The new CAMS Radiation Service v4.5 – method improvements and variability class-dependent validation

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The CAMS radiation service principle

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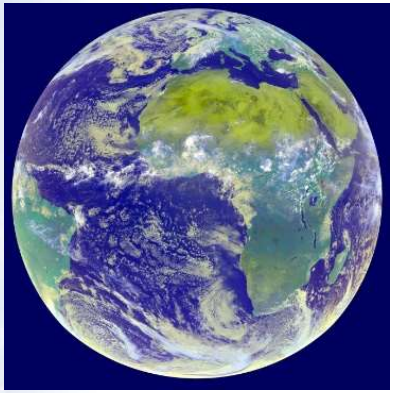

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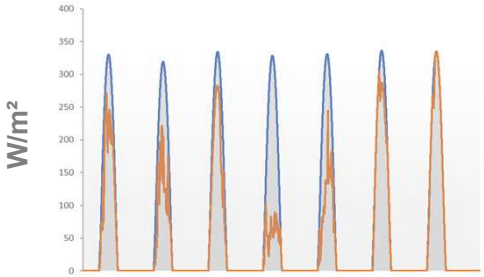
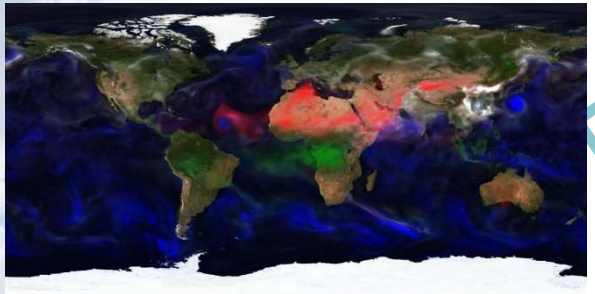
clouds from satellite

Heliosat-4 and McClear physical approaches, fast radiative transfer





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aerosol H_2O, O_3 from model

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Energy Meteorology

Surface solar irradiation retrieval from MSG/SEVIRI based on APOLLO Next Generation and HELIOSAT-4 methods

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Abstract

This study investigates the optimum usage of the new APOLLO Next Generation (APOLLO_NG) cloud retrieval scheme in the Heliosat-4 solar surface irradiance retrieval scheme. APOLLO_NG replaces the previously used APOLLO scheme and introduces a probabilistic cloud mask instead of binary cloud masking used previously. A cloud probability threshold of 1 % was found optimal for the usage of the Heliosat-4 cloud

Qu
Schroedter-Homscheid
Lefèvre
Gschwind et al., Contrib. Atm. Sci., 2019

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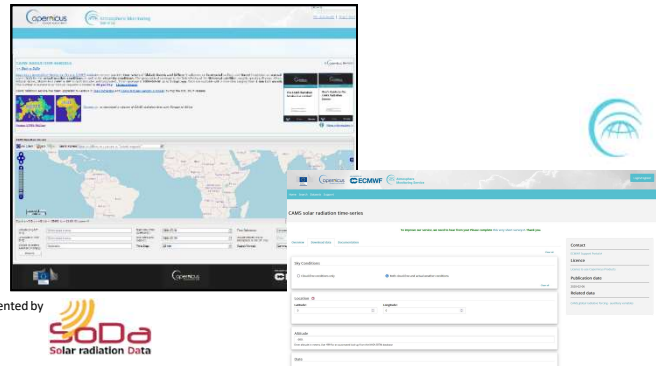
Time series on-the-fly and gridded data

on-the-fly processing of time series

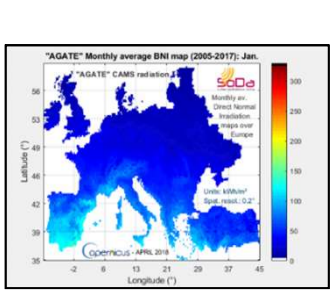
- global, diffuse, direct and direct normal irradiation
- time series 2004 onwards
  1 min, 15 min, 1 hour, 1 day, 1 month temporal resolution
- any point within satellite field of view
- interactive access on CAMS ADS and user portal
- OGC script access possible or via open source library
- transparent access to all input data used if 1 min is selected

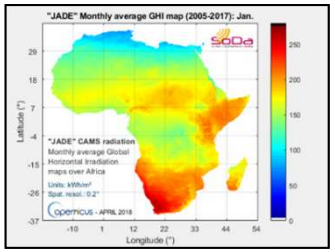
pre-calculated gridded data

- 15 min temporal resolution
- 2005-2022
- 0.2° gridded data
- update foreseen 0.1° gridded



implemented by





https://www.soda-pro.com/web-services/radiation/cams-mcclear

https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-solar-radiation-timeseries

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Recent improvements

	CAMS 3.2 (until 05/2021)	CAMS 4.0 (until 09/2022)	CAMS 4.5 (from 09/2022)
Calibration	Reflectances as provided by EUMETSAT	Time-dependent updated calibration coefficients from KNMI based on Meirink et al. 2013 & updates	same
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)	same
	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	same
Cloudy/ Clear decision Heliosat-4	based on a binary mask	Cloud probability threshold 1%	same
Circumsolar correction	Single COT value	Empirical apparent COT modification factor for direct normal iradiance (DNI) calculation: • 0.41 for optical thin ice clouds • 0.20 for water/mixed phase clouds	same
Aerosol/ TWC/O3	MACC reanalysis & CAMS NRT, various versions	MACC reanalysis & CAMS NRT, various versions	CAMS reanalysis
Bias correction	Empirical multiplication factor	Re-trained bias correction	No bias correction

Bias correction scheme removed

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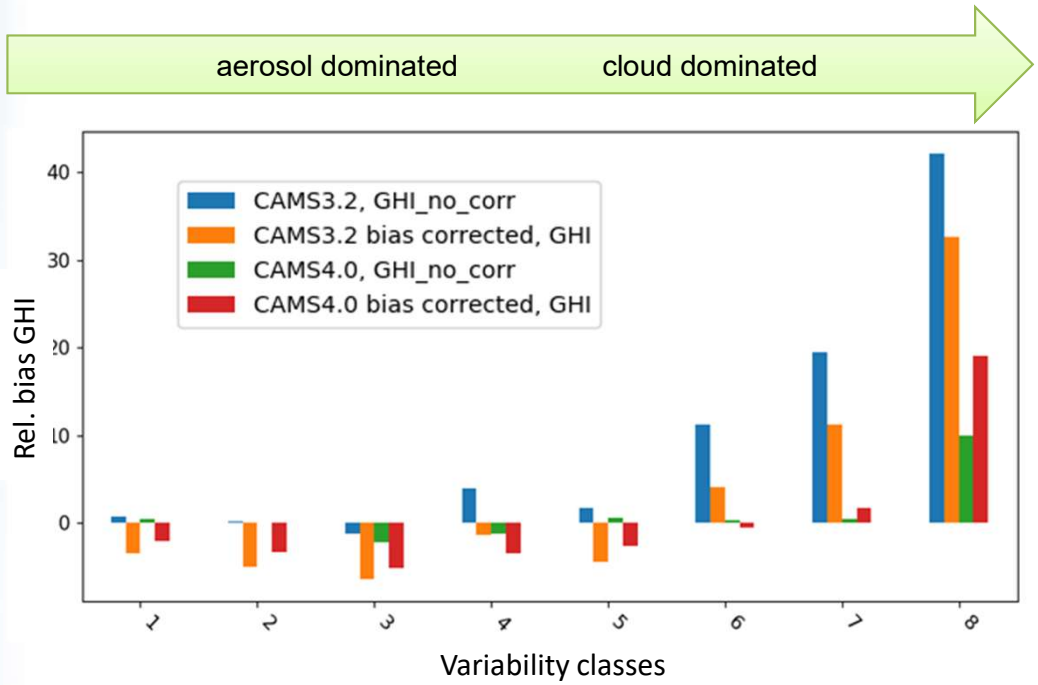

Example: BSRN Cabauw, 2015

- Clear improvement from v3.2 to v4 in cloudy situations
- Bias correction

  V3.2:
  compensating errors in aerosol- and cloud dominated situations

  V4.0:
  bias correction worse in most situations

  -> switched off in v4.5

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Further results v3.2 vs. pre-version 4

International Energy Agency
Photovoltaic Power Systems Programme

IEA PVPS TASK 16 - SOLAR RESOURCE FOR HIGH PENETRATION AND LARGE SCALE APPLICATIONS

Worldwide benchmark of modelled solar irradiance data

IEA PVPS Task 16, Report IEA-PVPS T16-05:2023

ISBN 978-3-907281-44-4

Main Authors: A. Forstinger, S. Wilbert, A. R. Jensen, B. Kraas, C. Fernández-Peruchena, C. A. Gueymard, D. Ronzio, D. Yang, E. Collino, J. Polo Martinez, J. A. Ruiz-Arias, N. Hanrieder, P. Blanc, Y.-M. Saint-Drenan

The Technical Report is available for download from the IEA-PVPS website www.iea-pvps.org.

See next presentation…

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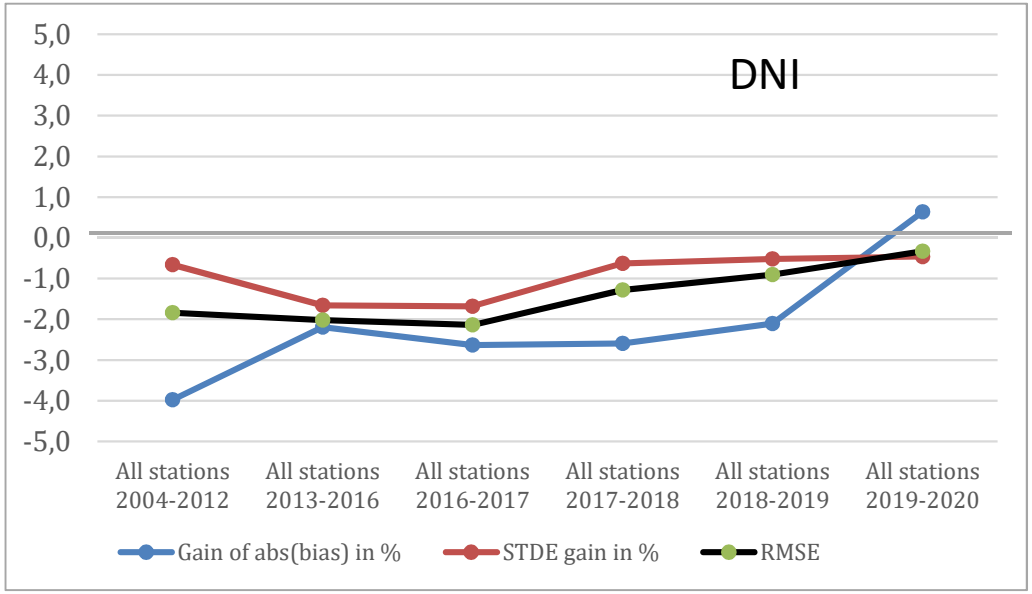
CAMS reanalysis

Replacing consecutive updates with the CAMS reanalysis -> used in v4.5
Minor changes in GHI, but positive impact for DNI and DIF

Abs. Bias
STDV
RMSE

better



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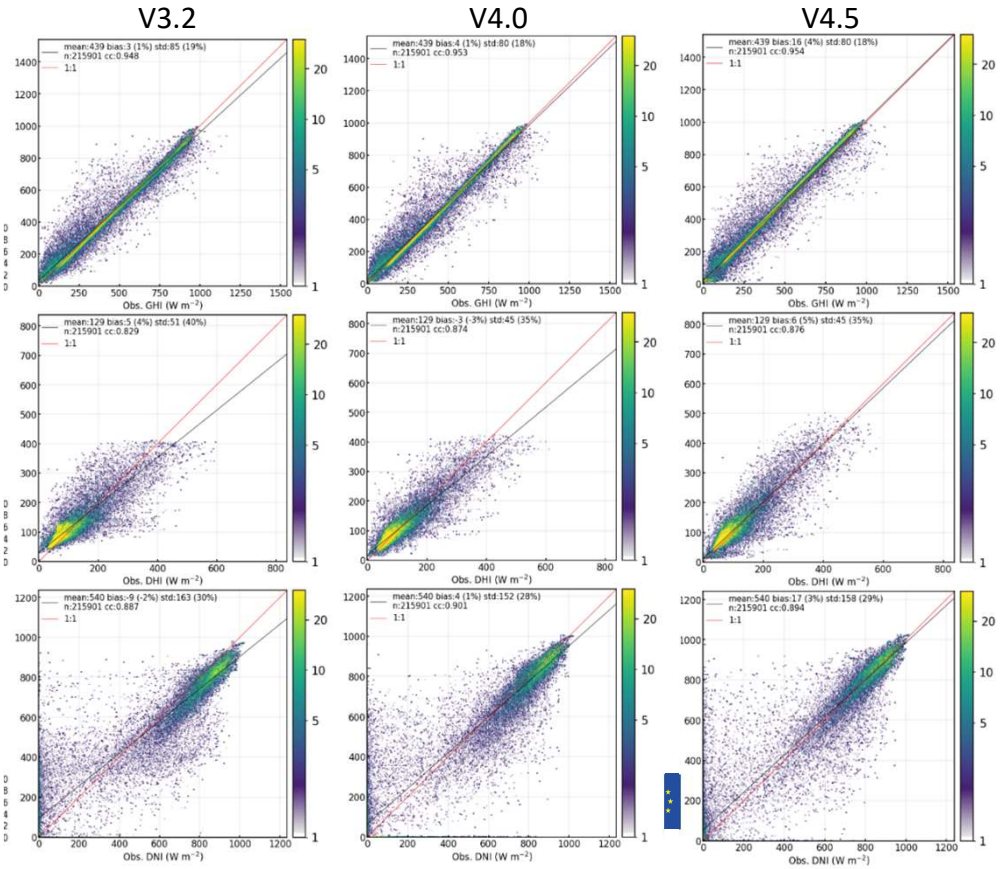
V3.2 -> v4 (new clouds) -> v4.5 (new AER/TWC/O3)



Note: This is 1 min data == developer view

For users more relevant is hourly validation which overcomes the point/area mismatch.

This is done in regular quarterly validation reports (see CAMS web page)

Example: Carpentras, 2017, 1 min data

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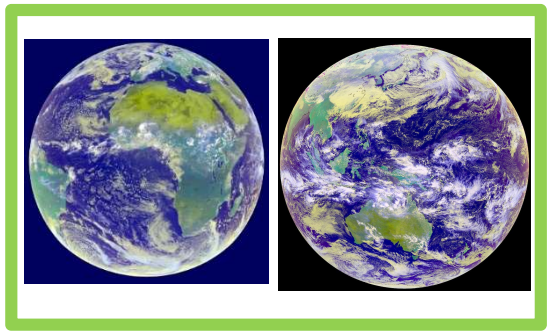
Extension to Himawari-8 FOV ongoing



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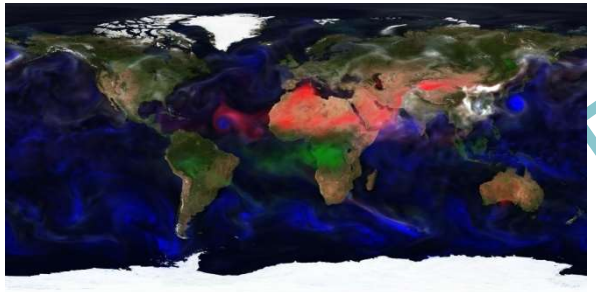
clouds from satellite

Heliosat-4 and McClear physical approaches, fast radiative transfer



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aerosol H_2O, O_3 from model

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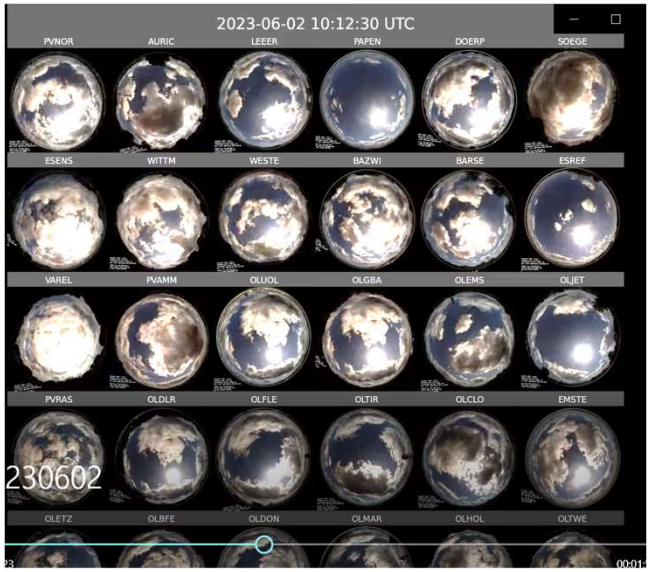
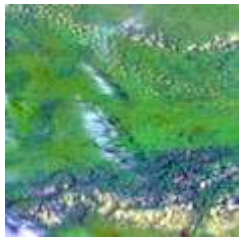
Deeper insights into quality

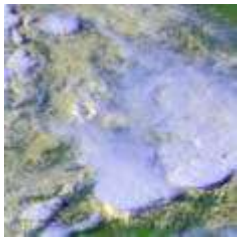
I'm not a cloud…

Well, plane-parallel assumption is used…



Clouds as seen in DLR's sky camera network





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From Karlsruher Wolkenatlas

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Deeper insights into quality

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I'm not a cloud…

Well,
plane-parallel
assumption is used…

Study set-up

- Himawari field of view; 2018; Baseline Surface Radiation Network (BSRN) and Bureau of Meteorology (BOM) stations GHI and DNI
- CAMS pre-operational (HIMAWARI FOV) version 4.5, download from sandbox
- Conditional evaluation:
  Ground based variability classes time series

  Variability class dependent analysis can help in assessment of all sky irradiance under different cloudy conditions without directly using the cloud parameters
- Conditional evaluation:
  Satellite-based cloud type classification

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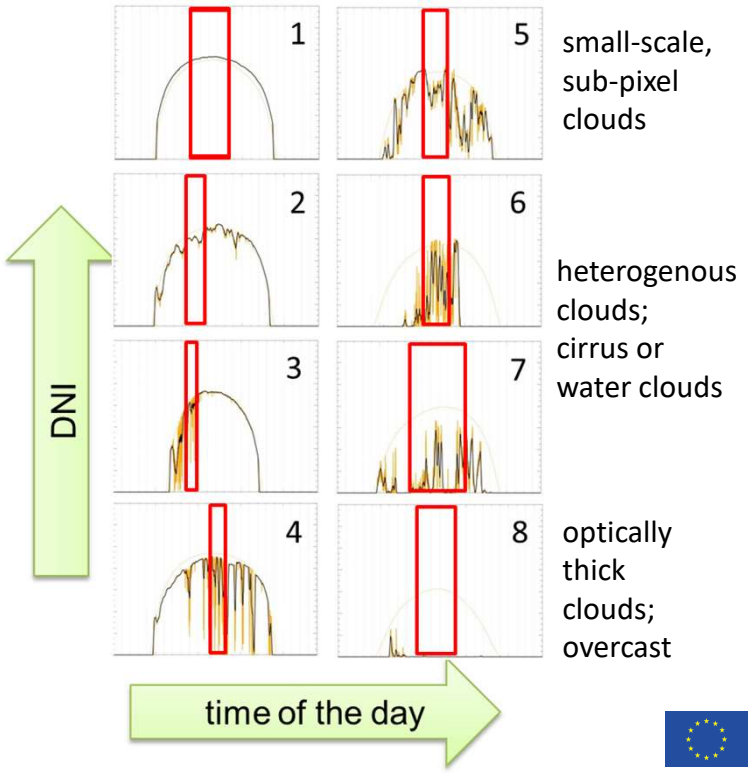
Ground based variability classes dependent evaluation



8 classes defined by ground based direct irradiance patterns

Reference:
Schroedter-Homscheidt, et al., Contrib. Atm. Sci., DOI:10.1127/metz/2018/0875

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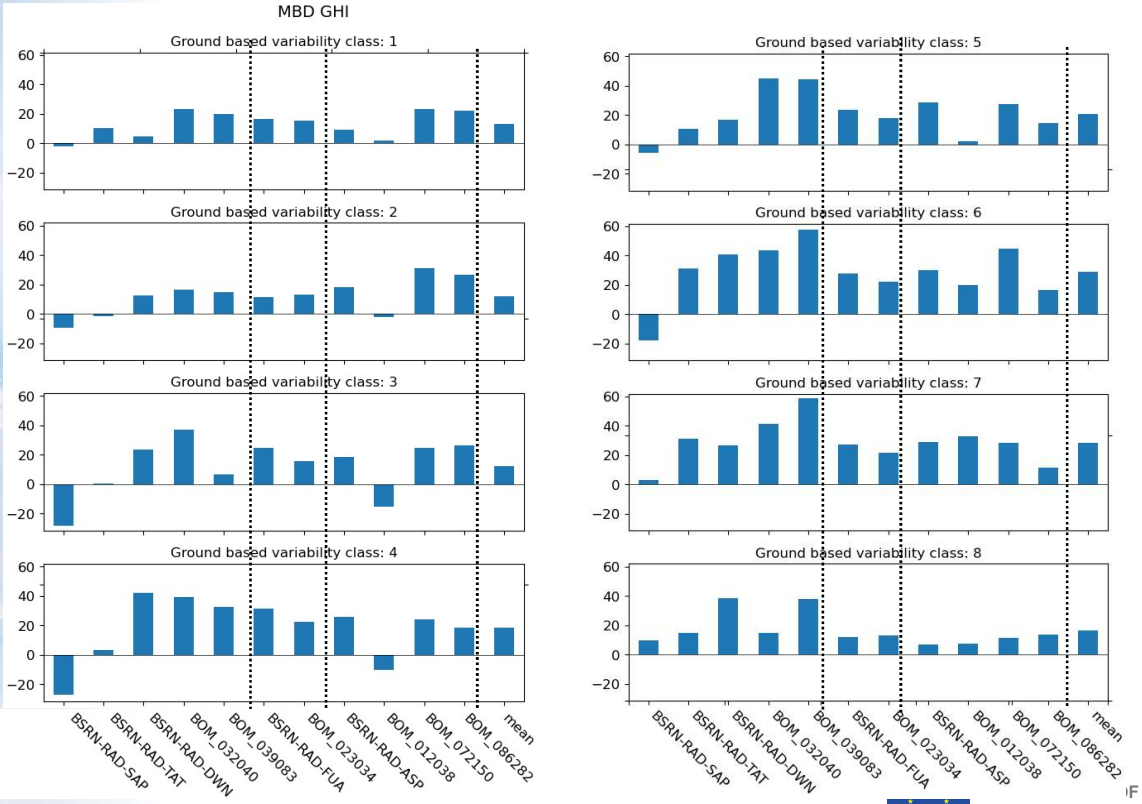
Ground based variability classes dependent evaluation - biases



- CAMS v4.5 GHI MBD
- Largest positive biases in variable cloud conditions
- Same result for RMSD (see backup slides)

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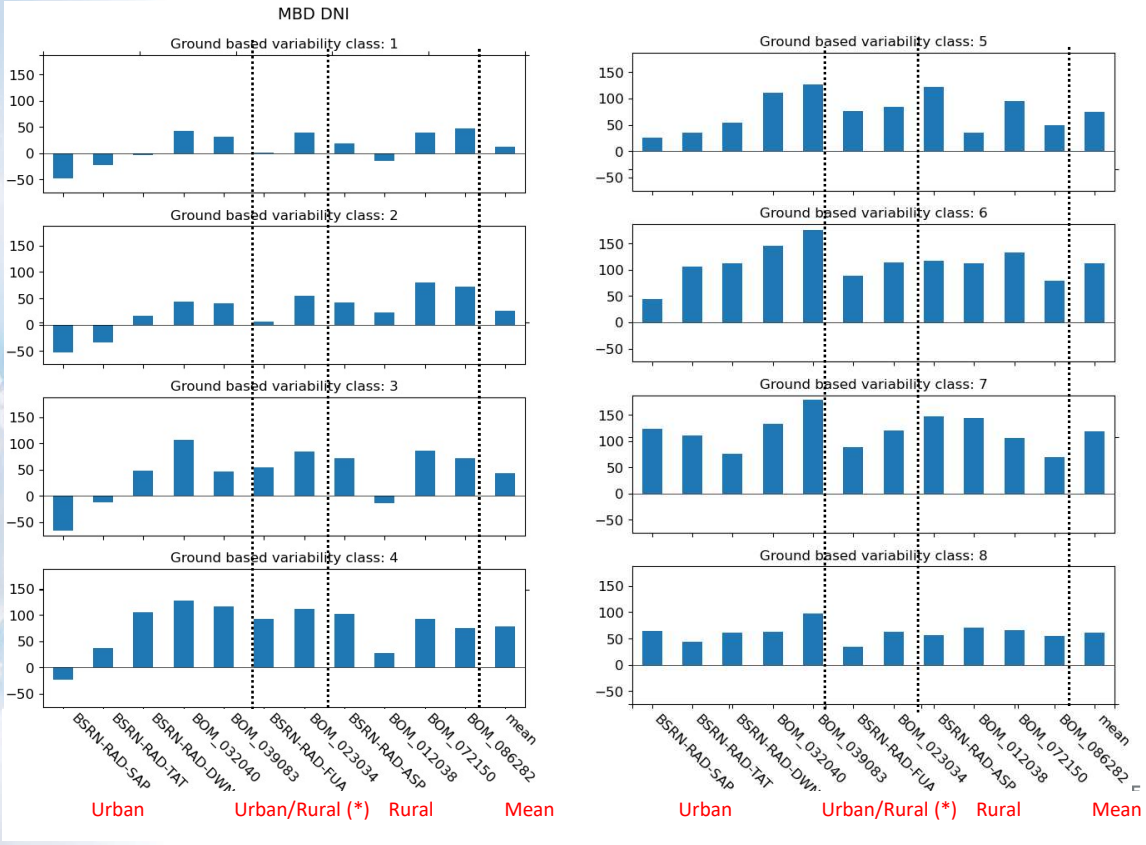
Ground based variability classes dependent evaluation



- CAMS v4.5 DNI MBD
- Largest positive biases in variable cloud conditions
- Same result for RMSD (see backup slides)

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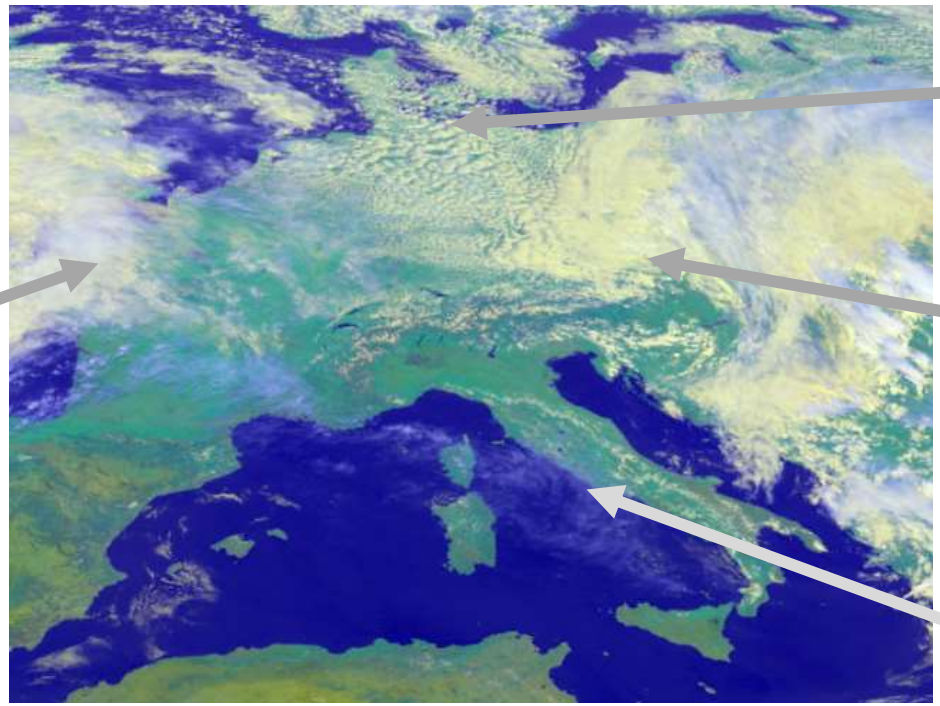
Cloud types



optically thick, high level (type 7)

optically thick, low level (type 5)

optically thick, medium level (type 6)

thin cirrus (type 8)

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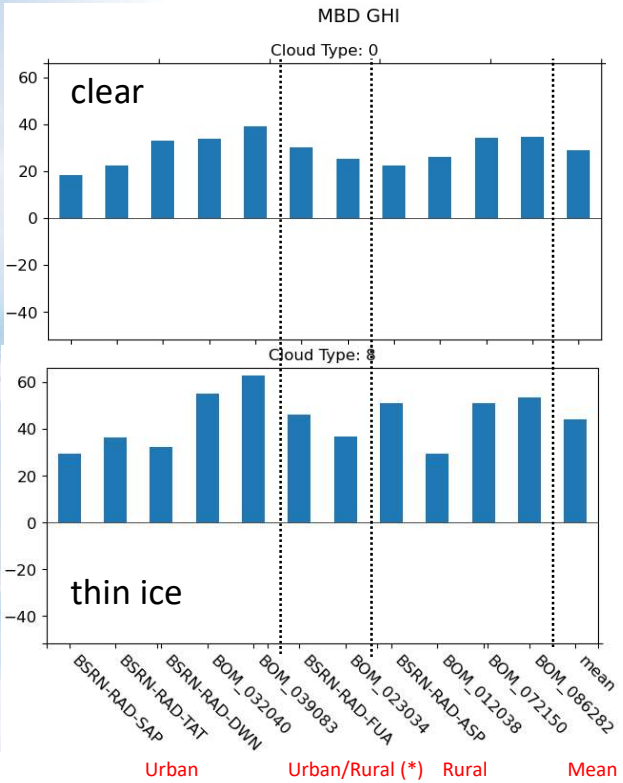
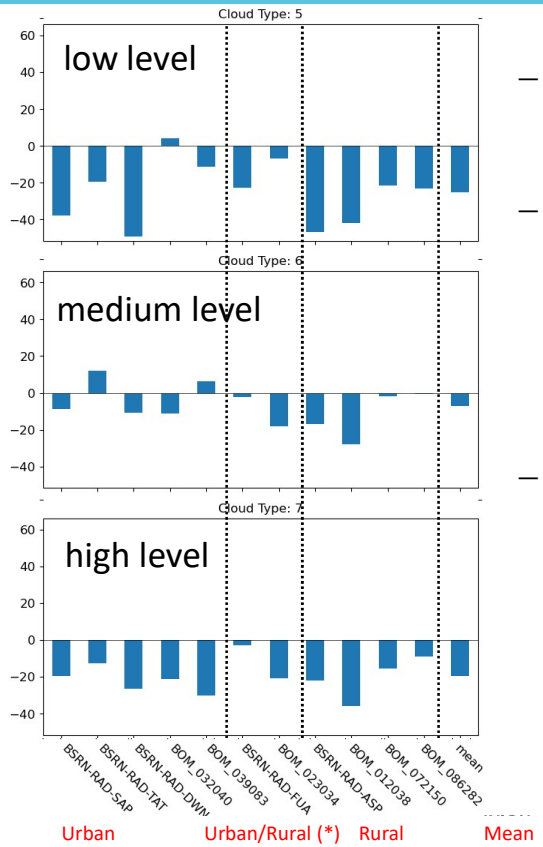
Cloud type based evaluation





- CAMS 4.5 GHI MBD, 1-minute resolved data
- Bias is positive for clear sky and thin ice clouds and negative in most of the regions for low, and medium clouds.
- Bias is negative for high level clouds in all regions

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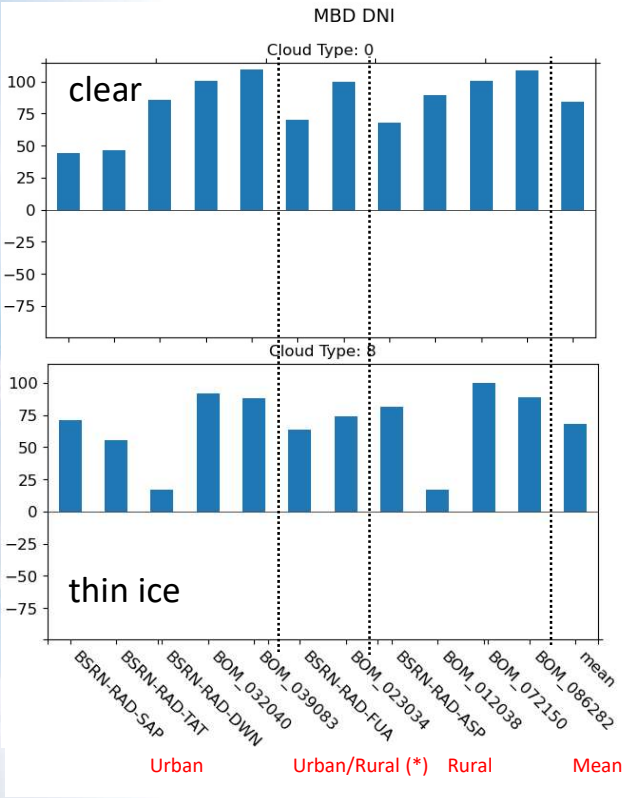
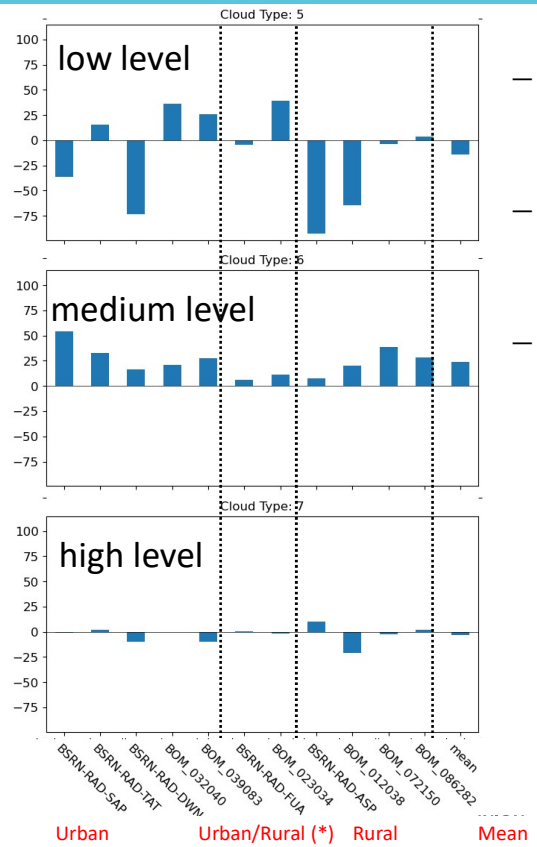
Cloud type based evaluation





- CAMS 4.5 DNI MBD, 1-minute resolved data
- Bias is positive for clear, thin and medium clouds
- Different biases at different locations for low and high clouds

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Conclusions

- Significant method changes from v3.2 to v4 and v4.5
  - New SEVIRI calibration
  - New cloud scheme
  - New aerosols

- Next generation of method improvements in preparation
  - Looking closer at sub-pixel/variable/multi layer clouds
  - Especially in cases where cloud retrievals are known to be inaccurate
    - Solar energy users need to use all cases
    - no choice to omit such non-valid cloud retrievals as the cloud community can do
  - Preparing a more flexible use of CAMS aerosols and their optical properties (not shown, but in preparation …)

Conditional assessment will be done deeper in https://www.cameo-project.eu/

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Contact point & references

- general inquiries and user requests: copernicus-support@ecmwf.int
- specific for the Solar Radiation Service team: marion.schroedter-homscheidt@dlr.de
- User's Guide at http://atmosphere.copernicus.eu/documentation
- Heliosat-4 method
  - Qu et al., Fast radiative transfer parameterisation for assessing the surface solar irradiance: The Heliosat-4 method, Contr. Atm. Sci., 2017
  - Schroedter-Homscheidt et al., Surface solar irradiation retrieval from MSG/SEVIRI based on APOLLO Next Generation and HELIOSAT-4 methods, Contr. Atm. Sci., Vol. 31 No. 6 (2022), p. 455 – 476, DOI: 10.1127/metz/2022/1132
- McClear method
  - Lefèvre et al., McClear: a new model estimating downwelling solar radiation at ground level in clear-sky conditions, AMT, 2013
  - Gschwind et al., Improving the McClear model estimating the downwelling solar radiation at ground level in cloud-free conditions – McClear-v3, Contrib. Atm. Sci., 2019
- Broadband irradiation evaluation: Quarterly validation reports at https://atmosphere.copernicus.eu/supplementary-services

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Backup slides

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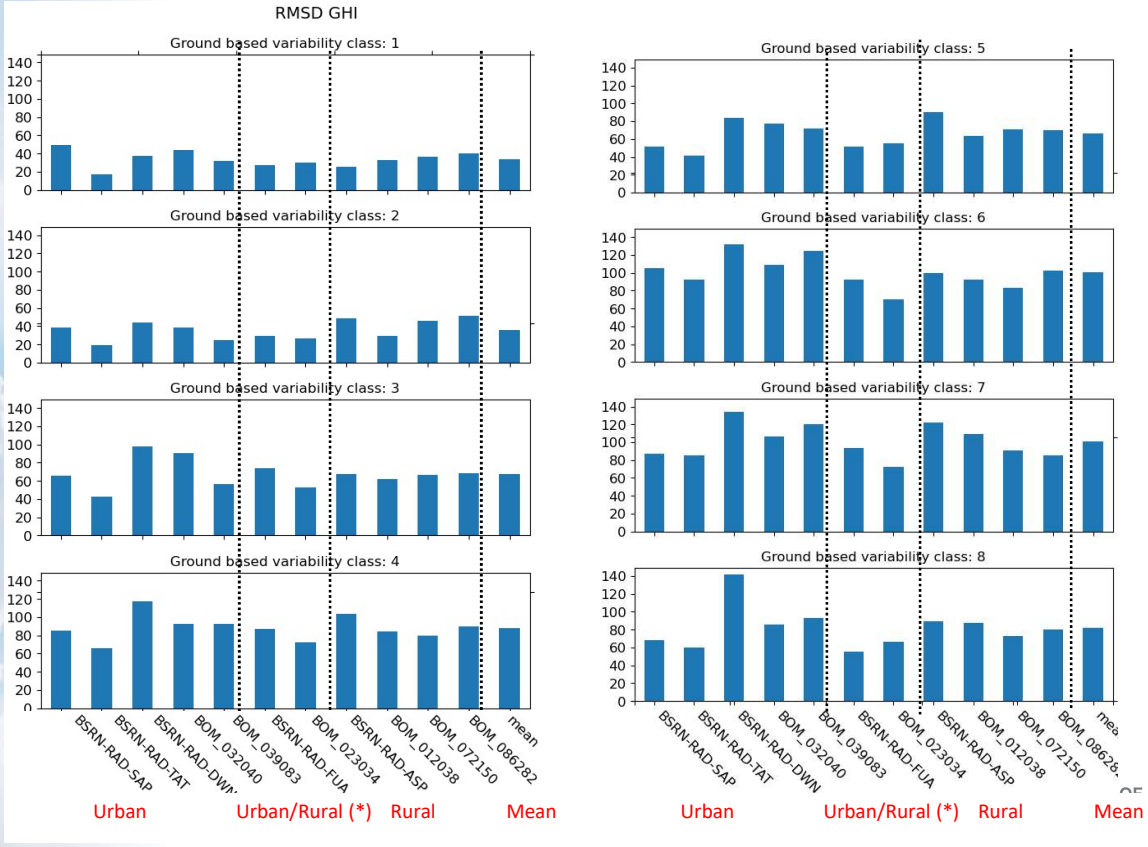
Ground based variability classes dependent evaluation



- CAMS 4.5 GHI RMSD
- Largest value in optically thick, but variable cloud conditions

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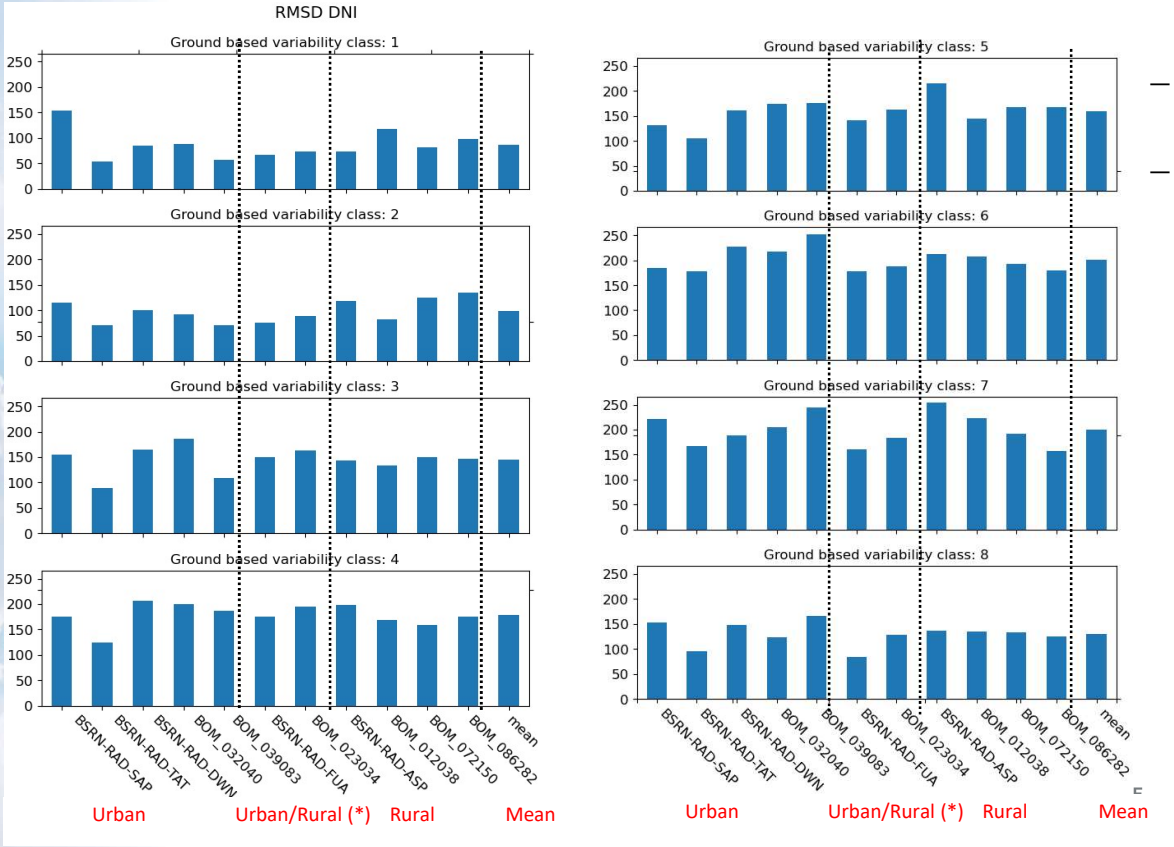
Ground based variability classes dependent evaluation



- CAMS 4.5 DNI RMSD
- Largest value in optically thick, but variable cloud conditions

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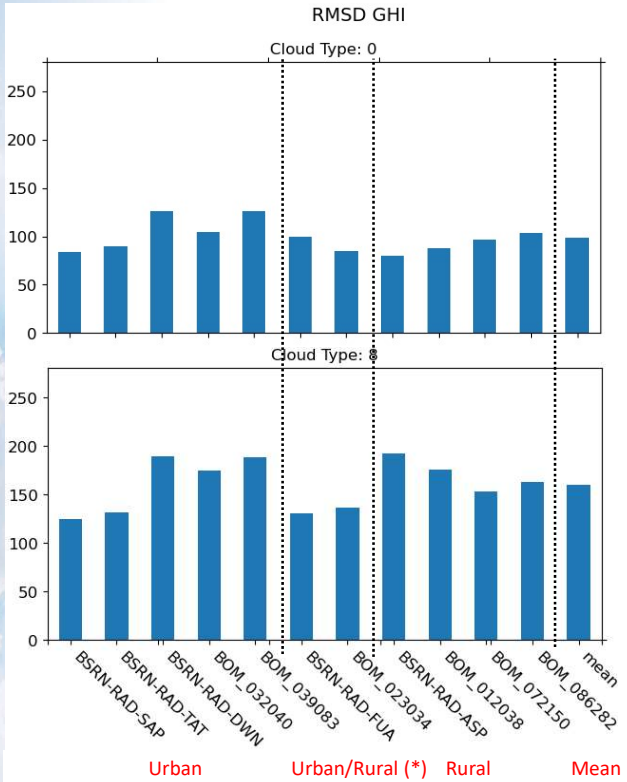
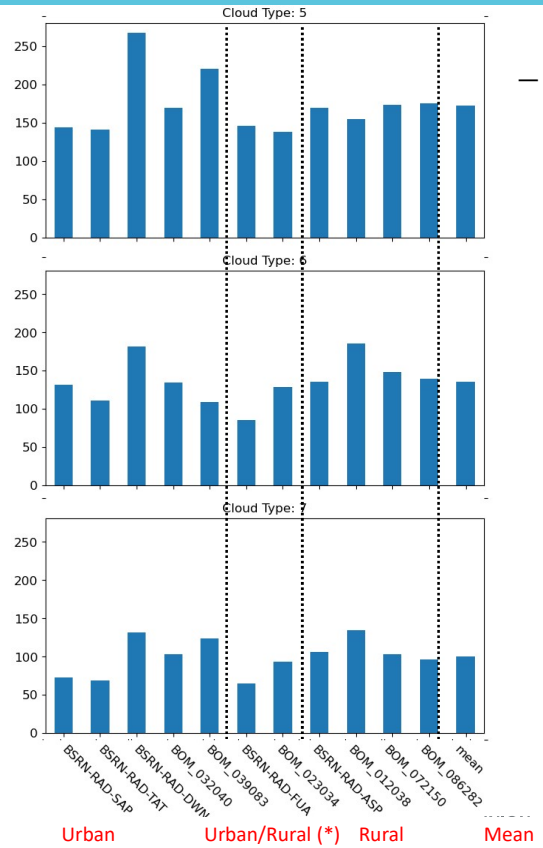
CAMS Cloud type based evaluation





– CAMS 4.5 GHI RMSD, 1-min resolved data

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CAMS Cloud type based evaluation

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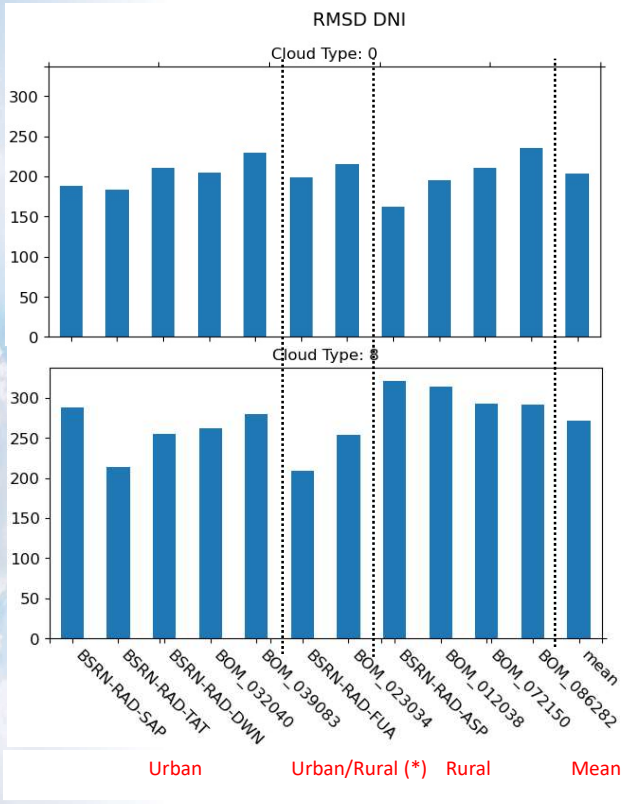

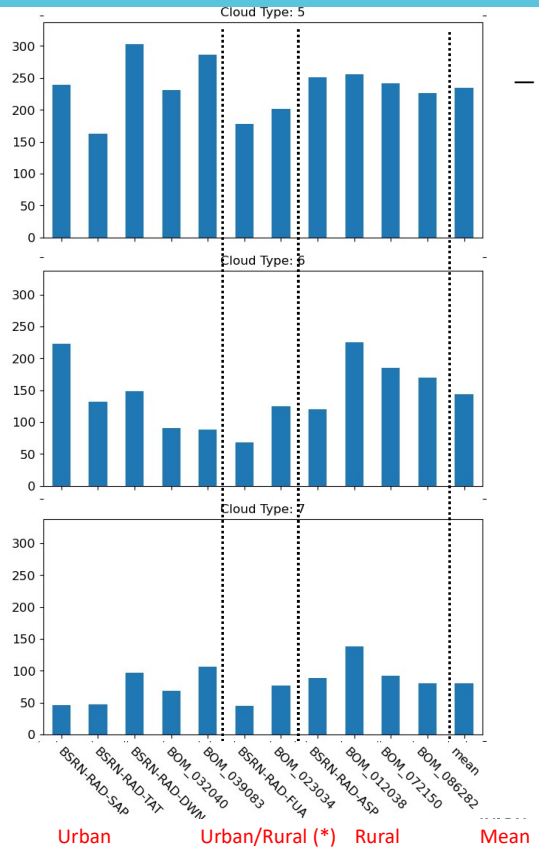

– CAMS 4.5 DNI RMSD, 1-min resolved

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