→ 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

agriculture and rural development
eo4sd

The consortium of EO4SD – Agriculture and Rural Development

The Netherlands

SATELLIGENCE

Service provision

eleaf
FEED THE WORLD

Nelen & Schuurmans

Data integration

ITC
UNIVERSITY OF TWENTE.

Capacity development

DHI GRAS Denmark

GeoVille
geoville.com Austria

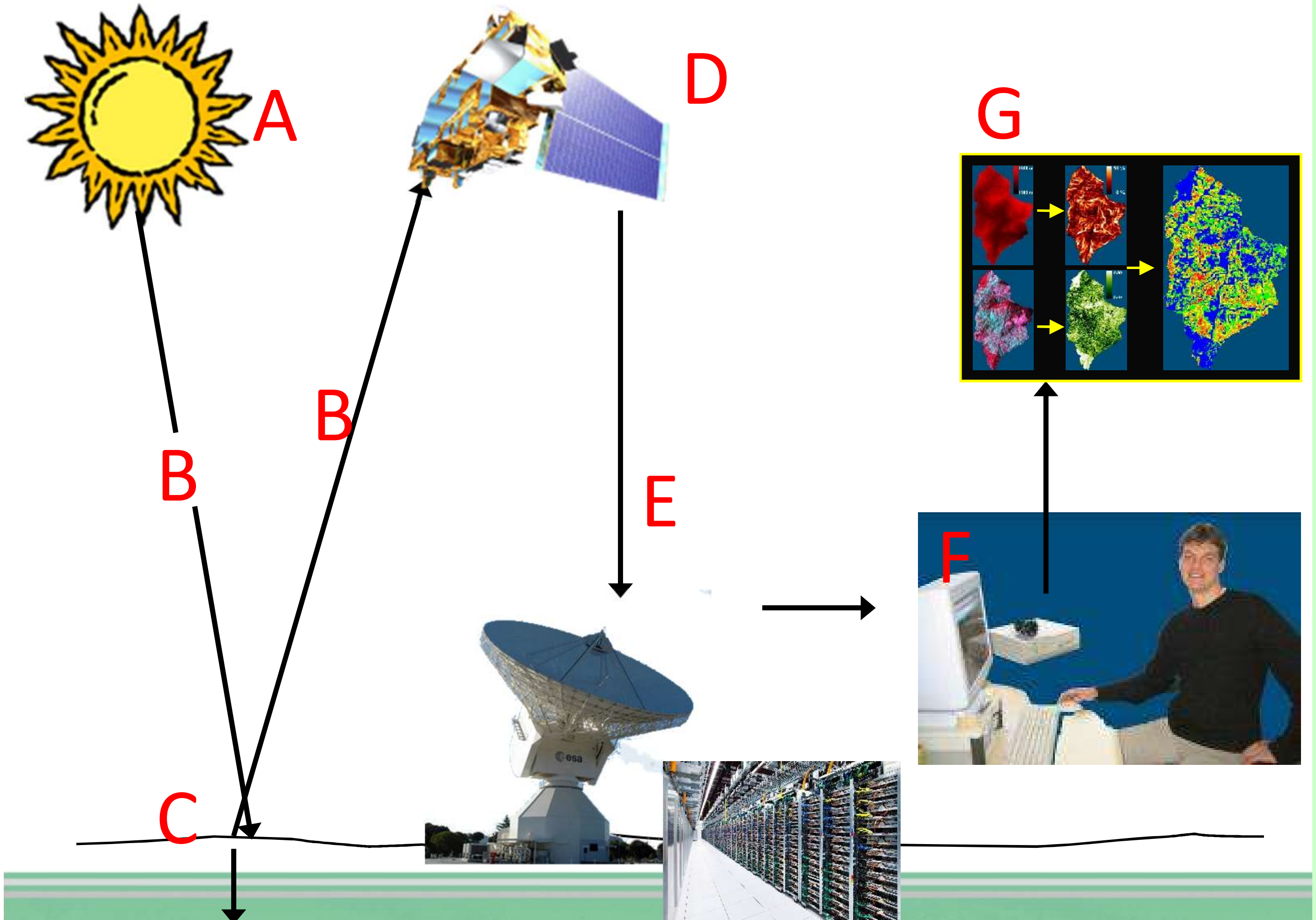
space·tec PARTNERS Belgium

Communication

ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

Remote sensing

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



A: Source of energy

B: Interaction with atmosphere

C: Interaction with earth surface

D: Recording energy

E: Transmission, reception, processing

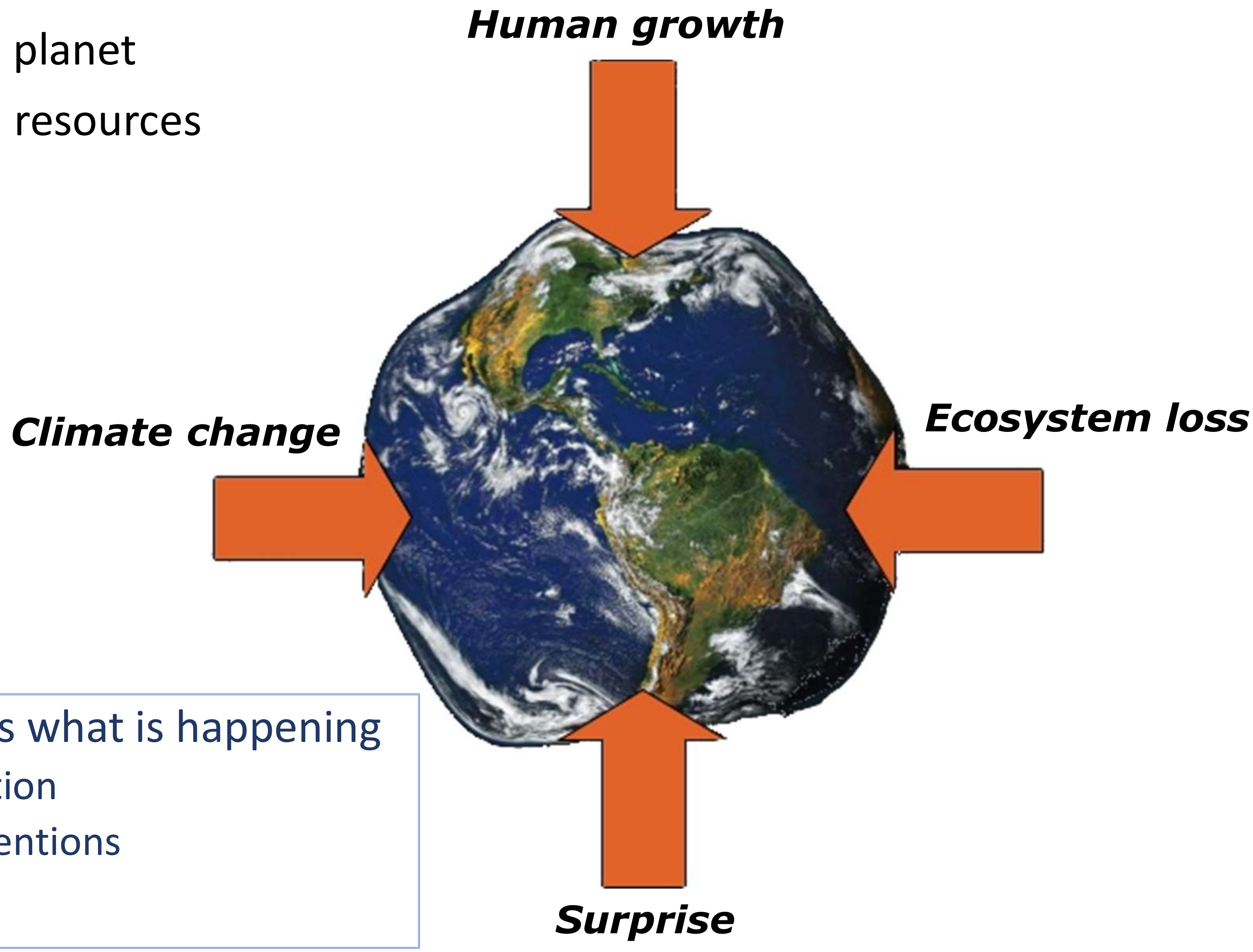
F: Analysis

G: Application

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

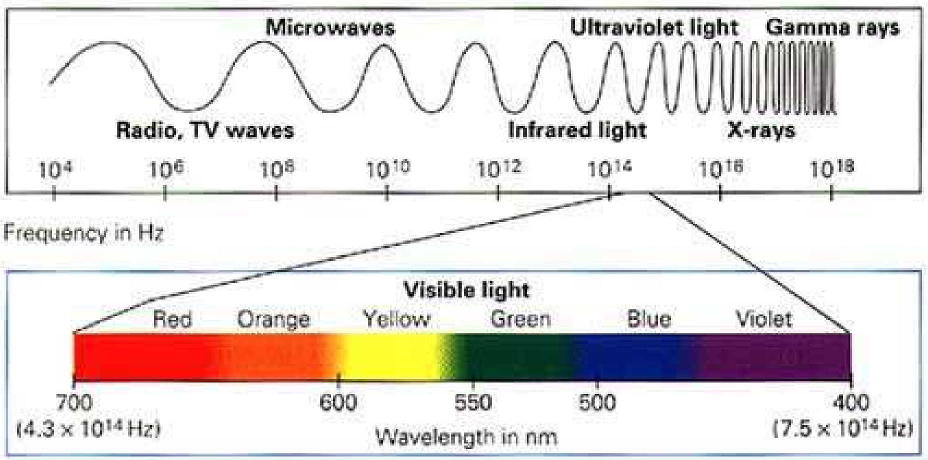
http://eohandbook.com/sdg/

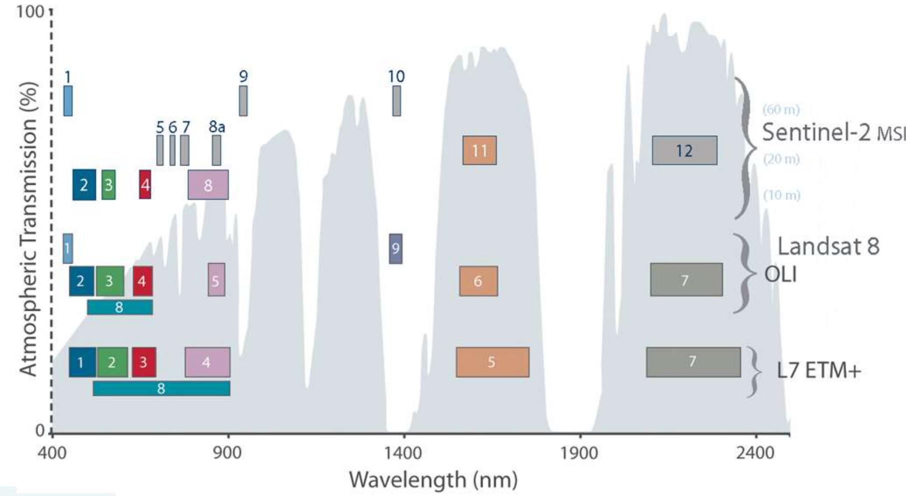
EXAMPLE

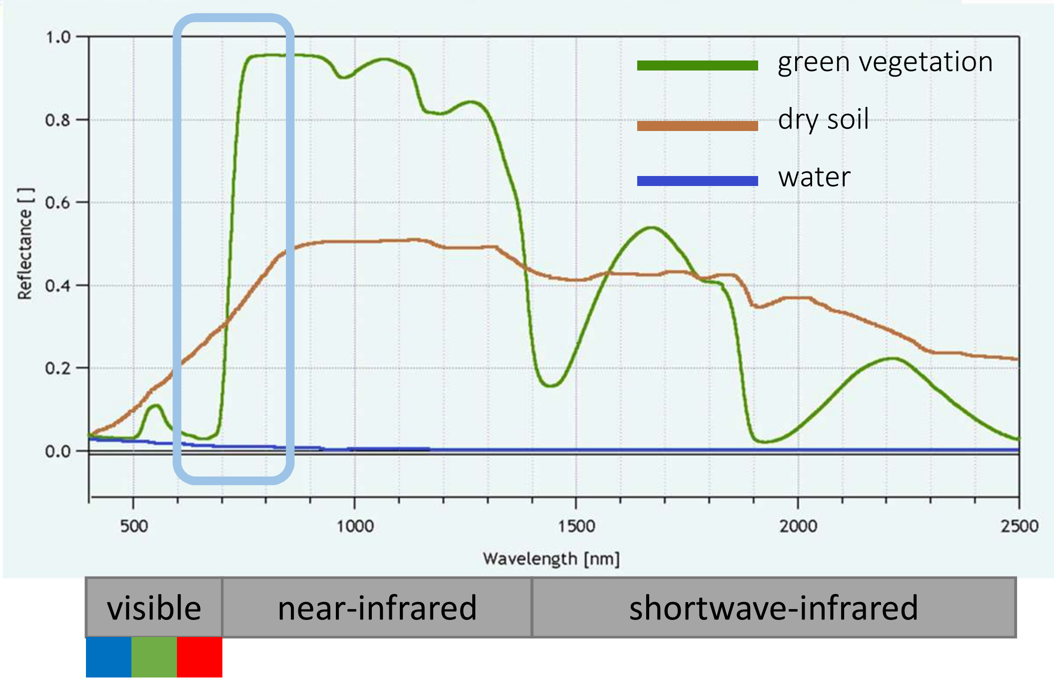
Goal 15: Life on Land

- 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?

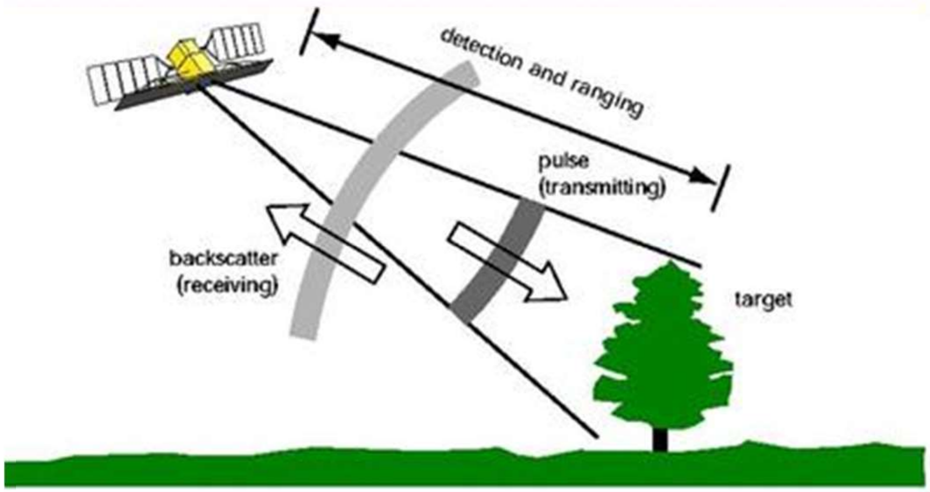


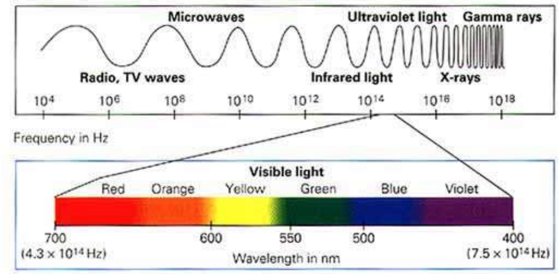


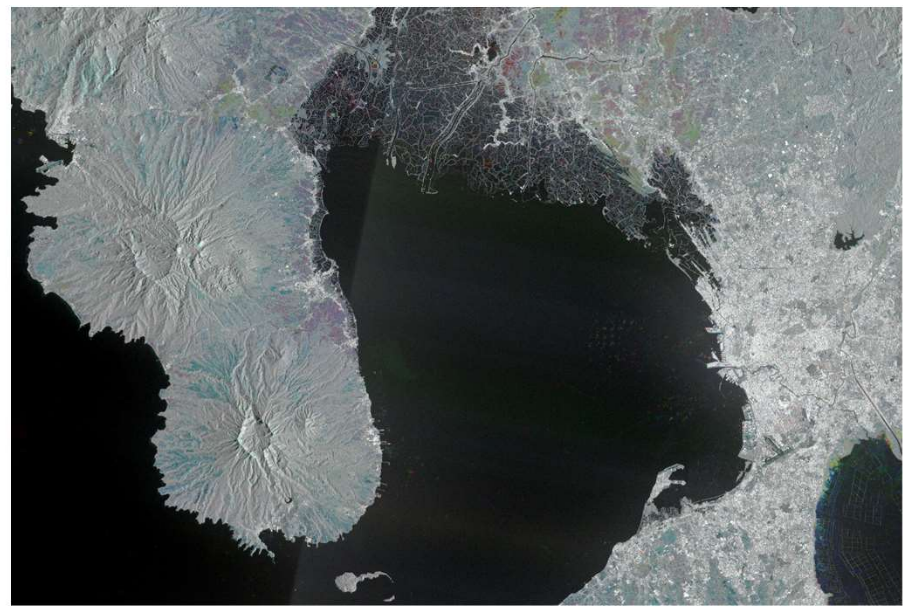


Sentinel-2: 13 May 2018 (Manila)

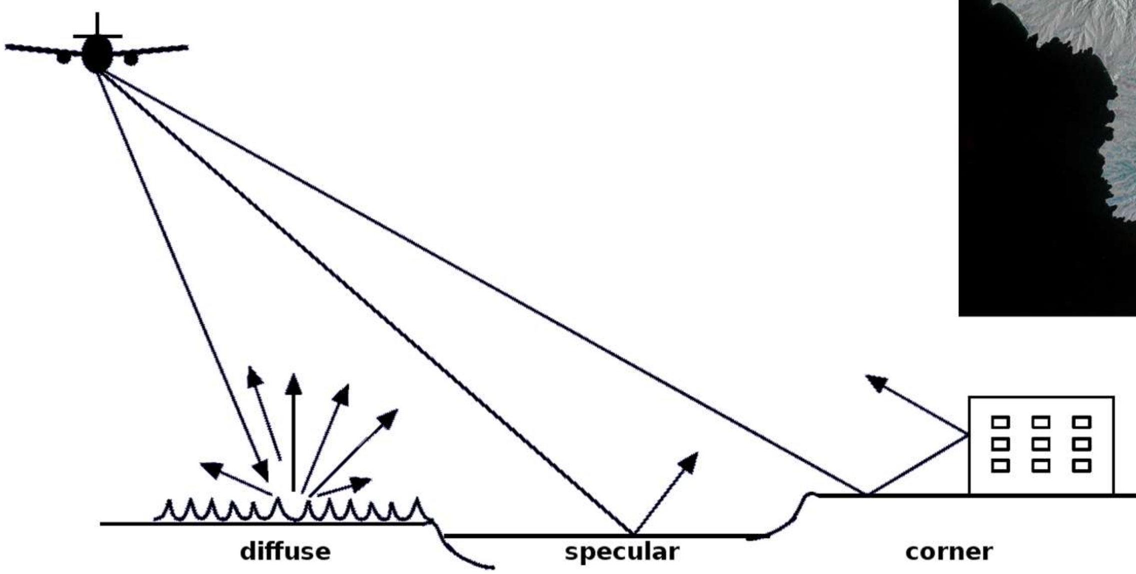
Active sensors: radar







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



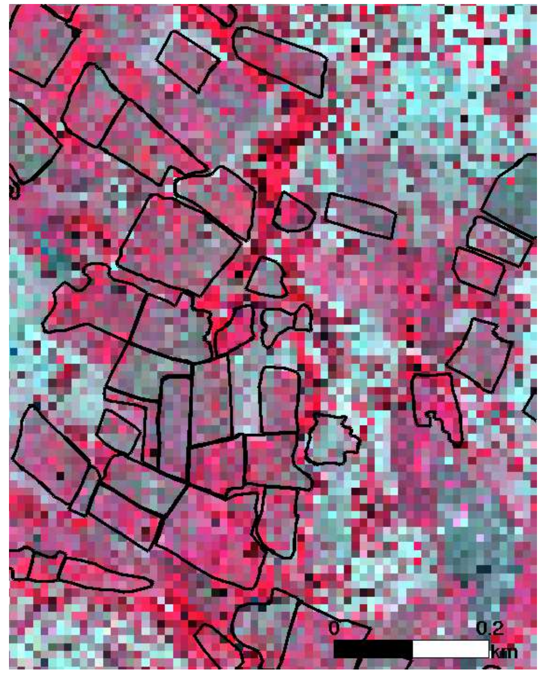
Remote sensing data sources: spatial detail (1)

Image courtesy: STARS project

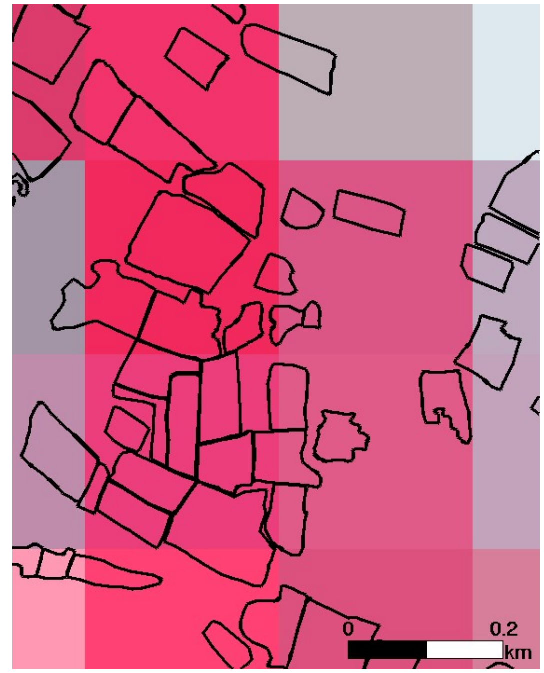
Remote sensing data sources: spatial detail (2)

WorldView-3: ~1m

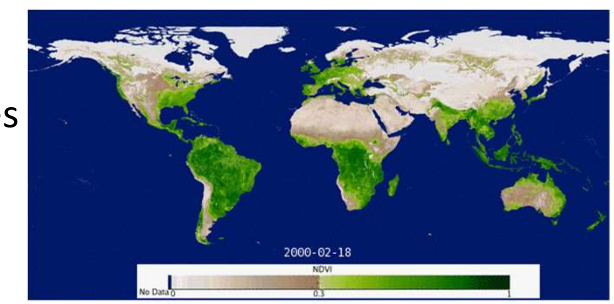
Sentinel-2: 10m



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

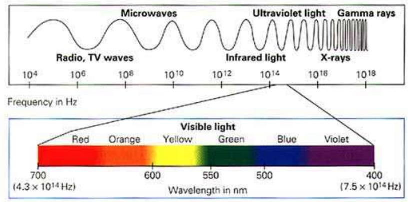


Medium resolution sensors

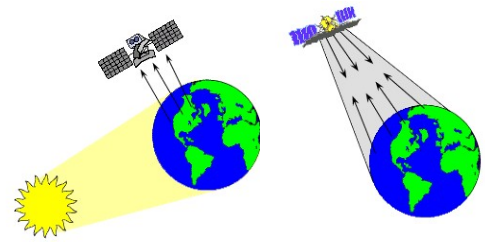
sensor	platform	spectral range	number of bands	resolution	swath width	repeat coverage	launch
AVHHR	NOAA POES 6-19	VIS, NIR, MWIR	5	1100m	2400km	12 hours	1978
AVHRR	METOP	VIS, NIR, SWIR, MIR	5	1100m	2400km	12 hours	2007
SEAWIFS	Orbview-2	VIS, NIR	8	1100m 4500m	1500km 2800km	1day	1997
VEGETATION	SPOT 4, 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

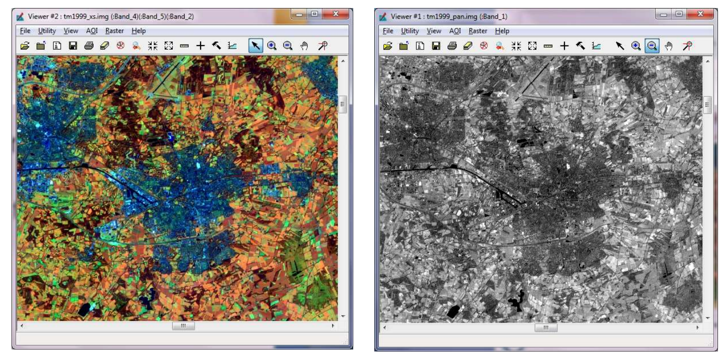
- Part of spectrum
  - Optical or microwave



  - Active or passive



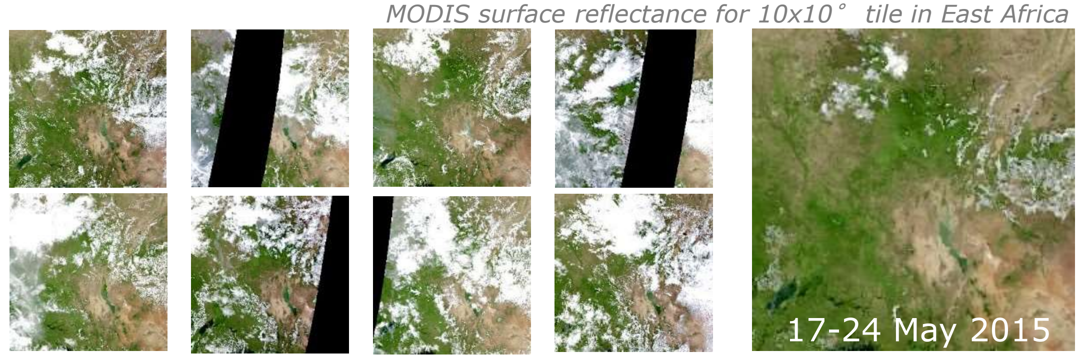
  - Number of spectral bands (or equivalent: polarization)



- Spatial detail (spatial resolution)

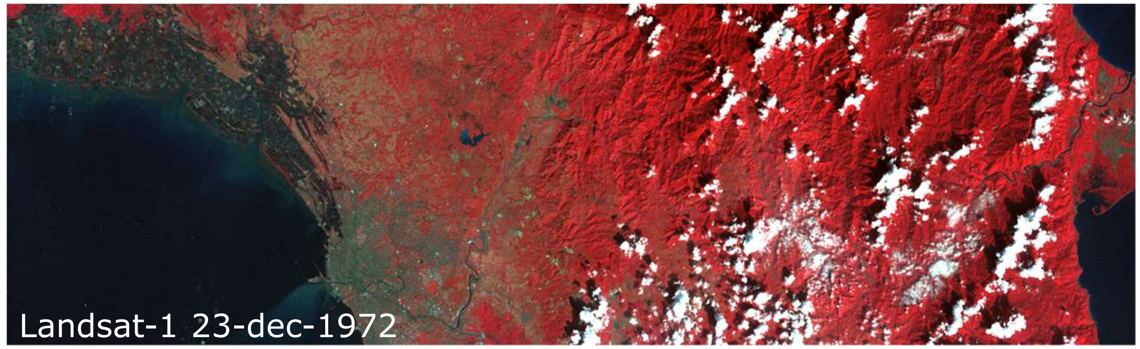
- Repeat frequency

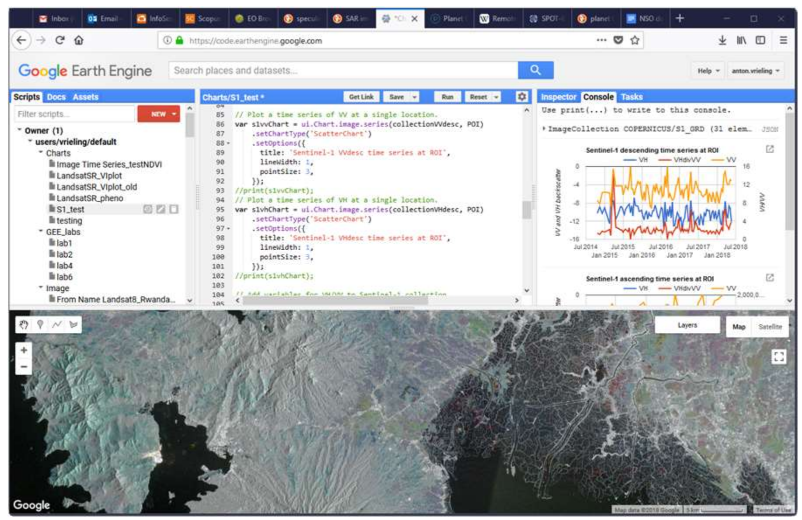
MODIS surface reflectance for 10x10° tile in East Africa

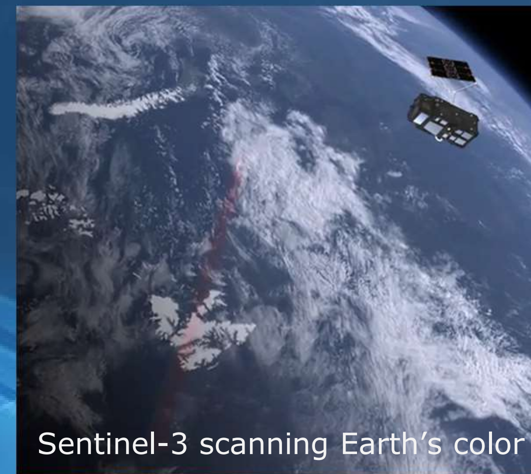


Data providers (a non-exhaustive list!)

- 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 / …







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

Long-term (decadal) continuous, consistent data

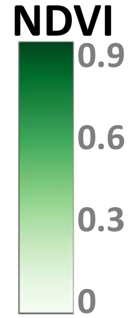
Copernicus programme

- 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.

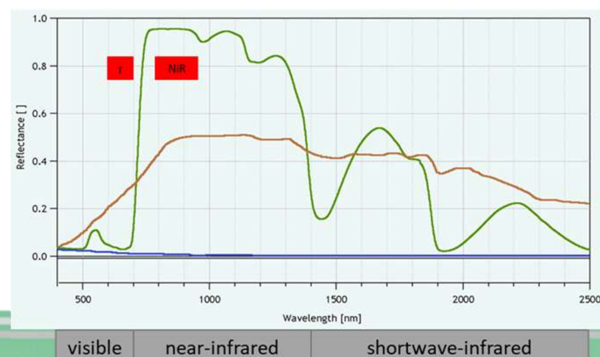
Sentinel-2: one example

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



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

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



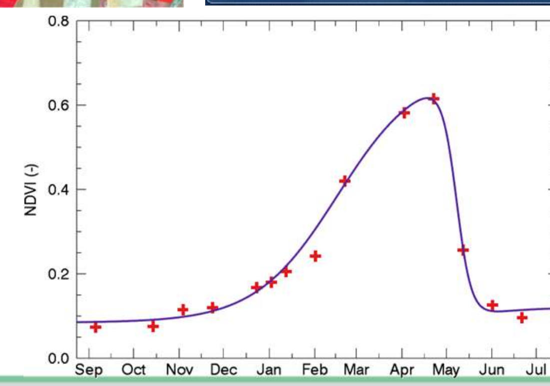
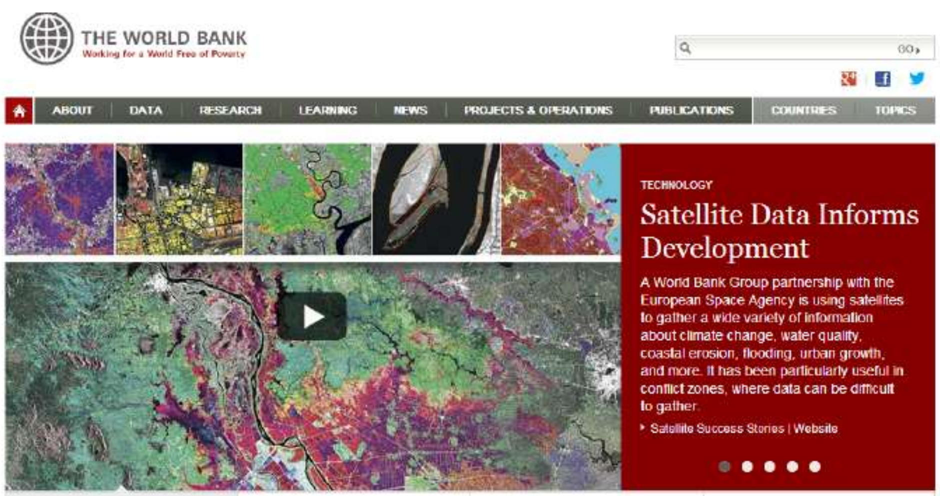


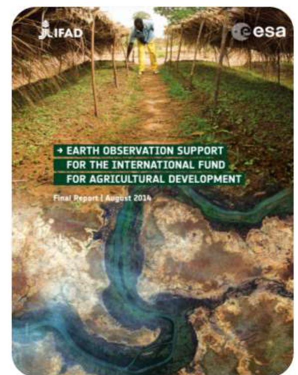
Image type selection: key questions

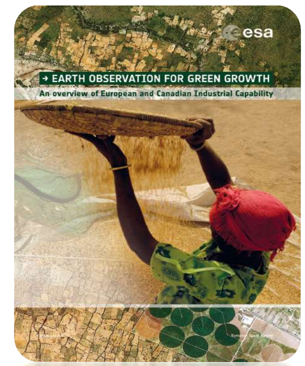
- What is the information needed?
  - What can be observed to fulfil that need?
  - How much spatial detail is required?
  - How frequent do we need information?
- How large is the area of interest?
- Are clouds a major issue? (observations at critical times)
- What are image costs?
- HOW TO TURN PIXEL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

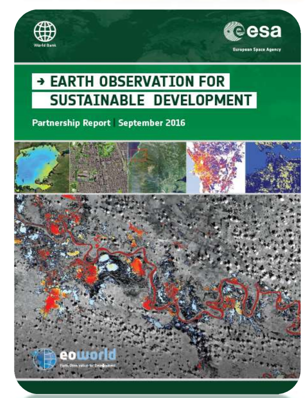
Promoting data literacy and use in international development

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









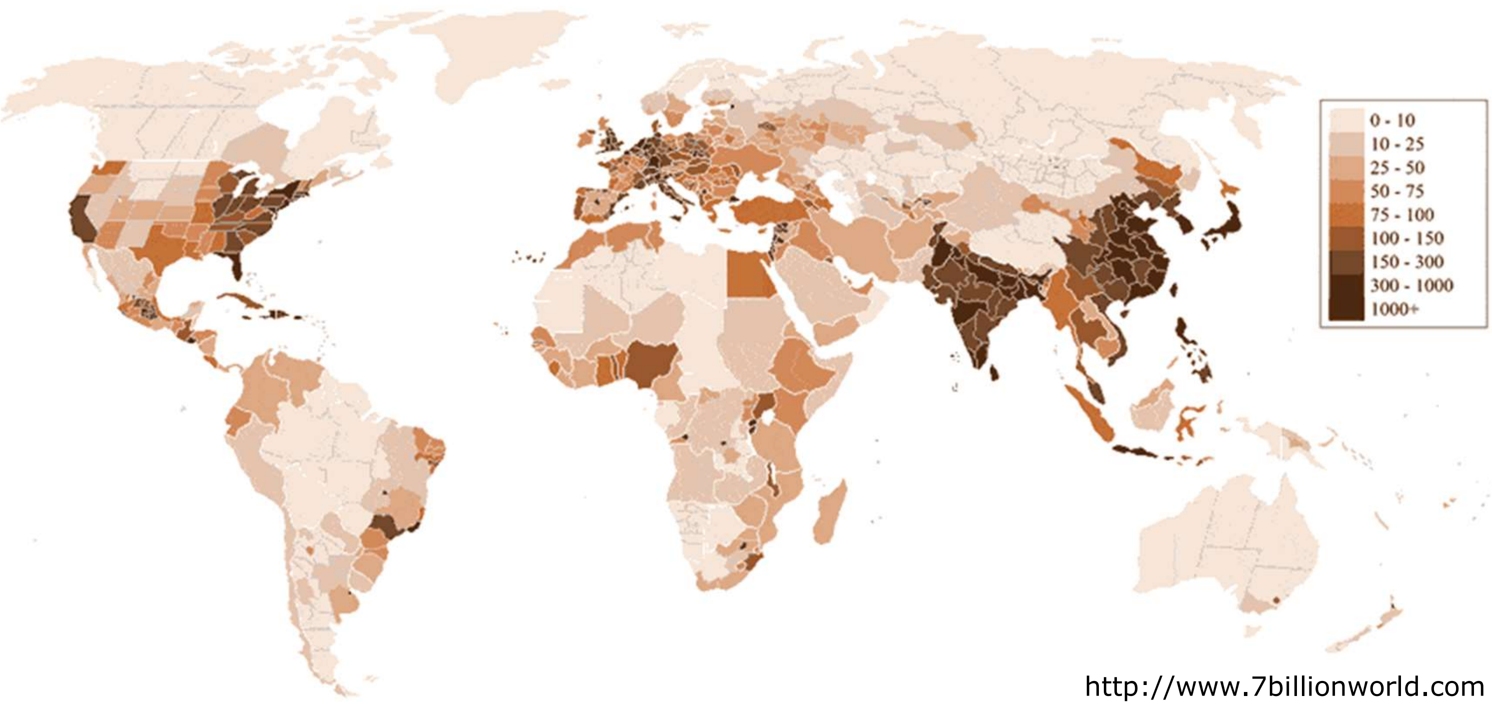
Promoting data literacy and use in international development

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

Longer-term vision

A closer look at agriculture: feeding the world

	Country	2013 Population	% of World Pop.	Area (km²)	Density (p/km²)	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%

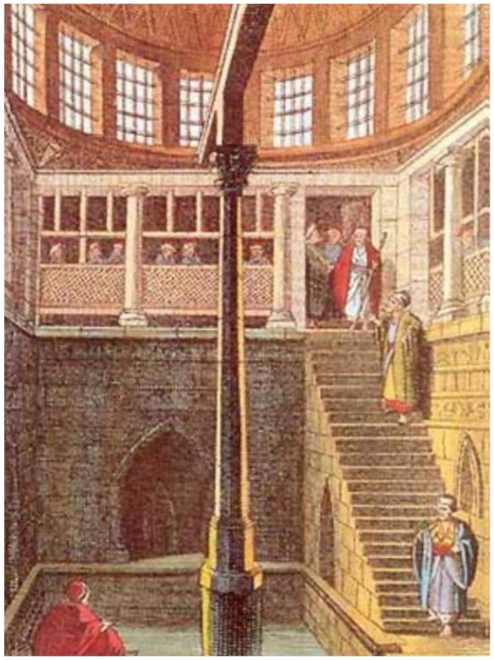


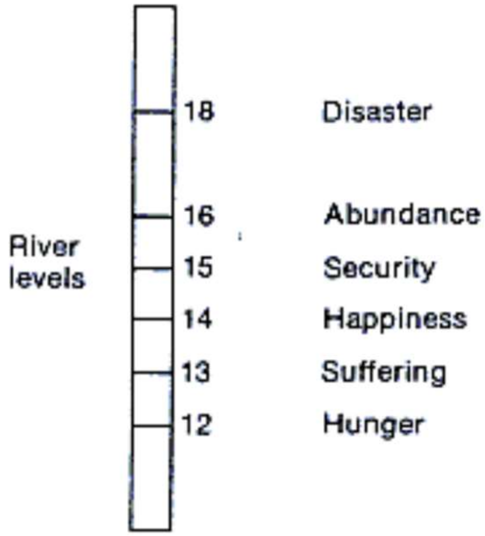
http://www.7billionworld.com

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

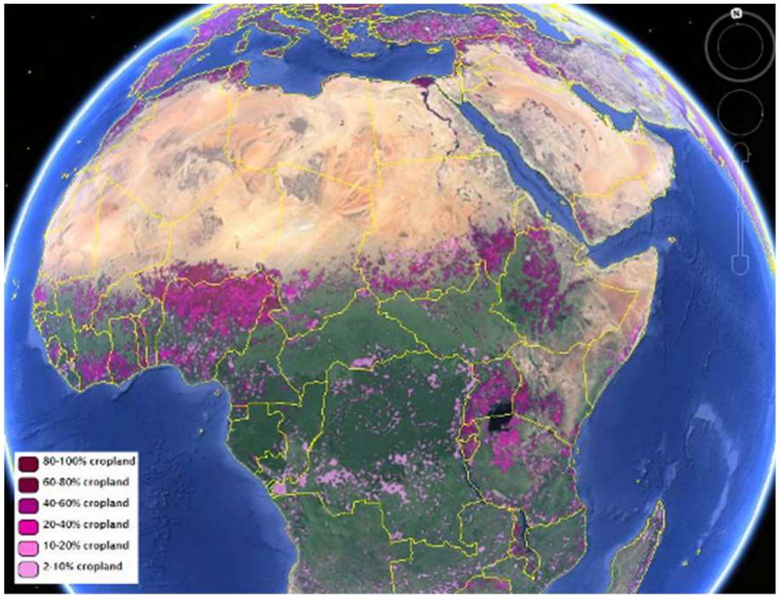


Image: http://www.iiasa.ac.at/web/home/about/news/150116-Cropland-Maps.html

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

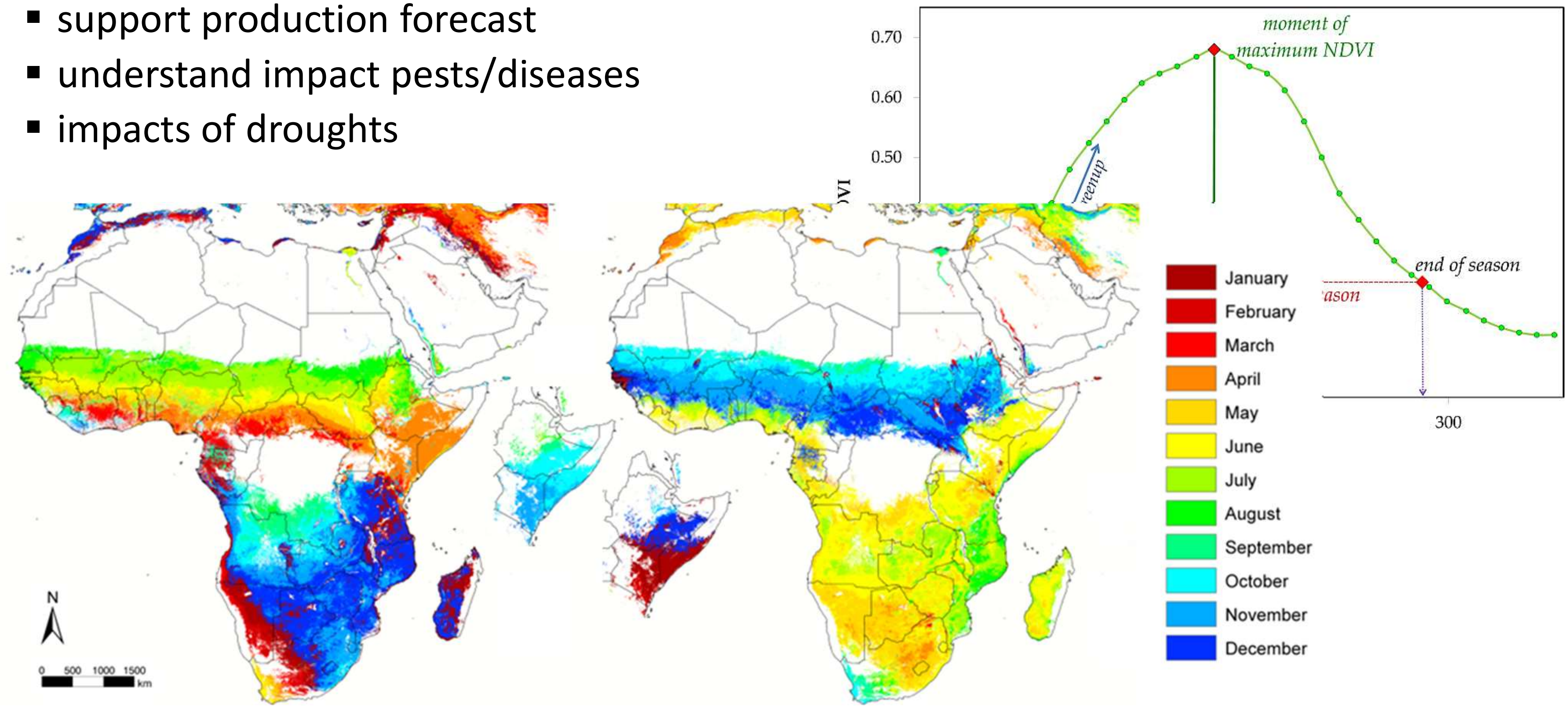
Where (3): Pastoral sector

- Key grazing areas for nomadic livestock
- Water points

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

When (1)

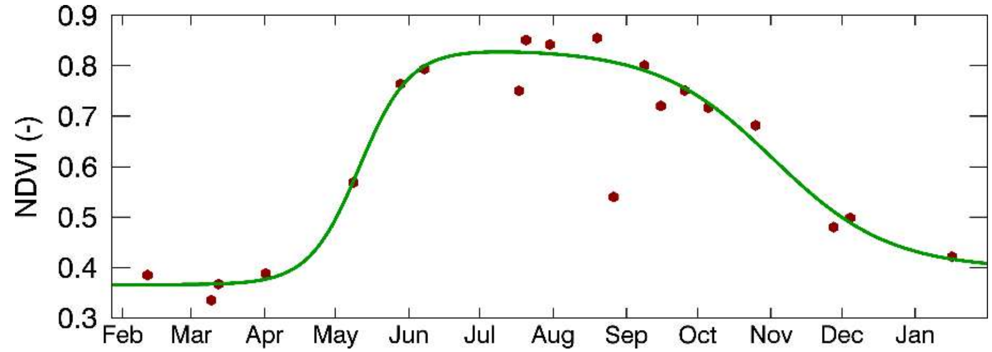
- If we do not know when crops grow, we cannot detect them…
- Timely estimates of crop/forage status (physical characteristics):
  - support production forecast
  - understand impact pests/diseases
  - impacts of droughts

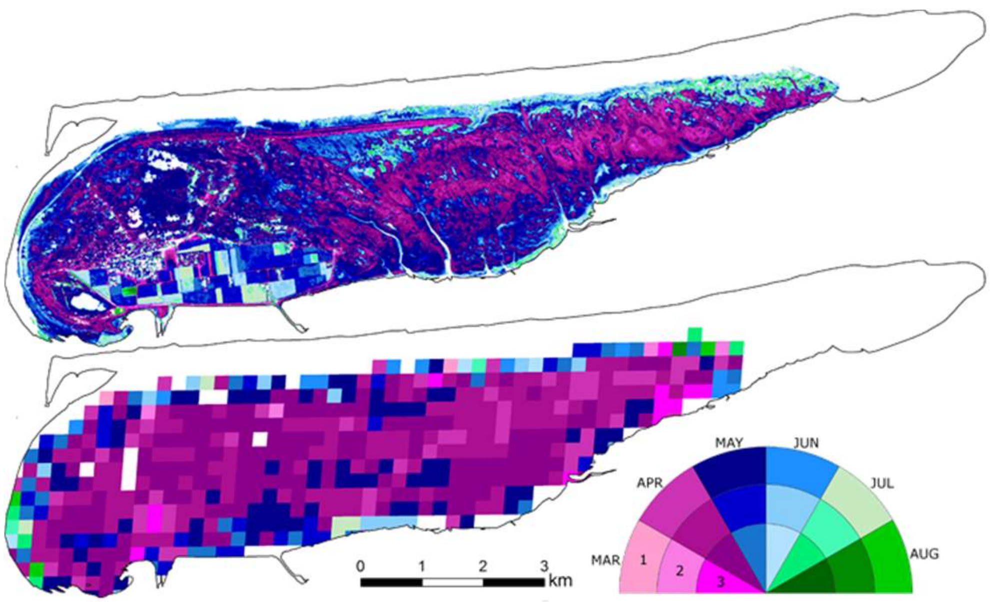


start of season   end of season

When (2): recent options at high-resolution

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

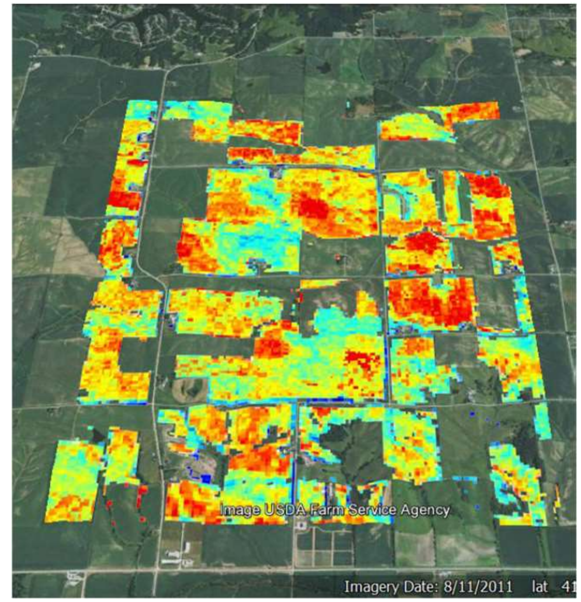




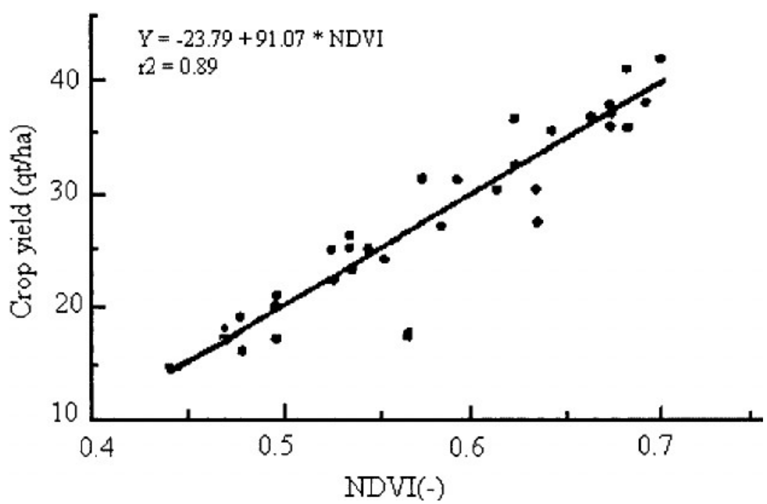
innovators
rsforebv

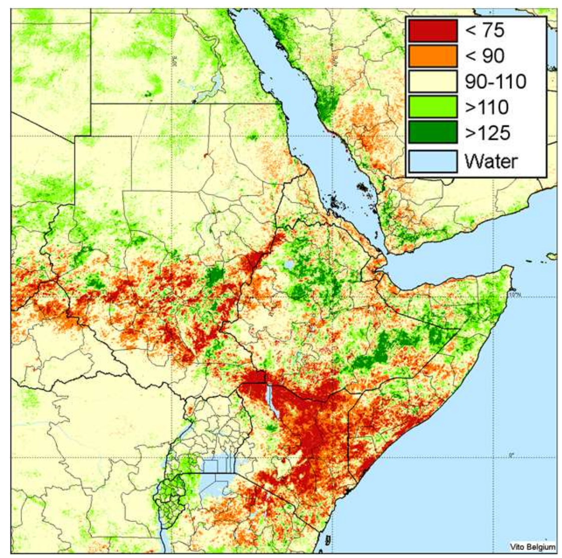
How much

- 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 Lobelll et al. (2015). A scalable satellite-based crop yield mapper, RSE 164, pp 324-333

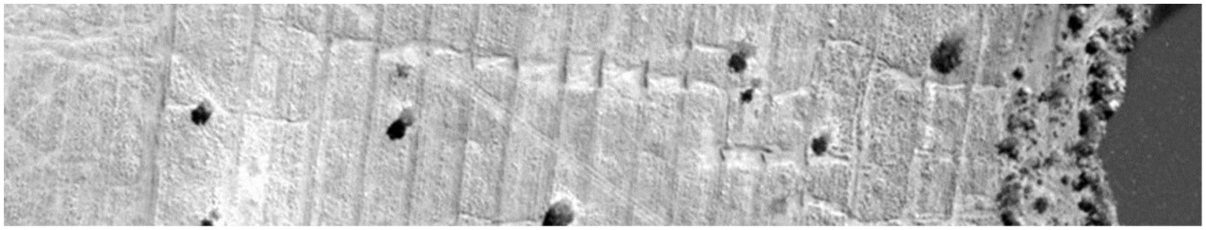




NDIV June 2011 vs. mean('98-2010)

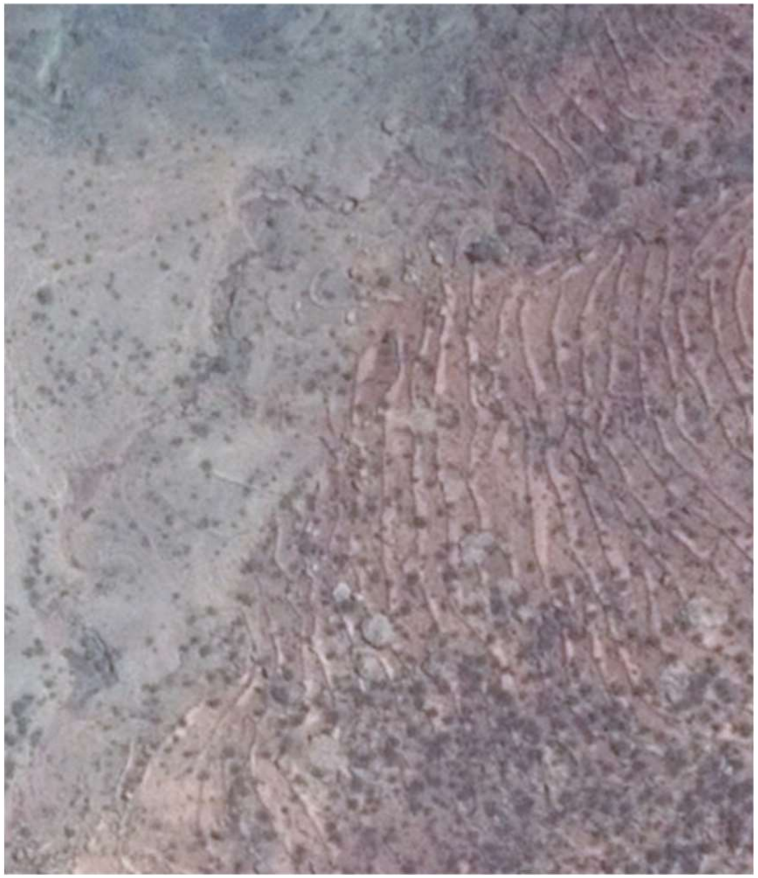
How?

- Management practices
  - soil conservation
  - irrigation
  - tillage
  - …



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

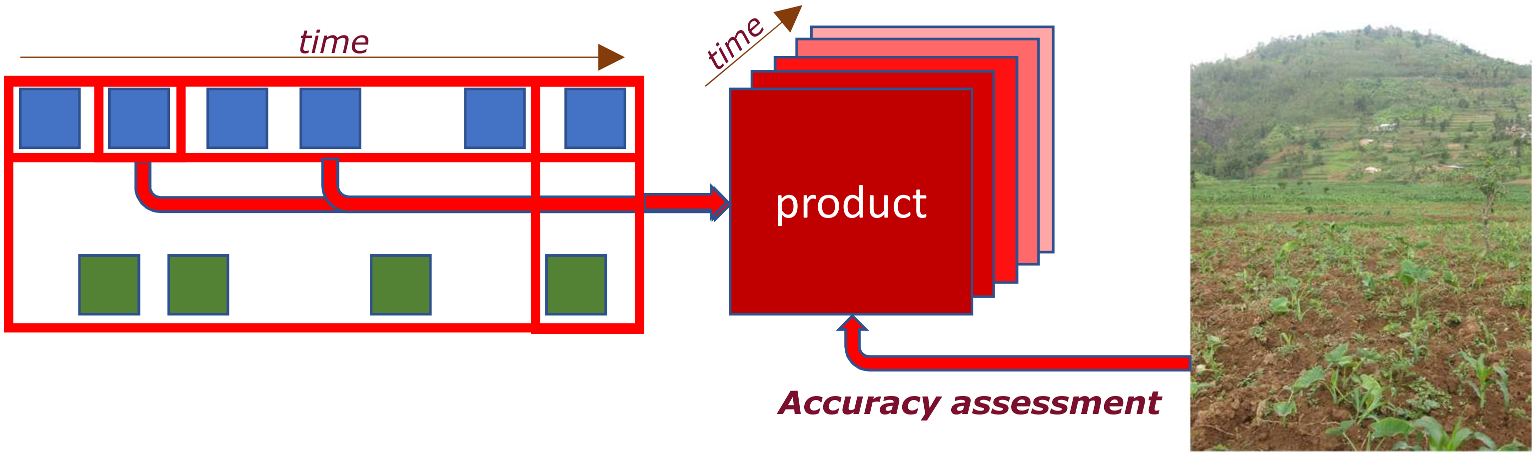
Own photo (3 April 2016) near Abuna Yemata (Hawzen), Tigray, Ethiopia



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

From images to information

- Source 1:
- Source 2:



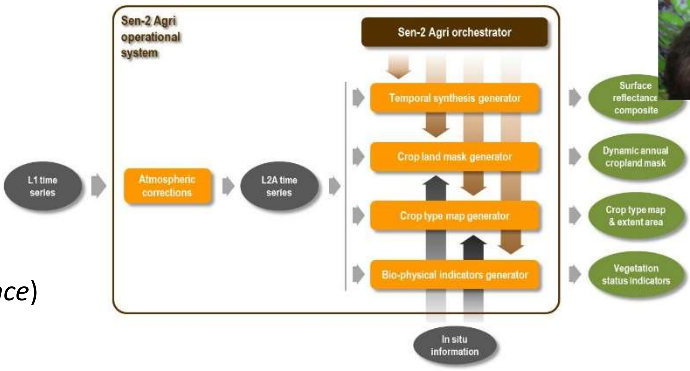
- Make 1 product with one image *(e.g., land use map)*
- Make 1 product with multiple images of same source
- Make 1 product combining single images from two sources *(near in time)*
- Make 1 product combining multiple images from more sources

- Combine products in time *(e.g., land use change)*

- How does product compare to field reality?

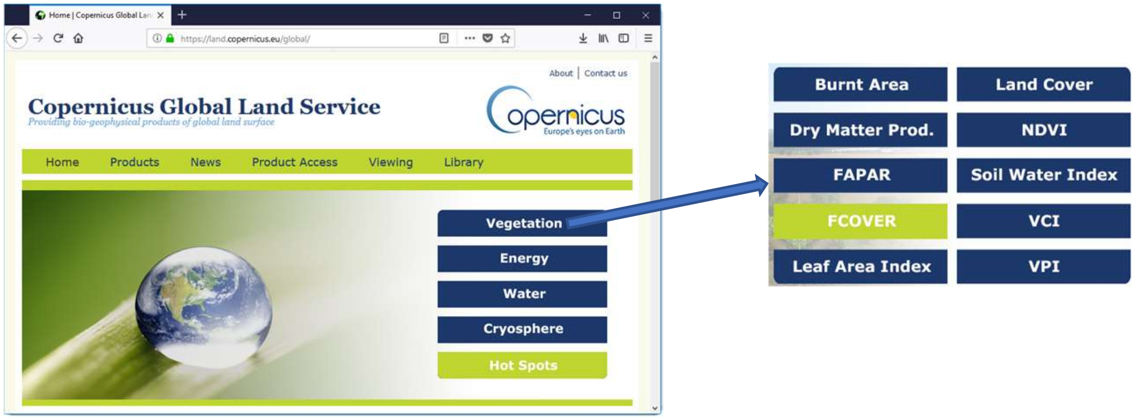
How to obtain information?

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



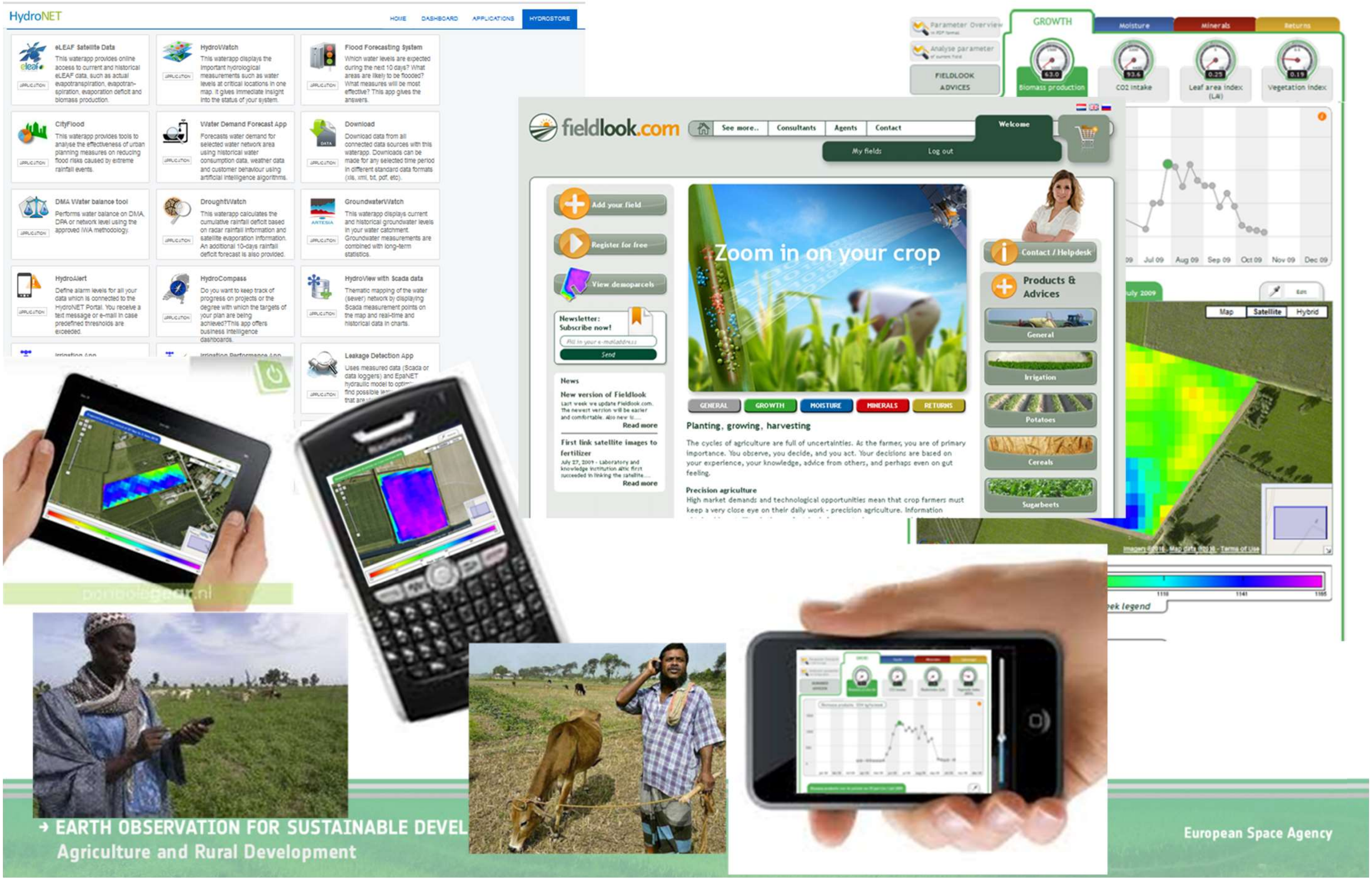
- Use free, existing products
  - Raw images
  - Processed products (*e.g. surface reflectance*)
  - Higher-level products

  - 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

ICT revolution



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/