

Ray-Tracing Software Comparison for Linear Focusing Solar Collectors

Tiago Osório¹, Pedro Horta¹, Marco Larcher², Ramón Pujol-Nadal³, Julian Hertel³, De Wet van Rooyen⁴, Anna Heimsath⁴, Simon Schneider⁵, Daniel Benitez⁵, Antoine Frein⁶ and Alice Denarie⁶

¹ST Renewable Energies Chair, University of Évora (UEvora), Portugal, ²Institut für Solartechnik (SPF), Switzerland, ³University of the Balearic Islands (UIB), Spain, ⁴Fraunhofer Institute for Solar Energy Systems (ISE), Germany, ⁵German Aerospace Center (DLR), Germany/Spain, ⁶Politecnico di Milano (POLIMI), Italy.

Participants and software tools in the study

Within IEA/SHC Task 49 a comparison between Ray-Tracing software tools was conducted:

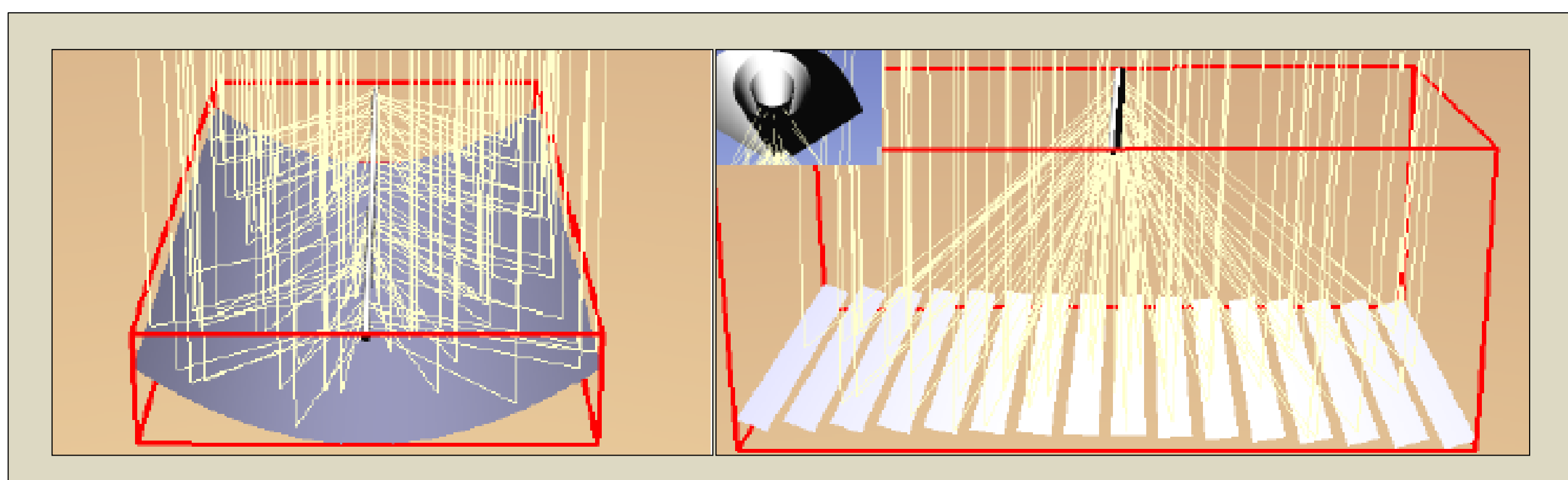
1. Description of the software features regarding sun model, real materials, surface errors, angular variation of optical properties and refraction model
2. Simulations of two exemplary cases, a PTC and a LFC with predefined conditions: geometry, sun model and material properties

Participant	Software	Licence	Simulation
UEvora	Tonatiuh	Open-source	PTC, LFC
SPF	OptiCAD	Commercial	PTC
UIB	OTSun	In-house	PTC, LFC
ISE	Raytrace3D	In-house	PTC, LFC
DLR	STRAL	In-house*	PTC
DLR	SPRAY**	In-house*	PTC
POLIMI	SolTrace	Open-source	LFC

*copy available on license-fee
**experimental features for PTC RT

Simulation cases

	PTC	LFC
Geometry	5.8 m width parabola 1.71 m of focal length	16 parabolic heliostats (0.75 m) 7.4 m height
Secondary	---	CPC: $\theta_a = 48.39^\circ$; ht = 41 mm
Receiver tube	35 mm absorber radius 62.5 mm outer radius and 5 mm thickness glass tube	
Collector length	12 m	
Materials	reflector: $\rho = 0.935$; absorber: $\alpha = 0.955$; glass: $\rho = 0.035$; $\tau = 0.965$; $n = 1.52$	
Slope deviation	$\sigma_s = 2.5$ mrad	
Clear sky	Buie 5%	



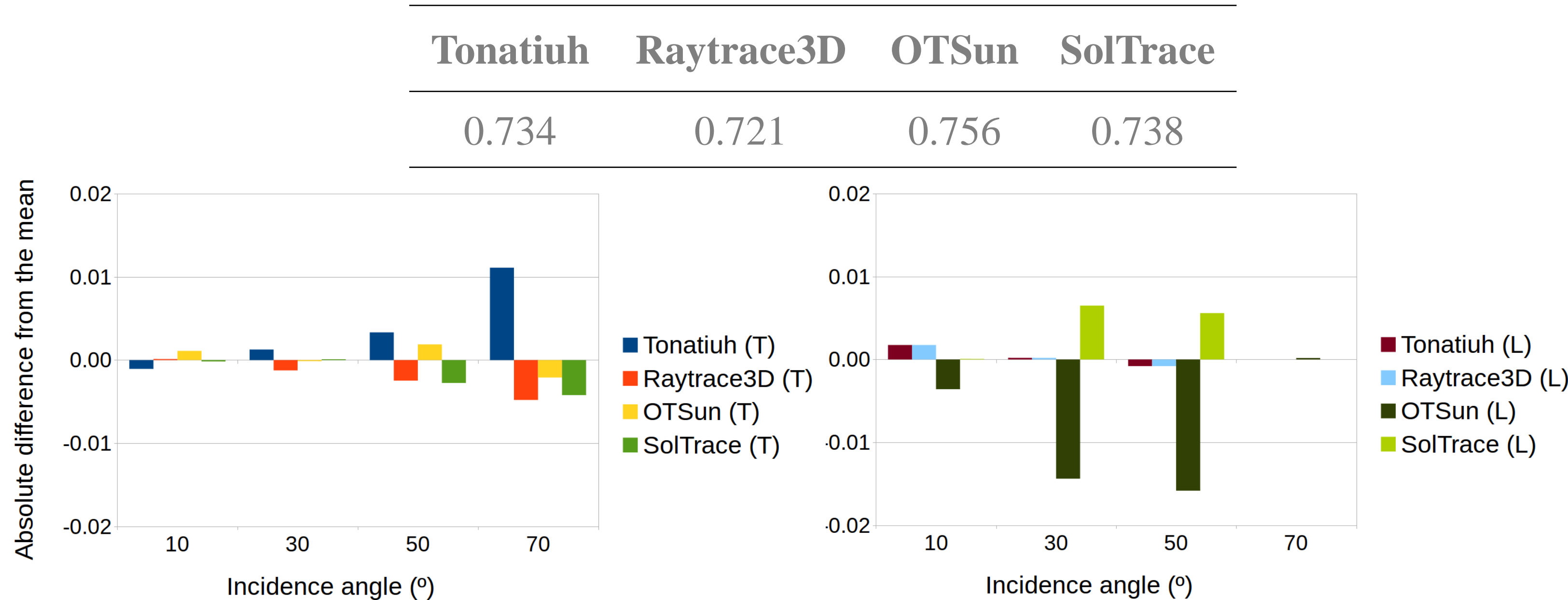
Simulation options

Options taken in each simulation – restricted by the software features – to meet the proposed conditions

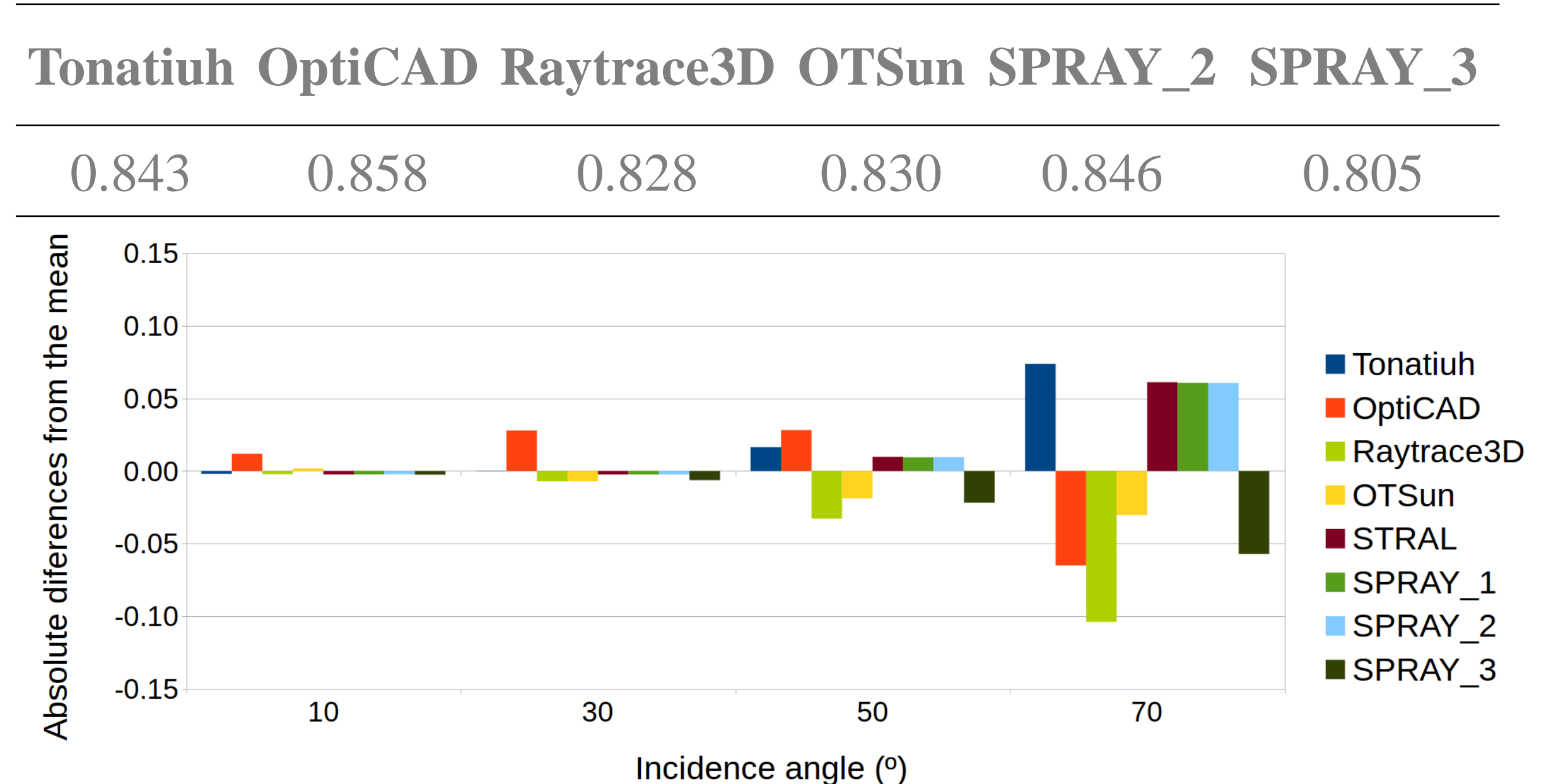
Software	Sun model	Materials	Reflector surface error	Optical properties angular variation
Tonatiuh	Buie 5%	Real	Univ. normal dist.	No
OptiCAD	3 mrad Gauss	Real	Univ. normal dist.	Yes
OTSun	Buie 5%	Real	Univ. normal dist.	Yes
Raytrace3D	Buie 5%	Real	Univ. normal dist.	Yes
STRAL	Buie 5%	Absorber: $\alpha = 1$ No glass tube	Biv. normal dist.	No
SPRAY_1	Buie 5%	Absorber: $\alpha = 1$ No glass tube	Biv. normal dist.	No
SPRAY_2	Buie 5%	Real ($n = 1$)	Biv. normal dist.	No
SPRAY_3	Buie 5%	Real (no AR)	Biv. normal dist.	Yes
SolTrace	3 mrad Gauss	Real	Univ. normal dist.	Yes

Results and Conclusions

LFC optical efficiency and IAMs



PTC optical efficiency and IAM



- **Software features:** the main differences were in the degree with which each software could model the angular dependency of the material optical properties
- **Physical models:** refraction on the glass tube is not modeled in the same way by the different tools
- **Conclusions:** although good agreement was obtained it was clear that different modeling options by different software tools produce different optical efficiency values and IAM curves