Airborne Hyperspectral Measurements and Superficial Soil Organic Matter

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OUTLINE

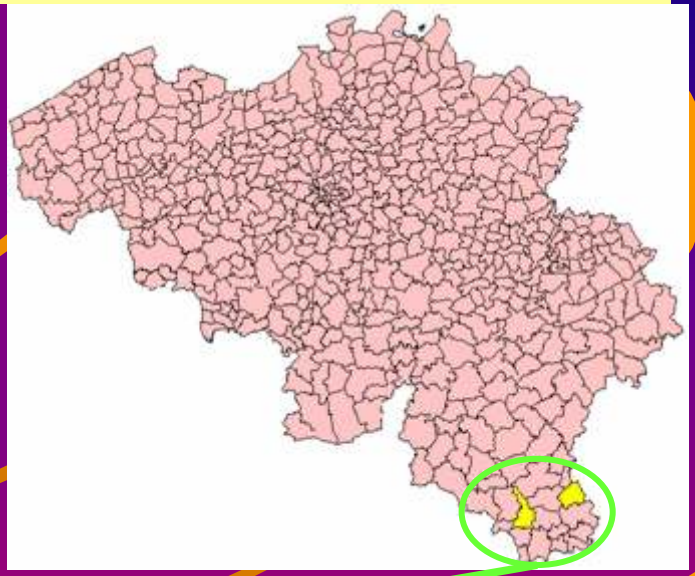
- Research Goals
- Study Area
- Field And Laboratory Measurements
- Data Analysis And Methodology
- Results
- Conclusion & Perspectives

RESEARCH GOALS

- Validate Soil Organic Matter (SOM) Prediction Model by Means of Hyperspectral Images
- Study the impact of disturbing factors on SOM-Hyperspectral signal relationship

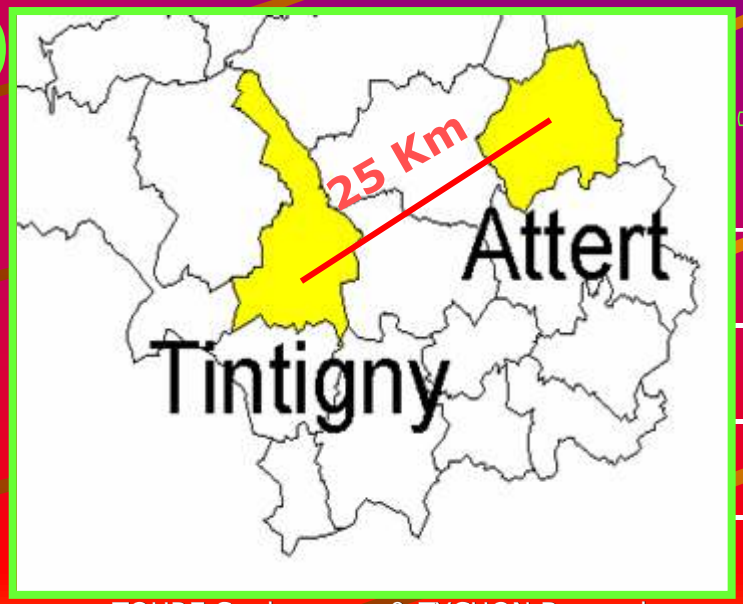
STUDY AREA : SOUTHERN BELGIUM

✈**Study area located in the Province of Luxemburg, Southern Belgium**



☞**TINTIGNY (2002)**

- Area : 50 km²
- 14 agricultural parcels
- 135 soil samples
- Sandy to clayey soils



☞**ATTERT (2003)**

- Area : 50 km²
- 10 agricultural parcels
- 100 soil samples
- Sandy to clayey soils

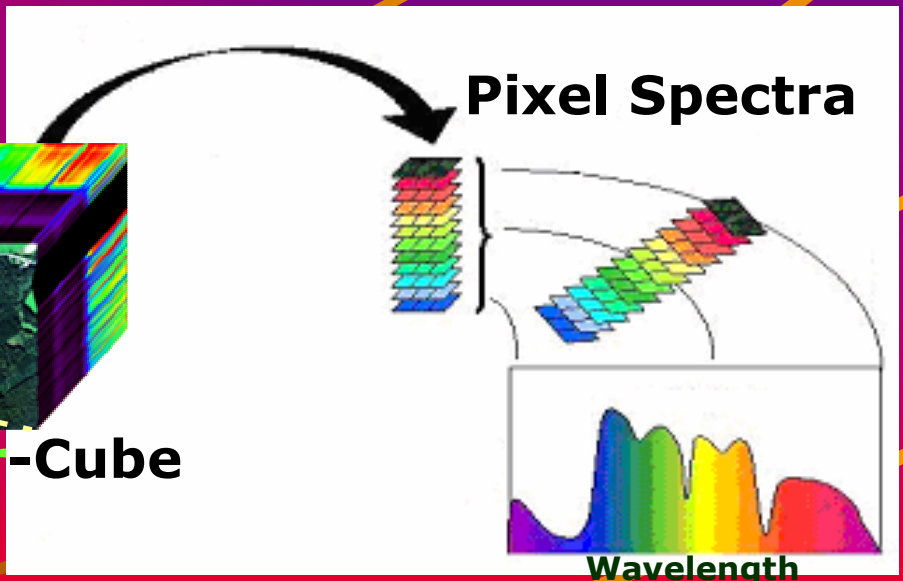
MEASUREMENTS

✈ Casi airborne campaign :

- Pixel resolution : 2.5x2.5 m
- Casi 96 spectral bands : 400-950 nm

Hyperspectral image

Hyper-Cube



MEASUREMENTS

Casi airborne campaign :

- Pixel resolution : 2.5x2.5 m
- Casi 96 spectral bands : 400-950 nm

✈Soil properties:

- Soil samples
- Soil moisture
- Surface roughness (SR)

SR = St.Dev Relative height of 100 nails.

MEASUREMENTS

Casi airborne campaign :

- Pixel resolution : 2.5x2.5 m
- Casi 96 spectral bands : 400-950 nm

Soil properties:

- Soil samples
- Surface roughness
- Soil moisture

✈ASD measurement 400-2500 nm:

- Laboratory measurements
- Field acquisition

DATA ANALYSIS AND METHODOLOGY

- Soil chemical analysis
- Spectral Signature Analysis
- Statistical analysis :

- Defining Best Correlated Bands by Stepwise Procedure
- Multi-regression : $SOM_p = A_0 + A_1 R_{\lambda 1} + A_2 R_{\lambda 2} + \ldots A_n R_{\lambda n}$

- Calibration & Validation

- 1/3 Samples for validation
- Prediction evaluation $RMSE\_and\_PRMSE = \sqrt{\frac{\sum_1^n \left(V_{fi} - V_{pi}\right)^2}{n-1}}$

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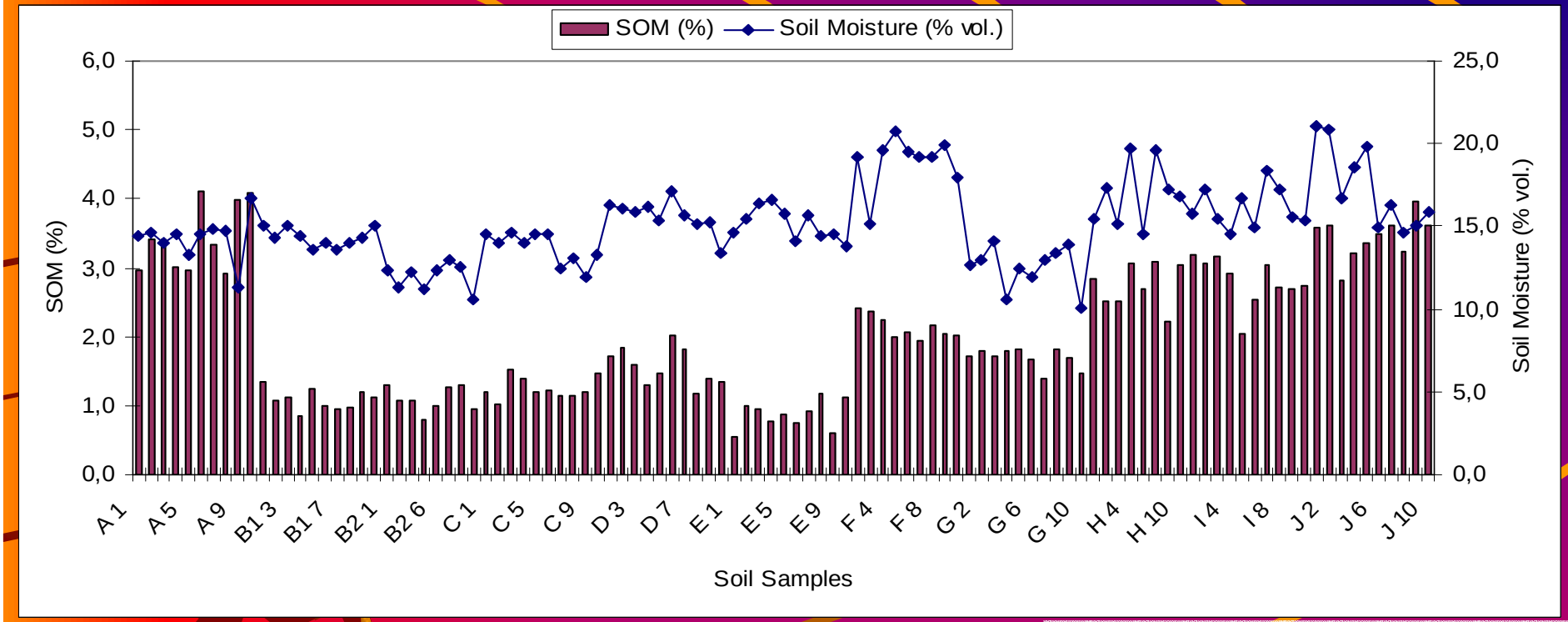
- Results :
  - SOM and Soil Moisture
  - Surface Roughness
  - Spectra pre-proceesing
  - Calibration & Validation phase
  - Disturbing factors
- Conclusion & Perspectives

RESULTS : SOM and Soil Moisture



SOM (%)

Max = 4.1

Mean = 2.0

Min = 0.6

St.Dev.= 0.96

- Large range of SOM;
- Mean value in good agreement with previous studies;
- No evident relationship with soil moisture.

Soil Moisture (% vol.)

Max = 21.1

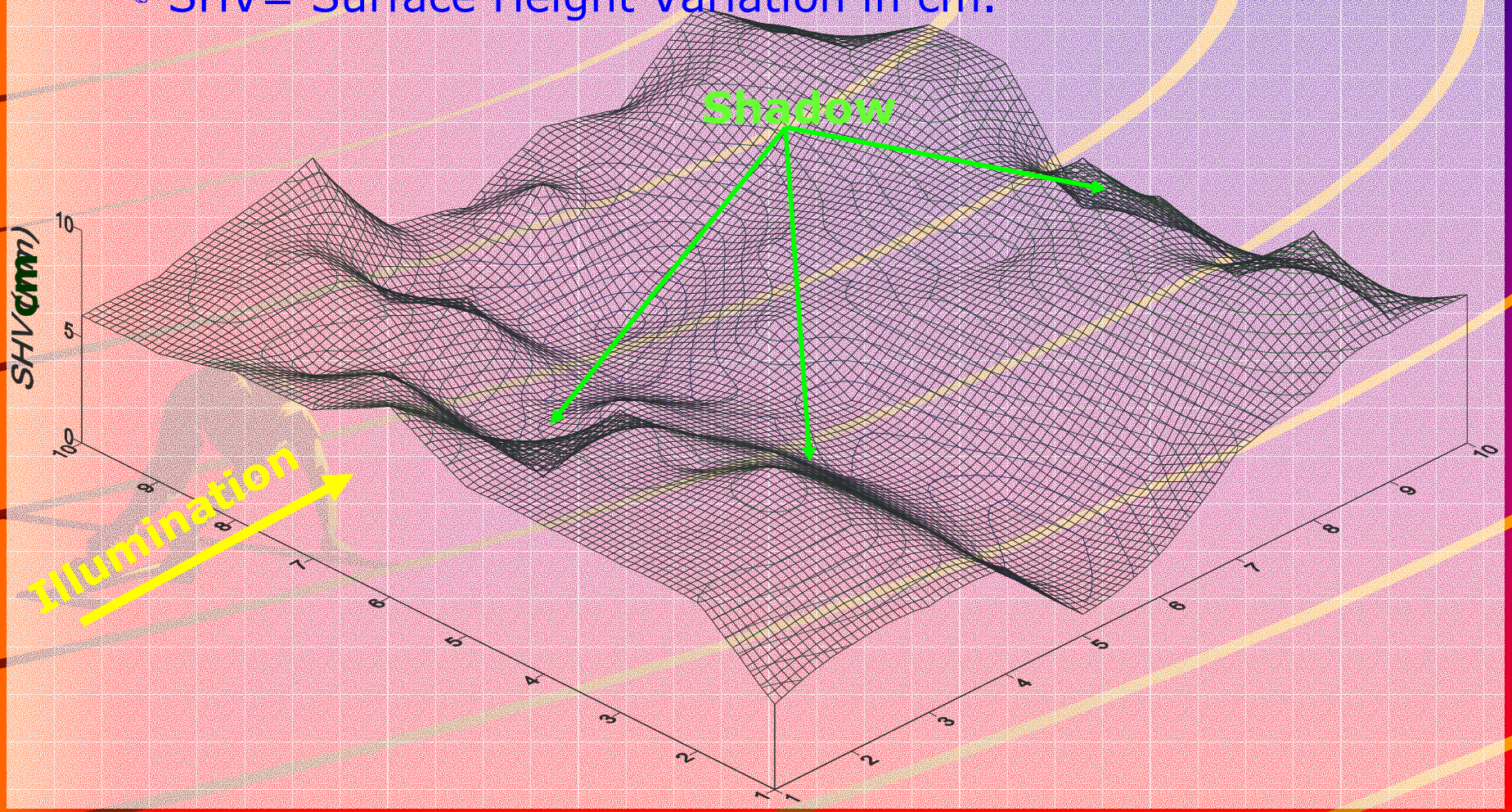
Mean = 15.2

Min = 10.1

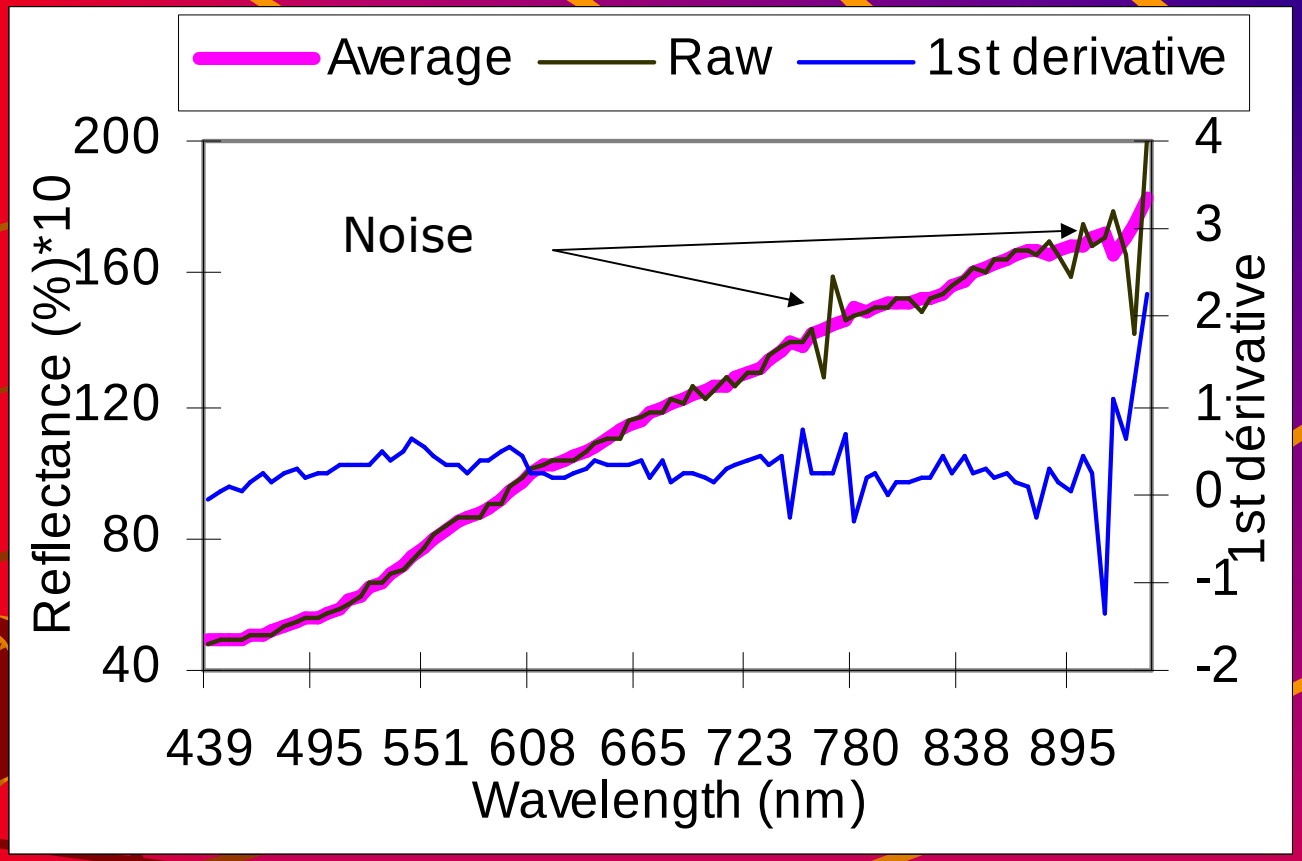
St.Dev.= 2.4

RESULTS : Surface Roughness

- Soil surface modelling with hand-crafted instrument
  - SHV= Surface Height Variation in cm.



RESULTS : Spectra pre-proceesing



✈Noise and atmospheric effects are reduced by smoothing and 1st derivative algorhitms.

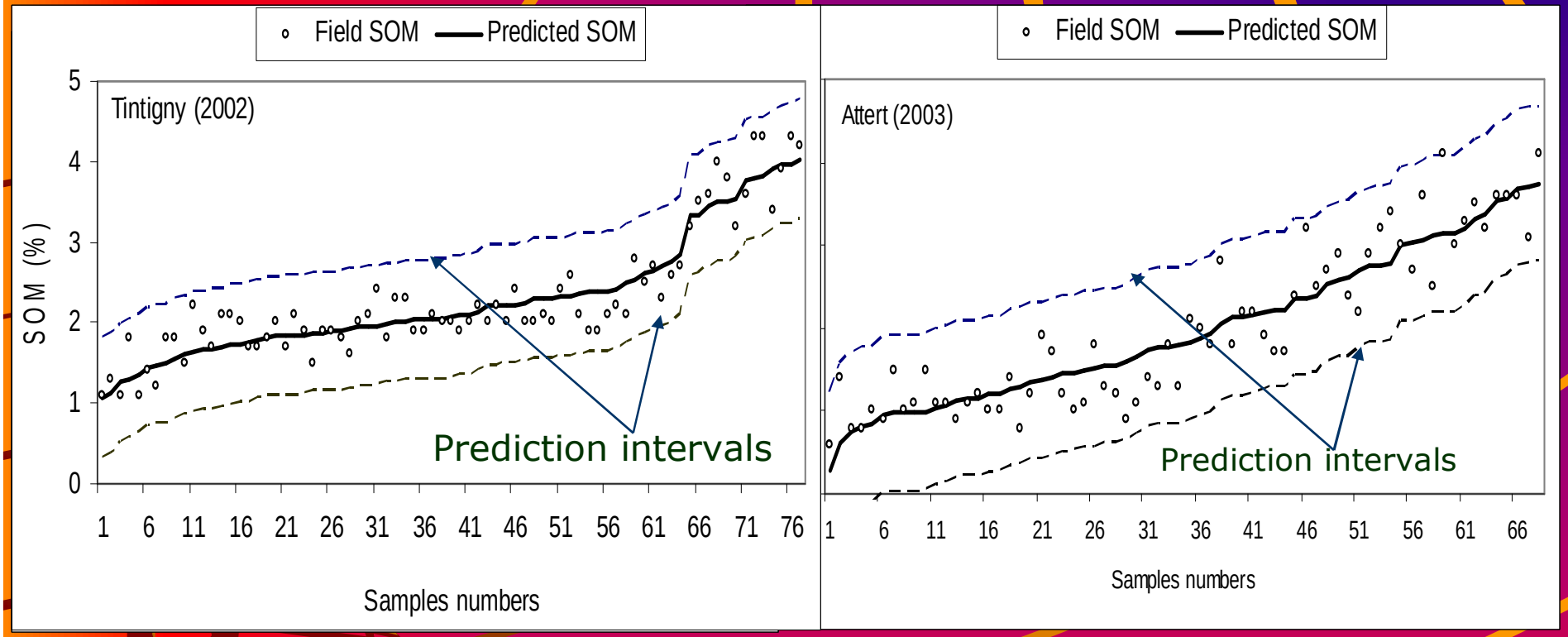
RESULTS : Calibration phase 1

Tintigny	654	552	706	688	879	856	546	717	678		
Attert	948	734	563	769	918	677	557	484	467	705	591

- Best models for Tintigny (9 bands) and Attert (11 bands)
- The models were applied to Tintigny and Attert site respectively:

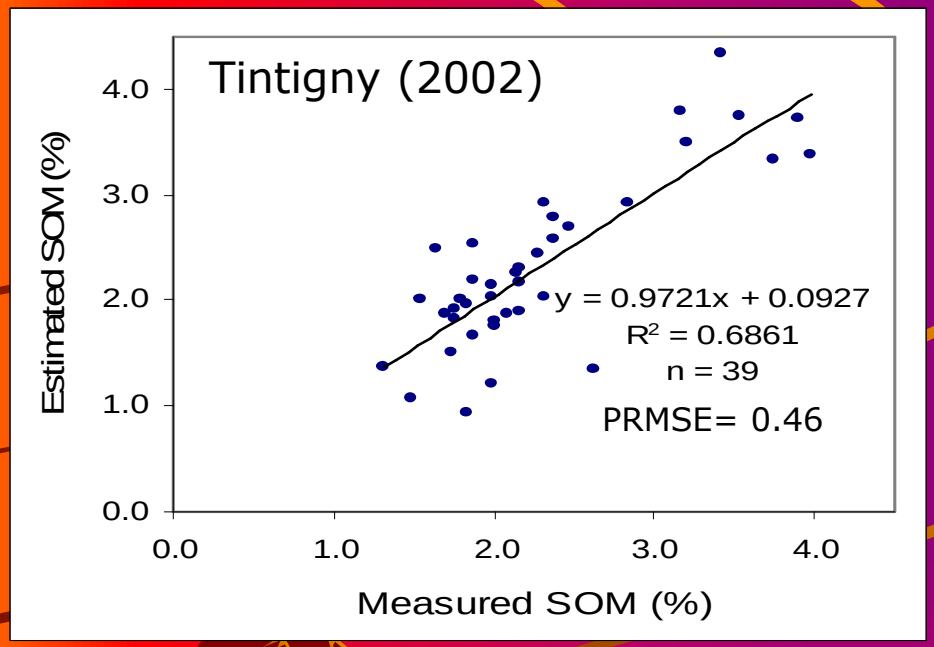
	Tintigny site (n=77)		Attert site (n=68)	
	Field SOM	Predicted SOM	Field SOM	Predicted SOM
Mean	2.28	2.28	1.99	1.99
St. deviation	0.78	0.74	0.97	0.89
R^2	0.88		0.85	
ME(%)	-0.003		-0.001	
RMSE	0.266		0.373	

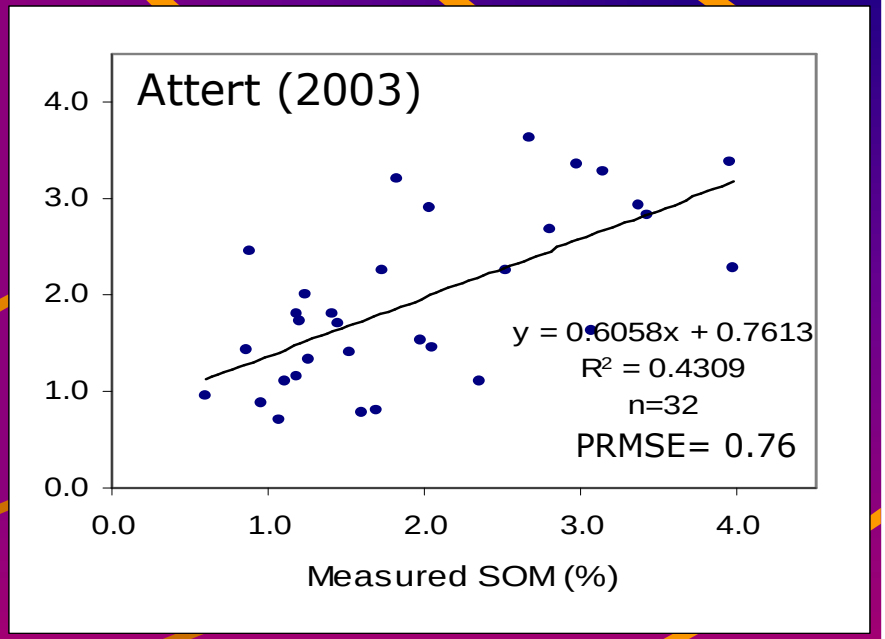
RESULTS : Calibration phase 2



- Good fit of field data in the Prediction intervals
- Bigger Prediction intervals for Attert site

RESULTS : Validation phase

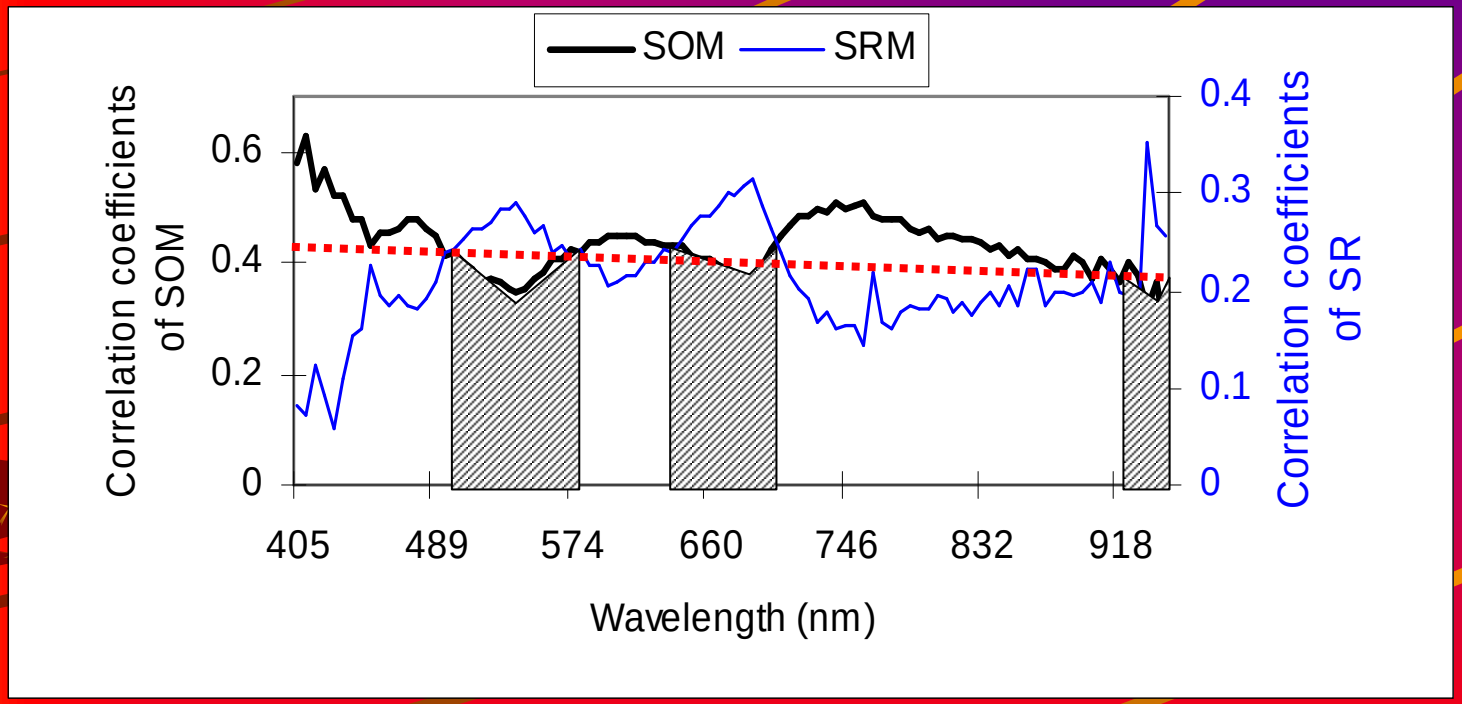




- Validation with independent set of data
- Better accuracy for Tintigny site with PRMSE = 0.46 vs. 0.76 for Attert site
- Validation from one site to another did not work well
- Relationships between SOM and reflectance are site dependent

RESULTS : Disturbing factors

- Influence of disturbing factors is difficult to quantify:
  - Soil Moisture
  - Vegetated debris
  - Soil Roughness



CONCLUSIONS

- Hyperspectral Remote Sensing is a useful tool to derive SOM
- Predictive equations are site dependent
- Disturbing factors should be taken into account
- The method has the advantage of using small samples to determine SOM on regional scale

PERSPECTIVES

- Impacts of disturbing factors are under study:

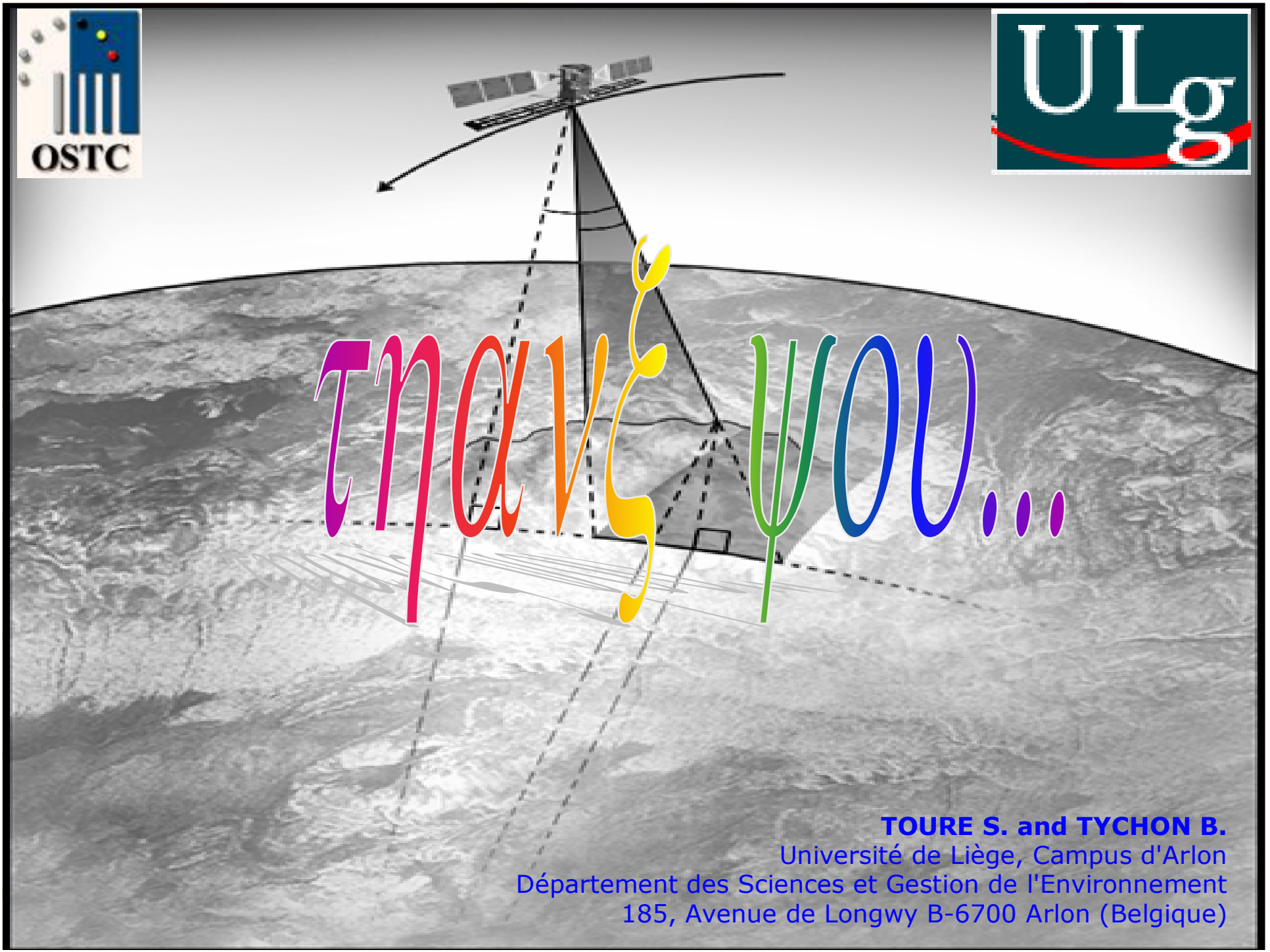
  - to better understand their effects

  - to quantify their impacts

- Using of unmixed models to separate disruptive elements from SOM-Reflectance relationship:

  - Endmembers spectral mixture model (Roberts et al., 1998; Galvao et al., 2001)

  - Rayleigh Criterion (Ogily, 1991; Matthias et al., 2000)



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