Remote Measurement of Heliostat Reflectivity with the Backward Gazing Procedure

François Hénault (a), Gilles Flamant (b), Cyril Caliot (c)

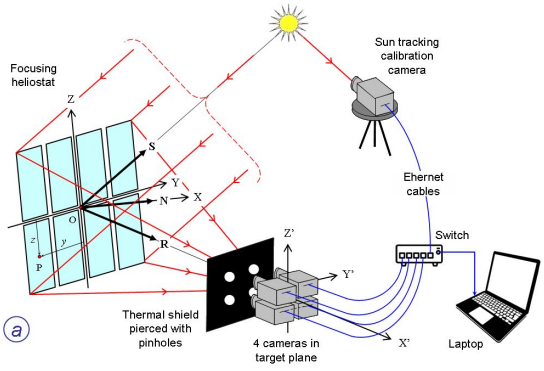
(a) Institut de Planétologie et d'Astrophysique de Grenoble, Université Grenoble-Alpes, CNRS, France
(b) Processes, Materials and Solar Energy laboratory, PROMES CNRS, 7 Rue du Four Solaire, 66120 Font-Romeu-Odeillo-Via, France
(c) CNRS, UPPA, E2S, LMAP, 1 Allée du parc Montaury, 64600 Anglet, France

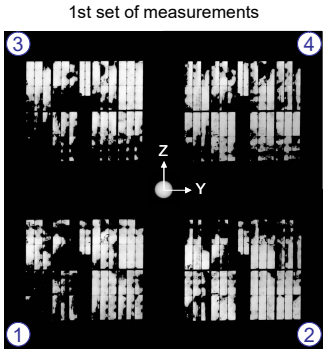
Summary

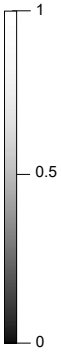
• In Concentrated solar power (CSP) tower plants, the reflectivity of the heliostats plays a major role on the achieved performance and system efficiency.
• It implies that the mirrors must be cleaned regularly, and their reflectivity measured periodically
• Reflectivity losses typically originate from dust deposition in dessertic environment, optical coatings degradation due to day/time thermal cycles and humidity
• These measurements can be done with portable reflectometers with the drawbacks of excessive measurement times and low spatial resolution
• Here is described a **backward gazing method** originally developed to measure mirror shapes errors. It consists in acquiring four simultaneous heliostat images observed from the solar receiver
• This method is suitable to **remote measurements** of heliostat reflectivity in **quasi real-time**, with high accuracy and spatial resolution

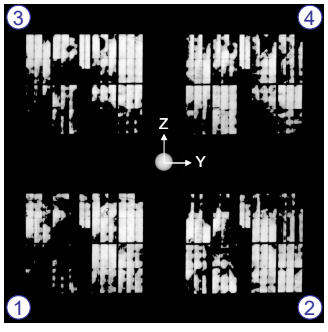
Experiment

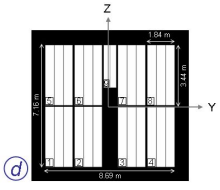
(a) Backward gazing principle
(b) Solar tower equipped with cameras
(c-d) Geometry of the heliostat
(e-f) Experimental apparatus

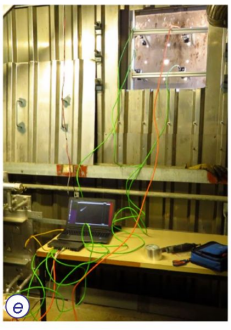


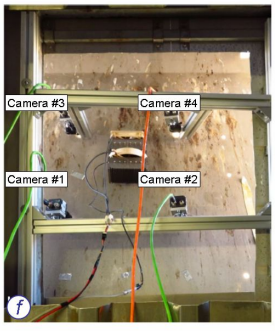










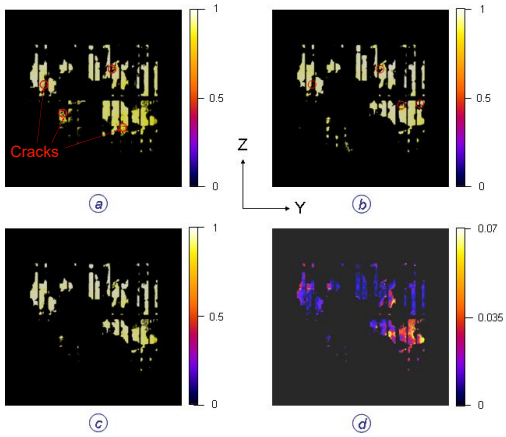


Results

- Assuming that absolute accuracy and repeatability are equivalent, the method allows **remote measurements of heliostat reflectivity in quasi real-time**
- The measurement accuracy is currently estimated to 5% Peak-to Valley (PTV) and 1% RMS.
- The spatial resolution is typically 1000 x 1000 pixels or higher
- It allows evaluating soiling effects due to dust accumulation and moisture, as well as surface defects and cracks inside the optical coatings
- It does not disturb the heat production process in Sun-tracking mode
- Higher accuracy and spatial coverage are achievable by adding more observing cameras

Module number	Spatial coverage (%)	Reflectivity measurements in %			
		Measurement #1	Measurement #2	Difference error PTV	Difference error RMS
1	0,3	29,4	64,4	± 1,8	1,0
2	5,0	44,2	61,6	± 4,8	0,9
3	24,3	83,9	84,6	± 5,6	1,2
4	36,2	71,9	85,9	± 4,3	1,4
5	38,9	89,3	89,5	± 5,5	1,4
6	8,6	87,2	89,8	± 4,8	1,3
7	31,0	87,1	86,7	± 5,0	1,6
8	22,7	85,1	90,6	± 5,1	0,9
9	63,9	88,2	90,9	± 5,0	0,8
Average		79,6	84,9	± 4,7	1,2

Reflectivity statistics for each heliostat module



(a) Initial measurement (b) Second measurement 30 minutes later
(c) Averaged reflectivity map (d) Difference repeatability map

Contact: francois.henault@univ-grenoble-alpes.fr