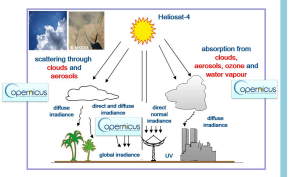
CAMS Solar Radiation Service, variability-based evaluation and service evolution to other parts of globe

Faiza Azam[1], Jethro Betcke[1], Marion Schroedter-Homscheidt[1], Mireille Lefevre[2], Yves-Marie Saint-Drenan[2], Laurent Saboret[3], Stéphane Andrietti[3]

[1]German Aerospace Center (DLR), Institute of Networked Energy Systems, Oldenburg, Germany; [2]MINES Paris, France; [3]Transvalor, France faiza.azam@dlr.de

CAMS Solar Radiation Service

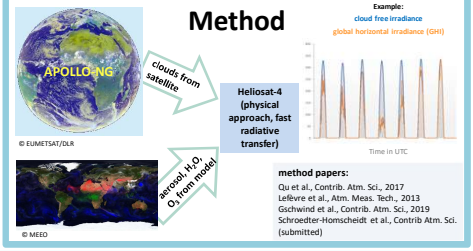
Copernicus Atmospheric Monitoring service (CAMS) offers **Solar radiation services (CRS)** providing information on surface solar irradiance (SSI). The services meet the needs of European and national policy development and the requirements of partly commercial downstream services in the solar energy sector for e.g. planning, monitoring, efficiency improvements, and integration of renewable energies into the energy supply grids. CRS is provided by DLR with the SoDa team MINES Paris and Transvalor and with FMI (Finnish Meteorological Service).



Data characteristics

- Feb. 2004 upto 2 days behind real time, online
- Global, Diffuse, Direct & Direct normal irradiation
- Temporal resolution: 1 min, 15 min, 1 hour, 1 day, 1 month
- Global coverage for clear sky parameters and total-sky radiation time series and gridded data for Europe/Africa/Middle East
- Expert mode with all input parameters used and data provided with and without bias correction

Method

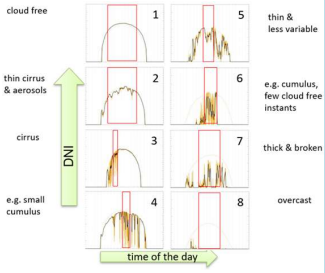


CAMS Radiation Scheme (recent improvements)

	CAMS 3.2 (previous version)	CAMS 4.0 (operational)
Calibration	Reflectances as provided by EUMETSAT	Time-dependent updated calibration coefficients from KNMI based on Meirink et al. 2013 & updates
Cloud retrieval	APOLLO, binary cloud mask based on Kriebel et al. 1988 and 1989	APOLLO-NG, probabilistic cloud mask from Klüser et al. 2015 (cloud confidence level)
	Cloud optical thickness (COT) using Stephens et al. 1984 scheme with clipping at COT < 0.5	COT using Stephens et al. 1984 scheme with COT LUTs extended to 0.001
Cloudy/Clear decision Heliosat-4	Is based on a binary mask	Cloud probability threshold 1%
Circumsolar correction	Single COT value	Empirical apparent COT modification factor for direct normal irradiance (DNI) calculation: • 0.41 for optical thin ice clouds • 0.20 for water/mixed phase clouds
Bias correction	Empirical multiplication factor	Re-trained bias correction

Ground based variability classes

- DNI has greater sensitivity to clouds compared to GHI
- 8 variability classes are defined based on ground-based 1-minute-resolved DNI patterns
- Automatic classification is possible from ground-based direct irradiance time series, sky cameras and using cloud mask from satellite
- Method ground based variability classes: Schroedter-Homscheidt, et al., Meteorol. Z., DOI:10.1127/metz/2018/0875

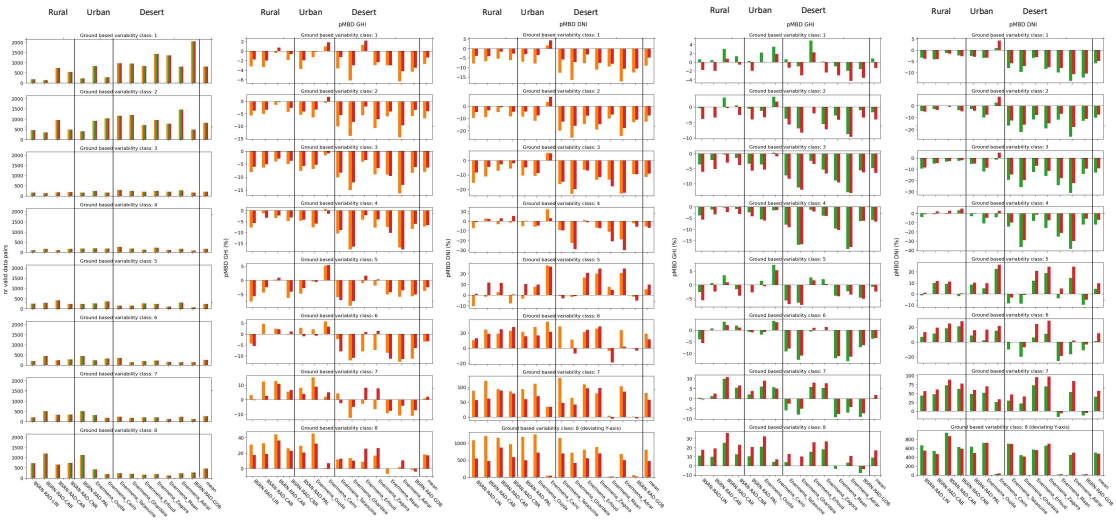


Validation

- Variable classes based assessment of all-sky SSI
- Data used (year 2015):

  Ground based variability classes time series; CAMS GHI & DNI for versions 3.2 and 4.0; BSRN & Enermena stations GHI and DNI as reference
- Percental relative mean bias (pMBD) are shown
- CAMS 4.0 vs CAMS 3.2:
  - quality of CAMS Radiation Services improved significantly
  - some stations in desert regions: increased DNI bias under 'variable cloud conditions', but very small number of occurrences
- Current operational version, CAMS 4.0:
  - bias correction as a post processing is not effective anymore for GHI, it was mainly correcting instrument calibration errors
  - GHI: both aerosol and thick cloud dominated cases are made worse but compensate each other
  - DNI: variable cloud situations are made worse

Decision: bias correction scheme will be removed in CAMS 4.5

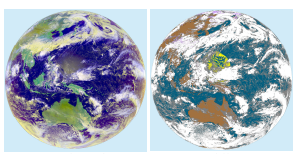


Service extension to other parts of globe

- In the previous CAMS-72 project (2019-2021), a feasibility study was performed for the extension of CRS to other parts of the globe using the third generation of geostationary satellite instruments as Geostationary Operational Environmental Satellite 16 (GOES-16) by NASA and NOAA and HIMAWARI-8 Advance HIMAWARI Imager (AHI) by Japan Meteorological Agency (JMA). The evaluation of the results was in line with the literature on using these instruments in the retrieval scheme.
- One of the objective of the current CAMS2-73 project is the service provision in the HIMAWARI field of view.
- AHI data acquisition: For the online processing chain, near real time data available from EUMETSAT's EUMETCast is used. For the offline processing of the historical data, Austrailian Bureau of Meteorology's (ABOM) archive data or the previously downloaded EUMETCast data is used.
- AHI has 16 bands. For all-sky, APOLLO-NG is currently using the full disk data in 2 km spatial resolution and in the full temporal resolution of 10 minutes for bands 3, 4, 5 , 13 and 15.
- HIMAWARI is currently being integrated in the CRS operational processing chain at DLR and Transvalor.

	Scan	Scan Coverage (km)	Temporal resolution (minutes)	*Spatial resolution (km)
HIMAWARI-8 AHI	Full Disk	Asia	10	0.5 - 2.0
	Japan region	2000 x 1000	2.5	0.5 - 2.0
	Target area	1000 x 1000	2.5	0.5 - 2.0
	Landmark area	1000 x 500	0.5	0.5 - 2.0

* Spatial resolution: 0.5km (band 3), 1km (band 1,2,4), 2km (band 5-16)



May 15, 2022, 03:00 UTC (JST: 12:00) HIMAWARI-8 AHI color composite (left) and the APOLLO-NG cloud mask (right). Cloud masking: Fully cloudy in white, partially cloudy in grey & glint area in yellow

References

- Kriebel et al., 1989: Optical Properties of Clouds Derived from Fully Cloudy AVHRR Pixels. Beiträge zur Physik der Atmosphäre, Vol. 62, No. 3, pp. 165-171, August 1989
- Klüser et al., 2015: APOLLO_NG – a probabilistic interpretation of the APOLLO legacy for AVHRR heritage channels, Atmos. Meas. Tech., 8, 4155-4170
- Lefèvre et al., 2013: McClear: a new model estimating downwelling solar radiation at ground level in clear-sky conditions, AMT, 2013
  Gschwind et al., 2019: Improving the McClear model estimating the downwelling solar radiation at ground level in cloud-free conditions – McClear-v3, Contrib. Atm. Phys./Meteorol. Z., 2019
- Stephens et al., 1984: A Shortwave Parameterization Revised to Improve Cloud Absorption, Journ. Atm. Scienc., Vol 41, no 4, 687-690
- Schroedter-Homscheidt, M., et al., 2018: Classifying ground-measured 1 minute temporal variability within hourly intervals for direct normal irradiances. – Meteorol. Z. 27, 2, 160–179. DOI:10.1127/metz/2018/0875
- Schroedter-Homscheidt, M., et al., Surface solar irradiation retrieval from MSG/SEVIRI based on APOLLO Next Generation and HELIOSAT-4 methods, submitted Contrib Atm. Sci.
- Meirink, J.F., et al., 2013: Inter-calibration of polar imager solar channels using SEVIRI, Atmos. Meas. Tech., 6, 2495-2508.
- Qu et al., 2017: Fast radiative transfer parameterisation for assessing the surface solar irradiance: The Heliosat-4 method, Contrib. Atm. Phys./ Meteorol. Z., 2017
- User's Guide at http://atmosphere.copernicus.eu/documentation

Acknowledgments

- This work is supported by the CAMS program, which is part of the EU Copernicus Program and implemented by ECMWF on behalf of the EU.
- We are thankful to: Australian Bureau of Meteorology's (ABOM) and EUMETSAT for HIMAWARI data provision; the Baseline Surface Radiation Network (BSRN) and Enermena for the ground measurements of GHI and DNI data.