



# PVGIS 5.2: Adapting PVGIS to Trends in Climate, Technology and User Needs

COST PEARL PV, 15 March 2022

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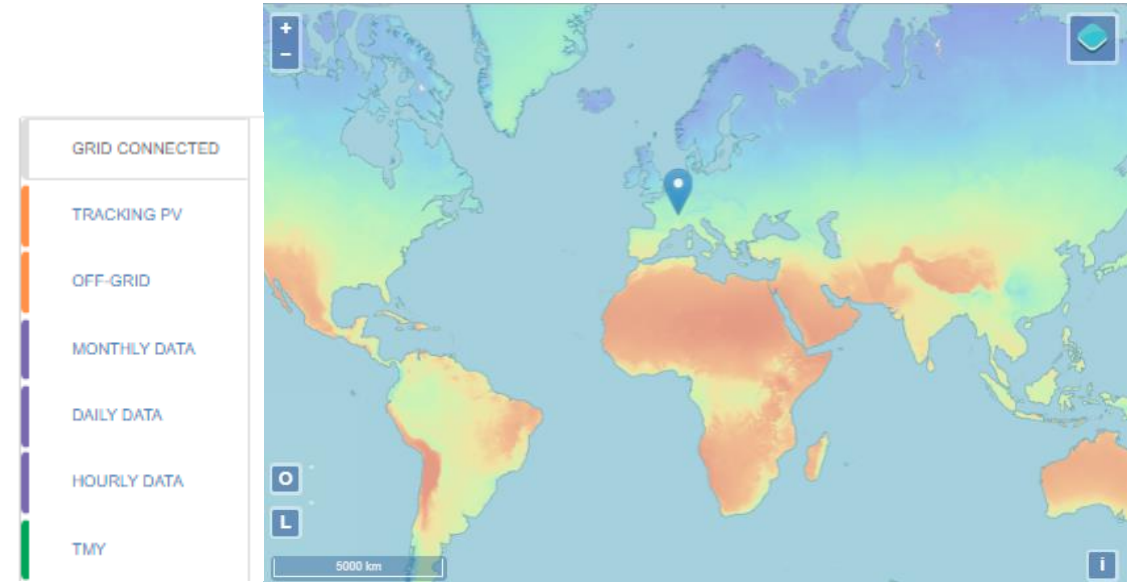
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- The PVGIS approach
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- Ground Station Verification
- First look at implications for PV output
- Conclusions

# PVGIS: online tool for PV production estimation

- PVGIS provides high-quality and high-resolution data at continental scale:
  - Solar radiation
  - Climatological variables
  - PV production estimates
- Created by JRC 20 years ago, available for free, no registration
- In 2021, 3.2 million users and over 465 millions data requests



**[Link to the PVGIS Tool](#)**

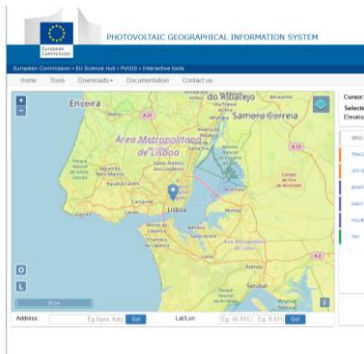
# How it works

User selects location & PV system parameters

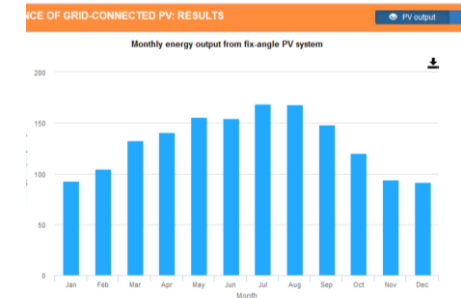
PVGIS identifies the “tile” with the full hourly time series for the location

Makes an on-the-fly calculation of hourly PV production

Outputs the average monthly and yearly production in kWh

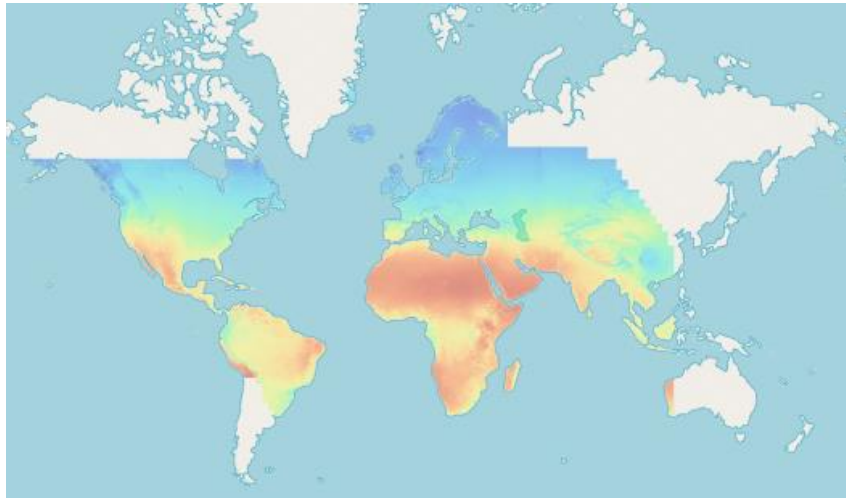


$$\begin{aligned} P(G', T') &= G' P_{STC} \left( 1 + k_1 \ln(G') \right. \\ &\quad \left. + k_2 (\ln(G'))^2 + k_3 T' \right. \\ &\quad \left. + k_4 T' \ln(G') + k_5 T' (\ln(G'))^2 \right) \end{aligned}$$



# PVGIS 5.1

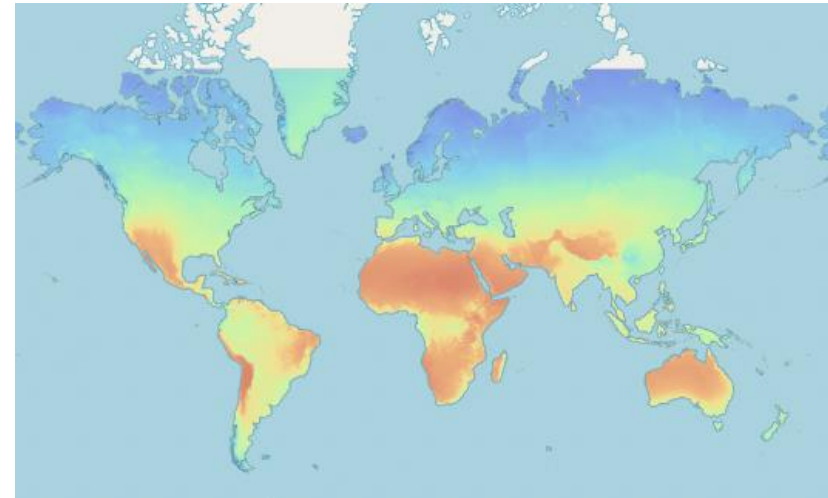
Solar data: SARAH  
Other: ERA-Interim



2005 - 2016

# PVGIS 5.2

Solar data: SARAH2  
Other: ERA5 & ERA5-Land



2005 - 2020

# Database Update

Parameter	PVGIS 5.1
<b>Solar radiation</b> (satellite)	CMSAF SARA-H-1 Time frame 2005-2016 Resolution: 1 h temporal, 5 x 5 km spatial Meteosat images with CMSAF SPECIMAGIC
<b>Solar radiation</b> (reanalysis)	ECMWF ERA5 Time frame 2010-2016 Resolution: 1 h temporal, 31 x 31 km spatial
<b>Temperature</b>	ECMWF ERA-Interim, res. 1 h <sup>(*)</sup> , 81 x 81 km
<b>Wind Speed</b>	ECMWF ERA-Interim, res. 1 h <sup>(*)</sup> , 81 x 81 km
<b>Other TMY variables</b>	ECMWF ERA-Interim, res. 1 h <sup>(*)</sup> , 81 x 81 km
<b>Spectral corrections</b>	SARA-H-1 (2011)
<b>Digital Elevation Model</b>	SRTM 3 DEM (90 m)
<b>Horizon</b>	GRASS function, from DEM

<sup>(\*)</sup> Interpolated from 3h data

# Database Update

Parameter	PVGIS 5.1	Proposed Update
<b>Solar radiation</b> (satellite)	CMSAF SARA-H-1 Time frame 2005-2016 Resolution: 1 h temporal, 5 x 5 km spatial Meteosat images with CMSAF SPECMAGIC	<b>CMSAF SARA-H-2</b> <b>Time frame 2005-2020</b> <b>Resolution: unchanged</b>
<b>Solar radiation</b> (reanalysis)	ECMWF ERA5 Time frame 2010-2016 Resolution: 1 h temporal, 31 x 31 km spatial	<b>ECMWF ERA5</b> <b>Time frame 2005-2020</b> <b>Resolution: unchanged</b>
<b>Temperature</b>	ECMWF ERA-Interim, res. 1 h <sup>(*)</sup> , 81 x 81 km	<b>ERA5-Land resolution: 1 h, 9 x 9 km</b>
<b>Wind Speed</b>	ECMWF ERA-Interim, res. 1 h <sup>(*)</sup> , 81 x 81 km	<b>ERA5-Land resolution: 1 h, 9 x 9 km</b>
<b>Other TMY variables</b>	ECMWF ERA-Interim, res. 1 h <sup>(*)</sup> , 81 x 81 km	<b>ERA5-Land resolution: 1 h, 9 x 9 km</b>
<b>Spectral corrections</b>	SARA-H-1 (2011)	Unchanged
<b>Digital Elevation Model</b>	SRTM 3 DEM (90 m)	Unchanged
<b>Horizon</b>	GRASS function, from DEM	Unchanged

<sup>(\*)</sup> Interpolated from 3h data

# Pipeline for PVGIS binary data files

A new software “pipeline” has been created to produce a new PVGIS database with updated binary files. Steps for each parameter include:

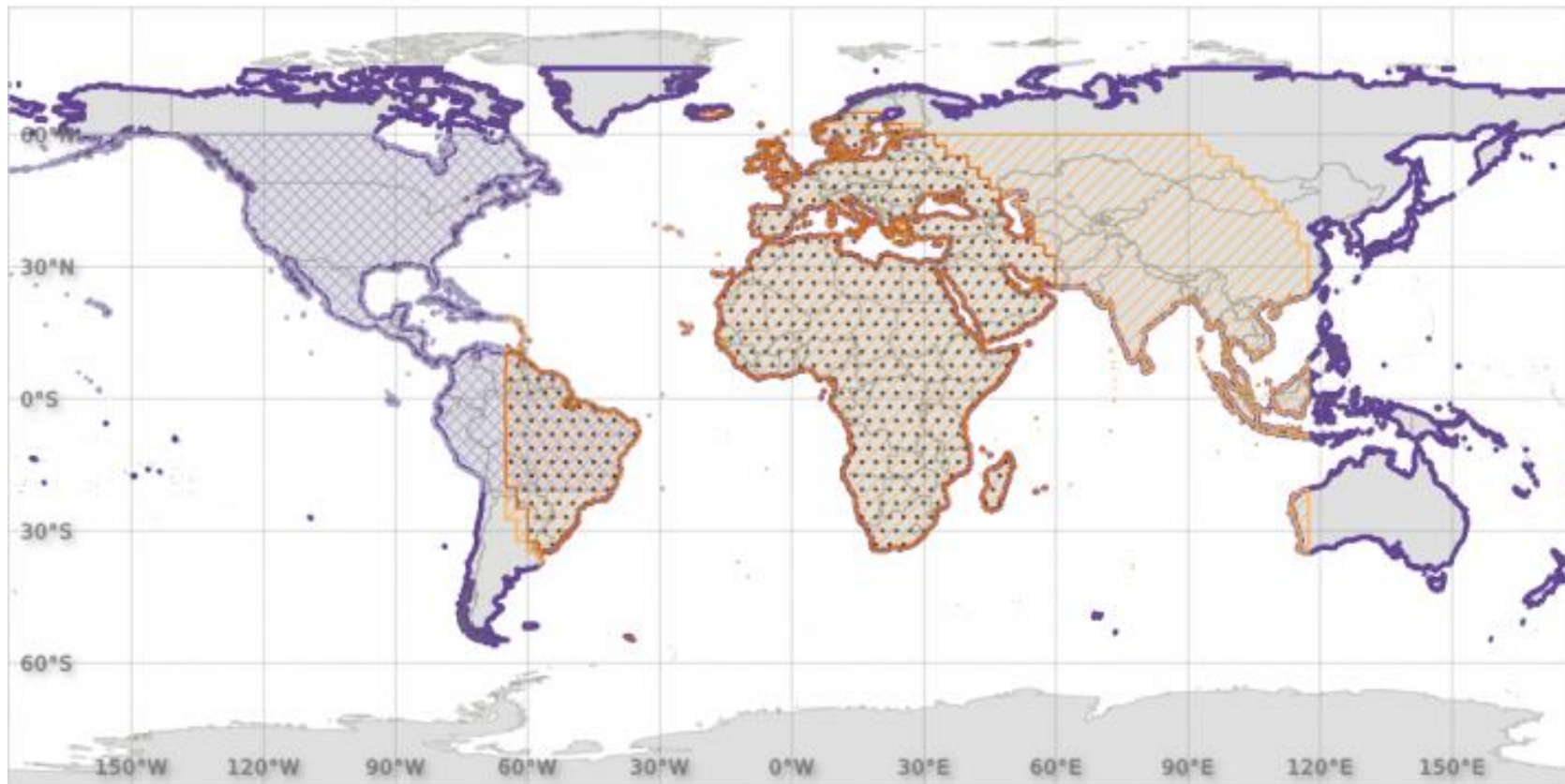
- Obtain GIS raster data per variable (2005 to 2020)
- Geo shift to PVGIS tile coordinate system
- Re-format to hourly time series per pixel into the PVGIS tiles (2.5° x 2.5°)
- Create tile binary files (one for each variable)

*We acknowledge the support and collaboration with the Deutscher Wetterdienst, Satellite-based Climate Monitoring Referat and the EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF) work programme*



# PVGIS 5.2

## Coverage of Solar Radiation Databases

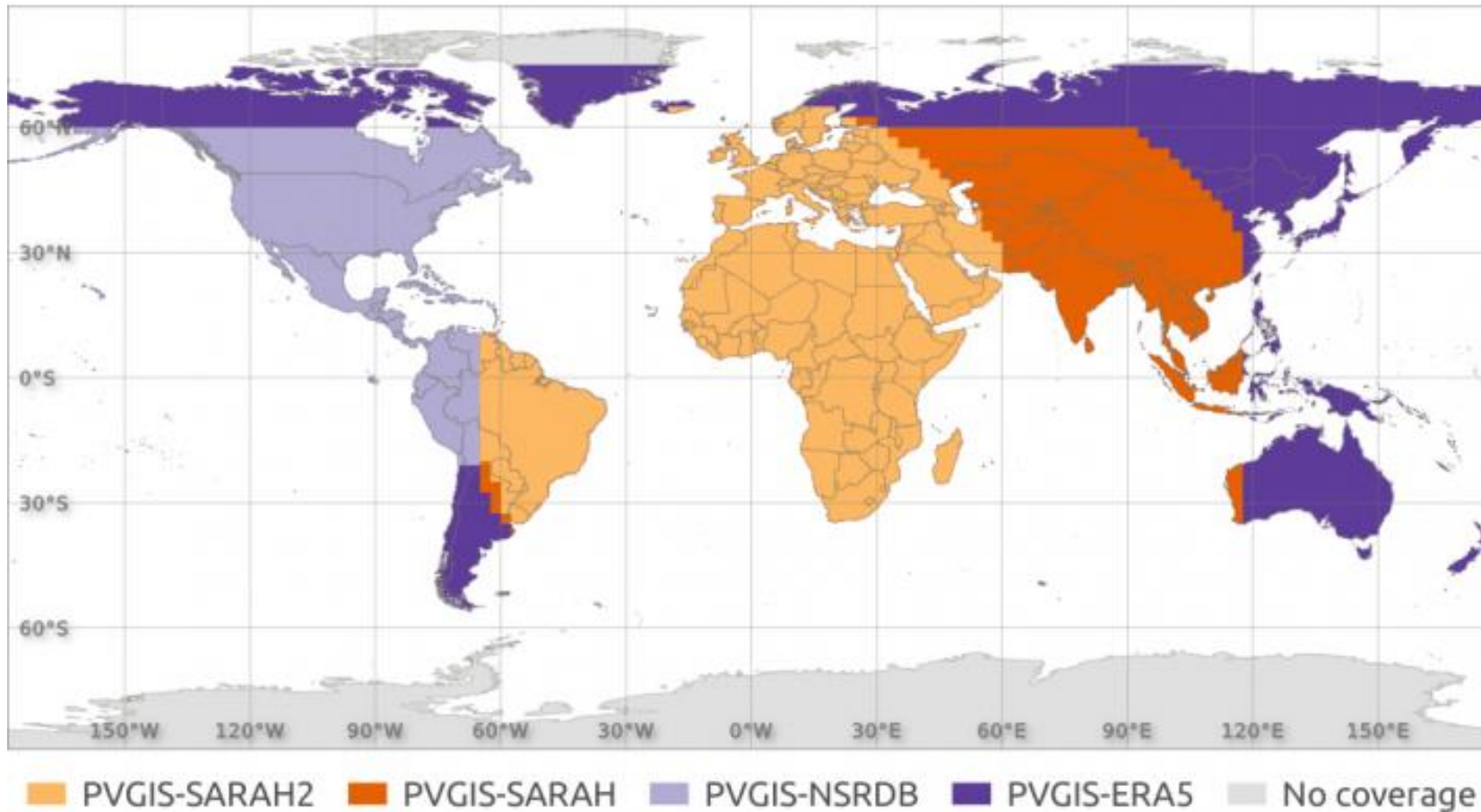


⋯ PVGIS-SARAH2    / PVGIS-SARAH    ✖ PVGIS-NSRDB    □ PVGIS-ERA5    □ No coverage

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# PVGIS 5.2

## Default Solar Radiation Databases

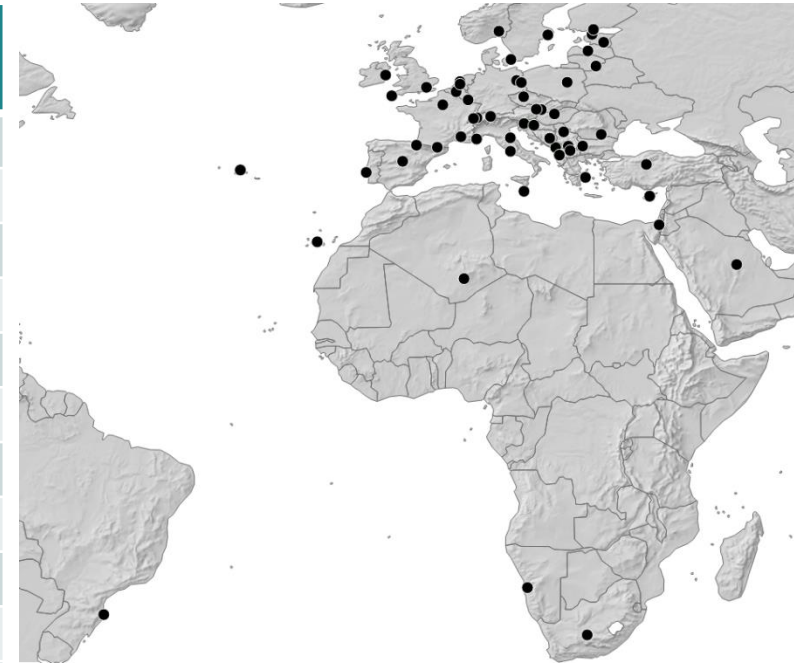


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# Validation vs. Ground Station Data (BSRN)

## Validation of SARA-2 hourly global horizontal irradiance

Station	MBD (W/m <sup>2</sup> )	rMBD (%)	RMSD (W/m <sup>2</sup> )	rRMSD (%)	Points	Year_0	Year N
cab	1.3	0.5	86.9	37.3	74,143	2005	2020
cam	-1.6	-1.2	74.3	56.6	98,709	2005	2017
car	6.7	3.0	56.5	24.9	94,748	2005	2018
cnr	7.0	2.3	85.2	28.3	55,756	2009	2020
daa	3.3	1.3	79.6	31.8	45,316	2005	2020
ena	2.0	1.0	65.8	34.4	7,696	2015	2015
flo	4.3	1.6	112.2	40.8	40,258	2013	2020
gob	3.3	0.6	60.8	11.1	37,745	2012	2020
iza	-68.7	-23.0	176.5	59.2	96,969	2009	2020
lin	2.2	1.4	70.0	43.3	95,861	2005	2018
pay	0.7	0.4	72.4	37.1	105,299	2005	2020
sbo	10.2	2.3	74.0	16.7	35,734	2005	2012
tam	1.4	0.3	98.0	17.6	67,781	2005	2020
tor	-1.7	-1.4	58.6	47.5	128,015	2005	2020



MBD: mean bias deviation  
RMSD: root mean square deviation

# Validation vs. Ground Station Data (BSRN)

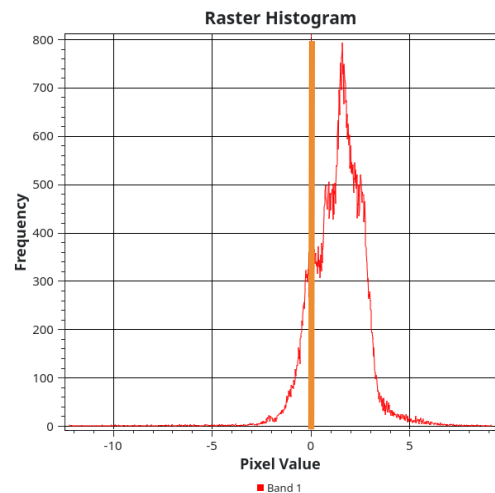
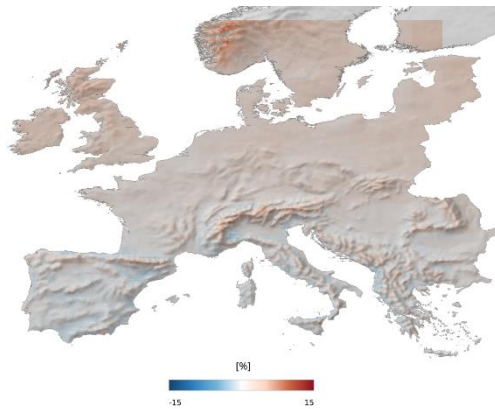
Comparison SARA-H1 vs SARA-H2 (excl. Izaña)

	MBD General	St Dev	RMSD General	St Dev
<b>Radiation</b>	W/m <sup>2</sup>	W/m <sup>2</sup>	W/m <sup>2</sup>	W/m <sup>2</sup>
SARA-H1	-0.8	4.7	81.1	18.9
SARA-H2	2.2	3.4	75.7	16.0

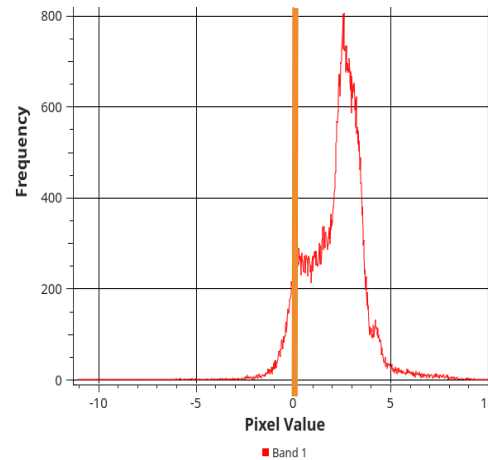
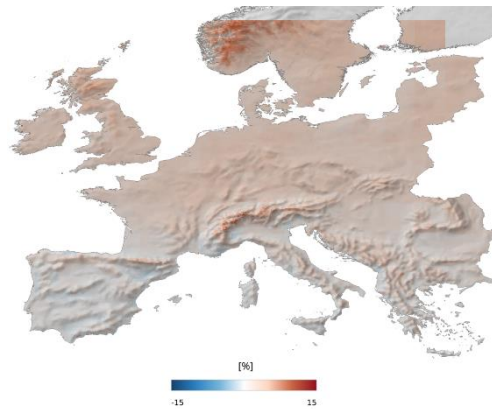
Comparison ERA-Interim vs ERA5-Land

	MBD General	St Dev	RMSD General	St Dev
<b>Temperature</b>	°C	°C	°C	°C
ERA-Interim	0.9	3.6	4.6	3.1
ERA5-Land	0.3	1.9	2.8	1.67

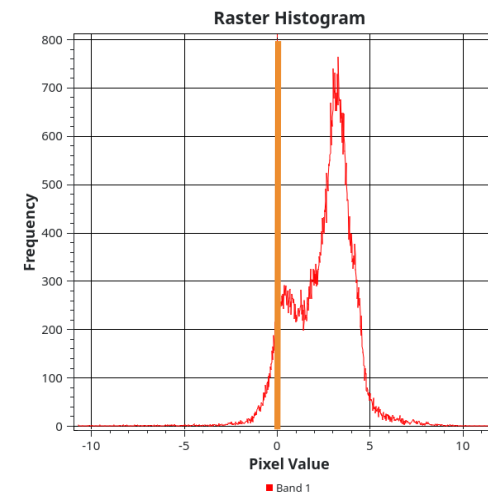
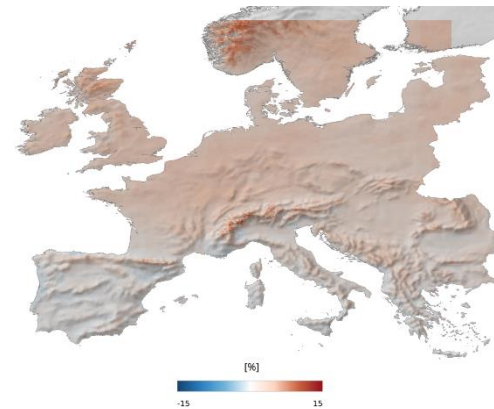
# Annual average global horizontal irradiation



SARAH-2 vs. SARAH-1  
(2005-16)



SARAH-2 (2005-20) vs.  
SARAH-1 (2005-16)



SARAH-2 (2009-20) vs.  
SARAH-1 (2005-16)

% difference of calculated  
values considering

SARAH-2 vs SARAH-1



# Conclusions

- CMSAF SARA-H-2 and ECMWF ERA5-Land data for Europe reformatted for PVGIS database and validated against ground stations data and PVGIS 5.1 datasets.
- Preliminary analysis shows that including 2017-2020 data leads to increases in both annual irradiation and PV production by a few % for most locations. Further validation is in progress.
- PVGIS 5.2 released on 1 March based on SARA-H-2 and ERA5-Land data.
- What's next: updated PV performance model & more.

# Thank you



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