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# A novel data set for solar energy applications based on high resolution reanalysis COSMO-REA6

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*In the field of renewable energy (RE) reanalyses gain steadily increasing attention. The output fields of wind and radiation are one of the best sources for RE analysis.*
*Here we assess the quality of global radiation provided by the reanalyses COSMO-REA6.*
*Comparisons with reference observations from the Baseline Surface Radiation Network (BSRN) over two decades reveal systematic deficiencies under clear and cloudy sky cases.*
*A post-processing of the radiation is developed to ensure the observed statistical distribution.*

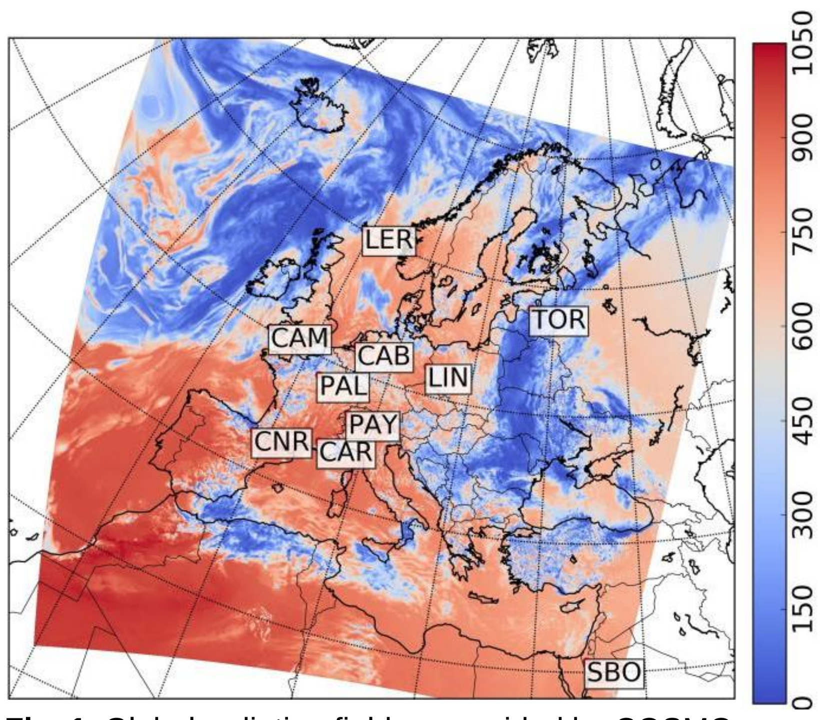



**Fig. 1**: Global radiation field as provided by COSMO-REA6 for 12 UTC, 01 June 2014. The abbreviations show the considered Baseline Surface Radiation Network (BSRN) stations and their locations.

### COSMO Regional Reanalysis

One major goal of the Hans-Ertel-Centre research group is the **development** of **regional reanalyses using the COSMO NWP model**. While several further products are currently under development, three **COSMO reanalysis data sets** are **available**:

- **COSMO-REA6** covering the European continent at 6 km grid size (available period: 1995-2015)
- **COSMO-REA2** for Central Europe in a convection-permitting setup at 2 km grid size (available period: 2007-2013)
- **COSMO-ENS-REA12** for the European continent at 12 km grid size in an ensemble setup (available period: 2006-2010)

Further information on the reanalyses and derived products are available at **http://reanalysis.meteo.uni-bonn.de**

## Assessment of COSMO-REA6 global radiation (GHI)

### Example time series at Lindenberg, Germany.

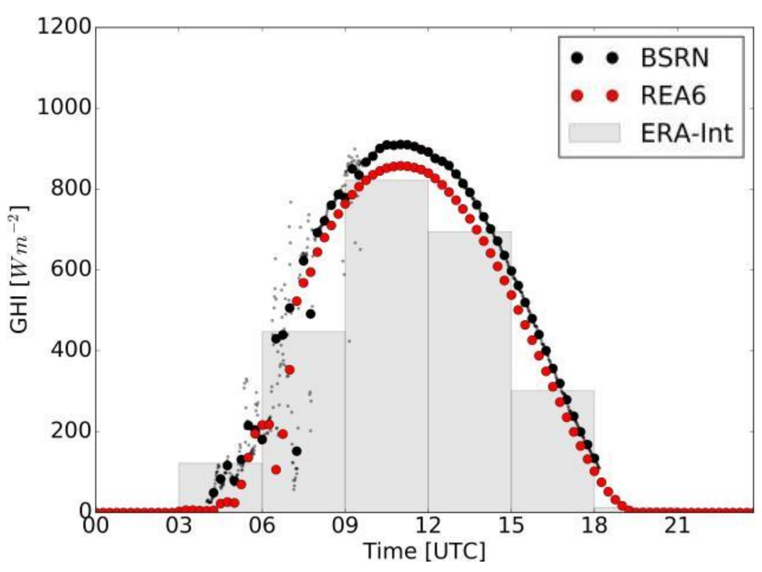



**Fig. 2**: GHI time series at Lindenberg, Germany (23.06.2008). BSRN observations are available every minute (shaded), REA6 values every 15 minutes and ERA-INT provides 3 hour averages. Additionally shown are 10 minute averages of BSRN obs to match the spatial scale of COSMO-REA6.

- REA6 shows potential to represent short time cloud variability
- GHI in clear sky situations is slightly underestimated

### Representation of absolute GHI values

- High standard quality controlled observations from 10 BSRN stations across Europe are used as reference.
- Yearly GHI sums are good (-5 %)
- Diurnal & seasonal cycle are eliminated by considering the hemispheric transmissivity (T), i.e. normalization with the maximum available radiation varying with the solar elevation angle.
- REA6 shows distinct differences in the occurrence of low (<0.4) and high transmissivity (Fig. 4) compared with observations.

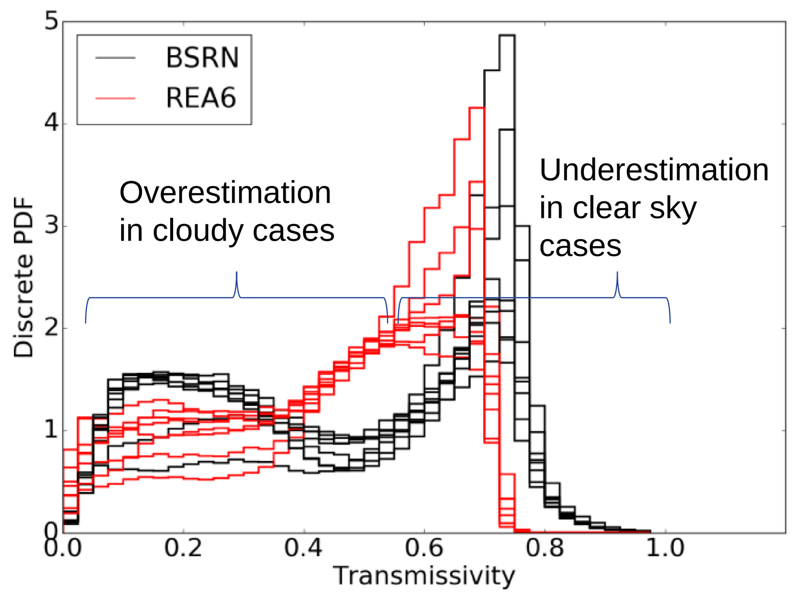


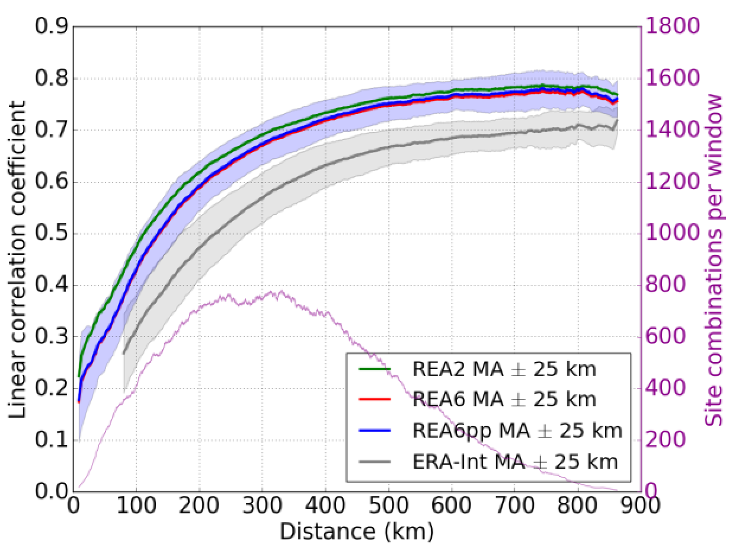

**Fig 4**: Discrete probability density function (PDF) for transmissivity for all BSRN observations and corresponding COSMO-REA6 estimates.

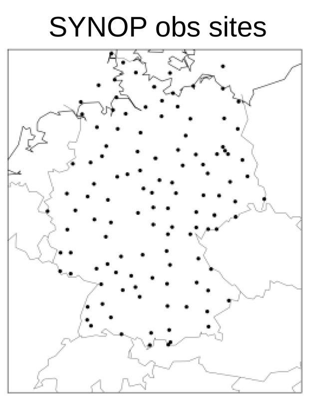
| Bias | Reason |
|---|---|
| Negative BIAS of Q for high transmissivity cases | Aerosol optical depth in climatology is too high. |
| Positive BIAS of Q for low transmissivity cases | Optically too thin or too few clouds in COSMO-REA6 |

Bias compensation effects

Motivation for post-processing

### Representation of atmospheric processes




Is there an added value by using regional reanalyses compared to global reanalyses?

Which spatial scales are well represented in the reanalyses?

Correlations between observed and modeled site-to-site differences in radiation as function of distance between two sites.

**Fig 3**: Linear correlations of observed and modeled site-to-site wind speed differences as function of the distance between two sites. Shaded is the standard deviation of all correlations in the considered moving average (MA) window. REA6pp is the COSMO-REA6 post-processed radiation (see results). Compared are three hour averages from 2007 - 2013.

COSMO-REA6 represents clouds significantly better than ERA-INTERIM

## Post-processing of COSMO-REA6 global radiation

- Under- and overestimation motivates different scaling factors $a$ for "clear" and "cloudy" conditions:

$$T_{post}(T) = \begin{cases} T\, a_{cloudy}, & T < T_{Th} \\ T\, a_{clear}, & T \geq T_{Th} \end{cases}$$

- A weight function guarantees a smooth transition from negative to positive adjustments.
- The scaling factors represent the slope of the linear orthogonal distance regression (ODR) between observation and REA6.
- Relationship of transmissivity and cloud conditions motivates $T_{Th}$ (Fig. 5)

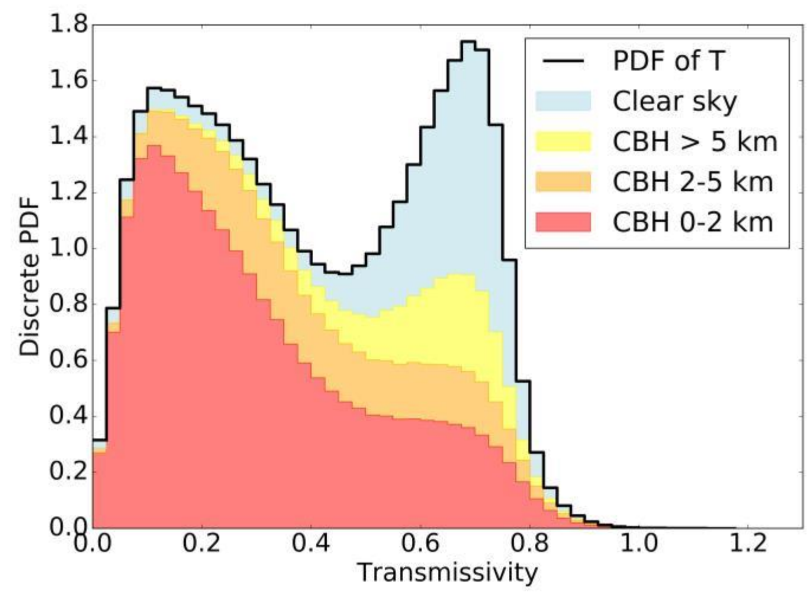



**Fig. 5**: Histogram of transmissivity for three cloud base height (CBH) classes and for clear sky situations. Considered are only SYNOP observations with a corresponding Ceilometer obs of CBH.

- Larger adjustments during winter and small solar elevation angles necessary
- Cross validation shows good spatial applicability

- Transmissivity distribution is bimodal
- Low transmissivity peak is mainly formed by liquid cloud conditions
- High transmissivity peak is mainly formed by clear sky and ice cloud conditions
- $T_{Th}$ is set to the minimum value of 0.5

## Results

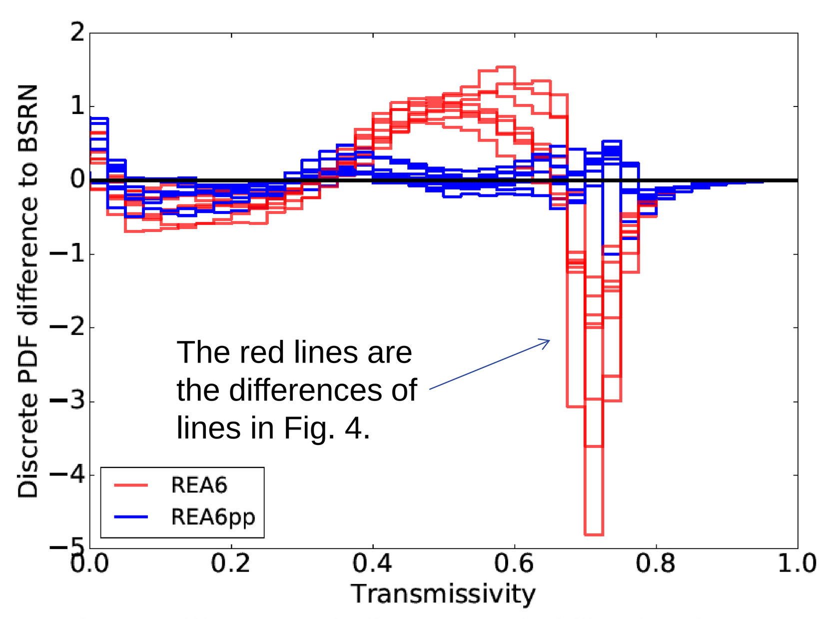



**Fig. 6**: Difference of discrete probability density functions before (REA6) and after the post-processing (REA6pp). The reference density is the observed one.

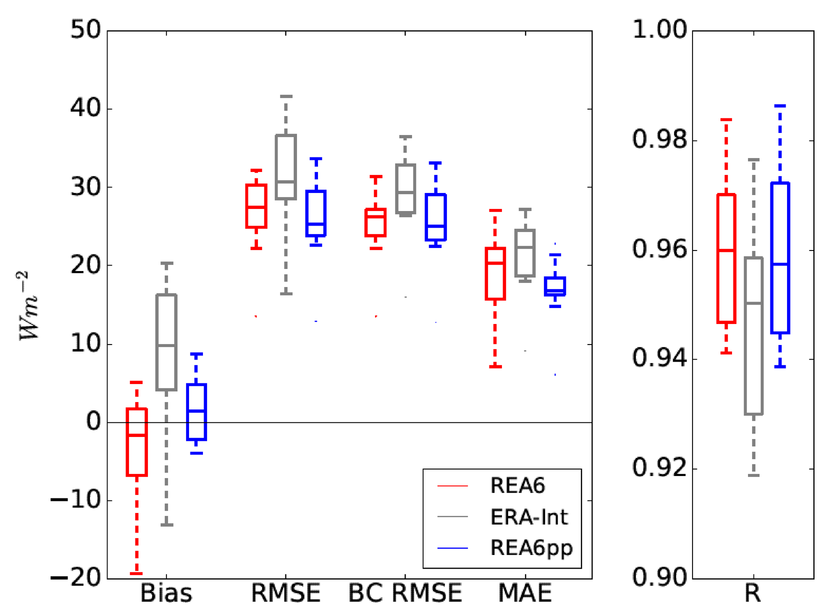



**Fig. 7**: Statistical assessment of daily mean GHI over the years 1995 – 2014. Each boxplot is calculated over the 10 BSRN sites.

The post-processing reduces the over and underestimation effects in transmissivity for each individual site.

- The post-processed improves especially the bias and MAE. The scores are comparable to the satellite based product SARAH
- The shorter whiskers show that systematic deficits at some stations can be reduced without compromising the quality at other stations

**Outlook**: Photovoltaic power yield simulation and wind power yield simulation
Investigate extremes and spatial compensation effects (based on REA6pp)

**Data availability and publications**

- The post-processed global radiation and other selected variables of the COSMO reanalyses are now freely available on our web page: http://reanalysis.meteo.uni-bonn.de/
- We recently submitted the content of this poster to Solar Energy.