On quality control procedures for solar radiation and meteorological measures, from subhourly to montly average time periods

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Controlling the quality of measurements of meterological variables and solar radiation. From sub-hourly to monthly average time periods

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ENDORSE GA n° 262892
2011 - 2013
www.endorse-fp7.eu

European Geosciences Union 2012, Vienna (Austria) 22 – 27 April 2012

Long-term radiation and meteorological measurements are available from a large number of ground measuring stations. However, close examination of the data often reveals a lack of quality, often for extended periods of time. Quality Control Procedures (QCPs) are a measure of how well data serve the purpose for which they were produced. We have searched in the bibliographic references the QCPs that are available for the solar radiation and meteorological data series which are of interest in the field of renewable energies, grouping them together by average time periods, checking them and modifying them if necessary. All of the QCPs that are presented in this document are applicable for all latitudes; they are not optimized regionally nor seasonably with the aim of being generic. The reseach leading to those results has partly received funding from the European Union's Seventh Framework Programme (FP7/2007-2013).

TYPES OF QUALITY CONTROL PROCEDURES (QCPs)

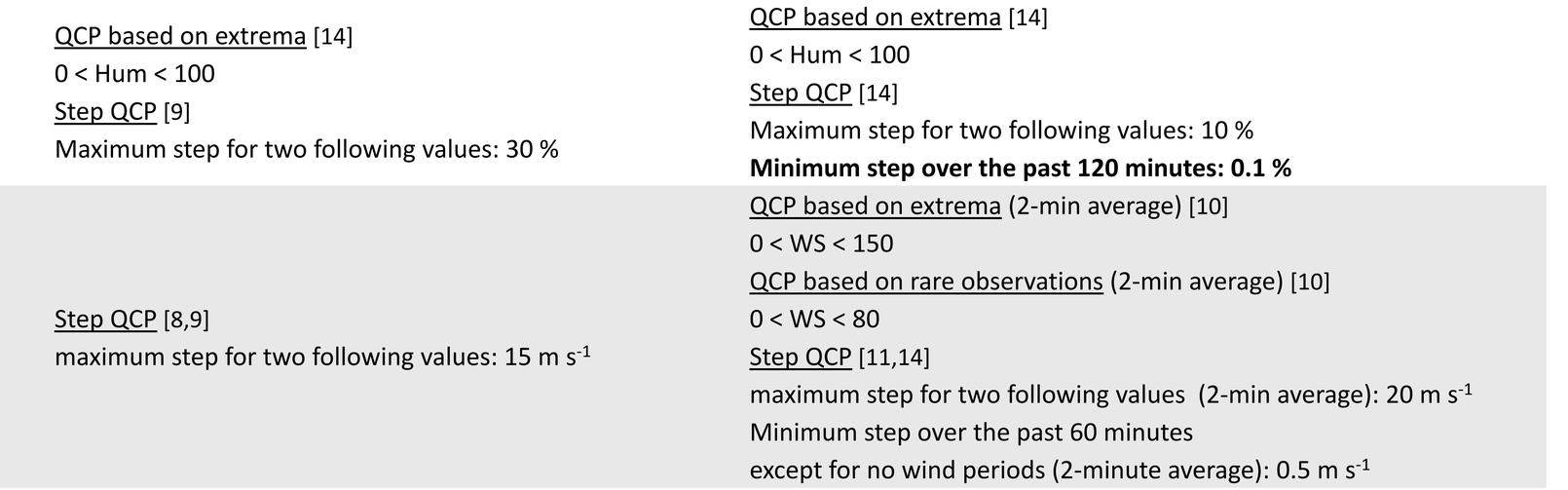
- **Range QCPs**: verify that values are within a specific range (*based on extrema* for physically possible values and *based on rare observations* for possible but extremely rare values).
- **Step QCPs**: aimed at detecting unrealistic increments or stagnations in the time series, with respect to their sampling and integration period.
- **Consistency QCPs**: verify the consistencies between two or more independent time series.

	Monthly	Daily	Hourly	Sub-hourly (1-minute average except for WS which is 2-minute)
Global Horizontal Irradiance GHI (Wm^{-2})	QCP based on extrema [3,7] 0.03 GHItoa < GHI < 1.2 I_0 QCP based on rare observations [2,3,13] 0.03 GHItoa < GHI < GHItoa	QCP based on extrema [3,7] 0.03 GHItoa < GHI < 1.2 I_0 QCP based on rare observations [2,3,13] 0.03 GHItoa < GHI < GHItoa	**QCP based on extrema** [3,4,7] **0.03 GHItoa < GHI < min (1.2 I_0, 1.5 I_0 cos(SZA)$^{1.2}$ + 100)** QCP based on rare observations [4,5,7] 0.03 GHItoa < GHI < 1.2 I_0 cos(SZA)$^{1.2}$ + 50	**QCP based on extrema** [3,4,7] **0.03 GHItoa < GHI < min (1.2 I_0,1.5 I_0 cos(SZA)$^{1.2}$ + 100)** QCP based on rare observations [3,4] 0.03 GHItoa < GHI < 1.2 I_0 cos(SZA)$^{1.2}$ + 50 Step QCP [14] Maximum step for two following measures: 1000 W m^{-2}
Beam Normal Irradiance BNI (Wm^{-2})	QCP based on extrema [4] 0 < BNI < I_0	QCP based on extrema [4] 0 < BNI < I_0	QCP based on extrema [4] 0 < BNI < I_0 QCP based on rare observations [4] 0 < BNI < 0.95 I_0 cos(SZA)$^{0.2}$ + 10	QCP based on extrema [4] 0 < BNI < I_0 QCP based on rare observations [4] 0 < BNI < 0.95 I_0 cos(SZA)$^{0.2}$ + 10
Diffuse Horizontal Irradiance DHI (Wm^{-2})	QCP based on extrema [3,7] 0.03 GHItoa < DHI < 0.8 I_0	QCP based on extrema [3,7] 0.03 GHItoa < DHI < 0.8 I_0	**QCP based on extrema** [3,4,5,7] **0.03 GHItoa < DHI < min (0.8 I_0, 0.95 I_0 cos(SZA)$^{1.2}$ + 50)** QCP based on rare observations [3,4] 0.03 GHItoa < DHI < 0.75 I_0 cos(SZA)$^{1.2}$ + 30	**QCP based on extrema** [3,4,7] **0.03 GHItoa < DHI < min (0.8 I_0, 0.95 I_0 cos(SZA)$^{1.2}$ + 50)** QCP based on rare observations [3,4] 0.03 GHItoa < DHI < 0.75 I_0 cos(SZA)$^{1.2}$ + 30
Temperatutre Temp (°C)	QCP based on extrema [10,14] -90 < Temp < + 60 QCP based on rare observations [10,14] -80 < Temp < + 50	QCP based on extrema [10,14] -90 < Temp < + 60 QCP based on rare observations [10,14] -80 < Temp < + 50	QCP based on extrema [10,14] -90 < Temp < + 60 QCP based on rare observations [10,14] -80 < Temp < + 50 Step QCP [8,9] Maximum step for two following measures: 8 °C	QCP based on extrema [10,14] -90 < Temp < + 60 QCP based on rare observations [10,14] -80 < Temp < + 50 Step QCP [11,14] Maximum step for two following measures: 3 °C Minimum step over the past 60 minutes: 0.1 °C
Relative Humidity Hum (%)	QCP based on extrema [14] 0 < Hum < 100	QCP based on extrema [14] 0 < Hum < 100	QCP based on extrema [14] 0 < Hum < 100 Step QCP [9] Maximum step for two following values: 30 %	QCP based on extrema [14] 0 < Hum < 100 Step QCP [14] Maximum step for two following values: 10 % **Minimum step over the past 120 minutes: 0.1 %**
Wind Speed WS ($m\ s^{-1}$)			Step QCP [8,9] maximum step for two following values: 15 m s^{-1}	QCP based on extrema (2-min average) [10] 0 < WS < 150 QCP based on rare observations (2-min average) [10] 0 < WS < 80 Step QCP [11,14] maximum step for two following values (2-min average): 20 m s^{-1} Minimum step over the past 60 minutes except for no wind periods (2-minute average): 0.5 m s^{-1}
Consistency checks	[7] DHI ≤ 1.1 GHI	[7] DHI ≤ 1.1 GHI	[1,5,6,13] For GHI > 20 W m^{-2} (if not, test not possible) |1 - GHI / (BHI + DHI)|= 0.15 DHI ≤ 1.1 GHI	[4,7,12] For GHI > 50 W m^{-2} (if not, test not possible): DHI/GHI < 1.05, for SZA < 75° DHI/GHI < 1.10, for 93° > SZA > 75° For DHI+BHI > 50 W m^{-2} (if not, test not possible) |1- GHI / (BHI+DHI)| ≤ 0.08, for SZA < 75° |1 - GHI / (BHI+DHI)| ≤ 0.15, for 75°< SZA <93°

GHItoa = Horizontal Irradiance at top of atmosphere; I_0 = normal irradiance at the top of the atmosphere corrected from Sun-Earth distance; SZA = Solar Zenithal Angle (rad); BHI = Beam Horizontal Irradiance.
QCPs in bold have been modified compared to their corresponding bibliographic references.

Quality Control (QC) Output Report:

After checking the plausibility of the data, some graphs, histograms and figures of flagged values may help in the interpretation of the result of QC and also to detect some other features of data.



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