Photovoltaic Power Forecasting using Sky images and Sun Motion

Arne Berresheim and Antonio Agudo

Universitat Pompeu Fabra, Spain

Institut de Robòtica i Informàtica Industrial, CSIC-UPC, Spain

ICASSP 2024 KOREA

Universitat Pompeu Fabra Barcelona · Institut de Robòtica i Informàtica Industrial · CSIC · UPC

Problem Statement

- Given *ground-based visual signals*, our goal is to infer the photovoltaic (PV) power that is generated by a solar panel system.
- Scenarios involving cloudy or partly cloudy days have proven themselves as most complex with *uncertain meteorological conditions*.
- Color visual signals are exploited to compute some *physical qualities;* a key factor to constrain the problem and obtain better solutions.

Nowcast and Forecast Models

- Two variants: 1) **Nowcast** (a single image is used as input) to predict the PV output, 2) **Forecast** (images of the last 16 minutes together with the corresponding PV power production) to predict the PV output in 15 minutes.
- Two convolutional-based *neural models* are proposed, being them quite similar. In both cases, the *usage of physical qualities* is consistently exploited in order to improve the training process.
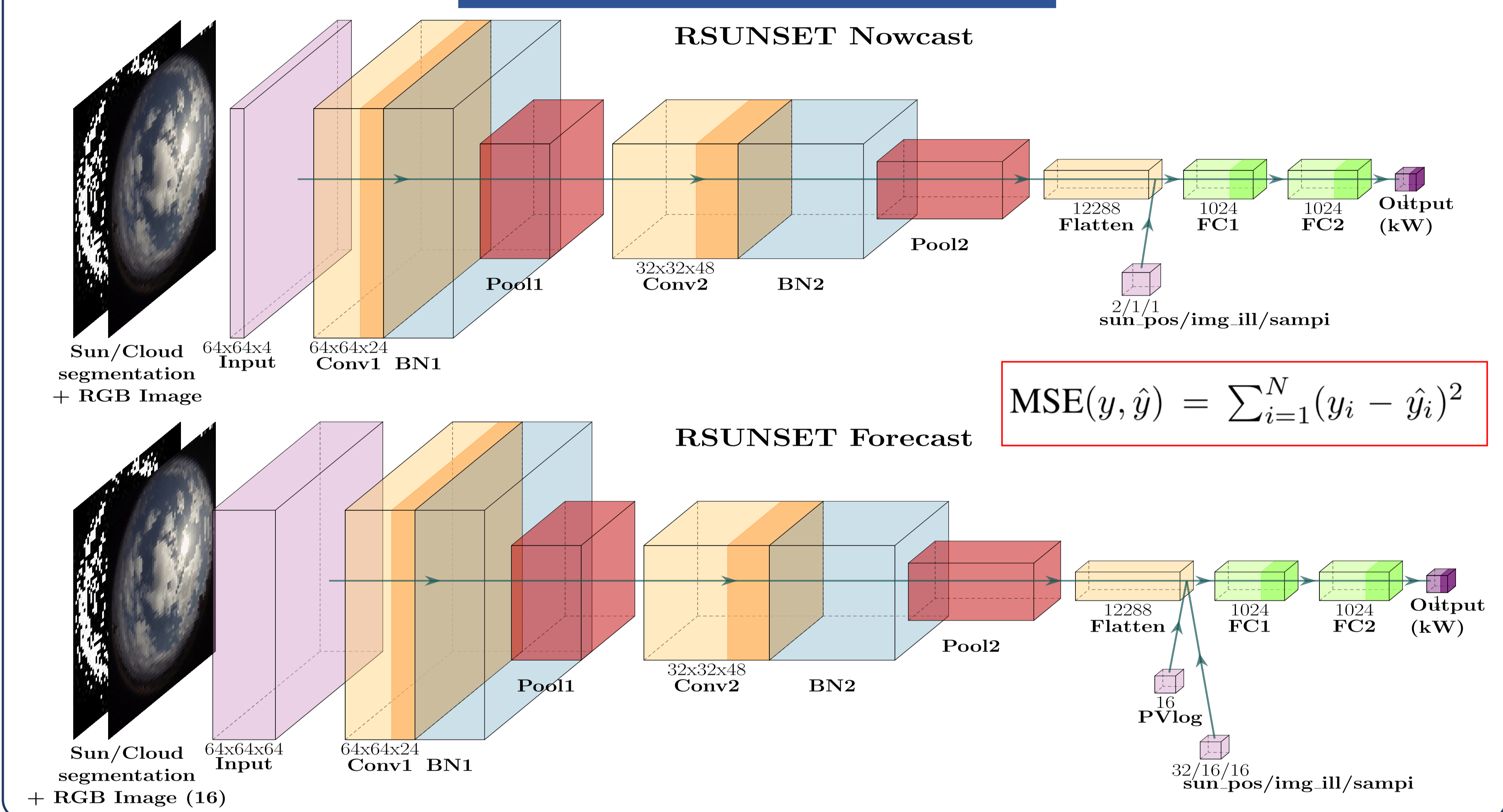
Cloud segmentation, sun motion, and sun area mean pixel intensity

- As *no sophisticated annotations* are given, we propose to infer some qualities -image illumination, cloud segmentation, sun segmentation, sun position and sun area mean pixel intensity (SAMPI)-, using image processing, and add them as *additional input to the model*. Every type of information is included in a form in the neural architecture.
- In practice, the metric that combines information about sun position and cloud coverage SAMPI and the sun position provide the best results.

Neural Architectures

$$\text{MSE}(y, \hat{y}) = \sum_{i=1}^{N}(y_i - \hat{y}_i)^2$$

Experimental Results
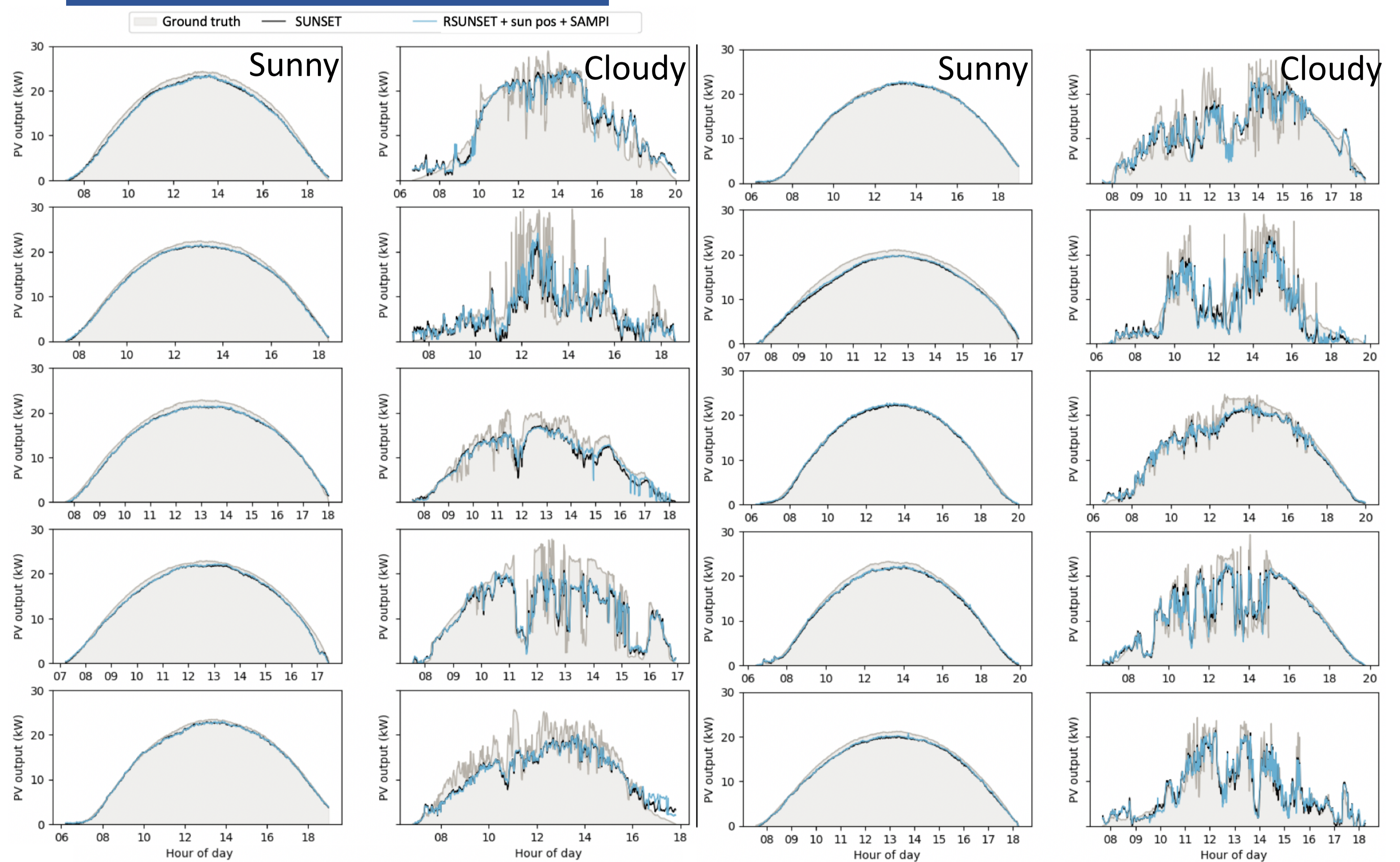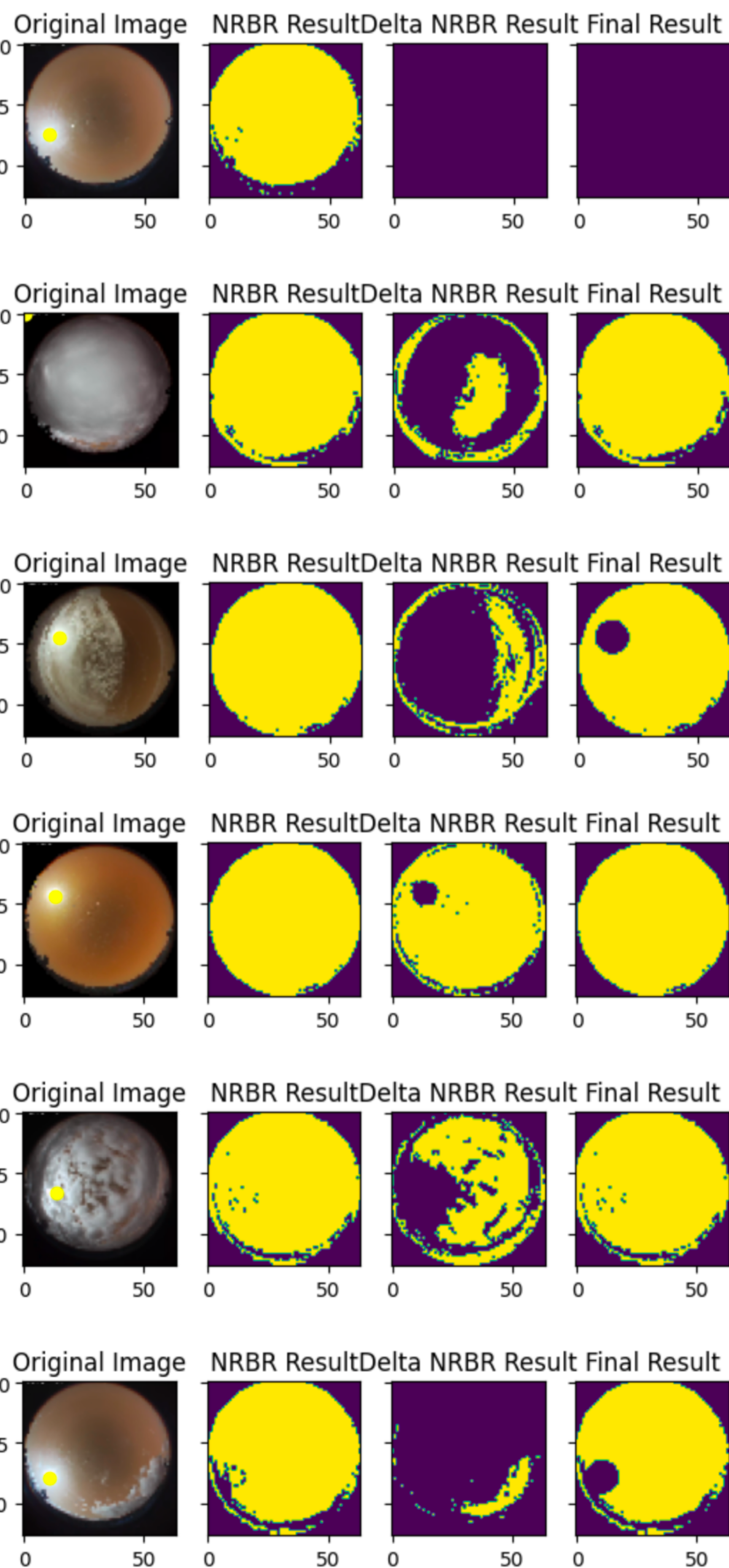
	Overall (kW)		Sunny days (kW)		Cloudy days (kW)	
Model	RMSE	MAE	RMSE	MAE	RMSE	MAE
SUNSET [20]*	2.43	1.50	0.8	0.66	3.34	2.34
RSUNSET (Ours)	2.44	1.52	0.85	0.70	3.35	2.34
+image illumination	2.47	1.56	0.88	0.73	3.37	2.38
+cloud segmentation	2.71	1.74	1.00	0.75	3.70	2.72
+sun segmentation	2.53	1.61	0.89	0.71	3.46	2.50
+sun position	2.43	1.52	0.84	0.69	3.33	2.34
+SAMPI	2.46	1.54	0.83	0.69	3.38	2.38
+sun position & SAMPI	**2.40**	**1.48**	**0.79**	**0.65**	**3.30**	**2.30**
SUNSET [20]*	3.03	1.71	**0.61**	**0.50**	4.27	2.95
RSUNSET (Ours)	8.70	7.18	9.22	8.16	8.15	6.20
+sun position & SAMPI	**8.13**	**6.65**	8.62	7.55	**7.61**	**5.75**

(rows grouped as: Nowcast / Forecast)

Our nowcast and forecast models successfully *outperform state-of-the-art approaches*, being even *more robust* than those against occlusion and noise artifacts.