A comparison of data sources for creating a long-term time series of daily gridded solar radiation for Europe

Jędrzej S. Bojanowski
Anton Vrieling, ITC
Andrew K. Skidmore, ITC
Crop monitoring and yield forecasting

CROP GROWTH MODEL

- Incoming solar radiation
- Mean daily temperature
- Precipitation
- Crop variety parameters
- Management practices
- Crop calendar
- Soil type
- Biomass
- Yield
What limits the plant growth?

Climatic constraints to plant growth (from Nemani et al., *Nature* 2003)

Solar radiation determines the potential growth
Objective

To provide an approach for accurate estimation of daily surface solar radiation

► covering Europe with ground resolution ≤ 25 km
► ~30 years of past spatio-temporal distribution
► in near real-time (delay of 2-3 days)
► consistent in spite of different data sources (not as rigorous as for a climatology)
Solar radiation data sources

**Meteorological observations**

**Satellite**

**Reanalysis**

Measured and modelled solar radiation

LSA SAF MSG + CM SAF MFG

ERA-Interim

Intercomparison
Measuring & modelling solar radiation

Measured solar radiation

Modelled from:
- sunshine duration \((n)\)
- cloud cover \((C_w)\) and air temperature difference \((T_x - T_n)\)

\[
I_s = I_x \left( A_a + \frac{A_b}{N} \right) 
\]

\[
I_s = I_x \left[ S_a \sqrt{T_x - T_n} + S_b \sqrt{1 - \frac{C_w}{8}} \right] + S_c
\]

\[
I_s = I_x H_a \sqrt{T_x - T_n} + H_b
\]

RRMSE=15%

Replaced by Meteosat-derived coefficients
(Bojanowski et al., AgrForMet, 2013)

Coefficients typically determined for locations where the solar radiation is measured, and then interpolated
## Data sources

<table>
<thead>
<tr>
<th></th>
<th>SIS</th>
<th>DSSF</th>
<th>ERA-Interim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provider</td>
<td>Climate Monitoring SAF</td>
<td>Land Surface Analysis SAF</td>
<td>ECMWF</td>
</tr>
<tr>
<td>Satellite</td>
<td>Meteosat First Generation</td>
<td>Meteosat Second Generation</td>
<td>-</td>
</tr>
<tr>
<td>Sensor</td>
<td>MVIRI</td>
<td>SEVIRI</td>
<td>-</td>
</tr>
<tr>
<td>Status</td>
<td>dataset</td>
<td>operational, near real-time</td>
<td>dataset</td>
</tr>
<tr>
<td>Resolution</td>
<td>daily, 0.03 degree</td>
<td>daily, 5 km</td>
<td>daily (two 12h forecasts), 0.75 degree</td>
</tr>
</tbody>
</table>

### Comparison with ground measurements

- **CM-SAF vs. SIS**
  - \( y = 1.05x + 0.2 \)
  - \( R^2 = 0.94 \)
  - \( RRMSE = 18.88\% \)
  - \( MBE = 0.85 \)
  - \( N = 467010 \)

- **CM-SAF vs. DSSF**
  - \( y = 0.92x + 2.13 \)
  - \( R^2 = 0.83 \)
  - \( RRMSE = 29.6\% \)
  - \( MBE = 1.11 \)
  - \( N = 1120374 \)
CM SAF SIS vs LSA SAF DSSF

'Annual' average

Standard deviation

2005 (227 overlapping days)
Grid-based intercomparison

Positive mean bias indicates that the estimate represented by a row has a higher value than estimate represented by a column.

Bojanowski et al. 2014
Solar Energy
Creating a long-term dataset (not a climatology)

Meteosat First and Second Generation data can be merged to create the solar radiation dataset covering years 1983-onwards

Done by Rebekka Posselt et al. (RSE, 2014)

► the two narrowband visible channels of the MSG were combined to simulate the MFG broadband visible channel → then MagicSol (Heliosat) algorithm was applied

► How this dataset can be prolonged in near real-time? Should MSG and forthcoming MTG be used to simulate MFG to derive operational product?
Conclusions (user perspective)

- Satellite-derived solar radiation is more **accurate and consistent** than currently used measured, modelled and interpolated solar radiation used in the European crop model.

- ERA-Interim can be used as a back-up solution for operationally working systems (such as crop monitoring).

- MFG and MSG solar radiation data are similar enough to create a dataset whose accuracy would satisfy a crop modellers community.

- Is there a possibility to fill the gap between long-term data record and near real-time product?

Thank you for your attention!