First Demonstration of Agriculture Height Retrieval with PolInSAR Airborne Data

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Motivation

- PolInSAR applied to vegetation height retrieval
  - Forests:
    • Demonstrated with airborne data
      • Different bands: P, L, X
      • Different forest types: boreal, tropical, etc.
    • Model: RVoG and variants
  - Agriculture:
    • Demonstrated ONLY with indoor data at EMSL
      • Single samples of corn (S, C, X band) and rice (C, X band)
    • Model: RVoG and OVoG

Objective: experimental demonstration with airborne data
Data set: ground measurements

- AgriSAR2006 (ESA funded campaign)
Data set: interferometric acquisitions

- PolInSAR data (DLR funded campaign):
  - E-SAR system: L band, full pol.
  - 3 flights over the same site (7.5 minutes between passes)
Vertical wavenumber

- Crops (short vegetation): Large baselines are required to ensure enough sensitivity
Vertical wavenumber

Optimum range of $k_z$ for $h = 1$ m

[Cloude2009, Ch.8]
Vertical wavenumber

Optimum range of $k_z$ for $h = 1.7$ m

[Cloude2009, Ch.8]
Results

• This study:
  – One date: 1-Aug-2006
  – 3 crop types (map):
    • Winter rape (yellow)
    • Corn (pink)
    • Winter wheat (orange)
Initial inspection: Coherence HH

Uncompensated MoCo in 2nd flight
$B=90\text{m. Coherence at all channels}$
B=90m. Phase at all channels (no topo)
Retrieval algorithm

• Direct model: RVoG, as in forests

• Inversion (steps):
  – 1st. Line fit for topography estimation ($\phi_0$). 2 options:
    • Fit to the usual set of 8 coherences: linear, Pauli & optimum
    • ML algorithm with ESM [Ferro-Famil, IGARSS'09]
  – 2nd. Estimation of height. E.g:

    $$ h_v = \frac{1}{k_z} \left[ \arg (\gamma_v e^{-j\phi_0}) + \eta (\pi - 2 \sin^{-1}(|\gamma_v|^{0.8})) \right] \quad \text{with} \quad \eta = 0.8 \quad \text{[Cloude2009, eq.8.38]} $$

• Data pre-processing: a priori knowledge of system coherence or decorrelation $\gamma_{sys} = 0.95$
Results: area
Results: topography (w.r.t. DEM)
Results: vegetation height
Results: vegetation height (fields)
Comparison with in-situ data: Rape

\[ \bar{h} = 1.61 \text{ m} \]
\[ \sigma_h = 0.22 \text{ m} \]
Difference < 9%

Height (cm)

175
172
170

In far range

\[ \bar{h} = 1.76 \text{ m} \]
\[ \sigma_h = 0.20 \text{ m} \]
Difference < 20%

Height (cm)

155
145
150

In near range

\[ \bar{h} = 1.60 \text{ m} \]
\[ \sigma_h = 0.24 \text{ m} \]

Height (cm)

NA

\[ \bar{h} = 1.67 \text{ m} \]
\[ \sigma_h = 0.25 \text{ m} \]

Height (cm)

NA
Comparison with in-situ data: Maize

$\bar{h} = 0.98 \text{ m}$

$\sigma_h = 0.31 \text{ m}$

Difference <10%
Comparison with in-situ data: Wheat

$\bar{h} = 1.06 \text{ m}$
$\sigma_h = 0.33 \text{ m}$

Difference < 28%

$\bar{h} = 1.31 \text{ m}$
$\sigma_h = 0.47 \text{ m}$

Difference < 40%
Summary of preliminary results

- Analysis at field level (if ground measurements are representative):
  - Rape:
    - Homogeneous estimates around true height
    - Near range: slight overestimation
    - Far range: slight underestimation
    - Ground-to-volume ratio depends on incidence angle
  - Maize:
    - Heterogeneous field, both in estimates and ground data (reality)
    - Right order for the estimates
  - Wheat:
    - Overestimation of height
Next steps…

- Analysis at point level, with coordinates of the ground measurements
- Extension to the rest of crop types in this site
- Influence of baseline and incidence angle, and MB approaches
- Study about the sensitivity w.r.t. ground-to-volume ratio
- Modified model: OVoG
- Time series of the observations or estimates..