Experimental and Numerical Evaluation of Drift Errors in a Solar Tower Facility with Tilt-Roll Tracking-Based Heliostats

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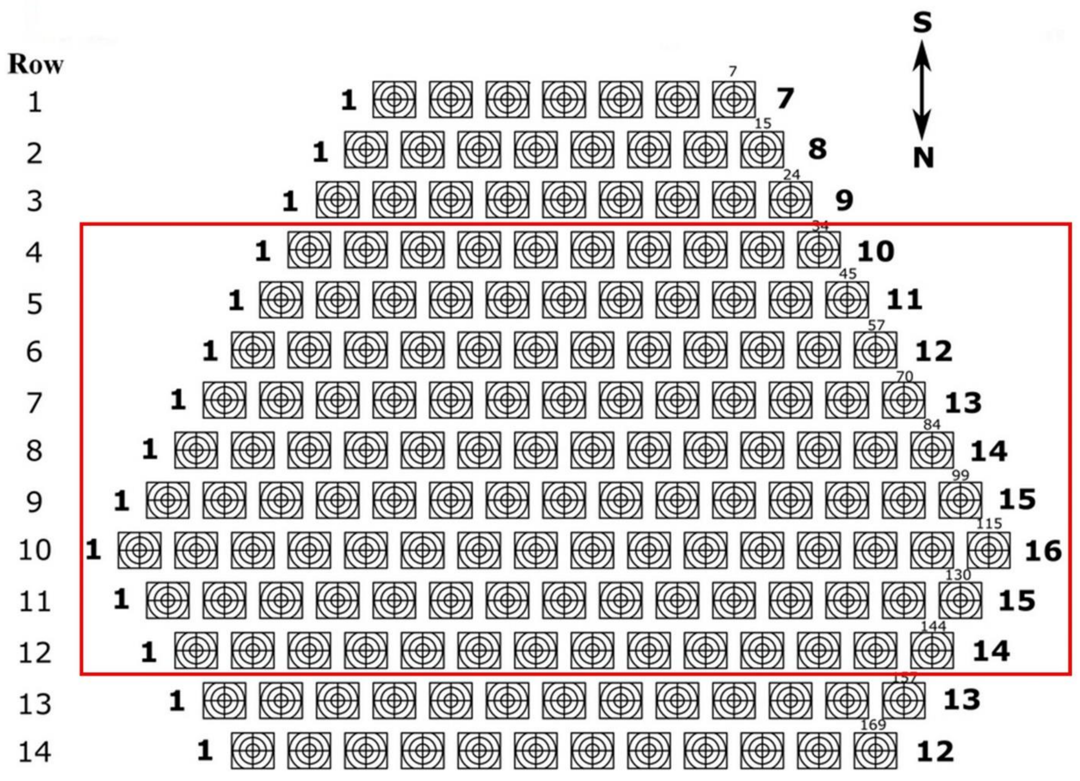
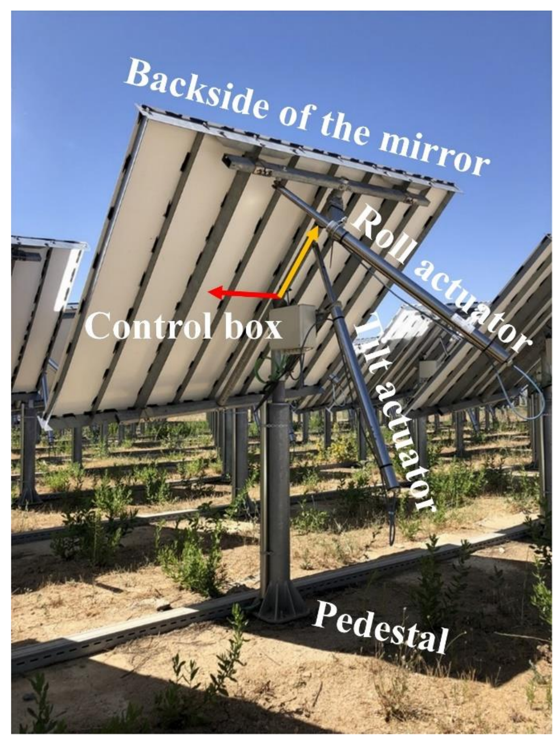
Reliable and suitable operation of solar tower facilities requires to analyze the drift errors, which are due to misalignments in the installation and assembly of the heliostats. This work addresses the analysis of drift errors in the solar tower of IMDEA Energy Institute in Móstoles, Madrid, Spain. It comprises the characterization of the drift by analyzing flux maps acquired along the day and ray-tracing studies to find the source of the drift observed in the experiments.

EXPERIMENTAL STUDY

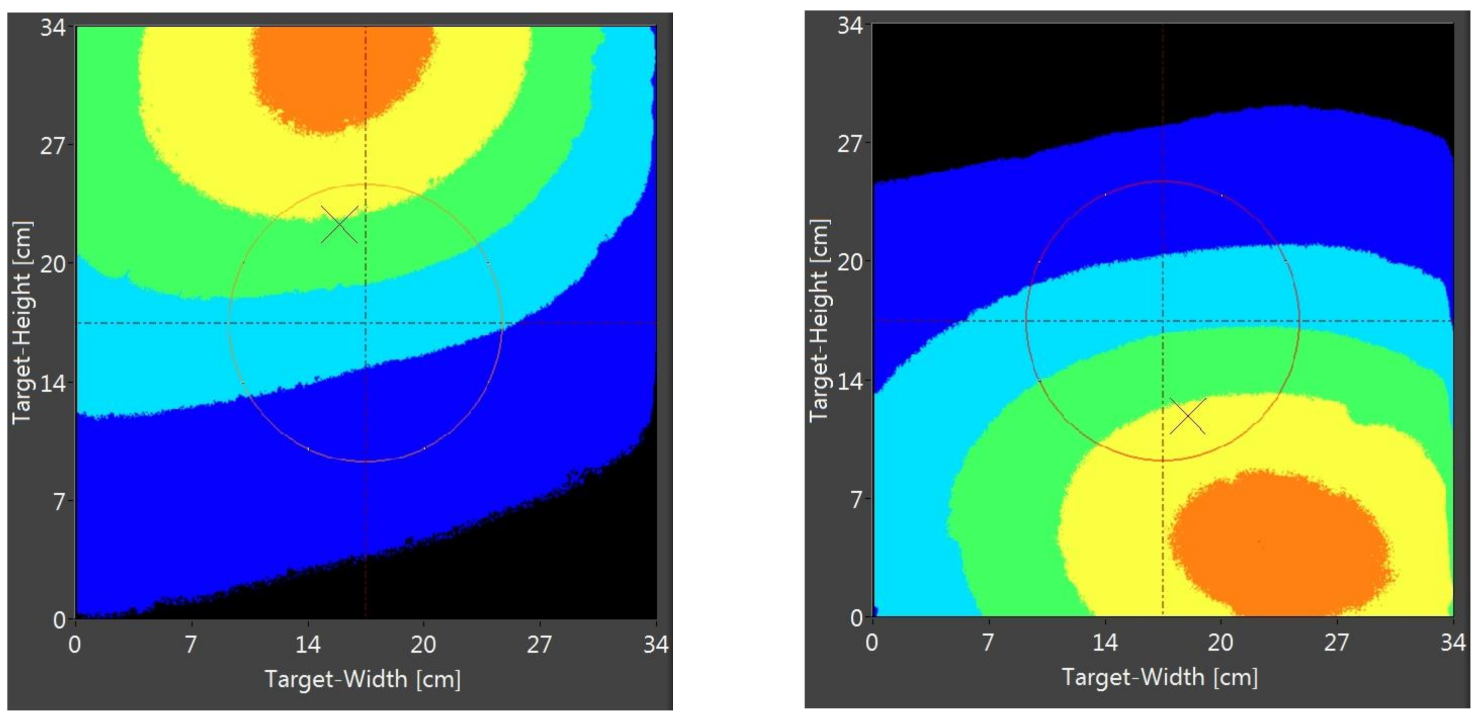


Layout of the heliostat field. The red box indicates the group of heliostats (rows 4 to 12) for which the drift is investigated.

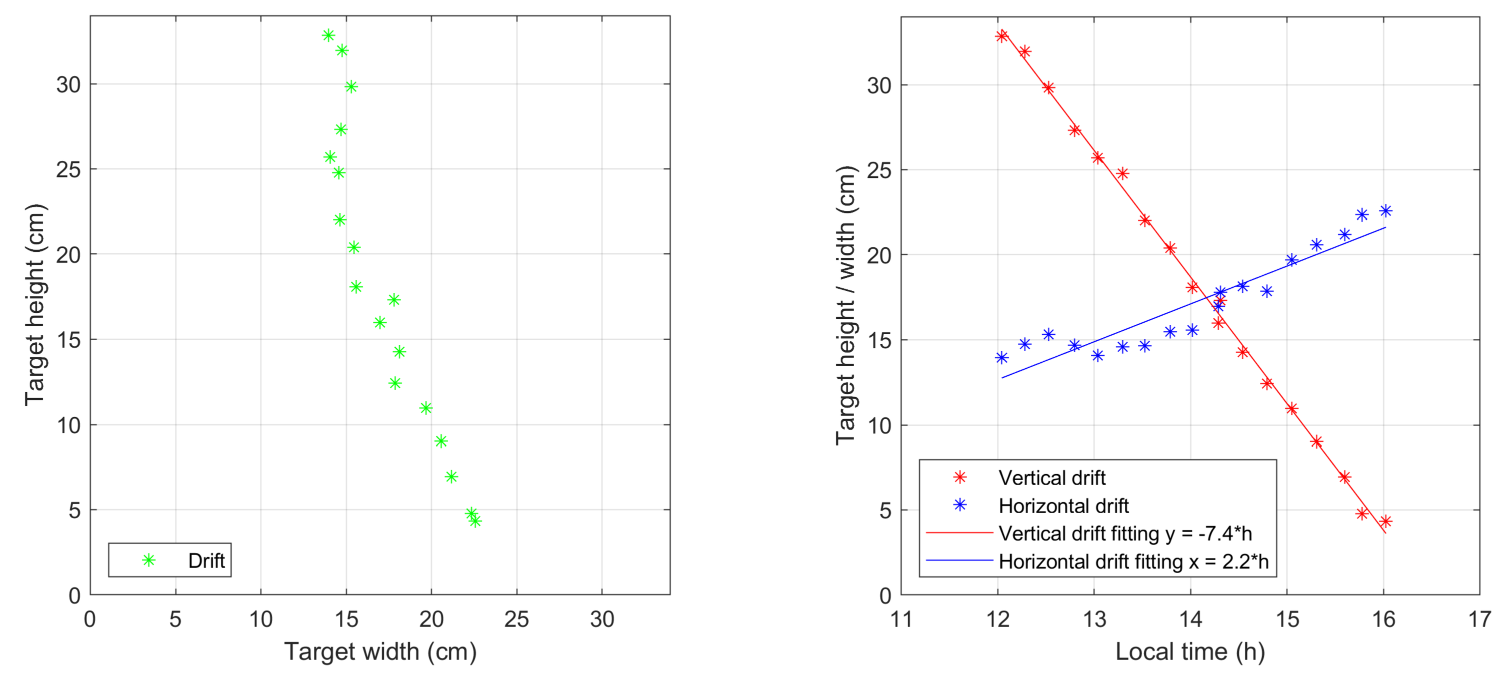
IMDEA Energy solar field is composed of 169 heliostats of 3 m^2 distributed in 14 rows [1,2]. In order to characterize the drift, flux maps were acquired with a flux mapping acquisition system (FMAS) [3]. This FMAS is based on a CCD camera located on the ground and a moving Lambertian target located in the top of the tower with a Gardon-type sensor embedded in it. The drift was investigated for a group of 120 heliostats in summer solstice. Several flux maps were acquired along the day every approximately 15 minutes from 12:02 PM to 16:00 PM. Using all the flux maps, the drift is obtained by computing the maximum irradiance point (x and y coordinates on the Lambertian target) of each one. Assuming that the drift in both directions follows approximately a linear behavior, the data are fitted with a linear regression resulting in a drift with a velocity of -7.4 cm/h in the vertical direction and 2.2 cm/h in the horizontal direction.



Heliostat tracking system. The tilt and roll axes are represented with a red and a yellow arrow, respectively.

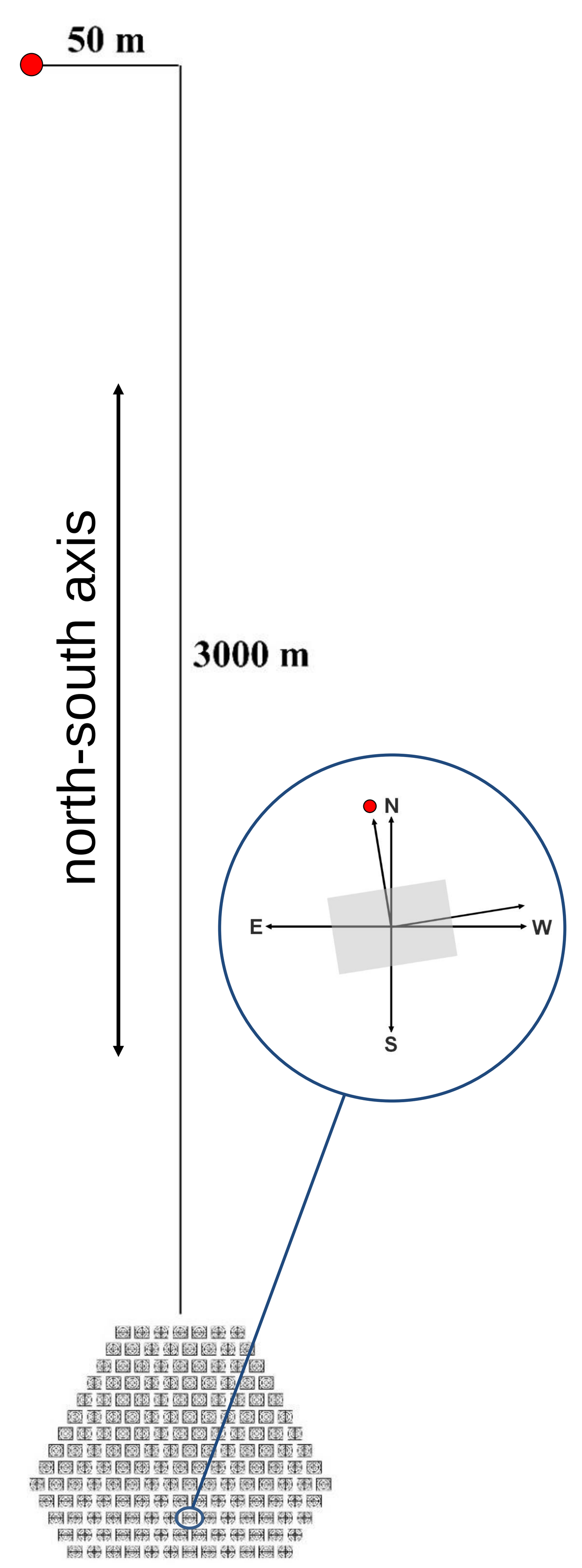


Experimental flux maps acquired at 12:02 PM (left) and 16:00 PM (right).



Experimental drift along the day on the target (left) and vertical and horizontal drift components vs local time with their respective linear fits (right).

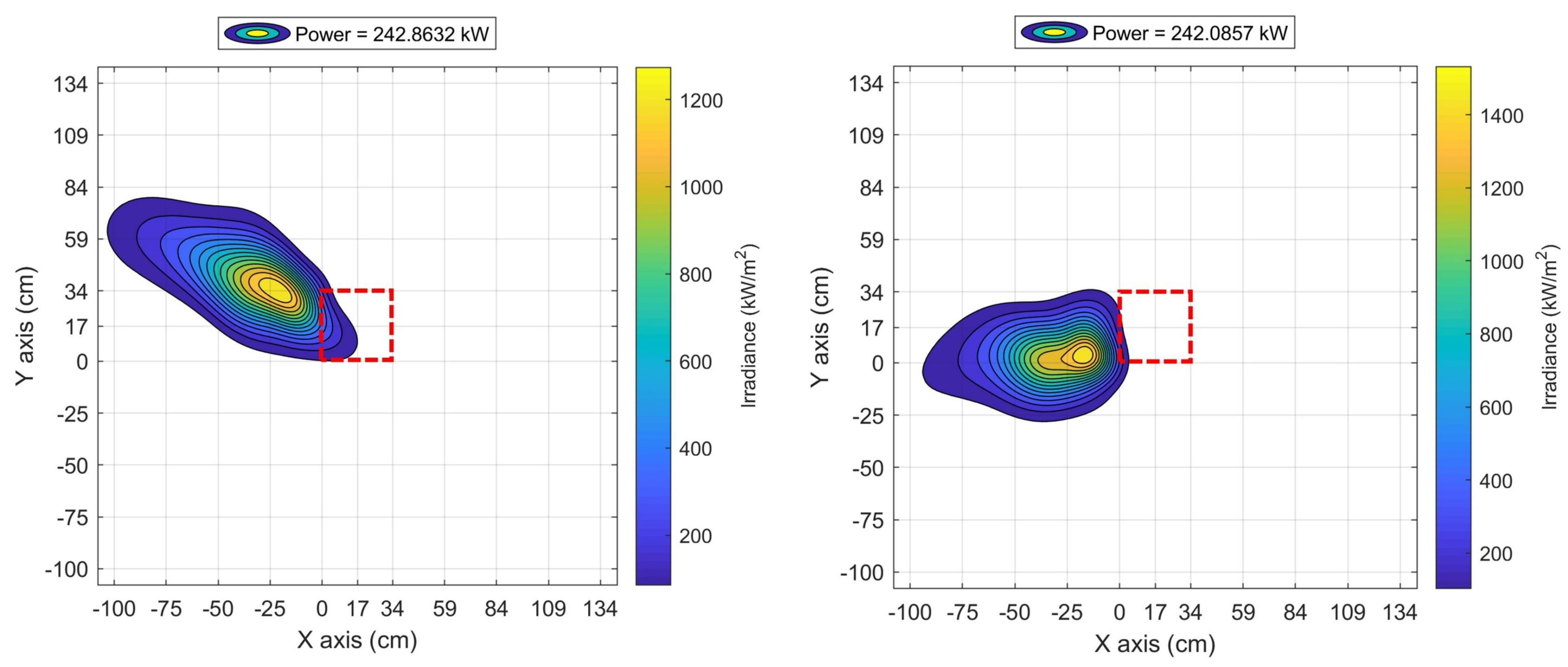
NUMERICAL STUDY



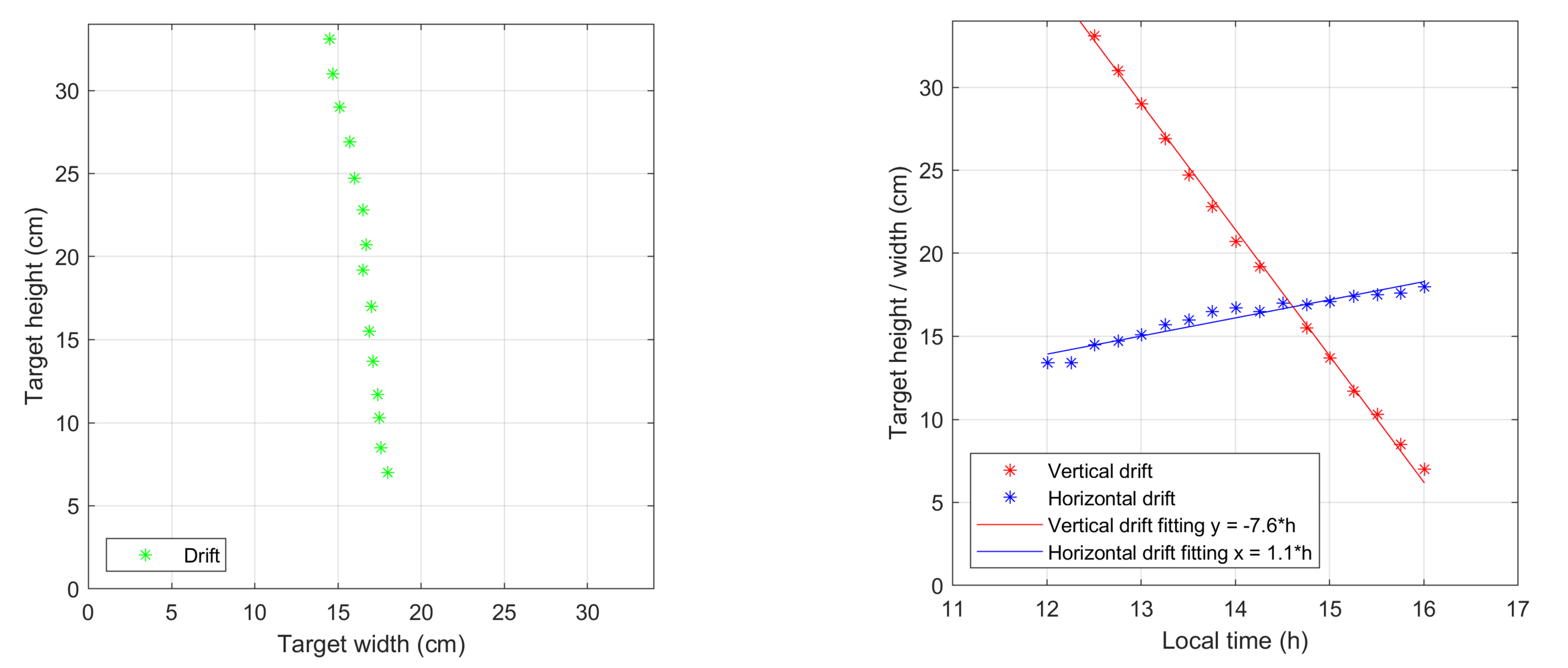
Point where heliostats are facing

To investigate the source of the drift observed in the experiments, Monte Carlo ray-tracing simulations of the experimental flux maps were performed. This was done by introducing different misalignments in the tracking system of the heliostats and comparing the numerical drift obtained with the experimental one. We found out that by considering rotations of the heliostats pedestal towards the east, the experimental drift is very well reproduced by the simulations.

In fact, when heliostats are facing to the red point of the figure on the left, the numerical and experimental velocities of the main component of the drift, the vertical one, are practically the same. However, there is a factor of 2 of difference in the velocity of the horizontal component. Future works will consider the effect of the experimental offsets applied to the tilt and roll motors in the simulations. In this way, the maximum irradiance point of the numerical flux maps will be inside the target employed in the experiments.



Numerical flux maps simulated at 12:00 PM (left) and 16:00 PM (right). Red dashed square represents the 34 cm x 34 cm target employed for acquiring the experimental flux maps.



Numerical drift along the day on the target (left) and vertical and horizontal drift components vs local time with their respective linear fits (right). All the flux maps have been shifted the same distance in order to be able to represent the numerical drift in the same way than the experimental one, i.e., employing the dimensions of the target employed in the experiments.

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