nextSENSE: solar energy nowcasting & short-term forecasting system

Stelios Kazadzis
PMOD World Radiation Center, Switzerland
H. Kontoes
Beyond/National Observatory Of Athens, Greece
& e-Shape collaborators
Armines Paris-Tech, France

- Global and international initiatives for the mitigation of climate change ➜ Renewables will play a key role

European Green Deal

E-Shape: Applications powered by Europe:

- UN 2030 Agenda for Sustainable Development :
  UN Sustainable Development Goal 7
  - 7.1: ensure universal access to affordable, reliable, and modern energy services
  - 7.2: increase the share of renewable energy in the global energy mix

Evolution of renewable energy targets

- 45% REPowerEU Plan (2022)
- 40% Proposal to revise the directive (2021)
- 32% Recast directive (2018)
- 27% Figure agreed by EU leaders (2014)
- 22%
- 20% Target set in 2009
- 14%

- EU directives for renewable energy goals
  - The Paris Climate Agreement
  - Re-power Europe
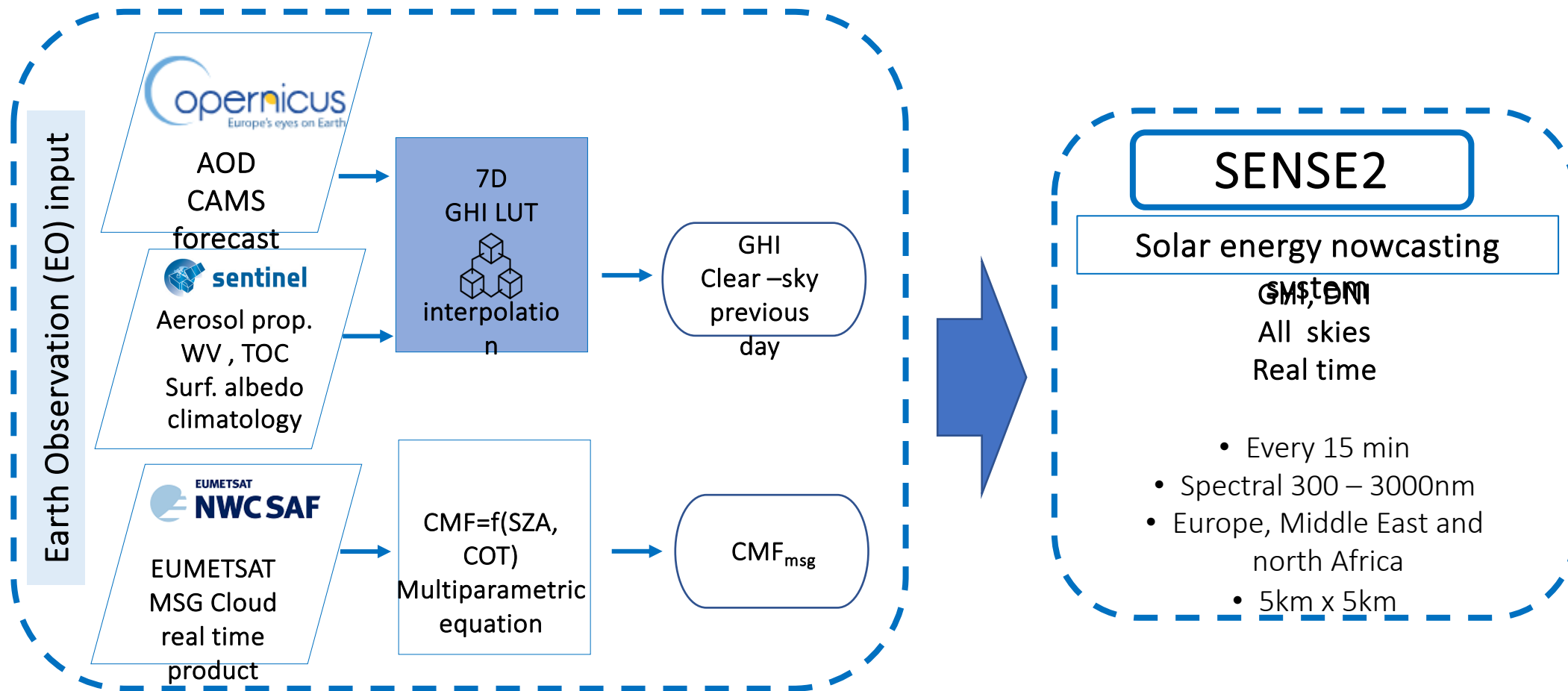 - The GEO Initiative GEO-VENER (GEO Vision for Energy) and GEO-CRADLE initiative
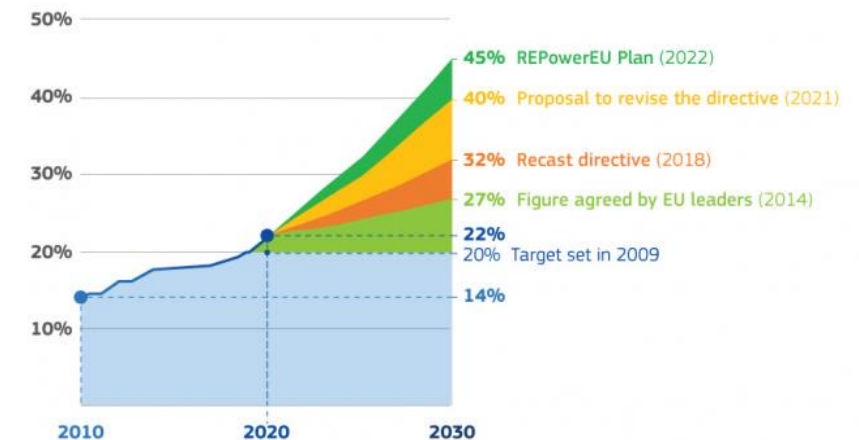
The problem

- Increase demand for solar energy ➔ more efficient production and integration to the electricity grid is needed – minimize cost for PV installations & infrastructure

- Fast, accurate, high spatial and high temporal resolution energy forecasts can contribute significantly towards this direction

- In order to nowcast or forecast solar energy in different time scales we need to know and understand changes in the Atmosphere, and how they affect solar radiation

- **Utilizing European EO resources:** Provide innovative and mature products and services for renewable energy development and management

e-shape

EuroGEO Showcases: Applications Powered by Europe: 2019-2023

SENSE2: Solar Energy Nowcasting system

Earth Observation (EO) input

Copernicus
Europe's eyes on Earth

AOD
CAMS
forecast

sentinel

Aerosol prop.
WV , TOC
Surf. albedo
climatology

EUMETSAT
NWC SAF

EUMETSAT
MSG Cloud
real time
product

7D
GHI LUT
interpolation

GHI
Clear –sky
previous
day

CMF=f(SZA, COT)
Multiparametric
equation

CMF_{msg}

SENSE2

Solar energy nowcasting
system
GHI, DNI
All skies
Real time

- Every 15 min
- Spectral 300 – 3000nm
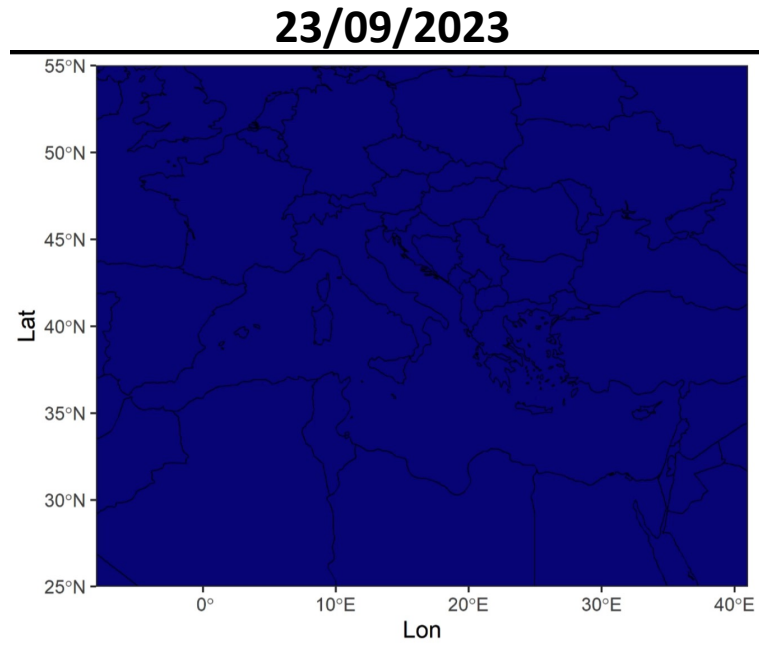- Europe, Middle East and north Africa
- 5km x 5km

SENSE2: Solar Energy Nowcasting system

Output:
Real time solar radiation for Europe, NAME (5Km², 15 min)

Validation with BSRN surface based solar radiation

23/09/2023

GHI (W/m²)

N=76778
MBE=11.3W/m2(2.3%)
RMSE=102W/m2(21.2%)
r=0.93
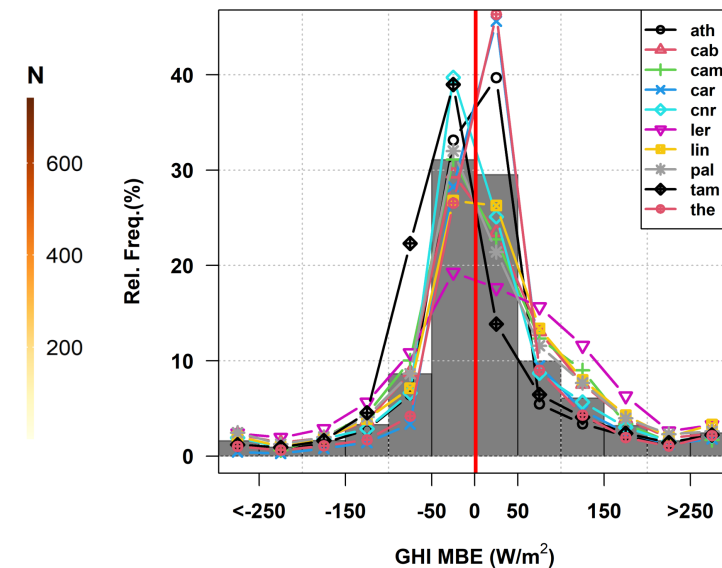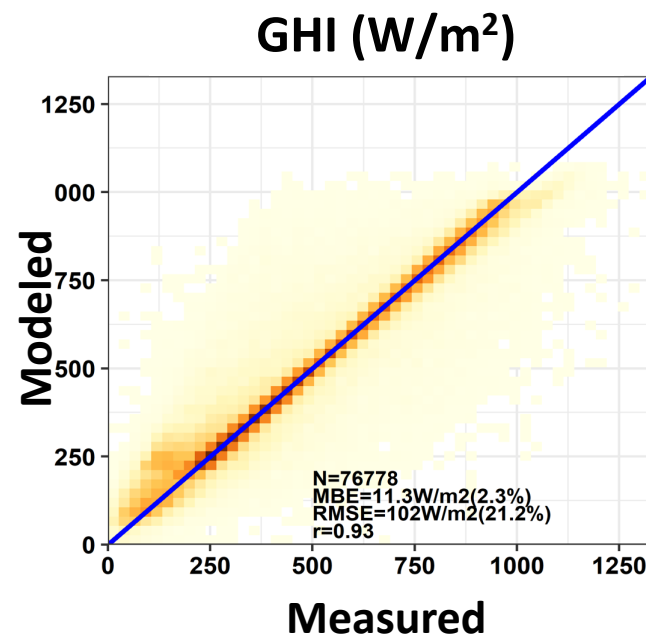
Kosmopoulos et al., 2018
Papachristopoulou et al. AMT, under review

NextSENSE2: Solar Energy short-term forecasting system

Earth Observation (EO) input

Copernicus
AOD CAMS forecast

sentinel
WV , TOC surface albedo climatology

7D GHI LUT interpolation

GHI Clear –sky previous day

COT MSG

EUMETSAT NWC SAF product

$CMF=f(SZA, COT)$ Multiparametric equation

CMF_{msg}

SENSE2

Solar energy nowcasting system

GHI, DNI
All skies
Real time

- Every 15 min
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COT MSG image t-1

COT MSG image t

Optical Flow

Cloud Motion Vectors CMVs

COT forecasted t_{+15min},....

Cloud motion vector

NextSENSE2

Solar energy short term forecasting system

GHI, DNI
All skies
forecasted

- Up to 3h ahead

NextSENSE 2 service

https://solar.beyond-eocenter.eu/#solar_short

NextSENSE2:

- Past data: Exploitation of historical data to define long term solar potential to specific areas

- Now-casting: Provide in real time the current solar radiation/energy at a pan-European and middle East and North African scale

- Short term forecasting: Provide a forecast for the next 0 to 4 hours solar radiation/energy at a pan-European and middle East and North Africa scale

- Long term forecasting: Provide a forecast for the next 1 to 2 days solar radiation/energy

- Spectral data : Health (UV Index, DNA Damage, Vitamin D), Agriculture (PAR)

nextSENSE2: solar energy nowcasting and short-term forecasting system

- **Objective:** provide EO and Copernicus (CAMS) based
  nowcasting (real-time) and short/long-term forecasting
  of broadband and spectral surface solar irradiance
  and solar energy,
  at high spatiotemporal resolution (coverage: Europe, Mediterranean basin, MENA)

- Support of TSOs, DSOs and national solar plant development initiatives.

- **Expected user community:** Grid operators, Power and Electricity corporations, ministries, energy trading companies, researchers in Energy and citizens.

- **Supporting infrastructure:** GEO-CRADLE, Beyond Collaborative Ground Segment Data Site

- Partners:
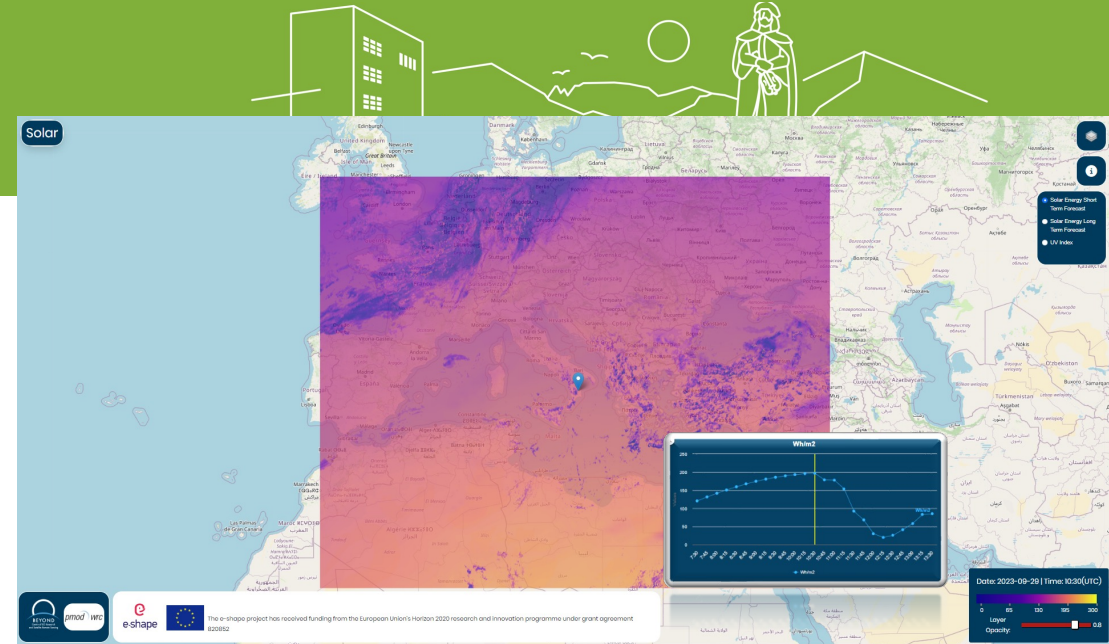
The Solar Energy forecasting pilot of E-shape & co-design aspects

- Past data: Exploitation of historical data to define long term solar potential to specific areas

Solar park characterization/planning and economic studies

Ministry of electricity and renewable Energy of Egypt & Mahdi Yacoub Heart Foundation Center, Egypt
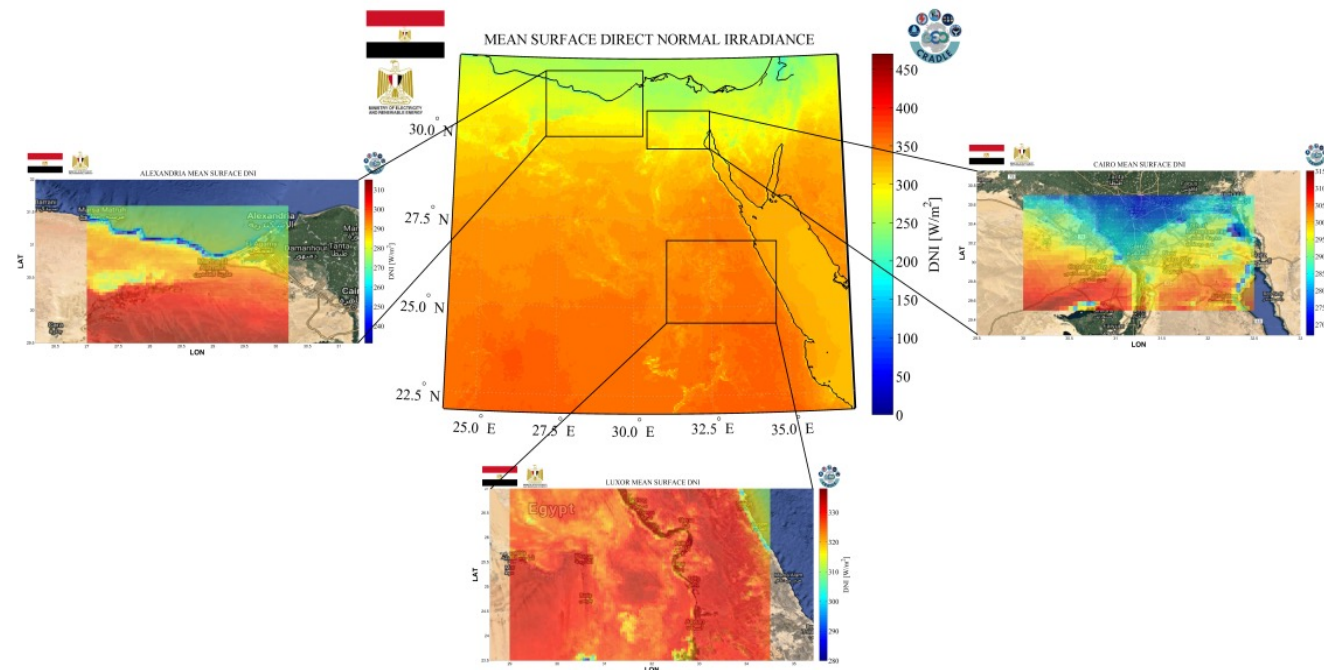
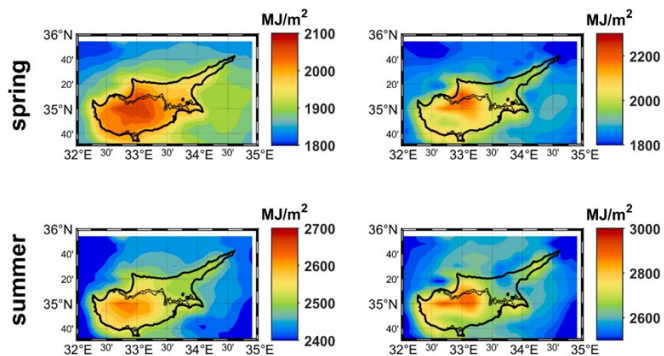## The Solar Energy forecasting pilot of E-shape & co-design aspects

- Now-casting: Provide in real time the current solar radiation/energy at a pan-European and middle East and North African scale

Cyprus Solar
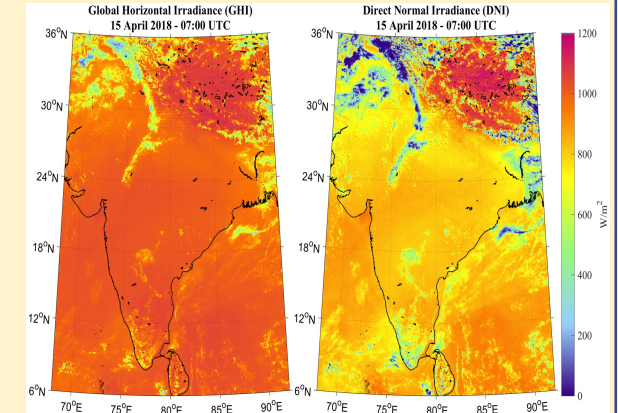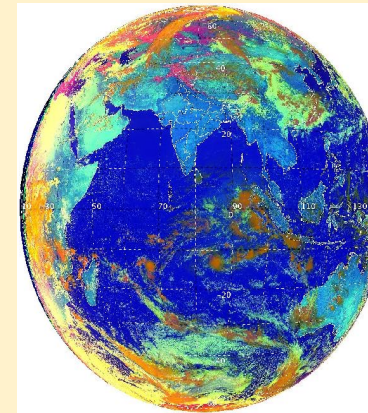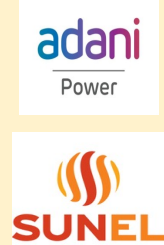
**Egypt: Economic impact**
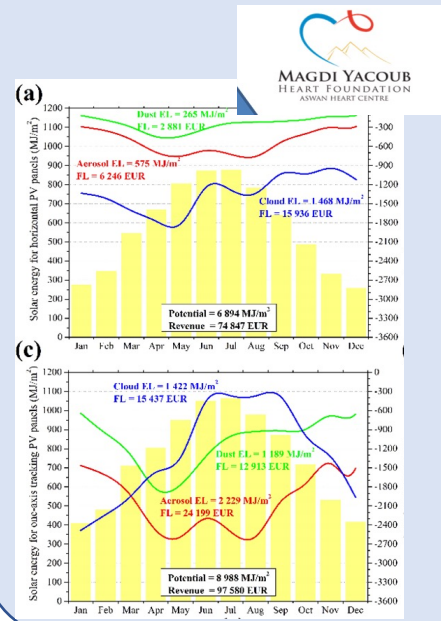
India: Sunel & Adani power

Masoom & Kazadzis., 2020
Fountoulakis 2022
Kosmopoulso at al., 2018

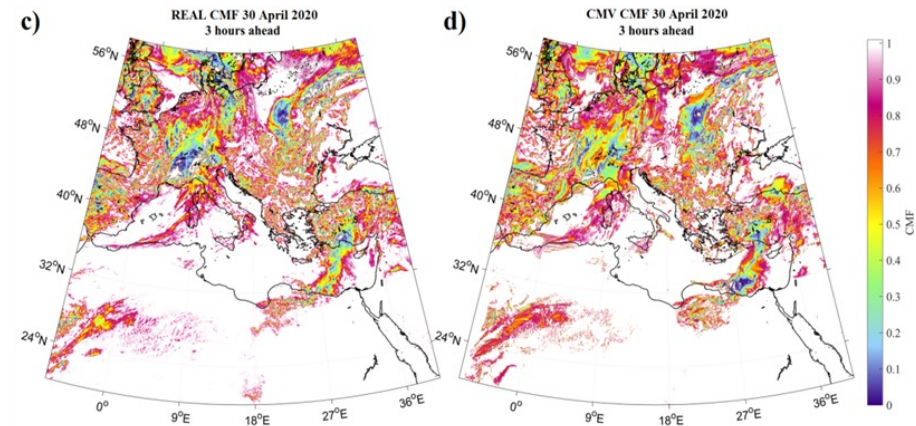## The Solar Energy forecasting pilot of E-shape & co-design aspects

- Short term forecasting: Provide a forecast for the next 0 to 4 hours solar radiation/energy at a pan-European and middle East and North Africa scale

Ind, Power transmission Operator Greek TSO

PARTICIPATION OF UNITS IN TOTAL PRODUCTION (%)
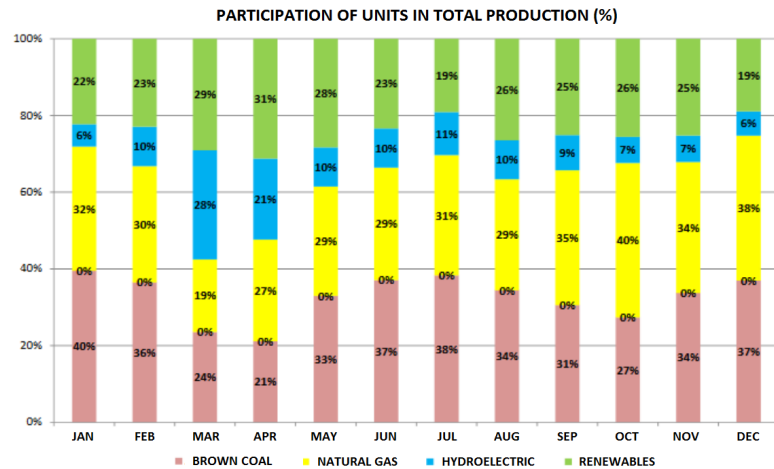
Public Power Corporation Renewables

Management of new PV parks
Energy demand and trade (new legislation)

The Solar Energy forecasting pilot of E-shape & co-design aspects

- Long term forecasting: Provide a forecast for the next 1 to 2 days solar radiation/energy

Public Power Corporation Renewables

Greek REN Authority   ->
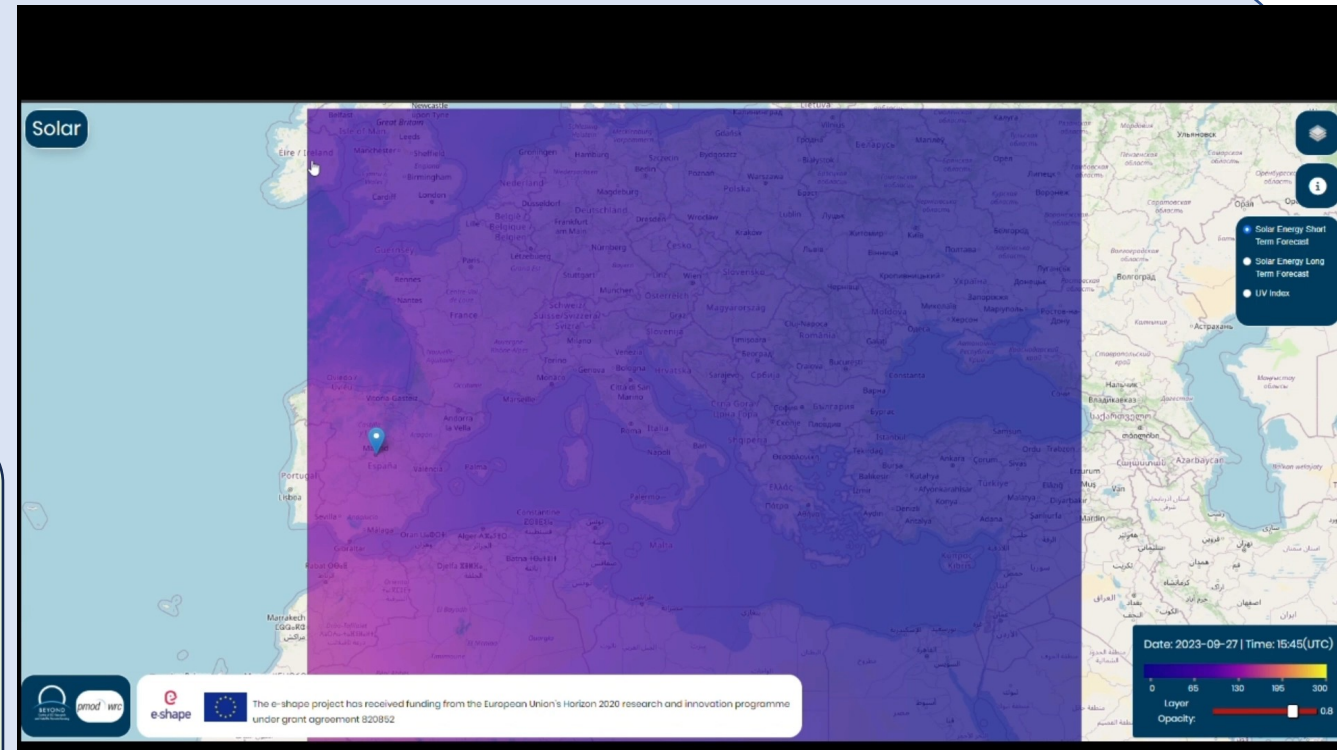Forecast NWP of clouds 1-2 days ahead
CAMS forecast for aerosol
Management of new PV parks
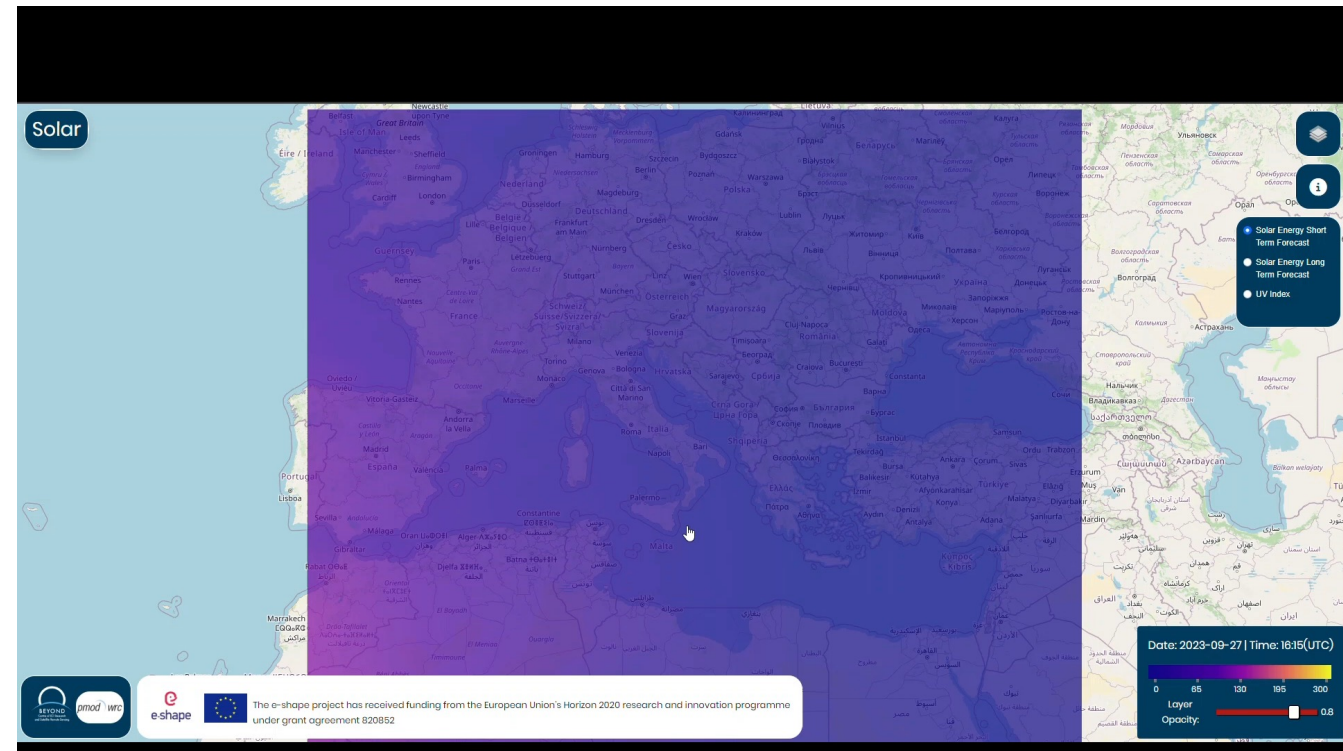Energy demand and trade (new legislation)

Long-term

Other applications developed / Use of Spectral solar data

Health:

- Forecasting up to 2days of the solar UV index (UV irradiance erythema on human skin)

UVI forecast

Science:

-Cloud and aerosol forecast improvements based on the triangle:

models –satellite EO – in situ data

- Destination Earth EU initiative (ESA, EUMETSAT, ECMWF data lakes) digital Innovation highly important for solar and wind applications

Way forward

User oriented apps

- Site adaptation: use such models as a base and integrate (local aspects) in situ measurements / historical data / AI techniques / probabilistic methods

- (Scaling up vs model accuracy trade off). Model adaptation to the infrastructure scale

Demonstrate/convince stakeholders of the importance of model accuracy where few % improvement equals high profits in a multibillion renewable future investment

EuroGEO renewable energy strategy:

GEO VENER, GEO-Cradle initiatives evolution (re-organization – Energy action group) towards targeted actions

Define roadmaps for sustainability of such applications - design of future joined actions

Addressing Green deal, EU energy legislation, agreements and initiatives and UN SDG goal for clean energy