



# Evaluating the spatial and temporal variations of the performance of CAMS Radiation Service and HelioClim-3 databases of surface irradiation in Germany

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# Evaluating the spatial variations of the performance of CAMS Radiation Service and HelioClim-3 databases of surface irradiation in Germany



## Partners



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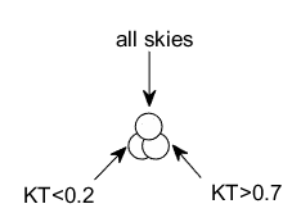
Lucien WALD  
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☉ Average GHI: 40 Wh/m<sup>2</sup>

☉ Average GHI: 45 Wh/m<sup>2</sup>

☉ Average GHI: 50 Wh/m<sup>2</sup>



## CAMS-RAD and HelioClim-3 in a nutshell

From MSG: 3 km at nadir, every 15 min, Feb. 2004 onwards

- Both databases contain global horizontal radiation as well as its direct and diffuse components
- Data are updated in real time and available via the SoDa website ([www.soda-pro.com](http://www.soda-pro.com))
- CAMS-RAD version 3.2 is based on the physical Heliosat-4 method and use cloud properties from the APOLLO algorithm (DLR)
- HelioClim-3 version 5 (hc3v5) is based on the Heliosat-2 method (cloud index)
- Both methods use the Copernicus McClear service version 3 providing irradiation in cloud-free conditions calculated on the basis of CAMS aerosol data

## In-situ measurements

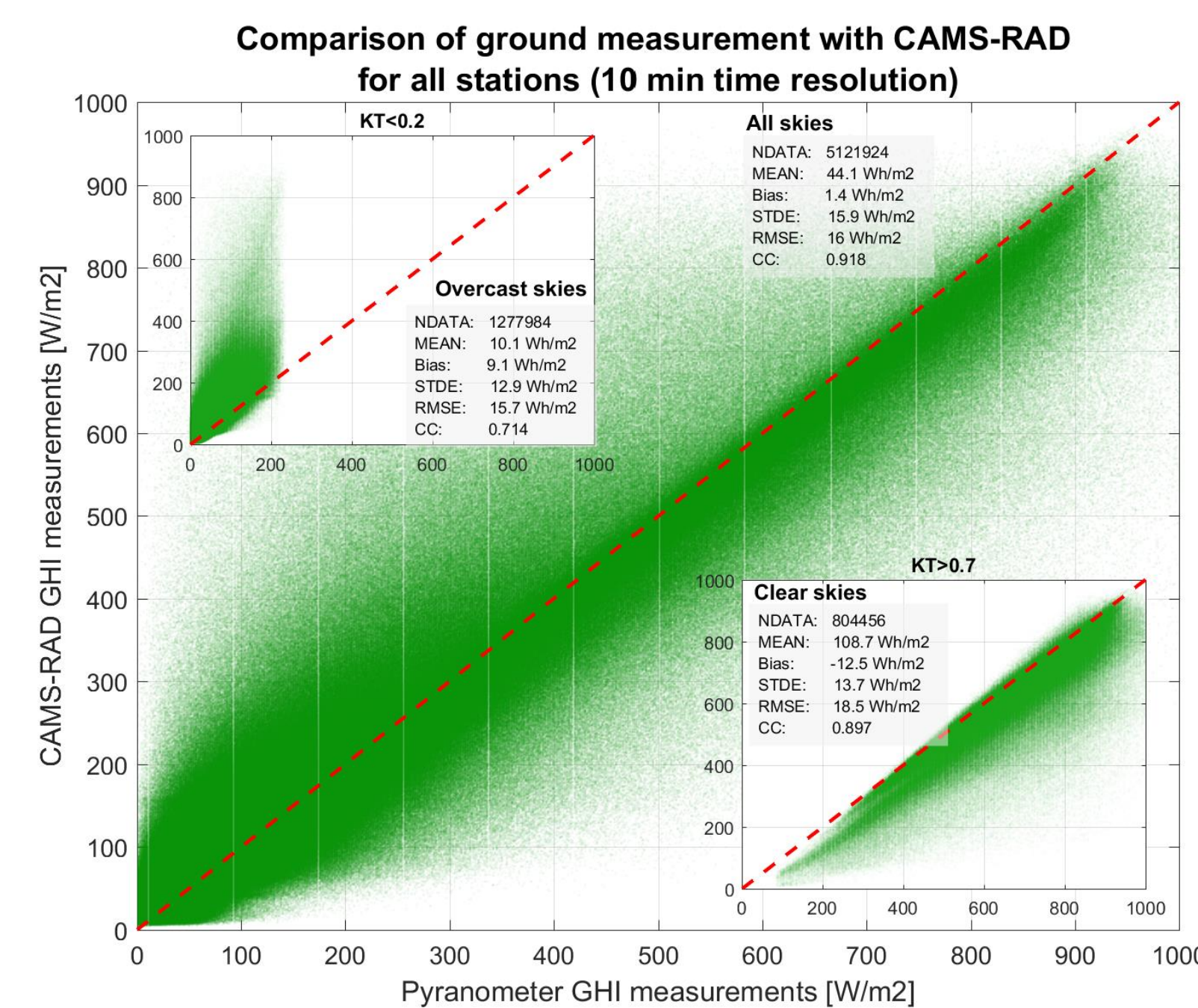
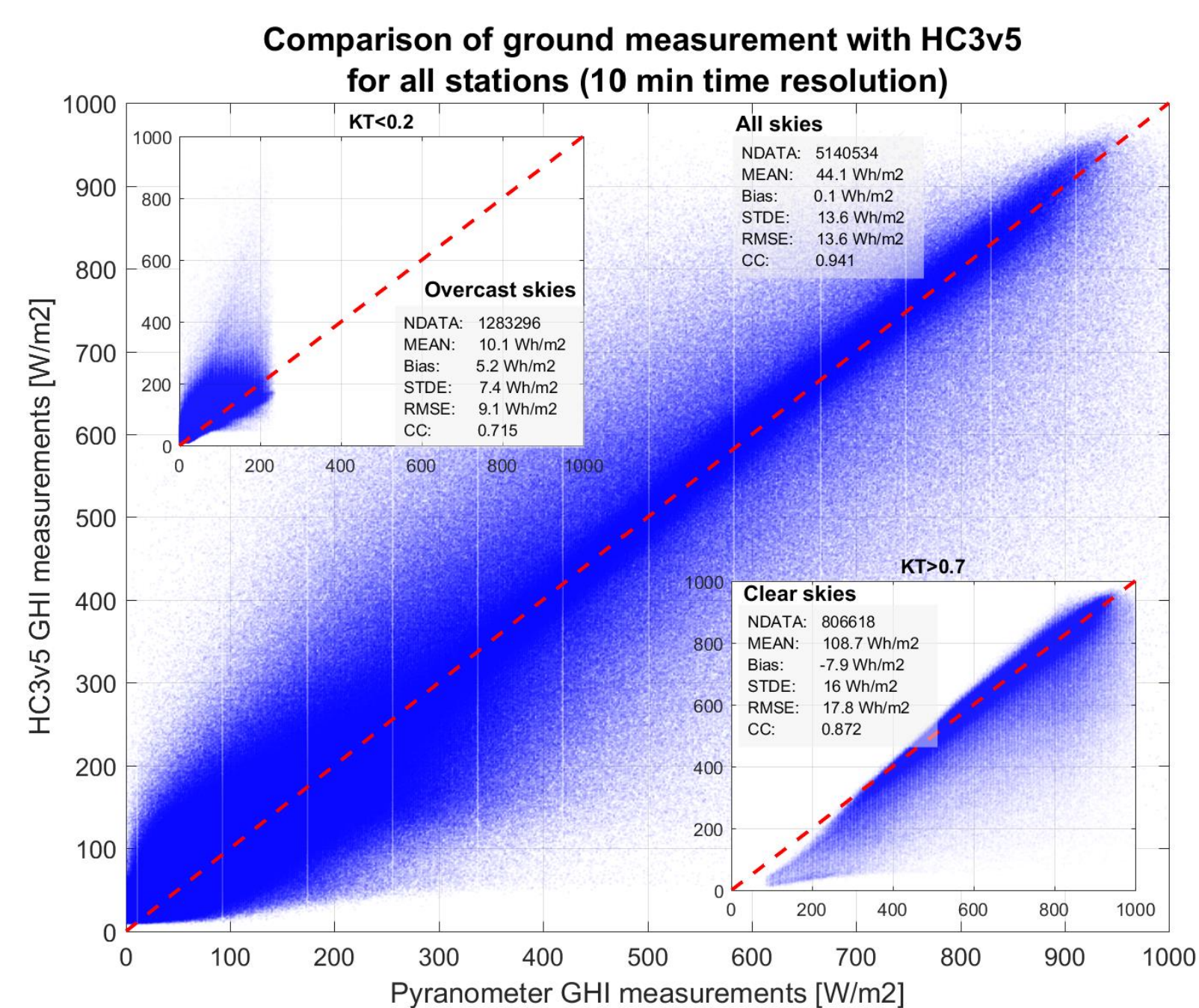
- 10 min measurements of global (GHI) and diffuse (DHI) irradiation made by pyranometers (CM11 and CM21) and SCAPP
- 26 stations; period 2010-2018 (9 years)
- Available online from the Deutscher Wetterdienst (DWD) climate data center: ([ftp://opendata.dwd.de/climate\\_environment/CDC/](ftp://opendata.dwd.de/climate_environment/CDC/))

## Quality Check, Validation - Protocol and Results

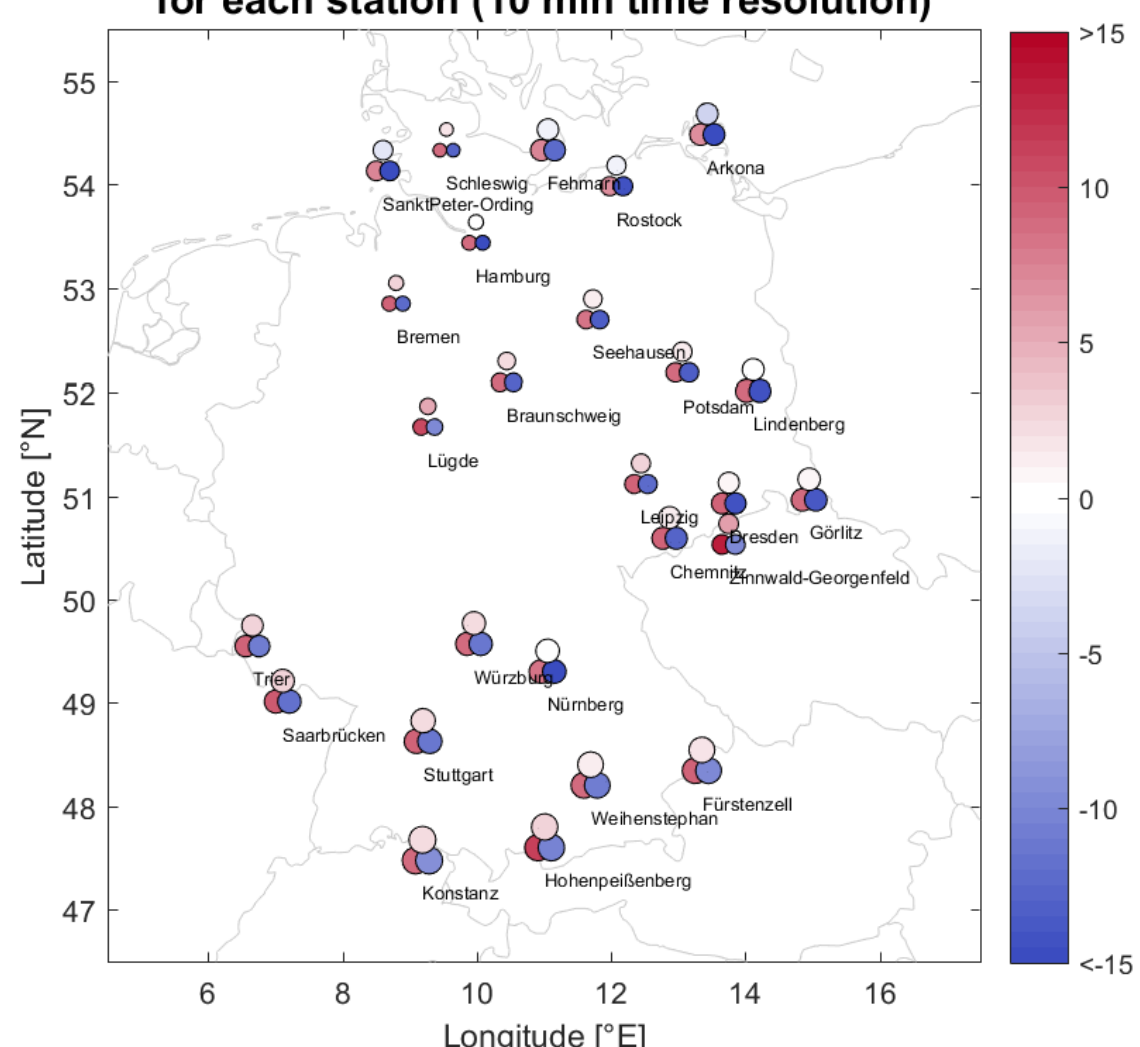
- Discard non-plausible data using quality check procedures from EU-funded FP7 ENDORSE project
- Compute bias, mean of absolute errors, standard deviation of errors, root mean square error, and correlation coefficient
- A conditional validation has been conducted using three classes defined on the basis of the measured clearness index (all data,  $KT < 0.2$  for overcast skies and  $KT > 0.7$  for clear skies)

## Results and conclusion

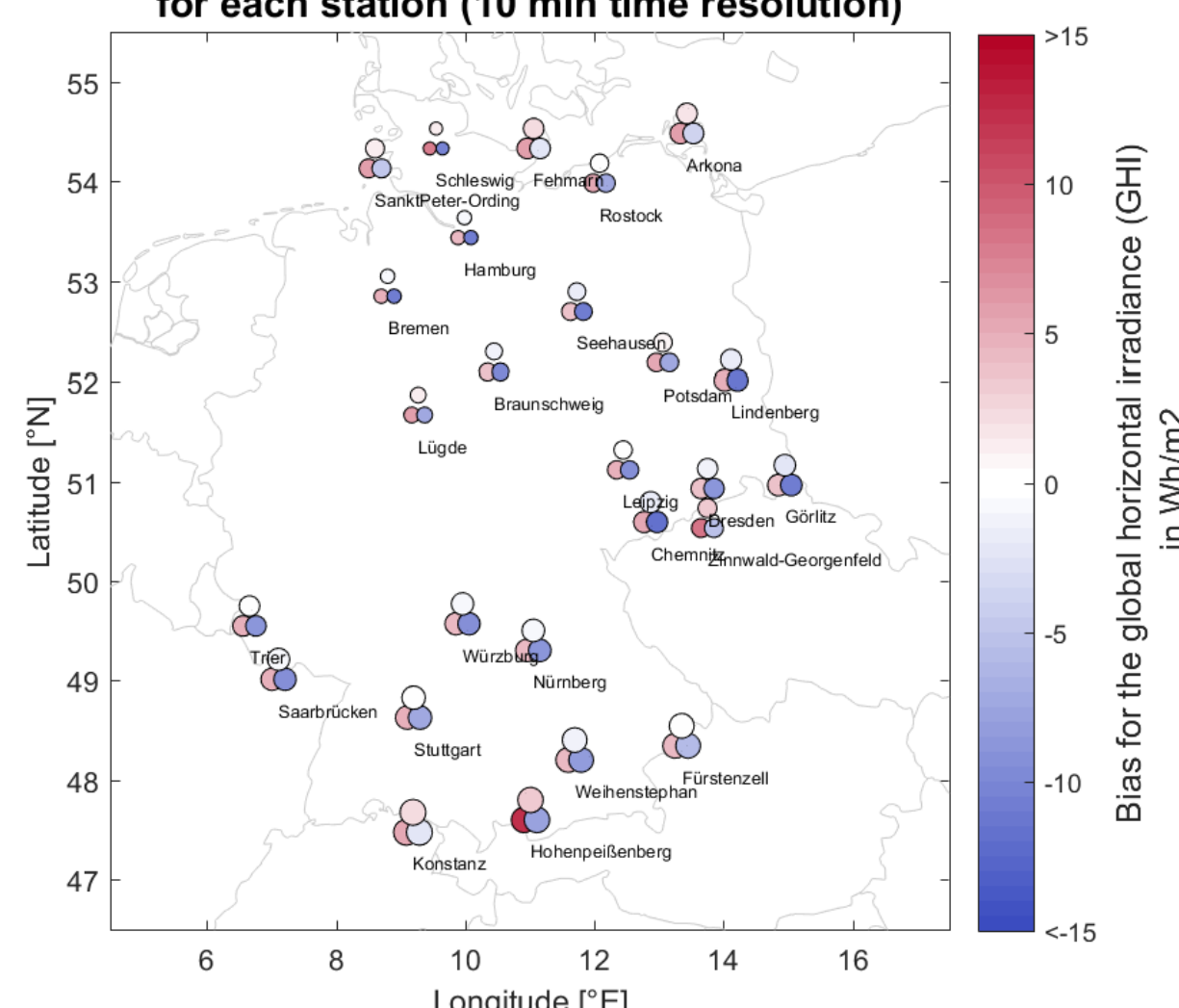
- Very good correlation for both CAMS and HC3v5. Both reproduces well the temporal variations of the solar radiation
- Very small bias for all-sky class but positive bias in overcast skies and negative bias in clear skies
- The bias are more pronounced for CAMS-RAD than for HC3v5
- The biases observed for the two considered classes can be partly explained by the validation procedure but other possible causes are to be investigated



Comparison of ground measurement with CAMS-RAD for each station (10 min time resolution)



Comparison of ground measurement with HC3v5 for each station (10 min time resolution)



|                      | All-skies                    |                           |                            |        | KT>0.7                       |                           |                            |        | KT<0.2                       |                           |                            |        |    |       |       |    |    |    |    |    |    |       |       |
|----------------------|------------------------------|---------------------------|----------------------------|--------|------------------------------|---------------------------|----------------------------|--------|------------------------------|---------------------------|----------------------------|--------|----|-------|-------|----|----|----|----|----|----|-------|-------|
|                      | Average (Wh/m <sup>2</sup> ) | Bias (Wh/m <sup>2</sup> ) | Stdev (Wh/m <sup>2</sup> ) | CC (-) | Average (Wh/m <sup>2</sup> ) | Bias (Wh/m <sup>2</sup> ) | Stdev (Wh/m <sup>2</sup> ) | CC (-) | Average (Wh/m <sup>2</sup> ) | Bias (Wh/m <sup>2</sup> ) | Stdev (Wh/m <sup>2</sup> ) | CC (-) |    |       |       |    |    |    |    |    |    |       |       |
| Konstanz             | 48                           | 48                        | 2                          | 16     | 13                           | 0.932                     | 0.957                      | 115    | 115                          | -9                        | -2                         | 12     | 12 | 0.915 | 0.922 | 11 | 11 | 9  | 5  | 13 | 7  | 0.693 | 0.699 |
| Hohenpeißenberg      | 48                           | 48                        | 3                          | 17     | 15                           | 0.919                     | 0.933                      | 105    | 105                          | -10                       | -8                         | 12     | 14 | 0.942 | 0.922 | 11 | 11 | 11 | 12 | 14 | 11 | 0.679 | 0.732 |
| Weihenstephan        | 47                           | 47                        | 1                          | -16    | 14                           | 0.926                     | 0.942                      | 111    | 111                          | -11                       | -8                         | 13     | 17 | 0.910 | 0.861 | 11 | 11 | 9  | 4  | 12 | 7  | 0.707 | 0.729 |
| Fürstzell            | 47                           | 47                        | 2                          | 0      | 15                           | 0.931                     | 0.95                       | 112    | 112                          | -10                       | -6                         | 12     | 16 | 0.920 | 0.883 | 11 | 11 | 9  | 4  | 13 | 7  | 0.696 | 0.702 |
| Stuttgart            | 46                           | 46                        | 2                          | 0      | 16                           | 0.919                     | 0.944                      | 113    | 113                          | -11                       | -7                         | 14     | 17 | 0.884 | 0.853 | 11 | 11 | 9  | 5  | 13 | 7  | 0.706 | 0.706 |
| Saarbrücken          | 45                           | 45                        | 3                          | -1     | 17                           | 0.912                     | 0.941                      | 112    | 112                          | -12                       | -9                         | 13     | 17 | 0.896 | 0.832 | 10 | 10 | 10 | 5  | 14 | 7  | 0.706 | 0.726 |
| Nürnberg             | 46                           | 46                        | 0                          | -1     | 16                           | 0.916                     | 0.942                      | 110    | 110                          | -15                       | -9                         | 17     | 17 | 0.855 | 0.864 | 11 | 11 | 8  | 4  | 12 | 7  | 0.717 | 0.722 |
| Trier                | 44                           | 44                        | 3                          | 0      | 16                           | 0.922                     | 0.932                      | 112    | 112                          | -11                       | -9                         | 13     | 19 | 0.904 | 0.804 | 10 | 10 | 9  | 5  | 13 | 7  | 0.716 | 0.707 |
| Würzburg             | 45                           | 45                        | 2                          | -1     | 16                           | 0.922                     | 0.934                      | 112    | 112                          | -11                       | -9                         | 13     | 18 | 0.901 | 0.820 | 10 | 10 | 9  | 4  | 13 | 7  | 0.728 | 0.713 |
| Zinnwald-Georgenfeld | 43                           | 43                        | 6                          | 3      | 19                           | 0.875                     | 0.922                      | 103    | 103                          | -10                       | -5                         | 13     | 15 | 0.925 | 0.908 | 11 | 11 | 13 | 8  | 17 | 9  | 0.7   | 0.689 |
| Chemnitz             | 45                           | 45                        | 1                          | -2     | 16                           | 0.919                     | 0.923                      | 105    | 105                          | -13                       | -12                        | 13     | 19 | 0.922 | 0.853 | 10 | 10 | 9  | 5  | 13 | 7  | 0.711 | 0.701 |
| Dresden-Klotzsche    | 44                           | 44                        | 1                          | -1     | 16                           | 0.911                     | 0.937                      | 109    | 109                          | -14                       | -9                         | 15     | 17 | 0.871 | 0.851 | 10 | 10 | 9  | 4  | 13 | 7  | 0.713 | 0.708 |
| Görlitz              | 45                           | 45                        | 1                          | -2     | 16                           | 0.919                     | 0.938                      | 108    | 108                          | -14                       | -11                        | 13     | 17 | 0.907 | 0.862 | 10 | 10 | 9  | 4  | 13 | 7  | 0.717 | 0.709 |
| Leipzig              | 43                           | 43                        | 3                          | 0      | 15                           | 0.923                     | 0.936                      | 111    | 111                          | -12                       | -9                         | 13     | 17 | 0.903 | 0.845 | 10 | 10 | 9  | 5  | 12 | 7  | 0.73  | 0.71  |
| Lügde                | 41                           | 41                        | 5                          | 1      | 17                           | 0.901                     | 0.929                      | 109    | 109                          | -10                       | -7                         | 13     | 17 | 0.910 | 0.851 | 10 | 10 | 11 | 6  | 14 | 7  | 0.706 | 0.665 |
| Lindenberg           | 45                           | 44                        | 0                          | -2     | 16                           | 0.917                     | 0.942                      | 107    | 107                          | -14                       | -11                        | 13     | 16 | 0.895 | 0.860 | 10 | 10 | 9  | 5  | 13 | 7  | 0.728 | 0.767 |
| Braunschweig         | 42                           | 42                        | 2                          | -1     | 16                           | 0.914                     | 0.939                      | 109    | 109                          | -13                       | -10                        | 13     | 18 | 0.894 | 0.833 | 10 | 10 | 9  | 4  | 13 | 6  | 0.726 | 0.729 |
| Potsdam              | 43                           | 43                        | 1                          | 1      | 15                           | 0.92                      | 0.948                      | 108    | 108                          | -13                       | -7                         | 13     | 14 | 0.893 | 0.888 | 10 | 10 | 9  | 5  | 13 | 7  | 0.732 | 0.758 |
| Seehausen            | 43                           | 42                        | 1                          | -2     | 15                           | 0.918                     | 0.932                      | 107    | 107                          | -13                       | -11                        | 13     | 18 | 0.901 | 0.837 | 10 | 10 | 8  | 4  | 13 | 7  | 0.725 | 0.736 |
| Bremen               | 41                           | 41                        | 3                          | -1     | 15                           | 0.912                     | 0.929                      | 108    | 108                          | -12                       | -11                        | 13     | 19 | 0.893 | 0.809 | 10 | 10 | 9  | 5  | 14 | 7  | 0.718 | 0.738 |
| Hamburg              | 41                           | 41                        | 0                          | -1     | 16                           | 0.907                     | 0.939                      | 107    | 107                          | -17                       | -11                        | 16     | 17 | 0.853 | 0.859 | 10 | 10 | 9  | 4  | 13 | 6  | 0.723 | 0.746 |
| Rostock              | 43                           | 43                        | -1                         | 0      | 14                           | 0.934                     | 0.948                      | 107    | 107                          | -14                       | -7                         | 14     | 14 | 0.877 | 0.884 | 9  | 9  | 7  | 5  | 11 | 7  | 0.733 | 0.746 |
| Sankt Peter-Ording   | 43                           | 43                        | -2                         | 1      | 14                           | 0.935                     | 0.964                      | 106    | 106                          | -15                       | -5                         | 15     | 9  | 0.876 | 0.954 | 9  | 9  | 7  | 6  | 10 | 7  | 0.76  | 0.796 |
| Schleswig            | 40                           | 40                        | 2                          | 1      | 15                           | 0.913                     | 0.93                       | 106    | 106                          | -13                       | -10                        | 13     | 16 | 0.900 | 0.859 | 9  | 9  | 9  | 8  | 13 | 9  | 0.732 | 0.763 |
| Fehmarn              | 44                           | 44                        | -1                         | 2      | 14                           | 0.938                     | 0.965                      | 107    | 107                          | -12                       | -2                         | 13     | 8  | 0.885 | 0.959 | 9  | 9  | 7  | 6  | 10 | 7  | 0.739 | 0.767 |
| Arkona               | 44                           | 44                        | -4                         | 2      | 14                           | 0.936                     | 0.968                      | 106    | 106                          | -16                       | -4                         | 15     | 7  | 0.863 | 0.970 | 9  | 9  | 7  | 6  | 9  | 7  | 0.710 | 0.787 |
| All stations         | 44                           | 44                        | 1                          | 0      | 16                           | 0.918                     | 0.941                      | 109    | 109                          | -13                       | -8                         | 14     | 16 | 0.897 | 0.872 | 10 | 10 | 9  | 5  | 13 | 7  | 0.714 | 0.715 |