

PMOD/WRC Semester and MSc projects 2026/2027



Introduction

The Physikalisch-Meteorologisches Observatorium Davos/World Radiation Center (PMOD/WRC) was formed in 1907 and is based in Davos. PMOD/WRC has six key areas that will be further developed in the coming years. These are:

- World Radiation Center: serve as an international calibration center for meteorological radiation instruments and develop radiation instruments for use on the ground and in space.
- Space projects: develop instruments for imaging and radiation measurements of the Sun.
- Technology: underpin the design and development of the instruments for ground and space.
- Climate science: research the Earth's ozone layer and climate evolution
- Solar Science: research the causes of solar activity.
- Teaching: carry out teaching at different levels at ETH-Zürich.

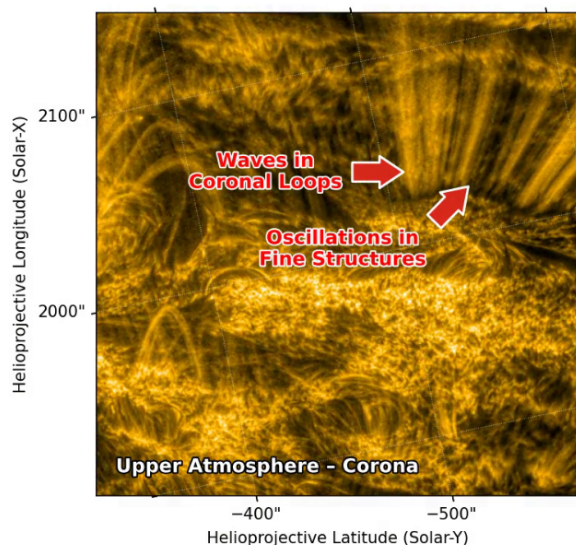
There are MSc projects available that are described below. Please contact the lead supervisor if you require more information. The topics available are wide-ranging, covering solar physics, climate modelling and instrumentation for both ground and space measurements.

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Investigating Waves and Oscillations in the Solar Atmosphere

Background: The outer atmosphere of the Sun is filled with waves and oscillations. Many of these are thought to originate from sound waves generated in the solar interior and travel upward. These wave patterns can be observed in a wide range of structures, from fine jet-like structures to a few megameters in size to large loop-like structures that extend tens to hundreds of megameters in the outermost layer of the Sun, known as the solar corona. Waves in different structures may interact with each other and could play important roles in transporting energy and material into the corona. This process is closely related to the two major questions in solar physics: why the corona is extremely hot and how the solar wind (a continuous flow of charged particles released from the Sun) is generated.

Project: The project aims to compare the characteristics of oscillations in different structures across the solar atmosphere. In particular, we focus on oscillations in: 1. Dynamic fibrils: jet-like fine structures in the lower atmosphere; 2. Coronal loops: large structures extending into the corona. The student will analyze the wave patterns in an imaging sequence from the Extreme Ultraviolet Imager on board the ESA Solar Orbiter space mission (see the preview video below).



([Click to view the movie](#)): Extreme Ultraviolet Imager data showing the oscillating fine structures in the lower atmosphere and propagating wave patterns in the coronal loops above a sunspot.

Key Questions: 1. How do the key properties like periods, wave speeds, and phase shifts vary between the oscillations in lower-lying fine structures and the extending coronal loops? 2. Are waves in different layers of the solar atmosphere connected or coupled?

Skills or knowledge required for the project: Interests in solar physics data analysis, basic programming skills (preferably Python)

Workplace: ETH Zürich or PMOD/WRC Davos

Supervisors: Prof. Louise Harra louise.harra@pmodwrc.ch (ETH, PMOD/WRC), Dr. Yingjie Zhu yingjie.zhu@pmodwrc.ch (ETH), Dr. Krzysztof Barczynski (PMOD/WRC) krzysztof.barczynski@pmodwrc.ch

Analysis of solid particle injection strategies for geoengineering

Background:

Stratospheric aerosol injection (SAI) is one of the most widely discussed scenarios for potential future solar radiation modification to counteract climate change. The traditionally considered sulfur-based SAI approach has side effects, such as stratospheric ozone depletion and absorption of terrestrial radiation, which has important implications for large-scale atmospheric circulation and regional climate. Using different injection locations, amounts, and timing these side effects can be somewhat reduced. In recent years, less absorptive materials have been suggested as an alternative to sulfate, such as calcite and diamond dust. However, all research on solid particle injections has been so far just repeating the default injection schemes of SO₂, and there were no experiments to identify their optimal injection strategies, while the behavior of solid particles in the atmosphere has significant differences compared to sulphate aerosols.

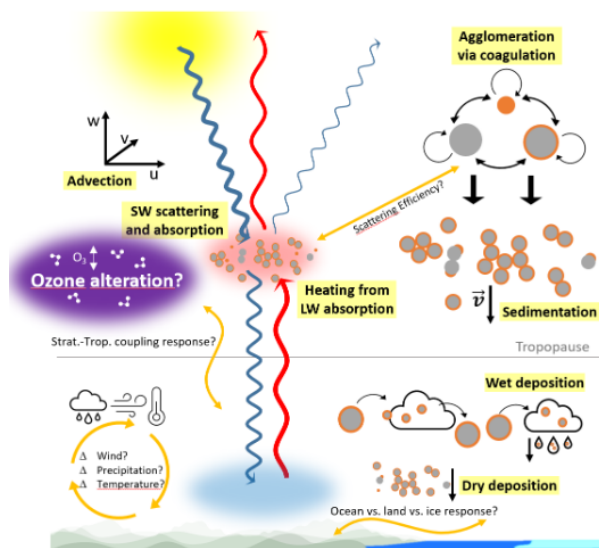


Figure 1: Schematic illustration of the processes involved in the SAI (left) and Aerosol Optical Depth from the sulfur experiments with different injection locations (Henry et al., 2022).

Key question: What is the optimal SAI strategy for non-absorptive materials?

The project: Analyse different simulations with a global chemistry-aerosol circulation model (SOCOL) where several injection scenarios are applied for various SAI materials. The focus will be on analyzing changes in physical quantities such as temperature, precipitation, winds, etc.

Skills or knowledge required for the project:

Strong interest in atmospheric sciences, data analysis, and some experience with programming languages (Python, Matlab, Bash, etc).

Workplace: ETH D-PHYS, possibly PMOD/WRC Davos

Supervisors: Dr. Jan Sedlacek jan.sedlacek@pmodwrc.ch (PMOD/WRC), Dr. Timofei Sukhodolov Timofei.Sukhodolov@pmodwrc.ch (PMOD/WRC)

Investigating Beryllium-10 deposition under different climate states

Background:

Beryllium-10 (^{10}Be) is a cosmogenic isotope produced in the atmosphere. Its production rate is modulated by solar magnetic field, hence ^{10}Be records can be used as a proxy for past solar activity, including both slow cyclical changes and fast solar eruptive events. Records can be derived thousands of years back, e.g. from Antarctic ice cores. However, they need to be interpreted in the context of their formation; ^{10}Be is mainly produced in the stratosphere and subsequently transported to the surface via various atmospheric transport pathways. The characteristics of large-scale atmospheric transport have changed over time, as the climate changed. Glacial climates, for instance, feature different meridional temperature gradients and altered atmospheric circulation. Therefore, a stronger or weaker “polar bias” is hypothesized for ^{10}Be deposition during different epochs.

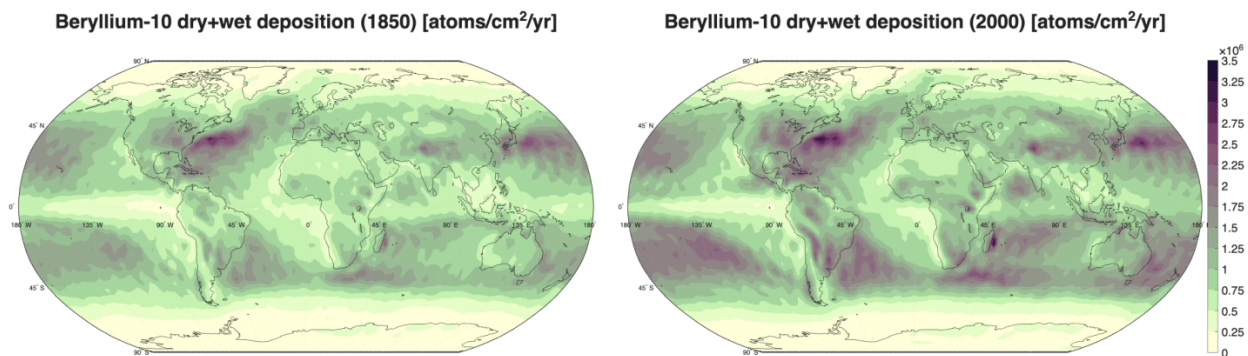


Figure 1: Beryllium-10 total deposition maps for the early-industrial and near-current day climate states. There are differences in magnitude, but no jarring differences in patterns for these two similar climate states. The anomalies between climate states that are much farther apart in time and represent glacial versus interglacial climates will be much larger and more complex.

Key question: How did Beryllium-10 deposition change under changing climatic conditions?

The project: Analyze different simulations to explore how ^{10}Be transport and deposition changed under different climatic states by employing the global aerosol-climate model (SOCOL). Climate states from the Last Glaciation, through the Deglaciation, and into the Holocene will be simulated, by forcing the model with adequate boundary conditions. The focus will be on analyzing changes in physical quantities such as temperature, precipitation, winds, etc.

Skills or knowledge required for the project: Strong interest in atmospheric sciences, data analysis, and some experience with programming languages (Python, Matlab, Bash, etc).

Workplace: ETH D-PHYS, possibly PMOD/WRC Davos

Supervisors: Andrin Jörimann andrin.joerimann@pmodwrc.ch (PMOD/WRC), Dr. Timofei Sukhodolov Timofei.Sukhodolov@pmodwrc.ch (PMOD/WRC)

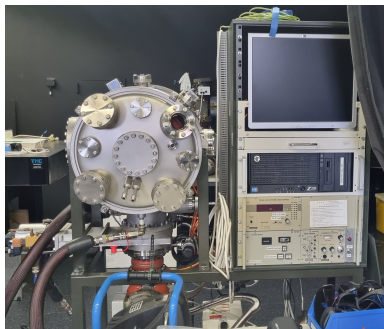
Refurbishment, Upgrade, and Commissioning of an Outgassing Test Facility in Compliance with ECSS Standards

Background: Outgassing properties of materials are critical for space applications, as released volatile compounds can condense on sensitive surfaces and degrade mission performance. The European Space Agency defines strict requirements for material selection and testing under the ECSS-Q-ST-70-02 standard.

An existing outgassing test facility is available but currently non-operational and not compliant with modern state-of-the-art practices. The system requires technical refurbishment, modernization, and validation before it can be used for reliable material qualification.

Key questions:

- What gaps exist between the current system and ECSS requirements?
- Which upgrades are necessary to achieve a state-of-the-art, compliant test facility?
- How can the system performance be validated reliably?
- How should a standardized, ECSS-compliant outgassing test procedure be defined?



The Project:

The objective of this thesis is to restore, upgrade, and commission the outgassing test stand according to ECSS requirements, and to develop a standardized, fully documented test procedure for future use.

Required Qualifications:

- Background in Mechanical Engineering, Aerospace Engineering, Physics, or related field
- Basic knowledge of vacuum technology and thermal

systems

- Interest in space standards (ECSS) and material testing
- Hands-on mentality and structured working style

Preferred Skills:

- Experience with vacuum systems or laboratory instrumentation
- Familiarity with contamination control or materials engineering
- Programming/data acquisition skills (e.g. Python, MATLAB)

Workplace: mostly at PMOD/WRC, but also occasionally at ETH.

Supervisors: Daniel Pfiffner d.pfiffner@pmodwrc.ch (PMOD/WRC), Valeria Büchel valeria.buechel@pmodwrc.ch (PMOD/WRC)

How well can we forecast aerosols for solar applications ?

Background:

Aerosols are particles in the atmosphere attenuating solar radiation. There are global networks that measure aerosol optical depth which is the parameter that can be used for such effects. For solar energy applications what is needed is to know the amount of solar radiation during the next days so to maximize efficiency on using, storing or selling solar based power to the energy market. There are models (e.g. CAMS) that forecast aerosol optical depth (AOD) and can be used for such applications. Evaluating these forecasts and estimating the discrepancies effect on solar radiation is crucial for understanding the uncertainties associated with solar forecasting.

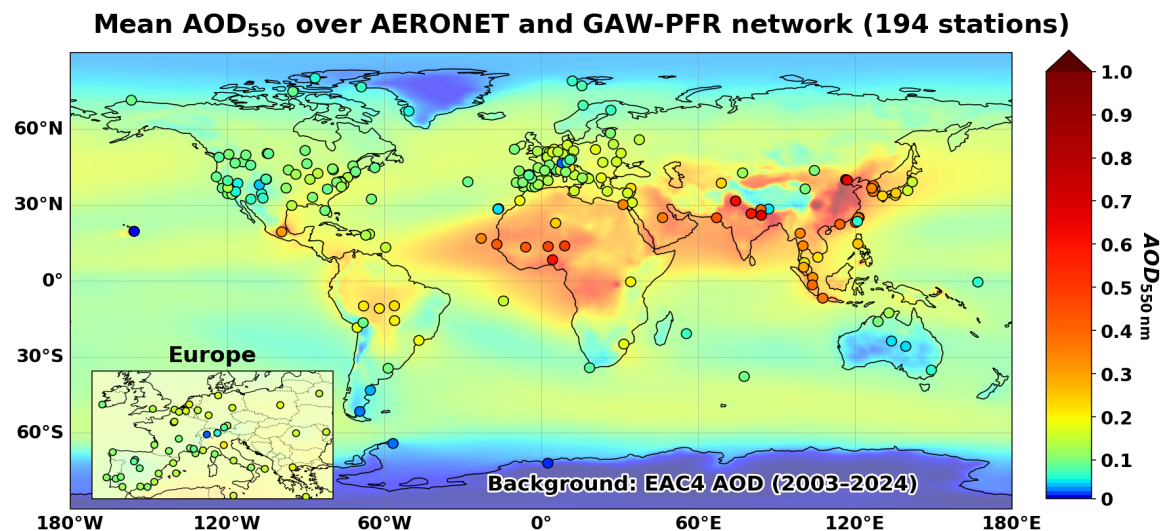


Figure: Total global aerosol optical depth from CAMS model (2003-2024 in the background) and ground-based measurements.

Key question: How well models like the Copernicus Atmosphere Monitoring Service can forecast aerosol optical depth and what is the effect of relevant discrepancies to solar radiation forecasting ?

The Project: Analysis of existing ground based and model aerosol data on a global scale. Use of radiative transfer models to understand the impact on solar radiation.

Skills or knowledge required for the project: Moderate programming skills, analysis of relatively large data series. Knowledge of basic aerosol – radiation interactions.

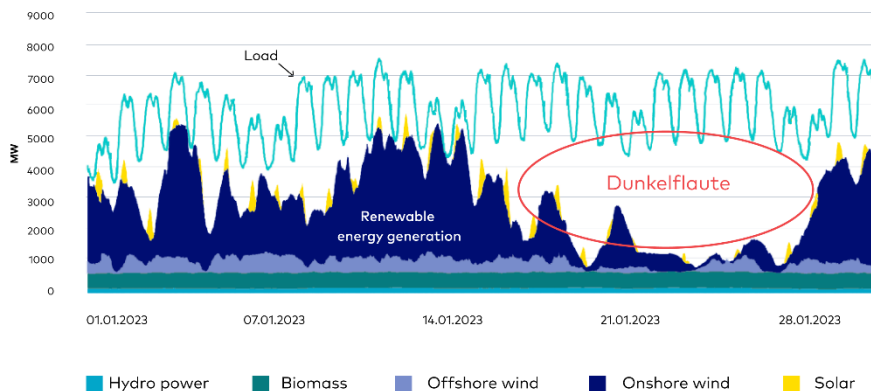
Workplace: PMOD/WRC Davos or ETH Zurich

Supervisors: Stelios.kazadzis@pmodwrc.ch, anna.moustaka@pmodwrc.ch

Solar Energy Droughts identification methods

Background: Prolonged shortages in solar energy (solar energy droughts) due to extreme climate conditions (prolonged cloudiness, aerosol episodes), are underrepresented in operational tools and policies. Forecasts rely on historical climate data and medium-range weather models focusing on solar energy. Despite the growing risk of low-generation periods, solar drought forecasts remain rare and tools lack the use of earth observation and fine spatial and temporal resolution at scale. Solar droughts or “*Dunkelflaute*” is a phenomenon that can occur mostly in late autumn or during the winter months for several days or weeks due to increasingly cloudy skies and also during

Dunkelflaute in Germany in January 2023



intense aerosol (dust mainly) events. This can lead to a decrease in the overall contribution of renewable energy to the electricity grid, posing challenges for maintaining a stable and reliable energy supply for an energy system that is powered solely by renewable resources.

Taken from: <https://www.gridx.ai/knowledge/what-is-dunkelflaute>

Key question: Could past and forecast projections of solar and solar power data be used for identifying solar energy drought patterns ?

The Project: Analysis of past and future solar related datasets and other atmospheric datasets and use of statistical methods to identify solar droughts.

Skills or knowledge required for the project: Data analysis , programming

Workplace: PMOD/WRC Davos or ETH Zurich

Supervisors: stelios.kazadzis@pmodwrc.ch, kyriaki.papachr@pmodwrc.ch

Linking surface based and total column aerosol observations in different altitude areas

Background: Atmospheric aerosols remain one of the largest sources of uncertainty in climate research due to their complex interactions with radiation and clouds. While in situ measurements of aerosol scattering and absorption provide highly resolved insights into particle properties and local processes, they do not directly capture the full atmospheric column. Conversely, column-integrated observations such as aerosol optical depth (AOD), routinely obtained through networks like GAW PFR, offer a comprehensive view of the total aerosol load but lack vertical specificity. Bridging these complementary measurement approaches represents a key scientific challenge and an exciting opportunity to advance our understanding of aerosol radiative effects and improve the interpretation of both ground-based and satellite observations.

This MSc project leverages the unique observational contrast between the high-alpine station at Jungfraujoch and the lower-altitude site of Payerne to explore aerosol properties across different atmospheric regimes. Jungfraujoch frequently samples free-tropospheric air masses, while Payerne is more strongly influenced by boundary layer dynamics and regional emissions. Methods including machine learning techniques could be used on linking in situ scattering and absorption measurements with columnar AOD observations at these sites. The project aims to provide new insights into aerosol vertical distribution, variability, and representativeness



Jungfraujoch observatory and AOD observations

Key question: The central scientific question of this project is whether physical or machine learning techniques can be used to robustly link in situ aerosol scattering and absorption measurements with column-integrated aerosol optical depth

(AOD) observations, in order to better constrain aerosol vertical distribution and improve the representativeness of surface-based measurements.

The Project: Using long term measurements of scattering, absorption in situ and AOD data for two Swiss sites (Jungfraujoch and Payerne). Use physical and ML methods to investigate links.

Skills or knowledge required for the project: Basic use of ML techniques and understanding of aerosol properties

Workplace: PMOD/WRC Davos or ETH Zurich

Supervisors: stelios.kazadzis@pmodwrc.ch in collaboration with MeteoSwiss

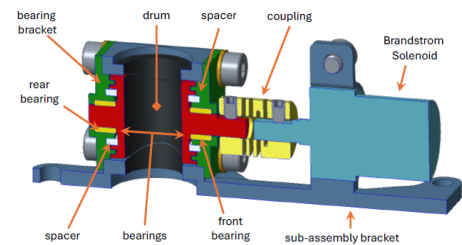
ECSS-Compliant Design and Optimization of Solenoid-Driven Shutter Mechanisms for the M-SoSpIM Instrument (ESA M-MATISSE)

Background:

The ESA M-MATISSE mission aims to unravel the complex coupling between the Martian plasma system and the solar wind. A key instrument in this endeavor is M-SoSpIM (Mars Solar Spectrometer and Irradiance Monitor), designed to measure solar irradiance. To protect the sensors and enable dark current calibration, the instrument utilizes 6 mechanical shutters. These components must operate with high reliability under space conditions throughout the lifetime.

Key question:

According to ECSS standards, all space mechanisms must demonstrate a positive Motor Margin. This ensures that the motor's available torque – under worst-case scenarios – exceeds the required load torque by a specific safety factor. Finding the "Sweet Spot" between thermal, electrical and mechanical considerations is a critical engineering task.



The Project:

The student will be responsible for the analytical verification and optimization of the shutter drive trains. Key tasks include:

- Load Modeling: Calculating static and dynamic loads, including bearing friction, spring preloads, and moments of inertia. Analytical tools and existing test data can be used.
- Motor Characterization: Measuring torque-voltage curves relative to adjustable voltage pulse duration and winding resistance. A basic test setup exists.
- Thermal & Mechanical Analysis: Assessing the impact of changing the input voltage profile (pulse length) on torque output as well as thermal behavior.
- Margin Calculation per ECSS: Performing the formal torque margin verification
- Design Optimization: Developing trade-offs to optimize performance (e.g. adjusting supply voltage, refining voltage pulse, or selecting alternative motor winding properties)

Skills or knowledge required for the project:

Background in mechanical, thermal, and electrical engineering. Analytical mindset with an interest in space industry standards (ECSS).

Workplace: PMOD/WRC Davos or ETH Zurich

Supervisors: Stefan Wismer (ETH Zürich | Space), Daniel Pfiffner (PMOD)

EarthCARE radiative closure experiments using Surface-Based spectral UV measurements

Background:

The EarthCARE satellite mission, a joint initiative by the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA), aims to improve our understanding of clouds, aerosols, and the Earth's radiation balance. Of particular importance are the Level 2 multi-sensor products describing aerosol and cloud fields. Surface-based solar radiation measurements, such as those obtained with the Brewer spectroradiometer, provide high-quality spectral observations that can be used to validate satellite data.

The project:

The project focuses on EarthCARE (EC) overpasses during the RACE-ECV campaign conducted by PMOD. In addition to Brewer measurements, the campaign includes a range of complementary observations characterizing aerosol and cloud conditions, including a CIMEL sun photometer, a cloud camera, aerosol lidar, and broadband shortwave radiation instruments. The student will analyze this unique dataset to compare surface solar radiation measurements with radiative transfer simulations, using both EarthCARE and ground-based observations as input.

Key questions:

(1) How accurately do EarthCARE aerosol and cloud products reproduce surface solar radiation measurements? (2) Under cloud-free conditions, how well does the EarthCARE aerosol model perform in the UV spectral region?

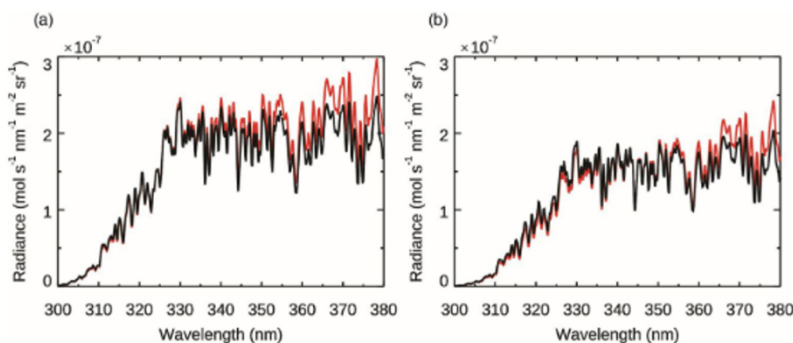


Fig. Satellite measured (OMI) radiance spectra during clean sky scenes (black lines) and red lines during (a) Saharan dust and (b) biomass smoke. At longer wavelengths the aerosols increase radiances while for shorter wavelengths reduce the signal.

taken from Jethva et al. 2022 (<https://doi.org/10.1029/2022EA002354>)

Skills or knowledge required for the project: Strong interest in atmospheric physics and radiative transfer and first experience with programming languages.

Workplace: ETH Zürich or PMOD/WRC Davos

Supervisors : Dr. Kyriaki Papachristopoulou (kyriaki.papachr@pmodwrc.ch) Dr. Stelios Kazadzis (stelios.kazadzis@pmodwrc.ch),

Assessing the impact of 3D cloud scenes on solar energy applications

Background:

Satellite-based estimates of surface solar radiation in real time, using cloud properties from geostationary satellites, is an important tool for solar-energy-related applications. NextSENSE2 (Fig.) is solar energy nowcasting system which rely on 2D cloud information from geostationary satellites and the 1D radiative transfer modelling. One of the sources of error for the instantaneous satellite-based estimates of surface solar radiation, is that the cloud information from geostationary satellite data omits the 3D cloud structure. Solar radiation/energy nowcasting and short-term forecasting applications strongly depend on the cloud spatiotemporal variability, which affects the direct sun radiation (sun visibility), and may result in rapid solar radiation changes, including also the enhancement of solar radiation compared with the cloudless atmosphere.

The project: The project focuses on using 3D cloud scenes from an innovative synergistic product of the geostationary Meteosat Third Generation (MTG) satellite with the FCI imager and the polar orbiting EarthCARE satellite with lidar and radar capabilities onboard in order to investigate improvements in the NextSENSE2 model. The prototype MTG product will leverage the advantages of EarthCARE and MTG, to show that it enhances the accuracy of the real-time estimates of surface solar radiation. The realistic 3D scenes of cloud properties provided by the prototype MTG product, will be used as input to 3D RT simulations, performed with the 3D MYSTIC RT code. The 3D cloud structure will enable the accurate modelling of 3D cloud effects on the surface irradiances (i.e., irradiance enhancement by cloud reflections, cloud shadows etc.), which cannot be reproduced with 1D RT calculations. The surface solar energy products will be evaluated with surface solar radiation measurements.

Key question:

To quantify improvements in real-time satellite-based estimates of surface solar radiation in the NextSENSE2 framework by using prototype MTG 3D cloud scenes, compared with the conventional approach.

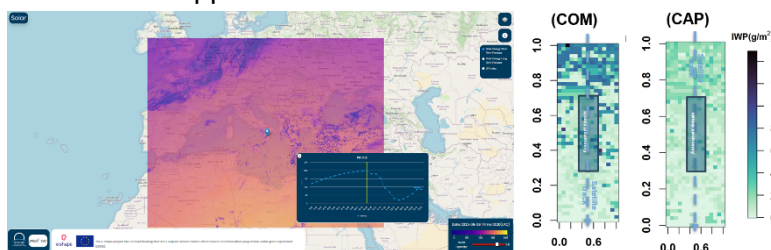


Fig. The NextSENSE2 solar energy nowcasting system - left (https://solar.beyond-eocenter.eu/#solar_short) and EarthCARE 3D cloud scenes of vertically integrated ice water path (IWP) based on the scene construction algorithm of Qu et al. 2023 (<https://doi.org/10.5194/amt-16-2319-2023>)

Skills or knowledge required for the project: Strong interest in atmospheric physics, radiative transfer and solar energy applications and first experience with programming languages.

Workplace: ETH Zürich or PMOD/WRC Davos

Supervisors : Dr. Kyriaki Papachristopoulou (kyriaki.papachr@pmodwrc.ch), Dr. Stelios Kazadzis (stelios.kazadzis@pmodwrc.ch),

Thermal Model for Solar Radiometers on the Ground and in Space

Background:

The PMO8 absolute radiometer for solar irradiance, is a commercially available solar radiometer, developed by Davos Instruments AG in collaboration with PMOD/WRC. It aims at very high precision measurements. It serves as a transfer standard and calibration reference for solar irradiance measurements around the world, supporting climate research and solar energy assessments. Similar radiometers operate in various environments, such as on satellite missions, or as primary standards at cryogenic temperatures (~ 12 K).

Project Goal:

This project aims to develop theoretical and numerical models of these solar radiometers to better understand their thermodynamic properties and optimize their design and performance.

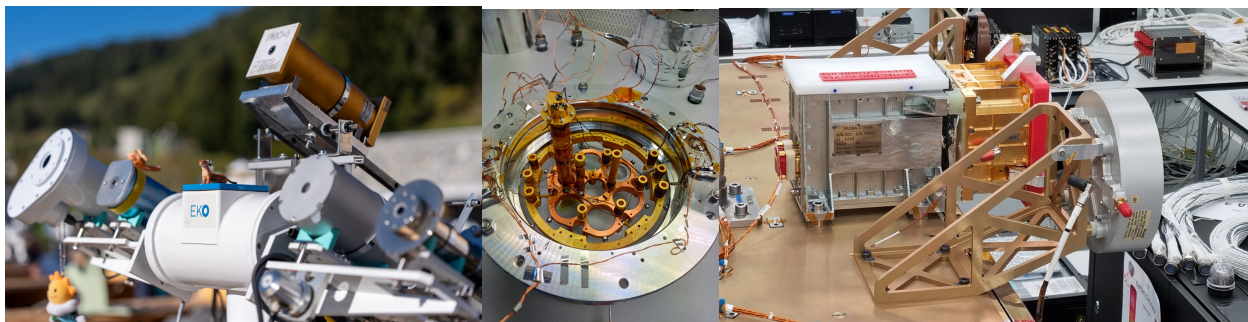
The Project:

Within this project, the performance of existing solar radiometers will be assessed using experimental and model approaches. A thermal model will be developed and verified with experiments. Thermal effects will be characterised and the influence of these effects on the measurements will be quantified.

Are you interested in an MSc thesis in collaboration with a dynamic spin-off company and a leading research institute in the field of radiation climatology, combining experimental work and modelling? The work will be carried out in Davos, supervised by PMOD/WRC, an established research institute and Davos Instruments AG, a start-up company, both located in Davos.

Knowledge and Skills required:

The project requires solid knowledge in the fields of thermodynamics, material properties, radiative heat transfer. Important skills include programming, numerical analysis, lab experiments (thermal, optical).



Commercial solar radiometers (left), the Cryogenic Solar Absolute Radiometer (middle), and the Digital Absolute Radiometer (DARA) on the ESA satellite PROBA3 (right).

Supervisors:

Dr. Markus Suter (Davos Instruments AG, markus.suter@davos-instruments.ch), Dr. Wolfgang Finsterle (PMOD/WRC, wolfgang@pmodwrc.ch)

Survey of X-Class Solar Flares in Total Solar Irradiance Time Series

Background:

Solar flares are transient dynamical events in the solar atmosphere associated with the release of large amounts of magnetic energy. Solar flares are detected as X-ray and EUV flashes but leave traces also in other spectral regions, including the Total Solar Irradiance (TSI). Improved knowledge of the spectral and energetic characteristics of solar flares will help to better understand the underlying physical processes and the associated effects on the heliosphere, including the near-Earth environment (Space Weather).

Project Goal:

The goal of the project is to document the TSI response to known X-class solar flares.

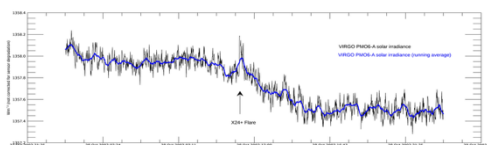


Figure 1: This X-class solar flare produced a peak in TSI

The Project:

The TSI time series from the SOHO/VIRGO, PICARD/PREMOS, FY-3E/DARA and PROBA3/ DARA space missions cover more than 30 years of continuous measurements. The TSI is the total radiative energy from the Sun that is reaching Earth. It provides a quantitative measure of the total energy released by the Sun. TSI variations are associated with solar magnetic activity, fluid dynamics, and transient events in the solar atmosphere. Strong solar flares sometimes are visible as peaks in TSI, although the peak amplitude does not strictly follow the flare amplitude in X-rays. To better understand the relationship between strength of the flare and its visibility in TSI a systematic survey of the TSI response to known X-class flares should be compiled. In a following step the TSI response should be characterized and parametrized. Possible methods include:

1. Visual identification of patterns in TSI time series that coincide with X-class flares
2. Pattern recognition in time-frequency space (e.g. using wavelet analysis)
3. Pattern recognition by machine learning

Knowledge and Skills required: Time series analysis, programming, solar physics

Work Place: This project can be carried out remotely or at PMOD/WRC in Davos.

Supervisors: Dr. Wolfgang Finsterle (wolfgang@pmodwrc.ch), Dr. Jean-Philippe Montillet (jean-philippe.montillet@pmodwrc.ch), Dr. Margit Haberreiter (margit.haberreiter@pmodwrc.ch)