POLITECNICO DI MILANO

Temporal Decorrelation analysis of TropiSCAT

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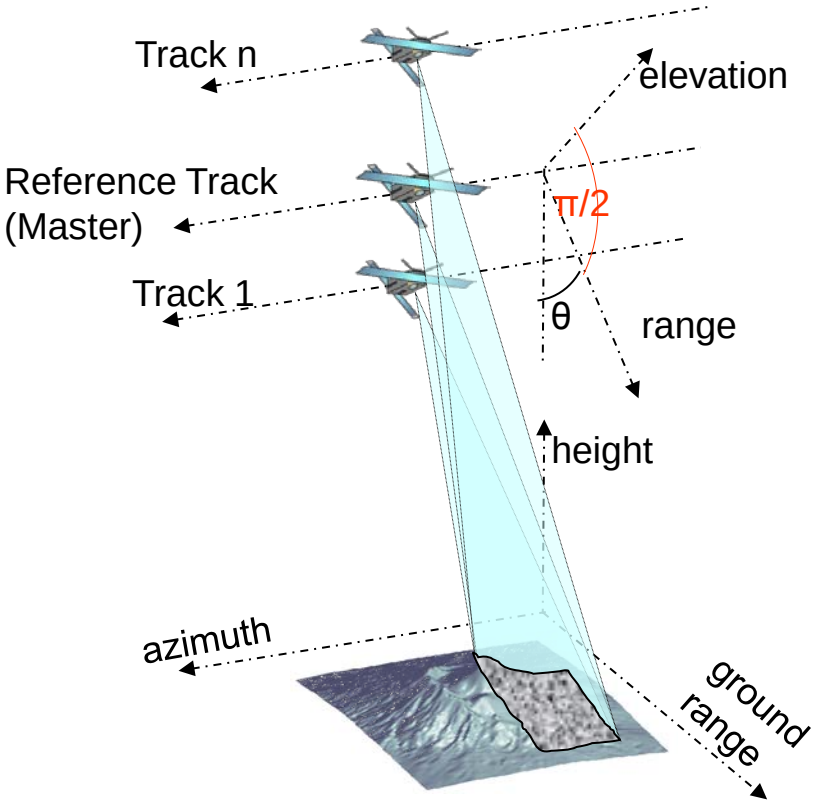
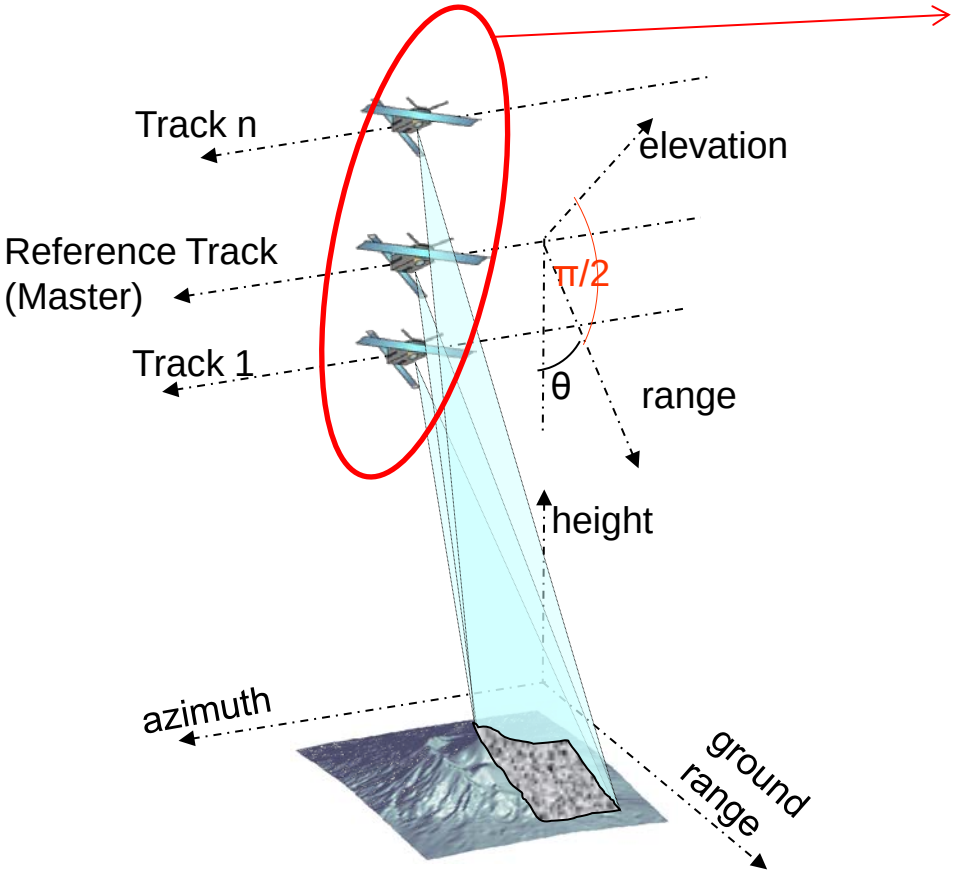
Outline

- Introduction and motivation
- Methodology
- Results and quantitative assessment
- Conclusions

Multiple flight lines

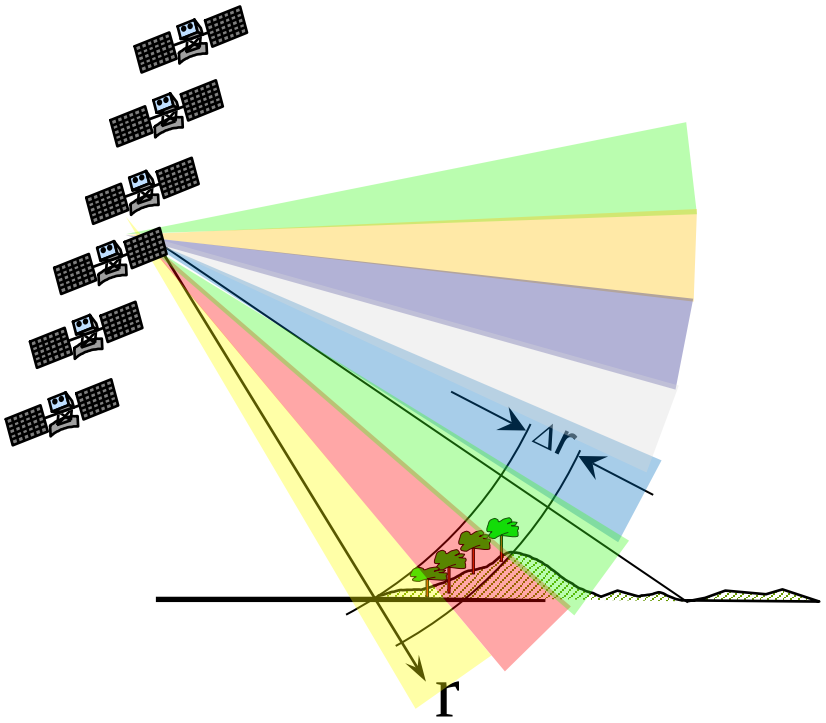


Multiple flight lines ⇔2D Synthetic Antenna



An antenna array is formed in the direction of elevation

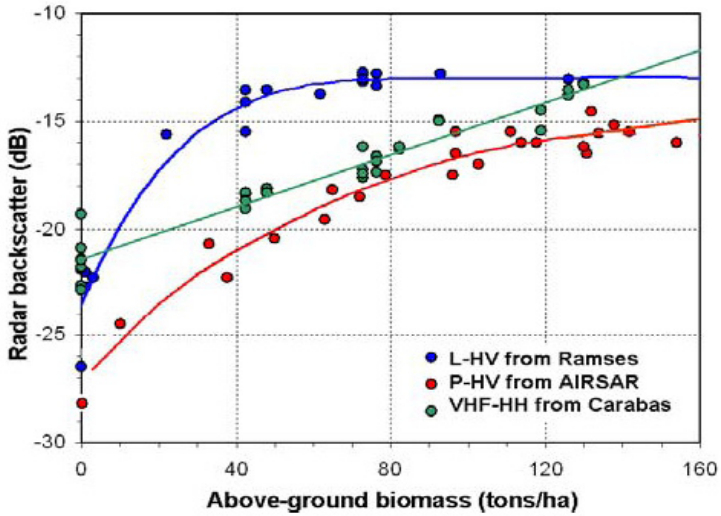
⇔ Resolution of targets at different elevation within each SAR range/azimuth resolution cell



Forest biomass retrieval

Longer wavelength SARs ⇔ precious tool for forestry remote sensing

- Under foliage penetration capabilities
- Mitigate saturation in backscatter vs forest biomass law



From Le Toan et al., 2004

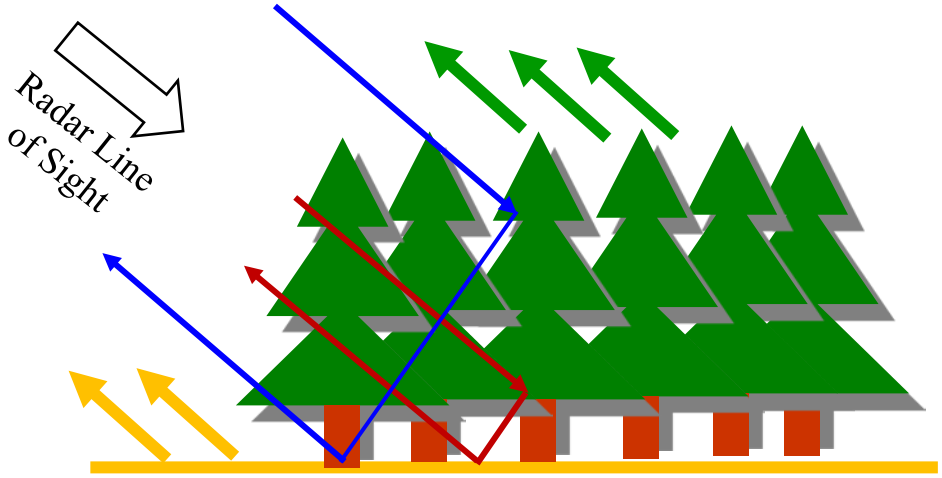
Forest biomass retrieval

Longer wavelength SARs ⇔ precious tool for forestry remote sensing

- Under foliage penetration capabilities
- Mitigate saturation in backscatter vs forest biomass law

Sensitivity to the whole forest structure ⇔ many different scattering mechanisms

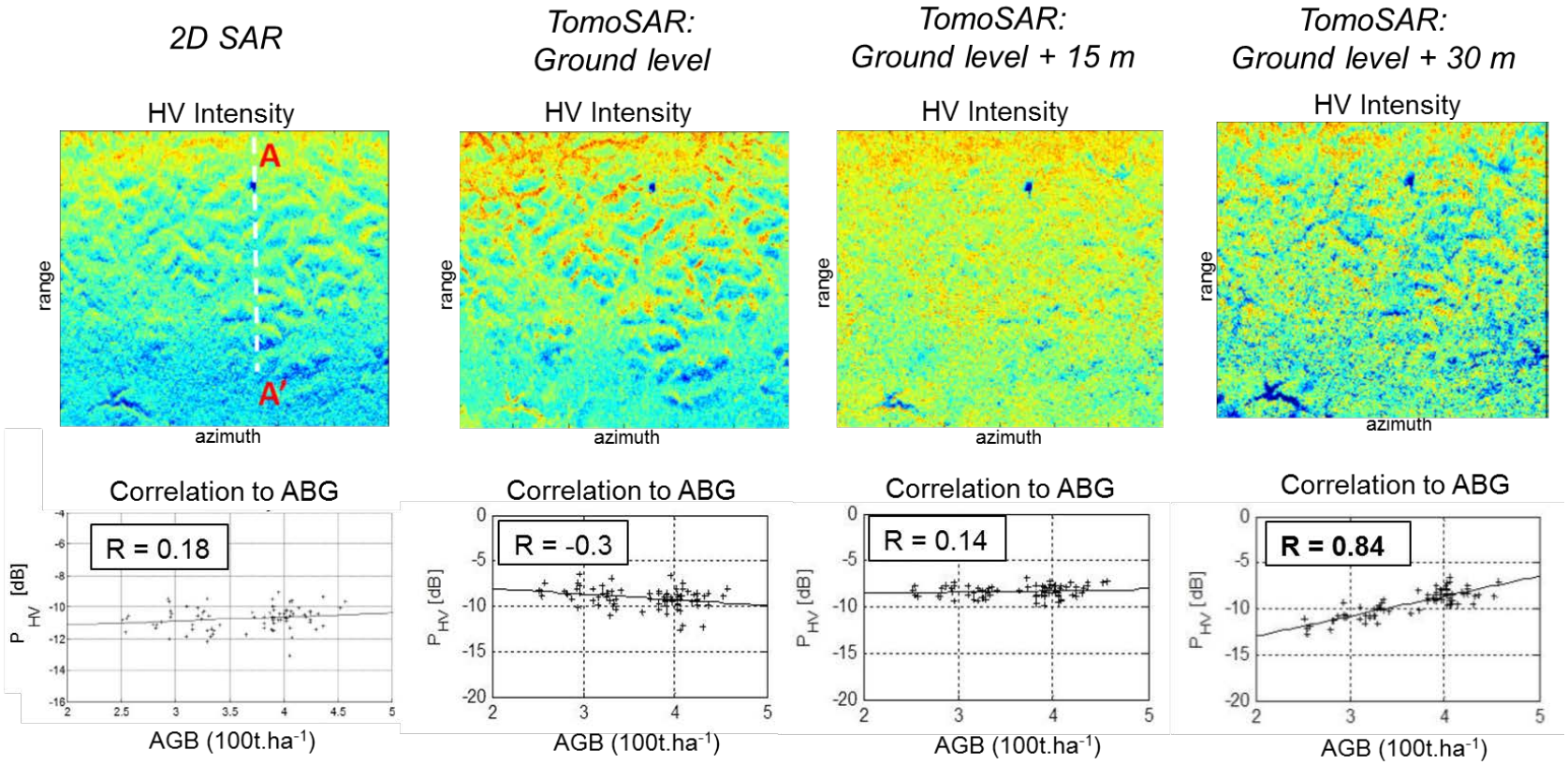
- **Back scatter from the canopy**
- **Back scatter from the ground (Bragg)**
- **Trunk-Ground forward scatter**
- **Canopy-Ground forward scatter**



3D Tomography is a powerful tool to separate and understand the mechanisms

Different TomoSAR layers exhibit different correlation to forest biomass

- The best correlation is found at 30 m above the ground
- The ground layer is poorly or negatively correlated to forest biomass, and strongly varying with topographic slopes



Ho Tong Minh *et al., 2013*

Motivation

These results are from 1 day campaigns

- all acquisitions in about 1 hour
- same weather conditions (sunny)

What about repeat pass tomography

- Ho Tong Minh et al showed that 3 day tomography is possible considering temporal decorrelation – sunny days only

- **Consider the impact of rainy days**
- **Implement repeat pass tomography in the very same way as Biomass**

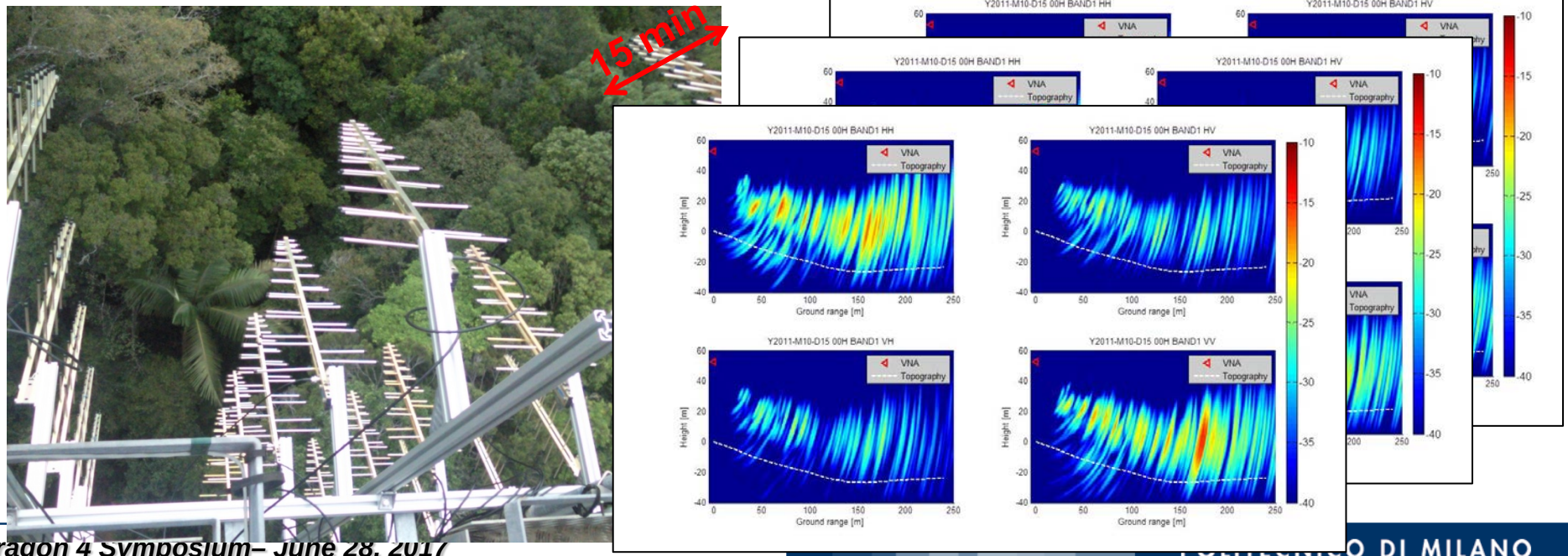
TropiSCAT

TropiSCAT – ESA – 2011

⇔ a static ground-based radar observing a tropical forest

- Located in French Guyana – same site as TropiSAR
- Team members from ONERA, CNES, CESBIO, POLIMI
- 20 antennas installed on top of the Guyaflux tower (55 m)
- Fully polarimetric (HH, HV, VH and VV)
- Vertical resolution capabilities
- One image every 15 minutes over a time span of one year

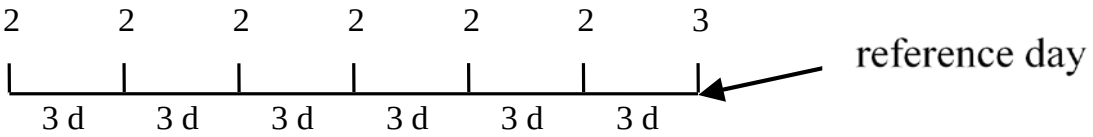
⇒ Access to the vertical structure of temporal decorrelation



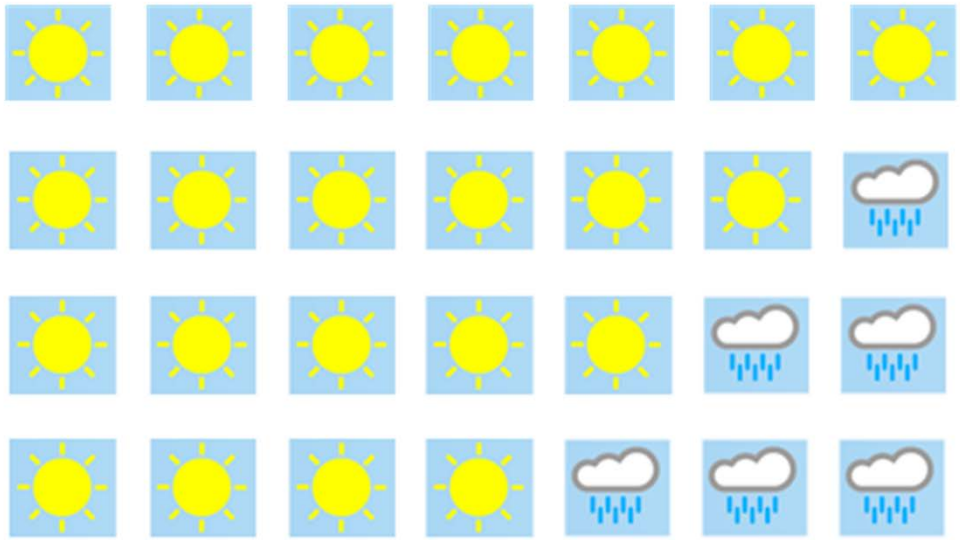
7 – day Tomograms: methodology

Simulating BIOMASS repeat-pass tomography:

- Two antennas per day every 3 days at 06:00 am
- 7 – day tomogram is compared against a reference from “instantaneous” tomography



- The dataset covers the time span starting from December 6, 2011 to February 29, 2012
- 63 7-day tomograms under various weather conditions



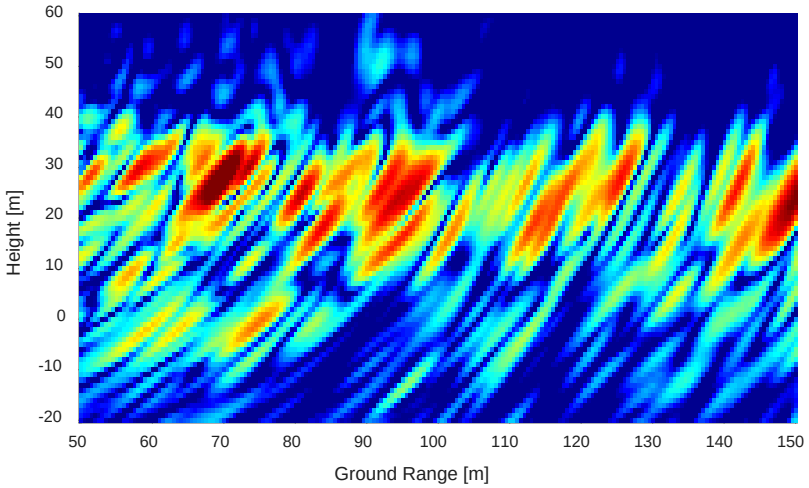
N = 5 7-day Tomograms

N = 25 7-day Tomograms

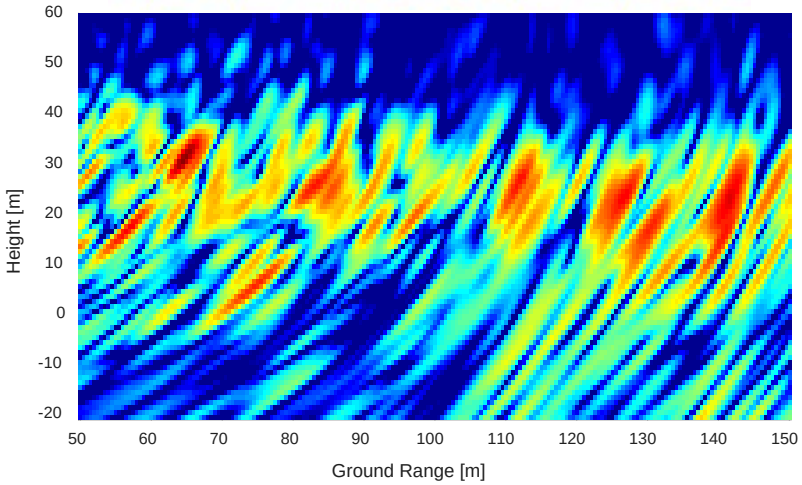
N = 27 7-day Tomograms

N = 9 7-day Tomograms

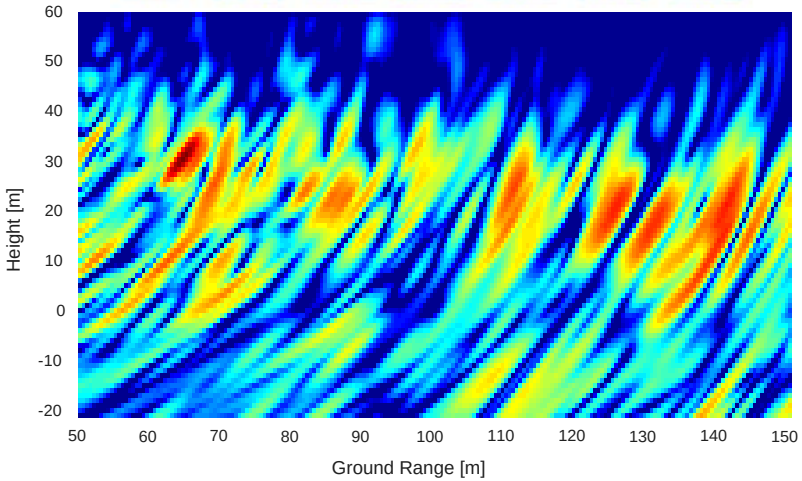
Instantaneous Tomograms – VV



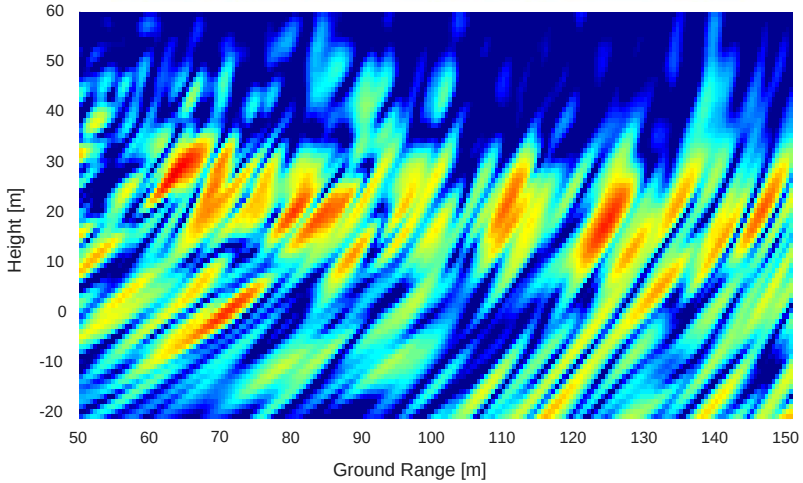
7 – day Tomograms – 0/7 rain day - VV



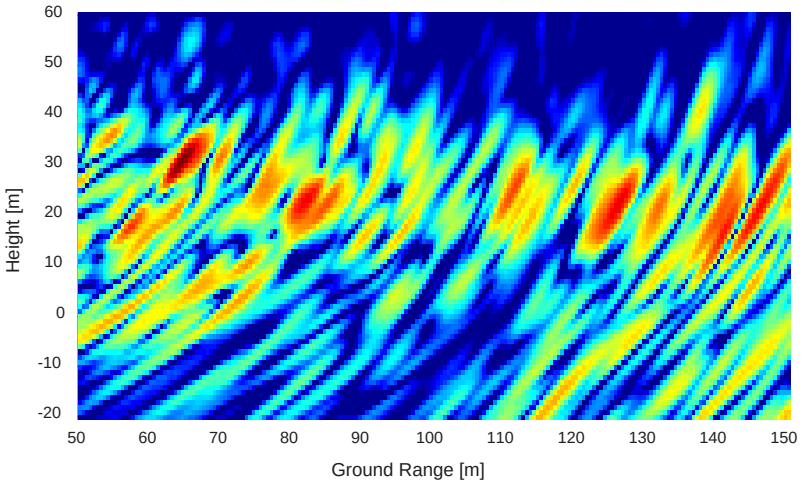
7 – day Tomograms – 1/7 rain day - VV



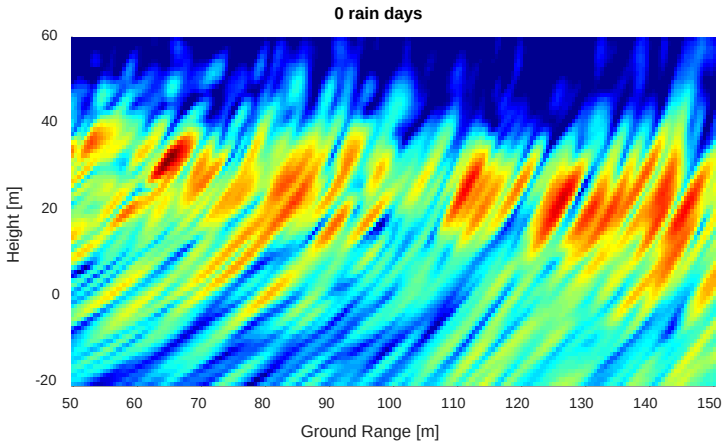
7 – day Tomograms – 2/7 rain day - VV



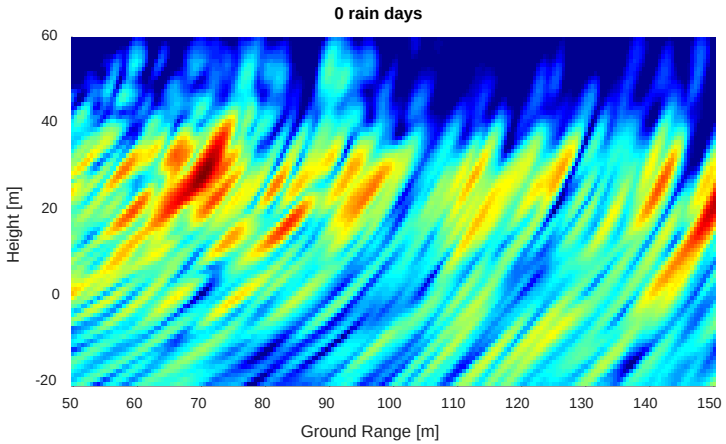
7 – day Tomograms – 3/7 rain day - VV



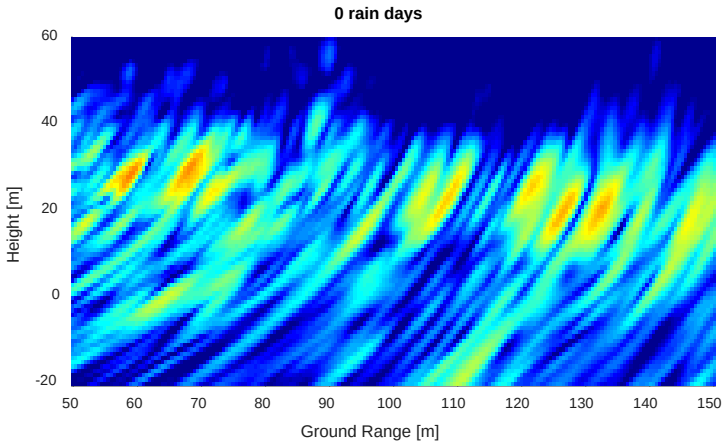
Average 7-day tomograms - VV



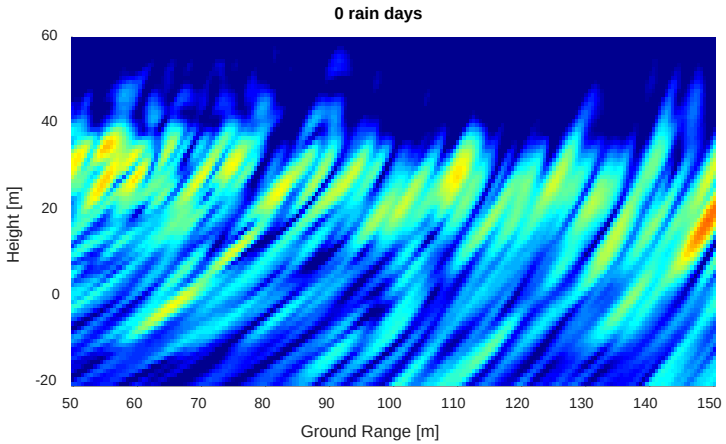
Average 7-day tomograms - HH



Average 7-day tomograms - HV

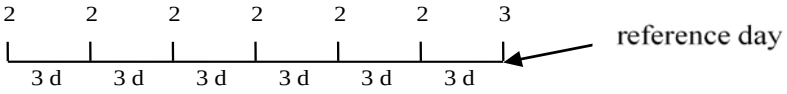


Average 7-day tomograms - VH



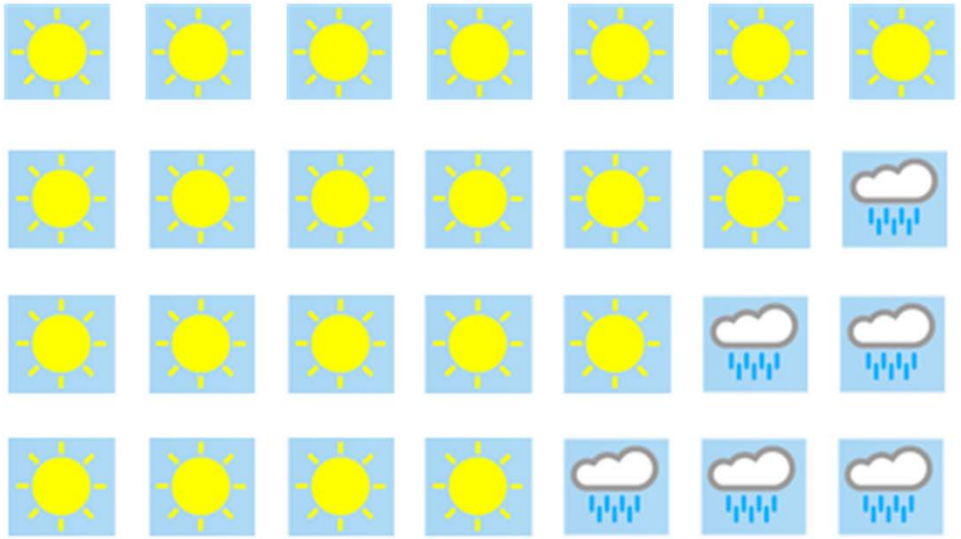
Relative RMSE w.r.t. Instantaneous tomograms

$$RMSE = \sqrt{\frac{1}{N}\sum_{i}\left(P_7^i - P_0^i\right)^2} \qquad RMSE_{rel} = \frac{RMSE}{\langle P_0 \rangle}$$



P_0^i = *reference (instantaneous) tomogram power*

P_7^i = *7-day tomogram power*



N = 5 7-day Tomograms

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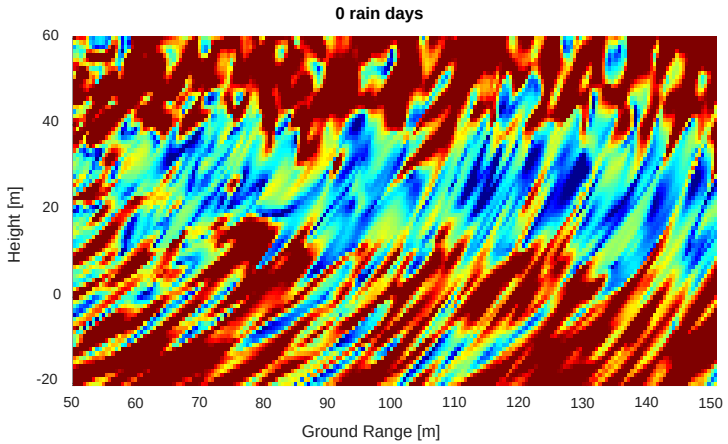
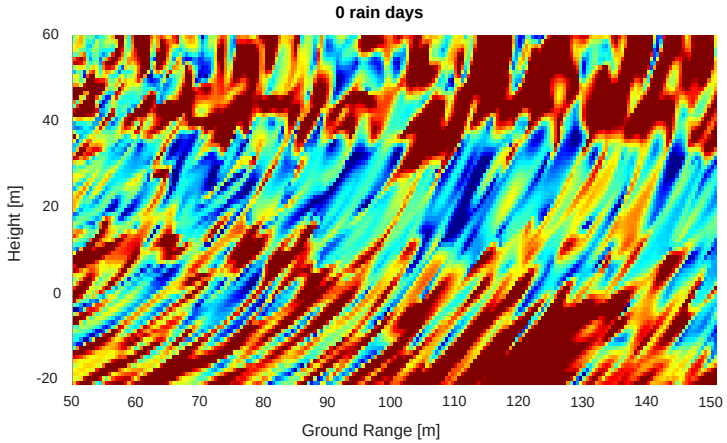
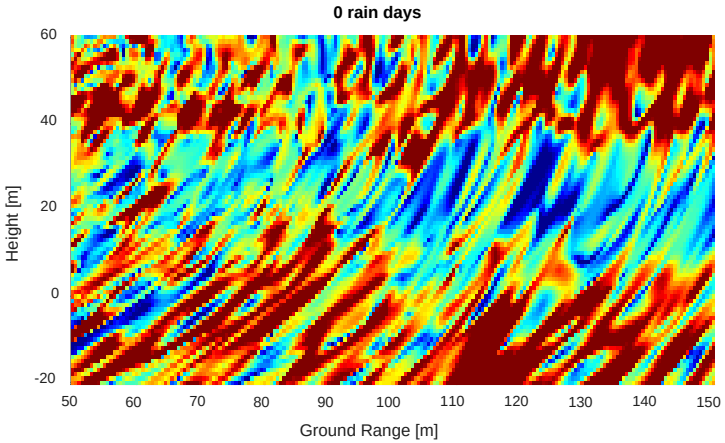
Relative RMSE– VV



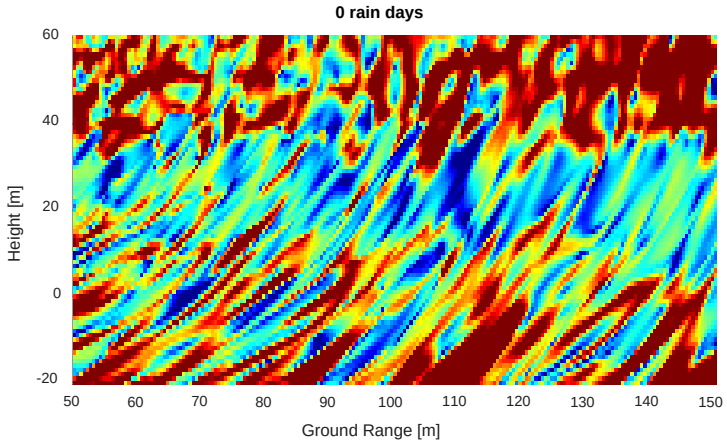
Relative RMSE– HH



Relative RMSE– HV

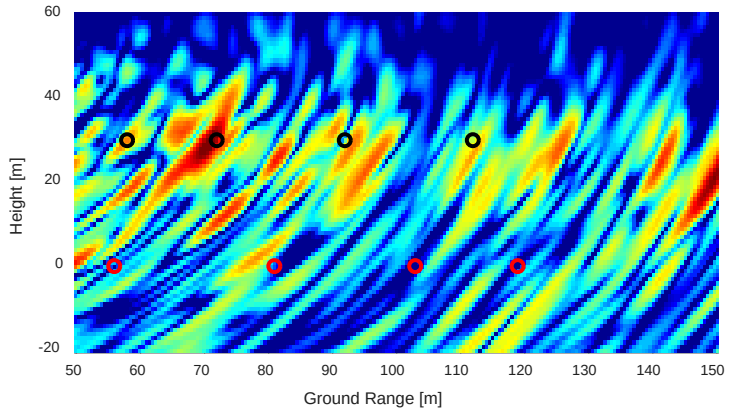


Relative RMSE– VH

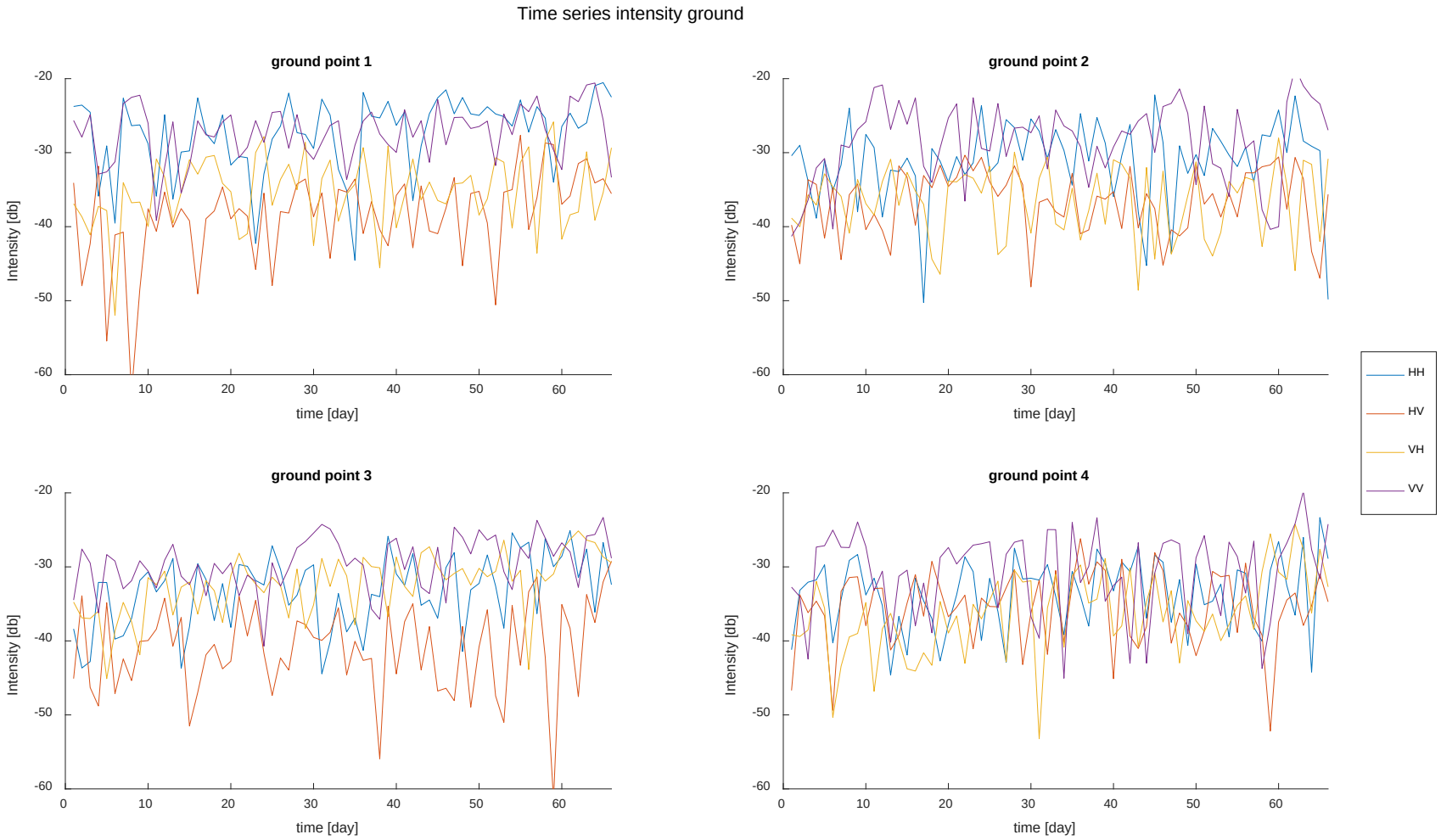


Time series intensity

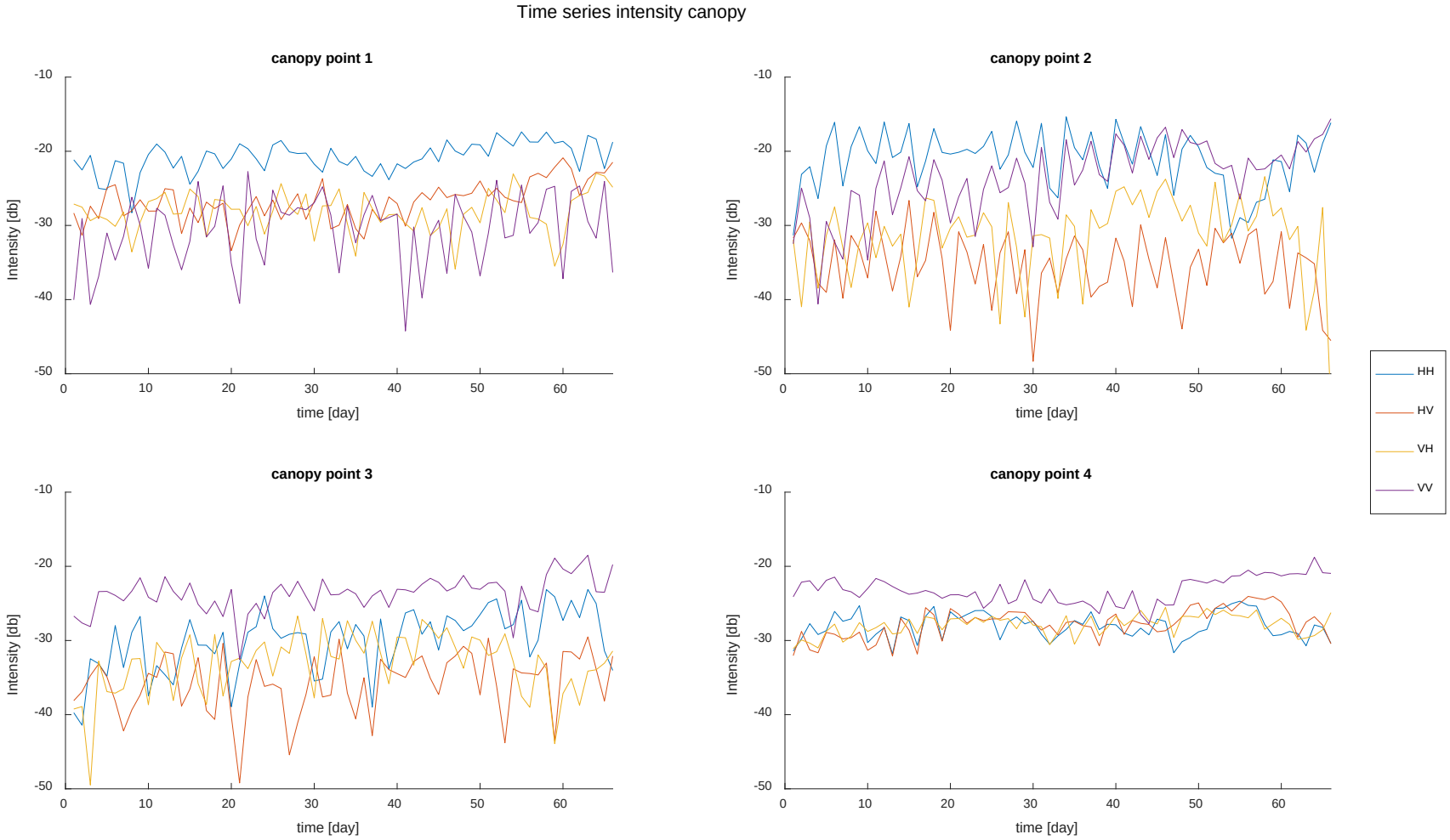
- 4 points at 30 m (canopy)
- 4 points at 0 m (ground)



Time series intensity ground

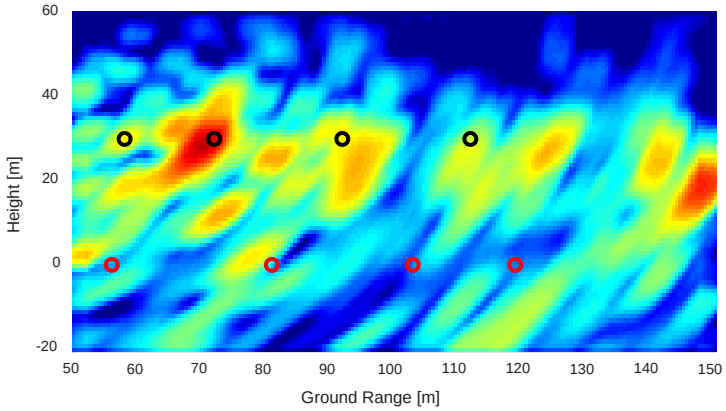


Time series intensity canopy

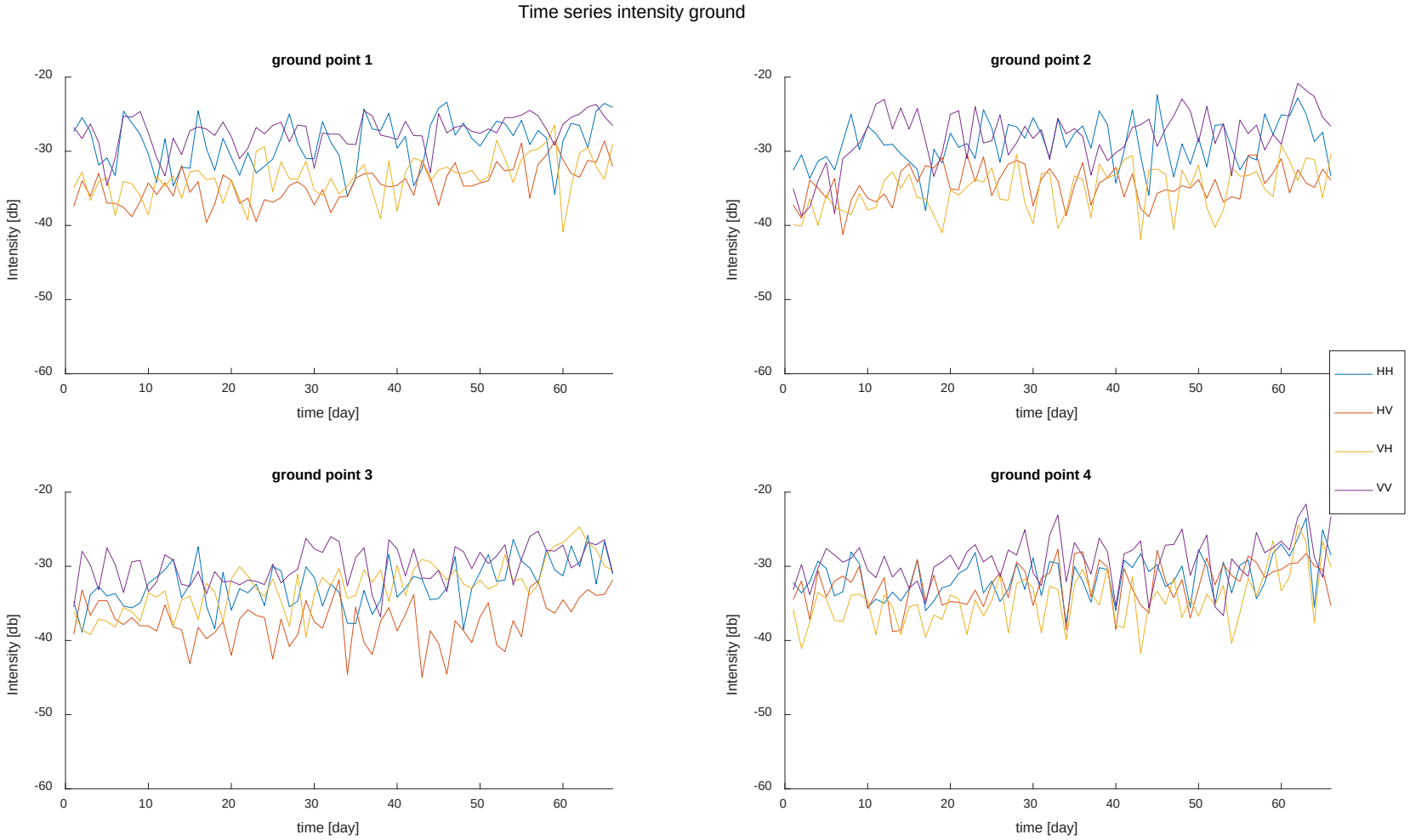


Multilooking

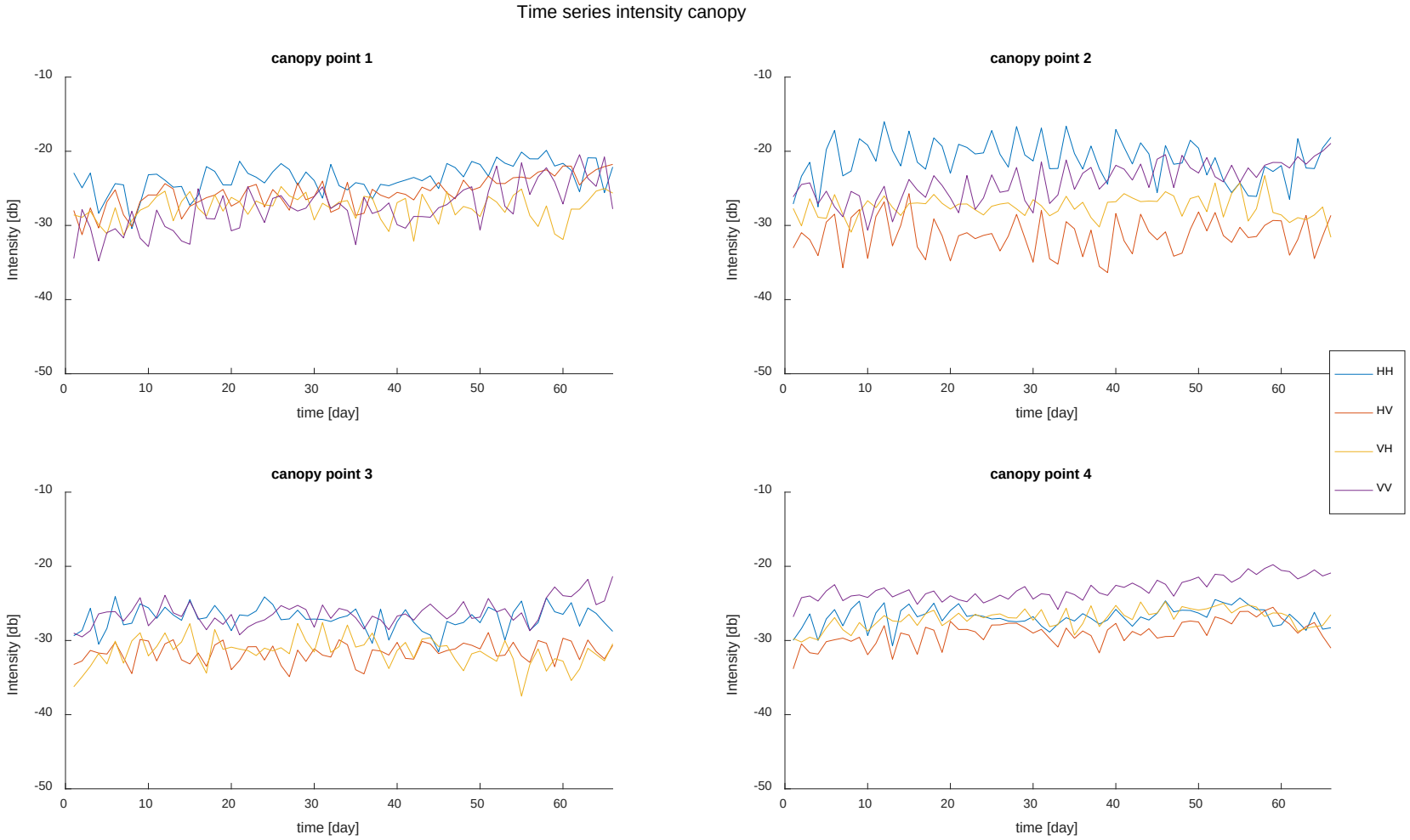
Multilooking is carried out by employing an averaging window of 3 × 5 m (height-ground range)



Time series intensity ground – multilooking



Time series intensity canopy – multilooking



Time series intensity relative standard deviation

$$\sigma = \sqrt{\frac{1}{N-1}\left(P_7^i - \bar{P}\right)^2} \qquad \sigma_{rel} = \frac{\sigma}{\bar{P}}$$

Without multilooking

(dB)

	HH	HV	VH	VV
G1	-1.3303	0.6809	-0.0593	-1.3327
G2	-0.0904	-1.1440	-0.6211	0.0211
G3	-0.2624	1.0142	-1.0985	-1.5446
G4	0.1471	-0.1926	1.3970	0.1341
C1	-3.7896	-2.0142	-2.3662	-0.5595
C2	-1.4536	-0.4614	-0.6374	-0.6876
C3	-1.0350	-1.3671	-1.1914	-2.8137
C4	-4.0021	-3.4681	-5.2880	-3.9227

With multilooking

(dB)

	HH	HV	VH	VV
G1	-1.7792	-1.9100	-1.6504	-3.7060
G2	-1.4521	-2.8327	-1.8024	-1.2443
G3	-1.2203	-1.7301	-0.6749	-2.5906
G4	-1.0641	-2.3218	0.6378	-1.0877
C1	-3.7763	-3.3532	-4.3509	-0.8766
C2	-2.2587	-2.5040	-4.3392	-2.5888
C3	-4.5715	-5.2726	-3.5342	-3.3916
C4	-5.2378	-4.3424	-5.4714	-4.4550

Time series intensity variation

$$\sigma_{rad} = \frac{\bar{P}+\sigma}{\bar{P}} = 1 + \sigma_{rel}$$

Without multilooking

(dB)

	HH	HV	VH	VV
G1	2.3959	3.3641	2.9808	2.3949
G2	2.9653	2.4759	2.7108	3.0209
G3	2.8811	3.5470	2.4957	2.3063
G4	3.0845	2.9151	3.7647	3.0779
C1	1.5163	2.1189	1.9864	2.7395
C2	2.3441	2.7857	2.7033	2.6801
C3	2.5236	2.3803	2.4553	1.8274
C4	1.4548	1.6136	1.1258	1.4775

With multilooking

(dB)

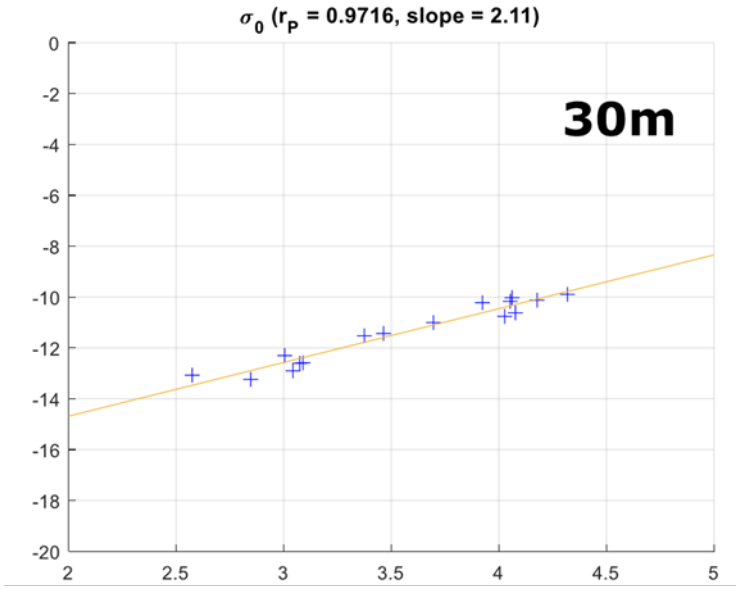
	HH	HV	VH	VV
G1	2.2112	2.1595	2.2630	1.5412
G2	2.3447	1.8209	2.2019	2.4326
G3	2.4429	2.2308	2.6860	1.9054
G4	2.5108	2.0028	3.3409	2.5004
C1	1.5203	1.6496	1.3583	2.5941
C2	2.0262	1.9363	1.3615	1.9060
C3	1.3002	1.1294	1.5932	1.6375
C4	1.1374	1.3606	1.0846	1.3306

Conclusions

The presented results were obtained

- Without any amplitude/phase calibration to compensate for changes at the antennas

- VH Tomography appears to be the least disturbed by weather variations (HV is most likely affected by leakage)
- Intensity variations are within 3 dB without multilooking, which should translate into a biomass error of ≈ 60 tons/ha, with multilooking the variations are within 2 dB, translate into a biomass error of ≈ 50 tons/ha (less than 20%)



AGB
Hundreds of tons per hectare

Thank you for your attention