Viewing Forest in Pol-InSAR

Tobias Mette (*tobias.mette@dlr.de*), Florian Kugler, Kostas Papathanassiou, Irena Hajnsek

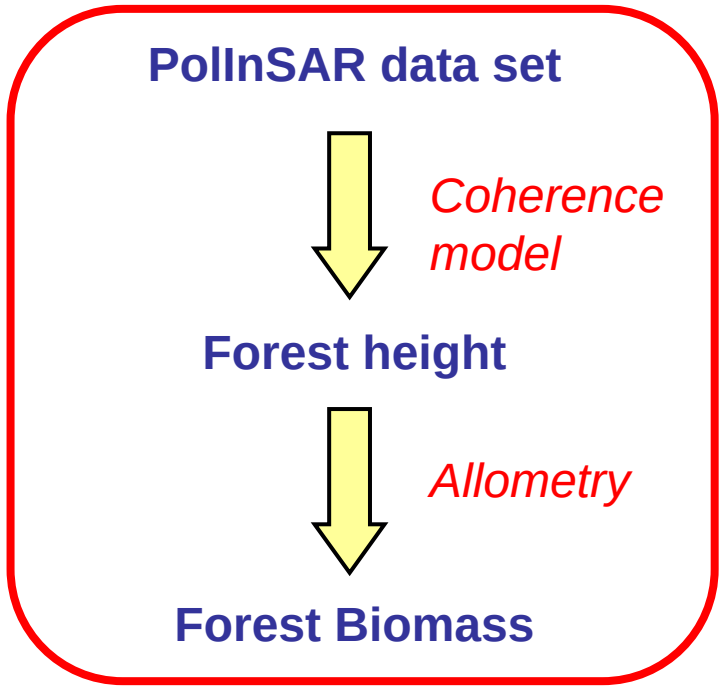
DLR - German Aerospace Center
Microwaves and Radar Institute,
Pol-InSAR Research Group

Content & Background

PolInSAR = polarimetric SAR interferometry

Sensitive to height distribution of scattering processes in forest

- Test site Traunstein
- Radar parameters and characteristics
- Coherence – volume decorrelation – forest height
- Allometry - height to biomass
- Summary and Outlook



Test site Traunstein

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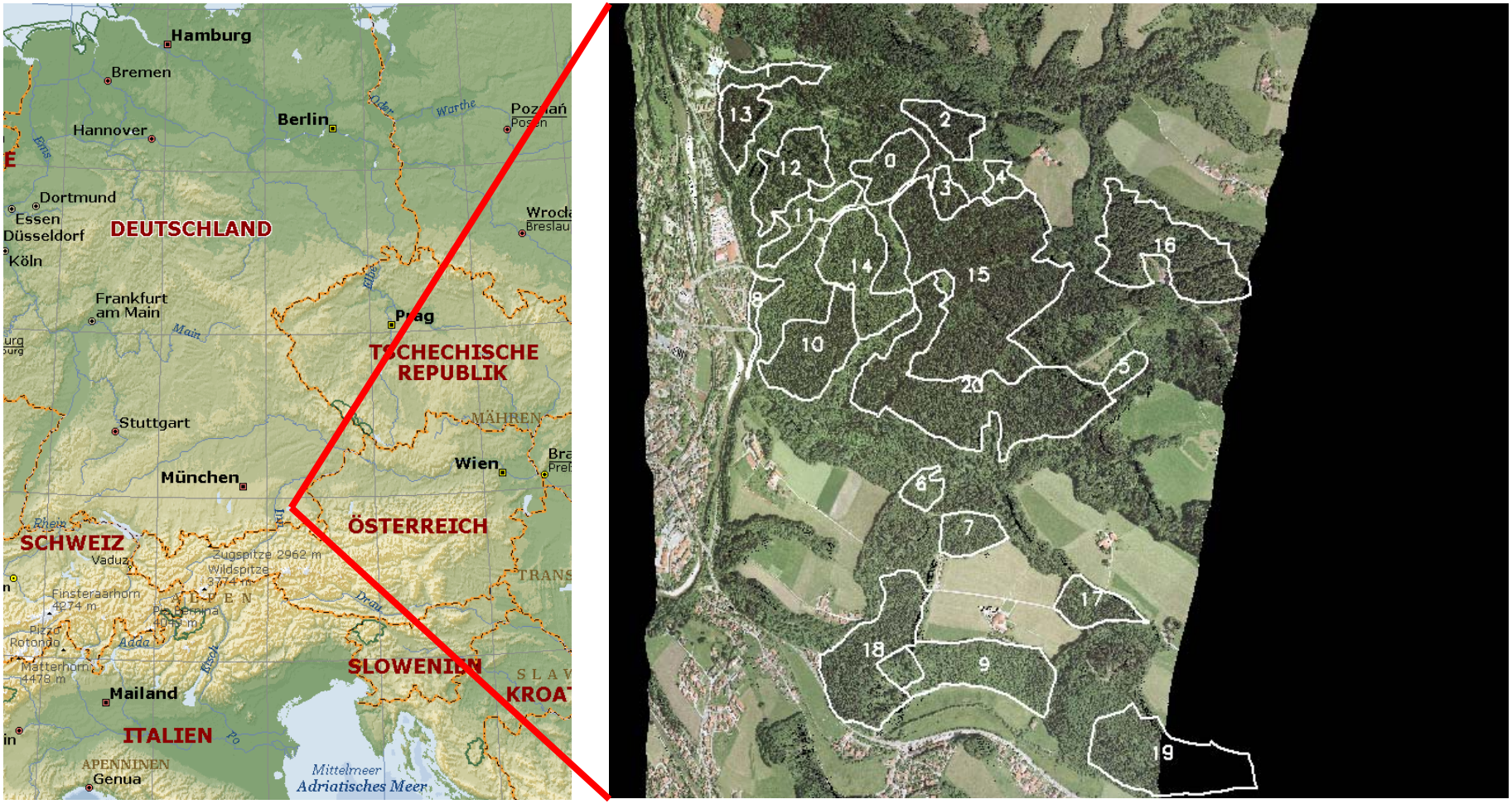
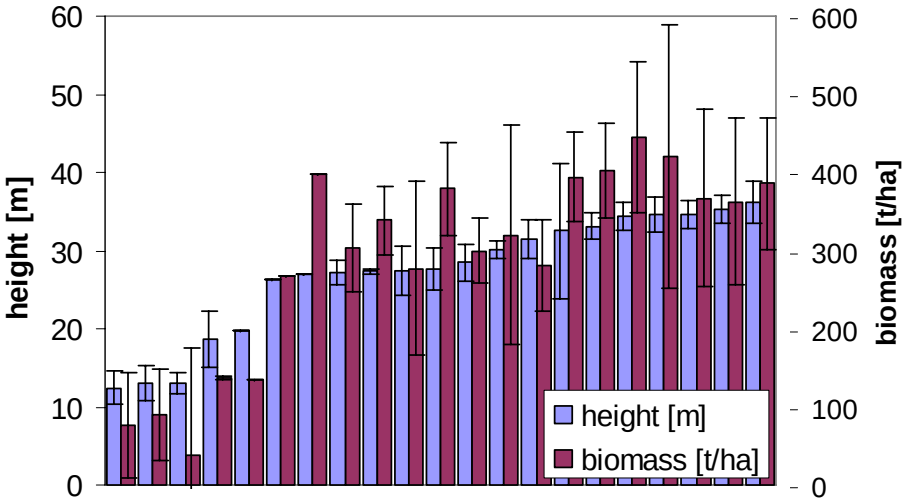


Ground data & radar data



Ground data (Forest inventory)

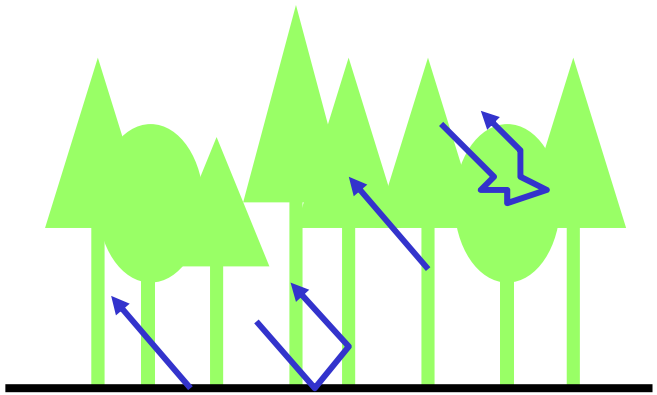
- mainly spruce
- up to 40m height, 450t/ha biomass
- 21 stands (~ 6 plots/ stands)

Polarimetric interferometric SAR (E-SAR sensor)

- L-band (23cm, 1200MHz)
- Fully polarimetric (HH,VV,HV/VH)
- 5m baseline at 3000m flight height
- Repeat pass (20min)

Radar characteristics and parameters

Radar characteristics & volume scattering



Radar penetrates clouds → all weather capability

object characteristics in microwave spectrum → geometric & dielectric properties

penetrates canopy, interacts with tree structures and ground → volume scatterer

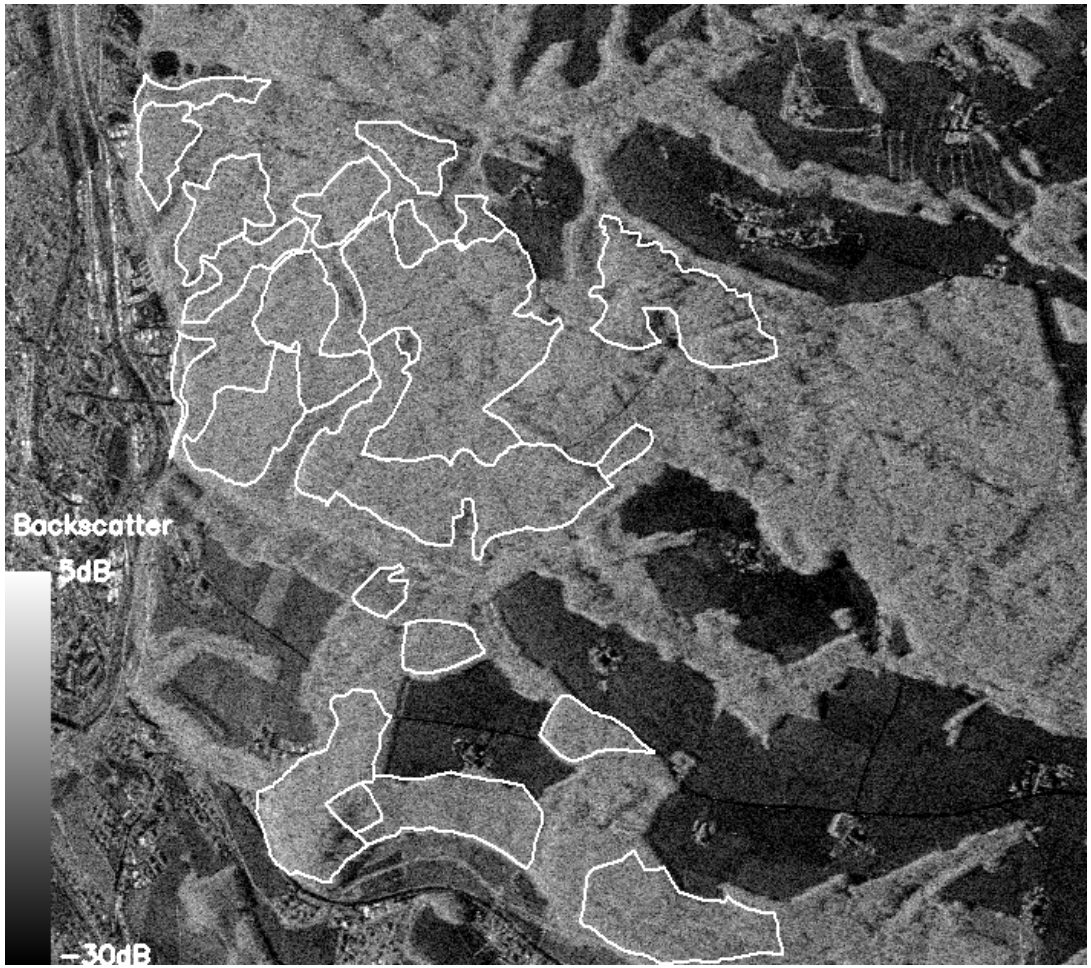
Single SAR image – backscatter intensity

Object microwave signature

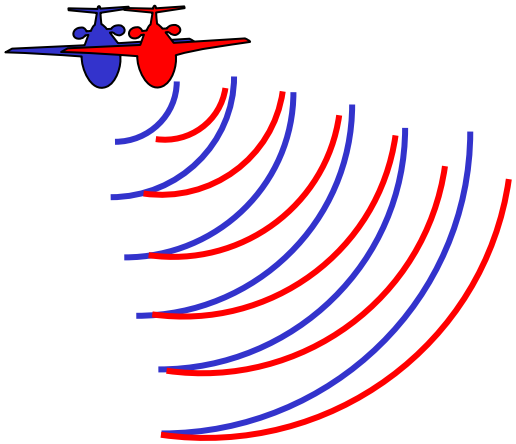
- Wavelength
- Incidence angle
- Polarization

At L-band

Volume scattering over forest stronger than *Surface scattering* over fields, but little differences within forest (saturation at 40-50 t/ha)

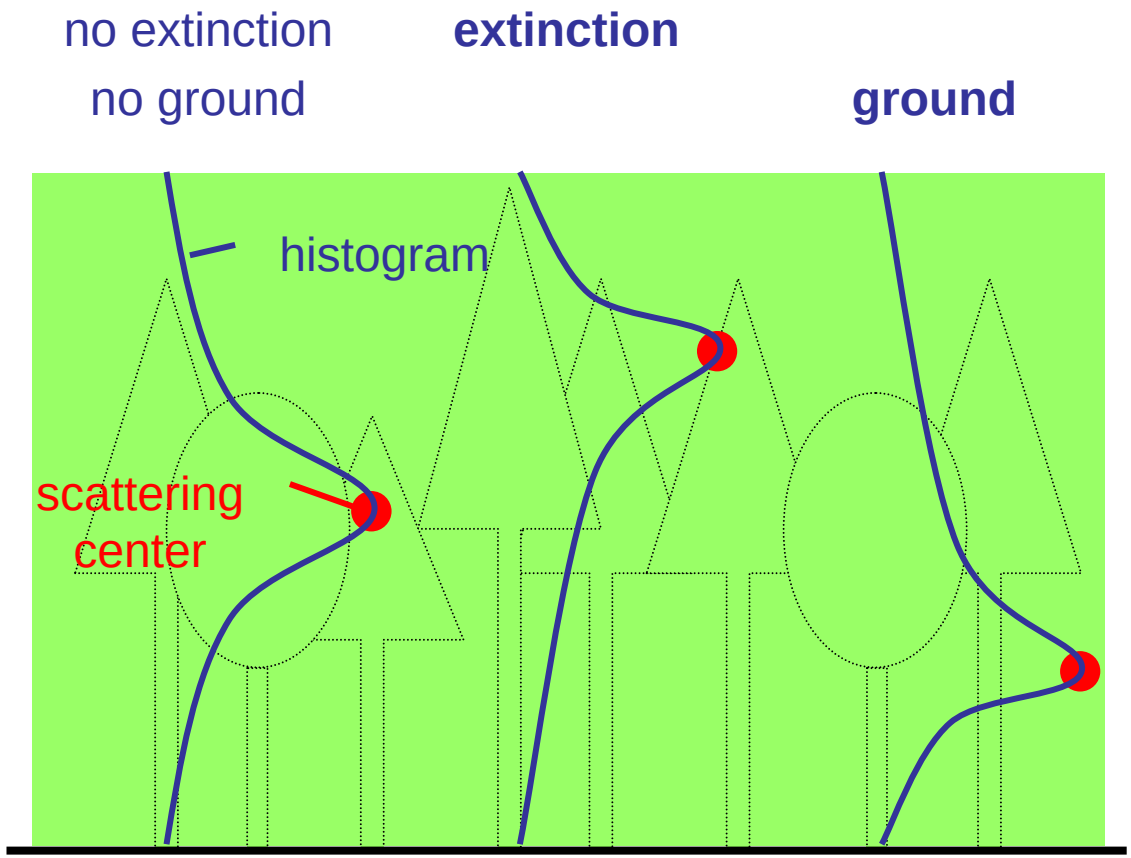


Interferometric SAR images – the 3rd dimension



Interferometric SAR images:

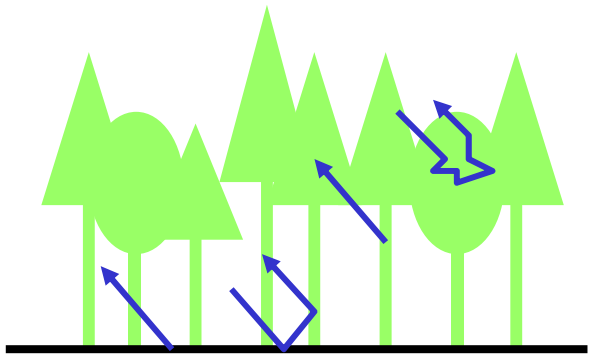
- 3rd dimensions (height) in interferometric phase
- In forests, height of scattering center depends on extinction and ground

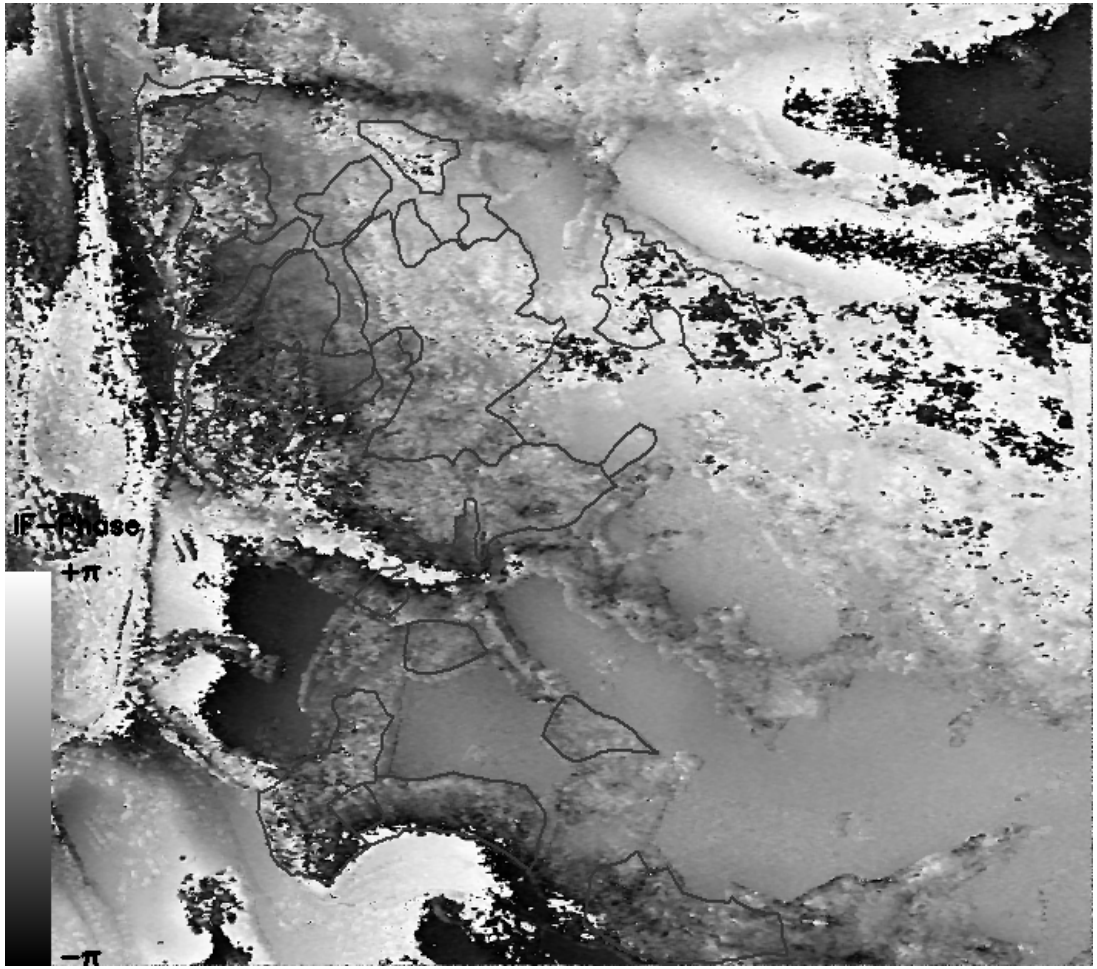


Interferometric phase

Object height measure

Forest at L-band has a ***noisy*** phase due to different penetration depths into forest (ground, extinction).





Interferometric coherence

Object height statistics

= phase correlation in a certain window

$$\gamma = \frac{\left\langle i_1 \cdot i_2^* \right\rangle}{\sqrt{\left\langle i_1 \cdot i_1^* \right\rangle \cdot \left\langle i_2 \cdot i_2^* \right\rangle}}$$

$$0 \geq \gamma \geq 1$$

Volume scatterers

- higher height = lower coherence
- Volume decorrelation

Interferometric coherence - Volume decorrelation - Forest height

Volume decorrelation - the ideal sinc-function

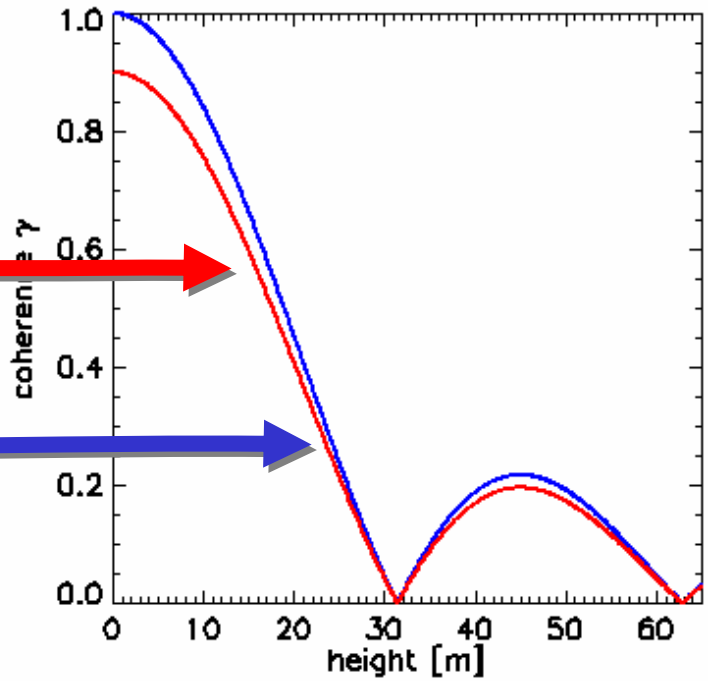
$$\gamma = \gamma_{vol} \cdot \gamma_{range} \cdot \gamma_{system/processing} \cdot \gamma_{temporal}$$

Volume decorrelation
- function of height
- inversion

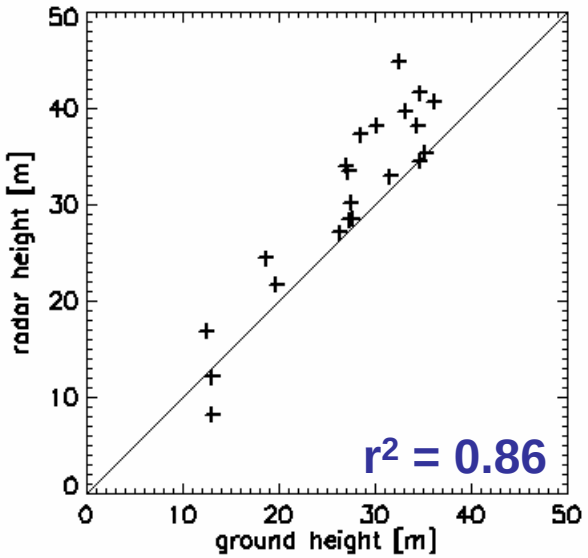
Other decorrelations
- not related to height
- error in inversion

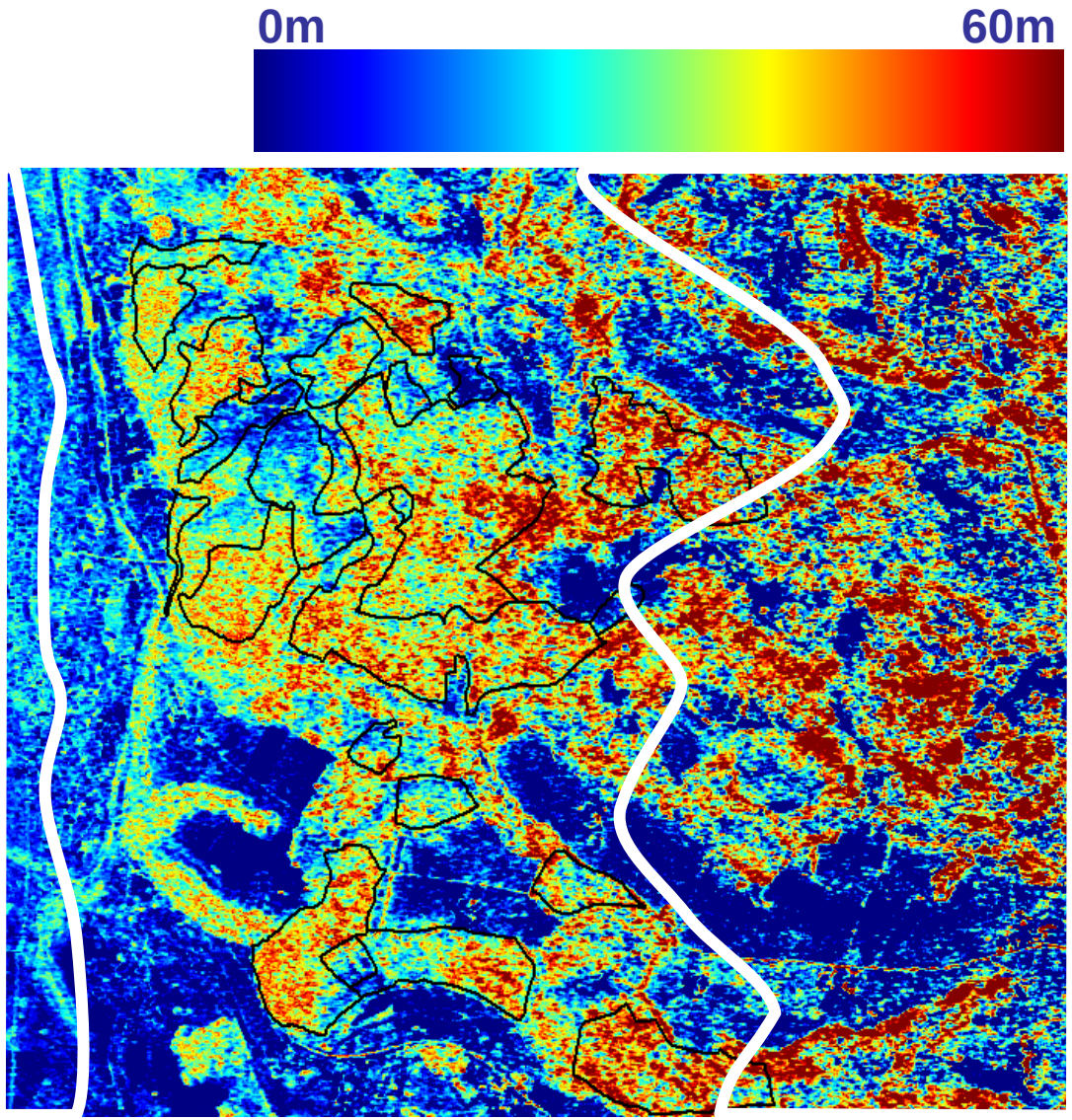
$$\gamma_{vol} = \frac{\sin(\frac{1}{2} \cdot \Delta kz \cdot h)}{\frac{1}{2} \cdot \Delta kz \cdot h} \cdot 0.9$$

example

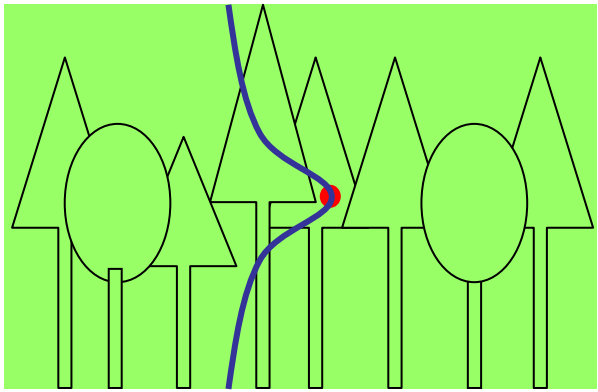


Sinc-Inversion results



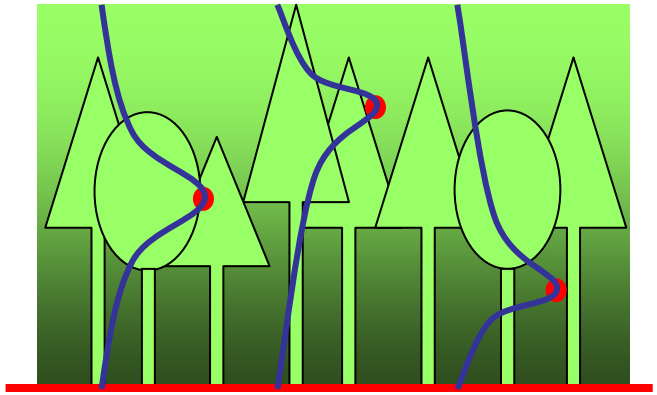


The Random Volume over Ground model (RVoG)



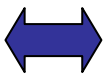
Sinc

RVoG



Model parameters *System observables*

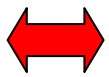
- *height*



Coherence (InSAR)

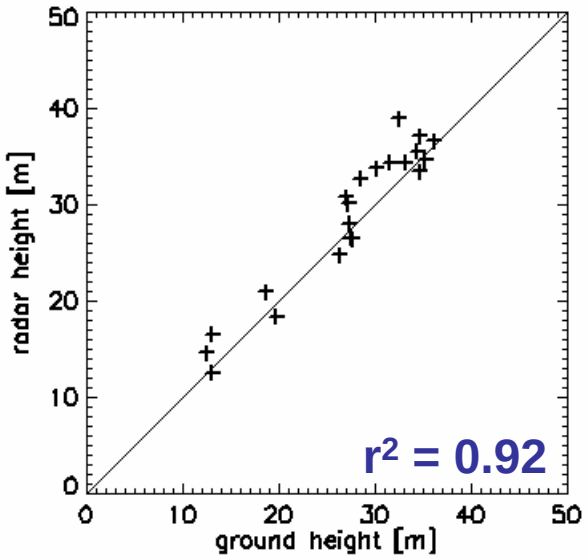
Model parameters *System observables*

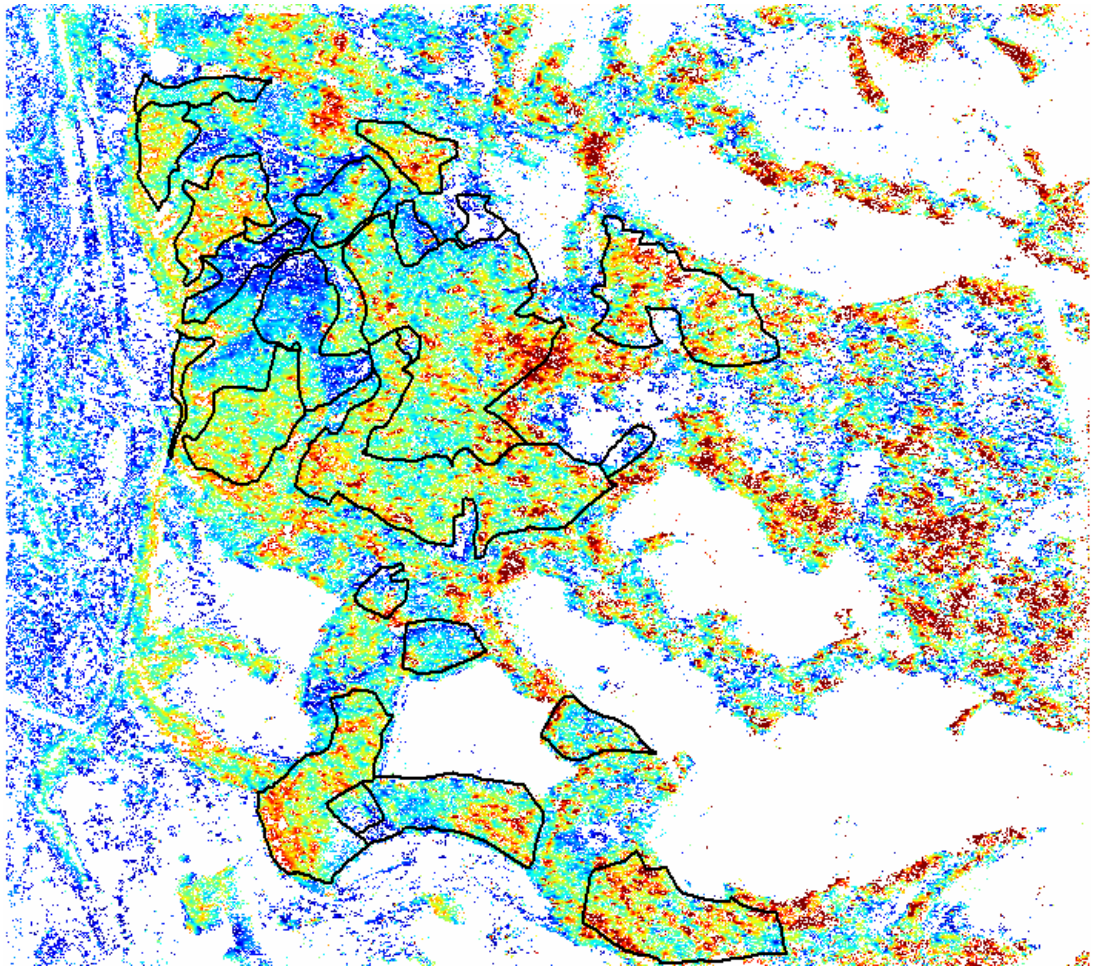
- *height*
- *extinction*
- *ground contrib.*



Coherence at 3 polarizations (PolInSAR)

RVoG-Inversion results





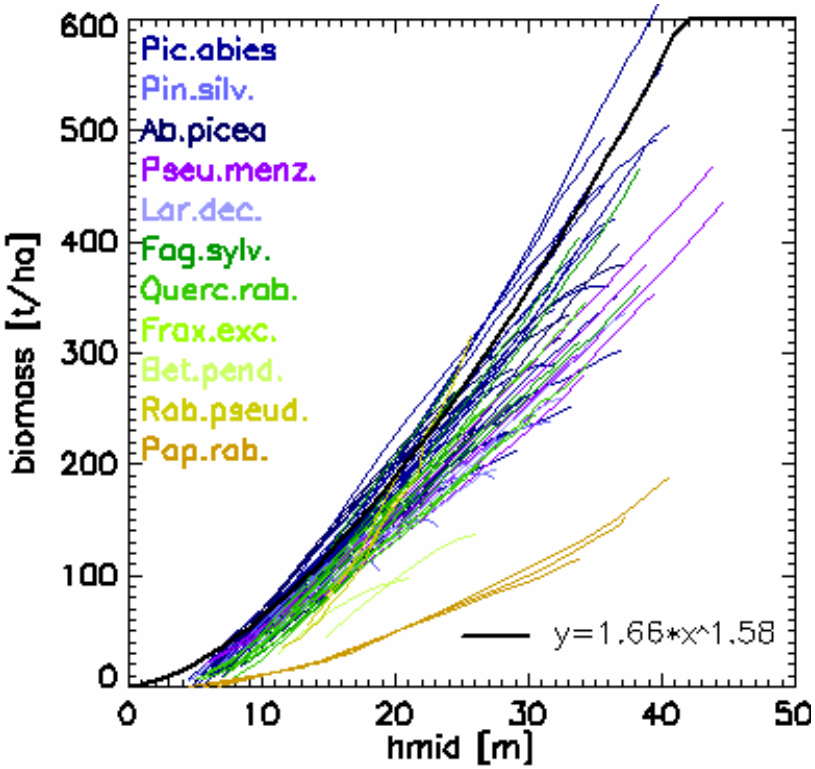
Height biomass allometry

Allometry: height to biomass

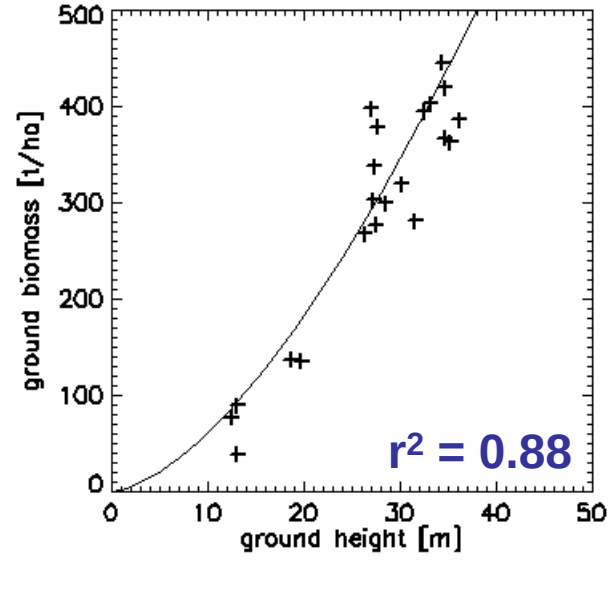
$$Biomass = 1.66 \cdot height^{1.57}$$

Variability

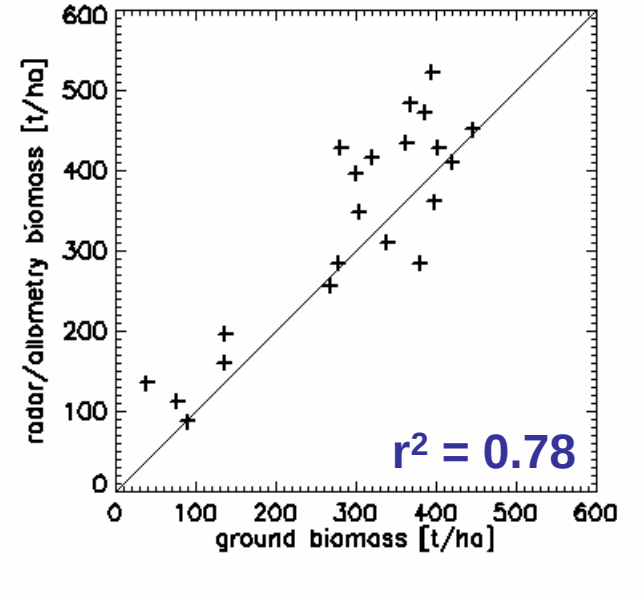
- ~15% site conditions
- ~20% between climax species, not poplar/birch
- unlimited reduction due to thinning/ management concept



Allometry: Pol-InSAR to biomass



Performance of height-biomass allometry from the ground measurements



Biomass estimation from Pol-InSAR heights and an assumed height-biomass allometry

Summary and outlook

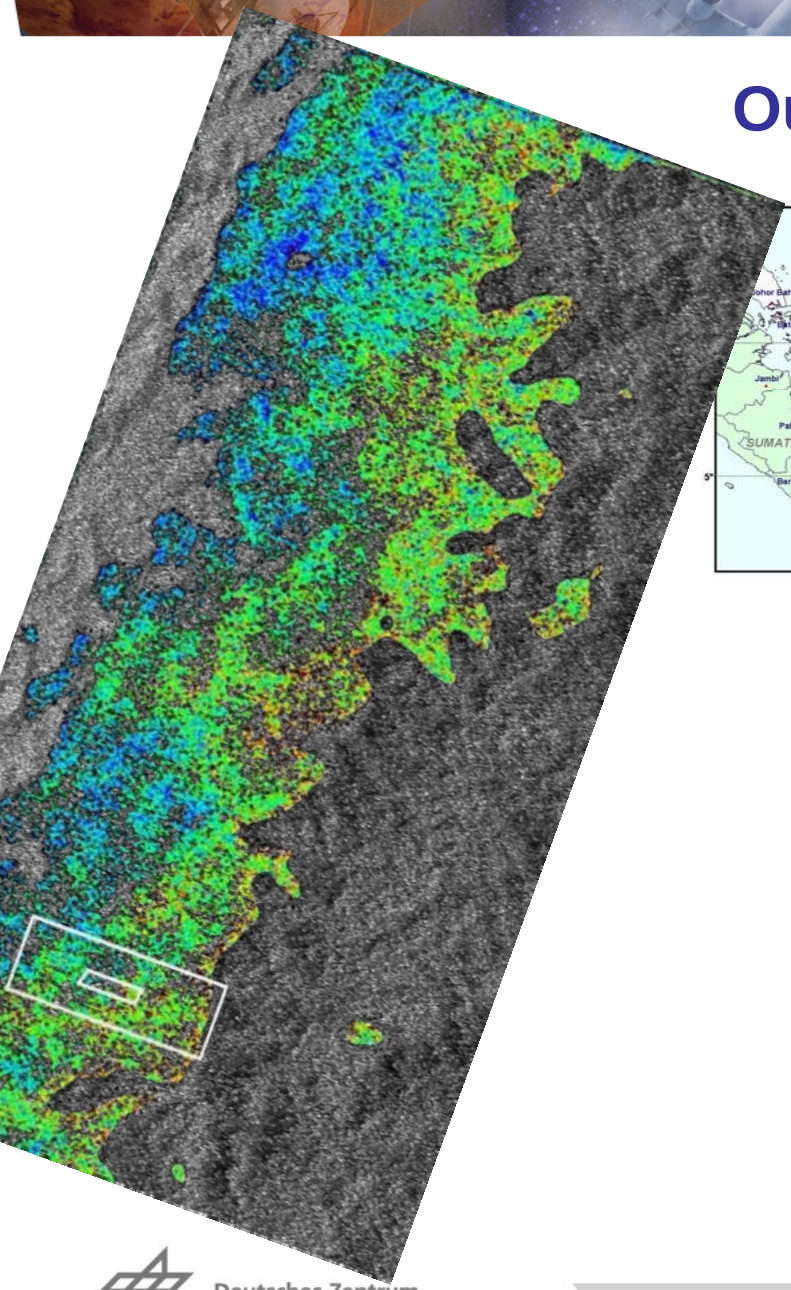
Summary

1. Radar at long wavelength (L- and P-band) penetrates the canopy and interacts with tree structures and the ground (Forest = Volume scatterer)
2. Interferometric coherence is a function of volume height (=> height inversion)
3. Polarimetry increases the observation space and allows for more differentiated models (=> RVoG)
4. L-band: height inversion performance: r^2=0.86 (sinc-inversion), r^2=0.92 (RVoG)
5. Reference height–biomass allometry for even-aged managed forests
6. Height-biomass allometry: r^2=0.88 (inventory data), r^2=0.78 (PolInSAR)

Future steps:

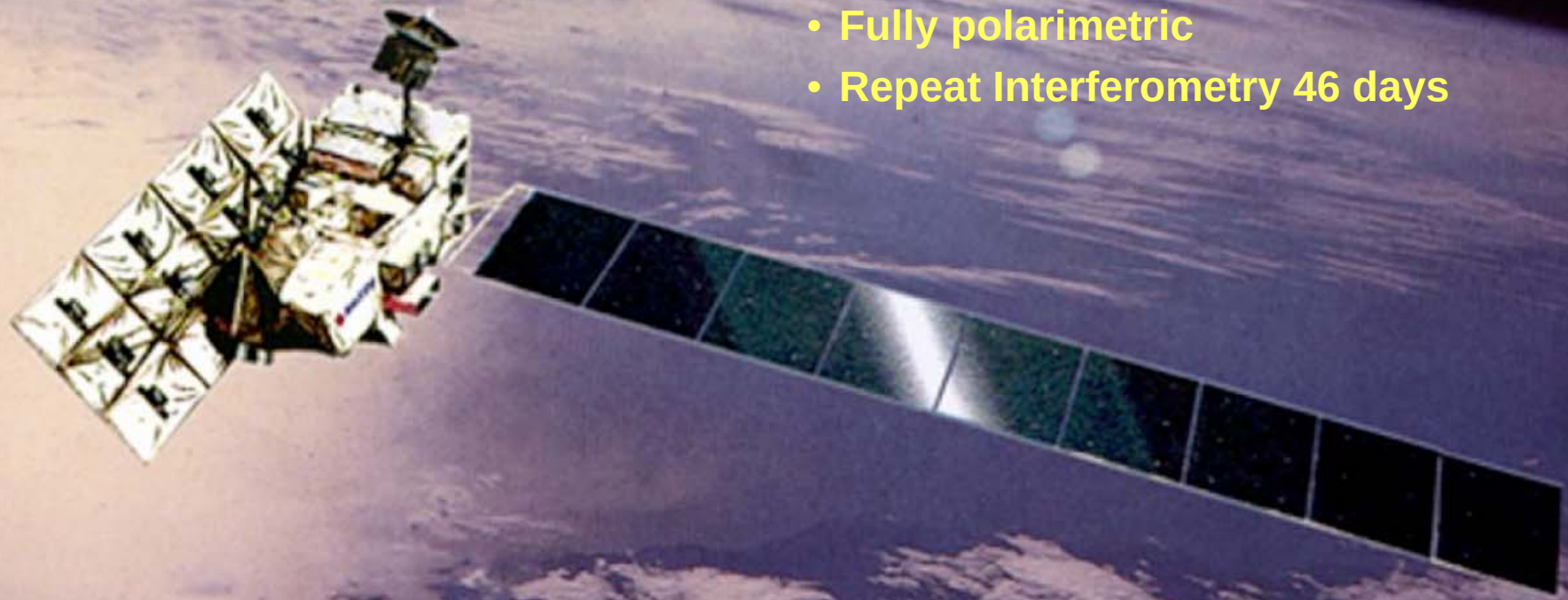
- Height inversions at other frequencies – X-band/ P-band
- Compensation/ modelling of other decorrelations, esp. temporal decorrelation
- Models with higher complexity – dual/ multiple baselines or frequencies
- Height definition / height-biomass allometry in heterogeneous forest
- Density dependence of the height inversion

Outlook Indrex



Outlook ALOS

- Advanced land observing satellite (JAXA, Japan)
- Launch 23.1.2006
- PALSAR Phased array L-band SAR
- Fully polarimetric
- Repeat Interferometry 46 days



Thank you for your attention ...