A Joint Israeli – French Earth Observation Scientific Mission with High Spatial and Temporal Resolution Capabilities

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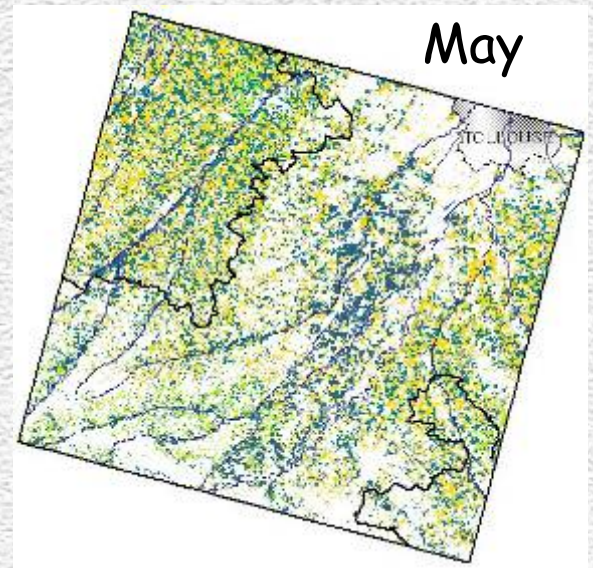
Why a new EO mission ?

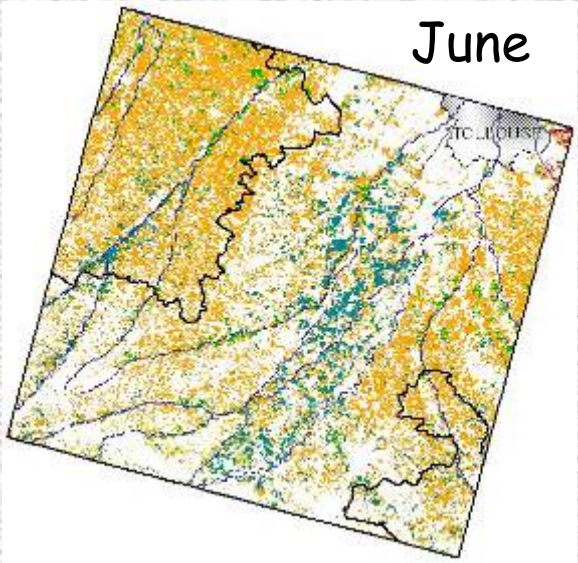
- EO data currently available for land science and applications
  - High resolution (1 - 30m), poor temporal sampling
  - Medium/coarse resolution (0.3 - 40km), high temporal sampling

- Regional scales (landscape, region): environment monitoring, resources management and sustainable development issues

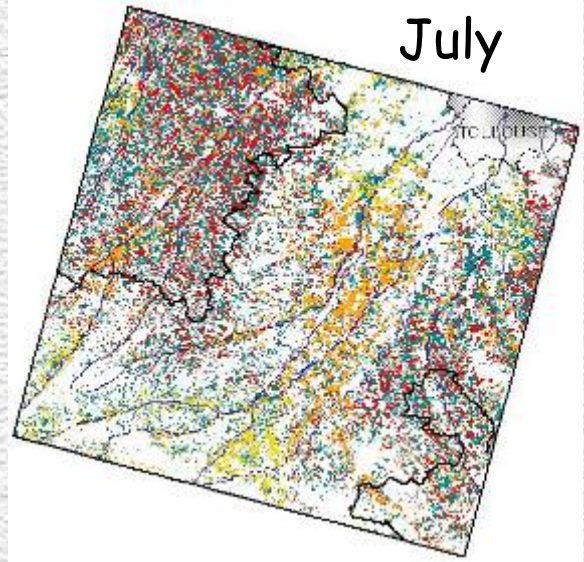
Evolution of water requirements for wheat crops, corn, sunflower, soybean (2002)



wheat is the most water demanding



wheat plus other crops

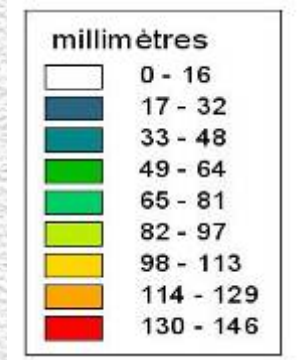


wheat is harvested. Summer crops are now the most water demanding

50x50 km area, 20 m resolution

SPOT + weather data + model

***(Allen et al. 1998* FAO n°56)**



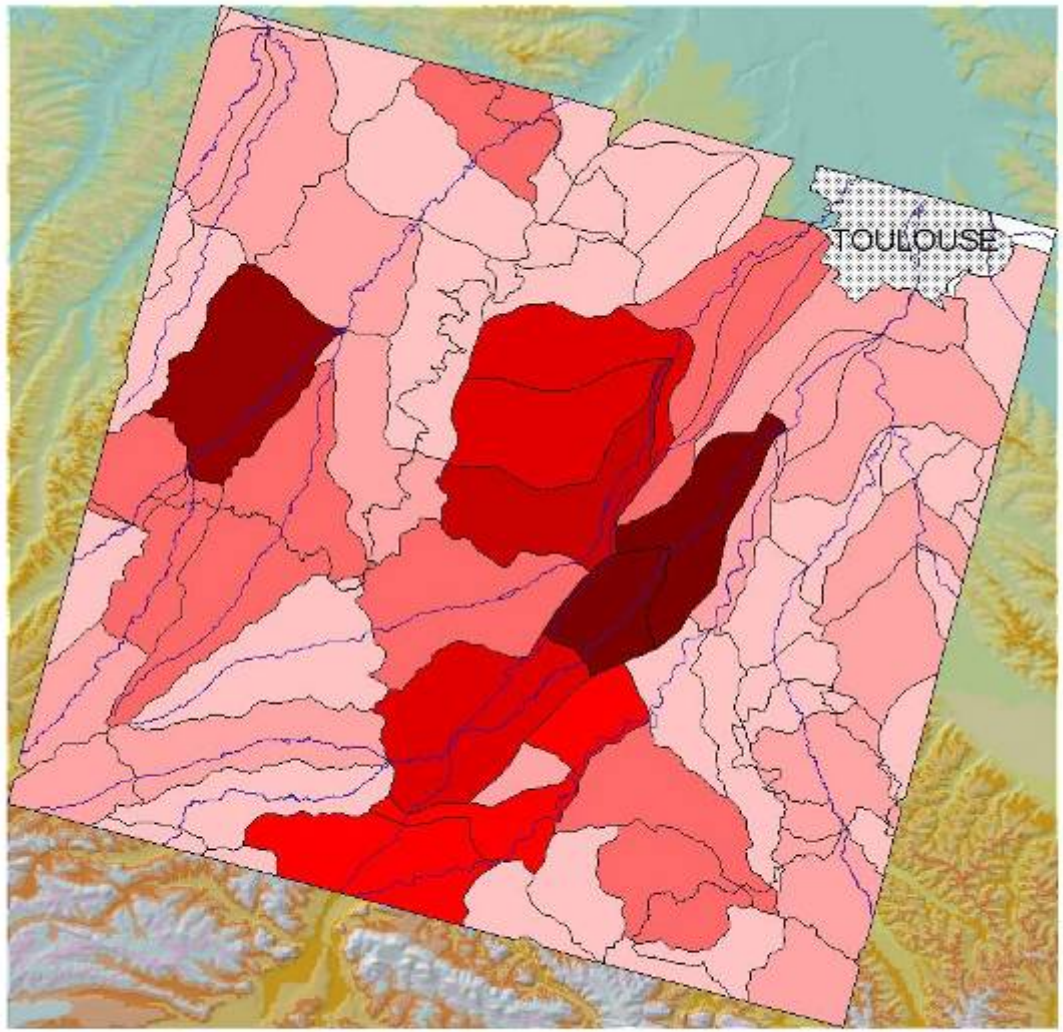
1 Millimeter

= 1 liter/m^2

= 10 m^3 / ha

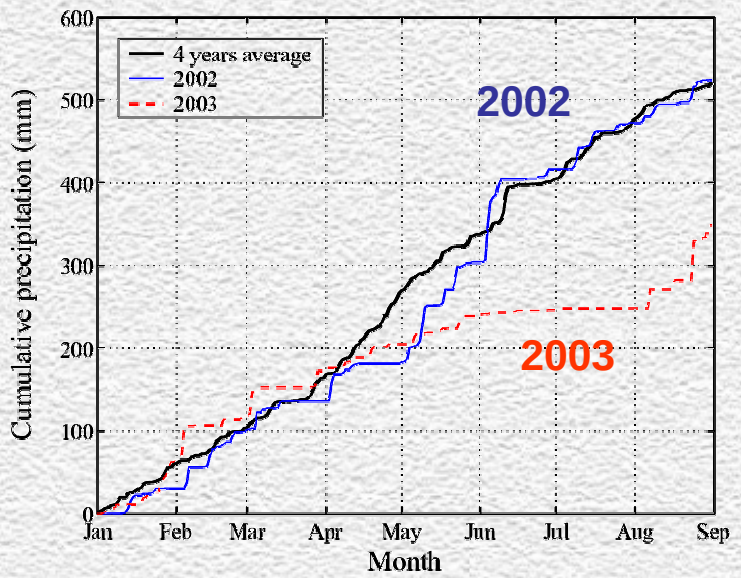
Water requirement of maize cumulated per hydrographic zones

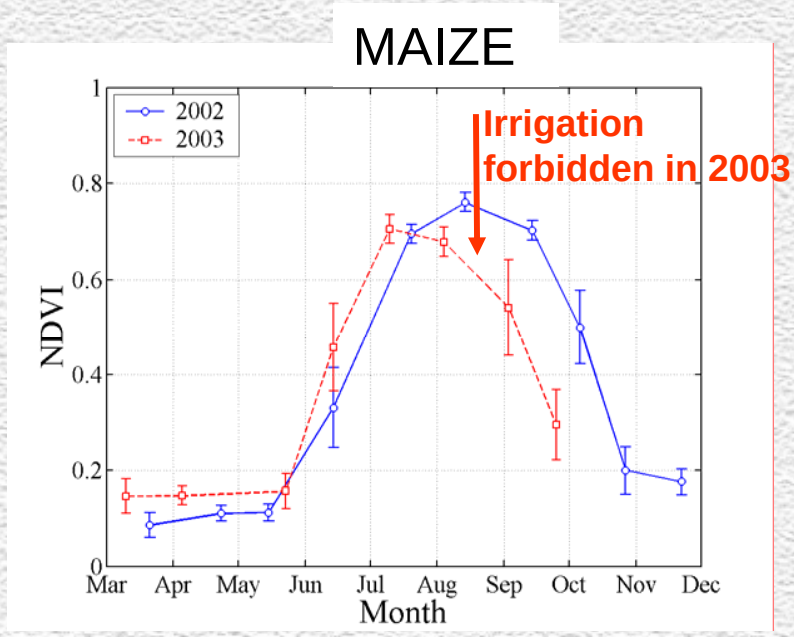
June - July - August 2002



2003 versus 2002

Extreme drought and heat wave in 2003 (May- late August)



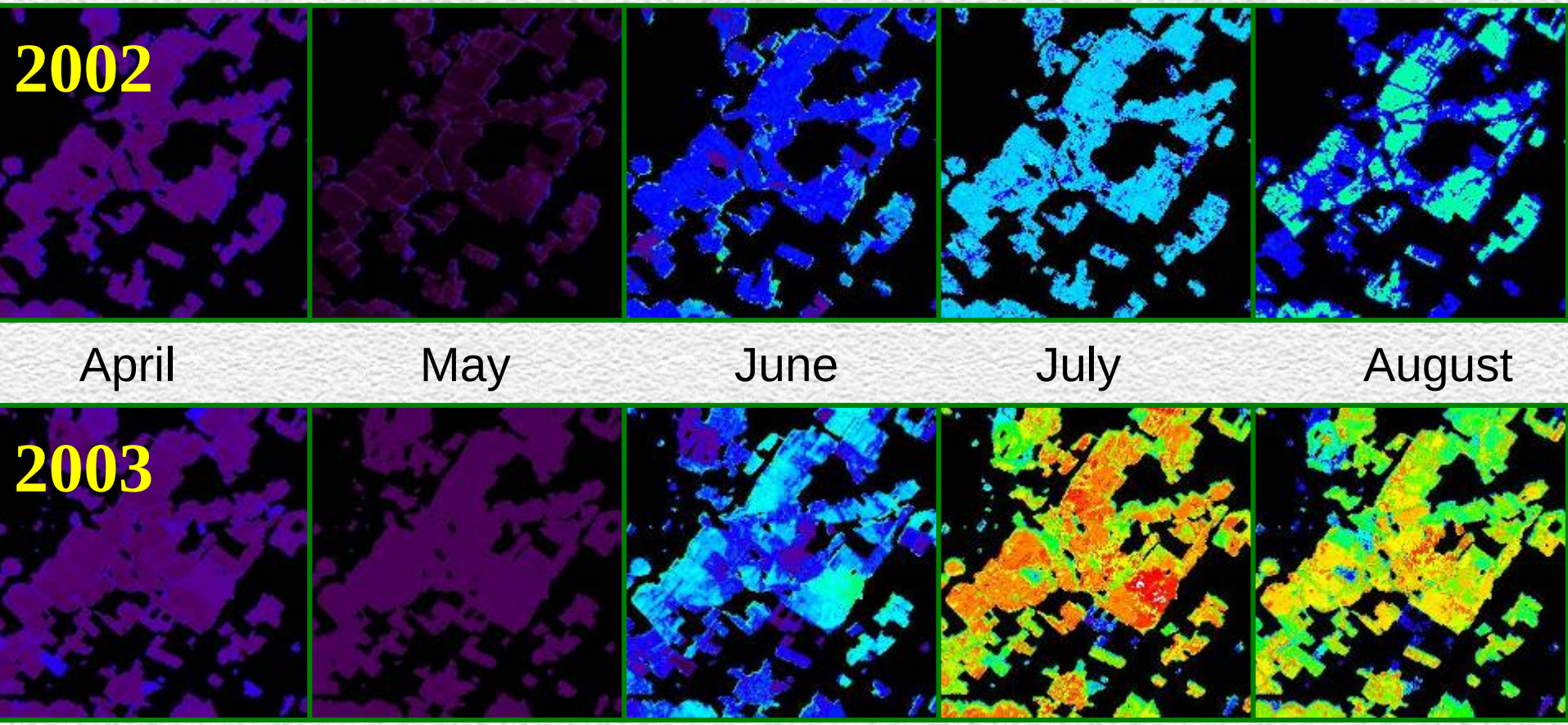


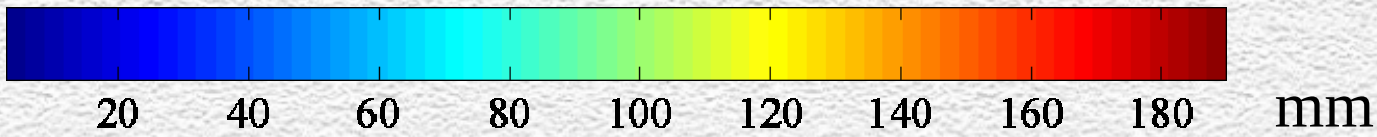
SPOT NDVI for maize in 2002 and 2003.

Average for the whole 50x50 km² area

Monthly cumulated irrigation

Zoom over a 5x5 km window





Why a new EO mission ?

- EO data currently available for land science and applications
  - High resolution (1 - 30m), poor temporal sampling
  - Medium/coarse resolution (0.3 - 40km), high temporal sampling
- Regional scales (landscape, region): environment monitoring, resources management and sustainable development issues
- **Needs :**
  - **Obtain the data where and when needed, with suitable temporal, spatial, spectral characteristics. Typically every 5-15 days for vegetation functioning, agriculture, water management, …**
  - **Ready to use data. It's not the role nor the expertise of the users to calibrate the data and to apply atmospheric and geometric corrections.**

Venμs 1st objective is to investigate and demonstrate the benefit of high repetitivity and high resolution data for land and possibly coastal zones: 2 days revisit cycle, 5-10 m resolution

2nd objective is to develop a dedicated ground segment to deliver state of the art quality products

NEEDS : the strategic challenge of data assimilation within models

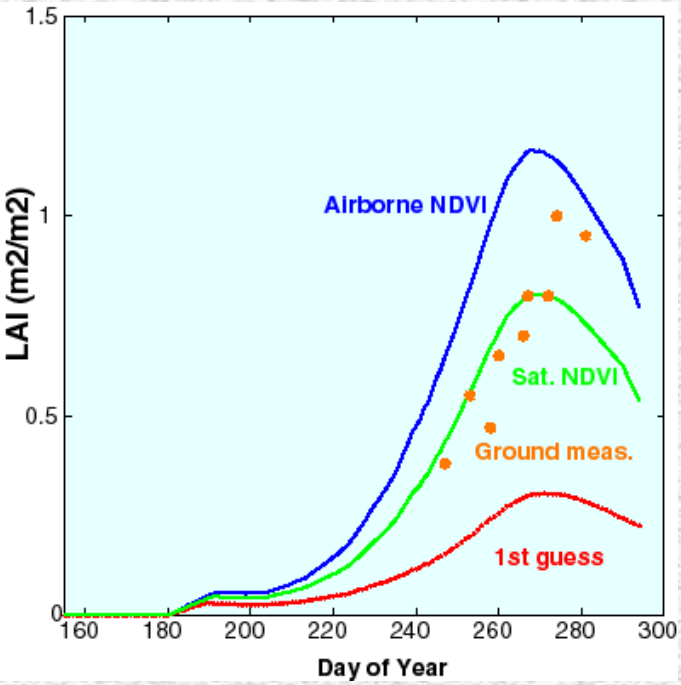
Needs : Diagnostics, Forecasting and scenarios studies at scales ranging from landscape to regions

Satellite Remote sensing alone does not allow to retrieve the required information : water balance, yield and production, ...

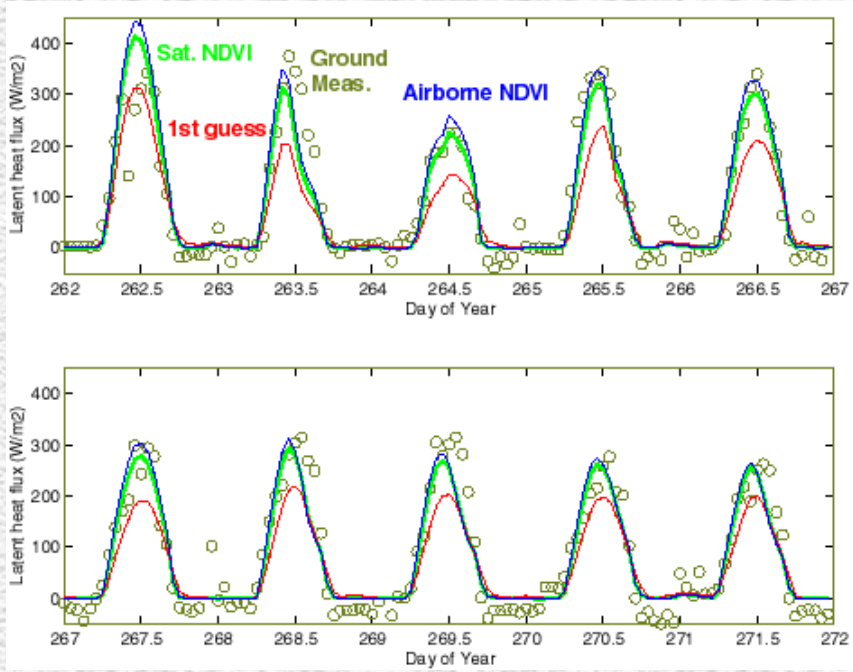
Coupling of remote sensing data and models

Assimilation of satellite measurements in coupled vegetation and SVAT models

Assimilation of 1x1km AVHRR NDVI to adjust growth parameters of fallow grassland over the central west site of Hapex-Sahel experiment, Niger, 1992.



Model simulation of LAI obtained with first guess (dotted line) and adjusted (solid line) parameters, respectively, and ground measurements of LAI (*).



Model simulation of daily surface latent heat flux obtained with LAI predicted with first guess (red line) and adjusted (blue and green lines) growth parameters.

(Cayrol et al., JAM, 2000)

VENμS Uniqueness - Summary

- **Temporal resolution**

2 days revisit time for monitoring rapid changes : objective of a cloud free (composite) image every 7 or 10 days

- **Spectral resolution**

super spectral sensor – 12 spectral bands VIS-NIR for land applications

- **Spatial resolution**

pixel size of 5.3 m for Level 1, 10m for level 2 and 3
Registration requirement: 3 m rmse

- **Tilting capability**

30 deg across and along track

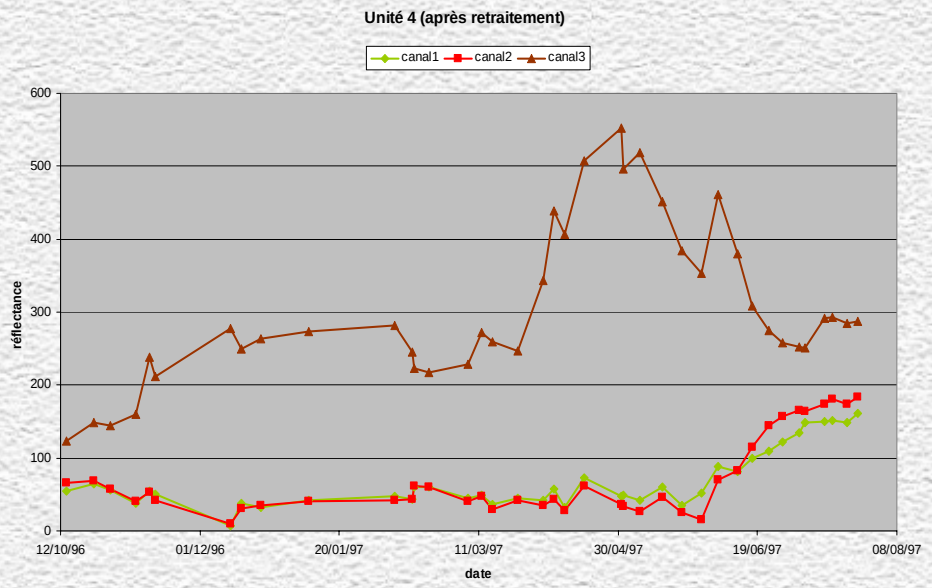
- **View angle**

Constant view angle can be achieved every 2 days, at constant local solar time

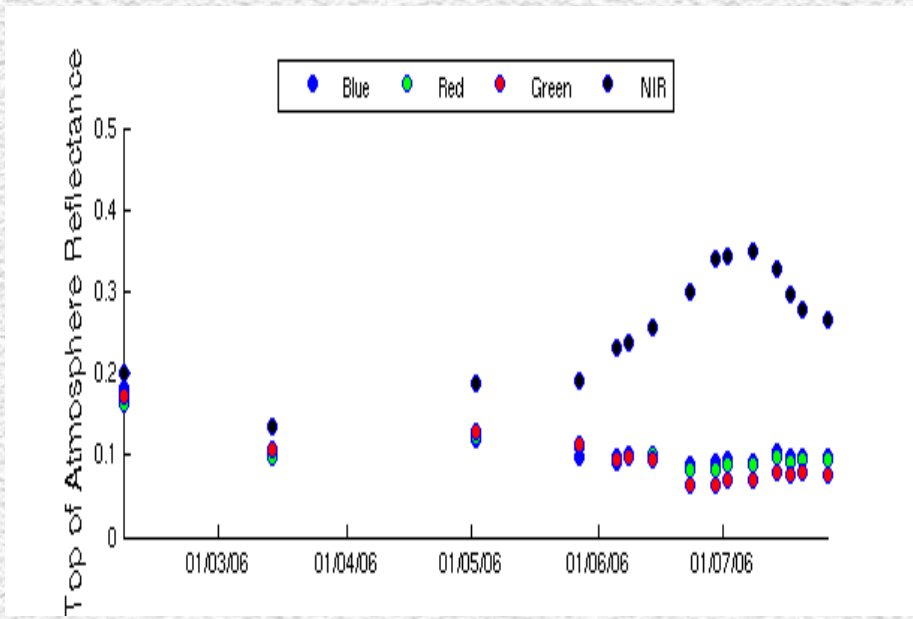
- **Stereo pairs with a small angle difference at 620nm**

Cloud screening based on altitude, DEM

Benefit of constant view angle and constant local solar time



Reflectance time series from **SPOT** (Romania)
(After atmospheric correction but with directional effects)

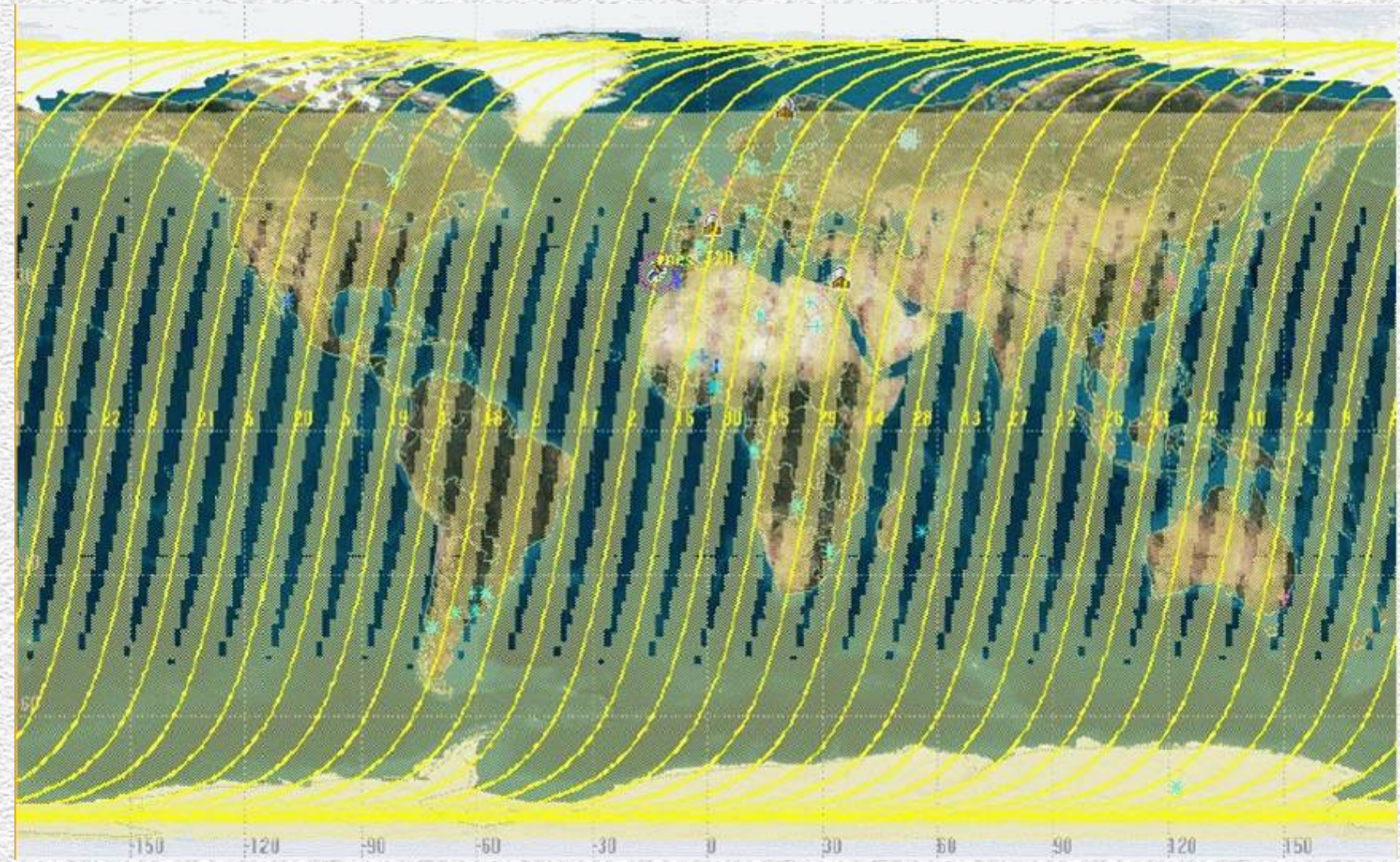


Reflectance time series from **FORMOSAT 2** (France)
(Before atmospheric correction, but with no directional effects)

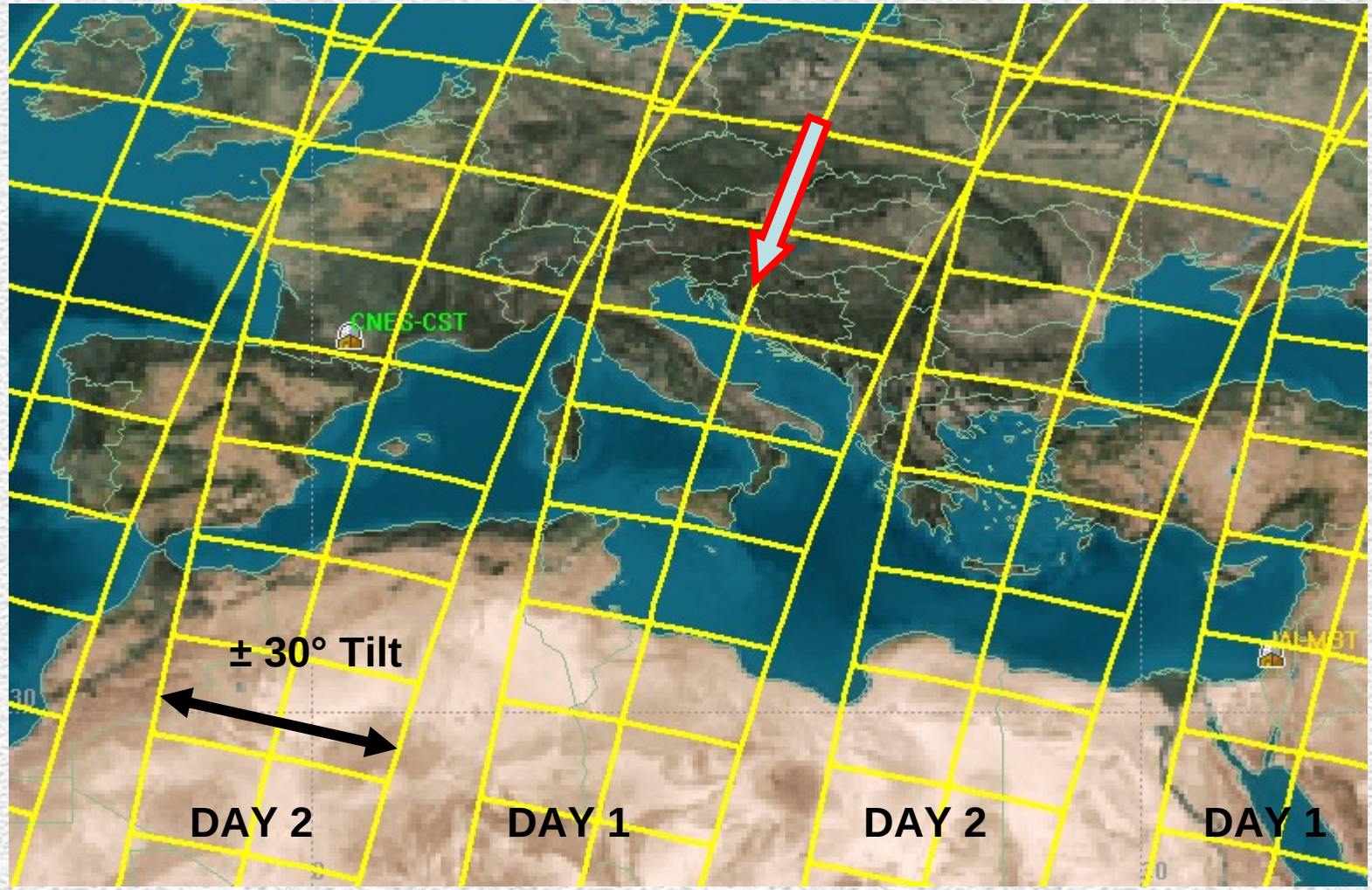
Imaging capabilities

- 50 sites of 27x 54 km + calibration and image quality sites
- Data strips longer than 54 km are feasible
- 140 images of 27x27 km within 2 days (>20000/year)
- Maximum of 15 images per orbit
- Angular sampling could be achieved for a few sites (± 30° roll and pitch)
- Moon viewing for calibration

Venμs Orbits



Venμs Orbits

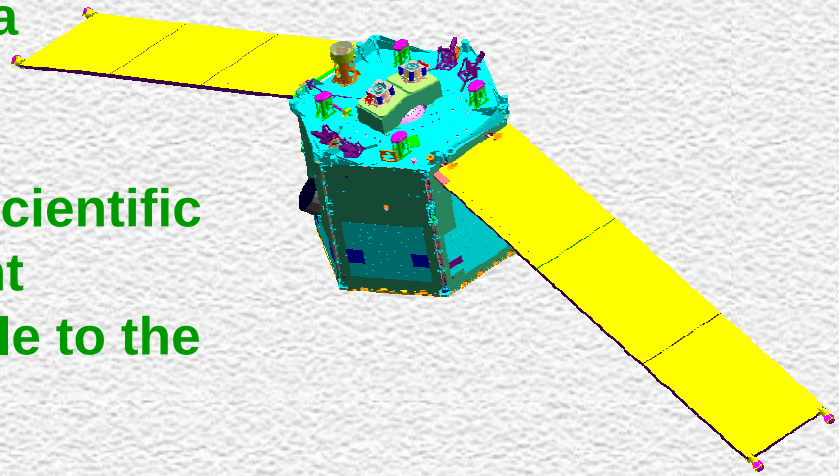


VENμS main characteristics

- **Orbit:** near polar, **sun-synchronic** } **Altitude:** 720 km
- **Revisit time:** two days } **Inclination:** 98.27°
- **Swath:** 27.56 km
- **Weigth:** ~220 kg
- **Onboard image memory :** 30 Gbytes
- **Image downloaded at Kiruna :** 155 Mbits/s
- **Radiometric resolution:** 10 bits
- **Equator crossing time:** 10H30 AM
- **Mission launch date & duration:** 2009 - 2.5 years +1.5yr

VENμS organization

- CNES is responsible for the camera (manufactured by Elop)



- CNES develops and operates the Scientific Mission and Image Ground Segment (SMIGS), and make the data available to the users
- Israeli Space Agency designs, manufactures and tests the VENμS Platform (IMPS)

Scientific mission (720 km) – 2.5 years

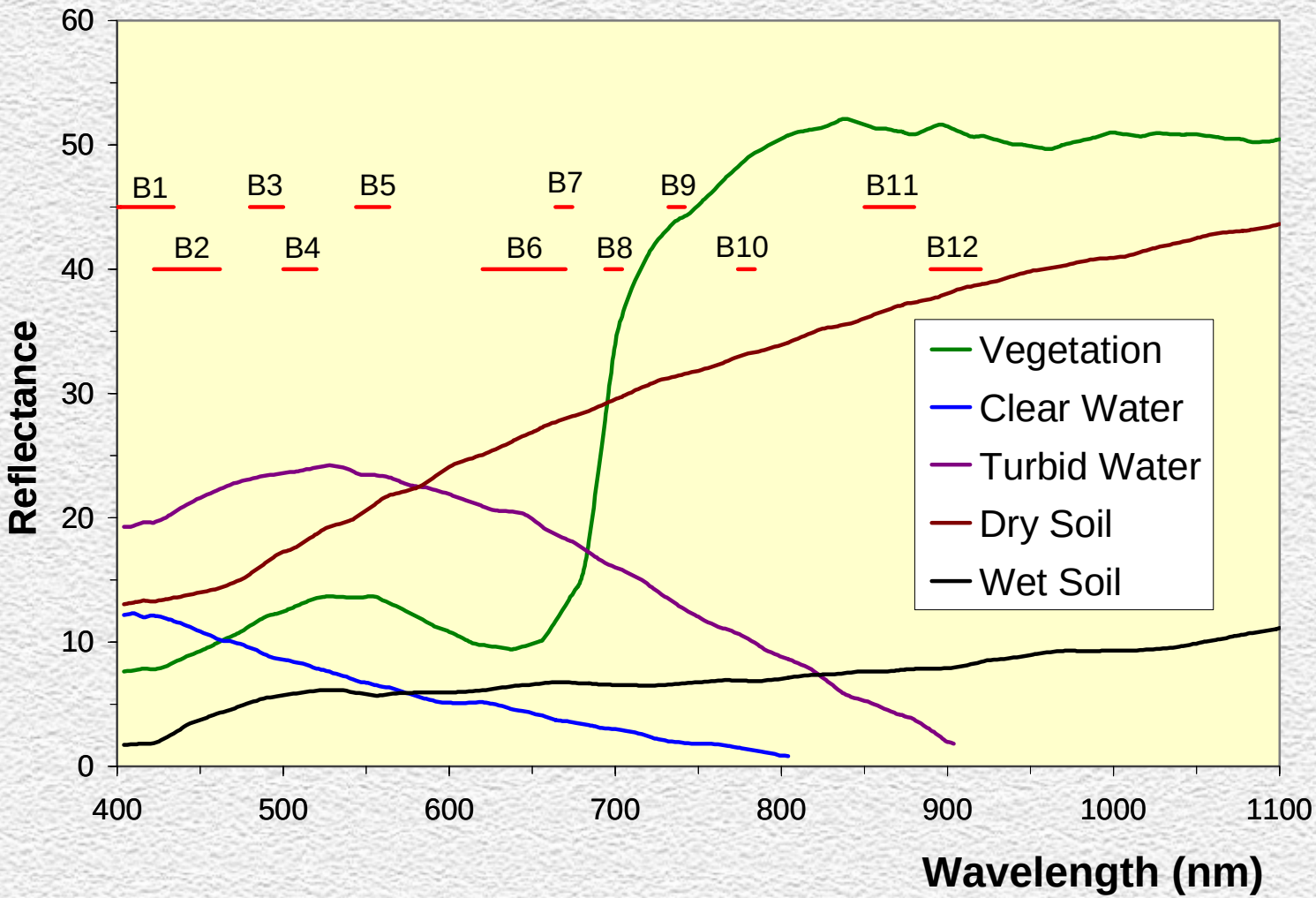
Orbit change

Technological mission (410 km) – 1 year

electrical propulsion system

End of commissioning phase

Camera : Band Setting



Band Setting (Requirements)

Bands	λ0 (μm)	Δλ (nm)	SNR for Lmin at 5.3GSD	Required Resolution (meters)	SNR for Lmin at resolution	Main Driver
B1	0.420	40	25	21.2	100	Aerosols
B2	0.443	40	25	21.2	100	Aerosols, clouds
B3	0.490	40	25	21.2	100	Aerosols
B4	0.555	40	50	10.6	100	Land
B5	0.620	40	50	10.6	100	Land
B6	0.620	40	50	10.6	100	DEM, image quality
B7	0.667	30	45	10.6	90	Land
B8	0.702	16	55	10.6	110	Land
B9	0.742	16	55	10.6	110	Land
B10	0.782	16	55	10.6	110	Land
B11	0.865	40	50	10.6	100	Land
B12	0.910	20	25	21.2	100	Water vapor

Image quality

❑ Needs

- ♦ Spatial and temporal image composites that can be used over a whole area to monitor seasonal and interannual evolutions

⇨ Need to provide consistent and homogeneous measurements through time and space, with physical meaning (radiances)

❑ Constraints

- ♦ Geometrical registration (within bands, multitemporal)
- ♦ Radiometric calibration, knowledge of the spectral responses, and spectral stability
- ♦ Minimisation of perturbing effects : directional and atmospheric

Calibration and Stability Requirements

- Data calibration: absolute - 3%-5% inter-band - 3%
- Stability with time of the equivalent wavelength $\leq$ 1 nm at 667, 702, 742, 782nm, and $\leq$ 2 nm for the others
- Variation of the equivalent wavelength within the field of view $\leq$ 3 nm
- Multispectral registration $\leq$ 0.25 pixels
- Shift of the time of overpass for image acquisition throughout the mission duration: lower than ± 5 minutes

Calibration and Stability Requirements

- *A-priori* accuracy of image location:
  - ± 1km on the across track direction
  - ± 3km on the along track direction
- For a given site, the viewing angle should be the same for multitemporal images within ± 2 degrees for zenith and ± 5 degrees for azimuth (unless different angles are requested).
- Altitude, and other factors such as the multitemporal registration of the pixels, is ≤ 0.25 pixel after ground-processing

Ground segment : Products

Level 1: **single acquisition**

Geometrically corrected (maps) of top of the atmosphere reflectances. One map projection per site.

Level 2: **single acquisition**, geophysical variables

Surface reflectances, atmospheric water vapor content and aerosol optical depth

Level 3 : **time composite**, geophysical variables

Surface reflectances, atmospheric water vapor content and aerosol optical depth

Level 2 Algorithm

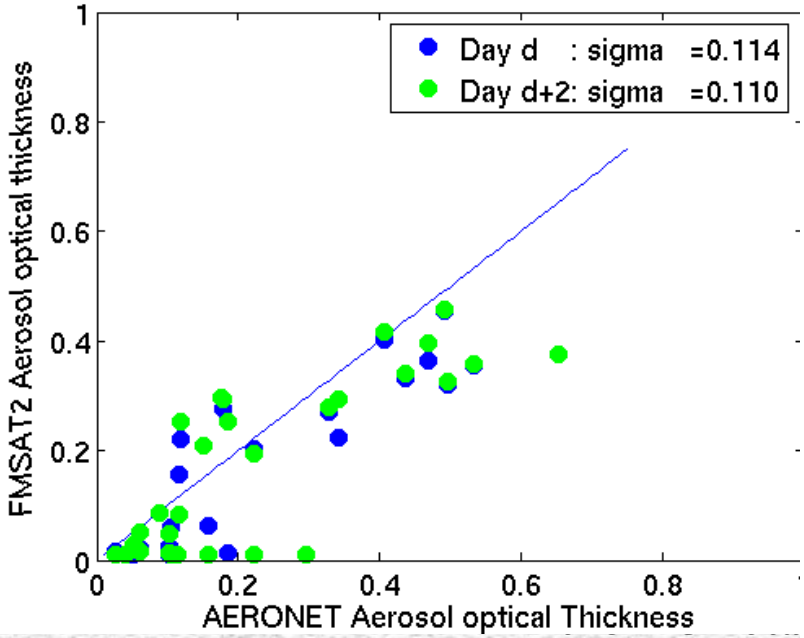
Atmospheric correction

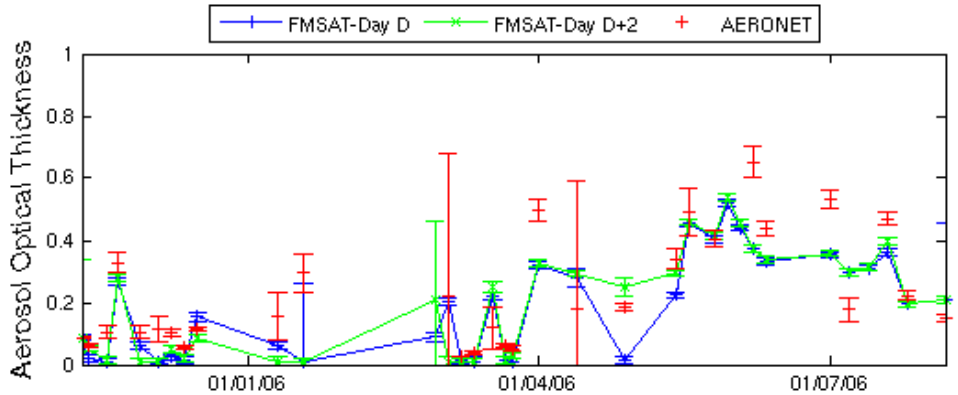
- **Main difficulty : correction of aerosol effects**
  - Very high variability of Aerosol Optical Properties
  - No reliable global source of measurements

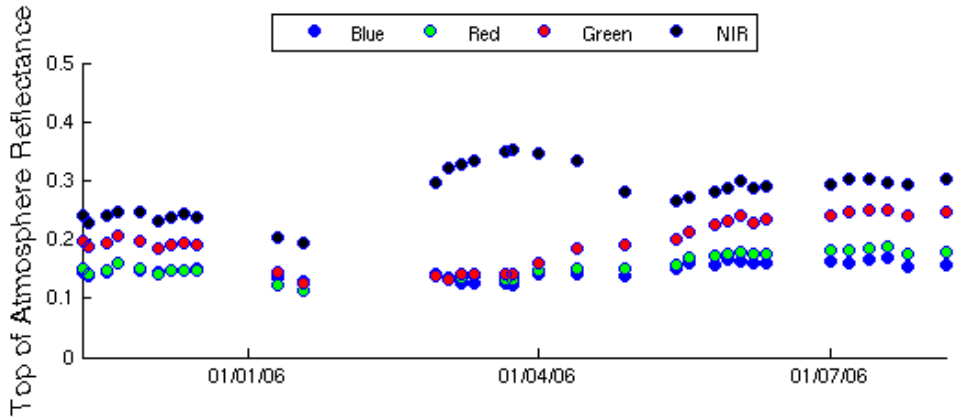
- **Use of the following properties :**
  - No directional effects on VENµS time series
  - Surface reflectance vary :
    - Quickly against distance
    - Slowly against time (with exceptions...)
  - Aerosol optical properties vary :
    - Quickly against time
    - Slowly with distance (uniformity over a few km)

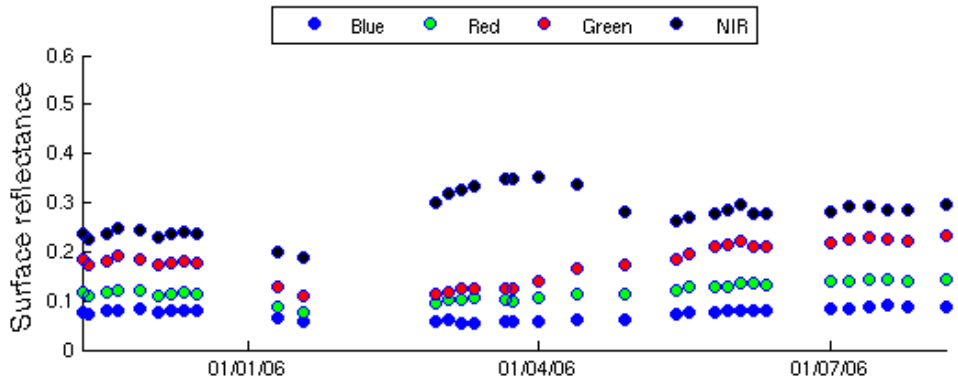
Level 2

Atmospheric correction
First results with FORMOSAT : Morocco

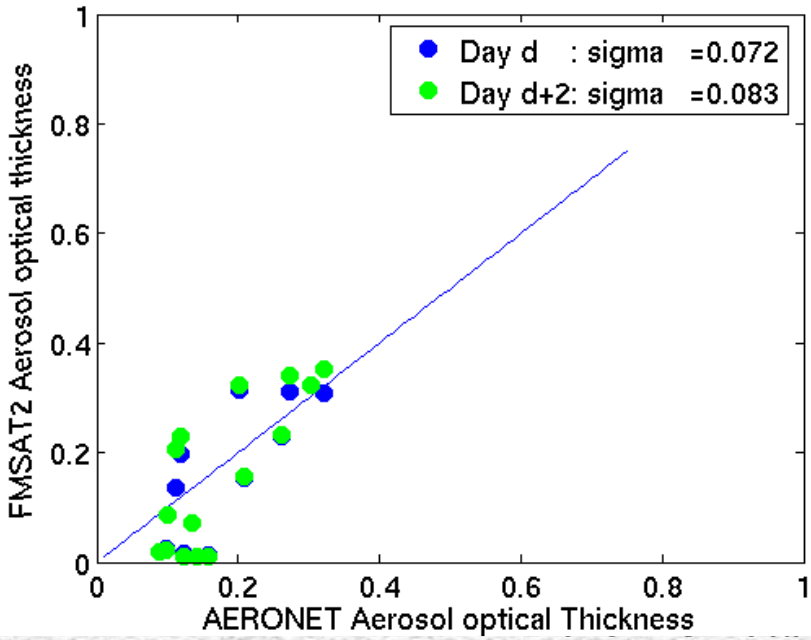


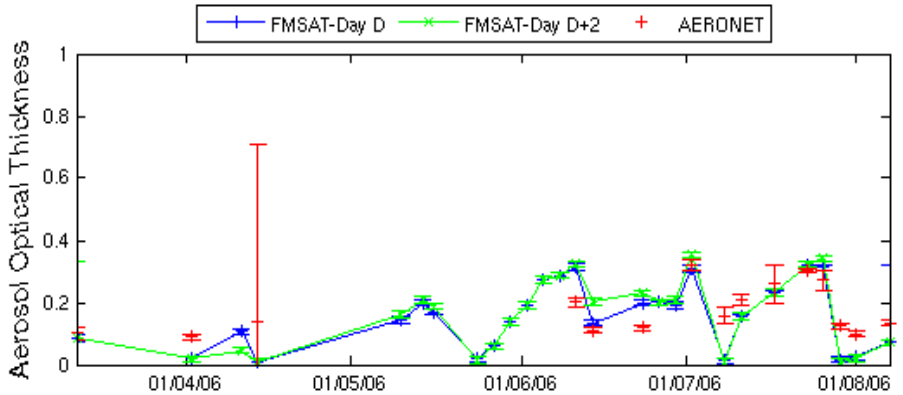


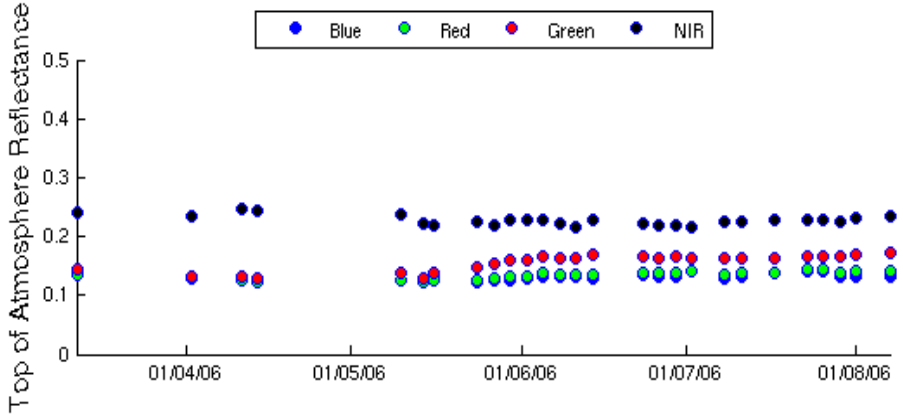


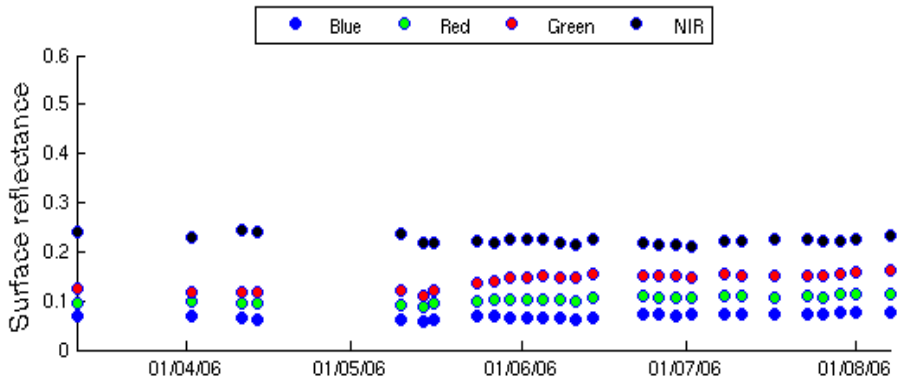


Atmospheric correction
First results with FORMOSAT : La Crau France

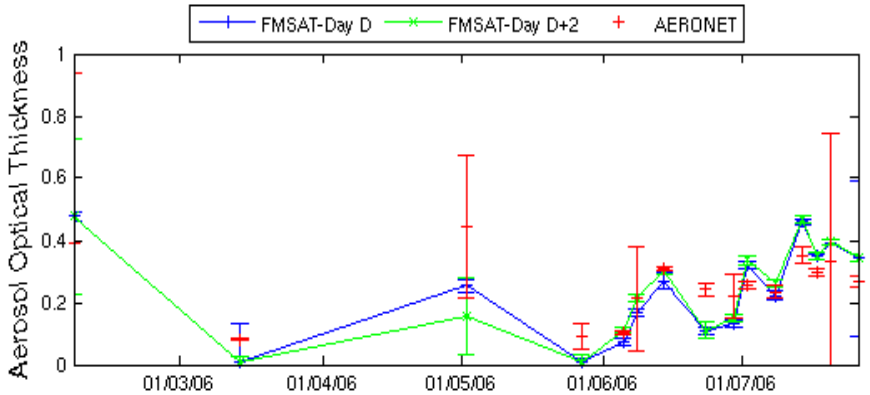


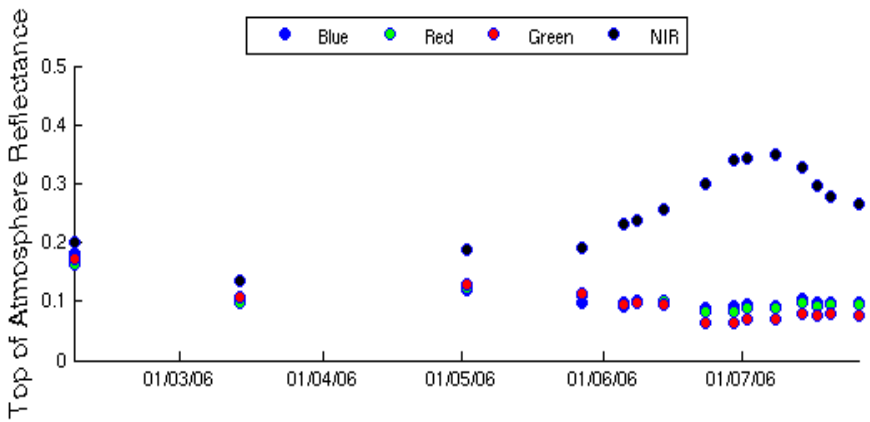


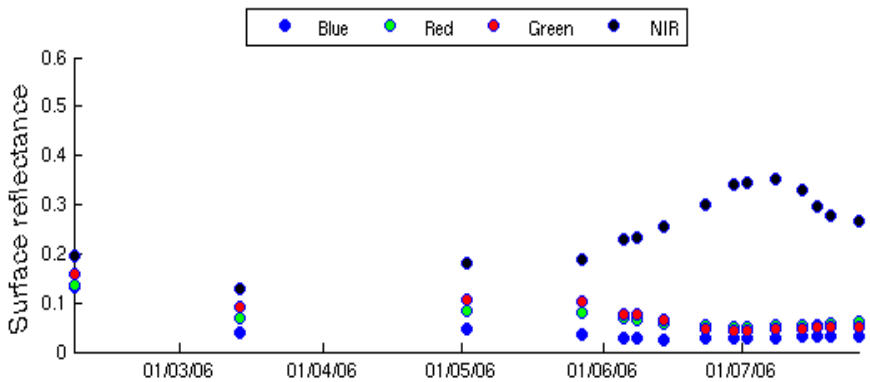


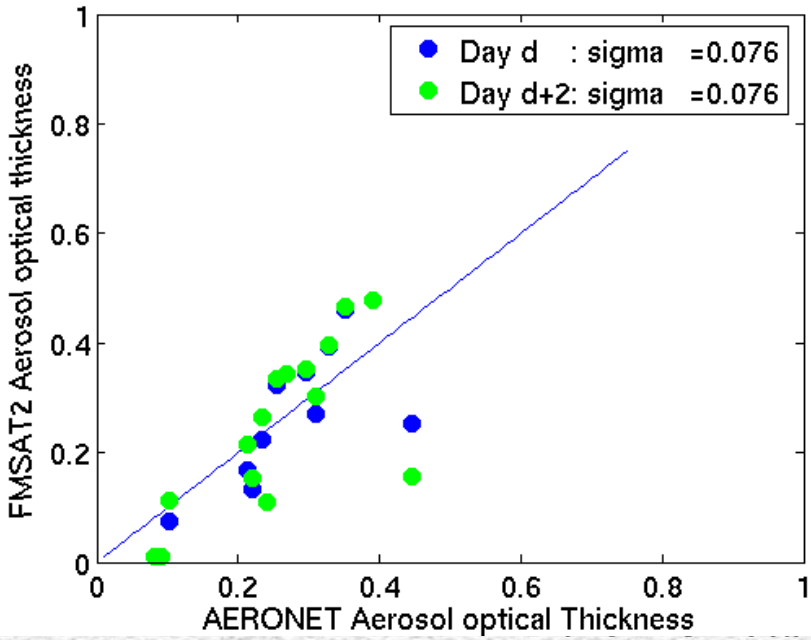


Atmospheric correction
First results with FORMOSAT : Muret (France)









Preliminary time series of Formosat 2 images acquired over Morrocco from 10 November 2005 to 10 January 2006 (Tensift, Marrakech)

Resolution in multispectral mode : 8 m
(2 m in Panchromatic)

Daily revisit capability.
Here 1 image every 4 days was programmed

4 spectral bands : blue, green, red, near-infrared

Target observed with the same viewing angle

Image window: 7,4 x 4,3 km (full image 24x24 km)

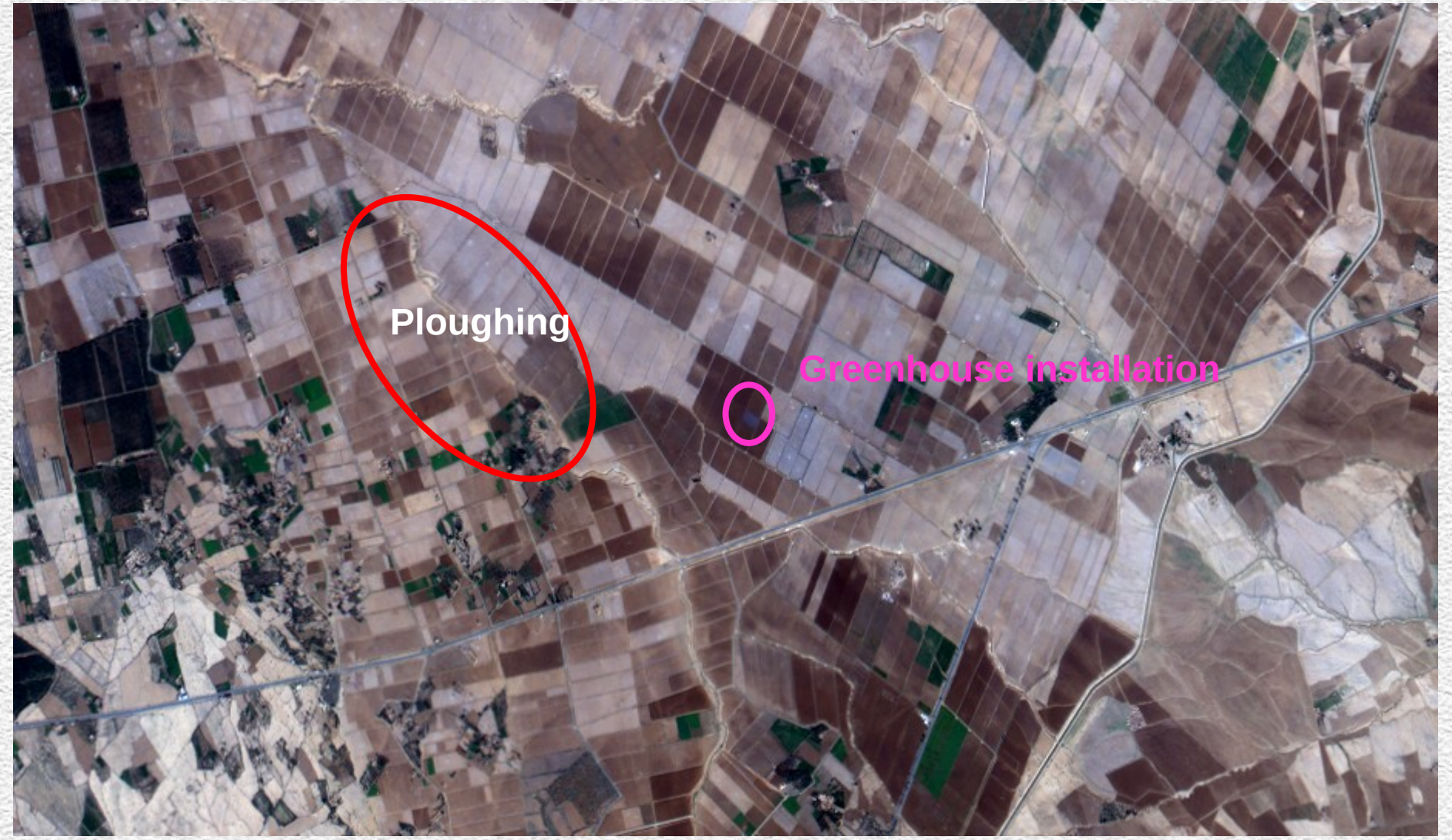
10 november 2005

12 november 2005

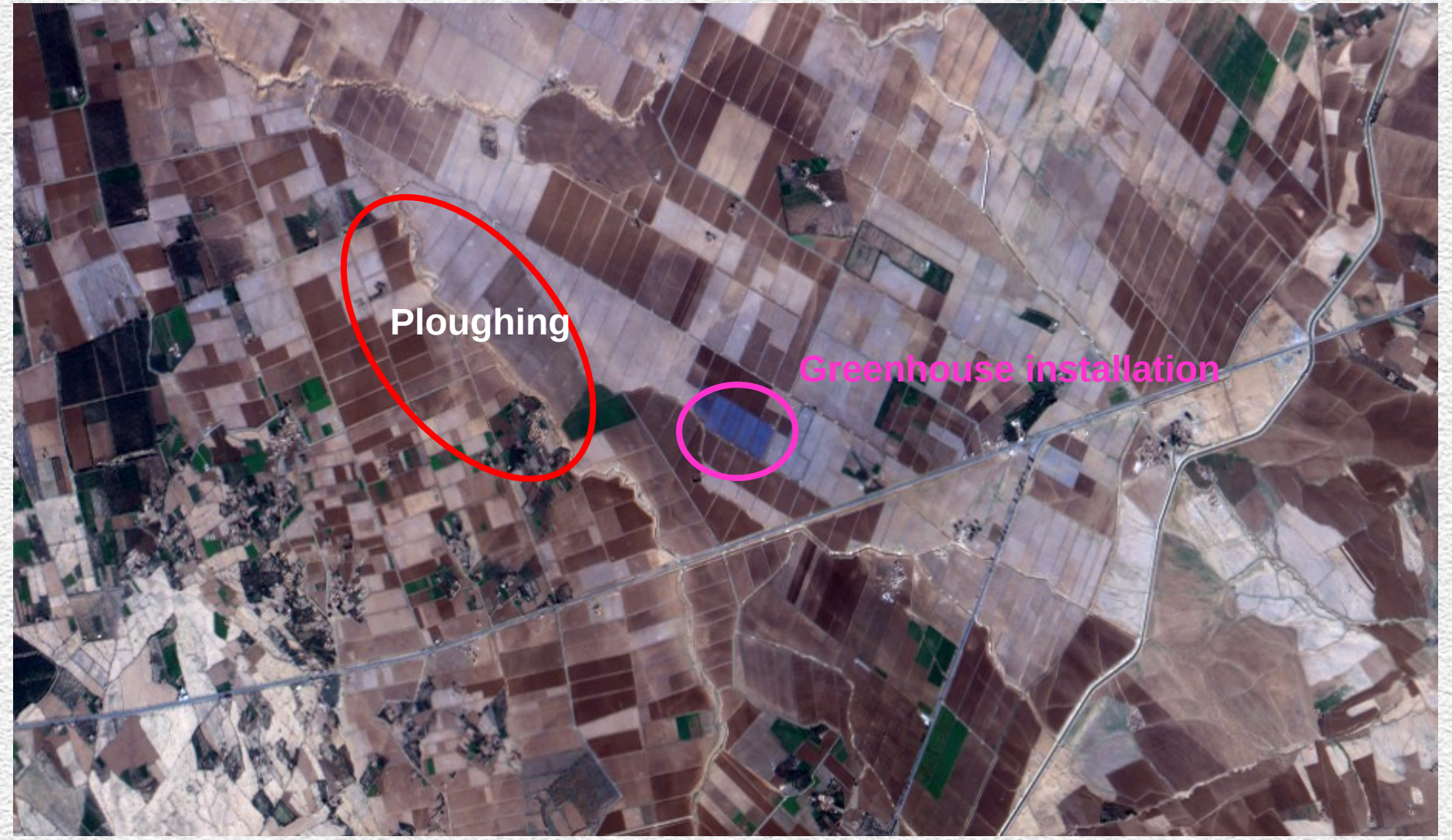
18 november 2005

21 november 2005

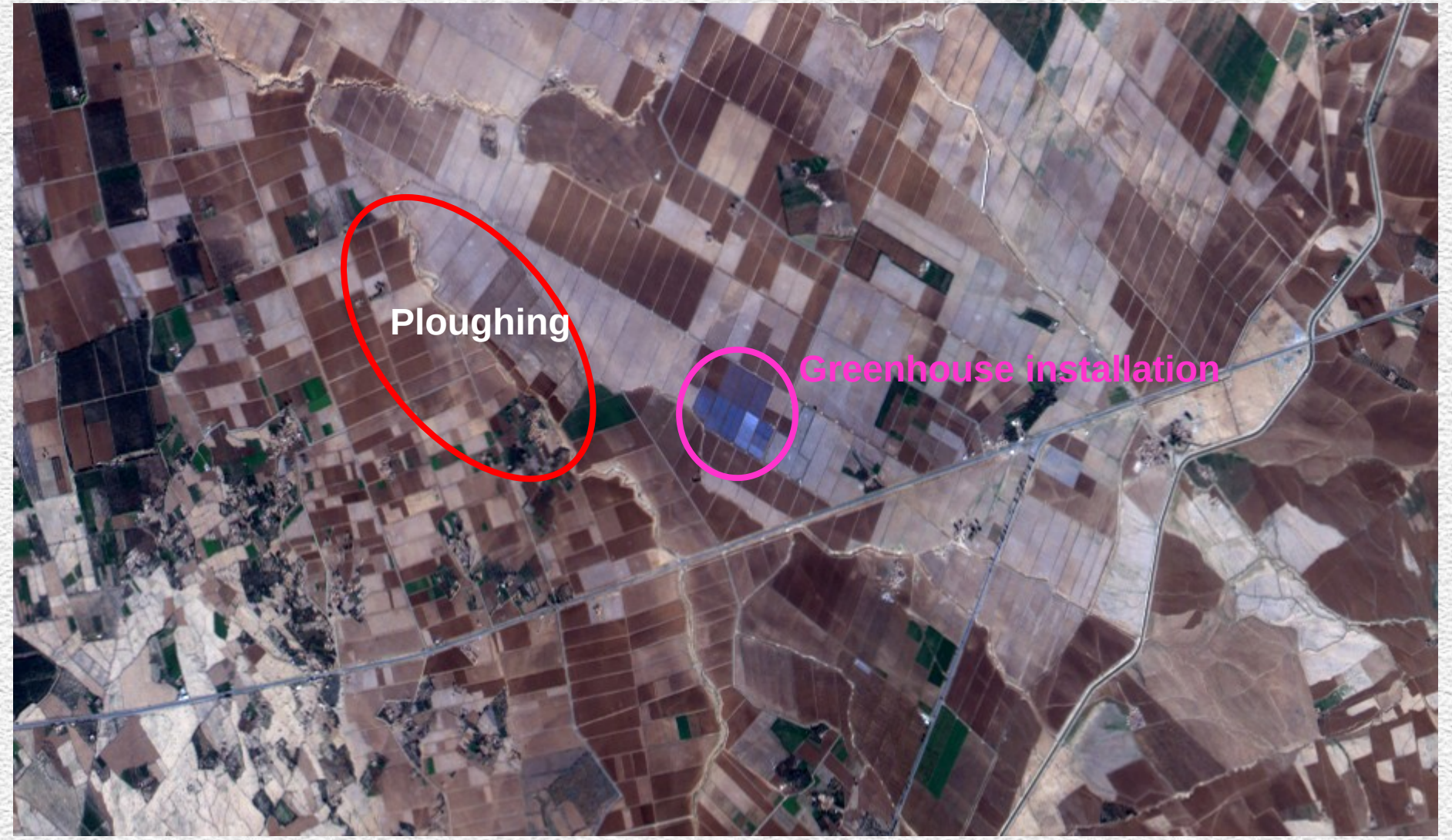
28 november 2005



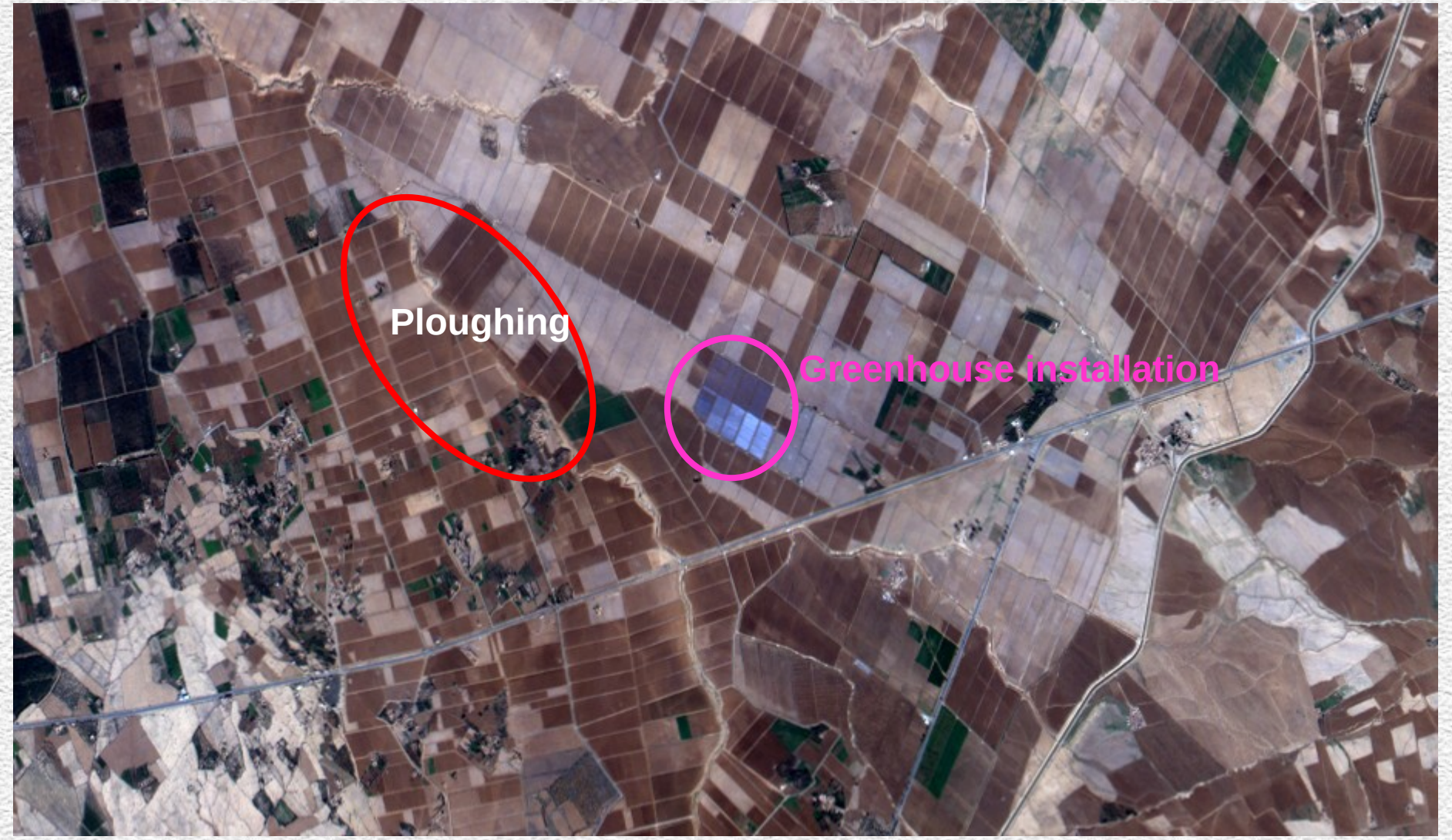
4 december 2005



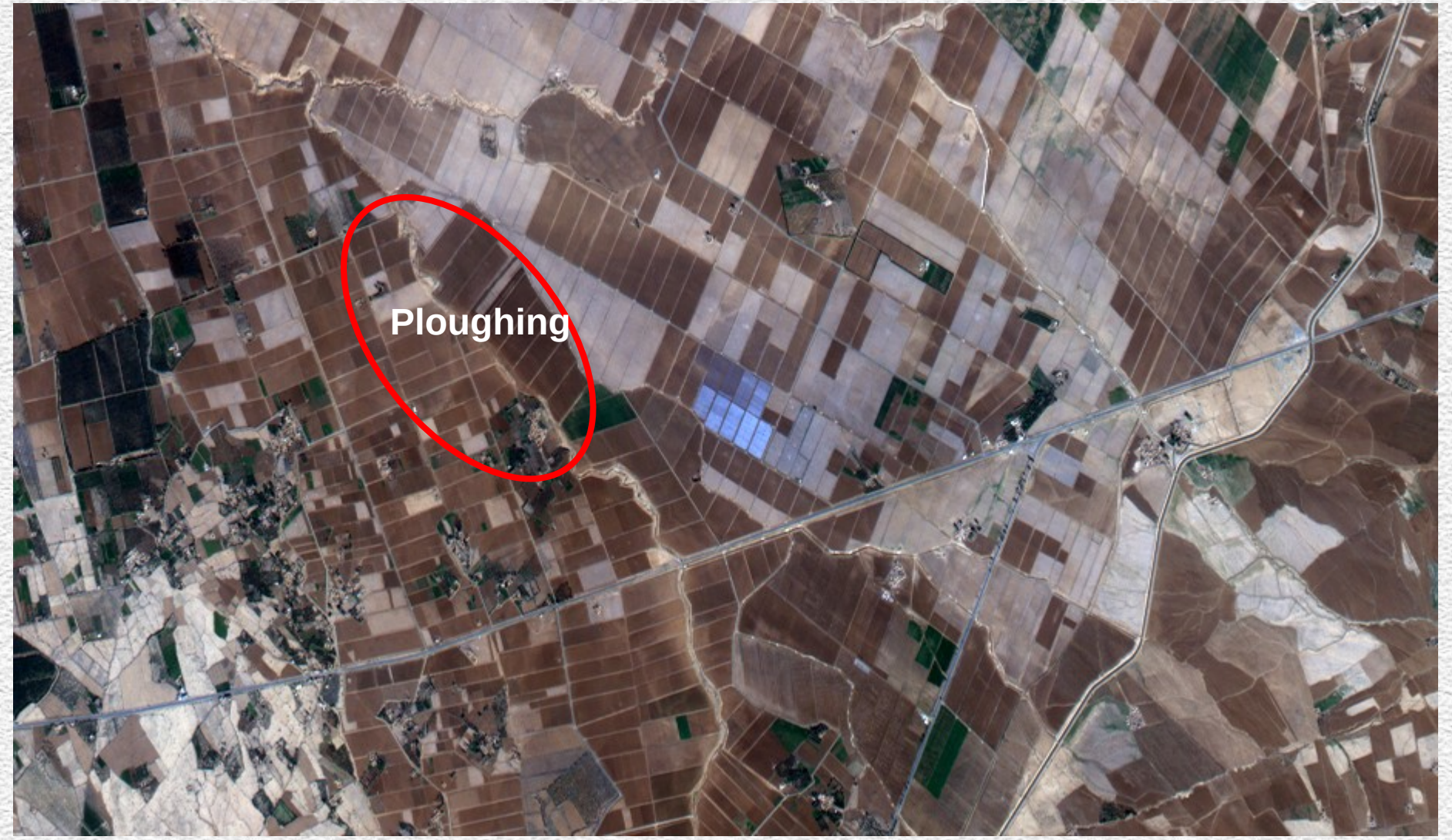
8 december 2005



12 december 2005

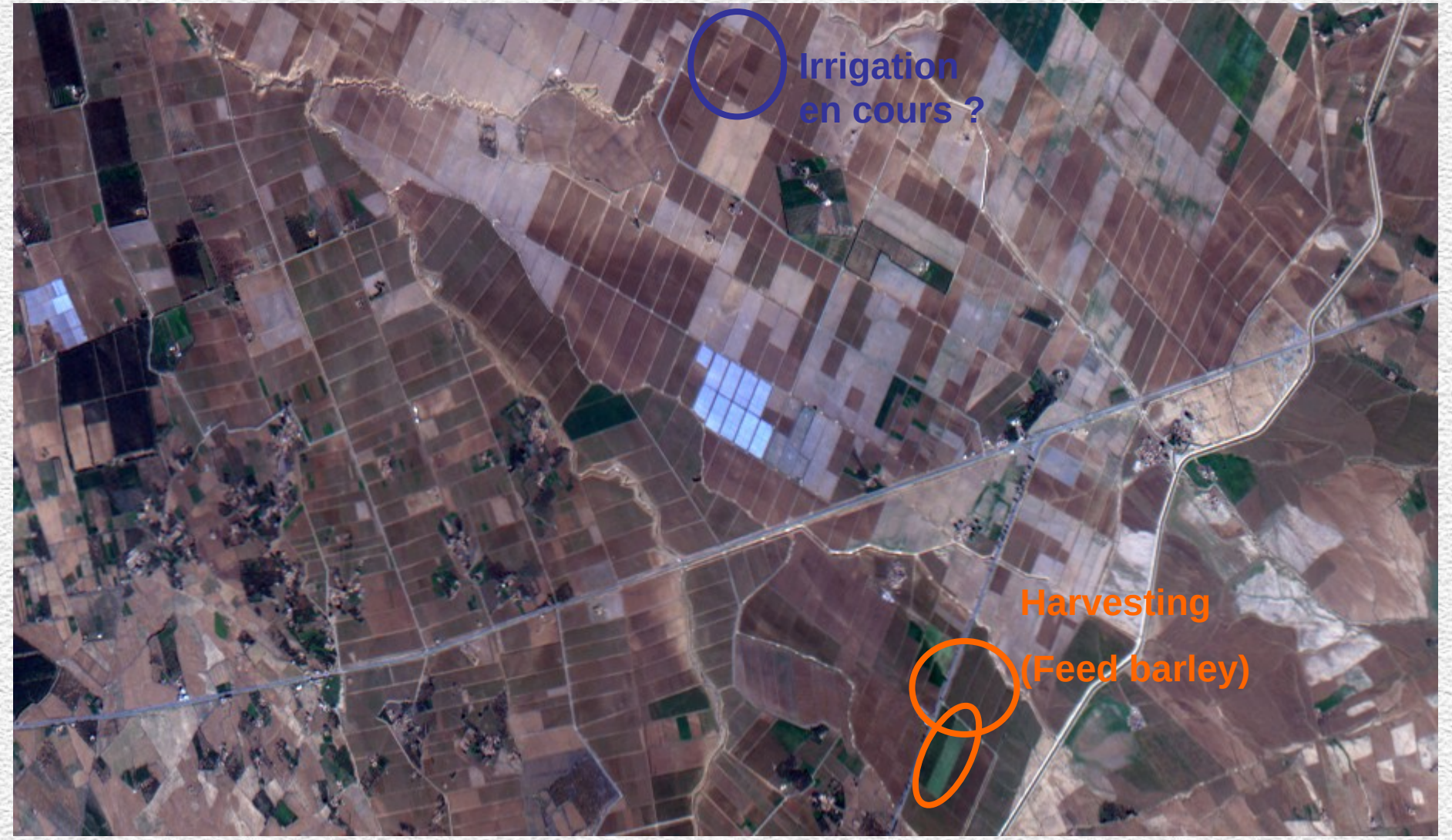


16 december 2005



29 december 2005

10 janvier 2006



Preliminary time series of Formosat 2 images acquired over South West of France from 6 February 2006 to 26 July 2006

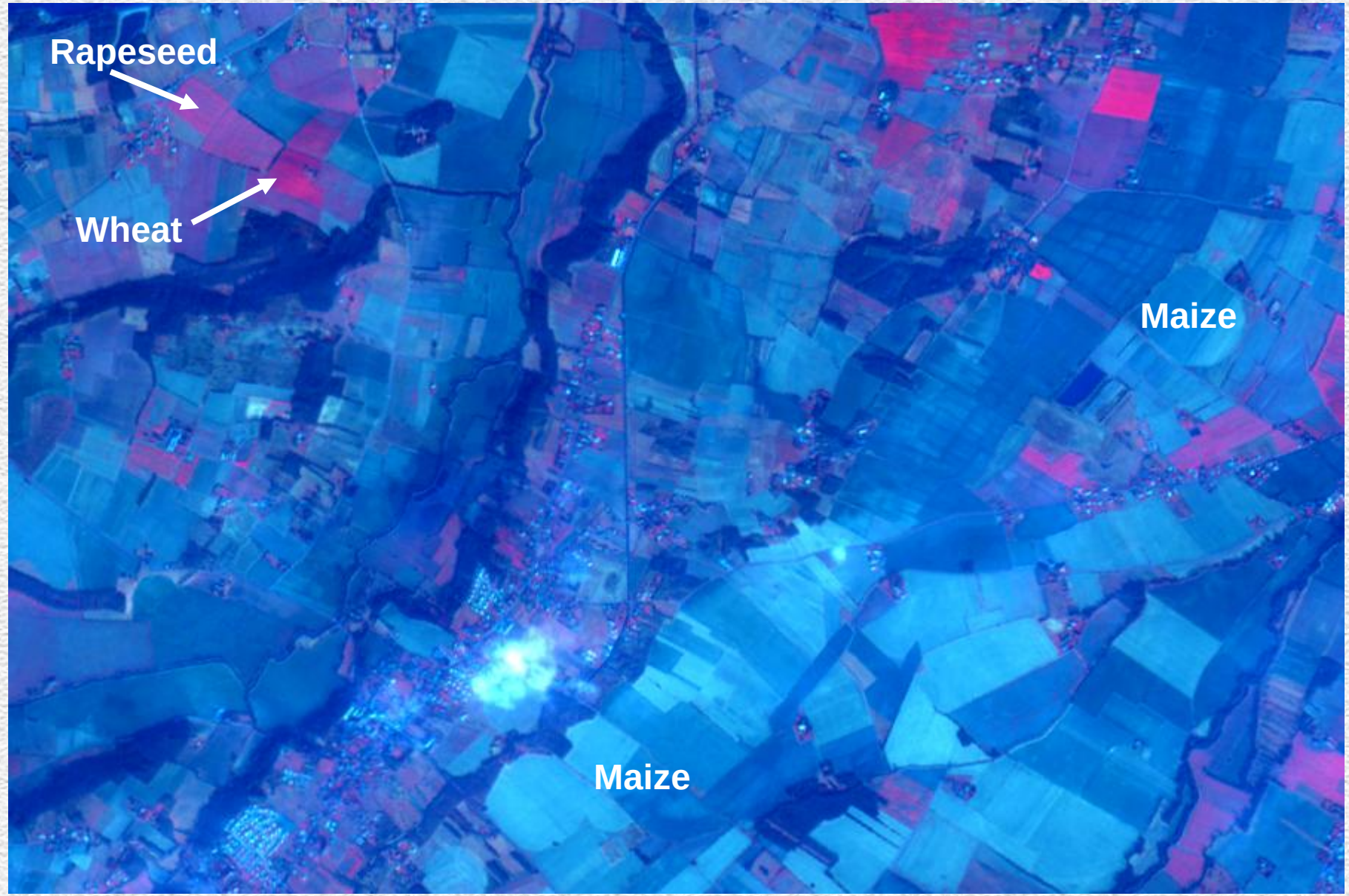
Daily revisit capability.
Here 1 image every 3 days was programmed

Top of the atmosphere reflectances

Target observed with the same viewing angle

Image window: 7,3 x 4,8 km (full image 24x24 km)

February 6 - 2006



February 17 - 2006

March 14 - 2006

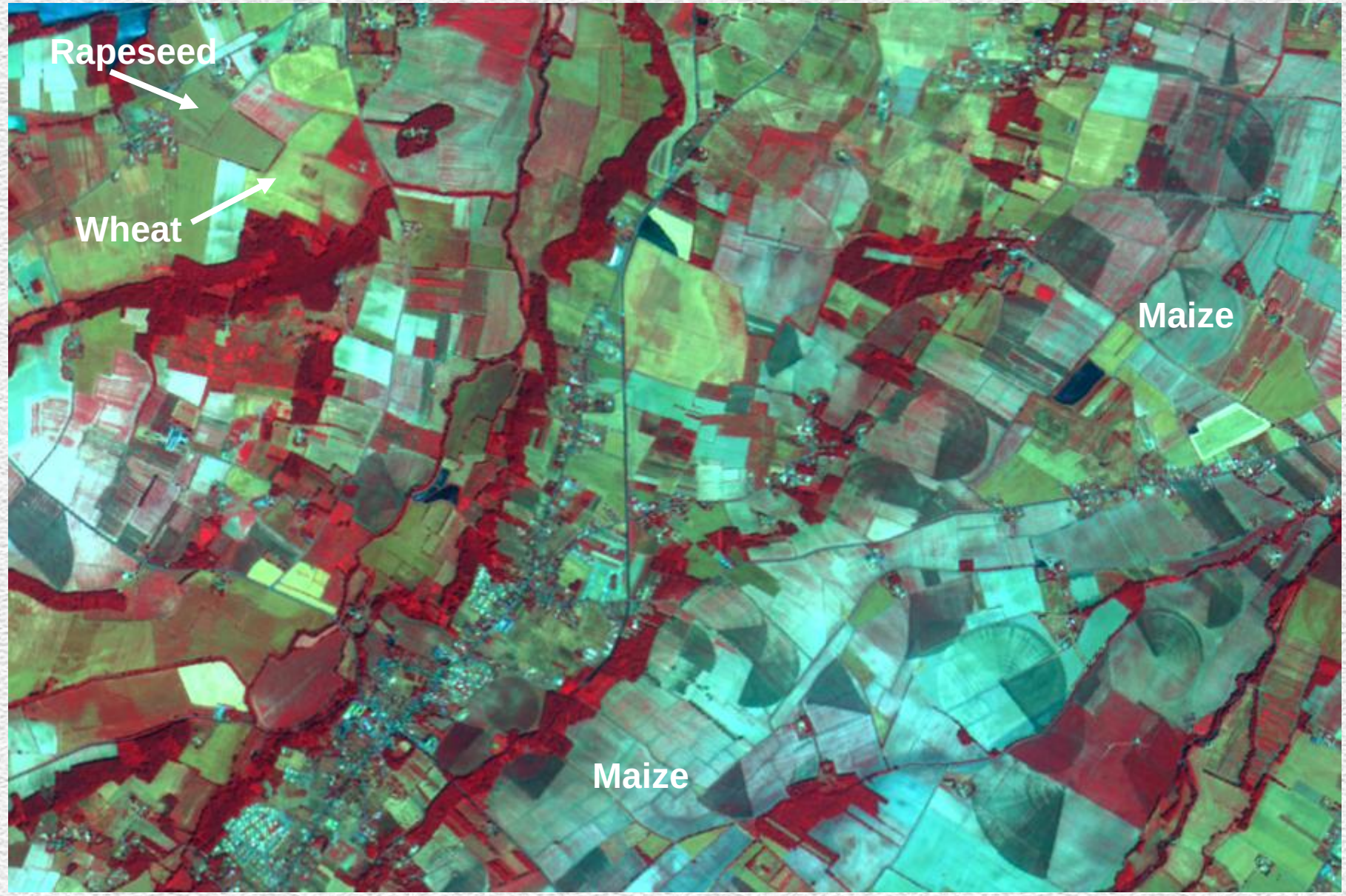
May 2 - 2006

May 27 - 2006

June 5 - 2006

June 8 - 2006

June 14 - 2006



June 23 - 2006

June 29 - 2006

July 2 - 2006

July 8 - 2006

July 14 - 2006

July 17 - 2006

July 20 - 2006

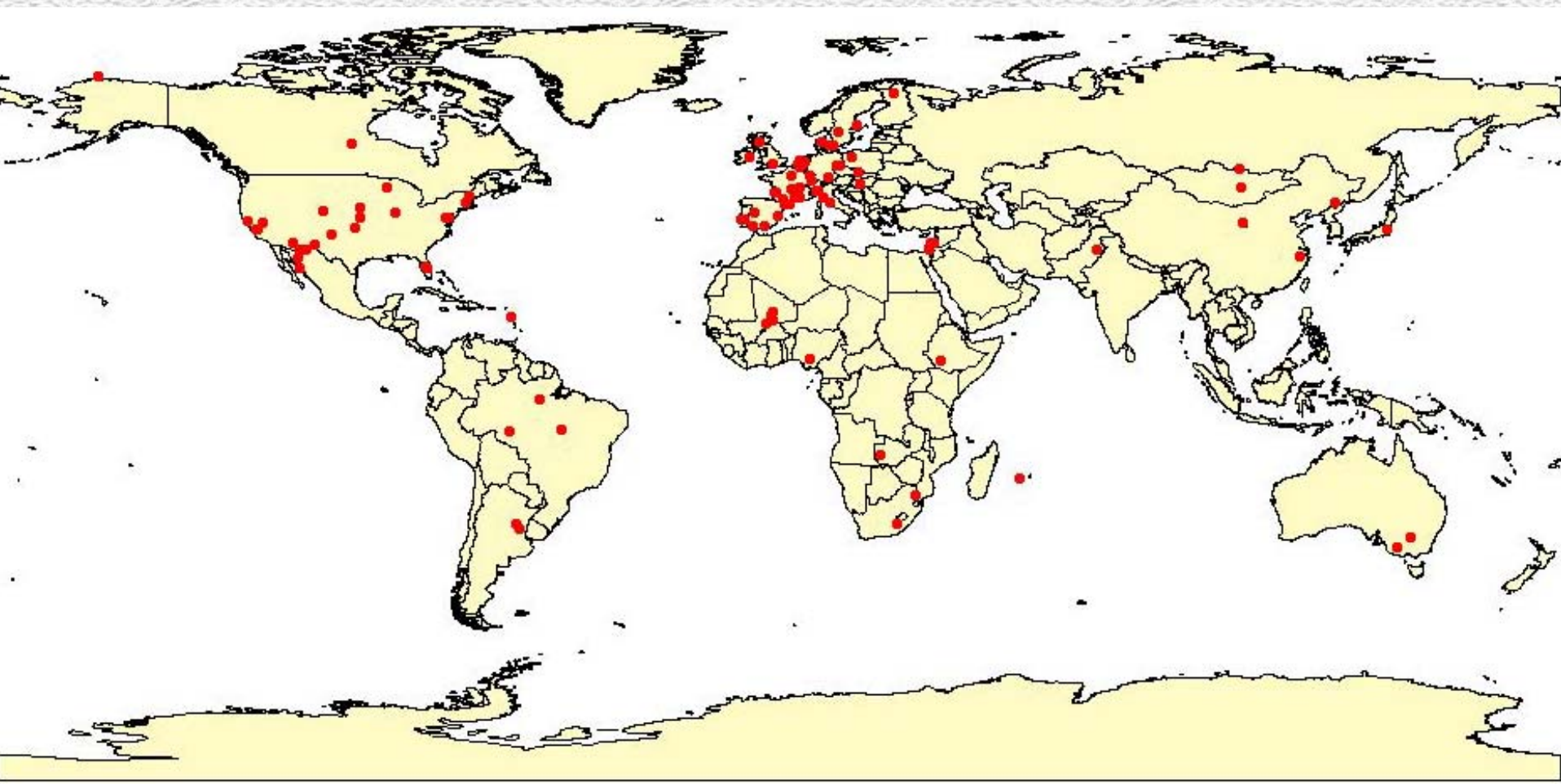
July 26 - 2006

SITE SELECTION PROCEDURE

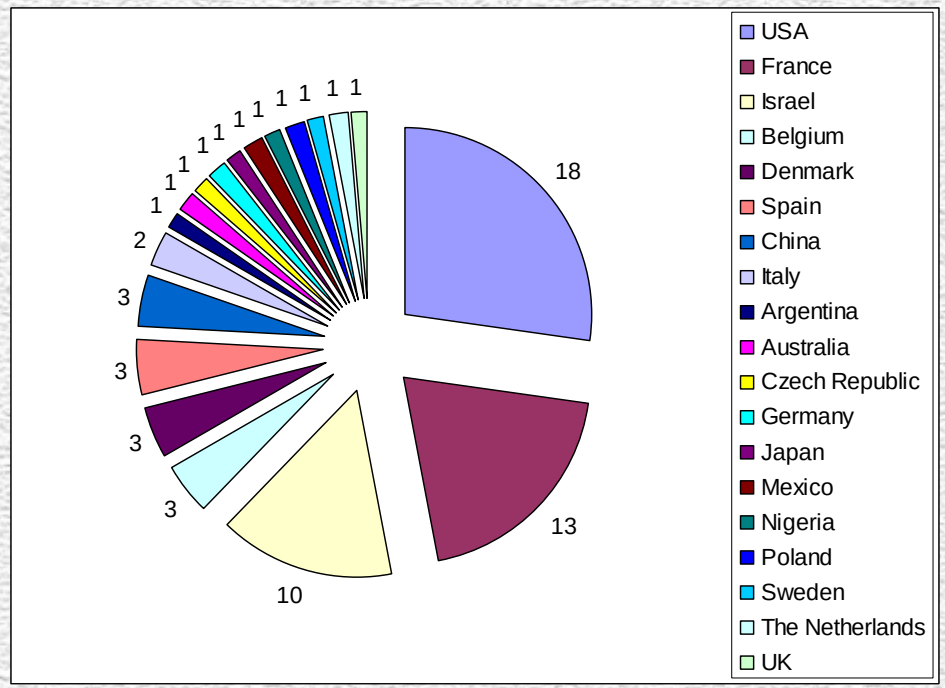
- Call for proposal released in May 2006. Two steps : 1/outline proposals, pre-selection 2/ final full proposals
- Dead line for the outline proposals : 28 june 2006
- 70 proposals received, 110 sites proposed
- For pre-selected proposal, full proposal will be requested by the end of 2006
- The plan is to acquire images over the selected sites during the whole 2.5 years of the mission
- About 50 sites can be observed, plus image quality sites

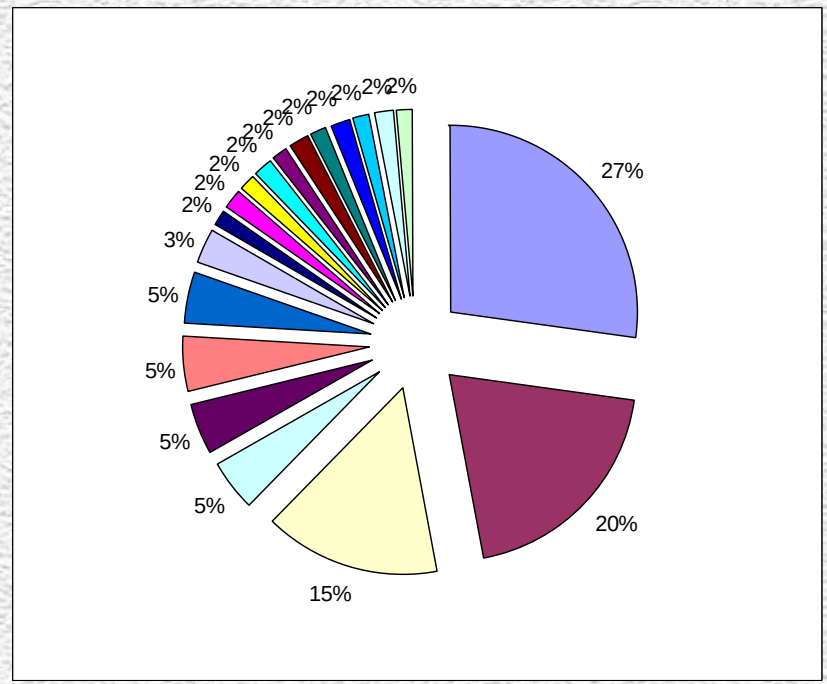
- Analysis of the technical feasibility, simulation of the acquisitions are currently being carried out

SITE PROPOSALS

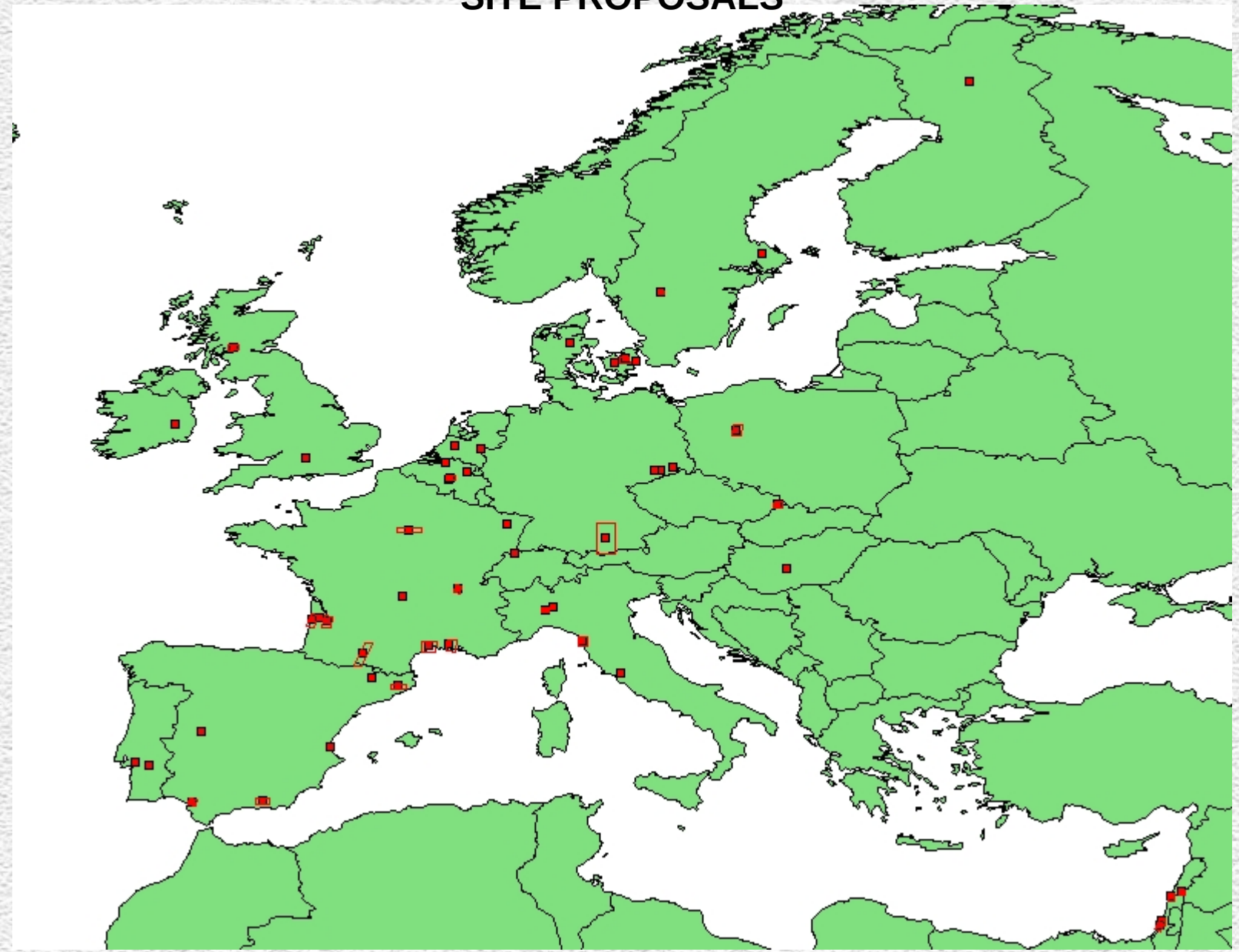


Country of proposal PIs





SITE PROPOSALS



CHRIS/PROBA and VENμS ?

- Only a few of the sites proposed for VENμS are CHRIS sites
- The probability of simultaneous availability of CHRIS and VENμS is very low
- The expertise gained by CHRIS PI's could be applied to some extent to VENμS (e.g. use of red-edge bands, atmospheric corrections, water colour…)
- According to its mission objectives and launch date (2009) VENμS project is mainly interested by sites with long term operation of ground measurements devoted to land surface functioning studies
- High quality project dealing with pre-processing algorithm or the use of site networks (EuroFlux, AERONET, …) are also of interest
- Still time to submit short (outline) proposals, especially for sites outside western Europe and coastal areas
- All the acquired images will be freely available by ftp 3 months after acquisition to every registered users

For further information:

gerard.dedieu@cesbio.cnes.fr

http://venus-mission.cnes.fr

http://www.cesbio.ups-tlse.fr

Summary of the results of a phase 0 CNES study for an operational mission (1/2)

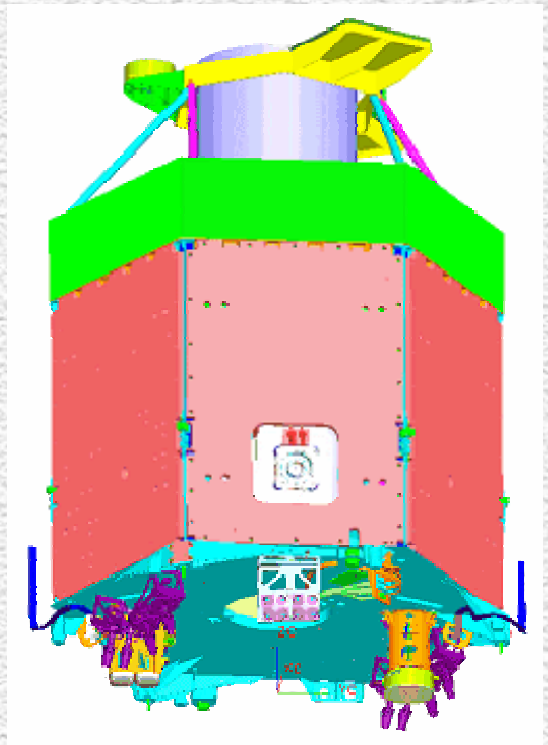
- With one receiving station, the mission will provide unique high resolution (20m) and high repetitivity (2 days) measurements in 9 spectral bands over the whole Europe and Africa for regional applications.
- Global scale observation at 100m resolution, every 2 days, with one receiving station.
- The availability of 3 high latitude receiving stations with duplicated ground segments would allow to generate global 20 m products every 7/10 days
- A single mission ensures continuity of SPOT-HRV, LANDSAT and VEGETATION/MERIS data
- The highest priority is given to the temporal repetitivity and spatial coverage, then to the spatial resolution and lastly to the spectral richness
- The users will be supplied with « ready-to-use » products: no additional geometrical and radiometrical correction

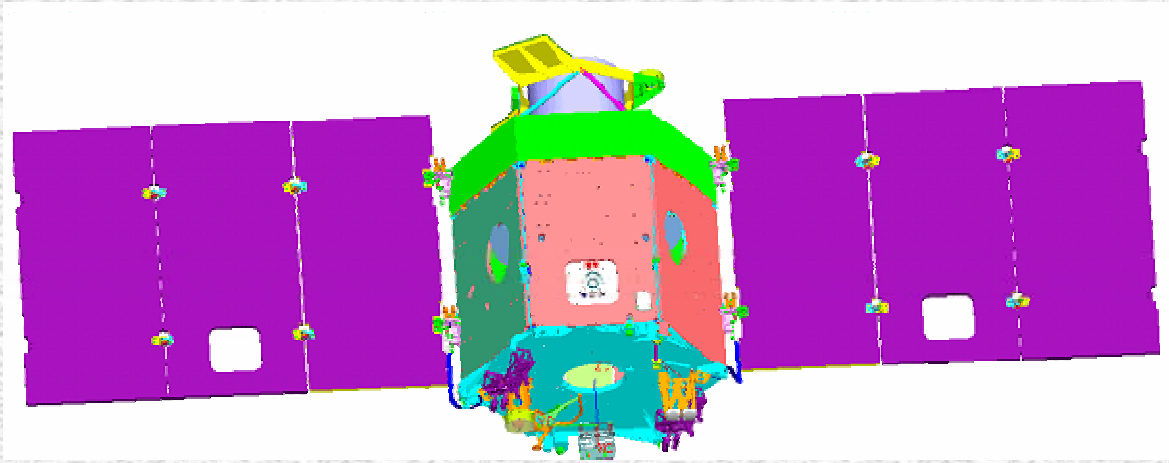
Summary of the results of a phase 0 CNES study for an operational mission (2/2)

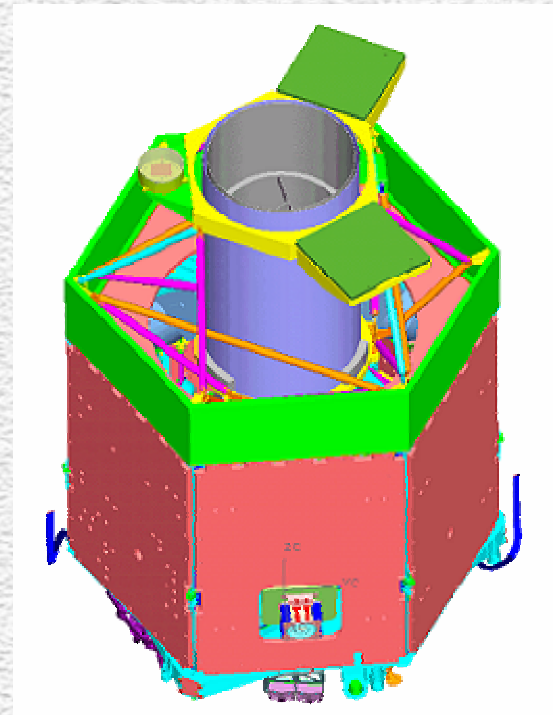
- The proposed 20 years duration of the programme ensures long term continuity in order to monitor changes and to justify users' investments

- Possibility to adapt the revisit period :

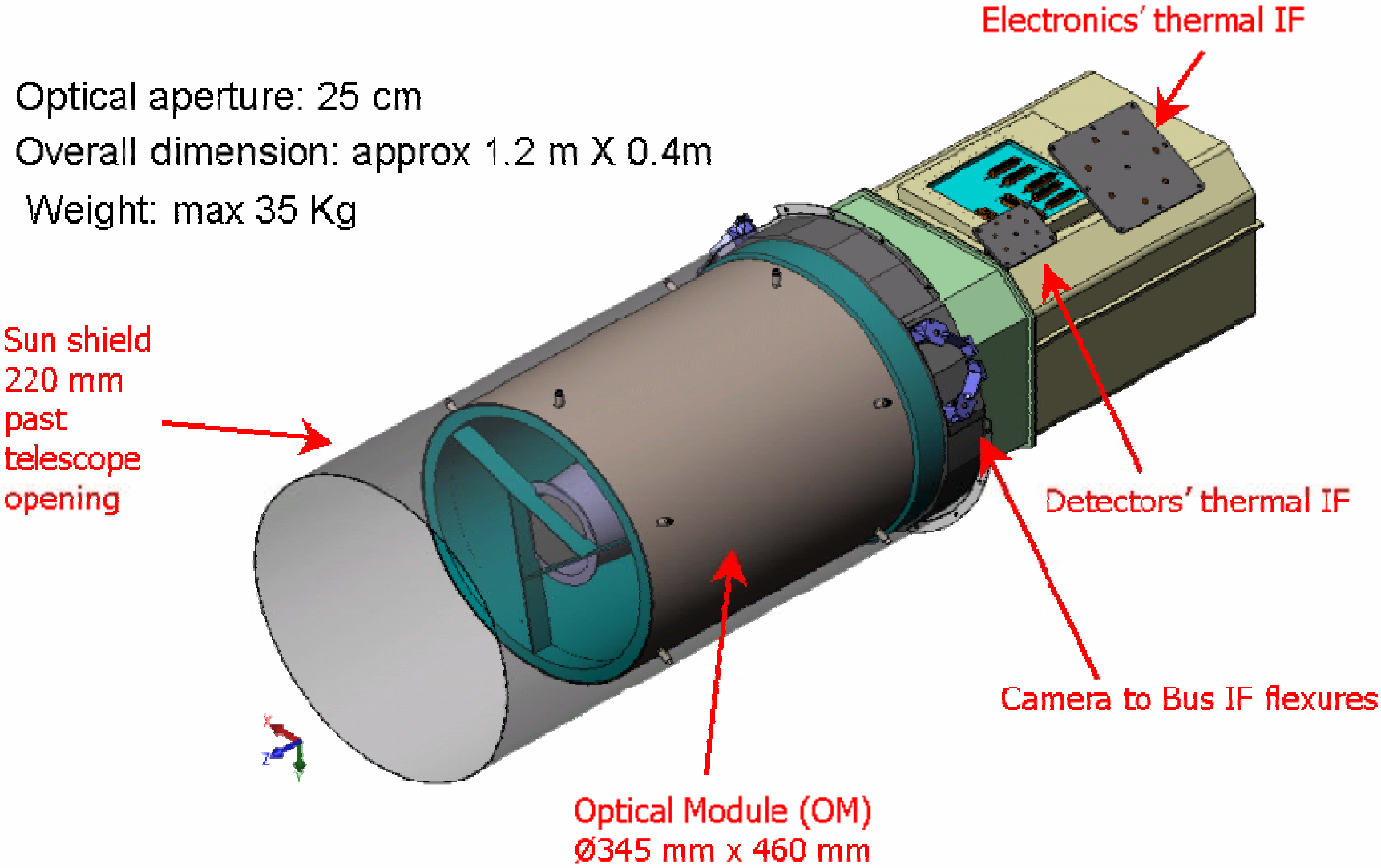
Revisit period (days)	1	2	3	6
Number of satellites	6	3	2	1

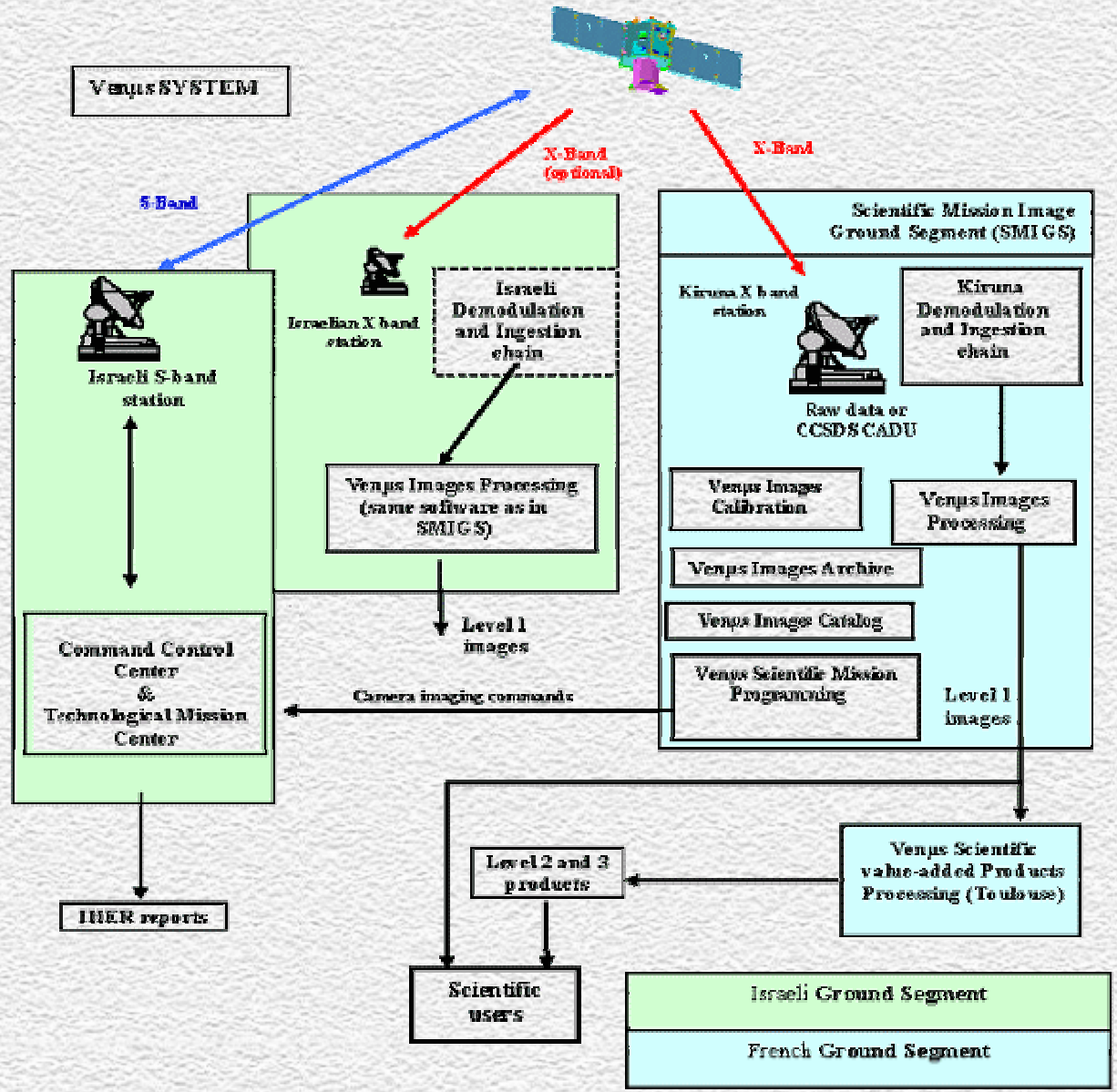






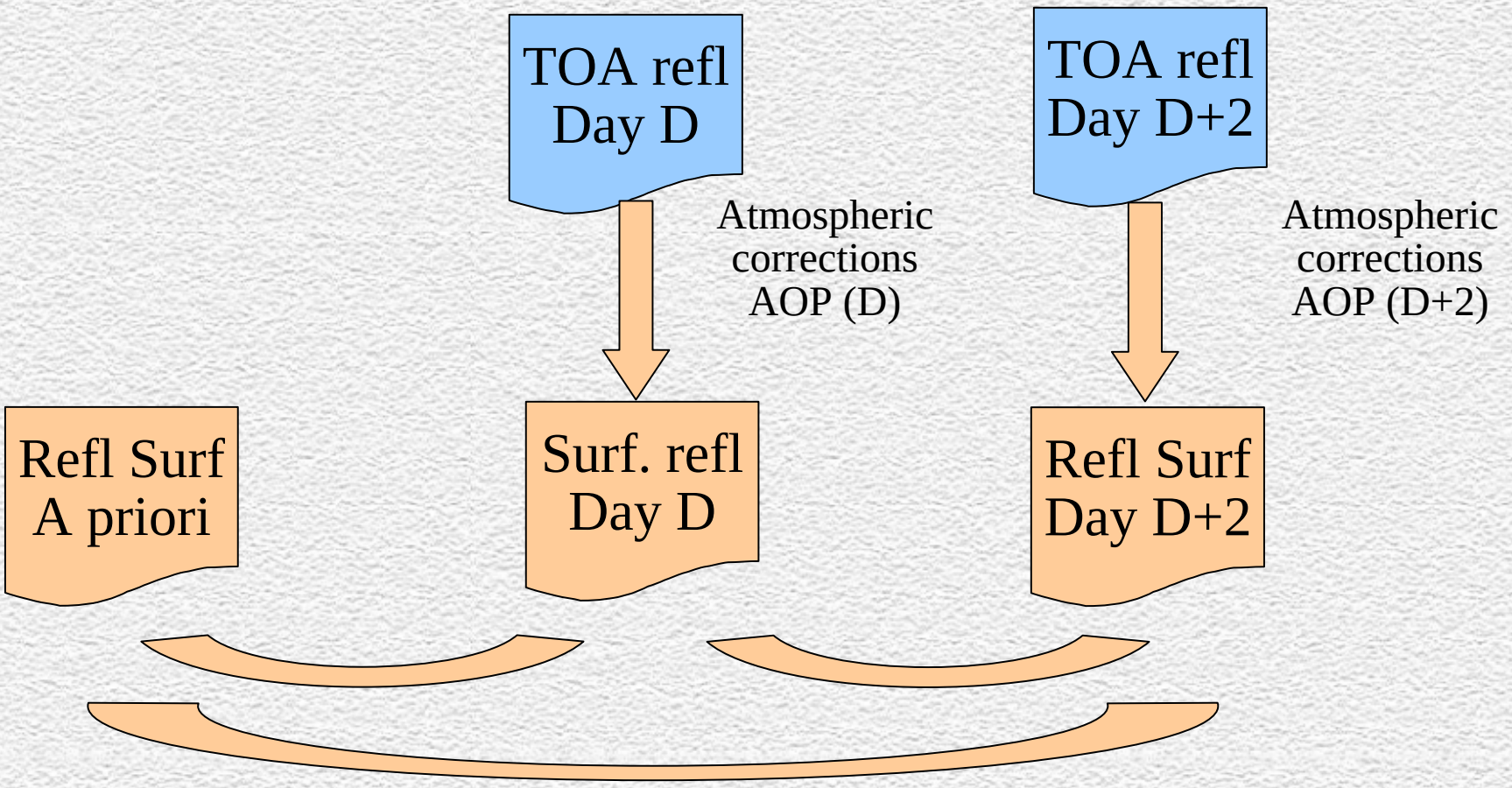
- Optical aperture: 25 cm
- Overall dimension: approx 1.2 m X 0.4m
- Weight: max 35 Kg




Venus SYSTEM
S-Band
X-Band (optional)
X-Band
Scientific Mission Image Ground Segment (SMIGS)
Israeli S-band station
Israelian X band station
Israeli Demodulation and Ingestion chain
Kiruna X band station
Kiruna Demodulation and Ingestion chain
Raw data or CCSDS CADU
Venus Images Processing (same software as in SMIGS)
Venus Images Calibration
Venus Images Processing
Venus Images Archive
Venus Image Catalog
Level 1 images
Command Control Center & Technological Mission Center
Camera imaging commands
Venus Scientific Mission Programming
Level 1 images
IHER reports
Level 2 and 3 products
Venus Scientific value-added Products Processing (Toulouse)
Scientific users
Israeli Ground Segment
French Ground Segment

Level 2 algorithms

- **Algorithmic details of atmospheric correction**



The algorithm searches AOP(D)- AOP(D+2) that minimise differences between the 3 surface reflectances