Global, diffuse and direct irradiances modelling over northwestern Europe using MAR regional climate model MAR: validation and construction of a 30-year climatology

Julien Beaumet1, Sébastien Doutreloup1, Xavier Fettweis1, Charlotte Lang1 & Michel Epicier1
1Laboratoire de Climatologie et Topoclimatologie, University of Liège, Belgium

EGU2015-11493

1. Introduction

Context:
- Growing interest and growing PV production in EU countries
- Assess and manage available solar resources over space and time
- Local issues due to integration in low voltages grids and interests in forecasts (see PREMASOL project)

Modelling issues:
- Model solar global irradiance using Regional Climate Models at high resolution
  - Decompose global irradiance into diffuse and direct irradiances

Statistical decomposition of global into diffuse and direct irradiances
Use of the sigmoid model from Ruiz-Arias et al., (2010)1
1) Determination of the atmospheric clearness index (kt):
   \[ \text{kt} = \frac{I_{g}}{I_{g}^*} \]
   \( I_{g}^* \) : Global solar irradiance, \( I_{g} \): Extra-terrestrial irradiance, \( \text{Coszen} \) : Cosine of the sun zenith angle.
2) Determination of diffuse fraction (K):
   \[ K = A - B*\exp(-C*D^k) \]
   \( A, B, C, D \): empirical parameters from global adjustment (Ruiz-Arias et al., 2010)

2. Method

RCM : Modèle Atmosphérique Régional (MAR) 1,2
- Hydrostatic - 10 km horizontal resolution
- Forcing : ERA-Interim reanalysis - Outputs every 30 minutes
- ECMWF radiation scheme, SISAT surface model, Peter Bechtold cumulus scheme
- CORINE land cover data set, increased moisture at border and in radiation scheme

Solar irradiances observations:
- Data from the European Solar Radiation Atlas (ESRA)
- Extraction of global and diffuse irradiances from the 1986-1990 period at hourly and daily time scale for the stations of:
  - Uccle, Brussels agglomeration, Belgium (50.798°N, 4.359°E)
  - Braunschweig, Lower Saxony (40 kms E. of Hannover), Germany (52.29°N, 10.448°E)

Calculation of normalized root mean square errors (nRMSE %), normalized bias (nBIAS %) and coefficient of determination (R²) for the estimation of hourly and daily sums of global, direct and diffuse irradiances at Braunschweig and Uccle for the 1986 – 1990 period.


Building of a 30-year climatology over northwestern Europe of global, diffuse and direct irradiance at 10 kilometres of horizontal resolution using MAR model – Calculation of seasonal distribution

5. Trends and variability analysis

Calculation of trends and standard deviations of global irradiance over the 1981-2010 period

6. Conclusions

Conclusions:
- Ability of the MAR to successfully model global irradiances at hourly and daily time scale
- Less successful modeling of diffuse and direct irradiances : addition of the errors of two model (MAR and signal model)
- Overestimation of global irradiance in summer causing overestimation (underestimation) of direct (diffuse) irradiances
- Underestimation of convective clouds and their thickness in MAR model
- MAR suggests a positive/negative trend in global radiation over the last 30 years in northwestern Europe (to be verified and assessed possible cause)

Short-term perspectives:
- Increase vertical resolution (vertical layers) in MAR model in order to improve modeling of convective clouds
- Test more complex model for the decomposition of global into diffuse and direct irradiances
- Model intercomparisons (MAR, WRF-ARW, COSMO)

References
1) Bechtold et al., 2010
2) Doutreloup et al., 2010
4) Ruiz-Arias et al., 2010
5) Arnaud et al., 2010
6) Bechtold et al., 2010
7) Bechtold et al., 2010