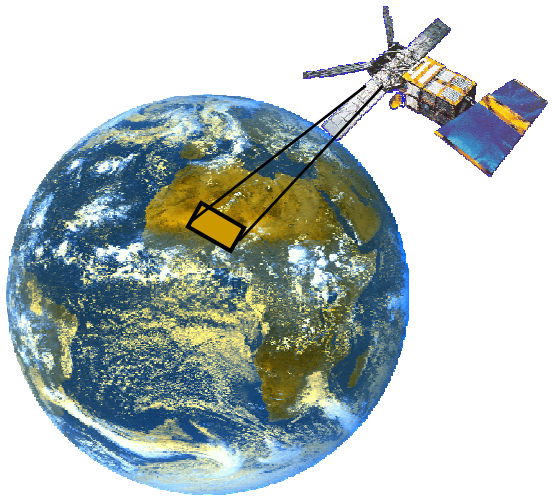
Remote Sensing for Epidemiological Studies

Joint ICTP-IAEA Conference on Predicting Disease Patterns According to Climate Changes
The Abdus Salam International Centre for Theoretical Physics
12-14 May 2008, Triest, Italy



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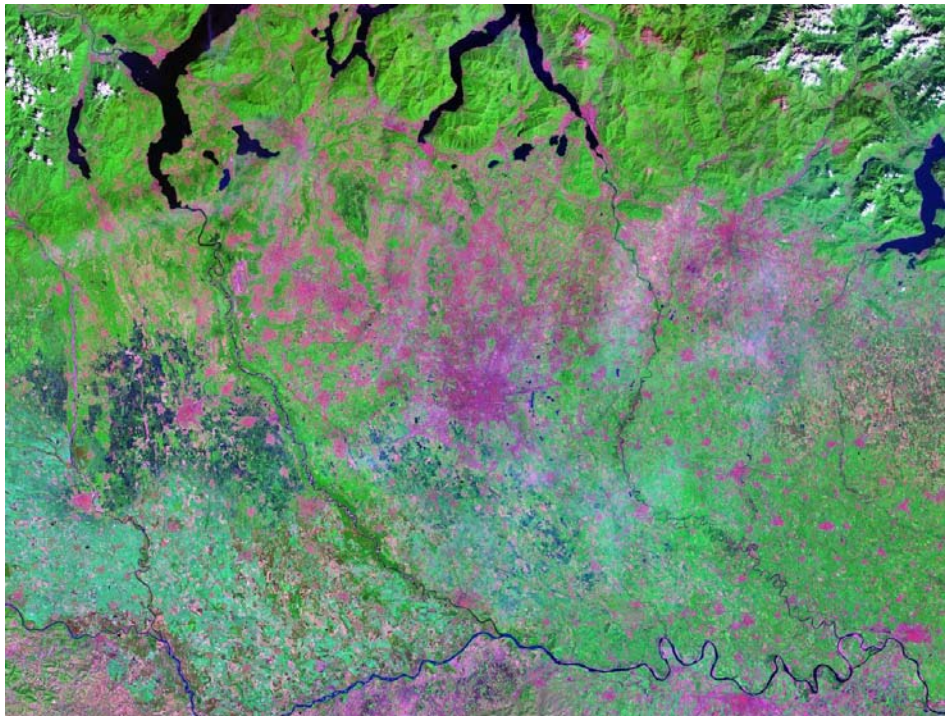
Satellite Pictures for Epidemiological Studies?

- Since 1972 Landsat satellites have delivered …



Thor-Delta rocket prepared to launch Landsat 1 on July 23, 1972. © NASA

Landsat Image of Milan & surroundings

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Conclusions from Two Recent Review Papers

- 187 articles dealing with RS and health issues, of which 68 (!) are reviews
  - Remote sensing techniques
    - Vegetation indices such as NDVI (~50 %)
    - Classification of land use for delimit vector habitat and breeding sites (~45 %)
    - Land surface temperature (~27 %)
  - Health applications
    - Parasistic diseases (~59 %)
      - incl. schistosomiasis, malaria, and trypanosoniasis
    - Viral diseases (~12 %)
      - surprisingly no studies on West-Nile virus, Niphan encephalities and avian influence
    - Bacterical diseases (~ 9 %)

Titles of Some Review Papers

- Remote sensing and human health: New sensors and new opportunities
  - Beck at al. (2000) Emerging Infectious Diseases, 6(3), 217-226
- Sizing up human health through remote sensing: uses and misuses
  - Herbreteau et al. (2005) Parassitologia, 47(1), 63-79
- Thirty years of use and improvement in remote sensing, applied to epidemiology: From early promises to lasting frustration
  - Herbreteau et al. (2007) Heath & Place, 400-403
- Surveillance of arthropod vector-borne infectious diseases using remote sensing techniques: A review
  - Kalluri et al. (2007) PLoS Pathogens, 3(10), 1361-1371

Noted Problems

- Costs of images
- Restricted availability of images
- Lack of spatial detail
- Technical nature of image processing
- Poor or missing interfaces to models

These problems are not unique to epidemiology

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Trends in Remote Sensing

- The gap between remote sensing and applications has (finally) been recognised as a problem by politicians
- Efforts to produce user-tailored information products from remote sensing
  - Level 0: Sensor raw data
  - Level 1: Calibrated, georeferenced sensor measurements

  - Level 2: Georeferenced geophysical products
    - Land cover, leaf area index, soil moisture, water dynamics, etc.
  - Level 3: Multi-source geophyiscal products
- European initiatives
  - Global Monitoring for Environment and Security (GMES)
  - EUMETSAT Satellite Application Facilities (SAFs)

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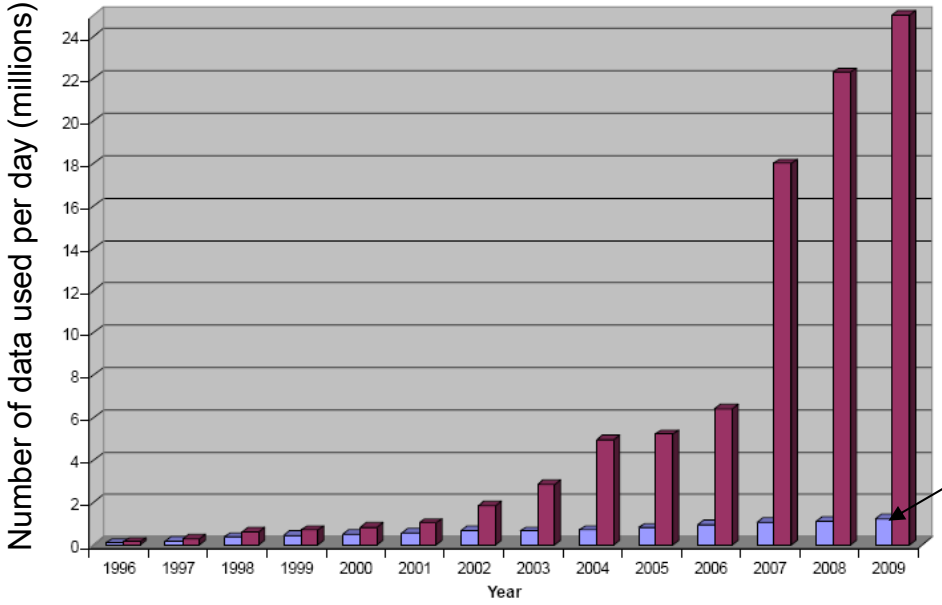
Data Assimiliation

- It is hardly every possible to simply *"plug in and play"*
- Use of remote sensing data in models requires in general
  - Adaptation of models (improvements of physical functions)
  - Data assimilation techniques
- Numerical Weather Prediction (NWP): leads the field



Quantity of satellite data used at the European Centre for Medium-range Weather Forecasts (ECMWF)

Conventional data

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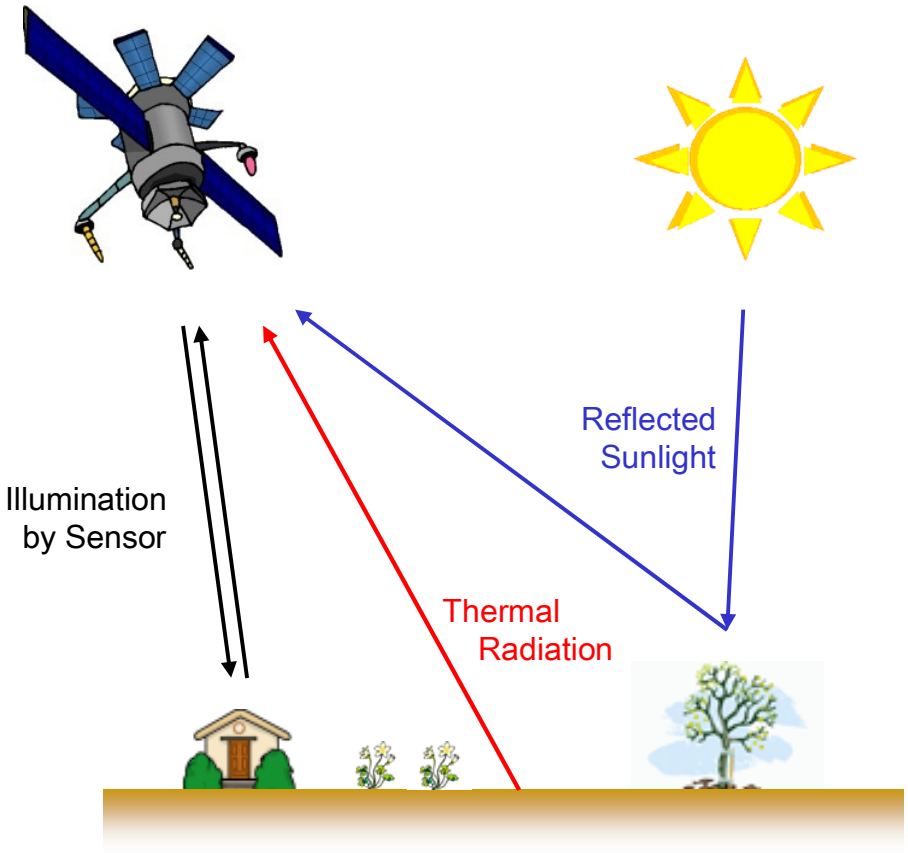
Suggested Way Foreward

- Kalluri et al. (2007):
  - "Applications of remote sensing data in epidemiology involves retrieving environmental variables that characterise the vector ecosystem such as land cover, temperature, humidity or vapor pressure, and precipitation."

- Health studies should use existing Level 2 or Level 3 remote sensing products
  - Concentrate on physical processes and vector/disease behaviour
  - Cooperation with remote sensing experts is necessary for developing the model interfaces

Remote Sensing Techniques



Digital photo without flash light

Digital photo with flash light

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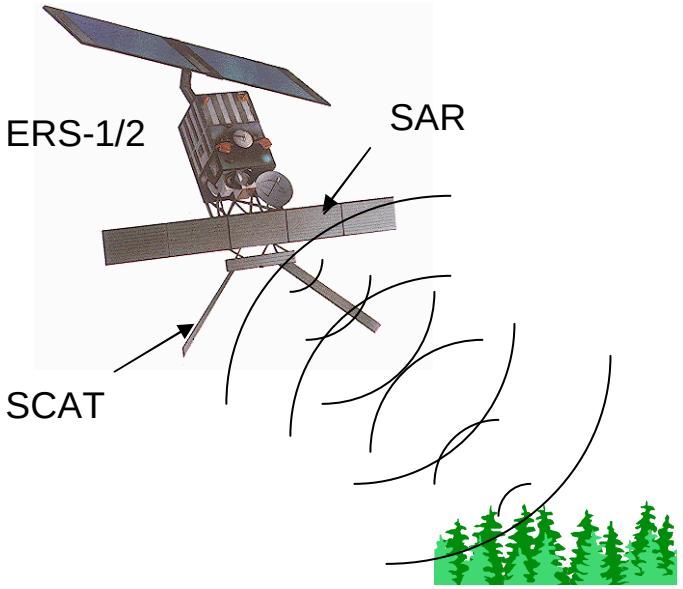
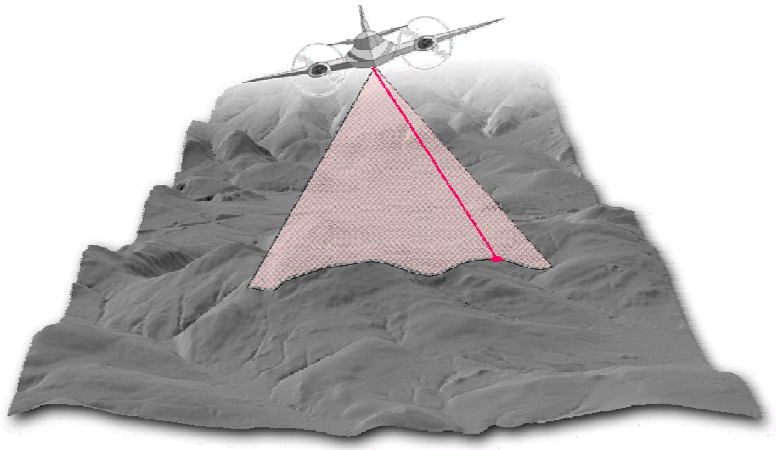
Active Remote Sensing Techniques

- Operations in the optical and microwave regions of the electromagnetic spectrum
  - Lidar = Light Detection and Ranging (λ = 0.8 – 1.55 μm)
  - Radar = Radio Detection and Ranging (λ = 1 – 20 cm)
- Major differences between the two wavelength regions
  - Microwaves can penetrate clouds, fog, etc.
  - Beam is much broader in the case of radars compared to lidar (factor ~10^5)
  - Target size >> lidar wavelength
  - Microwaves are very sensitive to water content of targets

Laser and Radar Techniques

- **Spaceborne Radar**
  - Monitoring of dynamic, large-scale phenomena
  - Side-looking for image formation
- **Airborne Laser Scanning**
  - Mapping of relatively static land surface objects
  - Scanning of laser pulses across the flight line





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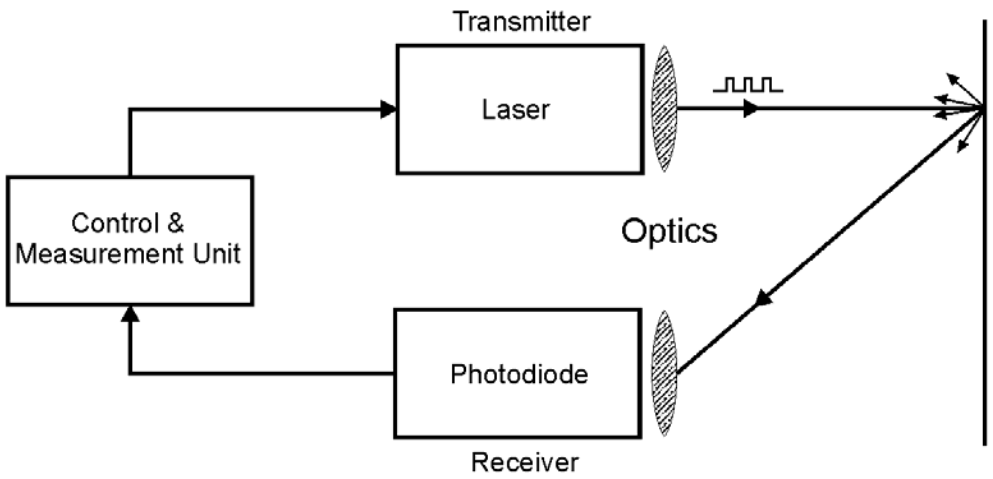
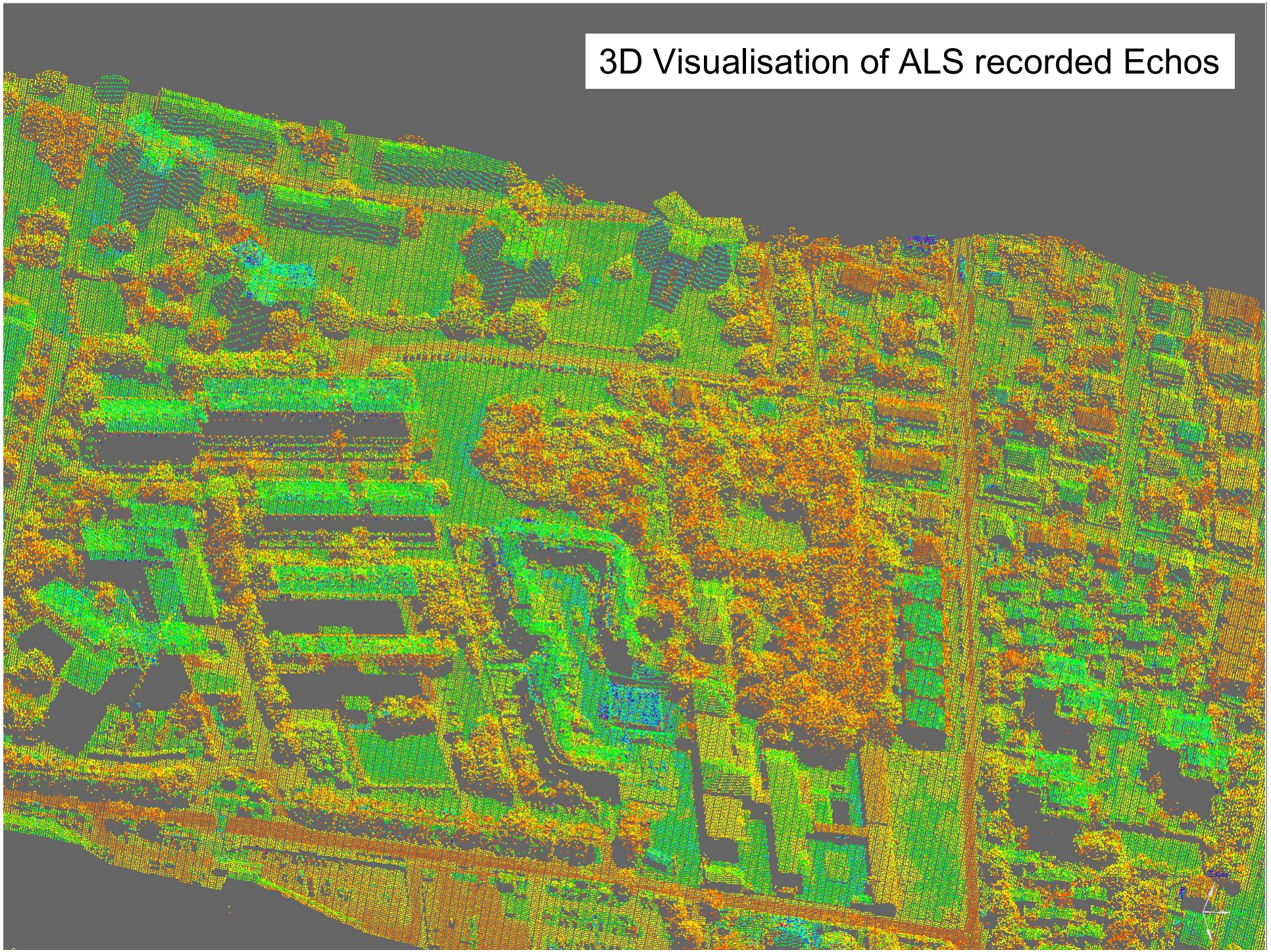
Basic Laser Scanner Operation

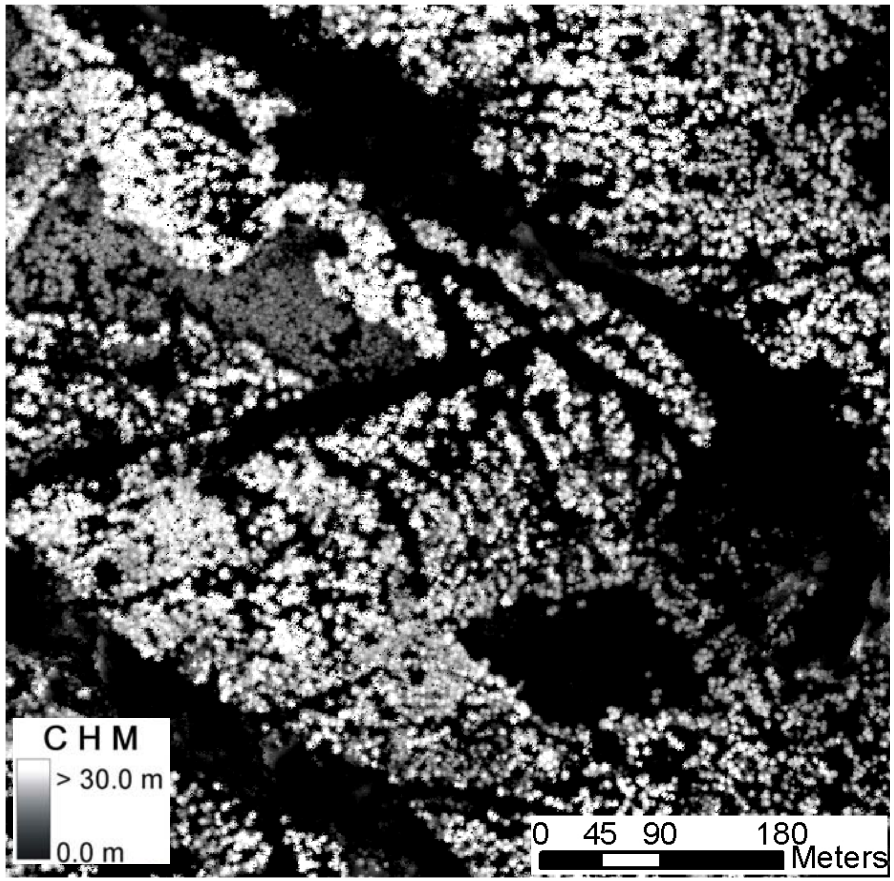


Components of a laser scanner system

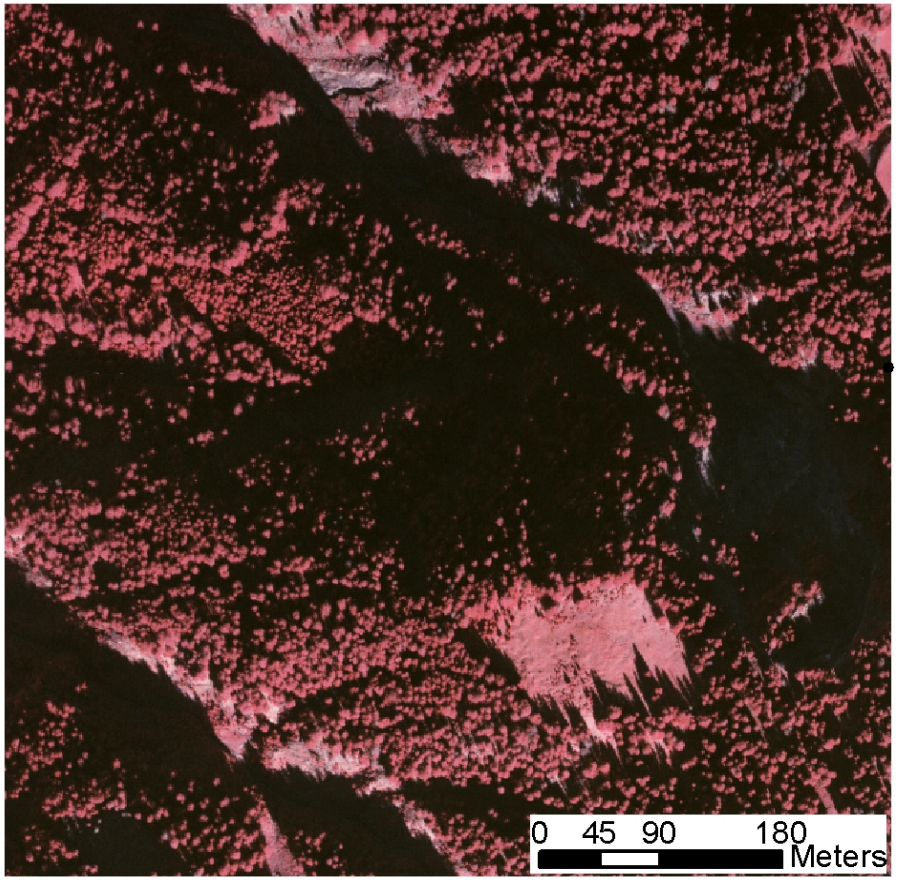
- Subsystems of a laser scanner
  1. Transmitter: pulsed laser
  2. Transmitter optics: small beam divergence and expanded beam diameter
  3. Receiver optics
  4. Detector: Photodiode
  5. Scan mechanism: rotating mirror or glass fibers
  6. Electronic system for data processing, storage, etc.


3D Visualisation of ALS recorded Echos

Canopy Height Model



Orthophoto



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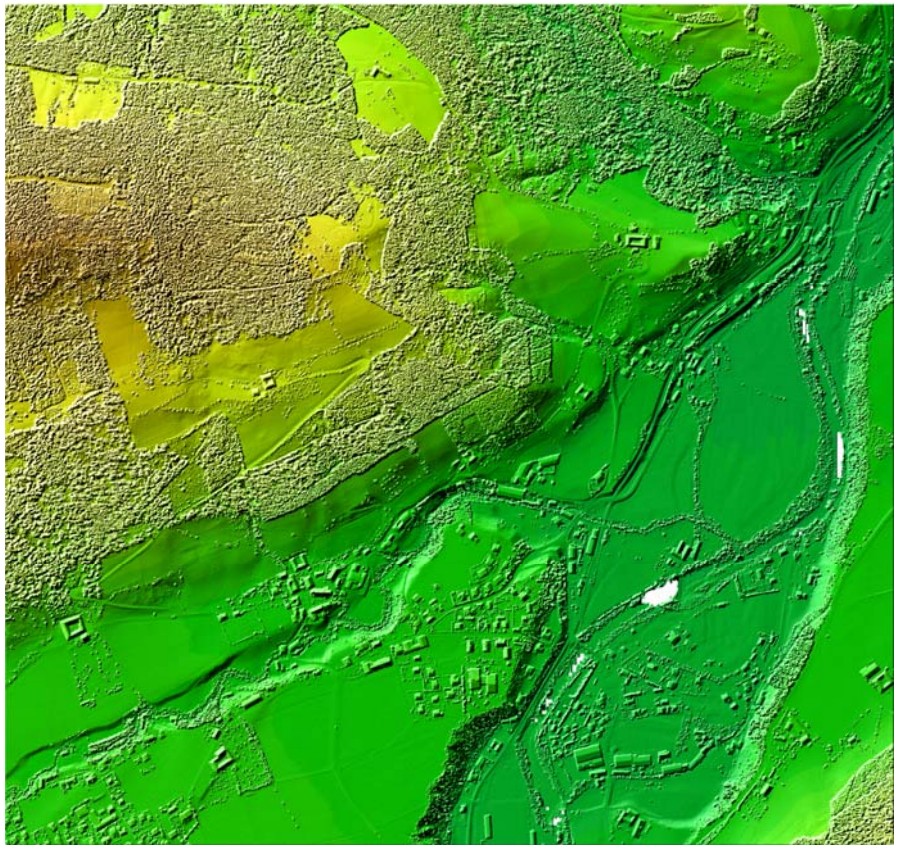
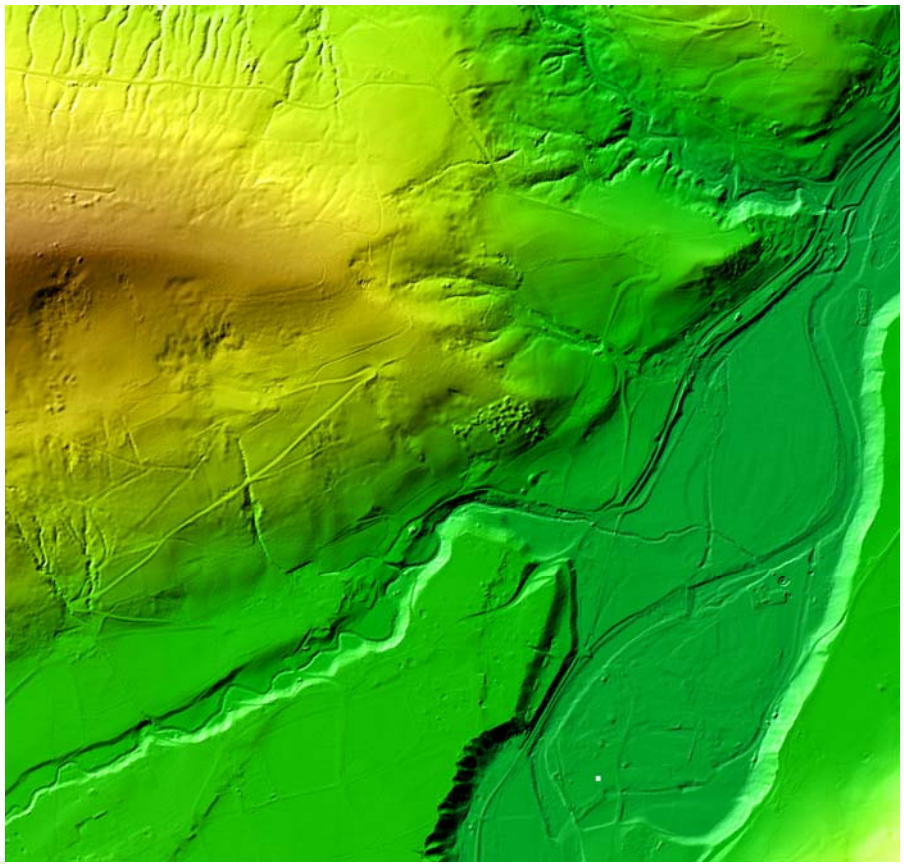
Terrain Models from Airborne Lidar Systems





OÖ Landesregierung
Almtal

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Stem Volume

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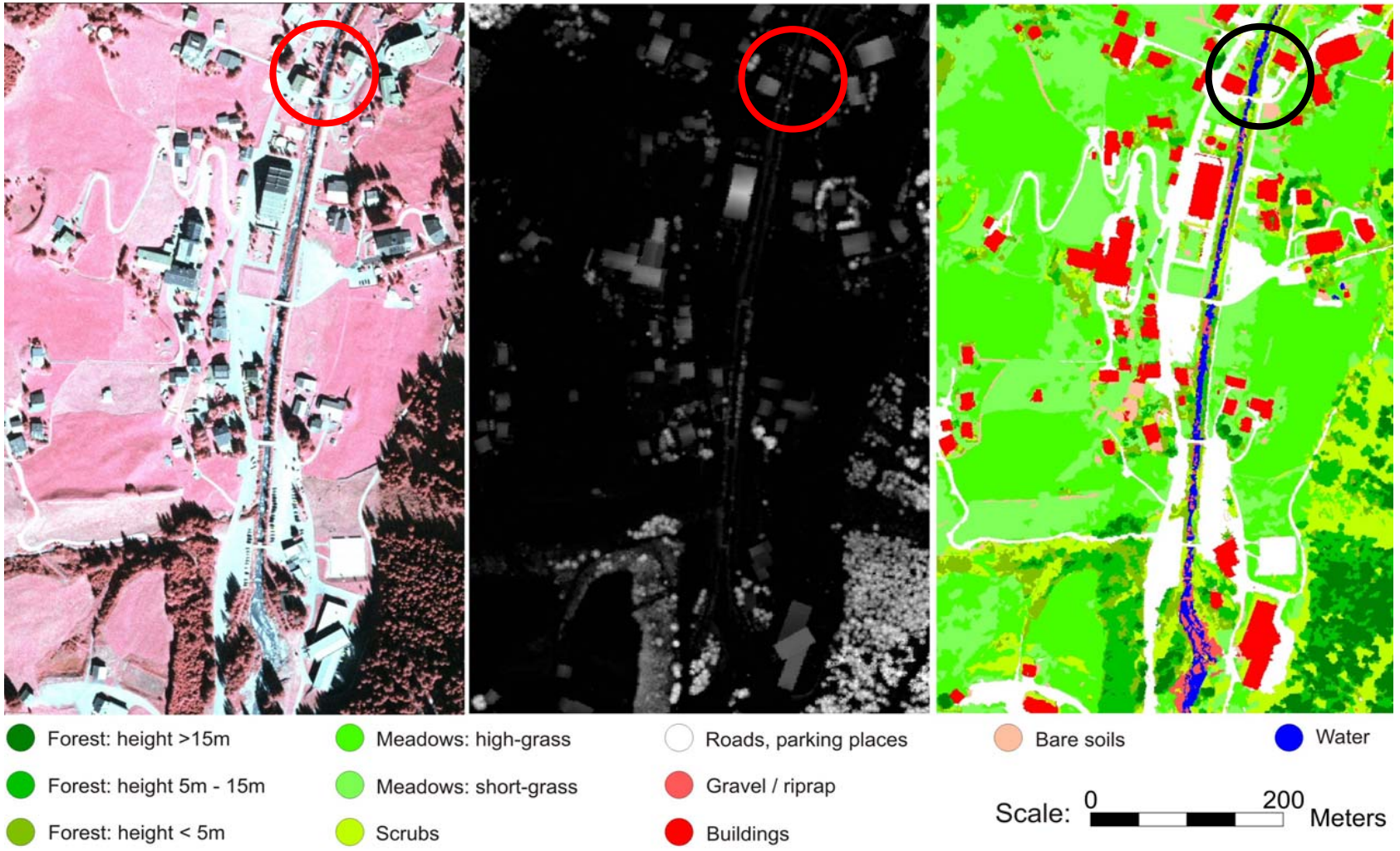
Land Cover Classification



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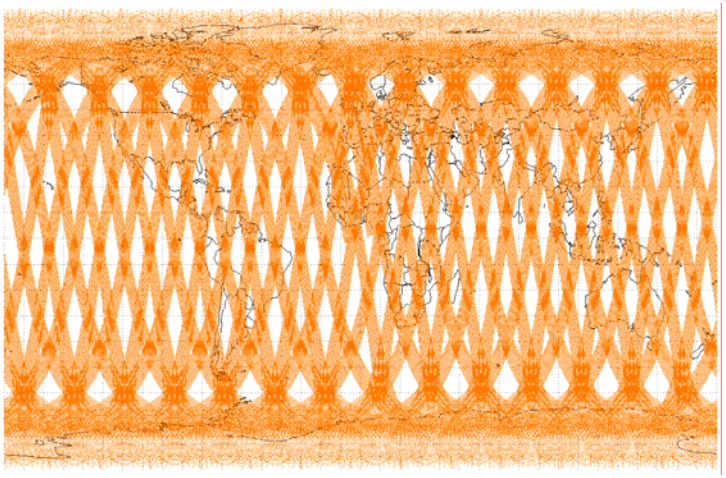
Radar Satellites - METOP

- Metop-A was launched 19 October 2006 from Baikonur Cosmodrome

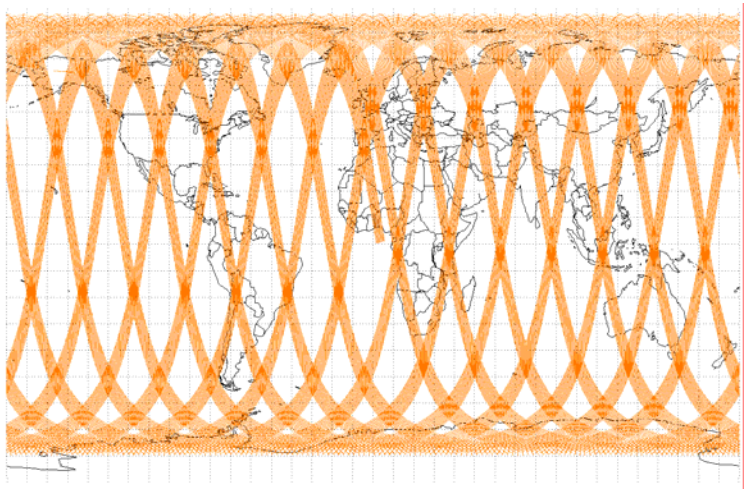
METOP Display at EUMETSAT in Darmstadt

Soyuz launch vehicle of METOP

Daily Global Coverage



- METOP ASCAT
  - 2 swath with each 500 km
  - 25 km resolution
  - 100 % duty cycle
  - 82 % daily global coverage



- ENVISAT ASAR Global Monitoring Mode
  - 405 km swath
  - 1 km resolution
  - Potentially 100 % duty cycle

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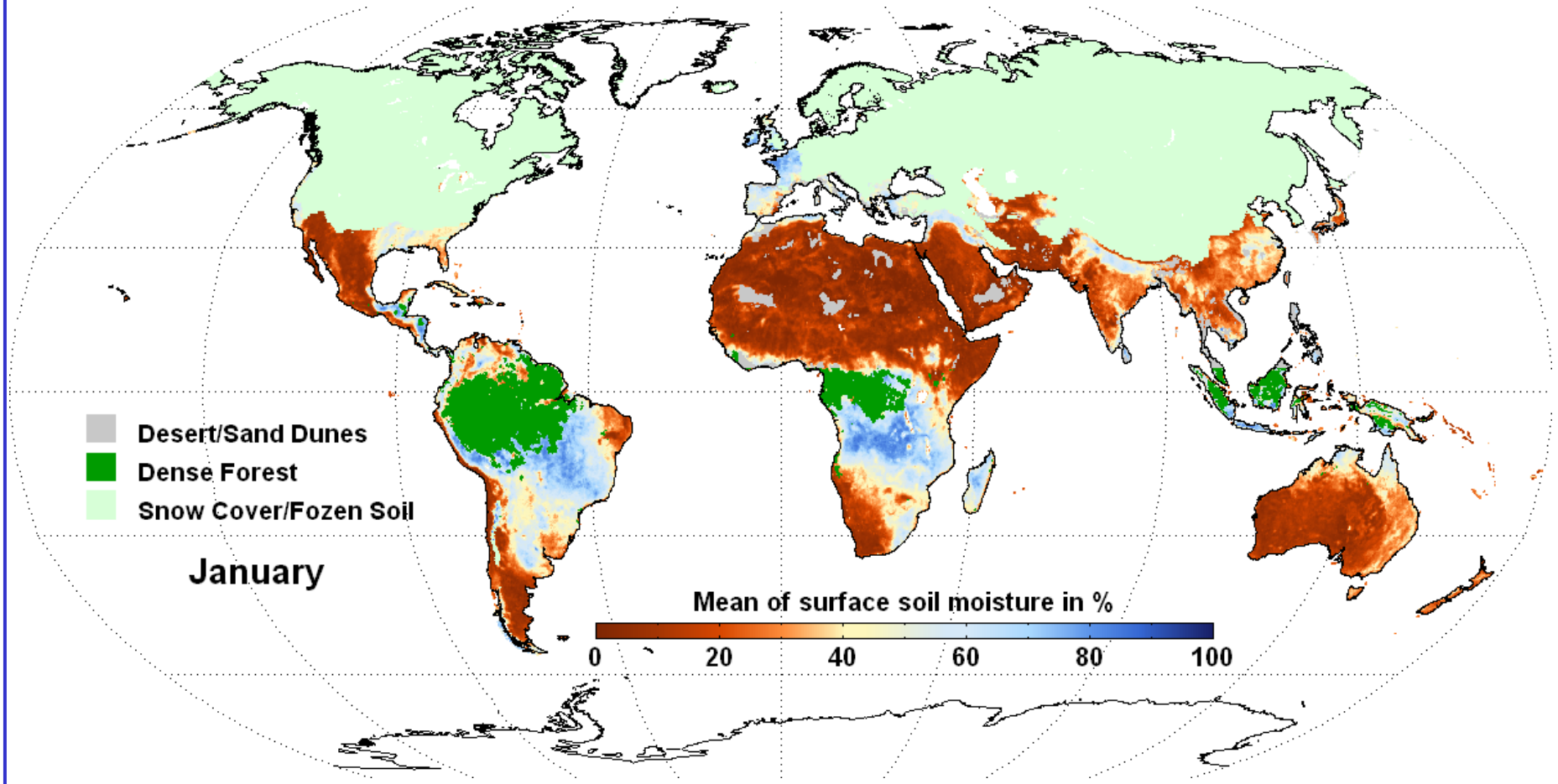
Soil Moisture Dynamics from ERS-1/2 SCAT



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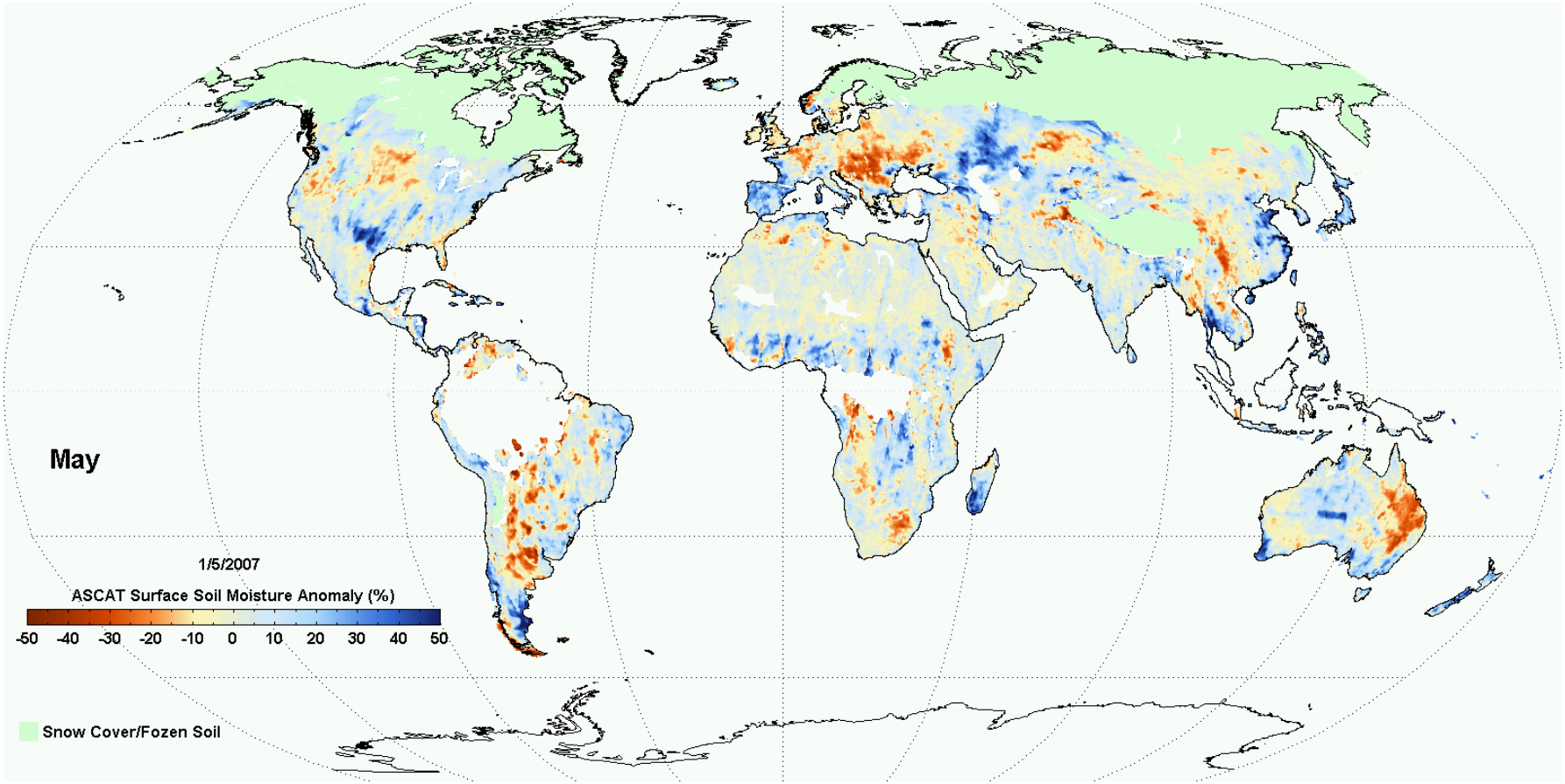
METOP ASCAT Daily Soil Moisture Anomalies



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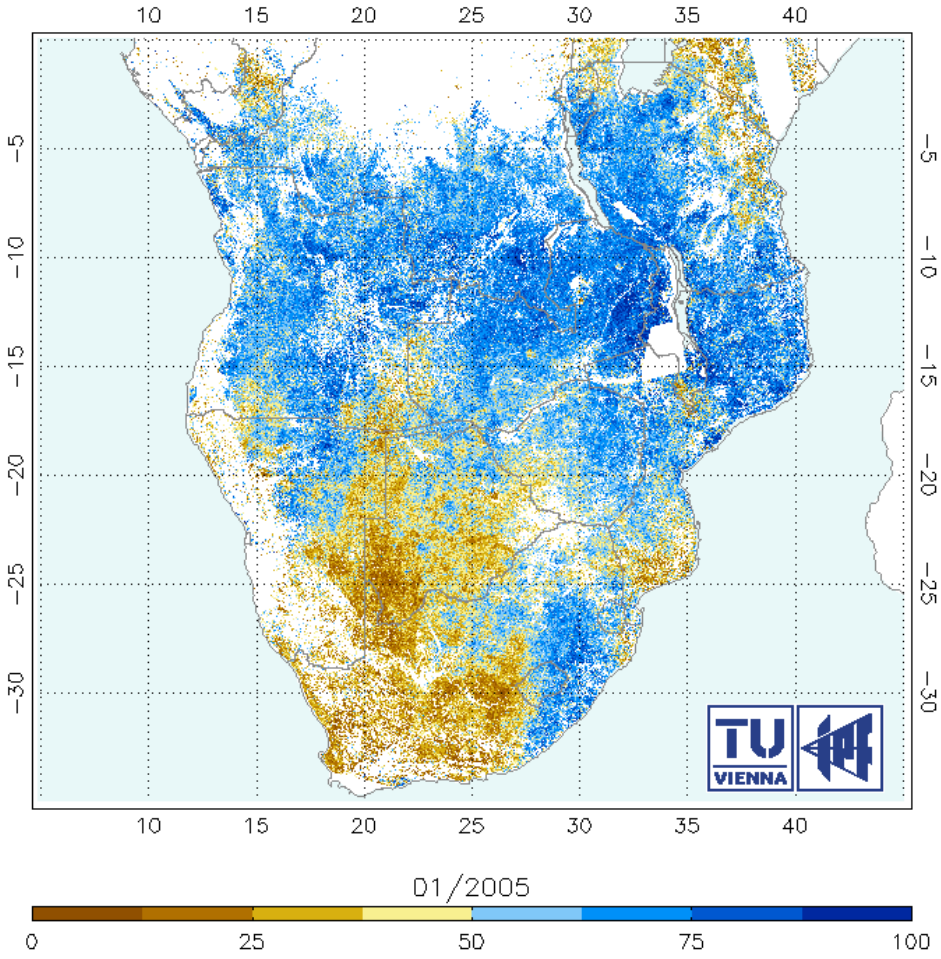
SHARE

Soil Moisture for Hydrometeorologic Applications in the SADC region

TIGER

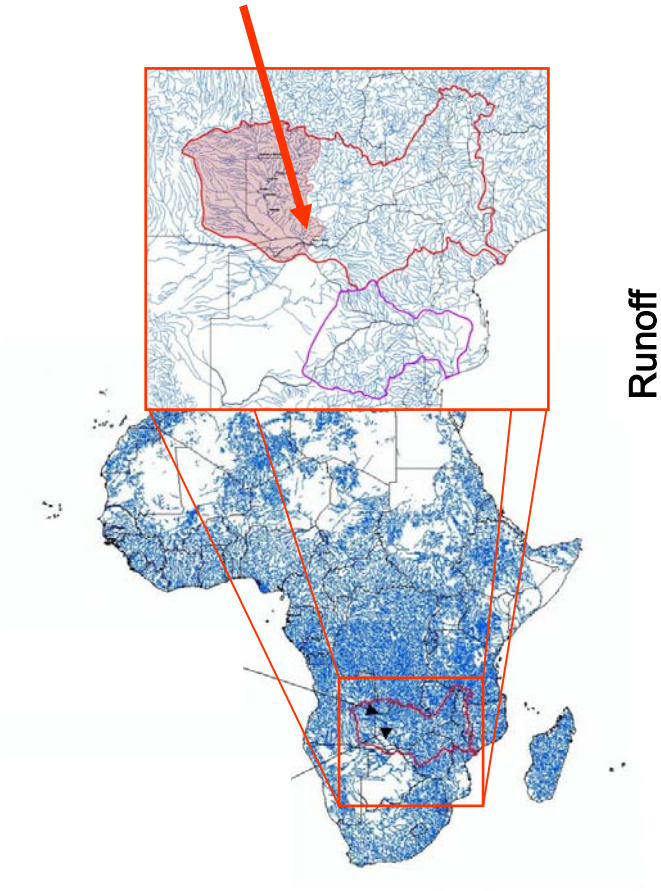
Soil Moisture from ENVISAT ASAR



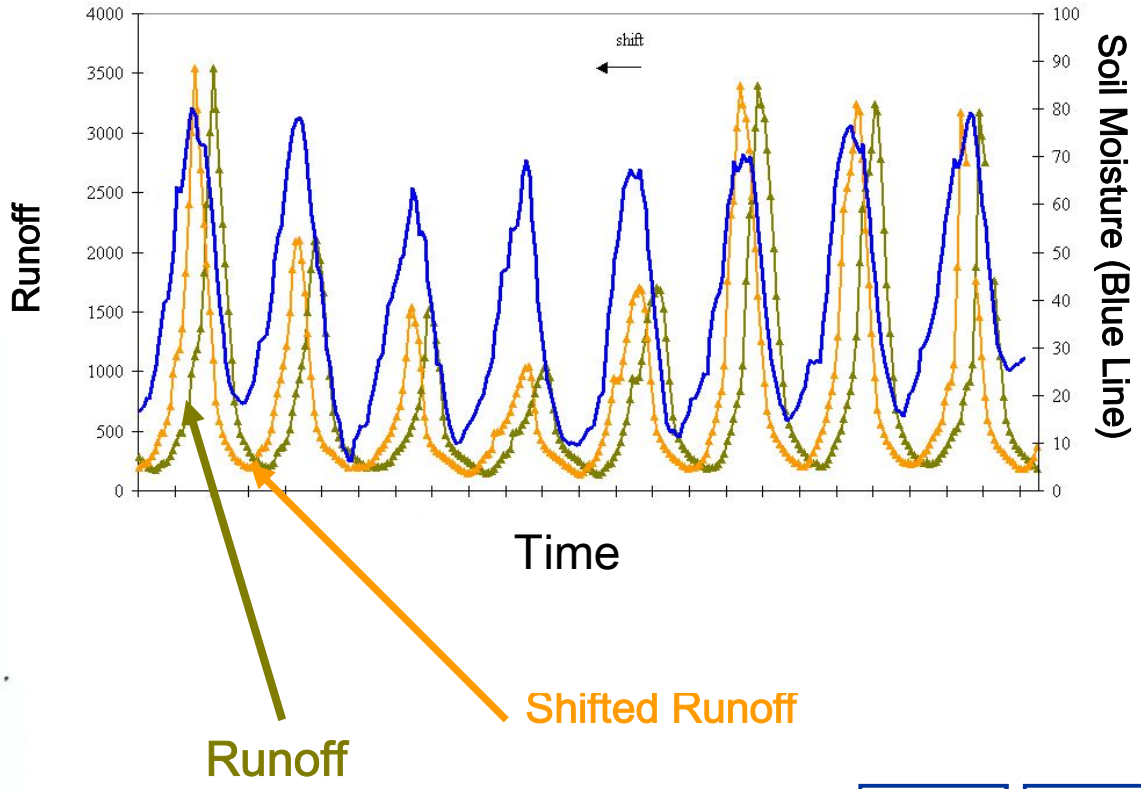
TU WIEN

SCAT Soil Moisture verus River Runoff

Sambesi – Nana‘s Farm



60 days shift



Scipal et al. (2005) *Hydrology and Earth System Sciences*

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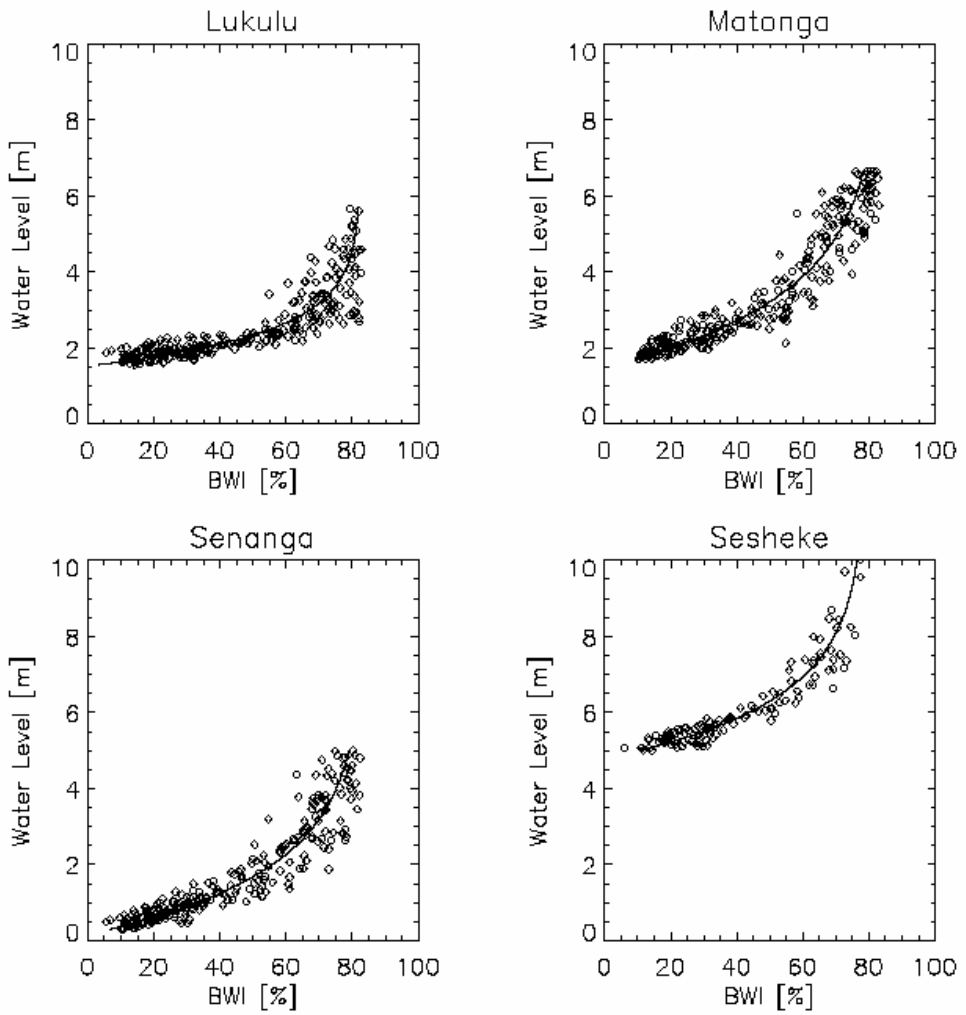
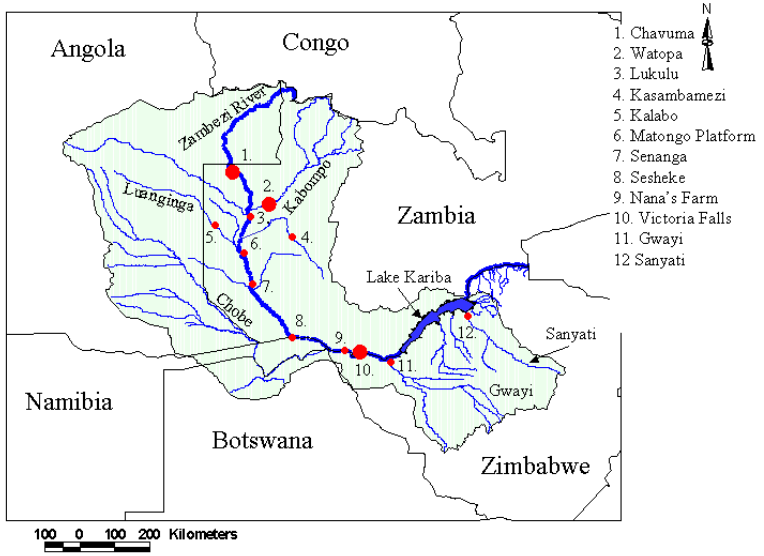
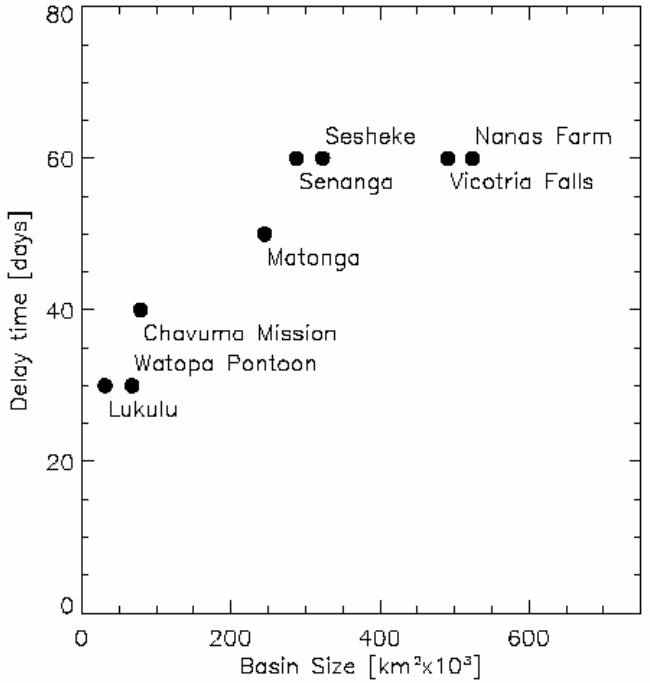
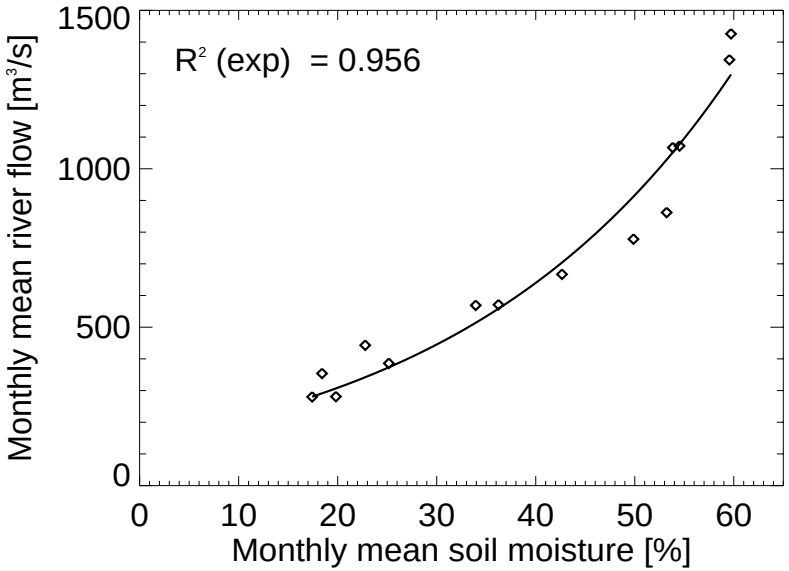
Time Shift and Catchment Size

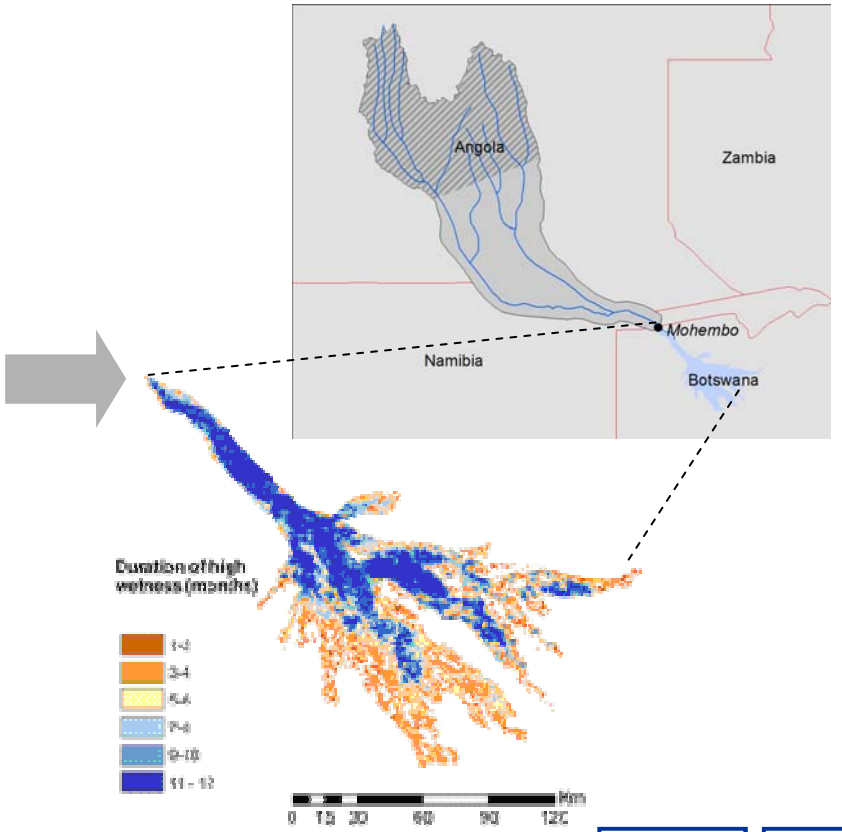






ASAR GM Soil Moisture and Runoff Okavango





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Conclusions

- Remote sensing is more than satellite pictures …
- Remote sensing provides observations for
  - environmental monitoring
  - validating and improving models
  - data assimilation
- Epidemiology should use value-added satellite products which become increasingly available (Level 2/3)

- European Space Agency is open towards new user communities
  - Definition of projects by dedicated users
  - Project idea: „Remote sensing in support to predicting blue-tongue disease patterns“

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