→ POLINSAR 2013
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Scattering mechanism analysis using multi-angular polarimetric Radarsat-2 datasets

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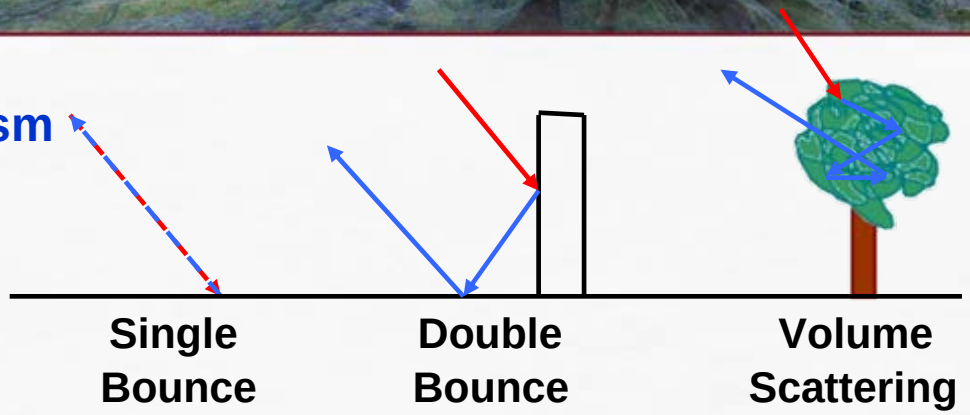
Outline

- **Introduction**
  - Potential use of angular diversity
  - Radarsat-2 and ground truth campaigns
- **Scattering mechanism analysis**
  - Multi-angular behaviors over agricultural fields
  - Specific analysis of bare surface
- **Wheat height characterization**
  - Methods for vegetation height characterization
  - Multi-angular approach
- **Summary & perspective**

Potential use of angular diversity

Scattering mechanism



Coherence matrix

Scattering matrix

$$S = \begin{bmatrix} S_{hh} & S_{hv} \\ S_{vh} & S_{vv} \end{bmatrix}$$

$$T = \begin{bmatrix} T_{11} & T_{12} & 0 \\ T_{12}^{*} & T_{22} & 0 \\ 0 & 0 & T_{33} \end{bmatrix} = \lambda_1 (e_1 \cdot e_1^{+}) + \lambda_2 (e_2 \cdot e_2^{+}) + \lambda_3 (e_3 \cdot e_3^{+})$$

H/A/α decomposition

$$C = \begin{bmatrix} \sigma_{hhhh} & 0 & \sigma_{hhvv} \\ 0 & 2\sigma_{hvhv} & 0 \\ \sigma_{hhvv}^{*} & 0 & \sigma_{vvvv} \end{bmatrix} = a[C_{\text{canopy}}] + \lambda_{\text{odd}}[C_{\text{odd}}] + \lambda_{\text{even}}[C_{\text{even}}] + \lambda_{\text{diff}}[C_{\text{diff}}]$$

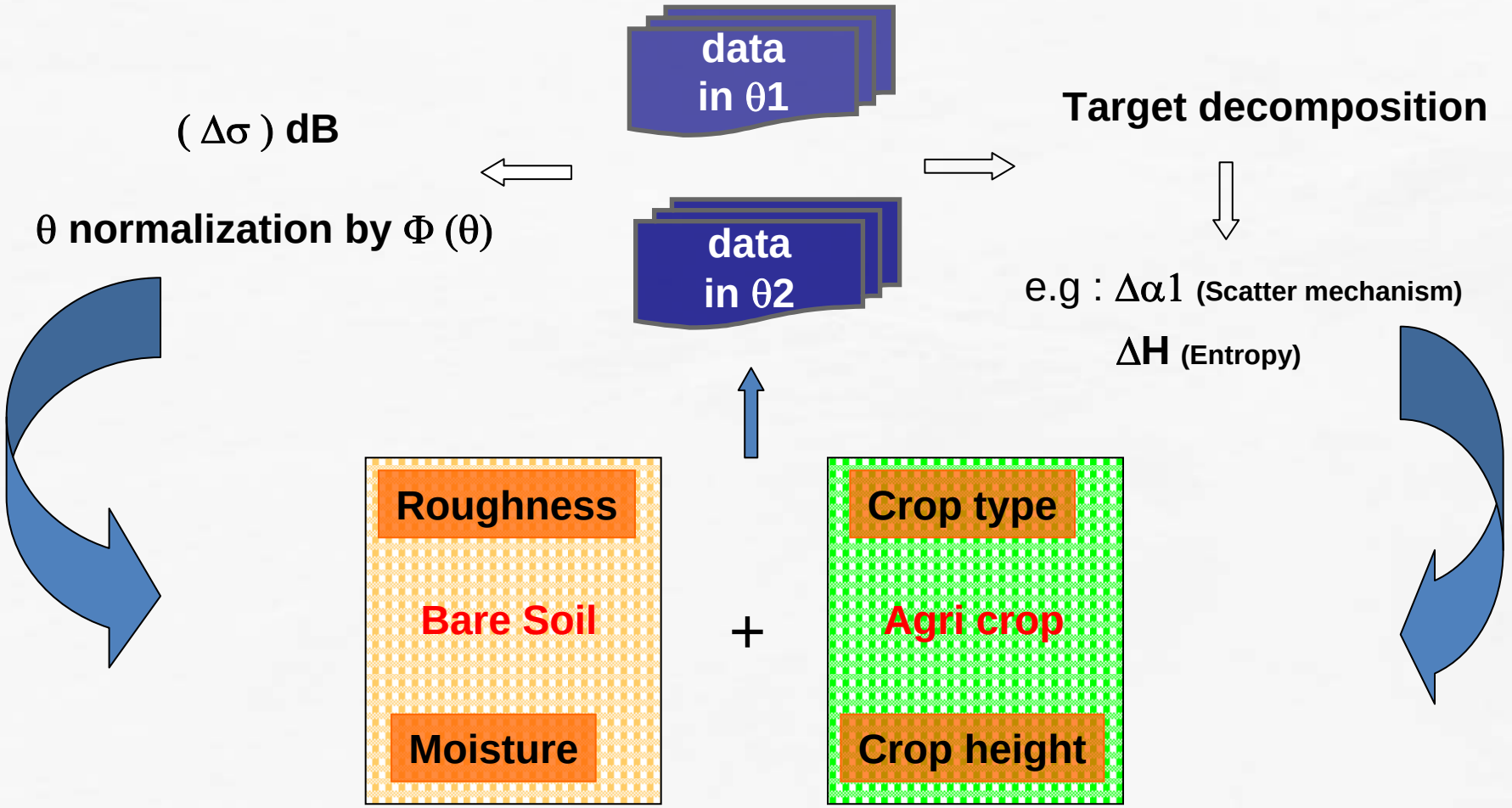
Vanzyl2011 decomposition

Reflection symmetry hypothesis

Covariance matrix

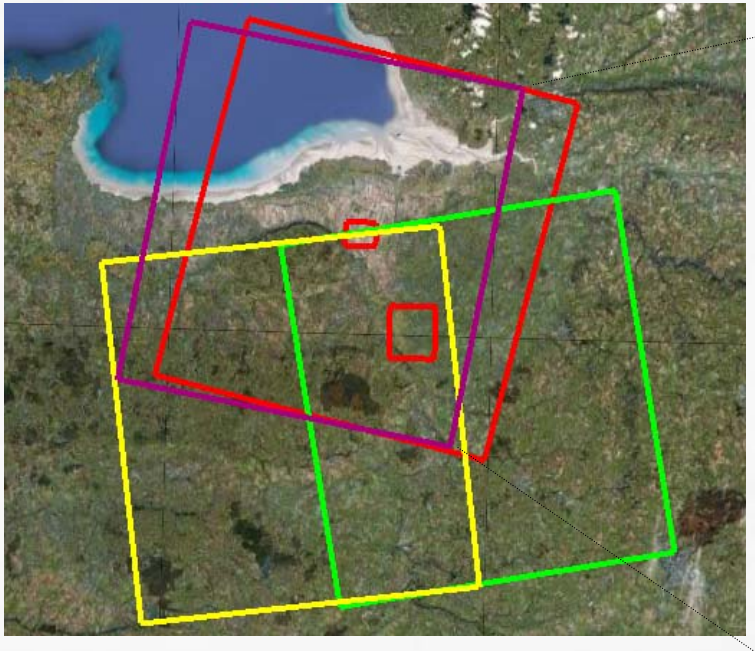
Potential use of angular diversity

Multi-angular observation



Radarsat-2 and ground truth Campaigns

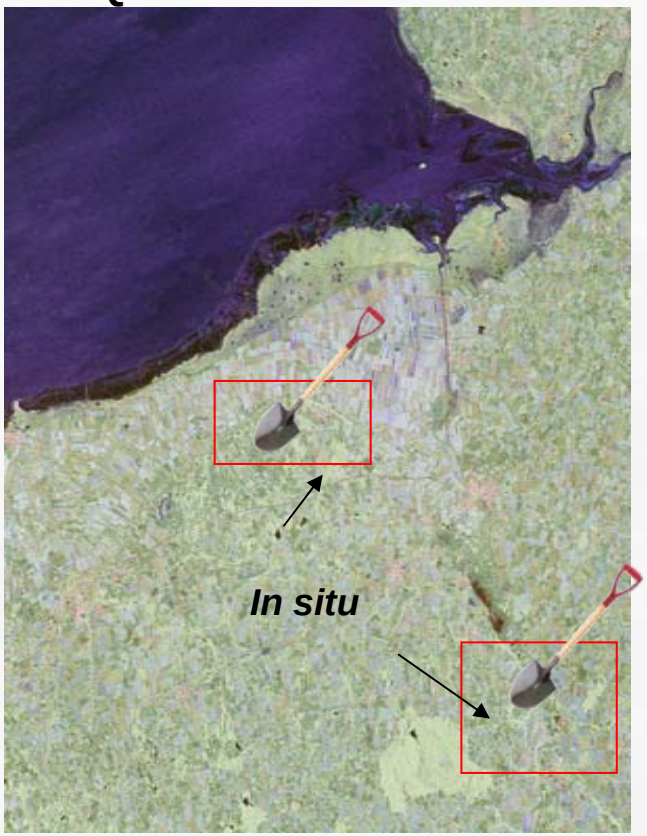
swaths of multi-angular acquisitions



Acquisition Date and Time

Mode	$\theta_{near}(^\circ)$	$\theta_{far}(^\circ)$	Date (2011)	Time
FQ2	20.0	21.8	27/3	06:31
FQ14	33.4	35.1	27/3	17:53
FQ20	39.2	40.7	31/3	06:14
FQ31	48.3	49.4	23/3	18:09

FQ20 31/03/2011 40°

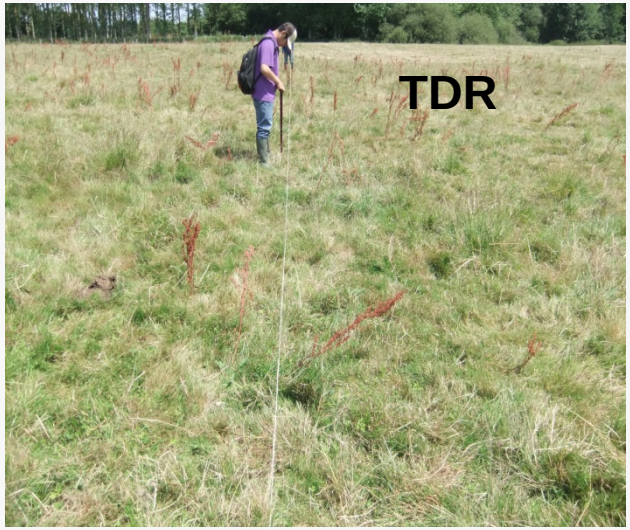


HH+VV Surface bounce
HH-VV double scattering
HV Volume scattering

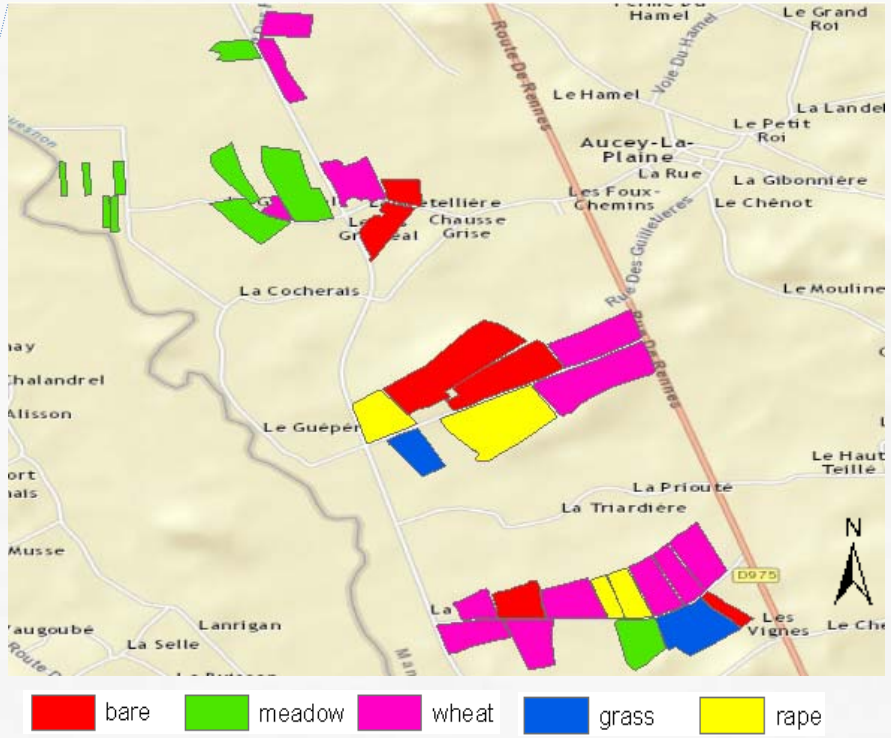
Radarsat-2 and ground truth Campaigns

Campaign in Apr& Nov 2011

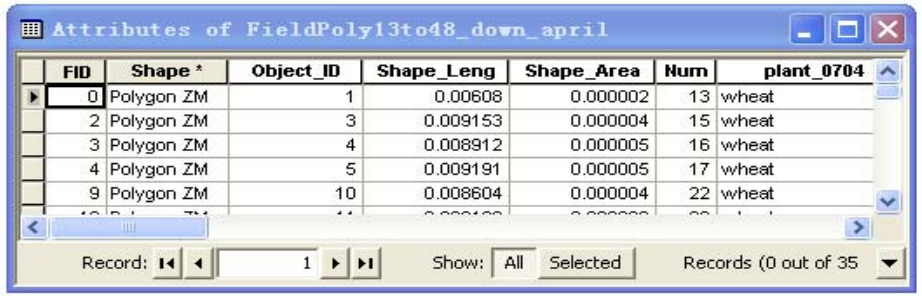
- GPS positioning
- Soil moisture
- Land cover
- Vegetation height
- GIS database



Land cover truth



GIS database



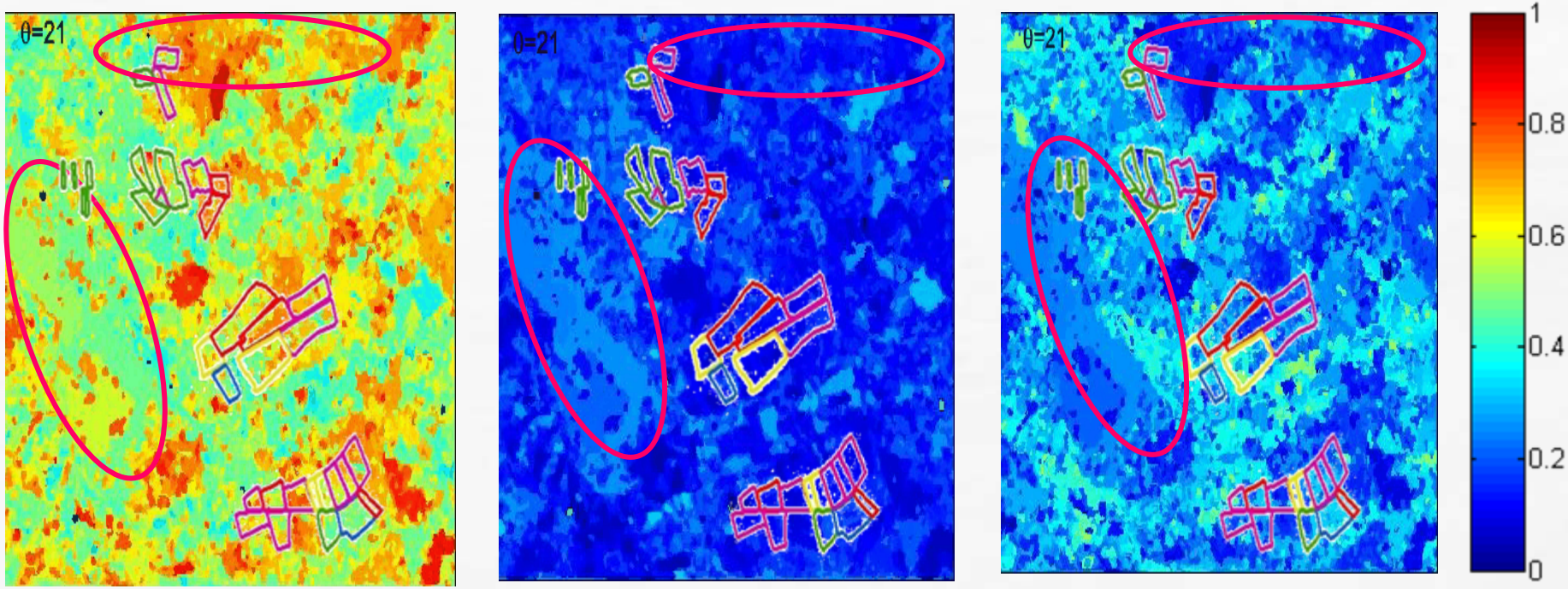
FID	Shape *	Object_ID	Shape_Leng	Shape_Area	Num	plant_0704
0	Polygon ZM	1	0.00608	0.000002	13	wheat
2	Polygon ZM	3	0.009153	0.000004	15	wheat
3	Polygon ZM	4	0.008912	0.000005	16	wheat
4	Polygon ZM	5	0.009191	0.000005	17	wheat
9	Polygon ZM	10	0.008604	0.000004	22	wheat

Record: 1 Show: All Selected Records (0 out of 35

Radarsat-2 and ground truth Campaigns

Vanzyl2011 decomposition on data acquired in March 2011

single bounce | **double bounce** | **volume scattering**



$$\frac{p_s}{p_s + p_d + p_v} + \frac{p_d}{p_s + p_d + p_v} + \frac{p_v}{p_s + p_d + p_v} = 1$$

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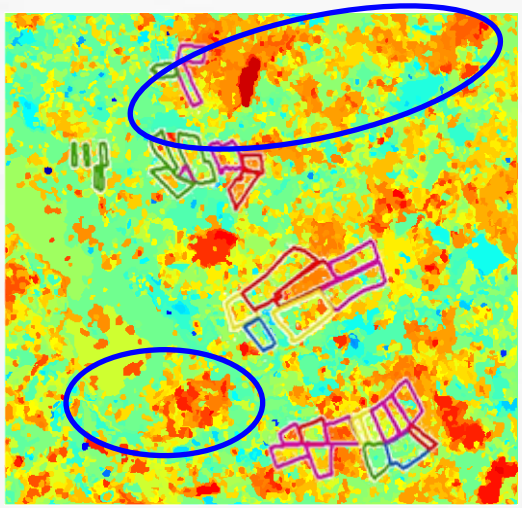
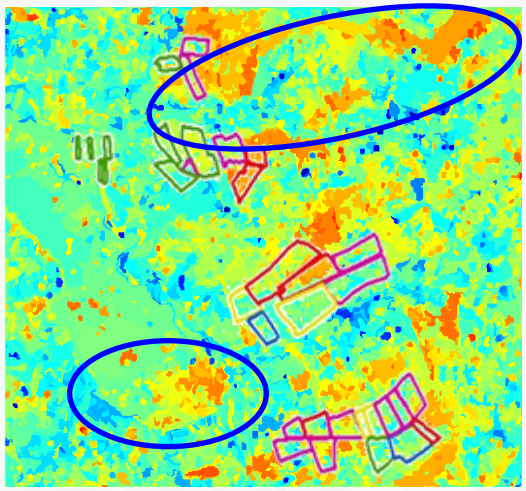
- Summary & perspective

Multi-angular behaviors over agri fields
-single bounce

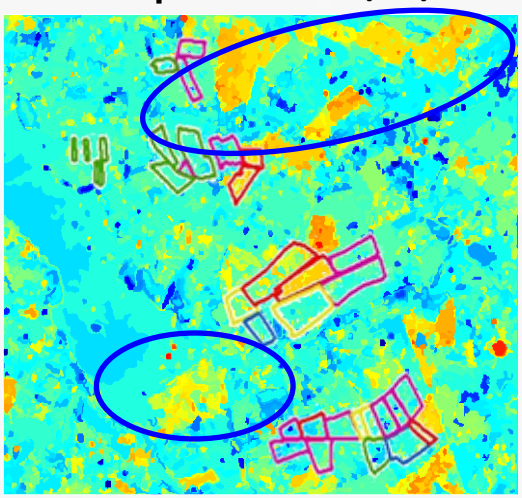
21° acquired on 27/03/2011



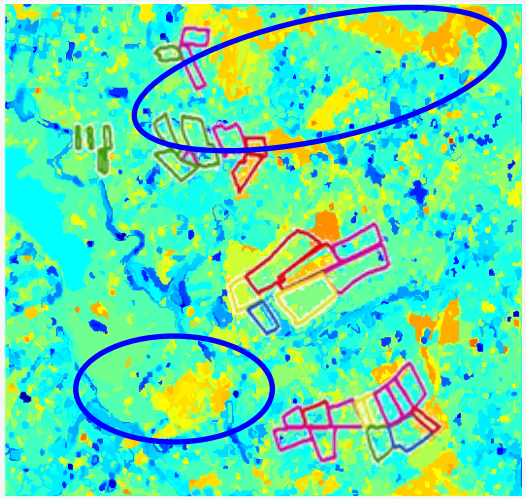
34° acquired on 27/03/2011

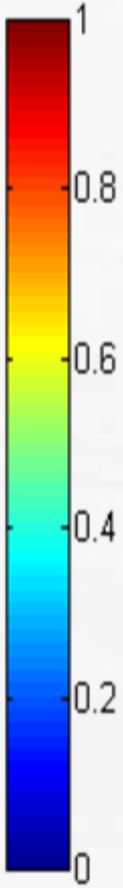


40° acquired on 31/03/2011



49° acquired on 23/03/2011





single bounce

→

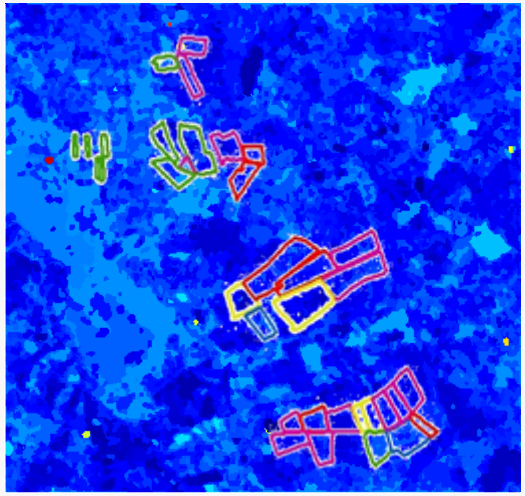
saturates if

incidence angle

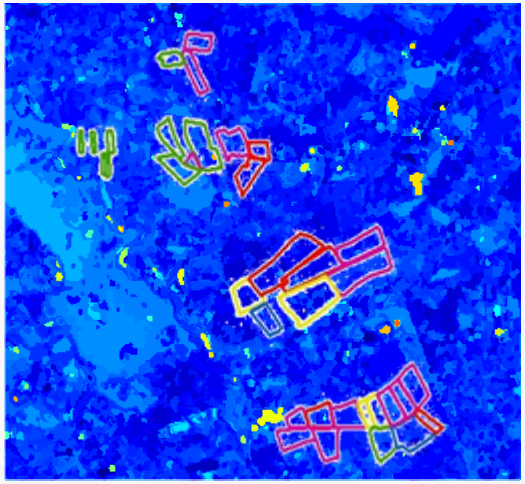
$\theta > 40^{\circ}$

Multi-angular behaviors over agri fields
-double bounce

21° acquired on 27/03/2011



34° acquired on 27/03/2011



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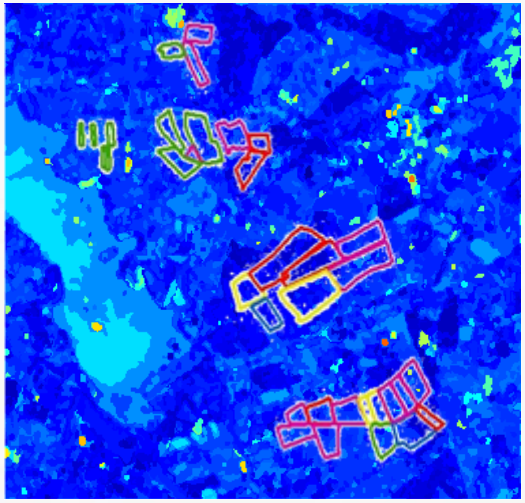
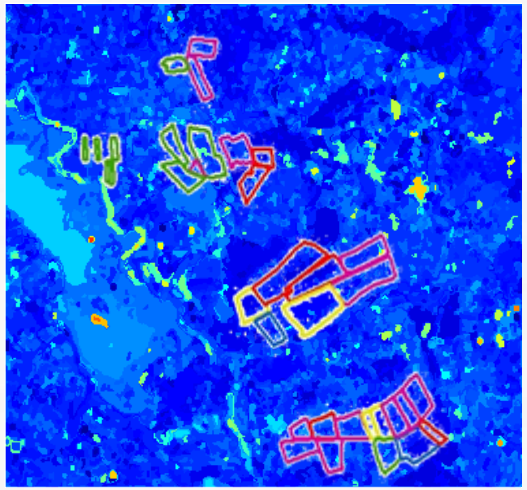
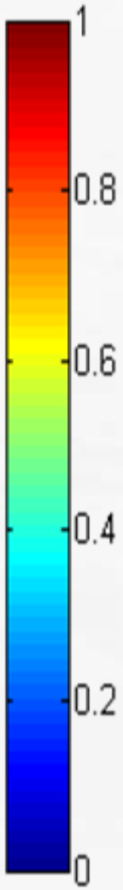


49° acquired on 23/03/2011





double bounce

→

not so sensitive

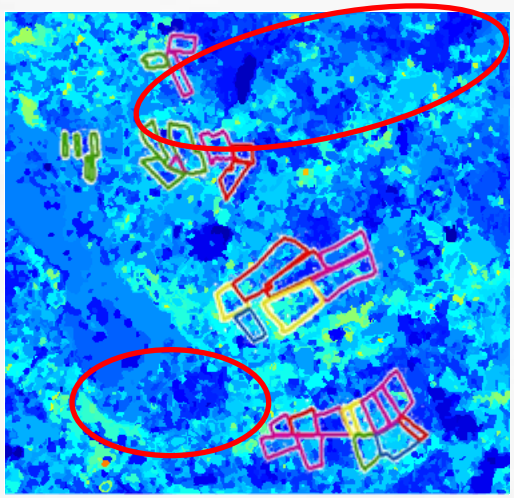
IF

incidence angle

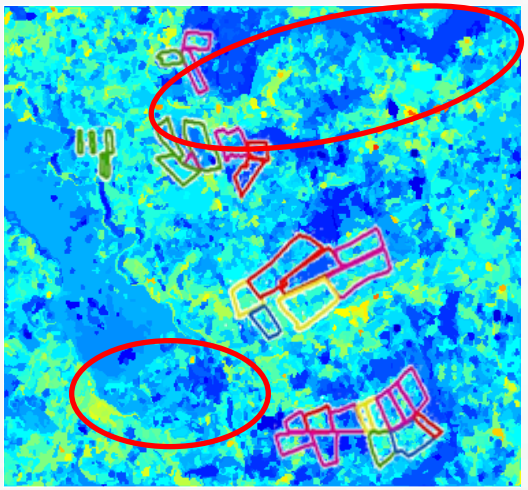
changes

Multi-angular behaviors over agri fields
-volume scattering

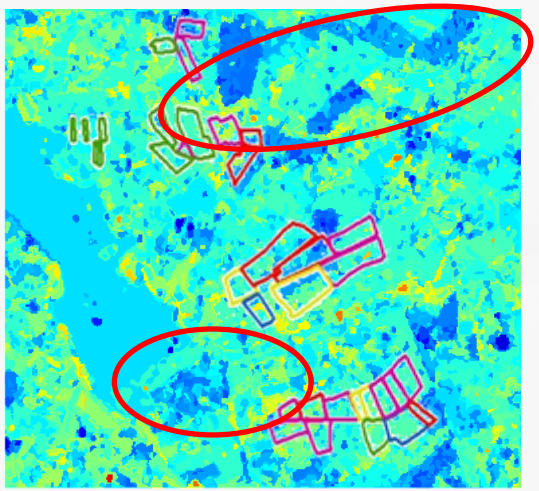
21° acquired on 27/03/2011



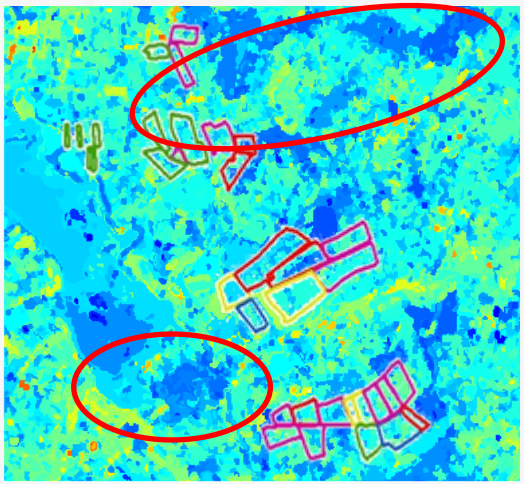
34° acquired on 27/03/2011

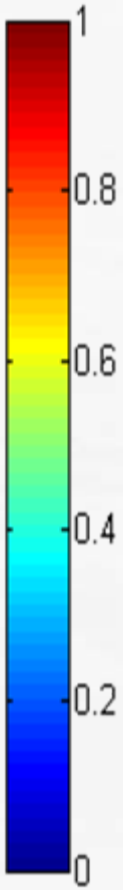


40° acquired on 31/03/2011



49° acquired on 23/03/2011

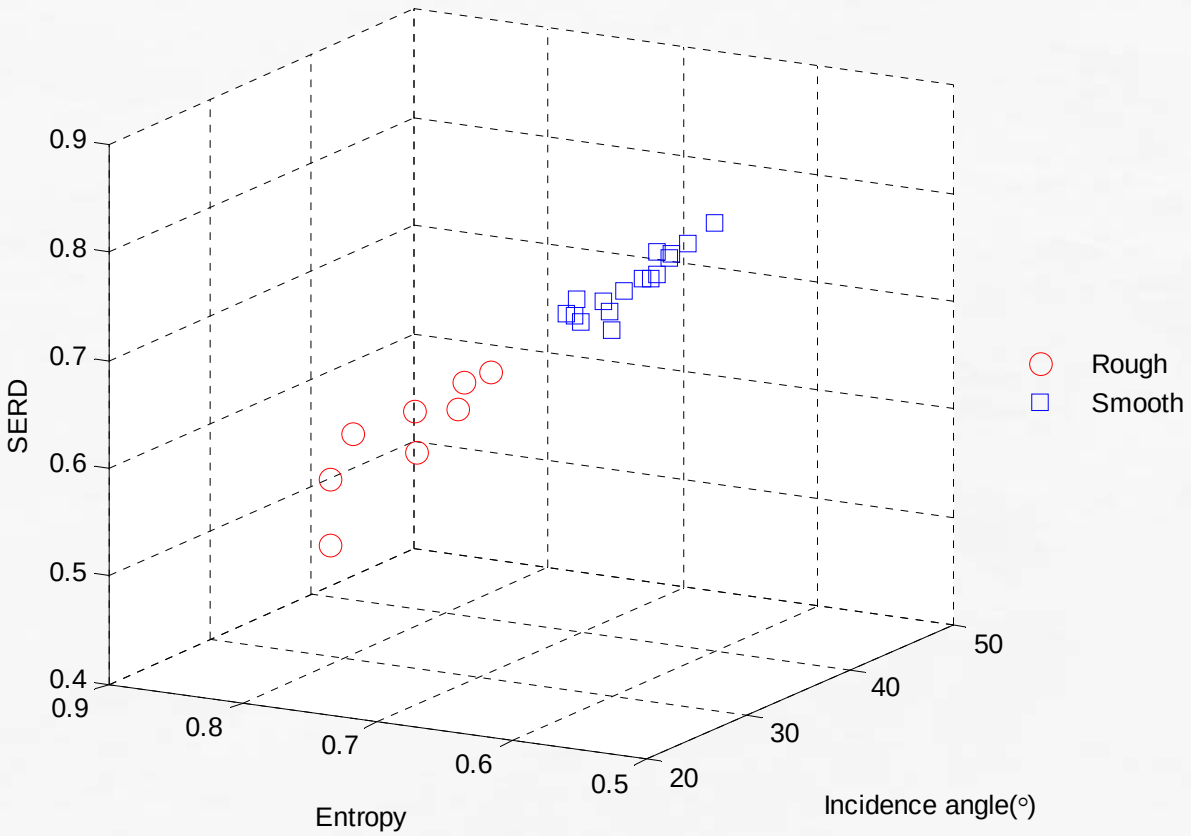




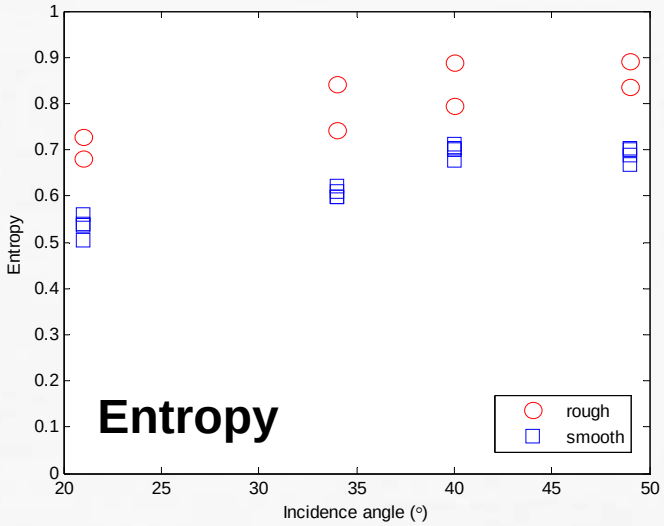
Volume scattering → saturates if incidence angle $\theta > 40$

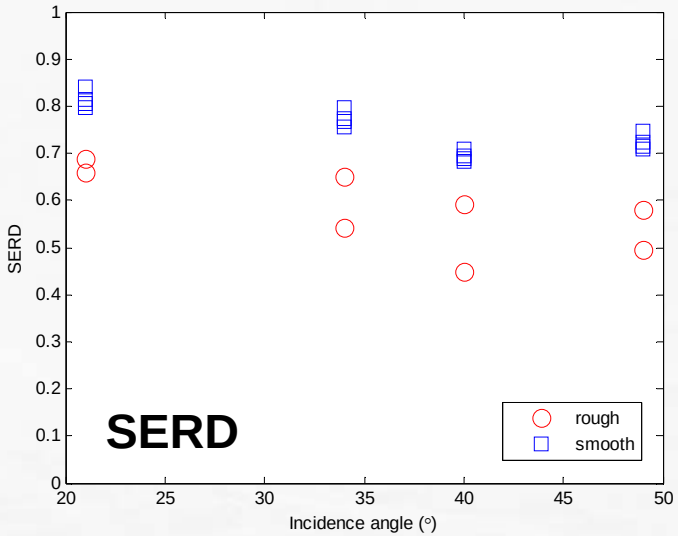
Specific analysis of bare surface

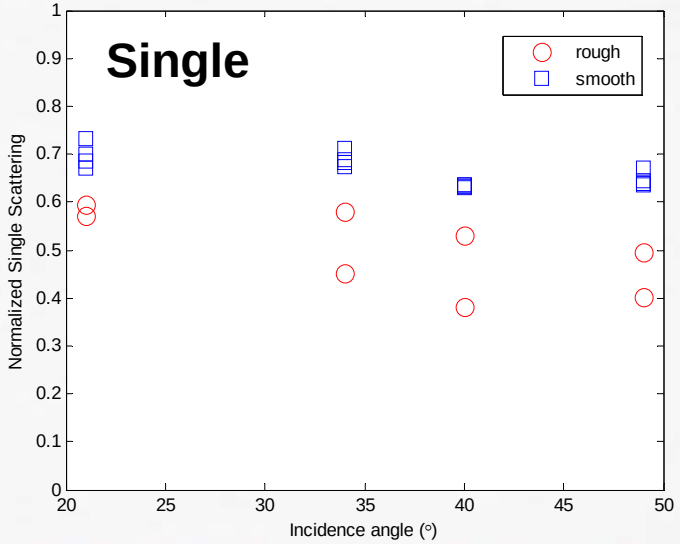
Roughness discrimination in H /SERD / θ space

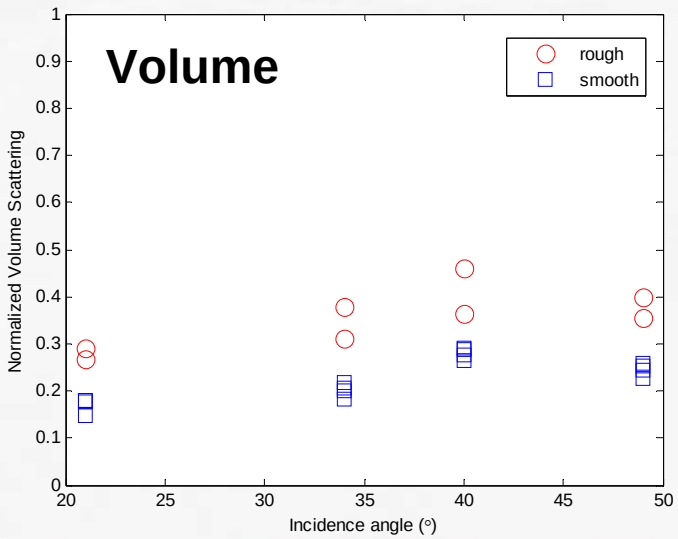


Specific analysis of bare surface









Rougher surface
→
Higher Entropy
→
Lower SERD
→
Lower Single bounce
→
Higher Volume scattering

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Methods for vegetation characterization

Scattering difference

$$\Delta(G/V) = \frac{Ps}{Pv} - \frac{Pd}{Pv}$$

Ps, Pd→ Eigenvalue of ground component matrix

Pv → Volume scattering components

L band→ As crop height ↗ , Δ(G/V) ↘

Ref.Jagdhuber- Thesis2012

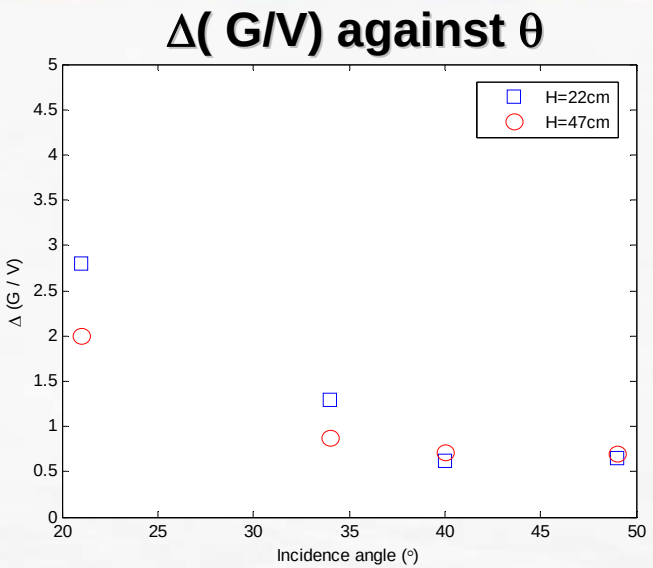
HH, VV correlation

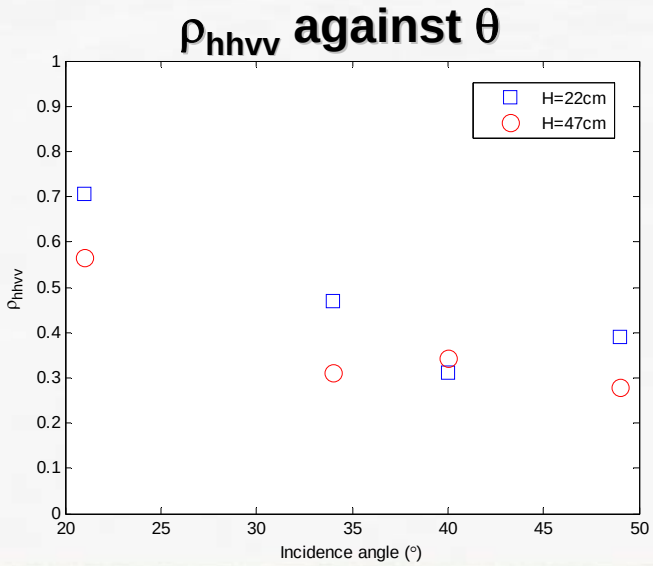
$$\rho_{hhvv} = \frac{|< S_{hh} S_{vv}^{*} >|}{\sqrt{|S_{hh}|^2 |S_{vv}|^2}}$$

RS2 in 30° → As crop height ↗ , ρ_{hhvv} ↘

Ref.Gherboudj-2011(Remote Sensing of Environment)

Methods for vegetation characterization



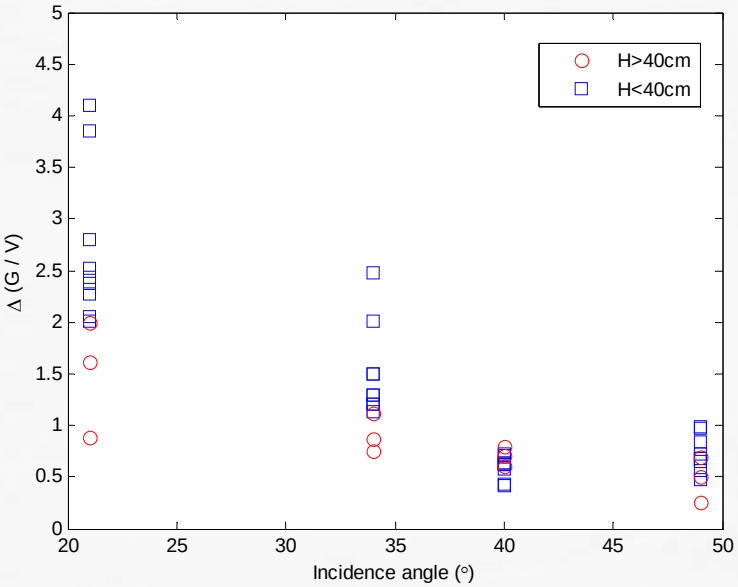


Ground to volume difference → sensitive to wheat height

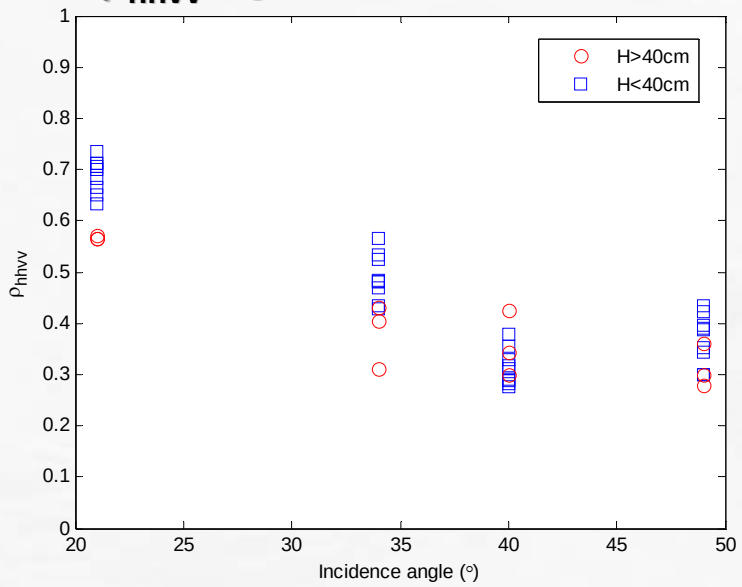
Increasing θ → increasing volume scattering→ decreasing correlation

Methods for vegetation characterization

Δ(G/V) against θ for all fields



ρ_{hhvv} against θ for all fields



θ ↗ → Δ(G/ V) ↘
Dynamic range ↘
H ↗ → Δ(G/ V) ↘ IF θ < 40

θ ↗ → ρ_{hhvv} ↘

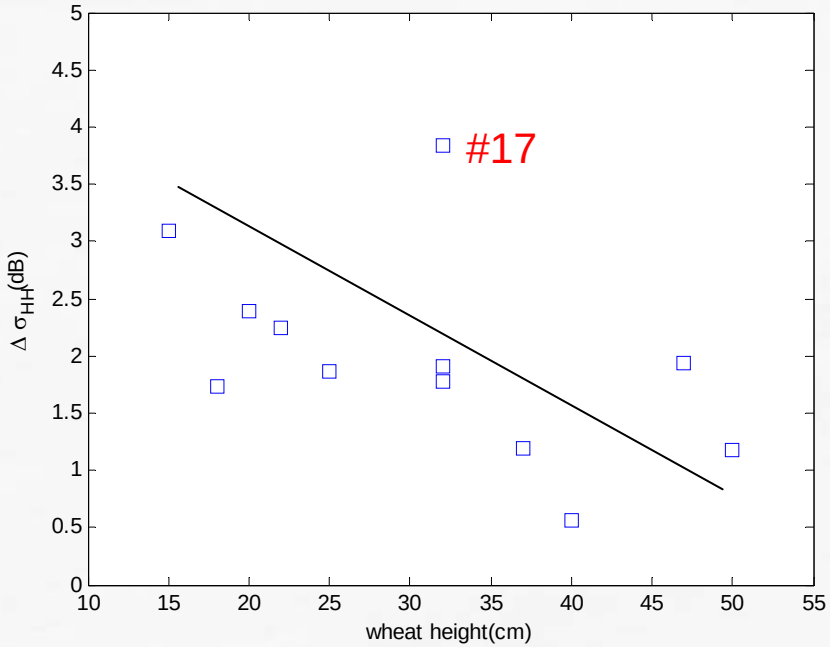
H ↗ → ρ_{hhvv} ↘ IF θ < 40

Higher θ . Higher stem . More foliage → more volume diffusion

Multi-angular approach

$\Delta\ \sigma_{HH}$(dB) → crop height

$\Delta\ \sigma_{HH}$(dB) against crop height



#17 with higher density

$\Delta\ \sigma_{HH}$ (dB) ↘ as H ↗

In bare surface, $\Delta\ \sigma_{HH}$ **(dB)** depends more on roughness than soil moisture (Ref. zribi2002)

⇩

In wheat fields, Height→ similar effect as roughness for bare surface

Multi-angular approach

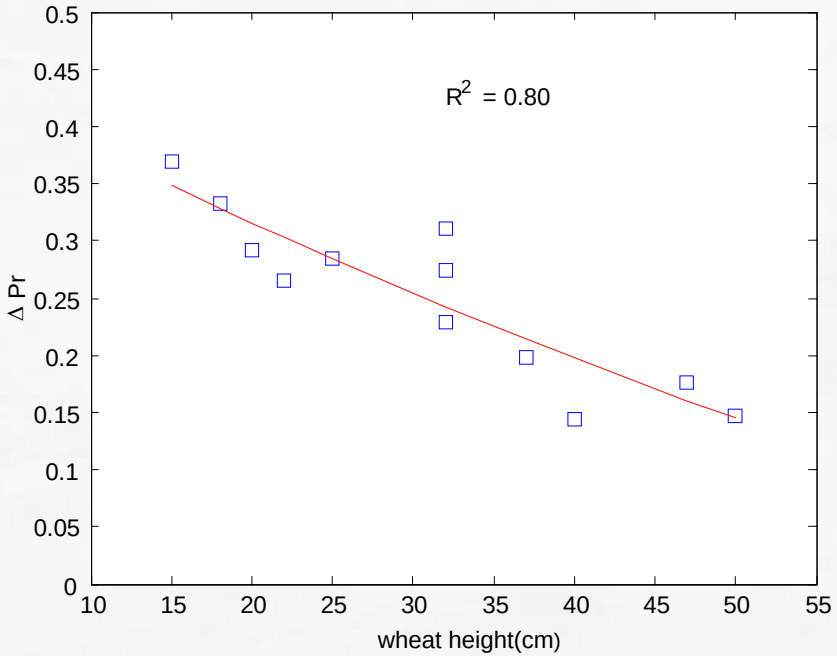
Δ Pr → crop height

$$P_r = \sqrt{\frac{3}{2}}\sqrt{\frac{\lambda_2^{\,2} + \lambda_3^{\,2}}{\lambda_1^{\,2} + \lambda_2^{\,2} + \lambda_3^{\,2}}}$$

Ref.lunebuerg2001

$$\Delta P_r = P_r(\theta_2) - P_r(\theta_1)$$

Δ Pr against wheat height



IF θ change

Depolarizing level change in higher wheat < change in lower vegetation

→ volume scattering in lower wheat : more sensitive to θ variation

Summary & perspective

Summary

- Explore the polarimetric difference of multi-angular observation
- Single bounce & volume scattering saturates at incidence angle around 40
- Multi-angular scattering mechanism descriptors → potential to improve roughness classification over bare surface
- Differences among 3 scattering mechanism & HH, VV correlation→ both decrease as wheat height increases if $\theta < 40$
- Multi-angular parameters $\Delta \sigma_{HH}$ & Δ Pr → potential to describe wheat height

Perspective

Ground-based SAR measurement in multi-angular configuration


Thank you for your attention !
Questions?
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