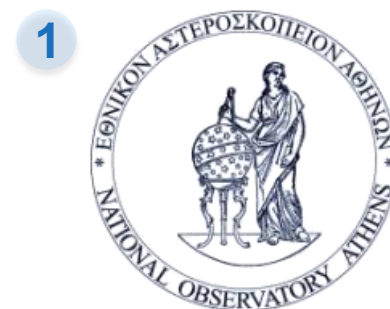
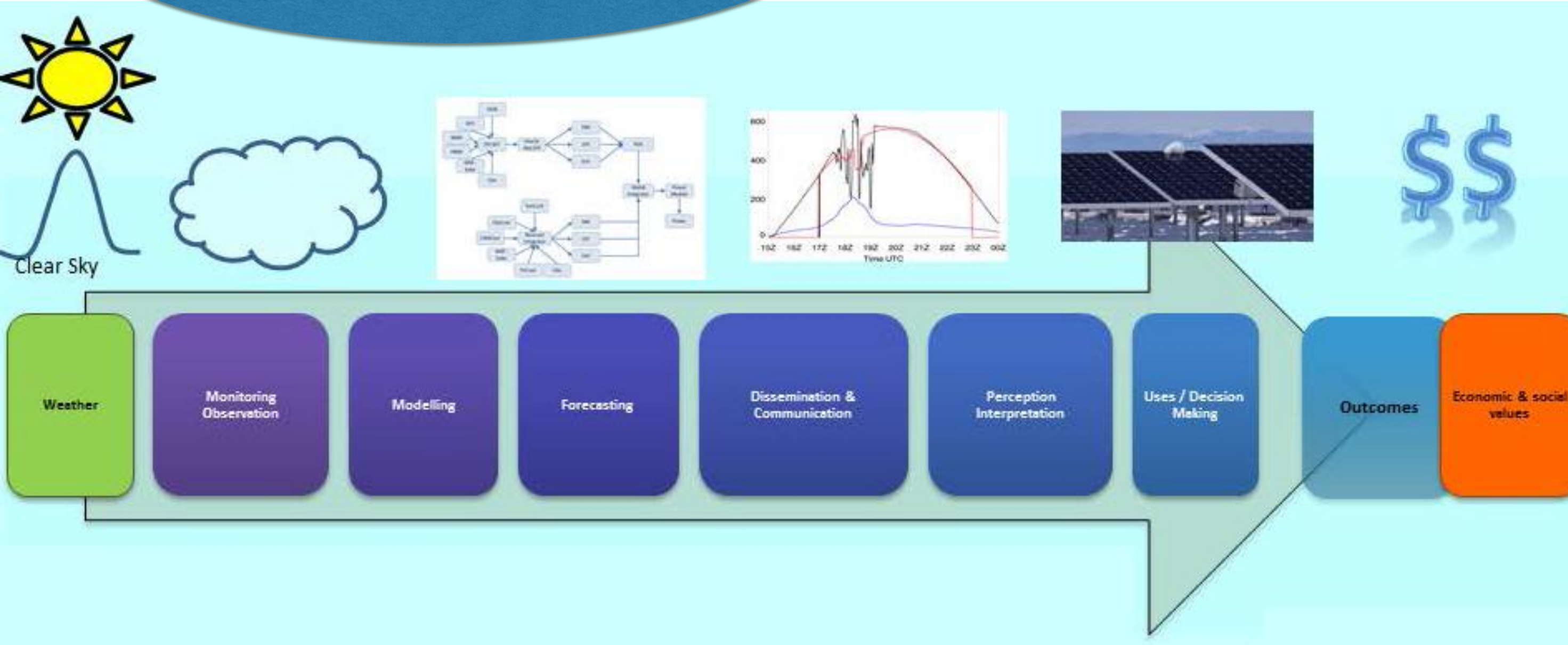


Access to solar energy applications using EO data through GEO activities: Validation and demonstration of the SENSE system

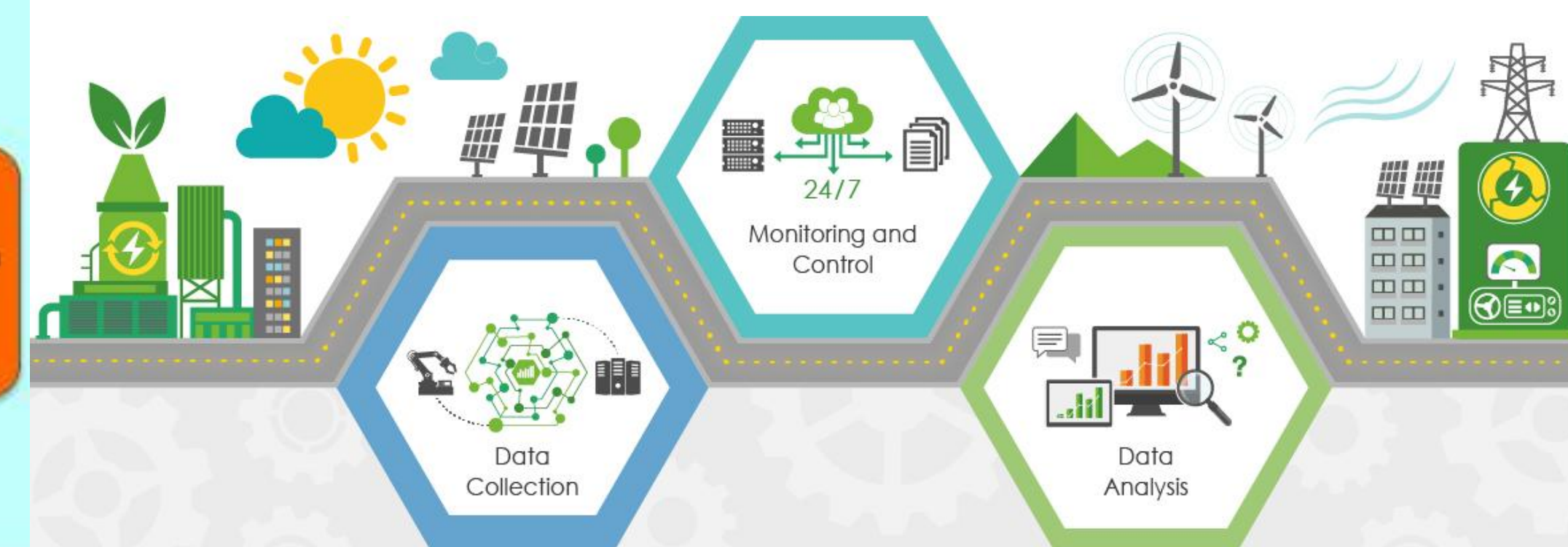
Kosmopoulos Panagiotis¹, Kazadzis Stelios², Kontoes Charalampos¹,
El-Askary Hesham³, Zografos Dimitris⁴, Krestos George⁴



Solar energy applications: **the problem**



Energy management and control of the low carbon technologies and public health.



Accurate solar energy forecasts are crucial in the **energy market**, where on-the-spot energy prices are defined by supply and demand equilibriums. If the energy suppliers can have an accurate estimation for the solar energy production from the solar systems (e.g. 3 hours ahead), this provides them with a comprehensive advantage with clear economic benefits for their day-to-day market operations.

Solar energy applications: **the solution**

Inputs



**Sentinel/EUMETSAT
Satellite data**



**Copernicus atmosphere
monitoring services**



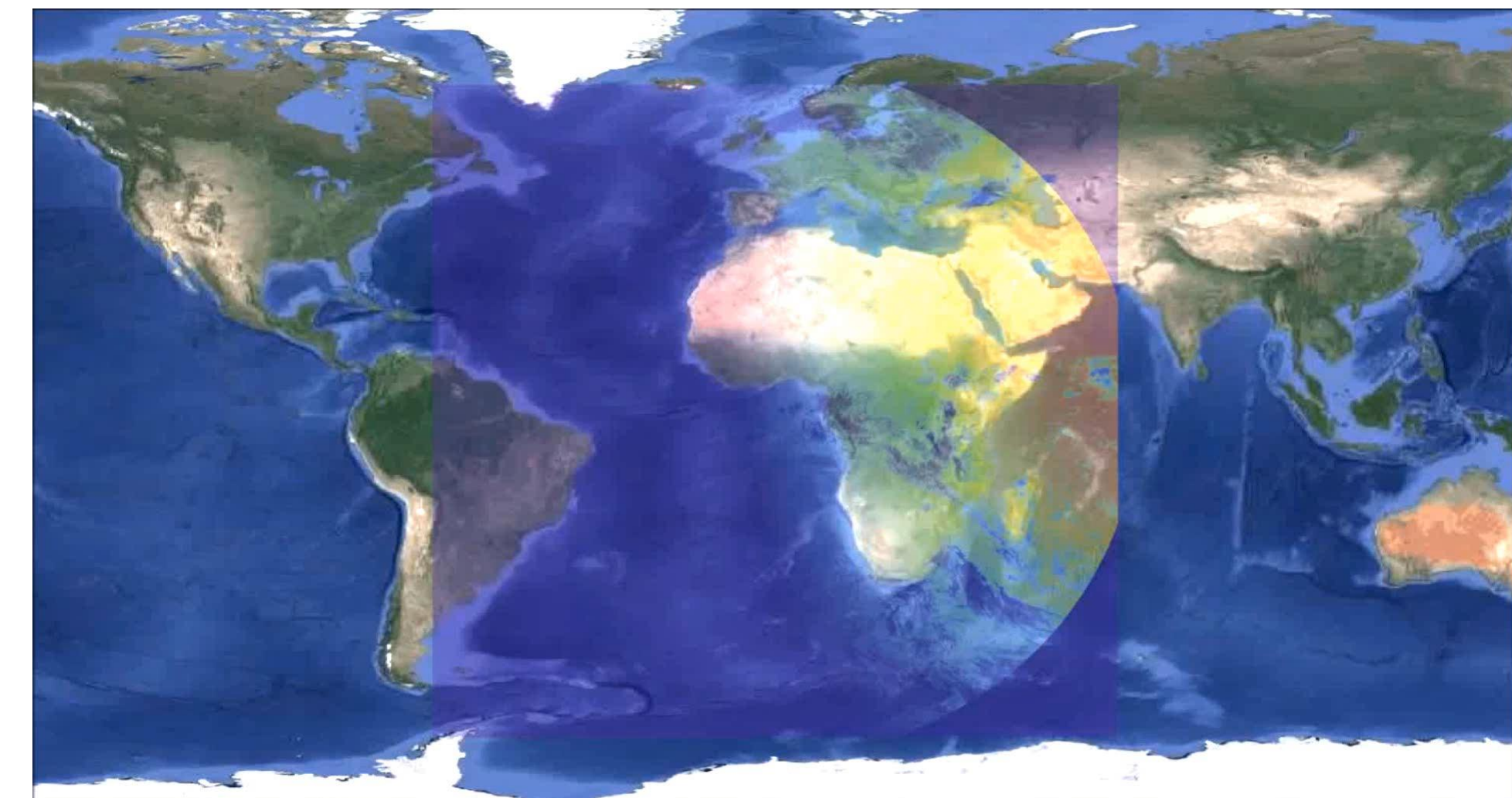
Actinometric platform

Initiatives



SENSE basics

<http://geocradle.eu/en/>



System outputs

- Realistic assessment of solar energy potential
- Provision of real-time solar energy (GHI, DNI, PV) applications
- Solar potential forecasts for energy production and planning
- Applicability anywhere

Potential end-users

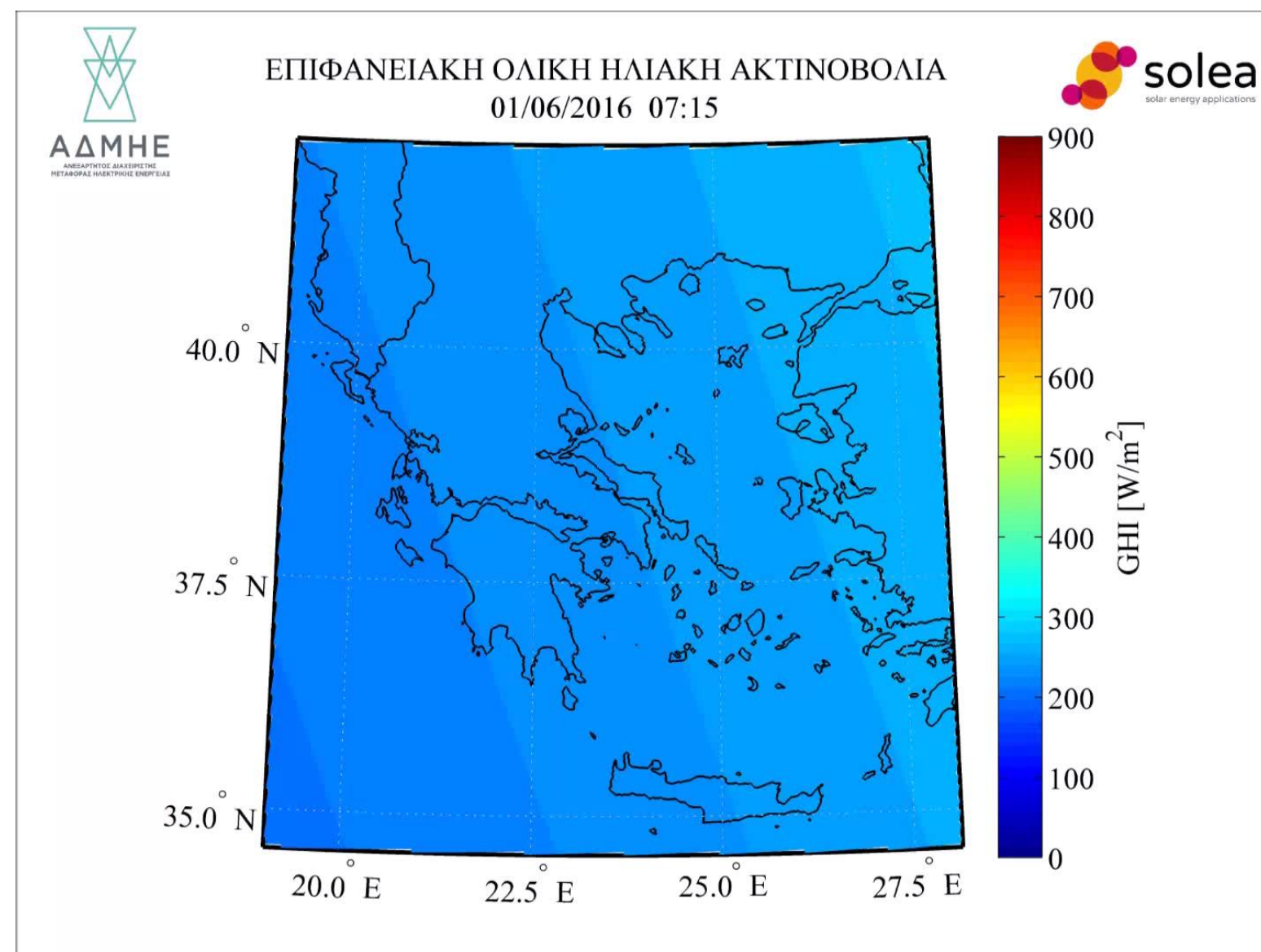
- Public and private energy managing authorities
- Energy and environmental political leadership
- PV constructors
- Energy investors, suppliers and users
- Scientific community

Solar energy applications: **examples**

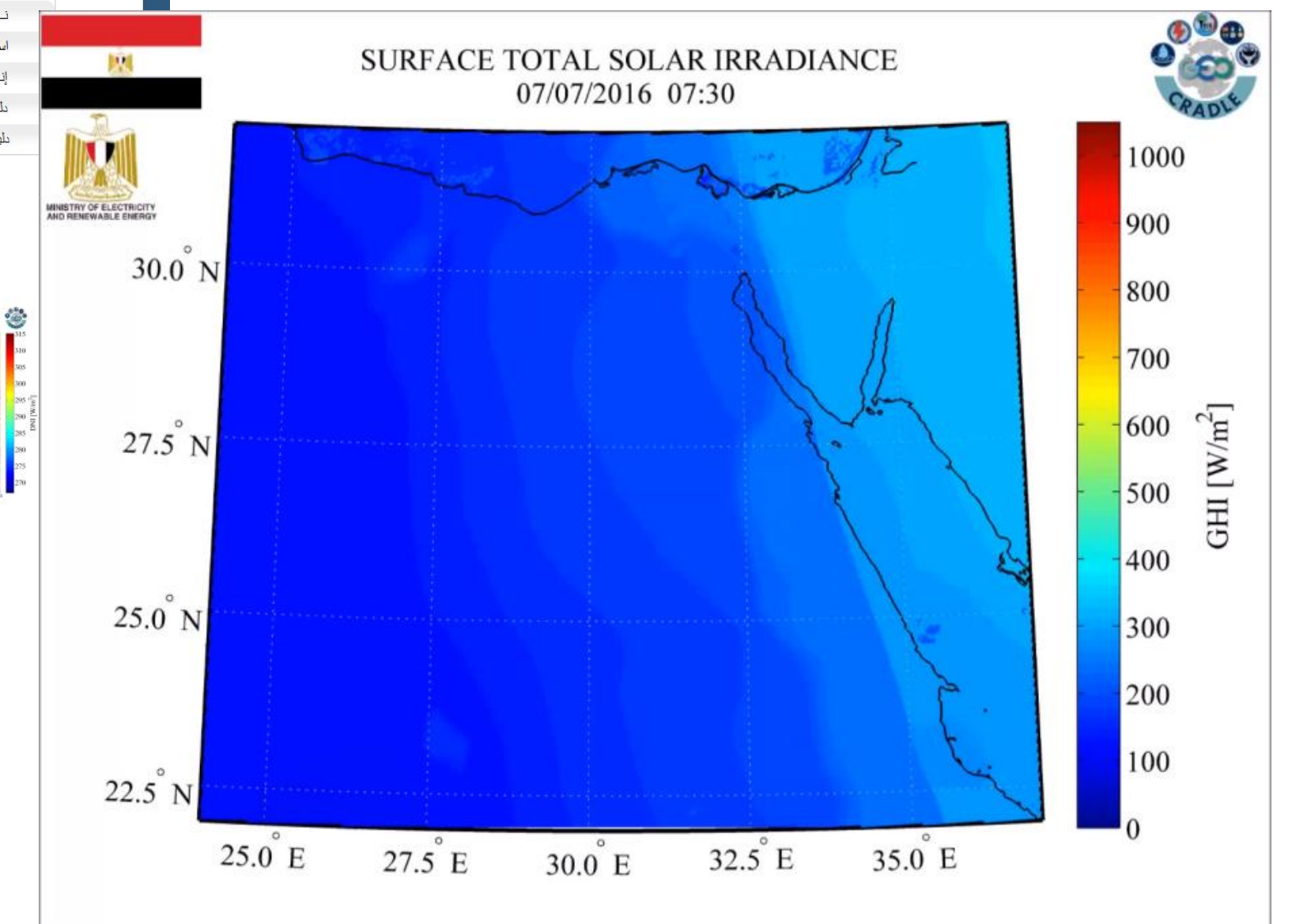
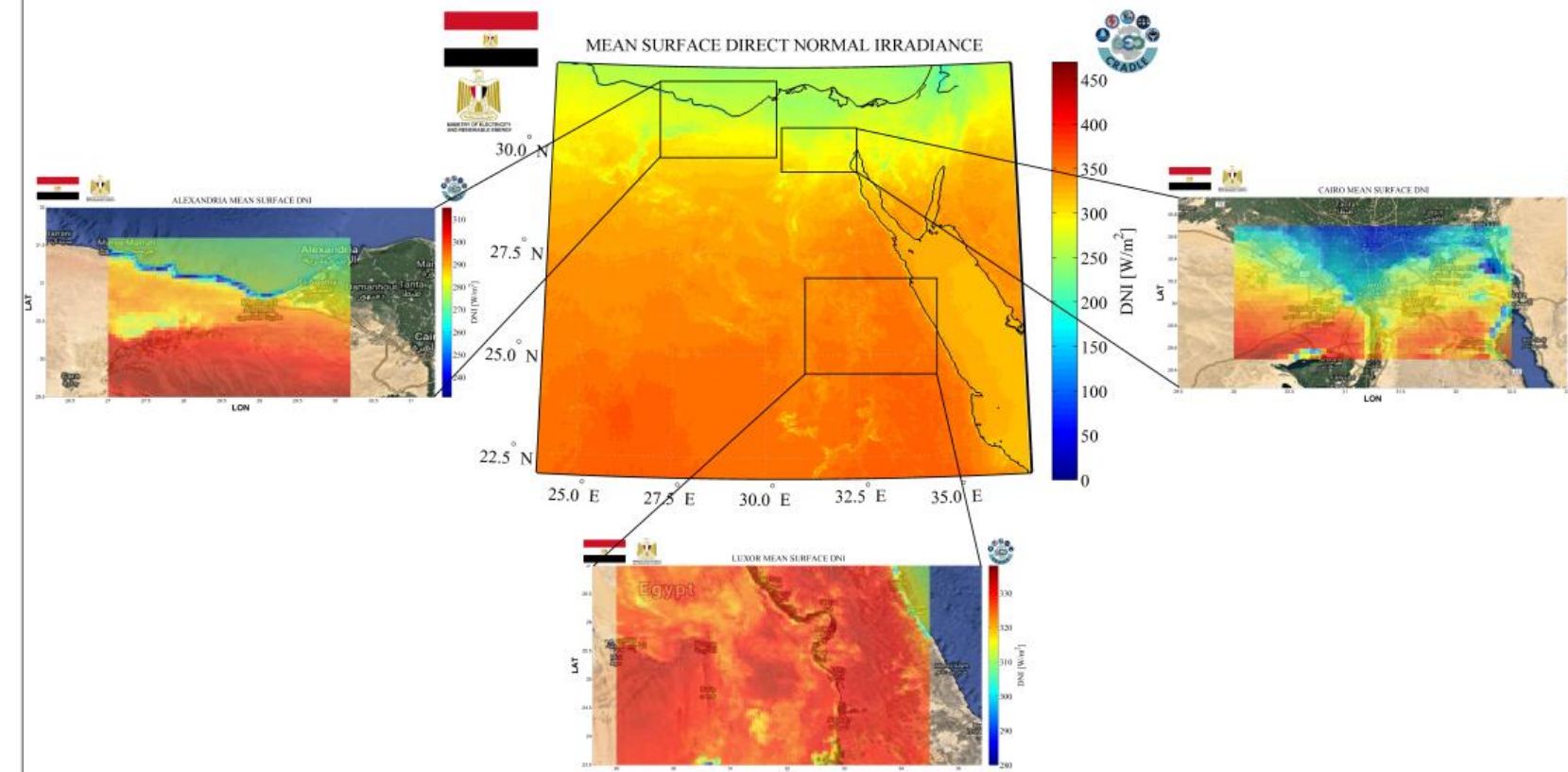
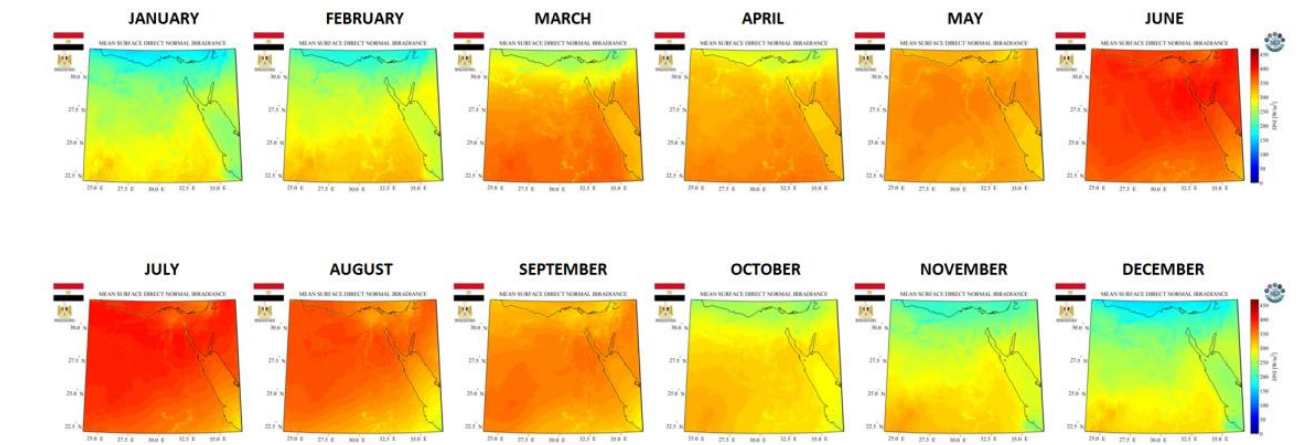


Solar energy forecasts in real-time

Efficient control and management of the energy supply and demands, and integration of the produced energy from solar farms into the electricity grid.



Operational and solar atlas services



Such energy management and support systems are able to fulfill all the regional needs for optimum solar energy exploitation and for active and effective integration of solar energy exploitation technologies into the national sustainable development economies and strategies.



<http://geocradle.eu/en/>

Access To Solar Energy Applications Using EO Data Through GEO Activities: Validation And Demonstration Of The SENSE System

Kosmopoulos Panagiotis¹, Kazadzis Stelios², Kontoes Charalampos¹, El-Askary Hesham³, Zografos Dimitris⁴, Krestos George⁴



Motivation

Southern Europe and North Africa present unique solar energy potential and its exploitation is critical for the regional sustainable development, through an effective energy planning, power transmission and distribution. In the framework of the H2020, EU-funded GEO-CRADLE project (<http://geocradle.eu/en/>), we have demonstrated a novel Solar Energy Nowcasting System (SENSE, <http://solea.gr/>), in order to provide tailored solutions to the Energy Sector. It addresses solar energy related end-user needs that have been defined during the course of GEO activities (e.g. GEO-Vener) and other initiatives (International Energy Agency, United Nations, SDGs, etc.). The niche for this feasibility study is the operational, satellite-driven SENSE that produces instant estimates and short-term forecasts (STF) of solar energy in high spectral, spatial and temporal resolution (1nm, 0.05x0.05 degrees, 15min). SENSE is a sophisticated energy management system and is based on the synergy of Radiative Transfer Model (RTM) simulations, speed-up technologies (neural networks and multi-regression functions) and Big Earth Observation (EO) Data as inputs in real-time. The exploitation of EO data through GEO activities and SENSE will provide access to advanced solar energy related products, in support to large scale solar farm projects, grid operators, national and private electrical transmission and handling entities, so as to guarantee the uninterrupted energy flow and the power grid stability.

Influence of climatic conditions from the maximal use of the produced energy → need for optimal energy planning → Energy Management: An integral part of the overall state administration

Energy dependence, increasing energy prices, efficient energy use

The Solar Energy Nowcasting System (SENSE)

Inputs: Sentinel-6PREDESAT Satellite data, Copernicus atmosphere monitoring services, Actinometric platform

Initiatives: GEOSS, Geo View for Energy (GEO-VENER), Euro GEOSS

SENSE basics: <http://geocradle.eu/en/>, <http://solea.gr/>

System outputs: Realistic assessment of solar energy potential, Provision of real-time solar energy (DNI, DNIv, PV) applications, Solar potential forecasts for energy production and planning, Application expertise

Potential end-users: Public and private energy managing authorities, Energy and environmental public bodies, PV manufacturers, Energy companies, suppliers and users, Scientific community

Reliability of SENSE

The reliability of SENSE's outputs and STF was tested against Baseline Surface Radiation Network (BSRN) measurements, under various atmospheric, climatological, geographical and altitudinal conditions. For the SENSE's STF of 0 to 3 hours ahead, we performed a cloud motion vector analysis by using a nonlinear autoregressive exogenous model.

Mean GHI differences in W/m^2 derived by SENSE as compared to the BSRN stations for various time horizons:

15-min:	-100 to 40 W/m^2
Hourly:	-70 to 40 W/m^2
Daily:	-40 to 30 W/m^2
Monthly:	-20 to 20 W/m^2

CO₂ map from MSG at 15h/3014 and time 11:00 UTC. STF results for 1 hour ahead (6 time steps of 15 minutes) for the same date and time. Note that the forecast horizon of 60 minutes was applied at the time of 11:00 UTC.

Mean forecast performance in terms of percentage error (%)

Solar energy applications

GLOBAL HORIZONTAL IRRADIANCE 23/08/2017 11:47

Solar energy forecasts in real-time

End-users of the SENSE's solar energy services are the Independent Power Transmission Operator in Greece, and in Egypt, the Ministry of Electricity and Renewable Energy and the Magdi Yacoub Heart Foundation in Aswan.

Conclusions

The solar energy management systems (SENSE) using EO and Copernicus data are ideal for:

- Realistic assessment of solar energy potential
- Provision of solar energy applications of high precision in real-time
- Solar potential forecasts for efficient energy planning and electrical production control

Major applications & contribution to emerging technology

- Location studies for the placement of PV and CSP installations
- Large scale and precise solar energy calculations to assist public authorities in energy planning policy
- Supporting the work of various scientific communities
- Provision of specialized data of high spectral precision for private and public sectors dealing with health protection, energy consumption and solar energy exploitation

Acknowledgments: This study has been implemented in the framework of the GEO-CRADLE project (<http://geocradle.eu/>) which has received funding from the EU's Horizon 2020 research and innovation programme under grant agreement No 680732. **References:** 1) Kosmopoulos, P.G., Kazadzis, S., Taylor, M., Kazadzis, H., Karamitros, I., Katsoulas, S. and Bell, A.F. Assessment of the surface solar irradiance derived from machine learning techniques and verification with ground-based measurements. *Applied Solar Energy*, 11, pp 407-414. DOI: 10.1016/j.apse.2016.07.001. 2) El-Askary, H., Kosmopoulos, P.G., and Kazadzis, S. Success Plan for the assessment, operation and exploitation of a Solar Farm Aswan's Solar Farm Project - Selection of the Right "Nuclear Heat" Hospital. July 2017, Aswan, Egypt, 2017.