Observations and discussions of TanDEM-X forest spectra over the rain forest

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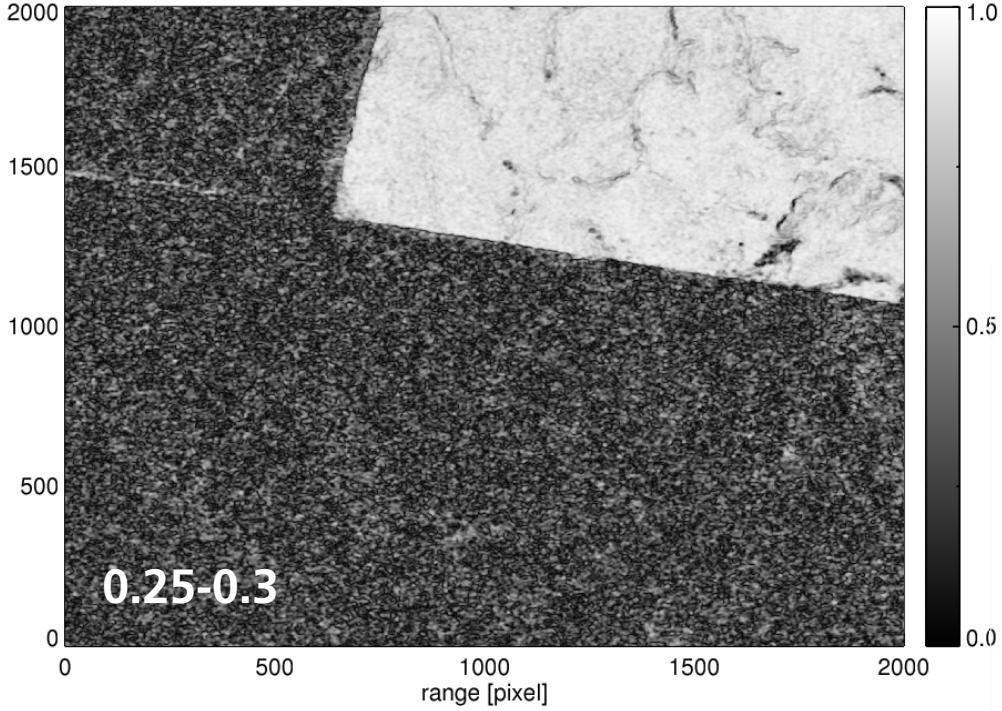
TanDEM-X: decorrelation & forest spectra

- Observations of low coherence
- Spectral analysis of the interferograms
  - Explanation
  - Analytical modeling and simulations
- Discussion on the consequences of our findings
  - Mostly unanswered questions

TanDEM-X: Amazon forest

Coherence: forest & clear-cut

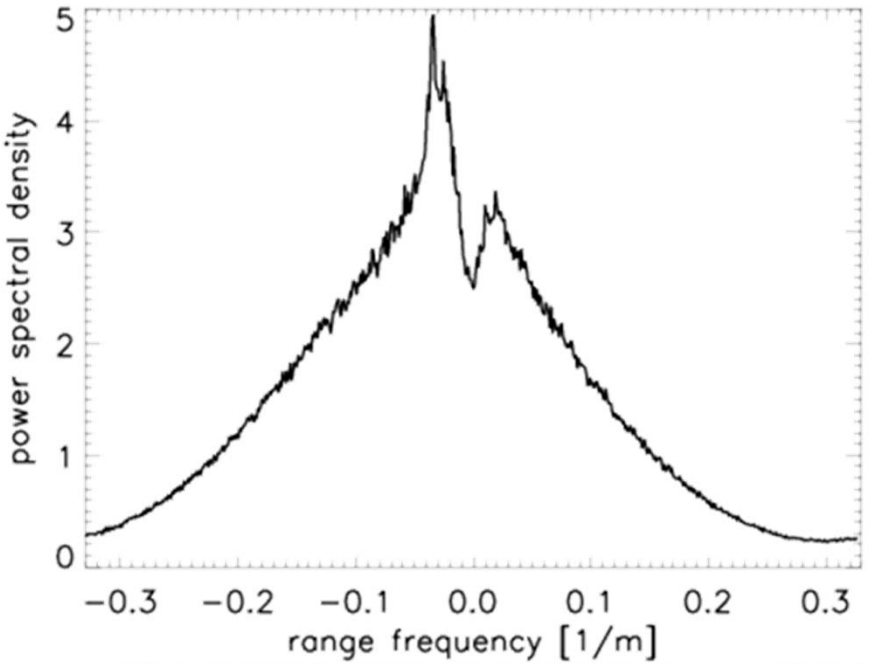


Rondonia (Brazil), October 23rd, 2010
TanDEM-X, 25m height of ambiguity

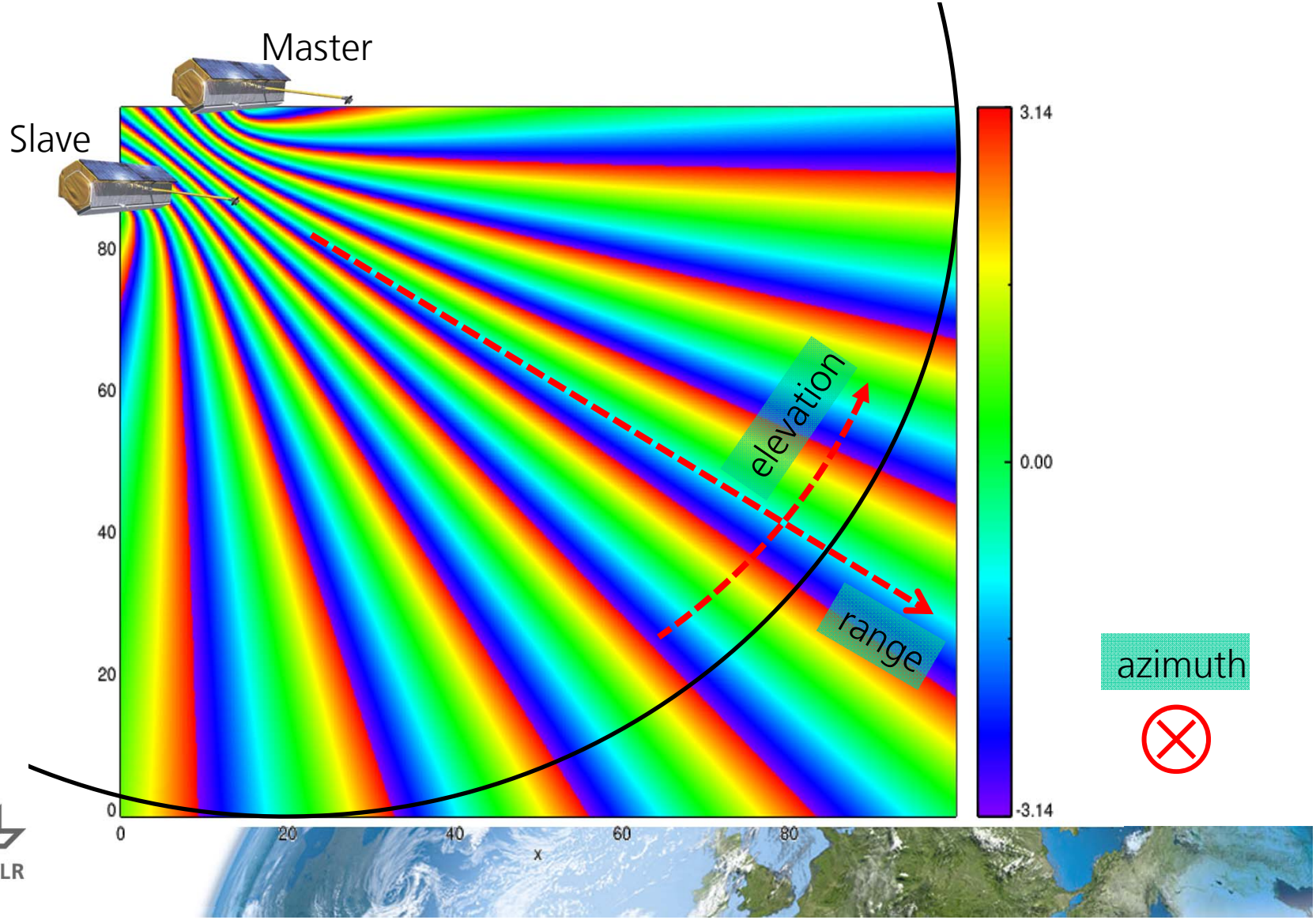
master slave

$$S(f_r, a) = E\left[\left|\int y_m(r,a)\, y_s^*(r,a) \exp(-j2\pi f_r r)\, dr\right|^2\right]$$

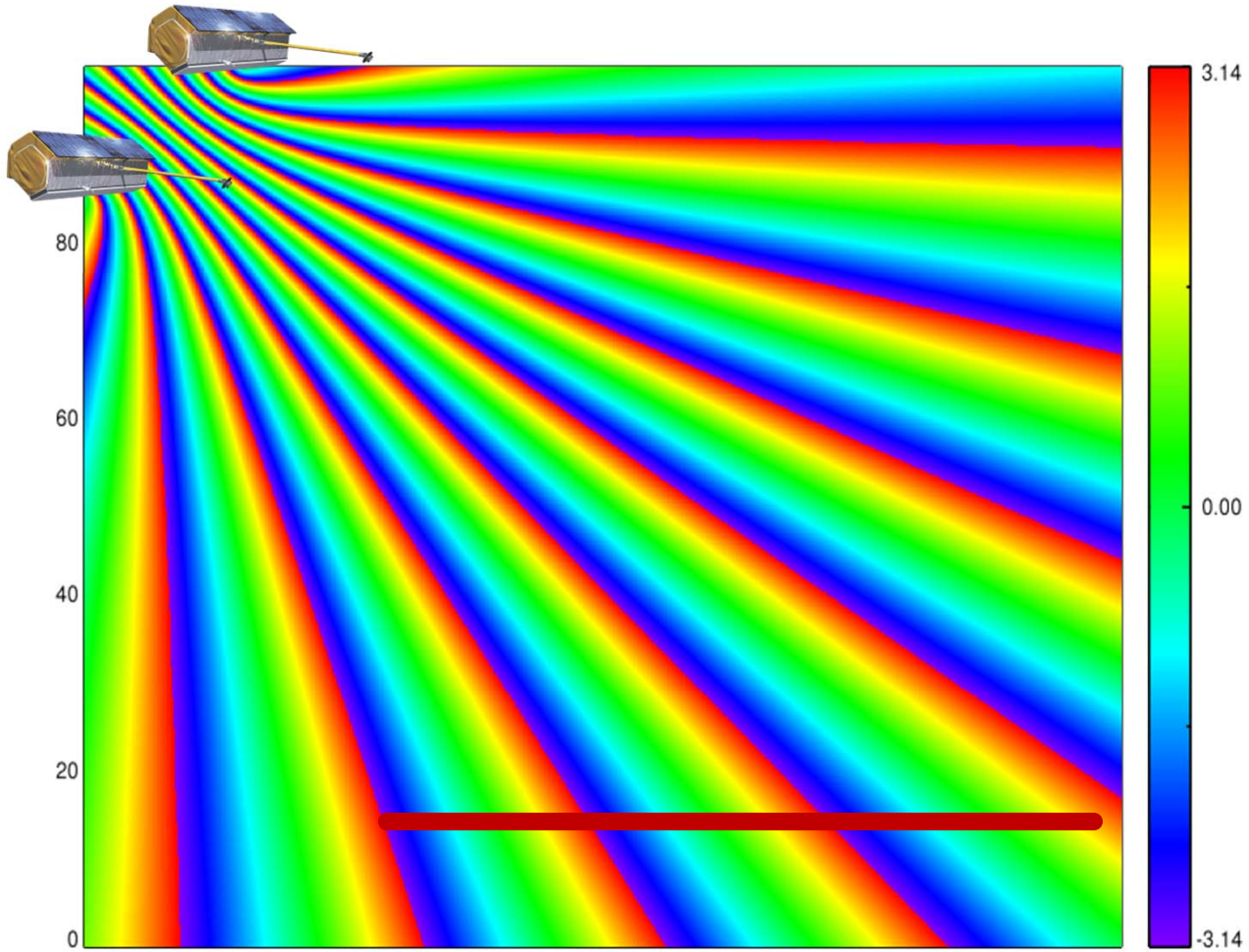
Range spectrum of interferogram



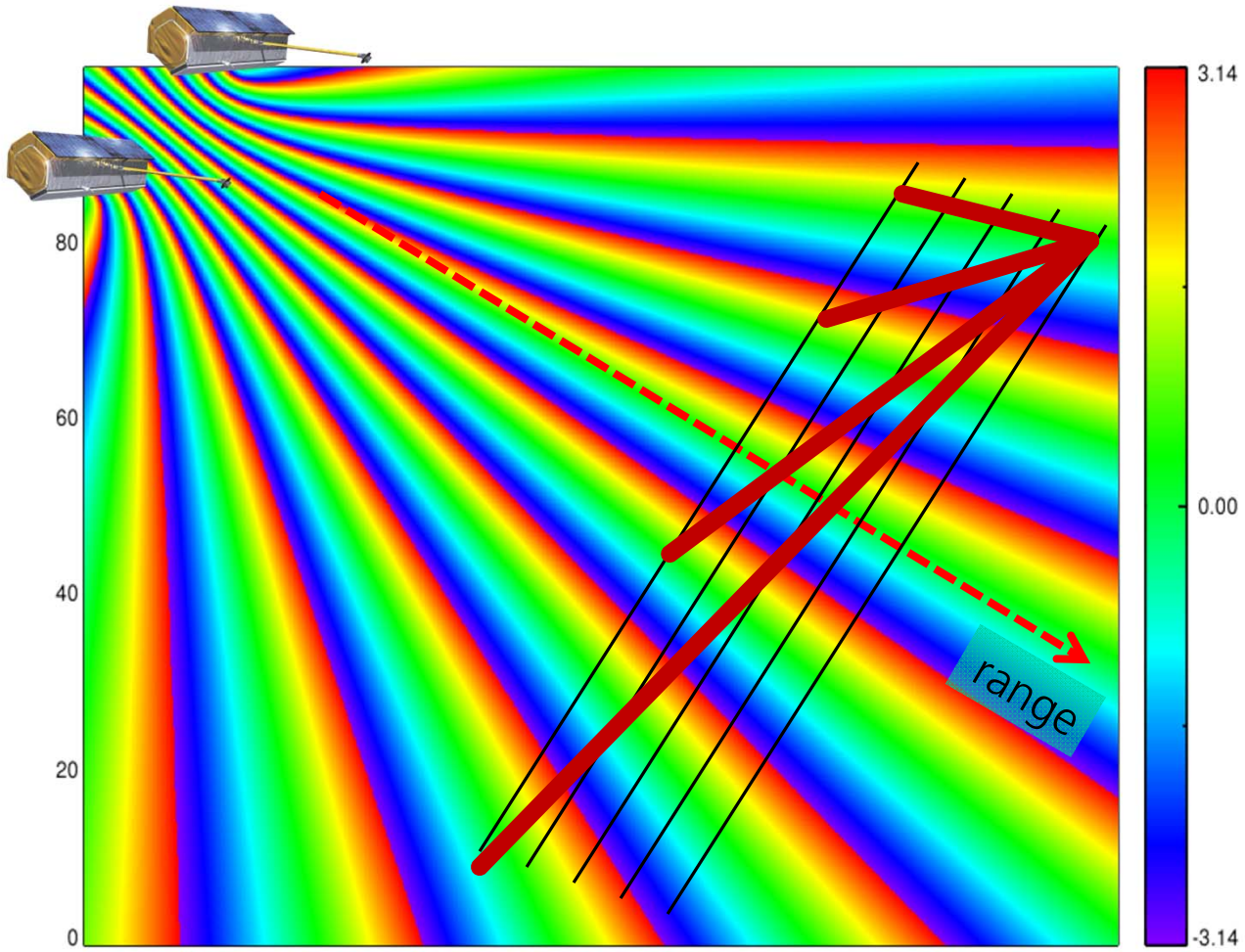
Interferometry allows to locate targets in the third dimension

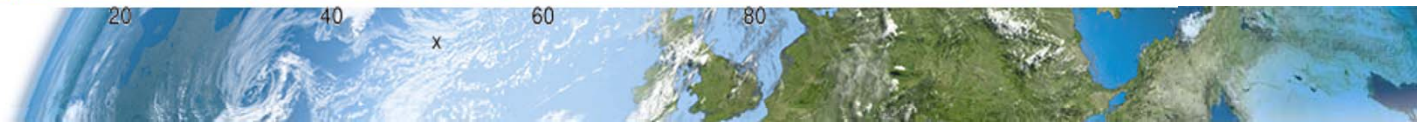


Flath-Earth phase



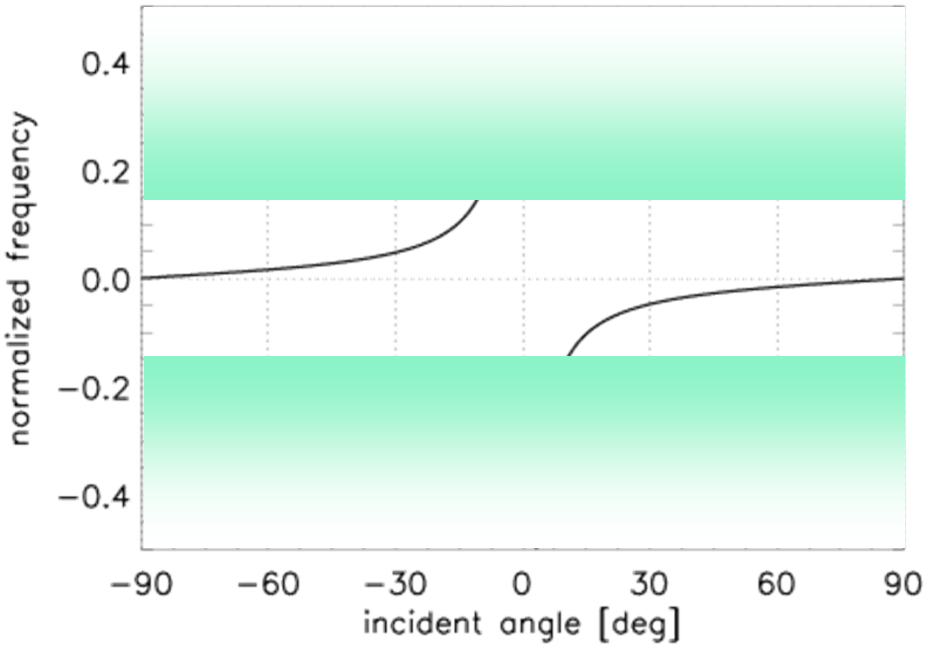
Slopes correspond to frequencies in the interferogram





Slopes and range frequencies (typical TanDEM-X params)

- Tangent (cotangent) relation:
  - Zero frequency = shadow (line of sight)
  - Singularity = orthogonal incidence
  - Jacobian effect



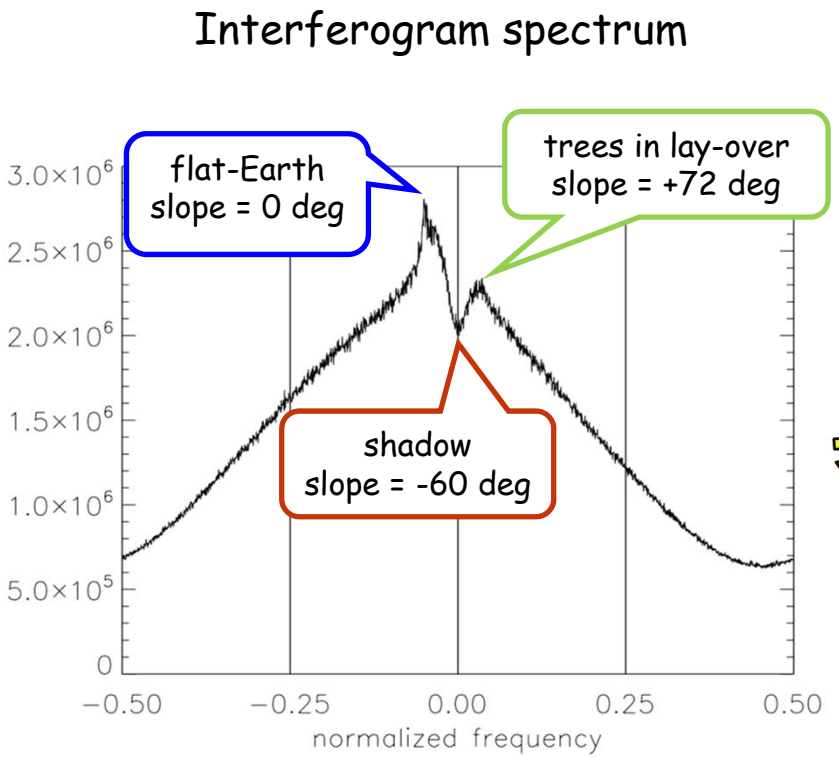
one slope = one frequency

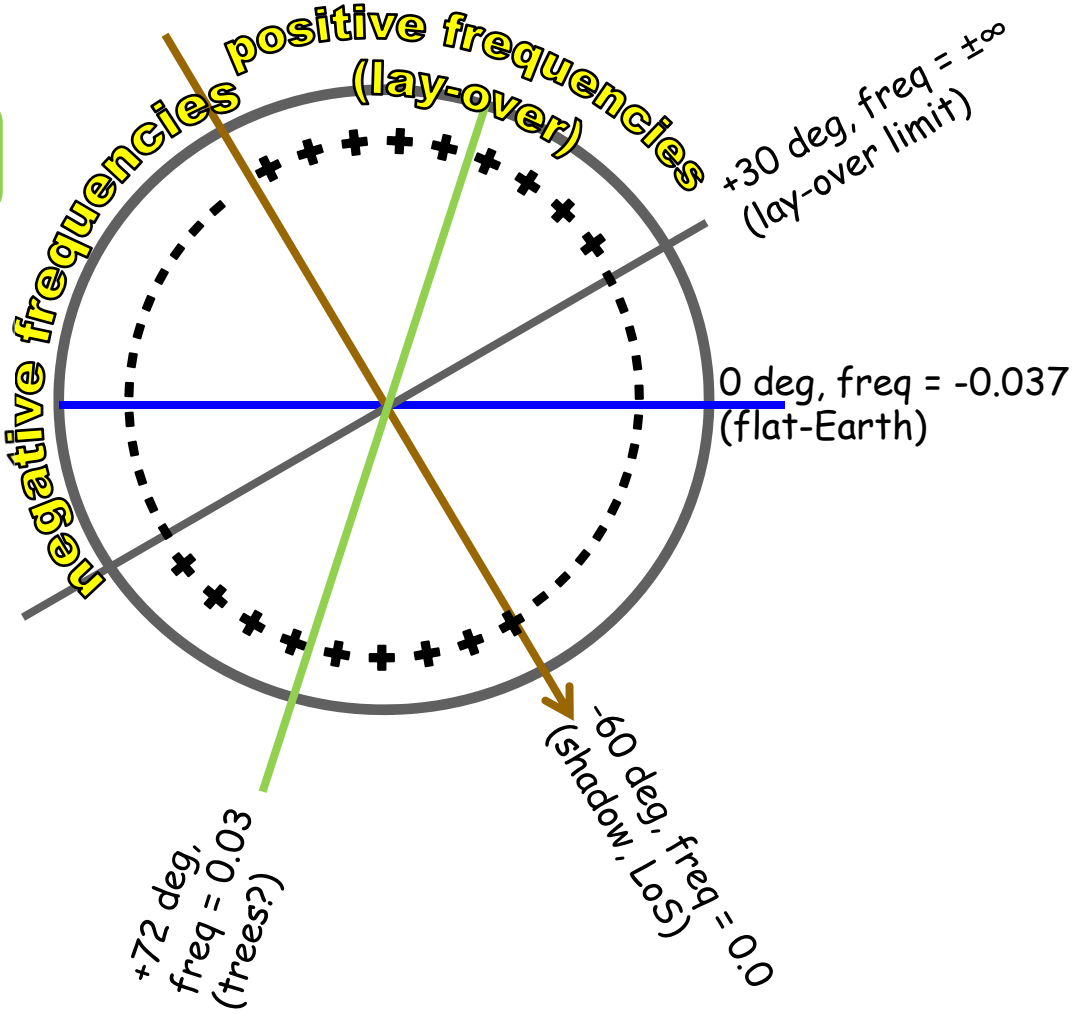
interferometric frequency

$$f = -\frac{f_0 B_\perp}{2R_0 \tan(\vartheta_{inc})}$$

incident angle

Interferometry, shadow & lay-over

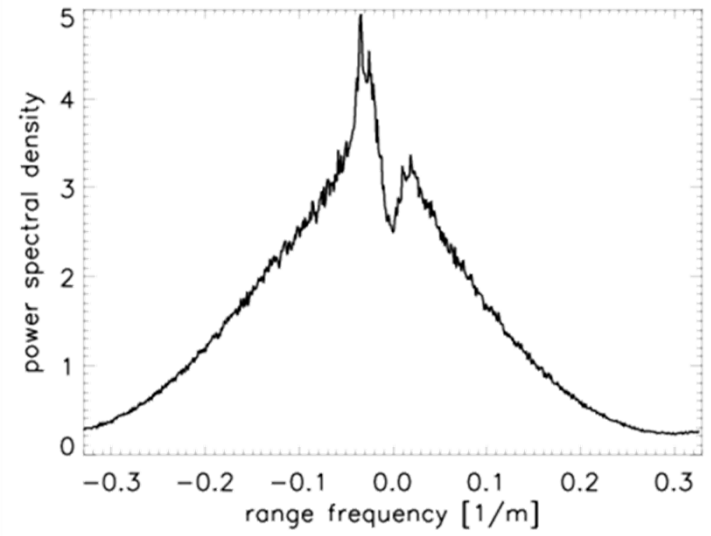




incident angle = 30 deg
height of ambiguity = 25 m

Details on spectral shapes

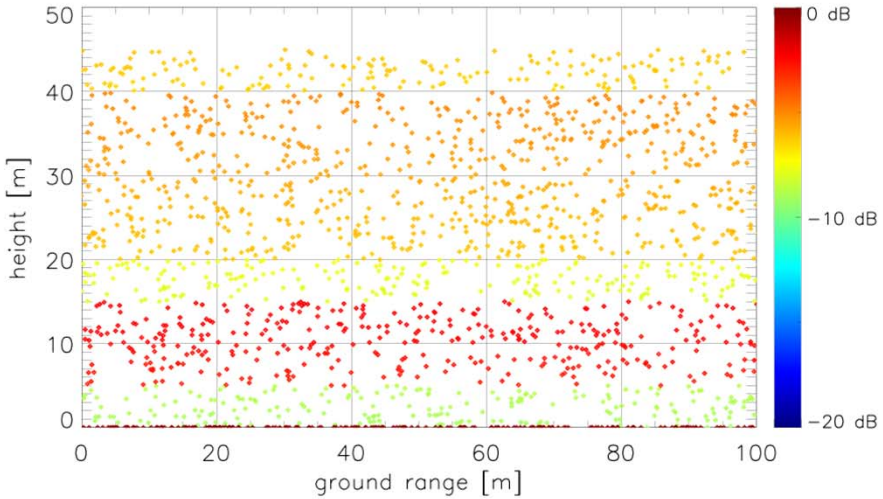
- Jacobian
  - Slopes are packed closer around zero-frequency (LoS) in the interferogram
- Shadow effect
- Broadening of spectral components
  - Slopes are finite (windowing)
  - Range variations
  - Topography
- Decorrelated components form a noise pedestal
  - Its shape depends on the spectral weighting

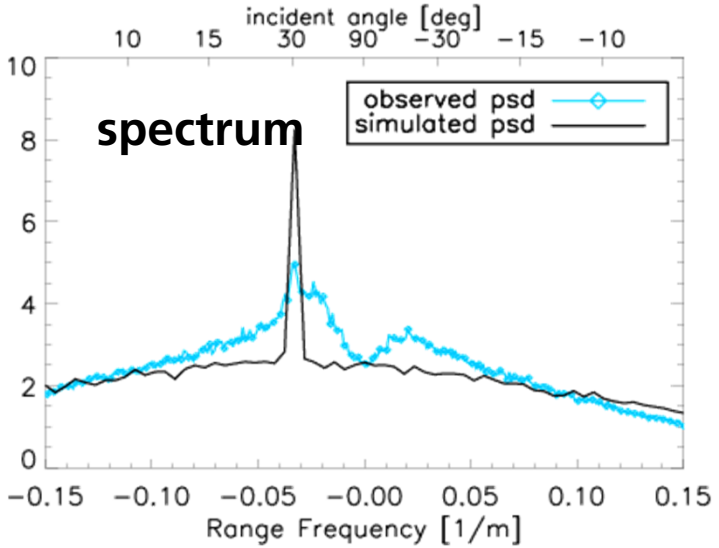


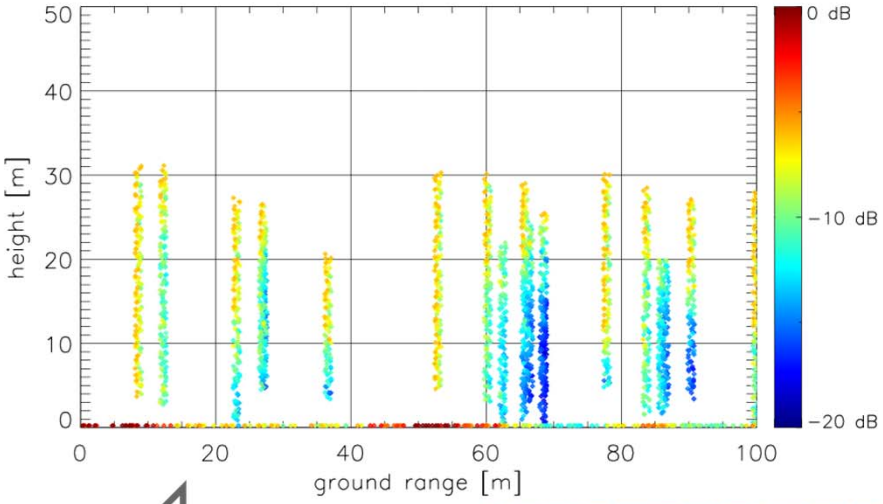
Simulations

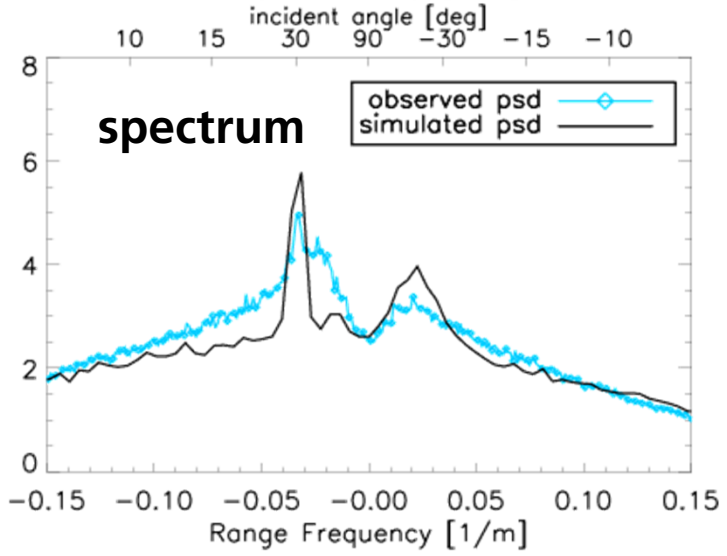
- Simulation of range sections (a few dozens of pixels)
- Forest modeled with clouds of point targets (depending on the model)
- No noise, no temporal decorrelation, pure geometric effects
- Simulation of images, then interferograms
- Extinction effect: scatterers are attenuated when shadowed by others in the LoS

The forest is not horizontally homogeneous









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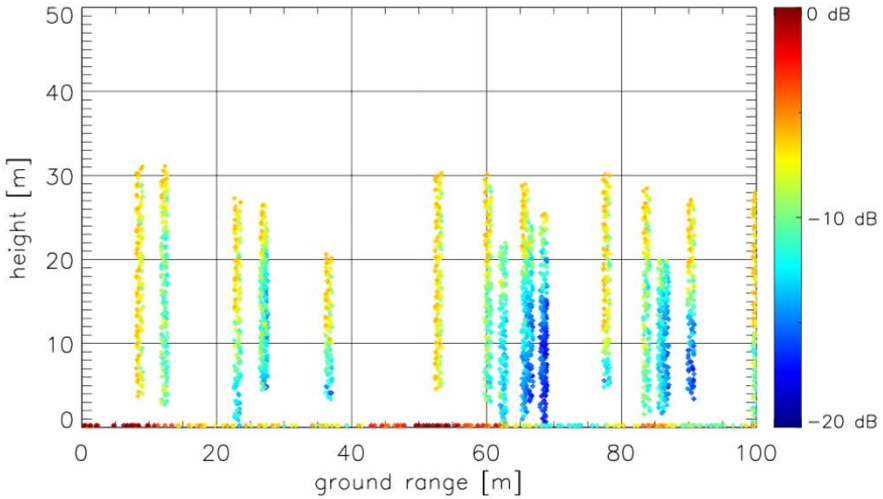
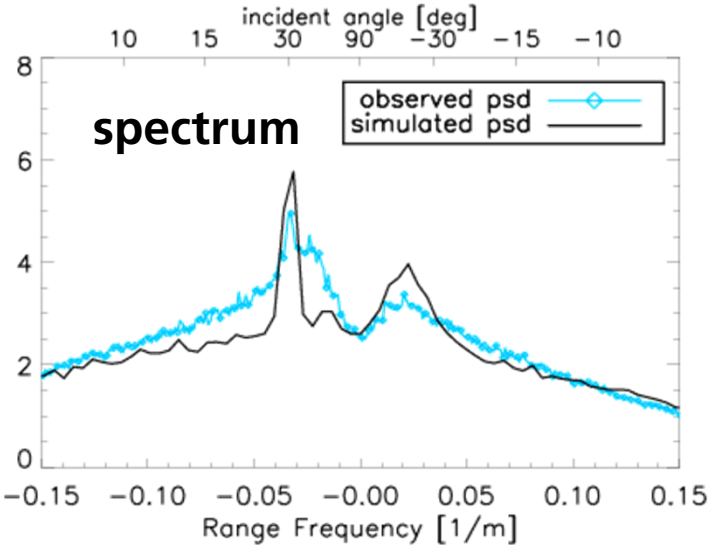
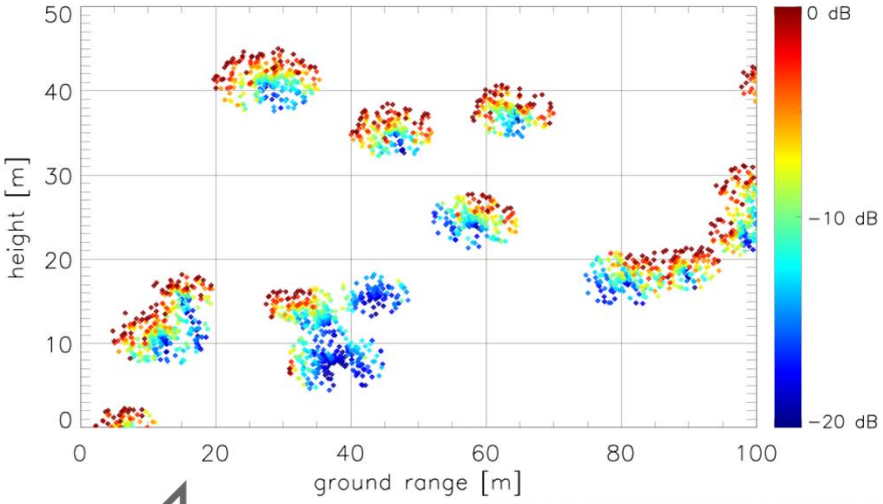
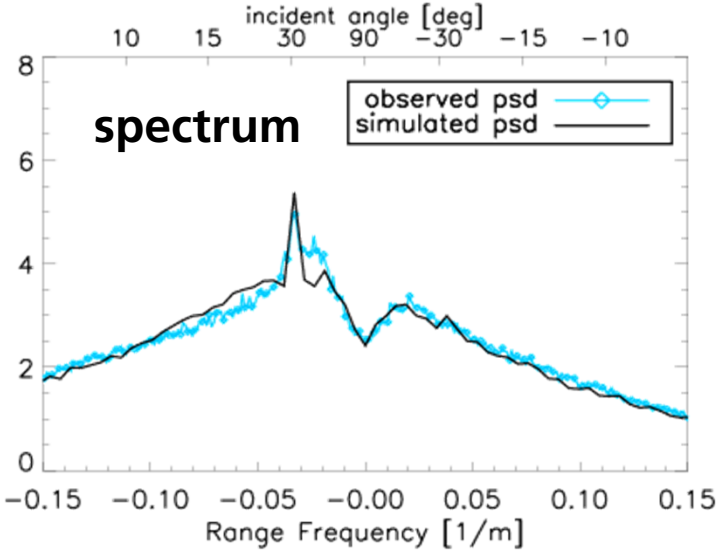


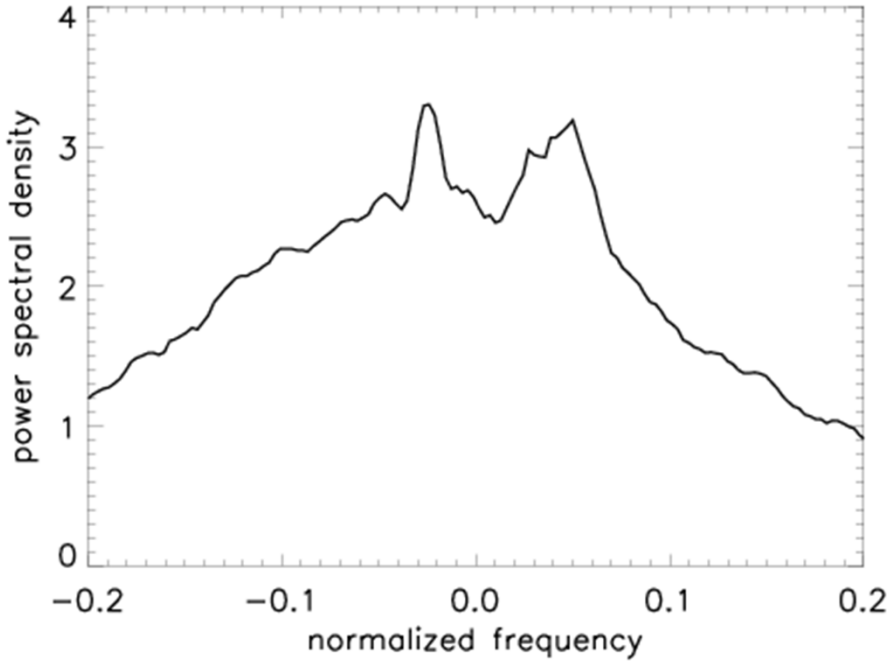






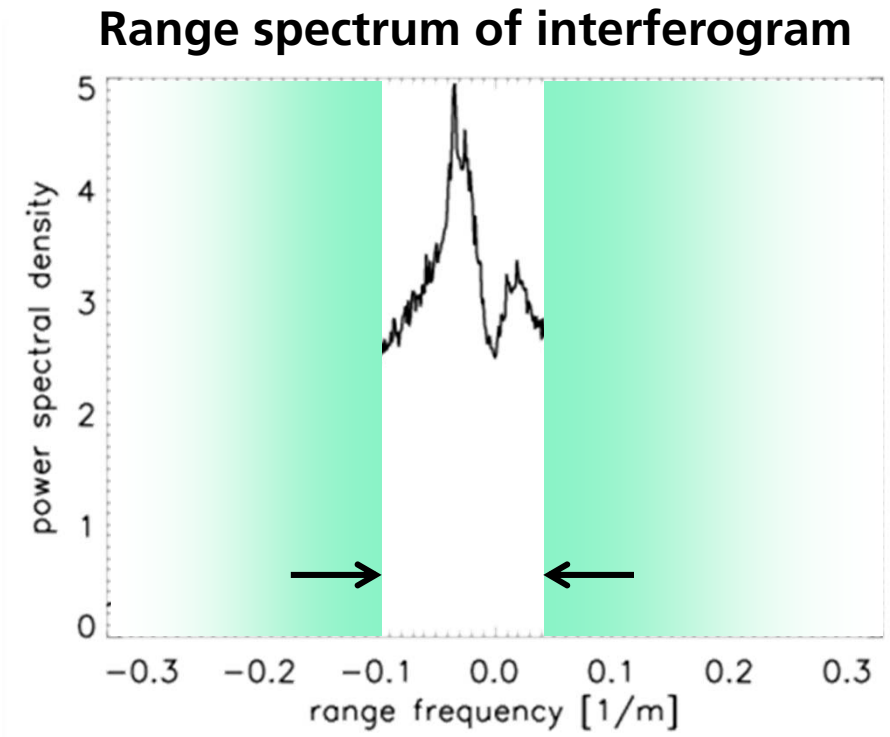
F-SAR, 385MHz, X-band, height of ambiguity: ~5m

- With TanDEM-X we have observed such features in Brazil and Indonesian forests
- With F-SAR and a different geometry, also in southern Germany



Multilooking

- Spatial averaging
  - is equivalent to filtering spectrally the interferogram
  - risks to suppress components with a physical meaning



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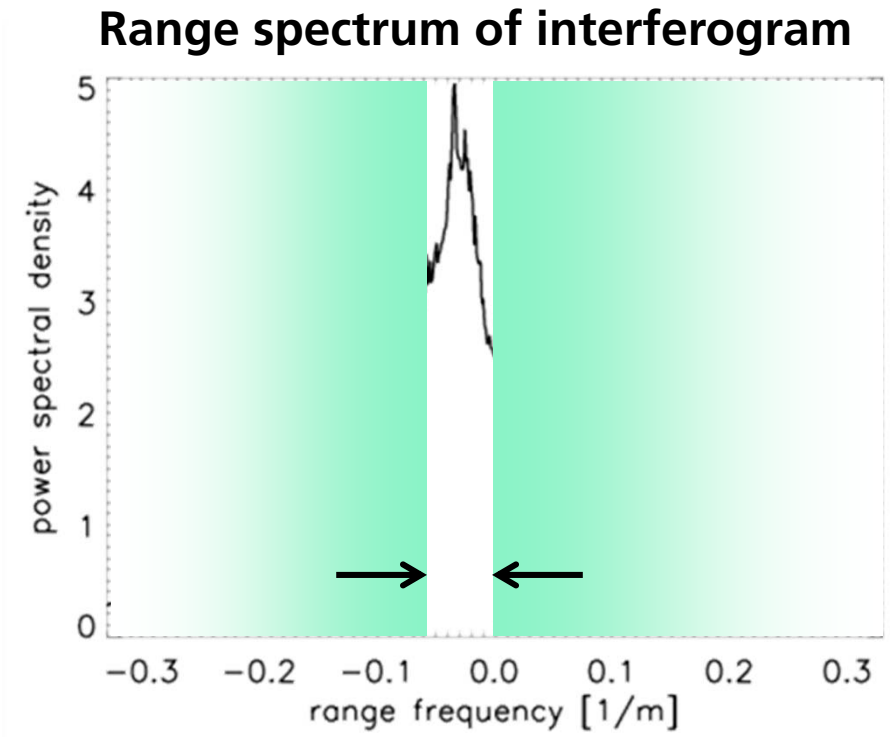
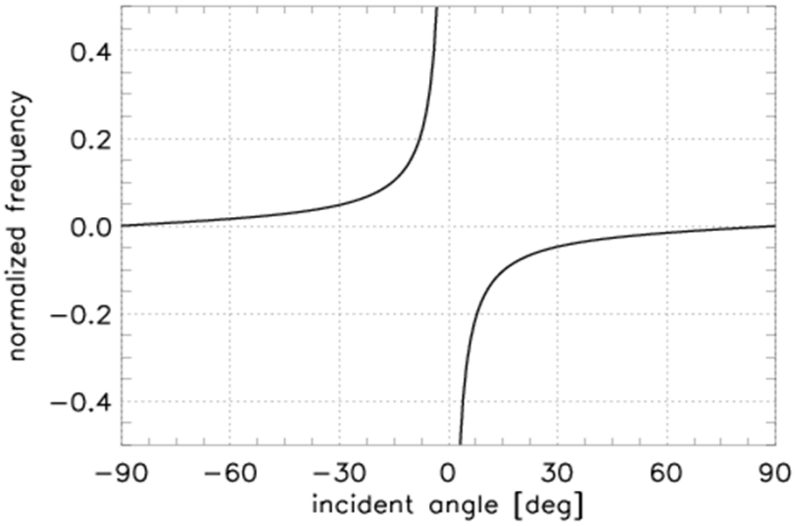
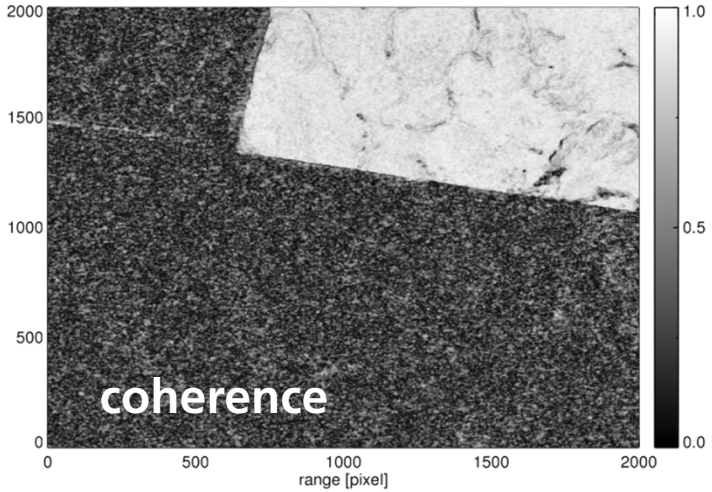


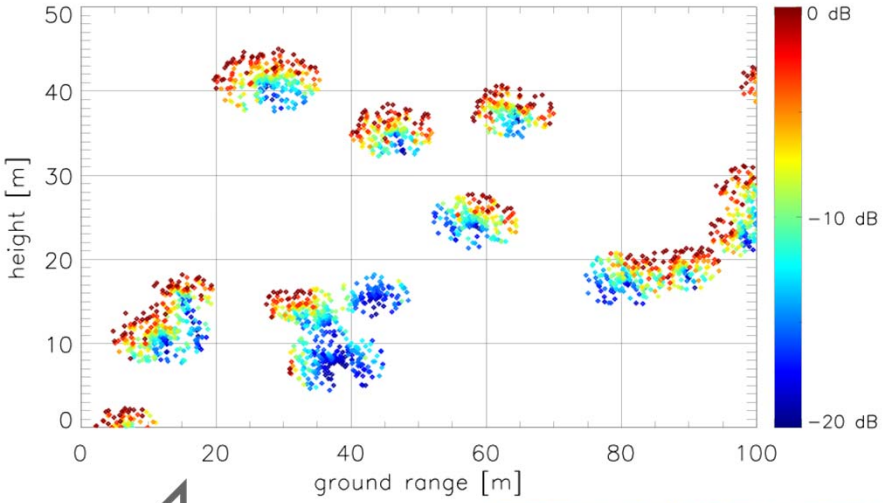
Discussion

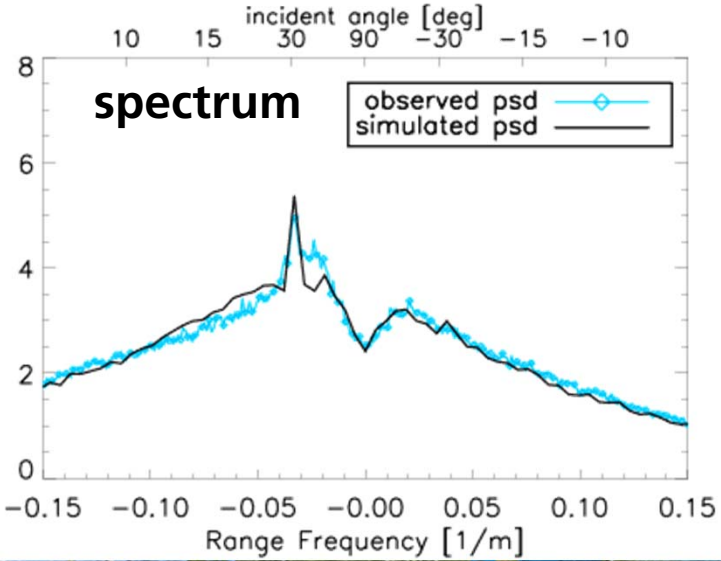
- First conclusions:
  - Our results indicate a sensitivity of interferograms to the horizontal structure of the forest (level of sparsity? canopy characterization?)
  - The spectral shape points to a surface-like object: the volumetric effect on the coherence could be due to gaps more than to genuine penetration
  - Coherence is not a complete description of these interferograms
  - Spatial averaging suppresses physical slopes
- Tomography: emphasis on vertical structure (a lot of spatial averaging)
  - Which are the consequences for forest modeling and inversion in X-band?
  - Is it more a phase unwrapping problem or a low-order lay-over?
  - Which the best multi-baseline processing?

Final Summary









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Thank you for your attention!