PhD position “GeoFishEye”

Network of low-cost sky-imagers for the characterization of solar surface radiation

About the position

Context and challenges

The characterization and forecasting of solar radiation is critical for various fields, including meteorology, climate science, and solar energy applications. Alongside numerical weather models (NWP), satellites, and pyranometers, all-sky imagers (ASIs) are of great interest because they have the potential to accurately capture temporal variabilities of important characteristics of the solar radiation reaching the surface of the Earth. They indeed provide estimations at a higher resolution than NWP or satellites and yet cover a significantly larger geographical area than pin-point measurements provided by pyranometers. Additionally, while NWP, satellites, and pyranometers summarize the solar radiation with at best two components – a diffuse and a direct irradiance, sky imagers can be a good proxy for the angular distribution of the solar downwelling radiance. Moreover, sky imagers can be used to infer more than just characteristics of solar radiation; they are for example useful to estimate the Aerosol Optical Depth (AOD), at least during clear-sky moments, or to estimate the fraction and the nature of the cloud coverage. Lastly, images from multiple ASI can be combined to estimate the position and movement of clouds.

This latter feature is very promising for the field of solar surface irradiance forecasting, as it has the potential to anticipate complex cloud movements at high resolution. However, while several algorithms have been proposed to extract cloud location and speed from multiple ASI, it remains an active domain of research. Furthermore, most commercially available ASIs are high-quality sensors and are thus relatively expensive. This limits their potential for a large deployment, in particular in networks.

This thesis’s aim is to propose novel algorithms to exploit multiple all-sky imagers jointly for three-dimensional cloud reconstruction, and to study the potential of low-cost devices to be used in that configuration.

Scientific Objectives & Methodology

The first objective of this project is to develop specialized algorithms that can effectively utilize data from multiple ASIs, located close to one another, to accurately estimate the distribution of solar radiation and the actual location of elevation of clouds. The PhD candidate will be responsible for implementing and comparing various approaches to tackle this challenge. One potential method involves first identifying and pinpointing the location of clouds based on geometrical considerations and stereoscopic techniques, followed by utilizing radiative transfer models to deduce the distribution of radiation from these clouds. An alternative approach is to employ deep-learning methods that have demonstrated promising results in merging several cloud images and computer vision (e.g. scene flow estimation). To use this technique, ground truth data would be necessary, and the candidate could leverage existing networks of sky imagers coupled with a pyranometer to obtain this information.

The second objective of this thesis is to study the impact of low-cost sky-imagers on the proposed algorithms' performance. This part could be done as a simulation study, but the PhD candidate will also have the opportunity to design and build low-cost ASIs to be deployed as a network for a location of interest.

About SCIDOSOL

The PhD thesis is funded by the SciDoSol chair at Mines Paris - PSL. The SciDoSol chair – "Sciences de la Donnée appliquées à l'énergie Solaire", or "Data science for solar energy" – has been launched in 2022 for 5 years and aims to tackle various challenges of the energy transition related to the characterization, forecasting, and exploitation of the solar resource. To reach its goals, the chair intends to leverage the large volume of data provided by Earth observation in combination with state-of-the-art data-science techniques.
The PhD candidate will be located at Campus Pierre Laffitte in Sophia Antipolis (France), within the OIE (Observation, Impacts, Energy) center of Mines Paris – PSL.

Pre-requisite:

The candidate must hold an Engineering degree or a Master of Science. He/she should have a solid scientific culture and excellent analytical skills. Prior knowledge or strong interest in remote sensing, atmospheric science, applied mathematics, and image treatment are expected.

The candidate must demonstrate good programming skills; while not strictly required, a good knowledge of Python is preferred. Prior experience with deep learning is not necessary but would be appreciated.

Proficiency in English – scientific writing in particular – is required; French is not required but would be beneficial.

Practical information

Application: To candidate, please send the following documents to hadrien.verbois@minesparis.psl.eu (cc: yves-marie.saint-drenan@minesparis.psl.eu and philippe.blanc@minesparis.psl.eu):

- A detailed CV
- A letter of motivation
- 2 letters of recommendation

Note that the letter of motivation will be used to assess the candidate's scientific project and scientific writing.

If you have any questions regarding the position, please contact hadrien.verbois@minesparis.psl.eu.

Workplace: Sophia Antipolis

Net Monthly Salary: 2100€