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Does satellite image classification improve crop area estimation?

Qinghan Dong

Flemish Institute for Technological Research

Content

- Objectives & research questions
- Study areas
- Methodology
- Results:
  - Northern Europe
  - North China plain
- Discussions

General objectives

- Using of remote sensing as principal information for crop area estimation.

  The estimation is needed :

  - As a crop mask to feed in crop yield models
  - For deriving regional crop production estimates

Principal Research question

- **If remote sensing can be used as the primary information source for accurately estimating crop area**
- If the estimation can be made early in the growing season
- If it can cover the large area
- If the procedure can be “(pre-)operational”

The secondary technical questions:

- Potential of new, wide swath sensors (DMC, AWiFS or HJ series)?
- Minimal/optimal number of images required?
- Optimal timing of image acquisition?
- Ground truth: number of samples & distribution?

Study areas:

2 test sites located in different environments

- Northern Europe (NEU): Belgium, Northern France (Picardie) up to the Netherlands (Flevoland)
  - Small to medium size parcels
  - Wealth of reference data (incl. at parcel level)
- North China plain (NCP)
  - Small to medium size parcels
  - Late availability and questionable liability for reference data

Method (1): Hard classification

- Supervised Maximum Likelihood classifier - an adapted version was developed to deal with missing values
- Optical HR data from:
  - “Traditional sensors” as Landsat5-TM / Landsat7-ETM+
  - “Wide swath sensors” as IRS-P6 AWiFS and DMC / HJ1
- Trained with:
  - Field survey data (60% of dataset)
  - Interpretation of VHR/HR imagery
- Result: detailed map of main agricultural crops

Method (2): Sub-pixel classification

- Neural Network (NN)
  - IN: LR/MR/HR pixel values (VGT, DMC... reflectances or indices)
  - OUT: Area Fractions (AF) per pixel
  - 2 stages:
    - Calibration: estimate NN parameters (weights) based on HR reference AFIs (per crop) for limited test site
    - Extrapolation: application of NN on LR/MR images for wider areas
- Result: estimated AFIs per crop

Results for Northern Europe (NEU)

Test site: North Europe:
(Belgium, North France and Flevoland)

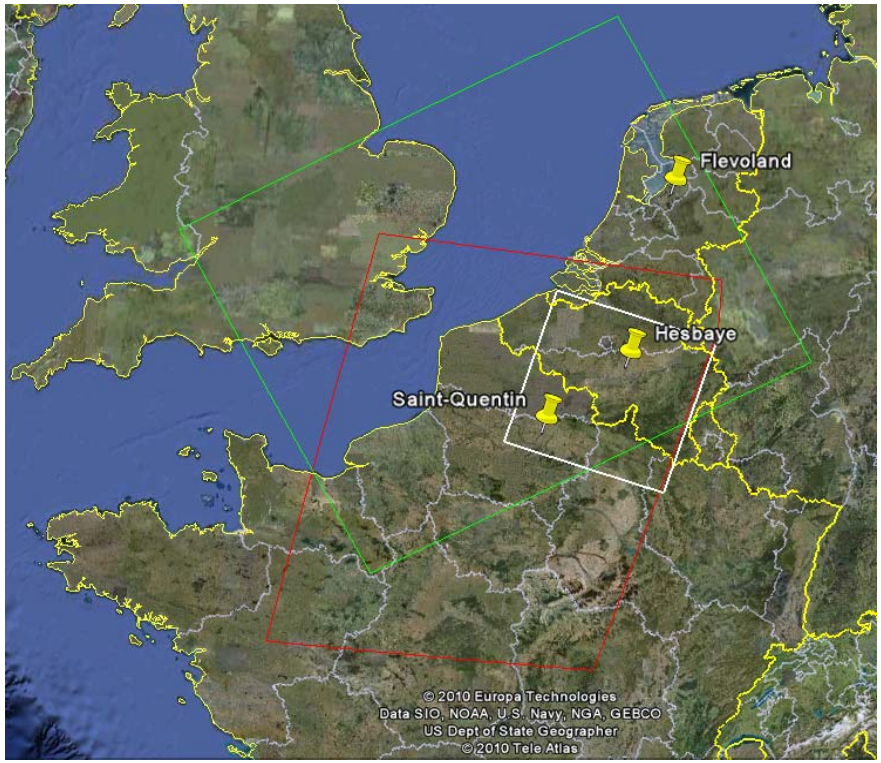


Figure 1: calibration sites in Hesbaye and Saint-Quentin, validation site in Flevoland (NL). Landsat (white), AWiFS (red) and DMC frames (green) are added.

Test site characteristics

- Two original cal/val sites: Hesbaye and Saint Quentin, selected for high availability of reference data
- Main crops:
  - *winter wheat and winter barley (October – July)*
  - *Maize and sugar beats (May - October)*
  - *North of Belgium small parcels (1.7 ha) and North of France larger parcels.*
- A second site for validation use was selected in a later stage: Flevoland

Field and Reference data collection

Field data

End of June 2007: organized in Saint Quentin and Hesbaye, the survey allowed to collect the data for crop (10) and land-use types(6). 599 polygons.

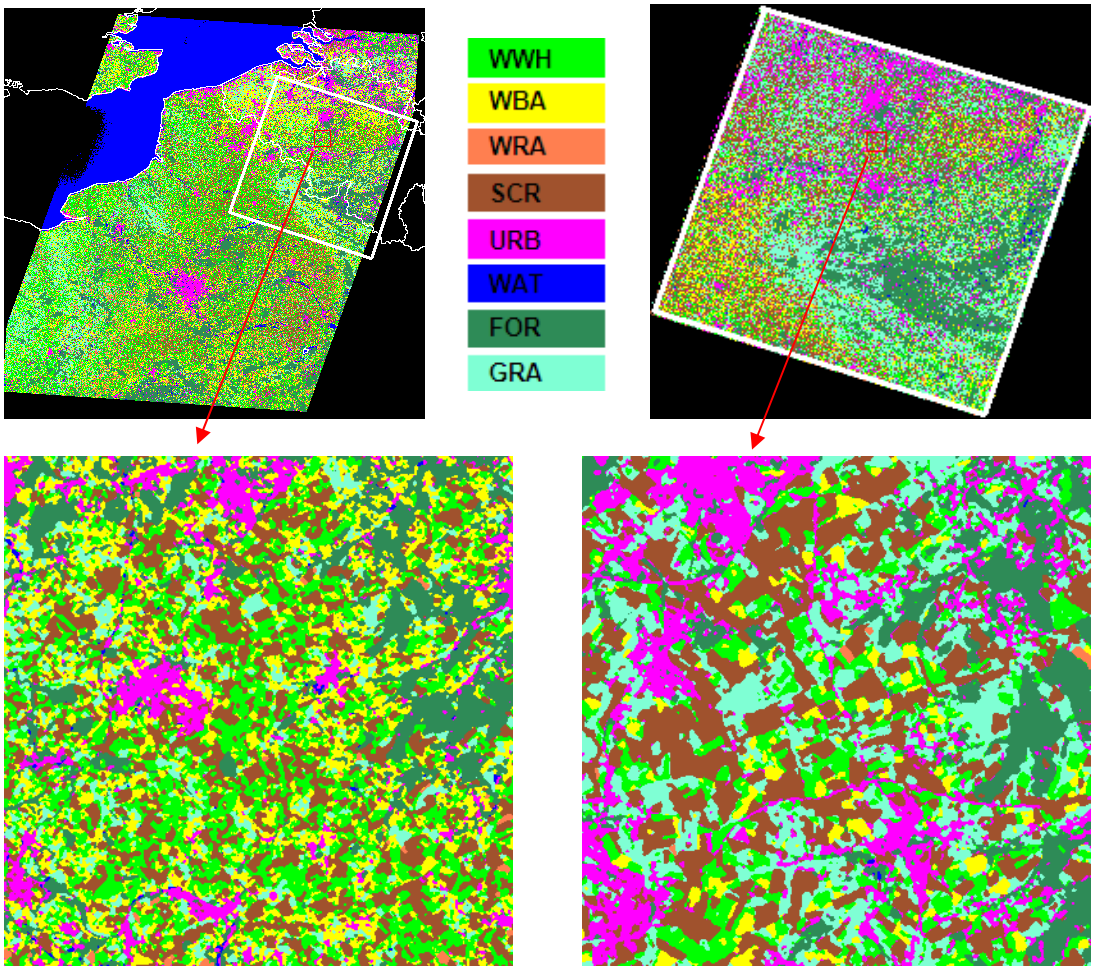
Mid July 2009: organized in Saint Quentin, Hesbaye and Flevoland: 1152 and 722 polygons for both sites

Crops	Land-use
winter wheat	urban areas
winter barley	grassland,
winter rapeseed	orchards
maize	deciduous forest,
sugar beets	pine forest
potatoes,	water
spring barley	
flax	
vegetables	
oats	

Reference data

EPR-SIGEC-CLC2000

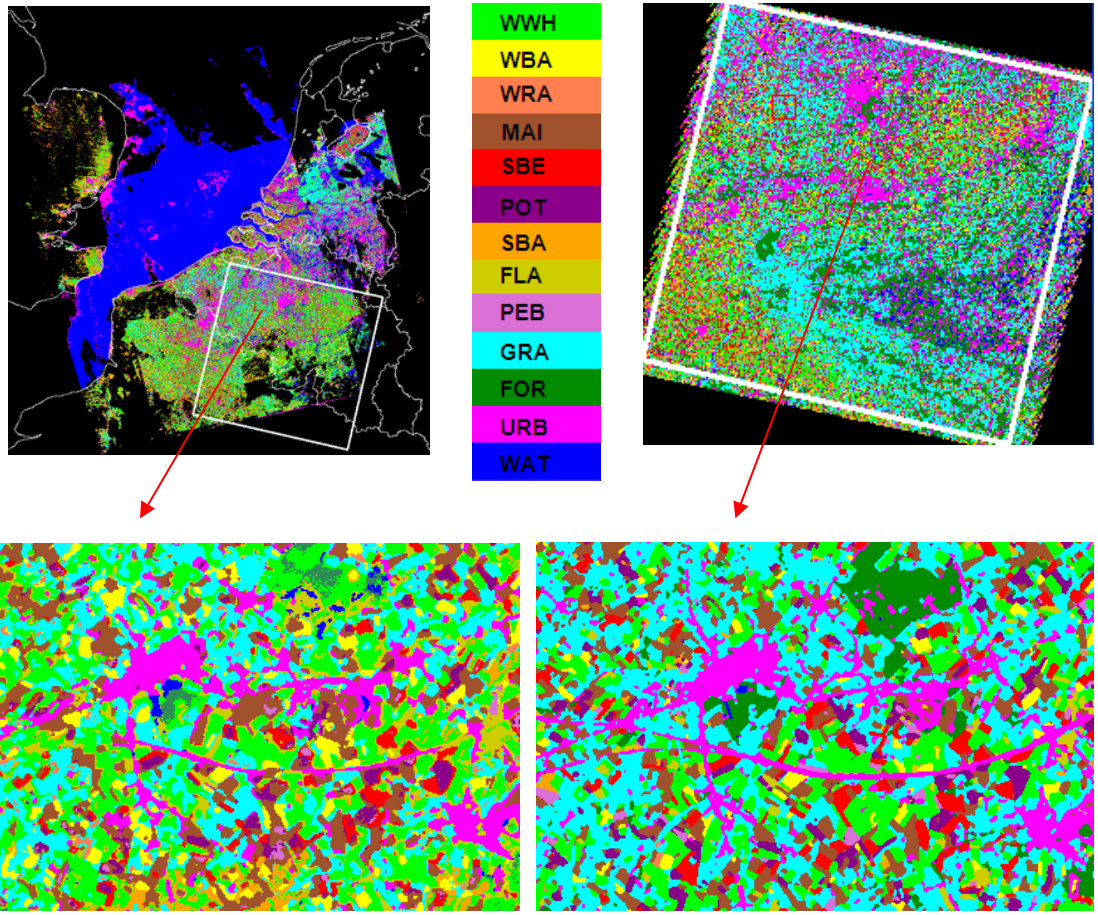
Classification 2007 (AWiFS /ETM+)



2007 results

- Although less details are available on the AWiFS classification, the results derived from AWiFS data cover a much large areas.
- High accuracies for the classification of AWiFS and ETM+ images were achieved (96,6 % and 90,4 %).
- Against reference data (EPR-SIGEC-CLC2000), the accuracy can only reach 53,6% and 67,3%
- Timing of the field survey and timing of image registration/ acquisition may play a role for improving accuracies

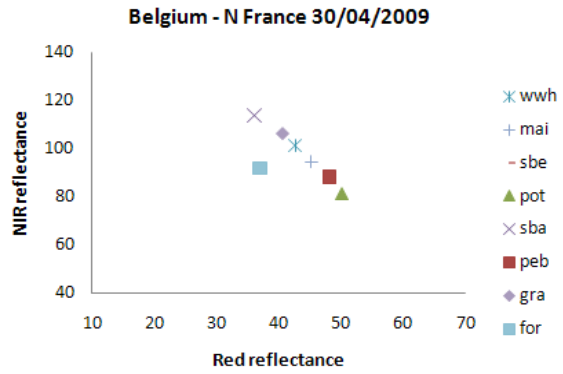
2009 Classification Results: Belgium / North France (DMC / LANDSAT)

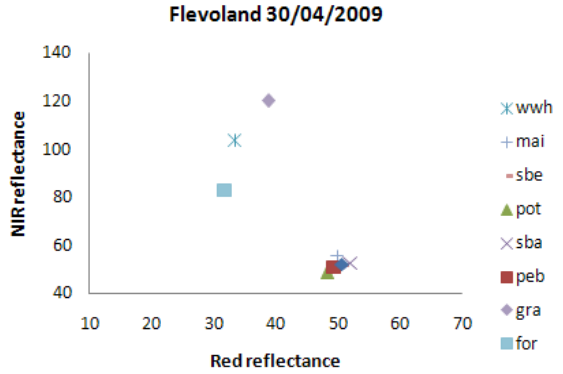


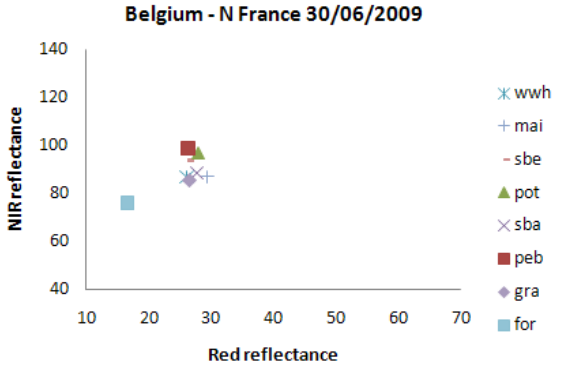
2009 results

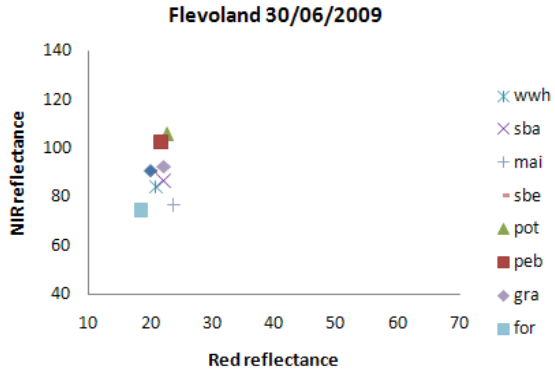
- The validation against the ground truth data show a accuracy between 70 to 80 % of the classifications, respectively for maps derived from DMC and LANDSAT ETM+ data
- Against the reference data the accuracies fell to 42,6% and 60,2 %
- SWIR band and the presence of an August image in the time series are important factors
- When the crop mapping is extended from Belgium and the North of France till **Flevoland**, the accuracy of the classification against the ground truth data (validation data subset) dropped to 53,4%.
- Only two dominant classes – winter wheat and grassland- can be classified with reasonably high confidence.

Spectral signatures (red and NIR) of crops in Belgium/ N- France and Flevoland









Conclusions (1)

- AWiFS and DMC sensors can scan a wide area of farming with much details, thanks to the their wide swath and high spatial resolution characteristics.
- Accuracies by using RS as primary information source to assess crop areas remains weak.

Derived Sensors	Mapping area	Accuracy using ground truth data	Accuracy using reference data	Year of exercise
TM/ETM+	Belgium N. France	90%	67%	2007
AWiFS	Belgium N. France	97%	54%	2007
TM/ETM+	Belgium N. France	81	60%	2009
DMC	Belgium N. France	70%	43%	2009

Conclusion (2)

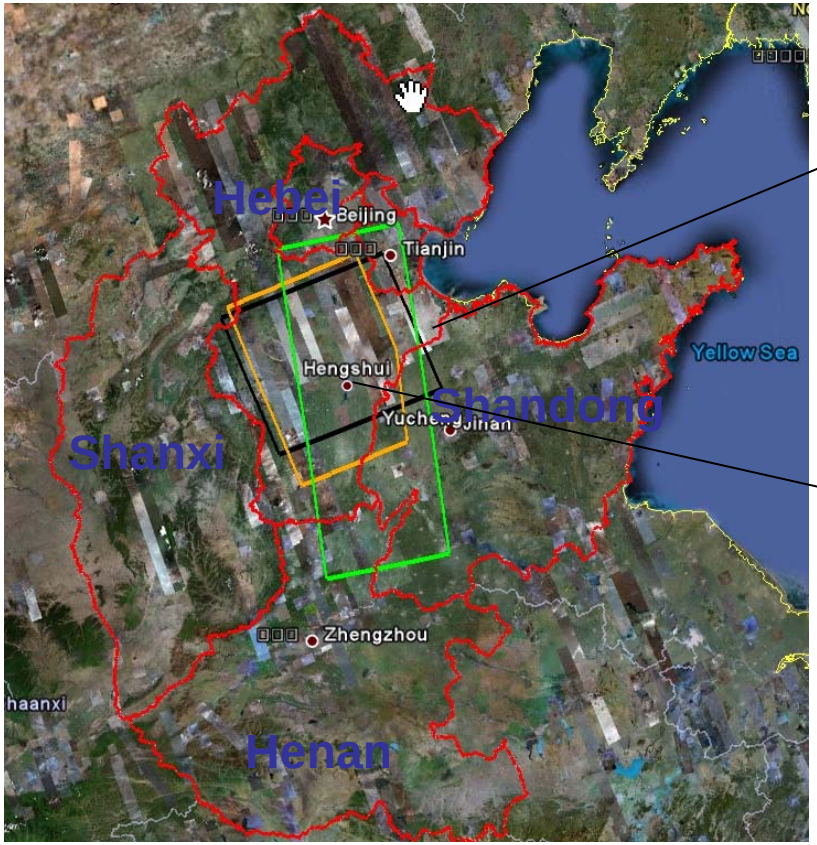
- The phenological transition in different agricultural zones is covered by AWiFS or DMC imagery. A stratification of these zones seem necessary. The imagery provided by TM, LISS3 or their equivalents are more suitable for this purposes.

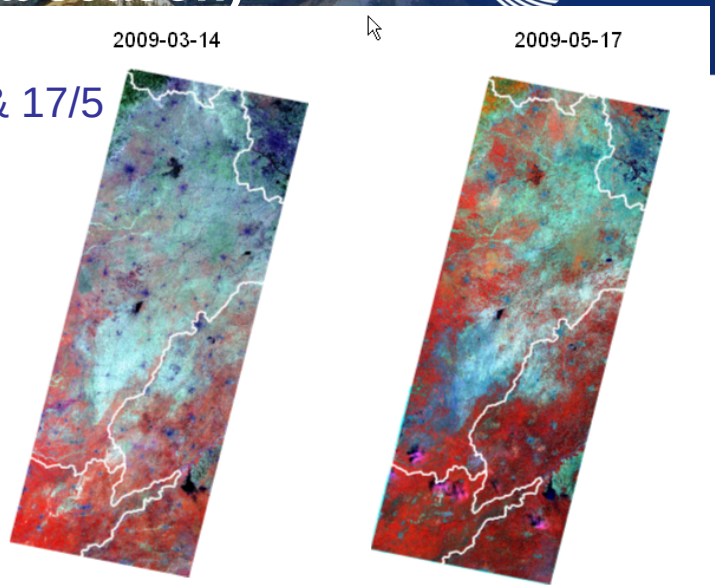
- The integration of the SWIR band and the registration of RS data at some crucial phenological periods are important. More research needs to be done on this topic.

Results for the North China plain (NCP)

NCP (winter wheat season)

Landsat-TM, 14/3 & 17/5



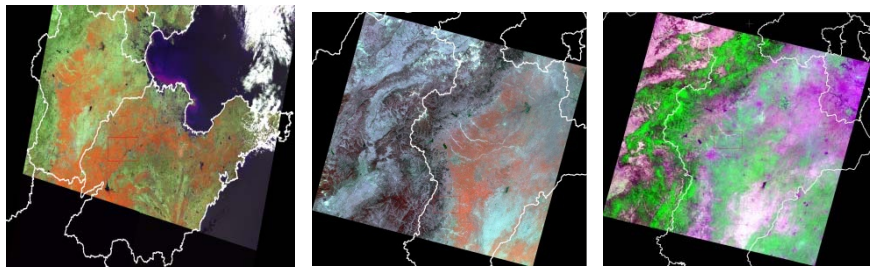


"Traditional" vs.

"Wide swath"

Shandong

AWIFS, 21/4 HJ-1, 25/3 HJ-1, 26/5



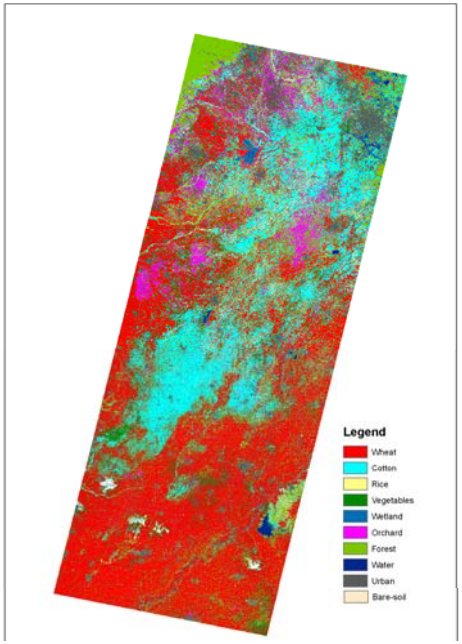
+ field survey data from CAS

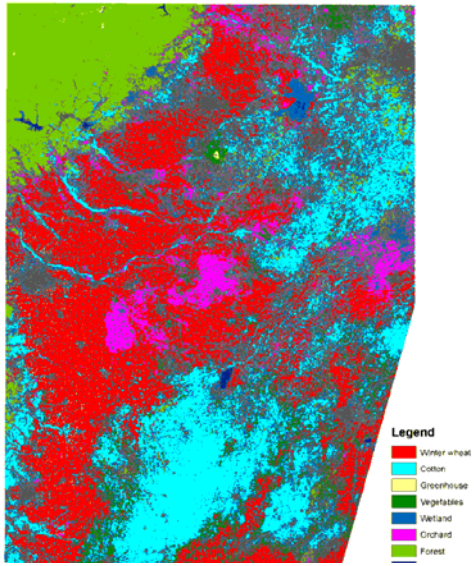
NCP crop maps (hard classif)

Landsat-TM (30m)

↓

OA: 88%





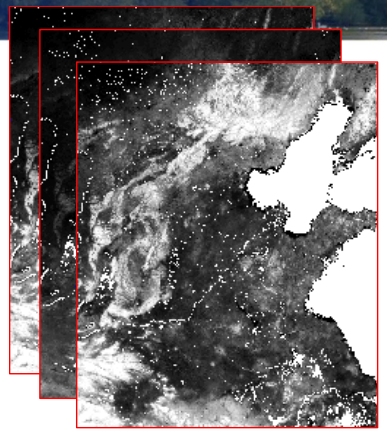
AWiFS-HJ1 (50m)

↓

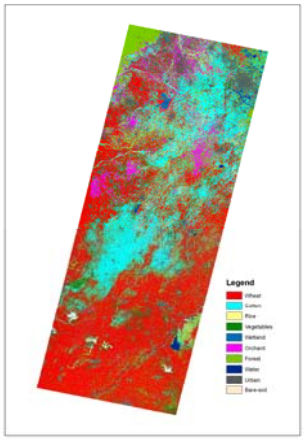
OA: 93%

- Both maps:
  - Confusion of 'Water' with Wetland' and Forest' (wetland vegetation)
  - Confusion of 'Cotton' with 'Bare soil' (drought) and 'Forest' (mixed farming)
  - Effect of agro-ecological differences → stratification?
- Comparison of area fractions (overlapping zone): wheat area ± identical, cotton area AWiFS-HJ1 > Landsat

NCP area fraction images



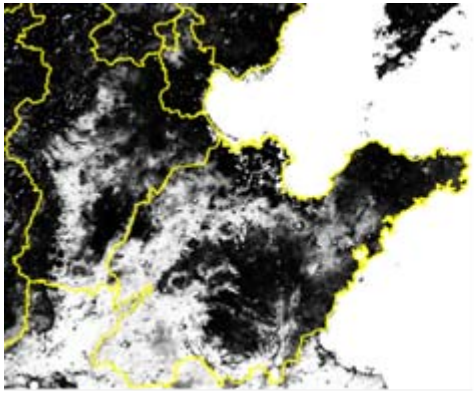
SPOT-VGT time series

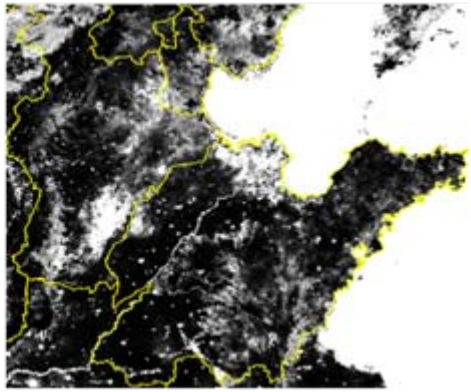


Landsat-TM classif

NN

‘Sub-pixel classification’ of SPOT-VGT images using neural networks





Area fraction images for wheat & cotton

Crop area estimates from sub-pixel classif comparable with “reference” areas from hard classif (+/- 3.5%)

NCP results

- Crop mapping:
  - Hard classif: AWiFS-HJ1 vs Landsat
    - Good overall accuracy, though confusion between classes: stratification as a solution…
    - Resolution of 30m or 50m: little impact on accuracy
  - Sub-pixel classif:
    - Good results, provided that reference crop map is reliable
- Crop area estimates:

  No reference statistics for 2009 available yet, but some numbers can be found in press

NCP results

Regional area estimate (km^2)	Winter Wheat	Cotton	Orchard	Forest	Built-up	Area of district
Hengshui - hard clas.	1886,5	1849,9	633,1	1123,1	940,2	8826,2
Hengshui - subpixel clas.	1966,2	2077,4	150,9	1647,0	987,9	
Numbers quoted by media	*2780*	*1380*				
Liaocheng - hard clas.	5234,1	383,1	145,1	1163,3	675,3	8658,0
Liaocheng - subpixel clas.	4698,7	371,6	122,5	1076,3	515,1	
Numbers quoted by media	*3620*	*960*				
Puyang - hard clas.	2906,6	62,4	75,8	575,5	209,1	4215,9
Puyang - subpixel clas.	2602,6	98,3	34,7	343,8	180,3	
Numbers quoted by media	*2155*	*125*				

General conclusions

- Image classification of LANDSAT TM/ETM+ can achieve an accuracy of 60 to 70% for a homogenous, not very extended area (Belgium/North France).
- However when the area is too extended or too heterogeneous such as the cases for the NCP, the image classification generates poor results for crop area estimation.
- The bias in the image classification :
  - Satellite images are unbiased regarding the radiometric measurements.
  - Classification procedure, an information extraction, is rather subjective (the procedure can be tuned in many ways). Quite often, un accuracy above 90% can be achieved.
  - Yet, an accuracy of 70%-80% for a classification can be considered acceptable. But cannot be accepted from the viewpoint of area estimates.
- The approach needs to be reviewed and combined
  - Area Sampling Frames in the regional Crop Inventories
  - Stratification using the satellite images
  - Regression analysis for several estimators