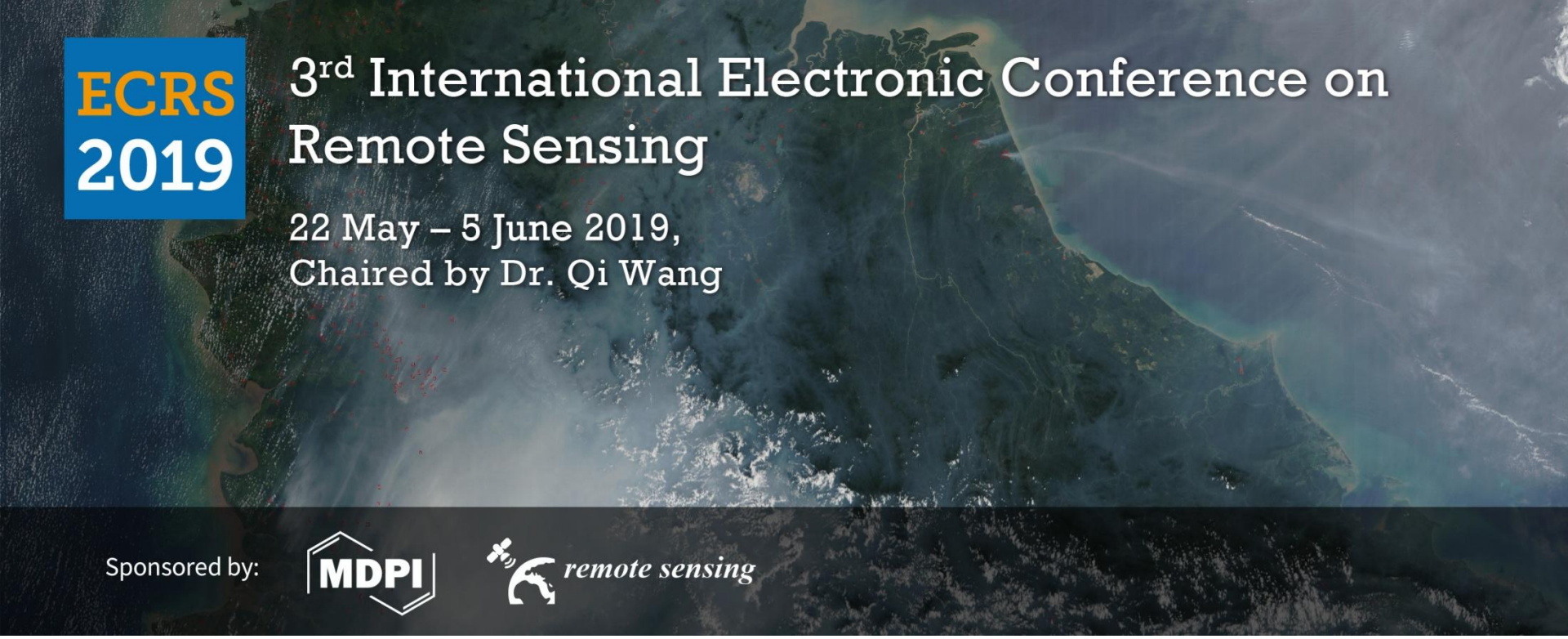

Estimation of sunflower yields at a decametric spatial scale A statistical approach based on multi-temporal satellite images

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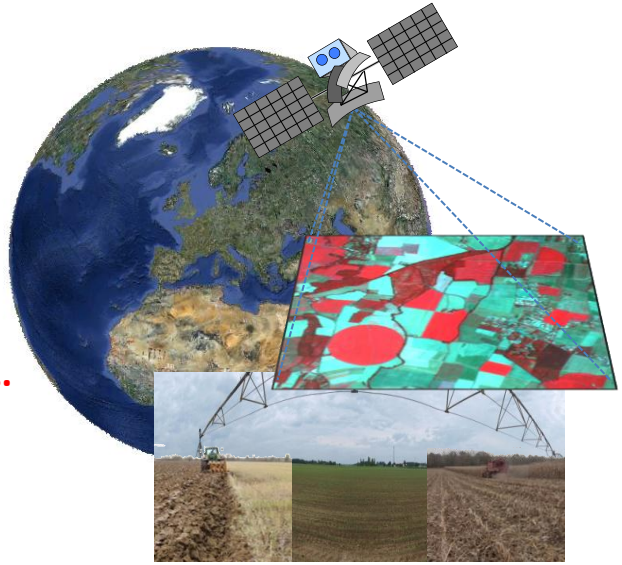
- **Global issues**

Climate change *(increase of mean temperature, modification of precipitation patterns)*

→ **Effects on agriculture?**

Population growth *(9,3 milliards in 2050 ?)*

→ **Increase of food needs…**



→ **Accurate managements need to combine sustainability of resources and sufficient level of production to meet the food needs…**

- **Satellite missions at high spatial and temporal resolutions**

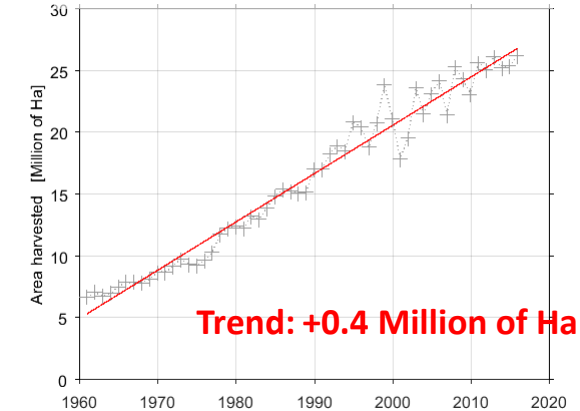
On going microwave missions: *TerraSAR-X, Tandem-X, Radarsat-2, COSMO-SkyMed, Sentinel-1a/b, Alos-2…*

On going optical missions: *Landsat, Sentinel-2, Venμs, Pléiades…*

Coming soon : *TerraSAR-X2, Radarsat Constellation, Tandem-L…*

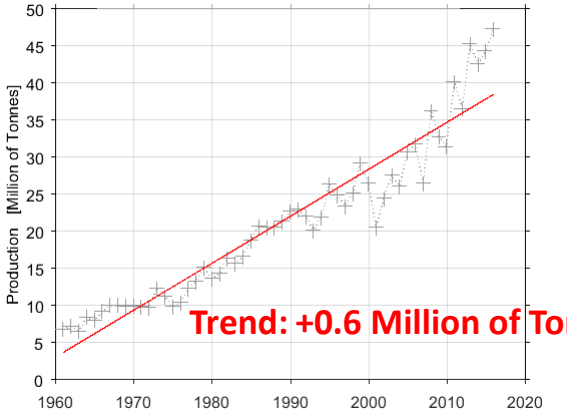
- **Sunflower worldwide – From 1961 to 2016 (*FAOSTAT*)**

Area harvested



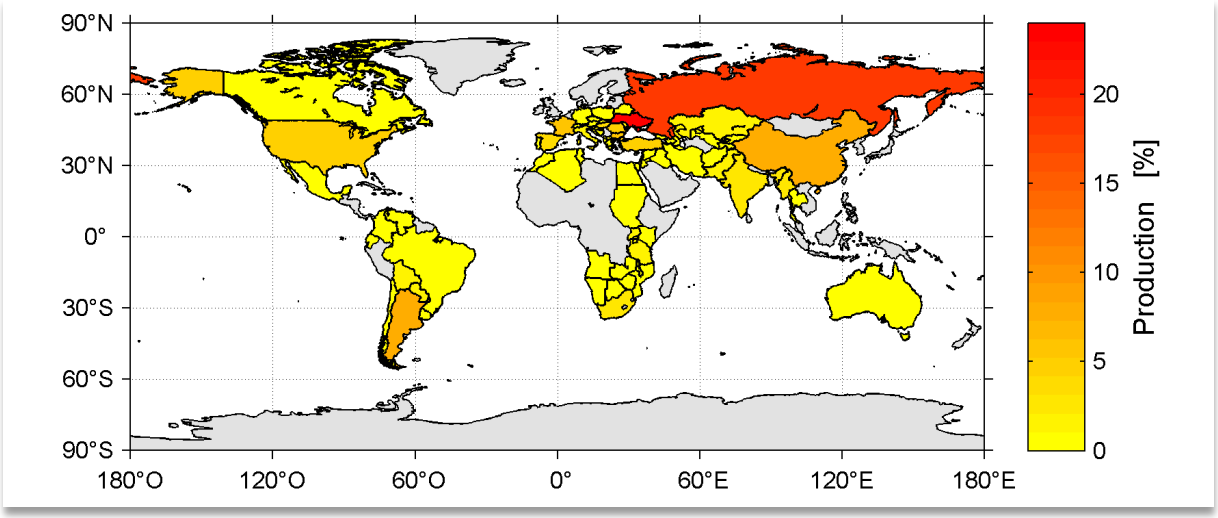
Trend: +0.4 Million of Ha per year

Production



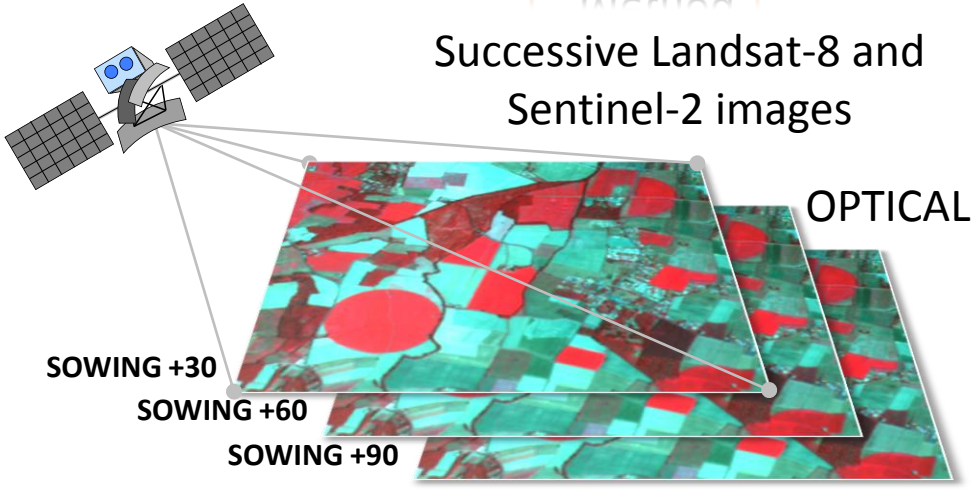
Trend: +0.6 Million of Tonnes per year

- **Distribution of the world production in 2010**

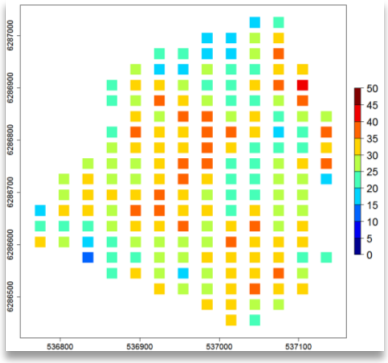


5 countries account for 58% of the total production
Ukraine, Russia, China, Argentina and France

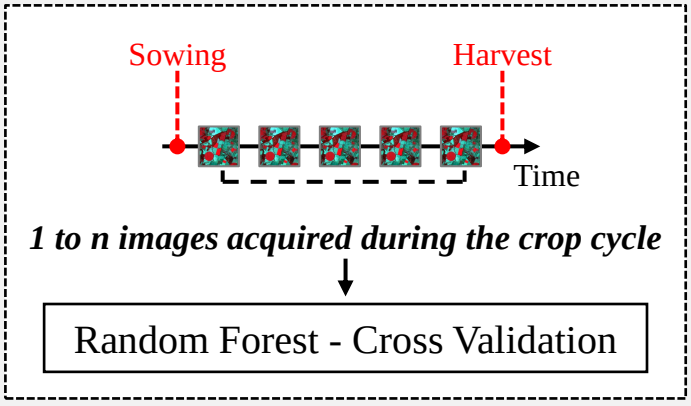
Successive Landsat-8 and Sentinel-2 images



Yields collected at the intra-field scale

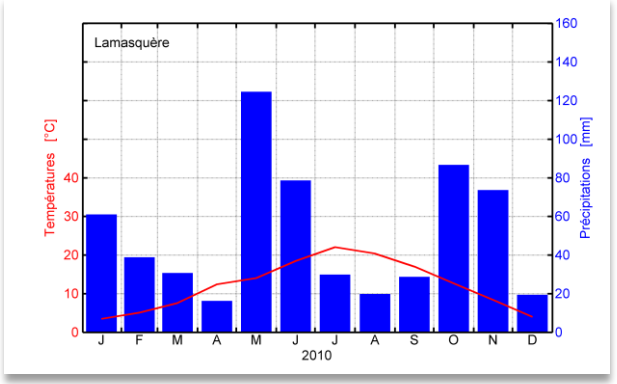


Yield forecast in real-time



Objective ➔ *Estimation of the sunflower yields all along the agricultural season (updating estimates after each satellite acquisition)*

REGION OF INTEREST IN FRANCE



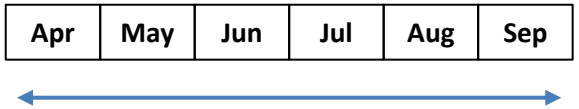
- Meteorological conditions are steered by a **temperate climate**

- **Surface dedicated to agriculture:**
  - 56,8% seasonal crops
  - 32,1% grasslands
  - 7,9% forests
  - 2,4% urban areas
  - 0,8% lakes

➔ **High spatial and temporal dynamics of the surface states**

- **The approach consists in using multi-temporal optical acquisitions**

Agricultural season



Optical satellite images

Years	2016		2017
Satellites	Sentinel-2	Landsat-8	Sentinel-2
Dates (M-D)	05-21 ; 06-20 07-10 ; 07-30	04-15 ; 06-09 ; 07-04 08-12 ; 09-06 ; 09-13	04-06 ; 05-06 ; 05-16 05-26 ; 06-05 ; 06-25 07-05 ; 08-04 ; 08-14 08-24 ; 09-13

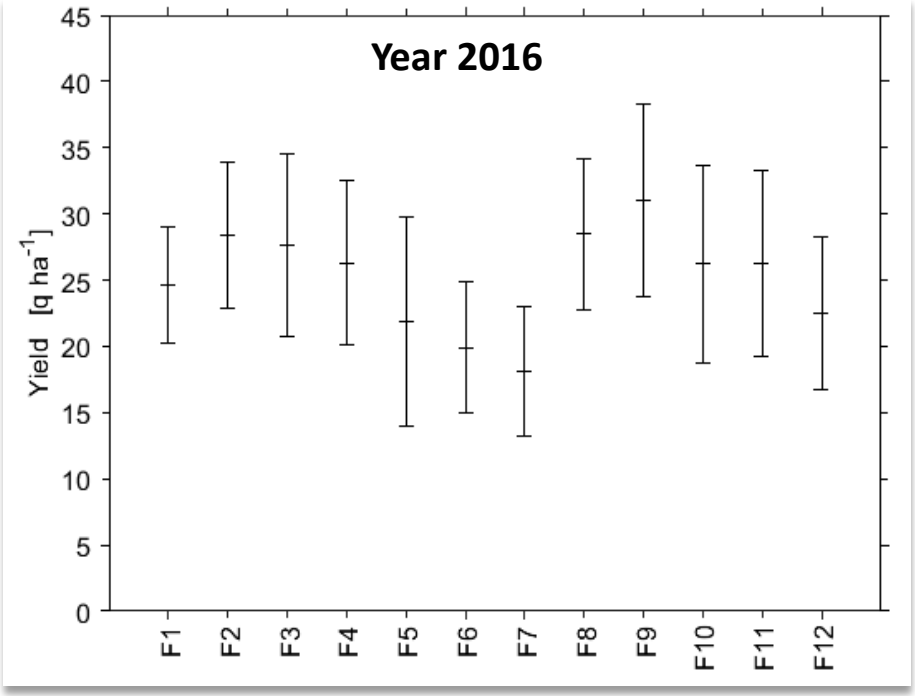
➔ **Use of 6 reflectances: blue, green, red, NIR, SWIR-1/2**

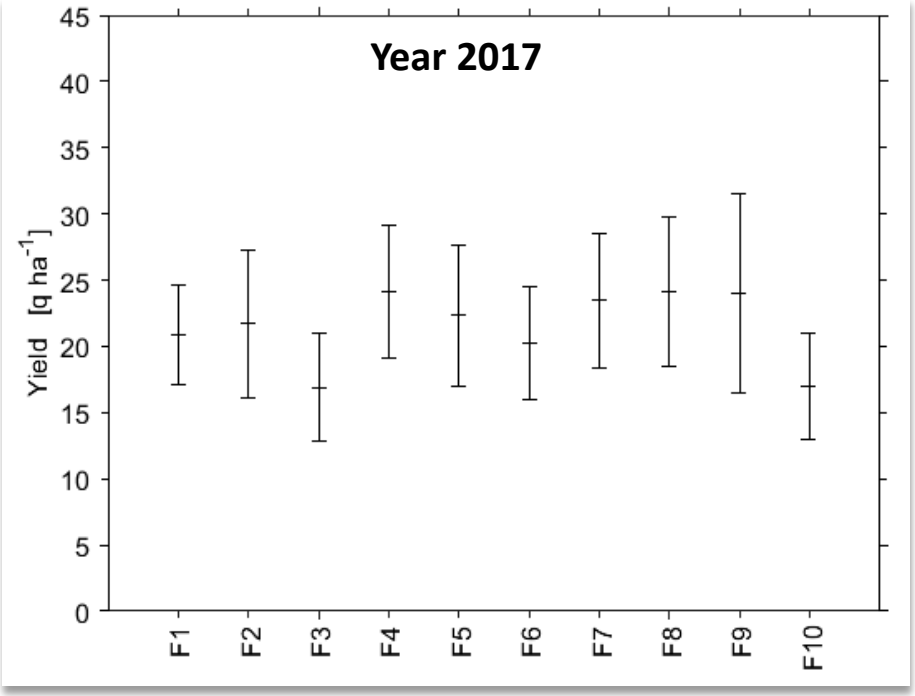
➔ **NDVI derived from red and NIR reflectances**

- **Measurements of sunflower yields**

Descriptive statistics by field (μ,σ)

Agricultural seasons 2016 et 2017 (12 et 10 fields)



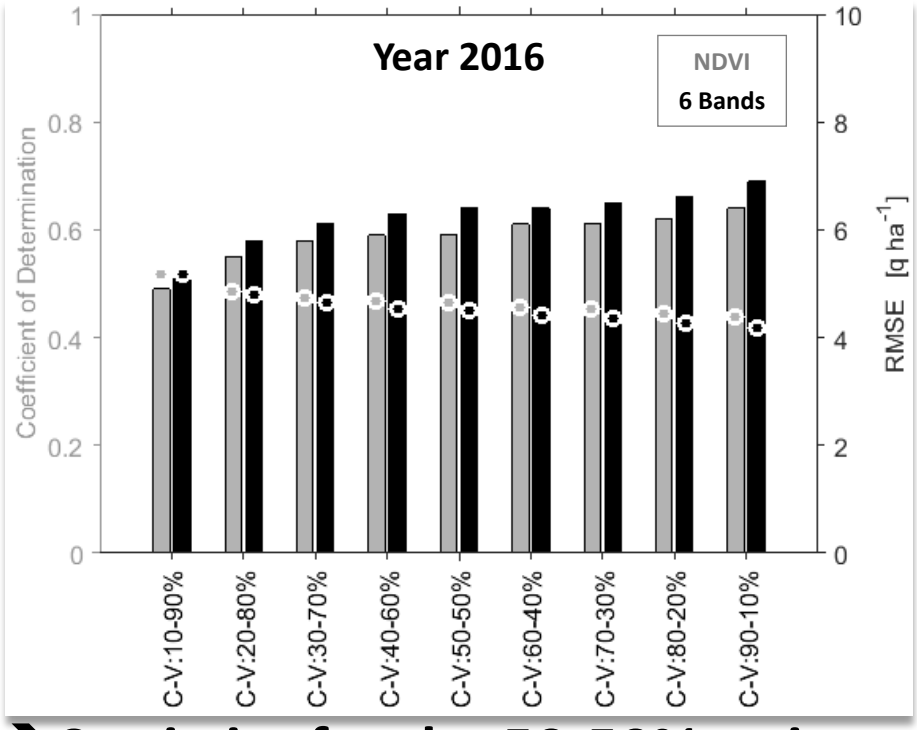


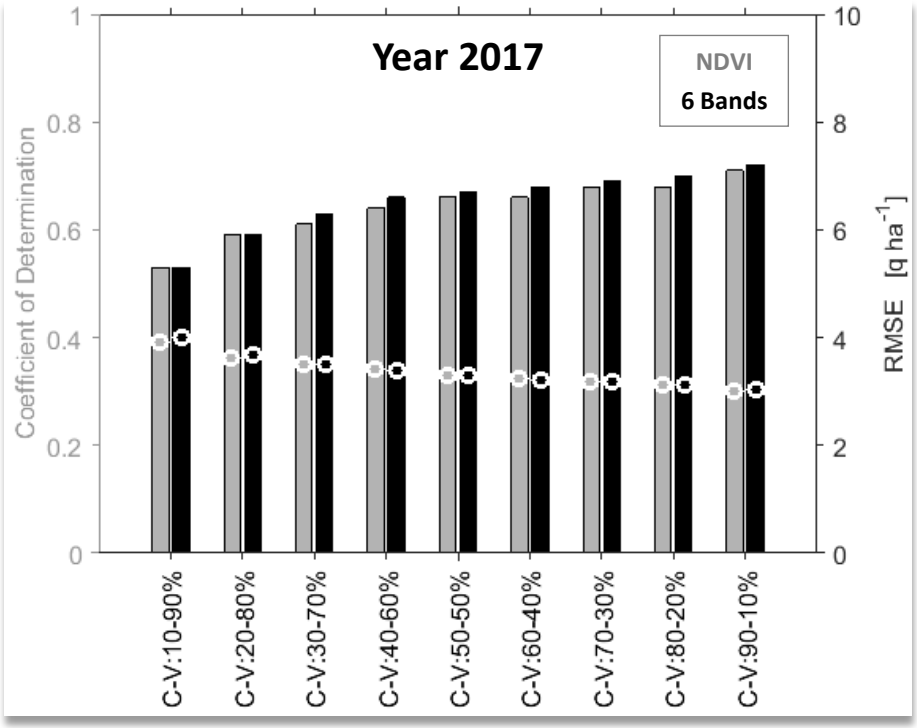
➔ **Mean yield:**

- 2016 → **25.1 q.ha^{-1}** (CV 18 to 36%)
- 2017 → **21.5 q.ha^{-1}** (CV 18 to 31%)

- **Test of different ratio of data for Cal/Val**

Using all the images during the agricultural season



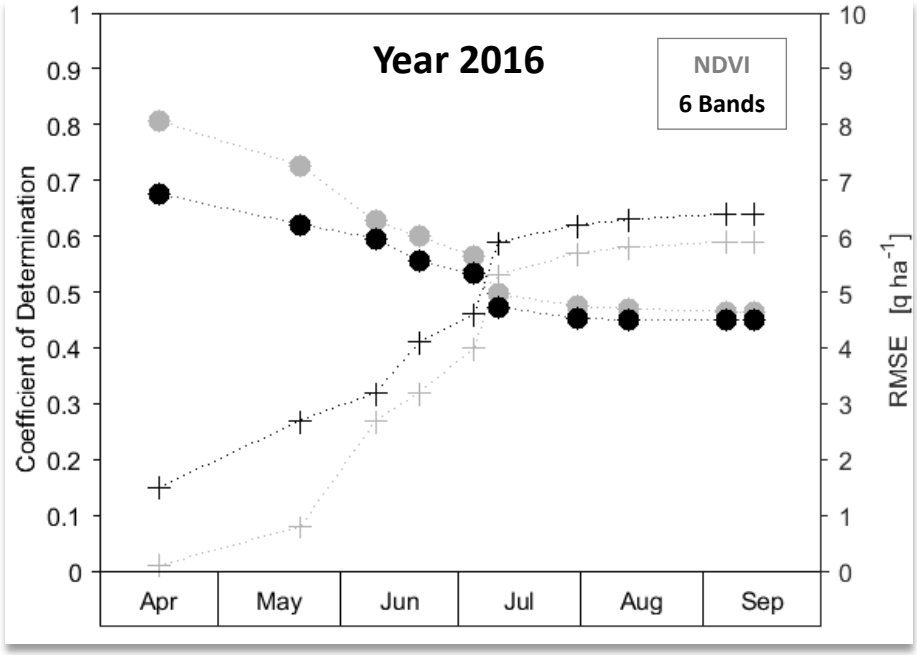


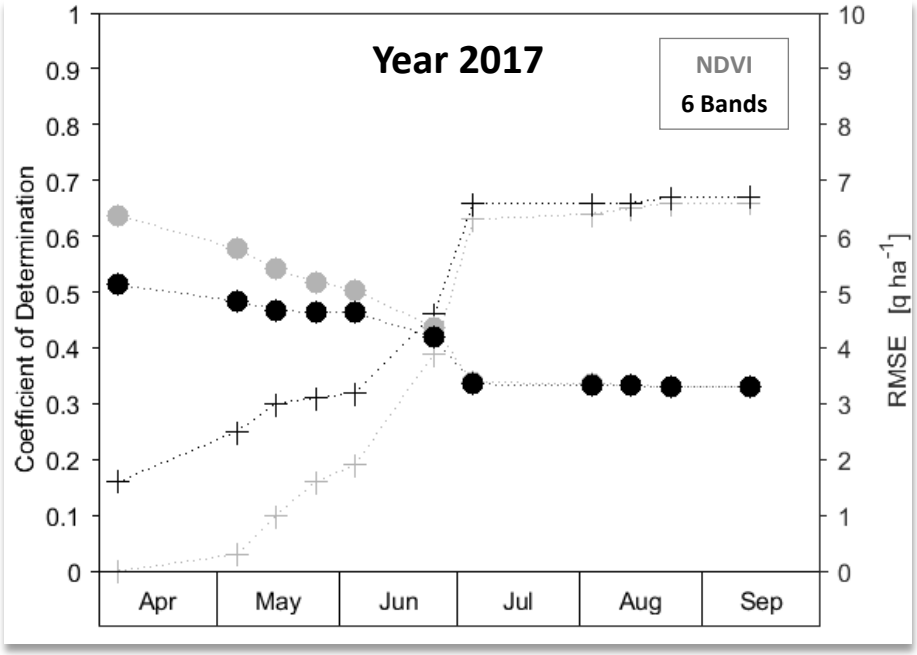
➔**Statistics for the 50-50% ratio:**

- 2016 → R^2=**0.59/0.64**, RMSE=**4.6/4.5** q.ha^{-1} for NDVI or 6 bands,
- 2017 → R^2=**0.66/0.67**, RMSE=**3.3/3.3** q.ha^{-1} for NDVI or 6 bands

- **Forecast of yield throughout the agricultural season**

Using an increasing number of successive images



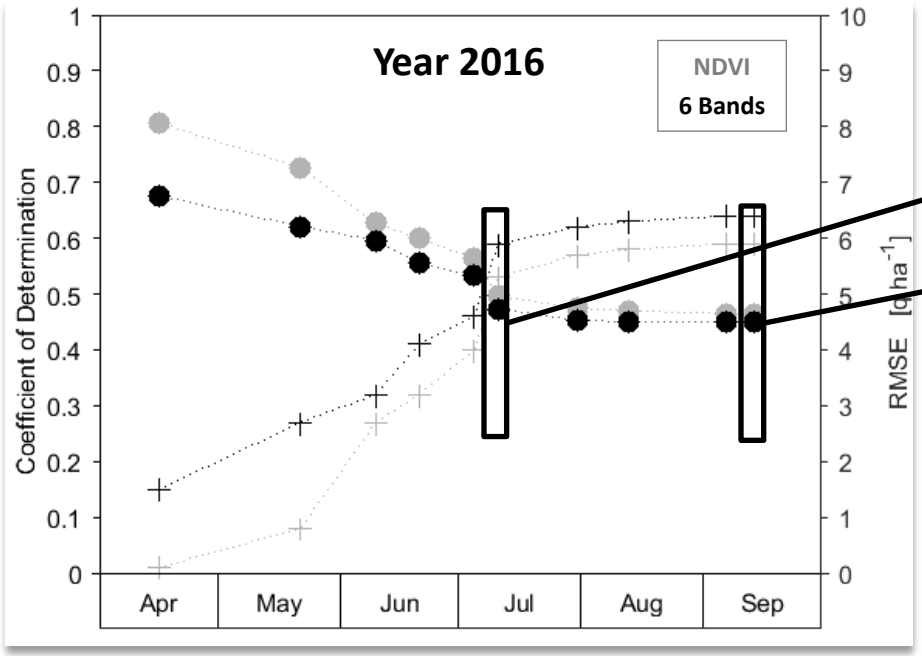


➔ **Statistic performances saturate from flowering**

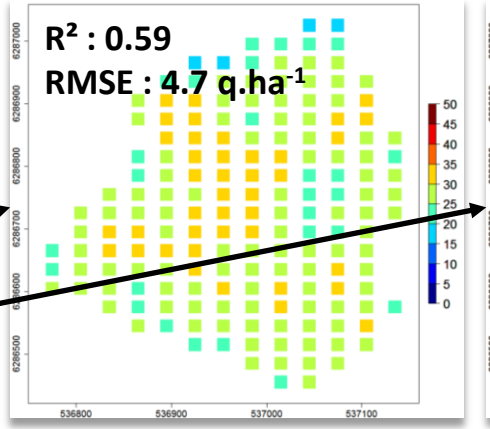
➔ **Early accurate estimates: start of July…**

- **Forecast of yield throughout the agricultural season**

Using an increasing number of successive images

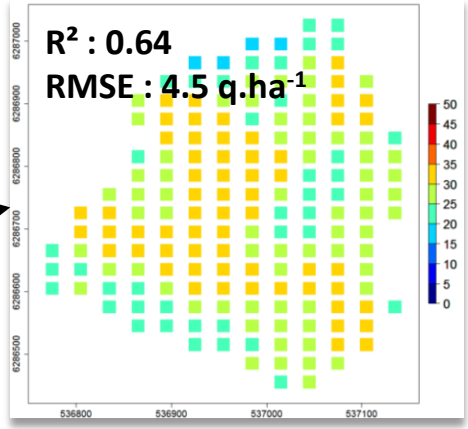


6 images

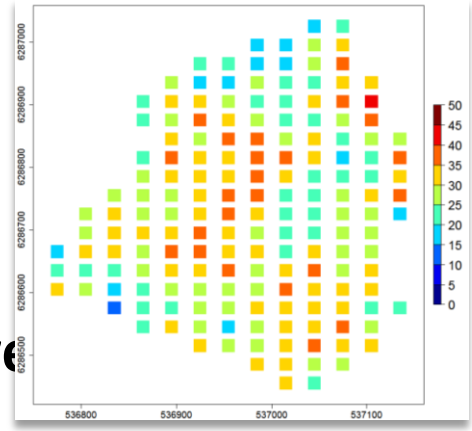


Yields at flowering

10 images



Yields at harvest



Observed yields

➔ **Statistic performances saturate from flowe**

➔ **Early accurate estimates: start of July…**

- **The statistical approach based on multi-temporal optical images allows the estimation of crop yields with acceptable performances at a decametric spatial scale.**

  → *This approach is in the framework of the on-going generation of satellite mission and must be extended adding other satellite data…*

- **The proposed approach provides a useful tool for the monitoring of sunflower cultivated in southwestern France.**

  → *The approach must be extended to other crops…*

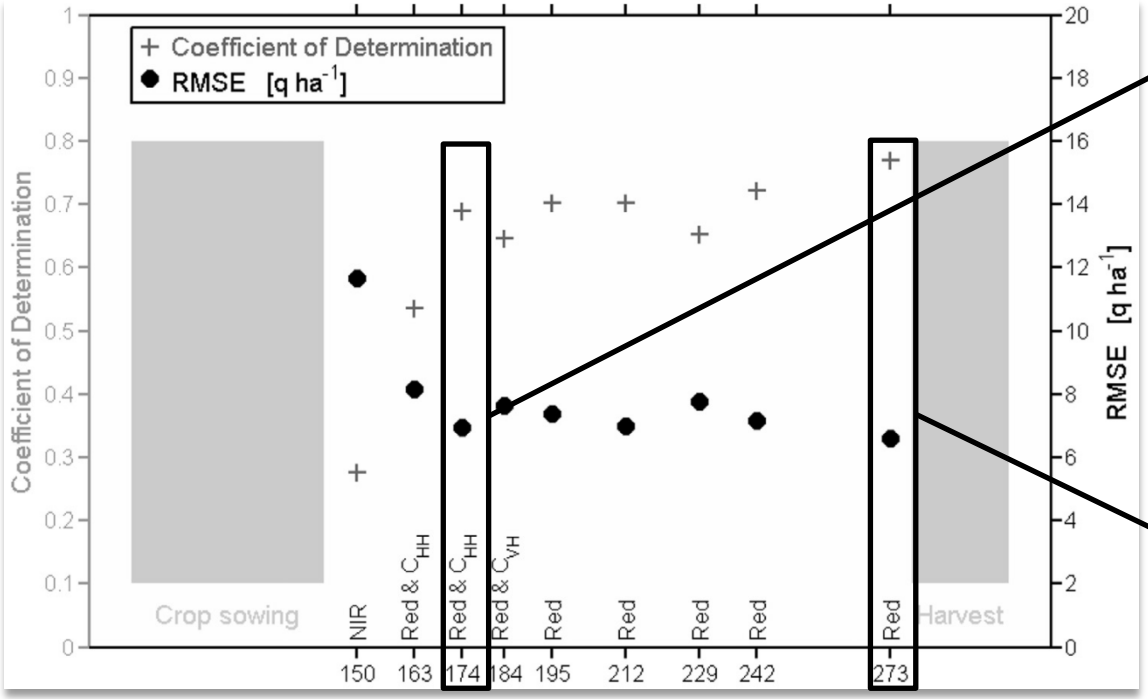
- **Interesting early accurate estimation of yield are observed for sunflower, whatever the considered year.**

  → *The approach must be confirmed analyzing several other agricultural seasons…*

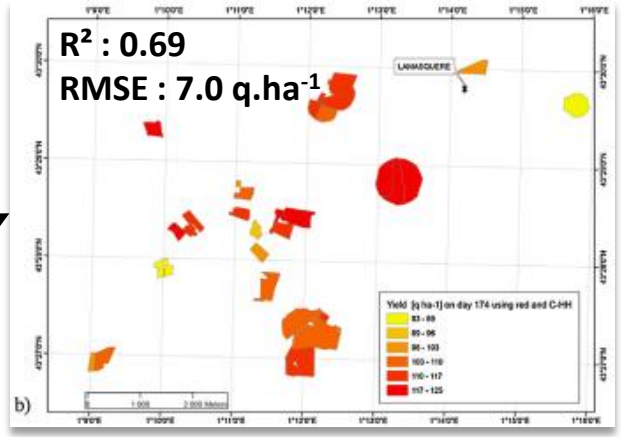
- **Those promising results are consistent with previous studies.**

• Yield estimates at the field scale…

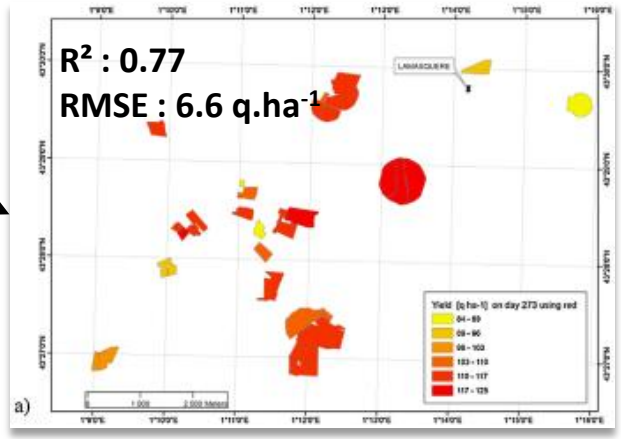
Approach applied to corn and wheat



Best performances and satellite configurations throughout the agricultural season of corn



3 months before harvest



Just before harvest

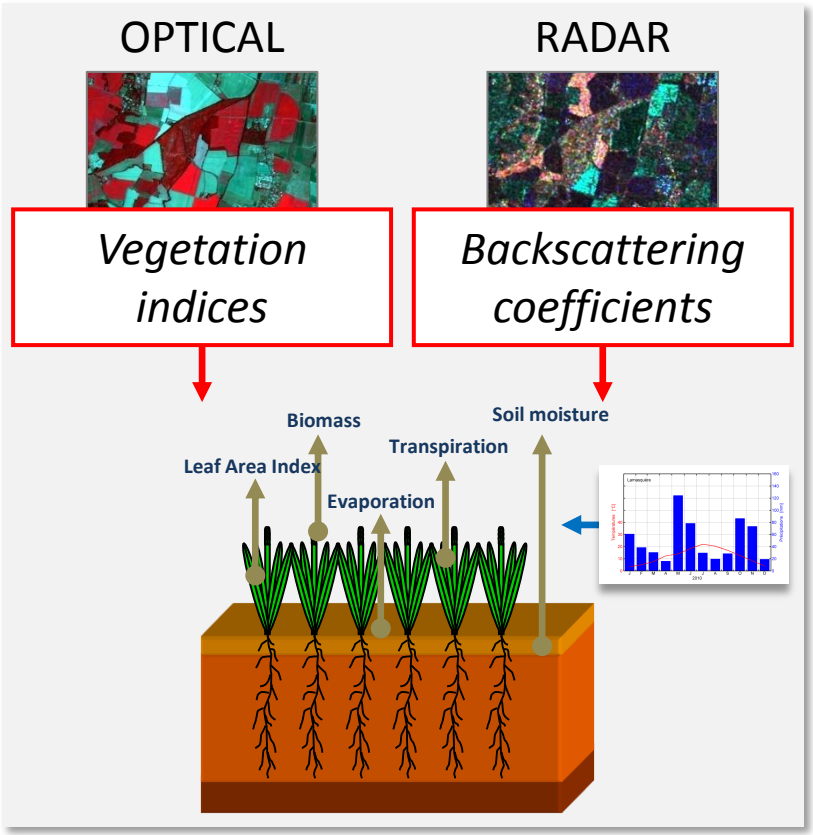
For more details…

Estimation of corn yield using multi-temporal optical and radar satellite data and artificial neural networks
R. Fieuzal, C. Marais Sicre and F. Baup - *International Journal of Applied Earth Observation and Geoinformation* – 2017

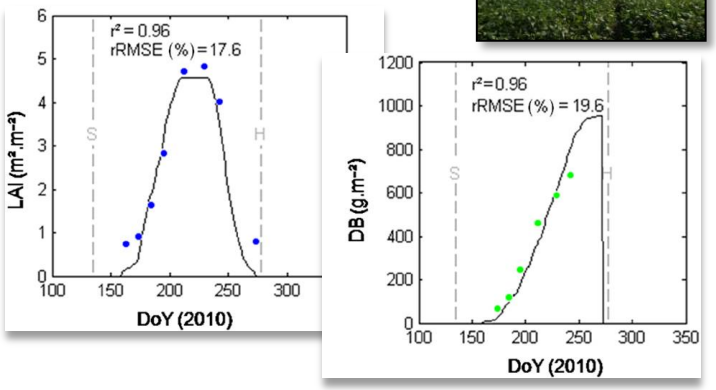
Forecast of wheat yield throughout the agricultural season using optical and radar satellite images
R. Fieuzal and F. Baup - *International Journal of Applied Earth Observation and Geoinformation* - 2017

• Yield estimates at the field scale…

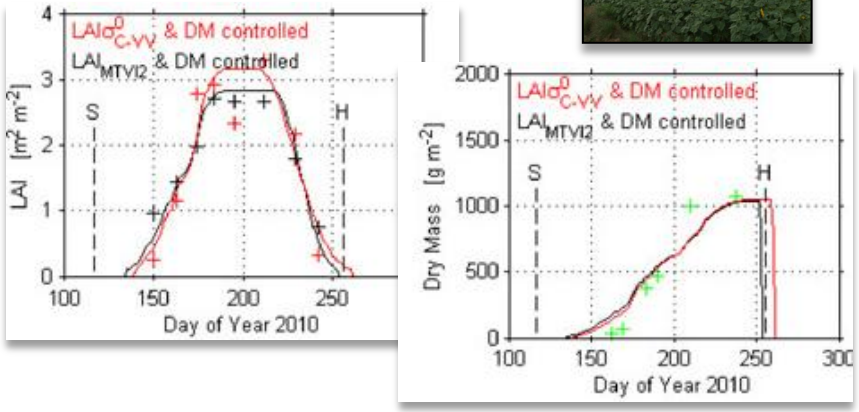
Approach applied to soybean and sunflower



Soybean



Sunflower



For more details…

Assimilation of LAI and Dry Biomass data from optical and SAR images into an agro-meteorological model to estimate soybean yield - J. Betbeder, R. Fieuzal and F. Baup - *IEEE Jour. of Sel. Top. in App. Earth Obs. and Remote Sensing* – 2016

Estimation of sunflower yield using a simplified agro-meteorological model controlled by multi-spectral satellite data (optical or radar) - R. Fieuzal, C. Marais-Sicre and F. Baup - *IEEE Jour. of Sel. Top. in App. Earth Obs. and Remote Sensing* - 2017

Thank you for your attention