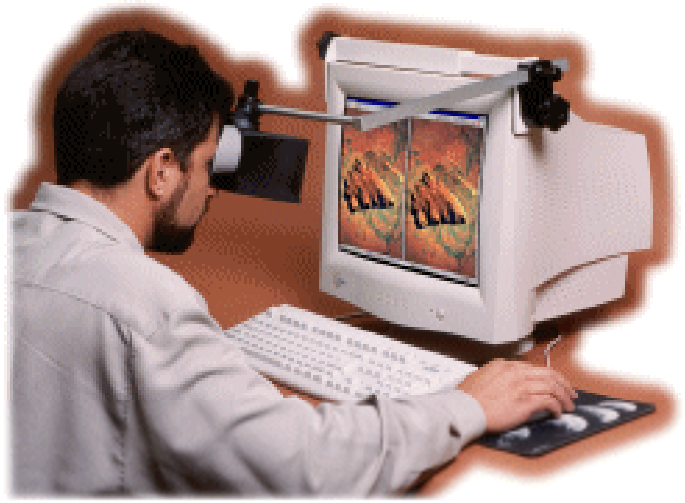




Stereoscopy: Screen-scope

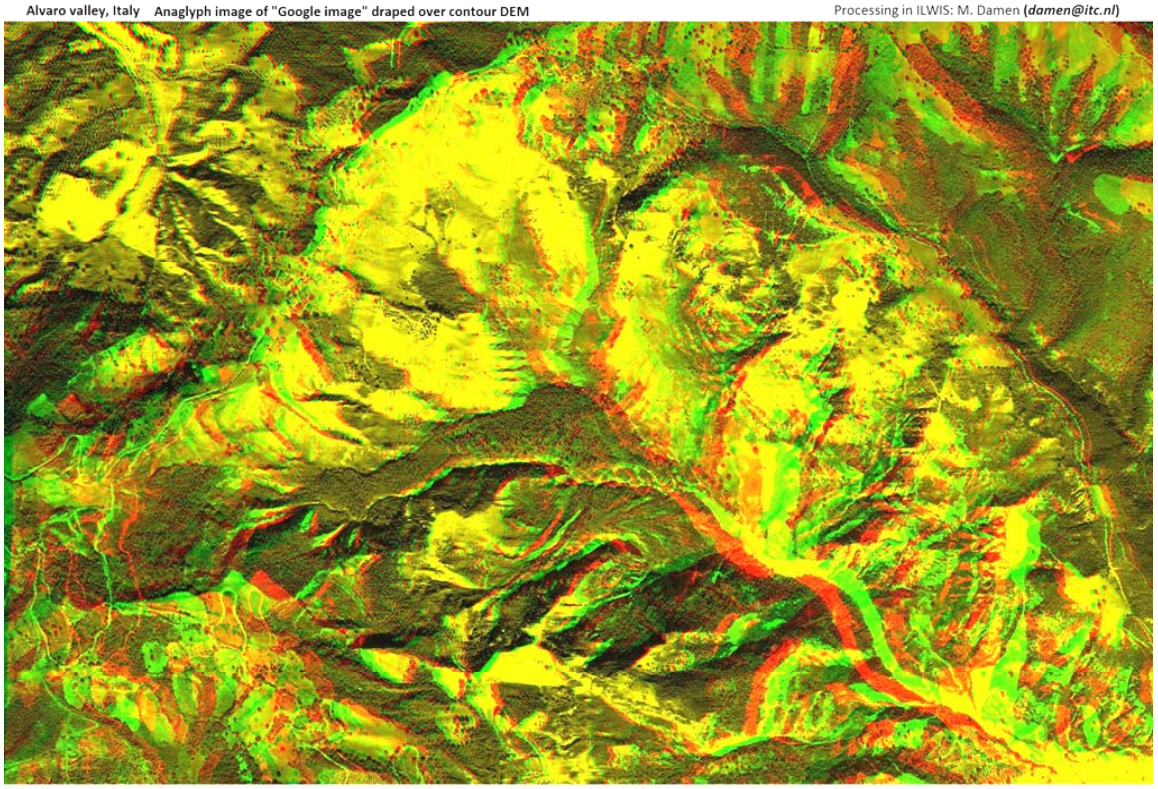
- **In ILWIS software 3D visualization possible by combining**
  - **a. overlapping aerial photographs**
  - **b. drape of (satellite) image over DEM**

- **Examples:**
  - **- Landsat & SRTM**
  - **- Aster VNIR & DEM**
  - **- "Google" image & Lidar**



Digital Terrain Models (DTM) – Sources

Alvaro valley, Italy – Aerial photo draped over contour interpolated DTM

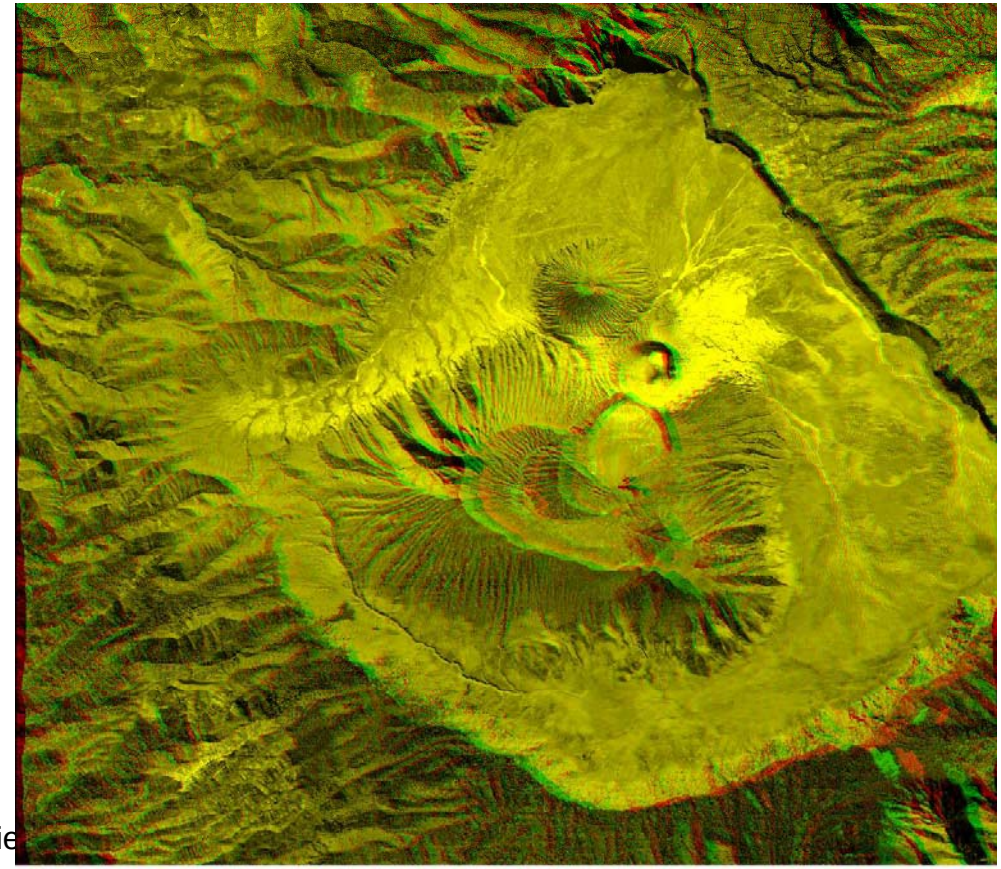


Digital Terrain Models (DTM) – Sources

Alvaro valley, Italy – Colour aerial photograph

Digital Terrain Models (DTM) – Sources

Bromo volcano, Indonesia – Quickbird image draped over Aster DTM



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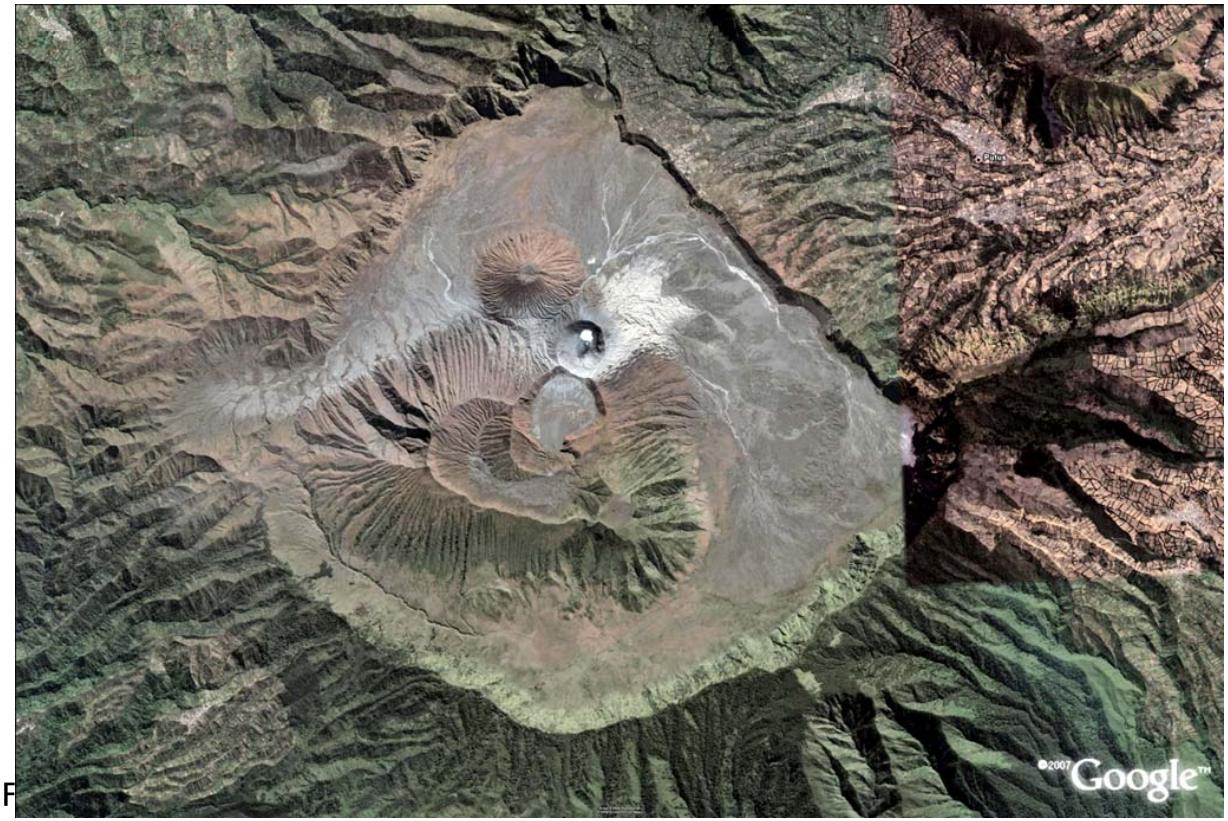
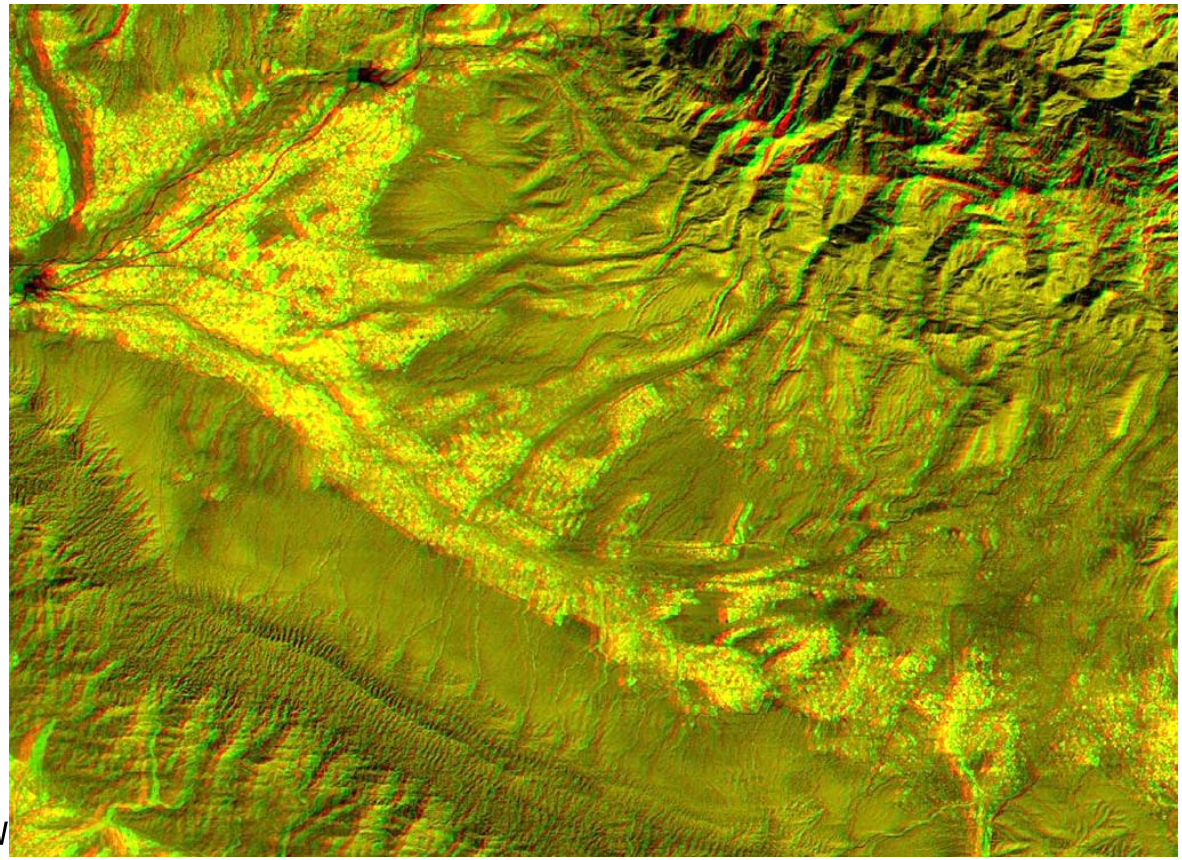


Digital Terrain Models (DTM) – Sources

Doon valley, North India – Aster image draped over Aster DTM



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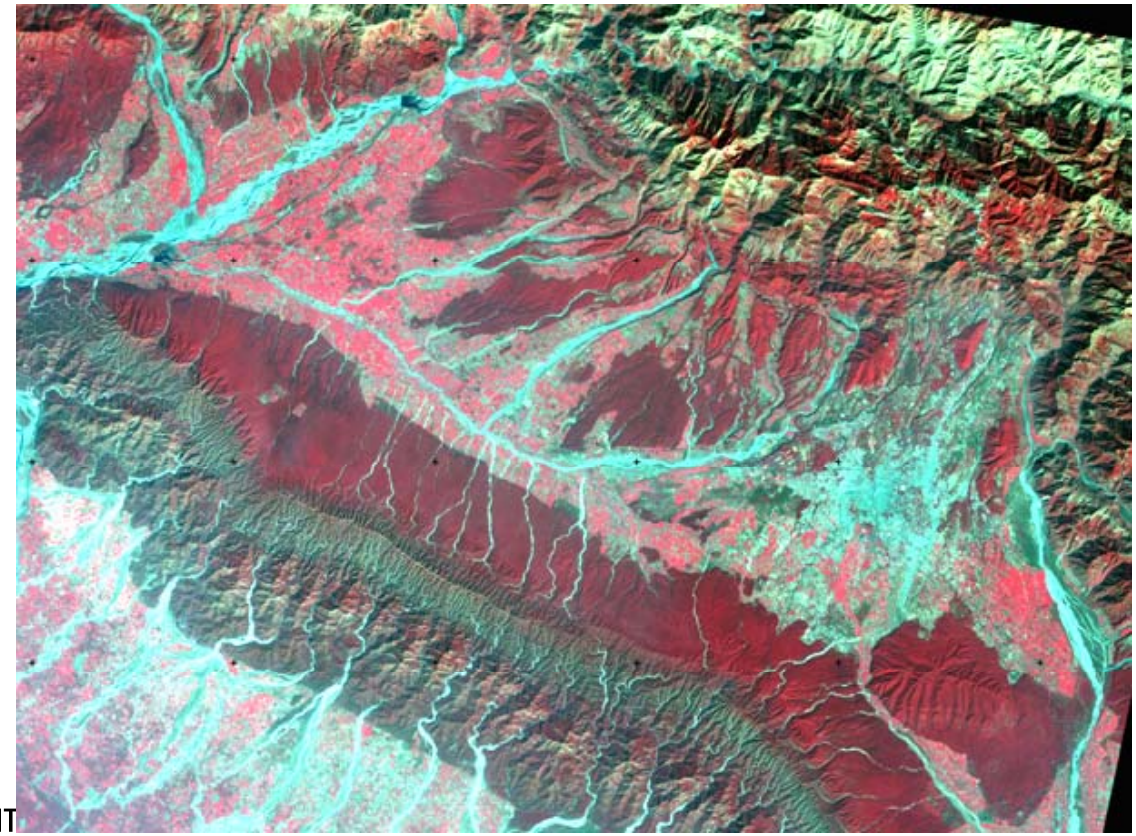
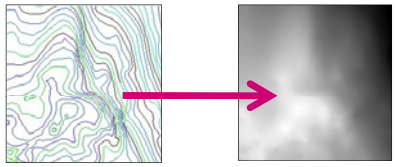
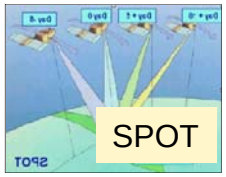


Digital Elevation Models (DEM) – *Sources*

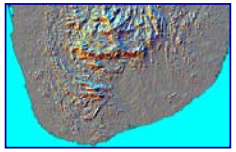
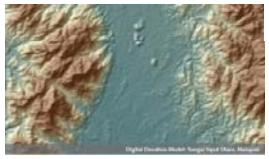
- **Topographical maps - Interpolation of contours**



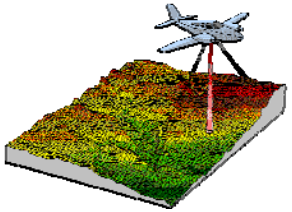
- **Stereoscopic 3-D images (aerial photos, optical satellite images)**

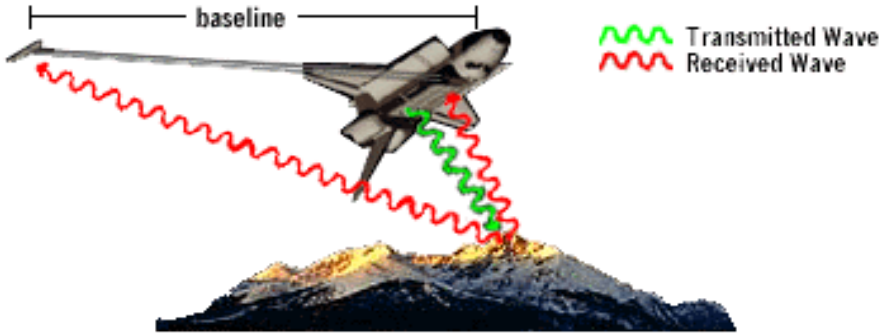
- **Radar (SRTM & Terra SAR-x)**

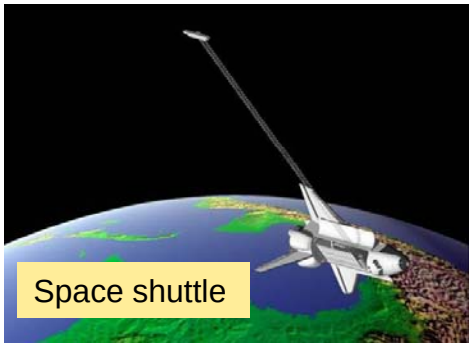



- **Airborne Laser Scanning (LiDAR)**

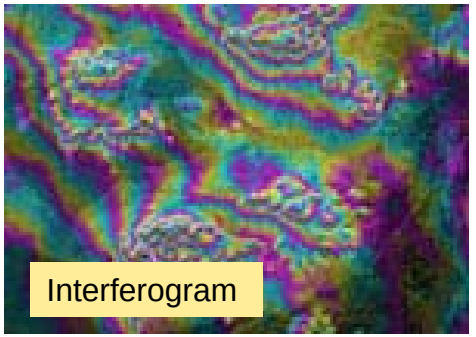


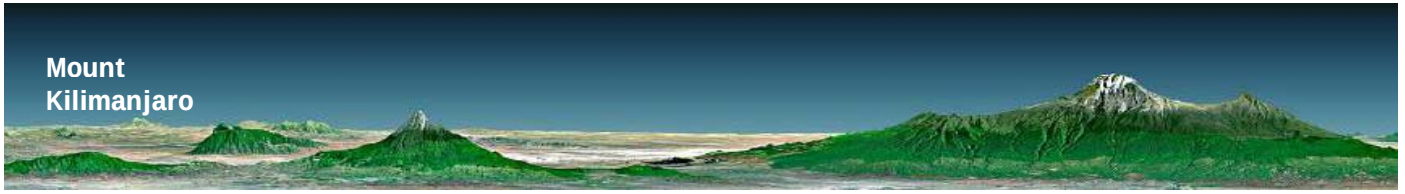
Shuttle Radar Topography Mission (SRTM)





- **Shuttle mission: February 2000**
- **Single-pass SAR interferometry, C & X-bands**
- **Digital Surface Model (a 'raw DEM')**
- **Near-to-global coverage (80% of landmass)**
- **1 arc second spatial resol. = approx. 91 m.**

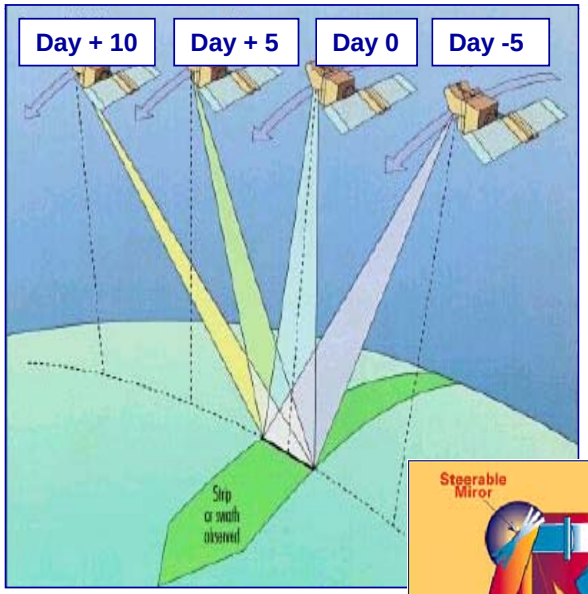


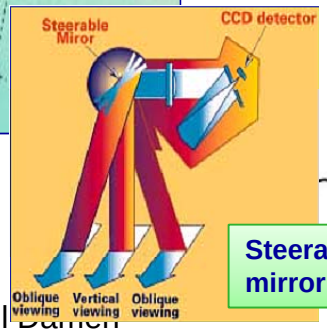


RS sensors – Spaceborne : Stereo

Stereo capability

- Example: SPOT

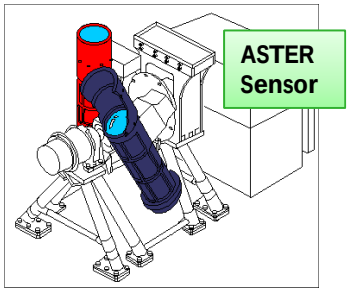


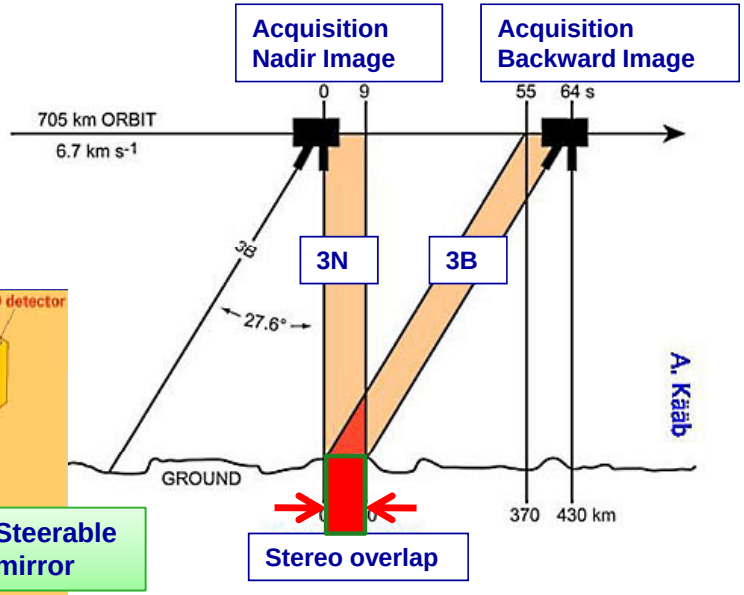


Steerable mirror

Stereo capability

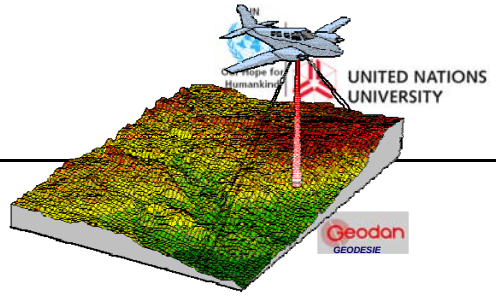
- Example: ASTER
- Combining Nadir & Backward looking image





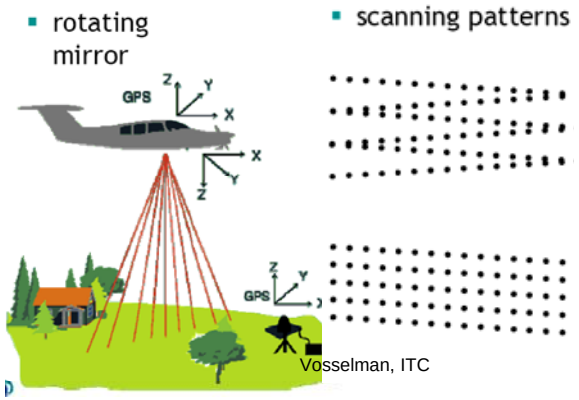
Stereo overlap

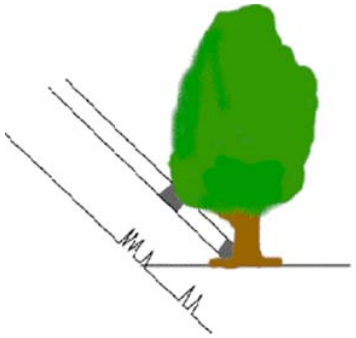
Air-borne Laser Scanning



LiDAR : Light Detection And Ranging

- **The laser scanner emits laser beams with a high frequency and collects the reflections.**
- **The laser-scanner records the time difference between the *emission* and *reflection*.**
- **Together with accurate information about the position and orientation of the air-plane during the flight, the elevation of the 'scanned' area is measured**
- **Reflection strength depends on terrain type and wavelength**
- **Multiple reflections possible: for instance on the vegetation and the ground**





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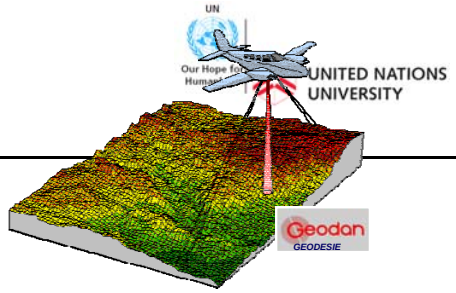
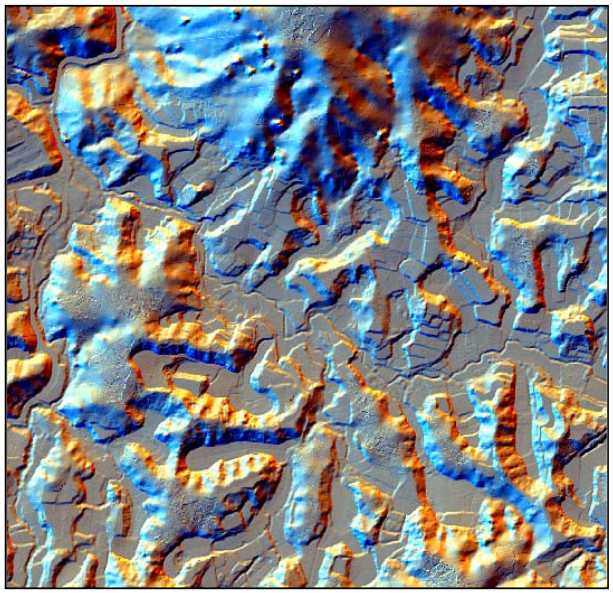
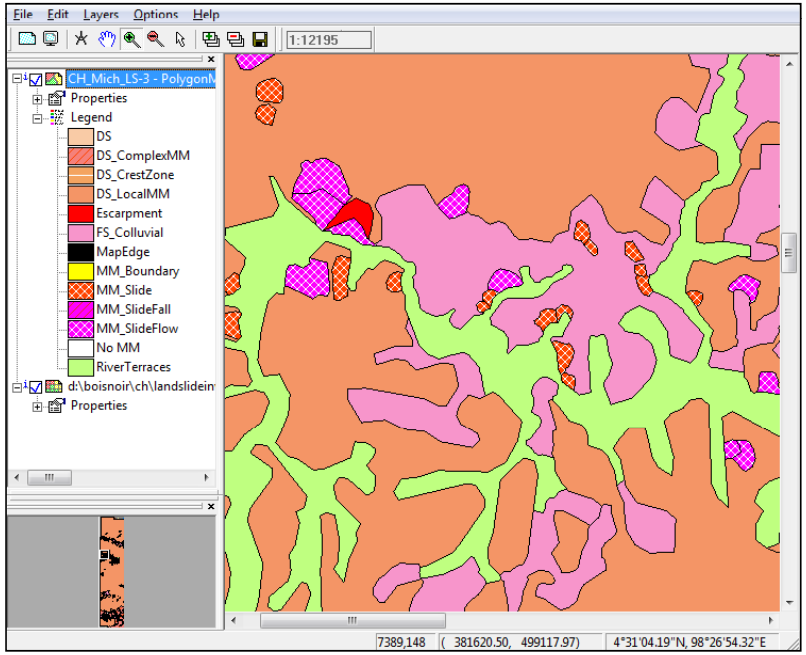


Interpretation of landslides

- Cameron Highlands, Malaysia



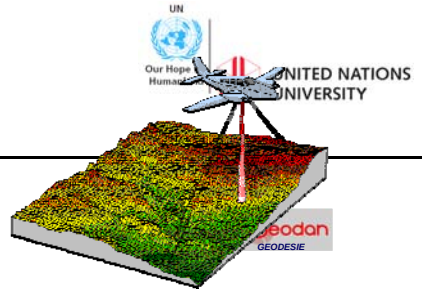


- **Lidar DEM with colour hill-shade in tea area. Vegetation filtered out**

Processing; Khamarrul Razak, ITC

Interpretation: Michiel Damen, ITC

Active RS Laser Scanning



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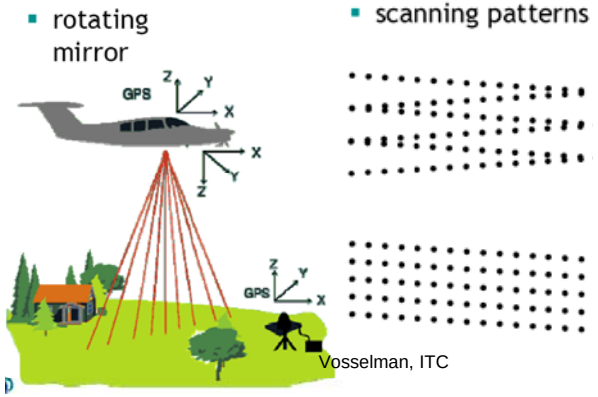

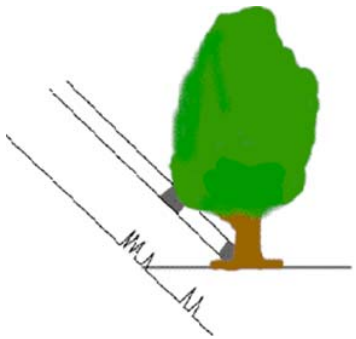

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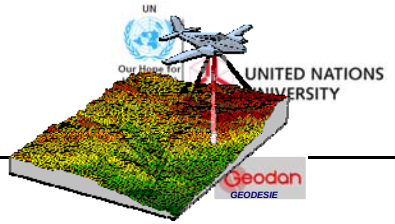
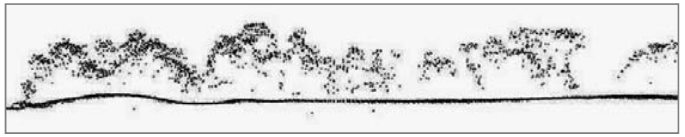
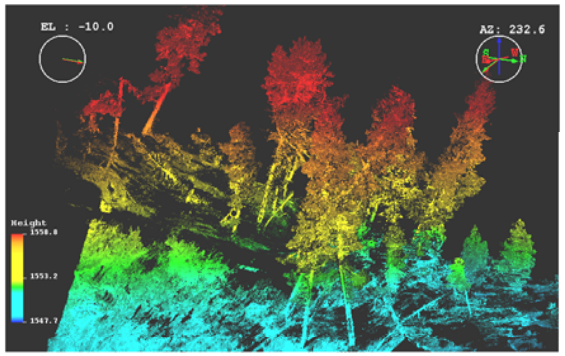


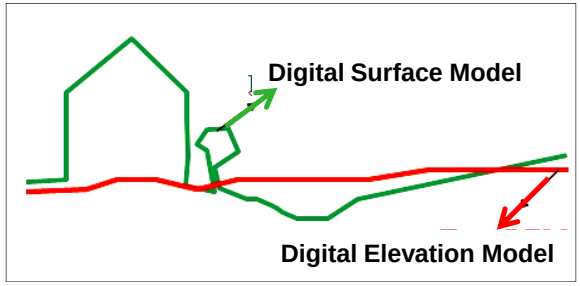
LiDAR : Light Detection And Ranging

- Multiple reflections possible: for instance on the vegetation and the ground
- Can be used for :
  - o biomass estimation and analysis of tree structure,



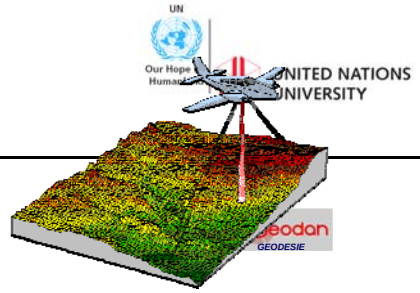


  - o determining height of houses



  - o filtering out of vegetation for (morphological) landslide mapping or
  - …..many more applications

Active RS : Laser Scanning



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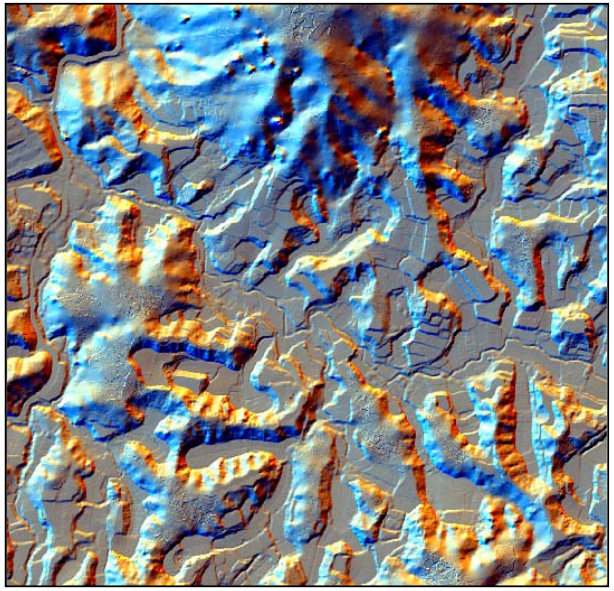

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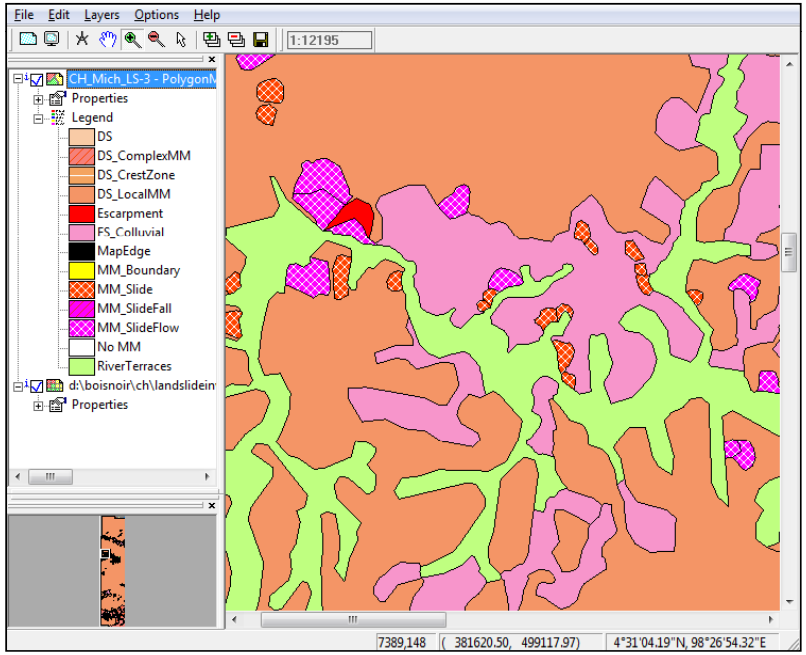

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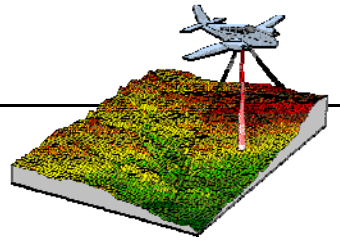
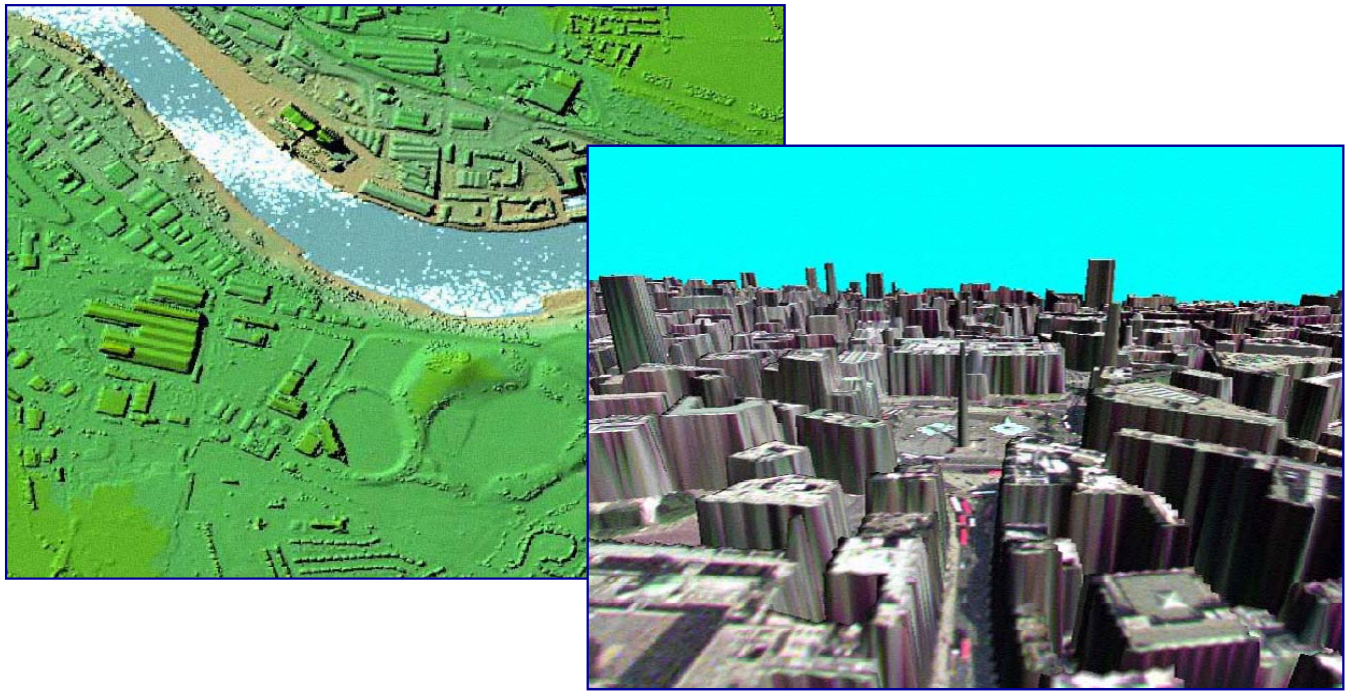
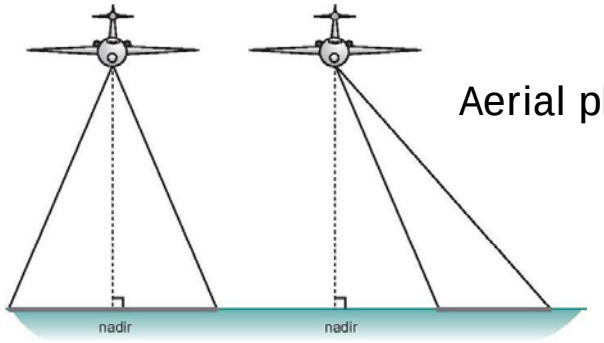


Examples of Digital Surface models

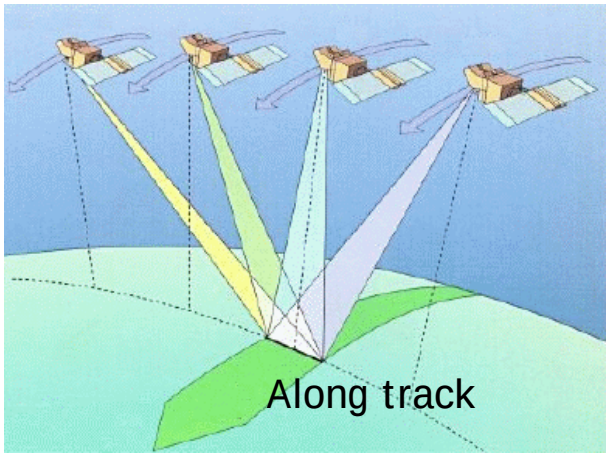
- River area
- Urban

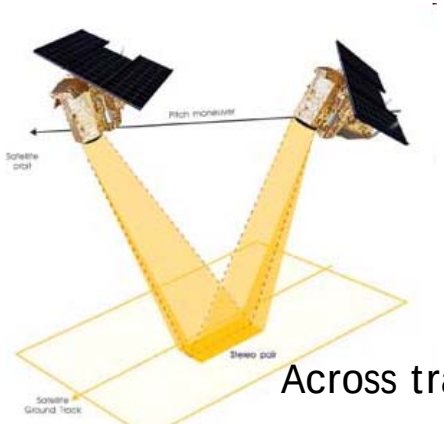


Stereoscopy (3) – remote sensors



Aerial photos





Across track

Airborne damage surveys

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Airborne Unmanned Vehicle

- High resolution orthophotos
- Digital elevation models