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Copernicus Atmosphere Monitoring Service

Preparing the CAMS Radiation Service for MTG

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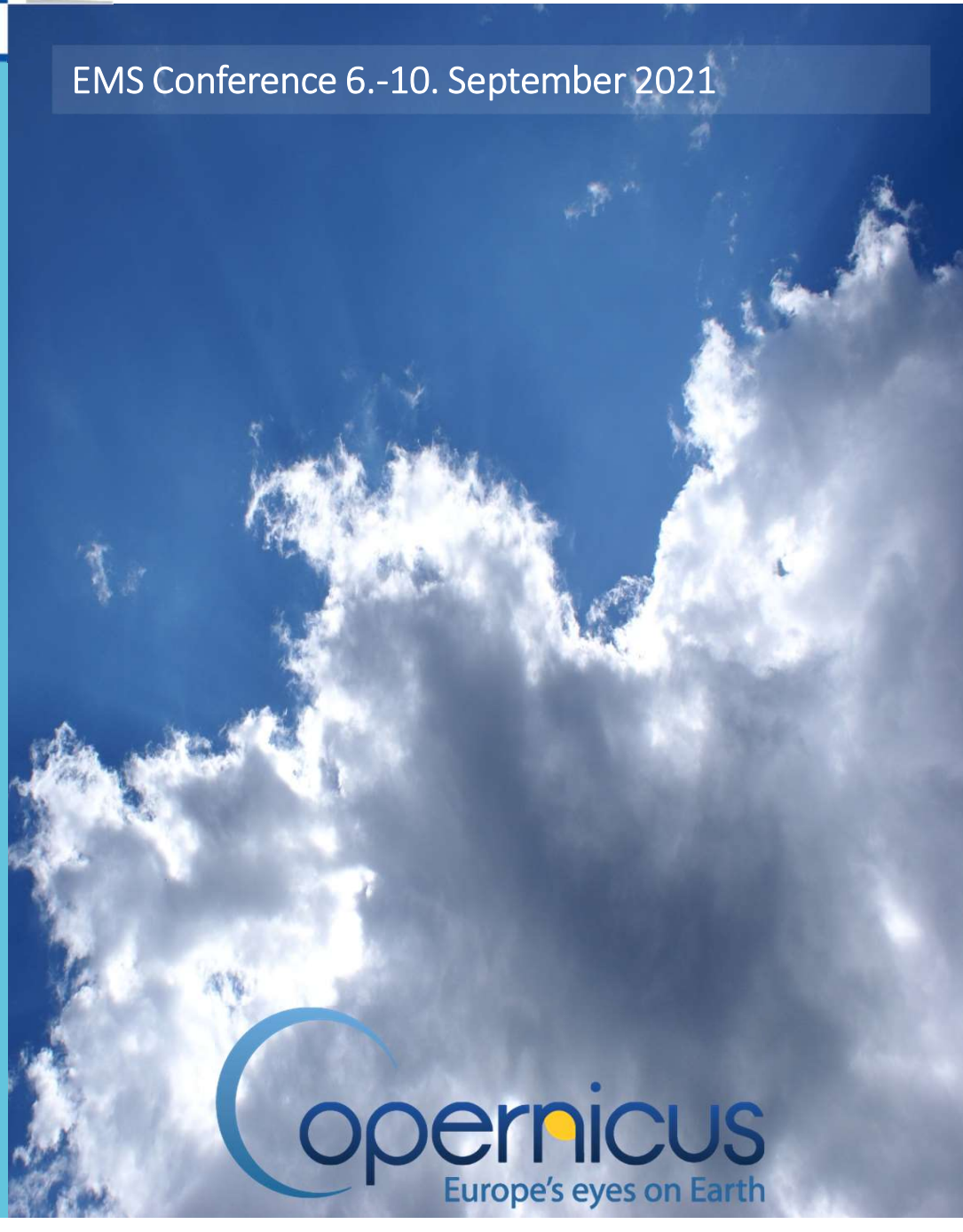
(Armines), L. Saboret, E. Wey (Transvalor)

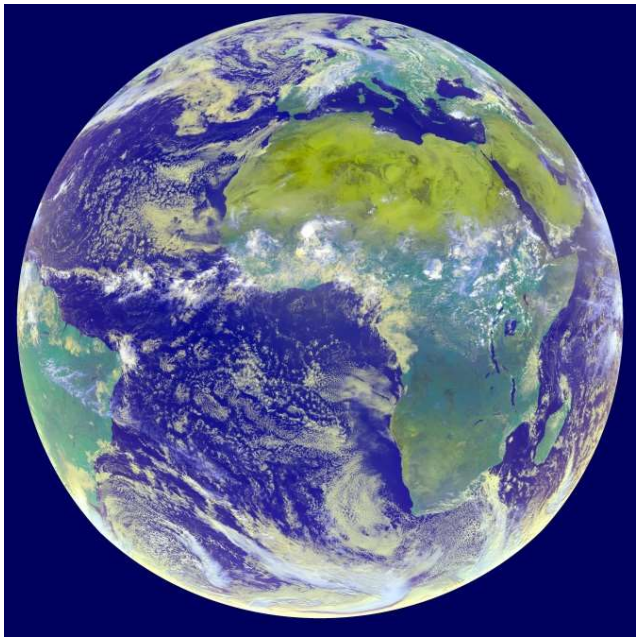
DLR with ARMINES TRANSVALOR TROPOS Leibniz-Institut für Troposphärenforschung



Outline

- News from CAMS Radiation Service
  - Version 4.0 is online
  - Algorithm changes
  - Validation results v3.2 vs. v4.0

- Preparing for MTG
  - Himawari-8 and GOES-16 evaluation for experimental APOLLO_NG/Heliosat-4 (DLR)
  - Study based on SEVIRI HRV to quantify the value of higher spatial resolution



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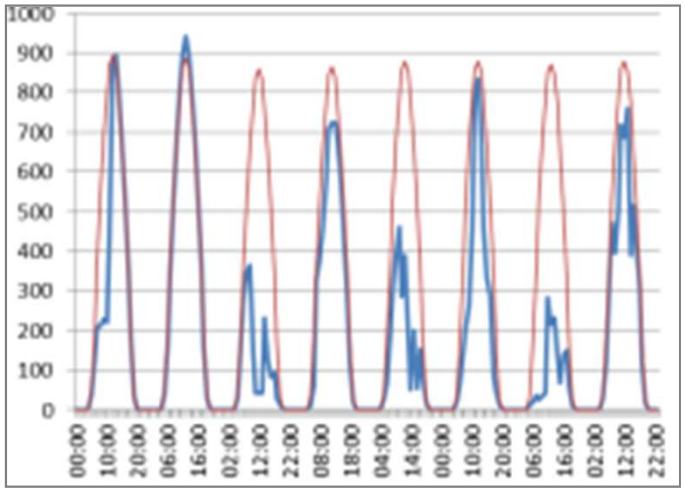
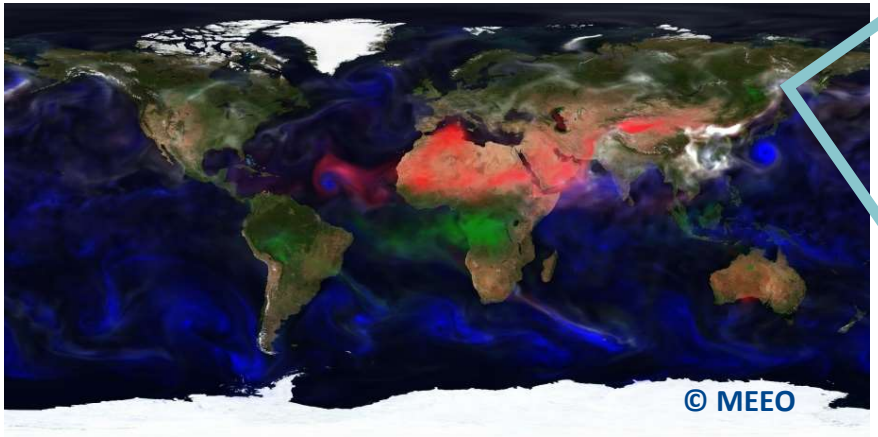
clouds from satellite

Heliosat-4 and McClear physical approaches, fast radiative transfer



irradiance,

cloud free irradiance



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aerosol H_2O, O_3 from model

method papers

Qu et al., Contrib. Atm. Phys., 2017
Lefèvre et al., Atm. Meas. Tech., 2013
Gschwind et al., Contrib. Atm. Phys., 2019

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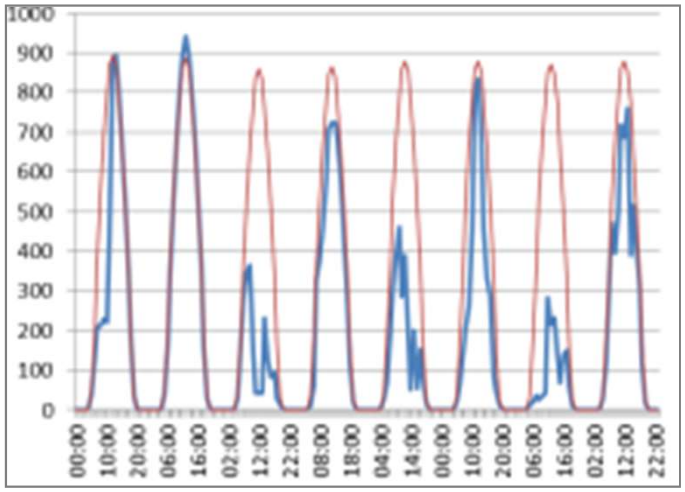
clouds from satellite

Heliosat-4 and McClear physical approaches, fast radiative transfer

New: circumsolar treatment



irradiance,

cloud free irradiance

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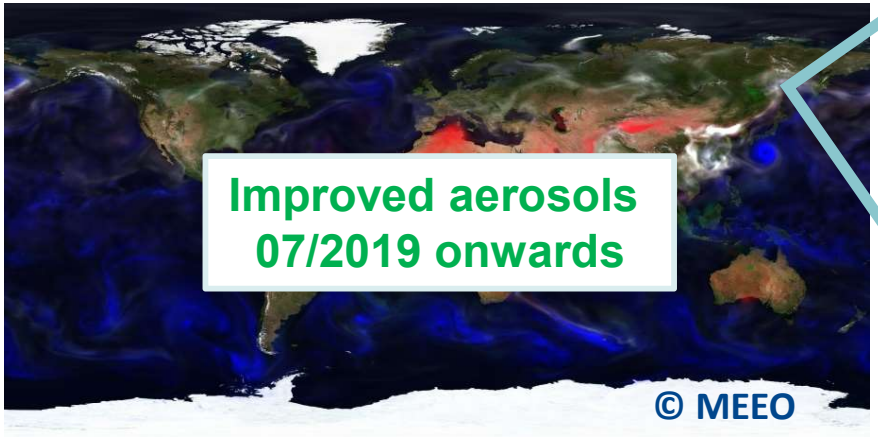

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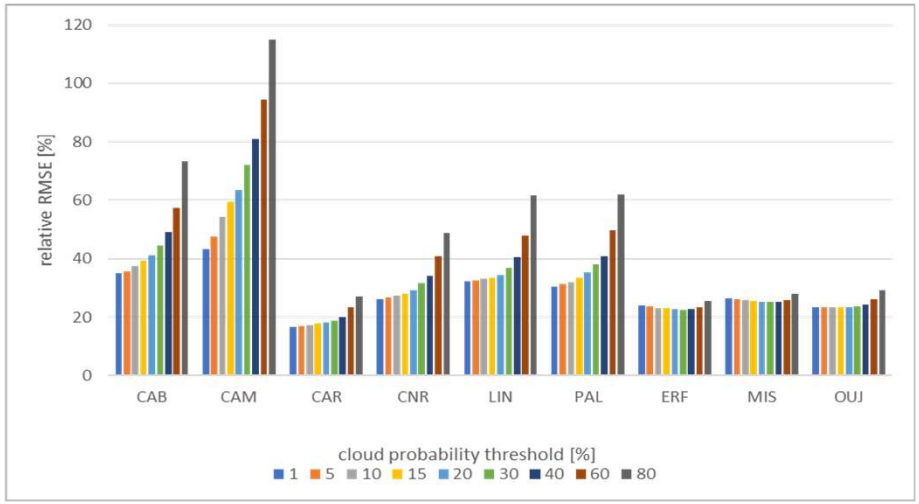
method papers

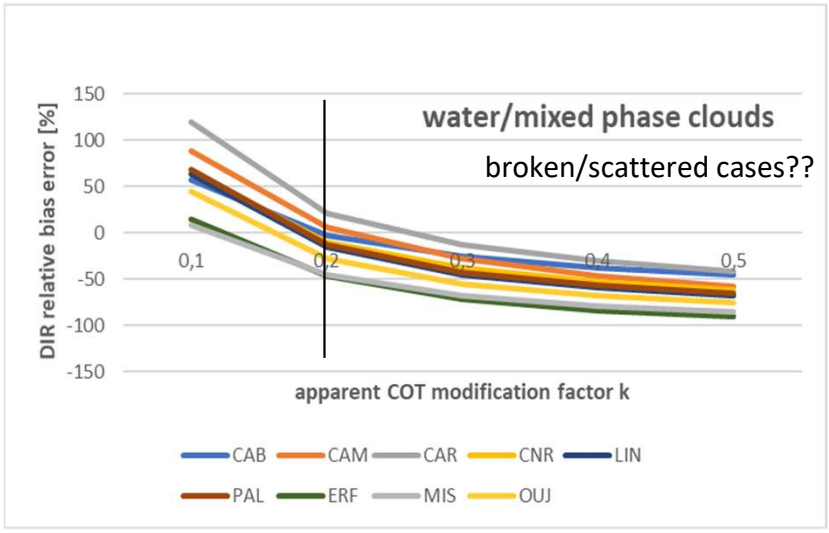
Qu et al., Contrib. Atm. Phys., 2017
Lefèvre et al., Atm. Meas. Tech., 2013
Gschwind et al., Contrib. Atm. Phys., 2019
Schroedter-Homscheidt et al., Contrib. Atm. Phys., in prep.

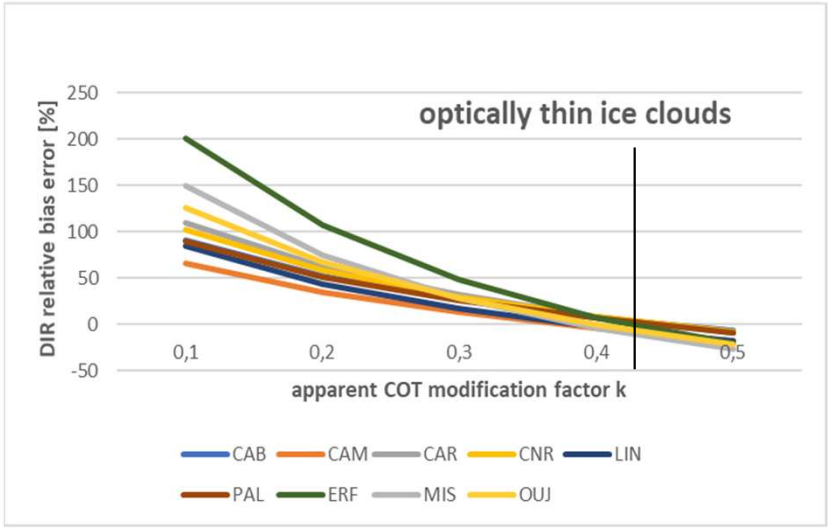
Main method changes

- Time-dependent calibration update following Meirink et al. (KNMI)
- Extension of COT LUTs to 0.001 instead of clipping at 0.5
- Bayesian cloud masks in APOLLO_NG (Klüser et al., AMT, 2015)
- Cloud probability threshold, very sensitive selection
- Circumsolar correction for DIR



RMSE for hourly DIR as function of cloud probability threshold





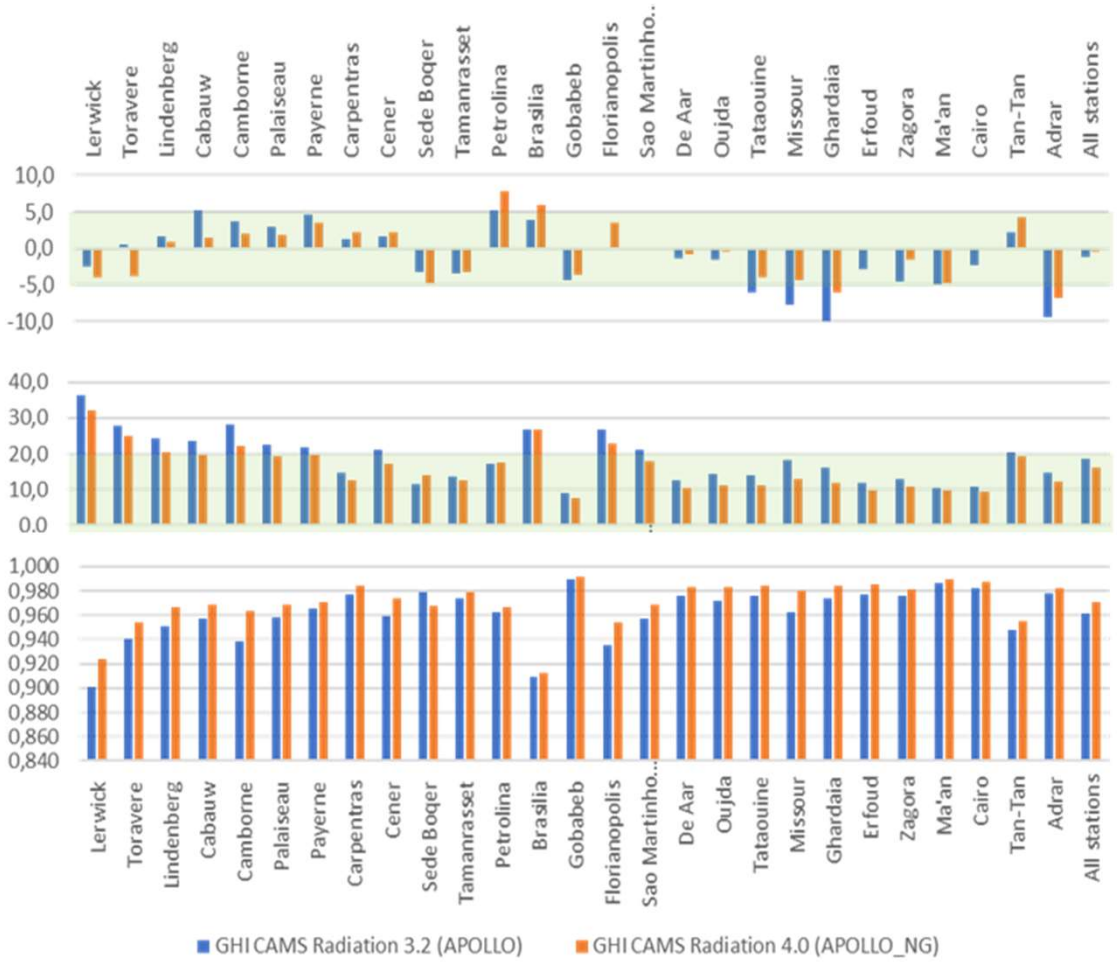
optimum apparent COT modification factor in different cloud conditions

Evaluation results – SEVIRI

Study design:
GHI (Global horizontal irradiation)
hourly evaluation; 2004 to 2020
CAMS operational v3.2 (old)
CAMS operational v4.0 (online)

Note: Bias correction method as originally developed for v3.2 was updated for v4.0, but is now nearly passive for GHI.

Thanks to BSRN & EnerMENA station teams for providing their data.

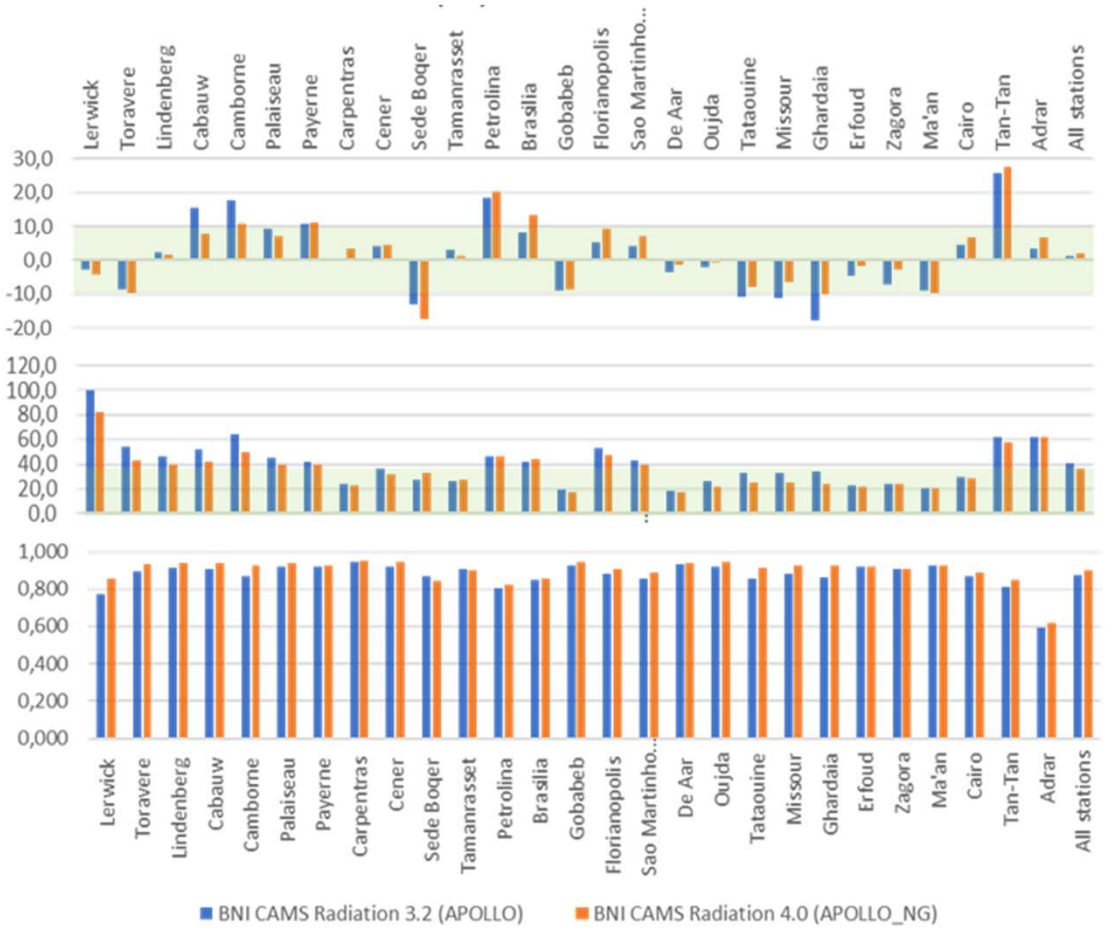


Hourly GHI – rel. bias, rel. RMSE and correlation coefficient change from CRS 3.2 to CRS 4.0

Evaluation results – SEVIRI

Study design:
BNI (beam normal irradiation)
hourly evaluation; 2004 to 2020
CAMS operational v3.2 (old)
CAMS operational v4.0 (online)

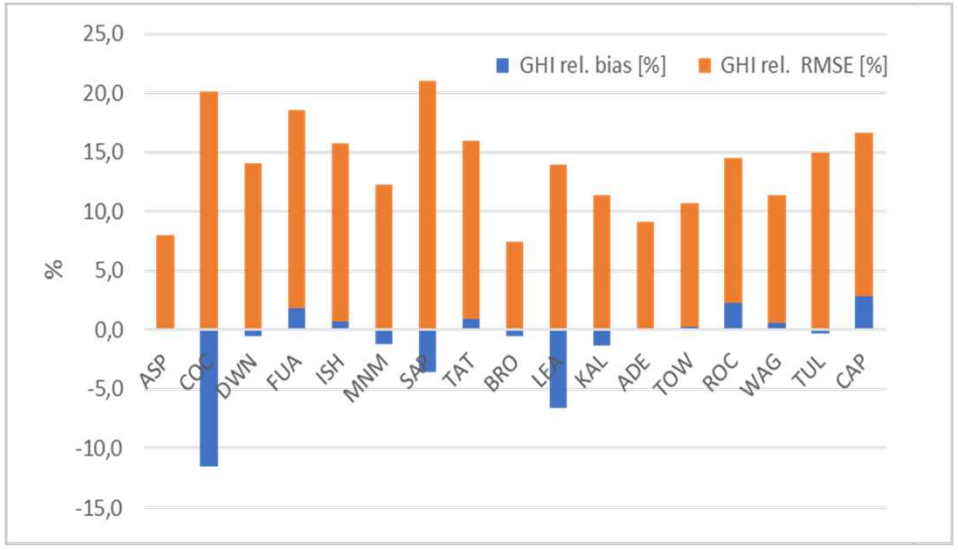
Thanks to BSRN & EnerMENA station teams for providing their data.

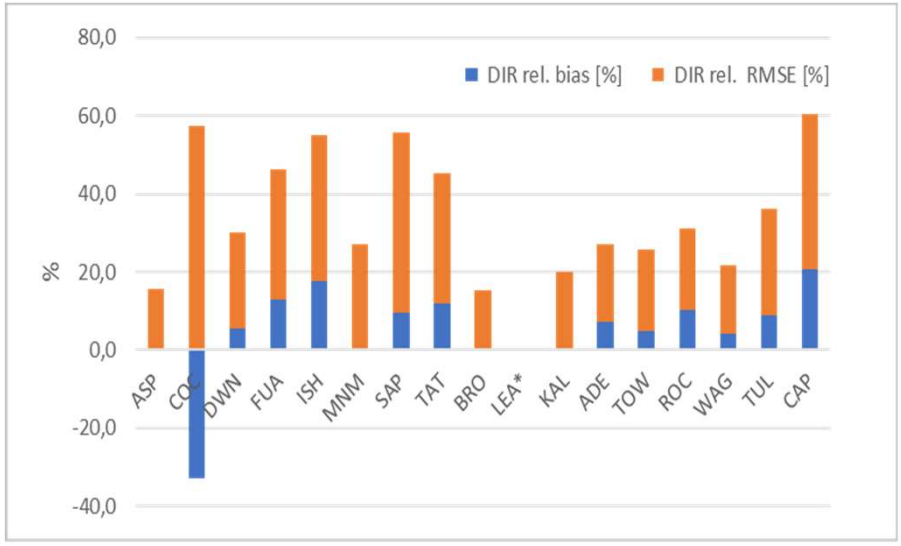


Hourly BNI – rel. bias, rel. RMSE and correlation coefficient change from CRS 3.2 to CRS 4.0

Preparing for MTG - Evaluation results – Himawari-8

Study design:
hourly evaluation; 6 days/month – each 5/10/15/20/25/30 of each month in 2018
experimental version: APOLLO_NG/Heliosat-4(DLR) based on 2 km channels, no bias correction applied

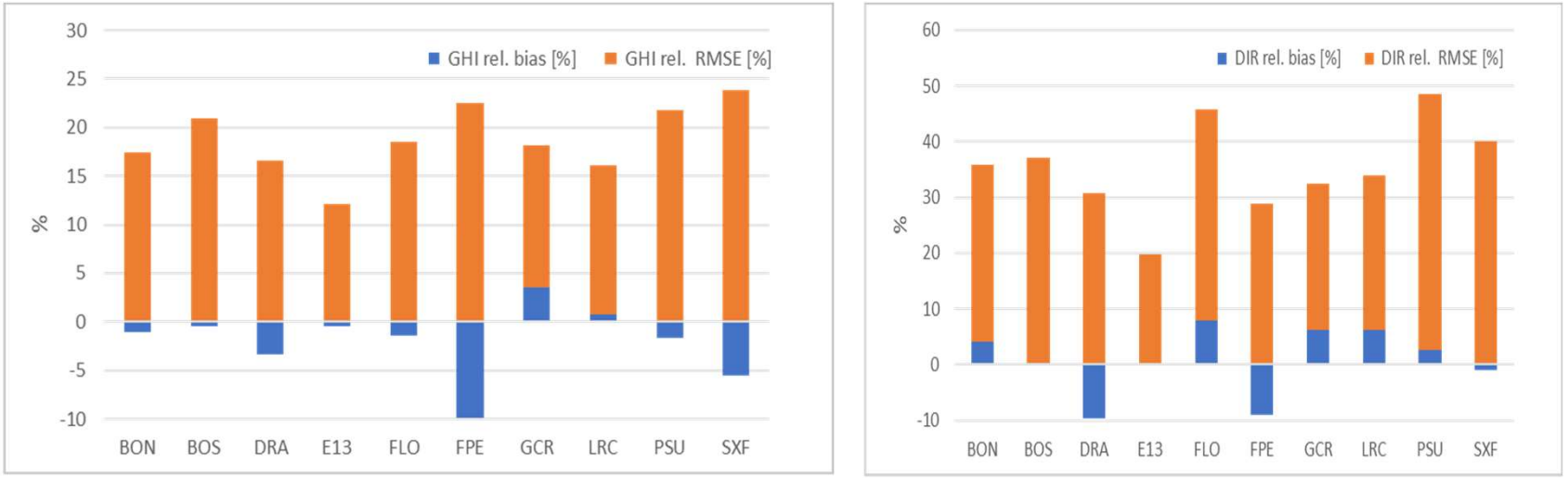




Hourly GHI and DIR validation for HIMAWARI -8 for the year 2018 - outliers COC and LEA are mixed pixels at the coastline.
Station LEA does not provide enough DIR observations and is excluded.

Preparing for MTG - Evaluation results – GOES-16

Study design:
hourly evaluation; 6 days/month – each 5/10/15/20/25/30 of each month in 2018
experimental version: APOLLO_NG/Heliosat-4(DLR) based on 2 km channels, no bias correction applied

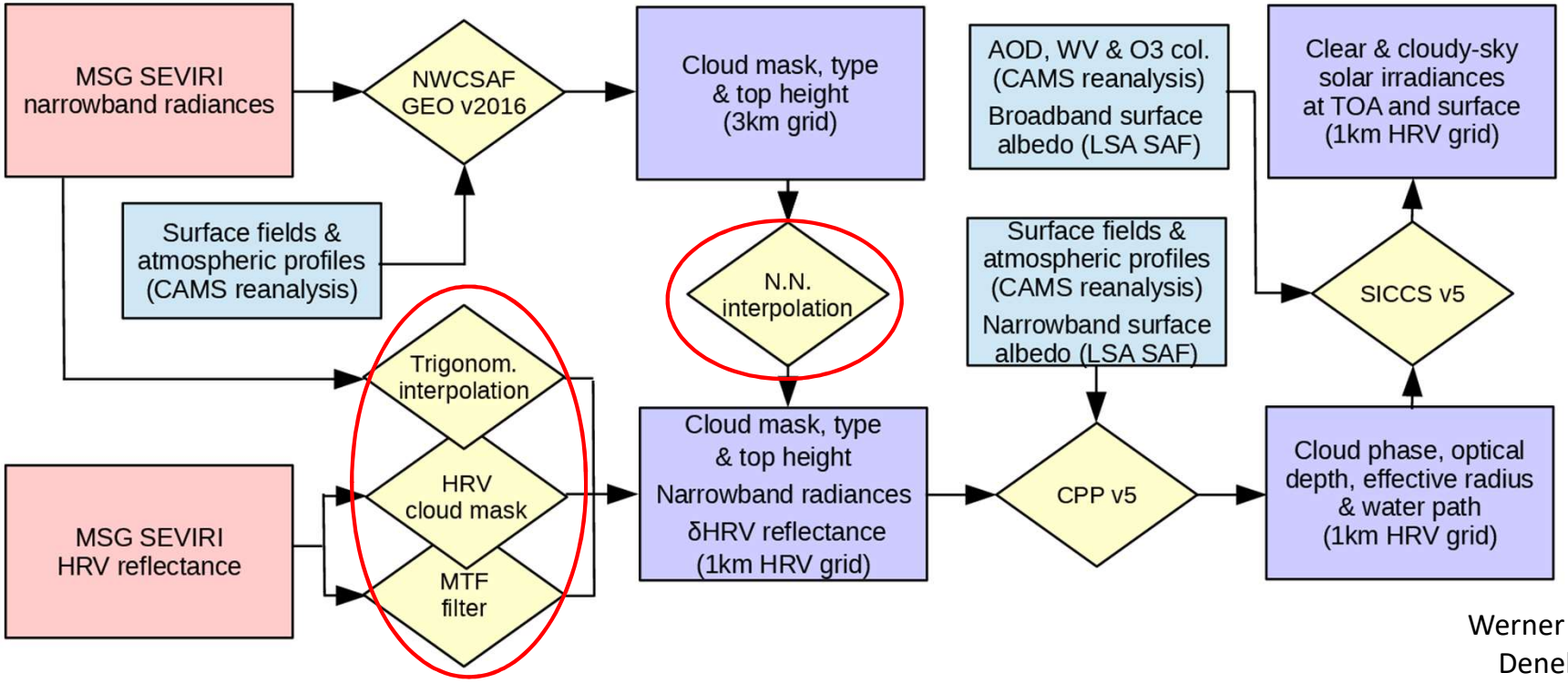


Hourly GHI and DIR validation for GOES-16 for the year 2018 – long snowy season increases all metrics in BON, BOS, FPE, SXF in 2018; DRA affected by parallax effects in broken cloud conditions

Preparing for MTG – Use of higher spatial resolution

Study design:

- TROPOS implementation of CPP/SICCS cloud/irradiance algorithms (!= CAMS algorithm)
- extended to use HRV broad band channel in multi-spectral cloud physical retrieval



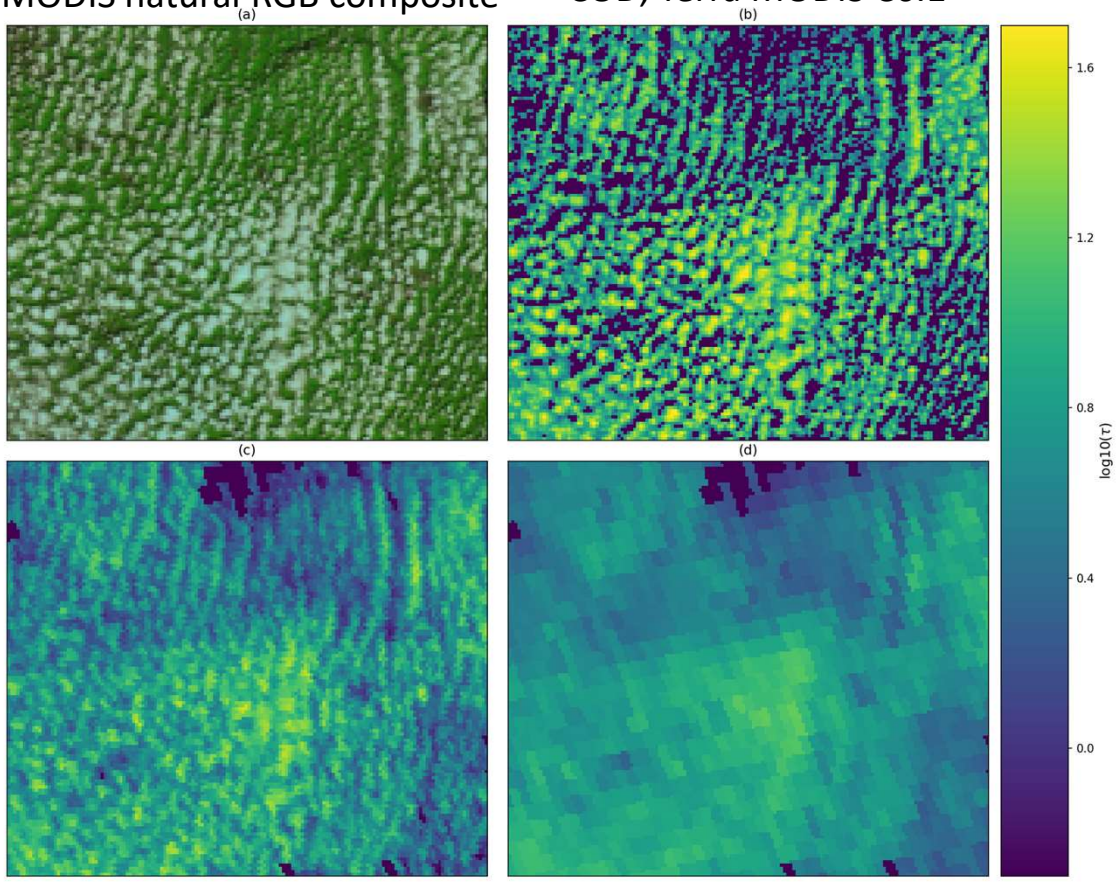
Bley and Deneke, AMT, 2013

Werner & Deneke, AMT, 2020
Deneke et al., AMT, 2021

Preparing for MTG – Effects of higher spatial resolution

MODIS natural RGB composite

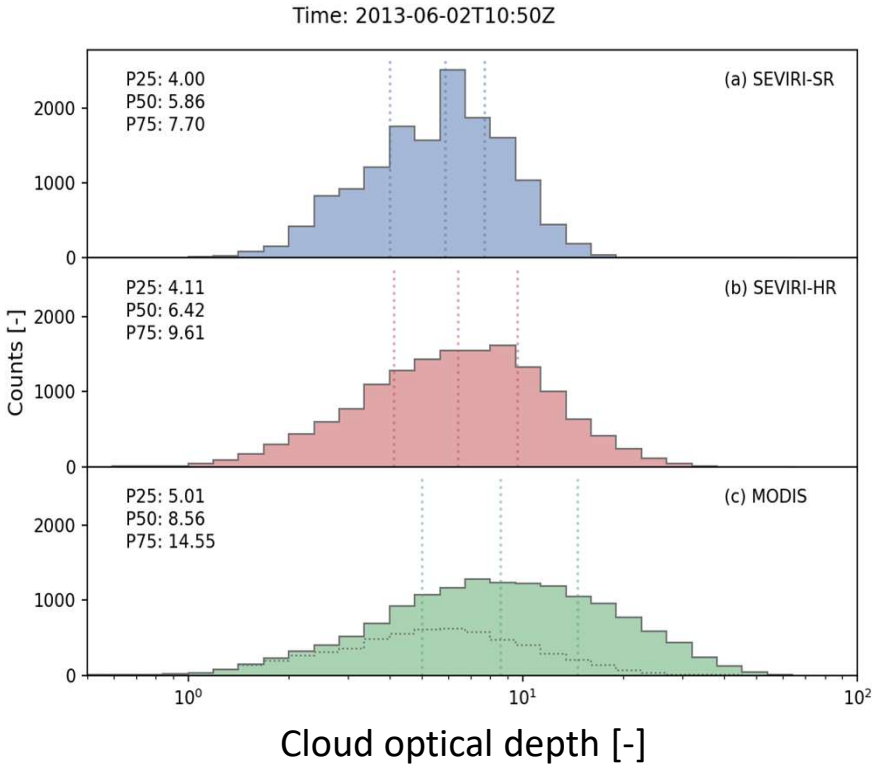
COD, Terra MODIS C6.1



COD SEVIRI HRV-based

COD, SEVIRI 2 km standard

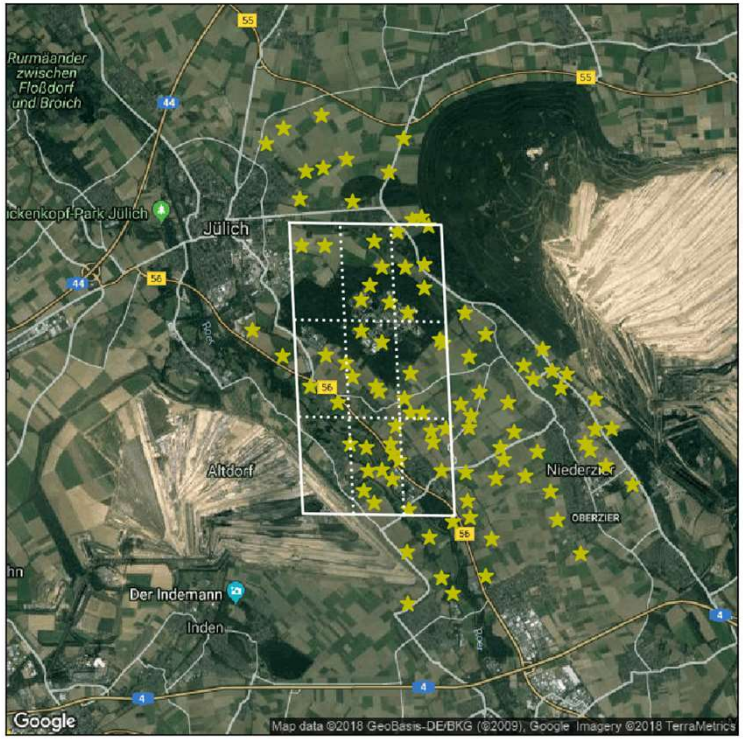
2 June 2013, 10:50 UTC



MetPVNet

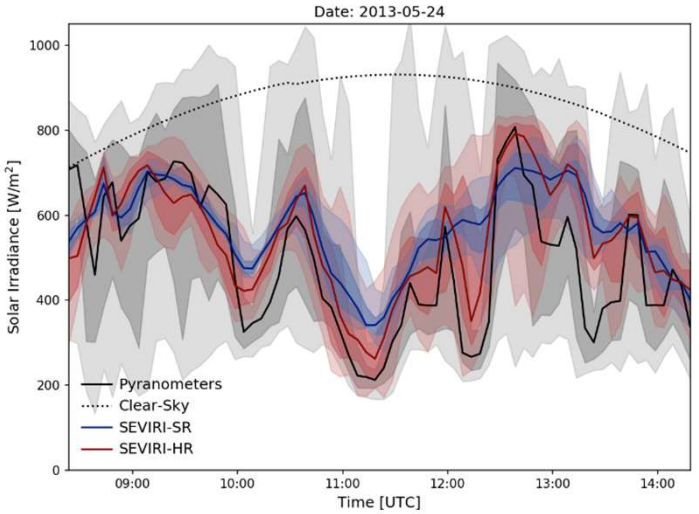
Deneke et al., AMT, 2021

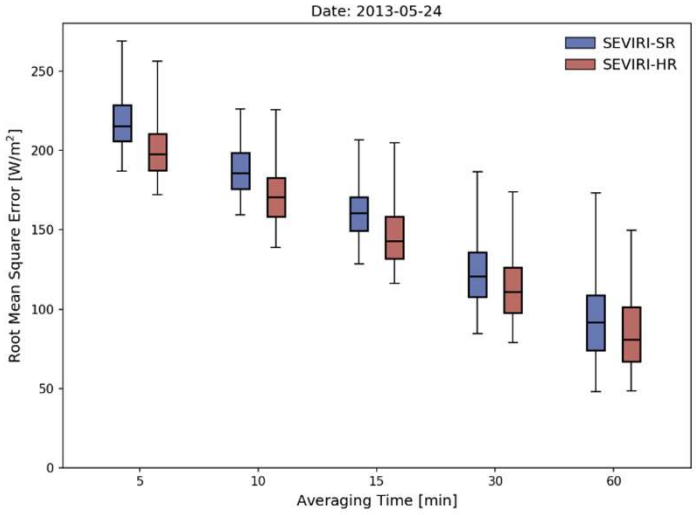
Preparing for MTG – Use of higher spatial resolution



Pyranometer network HOPE campaign, 2013

GHI Stations as yellow stars, SEVIRI standard resolution pixel in white solid line
HRV pixels in dotted white lines





GHI variability

Black/grey: ground observation

Blue/light blue: 3 km SEVIRI

Red/light red: HRV SEVIRI

All data resampled to 5 min

Daily mean RMSE for GHI

Averaging periods
from 5 to 60 min

HRV/3km combination performs better in this case, note: this is not valid for all days evaluated

MetPVNet

Deneke et al., AMT, 2021

Conclusions

The CAMS Radiation Service Version 4.0 update (active since 28 June 2021)

- Applies probabilistic cloud mask of APOLLO_NG
- Several bug fixes (no COD clipping for small values anymore)
- Direct irradiance adapted for circumsolar radiation so that pyrheliometer observation is met
- Validated for SEVIRI

Preparations for MTG

- Validated for SEVIRI, Himawari-8, and GOES-16 without any bias correction
- Quantification of cloud optical depth as function of spatial resolution
- Study on impact of HRV spatial resolution merged with standard 3 km SEVIRI channel resolution

Thanks to:

MetPVNet

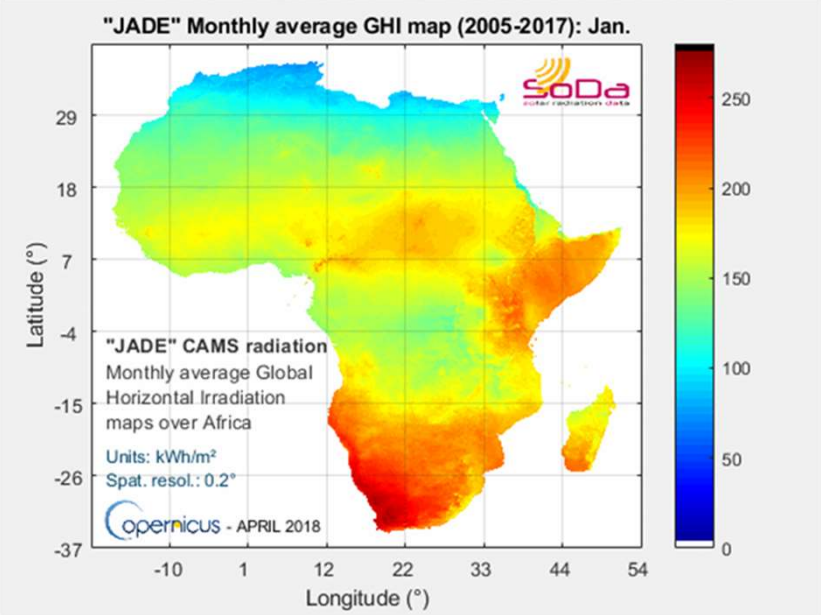
Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

Contact point & references

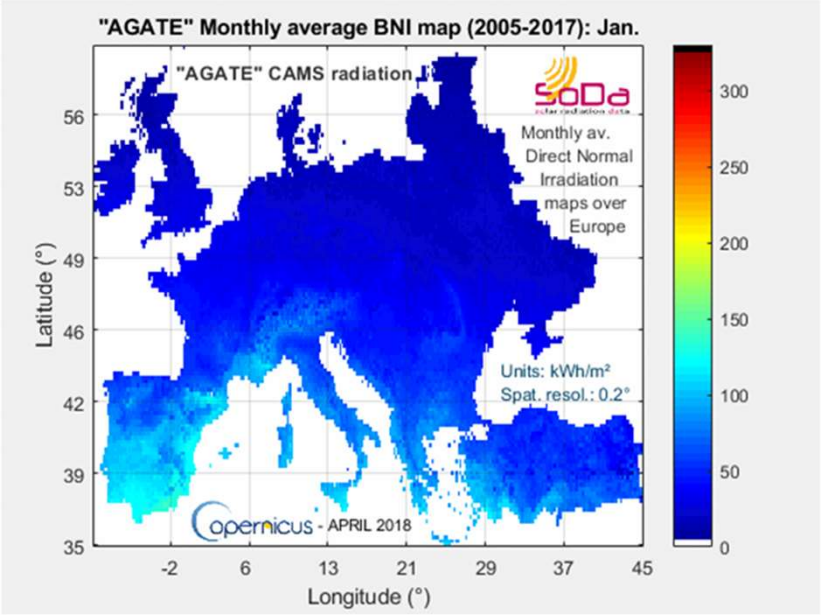
- General inquiries and user requests: copernicus-support@ecmwf.int
- Specific for the Solar Radiation Service team: marion.schroedter-homscheidt@dlr.de
- See additional slides on data access
- User's Guide at http://atmosphere.copernicus.eu/documentation
- Heliosat-4 method: Qu et al., Fast radiative transfer parameterisation for assessing the surface solar irradiance: The Heliosat-4 method, Contrib. Atm. Phys./ Meteorol. Z., 2017
- 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. Phys./Meteorol. Z., 2019
- UV and broadband irradiation evaluation: Quarterly validation reports at https://atmosphere.copernicus.eu/supplementary-services

Additional slides – data access

Gridded datasets

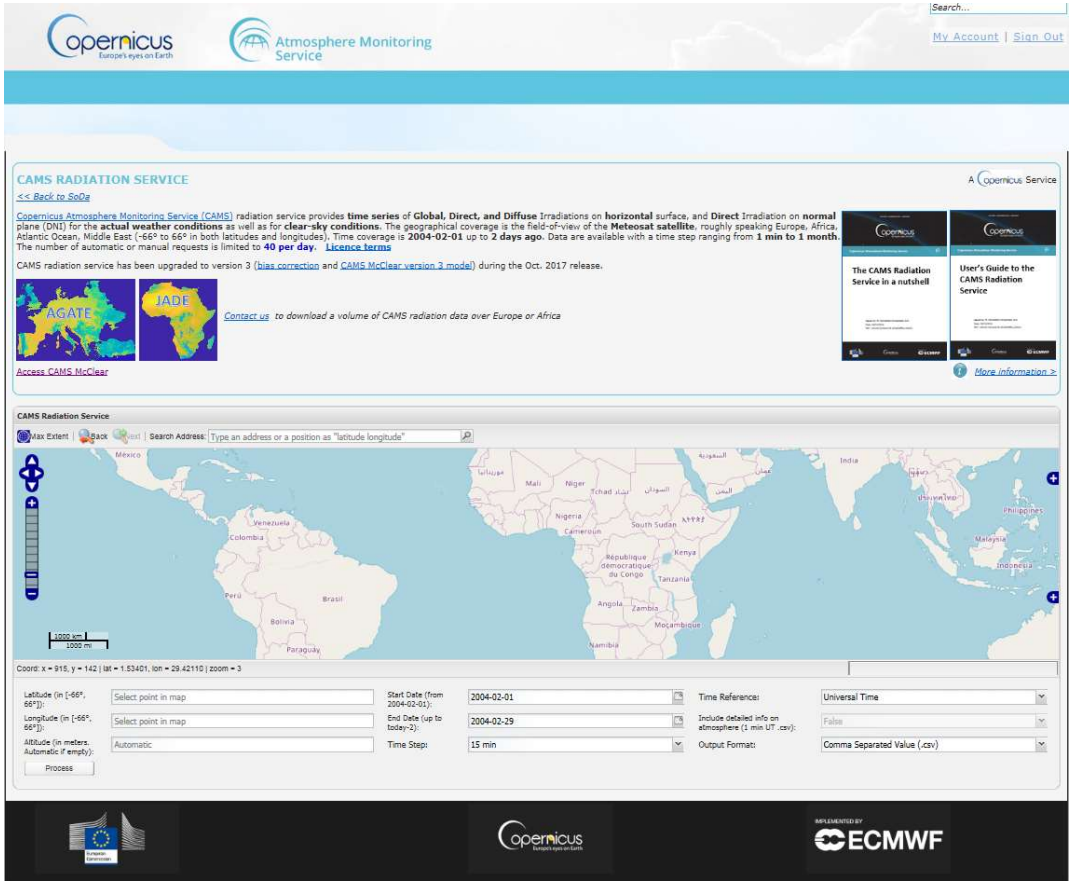


- 15 min temporal resolution
- 2005-2017
- 0.2° gridded data



Figures: Monthly average GHI for Africa and BNI for Europe for January

Time series of total- sky irradiation in Europe/Africa/Middle East

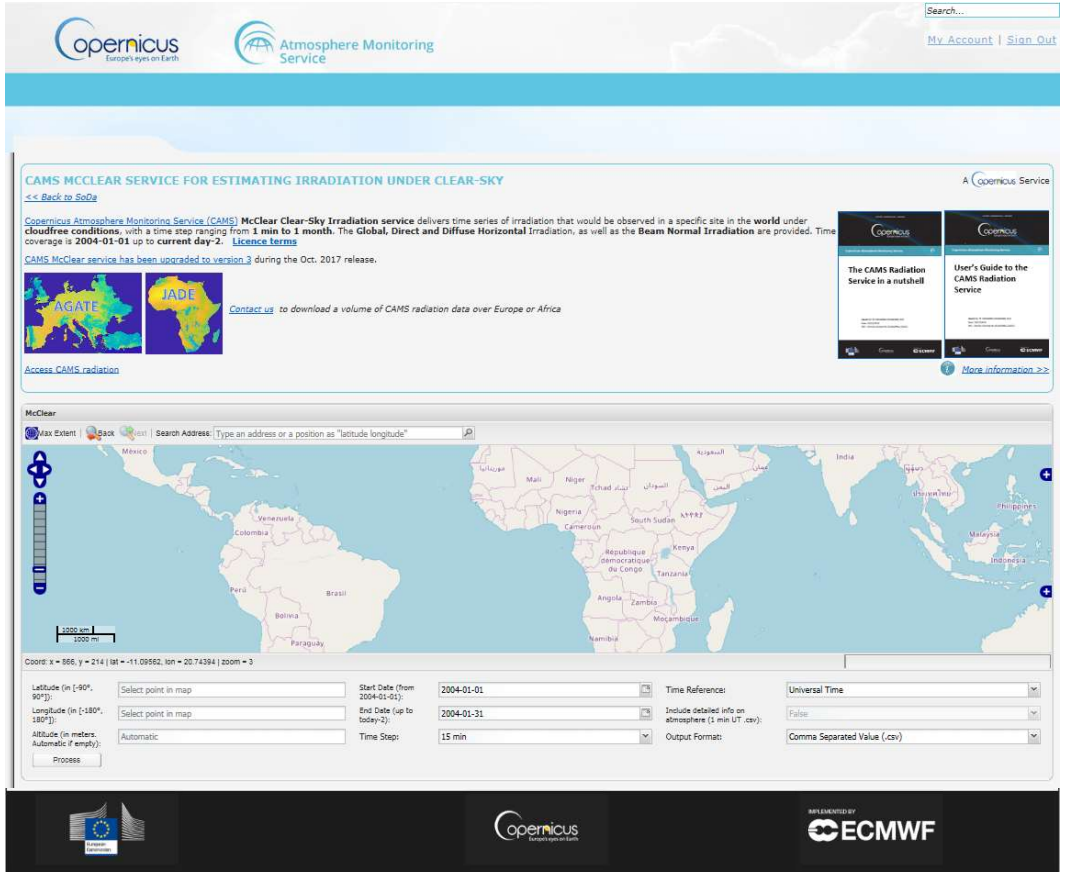


- start in 2004
- after 1-2 days delay online

- global, diffuse, direct and direct normal irradiation
- time series
- 1 min, 15 min, 1 hour, 1 day, 1 month temporal resolution

- CAMS Atmospheric Data Store (https://ads.atmosphere.copernicus.eu)
- interactive and OGC script access possible

Clear sky (cloud-free) irradiation in global coverage – time series at location of interest



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- 1 min, 15 min, 1 hour, 1 day, 1 month temporal resolution

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- interactive and OGC script access possible

Detailed expert mode

- maximum transparency
- all input values
- bias-corrected but also un-corrected irradiation

```
# Columns:
# 1. Observation period (ISO 8601)
# 2. TOA. Irradiation on horizontal plane at the top of atmosphere (Wh/m2)
# 3. Clear sky GHI. Clear sky global irradiation on horizonta
(Wh/m2)
# 4. Clear sky BHI. Clear sky beam irradiation on horizontal
(Wh/m2)
# 5. Clear sky DHI. Clear sky diffuse irradiation on horizontal plane at ground level
(Wh/m2)
# 6. Clear sky BNI. Clear sky beam irradiation on mobile plane following the sun at
normal incidence (Wh/m2)
# 7. GHI. Global irradiation on horizontal plane at ground
# 8. BHI. Beam irradiation on horizontal plane at ground le
# 9. DHI. Diffuse irradiation on horizontal plane at ground
#10. BNI. Beam irradiation on mobile plane following the sun at normal incidence (Wh/m2)
#11. Reliability. Proportion of reliable data in the su
#12. sza. Solar zenith angle for the middle of the summ
#13. atm. Atmospheric profile code: afglus=U.S. standar
afglms=midlatitude summer afglmw=midlatitude winter afg
afglsw=subarctic winter
#14. tco3. Total column content of ozone (Dobson un
#15. tcwv. Total column content of water vapour (kg
#16. AOD BC. Partial aerosol optical depth at 550 n
#17. AOD DU. Partial aerosol optical depth at 550 nm for dust
#18. AOD SS. Partial aerosol optical depth at 550
#19. AOD OR. Partial aerosol optical depth at 550                atter
#20. AOD SU. Partial aerosol optical depth at 550
#21. AOD 550. Aerosol optical depth at 550 nm
#22. AOD 1240. Aerosol optical depth at 1240 nm
#23. alpha. Angstroem coefficient for aerosol
#24. Aerosol type. Type of aerosol: -1=no value 5=urban 7=continental clean 8=continental
polluted 9=continental average 10=maritime clean 11= maritime polluted 12=maritime
tropical 13=antarctic 14=desert
#25. fiso. MODIS-like BRDF parameter fiso
#26. fvol. MODIS-like BRDF parameter fvol
#27. fgeo. MODIS-like BRDF parameter fgeo
#28. albedo. Ground albedo
#29. Cloud optical depth  (value of the nearest acquisition ti                    )
#30. Cloud coverage of the pixel (percentage from 0 to 100, va                    test
acquisition time of the pixel)
#31. Cloud type (value of the nearest acquisition time of the p                   alue 0=no
clouds 5=low-level cloud 6=medium-level cloud 7=high-level cloud 8=thin cloud
#
```

radiation without clouds

radiation with clouds

sun position

ozone, water vapour

aerosols

surface reflection

clouds