Ray-Tracing Software Comparison for Linear Focusing Solar Collectors

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Participants and software tools in the study

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

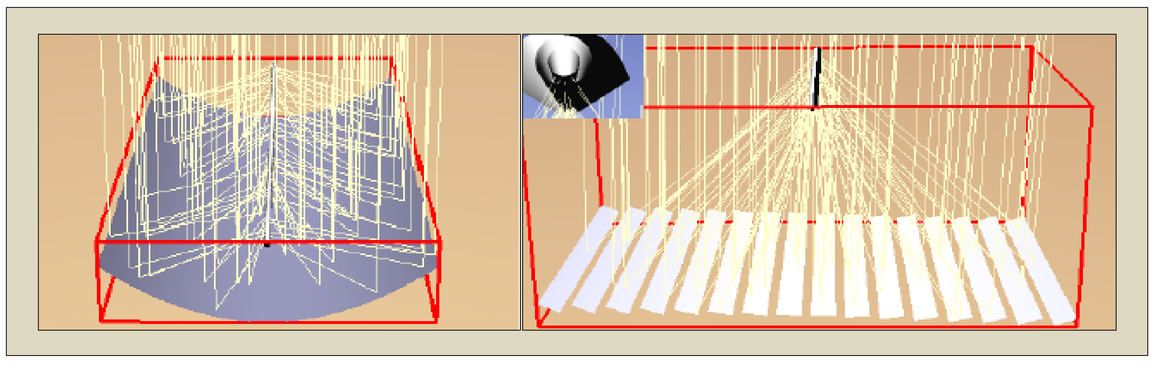
1. Description of the software features regarding sun model, real materials, surface errors, angular variation of optical properties and refraction model
2. Simulations of two exemplary cases, a PTC and a LFC with predefined conditions: geometry, sun model and material properties

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: θa = 48.39 º; 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: ρ = 0.935; absorber: α = 0.955; glass: ρ = 0.035; τ = 0.965; n = 1.52	
Slope deviation	σ_s = 2.5 mrad	
Clear sky	Buie 5%	



Simulation options

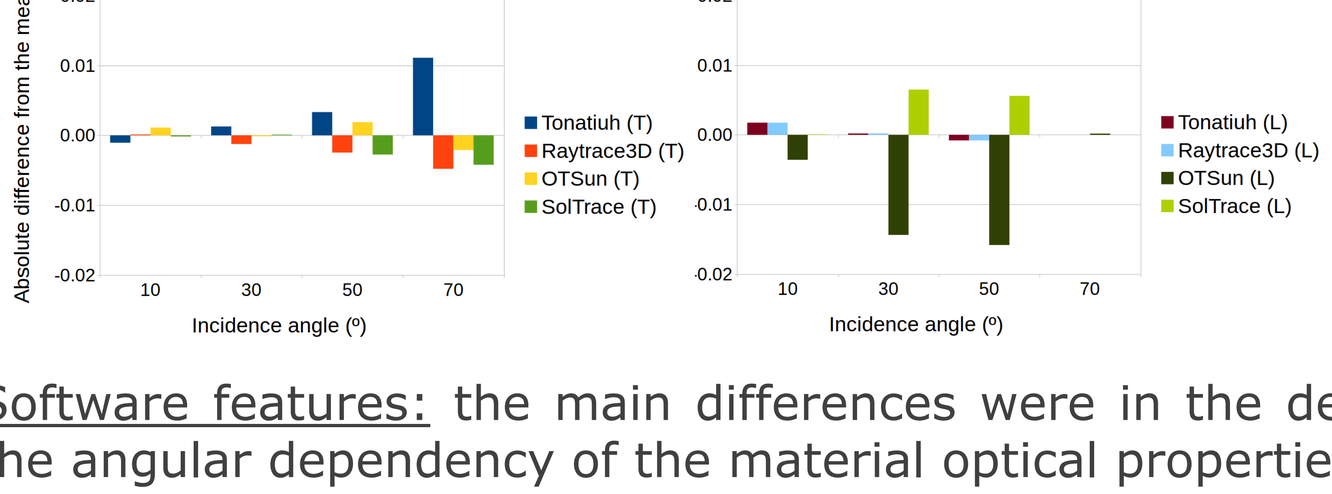
Options taken in each simulation – restricted by the software features – to meet the proposed conditions

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: α = 1 No glass tube	Biv. normal dist.	No
SPRAY_1	Buie 5%	Absorber: α = 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

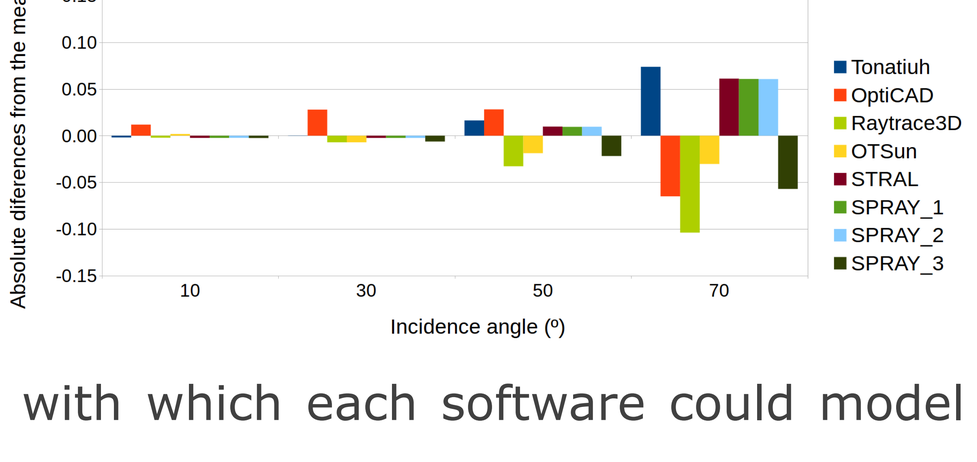
LFC optical efficiency and IAMs

Tonatiuh	Raytrace3D	OTSun	SolTrace
0.734	0.721	0.756	0.738



PTC optical efficiency and IAM

Tonatiuh	OptiCAD	Raytrace3D	OTSun	SPRAY_2	SPRAY_3
0.843	0.858	0.828	0.830	0.846	0.805



- 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

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