WHICH VEGETATION STRUCTURE VARIABLES ARE BEST ESTIMATED FROM REMOTE-SENSING OBSERVATIONS IN THE SOLAR REFLECTIVE DOMAIN?

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Background

- **Structural variables are key inputs for:**
  - Main canopy functioning processes (photosynthesis/transpiration/respiration …)
  - Remote sensing observations through radiative transfer (scattering, absorption, fluorescence…)
- **Several variables related to the green elements**
  - GF (green fraction)
  - FVC (cover fraction) FVC=GF(0°)
  - FAPAR (FAPARb FAPARw) FAPARb(sza)≈1-GF(vza)
  - LAI / PAI / GAI / GLAI with variants (effective/apparent)

	Only leaf	**All vegetation elem.**
Green+non green	LAI	PAI
Green	GLAI	**GAI**

Upward looking Indirect methods

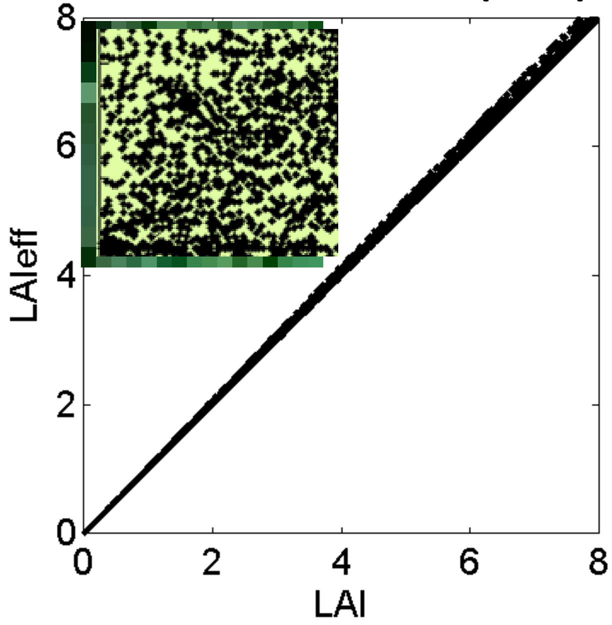
downward looking Indirect methods Incl. Remote Sensing

Destructive measurements

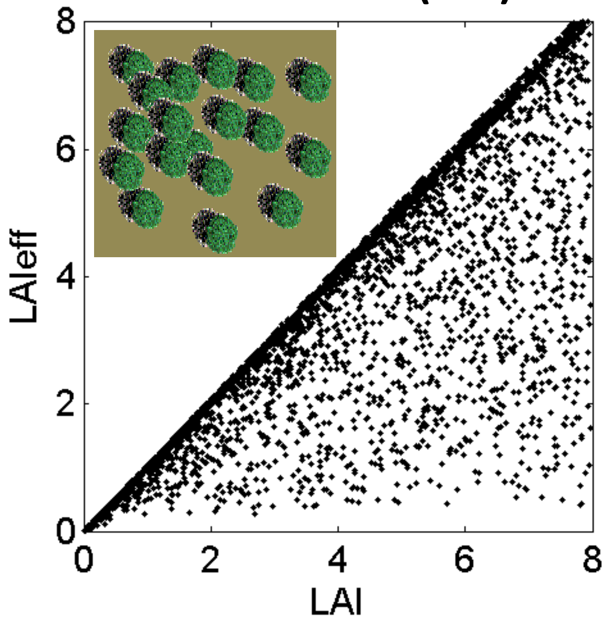
Destructive measurements

LAI and effective LAI

1D turbid medium (SAIL)



2.5D Geometric (SLC)



Consistently with indirect measurement methods,

The effective LAI (LAIe) is the LAI value that provides the closest directional variation of the GF under turbid medium assumption

Objectives

Evaluate the retrieval performances depending on:

The variable targeted

- FAPARb(sza)
- FAPARw
- FIPAR(sza)
- GF(vza)
- LAI (GAI)
- LAIe (GAIe)

The type of structure (clumping)

- Turbid
- clumped

Methods: Radiative transfer model simulations

- Leaf optical properties: PROSPECT
- Soil reflectance: typical soils with brightness
- Canopy reflectance:
  - 2.5D SLC model (clumping at the stand level)
    - LAI, ALA, Crown-Cover, D/H, hot: 5 variables
  - 1D model (assumes turbid medium)
    - SLC with Crown-Cover=1

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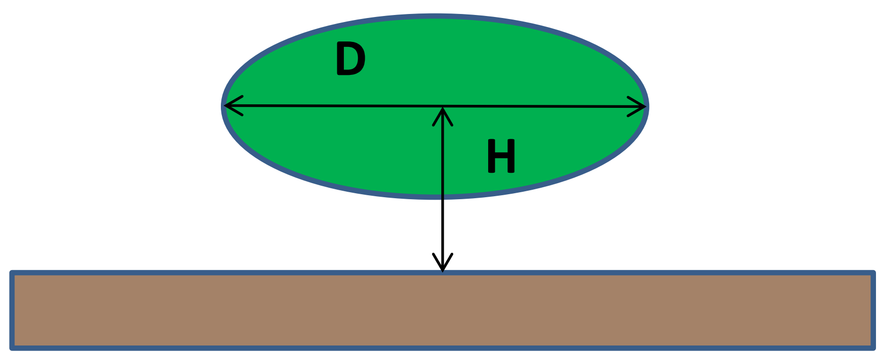
Coupled soil–leaf-canopy and atmosphere radiative transfer modeling to simulate hyperspectral multi-angular surface reflectance and TOA radiance data

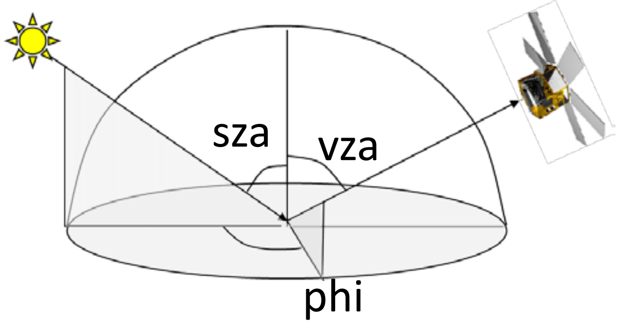
Wout Verhoef [a,*], Heike Bach [b]



Distribution of RTM input variables for Test cases and LUT generation

Uniform (independent) distributions considered within the typical range of variation

	Variable	Mini	Maxi
Canopy	LAI	0	8
	LIDFa	-1.0	1.0
	LIDFb	-0.3	0.3
	hot	0.1	0.5
	Crown-cover	0.3	1.0
	D/H	0.2	1.0
Leaf	N	1.20	2.20
	Cab (µg m-2)	30	90
	Cdm (gm-2)	0.0030	0.010
	Cw. Rel.	0.60	0.85
	Cs	0.00	0.00
Soil	Bs	0.50	1.0

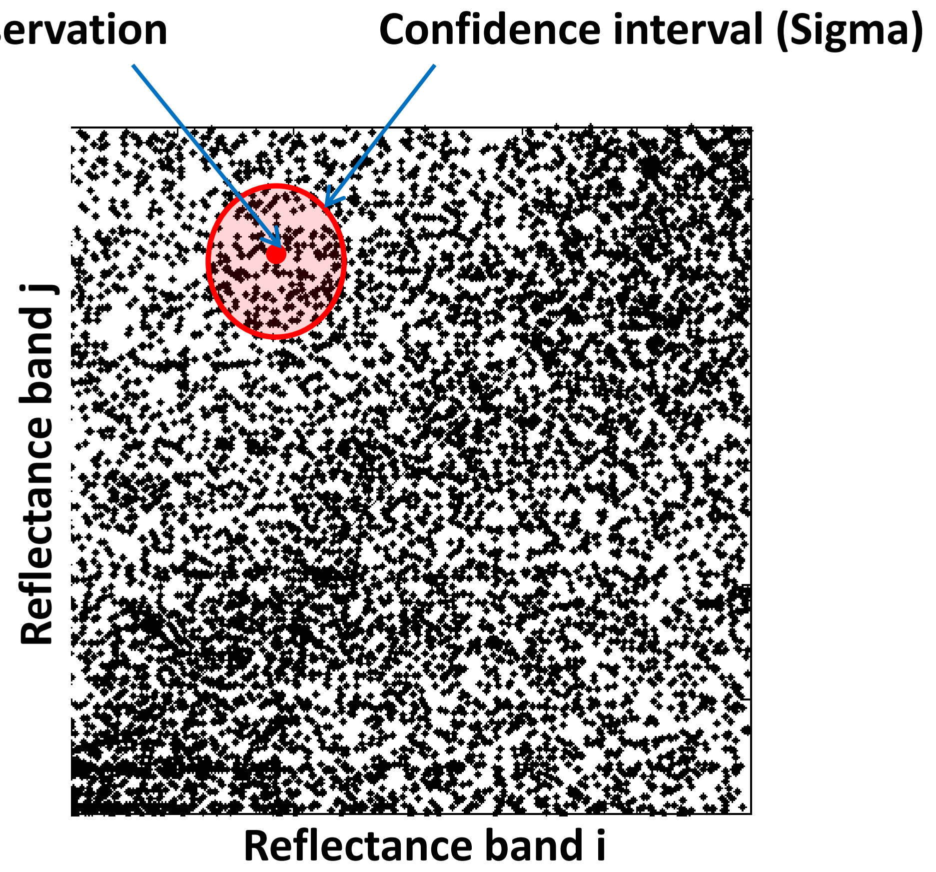


Angles	Values (°)
sza	30 45 57
vza	0 15 30 45 57 75 85
phi	90

Output variables

- LAI (actually input)
- GF(vza)
- FAPARb(SZA)
- FAPARw
- LAIe
  - Miller's formula
    $$LAI = 2\int_0^{\pi/2} -\log(1 - GF(\text{vza})).\sin(\text{vza}).\cos(\text{vza})\, d\,\text{vza}$$
  - GF(57°) $LAI = -\frac{0.5}{\cos(57°)}\log(1 - GF(57°))$

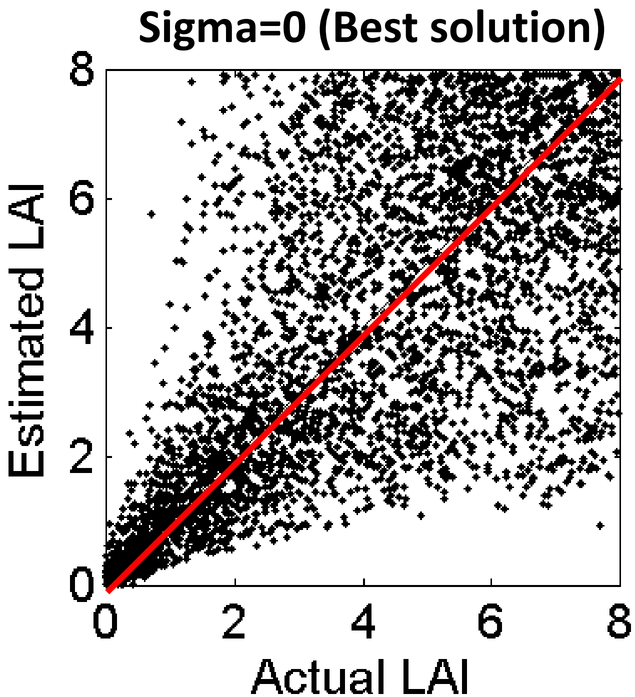
LUT algorithm



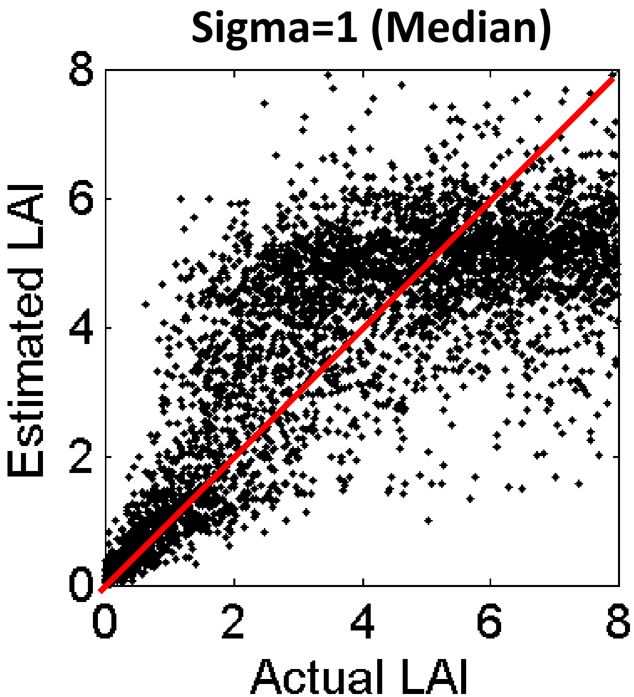
The solution is computed as the median of cases that are within the confidence interval of the observation

When sigma=0, it corresponds to the best (closest) solution

Effect of Inversion Procedure on LAI Estimates



Very little biase but large scattering



Smaller scattering but larger biases

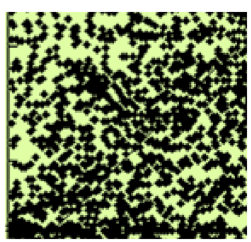
A balance should found between accuracy (biases) and precision (scattering)

Because many cases available, best solution was chosen

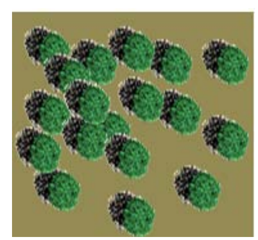
Test and LUT combinations

		Test (1000)	
		turb	**clump**
LUT (49000)	**turb**		
	clump		

Combination of test and LUT type of canopy architecture

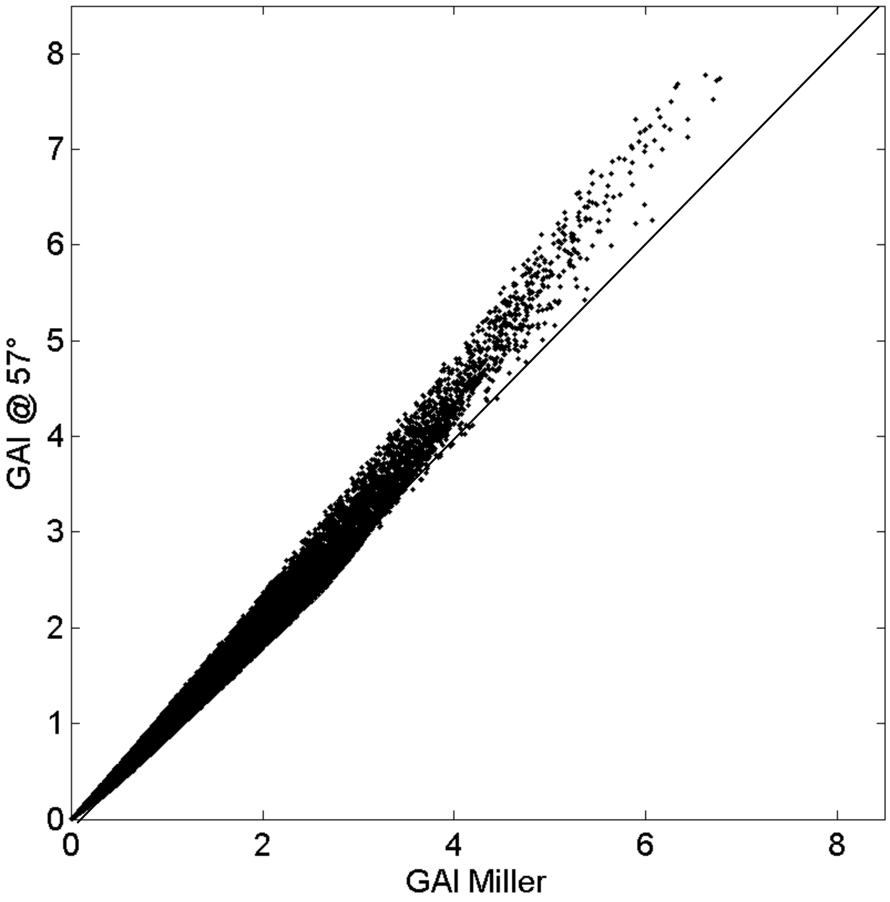


turb



clump

RESULTS: selection of variables

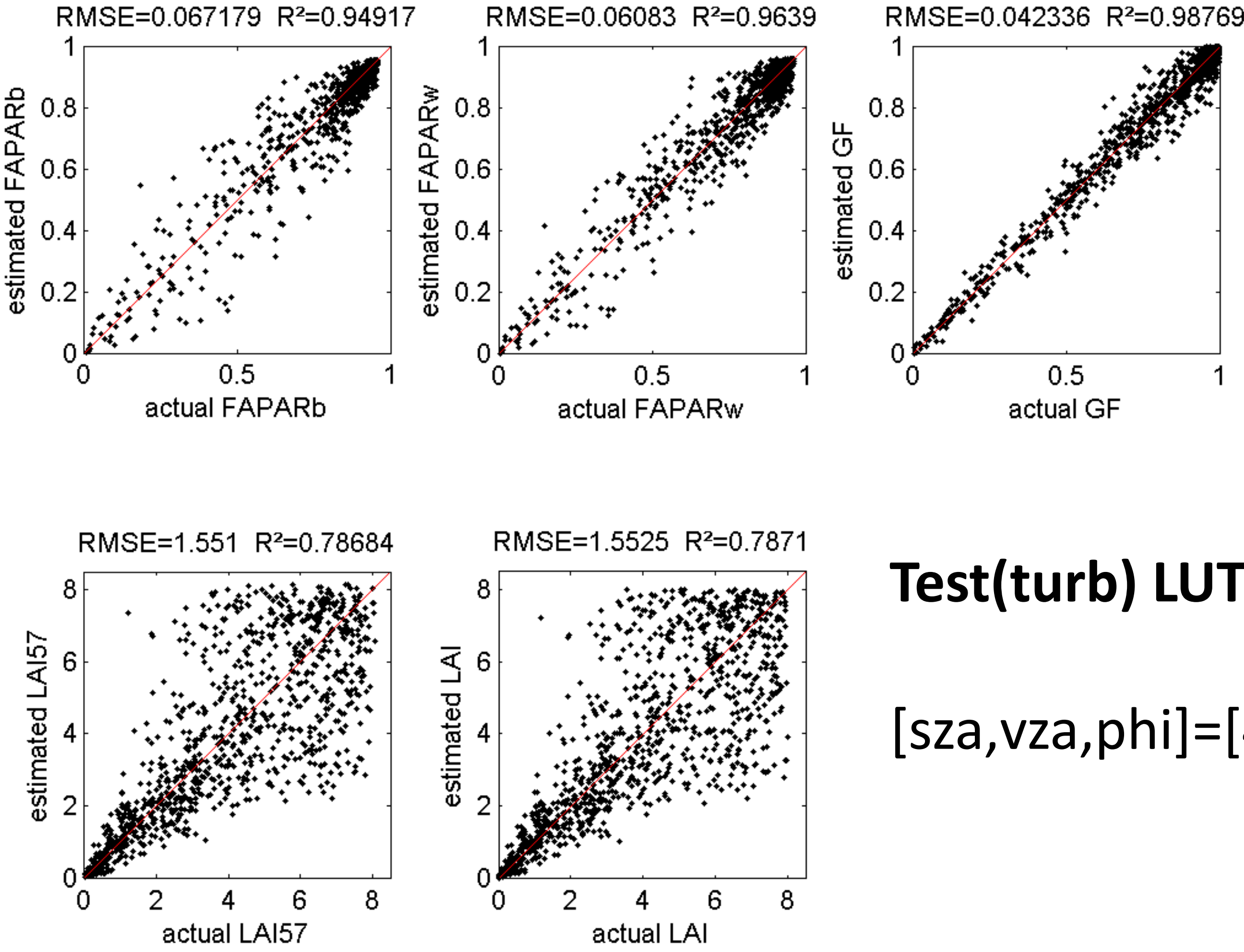


Relatively good consistency between GAI values derived from the Miller's formula and from the 57° direction even for the clumped canopies

Selection of variables to be investigated

- GF
- FAPARb (≈0.94 FIPAR)
- FAPAw
- LAIe(Miller) (≈LAIe(GF(57°)))
- LAI

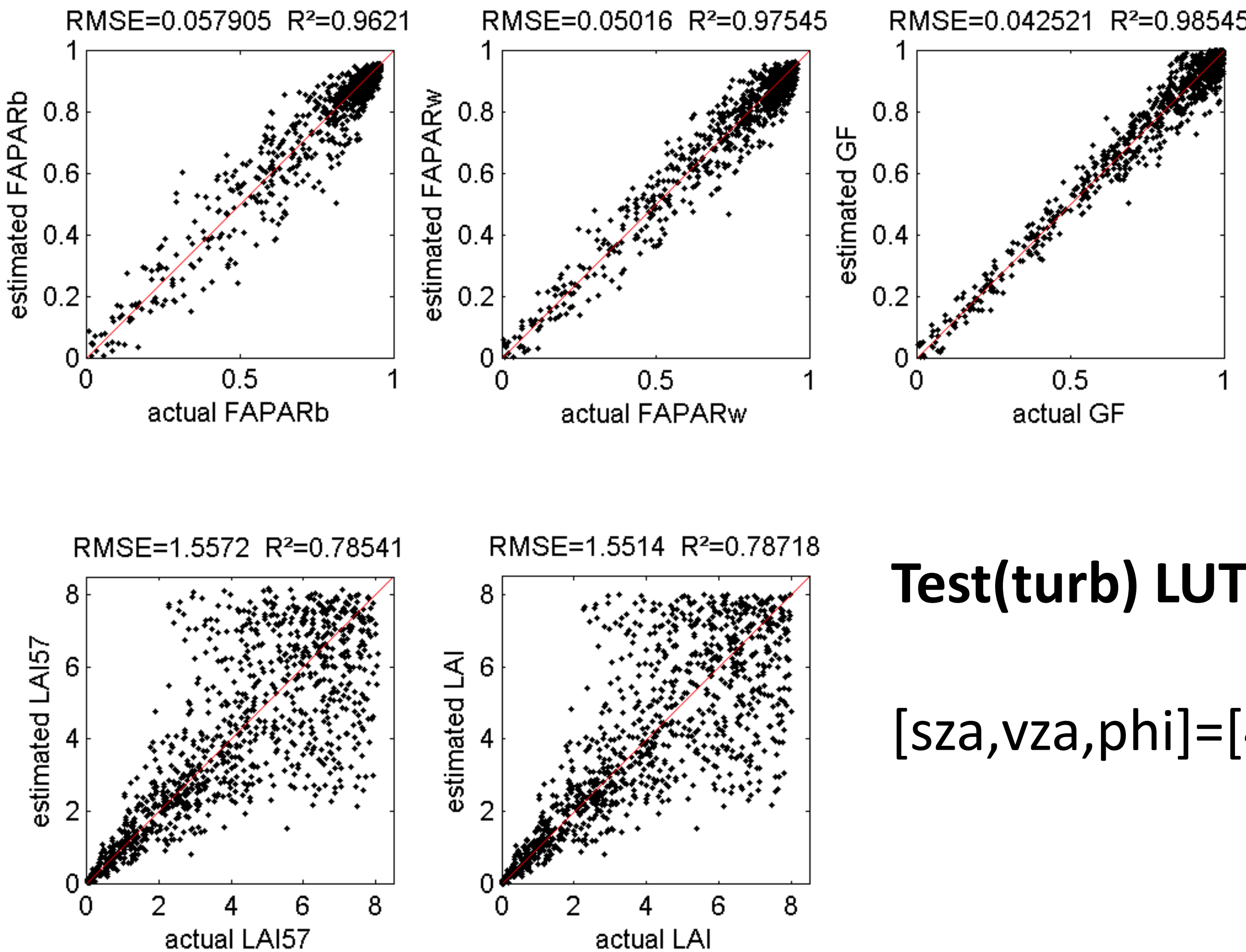
RESULTS : sample of results



Test(turb) LUT(turb)

[sza,vza,phi]=[45°,0°,90°]

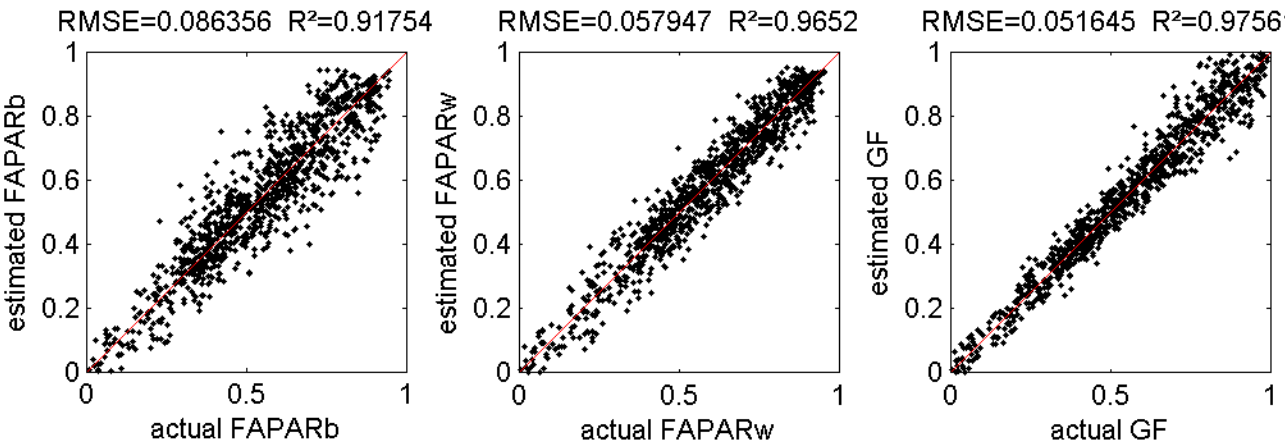
RESULTS : sample of results

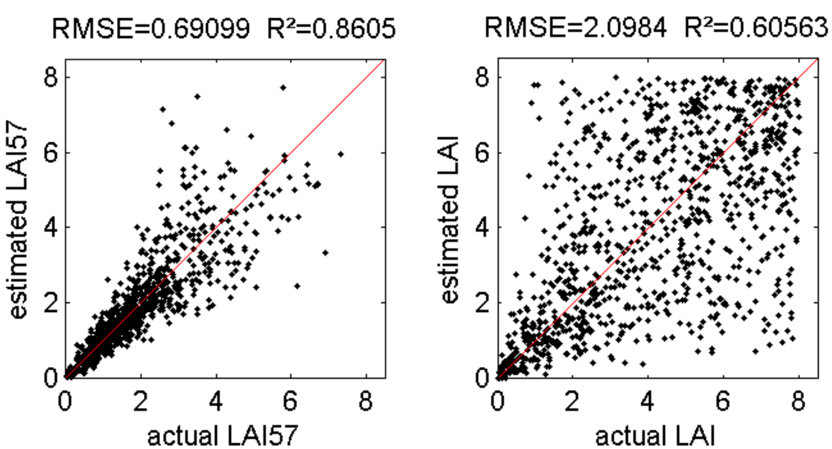


Test(turb) LUT(turb)

[sza,vza,phi]=[45°,30°,90°]

RESULTS : sample of results



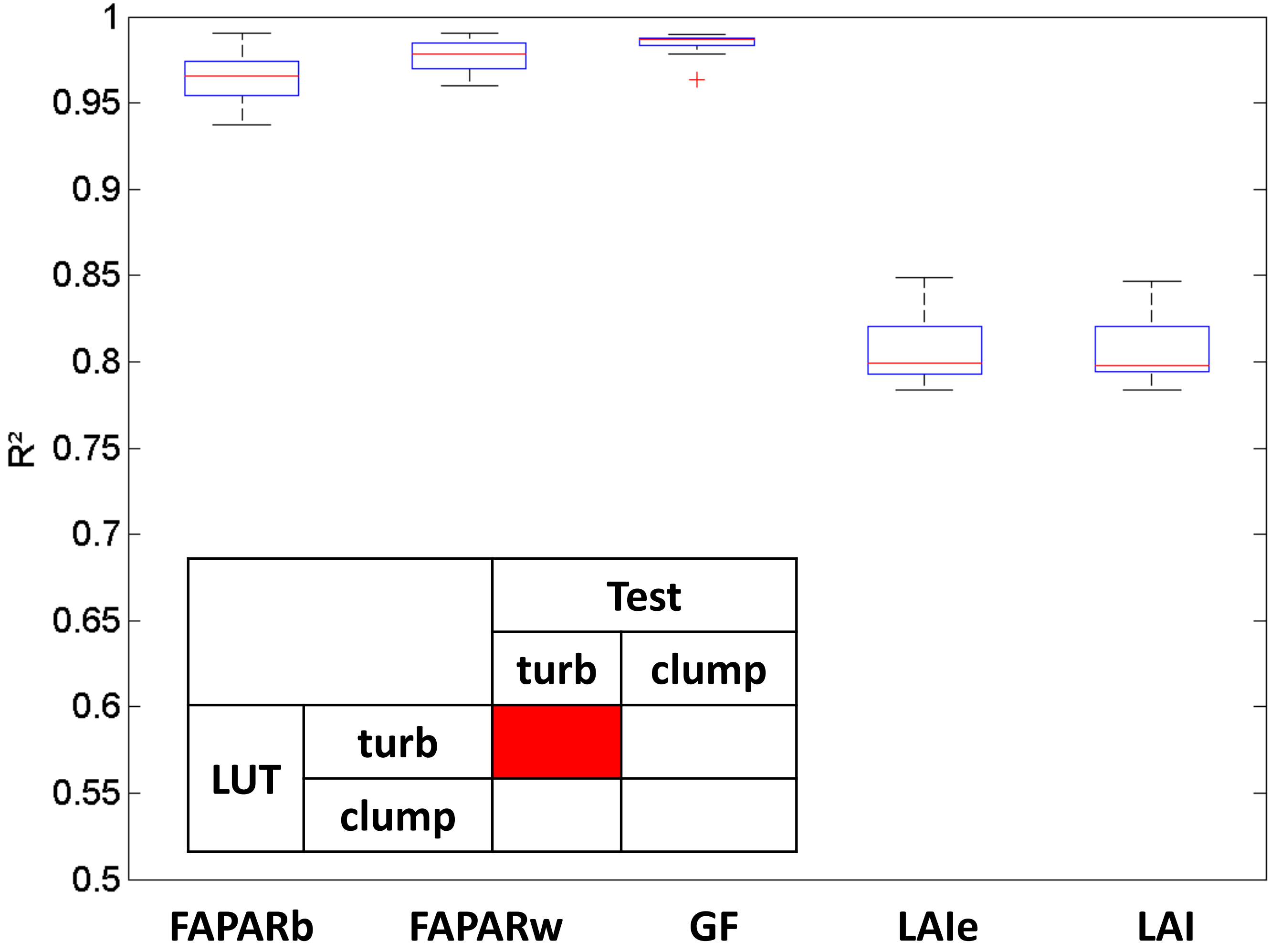


Test(clump) LUT(clump)

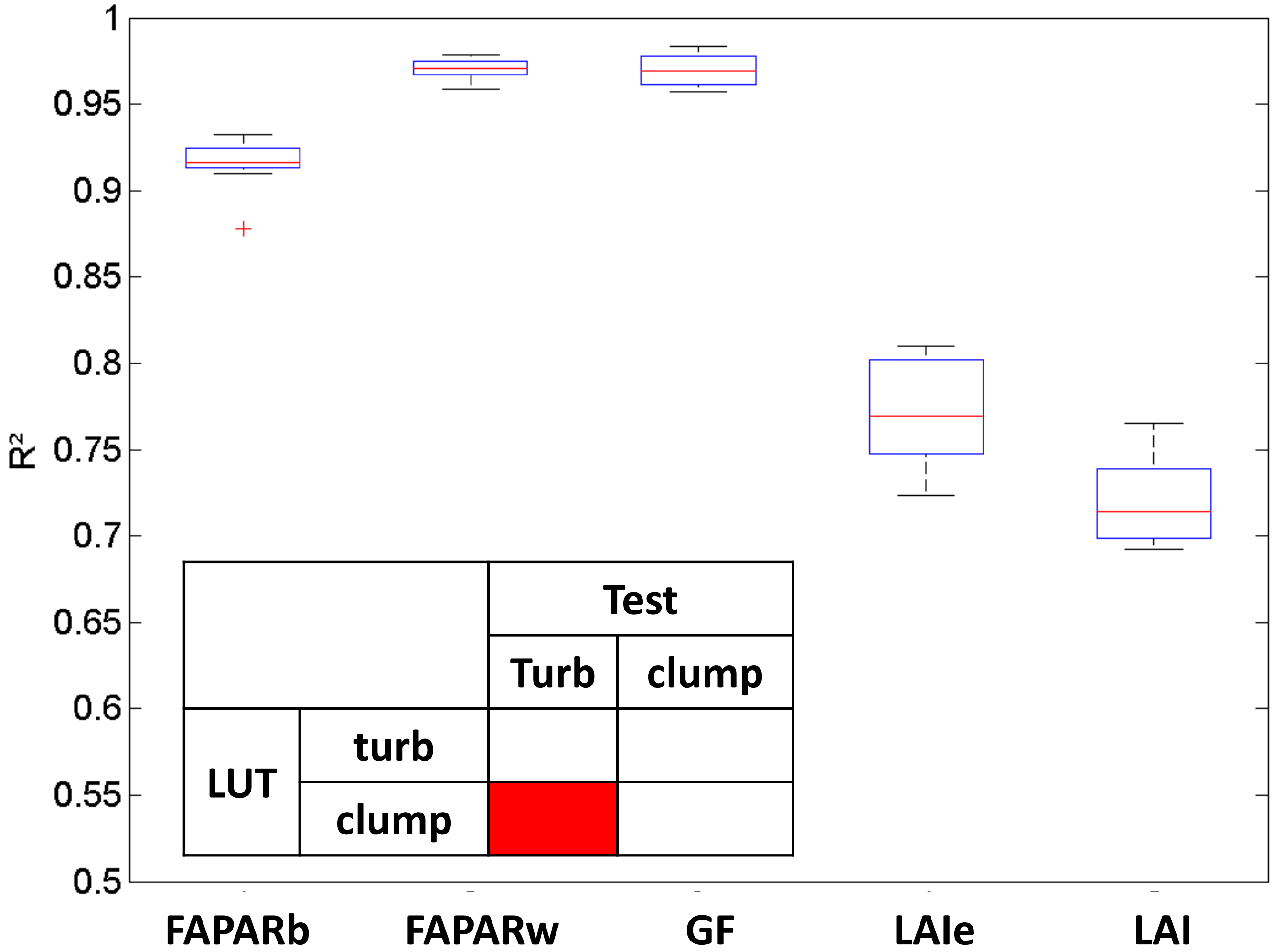
[sza,vza,phi]=[45°,30°,90°]

Large degradation for LAI!!

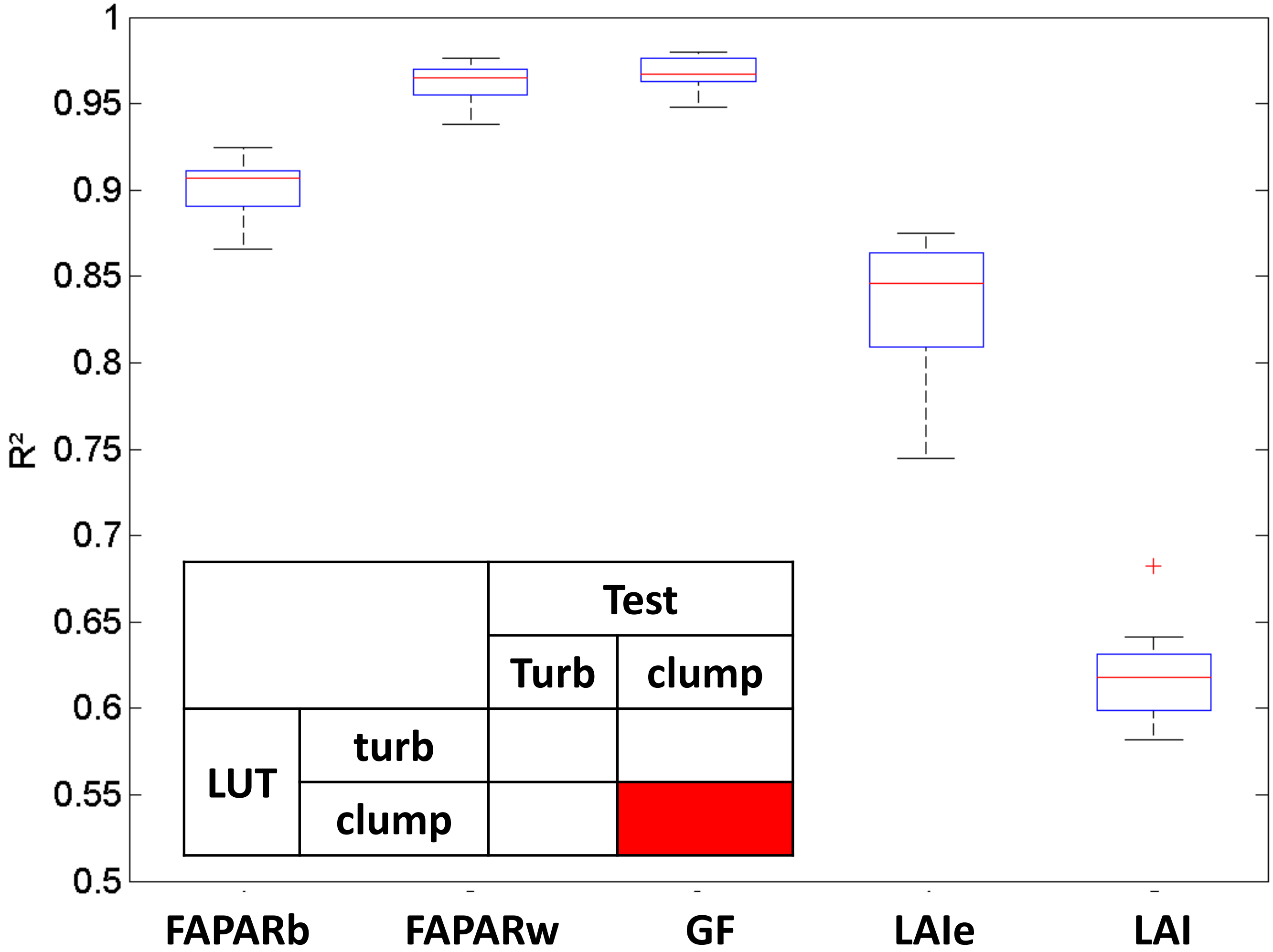
RESULTS: synthesis



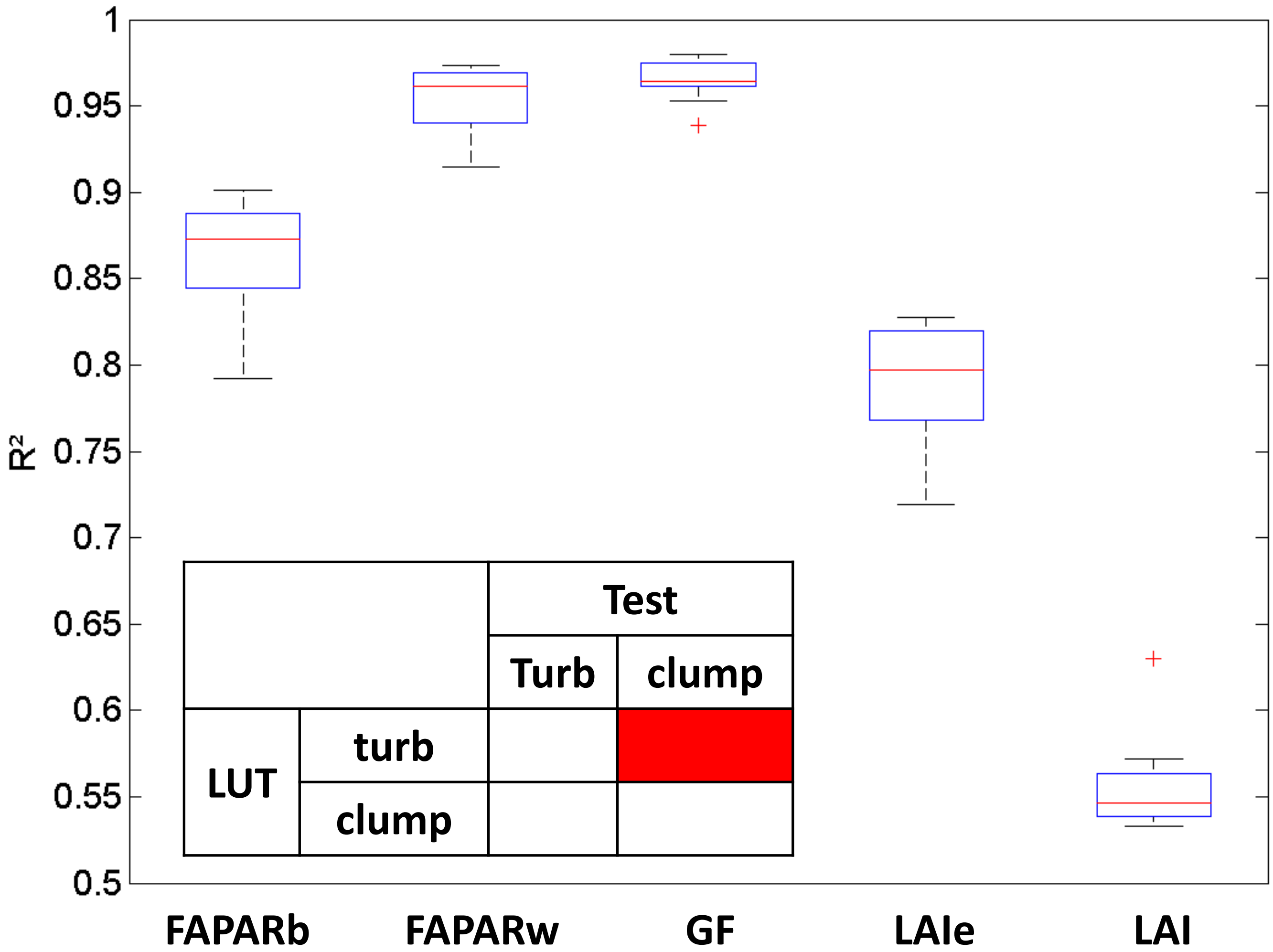
RESULTS: synthesis



RESULTS: synthesis



RESULTS: synthesis



Conclusion

- **Effective LAI: a defintion is proposed:** *The effective is the LAI value that provides the same GF(vza) under turbid medium assumption (Applying Miller's formula or GF(57°))*

- **Strong differences in retrieval performances between variables**
  - **GF > FAPARw > FAPARb > LAIe > LAI**
  - **Importance of the GF:**
    - **at kilometric scale: GF(vza) input to DGVM: consistency with the structure assumptions**
    - **At decametric scale:**
      - **use prior information on the type of canopy to derive other variables (FAPAR, LAI)**
      - **A sensor looking at 57°?**
- **Slight improvement when using a more realistic RT model in case of clumped canopies**

- **Need to extend the investigation using directional observations**