Variability class dependent evaluation of the CAMS Radiation Service

Faiza Azam[1], Jethro Betcke[1], Marion Schroedter-Homscheidt[1], Mireille Lefevre[2], Yves-Marie SaintDrenan[2], Laurent Saboret[3], and Stephane Andrietti[3]

German Aerospace Center (DLR), Institute of Networked Energy Systems

[1]Institute of Networked Energy Systems, German Aerospace Center (DLR)

[2]MINES Paris / Armines

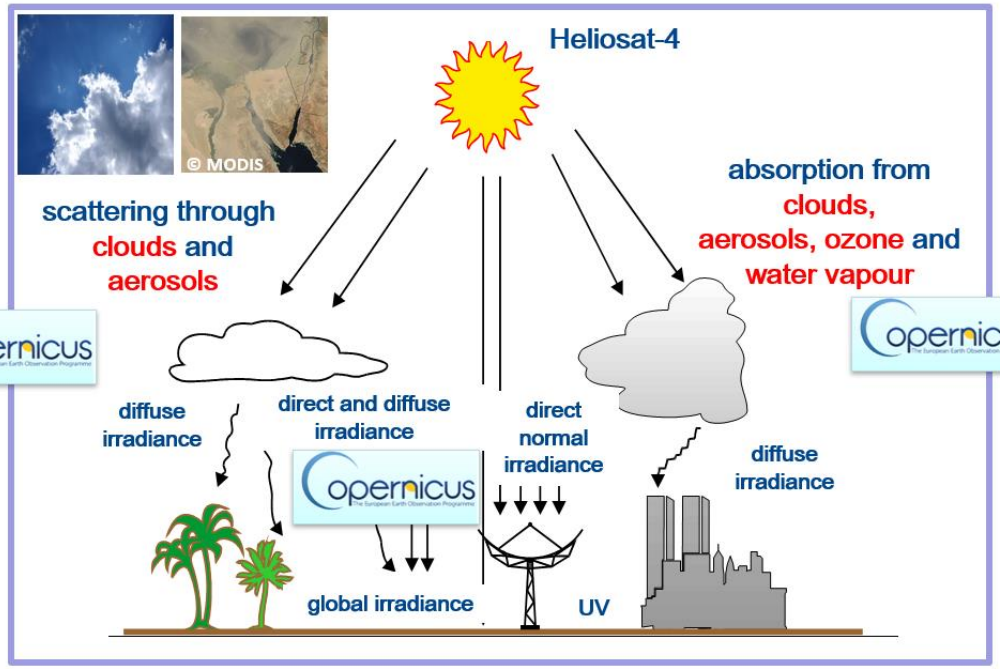
[3]Transvalor

Outline

- CAMS Radiation Service
- CAMS Radiation schemes (recent improvements)
  - CAMS 3.2 vs CAMS 4.0
- Ground based variability classes validation
  - Variability classes
  - Validation procedure
- Validation results
- Conclusion/Outlook

CAMS Radiation Service

- Copernicus (EU Earth Observation Programme)
  - **C**opernicus **A**tmospheric **M**onitoring **S**ervice (CAMS)
  - CAMS is implemented on behalf of EU by ECMWF
    - **C**AMS **R**adiation **S**ervice (CRS)
      - Incoming Surface Solar Irradiance (SSI)



  - CRS is provided by DLR with ARMINES, TRANSVALOR, FMI

CAMS Radiation Service

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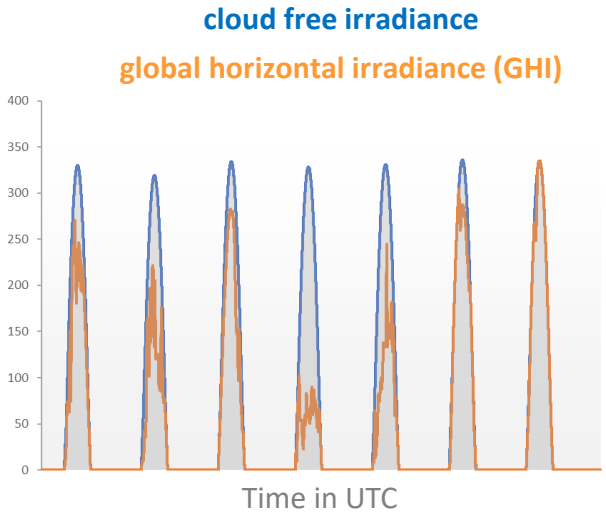
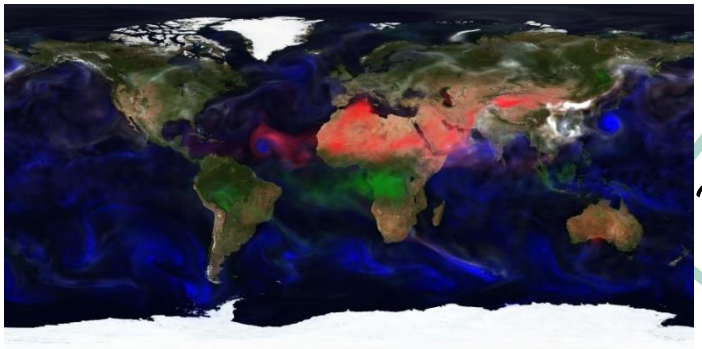
clouds from satellite

Heliosat-4
(physical approach, fast radiative transfer)





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aerosol, H_2O, O_3 from model

method papers:

Qu et al., Contrib. Atm. Sci., 2017
Lefèvre et al., Atm. Meas. Tech., 2013
Gschwind et al., Contrib. Atm. Sci., 2019
Schroedter-Homscheidt et al., Contrib Atm. Sci. (submitted)

DLR

CAMS Radiation scheme (recent improvements)

- CAMS 4.0 operational since June 28, 2021

	CAMS 3.2	CAMS 4.0
Calibration	Reflectances as provided by EUMETSAT	Time-dependent update Calibration coefficients from KNMI (Meirink et al. 2013)
Cloud retrieval	APOLLO, binary cloud mask based on Kriebel et al. 1988/1989	APOLLO-NG, probabilistic cloud mask from Klüser et al. 2015 (cloud confidence level)
	COT using Stephens scheme (Stephens et al. 1984) with clipping at COT < 0.5	COT using Stephens scheme (Stephens et al. 1984) with COT LUTS extended to 0.001
Cloudy/Clear decision for Heliosat-4	Based on binary mask	Cloud probability threshold 1%

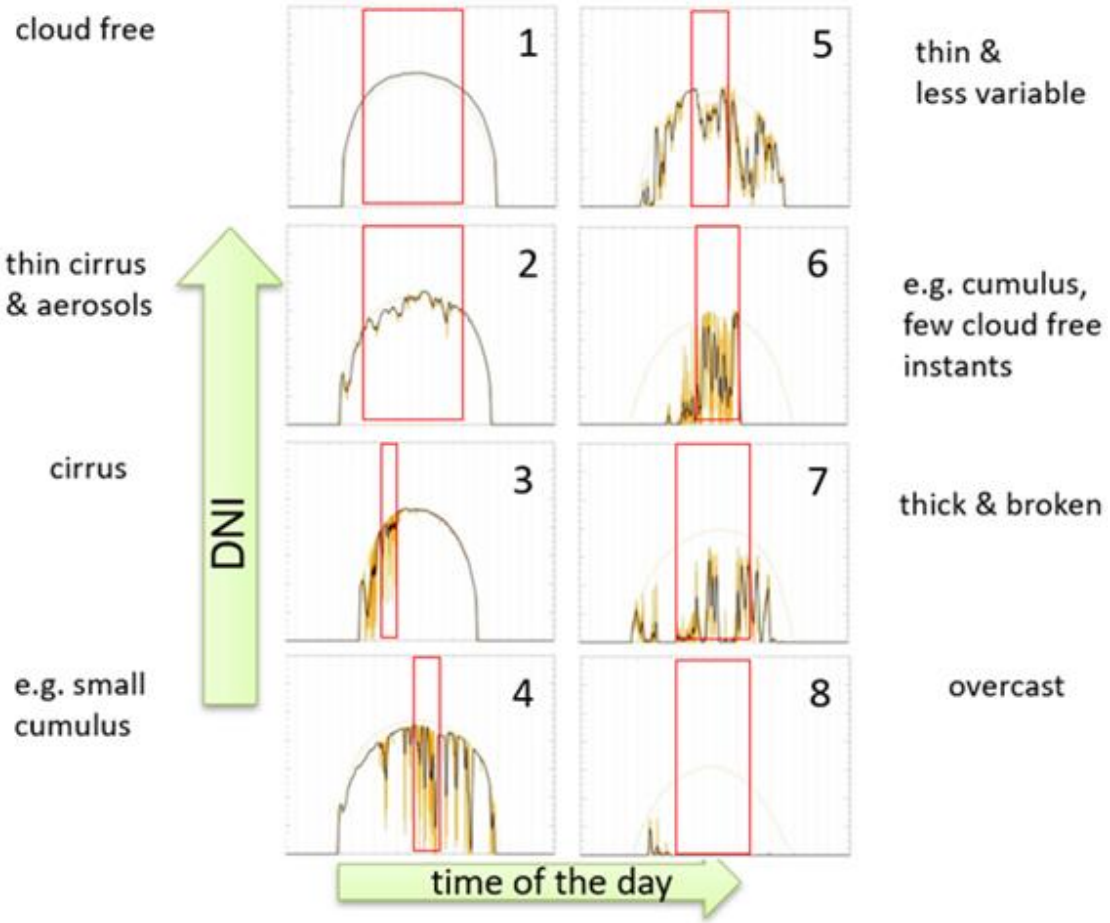
CAMS Radiation schemes (recent improvements)

- CAMS 4.0 operational since June 28, 2021

	CAMS 3.2	CAMS 4.0
Circumsolar correction	Single COT value	Empirical apparent COT modification factor for DNI calculations: • 0.41 for optical thin ice clouds • 0.20 for water/mixed phase clouds
Bias correction (post-processing)	Empirical multiplication factor	Retrained bias correction

- Bias correction compares CAMS with BSRN as reference. For all-sky irradiance, biases are dominated by errors in the satellite based cloud properties determination and its input (as calibration)
- Uncorrected and bias-corrected irradiances are provided in expert output mode

Ground based variability classes



Example variability classes 1-8

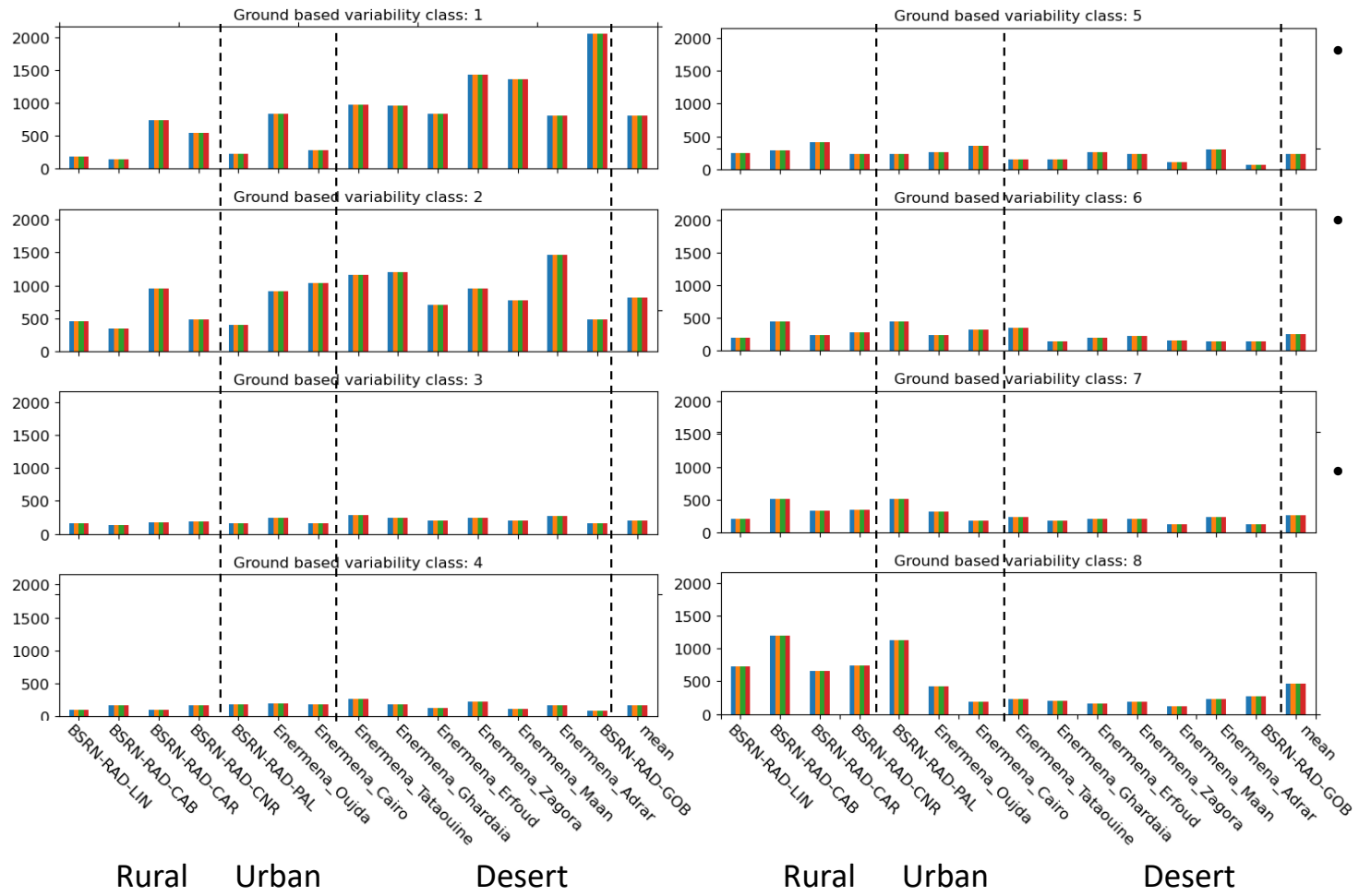
Hours being classified, 1-min resolved data, 10 min moving average

- 8 classes defined by ground based direct irradiance patterns
- Class 1 is cloud free and class 8 is overcast
- Classes 2-5: cloudy cases with large number of optically thin clouds
- Classes 6-8: optically thick, scattered or broken clouds
- Automatic classification possible from ground-based direct irradiance time series, sky cameras and using cloud mask from satellite
- Method paper ground based: Schroedter-Homscheidt, et al., Meteorol. Z., DOI:10.1127/metz/2018/0875

Validation procedure

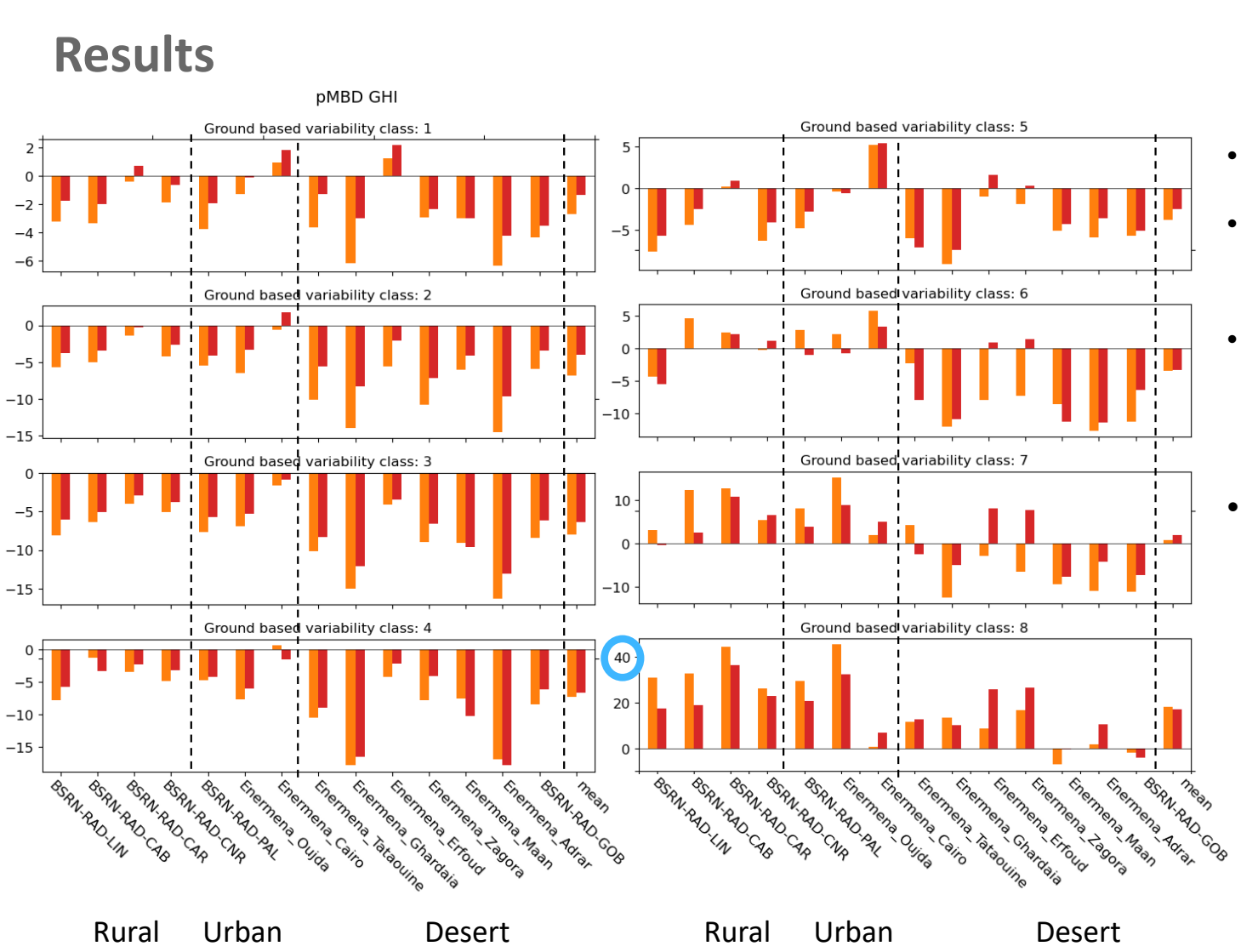
- A new scheme is developed for the evaluation of CAMS services based on variability classes
- Data used in the evaluation:
  - Ground based variability classes time series for the year 2015
  - CAMS Global horizontal irradiance (GHI) and Direct normal irradiance (DNI), previous version 3.2 and current operational version 4.0, 2015
  - BSRN & Enermena stations GHI and DNI as reference, 2015
- Variability class dependent analysis can help in assessment of all sky irradiance under different cloudy conditions without directly using the cloud parameters

Results



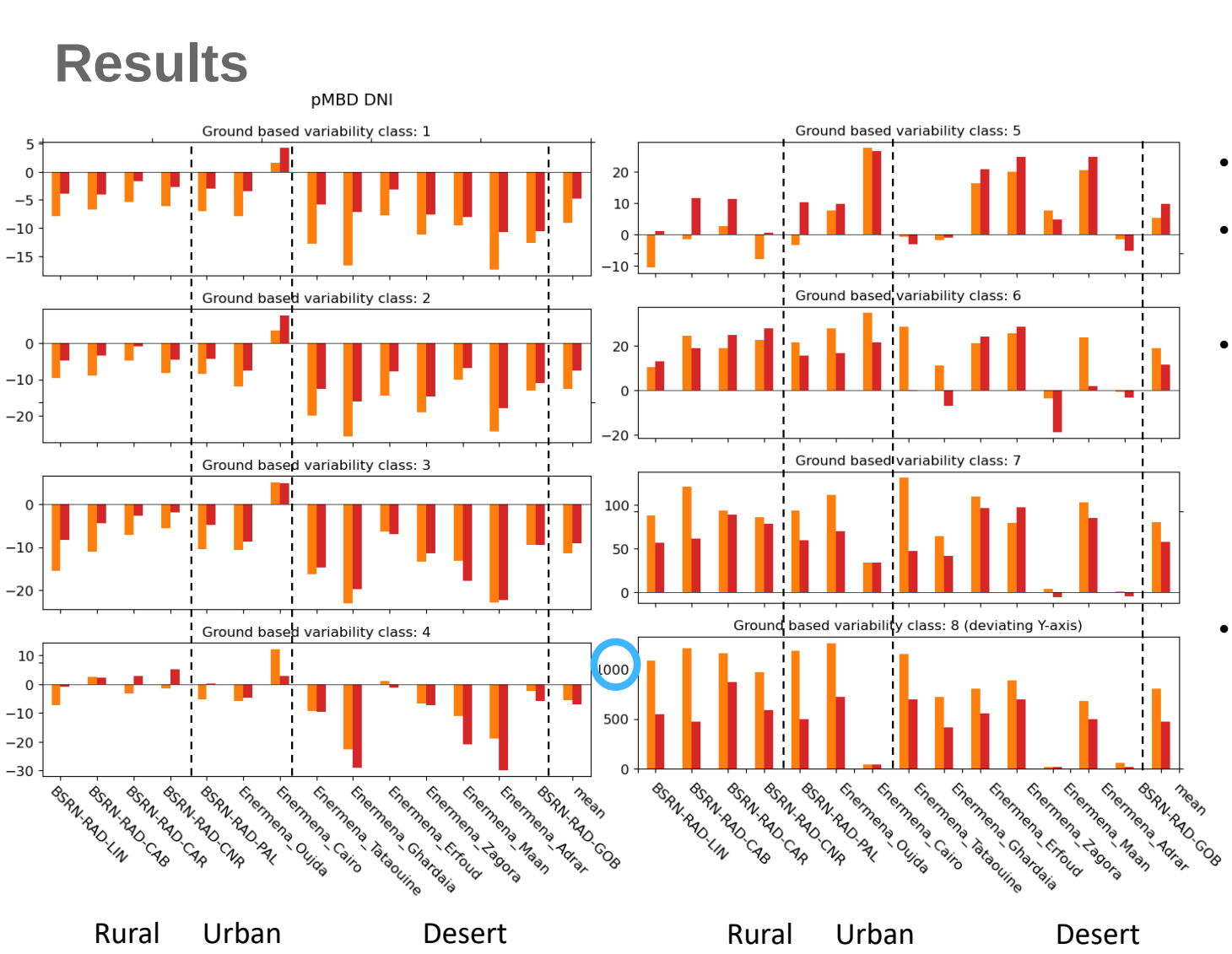
- Distribution of variability classes 1-8 (variability classes pairs)
- Rural/urban regions:
  - Relatively less cases in classes 1 and 2
  - Large number in overcast
- Desert regions:
  - More clear sky and nearly clear sky cases
  - Less number in cloudy classes

Results



- Bias corrected GHI
- Percental relative mean bias (pMBD)
- Rural/urban regions:
  - Bias improved in all classes
- ´Desert regions:
  - Better results for clear sky, thin cloud classes
  - Different results at different stations for classes with optically thick clouds and overcast

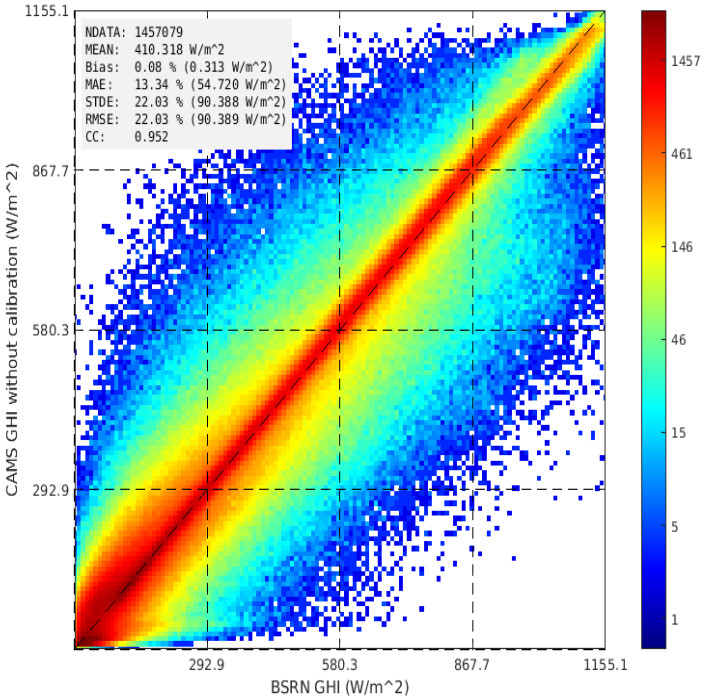
Results



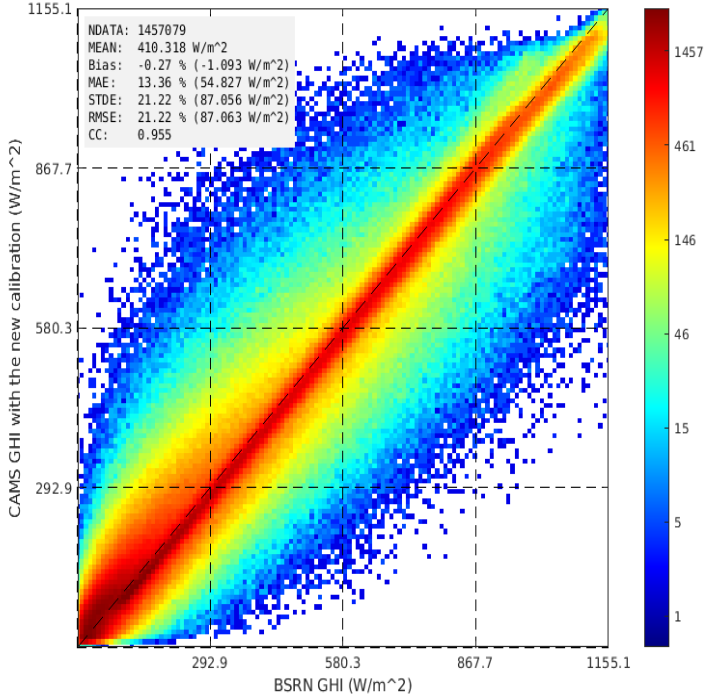
- Bias corrected DNI=BNI
- Percental relative mean bias (pMBD)
- Rural /urban regions:
  - Bias improved in classes with optically thin cloud and thick broken clouds and overcast
- Desert regions:
  - Better results for clear sky, very thin clouds and broken clouds classes
  - Bias improved for overcast

CRS CAMS 4.0 Bias Correction evaluation

- Other evaluation studies on the impact of bias correction: GHI
  - Bias correction nearly passive for GHI



CAMS 4.0 GHI uncorrected

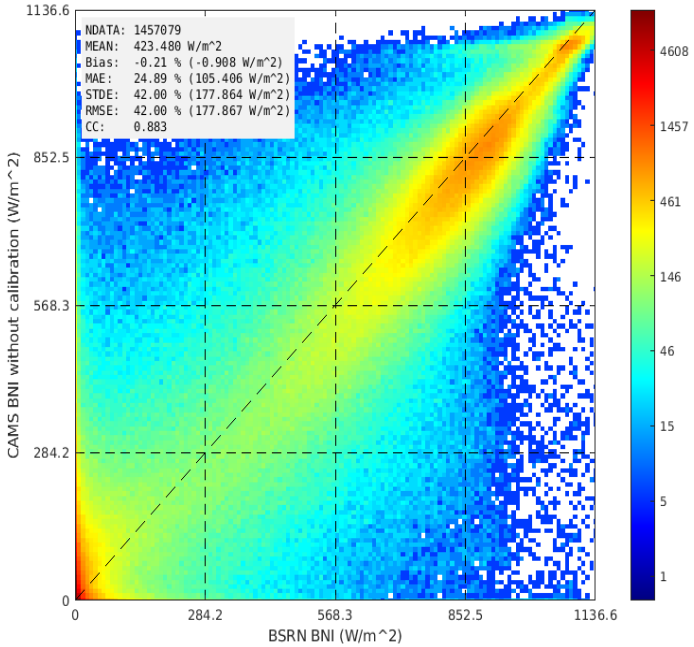


CAMS 4.0 GHI bias corrected

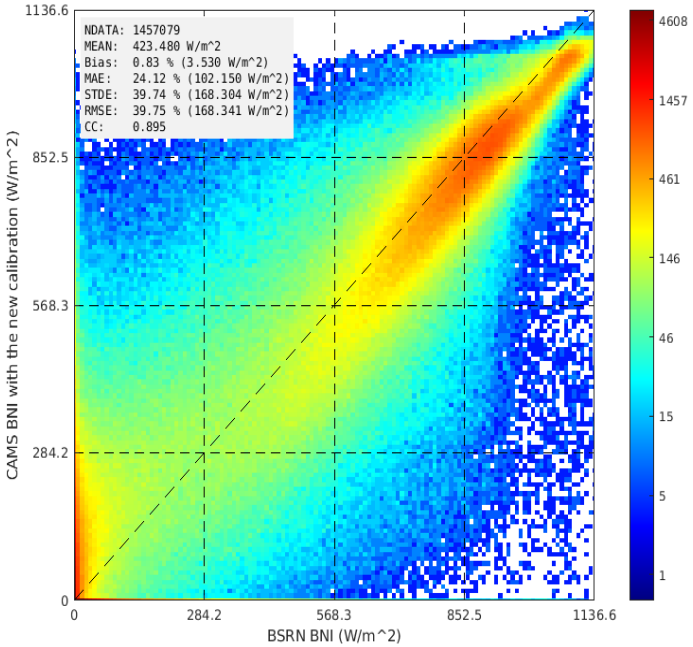
- Period
  - 2019,2020 and Q2 2021

CRS CAMS 4.0 Bias Correction evaluation

- Other evaluation studies on the impact of bias correction: DNI
  - Small changes for DNI



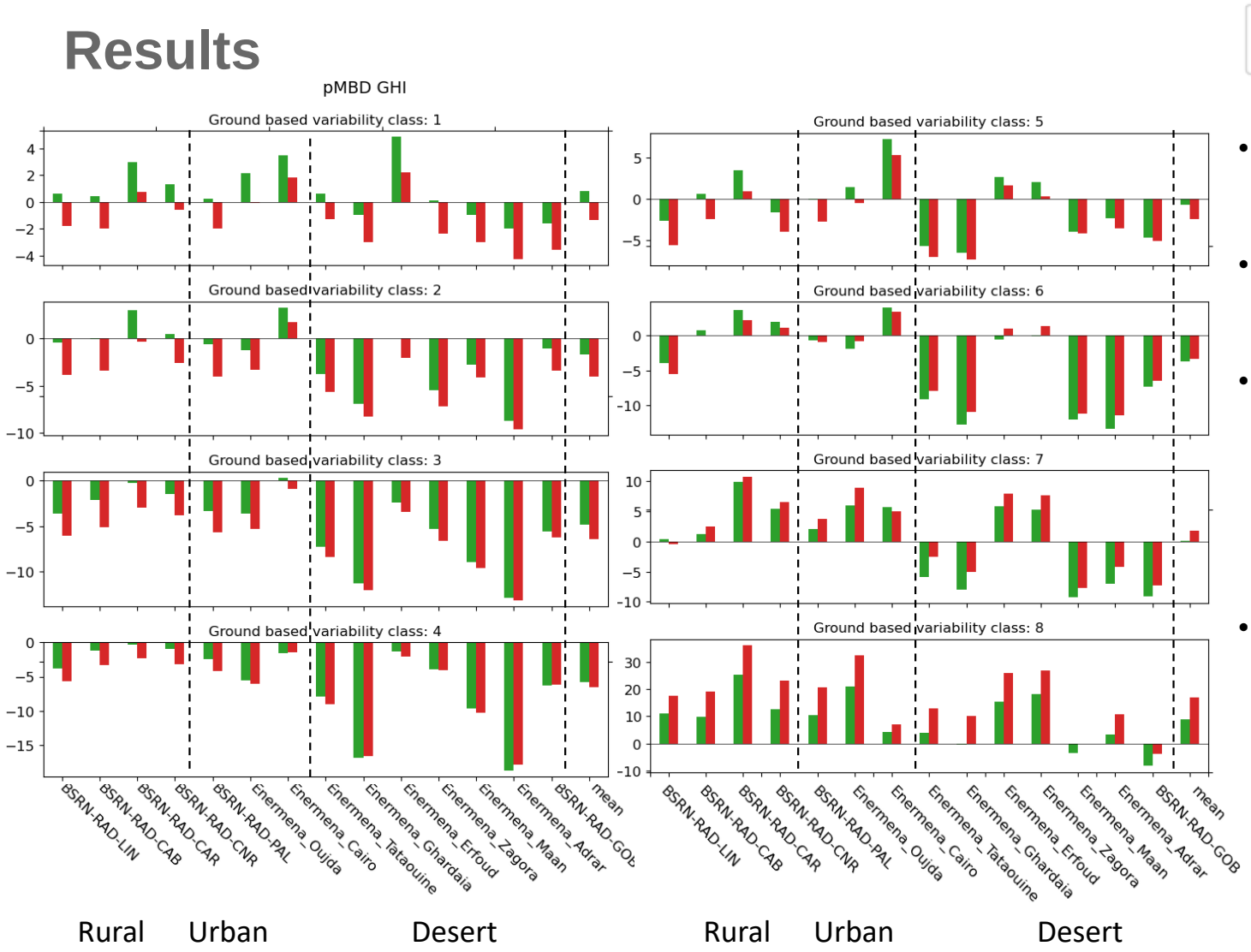
CAMS 4.0 DNI uncorrected



CAMS 4.0 DNI bias corrected

- Period
  - 2019,2020 and Q2 2021

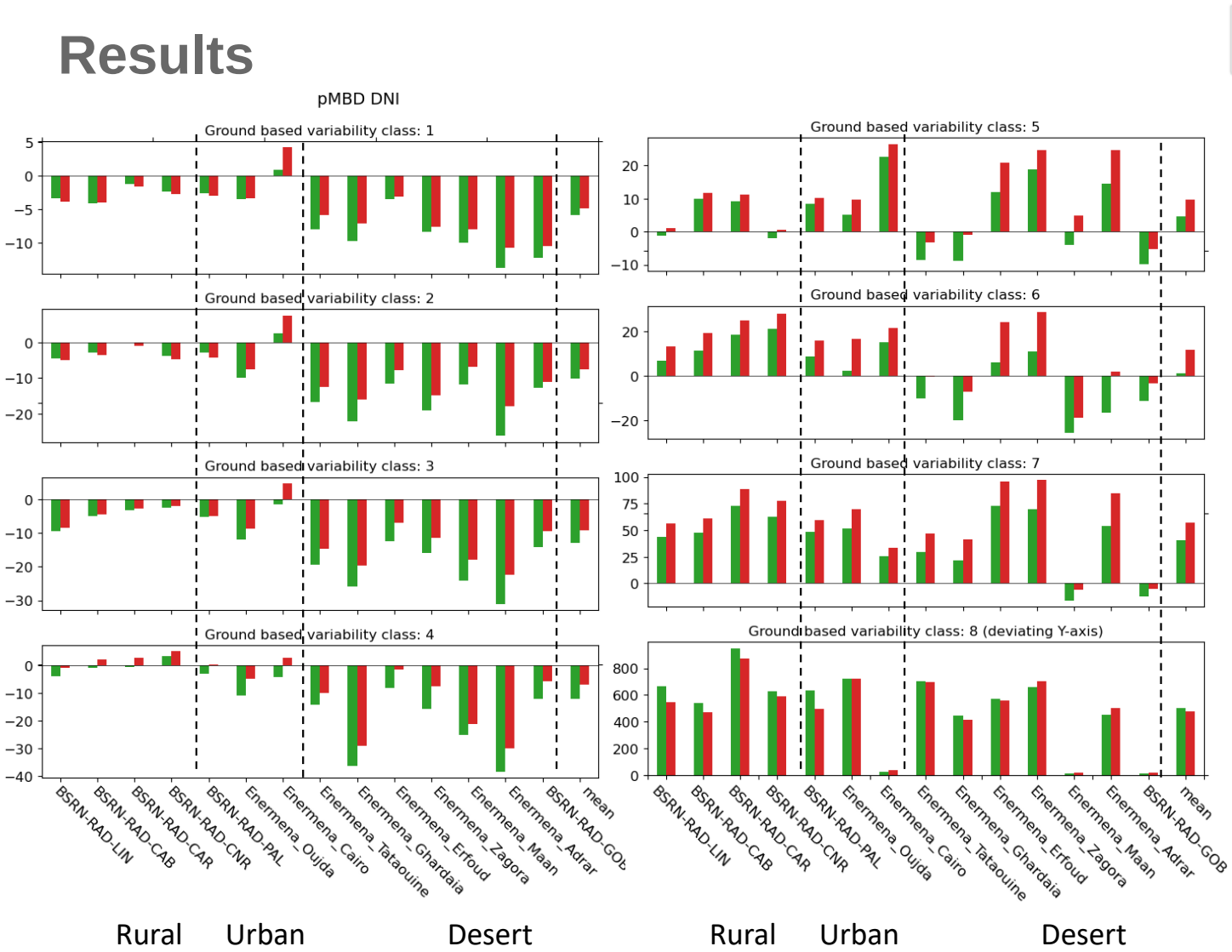
Results



- CAMS 4.0 GHI, with and without bias correction
- Percental relative mean bias (pMBD)
- Rural/urban regions:
  - Bias correction increase biases for all classes (1-8) at most of the stations
- Desert regions:
  - Bias correction only brings some inprovement in classes 6 and 7

In general bias correction not effective for CAMS 4.0 GHI

Results



- CAMS 4.0 DNI =BNI, with and without bias correction
- Percental relative mean bias (pMBD)
- Rural/urban regions:
  - Almost no impact of bias correction on classes 1-4. Bias increases for classes 5-7. Some improvement in class 8
- Desert regions:
  - bias correction increases biases in variable & optically thick cloud conditions

Bias correction not effective in variable and optically thick clouds cases for CAMS 4.0 DNI

Conclusion/Outlook

- Variability classes are derived from irradiance observations only
- They offer a monitoring of cloud types and aerosol impact independent of the cloud retrieval

- 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 occurences

- Current operational version, CAMS 4.0:
  - bias correction as a post processing not effective anymore for GHI
  - 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

- Next: Extend evaluation to HIMAWARI8 and GOES16.
- Next: Use variability class based diagnostics to revisit several cloud retrieval steps

Acknowledgements

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  - MINES Paris / Armines
  - Transvalor

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- User‘s Guide at http://atmosphere.copernicus.eu/documentation

Additional slides

Comparison statistics GHI and DNI