



*Département Énergétique et Génie des Procédés*

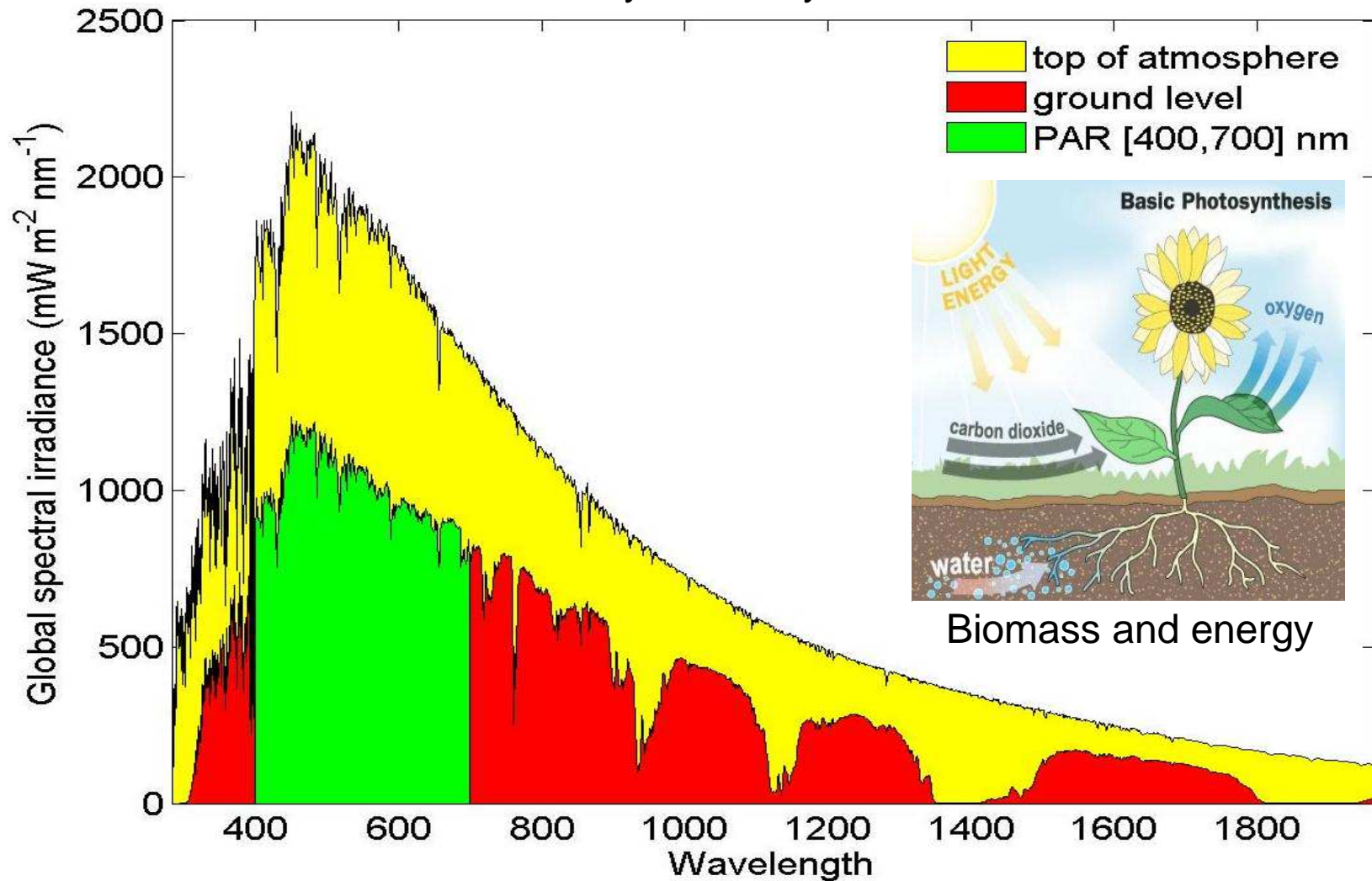
Center Observation, Impacts, Energy (O.I.E.)

October 6th, 2014 ■■

■ ***A new approach for estimating  
Photosynthetically Active Radiation (PAR) in  
clear-sky conditions***

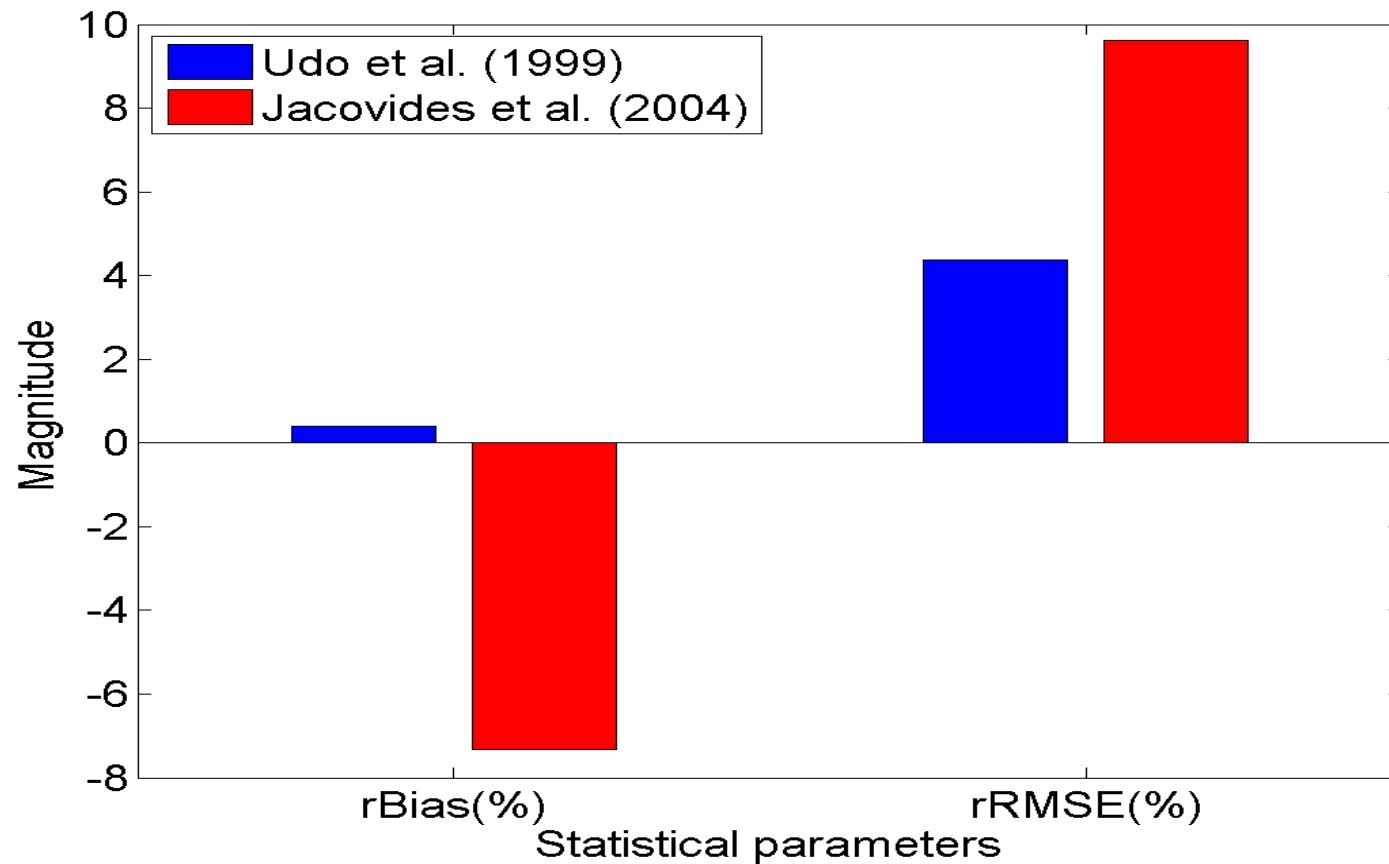
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PAR = Photosynthetically Active Radiation



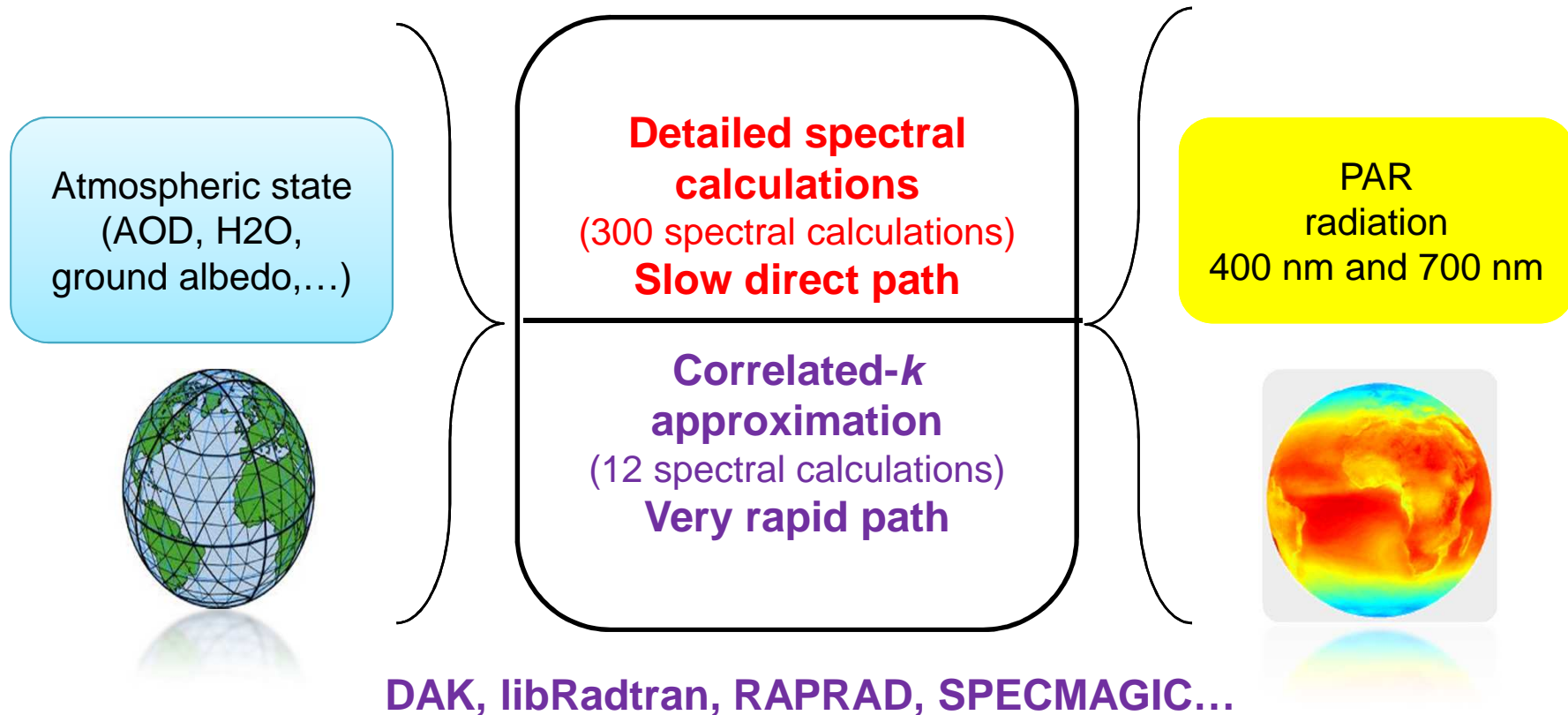
- PAR depend of aerosol properties (AOD), total water column (H<sub>2</sub>O), ground surface (ground albedo), etc...

- PAR measurements are rare in space and time.
- PAR is often calculated as a **constant proportion** of the broadband solar radiation : Udo et al. (1999) and Jacovides et al. (2004).



### Comparison with the numerical models

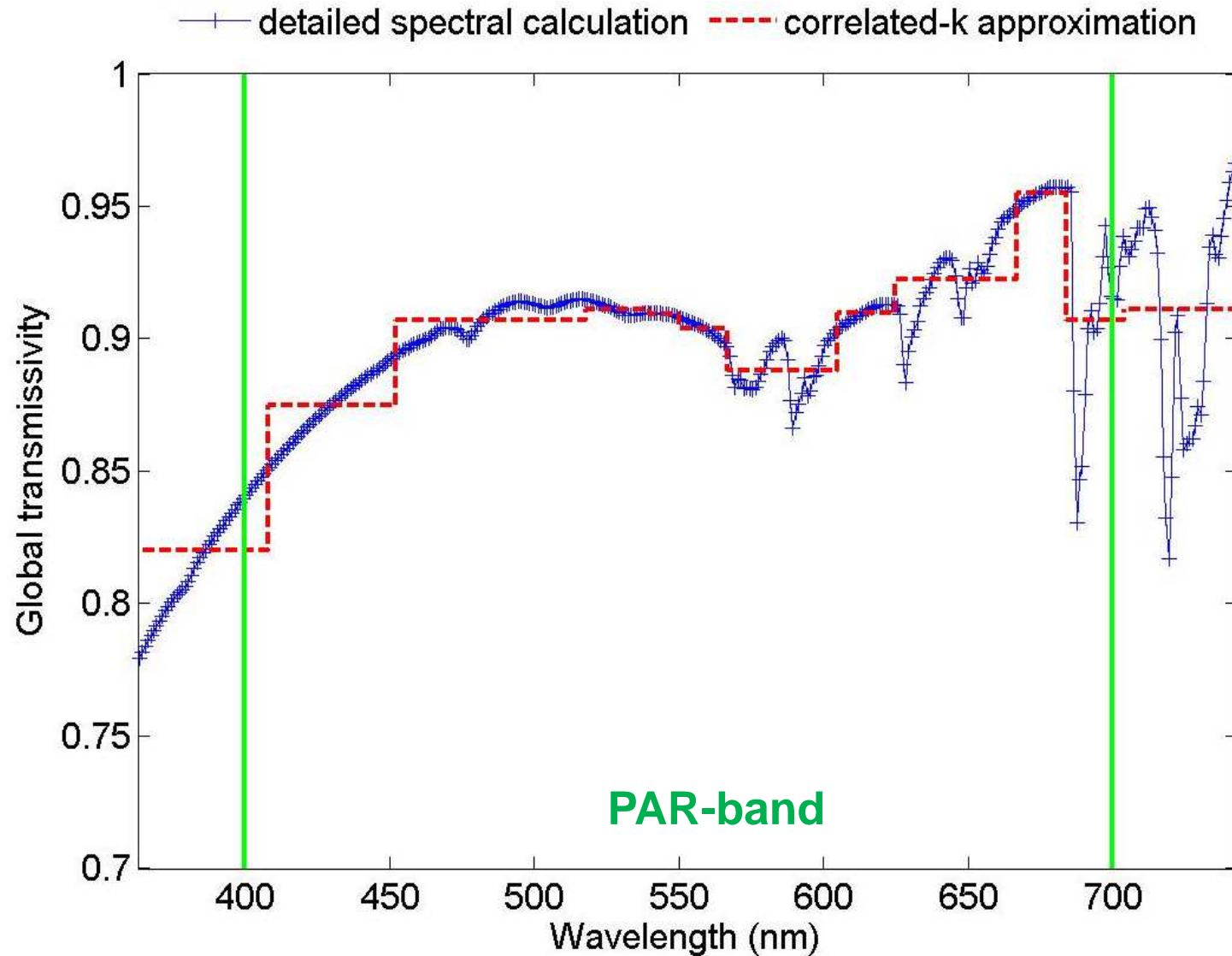
- Radiative transfer models



- **12 spectral calculations between 363 nm and 743 nm including PAR-band (400 nm and 700 nm)**

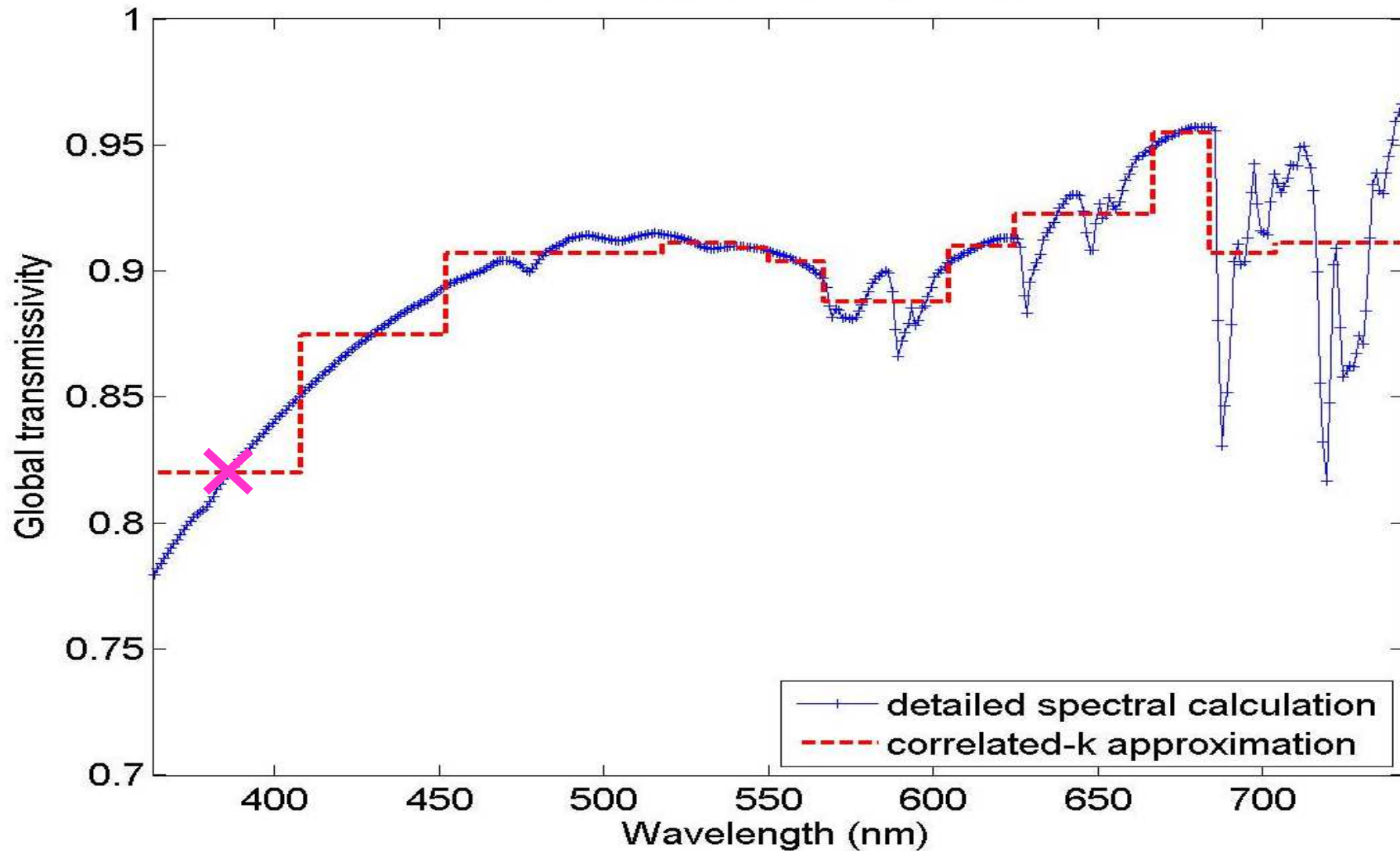
Kato, S., Ackerman, T., Mather, J., and Clothiaux, E.: The *k*-distribution method and correlated-*k* approximation for shortwave radiative transfer model. *Journal of Quantitative Spectroscopy and Radiative Transfer*, 62, 109-121, 1999.

- What is the problem ?

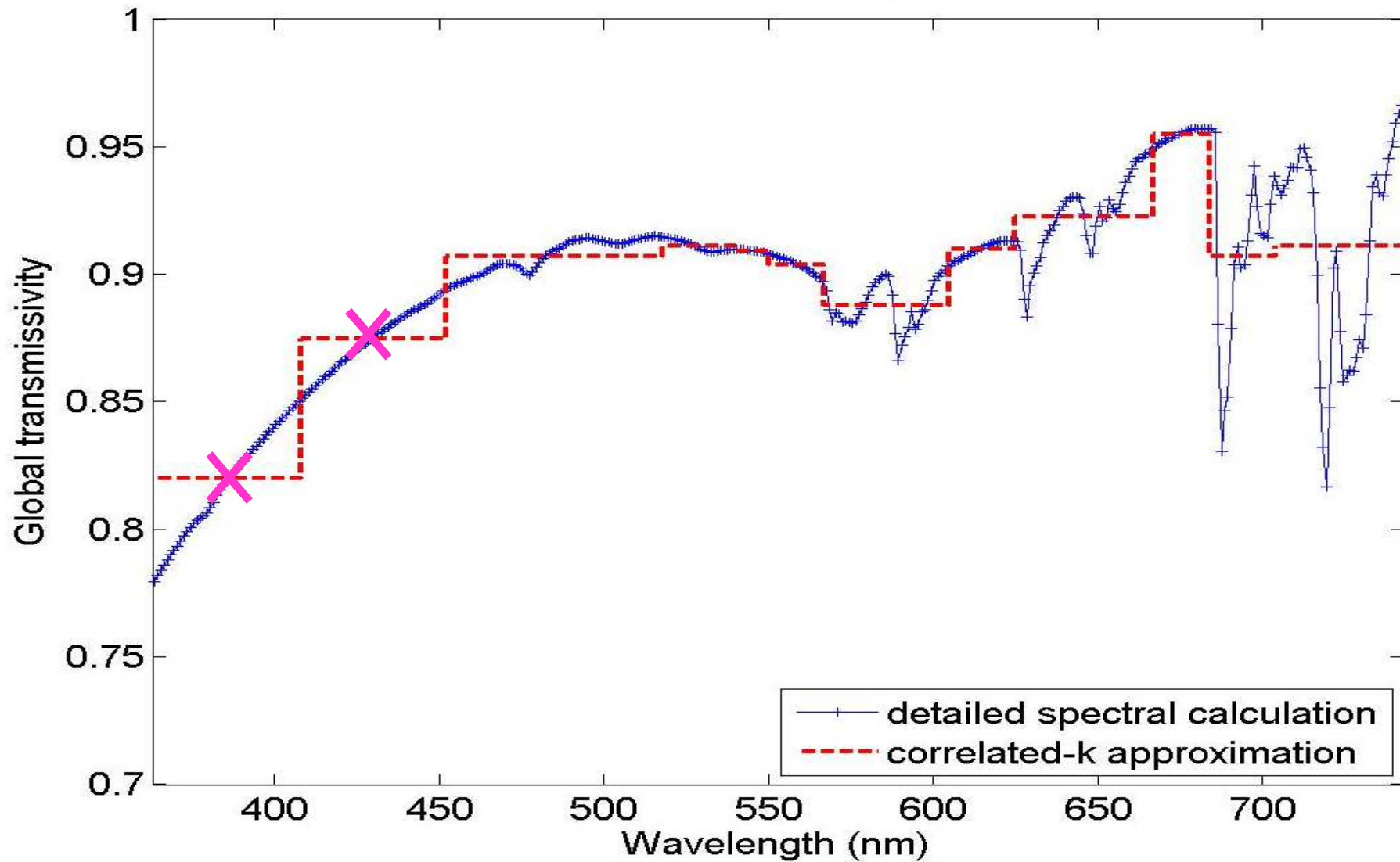


Atmospheric state:  
AFGLUS,  $\theta_s = 60^\circ$ ,  
rural aerosol model,  
TWC =  $67.24 \text{ kg m}^{-2}$ ,  
TOC = 323 DU,  
 $\rho_g = 0.28$ ; AOD at  
550 nm = 0.67 and  
h = 0 m.

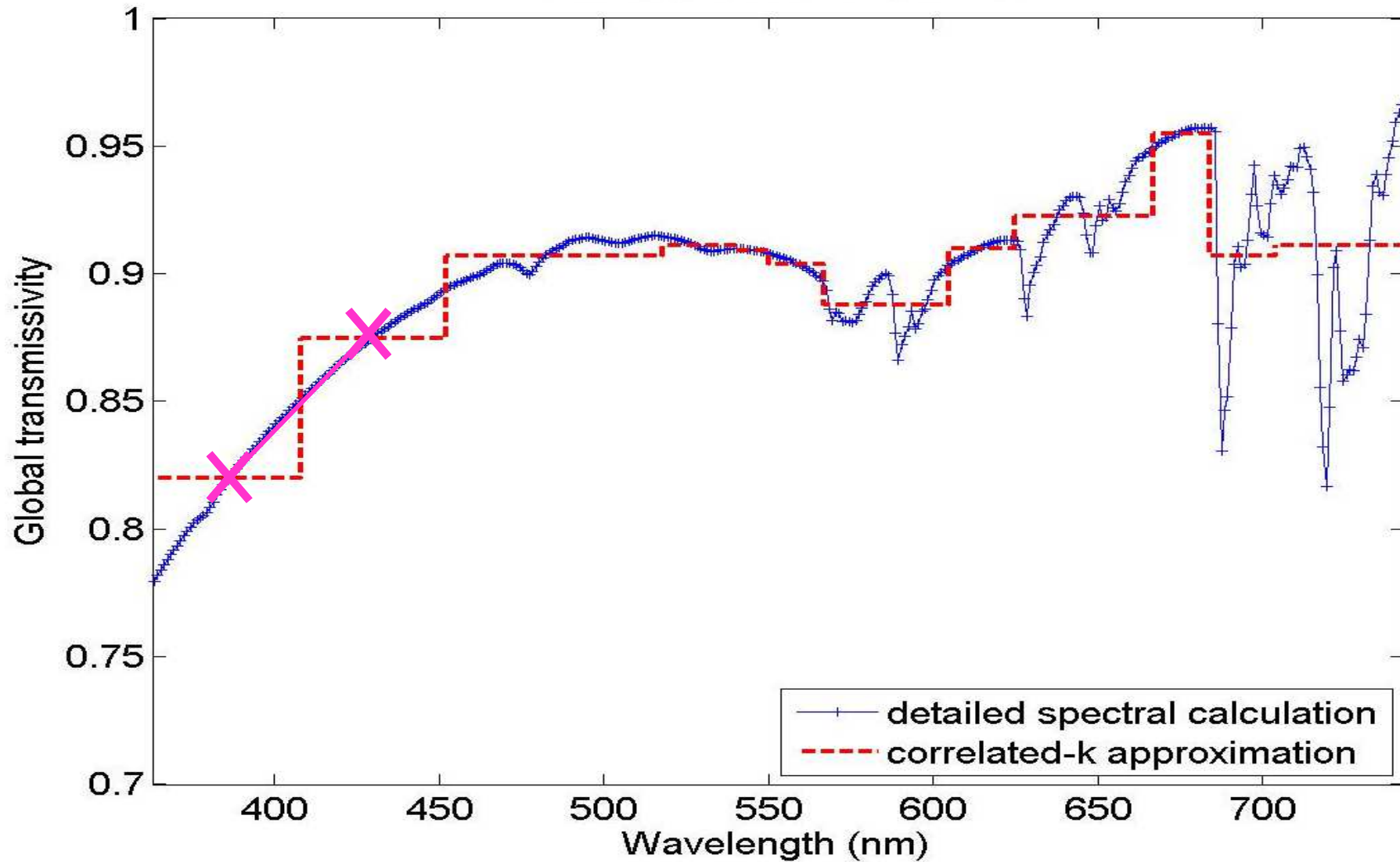
- Method for generating the high spectral resolution of transmissivity



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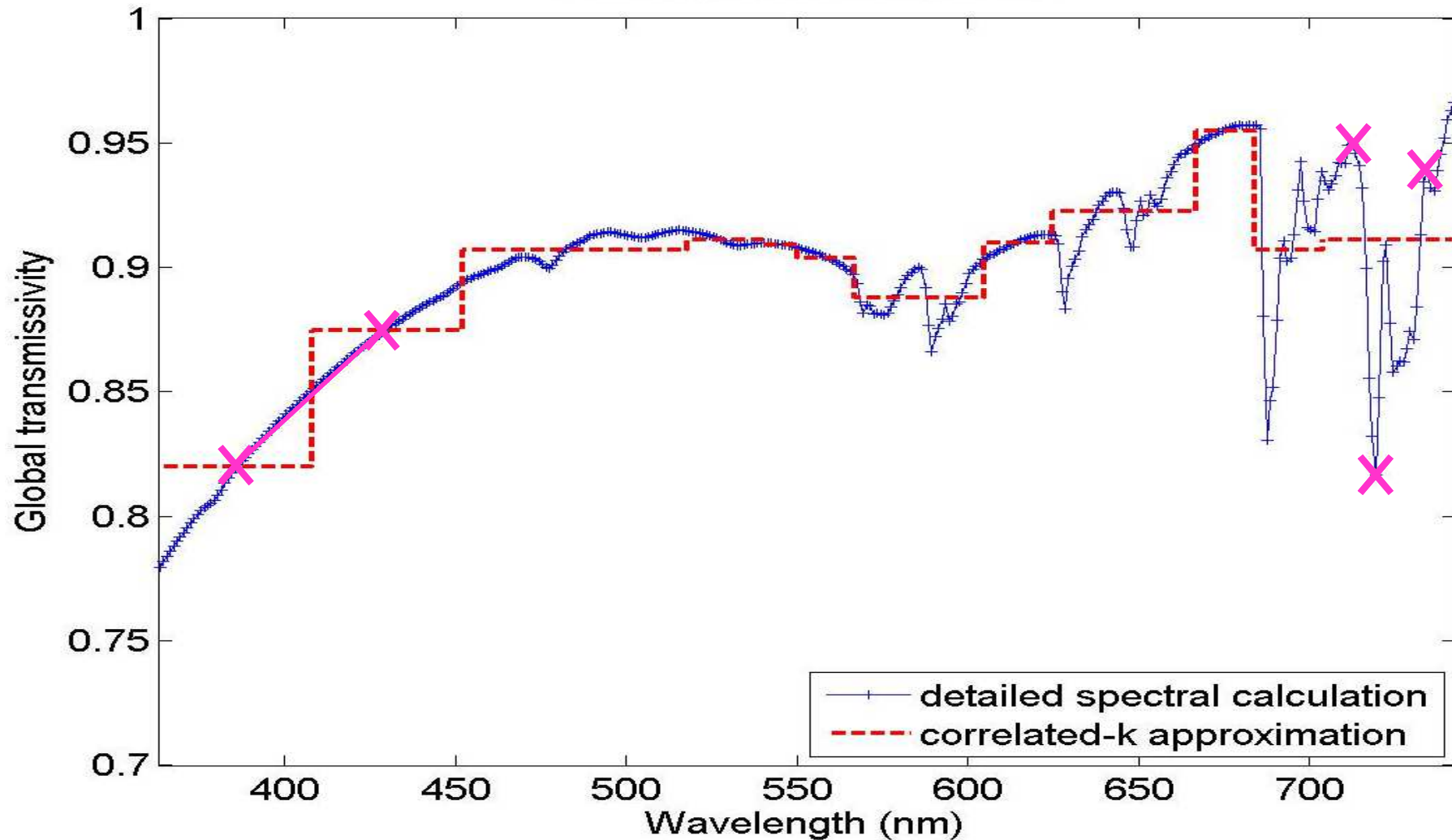


- Method for generating the high spectral resolution of transmissivity



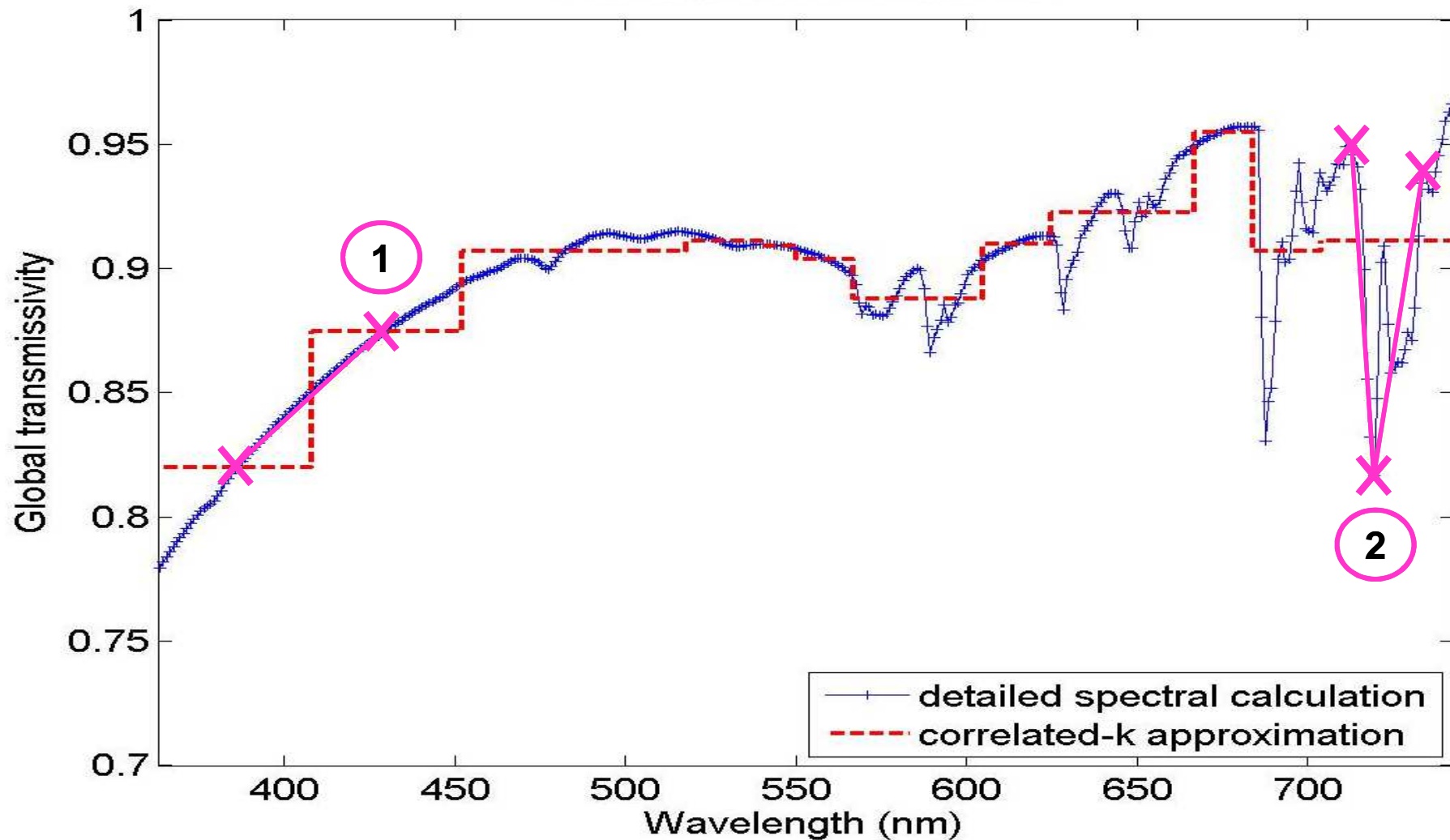


- Method for generating the high spectral resolution of transmissivity



- Applied same technique to other discrete positions

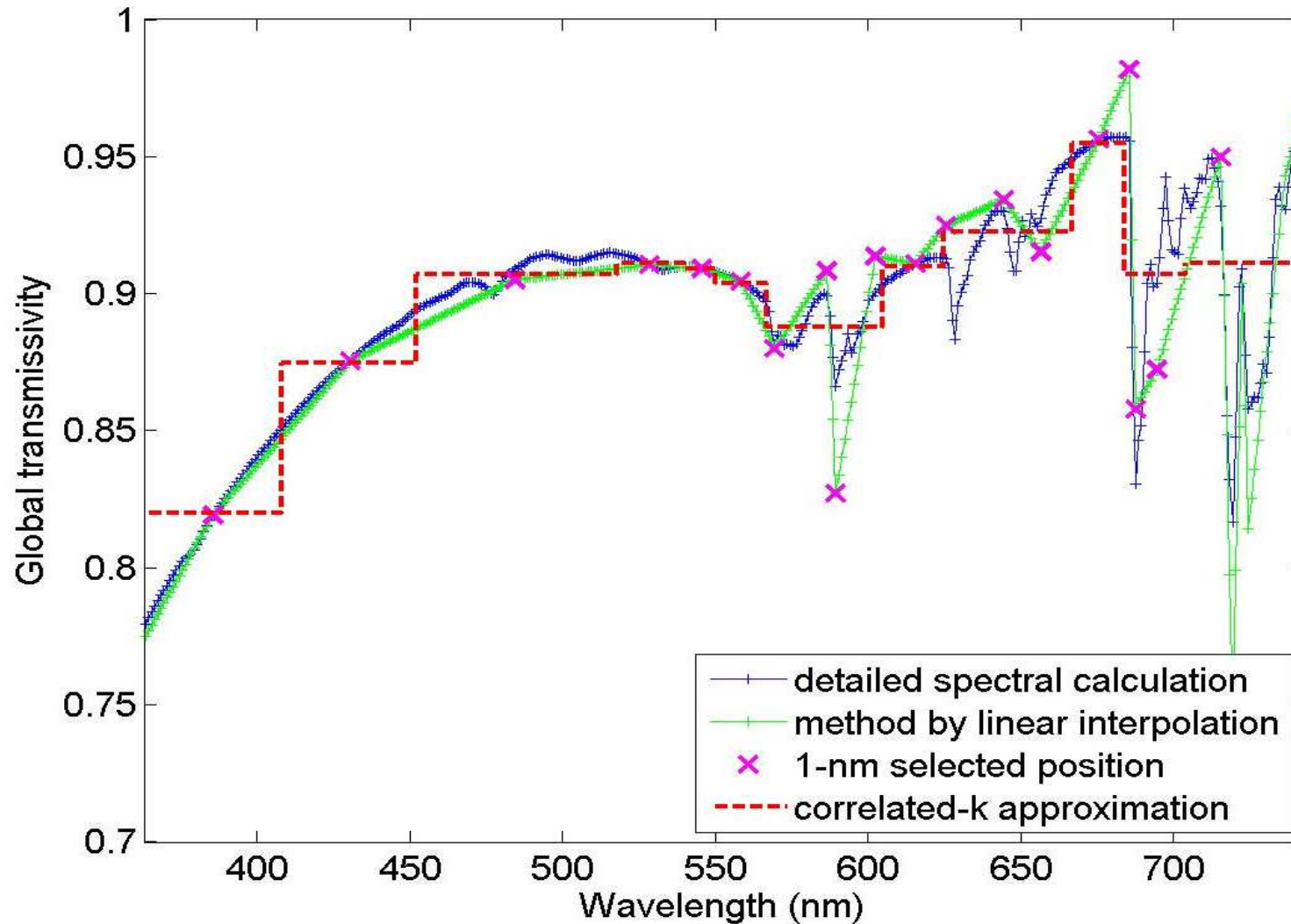
- Method for generating the high spectral resolution of transmissivity



1  $KT_{430-431nm} = 0.995 KT_{KB7} + 0.0013$

2  $KT_{760-761nm} = 0.7613 KT_{KB18}^{dir} - 0.3480$

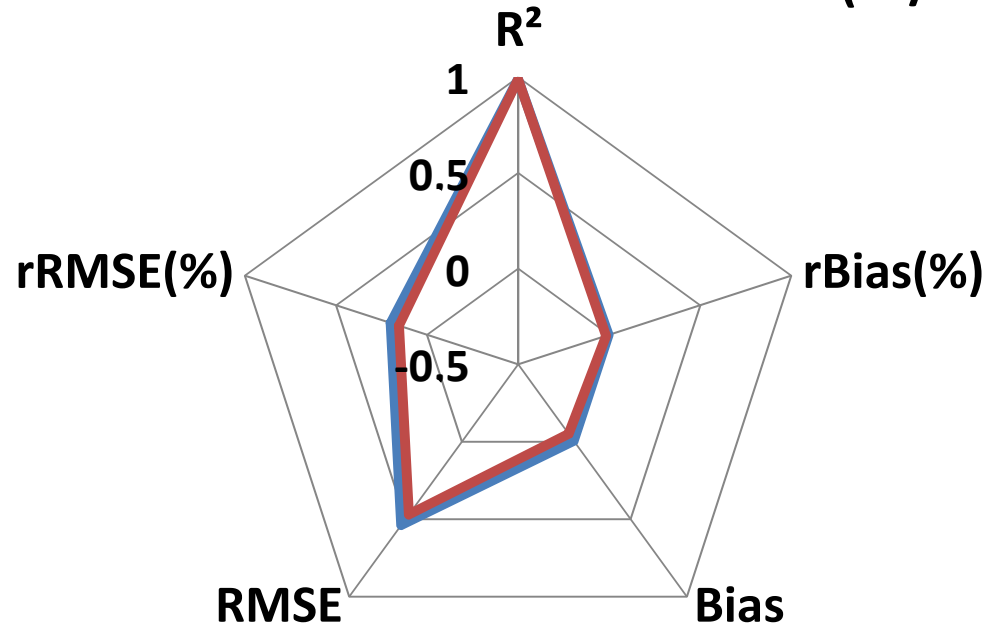
## 1. Performance of the method



- The method provides a good representation of the spectral distribution

## 2. Numerical validation: Synthesis of the performance of the novel approach

### Performance on the PAR irradiance (W/m<sup>2</sup>)



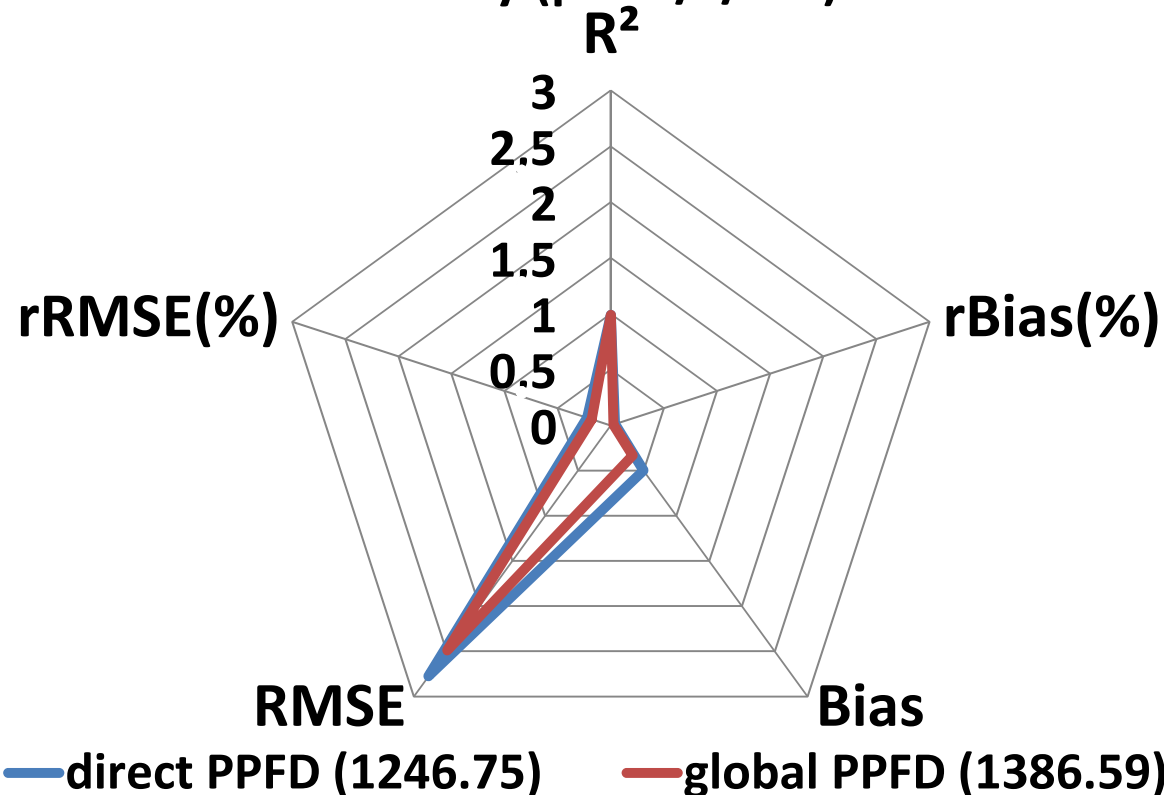
— direct PAR (268.74) — global PAR (305.06)

The values in the brackets are the average values of detailed spectral calculations.

• **The novel approach estimates the PAR radiation with high accuracy**

## 2. Numerical validation: Synthesis of the performance of the novel approach

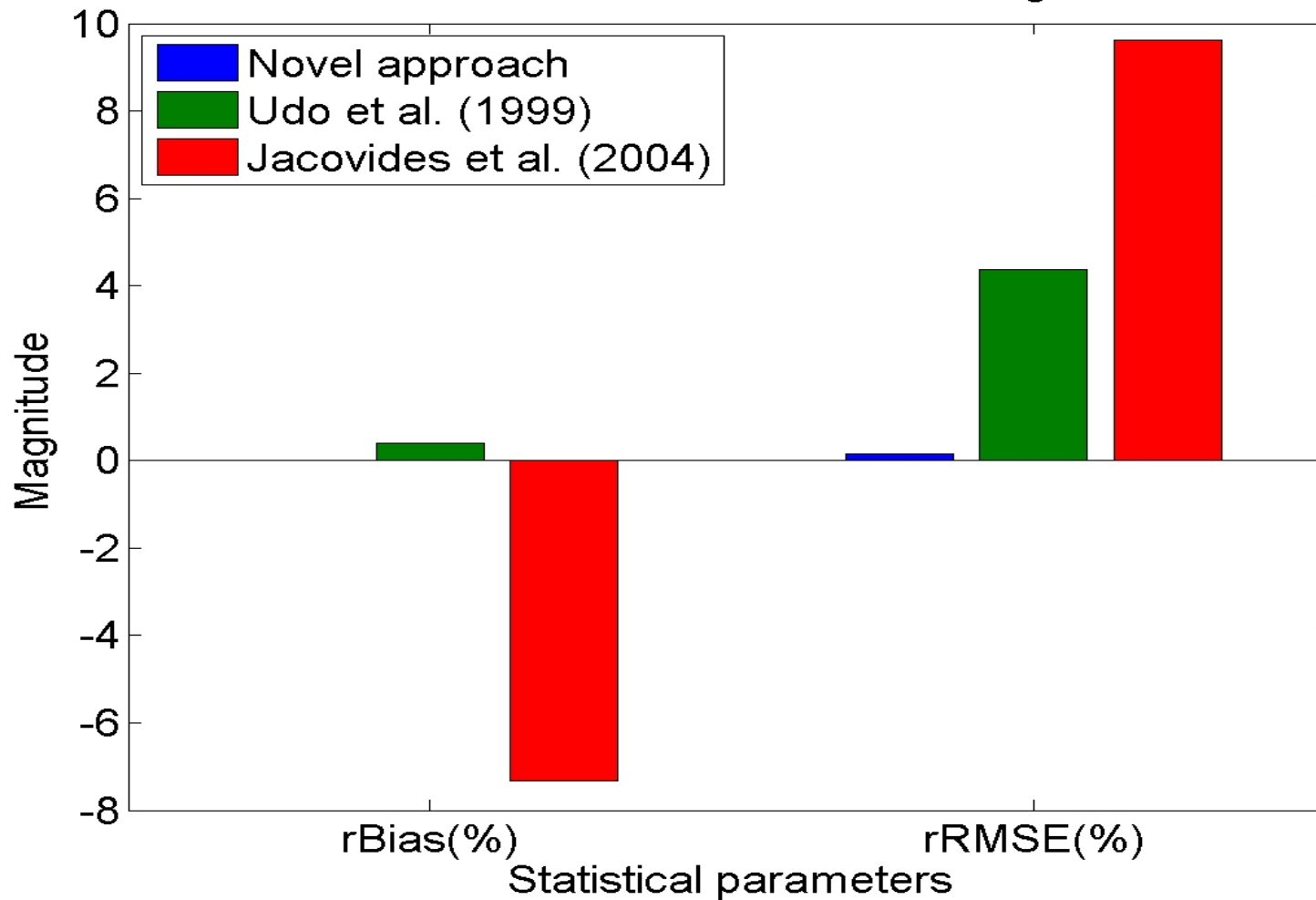
Performance on the photosynthetic photon flux density ( $\mu\text{mol/s/m}^2$ )



The values in the brackets are the average values of detailed spectral calculations.

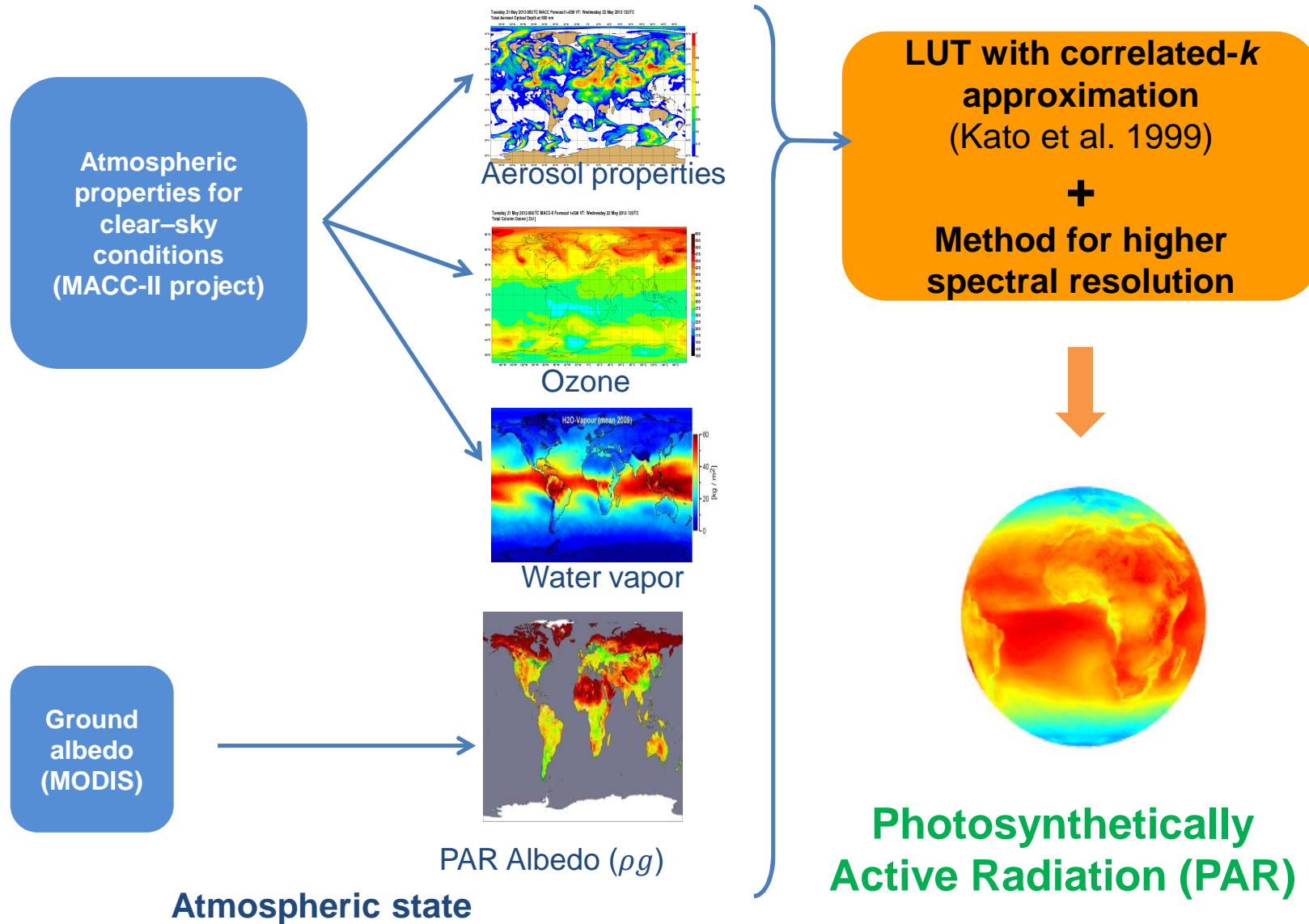
• **The novel approach estimates the PAR radiation with high accuracy**

### 3. Performance of different methods Jacovides et al. (2004); Udo et al. (1999) and novel approach.



- The novel approach provides much better results than empirical methods.

• Overview of planned operational chain

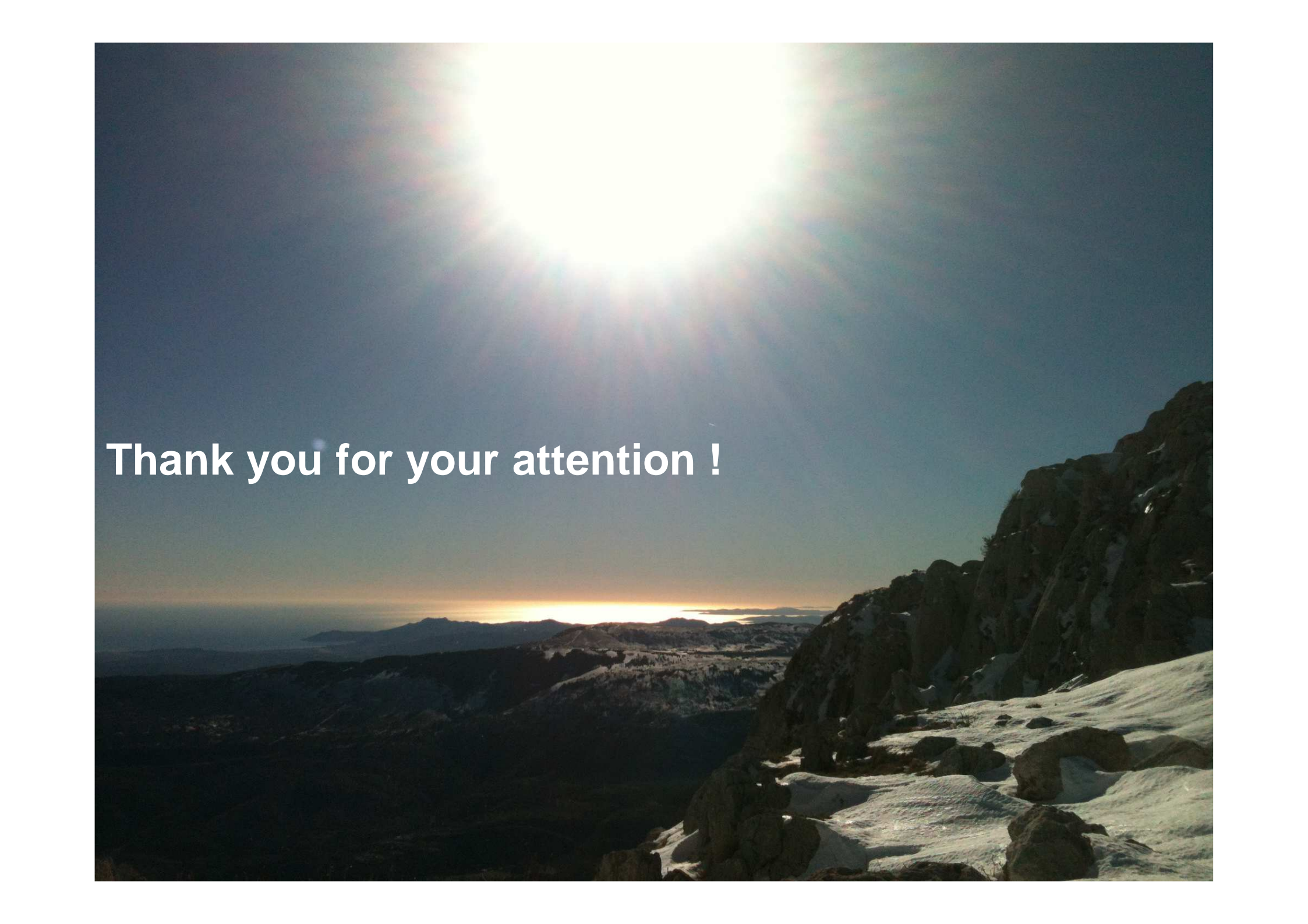


## Experimental validation



**NREL station: South Table Mountain facility**





**Thank you for your attention !**