

→ EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

Agriculture and Rural Development

InfoSession

25 July 2018 | ADB, Manila, Philippines

**Earth Observation services in the context of Sustainable Development:
key concepts, examples and opportunities**

EO4SD consortium, presented by Anton Vrieling



Nelen & Schuurmans



Satelligence



The consortium of EO4SD – Agriculture and Rural Development

The Netherlands



Service provision



Nelen & Schuurmans

Data integration



ITC
UNIVERSITY
OF TWENTE.

Capacity development



Communication

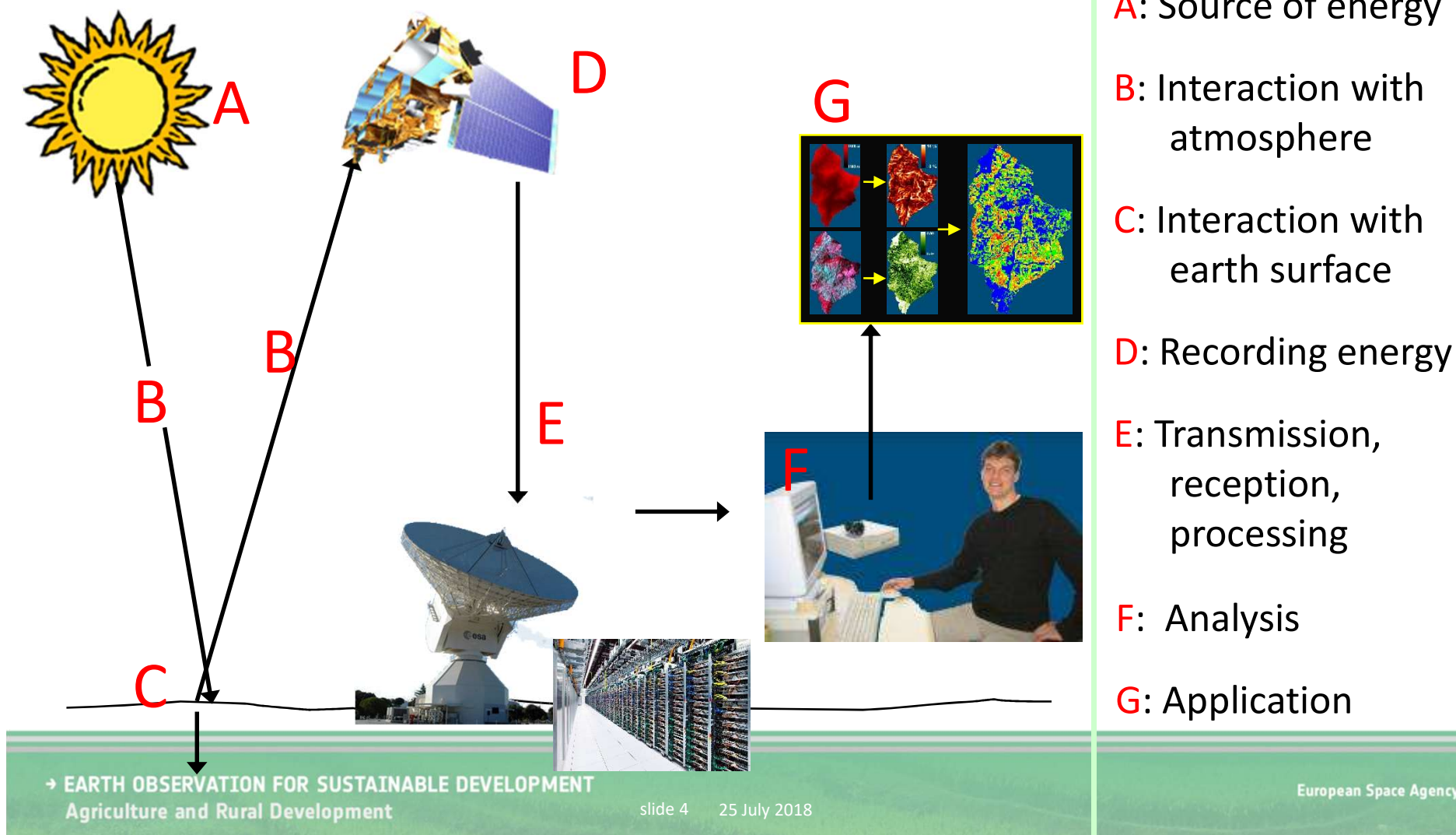
A photograph of a large, multi-story university building with a red-tiled roof and many windows. The building is surrounded by greenery, including trees and a hedge. A sign in the bottom right corner identifies it as the University of Twente, Faculty ITC. A black text box is overlaid on the left side of the image.

ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

UNIVERSITY
OF TWENTE
FACULTY ITC

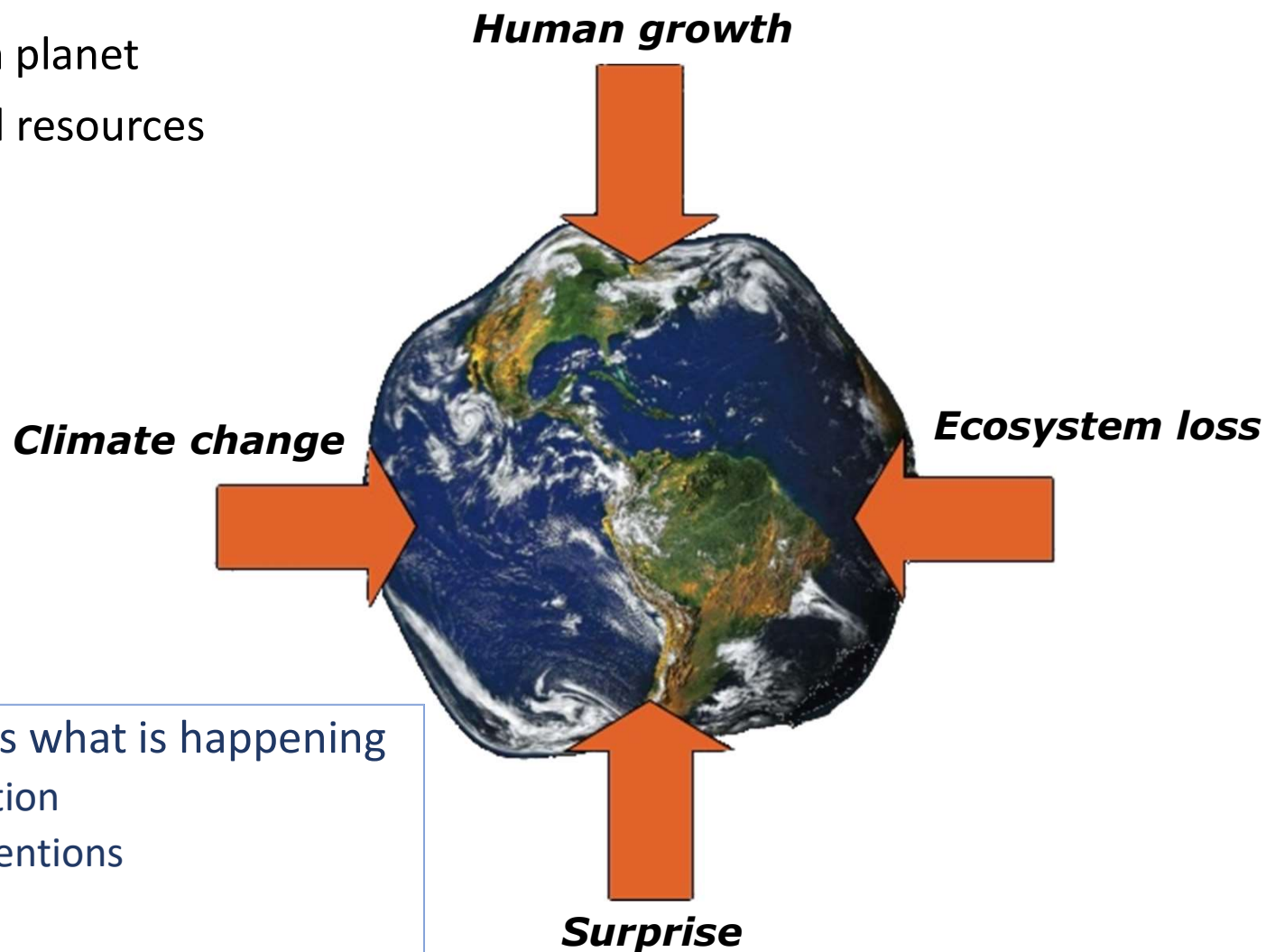
Remote sensing

...is the science of acquiring information about the Earth's surface without actually being in contact with it.



Remote sensing: a tool to study the environment

- Large pressures on planet
- Changes to natural resources



- Know for large areas what is happening
 - Agricultural production
 - Effectiveness interventions
 - ...

Rockström & Karlberg, 2010. *Ambio* 39: 257-265

Sustainable development goals



17 Goals, with 169 Targets, and 232 unique Indicators

SDG and satellites

<http://eohandbook.com/sdg/>

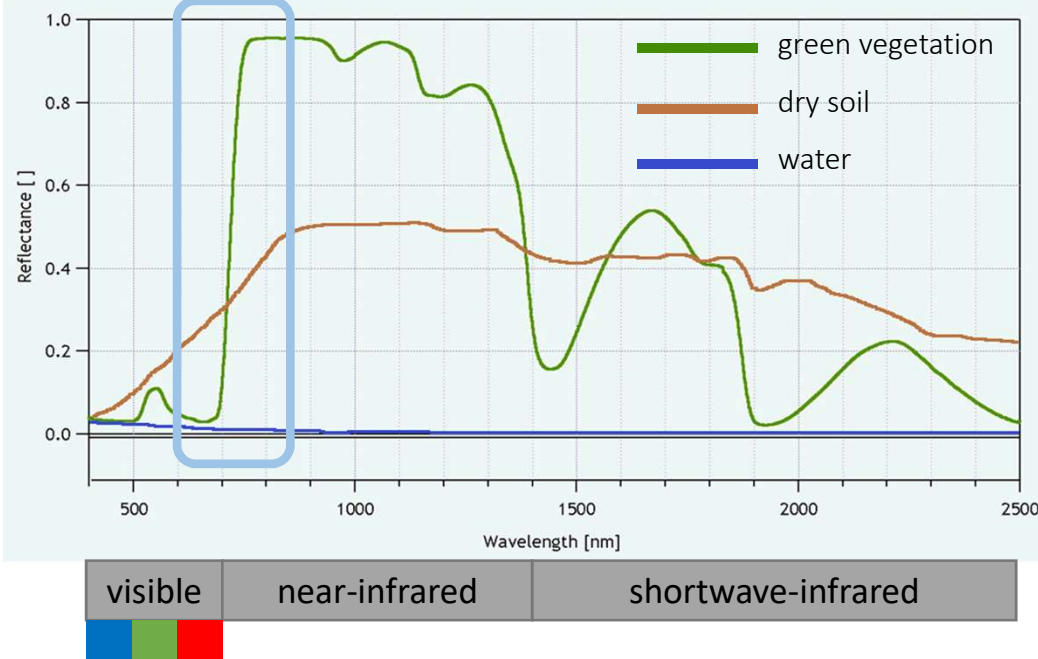
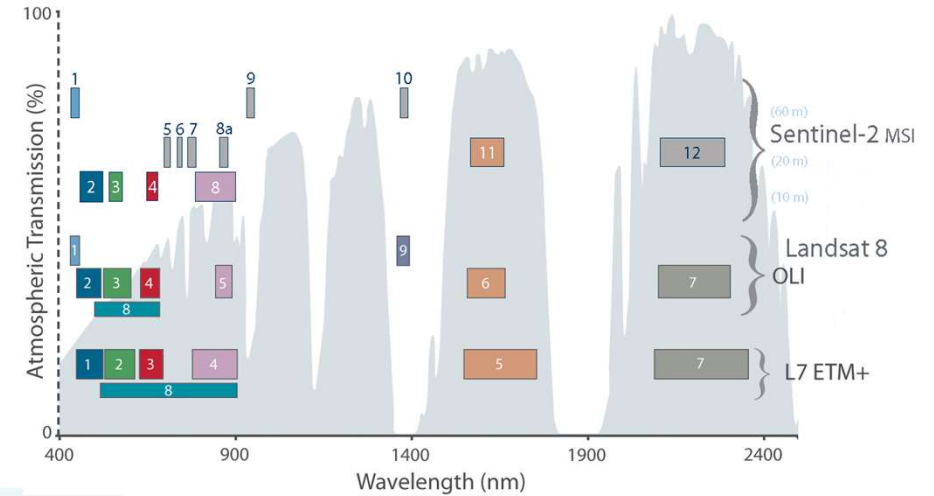
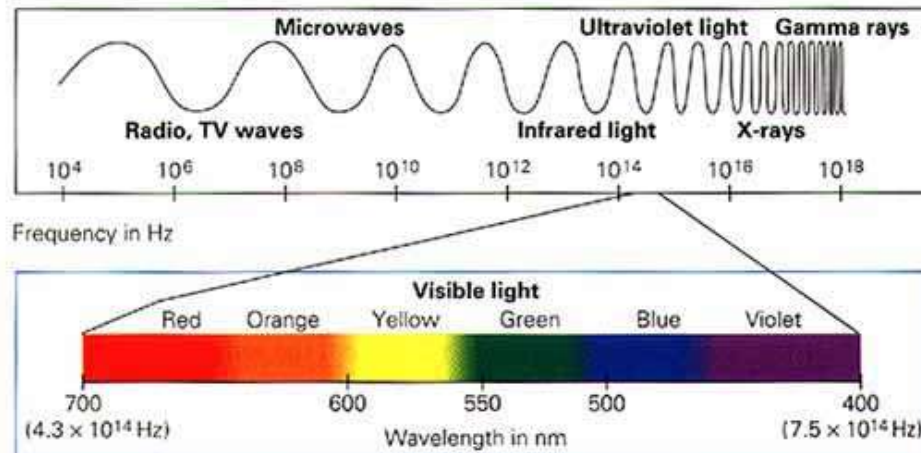
EXAMPLE

Goal 15: Life on Land

- Target 15.3: By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a *land degradation-neutral* world
- Indicator: 15.3.1: Proportion of degraded land over total land area
- Sub-indicators:
 - Land cover and land cover change
 - Land productivity
 - Metrics (ANPP Trend, State and Performance)
 - Carbon stocks, above and below ground (but SOC currently)

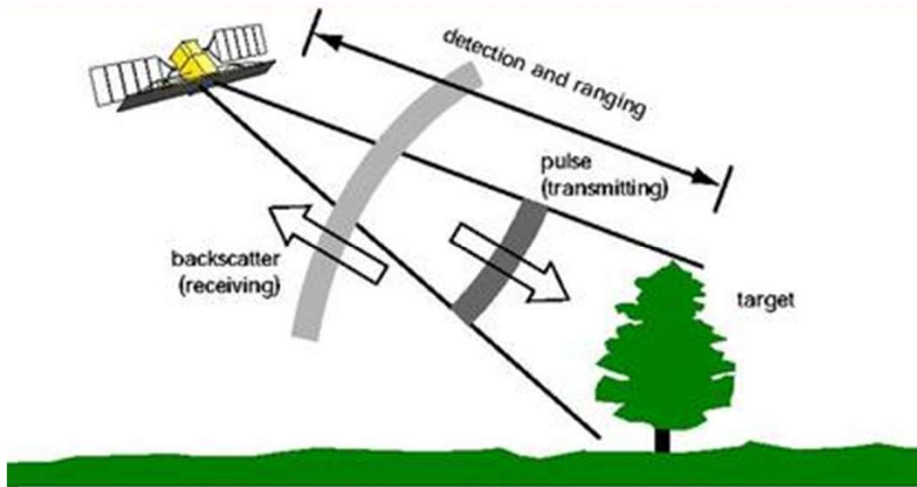
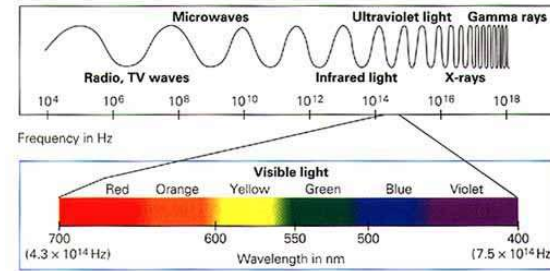


What do we sense?

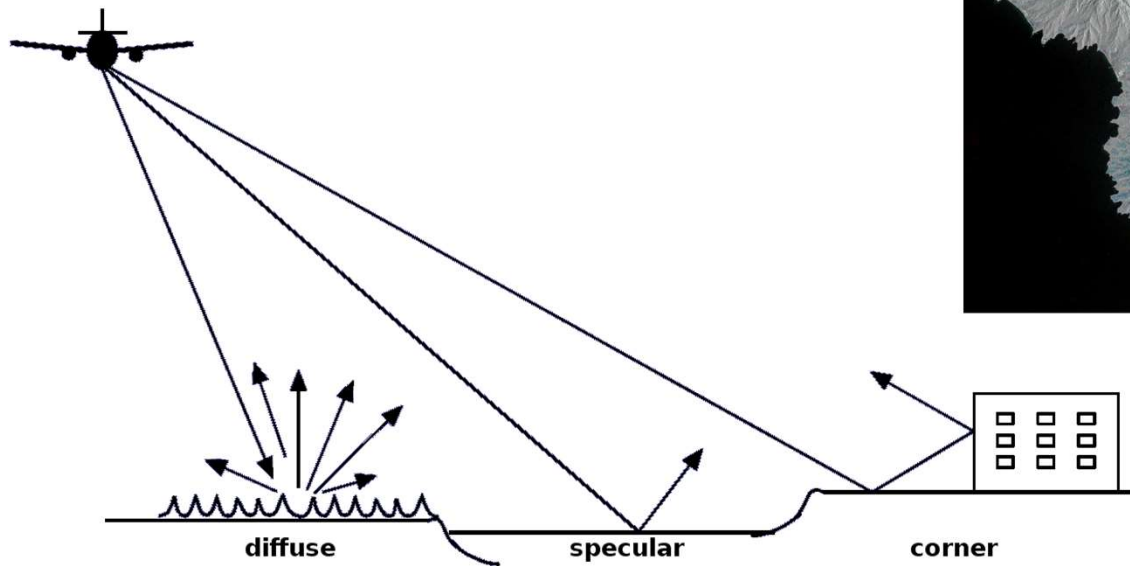


Sentinel-2: 13 May 2018 (Manila)

Active sensors: radar



Sentinel-1 VH: Manila bay
1Sep-30Nov, 1Jun-31Aug, 1Apr-30May



Remote sensing data sources: spatial detail (1)



Image courtesy: STARS project

Remote sensing data sources: spatial detail (2)

WorldView-3: ~1m



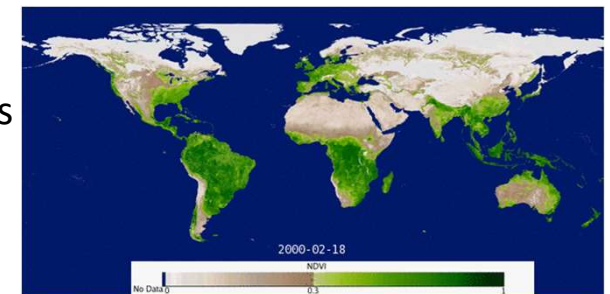
Sentinel-2: 10m



MODIS: 250m



- Advantage medium resolution:
 - daily observation → peek through clouds → seasonal changes
 - wide geographical coverage
 - reasonable data volume
 - long consistent time series to assess anomalies

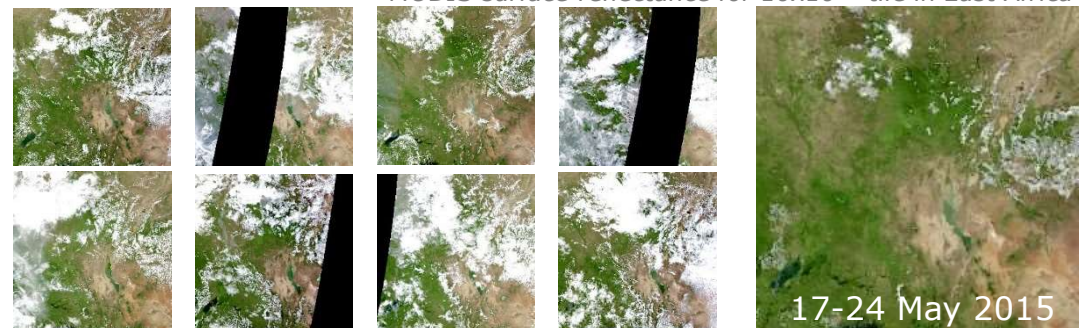
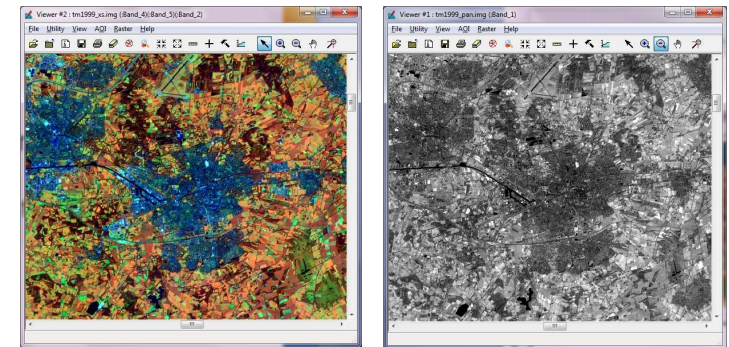
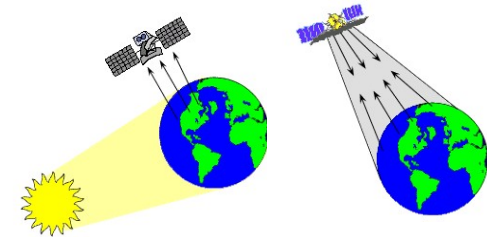
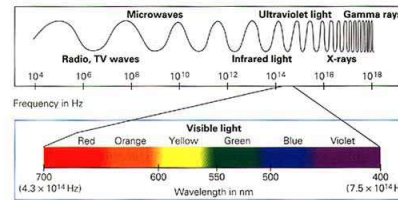


Medium resolution sensors

sensor	platform	spectral range	number of bands	resolution	swath width	repeat coverage	launch
AVHRR	NOAA POES 6-19	VIS, NIR, MWIR	5	1100m	2400km	12 hours	1978
AVHRR	METOP	VIS, NIR, SWIR, MIR	5	1100m	2400km	12 hours	2007
SEAWIFS	Orbview-2	VIS, NIR	8	1100m 4500m	1500km 2800km	1day	1997
VEGETATION	SPOT 4, 5	VIS, NIR, SWIR	4	1100m	2200km	1day	1998-2014
MODIS	Terra/Aqua	VIS, NIR, SWIR, TIR	36	250- 1000m	2330km	<2days	1999
MERIS	ENVISAT	VIS, NIR	15	300m 1200m	1150km	<3days	2000
Suomi NPP	VIIRS	VIS, NIR, SWIR, TIR	22	375m 750m	3040km	1 day	2011
PROBA-V	PROBA-V	VIS, NIR, SWIR	4	300m 1000m	2250km	1 day	2013
SENTINEL 3	OLCI	VIS, NIR, SWIR	21	300m	1270km	<2 days	2016

Key sensor characteristics

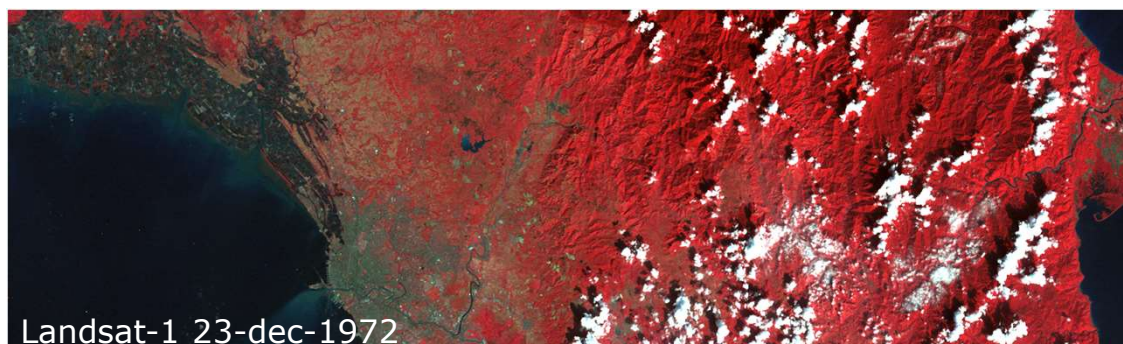
- Part of spectrum
 - Optical or microwave
 - Active or passive
 - Number of spectral bands (or equivalent: polarization)
- Spatial detail (spatial resolution)
- Repeat frequency



Data providers (a non-exhaustive list!)

- Public sector

- ESA, EUMETSAT
- NASA, NOAA
- JAXA
- ISRO
- ..



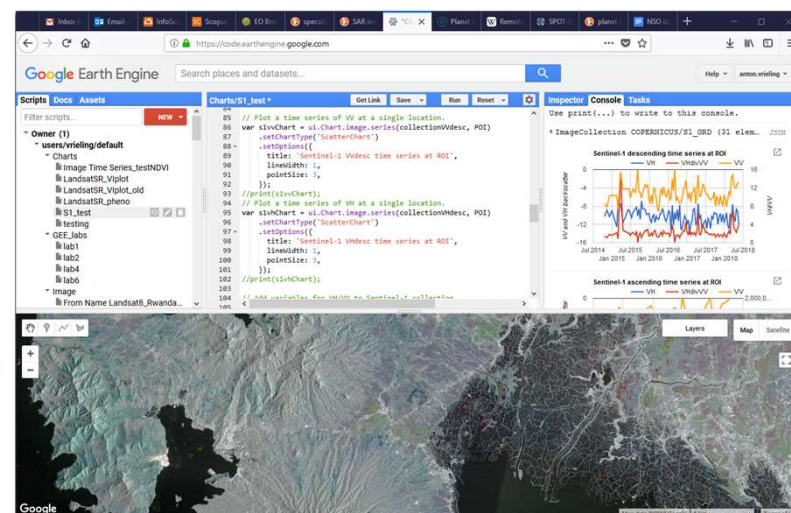
- Commercial sector

- DigitalGlobe
- Planet Labs
- EADS Astrium
- Resellers (e.g., Satellite Imaging Corporation)
- ...

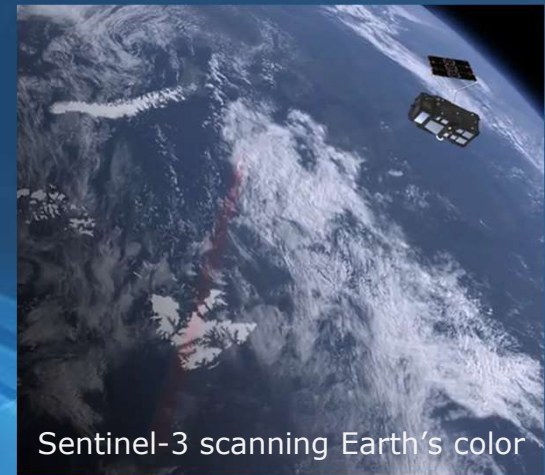


- Trends → online access and computing

- Google / Amazon / ...






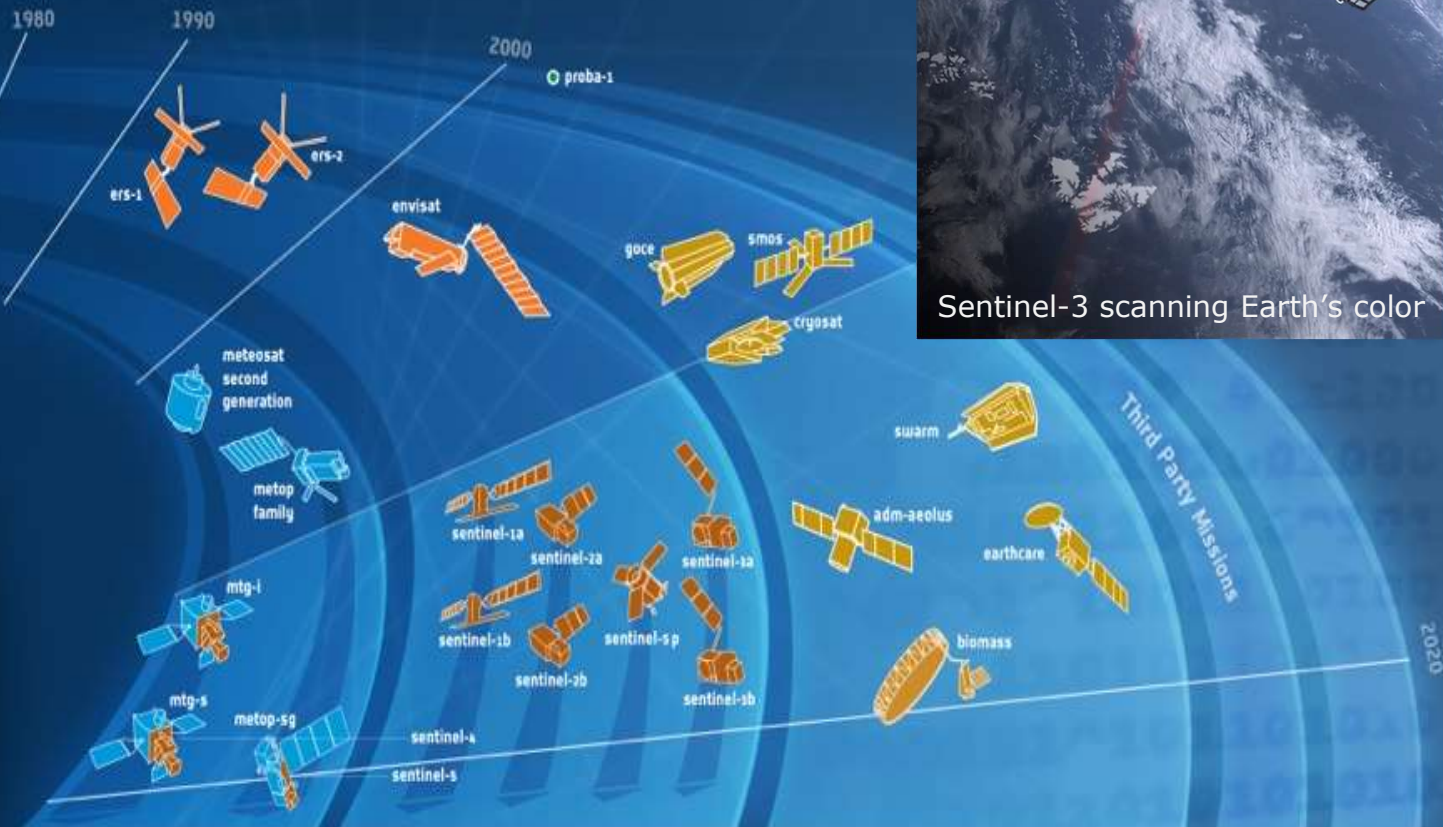
→ THE ESA EARTH OBSERVATION PROGRAMME



Sentinel-3 scanning Earth's color

The Sentinel Family

-  S1A/B
-  S2A/B
-  S3A/B
-  S4A/B
-  S5P
-  S5A/B/C
-  S6 J-CS A/B



Meteorological Missions

driven mainly by Weather forecasting and Climate monitoring needs. These missions developed in partnership with EUMETSAT include the Meteorological Operational satellite programme (MetOp), forming the space segment of EUMETSAT's Polar System (EPS), and the new generation of Geostationary Meteorological satellites (MSG & MTG satellites).

Copernicus Sentinel Missions

driven by Users needs to contribute to the European Global Monitoring of Environment & Security (GMES) initiative. These satellite missions developed in partnership with the EU include C-band imaging radar (Sentinel-1), high-resolution optical (Sentinel-2), optical and infrared radiometer (Sentinel-3) and atmospheric composition monitoring capability (Sentinel-4 & Sentinel-5 on board Met missions MTG and EPS-SG respectively).

Earth Explorer Missions

driven by Scientific needs to advance our understanding of how the ocean, atmosphere, hydrosphere, cryosphere and Earth's interior operate and interact as part of an interconnected system. These Research missions, exploiting Europe's excellence in technological innovation, pave the way towards new development of future EO applications.

Missions With Partners

ESA Operated Missions

Long-term (decadal) continuous, consistent data

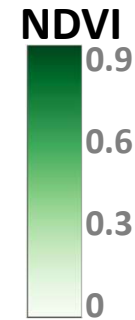
Copernicus programme



- The world's largest single earth observation programme, directed by the European Commission in partnership with the European Space Agency (ESA).
- Headed by the **European Commission (EC)**
 - Acting on behalf of the European Union, setting requirements, managing the services
- in partnership with the **European Space Agency (ESA)**
 - Provision of 30 satellites (**Sentinels**) for the operational needs, space segment & ground segment.
- Objectives:
 - Global, continuous, autonomous, high quality, wide-range **EO capacity**.
 - **Providing accurate, timely and easily accessible information** for, a.o. improving the management of the **environment**, understanding and mitigating the effects of **climate change**, and ensure **civil security**.

Sentinel-2: one example

- Launch June 2015 and March 2017
- 5-day revisit at 10, 20, 60m resolutions



Sentinel-2 imagery – False Color Composite (NIR, red, blue)
Area west of Erbil (north Iraq)

$$NDVI = \frac{\rho_{NIR} - \rho_{red}}{\rho_{NIR} + \rho_{red}}$$

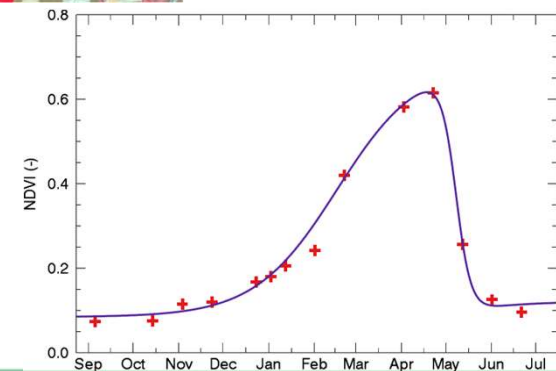
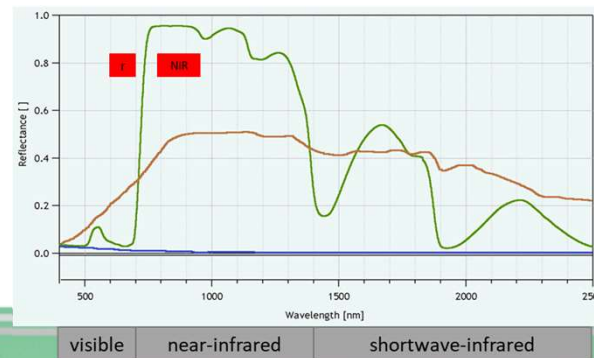


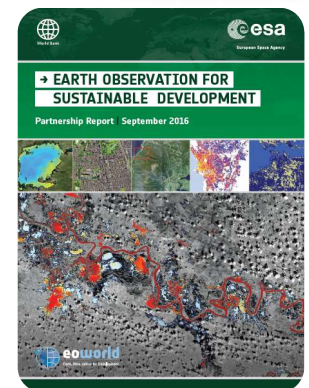
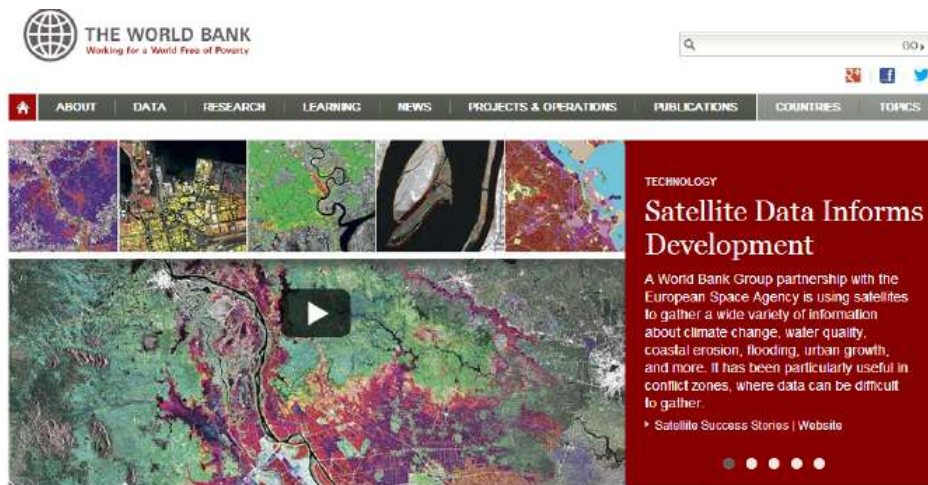
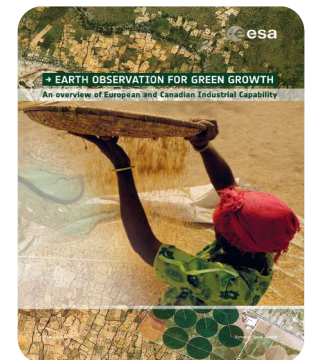
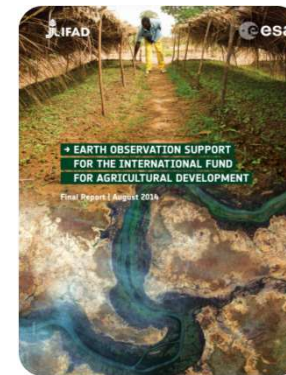
Image type selection: key questions

- What is the information needed?
 - What can be observed to fulfil that need?
 - How much spatial detail is required?
 - How frequent do we need information?
- How large is the area of interest?
- Are clouds a major issue? (observations at critical times)
- What are image costs?
- HOW TO TURN PIXEL DATA INTO INFORMATION??

Promoting data literacy and use in **international development**



- 65 small-scale demonstrations of EO services in support of IFI projects since 2008



Promoting data literacy and use in **international development**



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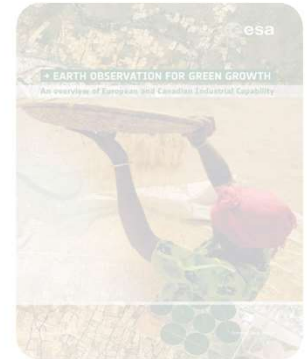
ADB

European
for Reconstruction and
Development

European
Investment
Bank

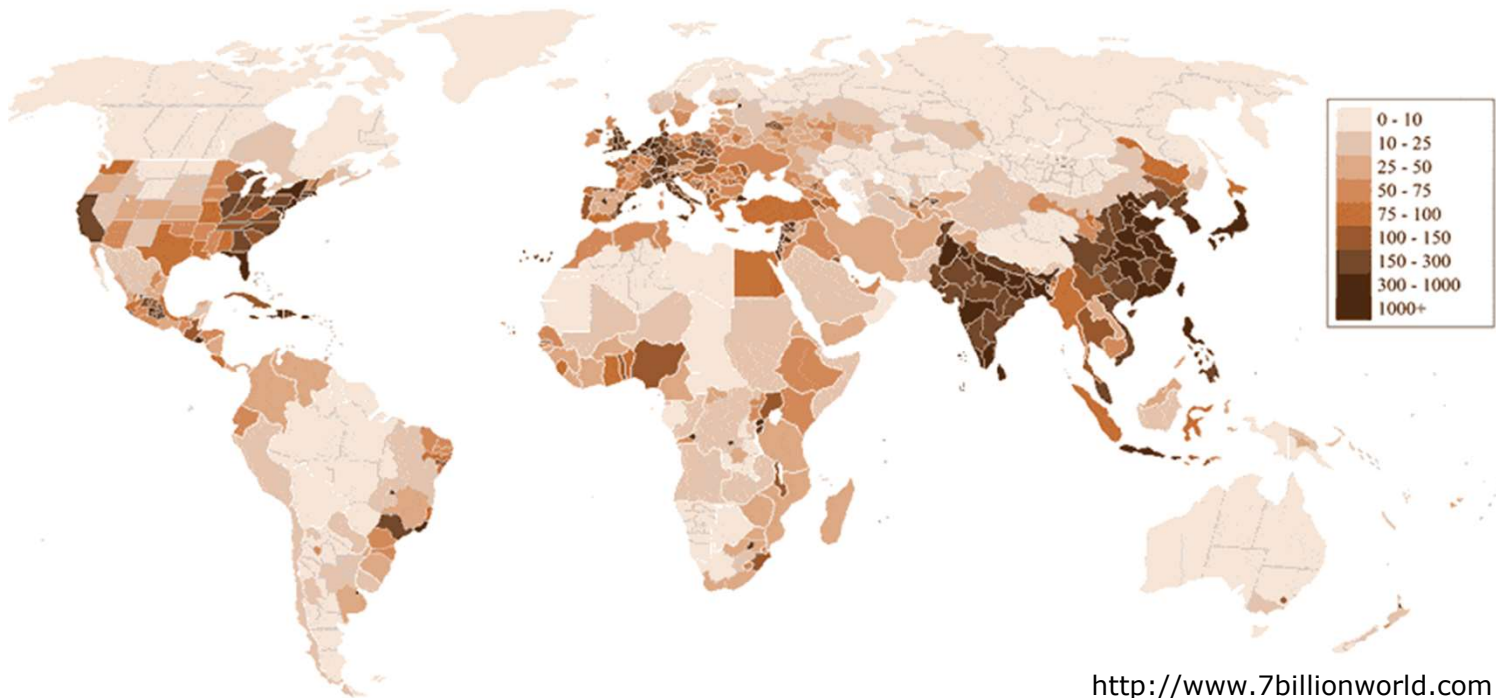
THE WORLD BANK
Working for a World Free of Poverty

ABOUT DATA RESEARCH LEARNING



A closer look at agriculture: feeding the world

	Country	2013 Population	% of World Pop.	Area (km ²)	Density (p/km ²)	Change/Yr (curr.)	2050 Pop. (proj.)	% of World Pop.	Change 2013-2050
1	Asia	4,298,723,288	60.0%	31,915,445,635	135	1.03%	5,164,061,493	54.1%	20%
2	Africa	1,110,635,062	15.5%	30,955,879,982	36	2.46%	2,393,174,892	25.1%	115%
3	Europe	742,452,170	10.4%	23,048,931,144	32	0.08%	709,067,211	7.4%	-4%
4	Latin America and Caribbean	616,644,503	8.6%	20,546,598,127	30	1.11%	781,566,037	8.2%	27%
5	Northern America	355,360,791	5.0%	21,775,892,579	16	0.83%	446,200,868	4.7%	26%
6	Oceania	38,303,620	0.5%	8,563,295,328	4	1.42%	56,874,390	0.6%	48%
7	WORLD	7,162,119,434	100.00%	136,806,987,966	52	1.15%	9,550,944,891	100%	33%

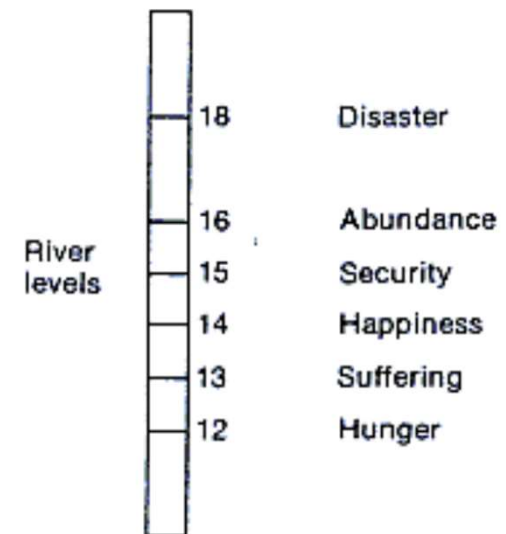
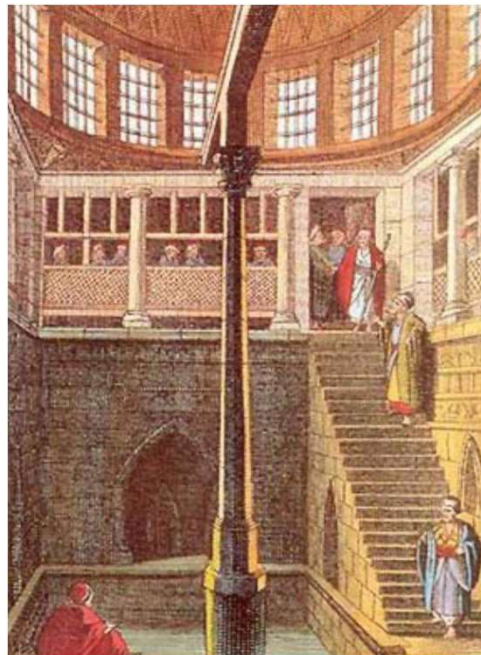


<http://www.7billionworld.com>

European Space Agency

Information for food security: the first crop information system

- Nilometer: A graded column housed on the banks of the Nile to measure water levels at critical dates and thus predict the harvest. Nile water level measurements go back 5000 years



Food security: current sources of information

- Statistics departments / Ministry of Agriculture
 - Household surveys
 - Field sampling (e.g., crop cutting)
 - Use of area frame sampling
- To be useful:
 - Consistent, high quality, representative, quick availability
 - However
- Need for other sources of information
 - Spatial and temporal detail
 - Geo-information and remote sensing as input

Remote sensing: what information are we after?

- **Where are:**
 - fields
 - crops
 - key grazing areas
 - **When:**
 - are crops grown
 - is forage developing
 - **How much:**
 - crop/forage is produced
 - **How:**
 - are crops grown: Crop management
-
- What are trends in productivity? Degradation?
 - What are impacts of climate variability on food production?
 - How to turn satellite information into action?
 - ...



Where (1): fields

- Fundamental layer: where are fields?
- Many countries lack information
 - Global layers: accuracy and smallholder fields?
 - New products emerging based on satellite data with more detail

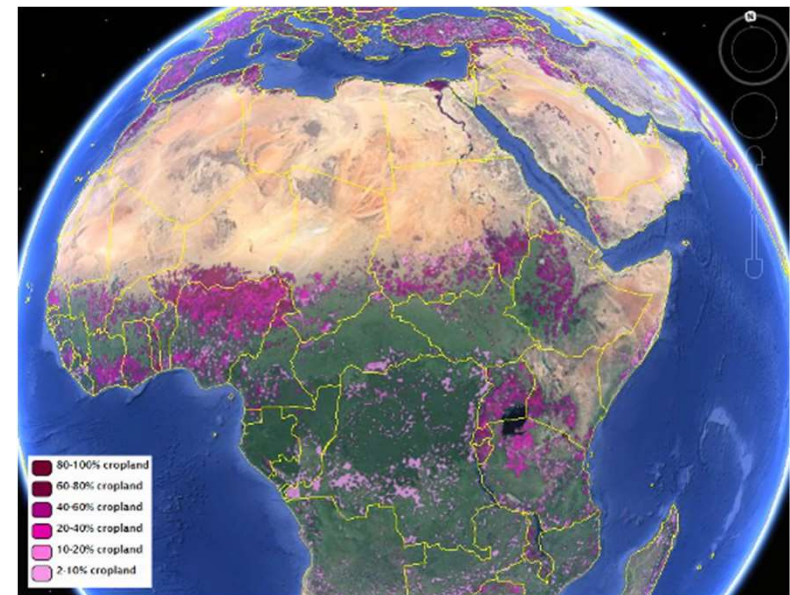


Image: <http://www.iiasa.ac.at/web/home/about/news/150116-Cropland-Maps.html>

Where (2): crops

- Which crops are grown where?
- Difficulties:
 - Small fields
 - Multi-cropping
 - Annual (seasonal) changes
 - Similar spectra
 - Persistent clouds in growing season
- Options
 - Single image vs. multi-temporal data
 - Radar
 - Very fine detail (UAV)



Image: https://en.wikipedia.org/wiki/Agriculture_in_Ethiopia

Where (3): Pastoral sector

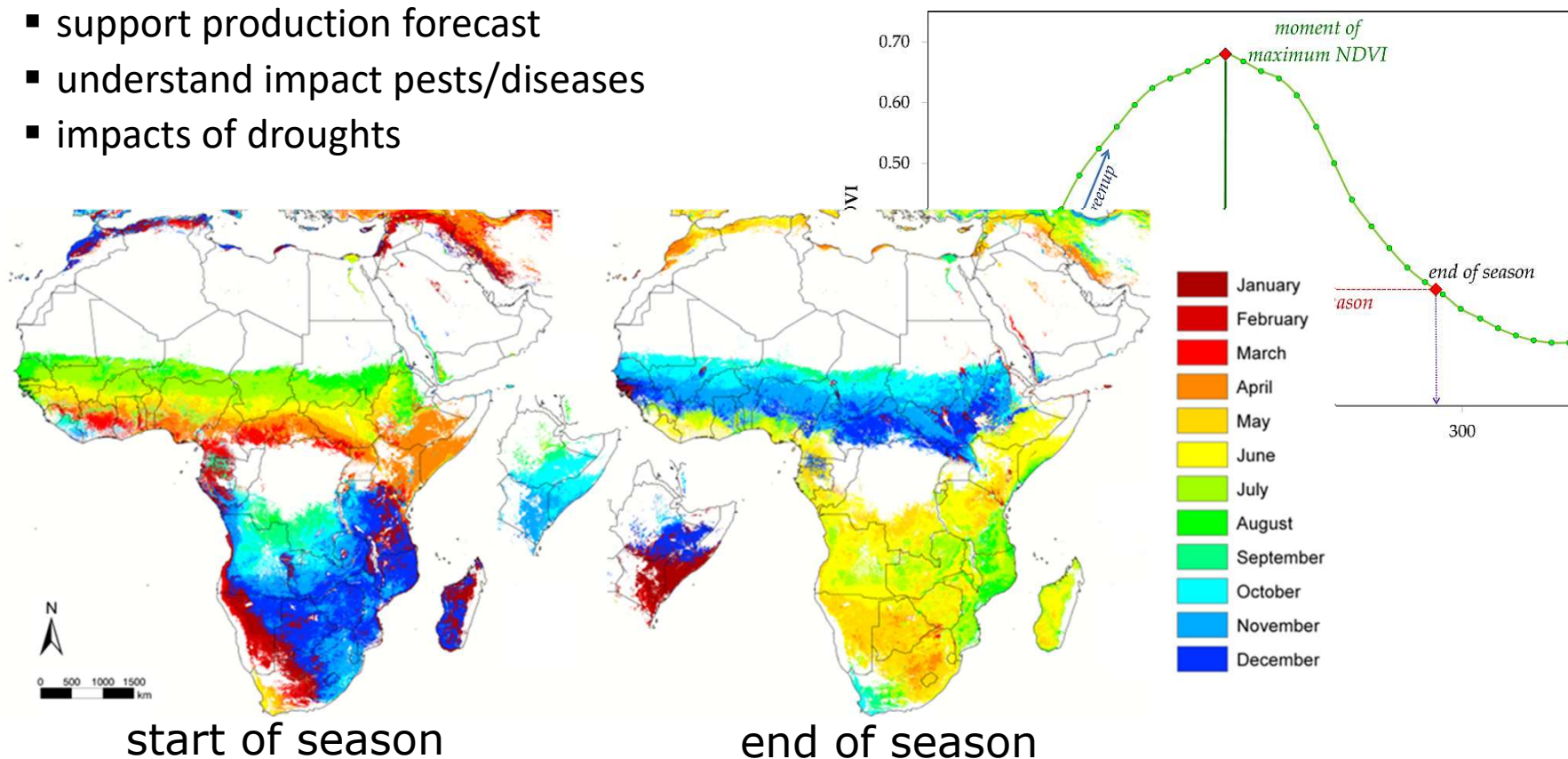
- Key grazing areas for nomadic livestock
- Water points



Image: <https://www.flickr.com/photos/ilri/23595231984/in/album-72157623247974374/>

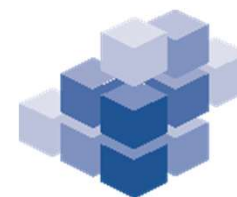
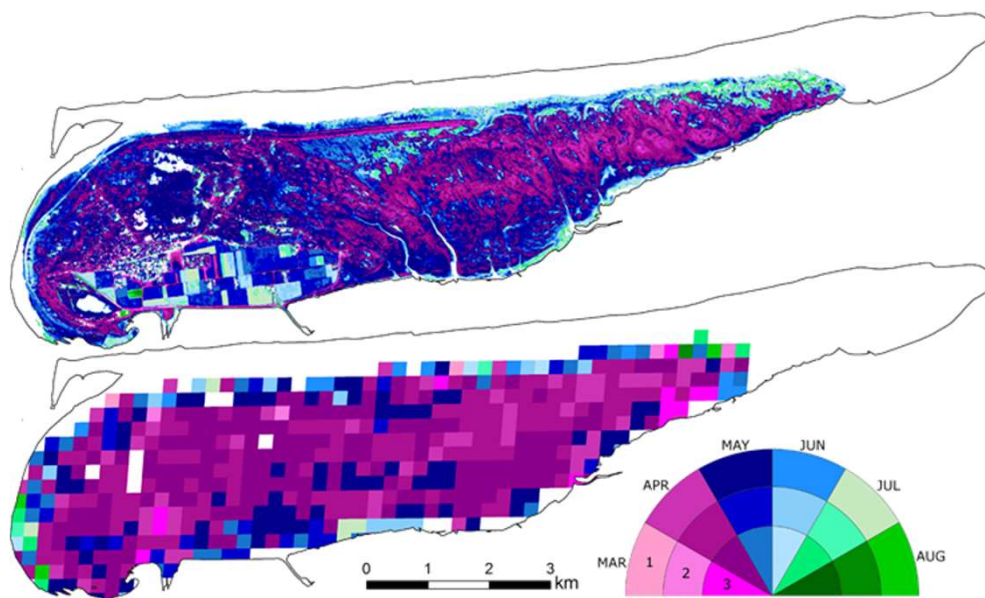
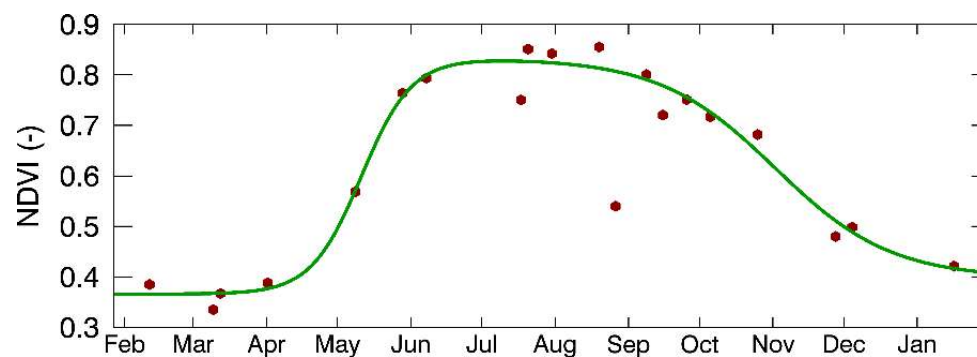
When (1)

- If we do not know when crops grow, we cannot detect them...
- Timely estimates of crop/forage status (physical characteristics):
 - support production forecast
 - understand impact pests/diseases
 - impacts of droughts



When (2): recent options at high-resolution

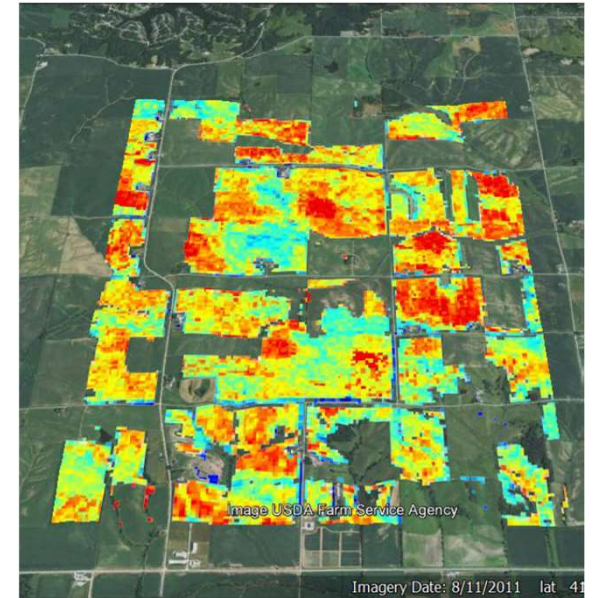
- Sentinel-2:
 - 10m resolution
 - 5-day repeat
 - but, no long series...



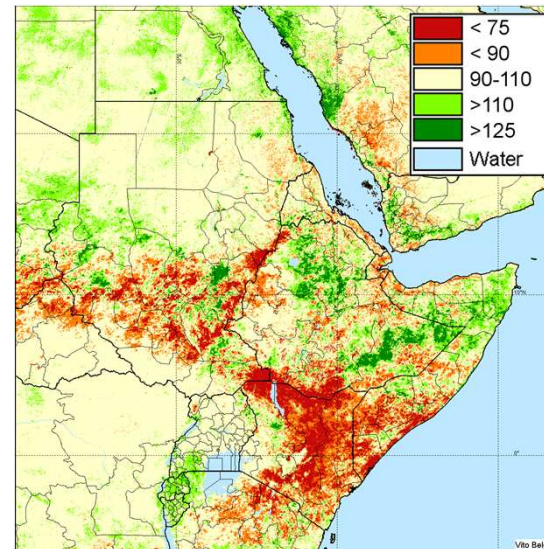
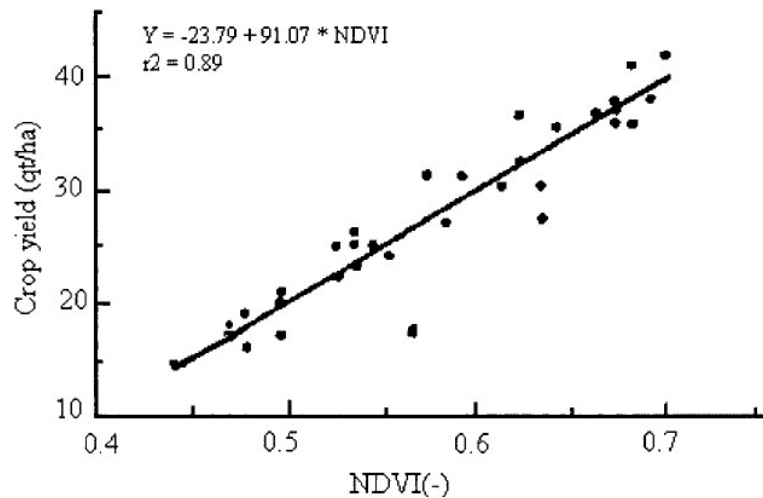
innovators
rsforebv

How much

- Spatial variability
 - In field, between fields, between admin-units?
- Temporal variability
- Production estimate vs anomaly
- Empirical relationship vs crop model



Yield variability at field and sub-field level from Lobell et al. (2015). A scalable satellite-based crop yield mapper, RSE 164, pp 324-333

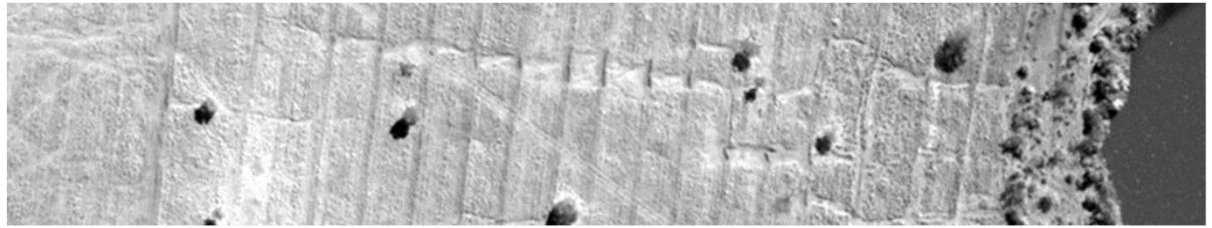


NDVI June 2011 vs. mean('98-2010)

How?

- Management practices

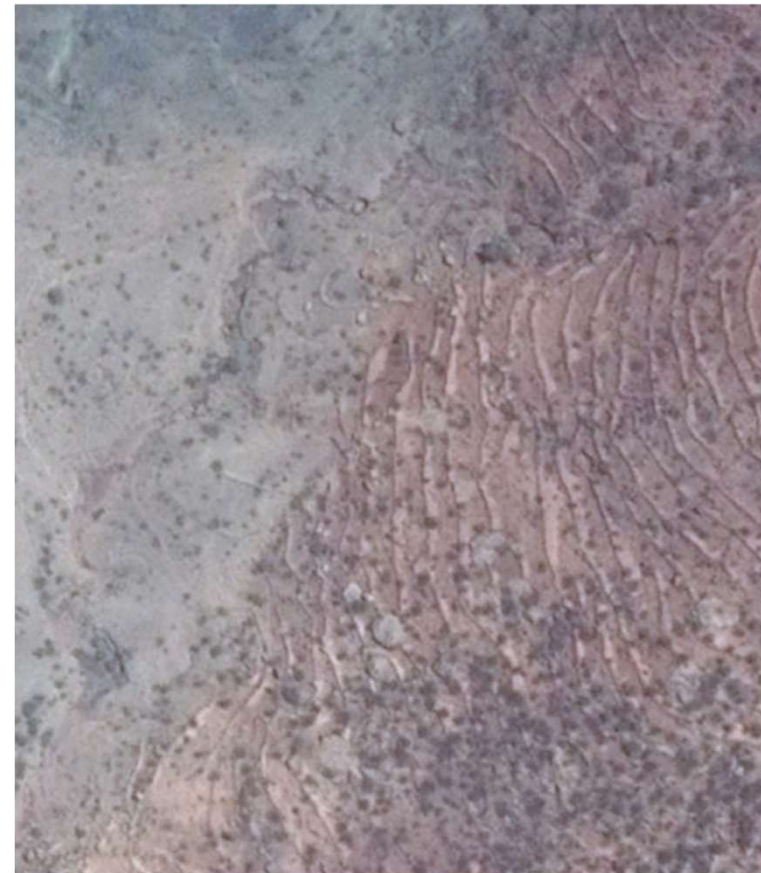
- soil conservation
- irrigation
- tillage
- ...



QuickBird image near Uberlandia (MG), Brazil, taken on 4 August 2003

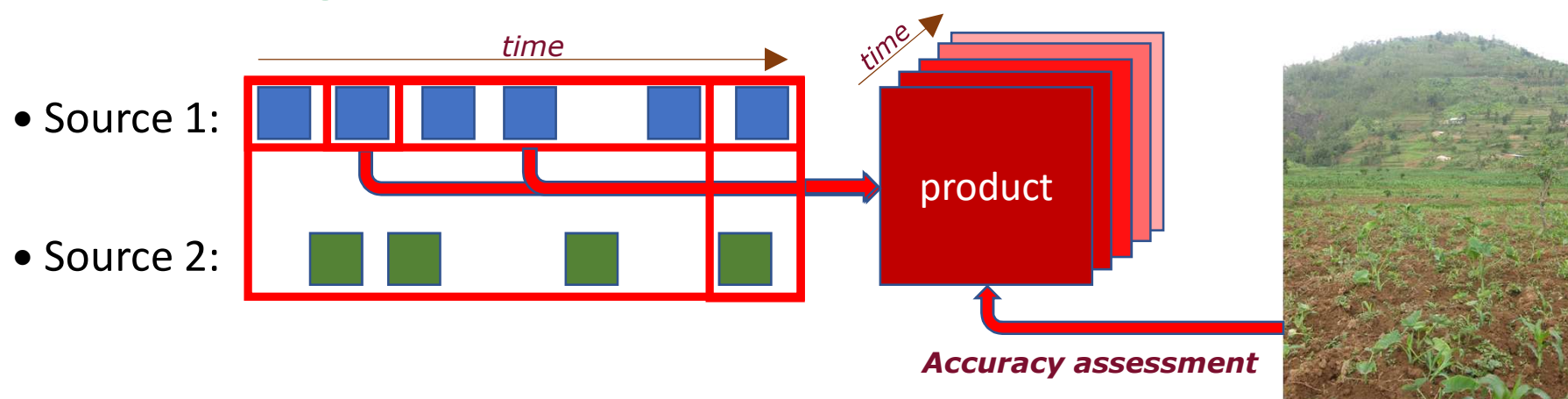


Own photo (3 April 2016) near Abuna Yemata (Hawzen), Tigray, Ethiopia



Stone rows along contour on Google Earth image near Abuna Yemata (Hawzen), Tigray, Ethiopia

From images to information



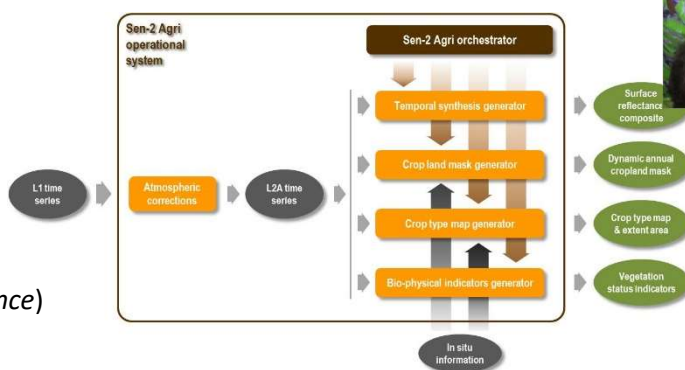
- Make 1 product with one image (*e.g., land use map*)
- Make 1 product with multiple images of same source
- Make 1 product combining single images from two sources (*near in time*)
- Make 1 product combining multiple images from more sources
- Combine products in time (*e.g., land use change*)
- How does product compare to field reality?

How to obtain information?

- Do it yourself
 - Specialized software
 - Online options (e.g., Google Earth Engine)
 - Existing tools (e.g., Sen2Agri)
 - Expertise needed
 - Capacity building



- Use free, existing products
 - Raw images
 - Processed products (e.g. surface reflectance)
 - Higher-level products
 - Do they suit needs?



- Get experts on board
 - No need for processing facilities
 - No need for image interpretation
 - Direct access to required information
 - Comes at a cost but possibly cheaper than setting it up from scratch



Burnt Area	Land Cover
Dry Matter Prod.	NDVI
FAPAR	Soil Water Index
FCOVER	VCI
Leaf Area Index	VPI

ICT revolution

HydroNET

HOME DASHBOARD APPLICATIONS HYDROSTORE

eLEAF Satellite Data
This waterrapp provides online access to current and historical eLEAF data, such as actual evapotranspiration, evapotranspiration deficit and biomass production.

HydroVizWatch
This waterrapp displays the important hydrological measurements such as water levels at critical locations in one map. It gives immediate insight into the status of your system.

Flood Forecasting System
Which water levels are expected during the next 10 days? What areas are likely to be flooded? What measures will be most effective? This app gives the answers.

CityFlood
This waterrapp provides tools to analyse the effectiveness of urban planning measures on reducing flood risk caused by extreme rainfall events.

Water Demand Forecast App
Forecasts water demand for selected water network area using historical water consumption data, weather data and customer behaviour using artificial intelligence algorithms.

Download
Download data from all connected data sources with this waterrapp. Downloads can be made for any selected time period in different standard data formats (xls, xml, csv, pdf, etc.).

DMA Water balance tool
Performs water balance on DMA, DPA or network level using the approved IHA methodology.

DroughtWatch
This waterrapp calculates the cumulative rainfall deficit based on radar rainfall information and satellite evaporation information. An additional 10-days rainfall deficit forecast is also provided.

GroundwaterWatch
This waterrapp displays current and historical groundwater levels in your water catchment. Groundwater measurements are combined with long-term statistics.

HydroAlert
Define alarm levels for all your data which is connected to the HydroNET Portal. You receive a text message or e-mail in case predefined thresholds are exceeded.

HydroCompass
Do you want to keep track of progress on projects or the degree to which the targets of your plan are being achieved? This app offers business intelligence dashboards.

HydroView with Scada data
Thematic mapping of the water (sewer) network by displaying Scada measurement points on the map and real-time and historical data in charts.

Leakage Detection App
Uses measured data (Scada or data loggers) and Epan-Net hydraulic model to optimise find possible leaks and their size.

Information DMS

Information Performance DMS

fieldlook.com

See more... Consultants Agents Contact

Welcome

My fields Log out

Add your field

Register for free

View demoparcels

Newsletter: Subscribe now!

Fill in your e-mail address

Send

News

New version of Fieldlook:
Last week we update fieldlook.com. The newest version will be easier and comfortable, also new to...
[Read more](#)

First link satellite images to fertilizer
July 27, 2009 - Laboratory and Knowledge Institution are first succeeded in linking the satellite...
[Read more](#)

Zoom in on your crop

GENERAL GROWTH MOISTURE MINERALS RETURNS

Planting, growing, harvesting

The cycles of agriculture are full of uncertainties. As the farmer, you are of primary importance. You observe, you decide, and you act. Your decisions are based on your experience, your knowledge, advice from others, and perhaps even on gut feeling.

Precision agriculture
High market demands and technological opportunities mean that crop farmers must keep a very close eye on their daily work - precision agriculture. Information

Parameter Overview
eLEAF Portal

Analyse parameter
eLEAF Portal

FIELDLOOK
ADVISES

GROWTH
Biomass production 43.0

MOISTURE
CO2 intake 93.6

MINERALS
Leaf area index (LAI) 0.25

RETURNS
Vegetation index 0.19

Contact / Helpdesk

Products & Advices

General

Irrigation

Potatoes

Cereals

Sugarbeets

Map **Satellite** **Hybrid**

Map data 2009 © - Terms of Use

Legend

1100 1140 1180



→ EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT
Agriculture and Rural Development



European Space Agency

To retain

- Many satellite images exist
 - Imaging technique
 - Cost
 - Spatial coverage
 - Spatial detail
 - Temporal frequency & length series
- Many applications require frequent observation throughout season
 - Mapping & change assessment
- Images are great, but...
 - ≠ information
 - generating products requires effort:
 - expertise in processing and dealing with large data amounts
 - compare products against in situ data?
 - accuracy of products (depending also on application)
- Numerous companies provide information using Earth Observation data
 - Provide the required information directly for further processing / use
 - To consider if link to ground data / validation is provided also
 - Could be cost-efficient
 - Capable of timely, accurate and repeatable service provision

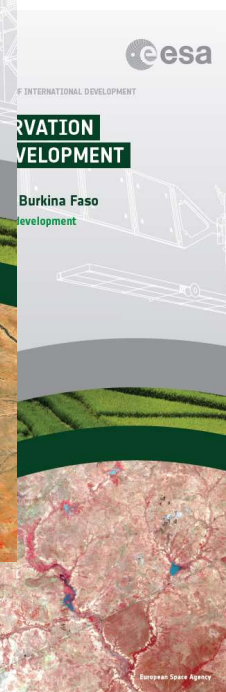
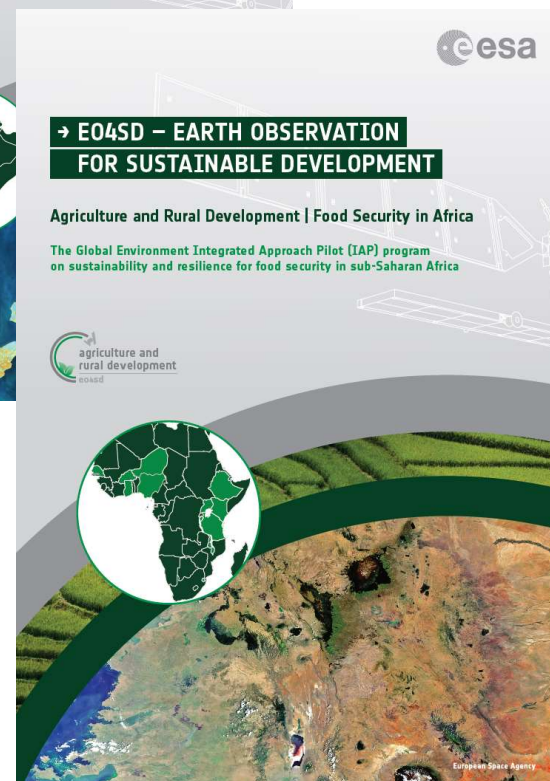
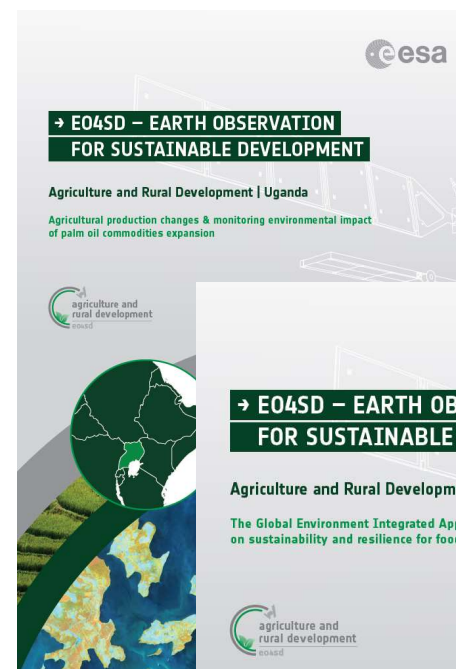
For more information

<http://eo4idi.eu>

<http://eo4sd.esa.int/>



Agriculture is critical to the future of sustainable development. Globally the entire sector is being challenged to produce approximately 70% more food to feed 9 billion people by 2050. It has been acknowledged that most of this increase will need to come from greater land and water productivity as well as expansion of arable and irrigated areas. However, currently, agriculture consumes 70% of global freshwater, and emits about a quarter of all global greenhouse gases. Some of the current farming practices have negative consequences on water quality, and they



→ EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT
Agriculture and Rural Development

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