ECMWF

European Commission

ICWG workshop 2018

Copernicus Atmosphere Monitoring Service

Services for solar energy users: success and existing problems

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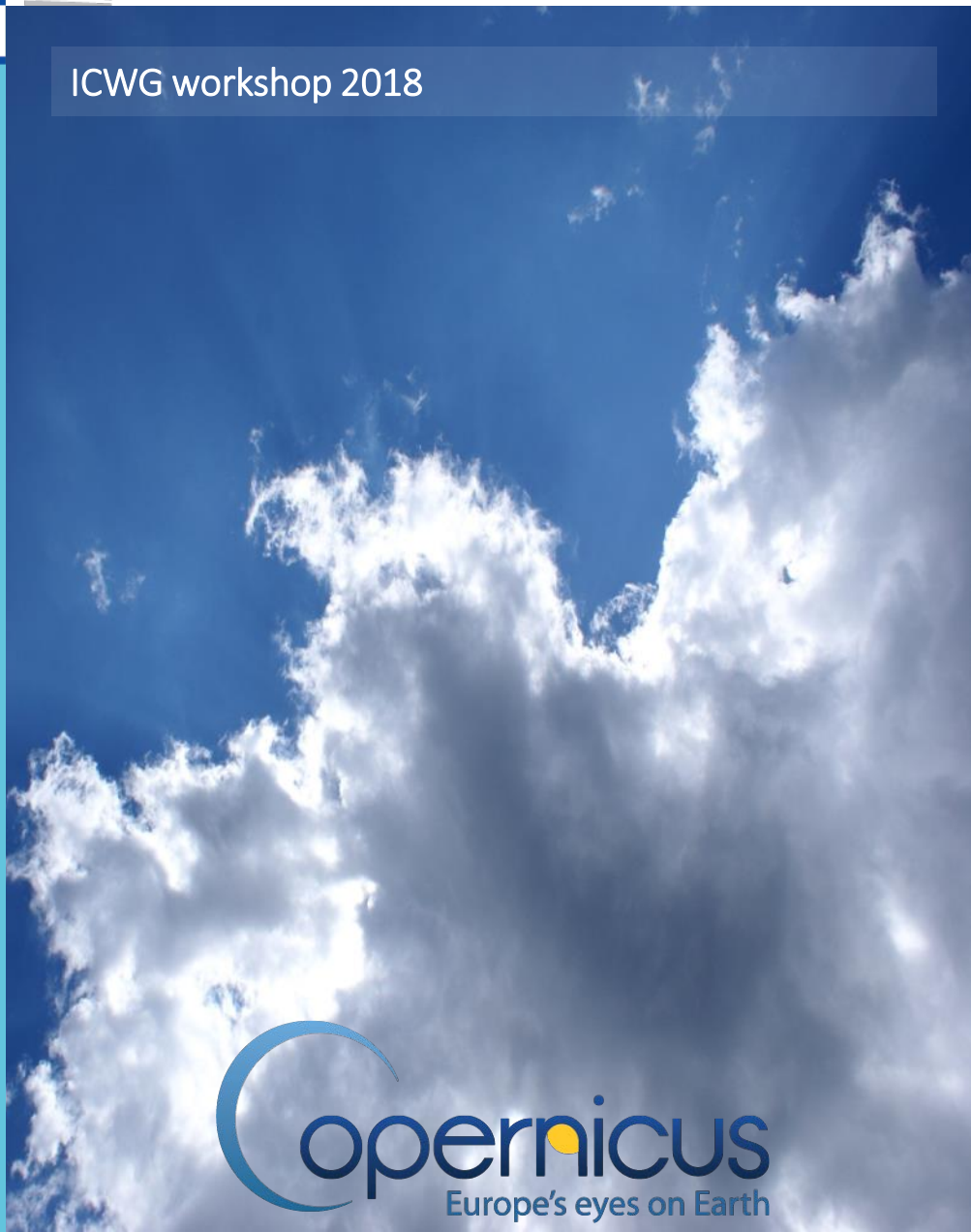
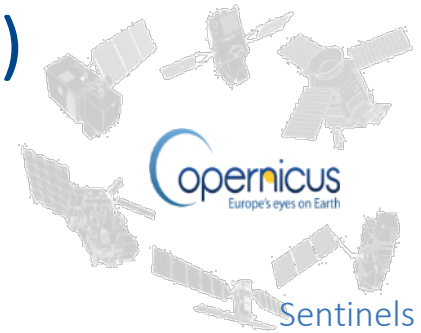
DLR ARMINES TRANSVALOR FINNISH METEOROLOGICAL INSTITUTE



Outline

- **Solar radiation at the ground – services for solar energy users**
- **CAMS Radiation Service for solar energy users**
- **Some validation examples**
- **User acceptance**
- **Known issues & searching solutions together with the cloud retrieval community**

Copernicus Atmospheric Monitoring Service (CAMS)

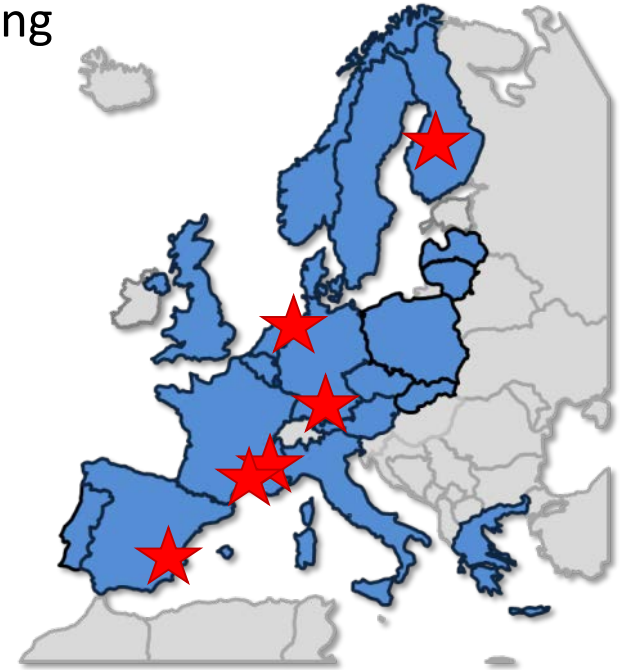


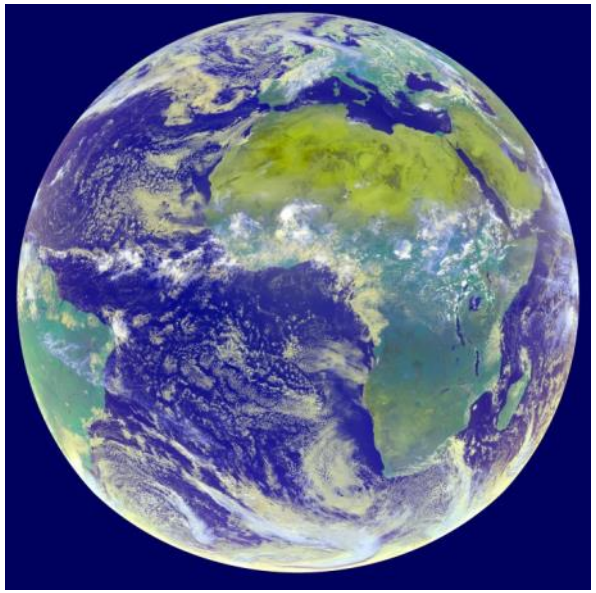
CAMS provides policy makers, businesses, scientists and citizens alike with reliable information about **atmospheric composition**.

CAMS builds up knowledge and boosts informed decision-making on topics such as air quality, health, **solar energy** and climate.

CAMS is implemented by **ECMWF** and currently consists of 133 service providers from 30 different countries.

The **CAMS Radiation Service** is provided by DLR with Armines, FMI, and Transvalor.





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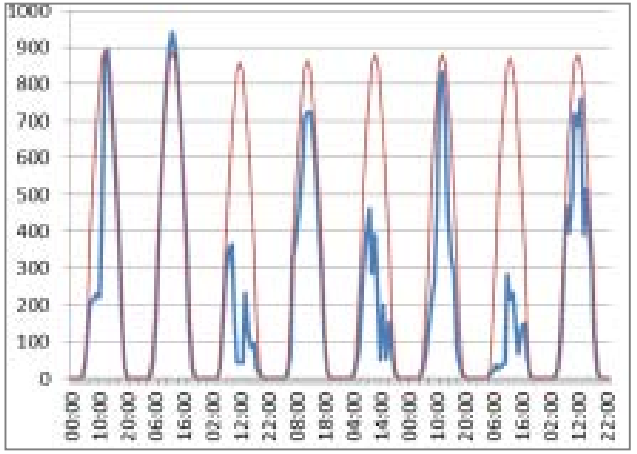
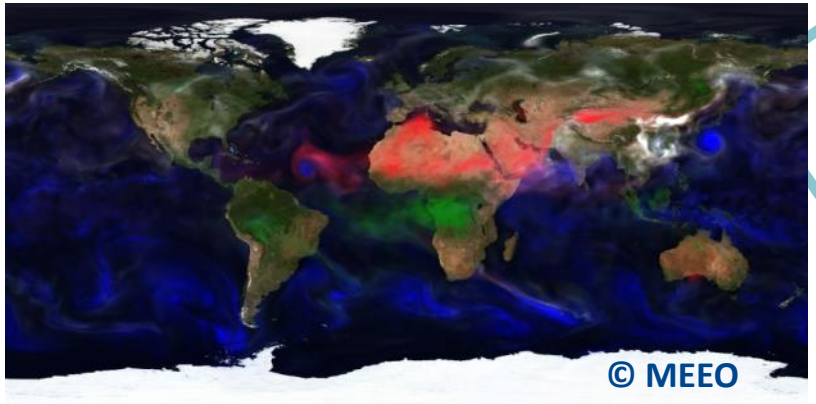
APOLLO
APOLLO_NG

Heliosat-4 and McClear physical approaches, fast radiative transfer, on-the-fly processing



irradiance,

cloud free irradiance



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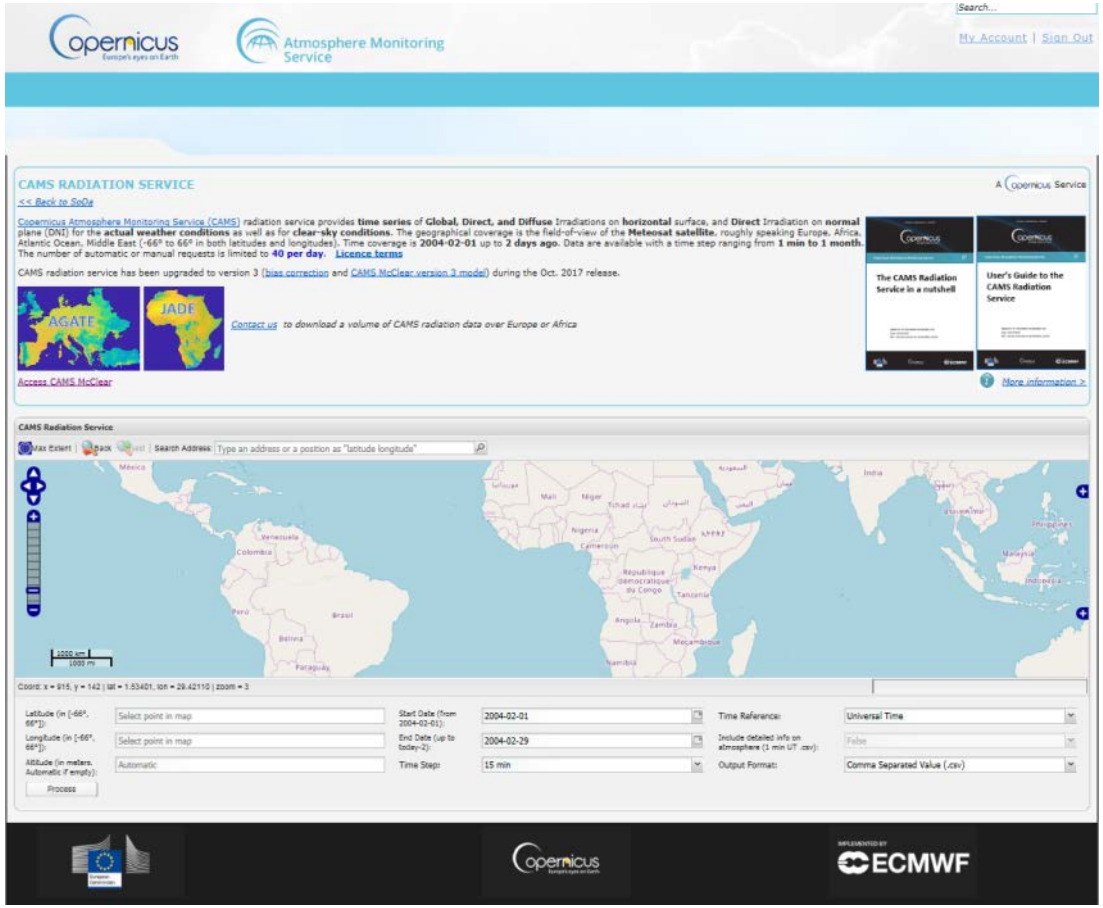
aerosol
H2O, O3
from CAMS

CAMS radiation service method papers
Qu et al., MetZet, 2017
Lefèvre et al., AMT, 2013

Time series of all- sky irradiation in Europe/Africa/Middle East and clear-sky irradiation world wide



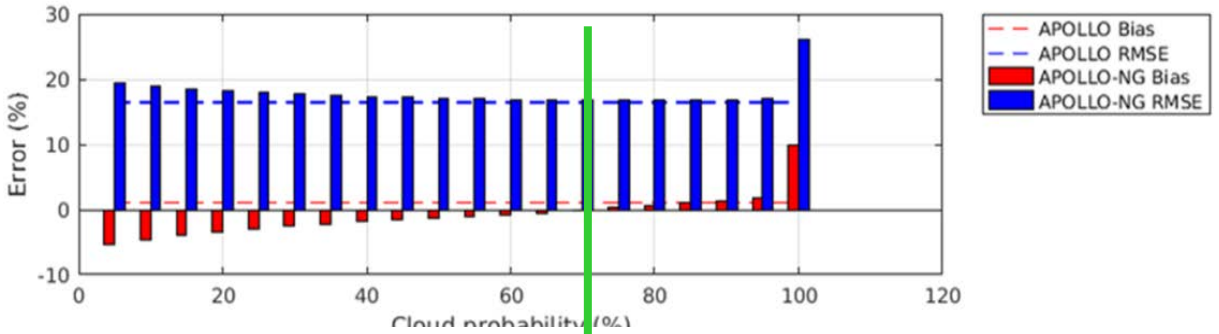
- **start in 2004**
- **after 1-2 days delay online**
- **global, diffuse, direct and direct normal irradiation**
- **time series**
- **1 min, 15 min, 1 hour, 1 day, 1 month temporal resolution**
- **interactive and OGC script access possible**
- **free for any use**
- **about 20 000 requests per quarter**

Solar energy specific services around the world

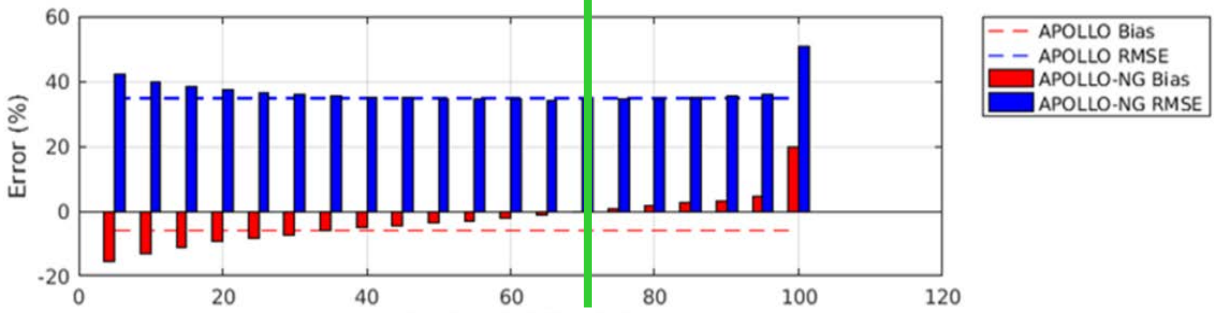
- there are various physical based solar irradiance retrievals now available
  - CLAVR-x & FARMS from NOAA/NREL; CPP&SICCS from KNMI; APOLLO_NG & HELIOSAT-4 from CAMS; plans in Australia, China, ...
- they are replacing step by step the previously used cloud index algorithms
- physical retrievals provide chances
  - but also rely on physical cloud and aerosol property retrievals being accurate enough
  - validation against radiation offers a different view on retrievals

Validation results for CAMS Radiation Service (CRS)

Global Horizontal Irradiance



Direct Normal Irradiance



Cloud probability treshold for cloud masking in %

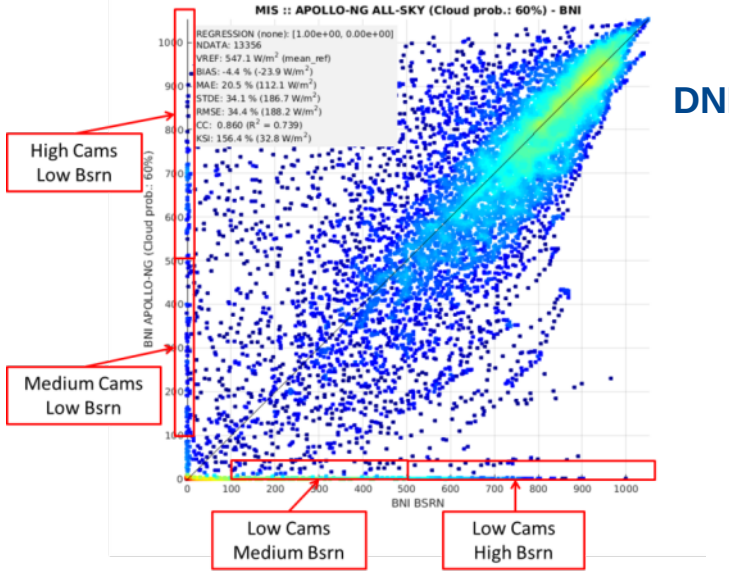
APOLLO_NG probabilistic cloud masking
+ COD with uncertainty

Main result:
bias-free for both global and direct radiation if cloud probability set to 70%

in physical retrieval only
- without any bias correction
as used previously

Up to now shown for Northern Africa and Southern Europe

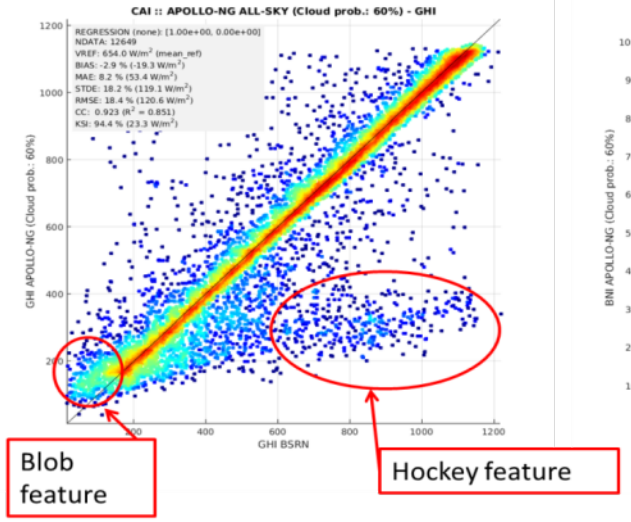
Examples from CRS



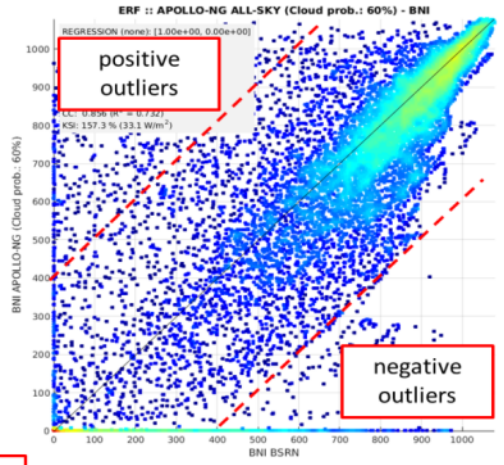
DNI

more questions if we look into single stations -> detailed single case analysis for these subsets

GHI



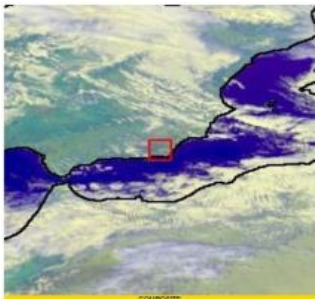
DNI

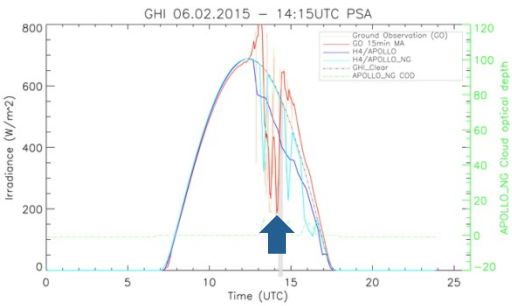


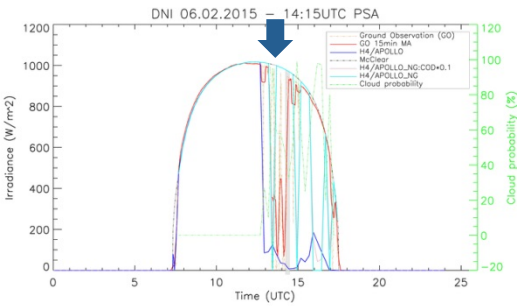
Cases showing typical problems

GroundOBS
SatOBS APOLLO_NG
SatOBS APOLLO

small scattered clouds

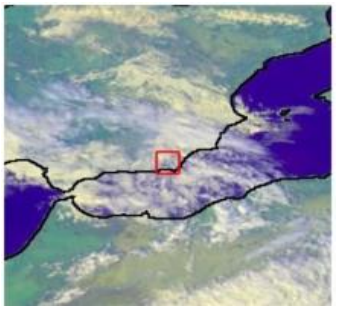


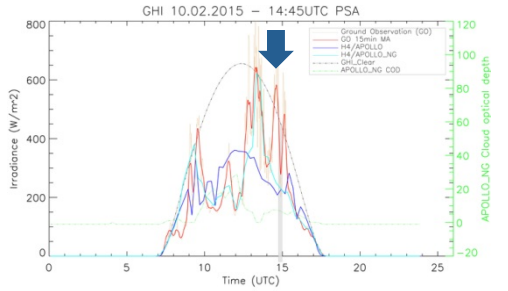


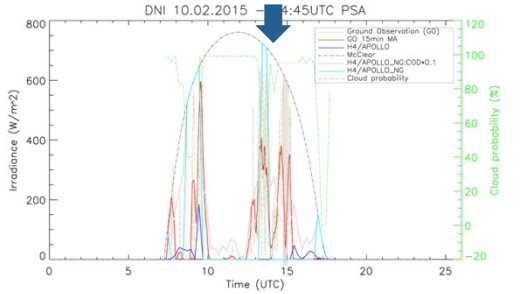


GHI **BNI**

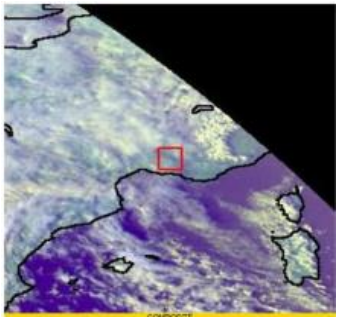
multilayer clouds + strong horizontal variability

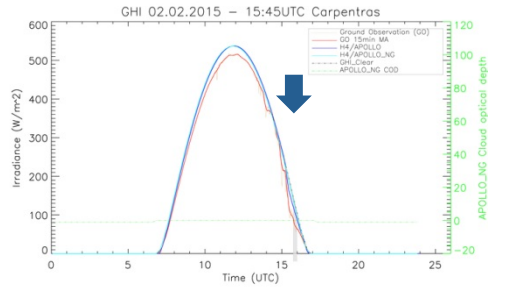


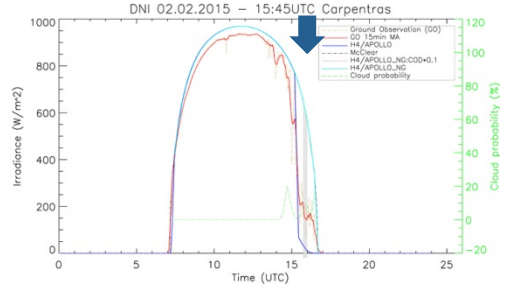




multilayer clouds + strong variability + low sun







Remote sensing for solar energy

Cloud community

You should not use our cloud physical products if our assumptions are not met.

And if you do, you should not complain ...

Well, they did a lot to quantify restrictions of current retrievals.

Exact solutions are known.

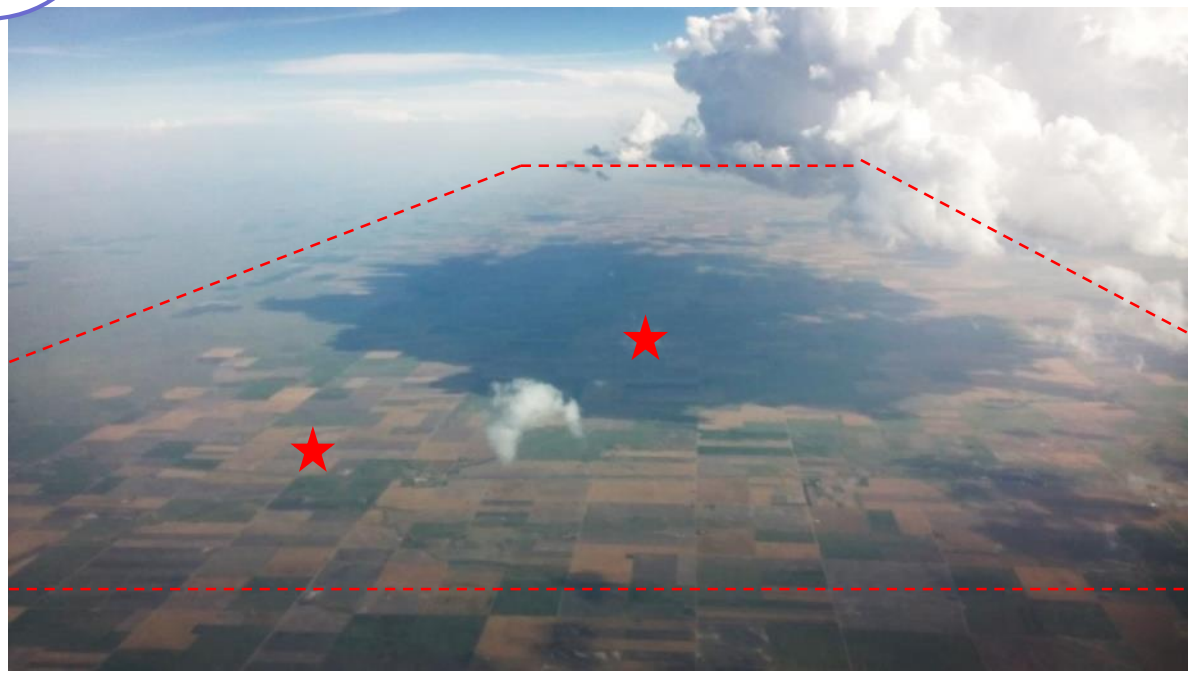
Computationally efficient parameterisation for operational remote sensing in GEO orbits ???

Your satellite data has
18% RMSE in GHI and 35% for DNI.
I'll use a ground observation
with 5% RMSE according
to the instrument data sheet.
This is more accurate.

Solar energy users

What is accuracy?

1 cm² ground OBS
vs. power plant scale solar energy (e.g. 1 km²)
vs. satellite pixel



Source: H. Ruf

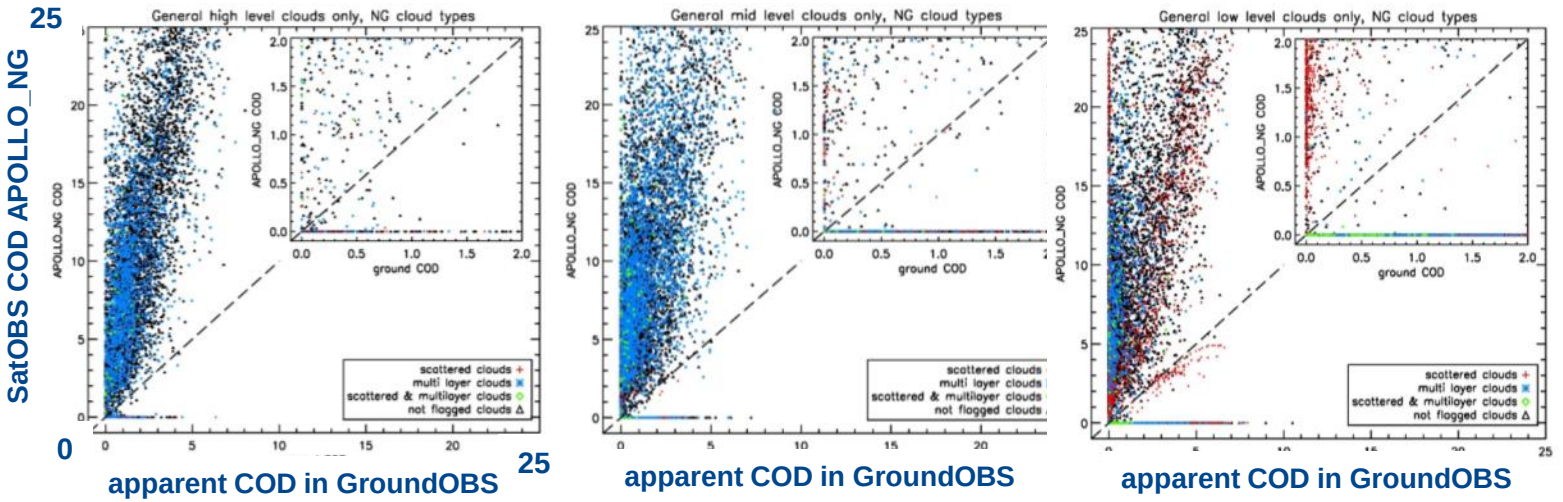
One more: retrieved COD is too high in COD<7 range

very important for concentrating solar power and direct/diffuse split for photovoltaics

high water or mixed phase clouds

medium height water clouds

low water clouds



scattered clouds
multilayer clouds
other clouds

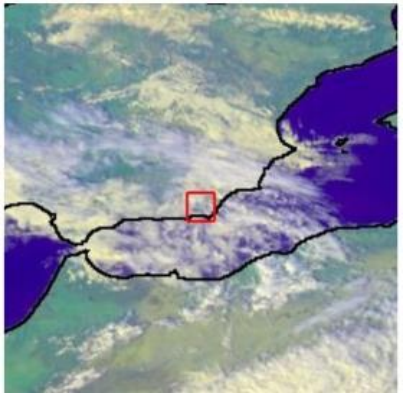
- **coding error ? but others have seen similar**
- **scientific explanation not very well discussed**
- **your ideas ?**

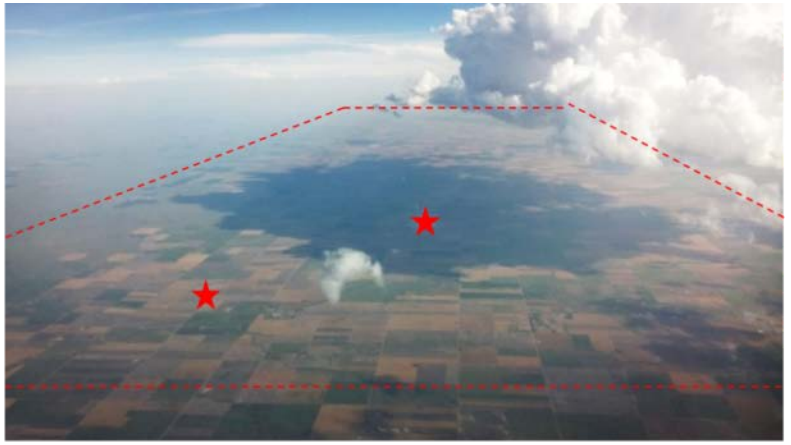
y-axis: COD as from APOLLO_NG
(reflectances 0.6 and 3.7 channels, iterative two-stream,
Mie and Baum et al optical properties, all cloud-affected pixels)

x-axis: **COD from BSRN direct normal irradiance observations**,
(McClear model estimates AOD and water vapour effect first, before deriving OD,
all sun geometries, but **COD only < 7 as from direct irradiances**)

Some ideas... more to come...

- real clouds transmissivity is higher as assumed in plane parallel assumption (e.g. Greuell, 2013; seen as well in CAMS)
- investigate optimum handling of interpolation issues with rapid scan data and higher resolution multispectral data
- point vs. area average in validation
- apply automatic detection of difficult cases (scattered, multilayer, low sun,...) for applying any 3D parameterizations
- do error propagation on individual pixel basis -> reliability information (index or quantitative) on each radiation value e.g. as input to solar nowcasting
- **learn more from cloud experts, do not overlook existing knowledge**





Source: H. Ruf

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