

Earth Observation: New Challenges in Solar Energy Resource

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Laboratory of Atmospheric Physics, University of Patras (in brief)

- **University of Patras (UPAT):** Founded in 1964 (upatras.gr)
The third largest University in Greece, 35 Departments, 178 laboratories and clinics



- **Laboratory of Atmospheric Physics**

Team of 30 researchers (Professors, postdocs, PhD and MSc, Lab assistants)

Research Activities:

Solar Radiation resource forecasting

Weather and atmospheric pollution monitoring and modeling

Artificial intelligence methods in atmospheric and environmental physics

Stable isotopes ($\delta^{18}\text{O}$ & $\delta^2\text{H}$) in rain and in atmospheric water vapor

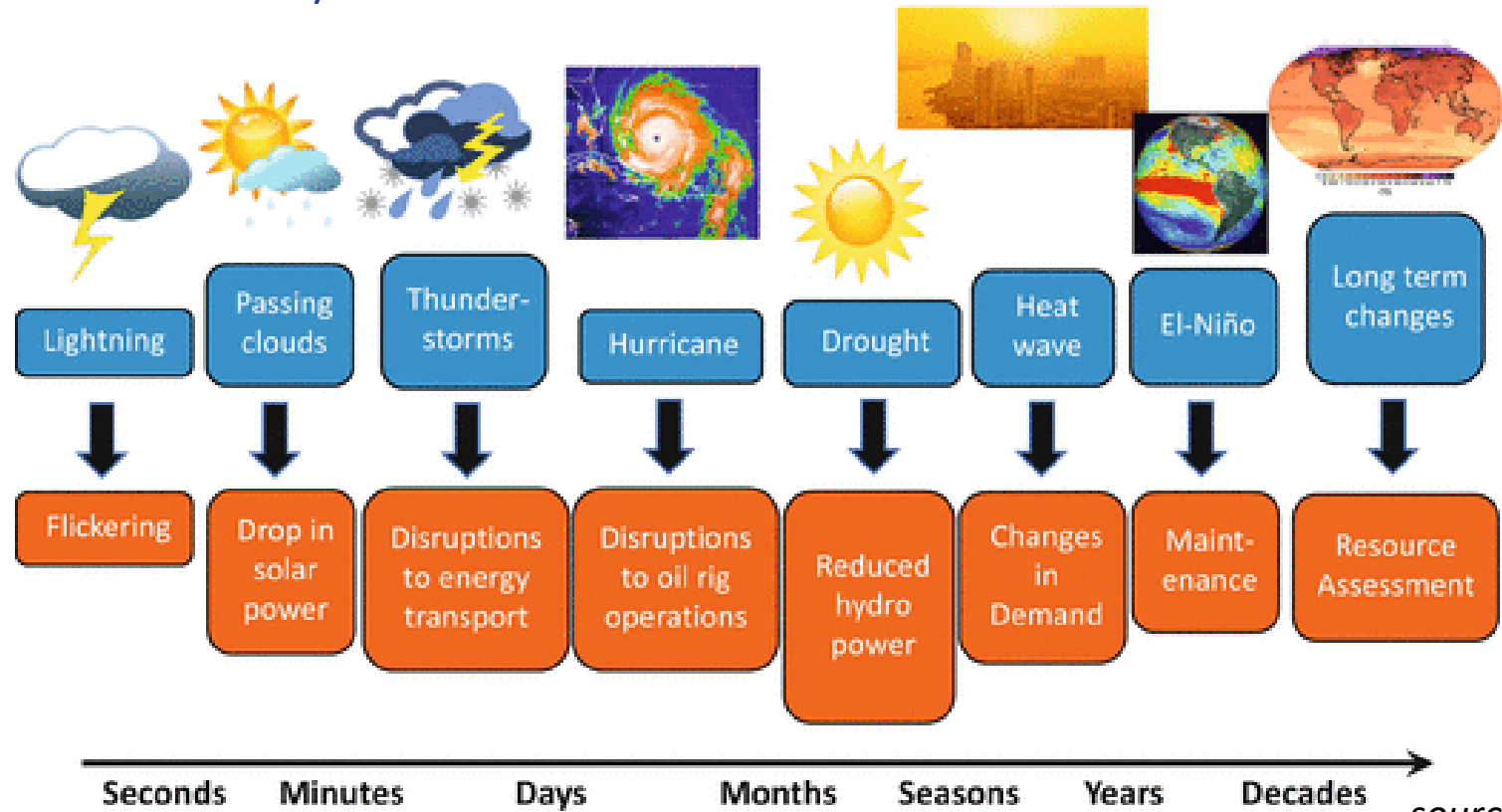
Ultraviolet radiation: Measurements, modeling and biological dose rates

Early warning models of epidemic spread



What is Energy Meteorology?

- **Energy Meteorology** is in the interface of renewable energy and atmospheric physics.
- Atmospheric physics is needed for the **assessment** and **forecasting** of the power output from solar and wind energy systems as well as for the **planning, monitoring, and efficient operation** of these systems.



source: WEMC

What energy meteorology offers to the solar sector?

- **Higher penetration in the energy mix and efficient grid integration**
- **Efficient use of large scale applications**

Most important:

International collaboration and consensus



Huge quantity of energy from the Sun ($175 \cdot 10^6$ GW)

Required surfaces of PV plants for the total primary energy need
(Horizontal PV, 1 kWc: 6 m^2 , 1590 kWh/kWc , $PR=0.8$)

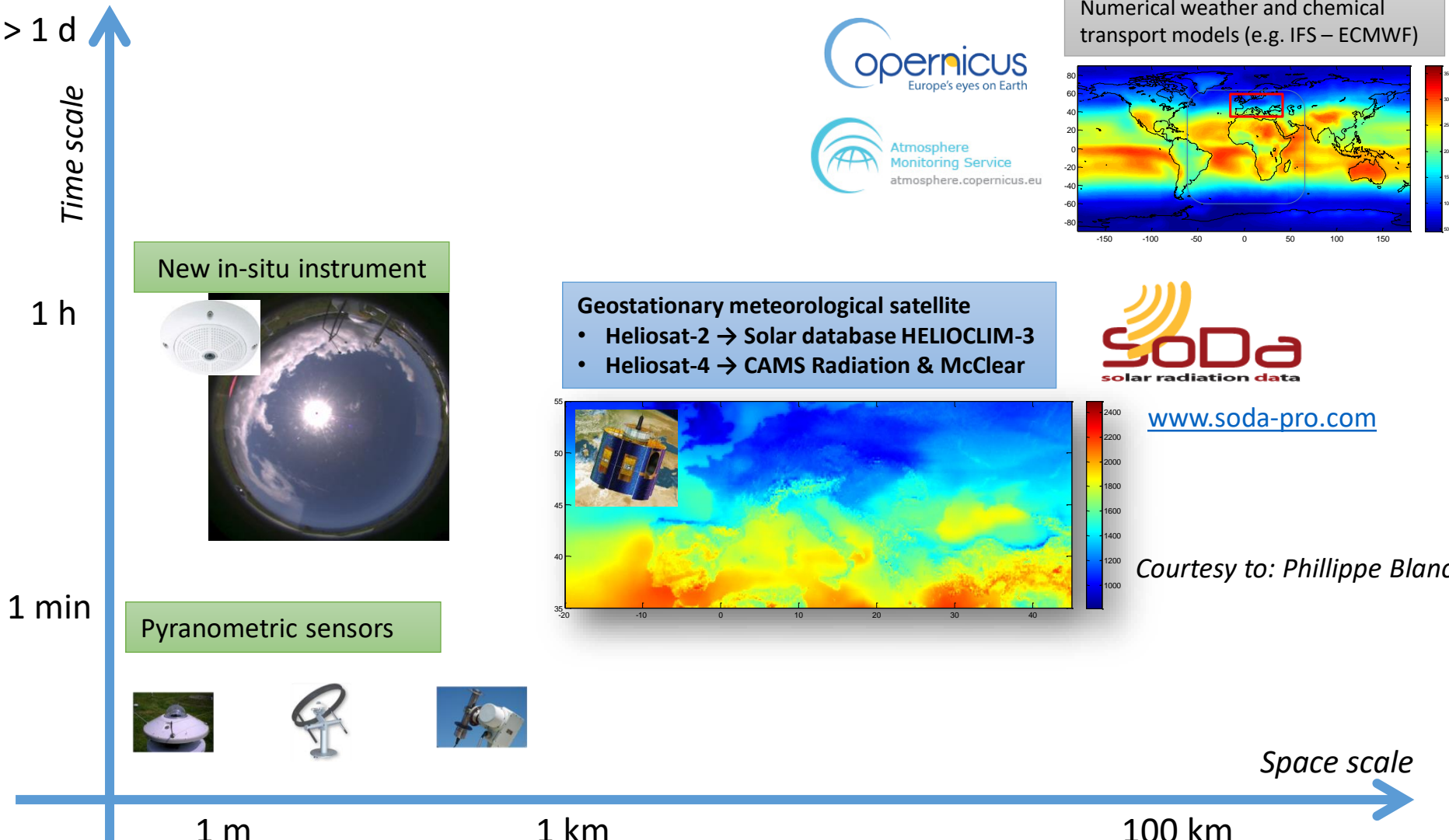


107 TWp @Capacity factor of 18 %, $800 \text{ km} \times 800 \text{ km} = 640,000 \text{ km}^2$

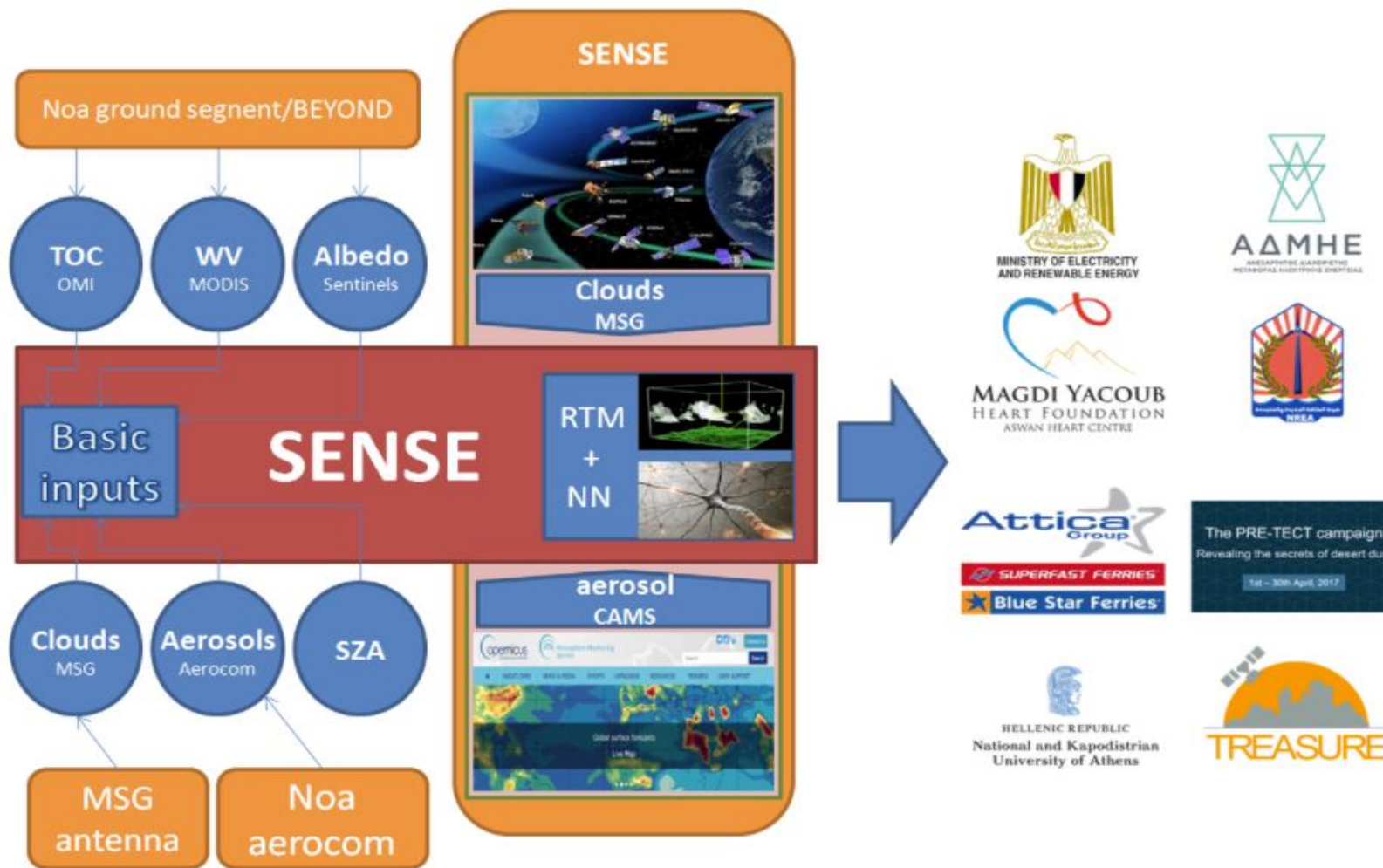
< 1.25 % of the land-use for agriculture, Equivalent of the surface of cities (2015)

Earth Observation systems for Solar Energy

Different time and space scales of solar resource assessment

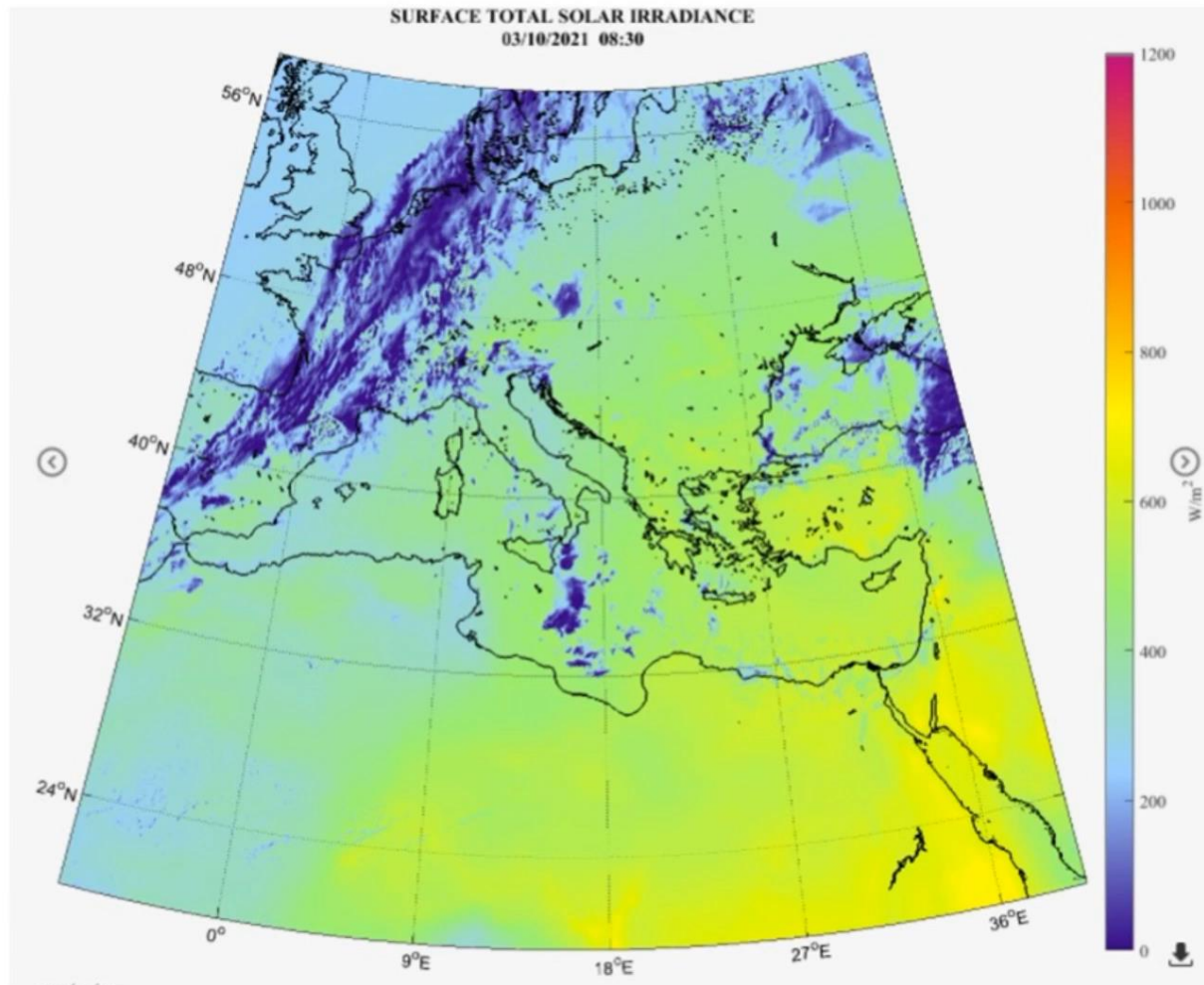


Satellite-derived information: Architecture and Strategy



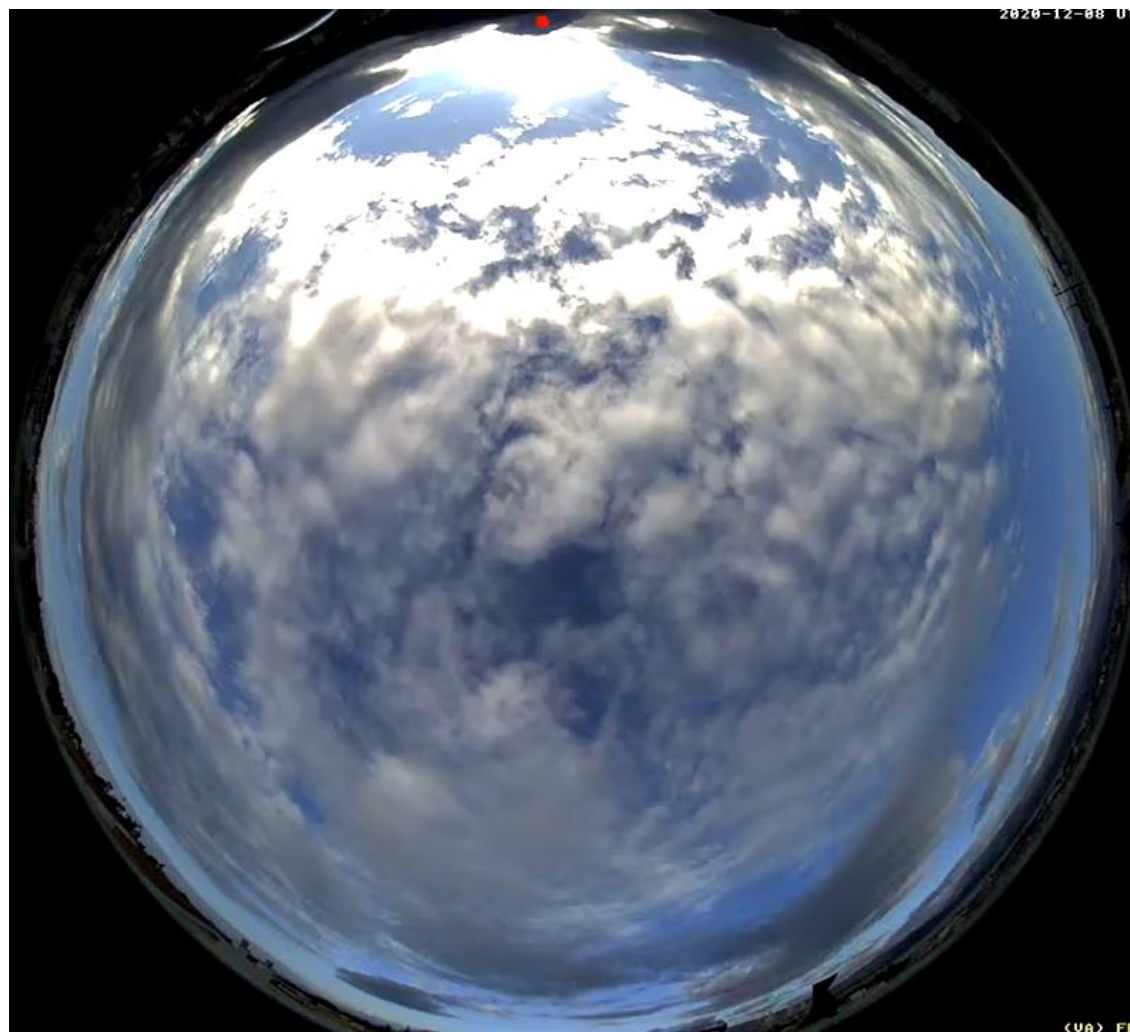
source: BEYOND EO Center

Satellite-derived information: A closer step to city scale?



source: BEYOND EO Center

The ground truth

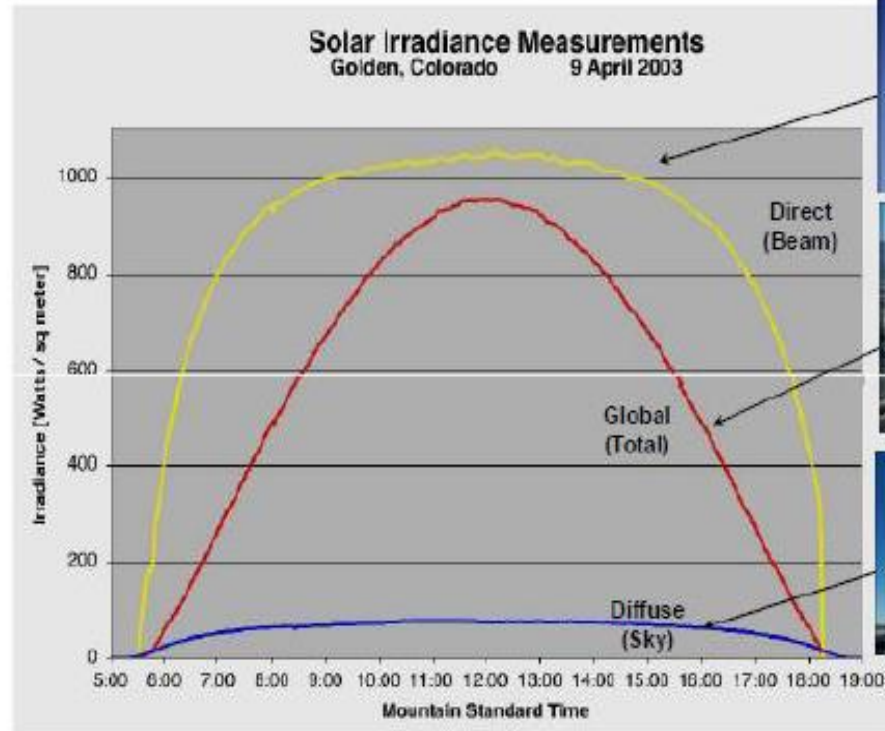


source: [DeepSky-project.com](https://www.deepsky-project.com/)

Direct, diffuse and global irradiance

- **Global horizontal irradiance (GHI):** Solar radiation measured with an instrument mounted horizontally
- **Diffuse horizontal irradiance (DHI):** Measured using an instrument that has a shade to block out the direct radiation.
- **Beam normal irradiance (BNI)** is measured using an instrument that tracks the sun and shades out the diffuse, it only records the direct component.

$$\underline{\underline{GHI = BNI \times \cos\theta + DHI}}$$



http://www.nrel.gov/midc/srrl_bms

Concentrating solar power and photovoltaics




Source: <https://helioscsp.com/>

CAMS Radiation Service (CRS)

Browser header showing address bar: soda-pro.com/web-services/radiation/cams-radiation-service

Implemented by ECMWF as part of The Copernicus Programme



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CAMS Radiation Service

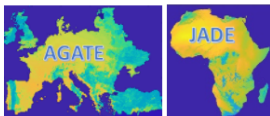
A Copernicus Service

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Copernicus Atmosphere Monitoring Service (CAMS) radiation service provides time series of Global, Direct, and Diffuse Irradiations on horizontal surface, and Direct Irradiation on normal plane (DNI) for the actual weather conditions as well as for clear-sky conditions. The geographical coverage is the field-of-view of the Meteosat satellite, roughly speaking Europe, Africa, Atlantic Ocean, Middle East (-66° to 66° in both latitudes and longitudes). Time coverage is 2004-02-01 up to 2 days ago. Data are available with a time step ranging from 1 min to 1 month. [Licence terms](#)

The CAMS Radiation Service is limited to **100 requests per day**. As the time of on-the-fly computations is quite high, this limitation prevents our servers from overload, which would endanger the SoDa Service as a whole. **Please be aware that any abuse will automatically result in the deactivation of your SoDa account credentials.**

Current version is 4.0.






to download a volume of CAMS radiation and CAMS McClear over Europe or Africa

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CAMS Radiation Service (CRS)

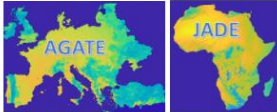
You can select site, start/end date and time step

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CAMS Radiation Service

Max Extent Back text Search Address: Type an address

Latitude (in [-66°, 66°]): Start Date (from 2004-02-01): Time Reference:

Longitude (in [-66°, 66°]): End Date (up to today-2): Include detailed info on atmosphere (1 min UT .csv):

Altitude (in meters. Automatic if empty): Time Step: Output Format:

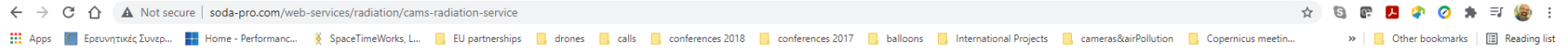
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CAMS Radiation Service (CRS)

*By clicking on proves button, you get the result file (highlighted in blue).
The file is downloaded when you click on it.*



CAMS Radiation Service

Max Extent | Back | Search Address: Type an address

Coord: x = 379, y = 1 | lat = 25.44294, lon = -90.09576 | zoom = 3

Latitude (in [-66°, 66°]):	<input type="text" value="-7.92904"/>	Start Date (from 2004-02-01):	<input type="text" value="2004-02-01"/>	Time Reference:	<input type="text" value="Universal Time"/>
Longitude (in [-66°, 66°]):	<input type="text" value="-54.23639"/>	End Date (up to today-Z):	<input type="text" value="2004-02-29"/>	Include detailed info on atmosphere (1 min UT .csv):	<input type="text" value="False"/>
Altitude (in meters. Automatic if empty):	<input type="text" value="Automatic"/>	Time Step:	<input type="text" value="15 min"/>	Output Format:	<input type="text" value="Comma Separated Value (.csv)"/>

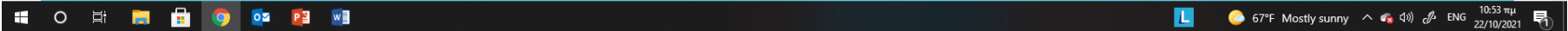
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The challenge



KEEP
CALM

AND

USE

Copernicus

DATA

A solar energy company is considering to build a new solar farm in one of the five following cities: Barcelona (Spain), Ghent (Belgium), Berlin (Germany), Nancy (France), and Nicosia (Cyprus).

Find out which city will provide the highest revenues based on the solar potential and decide where to build their next solar farm!