Building capacities for evolving geospatial needs in Myanmar

Evolution of Geospatial Science and Technology

Implications for education

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University of Twente

ITC

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MIMU

Myanmar Information Management Unit

CONTENT

- ITC – who are we?
- A brief history of GIS systems
- Developments in Spatial Sciences
- From cartography to multidisciplinarity
- Drivers of developments
- There is good news and bad news
- Towards criteria for a specialists in spatial analysis

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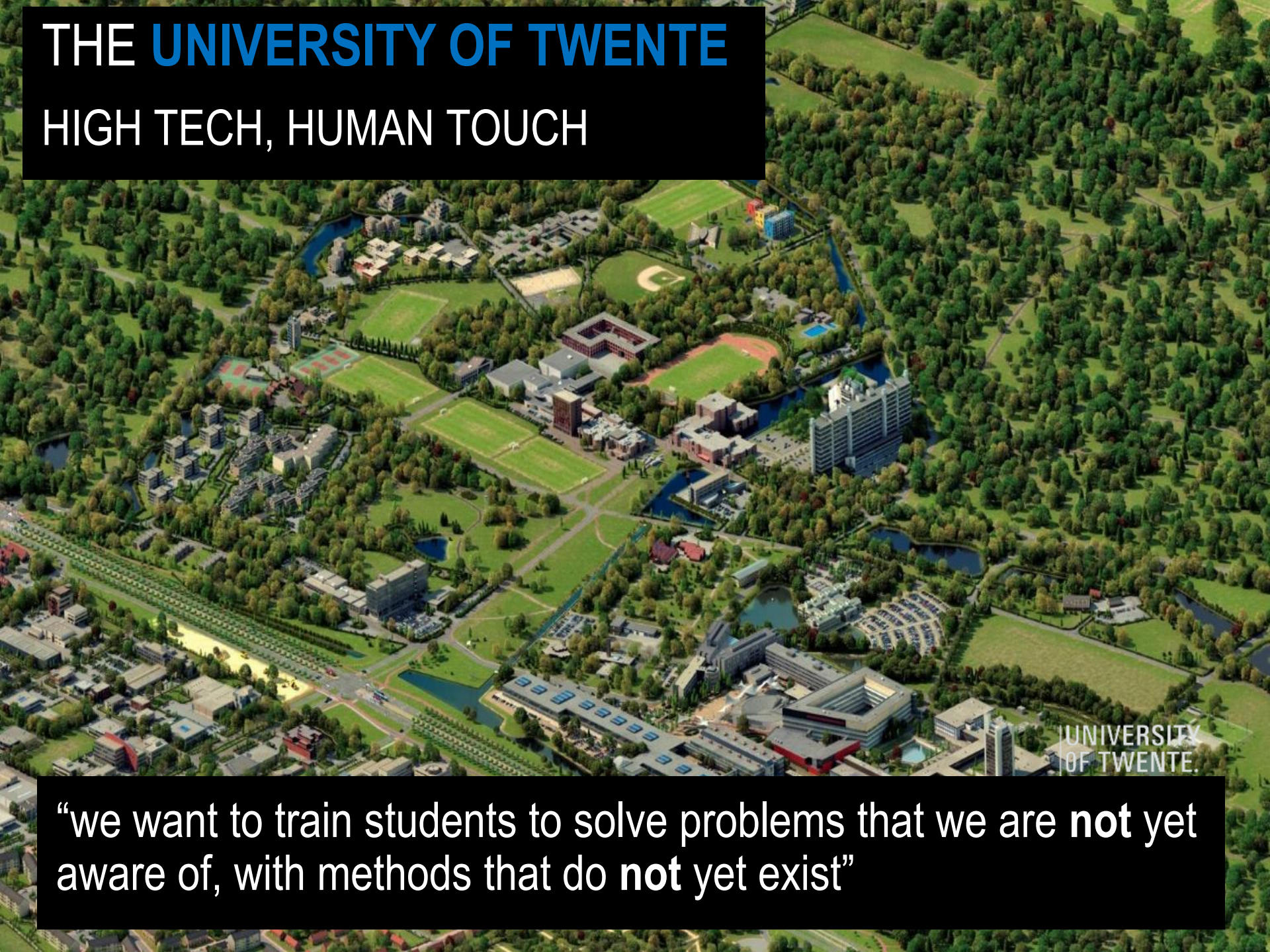
HIGH TECH, HUMAN TOUCH



"we want to train students to solve problems that we are **not** yet aware of, with methods that do **not** yet exist"

ITC - FACULTY OF GEOINFORMATION SCIENCE AND EARTH OBSERVATION

Every year ~700 students from 55+ nationalities enroll in different types of education

Nr 6 in world ranking on earth observation education

ITC's Mission
Capacity development through education and research

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GIS - A SHORT HISTORY OF SYSTEMS

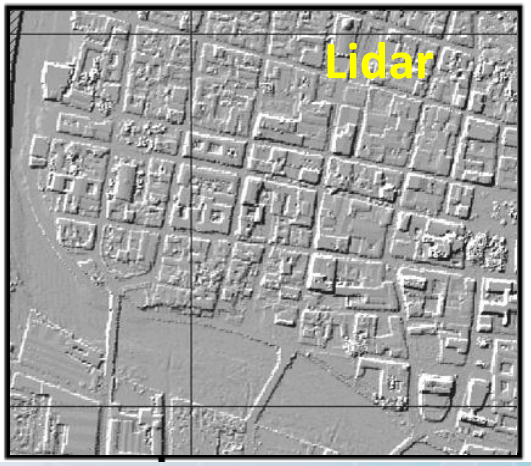
- 60-ties: First operational system in Canada CGIS (not public domain)
- 70-ties: Public domain systems: GRASS, MOSS, CAD drawing platforms, military sponsored systems
- 80-ties: Commercial: ARC/INFO by Environmental Systems Research Institute (ESRI), MapInfo Corporation and ERDAS (Earth Resource Data Analysis System)
- 90-ties: Mainstream, ArcGIS is gradually replacing locally developed systems in public services and cities (in the Netherlands)
- 2000 and beyond: science community driven developments:
  - Open-source Quantum GIS (QGIS), includes GRASS and SAGA
  - specialized freeware: GDAL for format conversion, spatial modelling software (e.g. PCRaster), Geostat software, OBIA software, Radar and Lidar apps
  - Dedicated tools based on GIS: various Spatial Decision Support Systems or e.g. Early Warning Flood Systems, webGIS
- 2004 and beyond: Google Earth (2004), Google Maps, Open Street Map (2004)
- NOTE: parallel development in Medical Sciences for image analysis: spectral analysis and pattern recognition software

THREE DEVELOPMENTS IN SPATIAL SCIENCES

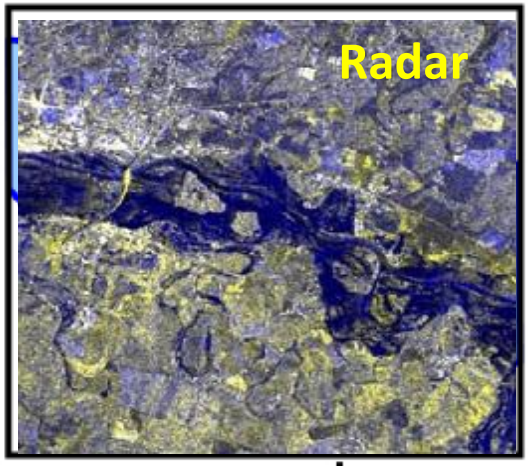
- **GIS** is about storage/retrieval and spatial analysis of vector and raster data, increasingly about communication
- **Remote Sensing/Earth Observation**: provides much of the data and information, airborne and space borne platforms
  - development driven by space industry and societal needs
- **Spatial statistics and analytics:**
  - Interpolation: spatial data from point observations
  - Complexity of data: multivariate spatial statistics evolving in to machine learning

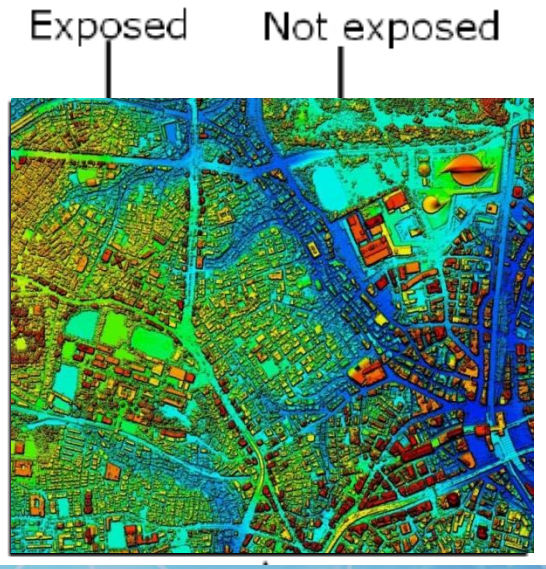
GIS EXAMPLE: EXPOSURE TO FLOODING

Elements at risk:
Building footprint



Hazard:
Hazard footprint





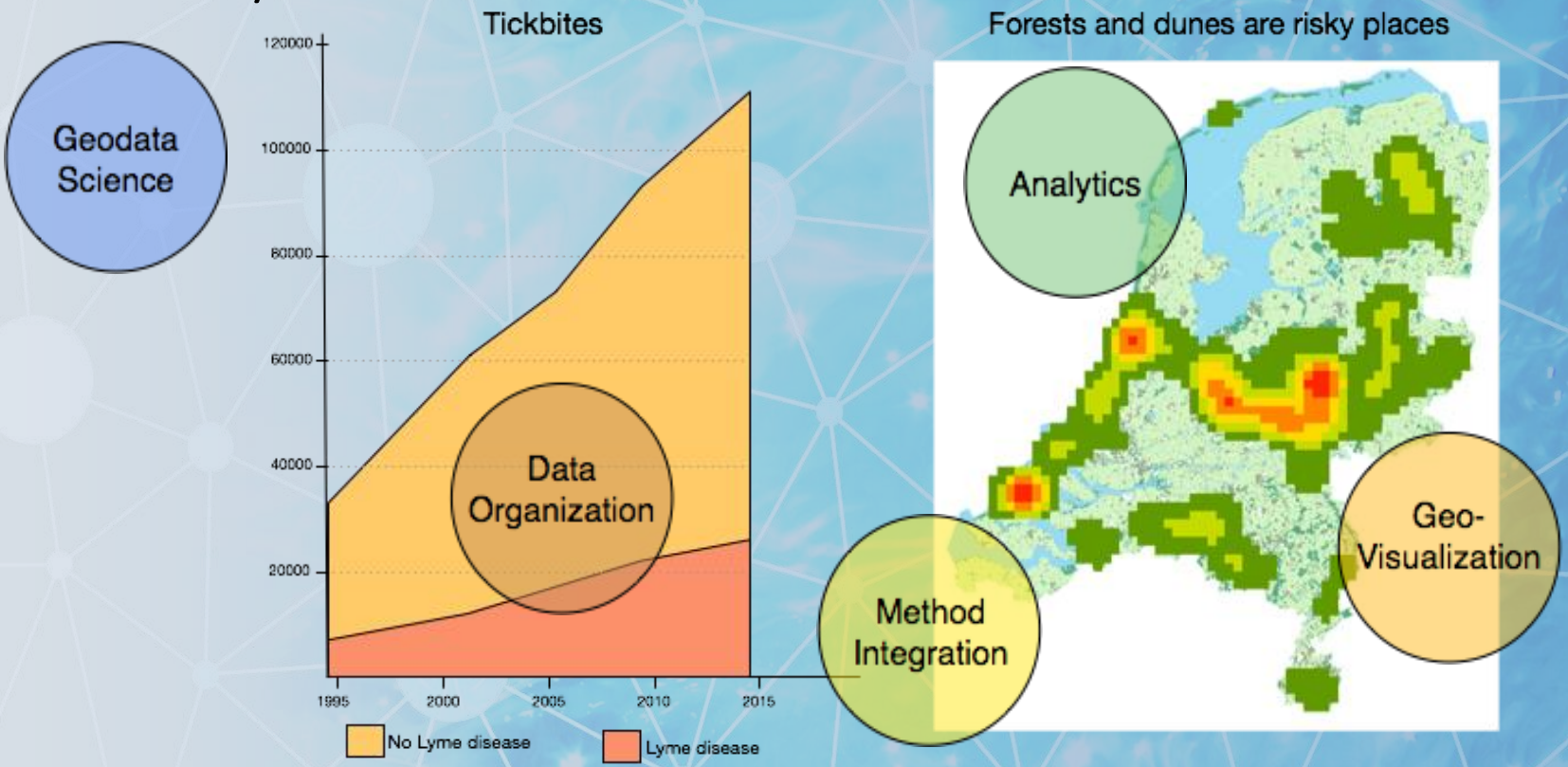
- High res imagery
- LIDAR
- UAV
- open street map

- GIS/DEM operations
- Radar images
- Community based mapping
- Spatial Modelling

Vulnerability
- Structure info (damage curves)
- Community based info
- Spatial multicriteria analysis

GIS: COMPLEX ANALYSIS AND VISUALISATION

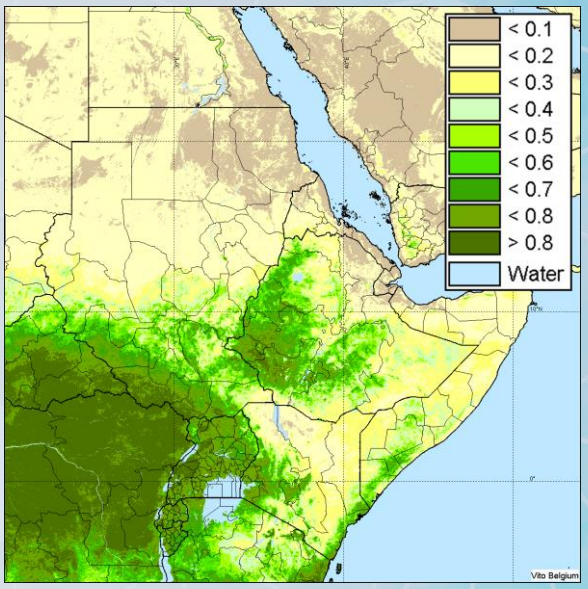
Increase of Lyme disease in the Netherlands



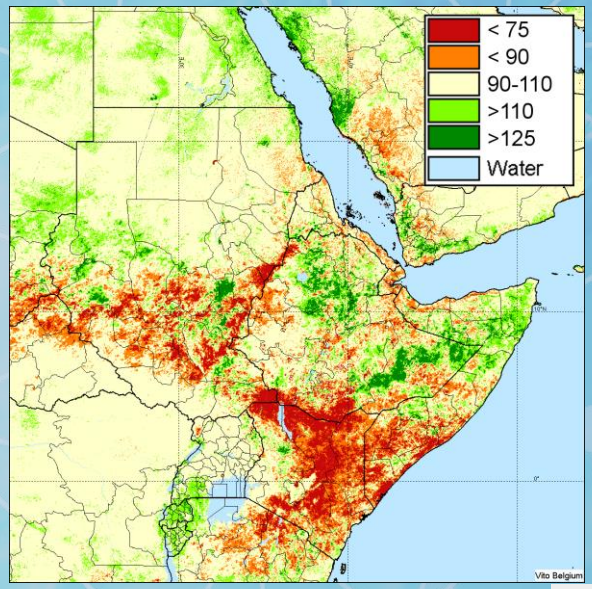
Source: Kraak et al, 2017

EARTH OBSERVATION: NDVI & FOOD SECURITY

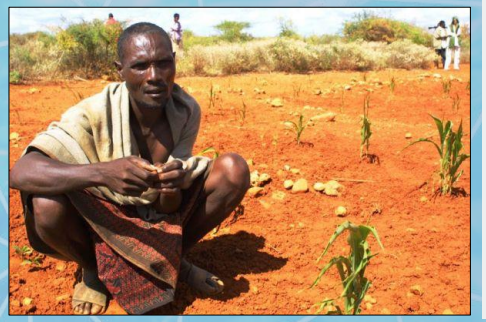
NDVI June 2011

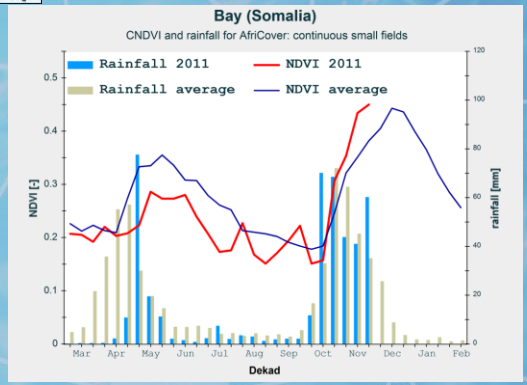


vs. mean('98-2010)



Ground truth:
Results are better if checked with ground and meteo information by Agricultural experts





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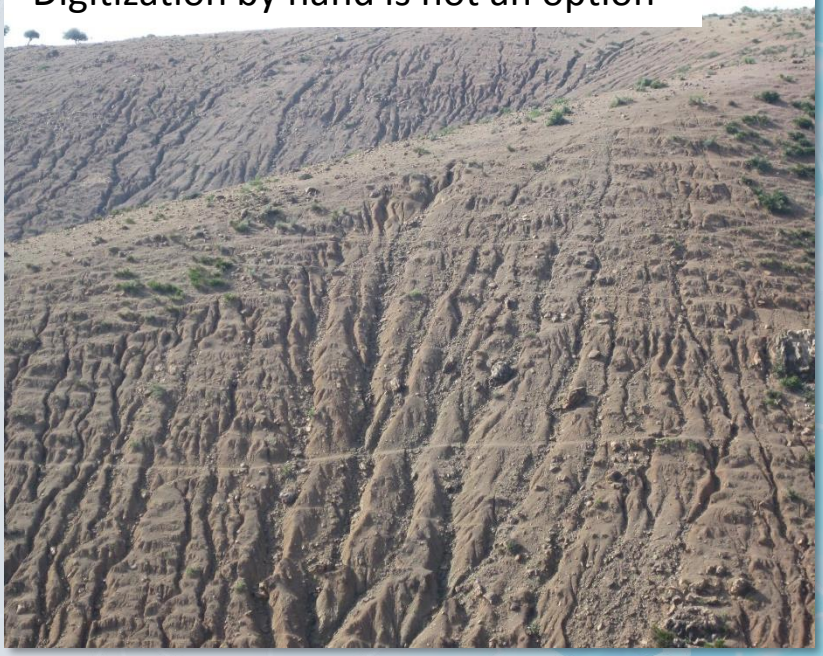
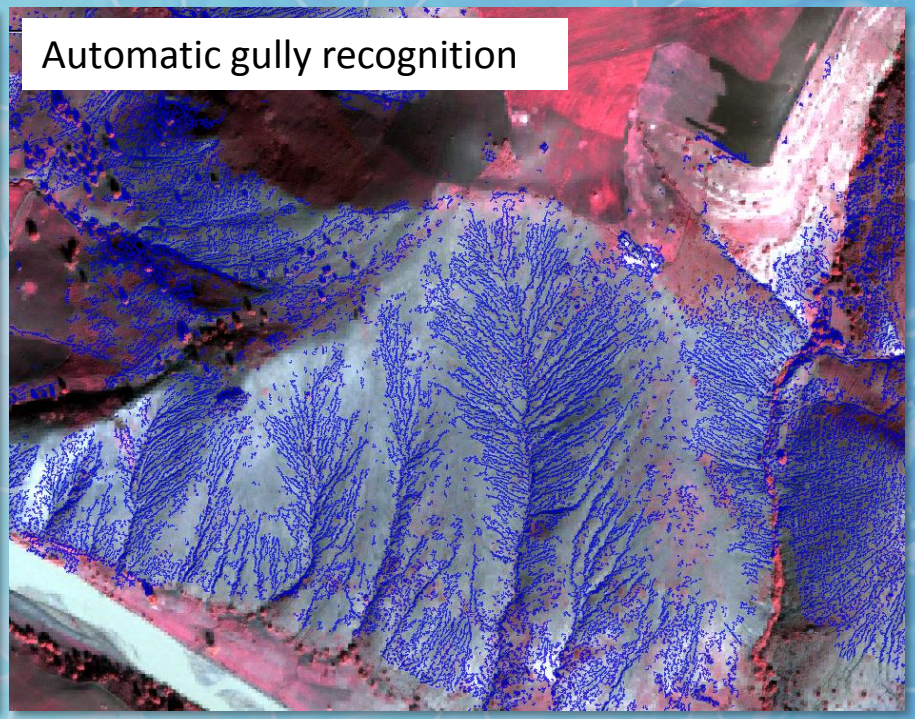
Source: Vrieling et al, 2016

OBJECT ORIENTED ANALYSIS OF VERY HIGH RES IMG

Digitization by hand is not an option



Automatic gully recognition

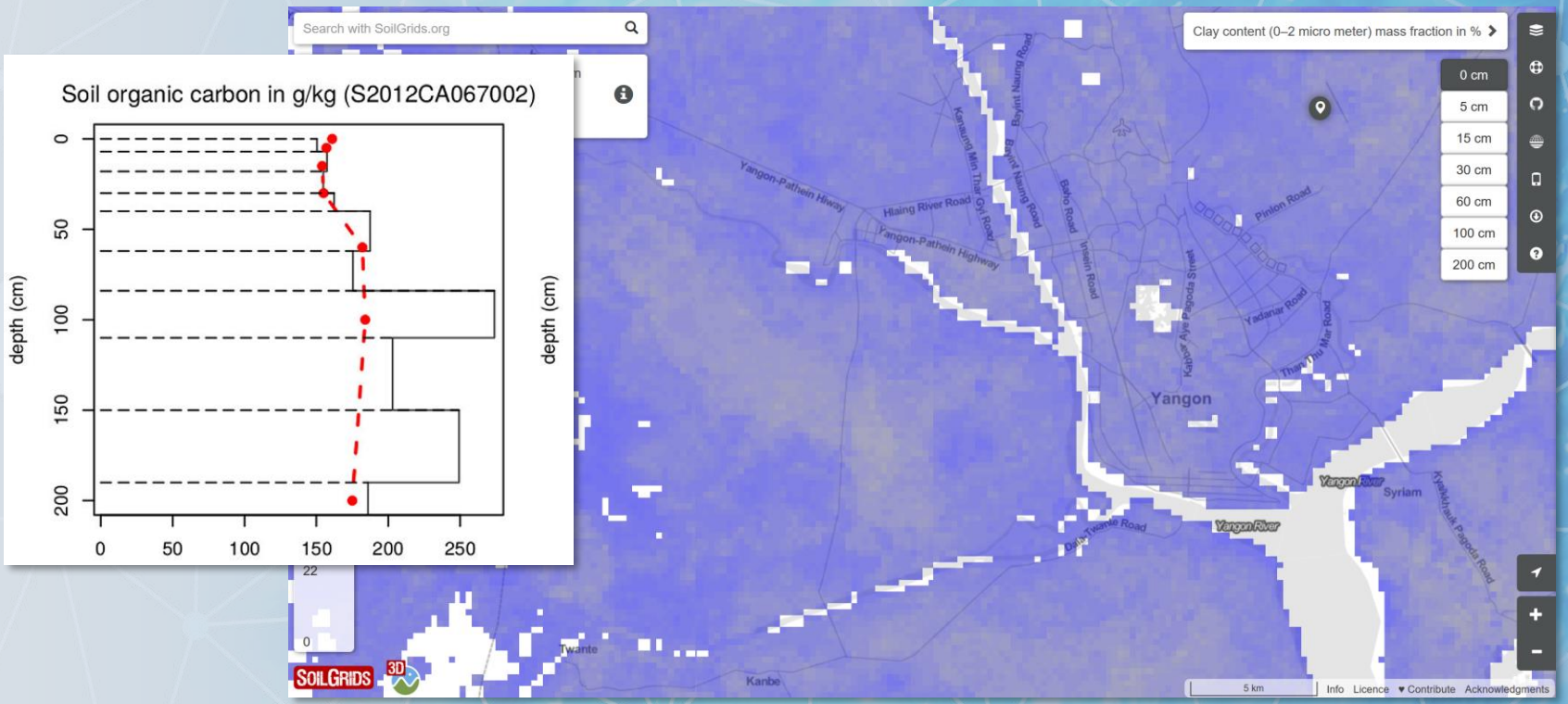


Not 100% accurate: you need land degradation knowledge to correct and interpret

Shruthi et al., 2012

SPATIAL ANALYTICS DEVELOPMENTS

SOILGRIDS.ORG: global soil information at 250m resolution, 7 depths, based on spatial interpolation of observations and machine learning



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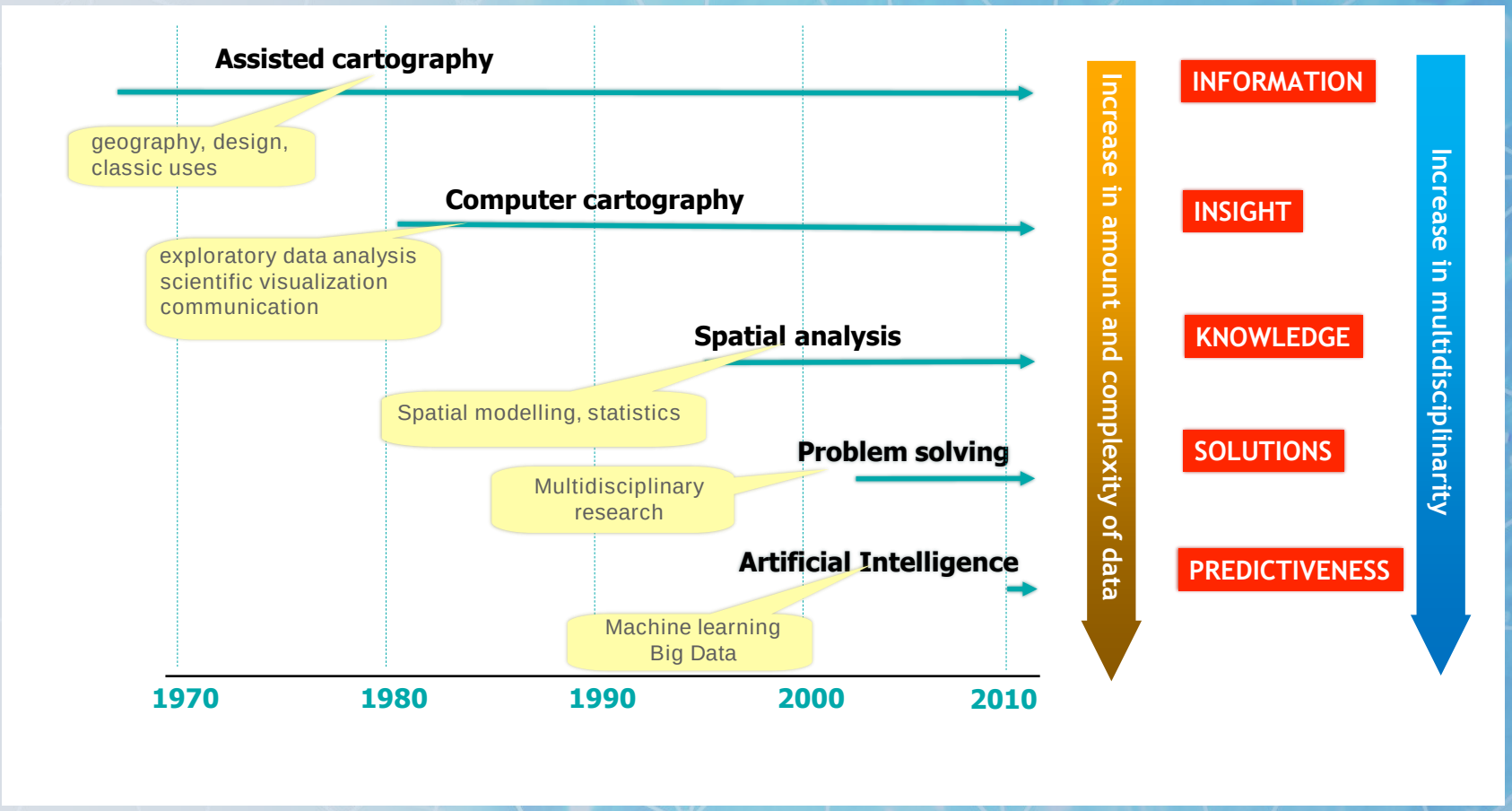
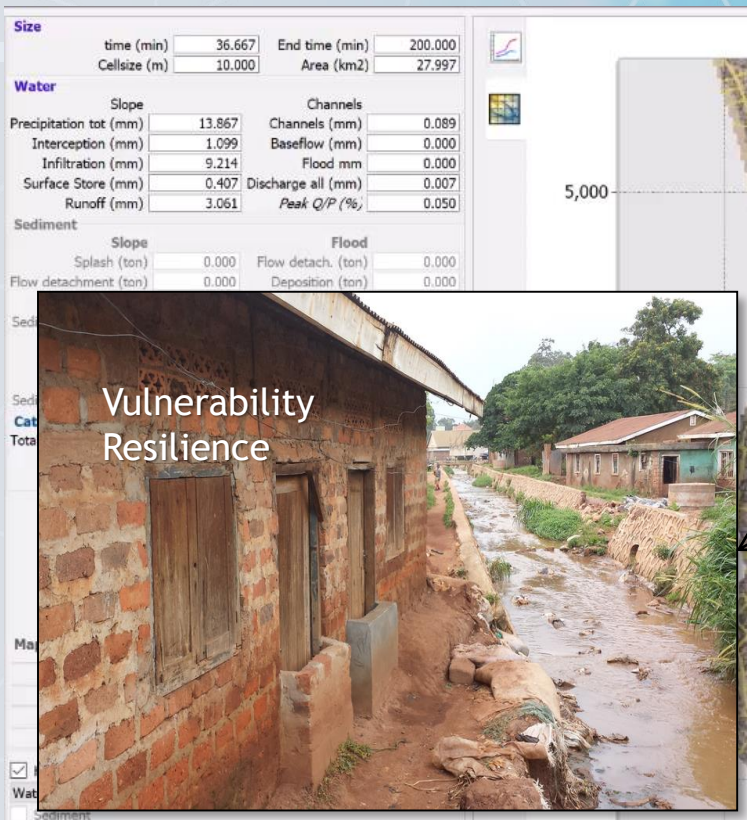
ISRIC World Soil Information

Hengl et al., 2017

DEVELOPMENT OF SPATIAL SCIENCES



GIS USED AS INPUT FOR COMPLEX SPATIAL FLOOD MODELLING



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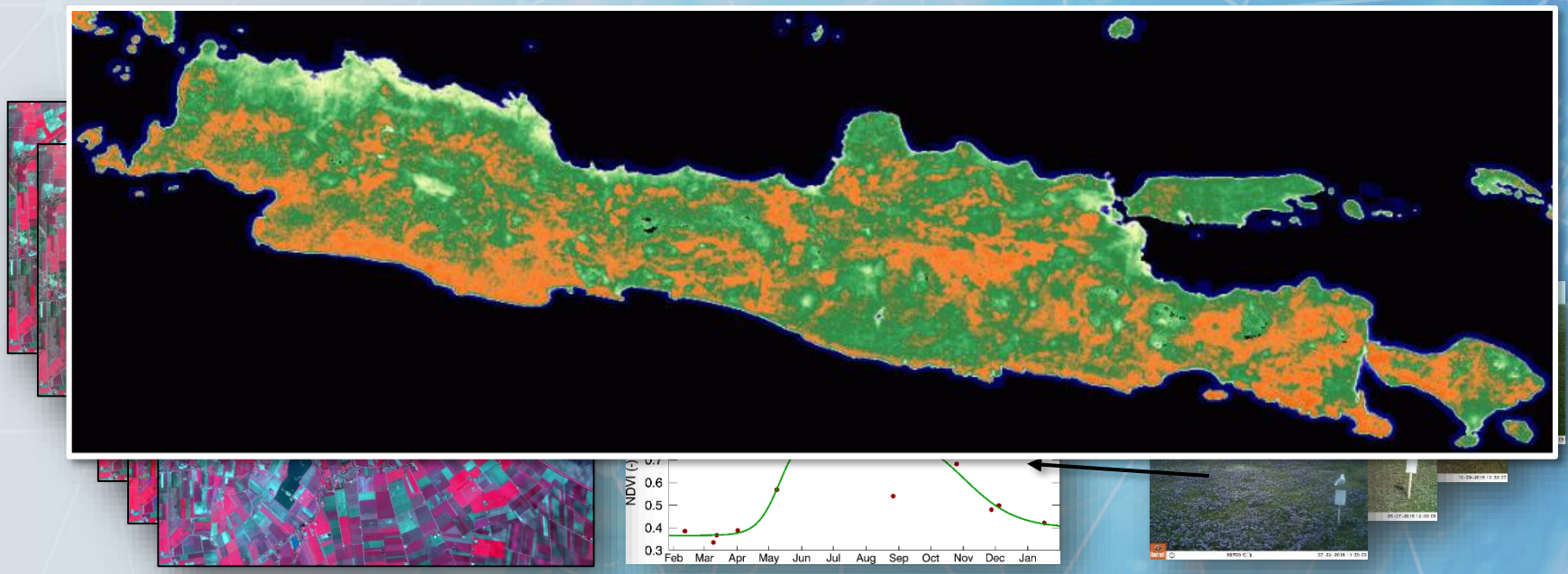
Jetten & Sliuzas, 2016

VEGETATION DYNAMICS: PHENOLOGY

Understand vegetation seasonality, crop dynamics

Using new data, high resolution sources such as Sentinel-2 and MODIS-AVHRR



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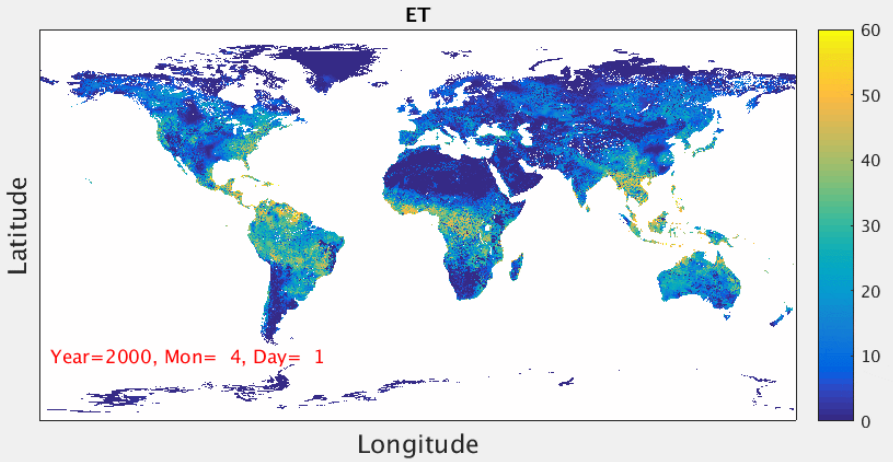
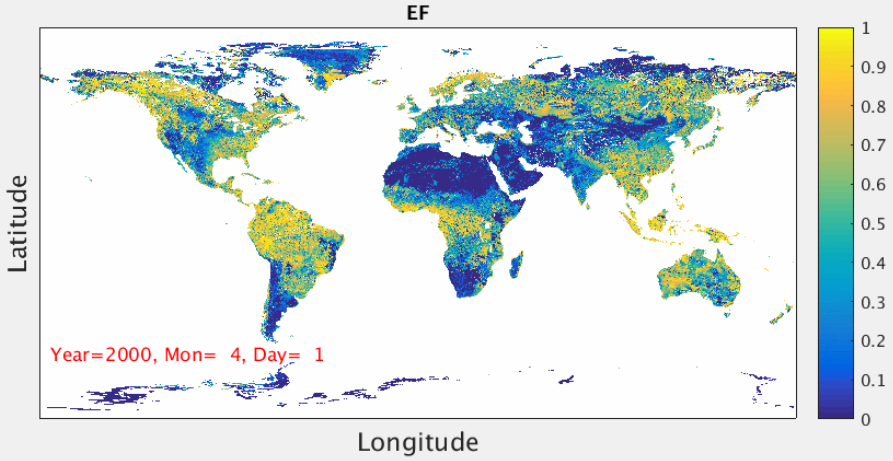
Anton Vrieling
Cees de Bie

HIGH RESOLUTION HYDROLOGICAL FLUXES





2000-present: 5x5km daily Evaporation and Heat Fluxes

For ecosystem services, agriculture and drought

Global databases instead of local/national databases

http://en.tpedatabase.cn/

Su, 2002,; Chen et al., 2013, 2014

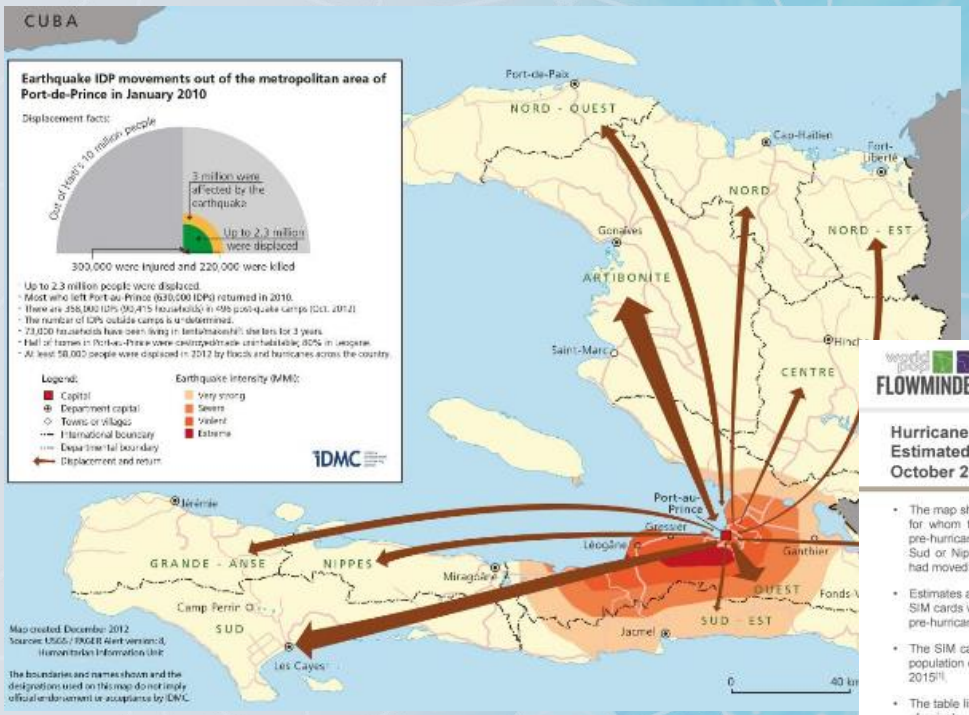
URBAN OBSERVATORY FOR PLANNING AND GOVERNANCE

- **VHR imagery** (very high resolution) allows for a more detailed extraction of urban structure types and degree of integration/fragmentation
- So not observation of details, but interpretation of meaningful social units: slums, business centres etc.
- **City scale** to **community scale**

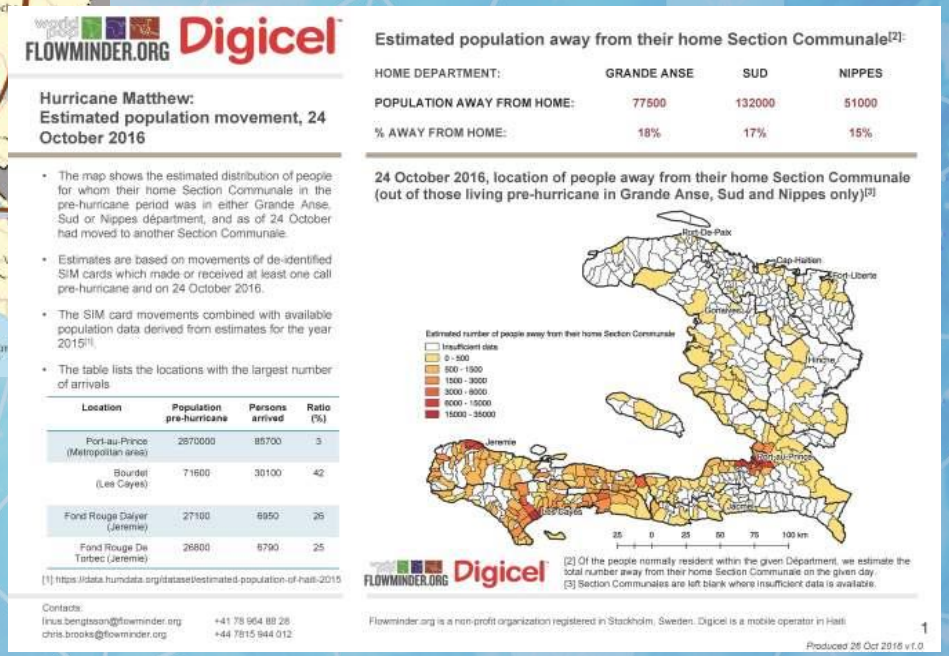
DRIVERS OF RECENT DEVELOPMENTS

- Complete location awareness and use: we want to know everything immediately and timely and actionable: Google analytics, Facebook, but also Mobile phone location: disasters and agricultural services
- UN, WB, ADB, Insurance companies: financing data acquisition (LiDAR coverage of countries)
- Citizen science: use of big fuzzy data as a source information
- UAVs (drones): very high res spatial data, possibly replacing airborne platforms
- Free sources: Open street map and Humanitarian OSM.
- Free sources: global meteo/hydro/vegetation/soil databases, to be used where national databases do not exist
- Changing roles common services: meteorology to early warning, forestry for biodiversity
- 3D: Virtual Reality and Augmented Reality techniques

ANALYZING MOBILE PHONE DATA TO ESTIMATE DISPLACEMENT AFTER NATURAL DISASTER



- Trace victims during an event
- Also through social media
- Warn people during an event



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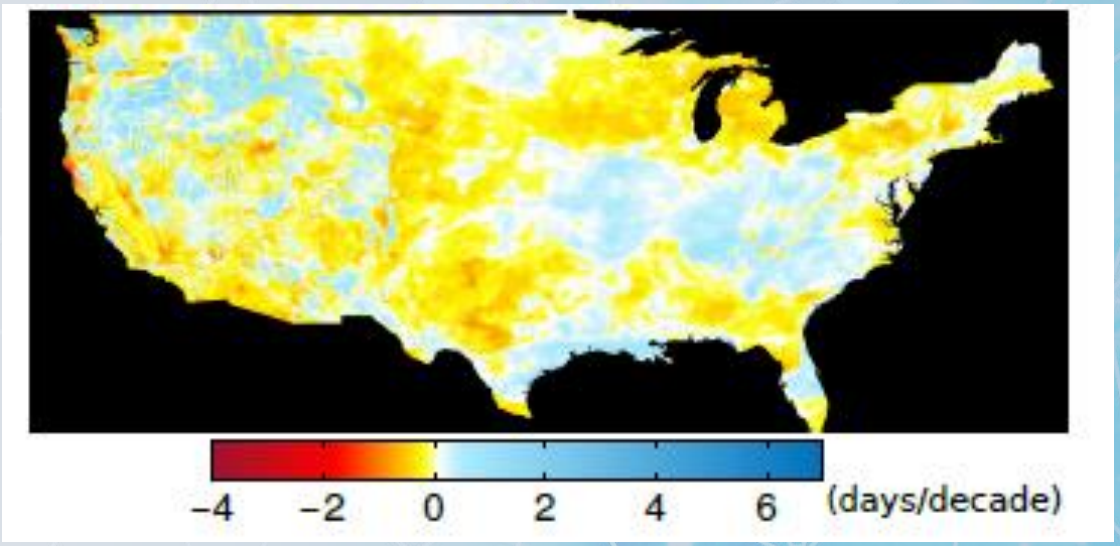
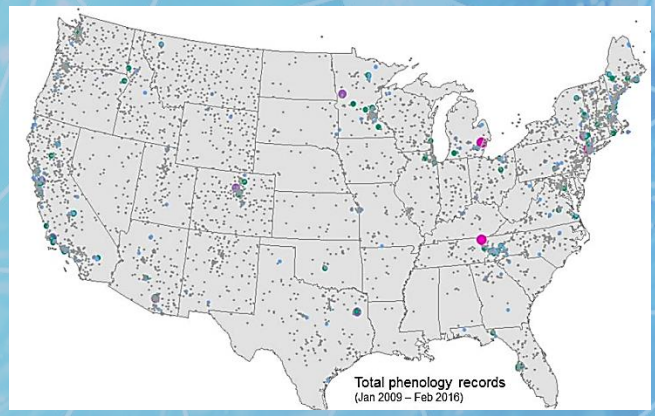
Source: WFP/Lucia Casarin

EXAMPLE OF CITIZEN SCIENCE

- Climate change analysis in the US based on timing of reports on spring flowering of common Lilac
- Possible shift in start of spring from -40 to +60 days





US: 8 million citizen observers

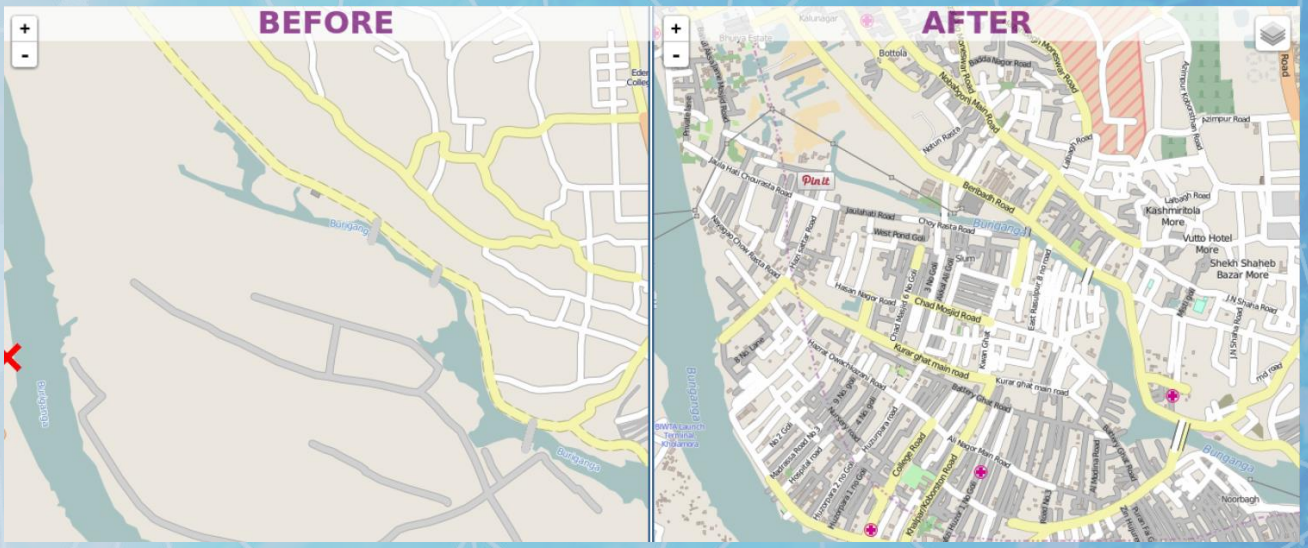
Source: Zurita Mila et al, 2016

EXAMPLE OF CITIZEN SCIENCE

"Mapathons"

Volunteers (students, school children)

map areas for the Red Cross



MISSING MAPS

Humanitarian Open Street Map Team

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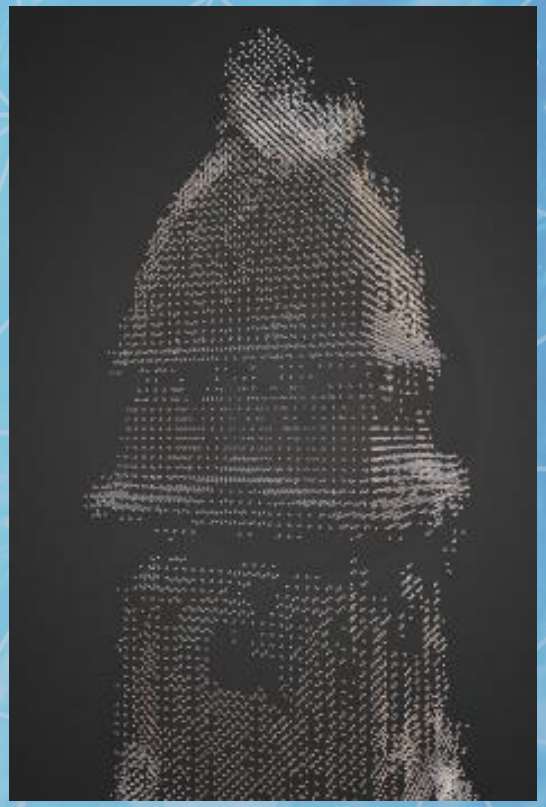
source: Lemmens, 2017

UAVs IN BUILDING DAMAGE ASSESSMENT

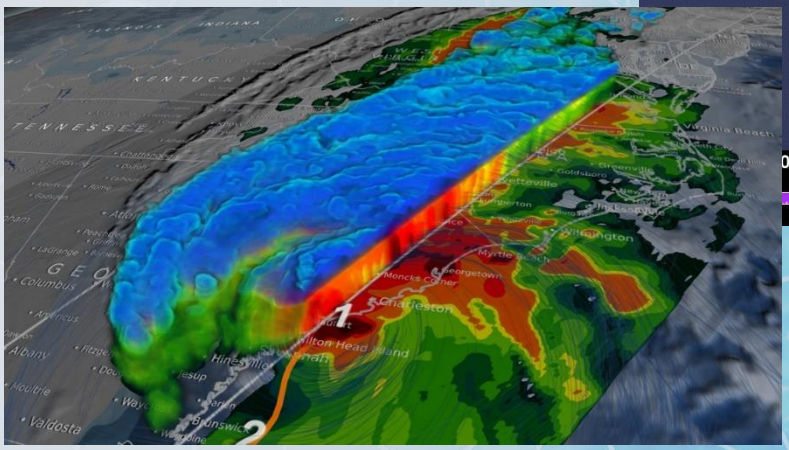
- 3D point clouds (“big data”)
- Combine into object, filtering, shadow removal
- Interpretation to building damage



Source: Vetrivel & Kerle, 2018

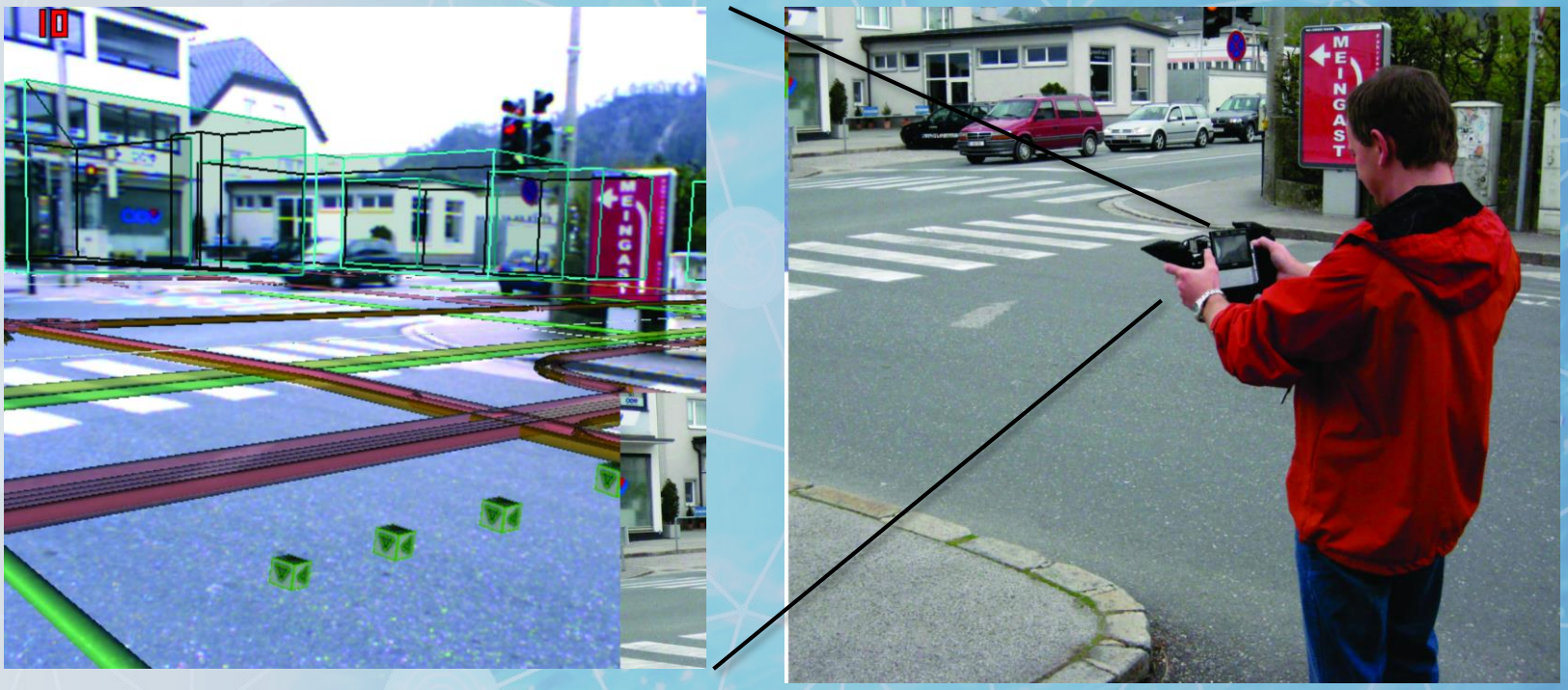
CHANGING ROLE OF SERVICES

Met office services are more application oriented: extremes, early warning



Hurricane Matthew:
30 min 0.1° rainfall intensity data, based on physical cloud models and radar

AUGMENTED REALITY FOR PUBLIC SERVICES



3D underground information of pipelines, cables etc.

De Mulder et al., 2012


GOOD
BAD
NEWS

A VERY GOOD TIME TO BE IN THE GI-SCIENCE AND EARTH OBSERVATION BUSINESS!

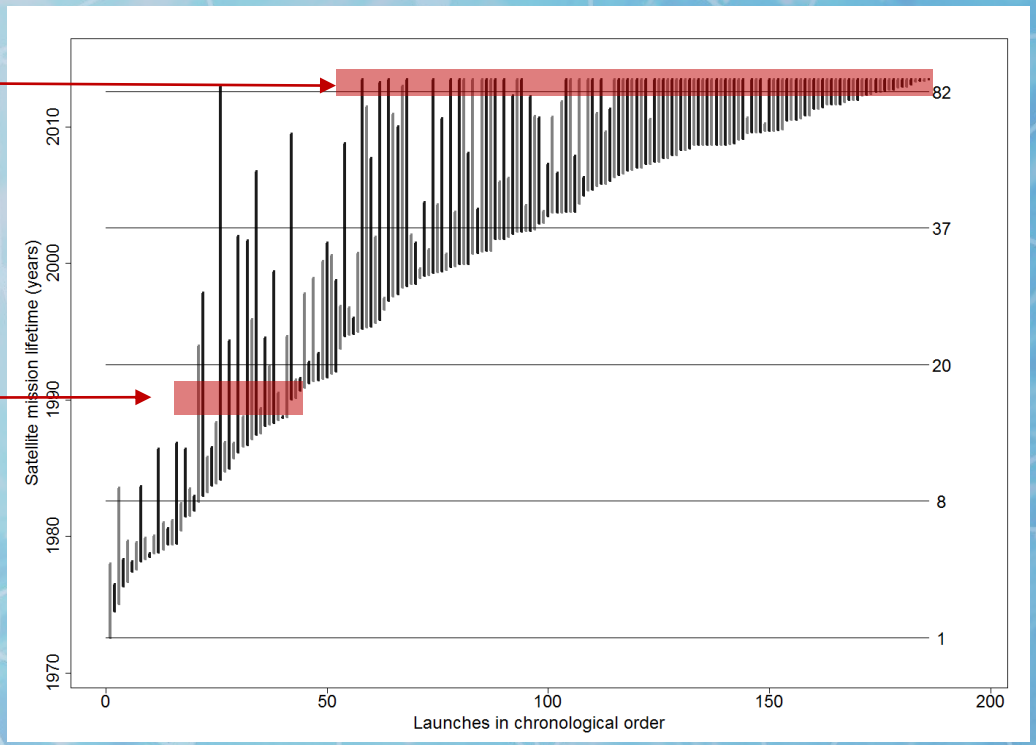
The lifespan of all near-polar orbiting, land imaging, civilian satellites shown in chronological order over 40 years (1972-2013)

What students have available today ☺

What I had available as a student ☹

↓ cost

↑ quality, resolution, processing capability



source: Belward & Skoeien, 2015

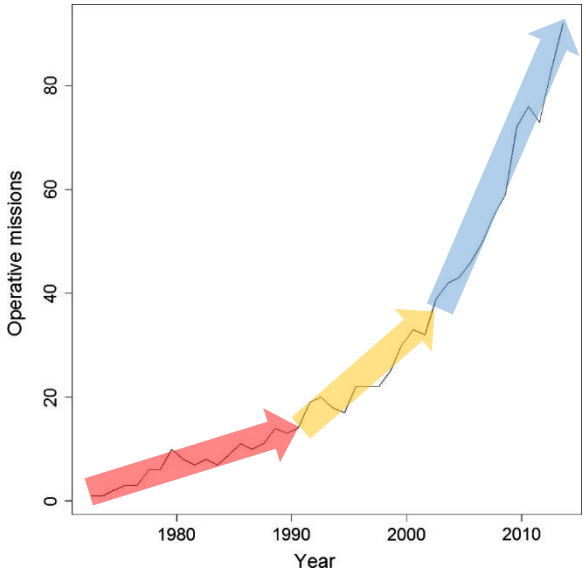
A VERY GOOD TIME TO BE IN THE GI-SCIENCE AND EARTH OBSERVATION BUSINESS!

earth observation capability is increasing more rapidly than ever …

… and it is only a fraction of the information available for mapping and monitoring

We also have:

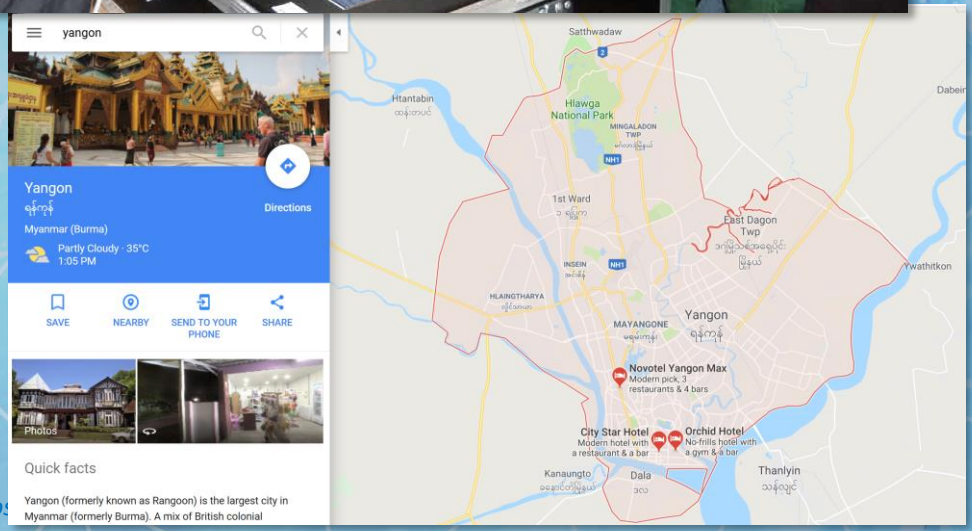
- Cubesats and micro satellites
- Airbourne sensors (drones)
- Land based measurement / sensor networks
- The internet of things / sensor webs
- Citizen science



source: Belward & Skoeien, 2015

GIS IS GREAT FOR COMMUNICATION

- **Intuitive use**
  everyone is used to seeing digital maps
- **Stakeholder involvement**
  collaborative planning and decision making processes
- **Models and tools (**ABM, 3D visualisation, map-table, Web-GIS etc)
  - to investigate interactions between factors
  - facilitate stakeholder communication
  - On-the-fly planning



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ALSO SOME BAD NEWS - TECHNICAL

Local/national ground information and legacy information is often scattered or a digital mess:

- Basic data: e.g. geology and soil and land use maps are missing in many countries, or very large scaled and generalized
- Timeseries, e.g. of river discharge is missing, erratic
- Sensus data is outdated or not present
- Informal settlements have no data at all
- Land admin and cadaster data missing

- Global databases replace these but they are perceived to be 100% true … !

AND SOME BAD NEWS IN TERMS OF POLICY

- The metadata, provenance and quality indicators are missing
- Measured data are often project related so scattered in place and time
- Data in a country is not available in one location, but fragmented
- International consultants often create their own database, leave behind a harddisk or a temporary webservice
- “Knowledge is power” – reluctance to share ownership
- Unclear responsibilities

CONTRADICTION

- The traditional role of generator of spatial data is disappearing: data is produced globally by a wide range of sources in enormous quantities … but with not clear if it can be used on a detailed scale

- … but a lot of basic data is still not digitized and often scattered, incomplete, or its use is restricted. Traditional skills are needed!

Global data abundance versus local data scarcity !

WHAT DO YOU WANT THE GIS EXPERT TO BE?

THE GEOMATICS EXPERT

- ✓Deep knowledge of the territory (geodesy, cartography) — Geodetic expert?
- ✓Securing all public and private lands (land registry, registration and publicity of land rights) — Legal expert?
- ✓Protection and sustainable development of resources (water, soil, forests, mines) — Natural resources expert?
- ✓Response planning and regional planning — Planning expert?
- ✓Monitoring of natural phenomena — Disaster expert?
- ✓Infrastructure management — Infrastructure expert?
- ✓Establishment of municipal property tax — Financial expert?

Can you combine this in one study?

Source: Eric Loubier, Director Earth Sciences Sector Natural Resources Canada

…OR MORE MULTI-DISCIPLINARY?

Traditional role

- ✓Can design and maintain spatial databases
- ✓Can analyze and quantify data quality and uncertainty
- ✓Can derive information from many different new sources
- ✓Can do advanced spatial statistics/analytics
- ✓Can find the right tools to do spatial analysis
- ✓Can use GIS to communicate effectively

Changing role

- ✓Can engage in scientific problem solving, academic thinking
- ✓Can find the right data sources to solve problems
- ✓Can engage in multidisciplinary research, project team skills

THE GIS EXPERT: AN EVOLVING ROLE

Geoinformatics expert

Spatial Data expert
Data quality expert
Geo-analytics expert
Communications expert
"The spatial analysis is the answer"

Analysis

Application expert

Process knowledge
Generates primary data
Advanced domain modelling
Direct contact stakeholders
"The spatial analysis supports the answer"

Analysis is done by both:

Geoinformatics expert is more data oriented (lack of field experience)

Application expert is more process oriented (lack of data experience)

UNIVERSITIES: TOWARDS COMPETENCIES

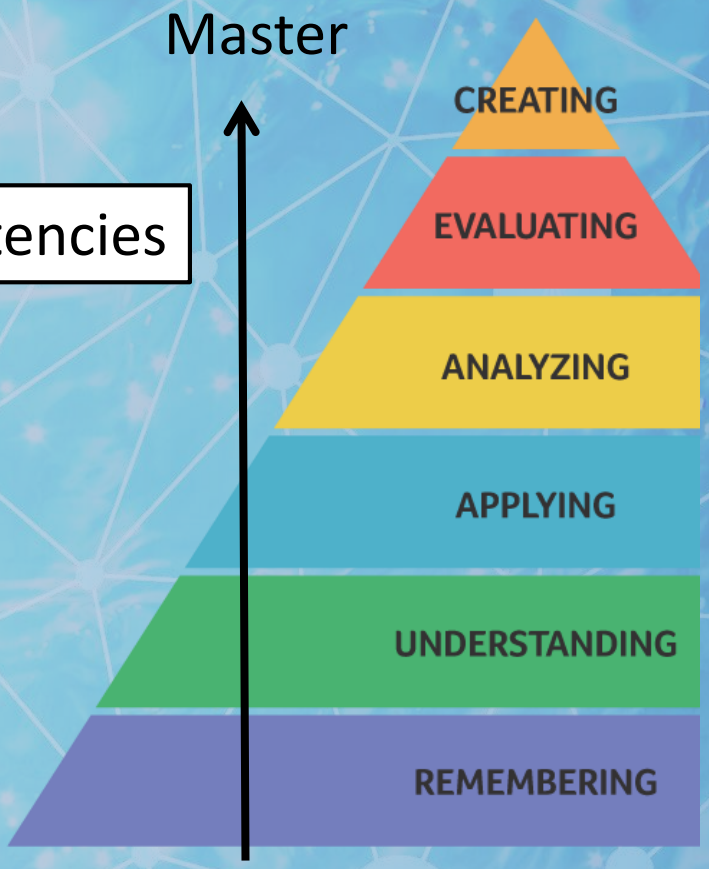
Knowledge

Skills

Attitude

competencies

Self critical
Academic
Creative
cooperative



CONCLUSIONS

- Big advances in technology, from simple spatial analysis to complex multidisciplinary analysis
- Spatial sciences has become mainstream, known to a wide public, used by many services
- Exponential increase in data sources and types, many of them free
- The role of the GIS expert changes, he/she can be the spatial data analysis expert …
- … while for complex processes cooperation with domain experts is needed
- Demands to Higher Education change as well

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Thank you