WACORE

Woody Plant Water Content Assessment via Microwave Corner Reflection

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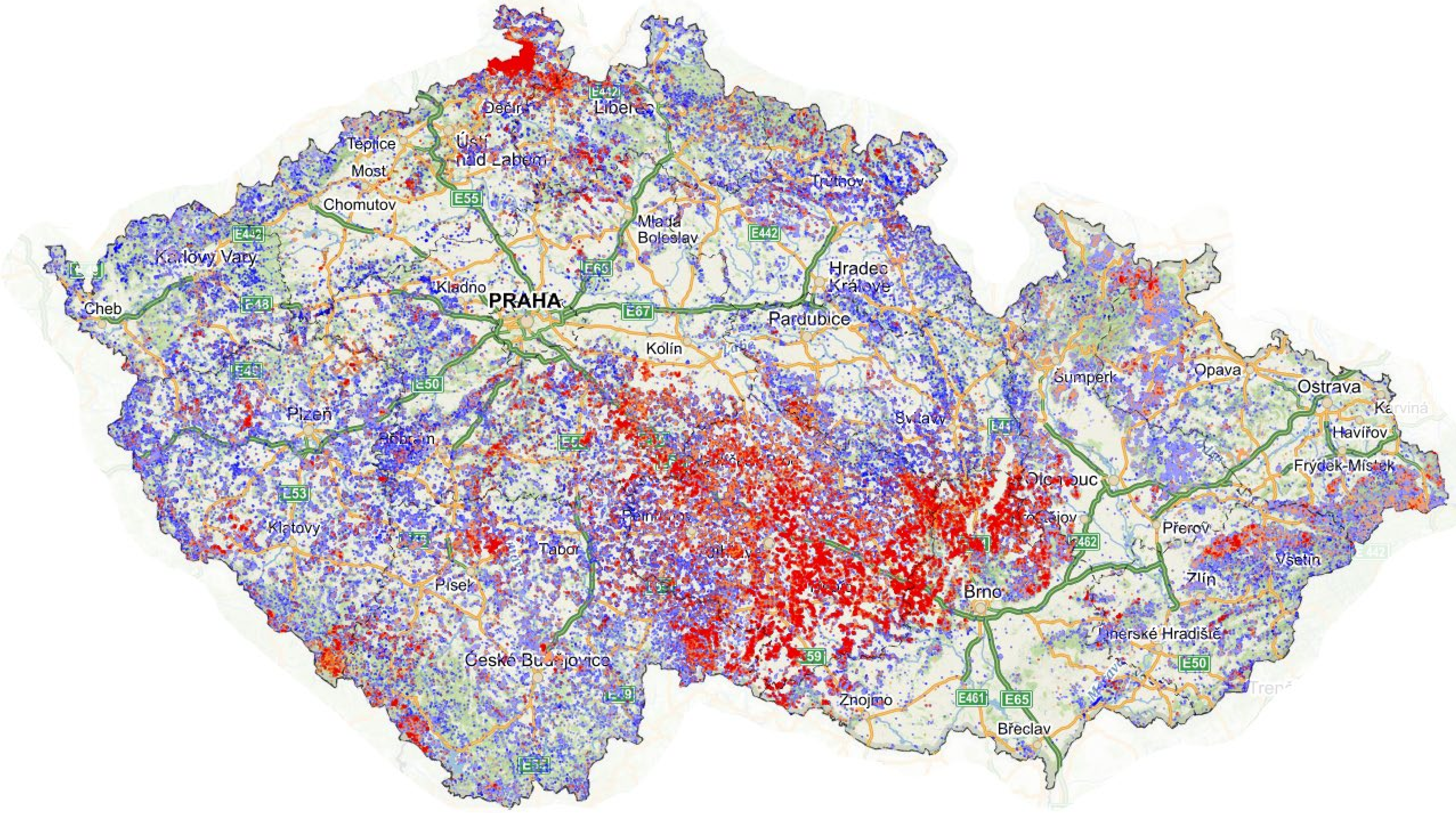
PRAHA
Teplice
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Chomutov
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Mladá Boleslav
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Pardubice
Kolín
Šumperk
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Frýdek-Místek
Plzeň
Svitavy
Klatovy
Tábor
Přerov
Zlín
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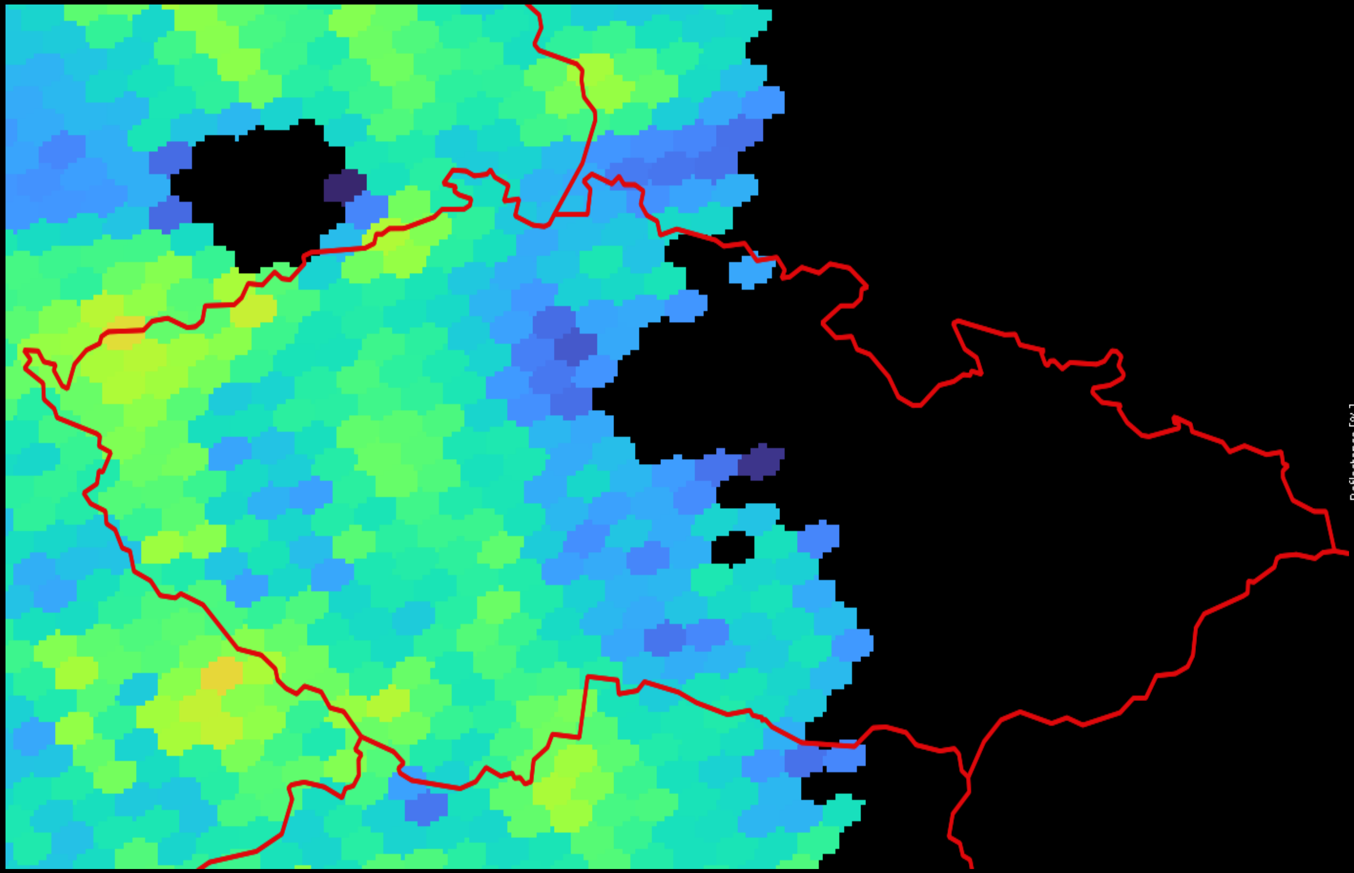
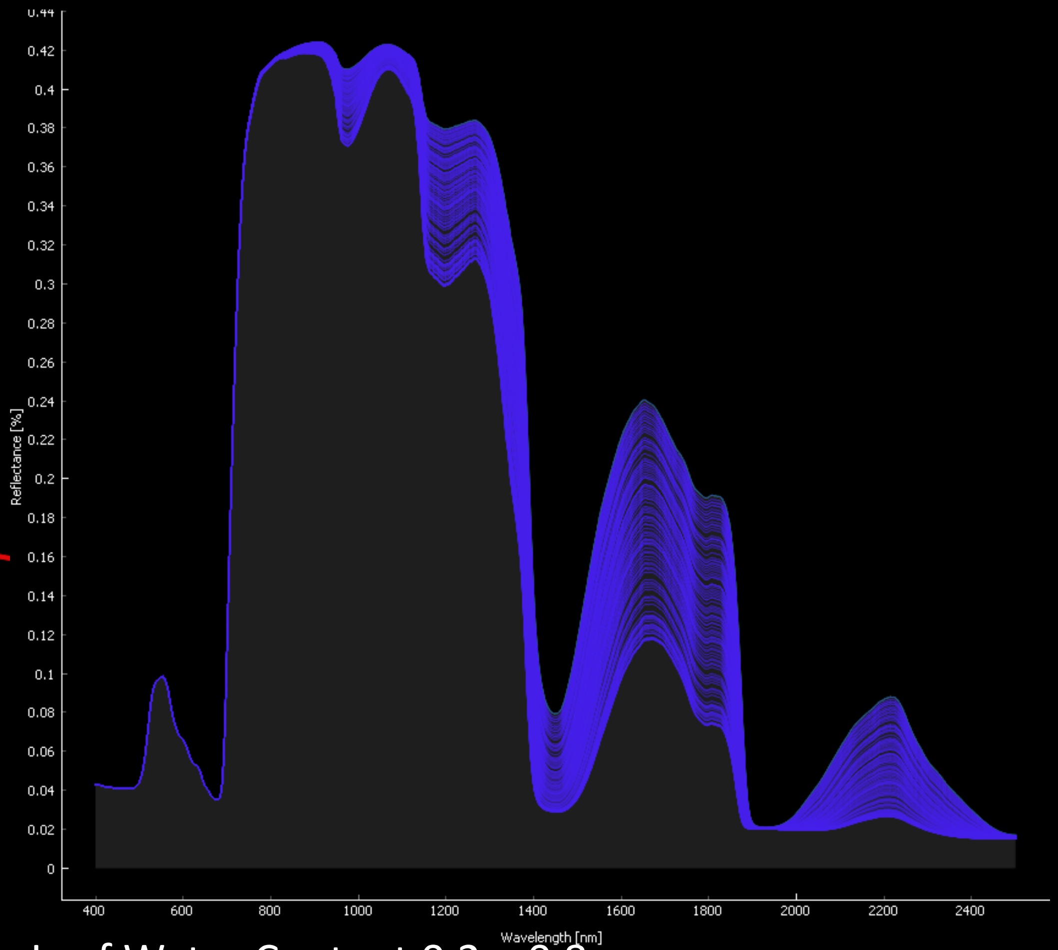
E59

SMOS VOD



Prospect Pro



Leaf Water Content 0,2 – 0,8 mm

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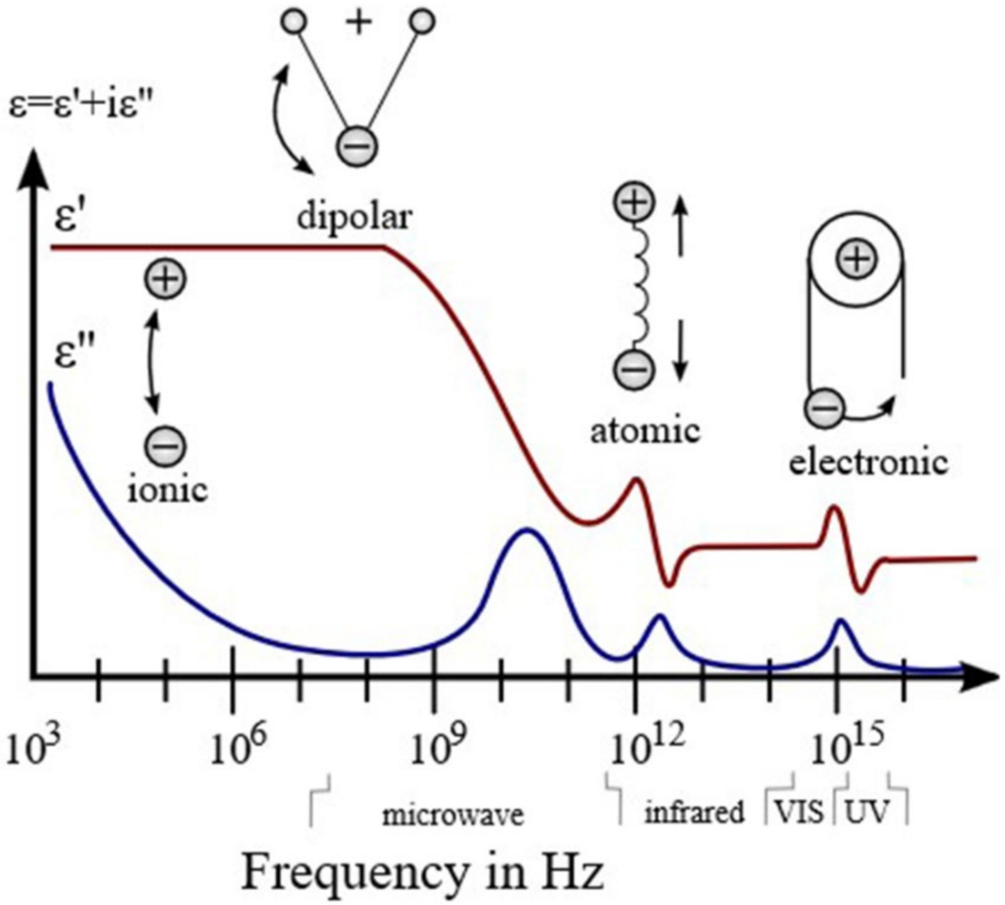
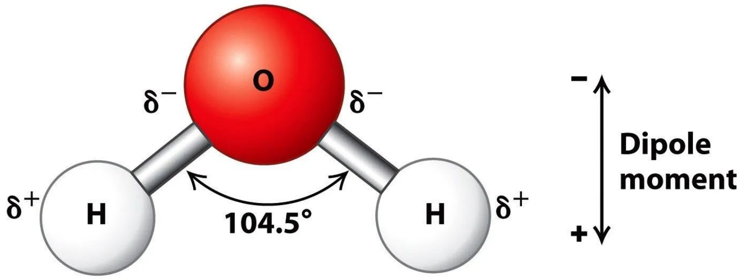
„If you are trying to assess wetness from active microwave sensors you are in deep shi*.“

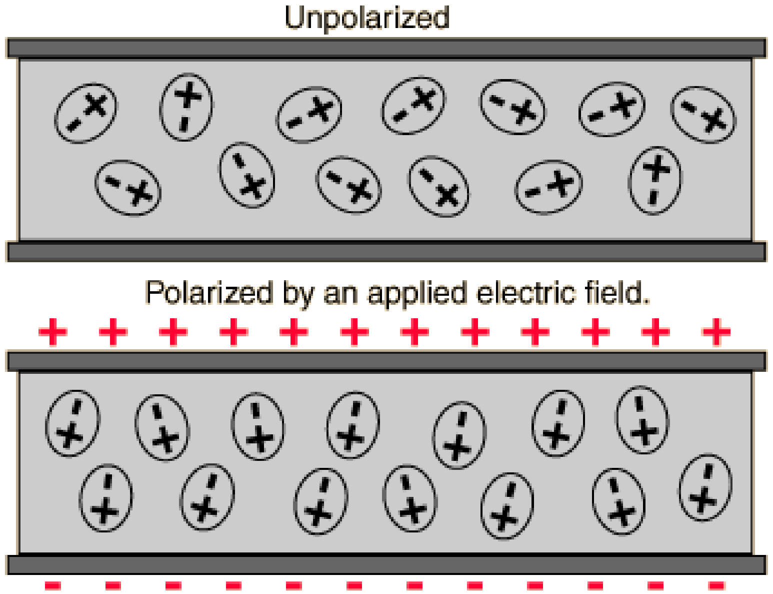
Dr. Yann Kerr - LPS2022 - Investigator for soil moisture ESA

How we detect water



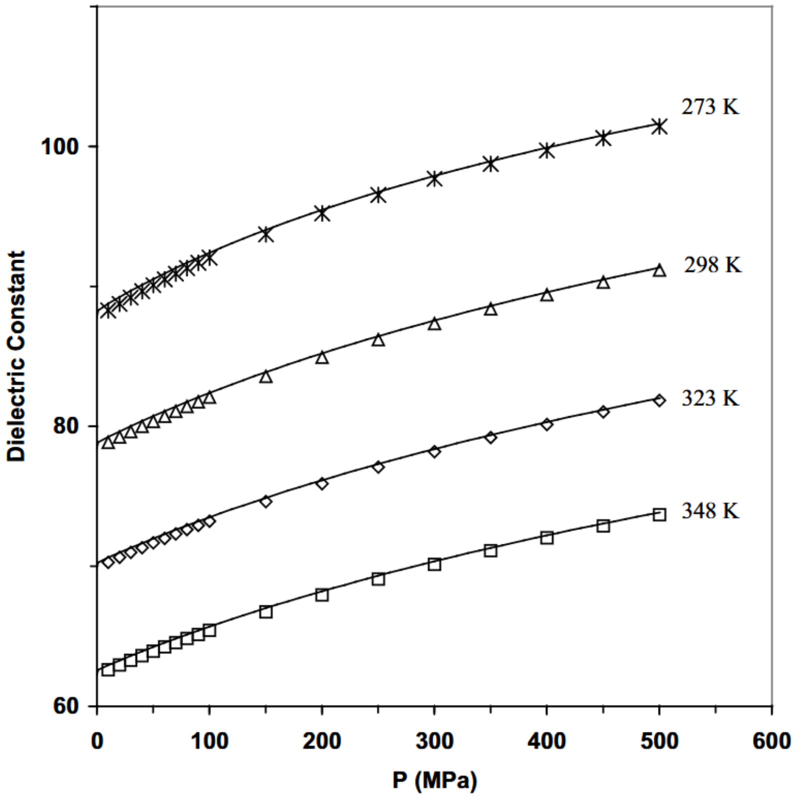


https://alevelbiology.co.uk/notes/water-structure-properties/



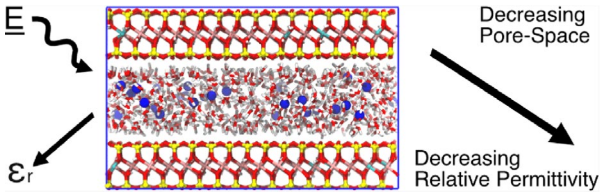
https://en.wikipedia.org/wiki/Permittivity

Pressure & Temperature



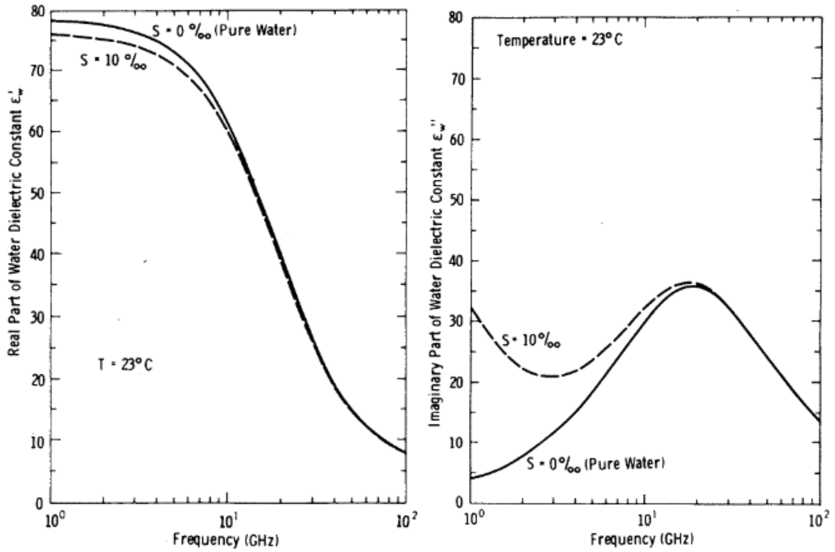
Braz. J. 2004

Decrease in relative permittivity with decreasing pore spacing



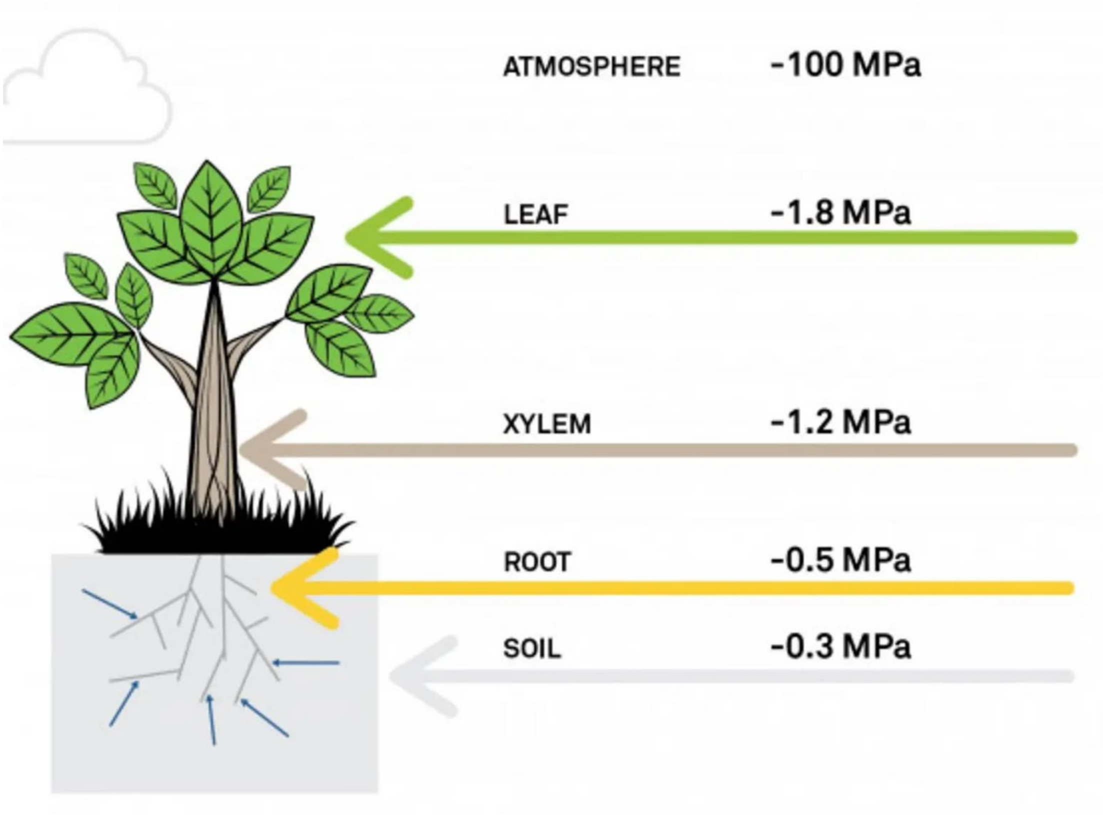
Underwood and Bourg 2022

The effect of salinity on the dielectric constant of water for (a) ϵ‘ and ϵ‘‘

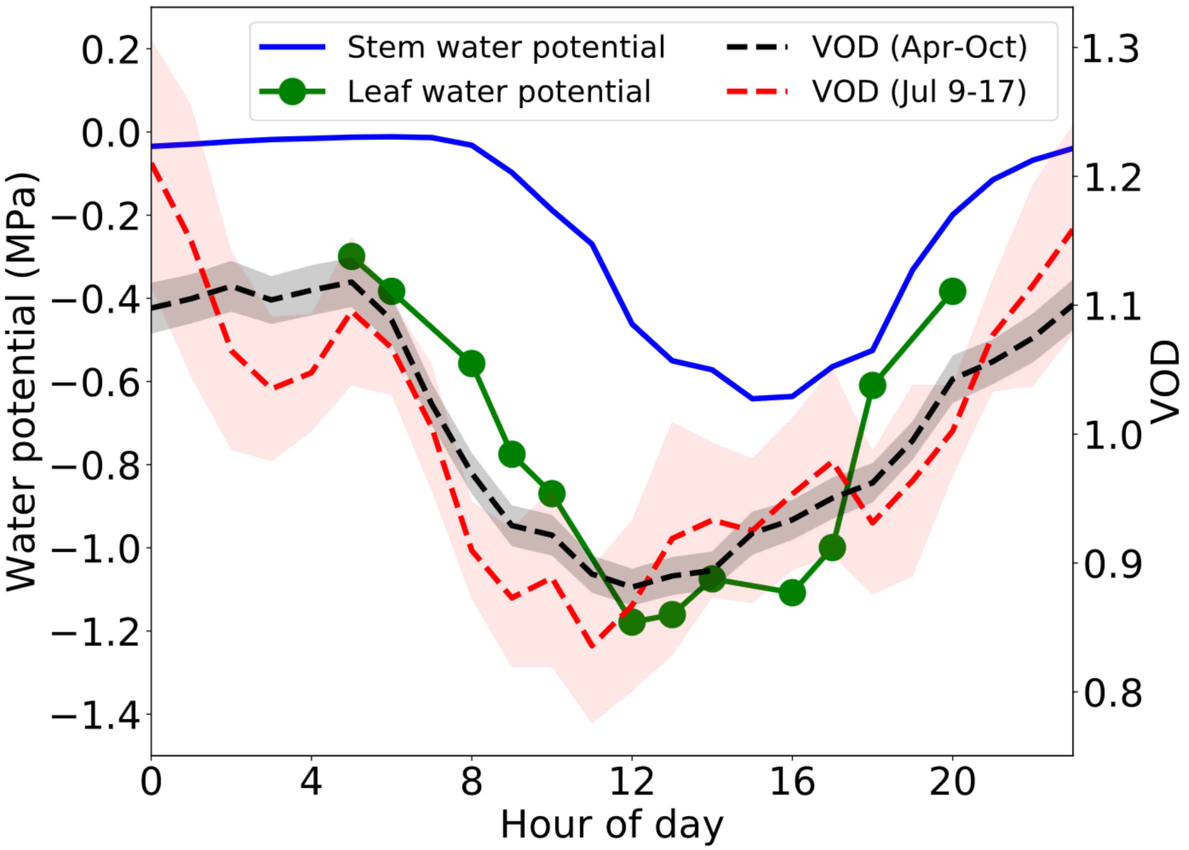


Ulaby & Jedlicka 1984

Long-term vs short-term changes in VOD



https://metergroup.com/education-guides/the-researchers-complete-guide-to-water-potential/



Holtzman et. al. 2021.

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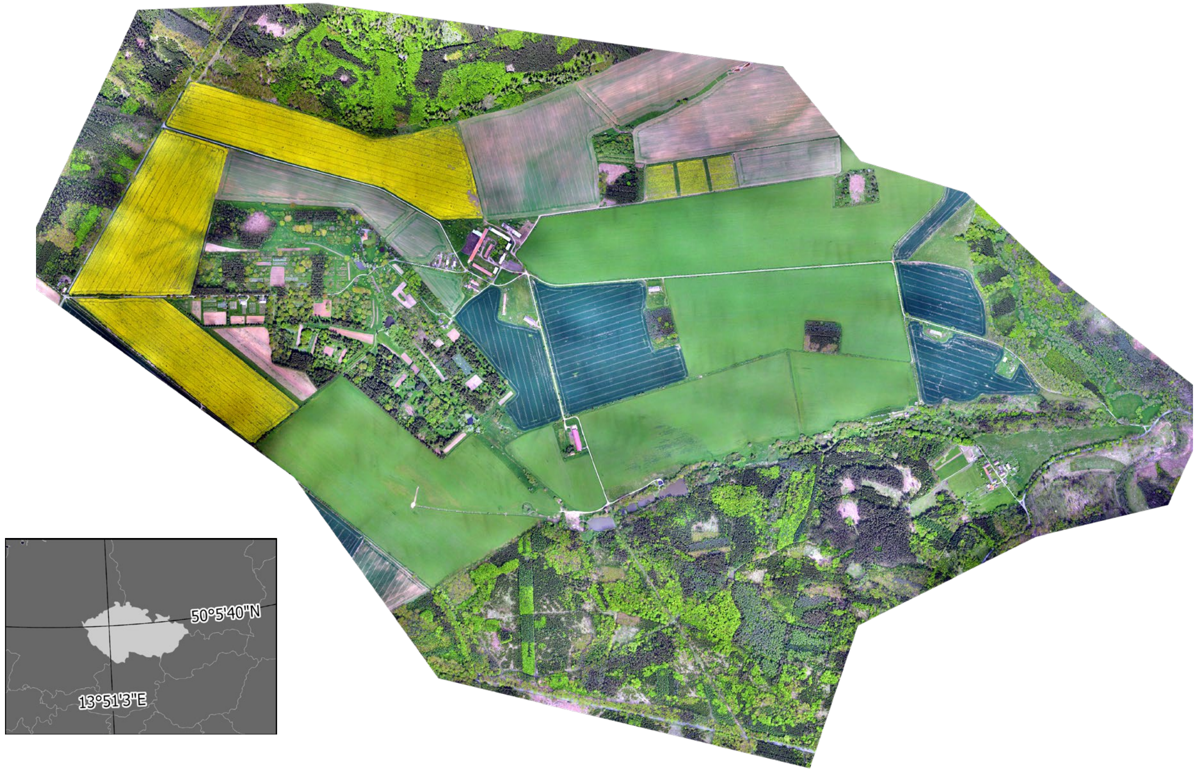
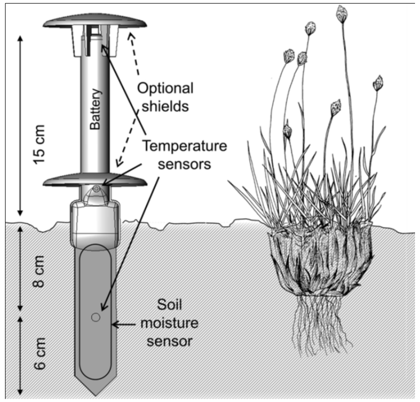
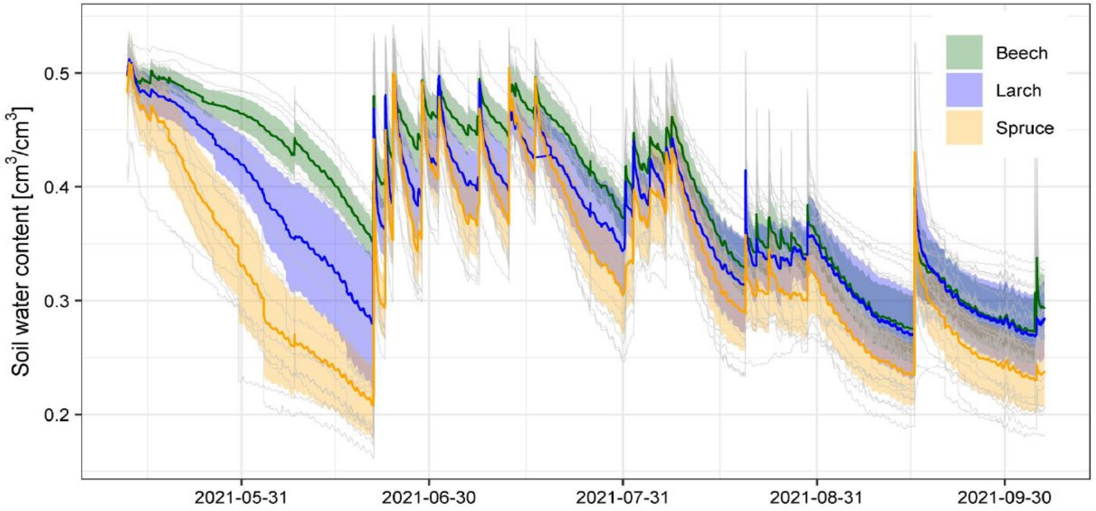
Amalie

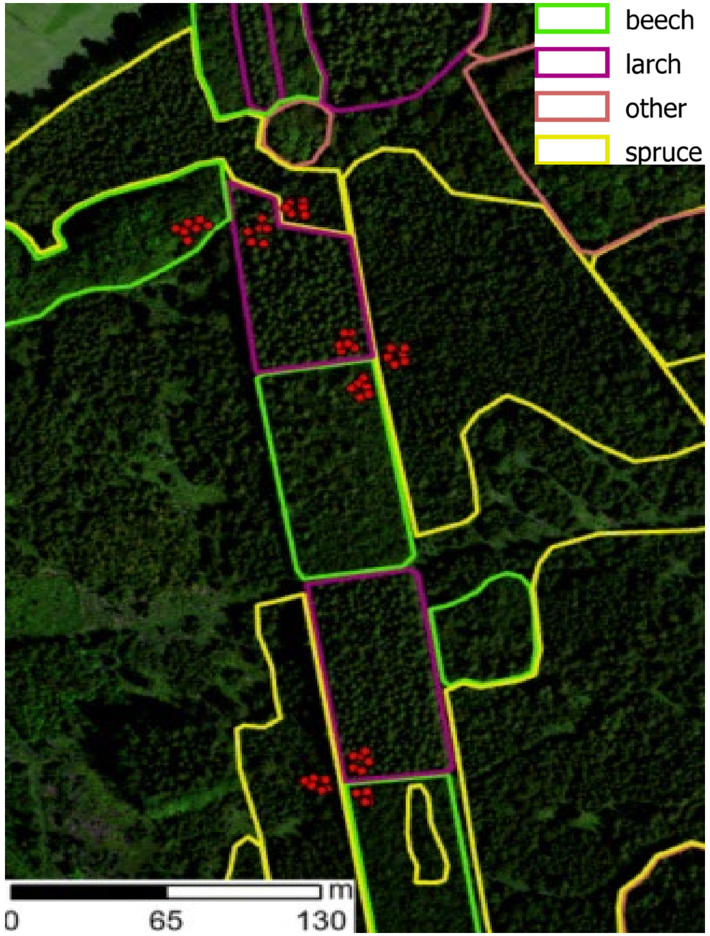


Tharandter Forest

In situ data – 38 climatic stations







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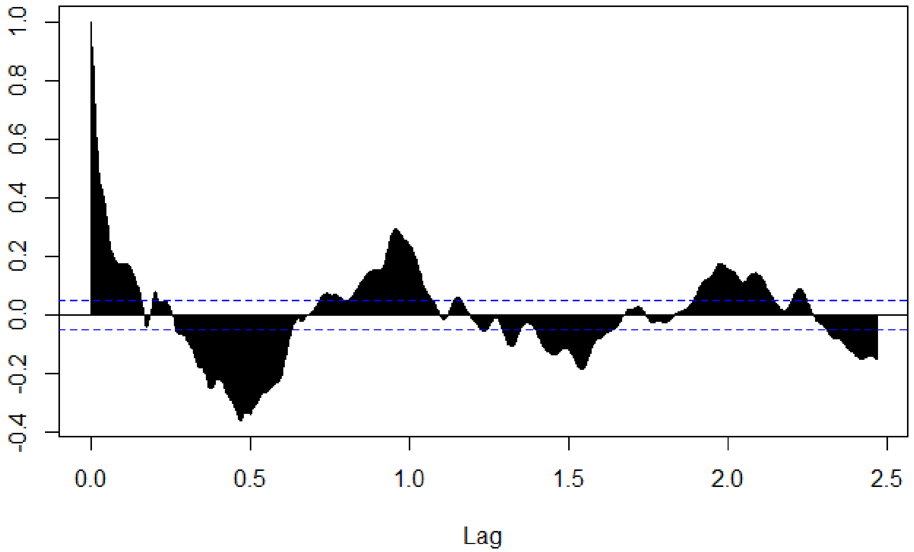
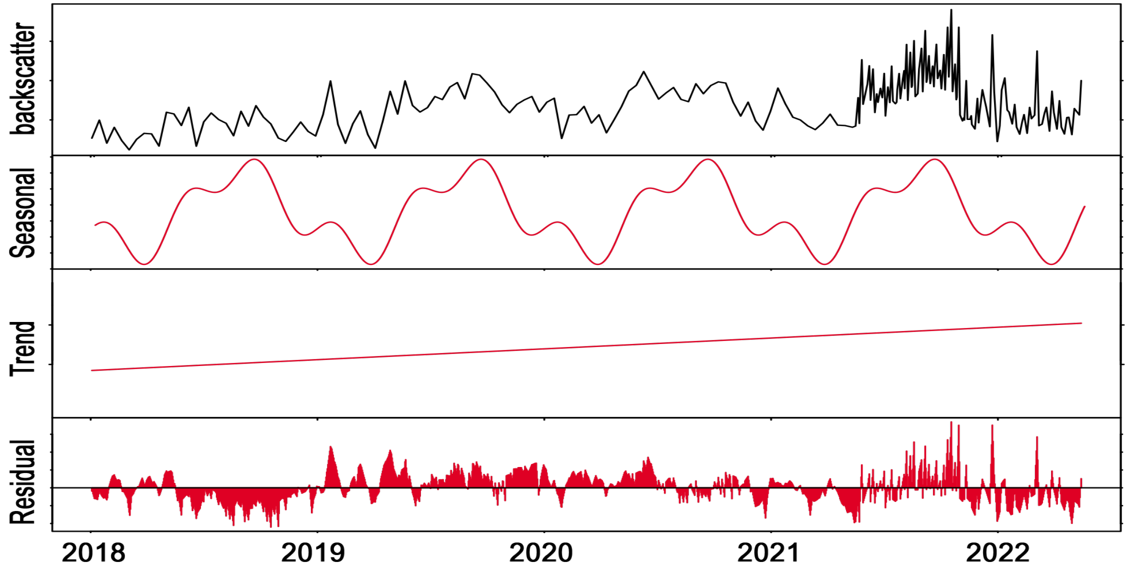
The assumptions

- 225 Sentinel-1 images VV, VH RTC
- Sentinel -1 C band will have limited and varying penetration
- The canopy will react on the wetness (with some delay)
- Significant effect of plant phenology





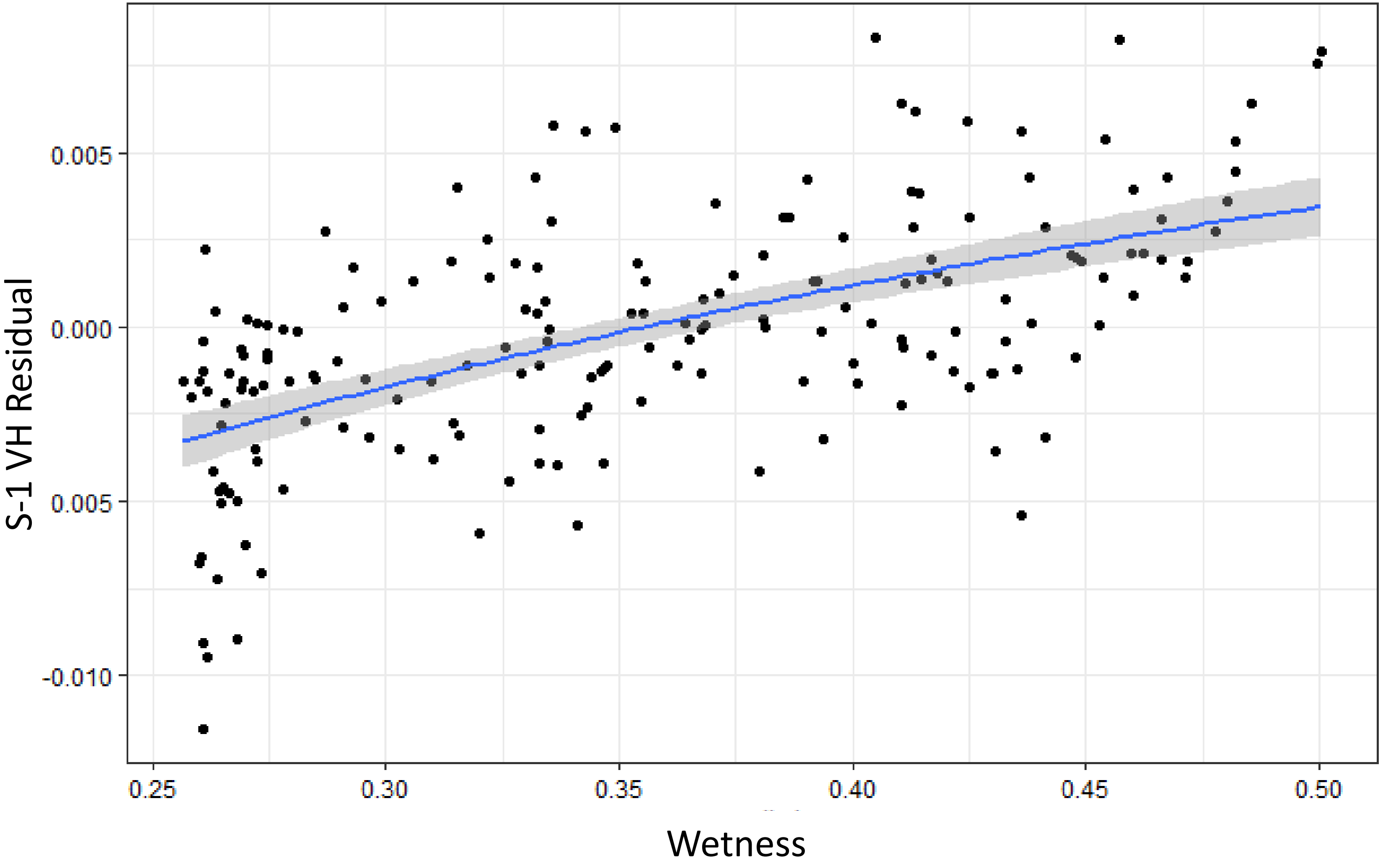
First results
R^2

- The backscatter signal corresponds to the wetness best in Winter
- VH corresponds better than VV

			0-15 cm	15-30 cm
Spring	VH	beech	0.28337	0.26568
	VH	larch	0.06146	0.07365
	VH	spruce	0.02192	0.01263
	VV	beech	0.06612	0.0622
	VV	larch	0.00023	0.0019
	VV	spruce	0.00521	0.00063
Summer	VH	beech	0.1639	0.11978
	VH	larch	0.02974	0.0429
	VH	spruce	0.03513	0.04363
	VV	beech	0.15852	0.13025
	VV	larch	0.02013	0.02293
	VV	spruce	0.02841	0.05768
Autumn	VH	beech	0.49239	0.29461
	VH	larch	0.16079	0.26741
	VH	spruce	0.12833	0.20459
	VV	beech	0.19623	0.25356
	VV	larch	0.10911	0.18921
	VV	spruce	0.0989	0.18802
Winter	VH	beech	0.17114	0.06257
	VH	larch	0.38419	0.27522
	VH	spruce	0.4548	0.29217
	VV	beech	0.17936	0.06831
	VV	larch	0.47007	0.4302
	VV	spruce	0.50008	0.35636

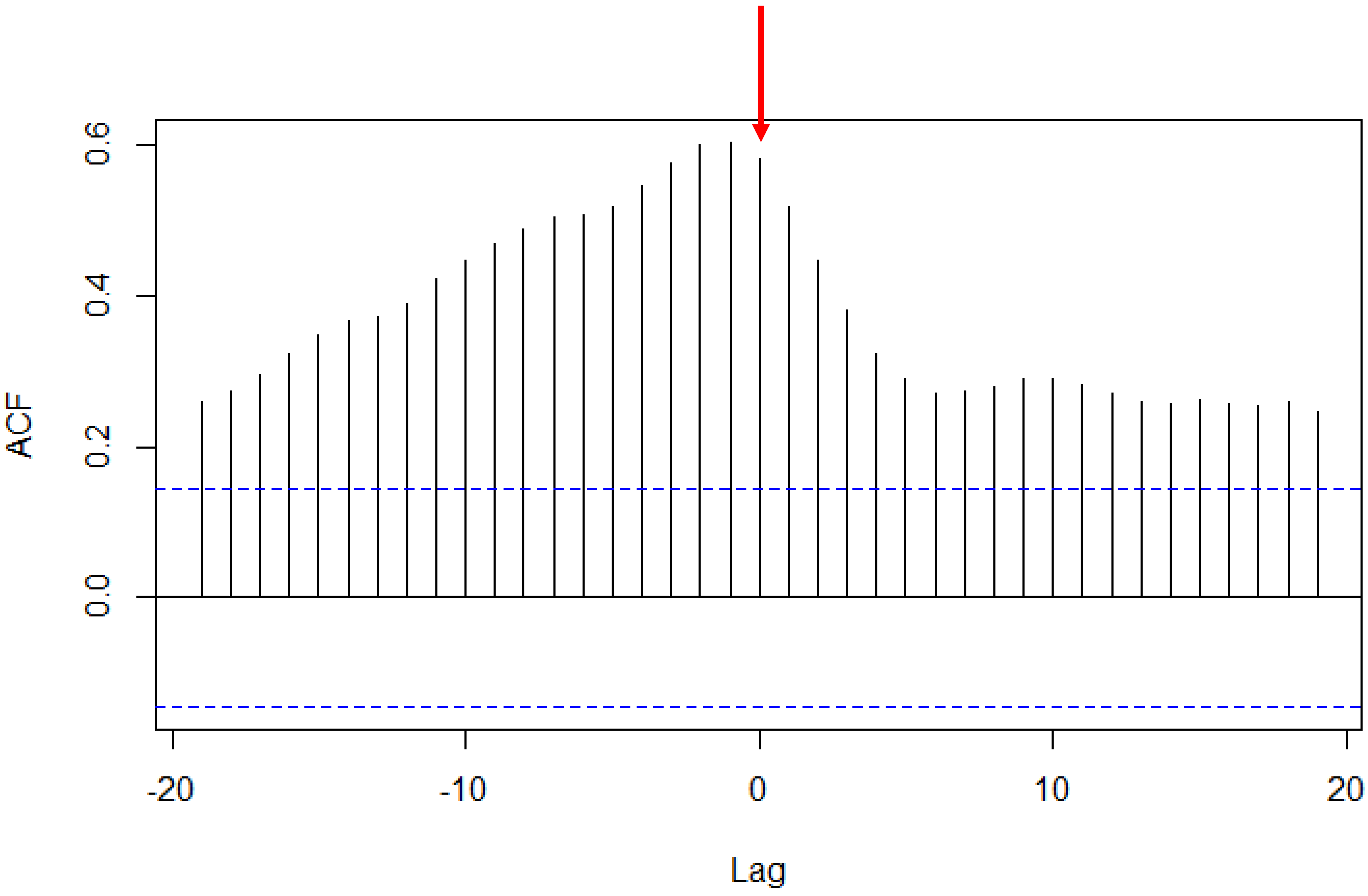
First results

- The backscatter signal corresponds to the wetness
- VH corresponds better than VV (spearman 0.58 vs. 0.43)
- R^2 0.34



Lag between wetness and backscatter

The lag is between 1 – 2 days



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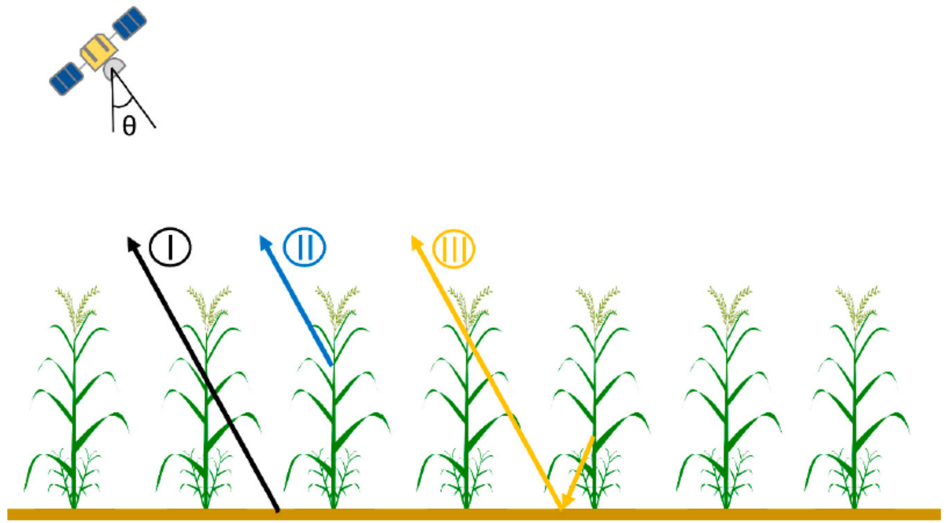
MSCA POSTDOCTORAL FELLOWSHIPS COFUND

Water Cloud Model



$$\sigma^0 = \sigma^0_{veg} + t^2\sigma^0_{soil} + \cancel{\sigma^0_{soil+veg}}$$

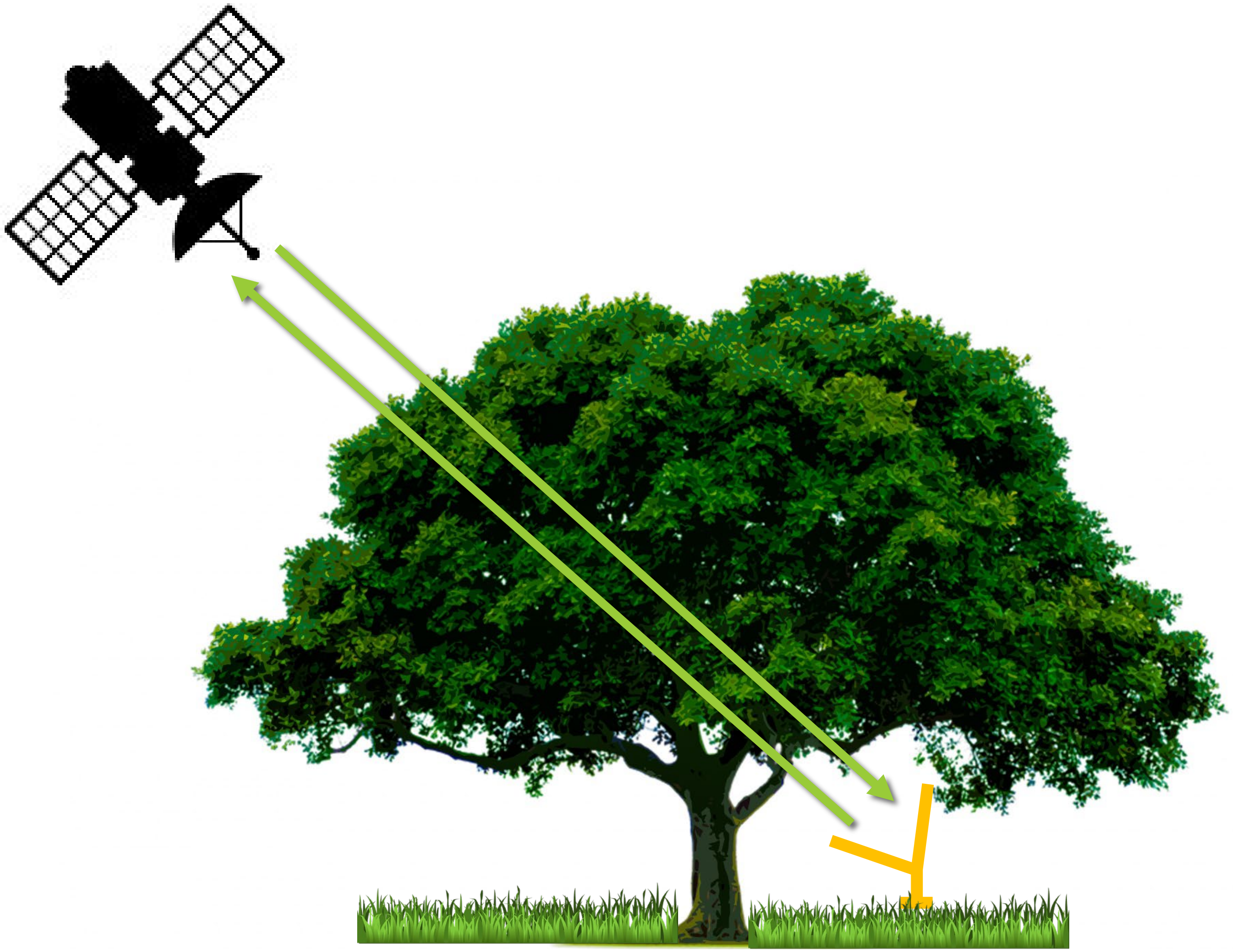
$$\sigma^0_{veg} = AV_1\left(1 - t^2\right)\cos(\theta)$$

$$\sigma^0_{soil\ (dB)} = C + D \cdot SM$$

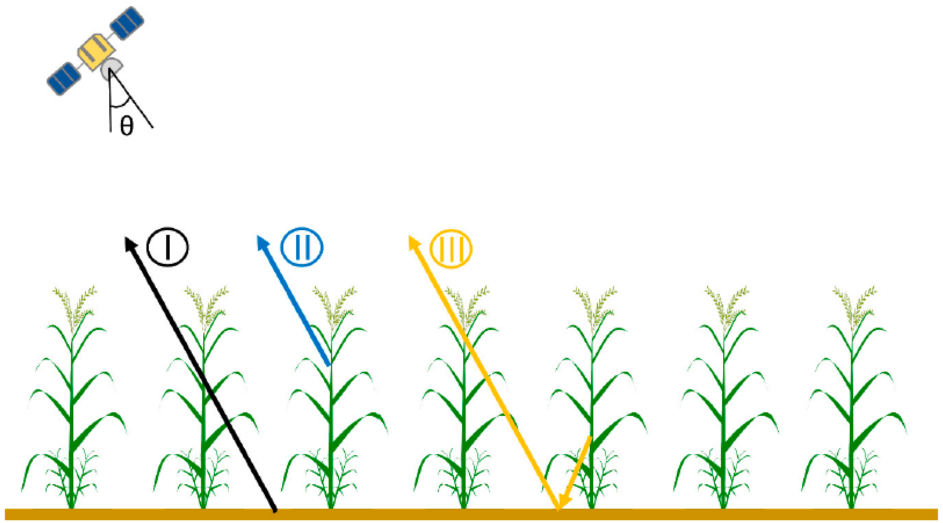
$$t^2 = BV_2$$

Solution!

- Reflection from the corner reflector is **predictable**



Water Cloud Model



$$\sigma^0 = \sigma^0_{veg} + t^2\cancel{\sigma^0_{soil}} + \cancel{\sigma^0_{soil+veg}}$$

$$\sigma^0_{veg} = AV_1\left(1 - t^2\right)\cos(\theta)$$

$$\cancel{\sigma^0_{soil\ (dB)} = C + D \cdot SM} \Rightarrow$$ Known value

$$t^2 = BV_2$$

Will it work?

Tower RADAR

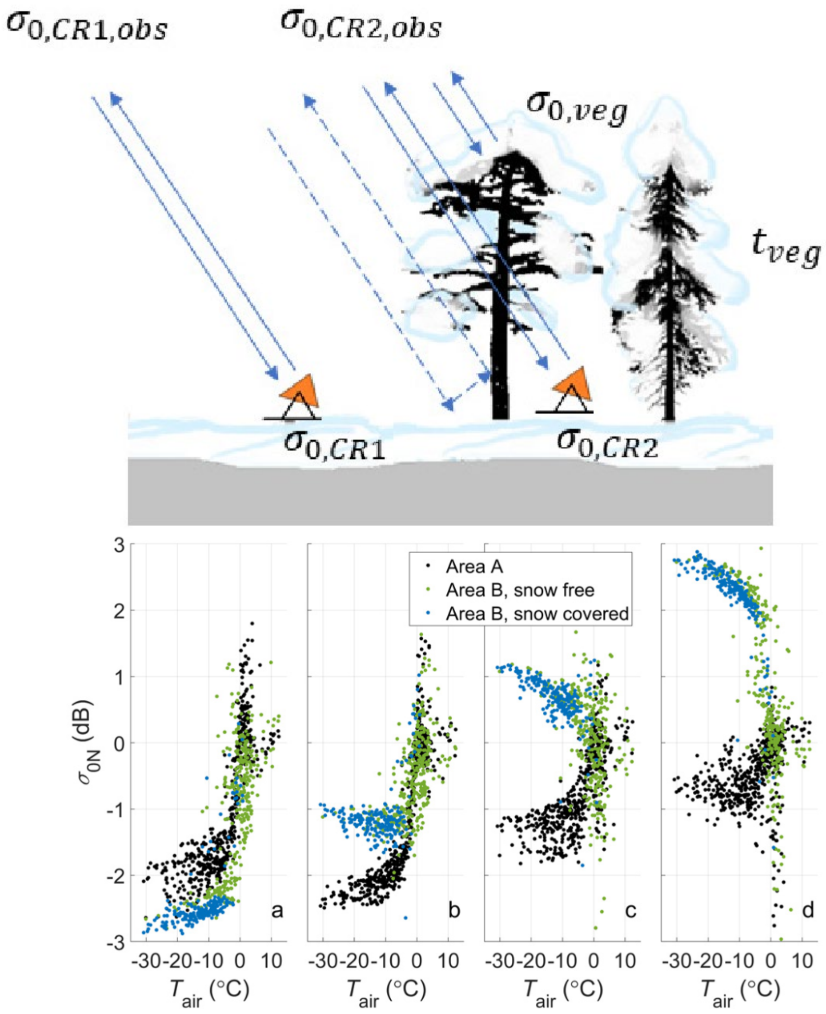


Fig. 7. σ_{0N} from Areas A and B (refer to Fig. 1) against T_{air} at (a)–(d) L-, S-, C-, and X-bands. σ_{0N} normalized to observed $< \sigma_0 >$ at $T_{air} > 5$ °C (summer conditions).

Lemmetyinen et. al. 2022

Airborn SAR

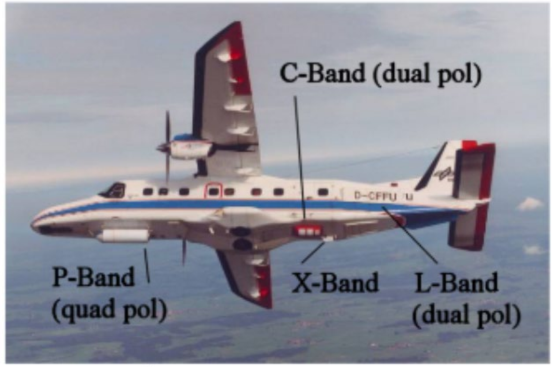
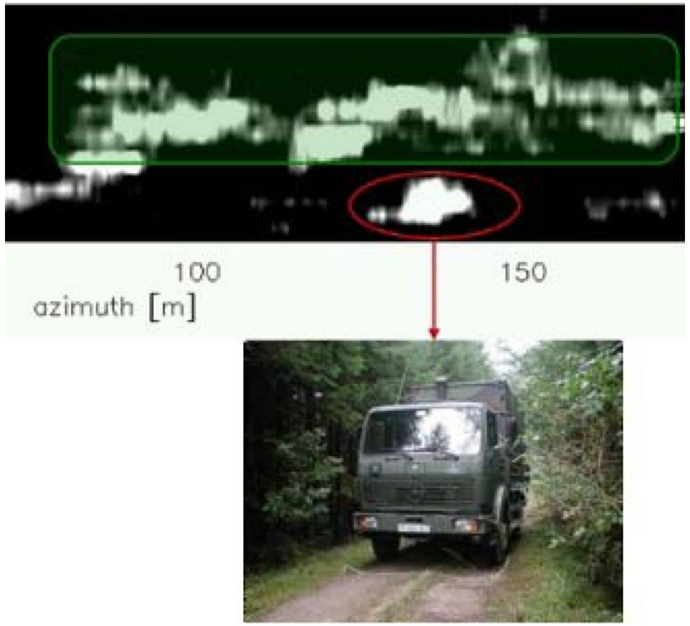
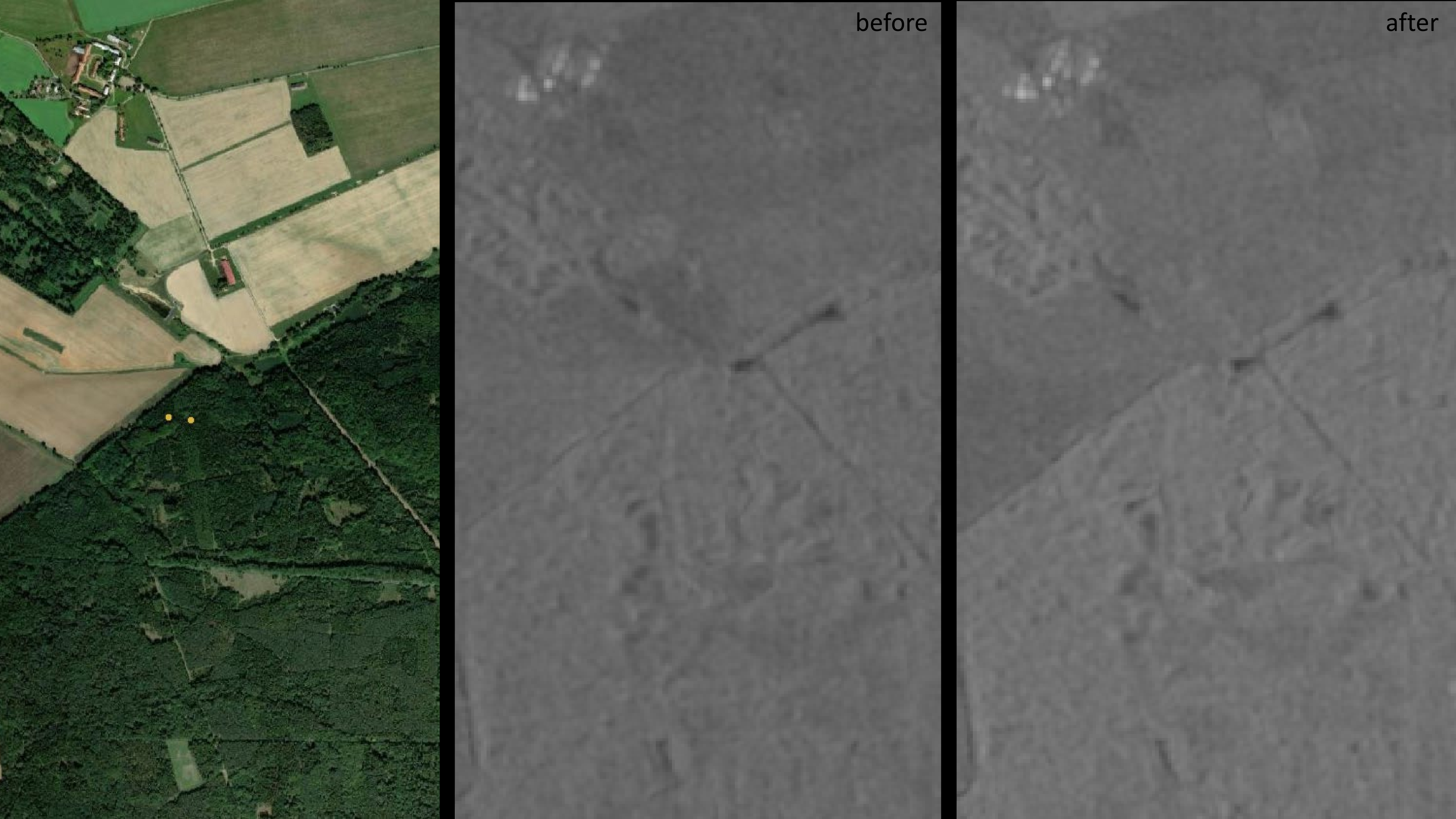


Figure 1: The DLR E-SAR system.



Horn, Ralf, et al. 2008

4. May 2023


before
after

Design of corner reflector
signal-to-clutter ratio (SCR)

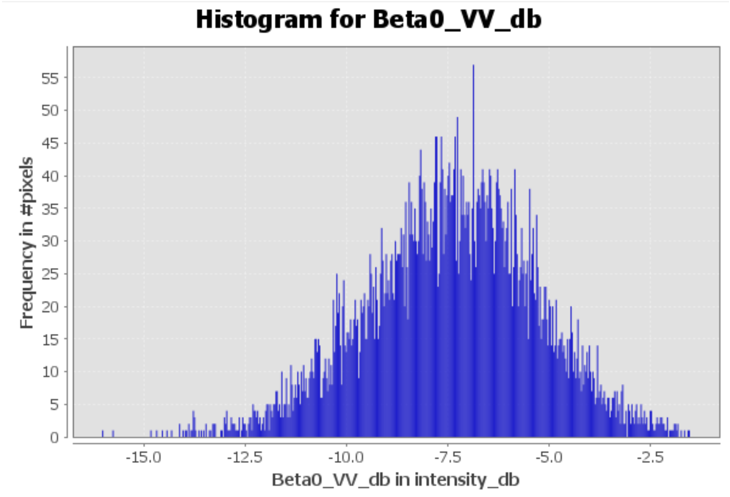
$$SCR = \frac{\sigma_T}{\langle \sigma_C \rangle} = \frac{\sigma_T}{\langle \sigma^0 \rangle A}$$

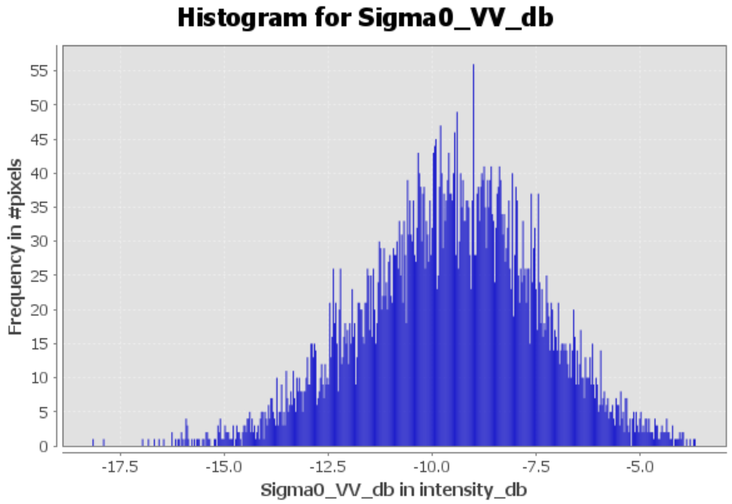
SCR should be <20;30> dB
Curlander and McDonough, 1991; *Freeman*, 1992

transmissivity (γ) *<-6; -7.5> dB*
Unterholzner 2023, Lemmetyinen 2021

$\mathbf{A_{ground}}$ = 80,7m (19dB)

$\boldsymbol{\sigma_{clutter}}$





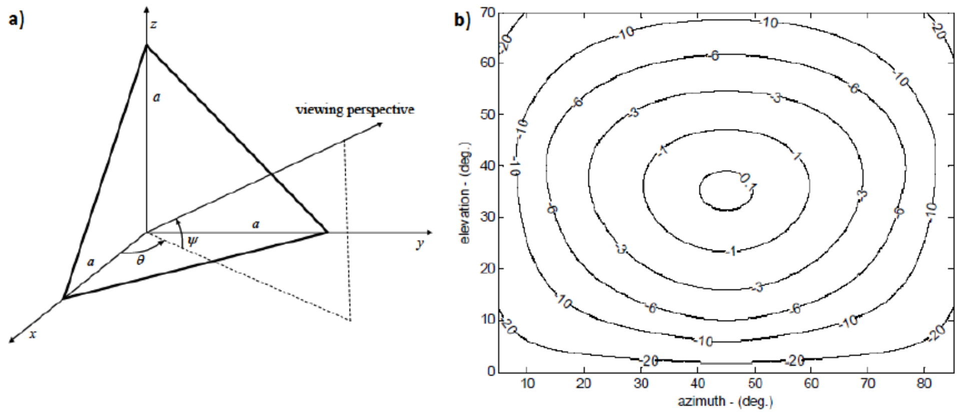


Figure 2.7: a) Viewing geometry of a trihedral CR at boresight. b) The RCS response of a triangular trihedral CR as a function of azimuth (θ) and elevation (ψ) angle relative to the peak RCS. a is known as the inner leg dimension. After Doerry and Brock [2009].

SCR [dB]=(σ_{target}[dB] + *γ[dB])* −($\sigma_{clutter}$[dB] + A_{ground}[dB])

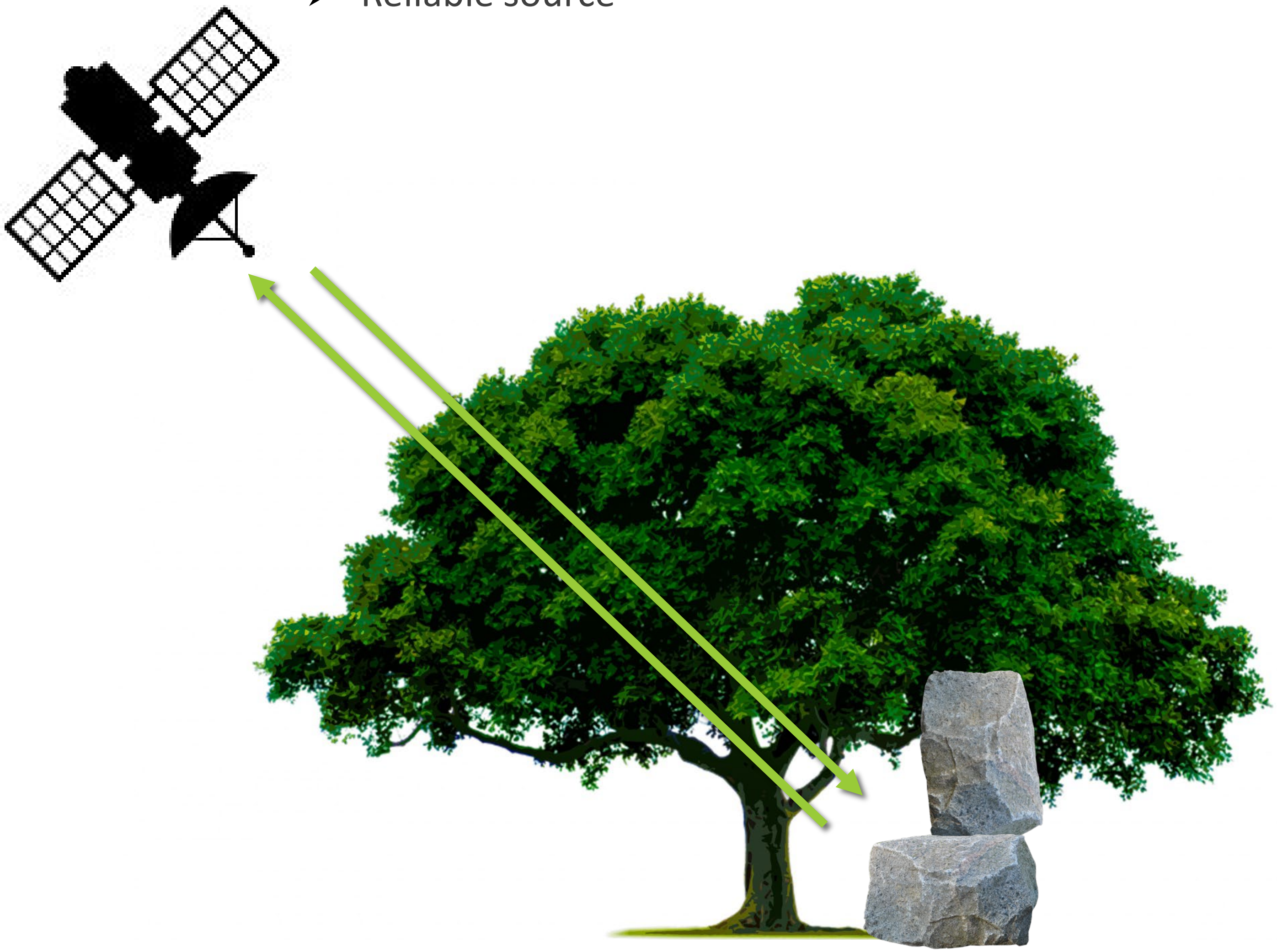
20 = RCS_t – 7.5 –(-10 + 19) => RCS_t = 36.5 => **minimal 1.3 m Corner reflector**

30 = RCS_t – 7.5 –(-10 + 19) => RCS_t = 46.5 => **ideally 2.5 m Corner reflector**

Global Mapping

- Find global permanent **scatters in forests** (natural corner reflectors)

- Make GLOBAL **map of water** vegetation content
  - Hight spatial / temporal resolution
  - Reliable source



WaCoRe

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Thank you!

Suggestions?

Questions?

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Sources

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