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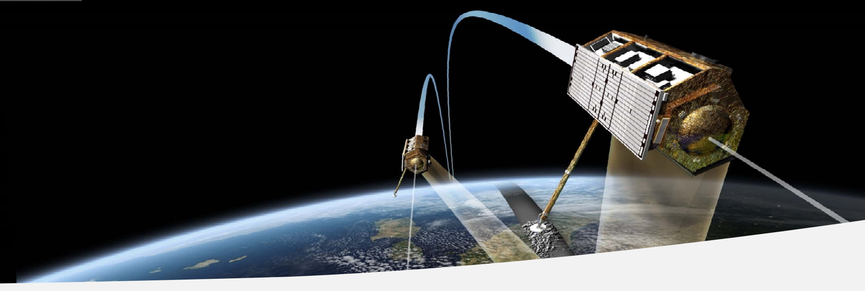

A PROPOSAL FOR A SAR INTERFEROMETRIC MODEL OF SOIL MOISTURE

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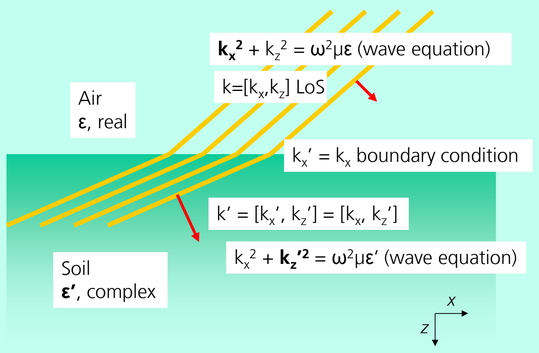
OBJECTIVE: to propose a simple scattering & interferometric model that can explain SAR ***interferometric phases*** and ***coherences*** in terms of ***soil moisture variations***; *report experiments of* ***moisture inversion*** *on real data.*

THE PROPAGATION MODEL: A PLANE WAVE IN A LOSSY DIELECTRIC

The soil is modeled as a ***lossy dielectric*** with a complex dielectric constant, which depends on the soil moisture.

A plane wave propagates in the dielectric

- ***The horizontal wavenumber is the same as in the air***, since the boundary condition has to hold.
- ***The vertical wavenumber is a function of the dielectric constant (moisture)***, plus the geometry and wavelength.



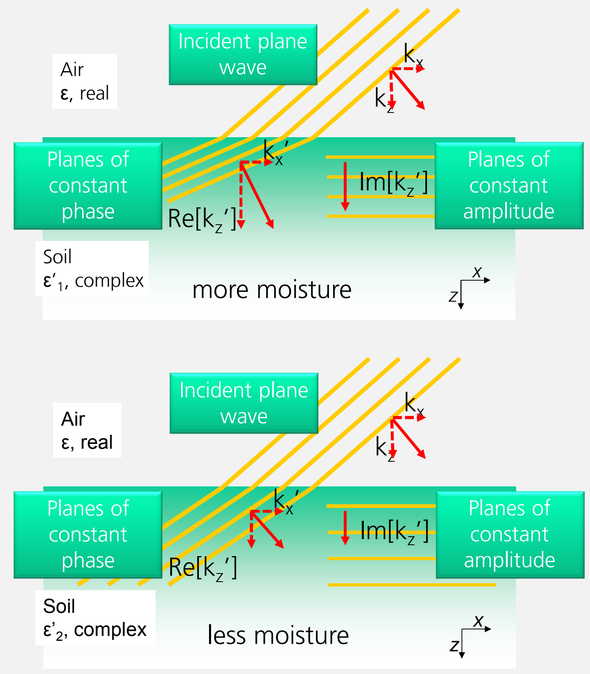
The plane wave in the air

$$E(r) = E_0 e^{j k_x x + j k_z z}$$

$$k_z'(\varepsilon') = \sqrt{\omega^2 \mu \varepsilon' - k_x^2}$$

The plane wave in the soil

$$E(r) = E_0' e^{j k_x' x + j k_z' z}$$



DIFFERENTIAL PROPAGATION YIELDS INTERFEROMETRIC EFFECTS

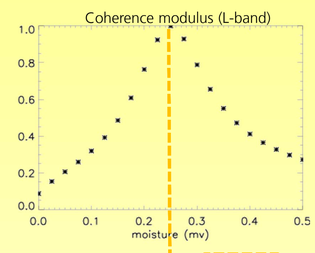
The ***expected interferogram*** for a homogeneous volume of scatterers (with Born approximation):

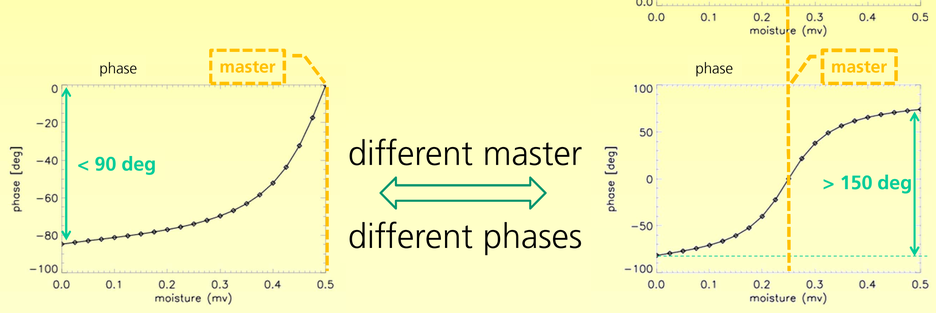
$$i_{1,2} = \int_0^{+\infty} e^{-j2k_z'(\varepsilon_1)z} \left(e^{-j2k_z'(\varepsilon_2)z}\right)^* dz$$

$$= \frac{1}{j2k_z'(\varepsilon_1) - j2\left(k_z'(\varepsilon_2)\right)^*}$$

INTERFEROMETRIC COHERENCE

$$\gamma = \frac{2j\sqrt{\mathrm{Im}[k_z'(\varepsilon_1)]\,\mathrm{Im}[k_z'(\varepsilon_2)]}}{k_z'(\varepsilon_2)^* - k_z'(\varepsilon_1)}$$



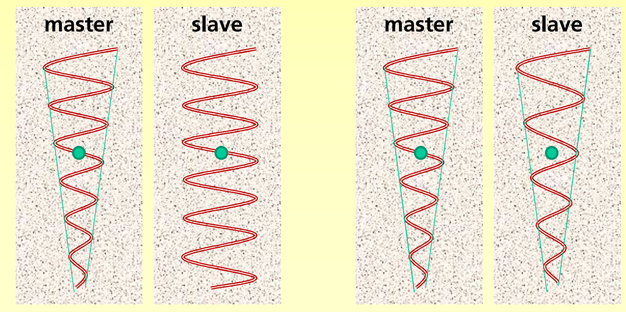


PENETRATION IS NOT THE KEY

The ***change in the real vertical wavenumber*** is the decisive effect for the interferometric phase

Change in the imaginary part:
attenuation difference
no effect on the mean phase
(no differential effect)

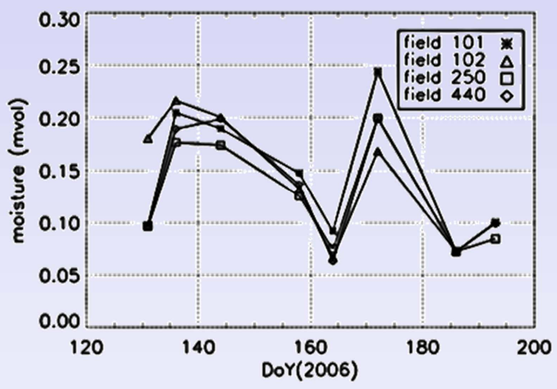
Change in the real part:
phase propagation difference
phase effect
(differential effect)



AGRISAR campaign 2006

- L-band SAR interferometric data
- *In-situ* measurements of moisture
- Analysis on one corn field

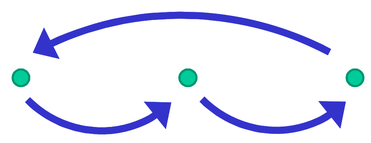
IN-SITU MEASUREMENTS



Data by Univ. of Kiel, distributed by ESA

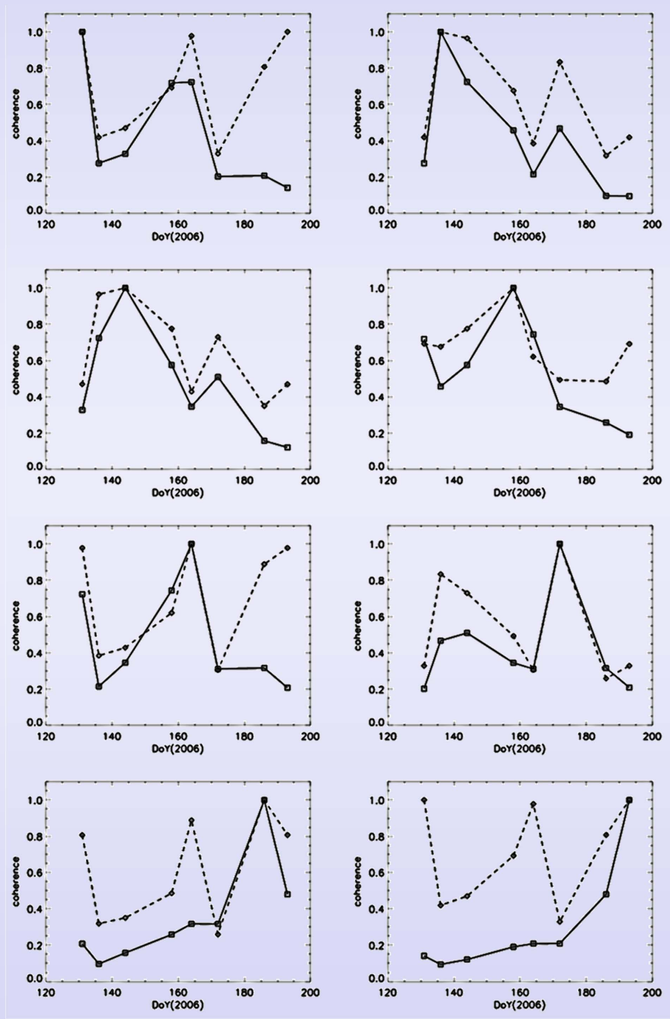
Coherence amplitudes are ambiguous: they do not tell whether the moisture has increased or decreased.

Interferometric phases are not *conservative:* given three images, two interferograms are not able to predict the third one: this property can be exploited in the inverse problem.



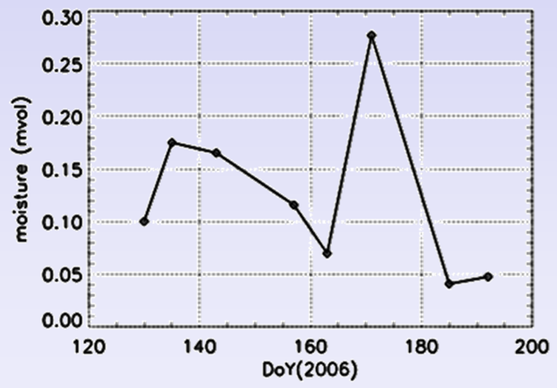
$$\measuredangle(i_{1,2}\ i_{2,3}\ i_{3,1}) \neq 0$$

FORWARD-MODEL COHERENCE PREDICTIONS FROM *IN-SITU* OBSERVATIONS



INVERTED MOISTURE

based on coherences and phase triplets



TRIPLET MISMATCH PREDICTION

7 images = 35 triplets