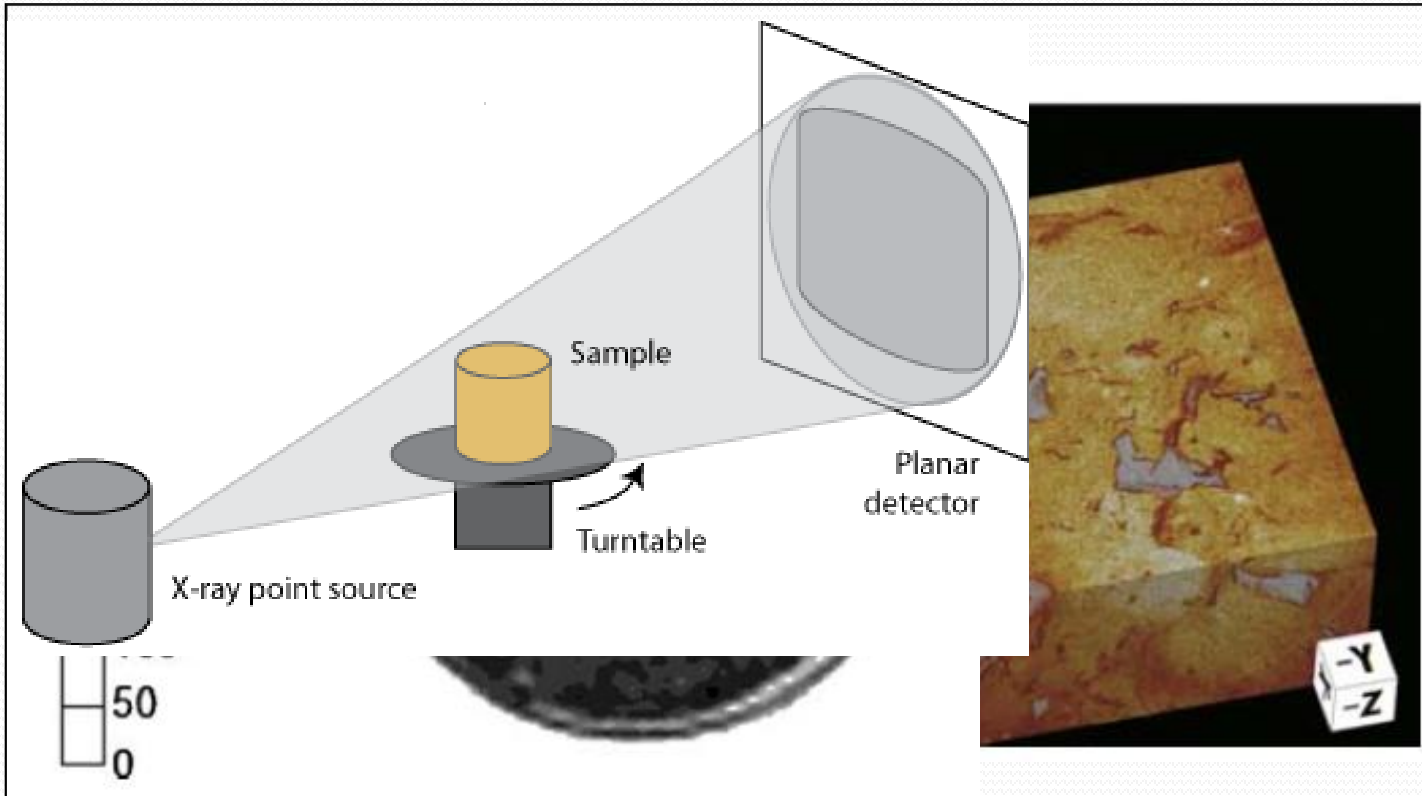
Analysing the soil structure under different mulch and tillage systems using X-Ray tomography

Beckers Eleonore
Beekkerk van Ruth Jöran

16/12/2010

Fundamentals of X-ray tomography



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Impact of soil structure on GHG emissions

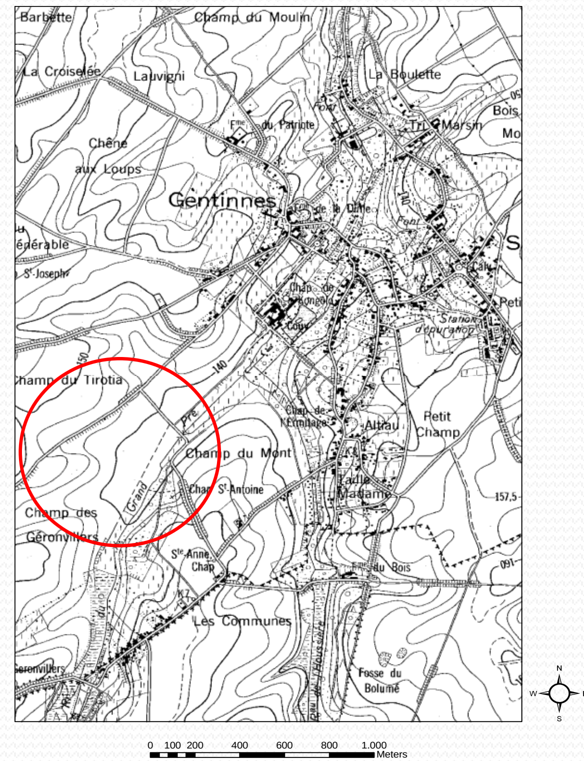
Context

- Interdepartmental project: Bordia, Gembloux
  - Winter wheat
  - Simplified/conventional tillage
  - With/without straw restitution
- Influence of soil structure (connectivity, porosity,…) on the GHG fluxes.
- GHG: CO_2, but also CH_4 and N_2O

Impact of soil tillage on horizontal water flows

Context

- PhD by Mrs Beckers (GxABT)
- CRA-W site (Gentinnes, Champ du mont)
- Loam with clay enriched sub layer
- Ploughing and reduced tillage (since 2004)



Impact of soil tillage on horizontal water flows

Materials and methods

- Samples: cylinders
  (H= 5 cm, D= 3 cm)
- Ap (heavy loam with 15 % clay)
- Sampling →
  - Retention curves (10 s.)
  - X-Ray tomography (10 s.)

Date	Simplified tillage	Conventional tillage
08/08	Winter wheat harvest	
	Stubble ploughing (5-7 cm)	
09/08	Stubble ploughing (5-7 cm)	
	Superficial tillage	Ploughing
	Mustard sowing (rotary harrow + seed drill)	
04/09	Superficial works (rotary harrow + roller)	
	Beet sowing	
10/09	Beet harvest	
	Superficial tillage	Ploughing + cultivator
	Winter wheat sowing (rotary harrow + seed drill)	
03/10	Sampling	
08/10	Winter wheat harvest	
?	?	

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Materials and methods

- Water below pF 4.2 eliminated (Richards apparatus, 1.5 MPa)
- Micro X-ray tomography, Skyscan-1172 (ULg, Applied chemistry lab)
- Fine resolution: 17µm
- Choice over macro tomography (resolution = 0.5 mm)

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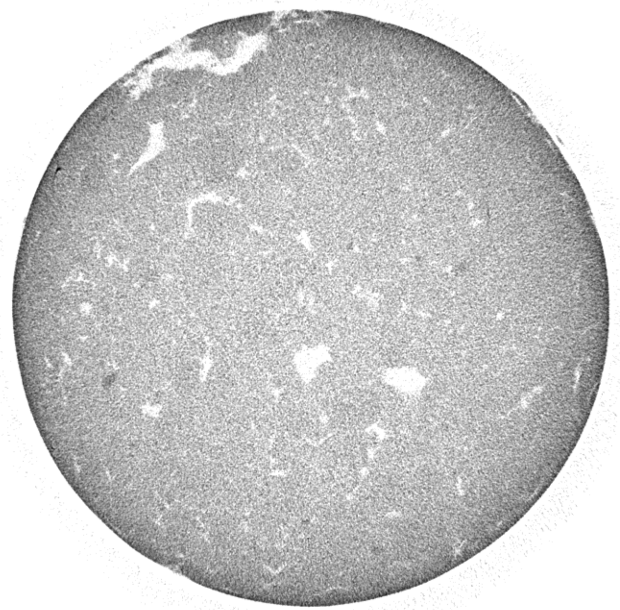
Materials and methods

- Over 1000 2D images: scale of grey
- Pre-treatement under Matlab
  - Image trimming (compaction, cracks)
  - Tresholding (-> binary image)
  - Knowledge of the density -> loop
- Skyscan® -> parameters and 3D model

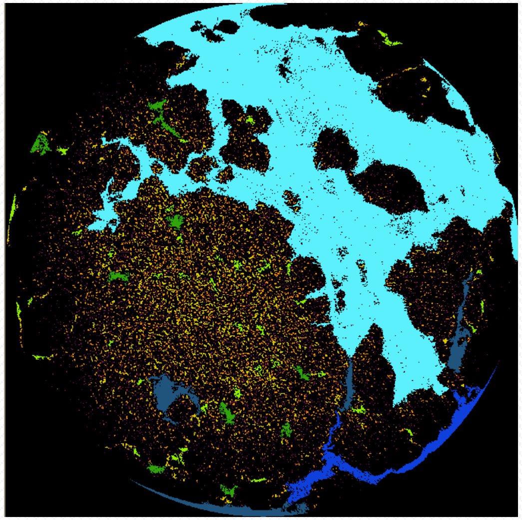


Impact of soil tillage on horizontal water flows

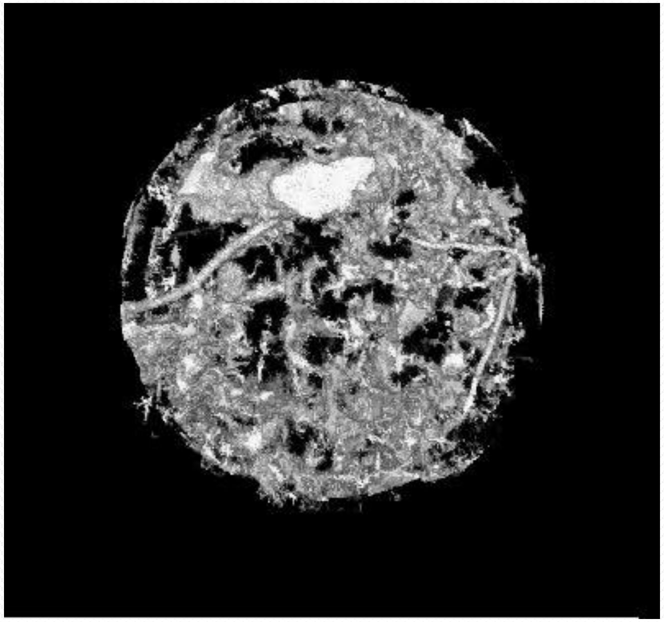
Materials and methods

- Open/Closed porosity, number of pores
- Geometry (Volume, area, shape,...)

- 2D



3D



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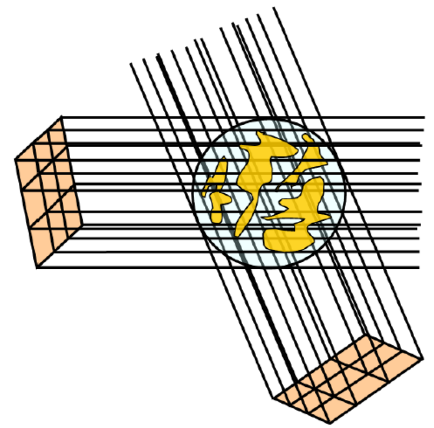
Materials and methods: parameters

- Degree of anisotropy: between 0 (isotropic) and 1 (anisotropic)
  - Lines sent trough the sample for all the angular positions
  - MIL (Mean Interception Length) computed
  - Polar plot of the vectors
  - Three main orthogonal axis (eigenvectors)
  - Eigenvalue (EV) of each axis: proportional to MIL
  - DA = 1-MinEigenvalue/MaxEigenvalue
- Connectivity
  - Euler Number, fragmentation index



$$En = \frac{Objects - Meshes}{Volume}$$

$$Fi = \frac{(S_1 - S_2)}{(V_1 - V_2)}$$

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Results *(X-ray tomography)*

- Conventional tillage
  - Vertical porosity more developed (High EV)
  - Important poral connectivity
  - Important anisotropy (high DA)
- Simplified tillage
  - No significant porosity orientation (3 horizontal, 2 vertical)
  - Greater number of small pores
  - Moderate anisotropy

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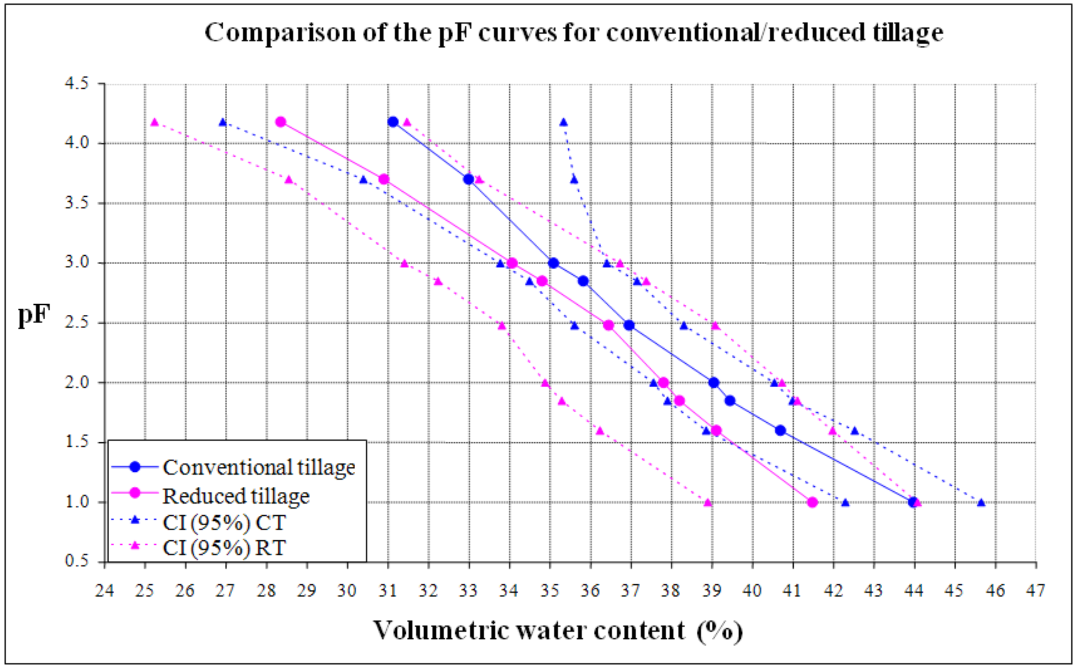
Results *(pF curves)*

- Simplified tillage:
Greater water reserve
(between pF 2.5 and 4.2)

- Conventional tillage:
Greater efficient porosity
(between pF 1 and 2.5)



➢ More efficient water supply in simplified tillage

Impact of soil tillage on horizontal water flows

Conclusions

- **Simplified tillage**
  - Greater efficient water reserve
  - Anisotropy less developed, no significant pore orientation
- **Conventional tillage**
  - Greater efficient porosity and poral connectivity
  - Vertical porosity and anisotropy more developed
    - Parallelism between pF and tomography results
- **Future study**: impact of the structure modification on water flows

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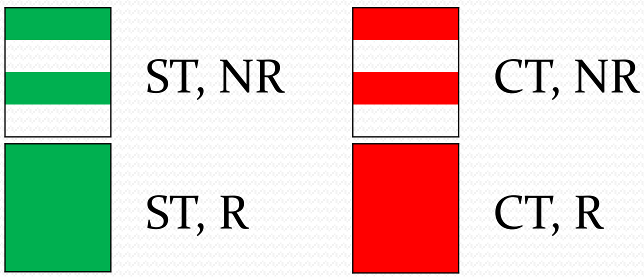
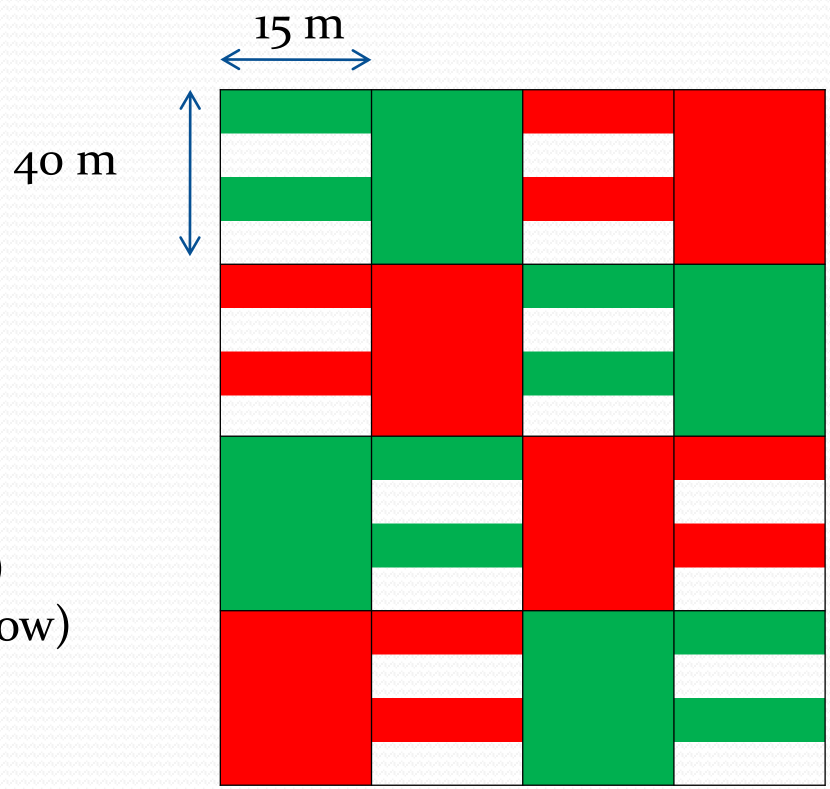
Experimental field





CT: Conventional Tillage (plough)
ST: Simplified Tillage (rotary harrow)
R: straw Restitution
NR: No straw Restitution

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Credits: Delphine Dufranne, GxABT

Ploughing: 6 furrows depth=25 cm

Credits: Delphine Dufranne, GxABT

Sowing: -Superficial works: 10 cm
-Rotary harrows: 10 cm
-Mechanical sowing

Conventional Tillage = ploughing + sowing

Simplified Tillage = sowing

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Materials and methods

- Monitoring of climatic variables (temperature, moisture,…)
- Respiration (CO_2)
  - Automated dynamic closed chambers
  - Static chambers : Spatial variability
- Soil structure
  - X-ray tomography
  - Comparison macro/micro scans
- Process 2D/3D tomographic profiles -> structural parameters

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Prospects

- Link CO_2 fluxes with structural parameters
- Generalise to the treatment: tillage and straw incorporation
- After results with CO_2, trials with CH_4 and N_2O
- General conclusions concerning soil treatments and GHG emissions

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