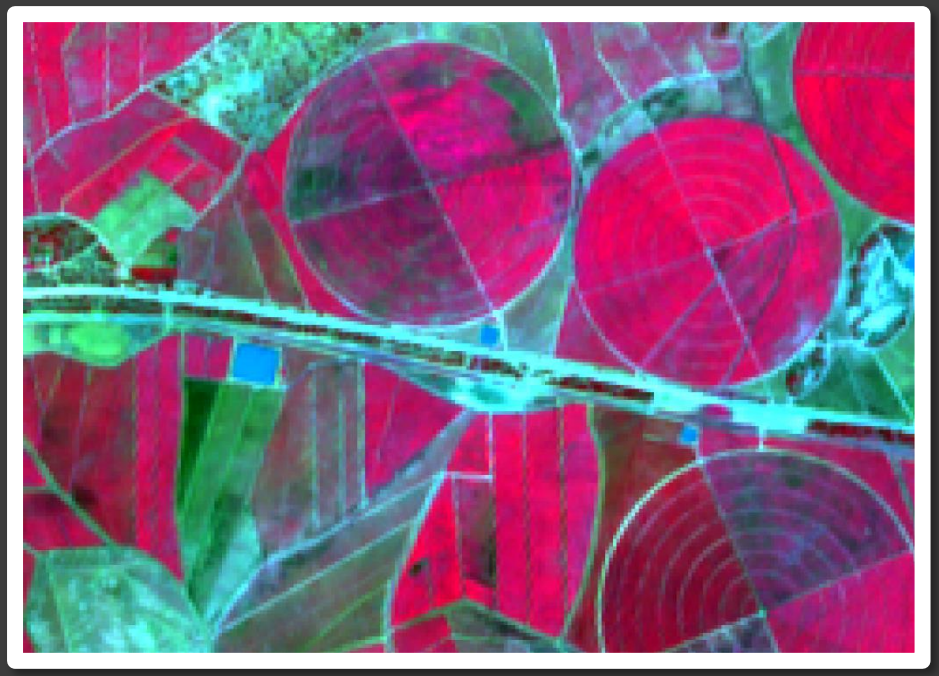


USE OF SPATIAL CONTEXT INFORMATION DURING RTM INVERSION

Clement ATZBERGER

Tartu - 25 August 2017

BOKU - UNIVERSITY OF NATURAL RESOURCES & LIFE SCIENCES

History: … since 1875
Staffing: … ca. 20 (mostly permanent)
Teaching: … several bachelor & master programs
Thematics: … Remote sensing & photogrammetry
… GIS & land information
… Surveying & geodesy

REMOTE SENSING GROUP AT BOKU

ACTIVITIES

Biophysical parameter

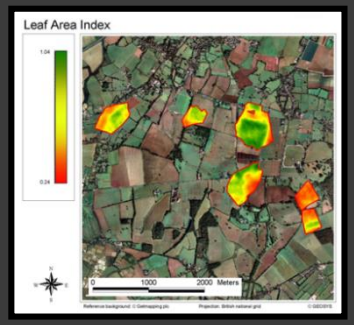
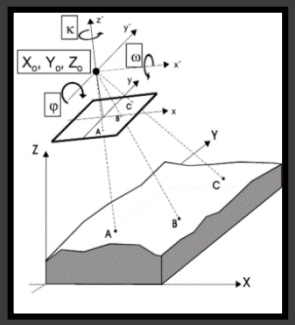
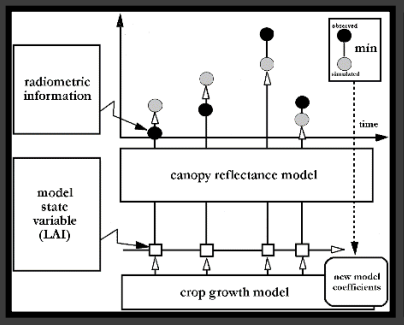


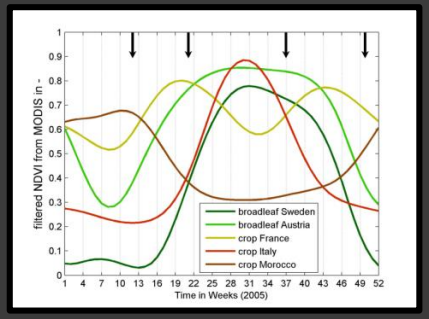
Photo-grammetry



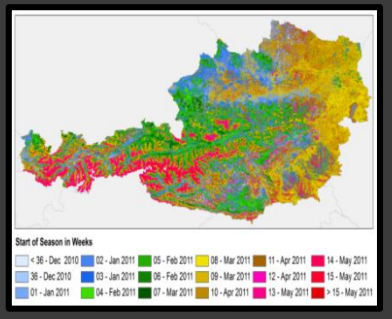
RS data assimilation



Time series analysis

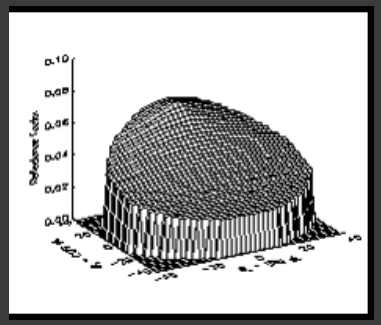


Land surface phenology

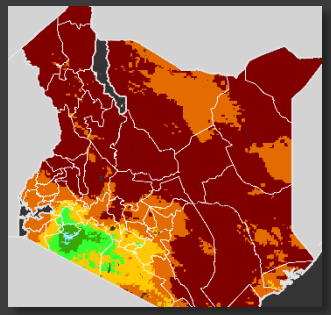


Precision agriculture

BRDF modeling

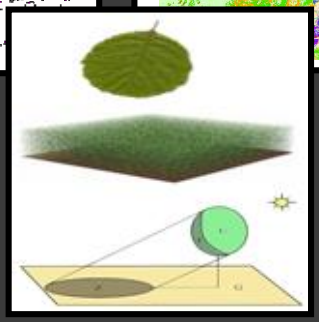


Drought monitoring

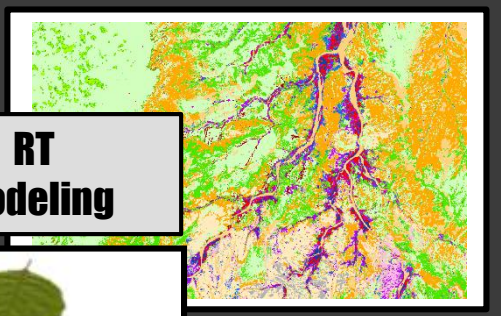


Laser scanning

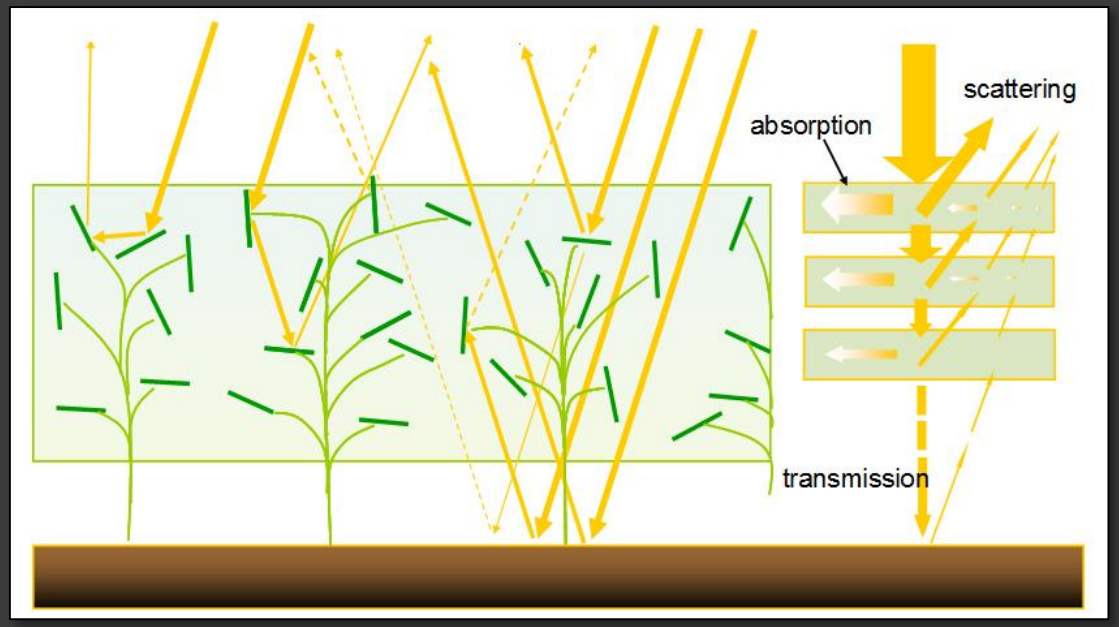
RT modeling



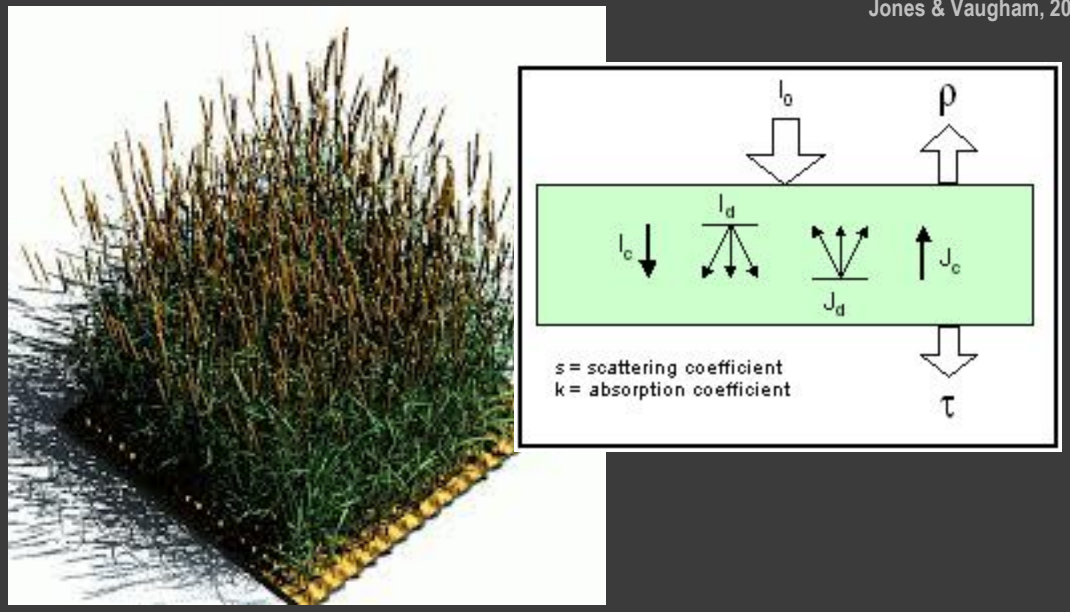
LULC mapping



MAPPING OF VEGETATION TRAITS: RTM



Jones & Vaugham, 2010



Radiative transfer modeling:

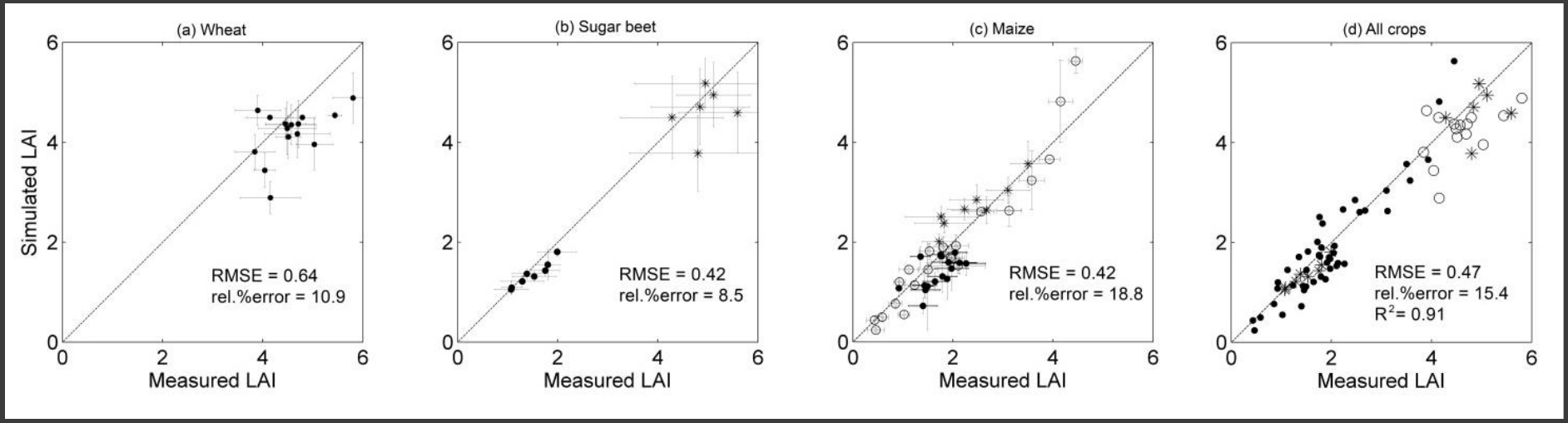
"Use of physical laws"

… therefore some advantages (in theory):

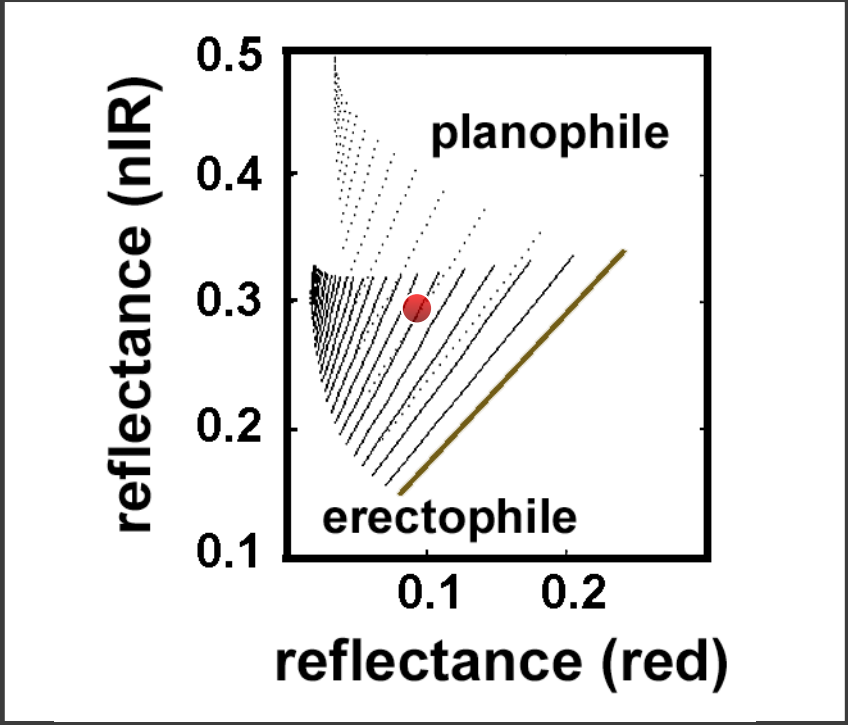
- Field data only for validation needed
- More generic (time, landscape)
- Not sensor specific
- Data redundancy not a problem

MAPPING OF VEGETATION TRAITS: RTM

PROSAIL



MAPPING OF VEGETATION TRAITS: "ILL-POSEDNESS"



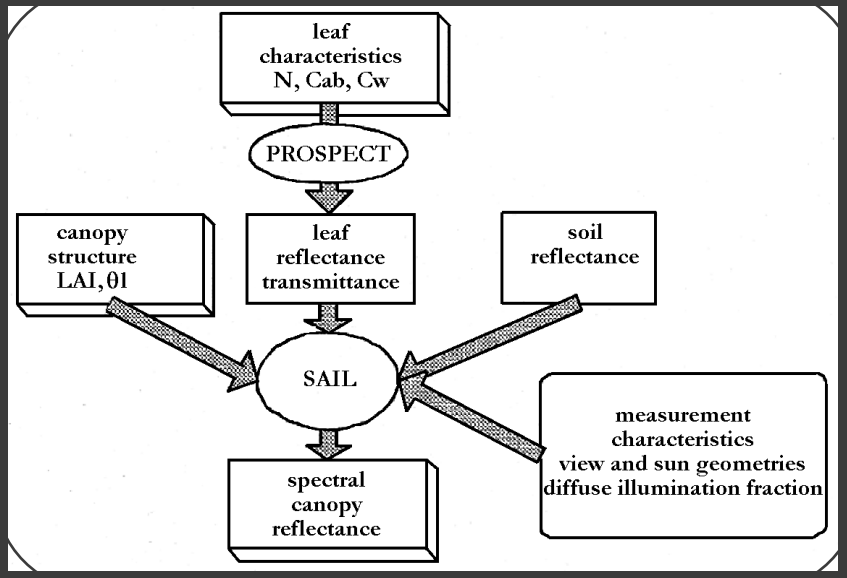
Assumption:
'erectophile'

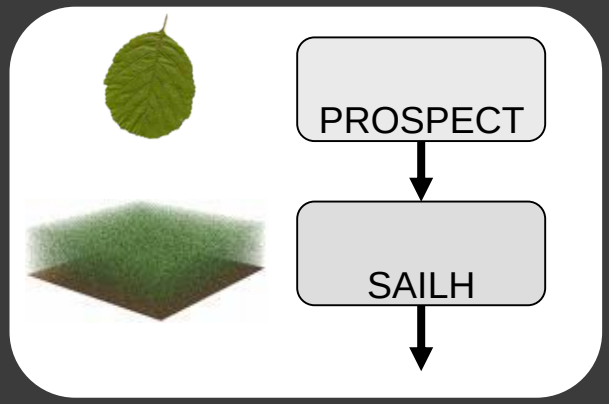
LAI = 2.4
RSOIL= bright

Assumption:
'planophile'

LAI = 1.0
RSOIL= medium

The ill-posed inverse problem illustrated in the red-nIR feature space. LAI-isolines range from 0 (bare soil) to LAI=5 in steps of 0.5 (SAILH+PROSPECT simulations)

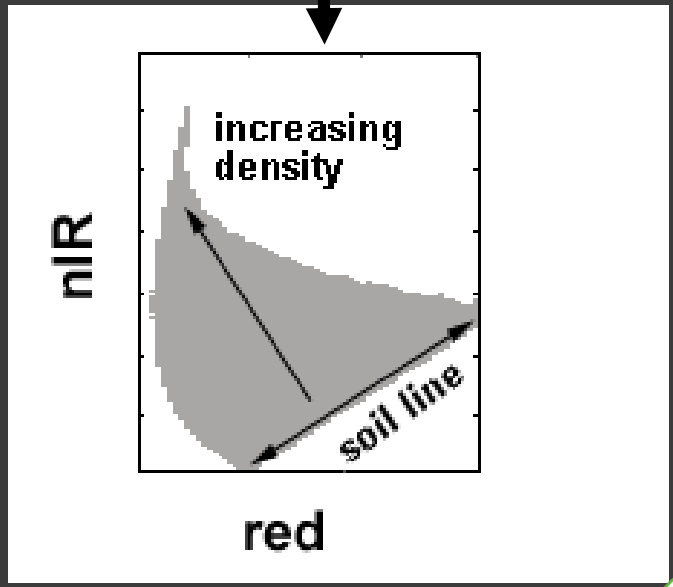




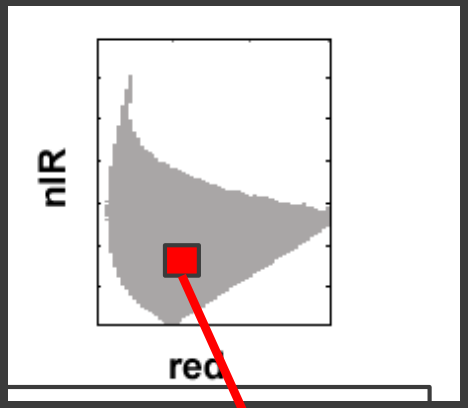
1.300		50		50
LAI	x	*SCALE*	x	*ALA*

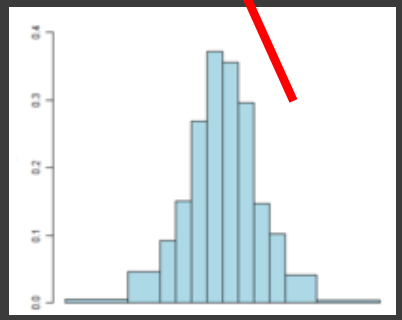
Large number (> 3 Mio) of canopy reflectances were simulated using PROSAIL RTM … using different combinations of LAI, soil brightness and ALA … with all other parameters set constant.

…. the resulting Tasseled Cap is well known (theory & practice)

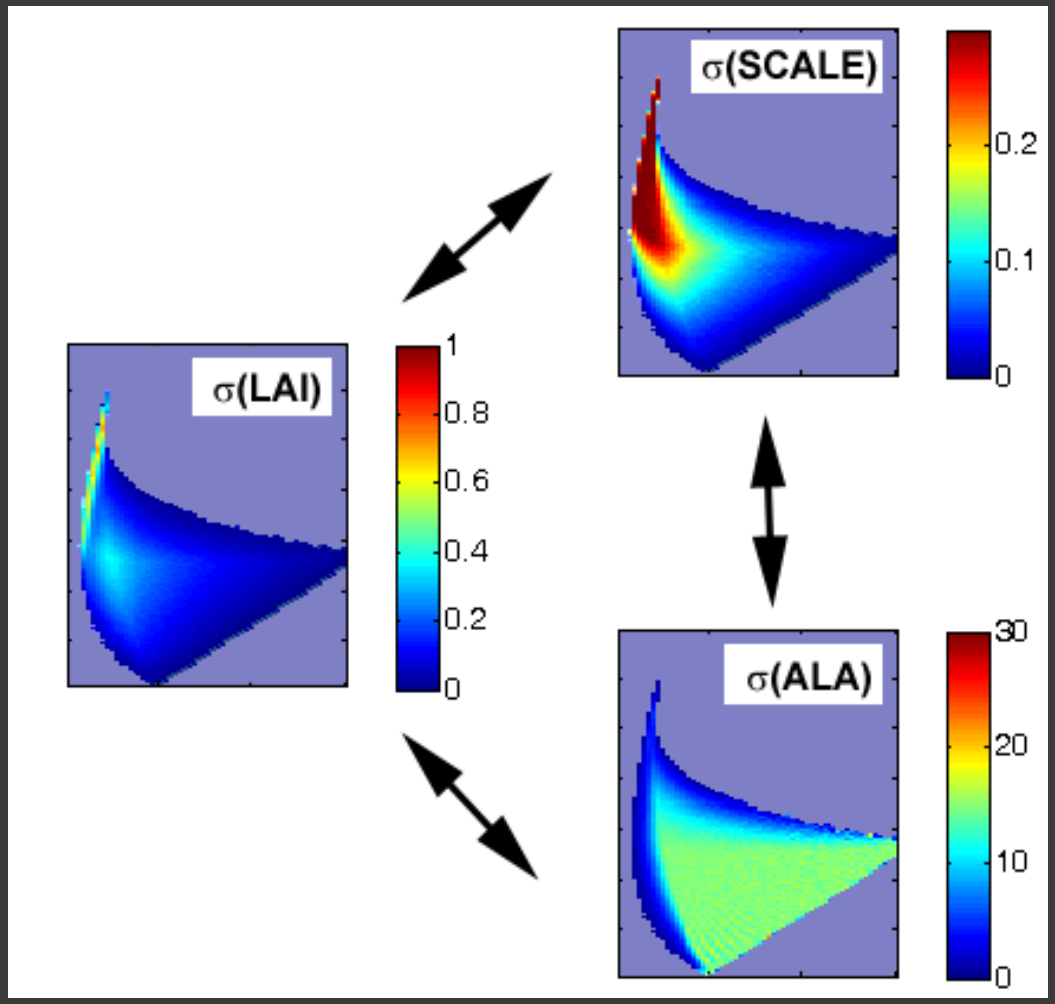


Counterbalancing effect of LAI , soil brightness, and ALA





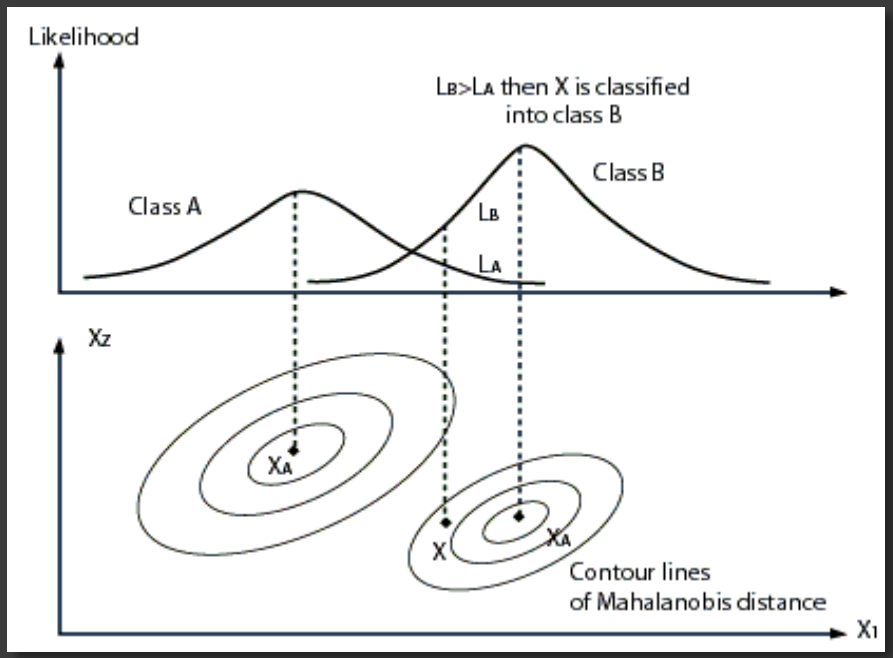
LAI distribution inside one cell

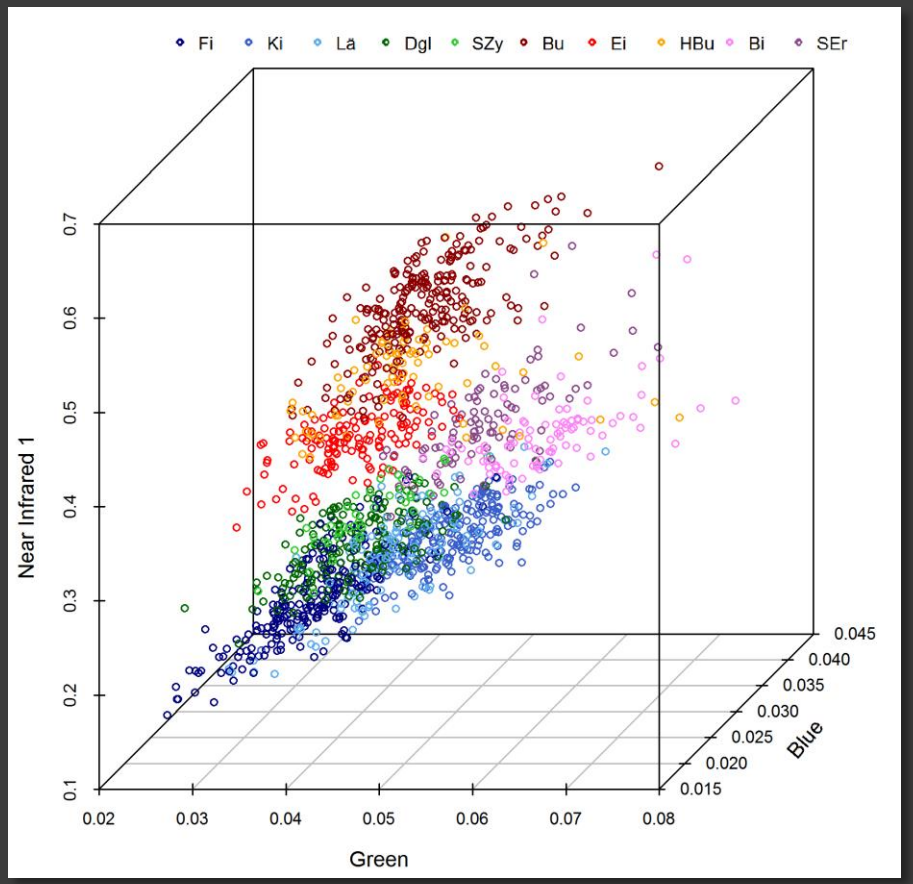


Interpretation: ….In areas with high stdev, the respective parameter cannot be retrieved accurately !

One can easily imagine, that adding variability in leaf pigmentation, leaf sizes, observation/illumination geometries, etc. will further amplify the problem !

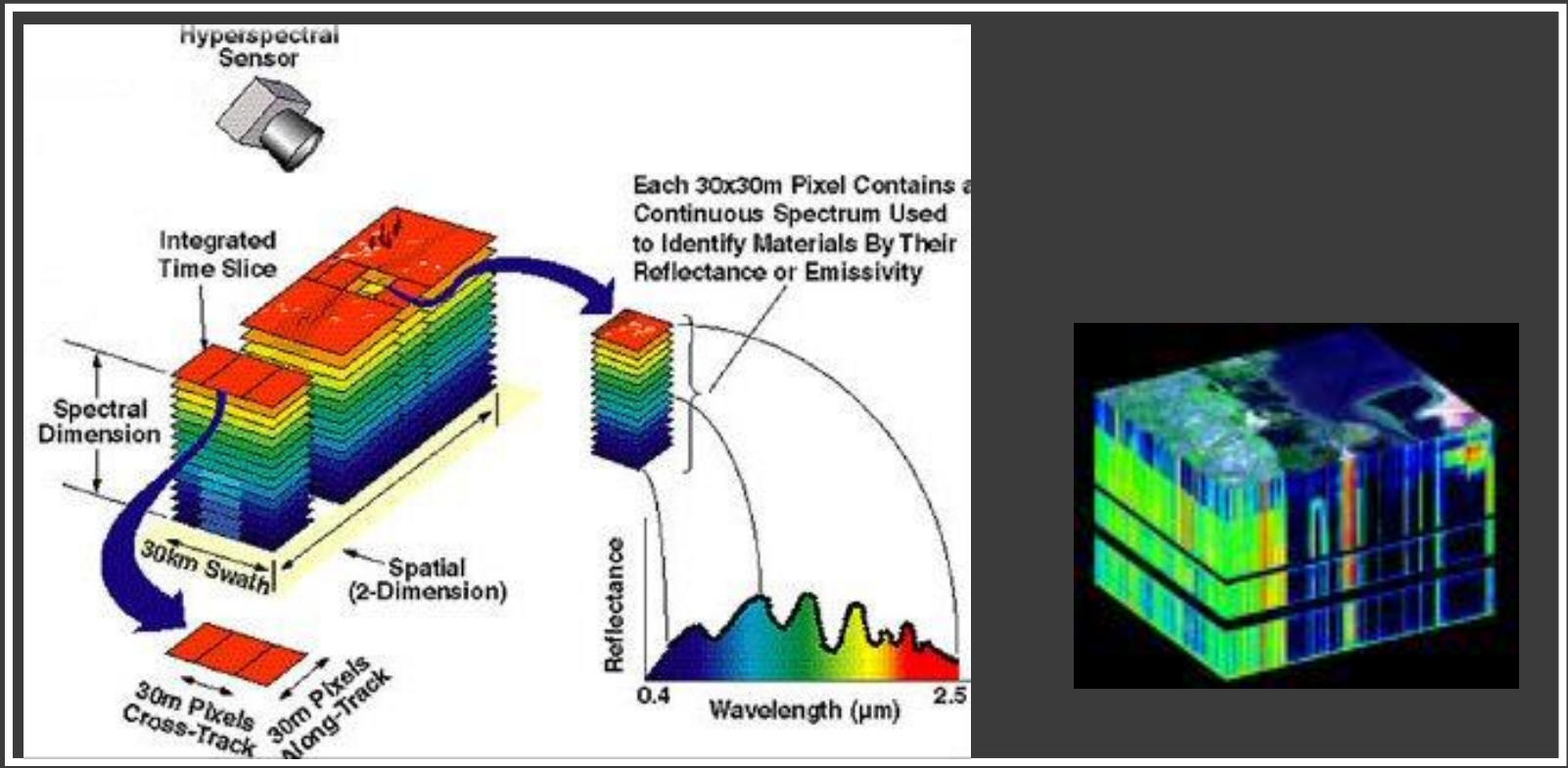
MAPPING OF VEGETATION TRAITS: "ILL-POSEDNESS"





COPING WITH ILL-POSEDNESS

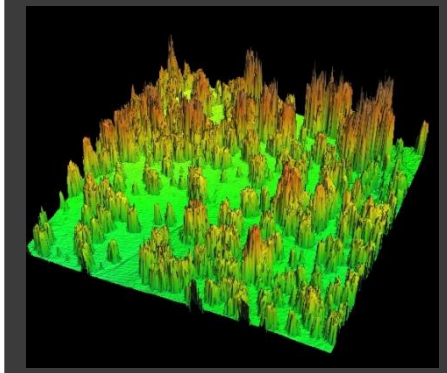
Increasing the dimensionality of the data

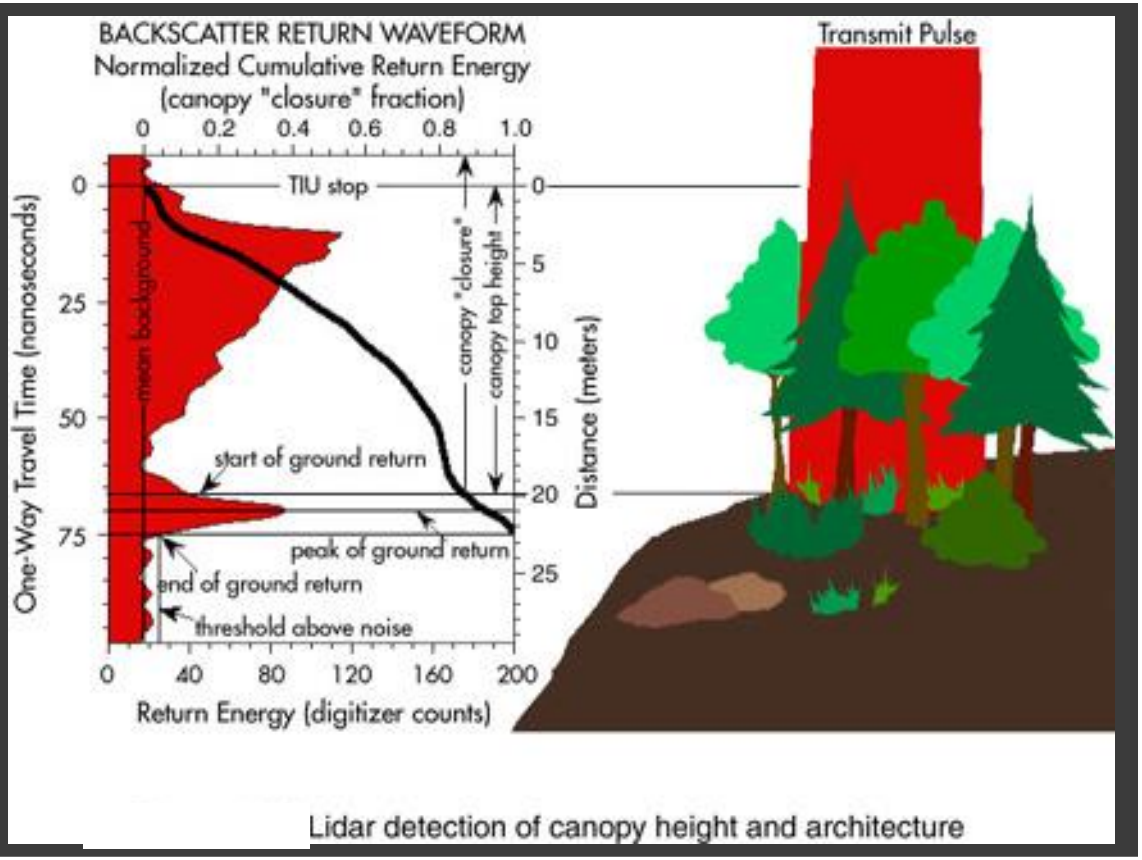


By mapping the Earth surface in many continuous spectral bands, a better inversion of radiative transfer models can be achieved (source: web)

COPING WITH ILL-POSEDNESS

Increasing the dimensionality of the data

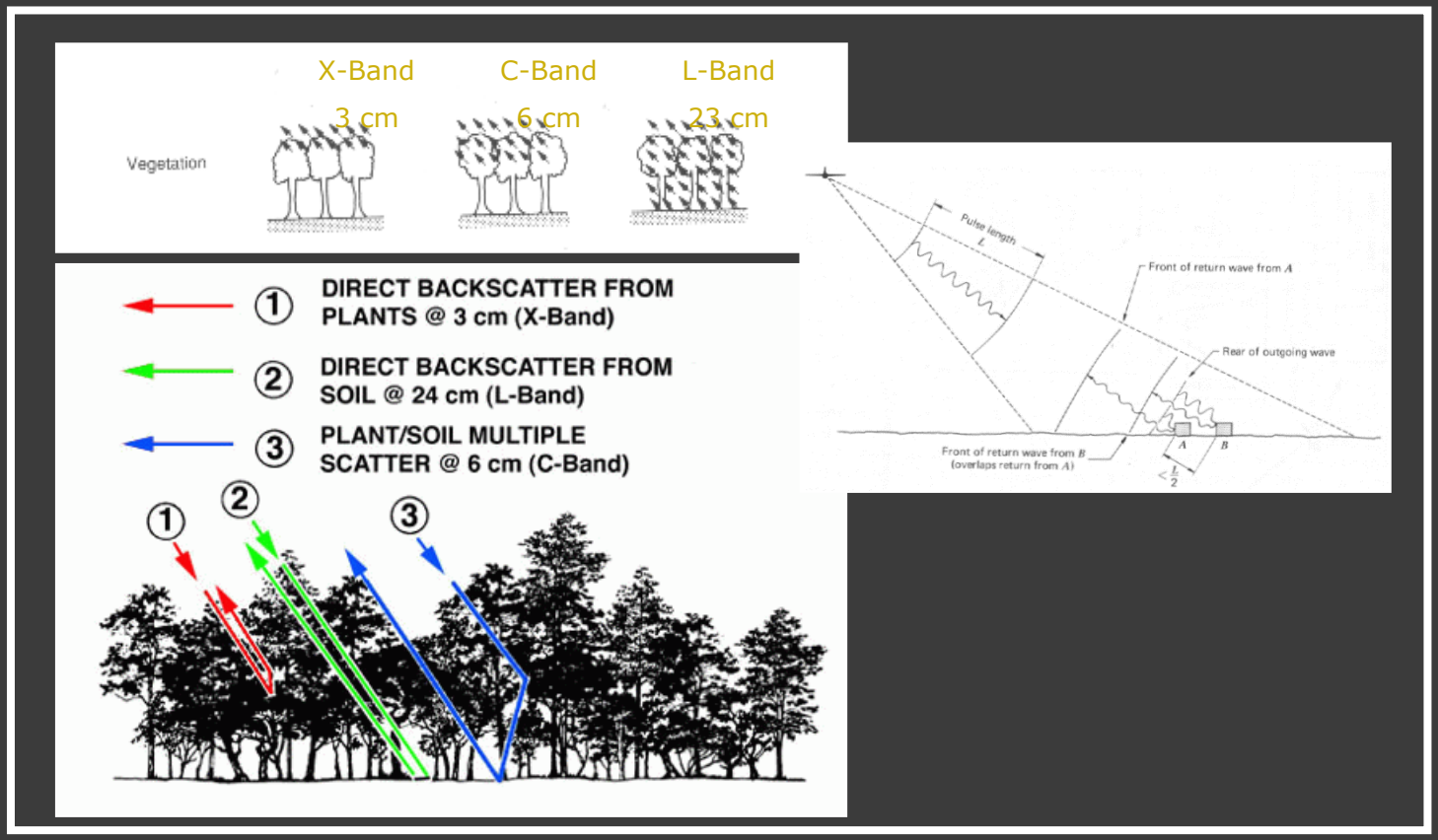




The number of variables to be retrieved can be reduced if some variables can be mapped from other EO data (e.g. canopy height and architecture from LIDAR measurements) (source: web)

COPING WITH ILL-POSEDNESS

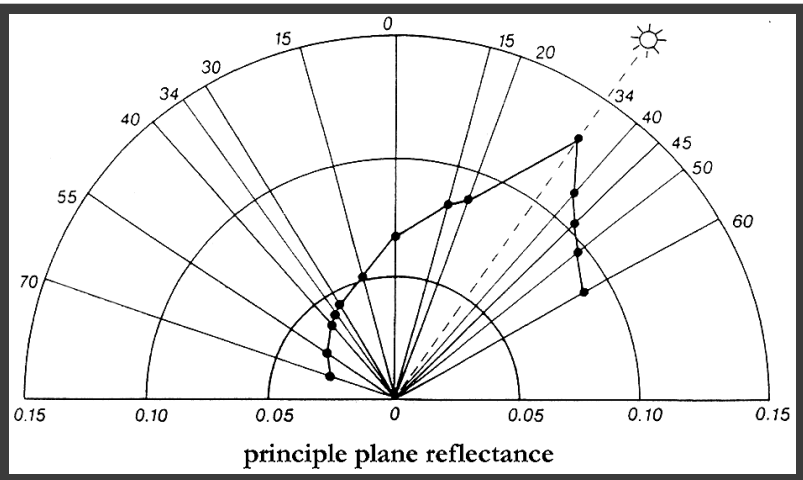
Increasing the dimensionality of the data

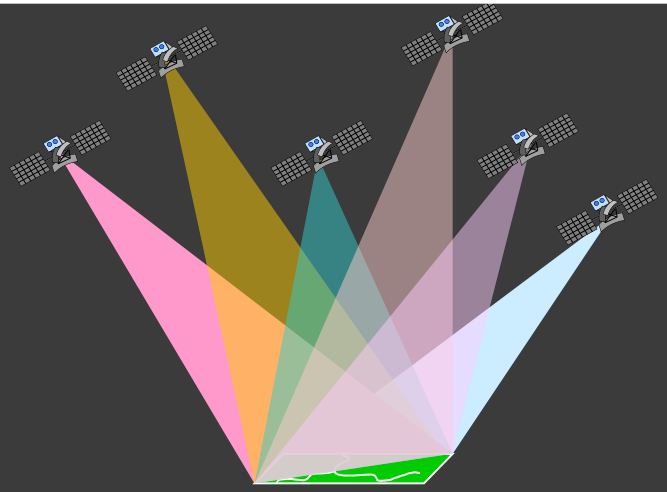


The ill-posed problem can be considerably reduced by increasing the dimensionality of the data set – here: by combining optical and microwave data sets (source: web)

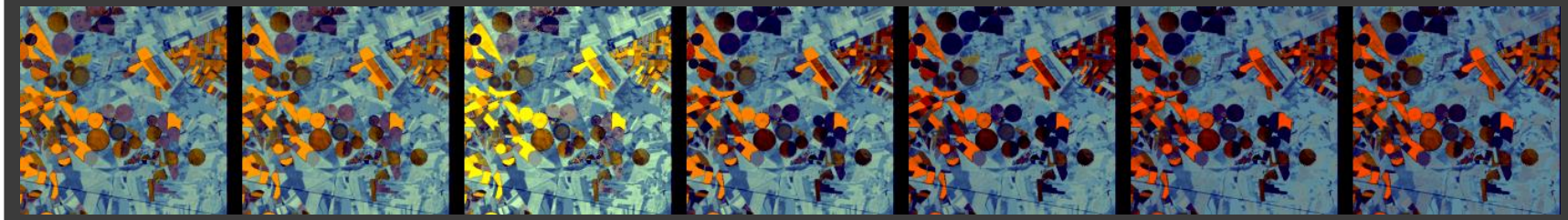
COPING WITH ILL-POSEDNESS

Increasing the dimensionality of the data





-60° -45° hot spot nadir view +22° +45° +60°

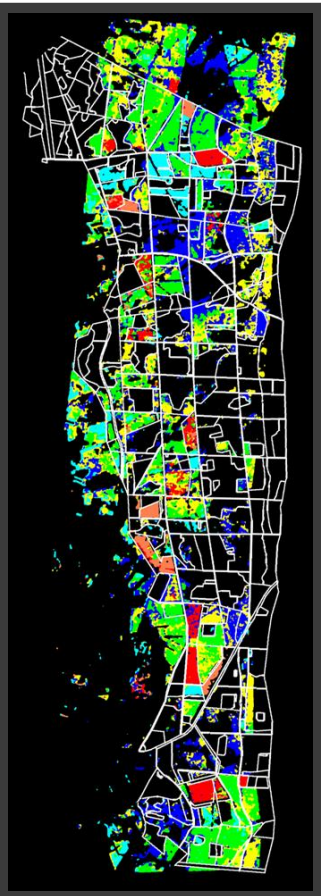


660 nm, 730 nm, 840 nm

The ill-posed problem can be considerably reduced by increasing the dimensionality of the data set – here: combining spectral and directional data (source: web)

COPING WITH ILL-POSEDNESS

Including (external) prior information



$$F(\theta) = \sum_{i=1}^{I} \left(\frac{\rho_i - M_i(\theta)}{\sigma_i} \right)^2 + \sum_{j=1}^{J} \left(\frac{\theta_j - \mu_j}{\sigma_j} \right)^2$$

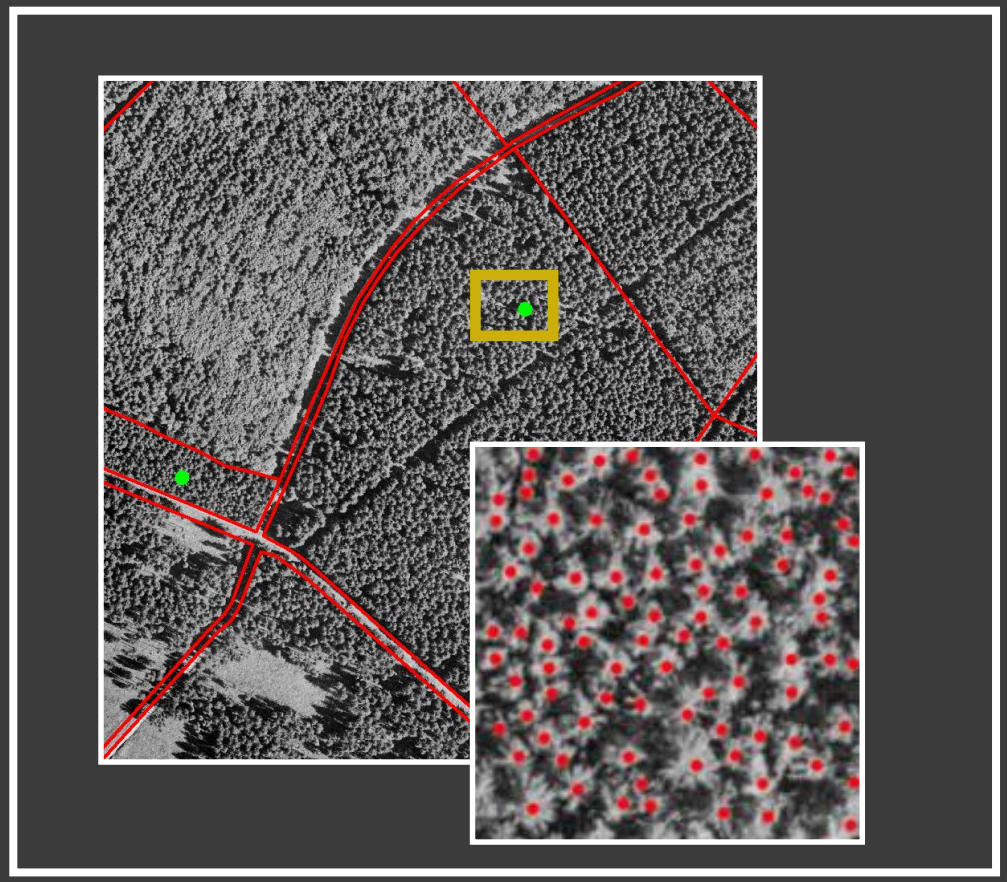
spectral info

prior info

The error surface can be better reshaped and restricted, if externally derived prior information is available (e.g. land cover classification yielding information on plant architecture)

COPING WITH ILL-POSEDNESS

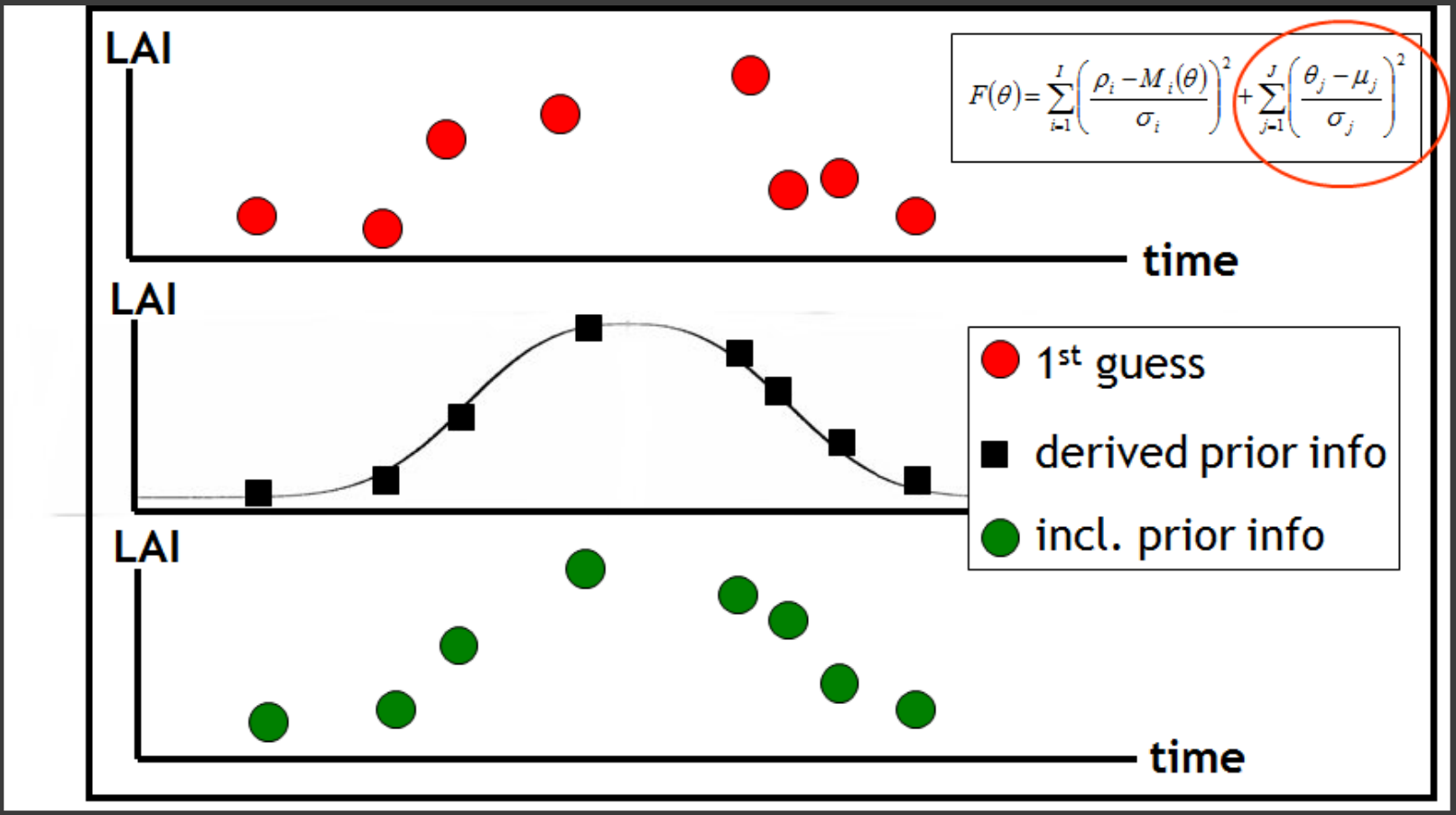
Including (external) prior information



The number of variables to be retrieved can be reduced if some variables can be mapped from other EO data (e.g. stem density from orthophotos) (source: Schlerf & Atzberger)

COPING WITH ILL-POSEDNESS

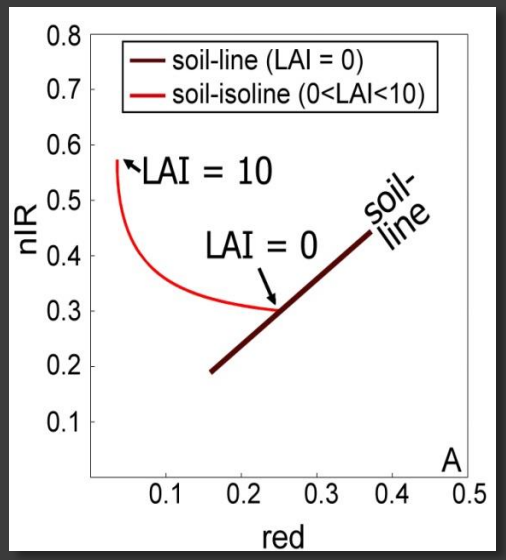
Exploiting the temporal consistency

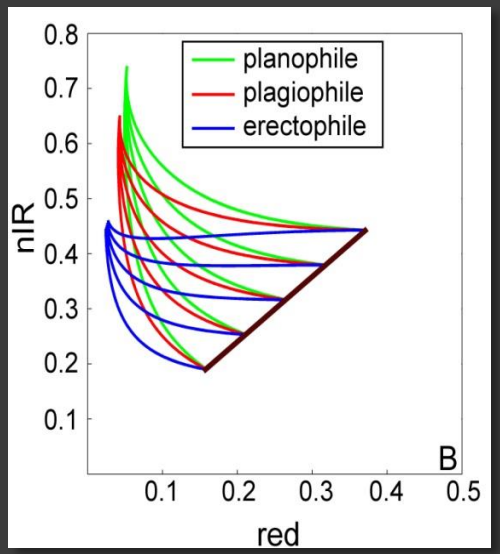


OBJECT-BASED RTM INVERSION

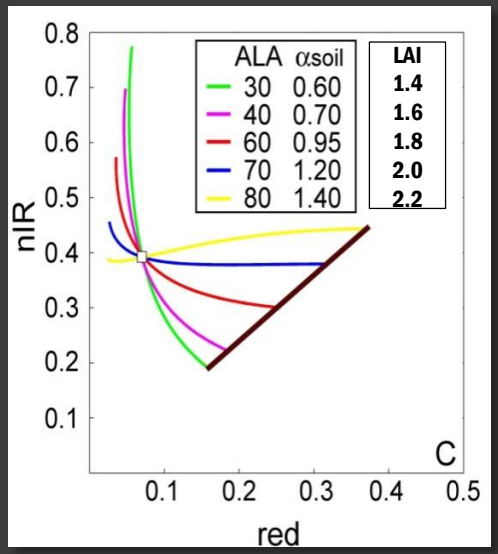
Exploiting the spatial/context information

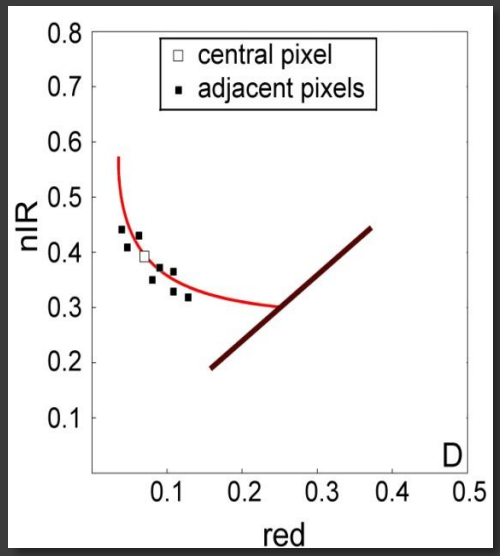
OBJECT-BASED RTM INVERSION: THEORY





Exploiting spatial auto-correlation

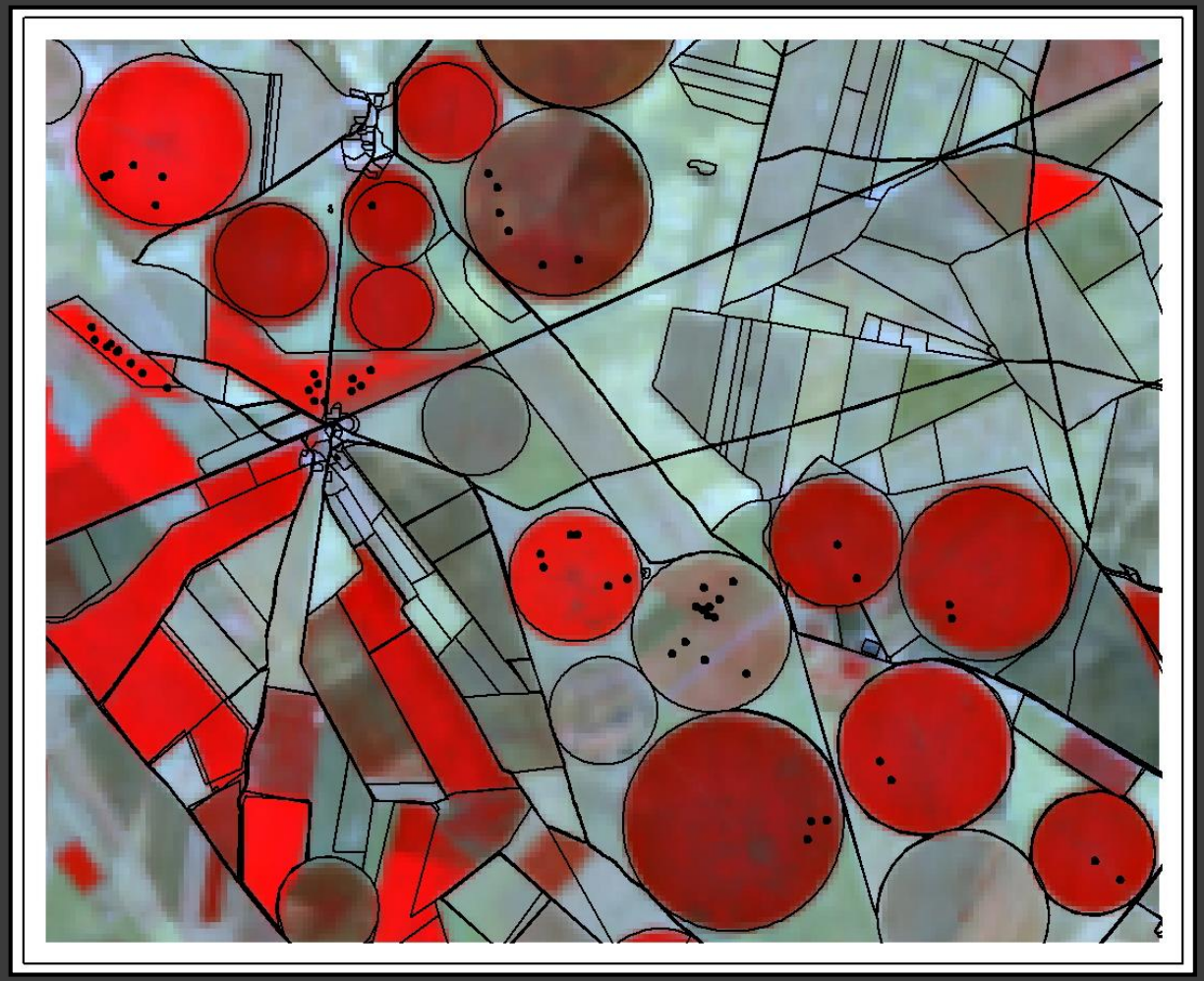




Optimization of „soil-isolines“ for pixels within 3 x 3 gliding windows, assuming that only LAI shows a remarkable variation within ± 1 pixel

OBJECT-BASED RTM INVERSION: TEST

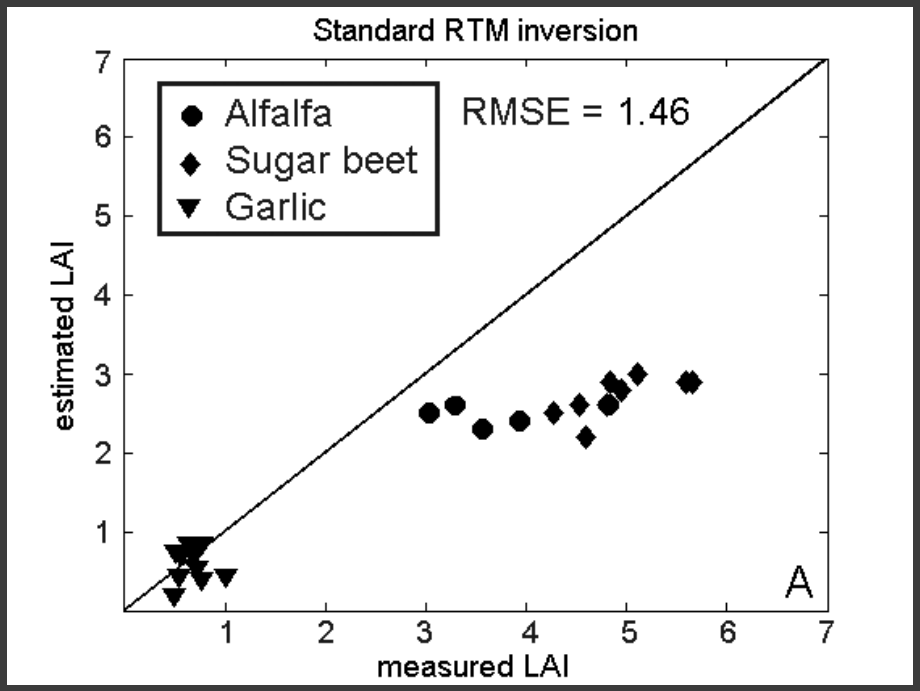
Experiment

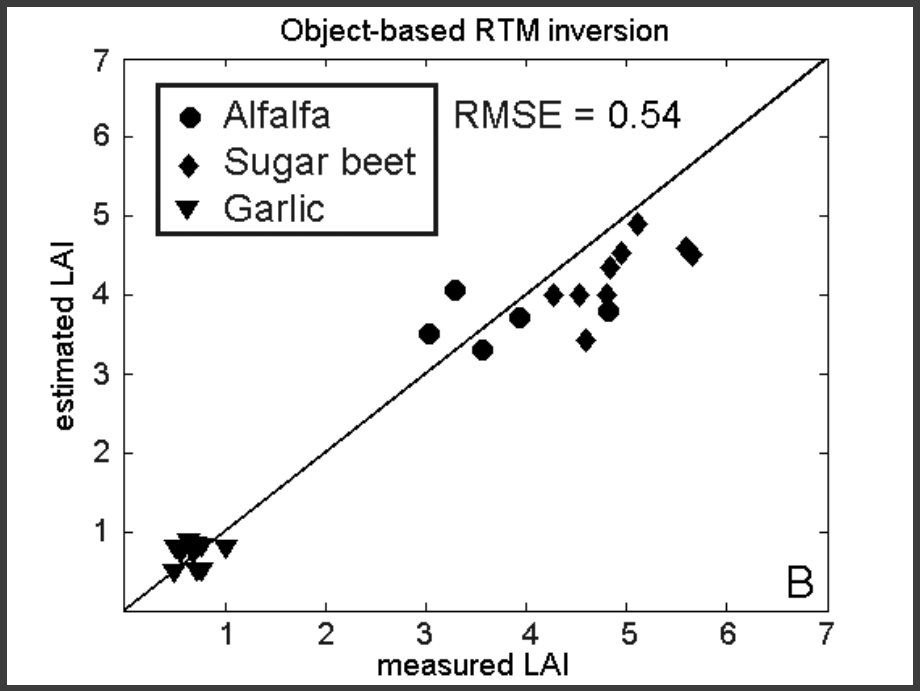


Barrax test site for testing
the proposed model regularization

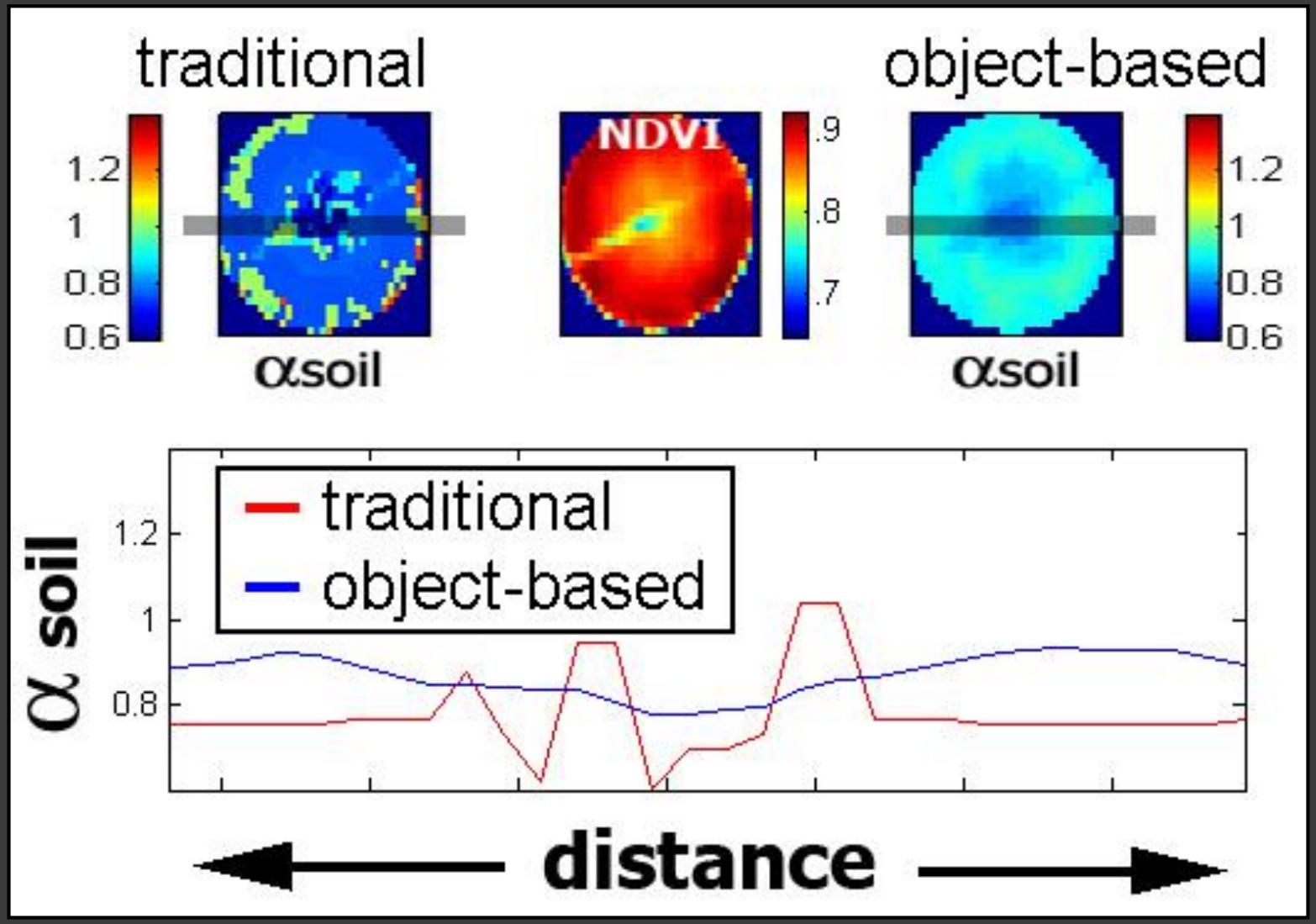
OBJECT-BASED RTM INVERSION: TEST

Exploiting spatial information



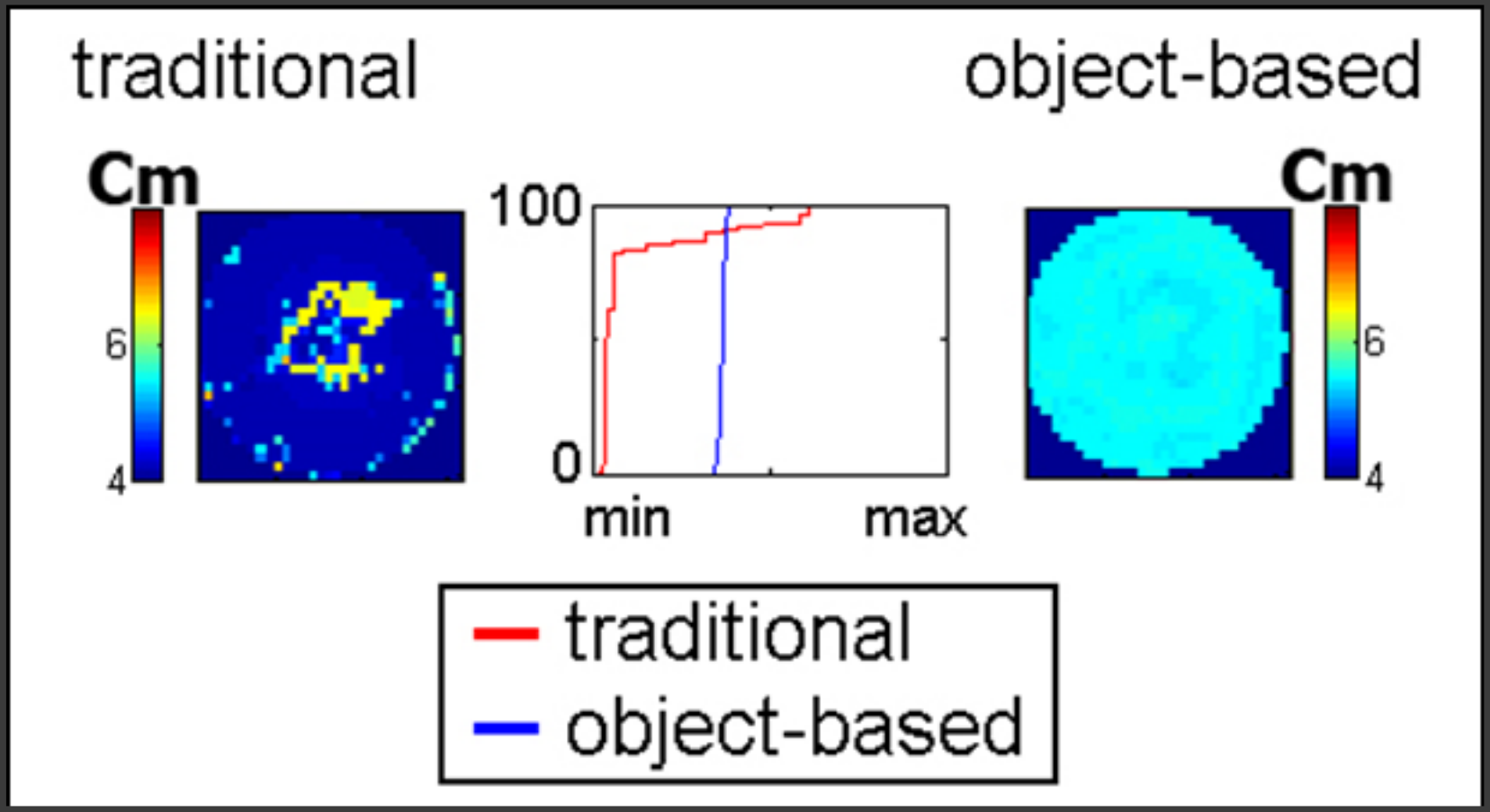


OBJECT-BASED RTM INVERSION: TEST



Estimated variation of the soil brightness factor along a horizontal line in the Alfalfa test field for the traditional approach and the proposed object-based inversion

OBJECT-BASED RTM INVERSION: TEST



… THE ARRIVAL OF A GAME CHANGER …

IMPROVED EXPLOITATION OF SPATIAL CONTEXT

CONCLUSION

1. RTM are very powerful tools for retrieving vegetation characteristics !

2. Ill-posedness is a serious problem, …, although not only for RTM inversion !

3. All dimensions & a priori information should be used (wavelength, direction, polarization, time …) !

4. Exploitation of spatial dimension deserves more attention !

CONTACT

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