Accuracy of Meteonorm
(7.1.6.14035)

A detailed look at the model steps and uncertainties

22.10.2015

Jan Remund

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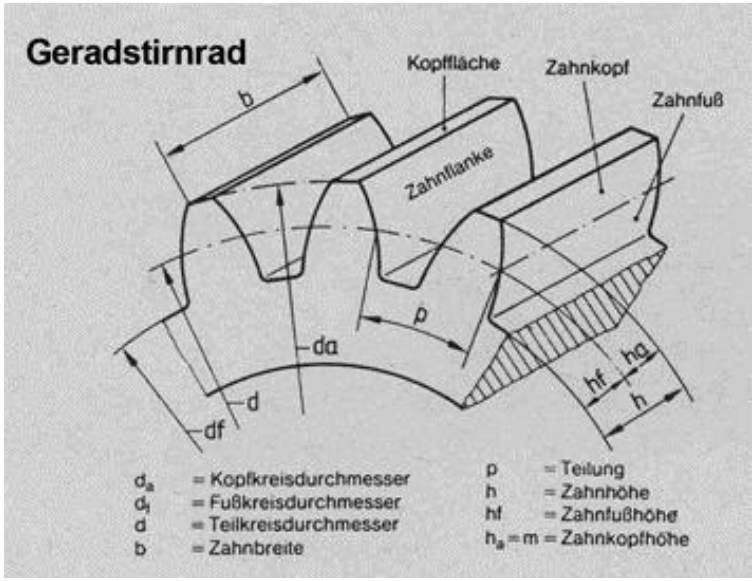

- The atmosphere is a choatic system, not as exactly describable as many technical parts
- Engineers have to learn to work with (higher levels of) uncertainties

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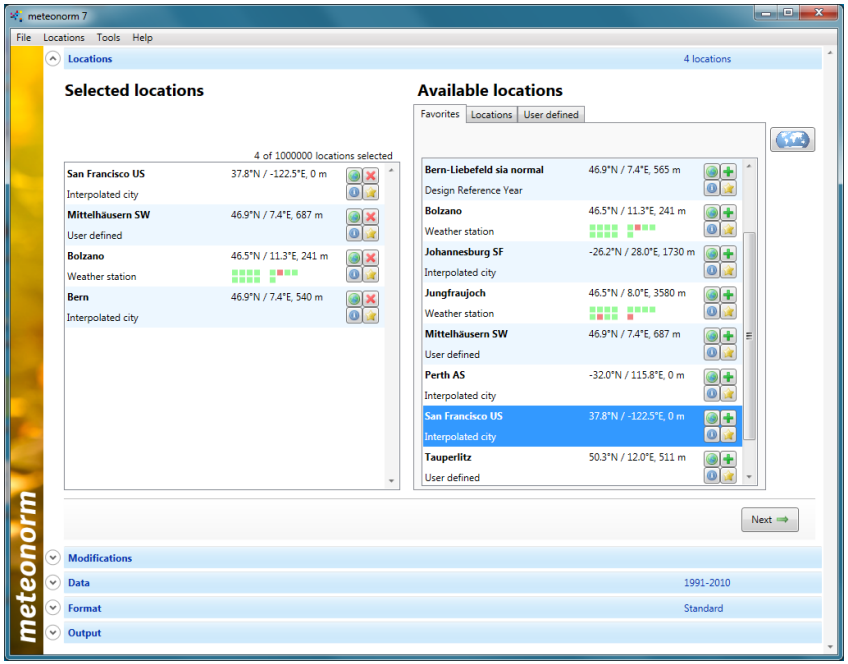


Introduction

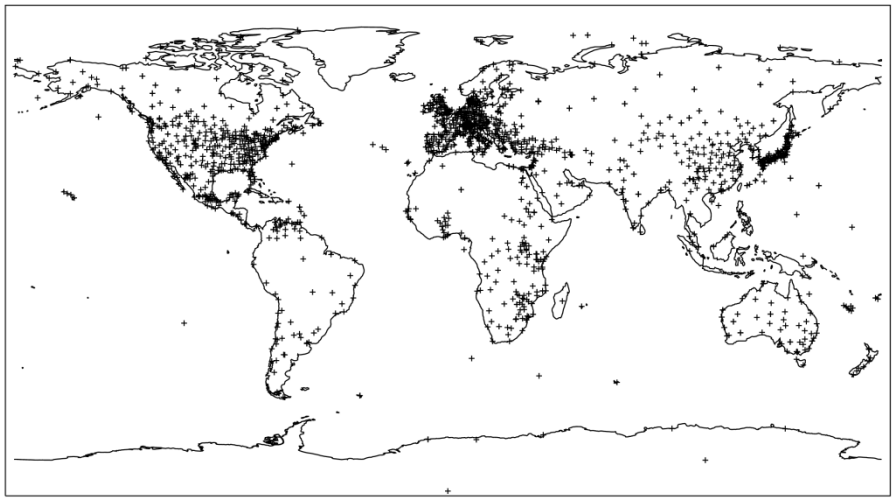
- Meteonorm
  - since 1985, initiated by Swiss Federal Office of Energy
  - software version 7.1 > 2000 active users
  - plugin, webservice (included in most known simulation tools)
- Meteonorm is a combination of
  - climate database & weather generator
  - ground measurements and satellite data
- Main result: Typical Meteorological Year (TMY) for any site
- Includes also current data:
  - based on satellite data for radiation and ground stations for non-radiation parameters

Climate data: overview

1. Ground measurements
2. Satellite data: 5 geostationary satellites
3. Interpolation of ground measurements
4. Mixing of ground and satellite data

Climate data: measurements

- ~ 1700 ground measurements
- Main source: «GEBA»:
  - Main period: 1991-2010
- Other sources:
  - BSRN, WMO, SYNOP, weather services
  - 15 different sources:



Parameters measured at location

Measurements first period		Measurements second period	
Radiation:	1964-1989	Radiation:	
Temperature:	1961-1990	Temperature:	2000-2009

Ta	Gh	FF	Td	Ta	Gh	FF	Td
RR	Rd	Sd	DD	RR			

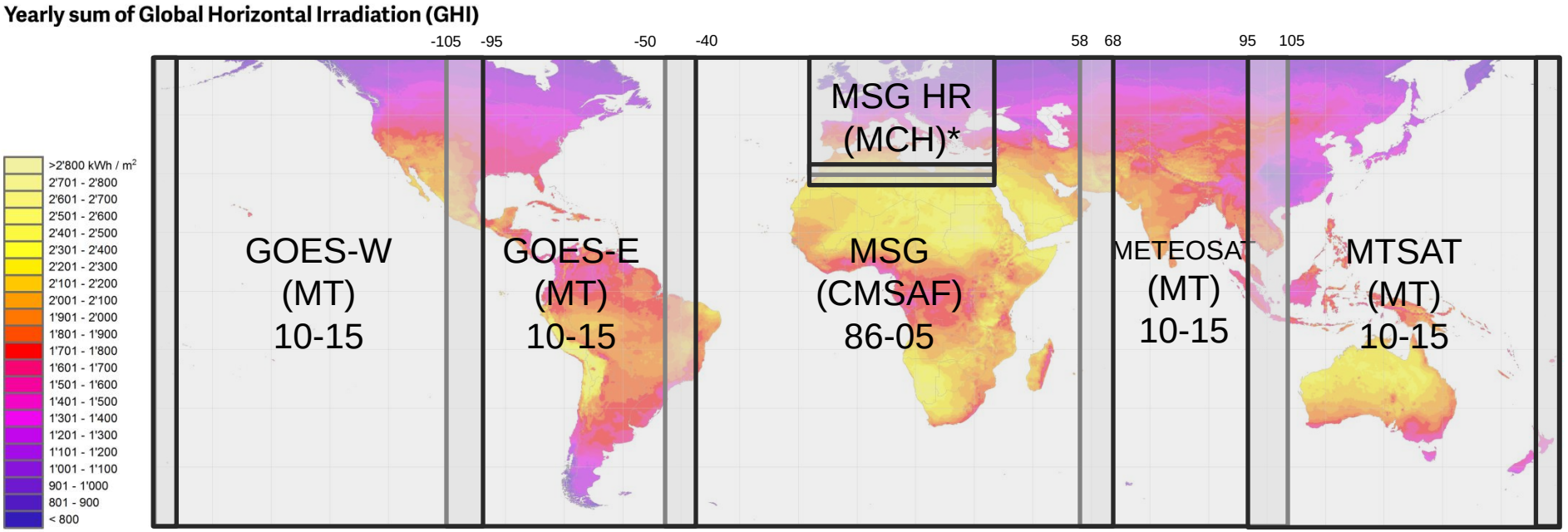
Source for radiation data: GEBA

green = measured
Red = not measured = interpolated

- Plus ~ 8300 non radiation measurements, 7 further parameters

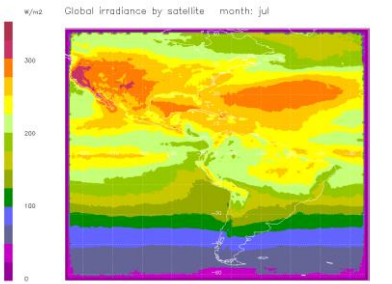
Climate data: satellite data

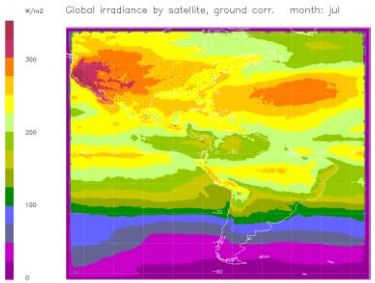
- Satellite data: 5 geostationary satellites, 1/8° resolution
  - Heliosat method (own = «MT») for India, Japan, USA
  - CMSAF (DWD) for Africa
  - MeteoSwiss (MCH) for Europe and Northern Africa, 1/40° resolution



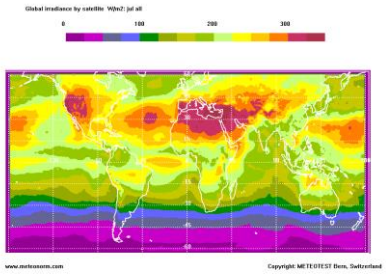
Climate data: satellite data

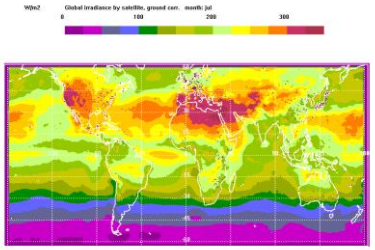
- Correction in three steps:
  - **Regional adaptation** with linear regression (if r^2>0.75 and small offset) and interpolation at 4 x 4 ° grid per satellite
  - **Fusion** of satellites (smoothing at overlaps)
  - **Local adaptation** to ground based at point of measurements and interpolation of deviations to correct whole grid





Regional correction

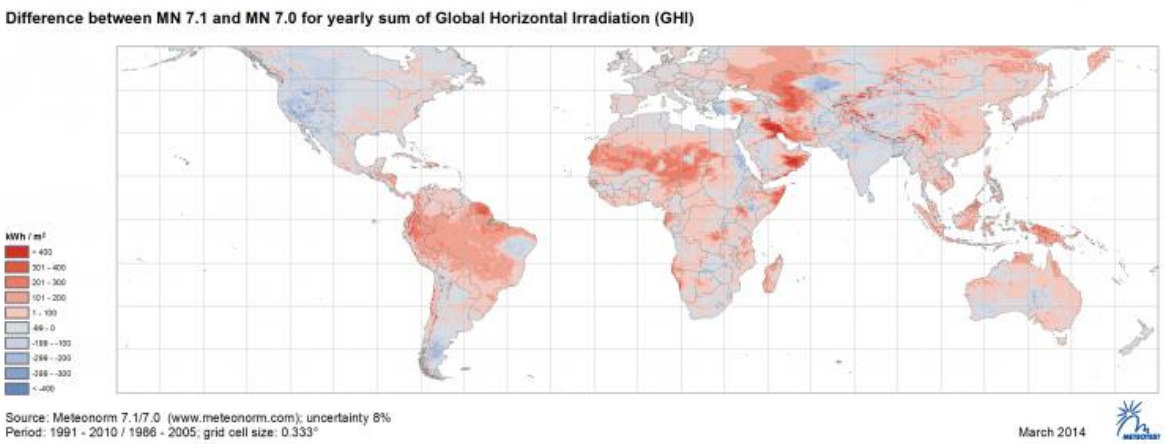


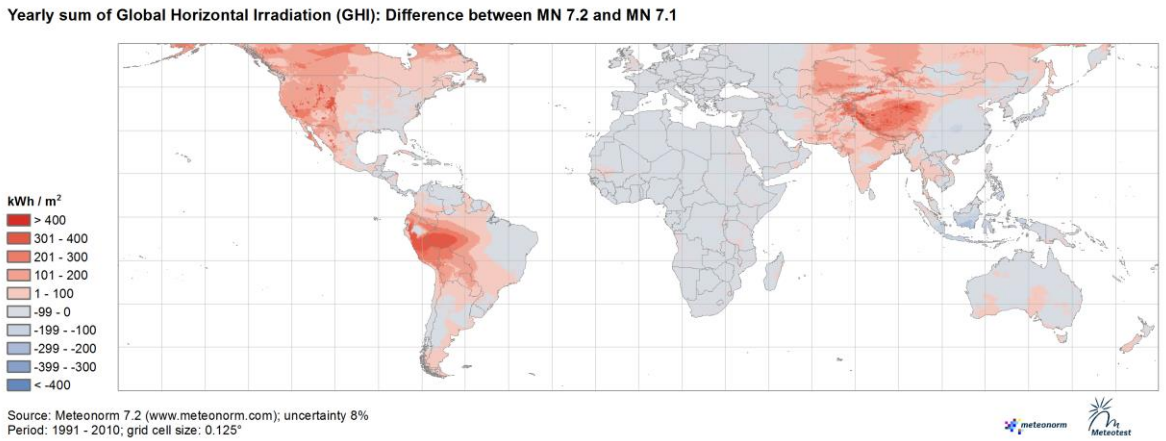


Local correction

Climate data: satellite data

- Updates approximately every year → difference maps (see FAQ)





Stable in
- Europe
- Africa
- Japan
- Australia
- Eastern USA

Unstable in
- Central America
- South America
- Asia

Pro:
- Get the best

Con:
- Changing results

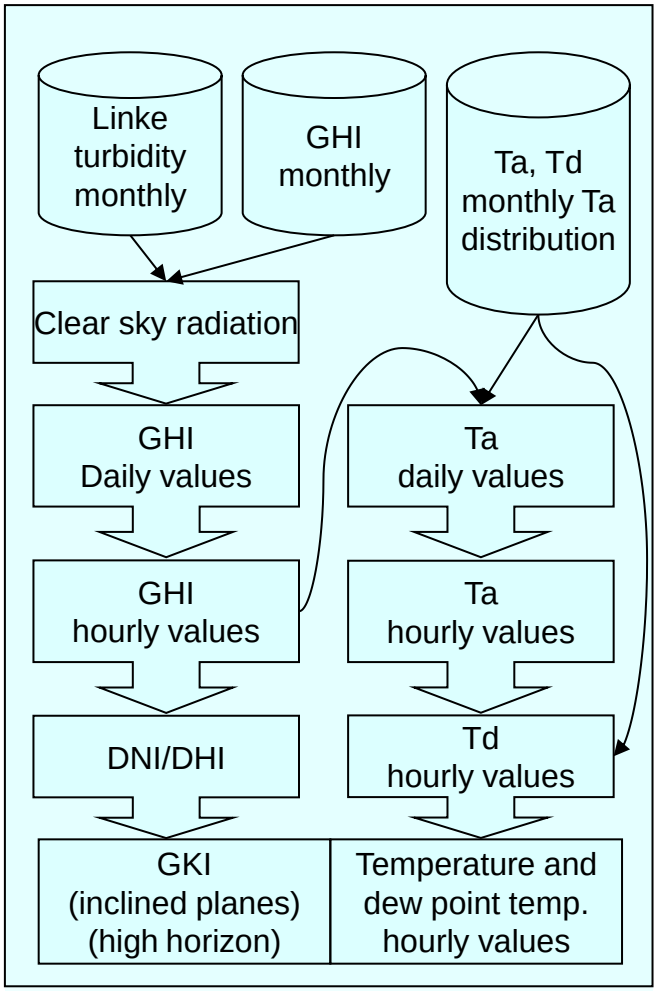
→ Serial number matters

Climate data: interpolation

- Interpolation of ground measurements with IDW+
  - 6 nearest locations at similar altitude and latitude
  - description in handbook (Shepard's gravity interpolation)
- Mixing of ground and satellite data
  - if distance to nearest site < d_1 then 100% ground
  - if distance to nearest site < d_2 100-0% ground and 0-100% sat.
  - if distance to nearest site > d_2 100% satellite
    - d_1 = 10/20/30 km (Europe/Africa/Rest)
    - d_2 = 50/100/200 km (Europe/Africa/Rest)

Chain of algorithms

- Generation of daily values of GHI
- Generation of hourly values of GHI
- Splitting into DNI and DHI
- Calculation of GKI (inclined planes)
- Generation of hourly values of
  - Temperature (Ta)
  - Humidity (RH)
  - Precipitation (RR)
  - …
- Generation of minute values of
  - GHI, DNI, Ta, FF

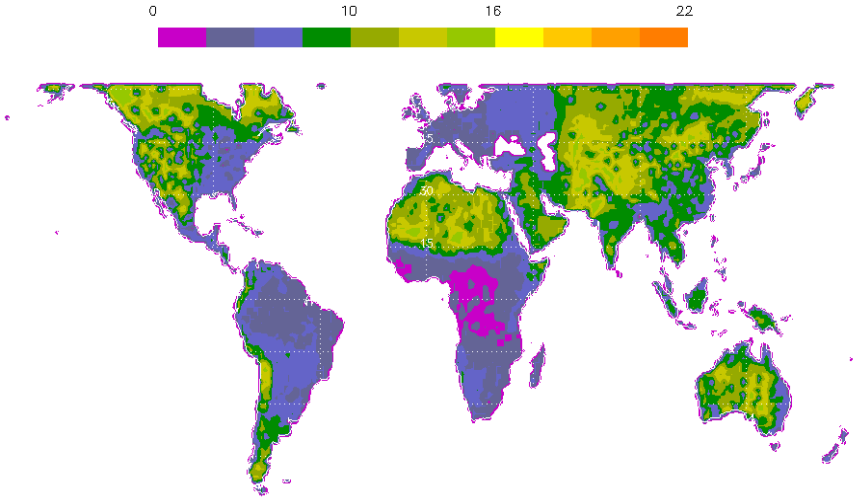


Uncertainty model

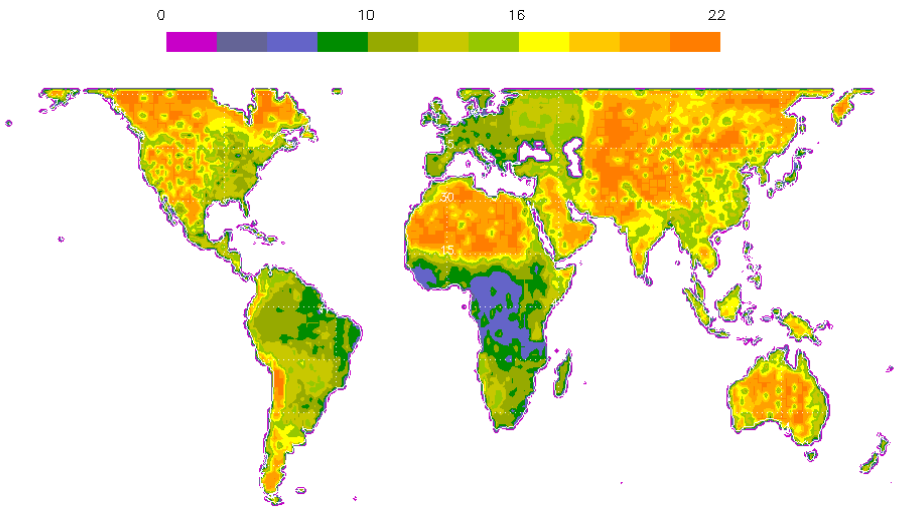
- Steps of uncertainty model = steps of chain of algorithms
- Expert model for measurement uncertainty
- Uncertainty = RMSE = approx. 1 standard deviation
- Three parts:
  - Uncertainty of ground data
    → duration, sdev, trend, currentness, climate uncertainty
    → 1-10% (typically 3%)
  - Uncertainty of interpolation
    → distance to nearest site (1-6%)
    → satellite (albedo, latitude, 3-10%)
  - Combined uncertainty: → Geometric sum of both
  - Uncertainty of chain
    → diffuse/direct/inclined

Uncertainty information

- GHI uncertainty

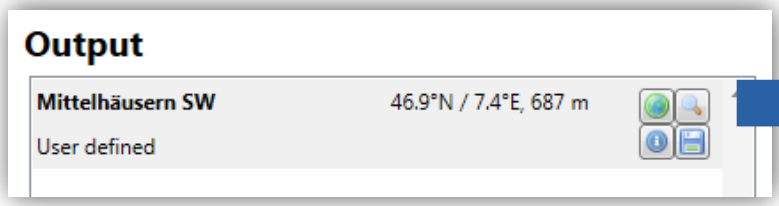


- DNI uncertainty

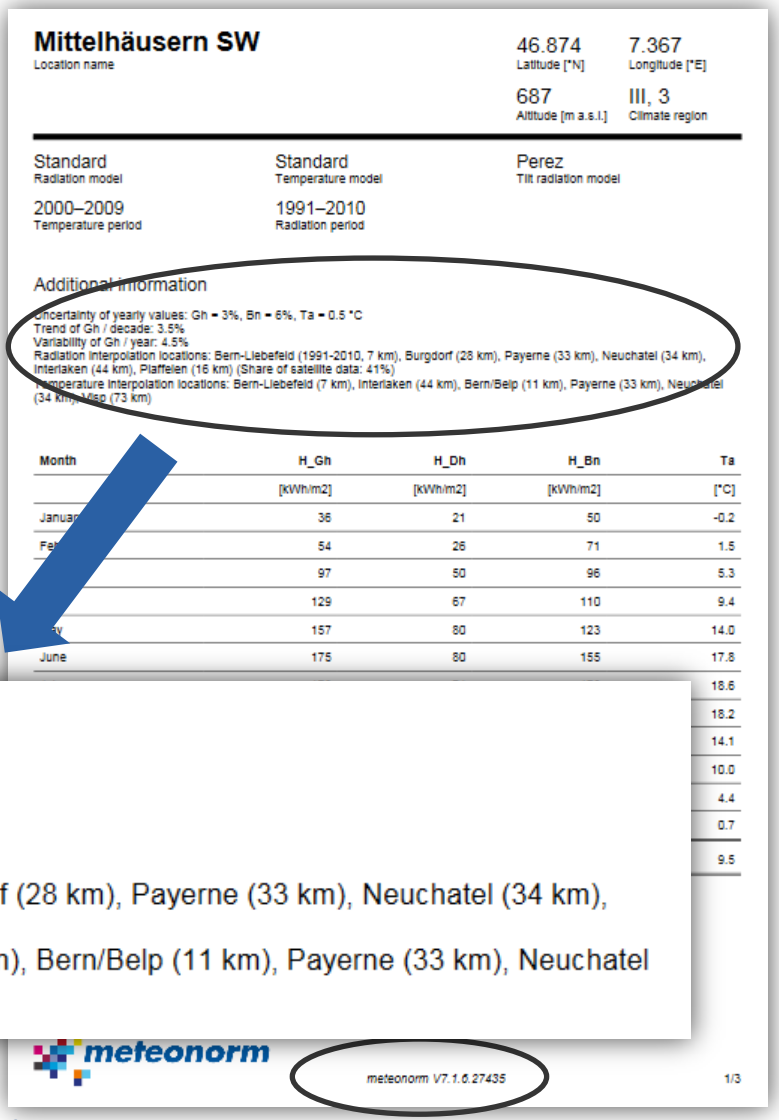


Uncertainty information

- Values shown in the results section



- standard deviations
- Trends, variability (standard dev.)
- Distances and time period of nearest ground stations, share of satellite



Additional information

Uncertainty of yearly values: Gh = 3%, Bn = 6%, Ta = 0.5 °C
Trend of Gh / decade: 3.5%
Variability of Gh / year: 4.5%
Radiation interpolation locations: Bern-Liebefeld (1991-2010, 7 km), Burgdorf (28 km), Payerne (33 km), Neuchatel (34 km), Interlaken (44 km), Plaffeien (16 km) (Share of satellite data: 41%)
Temperature interpolation locations: Bern-Liebefeld (7 km), Interlaken (44 km), Bern/Belp (11 km), Payerne (33 km), Neuchatel (34 km), Visp (73 km)

Conclusions

- Easy to use
- Variable uncertainty (2 – 10%)
- Good input for «ensemble predictions» for expertises as it's based on other sources as most other sources
- ~~«it's only TMY, but i like it»~~
  - Time series of satellite data and ground (GEBA) as «Measurement Archive» available and enhanced in future

Measurement Archive

The measurement archive contains historical, unaltered data from meteorological stations or satellites out of our Meteonorm archive.

Thank you for your attention!

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