

Variabilität der Solarstrahlung auf unterschiedlichen räumlichen Skalen

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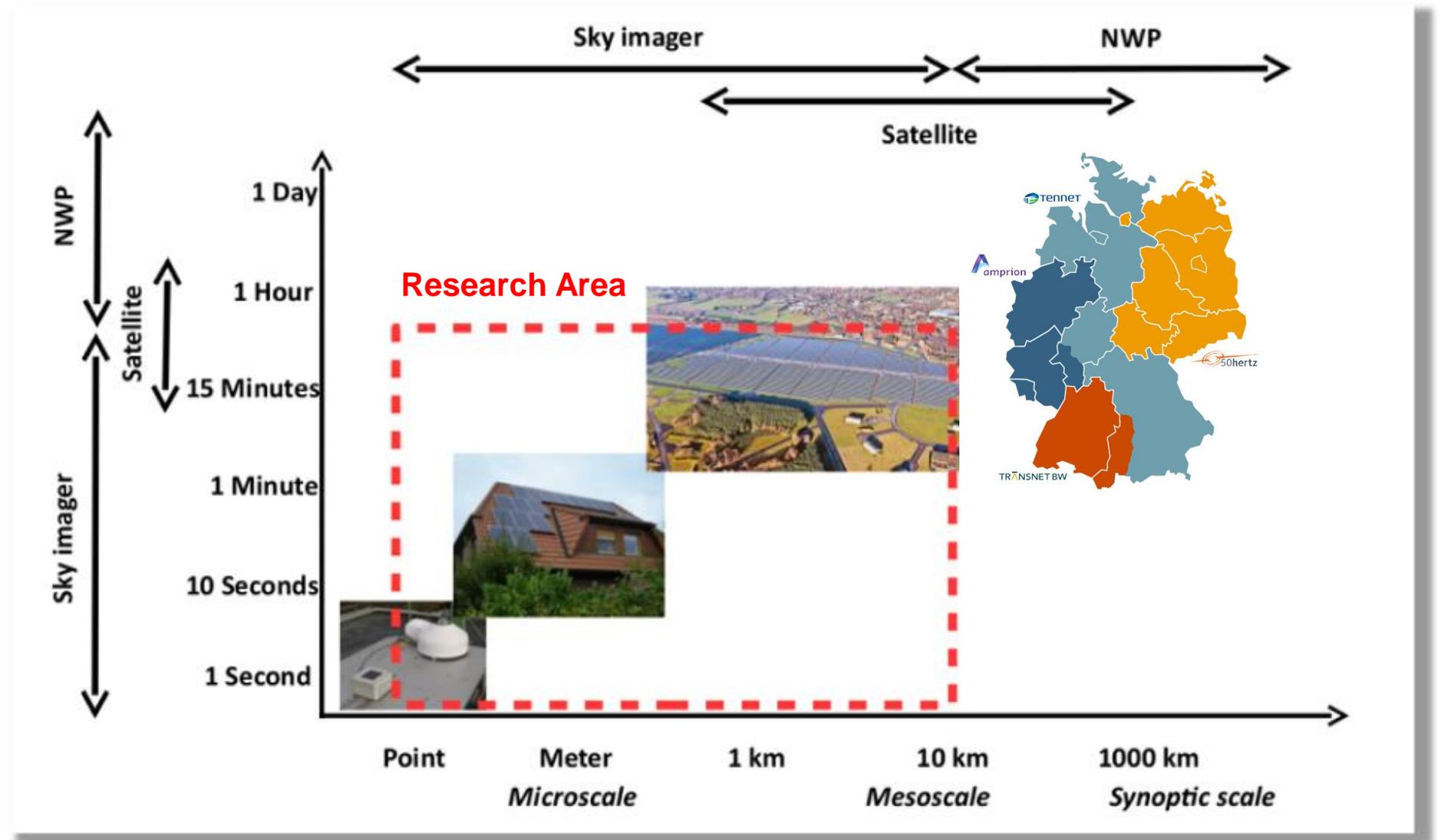




The image shows a photovoltaic measurement station. In the foreground, there is a white satellite dish on the left and a complex metal frame holding several sensors. One sensor is a LiCOR PYRANOMETER PY 90727. Another sensor is a LiCOR LiCOR 100. The background shows a large array of solar panels on a roof, with trees and a house visible in the distance.

Motivation und Datenbasis

Variabilität der Solarstrahlung – Modelle und Instrumente für unterschiedliche Skalen



NextGEMS

Next Generation Earth Modelling Systems

<https://nextgems-h2020.eu>

EU-Projekt - September 2021 bis August 2025

Wie wird sich das Klima auf globaler und regionaler Ebene verändern? Wie wird das Wetter inklusive seiner Extremereignisse in Zukunft aussehen?

IFS (ECMWF) und ICON (DWD)

Was können wir daraus für die zukünftige Solarenergie lernen?

Zeigt der 30-Jahre-Lauf auf km-Skala das richtige Solarwettergeschehen eines Jahres?



Betrachtete Datenbasen



Eye2Sky

DLR

$\Delta x = 50\text{m}$

$\Delta t = 1 \text{ min}$

Meteosat
Seviri HRV

DLR-
Heliosat3

$\Delta x \sim 2\text{km}$

$\Delta t = 15$
min

NWP
ICON-D2

Run 3
UTC

$\Delta x \sim 2.2$
km

$\Delta t = 15$
min

NWP
NextGEMS

Klimalauf

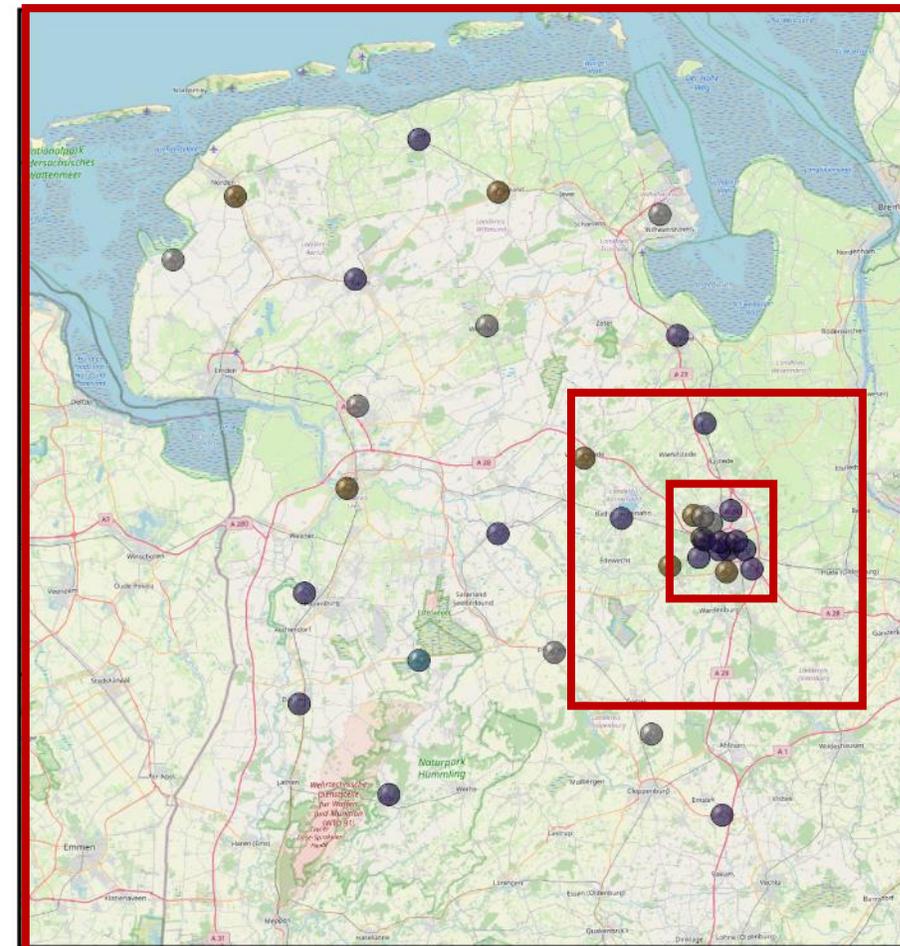
$\Delta x \sim 5 \text{ km}$

$\Delta t = 30$
min

Eye2Sky Messnetz

- 30 Stationen mit All-Sky Imagern (ASI)
- davon 12 Stationen mit meteorologischen Instrumenten
- ~110km x 100km in Nord-West-Deutschland

Eye2Sky - Cloud camera and meteorological measurement network in Oldenburg



Meteorological sensors

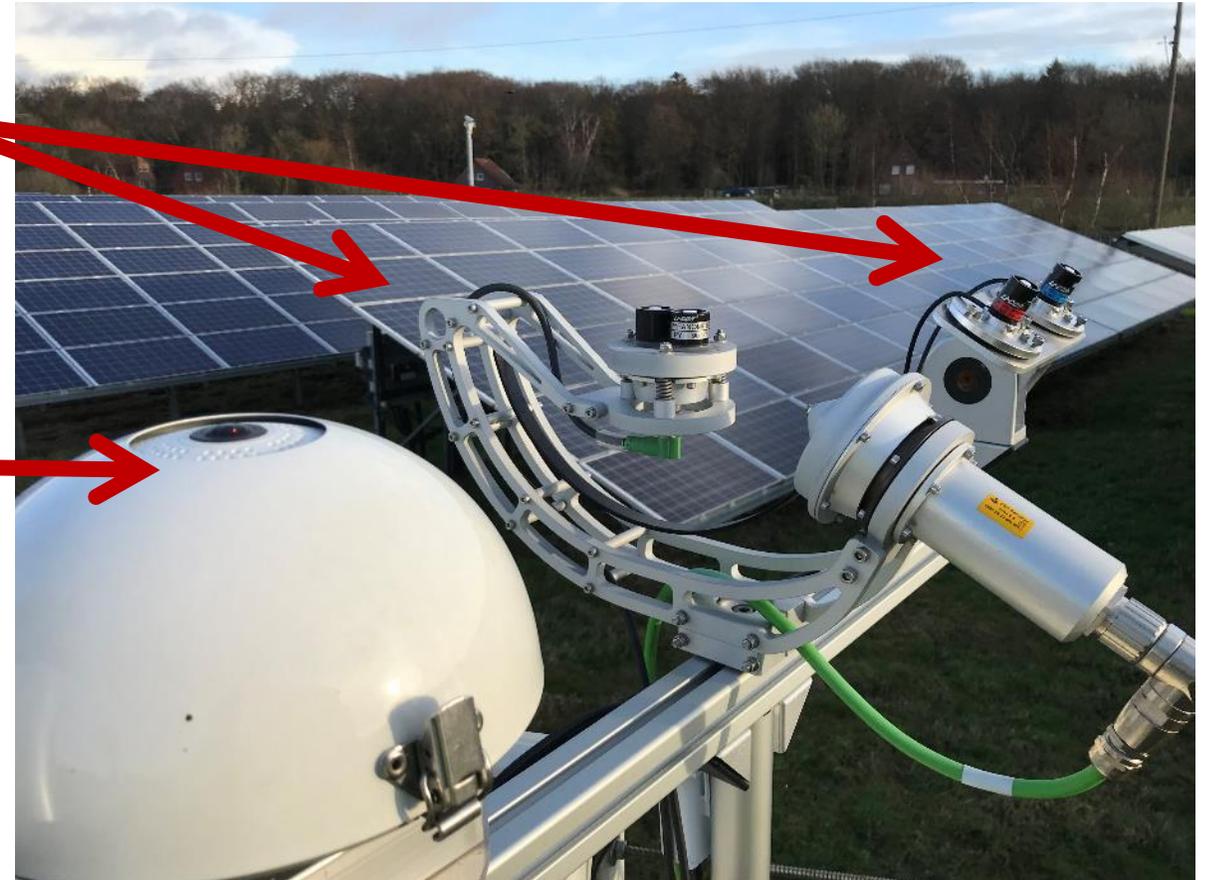
- Solar irradiance sensors (GHI, DHI, DNI, GTI)
- Air temperature and humidity

All-sky imagers

- Commercial surveillance camera used
- Fish eye lenses with 180° field of view
- Recording images every 30s

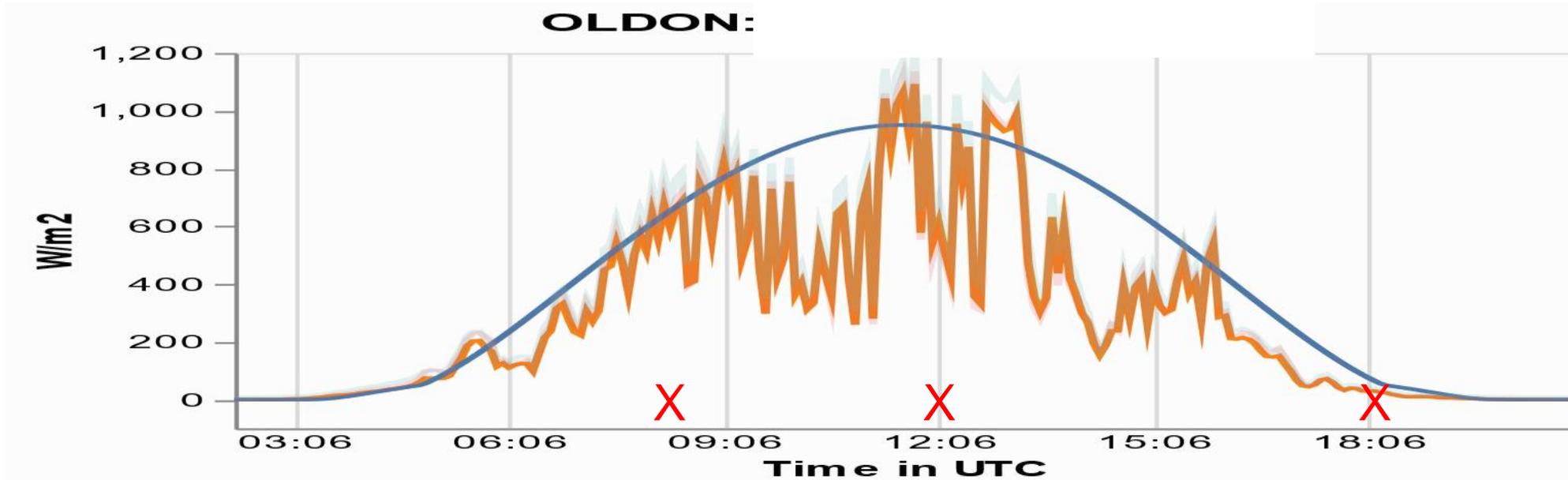
Ceilometers

- 6 atmospheric lidars (ceilometer) measuring cloud height

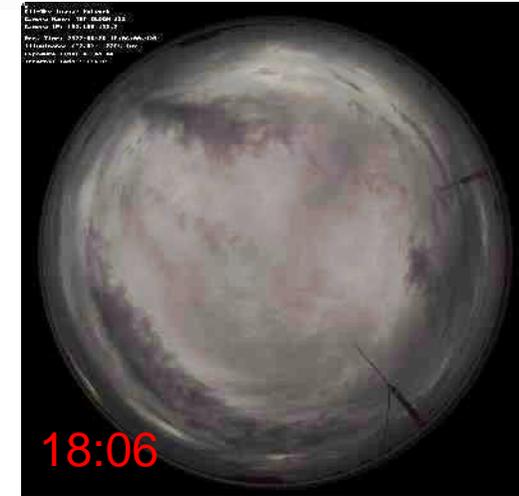
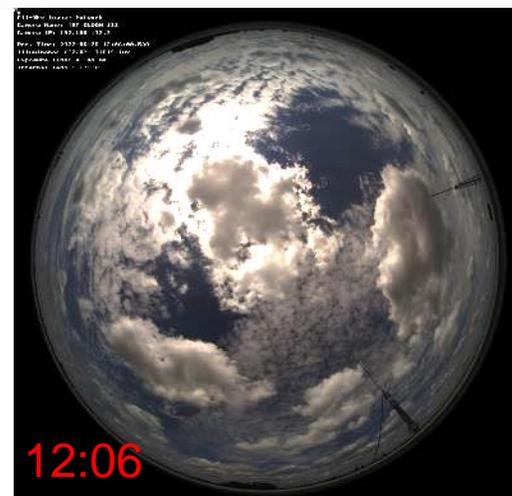


Photography of Eye2Sky station PVNOR

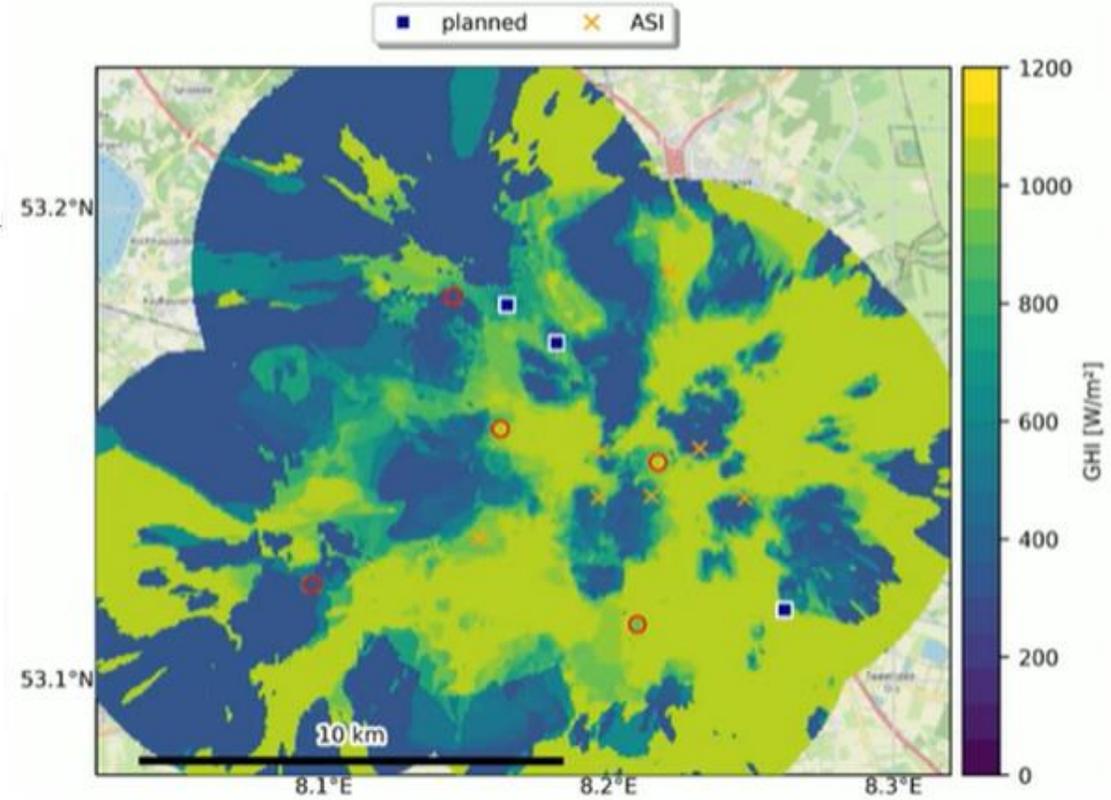
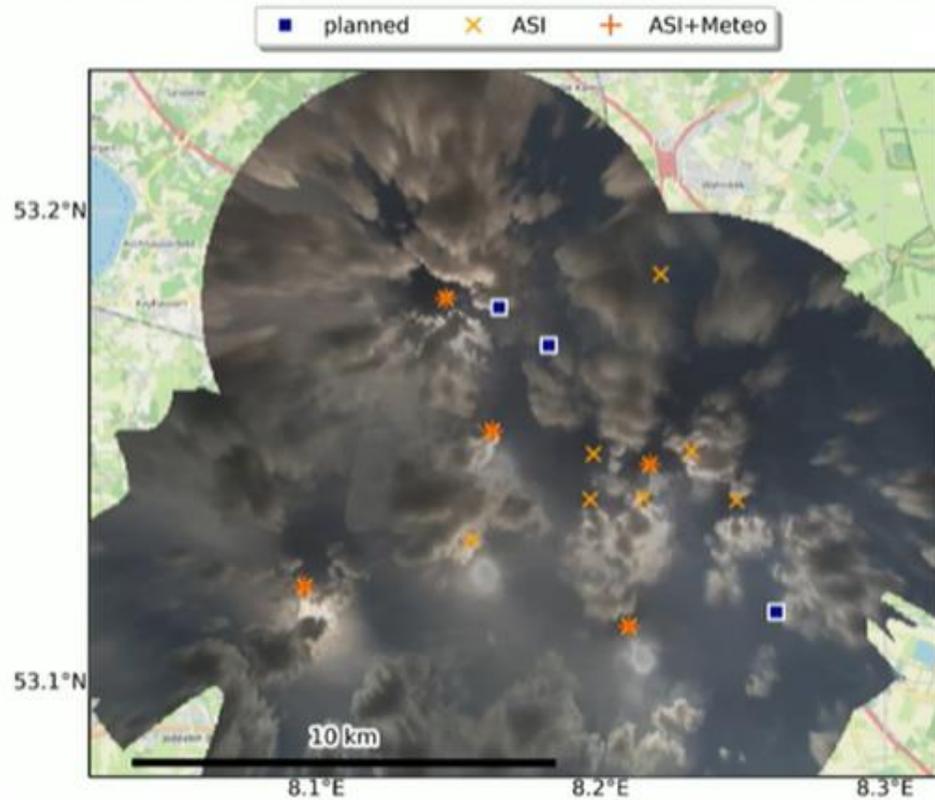
Beispieltag 2022-06-26



*Global Tilted
Irradiance,
30° Süd
Clearsky
Global Tilted
Irradiance,
30° Süd*



Strahlungskarte Eye2Sky

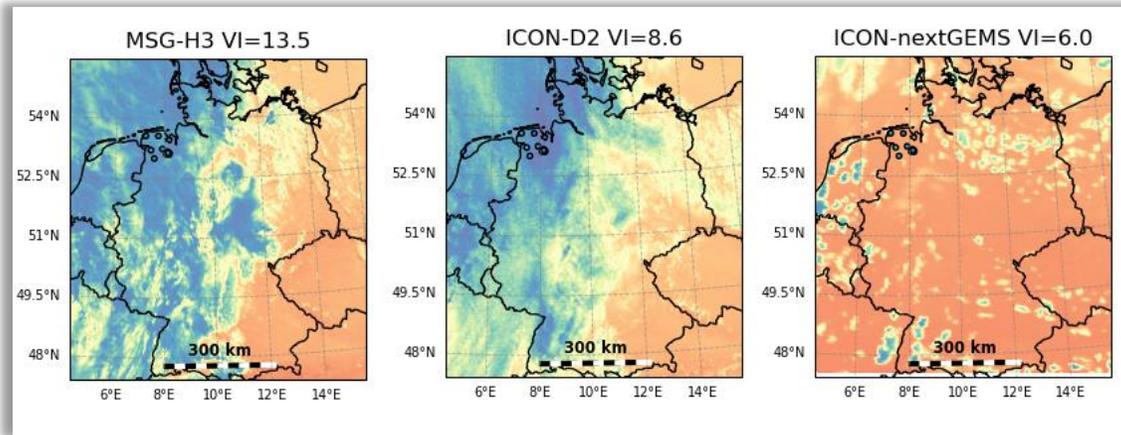


Modell:

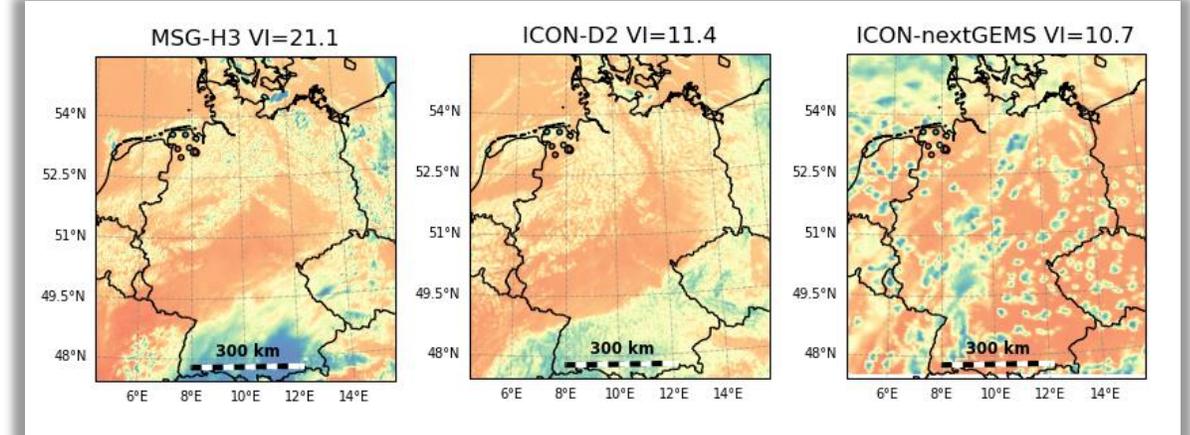
- Blum, Niklas (2022): *Nowcasting of Solar Irradiance and Photovoltaic Production Using a Network of All-Sky Imagers*. Dissertation, RWTH Aachen
- Blum, Niklas et al. (2022): *Analyzing Spatial Variations of Cloud Attenuation by a Network of All-Sky Imagers*. Remote Sensing, 14 (22), Seite 5685.

Vergleich der Strahlungskarten

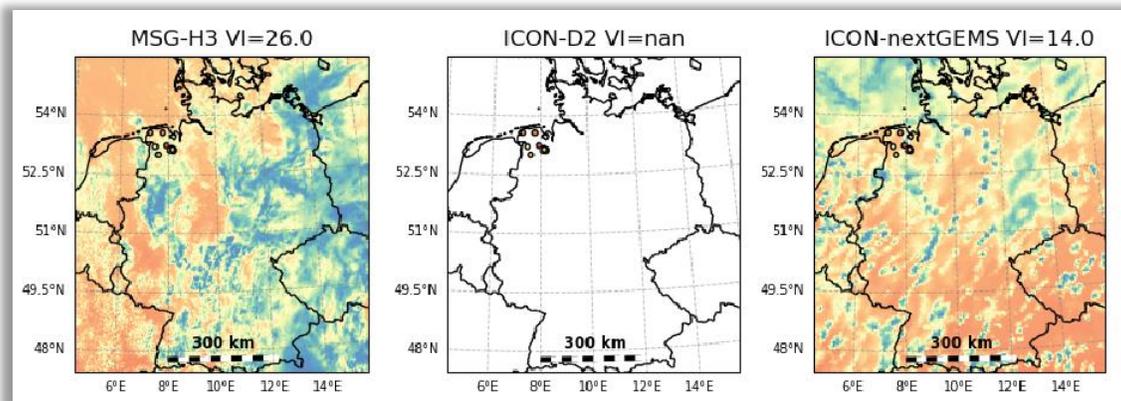
Erster Eindruck: 2022-06-27 bis 2022-06-30 - 12:00 UTC



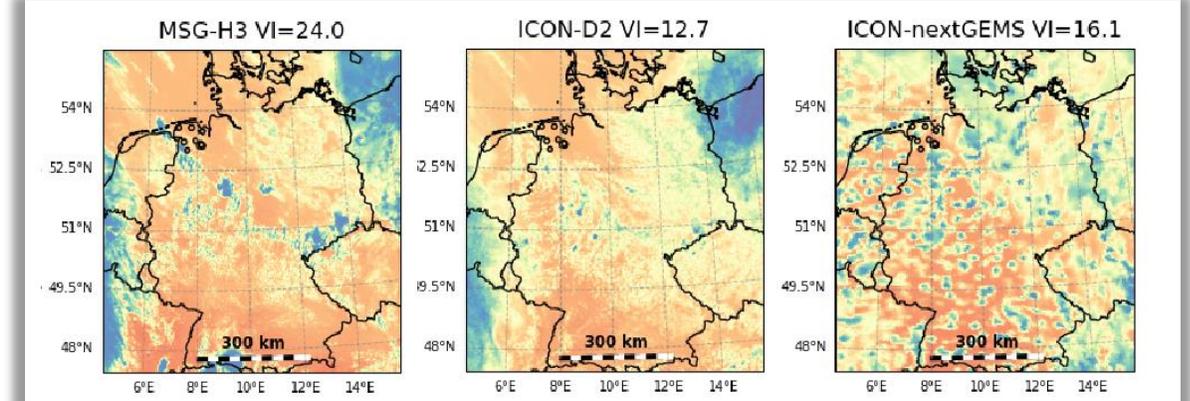
2022-06-27



2022-06-28

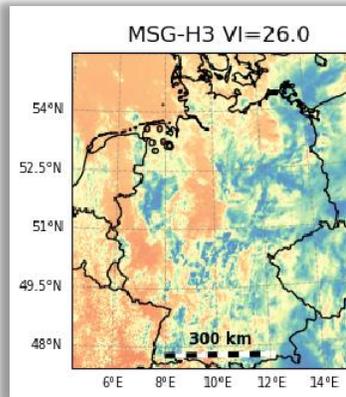
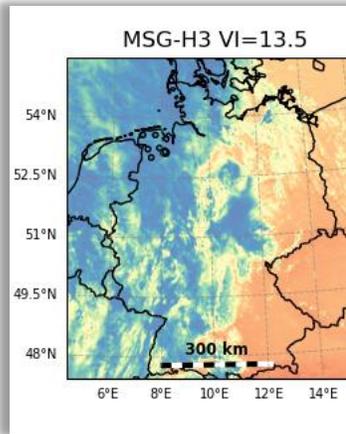


2022-06-29



2022-06-30

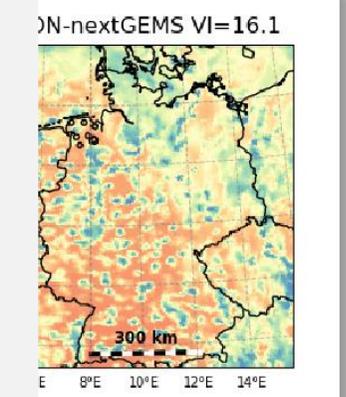
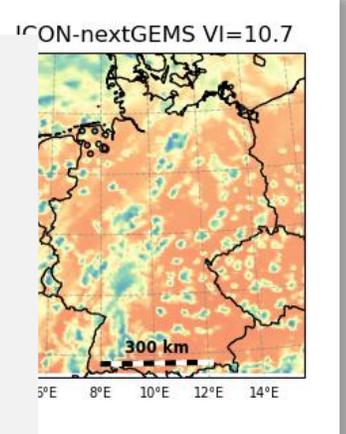
Erster Eindruck: 2022-06-27 bis 2022-06-30 - 12:00 UTC



ICON D2 Prognose passt gut zur MSG Beobachtung

Das Klimamodell kann tagesscharf nicht passen

Kann ICON-NextGEMS die für die Jahreszeit passenden Strukturen in der beobachteten Häufigkeit prognostizieren?



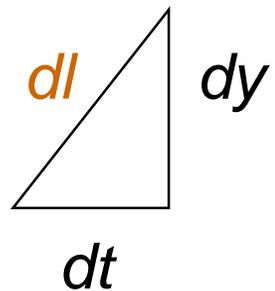
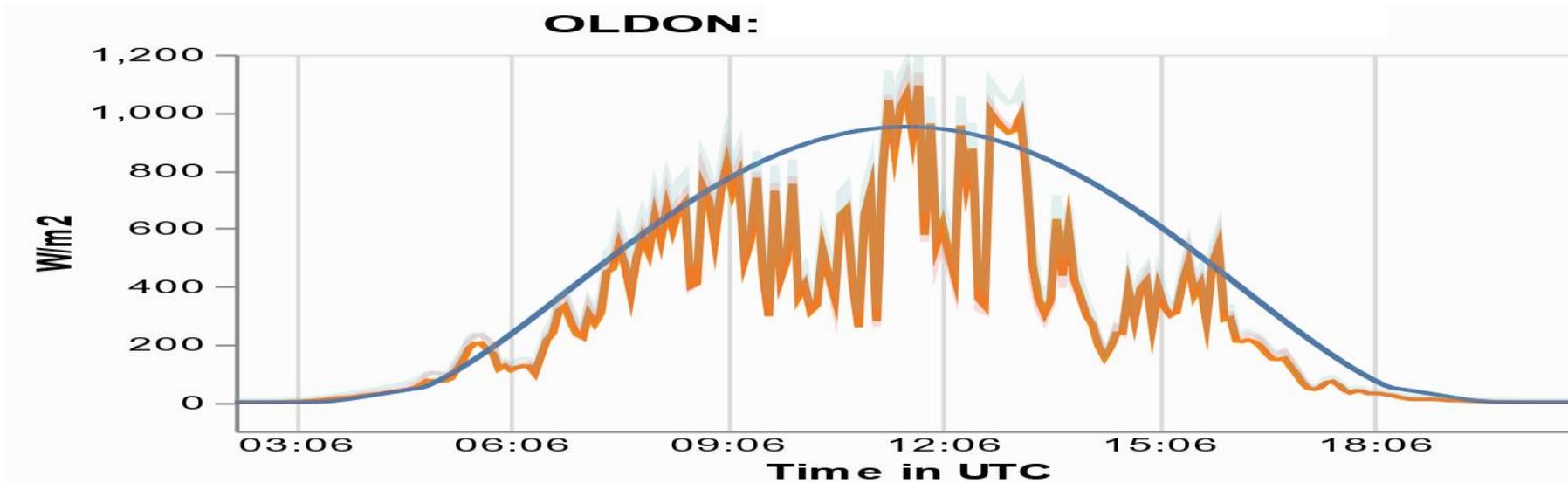
2022-06-29

2022-06-30

Metrik: Variabilitäts-Index – VI

- Stein, J., Hansen, C. W., and Reno, M. J.
The Variability Index: A New and Novel Metric for Quantifying Irradiance and PV Output Variability.
United States: N. p., 2012. Web.

- $VI = \text{Länge der bewölkten Kurve} / \text{Länge der unbewölkten Kurve}$

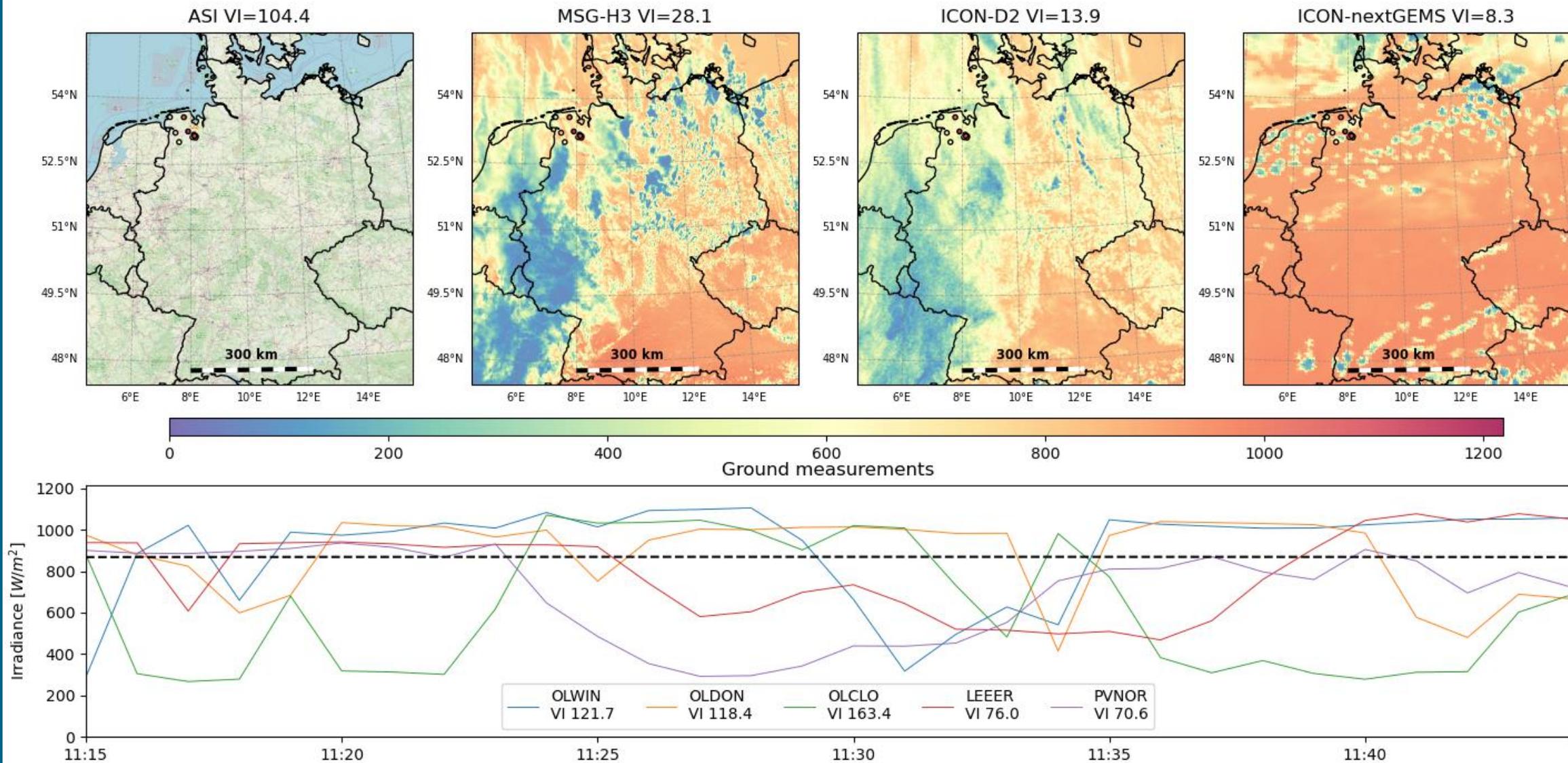


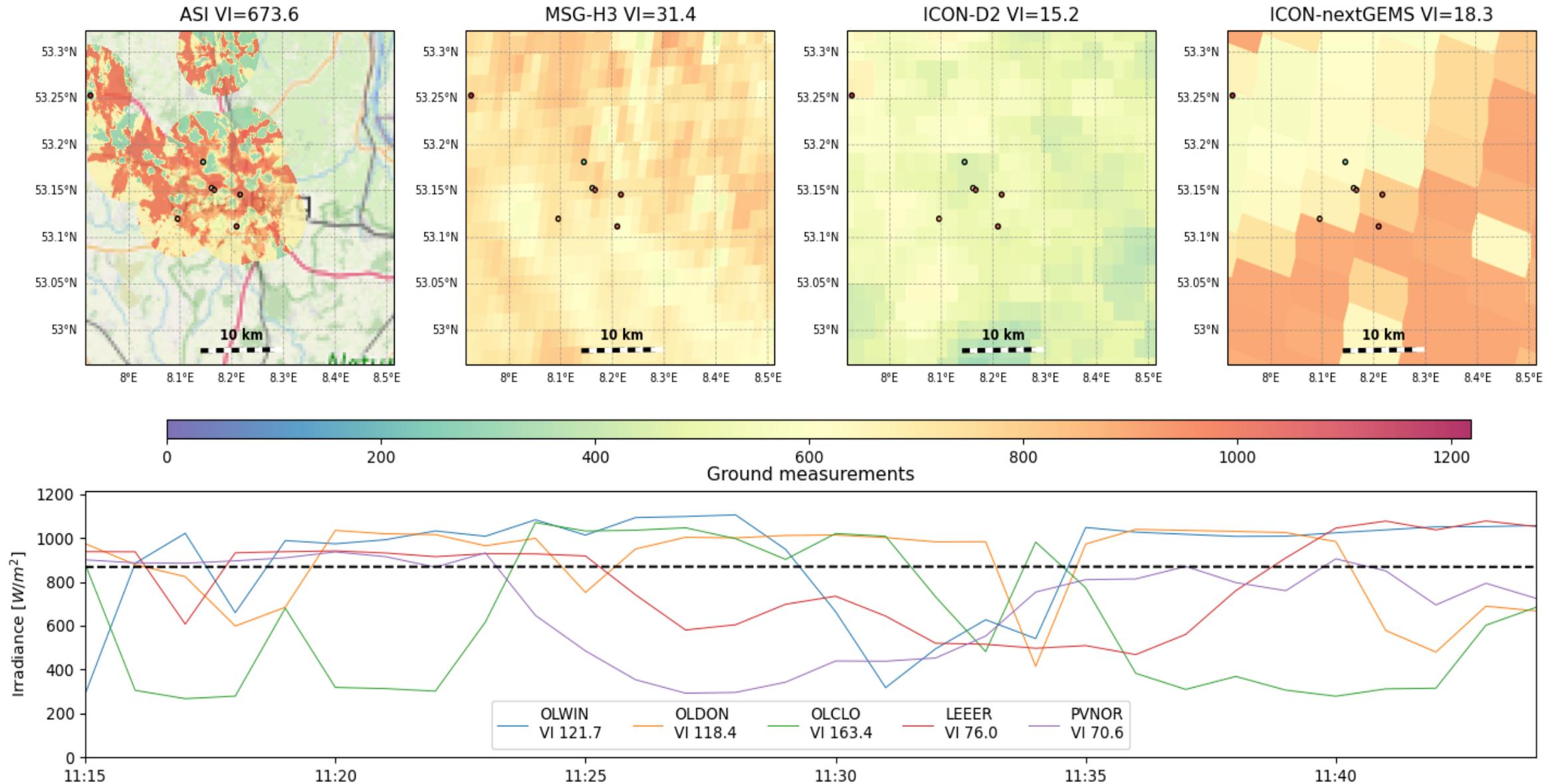
Übertragung auf räumliche Gradienten

$$VI = \sum_{i=2}^N \sqrt{(G_i - G_{i-1})^2 + (t_i - t_{i-1})^2} / \sum_{i=2}^N \sqrt{G_{Ci} - G_{Ci-1})^2 + (t_i - t_{i-1})^2}$$



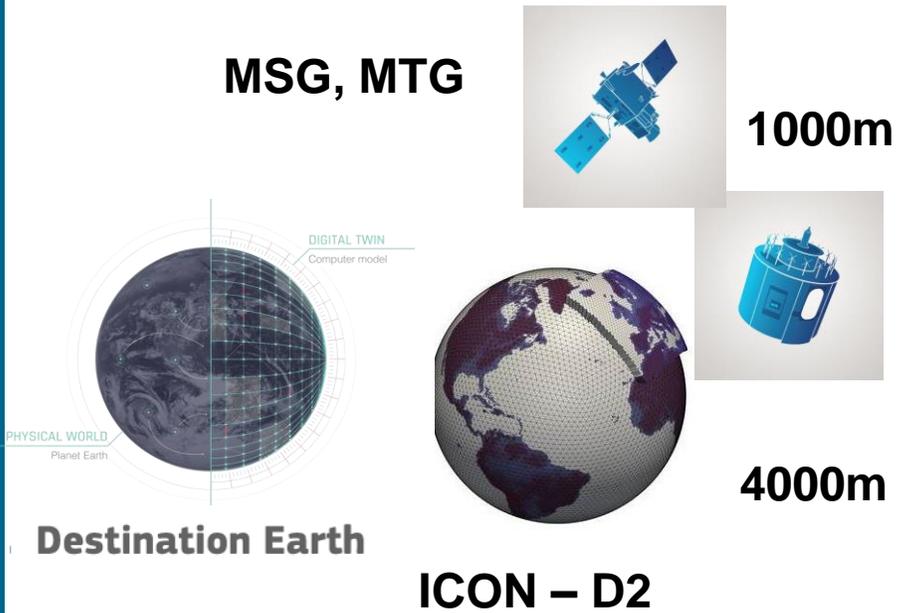
$$VI = \sum_{i=2}^N \sqrt{(G_{x_i} - G_{x_{i-1}})^2 + (x_i - x_{i-1})^2} / \sum_{i=2}^N \sqrt{G_{Cx_i} - G_{Cx_{i-1}})^2 + (x_i - x_{i-1})^2}$$





Reduktion der räumlichen Auflösung

auf Eye2Sky Strahlungskarte

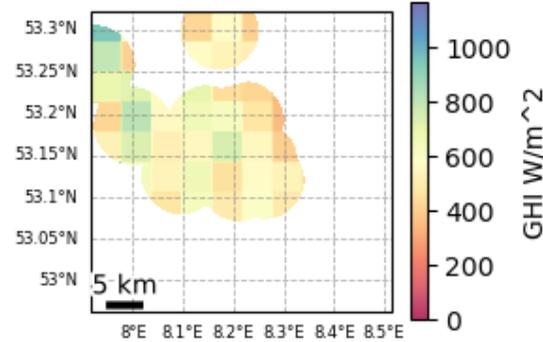
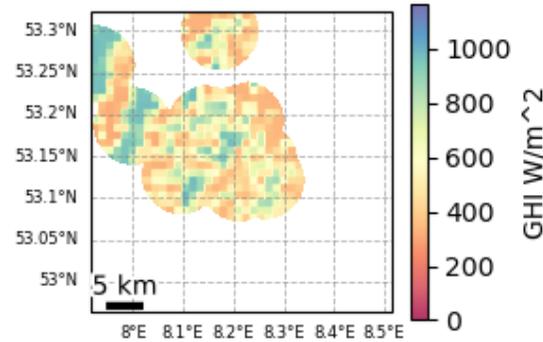
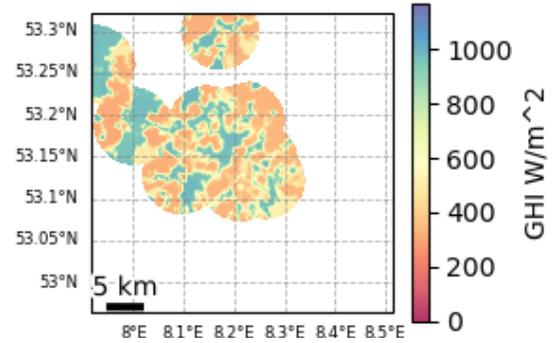


200m

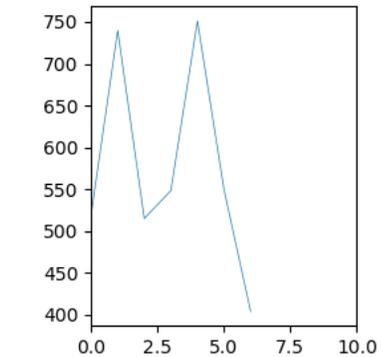
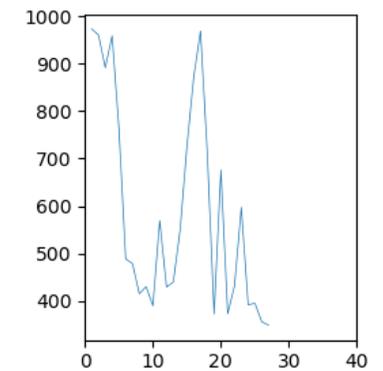
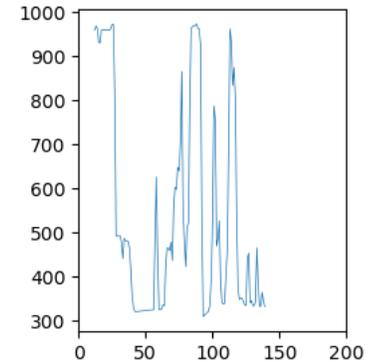
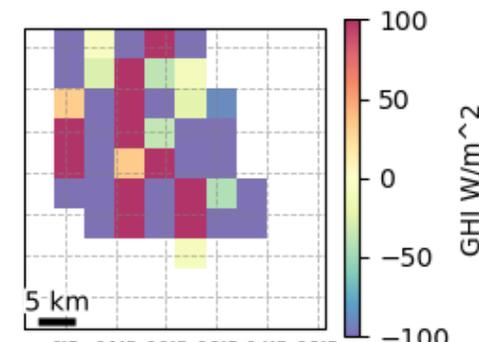
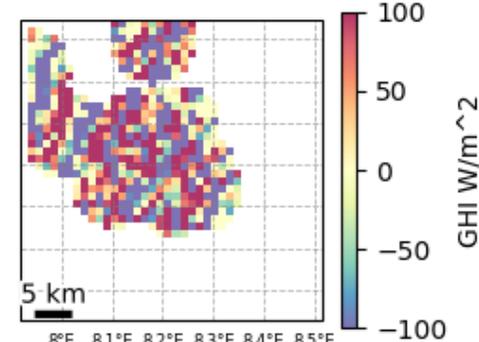
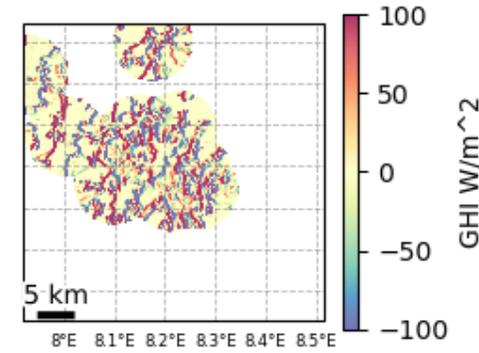
1000m

4000m

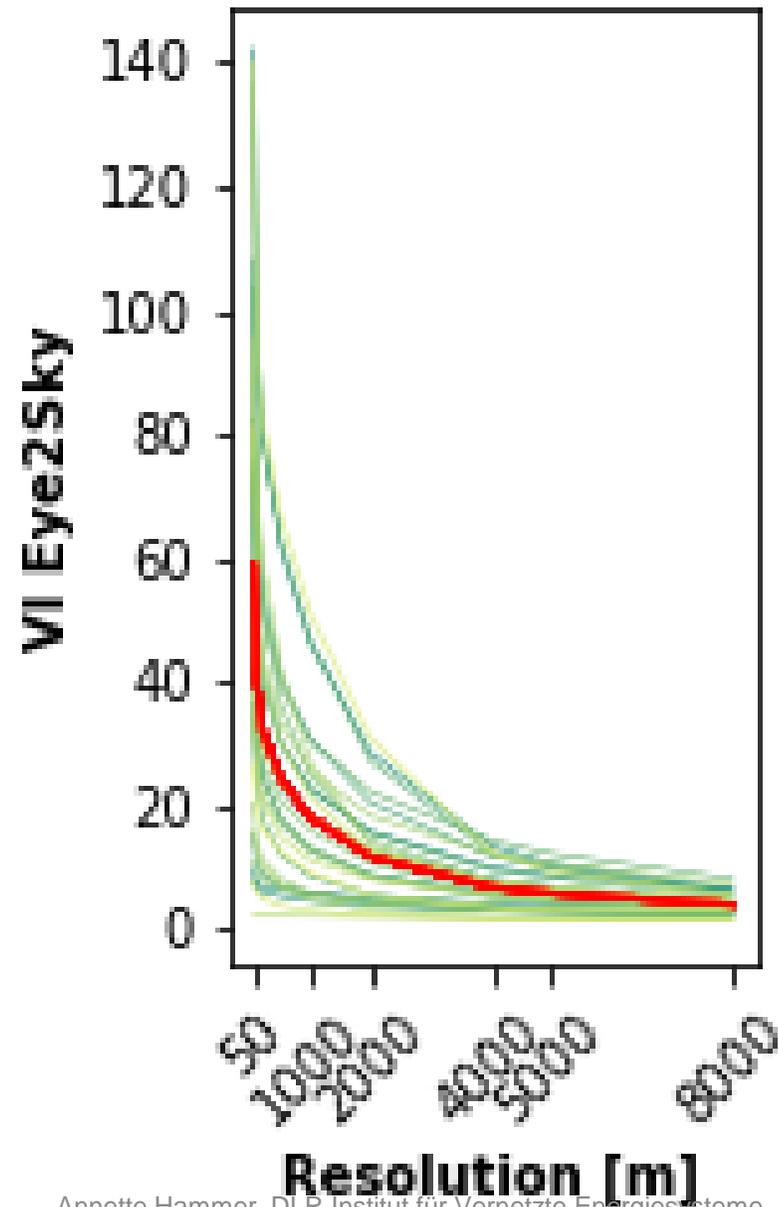
GHI map



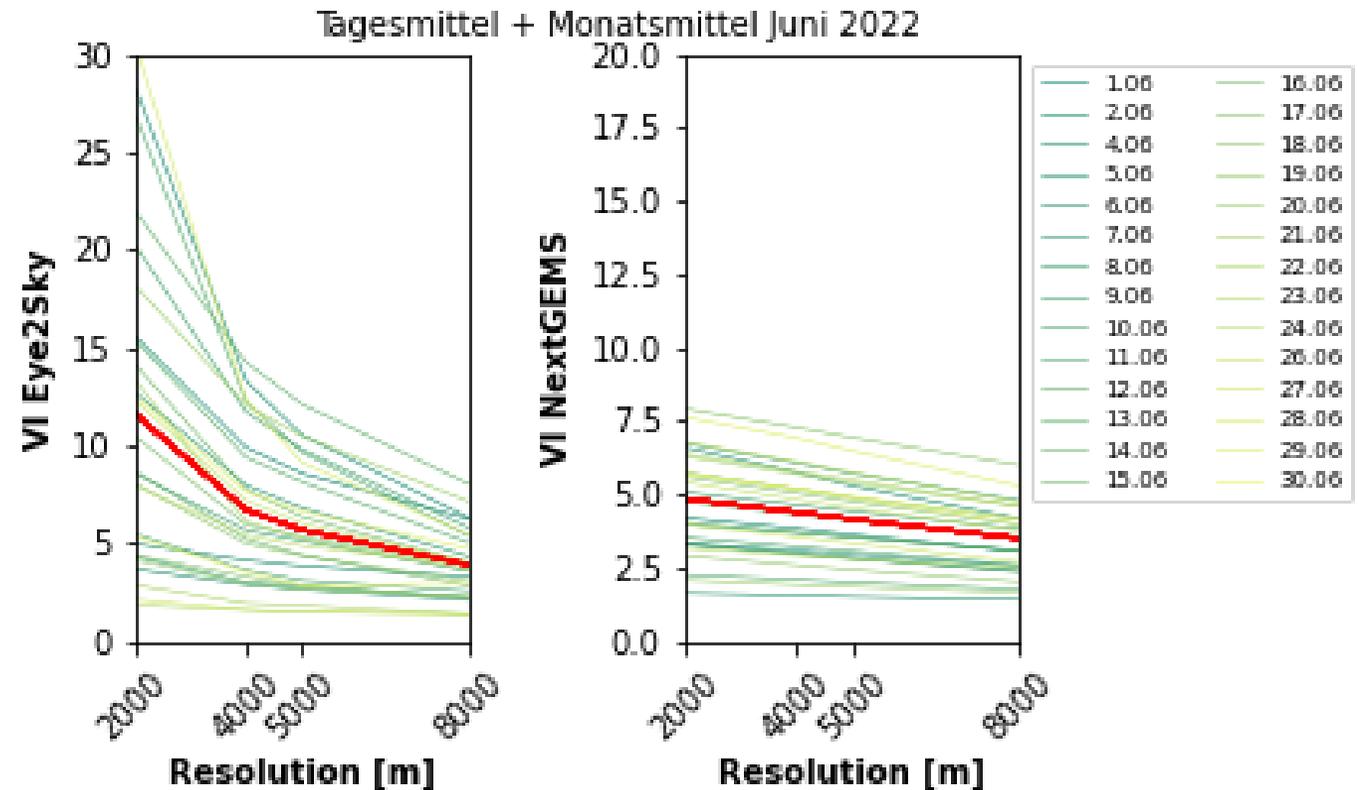
GHI Gradients



Ergebnisse für Juni 2022, Tages- und Monatsmittel



Vergleich Eye2Sky vs. NextGEMS ICON



Zusammenfassung

Vorläufige Ergebnisse



- Eye2Sky Strahlungskarten enthalten Wolkenstrukturen in hoher Auflösung
- Bei Variabilitätsmetrik sollten Gitter, Maßstab, etc. sinnvoll abgestimmt werden
- ICON-D2 zeigt ähnliche Muster wie MSG-Heliosat3 mit geringerer Variabilität
- ICON-NextGEMS Analysen sind begonnen; Ideen hierzu willkommen

Vielen Dank!



Website:

<https://www.dlr.de/ve/en/eye2sky>

Video:

[Portrait of Eye2Sky in 5 Min Video](#)

