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TECHNICAL NOTE

THE EUROPEAN SOLAR RADIATION ATLAS: A VALUABLE DIGITAL TOOL

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The new CD-ROM-based European Solar Radiation Atlas (ESRA) (2000) is now available. It is published by Les Presses de l'Ecole des Mines de Paris on behalf of the European Commission. This atlas, in two volumes, is an instrument dedicated to providing knowledge and aiding exploitation of the solar resources across a wide sweep of Europe, from the Urals to the Azores and from Northern Africa to Polar Circle. It is a powerful tool for architects, engineers, meteorologists, agronomists, local authorities, and tourism professionals, as well as for researchers and students. The input data are based on the period 1981–1990.

The first volume provides a broad overview with supporting maps. It starts by describing the course of the Sun across the sky as it varies across the year with geographical location. Then the interactions of the solar radiation with the atmosphere and its components (haze, turbidity, clouds, etc.) and the separation of the solar radiation into the direct and diffuse parts are discussed. The outline structures of the database and the ESRA software package are next described. Sixteen coloured maps provide data on the monthly mean global, beam, diffuse irradiation on horizontal surface and the clearness index for March, June, September and December. The mapped values are averages over the 10-year period 1981–1990. Additionally there are the corresponding four annual maps, also a country-based relief map and a map of ground observing stations used. There are two special maps giving zones of similar irradiation and zones of similar biomass productivity.

The second more technical volume comprises a book of 296 pages and a CD-ROM. The book describes the detailed content of the CD-ROM, explaining how it was constructed and how to use the software. The CD-ROM contains a database, which offers spatial (every 10 km approximately) and temporal climatic information for different time scales (from climatological means — more than 700 stations — to hourly values — 7 stations). It includes the solar resources: irradiation (global and its components), sunshine duration, as well as air temperatures, precipitation, water vapour pressure, air pressure for a number of stations. The CD-ROM also contains the software to exploit the database.

The software uses either a 'map' or a 'station' mode at user choice. In the first case, any geographical site can be designated. In the second mode, only the available measuring stations can be selected. The software includes algorithms covering the following fields: solar geometry, optical properties of the atmosphere, estimation of hourly irradiation on slope under cloudless skies, estimation of solar irradiation values (going from daily to hourly values, conversion from horizontal to tilted surfaces), spectral irradiance, illuminance, daily mean profiles of temperature and other statistical quantities (central moments, extremes, probability, cumulative probability and utilizability curves). Graphics can be displayed in two or three dimensions. Applications in solar engineering can be handled, too. The examples provided address the four most widely developed solar energy applications using simplified design methods: solar water heaters, passive solar buildings,

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photovoltaic cells and biomass production. In each case, typical computation processes are described and the way to use the solar radiation data as inputs is explained. The database can be consulted with mouse clicking and exported towards other software, such as spreadsheets. Maps can be transferred to image editing or suitable word processing programmes.

All information needed to run the software is provided in this second volume. This volume describes in detail every aspect of the ESRA. The scientists constructing the ESRA decided to clearly report all details of scientific importance. Meteorological and radiation data were collected to establish maps, to test algorithms and to compose the published database. The data, their sources, the quality control applied, their detailed processing and their format within the CD-ROM are extensively discussed in Volume 2. These data were used to select the most appropriate algorithms to be included in the software. Algorithms and chains of algorithms were selected after careful and extensive testing. This testing aspect is well presented in the book. All the equations and algorithms used are fully described in Volume 2. The software sources are also given in the CD-ROM, thus allowing extensive analyses of the capabilities and the limitations of the software. A few new algorithms were developed. Among them is a model for the assessment of the irradiance and irradiation under clear-sky conditions developed by Page (1995), which was proved to perform very well in checks by independent authors (Rigollier *et al*., 2000a).

Maps are one attractive aspect of the ESRA. Spatial interpolation techniques do not lead to satisfactory results for meteorological parameters. For a start, terrain height is so impactive. Hence, maps were constructed only for solar radiation, its components and the clearness index. An innovative method was developed, following the path shown by Zelenka (1994), and based on the fusion of ground-measured data and satellite-derived maps of radiation (Beyer *et al*., 1997).

The ESRA is a logical follow-up of the digital third edition of the previous atlas performed by Scharmer and Page on behalf of the European Commission. The 10 years mean monthly data for the period 1966–1975 published in this third edition should be seen as a valuable complement to the 1981–1990 database of the ESRA. A comparison is possible for a few stations, where digital values are available for both periods.

The ESRA continues, at enlarged scale, the previous work of the European Commission on solar radiation mapping (Commission of the European Communities, 1984a,b) and complements similar works in other European programmes, e.g. the European Wind Atlas (Troen and Petersen, 1989), the Solar Radiation Atlas of Africa (Raschke *et al*., 1991), the European Daylighting Atlas (Commission of the European Communities, 1995), the Russian Atlas of Hydrometeorological Data (1991), as well as work performed on a regional basis (Bayerischer Solar- und Windatlas, 1995). These atlases are on paper only. Compared to them, the ESRA benefits from the advances in information technologies. Databases are available, digital values can be exported, interactivity is everywhere, complex computations can be performed. The elevation of any geographical location is embedded in the database. In addition, the ESRA offers map capabilities, which are presently unique in solar radiation atlases. The MeteoNorm series (version 3, 1997 and 4, 2000) are another example of digital atlases.

The CD-ROM-based atlases have their advantages and limitations. Further progress in the dissemination of information on solar radiation and resources is expected due to the World Wide Web capabilities. This approach is already demonstrated by several projects, which have established the following Web sites:

- Minister of Natural Resources of Canada RETScreen project (http://retscreen.gc.ca),
- NASA surface meteorology and solar energy data set (http://eosweb.larc.nasa.gov/sse/),
- Satellight (Fontoynont *et al*., 1998; Reise *et al*., 1999; http://www.satel-light.com),
- Helioserve (Angles *et al*., 1999; http://www.helioclim.net),
- SoDa (Rigollier *et al*., 2000b; http://www.helioclim.net).

The ESRA was realised on behalf of the European Commission, by a team led by the company GET (Jülich, Germany), and comprising the Deutsche Wetterdienst (Hamburg, Germany), Armines/Ecoles des Mines de Paris et de Nantes (France), Instituto Nacional de Engenharia e Tecnologia Industrial (Lisbon, Portugal), the Technical University of Lyngby (Denmark), the World Radiation Data Centre (Saint-Petersburg, Russia), and Institut Royal de Météorologie (Brussels, Belgium) (Scharmer, 1994). John Page (Sheffield, UK) and Robert Dogniaux (Brussels, Belgium) acted as advisors.

The ESRA is available from Les Presses de l'École des Mines (Tel.: + 33-1-4051-9317; e-mail: delamare@dg.ensmp.fr), 60, boulevard Saint-Michel, 75272 Paris cedex 06, France. http:

//www.ensmp.fr/Fr/Services/PressesENSMP/Collections/ScTerEnv/Intro/col-ScTerEnv.html. More technical information as well as some samples of maps can be found on the HelioClim web server: http://www.helioclim.net.

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