



## e-shape SC3: High PV penetration at Urban Scale

*Near on-the-fly Service for solar variability assessment and forecasting*

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MINES Paris - PSL



Learn more here:



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## Renewable Energy Showcase

### Pilot #3.2: High PV penetration at urban scale

- **Objective:** develop GIS-tools dedicated to **high photovoltaic penetration** at urban scale, providing **EO based information** about **urban energy system** modeling, electric energy demand profiles and accurate electric production of fleet of **PV rooftop systems**
- **Expected user community:** Urban planners, grid operators, aggregator for energy trading, researchers in Energy and Urban planning and citizens (self-consumption)
- **Two parts of the pilot:**  
*part 1: PV variability at urban scale (pilot in Nantes)*  
*Part 2: EO-data for PV integration in the urban energy system (pilot in Oldenburg)*
- **Partners:**



- **Supporting infrastructure:** DIAS WEkEO

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## The European Solar Rooftops Initiative

*Part of the EU Solar Energy Strategy and RePowerEU*

- [EU Solar Energy Strategy \(pdf\)](#)
- Solar Rooftops (residential, public, industries, commercial): potential of 25 % of the EU's electricity consumption
- Acceleration of PV rooftop installations with a series of measures (limit the length of permitting, PV compulsory for new building, etc.)

*First year: + 19 TWh of PV electricity production*

*+ 58 TWh by 2025*

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## Solar Cadaster: high resolution (metric) urban solar mapping



- Photovoltaic (PV) systems (rooftop, parking shades, etc.) in urban areas are very interesting
  - Low cost since the price of PV modules are constantly and dramatically decreasing*
  - No emission of pollutants nor GHGs during their exploitation*
  - Production of electricity where this electricity is consumed*
  - Added value to unused urban roofs / parking shades*
  - Positive impact on Urban Heat Islands*
- Solar Cadasters enable to:
  - Analyse the solar potential of roofs / shades over a city w.r.t. the local electricity consumption*
  - Help public or private decision-makers and investors,*



## Solar Cadaster from In Sun We Trust

In Sun We  
for the gen



[nantes-metropole.insunwetrust.solar](https://nantes-metropole.insunwetrust.solar)

with the support of:

The French national mapping agency (IGN)

MINES ParisTech

Transvalor Innovation - SoDa

IGN



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European  
Commission

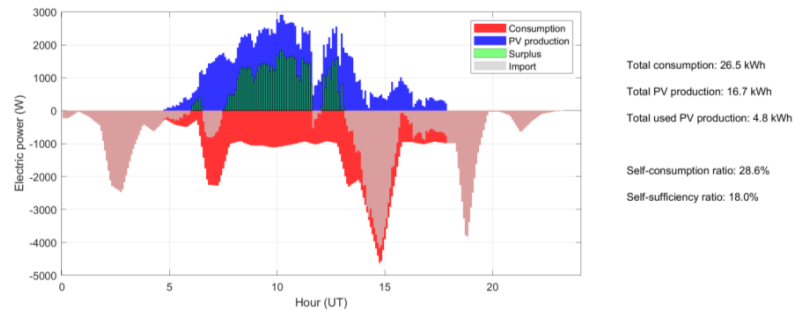




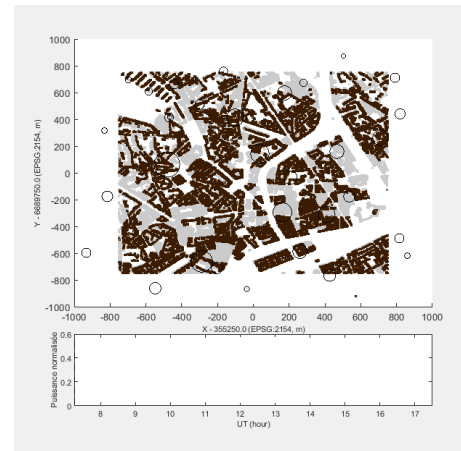
## Our vision: From “static” Solar Cadaster to dynamic Solar assessment and forecasting at urban scale “on-the-fly”

- **From Solar Cadaster:** pre-computed solar map at high resolution providing typically multi-year average yearly or monthly PV yields
- **To the computation “on-the-fly”** over a zone of interest to promote and sustain high PV penetration in cities (temporally resolved, < 15 min, spatially resolved, < 1m)
- **At least three identified use-cases in e-shape**

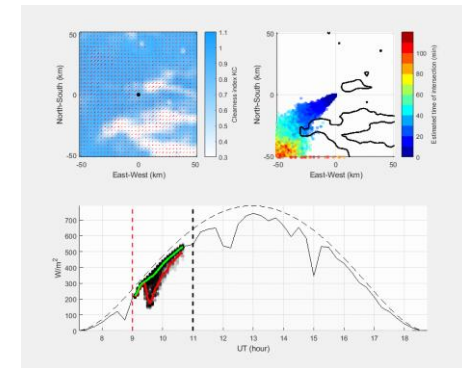
**PV self-consumption** (sizing individual or collective PV systems) when compared to concomitant electric consumption



**PV integration in the grid:** Simulated PV injection in different source points of the electric grid for different scenarios of PV penetration (for Distrib. System Operator)



**Energy trading** (SPOT market) with portfolio of PV rooftop systems with portfolio of PV rooftop systems





## Our vision: From “static” Solar Cadaster to dynamic Solar assessment and forecasting at urban scale “on-the-fly”

- **Solar Assessment and Forecasting As A Service (SAF-AAS)**

*Input data agnosticism (Solar data, weather data, DEM, DSM, ...)*

*Based on interoperable, standard (OGC compliant ) Web Service (Web Processing Service)*

*Deployed on scalable, parallel HPC cloud infrastructures*

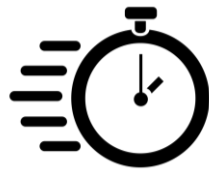
*Allow wise (elastic) computer resources management (un-shelve - shelve on-the-fly UCs) => impact on the cost !*

*Enable a variety of access from Web, desktop applications to M2M transactions*

*Provide standard and interoperable output results (NetCDF + Climate & Forecast compliant)*



Cloud-based



ON-demand  
the-fly



Scalable



Input agnostic





# Data and Data and Information Access Services (DIAS)

- Data used**

*Copernicus Atmospheric Monitoring Services (CAMS)*

*aerosols, water vapor, all-sky irradiation (CAMS-Rad)*

*Satellite-based decametric DEM (e.g. SRTM, ASTER)*

*Digital Surface Model (10-25 cm resolution) (e.g. IGN)*

*Building footprints (e.g. Open Street Map, BDTOPO© from IGN)*



- DIAS WEKEO**



*"Back-office": Providing cloud processing requested on-the-fly through asynchronous OGC Web Processing Services (WPS)*

*"Front-Office": Hosting a Jupyter Hub with Jupyter Notebooks exemplifying in Python different use-cases with:*

- GIS-like interface
- WPS asynchronous request "assistance" with GUI
- Output data exploitation and representation





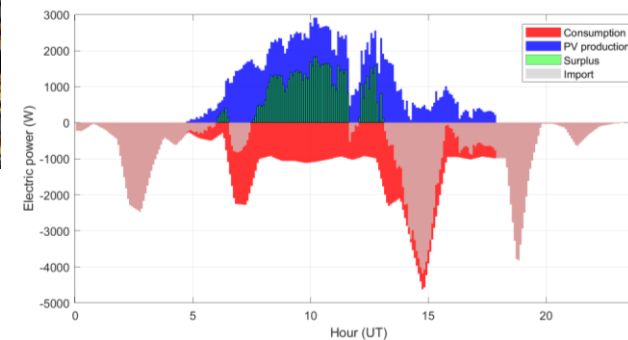
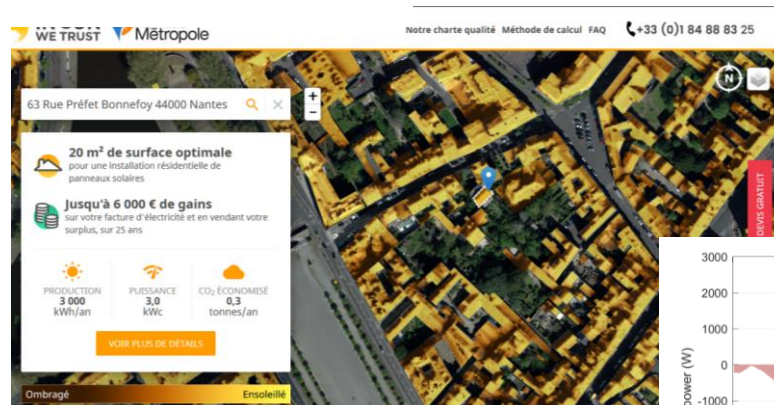
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## Historical analysis of PV variability (use case #1)

- Usage: PV self-consumption  
(individual or collective systems)



1-h electric consumption from  
the customers or a model



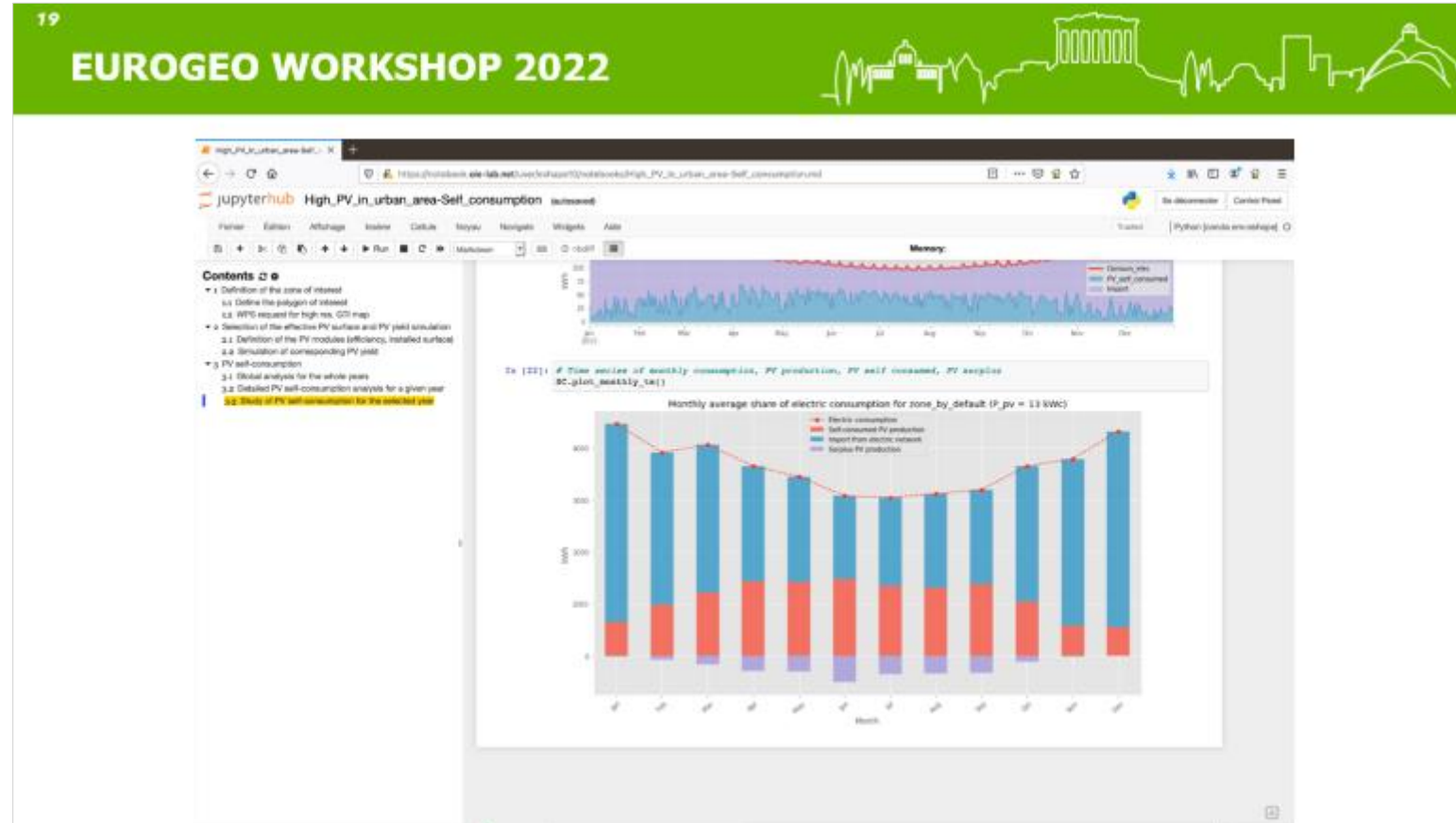
Total consumption: 26.5 kWh  
Total PV production: 16.7 kWh  
Total used PV production: 4.8 kWh  
  
Self-consumption ratio: 28.6%  
Self-sufficiency ratio: 18.0%

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Available pilot on Jupyter Notebook



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## Available pilot on Jupyter Notebook

- Hands-on session recording - Youtube:  
<https://www.youtube.com/watch?v=Sj9eMoLFi0g>
- To get an account to test the pilot:  
[lionel.menard@minesparis.psl.eu](mailto:lionel.menard@minesparis.psl.eu)



## Energy trading (SPOT market) with portfolio of PV rooftop systems (use case #3)




- Solar Forecasting at urban scale

*Satellite-based CMV forecasting for 2-h max horizon*



*Article*

### **A New Approach for Satellite-Based Probabilistic Solar Forecasting with Cloud Motion Vectors**

Thomas Carrière <sup>1</sup>, Rodrigo Amaro e Silva <sup>2</sup>, Fuqiang Zhuang <sup>2,3</sup>, Yves-Marie Saint-Drenan <sup>2</sup>  
and Philippe Blanc <sup>2,\*</sup>

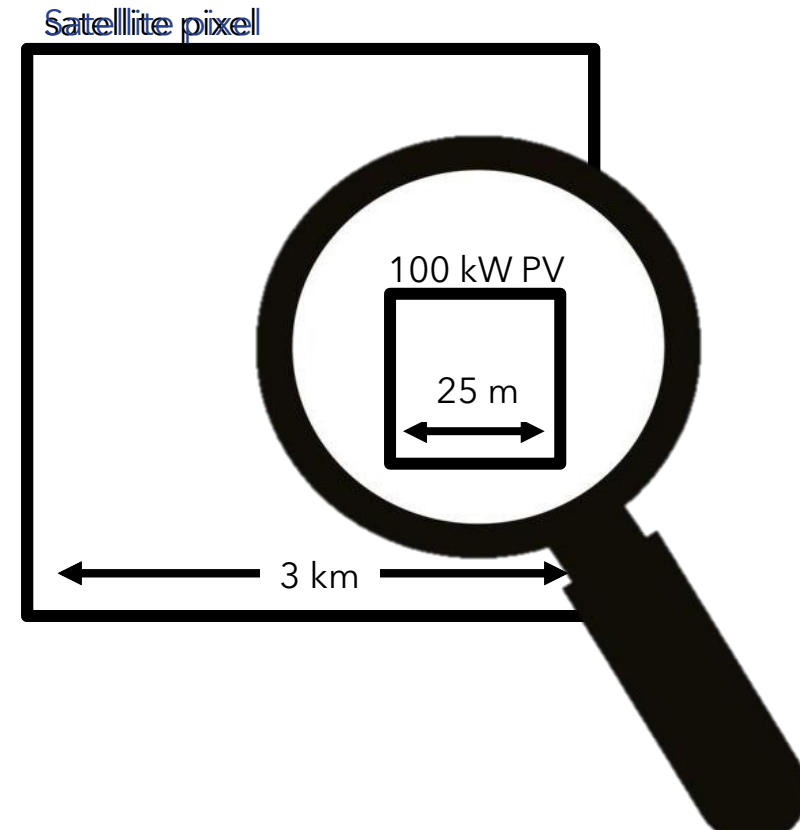


***Coupling solar forecasting model & dynamic solar cadaster***



## Relevance of dynamic solar cadaster

- It's all a matter of spatial scale

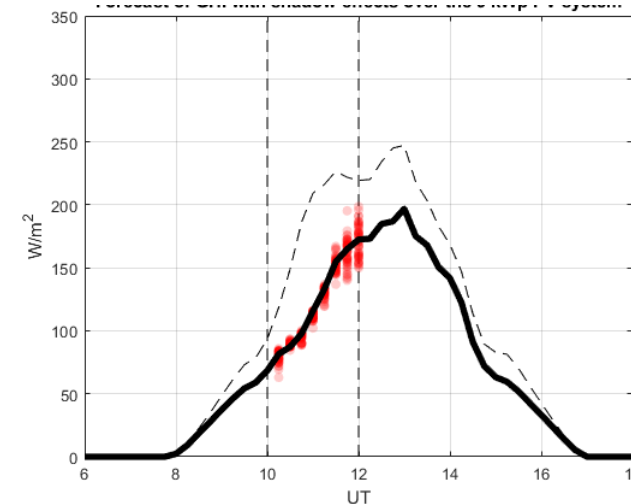
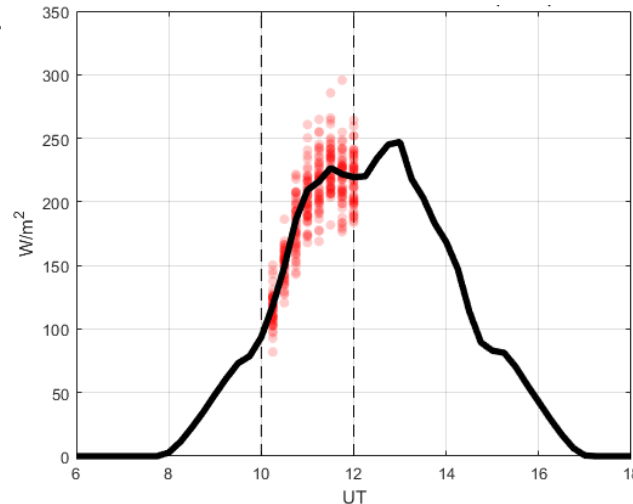






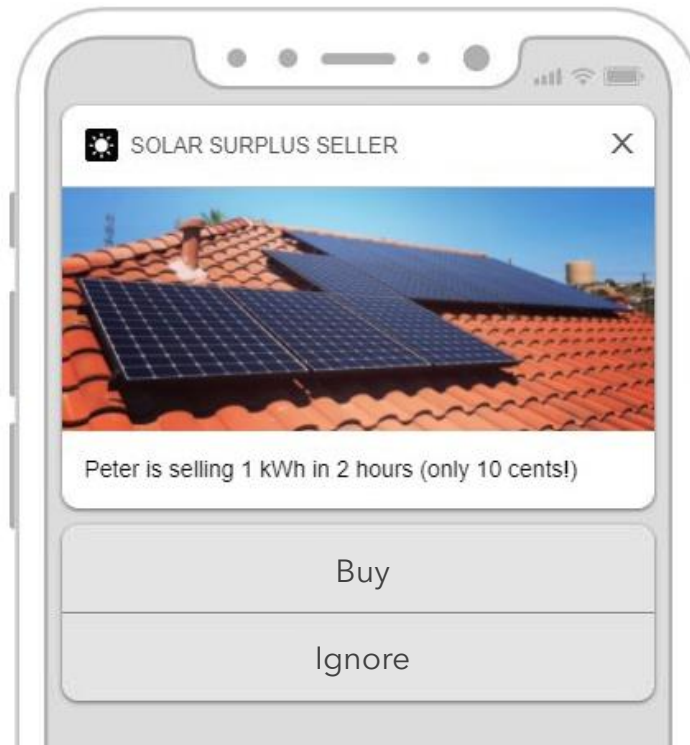
## Relevance of dynamic solar cadaster

- With a great ir

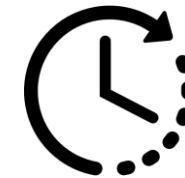


We could overestimate it by 10-100% !

## Energy trading (SPOT market) with portfolio of PV rooftop systems (use case #3)



Quantity  
(1 kWh)

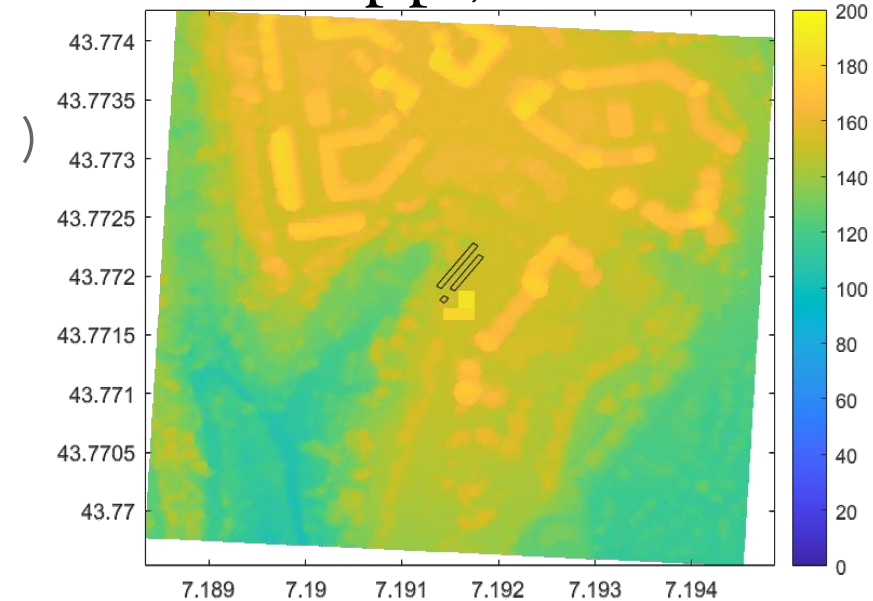
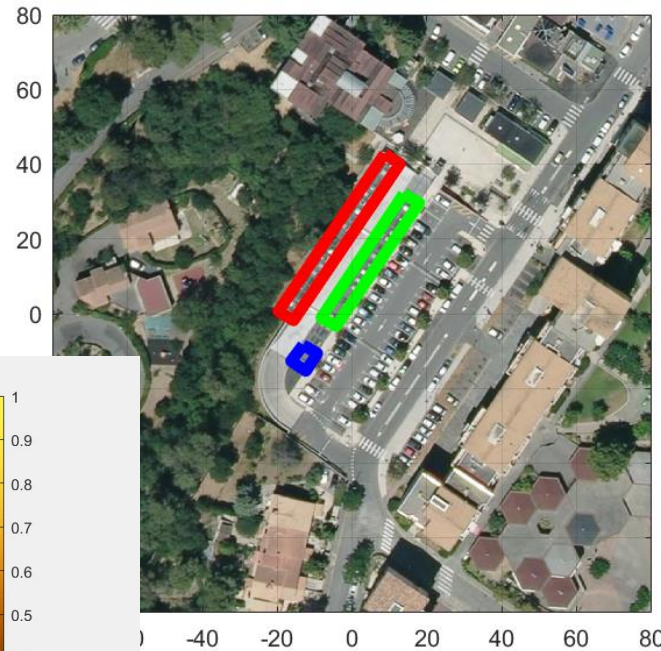
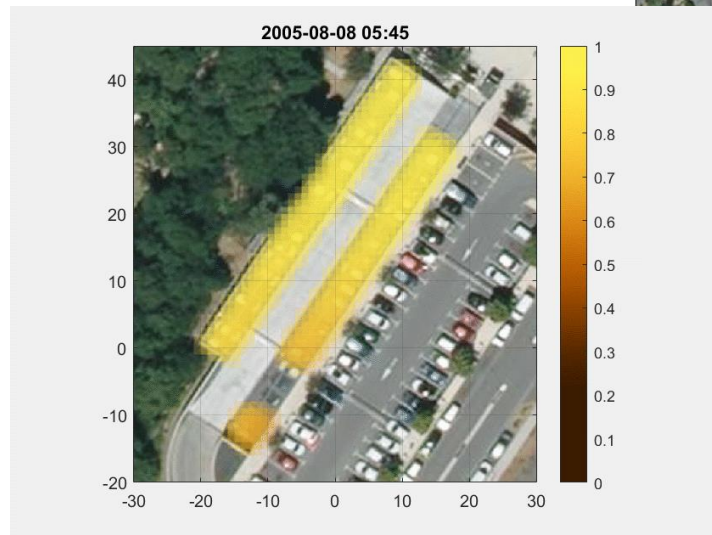


Horizon  
(in 2 hours)

**Forecasting** = business enabler

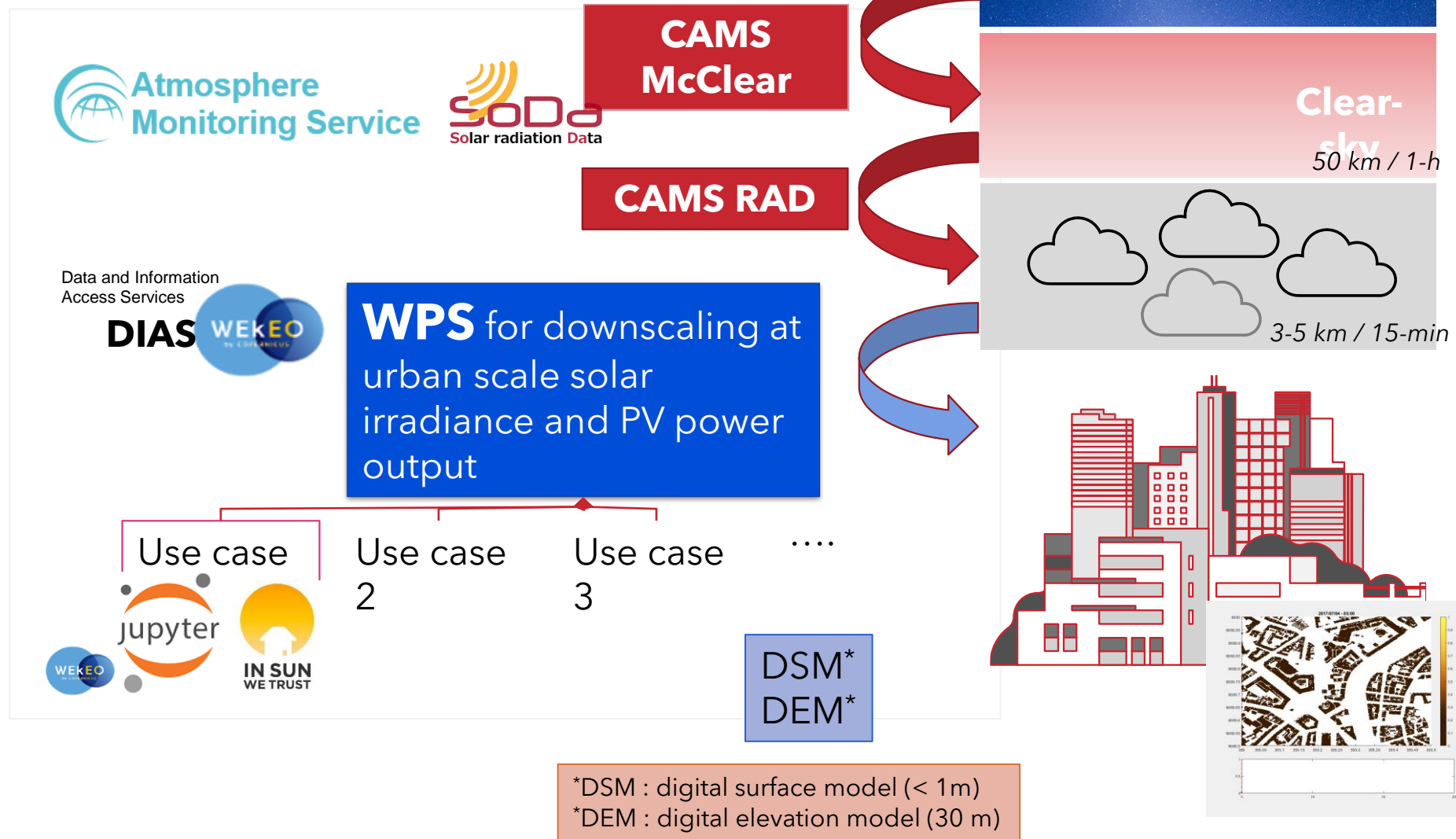
## Local urban planning and PV (Use-case supp.)

- Study of a F impacted b



- Before the "new building": 1200 kWh/kWp
- Impact of the new building:
  - 18.3 %
  - 980 kWh/kWp
  - Annual loss: ~2000€/year

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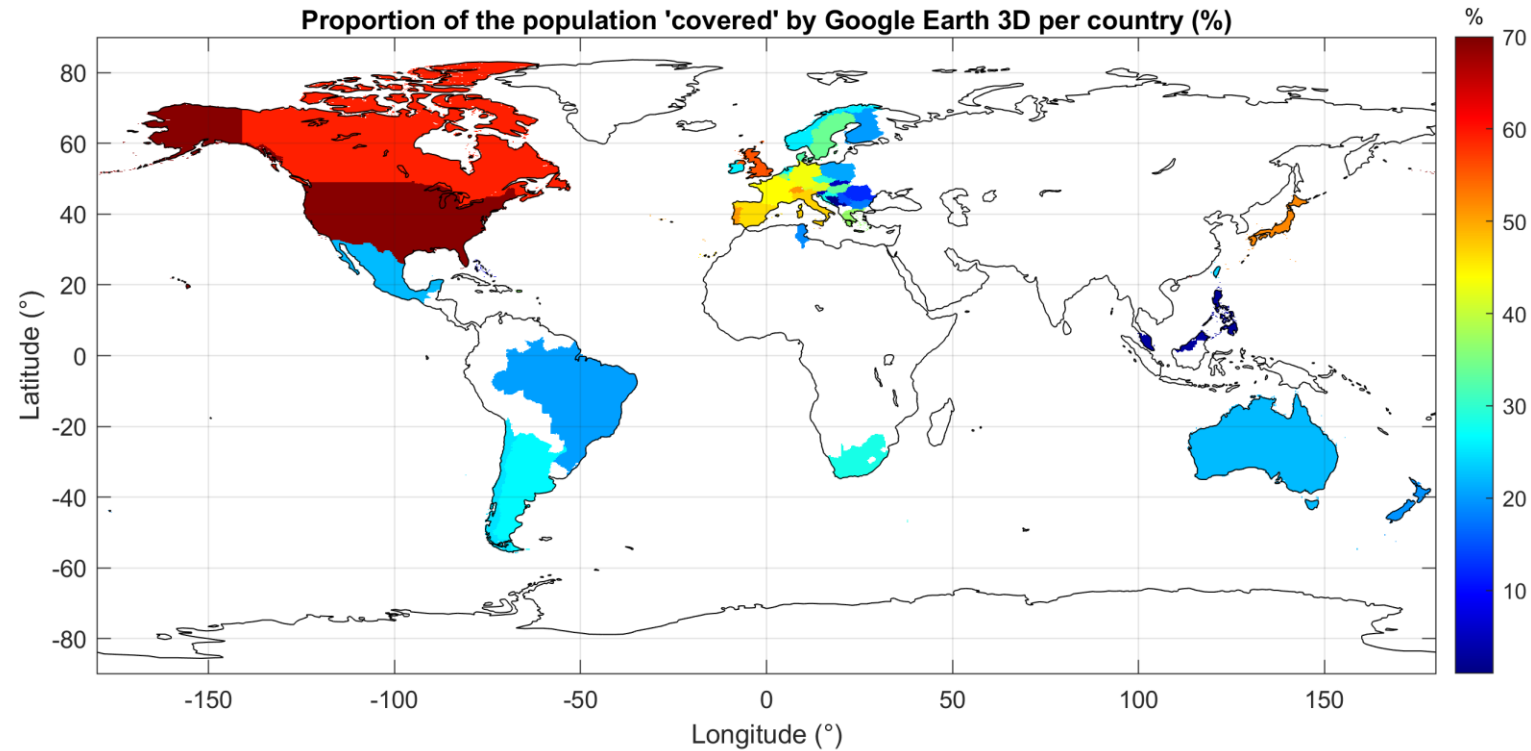


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## Coverage of 3D information from Google Earth





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