Global solar radiation: comparison of satellite and ground based observations

Petr Skalak¹,², Piotr Struzik³, Aleš Farda²,¹, Pavel Zahradníček²,¹, Petr Štěpánek²,¹

1) Czech Hydrometeorological Institute, Praha, Czech Republic
2) Global Change Research Centre AS CR, Brno, Czech Republic
3) Institute of Meteorology and Water Management, Krakow, Poland

skalak@chmi.cz
CHMI Radiation Network

- 19 stations in total
- established in 1984 with 11 stations (the oldest records since 1953)
- monitoring of solar radiation (global radiation + components, UV radiation)
- equipped with Kipp&Zonen CM11 and CMP 11 pyranometers

Q: How can we get information on solar radiation at other locations?
Sunshine duration at CHMI stations

Sunshine duration (SD), global radiation (GLBR)


Number of stations

Campbell Stokes heliograph replaced by SDx series of sunshine detectors from Meteoservis Vodňany
Applicability of sunshine duration

Sunshine duration (SD) can be recalculated into global radiation (GLBR) but detailed metadata are needed:

- changes of instrumentation and its location
- the real horizon at the station and its changes in time (tree growth, new buildings...)

→ not often well documented at voluntary (i.e., majority of) stations

Q: Would it look the same if more stations were available? Aren’t we missing some information on the real spatial variability of GLBR?


Solar radiation from satellites

Annual sum of downwelling solar shortwave radiation [kWh/m²] in 2013 derived by EUMETSAT LSA SAF
EUMETSAT satellite radiation data

EUMETSAT Climate Monitoring Satellite Application Facility (CM SAF)
- http://www.cmsaf.eu
- operational and climate monitoring products including surface incoming solar radiation (SIS)
  - **SIS** = irradiance the **200-400 nm** wavelength region
  - operational products released 8 weeks after observation at the latest

CM SAF **SARAH** (Surface Solar Radiation Data record – Heliosat) Dataset
- combining Meteosat 1\textsuperscript{st} and 2\textsuperscript{nd} generation data into a single homogenous dataset
- 1983-2013*
- hourly, daily and monthly time resolution
- almost full disc coverage (-65° to 65° in longitude and latitude) in 0.05° spatial resolution

EUMETSAT satellite radiation data

EUMETSAT Land Surface Analysis Satellite Application Facility (LSA SAF)

- http://landsaf.meteo.pt
- operational products including Downward Surface Shortwave Flux (DSSF)
  - DSSF = irradiance in the wavelength interval 300-4000 nm
- operational products released instantly
- 2009 - today*
- 30 minutes and daily time resolution
- full disc coverage over land in 0.05° spatial resolution

*) based on LSA SAF Web User Interface
DSSF validation against stations

Comparison of monthly sums of LSA SAF DSSF estimates with CHMI stations measurements of global radiation (GLBR) in 2011-2014

- up to 19 stations versus the nearest grid point (mean distance: 2.1 km)
- DSSF data partly incomplete (Aug 2011, Sep-Dec 2012 missing/omitted)

<table>
<thead>
<tr>
<th>Station ID</th>
<th>LATITUDE</th>
<th>LONGITUDE</th>
<th>ALTITUDE</th>
<th>DISTANCE [km]</th>
<th>AZIMUTH [°]</th>
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</table>
DSSF & GLBR monthly sums

- DSSF estimates against in-situ records over the whole period 2011-2014 at selected two stations

**H3HRAD01**

\[ y = 0.9881x - 11.122 \]

\[ R^2 = 0.9957 \]

**H1LBOU01**

\[ y = 1.0871x - 45.529 \]

\[ R^2 = 0.9702 \]
DSSF-GLBR differences in time

- No apparent similarity of bias evolution among stations.
- Some biases may be affected by local circumstances or choice of a DSSF grid point.
Annual course: bias & absolute bias
Bias & absolute bias among stations

\[ y = 0.0154x + 8.8124 \]
\[ R^2 = 0.7877 \]
Size and significance of errors

LSA SAF Product Requirements for DSSF at the MSG pixel resolution for 30-min or daily data:

• Accuracy 10% for DSSF > 200 W/m$^2$
• Accuracy 20 W/m$^2$ for DSSF < 200 W/m$^2$

CM SAF Target Accuracy for monthly mean surface solar irradiance (SIS) in SARAH:

• 15 W/m$^2$ corresponding to ca. 40 MJ/m$^2$ in monthly sum
Size and significance of errors

- Majority of data points fit within ±40 MJ/m² quality target
- In the summer half year ±10% relative error is met
Conclusions & outlooks

• LSA SAF DSSF provides realistic but biased estimates of Downwelling Shortwave Solar Flux and derived monthly totals of irradiance
• Negative bias dominates
• Higher elevated locations (mountains) show bigger errors
• For operational products of CHMI only summer half-year data seems to be suitable (relative error <10%)

• Validation of the CM SAF SARAH dataset on daily/monthly time scale
• Exploring a potential of the SARAH to be used as a reference dataset to correct a bias of climate models → global radiation from GCMs/RCMs often used by models of the climate change impact community)
Thank you for attention