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# SCIDOSOL newsletter

## Open science for the solar community

## EDITO

**We are pleased to present the third edition of the SciDoSol newsletter.**

In this issue, we showcase the research conducted under the SciDoSol Chair, highlighting innovative projects that contribute to advancing solar energy knowledge and applications.

**We also feature two recent events:**

- the UNDERSOLAR Project 2025, led by SciDoSol,
- the first Summer Camp organized by Mines Paris – PSL, in which SciDoSol was engaged.

Through our actions, we aim to actively support the scientific community, broaden current knowledge, and create real impact for society, fostering science and innovation that serve a sustainable future.

## On the agenda

### Spotlight on research activities

Update on 6 ongoing projects

### Society and training

- Low-tech UNDERSOLAR Project 2025
- Summer Camp 2025

## Save the date!

**Solar Winter School 2026**

February 16 – 20, 2026

We hope you enjoy this edition and look forward to sharing more news and achievements with you soon.

The SciDoSol team

**Vadim BECQUET**
PhD student

# Convolutional neural networks for the estimation of surface solar irradiance for optimal use of third-generation geostationary meteorological satellites

**This research focuses on improving the estimation of Global Horizontal Irradiance (GHI) using deep learning models that leverage spatial context from multispectral satellite imagery.**

**Reliable Global Horizontal Irradiance data are crucial for:**

- optimizing solar energy systems
- weather forecasting
- climate modeling
- various environmental applications.

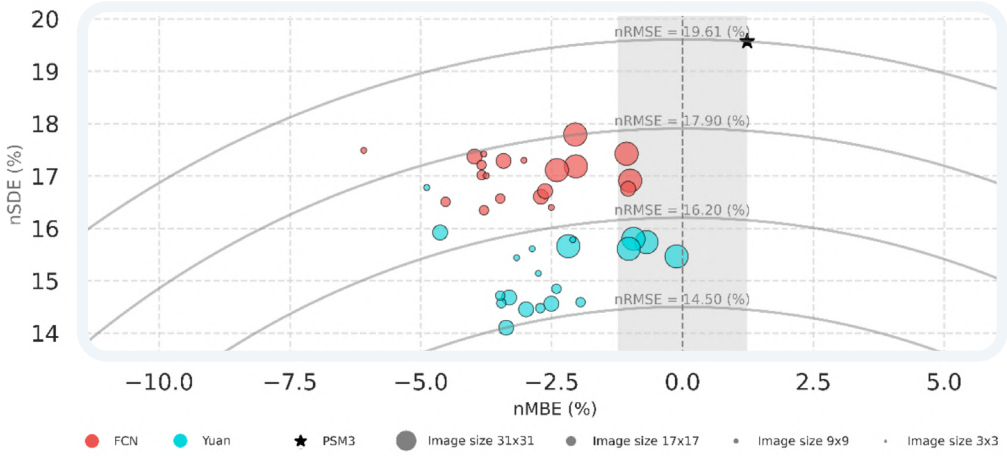
Traditional satellite-based methods face limitations due to their pixel-centric approach, which neglects significant spatial interactions such as 3D cloud effects and horizontal photon transport.

These limitations are expected to be impacted by the increased spatial resolution of third-generation geostationary satellites, which makes such spatial inconsistencies more pronounced.

This research evaluates deep-learning models that explicitly integrate spatial context from GOES-16 satellite images, exploring how image size and network architecture impact the accuracy and generalization of GHI estimations.

**Results indicate significant performance improvements over state-of-the-art physical models, especially under cloudy conditions.**

*Target diagram of models' performances on the test set for different image sizes.*




There are 5 training runs shown for each model and image size.

PSM3 is the state-of-the-art physical model benchmark, FCN is the Fully-Connected model, and Yuan is the Convolutional model.

Vadim's PhD thesis defense is planned by the end of 2025.

A related article, **"Spatial Context Importance in Deep Learning for Global Horizontal Irradiance Estimation from Satellite Imagery"**, was recently submitted for publication to *Solar Energy*.

**Max ARAGÓN CERECEDES**
PhD student

# All sky camera networks for clouds, aerosols, and solar radiation

Detailed characterisation of clouds, aerosols, and radiation requires sophisticated ground-based instruments. Unfortunately, these instruments offer narrow spatial coverage and insufficient data for comprehensive analyses. All-sky imagers, i.e. upward-looking hemispherical cameras offer skydome-level coverage and promise a cost-effective alternative with broader spatial observations.

Moreover, deploying several cameras in a network setup provides enhanced results due to the advantages of multi-view perspectives. The novelty of all-sky camera networks means few public datasets exist for developing multi-camera algorithms.

**This thesis explores the potential of physics-based simulations to generate synthetic all-sky camera networks datasets applicable to real-world scenarios.**

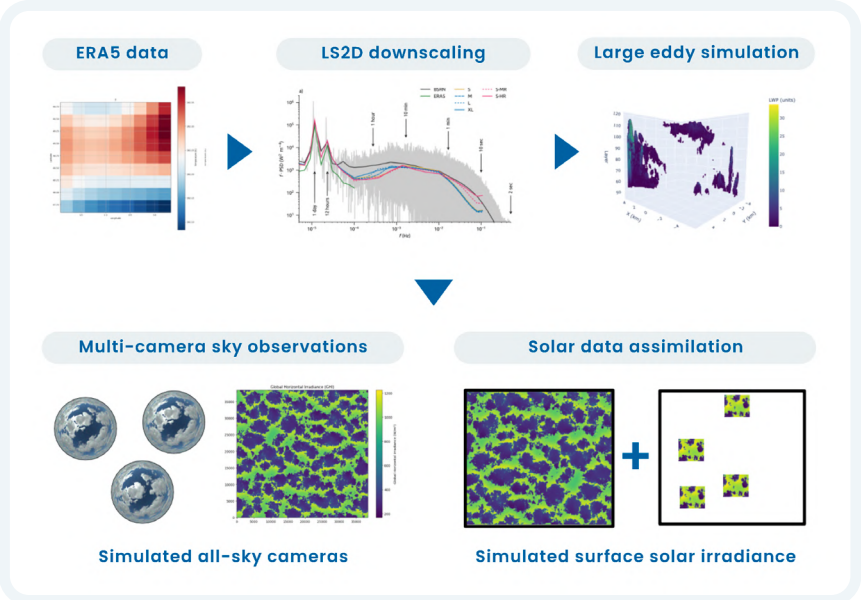
Synthetic-based pre-trained deep learning models are applied to actual all-sky camera networks using simulation-to-reality transfer learning.

This work assesses the impact of enhanced harmonisation, achieved via color and style transfer techniques, when applied to real sky camera networks.

**Applications for this research include:**

- Retrieval of cloud and aerosol properties using several cameras
- Optimal design of camera networks for PV (photovoltaic) parks
- Refinement of solar surface irradiance simulations using all-sky camera networks

*Physics-based framework to produce synthetic datasets for model training and validation*



**Jose GOMEZ GOMEZ**
PhD student

# Surface Solar Irradiance variability characterization and modelling

The intermittent nature of solar energy, driven by cloud cover and atmospheric conditions, presents a significant hurdle for the reliable integration of solar power into the electrical grid.

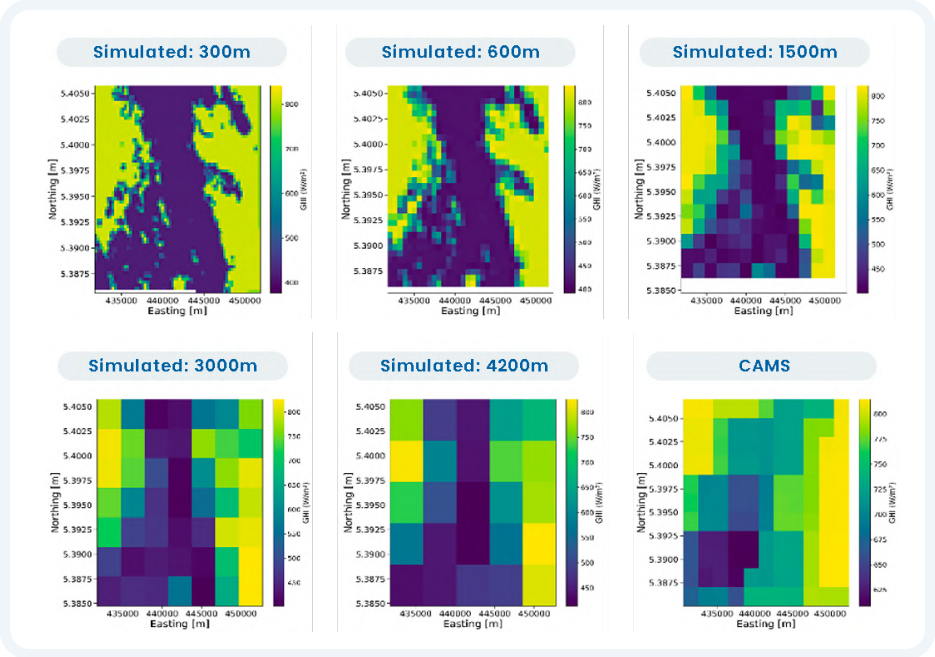
**To describe and model the variability of the Surface Solar Irradiance (SSI), we are developing and validating advanced data-driven methods for downscaling SSI data.**

The objective is to increase the resolution of existing satellite-based irradiance data in 3 key dimensions: temporal, spatial, and spatiotemporal, capturing the dynamic evolution of the solar resource over a specific area. We are developing and applying novel validation metrics to ensure that our models generate realistic irradiance patterns.

**The ability to generate high-resolution, physically plausible SSI data is relevant for the solar energy industry, as it:**

- allows for more accurate forecasting of power plant output on short timescales,
- aids in the optimal design and layout of new solar farms,
- improves the management of grid stability in regions with high solar penetration.

*Multiple resolution view of SSI through Polar orbiting satellite and comparison with CAMS radiation service map*



**Valentin BAUER**
Researcher

# Diffuse Sky Radiance Measurement using a Low-Cost Fish-Eye Camera

State-of-the-art pyranometers and pyrheliometers can precisely measure broadband surface solar irradiance components.

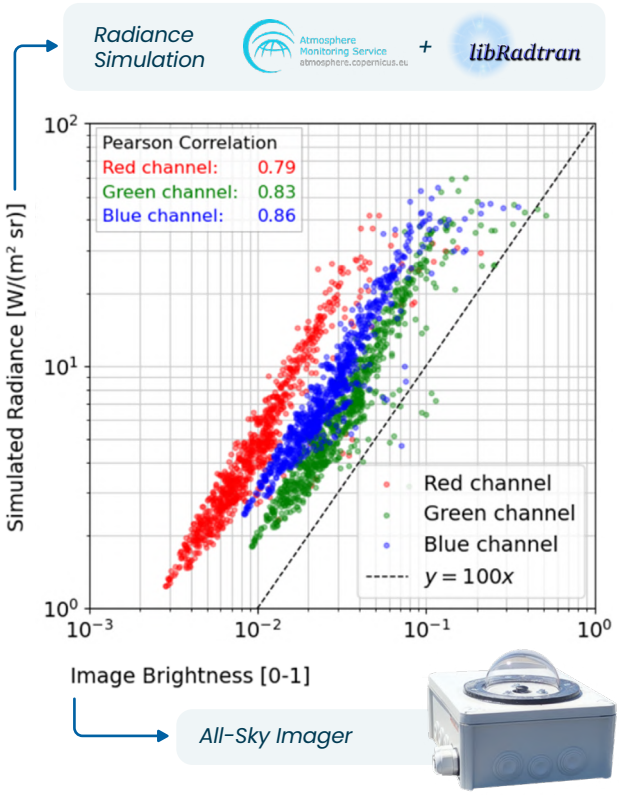
However, their high cost is a barrier to widespread deployment.

Also, characterizing the sky's radiance in greater angular and spectral detail is necessary to improve solar forecasting and atmospheric analysis.

- We designed and assembled a low-cost (approx. 250€) fish-eye camera based on a Raspberry Pi 4, and propose a methodology using open-source software to estimate diffuse sky radiance per pixel in three spectral bands.
- **We showed that measured brightnesses using our prototype relate linearly to the simulated radiance, validating our approach.**
- **This system makes detailed sky radiance measurements affordable.**

**The following actors could benefit from this system:**

- Solar plant operators, able to manage their plant more efficiently, maximizing profitability
- Researchers, equipped to explore new applications in atmospheric science and solar energy
- Companies that provide solar forecasts




***Clear sky measured brightness vs. simulated radiance*** *for camera in Vienna, Austria at 18 time points over two days. Diffuse sky radiance is simulated and measured at fixed points on the celestial hemisphere. Color channels are processed separately.*

**Susanne WEYAND**
PhD student

# FishSPN1: Data fusion of information from a fish-eye camera and a global/direct/diffuse pyranometric sensor with no moving parts

**Solar surface irradiance (SSI) is a key variable for climate change and the renewable energy transition.**

For various applications, the accuracy of the SSI measured by pyranometric sensors is of interest, provided that in-situ sensors are properly maintained and quality-checked.

The spectral and spatial distribution of solar sensor stations is globally low and unevenly distributed. Simultaneous measurements of global horizontal irradiance (GHI), diffuse horizontal irradiance (DHI), and direct normal irradiance (DNI) are even rarer.

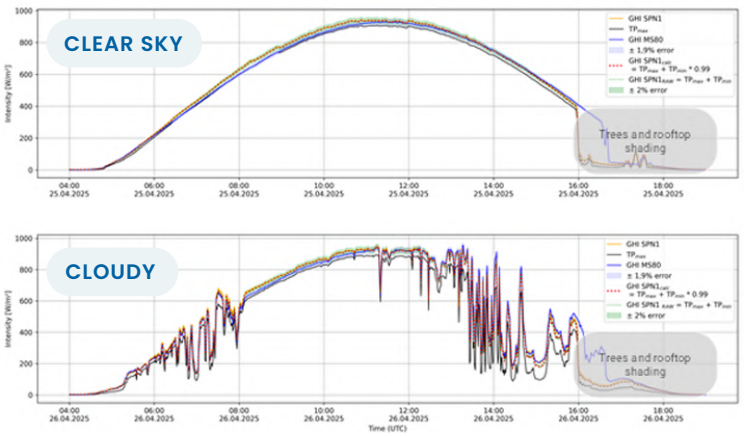
An accurate measurement with less maintenance and error possibility will enhance the availability of TIER 1 stations (which measure simultaneously GHI, DHI, and DNI).

**The SPN1 pyranometer provides the measurements of the three components with no moving parts, and hence less maintenance. However, errors of up to 10% are observed in the diffuse and direct measurements.**

## This work focuses on reducing SPN1 errors by combining the measurements with All Sky Imager camera data.

*Current efforts focus on the quality control of the EKO and SPN1 pyranometers measurements and identification of error sources.*

*GHI SPN1 vs EKO MS80 measurement for clear sky and cloudy days*




**Improved solar station measurements will benefit:**

- the international solar community
- grid operators
- renewable energy planners and maintainers
- weather forecasting services
- service companies providing intra-day forecasts for grid operators

**Susanne is starting cooperations with the SPN1 developer and service companies providing intra-day forecasts for grid operators like Solaïs/CalibSun.**

**Yehia EISSA, Yves-Marie SAINT-DRENAN, Philippe BLANC**
Senior scientists

**The downwelling surface solar irradiance is a main variable in:**

- the integration of solar energy systems in electricity grids,
- climate and weather studies.

# Impact of circumsolar irradiance and aerosol optical depth on CAMS surface solar irradiance estimates

**The McClear clear-sky model** is commonly used by the solar community to retrieve clear-sky irradiances. It is a physical model utilizing information on aerosol optical properties, water vapor, ozone, solar geometry, vertical profiles of atmosphere, site elevation and ground albedo. The model provides very accurate global horizontal irradiance estimates with negligible bias.

**Albeit still good, the beam and diffuse horizontal irradiance estimates exhibit biases** mainly due to the aerosol optical depth used as input to McClear and the forward scattered circumsolar irradiance surrounding the solar disc, which is not modelled by McClear but intercepted within the solid angle aperture of radiometers measuring beam irradiance (and blocked by those measuring diffuse irradiance).

## In this study, the influences of the circumsolar irradiance and aerosol optical depth on McClear estimates are evaluated.

A circumsolar correction method developed originally for desert regions is tested for its applicability in all regions. Analysis reveals that accounting for circumsolar irradiance improves retrievals, and more emphasis needs to be placed on accuracy of the aerosol optical depth used as an input to further improve the clear-sky retrievals of McClear.

*Forward-scattered circumsolar irradiance is blocked to a large extent from diffuse irradiance measurements but included in their radiative transfer simulations.*

◀ The shaded EKO-MS80 Pyranometer mounted on the EKO STR-21G Sun Tracker for diffuse horizontal irradiance measurements

SOCIETY AND TRAINING

# LOW-TECH UNDERSOLAR PROJECT 2025


**Led by SciDoSol, UNDERSOLAR is an engineering project for second-year students in the Civil Engineering Program.**

With the support of TotalEnergies, the project resulted in close collaboration with L'INDUSTREET, a training center for emerging industrial professions.

This unique cooperation brought together engineering students and future technicians to explore solar concentration technologies and low-tech approaches, in partnership with the company Lytefire.

## Future engineers and technicians team up for solar innovation

The 2025 edition, held from March to May on the Sophia Antipolis campus, showcased creativity, technical skills, and a commitment to sustainable solutions.

**Participants designed and built two prototypes of innovative solar systems:**

- a double-reflection parabolic oven, featuring a precise arrangement of mirrors,
- a Fresnel lens oven combined with a flat reflector to maximize heat concentration.

The performance of these devices was successfully validated with the help of a professional chef.

**A concrete demonstration of the potential of solar-powered cooking.**

# SUMMER CAMP 2025

**MINES Paris – PSL organized its first all-female Summer Camp** from August 19 to 28 on its Pierre Laffitte Campus in Sophia Antipolis.

**30 young women**, ages 14 to 17, from 9th to 11th grade* – called "Summer Campeuses" during the program – took part in the summer camp this year.

** troisième" to "première" in French school system*

This initiative was made possible with the support of our dedicated partners, Petroineos and RTE, who share our belief: it is essential to inspire vocations from an early age by offering all young women the same opportunities to explore and succeed.

The program also reflects our ambition to develop **new training courses focused on sustainable development** on the Pierre Laffitte Campus, including the I-BE3 Bachelor of Engineering, which will launch in September 2026.

During this Summer Camp, in addition to visits and meetings with inspiring women scientists, participants were invited to choose one of three workshops at the beginning of their stay, to be carried out in teams of ten over eight half-days:

- a textile recycling workshop
- a workshop on data science for decarbonization
- or a solar oven workshop

**The solar oven workshop, a variation of the UNDERSOLAR project, was supported and organized by SciDoSol.**

This educational, experimental, and bilingual (French/English) project aims to provide a hands-on demonstration of solar energy conversion into:

- **electrical energy:** building a photovoltaic USB charger based on a comprehensive educational resource by *Planète Énergie* (TotalEnergies Foundation)
- **thermal energy:** low-tech construction of two solar ovens followed by experimentation.

This project was accompanied by a series of introductory courses on the solar system, the topocentric position of the Sun, the basics of solar radiation and meteorology, as well as the challenges related to solar energy as a resource.

*Project design and supervision: Ms. Susanne Weyand, PhD student at SciDoSol and Ms. Candice Barnes, PhD student at the O.I.E. (Observation, Impacts, Energy) center.*

# SOLAR WINTER SCHOOL 2026

## SAVE THE DATE!

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In Sophia Antipolis,
on the week of
**February 16 – 20, 2026**

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