SPECTRALLY RESOLVED SOLAR IRRADIANCE DERIVED FROM METEOSAT CLOUD INFORMATION - COMPARISON OF TWO METHODS

Jethro Betcke*, Tanja Behrendt, Jan Kühnert, Annette Hammer, Elke Lorenz, Detlev Heinemann

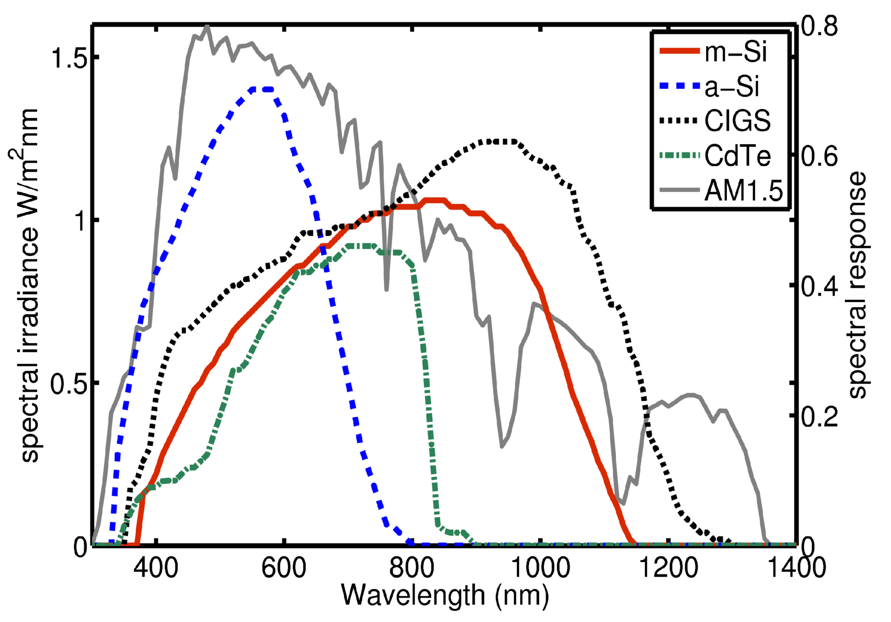
Carl von Ossietzky University Oldenburg, Energy and Semiconductor Laboratory, Energy Meteorology Group

*Corresponding author: Jethro.Betcke@uni-oldenburg.de

CARL VON OSSIETZKY universität OLDENBURG

Introduction

- The rated efficiency of photovoltaic (PV) modules is measured at a constant AM1.5 spectrum. However, in field conditions the spectral irradiance varies temporally and spatially.
- Thin film solar cells have a narrow spectral response *SR(λ)*. Annual energy gain due to the difference between AM1.5 and actual spectrum can be in the range of ± 10%.
- Ground based spectral measurements are sparse and satellite based spectral irradiance data potentially provide a good alternative.
- Two spectral models have been developed for different applications.
- The aim of this work is to test the suitability of both models for the integration into PV system simulation.



Quantification of the spectral effect on solar cell power output

In a first approximation, and keeping all other variables constant, the power output of a PV system is proportional to the weighted irradiance G_w:

$$G_w = G \frac{\int SR(\lambda)\, n(\lambda)\, d\lambda}{\int SR(\lambda)\, n_{AM1.5}(\lambda)\, d\lambda} \qquad G = \int E(\lambda)\, d\lambda \qquad n(\lambda) = \frac{E(\lambda)}{G}$$

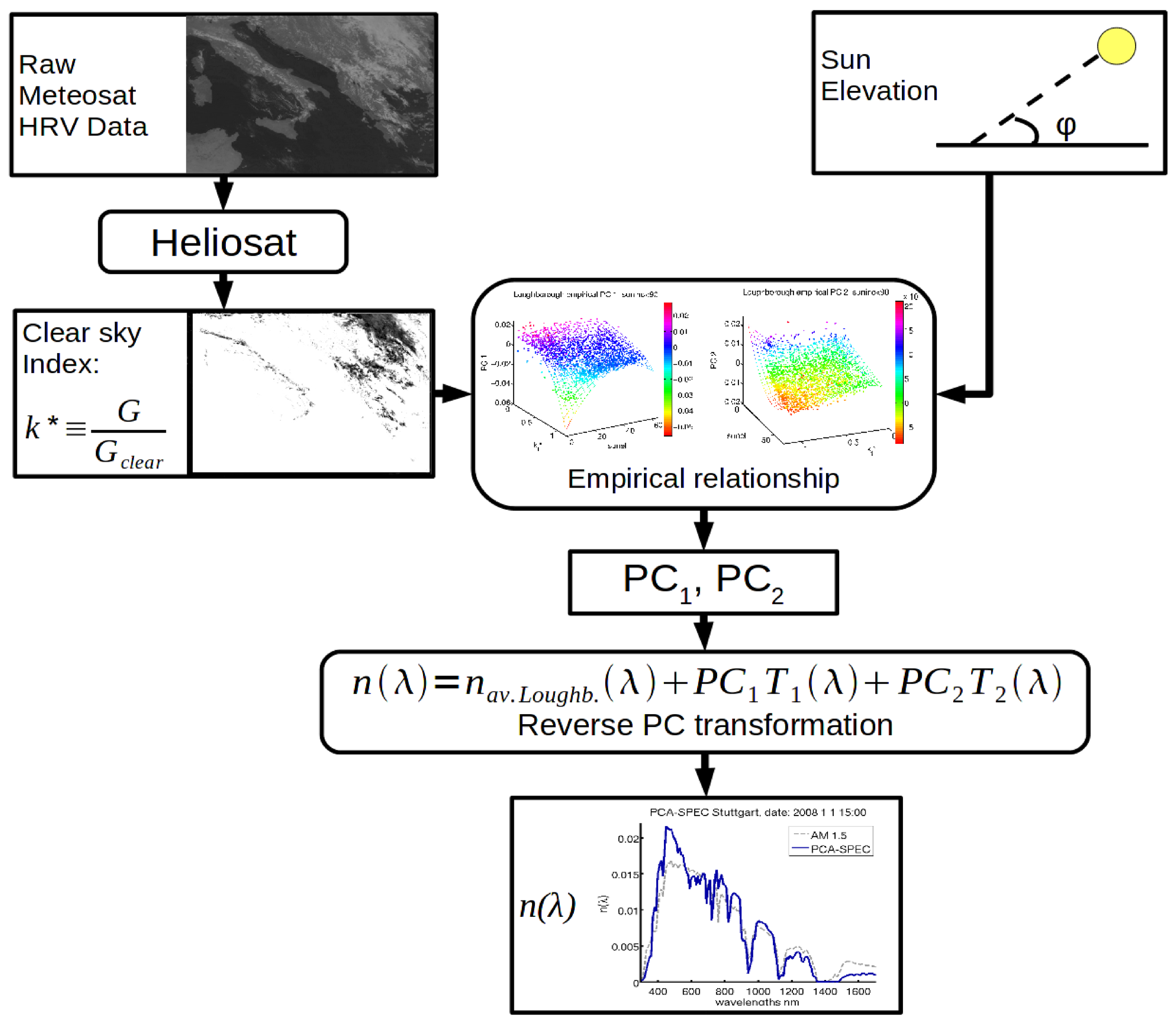
G = global irradiance

E(λ) = spectral irradiance

n(λ) = normalised spectral irradiance

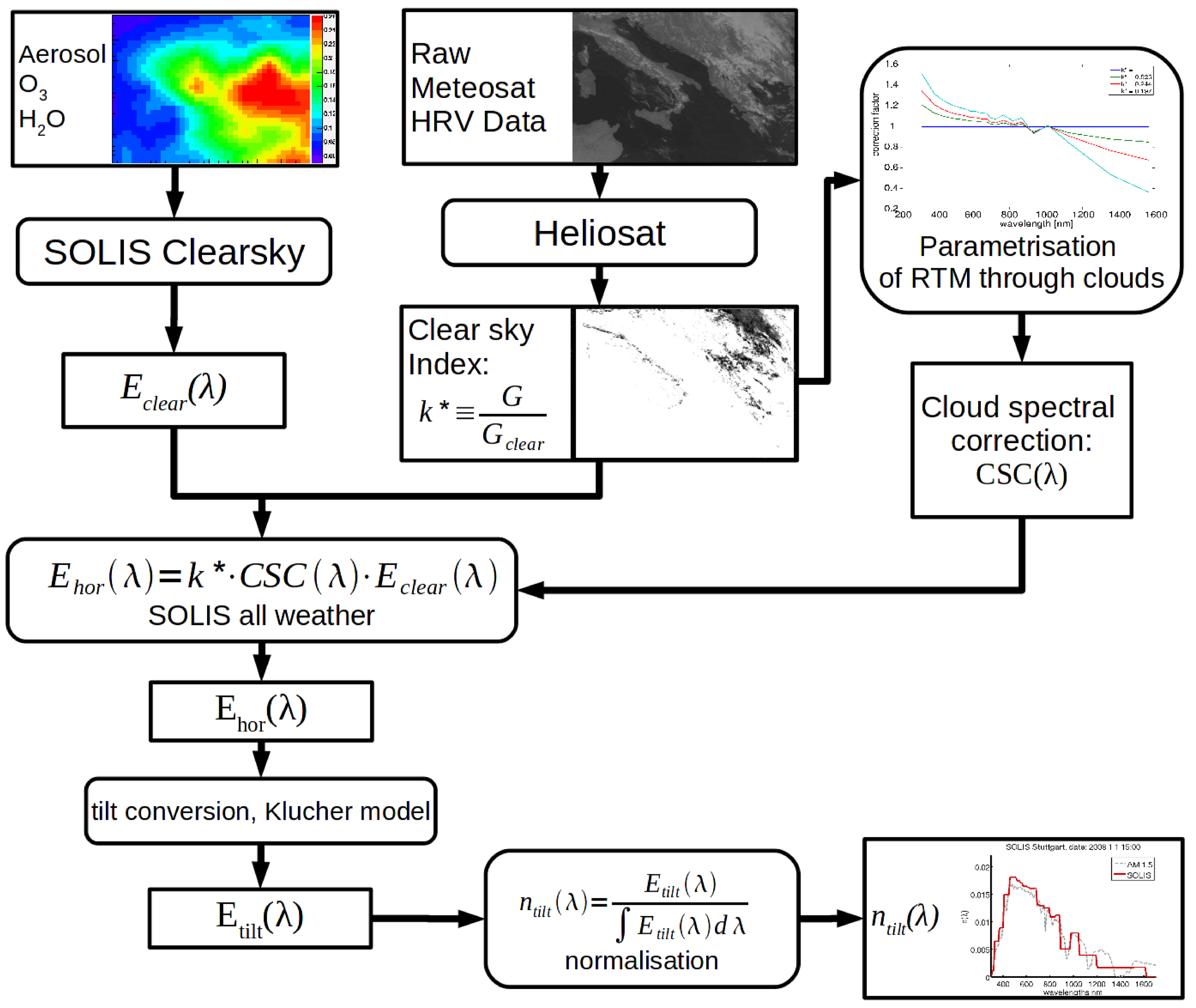
Simple empirical model: PCA-SPEC

- Intended for integration in solar energy system simulation software
  => Simple set-up and short calculation time are most important.
- Empirical model derived from hourly values integrated from 10 min. measurements at Loughborough UK on a SSE oriented plane with tilt 53°, in 10 nm spectral resolution.
- Using Principal Component Analysis 141 bands were described with two parameters



Radiative transfer modelling with SOLIS

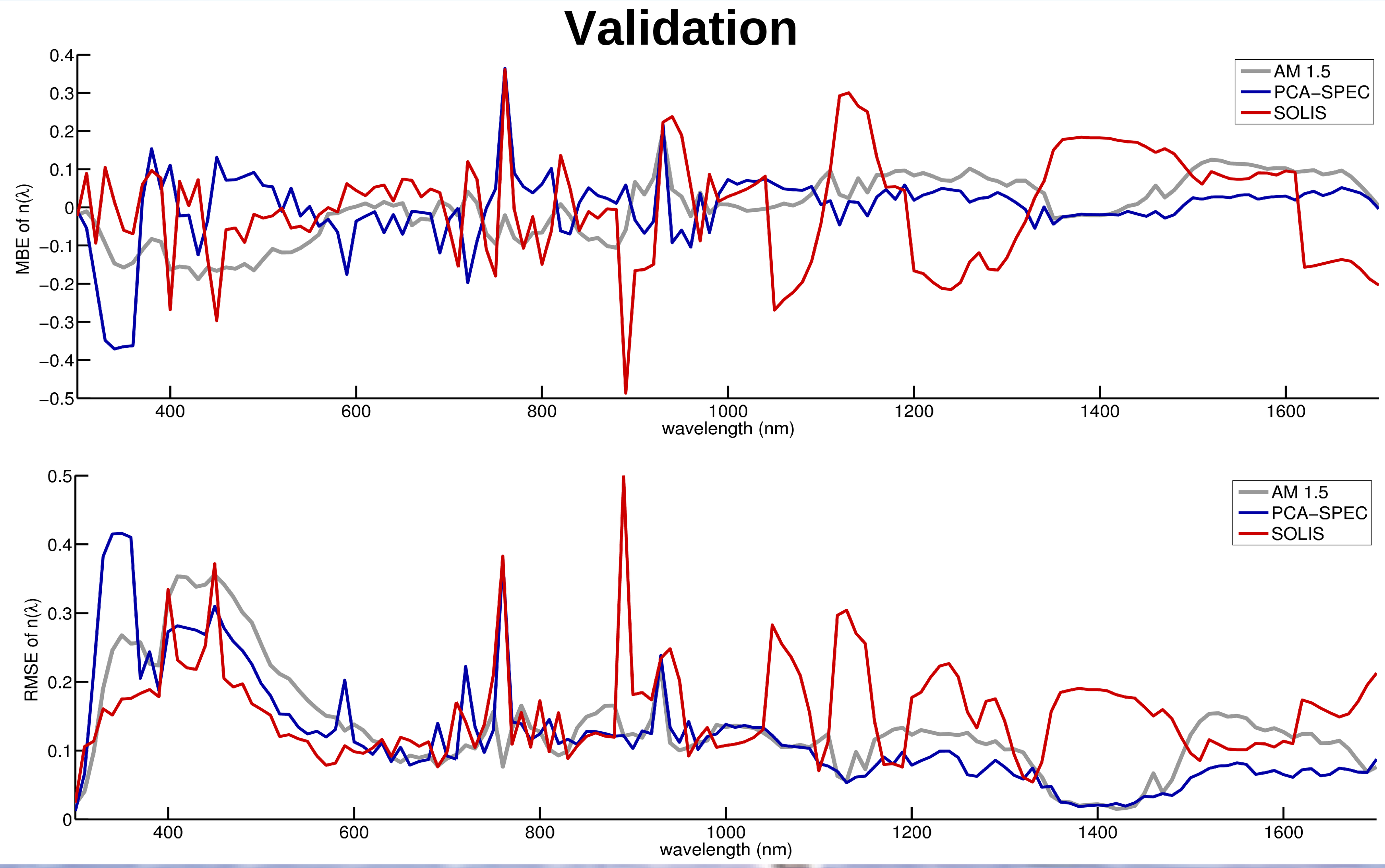
- Intended for fundamental research and accurate calculations
  => Long calculation time and complex set-up.
- Based on a partial parametrisation of radiative transfer calculations with correlated k method implemented in libRadtran.

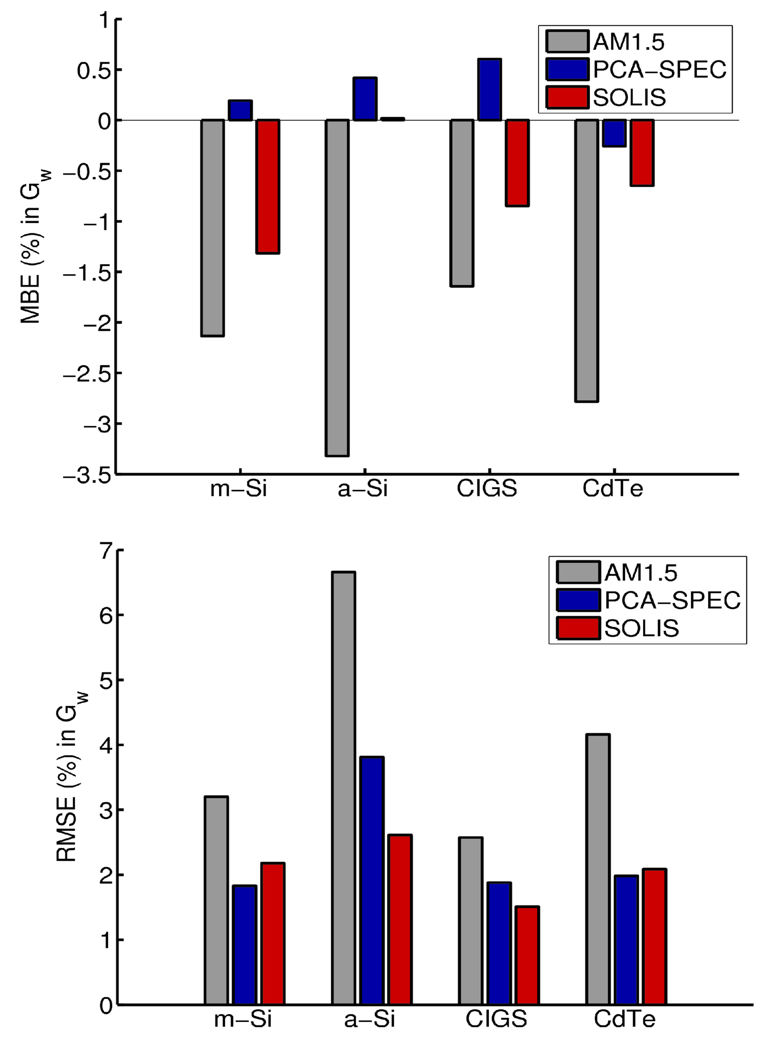


Validation

Validation Data

- One year of data measured at Stuttgart in 2007 on south orientated plane with tilt of 33°.
- Original measurements with temporal resolution of 1 minute, spectral resolution of 1 nm, were integrated to hourly 10 nm values.
- No local measurement of G_{hor} => k* can only be determined using Heliosat
- In the expression for G_w only *n(λ)* was derived from the models, G was derived from measurements.





Conclusions and Outlook

- Ignoring spectral effects in the simulation of photovoltaic systems can lead to substantial errors in the calculated power yield.
- Both satellite based models give comparable and substantial accuracy improvements for the weighted irradiance, and hence the power.
- Improvements for the SOLIS method are expected by using instantaneous and high resolution values for the atmospheric parameters, and by improvements to the cloud spectral correction and the tilt model.
- Improvements for the empirical PCA-SPEC model are expected by including the effect of tilt and orientation.
- In future work the models will be combined with PV system simulation software and validated for different climate zones.

Acknowledgements

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