High resolution short-term solar forecasting for the integration of PV in Energy Systems

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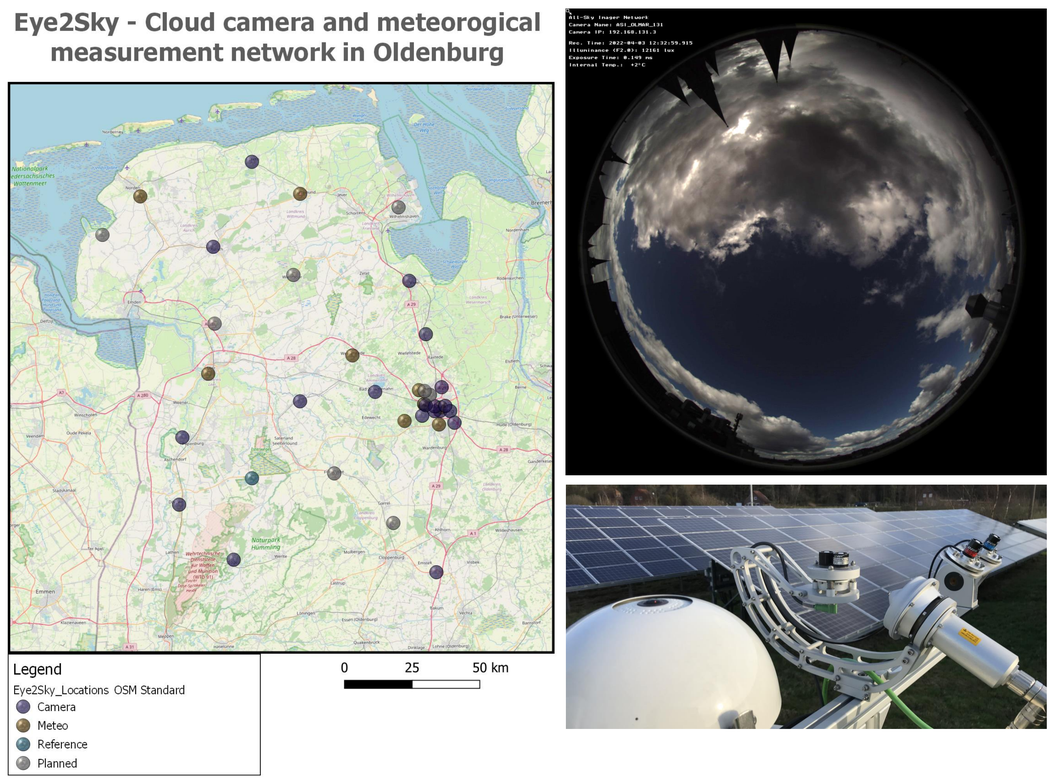

Fig. 1: Map of the Eye2Sky network (left), an example camera image for a site in Oldenburg in 2022 (top right) and the instrumentation of a station with meteorological sensors showing the camera, the rotating shadowband irradiometer and the sensors for irradiance on a tilted plane (bottom right).

The Eye2Sky Network

In recent years, DLR has installed a network of cloud cameras and meteorological instruments in north-west Germany (see Fig. 1). As of 2023, it comprises 33 stations in total, of which 18 stations are equipped with an All-Sky-Imager (ASI), a web-cam with a fish-eye lens facing to the sky. Further 11 stations have an ASI complemented with meteorological sensors (MET) measuring amongst others solar irradiance. Two stations are ceilometers (CEI) for cloud height information. The two reference stations (REF) are equipped with high quality solar trackers.

With distances of only a few kilometers, 17 stations are densely distributed in the city of Oldenburg. Sky images from several ASI do overlap here and provide 3-dimensional cloud information. The other 16 stations are installed in the rural areas to the west and north-west of Oldenburg [1].

Measurement frequency:	
ASI:	1/30 s
MET & REF:	1/1 s
CEI:	1/15 s

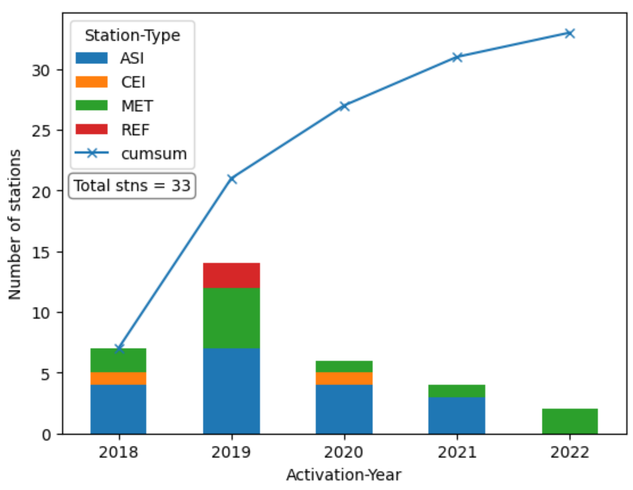

Fig. 2 (right): Number of stations installed per year and station type in the Eye2Sky Network

Applications

The Eye2Sky network provides valuable measurements along with very high resolution image-based nowcasts of solar irradiance.

Eye2Sky addresses grid operators, PV plant owners and operators, energy traders, forecast providers and many more stakeholders in a rapidly developing energy system with a strongly increasing number of PV installations.

Short-term forecasting / Nowcasting

The high resolution of the Eye2Sky network allows very short-term forecasting of cloud cover, solar irradiance and PV power output. For that purpose, advanced image analysis, cloud tracking and modelling merges multiple ASI sky and cloud observations into maps of solar irradiance [2,3]. Figure 3 shows an example.

Spatial resolution	50 meter x 50 meter
Temporal resolution	1 minute
Update frequency	30 seconds
Forecast horizon	Up to 1 hour, depending on cloud conditions
Spatial coverage	Domain Oldenburg: 10 km x 12 km
	Domain Weser-Ems: 100 km x 120 km

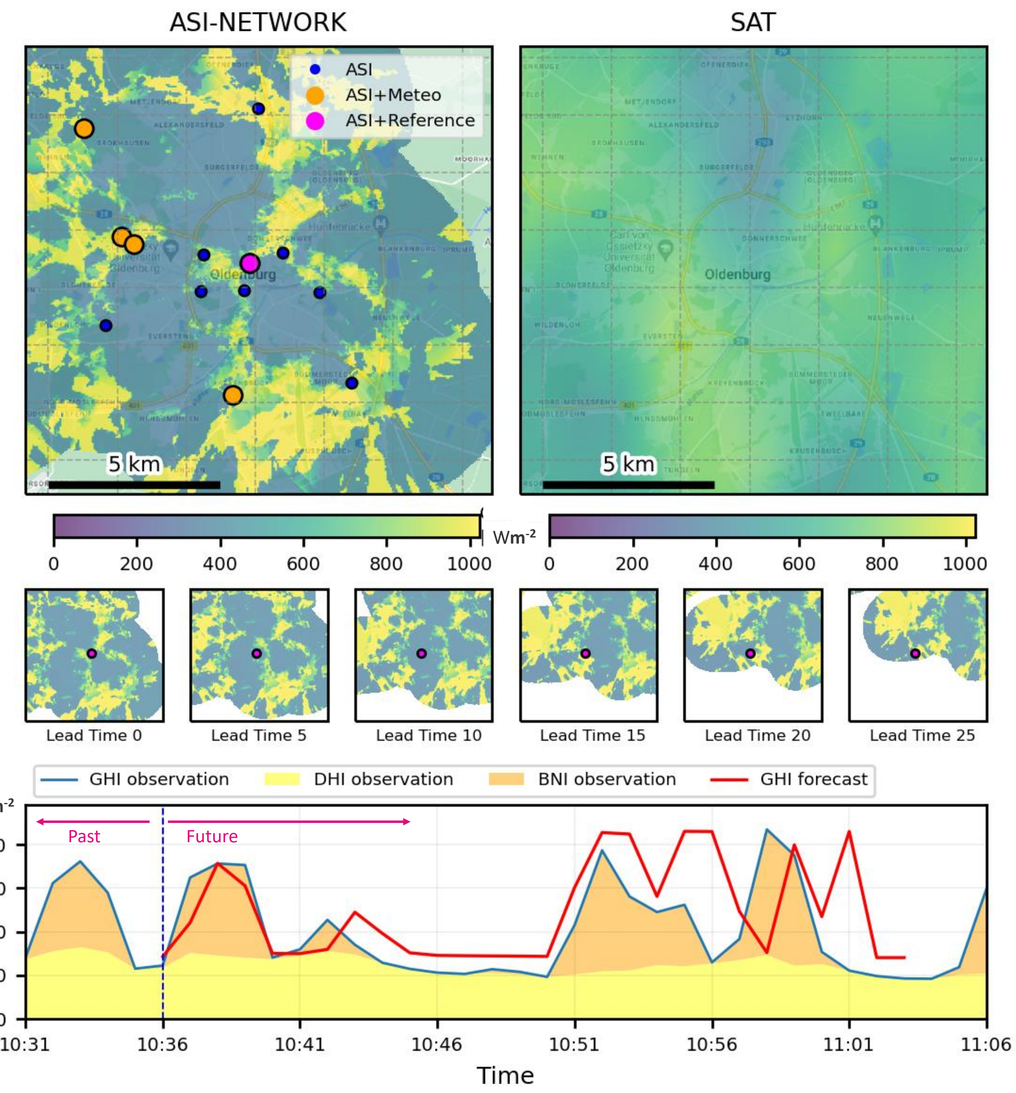

Fig. 3: Example of a nowcast of global horizontal irradiance (GHI) for the city of Oldenburg with ASI images of 17 stations included in the modelling. For comparison of the level of detail, GHI derived from MSG satellite image is shown (top right). In this scenery, small-scale clouds from south-western direction were approaching the city. The predicted GHI maps (center row) and timeseries (bottom, red line) for the location in the center of the map (magenta circle) shows good agreement with observations highlighting the cloud induced short-term variability in solar radiation.

Future plans

Next activities will focus on the validation of the forecasts and the comparison with other forecasting methods, the representation of temporal and spatial variability of solar irradiance and the influence of network design on forecast quality.

Besides, we are working on the next generation of short-term forecasting methods by combining ASI data, satellite imagery and numerical weather predictions for a seamless forecast covering larger areas and forecast horizons [4].

Additionally, we are preparing the measurement data for a publication as open data.

References:
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[4] Nouri, B.; Lezaca, J.; Hammer, A.; Blum, N.; Roy, A.: Multi-source observations to improve solar forecasting within the Smart4RES project. 2022. https://elib.dlr.de/147659/