Correction of Satellite-Derived DNI Time Series Using Locally-Resolved Aerosol Data

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Major factors influencing DNI
1) cloud attenuation
2) aerosols
3) water vapour

DNI daily profile for different aerosol loads

0.1 - 0.5 change of AOD = 40% decrease of DNI

DNI daily profile for different water vapour content

Influence on GHI is several times lower
Requirements for AOD data

- high time resolution - at least daily
- continuous in time, no gaps
- homogeneous spatial coverage – no regions without data
- high spatial resolution, site specific

AOD in satellite radiation databases

- Chemical transport models (MACC, GOCARD, MATCH…)
- Satellite derived products (MODIS, MERA, OMI,…)
- Local (nearby) measurements (AERONET, DNI derived, visibility)

Common AOD problems

- Regional bias (models, satellite)
- Low resolution (50 – 200 km) – not site specific (models, satellite)
- Missing data (satellite, local measurements)
- Old radiation databases use monthly AOD data
Monthly vs. daily aerosol data

MACC AOD monthly average
Monthly vs. daily aerosol data

BLU: monthly averaged AOD data
RED: data with daily variability of AOD (SolarGIS data)
AOD problems – low resolution of database

Sede Boqer (Israel) – DNI BIAS -11.0

Sede Boqer
Complex geography, terrain, sea (low res MACC data do not describe inter-pixel variability)
AOD problems – missing data

Satellite (MODIS-Terra) AOD data coverage for 3 September 2012
Problems of DNI due to aerosols

- Inaccurate day-by-day variability
- Systematic over/under-estimation
AOD database used in SolarGIS model

Chemical transport model MACC
- operated by ECMWF, reanalysis data + operational model
- 1.125 deg resolution (original resolution 0.8 deg)
- period 2003 – 2012
- 6 hourly time step reduced to daily data
- Gaps free
Adaptation of satellite time series to local measurements

Inputs
- Time series of irradiance data derived from satellite data (10+ years)
- Ground measurements of DNI and GHI (high quality, 12+ months)

Output
- Time series of irradiance data with reduced uncertainty

Aim
- Remove systematic deviation from satellite data
- Decrease bias, RMSE
- Improve distribution of values
Standard method to reduce systematic deviation

Statistical approach, postprocessing
(CDF fit, rescale)

input data
(satellite, AOD, WV, altit.,...)

satellite based radiation model

GHI, DNI

on-site measurements

adaptation of GHI, DNI

final GHI, DNI
Proposed method to remove systematic deviations

Adaptation of inputs – correction of source of bias
(AOD correction)

- on-site measurements
- adaptation of AOD

input data (satellite, AOD, WV, altit.,…)

satellite based radiation model

final GHI, DNI
Correction of aerosols

Example: Geraldton, Australia

- monthly correction factor derived from local ground measurements
- applied to the daily aerosol data from MACC model
- correction in the range of -0.03 to -0.06
Results of site adaptation

original DNI data

DNI with AOD adaptation
# Results of site adaptation

<table>
<thead>
<tr>
<th></th>
<th>BIAS</th>
<th>RMSE</th>
<th>KSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORIGINAL DATA</td>
<td>-8.65 %</td>
<td>26 %</td>
<td>156</td>
</tr>
<tr>
<td>CDF FIT</td>
<td>-0.05 %</td>
<td>25 %</td>
<td>26</td>
</tr>
<tr>
<td>AOD adaptation</td>
<td>-0.2 %</td>
<td>25 %</td>
<td>29</td>
</tr>
</tbody>
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Both methods provide significant improvements of all measures.
Results of site adaptation

Cumulative distribution

original data

CDF fit

AOD adaptation
Results of site adaptation

Coherence of GHI and DNI

original data

CDF fit
- destroys GHI/DNI coherence
- does not follow physical principles

AOD adaptation preserves GHI/DNI coherence
Use of AOD correction for improvement of SolarGIS database

- Regional adaptation of the AOD database used in SolarGIS model
- Based on the AERONET data and ground measurements
- Aim: identify and remove regional bias of the MACC AOD database, reduce DNI uncertainty
Regional AOD correction

- Pre-selection and validation of the data of heterogeneous quality
- Analyzing regional patterns of the systematic AOD bias
- Analysis of seasonal pattern of the AOD bias
- Analysis of outliers, specific local AOD conditions
- Derivation of regional correction factor
  - Harmonization of clusters of sites
  - Barrier effect of the mountain ridges and other geographical features
Time period with available AERONET data

All AERONET sites: ~650
More than 15 days of data: 460 site
More than 365 days of data: 235 sites
Average deviation AERONET – MACC data

- Overall slight overestimation by MACC
- Regions with higher overestimation:
  Arabic peninsula, N. India, China, SW US
Results:

- Reduced uncertainty of DNI and GHI data
  Regions with available AOD or DNI ground data
    - DNI uncertainty 5-8 %

- Reduction of uncertainty is not as high as for site specific AOD correction, but regional problems were mitigated

![SolarGIS DNI](image-url)