Solar ground measurements processing by automatic and manual tools

Solargis approach to quality control

Jozef Dudzak, Marketa Hulik Jansova, Tomas Cebecauer and Branislav Schnierer

SOLARGIS

Agenda

- Why ground measurements
- Solargis quality assessment procedure

Why ground measurements

Solar radiation	Ground measurements	Satellite models
Accuracy	Very high to very low*	High
Temporal resolution	seconds - 1 min	10/15 min
Data availability	Need to wait	Instant access (any site worldwide)
Period	Typically up to 1-2 years	Up to 27 years
Initial costs	High	Low
Operational costs	High	Very low or none
Gaps in data	Often	No gaps
Data quality control	Required	Not required
Data consistency	Low	Very high
Forecasts	Not available	Up to 10 days ahead

* In case of poor maintenance

Photo: Solargis

SOLARGIS

Why ground measurements

- High quality measurements can be used for improvement of the accuracy of models by site adaptation
- Reduced uncertainty of site adapted satellite data provides better conditions for project financing

Usage of ground measurements:

- Improvement of satellite-based model
- Improvement of forecast accuracy
- PV performance evaluation
- Identification of PV operation issues

About ground measurements

- **Current status (our experience)**
  - Missing knowledge of proper operation
  - Suboptimal practices
  - Solar and meteo measurements are often degraded

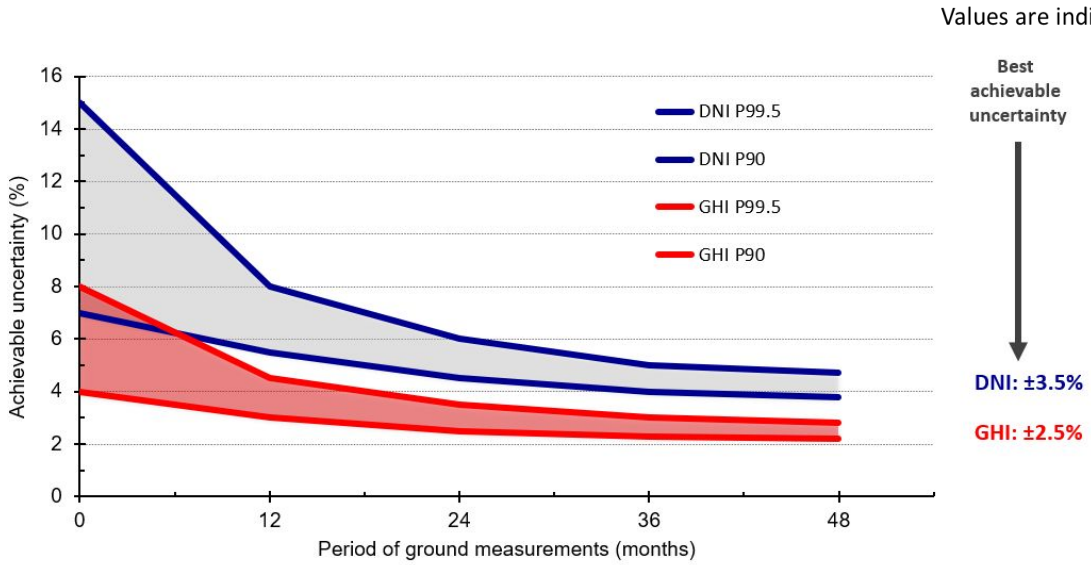
- **Best practices**
  - More than one instruments to be installed on a site (if feasible)
  - Choice of instruments (optimal)
    - Class A pyranometers (GHI1, GHI2, DIF) + ventilation unit
    - Class A pyrheliometers (DNI)
    - Class A albedometer (RHI, GHI)
  - Fine temporal resolution of data (1min, 5 min)
  - Regular cleaning, maintenance and calibration of instruments by trained personnel
  - Data quality control by a knowledgeable expert

SOLARGIS

About ground measurements

Length of measurement campaign for model site adaptation

- Less than 12 months - Preliminary model data verification only
- 12+ months - Validation and site-adaptation of satellite-based model
- 24+ months - More robust validation + site-adaptation with lower uncertainty



What to do to have high quality ground measurements

Photo: GeoSUN Africa

- Good station operation
  - Obey best practices
  - Professional installation
  - Accurate characteristics of data (coordinates, calibrated and described instruments, cleaning and maintenance logs)
  - Professional operation and maintenance
- Precise QC
  - Time reference harmonization
  - Physical outliers
  - Detection of instrument & location specific issues (logger issue, tracking issue, dew/frost, shading, ...)

SOLARGIS

Is quality control important?

Definitely **YES!**

Our internal analysis has shown that, on average, **13% of GHI and DIF** measurements are affected by errors during the station operation.

15% of GTI measurements and
23% of DNI measurements were also affected by errors.

Analysis was performed on projects from last 4 years.

SOLARGIS

Solargis quality assessment procedure

SOLARGIS ANALYST

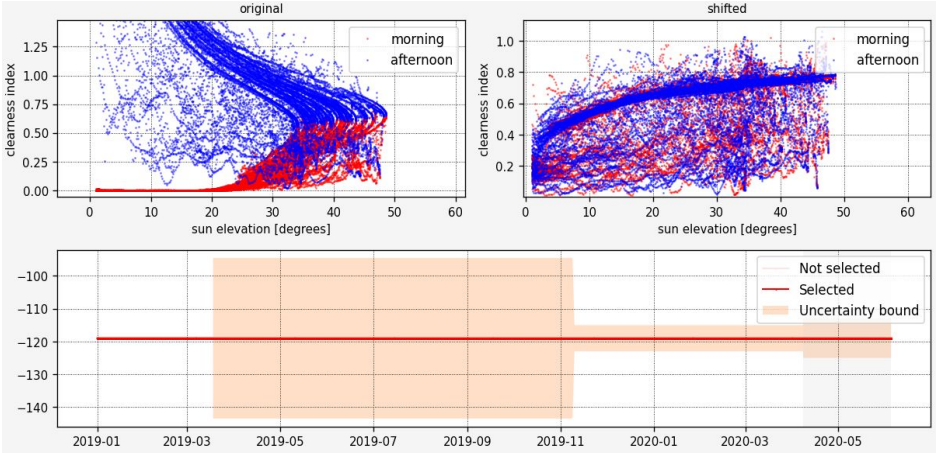
- Step 1: Time reference control
- Step 2: Basic numerical check of physical limits
- Step 3: Extended numerical identification of systematic data errors
- Step 4: Manual quality control

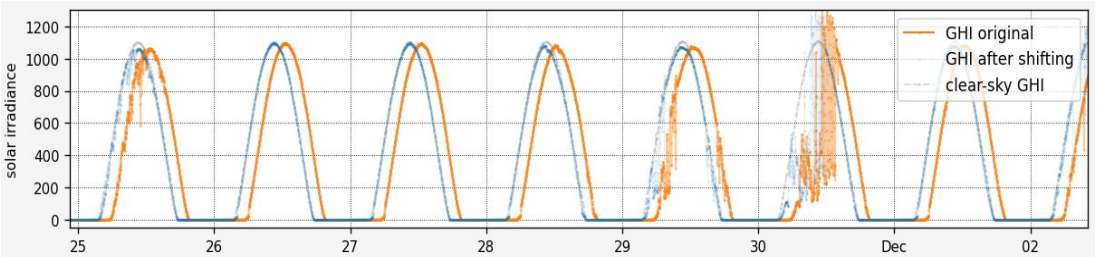
All quality control steps and tools for data handling are fully integrated into the Solargis Analyst.

SOLARGIS

Time reference control

- Issue description
  - Time in UTC -> determines the solar position calculation
  - Basic prerequisite for data quality tests
  - Typical issues
    - Shift with respect to UTC
    - Daylight saving time
    - Random shifts and drifts
    - Timestamp definition (left, right, center)
- Automatic detection based on
  - Symmetry of profile between morning and afternoon
  - Alignment with the reference
- Limitations
  - Wrong coordinates
  - Mix with other issues
  - Shifts during day



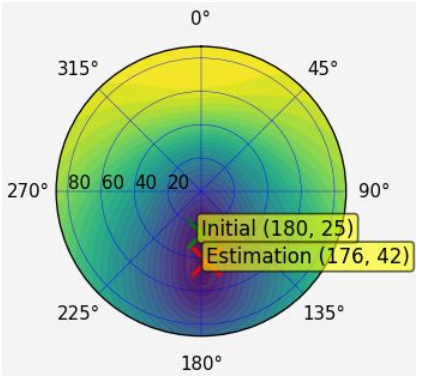


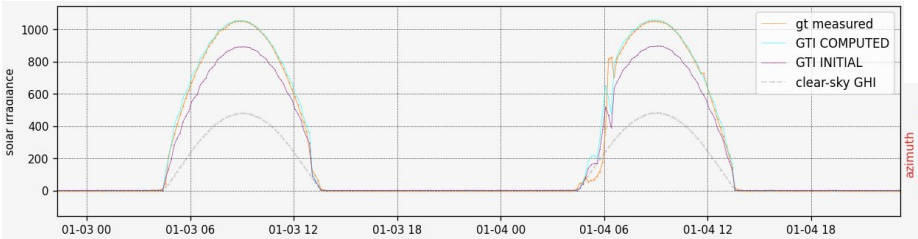
SOLARGIS

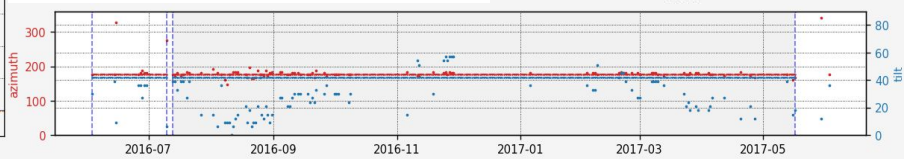
Instrument misalignment and GTI configuration

- Issue description
  - Pyranometer for measuring GHI not placed horizontally
  - Fixed tilted pyranometer azimuth and tilt not given or given properly
- Automatic detection based on
  - Similarity of misaligned profiles
- Limitations
  - For now we can only estimate fixed mounting GTI parameters

Photo: Iberdrola
https://www.kintech-engineering.com/wp-content/uploads/2018/07/Case_Study_09.pdf



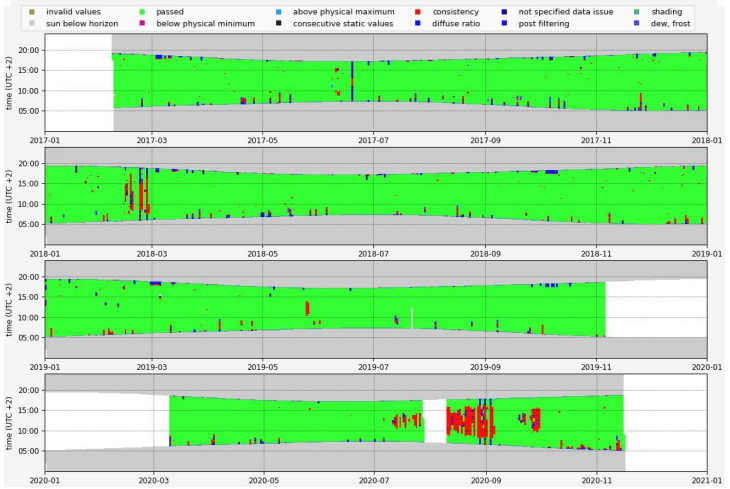




SOLARGIS

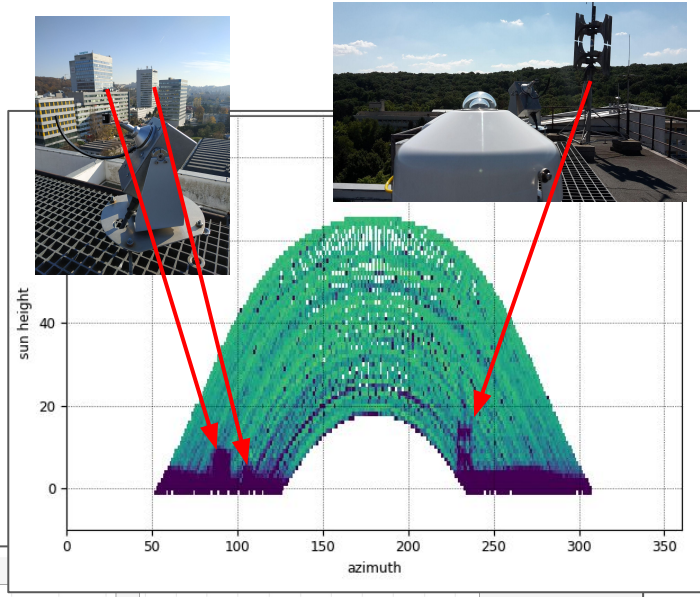
Physical limits and large outliers

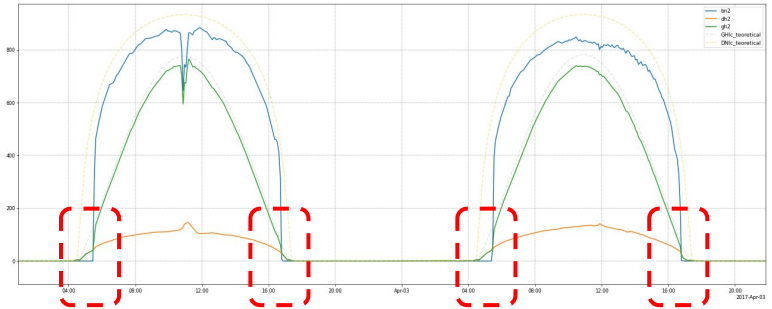
- Issue description
  - Data Logger problems and other issues can drive the measurements to unphysical values
  - There are consistency rules between 2 or 3 radiation components
- Automatic detection based on
  - Methods defined in BSRN procedures and methods implemented in-house by Solargis
- Limitations
  - In case of inconsistency we are not able to say which component is affected
  - Many issues are still in the range of physical values

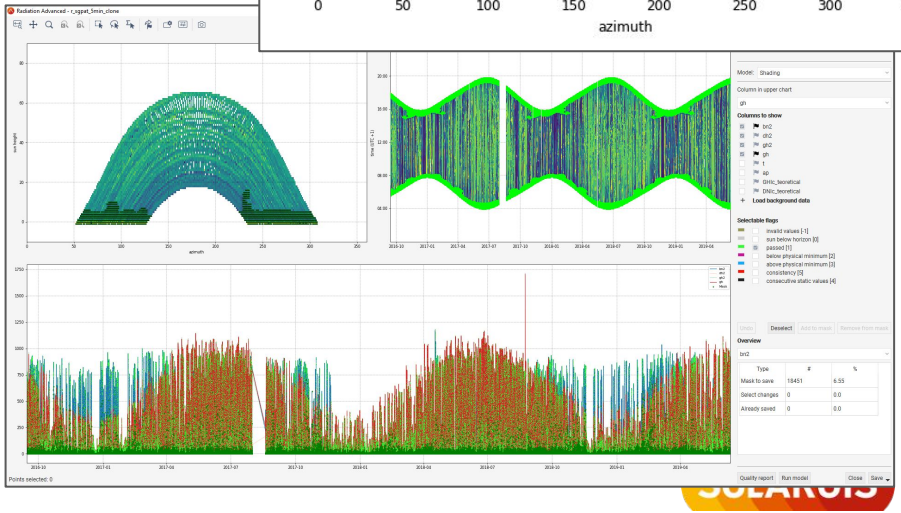


Shading detection

- Issue description
  - Shading of instruments by horizon or nearby objects
  - Global, direct and reflected irradiation are affected.
- Automatic detection based on
  - Systematic decrease of measured irradiation values
- Limitations
  - Disappearing/appearing shading
  - Half-transparent objects

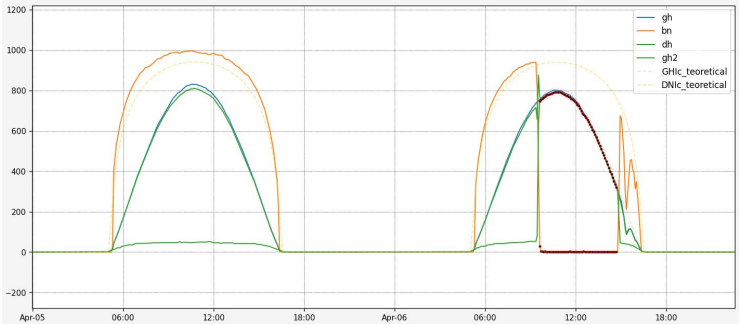


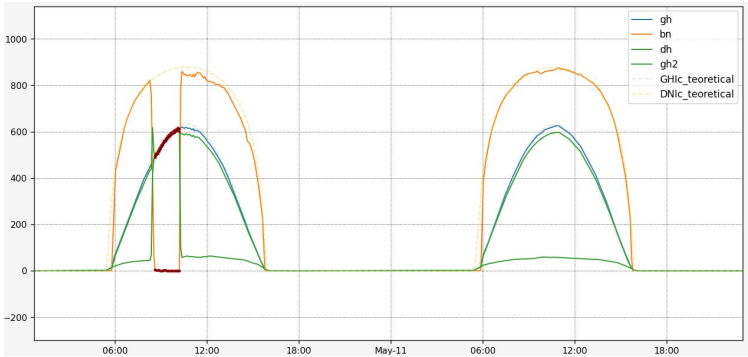




Tracker malfunction

- Issue description
  - Pyrheliometer (DNI) is not tracking sun properly
- Automatic detection based on
  - Zero or low DNI values during cloudless conditions
  - Inconsistent information compared to other components of solar radiation
- Limitations
  - Partial tracking malfunction (slight misalignment of the pyrheliometer)

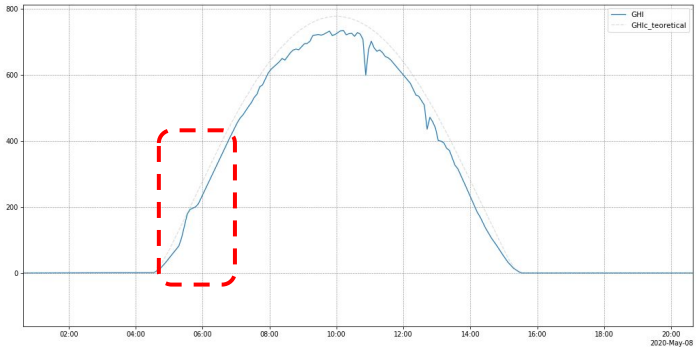


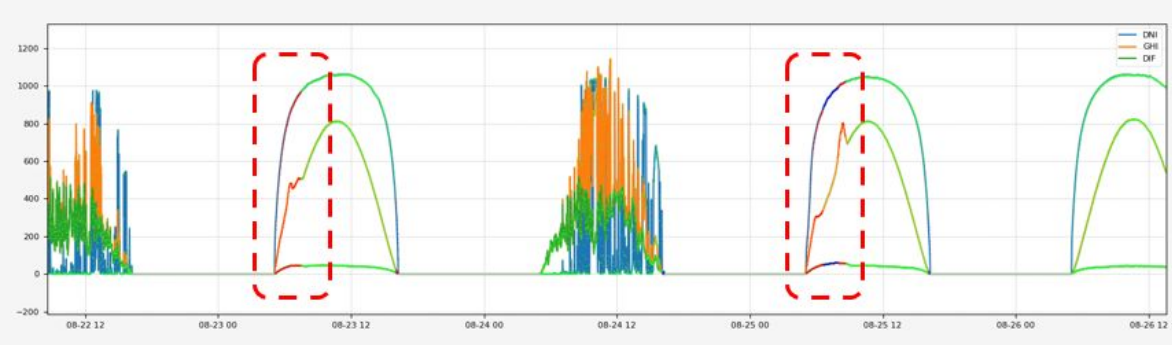


Dew/frost detection

- Issue description
  - Deterioration of the measurement due to dew or frost on the instrument
- Automatic detection based on
  - Specific “S” shape of the measurement during this event
- Limitations
  - Only available for pyranometers with glassdome

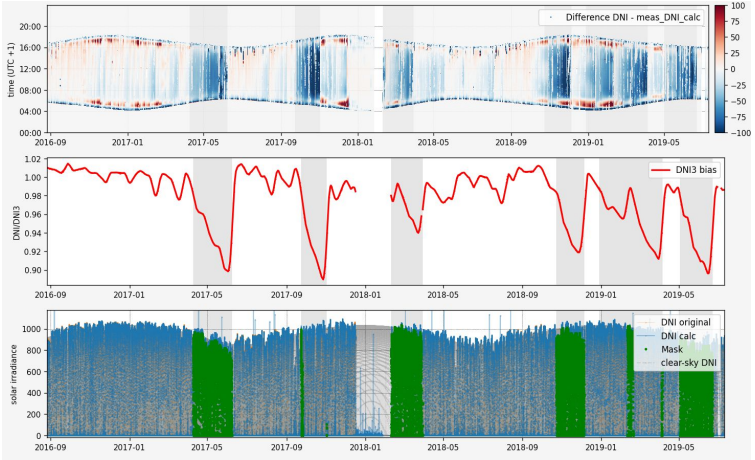
Source: DOI - 10.13140/RG.2.1.1515.6568

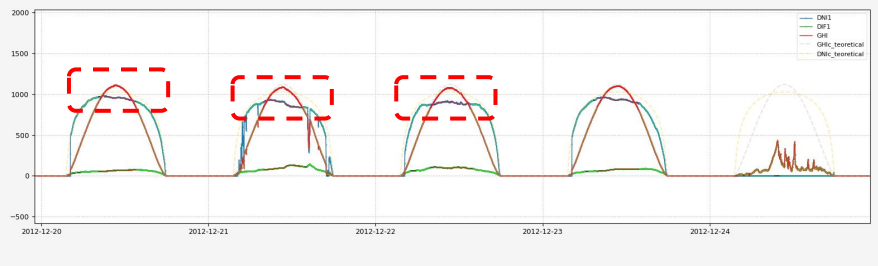




Signal degradation

- Issue description
  - Systematic degradation of signal due to soiling or calibration issues
  - More accurate detection when all three solar radiation components are available
- Automatic detection based on
  - Systematic decrease of signal in time period
- Limitations
  - Soiling does not always cause systematic degradation of signal
  - We need to work with longer time periods (at least 14 days)





Manual assessment

- Description
  - Assessment and flagging by skilled operator (rare, random, convoluted or smaller issues)
  - Identification of less frequent issues (artificial noise, station grounding issue)
  - Control of residual issues after automatic tools
  - Control of site specific conditions and issues
  - Final approval of data quality for further processing
- Requirements
  - Well trained operator required
  - Reliable software tool for analysis of solar data
  - Site and instruments specification
  - Good installation and operation of measurement station
  - The most time consuming part of QC

How to avoid these issues in your data?

- Consider the frequency of cleaning events regarding to climate (dust deposition) region.
- Store detailed information about each maintenance and cleaning event.
- It is recommended to perform instrument cleaning during the daytime. It allows identifying the soiling of the instrument.
- Check the installation and alignment of instruments during every maintenance (cleaning) event
- Instal ventilation and heating units on instruments
- Instal instrument on the position without shading, reflection or another artificial effects on measurements (eg. albedometer above representative ground coverage)
- Use UTC without daylight-saving time

Summary

Why we went through this procedure?

- We need high quality data to be able to further process them and rely on them
- Usage of flagged data:
  - **Perform model site adaptation and reduce uncertainty**
  - Perform gap filling and create consistent dataset (of multiple years)
  - Perform PV performance analysis - KPI calculations
  - Improve forecasts
  - Improve satellite-based model (public sites)

Conclusion

Ground measurements are important record of local climate, but

- High quality measurements require attention
  - Station installation
  - Instruments maintenance
  - Data quality control

Data quality control is time-consuming work **but necessary to achieve the highest data quality.**

Solargis Analyst

- Helps not only with quality control but also with data management, visualisation and analysis of ground measurements
- Includes analytical tools for solar resource assessment
- Development of new features to support the industry
- More info: solargis.com/products/analyst

SOLARGIS

Solar ground measurements processing by automatic and manual tools

Solargis approach to quality control

Jozef Dudzak, Marketa Hulik Jansova, Tomas Cebecauer and Branislav Schnierer

SOLARGIS