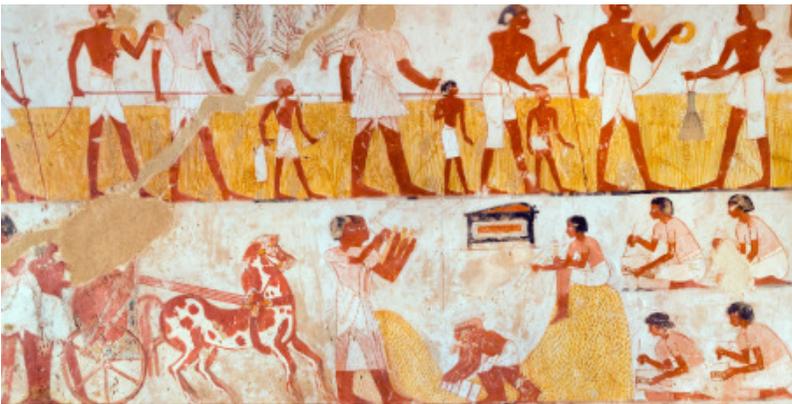


A review of agriculture applications of earth observation satellites.

1959-2018

Agriculture forecast and nowcasting

- A story beginning before the space age: Pharaoh (Sesostris?) and his intelligent minister Joseph stored $1/5^{\text{th}}$ of the wheat harvest during 7 abundant years and used their stock to centralize power in Egypt during 7 following lean years.



Map originating most probably from Google maps (Landsat 8?)



1959-1962: discovery of the earth from space.

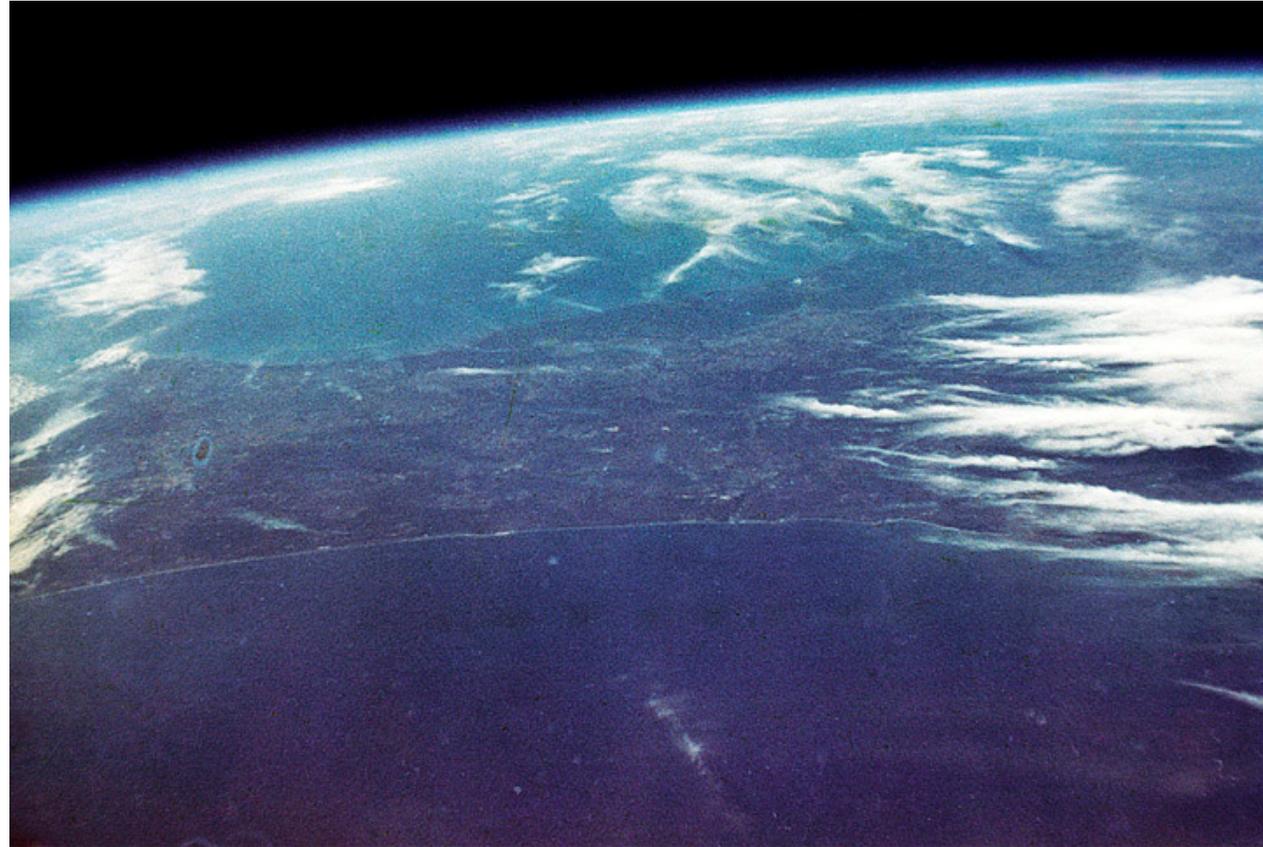


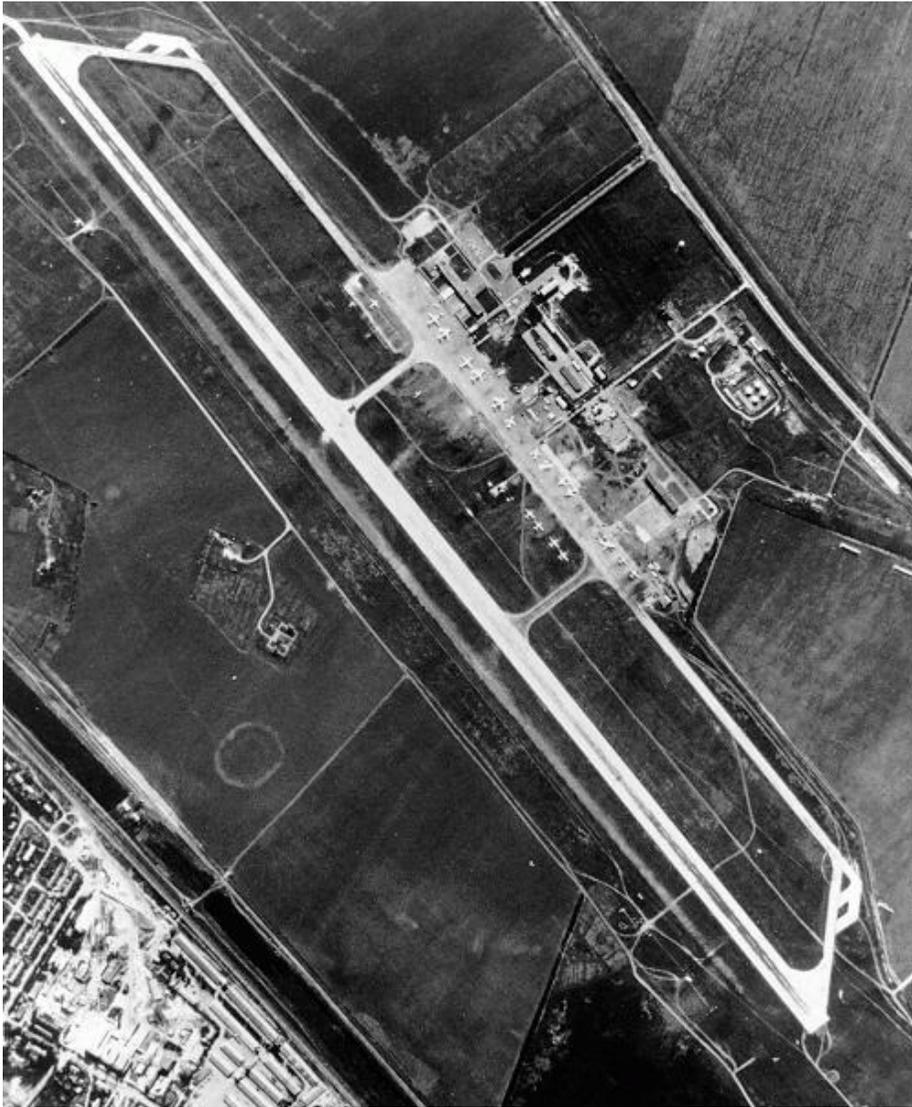
Explorer 4: 1959



TIROS: 1960

Florida image by John Glenn, 1962, manned space demonstrated the capabilities of resolving details from space.





1960 – 1972: high quality images from the CORONA satellite programme: similar in quality to high altitude aerial photograph. Lack of flexibility related to use of film cartridges (70 mm). Similar Soviet missions beginning with Kosmos 4.

Civilian use is only possible now because of progressive declassification.

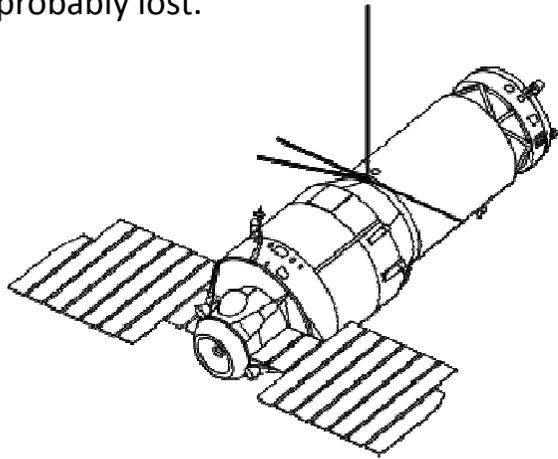


Progress between 1962 and 1970

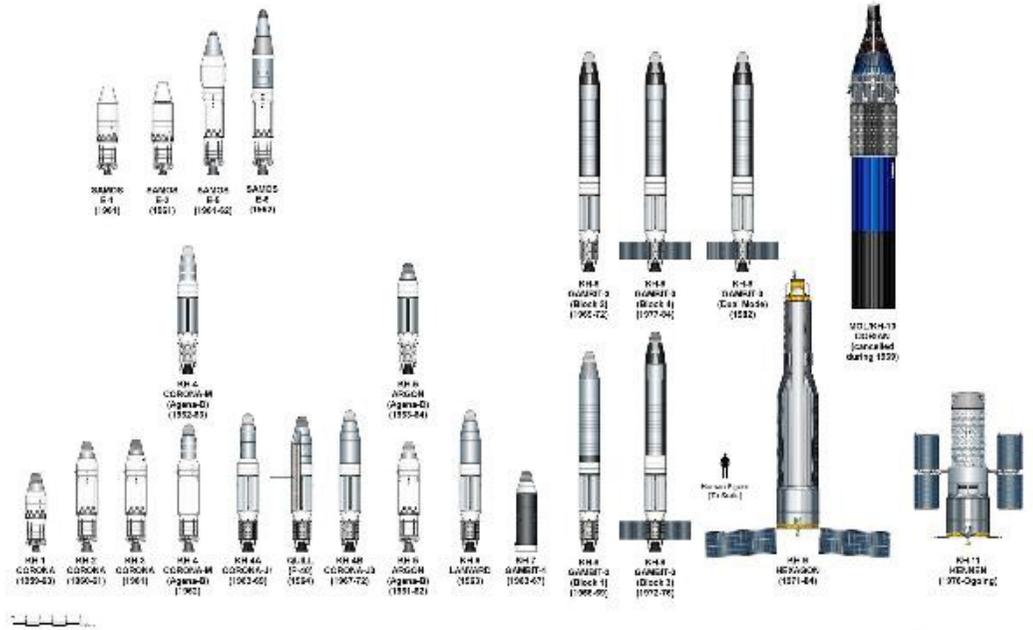
Essentially a development of meteorological imagery in the TIROS programme and ESSA operational satellites.

Military reconnaissance satellites both in the United States and Soviet Union.

Probably an advance in digital imaging on the Soviet side but no intent of civilian use, most of the data acquired is probably lost.



U.S. Satellite Reconnaissance Systems

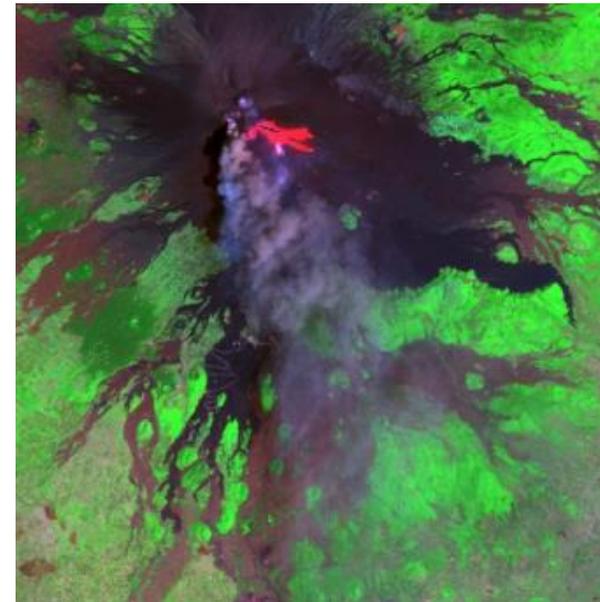
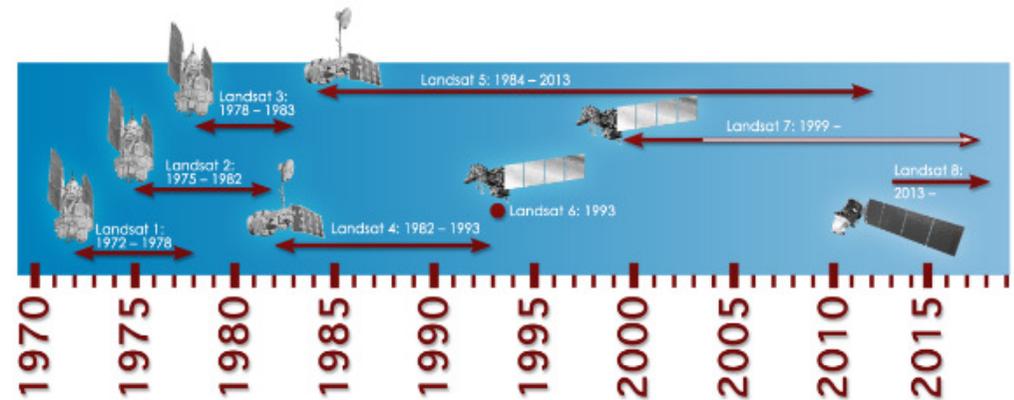


1964: start of the NIMBUS series

Advanced Very High Resolution Radiometer (AVHRR): an instrument which beside meteorology found rapidly land and sea applications. AVHRR flew and flies on various NASA, NOAA, ESA and EUMETSAT METOP satellites. The SEVIRI instrument on METEOSAT has commonalities in objectives with AVHRR.

The first success case: LANDSAT: thematic mappers.

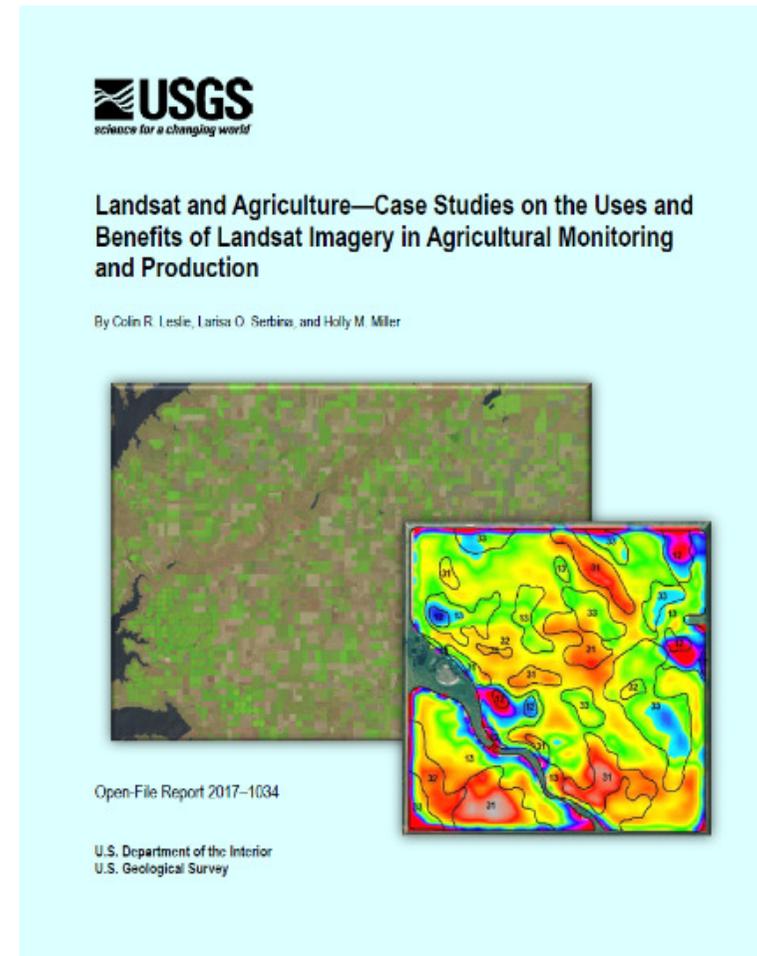
- Began as an experimental technology earth digital observation programme in 1972
- Now, LANDSAT is a prime source for the study of global change on the earth and since 2013 operates its eighth version: the LANDSAT continuity mission with joint data management by NASA and the USGS (US Geological Service). One of its satellite (LANDSAT 5) holds the record of the longest operating earth observation satellite, launched in 1984 and decommissioned in 2013.



LANDSAT image of the Etna 2001 eruption,
The wavelength ranges used by Landsat are these: deep blue, blue, green, red, four near and shortwave infrared bands, a panchromatic (grayscale) band, and two thermal Infrared bands.

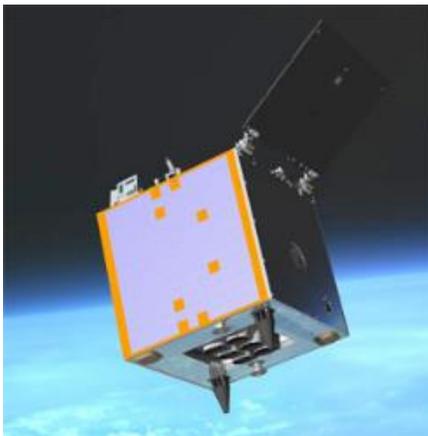
Landsat became fundamental for agriculture applications.

- Monitoring agriculture from space.
- Estimating crop production
- Monitoring consumptive water use.
- Field level management tools leading to increase yields.



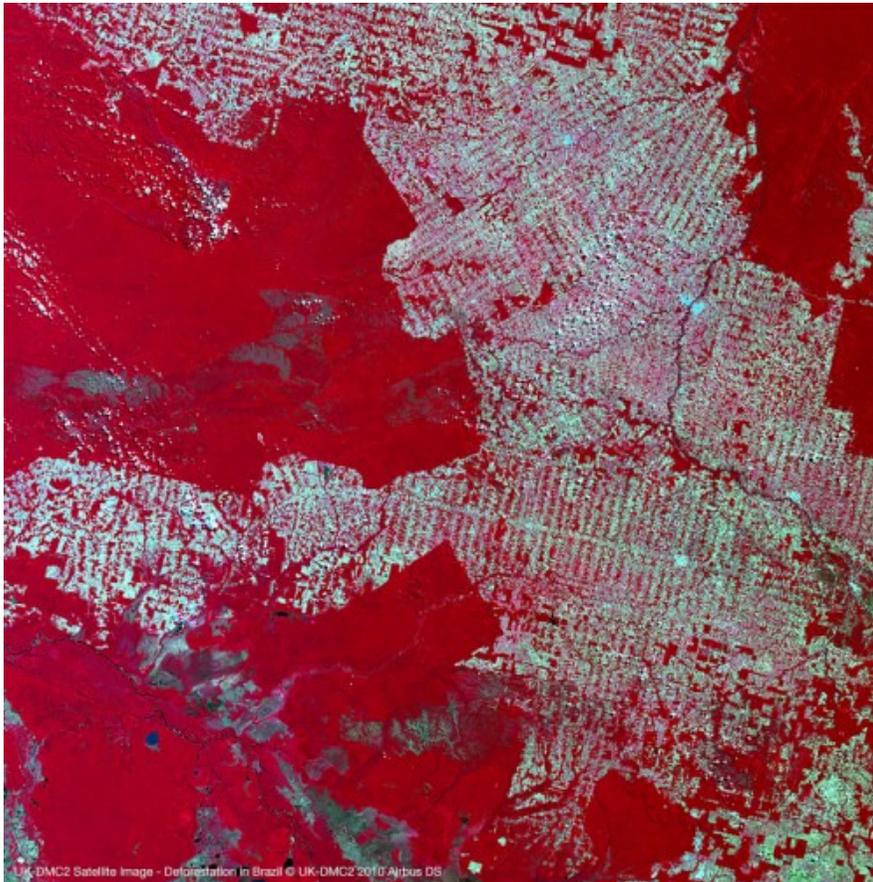
A British Landsat companion: DMC

- DMC (Disaster Monitoring Constellation) has been deliberately designed to be compatible with LANDSAT
- DMC is coordinated by Surrey Satellite Technology

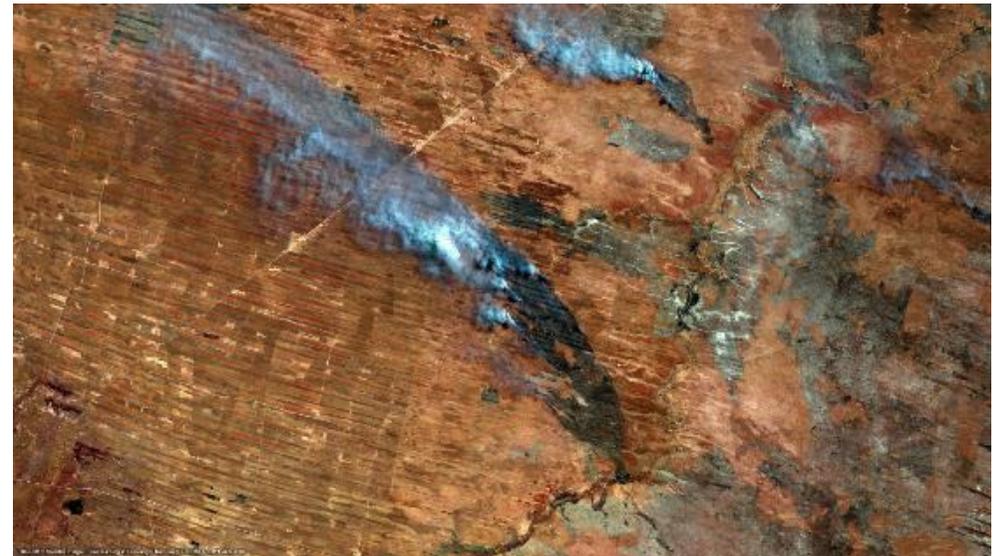


Volcanoes of central Java, high repeat rate is important for agriculture and thus DMC is used by USDA as a complement to LANDSAT.

DMC-2 imaging, deforestation of Amazonia



Biomass burning in Namibia



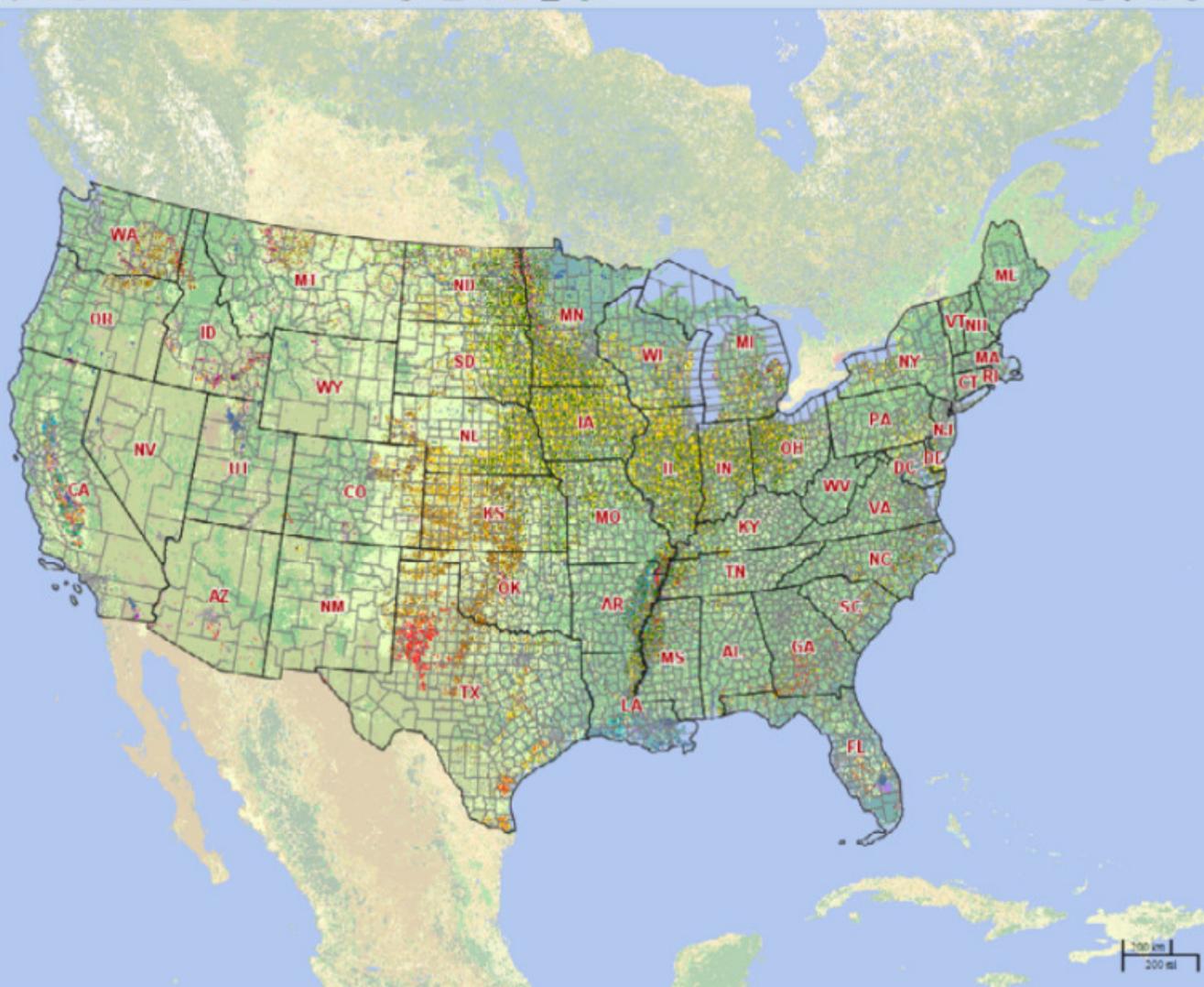


Layers Legend



Cropland Data Layer:

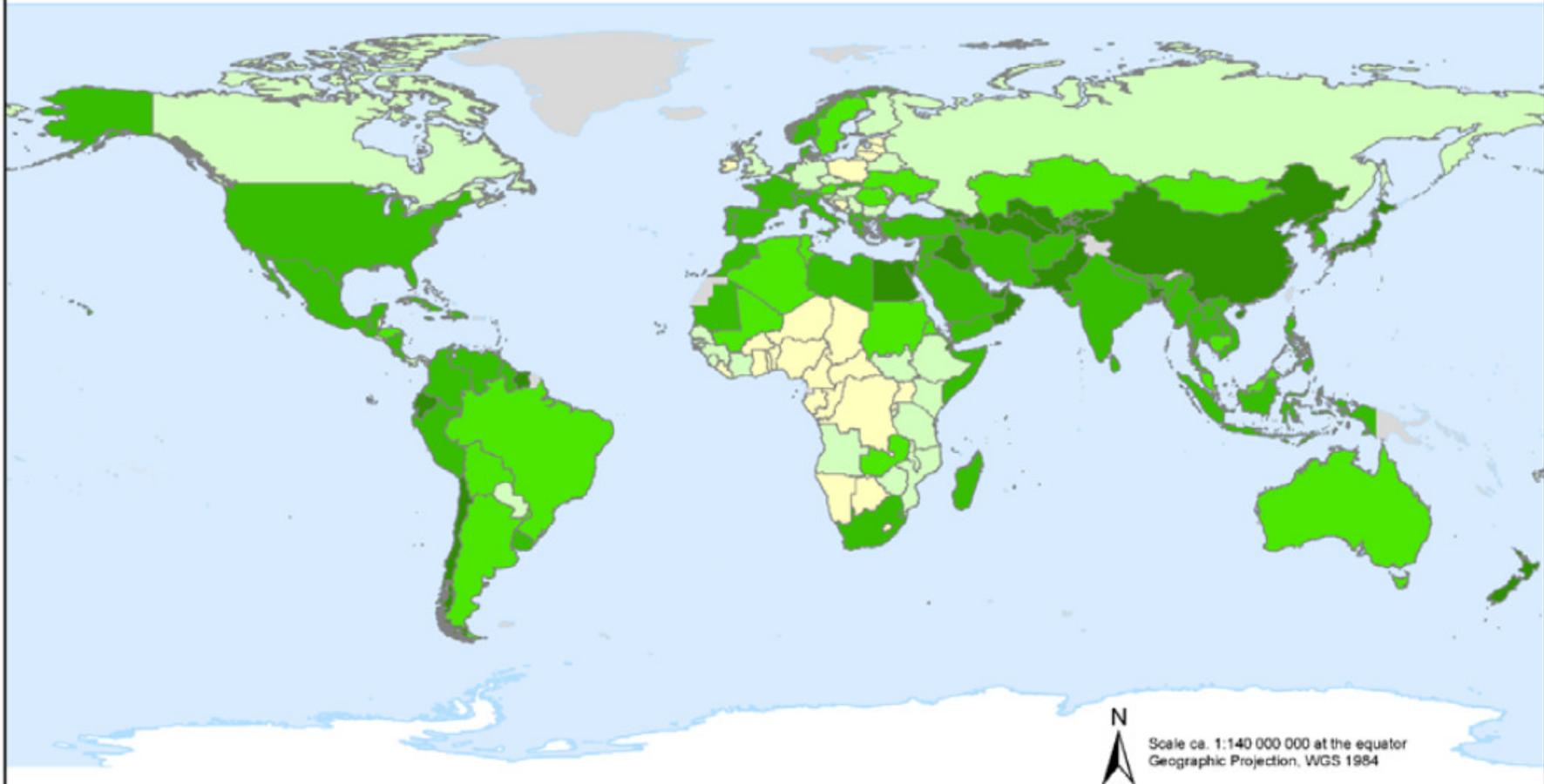
- Corn
- Cotton
- Rice
- Sorghum
- Soybeans
- Sunflower
- Peanuts
- Tobacco
- Sweet Corn
- Pop or Orn Corn
- Mint
- Barley
- Durum Wheat
- Spring Wheat
- Winter Wheat
- Other Small Grains
- Dbl Crop WinWht/Soybeans
- Rye
- Oats
- Millet
- Speltz
- Canola
- Flaxseed
- Safflower
- Rape Seed
- Mustard
- Alfalfa
- Other Hay/Non Alfalfa
- Camelina
- Buckwheat





Food and Agriculture
Organization of the
United Nations

Part of cultivated area under irrigation



Scale ca. 1:140 000 000 at the equator
Geographic Projection, WGS 1984

Legend



Source: AQUASTAT
Geographic Projection

FAO - AQUASTAT, 2015

Disclaimer

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

LANDSAT operates in conjunction with other present satellite data systems.

NASA

- MERIS
- Several NASA or commercial imaging satellites.

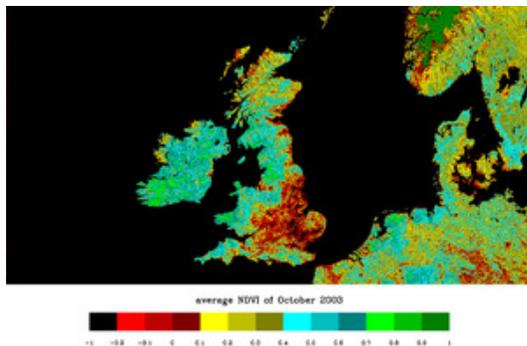
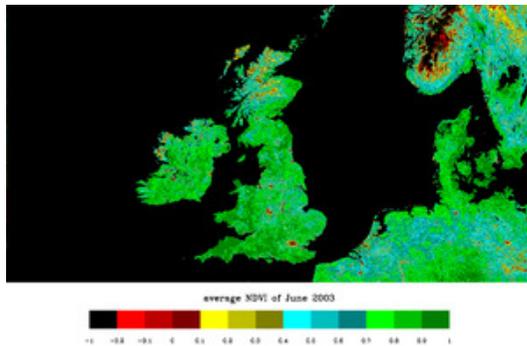
ESA and other European ventures

- MODIS
- DMC
- SPOT 4- SPOT 5
- **Off course: COPERNICUS and the SENTINEL satellites.**
- New addition: SMOS

Data exploitation requires the definition of indexes common to all platforms: NDVI.

$$\text{NDVI} = (\text{NIR} - \text{red}) / (\text{NIR} + \text{red})$$

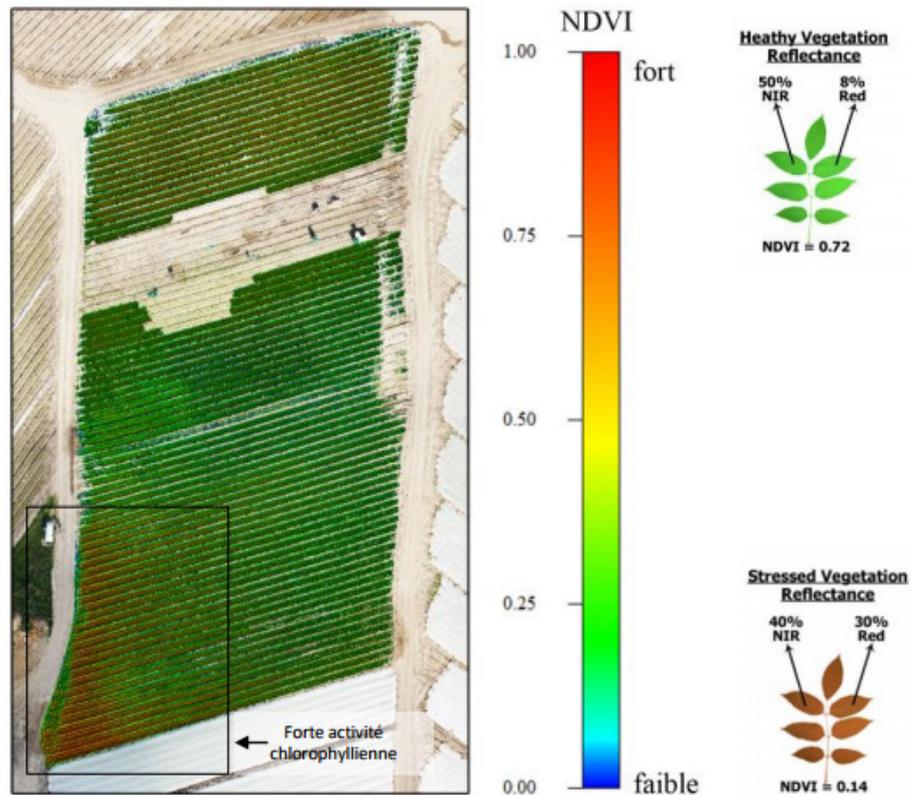
Seasonal variations: June and October



Danger of reducing to a single index

- NDVI means Normalized difference vegetation index.
- It is not crop specific, each crop has a specific index varying with the plant cycle.
- **Big Data means that the entire spectral and spatial data are used.**

An example from DronesImaging company

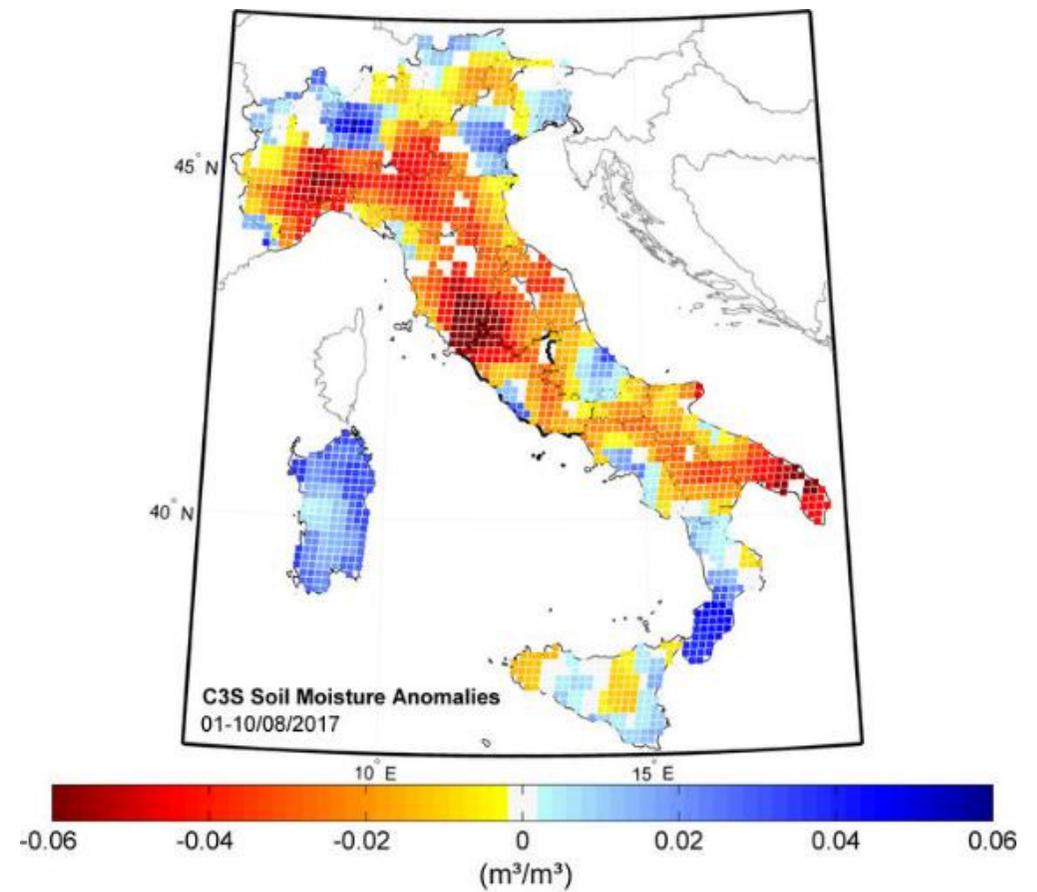
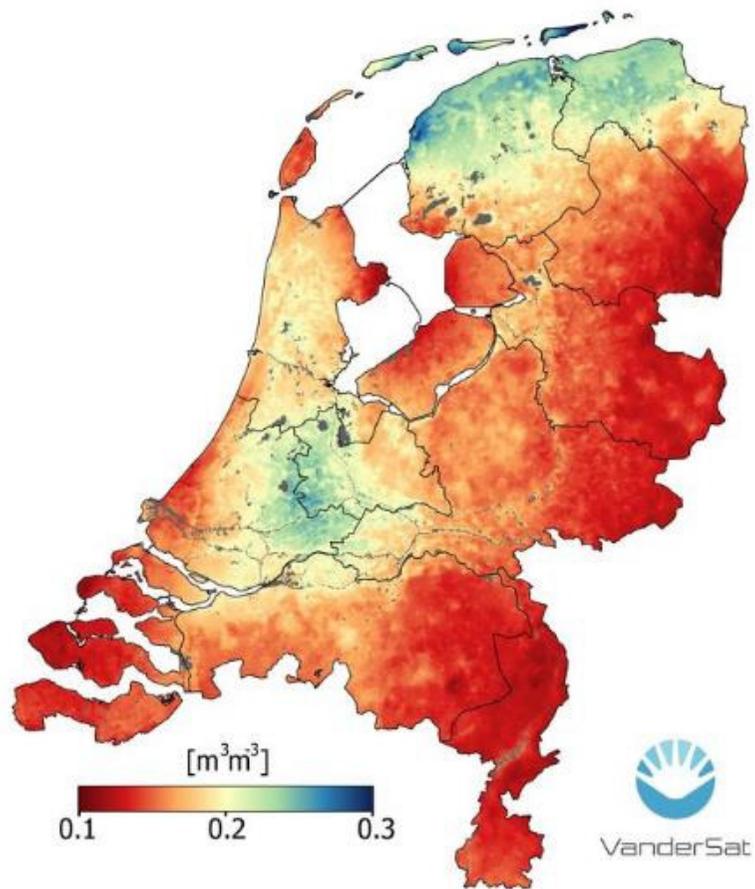


The 5 cm resolution of the image corresponds to an imaging by drones.

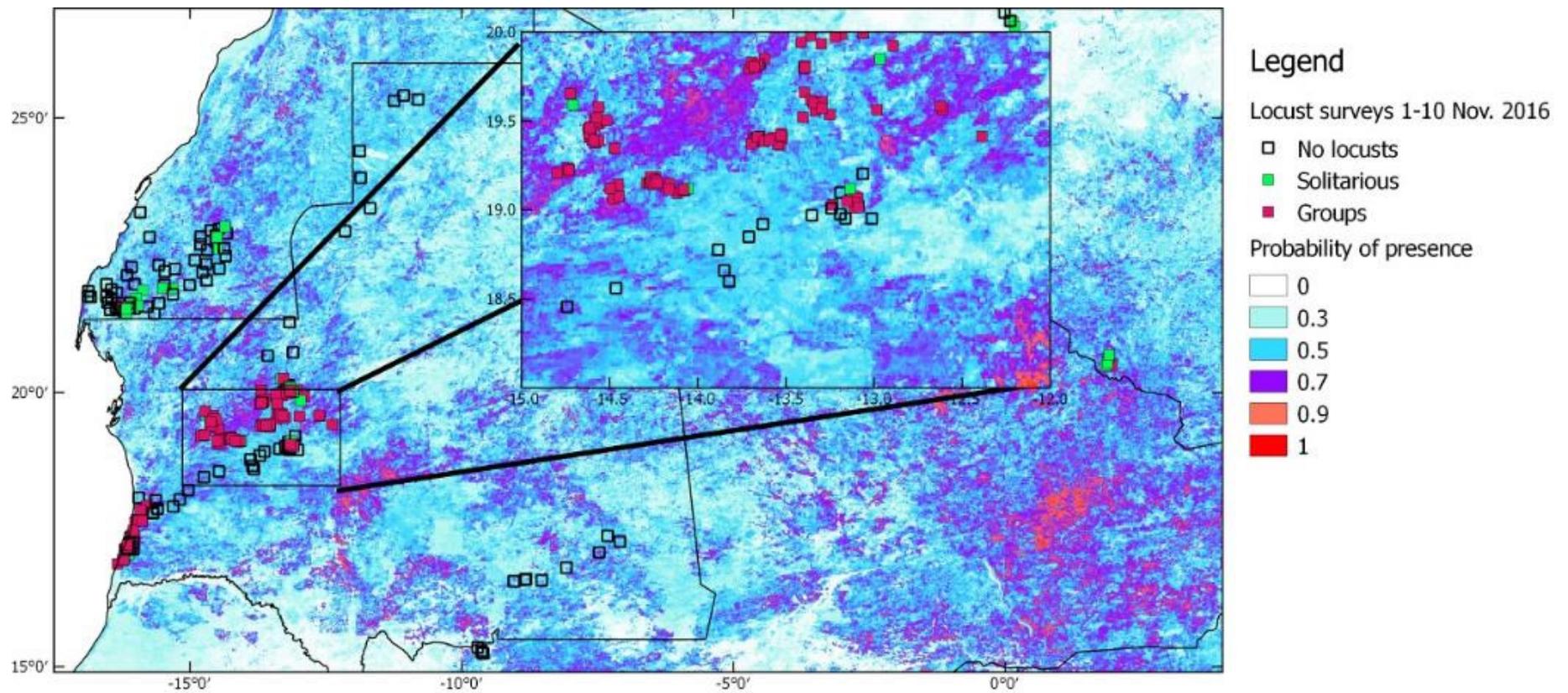


NDVI from MODIS (NASA)

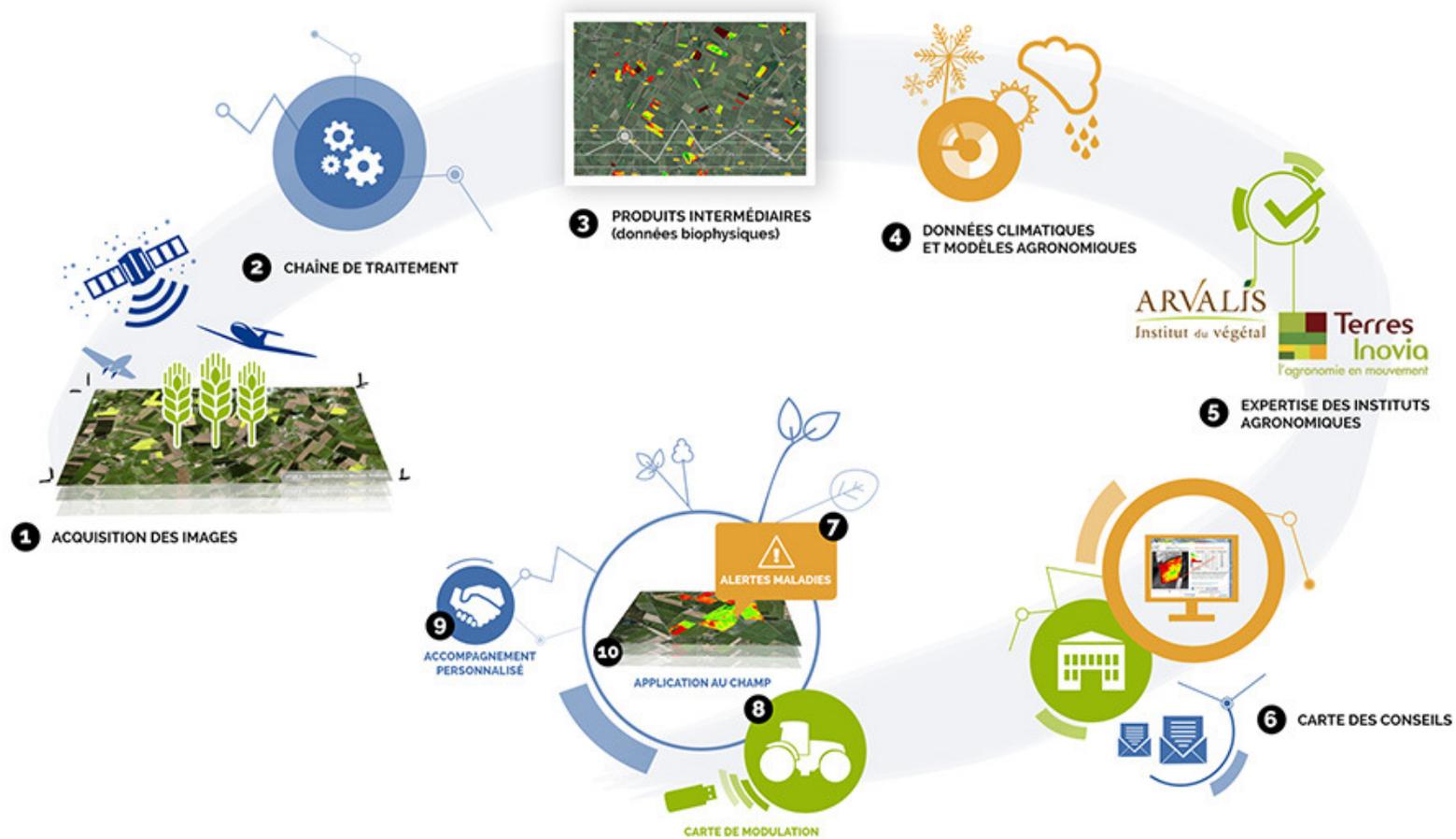
June 2017, soil moisture in the Netherlands: SMOS



Models deduce locusts from SMOS and MODIS



French FARMSTAR agriculture assistance company: based on ASTRIUM images: SPOT, PLEIADES and DMC.



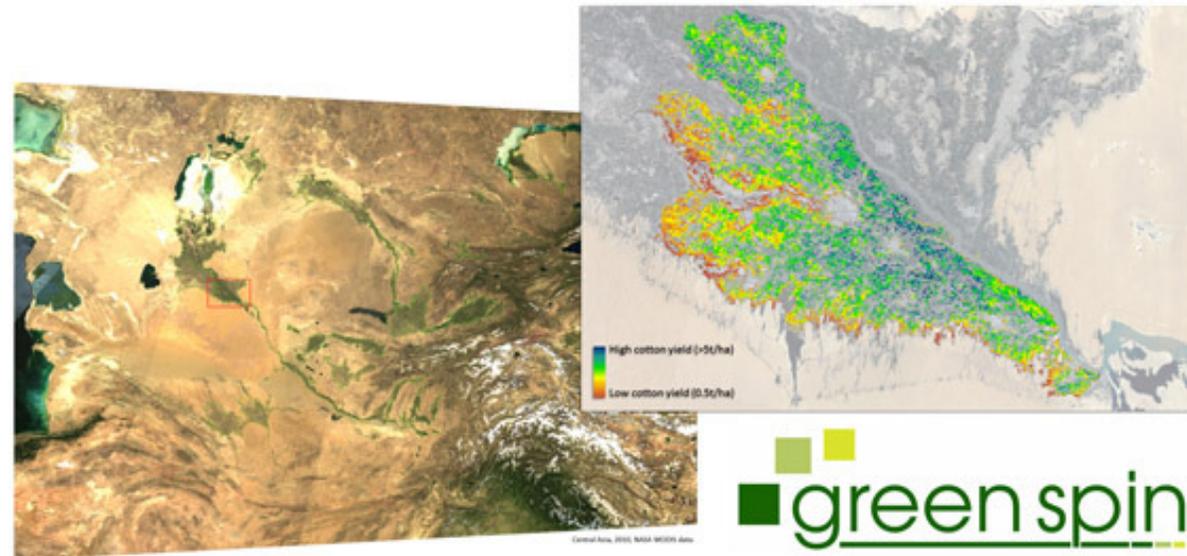
2017: FARMSTAR uses the new VENUS satellite

VENUS is a Franco-Israeli satellite launched in 2017 and allows a good monitoring of irrigated agriculture. As LANDSAT and SENTINEL 2, it uses validation sites.



Arizona image (CNES document).

GREEN SPIN: a service for forecasting crops, based on SENTINEL and LANDSAT 8: support of DLR, ESA, COPERNICUS and Spin-Off of Würzburg University.



Cotton yields in Khorezm, a central Asian oasis region.



Düngepläne

Jahr 2016 Gabe 1

[+ Neue Applikationskarte erstellen](#)

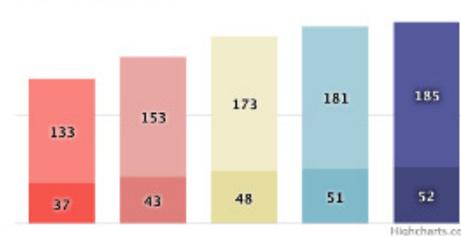
| Name | Nummer | Strategie | Planungsgrundlage | Düngermenge | Stickstoffmenge | | | |
|-------------|--------|-----------------|-------------------|-------------|-----------------|----------------------------|------------------------|-------------------------|
| Loersweil | 55-1 | homogenisieren | 35 kg/ha | 885 kg | 252 kg | bearbeiten | export | löschen |
| Eselhof | 89-4 | homogenisieren | 45 kg/ha | 975 kg | 273 kg | bearbeiten | export | löschen |
| Fuchsbau | 09-1 | einheitlich | 40 kg/ha | 564 kg | 158 kg | bearbeiten | export | löschen |
| Haldenplatz | 04-8 | homogenisieren | 55 kg/ha | 880 kg | 246 kg | bearbeiten | export | löschen |
| Koppelweide | 55-6 | diversifizieren | 50 kg/ha | 1.095 kg | 307 kg | bearbeiten | export | löschen |

Planungsdetails

| | |
|--------------------|--------------------|
| Schlag: | Koppelweide (55-6) |
| Jahr: | 2016 |
| Gabe: | 1 |
| Gesamtfläche: | 6,1 ha |
| Gesamtdüngermenge: | 1.095 kg |
| Gesamtstickstoff: | 307 kg |

Zonen

Düngermenge in kg/ha



Ihre Angaben

| | |
|-------------------------|-----------------|
| Strategie: | diversifizieren |
| Mittleres Ertragsziel: | 85 dt/ha |
| Planungsgrundlage N/ha: | 50 kg/ha |
| Intensität: | stark |
| Stickstoffgehalt: | 28 % |

Some reflexions on this short survey.

- The described satellites and the few presented applications cover essentially the 30 m. scale.
- Real high spatial resolution as used now in military reconnaissance is rare in current applications.
- Repeat rate has become so important that the large satellites are seconded by a zoo of intelligent mini-satellites, sometime managed by private companies or small countries.
- Clouds will always be present and thus will limit the capability of satellite measurements.
- **Full use of the data is still to come**

The future: precision agriculture

- Only real time present action: **irrigation management.**
- Generalisation: go to high spatial resolution and the individual plant.
- **High resolution hyperspectral: really big data.**
- Real time operation of farm machines.
- Maybe, the age of local drones coordinating GPS driven machines and modulating harvest and phytopharmacy.

